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Lead Agencies:

U.S. Fish and Wildlife Service
U.S. Bureau of Reclamation
Hoopa Valley Tribe
Trinity County

Trinity River Fishery Restoration

Supplemental Environmental Impact Statement/ Environmental Impact Report

April 2004

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Acronyms and Abbreviations

˚C	degree Celsius
˚F	degree Fahrenheit
5C	Five Counties Salmonid Conservation Program
A	adverse change
AEAM	Adaptive Environmental Assessment and Management
B	beneficial change
BA	biological assessment
BETTER	Box Exchange Transport Temperature and Ecology of Reservoirs Model
BIA	Bureau of Indian Affairs
BLM	Bureau of Land Management
BO	biological opinion
CALSIM	California Simulation Model
CAPX	California Power Exchange
CCWD	Contra Costa Water District
CDFG	California Department of Fish and Game
CEQA	California Environmental Quality Act
CESA	California Endangered Species Act
cfs	cubic feet per second
COA	Coordinated Operating Agreement
columnaris	*Flavobacter columnare*
Court	U.S. District Court
CVP	Central Valley Project
CVPIA	Central Valley Project Improvement Act
DBP	disinfection by-products

Delta	Sacramento-San Joaquin River Delta
DOI	U.S. Department of the Interior
Draft EIS/EIR	Draft Environmental Impact Statement/Environmental Impact Report
DSM2	Delta Simulation Model 2
DWR	California Department of Water Resources
EC	electrical conductivity
ESA	Endangered Species Act
ESU	Evolutionary Significant Unit
EWA	Environmental Water Account
FERC	Federal Energy Regulatory Commission
GWh	gigawatt hours
HB	highly beneficial change
ICH	*Ichthyopthirius multifilis*
IOU	investor-owned utilities
ISO	California Independent System Operator
km	kilometer
kW	kilowatt
kWh	kilowatt-hour
LKRP	Lower Klamath Restoration Partnership
M&I	municipal and industrial
maf	million acre-feet
MDO	Memorandum Decision and Order
msl	mean sea level
MW	megawatt
NC	no change

NCRWQCB	North Coast Regional Water Quality Control Board
NEPA	National Environmental Policy Act
NOAA Fisheries	National Marine Fisheries Service
NOI	Notice of Intent
NOP	Notice of Preparation
No_x	oxides of nitrogen
NP15	California ISO North Path 15
OCAP	Operations Criteria and Plan
PEIS	Programmatic Environmental Impact Statement
PFMC	Pacific Fishery Management Council
PG&E	Pacific Gas and Electric Company
ppt	parts per thousand
Program	Trinity River Restoration Program
Reclamation	U.S. Bureau of Reclamation
RM	river mile
ROD	Record of Decision
RTM	U.S. Bureau of Reclamation's Temperature Model
RTO	regional transmission organization
SCE	Southern California Edison
SDIP	South Delta Improvements Project
SDWA	Safe Drinking Water Act
Service	U.S. Fish and Wildlife Service
SLC	State Lands Commission
SNTEMP	Service's Stream Network Temperature Model
SO_2	sulfur oxide
SP15	California ISO South Path 15
Supplemental EIS/EIR	Trinity River Fishery Restoration Supplemental Environmental Impact

	Statement/Environmental Impact Report
SVWMA	Sacramento Valley Water Management Agency
SWP	California State Water Project
SWRCB	State Water Resources Control Board
taf	thousand acre-feet
TAMWG	Trinity Adaptive Management Working Group
Task Force	Trinity River Basin Fish and Wildlife Task Force
TCD	Temperature Control Device
THM	trihalomethanes
TMDL	Total Maximum Daily Load
TRD	Trinity River Division
TRFES	Trinity River Flow Evaluation Study
TRRP	Trinity River Restoration Program
TRSAAM	Trinity River System Attribute Analysis Method
TRSSH	Trinity River Salmon and Steelhead Hatchery
USACE	U.S. Army Corps of Engineers
USDA	U.S. Department of Agriculture
USFS	U.S. Forest Service
Wanger Decision	Memorandum Decision and Order re: Cross Motions for Summary Judgement in the Case of Westlands, et al., v. United States, et al.
Western	Western Area Power Administration
WQCP	Water Quality Control Plan
yd^3	cubic yards
yd^3/year	cubic yards per year

SECTION 1.0

Introduction and Purpose and Need

1.1 Introduction

This Trinity River Fishery Restoration Supplemental Environmental Impact Statement/Environmental Impact Report (Supplemental EIS/EIR) addresses the environmental issues, alternatives, and impacts associated with restoration of the natural production of anadromous fish on the Trinity River downstream of Lewiston Dam. This document updates, amends, and, in some cases, affirms assumptions, analyses, and conclusions of the previous environmental documents associated with Trinity River Fishery Restoration. These prior documents were prepared pursuant to both the National Environmental Policy Act (NEPA) (42 United States Code [USC] § 4321 et seq.) and the California Environmental Quality Act (CEQA) (Cal. Pub. Resources Code, § 21000 et seq.). (See section 1.8, "Similarities and Differences between NEPA and CEQA.") NEPA is a federal law setting forth the parameters and principles of environmental review for federal agencies, while CEQA is a California law governing environmental review conducted by state, regional, and local agencies.

Those aspects of this Supplemental EIS/EIR intended to satisfy NEPA requirements were prepared in response to federal court rulings that resulted from a legal challenge to the original EIS. The original EIS/EIR was circulated as a public draft in October 1999, finalized in October 2000, and resulted in a signed Record of Decision (ROD) in December 2000. These documents are available from U.S. Bureau of Reclamation (Reclamation) and Trinity County.

Although the above-mentioned federal court rulings did not address issues arising under CEQA, this new document is also intended to satisfy CEQA requirements. Although entitled a Supplemental EIR for ease of reference (because the federal court rulings required preparation of a Supplemental EIS), the portions of the document devoted to CEQA compliance are more precisely characterized as a "partially recirculated draft EIR." (See Cal. Code of Regulations, tit. 14, § 15088.5, subd. (c).) The CEQA portions of the new document do not constitute a true Supplemental EIR, in the normal sense of state law term-of-art, in that Supplemental EIRs normally are prepared only after an original EIR has been "certified" and a proposed project has received at least one or more project approvals subject to CEQA. (See Cal. Pub. Resources Code, § 21166; Cal. Code of Regs., tit. 14, §§ 15162, 15163).

Although the federal co-lead agencies and CEQA lead agency (Trinity County) together published in October 2000 a document entitled, Final EIS/EIR for the Trinity River Fishery Restoration, that document was not a true Final EIR, as it was never "certified" by the Board of Supervisors of Trinity County. (See Cal. Code Regs., tit. 14, § 15090.) Thus, that Final EIS/EIR was not a joint NEPA/CEQA document, but rather was a pure NEPA document only, despite its title. Trinity County intends that, once this Supplemental EIS/EIR is circulated for public review and comment, the County, together with the other lead agencies, will respond to all comments on both the original Draft EIS/EIR and this Supplemental EIS/EIR. In doing so, Trinity County reserves the right to use some of the material provided in the original Final EIS/EIR.

This Supplemental EIS/EIR was prepared by the U.S. Fish and Wildlife Service (Service), Hoopa Valley Tribe, Trinity County, and Reclamation (see Section 5.1 of the Draft EIS/EIR for agency involvement and a list of the agency approvals for the project to proceed [Service et al., 1999]). This Supplemental EIS/EIR meets the legal requirements of NEPA and CEQA. This document discloses relevant information to all interested parties and invites such parties to play a role in both the decisionmaking process and the implementation of that decision. This Supplemental EIS/EIR also provides federal, state, and local decisionmakers with detailed information concerning the significant environmental, social, economic, cultural, and other impacts associated with the alternative courses of action.

1.2 Court Proceedings

A Final EIS on the Trinity River Restoration Program (TRRP or Program) was published in October 2000, and a ROD was executed on December 19, 2000. Central Valley water and power interests filed suit in the U.S. District Court (or Court) for the Eastern District of California seeking to enjoin implementation of the ROD. On December 9, 2002, Judge Oliver Wanger of the court issued a Memorandum Decision and Order (MDO) re: Cross Motions for Summary Judgement in the Case of Westlands, et al., v. United States, et al., (sometimes referred to as the "Wanger Decision" or "Judge's ruling" in this document). (See 275 F. Supp. 2d 1157 (E.D. Cal. 2002).) The MDO identified a number of instances in which, according to Judge Wanger, the federal defendants had not fully complied with NEPA and the Endangered Species Act (ESA) (16 USC § 1531 et seq.). Therefore, the MDO enjoined the federal defendants from implementing any of the flow-related aspects of the ROD pending completion of a Supplemental EIS. The Supplemental EIS was required to cure certain problems with the original NEPA documents, and to address certain information that came to light after completion of the Draft EIS/EIR for the proposal. Because the original documents had included what the court considered an overly narrow statement of purpose, and had failed to include an adequate range of project alternatives, the court required the Supplemental EIS to revisit those issues. The document was also required to address the environmental effects of certain "reasonable and prudent measures" required by two Biological Opinions (BO) issued by the Service and the National Marine Fisheries Service (now NOAA Fisheries) after completion and circulation of the Draft EIS/EIR. Finally, the Supplemental EIS was to examine the effects of the proposed actions on electrical power production, specifically in relation to the California energy crisis that occurred in late 2000, and conditions continuing thereafter. The court also found that the BOs exceeded the authority granted to Service and NOAA Fisheries under ESA, in that the BOs impermissibly required what amounted to major modifications to operations of the Central Valley Project (CVP). Following the MDO, the court issued final judgment in the case on February 20, 2003. The final judgment is summarized in Table 1-1, which includes references to the parts of this document that address the final judgment.

The Court's ruling in this case emphasized the need for Interior to take into account ESA impacts throughout the CVP in developing reasonable and prudent measures and implementing terms and conditions for any authorized incidental take of listed species. With respect to the treatment of ESA impacts in the original EIS, the Court found that it "was arbitrary and capricious for the EIS and Final EIS

not to address impacts of X2 [Delta salinity] reasonable and prudent measures and CVP re-operation." Westlands Water Dist. v. U.S. Department of the Interior, 275 F.Supp.2d at 1196. To comply with the Court's ruling, the federal defendants recognized that Reclamation needs to assess the impacts on listed species throughout the entire CVP system to the extent that those species may be affected by the range of possible Trinity operations under the various alternatives under consideration in the Supplemental EIS/EIR. Ideally, Reclamation would have been able to complete its renewed consultation with the Service and the NOAA Fisheries so that new Supplemental BOs would have been provided before publication of the Public Draft EIS/EIR. However, that early coordination simply has not been possible because of the complicated nature of the comprehensive Operations Criteria and Plan (OCAP) ESA consultation, and the timeline required for completion of this document.

The OCAP process includes consultation with Service and NOAA Fisheries under section 7 of the ESA to determine the potential impacts on ESA-listed endangered and threatened species throughout the entire CVP, including the Trinity River Division (TRD). Pursuant to the ESA regulations, 50 C.F.R. § 402.12, as the lead federal "action" agency for OCAP, Reclamation must prepare a biological assessment (BA) that takes into account the range of ongoing and proposed actions that comprise CVP operations. These OCAP-related actions include several developments that were not in place in 2002 at the time of the initial BOs and the initial EIS for the Trinity River fishery restoration. These developments include the following:

- Proposed new water diversion on the Sacramento River near Freeport, California
- Proposed inter-tie between the Delta Mendota Canal and the State Water Project's California Aqueduct
- California Department of Water Resources' South Delta Improvement Plan, which includes both possible increased diversions at the Banks Pumping Plant and construction and operation of in-channel barriers in the South Delta area.

Reclamation's BA also must include assumptions regarding management of the Environmental Water Account (EWA), itself a complicated operational assessment. *Cf.* Laub v. U.S. Department of the Interior, 342 F.3d 1080, 1083-84 (9th Cir. 003)(describing EWA in context of CALFED).

Consistent with the direction provided by the U.S. District Court, this Supplemental EIS/EIR addresses the shortcomings of the original

Draft EIS/EIR identified by the court. Anticipating the possible need for a Supplemental EIS in the aftermath of a March 2001 decision granting a preliminary injunction, the co-lead agencies began the scoping process for such a document in January 2002.

TABLE 1-1
Summary of Court-identified Shortcomings in Previous EIS/EIR

Summary Issues	Supplemental EIS/EIR Reference	Comment
Purpose and scope of the Draft EIS/EIR was unfairly and unlawfully narrowed.	Section 1.3, Purpose and Need for the Action	Note change from Purpose Statement in 1999 EIS/EIR.
Reasonable Integrated Management Alternative was not fairly considered.	Section 2.0, Description of Alternatives	Note clarification made to alternatives regarding integrated management, also alterations made to Revised Mechanical Restoration (formerly Mechanical Restoration) and Modified Percent Inflow (formerly Percent Inflow), and the addition of the 70 Percent Inflow Alternative. "Integrated Management" is defined as the use of both flow and non-flow measures to restore the Trinity River fishery.
Consideration of power supply and reliability was inadequate.	Section 3.5, Power Resources	Note revised methodology used to evaluate alternatives, discussion of power supply reliability with regard to the California energy crisis, and relative measures of power supply reliability.
Service BO improperly identified "reasonable and prudent measures" for salinity control that were impermissible because they required more than "minor changes" to the proposed action.	Section 3.4, Fisheries	Note updated analysis of the impact of alternatives on relative habitat provided by X2 position.
National Oceanic and Atmospheric Administration Fisheries (NOAA Fisheries) improperly mandated implementation of the instream flow releases proposed in the preferred alternative as a purported reasonable and prudent measure to minimize the harm of channel rehabilitation and gravel placement projects.	Section 3.3, Water Quality; Section 3.4, Fisheries; Section 3.5, Power Resources	Note updated analysis on the impact of the alternatives on relative mortality of winter-run Chinook salmon. Also note analysis of the frequency of Power Plant Bypasses in Section 3.3 Water Quality and the cost of possible bypasses in Section 3.5 Power Resources.

Note: NOAA Fisheries was formerly known as and referred to in the 1999 EIS/EIR as National Marine Fisheries Services (NMFS)

As this Supplemental EIS/EIR is available for public review, the Ninth Circuit Court of Appeals is considering appeals filed in the aftermath of the U.S. District Court decision. Notably, the federal defendants appealed on only one issue: whether the U.S. District Court was correct in invalidating the statement of purpose in the original Draft EIS/EIR. Although this Supplemental EIS/EIR reflects

the U.S. District Court's direction, it is possible that the Court of Appeals will disagree with the U.S. District Court on this issue, and will uphold the original version. The Hoopa Valley Tribe, another co-lead agency, filed an appeal of a much broader scope: its appeal seeks to overturn virtually all aspects of the U.S. District Court decision finding problems with the EIS and ROD. Again, it is possible that the appellate court will overrule the U.S. District Court and, therefore, render the Supplemental EIS process unnecessary, in whole, or in part.

1.3 Purpose and Need for the Action

NEPA regulations require that each EIS briefly specify the purpose and need to which the agency is responding in proposing the various alternatives, including the proposed action. Similarly, CEQA requires that each EIR include a statement of the objectives sought by the proposed project. The objectives are intended to help the implementing agency develop a reasonable range of alternatives and aid decisionmakers in preparing findings or a statement of overriding considerations, if necessary.

1.3.1 Purpose and Need Statement

The purpose and need as stated in the original Draft EIS/EIR is as follows:

> The purpose of the proposed action is to restore and maintain the natural production of anadromous fish on the Trinity River downstream of Lewiston Dam[1].
>
> The need for this action results from Congress' (1) mandate that diversions of water from the Trinity River to the CVP not be detrimental to Trinity River fish and wildlife resources; (2) finding that construction and operation of the TRD has contributed to detrimental effects to habitat and has resulted in drastic reductions in anadromous fish populations; (3) finding that restoration of depleted stocks of naturally-produced anadromous fish is critical to the dependent tribal, commercial, and sport fisheries; and (4) confirmation of the federal trust responsibility to protect tribal fishery resources affected by the TRD (see Section 1.3 for Congressional actions).

In response to the judgement of the U.S. District Court (see Section 1.2), the statement of the Program's purpose has been revised as follows:

> The proposed action is to restore and maintain the natural production of anadromous fish in the Trinity River Basin downstream of Lewiston Dam, including fishery restoration to pre-TRD levels, and to meet the U.S. Government's tribal trust obligations.

Secondary consideration is given to (1) meeting the other restoration goals of the Act of October 24, 1984, Public Law 98-541, as amended, and (2) achieving a reasonable balance among competing demands

[1] For purposes of this document, "restore" is defined as reviving the well-being, vitality, and use thereof, but not necessarily to an original or other pre-established condition.

for use of CVP water, including the requirements of fish and wildlife, agricultural, municipal and industrial (M&I), and power contractors.

The need for this action remains unchanged as a result of the following Judge's Ruling and results from Congress':

1. Mandate that diversions of water from the Trinity River to CVP not be detrimental to Trinity River fish and wildlife resources.
2. Finding that construction and operation of the TRD has contributed to detrimental effects to habitat and has resulted in drastic reductions in anadromous fish populations.
3. Finding that restoration of depleted stocks of naturally-produced anadromous fish is critical to the dependent tribal, commercial, and sport fisheries.
4. Confirmation of the federal trust responsibility to protect tribal fishery resources affected by the TRD. (See Section 1.5 for Congressional actions.)

In formulating the preferred alternative and other alternatives, the federal lead agencies have proposed restoration options in which actions increasing and managing flows and improving conditions within the Trinity River would be closely integrated with ongoing or proposed actions to improve conditions in the tributaries of the Trinity River and within the entire Trinity River watershed. Such coordination is intended to take full advantage of non-flow means of improving fishery habitat within the mainstem while striking a reasonable balance between efforts to increase natural anadromous fish production and the need to continue providing water and power for CVP contractors within the Central Valley and elsewhere.

1.3.2 Goals and Objectives

The following goal established a framework for the Draft EIS/EIR and was the primary CEQA driver in the development of alternatives:

- Restore and maintain a "healthy" Trinity River downstream of Lewiston Dam. (See Section 3.2 of the Draft EIS/EIR for discussion of the "healthy river" concept.)

As CEQA lead agency, Trinity County believes that this general goal is consistent with the above-described statement of federal purpose and need, and with the statutory mandates and responsibilities of the state "responsible agencies" that must rely on the EIR portion of the joint EIS/EIR. The goal was clarified by establishing qualitative "healthy river" objectives. These objectives relied heavily on the known and presumed attributes of the pre-dam Trinity River. These pre-dam attributes provided the diverse habitats that once supported

the bountiful fish and wildlife populations. The healthy river objectives are as follows:

- Re-establish and maintain pre-dam habitats, especially alternate bar features.
- Mobilize and transport a wide variety of sediment sizes.
- Restore dynamic riparian plant communities in the river channel and its floodplain.

Objectives specific to salmonid population restoration are as follows:

- Provide suitable habitats below Lewiston Dam for all inriver salmonid life stages.
- Provide appropriate temperature regimes for salmonids below the dams.

The following project objectives apply only to Trinity County as the lead agency for CEQA purposes:

- Minimize high Trinity River water levels that would displace large numbers of existing Trinity County residents from their homes.
- Maximize the potential for the Trinity River to attract additional recreationalists into Trinity County, such as anglers and boaters.
- Minimize avoidable impacts to recreational activities on Lewiston and Trinity Reservoirs.
- Protect County of Origin and Area of Origin Water Rights.
- Comply with requirements and water quality objectives under the California Porter-Cologne Act and the federal Clean Water Act.
- Comply with Trinity County General Plan.

The following are project objectives for CEQA compliance that apply to state responsible and trustee agencies such as the North Coast Regional Water Quality Control Board (NCRWQCB), the California Department of Fish and Game (CDFG), and (possibly) the State Water Resources Control Board (SWRCB), and the State Lands Commission (SLC):

- Comply with the Water Code to ensure the highest reasonable quality of waters of the state, while allocating those waters to achieve the optimum balance of beneficial uses.
- Protect the public trust assets of the Trinity River watershed.
- Conserve, restore, and manage fish, wildlife, and native plant resources.

- Double populations of naturally-produced salmon, steelhead, and anadromous fish in the waters of California, including the Trinity and Sacramento Rivers and the Sacramento-San Joaquin River Delta (Delta), pursuant to the Fish and Game Code Section 6900-6924, the Salmon, Steelhead Trout, and Anadromous Fisheries Program Act.

The role, if any, of the SWRCB in Trinity River restoration efforts remains to be seen. At present, there are no pending plans to seek SWRCB approval of higher flows, and no such approval is necessary for the Secretary of Interior to voluntarily opt not to divert from the Trinity River the full amounts of water authorized under its current water rights permits. However, SWRCB involvement remains a possibility because, following completion of a ROD, Trinity County may re-initiate a 1990 petition to the SWRCB related to Water Right Orders 90-05 and 91-01. The petition may request amendment of Reclamation's seven Trinity River water permits for protection of Trinity River Basin public trust resources through increased minimum instream flows and implementation of Trinity River water quality objectives, and implementation of feasible mitigation measures identified in this Supplemental EIS/EIR.

As the CEQA lead agency, Trinity County has decided that the EIR portion of the EIS/EIR should be sufficient for any future action taken by SWRCB, should it get involved in some fashion. For this reason, the EIS/EIR contemplates possible action by the SWRCB. Many of the proposed mitigation measures could ultimately be within the jurisdiction of the SWRCB if not implemented voluntarily by the federal lead agencies.

The role, if any, of the SLC in Trinity River restoration efforts remains to be seen. The SLC has not claimed jurisdiction or permitting requirements for Trinity River Restoration Projects. However, the SLC has reserved the right to claim jurisdiction at a later date.

Trinity River Restoration Program Goals. Congressional directives identified the goals as the restoration and maintenance of fish populations in the Trinity River in order to meet the federal government's trust responsibility to area Indian tribes and to provide a meaningful tribal, commercial, and sport fishery. Although quantifiable project objectives for fish numbers and habitat area were considered for the Draft EIS/EIR, they were ultimately not adopted because of the complexity, uncertainty, and other confounding factors involved in establishing and monitoring such targets. However, the Trinity River Basin Fish and Wildlife Task Force (Task Force) adopted the Trinity River inriver spawner escapement goals and Trinity River Salmon and Steelhead Hatchery (TRSSH) production goals developed by CDFG (Table 1-2). These goals were subsequently

documented in the 1983 EIS on the Trinity River Basin Fish and Wildlife Management Program (Service, 1983). Because the Task Force no longer exists, the goals are sometimes referred to as the TRRP goals. They are provided here for reference purposes only and are non-binding on the program.

TABLE 1-2
Trinity River Restoration Program Goals

Species	Inriver Spawning Goals	Hatchery Goals	Total
Fall Chinook Salmon	62,000	9,000	71,000
Spring Chinook Salmon	6,000	3,000	9,000
Coho Salmon	1,400	2,100	3,500
Steelhead	40,000	10,000	50,000

Current spawner escapement levels are extremely low compared to historical estimates (see Section 3.4) and the TRRP inriver spawner escapement goals. The post-dam average of naturally-produced fall Chinook salmon represents only 20 percent of the 62,000 goal; whereas, the averages for naturally-produced spring Chinook salmon, coho salmon, and steelhead (winter only) represent 40, 14, and 5 percent, respectively, of their inriver escapement goals. Although the fall Chinook spawner escapement has occasionally exceeded the inriver goals, many of those fish were hatchery produced. These infrequent large escapements are not indicative of healthy, naturally producing populations, but of hatchery surplus (see Section 3.4 for additional information on historical and current fish populations).

Restoration and maintenance of natural production requires that a sufficient number of the fish that spawn inriver begin their lives not in the hatchery, but as eggs in the river. Unfortunately, a very small proportion of inriver eggs survive to return as spawning adults; whereas, a large proportion of hatchery-produced fish do return to spawn. Assuming that naturally-produced and hatchery-produced fish are subject to the same environmental conditions and mortality factors (e.g., harvest) after the hatchery releases them (typically as smolts), the comparatively low returns of naturally-produced fish indicate poor survival rates of the younger freshwater life stages (eggs, fry, and/or juvenile fish). These low inriver survival and recruitment rates are compelling evidence that rearing habitat is a substantial limiting factor in the restoration and maintenance of anadromous fish populations (see Section 3.4).

In the future, quantitative population objectives for Trinity River salmonids may be established by NOAA Fisheries and/or the CDFG as part of the recovery planning process under the federal and/or state ESA, respectively. Currently, Trinity River naturally-produced coho salmon are listed as threatened under the federal and state ESA.

1.4 General Setting and Location

The Trinity River originates in the rugged Salmon-Trinity Mountains of northwest California, at a point approximately 10 miles southwest of the town of Weed, California. The river flows generally southward until it is impounded by Trinity and Lewiston Dams. From Lewiston Dam the river flows generally westward for 112 miles until entering the Klamath River near the town of Weitchpec on the Yurok Reservation. The Trinity River passes through Trinity and Humboldt Counties and the Hoopa Valley and Yurok Reservations, and it drains approximately 2,965 square miles. The Klamath River flows northwesterly from its confluence with the Trinity River for approximately 40 miles before entering the Pacific Ocean. (For a map of the general setting and location refer to Figure 1-1.)

In general, the proposed alternatives focus on the 40 miles of Trinity River below Lewiston Dam (i.e., the portion of the river upstream of the confluence with the North Fork). The detrimental impacts of the dams are particularly severe in this stretch because tributary inflows are relatively minor (whereas tributary inflow downstream of the North Fork, in combination with the minor inflows above the confluence, is significant enough to maintain a semblance of the pre-dam channel). The direct and indirect impacts of the alternatives occur within and outside the Trinity River Basin, which requires active coordination with ongoing or proposed efforts in Trinity River tributaries and the larger watershed to improve habitat conditions for anadromous fish. Such integrated efforts will ensure that the lead agencies take advantage of non-flow means of habitat improvements while attempting to strike a reasonable balance between efforts to increase natural anadromous fish production and the need to continue providing water and power for CVP contractors within the central valley and elsewhere. Although the alternatives focus on the mainstem, each action alternative includes components requiring active integration with ongoing or proposed efforts in Trinity River tributaries and the larger watershed to improve habitat conditions for anadromous fish. Anticipated impacts and benefits are generally discussed in the context of three geographic areas: the Trinity River Basin, the Lower Klamath River Basin/Coastal Area, and the Central Valley (see Section 3.0). The extent of analysis for each geographic area varies depending on the resource issue.

There are no changes from the original Draft EIS/EIR except for those changes identified in court order. (See Table 1-1.)

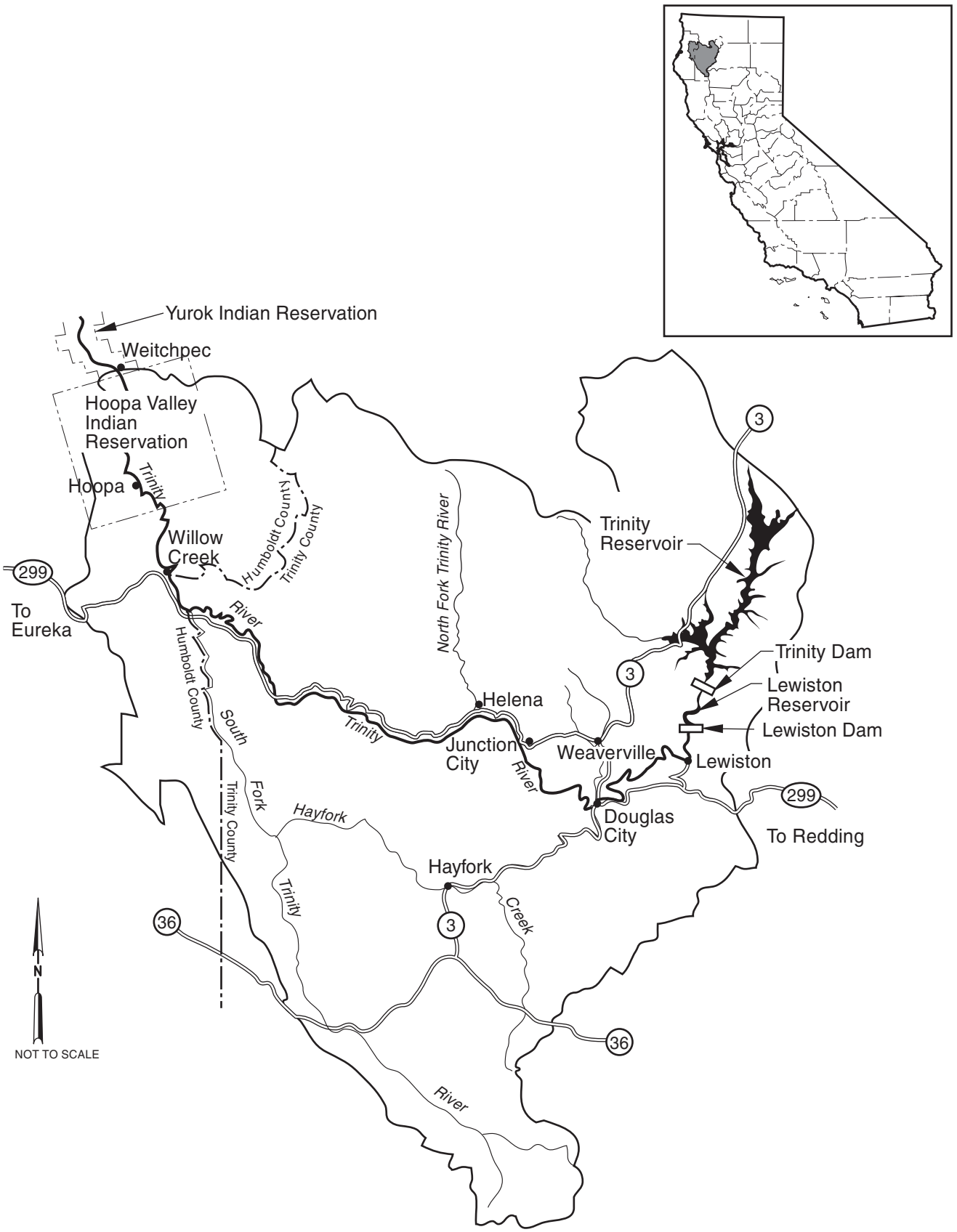

FIGURE 1-1
TRINITY RIVER BASIN
(EXCLUDING PORTION UPSTREAM OF TRINITY RESERVOIR)
TRINITY RIVER FISHERY RESTORATION SUPPLEMENTAL EIS/EIR

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1.5 Legislative and Management History

The following is a brief chronology of the most pertinent legislation, authorities, and management actions.

In 1855, President Pierce established the Klamath River Reservation, a strip of territory commencing at the Pacific Ocean and extending 1 mile in width on each side of the Klamath River for a distance of 20 miles. On August 21, 1864, the federal government established the Hoopa Valley Reservation on the Trinity River, 12 miles square and bisected by 5 miles of the Trinity River. In 1891, an executive order extended the Hoopa Valley Reservation from the mouth of the Trinity River to the ocean, thereby encompassing and including the original Hoopa Valley Reservation, the Klamath River Reservation, and the connecting strip between. In 1988, Congress, under the Hoopa-Yurok Settlement Act, separated the Hoopa Valley Reservation into the present Yurok Reservation (a combination of the original Klamath River Reservation and extension) and the Hoopa Valley Reservation (the Reservation as proclaimed in 1864). Several court rulings in the 1970s established that an important "Indian purpose" for the reservations was to reserve the tribes' rights to take fish from the Klamath and Trinity Rivers, rights that were confirmed as part of the Hoopa-Yurok Settlement Act. Courts have also recognized that sufficient water is reserved to achieve the purposes of Indian reservations.

The Rivers and Harbors Act of 1938 authorized construction of the CVP and stipulated the use of dams and reservoirs for improvement of river navigation and flood control, irrigation and domestic water use, and power generation. The Rivers and Harbors Act also provided for wildlife conservation to be given "due regard" in planning federal water projects.

Congress authorized the construction and operation of the TRD by statute in 1955 (P.L. 84-386). Although the 1955 Act provided for the diversion of water from the Trinity Basin to the Central Valley, Congress specifically directed the Secretary "to adopt appropriate measures to insure the preservation and propagation of fish and wildlife(.)" Legislative history for the 1955 Act further elaborated on the expected diversions, stating that only water deemed "surplus"– those waters "wasting away to the Pacific Ocean," the diversion of which would not have a "detrimental effect to the Fishery Resources" of the Trinity and Klamath Rivers – be exported to the Central Valley. The TRD was completed in 1963, and full operation began in 1964.

The Task Force, composed of federal, state, and local agencies and tribes, was initially established in 1971 in response to concerns and observed negative effects of the TRD on fish and wildlife in the

Trinity River Basin. The Task Force developed the Trinity River Basin Comprehensive Action Program to restore anadromous fish populations and to formulate a long-term management program.

In 1976, the Magnuson Fishery Conservation and Management Act was passed to better manage salmon, partially in response to decreased Trinity runs. The act established the Pacific Fishery Management Council (PFMC), which established fishery management plans based on input from federal, state, tribal, and other entities.

An EIS prepared by the Service and released in November 1980, determined that an 80 percent decline in Chinook salmon and 60 percent decline in steelhead populations had occurred since commencement of TRD operations. The EIS further estimated total habitat losses in the Trinity River Basin to be 80 to 90 percent.

In January 1981, continued concerns about the fishery led to the Secretary signing a Secretarial Decision directing the Service to conduct a 12-year Trinity River Flow Evaluation Study (TRFES) "summarizing the effectiveness of restoration of flows and other measures including intensive stream and watershed management programs." The Secretary's action was based on statutory requirements as well as tribal trust responsibilities that compelled the "restoration of the river's salmon and steelhead resources to pre-project levels."

In 1983, an EIS on the Trinity River Basin Fish and Wildlife Management Program was prepared by the Service (Service, 1983). The environmental document analyzed habitat restoration actions, watershed rehabilitation, and improvements to the TRSSH. The EIS clarified that the hatchery's purpose was to mitigate for the loss of the 109 miles of habitat upstream of Lewiston Dam; whereas, the restoration and rehabilitation projects were explicitly designed to increase natural fish production below the dam.

In 1984, the Trinity River Basin Fish and Wildlife Management Act (P.L. 98-541) was enacted. It formalized the TRRP, reaffirmed the restoration goals established by the Task Force, and directed the Secretary to implement measures to restore fish and wildlife habitat in the Trinity River and its tributaries, and to modernize and otherwise increase the effectiveness of the Trinity River fish hatchery. The TRRP was aimed at implementing a fish and wildlife management program "to restore natural fish and wildlife populations to levels approximating those which existed immediately prior to the construction of the Trinity Division."

In October 1992, Congress enacted the Central Valley Project Improvement Act (CVPIA) (P.L. 102-575). One purpose of CVPIA

was to protect, restore, and enhance fish, wildlife, and associated habitats in the Trinity River Basin. The act also directed the Secretary to finish the TRFES and to develop recommendations "based on the best available scientific data, regarding permanent instream fishery flow requirements and TRD operating criteria and procedures for the restoration and maintenance of the Trinity River fishery." The CVPIA also recognized the importance of protecting and restoring the Trinity River fishery in order to meet the federal government's trust responsibility, and specifically provided for the Secretary to consult with the Hoopa Valley Tribe on the TRFES and, upon concurrence, to implement the recommendations accordingly.

In 1993, the Service and Trinity County initiated an Environmental Assessment/Environmental Impact Report evaluating the Trinity River channel rehabilitation projects being promoted by the TRRP. However, ongoing construction work on several pilot projects generated numerous citizen complaints about the resulting turbidity of the river. In July 1994, the office of the Secretary mandated that an EIS be prepared prior to construction of any new channel rehabilitation projects. In addition, the Secretary's office determined that the EIS must also evaluate the permanent commitment of water as recommended in the TRFES. Therefore, the preparation of an EIS/EIR was initiated to evaluate the mechanical restoration activities and TRFES recommendations along with a range of reasonable alternatives. The Notice of Intent (NOI) to prepare the EIS/EIR was published on October 12, 1994.

In 1996, Congress re-authorized and amended the 1984 Trinity River Basin Fish and Wildlife Management Act (P.L. 104-143). The 1996 amendments clarified that "restoration is to be measured not only by returning adult anadromous fish spawners, but by the ability of dependent tribal, commercial, and sport fisheries to participate fully in the benefits of restoration." The amendments also confirmed that the purpose of the hatchery was to mitigate for the loss of habitat above the dams, and that the hatchery should not impair "efforts to restore and maintain naturally reproducing anadromous fish stocks within the basin."

Developments in the restoration program since the December 2000 ROD include, as directed by the court ("…all other non-flow related activities identified in ROD should proceed…"), the following:

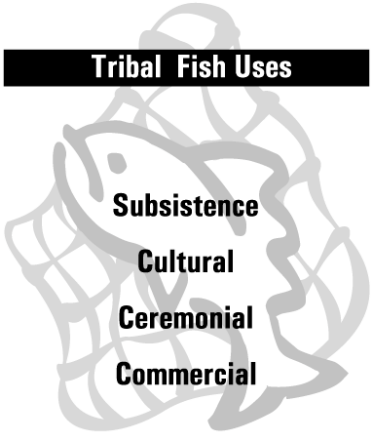
- The TMC has been established
- An Executive Director has been hired
- The TAMWG has been chartered and members appointed
- A physical office has been constructed

- A 13-member staff has been hired
- The initial members of the Science Advisory Board have been appointed

Continuation of these efforts would be re-evaluated pending final approval of ROD.

1.6 Indian Tribes

Secretarial Order No. 3175 states that the U.S. Department of the Interior (DOI), "when engaged in the planning of any proposed project or action, will ensure that any anticipated effects on Indian trust resources are explicitly addressed in the planning, decision and operational documents; i.e.,... Environmental Impact Statements...that are prepared for the project" (DOI, Office of the Secretary, 1993: although expired, the order was incorporated into the DOI, 512 DM Part 2). This mandate was affirmed in a Presidential directive reaffirming the sovereign rights of Indian tribes and the government-to-government status of relations between the United States and recognized tribes. Accordingly, the Draft EIS/EIR provides a detailed assessment of potential effects on Indian trust resources and how these effects may impact Indian tribes. Consistent with DOI policy, the analysis addresses only those tribes of the Klamath/Trinity Region that are officially recognized by the United States (Pevar, 1992) – the Hoopa Valley[2], Karuk, Klamath, and Yurok. Local unrecognized tribes include the Nor-El-Muk Band of Wintu Indians (Hayfork) and the Tsnungwe Tribe (Salyer/Burnt Ranch).



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The traditional and current homeland of the Hoopa Valley Tribe lies along the banks of the Trinity River in the Hoopa Valley. The river is central to Hupa culture, society, economy, and language; its physical condition is a major determinant of the tribe's material, psychological, sociological, economic, and spiritual well-being. The condition of the Trinity River also has important implications for the Yurok Tribe. The traditional homeland of the Yurok Tribe extends from the Pacific Ocean along the lower Klamath River and into the Trinity River Basin. The Yurok Tribe has always depended on the fish, water, and other resources of the Trinity and Klamath Rivers. The traditional and present territories of the Karuk and Klamath (Oregon) Tribes are located along the upper Klamath River, above the river's confluence with the Trinity. Both of these tribes also depend on the resources of the Trinity River, primarily as it influences the Klamath River ecosystem.

The tribal trust discussion focuses principally on the Hoopa Valley and Yurok Tribes, because, of the Indian tribes of the Klamath/ Trinity Region, they would be the most directly affected by the project. It should be understood, however, that the impacts are pertinent to the Karuk and Klamath people because they share a common regional heritage with the Hupa and Yurok and may be

[2] In this discussion, the terms Hoopa Valley and Hupa refer to separate designations for the *Natinixwe*, or Indian people of the Hoopa Valley. Hoopa Valley is used when referring to the tribal designation; Hupa refers to the people that share a language and culture.

impacted by the project, particularly as it affects the hydrology of the Klamath River.

1.6.1 Tribal Trust Responsibility

From their earliest contact with the Indians of North America, the European powers and the United States have dealt with Indians on a government-to-government basis. In principle, all treaties, statutes, and executive orders implementing federal Indian policy are premised upon this long-standing relationship.

Numerous court cases have found that the United States has a duty of protection toward Indians. In United States v. Mitchell (463 U.S. 206, 225 [1983]), the Supreme Court reaffirmed the principle of "the undisputed existence of a general trust relationship between the United States and the Indian people." The federal government's obligation to honor the trust relationship and to fulfill its treaty commitments is the trust responsibility. The federal government has extended the trust responsibility through federal statutes, agreements, and executive orders. These documents can create trust obligations in the same way that a treaty does. The trust responsibility imposes an independent obligation upon the federal government to remain loyal to Indians and to advance their interests, including their interest in self-government. The American Indian Policy Review Commission's Final Report stated:

> "The purpose behind the trust doctrine is and always has been to ensure the survival and welfare of Indian tribes and people. This includes an obligation to provide those services required to protect and enhance Indian lands, resources, and self-governance, and also includes those economic and social programs which are necessary to raise the standard of living and social well-being of the Indian people to a level comparable to the non-Indian society" (United States American Indian Policy Review Commission, 1997).

1.7 Project Facilities

The TRD is integrated and coordinated with operations of the CVP. CVP operations are directed in part by the Coordinated Operating Agreement (COA) between Reclamation and the State of California Department of Water Resources (DWR), the CVP Operations Criteria and Plan (OCAP), various water quality standards, and BOs for winter Chinook salmon and Delta smelt. These operational prescriptions are used by Reclamation and DWR to manage both the CVP and the California State Water Project (SWP). For a thorough description of water operations and management of the CVP and the SWP, refer to Section 3.3.

1.7.1 Trinity River Division

The TRD, constructed as part of the CVP, is operated and maintained by Reclamation in conjunction with eight other CVP divisions. Congressional committee reports on the authorizing act of the TRD stated that an average supply of 704,000 acre-feet, considered "surplus" to the present and future needs of the Trinity River Basin, could be exported from the Trinity River Basin to the Central Valley without detrimental effects on fishery resources. From 1964-1997, approximately 988,000 acre-feet have been diverted annually to the Central Valley (range 218,000 to 1,799,000), representing about 74 percent of the inflow above Trinity Dam (see Figure 1-2 and Water Resources [Section 3.2] for additional information). Diversions during the first 21 years of operation were substantially greater, an average of 1,146,800 acre-feet annually, or 79 percent of inflow, than were diversions during the most recent 13 years, which averaged 732,400 acre-feet annually, or 64 percent of inflow (however, a portion of the recent increase in instream releases is due to winter storm events, which provide limited benefits to salmon).

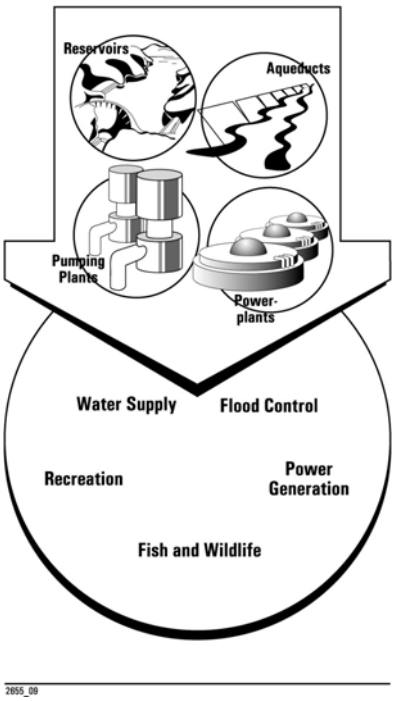
The TRD stores and regulates the entire runoff of the Trinity River upstream of Lewiston Dam. Diverted water is transported via the Clear Creek Tunnel to Whiskeytown Reservoir. From there, Trinity River water can either be transported via a second tunnel (Spring Creek Conduit) to Keswick Reservoir or released down Clear Creek to enter the Sacramento River.

The TRD has the capacity to generate substantial amounts of hydropower. Releases from Trinity and Lewiston Reservoirs can generate up to 139,650 and 350 kilowatts (kW), respectively. Water diverted from Lewiston Reservoir can generate 146,000 kW at the J.F. Carr Powerhouse (at the end of the Clear Creek Tunnel) and 200,000 kW at the Spring Creek Powerplant.

In total, the TRD represents approximately 25 percent of the total power generation capability of the CVP.

1.7.2 Central Valley Project

The CVP provides water for irrigation, M&I use, hydropower, and fish and wildlife purposes in and outside of the Central Valley of California. The CVP supplies irrigation water to approximately 200 water districts, individuals, and companies pursuant to annual demand for approximately 4.5 million acre-feet (maf) of water. These supplies are provided to entities with pre-1914 water rights, and through contracts to water service, water rights settlement, and exchange water contract holders. M&I water is supplied to about 40 districts and utilities under contracts totaling about 0.5 maf. Except in times of water shortage, Reclamation operates the CVP to deliver the amounts of water specified in its water service contracts and other water rights agreements. Major structures of the CVP include 20 reservoirs, with combined storage capacity of 11 maf; 9 powerplants and 2 pumping-generating plants with a maximum capacity of about 2.0 million kW; and approximately 500 miles of major canals and aqueducts.

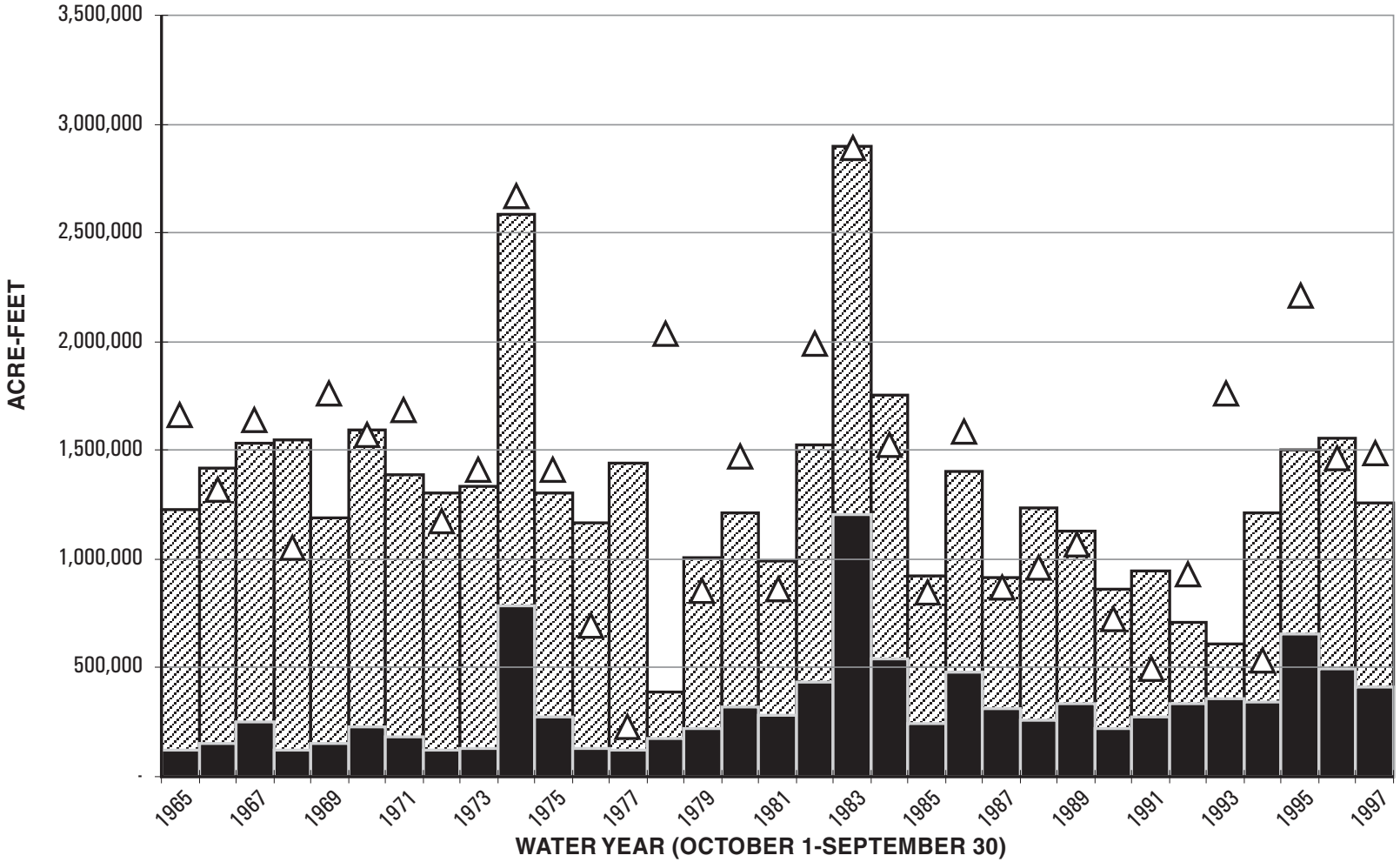


Although Reclamation is responsible for hydropower generation within Reclamation's water operating constraints, power dispatch functions and the marketing of the hydropower are the responsibility of Western Area Power Administration (Western). The power function is subordinate to the following higher priority, legislatively defined functions of the CVP: river regulation, flood control, domestic uses, improvement of navigation, irrigation, and fish and wildlife. Reclamation law states that surplus hydroelectric power and energy (net of project use) must be transmitted and disposed of "in a manner as to encourage the most widespread use thereof at the lowest possible rates to consumers consistent with sound business principles."

1.7.3 State Water Project

The SWP, a water storage and delivery system of reservoirs, aqueducts, powerplants, and pumping plants, extends for more than 600 miles, two-thirds the length of California. Project functions include water supply, flood control, power generation, recreation, and fish and wildlife enhancement.

The DWR, the operator of the SWP, has contracted to supply 4.16 maf annually to 30 public agencies in the San Joaquin Valley, south coast, and Southern California. Current annual deliveries are approximately 3.5 maf.



LEGEND

- Trinity River Exports
- Trinity River Release at Lewiston Dam
- Trinity Reservoir Inflow

NOTE

Differences between Trinity River inflow and sum of releases and exports (e.g., 1978-1979 and 1994-1995) are primarily attributable to carryover storage operations from previous water year.

Source: U.S. Bureau of Reclamation, Central Valley Operations

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FIGURE 1-2
TRINITY RIVER INFLOWS, INSTREAM RELEASES, AND EXPORTS
TRINITY RIVER FISHERY RESTORATION SUPPLEMENTAL EIS/EIR

1.8 Similarities and Differences between NEPA and CEQA

This document is designed to comply with both NEPA and CEQA. NEPA and CEQA are laws that require governmental agencies to evaluate the environmental impacts of their proposed decisions before making formal commitments to carry them out, and that such evaluation be done in detail, and with public involvement. NEPA is a federal law and applies to federal agencies, whereas CEQA is a California law and applies to state and local agencies. For this project, NEPA requires preparation of an EIS, and CEQA requires preparation of an EIR. In 1999, by preparing a single Draft EIS/EIR that complied with both statutes, the involved agencies were able to avoid unnecessary duplication of effort. As explained in Sections 1.1 and 1.2, the November 2000 document styled a "Final EIS/EIR" was in fact a pure NEPA document, as Trinity County has not treated it as a Final EIR. This Supplemental EIS/EIR, in contrast, is a joint CEQA/NEPA document, as was the original Draft EIS/EIR. As also explained in Section 1.1, the CEQA portion of this new document could more precisely be described as a partially recirculated Draft EIR. (See Cal. Code Regs., tit. 14, § 15088.5.)

Despite the similarities between the two laws, important differences remain. NEPA is a procedural law requiring agencies to evaluate a range of reasonable alternatives, disclose potential impacts, and identify feasible mitigation. Under NEPA, reasonable alternatives must be rigorously and objectively evaluated, with the common practice being that all alternatives are examined at virtually the same level of detail as any "preferred alternative." Under CEQA, in contrast, lead agencies typically analyze a "proposed project," akin to a preferred alternative, and address alternatives at a lesser level of detail ("meaningful detail," according to the California Supreme Court). In this document, the Revised Mechanical Alternative and Modified Percent Inflow Alternative have been prepared in response to the order of the U.S. District Court for the Eastern District of California. (See Section 1.2.) Because the plaintiff in the litigation resulting in that order did not and could not raise any CEQA issues, the order does not dictate any particular course of action to Trinity County as CEQA lead agency. Even so, the County treats these new alternatives as CEQA and NEPA alternatives.

The CEQA practice of identifying a "significance threshold" for expected impacts presents an important or critical feature of the document. Impacts to be covered include those to endangered, threatened, and rare species and their habitats (*CEQA Guidelines*, § 15065, subd. [a]). Thus, when an EIR shows that a project has the potential to reduce the number of, or restrict the range of, a species

officially listed under either the federal ESA or the California Endangered Species Act (CESA), the lead agency has a mandatory legal obligation to treat that impact as significant, and to mitigate if feasible. Thresholds of significance for other issue areas/resources are developed using applicable regulations where they exist, the standard "Environmental Checklist" used in CEQA practice (Appendix G to the *CEQA Guidelines*), or best professional judgment. Notably, CEQA generally requires the determination as to whether a proposed project would have a "significant environmental effect" to be based on a comparison between project effects and *existing environmental conditions*. Under NEPA, in contrast, federal agencies are required to compare the environmental effects of "action alternatives" against those of the "no action" alternative. Such comparisons frequently compare possible *future* scenarios. In this document, sections within each chapter entitled, "Existing Conditions versus Preferred Alternative" are intended to comply with the CEQA requirement.

CEQA requires that this Supplemental EIS/EIR propose mitigation measures for each significant effect of the project subject to the approval of an agency governed by California law, even where the mitigation measure cannot be adopted by the "lead agency" (Trinity County for this project), but can only be imposed by another responsible agency. The primary responsible agencies, defined as entities other than the lead agency that must use this EIR to approve some aspect of the approved program, are the NCRWQCB and Department of Fish and Game. As explained in Section 1.3.2, it is unclear at present whether the SWRCB or the SLC will also function as responsible agencies.

1.9 Scoping and Public Involvement

1.9.1 Original Draft EIS/EIR

The Service began the public process by preparing an NOI to prepare an EIS, which was published in the Federal Register on October 12, 1994. Trinity County forwarded a Notice of Preparation (NOP) of an EIR to the State Clearinghouse (No. 94123009) on November 16, 1994. The new State Clearinghouse number is 1994123009.

Joint NEPA/CEQA scoping meetings were held from October 27, 1994, through November 3, 1994, in Willows, Weaverville, Hoopa, and Eureka, California. During those meetings, members of the public were asked what issues they felt should be addressed. As this environmental process continued, the lead agencies also received letters that helped to identify areas of concern. Issues identified included:

- Fishery resources
- Tribal trust obligations
- Impacts to CVP agriculture and/or M&I water contractors
- Vegetation and wildlife resources
- Water quality, including inriver temperature concerns
- Water management
- CVP power generation
- Recreation, including recreation economics
- Socioeconomics
- Land use
- Flooding along the Trinity River
- Aesthetics, as it relates to drawdown of reservoirs
- Ocean sport and commercial fishing
- Upland watershed rehabilitation

These issues were used to develop the resource areas described in Section 3.0 of the original Draft EIS/EIR.

Public meetings were held March 25 through April 4, 1996, in the following locations: Orleans, Eureka, Hoopa, Weaverville, Willows, Fresno, Sausalito, and Coos Bay (Oregon). These meetings included a legislative update, the preliminary TRFES recommendations, range of EIS/EIR alternatives, potential impact areas, analytical tool description, and schedule. Public input was accepted in each of these areas, as well as others.

A second round of public information meetings was held October 28, 29, and 30, 1997, at Hoopa, Weaverville, and Sacramento, respectively. These meetings provided an update on the alternatives and preliminary analysis results. Additionally, a public meeting was

held February 17, 1998, in Weaverville, to present some of the proposed significance criteria that have been developed to help identify the significance of various impacts.

In addition to the public meetings, a series of newsletters (January 1996, September 1996, and October 1997) were mailed out to a large number of interested parties. In the fall of 1998, the Service posted an Internet web page about the EIS/EIR (http://www.ccfwo.r1.fws.gov/ccfwo/treis.htm). Trinity County also maintained a public list server concerning Trinity River activities [3].

1.9.2 Supplemental EIS/EIR

The second scoping process for this project undertaken in the aftermath of the U.S. District Court's preliminary injunction of March 2001 (see Section 1.2), was designed to further refine issues identified in previous scoping efforts prior to issuance of the original Draft EIS/EIR, and to allow the public to comment on aspects of the program that have changed during the court proceedings.

Public notification was made through a notice that was published March 25, 2002, in the Federal Register. Notices were also sent to about 730 individuals, interest groups, and other organizations (including the Sacramento and Redding area media). An NOP (NOP-1994123009) was filed with the State Clearinghouse on April 19, with the comment period ending May 23, 2002. The scoping process for the Program formally began with an NOI and ended with final acceptance of all written comments on May 23, 2002. A scoping meeting was held on May 9, 2002, in Redding, California, and is described below. A CEQA-only scoping meeting was held at the Trinity County Board of Supervisors in Weaverville on May 21, 2002.

A second notification, after the U.S. District Court entered its final judgement, was made through a notice that was published June 17, 2003, in the Federal Register. Notices were also sent to the Sacramento, Redding, and Eureka media via legal notices in the Sunday, July 6, 2003, edition of each cities' newspaper. The scoping process formally began with the NOI and ended with final acceptance of all written comments on July 18, 2003. Two scoping meetings were held, one on July 8, 2003, in Redding, California, and one on July 10, 2003, in Hoopa, California. Additional CEQA scoping did not take place.

[3] To subscribe to the "env-trinity" list server, send a blank e-mail message to env-trinity-subscribe@igc.topica.com or by sending an e-mail message to tstokely@trinityalps.net to request a subscription invitation.

1.9.3 Future Actions

This environmental process includes a public comment period, during which the public is asked to supply the lead agencies with comments on this Supplemental EIS/EIR. (See cover sheet for public comment timetable and addresses.) During the public comment period, public meetings or hearings will be held so that the lead agencies can receive the public's oral and written comments.

After the public comment period closes, the lead agencies will consider and respond to the comments and produce a Final Supplemental EIS/EIR. No earlier than 30 days after the availability of the Final Supplemental EIS/EIR, the lead NEPA agencies will produce a ROD. The Trinity River Supplemental EIS/EIR is a non-delegated NEPA action because both the Assistant Secretary for Water and Science and the Assistant Secretary for Fish, Wildlife, and Parks have signatory authority. Trinity County as the CEQA lead agency intends to certify the EIR no earlier than 10 days after providing state responsible and other commenting public agencies a written response to their comments.

1.10 Other Related Environmental Processes

Implementation of the selected alternative could require, as appropriate, permits from the Army Corps of Engineers (USACE), Trinity County, CDFG, NCRWQCB, SLC, and others. Implementation of the selected alternative would also require consultation with the Service and NOAA Fisheries on impacts to endangered, threatened, and proposed species.

The CVPIA Programmatic Environmental Impact Statement (PEIS), prepared by Reclamation, addresses the operation and impacts of the CVP, including the TRD. Conversely, this Trinity River Supplemental EIS/EIR addresses many Central Valley issues.

The CALFED San Francisco Bay/Sacramento-San Joaquin Delta (Bay-Delta) program is attempting to develop long-term solutions for resolving water use, ecosystem restoration, water quality, and levee stability issues in the Delta. CALFED is analyzing a variety of storage, conveyance, and other activities. Trinity River exports affect water quality and quantity in the Sacramento River and Delta. An EIS/EIR completed in the summer of 2000, has been prepared for this action as well. The Sacramento County Superior Court upheld the EIR portion of the joint document against a CEQA challenge, and the matter is now on appeal in the California Court of Appeal for the Third Appellate District.

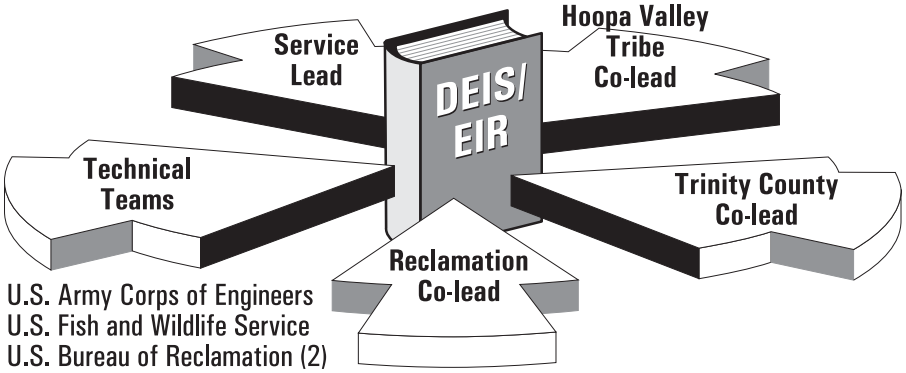
An EIS is being prepared by Reclamation on long-term operations of the Klamath Project. Changes in present project management could impact both Klamath River and Trinity River resources. For example, Trinity River anadromous fish must pass through the lower Klamath River during both juvenile outmigration and adult migration. Furthermore, juvenile fish from the Trinity River may spend an extended time rearing in the Klamath River estuary. The Klamath Project Operations EIS is in the early stages of preparation.

The CVP-OCAP is currently being revised and will undergo formal Section 7 consultation under the ESA with Service and NOAA Fisheries. Operation of the TRD is conducted in an integrated fashion with the other facilities that comprise the CVP. The effects of proposed changes in the operation of the TRD will be part of the project description of the CVP-OCAP for the Section 7 format consultation process. Potential effects upon listed species and the environmental effects resulting from possible compensatory actions associated with proposed changes in the TRD are disclosed in this document. CVP-OCAP is not subject to NEPA review in part because the CVP facilities pre-date NEPA.

Accordingly, because these environmental reviews are occurring simultaneously, Service, Reclamation, and other involved parties are making every effort to assure that the analyses, models, data, and assumptions are fully coordinated.

1.11 Preparers of the Draft EIS/EIR

In 1994, the Secretary initiated the Trinity River EIS/EIR. The Secretary directed the Service to be the lead agency on the project. On October 12, 1994, the Service published NOI to prepare an EIS in the Federal Register. It was determined that the Hoopa Valley Tribe, Trinity County, and Reclamation would be co-leads. Six technical teams were established to collect, analyze, and present technical information. The teams were lead by representatives of Western, USACE, Bureau of Land Management (BLM), Service, and Reclamation (see Section 5.2 of the Draft EIS/EIR for a list of individuals). Thirteen agencies (either cooperating, responsible, or trustee agencies) provided input on this Draft EIS/EIR (see Section 5.2 of the Draft EIS/EIR for a list of the agencies and individuals). In addition, the Karuk and Yurok Tribes were actively involved in preparation of the EIS/EIR. All of these same agencies have participated in the preparation of the Supplemental EIS/EIR.



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1.12 Areas of Controversy

The following issues associated with the proposed Trinity River Fishery Restoration action are controversial:

- Water supply impacts on various CVP contractors
- Impacts on Central Valley fisheries, including the winter-run salmon and Delta smelt
- Flooding issues in the Trinity River Basin
- Changes in power generation at CVP facilities
- Water quality impacts in the Trinity River Basin due to channel modification projects

SECTION 2.0

Description of Alternatives

This section presents alternatives that were developed to restore the natural production of anadromous fish in the Trinity River watershed (as described in the purpose and need statement), as well as the No Action baselines. The alternatives were formulated from public input, scientific information, and professional judgment, in a manner consistent with NEPA and CEQA. Analysis of the anticipated impacts associated with each alternative is presented in Section 3.0. Presented in the Draft EIS/EIR, but omitted here, are additional alternatives, including alternatives that were determined to be infeasible or inconsistent with the purpose and need. Two alternatives from the Draft EIS/EIR have been amended to improve their feasibility, per the judges ruling. A third alternative, the 70 Percent Alternative was added as a result of the scoping process.

2.1 Alternatives

The following alternatives were fully analyzed in this Supplemental EIS/EIR and are described in detail below:

- No Action (future without the proposed action) – This alternative is the measure against which for NEPA purposes the environmental impacts and other aspects of the action alternatives were compared. (For CEQA purposes, effects are determined against a "baseline" of existing conditions. See Section 1.8; Cal. Code Regs., tit. 14, Section 15125, Subd. (a).) Unless otherwise noted, the operations, policies, requirements, and other assumptions incorporated into the No Action are adopted into the other alternatives.
- Revised Mechanical – This alternative is included as a result of the December 9, 2002 MDO re: Cross Motions for Summary Judgment by Judge Oliver Wanger. This alternative was derived from public input received during the comment period for the EIS/EIR comment process, including comments submitted by the Sacramento Municipal Utility District and the Northern California Power Agency. The alternative is intended to aggressively employ non-flow measures to minimize instream flow needs in the Trinity River, and to maximize restoration of tributaries and watershed areas as means of improving mainstem conditions. Trinity River Restoration Projects with mechanical maintenance are proposed to meet the goal of restoring Trinity fisheries. Additional upslope erosion control work and tributary

habitat restoration projects are proposed with this alternative. Flow schedules are dependent on water-year class (see Table 2-1): critically dry, dry, normal, wet, and extremely wet.

TABLE 2-1
Water-year Class

Water-year Class	Exceedance Probability	Occurrence Every 100 Years	Trinity Reservoir Inflow for Designation (acre-feet)
Critically dry	p > .88	12	<650,000
Dry	.60 < p < .88	28	650,000-1,024,999
Normal	.40 < p < .60	20	1,025,000-1,349,999
Wet	.12 < p < .40	28	1,350,000-1,999,999
Extremely wet	p < .12	12	>=2,000,000

Note: Water-year classifications would be forecast using 50 percent exceedance methodology.

- Flow Evaluation – This alternative has variable flow schedules dependent on five water-year classes: critically dry, dry, normal, wet, and extremely wet as described in Table 2-1. Trinity River Restoration Projects maintained by streamflow are proposed to meet the goal of restoring Trinity fisheries. Additional upslope erosion control work is proposed with this alternative. Streamflow is used to maintain stream channel.

- Modified Percent Inflow – This alternative determines each year's release schedule by calculating 30 percent of the previous week's inflow to Trinity Reservoir on the ascending hydrograph limb and 50 percent of the previous week's inflow to Trinity Reservoir on the descending hydrograph limb. Peak releases would be determined by water-year class. Minimum flow levels during the remainder of the year are intended to meet water temperature requirements. Stream restoration projects maintained by stream flow are proposed to meet the goal of restoring Trinity fisheries. This alternative also responds to the decision of the U.S. District Court, which found the original Percent Inflow Alternative to be infeasible, as it did not always guarantee minimum flows of at least 340,000 acre-feet annually, as required by the CVPIA. The new version does guarantee such minimum flows.

- 70 Percent Inflow – This alternative is similar to the Modified Percent Inflow, except that releases for any given week are equal to approximately 70 percent of the previous week's Trinity Reservoir inflow and there are no target peak releases. This 70 percent figure is based on a large number of comments received on the Draft EIS/EIR from people who believed that the Preferred Alternative allowed too little water to flow down the Trinity River, and reported in Scoping Comments on the

Supplemental EIS/EIR. Trinity River Restoration Projects maintained by stream flow are proposed to meet the goal of restoring Trinity fisheries. Because the U.S. District Court suggested that the Maximum Flow Alternative was unrealistic, the 70 Percent Inflow Alternative is intended to be a more viable means of using high instream flows to achieve various geomorphic and other environmental objectives in the mainstem. Inclusion of this alternative also improves the ability to differentiate effects between alternatives.

- Maximum Flow – This alternative has variable flow schedules dependent on five water-year classes: critically dry, dry, normal, wet, and extremely wet outlined in Table 2-1. This alternative does not include stream rehabilitation projects.

In practice, the actual amount and pattern of water released from Lewiston Dam could on occasion exceed the flow schedules described in this Supplemental EIS/EIR. For example, releases may be increased for short periods to meet Safety of Dam criteria (i.e., to protect public health and safety during periods of intense precipitation, when the reservoirs are in danger of overflowing). Although the alternatives in this Supplemental EIS/EIR accommodate a wide range of hydrological, meteorological, and operational conditions, they cannot predict all possible scenarios.

Although actions unique to some alternatives could be applied to all alternatives, unless otherwise noted they are not, for reasons of clarity and evaluation. Associating certain actions with certain alternatives in a Draft EIS/EIR does not preclude hybridizing alternatives in a ROD; both NEPA and CEQA allow decisionmakers to integrate components from various alternatives where the environmental impacts of such hybrids can be ascertained from analyses of the alternatives from which they are put together.

The No Action Alternative, or future without the proposed action, is the measure against which the environmental impacts and other aspects of the action alternatives were compared. Unless otherwise noted, the operations, policies, requirements, and other assumptions incorporated into the No Action are adopted into the other alternatives.

CEQA also required that the Preferred Alternative be compared to an existing conditions baseline. The year 2001 was used as the existing conditions baseline because of the transition from PROSIM to California Simulation Model (CALSIM).

2.1.1 Selection of the Proposed Action and Preferred Alternative

The Flow Evaluation Alternative, coupled with additional watershed protection efforts (described in the Mechanical Restoration Alternative in the original EIS/EIR), was identified as the Preferred Alternative in terms of best meeting the purpose and need and goals and objectives, while also minimizing adverse impacts. The selection of the Preferred Alternative also used the following screening criteria, which were jointly developed by the four co-leads (Service, Reclamation, Hoopa Valley Tribe, and Trinity County). The Preferred Alternative:

- Substantially increases natural production of anadromous fish on the Trinity River
- Substantially restores inriver and ocean fishing opportunities
- Improves tribal access to trust resources
- Balances environmental and social beneficial and adverse impacts across the Trinity River Basin, Lower Klamath River Basin/Coastal Area, and Central Valley Basin while meeting the mandate from the SWRCB in Water Rights Orders 90-05 and 90-01 to cause no harm to the Trinity River fishery as a result of diversions to the Sacramento River for temperature control
- Allows for the continued operation of the TRD, including water exports
- Limits flooding impacts on the Trinity River

These screening criteria were developed not only to respond directly to the stated purpose and need (restoring and maintaining natural production of anadromous fish), but to minimize adverse impacts as a result of implementing the project. Given these criteria, the co-leads determined that the Flow Evaluation Alternative represented the best overall approach to substantially increasing natural production of anadromous fish and fishing opportunities, while allowing for continued water exports and flood control. Subsequent analysis has confirmed that the flow evaluation is likely to be the most efficient alternative in terms of meeting the healthy river objectives described in Section 1.3.2, Goals and Objectives.

The watershed protection component of the Mechanical Restoration Alternative was included within the Preferred Alternative because the lead agencies believe it would enhance the benefits derived from the Flow Evaluation Alternative (although the model used to evaluate changes in fish production did not detect a measurable increase). Furthermore, the proposed watershed protection activities were included as part of the Preferred Alternative because (1) they

have been determined in the past to help restore fish habitat by reducing sediment inputs to the Trinity River; (2) they are consistent with the ROD for the Northwest Forest Plan and its Aquatic Conservation Strategy to reduce upslope sediment production by improving drainage on necessary roads, while also decommissioning roads that no longer serve management purposes; (3) they are consistent with the Total Maximum Daily Load (TMDL) process established under the Clean Water Act, which has identified the Trinity River as a waterbody impaired by sediment and in need of remedial measures; and (4) a broad range of interest groups (e.g., environmentalists and Central Valley water users) specifically requested that non-flow watershed protection measures be fully considered for inclusion into the Preferred Alternative.

The 600 thousand acre-feet (taf) carryover storage level associated with the Flow Evaluation Alternative would be maintained for the Preferred Alternative except in exceedingly dry years if deemed necessary to avoid potentially infeasible operations at Shasta Dam. In such years (identified as potentially occurring in the future per the modeling analysis), carryover storage would be reduced to 400 taf.

Additionally, the Preferred Alternative included provisions for short-term operations in the case of potential power emergencies. If requested by Western, the lead agencies agreed to consider short-term changes in operation that would maximize power generation over projected periods of emergency needs, such as during rolling blackouts.

2.1.2 No Action Alternative

The No Action Alternative represents ongoing activities and operations and is intended to meet the both the NEPA requirement for a "No Action" alternative (40 C.F.R. Section 1502.14(d) and the CEQA requirements for a "No Project" alternative (Cal. Code Regs., tit. 14 Section 15126.6, Sub(e) ("existing conditions…as well as what would be reasonably expected to occur if the project were not approved, based on current plans and consistent with available infrastructure and community services.") Components of this alternative are approved programs that have obtained all environmental clearances and permits. The No Action Alternative reflects conditions in the year 2020 and includes projections concerning future growth and land use changes per the DWR Water Plan Update (Bulletin 160-98). The year 2020 was identified as the planning horizon because of the interrelationship with the DWR Bulletin 160-98, data from the Trinity County General Plan, and the Central Valley Draft PEIS. The No Action Alternative includes assumptions concerning concurrent but separate issues, such as the assumption that ocean harvest limitations for sport and commercial

salmon fishing would be consistent with policies that have been in place since 1992, and have been evaluated in a separate process by NOAA Fisheries and other groups.

Table 2-2 identifies the operations, policies, and regulatory requirements assumed under the No Action Alternative.

TABLE 2-2
Operations, Policies, and Regulatory Requirements Assumed under the No Action Alternative

Issue or Policy	Description
Acreage Limitations in Contracts	Existing acreage limitation regulations adopted to implement Reclamation Reform Act of 1982.
CVP Operations	Continued operations as presented in CVP-OCAP 1992 and other operational procedures for CVP, adjusted for BOs and water quality standards. (BO [May 1995] for Winter-run Chinook Salmon and Delta Smelt. BO for Winter-run Chinook Salmon (NOAA Fisheries, 1993) assumptions include maintenance of minimum Shasta Reservoir carryover storage of 1.9 maf in all years, except in driest 10 percent of years where reconsultation is needed. Monthly temperature targets at Bend Bridge and Jellys Ferry per the BO, Bay-Delta Plan Accord, and SWRCB Order 95-06).
Contract Amounts for CVP (including shortage criteria)	Contracts would be renewed, per 1956 and 1963 Acts, prior to year 2020, including contracts with CVP and DWR associated with the Cross-Valley Canal.
	Maximum Contract Amount: Not-to-exceed existing contract amounts. Water deliveries not-to-exceed capacity of existing conveyance facilities.
	Agricultural Water Service Contracts, Water Rights Contracts, and Exchange Contracts: CVP water deliveries limited by maximum contract; projected use as addressed in environmental documentation or maximum contract amount, whichever is less. Shortage criteria per OCAP.
	Municipal and Industrial Water Service Contracts: Total demand based upon year 2020 demands in DWR Bulletin 160-93. CVP water deliveries limited by (1) maximum use between 1980 and 1993; (2) projected use as addressed in approved environmental documentation; or (3) maximum contract amount, whichever is less. Shortage criteria with maximum shortage of 50 percent.
	Refuges: Delivery of Level 1 and Level 2 water supplies by existing suppliers. Shortage criteria using SWRCB Shasta criteria.
CVP Conservation Program	A long-term adaptive management program to address biological needs of special-status species with an emphasis on habitat in areas affected by the CVP.
Coordinated Operations of CVP and SWP	Based on COA framework with additional assumptions to implement new provisions of Bay-Delta Plan.
Delta Factors	Continued use of seasonal barriers at Old River and continued operation of Delta Cross-Channel gates.
Land Retirement	Retirement of 45,000 acres between 1992 and 2020 under existing California land retirement programs, per DWR Bulletin 160-93.
Minimum Instream Flow Requirements	**Sacramento River:** Per SWRCB Order 91-01 and the Winter-run Chinook Salmon BO.

TABLE 2-2
Operations, Policies, and Regulatory Requirements Assumed under the No Action Alternative

Issue or Policy	Description
for CVP Facility	**American River:** Per Modified SWRCB D-1400 strategy of CVP operations with a fixed amount of flood control storage under the USACE interim requirements.
	Stanislaus River: Per SWRCB D-1422, including water quality standards on the San Joaquin River at Vernalis and dissolved oxygen requirements at Ripon, and 155,700 acre-feet/year in all years but critically dry years, then 98,300 acre-feet/year per initial studies conducted under the 1987 agreements with CDFG and the Service.
	Trinity River: Per Secretary's 1991 Decision, a flow not less then 340,000 acre-feet/year in all years. The flow criteria described in the Wanger Decision was not used for continuity between model runs, allowing the results of the CALSIM to be compared to the results of the PROSIM.
Shortage Criteria for SWP	Monterey Agreement provisions for SWP.
Non-CVP Water Users	Use water demands in DWR Bulletin 160-93.
Power Marketing	Existing agreement between United States and Pacific Gas and Electric Company (PG&E) would not be renewed. Project use load met at all times.
Red Bluff Diversion Dam Gate Closure	Mid-May through mid-September per Winter-run Chinook Salmon BO.
Tracy Direct Loss Mitigation Agreement	Reduces and offsets direct fish loss associated with operations of the Tracy Pumping Plant and Fish Facility.
Water Conservation	Water conservation levels based on assumptions presented in DWR Bulletin 160-93 for all water users, plus requirements by 1982 Reclamation Reform Act for CVP contractors.
CVP Rate Setting and Water Pricing	Existing rate setting and cost-allocation policies, and ability-to-pay policies per Reclamation Mid-Pacific Region Policies, including 1988 policies, and Reclamation Reform Act draft rules and regulations.
Water Transfer	CVP water can be transferred between CVP water service contractors. SWP water can be transferred per the Monterey Agreement, and water rights holders can transfer water under SWRCB guidelines.
Water Rights	Total water rights would be delivered in all water-year classes (except in shortage conditions) even if water rights had not been previously fully used.
U.S. Department of Agriculture (USDA) Farm Commodities Program	Program would remain in place and would follow 1992 policies.

Water Management. The flow schedule for the No Action Alternative is based on existing CVP operations and Section 3406(b)(23)(B) of the CVPIA, which states:

> "If the Hoopa Tribe and the Secretary do not concur, the minimum Trinity River instream fishery releases established

> under this paragraph (340,000 acre-feet annually) shall remain in effect unless increased by an Act of Congress, appropriate judicial decree, or agreement between the Secretary and the Hoopa Valley Tribe."

The No Action release pattern (called a hydrograph) is shown on Figure 2-1. The TRD would be operated such that not less than 340,000 acre-feet of water would be released annually, regardless of water-year class. Although this quantity of water could be exceeded in the future for other purposes, such as Trinity Reservoir Safety of Dams releases (Reclamation, 1979), this alternative assumes an annual flow not less than 340,000 acre-feet. Spills and other releases in excess of proposed flow schedules are assumed to continue for all alternatives, and are included in the analysis in Section 3.0 in the context of monthly projected reservoir inflows and storage. It should be noted that the flow schedule for No Action and Mechanical Restoration Alternatives does not use the flow criteria described in the Wanger Decision. This was done because 340,000 acre-feet represent the minimum flows contemplated by the CVPIA in the absence of higher flows set by the Secretary of Interior with the Hoopa Valley Tribe's concurrence, and because Judge Wanger, in response to requests by the Hoopa Valley Tribe, has set differing flows each of the last three years based on hydrological and meteorological conditions each such year, as opposed to a set of flows that can be applied predictably each year. (See Section 3.2 Water Resources for a description of the change from analysis with PROSIM to CALSIM.) The use of 340,000 acre-feet also permits consistency between model runs, allowing CALSIM and PROSIM results to be comparable. The CALSIM used in identifying water supplies does not take into account daily or weekly flood control operations, which generally vary substantially from monthly values. Instead, flood operations are considered under a monthly time step. Refer to the Water Resources/Water Quality Technical Appendix A for a more detailed analysis of projected Safety of Dam releases.

Water Operations. It is assumed that the CVP, including the TRD, would operate based on the current (1992) CVP-OCAP, stipulations included in various water quality standards, long-term BO for the Sacramento River Winter-run Chinook Salmon (NMFS, 1993), and the 1995 BO for Delta Smelt (Service, 1995). In addition, this alternative includes operating the CVP and SWP in accordance with the COA, and it complies with the December 15, 1994, Bay-Delta Accord Principles of Agreement. Overall operation of CVP facilities, including coordinated operations with SWP facilities, is currently the

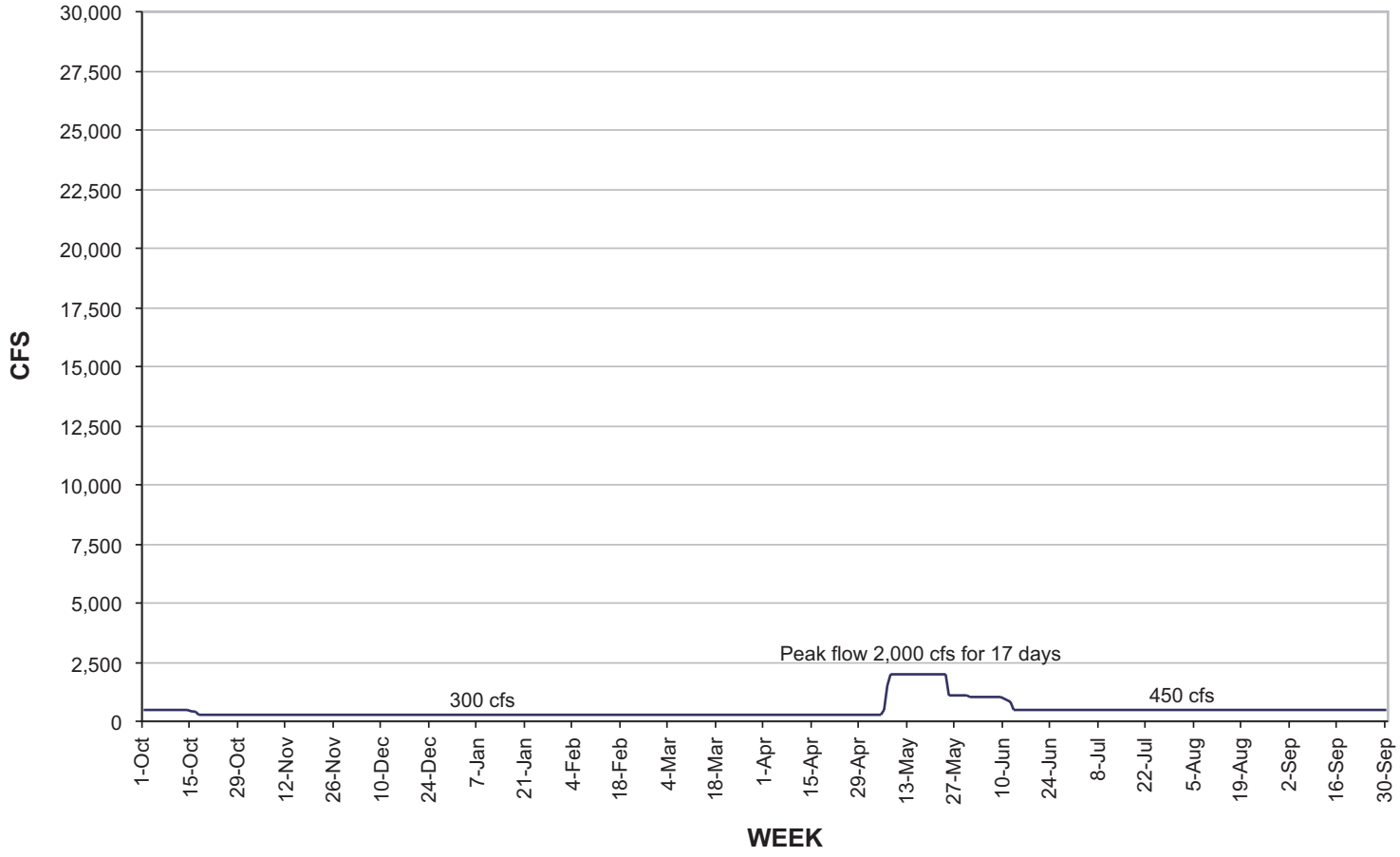

FIGURE 2-1
NO ACTION HYDROGRAPH
TRINITY RIVER FISHERY RESTORATION SUPPLEMENTAL EIS/EIR

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subject of proposed update to CVP-OCAP. The updated CVP-OCAP will be the basis for updated BOs for both winter-run salmon and Delta smelt. For more information on the updated CVP-OCAP, see Section 4.0 Cumulative Effects. Exports from Lewiston Reservoir to the Sacramento River would typically be highest in the spring to achieve temperature needs on the upper Sacramento River and to meet other CVP demands. Trinity Reservoir would be operated to maintain a minimum carryover storage of 400,000 acre-feet between water years (i.e., on October 1). Powerplant bypass operations are assumed to continue at a similar frequency as historical operations. Future powerplant bypasses would be evaluated on a case-by-case basis.

Subsequent to the modeling analyses conducted for the original 1999 Draft EIS/EIR, the California Court of Appeal for the Third Appellate Court in 2000 struck down a portion of the Monterey Agreement signed by the DWR and SWP contractors in 1994. (See *Planning and Conservation League v. Department of Water Resources* (2000) 83 Cal. App. 4th 892.) The agreement amendments changed the prior method of allocating water supply deficiencies, which reduced supplies to agricultural contractors before those to urban contractors were cut. The No Action and all other Trinity alternatives assume the Monterey Agreement is in place, and SWP supplies are allocated among agricultural and M&I contractors evenly in proportion to their entitlement. The Monterey Agreement, as simulated in the No Action Alternative, has no effect on the total amounts of SWP water deliveries, rather it only affects the delivery allocation to contractors south of the Delta once an overall delivery level has been determined. Therefore, the Monterey Agreement does not have any impact on the amount of water the SWP exports from the Delta. The amount of water exported is a function of demand, available supply, and export restrictions.

Accordingly, it is not anticipated that this court decision will have any significant impact on the results of the modeling analyses conducted for the Draft EIS/EIR and the Supplemental EIS/EIR.

Watershed Protection. It is assumed that the following programs and ordinances, relating to overall watershed protection in the Trinity River Basin (including tributaries to the mainstem), would continue:

- Riparian habitat improvements, such as Watershed protection under the jurisdiction of U.S. Forest Service (USFS) and BLM, would continue, including implementation of existing land management plans and the ROD on the President's Northwest Forest Plan (USDA and DOI, 1994).

- Trinity County's Decomposed Granite Grading Ordinance (No. 379) would be enforced for lands and projects under its jurisdiction.
- California Forest Practice Rules that regulate timber harvest activities on private lands within the Trinity River Basin would be enforced by California Department of Forestry and Fire Protection.
- Implementation of the South Fork Trinity River Action Plan would continue. The plan includes watershed restoration to reduce sediment sources, upgrading inefficient irrigation systems and dedicating the saved water to instream fishery flows, cattle exclusion fencing to decrease sediment inputs and improve water quality, and riparian plantings to help decrease water temperatures and conserve streambanks.
- The BLM would continue to acquire sensitive lands in the Grass Valley Creek watershed and along the Trinity River corridor.
- Upslope Watershed restoration, including upslope sediment management and land treatment, will assist in meeting the stated mandate of the December 2000 ROD; the goals and objectives of the TRRP, P.L. 98-541; and the Trinity River TMDL for controlling fine sediment.
- Fish passage restoration types will include the removal of structures impeding the migration of anadromous and resident fish species.
- Instream habitat improvements would continue. These activities include mechanical alterations and coarse sediment augmentations.
- Water conservation and water right acquisition are components of water supply restoration. These restoration types are aimed at improving water quantity and quality.
- Land conservation, including acquisition of the fee title or conservation easements, will allow for management activities consistent with watershed and tributary restoration riparian reserve allocations and Wild and Scenic River Corridor Criteria.

Additional Information about these Watershed Protection strategies can be found in Technical Appendix E.

Fish Habitat Management. The No Action Alternative assumes current habitat improvement projects and programs, such as the dredging of sediment control ponds in Grass Valley Creek, operation of Buckhorn Reservoir, placement of spawning gravel, and maintenance of the 27 existing channel rehabilitation projects would

continue. Though not guaranteed, these projects are administered by a variety of federal and state agencies.

The existing 27 channel rehabilitation projects constructed between the early 1980s and 1994 would be mechanically maintained. If side channels are blocked by sediment two or three times following sediment removal, those projects will be abandoned.

Spawning gravel would be placed as needed in the river below Lewiston Dam. Spawning gravel would be obtained from within Trinity River Watershed. The gravel would be screened to eliminate fine sediments, excessive amounts of which are detrimental to fish habitat. Spawning gravel placement for this alternative is estimated to average 3,400 cubic yards (yd^3) per year; however, much of the placement is associated with Safety of Dam releases (i.e., gravel placement volumes would likely be significantly higher in wetter years). In the absence of Safety of Dam releases, spawning gravel needs excluding Safety of Dam releases are estimated to range from 600 to 750 yd^3 annually.

Fish Population Management. Fishing would continue under current harvest plans approved by the Klamath Fishery Management Council, PFMC, Hoopa Valley Tribe, Yurok Tribe, and California Fish and Game Commission. Fisheries that do not have comprehensive management plans would continue to be managed by the responsible agencies or tribes. The TRSSH would continue to produce fish at current levels, as shown in Table 2-3.

TABLE 2-3
Trinity River Salmon and Steelhead Hatchery Production

Species	Egg Take	Smolt Release	Yearling Releases
Spring Chinook	3,000,000	1,000,000	400,000
Fall Chinook	6,000,000	2,000,000	900,000
Coho	1,200,000	N/A	500,000
Steelhead	2,000,000	N/A	800,000

Dam Modifications. The No Action Alternative assumes no modifications of Trinity or Lewiston Dams.

Estimated Costs. To manually remove vegetation from all 27 sites would cost a total of about $30,000 every 3 years. To mechanically remove root systems on channel rehabilitation projects, and to modify side-channel openings as needed, would cost a total of about $30,000 every 5 years.

Spawning gravel costs were derived from estimates of gravel requirements and costs of dredging, sifting, purchase, transportation, and placement. For this alternative, the spawning gravel requirements were estimated to average 3,400 cubic yards per year

(yd^3/year). A cost of $30 per yd^3 was estimated for dredging and sifting, purchase, transportation, and placement. Average annual spawning gravel costs were therefore estimated at $102,000 (with significant inter-year variability due to Safety of Dam releases).

Integrated Management. The No Action Alternative would not include an integrated management component.

2.1.3 Revised Mechanical

This alternative replaces the Mechanical Restoration Alternative described in the 1999 Draft EIS/EIR.

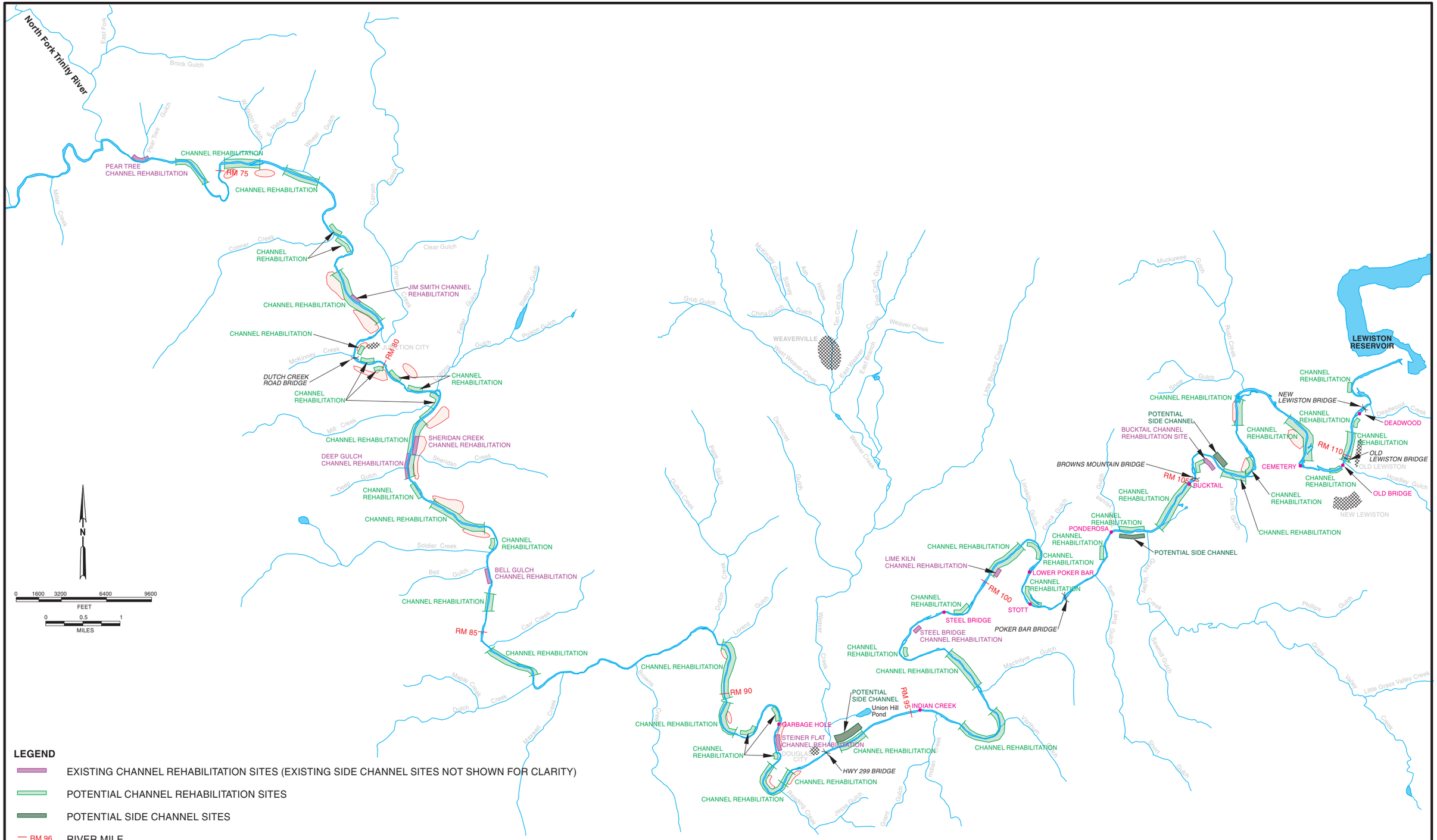
The Revised Mechanical Alternative is included as a result of the December 9, 2002 Wanger Decision. The Wanger Decision concludes that an alternative using non-flow measures and minimizing impacts on CVP interests was not fairly considered in the Draft EIS/EIR. The decision also concludes that such an alternative might achieve the statutory goal of restoring the Trinity River fishery. The basis for this conclusion is described on page 91 of the Wanger Decision:

> "The ultimate NEPA issue centers on whether the intentional narrowing of the EIS purpose to concentrate on increased water flows and channel rehabilitation prevented the decision-maker and the Court from assessing the utility of a variable flow alternative that uses non-flow measures to serve all the statutory objectives of the 1984 Act as amended, the CVPIA, and the secondary purposes of minimizing effects on all other CVP water users."

This Revised Mechanical Alternative was derived from public input received during the comment period for the Draft EIS/EIR comment process.

The Revised Mechanical Alternative also includes an adaptive management plan similar to the plan that is described in the Flow Evaluation Alternative. However, the adaptive management plan under this alternative would combine the Trinity Adaptive Management Working Group with the Trinity Management Council to form one consolidated Federal Advisory Committee reporting directly to the Secretary.

Water Management. Annual releases would vary by water-year class as shown in Table 2-4. These releases are consistent with information provided by Sacramento Municipal Utilities District in its comment submittals on the Draft EIS/EIR and during the scoping for the Supplemental EIS/EIR.



LEGEND

- EXISTING CHANNEL REHABILITATION SITES (EXISTING SIDE CHANNEL SITES NOT SHOWN FOR CLARITY)
- POTENTIAL CHANNEL REHABILITATION SITES
- POTENTIAL SIDE CHANNEL SITES
- RM 96 — RIVER MILE
- GOLD MINING DREDGER TAILINGS (APPROXIMATED FROM 1975 AIR PHOTOS)
- POTENTIAL DREDGING POOL LOCATIONS

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Source: McBain & Trush

FIGURE 2-2
TRINITY RIVER
EXISTING AND POTENTIAL
CHANNEL REHABILITATION SITES
TRINITY RIVER FISHERY RESTORATION SUPPLEMENTAL EIS/EIR

TABLE 2-4
Annual Volumes and Peak Releases – Revised Mechanical Alternative

Water-year Class	Acre-feet	Peak Flow (cfs)
Critically Dry	340,000	1,500
Dry	380,000	4,500
Normal	485,000	6,000
Wet	513,000	6,000
Extremely Wet	556,000	6,000

Note:
cfs = cubic feet per second

The release pattern for each water-year class is illustrated on Figure 2-3. This flow schedule was developed to maintain minimum base flow releases of 300 cfs for suitable fisheries habitat during the fall and winter salmonid spawning and rearing periods, and minimum flow releases of 450 cfs for the summer holding period. In addition, peak flows are capped at 6,000 cfs. This capped peak flow is supplemented by mechanical habitat maintenance including dredging of silt and sand from mainstem ponds, increasing sediment trapping in tributaries, and mechanical control of point bar revegetation where needed, as discussed below.

Water Operations. The timing of diversions through the Clear Creek Tunnel would be based on water availability and CVP demand, as presently operated by Reclamation. Timing would mimic historical operations to establish in late spring and maintain through fall the thermal connection between Carr Powerhouse discharge and Spring Creek Tunnel intake, so as to attempt to improve temperatures on the upper Sacramento River for anadromous fish, listed and otherwise. Trinity Reservoir would be operated to maintain a minimum carryover storage of 500,000 acre-feet between water years.

Watershed Protection. The Revised Mechanical Restoration Alternative would include measures to limit sediment inputs into the Trinity River beyond those assumed under the No Action Alternative, including accelerated road decommissioning, road maintenance, and road rehabilitation on public and private lands. These additional measures would essentially represent a modification of a portion of a 1993 proposal by the Committee for Healthy Communities in Healthy Forests, as endorsed by the Trinity BioRegional Group and Trinity County for implementation of the President's Forest Plan.

Accelerated road decommissioning, road maintenance, and road rehabilitation would primarily be focused on public lands within Trinity National Forest watershed (South Fork and mainstem areas below Lewiston Dam), which contains approximately 3,450 miles of mostly unpaved roads. The area would also include a small portion

of the Six Rivers National Forest in the lower South Fork and lower mainstem watersheds, as well as the private lands and county roads within the entire Trinity River watershed. This type of proposed work is identified as critical in restoring salmon and steelhead habitat as part of the ROD on the President's Forest Plan (Option 9: USDA and DOI, 1994). The USFS, through the plan, adopted new Riparian Management Zone Standards and Guidelines prescribing improved standards for roads and decommissioning of those roads deemed unnecessary.

Road decommissioning would consist of removing culverts, out-sloping, and ripping roads (primarily Level 1 roads) that cannot be maintained with existing and foreseeable budgets. Many of the roads are already closed to public traffic, but pose potential and ongoing erosion problems. Rehabilitation of the remaining roads would consist of resurfacing or culvert replacement over 22 years to support ongoing USFS, county, and private efforts, which are currently very limited due to funding and staffing. Annual maintenance would ensure that all drainage structures perform as designed.

BLM's Trinity River Watershed Analysis contains an average annual sediment yield estimate at Hoopa of 1,283 yd^3 per square mile (BLM, 1995). Extrapolating this to the entire basin (exclusive of the areas upstream of Lewiston Dam and federally designated roadless/ wilderness areas), the 2,223-square-mile area in question would produce approximately 2.85 million yd^3 of sediment per year. Full-scale implementation of the watershed protection program would result in a reduction of 240,00 to 80,000 yd^3/year, which is approximately 7 percent of the average annual sediment produced in the Trinity River Basin.

Fish Habitat Management. This fish habitat management component of the Revised Mechanical Alternative has incorporated much of the research and conclusions provided by Sacramento Municipal Utility District in its comment submittals on the Draft EIS/EIR and during the scoping for the Supplemental EIS/EIR.

Mechanical restoration efforts under the Revised Mechanical Alternative would include the following:

- Mechanical removal of tributary mouth bars (deltas) at Rush Creek, Indian Creek, Reading Creek, Weaver Creek, and others to eliminate the backwater effects caused by these bars and, thus, reduce siltation and improve habitat upstream in the Trinity River. The intent is to also provide anadromous fish (primarily coho and steelhead) access to the tributaries, thus providing additional fishery habitat. Material mechanically removed from the bars (deltas) will be sorted, and the gravel component suitable for spawning gravel replacement (estimated

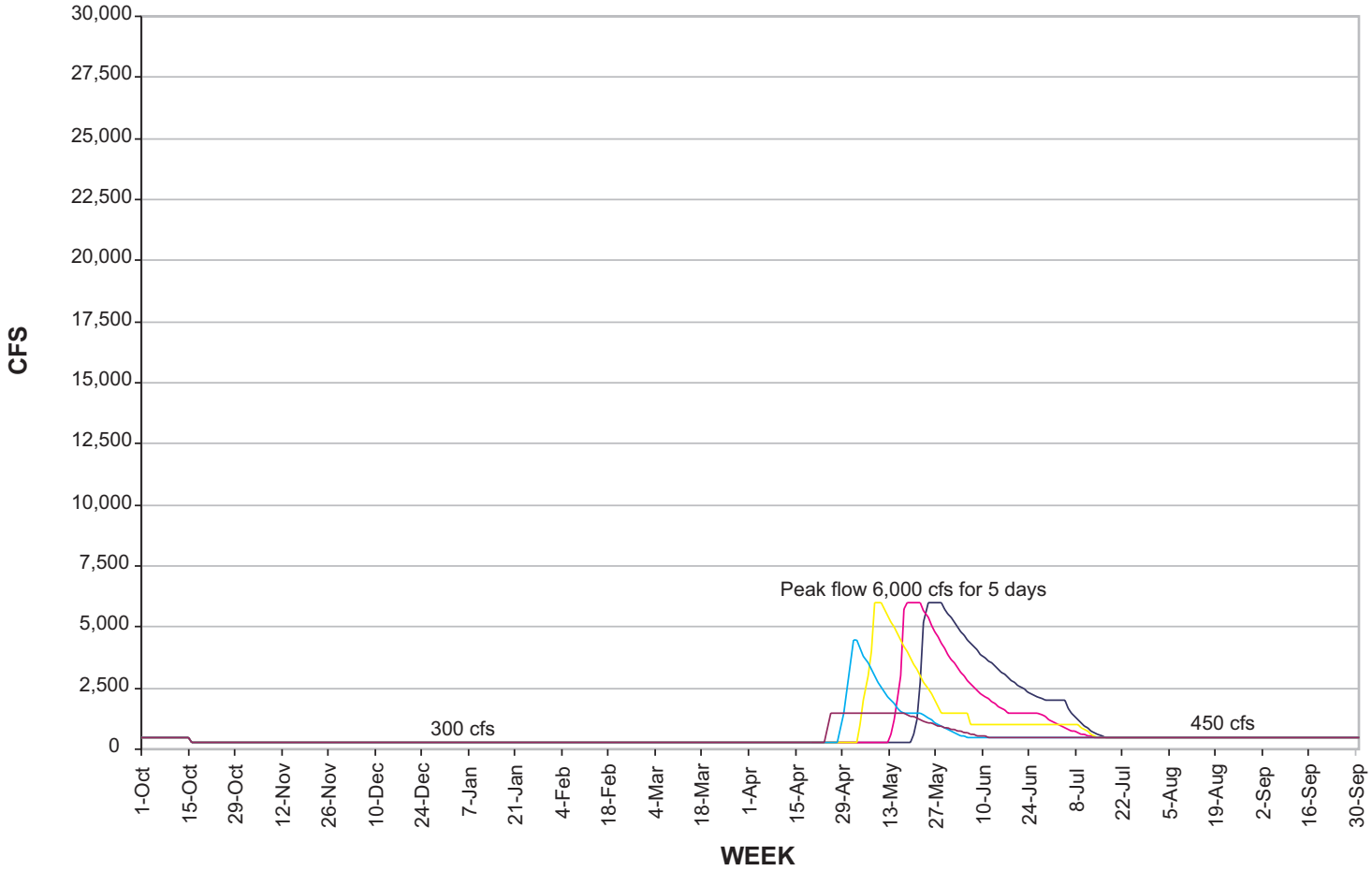

FIGURE 2-3
REVISED MECHANICAL HYDROGRAPH
TRINITY RIVER FISHERY RESTORATION SUPPLEMENTAL EIS/EIR

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requirement 10,000 yd^3/year [Service et al., 1999]) will be used for that purpose. The remainder will be disposed of outside the floodplain, thereby removing a source of finer sediments that could contribute to spawning gravel degradation.

- Removal of single-sided berms and construction of large, sloping gravel banks would not proceed until sites where both banks could be treated are identified and hydraulically evaluated.
- Dredging sand and silt from specific pools in the mainstem below the confluence of Grass Valley Creek by mechanical means.
- Expansion of the capacity and increased the frequency of sediment removal at the two existing Grass Valley Creek sediment ponds.
- Removal of vegetation, whenever possible, by both mechanical means and hand crews rather than just by hand crews.

Gravel introduction will be required at a rate that balances the transport capacity of the released flows.

Sediment transport analyses for the Revised Mechanical hydrographs for the flow year classes for the reach upstream of the Rush Creek confluence indicate that the average annual volume of gravel augmentation required to balance the loss of spawning gravel would be approximately 3,000 yd^3/year. However, consultants for Sacramento Municipal Utility District have advocated different methodology for determining sediment transport rates.

Accordingly, development of a hydraulic model to provide guidance on appropriate locations for local gravel placement and to provide more cost-effective designs, would also be required.

Fish Population Management. Under this alternative, fish population management would occur under three categories: harvest restrictions, predator control, and increased hatchery production. Previous analyses have determined that these measures would not increase production of anadromous salmonids because habitat was limiting potential production of salmonids. Therefore, these measures could not be undertaken until the alternative had been implemented over sufficient time to maximize its habitat-creating potential. Measures described below would be implemented after habitat has been maximized under this alternative.

The implementation of harvest restrictions would be pursued following habitat improvements in the river. Harvest restrictions were previously analyzed for effectiveness in increasing natural production of anadromous fish in the Trinity River. However, the 1984 TRB Act, Pub. L. 104-143, Section 2, emphasizes that restoration is measured by the ability of tribal and other fishermen to harvest.

Therefore, harvest restrictions are inconsistent with the purpose of the action. The results of the analysis indicated that although spawner escapement increased due to increasing harvest restrictions, natural production, as indicated by the production index, actually decreased. After the habitat improvement projects are complete and after a sufficient time it is determined that available habitat is being underused, then harvest restrictions would be implemented. See the Draft EIS/EIR for additional information.

An increase in hatchery production does not meet the purpose of the proposed action, which is to restore the natural production of anadromous fish. Evidence suggests that increasing hatchery production can significantly impair efforts to restore and maintain naturally reproducing fish stocks. Increases in hatchery releases would not be successful unless habitat in the Trinity River was improved to accommodate the increased number of fish.

After salmonid habitat conditions improve, a reassessment of harvest management, predator control, and increased hatchery production would be conducted. Assuming improved habitat conditions, modifications to exiting fish population management could be employed in some cases to speed restoration.

Dam Modifications. The maximum release of 6,000 cfs associated with this alternative would not require modification to either Trinity or Lewiston Dam.

Estimated Costs. Estimated cost for implementation of the mechanical stream restoration projects is identical to those costs included in the Mechanical Restoration Alternative.

Integrated Management. The Revised Mechanical Alternative would include both flow and non-flow measures intended to improve fishery habitat. The combination of flows, flow timing, ongoing mechanical maintenance, and conditions throughout the watershed would be monitored, and modified if necessary, in an attempt to optimize fish production. However, annual flow volumes would be capped at the levels described above. An assessment of hatchery operations, harvest options, and predator effect would also be conducted following stabilization of habitat improvements.

2.1.4 Flow Evaluation

This alternative has been designated as the Preferred Alternative.

The Flow Evaluation Alternative is based on recommendations in the TRFES (Service and Hoopa Valley Tribe, 1999). This alternative would restore and maintain the fishery through managed flows and mechanical rehabilitation projects designed to restore a necessary level of ecosystem function. Flows would be higher than the No

Action Mechanical and Revised Mechanical Alternatives in all water-year classes. Flow volumes and timing are designed to address both habitat and temperature needs for all riverine life stages of salmonids. Peak flows are designed to support the physical processes necessary to maintain habitat in an alluvial river. In addition, the alternative includes significant mechanical habitat management and watershed protection components. The management and protection components are included because it was concluded that the recommended variable flow release schedule alone would not be adequate to remove the vegetation necessary to restore fishery habitat.

The Flow Evaluation Alternative also includes an adaptive management program. The adaptive management program would initially operate within the bounds of the TRFES recommendations. Adaptive management is a formal, systematic, and rigorous program of learning from the outcomes of management actions. Adaptive management accommodates change and improves management, which may alter some findings of the TRFES. Decisionmakers use adaptive management programs to manage environments characterized by complexity, shifting conditions, and any remaining uncertainty.

The Flow Evaluation adaptive management program would combine assessment and management by using conceptual and numerical models, and the scientific method to develop and test management choices. The adaptive management program would assess the effects of reservoir operations, instream flows, and mechanical habitat manipulations on biotic resources of the Trinity River. Specifically, the program would perform the following:

1. Define objectives in measurable terms
2. Develop hypotheses, build models, compare options, and design system manipulations and monitoring programs
3. Propose modifications to operations that protect, conserve, and enhance biotic resources
4. Implement monitoring and research programs to examine how selected management actions meet resource management objectives

The Adaptive Environmental Assessment and Management (AEAM) program would be administered by an executive director hired by the Trinity Management Council, the decisionmaking group within the AEAM program. The Council would serve as a policy group that initiates actions, reviews, modifies, accepts, or remands recommendations made by the Executive Director and staff. Also included in the process would be the TRRP staff (Technical Modeling and

analysis Group, Rehabilitation Implementation Group), Science Advisory Board, Stakeholder group (TAMWG), and regulatory agencies. The TMC and TAMWG would typically convene on a quarterly basis throughout the year to make decisions (or advise in the case of TAMWG) concerning the coming year's dam releases, budgeting activities, and other management actions. A detailed description of the AEAM was given in the TRFES, pages 278 through 289. Appendix F of the Trinity River Mainstem Fishery Restoration Final EIS/EIR further refines the structure of the AEAM program. Roles and responsibilities of these groups have since been refined and clarified in their respective bylaws and the TAMWG charter signed by the Secretary of the Interior.

The adaptive management program could result in modifications to the Flow Evaluation hydrographs described in this Supplemental EIS/EIR. Modifications to the proposed restoration activities (flow schedules and channel rehabilitation projects) resulting from the AEAM program could be subject to additional NEPA and CEQA review. All mechanical ground-disturbing actions taken under this alternative would be subject to site-specific environmental review.

Water Management. Annual releases would vary by water-year class as shown in Table 2-5

TABLE 2-5
Annual Volumes and Peak Releases – Flow Evaluation Alternative

Water-year Class	Acre-feet	Peak Flow (cfs)
Critically Dry	369,000	1,500
Dry	453,000	4,500
Normal	647,000	6,000
Wet	701,000	8,500
Extremely Wet	815,000	11,000

Note: Peak flow releases and timing: 11,000 cfs/5 days in May (extremely wet water-year class only).

The release pattern for each water-year class (Figure 2-4) was developed to address the needs of each of the life stages of the anadromous fish present in the Trinity River, including the ability of the river to move sediment and reshape itself (i.e., fluvial geo-morphic process). Flow releases are different for each water-year class because different geomorphic processes are addressed in different water years, as was the case prior to dam construction. The following four primary components were identified and are addressed by the release patterns:

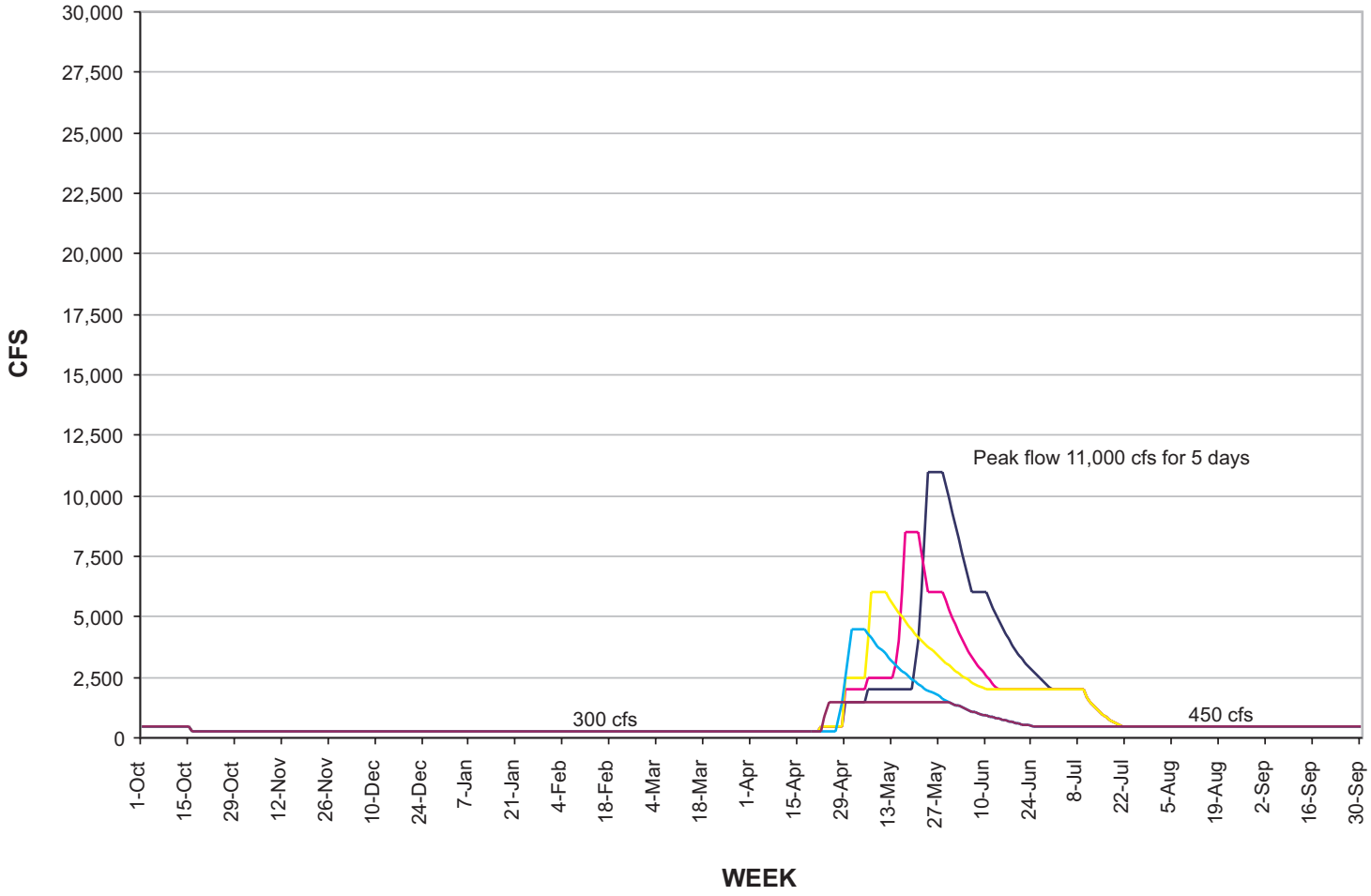

FIGURE 2-4
FLOW EVALUATION HYDROGRAPH
TRINITY RIVER FISHERY RESTORATION SUPPLEMENTAL EIS/EIR

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- **Summer/fall temperature control flows (July 1 through mid-October) –** These were developed in response to summer and early fall conditions when warm water temperatures are a concern for holding and spawning spring Chinook salmon. NCRWQCB criteria follow: from July 1 to September 14, temperatures no greater than 60 degrees Fahrenheit (°F) at Douglas City; from September 15 to September 30, temperatures no greater than 56°F at Douglas City; and from October 1 to December 31, temperatures no greater than 56°F at the confluence with the North Fork. Generally, flows of 450 cfs would be required during these periods to meet these temperatures.

- **Salmonid spawning/rearing flows (mid-October through late April/mid-May depending on water-year class) –** These were developed to provide suitable spawning and rearing habitat for Chinook and coho salmon and steelhead. Flows of 300 cfs would be released during this period, because effective spawning has been observed at this flow level. In addition, such flows would provide habitat, minimize the potential for dewatering of redds, and protect early life stages of salmonids.

- **Fluvial geomorphic/salmonid smolt temperature control flows (late April/mid-May through June 30) –** These were developed to provide fluvial geomorphic processes and suitable temperature and flow conditions for outmigrating salmonid smolts. Peak flows of 11,000 cfs would be released for 5 days beginning May 24 during extremely wet water years to assist in geomorphic processes such as mobilizing sediment, scouring the riverbed, reshaping the channel, and removing encroaching vegetation. These higher magnitude flows are geomorphically more efficient (more sediment transport per unit of water, and greater depth of scour) than lower flows, and the magnitude of 11,000-cfs flows was found to cause scour depths on exposed point bars sufficient to scour away 2- to 3-year-old willow seedlings, which is a critical process to prevent future riparian encroachment and habitat simplification. The peak levels would vary for each water-year class, down to a minimum of 1,500 cfs in critically dry years. During such years, these flows would not be sufficient to recontour the channel, but would help prevent the germination of unwanted vegetation.

- **Ramping rates (all times of year) –** The rate at which flow releases are either increased (ramped up) or decreased (ramped down) were developed in the TRFES to mimic natural ramping rates for the Trinity River.

Water Operations. The timing of diversions through the Clear Creek Tunnel would be shifted from spring/summer to the summer and early fall periods to maintain suitable release temperatures for the inriver fishery resources. Summer/fall is a critical period for holding/spawning spring Chinook salmon, migrating/spawning fall Chinook salmon, and holding summer steelhead. Shifting exports to the summer/early fall maintains coldwater reserves in Trinity Reservoir for use in the Trinity River, versus exporting this water earlier to assist coldwater maintenance in the Sacramento River. Additionally, exporting water through the Clear Creek Tunnel during summer/early fall results in water moving quickly through Lewiston Reservoir, thereby not allowing the water (which is eventually released from Lewiston Dam) to warm. The alternative assumes that Trinity Reservoir would be operated to maintain a minimum carryover storage of 600,000 acre-feet between water years. The increased carryover provides cooler water for dam releases for the benefit of the inriver fishery resources and reduces the need for Trinity Powerplant bypasses to provide cooler water. Operations under this alternative are conditioned by the 2000 NOAA Fisheries BO, as modified by the Judge's ruling.

Watershed Protection. Watershed protection for the Flow Evaluation Alternative is identical to the watershed protection described for the Mechanical Restoration Alternative.

Fish Habitat Management. In addition to those described in No Action, 47 mechanical rehabilitation projects would be constructed because the flow schedule associated with this alternative is too low to remove the existing riparian berms along the river. Figure 2-2 shows the location of each proposed potential rehabilitation site and existing sites. Actual sites may deviate slightly from those labeled on the figure and will undergo their own NEPA/CEQA analysis. After portions of the berms are mechanically removed, projected high flows and gravel transport would naturally create and maintain dynamic alluvial features and floodplain riparian communities. Consequently, no additional mechanical maintenance is planned for the proposed or existing channel rehabilitation projects. However, adaptive management would allow for future instream projects to be evaluated and implemented if they are deemed necessary.

The proposed mechanical rehabilitation projects would involve the following:

- A total of 47 mechanical rehabilitation projects would be constructed between the Lewiston Dam and the confluence with the North Fork Trinity River. The sites would encompass approximately 665 acres. Construction would be scheduled between June 15 and October 15 (based on consultation with NOAA Fisheries) to minimize impacts to Chinook, coho, and steelhead.

- Of these 47 mechanical rehabilitation projects, 44 would be channel rehabilitation projects, and the remaining three would be side-channel projects. Twenty-four of the channel projects would be built in the first 3 years following finalization of ROD, and the remainder would be completed contingent upon an evaluation by the adaptive management program. A typical mainstem rehabilitation project would be approximately 150 feet wide (measured from the water's edge) and 500 to 5,000 feet long. A typical side-channel improvement would be 80 feet wide and 800 feet long.
- A typical project would take 6 weeks to construct and would require the use of front-end loaders, bulldozers, screens, and trucks.
- Each bank rehabilitation project will remove the confining riparian berms, remove the large volumes of sand stored within the berms from frequently flooded areas, reconstruct functional floodplains that are frequently inundated by the proposed high flow regime, and revegetate portions of the newly constructed floodplains with native woody riparian vegetation that increases overall riparian structure, cover, and diversity within the Trinity River corridor.
- Several bank rehabilitation projects may include reclaiming historical gravel mining pits and gold dredger tailings into off-channel riparian and aquatic wetlands.

Spawning gravel placement would average about 10,300 yd^3 annually, with an estimated range from 0 yd^3 in critically dry water years to 60,000 yd^3 or more in extremely wet water years (actual amounts would be determined by ongoing monitoring). The estimates assume that there would be no need for additional gravel placement as a result of Safety of Dam releases.

Fish Population Management. Population management under this alternative would be the same as the No Action Alternative.

Dam Modifications. The maximum release of 11,000 cfs associated with this alternative would not require modification to either Trinity or Lewiston Dam.

Estimated Costs. The cost of constructing the 47 new channel rehabilitation projects follows: 44 channel rehabilitation projects at $300,000 each and three side-channel projects at $100,000 each. Of the total cost of $13,500,000, approximately 25 percent is expected to be incurred in the first 3 years.

Spawning gravel costs are estimated to average $206,000 annually, with a range of $0 in critically dry water years to $982,000 in extremely wet water years.

Cost estimates for the adaptive management program range from $2,450,000 to $4,450,000 annually. Because of the inherent flexibility of adaptive management, future costs may significantly vary from these estimates.

Integrated Management. The Flow Evaluation Alternative would include both flow and non-flow measures intended to improve fishery habitat. The combination of flows, flow timing, ongoing mechanical maintenance, and conditions throughout the watershed would be monitored, and modified if necessary, in an attempt to optimize fish production. However, annual flow volumes would be capped at the levels described above.

2.1.5 Modified Percent Inflow

This alternative replaces the Percent Inflow Alternative described in the 1999 Draft EIS/EIR.

The Modified Percent Inflow Alternative would approximate natural flow patterns, at a reduced scale, by releasing water into the Trinity River at a proportion of the rate it flows into Trinity Reservoir. Each water year would have a set schedule from July 1 to April 14, with base flows and peak releases determined by water-year class. However, the ascending and descending limb of the hydrograph would be determined by calculating 30 percent of the previous week's inflow to Trinity Reservoir on the ascending limb and 50 percent of the previous week's inflow to Trinity Reservoir on the descending limb. Peak flows under this alternative, are outlined in Table 2-6. Each year's release schedule would be unique, varying according to the hydrology of a specific year. The minimum instream release built into the alternative is 250 cfs, and the maximum release would be 13,000 cfs. The 250-cfs release would occur on a single day in October for most water year types in an effort to keep spawners from grouping to tightly in the region immediately below Lewiston. For all other days, the minimum flow would be 300 cfs. All mechanical ground-disturbing actions taken under this alternative would be subject to site-specific environmental review. AEAM would not be included under this alternative because flow levels are fixed.

Water Management. Annual flows would vary each year. However, for comparison and modeling purposes, Table 2-6 presents the average annual release for each water-year class. The release pattern for each water-year class is shown on Figure 2-5.

TABLE 2-6
Representative Annual Volumes and Peak Releases – Modified Percent Inflow Alternative

Water-year Class	Acre-feet	Peak Flow (cfs)
Critically Dry	369,000	1,500
Dry	438,000	4,500
Normal	483,000	6,000
Wet	540,000	8,500
Extremely Wet	720,000	13,000

Note: This table presents median release volumes for each water-year class.

Water Operations. The timing of diversions through the Clear Creek Tunnel would be altered similar to the altered diversion timing for the Flow Evaluation Alternative. Diversions would be shifted to the summer and early fall to maintain suitable release temperatures for the inriver fishery. Trinity Reservoir would be operated to maintain a minimum carryover storage of 600,000 acre-feet between water years. The increased carryover, relative to No Action, provides cooler water for dam releases for the benefit of the inriver fishery and reduces the need for Trinity Powerplant bypasses to provide cooler water.

Watershed Protection. Watershed protection practices under this alternative would be identical to the No Action Alternative.

Fish Habitat Management. This alternative would incorporate the same mechanical channel rehabilitation projects and schedule described in the Flow Evaluation and No Action Alternatives; however, because this alternative does not include an adaptive management program, with regard to flow volumes, a less systematic review of the projects would be conducted at year 3 before commencing with the balance of the proposed projects. As in the Flow Evaluation Alternative, the Percent Inflow Alternative assumes that flow alone would maintain the proposed and existing projects. Consequently, no mechanical maintenance would be necessary. Spawning gravel requirements for this alternative are estimated to average 950 yd^3/year, with a range from 0 yd^3 in critically dry water years to 4,650 yd^3 in extremely wet water years. These estimates assume that no gravel placement would be necessary as a result of Safety of Dam releases.

Fish Population Management. Population management under this alternative would be the same as the No Action Alternative.

Dam Modifications. Reviews of historical hydrology, in terms of scheduled peaks to the Trinity Reservoir, indicate the maximum

release would be about 13,500 cfs. Accordingly, no modification to either Trinity or Lewiston Dam was assumed necessary.

Estimated Costs. The cost of constructing the 47 new channel rehabilitation projects follows: 44 channel rehabilitation projects at $300,000 each and three side-channel projects at $100,000 each. Of the total cost of $13,500,000, approximately 25 percent is expected to be incurred in the first 3 years.

Spawning gravel costs are estimated to average $19,000 annually, with a range of $0 in critically dry and dry water years to $93,000 in extremely wet water years.

Integrated Management. The Modified Percent Inflow Alternative would include both flow and non-flow measures intended to improve fishery habitat. The combination of flows, flow timing, ongoing mechanical maintenance, and conditions throughout the watershed would be monitored, and modified if necessary, in an attempt to optimize fish production. However, annual flow volumes would be capped at the levels described above.

2.1.6 70 Percent Inflow

This alternative was not analyzed in the 1999 Draft EIS/EIR, but was suggested by hundreds of commentors, and thus was added for consideration in the Supplemental EIS/EIR.

The 70 Percent Inflow Alternative is similar to the Modified Percent Inflow Alternative, except that releases for any given week are equal to approximately 70 percent of the previous week's Trinity Reservoir inflow. There are no target peak releases; however, the No Action hydrograph serves as a "floor" (defining the minimum potential releases) to ensure that annual releases do not fall below the 340,000 acre-feet minimum allowable by federal law. Each year's release schedule would be unique, varying according to the hydrology of a specific year. The 70 percent figure is based on a large number of comments received on the Draft EIS/EIR. Commentors referred to this calculation as the "Tennant Method."[4] The minimum instream release built into the alternative is 300 cfs, and the maximum release, based on the period of record, would be 11,000 cfs. That figure is comparable to 70 percent of the highest recorded inflow above Trinity Dam, with minimum yearly releases of 340,000 acre-feet. All mechanical ground-disturbing actions taken under this alternative would be subject to site-specific environmental review. AEAM would not be included under this alternative because flow levels are fixed. The timing of releases under this alternative

[4] The "Tennant Method" is a shorthand approximation for determining optimum flow releases.

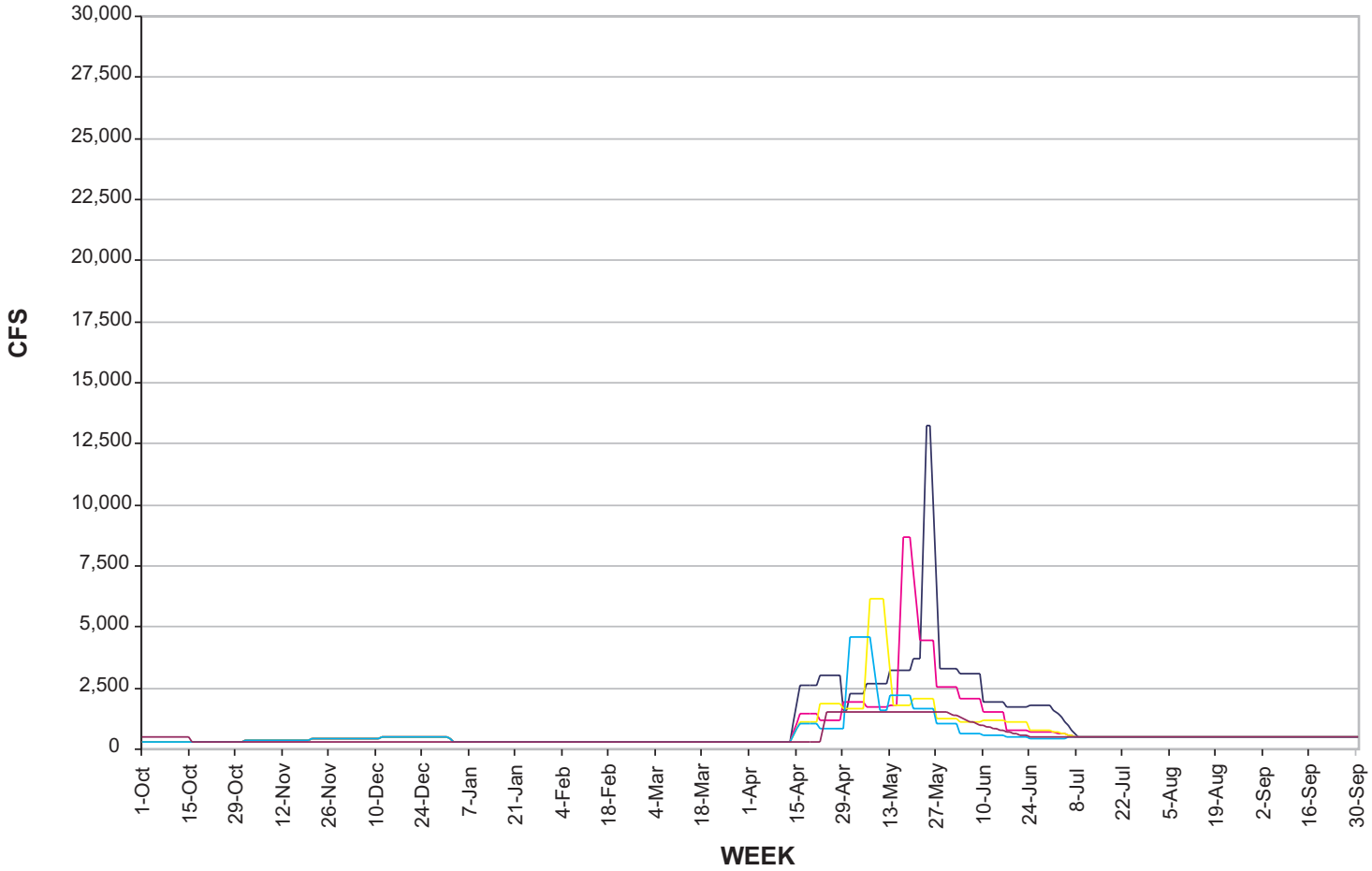

FIGURE 2-5
MODIFIED PERCENT INFLOW HYDROGRAPH
TRINITY RIVER FISHERY RESTORATION SUPPLEMENTAL EIS/EIR

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would be more likely to "piggy back" on flows caused by winter rain events. This may reduce the need for dredging tributary deltas.

Water Management. Annual flows would vary each year. However, for comparison and modeling purposes, Table 2-7 presents the average annual release for each water-year class. The release pattern for each water-year class is shown on Figure 2-6.

TABLE 2-7
Annual Volumes and Peak Releases – 70 Percent Inflow Alternative

Water-year Class	Acre-feet	Peak Flow (acre-feet)
Critically Dry	421,000	2,000
Dry	632,000	2,286
Normal	833,000	3,045
Wet	1,187,000	4,333
Extremely Wet	1,732,000	6,554

Note: Peak flow over modeled hydrologic record: 11,000 cfs.

Water Operations. The timing of diversions through the Clear Creek Tunnel would be altered similar to the altered diversion timing for the Flow Evaluation Alternative. Diversions would be shifted to the summer and early fall to maintain suitable release temperatures for the inriver fishery. Trinity Reservoir would be operated to maintain a minimum carryover storage of 600,000 acre-feet between water years. The increased carryover, relative to No Action, provides cooler water for dam releases for the benefit of the inriver fishery and reduces the need for Trinity Powerplant bypasses to provide cooler water.

Watershed Protection. Watershed protection practices under this alternative would be identical to the No Action Alternative.

Fish Habitat Management. Fish habitat management would be identical to the No Action Alternative. However, this alternative assumes seasonal flows large enough to maintain the planned improvement projects. Consequently, no mechanical maintenance would be necessary. Spawning gravel requirements for this alternative are estimated to average 950 yd^3/year, with a range from 0 yd^3 in critically dry water years to 4,650 yd^3 in extremely wet water years. These estimates assume that no gravel placement would be necessary as a result of Safety of Dam releases.

Fish Population Management. Population management under this alternative would be the same as the No Action Alternative.

Dam Modifications. Reviews of historical hydrology, in terms of weekly inflows to the Trinity Reservoir, indicate the maximum release would be about 11,000 cfs. Accordingly, no modification to either Trinity or Lewiston Dam was assumed necessary.

Estimated Costs. Cost would be identical to the No Action Alternative, less the site maintenance costs. Spawning gravel costs are estimated to average $19,000 annually, with a range of $0 in critically dry and dry water years to $93,000 in extremely wet water years.

Integrated Management. The 70 Percent Inflow Alternative would include both flow and non-flow measures intended to improve fishery habitat. The combination of mechanical maintenance, and conditions throughout the watershed would be monitored, and modified if necessary, in an attempt to optimize fish production.

2.1.7 Maximum Flow

The Maximum Flow Alternative would use all of the Trinity River inflows above Trinity Dam to restore the river ecosystem through managed flows, which would include periodic peak flow releases of 30,000 cfs that would promote streambed movement and restoration of pre-dam channel geomorphology. These occasional large releases would occur in extremely wet water years and would be intended to approximate pre-dam floods. This alternative restores and maintains the river and its fishery resources using only flows and spawning gravel placement. All mechanical ground-disturbing actions taken under this alternative would be subject to site-specific environmental review.

Water Management. Annual releases would vary by water-year class, as shown in Table 2-8. The release pattern for each water-year class is shown on Figure 2-7.

TABLE 2-8
Annual Volumes and Peak Releases – Maximum Flow Alternative

Water-year class	Acre-feet	Peak Flow (cfs)
Critically Dry	463,000	2,000
Dry	889,000	3,800
Normal	1,206,000	5,429
Wet	1,508,000	6,786
Extremely Wet	2,146,000	30,000

Note: Peak flow releases and timing: 30,000 cfs/5 days in May (extremely wet years only).

Water Operations. This alternative plans for no exports to the Central Valley because the water entering the Trinity Reservoir would be needed to meet the flow schedule shown in Table 2-8 and on Figure 2-7. The alternative calls for a ramping up of releases as early as January (depending on water-year class); hence, Reclamation would need to modify its methods of determining water-year classes (i.e., make their determinations earlier). This alternative assumes that Trinity Reservoir would be operated to maintain a minimum

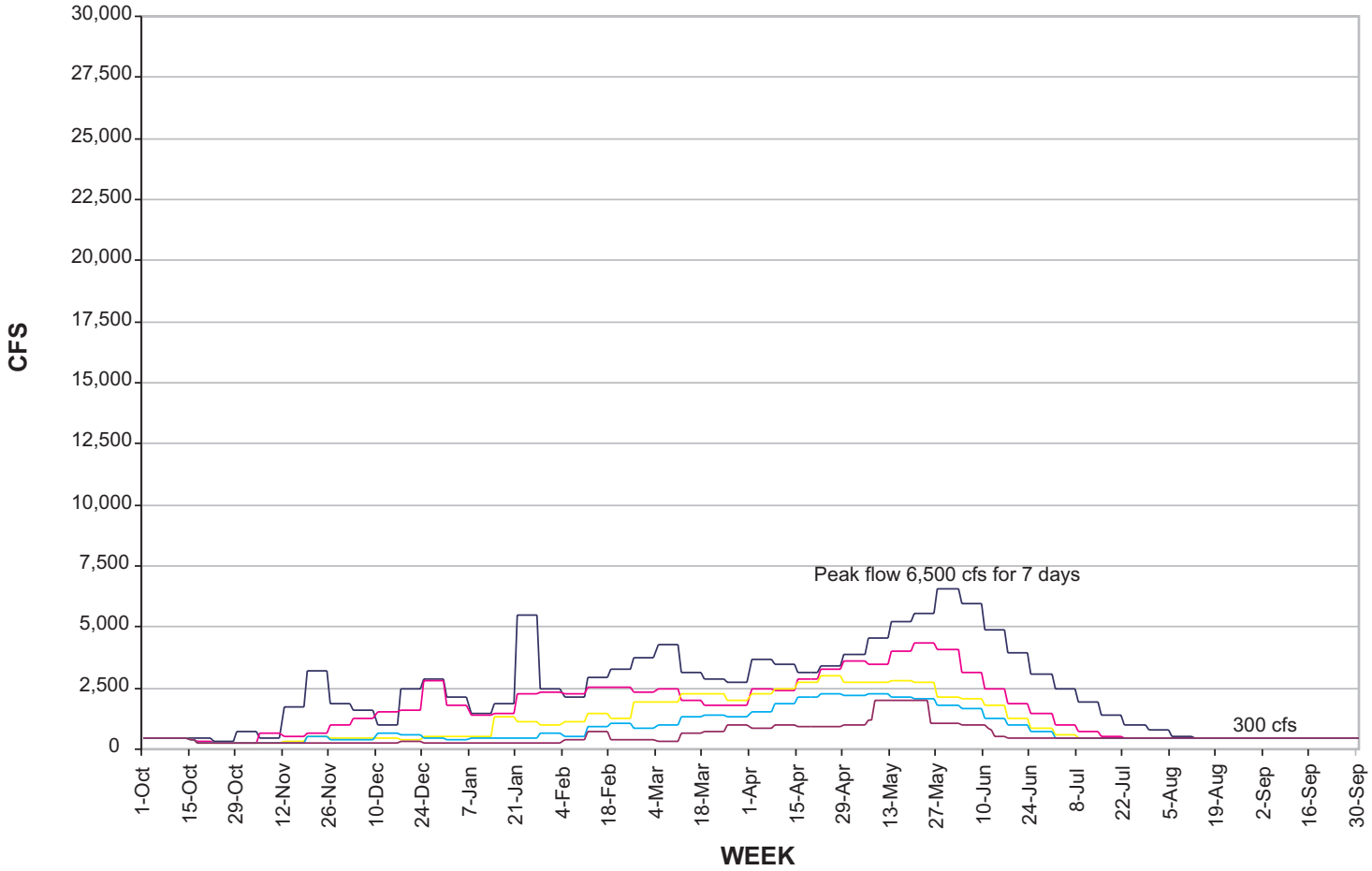

FIGURE 2-6
70 PERCENT INFLOW HYDROGRAPH
TRINITY RIVER FISHERY RESTORATION SUPPLEMENTAL EIS/EIR

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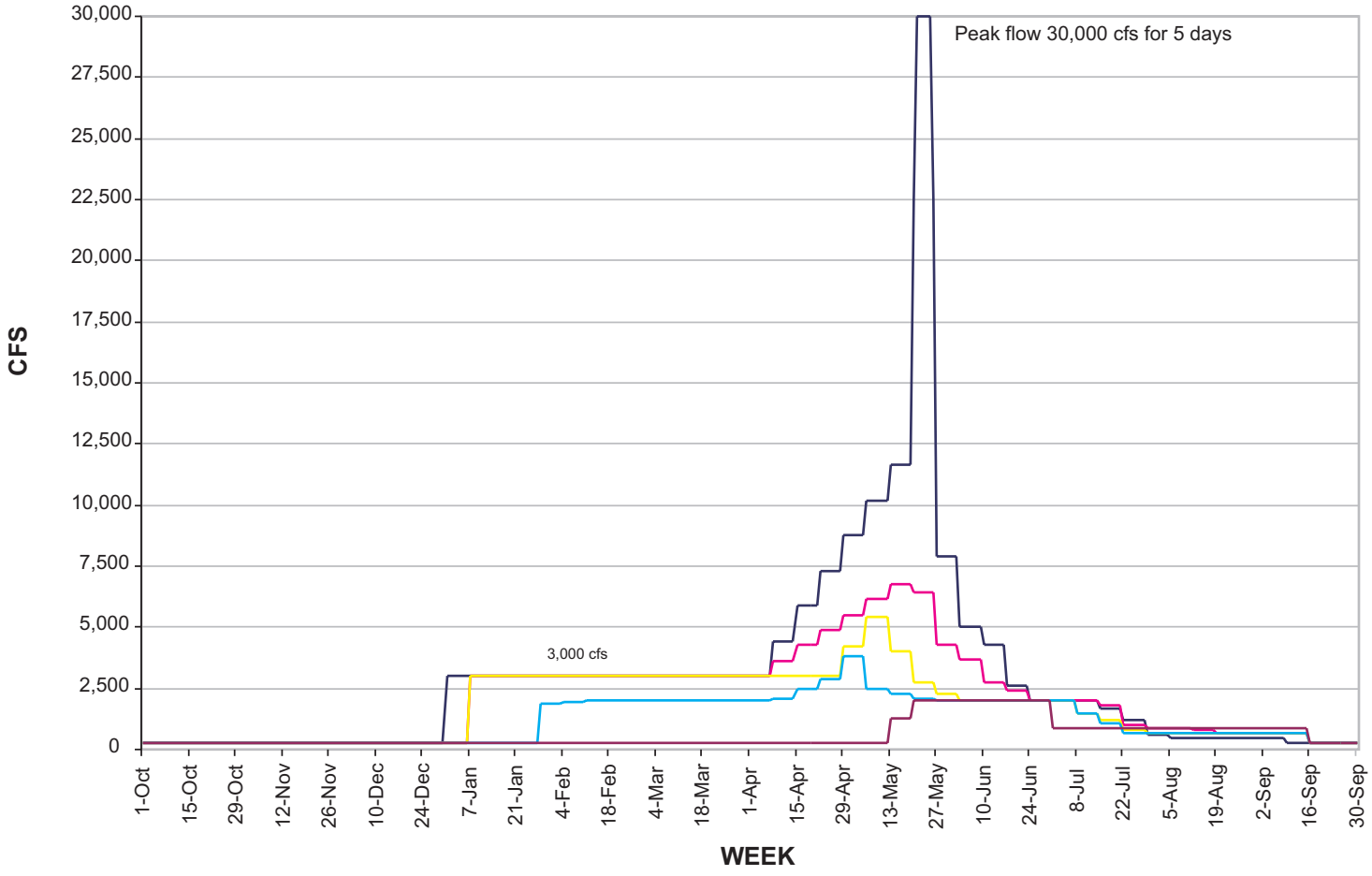

FIGURE 2-7
MAXIMUM FLOW HYDROGRAPH
TRINITY RIVER FISHERY RESTORATION SUPPLEMENTAL EIS/EIR

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carryover storage of 400,000 acre-feet between water years. (Although the Flow Evaluation, Modified Percent Inflow and 70 Percent Inflow Alternatives assume a minimum carryover of 600,000 acre-feet for temperature benefits, the high peak flows associated with this alternative preclude an increase in minimum carryover.)

Watershed Protection. Watershed protection practices under this alternative would be the same as the No Action Alternative.

Fish Habitat Management. Because this alternative assumes periodic major flow events with the ability to dramatically reshape the river, no mechanical rehabilitation projects would be constructed, nor would mechanical maintenance be needed for existing projects.

This alternative's large releases would transport and distribute more spawning gravel than any other alternative. Estimates of spawning gravel replacement average 16,400 yd^3/year, ranging from 0 yd^3 in critically dry water years to more than 100,000 yd^3 during extremely wet water years (a lack of data from large magnitude flows precludes a more precise upper-end estimate). The actual amounts of gravel placement would be determined by ongoing monitoring.

Fish Population Management. Fish population management under this alternative would be the same as the No Action Alternative.

Dam Modifications. Trinity Dam would be modified to accommodate the increased peak flows associated with this alternative (modifications to Lewiston Dam would not be necessary). Modifications to Trinity Dam would affect the release capability and, therefore, the Safety of Dams operational requirements because more flow can be released under controlled conditions. One of the following options could be used for these modifications (the options would be fully evaluated in a subsequent environmental document):

- **New penstock and tunnel connection –** Construction would take a minimum of 1 year and include the installation of an 11-foot-diameter penstock, one new guard and regulating gate, a control structure, and a one-half-acre stilling basin at Trinity Dam. It would also require the construction of a tunnel connection between the main outlet and the fixed-crest morning-glory spillway tunnel, plus a gate chamber housing a guard and a regulating gate.
- **Tunnel connection and spillway ring gate –** Construction would take a minimum of 1 year and include construction of a tunnel connection between the main outlet and the spillway tunnel at Trinity Dam, plus a gate chamber housing a guard and a regulating gate. It would also require replacing the fixed-crest morning-glory spillway with a 54-foot-diameter sliding ring gate.

- **New penstock and spillway ring gate –** Construction would take approximately 1 year and include construction of an 11-foot-diameter penstock, one new guard and regulating gate, a control structure, and a 0.5-acre stilling basin at Trinity Dam. It would also require replacing the fixed-crest morning-glory spillway with a 54-foot-diameter sliding ring gate.

Similar equipment would be needed for all three methods, such as boom cranes, concrete batch and mixing plants, backhoes, dump - trucks, concrete trucks, pumps, and drilling equipment. A temporary construction staging area would be required for each method, ranging in size from 6 to 12 acres.

A new stilling basin and control house would be constructed in the river for the penstock-and-tunnel-connection and the penstock-and-spillway-ring-gate methods. This work would start with the installation of a temporary cofferdam and dewatering facilities, continue with the construction of the stilling basin and control structures, and end with the removal of the cofferdam and the restoration of the river channel. These activities would last about 6 months, during which reservoir releases would occur through the auxiliary outlet. The auxiliary outlet connects to the spillway tunnel and chute, which discharges about 600 feet downstream from the embankment toe.

New access roads would not be required for any of the methods, provided the dam crest road could be reserved for contractor use only. All existing roads and temporary staging areas that were used for construction would be restored to pre-project conditions.

Estimated Costs. Cost estimates for each of the three Trinity Dam modification options (Reclamation, 1996) are as follows:

- New penstock and tunnel connection – $72,980,000
- Tunnel connection and spillway ring gate – $63,600,000
- New penstock and spillway ring gate – $23,080,000

Spawning gravel costs are estimated to average $328,000 annually, ranging from $0 to over $2,000,000.

A detailed flood plain review would be necessary to determine the total number of properties to be purchased because of increased peak flows.

Integrated Management. The Maximum Flow Alternative would include both flow and non-flow measures intended to improve fishery habitat. The combination of flows, flow timing, ongoing mechanical maintenance, and conditions throughout the watershed would be monitored, and modified if necessary, in an attempt to optimize fish production. However, annual flow volumes would be capped at the levels described above.

SECTION 3.0

Affected Environment and Environmental Consequences

3.1 Introduction

Section 3.0 describes the affected environment and the environmental consequences of implementing the various alternatives described in Section 2.0. Issues discussed include water resources, water quality, fishery resources, and hydroelectric power resources.

Each section includes a discussion of the affected environment (CEQA existing conditions) and environmental consequences (CEQA environmental impacts). Section 4.0 will provide a summary of significant adverse environmental impacts and proposed mitigation, the anticipated level of significance after mitigation is implemented, and those impacts that cannot be avoided and remain significant in accordance with Public Resources Code §21100, subd. (b)(2) and *CEQA Guidelines* §15126.2 Subd. (b).

Section 3.2 identifies specific adverse effects to the water delivery systems caused by potential implementation of these alternatives. However, it is understood that the change in water delivery patterns prescribed in these alternatives will have effects on water quality and fisheries. Those effects are identified and described, and mitigation is recommended in the appropriate sections.

Each resource area discussion is organized as follows:

- Affected Environment (CEQA Existing Conditions): These subsections describe the existing regional and local conditions. Information presented is the most current available and is used as the CEQA baseline for analysis for all sections that are qualitatively analyzed. Existing conditions with regard to sections that use hydrologic models (see Section 3.2, Water Resources, and the Water Resources/Water Quality Technical Appendix A for information regarding the use of water-related models) assume a modeled 1995 condition with regard to CVP/SWP operations.
- Environmental Consequences (CEQA Environmental Impacts): These subsections identify the anticipated impacts within the context of each section. Those impacts that are deemed to be potentially significant prior to mitigation are identified as such in the text. For some sections, impacts are analyzed and identified

based on modeling simulations. The following subsections are also presented under Environmental Consequences:

- Methodology: These subsections identify the method used to analyze impacts, as well as the key assumptions used in the analysis process. All sections that incorporate quantitative assessments reference complimentary technical appendices within each of the relevant Methodology subsections. Key assumptions used in qualitative analyses are also described for those sections that did not include the use of quantitative tools.

- Significance Criteria: These subsections identify what the lead agencies believe to be potentially significant effects on the environment in accordance with *CEQA Guidelines* §§15065 and consistent with guidance provided by Appendix G of the *CEQA Guidelines* (Environmental Checklist Form), and agency standards, any applicable legislative or regulatory requirements, and to professional judgement. All impacts that do not exceed the stated significance criteria described for each section are determined to be less than significant and are therefore not discussed in detail in the document (Public Resources Code §21100 and *CEQA Guidelines* §§15128).

- Mitigation: These subsections identify what lead agency staff and consultants believe to be potentially feasible mitigation measures that would reduce significant impacts associated with each of the alternatives. Where no feasible mitigation can be identified, such impacts are identified as significant and unavoidable.

Numerous models were used to assist in the identification of potential impacts associated with the implementation of any of the alternatives. Figure 3.1-1 illustrates the relationship of the primary modeling tools used to analyze impacts in the Draft EIS/EIR. Arrows indicate what data is used for additional model runs. Figure 3.1-2 illustrates the relationship of those models used to analyze impacts for this Supplemental EIS/EIR. A description of each model, key assumptions, and use is provided in each section where a given model is used, as well as the associated technical appendices. As indicated in the figure, model runs were performed to address shortcomings identified by the court. Specifically, CALSIM (the replacement for PROSIM) was used to evaluate changes to Water Resources; Reclamation Salmon mortality and temperature models

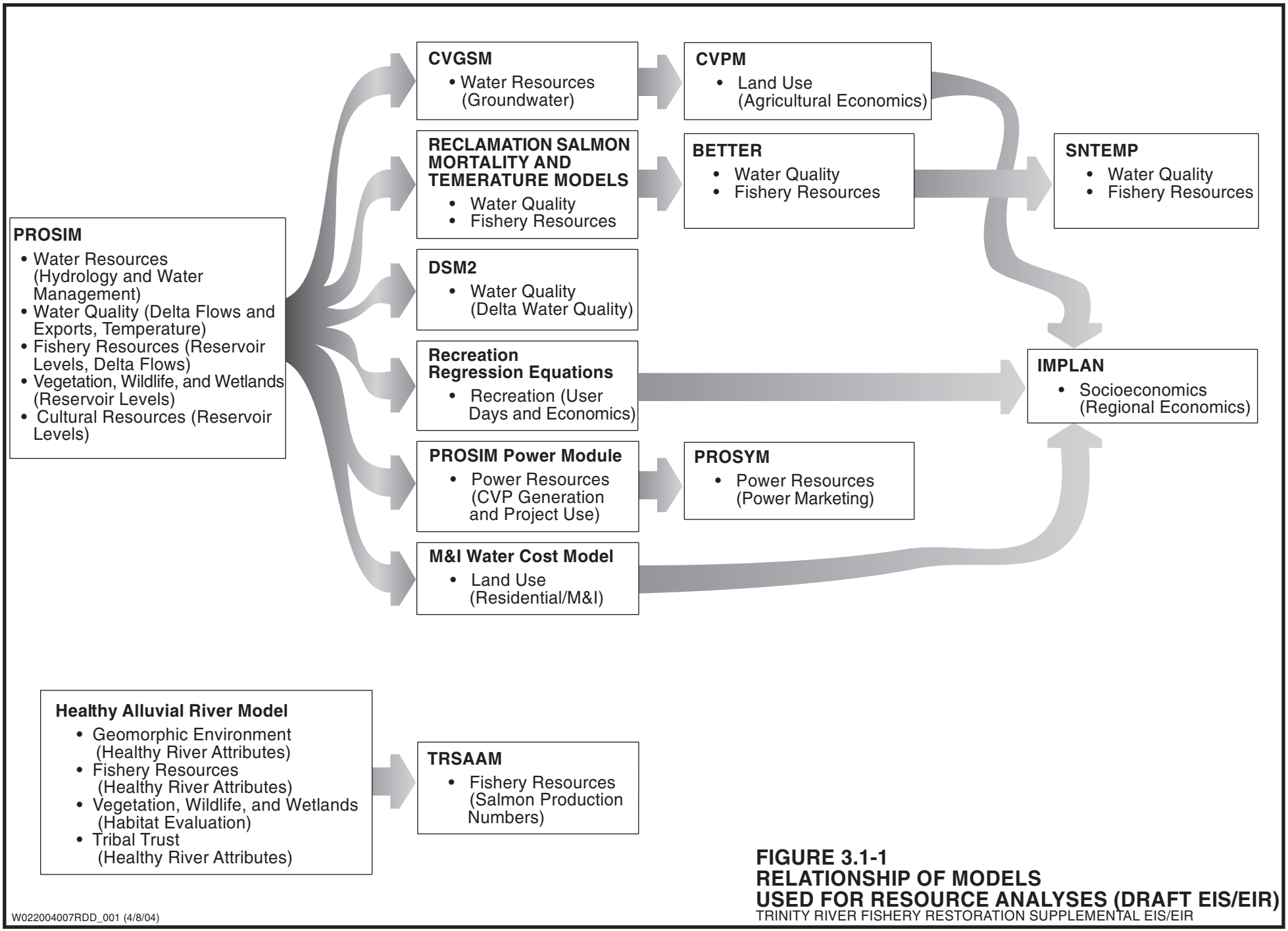

FIGURE 3.1-1
RELATIONSHIP OF MODELS USED FOR RESOURCE ANALYSES (DRAFT EIS/EIR)
TRINITY RIVER FISHERY RESTORATION SUPPLEMENTAL EIS/EIR

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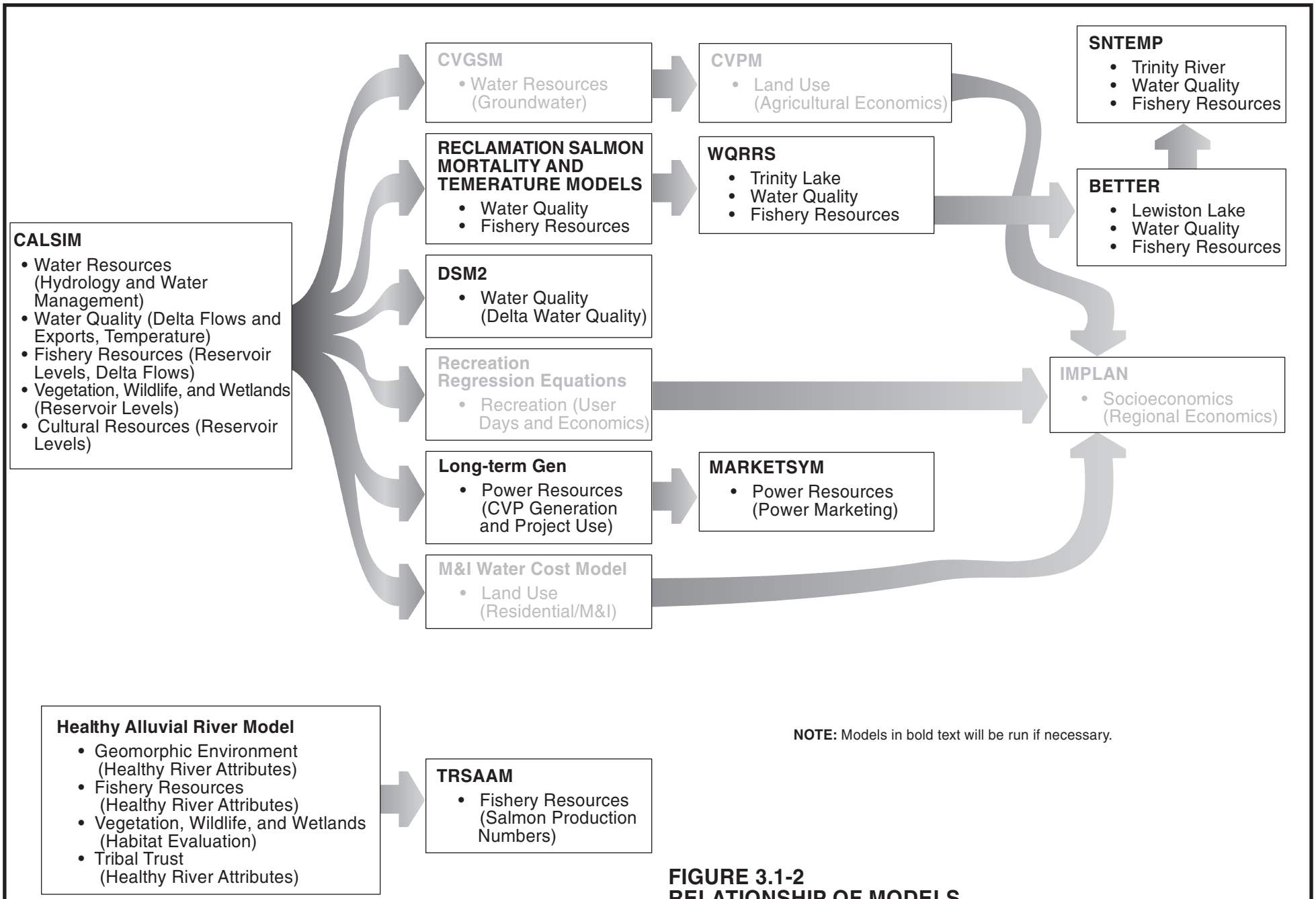

FIGURE 3.1-2
RELATIONSHIP OF MODELS USED FOR RESOURCE ANALYSES (SUPPLEMENTAL EIS/EIR)
TRINITY RIVER FISHERY RESTORATION SUPPLEMENTAL EIS/EIR

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were used to evaluate temperature and mortality effects, WQRRS, Box Exchange Transport Temperature and Ecology of Reservoirs Model (BETTER), and Service's Stream Network Temperature Model (SNTEMP) were run to evaluate temperature effects on the Trinity River. Delta Simulation Model 2 (DSM2) was used to evaluate the effects on constituents in the Bay Delta. Long-term Gen and MARKETSYM were used to update impacts to Power Resources. Figures 3.1-1 and 3.1-2 graphically illustrate the models used in this Supplemental EIS/EIR and the previous 1999 Draft EIS/EIR. Model results were then compared to previous model results to evaluate whether further analysis was warranted in resource areas not addressed by the Court in every case, the model results were found to be similar to pervious model results. Many of these models have been used in other large-scale water management studies, including the CVPIA PEIS (and technical appendices), which includes a very detailed description of the same models used to identify potential water management effects.

For most issues the discussion is divided into the Trinity River Basin, the Lower Klamath River Basin/Coastal Area, and the Central Valley. However, the power section is not subdivided because the power system operation spans all basin areas. Figure 3.1-3 shows the three geographic impact areas.

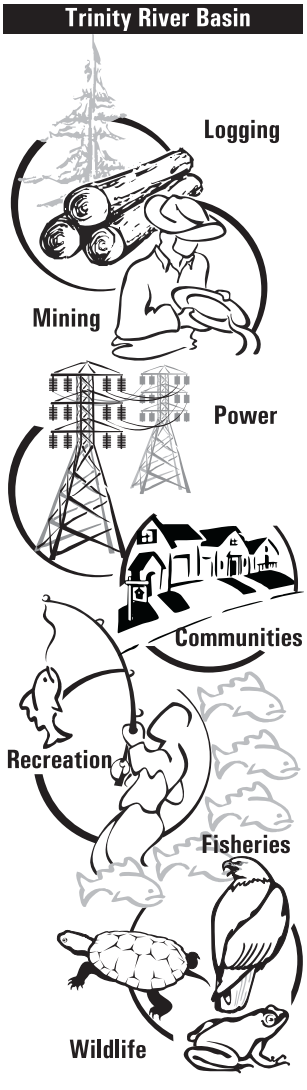
The following describes the general setting of the Trinity River Basin, the Lower Klamath River Basin/Coastal Area, and the Central Valley.

3.1.1 Trinity River Basin

The Trinity River drains a watershed of approximately 3,000 square miles; approximately one-quarter of which is above Lewiston Dam. The terrain is predominantly mountainous and forested, with little available farming area. Elevations in the basin range from 8,888 feet above sea level in the headwater areas to less than 300 feet at the confluence with the Klamath River.

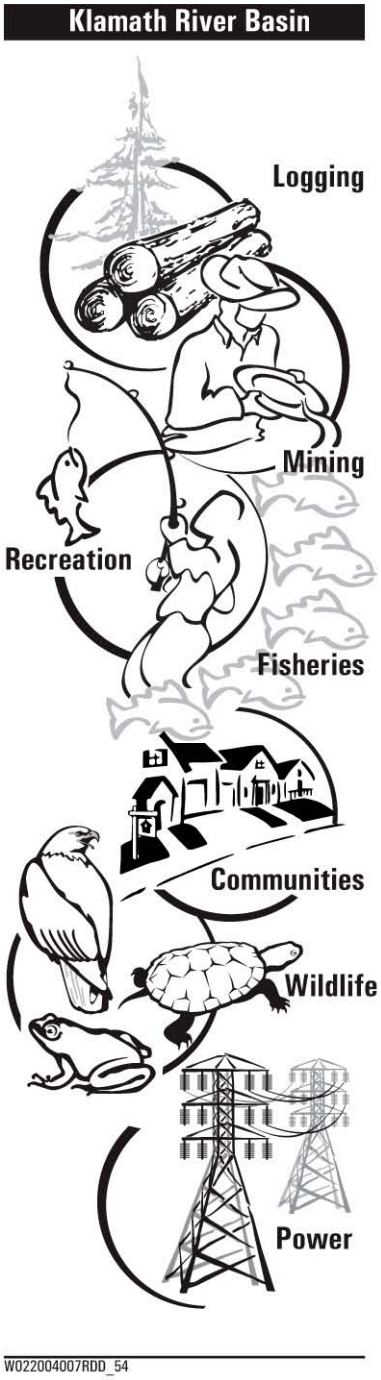
The Trinity River is the largest tributary to the Klamath River. It consists primarily of the mainstem and the North and South Forks, and New River. The Trinity River originates approximately 20 miles southwest of Mount Shasta in the canyons bordered by the Scott Mountains, the Eddy Mountains, and the Salmon-Trinity Alps.

Trinity and Lewiston Dams regulate Trinity River flows beyond approximately RM (river mile) 112. The mainstem flows a total of 170 miles west from its origins to the Klamath River confluence at Weitchpec, which is located 43.5 miles upstream from the Pacific Ocean. The majority of lands directly adjacent to the river are managed by either the USFS or the BLM; however, about half of the



land bordering the river between Lewiston Dam and the North Fork is private.

Trinity Reservoir, impounded by Trinity Dam, stores Trinity River water. Lewiston Dam regulates releases from Lewiston Reservoir to the Trinity River and provides a forebay for the diversion of flows from the Trinity River Basin through the Clear Creek Tunnel.



Urban development within the Trinity River Basin is primarily limited to the communities of Lewiston, Weaverville, Junction City, Hayfork, Willow Creek, Trinity Center, and Hoopa. In addition, several smaller communities have sprung up along State Highway 299 on level terrain adjacent to the Trinity River. Access to the river is provided by State Highway 299, which follows it from Junction City to Willow Creek. At this point, the river veers north, and State Highway 96 parallels it to its confluence with the Klamath River. Numerous recreation sites exist along the river (see Section 3.8 of the Draft EIS/EIR).

The Hoopa Valley Indian Reservation is located north of Willow Creek along the Trinity River and State Highway 96. The reservation is approximately 144 square miles, with the northern border lying near Weitchpec at the confluence with the Klamath River.

3.1.2 Lower Klamath River Basin/Coastal Area

The Klamath River Basin is located adjacent to and north of the Trinity River Basin. The entire basin drains approximately 15,600 square miles. Most of the land is under public ownership in the form of eight national forests; two national parks; BLM lands, Reclamation lands, Department of Defense lands, and Hoopa Valley and Yurok Indian Reservations, held in trust by the Bureau of Indian Affairs (BIA); as well as state and county properties. The lower Klamath River Basin extends from the confluence of the Trinity and Klamath Rivers to the Pacific Ocean. Private timber companies and the federal government own much of the land in the lower basin. The Yurok Indian Reservation extends along the entire length of the lower Klamath River. Land uses in the lower Klamath River Basin have generally been tied to natural resources, predominantly logging, mining, fisheries, and recreation. Klamath, Klamath Glen, and Requa are the primary communities.

The coastal component of this assessment area extends from southern California to the Oregon/Washington border. The area includes all ocean waters and resources that could be impacted by the proposed action and alternatives.

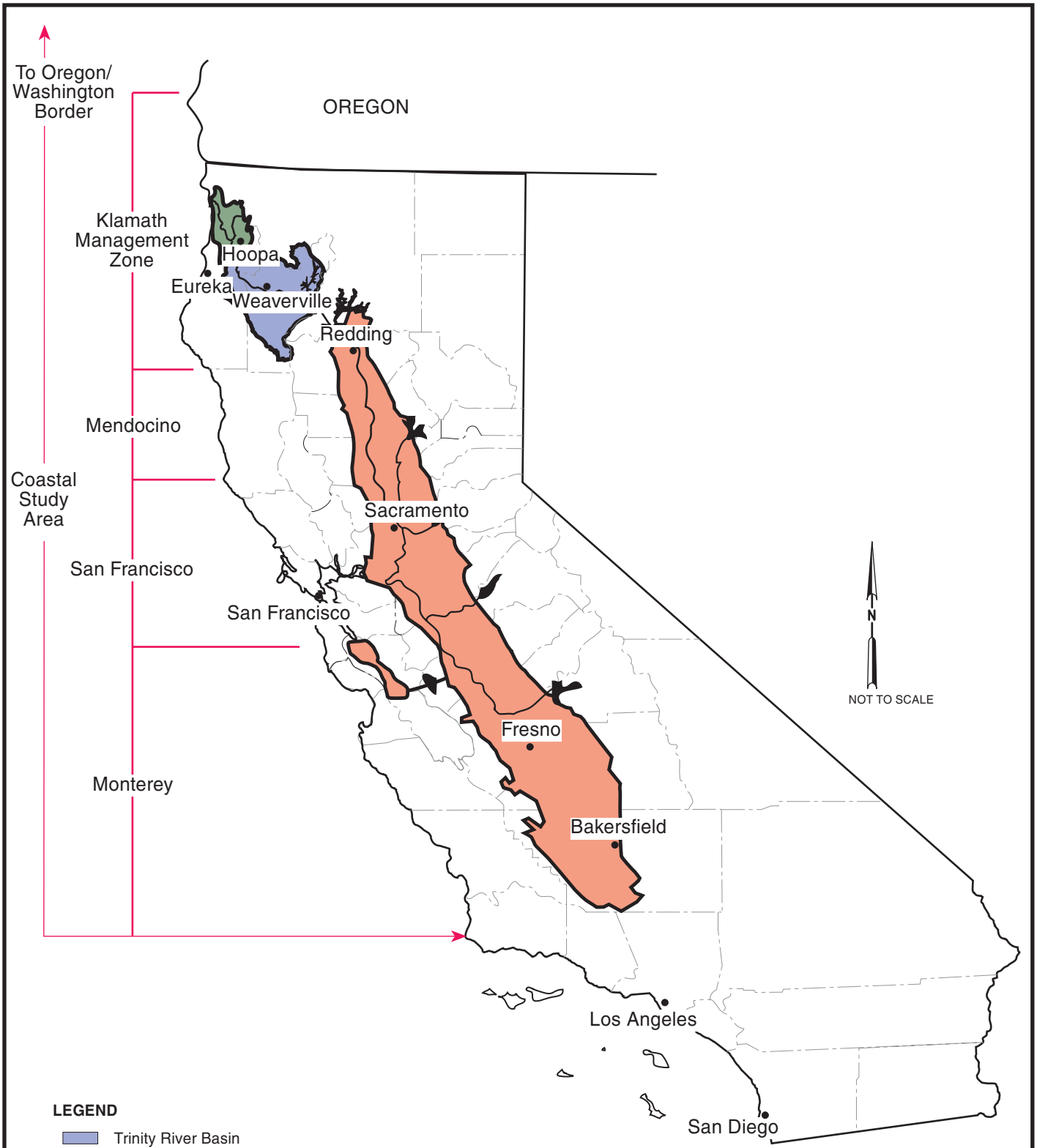


FIGURE 3.1-3
GEOGRAPHIC SCOPE OF DRAFT EIS/EIR
TRINITY RIVER FISHERY RESTORATION SUPPLEMENTAL EIS/EIR

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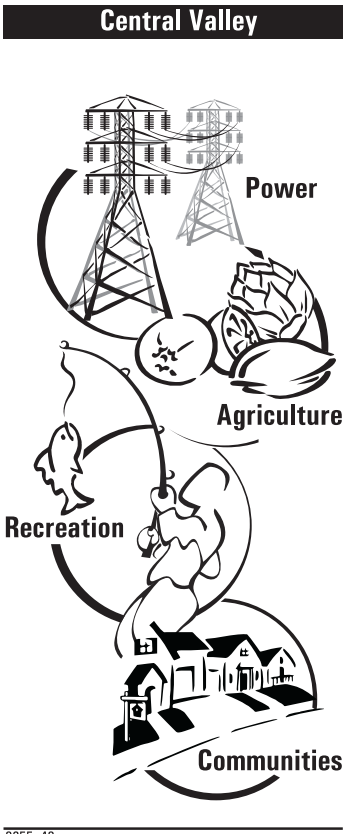
3.1.3 Central Valley

The Central Valley consists of the Sacramento River Basin (Sacramento Valley), the San Joaquin River Basin (San Joaquin Valley), and the Tulare Basin. The Sacramento River and its tributaries flow southward, draining the Sacramento River Basin. The San Joaquin River and its tributaries flow northward, draining the San Joaquin Basin. The Tulare Basin lies south of the San Joaquin River and includes the Kings, Tule, Kaweah, and Kern Rivers. The Sacramento and San Joaquin River systems join at the Delta and flow through Suisun Bay and Carquinez Straits into San Francisco Bay and the Pacific Ocean.



Major water management features of the Central Valley include 20 reservoirs, with a combined storage capacity of approximately 11 maf; 9 powerplants and 2 pumping-generating plants, with a maximum capacity of about 2 million kW; and approximately 500 miles of major canals and aqueducts. The federally operated CVP and state-operated SWP are the primary water conveyance systems in the state, which together deliver an annual total of approximately 9 maf of water. The Central Valley is one of the world's premier agricultural regions, accounting for 40 percent of the United States vegetable, fruit, and nut production. Approximately 6 percent of the region is urbanized. The largest urban area in the valley is the City of Sacramento, and the primary access route through the valley is Interstate 5.

3.2 Water Resources

This section describes the hydrology and management of water associated with CVP operations. Because operations span the Trinity River Basin and Central Valley areas, operations and facilities are discussed in both geographic areas, as appropriate.

Reservoir inflows, stream gains, diversion requirements, irrigation efficiencies, return flows, and groundwater operation are all components of the Project study area hydrology. The hydrologic analysis determines project operational effects of each listed alternative, while balancing reservoir operations, making water delivery allocations, and meeting fish and wildlife requirements.

To evaluate the effects to reservoir operations, water delivery allocations and meeting fish and wildlife requirements the CALSIM flow evaluation model was used. The choice of models is discussed in the Methodology section of this section. Flows used for the hydrologic model are based on the historical record, modified to reflect a constant future level of development. Historical flows are modified to account for changes in storage and diversion; examples follow:

- Construction of new storage or regulation facilities
- Changes in the projected operation of existing storage facilities
- Changes in upstream (i.e., external to model) imports and exports

The results presented in this section should only be used in a comparative mode. The Analysis of Alternatives section presents the results of each Action Alternative simulation compared to the results of the No Action and/or Existing Conditions simulation(s), to determine the incremental effects, of each alternative. The results from a single simulation might not necessarily represent the exact operations for a specific month or year, but are intended to reflect long-term trends.

3.2.1 Surface-water Hydrology and Management

Affected Environment.

Trinity River Basin. The Trinity River drains a watershed of approximately 2,965 square miles, about one-quarter of which is above Lewiston Dam. Elevations range from 8,888 feet mean sea level (msl) at Sawtooth Mountain in the Trinity Alps to 300 feet msl at the confluence of the Trinity and Klamath Rivers. Average precipitation for this watershed is approximately 62 inches per year; throughout the basin it varies from 30 to 70 inches and typically occurs as rain in the lower elevations and snow at the higher elevations.

The Trinity River is the largest tributary to the Klamath River. The Trinity River flows a total of 170 miles from its headwaters to its

confluence with Klamath River at Weitchpec, 43.5 miles upstream from the Pacific Ocean. Trinity and Lewiston Dams currently regulate Trinity River flows below RM 112. Prior to the completion of the TRD, flows in the Trinity River were highly variable, ranging from summer flows of 25 cfs to extreme winter events with instantaneous peak flows greater than 100,000 cfs. Annual hydrographs typically followed a seasonal pattern of high winter and spring flows followed by low summer and fall flows. Total annual flow volumes at Lewiston ranged from 0.27 to 2.7 maf, with an average of 1.2 maf.

The TRD was authorized in 1955, and began operating in 1964. The TRD consists of a series of dams, tunnels, and powerplants that export water from the Trinity River Basin into the Sacramento River Basin. With a capacity of 2.448 maf, Trinity Reservoir is the center-piece of the TRD. Releases from Trinity Reservoir are re-regulated in Lewiston Reservoir prior to release downstream into the Trinity River. Lewiston Reservoir also acts as a forebay for the trans-basin export of water into Whiskeytown Reservoir via the Clear Creek Tunnel.

Since completion of the dam in 1964, an average of 74 percent of the river's inflow from above Lewiston Dam has been exported annually, or about 988,000 acre-feet (for example, see Figure 1-2). In recent years (1985 to 1997), annual exports have decreased to an average of 732,400 acre-feet, reflecting an increase in instream releases from 120,500 to 340,000 acre-feet. Post-dam Trinity River flows at Lewiston have been as low as 120,100 acre-feet annually (10 percent of pre-dam levels). Current minimum releases to the Trinity River are not less than 340,000 acre-feet annually, as mandated by the 1992 CVPIA. Although these releases are larger than most from 1965 through 1992, they still represent drought-level flow conditions relative to pre-dam hydrology (Figure 3.2-1). According to records of pre-dam flows at Lewiston and post-dam inflow to Trinity Reservoir, 340,000 acre-feet approximates the third lowest natural flow since 1912. Recent administrative and legal proceedings have further increased releases to the Trinity River. According to the February 20, 2003 Wanger Decision, releases are 453,000 acre-feet in dry and wetter water years, and 369,000 acre-feet in critically dry water years. These flow releases represent the current release schedule for the Trinity River.

All but the largest runoff events are retained in the reservoirs for later export or downstream release, eliminating most of the vari-ability in flow below Lewiston Dam. The decrease in flows is most pronounced in the late winter and early spring months (January to June). From 1965 to 1992, post-dam flows (excluding unplanned releases) were a fairly constant 150 to 300 cfs year-round, as opposed

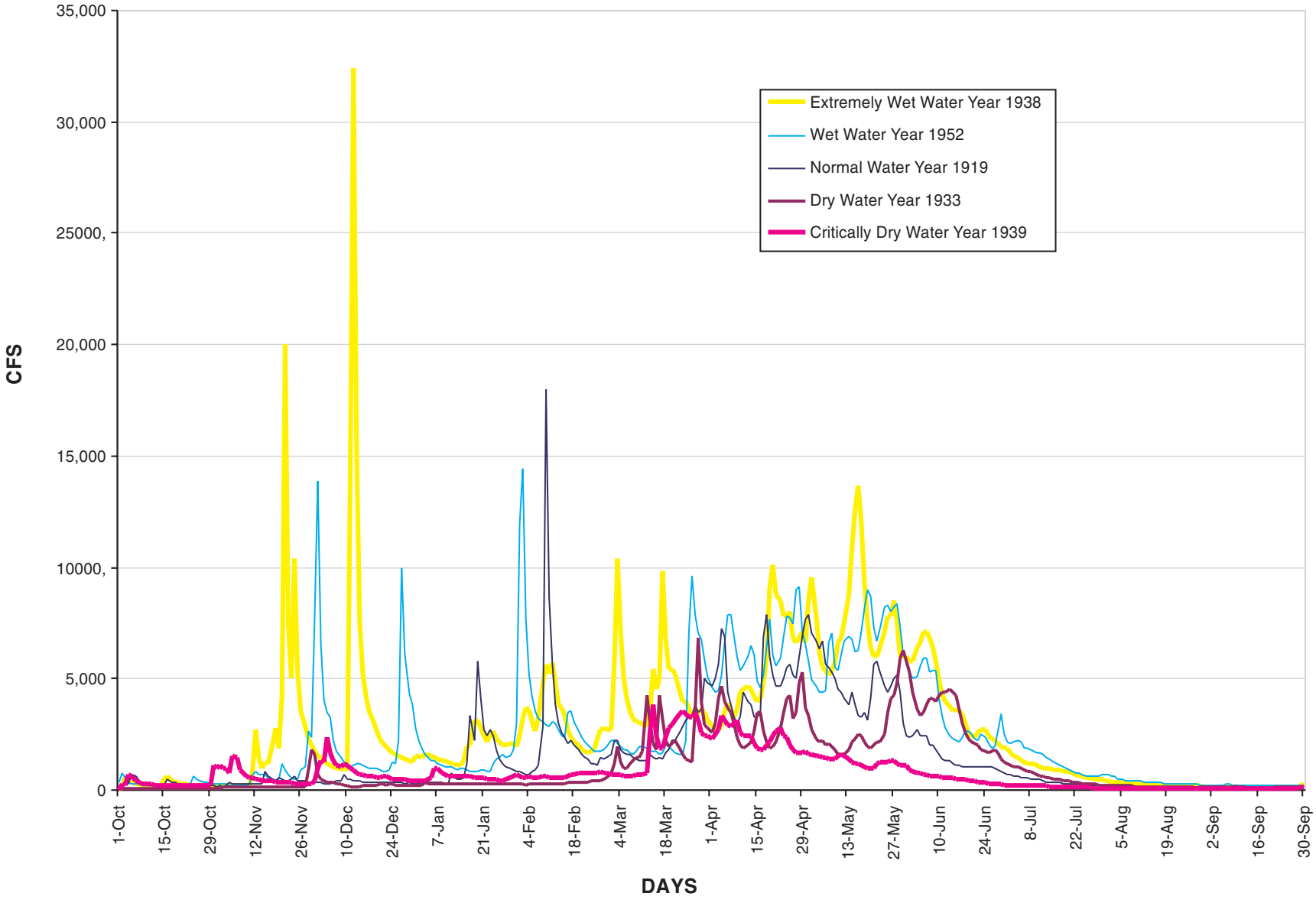


FIGURE 3.2-1
PRE-DAM DAILY FLOW COMPARISONS
TRINITY RIVER FISHERY RESTORATION SUPPLEMENTAL EIS/EIR

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to the pre-dam flows of 25 to 71,000 cfs or more. Since 1992, spring releases have occasionally ranged up to 6,000 cfs. Lewiston Dam releases are the major component of Trinity River flows until the confluence with the North Fork Trinity River. Downstream of the confluence, the accretion of tributary inflows reduces the dampening effects of the TRD. Accordingly, the frequency and magnitude of flood events have decreased dramatically at Lewiston, but much less so downstream at Burnt Ranch and Hoopa because of the increasing influence of tributary accretions (approximately 60 and 100 miles downstream of Lewiston Dam, respectively). (See Geomorphic Environment, Section 3.2, in the Draft EIS/EIR for more information on pre- and post-dam conditions.)

Although flood control is not an expressly authorized function of the TRD, Reclamation's Safety of Dams criteria provide a measure of downstream flood control. During the flood season, exports to the Central Valley are made to provide additional space within Trinity Reservoir as necessary (however, exports are not made if the Sacramento River is at or near flood stage).

TRD operations are integrated with operations of the Shasta Division of the CVP (Figures 3.2-2 and 3.2-3). For example, TRD exports have been made in consideration of minimum flow requirements in the Trinity and Sacramento Rivers, storage levels in Trinity and Shasta Reservoirs, and other CVP operating requirements (e.g., CVP deliveries, water quality requirements, the Winter-run BO). Trinity Reservoir is also operated to maximize power production during the summer and fall, in coordination with the Shasta Division.

The Winter-run BO mandates temperature requirements in the Sacramento River below Keswick Dam. Compliance with the BO is a major influence on Shasta Division operations. The TRD exports are used in conjunction with releases from Shasta Reservoir to meet temperature requirements and manage the coldwater pool in Shasta Reservoir. The majority of TRD exports occur in the spring and summer. At the same time, temperature objectives to protect Trinity River salmon must also be met. Addressing the temperature needs of the two systems is only one of the factors driving operations.

The TRD water is also used to dilute and transport acid mine drainage from the Spring Creek Debris Dam adjacent to Keswick Reservoir. The Spring Creek Debris Dam receives polluted runoff from Iron Mountain Mine, an EPA-identified Superfund site. Flows from the Spring Creek Powerplant are typically maintained at a minimum of 200 cfs to help dilute the polluted runoff and to avoid pollution events. Additional information on the operation of the TRD and CVP is provided in the Water Resources/Water Quality Technical Appendix A.

Lower Klamath River Basin/Coastal Area. The Klamath River Basin is located adjacent to and north of the Trinity River Basin. It drains approximately 15,600 square miles. Basin elevations range from more than 9,500 feet msl at the headwaters near Mount McLoughlin to sea level at the mouth of the river. Discharge near the mouth of the Klamath River averages approximately 13 maf per year. Prior to dam completion, the Trinity River contributed approximately 33 percent of the flow at the mouth of the Klamath River. After dam completion, Trinity River contributions averaged 28 percent.

The Upper Klamath River Basin supports over 2,000 private farms operating on approximately 556,000 acres. Approximately 40 percent (220,000 acres) of these lands are irrigated with Reclamation water. The potential for agricultural drought and impacts to endangered species, in addition to tribal trust issues, has led to competing interest in the Klamath River water supply.

During the spring of 2001, over 1,300 farms in the Klamath River Basin endured significant water shortages as a result of drought conditions. Additionally, in September 2002, the combination of an early peak in the return of a large run of fall Chinook salmon, low river discharges, warm water temperatures, and possible extended residence time of salmon created optimal conditions for parasite proleferation and precipitated an epizootic of *Ichthyopthirius multifilis* (Ich) and *Flavobacter columnare* (columnaris) that caused the death of an estimated 34,056 fish in the Klamath river (Service, 2003). An additional CDFG Report stated that "the cause of death for adult steelhead, coho salmon, and Chinook salmon during September 2002 was disease from the ciliated protozoan ICH and the bacterial pathogen columnaris. These parasites occur naturally, are common worldwide, and are present at all times in the Klamath River and other aquatic systems. Fish entering the lower Klamath River during mid-September 2002 encountered low flows and high water temperatures (69°F or 20.5 degrees Celsius [°C]). Temperatures in this range are stressful to coldwater fish species, and provide favorable conditions for certain fish pathogens such as ICH and columnaris." (CDFG, 2003) Ongoing review and resolution of the Upper Klamath resource issues might eventually affect flows in the Lower Klamath River. However, the possible effects of such changes are not known at this time.

In a March 5, 2003 court hearing, Judge Oliver Wanger directed the DOI to determine what actions would be necessary to "assure against the risk of fish losses that occurred late in the season last year." Judge Wanger subsequently issued a ruling on April 4, 2003, allowing Reclamation to use an additional

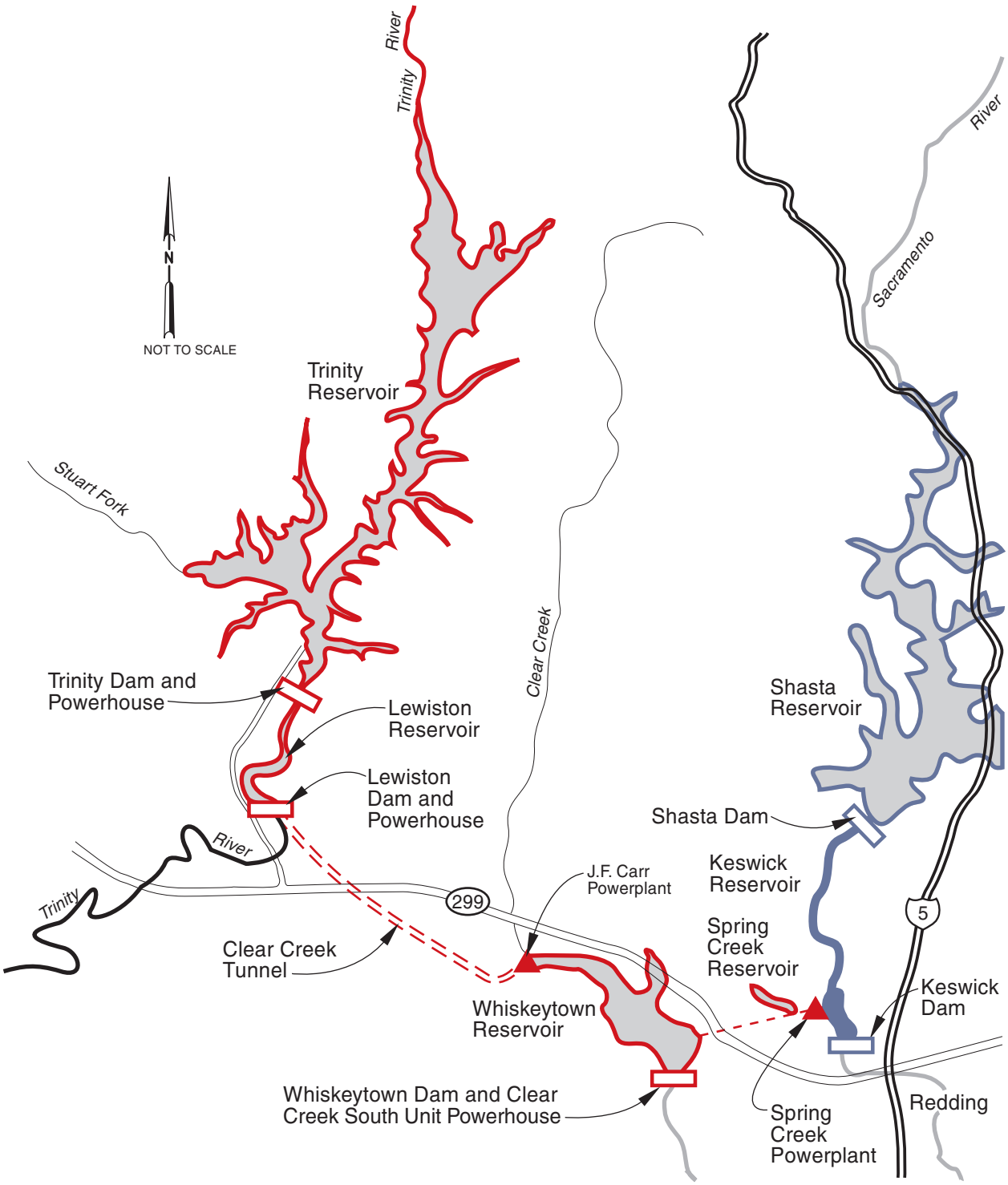

FIGURE 3.2-2
TRINITY RIVER DIVISION AND NEIGHBORING SHASTA DIVISION
TRINITY RIVER FISHERY RESTORATION SUPPLEMENTAL EIS/EIR

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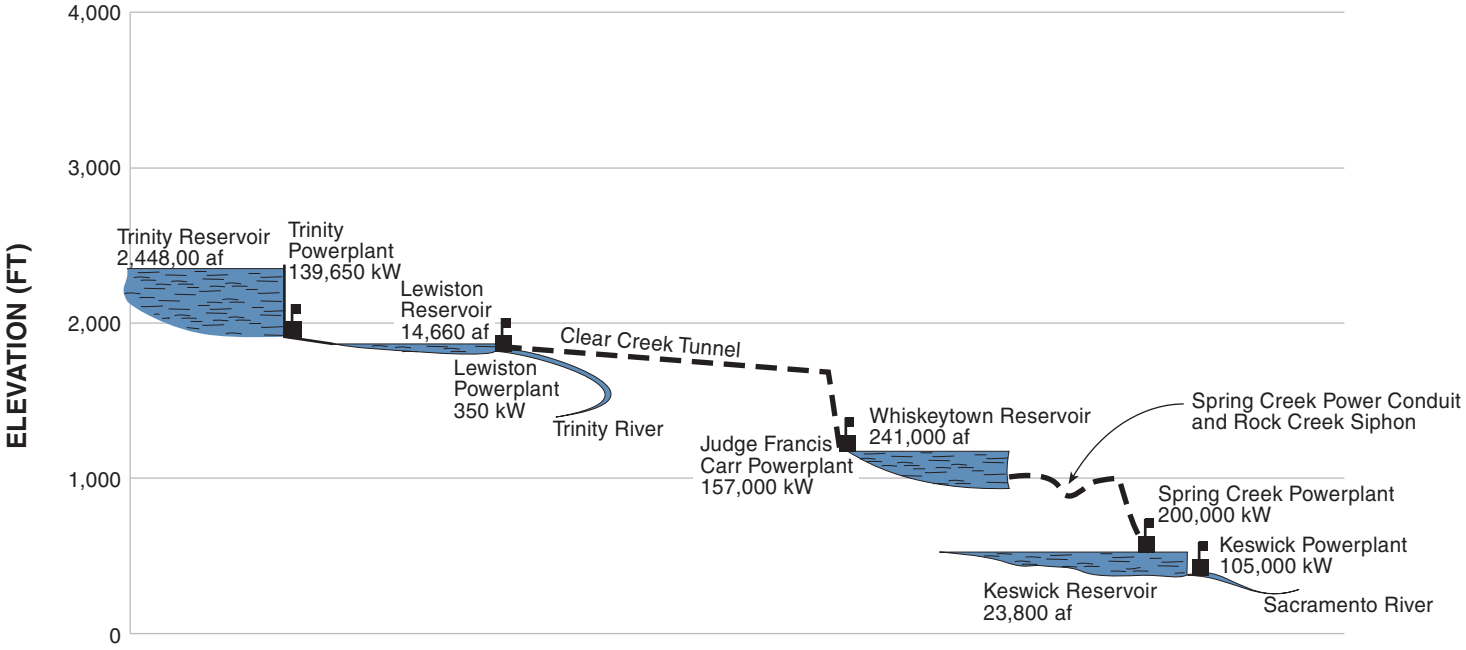

FIGURE 3.2-3
DEVELOPED PROFILE, TRINITY RIVER DIVERSION
TRINITY RIVER FISHERY RESTORATION SUPPLEMENTAL EIS/EIR

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50,000 acre-feet from the TRD of the CVP "at its reasonable discretion" to prevent a recurrence of the September 2002 fish die-off.

In late summer of 2003, an Action Plan was developed that recommended increased Trinity River flows to reduce the likelihood, and potentially reduce the severity, of a fish die-off occurring during the fall-run Chinook salmon migration. The Action Plan provided flows known to be adequate for unimpaired salmon migration through the lower Klamath River. It was expected that increasing flows would reduce or eliminate adverse in-river conditions that contributed to the adult fish die-off of 2002.

An initial presentation of increased late-summer Trinity River Dam release options and request for written comments was given at the TMC meeting on June 26, 2003. Written comments were received through July 18, 2003. A technical workgroup of state, federal, and tribal biologists was convened on July 23 and 24, 2003, to consider comments received and evaluate alternatives. The group developed a revised alternative, the Action Plan Flows option, that addressed these concerns. Additional updates were provided to a broadly representative group of stakeholders on July 29, 2003, at a TAMWG meeting in Weaverville, California, and a TMC conference call on July 30, 2003. A letter of support for the proposed action was forwarded directly to the Secretary of the Interior from the TMC and TAMWG in a letter dated August 8, 2003.

Projected flow conditions and a large fall-run Chinook salmon escapement on the lower Klamath River in 2003 were similar to conditions that existed during the die-off in 2002. The two triggers established for initiating the preventive flow release (low flow and a large return of fall-run Chinook salmon) were met as of August 20, 2003. Reclamation implemented the release schedule proposed in the Action Plan; 33,000 acre-feet of water, obtained through a water transfer with MWD, was used as a preventative means to reduce the likelihood of another fish die-off in 2003. No fish die-off was observed in 2003. An assessment of the Action Plan is included in the Water Resources Technical Appendix.

Central Valley. The CVP, of which the TRD and Shasta Division are key components, is the largest surface-water storage and delivery system in California, covering 35 of the state's 58 counties. The project includes 20 reservoirs, with a combined storage capacity of approximately 11 maf; and 9 powerplants and 2 pump-generating plants, with a combined generation capacity of approximately 2 million kW (Figures 3.2-4 and 3.2-5). Operations of the CVP are quite complex given the multiple demands that must be met.

Key Shasta Division operational issues include the following:

- Flood control
- Storage and release of water for agricultural, M&I, fish and wildlife, refuges, and other needs
- Navigation flows
- Temperature control as specified by the 1993 Winter-run Chinook BO
- Bay-Delta water quality requirements
- Generation of hydroelectric energy

Historically, the vast majority of CVP water has been delivered to agricultural users. However, continued urban growth is resulting in greater demand from CVP M&I customers (see Land Use, Section 3.9, of the Draft EIS/EIR). In contrast to CVP, where most of the customers are agricultural, over 50 percent of SWP deliveries go to urban areas, primarily in Southern California.

Current CVP operations are guided by a series of documents including the 1992 CVP-OCAP, various BOs for endangered species, the COA between the CVP and SWP, and the Regional Water Resources Control Board water quality plans. The 1992 OCAP is currently being updated and will likely be finalized in 2004. Additional information on the operation of CVP and assumptions made for this analysis are provided in the Water Resources/Water Quality Technical Appendix A, as well as the CVPIA PEIS and associated appendices (Reclamation, 1997a).

In his final ruling, Judge Wanger identified two specific measures in the original BOs that were improperly adopted by Reclamation, one each from NOAA Fisheries and the Service. The determination was that the environmental effects resulting from the implementation of reasonable and prudent measures for the project were not analyzed or disclosed to the public in a proper form or in a timely manner. The reasonable and prudent measures are outlined in two BOs received on the program: one from the National Marine Fisheries Service (since renamed NOAA Fisheries), dated October 12, 2000; and one from the Service, dated October 12, 2000. Judge Wanger's December 10, 2002 Summary Judgement ruling set aside the X2 reasonable and prudent measures[1] in the Service BO

[1] X2 is measured as km from the Golden Gate Bridge. Higher X2 values indicate saltwater intrusion into the Delta. The X2 is also discussed in Section 3.4, Fishery Resources. The X2 reasonable and prudent measure states: If Reclamation in its annual operations planning process detects that implementation of the Preferred Alternative will result in upstream (eastward) movement of X2 in any month between February 1 through June 30 of 0.5 km, Reclamation shall incorporate within its operating plan measures that can and will be implemented to minimize or eliminate such upstream movements.

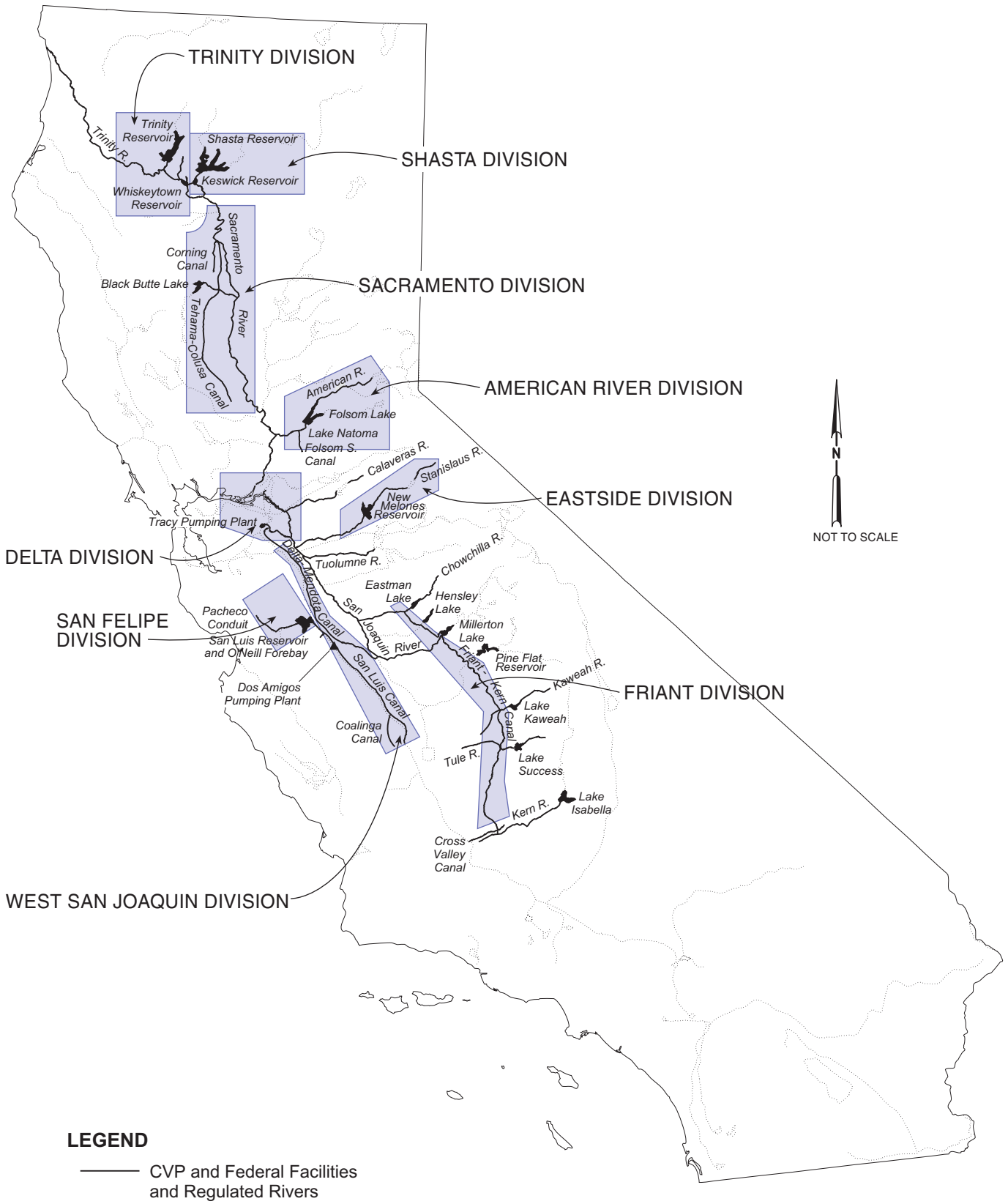

FIGURE 3.2-4
CENTRAL VALLEY PROJECT FACILITIES, REGULATED RIVERS, AND DIVISIONS
TRINITY RIVER FISHERY RESTORATION SUPPLEMENTAL EIS/EIR

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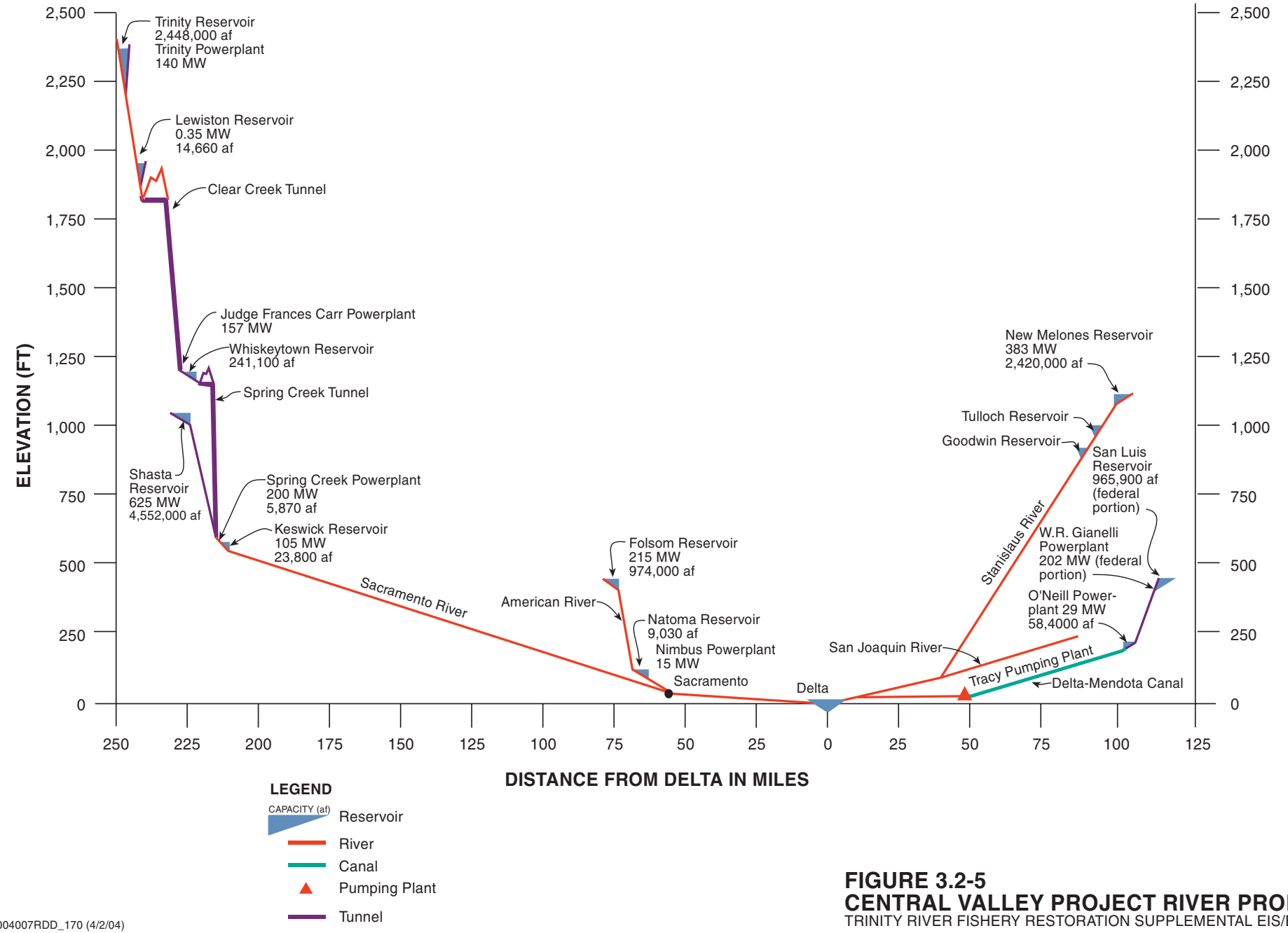

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FIGURE 3.2-5
CENTRAL VALLEY PROJECT RIVER PROFILE
TRINITY RIVER FISHERY RESTORATION SUPPLEMENTAL EIS/EIR

and the temperature reasonable and prudent measures in the NOAA Fisheries BO because of undisclosed impacts.

The Court's ruling in this case emphasized the need for Interior to take into account ESA impacts throughout the CVP in developing reasonable and prudent measures and implementing terms and conditions for any authorized incidental take of listed species. With respect to the treatment of ESA impacts in the original EIS, the Court found that it "was arbitrary and capricious for the EIS and Final EIS not to address impacts of X2 [Delta salinity] reasonable and prudent measures and CVP re-operation." Westlands Water District v. U.S. Department of the Interior, 275 F.Supp.2d at 1196. To comply with the Court's ruling, the federal defendants recognized that Reclamation needs to assess the impacts on listed species throughout the entire CVP system to the extent that those species may be affected by the range of possible Trinity operations under the various alternatives under consideration in the Supplemental EIS/EIR. Ideally, Reclamation would have been able to complete its renewed consultation with the Service and the NOAA Fisheries so that new Supplemental BOs would have been provided before publication of the Public Draft EIS/EIR. While consultation is not formally complete, the results of the informal consultation are presented in this document. The results of the impact analyses for both winter-run Chinook and Delta smelt (X2 position) are discussed in Section 3.4 Fishery Resources. Specifically, impacts to winter-run Chinook salmon are discussed under Environmental Consequences of Section 3.4.1 Native Anadromous Species; and a detailed analysis of X2 position is discussed in the methodology section of Section 3.4.2 Resident Native and Non-native Fish.

ESA consultation for the Trinity Supplemental EIS/EIR is occurring through the Reclamation OCAP process, currently underway among Reclamation, FWS, and NOAA Fisheries. The OCAP consultation will consider the effect of all CVP facilities and current programs and projects on endangered and threatened species. By including the Trinity Division program into the OCAP consultation process, Reclamation will address one of the district court's concerns regarding the need to consider the aggregate impacts of all CVP operations and thereby achieve a consistent approach between numerous projects that comprise the CVP operations. Based on discussions to date with biologists at FWS and NOAA Fisheries, Reclamation does not expect either of the reasonable and prudent measures from the 2000 BOs on Trinity, both of which were set aside by Judge Wanger in his December 2002 ruling, to be carried forward into the forthcoming OCAP BOs. The absence of the previous reasonable and prudent measures from the forthcoming OCAP BOs means that there is would be no legal requirement for the Trinity Supplemental

EIS/EIR to address the possible environmental impacts of those specific reasonable and prudent measures.

The OCAP process includes consultation with Service and NOAA Fisheries under section 7 of the ESA to determine the potential impacts on ESA-listed endangered and threatened species throughout the entire CVP, including the TRD. Pursuant to the ESA regulations, 50 C.F.R. § 402.12, as the lead federal "action" agency for OCAP, Reclamation must prepare a BA that takes into account the range of ongoing and proposed actions that comprise CVP operations. These OCAP-related actions include several developments that were not in place in 2002 at the time of the initial BOs and the initial EIS for the Trinity River fishery restoration. These developments include the following:

- Proposed new water diversion on the Sacramento River near Freeport, California
- Proposed inter-tie between the Delta Mendota Canal and the State Water Project's California Aqueduct
- California Department of Water Resources' South Delta Improvement Plan, which includes both possible increased diversions at the Banks Pumping Plant and construction and operation of in-channel barriers in the South Delta area.

Reclamation's BA also must include assumptions regarding management of the EWA, itself a complicated operational assessment. *Cf.* Laub v. U.S. Department of the Interior, 342 F.3d 1080, 1083-84 (9th Cir. 003)(describing EWA in context of CALFED).

Flows in the upper Sacramento River are primarily regulated by Shasta Dam and are re-regulated 15 miles downstream at Keswick Dam. The watershed above Shasta Dam drains approximately 6,650 square miles with an average annual runoff of 5.7 maf. With a capacity of 4.6 maf, Shasta Dam has the largest capacity of any reservoir in the state. Annual releases range from 9 maf in wet years to 3 maf in dry years. From 1964-1996, Keswick releases averaged 7.3 maf annually, of which TRD exports accounted for 14 percent. In recent years (1986-1996), Keswick annual releases averaged 5.9 maf, of which 12 percent was TRD export.

The Winter-run BO is one of the most influential factors governing Shasta releases, both in terms of quantity and timing. The BO sets water temperature requirements below Keswick Dam for April through October, and establishes an end-of-September minimum carryover storage for Shasta Reservoir of 1.9 maf. To meet the temperature objectives, a dynamic evaluation of ambient air temperature, weather forecasts, water temperature at the release point, and release rate occurs. Determination of the appropriate

release rate is often made based on the temperature of the water released rather than the rate needed to support CVP operations. Generally, it takes higher releases to meet temperature targets with warmer water and lower releases with colder water. The coldwater pool in the reservoir is essentially a function of the volume of water in the reservoir. More cold water is available when the reservoir is full, less is available as the reservoir is drawn down. In years when CVP facilities cannot be operated to meet required temperature and storage objectives, Reclamation re-initiates consultation with NOAA Fisheries.

To meet daily temperature requirements at Bend Bridge (or Jellys Ferry in dry years) in the summer and early fall, Reclamation attempts to maintain a minimum coldwater pool in Shasta Reservoir, as well as Trinity and Whiskeytown Reservoirs, throughout the summer. Spring exports from the TRD allow cold water to be held in Shasta for summer release during the critical salmon incubation period. In addition, Reclamation operates the system to attempt to minimize warming within Whiskeytown Reservoir, which is prone to warming in a similar manner to Lewiston Reservoir. Excessive warming of Whiskeytown Reservoir can in turn require that additional Shasta releases be made to dilute warm Whiskeytown releases through Keswick. Alternatively, exports from Trinity can also be increased to reduce warming affects to Whiskeytown. Typically, CVP operations include bringing exports into Whiskeytown Reservoir in late May and June.

Aside from making water available for downstream uses, Trinity exports for the remainder of the water year are managed to maximize the following:

- Movement of water through Whiskeytown Reservoir to inhibit warming so that releases to the Sacramento river stay relatively cold
- Conservation of Shasta coldwater reserves
- Production of high-value summer and early fall power generation

The TRD water not only assists in Sacramento temperature needs, but is also used for agricultural, M&I, and Delta water quality purposes. The agricultural contractors account for the vast majority of consumptive uses of water along the Sacramento River. Of the total amount that is diverted for agricultural use, a portion of the water that is applied to fields but is not actually used by crops is assumed to return to the Sacramento River either through surface-water runoff or groundwater subsurface drainage. This water is then available for other downstream uses, including CVP contractors

within the Bay Area (e.g., Contra Costa Water District) or those served through Delta exports (e.g., the San Joaquin Exchange contractors, or agricultural and M&I water service contractors located south of the Delta).

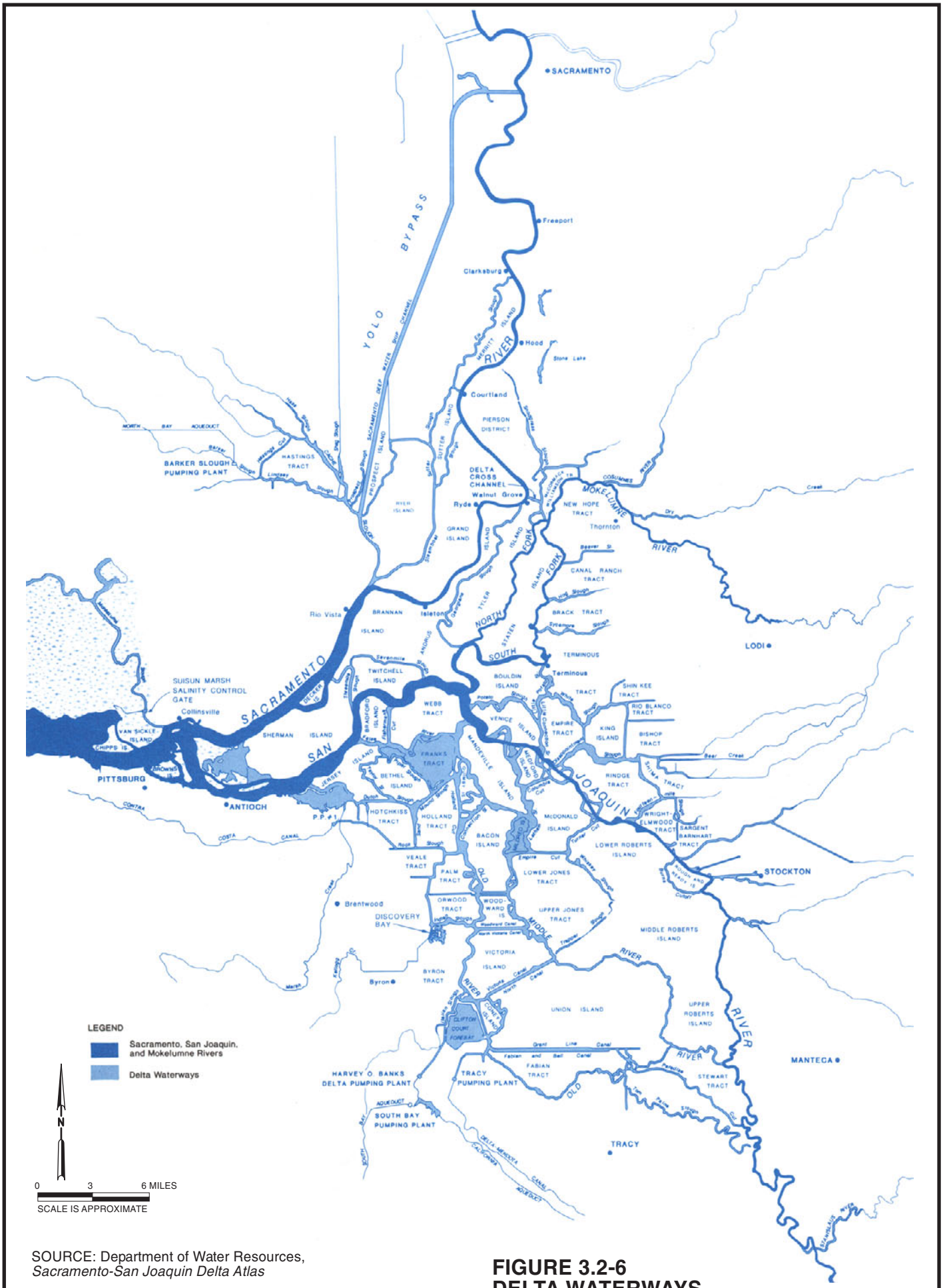
The CVP supplies up to approximately 6.2 maf annually to water contractors in the Central and Santa Clara Valleys as well as Contra Costa County. (The Friant Division, which holds contracts for 1.9 maf, is not included in this discussion because those contractors are independent of CVP operations that might be affected by changes in the TRD.) The CVP is required by contracts to make deliveries up to the contract amount, if requested, except in periods of water shortage. During periods of reduced supply, water deliveries are decreased according to terms in the contracts. Contractors are grouped into the following three general categories:

1. **Sacramento River Water Rights Settlement Contractors.** These contractors claimed water rights in the Sacramento Basin prior to construction of Shasta Dam. Contract provisions allow for reductions of up to 25 percent of contracted amounts during dry conditions (as determined by the Shasta Inflow Index).

2. **San Joaquin River Exchange Contractors.** These contractors claimed water rights in the San Joaquin River and agreed to exchange these rights for CVP water diverted from the Bay-Delta and delivered to the Mendota Pool. Contract provisions allow for reductions of up to 25 percent of contracted amounts under dry conditions (as determined by the Shasta Inflow Index).

3. **CVP Water Service Contractors.** These agricultural and M&I water service contractors entered into agreements with Reclamation for delivery of CVP water as a supplemental supply. Water deliveries to agricultural water service contractors can be reduced to zero in particularly dry years. Maximum curtailment levels are not specified for most M&I water service contractors. Historically, Reclamation has limited maximum curtailments to M&I contractors to 25 percent; future system demands are assumed to potentially require curtailments of up to 50 percent. Water availability for delivery to CVP water service contractors during periods of insufficient supply is determined based on a combination of operational objectives, hydrologic conditions, and reservoir storage conditions.

The Bay-Delta is located at the confluence of the Sacramento and San Joaquin Rivers and consists of a maze of channels, sloughs, and dredger cuts that drain to the ocean through an area of 1,200 square miles (Figure 3.2-6). Average annual flow into the Bay-Delta is about 27.8 maf, accounting for approximately 40 percent of all the surface



SOURCE: Department of Water Resources, *Sacramento-San Joaquin Delta Atlas*

FIGURE 3.2-6
DELTA WATERWAYS
TRINITY RIVER FISHERY RESTORATION SUPPLEMENTAL EIS/EIR

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water in California. The Sacramento Basin contributes approximately 75 percent of the freshwater flows into the Bay-Delta. Trinity River exports on average 4 percent of the annual Sacramento River inflow to the Bay-Delta. Annual Bay-Delta inflow varies widely, as evident during a recent 10-year period when annual flows ranged from 5.9 maf (1977) to 70 maf (1986). Bay-Delta outflow is greatly influenced by tidal and seasonal variations, largely due to the influence of the Pacific Ocean. For example, average tidal flow (ebb or flood tide) at Chipps Island near Pittsburg is approximately 170,000 cfs, compared to an average net winter freshwater outflow of 32,000 cfs and a summer net outflow of 6,000 cfs. (The effect of flows on salinity levels and other water quality parameters in the Delta are discussed in Water Quality, Section 3.4, in the 1999 EIS/EIR.)

Environmental Consequences.

Methodology. CALSIM II is a general-purpose planning simulation model developed by DWR and Reclamation for simulating the operation of California's water resources system, specifically CVP and SWP, and has become the new standard for evaluating systemwide water resource operations in the Central Valley. On a monthly time-step, CALSIM II routes water through a simulation network representing the CVP and SWP systems. The model user describes the physical system (e.g., dams, reservoirs, channels, or pumping plants), operational rules (e.g., flood-control diagrams, minimum flows, and delivery requirements), and priorities for allocating water to different uses in programming statements, which are typically reviewed by a broad array of water resource interests. CALSIM II is the replacement for the PROSIM/SANJASM (Reclamation) computer models used to analyze potential water supply-related impacts in the 1999 EIS/EIR. CALSIM and PROSIM are both monthly planning models designed to simulate the hydraulic system composed of the CVP and SWP. They assess impacts to the hydrology system potentially impacted by the project alternatives. Operations of CVP and SWP for the purpose of water supply, flood control, recreation, maintenance of instream flows as set forth in the CVPIA, water quality, fish and wildlife, reservoir storage, Delta flow and water quality requirements, and hydroelectric power generation are defined by the user via input data files. For this analysis, CALSIM II results are very comparable to previous results from PROSIM. However, CALSIM II also includes recent programs such as CVPIA 3406b(2) water accounting and EWA neither of which was fully included in previous analysis. Accurate portrayals of CVPIA 3406b(2), EWA, and other operational updates necessitated the use of CALSIM II.

CALSIM II is intended for use in a comparative mode. The results from alternatives are compared to the results of the No Action

Alternative, to determine the incremental effects of each alternative. For CEQA purposes, comparisons are made against existing conditions (see Section 1.8).

The results from a single simulation are not intended to necessarily represent the exact operations for a specific month or year, but instead reflect long-term trends.

CALSIM II includes a variety of model enhancements to better characterize and simulate the operations of both the CVP and SWP systems. These enhancements are briefly described below.

CALSIM II includes an updated hydrology developed jointly by DWR and Reclamation that represents an improvement over the hydrology used previously. As defined in CALSIM II, hydrology includes water diversion requirements (demands), stream accretions and depletions, rim basin inflows, irrigation efficiency, return flows, nonrecoverable losses, and groundwater operation. Historical hydrology is adjusted to account for constant future levels of development. Adjustments to historical water supplies are determined by imposing future projections of land use on historical meteorological and hydrologic conditions.

Alternatives that include release schedules that vary by water-year class all determine the type of water year according to Trinity Reservoir inflow. CALSIM uses perfect foresight to predict water-year classification, whereas during normal operations some forecasting is necessary to predict the type of water year during the spring runoff period. To maintain the desired exceedance probabilities prescribed for the alternatives, a 50 percent exceedance forecast would be used. Use of a 50 percent exceedance forecast would ensure over the long-term that the desired year-type probabilities are achieved, and also that the effects of implementing the alternatives most closely matches the CALSIM results. See Table 3.2-1 for water-year class.

TABLE 3.2-1
Water-year Class

Water-year Class	Exceedance Probability	Occurrence Every 100 Years	Trinity Reservoir Inflow for Designation (acre-feet)
Critically dry	p > .88	12	<650,000
Dry	.60 < p < .88	28	650,000-1,024,999
Normal	.40 < p < .60	20	1,025,000-1,349,999
Wet	.12 < p < .40	28	1,350,000-1,999,999
Extremely wet	p < .12	12	>=2,000,000

Note: Water-year classifications would be forecast using 50 percent exceedance methodology.

CALSIM II has improved allocation logic and assumptions compared to the PROSIM model that govern deliveries to north of the Delta and south of the Delta CVP and south of the Delta SWP contractors. Deliveries are determined using runoff forecast information that incorporates uncertainty and standardized rule curves (i.e., Water Supply Index versus Demand Index Curve) to estimate the water available for delivery and carryover storage. Updates of delivery levels occur monthly, January through May for SWP and March through May for CVP, as water supply parameters become more certain and forecasts become more accurate. The south of the Delta SWP delivery is determined according to water supply parameters and operational constraints. The CVP systemwide delivery and south of the Delta delivery are determined similarly, with specific consideration for export constraints.

CALSIM II incorporates new procedures for dynamic modeling of CVPIA 3406(b)(2) water and the EWA. Per the October 1999 Decision and the subsequent February 2002 Decision, CVPIA 3406(b)(2) accounting procedures are based on system conditions under operations associated with SWRCB D-1485 and D-1641 regulatory requirements. Similarly, the operating guidelines for selection of actions and allocation of assets under the EWA are based on system conditions under operations associated with SWRCB D-1641 regulatory requirements. This requires sequential layering of multiple system requirements and simulations.

CALSIM II focuses on the major CVP and SWP facilities, but operations of many other municipal- and irrigation district-operated facilities are also included to varying degrees. CALSIM assumptions can also be adjusted to account for varying levels of development, as evaluated by the No action (2020) and Existing Conditions (2000).

Similar to the PROSIM model used for analysis in the Draft EIS/EIR, assumptions used in the CALSIM II represent the best efforts of expert hydrologists to simulate the CVP and SWP, and to predict future changes to the systems. CALSIM II separates CVP and SWP into a number of nodes that can each be assigned operational rules for inputs (i.e., streamflow from upstream areas) or outputs (i.e., water diversions). Accordingly, assumptions as to inputs and outputs are key when determining what effects are to be studied. The nodes are interconnected such that they approximate the flow of water in the joint CVP-SWP systems. Future projections are based on the assumption that the hydrology that occurred and was recorded over an approximately 72-year period (1922 to 1993) is representative of the range of hydrology that will again occur in the future. Particularly dry (1928 to 1934) and wet (1967 to 1971) periods over the historical record can be isolated to simulate relatively extreme

circumstances that might occur in the future. Key facilities for which operations are modeled with CALSIM II include the following:

- Trinity/Lewiston, Whiskeytown, and Shasta Reservoirs
- Folsom Reservoir
- San Luis Reservoir
- Oroville Reservoir (SWP)
- Tracy (CVP) and Banks (SWP) Pumping Plants

Key operational parameters to the Trinity River Basin include Trinity River flows and associated exports to the Central Valley, as well as carryover storage in Trinity Reservoir. Key operational parameters in the Central Valley include Trinity exports via the Clear Creek Tunnel through the Spring Creek Powerhouse, carryover storage at Shasta Reservoir, CVP deliveries (both north and south of the Delta), and Bay-Delta inflow and outflow.

CVPIA 3406(b)(2) allocates 800 taf (600 taf in Shasta index critical dry years) of CVP water to targeted fish actions. The full amount provides support for SWRCB D-1641 implementation. According to monthly accounting, 3406(b)(2) actions are dynamically selected according to an action matrix. Several actions in this matrix have defined reserve amounts that limit 3406(b)(2) expenditures for lower priority actions early in the year so that the higher priority actions can be met later in the year.

Under CALFED, the EWA acquires water through "operational" and "fixed" assets, and then allocates water to targeted fish actions. Operational assets include relaxation of regulatory requirements and dedication of conveyance capacities to EWA purposes. Fixed assets include water purchased from willing sellers or previously banked supplies. According to monthly accounting, EWA assets are evaluated and actions are dynamically selected according to an action matrix similar to that used in the simulation of 3406 (b)(2) Water Management. Several actions in this matrix have defined reserve amounts that limit EWA allocation for lower priority actions early in the year so that the higher priority actions can be met later in the year, subject to uncertain operational assets.

CALSIM II represents the best tool currently available for attempting to predict future impacts on a hydrological system that, by any assessment, is extremely complex. Accordingly, model output and associated conclusions embody the best information that can be obtained in light of current levels of knowledge and modeling ability.

Alternative Analysis.

Analysis of Alternatives**.** For NEPA purposes, the No Action Alternative is used as the baseline for comparison of alternatives. For CEQA purposes, comparisons are made against existing

conditions (see Section 1.8). The No Action and the other alternatives reflect future conditions at the year 2020 level of development. These future conditions are based on projections concerning future growth, land use changes, and changes in CVP operational policies that are being considered and are undergoing separate environmental documentation. The hydrology and demands included in these simulations are based on information contained in DWR Bulletin 160-98. At the year 2020 level of development, annual CVP contracts are assumed to total 6.5 maf (with annual demands ranging from 6.2 to 6.5 maf), and annual SWP entitlements are assumed to total 4.2 maf (with annual demands ranging from 3.4 to 4.2 maf)[2]. The greatest increases in CVP demands are assumed to occur north of the Delta in association with M&I water rights and water service contracts with the CVP's American River Division (approximately a 251,000- acre-feet increase in annual demand). See Table 2-2 of Draft EIS/EIR for a complete table of assumptions used in the No Action Alternative.

The impacts of the alternatives were analyzed for three representative periods: the long-term period (1922-1993), the wet hydrologic period (1967-1971), and the dry hydrologic period (1928-1934). The periods were based on Sacramento River Basin hydrology. It should be noted that hydrologic conditions in the Sacramento River Basin do not always match those in the Trinity River Basin.

As described previously with regard to potential curtailments, the agricultural water service contractors are the CVP contract holders that are assumed to be most affected by reductions in CVP water supplies. The Sacramento River Water Rights Settlement and San Joaquin River Exchange Contractors are assumed to be generally unaffected by a reduction in Trinity exports, as their respective contracts tie curtailments in dry years (of up to 25 percent) to the Shasta Inflow Index. This index accounts only for inflow in Shasta Reservoir. Because Trinity exports enter the Sacramento River downstream of Shasta Reservoir (through Keswick Reservoir), it was assumed that no additional curtailments would be experienced by the Sacramento River Water Rights Settlement and San Joaquin River Exchange Contractors as a result of decreased Trinity exports.

Significance Criteria. Significance criteria were not developed for Surface-water Hydrology and Management because changes to releases, reservoir levels, and water deliveries were not considered to be impacts relative to the surface hydrology of the CVP system. However, it is understood that the change in water delivery patterns

[2] Elsewhere in this document, current deliveries for CVP and SWP are described at current levels. Because the SWP does not include certain storage facilities originally envisioned, its actual yield is only about half of what the "entitlements" counted on by various water contractors. See for example *Planning and Conservation League versus Department of Water Resources*, (2000) 83 Cal.App.4th 83; and *Santa Clarita Organization for Planning the Environment versus County of Los Angeles*, 2003 106 Cal.App.4th 715.

prescribed in these alternatives will have a significant effect on water quality, fisheries, power resources, and other uses. Those effects are identified and described, and mitigation is recommended in the appropriate sections.

No Action. The No Action Alternative would essentially maintain recent historical operations of the TRD and the CVP at a projected 2020 level of development.

This alternative assumes an annual Trinity River minimum instream flow requirement not less than 340,000 acre-feet for all water-year classes. TRD exports are assumed to continue to be used to conserve the coldwater pool in Shasta Reservoir through spring and early summer diversions in response to the Winter-run BO. Figure 3.2-7 illustrates how to read a frequency distribution curve. Table 3.2-2 and Figures 3.2-8 through 3.2-12 present the results of the No Action Alternative as compared to the other alternatives.

Revised Mechanical. Compared to the No Action Alternative, this alternative generally has a larger spring peak release. The long-term average annual instream release would increase by 99,000 acre-feet (23 percent) compared to the No Action Alternative.

Compared to the No Action Alternative, this alternative would reduce long-term average annual exports from the TRD by about 95,000 acre-feet (12 percent). Dry-period annual exports would be reduced by 61,000 acre-feet (12 percent). Whiskeytown water levels would be generally unaffected, including during the dry period.

Shasta Reservoir storage would be only slightly impacted due to reduced TRD exports in the long-term average, and dry-period effects would be more substantial. Under this alternative, long-term average end-of-water-year storage is only slightly less than the No Action Alternative (14,000 acre-feet decrease, or 1 percent), and dry-period levels drop 41,000 acre-feet (3 percent). The BO end-of-water-year minimum storage criterion of 1.9 maf is not met in 14 percent of the years, compared to 11 percent for the No Action Alternative.

Long-term average annual CVP deliveries decrease by 36,000 acre-feet (1 percent). Reductions during the dry period average 80,000 acre-feet (2 percent). Annual Delta exports through the Tracy Pumping Plant are reduced by 24,000 acre-feet (1 percent) over the long term and 24,000 acre-feet (1 percent) during the dry period. Annual Delta inflow would decrease by 84,000 acre-feet (less than 1 percent) over the long term and 71,000 acre-feet (1 percent) during the dry period. Average annual Delta outflow would decrease by

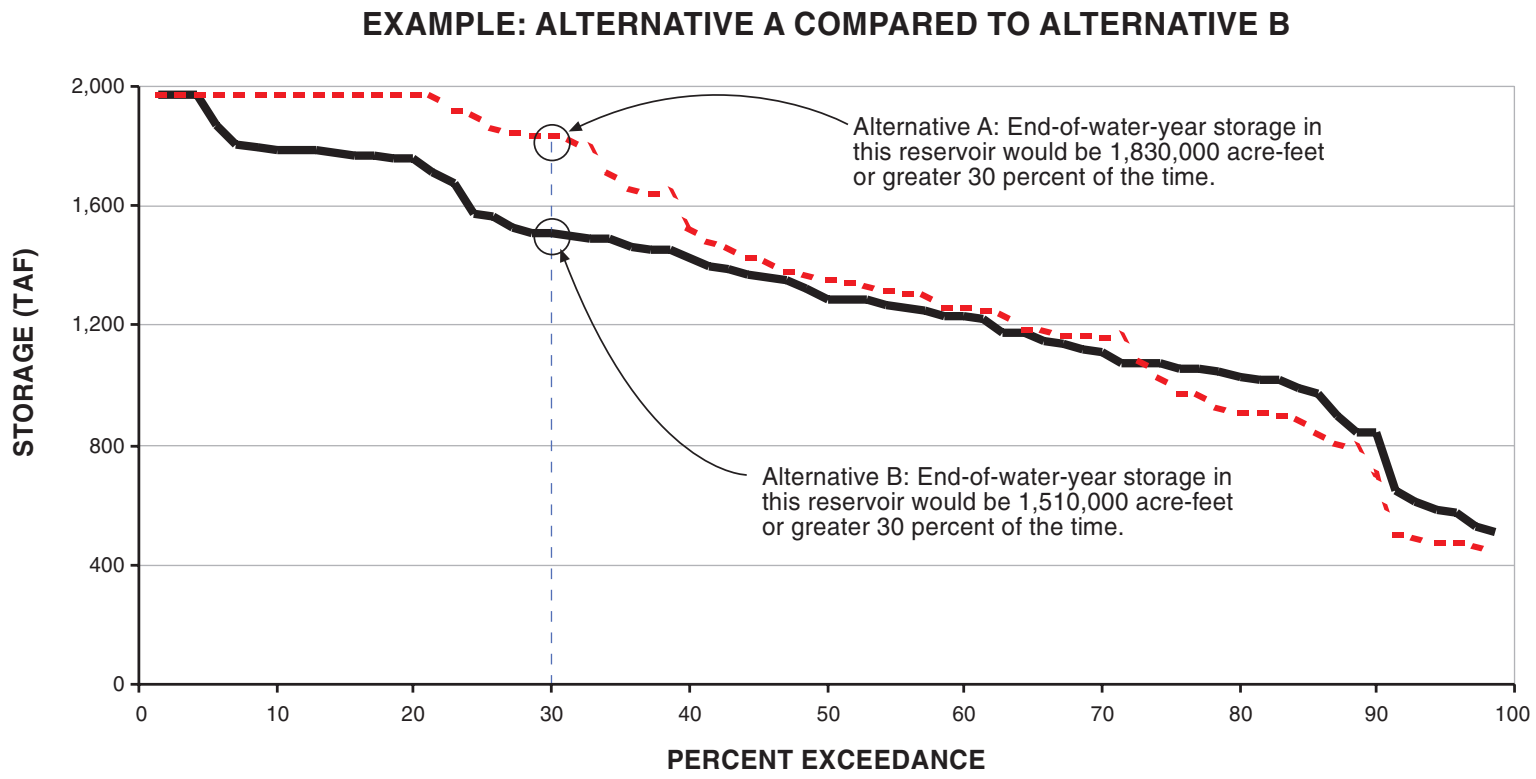

FIGURE 3.2-7
HOW TO READ A FREQUENCY DISTRIBUTION CURVE
TRINITY RIVER FISHERY RESTORATION SUPPLEMENTAL EIS/EIR

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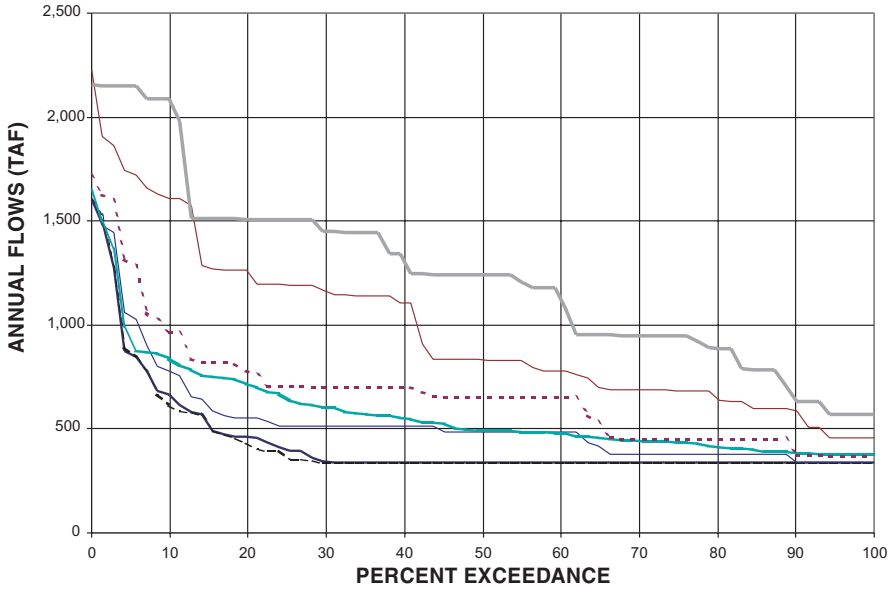
TABLE 3.2-2
Comparison of Impacts on Water Resources

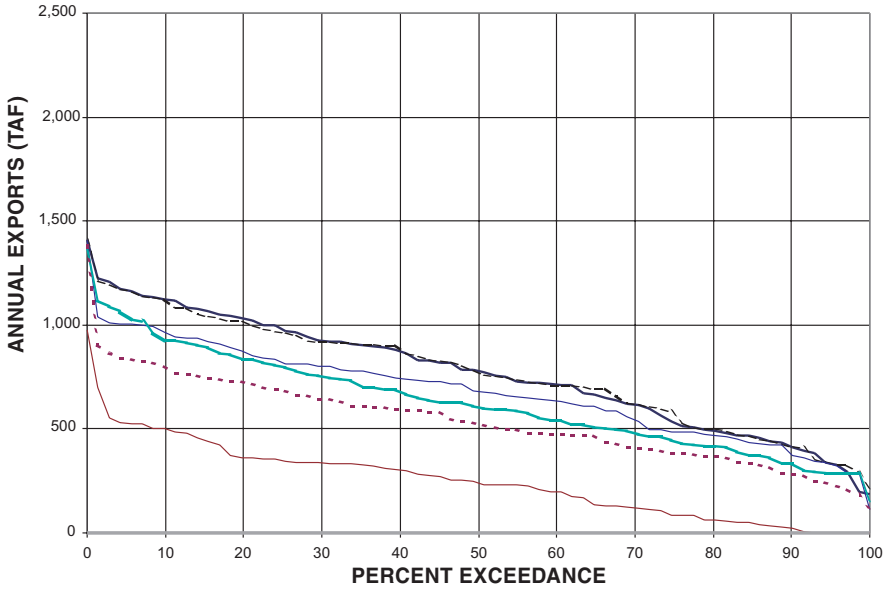
Parameter	Hydrologic Conditions	Alternatives Compared to No Action						Existing Condition
		No Action	Revised Mechanical	Flow Evaluation	Modified Percent Inflow	70 Percent Inflow	Maximum Flow	
Trinity Reservoir Elevation (feet)								
30-May	Dry	2,261	-7	-4	-9	-29	-39	2,261
	Wet	2,363	-2	-6	-1	-25	-131	2,363
	Average	2,328	-6	-9	-6	-28	-92	2,328
30-Sep	Dry	2,205	-8	8	-9	-12	-12	2,203
	Wet	2,327	-4	-6	0	-8	-112	2,327
	Average	2,286	-8	-6	-5	-11	-69	2,286
Shasta Reservoir Elevation (feet)								
30-May	Dry	987	-4	-3	-2	-16	-22	988
	Wet	1,060	0	0	0	-1	-1	1,060
	Average	1,043	-1	-3	-2	-7	-12	1,042
30-Sep	Dry	914	-4	-3	-2	-20	-27	919
	Wet	1,012	0	-2	-1	-9	-8	1,012
	Average	987	-1	-5	-3	-17	-23	988
San Luis Reservoir Elevation (feet)								
30-May	Dry	518	7	69	71	74	-55	514
	Wet	566	-3	-5	-3	-11	-5	565
	Average	527	6	1	1	-7	-11	568
30-Sep	Dry	397	4	65	70	70	3	459
	Wet	407	1	1	1	87	99	499
	Average	404	0	6	6	12	11	417
Trinity River Exports (taf/year)	Dry	525	-12%	-28%	-15%	-57%	-100%	524
	Wet	1,024	-15%	-35%	-17%	-74%	-100%	1,027
	Average	773	-12%	-30%	-18%	-68%	-100%	769
Trinity Reservoir Storage (taf)								
30-Sep	Dry	693	-10%	3%	-7%	-15%	-16%	673
	Wet	1,814	-3%	-4%	0%	-5%	-61%	1,816
	Average	1,403	-6%	-6%	-4%	-9%	-47%	1,403
Shasta Reservoir Storage (taf)								
30-Sep	Dry	1,506	-3%	-3%	-2%	-17%	-24%	1,540
	Wet	3,120	0%	-1%	0%	-6%	-5%	3,117
	Average	2,680	-1%	-4%	-2%	-11%	-14%	2,692
San Luis Reservoir Storage (taf)								
30-Sep	Dry	541	5%	9%	16%	17%	4%	570

TABLE 3.2-2
Comparison of Impacts on Water Resources

Parameter	Hydrologic Conditions	Alternatives Compared to No Action						Existing Condition
		No Action	Revised Mechanical	Flow Evaluation	Modified Percent Inflow	70 Percent Inflow	Maximum Flow	
	Wet	684	1%	0%	1%	2%	12%	726
	Average	554	0%	0%	1%	1%	8%	568
CVP Deliveries North of the Delta (taf/year)	Dry	2,422	-1%	-2%	-1%	-3%	-9%	2,200
	Wet	2,878	0%	0%	0%	0%	-3%	2,566
	Average	2,730	0%	-1%	0%	-1%	-4%	2,448
CVP Deliveries South of the Delta (taf/year)	Dry	1,770	-4%	-8%	-6%	-11%	-15%	1,730
	Wet	3,040	-1%	-2%	-1%	-6%	-13%	3,050
	Average	2,600	-1%	-2%	-1%	-5%	-11%	2,630
Exports, Tracy Pumping Plant (taf/year)	Dry	1,688	-1%	-5%	-3%	-8%	-13%	1,640
	Wet	2,584	-1%	-1%	-1%	-6%	-11%	2,562
	Average	2,333	-1%	-2%	-1%	-5%	-11%	2,337
Exports, Banks Pumping Plant (taf/year)	Dry	1,863	1%	-1%	1%	-2%	-1%	1,754
	Wet	3,791	0%	0%	0%	-1%	-1%	3,620
	Average	3,109	0%	0%	0%	-1%	-2%	3,012
Exports, Tracy and Banks Pumping Plants (taf/year)	Dry	3,551	0%	-3%	-1%	-5%	-7%	3,395
	Wet	6,375	0%	0%	0%	-3%	-5%	6,181
	Average	5,441	0%	-1%	-1%	-3%	-5%	5,349
Delta Inflow (taf/year)	Dry	11,635	-1%	-1%	-1%	-2%	-3%	11,564
	Wet	28,231	0%	-1%	-1%	-2%	-3%	28,379
	Average	21,214	0%	-1%	-1%	-2%	-3%	21,274
Delta Outflow (taf/year)	Dry	6,551	0%	1%	0%	-1%	-1%	6,605
	Wet	20,440	-1%	-1%	-1%	-2%	-2%	20,686
	Average	14,399	0%	-1%	0%	-2%	-2%	14,501
Trinity River Releases by Sacramento River Index (taf/year)	Critically dry	341	0%	8%	13%	24%	36%	341
	Dry	341	11%	33%	31%	86%	158%	341
	Below Normal	341	42%	90%	40%	145%	264%	341
	Above Normal	341	50%	106%	58%	249%	343%	341
	Wet	341	63%	140%	107%	410%	531%	341



ANNUAL FLOWS IN THE TRINITY RIVER BELOW LEWISTON



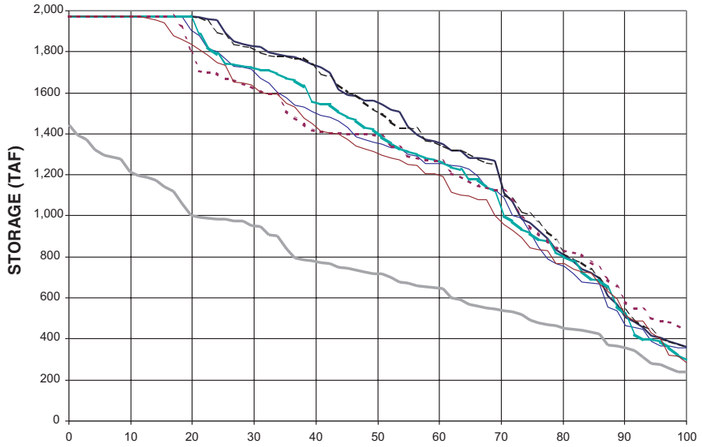
TRINITY RIVER BASIN EXPORTS

LEGEND

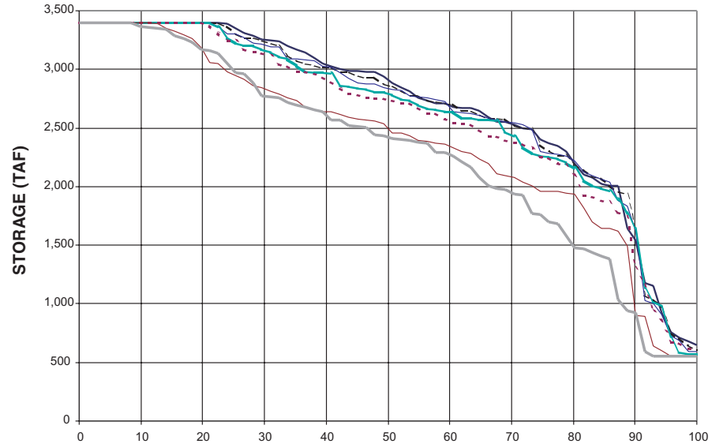
- No Action Alternative
- Revised Mechanical Alternative
- Flow Evaluation Alternative
- Modified Percent Inflow Alternative
- 70 Percent Inflow Alternative
- Maximum Flow Alternative
- Existing Condition

FIGURE 3.2-8
SIMULATED FREQUENCY OF ANNUAL FLOWS IN THE TRINITY RIVER BELOW LEWISTON AND ANNUAL TRINITY RIVER BASIN EXPORTS
TRINITY RIVER FISHERY RESTORATION SUPPLEMENTAL EIS/EIR

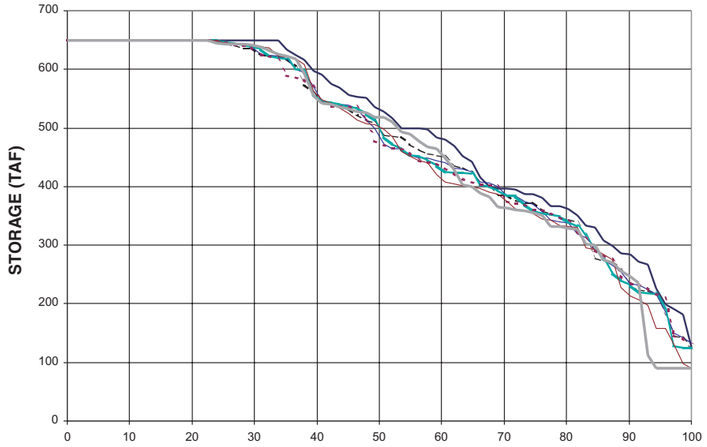
W022004007RDD_702 (4/2/04)



TRINITY RESERVOIR



SHASTA RESERVOIR



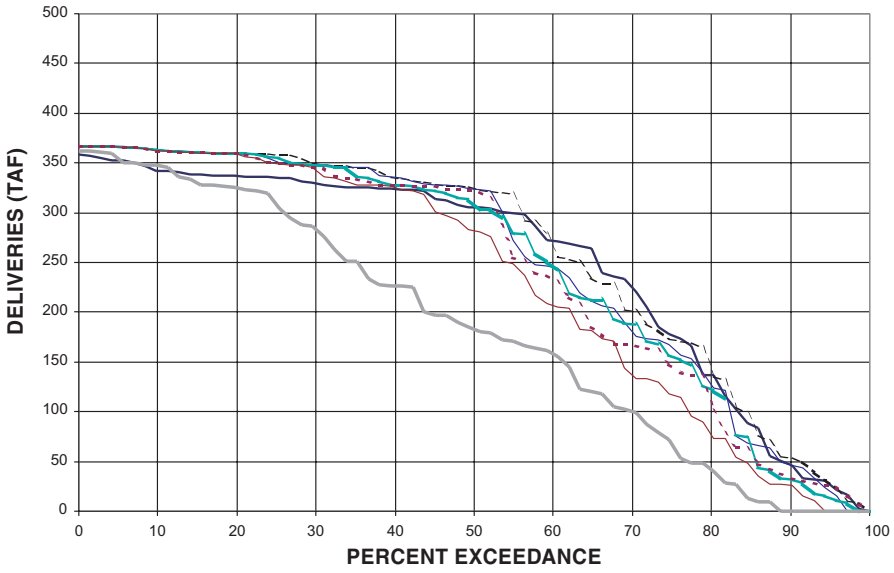
FOLSOM RESERVOIR

LEGEND

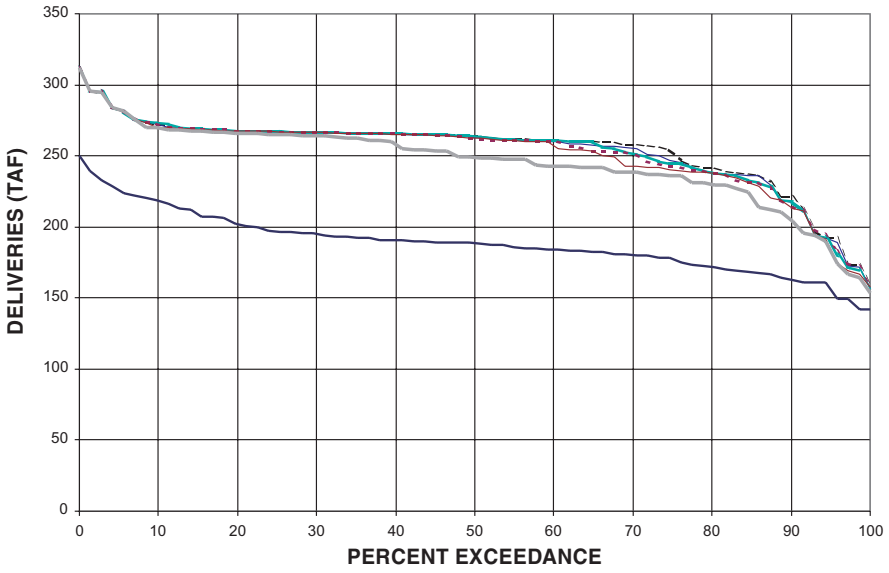
- No Action Alternative
- Revised Mechanical Alternative
- Flow Evaluation Alternative
- Modified Percent Inflow Alternative
- 70 Percent Inflow Alternative
- Maximum Flow Alternative
- Existing Condition

FIGURE 3.2-9
SIMULATED FREQUENCY OF END-OF-WATER-YEAR STORAGE – SHASTA, TRINITY, AND FOLSOM RESERVOIRS
TRINITY RIVER FISHERY RESTORATION SUPPLEMENTAL EIS/EIR

W022004007RDD_703 (4/2/04)



CVP AGRICULTURAL WATER SERVICE CONTRACTORS NORTH OF DELTA



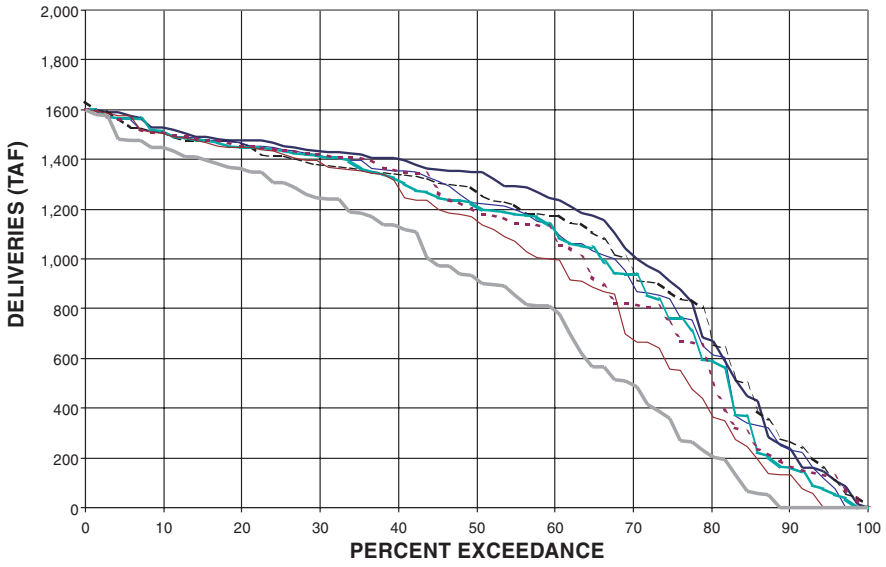
CVP M&I WATER SERVICE CONTRACTORS NORTH OF DELTA

LEGEND

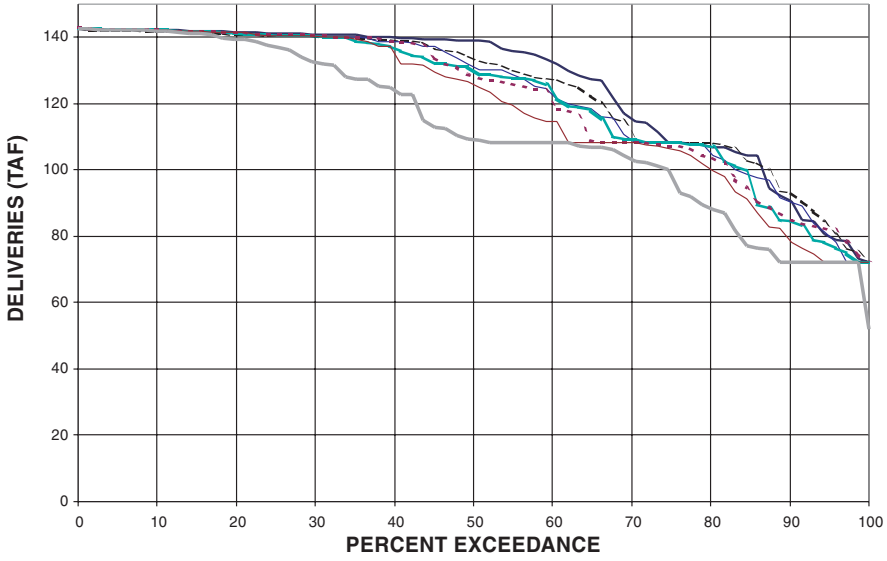
- No Action Alternative
- Revised Mechanical Alternative
- Flow Evaluation Alternative
- Modified Percent Inflow Alternative
- 70 Percent Inflow Alternative
- Maximum Flow Alternative
- Existing Condition

FIGURE 3.2-10
SIMULATED FREQUENCY OF ANNUAL DELIVERIES – CVP WATER SERVICE CONTRACTORS NORTH OF THE DELTA
TRINITY RIVER FISHERY RESTORATION SUPPLEMENTAL EIS/EIR

W022004007RDD_704 (4/2/04)



CVP AGRICULTURAL WATER SERVICE CONTRACTORS SOUTH OF DELTA



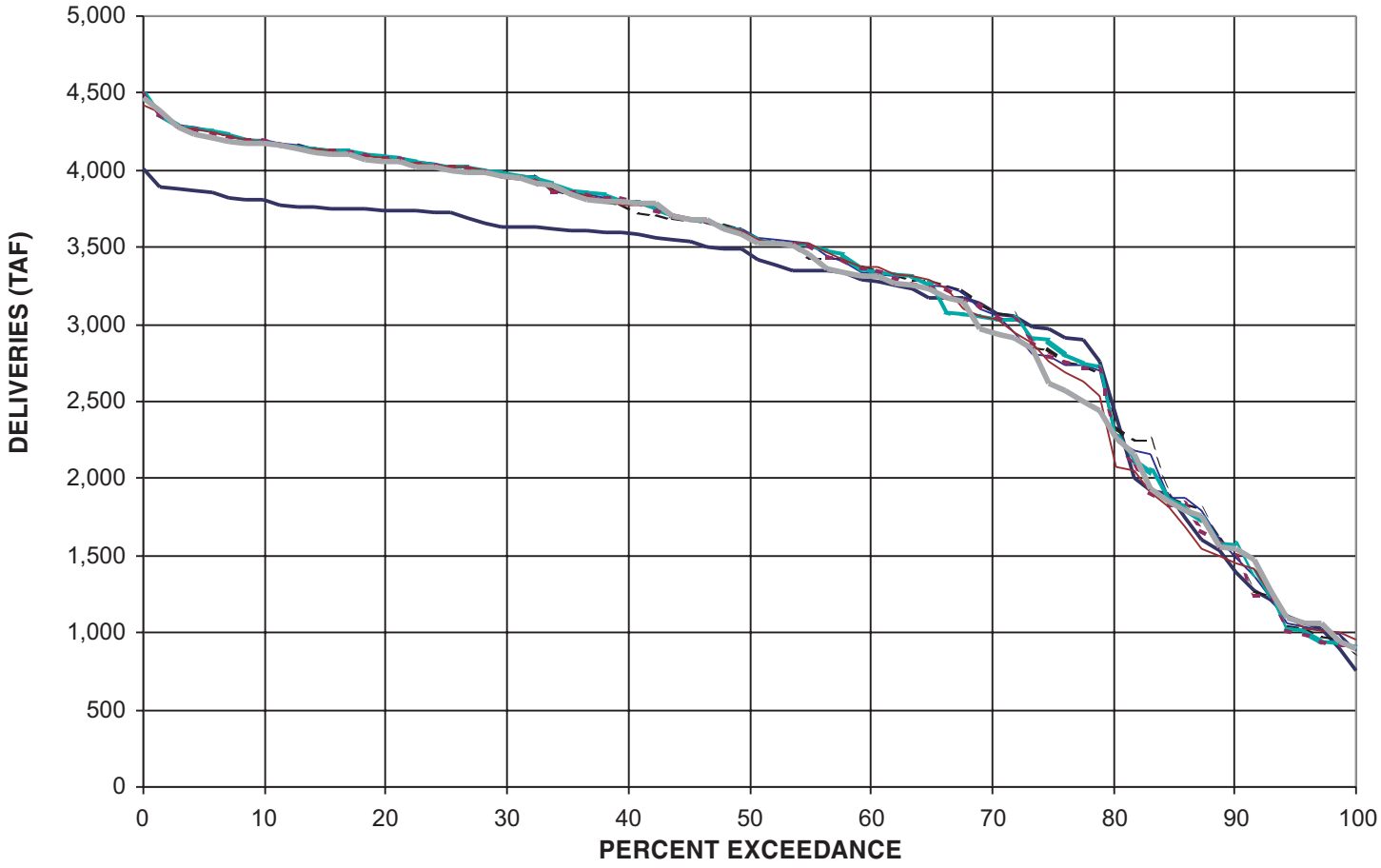
CVP M&I WATER SERVICE CONTRACTORS SOUTH OF DELTA

LEGEND

- No Action Alternative
- Revised Mechanical Alternative
- Flow Evaluation Alternative
- Modified Percent Inflow Alternative
- 70 Percent Inflow Alternative
- Maximum Flow Alternative
- Existing Condition

FIGURE 3.2-11
SIMULATED FREQUENCY OF ANNUAL DELIVERIES – CVP WATER SERVICE CONTRACTORS SOUTH OF THE DELTA
TRINITY RIVER FISHERY RESTORATION SUPPLEMENTAL EIS/EIR

W022004007RDD_705 (4/2/04)



LEGEND

- No Action Alternative
- Revised Mechanical Alternative
- Flow Evaluation Alternative
- Modified Percent Inflow Alternative
- 70 Percent Inflow Alternative
- Maximum Flow Alternative
- Existing Condition

FIGURE 3.2-12
SIMULATED FREQUENCY OF ANNUAL DELIVERIES TO SWP AGRICULTURAL AND M&I ENTITLEMENT HOLDERS SOUTH OF THE DELTA
TRINITY RIVER FISHERY RESTORATION SUPPLEMENTAL EIS/EIR

W022004007RDD_706 (4/2/04)

less than 1 percent (53,000 acre-feet in the long-term period and 15,000 acre-feet in the dry period).

Flow Evaluation. Compared to the No Action Alternative, the TRD would be operated to release more Trinity Reservoir water to the Trinity River. Compared to the No Action Alternative, this alternative generally has a larger spring peak release. The long-term average annual instream release would increase by 238,000 acre-feet (55 percent) compared to the No Action Alternative.

Compared to the No Action Alternative, this alternative would reduce long-term average annual exports from the TRD by about 232,000 acre-feet (30 percent). Dry-period annual exports would be reduced by 145,000 acre-feet (28 percent). Under this alternative, the target minimum storage in Trinity Reservoir would be 600,000 acre-feet. Dry-period storage would average 3 percent more than No Action, reflecting the greater carryover storage level. In spite of this increase in required minimum carryover storage, average end-of-water-year carryover storage would decrease by 82,000 acre-feet (6 percent). Whiskeytown water levels would be generally unaffected, including during the dry period.

In this alternative, long-term average end-of-water-year Shasta Reservoir storage decreases compared to the No Action Alternative (95,000-acre-feet decrease, or 4 percent), and dry-period levels drop 51,000 acre-feet (3 percent). The BO for Winter-run Chinook salmon (NOAA Fisheries, 1993) end-of-water-year minimum storage criterion of 1.9 maf is not met in 17 percent of the years, as opposed to 11 percent under the No Action Alternative. Long-term average annual CVP deliveries decrease by 77,000 acre-feet (1 percent). Reductions during the dry period average 187,000 acre-feet (4 percent). Annual Delta exports through the Tracy Pumping Plant are reduced by 52,000 acre-feet (2 percent) over the long term and 83,000 acre-feet (5 percent) during the dry period. Annual Delta inflow would decrease by 204,000 acre-feet (1 percent) over the long term and 154,000 acre-feet (1 percent) during the dry period. Average annual Delta outflow would decrease by 123,000 acre-feet (1 percent) over the long term, but would be similar to No Action for the dry period. The effect of this alternative on X2 position in the Bay-Delta is discussed under Section 3.4 Fishery Resources, see specifically the Methodology Section.

Modified Percent Inflow. This alternative was designed to partially mimic natural flow patterns and variability by releasing from Lewiston Dam a percentage of the previous week's inflow to Trinity Reservoir during the ascending and descending limits of the spring hydrograph. Accordingly, Trinity River flows would vary each week during Spring runoff depending on inflow and, therefore, would be more unpredictable than the other alternatives.

Compared to the No Action Alternative, this alternative would reduce long-term average annual TRD exports by 143,000 acre-feet (18 percent), and the export pattern may help meet Trinity River instream temperature requirements. Trinity Reservoir end-of-water-year storage decreases by 47,000 acre-feet during the dry period as compared to No Action. Shasta Reservoir storage levels would be slightly affected, particularly during the dry period. The end-of-water-year Shasta storage decreases by 2 percent for both the long-term and the dry periods. End-of-water-year storage in Shasta Reservoir would be below the BO minimum threshold (1.9 maf) in 14 percent of the years.

Long-term average annual CVP deliveries decrease by 61,000 acre-feet (1 percent). Reductions during the dry period average 146,000 acre-feet (3 percent). Compared to the No Action Alternative, long-term average annual Delta inflow would be reduced by 125,000 acre-feet (1 percent), and Delta outflow would be reduced by 66,000 acre-feet (less than 1 percent).

70 Percent Inflow. This alternative was designed to mimic natural flow patterns and variability by releasing from Lewiston Dam 70 percent of the previous week's inflow to Trinity Reservoir throughout the year. Accordingly, Trinity River flows would vary each week depending on inflow and would, therefore, be more unpredictable than the other alternatives.

Compared to the No Action Alternative, this alternative would reduce long-term average annual TRD exports by 523,000 acre-feet (68 percent), and the export pattern may help meet Trinity River instream temperature requirements. Thus, average end-of-water-year storage in Trinity Reservoir would decrease during the dry period by 101,000 acre-feet (15 percent). Shasta Reservoir end-of-water-year storage levels would decrease by 296,000 acre-feet (11 percent) on the long-term average and 261,000 acre-feet (17 percent) over the dry period. End-of-water-year storage in Shasta Reservoir would be below the BO minimum threshold (1.9 maf) in 20 percent of the years.

Annual exports through the Tracy Pumping Plant would decrease by 110,000 acre-feet (5 percent) on the long-term average and 135,000 acre-feet (8 percent) over the dry period. Compared to the No Action Alternative, long-term average annual Delta inflow would be reduced by 483,000 acre-feet (2 percent), and Delta outflow would be reduced by 318,000 acre-feet (2 percent). Long-term average annual CVP deliveries would be reduced by 160,000 acre-feet (3 percent).

Maximum Flow. This alternative would increase Trinity River instream flows by a greater degree than any other alternative. The

long-term average annual instream release schedule would increase by approximately 806,000 acre-feet more water than No Action, or 185 percent of No Action levels.

Under this alternative, TRD exports would be eliminated. In essence, the reservoir would be managed to ensure the availability of water for the spring peak releases, with no increase by minimum storage level. Thus, average end-of-water-year storage (September 30) in Trinity Reservoir would decrease during the dry period by about 113,000 acre-feet (16 percent) compared to the No Action Alternative. Storage would decrease over the long term by about 653,000 acre-feet (47 percent) due to the spring geomorphic flow requirements and the low refill potential of the reservoir.

Operations of the remaining CVP facilities would need to be modified due to the reduction in available water (773,000 acre-feet on an average annual basis) from the TRD. In the absence of exports from the TRD, Whiskeytown Reservoir storage would fall below No Action levels during the dry period. During this period, local inflow would be insufficient to meet Clear Creek minimum flow requirements, and Whiskeytown Reservoir would have to be drawn down to provide additional releases.

Long-term average end-of-water-year Shasta Reservoir storage would be less than the No Action Alternative by approximately 387,000 acre-feet (14 percent). Dry-period average annual storage would be reduced by 361,000 acre-feet (24 percent). The reduction in Shasta Reservoir storage would reduce the ability of CVP to maintain the coldwater pool for releases to meet the 1993 Winter-run Chinook BO temperature requirements and associated 1.9-maf minimum carryover storage level, as well as all other Central Valley demands. End-of-water-year storage in Shasta Reservoir would be below the 1.9-maf storage criterion more frequently than under the No Action Alternative (28 percent of the years as compared to 11 percent). In comparison to the No Action Alternative, the elimination of Trinity exports would result in a decrease in average annual CVP deliveries during the dry period by about 490,000 acre-feet (12 percent). Long-term average annual CVP deliveries would decrease by 401,000 acre-feet (8 percent).

Average annual Delta exports through Tracy Pumping Plant during the dry period would be reduced by 224,000 acre-feet (13 percent). Compared to the No Action Alternative, long-term average annual Delta inflow would be reduced 666,000 acre-feet (3 percent), and long-term average annual Delta outflow would be reduced 325,000 acre-feet (2 percent).

Existing Conditions versus Proposed Action. Consistent with *CEQA Guidelines* Section 15125, Subdivision(a), which provides that the

normal "baseline" for impact assessment is normally existing conditions at the time of release of a NOP for an EIR, the following discussion identifies differences between 2001 existing conditions and conditions in 2020 under the Proposed Action, and what portion of this change is attributable to the project (by comparing Proposed Action impact levels to both existing condition and No Action levels). Compared to existing conditions (i.e., 2001), the Proposed Action would release more water to the Trinity River. It is important to note that the 2001 existing conditions analysis assumed a release hydrograph identical to the No Action Alternative (not less than 340,000 acre-feet/year); however, actual Trinity River flows in recent years have varied due to a variety of factors (e.g., altered flow schedules that were being evaluated as part of the TRFES, Safety of Dam releases and releases ordered by the U.S. District Court in response to petitions for higher releases filed by Hoopa Valley and Yurok Tribes).

A large portion of the change in water impacts between 2001 existing conditions and the year 2020 under the Proposed Action is attributed to growth and development that is expected to occur independent of the preferred alternative. Existing conditions assumes a 2001 level of social and economic development, whereas the Proposed Action assumes a 2020 level of development (as do the other alternatives).

Implementation of the Proposed Action would reduce long-term average annual exports from the TRD by 232,000 acre-feet (30 percent) and attempt to increase Trinity Reservoir minimum storage from 400,000 to 600,000 acre-feet. However, end-of-water-year Trinity Reservoir storage over the average period decreased by 82,000 acre-feet (6 percent) compared to 2001 conditions, but dry-year storage increased 39,000 acre-feet as a result of higher dry-year carryover storage targets in the Proposed Action. Shasta Reservoir long-term end-of-water-year storage would be less than existing conditions by 107,000 acre-feet (4 percent). This reduction is attributable to decreased TRD exports as well as increased demand levels in 2020. The BO storage threshold of 1.9 maf would be met less frequently than in existing conditions (17 percent of years compared to 13 percent). The reduced frequency of meeting the threshold is attributable to non-project changes between 2001 and 2020.

Compared to existing conditions, long-term annual Delta exports through the Tracy Pumping Plant would be reduced by 52,000 acre-feet (2 percent) under the Proposed Action. Long-term average annual Delta inflow would be reduced by 204,000 acre-feet (1 percent). This reduction is primarily due to decreased TRD exports as a result of the Proposed Action. Average annual Delta outflow would be reduced by 123,000 acre-feet (1 percent). The effect on relative X2 position in the Bay Delta is discussed under Section 3.4 Fishery Resources, see specifically the Methodology Section.

Mitigation. As described previously, significance criteria only identifies specific adverse effects to the water delivery systems caused by potential implementation of these alternatives. However, it is understood that the change in water delivery patterns prescribed in these alternatives will have a significant effect on water quality and fisheries. Those impacts are discussed in the Water Quality (Section 3.3), Fishery Resources (Section 3.4), and Power Resources (Section 3.5) sections. ***In light of the beneficial impacts of using late-summer Trinity River Dam releases in 2003 to avoid or minimize a recurrence of the 2002 die-off in the lower Klamath, the use of similar late-summer releases in future years is identified as a possible mitigation measure to protect the fishery resources of the Trinity River and lower Klamath River, which could be selected as part of any of the alternatives under consideration.***

Numerous demand- and supply-related programs are currently being studied across California, many of which are being addressed through the ongoing CALFED and CVPIA programs and planning processes. Although none of these actions would be directly implemented as part of the alternatives discussed in this Supplemental EIS/EIR, each could assist in offsetting impacts resulting from decreased Trinity River exports. Examples of actions being assessed in the CALFED and CVPIA planning processes include the following:

- Develop and implement additional groundwater and/or surface-water storage. Such programs could include the construction of new surface reservoirs and groundwater storage facilities, as well as expansion of existing facilities. Potential locations include sites throughout the Sacramento and San Joaquin Valley watersheds, the Trinity River Basin, and the Delta.
- Purchase long- and/or short-term water supplies from willing sellers (both in-basin and out-of-basin) through actions including, but not limited to, temporary or permanent land fallowing.
- Facilitate willing buyer/willing seller inter- and intra-basin water transfers that derive water supplies from activities such as conservation, crop modification, land fallowing, land retirement, groundwater substitution, and reservoir re-operation.
- Promote and/or provide incentive for additional water conservation to reduce demand.
- Decrease demand through purchasing and/or promoting the temporary or permanent fallowing of agricultural lands.
- Conserve water supplies by promoting additional water recycling.

3.3 Water Quality

Affected Environment.

Trinity River Basin. Trinity River water temperatures are influenced by Trinity and Lewiston Reservoir release temperatures, flow rates, channel geometry, regional meteorology, and tributary flows and temperatures (the effect of Trinity and Lewiston Reservoirs diminishes with distance downstream). Generally speaking, the greater the release volumes from the dams, the less susceptible the river's temperature is to other factors. Trinity Reservoir releases tend to be cold (42 to 47°F), whereas Lewiston Reservoir, which is much shallower, tends to provide releases that are more affected by ambient temperatures.

During storm periods, turbidity in the Trinity River from Lewiston Dam to the South Fork is caused primarily by heavy inflows of suspended sediment from tributaries and the reservoirs. Highly erosive soils comprise approximately 17 percent of the Trinity River Basin, resulting in significant sediment loads entering the river. The reduced flows since the construction of the dams are partially responsible for these sediments to accumulate in the river. High flows, which historically flushed these sediments through the system, have become less frequent and of lower magnitude (see Geomorphic Environment [Section 3.2] of the Draft EIS/EIR).

Elevated concentrations of mercury have been found in water, sediment, and biota (fish, frogs and predatory aquatic insects) in the Trinity River Basin similar to other river basins in California that have been subjected to historical gold mining operations (U. S. Geological Survey, unpubl. data). Recent sediment samples collected within and adjacent to some planned channel rehabilitation project sites of the TRRP in the Trinity River have contained mercury concentrations that are above what are considered naturally occurring levels. (Ashley and Rytuba, 2002).

Natural sources of mercury to the watershed may include wet and dry deposition of mercury from the atmosphere, and indigenous mercury that naturally occurs in rocks and soils. Some elemental mercury was likely introduced to the basin during mining operations. This elemental mercury was likely subject to chemical and biological processes that transform some of the elemental mercury into new mercury phases. Transformation of elemental mercury into dissolved mercury species that can become methylated can be a concern because of the potential for biota to bioaccumulate mercury, thus passing toxins on to more complex life forms. Sulfate reducing bacteria in anaerobic environments are typically the source of methylation. The potential for methylation is not only dependent on

solubility of mercury species present, but also many other chemical variables, such as sulfate and organic carbon, and physical parameters such as temperature, pH, oxidation-reduction potential, and the bacterial community.

Methylmercury is the form of mercury that is of most concern because it most readily bioaccumulates at successive trophic levels within food webs such that very high concentrations of methylmercury can occur in fish and other organisms high in the food chain. Methylmercury contamination and exposure can adversely affect reproductive success and health of fish and other species. It can potentially diminish productivity of affected species and poses a potential health risk to populations of wildlife who consume fish or other contaminated species because it is a potent neurotoxin.

The primary source for the gold in the Trinity watershed is low sulfide quartz gold vein deposits. Gold in these deposits is commonly associated with pyrite, and minor amounts of base metals. Weathering of these deposits may also locally cause elevated sulfate concentrations and enhance mercury methylation by exposure to sulfate-reducing bacteria. In the upper Trinity River Basin (above Trinity Lake), the Altoona mercury mine in the East Fork Trinity River watershed releases mercury and sulfate that results in methylation of mercury and elevated levels of mercury in down-stream biota. Although mercury deposits are widespread in western California and the source of mercury used in placer mining, the Altoona is the only mercury district in the Trinity Watershed (Rytuba, 2002). No information exists to indicate that methyl mercury contamination from the Altoona Mine has migrated in significant amounts to areas downstream of Lewiston and Trinity Dams, although some preliminary sampling efforts in the basin have been initiated.

Water quality objectives regarding Trinity River temperature, turbidity, and sediment were determined by the NCRWQCB in conjunction with federal, state, and local agencies. Temperature standards are effective from July 1 through December 31 for the upper reach between Lewiston Dam and the North Fork Trinity River. Standards for the Trinity River are presented in Table 3.3-1. The objectives also stipulate that water released into the Trinity River may be no more than 5°F warmer than receiving water temperatures. Turbidity standards state that turbidity shall not increase more than 20 percent above naturally occurring background levels. The NCRWQCB does issue permits and waivers that identify allowable dilution zones within which higher percentages can be tolerated. The NCRWQCB criteria for sediment, suspended material, and settable material in the basin are narrative, meaning that standards are not based on

numerical goals. Rather, criteria are set to avoid nuisance and maintain beneficial uses in the river. These standards are used to condition activities that affect, or potentially affect, water quality. When appropriate, the NCRWQCB may establish appropriate numeric water quality standards in waste discharge orders for narrative standards. Waste discharge orders are considered on a case-by-case basis, and are typically tied to naturally occurring water quality background conditions. In addition to the state criteria, the Hoopa Valley Tribe has established water quality standards pursuant to the Clean Water Act; and the U.S. Environmental Protection Agency (EPA) completed a sediment TMDL criteria for the middle and lower Trinity River at the end of 2001 (see Section 4.0, Cumulative Effects, of the Draft EIS/EIR) and a sediment TMDL for the South Fork Trinity River in 1999. Implementation of the TMDL criteria is still pending.

TABLE 3.3-1
NCRWQCB Temperature Objectives for the Trinity River

Temperature Not to Exceed	Time Period	River Reach
60°F (15.6°C)	July 1 through September 14	Lewiston Dam to Douglas City Bridge
56°F (13.3°C)	September 15 through October 1	Lewiston Dam to Douglas City Bridge
56°F (13.3°C)	October 1 through December 31	Lewiston Dam to confluence with North Fork

Trinity River water quality is also explicitly protected by Water Right Orders 90-05 and 91-01. These orders state that exports from the TRD to the Central Valley for Sacramento River temperature control shall not harm Trinity River fisheries, as measured by compliance with specific temperature requirements in the Trinity River. The temperature requirements contained in Water Right Orders 90-05 and 91-01 for the Trinity River is 56°F (13.3°C), respectively, at Douglas City and the North Fork confluence, as shown in Table 3.3-1. The summer objective at Douglas City of 60°F (15.6°C) is not a requirement of Water Right Orders 90-05 and 91-01.

On May 17, 1996, EPA granted program authorization to the Hoopa Valley Tribe with respect to Section 303 of the Clean Water Act. Since that time, the Hoopa Valley Tribe has pursued development of a Water Quality Control Plan (WQCP) through the Hoopa EPA. An important component of the Hoopa Valley WQCP is water temperature criteria for waters within the Reservation, which includes part of the Trinity River and several tributaries to the river. The temperature criteria presented in Table 3.3-2 were adopted by the Hoopa Valley Tribal Council on June 8, 2000. The EPA approved the temperature criteria on September 2002. Water temperature in this Hoopa Valley WQCP is measured near the confluence of the

Trinity River at Weitchpec. The water temperature standards developed for the Hoopa Valley WQCP were designed to conform with the flow regime specified by the TRFES, which is the basis of the Proposed Action of the 1999 Draft EIS/EIR, and this Supplemental EIS/EIR. A complete description of the Hoopa Valley temperature requirements can be found in Technical Appendix B (Service et al., 2000).

TABLE 3.3-2
Water Temperature Criteria (°C) of the Hoopa Valley Tribe Water Quality Control Plan for the Trinity River

Water-year Class	**Time Periods**				
Extremely Wet, Wet, and Normal	May 23 - Jun 4	Jun 5 - Jul 9	Jul 10 - Sep 14	Sep 15 - Oct 31	Nov 1 - May 22
Criteria[a]	15.0	17.0	22.1	19.0	13.0
Dry and Critically Dry	May 23 - Jun 4	Jun 5 - Jun 15	Jun 16 - Sep 14	Sep 15 - Oct 31	Nov 1 - May 22
Criteria[a]	17.0	20.0	23.5	19.0	15.0

[a]Criteria represent 7-day running averages and are not to be exceeded.

Lower Klamath River Basin/Coastal Area. Water quality in the lower Klamath River is regulated by the NCRWQCB. Standards for the Trinity River generally apply to the Klamath River because beneficial uses are similar, except that there are no time- and location-specific temperature objectives. Current water quality concerns in the Klamath River Basin are the result of agricultural practices, water management, timber harvesting activities, natural geologic instability, and mining operations.

Water quality in the lower Klamath River can be influenced by dam releases from Iron Gate Dam on the Klamath River or dam releases from Lewiston Dam on the Trinity River. Water quality in the upper Klamath River Basin is at times characterized as being turbid and high in nutrients. As a consequence of the excess nutrients from agricultural runoff, at times the water quality of the Klamath River is degraded. Excessive nutrients have resulted in an abundance of phytoplankton blooms that have periodically lowered dissolved oxygen concentrations to levels considered to be unsafe for aquatic life. Lower in the Klamath River, the effects of the high nutrient loads from the upper basin are typically diluted by tributary flow, including the Trinity River, the largest of tributaries.

Lower Klamath River water temperatures may be influenced by releases from Iron Gate Dam. However, the Trinity River has a greater influence on water temperature of the Lower Klamath River than the releases from Iron Gate Dam. The two systems are different in that the coldwater storage of Trinity Reservoir is much greater than that of the upper Klamath River Basin reservoirs. Empirical data and a temperature model of the Trinity River has provided

insight into the effects that variable Lewiston Dam releases may have on water temperatures at the confluence of the Klamath River at Weitchpec (Service and Hoopa Valley Tribe, 1999). Empirical data have shown the influence of a high Lewiston Dam release on Klamath River water temperatures. In June of 1992, a 10-day Lewiston Dam release of 6,000 cfs occurred and greatly influenced the temperature of the lower Klamath River. This release decreased temperature in the mainstem Klamath River (immediately below the confluence) by nearly 4.5°F. Because 1992 was a critically dry year, tributary accretion in both the Klamath and Trinity Rivers was very small. As a consequence, the high release from Lewiston Dam resulted in the Trinity River becoming the dominant cold water source at the confluence. These interactions were confirmed during 2003 operations for late fall temperature maintenance.

Modeled dam releases from Lewiston Dam also provided assessments of the likely effects of releases on water temperatures at the confluence of the Klamath River during the spring and early summer (Service and Hoopa Valley Tribe, 1999). These evaluations focused on recommended flows identified in the Analysis of Alternatives, and the following generalities were identified from this evaluation. First, the model predicts that high-level releases can result in Trinity River water temperatures being colder than the Klamath River. Conversely, low-magnitude releases can result in Trinity River water temperatures becoming warmer than the Klamath River in the lower reaches. The main factor that can offset temperature differentials is likely the quantity of tributary accretion. When the Lewiston Dam release is large under drought conditions (low tributary accretion) or small during wet conditions, the temperature differentials become greatest. Marked temperature differentials may have a harmful effect on sensitive fishery resources. When dam release magnitudes are matched to emulate pre-TRD hydrologic conditions, the differences are lessened. For more detailed information on this subject see Appendix L of the *Trinity River Flow Evaluation Report* (Service and Hoopa Valley Tribe, 1999).

Central Valley. Shasta Dam is a major influence on Sacramento River water quality and, consequently, on the Bay-Delta. Operation of the TRD also affects water quality in the Sacramento River through the timing, magnitude, and temperature of exports, and the coordination with Shasta releases. Sacramento River water quality from Keswick Dam to the Red Bluff Diversion Dam is primarily influenced by Shasta Division releases and Trinity River exports. Downstream of the Red Bluff Diversion Dam, tributary inflow lessens the influence of the Shasta Division and TRD exports. During warm weather, Sacramento River water temperatures tend to increase downstream from Keswick Dam. This effect is magnified during dry water years with lower instream flows.

Following adoption of Water Right Orders 90-05 and 91-01 by SWRCB and implementation of the 1993 Winter-run Chinook BO, temperature requirements became a much more important constraint in the operation of the Shasta Division. Water Right Orders 90-05 and 91-01 implement the year-round 56°F Sacramento River temperature objective contained in the Sacramento River Basin Plan (Basin Plan) for the protection of all Sacramento River Chinook runs (winter, spring, fall, and late fall). The BO requires a minimum Shasta Reservoir carryover storage of 1.9 maf on September 30. The BO also set temperature compliance standards at downstream measuring points (Table 3.3-3 and Figure 3.3-1). Before the BO and Water Right Orders 90-05 and 91-01, Shasta Dam was operated to maximize water deliveries, power generation, and flood control.

TABLE 3.3-3
Temperature Standards Required by 1993 Winter-run Chinook BO

Water-year Class[a, b]	September 30 Storage in Shasta[c]	Temperature Compliance Standards (Daily Average Water Temperature Not to Exceed)
Wet	All levels	56°F at Bend Bridge April 15 through September 30 60°F at Bend Bridge October 1 through October 30
Above Normal	All levels	56°F at Bend Bridge April 15 through September 30 60°F at Bend Bridge October 1 through October 30
Dry	3.2 maf	56°F at Bend Bridge April 15 through September 30 60°F at Bend Bridge October 1 through October 30
Dry	2.5 maf	56°F at Bend Bridge April 15 through August 31 56°F at Jellys Ferry September 1 through September 30 60°F at Jellys Ferry October 1 through October 30
Dry	1.7 maf	56°F at Jellys Ferry April 15 through September 30 60°F at Jellys Ferry October 1 through October 30
Critical	All levels	56°F at Jellys Ferry April 15 through September 30 60°F at Jellys Ferry October 1 through October 30
Extremely Critical	3.2 maf	56°F at Jellys Ferry April 15 through September 30 60°F at Jellys Ferry October 1 through October 30
Extremely Critical	2.5 maf	Reclamation must re-initiate consultation with NOAA Fisheries 14 days prior to the first announcement of water delivery allocations
Extremely Critical	2.0 maf	Reclamation must re-initiate consultation with NOAA Fisheries 14 days prior to the first announcement of water delivery allocations
Extremely Critical	1.7 maf	Reclamation must re-initiate consultation with NOAA Fisheries 14 days prior to the first announcement of water delivery allocations

[a]Based on the Sacramento River Index, which differs from water-year index used elsewhere in document.
[b]Water-year class projections must be Reclamation's 90 percent probability of exceedance forecast of runoff released in February, or an exceedance forecast at least as conservative. Actual runoff will be less than a 90 percent forecast in only 10 percent of years. Forecasts made later in the water year are more accurate than forecasts made earlier in the year.
[c]When carryover storage is less than 1.9 maf, Reclamation must re-initiate consultation with NOAA Fisheries prior to first water allocation announcement.

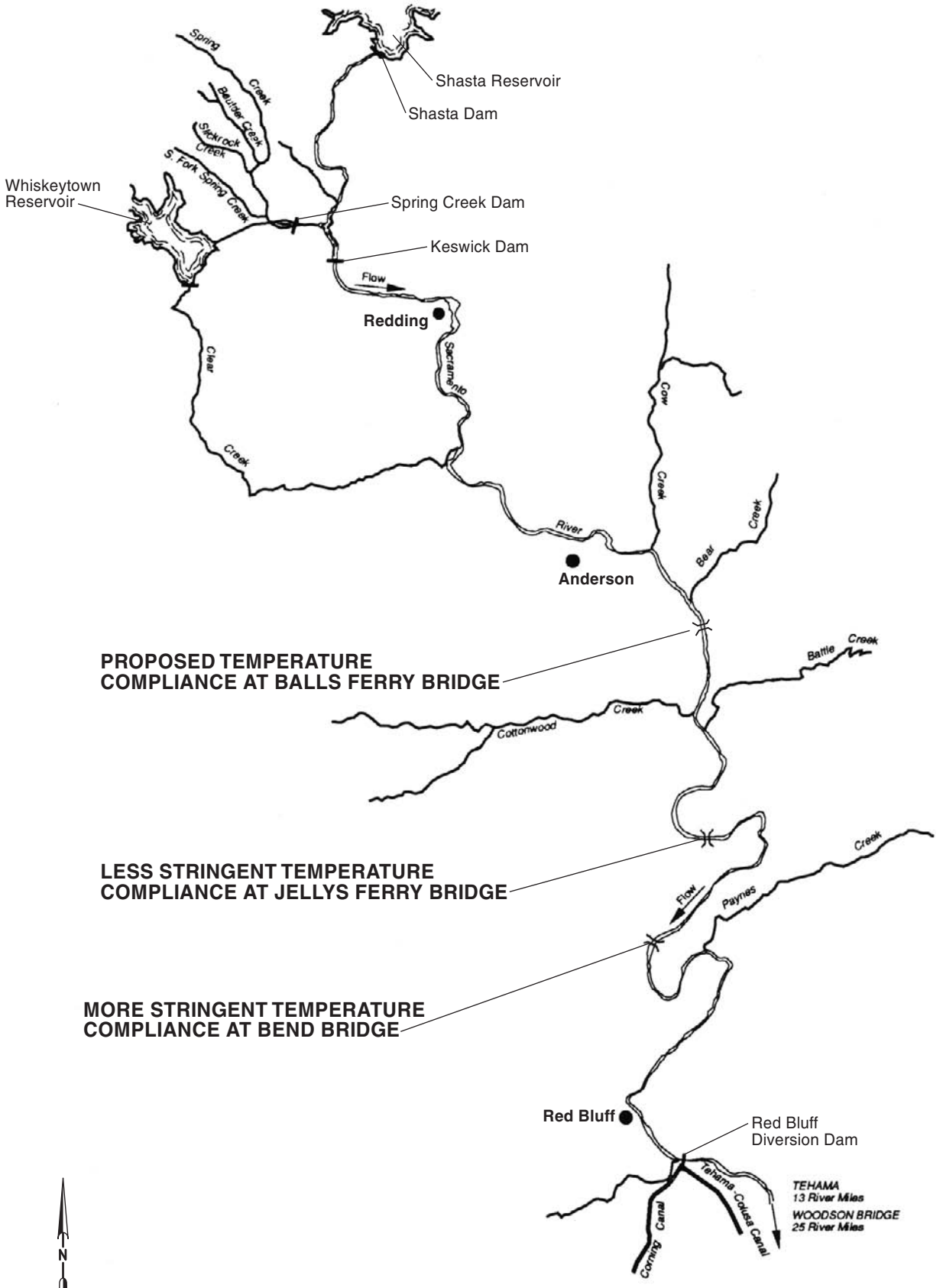


FIGURE 3.3-1
LOCATIONS OF WINTER-RUN CHINOOK SALMON BIOLOGICAL OPINION TEMPERATURE COMPLIANCE
TRINITY RIVER FISHERY RESTORATION SUPPLEMENTAL EIS/EIR

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The Shasta Division currently imports Trinity water in the spring and summer to conserve the coldwater pool in Shasta Reservoir for release later in the year. An important aspect of this coordination is to move Trinity water through Whiskeytown Reservoir at a rate sufficient to prevent warming. Water moving too slowly can result in warming, requiring additional coldwater releases from Shasta Dam to meet downstream temperature standards, which can reduce the amount of cold water available to meet standards later in the year and also affect water quality and deliveries in the Bay-Delta. Lower storage levels in Shasta Reservoir can also increase Shasta release temperatures, again requiring higher flows to comply with downstream temperature objectives. Alternatively, exports from Trinity can also be increased to reduce warming affects to Whiskeytown. Reclamation recently added a TCD to the upstream (reservoir side) face of Shasta Dam. The TCD allows dam operators to pull cold water from lower depths throughout the year, increasing the ability to generate power while assisting in meeting temperature objectives in the Sacramento River.

Dilution of Iron Mountain Mine runoff is also an important Sacramento River water quality consideration. Runoff from the mine, an EPA Superfund site near Redding, can be highly acidic and contain toxic metals. Runoff is held at Spring Creek Debris Dam, located upstream from the tailrace of Spring Creek Powerplant.

The debris dam allows mine runoff to be released into Keswick Reservoir on a controlled schedule so that it can be diluted to safe levels. During wet periods when the debris dam fills and spills, runoff flows directly into Keswick Reservoir, and metal concentrations occasionally exceed desirable levels in the Sacramento River.

Releases of water from Whiskeytown Reservoir (of which Trinity River exports are a major part) to the Spring Creek Powerplant are typically maintained at a minimum level of 200 cfs to help dilute the polluted water prior to entry into Keswick Reservoir. In the future, minimum releases may be lowered. This number should be considered very conservative given the ongoing construction of metal emission control systems associated with Iron Mountain Mine.

Water quality in the Bay-Delta is primarily affected by the way water moves through the region. Freshwater inflows are continuously influenced by the tidal cycle, which moves into and out of the Bay-Delta approximately twice a day. This tidal interaction is important because it moves the saltwater/freshwater interface back and forth, which influences water quality at specific locations throughout the Bay-Delta, both daily and seasonally. Water exports from the Bay-Delta are impacted by these changing water quality characteristics.

Currently, a combination of agreements and directives are used to maintain water quality in the Bay-Delta, including the following:

- Bay-Delta Accord
- SWRCB D-1485, as amended by WR 95-1, and 95-6 and 98-9
- Coordinated Operations Agreement

These agreements and directives outline standards and operating procedures that, when used in conjunction with upstream water quality plans and BOs for endangered species, determine water quality in the Bay-Delta.

The Bay-Delta Accord, formulated by CALFED and representatives of several urban, agricultural, and environmental groups, is effective until the adoption of final Delta water quality standards. Originally intended to be valid for 3 years, the Bay-Delta Accord has been extended twice. The Bay-Delta Accord established new outflow standards, modified BOs for winter-run Chinook salmon and Delta smelt to increase water project flexibility, and established a funding mechanism for non-flow-related measures.

SWRCB Bay-Delta water quality standards are conditioned by water-year class and, in general, become less stringent in critically dry years. The SWRCB May 1995 Water Quality Control Plan, as amended by WR 95-1, 95-6, and 98-9, outlines standards for salinity, chloride, and habitat protection (X2 criteria for example). X2 criteria refer to the management of upstream movement of water with 2 parts-per-thousand (ppt) concentration of salt. X2 is measured as kilometers (km) from the Golden Gate Bridge. Higher X2 values indicate salt water intrusion into the Delta. X2 is also discussed in Section 3.4, Fishery Resources. X2 is sometimes used as a measure of Delta smelt habitat.

Water quality standards are much more difficult to meet in critically dry years because there is less water supply to meet them and multi-objective CVP purposes must be made on a tradeoff basis with limited resources. Water quality standards become more protective (or enhanced) as conditions become wetter, and there are generally more water resources and project flexibility to meet these competing multi-objective needs. Because of their ability to significantly alter flows, and therefore water quality in the Bay-Delta, the major export pumps are also regulated. Exports from the pumps are restricted according to Delta inflow and San Joaquin River flow. These limits are intended to be monitored in real time in order to detect fish in the areas adjacent to the pumps. Currently, exports are limited to 35 percent of Delta inflow from February through June and 65 percent of inflow for the remainder of the year. In 1995, the export/inflow ratio averaged 18.4 percent, with a low of 6.2 and a daily maximum of 64.3. Exports

are also limited between April 15 and May 15 to 1,500 cfs or 100 percent of San Joaquin River flow at Vernalis, whichever is greater. The San Joaquin export limit is only used if it is more restrictive than the 35 percent limit.

The Delta provides drinking water for about 20 million people, making water quality, and the ability to adequately treat Delta water, a major concern. Fresh water that is not used in the Delta, or not exported from the Delta flows, to the Pacific Ocean through San Francisco Bay, which helps prevent saline water from encroaching into the Delta and degrading water quality. Managing the balance between water taken from the Delta for drinking water and water left in the Delta to protect water quality is a key concern.

The Safe Drinking Water Act (SDWA) was enacted and signed into law in 1974. Through the SDWA, the EPA was given the authority to set standards for contaminants in drinking water supplies. The EPA was required to establish primary regulations for the control of contaminants that affect public health, and secondary regulations for compounds that affect the taste or aesthetics of drinking water. Under the SDWA, Department of Health Services has the primary enforcement responsibility (referred to as "primacy"). The Health and Safety Code and Title 22 of the California Code of Regulations establishes Department of Health Services authority and stipulates drinking water quality and monitoring standards. To maintain primacy, a state's drinking water regulations can be no less stringent than the federal standards. Water in the Delta generally meets public water supply water quality standards identified by EPA and the Department of Health Services. However, stricter federal standards have been promulgated and are significantly more difficult and costly to meet. The standards of concern relate to disinfection byproducts and the potential requirements for more rigorous disinfection. Since 1914, chlorine has been the preferred disinfectant in most United States public surface-water systems. It is relatively easy to use, inexpensive, and it persists in water, continuing to kill bacteria throughout the distribution system. In the mid-1970s, concern arose over newly discovered compounds that form when chlorine combines with naturally occurring organic, carbon-based materials, such as decaying vegetation or some salts. Known as disinfection by-products (DBP), these synthetic organic compounds are suspected carcinogens.

For drinking water, DBPs have only been consistently measured since the early 1980s, because EPA first adopted a maximum contaminant level for trihalomethanes (THM) in 1981. Constituents that can cause DBPs include bromide (naturally occurring in seawater) and organic carbon. Tidal currents created by the rise and fall of sea levels modify stream flow, particularly when outflows are low or when tides are high. Intruded seawater is a major source of

bromide, particularly in the western Delta. Intrusion profoundly affects Delta water withdrawn at the CCWD, SWP, and CVP intakes. The presence of bromide in a drinking water source complicates the disinfection process because it is heavier than chlorine and the THM standard is based on weight. Hence, it takes fewer molecules of brominated THMs to exceed the drinking water standard. Another method of disinfection, ozone treatment, is also complicated by the presence of bromide because it forms bromate, which is also a DBP.

Of the agricultural land acreage in the Delta, 80 percent contain peat soils. The organic carbon content of peat soil is 50 to 80 percent, and intermediate organic-type soils have 30 to 50 percent organic matter. High organic content makes peat soil highly productive for agriculture, but prone to wind erosion and subsidence. Subsidence is the result of exposure of peat to oxygen, which converts the organic carbon solids to carbon dioxide gas and aqueous carbon. Organic carbon can also form THMs, including the most common THM, chloroform.

Environmental Consequences.

Methodology. Several water temperature models were used to evaluate the effects of each alternative on Trinity River water temperatures. These models included: (1) Reclamation's Temperature Model (RTM), which predicts Trinity Dam release temperatures as a function of storage and outlet works used; (2) a 2-dimensional temperature model of Lewiston Reservoir based on the BETTER, which predicts temperatures at outflow locations; and (3) the SNTEMP, which predicts Trinity River water temperatures below Lewiston Reservoir. These models were used in sequence, with output of upstream models used as input for downstream models.

The monthly RTM (sometimes referred to as the Sacramento River Basin Temperature model) is used as an analytical tool for evaluating the effects of reservoir operations on riverine water quality conditions. The RTM simulates temperature profiles in five major reservoirs (Trinity, Whiskeytown, Shasta, Folsom, and Oroville Reservoirs), four downstream regulating reservoirs (Lewiston Reservoir, Keswick Reservoir, Thermalito Afterbay, and Natoma Reservoir), and three major river systems (Sacramento, Feather, and American Rivers). The model was developed as a tool for evaluating the effects of monthly simulated CVP-SWP reservoir operations on basin water temperatures. For this analysis the BETTER model was used to predict temperatures in Lewiston Reservoir because it was developed specifically for Lewiston, rather than as a piece of the entire CVP. The RTM was also used for the CVPIA EIS.

For each alternative, simulations of the RTM and BETTER were performed for five specific years (1983, 1986, 1989, 1990, and 1977)

representing five different water-year classes (extremely wet, wet, normal, dry, and critically dry). Lewiston Dam release temperatures predicted from the BETTER model were subsequently modeled in the SNTEMP under projected cold-wet, median, and hot-dry hydrometeorological conditions. Model results identified the percentage of time that NCRWQCB temperature objectives would be met. Table 3.3-4 presents the combinations of flows and temperatures necessary to meet temperature objectives under median weather conditions. Table 3.3-5 presents the modeling results for each alternative under median conditions. Cold-wet and hot-dry conditions are presented in the Water Resources/Water Quality Technical Appendix A.

TABLE 3.3-4

Combinations of Discharge and Water Temperatures Necessary to Meet SWRCB Temperature Objectives for the Trinity River Under Median Climatic Conditions

Water Temperature of Releases (°F)	Lewiston Dam Discharge (cfs)					
	150	300	450	600	900	1,200
	July 1 through September 14: Target 60°F at Douglas City[a]					
46	59.9	55.9	53.7	52.3	50.7	49.8
47	60.2	56.4	54.3	53.0	51.4	50.6
48	60.6	56.9	55.0	53.7	52.3	51.5
49	60.9	57.4	55.6	54.4	53.0	52.2
50	61.2	58.0	56.3	55.1	53.9	53.1
51	61.5	58.6	57.0	55.9	54.7	54.0
52	61.8	59.1	57.5	56.6	55.4	54.8
53	62.2	59.6	58.2	57.3	56.3	55.7
54	62.5	60.1	58.8	58.0	57.0	56.4
55	62.8	60.7	59.5	58.7	57.8	57.3
56	63.1	61.1	60.0	59.3	58.5	58.1
57	63.4	61.7	60.7	60.1	59.4	58.9
58	63.7	62.1	61.3	60.7	60.1	59.7
59	64.0	62.7	62.0	61.5	60.9	60.6
60	64.3	63.2	62.6	62.2	61.8	61.5
	September 15 through September 30: Target 56°F at Douglas City[a]					
46	56.2	52.6	50.9	50.0	48.9	48.3
47	56.6	53.2	51.6	50.7	49.7	49.2
48	57.1	53.9	52.4	51.5	50.6	50.1
49	57.5	54.4	53.1	52.3	51.4	50.9
50	57.9	55.2	53.9	53.1	52.3	51.9
51	58.4	55.8	54.7	54.0	53.2	52.8
52	58.8	56.4	55.3	54.7	54.0	53.6
53	59.2	57.1	56.1	55.5	54.9	54.6
54	59.6	57.7	56.8	56.2	55.7	55.4
55	60.0	58.4	57.6	57.1	56.6	56.3
56	60.4	58.9	58.2	57.8	57.3	57.1
57	60.9	59.6	59.0	58.6	58.3	58.0

TABLE 3.3-4

Combinations of Discharge and Water Temperatures Necessary to Meet SWRCB Temperature Objectives for the Trinity River Under Median Climatic Conditions

Water Temperature of Releases (°F)	Lewiston Dam Discharge (cfs)					
	150	300	450	600	900	1,200
58	61.2	60.1	59.6	59.3	59.0	58.8
59	61.6	60.8	60.4	60.2	59.9	59.8
60	62.1	61.5	61.2	61.0	60.8	60.7
	October 1 through December 31: Target 56°F at North Fork Confluence[a]					
46	56.8	54.4	52.9	51.8	50.6	49.8
47	56.9	54.8	53.3	52.4	51.2	50.5
48	57.1	55.1	53.9	53.0	51.9	51.3
49	57.3	55.5	54.3	53.5	52.5	51.9
50	57.4	55.9	54.8	54.1	53.3	52.7
51	57.6	56.2	55.3	54.7	54.0	53.5
52	57.7	56.5	55.8	55.3	54.6	54.2
53	57.9	56.9	56.3	55.9	55.3	55.0
54	58.0	57.2	56.7	56.4	55.9	55.7
55	58.2	57.6	57.2	57.0	56.6	56.5
56	58.3	57.9	57.7	57.5	57.3	57.1
57	58.4	58.3	58.2	58.1	58.0	57.9
58	58.6	58.6	58.6	58.6	58.6	58.6
59	58.7	58.9	59.1	59.1	59.3	59.3
60	58.9	59.3	59.5	59.7	60.0	60.1

[a]Shaded cells indicate combinations that can meet temperature objectives.

TABLE 3.3-5

Water Quality Summary Table Sacramento River Impacts (CALSIM)

	No Action	Revised Mechanical	Preferred Flow	Modified Percent	70 Percent	Maximum Flow	Existing Condition
Sacramento River Violations							
Percentage of months with violations	30.8%	33.5%	35.7%	34.3%	39.1%	42.5%	29.0%
Shasta Carryover Storage Violations							
Percentage of years less than 1.9 maf	11.1%	13.9%	16.7%	13.9%	19.4%	27.8%	12.5%
Average Modeled Position of X2 in Delta, Distance from Golden Gate Bridge (km)							
Average Period (1922-1993)	75.8	75.8	75.9	75.9	76.1	76.1	75.7
Wet Period (1967-1971)	71.2	71.3	71.4	71.2	71.4	71.6	70.8
Dry Period (1928-1934)	80.8	80.8	80.8	80.7	80.8	80.8	80.7

Each alternative was also evaluated for its ability to meet the water temperature objectives of the Hoopa Valley Tribe's WQCP (Hoopa Valley Tribe, 2000). This evaluation relied upon model-predicted dam-release water temperatures from the SNTEMP, as well as hydro-meteorological conditions of representative years modeled by BETTER. These years included 1977 (critically dry), 1990 (dry), 1989 (normal), 1986 (wet), and 1983 (extremely wet). This evaluation provided estimates of the percentage of time the objectives would be met.

Each alternative's effect on turbidity, sediment, and water quality of the lower Klamath River were analyzed qualitatively. An evaluation of the flow schedules of the Proposed Action (Service and Hoopa Valley Tribe, 1999) provided information to provide qualitative assessments of the likely effects of alternative flows on water quality in the lower Klamath River. Flow alternatives were assessed for their ability to provide temperatures beneficial to salmonids in the Klamath River and their ability to provide dilution for potentially polluted Klamath River water.

Temperature effects in the Sacramento River were analyzed using CALSIM and RTM; the Shasta TCD was assumed to be fully operational. Although these models are the best available tools for analyzing temperature impacts, they do use monthly time steps, whereas actual operations would be dependent on daily, and sometimes hourly, variations in flow, climate, and exports (therefore, daily impacts could be masked). The ability to dilute uncontrolled acid mine runoff from Spring Creek Debris Dam is assumed to be relatively unaffected by any of the alternatives because of uncontrolled spills from Spring Creek Debris Dam (which would typically be in the winter/early spring months) would correlate with increased inflow to Shasta and Whiskeytown Reservoirs, which, in turn, would be available for release to dilute water in Keswick Reservoir.

A minimum 200-cfs release through Spring Creek Powerhouse to mobilize acid mine drainage into Keswick Reservoir is assumed in all alternatives (except Maximum Flow because no exports are assumed). As described above under Affected Environment, this should be viewed as a conservative number.

CALSIM operations ensure facilities within the CVP remain viable. In the case of Whiskeytown Reservoir, elevations are maintained at a sufficient level to assure diversion capability for all uses, including utilities that divert water from Whiskeytown for domestic and agricultural uses. CALSIM operating rules also ensure that flows are sufficient to provide minimum water quality standards are maintained in the Bay-Delta for all alternatives on a monthly basis. However, inflows to the Bay-Delta and Delta exports were further

evaluated for their effects on water quality using DWR's DSM2 Delta model to analyze potential impacts associated with each alternative to drinking water quality versus the No Action Alternative. The hydrodynamic model, DSM2, simulates the channel flows, tidal effects, and water quality of the Bay-Delta estuary. For the purposes of this analysis, model simulations were conducted for a 15-year historical hydrologic sequence (water years 1976-1990). This period was selected to cover a broad range of Delta inflows and exports and is generally representative of the 72-year historical hydrologic sequence used in CALSIM. DSM2 results may identify modeled exceedances for some standards in some locations for individual months, assuming the model provides a more detailed representation of the Delta. DSM2 results were evaluated for changes in electrical conductivity (EC) concentrations at six Delta locations critical to drinking water quality. These locations include Greens Landing on the Sacramento River, North Bay Aqueduct, Contra Costa Canal Intake, Old River at Highway 4, Delta-Mendota Canal Intake, and Clifton Court Forebay, as shown on Figure 3.3-2.

Mercury.

It is assumed that those alternatives, which may increase mercury's bioavailability via methylation (or potential for methylation) and concentration in biota, may cause significant impacts. The primary causes of increased bioavailability of mercury is through inadvertant release of mercury to stream courses or through creation of habitats prone to creation of methylmercury. Alternatives were evaluated for the potential to cause either of these conditions.

Water Quality.

Significance Criteria. The following impacts were considered significant for both the Trinity River Basin and the Central Valley:

- Substantial degradation of water quality, such that existing beneficial uses are precluded specifically because of adverse water quality.
- Violation of any water quality standards or waste discharge requirements.
- Substantial alterations of the course of a stream or river in a manner that would result in substantial erosion or siltation on- or offsite.
- Short- or long-term increases in turbidity of 20 percent or more over naturally occurring background levels.
- Contamination of a public water supply.

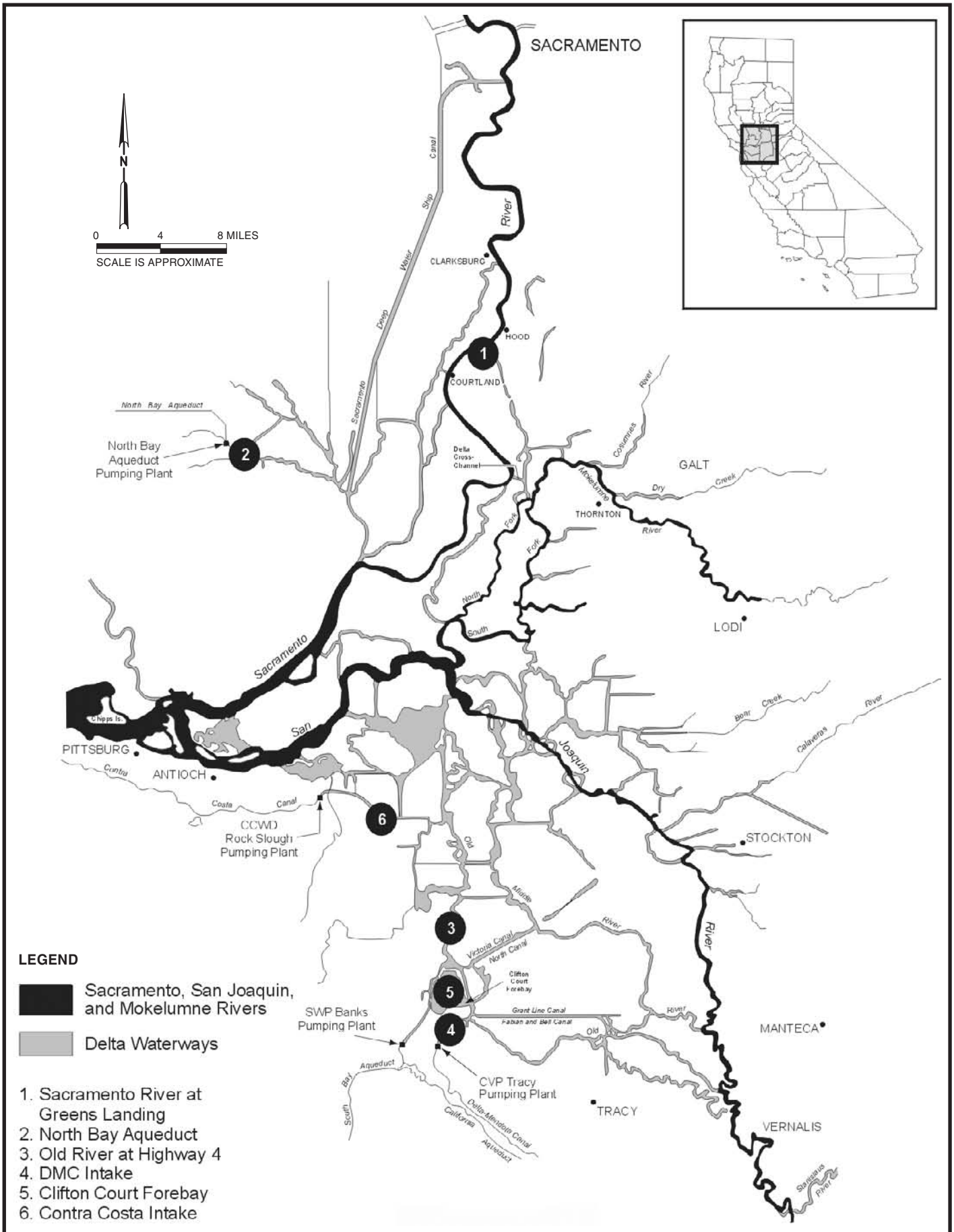

FIGURE 3.3-2
OUTPUT LOCATIONS FOR SIMULATED AVERAGE MONTHLY WATER QUALITY
TRINITY RIVER FISHERY RESTORATION SUPPLEMENTAL EIS/EIR

W022004007RDD_926 (4/2/04)

- Variation in instream temperatures so as to cause mortality to state or federally listed aquatic species. For purposes of analysis, this is defined as an increase in the frequency of temperature violations[3], or a relative change in carryover storage meeting targets at Shasta Reservoir compared to No Action.
- Degradation of a water quality constituent for which a waterbody is listed as impaired (e.g., under California's Clean Water Act 303(d) list).
- Existing standards are exceeded for mobilization of mercury.
- Conditions are created which would increase the potential for formation of mercury methylation beyond naturally occurring rates.

If an alternative will increase mobilization of mercury to the stream course and will increase potential for mercury methylation in the local area (i.e., will increase severity of mercury contamination within the lower Trinity River watershed), such that quantities may be deleterious to water quality, aquatic and terrestrial life, it is considered significant.

No Action. Exports to the Central Valley would be similar to current operations and would generally maintain current temperatures in the Trinity River (Table 3.3-4). Under the No Action Alternative, Sacramento River temperature objectives established in the BO would not be met in some months (Table 3.3-3). These months are distributed across wet to dry hydrology due to the variable nature of the standards depending on water-year class. Carryover violations at Shasta Reservoir would occur in 11.1 percent of the years (Table 3.3-5). Existing Trinity River channel rehabilitation projects would be maintained, resulting in occasional, short-term increases in turbidity. Because this alternative does not provide dam releases sufficient in magnitude or duration to emulate pre-TRD flow patterns during the spring and early summer, except possibly in critically dry years, there would be times when water temperatures would be warmer than the Klamath River. Minimum Bay-Delta water quality standards are assumed to be met on a monthly basis.

Revised Mechanical.

Trinity River Basin. The frequency of Trinity River modeled temperature violations remain similar or decreased compared to No Action levels. Construction of the 47 new channel rehabilitation projects associated with this alternative would result in potentially

[3] For this study, an increase of 0.5°F as established in the 1993 Winter run BO issued. Notably, the use of a 0.5°F change in temperature as a significant impact represents a very conservative approach, in that the Central Valley Regional Water Quality Control Board normally considers a temperature change to be significant if a 1.0-degree change occurs.

significant short-term turbidity impacts in relation to NCRWQCB objectives (actual implementation of the projects would undergo a site-specific environmental review).

The use of suitably sized floating dredges that can pump water-sediment mixtures to off-channel holding impoundments will eliminate turbidity problems associated with other forms of mechanical removal from the river.

The Revised Mechanical Restoration Alternative was considered to have potentially significant impacts relative to increased levels of mercury in-river due to the construction of channel rehabilitation projects, which have the potential to increase mobilization of mercury to the stream course and to increase potential for mercury methylation.

Lower Klamath River Basin/Coastal Area. Because this alternative provides releases greater than the No Action Alternative, and flows are sufficient in magnitude and duration to partially emulate pre-TRD flow patterns during the spring and early summer, water quality of the lower Klamath River would improve. Water temperatures of the lower Trinity River would be reduced compared to the No Action Alternative, and as a consequence, the water temperature of the lower Klamath River would also be reduced. As compared to the No Action Alternative, the additional flows of this alternative would dilute Klamath River flow that could be of poor quality due to sediments or nutrients. During the late summer and early fall when flows are equal to the No Action Alternative there would be no significant differences in water quality.

Central Valley. Sacramento River modeled temperature violations occurred at a significantly higher frequency than under the No Action Alternative (33.5 versus 30.8 percent). Violations occurred in both wet and dry conditions due to the variable nature of the standards. The modeled frequency of Shasta carryover violations was slightly greater than the No Action Alternative with an increase of 2.8 percentage points. The increase in frequency of temperature violations and the change in carryover storage violations is at least partially attributable to the increase in demand for water under the 2020 condition. Because demand is forecast to occur downstream of compliance points in the Sacramento River, water deliveries assist in meeting temperature standards. Increased demand in the 2020 period results in lower carryover storage in the Central Valley reservoirs as system wide resources are used to meet demand.

CALSIM results indicate that carryover storage at Shasta Reservoir is significantly reduced compared to No Action. However, the increase in public demand in the year 2020 has a larger incremental effect on

carryover storage compared to the impacts of the modeled alternative.

There was no change in the modeled position of X2 over the period of record compared to No Action. During the wet and dry period, X2 position showed no significant change. Delta standards continue to be met under this alternative.

DSM2 Delta water quality results show that the long-term average monthly EC values do not change significantly from those for the No Action Alternative. The maximum increase in dry-period monthly EC values is 5 percent, for the month of January at Contra-Costa Canal Intake.

Flow Evaluation.

Trinity River Basin. The frequency of Trinity River modeled temperature violations remain the same or decreased in all water-year classes compared to No Action levels. This improvement in water temperature, of up to 16 percent in dry and critical dry water years, is the result of increased flows and a higher carryover storage target. Construction of the 47 new channel rehabilitation projects associated with this alternative would result in potentially significant short-term turbidity impacts in relation to NCRWQCB objectives (actual implementation of the projects would undergo a site-specific environmental review).

The Flow Evaluation Alternative was considered to have potentially significant impacts relative to increased levels of mercury in-river due to the construction of channel rehabilitation projects, which have the potential to increase mobilization of mercury to the stream course and to increase potential for mercury methylation.

Lower Klamath River Basin/Coastal Area. Because this alternative provides releases greater than the No Action Alternative, and flows are sufficient in magnitude and duration to partially emulate pre-TRD flow patterns during the spring and early summer, water quality of the lower Klamath River would improve. Water temperatures of the lower Trinity River would be reduced compared to No Action, and, as a consequence, the water temperature of the lower Klamath River would be reduced. Furthermore, the additional flows of this alternative would dilute Klamath River flows that could be of poor quality due to sediment and nutrients. During the late summer and early fall when flows are equal to the No Action Alternative there would be no significant differences in water quality.

Central Valley. Sacramento River modeled temperature violations occurred at a higher frequency than under the No Action Alternative (35.7 versus 30.8 percent). Violations occurred in both wet and dry conditions due to the variable nature of the standards. This impact

would be significant. Shasta Reservoir carryover storage violations would increase 5.6 percentage points compared to No Action. The increase in frequency of temperature violations and the lack of change in carryover storage violations is at least partially attributable to the increase in demand for water under the 2020 condition. Because demand is forecast to occur downstream of compliance points in the Sacramento River, water deliveries assist in meeting temperature standards.

The modeled position of X2 increased (moved east) by 0.1 km over the period of record compared to No Action. During the wet period, X2 position increased 0.2 km, and during the dry period, X2 showed no change. Delta standards continue to be met under this alternative. Graphic representations of relative X2 position under the No Action and Flow Evaluation is included in the Water Resources/Water Quality Technical Appendix A.

DSM2 Delta water quality results show that the long-term average monthly EC values do not change significantly from those for the No Action Alternative. The maximum increase in dry-period monthly EC values is 10 percent for the month of January at Contra-Costa Canal Intake.

Modified Percent Inflow.

Trinity River Basin. Except for wet water years (5 percent greater) modeled Trinity River water temperature violations would be less in comparison to No Action. Construction of 47 new channel rehabilitation projects would result in potentially significant short-term turbidity impacts in relation to NCRWQCB objectives (actual implementation of the projects would undergo a site-specific environmental review).

The Modified Percent Inflow Alternative was considered to have potentially significant impacts relative to increased levels of mercury in-river due to the construction of channel rehabilitation projects, which have the potential to increase mobilization of mercury to the stream course and to increase potential for mercury methylation.

Lower Klamath River Basin/Coastal Area. Because this alternative does provide releases greater than the No Action Alternative, and flow patterns are sufficient in magnitude and timing to partially emulate pre-TRD flow patterns during the spring and early summer, water quality of the Klamath River would improve relative to the No Action Alternative. Water temperatures would improve, and the additional flows of this alternative would dilute Klamath River flow that can be of poor quality due to sediments and nutrients during the early summer. During the late summer and early fall; compared to No Action, the projected low releases under this alternative would significantly reduce

the benefits of Trinity River dilution effect, and would result in significantly increased water temperatures of the Klamath River.

Central Valley. Sacramento River modeled temperature violations would occur more frequently than No Action levels (34.3 versus 30.8 percent), resulting in a significant impact. The months with violations occur across wet and dry conditions due to the variable nature of the standards.

The modeled frequency of Shasta carryover violations was slightly greater than the No Action Alternative with an increase of 2.8 percentage points.

In comparison with No Action, modeled position of X2 would increase (move east) 0.1 km over the period of record. In the wet condition and in the dry period, X2 would remain unchanged or have approximately 0.1 km westward. Delta standards continue to be met under this alternative.

DSM2 Delta water quality results are very similar to the No Action Alternative. The maximum increase in long-term average EC levels is limited to 2 percent. The maximum increase in dry-period monthly EC values is 8 to 9 percent for the month of December at Contra-Costa Canal Intake and Old River at Highway 4.

70 Percent Inflow.

Trinity River Basin. Modeled Trinity River water temperature violations increased substantially during extremely wet and wet water years in comparison to No Action because of the relatively low reservoir inflows in the fall months, with subsequent low releases under this alternative. The resultant Trinity River temperature increases would be significant. Construction of 20 new channel rehabilitation projects would result in potentially significant short-term turbidity impacts in relation to NCRWQCB objectives (actual implementation of the projects would undergo a site-specific environmental review).

The 70 Percent Inflow Alternative was not considered to have potentially significant impacts because no increase in bioavailability of mercury would be realized.

Lower Klamath River Basin/Coastal Area. Because this alternative does provide releases greater than the No Action Alternative, and flow patterns are sufficient in magnitude and timing to partially emulate pre-TRD flow patterns during the spring and early summer, water quality of the Klamath River would improve relative to the No Action Alternative. Water temperatures would improve and the additional flows of this alternative would dilute Klamath River flows during the early summer. During the late summer and early fall the

projected low releases under this alternative would significantly reduce the benefits of Trinity River dilution, and would significantly increase water temperatures of the Klamath River compared to No Action.

Central Valley. Sacramento River modeled temperature violations would occur more frequently than No Action levels (39.1 versus 30.8 percent), resulting in a significant impact. The months with violations occur across wet and dry conditions due to the variable nature of the standards.

The modeled frequency of Shasta carryover violations was significantly greater than the No Action Alternative with an increase of 8.3 percentage points. This change is considered significant.

In comparison with No Action, the modeled position of X2 would increase (move east) 0.3 km over the period of record. During the wet period, X2 position increased 0.2 km, while during the dry period, X2 showed no change. Delta standards continue to be met under this alternative.

CALSIM results also project reductions in Delta outflow. DSM2 Delta water quality results show a small increase (over No Action) in the long-term monthly averaged values of EC. The maximum increase in long-term values is 5 to 6 percent in the months of October and November at Contra-Costa Canal Intake and Old River at Highway 4. The maximum increase in the dry-period averaged monthly values is also limited to 6 percent.

Maximum Flow.

Trinity River Basin. The elimination of TRD exports resulted in additional modeled Trinity River temperature violations of NCRWQCB temperature standards in all five water-year classes, compared to No Action levels. The increased frequency of violations reflects the slower rate at which water moves through Lewiston Reservoir (i.e., lack of diversions to the Central Valley), and the associated warming effect (due to the reservoir's relatively shallow depth). Typically, these violations would occur in fall months. The resultant Trinity River temperature impact would be significant. Because this alternative does not include mechanical channel rehabilitation there would be no associated impacts to turbidity.

The Maximum Flow Alternative was not considered to have potentially significant impacts because no increase in bioavailability of mercury would be realized.

Lower Klamath River Basin/Coastal Area. Because this alternative does provide dam releases greater than the No Action Alternative, and flows are sufficient in magnitude and duration to partially emulate

pre-TRD flow patterns during the spring and early summer relative to the No Action Alternative, the increased flow during the spring and early summer would improve water temperatures of the lower Klamath River. As compared to the No Action Alternative, the additional flows of this alternative would dilute Klamath River flow that could be of poor quality. During the late summer and early fall (beginning in September) when dam releases are reduced to less than those of the No Action Alternative, there would be a slight reduction in Klamath River water quality.

Central Valley. The elimination of TRD exports would significantly reduce the ability to meet temperature criteria in the Sacramento River. River temperatures would exceed the BO temperature objectives on average, approximately 12 percent more frequently compared to the No Action Alternative.

Shasta Reservoir carryover storage violations would increase 16.7 percentage points compared to No Action due to increased reliance on the reservoir to meet river temperature requirements in spring and early summer. This would be a significant effect.

Relative to No Action, modeled X2 position would increase (move east) 0.4 km in the average condition, 0.5 km in the wet condition resulting in a significant impact, and would have no increase in the dry condition. However, as previously noted, CALSIM operates the system to meet water quality standards in the Delta.

CALSIM results project reductions in Delta outflow compared to No Action, resulting in a general elevation of EC values compared to No Action. The greatest increase is at the Delta-Mendota Canal Intake, where January EC levels rise up to 9 percent in critical dry years. The maximum increase in the long-term averaged monthly values is 8 percent in October at Contra-Costa Canal Intake.

Existing Conditions versus Proposed Action.

Trinity River Basin. The modeled Proposed Action in the year 2020 has similar or fewer temperature violations in the Trinity River depending on water-year class than the modeled existing conditions. This is largely due to the diversion pattern under the Proposed Action that reduces Lewiston Reservoir warming in mid- to late-summer and the difference in minimum carryover storage. The greatest improvements (approximately 8 to 16 percent) are modeled to occur in the dry and critically dry water-year classes. Construction of the channel rehabilitation projects would result in an increase in short-term turbidity impacts compared to existing conditions, resulting in potentially significant short-term turbidity impacts in relation to NCRWQCB objectives (actual implementation of the projects would undergo a site-specific environmental review). However, the watershed protection component of the Proposed

Action would reduce sediment inputs into tributaries and, subsequently, into the Trinity River by 240,000 to 480,000 yd^3/year, which is approximately 9 to 17 percent of the average annual sediment produced in the basin. Implementation of this alternative is assumed to result in beneficial effects.

The Flow Evaluation Alternative was considered to have potentially significant impacts as compared to Existing Conditions relative to increased levels of mercury in-river due to the construction of channel rehabilitation projects, which have the potential to increase mobilization of mercury to the stream course and to increase potential for mercury methylation.

Lower Klamath River Basin/Coastal Area. The Proposed Action in the year 2020 provides variable releases by year class and large-magnitude flows during the spring and into mid-summer, thereby improving water quality of the lower Klamath River compared to existing conditions. Water temperatures of the lower Trinity River would be reduced compared to the existing conditions; and, as a consequence, the water temperature of the lower Klamath River would be maintained or slightly improved. The Proposed Action would provide additional flows that would contribute to dilution of Klamath River water. During the late summer and early fall when flows are equal to existing conditions, there would be no significant differences in water quality.

Central Valley. Modeled Sacramento River temperature violations would occur more frequently under the Proposed Action than under existing conditions (35.7 versus 29.0 percent of the months). However, 27 percent of the noncompliance is attributed to the increase in water demand assumed for the 2020 level of development. In spite of the large share of noncompliance attributed to increased demand, the increased frequency of violations attributable to Trinity is considered significant.

Proposed Action carryover storage violations also increased compared to existing conditions. For these reasons, the Preferred Alternative would cause significant effects relating to carryover storage.

Although CALSIM operates system resources to meet Delta water quality standards, there is a slight increase in modeled X2 position between existing conditions and the Proposed Action. Over the period of record average X2 position would increase approximately 0.1 km. In the wet period, X2 would increase approximately 0.6 km, and in the dry period, X2 is essentially unchanged. Delta standards continue to be met under this alternative. This change is considered less than significant.

CALSIM results also project general reductions in Delta inflow and outflow, as well as a substantial increase in SWP exports at Banks Pumping Plant to meet increased 2020-level demands in the Proposed Action relative to existing conditions. Due to these changes in Delta conditions, DSM2 Delta water quality results show increases in average monthly EC concentrations. The greatest increase is at the Contra-Costa Canal Intake, where April EC levels rise up to 10 percent in critical dry years. The maximum increase in the long-term averaged monthly values is 9 percent in January at Contra-Costa Canal Intake. However, these changes are primarily the result of increased demand, and the increment attributable to the preferred alternative is considered less than significant.

Mitigation.

The following mitigation would be implemented to reduce significant Trinity River turbidity-related impacts associated with the Flow Evaluation, 70 Percent Inflow, Modified Percent Inflow, and Revised Mechanical Restoration Alternatives to less than significant levels:

- A 401 water quality certification would be obtained from the NCRWQCB, after completion of site-specific environmental review, and a construction procedure would be developed to meet the Basin Plan turbidity requirements. Monitoring would be conducted as specified by the NCRWQCB, and efforts would be taken to reduce levels if they are 20 percent or more over background (e.g., isolating the work area and/or slowing or halting construction until the 20 percent level is achieved).
- Notify individual diverters with state diversion permits and riparian water rights within 2 miles downstream of any mechanical channel rehabilitation activity at least 2 days in advance of activities likely to produce turbidity.
- The Service and Reclamation shall provide the opportunity for full NOAA Fisheries participation on the technical team ("designated team of scientists" [Service and Reclamation, 2000], "technical modeling and analysis team" [TRMFR Draft EIS]) offering restoration program recommendations, and on the Trinity Management Council polity group (described in the TRMFR Draft EIS and Service and Reclamation [2000]). (Term from NOAA Fisheries BO.)
- The Service and/or Reclamation shall meet with NOAA Fisheries annually in March to coordinate during the advanced development and scheduling of habitat rehabilitation projects, including mainstem channel rehabilitation projects, sediment augmentation program, and dredging of sediment collection pools. (Term from NOAA Fisheries BO.)

Significant Trinity River temperature impacts identified for the Maximum Flow, 70 Percent Inflow, and Modified Percent Inflow Alternatives would need to be evaluated by the NCRWQCB and NOAA Fisheries.

The following mitigation could reduce impacts of temperature violations in the Trinity River:

- Bypassing the Trinity Powerplant could offset impacts to temperature related to Trinity Reservoir releases. Preliminary analysis of powerplant bypasses indicates that pulling colder water from lower in the reservoir could help alleviate temperature impacts in the Trinity and Sacramento Rivers. The magnitude, timing, costs, and benefits of powerplant bypasses would need to be evaluated on a case-by-case basis during specific dry/critically dry years with low carryover storage (see Section 3.5, Power Resources). (Term from NOAA Fisheries BO.)
- Changing operations of the TRSSH to use colder water from lower in Lewiston Reservoir to rear hatchery-produced fish. Currently, warmer water from the upper levels of Lewiston Reservoir is used to promote growth in rearing salmon and steelhead.
- "Slugging" Lewiston Reservoir with large quantities of cold water from Trinity Reservoir could reduce the warming effect of Lewiston Reservoir. This technique has been used in the past when climatic or hydrologic conditions have induced temperature violations.
- Increasing minimum storage requirements in Trinity Reservoir could increase the coldwater pool available for summer and fall releases.
- In years that Reclamation has reinitiated consultation pursuant to criteria established in the winter-run Chinook salmon CVP-OCAP BO, evaluate drawdowns of Trinity Reservoir below the 600 TAF minimum end-of-water year carryover level to the extent needed to avoid significant temperature-related loss of the early life stages of winter-run Chinook salmon (>10 percent as predicted by Reclamation's Salmon Mortality Model). Implementation of drawdowns below the 600 TAF minimum end-of-year carryover level in Trinity Reservoir shall be determined by Reclamation, Service, and NMFS on a case-by-case basis in dry and critically dry water years. (Term from NOAA Fisheries BO.)

The following mitigation measures would reduce potentially significant impacts from mercury release and mercury methylation to less than significant levels:

- Sediments removed during construction of restoration sites would be disposed in compliance with applicable hazardous materials regulations. Initial indications from sampling efforts in the watershed indicate that mercury levels are within allowable thresholds. However, sampling for presence of mercury in sediments excavated during construction of restoration sites will be conducted. Sediments slated to be excavated will be sampled once for every twenty feet of linear distance parallel to the river. Two thresholds will be used to determine hazardous nature of mercury contaminants. The first, called a NOAA ERL benchmark, will be used to determine whether sampled sediments must be removed from the river course or may be left within the normal course of the river. Sediment will be left in place where samples were recorded below 0.15 mg/kg for mercury. Sediment samples above the NOAA ERL benchmark, but below the TTLC and STLC thresholds (20 mg/Kg and 0.2 mg/L respectively) will be excavated and deposited above the 100 year flood plain. Deposits will be covered with topsoil and revegetated. Samples above TTLC and STLC thresholds will be treated as hazardous waste, removed, and transported to an approved hazardous waste treatment site. All activities will be performed pursuant to applicable laws.

- During the normal permitting process for construction of the restoration sites, TRRP staff will coordinate with the NCRWQCB to ensure that water quality objectives are met. During coordination with NCRWQCB staff, it may be determined that the above standards should be modified to better reflect local conditions at the restoration sites. Should alternate thresholds be identified by NCRWQCB staff, they would supercede the thresholds outlined above.

- Final design of the restoration projects shall include consideration of potential sources of sulfate and possible creation of anaerobic wetland environments that would accelerate mercury methylation. Restoration sites that create an interface between a known source of sulfate and an anaerobic condition are to be avoided.

Significant impacts identified for the increased frequency of Sacramento Basin temperature and carryover storage violations for the Maximum Flow, Flow Evaluation, 70 Percent Inflow, Revised mechanical, and Modified Percent Inflow Alternatives would need to be evaluated by NOAA Fisheries pursuant to the ESA. Such

consultation could result in modification of the existing BO. An evaluation of effects on Sacramento fisheries and potential mitigation is presented in Section 3.4 fishery resources. Currently, ongoing ESA consultation with NOAA Fisheries is occurring through the OCQP process , as described in Section 1.

The following mitigation could reduce impacts of temperature violations in the Sacramento River:

- Bypassing the Trinity Powerplant in order to provide colder water for diversion to the Sacramento River (see above). (Term from NOAA Fisheries BO.)
- Reducing wet-season instream flow requirements for the Sacramento River to increase dry-season carryover storage in Shasta Reservoir.
- If approved by EPA, rescheduling the wet-season portion of the 200-cfs Iron Mountain Mine dilution flows to spring/summer in a way that would improve Sacramento River temperatures.
- Be prepared to make use of the auxiliary bypass outlets on Trinity Dam as needed, and pursuant to reinitiation of ESA Section 7 consultation regarding Sacramento River winter-run Chinook salmon, to protect water quality standards; associated actions may include modification of the export schedule of Trinity Basin diversions to the Sacramento River. (Term from NOAA Fisheries BO.)

In addition to consultation under ESA, the potentially significant water quality-related impacts (impacts to listed salmonids in the Sacramento River) could be lessened by the development of additional water supplies to meet demands. A number of demand- and supply-related programs are currently being studied across California, many of which are being addressed through the on-going CALFED and CVPIA programs and planning processes. Although none of these actions would be directly implemented as part of the alternatives discussed in this Supplemental EIS/EIR, each could assist in offsetting impacts resulting from decreased Trinity River exports. Examples of actions being assessed in the CALFED and CVPIA planning processes include:

- Develop and implement additional groundwater and/or surface-water storage. Such programs could include the construction of new surface reservoirs and groundwater storage facilities, as well as expansion of existing facilities. Potential locations include sites throughout the Sacramento and San Joaquin Valley watersheds, the Trinity River Basin, and the Delta.

- Purchase long- and/or short-term water supplies from willing sellers (both in-basin and out-of-basin) through actions including, but not limited to, temporary or permanent land fallowing.
- Facilitate willing buyer/willing seller inter- and intra-basin water transfers that derive water supplies from activities such as conservation, crop modification, land fallowing, land retirement, groundwater substitution, and reservoir re-operation.
- Promote and/or provide incentive for additional water conservation to reduce demand.
- Decrease demand through purchasing and/or promoting the temporary fallowing of agricultural lands.
- Increase water supplies by promoting additional water recycling.

Because the outcome of the planning processes described above remains unknown, water quality impacts to salmonid species in the Sacramento River are considered at present to be significant and unavoidable. It is anticipated as a result of presently ongoing consultation with NOAA fisheries on the revised CVP-OCAP that some or all of the above mitigation measures may be adopted as terms and conditions of any BO that results from that consultation. Additional discussion of these impacts are addressed in Section 3.4, Fishery Resources.

3.4 Fishery Resources

Fishery resources include fish populations and their habitats. This section discusses the existing environment within the Trinity River Basin, Lower Klamath River Basin/Coastal Area, and Central Valley with regard to native anadromous fish, resident native and non-native fish, and reservoir species, as well as the environmental consequences of implementing each of the alternatives presented in Section 2.0.

The conclusions reached through this section are based on detailed technical studies described at much greater length in the Fishery Resources Technical Appendix B. To the degree possible, the conclusions described in this section are expressed in language understandable to lay readers, as well as in relatively uncomplicated quantitative terms embodied in tables.

3.4.1 Native Anadromous Species

Anadromous fisheries have been impacted by a number of factors, including dams, which have substantially reduced habitat on the Trinity and Klamath Rivers and rivers in the Central Valley. In spite of those impacts, reduced anadromous salmonid fishery resources are still found within the Trinity River Basin, Lower Klamath River Basin/Coastal Area, and the Central Valley. Many of the fish species found within the lower Klamath River Basin are also found within the Trinity River Basin. The coastal areas adjacent to the Klamath River Basin provide habitat for maturing and adult anadromous fish species that return to the lower Klamath and Trinity River Basins. The TRSSH is intended to mitigate for the reduced salmon and steelhead production resulting from the loss of habitat and associated production upstream of Lewiston Dam by releasing steelhead, coho salmon, and Chinook salmon young into the Trinity River. Other native anadromous fish species found in the areas affected by the project include Pacific lamprey, green and white sturgeon, and eulachon.

Affected Environment.

Trinity River Basin. The native anadromous salmonid species of interest in the Trinity River and its tributaries include steelhead, coho salmon, and Chinook salmon. Of the three species, there are two spawning populations of Chinook salmon (spring and fall) and two spawning populations of steelhead (winter and summer). All anadromous species begin their life in fresh water, then migrate to the ocean to mature, and return to spawn in fresh water. Some life history and habitat requirements of these species and the spawning populations within species are presented in Table 3.4-1.

Although the three species have similar growth and migration patterns (Figure 3.4-1), they differ in the time of year they migrate and spawn, as well as when egg incubation typically occurs (Figure 3.4-2).

TABLE 3.4-1
Life History and Habitat Needs for Anadromous Salmonid Fish in the Trinity River Basin

Name	Migration	Spawning	Rearing	Rearing Habitat Description
Chinook (spring)	Spring-Summer	Early Fall	Winter-Spring-Summer	Shallow, slow-moving waters adjacent to higher water velocities for feeding.
Chinook (fall)	Fall	Fall	Winter-Spring-Summer	Shallow, slow-moving waters adjacent to higher water velocities for feeding.
Steelhead (winter)	Fall-winter	February-April	Year round	Areas of clean cobble where there is refuge from high velocities; juveniles overwinter for 1 to 2 or more years.
Steelhead (summer)	Spring-Summer	February-April	Year round	Areas of clean cobble where there is refuge from high velocities; juveniles overwinter for 1 to 2 or more years.
Coho	October-December	November-December	Year round	Backwater areas of slow water and pool margins; juveniles overwinter 1 year.

Adequate flows, temperatures, water depths and velocities; appropriate spawning and rearing substrates (e.g., riverbed gravels); and availability of instream cover and food are critical for the production of all anadromous salmonids. Spring Chinook salmon and summer steelhead also need long-term adult holding habitat in which pool size and depth, temperature, cover, and proximity to spawning gravel are important requirements. Newly emerged fry and juveniles of all species require rearing habitat with low velocities, open cobble substrate, and cool water temperatures. Emigration of smolts to the ocean and the immigration of spawning adults require adequately timed flows with the appropriate temperature, depth, and velocity.

Native non-salmonid anadromous species found in the Trinity River Basin include green and white sturgeon and Pacific lamprey. These fish spend their early life stages in fresh water, migrate to the ocean

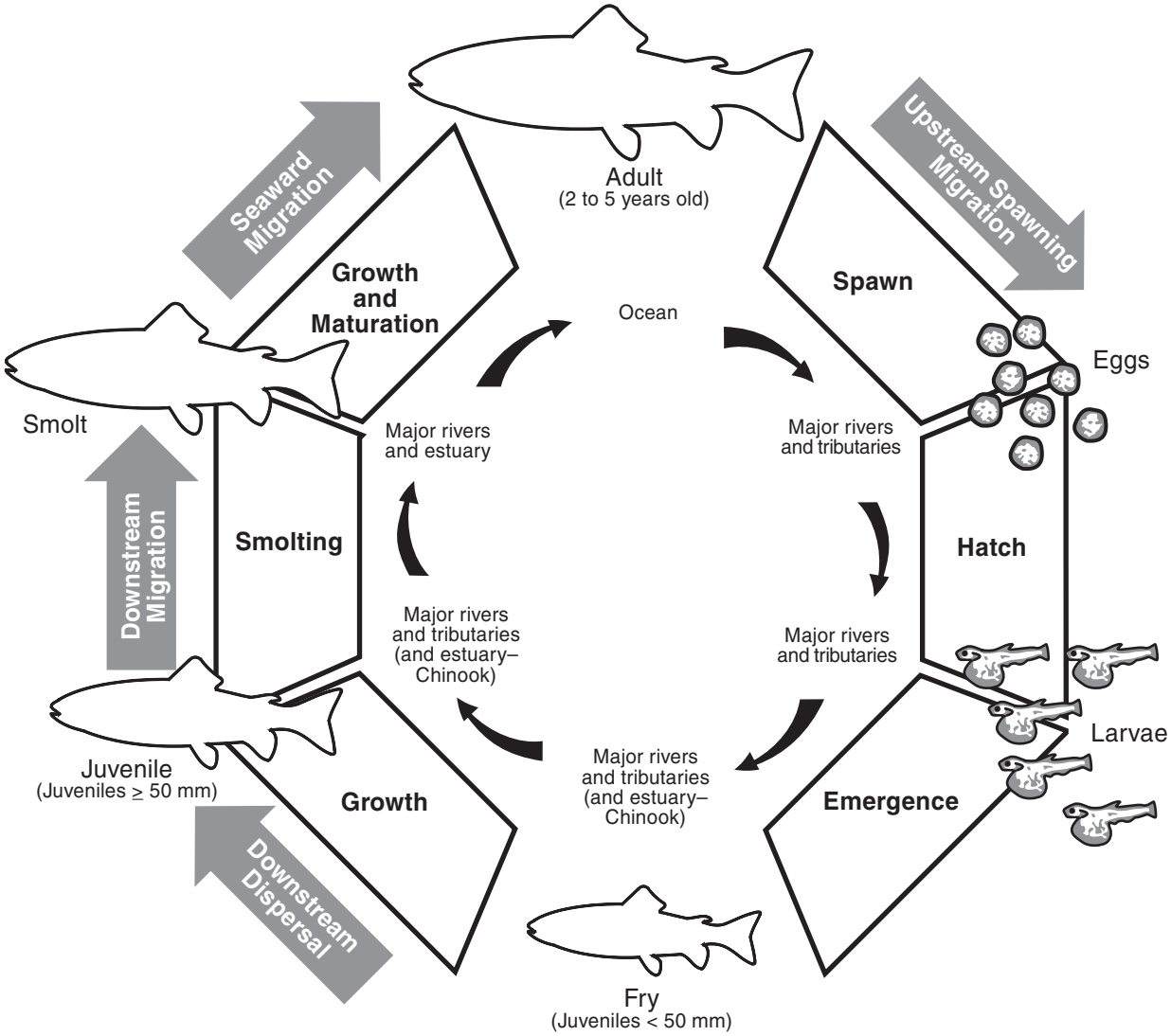

FIGURE 3.4-1
GENERAL LIFE HISTORY
OF ANADROMOUS SALMONIDS
TRINITY RIVER FISHERY RESTORATION SUPPLEMENTAL EIS/EIR

W022004007RDD_012 (4/2/04)

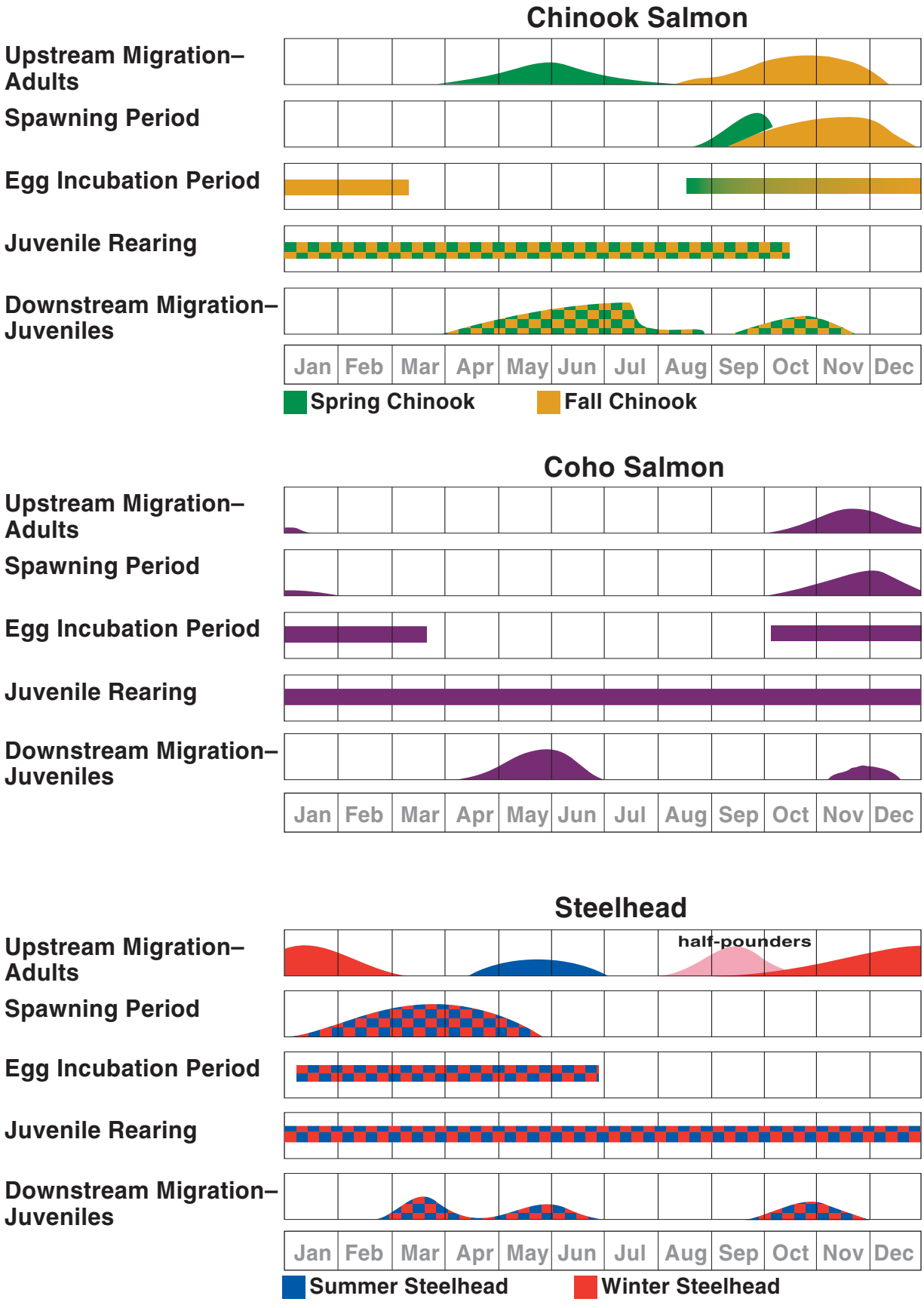

FIGURE 3.4-2
TEMPORAL DISTRIBUTION OF ANADROMOUS SALMONID
TRINITY RIVER FISHERY RESTORATION SUPPLEMENTAL EIS/EIR

W022004007RDD_301 (4/2/04)

for maturation, and return to their natal stream to spawn (Table 3.4-2). Status information on native non-salmonid anadromous species residing in the Trinity River Basin is very limited. However, the Klamath/Trinity River Basin is known to contain the largest spawning population of green sturgeon in California. In contrast, only small runs of white sturgeon occur.

TABLE 3.4-2
Life History and Habitat Characteristics of Non-salmonid Native Anadromous Fish in the Trinity River and/or Klamath River Basins

Name	Migration	Spawning	Rearing	Rearing Habitat Descriptions
Pacific Lamprey	April-July	Spring-early summer	Year round	Developing larvae burrow into silty river-bottom substrates, where they remain for 4 to 5 years before emigrating to the ocean.
Green and White Sturgeon	February-July	March - July	Year round	Juveniles inhabit estuarine environments for 4 to 6 years before migrating to the ocean.
Eulachon	March-April	March-April	--	Adhesive eggs anchored to bottom until hatched; larvae quickly transported to ocean.

Trinity River Restoration Program Goals. The 1983 EIS on the Trinity River Basin Fish and Wildlife Management Program (Service, 1983) documented the inriver spawner escapement goals and the TRSSH production goals developed by CDFG. The goals were subsequently adopted by the TRRP as escapement numbers. The inriver goals represent the total number of naturally-produced adult spawners (excluding jacks) for the Trinity River Basin below Lewiston Dam and exclude fish caught by the commercial, recreational, and tribal fisheries (Table 3.4-3). The hatchery goals represent numbers of adult fish needed by the hatchery, exclusive of fisheries for Chinook and coho salmon (an undefined inriver harvest is included in the restoration program goals for steelhead).

TABLE 3.4-3
Trinity River Restoration Program Goals

Species	Inriver Spawner Goals	Hatchery Goals	Total
Fall Chinook Salmon	62,000	9,000	71,000
Spring Chinook Salmon	6,000	3,000	9,000
Coho Salmon	1,400	2,100	3,500
Steelhead	40,000	10,000	50,000

Because the project purpose is the restoration and maintenance of the natural production of anadromous salmonids below Lewiston Dam, the following discussions concern the inriver spawner escapement goals (adults only) and the numbers of fish returns (jacks and adults) that were naturally produced. Restoration and maintenance of natural production implies that the fish spawning in river began their life as eggs in the river and that a sufficient percentage of those eggs spawned in the river survive to return as adults to spawn; in other words, naturally producing populations are self-sustaining.

Inriver spawner escapement is the number of fish returning to spawning grounds, which in reality consists of two factions: naturally-produced fish and hatchery-produced fish. However, hatchery-produced fish are not considered to contribute towards the inriver spawner escapement goals of the TRRP, although their offspring do (i.e., if hatchery-produced fish spawn inriver and their offspring survive to return to spawn, these offspring are naturally produced by definition [see "natural production" in glossary]). The best available data indicate that large numbers of hatchery-produced fish spawn inriver. Typically, more fish spawn inriver than are spawned at the hatchery, and relatively fewer inriver eggs survive to return as adults. Assuming that hatchery- and naturally-produced fish are subject to the same environmental conditions after the hatchery releases its fish (typically as smolts), the relatively low returns of naturally-produced fish are indicative of low survival rates of young freshwater life stages (eggs, fry, and/or juvenile fish).

Fall Chinook Salmon Populations. Although annual pre-dam escapement data are sporadic, estimates of Chinook salmon in the Trinity River prior to 1964 above the North Fork have ranged from 19,000 to 75,600, and averaged 45,600 for the 5 years of available data. Comparisons between pre- and post-dam averages are problematic because (1) few pre-dam estimates exist; (2) pre-dam estimates typically represent fish spawning in the river above the North Fork, while post-dam estimates are above Willow Creek; and (3) post-dam estimates are only for the river below Lewiston and are confounded by large numbers of hatchery-produced fish that spawn in natural areas (recent changes have been implemented to reduce competition of hatchery-produced fish with naturally-produced spawners).

Comparisons between pre-dam escapements and the TRRP inriver spawner escapement goals are also problematic because the inriver goals represent the numbers of fish that could be produced in the entire Trinity River Basin below Lewiston Dam once successful restoration is completed, whereas the pre-dam numbers are sporadic and limited to the Trinity River above the North Fork. Because of these problems, the following discussions focus on the current post-

dam estimates relative to the TRRP inriver spawner escapement goals as an indicator.

According to the TRRP goals, the hatchery is to produce 9,000 returning fall Chinook spawners for the hatchery, and the river below Lewiston is supposed to produce 62,000 naturally-produced fall Chinook spawners. Both of these goals are exclusive of harvest. Yearly estimates of fall Chinook salmon runs in the Trinity River Basin have been made by the CDFG since 1978, as a part of the Klamath Basin Fall Chinook Salmon Spawning Escapement Estimate (see the Fishery Resources Technical Appendix B). CDFG's post-dam inriver spawner escapement estimates for the Trinity River Basin upstream of the Willow Creek weir from 1982 through 2002 averaged 31,848 fall Chinook salmon, of which an average of 19,801 are hatchery-produced/origin fish. The river below Lewiston produced an average of 12,047 naturally-produced fall Chinook spawners, which is approximately 19 percent of the TRRP goal of 62,000 naturally-produced fall Chinook salmon (Table 3.4-4). Naturally-produced fish have ranged from 10 to 94 percent of inriver spawner escapements (Figure 3.4-3), with an annual average of 42 percent.

TABLE 3.4-4
Comparison of TRRP Inriver Spawner Escapement Goals to Average Numbers of Naturally-produced Fish

Species	TRRP Inriver Spawner Escapement Goals	Average Inriver Escapement of Naturally-produced Fish	Years of Available Data	Percent of TRRP Goal Met
Fall Chinook Salmon	62,000	12,047	1982-2002	19
Spring Chinook Salmon	6,000	3,217	1982-2002 (excluding 1983 and 1995)	54
Coho Salmon	1,400	582	1991-2002 (excluding 1996)	42
Steelhead	40,000	2,326	1992-2002 (excluding 1995-2001)	6

Spring Chinook Salmon Populations. Escapement surveys for the years 1982 through 2002 (excluding 1983 and 1995 because surveys were not conducted in those years) indicate that an average of 61 percent of the inriver spawner escapement of Trinity River spring Chinook salmon is hatchery produced/origin. Conversely, only 39 percent (3,217 annually) were naturally produced, which represents approximately 71 percent of the TRRP goal of 6,000 spring Chinook in the Trinity River (Table 3.4-4).

Coho Salmon Populations. Trinity River coho salmon populations were historically much smaller than Chinook salmon populations. Pre-dam estimates for coho salmon spawning above Lewiston were 5,000 fish (Service/CDFG, 1956). Total run size for Trinity River

coho salmon below Lewiston Dam for 1973 through 1980 averaged 3,300 adults (Leidy and Leidy, 1984). The estimate includes hatchery production. From 1991 through 2002 (excluding 1995 when no surveys were made), naturally-produced coho salmon spawning in the Trinity River upstream of the Willow Creek weir averaged 582 fish, ranging from 0 to 19 percent of the total annual inriver escapement (an annual average of 7 percent). Approximately 11,332 of the coho salmon spawning inriver are produced by the hatchery. The average of 582 naturally-produced coho salmon represents approximately 42 percent of the TRRP goal (Table 3.4-4).

Steelhead. Pre-dam winter steelhead spawner escapements in the Trinity River and its tributaries upstream of Lewiston have been estimated to range from 6,900 to 24,000 adults. From the years 1980, 1982-1984, and 1988-2002, the estimated total inriver spawner escapement of the fall/early winter portion of winter steelhead upstream of the Willow Creek weir averaged 7,880 adult fish. Estimates of inriver naturally-produced spawning steelhead for the years 1992 through 1995 and 2002 averaged 2,326 fish upstream of the Willow Creek weir (surveys from fall and early winter period only). This average represents approximately 6 percent of the TRRP inriver spawner escapement goal of 40,000 adult steelhead (Table 3.4-4). Estimates for the remaining winter portion of the escapement are unavailable because increased river flows render fish-counting weirs inoperable.

Pre-dam summer steelhead spawner escapements for the Trinity River upstream of Lewiston were estimated to average 8,000 adults annually. Recent post-dam CDFG survey estimates have ranged from 20 to 1,037 adult summer steelhead in the tributaries and Trinity River. The TRRP escapement goals do not establish specific targets for summer steelhead in the Trinity River, nor does the TRSSH mitigate specifically for summer steelhead.

Some Trinity River steelhead return to the river 4 to 6 months after first emigrating to the ocean. Upon their return these fish are known as half-pounders. They feed in the river but do not spawn. They subsequently return to the ocean before returning to spawn. When in the half-pounder phase, these fish are not counted as part of the escapement, but they are important to the sport fishery.

Species Listed and Proposed for Listing under the Endangered Species Act and California Endangered Species Act. The Southern Oregon/ Northern California Evolutionary Significant Unit (ESU) of naturally-produced coho salmon was listed as threatened pursuant to the ESA on April 25, 1997. This listing includes naturally-produced coho from the Trinity River and Klamath River Basins. Critical

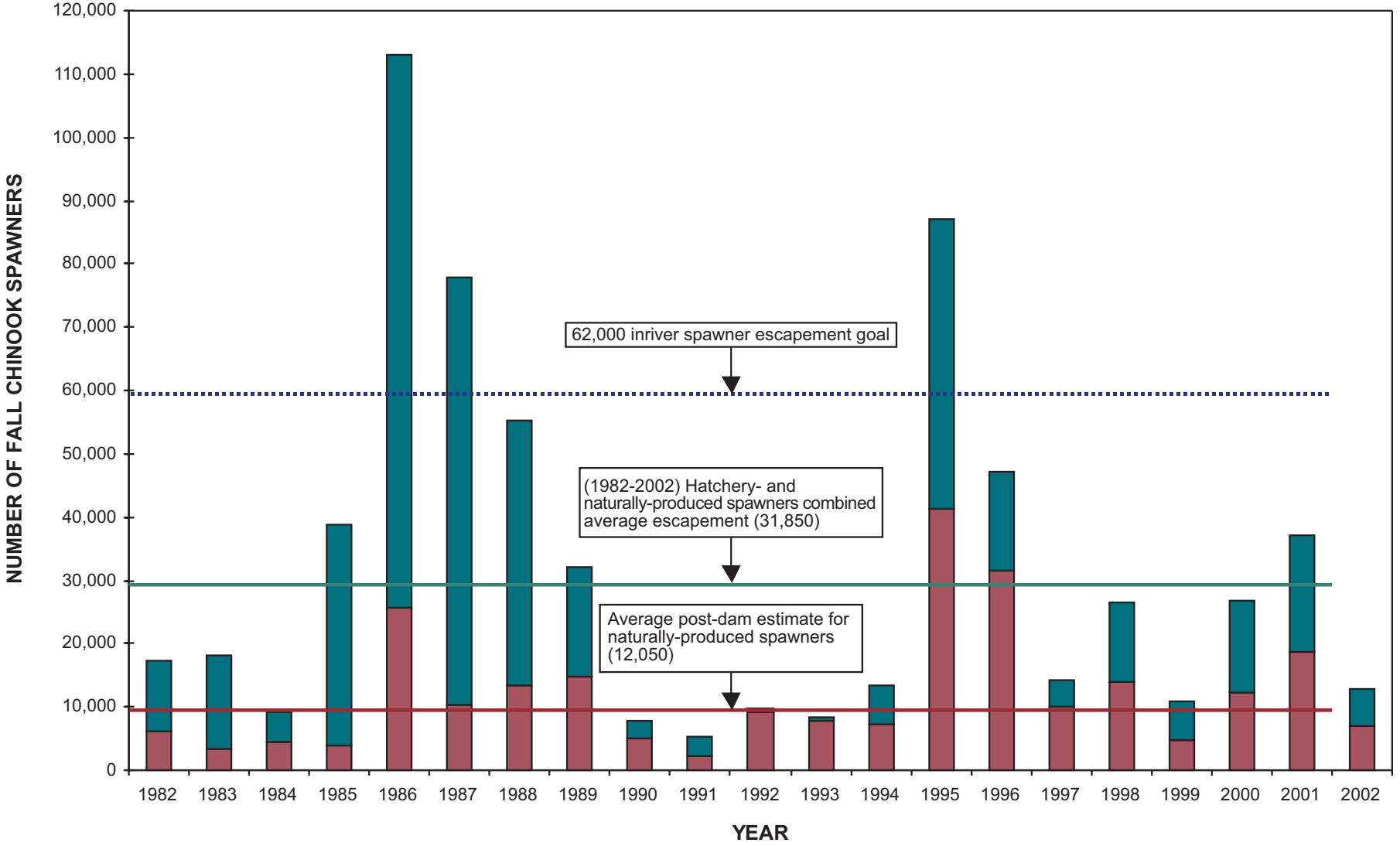

FIGURE 3.4-3
FALL CHINOOK SPAWNER ESCAPEMENT IN THE TRINITY RIVER (1982-2002)
TRINITY RIVER FISHERY RESTORATION SUPPLEMENTAL EIS/EIR

W022004007RDD_19 (4/8/04)

habitat for the ESU was designated on May 5, 1999. Under CESA, coho salmon runs north of San Francisco are a state species of special concern.

The Klamath Mountains Province ESU steelhead, which includes stocks from the Trinity River, was first proposed for listing as threatened on March 16, 1995; but on April 4, 2001, NOAA Fisheries, following a re-evaluation of the status of the species, determined that the population did not warrant threatened status.

Trinity River Salmon and Steelhead Hatchery. The TRSSH is operated by CDFG and funded by Reclamation to mitigate for the loss of salmonid production above Lewiston Dam. TRSSH's current goals are to release sufficient juveniles to provide for returns to the hatchery of 12,000 Chinook (3,000 spring and 9,000 fall), 2,100 coho, and 10,000 steelhead through artificial propagation. Concerns regarding the potential impacts of hatchery operations on naturally-produced populations of the Klamath River Basin (including the Trinity River) prompted the CDFG to institute new hatchery operations in 1996 to minimize future impacts.

Fish Harvest. The harvest of Klamath River Basin fall Chinook salmon (including Trinity River Basin) is managed jointly by the CDFG, Oregon Department of Fish and Wildlife, California Fish and Game Commission, Yurok Tribe, Hoopa Valley Tribe, NOAA Fisheries, and BIA. The PFMC and the Klamath Fishery Management Council are allocation forums for the ocean and ocean/inriver fisheries, respectively. The mixed-stock ocean population is harvested by commercial and sport fisheries; and the inriver population is harvested by tribal (ceremonial, subsistence, and commercial) and sport fisheries. Chinook salmon harvest (both fall and spring) includes both naturally-produced and hatchery-produced fish.

Coho harvest in the ocean commercial troll fishery has been prohibited in California and Oregon, and reduced in Washington, since 1994. Coho harvest has also been prohibited in the California ocean sport fishery, and reduced in Oregon. Coho harvest is only allowed in the tribal inriver fisheries as incidental take during the harvest of Chinook salmon.

Steelhead are rarely caught in the ocean commercial and sport fisheries, but are harvested by the inriver tribal and sport fisheries.

Historically, Klamath/Trinity River Chinook and coho populations have been harvested in the ocean from Monterey County, California, to the Oregon/Washington border. Ocean harvest of naturally-produced salmon may have been sufficient in the late 1970s to cause declines in Klamath River Basin (including Trinity River)

populations, but, based on the best available data, fall Chinook harvest management restrictions implemented since 1986 have decreased harvest impacts to levels believed to be sustainable.

Habitat Conditions. Construction and operation of the TRD, combined with watershed erosion, large-scale gold dredging, and other harmful land management activities, have caused major changes in habitat conditions in the Trinity River. Factors that have resulted in adverse effects on fish habitat include:

- Obstruction to river reaches upstream of Lewiston Dam
- Changes to quantity and timing of flows
- Changes in channel geomorphology
- Changes in substrate composition caused by addition of fine sediments and restriction of gravel recruitment
- Changes in water temperature

The TRD dams blocked access to 59 miles of Chinook salmon habitat, 109 miles of steelhead habitat, and an undetermined amount of coho salmon habitat (Service, 1994). Much of this habitat was prime spawning and rearing habitat. In the case of the Chinook, it represented 50 percent of spawning habitat in the basin. As early as 1980, overall decline in spawning habitat was estimated at 80 to 90 percent (Service, 1980). Furthermore, elimination of the upstream reaches greatly reduced the diversity of the entire river system, thereby reducing habitat choices for salmonids.

For the first 21 years of TRD operations, Lewiston Dam releases to the Trinity River were only 21 percent of natural flows. The volume of water initially set aside for Trinity River fishery resources during this time period was 120 taf, which was only exceeded during extreme storm events or for fishery studies. Perhaps more significantly, the peak winter and spring flows were eliminated or greatly reduced. The harmful effects of the reduced flows were manifested in several ways, including changes to channel geomorphology, substrate composition, and water temperatures. Ultimately, the reduction in flows has lead to a reduction in habitat. For example, spawning habitat losses have been estimated to be 80 percent in the first 2 miles below Grass Valley Creek, and 50 percent in the 6 miles downstream of that confluence (Service, 1994).

Reduced river flows, increases in fine sediment input, and reductions in coarse sediment recruitment are the primary factors in changes to channel geomorphology resulting in the reduced quality, quantity, and suitability of fish habitat and reduced survival of freshwater life stages. The altered channel geomorphology reduced the number and

quality of alternate bar sequences. Important salmonid habitats associated with alternate bars include: pools that provide cover from predators and cool resting places for juveniles and adults; gravelly riffles where adults typically spawn; open gravel/cobble bars that create shallow, low-velocity zones important for emerging fry; and slack-water habitats for rearing juveniles.

Since TRD operation, the Trinity River has become channelized (i.e., the river banks have become more vertical, and there is little lateral movement of the channel within the floodplain). Consistently low river flows allowed the encroachment and establishment of riparian vegetation. The roots of the vegetation, which bound spawning gravel, and the stalks of the vegetation, which encouraged deposition of fine sediment, lead to the formation of sand berms along the river banks. This encroachment of riparian vegetation and subsequent berm formation further narrows the channel and reduces shallow, low-velocity salmonid rearing habitat and habitat diversity. (See Geomorphic Environment [Section 3.2] in the Draft EIS/EIR for additional information.)

Changes in substrate composition have occurred because of increases in fine sediment (from increased watershed erosion and attenuation of sediment-transporting flows) and the reduction of coarse sediment (e.g., gravel) recruitment (due to the dams). Fine sediment fills in spaces between gravels and cobbles, which inhibits the percolation of water through these areas, degrading and reducing available spawning habitats. Sedimentation of spawning areas can inhibit flow (and thus oxygen) to incubating eggs as well as create an impenetrable barrier that prevents salmon sac-fry from emerging from their gravel nest. Accumulation of fine sediments can also decrease the amount of space between gravel and cobble, thereby decreasing the amount of available habitat for overwintering juvenile coho salmon and steelhead that burrow into the substrate. Sedimentation may also decrease aquatic invertebrate production and diversity, thereby limiting the primary food source for juvenile salmonids.

Construction and operation of the TRD changed the thermal diversity available to Trinity River anadromous salmonids. The dams blocked access to the upstream reaches that are dominated by snowmelt runoff and remain cool throughout the year. Prior to the dam, these areas provided important juvenile rearing and adult holding habitats for salmonids when the majority of the lower mainstem habitats (i.e., below Lewiston) had likely become too warm. The upstream tributaries (dominated by snowmelt) provided increased flows and decreased temperatures during the spring and early summer that aided smolt emigration through much of the mainstem. Because these habitats are now blocked by the TRD, and

much of the snowmelt is retained in the TRD reservoirs, it is necessary to artificially maintain cooler temperatures below the dam than those that existed prior to the dam. In other words, the mainstem below the dam must now function thermally like the upstream reaches and tributaries (for anadromous salmonids). Exacerbating the problem is the decrease in geomorphic diversity below the dam. Prior to the TRD, water temperatures in the deep mainstem pools stratified; bottom layers were documented as much as 7°F cooler than upper layers (Moffett and Smith, 1950). The cool temperatures at the bottom of the pools provided important thermal refugia for migrating adult and rearing juvenile salmonids. The altered flow regime and channel geomorphology decreased or eliminated the temperature stratification in pools in the summer/ early fall months. Although average post-dam monthly water temperatures at Lewiston are cooler than pre-dam temperatures during June to November, this benefit has not fully compensated for the lost thermal diversity in the system (i.e., above the dams) or for the reduction in stratified pools.

Habitat Restoration Projects. Since the early 1980s, the Trinity River Basin Fish and Wildlife Restoration Program has conducted a variety of restoration activities in the Trinity River and its tributaries. Some activities conducted in tributaries include watershed restoration work, as well as habitat enhancement projects, and dam construction and pool dredging in Grass Valley Creek to decrease the amount of fine sediment entering the Trinity River. Restoration activities that have been implemented in the mainstem include gravel placement, pool dredging, and construction of several channel rehabilitation projects (side channels and bank rehabilitation of point bars).

The Trinity River Basin Fish and Wildlife Restoration Program constructed 27 channel rehabilitation projects on the Trinity River between Lewiston Dam and the North Fork: 18 side-channel projects and 9 bank rehabilitation projects (also known as feathered-edge projects). Monitoring documented Chinook salmon spawning within the constructed side-channels. Observations also indicate that the side channels are used extensively during the spring by rearing Chinook salmon juveniles and coho fry. (Glase, 1994 pers. comm).

The remaining nine projects were bank rehabilitation projects between Lewiston Dam and the North Fork. The projects were constructed by physically removing vegetated sand berms along the bank to restore the channel to a pre-dam configuration. Channel rehabilitation sites are significantly wider and shallower than corresponding control sites at intermediate and high flows. Along with promoting formation of alluvial features characteristic of unregulated rivers, channel rehabilitation projects have been shown to increase the amount and diversity of habitat for adult and juvenile salmon and steelhead. During recent

investigations, salmonid fry habitat indexes were greater at rehabilitation sites than at corresponding control sites. Catch-per-effort for Chinook salmon fry was also greater at rehabilitation sites than at control sites, suggesting greater habitat use at these sites. Spawning surveys at project locations have also shown high use of these areas by spawning Chinook salmon.

The Trinity County Planning Department and the Trinity County Resource Conservation District compiled a database of 477 known fishery and watershed restoration projects in the Trinity River Basin and the Lower Klamath River Basin between the confluence of the Trinity River and the mouth of the Klamath River (Trinity County Planning Department, 2003).

Lower Klamath River Basin/Coastal Area. The Klamath River is California's second largest river, with an average annual flow in excess of 13 maf. The river provides habitat for Chinook and coho salmon, and winter and summer steelhead. Coastal cutthroat trout are also found in the lower reaches.

Native non-salmonid anadromous fish found in the Klamath River include Pacific lamprey and green and white sturgeon. Large runs of candlefish (eulachon) occurred in the lower Klamath River as recently as the 1970s; however, today the run size is small and sporadic. In some years, e.g., 1999, a small run is documented, while in other years the run goes unnoticed. The reasons for their decline are not known.

The coastal area adjacent to the Klamath River Basin provides habitat for the oceanic stages of anadromous fish found in the lower Klamath and Trinity River Basins. Habitat conditions in the coastal area and ocean environment are subject to natural ecosystem productivity as affected by physical and biological oceanic processes, weather, and climate. The primary influence of humans on anadromous salmonids in the coastal areas adjacent to the Klamath River Basin is ocean commercial and sport harvest.

CDFG compiles annual estimates of fall Chinook spawner escapements and tribal and sport harvests in the Klamath River Basin. The average inriver fall-run Chinook salmon estimate for the Klamath River Basin for the period 1982 through 2002 is approximately 128,700 adults and jacks. The estimated total spawner escapement (inriver run: inriver harvest and harvest mortality) in the Klamath River Basin during that period has averaged approximately 90,500 spawners. Klamath River Basin fall Chinook are managed for a 33 to 34 percent brood escapement rate, or a minimum escapement level of 35,000 fish, whichever is greater (excluding returns to hatcheries). This minimum was established in 1989 by the PFMC. Long-term declines of Klamath River Basin fish populations have

been attributed to land use conflicts, water diversions, harvest, ocean conditions, dams, and inriver habitat conditions.

The lower Klamath River supports a sport fishery for anadromous salmonids. In addition, approximately 80 percent of the Klamath/ Trinity Indian gill-net harvest of salmon occurs in the lower Klamath River.

Central Valley. The Central Valley provides habitat for several species of native anadromous fish, including freshwater stages of Chinook salmon and steelhead. (A thorough discussion of Central Valley fisheries is provided in the CVPIA PEIS and associated appendices.) The Sacramento and San Joaquin Rivers provide corridors to the ocean for anadromous salmonids spawned and reared within Central Valley rivers, streams, and hatcheries.

The Sacramento River is the largest river system in California and, along with the hatcheries on its tributaries, produces more than 90 percent of the Central Valley salmon and steelhead. The Sacramento River supports four runs of Chinook salmon: fall, late-fall, winter, and spring, with fall Chinook being the most abundant. From 1967-1991 the fall Chinook spawner escapement in the mainstem Sacramento River averaged 77,000 fish; for late-fall Chinook it averaged 14,000 fish, and for spring Chinook it averaged 11,000 (Reclamation, 1997). Most of the Central Valley fall steelhead are also found in the Sacramento River Basin. Coho salmon and cutthroat trout are not currently known to reside in the Central Valley.

Many factors affect the abundance of anadromous fishery resources in the Central Valley. Many of the same factors that resulted in declines in fishery resources over the past 150 years continue to plague existing populations. Those factors include: modification and loss of habitat, reduction in magnitude and change in timing of streamflows, damming and diversions, deterioration of water quality (including temperature), sport and commercial harvest, and competition and loss of genetic diversity through cross breeding with hatchery-produced fish. The direct cause and effect relationships of any one or all of these factors as they may have and continue to affect anadromous fish populations are unknown. Cumulatively, they have taken their toll on these species' ability to exist in the Central Valley. Ongoing efforts to arrest the decline and restore native anadromous fish populations, including projects resulting from the 1992 CVPIA, are ongoing in an attempt to reverse the decline of those populations.

Native non-salmonid anadromous fish in the Central Valley include green sturgeon, white sturgeon, and Pacific lamprey. The population of adult white sturgeon in the Central Valley has been estimated to be

64,000 fish. Adult green sturgeon abundance is estimated at 870 fish. There are no estimates of Pacific lamprey in the Central Valley.

The population status of most, if not all, of these species are less precisely known than that of the anadromous salmonids in the Central Valley. With the exception of hatchery and commercial harvest, the factors affecting the abundance of native non-salmonid anadromous species are likely similar to those for native salmonid species. Reductions and timing of flows, loss of habitat quantity and quality, and water diversions likely have been largely responsible for declines in population of these species.

Limiting Factors. Major factors limiting native anadromous fish populations in the Central Valley include:

- Water diversions, including several large diversions and hundreds of unscreened diversions throughout the Sacramento and San Joaquin Rivers.
- Water diversions at the state and federal pumps in the Delta.
- Increased water temperatures within Central Valley rivers and the Delta.
- Blockage of habitat by major dams (e.g., Shasta Dam).
- Habitat loss and degradation in the rivers and the Delta.
- M&I, agricultural, and mining waste discharge that degrades water quality.
- Predation by introduced species.
- Inadequate instream flows within the rivers and reduced outflows in the Delta.
- Altered Delta inflow and outflow that affect salinity, currents, nutrient levels, and pollutant concentrations.

Species Listed and Proposed for Listing under the Endangered Species Act and California Endangered Species Act. Winter-run Chinook salmon were listed endangered under the CESA in 1989. They were listed as threatened under the ESA in 1989 under emergency provisions, and formally listed in 1990. (For a discussion of the legal requirements created by both CESA and ESA, see Section 5.0 of the Draft EIS/EIR.) On January 4, 1994, they were reclassified as endangered. On June 16, 1993, NOAA Fisheries designated critical habitat for the species as the Sacramento River from Keswick Dam to San Francisco Bay. The Central Valley ESU steelhead was listed as threatened under the ESA on May 18, 1998. Central Valley ESU spring Chinook salmon were listed as threatened under the CESA on February 6, 1999, and were listed as threatened under the ESA on November 15, 1999. Fall and

late-fall Chinook salmon ESUs remain candidates for listing under ESA.

Environmental Consequences.

Methodology. Alternatives were compared against one another under the following set of conditions likely to be in place by the year 2020:

- The Trinity River Hatchery would be operated as it is currently, and operations would not impact natural production of anadromous salmonids.
- All anadromous salmonid species would respond similarly to actions of any particular project, except as noted below.
- Any rehabilitation sites and/or watershed work are assumed to be complete, and the river system processes would be functioning at the full level of their ability within the given flow regime(s). The anadromous fish populations, although not constant from year to year because of varying environmental conditions (especially oceanic factors), would be at their long-term average.
- Except as noted, the analysis assumed the historical distribution of Trinity River Basin water-year classes.

The Trinity River System Attribute Analysis Method (TRSAAM) was developed to analyze the proposed alternatives. The TRSAAM was developed using the fundamentals and relationships of key river system characteristics and functions that create and maintain diverse salmonid habitats (Service and Hoopa Valley Tribe, 1999) (see the Geomorphic Environment [Section 3.2] of the Draft EIS/EIR). The methodology used to analyze the geomorphic environment (i.e., healthy alluvial river model) was modified and used to evaluate the impacts of the alternatives on fishery resources. The TRSAAM used 9 of the same 10 attributes and objectives presented in Table 3-1 of the Draft EIS/EIR. Water temperatures were evaluated separately as to their ability to meet salmonid smolt emigration requirements because of the possible independent nature of temperature effects separate from structural habitat considerations (Fishery Resources Technical Appendix B). Together, the 10 TRSAAM attributes and the smolt water temperatures assessment were identified as essential to the integrity of a healthy alluvial river system and to the restoration of naturally-produced salmon and steelhead populations.

The TRSAAM analysis assumes that the geomorphic environment and the quality and quantity of fish habitat are intrinsically connected. Restoring these attributes would restore the diverse, high-quality habitats that salmon and steelhead need to survive and

successfully reproduce; the more high-quality habitat available, the better the populations' recovery will be. Because there are three species of salmonids, each with different depth and velocity preferences for each life stage, a wide variety of habitats is needed to provide suitable conditions for all life stages of all species.

Each alternative's flow schedule was assessed for its ability to meet the thresholds and frequencies associated with 9 of the 10 attributes (flow schedules did not include consideration of uncontrolled spills). Each objective of the attributes was assigned a score of 0, 1, or 2, depending on how well the objective was satisfied. For each alternative, the total score was divided by the maximum potential score. The assumptions used in the TRSAAM analysis included the following:

- If actions are made that move closer to meeting desirable system attributes, fish production will increase.
- Except as noted below, all attributes are weighted equally for evaluation of fish production. (This assumption was made because data were not available to determine relative weighting of the attributes.)
- Attributes provide and maintain habitat for all freshwater life stages of anadromous fish.
- Decline of one attribute can negate the benefits to fish of all other attributes. (For example, the benefit of increased spawning habitat may be negated if there is insufficient rearing habitat to support the resulting higher numbers of fry. In this case, limited rearing habitat could act as a bottleneck to fish production, thereby negating the benefits of attributes that affect earlier life stages.)
- Numbers derived from this analysis are considered an index, intended to show differences in habitat restoration potential for alternatives.

The methods for assessment of water-temperature influences on potential salmonid smolt production in the Trinity River are found as Attachment B5 to the Fishery Resources Technical Appendix B. The object of this analysis was to assess, evaluate, and discriminate differences (if any) among proposed project alternatives with regards to the effects of water temperature on the smolting success of anadromous salmonids in the mainstem Trinity River. Water temperature is crucial to the success of salmonid populations. To assess temperature effects on smolt outmigration as a potentially limiting factor, the evaluation of water temperature effects was removed from TRAASM and evaluated independently. Adverse water temperature conditions could result in large losses of sensitive

salmonid life stages (i.e., smolts) regardless of other habitat conditions within the watershed. A detailed evaluation of the effects of water temperature on emigrating smolts for the three principal salmonid species, steelhead, coho salmon, and Chinook salmon, in the Trinity River was conducted because of its importance to survival during outmigration and recruitment to the population.

This analysis focused on potential smolt survivability, using smolt life-stage-specific temperature threshold criteria identified for these species in the Trinity River (Service and Hoopa Valley Tribe, 1999). Additional information used in this analysis included smolt emigration timing, specific river flows, and flow/temperature relationship estimates. These factors were used to estimate smolt survival estimates and to develop an index of smolt survival suitability for each of the species for each alternative and No Action. These indices, predicting smolt outmigration success at Weitchpec, were then compared to distinguish performance of proposed project alternatives in meeting the water temperature needs of steelhead, coho salmon, and Chinook salmon the Trinity River.

Furthermore, the influence of differing flow regimes and resulting water temperatures on Chinook salmon smolt survival was used to develop an adult Chinook harvest index. This index, which used input parameters developed from the Trinity River Chinook salmon life cycle (SALMOD) model (Williamson, et al., 1993; and Service and Hoopa Valley Tribe, 1999), was calculated for each alternative and No Action. The calculated Chinook salmon harvest index for each alternative was compared to that estimated for the No Action Alternative to distinguish the effects of water temperature conditions on Chinook salmon populations in the future.

Additionally, as a comparative tool, fine- and coarse-sediment transport was computed for each alternative and for each water-year class for that alternative. The weighted annual fine- and coarse-sediment transport rates for the Lewiston and Limekiln gaging stations as reported in the Trinity River Flow Evaluation Study (Service and Hoopa Valley Tribe, 1999) were averaged and summarized. The implications of the computed fine- and coarse-sediment transport rates were considered in light of the following:

1. Ability to transport and route coarse sediment delivered from tributaries

2. Coarse-sediment imbalance in the reach immediately downstream of Lewiston Dam, which would require compensating coarse-sediment introduction to maintain coarse-sediment storage

3. Ability to transport large volumes of fine sediment, which would reduce fine-sediment storage in the mainstem Trinity River

To assess the ability of each alternative to provide conditions conducive to riparian seed dispersal and riparian forest regeneration along the mainstem Trinity River, the stage-discharge curve at the Lewiston gaging station, and assumptions of target floodplain surface for riparian inundation, the hydrograph for each alternative was evaluated for riparian initiation. The hydrographs for extremely wet and wet water years were plotted, and the receding hydrograph necessary for riparian initiation was also plotted. For the 70 Percent Inflow Alternative and Modified Percent Inflow Alternative, median extremely wet and wet years were used from the 1912 through 2002 period of record.

The following additional assumptions were used to qualitatively evaluate effects of project alternatives on native anadromous species in the Lower Klamath River Basin:

- Increased coldwater releases to the Trinity River are not harmful for emigrating and immigrating anadromous salmonids in the Lower Klamath River Basin.
- Large increments of increased flow in the Trinity River would improve habitat conditions and river health in the Lower Klamath River Basin.
- Mechanical rehabilitation of riverine habitats within the Trinity River would not affect anadromous salmonids in the Lower Klamath River Basin.
- Watershed protection in the Trinity River would improve habitat conditions and system health in the Lower Klamath River Basin.

Except as noted below, it was assumed that any benefits or adverse effects on native non-salmonid anadromous fish in the Trinity and Klamath River Basins would be the same as those for anadromous salmonids. This assumption is based on the fact that native non-salmonid anadromous fish evolved in and adapted to the same pre-dam environment that native salmonids did.

It was assumed that there would be no measurable effects on food availability, rates of survival, or other impacts to anadromous salmonids in the adjacent coastal areas as a result of any of the alternatives.

The effects of each alternative on the anadromous salmonids in the Sacramento River were evaluated using Reclamation's Sacramento River Salmon Mortality Model (see the Fishery Resources Technical Appendix B). The Sacramento River Salmon Mortality Model

estimated effects to Chinook salmon eggs and fry for all four runs of Chinook salmon spawning in the Sacramento River from Keswick Dam to Woodson Bridge. Because there is no model similar to the salmon mortality model, effects on steelhead were estimated by extrapolating late-fall Chinook salmon mortality estimates because of the similarity in temporal distribution and relatively similar effects of temperature on the early life stages of this species.

Increases in salmon egg and fry life-stage mortality are assumed to occur as the result of increased water temperatures. The Reclamation salmon loss model uses weekly average water temperatures obtained from the Sacramento River Water Temperature Model and tracks water temperature impacts on Chinook salmon egg and larval (sac-fry) development. Algorithms are used to compute cumulative survival of eggs spawned in a particular week through fry emergence from the spawning gravel. Temperature mortality schedules (relationships) for Chinook salmon eggs and larvae were developed establishing temperature-related instantaneous daily mortality rates for modeling salmon losses. The model uses spatial and temporal distribution information of spawning activity specific for each salmon run in the Sacramento River. Three river reaches: Keswick to Ball's Ferry (upper), Ball's Ferry to Red Bluff (middle), and downstream of Red Bluff (lower) are used in the analysis of temperature-related losses of Chinook salmon. Within each river reach, a specific temperature-related loss estimate is calculated. From these three partial loss estimates, a cumulative salmon loss estimate for each run is then calculated for each water year for the simulated period of 1922 through 1993. The average annual estimated loss for the period of simulation for each alternative was then compared to that for No Action. The precision of the mortality model is unknown; however, for this analysis, it is assumed that differences in estimated mortality greater than 1 percent (rounded to whole numbers) would be significant.

Impacts to winter-run Chinook salmon were subject to an additional level of detailed analysis, in part because of their endangered status under the ESA. Winter-run mortality estimates were evaluated by year class to discern particular classes of water years and conditions that would result in greater impacts than others. For this evaluation, a standard Sacramento water-year classification was used (sometimes referred to as the 40-30-30 index). This index has slightly different terminology than that used for designation of water year classes on the Trinity River.

To distinguish differences among project alternatives and the No Action Alternative for non-salmonid anadromous fish, including sturgeons, comparisons of Sacramento River flows and outflows from the Delta were conducted. Changes in these flows were

assumed to affect habitat quantity and quality within the Delta. Significant decreases in flows in the Sacramento River may reduce habitat area for spawning, rearing, and food production, and may result in increased water temperatures and poorer habitat quality within the river. These factors may act to adversely affect populations of the life stages of those species while occupying the Sacramento River. Reductions of outflows from the Delta may result in reduced habitat area and quality for spawning and rearing life stages of Delta species. Additionally, food production is affected by outflows in the Delta. Changes in food productivity may adversely affect growth and survival of young life stages while in the Delta.

Significance Criteria. Effects were considered significant for anadromous salmonids and other native anadromous species if they resulted in any of the following:

- Potential for reductions in the number, or restrictions of the range, of an endangered or threatened native anadromous species or a native anadromous species that is a candidate for state listing or proposed for federal listing as endangered or threatened
- Potential for substantial reductions in the habitat of any native anadromous species other than those that are listed as endangered or threatened or are candidates (CESA) or proposed (ESA) for endangered or threatened status
- Potential for causing a native anadromous fish population to drop below self-sustaining levels
- Substantial adverse effect, either directly or through habitat modifications, on any native anadromous species identified as a sensitive or special-status species in local or regional plans, policies, or regulations
- Substantial interference with the movement of any native anadromous species
- A conflict with, or violation of, the provisions of an adopted Habitat Conservation Plan, Natural Community Conservation Plan, or other approved local, regional, or state habitat conservation plan relating to the protection of native anadromous species
- Mortality of state or federally listed anadromous species, or species that are candidates for listing (CESA) or proposed for listing (ESA)
- Reductions in the size of a native anadromous species' population sufficient to jeopardize its long-term persistence

- Temporary impacts to habitats such that native anadromous species suffer increased mortality or lowered reproductive success that jeopardizes the long-term persistence of those local populations
- Permanent loss of essential habitat of a listed species or special-status native anadromous species
- Reduction in the quantity or quality of habitats in which native anadromous populations occur sufficient to reduce the long-term abundance and productivity of local populations

No Action. The No Action Alternative performed poorly in meeting the river system attributes and habitat requirements necessary for restoring the natural production of anadromous salmonids in the Trinity River. The TRSAAM results indicated that fishery habitat in the Trinity River in the year 2020 would not provide the conditions necessary to restore and maintain salmonid populations, including the threatened (federal) coho salmon population (Table 3.4-5). In addition, the smolt temperature survival analysis resulted in survival indices of 0.60, 0.84, and 0.41 (on a scale of 0.0 to 1.0) for steelhead, coho salmon, and Chinook salmon, respectively. The Chinook harvest index was estimated to be approximately 4,400 adults (Table 3.4-5). The weighted average sediment transport for No Action and each alternative is summarized in Table 3.4-6. The fine- and coarse-sediment transport rates for the Lewiston and Limekiln gaging stations, as reported in the Trinity River Flow Evaluation Study, were averaged for the results shown in Table 3.4-6. For the No Action Alternative, coarse- and fine-sediment transport averaged approximately 680 and 230 yd^3, respectively. The No Action Alternative hydrograph has a recession limb steeper than that required to initiate riparian vegetation on floodplains. Therefore, the No Action Alternative is not conducive to riparian regeneration during any water-year class.

TABLE 3.4-5
Results of the Analysis of Impacts to Anadromous Salmonids in the Mainstem Trinity River

Result	Alternative					
	No Action	Revised Mechanical	Flow Evaluation	Modified Percent	70 Percent Inflow	Maximum Flow
TRAASM Score	4	37	49	51	50	58
TRAASM Score – (percent of total possible)	6%	53%	70%	73%	71%	83%
Average Annual Releases (taf) [a]	340	455	595	501	934	1,225
Percent Increase of Release Compared to No Action	NA	34%	75%	47%	175%	260%
Minimum River Release as a Percentage of Total Inflow to Trinity Reservoir	28%	37%	49%	41%	76% [b]	100%
Steelhead Survival Index	0.60	0.67	0.80	0.58	0.74	0.81
Steelhead Survival Index – Percent Change from No Action	NA	12%	33%	-3%	23%	35%
Coho Survival Index	0.84	0.91	0.95	0.91	0.94	0.99
Coho Survival Index – Percent Change from No Action	NA	8%	13%	8%	12%	18%
Chinook Survival Index	0.41	0.51	0.60	0.49	0.55	0.76
Chinook Survival Index – Percent Change from No Action	NA	23%	45%	21%	32%	84%
Chinook Harvest Index	4,364	20,506 to 32,013[c]	44,486	30,794	37,311	66,646
Chinook Harvest Index –Difference from No Action	NA	16,142 to 27,649[c]	40,122	26,430	32,947	62,282
Percent Increase in Chinook Harvest Index from No Action	NA	370% to 634%[c]	919%	606%	755%	1,427%

[a] Weighted Annual Mean derived from frequency of release schedules over time.

[B] This alternative has a floor of 340,000 acre-feet/year and has minimum flow releases of 450 cfs during summer months and 300 cfs during winter months that increases the total yield above the 70% of total on average.

[c]Results for this alternative vary based on habitat assumptions.

TABLE 3.4-6
Summary of Weighted Average Annual Fine- and Coarse-sediment Transport for Differing Alternatives

Alternative	Weighted Average Coarse-sediment Transport (yd^3)	% Different from No Action	Weighted Average Fine-sediment Transport (yd^3)	% Different from No Action
No Action	680	0	230	0
Revised Mechanical	1,070	57	370	61
Preferred	8,570	1,160	1,870	73
Modified Percent Inflow	5,370	690	1,100	378
70 Percent Inflow	16,900	2,385	3,220	1,300
Maximum Flow[a]	156,000	22,841	21,500	9,248

[a]Rating curve is extended far beyond measured data, resulting in abnormally large predictions of sediment transport. Results should be considered qualitatively “very large.”

Revised Mechanical. This alternative would result in benefits to habitat for native anadromous species in the Trinity River relative to the No Action Alternative. Improved habitat conditions would benefit rearing and juvenile life stages and improve juvenile emigration, which would result in greater production and substantial increases in anadromous fish populations. This alternative had a TRAASM score of 37 (53 percent of possible) and had smolt temperature survival index scores of 0.67, 0.91, and 0.51 for steelhead, coho salmon, and Chinook salmon, respectively (Table 3.4-5). The increase in TRAASM score was approximately nine times greater than the No Action Alternative. The smolt temperature survival indices were 12, 8, and 23 percent greater than No Action for steelhead, coho salmon, and Chinook salmon, respectively. Depending on the assumptions used for the level of habitat created/restored for this alternative, the adult Chinook salmon harvest index ranged from approximately 20,500 to 32,000 adults, an increase of approximately 370 to 630 percent greater than the No Action Alternative. For this alternative, the estimated annual coarse- and fine-sediment transport volumes are modest, similar to those for No Action, and are approximately 1,070 and 370 yd^3, respectively (Table 3.4-6). These estimates are approximately 80 to 90 percent less than those estimated for the Preferred Alternative. The recession limbs of the hydrograph during extremely wet years would likely result in riparian initiation on floodplains and initiate riparian regeneration during those water years. This alternative would also provide small benefits to native anadromous species in the Lower Klamath River Basin by providing increased juvenile outmigration flows and somewhat lower water temperatures.

Revised Mechanical would result in adverse effects to Sacramento River fall- and spring-run chinook due to an estimated 1 percent average increase in mortality compared to No Action (Table 3.4-7). Impacts to spring-run Chinook would be significant due to incremental increases in early life stage mortality, principally, in below normal, dry, and critical water years (Table 3.4-8). Likewise, impacts to winter-run would be significant due to an incremental increase in mortality of 2.7 percent in critical water years (Tables 3.4-9 and 3.4-10). The Revised Mechanical Alternative may adversely impact habitat for other native anadromous species in the Central Valley through reductions in flow into/from the Delta.

TABLE 3.4-7
Percent Change in Temperature-related Losses of the Early Life Stages of Anadromous Salmonids in the Sacramento River as Compared to the No Action Alternative[a]

	Estimated Change in Average Annual Losses					
Species	Revised Mechanical	Flow Evaluation	Modified Percent Inflow	70 Percent Inflow	Maximum Flow	Flow Evaluation Compared to Existing Conditions
Fall Chinook	1	3	2	7	9	3
Late-fall Chinook	0	0	0	0	0	0
Winter Chinook	0	1	0	3	8	1
Spring Chinook	1	8	4	23	31	8
Steelhead	0	0	0	0	0	0

[a]Estimated average annual losses over the 1922 through 1993 simulation period compared to No Action.

TABLE 3.4-8
Temperature-related Losses of the Early Life Stages of Spring Chinook Salmon in the Sacramento River by Water-year Class

	Estimated Average Annual Losses of Early Life Stage Spring-run Salmon						
Year Class[a]	No Action	Revised Mechanical	Flow Evaluation	Modified Percent Inflow	70 Percent Inflow	Maximum Flow	Existing Conditions
Wet	5.7	6.4	8.2	6.8	14.4	17.3	5.3
Above Normal	4.8	5.3	8.4	6.3	20.3	34.4	4.7
Below Normal	19.6	21.3	29.3	25.3	50.9	57.0	19.2
Dry	24.1	25.6	40.9	30.2	71.5	85.4	22.4
Critical	81.2	84.0	87.8	85.1	94.1	98.9	86.1

[a]Based on Sacramento River Index (40-30-30).

TABLE 3.4-9
Temperature-related Losses of the Early Life Stages of Winter-run Chinook Salmon in the Sacramento River by Water-year Class (Percent)

	Estimated Average Annual Losses of Early Life Stage Winter-run Salmon						
Year Class[a]	No Action	Revised Mechanical	Flow Evaluation	Modified Percent Inflow	70 Percent Inflow	Maximum Flow	Existing Conditions
Wet	0.2	0.3	0.3	0.3	0.5	0.5	0.2
Above Normal	0.3	0.3	0.3	0.3	0.3	0.7	0.3
Below Normal	0.7	0.8	1.2	1.2	3.8	6.8	0.6
Dry	3.5	3.8	2.8	3.6	5.4	12.6	2.9
Critical	45.9	48.6	50.1	47.9	59.2	79.5	45.6

[a]Based on Sacramento River Index (40-30-30).

TABLE 3.4-10
Percent Change in Temperature-related Losses of the Early Life Stages of Winter-run Chinook Salmon in the Sacramento River by Water-year Class Compared to No Action (Percent)

	Change in Estimated Average Annual Losses of Early Life Stage Winter-run Salmon Compared to No Action					
Year Class[a]	Revised Mechanical	Flow Evaluation	Modified Percent Inflow	70 Percent Inflow	Maximum Flow	Existing Conditions versus Flow Evaluation
Wet	0.0	0.0	0.0	0.2	0.3	0.1
Above Normal	0.0	0.0	0.0	0.1	0.4	0.0
Below Normal	0.1	0.5	0.5	3.1	6.2	0.6
Dry	0.3	-0.7	0.1	1.9	9.1	-0.1
Critical	2.7	4.2	2.0	13.3	33.6	4.5

[a]Based on Sacramento River Index (40-30-30).

Flow Evaluation. This alternative would result in benefits to habitat for native anadromous species in the Trinity River relative to the No Action Alternative. Improved habitat conditions would benefit rearing and juvenile life stages and improve juvenile emigration, which would result in greater production and substantial increases in anadromous fish populations. This alternative had a TRAASM score of 49 (70 percent of possible) and had smolt temperature survival index scores of 0.80, 0.95, and 0.60 for steelhead, coho salmon, and Chinook salmon, respectively (Table 3.4-5). Except for the Maximum Flow Alternative, this alternative had the largest estimated smolt survival indices. The increase in TRAASM score was approximately 12 times greater than the No Action Alternative. The smolt temperature survival indices were 33, 13, and 45 percent greater than No Action for steelhead, coho salmon, and Chinook salmon, respectively. The adult Chinook salmon harvest index was estimated to be approximately 44,500 adults, an increase of approximately 920 percent greater than the No Action Alternative. For this alternative, the estimated annual coarse- and fine-sediment transport volumes are balanced, from 8- to 12-fold greater than those for No Action, and are approximately 8,570 and 1,870 yd^3, respectively (Table 3.4-2). The recession limbs of the hydrograph during extremely wet years would likely result in riparian initiation on floodplains and initiate riparian regeneration during those water years. This alternative would also provide some benefit to native anadromous species in the Lower Klamath River Basin by providing increased juvenile outmigration flows and lower water temperatures.

Under the Flow Evaluation (Preferred) Alternative, the average winter-run mortality in the Sacramento River for critical dry water years is estimated to be 50.1 percent, an increase of 4.2 percent over No Action (Tables 3.4-9 and 3.4-10). This increase in mortality would be a significant impact. For dry water years, the average mortality is

estimated to be 2.8 percent, a reduction of 0.7 percent compared to No Action. The average for dry years is largely influenced by temperature operations in water-year 1932, a dry year within a string of dry and critical dry years, when mortality under No Action was 46.2 percent compared to mortality of 35.7 percent under Flow Evaluation. Discounting the effects of this single year results in an average mortality of 0.6 percent under both Flow Evaluation and No Action. In below-normal years, winter-run mortality under Flow Evaluation, on average, would be 1.2 percent, an increase of 0.5 percent over No Action. This would be a significant impact. However, if water-year 1935 is discounted, the incremental increase would be 0.1 percent, a less than significant impact. Water-year 1935 is notable because of the relatively low carryover storage in Shasta Reservoir at the beginning of the water year. There is no significant incremental impact on winter-run Chinook salmon in above-normal or wet water years.

There would be significant adverse impacts to early life stages of Sacramento River fall-run (3 percent) and spring-run (8 percent) Chinook salmon during dry, critically dry, or below normal water years (Tables 3.4-7 and 3.4-8). Increased losses of eggs and sac-fry fall- and spring-run Chinook salmon would occur as a result of increased water temperatures during drought conditions (1924-1925, 1935-1936, 1959-1963, and 1988-1991). These temperature increases would result in higher mortality, compared to No Action, of incubating and developing salmon eggs and pre-emergent fry life stages. Incremental increases in early life stage mortalities of fall, winter, and spring Chinook salmon, as determined in this Supplemental EIS/SEIR (beyond those estimated for the 2000 EIS/EIR), are a result of a less conservative assumption of the efficiency of the Shasta TCD that is used in the water temperature model. The Flow Evaluation Alternative may also adversely impact habitat for other native anadromous species in the Central Valley through reductions of inflows and outflow to the Delta.

Modified Percent Inflow. This alternative would result in benefits to habitat for native anadromous species in the Trinity River relative to the No Action Alternative. This alternative would provide flow conditions that would greatly improve the geomorphic condition of the Trinity River. However, under this alternative, water temperatures could likely be limiting to salmonids and could adversely affect and limit populations of these species. This alternative had a TRAASM score of 51 (73 percent of possible) and had smolt temperature survival index scores of 0.58, 0.91, and 0.49 for steelhead, coho salmon, and Chinook salmon, respectively (Table 3.4-5). The increase in TRAASM score was approximately 13 times greater than the No Action Alternative. However, compared to No Action, the smolt temperature survival indices were

3 percent less for steelhead, and 8 and 21 percent greater for coho and Chinook salmon, respectively. The adult Chinook salmon harvest index was estimated to be approximately 30,800 adults, an increase of approximately 600 percent greater than the No Action Alternative. For this alternative, the estimated annual coarse- and fine-sediment transport volumes are more robust than those for the No Action Alternative, and are approximately 5,370 and 1,100 yd^3, respectively (Table 3.4-6). However, these estimates are approximately 40 percent less than those estimated for the Preferred Alternative. The Modified Percent Inflow Alternative has recession limbs steeper than that required to initiate riparian vegetation on floodplains. Because the analyses for the Modified Percent Inflow Alternative uses the median years for extremely wet and wet water years, the median year does not represent all years for those two water-year classes. Therefore, there could be an individual year within the record where the recession limb is sufficient to initiate riparian vegetation. This alternative may provide some benefit to native anadromous species in the Lower Klamath River Basin by providing increased juvenile outmigration flows and moderation of water temperatures.

Under the Modified Percent Inflow Alternative, the average Sacramento River winter-run mortality for critical dry water years is estimated to be 47.9 percent, an increase of 2 percent over No Action (Tables 3.4-9 and 3.4-10). This increase in mortality would be a significant impact. For dry water years, the average mortality is estimated to be 3.6 percent, an increase of 0.1 percent compared to No Action. In below-normal years, winter-run mortality under Modified Percent Inflow, on average, would be 1.2 percent, an increase of 0.5 over No Action. This would be a significant impact. There is no significant incremental impacts on winter-run Chinook salmon in above-normal or wet water years.

In the Central Valley there would be significant adverse impacts to early life stages of Sacramento River fall- and spring-run Chinook salmon (Tables 3.4-7and 3.4-8). Impacts to spring-run Chinook would be significant due to incremental increases in early life stage mortality, in all water year types but principally, in below normal, dry, and critical water years (Table 3.4-8). Similar to the case for the Maximum Flow, Flow Evaluation, and 70 Percent Inflow Alternatives, increased losses of eggs and sac-fry of fall- and spring-run Chinook salmon (2 and 4 percent, respectively) would occur because of increased water temperatures during drought conditions. These temperature increases would result in higher mortality, compared to No Action, of incubating and developing salmon eggs and pre-emergent fry life stages. During a few water years, such as those drought years of 1926, 1935, 1977, and 1990, Chinook salmon would experience larger mortalities than those for the No Action

Alternative. Inflows to the Delta would be significantly less than those for No Action for a substantial number of years, and, on average, Delta outflows in some months would be significantly less, compared to the No Action Alternative. These reductions may be sufficient so as to result in adverse effects to other native anadromous species in the Delta.

70 Percent Inflow. This alternative would result in benefits to habitat for native anadromous species in the Trinity River relative to the No Action Alternative. Improved habitat conditions would benefit rearing and juvenile life stages and improve juvenile emigration, which would result in greater production and substantial increases in anadromous fish populations. This alternative had a TRAASM score of 50 (71 percent of possible) and had smolt temperature survival index scores of 0.74, 0.94, and 0.55 for steelhead, coho salmon, and Chinook salmon, respectively (Table 3.4-5). The increase in TRAASM score was approximately 13 times greater than the No Action Alternative. The smolt temperature survival indices were 23, 12, and 32 percent greater than No Action for steelhead, coho salmon, and Chinook salmon, respectively. The adult Chinook salmon harvest index was estimated to be approximately 37,300 adults, an increase of approximately 750 percent greater than the No Action Alternative. For this alternative, the estimated annual coarse- and fine-sediment transport volumes are very large, and are approximately 16,900 and 3,220 yd^3, respectively (Table 3.4-6). These estimates are approximately 12- to 18-fold greater than those for the Preferred Alternative. The huge volume of coarse sediment transported by this alternative would require a much larger gravel supplementation program to keep coarse-sediment volumes balanced in the mainstem Trinity River. The recession limbs of the hydrograph during extremely wet years would likely result in riparian initiation on floodplains and initiate riparian regeneration during those water years. This alternative would also provide some benefit to native anadromous species in the Lower Klamath River Basin by providing increased juvenile outmigration flows and lower water temperatures.

Under the 70 Percent Inflow Alternative, the average Sacramento River winter-run mortality for critical dry water years is estimated to be 59.2 percent, an increase of 13.3 percent over No Action (Tables 3.4-9 and 3.4-10). This increase in mortality would be a significant impact. For dry water years, the average mortality is estimated to be 5.4 percent, an increase of 1.9 percent compared to No Action. In below-normal years, winter-run mortality under 70 Percent Inflow, on average, would be 3.8 percent, an increase of 3.1 over No Action. This would be a significant impact. There is no incremental impact on winter-run Chinook salmon in above-normal or wet water years.

There would be significant adverse impacts to early life stages of Sacramento River fall-run (5 percent) and spring-run (23 percent) Chinook salmon (Tables 3.4-7 and 3.4-8). Impacts to spring-run Chinook would be significant due to incremental increases in early life stage mortality, in all water year types (Table 3.4-8). Similar to the case for the Maximum Flow, Modified Percent Inflow, and Flow Evaluation Alternatives, increases in losses of eggs and sac-fry fall- and spring-run Chinook salmon would occur because of increased water temperatures during drought conditions (1923-1933, 1935-1936, 1959-1964, and 1987-1992). However, large increases in losses are also expected in many below normal and dry water years as well. The reductions in streamflows in the Sacramento River , are the result of the lower diversion to the Sacramento River from the TRD. Additionally, while some of the reductions in the inflows to and from the Delta are a result of increased demands expected at the 2020 level of development, a significant portion of these reductions are a result of implementation of the 70 Percent Inflow Alternative. The 70 Percent Inflow Alternative may also adversely impact habitat for other native anadromous species in the Central Valley through reductions in flow in the Sacramento River and/or into/from the Delta.

Maximum Flow. This alternative would result in substantial improvements to habitat for native anadromous salmonids in the Trinity River relative to the No Action Alternative. Improved habitat would benefit rearing and juvenile life stages and improve juvenile emigration, which would result in greater production and substantial increases in anadromous salmonid populations. This alternative had a TRAASM score of 58 (83 percent of possible) and had smolt temperature survival index scores of 0.81, 0.99, and 0.76 for steelhead, coho salmon, and Chinook salmon, respectively (Table 3.4-5). The increase in TRAASM score was approximately 15 times greater than the No Action Alternative. The smolt temperature survival indices were 35, 18, and 84 percent greater than No Action for steelhead, coho salmon, and Chinook salmon, respectively. The adult Chinook salmon harvest index was estimated to be approximately 66,700 adults, an increase of approximately 1,430 percent greater than the No Action Alternative. For this alternative, the estimated annual coarse- and fine-sediment transport volumes are estimated to be huge, and are approximately 156,000 and 21,500 yd^3, respectively (Table 3.4-6). However, the rating curve was extended far beyond measured data, resulting in abnormally large predictions of sediment transport. Therefore, the results should be considered qualitatively "very large." The huge volume of coarse sediment transported by this alternative would require a much larger gravel supplementation program to keep coarse-sediment volumes balanced in the mainstem Trinity River. The recession limbs of the hydrograph during

extremely wet years would likely result in riparian initiation on floodplains and initiate riparian regeneration during those water years. This alternative would also provide some benefit to native anadromous species in the Lower Klamath River Basin by providing increased juvenile outmigration flows and lower water temperatures.

Under the Maximum Flow Alternative, the average Sacramento River winter-run Chinook salmon mortality for critical dry water years is estimated to be 79.5 percent, an increase of 33.6 percent over No Action (Tables 3.4-9 and 3.4-10). This increase in mortality would be a significant impact. For dry water years, the average mortality is estimated to be 12.6 percent, an increase of 9.1 percent compared to No Action. In below-normal years, winter-run mortality under Maximum Flow, on average, would be 6.8 percent, an increase of 6.2 over No Action. This would be a significant impact. There is no significant incremental impact on winter-run Chinook salmon in above-normal or wet water years.

Compared to the No Action Alternative, the Maximum Flow Alternative, which does not include diversions to the Sacramento Valley, would result in an adverse increase in water temperatures in the Sacramento River, thereby significantly increasing early life-stage losses of fall-run (9 percent) and spring-run Chinook salmon (31 percent) (Tables 3.4-7 and 3.4-8). Impacts to spring-run Chinook would be significant due to incremental increases in early life stage mortality, in all water year types (Table 3.4-8). Increased losses of eggs and sac-fry of fall- and spring-run Chinook salmon as compared to No Action primarily occurred because of increased water temperatures during drought conditions (1922-1926, 1930-1936, 1976-1977, and 1985-1991). However, very large increases in losses are also expected in many years in all water year classes. These temperature increases would result in higher mortality of incubating and developing salmon eggs and pre-emergent fry life stages as compared to No Action. Incremental increases in early life stage mortalities of fall, winter, and spring Chinook salmon, as determined in this SUPPLEMENTAL EIS/SEIR (beyond those estimated for the 2000 EIS/EIR), are a result of a less conservative assumption of the efficiency of the Shasta TCD that is used in the water temperature model. The Maximum Flow Alternative may adversely impact habitat for other native anadromous species in the Central Valley through reductions in flows in the Sacramento River and/or into/from the Delta.

Existing Conditions versus Proposed Action. Implementation of the Proposed Action would substantially restore the diverse fish habitats necessary for restoration and maintenance of anadromous fish populations compared to existing conditions. The degree of improvement is similar to that of the Flow Evaluation Alternative

over the No Action Alternative. Although the river and its fish habitats would continue to gradually degrade under the No Action Alternative, the majority of the degradation occurred in the decades immediately following dam construction. Therefore, naturally producing anadromous fish numbers are not expected to substantially change from existing conditions versus the projected numbers for the No Action Alternative (TRSAAM was not designed to detect temporal changes). Because the Proposed Action also includes the watershed protection component of the Revised Mechanical Alternative, it would likely accelerate and enhance the improvements in habitat and the resultant increases in fish production. The Proposed Action would also benefit the Klamath River beyond the benefits accrued by either the Flow Evaluation Alternative or Revised Mechanical Alternative individually.

Compared to existing conditions, the Proposed Action would significantly affect native anadromous fish in the Central Valley similar in magnitude to the impacts of the Flow Evaluation Alternative compared to the No Action Alternative. Compared to existing conditions, the Proposed Action would adversely affect fall-run (3 percent), winter-run (0.6 percent in Below Normal years and 4.5 percent in critical years), and spring-run Chinook salmon (from 18 percent in critical years to 18.5 percent in dry years) by increasing mortality of early life stages of these species within the upper Sacramento River (Table 3.4-7, 3.4-8, and 3.4-9).

Mitigation.

Per the NOAA Fisheries BO (NOAA Fisheries, 2000; under separate cover), implementation of the Proposed Action is not likely to jeopardize Southern Oregon/Northern California Coast (SONCC) coho salmon, Sacramento River winter-run Chinook salmon, Central Valley spring-run Chinook salmon, or Central Valley steelhead. NOAA Fisheries does anticipate that SONCC coho salmon habitat adjacent to and downstream of the channel rehabilitation projects associated with the Proposed Action may be temporarily degraded during construction. Construction of these projects, which will create a substantial amount of additional suitable habitat, may temporarily displace an unknown number of juvenile coho salmon but is not expected to result in a lethal take.

In the NOAA Fisheries BO, implementation of the proposed action was determined to avoid incidental take of Central Valley spring-run Chinook or Central Valley steelhead. The BO also concluded that the Proposed Action will result in a minute increase in the level of Sacramento River winter-run Chinook incidentally taken in all years except critically dry years. Results from this Supplemental EIS/EIR confirm the incremental increase in winter-run Chinook salmon mortality in below normal and dryer water years, but also result in

higher mortality for spring-run Chinook than previously estimated in the 2000 EIS/EIR. Mitigation for impacts to spring-run Chinook salmon in the Sacramento River follows.

Spring-run mitigation includes the following: continued use of the optional 45-day closure of the Delta Cross Channel gates, as is current practice, would offset the incremental spring-run mortality caused by reduced export of Trinity water into the Sacramento River. Closure of the Delta Cross Channel gates is currently an optional management tool available to NOAA Fisheries as described under SWRCB D-1641. Implementation of this mitigation measure would prescribe continued use of this mitigation. Impacts of the continued use of the Delta Cross Channel gates was included in the assumptions governing CALSIM (see Table 2-1 in Section 2.0, Description of Alternatives).

NOAA Fisheries outlined the following reasonable and prudent measures to minimize the effects of incidental take of SONCC coho salmon and Sacramento River winter-run chinook salmon. It is important to note that Judge Wanger's MDO invalidated several aspects of the NOAA Fisheries BO; however the following RPMs are assumed to remain in effect.

The Service and Reclamation shall:

1. Ensure that NOAA Fisheries is provided the opportunity to be represented during implementation of the AEAM program.
2. Ensure that the replacement bridges and other infrastructure modifications, needed to fully implement the proposed flow schedule, are designed and completed as soon as possible.
3. Periodically coordinate with NOAA Fisheries during the advanced development and scheduling of the habitat rehabilitation projects described in the Draft EIS/EIR.
4. Complete "the first phase of the channel rehabilitation projects" (Service and Reclamation, 2000) in a timely fashion.
5. Implement emergency consultation procedures during implementation of flood control or "safety of dams" releases from Lewiston Dam to the Trinity River.
6. In dry and critically dry water-year classes, Reclamation and Service shall work cooperatively with the upper Sacramento River Temperature Task Group to develop temperature control plans that provide for compliance

with temperature objectives in both the Trinity and Sacramento Rivers.

The detailed mitigation measure outlined below describes the re-consultation process for temperature compliance for winter-run Chinook salmon, which would reduce impacts associated with the Flow Evaluation to a less than significant level and maintain consistency with the measures outlined in the NOAA Fisheries BO. The effectiveness of this measure as mitigation for other action alternatives varies, as outlined in Table 3.4-11 and 3.4-12.

TABLE 3.4-11
Estimated Mortality of Winter-run Chinook during Critical Water Years with Compliance Target at Bend Bridge/Jelly's Ferry

	Chinook Salmon Mortality (%) during Critical Water-year Classes						
Year	**No Action Alternative**	**Revised Mechanical**	**Preferred Alternative**	**Modified Percent Inflow**	**70 Percent Inflow**	**Maximum Flow**	**Existing Conditions**
1924	98.7	99.6	99.1	99.4	100	100	99.4
1929	0.6	0.6	0.2	0.7	1.8	16.0	1.2
1931	87.8	92.1	93.9	89.7	100	100	95.0
1933	58.9	73.0	59.8	62.4	89.9	95.9	23.4
1934	100	100	100	100	100	100	96.3
1976	0.4	0.4	0.4	0.4	0.5	3.4	0.4
1977	93.6	93.4	94.5	93.5	100	100	93.0
1988	0.8	2.7	2.8	1.3	10.1	79.3	5.1
1990	0.6	1.4	4.4	2.1	14.3	80.0	1.0
1991	1.8	3.0	17.0	4.8	36.2	100	4.8
1992	62.1	68.3	79.1	72.6	98.4	100	81.9
Average	45.9	48.6	50.1	47.9	59.2	79.5	45.6

TABLE 3.4-12
Estimated Mortality of Winter-run Chinook during Critical Water Years with Compliance Target at Ball's Ferry

	Chinook Salmon Mortality (%) during Critical Water-year Classes						
Year	**No Action Alternative**	**Revised Mechanical**	**Preferred Alternative**	**Modified Percent Inflow**	**70 Percent Inflow**	**Maximum Flow**	**Existing Conditions**
1924	82.7	85.9	85.2	84.6	99.1	100.0	85.6
1929	2.3	2.3	1.3	2.7	0.7	1.9	3.2
1931	76.6	81.6	84.2	79.6	98.8	100.0	85.8
1933	24.6	38.2	25.5	33.6	72.9	85.2	10.3
1934	93.6	99.7	96.1	99.9	100.0	100.0	82.6
1976	2.3	2.5	2.5	2.5	2.7	4.1	1.9
1977	85.3	83.9	85.6	84.9	93.1	100.0	83.7
1988	0.6	4.7	1.0	1.8	3.1	34.4	2.0
1990	0.7	0.7	1.0	0.7	4.6	53.3	0.6
1991	0.7	0.7	1.6	1.0	22.5	87.2	0.9
1992	27.0	30.3	35.3	34.8	88.2	99.9	40.3
Average	36.0	39.1	38.1	38.7	53.2	69.6	36.1

Adverse impacts would result from the implementation of the Maximum Flow, Flow Evaluation, Modified Percent Inflow, Revised Mechanical, and the 70 Percent Inflow Alternatives to federal- and state-listed endangered winter-run Chinook salmon when drawdown of Shasta Reservoir results in storage levels of less than 1.9 maf on September 30 or in critically dry water years. Under such conditions it would be necessary to re-consult with NOAA Fisheries under terms of the 1993 Winter-run Chinook BO (NOAA Fisheries, 1993). This mitigation measure would make such re-consultation mandatory and would require upstream movement of the temperature compliance point in years when it was determined that there was not enough cold water to maintain temperature compliance at Bend Bridge/Jelly's Ferry.

Re-consultation would result in changes to operations that would act to minimize losses to Chinook salmon according to actual and forecast conditions, typically an adjustment to the location of downstream temperature targets. Adjustment to targets would most likely occur in drier water years (critical dry, dry, or below-normal water-year classes), especially in consecutive dry years, although it is possible that no adjustment would be made because of unusually cool climatic conditions or unusual rainfall patterns. The more likely outcome of re-consultation would be to move the existing target for temperature compliance from Bend Bridge/Jelly's Ferry (depending on date) to a location farther upstream, such as Ball's Ferry. Movement of the compliance point would avoid catastrophic loss of the coldwater pool, by making it more likely to provide cold water throughout the early life stage, albeit over a reduced habitat area. Moving the target upstream has the result of reducing mortality below the modeled levels in Table 3.4-9.

Section 3.2, Water Resources, outlines the basic relationship among reservoir storage, release rate, and downstream temperature, and how these three factors govern water management on the upper Sacramento River. Generally, it takes higher releases to meet temperature targets with warmer water or lower releases with colder water. For an example of flow-temperature relationships and the effect of instream warming, see Table 3.3-4 in Section 3.4, Water Quality. The coldwater pool in a reservoir is essentially a function of the volume of water in the reservoir. More cold water is available when a reservoir is full; less is available as the reservoir is drawn down. As described in this mitigation, changes in the compliance point would result in changes to scheduled operations of the TCD, and therefore temperatures of water released from Shasta Reservoir, but not the rate of release (e.g., flow or cfs). Raising the temperature of the water released from Shasta Reservoir increases the amount of time that cold water is available, but decreases the total area of habitat covered by the colder water. Conceptually, this improves the

likelihood that at least a portion of the early life-stage winter-run Chinook salmon would be protected by adequate temperatures, rather than subjecting the entire run to catastrophic temperatures when the coldwater pool is exhausted. Specific recommendations for implementing these actions are outlined below.

Re-initiation of consultation has been a regular practice between Reclamation and NOAA Fisheries. Between 1993 and 2003, formal re-consultation between Reclamation and NOAA Fisheries occurred 24 times. Of these formal re-consultations, 9 have resulted in upstream movement of the compliance point, primarily as a measure to conserve the coldwater pool. The remaining 15 re-consultations have been advisory notices alerting NOAA Fisheries of temperature exceedances. Upstream movement of compliance points has ranged from early adjustment from Bend Bridge to Jelly's Ferry to late-season adjustments to Clear Creek. Figure 3-3.1 in Section 3.3, Water Quality, provides a graphic description of the relative locations of compliance points. Re-initiation of consultation has occurred in both wet and dry years, and under variable carryover storage scenarios. Table 3.4-13 provides specific details regarding re-initiation of consultation between 1993 and 2003.

Consistent with the 1993 Winter-run Chinook BO, under this mitigation measure, re-consultation with NOAA Fisheries would be required in water years with Shasta carryover storage less than 1.9 maf and in critical dry years. The results of the consultation would likely be to move the temperature compliance point for winter-run salmon to an upstream point such as Ball's Ferry (approximately 10 river miles upstream). This would likely reduce incremental mortality during the critical period of spawning, incubation, and alevin swim-out.

The estimated average mortality of winter-run Chinook salmon (with Ball's Ferry as a compliance point) for the Preferred Alternative for critical dry water years is 38.1 percent (Table 3.4-12). This is a reduction in mortality of 12 percent and is approximately 8 percent less mortality than that estimated for the No Action Alternative. As shown in Table 3.4-11, by moving the compliance point to Ball's Ferry in some critical dry water years, the resulting improvement in winter-run early life-stage survival is very large. In water-year 1933, for example, the estimate improvement is approximately 34 percent. For water-year 1992, the improvement is approximately 45 percent. However, because of the vagaries of climate and the variable hydrologic influence of tributaries to the Sacramento River (particularly with regard to temperature of accretions), implementation of this mitigation is not a guarantee of reduced impacts. It is also important to note that although this mitigation will tend to reduce the incremental impact from implementation of an action

TABLE 3.4-13
History of Re-initiation between Reclamation and NOAA Fisheries

Water Year	Water Year Starting Shasta Storage (taf)	End of April Shasta Storage (taf)	Water-year Class (40-30-30 Index)	Starting Compliance Point	Date	Action	Change in Compliance Point
1993	1,683	4,263	Above Normal	Bend Bridge			
1994	3,102	3,534	Critical	Jelly's Ferry			
1995	2,102	4,165	Wet	Bend Bridge	07/13	Conserve cold water	Jelly's Ferry
1996	3,136	4,308	Wet	Bend Bridge	05/17	Exceed 56°F 04/26	
					07/12	Exceed 56°F 05/27	
					07/18	Conserve cold water	Jelly's Ferry
					08/28	Conserve cold water	Ball's Ferry
					09/23	Transition to stable min. flow for fall-run salmon by 10/15	Clear Creek
1997[a]	3,089	3,937	Wet	Bend Bridge	05/20	Exceed 56°F at Bend Bridge 3 days	
					07/30	Exceed 56°F at Bend Bridge 4 days	
					08/08	Conserve cold water	Jelly's Ferry
					09/19	Exceed 56°F at Jelly's Ferry 08/29 to 09/13	
					10/15	Exceed 56°F at Jelly's Ferry 09/20 to 09/30	
1998	2,308	4,061	Wet	Bend Bridge	06/09	Exceed 56°F at Bend Bridge 3 days	
					06/25	Exceed 56°F at Bend Bridge 4 days	
					09/18	Temp. exceed 56°F since 09/12	Jelly's Ferry
1999	3,441	4,256	Wet	Bend Bridge	08/19	Exceed 56°F at Bend Bridge 4 days	
2000	3,327	4,153	Above Normal	Bend Bridge	06/02	Exceed 56°F at Bend Bridge 3 days	

TABLE 3.4-13
History of Re-initiation between Reclamation and NOAA Fisheries

Water Year	Water Year Starting Shasta Storage (taf)	End of April Shasta Storage (taf)	Water-year Class (40-30-30 Index)	Starting Compliance Point	Date	Action	Change in Compliance Point
					07/14	Conserve cold water	Jelly's Ferry
					08/29	Conserve cold water	Ball's Ferry
					10/16	Exceed 56°F at Ball's Ferry 3 days	
2001	2,985	4,020	Dry	Jelly's Ferry	07/17	Exceed 56.5°F at Jelly's Ferry 2 days	
					01/10/	Exceed 56°F at Jelly's Ferry 08/28 to 09/1 and 09/15 to 09/30	
2002	2,200	4,297	Dry	Jelly's Ferry	06/05	Exceed 56°F at Jelly's Ferry 05/18	
2003	2,558	4,537	Above Normal	Bend Bridge	06/18	Exceed 56°F at Bend Bridge 05/14	
					08/28	Conserve cold water	Ball's Ferry

[a]Operation of the Shasta TCD began.

alternative (compared to No Action) to less than significant levels, the absolute level of mortality may remain substantial. Furthermore, implementation of this mitigation may be applicable and assist in reducing impacts to spring-run Chinook salmon in the upper Sacramento River.

During other, wetter water-year classes with adequate carryover storage there would be no need to initiate consultation with NOAA Fisheries or to move compliance points upstream because there are no significant differences between the Preferred Alternative and No Action.

As noted previously, implementation of this mitigation measure is based only on the movement of the temperature compliance point upstream. The intent of this measure is to modify temperature management solely through manipulation of the TCD, maximizing the amount of time that cold water is available to early-stage winter-run salmon. Accordingly, there are no projected impacts to other water users, such as South-of-Delta exporters beyond those described in Section 3.2, Water Resources. Implementation of this mitigation measure is expected to be consistent with the CVP-OCAP BO expected to be released June 30, 2004.

It is possible that additional measures may be required through the OCAP ESA consultation to offset impacts to winter-run salmon resulting from other aspects of CVP or SWP operations beyond increases to Trinity River instream flow. Possible results of the OCAP ESA consultation include the following:

- Changes to gate operations at Red Bluff Diversion Dam
- Earlier closures of the Delta Cross Channel gates
- Improvements in fish screens at the CVP Delta pumping plant (Tracy)
- Improvements in fish screens at the SWP Delta pumping plant (Banks)
- Reductions in the pre-screen loss rate at Clifton Court Forebay (adjacent to the Banks Pumping Plant)

At this time, it is unknown whether any of these conditions will be included as conditions to the OCAP ESA consultation. However, all of these measures would be subject to individual environmental review and are beyond the scope of this Supplemental EIS/EIR.

3.4.2 Resident Native and Non-Native Fish

Affected Environment.

Trinity River Basin. Resident native fish species found in the Trinity River Basin include gamefish such as rainbow trout, and non-gamefish

such as speckled dace, Klamath smallscale sucker, three-spined stickleback, and coast range sculpin. The abundance of resident native species, and the factors affecting their abundance within the basin, are not well understood; however, all these species existed in the pre-dam Trinity River and are presumably adapted to those conditions.

Non-native fish species found in the Trinity and Klamath River Basins include striped bass, American shad, brown trout, and brook trout. Striped bass have only recently been reported to occur in the Trinity and Klamath River Basins; reports are rare. American shad are known to occur in the lowermost portions of the Trinity River Basin, but are primarily found in the lower Klamath River Basin. Anadromous brown trout were propagated in the TRSSH until 1977, when this practice was discontinued because of the small numbers and the lack of anadromous characteristics of fish entering the hatchery. Currently, brown trout are largely limited to the upper portions of the river, although CDFG, on occasion, capture brown trout in the estuary during the spring. Brook trout provide a significant sport fishery in the tributary streams and high elevation reservoirs of the Trinity River Basin. Its life cycle and habitat requirements are similar to that of brown trout.

The abundance of all of these species in the Trinity and lower Klamath River Basins is unknown. Factors that affect their abundance in the Trinity and lower Klamath River Basins are generally unknown, but may be similar to those factors affecting native anadromous species.

Lower Klamath River Basin/Coastal Area. In addition to the native resident species found in the Trinity River Basin, marbled sculpin, threespine stickleback, staghorn sculpin, coastal cutthroat, and starry flounder are known to occur in the lower Klamath River Basin. Marine species such as topsmelt, shiner perch, arrow goby, and sharpnose sculpin may occasionally occur in the lower Klamath River estuary. The abundance and distribution of all of these species, and the factors affecting their abundance in the lower Klamath River Basin, are not known.

Non-native species known to occur in the lower Klamath River are similar to those found in upstream areas including the reservoirs. Some of these species include yellow perch, black crappie, green sunfish, gold shiner, and brown bullhead.

In the coastal area, numerous native marine species are found in tidepool and nearshore habitats adjacent to the lower Klamath River Basin. There are as many as 250 species of tidepool and nearshore fish in the coastal waters of California, most of which would be expected to occur in the coastal waters adjacent to the project. Important recreational species include halibut and sanddab, herring,

surf perch, lingcod, greenling, smelt, sole, flounder, and rockcod. In addition, important commercial fisheries exist for the flatfish, sablefish, Pacific hake, rockfish, albacore tuna, and lingcod. Most or all of these species are landed in Eureka and Crescent City, California, and Brookings, Oregon.

Central Valley. Many of the native fish found in the lower Klamath and Trinity River Basins also occur in the Central Valley. In addition to those, the following native resident species also occur: Pacific brook lamprey, hardhead, hitch, blackfish, California roach, Sacramento pikeminnow, Sacramento sucker, tule perch, prickly sculpin, longfin smelt, Sacramento splittail, and Delta smelt.

The Delta smelt was listed as threatened by federal and state governments in 1993. The species occurs in the Delta and within the lower Sacramento River downstream of Isleton and in the lower San Joaquin River downstream of Mossdale. It is rarely found in habitats where salinity is greater than 10 to 12 ppt; it prefers salinity of approximately 2 ppt. Critical habitat for Delta smelt was determined by the Service to include portions of Contra Costa, Sacramento, San Joaquin, Solano, and Yolo Counties (Service, 1994). Provisions within the Bay-Delta Accord, including the allowable ratio of Delta inflows to exports (generally 35 percent inflows/ exports for February through June and 65 percent inflows/exports for July through January) have direct bearing on the abundance of aquatic species in the Delta. Reduction of Delta outflows, high Delta outflows, losses to entrainment at water diversions, changes in food organisms, toxic substances, disease, competition, predation, and loss of genetic integrity in the Delta are suspected causes in the population declines of Delta smelt. The Sacramento splittail was listed as threatened on February 8, 1999. However, after a thorough review, Service removed the Sacramento splittail from the list of threatened species effective September 22, 2003. They are found in the Sacramento San Joaquin estuary, although their historical range was greater. They have declined by 62 percent over a 13-year period.

Many of the fish in the Central Valley and Bay-Delta are introduced species. CDFG estimates that at least 50 species of fish have been introduced at one time or another into the Delta and San Francisco Bay estuary. Of 79 total fish species in the Central Valley, 32 were introduced. Principal introduced gamefish include striped bass, other basses, channel and white catfish, American shad, and sunfish. Notable non-gamefish include threadfin shad, goldfish, carp, golden shiners, fathead minnows, mosquitofish, and yellowfin goby.

Environmental Consequences.

Methodology. Except as noted below it was assumed that any benefits or adverse effects on resident native fish species in the

Trinity and Klamath River Basins would be similar to those for anadromous salmonids. This assumption is based on the premise that native resident fish evolved in and adapted to the same pre-dam environment that native anadromous salmonids did (the assumption does not apply to non-native resident fish).

Additional assumptions included the following:

- Mechanical rehabilitation projects in Trinity River would not affect resident native or non-native species in the lower Klamath River Basin.
- Watershed protection in the Trinity River would benefit resident native and non-native fish in the lower Klamath River.

Impacts to resident native and non-native fish in the Sacramento River were assessed qualitatively based on known population status, life history, and habitat needs. Impacts on fish in the Delta were assessed based on changes in Delta flows. A detailed evaluation was conducted on the Delta smelt because of their threatened status.

To distinguish differences between project alternatives and the No Action Alternative for resident fish, including Delta smelt, comparisons of Delta inflow to export ratios, position of X2 (salinity in the Delta equal to 2 ppt), and outflow from the Delta were conducted. The months most critical to Delta smelt, February through June, were scrutinized to determine if changes in flows in those months would be significant enough to potentially adversely affect those species in the Delta regions of the Central Valley. The detailed review of Modeled X2 position is described below. Graphic representations of relative X2 position are presented in Appendix B. Changes in the ratio of inflow to exports, position of X2, and out-flows from the Delta could negatively affect sensitive Delta species by adversely moving the position of optimal larval and juvenile rearing habitat area in Suisun Bay. Changes in flows in the Delta may also adversely affect those species by transporting larvae and juveniles into areas in the Delta where they may become entrained by the state and federal pumps.

The 2000 Service BO included a condition related to X2 that was the subject of specific comment in Judge Wanger's ruling, and, sub-sequently, a detailed analysis in this Supplemental EIS/EIR. Following is the specific reasonable and prudent measure (Reasonable and Prudent Measure) text from the 2000 Service BO:

- If Reclamation in its annual operations planning process detects that implementation of the Preferred Alternative will result in upstream (eastward) movement of X2 in any month between February 1 through June 30 of 0.5 km, Reclamation shall incorporate within its operating plan measures that can and will

be implemented to minimize or eliminate such upstream movements.

During the court proceeding, testimony was heard from both Service and USBR regarding the likely effect that implementation of the reasonable and prudent measure would have on CVP operations. Judge Wanger's ruling on the matter focused on the likelihood that the reasonable and prudent measure would result in additional water for X2 management that would be re-allocated away from another existing use and the impact to the existing use was not disclosed in the EIS/EIR. Specifically, the MDO states:

> Whenever CVP water is diverted to a different use, an impact is experienced throughout the system. The effects on the Preferred Alternative from the X2 reasonable and prudent measure pose potential unquantified but significant environmental and other consequences. The conflict between Service's "insignificance" opinion and the Bureau's views of the FEIS's X2 reasonable and prudent measure consequences … are not addressed or resolved … making impossible a finding that further analysis of X2 reasonable and prudent measures was not required. It was arbitrary and capricious for the EIS and FEIS not to address impacts of X2 reasonable and prudent measures and CVP re-operation.

First, it is important to note that, as currently stated, the reasonable and prudent measure is not implementable because there is no operational mechanism for direct comparison of monthly X2 position between No Action and the Preferred Alternative on either a real time or predictive basis. This likely accounts for the "conflict" identified in the MDO. The reasonable and prudent measure is based entirely on the CALSIM model, which is only a tool for comparing alternatives, not for real-time operations. For the reasonable and prudent measure to be implementable, two pieces are needed. First, a theoretical model of how the system would be operated under current conditions (i.e., how operations would be conducted if Trinity Restoration did not occur) would need to be developed in order to track a modeled value for X2 into the future. Secondly, because the current month's X2 position is partially driven by operations from the previous month, some mechanism would be needed to retroactively manage the previous month's operations. Thus, disclosure of the water cost of implementing the X2 reasonable and prudent measure is not feasible because implementation of the reasonable and prudent measure is not feasible.

However, impacts of the alternatives to X2 position were analyzed in an effort to disclose impacts from implementing action alternatives. CALSIM output was evaluated using mapping software to track relative X2 position between alternatives. Output from this analysis

indicates that there is no substantial change in critical habitat between the Existing Conditions and Preferred Alternative model runs (2001 Level of Development). Contrary to NEPA-focused analysis, ESA consultation requires comparison of the action alternative to existing conditions. NEPA review is described below. This is partially a result of X2 moving in both the upstream and downstream direction under the Preferred Alternative when compared to Existing Conditions, and also a result of the majority of exceedances (differences greater than 0.5 km) occurring in above normal or wet water years, when critical habitat is not limiting. Additionally, in a large number of the below normal or drier years, X2 exceedances occur when both the Existing Condition and the Preferred Alternatives are greater than 73 km, thus limiting habitat to the less desirable area east of Chipps Island. None of the modeled output identifies a case when the Preferred Alternative causes a loss of the critical habitat in Honker Bay that would have otherwise been available under the Existing Condition. However, the modeling does indicate that X2 does trend slightly (approximately 0.14 km, on average between February and June of the modeled period) to the east under the Preferred Alternative, when compared to the Existing Condition. This conclusion is expected to be consistent with the CVP-OCAP BO due to be released June 30, 2004. Further discussion of impacts under the CVP-OCAP consultation is presented in Chapter 4.

As noted above, NEPA analysis requires a slightly different comparison than ESA consultation. However, the same general conclusion is reached for NEPA analysis as for the ESA consultation. Compared to No Action, Maximum Flow causes the largest X2 shift towards the east between February and June, 0.13 km on average. Other action alternatives were lower. For example, Revised Mechanical resulted in a shift of 0.01 km; Modified Percent Inflow was 0.02 km; and Flow Evaluation was 0.04 km, on average, between February and June. In all cases, X2 shifts occurred in both the upstream and downstream direction, compared to No Action, and the large majority of exceedances occur in wetter years, when habitat is not limiting. Because there was no impact under the action alternatives, there is no need for mitigation, and the reasonable and prudent measure identified by the Service is no longer necessary.

To distinguish differences between project alternatives and the No Action Alternative for non-native resident fish, including striped bass and American shad, comparisons of Sacramento River flows, Delta inflow to export ratios, position of X2, and outflow from the Delta were also conducted. Excessive water exports compared to inflows in the Delta result in flow patterns in the Delta that can lead to greater numbers of fish eggs and larvae being entrained and lost at the Delta Pumps. Food productivity may also be negatively affected

by changes in Delta outflows. Reductions in food availability could adversely affect populations of important gamefish species such as striped bass and shad.

Significance Criteria. Impacts are considered significant to resident native and non-native fish species if they result in any of the following:

- Potential for reductions in the number, or restrictions of the range, of an endangered or threatened resident or non-resident fish or a resident or non-resident fish that is a candidate for state listing or proposed for federal listing as endangered or threatened
- Potential for substantial reductions in the habitat of any resident or non-resident fish other than those that are listed as endangered or threatened or are candidates (CESA) or proposed (ESA) for endangered or threatened status
- Potential for causing a resident or non-resident fish population to drop below self-sustaining levels
- Substantial adverse effect, either directly or through habitat modifications, on any resident or non-resident fish identified as a sensitive or special-status species in local or regional plans, policies, or regulations
- Substantial interference with the movement of any resident or non-resident fish.
- More than 10 percent modeled exceedance in the ratio of Delta inflows to exports, Delta outflows, over the 72-year simulation period (this percentage was judged to be conservative given it would be applied over the entire the analysis period). Such reductions in Delta flows are considered to be significant with regard to potentially adversely affecting habitats for Delta species, particularly Delta smelt.
- A change in Modeled X2 position such that habitat for Delta smelt is significantly reduced.
- A conflict with, or violation of, the provisions of an adopted Habitat Conservation Plan, Natural Community Conservation Plan, or other approved local, regional, or state habitat conservation plan relating to the protection of resident fish
- Mortality of state or federally listed resident fish, or species that are candidates for listing (CESA) or proposed for listing (ESA)
- Reductions in the size of a resident fish population sufficient to jeopardize its long-term persistence

- Temporary impacts to habitats such that resident fish suffer increased mortality or lowered reproductive success that jeopardizes the long-term persistence of those local populations
- Permanent loss of critical habitat of a listed species or special-status resident fish
- Reduction in the quantity or quality of habitats in which resident fish populations occur sufficient to reduce the long-term abundance and productivity of local populations
- Upstream X2 movement greater than 0.5 km in any month compared to No Action in February through June of any year[4]

No Action. As described under the Native Anadromous Species discussion above, the No Action Alternative performed poorly in achieving the Trinity River system attributes that benefit fish. Implementation of the No Action Alternative would result in the continued degradation of Trinity River habitat for resident native and non-native fish, although the degradation would not be as great as occurred immediately following TRD implementation. Impacts to resident native and non-native species in the Lower Klamath River Basin/Coastal Area and Central Valley would likely be relatively unchanged from existing conditions.

Revised Mechanical. Implementation of the Revised Mechanical Alternative would benefit resident native and non-native species in the Trinity River by enhancing habitat conditions for juvenile and adult life stages compared to the No Action Alternative. Conditions in the lower Klamath River would likely improve somewhat relative to the No Action Alternative. Populations of resident species in the lower Klamath River and estuary may benefit from implementation of this alternative as a result of increased flows into the Klamath River.

In the Central Valley, the allowable ratio of Delta inflows to exports, agreed upon in the Bay-Delta Accord, were not exceeded for any year simulated. On average, the change in monthly outflow from the delta is less than 1 percent less that that from the No Action Alternative (Table 3.4-14). The average X2 positions are, on average, are approximately -0.1 percent less than No Action for the months critical to Delta sensitive species. The average monthly X2 position moved greater than 0.5 km upstream compared to the No Action Alternative in as many as 7 of the 72 years (9.7 percent) simulated (June) (Table 3.4-15). However, the position of X2 also moved downstream (westward) greater than 0.5 km compared to No Action in as many as 4 of the 72 years (5.8 percent) simulated. Taken

[4] This criterion was the foundation of why the court found the original FWS BO unlawful. This may be withdrawn from the service, and may not be carried forward in the new Section 7 consultation.

together, the net change in X2 position is not significantly different than those estimated for No Action. The frequency and magnitude of these changes may result in significant impacts to habitat conditions for resident Delta species, including Delta smelt.

TABLE 3.4-14
Percent Change in the Average Monthly Outflows (CFS) from the Delta (1922-1993)

	Compared to No Action					
Month	Revised Mechanical	Flow Evaluation	Modified Percent Inflow	70 Percent Inflow	Maximum Flow	Flow Evaluation Compared to Existing Conditions
February	0	0	0	-1	-1	-1
March	0	0	0	-1	0	0
April	0	0	0	-1	-1	0
May	0	-1	-1	-2	-2	-2
June	-2	-2	-2	-2	-3	-3
Average	0	-1	-1	-1	-1	-1

TABLE 3.4-15
Summary of the Change in X2 Position in the Delta during February through June compared to the No Action Alternative (1922-1993)

	Compared to No Action Alternative					
Alternative	Revised Mechanical	Flow Evaluation	Modified Percent Inflow	70 Percent Inflow	Maximum Flow	Flow Evaluation Compared to Existing Conditions
Number months > 0.5 km upstream	17	35	23	54	55	44
% months > 0.5km upstream	4.7%	9.7%	6.4%	15.0%	15.3%	12.2%
Number months > 0.5 Km downstream	14	29	19	12	23	39
% months > 0.5km downstream	3.9%	8.1%	5.3%	3.3%	6.4%	10.8%

Flow Evaluation. The Flow Evaluation Alternative would provide greatly enhanced conditions for resident native and non-native species in the Trinity River compared to the No Action Alternative. Conditions in the lower Klamath River would be somewhat improved relative to the No Action Alternative.

In the Central Valley, the allowable ratio of Delta inflows to exports, agreed upon in the Bay-Delta Accord, were not exceeded for any year simulated. During May and June, Delta outflows are up to 2 percent less than those for No Action (Table 3.4-15). Those reductions in Delta outflows may be significant and may adversely

affect habitat for Delta species. Compared to No Action for the months critical to sensitive Delta species, the relative changes in position of X2 for the Flow Evaluation Alternative are on average, less than or equal to 0.1 percent (Table 3.4-16). During February through June the estimated position of X2 moved upstream greater than 0.5 km in 35 (9.7 percent) of the months from 1922 through 1993 (Table 3.4-15). However, the position of X2 also moved downstream (westward) greater than 0.5 km compared to No Action in 29 (8.1 percent) of those month during the same period. Taken together, the net change in X2 position is not significantly different than those estimated for No Action. The frequency and magnitude of these changes would not result in significant reduction in habitat for resident species in the Delta.

TABLE 3.4-16
Comparison of No Action to Project Alternatives for Delta X2 Position (in km) for Months Critical to Sensitive Delta Species during the Period 1922 through 1993

	Alternative					
	Revised Mechanical	Flow Evaluation	Modified Percent Inflow	70 Percent Inflow	Maximum Flow	Existing Conditions
Month	Average Relative Change (Percent)					
February	0.0	-0.1	-0.1	-0.4	-0.4	-0.1
March	0.0	-0.1	-0.1	-0.2	-0.2	-0.1
April	0.0	-0.1	-0.1	-0.3	-0.1	-0.1
May	0.0	0.0	-0.1	-0.1	-0.1	-0.1
June	0.0	0.0	-0.1	-0.2	-0.1	-0.1

Modified Percent Inflow. Implementation of the Modified Percent Inflow Alternative would benefit resident native and non-native species in the Trinity River by enhancing habitat conditions for juvenile and adult life stages compared to the No Action Alternative. Conditions in the lower Klamath River would likely be unchanged relative to the No Action Alternative.

In the Central Valley, the allowable ratio of Delta inflows to exports, agreed upon in the Bay-Delta Accord, were not exceeded for any year simulated. During May and June, Delta outflows are up to 2 percent less than those for No Action (Table 3.4-15). Those reductions in Delta outflows are not significantly different than those for the No Action Alternative. Compared to No Action for the months critical to sensitive Delta species, the relative changes in position of X2 for the Modified Percent Inflow Alternative are on average, nearly unchanged (Table 3.4-16). During February through June the estimated position of X2 moved upstream greater than 0.5 km in 23 (6.4 percent) of the months from 1922 through 1993 (Table 3.4-15). However, the position of X2 also moved downstream

(westward) greater than 0.5 km compared to No Action in 19 (5.3 percent) of those months during the same period. Taken together, the net change in X2 position is not significantly different than those estimated for No Action. The frequency and magnitude of these changes would not result in significant reduction in habitat for resident species in the Delta.

70 Percent Inflow. The Flow Evaluation Alternative would provide greatly enhanced conditions for resident native and non-native species in the Trinity River compared to the No Action Alternative. Conditions in the lower Klamath River would be somewhat improved relative to the No Action Alternative.

In the Central Valley, the allowable ratio of Delta inflows to exports, agreed upon in the Bay-Delta Accord, were not exceeded for any year simulated. During all months from February through June, Delta outflows are up to 2 percent less than those for No Action (Table 3.4-15). Compared to No Action for the months critical to sensitive Delta species, the relative changes in position of X2 for the 70 Percent Inflow Alternative are generally less than or equal to 0.4 percent (Table 3.4-16). Compared to the No Action Alternative the relative changes in X2 position during February through June are less than 0.4 percent (Table 3.4-16). During February through June the estimated position of X2 moved upstream greater than 0.5 km in 54 (15.0 percent) of the months from 1922 through 1993 (Table 3.4-15). However, the position of X2 also moved downstream (westward) greater than 0.5 km compared to No Action in 12 (3.3 percent) of those months during the same period. Taken together, the net change in X2 position is significantly different (>10%) than those estimated for No Action. Therefore overall, the frequency and magnitude of these changes may result in significant reductions in Delta habitat for resident species, including Delta smelt. These impacts could be not be mitigated for.

Maximum Flow. The Maximum Flow Alternative would provide suitable habitat and greatly enhanced conditions for resident native and non-native species in the Trinity River compared to the No Action Alternative. The impacts of improved habitat conditions on non-native brown trout in the Trinity River are unknown, but it is unlikely they would benefit to a greater extent than native salmonid species. Conditions in the lower Klamath River would be somewhat improved relative to the No Action Alternative due to additional flows and habitat water quality.

In the Central Valley, the allowable ratio of Delta inflows to exports, were not exceeded for any year simulated. During the months February, April, May and June, Delta outflows are up to 3 percent less than those for No Action (Table 3.4-15). Those reductions in Delta outflows are not significantly different than those for the

No Action Alternative. Compared to the No Action Alternative the relative changes in X2 position during February through June are less than 0.4 percent (Table 3.4-16). During February through June the estimated position of X2 moved upstream greater than 0.5 km in 55 (15.3 percent) of the months from 1922 through 1993 (Table 3.4-15). However, the position of X2 also moved downstream (westward) greater than 0.5 km compared to No Action in 23 (6.4 percent) of those months during the same period. Taken together, the net change in X2 position is not significantly different (<10%) than those estimated for No Action. Therefore overall, the frequency and magnitude of these changes would not likely result in significant reductions in Delta habitat for resident species, including Delta smelt.

Existing Conditions versus Proposed Action. Trinity River impacts of the Proposed Action to existing conditions would be similar to the impacts of the Flow Evaluation Alternative compared to the No Action conditions in the year 2020. However, the watershed protection component of the Proposed Action would benefit resident native fish by reducing sediment inputs to the Trinity River.

In the Central Valley, the allowable ratio of Delta inflows to exports, agreed upon in the Bay-Delta Accord, were not exceeded for any year simulated. During the months February, May and June, Delta outflows are up to 3 percent less than those for No Action (Table 3.4-15). Those reductions in Delta outflows are not significantly different than those for existing conditions. Compared to No Action for the months critical to sensitive Delta species, the relative changes in position of X2 for the existing conditions are, on average, -0.1 percent (Table 3.4-16). Compared to the existing conditions the relative changes in X2 position for the Flow Evaluation Alternative, during February through June, are less than 0.1 percent (Table 3.4-16). During February through June the estimated position of X2 moved upstream greater than 0.5 km in 44 (12.2 percent) of the months from 1922 through 1993 (Table 3.4-14). However, the position of X2 also moved downstream (westward) greater than 0.5 km compared to existing conditions in 39 (10.8 percent) of those months during the same period. Taken together, the net change in X2 position is not significantly different (<10%) than those estimated for existing conditions. Therefore overall, the frequency and magnitude of these changes would not likely result in significant reductions in Delta habitat for resident species, including Delta smelt.

3.4.3 Reservoirs

Affected Environment.

Trinity River Basin. Trinity Reservoir supports a trophy smallmouth bass fishery and provides significant sport fishing for largemouth bass, trout, kokanee salmon, landlocked Chinook salmon, and other gamefish. The maximum surface area of the reservoir is 16,500 acres, with an irregular shoreline of about 145 miles. As is typical with most reservoirs, Trinity Reservoir is characterized by steep sides, with the upper one-fifth of the reservoir consisting of gentle slopes. Thermal stratification occurs between May and November, while the remainder of the year the reservoir is relatively isothermal (i.e., water temperature is the same at all depths). The banks of Trinity Reservoir have high erosion potential, and under windy conditions contribute to high turbidity near the shoreline.

Lewiston Reservoir is principally a trout fishery. Its total storage capacity is 14,600 acre-feet, covering about 610 acres with 15 miles of shoreline. Because Lewiston Reservoir is fairly shallow, thermal stratification can develop quickly when discharge from Trinity Reservoir is low. Historically, exports to the Central Valley have been intermittent, which results in rapid swings in Lewiston Reservoir surface temperatures.

Habitat and Life History Characteristics of Principal Species. Habitat conditions and forage for smallmouth bass in Trinity Reservoir appear to be nearly ideal. The cool water and the high percentage of gravel-rubble bottom have resulted in record-size smallmouth bass being taken. The species requires clean sand, gravel, or debris-littered bottoms to spawn, at depths of 1 to 3 feet up to 23 feet. Spawning begins in April. Optimal water temperatures for spawning are 55 to 61°F; optimal temperature for growth and survival is 68 to 81°F. Largemouth bass also begin spawning in April, typically when water temperatures reach 61°F. Spawning occurs at depths of 3 to 6 feet on sand, gravel, or debris-littered bottoms. Optimal growth and survival for largemouth bass occurs at water temperatures of 68 to 86°F.

Kokanee salmon are the non-anadromous (i.e., land-locked) form of sockeye salmon. They were introduced and have become well established in both Trinity and Lewiston Reservoirs. The species makes its spawning migration into streams between early August and February. They prefer spawning in water temperatures between 43 to 55°F.

Rainbow trout are the most abundant salmonid found in the two reservoirs. They spawn in the spring in streams flowing into the reservoirs. Juvenile trout migrate out of the spawning streams to

enter the reservoir to forage and mature where the cold, deep water provides suitable habitat. Optimum temperatures for growth are between 55° and 70°F.

Variable numbers of hatchery trout are stocked by CDFG into Trinity and Lewiston Reservoirs each year to support the sport fisheries. The timing and numbers of planted fish are dependent upon several factors, including water temperature, availability of hatchery fish, and reservoir surface acreage.

Factors Affecting Abundance. Fluctuating water level is frequently identified as the main adverse impact affecting reservoir fish production. Limited cover, associated with surface-level fluctuation, has also been identified as a primary limiting factor in terms of production. Rising water elevations during spring could cause largemouth bass to abandon nests. Conversely, severe drawdown of Trinity Reservoir could adversely affect both smallmouth and largemouth bass production in some years.

Temperatures within the reservoirs are dependent on season and reservoir storage conditions. Generally, temperatures are adequate to sustain reservoir fisheries. However, cool water in Trinity Reservoir might not be optimal for largemouth bass and kokanee salmon. Cold water in the reservoir appears to cause low zooplankton production and could be responsible for the stunted size (6 to 8 inches) of kokanee salmon.

Lower Klamath River Basin/Coastal Area. No reservoirs exist in this area.

Central Valley. The Central Valley contains numerous reservoirs supporting both coldwater and warmwater sport fisheries. The principal reservoirs include Shasta, Whiskeytown, San Luis, Folsom, and Oroville. These reservoirs were evaluated because they are the principal storage elements of the CVP and SWP, contain significant sport fisheries, and habitats supporting those fisheries that may be affected by project operations. Operations of the CVP and the SWP may affect the fish habitat by changing reservoir storage conditions (surface area and volume of reservoirs). Changes in reservoir surface area, depths, and timing of these changes may decrease or increase spawning and rearing habitats and food production supporting those reservoirs' warmwater gamefish. Principally, those CVP and SWP reservoirs are warmwater (bass, catfish, and sunfish) fisheries that are self-sustaining by natural reproduction. Coldwater fisheries in those reservoirs are supplemented by stocking programs and, as such, are less affected by changes in reservoir operations and habitat conditions.

Shasta Reservoir provides an outstanding fishery, with both cold-water and warmwater species commonly pursued by recreational anglers. Coldwater gamefish include Chinook and kokanee salmon and rainbow and brown trout. Warmwater gamefish include largemouth, smallmouth, and spotted bass, sunfish, black crappie, channel and white catfish, and bullhead. Whiskeytown Reservoir receives diverted water from Lewiston Reservoir via the Clear Creek Tunnel. Gamefish found in Whiskeytown Reservoir include rainbow and brown trout, kokanee salmon, largemouth bass, crappie, sunfish, catfish, and bullhead.

San Luis Reservoir principally serves to store and deliver water received from the Delta diversions for delivery to farmland in western Merced, Fresno, and Kings Counties. Due to pattern of water deliveries, drawdowns in excess of 60 feet occur annually. More than 30 fish species are known to occur in San Luis Reservoir. The species were generally introduced by transport as larvae or fry from the Delta. CDFG has periodically stocked catfish and largemouth bass in this reservoir, but the principal gamefish has been striped bass.

Folsom Reservoir contains a warmwater fishery of large and smallmouth bass, sunfish, and catfish, and a coldwater fishery of rainbow trout that is stocked by CDFG on an annual basis. Oroville Reservoir's warmwater sport fishery is for largemouth, spotted, and smallmouth bass and catfish. The coldwater fishery consists of rainbow and brown trout and Chinook salmon.

Lake Oroville is a DWR storage reservoir on the Feather River. Water is delivered out of the Reservoir to Thermolito forebay/ afterbays and from there to downstream users. Drawdown averages approximately 75 feet per year. Both warmwater and coldwater sportfisheries ("two story fishery") exist in Lake Oroville. Bass fishing is a popular sport and is recognized as a top bass angling fishery in the Western U.S. Species include spotted bass, largemouth, redeye, and smallmouth bass. In addition, black crappie, white crappie, and channel catfish up to 25 pounds are commonly caught in Lake Oroville. The principal coldwater species are planted brown trout and Chinook salmon. Brown trout up to 15 pounds and Chinook salmon up to 19 pounds have been caught in Lake Oroville in recent years.

Environmental Consequences.

Methodology. In the Draft EIS/EIR, a spreadsheet model was developed for the Trinity and Lewiston Reservoirs to evaluate the changes in reservoir habitat resulting from fluctuations of water-surface elevations and area. Impacts of the alternatives on warmwater fish communities in Trinity Reservoir were evaluated by

calculating a spawning habitat index and a rearing habitat index for largemouth and smallmouth bass. The changes in surface elevations and area were assumed to directly affect fish abundance and production. Changes in habitat indices, therefore, reflect expected changes in relative population abundance and production. For this Supplemental EIS, impacts of the alternatives on both warmwater and coldwater fish communities were evaluated qualitatively based on changes in reservoir surface acreages or in the case of San Luis Reservoir, storage.

Changes in reservoir acreages were evaluated for each alternative. Mean reservoir surface acreage for the primary spawning and rearing months of largemouth and small mouth bass (March through July) were compared among the alternatives to evaluate impacts to warmwater reservoir species over the 72-year simulation period.

Significance Criteria. Impacts to reservoir fisheries are considered significant if they result in any of the following:

- Potential for reductions in the number, or restrictions of the range, of an endangered or threatened reservoir fish or a reservoir fish that is a candidate for state listing or proposed for federal listing as endangered or threatened
- Potential for substantial reductions in the habitat of any reservoir fish other than those that are listed as endangered or threatened or are candidates (CESA) or proposed (ESA) for endangered or threatened status
- Potential for causing a reservoir fish population to drop below self-sustaining levels
- Substantial adverse effect, either directly or through habitat modifications, on any reservoir fish identified as a sensitive or special-status species in local or regional plans, policies, or regulations
- Substantial interference with the movement of any reservoir fish
- A conflict with, or violation of, the provisions of an adopted Habitat Conservation Plan, Natural Community Conservation Plan, or other approved local, regional, or state habitat conservation plan relating to the protection of reservoir fish
- Mortality of state or federally listed reservoir fish, or species that are candidates for listing (CESA) or proposed for listing (ESA)
- Reductions in the size of a reservoir fish population sufficient to jeopardize its long-term persistence

- Temporary impacts to habitats such that reservoir fish suffer increased mortality or lowered reproductive success that jeopardizes the long-term persistence of those local populations
- Permanent loss of critical habitat of a listed species or special-status reservoir fish
- Reduction in the quantity or quality of habitats in which reservoir fish populations occur sufficient to reduce the long-term abundance and productivity of local populations

Potentially significant impacts to reservoir fisheries were judged to occur if reservoir water surface areas (which correlate with habitat quantity and fish abundance) were reduced over 10 percent during the months of March through July over the 72-year simulation period.

No Action. Conditions under the No Action Alternative would remain relatively unchanged compared to existing conditions.

Revised Mechanical. There would be no impacts to reservoirs.

Flow Evaluation. Trinity Reservoir spawning habitat for bass would diminish due to decreased average water-surface areas, but to a less than significant degree. Impacts to other reservoirs would be negligible.

Modified Percent Inflow. Impacts to reservoirs would be negligible.

70 Percent Inflow. This alternative would likely adversely affect both largemouth and smallmouth bass spawning in Trinity Reservoir and, to a lesser degree, Shasta Reservoir. The annual change in surface area of Trinity Reservoir decreased nearly 10 percent (9.4 percent). Reductions of Trinity Reservoir surface areas ranged from 9 to 13 percent during the months of March through July as compared to No Action. An annual reduction of approximately 5.6 percent of Shasta Reservoir surface area was estimated. These decreases may result in adverse impacts to spawning warmwater reservoir species in Shasta Reservoir, but were not considered significant for this analysis. These decreases may result in adverse impacts to spawning warmwater reservoir species in Trinity Reservoir during March through July. Impacts to other reservoirs would be negligible (Table 3.4-10).

Maximum Flow. The Maximum Flow Alternative would likely adversely affect both largemouth and smallmouth bass spawning in Trinity Reservoir and, to a lesser degree, Shasta Reservoir. The decrease in surface area of Trinity Reservoir exceeded 10 percent (greater than 30 percent), a significant adverse impact to spawning for warmwater reservoir species. The range in decreases in surface area of Shasta Reservoir were up to nearly 8 percent. These

decreases may result in adverse impacts to spawning warmwater reservoir species in Shasta Reservoir, but were not considered significant for this analysis. Impacts to other Central Valley reservoirs would be negligible (Table 3.4-17).

Existing Conditions versus Proposed Action. The difference between existing conditions and the Proposed Action would be nearly identical to the difference between the No Action and the Flow Evaluation Alternative. This is because the other components of the Proposed Action (i.e., watershed protection) would not affect reservoirs.

Mitigation.

To reduce the impact of the Maximum Flow and the 70 Percent Inflow Alternatives on warmwater reservoir fish species in Trinity Reservoir to a less than significant level, the following mitigation should be implemented:

A smallmouth and largemouth bass stocking program should be initiated similar to the existing stocking program for coldwater species.

TABLE 3.4-17
Summary of Impact Analysis for Fishery Resources (Compared to the No Action Alternative)

Resource Concern	Geographical Area	Mechanical Restoration	Revised Mechanical	Flow Evaluation	Modified Percent Inflow	70 Percent Inflow	Maximum Flow	Flow Evaluation Compared to Existing Conditions
Native Anadromous Species	Trinity River Basin	B	HB	HB	HB	HB	HB	HB
	Lower Klamath River Basin	NC	B	B	B	B	B	B
	Central Valley	NC	NC	A	A	A	A	A
Resident Native Species	Trinity River Basin	B	B	B	B	B	B	B
	Lower Klamath River Basin	NC	B	B	B	B	B	B
	Central Valley	NC	A	A	A	A	A	A
Reservoir Species-Trinity Basin	Warmwater species	NC	NC	NC	NC	A	A	NC
	Coldwater species	NC	NC	NC	NC	NC	NC	NC
Reservoir Species-Central Valley	All species	NC	NC	NC	NC	NC	NC	NC

Notes:
A = Adverse Change
NC = No Change
B = Beneficial Change
HB = Highly Beneficial Change

3.5 Power Resources

The TRD is a key component of CVP hydropower as it provides approximately 30 percent of the power generation capability of the CVP through approximately 1 percent of overall generation capability statewide. This analysis of potential impacts on power resources focuses on effects on power generation, market value of power, and preference power customers. This section does not differentiate between the Trinity River Basin, Lower Klamath River Basin/Coastal Area, and Central Valley because impacts to power span the Trinity River Basin and Central Valley areas and beyond.

Affected Environment.

One of the conclusions stated in the Wanger Decision is that "inadequate consideration was given to power supply and reliability impacts in a changing hydropower environment." This section presents an overview of recent changes in the California power market and the role of the CVP within that market.

California Power Crisis. California's electric deregulation created a statewide electricity market with its own characteristics and governance.

When California deregulated, it established the California Power Exchange (CAPX) to operate a power exchange system from which the state's investor-owned utilities (IOU) (PG&E, Southern California Edison [SCE], and San Diego Gas & Electric) had to buy their power on a day-ahead and hour-ahead basis. The highest price power supply bid that was needed for each hour of the next day set the price for the entire market for that hour. The IOUs were also prevented from hedging into future markets. This eliminated new bilateral, negotiated agreements from the market place.

The winter of 2000-01 marked the second driest water year on record in the Pacific Northwest, reducing the amount of hydroelectric produced in the region, which increased the demand for natural gas in the region and decreased the amount available for export to California. Decreased natural gas exports coupled with historically low natural gas storage in California caused natural gas prices to rise dramatically. (Marcus and Hamrin, How we got in the California Energy Crisis, www.jbsenergy.com), also (Electricity Shortage in California: Issues for Petroleum and Natural Gas Supplies, www.eia.doe.gov.

In late May 2000, after the first unanticipated heat wave of the year, wholesale market prices became extremely volatile and provided opportunities for market manipulation. The California Independent System Operator (ISO) had responsibility to provide the system with

"spinning reserves," which it had to purchase on the spot market, and also had to make up for any differences between actual real-time loads and forecasted day-ahead and hour-ahead loads. ISO real-time purchases drove wholesale power prices even higher. By late 2000, market prices for electricity were routinely well over $100 per MWh, well in excess of retail rates.

The IOUs were unable to pass the increased costs on to their retail customers. As a result, their financial capabilities were quickly lost and they approached bankruptcy in late 2000. This eventually led to credit concerns on the part of power suppliers who withheld supplies over payment concerns.

The state became involved in purchasing power supplies in January 2001. At the end of January 2001, CAPX suspended its day-ahead and day-of market operations.

In early March 2001, DWR negotiated and executed 40 contracts for nearly 8,900 megawatts (MW) for periods ranging from 1-12 years to meet SCE and PG&E's needs. These contracts, negotiated during the power crisis, are at levels above current market prices, and the state is making an ongoing effort to renegotiate the contracts. The state has had some success in this regard.

In April 2001, PG&E filed a voluntary petition for bankruptcy protection under Chapter 11 of the U.S. Bankruptcy Code. Also in April, the Federal Energy Regulatory Commission (FERC) issued its initial order to provide market mitigation for summer 2001, followed by a second order in June that revised, clarified, and expanded the April order. By June 2001 prices had returned to levels far below those of the previous 12 months, where they have largely remained since. In May, the state authorized the sale of $13.4 billion in bonds to finance power purchases and other measures to ease the crisis.

In June 2001, a FERC administrative law judge mediated negotiations on the appropriate level of refunds due California from power suppliers. The talks broke down over a lack of documentation. Separately, a FERC order required ISO market participants to offer their generation to the market whenever it was physically available unless given a prior waiver by ISO. This "must-offer" requirement prevented withholding of supplies to drive up prices and contribute greatly to the stabilization of market prices in June 2001 and thereafter.

With the October 2001 California Public Utilities Commission order ending direct access in the state, California's deregulation of its retail electricity markets came to an end. The state is now in a position of being a major power purchaser and seller, and longer term bilateral contracts dominate the market.

In December 2001, FERC issued additional extensive orders clarifying the market mitigation framework that exists in California today. Parts of that framework expired on September 30, 2002. There are efforts underway to redesign the California wholesale power market.

In May 2002, documents surfaced indicating deliberate market manipulation by various power marketers, which in turn have led to calls for refunds, increased regulatory scrutiny, and possible litigation, over the events and prices of the 2000-2001 period. Meanwhile, the "must-offer" requirement, the construction of thousands of MW of new generation since 2000, and demand reductions which left 2003 consumption no higher than 2000 consumption have all worked together to produce relatively stable supplies and prices since June 2001.

California and the Western Systems Coordinating Council System. California moved toward deregulating its electric utility industry in 1996 with Assembly Bill 1890, which made fundamental changes to the electric market structure to increase competitive market forces.

This was, and is, part of a broader national transition from a highly regulated, vertically integrated industry to one with a competitive wholesale power supply market, common carrier bulk power transmission systems, and local distribution companies.

Industry restructuring began with passage of the 1992 Energy Policy Act, which required FERC-regulated, transmission-owning utilities to offer transmission service across their systems to eligible entities (e.g., utilities, power marketers, Independent Power Producers, etc.) under terms and conditions comparable to those the utility affords its own merchant function. FERC-regulated utilities are almost always IOU. Publicly owned utilities and federal power marketing agencies are not subject to the 1992 Energy Policy Act. However in practical terms, transmission-owning utilities have found it desirable to conform to the 1992 Energy Policy Act's requirements.

Although electric utilities have always traded electricity among themselves, it was not until passage of this Act that electricity became a commodity, traded among various parties in a manner similar to other energy commodities such as natural gas and crude oil. Non-utility generators were able to sell power across utility transmission systems. Today, it is not uncommon for the same kilowatt-hour (kWh) of electricity to be purchased and resold by multiple entities before reaching the end-use consumer.

As a result, the entire western North America interconnected electrical transmission system, composed of 13 western states and the Canadian provinces of British Columbia and Alberta, now functions as a single wholesale market (see Figure 3.5-1). This market is often

referred to as the Western Electricity Coordinating Council (WECC) region.

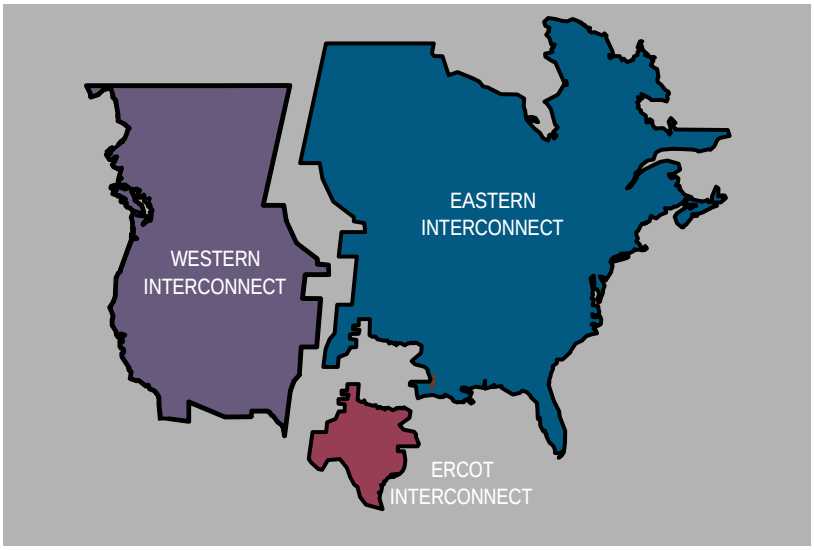

FIGURE 3.5-1
North America Interconnected Electrical Transmission System

A significant amount of business is conducted throughout the region using bilateral transactions as well as short-term or spot market transactions. Bilateral transactions occur at posted, cost-based rates or via negotiations between willing buyers and sellers.

Except for periods of transmission congestion, when electricity cannot move efficiently from one part of the system to another, prices throughout the west are highly correlated, as shown on Figure 3.5-2. Events in one subregion of the west (e.g., unit outage, extreme weather, etc.) impact the price of electricity throughout the western United States, as surplus power from one subregion moves to a power-short region. Short-term or spot market transactions are typically priced to reflect the indexed prices associated with particular "market hubs," which establish spot market (next day) prices that are used to index transactions at these hubs. The electricity trading hubs shown on Figure 3.5-2 are the Mid-Columbia, California-Oregon Border, California ISO North of Path 15 (NP15), California ISO South of Path 15 (SP15), and Palo Verde.

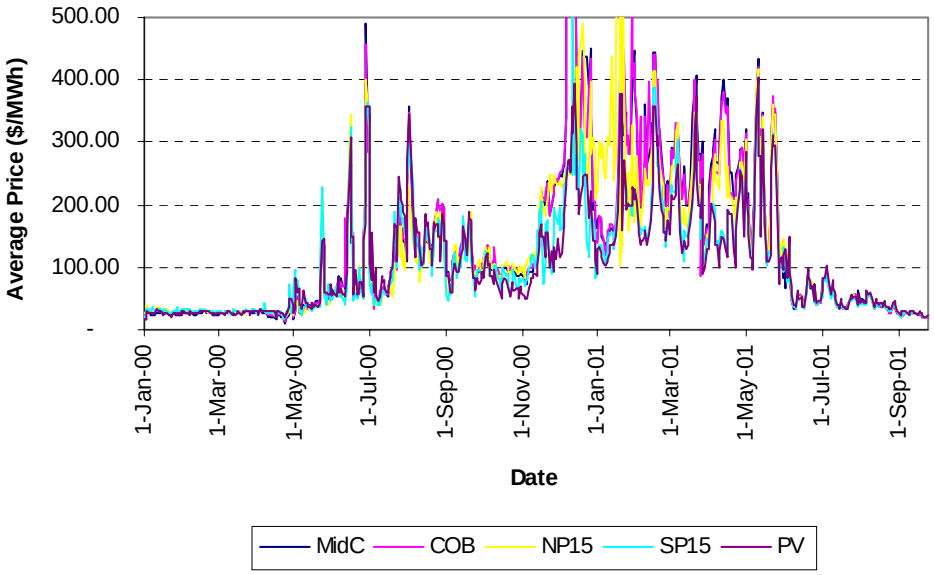

FIGURE 3.5-2
Average Daily Electricity Prices in the Western U.S. Calendar Year 2000 and 2001

The dramatic increase in electricity spot market price volatility, starting about May 2000 and continuing through June 2001, has been the subject of much discussion and

analysis. It is generally agreed that contributing causes included some or all of the following:

- Structural flaws in California's wholesale power markets (the forced use of the day-ahead and day-of markets by the state's IOUs for all of their power supply)
- Increased load growth without new power generation to meet it
- A drought in the Pacific Northwest
- A lack of natural gas pipeline capacity into and within California
- Electric transmission system constraints
- The exercise of market power by the owners and/or marketers of power generation facilities and gas pipeline facilities, which was reinforced by the above

Recently discovered documents indicate that the exercise of market power and "gaming" of the system was a significant factor in the crisis. Enron and other power marketers engaged in various trading practices that took advantage of the market structure to create shortages and higher market prices. Recent documents have come to light indicating that some of the practices used by power marketers were possibly illegal and could constitute fraud.

Two studies commissioned after extreme prices first began appearing during the summer of 2000 point to supply tightness as a contributing factor. The Northwest Power Planning Council stated in its report, "*…we believe the prices experienced this summer* (summer of 2000) *are symptomatic of an overall tightening of supply, exacerbated by a number of factors."*[5] Similarly, the Compliance Unit of the CAPX cited *"an inadequate supply of electricity"* as one of the factors that contributed to the high prices experienced during the summer of 2000 and that continued into the spring of 2001[6].

FERC noted the strong correlation between the California electricity market and western United States bilateral prices during the summer of 2000. "The events of this summer provide dramatic evidence of the interstate nature of electric systems and markets in the Western Interconnection. California is not an electrical island. Operationally, the transmission facilities currently controlled by the ISO are part of the much larger Western Interconnection. The reliability of California's electric system depends on access to generating resources located throughout the Western Interconnection" (Order in San Diego Gas & Electric Company, et al., 93 FERC 61,1231 (2000)).

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[5] Study of Western Power Market Prices Summer 2000, document 2000-18, Northwest Power Planning Council, October 11, 2000.

[6] Price Movements in California Power Exchange Markets Analysis of Price Activity: May-September 2000, California Power Exchange Compliance Unit, November 1, 2000.

It should be noted that federal, municipal, and other non-IOU utilities in California were not required to use the CAPX or ISO for power supply. They continued to use the traditional bilateral contract approach. As a result, and to the extent they did not need to make purchases in the wholesale markets, their consumers were generally sheltered from the high electricity prices.

Western wholesale power market prices have generally returned to historical levels, the result of increased regulatory scrutiny, new power generation coming online, an improved hydroelectric power generation outlook in the Pacific Northwest, significant load reductions and a slowing of the economy, and lower natural gas prices and increased natural gas storage levels within California.

The California deregulated retail market came largely to an end when the California Public Utilities Commission ended the ability of retail electric customers in the state to have "direct access" to the wholesale market. The financial aftermath of the experiment will continue for many years.

California is in the process of redesigning its wholesale power markets and is developing mechanisms requiring load-serving entities to have adequate capacity to meet the loads served. This is intended to reduce wholesale power market volatility by assuring that there is sufficient capacity available to meet peak loads.

Bulk Transmission Systems Operating Structure. In the meantime, FERC continues to push the formation of regional transmission organizations (RTO) which will be responsible for the operation, planning, and control of the bulk electric transmission systems. FERC has indicated that the entire western United States system should be under one RTO. The ISO has acted in this function in California. There are ongoing efforts to establish one or more RTOs in the remaining Western Systems Coordinating Council area. Whether there are ultimately one or more RTOs in the west is yet to be determined.

Within its geographic area, an RTO is responsible for tariff administration and design, congestion management, management of parallel path flows, provider of last resort for ancillary services, administration of the Open Access Same-time Information System site, market monitoring, system planning and expansion, and inter-regional coordination. In performing these functions, it is expected that an RTO will provide a nondiscriminatory bulk power transmission system that will foster fully competitive wholesale markets.

It is expected that the western United States will continue to function as an interrelated market, with any spot market price volatility reflected throughout the region.

The WECC region has historically relied upon transmission capacity to enable economic generation dispatch throughout the region and to use seasonal excess capacity among subregions. This also avoided the need to develop additional generation capacity. Utilities in the Northwest have been able to share summer-peaking capacity located in the Northwest to help meet winter peaks in the Southwest and vice-versa.

The bulk power transmission system that serves the West Coast was largely built in the 1960s and 1970s and is frequently loaded to capacity. The congestion now associated with the West Coast transmission system has been aggravated by heavy use encouraged by deregulation. Much of the increased use is attributed to open market access that was not contemplated when the system was developed.

Congestion management efforts now play a significant role in the operation of the transmission system. These efforts consist of identifying transmission solutions as well as generation location and demand side (load interruption) solutions to relieve system constraints.

Adequate, unconstrained transmission enables orderly and cost-effective dispatch of power throughout the western United States and Canada. Transmission constraints effectively reduce the size of the market and lead to sub-optimal generation dispatch, higher production costs, and higher market prices of available power. Evidence has emerged that during the 2000 power crisis various energy traders gamed the system to create transmission system congestion and thereby raise prices.

Market Drivers. Market drivers are conditions or actions that cause changes to the market. These drivers include the load-resource balance within an area or region, transmission access and constraints, natural gas prices, marginal costs of power generation, regulatory considerations, water availability for Pacific Northwest hydropower, and subregional interaction.

Load Resource Balance. A primary driver of the market price of power is the relationship between loads and resources. When loads are less than the power resources available, the market is in surplus and the price should fall or be steady. Conversely, when loads exceed available power resources, the market is in deficit and the market price can be expected to rise.

In California, for various reasons, few new power generation facilities were built for over 10 years.[7] Moreover, in the year 2000, ISO-area energy consumption increased 5 percent above the level the year before.[8] This situation has since reversed, as a large amount of power generation facilities have been built and electrical demand has receded. Figure 3.5-3 displays the amount of power generation facilities built by year in the entire WECC, and includes a projection for 2004.[9] As a point of comparison, the nameplate capacity of the CVP is approximately 2,000 MW. Longer term, the California Energy Commission was identified over 8,500 MW of new powerplants under construction as of February 2004, plus another 13,000 MW already permitted, another 17,000 MW in permitting, and a further 14,000 MW in the initial stages of development. (CEC, 2/5/04, http://ww.energy.ca.gov/electricity/wscc_proposed_generation.html)

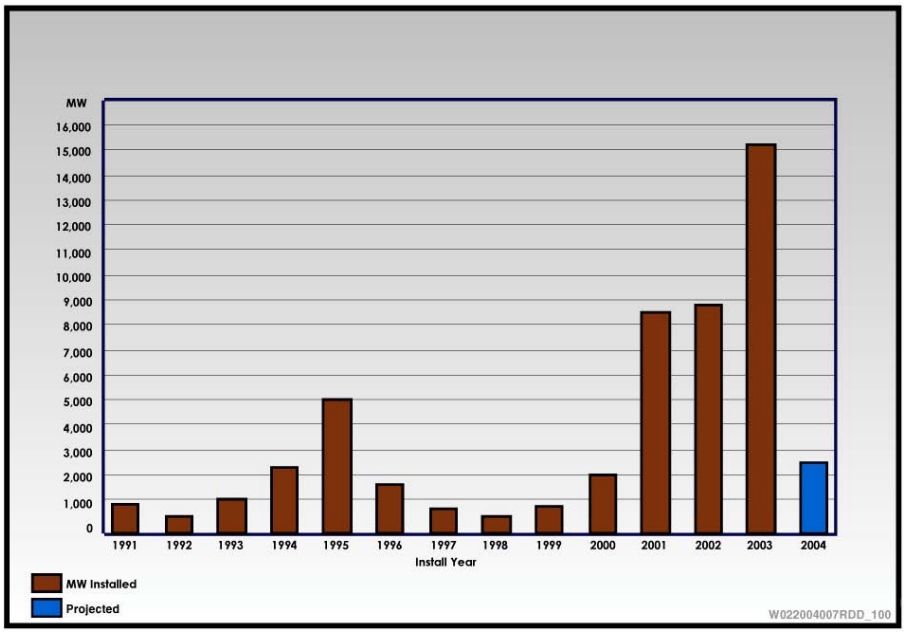


FIGURE 3.5-3
Power Generation Facilities Built by Year

[7] http://www.energy.ca.gov/sitingcases/backgrounder.html lists slightly over 1,000 Mw of CEC-licensed powerplants which came on line in California in the 1991-2000 period. This list does not include hydro or wind plants, or powerplants under 50 MW in size.

[8] However, peak demand in 2000 fell from 1999 levels.

[9] The CEC has a plant-by-plant listing of WECC resource additions on its website (see http:www.energy.ca.gov/electricity/wscc_proposed_generation.html). That listing shows approximate new resource additions of 2,200 MW in 2000, 8,600 MW in 2001, 9,600 MW in 2002, 16,400 MW in 2003, and 11,400 MW for 2004 (2,800 MW of which is listed as under construction as of October 2003). The CEC numbers for 2001-2 are somewhat higher than the numbers on Figure 3.5-3, probably because of different accounting for wind projects.

Hydroelectric Water Conditions. Hydroelectric water conditions (snowfall and rainfall) have a tremendous influence on the availability and price of power in the region. Hydroelectric generation is the predominant source of power in the Pacific Northwest and Canada (over 30,000 MW of capacity in the U.S. Pacific Northwest and over 10,000 MW of capacity in British Columbia, Canada). Temperature greatly influences the magnitude and runoff pattern and the short-term availability of hydropower. Endangered species considerations also have a significant effect on hydropower system operations.

Most WECC utilities that operate hydroelectric generation plants rely upon critical water planning; that is, they base their "firm" power capabilities on the historical low water runoff periods. Whenever water conditions are better than "critical" there is additional "non-firm" energy available. While the amount of non-firm energy can be substantial, it is by its very nature uncertain. Based on 50 years of record, the Pacific Northwest produces on average 2,500 to 2,700 MW of non-firm energy each year.

Within the region, the general practice has been to schedule thermal plant maintenance during periods of increased water availability, the "expected runoff pattern." Deviations in the expected pattern can greatly affect the overall supply of power.

Natural Gas Availability. As with any commodity, natural gas prices are a combination of supply and demand.

Demand for natural gas is increasing because it is a relatively clean fuel and easily transported to the end user. Proposed new electric power generation in the United States is predominantly natural-gas fired.

On the supply side, natural gas availability to the end user is a combination of production, pipeline capacity, and storage. The California Energy Commission issued its final report on Natural Gas Infrastructure Issues, October 2001. Quotes from that report follow:

> "Natural gas supplies in North America appear to be sufficient to meet demand in California and the remainder of the United States for the next 50 years, according to the United States Geological Survey.
>
> "Upstream demand for natural gas on the interstate pipelines serving California is diverting gas supplies from California. This reduces the effective capacity on the interstate pipeline system serving California. Interstate pipeline capacity expansions will be necessary to meet the level of demand experienced on interstate pipelines in 2000 and early 2001 and to meet expected increases in demand throughout the West.

Market forces are currently spurring expansions of these pipelines. "

"Increasing electric generator demand for natural gas in California calls for an integrated assessment of the interactions between the electricity and natural gas markets. The natural gas and electricity markets are becoming increasingly intertwined. Major uncertainties exist over how much natural gas California will need in the longer term as a result of in-state versus out-of-state gas-fired power plant development."

"The drought experienced throughout the West has reduced the supply of hydroelectric power to historically low levels. This reduction has driven the demand for natural gas by electric generators to very high levels, which has in turn strained the natural gas infrastructure. Core demand was likewise higher throughout the state during the winter of 2000-2001 due to colder than average temperature conditions.

This higher demand coupled with inadequate natural gas infrastructure on the SoCal Gas systems that limited the ability of California to receive gas was a factor that contributed to high prices for natural gas experienced in California in late 2000 and early 2001. Inadequate capacity on the El Paso interstate pipeline system to serve both upstream demand and California end users was also a factor.

The extraordinary high prices during this period appear to be the result of either the competitive market's rationing of supply thorough a scarcity premium or price manipulation through the exercise of market power by market participants, or both. In any case, prices would have been lower if the receipt capacity in Southern California has been greater."

"Infrastructure inadequacies resulting from high demand and low natural gas storage levels contributed to high gas prices and gas price volatility in 2000 and early 2001. The Energy Commission is optimistic that steps being taken will mitigate these inadequacies. The number of drilling rigs in-use has increased, and correspondingly, the supply of natural gas should increase. Intrastate pipeline companies are responding to demand for more capacity; the pipeline capacity serving California should increase. Intrastate receipt facilities are being expanded and should ameliorate the premium charged to California customers. Storage facilities are being optimized and expanded. Increased pipeline capacity planned and underway and expanded storage should allow consumers to use gas-on-gas competition, reducing

opportunities for charging premiums for natural gas in the future."

Based on the above, it appears that there will be increased pipeline capacity to import natural gas into California and increased in-state storage. This coupled with more typical water conditions in the Pacific Northwest should provide for adequate gas supplies in the state. In addition, numerous liquified natural gas (LNG) projects are in licensing in both California and Baja California, which will, if built, provide additional points of delivery for natural gas supplies from outside North America. (CEC letter to Tom Stokley and Russell Smith, May 23, 2002).

Central Valley Project Hydroelectric System.

Hydroelectric Operations and Generation Facilities. Western operates, maintains, and upgrades the transmission grid that was constructed by the CVP. Hydroelectric generation facilities were constructed as part of 11 CVP water supply facilities (Figure 3.5-4). Hydroelectric generation facilities include the turbines, generators, and powerplant substations and switchyards used to generate electricity and deliver it to a transmission system. CVP hydroelectric facilities have an installed generation capability of approximately 2,000 MW (Table 3.5-1).

TABLE 3.5-1
Hydroelectric Generation Facilities

CVP Division	Powerplant	Location	Generating Units	Capability (kW)
Trinity River	Trinity	Trinity Dam/ Trinity River	2	139,650
	Lewiston	Lewiston Dam/ Trinity River	1	350
	J.F. Carr	Whiskeytown Dam	2	157,000
	Spring Creek	Spring Creek Power Conduit	2	200,000
Shasta	Shasta	Shasta Dam/ Sacramento River	7[a]	625,000[b]
	Keswick	Keswick Dam/ Sacramento River	3	105,000
American River	Folsom	Folsom Dam/ American River	3	215,000
	Nimbus	Nimbus Dam/ American River	2	14,900
Delta	San Luis	San Luis Reservoir	8 (total)	202,000 (CVP share) (424,000 total)
	O'Neill	San Luis Canal	6	29,000
East Side	New Melones	New Melones Dam/Stanislaus River	2	383,000
Total Capability				**2,070,900**

[a]Includes two station service units.
[b]Installed capacity after all rewinds were completed in year 2000.

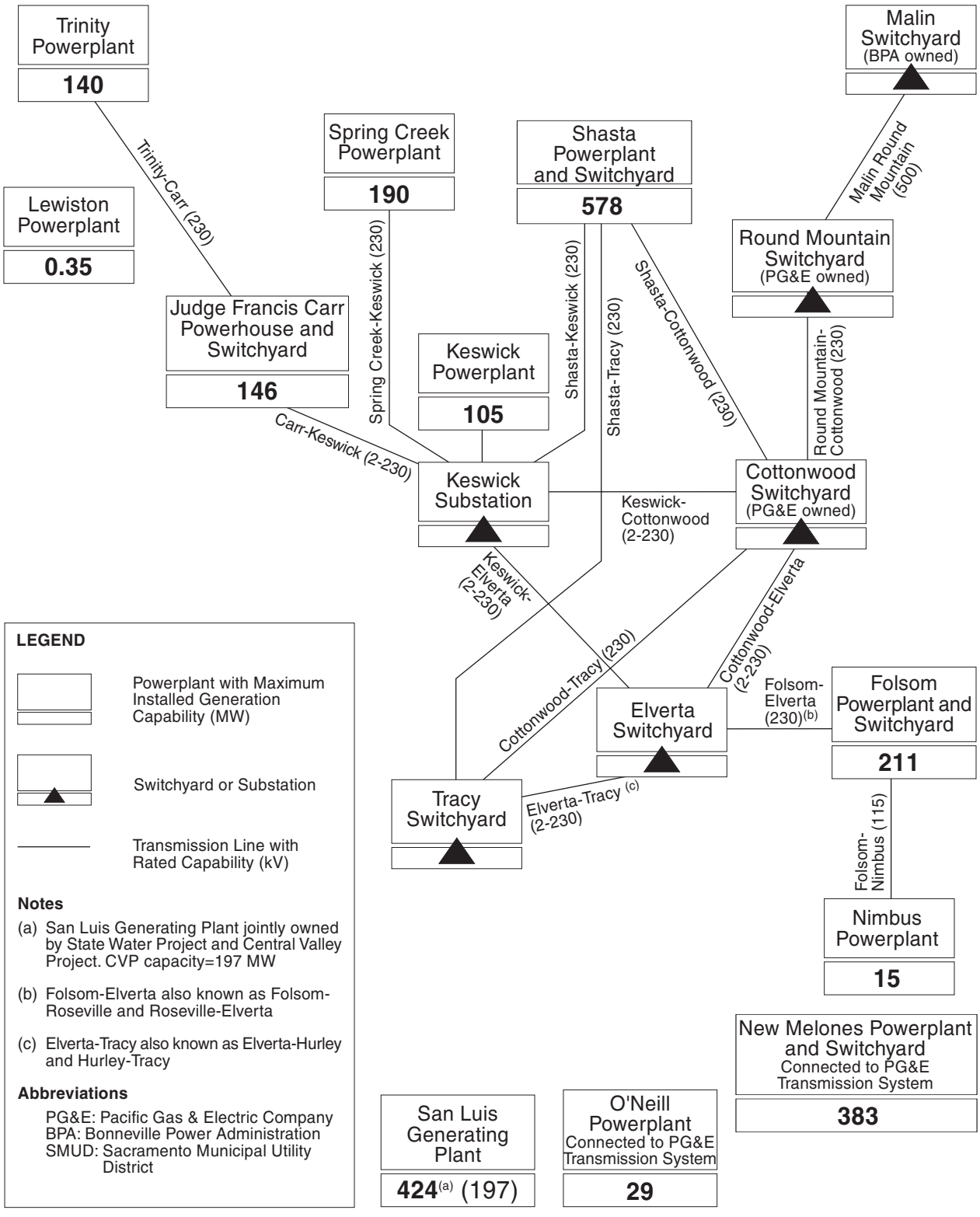
Western dispatches and markets CVP power to preference power customers. Preference power customers are entities such as municipalities and irrigation districts that are specifically entitled to preference under Reclamation law. Western is also responsible for meeting all project use load, which is the power required to operate CVP facilities. Although developed primarily for irrigation, this multiple-purpose project also provides flood control, improves Sacramento River navigation, supplies domestic and industrial water, generates electric power, conserves fish and wildlife, creates opportunities for recreation, and enhances water supply. Although the generation of power is not a primary operational objective, it is nonetheless a major economic benefit of CVP operations and, accordingly, affects project operations.

Among the CVP facilities, the TRD is a key component of the overall generation capability. The TRD, including the Trinity Powerplant, is efficient in terms of energy production per unit of water. Under normal operating conditions, 1 acre-foot of water generates 1,100 kWh as it moves through Carr, Spring Creek, and Keswick Powerplants. For comparison, 1 acre-foot of water from behind Shasta Dam (home to the largest powerplant in the CVP) generates between 370 and 550 kWh (depending on reservoir elevation) as it moves through Shasta and Keswick Powerplants. Efficiency of the TRD is approximately three to four times that of Shasta or New Melones Plants, and almost five times that of the Folsom Powerplant. The TRD is a peak power resource. Its power is dedicated first to meeting the requirements of CVP facilities. The remaining energy is marketed to various preference customers in Northern California.

The TRD includes the Trinity, Lewiston, J.F. Carr, and Spring Creek Powerplants. Water from Trinity Dam flows through the Trinity Powerplant into Lewiston Reservoir. The majority of this water is then exported to the Central Valley where it passes through the Clear Creek Tunnel and the J.F. Carr Powerplant before entering Whiskeytown Reservoir. Water released from Whiskeytown Reservoir flows to Clear Creek, the Clear Creek South Unit (owned by the City of Redding), or to Keswick Reservoir through the Spring Creek Power Conduit and Spring Creek Powerplant.

Water released through Lewiston Dam generates power at the Lewiston Powerplant. This power is used for station service and the TRSSH; the remaining power is delivered to the PG&E power grid.

CVP Generation in Relation to Total California Generation and Demand. California's annual energy demand in 1998 was approximately 250,000 gigawatt-hours (GWh) (California Energy



July 1996

FIGURE 3.5-4
CVP POWER GENERATION FACILITIES AND ASSOCIATED TRANSMISSION FACILITIES
TRINITY RIVER FISHERY RESTORATION SUPPLEMENTAL EIS/EIR

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Commission, 2000). Four years later, in 2002, it had grown only slightly, to about 254,000 GWh.[10] The CEC projects that demand for electricity will grow at approximately 2.0 percent annually between 2002 and 2013, resulting in a projected demand of 318,000 GWh in 2013. Peak demand in California typically occurs in late afternoons during the month of August in response to a string of days with high temperatures (California Energy Commission, 1999). California's peak demand in 2002 was approximately 50,700 MW and is projected to grow at approximately 1.7 percent annually between 2002 and 2013, resulting in a peak demand of 63,000 MW in 2013.[11] In comparison, total installed capacity of CVP generation is approximately 2,000 MW, although actual capacity is typically less. Actual capacity is less than installed capacity because hydrologic variation and competing uses such as water delivery and environmental requirements reduce the ability of the generators to operate at maximum capacity. The total installed CVP generation capacity of 2,000 MW equates to 4 percent of California demand in 1999, and 3 percent of projected 2010 demand. The TRD accounts for 25 percent (approximately 500 MW) of CVP installed capacity, which equates to approximately 1 percent of current California demand, and less than 1 percent of projected 2010 demand.

The role of the CVP in the context of the power market is further reduced when considered against the WECC[12] as a whole. As of 2003, approximately 185,000 MW of power generation capacity are in WECC. This includes approximately 60,000 MW of hydroelectric capacity. The single hour highest (peak) load in WECC in 2003 was approximately 135,000 MW. The average hourly load over the year 2003 is expected to be approximately 92,000 MW (805,920 GWh in the year).

In general, it is believed that, with 185,000 MW of generating capacity and 135,000 MW of peak load, there is somewhat of an overbuild of power generation facilities in WECC today. This is a much different situation than the one that existed in December of 2000 when the ROD for the Trinity River Fishery Restoration was issued. As shown on Figure 3.5-3, an exceedingly large amount of new generation has been added in WECC in the years 2001, 2002, and 2003.

Power Generation and Purchase. Power generation from CVP facilities fluctuates with reservoir releases and storage levels. Climatic condi-

[10] CEC, http://www.energy.ca.gov/energypolicy/documents/2003-02-25+26_workshop/2003-02-100-03-002SD.PDF,_Table_1.

[11] CEC, http://www.energy.ca.gov/energypolicy/documents/2003-02-25+26_workshop/2003-02-100-03-002SD.PDF,_Table_5.

[12] WECC is the new name of the WSCC. The name change occurred mid-2002.

tions such as drought or wet conditions are the primary factors affecting releases and storage, and the associated ability to generate power. For example, dry periods reduced the water level in the New Melones Reservoir to below the minimum power-pool levels, resulting in no power being generated at the facility from August through January in 1991 and August through January in 1992. Reservoir releases are also affected by mandated minimum streamflow requirements, flow fluctuation restrictions, water delivery contracts, and water quality requirements. For example, prior to construction of the Shasta Dam TCD, the BO on Sacramento River winter-run Chinook salmon has required Reclamation to release cold water from Shasta Dam outlets that bypass the powerplants. The BO has also increased the winter and spring water releases into the Sacramento River, thereby resulting in less water being available for release in the summer, when power needs are highest (the installation of the Shasta TCD in 1997 essentially eliminated the need to bypass the powerplants at Shasta Dam). These factors have resulted in actual generation typically being less than full capability.

Peak power loads typically occur in summer months when water conveyance, groundwater pumping, industrial loads, and air conditioning loads are greatest. In the past, CVP generation has been integrated with other power generation resources operated by PG&E to meet project use load and CVP preference power customer loads. The integration of CVP and PG&E generation is subject to a contract signed by DOI and PG&E, referred to as Contract 2948-A. In recent years this integration has also been affected by changes in the power supply industry. Contract 2948-A will expire after 2004 and will not be renewed. Future project power operations will be based on project use loads and CVP preference power customer loads. Currently, project use loads account for about 30 percent of the energy generated by CVP. In FY 2001, CVP net generation was 4,175 GWh and Project Use was 1,158 GWh (28 percent of net generation). In FY 2002, CVP net generation was 4,280 GWh and Project Use was 1,375 GWh (32 percent of net generation). During droughts and other times of low CVP generation, Western has exchanged or banked power with PG&E and purchased power from other entities (particularly those in the Pacific Northwest) to meet demands.

Reclamation, Western, and PG&E work together on a daily basis, comparing hydropower availability, total loads (including PG&E loads), and availability of PG&E resources and transmission capabilities. Daily operations are scheduled one day prior to actual use when the Reclamation dispatch center determines the necessary releases from Keswick, Lewiston, Tulloch, and Nimbus Reservoirs to meet hourly stream flows, water demands, water quality requirements, and power generation needs. Reclamation communicates the

dam releases to Western's Folsom dispatch office, which coordinates with the PG&E dispatch center. The three entities confirm and, if necessary, adjust the schedule.

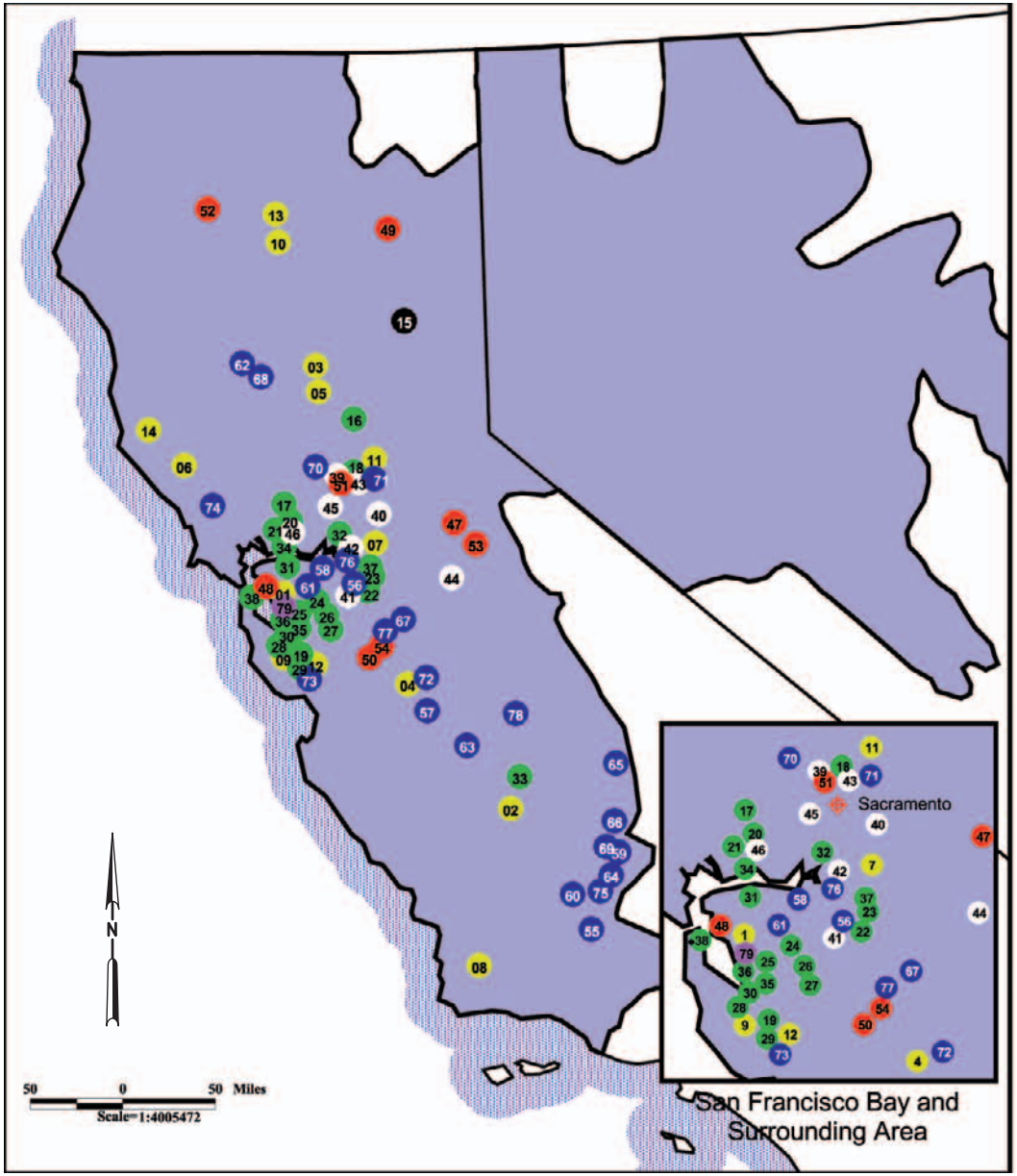
Preference Power. CVP power generation was initially intended to supply electricity for the power-consuming portions of the CVP (e.g., Delta export pumps, aqueducts, etc.). Power consumption by the CVP is referred to as project use. The Reclamation Act of 1939 provided for surplus power, which is power not needed for project use loads, to be sold first to preference power customers. Current Western preference power customers (in the Sierra Nevada Customer Service Region, see Figure 3.5-5) include irrigation and reclamation districts, cooperatives, public utility districts, municipalities, state and federal agencies, and other public bodies. Power surplus to preference power customer needs may be sold, if available, to non-preference power customers on a non-firm or short-term basis.

Table 3.5-2 presents a summary of the relative purchases by the five largest preference power customers. Currently, there are 77 CVP preference power customers (see Table 3.5-3). The five preference power customers with the largest energy purchases in federal fiscal year 1995 were the Sacramento Municipal Utility District and the cities of Santa Clara, Palo Alto, Redding, and Roseville. Figure 3.5-6 presents a summary of relative purchases by Western customers. Western power is typically a low-cost component of customers' overall resource mix. Other sources of electricity are typically more expensive. The concept of "first preference," that customers could have priority consideration for contracts to purchase power generated at specific plants, was added for Trinity County by the 1955 act authorizing the TRD, and for Tuolumne and Calaveras Counties by the Flood Control Act of 1962. By law, 25 percent of the excess energy (after project use power needs) resulting from power generated by the TRD must first be offered to preference power customers in Trinity County. Currently, the Trinity County Public Utility District, located in Weaverville, is a preference power customer falling under the first preference criterion for the TRD generation.

Current Power Marketing. Western sets prices for CVP hydropower based on its costs for delivering power to customers. However, the value of the electricity that Western sells to customers is set by the external markets and can fluctuate based on supply and demand. Although the value and annual project output can fluctuate, Western's costs remain essentially unchanged. This causes Western's

TABLE 3.5-2
Summary of Relative Purchases by the Five Largest Preference Power Customers

		FY 2002			FY 2001		
Customer	**Contract Rate of Delivery (Annual kW)**	**Energy MWh**	**Revenue ($)**	**Total Revenue ($)**	**Energy MWh**	**Revenue ($)**	**Total Revenue (%)**
Sacramento Municipal Utility District	361,000	2,103,719	49,969,934	27	2,237,711	43,884,582	26
Silicon Valley Power	216,532	678,572	20,976,531	11	1,466,957	27,160,036	16
Palo Alto	175,000	929,324	22,044,904	12	1,038,313	19,424,763	12
Redding	116,000	611,630	14,777,451	8	607,215	11,371,122	7
Roseville	69,000	552,680	12,860,275	7	614,201	10,928,684	7
CVP Power Sales to Customers		7,317,680	182,968,531		8,546,774	166,133,172	



MUNICIPALITIES
01. City of Alameda
02. City of Avenal
03. City of Biggs
04. Castle Joint Powers Authority *
05. City of Gridley
06. City of Healdsburg
07. City of Lodi
08. City of Lompoc
09. City of Palo Alto
10. City of Redding
11. City of Roseville
12. City of Santa Clara
13. City of Shasta Lake
14. City of Ukiah

RURAL ELECTRIC COOPERATIVES
15. Plumas-Sierra

FEDERAL AGENCIES

DEPARTMENT OF THE AIR FORCE
16. Beale AFB
17. David Grant Medical Center (Travis AFB)
18. McClellan AFB
19. Onizuka AFB
20. Travis AFB
21. Travis Wherry Housing (Travis AFB)

DEFENSE LOGISTICS AGENCY
22. Defense Distribution Depot (Sharpe Facility)
23. Defense Distribution Depot (Tracy Facility)
24. Parks Reserve Forces Training Area, Dublin

DEPARTMENT OF ENERGY
25. Lawrence Berkeley National Laboratory
26. Lawrence Livermore National Laboratory
27. Site 300
28. Stanford Linear Accelerator Center

NATIONAL AERONAUTICS & SPACE ADMIN.
29. Ames Research Center
30. Moffet Federal Airfield *

DEPARTMENT OF THE NAVY
31. Concord Naval Weapons Station
32. Dixon Naval Radio Station
33. Lemoore Naval Air Station
34. Mare Island Naval Shipyard
35. Oakland Army Base
36. Oakland Naval Supply Center
37. Stockton Naval Communications Station
38. Treasure Island Naval Station

STATE AGENCIES
39. California State Prison-Sacramento
40. California State University, Sacramento-Nimbus
41. Deuel Vocational Institution
42. Northern California Youth Center
43. Parks & Recreation, American River District
44. Sierra Conservation Center
45. University of California, Davis
46. Vacaville Medical Facility

PUBLIC UTILITY DISTRICTS
47. Calaveras Public Power Agency
48. East Bay Municipal Utility District
49. Lassen Municipal Utility District
50. Modesto Irrigation District
51. Sacramento Municipal Utility District
52. Trinity County Public Utilities District
53. Tuolumne Public Power Agency
54. Turlock Irrigation Distrtict

IRRIGATION & WATER DISTRICTS
55. Arvin-Edison Water Storage District
56. Banta-Carbona Irrigation District
57. Broadview Water District
58. Byron-Bethany Irrigation District
59. Cawelo Water District
60. Delano-Earlimart Irrigation District
61. East Contra Costa Irrigation District
62. Glenn-Colusa Irrigation District
63. James Irrigation District
64. Kern-Tulare Water District
65. Lindsay-Strathmore Irrigation District
66. Lower Tule River Irrigation District
67. Patterson Water District
68. Provident Irrigation District
69. Rag Gulch Water District
70. Reclamation District 2035
71. San Juan Water District
72. San Luis Water District
73. Santa Clara Valley Water District
74. Sonoma County Water Agency
75. Terra Bella Irrigation District
76. West Side Irrigation District
77. West Stanislaus Irrigation District
78. Westlands Water District

LOCAL & SUBURBAN PASSENGER TRANSPORTATION
79. Bay Area Rapid Transit District

* NDA Act Economic Development Allocations

Sierra Nevada Regional Office Marketing Area

FIGURE 3.5-5
WESTERN AREA POWER ADMINISTRATION, SIERRA NEVADA REGION, MARKETING AREA
TRINITY RIVER FISHERY RESTORATION SUPPLEMENTAL EIS/EIR

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CHART 1: WESTERN PREFERENCE POWER CUSTOMERS BY BASE RESOURCE ALLOCATIONS

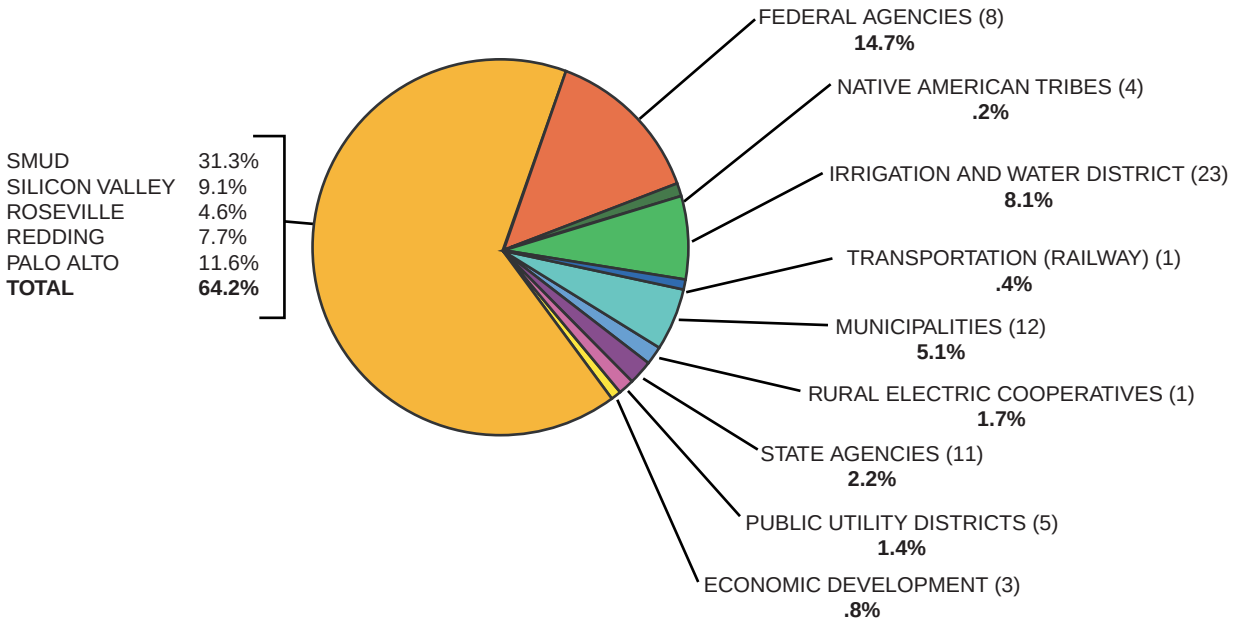
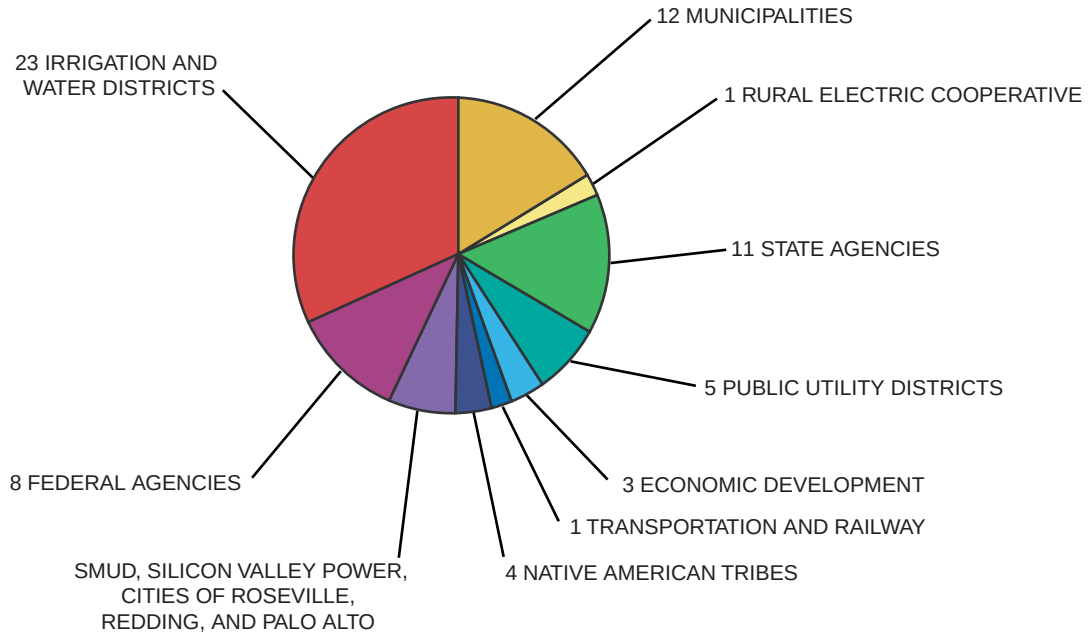


CHART 2: WESTERN PREFERENCE POWER CUSTOMERS SORTED BY CUSTOMER CLASS



SOURCE: WAPA POST-2004 POWER MARKETING PLAN IMPLEMENTATION BROCHURE

FIGURE 3.5-6
WESTERN PREFERENCE POWER CUSTOMERS
TRINITY RIVER FISHERY RESTORATION SUPPLEMENTAL EIS/EIR

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per-unit cost of electricity to vary. When long-term average generation decreases, Western's customers receive less electricity and are required to pay a higher per-unit cost. If Western rates are relatively low, Western customers are likely to continue to purchase power from Western as part of their long-term resource mix. For planning purposes, power customers evaluate capacity resources based on dry conditions to ensure reliability.

Reductions in reliable Western power supplies are likely to be offset by more expensive power from other sources.

Western has wide discretion within its statutory guidelines regarding with whom and on what terms it will contract for the sale of federal power. The sale of excess power is conducted so as not to impair the efficiency of CVP irrigation deliveries. Contract 2948-A allows for the sale, interchange, and transmission of electrical power and energy between the federal government and PG&E. The agreement allows PG&E to provide energy and capacity as required to meet project use and preference power customer loads; in return, the CVP generating units provide energy and capacity for integration with other PG&E resources. The agreement also recognizes the federal government's 400-MW entitlement on the Pacific Northwest/Pacific Southwest Intertie.

Under the terms of Contract 2948-A, Western delivers the generation of CVP Powerplants to PG&E, along with its wholesale purchases; and PG&E supports firm power deliveries to the preference power customers up to a maximum simultaneous demand of 1,152 MW. Western also purchases additional power to support the CVP marketing program and primarily imports it through use of

Western's share of the Pacific Northwest/Pacific Southwest Intertie and the California-Oregon Transmission Project.

Environmental Consequences.

Methodology. Every 6 months, Henwood Energy Services, Inc., develops an independent proprietary forecast of power prices in WECC that is used by many entities to evaluate future operations and investments relating to power resources. Over 50 entities have purchased Henwood's spring 2003 price forecast. These entities include both investor-owned and consumer-owned utilities, power plant developers, banks, and rating agencies. The forecast is widely accepted as a reasonable forecast. Henwood's spring 2003 price forecast was used as a starting point to evaluate the power impact of alternatives for Trinity River Fishery Restoration. The forecast is a fundamental-based forecast that uses Henwood's proprietary MARKETSYM model and updated database to forecast hourly market clearing prices in the WECC.

TABLE 3.5-3
Western Customers by Agency and Sub-agency Type and Associated Firm Power

Customers by Agency and Sub-agency Types	Long-term Firm (kW)
Federal Agencies	
Air Force, U.S. Department of	
Beale Air Force Base	20,507
David Grant Medical Facility, Travis	3,552
McClellan Air Force Base	10,655
Onizuka Air Force Base	3,500
Travis Air Force Base	11,299
Travis Wherry Housing (Air Force Base)	100
Category Total:	**49,613**
Defense Logistics Agency	
Parks Reserve Forces Training Area	500
Sharpe Facility	4,000
Tracy Defense Distribution Depot	3,800
Category Total:	**8,300**
Energy, U.S. Department of	
DOE/Lawrence Livermore/Site 300	2,000
DOE/Lawrence Berkeley National Laboratory	9,000
DOE/Lawrence Livermore National Laboratory	23,897
DOE/Stanford Linear Accelerator Center	12,903
Category Total:	**47,800**
National Aeronautics and Space Administration	
Ames Research Center	80,000
Moffett Federal Airfield	3,984
Category Total:	**83,984**
Navy, U.S. Department of	
Naval Air Station, Lemoore	21,869
Naval Communications Station, Stockton	2,943
Naval Radio Station, Dixon	915
Naval Weapons Station, Concord	2,687
Oakland Army Base	2,275
Category Total:	**30,689**
State Agencies	
Department Of Corrections	
California Medical Facility, Vacaville	1,800
California State Prison, Sacramento	2,300
Deuel Vocational Institution	1,700
Northern California Youth Center	2,200
Sierra Conservation Center	3,000
Category Total:	**11,000**
Department of Parks and Recreation	
California State Parks & Recreation, Folsom	100
Category Total:	**100**

TABLE 3.5-3
Western Customers by Agency and Sub-agency Type and Associated Firm Power

Customers by Agency and Sub-agency Types	Long-term Firm (kW)
State Universities	
CSUS Nimbus	40
University Of California, Davis	21,500
Category Total:	**21,540**
Municipalities	
Alameda, City of	21,145
Avenal, City of	622
Biggs, City of	1,300
Gridley, City of	4,200
Healdsburg, City of	1,490
Lodi, City of	5,173
Lompoc, City of	2,042
Oakland, Port of	745
Palo Alto, City of	171,200
Redding, City of	91,000
Roseville, City of	69,000
San Francisco, City & County of	2,012
Shasta Lake, City of	11,450
Silicon Valley Power	73,000
Ukiah, City of	4,917
Category Total	**459,296**
Public Utility Districts	
Calaveras Public Power Agency	8,000
East Bay Municipal Utility District	3,914
Lassen Municipal Utility District	23,500
Modesto Irrigation District	4,845
Sacramento Municipal Utility District	361,000
Trinity County PUD	17,000
Tuolumne Public Power Agency	8,000
Turlock Irrigation District	2,190
Category Total:	**428,449**
Rural Electric Cooperatives	
Plumas-Sierra Rural Electric Cooperative	17,900
Category Total:	**17,900**
Irrigation and Water Districts	
Arvin-Edison Water Storage District	30,000
Banta-Carbona Irrigation District	3,700
Broadview Water District	500
Byron-Bethany Irrigation District	2,200
Cawelo Water District	3,500
East Contra Costa Irrigation District	2,000
East Contra Costa Irrigation District	500
Eastside Power Authority	1,914
Glenn-Colusa Irrigation District	3,343
James Irrigation District	638

TABLE 3.5-3
Western Customers by Agency and Sub-agency Type and Associated Firm Power

Customers by Agency and Sub-agency Types	Long-term Firm (kW)
Kern-Tulare Water District	638
Lower Tule River Irrigation District	914
Patterson Water District	2,000
Provident/Princeton Irrigation District	750
Rag Gulch Water District	500
Reclamation District 2035	1,600
San Juan Water District	1,000
San Luis Water District (Fittje)	3,250
San Luis Water District (Kalijian)	3,400
Santa Clara Valley Water District	638
Sonoma County Water Agency	6,000
West Side Irrigation District	2,000
West Stanislaus Irrigation District	5,200
Westlands Water District	16,391
Westlands Water District 6-1	1,850
Westlands Water District 7-1	3,200
Category Total:	**97,626**
Railroads and Railways	
Bay Area Rapid Transit District	4,000
Category Total:	**4,000**
Economic Development	
Merced Irrigation District	3,724
Pittsburg Power Company	3,869
Category Total:	**7,593**
Grand Total:	**1,267,890**

The forecast of hourly market-clearing power prices also includes a forecast of hourly loads across the many subareas of WECC. A database of power generation available for operation in these areas is developed and updated along with the operating restrictions, heat rates, and fuel cost that need to be reflected in an analysis regarding operating the plants. The key transmission path constraints that may limit the ability to move power from one subarea of WECC to another from hour to hour are also maintained in the database. (See Power Resources Technical Appendix C.)

Choosing a Year for Analysis. The year 2005 was selected as an appropriate level of development for the analysis. The power generation overbuild situation is forecast to level out or be reduced by that time because loads are forecast to grow, and little new power generation is assumed to be added after 2003. Beyond 2005, it is more difficult to predict just when and how much new generation will be built.

Choosing a Topology for Analysis. The transmission across the WECC system was then defined in order to assess the ability to move electricity between subregions. As can be seen, on the topology map on Figure 3.5-6, the WECC is divided into 14 zones. The lines on the topology map reflect the ability of the transmission system to move power between the zones. The numbers on the lines indicate the maximum amount of power, in MW, that such line (path) can move in the indicated direction.

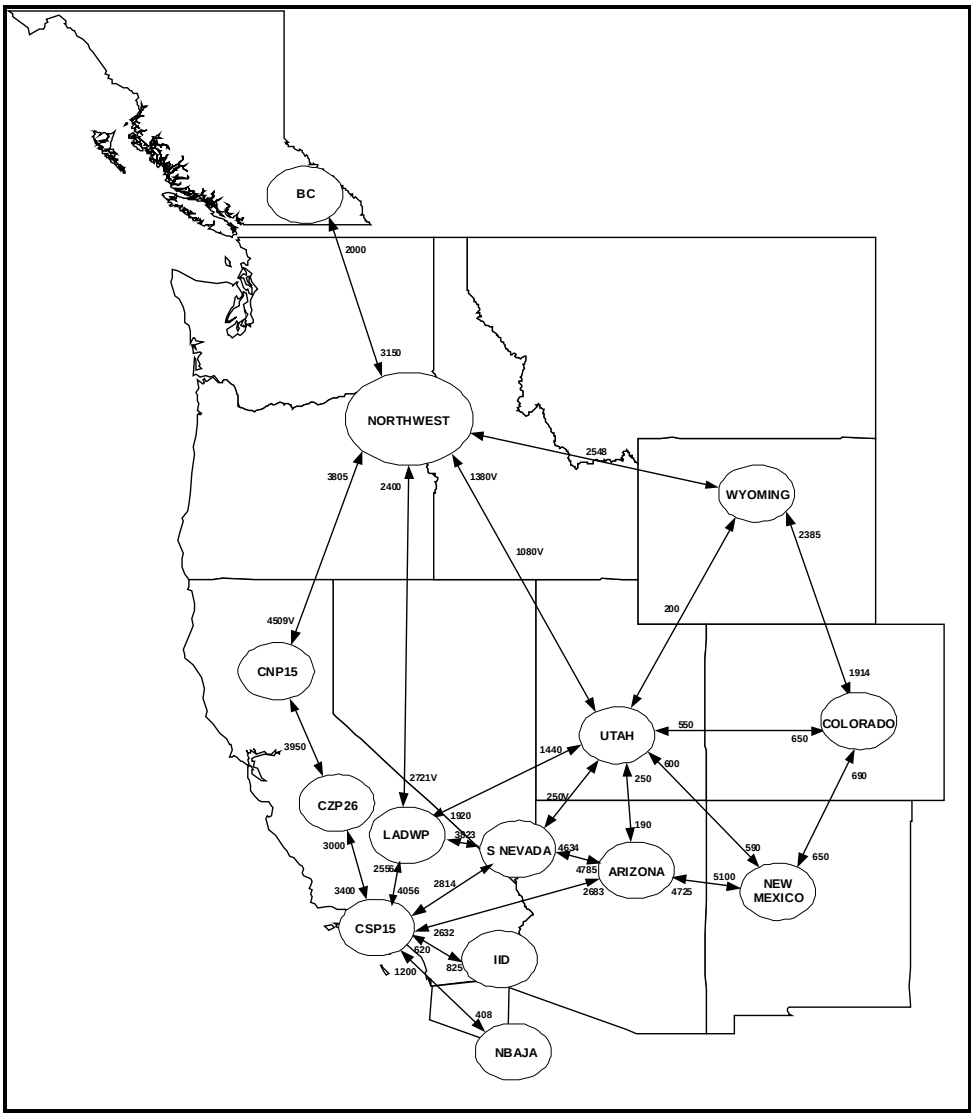

FIGURE 3.5-7
WECC Zones

This 14-zone topology provides a reasonable representation of major transmission constraints in WECC and can be used for market-clearing price formation analysis. Following definition of price and load forecasts and the transmission system, the MARKETSYM model was used to determine hourly dispatch of power generation against

loads across WECC in the year 2005. The analysis is repeated for each of the alternatives.

How the Model Computes Hourly Market Clearing Prices. The MARKETSYM model runs assume that there is no transmission constraint within a zone. In each hour being analyzed, the model first determines the load for the hour in one of the zones, and then determines which generating plants located in that zone must be operated to meet the load. The plants with the lowest bid price[13] are operated first. After the model orders power generation resources within the first zone, it then conducts the same analysis in each of the remaining zones. Then the model assesses low-cost resource that may not be running in one zone while a higher cost resource is operating in a different zone. If so, the model will attempt to move power generation between zones, if there is sufficient transmission capacity. The model continues to assess re-dispatch opportunities until all the zones reflect the same marginal cost or transmission constraints prohibit additional economic re-dispatch of power. At this point, the model can determine the market-clearing price in each zone for that hour. This operation is conducted for every hour of the model year.

Determining Hourly Amounts of CVP Generation. Monthly estimates of power generation at each of the CVP hydroelectric facilities were derived from CALSIM output. For each of the generators, it was assumed there was a minimum amount of power generation that would be needed to operate in every hour and a maximum capacity that could be operated in any hour. Monthly generation was disaggregated into hourly estimates given physical limitations and environmental constraints of the system. The remaining generation was shaped to reflect the hourly shape of loads in the ISO control area. The maximum power generation in any hour could not exceed the maximum capacity of that generator/system.

These hourly operations were then used for a stochastic analysis that assessed the effects of the alternatives against potential volatility. Deterministic, or static, analyses were also conducted to assess specific water conditions in the CVP. Deterministic analyses were conducted for the average condition (1922-1993) and for a representative wet year (1958) and a representative dry year (1937). On a yearly average, the generation at the CVP projects under 1958 water conditions is about 161 percent of the generation that would be

[13] WECC markets are currently bilateral markets. Sellers offer their power at a price they are willing to sell. In general, sellers will need to cover at least their operating cost from a sale or they will simply shut down. Sellers also need to cover additional amounts to cover fixed costs. Competition generally keeps sellers from making excessively high bids. The supply demand situation in the year 2005 is such that sellers will not be able to extrapolate monopoly prices. Henwood's bid price algorithm reflects competitive limits on bid prices. In the absence of competition, FERC has indicated they will impose some kind of price mitigation regulation.

expected to occur under average water conditions. On a yearly average, the generation at the CVP projects under 1937 water conditions is about 75 percent of the generation that would be expected to occur under average water conditions.

Taking Volatility into Account. Several key inputs needed in the modeling database are subject to weather-induced volatility. For example, the CVP Powerplants will generate different amounts of power, depending on how much rainfall occurs in any year. CALSIM output representing CVP power generation amounts under each of the alternatives will vary depending on rainfall conditions. This analysis considered 72 different annual generation levels for each CVP Powerplant for each of the alternatives, corresponding to historical rainfall levels over a 72-year history.

In addition to variations in CVP power generation levels caused by weather, other key inputs impacted by weather are as follows:

- Hydrogeneration levels in other parts of WECC
- Loads across WECC
- Natural gas prices that fuel natural gas priced generation

In December of 2000 when the ROD for the Trinity River Fishery Restoration was issued, WECC was in the midst of a severe drought, especially with regard to hydrogeneration affected by Pacific Northwest rainfall conditions. It was determined that the power impact analysis should reflect the possibility that such conditions could recur.

In order to assess future volatility, a stochastic analysis was conducted. In other words, each of the alternatives was analyzed at a 2005 level of development 72 times, representing the variability of the hydrologic period of record. At the same time, random Monte-Carlo draws for the key inputs described above, and also for forced outages, were included to reflect variable hourly loads in the 14 zones of WECC for a number of parameters that influence price. Historical correlation between these zonal load variations were reflected in the analysis. A single Monte-Carlo draw was conducted for each water year and applied to all alternatives. Monte-Carlo draws are a statistical method for generating a sample of simulated data. Monte-Carlo draws are used to generate large numbers of possible outcomes. Monte-Carlo draws for Pacific Northwest hydropower were also reflected in the 73 iterations based on historical volatility in these power generation amounts. Correlation between CVP hydropower and Pacific Northwest hydropower was reflected in the analysis based on historical correlations of these

levels[14]. Additionally, a deterministic run was analyzed, which more closely replicates recent generation experience without volatility (these data are presented in Table 3.5-4 at the end of this section).

Calculating the Value of CVP Power. The analysis then reflects an expected value of CVP power under each alternative. Value of the CVP power is calculated as CVP power generation levels (net of pumping load requirements) multiplied by the market-clearing price of power in the Northern California zone[15].

Ancillary Services. Power projects such as those owned by CVP have value not only from their ability to produce power, but also from their ability to provide ancillary services. Ancillary services are products needed for the power grid to be operated reliably. There are five typical kinds of ancillary services:

- Spinning Reserve - The portion of unloaded synchronized generation capacity that is immediately responsive to system frequency and that is capable of being loaded in 10 minutes, and that is capable of running for at least 2 hours.
- Non-spinning Reserve - The portion of offline generating capacity that is capable of being synchronized and ramping to a specified load in 10 minutes (or load that is capable of being interrupted in 10 minutes) and that is capable of running (or being interrupted) for at least 2 hours.
- Regulation Up and Regulation Down – The service provided either by Generating Units certified by the ISO as equipped and capable of responding to the ISO's direct digital control signals, or by System Resources that have been certified by the ISO as capable of delivering such service to the ISO Control Area in an upward or downward direction to match, on a real-time basis, demand and resource, consistent with established NERC and WECC operating criteria. Regulation covers both the increase or decrease in output of generation. Regulation Up and Regulation

[14] This analysis assumes that weather induced changes to CVP power generation is correlated to other Northern California hydrogeneration levels. That is, dry conditions in the CVP system likely occur in the same years as dry conditions exist in other California hydro resources. Hydrogeneration amounts in WECC outside of Northern California and the Pacific Northwest are small in comparison to Northern California and Pacific Northwest hydrogeneration levels. The analysis has included these hydrogeneration amounts at their average value in all cases.

[15] In making this calculation, project generation on heavy load hours for each month were valued at the average of all heavy load market-clearing prices for that month. Similarly, project generation on light load hours for each month was valued at the average of all light-load hour market-clearing prices for that month. This approach was taken for two reasons. First, much of the power bought and sold in WECC is packaged as "standard products," with a standard product being a flat heavy-load hour delivery for a day and a flat light-load hour delivery for a day. It is possible that the hourly load-shaping algorithm used here may overstate the amount of power that can be shaped due to issues regarding re-regulating reservoirs that exist on the CVP system. It is not practicable to capture all these limitations in this kind of analysis. The somewhat overly optimistic hourly shaping algorthim is offset by the somewhat pessimistic average pricing approach to reflect a reasonable estimation of the value of project generation.

Down are distinct capacity products, with separately stated requirements and Market Clearing Prices in each settlement period.

- Replacement Reserve – Generating capacity that is dedicated to the ISO, capable of starting up if not already operating, being synchronized to the grid, and ramping to a specific load point within a 60-minute period, the output of which can be continuously maintained for a 2-hour period.

Regulation Up and Regulation Down receive the highest prices of the ancillary services described here. However, Henwood assumes that CVP will not allow its generators to be automatically controlled by the ISO's direct digital control signals. Therefore, CVP projects would not realize these prices.

Spinning Reserve is the next highest value of the ancillary services. Henwood assumes that CVP projects could be offered as spinning reserve units to the ISO to the full extent of their capability less the then-current operating level. In general, the alternative that results in less hydrogeneration would result in more sales of spinning reserve[16]. Given the assumption of all unused capacity being sold as spinning reserve, there is nothing else left to sell to the remaining lower value ancillary services markets.

Air Emissions. Power modeling output can be used to measure sulfur oxide (SO_2), oxides of nitrogen (NO_x) and CO_2 emissions by powerplant for every hour. CVP project power generation does not create air emissions. When more hydroelectric power is available, air emissions from fossil fuel generators decrease, and vice versa. This analysis includes calculations of the expected levels of total WECC-wide SO_2, NO_x, and CO_2 emissions for the year 2005 under each of the alternatives studied. Results are available in Power Resources Technical Appendix C.

Reliability. As a measure of the effect on reliability of power supply in WECC of the alternatives, the analysis included calculations of the expected level of load that would not be served under the stochastic analysis in WECC. In other words, power generation is expected to be adequate to meet load in all hours of 2005 under "normal" conditions. Normal conditions do not reflect higher than normal loads caused by hotter than normal temperatures, drought conditions, or forced outages for maintenance.

The Monte-Carlo-driven stochastic analysis presented here results in some situations where load is higher than normal and resource availability is lower than normal. Therefore, it is possible that certain

[16] The exception is the Maximum Flow Alternative, which provides no water to the J.F. Carr and Spring Creek projects. With no water, these projects can provide no ancillary services.

areas of WECC may have difficulty meeting load in all hours of the year. This analysis evaluates unserved energy associated with any hour of any iteration for each of the alternatives studied. A comparison of expected levels of unserved energy will provide an indication of impacts to reliability associated with each alternative.

Historical operations of the TRD include bypasses of the Trinity Powerplant to achieve downstream temperature benefits. Such operations were noted in the NOAA Fisheries BO on the original Draft EIS/EIR and were subsequently rejected in Judge Wanger's ruling. However, because bypass operations are a potential facet of current operations, it is assumed that bypasses could occur under any of the alternatives considered in this document.

Consistent with the methodology outlined in the Powerplant Bypass Thematic Response in the Final EIS/EIR, bypasses were considered to be a possible operation during periods of low storage in Trinity Reservoir. Accordingly, each alternative was evaluated for the percentage of time modeled operations drew storage below 750,000 acre-feet in June-September of any year, or below 1,000,000 acre-feet in October of any year. An annual value of bypassed energy is presented for each alternative based on the modeled amount of energy that would have otherwise been produced at the powerplant. During periods of future power emergencies such as those seen in the California Power Crisis described earlier in this section, Reclamation would consider foregoing powerplant bypasses in order to generate power for short periods of time to avoid power system failures. However, such considerations would be on a case-by-case basis. In part, because of the very conservative approach to identifying potential bypass operations and the possibility that Reclamation would forego bypasses for short periods to avoid system-wide blackouts, it is assumed that the effects on powerplant reliability would be negligible.

Significance Criteria. Alternatives were analyzed for their impacts on hydropower generation, reliability, and value relative to the No Action condition. Long-term reductions in generation and reliability could require individual customers to either purchase additional power through the open power markets or construct new power facilities. Because natural gas plants are increasingly an economic and relatively clean source of fossil fuel power, it seems likely that elimination of some power from the TRD system would result in greater natural gas power generation somewhere in the Western United States, for ultimate consumption in California. It is therefore likely that air pollution from natural gas power generation would increase to a degree. The location of the resulting emissions, however, is impossible to predict. The powerplants at issue would

be subject to increasingly stringent air quality laws, such as the Clean Air Act; and the powerplants themselves would be required to operate pursuant to the terms of their permits, which necessarily require some level of pollution reduction.

To assess the severity of the impacts, the following significance criteria were developed:

- A 50-MW reduction in dry-year capability available for sale to preference power customers in January, February, March, June, July, August, September, or December (the months typically most sensitive to reduced capacity). Capability is defined as the amount of CVP capacity that can be sustained (given flow constraints) that efficiently supplies electricity to meet demands.
- A reduction of 5 percent or more in the annual energy available for sale to preference power customers in the average year.
- A reduction of 5 percent or more in the average energy available for sale to preference power customers during any month in the average year.
- Any decrease in CVP power that results in a cost increase of $0.50 per MWh for either an average preference power customer or a high-allocation preference power customer.

No Action. Under the No Action Alternative, the CVP power generation facilities would be operated in a manner similar to the operations discussed under Affected Environment and consistent with the criteria defined in the current draft CVP-OCAP. Predicted power generation and value, as modeled MARKETSYM, is presented in Table 3.5-4 at the end of this section. Under this operation, MARKETSYM estimates the value of net power generated by the CVP system for use by preference power customers as $122,800,000 per year. It is important to note that this is the value of net CVP generation, not revenue from sales of net CVP generation.

Under the No Action Alternative, Trinity County PUD would continue to receive benefits from the TRD in accordance with its status as a First Preference Power Customer. Modeled results indicate that Trinity County would be eligible for approximately 325 GWh per year from the TRD, almost four times current annual energy use (80 to 85 GWh). Based on the market analysis prepared for the Supplemental EIS/EIR, the value of Trinity County's First Preference Power purchases is approximately $3,100,000 per year. Actual costs for First Preference Power received by Trinity County PUD would be established by Western based, in part, on the amount of custom services purchased and allocations of CVPIA restoration charges to power customers. Both of which are beyond the scope of this analysis.

Under the No Action Alternative, bypass operations would be considered in 15 percent of the modeled months June-October over the period of record. Annual average value of generation would be reduced by $581,000 per year if every potential bypass were realized.

Revised Mechanical. Average annual CVP power generation under this alternative would be reduced. This alternative would reduce the amount of power generated by the TRD, resulting in a decrease in the value of net power available for use by preference power customers of $4,200,000 annually compared to No Action. If ancillary services are included in the value of the CVP, the net change is a reduction of $3,400,000 annually compared to No Action. This alternative was not analyzed in the original Draft EIS/EIR.

MARKETSYM output identified significant impacts of the Revised Mechanical Alternative. In the average year, CVP energy available for sale would be reduced by 3.6 percent compared to No Action, a less than significant impact. However, energy available for sale in average months would be reduced by more than 5 percent in 3 out of 12 months, which would constitute a significant impact.

Based on the MARKETSYM analysis, there is no impact to overall system reliability under this alternative, in either the CNP 15 node or the overall WECC.

Modeled projects of energy production at the TRD facilities is still well in excess of 83,000 MWh, which means that wholesale purchases will likely not be necessary.

Based on average energy purchases of 83,000 MWh per year, under the Revised Mechanical Alternative, Trinity County PUD would continue to receive benefits from the TRD in accordance with its status as a First Preference Power Customer. Modeled results indicate that Trinity County PUD would be eligible for approximately 299 GWh per year from the TRD, over three times current annual energy use (80 to 85 GWh). Actual costs for First Preference Power received by Trinity County would be established by Western through its regular rate-setting process, and would depend, in part, on the types of custom services Trinity County PUD would purchase from Western and future allocations of the CVPIA restoration fund, both of which are beyond the scope of this analysis.

Under the Revised Mechanical Alternative, bypass operations would be considered in 16 percent of the modeled months June-October over the period of record, an increase of 1 percent compared to No Action. Annual average value of generation would be reduced by $604,000 per year if every potential bypass were realized, $23,000 more than No Action.

The change in cost per unit of electricity for the average Western customer under the Revised Mechanical Alternative would be $.16, while the change for the high-allocation customer would be $.94.

Flow Evaluation. Average annual CVP power generation under this alternative would be reduced. This alternative would reduce the amount of power generated by the TRD, resulting in a decrease in the value of net power available for use by preference power customers of $8,800,000 annually compared to No Action. If ancillary services are included in the value of the CVP, the net change is a reduction of $7,200,000 annually compared to No Action. In the original Draft EIS/EIR, using different methodology, the Flow Evaluation Alternative was estimated to reduce net value to preference power customers by $5,600,000 annually.

MARKETSYM output identified several significant impacts of the Flow Evaluation Alternative. In the average year, CVP energy available for sale would be reduced by 7.3 percent compared to No Action. Energy available for sale in average months would be reduced by more than 5 percent in 9 out of 12 months.

Based on the MARKETSYM analysis, there is no impact to overall system reliability under this alternative, in either the CNP 15 node or the overall WECC.

Under the Flow Evaluation Alternative, Trinity County PUD would continue to receive benefits from the TRD in accordance with its status as a First Preference Power Customer. Modeled results indicate that Trinity County PUD would be eligible for approximately 260 GWh per year from the TRD, over three times current annual energy use (80 to 85 GWh). Actual costs for First Preference Power received by Trinity County would be established by Western through its regular rate-setting process and would depend, in part, on the types of custom services Trinity PUD would purchase from Western and future allocations of the CVPIA restoration fund, both of which are beyond the scope of this analysis.

Under the Flow Evaluation Alternative, bypass operations would be considered in 14 percent of the modeled months June through October over the period of record, a decrease of 1 percent compared to No Action. Annual average value of generation would be reduced by $408,000 per year if every potential bypass were realized, $173,000 less than No Action both because bypasses would occur less frequently and fewer GWh would be lost when bypasses did occur (802 GWh under 70 Percent Inflow compared to 1,141 GWh under No Action).

The change in cost per unit of electricity for the average Western customer under the Flow Evaluation Alternative would be $.33, while the change for the high-allocation customer would be $1.99.

Modified Percent Inflow. Average annual CVP power generation under this alternative would be reduced. This alternative would reduce the amount of power generated by the TRD, resulting in a decrease in the value of net power available for use by preference power customers of $7,800,000 annually compared to No Action. If ancillary services are included in the value of the CVP, the net change is a reduction of $6,800,000 annually compared to No Action. This alternative was not analyzed in the original Draft EIS/EIR.

MARKETSYM output identified several significant impacts of the Modified Percent Inflow Alternative. In the average year, energy available for sale would be reduced by 7 percent compared to No Action. Energy available for sale in average months would be reduced by more than 5 percent in 8 out of 12 months.

Based on the MARKETSYM analysis, there is no impact to overall system reliability under this alternative, in either the CNP 15 node or the overall WECC.

Under the Modified Percent Inflow Alternative, Trinity County PUD would continue to receive benefits from the TRD in accordance with its status as a First Preference Power Customer. Modeled results indicate that Trinity County PUD would be eligible for approximately 285 GWh per year from the TRD, over three times current annual energy use (80 to 85 GWh). Actual costs for First Preference Power received by Trinity County would be established by Western through its regular rate-setting process and would depend, in part, on the types of custom services Trinity PUD would purchase from Western and future allocations of the CVPIA restoration fund, both of which are beyond the scope of this analysis.

Under the Modified Percent Inflow Alternative, bypass operations would be considered in 16 percent of the modeled months June-October over the period of record, an increase of 1 percent compared to No Action. Annual average value of generation would be reduced by $547,000 per year if every potential bypass were realized, $34,000 less than No Action because fewer GWh would be lost (1,074 GWh under Modified Percent Inflow compared to 1,141 GWh under No Action).

The change in cost per unit of electricity for the average Western customer under the Modified Percent Inflow Alternative would be $.29, while the change for the high-allocation customer would be $1.76.

70 Percent Inflow Alternative. Average annual CVP power generation under this alternative would be reduced. This alternative would reduce the amount of power generated by the TRD, resulting in a decrease in the value of net power available for use by preference power customers of $21,700,000 annually compared to No Action. If ancillary services are included in the value of the CVP, the net change is a reduction of $19,400,000 annually compared to No Action. This alternative was not analyzed in the original Draft EIS/EIR.

MARKETSYM output identified several significant impacts of the Revised Mechanical Alternative. Compared to No Action, dry-year capacity would be reduced by more than 50 MW during off-peak hours in July and August. In the average year, CVP energy available for sale would be reduced by 17.3 percent compared to No Action. Energy available for sale in average months would be reduced by more than 5 percent in 9 out of 12 months, which would also constitute a significant impact.

Based on the MARKETSYM analysis, there is no impact to overall system reliability under this alternative, in either the CNP 15 node or the overall WECC.

Under the 70 Percent Inflow Alternative, Trinity County PUD would continue to receive benefits from the TRD in accordance with its status as a First Preference Power Customer. Modeled results indicate that Trinity County PUD would be eligible for approximately 182 GWh per year from the TRD, over twice its current annual energy use (80 to 85 GWh). Actual costs for First Preference Power received by Trinity County would be established by Western through its regular rate-setting process, and would depend, in part, on the types of custom services Trinity County PUD would purchase from Western and future allocations of the CVPIA restoration fund, both of which are beyond the scope of this analysis.

Under the 70 Percent Inflow Alternative, bypass operations would be considered in 19 percent of the modeled months June-October over the period of record, an increase of 3 percent compared to No Action. Annual average value of generation would be reduced by $449,000 per year if every potential bypass were realized, $132,000 less than No Action because fewer GWh would be lost (886 GWh under 70 percent Inflow compared to 1,141 GWh under No Action).

The change in cost per unit of electricity for the average Western customer under the Modified Percent Inflow Alternative would be $.81, while the change for the high-allocation customer would be $4.89.

Maximum Flow. Reductions in power generation under the Maximum Flow Alternative reflect the elimination of Trinity River diversions to the Sacramento River. The alternative would substantially reduce the amount of electricity generated by the TRD, resulting in a decrease in the value of net power available for use by preference power customers of $32,600,000 compared to the No Action condition. This is an estimate of the cost of power customers would pay to replace CVP hydro, on average, each year. If ancillary services are also valued, the impact increases to $45,100,000, because it is assumed that the TRD components are not available to serve as spinning reserve. However, this is unlikely to be the case under emergency conditions because of mitigation measures described below. In the original Draft EIS/EIR, using different methodology, this reduction was estimated as $26,000,000 annually.

MARKETSYM output identified several significant impacts resulting from the alternative. Compared to No Action, dry-year capacity would be reduced by more than 50 MW, both on-peak and off-peak in July and August, largely due to the elimination of generation at the J.F. Carr Powerhouse and reduction of generation at Spring Creek Powerplant. Likewise, on average, CVP energy available for sale would be reduced by 26 percent compared to No Action. Energy available for sale in average months would be reduced by more than 5 percent in 9 out of 12 months compared to No Action.

Based on the MARKETSYM analysis, there is no impact to overall system reliability under this alternative, in either the CNP 15 node or the overall WECC.

Under the Maximum Flow Alternative, Trinity County PUD would continue to receive benefits from the TRD in accordance with its status as a First Preference Power Customer. Modeled results indicate that Trinity County PUD would be eligible for approximately 91 GWh per year from the TRD, just over its current annual energy use (80 to 85 GWh). Actual costs for First Preference Power received by Trinity County would be established by Western through its regular rate-setting process and would depend, in part, on the types of custom services Trinity County PUD would purchase from Western and future allocations of the CVPIA restoration fund, both of which are beyond the scope of this analysis.

Under the Maximum Flow Alternative, bypass operations would be considered in 56 percent of the modeled months June-October over the period of record, an increase of 41 percent compared to No Action. Annual average value of generation would be reduced by $1,130,000 per year if every potential bypass were realized, $549,000 more than No Action.

The change in cost per unit of electricity for the average Western customer under the Modified Percent Inflow Alternative would be $1.21, while the change for the high-allocation customer would be $7.34.

Existing Conditions versus Proposed Action. In general, power operations of the CVP under existing conditions (i.e., 2000) are similar to the No Action Alternative (i.e., 2020). The major difference between the two is the amount of project load served under existing conditions is approximately 138 GWh greater than under No Action. This reduces the net generation available for sale, thus reducing the value of current operations by $2,800,000 compared to the future operations under No Action. Consequently, the reduction in project value to preference customers between the Proposed Action and existing conditions is $6,000,000 less than existing conditions per year. Taking ancillary services into account, the reduction is $4,500,000 per year.

Based on the MARKETSYM analysis, there is no impact to overall system reliability under this alternative, in either the CNP 15 node or the overall WECC.

Mitigation.

Operating criteria would be established to allow Western to respond to various emergency situations in accordance with their obligations to the North American Electric Reliability Council. This commitment would also provide for exemptions to a given alternative's operating criteria during search and rescue situations, special studies and monitoring, dam and powerplant maintenance, and spinning reserves. Such exemptions for responding to various emergency situations would be consistent with the Presidential Memorandum, dated August 3, 2000, directing federal agencies to work with California to develop procedures governing the use of backup power generation in power shortage emergencies.

Potentially significant power-related impacts could occur as a result of decreased surface-water supplies associated with the Revised Mechanical, Flow Evaluation, Modified Percent Inflow, 70 Percent Inflow, and Maximum Flow Alternatives. Although water supply changes were not considered an impact, the development of additional water supplies to meet demands would lessen the associated impacts. Conceptually, any additional water supply or demand reduction would free up water for use by other, competing uses, including power production. Numerous demand- and supply-related programs are currently being studied across California, many of which are being addressed through the ongoing CALFED and CVPIA programs and planning processes. Although none of these actions would be directly implemented as part of the alternatives

discussed in this Supplemental EIR/EIS, each could assist in offsetting impacts resulting from decreased Trinity River exports.

Power-related benefits associated with such programs would only occur if operations were conducted to provide increased power generation; otherwise, implementation of such programs could negatively affect power resources.

Examples of actions being assessed in the CALFED and CVPIA planning processes include:

- Develop and implement additional groundwater and/or surface-water storage. Such programs could include the construction of new surface reservoirs and groundwater storage facilities, as well as expansion of existing facilities. Potential locations include sites throughout the Sacramento and San Joaquin Valley watersheds, the Trinity River Basin, and the Delta.
- Purchase long- and/or short-term water supplies from willing sellers (both in-basin and out-of-basin) through actions including, but not limited to, temporary or permanent land fallowing.
- Facilitate willing buyer/willing seller inter- and intra-basin water transfers that derive water supplies from activities such as conservation, crop modification, land fallowing, land retirement, groundwater substitution, and reservoir re-operation.
- Promote and/or provide incentive for additional water conservation to reduce demand.
- Decrease demand through purchasing and/or promoting the temporary fallowing of agricultural lands.
- Increase water supplies by promoting additional water recycling.
- Develop or construct power generation facilities for use by CVP customers.
- Purchase replacement power resources to offset losses of CVP generation.
- Modify the current CVP Cost Allocation policy to ensure that costs allocated to CVP preference power customers are reduced in an amount equal to the cost of acquiring replacement power.

TABLE 3.5-4
Predicted Power Generation and Value as Modeled MARKETSYM

	Results of Case:	No Action	Revised Mechanical	Flow Evaluation	Modified Percent Inflow	70 Percent Inflow	Maximum Flow	Existing Conditions
1	**Market Clearing Prices**	**$/MWh**	**% Change**	**% Change**	**% Change**	**% Change**	**% Change**	**% Change**
	+2 SD	43.53	0.0	0.1	0.1	0.2	0.5	-0.1
	Mean	35.09	0.1	0.1	0.1	0.3	0.4	0.0
	-2 SD	27.99	0.0	0.1	0.1	0.4	0.5	0.0
2	**Expected Monthly Net Energy**	**MWh**	**% Change**	**% Change**	**% Change**	**% Change**	**% Change**	**% Change**
	Jan	142,609	-4.3	17.8	-17.4	-18.3	-4.5	-16.1
	Feb	206,674	-2.0	-5.2	-5.1	2.1	5.9	-3.3
	Mar	181,222	-2.4	-2.2	-10.4	7.0	-1.0	-9.2
	Apr	288,740	0.3	-0.5	-24.5	5.3	-3.1	-22.2
	May	471,487	-2.0	-4.4	-4.4	-10.7	-13.8	-1.4
	Jun	463,883	-5.5	-10.1	-3.5	-15.8	-24.0	0.7
	Jul	554,085	-1.3	-7.0	-1.2	-19.4	-37.7	1.1
	Aug	392,956	-1.8	-6.6	-1.9	-19.2	-51.3	0.5
	Sep	303,585	-2.4	-14.2	-8.8	-34.9	-43.0	3.1
	Oct	225,999	-15.8	-17.3	-13.3	-41.0	-38.9	1.4
	Nov	98,160	-10.9	-36.4	-19.8	-31.6	-57.4	-2.0
	Dec	162,089	-4.8	-8.9	5.5	-46.4	-32.8	-1.7
		3,491,490	-3.6	-7.3	-7.0	-17.3	-26.3	-2.8
3	**Expected Annual Net Energy**	**MWh**	**% Change**	**% Change**	**% Change**	**% Change**	**% Change**	**% Change**
	On-Peak	2,722,291	-3.3%	-6.7%	-3.4%	-15.5%	-22.7%	0.9%
	Off-Peak	769,199	-4.6%	-9.5%	-19.6%	-23.9%	-39.2%	-16.0%
	Total	3,491,490	-3.6%	-7.3%	-7.0%	-17.3%	-26.3%	-2.8%
4	**Expected a MW of July and August Capacity Based on Reclamation Generation**	**MW**	**% Change**	**% Change**	**% Change**	**% Change**	**% Change**	**% Change**
	On-Peak	601	-1.5%	-4.9%	-2.5%	-15.3%	-30.0%	0.0%
	Off-Peak	240	-3.3%	-9.6%	-5.4%	-21.5%	-34.4%	-0.2%

	Reclamation Expected Monthly and Annual Loads and Resources, MWh	Generation	Load	Change in MWh	Change in MWh	Change in MWh	Change in MWh	Change in MWh	Change in MWh	Change in MWh	Change in MWh	Change in MWh	Change in MWh	Change in MWh	Change in MWh
5															
	Jan	260,007	117,398	-6,680	-532	-7,595	-33,006	-4,935	19,903	-13,237	12,797	-23,649	-17,252	3,161	26,080
	Feb	289,404	82,729	-5,111	-955	-7,734	3,077	-5,822	4,676	1,210	-3,154	-3,219	-15,386	1,536	8,319
	Mar	305,146	123,925	-5,613	-1,262	-7,248	-3,329	-5,031	13,743	-12,632	-25,236	-12,882	-11,025	1,382	18,091
	Apr	344,021	55,281	-3,552	-4,346	-1,005	405	-1,610	69,055	9,149	-6,139	-2,463	6,616	6,009	70,077
	May	504,005	32,517	-5,815	3,839	-16,257	4,369	-10,928	9,913	-44,825	5,473	-60,213	4,776	2,777	9,563
	Jun	553,318	89,434	-16,608	9,041	-28,286	18,627	-17,144	-878	-65,030	8,045	-98,539	12,792	6,906	3,671
	Jul	697,260	143,174	-14,879	-7,865	-38,639	69	-21,711	-14,817	-112,654	-5,285	-191,184	17,815	4,403	-1,771
	Aug	554,938	161,982	-10,192	-3,091	-39,586	-13,732	-19,975	-12,439	-100,904	-25,455	-199,732	1,990	-4,791	-6,603
	Sep	410,099	106,514	-9,411	-2,169	-53,561	-10,385	-28,340	-1,691	-130,496	-24,522	-188,253	-57,742	7,645	-1,719
	Oct	283,365	57,366	-17,120	18,488	-40,993	-1,943	-28,374	1,684	-78,836	13,854	-121,392	-33,517	5,328	2,181
	Nov	199,241	101,081	-8,096	2,595	-23,241	12,488	-16,922	2,560	-45,480	-14,452	-63,336	-7,023	2,890	4,820
	Dec	256,743	94,655	-5,303	2,411	-14,670	-243	-8,950	-17,919	-38,744	36,391	-59,967	-6,871	2,886	5,606
	Annual	4,657,546	1,166,056	-108,378	16,153	-278,815	-23,602	-169,742	73,791	-632,479	-27,685	-1,024,828	-104,826	40,133	138,315

	Reclamation Expected Monthly and Annual Loads and Resources, MWh (based on a deterministic assessment)	Generation	Load	Change in MWh	Change in MWh	Change in MWh	Change in MWh	Change in MWh	Change in MWh	Change in MWh	Change in MWh	Change in MWh	Change in MWh	Change in MWh	Change in MWh
6															

TABLE 3.5-4
Predicted Power Generation and Value as Modeled MARKETSYM

Results of Case:	No Action		Revised Mechanical		Flow Evaluation		Modified Percent Inflow		70 Percent Inflow		Maximum Flow		Existing Conditions	
Jan	291,061	123,012	-2,455	5,188	-23,342	-3,006	-8,115	-2,448	-5,040	-1,625	-6,492	-1,187	-17,739	2,632
Feb	313,620	110,575	-14,158	2,165	-1,413	-10,189	-7,941	286	-5,911	-1,781	-5,236	-2,176	1,245	-2,109
Mar	322,289	103,269	-4,779	1,037	-11,884	-14,162	-7,237	-985	-5,104	-2,349	-6,137	-729	-13,168	-6,959
Apr	358,713	52,856	-1,957	-229	2,042	-4,727	-993	482	-1,415	220	-6,288	-163	10,794	-1,277
May	513,016	53,056	-5,885	-854	-56,826	-8,396	-7,846	-2,166	-7,991	-1,155	-6,331	-938	-42,478	-2,130
Jun	563,970	90,476	-6,787	3,012	-98,124	-12,728	-28,317	-3,643	-16,850	-1,842	-18,276	-1,310	-64,737	-3,801
Jul	693,652	149,308	-3,876	7,444	-193,068	-30,999	-39,189	-9,251	-22,194	-6,948	-13,802	-5,163	-112,658	-15,023
Aug	554,911	140,269	-9,845	1,522	-200,127	-22,708	-40,639	-4,284	-21,048	-4,489	-10,878	-2,052	-102,163	-8,532
Sep	416,940	108,724	-1,479	1,009	-188,464	-10,764	-53,600	-1,804	-29,473	-733	-9,490	-546	-131,176	-5,757
Oct	288,485	94,601	-538	46	-123,969	-7,409	-41,130	-3,296	-28,003	-2,829	-17,134	-404	-79,915	-8,831
Nov	214,714	105,625	-12,466	236	-65,014	-9,525	-23,121	-2,035	-16,748	-2,459	-8,003	-628	-47,300	-7,656
Dec	271,033	123,813	-13,733	-3,288	-62,876	-14,516	-15,793	-4,886	-9,670	-2,965	-5,631	-1,698	-41,422	-7,805
Annual	4,802,403	1,255,582	-77,958	17,289	-1,023,063	-149,130	-273,920	-34,030	-169,446	-28,955	-114,149	-16,994	-640,717	-67,428

7 Reclamation Net Value (based on Net Energy), $	2003 U.S. ($)	Change in 2003 U.S. ($)	Change in 2003 U.S. ($)	Change in 2003 U.S. ($)	Change in 2003 U.S. ($)	Change in 2003 U.S. ($)	Change in 2003 U.S. ($)
Jan	5,562,001	-233,068	890,565	-847,350	-1,024,649	-226,633	-749,648
Feb	6,899,260	-144,548	-342,469	-315,441	130,028	417,018	-182,634
Mar	6,062,268	-146,390	-135,514	-609,075	414,949	-77,548	-543,120
Apr	8,828,167	57,752	-21,645	-2,030,507	479,692	-315,696	-1,819,059
May	14,424,587	-279,535	-607,091	-618,232	-1,491,585	-1,918,174	-181,582
Jun	15,192,841	-789,358	-1,443,279	-525,378	-2,289,950	-3,516,773	98,237
Jul	20,509,625	-236,201	-1,370,413	-250,026	-3,857,282	-7,341,958	201,781
Aug	14,980,450	-248,381	-961,156	-275,670	-2,775,407	-7,517,197	58,831
Sep	12,322,829	-278,223	-1,672,152	-991,385	-4,190,738	-5,033,749	348,943
Oct	7,896,463	-1,198,208	-1,307,584	-1,028,491	-3,138,980	-2,957,070	107,477
Nov	3,746,575	-387,282	-1,296,423	-702,382	-1,107,978	-2,071,484	-52,625
Dec	6,376,967	-297,536	-562,109	395,011	-2,852,034	-2,066,448	-71,771
Annual	**122,802,033**	**-4,180,978**	**-8,829,268**	**-7,798,926**	**-21,703,932**	**-32,625,713**	**-2,785,171**

8 Reclamation Net Value (based on Net Energy), $ (deterministic assessment)	2003 U.S. ($)	Change in 2003 U.S. ($)	Change in 2003 U.S. ($)	Change in 2003 U.S. ($)	Change in 2003 U.S. ($)	Change in 2003 U.S. ($)	Change in 2003 U.S. ($)
Jan	$13,591,768	-$586,978	-$4,502,830	-$150,978	-$71,543	-$126,857	-$2,438,741
Feb	$8,710,297	-$712,125	-$654,680	-$291,317	-$158,675	-$122,519	$168,794
Mar	$9,970,199	-$353,702	-$1,098,638	-$195,495	-$86,645	-$155,960	-$102,347
Apr	$13,315,976	-$6,747,820	-$1,162,042	-$31,484	$59,302	-$131,828	$546,755
May	$19,078,234	-$515,550	-$2,567,787	$309,515	$126,703	$111,445	-$659,208
Jun	$18,548,357	-$197,331	-$3,509,378	-$407,973	-$256,057	-$310,772	-$1,189,602
Jul	$24,010,111	$445,511	-$6,141,877	-$864,540	-$466,113	-$245,500	-$2,983,722
Aug	$19,439,764	$254,460	-$7,158,787	-$1,297,190	-$579,766	-$326,741	-$3,259,051
Sep	$13,990,002	$156,535	-$7,139,566	-$1,949,949	-$1,057,278	-$345,227	-$4,548,066
Oct	$9,201,531	-$7,060	-$4,754,280	-$186,436	-$783,843	-$522,248	-$2,205,930
Nov	$6,284,399	-$864,501	-$3,117,609	-$791,888	-$530,325	-$273,105	-$1,460,837
Dec	$10,173,007	-$1,161,057	-$4,201,699	-$415,303	-$240,655	-$148,839	-$1,176,572
Annual	$166,313,646	-$4,189,619	-$46,009,173	-$7,273,038	-$4,044,895	-$2,598,150	-$19,308,527

TABLE 3.5-4
Predicted Power Generation and Value as Modeled MARKETSYM

	Results of Case:	No Action	Revised Mechanical	Flow Evaluation	Modified Percent Inflow	70 Percent Inflow	Maximum Flow	Existing Conditions
9	**Change in Cost per Unit of Electricity for Western customers, $/MWh**		**Change in 2003 U.S. ($)**	**Change in 2003 U.S. ($)**	**Change in 2003 U.S. ($)**	**Change in 2003 U.S. ($)**	**Change in 2003 U.S. ($)**	**Change in 2003 U.S. ($)**
	Average Customer (14 percent of load)	--	**.16**	**.33**	**.29**	**.81**	1.21	**.10**
	High-allocation Customer (85 percent of load)	--	**.94**	**1.99**	**1.76**	**4.89**	7.34	**.63**
10	**Reliability as Measured by E.N.S. in CNP15**	**MWh**	**Change in MWh**	**Change in MWh**	**Change in MWh**	**Change in MWh**	**Change in MWh**	**Change in MWh**
	Annual	0	0	0	0	0	0	0
11	**Reliability as Measured by E.N.S. in WECC**							
	Annual	4,599	0	0	0	0	0	0

SECTION 4.0

Other Impacts and Commitments

This chapter discusses the cumulative and growth-inducing impacts that may occur because of other related programs and activities. Several of these related programs are being implemented. Others are currently undergoing planning the preparation of environmental documentation. This chapter also discusses irreversible and irretrievable resource commitments, and compares short-term impacts versus long-term environmental benefits. Table 4-1 provides a summary of commitments, mitigation, and significant unavoidable impacts for the alternatives.

4.1 Cumulative Impacts

Cumulative impacts are the impacts on the environment that result from the incremental impacts of the proposed action when added to other past, present, and reasonably foreseeable future actions, regardless of what agency (federal or non-federal) or entity undertakes such other actions. It is recognized that the proposed action may be implemented in an interactive manner with other concurrent projects. In addition, these other projects may affect the impacts of the proposed action. The cumulative analysis addresses impacts associated with several related actions including the following:

Cumulative impacts are the impacts on the environment that result from the incremental impacts of the proposed action when added to other past, present, and reasonably foreseeable future actions.

- ESA consultation for the CVP-OCAP
- CALFED Bay-Delta Program
- Changes in federal farm support programs
- Changes to fisheries management
- Changes in Trinity River Basin Consumptive Water Use
- Five Counties Salmonid Conservation Program
- TMDL
- Lower Klamath Restoration Partnership
- Changes in California Forest Practice Rules
- Sacramento Valley Water Management Agency (SVWMA) (Phase 8)
- EWA

- Intertie proposed action
- Freeport Regional Water Project
- South Delta Improvement Project

Many other water resource activities are planned in California. These activities include water transfer actions and conveyance facilities in the Central Valley and central and southern coastal areas, and wetlands and other habitat restoration projects in the Central Valley. However, the cumulative impact of these programs on the proposed action would be minimal. The following actions are described at length because, in some instances, they could potentially change the level of impacts to the natural or human environment from that which has been described in previous chapters. Because of the uncertainty as to how, when, and to what degree each of these programs and activities will be implemented, this analysis identifies only the primary issues associated with each.

4.1.1 ESA Consultation for CVP-OCAP

As noted previously in this document, ESA and CESA consultation and compliance for this program is being conducted in conjunction with ESA and CESA consultation for CVP-OCAP. However, CVP-OCAP includes consideration programs and projects that were not included under the impact analysis conducted for the action alternatives because final details regarding CVP-OCAP were complex and subject to substantial delays. Notably, CVP-OCAP includes the following additions that were not included in the Supplemental EIS/EIR impact analysis:

- Implementation of CVPIA 3406(b)(2) as defined in May 2003.
- Refinement in modeling assumptions governing EWA assumptions.
- Inclusion of Napa draft propositions, including Freeport Regional Water Project, treatment of two-thirds of North Bay Aqueduct diversions as export, Delta Mendota Canal California Aqueduct Intertie, SWP conveyance of 100,000 acre-feet of CVP water to SWP to meet COA in-basin requirements. Shift of 35,000 taf of Placer County Water Agency demand from the Sacramento River to the American River.
- Modification of Cross Valley Canal operations to reflect changes in CVPIA (3406(b)(2).

Therefore, in terms of ESA compliance, the Preferred Alternative is one of many factors influencing endangered species, whereas in the impact analysis in Chapter 3.0, assumptions regarding CVP and SWP operations were held constant across alternatives, with the exception

TABLE 4-1
Comparison of Impacts on Water Resources

Parameter		Hydrologic Conditions	Existing Conditions	No Action	Preferred Flow	Cumulative
Trinity Reservoir Elevation (feet)	30-May	Dry	2,261	2,261	2,258	2,251
		Wet	2,363	2,363	2,356	2,355
		Average	2,328	2,328	2,319	2,317
	30-Sep	Dry	2,203	2,205	2,213	2,199
		Wet	2,327	2,327	2,321	2,321
		Average	2,286	2,286	2,281	2,276
Shasta Reservoir Elevation (feet)	30-May	Dry	988	987	984	977
		Wet	1,060	1,060	1,059	1,058
		Average	1,042	1,043	1,040	1,037
	30-Sep	Dry	919	914	912	901
		Wet	1,012	1,012	1,010	1,008
		Average	988	987	982	979
San Luis Reservoir Elevation (feet)	30-May	Dry	514	518	588	788
		Wet	565	566	561	658
		Average	568	527	528	602
	30-Sep	Dry	459	397	462	467
		Wet	499	407	408	495
		Average	417	404	410	420
Trinity River Exports (taf/year)		Dry	524	525	380	393
		Wet	1,027	1,024	670	635
		Average	769	773	541	540
Trinity Reservoir Storage (taf)	30-Sep	Dry	673	693	712	641
		Wet	1,816	1,814	1,743	1,740
		Average	1,403	1,403	1,321	1,289
Shasta Reservoir Storage (taf)	30-Sep	Dry	1,540	1,506	1,455	1,341
		Wet	3,117	3,120	3,080	3,046
		Average	2,692	2,680	2,585	2,529
San Luis Reservoir Storage (taf)	30-Sep	Dry	570	541	587	627
		Wet	726	684	685	705

TABLE 4-1
Comparison of Impacts on Water Resources

Parameter	Hydrologic Conditions	Existing Conditions	No Action	Preferred Flow	Cumulative
CVP Deliveries North of Delta (taf/year)	Average	568	554	555	547
	Dry	2,200	2,422	2,385	2,459
	Wet	2,566	2,878	2,871	2,924
CVP Deliveries South of Delta (taf/year)	Average	2,448	2,730	2,712	2,765
	Dry	1,725	1,767	1,617	1,628
	Wet	3,052	3,037	2,981	3,177
Exports, Tracy Pumping Plant (taf/year)	Average	2,631	2,598	2,539	2,623
	Dry	1,640	1,688	1,605	1,607
	Wet	2,562	2,584	2,553	2,673
Exports, Banks Pumping Plant (taf/year)	Average	2,337	2,333	2,281	2,314
	Dry	1,754	1,863	1,837	1,952
	Wet	3,620	3,791	3,794	3,927
Exports, Tracy and Banks Pumping Plants (taf/year)	Average	3,012	3,109	3,095	3,185
	Dry	3,395	3,551	3,442	3,559
	Wet	6,181	6,375	6,347	6,600
Delta Inflow (taf/year)	Average	5,349	5,441	5,376	5,499
	Dry	11,564	11,635	11,481	11,347
	Wet	28,379	28,231	27,896	27,894
Delta Outflow (taf/year)	Average	21,274	21,214	21,010	20,934
	Dry	6,605	6,551	6,605	6,358
	Wet	20,686	20,440	20,145	19,879
Trinity River Releases (taf/year)	Average	14,501	14,399	14,276	14,040
	Critically dry	341	341	370	368
	Dry	341	341	454	454
	Normal	341	341	648	648
	Wet	341	341	702	702
	Extremely wet	341	341	817	817

of the various levels of release into the Trinity River. Notably, the preferred alternative as described in this document is carried through the various CVP-OCAP documents and analyses as the future condition subject to review by responsible resource agencies.

CVP-OCAP is defined as the action proposed by Reclamation and DWR to operate the CVP and SWP to divert, store, and convey CVP and SWP water consistent with applicable law. The CVP and the SWP are two major inter-basin water storage and delivery systems that divert water from the southern portion of the Delta. Both projects include major reservoirs north of the Delta and transport water via natural watercourses and canal systems to areas south and west of the Delta.

The CVP also includes facilities and operations on the Stanislaus and San Joaquin Rivers. ESA consultation for CVP-OCAP includes consideration of the following listed species:

- Winter-run Chinook salmon
- Spring-run Chinook salmon
- Central Valley steelhead
- Delta smelt
- Coho salmon

Further, a separate consultation is also underway addressing the effects of operating the CVP and SWP on wildlife and plant species that are listed, or proposed for listing, under the federal ESA. These species include the following:

- Bald eagle
- California clapper rail
- Salt marsh harvest mouse
- Riparian brush rabbit
- Riparian woodrat
- California red-legged frog
- Giant garter snake
- Valley elderberry longhorn beetle
- Suisun thistle
- Soft bird's-beak

Separate consultation is also underway for wildlife species that are listed, or proposed for listing, under CESA that are not formally addressed in other consultations. These species include the following:

- Bank swallow
- Swainson's hawk
- Western yellow-billed cuckoo

As previously noted, CVP-OCAP includes actions and programs that were not included in the base assumptions defined in Chapter 2.0 and evaluated in Chapter 3.0. The differences between assumptions used for analysis in Chapter 3.0 and those used for CVP-OCAP are outlined in Table 4.2.

TABLE 4-2
Comparison of Modeling Assumptions Used in Supplemental EIS/EIR and CVP-OCAP Analyses

	Supplemental EIS/EIR Existing Conditions	Supplemental EIS/EIR Alternative Analyses	CVP-OCAP Analyses
Level of Development			
DWR 160-98	2001	2020	2020
South of Delta Water Demand			
Contra Costa Water District	143 TAF/year	151 TAF/year	158 TAF/year
State Water Project (including North Bay Aqueduct)	3.0-4.1 MAF/year	3.0-4.1 MAF/year	3.3-4.1 MAF/year
Facilities			
Freeport Regional Water Project	None	None	Included with modified operations on the Mokelumne River
Banks Pumping Capacity	6,680 cfs	6,680 cfs	8,500 cfs
Tracy Pumping Capacity	4,200 cfs with deliveries upstream of Delta-Mendota Canal constriction	4,200 cfs with deliveries upstream of Delta-Mendota Canal constriction	4,600 cfs with intertie

Future actions associated with terms and conditions required during the ESA consultation process and as further development of programs described in the CVP-OCAP project description have the potential to affect the cumulative condition.

4.1.2 CALFED Bay-Delta Program

In the August 28, 2000 CALFED ROD, state and federal agencies committed to implementing a long-term solution to problems affecting the Delta. The CALFED program includes efforts to address water quality and reliability, water storage options that include groundwater banking and offstream surface-water storage, and several water conveyance alternatives in the Delta. The CALFED process is intended to improve the Bay-Delta ecosystem and water quality, which would lead to increased salmon populations in Central Valley streams.

Future actions associated with CALFED have the potential to affect the cumulative condition.

4.1.3 Changes in Federal Farm Support Programs

The 2002 Farm Bill updated the way federal farm subsidies are determined. However, there remains some uncertainty about how the U.S. Department of Agriculture (USDA) would treat lands that are part of a grower's base acreage, yet fallowed if CVP water supplies are reduced. For this Supplemental EIS/EIR, it was assumed that USDA would remove such lands from the grower's base acreage and reduce their federal subsidies accordingly, resulting in a savings to the federal treasury.

In contrast, if growers who fallow their land because of water supply reductions continue to receive farm program payments associated with that land, then no savings would accrue to the federal treasury. However, net revenues to the farmers would increase. This may lead to greater participation in the Central Valley water transfer market, which may lead to a lower cost for water. Either or both of these impacts could increase the amount of water available for water acquisition. This would then increase water supply reliability of agricultural or municipal users. The water also could be acquired to increase instream flow releases. The Farm Bill also includes provisions relating to trade, nutrition programs, rural development, forestry and energy, among other provisions, all of which have the potential to affect physical change on the environment.

4.1.4 Changes to Fisheries Management

Artificial propagation of game fish, including west coast anadromous fish, has been an important tool in fishery management. Numerous federal, state, and local fish hatcheries and rearing facilities have made successful and substantial contributions to the size of anadromous fish populations. Most of these programs are well funded by their respective agencies, including the TRSSH, which has undergone a major rehabilitation to improve water quality and production facilities. Increased hatchery production could increase the number of salmon in the ocean and, therefore, increase the number of returning fish to all streams, including the Trinity River. However, concerns have been raised about the propagation of hatchery fish that are not subject to natural selection during reproduction and rearing, which may lead to competitive disadvantages for natural fish when hatchery fish are released en masse. Hatchery-raised fish may also reduce genetic variability and lead to genetic abnormalities or predisposition that are transferred to natural stock. Hatchery-raised fish may also be more subject to disease.

Salmon spend over two-thirds of their life cycle in the ocean. During this stage of their lives, they are difficult to study. Both sport and commercial harvests appear to have a major role in returning fish populations. However, until harvest impacts can be discerned from

natural phenomena of the sea (e.g., changes to temperature, upwellings, currents, and food availability), there is no exact method to assess the impacts of ocean fisheries. NOAA Fisheries has made advances in resolving some of these issues and will continue to address these concerns, leading to improved management of ocean fisheries. The preferred alternative focuses on restoring natural fish production and, as such, is projected to increase the number of fish produced and available for harvest accordingly.

4.1.5 Changes in Trinity River Basin Beneficial Water Use

The 1955 authorizing legislation for the TRD and the 1959 contract between Reclamation and Humboldt County require that not less than 50,000 acre-feet of water be released annually from the TRD and made available to Humboldt County and downstream water users. As water is released pursuant to that legislation and contract for beneficial use downstream of Lewiston Dam, it could reduce TRD exports and power generation above that are identified in this Supplemental EIS/EIR. The resultant impacts would be influenced by the timing and amount of releases and associated decreased exports. The mandate to release water in this context precedes enactment of NEPA and affords no discretion to the Secretary.

4.1.6 Five Counties Salmonid Conservation Program

The Five Counties Salmonid Conservation Program (5C) is a conservation strategy formed by the Counties of Del Norte, Humboldt, Mendocino, Trinity, and Siskiyou (located in Northwestern California), in response to the 1997 listing of the coho salmon as threatened.

The goal of the program was to seek opportunities to contribute to the long-term recovery of salmon and steelhead in Northern California. The objectives were as follows:

- Evaluate options for improving county plans, policies, and practices to provide or improve salmonid habitat
- Identify areas where counties might be vulnerable to challenges under the ESA
- Upgrade training programs and monitoring and reporting procedures

The mission of 5C is "to strive to protect the economic and social resources of Northwestern California by providing for the conservation and restoration of salmonid populations to healthy and sustainable levels and to base decisions on watershed rather than county boundaries." Specific environmental and economic 5C objectives include the following:

- Identifying potential problem sites through systematic inventories of fish passage barriers and potential erosion sources on county roads
- Improving county policies and road maintenance practices
- Increasing the amount of salmonid habitat by replacing inadequate stream crossings with structures that provide full passage
- Protecting riparian habitat corridors through education and incentive
- Developing model regulations only where other means can not be found to address land use activities regulated by the counties
- Securing various grant program funding
- Devising methods to streamline permitting procedures (ESA, Clean Water Act, and California Fish and Game Code)

Funding sources include NOAA Fisheries, For Sake of the Salmon, CDFG, State Water Resources Control Board, California Resources Agency, California Coastal Conservancy, National Fish and Wildlife Foundation, American Rivers, and Trinity County Resources Advisory Committee.

Work accomplished to date includes a University of California Cooperative Extension review of current land use activities, prioritization of watersheds by local fisheries biologists, completion of a Migration Barrier Inventory of county roads in each county, Implementation of 34 migration barrier removal projects on county roads which have restored over 100 miles of habitat for coho and Chinook salmon, cutthroat trout, and steelhead. The 5C has completed a sediment source inventory on over 1,700 miles of County roads. Based on that inventory, sediment reduction projects have been completed in individual counties. The program has completed its final draft of "A Water Quality and Stream Habitat Protection Manual for County Road Maintenance in Northwestern California Watersheds," which has been officially adopted by Del Norte and Trinity Counties. This manual will serve as a guide and framework for implementing improved road maintenance practices on county roads. The 5C also holds annual water quality and fish habitat training workshops for county roads staff, county land use planners, and policy makers.

The 5C is assisting in the long-term improvement of water quality and fish habitat in the Trinity and Klamath rivers.

4.1.7 Total Maximum Daily Load

The South Fork Trinity, Mainstem Trinity, and Klamath Rivers are listed on the State of California's Clean Water Act (CWA) Section 303(d) Impaired Waterbodies list (303(d) list). The 303(d) list describes waters that do not fully support all beneficial uses or are not meeting water quality objectives. The South Fork Trinity and Mainstem Trinity Rivers are identified as impaired by sediment, with the South Fork Trinity River also impaired by temperature. The Klamath River is identified as impaired by nutrients, temperature, and dissolved oxygen. For such water bodies, the CWA requires the development of TMDL allocations for the pollutants of concern. A TMDL allocation must estimate the TMDL, with seasonal variations and a margin of safety, for all suitable pollutants and thermal loads, at a level that would assure protection and propagation of a balanced indigenous population of fish, shellfish, and wildlife.

Because of a stipulated dismissal of a lawsuit by numerous environmental and fishery groups against the EPA, the EPA completed the South Fork Trinity River TMDL in December 1998. The Trinity River TMDL was completed in 2001, but implementation is still pending. The Klamath River TMDL is scheduled for completion sometime in 2004. Implementation of the respective TMDLs will require incorporation into the NCRWQCB's "*Water Quality Control Plan for the North Coast Region*" (Basin Plan) through an amendment process. To date, only the TMDL for the Garcia River has been incorporated into the Basin Plan. There is no current schedule for inclusion of the South Fork Trinity or Mainstem Trinity TMDL into the Basin Plan. However, ultimate completion and adoption of TMDL's for the South Fork Trinity, Mainstem Trinity, and Klamath Rivers could assist in the long-term improvement of water quality and fish habitat in the Trinity and Klamath Rivers.

4.1.8 Lower Klamath Restoration Partnership

The Yurok Tribe is participating in a major Lower Klamath Restoration Partnership (LKRP), a program to reduce sediment yields and improve fish habitat in the lower Klamath River and its tributaries. The LKRP is a cooperative effort between the Yurok Tribe, Simpson Timber Company, California State Coastal Conservancy, and Northern California Indian Development Council. The LKRP is undertaking a holistic approach to ecosystem management, which focuses on the protection, restoration, and management of the entire basin rather than focusing on the enhancement of single, isolated projects. This process involves a prioritization of watersheds to be restored based on geomorphology, road densities, management history, in-stream habitat, and biological surveys. All road systems and landslides within priority watersheds are assessed, followed by implementation of restoration projects to

solve the major erosion problems within the watershed. During the summer of 1999, five excavators and five bulldozers were working to repair priority erosion problems that were previously identified as priority projects by assessment efforts.

4.1.9 Changes in California Forest Practice Rules

The California Board of Forestry, which is a nine-member, governor-appointed body, is responsible for promulgation and adoption of rules and regulations that affect the harvest of timber from private lands within California. The listing of coho salmon as threatened or endangered throughout California and the CWA 303(d) listing of several north coast streams (see TMDL above), has resulted in changes to the Forest Practice Rules (FPR) to better protect impaired water bodies, including salmon and steelhead populations and their habitat. The rule changes are a result of a scientific panel's review of the FPR, which identified serious deficiencies in the FPRs in terms of protection for aquatic ecosystems, riparian ecosystems, and watersheds. California's coho recovery plan contains additional recommendations changes in FPR's. It is anticipated that the rule changes will complement current efforts to restore aquatic ecosystems, fish habitat, and watershed health in the Trinity River Basin and elsewhere by reducing sediment input to streams and rivers. Additional changes may occur as a result of the State Coho Recovery Plan.

4.1.10 Sacramento Valley Water Management Agreement (Phase 8)

Over the past several years, the SWRCB has been engaged in seven phases of proceedings regarding the responsibility for meeting the flow-related water quality standards for the Delta established in the 1995 Delta Water Quality Control Plan, resulting in Decision 1641. The flow-related standards provide requirements for the amounts of water flowing out from the Delta into the San Francisco Bay to maintain quality parameters within the Delta. The SWRCB hearings have focused on which users should provide this water, and Phase 8 of these proceedings focused on the water users in the Sacramento Valley. Senior water rights holders and water users throughout the Sacramento Valley felt that water releases for Delta water quality could infringe upon their water rights.

In response, DWR, Reclamation, Sacramento Valley water interests, and export water users entered the SVWMA in April 2001, providing an alternative to the Phase 8 proceedings. The SVWMA establishes a process by which local parties are to develop and implement various local water management projects that will increase water supplies cumulatively, meeting both in-basin demands and the Delta water

quality requirements set forth in the Delta Water Quality Control Plan. SVWMA proponents plan to implement the SVWMA in water year 2003. In 2005, Phase 8 upstream users are to provide 185,000 acre-feet of water to meet water quality standards through implementation of conjunctive management projects. Current preparations are underway for an EIR/EIS for the program.

The agreement includes a series of work plans that are to be implemented over an 8-year period. Currently, the short-term work plan consists of over 50 locally managed, publicly funded projects. These projects incorporate the following benefits:

- Facilitation of groundwater management and planning
- Water conservation and efficiency through facility improvements
- Fish passage improvements
- Provisions for water transfers and exchanges
- Flood protection
- Conjunctive water management opportunities
- Environmental improvements

An offstream storage project north of the Delta is a key component of the long-term plan. This storage is intended to provide additional water quality benefits to the Delta and provide additional storage space with other environmental benefits.

SVWMA could contribute to the cumulative condition in normal, dry, and critical water years. Signatories to SVWMA would initially seek water during below normal, dry, and critically dry years from reservoirs, groundwater pumping, and groundwater substitution opportunities upstream from the Delta. As future projects are further defined and implemented, physical effects on the cumulative condition are likely.

4.1.11 Environmental Water Account

The CALFED ROD describes the EWA as a cooperative management program intended to provide protection to fish in the Bay-Delta through environmentally beneficial operations of SWP and CVP facilities. Beneficial operations are intended to occur with no uncompensated cost to water users. For further explanation, see CVP-OCAP BA (Appendix G). EWA will expire in 2004, and will be subject to review and adjusted to best meet the needs of future years. Future operations and changes to EWA have the potential to affect the cumulative condition.

4.1.12 Intertie Proposed Action

A proposed intertie between the SWP and CVP facilities at or near Tracy, California could affect the cumulative condition. Currently, the CVP facility has a maximum pumping capacity of 4,600 cfs. The

canal downstream from the pump narrows at the final pools, reducing the maximum capacity that can be delivered to O'Neill Forebay to 4,200 cfs. An intertie would be built between the project facilities to accommodate the additional 400 cfs that cannot be moved through the final pool of the canal. The canal would potentially increase export capacity for the programs. For example, if the CVP allocations to its contractors were less than 100 percent, unused capacity in the intertie could provide additional capacity for the EWA to move water through the Delta, assuming that the CVP is not using the capacity for its own purposes. This capacity would typically be available during summer months, but the exact amounts are unknown.

4.1.13 Freeport Regional Water Project

The Freeport Regional Water Project will be a new facility that will divert up to a maximum of about 300 cfs from the Sacramento River near Freeport for Sacramento County and East Bay Municipal Utility District. East Bay Municipal Utility District will divert water pursuant to its amended contract with Reclamation. Sacramento County will divert using its water rights and its CVP contract supply. Diversions will result in some reduction in Delta export supply for both the CVP and SWP contractors. Future operations of this project have the potential to affect the cumulative condition.

4.1.14 South Delta Improvement Project

The CALFED ROD identifies the South Delta Improvements Project (SDIP) as a way to improve the use of the Delta for conveyance purposes. The intention of the SDIP is to increase conveyance capacity at the SWP Delta export facility to meet water supply demands in the Export Service Area. The SDIP includes several projects intended to maximize diversion capability into Clifton Court Forebay, while providing an adequate water supply for the South Delta Water Agency and reducing the effects of SWP exports on aquatic resources. The major components of the SDIP are as follows:

- Increasing the maximum allowable diversion capacity at the SWP Clifton Court Forebay to 8,500 cfs
- Dredging a portion of Old River to improve conveyance capacity
- Constructing permanent operable barriers to improve water supply reliability and water quality
- Dredging local channels to reduce the frequency of barrier operations and to accommodate improvements to existing agriculture

- Constructing a permanent operable fish control structure at the Head of Old River to improve conditions for salmon migrating up and down the San Joaquin River

CALFED agencies determined that the objectives outlined in the PEIS/EIR could not be met without some of these South Delta improvements (DWR and Reclamation, 2002).

4.1.15 Cumulative Impacts Analysis

ESA consultations for this program are occurring through the more comprehensive CVP-OCAP consultation. Modeling results for the CVP-OCAP consultation represent the updated cumulative condition for the Supplemental EIS/EIR because they include reasonably foreseeable programs and projects as determined jointly by the federal and state agencies responsible for operating the CVP and SWP. The Cumulative Impacts analysis for this Supplemental EIS/EIR focuses on changes to water resource operations, and the resulting impacts to the primary ESA issues associated with the Trinity River Program, winter-run Chinook salmon in the Sacramento River, and Delta smelt.

The following modifications were included in the CVP-OCAP modeling assumptions, compared to the Supplemental EIS/EIR modeling results presented in Chapter 3.0 of this Supplemental EIS/EIR:

- Implementation of the May 2003 CVPIA 3406(b)(2) decision
- Modification of Cross Valley Canal operations to reflect changes in CVPIA 3406(b)(2) accounting.
- Refinement of EWA logic
- Inclusion of Napa draft propositions for 2020 LOD studies, including the following:
  - Consideration of East Bay Municipal Utilities District as a Delta exporter
  - Treatment of two-thirds of North Bay Aqueduct diversions as an export
  - Delta Mendota Canal/California Aqueduct intertie
  - SWP conveyance of 100 taf of refuge water annually
  - Provision of 75 taf of CVP water to SWP to meet COA in-basin requirements
- Shift of 35 taf of Placer County Water Agency demand from the Sacramento River to the American River

For a complete description of the operation, facility, and modeling assumptions used in the CVP-OCAP consultation, see Appendix G. Table 4-3 outlines the CVP contract allocations assumed for the Existing Conditions, No Action/Preferred Alternative, and Cumulative Impacts conditions.

TABLE 4-3
CVP Contract Allocation Assumed to be used in Existing Conditions, No Action, Preferred Alternative, and Cumulative Impacts Scenarios

CVP Water Users	Existing Conditions (simulated 2001 levels) (taf)	No Action & Preferred Alternative (simulated 2020 levels) (taf)	Cumulative Impacts (simulated 2020 levels) (taf)
North of the Delta			
Agricultural Water Service Contractors	390	390	390
Sacramento River Water Rights Settlement Contractors	2,230	2,230	2,230
Municipal Water Rights	205	376	400
Municipal Water Service Contractors	260	340	510
Refuge Water Supplies	108	108	108
South of the Delta			
Agricultural Water Service Contractors	1,950	1,950	1,950
San Joaquin River Exchange Contractors	880	880	880
Municipal Water Service Contractors	154	154	154
Refuge Water Supplies	290	290	290
CVP Contracts on the Stanislaus River	160	160	160

The models on which 2020 projections were based take account for "probable future projects." This approach satisfies the separate CEQA obligation to address cumulative impacts.

Between 2001 and the year 2020, projected annual CVP M&I water service contracts and water rights demands are assumed to increase by approximately 251,000 acre-feet. The cumulative condition assumes an additional 194,000 acre-feet CVP M&I water demands. Annual SWP entitlements are projected to remain between 3.0 and 4.1 maf through the year 2020, increasing to 3.3 to 4.1 maf under the cumulative condition.

Potential changes to reservoir storage levels and water deliveries were modeled using CALSIM. Updates to the cumulative condition are presented here as an update to the cumulative analysis in the

2000 EIS/EIR. Results presented here are generally consistent with data used to develop conclusions for the cumulative analysis presented in the 2000 EIS/EIR, but provide an update on foreseeable projects.

Water Resources. Table 4-3 outlines the comparative changes in water resources between Existing Conditions, No Action, Preferred Flow, and the Cumulative condition. Additionally graphic representations of key water resource characteristics are presented on Figures 4-1 through 4-5

The primary change to system operations is described in Table 4-1, under the parameter "Trinity River Exports." As shown, the No Action Alternative and the Existing Condition scenario have very similar export characteristics, in large part because their minimum releases to the Trinity River are exactly the same (340,000 acre-feet). For the Preferred Alternative, instream releases are increased, resulting in less water available, on average, for export; 773,000 acre-feet under No Action compared to 541,000 acre-feet under the Preferred Alternative. Increased dry year demand in the Cumulative condition results in slightly higher diversions in the dry period as the CVP system attempts to meet increased demand outlined in Table 4-3.

The increased demand in the dry period is also evident in the parameter "Trinity Reservoir Storage," where the Trinity Reservoir end of year storage is drawn down by approximately 50,000 acre-feet in the dry period compared to the Preferred Alternative. A similar effect is demonstrated at Shasta Reservoir, with the Cumulative condition resulting in lower end-of-year storage in the dry period (1.3 maf) than the Preferred Alternative (1.5 maf), in large part due to increased demand. Trinity and Shasta Reservoir storage frequencies are presented on Figures 4-1 and 4-2. The change in release schedule to the Sacramento River is also described by lower flow in the Sacramento River. The timing and magnitude of this reduction is described on Figure 4-4, displaying flow in the Sacramento River below Keswick Dam the reregulating dam below Shasta Reservoir.

For all alternatives, the dry period includes some months where Shasta Reservoir drops to levels very close to theoretical minimum levels where structural concerns relating to "vortex" operations might mandate emergency changes to operations. Vortex operations refer to conditions whereby air might run through the dam intake-outlet structures, possibly resulting in catastrophic failure. Concerns about vortex operations are exacerbated in the Cumulative condition, where drawdowns are expected to occur more frequently. Secondary effects of reduced storage and flow are described below under Fishery Resources.

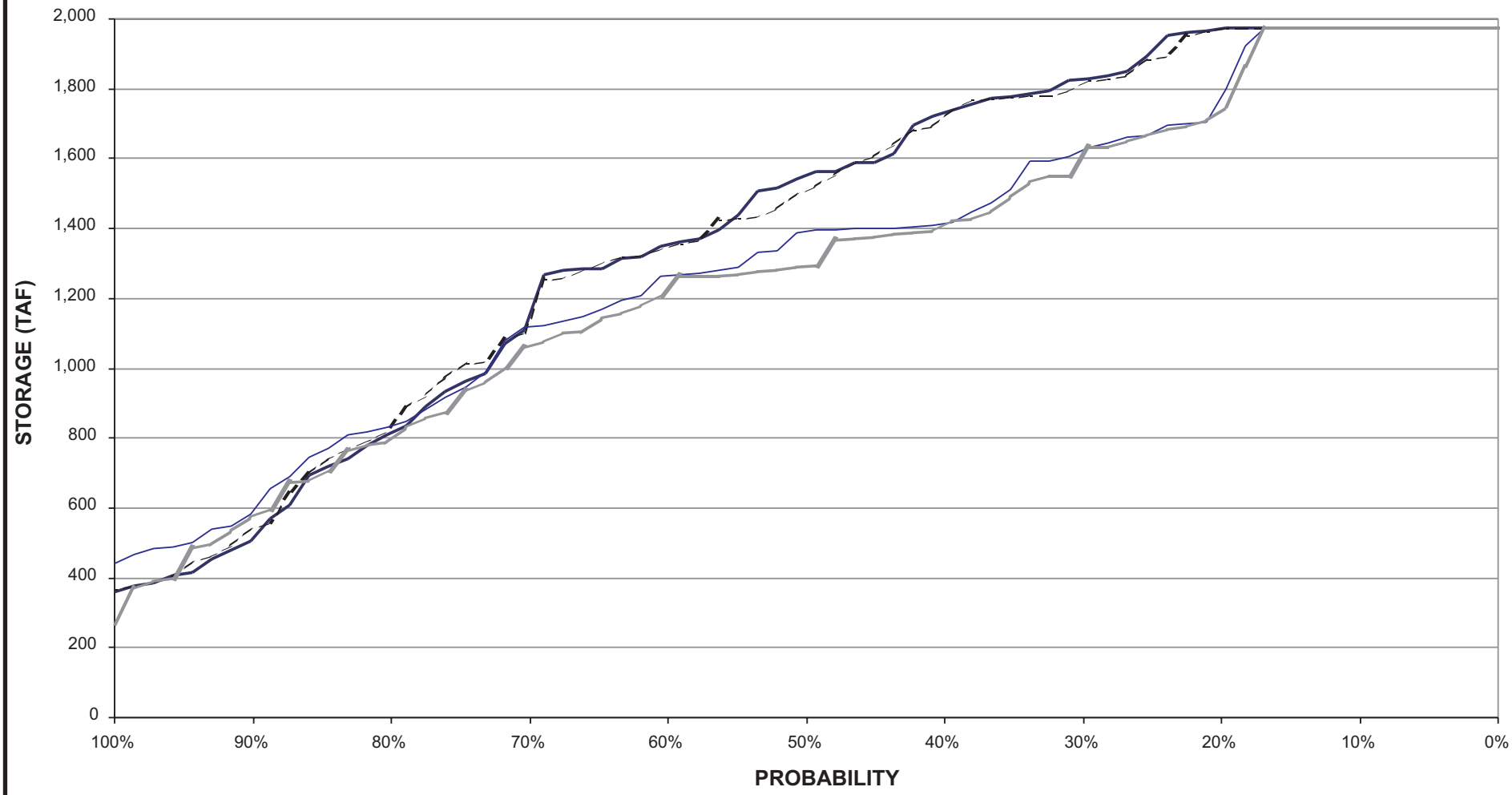

FIGURE 4-1
TRINITY RESERVOIR SIMULATED FREQUENCY OF END-OF-WATER-YEAR STORAGE, WATER YEARS 1922-1990
TRINITY RIVER FISHERY RESTORATION SUPPLEMENTAL EIS/EIR

W022004007RDD_991 (4/5/04)

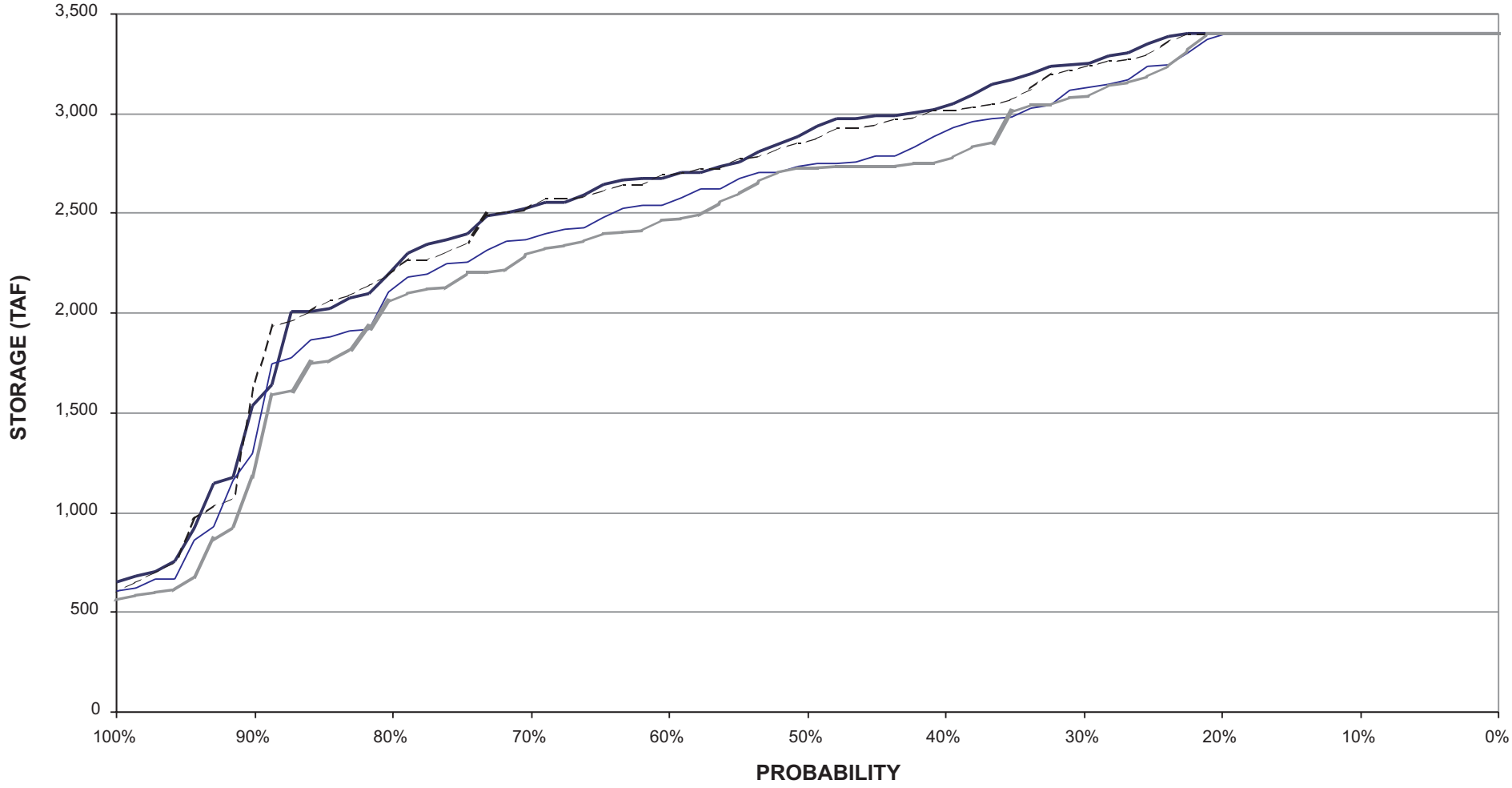

FIGURE 4-2
SHASTA RESERVOIR SIMULATED FREQUENCY OF END-OF-WATER-YEAR STORAGE, WATER YEARS 1922-1990
TRINITY RIVER FISHERY RESTORATION SUPPLEMENTAL EIS/EIR

W022004007RDD_992 (4/5/04)

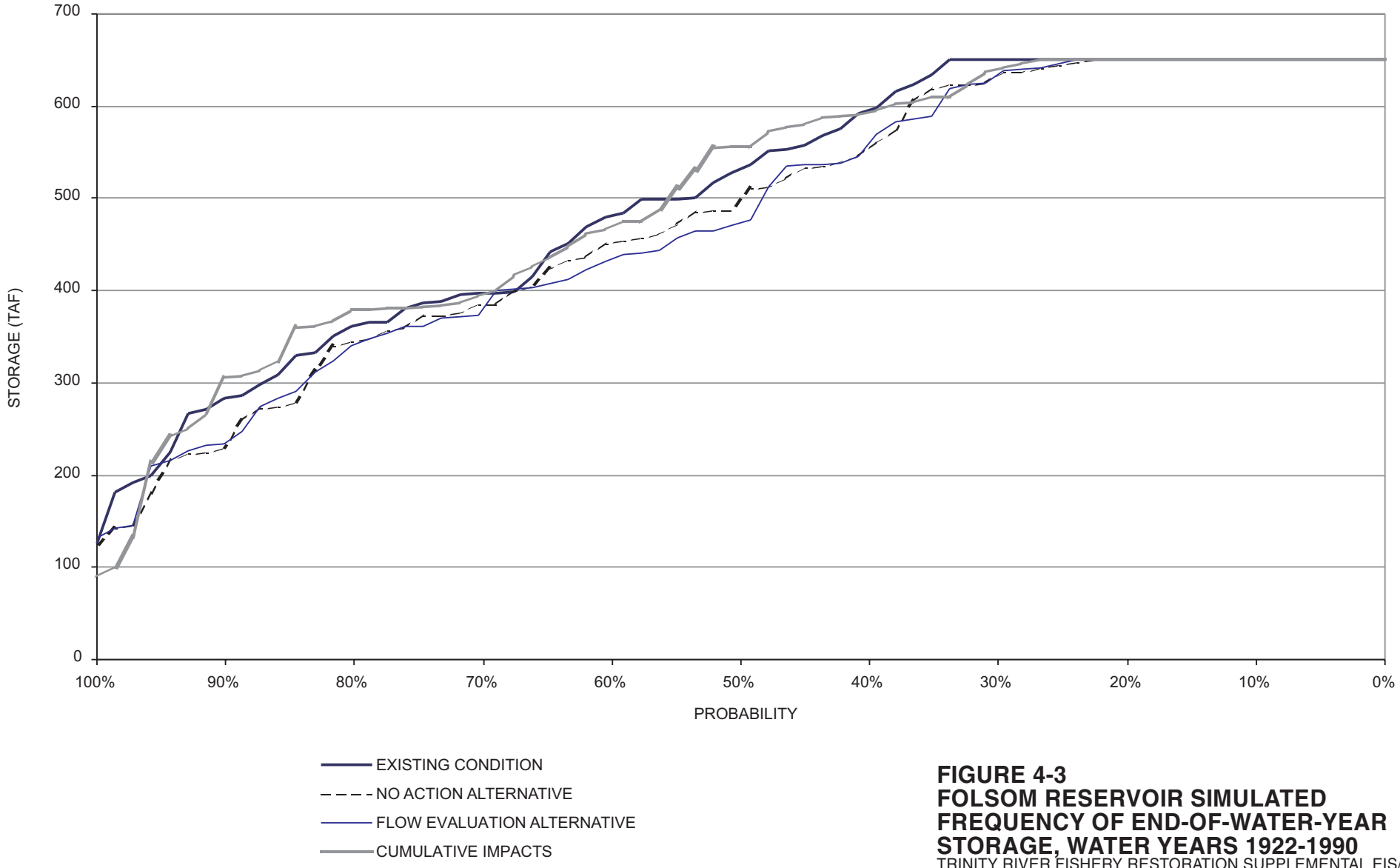

FIGURE 4-3
FOLSOM RESERVOIR SIMULATED FREQUENCY OF END-OF-WATER-YEAR STORAGE, WATER YEARS 1922-1990
TRINITY RIVER FISHERY RESTORATION SUPPLEMENTAL EIS/EIR

W022004007RDD_993 (4/5/04)

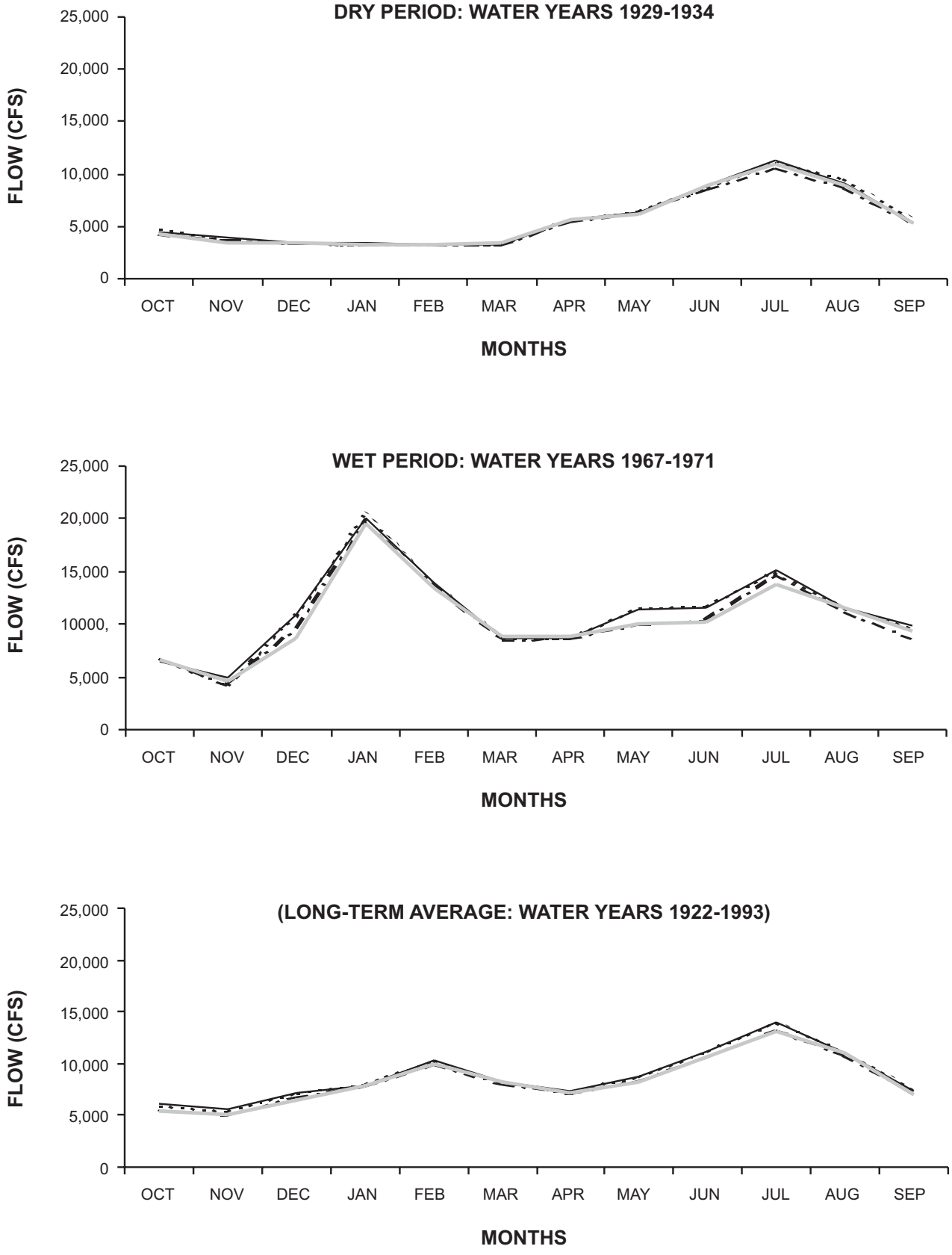

FIGURE 4-4
KESWICK RESERVOIR
SIMULATED MONTHLY FLOWS
TRINITY RIVER FISHERY RESTORATION SUPPLEMENTAL EIS/EIR

W022004007RDD_994 (4/5/04)

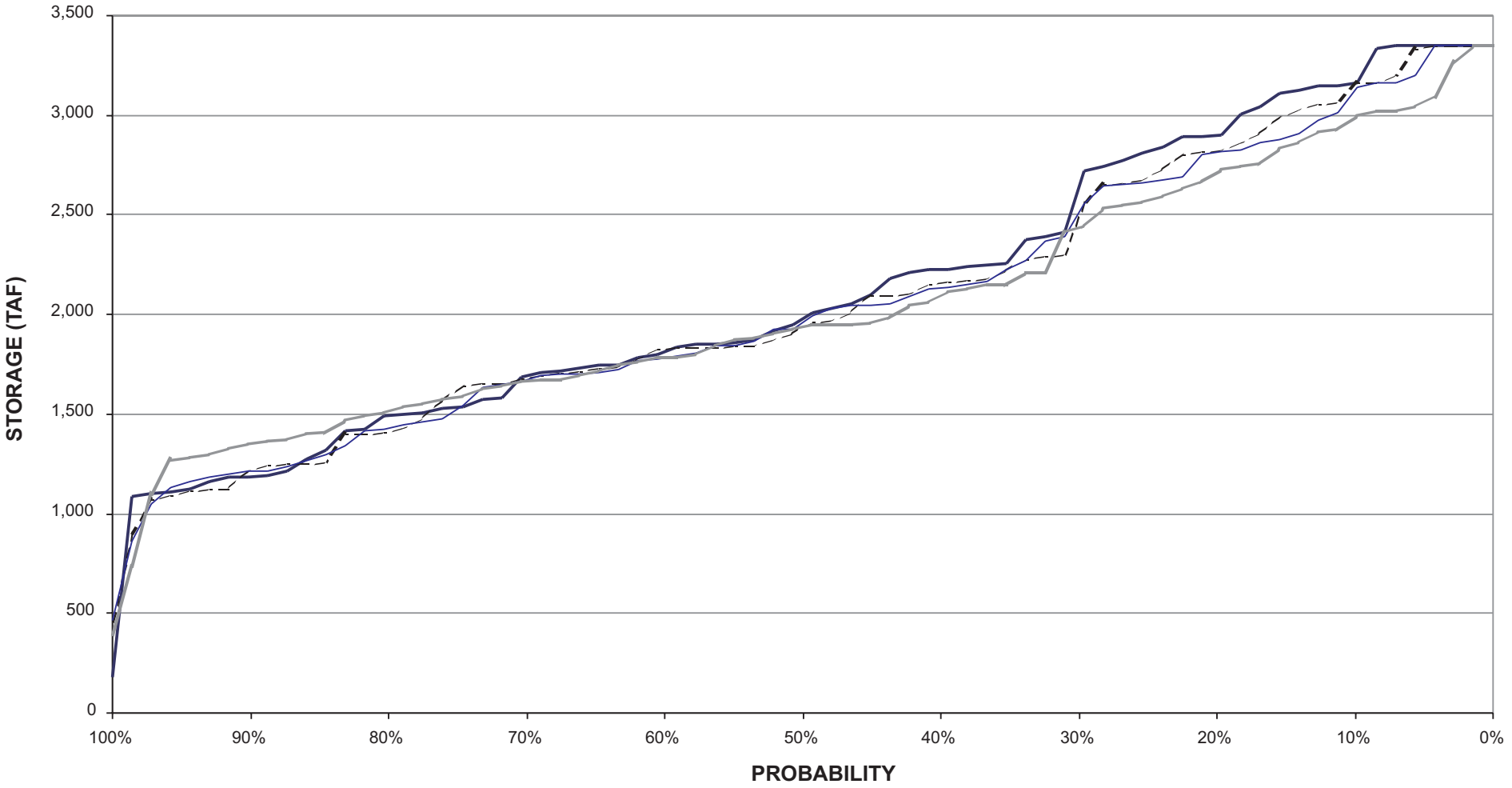

FIGURE 4-5
OROVILLE RESERVOIR SIMULATED FREQUENCY OF END-OF-WATER-YEAR STORAGE, WATER YEARS 1922-1990
TRINITY RIVER FISHERY RESTORATION SUPPLEMENTAL EIS/EIR

W022004007RDD_995 (4/5/04)

CVP Water Deliveries North of the Delta. Deliveries to agricultural and M&I water service contractors north of the Delta are a function of CVP available water supply. As shown in Table 4-1 under the parameter "CVP deliveries North of Delta," deliveries increase from Existing Conditions to the future conditions described in the other alternatives, on average increasing from approximately 2.4 maf to 2.7 maf to 2.8 maf under No Action, Preferred Alternative and the Cumulative condition. Changes in demand due to the Freeport Regional Water Project, increases for the CCWD and Sacramento County are included in this parameter.

CVP Water Deliveries South of the Delta. Deliveries to agricultural and M&I water service contractors south of the Delta are a function of available CVP water supply and the amount of water exported through the Delta. As shown in Table 4-1, under the parameter "CVP Deliveries South of Delta," dry period deliveries are reduced under the Preferred Alternative and Cumulative condition, compared to Existing Conditions and No Action. However, the Cumulative condition, due to the Napa provisions, increases deliveries in the wet period over all scenarios described in Table 4-1. On average, deliveries under the Cumulative condition are similar to existing conditions, although fluctuations between dry year and wet year deliveries may be greater.

The change in CVP deliveries south of the Delta is also reflected in the changes in modeled exports through the Banks Pumping Plant where annual diversions are expected to be greater than Existing Conditions in the dry period, wet period, and on average. In part, this increase also attributes to a decrease in Delta outflow. Secondary effects of reduced Delta outflow are described below under Fishery Resources.

Issue-specific Cumulative Impact Analysis. The previous EIS/EIR identified potentially significant cumulative impacts that are anticipated as a result of implementing the Preferred Alternative in relation to past, present, and reasonably foreseeable projects. The discussion identified those areas in which the impacts of the Preferred Alternative, when viewed against the backdrop of these other projects, would cause an incremental impact that is "cumulatively considerable" within the meaning of CEQA. Impacts discussed within issue areas, which were not included in the previous EIS/EIR, were omitted because the incremental impact of the Preferred Alternative was considered to be "de minimus" (CEQA Guidelines §§15130). A "de minimus contribution means that the environmental conditions would essentially be the same whether or not the proposed project is implemented" (CEQA Guidelines §§15130). This Supplemental EIS/EIR focuses on the impacts to Fishery Resources for the following two reasons:

1. The Cumulative condition uses the same set of assumptions as described in the ESA consultation for CVP-OCAP, which includes in-depth discussion of impacts to Fishery Resources.
2. The operational changes described in the Cumulative condition include effects to Fishery Resources that are "cumulatively considerable."

Fishery Resources. Implementation of the Preferred Alternative is expected to result in a cumulatively beneficial impact in terms of increased anadromous fish production within the Trinity River Basin. As described in Chapter 3.0, this increase in fish production would result in beneficial recreational impacts, and increased modeled adverse impacts to anadromous fish within the Sacramento River would be expected to occur with regard to increased losses of early life-stages (eggs and sac-fry) of some runs of Sacramento River Chinook salmon compared to the No Action Alternative and existing conditions. These impacts are attributable to a slight anticipated mortality of Chinook salmon eggs and sac-fry from increases of Sacramento River water temperature.

Trinity River Fisheries. Compared to the No Action Alternative, the implementation of the Preferred Alternative, in relation to the cumulative condition, would result in substantially restoring the diverse fish habitats necessary for the restoration and maintenance of anadromous fishery resources in the Trinity River Basin. The watershed protection component of the Preferred Alternative would accelerate and enhance habitat improvement and salmonid production through mechanical restoration. These improvements would be beneficial effects and substantially assist in the restoration of anadromous salmonid populations in the Trinity River. Increased populations would result in a greater number of fish being available for harvest.

The assumed increase in fish available for ocean commercial harvest would be a beneficial effect for the Northern/Central Oregon, KMZ-Oregon, KMZ-California, and Mendocino Regions.

Similar to the comparison to the No Action Alternative, the cumulative effects scenario would result in substantially restoring the diverse fish habitats necessary for the restoration and maintenance of anadromous fishery resources in the Trinity River Basin as compared to existing conditions. (As discussed in Section 3.4 Fishery Resources, while some habitat degradation is assumed to occur under the No Action condition, the majority of such degradation is assumed to have already occurred and, therefore, fishery habitats for existing conditions and the No Action Alternative are similar.) The watershed protection component of the Preferred Alternative would accelerate and enhance habitat improvements and salmonid

production through mechanical restoration. Compared to existing conditions, these improvements would be beneficial effects and would substantially assist in the restoration of anadromous salmonid populations in the Trinity River. The increased availability of fish for ocean commercial harvest for the Northern/Central Oregon, KMZ-Oregon, KMZ-California, and Mendocino Regions would be a beneficial effect.

Sacramento River Fisheries. This impact assessment focuses on the following two aspects of implementation of the Preferred Alternative:

1. Temperature impacts affecting winter-run and spring-run Chinook salmon mortality in the Sacramento River
2. Changes in X2 position that affect the relative amount of habitat available for Delta smelt

Winter-run and spring-run Chinook salmon are the subject of review in the ESA consultation for CVP-OCAP, as are Delta smelt. These impacts are considered separately.

Elevated instream water temperature can cause mortality in winter-run and spring-run Chinook salmon. As described in Chapter 3.0, the selection of downstream temperature targets can change the number of days that suitable temperatures may be provided for salmon. Essentially, the further downstream the temperature target is set, the fewer number of days it is possible to meet that target. However, targets that are further downstream are desirable because they provide more total habitat than upstream targets. Balancing the interplay between total habitat and time that the habitat is available has become a major operational effort since the publication of the 1993 Winter-run Chinook BO.

As stated in Chapter 3.0, the year-to-year downstream temperature target tends to be Bend Bridge, depending on water year type and carryover storage. In years when temperature compliance is forecast to be unachievable at the downstream targets, it is moved upstream until a target is set that is believed to be achievable through the management period. However, as stated in the CVP-OCAP BA, the proposed target is Balls Ferry, a location approximately 10 miles upstream of Bend Bridge, with downstream targets to be considered as additional water is determined to be available. The effects of these operations on winter-run and spring-run Chinook mortality, classified by water year type (Sacramento Index), is displayed in Tables 4-4 and 4-5.

TABLE 4-4
Comparative Levels of Mortality for Winter-run Chinook Salmon in the Sacramento River with the Bend Bridge and Balls Ferry Temperature Targets (Separated by Sacramento River Index)

		Existing Conditions		No Action		Preferred Alternative		Cumulative	
		Bend Bridge	Balls Ferry	Bend Bridge	Balls Ferry	Bend Bridge	Balls Ferry	Bend Bridge	Balls Ferry
Wet	Average	0.2	0.9	0.2	0.9	0.3	1.1	0.3	1.2
	Median	0.2	0.8	0.2	0.8	0.3	1.0	0.3	1.1
	Maximum	0.6	2.3	0.6	2.3	0.6	2.3	0.6	2.4
	Minimum	0.1	0.2	0.1	0.2	0.1	0.3	0.1	0.3
Above Normal	Average	0.3	1.7	0.3	1.7	0.3	1.9	0.3	2.1
	Median	0.2	1.7	0.2	1.7	0.2	2.0	0.2	1.9
	Maximum	1.1	3.0	1.1	3.1	1.1	3.5	1.1	4.0
	Minimum	0.1	0.4	0.1	0.4	0.1	0.4	0.1	0.4
Below Normal	Average	0.6	2.2	0.7	2.3	1.2	2.5	1.8	3.2
	Median	0.2	46.9	0.2	1.9	0.3	2.3	0.3	2.2
	Maximum	2.2	51.9	3.2	6.4	9.0	6.5	16.4	10.3
	Minimum	0.1	45.2	0.1	0.6	0.1	0.6	0.1	0.6
Dry	Average	2.9	4.3	3.5	4.7	2.8	3.9	5.2	4.6
	Median	0.2	1.8	0.2	1.9	0.4	2.1	0.4	2.1
	Maximum	37.3	26.6	46.2	31.1	35.7	28.0	69.7	39.5
	Minimum	0.1	0.6	0.1	0.8	0.1	0.7	0.1	0.8
Critical	Average	45.6	36.1	45.9	36.0	50.1	38.1	55.0	46.1
	Median	23.4	10.3	58.9	24.6	59.8	25.5	85.6	58.4
	Maximum	99.4	85.8	100.0	93.6	100.0	96.1	100.0	100.0
	Minimum	0.4	0.6	0.4	0.6	0.2	1.0	0.3	0.8

TABLE 4-5
Comparative Levels of Mortality for Spring-run Chinook Salmon in the Sacramento River with the Bend Bridge and Balls Ferry Temperature Targets (Separated by Sacramento River Index)

		Existing Conditions		No Action		Preferred Alternative		Cumulative	
		Bend Bridge	Balls Ferry	Bend Bridge	Balls Ferry	Bend Bridge	Balls Ferry	Bend Bridge	Balls Ferry
Wet	Average	5.3	5.9	5.7	5.9	8.2	6.9	8.3	6.7
	Median	4.8	5.6	5.1	5.8	6.3	7.2	6.4	6.9
	Maximum	12.7	8.9	14.8	8.2	35.0	10.4	27.8	10.3
	Minimum	1.9	2.9	2.0	3.1	2.9	3.1	2.5	3.1
Above Normal	Average	4.7	6.1	4.8	6.1	8.4	6.4	8.0	6.3
	Median	4.5	5.7	4.5	5.8	6.7	6.0	5.3	6.2
	Maximum	8.8	8.4	9.1	8.6	18.4	9.5	16.0	9.3
	Minimum	1.8	4.1	1.6	4.0	1.9	4.4	2.0	4.0
Below Normal	Average	19.2	10.9	19.6	12.6	29.3	17.2	32.6	20.8
	Median	6.1	44.8	6.4	6.4	12.0	7.5	15.5	7.4
	Maximum	85.8	47.9	92.7	58.3	98.4	82.1	98.7	98.3
	Minimum	1.1	39.8	1.1	2.7	2.2	2.8	2.3	2.8
Dry	Average	22.4	12.5	24.1	12.7	40.9	17.4	48.7	21.9
	Median	15.5	6.5	14.8	5.9	31.9	7.8	40.4	7.8
	Maximum	99.8	99.8	99.9	99.8	99.9	99.9	99.9	99.9
	Minimum	0.4	2.6	0.4	2.5	0.4	2.5	0.4	2.7
Critical	Average	86.1	73.7	81.2	64.5	87.8	78.3	89.6	83.0
	Median	99.3	96.5	96.5	96.3	99.0	96.5	98.9	98.7
	Maximum	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
	Minimum	20.5	7.6	19.4	6.2	22.2	11.1	26.2	12.8

As shown in Tables 4-4 and 4-5, mortality for both winter-run and spring-run Chinook salmon is highly variable, and can be influenced by management of the temperature target in the Sacramento River. The greatest influence of temperature target management is in Critically Dry years for both winter-run and spring-run Chinook salmon, although severe mortality (up to 100 percent in a given year) remains a possibility. Management of the temperature compliance point also outlines tradeoffs inherent in system operation. Use of the upstream temperature target (Balls Ferry) tend to benefit spring-run Chinook salmon in all water year types, but can slightly increase mortality of winter-run Chinook salmon in wetter years. This is likely a result of the relative distribution of spawners in the river. Existing Conditions tend to result in the lowest mortality for winter-run Chinook salmon for all year types, regardless of temperature compliance point.

Incremental increases in winter-run mortality occur in the Preferred Alternative compared to Existing Conditions and No Action, with a potentially significant impact occurring in Critically Dry water years. However, as noted in Chapter 3.0, this significant impact can be reduced to less than significant through the management of upstream targets in the Critically Dry water years. Compared to the Preferred Alternative, the cumulative condition results in incremental increases in winter-run Chinook salmon mortality, notably in the Dry and Critically Dry water years. However, this impact is reduced through the use of upstream temperature targets in Dry and Critically Dry water years. Regardless, the incremental effect of the cumulative condition is considered cumulatively considerable. Effects on spring-run Chinook salmon show similar trends as those for winter-run, with the exception that the upstream temperature target reduces mortality in all cases. The final analysis of cumulative effects on both winter-run and spring run Chinook salmon will be published in the CVP-OCAP BO.

A common surrogate parameter for Delta smelt habitat is relative salinity in the Delta, often measured as X2. The X2 criteria refer to the measurement of upstream movement of water with 2 ppt concentration of salt. The X2 is measured as km from the Golden Gate Bridge. Higher X2 values indicate salt water intrusion into the Delta. For Delta smelt, X2 is important because it represents suitable nursery habitat. Nursery habitat is required during the February through June timeframe. However, other factors that relate to habitat include depth of water and vegetation. Honker Bay, located just west of Chipps Island (73 km from the Golden Gate Bridge) is considered high-quality nursery habitat for Delta smelt. Generally, there is little benefit in terms of Delta smelt habitat from having extremely low X2 values because areas to the west, like San Pablo Bay, do not provide quality habitat. Table 4-6 presents average X2

position, by month for the various conditions considered here. As shown in Table 4-6, relative values of X2 are very similar, although there is a slight trend towards upstream values (approximately 0.1 to 0.2 km) moving from Existing Conditions to the Cumulative condition.

TABLE 4-6
Comparative X2 Positions, Averaged by Month

Month	Existing Conditions	No Action	Preferred Alternative	Cumulative
October	85.5	86.0	86.3	86.5
November	84.3	84.6	84.9	85.5
December	82.0	82.0	82.4	82.2
January	76.7	76.8	76.9	77.6
February	71.2	71.3	71.4	71.6
March	66.1	66.2	66.2	66.4
April	65.6	65.7	65.8	65.9
May	67.6	67.7	67.7	67.8
June	70.4	70.5	70.6	70.3
July	75.0	75.1	75.1	75.2
August	79.2	79.3	79.3	79.2
September	84.4	84.4	84.4	83.7

Table 4-7 presents the relative exceedances between scenarios. For this discussion, exceedances are defined as changes in X2 position, in any month between February and June greater than 0.5 km. For example, if the CALSIM modeling for the No Action Alternative results in a value of 75.6 for February of 1930, and 75.0 for February 1930, in the Existing Conditions, it would be reported in Table 4-7 as an upstream exceedance month.

TABLE 4-7
Relative X2 Exceedances of more than 0.5 km February through June over the Modeled Period

Alternative	Existing Conditions versus No Action	No Action versus Preferred Alternative	Existing Condition versus Preferred Alternative	Cumulative versus Preferred Alternative
Total Months with Upstream[a] Change of 0.5 km	28	35	26	94
Total Months with Downstream[b] Change of 0.5 km	41	29	13	44

[a]An upstream change is considered a negative impact on Delta Smelt habitat
[b]A downstream change is considered a positive impact on Delta Smelt habitat

As shown in Table 4-7, X2 changes in the various scenarios occur in both the upstream and downstream direction. Compared to Existing

Conditions, exceedances tend towards the downstream direction, resulting in benefits to total nursery habitat for Delta smelt. The Preferred Alternative results in both upstream and downstream exceedances of the 0.5 km threshold; however, as noted in Chapter 3.0, the incremental change in rearing habitat is not significant, especially after consideration of the relative value of habitat (i.e, Honker Bay-type habitat versus San Pablo Bay-type habitat). Compared to the Preferred Alternative, the Cumulative condition results in more occurrences of upstream exceedances. This effect is considered cumulatively considerable, and is the subject of ESA consultation through the CVP-OCAP process.

SECTION 5.0

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Technical Appendices

Water Resources/Water Quality
Technical Appendix A

Preliminary Results from Monitoring the Trinity River Fall Flows Action Plan

Trinity River Restoration Program

P.O. Box 1300, 1313 South Main Street, Weaverville, California 96093
Telephone: 530-623-1800, Fax: 530-623-5944

NC-156

MEMORANDUM

TO: Mike Ryan, Northern California Area Manager
Russell Smith, Environmental Resources Division Chief

FROM: Daryl Peterson, Trinity River Restoration Program, Technical Modeling Branch Chief

SUBJECT: Preliminary Results From Monitoring the Trinity River Fall Flows Action Plan

CC: Doug Schleusner, Executive Director, Trinity River Restoration Program

Introduction

In a March 5, 2003 court hearing, Judge Oliver Wanger directed the Department of the Interior to determine what actions would be necessary to "assure against the risk of fish losses that occurred late in the season last year." Judge Wanger subsequently issued a ruling on April 4, 2003 allowing Reclamation to use an additional 50,000 af from the Trinity River Division of the Central Valley Project "at its reasonable discretion" to prevent a recurrence of the September 2002 fish die-off.

In fall of 2003 an Action Plan was developed that recommended increased Trinity River flows to reduce the likelihood, and potentially reduce the severity, of a fish die-off occurring during the fall run Chinook salmon migration. The Action Plan provided flows known to be adequate for unimpaired salmon migration through the lower Klamath River. It was expected that increasing flows would reduce or eliminate adverse in-river conditions that contributed to the adult fish die-off of 2002.

An initial presentation of increased late-summer Trinity River dam release options and request for written comments was given at the TMC meeting on June 26, 2003. Written comments were received through July 18, 2003. A technical workgroup of state, federal, and tribal biologists was convened on July 23 and 24, 2003, to consider comments received and evaluate alternatives. That group developed a revised alternative, the Action Plan Flows option, that addresses these concerns. Additional updates were provided to a broadly representative group of stakeholders on July 29, 2003, at a TAMWG meeting in Weaverville, California, and a TMC conference call on July 30, 2003. A letter of support for the proposed action was forwarded directly to the Secretary of the Interior from the TMC and TAMWG in a letter dated August 8, 2003.

The need for implementing the Action Plan was both biological and legal in nature. In 2002, low flow conditions in the lower Klamath River, warm water temperatures, and an above average fall run Chinook salmon escapement combined to create conditions favorable to an epizootic outbreak resulting in a fish die-off. Biological consequences of a die-off in two consecutive years would substantially impact present efforts to restore the native Trinity River anadromous fish community and fishery. Reductions in the Trinity River fish

population would also affect Tribal fishery harvest opportunities, ocean harvest levels, recreational fishing, as well as public perception and recovery mandates. Last year's loss of 3 year-old and a potential loss of 4 year-old fish from the 1999 brood year affect the population structure, and may impede recovery goals authorized by the Trinity River Division Central Valley Project Act of 1955 (P.L. 84-386), the Trinity River Basin Fish and Wildlife Act of 1984 (P.L. 98-541), and the Central Valley Project Improvement Act of 1992 (P.L. 102-575), for naturally produced fall run Chinook salmon.

Projected flow conditions and a large fall run Chinook salmon escapement on the lower Klamath River in 2003 were similar to conditions that existed during the die-off in 2002. The two triggers established for initiating the preventive flow release (low flow and a large return of fall run Chinook salmon) were met as of August 20, 2003. Therefore, Reclamation implemented the release schedule proposed in the Action Plan as a preventative means to reduce the likelihood of another fish die-off in 2003.

Methods

The Action Plan used a conservative risk management approach to avert another fish die-off in 2003. The Action Plan had two flow components. The first component was a preventative flow release, using 33,000 acre-ft (af) of water. The preventative flow was intended to reduce the likelihood of a large scale fish die-off by ensuring adequate conditions for adult upstream migration though the lower Klamath River. The second component was an emergency response flow release, using an additional 17,000 af of water. This flow would be implemented to decrease the severity of a fish die-off if real-time monitoring indicated a rapid spread of the incidence and severity of the disease Ich.

Implementing components of the Action Plan were dependant on separate triggers for initiating preventive and emergency response flow releases. Triggers for initiating the preventive flow release were: (1) a fall run Chinook salmon population size estimate of greater than 110,000 for the Klamath Basin, and (2) a flow of less than 3,000 cfs in the lower Klamath River. Triggers for initiating the emergency response flow release would have been an estimated doubling in less than 7 days of either the incidence (proportion of fish infected) or severity (number of parasites per gill) of Ich. Evaluation of emergency action triggers were based on real-time monitoring of disease incidence conducted by the U.S. Fish & Wildlife Service, Fish Health Center, the Yurok Tribe, the Karuk Tribe and California Department of Fish & Game.

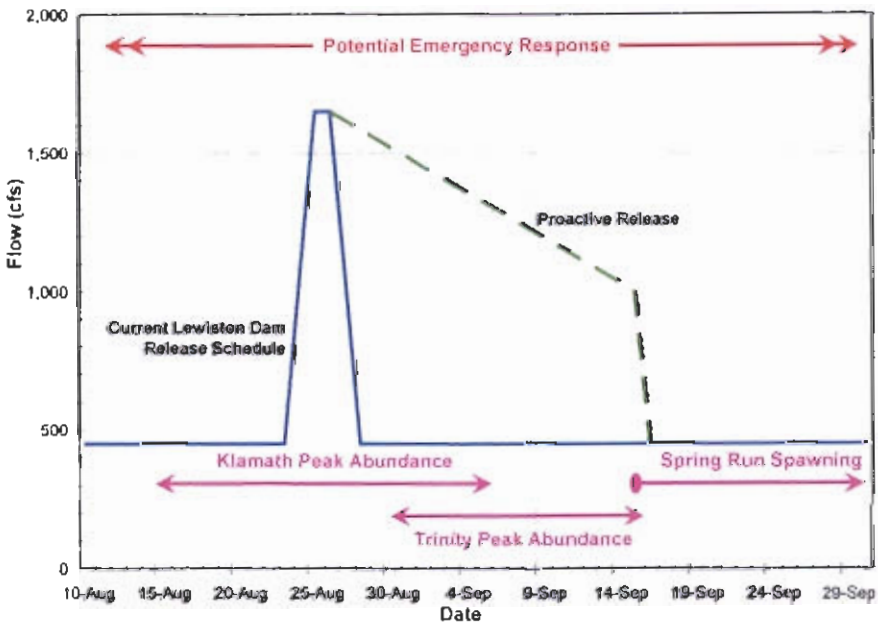

Figure 1. Daily Flow Schedule for Preventative Component of Action Plan.

Existing monitoring programs managed by the U.S. Fish & Wildlife Service, California Department of Fish & Game, the Hoopa Valley Tribe, the Yurok Tribe and the Karuk Tribe assessed the physical and biological effects associated with the Action Plan. Monitoring activities included weir counts, carcass and redd surveys, water temperature, water quality, angler and tribal harvest rates and adult salmon radio tracking, as well as disease incidence and severity from the real-time monitoring used as the trigger for the emergency action component of the Action Plan. Refugia dives and float surveys upstream of the Trinity River confluence were also conducted to evaluate the possibility of unintended effects on Klamath mainstem migrating adults.

Results

Results reported in this memo are preliminary and have not been peer reviewed for consistency with other findings and are subject to revision.

Figures 2, and 3 summarize results of key monitoring to assess effectiveness of the Action Plan release schedule. Additional information on run timing and migration patterns from weir operation, angler and tribal harvest and radio tracking studies is currently being prepared and will be reported in subsequent revisions of this memo.

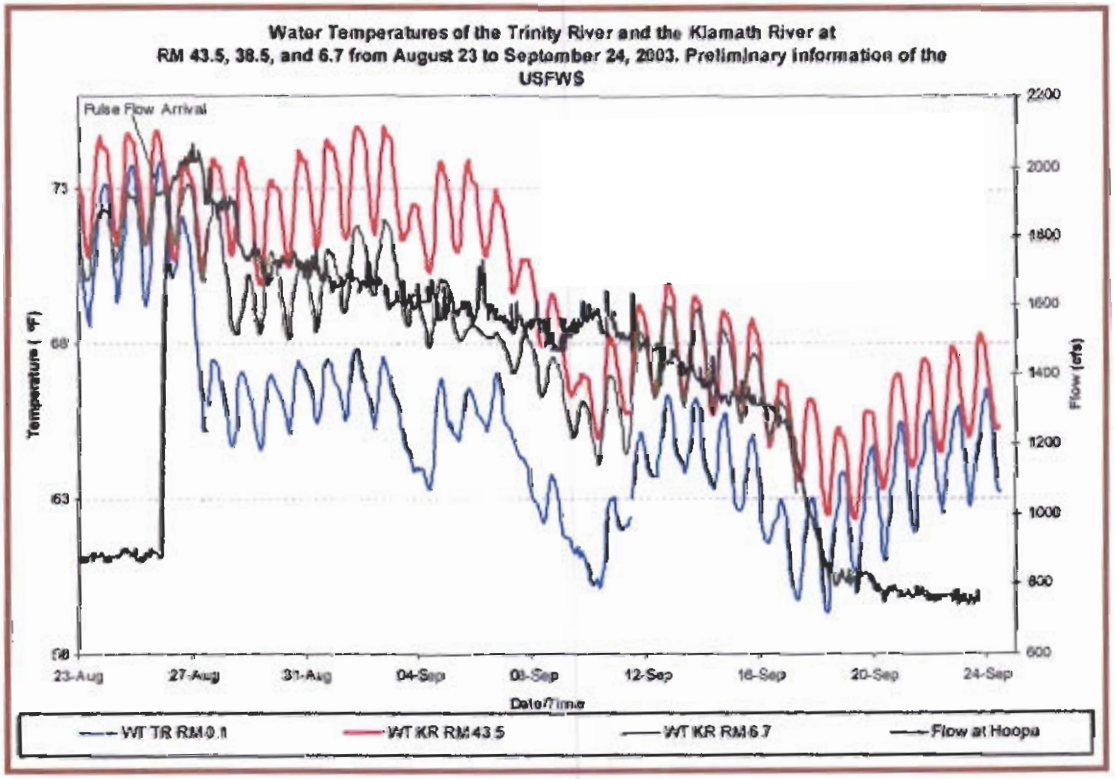

Figure 2. Trinity River flows reduce lower Klamath River water temperatures during the preventative action release schedule. River flow at Hoopa (black) during the fall of 2003, water temperature for the lower Trinity River near Hoopa (blue), Klamath River above Weitchpec (red) and lower Klamath River below the Trinity River confluence (green). Water temperatures above 71.6F inhibit adult Klamath Basin Chinook salmon migration. Preliminary data from Paul Zedonis, Fish & Wildlife Service, Arcata Field Office.

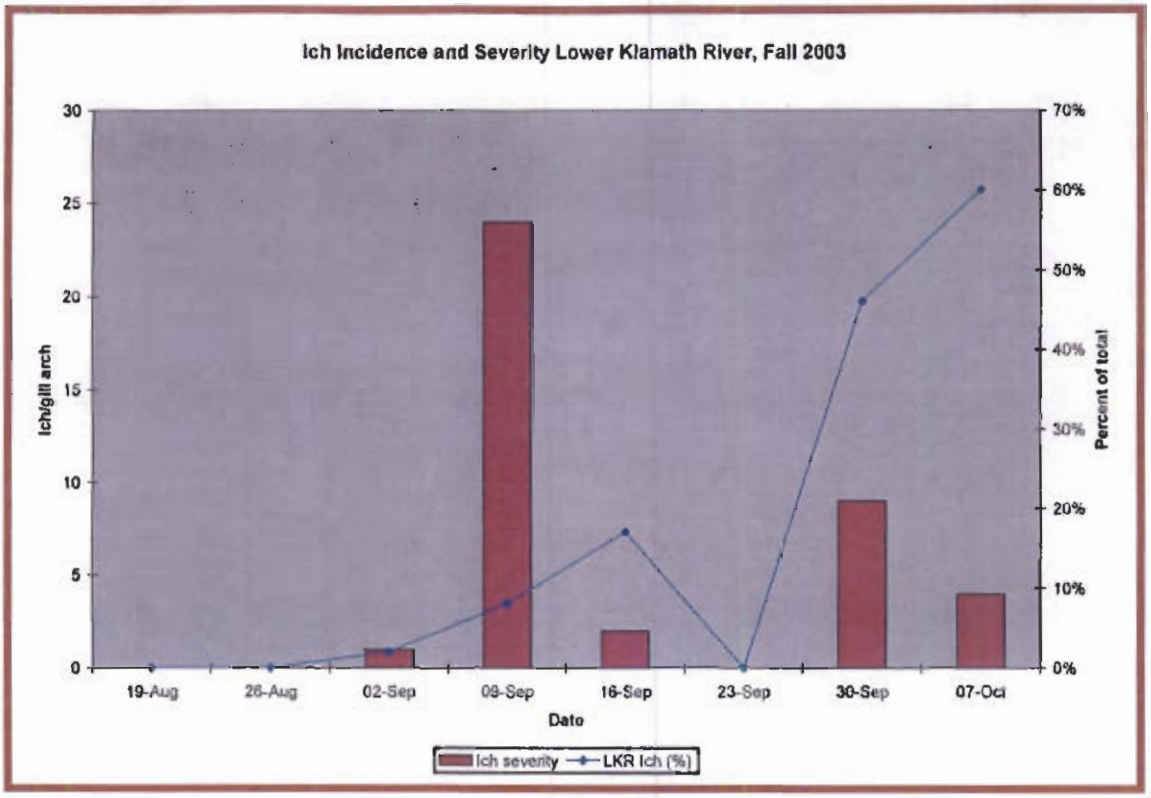

Figure 3. Incidence and severity of Ich (*Ichthyophthirius multifiliis*) on fall run Chinook salmon in the lower Klamath River during the fall of 2003. Disease incidence is reported as proportion of sampled fish with parasites (blue line). Severity is reported as the number of parasites per gill arch (red bars). Standard deviations not reported. Low value for incidence on 23 September is due to low sample size (n=10). Severity values greater than 30 parasites /gill arch is considered to a lower threshold for notable physiological stress. Preliminary data from Scott Foott, Fish & Wildlife Service, Fish Health Center, Red Bluff, Ca.

In addition, two preliminary conclusions from radio tracking studies to understand use of thermal refugia by adult Chinook salmon are relevant to the Trinity River fall flows (Josh Strange, University of Washington pers. com.).

- temperatures above 22C (71.6F) inhibit adult Chinook salmon migration and
- Fish die-off prevention flows from Trinity Dam substantially lowered temperatures in the lower Trinity and Klamath Rivers. During these higher flows thermal refugia use and migration delays were minimal among tagged Chinook salmon.

Conclusions

Monitoring results indicate that implementing the 2003 Trinity River Fall Flows Action Plan was successful in reducing the risk of a major die-off event. No observations of significant adult mortality were noted and the preventative flow schedule maintained water temperatures and flow magnitudes known to provide adequate fish migration in the lower Klamath River, specifically water temperatures were kept below 22C and flows near Klamath, Ca. (Terwar gage) greater than 3000 cfs.

Fall run Chinook salmon migration was unimpeded. Radio tracking of tagged fish demonstrated that migration delays were minimal. Congregations of large numbers of fish at known thermal refugia areas and

below critical riffles and rapids were not noted by divers. Observations of fish above the confluence of the Trinity River did not note any negative migration, or health effects to Klamath mainstem Chinook salmon due to these artificially increased flows.

Emergency response flows were not called for although monitoring revealed disease incidence increased throughout the sample period and a doubling did occur. Incidence of Ich did not exceed 20% (10% was assumed to be an acceptable background value) until late September by this time the majority of the fish had migrated out of the lower Klamath and monitoring indicated that disease severity was kept at a low level and therefore did not pose a threat to the physiological health of infected fish.

Spring run Chinook salmon spawning was not affected in the upper Trinity River by the preventative flow schedule. Weekly redd counts in the Trinity River immediately below Lewiston Dam indicate that minimal spawning occurred before September 15, 2003. Lewiston Dam releases returned to the normal (450 cfs) on September 16, 2003. Those redds noted were not threatened by de-watering following flow reductions. Anecdotal reports indicate that fish condition was excellent throughout the run (Loren Everest, Forest Service, Trinity River Management Unit pers. com.).

Existing Conditions

Trinity

Existing Conditions [EWA], Trinity Storage (S1) (TAF)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	
1922	1786	1684	1670	1667	1690	1740	1852	2007	2070	1957	1757	1564	
1923	1406	1378	1387	1414	1437	1489	1618	1591	1565	1346	1157	984	
1924	934	900	884	871	928	934	927	846	721	567	446	360	
1925	342	411	453	456	721	856	1163	1333	1323	1168	992	890	
1926	823	793	812	813	957	1059	1292	1278	1219	1039	871	742	
1927	720	876	1061	1179	1417	1595	1832	2014	2156	2074	1959	1773	
1928	1671	1729	1747	1804	1913	2100	2266	2283	2199	2039	1806	1616	
1929	1450	1425	1417	1245	1261	1321	1357	1384	1312	1137	909	778	
1930	751	734	861	868	967	1093	1207	1201	1148	973	807	694	
1931	666	652	643	652	671	728	794	757	698	582	461	376	
1932	349	337	333	346	367	520	623	729	716	608	491	406	
1933	377	370	361	353	354	471	638	708	805	653	537	456	
1934	428	414	417	472	556	713	839	811	707	591	472	387	
1935	365	424	455	490	569	629	857	970	941	772	654	570	
1936	545	535	532	639	774	891	1079	1163	1179	1051	920	808	
1937	748	731	716	701	699	799	1038	1263	1343	1223	1077	965	
1938	915	1032	1252	1349	1505	1766	2082	2420	2447	2270	2150	1975	
1939	1850	1850	1847	1778	1776	1884	1970	1888	1738	1526	1292	1071	
1940	934	880	934	1100	1426	1728	1965	2078	2033	1924	1727	1543	
1941	1383	1364	1503	1724	1974	2100	2300	2420	2447	2270	2150	1975	
1942	1850	1850	1850	1900	2000	1987	2203	2420	2447	2270	2150	1975	
1943	1850	1850	1850	1900	2000	2100	2293	2340	2369	2264	2145	1954	
1944	1850	1850	1808	1708	1751	1819	1874	1923	1871	1654	1458	1284	
1945	1195	1198	1263	1316	1482	1536	1690	1808	1852	1747	1551	1362	
1946	1324	1379	1570	1700	1755	1884	2116	2228	2204	2112	1885	1697	
1947	1533	1467	1488	1486	1546	1665	1763	1731	1669	1462	1283	1109	
1948	1050	1037	1029	1212	1234	1260	1453	1591	1760	1764	1652	1587	
1949	1583	1590	1591	1583	1615	1831	2101	2261	2223	2116	1913	1723	
1950	1559	1452	1433	1451	1507	1629	1798	1893	1841	1733	1535	1348	
1951	1438	1553	1811	1900	2000	2076	2240	2347	2377	2268	2039	1849	
1952	1692	1728	1850	1900	2000	2100	2300	2420	2447	2270	2150	1975	
1953	1850	1845	1850	1900	1943	2071	2287	2420	2447	2270	2150	1975	
1954	1850	1850	1846	1900	2000	2100	2300	2327	2289	2192	2005	1823	
1955	1771	1821	1850	1786	1781	1816	1879	1958	1912	1708	1516	1317	
1956	1228	1212	1520	1854	1991	2097	2290	2420	2447	2270	2150	1975	
1957	1850	1850	1813	1796	1957	2100	2171	2332	2403	2270	2150	1966	
1958	1850	1850	1850	1900	2059	2100	2300	2420	2447	2270	2150	1975	
1959	1850	1850	1818	1900	2000	2001	2133	2117	2065	1843	1612	1395	
1960	1307	1269	1248	1247	1381	1560	1688	1777	1797	1618	1424	1279	
1961	1194	1174	1253	1285	1508	1635	1800	1923	1966	1866	1640	1437	
1962	1348	1323	1345	1350	1484	1560	1787	1862	1847	1745	1559	1372	
1963	1482	1534	1707	1748	2000	2078	2300	2418	2447	2270	2146	1975	
1964	1850	1850	1841	1900	1888	1923	1962	1941	1866	1652	1450	1284	
1965	1205	1212	1748	1900	1971	1951	2195	2295	2350	2255	2073	1891	
1966	1788	1850	1850	1900	1968	2100	2300	2400	2437	2270	2049	1836	
1967	1673	1680	1823	1900	2000	2100	2221	2420	2447	2270	2150	1975	
1968	1850	1850	1835	1845	2000	2100	2190	2234	2169	1983	1790	1590	
1969	1431	1426	1486	1630	1755	1916	2260	2420	2447	2270	2150	1975	
1970	1850	1850	1850	1900	2000	2087	2142	2206	2175	1994	1770	1563	
1971	1401	1536	1667	1900	1929	2100	2292	2420	2447	2270	2150	1975	
1972	1850	1850	1842	1900	2000	2100	2259	2328	2293	2185	1970	1777	
1973	1625	1664	1773	1900	2000	2100	2269	2419	2447	2270	2146	1960	
1974	1850	1850	1850	1900	2000	2100	2300	2420	2447	2270	2150	1975	
1975	1850	1849	1841	1828	1925	2100	2236	2420	2447	2270	2150	1975	
1976	1850	1850	1837	1703	1737	1778	1879	1943	1862	1644	1459	1317	
1977	1226	1191	1174	1164	1156	1143	1125	1069	937	706	552	482	
1978	463	487	629	1029	1215	1501	1709	1909	2102	2056	1945	1786	
1979	1704	1701	1697	1719	1773	1922	2061	2229	2252	2143	1942	1754	
1980	1680	1742	1812	1900	2000	2083	2233	2290	2266	2183	1985	1796	
1981	1690	1682	1729	1824	1963	2089	2219	2216	2123	1925	1720	1510	
1982	1355	1598	1850	1900	2000	2100	2300	2399	2447	2270	2150	1975	
1983	1850	1850	1850	1900	2000	2100	2300	2420	2447	2270	2150	1975	
1984	1850	1850	1850	1900	1998	2100	2224	2322	2302	2207	2016	1829	
1985	1823	1850	1850	1777	1805	1856	2025	1993	1899	1671	1440	1267	
1986	1184	1134	1135	1253	1738	2080	2102	2129	2087	1902	1701	1517	
1987	1421	1386	1381	1400	1486	1698	1864	1781	1615	1390	1160	932	
1988	854	816	976	1045	1117	1192	1294	1325	1244	1035	855	720	
1989	688	724	737	758	784	1128	1343	1360	1303	1122	941	834	
1990	820	793	783	843	863	949	1000	1054	1034	879	695	609	
1991	577	557	540	529	533	611	694	716	719	612	497	414	
1992	386	370	360	361	501	643	893	968	878	713	593	506	
1993	479	472	489	545	683	1055	1275	1649	1859	1876	1765	1737	
Avg.	1320	1327	1375	1425	1524	1641	1800	1886	1878	1727	1562	1403	
Min.	342	337	333	346	354	471	623	708	698	567	446	360	
Max.	1850	1850	1850	1900	2059	2100	2300	2420	2447	2270	2150	1975	

Trinity

Existing Conditions [EWA], Whiskeytown Storage (S3) (TAF)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	
1922	217	206	206	206	206	217	240	240	240	240	240	235	
1923	217	206	206	206	206	217	240	240	240	240	240	235	
1924	217	206	206	206	206	217	240	240	240	240	240	235	
1925	217	206	206	180	206	217	240	240	240	240	240	235	
1926	217	206	206	206	206	217	240	240	240	240	240	235	
1927	217	206	206	206	206	217	240	240	240	240	240	235	
1928	217	206	206	206	206	217	240	240	240	240	240	235	
1929	217	206	206	206	206	217	240	240	240	240	240	235	
1930	217	206	206	206	206	217	240	240	240	240	240	235	
1931	217	206	206	206	206	212	218	214	240	240	240	235	
1932	217	206	206	206	206	217	216	225	240	240	240	235	
1933	217	206	206	206	206	217	233	239	240	240	240	235	
1934	217	206	206	206	206	217	228	234	240	240	240	235	
1935	217	206	206	206	206	217	240	240	240	240	240	235	
1936	217	206	206	206	206	205	221	231	240	240	240	235	
1937	217	206	204	205	206	217	240	240	240	240	240	235	
1938	217	206	206	206	206	217	240	240	240	240	240	235	
1939	217	206	206	206	206	217	240	240	240	240	240	235	
1940	217	206	206	206	206	217	240	240	240	240	240	235	
1941	217	206	206	206	206	217	240	240	240	240	240	235	
1942	217	206	206	206	206	217	240	240	240	240	240	235	
1943	217	206	206	206	206	217	240	240	240	240	240	235	
1944	217	206	206	206	206	217	240	240	240	240	240	235	
1945	217	206	206	206	206	217	240	240	240	240	240	235	
1946	217	206	206	206	206	217	240	240	240	240	240	235	
1947	217	206	206	206	206	217	240	240	240	240	240	235	
1948	217	206	206	206	206	217	240	240	240	240	240	235	
1949	217	206	206	206	206	217	240	240	240	240	240	235	
1950	217	206	206	206	206	217	240	240	240	240	240	235	
1951	217	206	206	206	206	217	240	240	240	240	240	235	
1952	217	206	206	206	206	217	240	240	240	240	240	235	
1953	217	206	206	206	206	217	240	240	240	240	240	235	
1954	217	206	206	206	206	217	240	240	240	240	240	235	
1955	217	206	206	206	206	217	240	240	240	240	240	235	
1956	217	206	206	206	206	217	240	240	240	240	240	235	
1957	217	206	206	206	206	217	240	240	240	240	240	235	
1958	217	206	206	206	240	217	240	240	240	240	240	235	
1959	217	206	206	206	206	217	240	240	240	240	240	235	
1960	217	206	206	206	206	217	240	240	240	240	240	235	
1961	217	206	206	206	206	217	240	240	240	240	240	235	
1962	217	206	206	206	206	217	240	240	240	240	240	235	
1963	217	206	206	206	206	217	240	240	240	240	240	235	
1964	217	206	206	206	206	217	240	240	240	240	240	235	
1965	217	206	206	206	206	217	240	240	240	240	240	235	
1966	217	206	206	206	206	217	240	240	240	240	240	235	
1967	217	206	206	206	206	217	240	240	240	240	240	235	
1968	217	206	206	206	206	217	240	240	240	240	240	235	
1969	217	206	206	206	206	217	240	240	240	240	240	235	
1970	217	206	206	206	206	217	240	240	240	240	240	235	
1971	217	206	206	206	206	217	240	240	240	240	240	235	
1972	217	206	206	206	206	217	240	240	240	240	240	235	
1973	217	206	206	206	206	217	240	240	240	240	240	235	
1974	217	206	206	206	206	217	240	240	240	240	240	235	
1975	217	206	206	206	206	217	240	240	240	240	240	235	
1976	217	206	206	206	206	217	240	240	240	240	240	235	
1977	217	206	206	206	206	217	240	240	240	240	240	235	
1978	217	206	206	206	206	217	240	240	240	240	240	235	
1979	217	206	206	206	206	217	240	240	240	240	240	235	
1980	217	206	206	206	206	217	240	240	240	240	240	235	
1981	217	206	206	206	206	217	240	240	240	240	240	235	
1982	217	206	206	206	206	217	240	240	240	240	240	235	
1983	217	206	206	206	206	217	240	240	240	240	240	235	
1984	217	206	206	206	206	217	240	240	240	240	240	235	
1985	217	206	206	206	206	217	240	240	240	240	240	235	
1986	217	206	206	206	206	217	240	240	240	240	240	235	
1987	217	206	206	206	206	217	240	240	240	240	240	235	
1988	217	206	206	206	206	217	240	240	240	240	240	235	
1989	217	206	206	206	206	217	240	240	240	240	240	235	
1990	217	206	206	206	206	215	236	240	240	240	240	235	
1991	217	206	206	206	206	217	227	224	237	240	240	235	
1992	217	206	206	206	206	217	240	240	240	240	240	235	
1993	217	206	206	206	206	217	240	240	240	240	240	235	
Avg.	217	206	206	206	206	217	239	239	240	240	240	235	
Min.	217	206	204	180	206	205	216	214	237	240	240	235	
Max.	217	206	206	206	240	217	240	240	240	240	240	235	

Trinity

Existing Conditions [EWA], Shasta Storage (S4) (TAF)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1922	2806	2886	2986	3091	3450	3832	4307	4436	4101	3471	3109	2989
1923	3095	3182	3313	3512	3639	3768	4069	3830	3428	2924	2552	2527
1924	2495	2442	2398	2418	2569	2485	2231	1908	1530	964	706	650
1925	632	787	888	1090	2333	2555	3213	3278	3055	2697	2402	2297
1926	2288	2309	2308	2351	3071	3273	3559	3370	2971	2515	2198	2098
1927	2095	2575	3091	3629	3462	4094	4552	4552	4264	3677	3267	3170
1928	3178	3252	3327	3592	4067	3965	4463	4377	3959	3200	2846	2709
1929	2725	2664	2661	2861	3056	3221	3273	3138	2893	2389	2057	2008
1930	1884	1807	2330	2544	2916	3391	3550	3440	3111	2675	2395	2348
1931	2299	2301	2287	2364	2451	2621	2362	2080	1681	1120	780	683
1932	630	623	825	972	1102	1523	1692	1898	1760	1494	1251	1176
1933	1140	1137	1129	1167	1206	1799	1933	1992	1873	1545	1250	1150
1934	1081	1050	1180	1480	1810	2070	2068	1880	1512	1091	815	708
1935	623	759	805	1108	1442	1831	2826	3039	2787	2497	2151	2025
1936	2014	1989	1998	2632	3519	3878	4094	3944	3711	3185	2754	2592
1937	2483	2368	2279	2248	2345	3002	3658	3797	3626	3200	2830	2673
1938	2650	3233	3310	3668	3560	3416	4058	4552	4500	4114	3700	3400
1939	3250	3252	3361	3557	3695	4099	3874	3563	3076	2498	2062	2006
1940	2012	1940	2100	2989	3252	3435	4161	4115	3803	3225	2879	2814
1941	2907	2929	3293	3317	3423	3940	4456	4552	4500	4098	3700	3400
1942	3250	3252	3316	3389	3516	3938	4552	4552	4500	4150	3700	3400
1943	3250	3252	3356	3541	3848	4118	4552	4521	4267	3711	3317	3240
1944	3208	3201	3224	3403	3709	4020	3965	3819	3523	3017	2651	2552
1945	2545	2761	3076	3267	3948	4267	4435	4442	4165	3585	3236	3145
1946	3189	3252	3265	3622	3606	4002	4192	4187	3867	3347	3041	2977
1947	3009	3112	3168	3174	3433	3956	4080	3703	3436	2896	2458	2370
1948	2493	2516	2497	3048	2837	3153	4060	4432	4403	3923	3546	3400
1949	3250	3173	3174	3179	3383	4071	4401	4362	4012	3352	3014	2935
1950	2909	2921	2866	3144	3552	4001	4327	4221	3929	3424	3096	3050
1951	3250	3252	3322	3624	3794	4264	4375	4400	3978	3347	3040	2976
1952	3090	3252	3306	3604	3739	4022	4290	4552	4500	4150	3700	3400
1953	3250	3237	3345	3366	3753	4226	4552	4552	4500	4047	3700	3400
1954	3250	3252	3351	3552	3661	4106	4546	4392	4210	3513	3247	3256
1955	3250	3252	3360	3564	3690	3858	3872	3949	3562	3023	2618	2645
1956	2623	2643	3252	3252	3288	4006	4522	4552	4500	4106	3700	3400
1957	3250	3200	3241	3367	3675	4129	4174	4449	4188	3613	3200	3286
1958	3250	3252	3338	3531	3252	3416	4173	4552	4500	4150	3700	3400
1959	3250	3200	3258	3648	3777	4067	4123	3983	3344	2808	2418	2500
1960	2446	2203	2192	2394	3120	3817	3975	3979	3731	3172	2803	2760
1961	2701	2824	3269	3479	3914	4280	4317	4285	3902	3200	2742	2735
1962	2600	2500	2785	2907	3675	4206	4482	4391	4103	3458	3117	3094
1963	3250	3252	3349	3514	3944	3983	4137	4544	4302	3877	3572	3400
1964	3250	3252	3333	3705	3923	4051	3865	3653	3445	2944	2593	2491
1965	2443	2608	3252	3368	3809	3937	4500	4441	4134	3532	3319	3307
1966	3200	3252	3359	3725	4037	4229	4552	4482	3816	3200	2830	2845
1967	2846	3215	3335	3551	3920	4033	4479	4552	4500	4150	3700	3400
1968	3250	3215	3317	3614	3654	4248	4270	4156	3639	3072	2786	2676
1969	2788	2798	3096	3358	3480	4030	4434	4552	4500	4083	3700	3400
1970	3250	3252	3317	3252	3431	4128	4088	3981	3731	2968	2712	2709
1971	2872	3252	3319	3515	3704	3873	4367	4552	4500	4103	3700	3400
1972	3250	3200	3338	3714	3979	4249	4419	4328	3828	3200	2853	2882
1973	3066	3252	3346	3552	3636	4162	4461	4545	4185	3629	3292	3248
1974	3250	3252	3267	3252	3694	3416	4289	4552	4500	4150	3700	3400
1975	3250	3213	3339	3513	3936	3756	4347	4552	4500	4150	3700	3400
1976	3250	3252	3328	3543	3724	3952	4025	3826	3369	3009	2960	2990
1977	3015	3085	3115	3144	3119	3105	2697	2536	2020	1231	776	757
1978	582	606	1127	3043	3567	4000	4552	4552	4234	3630	3293	3351
1979	3250	3241	3229	3388	3747	4263	4432	4459	3884	3258	3035	3024
1980	3119	3252	3367	3528	3292	4047	4356	4335	4037	3467	3192	3200
1981	3215	3177	3268	3588	4004	4256	4400	4180	3606	3016	2670	2668
1982	2796	3252	3276	3616	3530	3953	4094	4400	4288	4017	3700	3400
1983	3250	3252	3328	3371	3252	3417	4074	4552	4500	4150	3700	3400
1984	3250	3252	3285	3650	4005	4246	4346	4362	4132	3525	3350	3391
1985	3250	3252	3360	3559	3750	3967	4064	3742	3266	2760	2425	2401
1986	2381	2437	2594	3171	3252	3534	3972	3967	3602	3219	2916	3004
1987	3083	3066	3055	3174	3514	4249	4015	3740	3200	2682	2276	2196
1988	2068	2062	2530	2969	2979	3063	3069	3059	2555	2045	1749	1641
1989	1494	1705	1807	1918	2033	3420	3817	3608	3320	2811	2533	2553
1990	2688	2594	2537	2774	2826	3071	2909	3037	2858	2359	2167	2079
1991	1980	1924	1910	1919	1933	2363	2493	2418	2139	1832	1591	1537
1992	1440	1346	1347	1400	2057	2503	2714	2407	1987	1510	1101	925
1993	816	718	955	1609	2346	3810	4440	4552	4500	3892	3617	3400
Avg.	2646	2687	2809	3051	3300	3659	3931	3926	3644	3139	2795	2692
Min.	582	606	805	972	1102	1523	1692	1880	1512	964	706	650
Max.	3250	3252	3367	3725	4067	4280	4552	4552	4500	4150	3700	3400

Trinity

Existing Conditions [EWA], Trinity Import (D100) (TAF)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1922	203	104	31	15	6	6	20	6	4	92	169	164	820
1923	154	30	8	6	6	12	19	83	45	203	162	149	876
1924	46	30	15	15	6	6	28	6	92	124	92	60	521
1925	15	6	6	49	6	6	6	6	89	154	154	89	586
1926	61	30	6	6	6	12	6	6	45	154	138	104	574
1927	15	6	15	6	0	6	0	0	2	92	92	164	399
1928	92	0	6	6	6	0	7	79	89	138	203	164	790
1929	154	30	15	183	14	4	22	15	89	154	200	104	984
1930	15	6	6	15	6	6	24	6	56	154	138	89	522
1931	15	6	6	6	6	6	0	0	61	92	92	60	350
1932	15	6	6	0	0	0	0	0	51	92	92	60	322
1933	15	6	6	6	0	0	0	0	48	154	92	60	387
1934	15	6	6	6	6	0	0	6	92	92	92	60	381
1935	15	6	6	6	6	0	0	6	60	154	92	60	410
1936	15	6	6	6	6	0	0	6	45	123	108	89	410
1937	46	6	6	6	6	6	0	6	45	123	123	89	462
1938	46	30	0	0	0	0	0	0	20	158	191	96	151	692
1939	124	15	34	87	21	0	29	55	135	184	203	193	1080
1940	125	44	15	15	0	0	15	15	89	92	169	164	744
1941	154	30	0	0	0	0	0	203	196	203	120	162	1067
1942	119	17	0	0	0	98	0	35	161	199	99	152	879
1943	114	26	65	0	22	72	19	3	2	92	92	164	671
1944	97	10	44	110	6	6	27	15	89	203	169	149	926
1945	77	30	15	6	0	6	9	6	0	92	169	164	575
1946	46	0	0	0	6	0	6	74	89	92	203	164	680
1947	154	89	6	9	6	6	24	37	104	188	154	149	927
1948	92	30	15	15	6	15	6	15	2	1	92	45	336
1949	0	0	7	8	6	0	6	6	89	92	178	164	557
1950	154	104	15	15	6	6	14	6	89	92	169	164	835
1951	22	0	0	1	0	34	46	16	5	92	203	164	583
1952	154	0	0	0	0	66	157	183	131	203	103	153	1149
1953	114	0	36	0	81	0	9	18	182	203	107	155	905
1954	121	83	58	31	0	139	146	136	89	92	169	164	1227
1955	46	0	27	88	40	6	6	15	89	188	169	179	853
1956	77	30	0	0	0	45	82	155	133	191	99	152	963
1957	119	5	45	22	0	33	66	15	0	120	94	164	682
1958	203	80	101	108	154	0	0	203	196	203	112	155	1515
1959	116	0	32	99	4	132	67	75	89	203	203	196	1216
1960	77	30	15	15	14	15	17	15	89	169	169	119	746
1961	77	30	15	6	0	0	7	6	89	92	203	179	704
1962	77	34	15	15	0	6	24	6	89	92	169	164	692
1963	0	0	0	6	43	0	0	113	33	165	92	143	595
1964	126	118	52	21	64	8	24	15	104	203	184	149	1069
1965	77	30	0	0	26	99	0	6	2	92	169	164	665
1966	92	26	40	32	0	75	126	72	1	165	203	196	1029
1967	157	104	0	38	37	61	0	114	190	203	108	158	1171
1968	127	7	37	79	0	51	38	7	89	169	169	179	953
1969	154	30	15	0	0	0	0	203	143	186	95	148	974
1970	120	1	165	145	2	62	39	35	89	169	193	179	1199
1971	154	0	0	0	113	25	0	113	103	197	96	148	947
1972	113	14	31	53	16	203	0	29	89	92	191	164	996
1973	154	0	0	0	0	25	43	107	38	171	92	164	794
1974	133	74	0	139	9	0	46	163	196	203	104	149	1218
1975	109	0	30	42	0	0	19	121	196	203	101	155	976
1976	126	31	53	151	6	17	11	15	89	203	169	119	991
1977	77	30	6	6	7	15	36	6	120	203	132	60	698
1978	15	6	58	0	0	0	0	0	2	92	92	164	430
1979	71	0	0	6	6	6	6	6	0	92	169	164	526
1980	92	2	0	0	0	60	35	48	89	92	169	164	751
1981	92	0	0	18	6	0	6	22	89	169	169	179	749
1982	154	0	0	41	0	83	0	95	60	193	97	148	870
1983	149	37	0	0	0	65	69	191	196	203	154	173	1237
1984	126	129	0	102	0	50	19	57	89	92	169	164	996
1985	0	101	54	106	16	6	14	50	104	203	203	149	1006
1986	77	45	15	15	0	0	145	58	89	169	174	164	952
1987	92	30	7	6	6	6	15	135	171	203	203	196	1071
1988	61	30	15	15	14	15	13	6	140	200	154	104	768
1989	15	6	6	6	6	6	6	36	74	160	154	89	564
1990	46	30	7	6	6	6	25	0	60	138	154	60	537
1991	15	6	6	6	6	0	0	0	15	92	92	60	298
1992	15	6	6	6	0	0	0	6	104	154	92	60	449
1993	15	6	6	6	6	6	0	0	0	0	92	1	138
Avg.	85	26	18	28	12	24	23	47	84	146	142	136	772
Min.	0	0	0	0	0	0	0	0	0	0	92	1	138
Max.	203	129	165	183	154	203	157	203	196	203	203	196	1515

Trinity

Existing Conditions [EWA], Trinity Flow (C100) (TAF)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1922	18	18	18	18	17	18	18	98	34	28	28	27	340
1923	18	18	18	18	17	18	18	98	34	28	28	27	340
1924	18	18	18	18	17	18	18	98	34	28	28	27	341
1925	18	18	18	18	17	18	18	98	34	28	28	27	340
1926	18	18	18	18	17	18	18	98	34	28	28	27	340
1927	18	18	18	18	17	18	18	98	34	28	28	27	340
1928	18	18	18	18	17	38	18	98	34	28	28	27	360
1929	18	18	18	18	17	18	18	98	34	28	28	27	340
1930	18	18	18	18	17	18	18	98	34	28	28	27	340
1931	18	18	18	18	17	18	18	98	34	28	28	27	340
1932	18	18	18	18	17	18	18	98	34	28	28	27	341
1933	18	18	18	18	17	18	18	98	34	28	28	27	340
1934	18	18	18	18	17	18	18	98	34	28	28	27	340
1935	18	18	18	18	17	18	18	98	34	28	28	27	340
1936	18	18	18	18	17	18	18	98	34	28	28	27	341
1937	18	18	18	18	17	18	18	98	34	28	28	27	340
1938	18	18	18	18	17	18	18	98	34	28	28	27	340
1939	18	18	18	18	17	18	18	98	34	28	28	27	340
1940	18	18	18	18	17	18	18	98	34	28	28	27	341
1941	18	18	18	18	17	247	162	203	107	120	28	27	982
1942	18	18	275	164	134	18	18	98	34	28	28	27	861
1943	18	18	18	71	17	18	18	98	34	28	28	27	393
1944	18	18	18	18	17	18	18	98	34	28	28	27	341
1945	18	18	18	18	17	18	18	98	34	28	28	27	340
1946	18	18	18	18	17	18	18	98	34	28	28	27	340
1947	18	18	18	18	17	18	18	98	34	28	28	27	340
1948	18	18	18	18	17	18	18	98	34	28	28	27	341
1949	18	18	18	18	17	18	18	98	34	28	28	27	340
1950	18	18	18	18	17	18	18	98	34	28	28	27	340
1951	18	18	18	18	137	18	18	98	34	28	28	27	461
1952	18	18	43	28	107	18	18	98	34	40	28	27	477
1953	18	18	18	280	17	18	18	98	34	66	28	27	640
1954	18	18	18	18	130	18	18	98	34	28	28	27	454
1955	18	18	18	18	17	18	18	98	34	28	28	27	340
1956	18	18	18	18	17	18	18	98	34	28	28	27	341
1957	18	18	18	18	17	18	18	98	34	28	28	27	340
1958	27	18	18	18	333	188	102	225	63	54	28	27	1101
1959	18	18	18	18	17	18	18	98	34	28	28	27	340
1960	18	18	18	18	17	18	18	98	34	28	28	27	341
1961	18	18	18	18	17	18	18	98	34	28	28	27	340
1962	18	18	18	18	17	18	18	98	34	28	28	27	340
1963	18	18	18	18	17	18	73	98	34	28	28	27	396
1964	18	18	18	18	17	18	18	98	34	28	28	27	341
1965	18	18	26	81	17	18	18	98	34	28	28	27	411
1966	18	18	18	18	17	18	18	98	34	28	28	27	340
1967	18	18	18	18	17	18	18	98	34	31	28	27	344
1968	18	18	18	18	149	18	18	98	34	28	28	27	473
1969	18	18	18	18	17	18	18	178	34	28	28	27	420
1970	18	18	69	369	71	18	18	98	34	28	28	27	796
1971	18	18	18	20	17	18	18	98	34	28	28	27	342
1972	18	18	18	18	17	46	18	98	34	28	28	27	369
1973	18	18	18	52	71	18	18	98	34	28	28	27	429
1974	18	357	261	369	17	221	18	98	48	39	28	27	1501
1975	18	18	18	18	17	95	18	98	49	30	28	27	435
1976	18	18	18	18	17	18	18	98	34	28	28	27	341
1977	18	18	18	18	17	18	18	98	34	28	28	27	340
1978	18	18	18	19	17	18	18	98	34	28	28	27	341
1979	18	18	18	18	17	18	18	98	34	28	28	27	340
1980	18	18	18	159	220	18	18	98	34	28	28	27	684
1981	18	18	18	18	17	18	18	98	34	28	28	27	340
1982	18	18	98	18	176	18	60	98	34	28	28	27	622
1983	18	18	158	181	181	369	18	269	294	211	28	27	1771
1984	18	18	313	18	17	18	18	98	34	28	28	27	636
1985	18	18	18	18	17	18	18	98	34	28	28	27	340
1986	18	18	18	18	17	18	18	98	34	28	28	27	340
1987	18	18	18	18	17	18	18	98	34	28	28	27	340
1988	18	18	18	18	17	18	18	98	34	28	28	27	341
1989	18	18	18	18	17	18	18	98	34	28	28	27	340
1990	18	18	18	18	17	18	18	98	34	28	28	27	340
1991	18	18	18	18	17	18	18	98	34	28	28	27	340
1992	18	18	18	18	17	18	18	98	34	28	28	27	341
1993	18	18	18	18	17	18	18	98	34	28	28	27	340
Avg.	19	23	34	40	38	33	22	105	40	33	28	27	440
Min.	18	18	18	18	17	18	18	98	34	28	28	27	340
Max.	27	357	313	369	333	369	162	269	294	211	28	27	1771

Trinity

Existing Conditions [EWA], Tracy Export (D418) (TAF)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1922	270	230	260	260	236	238	147	92	179	282	280	266	2741
1923	268	253	260	154	145	162	152	118	179	283	280	267	2519
1924	258	225	260	260	210	49	48	76	48	49	84	156	1722
1925	153	90	224	225	234	49	163	129	156	176	276	263	2140
1926	227	190	161	260	235	137	152	49	67	94	99	218	1887
1927	141	252	259	259	235	191	175	140	179	283	280	267	2661
1928	263	253	260	260	244	263	152	49	179	283	280	266	2751
1929	249	253	231	260	200	49	48	49	89	162	160	178	1928
1930	189	97	184	184	188	261	97	49	104	168	161	193	1876
1931	208	177	49	248	125	49	48	49	87	49	89	150	1327
1932	106	101	184	184	243	185	113	69	87	95	236	253	1857
1933	228	160	41	35	47	37	48	49	48	49	49	173	963
1934	186	72	259	213	42	57	48	49	48	49	37	116	1174
1935	119	215	174	259	118	259	175	75	166	99	275	260	2194
1936	197	110	199	259	214	161	152	49	179	237	278	266	2299
1937	266	107	260	260	236	247	96	140	179	194	276	262	2523
1938	264	252	151	49	83	85	122	49	179	282	279	266	2061
1939	268	129	94	114	139	136	114	69	179	258	225	244	1968
1940	138	142	113	260	244	261	175	140	179	279	277	264	2471
1941	265	217	259	260	235	208	152	118	179	283	280	267	2721
1942	268	253	185	156	236	163	175	92	179	282	279	266	2535
1943	268	253	260	249	142	86	152	49	179	263	279	266	2445
1944	267	210	245	260	244	241	89	92	144	281	278	266	2618
1945	195	253	260	260	236	263	122	118	179	282	279	266	2712
1946	268	253	260	260	236	185	142	140	179	281	279	266	2749
1947	240	253	260	260	235	262	108	103	137	280	278	265	2680
1948	153	216	185	260	244	193	152	118	179	281	279	266	2525
1949	267	253	241	260	163	261	108	118	179	280	256	266	2651
1950	225	227	158	185	236	262	142	49	148	279	277	264	2451
1951	260	252	259	260	235	264	130	49	128	281	278	266	2663
1952	267	231	185	185	244	262	175	92	179	282	280	266	2649
1953	268	253	205	260	162	105	67	69	179	281	279	266	2394
1954	267	253	260	260	236	263	163	129	170	283	280	266	2829
1955	268	253	260	260	185	158	105	109	179	264	242	238	2520
1956	192	252	184	185	244	263	150	49	179	282	279	266	2525
1957	267	253	260	260	165	164	161	129	179	283	280	267	2667
1958	269	253	185	185	236	262	175	92	179	282	279	266	2664
1959	268	253	260	218	143	161	108	122	179	282	280	250	2523
1960	195	247	159	185	227	243	48	49	101	275	263	258	2249
1961	167	236	235	230	235	196	98	96	179	281	274	239	2465
1962	210	253	260	192	236	263	121	129	179	281	279	258	2660
1963	267	253	260	260	236	263	152	118	179	283	280	267	2816
1964	269	253	260	260	166	153	48	49	104	278	276	263	2379
1965	186	246	259	260	235	263	175	140	179	283	280	267	2774
1966	269	253	260	260	236	263	67	129	179	282	279	255	2732
1967	211	253	185	185	236	262	152	49	179	282	279	266	2538
1968	267	253	260	250	137	162	67	116	179	283	280	267	2519
1969	223	253	260	260	236	263	89	92	179	282	280	266	2684
1970	268	141	97	100	105	161	129	118	179	283	280	266	2127
1971	213	253	260	260	236	263	163	69	179	282	280	266	2725
1972	268	253	260	260	244	263	98	102	179	280	278	266	2750
1973	213	253	185	185	236	263	167	92	165	282	279	266	2586
1974	268	253	260	185	236	228	152	49	171	281	279	266	2627
1975	267	253	260	185	236	264	89	92	179	282	279	266	2652
1976	268	253	260	260	184	171	48	79	105	49	114	180	1970
1977	131	96	49	143	44	49	48	49	89	225	208	167	1299
1978	190	99	257	184	234	263	48	49	174	282	279	266	2325
1979	268	253	144	260	159	162	89	140	179	283	280	267	2483
1980	269	227	260	260	244	263	122	49	179	282	279	266	2699
1981	268	247	196	114	139	161	67	118	170	283	280	249	2292
1982	219	253	260	185	236	262	175	140	179	283	280	267	2739
1983	269	253	185	49	97	103	48	49	179	279	277	265	2053
1984	266	72	64	77	117	162	164	92	140	282	279	251	1966
1985	268	253	260	260	200	168	48	118	171	281	278	266	2569
1986	250	170	260	260	236	263	152	118	170	200	279	266	2621
1987	267	253	258	260	223	124	106	94	179	257	221	232	2474
1988	174	204	162	260	165	49	48	87	136	128	147	178	1738
1989	147	163	156	184	75	259	141	118	134	215	214	210	2015
1990	233	215	259	259	146	140	48	49	48	49	67	149	1662
1991	133	130	5	118	44	243	48	49	78	142	181	253	1423
1992	178	83	112	157	243	209	48	49	48	49	76	161	1413
1993	185	127	234	185	235	263	163	129	179	282	279	266	2528
Avg.	229	211	210	215	194	194	114	89	152	237	245	246	2335
Min.	106	72	5	35	42	37	48	49	48	49	37	116	963
Max.	270	253	260	260	244	264	175	140	179	283	280	267	2829

Trinity

Existing Conditions [EWA], Banks Export (D419) (TAF)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1922	190	169	327	468	472	465	203	224	397	261	411	374	3961
1923	337	311	343	523	192	226	177	152	208	398	411	339	3619
1924	196	132	316	261	210	18	18	76	18	26	293	119	1683
1925	109	144	224	225	254	18	171	144	164	117	393	252	2215
1926	135	69	161	303	235	137	157	114	145	382	307	145	2290
1927	215	397	321	332	456	448	204	224	280	202	411	340	3831
1928	175	397	434	455	401	465	180	43	157	253	441	368	3771
1929	207	211	231	350	200	97	42	18	75	245	196	88	1961
1930	69	18	259	264	188	318	97	103	185	425	378	252	2555
1931	57	91	125	248	97	51	18	34	79	259	300	146	1505
1932	83	79	267	280	354	217	59	134	208	103	18	227	2029
1933	140	82	142	444	127	304	42	43	18	191	26	74	1632
1934	98	18	279	279	312	59	18	18	35	171	121	185	1594
1935	122	206	174	361	236	417	204	20	353	441	406	267	3207
1936	316	138	248	449	485	465	171	149	219	441	408	327	3818
1937	313	89	284	385	472	465	204	193	279	372	395	288	3738
1938	230	397	264	523	472	465	180	201	397	289	411	427	4258
1939	411	397	434	378	236	253	81	69	93	408	441	317	3519
1940	225	155	181	367	485	465	204	188	241	441	402	311	3666
1941	169	180	442	519	472	448	180	201	305	236	411	427	3990
1942	411	361	303	297	458	189	204	224	397	397	411	427	4078
1943	411	397	451	430	343	350	180	132	186	198	412	363	3855
1944	340	107	325	333	330	242	129	136	252	441	441	397	3473
1945	227	397	321	261	472	413	122	139	274	441	417	359	3844
1946	255	397	351	507	114	382	142	159	248	441	441	367	3807
1947	250	249	323	202	235	247	108	95	170	441	411	323	3054
1948	212	215	185	320	121	193	178	201	333	441	441	374	3215
1949	222	125	241	279	163	324	108	120	203	350	263	282	2681
1950	62	100	158	269	422	244	142	144	349	441	441	381	3154
1951	310	397	351	523	472	413	130	165	288	385	441	365	4240
1952	205	277	266	523	485	465	200	92	374	401	440	427	4155
1953	411	299	205	518	162	442	67	205	397	292	411	427	3836
1954	382	397	381	445	306	437	192	197	170	407	380	397	4092
1955	306	337	318	449	106	130	66	109	189	248	99	214	2571
1956	90	220	277	296	485	465	150	201	397	261	411	427	3680
1957	411	241	279	397	419	448	161	155	243	336	327	360	3776
1958	411	392	261	451	434	465	204	224	397	306	411	427	4384
1959	411	285	334	455	204	77	108	122	259	393	441	328	3417
1960	294	94	222	309	273	290	18	107	137	383	243	284	2653
1961	59	255	235	230	294	196	98	18	37	377	372	299	2472
1962	201	219	276	164	472	427	121	32	188	354	441	387	3282
1963	411	397	316	449	431	438	180	201	189	178	411	427	4028
1964	411	397	326	445	122	153	42	112	206	441	419	350	3425
1965	281	311	339	523	472	315	204	133	200	256	429	340	3803
1966	289	397	470	509	272	445	67	135	239	422	385	397	4028
1967	232	370	266	477	430	465	180	201	397	441	441	427	4328
1968	411	360	432	379	204	443	18	116	242	384	441	368	3798
1969	250	252	321	523	472	423	89	224	374	224	411	427	3989
1970	411	397	402	324	325	350	129	121	214	316	441	397	3828
1971	300	397	438	459	138	444	170	69	344	375	411	427	3973
1972	404	280	431	446	261	428	98	102	117	352	387	275	3580
1973	232	397	260	460	472	333	167	181	317	407	404	363	3995
1974	411	397	322	522	459	228	180	201	397	341	411	427	4297
1975	411	358	432	451	472	465	89	224	383	411	441	427	4565
1976	411	397	431	367	184	171	42	79	105	267	422	318	3193
1977	207	183	136	143	55	62	18	43	86	29	276	92	1331
1978	34	73	257	282	472	465	42	201	391	309	411	427	3364
1979	340	132	135	513	257	465	89	173	282	362	390	296	3434
1980	229	266	320	523	485	420	155	155	240	259	411	427	3891
1981	363	113	323	454	237	447	67	118	170	441	411	320	3464
1982	288	397	319	523	472	465	204	224	397	246	411	427	4374
1983	411	397	472	161	150	158	169	43	245	441	441	427	3517
1984	310	193	200	281	317	355	164	151	168	323	441	397	3301
1985	388	397	433	392	200	168	42	118	171	441	411	395	3556
1986	279	262	320	455	472	465	179	144	283	411	411	396	4076
1987	345	72	145	328	238	239	106	21	149	439	383	312	2777
1988	153	112	162	437	78	29	42	87	78	226	54	78	1536
1989	49	162	156	208	59	317	141	118	134	441	411	329	2525
1990	236	154	261	435	116	153	18	72	18	18	279	282	2042
1991	66	80	18	116	58	285	42	43	75	203	38	85	1109
1992	61	55	105	157	316	209	42	23	18	247	80	214	1527
1993	51	18	234	296	469	456	192	212	395	441	415	361	3542
Avg.	255	245	288	376	310	318	122	130	227	326	364	327	3288
Min.	34	18	18	116	55	18	18	18	18	18	18	74	1109
Max.	411	397	472	523	485	465	204	224	397	441	441	427	4565

Trinity

Existing Conditions [EWA], Delta Inflows (TAF)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1922	780	718	1292	1227	2646	2452	1904	3616	3019	1320	1109	983	21065
1923	929	928	2506	2360	1252	1108	1878	1434	1104	1356	1112	931	16898
1924	774	795	935	942	1070	740	576	591	631	749	737	560	9097
1925	573	569	905	855	4021	1787	1653	1225	1073	880	1100	792	15432
1926	694	611	704	1166	2529	975	1629	1013	829	1112	863	643	12769
1927	708	1558	1343	2085	7793	3021	3231	1985	1309	1353	1126	931	26444
1928	742	1335	1139	1571	1696	6956	1993	1263	957	1347	1164	974	21136
1929	792	887	862	938	1017	812	607	641	750	931	821	545	9603
1930	578	515	1229	1466	1155	2186	895	887	921	1178	933	704	12648
1931	662	607	660	883	659	556	615	530	716	1038	777	578	8283
1932	561	507	1484	1515	1565	1148	945	1110	1186	807	727	777	12332
1933	699	609	620	938	725	973	809	575	696	800	587	531	8562
1934	571	518	1023	1341	978	904	814	588	751	759	564	584	9395
1935	641	749	742	2142	1008	1926	3512	1887	1483	1245	1132	818	17286
1936	875	671	780	2657	4680	2288	1804	1407	1134	1401	1144	910	19749
1937	911	692	859	990	3044	3341	1980	1641	1306	1278	1128	844	18015
1938	821	1548	4608	2349	8272	10658	4938	5024	3521	1358	1138	1395	45629
1939	1680	871	1058	997	830	1110	953	910	872	1273	1135	860	12548
1940	743	647	648	2505	3918	7092	4506	1586	1230	1516	1126	883	26400
1941	761	852	3278	6536	7257	6163	4798	3165	1627	1310	1138	1218	38104
1942	1124	942	4443	5257	8142	1982	3344	2750	2156	1471	1138	1247	33996
1943	1173	1164	2098	5706	3698	5805	2139	1687	1040	1378	1133	966	27987
1944	936	703	943	1013	1672	1612	990	1014	1130	1330	1135	1017	13493
1945	818	1009	1173	957	3204	1923	1198	1286	1293	1449	1143	961	16413
1946	823	1262	4712	3501	1717	1622	1156	1269	1219	1415	1172	971	20840
1947	842	911	1125	843	1232	1452	1027	892	997	1324	1154	904	12702
1948	733	794	751	1148	1041	1099	1888	2057	1459	1425	1167	983	14543
1949	836	787	935	826	766	3139	1029	1108	1117	1237	947	841	13569
1950	688	651	722	1514	2225	1444	1450	1346	1418	1434	1165	990	15047
1951	876	3487	6373	4765	4377	2235	1295	1581	1185	1452	1157	968	29750
1952	786	945	3186	5784	4911	4635	4582	4966	3219	1467	1172	1558	37210
1953	1561	872	2952	6632	1648	1562	1292	1899	1832	1447	1116	1299	24112
1954	995	1237	984	2251	3622	3358	2794	1811	968	1482	1086	1019	21608
1955	937	1044	1626	1391	937	823	998	954	1049	1095	795	732	12380
1956	686	813	6305	10804	5366	2808	1541	3019	1647	1324	1129	1345	36786
1957	1340	833	881	1082	2157	3205	1528	1345	1225	1412	1044	962	17012
1958	1462	993	1591	2542	10321	6357	6157	3746	2732	1357	1132	1449	39839
1959	1436	875	932	2416	3280	1573	879	974	1250	1399	1157	887	17059
1960	822	833	720	844	1949	1522	850	941	877	1277	941	831	12405
1961	673	784	1095	820	2007	1253	908	810	857	1278	1140	825	12451
1962	812	862	1088	722	3127	1970	1047	1064	1046	1372	1161	991	15263
1963	2418	1050	1790	1113	4457	2279	5413	2378	1265	1249	1130	1157	25698
1964	1141	1816	927	1758	968	936	888	996	916	1314	1169	941	13769
1965	813	966	5256	7915	2293	1788	3075	1846	1081	1489	1131	932	28584
1966	894	1564	1369	2254	1723	2036	1121	1122	1192	1369	1107	1002	16752
1967	791	1057	2785	3202	3372	4155	3532	3945	3511	1640	1209	1544	30744
1968	1468	942	1147	1981	3850	2562	1021	910	1211	1366	1109	974	18541
1969	850	891	1658	7794	7803	4360	3865	4788	2899	1298	1152	1528	38887
1970	1588	967	3910	13126	5132	2737	1285	1087	1121	1638	1169	1020	34779
1971	836	1280	4219	3319	1815	3148	1647	2062	1491	1624	1132	1298	23871
1972	1031	864	1337	1259	1610	2350	904	876	1245	1321	1100	830	14728
1973	760	1298	1707	5416	5470	4093	1466	1506	1377	1470	1124	966	26652
1974	1072	3941	4446	8382	2661	7192	4612	1986	1678	1420	1138	1510	40037
1975	1301	944	1153	1095	4049	5901	1825	2375	1862	1456	1181	1388	24529
1976	1380	1116	1117	965	859	1070	735	623	759	1081	851	766	11322
1977	685	587	577	575	525	566	631	477	745	945	853	534	7699
1978	581	514	1023	4386	3522	4550	2829	1992	1711	1382	1134	1081	24705
1979	947	706	703	1864	2978	2518	1377	1414	1376	1339	1102	863	17189
1980	859	898	1327	7066	7901	3979	1604	1470	1194	1294	1121	1069	29780
1981	967	695	1017	1703	1650	2309	1227	933	969	1333	1159	874	14835
1982	889	2408	5687	5141	6262	5537	8915	3435	2092	1306	1126	1659	44457
1983	2220	2808	5635	6619	9982	15599	5521	5148	5646	2712	1550	2098	65539
1984	1983	5024	9745	4561	2656	2663	1424	1172	1090	1571	1162	996	34047
1985	1007	2141	1544	1002	1016	1003	937	1060	974	1315	1131	1015	14145
1986	888	777	1216	1744	12075	9698	1904	1340	1294	1396	1210	1017	34559
1987	947	674	793	973	1240	1657	1003	794	971	1284	1045	835	12216
1988	784	629	1206	1826	919	639	679	716	881	914	606	546	10345
1989	594	638	715	858	585	3097	1439	1052	876	1280	1099	826	13057
1990	801	850	865	1291	894	930	778	542	593	706	769	723	9743
1991	573	508	494	522	537	2207	919	683	620	885	687	634	9269
1992	554	510	491	734	2103	1353	813	651	720	823	611	668	10030
1993	568	518	880	4326	3572	3106	2676	2214	1834	1498	1138	964	23296
Avg.	945	1077	1917	2792	3167	2967	2003	1655	1389	1299	1055	979	21245
Min.	554	507	491	522	525	556	576	477	593	706	564	531	7699
Max.	2418	5024	9745	13126	12075	15599	8915	5148	5646	2712	1550	2098	65539

Trinity

Existing Conditions [EWA], Total Delta Outflow (TAF)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1922	246	268	694	581	2103	1711	1455	3162	2180	492	246	231	13367
1923	259	316	2043	1787	891	642	1510	1021	486	400	246	238	9837
1924	246	376	295	421	636	620	383	251	308	415	184	179	4315
1925	247	284	467	437	3678	1672	1286	877	507	307	268	192	10223
1926	259	301	323	629	2165	614	1280	696	298	307	272	179	7321
1927	277	887	699	1536	7271	2336	2792	1479	591	564	246	211	18891
1928	246	627	419	893	1042	6260	1560	1009	343	523	246	228	13397
1929	253	388	378	344	604	613	411	402	359	246	274	179	4451
1930	237	333	736	1088	806	1601	607	608	366	307	236	179	7102
1931	319	279	415	426	433	387	405	283	296	410	184	179	4015
1932	283	276	1154	1099	1068	683	666	759	606	307	274	179	7354
1933	246	309	391	529	527	600	597	351	360	246	310	179	4645
1934	200	360	456	857	695	701	595	346	410	246	208	179	5253
1935	312	285	370	1648	633	1282	3141	1641	661	400	246	179	10798
1936	290	358	277	2031	4228	1612	1384	1065	480	400	246	204	12572
1937	249	431	277	407	2489	2801	1581	1140	577	400	246	179	10774
1938	246	850	4182	1833	8028	10233	4558	4619	2662	492	246	579	38528
1939	922	280	465	509	441	688	619	602	307	307	276	191	5606
1940	301	289	297	2044	3448	6402	4033	1095	505	492	246	203	19357
1941	246	391	2653	5963	6709	5507	4462	2724	880	492	267	402	30697
1942	365	269	3959	4991	7485	1599	2975	2321	1301	492	246	432	26435
1943	402	470	1354	5180	3225	5400	1734	1347	409	624	246	208	20599
1944	246	328	322	434	1193	1060	683	640	473	307	215	233	6135
1945	322	325	587	441	2558	1265	827	886	542	400	246	218	8616
1946	246	554	4133	2732	1347	1003	748	820	520	400	246	224	12972
1947	271	370	498	369	759	917	675	504	415	307	287	193	5566
1948	312	309	321	558	645	681	1508	1630	705	400	246	238	7551
1949	274	342	414	298	438	2591	688	709	449	307	246	188	6946
1950	319	272	356	1133	1572	883	1050	981	647	400	246	249	8109
1951	246	2818	5866	4090	3689	1516	943	1233	500	493	246	224	21863
1952	246	397	2795	5364	4181	3962	4145	4625	2425	492	246	738	29615
1953	782	268	2588	5929	1289	955	1082	1497	1016	560	246	484	16696
1954	252	529	277	1554	3073	2650	2350	1323	365	492	246	246	13357
1955	276	410	1025	786	633	470	764	607	420	307	253	179	6129
1956	324	292	6030	10589	4629	2009	1167	2640	787	492	246	546	29751
1957	585	268	277	436	1583	2551	1119	977	532	497	246	234	9303
1958	725	269	1093	2055	9930	5753	5823	3308	1916	492	246	633	32241
1959	659	268	277	1773	2994	1260	528	554	519	417	246	256	9750
1960	246	423	277	378	1501	934	678	640	335	307	245	179	6143
1961	364	271	566	440	1455	837	604	556	346	307	305	187	6239
1962	317	348	494	369	2658	1230	669	732	389	431	246	240	8121
1963	1722	323	1177	516	3851	1607	5137	1947	637	511	246	352	18026
1964	388	1124	277	1122	644	559	672	664	373	307	295	227	6651
1965	282	371	4723	7238	1555	1148	2645	1419	446	659	246	213	20945
1966	246	875	640	1541	1221	1259	852	679	500	400	246	244	8705
1967	261	414	2352	2859	2682	3469	3241	3554	2700	621	283	731	23168
1968	694	268	395	1409	3523	1934	820	514	498	400	246	228	10927
1969	301	341	1053	7301	7303	3626	3590	4303	2094	492	246	708	31358
1970	835	366	3396	12971	4699	2176	912	661	456	736	246	228	27681
1971	246	635	3622	2624	1413	2399	1216	1806	705	675	246	481	16069
1972	266	268	622	554	1086	1563	592	479	665	400	246	203	6943
1973	272	691	1261	5094	4926	3508	1017	1046	595	492	246	227	19375
1974	334	3268	3912	7762	1940	6747	4219	1576	835	530	246	685	32055
1975	538	268	409	454	3415	5238	1571	1896	1014	492	280	565	16140
1976	638	398	355	320	459	625	532	246	264	478	184	179	4679
1977	266	251	335	290	386	377	422	268	300	403	184	179	3660
1978	265	290	496	4227	2914	3905	2689	1576	862	492	246	283	18245
1979	246	273	355	1222	2694	1865	1104	941	620	400	246	184	10148
1980	299	349	741	6434	7376	3263	1233	1127	519	492	246	268	22347
1981	246	272	441	1176	1250	1705	977	528	326	307	284	205	7717
1982	322	1747	5121	4698	5578	4983	8521	2913	1271	492	246	887	36778
1983	1476	2216	5021	6699	9934	15636	5301	4921	4951	1716	638	1301	59809
1984	1318	4752	9595	4201	2226	2087	988	746	505	674	246	214	27552
1985	293	1497	838	369	605	681	729	636	340	307	270	265	6829
1986	283	317	631	1111	11687	9029	1480	917	560	492	312	259	27080
1987	246	287	335	389	788	1289	651	487	363	307	258	179	5578
1988	377	268	861	1201	643	484	492	394	406	246	209	179	5759
1989	312	262	359	462	436	2508	1021	634	336	307	291	229	7157
1990	252	425	277	615	633	568	586	334	241	340	229	179	4678
1991	285	232	412	277	405	1698	720	451	238	246	281	179	5423
1992	242	307	215	423	1665	928	616	395	385	246	254	179	5855
1993	244	298	421	4226	3061	2396	2226	1758	1024	492	246	212	16604
Avg.	384	574	1405	2288	2718	2441	1679	1284	739	442	256	298	14508
Min.	200	232	215	277	386	377	383	246	238	246	184	179	3660
Max.	1722	4752	9595	12971	11687	15636	8521	4921	4951	1716	638	1301	59809

Trinity

Existing Conditions [EWA], CVP Delivery North of Delta (TAF)
(sum of CALSIM variables D300, D8, D9, D302, D167A_IMI, D167B_IMI, D162_IMI, D168B, D168C_FRWP, and Del_CVP_Total_N)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1922	74	28	22	17	16	16	381	419	512	516	453	230	2683
1923	43	28	22	17	16	78	268	439	488	517	453	153	2520
1924	74	35	22	17	16	49	308	335	366	366	315	149	2051
1925	27	23	18	15	14	13	233	314	471	512	448	195	2283
1926	89	28	21	16	16	44	161	382	497	497	434	227	2411
1927	48	28	21	16	15	18	317	417	479	517	455	229	2560
1928	47	28	22	17	16	13	270	432	507	513	452	228	2545
1929	87	28	22	17	16	28	330	415	383	453	403	209	2390
1930	82	41	21	16	15	13	235	369	483	482	429	194	2381
1931	79	28	21	16	15	62	317	293	335	376	325	153	2022
1932	56	23	18	15	14	28	276	290	367	379	337	172	1976
1933	70	28	18	15	14	41	315	309	368	369	319	150	2015
1934	48	34	18	15	14	24	290	337	383	399	344	162	2069
1935	53	24	19	15	14	12	137	394	507	506	451	223	2354
1936	54	31	21	16	15	18	277	393	447	509	450	220	2451
1937	88	43	22	17	16	13	260	424	456	493	439	226	2496
1938	53	28	21	16	15	13	229	397	516	517	455	195	2456
1939	54	31	22	17	44	107	428	378	478	475	426	184	2642
1940	68	40	22	17	16	13	267	357	510	515	453	224	2502
1941	48	28	22	17	16	13	133	308	502	522	459	231	2298
1942	50	28	22	17	16	14	140	348	516	523	460	228	2359
1943	81	28	22	17	16	14	247	424	503	516	455	230	2553
1944	83	30	22	17	16	27	317	379	488	512	453	228	2571
1945	65	28	22	17	16	13	314	362	473	518	455	230	2512
1946	33	28	22	17	16	23	401	434	509	501	453	222	2660
1947	84	28	22	17	16	16	335	419	451	512	450	227	2577
1948	35	28	22	17	29	37	123	270	437	520	455	208	2181
1949	67	30	22	17	17	13	317	383	512	514	451	227	2570
1950	94	29	22	17	16	22	346	432	489	496	442	211	2615
1951	36	28	21	17	16	25	375	361	512	514	452	226	2583
1952	39	28	22	17	16	14	290	425	466	511	454	225	2507
1953	92	28	22	17	16	42	281	398	482	515	419	229	2539
1954	79	28	22	17	16	13	229	419	498	517	412	227	2477
1955	85	28	22	17	16	61	306	421	484	485	432	195	2551
1956	77	28	21	17	16	48	337	359	491	515	454	206	2569
1957	53	40	22	17	16	40	329	372	518	521	458	121	2507
1958	36	33	22	17	16	13	144	337	474	504	453	225	2273
1959	86	40	22	17	16	33	418	463	512	513	443	113	2674
1960	93	43	22	17	16	14	299	365	472	472	422	218	2452
1961	82	28	21	16	15	13	311	413	489	513	446	206	2555
1962	87	28	22	17	16	14	352	431	495	516	450	221	2648
1963	33	28	22	17	16	13	134	360	511	521	459	229	2342
1964	47	28	22	17	16	69	413	420	443	473	417	198	2561
1965	49	28	21	16	15	47	243	435	512	516	390	229	2503
1966	94	28	22	17	16	31	395	453	501	500	446	224	2726
1967	93	28	22	17	16	14	123	400	428	519	456	228	2344
1968	85	28	22	17	16	14	338	428	476	515	406	229	2573
1969	61	28	22	17	16	14	317	448	499	515	454	227	2617
1970	61	30	22	17	16	15	372	454	475	510	452	228	2650
1971	60	28	22	17	16	38	420	372	497	510	450	220	2649
1972	86	29	22	17	19	112	390	422	473	492	438	181	2679
1973	37	28	22	17	16	13	320	433	515	516	454	217	2588
1974	42	28	22	17	16	13	244	428	505	446	455	230	2446
1975	53	29	22	17	16	13	266	436	514	504	445	230	2544
1976	35	31	22	17	45	134	330	407	437	442	349	181	2430
1977	82	31	21	16	30	81	350	254	380	382	331	110	2068
1978	67	24	18	15	14	13	186	412	515	518	455	185	2422
1979	95	28	22	17	16	14	286	429	516	517	449	216	2605
1980	40	28	22	17	16	14	287	400	486	508	454	225	2495
1981	82	36	22	17	16	13	265	391	516	516	455	204	2532
1982	37	28	22	17	16	13	164	416	466	523	460	150	2312
1983	33	28	22	17	16	13	144	377	493	520	442	191	2296
1984	76	28	22	17	16	37	399	462	496	509	429	221	2710
1985	48	28	22	17	16	14	335	443	505	512	446	162	2548
1986	67	28	22	17	16	13	269	411	513	513	452	171	2493
1987	87	39	22	17	16	15	348	439	489	487	435	225	2619
1988	73	28	22	17	16	67	291	336	419	454	405	210	2337
1989	84	28	21	16	24	14	310	445	474	498	439	67	2419
1990	43	29	21	16	15	43	376	250	452	453	387	201	2286
1991	79	32	21	16	22	12	205	310	378	395	350	180	2001
1992	58	27	19	15	14	13	222	362	382	425	379	195	2110
1993	35	28	19	15	14	13	289	309	444	516	449	229	2361
Avg.	64	30	21	16	17	29	287	388	473	491	430	202	2449
Min.	27	23	18	15	14	12	123	250	335	366	315	67	1976
Max.	95	43	22	17	45	134	428	463	518	523	460	231	2726

Trinity

Existing Conditions [EWA], CVP Delivery So w/ CVC (TAF)
(equals CALSIM variable CVPTotalDel)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1922	204	123	107	137	166	155	194	310	448	551	463	281	3138
1923	193	116	97	119	144	160	195	310	456	562	472	285	3110
1924	195	117	99	122	148	75	83	120	155	161	158	131	1562
1925	110	59	34	25	35	135	158	244	355	423	366	239	2184
1926	174	100	76	87	108	126	146	204	292	336	300	212	2161
1927	162	91	64	65	82	159	195	317	470	581	486	291	2963
1928	198	119	101	126	153	147	187	307	452	556	467	283	3097
1929	194	116	98	120	146	107	121	171	235	258	240	186	1994
1930	150	82	51	45	60	114	136	192	269	304	275	201	1881
1931	158	88	59	57	73	76	84	121	157	164	160	132	1330
1932	110	60	35	26	36	84	95	132	183	200	187	144	1292
1933	116	64	41	35	46	79	89	124	170	182	173	138	1257
1934	113	62	38	31	41	100	115	166	228	262	235	165	1556
1935	126	72	51	51	64	92	135	226	314	367	323	221	2043
1936	166	94	68	73	91	159	194	277	403	488	416	261	2689
1937	184	109	87	103	126	121	167	244	343	406	353	234	2479
1938	172	98	74	82	103	155	195	302	434	532	449	276	2872
1939	191	114	94	115	139	145	187	273	399	484	412	259	2812
1940	184	108	86	102	125	125	149	252	363	435	374	243	2545
1941	176	102	78	89	111	161	195	316	456	562	472	285	3003
1942	195	117	99	122	148	161	195	306	441	541	456	278	3059
1943	192	115	96	117	142	155	195	301	432	529	447	275	2995
1944	191	114	94	114	138	158	189	281	412	501	425	265	2881
1945	186	110	89	107	130	152	191	304	438	538	446	282	2974
1946	192	114	95	116	141	148	175	293	427	522	435	278	2937
1947	190	113	93	112	136	135	184	274	395	478	407	257	2774
1948	183	107	85	101	123	120	155	294	422	514	436	270	2809
1949	188	112	92	110	134	128	178	273	399	483	412	259	2768
1950	184	108	86	102	125	131	170	252	364	435	375	243	2574
1951	176	102	78	90	111	167	189	284	416	506	429	264	2811
1952	190	111	90	108	132	142	195	310	448	551	463	281	3021
1953	194	116	97	119	144	160	189	292	425	519	423	284	2962
1954	192	113	92	111	135	148	189	306	450	554	465	282	3039
1955	194	116	97	120	145	143	178	260	369	442	380	245	2689
1956	177	103	79	91	113	156	189	294	429	525	443	273	2873
1957	190	113	93	113	137	162	189	317	463	571	478	288	3115
1958	196	118	100	124	150	142	186	308	444	545	459	280	3053
1959	193	115	96	118	143	160	187	306	447	550	462	281	3057
1960	193	116	97	119	144	110	141	200	281	321	289	207	2217
1961	160	90	62	61	78	142	195	289	414	504	428	266	2688
1962	187	111	90	107	131	150	184	287	426	520	440	272	2905
1963	189	113	93	112	136	154	194	317	467	577	483	289	3123
1964	197	118	101	125	152	136	169	242	349	391	338	262	2580
1965	173	99	75	84	105	153	182	326	473	585	489	292	3037
1966	198	119	102	128	154	158	188	298	436	535	451	276	3043
1967	191	114	95	115	140	140	188	298	428	524	442	273	2949
1968	190	113	93	112	137	160	187	311	455	560	470	284	3072
1969	195	117	98	121	147	151	195	310	448	551	463	281	3077
1970	193	116	97	119	144	159	190	307	452	556	467	283	3085
1971	194	116	98	120	146	154	183	307	449	552	460	283	3063
1972	194	116	97	119	145	149	182	283	405	492	418	262	2862
1973	185	109	88	104	127	151	195	305	439	539	454	278	2974
1974	192	115	95	116	141	154	195	297	426	521	363	349	2965
1975	189	113	93	112	136	163	195	306	442	542	403	332	3025
1976	192	115	96	117	142	109	124	174	240	264	245	188	2006
1977	151	83	53	47	62	85	96	137	117	205	188	144	1368
1978	116	64	41	36	47	154	195	302	434	532	449	276	2646
1979	191	114	94	115	139	160	195	323	467	578	483	290	3149
1980	197	118	101	126	152	151	195	302	434	532	449	276	3033
1981	191	114	94	115	139	160	189	305	450	553	465	282	3057
1982	194	116	97	120	145	142	186	326	473	585	489	292	3164
1983	198	119	102	127	154	143	180	267	380	457	392	251	2770
1984	180	105	82	95	117	160	189	298	439	538	454	277	2935
1985	192	115	95	116	141	150	184	286	418	509	373	312	2890
1986	188	111	91	109	132	143	182	298	429	524	443	273	2924
1987	190	113	93	113	137	122	189	274	393	475	406	257	2761
1988	182	107	85	100	123	102	114	166	219	235	223	178	1832
1989	147	79	48	39	53	92	155	226	314	366	322	221	2062
1990	166	94	68	72	91	99	110	160	210	223	214	174	1680
1991	145	78	46	36	50	89	101	145	196	217	200	150	1452
1992	119	66	44	40	51	101	144	210	298	358	307	195	1934
1993	139	82	65	75	92	146	185	306	441	542	456	279	2808
Avg.	177	104	83	97	119	137	170	265	380	459	389	252	2632
Min.	110	59	34	25	35	75	83	120	117	161	158	131	1257
Max.	204	123	107	137	166	167	195	326	473	585	489	349	3164

Trinity

Existing Conditions [EWA], X2_PRV (KM)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	
1922	74.9	83.2	85.0	78.5	77.8	66.9	65.7	66.3	60.8	61.6	73.5	82.7	
1923	86.0	86.4	84.8	70.2	66.4	69.8	74.1	68.8	70.3	76.2	79.9	84.8	
1924	86.4	87.0	83.6	84.6	82.2	77.8	77.0	80.2	84.8	84.4	82.3	87.8	
1925	89.6	88.0	86.1	81.9	81.1	63.7	64.8	66.9	70.8	76.0	81.8	84.8	
1926	88.1	87.1	85.4	84.5	79.1	67.1	73.6	69.9	73.6	81.0	83.5	85.2	
1927	88.8	86.8	77.0	75.9	69.4	54.6	59.3	59.2	64.3	72.7	76.1	83.6	
1928	86.9	87.1	79.8	80.7	75.2	71.7	57.3	63.0	68.5	78.3	78.5	84.4	
1929	86.6	86.8	83.3	82.6	83.1	78.2	77.3	79.8	81.0	82.0	85.5	85.8	
1930	89.0	88.1	84.9	78.1	72.8	72.6	68.1	73.8	75.9	80.2	83.2	86.2	
1931	89.1	85.8	85.6	82.7	81.5	80.2	81.5	81.3	84.2	84.6	82.4	87.8	
1932	89.6	86.9	86.0	75.0	71.7	70.4	73.9	74.9	74.6	75.9	81.8	84.6	
1933	88.6	87.7	85.4	83.1	80.0	78.2	77.4	77.0	81.1	82.0	85.5	84.9	
1934	88.7	89.3	84.7	81.7	75.8	74.7	75.1	76.2	81.0	81.0	85.2	87.8	
1935	89.6	86.2	85.5	83.5	71.4	74.0	70.2	61.9	64.4	71.9	78.5	84.3	
1936	88.5	86.4	83.8	85.2	70.4	59.4	63.7	66.0	69.0	75.9	79.8	84.8	
1937	87.6	87.3	82.7	84.8	82.6	67.2	62.0	64.4	68.0	74.1	79.2	84.6	
1938	88.6	87.7	77.6	62.3	63.7	52.0	47.1	51.4	53.0	57.5	72.2	82.3	
1939	78.8	74.3	81.7	80.5	79.5	79.4	76.8	76.5	76.8	81.9	83.7	85.2	
1940	88.2	86.0	85.3	85.1	70.3	60.9	53.6	54.5	65.0	74.2	77.6	84.1	
1941	87.4	87.3	83.4	67.7	56.4	51.0	51.5	53.0	57.6	67.5	75.4	82.7	
1942	81.7	82.4	84.7	65.1	56.9	50.3	60.8	59.2	60.8	65.5	74.8	83.1	
1943	81.3	81.5	80.1	71.8	58.8	57.4	53.8	61.0	65.6	76.0	76.4	83.7	
1944	87.1	87.2	84.7	84.3	81.9	72.9	71.3	73.9	75.5	78.1	82.5	86.7	
1945	87.2	85.1	84.2	79.5	80.2	66.2	67.8	71.3	72.2	76.0	79.8	84.8	
1946	87.1	87.2	80.7	63.5	61.0	64.8	69.1	72.5	73.2	76.6	80.0	84.9	
1947	86.9	86.4	83.6	80.6	81.9	76.1	73.5	74.7	77.6	79.8	83.1	84.7	
1948	88.0	85.6	84.7	84.3	80.0	76.9	76.0	69.4	66.9	72.2	78.6	84.4	
1949	86.3	86.1	84.1	82.2	84.1	81.0	67.1	72.5	74.3	78.1	82.5	85.7	
1950	88.5	85.6	85.7	83.9	74.4	68.0	71.1	70.6	71.1	74.3	79.2	84.6	
1951	86.0	86.8	68.1	56.6	55.6	55.3	62.8	68.7	68.8	75.5	78.0	84.2	
1952	86.7	87.0	83.2	67.3	57.1	55.1	55.4	54.9	54.1	58.6	72.5	82.4	
1953	77.0	75.0	82.3	67.6	56.4	63.6	69.1	69.7	67.6	69.7	75.2	83.3	
1954	80.5	84.8	80.3	84.0	72.0	62.1	60.8	61.0	65.7	76.9	78.5	84.4	
1955	86.0	86.0	82.6	74.8	74.2	74.9	78.2	75.3	76.4	79.3	82.9	85.6	
1956	88.9	85.6	85.1	62.0	50.1	52.0	59.6	66.0	62.1	69.8	76.2	83.6	
1957	79.7	78.1	83.3	85.0	82.1	70.5	63.8	67.7	70.2	75.5	78.0	84.2	
1958	86.4	78.7	83.5	74.6	66.8	51.4	51.3	50.9	55.4	60.8	73.2	82.6	
1959	78.2	76.7	82.9	84.9	71.3	62.1	66.4	74.3	76.8	77.8	80.1	84.9	
1960	85.9	86.8	82.7	84.8	83.1	71.5	71.8	74.1	75.6	80.8	83.4	86.0	
1961	89.0	84.8	85.4	80.2	80.5	70.6	72.4	75.2	77.0	81.0	83.5	84.3	
1962	88.1	85.6	83.8	80.7	82.0	66.5	68.1	73.0	74.2	79.2	80.3	84.9	
1963	86.4	72.0	79.9	72.8	76.8	61.9	64.5	56.2	61.2	71.1	76.3	83.6	
1964	83.0	82.4	73.7	81.9	73.8	74.9	76.9	75.9	75.9	80.0	83.2	84.5	
1965	86.7	86.0	83.4	63.3	53.5	61.2	66.9	62.1	65.5	75.3	75.8	83.5	
1966	86.8	87.1	77.2	76.6	69.7	68.4	68.5	71.3	74.2	77.3	80.2	84.9	
1967	86.3	86.4	82.7	68.4	62.2	59.9	58.0	57.6	57.0	58.7	70.8	80.7	
1968	76.5	75.7	82.6	82.1	72.1	61.4	62.9	69.8	75.8	77.8	80.4	85.0	
1969	86.8	85.5	83.9	75.0	57.2	50.6	54.6	55.7	54.9	60.0	73.0	82.5	
1970	77.3	74.6	79.8	64.7	49.4	51.4	58.8	67.6	73.2	77.6	75.7	83.4	
1971	86.3	86.9	79.6	64.1	61.5	64.6	62.3	66.6	65.2	71.7	74.4	83.0	
1972	80.4	84.4	85.4	79.5	78.5	72.4	68.2	74.0	77.8	76.2	79.9	84.8	
1973	87.6	86.6	78.8	71.9	59.0	54.2	56.0	65.9	69.1	74.3	77.7	84.1	
1974	86.5	84.6	66.3	59.1	51.6	58.9	52.6	53.8	62.0	69.3	75.5	83.4	
1975	77.8	78.1	83.3	82.0	80.8	64.2	56.2	62.6	63.5	68.3	75.7	82.4	
1976	79.0	77.2	80.0	82.0	83.5	80.7	77.9	78.0	84.2	85.4	81.5	87.6	
1977	89.5	87.4	86.9	84.7	85.1	82.3	82.3	81.2	84.6	84.6	82.6	87.9	
1978	89.6	87.4	85.8	81.4	63.5	59.7	57.0	58.7	63.6	69.6	76.1	83.6	
1979	84.7	86.4	85.9	84.0	73.9	63.7	64.0	67.8	70.6	74.4	79.3	84.6	
1980	88.3	86.1	83.9	77.7	59.1	51.4	55.7	64.3	68.0	74.9	77.9	84.2	
1981	85.3	86.6	86.0	82.3	73.6	69.5	66.6	69.6	75.6	81.0	83.5	84.9	
1982	87.6	85.3	71.3	58.7	55.3	52.0	52.6	48.4	55.6	64.0	74.3	83.0	
1983	75.7	69.7	64.4	56.6	51.8	46.5	42.0	48.6	51.6	52.3	60.9	71.3	
1984	69.0	68.4	58.1	49.6	53.1	58.6	61.5	67.9	72.4	76.6	76.0	83.5	
1985	86.8	85.8	72.6	73.0	79.5	77.0	76.1	75.0	75.9	80.8	83.4	85.3	
1986	85.8	85.7	84.5	79.1	73.0	52.2	48.1	60.4	68.3	74.5	77.7	82.3	
1987	84.9	86.5	85.5	84.3	82.7	76.0	70.9	74.1	77.7	80.9	83.4	85.6	
1988	88.9	84.5	85.4	77.0	71.7	74.3	77.8	78.6	80.8	81.0	85.2	87.8	
1989	89.6	86.2	86.2	84.0	81.3	80.1	67.1	69.5	74.1	80.3	83.2	84.6	
1990	86.6	86.8	82.6	84.8	79.4	76.6	77.3	77.1	81.5	85.3	84.1	86.7	
1991	89.3	86.8	87.3	83.3	85.0	81.9	70.7	73.3	78.0	84.2	86.2	85.9	
1992	89.0	87.9	85.5	87.7	83.2	70.7	71.6	74.8	79.5	81.0	85.2	86.3	
1993	89.1	87.9	85.7	82.6	63.9	59.5	60.7	61.4	63.7	68.3	75.7	83.4	
Avg.	85.5	84.3	82.0	76.7	71.2	66.1	65.6	67.6	70.4	75.0	79.2	84.4	
Min.	69.0	68.4	58.1	49.6	49.4	46.5	42.0	48.4	51.6	52.3	60.9	71.3	
Max.	89.6	89.3	87.3	87.7	85.1	82.3	82.3	81.3	84.8	85.4	86.2	87.9	

No Action

Trinity

No Action [EWA], Trinity Storage (TAF)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1922	1786	1684	1670	1667	1690	1740	1852	2007	2070	1957	1834	1640
1923	1544	1456	1466	1492	1515	1567	1696	1653	1626	1407	1186	1013
1924	963	929	913	899	957	962	935	854	729	575	454	367
1925	349	419	460	473	738	873	1180	1350	1354	1199	1023	921
1926	854	825	834	835	979	1081	1314	1290	1232	1051	869	739
1927	717	873	1059	1176	1414	1592	1829	2011	2153	2071	1957	1770
1928	1668	1726	1744	1801	1910	2100	2266	2310	2225	2110	1878	1681
1929	1515	1416	1407	1296	1312	1360	1397	1423	1351	1176	948	817
1930	743	726	854	861	960	1085	1200	1194	1152	977	811	697
1931	670	656	646	655	674	732	798	761	712	595	475	389
1932	362	350	347	359	380	533	637	742	712	604	487	402
1933	374	366	358	350	350	467	635	705	791	688	573	491
1934	462	449	452	507	591	748	844	816	700	579	460	375
1935	353	412	443	478	557	617	845	958	929	760	642	559
1936	534	523	520	627	762	880	1062	1145	1162	1034	902	791
1937	762	745	729	715	713	812	1046	1270	1350	1231	1085	972
1938	922	1040	1259	1356	1513	1774	2089	2420	2447	2270	2150	1975
1939	1850	1850	1841	1769	1766	1868	1958	1887	1750	1538	1322	1101
1940	992	914	968	1134	1460	1762	1998	2112	2067	1880	1684	1500
1941	1417	1398	1537	1757	2000	2100	2300	2420	2447	2270	2150	1975
1942	1850	1850	1850	1900	2000	1987	2203	2420	2447	2270	2150	1975
1943	1850	1850	1850	1900	2000	2100	2293	2340	2367	2261	2142	1951
1944	1850	1850	1808	1709	1752	1820	1875	1924	1872	1689	1478	1303
1945	1214	1217	1282	1326	1486	1540	1685	1803	1847	1743	1547	1357
1946	1319	1374	1565	1696	1751	1880	2112	2224	2200	2108	1881	1692
1947	1529	1448	1469	1467	1527	1646	1744	1711	1649	1438	1258	1085
1948	1056	1043	1035	1219	1232	1257	1450	1589	1715	1628	1516	1457
1949	1453	1460	1461	1454	1486	1701	1972	2132	2094	1988	1794	1605
1950	1440	1408	1389	1407	1455	1576	1746	1831	1780	1595	1398	1256
1951	1292	1407	1665	1755	1975	2071	2234	2341	2287	2178	1970	1780
1952	1624	1589	1735	1795	1985	2100	2300	2420	2447	2270	2150	1975
1953	1850	1845	1850	1900	1943	2071	2287	2420	2447	2270	2150	1975
1954	1850	1850	1850	1900	2000	2100	2300	2329	2290	2194	2006	1824
1955	1742	1792	1849	1786	1782	1817	1883	1963	1916	1731	1539	1340
1956	1251	1235	1543	1877	2000	2099	2292	2420	2447	2270	2150	1975
1957	1850	1850	1813	1796	1957	2100	2183	2353	2424	2270	2150	1966
1958	1850	1850	1850	1900	2059	2100	2300	2420	2447	2270	2150	1975
1959	1850	1850	1818	1900	2000	2012	2149	2129	2077	1855	1624	1425
1960	1337	1299	1278	1277	1411	1589	1717	1806	1827	1693	1465	1321
1961	1235	1215	1295	1326	1549	1677	1841	1964	2007	1858	1632	1429
1962	1340	1319	1341	1345	1480	1556	1783	1858	1843	1741	1555	1368
1963	1478	1529	1703	1744	2000	2078	2300	2418	2447	2270	2146	1975
1964	1850	1850	1841	1900	1888	1919	1958	1936	1862	1648	1446	1280
1965	1201	1207	1744	1900	1971	1955	2199	2299	2354	2259	2076	1894
1966	1792	1850	1850	1900	1968	2100	2300	2398	2435	2270	2049	1836
1967	1632	1640	1783	1898	2000	2100	2221	2420	2447	2270	2150	1975
1968	1850	1850	1834	1844	2000	2100	2183	2220	2155	1969	1776	1591
1969	1432	1427	1487	1631	1756	1917	2261	2420	2447	2270	2150	1975
1970	1850	1850	1850	1900	2000	2087	2145	2207	2176	1995	1762	1554
1971	1392	1528	1659	1893	1930	2100	2292	2420	2447	2270	2150	1975
1972	1850	1850	1842	1900	2000	2100	2259	2339	2305	2197	1969	1777
1973	1624	1664	1773	1900	2000	2100	2269	2419	2447	2270	2069	1884
1974	1850	1850	1850	1900	2000	2100	2300	2420	2447	2270	2150	1975
1975	1850	1849	1840	1827	1924	2100	2236	2420	2447	2270	2150	1975
1976	1850	1850	1837	1703	1737	1784	1884	1949	1868	1650	1464	1323
1977	1262	1227	1210	1200	1194	1180	1101	1044	910	679	533	463
1978	445	469	625	1026	1211	1498	1706	1906	2099	2053	1942	1783
1979	1687	1684	1679	1702	1755	1904	2044	2212	2235	2126	1924	1737
1980	1601	1643	1713	1900	2000	2083	2233	2290	2266	2183	1985	1796
1981	1690	1593	1639	1746	1885	2011	2142	2154	2061	1864	1644	1433
1982	1355	1599	1850	1900	2000	2100	2300	2399	2447	2270	2150	1975
1983	1850	1850	1850	1900	2000	2100	2300	2420	2447	2270	2150	1975
1984	1850	1850	1850	1900	1998	2100	2224	2323	2302	2208	2017	1830
1985	1824	1850	1850	1777	1805	1856	2025	1985	1892	1664	1433	1260
1986	1161	1111	1112	1231	1715	2057	2096	2133	2091	1906	1706	1522
1987	1426	1391	1386	1405	1491	1709	1875	1790	1703	1478	1248	1020
1988	941	903	1063	1132	1204	1261	1337	1358	1295	1085	905	770
1989	738	773	787	808	833	1177	1392	1405	1378	1174	993	885
1990	872	845	827	886	906	992	1039	1087	1066	912	727	641
1991	609	590	572	561	565	643	726	748	751	644	529	446
1992	417	401	391	393	532	674	924	999	915	749	627	541
1993	513	507	524	580	718	1090	1310	1683	1893	1910	1799	1771
Avg.	1322	1325	1374	1427	1529	1645	1803	1888	1881	1727	1561	1403
Min.	349	350	347	350	350	467	635	705	700	575	454	367
Max.	1850	1850	1850	1900	2059	2100	2300	2420	2447	2270	2150	1975

Trinity

No Action [EWA], Whiskeytown Storage (TAF)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	
1922	217	206	206	206	206	217	240	240	240	240	240	235	
1923	217	206	206	206	206	217	240	240	240	240	240	235	
1924	217	206	206	206	206	217	240	240	240	240	240	235	
1925	217	206	206	180	206	217	240	240	240	240	240	235	
1926	217	206	206	206	206	217	240	240	240	240	240	235	
1927	217	206	206	206	206	217	240	240	240	240	240	235	
1928	217	206	206	206	206	217	240	240	240	240	240	235	
1929	217	206	206	206	206	217	240	240	240	240	240	235	
1930	217	206	206	206	206	217	240	240	240	240	240	235	
1931	217	206	206	206	206	212	218	214	240	240	240	235	
1932	217	206	206	206	206	205	204	213	240	230	240	235	
1933	217	206	206	206	206	217	233	239	240	240	240	235	
1934	217	206	206	206	206	205	240	240	240	240	240	235	
1935	210	206	206	206	206	217	240	240	240	240	240	235	
1936	217	206	206	206	206	205	227	237	240	240	240	235	
1937	217	206	204	205	206	217	240	240	240	240	240	235	
1938	217	206	206	206	206	217	240	240	240	240	240	235	
1939	217	206	206	206	206	217	240	240	240	240	240	235	
1940	217	206	206	206	206	217	240	240	240	240	240	235	
1941	217	206	206	206	206	217	240	240	240	240	240	235	
1942	217	206	206	206	206	217	240	240	240	240	240	235	
1943	217	206	206	206	206	217	240	240	240	240	240	235	
1944	217	206	206	206	206	217	240	240	240	240	240	235	
1945	217	206	206	206	206	217	240	240	240	240	240	235	
1946	217	206	206	206	206	217	240	240	240	240	240	235	
1947	217	206	206	206	206	217	240	240	240	240	240	235	
1948	217	206	206	206	206	217	240	240	240	240	240	235	
1949	217	206	206	206	206	217	240	240	240	240	240	235	
1950	217	206	206	206	206	217	240	240	240	240	240	235	
1951	217	206	206	206	206	217	240	240	240	240	240	235	
1952	217	206	206	206	206	217	240	240	240	240	240	235	
1953	217	206	206	206	206	217	240	240	240	240	240	235	
1954	217	206	206	206	206	217	240	240	240	240	240	235	
1955	217	206	206	206	206	217	240	240	240	240	240	235	
1956	217	206	206	206	206	217	240	240	240	240	240	235	
1957	217	206	206	206	206	217	240	240	240	240	240	235	
1958	217	206	206	206	240	217	240	240	240	240	240	235	
1959	217	206	206	206	206	217	240	240	240	240	240	235	
1960	217	206	206	206	206	217	240	240	240	240	240	235	
1961	217	206	206	206	206	217	240	240	240	240	240	235	
1962	217	206	206	206	206	217	240	240	240	240	240	235	
1963	217	206	206	206	206	217	240	240	240	240	240	235	
1964	217	206	206	206	206	217	240	240	240	240	240	235	
1965	217	206	206	206	206	217	240	240	240	240	240	235	
1966	217	206	206	206	206	217	240	240	240	240	240	235	
1967	217	206	206	206	206	217	240	240	240	240	240	235	
1968	217	206	206	206	206	217	240	240	240	240	240	235	
1969	217	206	206	206	206	217	240	240	240	240	240	235	
1970	217	206	206	206	206	217	240	240	240	240	240	235	
1971	217	206	206	206	206	217	240	240	240	240	240	235	
1972	217	206	206	206	206	217	240	240	240	240	240	235	
1973	217	206	206	206	206	217	240	240	240	240	240	235	
1974	217	206	206	206	206	217	240	240	240	240	240	235	
1975	217	206	206	206	206	217	240	240	240	240	240	235	
1976	217	206	206	206	206	217	240	240	240	240	240	235	
1977	217	206	206	206	206	217	240	240	240	240	240	235	
1978	217	206	206	206	206	217	240	240	240	240	240	235	
1979	217	206	206	206	206	217	240	240	240	240	240	235	
1980	217	206	206	206	206	217	240	240	240	240	240	235	
1981	217	206	206	206	206	217	240	240	240	240	240	235	
1982	217	206	206	206	206	217	240	240	240	240	240	235	
1983	217	206	206	206	206	217	240	240	240	240	240	235	
1984	217	206	206	206	206	217	240	240	240	240	240	235	
1985	217	206	206	206	206	217	240	240	240	240	240	235	
1986	217	206	206	206	206	217	240	240	240	240	240	235	
1987	217	206	206	206	206	217	240	240	240	240	240	235	
1988	217	206	206	206	206	217	240	240	240	240	240	235	
1989	217	206	206	206	206	217	240	240	240	240	240	235	
1990	217	206	206	206	206	215	240	240	240	236	240	235	
1991	217	206	206	206	206	217	227	224	233	240	240	235	
1992	217	206	206	206	206	217	240	240	240	240	240	235	
1993	217	206	206	206	206	217	240	240	240	240	240	235	
Avg.	217	206	206	206	206	216	239	239	240	240	240	235	
Min.	210	206	204	180	206	205	204	213	233	230	240	235	
Max.	217	206	206	206	240	217	240	240	240	240	240	235	

Trinity

No Action [EWA], Shasta Storage (TAF)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1922	2806	2890	2995	3099	3459	3841	4315	4444	4096	3612	3158	3017
1923	3059	3205	3336	3535	3663	3791	4091	3850	3430	2968	2605	2576
1924	2542	2458	2413	2433	2583	2491	2261	1933	1552	996	727	649
1925	684	840	940	1132	2376	2587	3244	3307	3077	2705	2385	2268
1926	2255	2280	2292	2335	3056	3258	3544	3370	2969	2484	2176	2068
1927	2068	2549	3064	3603	3462	4094	4552	4552	4244	3623	3186	3072
1928	3086	3252	3327	3592	4067	3965	4463	4326	3962	3200	2801	2701
1929	2718	2782	2779	2936	3131	3308	3370	3230	3028	2468	2100	2089
1930	1995	1907	2430	2644	3022	3503	3663	3551	3166	2763	2439	2352
1931	2305	2303	2289	2366	2453	2623	2380	2099	1747	1293	865	749
1932	652	645	848	995	1124	1557	1716	1901	1741	1461	1171	1071
1933	1019	1016	1008	1046	1085	1678	1812	1870	1758	1398	1091	969
1934	886	874	1003	1304	1634	1906	1923	1743	1396	992	719	608
1935	594	716	762	1065	1399	1788	2783	2999	2738	2435	2076	1936
1936	1929	1904	1914	2548	3435	3794	4013	3878	3686	3200	2793	2649
1937	2538	2453	2378	2357	2449	3099	3754	3878	3704	3200	2814	2646
1938	2625	3207	3310	3668	3560	3416	4058	4552	4500	4150	3700	3400
1939	3250	3225	3340	3539	3670	4071	3879	3578	3093	2515	2039	2007
1940	2003	1967	2127	3016	3252	3435	4161	4115	3780	3276	2904	2822
1941	2843	2867	3293	3317	3423	3940	4456	4552	4500	4134	3700	3400
1942	3250	3233	3316	3389	3516	3938	4552	4552	4500	4100	3700	3400
1943	3250	3252	3356	3541	3848	4118	4552	4521	4248	3714	3296	3197
1944	3200	3199	3225	3405	3711	4022	3983	3836	3529	2981	2610	2496
1945	2447	2643	2941	3142	3917	4227	4397	4407	4110	3536	3163	3053
1946	3104	3252	3265	3622	3600	3996	4195	4185	3857	3346	3028	2928
1947	2930	3040	3089	3096	3364	3896	4035	3656	3366	2837	2377	2271
1948	2361	2435	2421	2979	2764	3080	3982	4360	4379	4000	3599	3400
1949	3250	3193	3194	3199	3395	4071	4392	4345	3984	3313	2947	2856
1950	2841	2753	2698	2977	3393	3842	4174	4084	3797	3399	3071	2976
1951	3223	3252	3322	3624	3794	4245	4359	4386	4025	3376	3021	2948
1952	3063	3252	3306	3604	3739	4022	4290	4552	4500	4150	3700	3400
1953	3250	3206	3345	3366	3753	4226	4552	4552	4500	4150	3700	3400
1954	3250	3252	3364	3552	3661	4106	4546	4395	4192	3490	3231	3224
1955	3250	3252	3360	3563	3695	3863	3976	4046	3660	3101	2720	2727
1956	2702	2726	3252	3252	3288	4012	4528	4552	4500	4150	3700	3400
1957	3250	3200	3241	3367	3675	4129	4210	4472	4185	3652	3215	3300
1958	3250	3252	3338	3531	3252	3416	4173	4552	4500	4150	3700	3400
1959	3250	3200	3258	3648	3777	4103	4164	4013	3379	2837	2442	2508
1960	2460	2248	2233	2435	3161	3858	4040	4038	3805	3200	2805	2731
1961	2705	2847	3312	3522	3914	4280	4371	4342	3946	3200	2745	2709
1962	2570	2508	2794	2916	3675	4175	4454	4346	4039	3391	3023	2981
1963	3250	3252	3349	3514	3944	4038	4137	4544	4350	3849	3512	3400
1964	3250	3252	3333	3705	3923	4087	3910	3696	3486	2951	2561	2520
1965	2525	2697	3252	3368	3809	3952	4500	4442	4110	3508	3277	3246
1966	3200	3252	3359	3725	4037	4229	4552	4476	3828	3200	2853	2785
1967	2765	3200	3335	3551	3920	4033	4479	4552	4500	4150	3700	3400
1968	3250	3213	3316	3612	3654	4248	4251	4124	3667	3081	2834	2783
1969	2885	2919	3240	3358	3480	4030	4434	4552	4500	4086	3700	3400
1970	3250	3252	3317	3252	3431	4128	4098	3986	3670	2919	2634	2615
1971	2787	3252	3319	3515	3709	3873	4371	4552	4500	4150	3700	3400
1972	3250	3200	3337	3714	3979	4249	4487	4383	3884	3200	2853	2876
1973	3060	3252	3346	3552	3636	4162	4461	4545	4163	3592	3306	3271
1974	3250	3252	3267	3252	3694	3416	4289	4552	4500	4150	3700	3400
1975	3250	3209	3336	3509	3936	3756	4347	4552	4500	4150	3700	3400
1976	3250	3252	3328	3543	3728	3962	4053	3867	3448	3097	3005	3037
1977	3026	3096	3004	3011	3004	3007	2659	2523	1984	1183	721	706
1978	559	609	1114	3030	3567	4000	4552	4552	4209	3667	3306	3367
1979	3250	3243	3234	3393	3752	4267	4436	4463	3886	3201	2956	2929
1980	3092	3252	3367	3528	3292	4047	4356	4335	4019	3435	3132	3123
1981	3143	3195	3286	3595	4010	4256	4400	4155	3575	2985	2588	2582
1982	2653	3252	3276	3616	3530	3953	4094	4400	4294	4093	3700	3400
1983	3250	3252	3328	3371	3252	3417	4074	4552	4500	4150	3700	3400
1984	3250	3252	3285	3650	4005	4246	4367	4371	4128	3468	3251	3274
1985	3250	3252	3360	3559	3750	3967	4063	3730	3205	2679	2304	2306
1986	2333	2398	2563	3140	3252	3534	3955	3972	3634	3200	2910	3019
1987	3097	3109	3115	3244	3584	4298	4117	3820	3200	2590	2185	2144
1988	2017	2015	2488	2931	2855	2986	3031	3029	2658	2306	2067	1963
1989	1806	2017	2119	2227	2338	3723	4110	3857	3486	2931	2534	2580
1990	2715	2644	2597	2833	2858	3103	2949	3085	2914	2459	2257	2191
1991	2095	2042	1971	1980	2015	2445	2567	2491	2211	1896	1678	1619
1992	1541	1433	1434	1487	2144	2590	2799	2488	2078	1651	1237	1034
1993	947	853	1090	1744	2481	3945	4552	4552	4500	3864	3592	3400
Avg.	2638	2693	2813	3052	3302	3663	3942	3932	3649	3150	2787	2680
Min.	559	609	762	995	1085	1557	1716	1743	1396	992	719	608
Max.	3250	3252	3367	3725	4067	4298	4552	4552	4500	4150	3700	3400

Trinity

No Action [EWA], Trinity Import (TAF)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1922	203	104	31	15	6	6	20	6	4	92	92	164	743
1923	92	89	8	6	6	12	19	100	45	203	194	149	922
1924	46	30	15	15	6	6	49	6	93	124	92	60	541
1925	15	6	6	40	6	6	6	6	74	154	154	89	562
1926	61	30	15	6	6	12	6	15	45	154	154	104	608
1927	15	6	15	6	0	6	0	0	2	92	92	164	399
1928	92	0	6	6	6	0	7	53	89	92	203	170	725
1929	154	104	15	123	14	15	22	15	89	154	200	104	1009
1930	61	6	6	15	6	6	24	6	45	154	138	89	557
1931	15	6	6	6	6	6	0	0	51	92	92	60	340
1932	15	6	6	0	0	0	0	0	68	92	92	60	339
1933	15	6	6	6	0	0	0	0	59	104	92	60	348
1934	15	6	6	6	6	0	30	6	104	98	92	60	428
1935	15	6	6	6	6	0	0	6	60	154	92	60	410
1936	15	6	6	6	6	0	6	6	45	123	108	89	416
1937	15	6	6	6	6	6	6	6	45	123	123	89	437
1938	46	30	0	0	0	0	0	0	27	158	191	96	151	699
1939	124	15	40	89	23	6	24	45	122	184	184	193	1050
1940	98	67	15	15	0	0	15	15	89	169	169	164	817
1941	77	30	0	0	0	0	0	203	196	203	120	162	990
1942	119	17	0	0	0	98	0	35	161	199	99	152	879
1943	114	26	65	0	22	72	19	3	5	92	92	164	673
1944	94	10	44	109	6	6	27	15	89	169	185	149	904
1945	77	30	15	15	6	6	18	6	0	92	169	164	598
1946	46	0	0	0	6	0	6	73	89	92	203	164	679
1947	154	104	6	9	6	6	24	39	104	193	154	149	948
1948	61	30	15	15	14	15	6	15	45	92	92	40	442
1949	0	0	7	8	6	0	6	6	89	92	169	164	548
1950	154	30	15	15	14	6	14	15	89	169	169	119	810
1951	77	0	0	0	0	14	47	16	89	92	182	164	682
1952	154	70	0	0	0	51	157	183	131	203	103	153	1204
1953	114	0	36	0	81	0	9	18	182	203	107	155	905
1954	121	83	54	35	0	139	146	135	89	92	169	164	1226
1955	76	0	0	87	38	6	3	15	89	169	169	179	831
1956	77	30	0	0	0	52	82	157	133	191	99	152	972
1957	119	5	45	22	0	33	54	6	0	141	94	164	682
1958	203	80	101	108	154	0	0	203	196	203	112	155	1515
1959	116	0	32	99	4	120	62	78	89	203	203	179	1186
1960	77	30	15	15	14	15	17	15	89	123	202	119	733
1961	77	30	15	6	0	0	7	6	89	141	203	179	753
1962	77	30	15	15	0	6	24	6	89	92	169	164	688
1963	0	0	0	6	39	0	0	113	33	165	92	143	591
1964	126	118	52	21	64	12	24	15	104	203	184	149	1074
1965	77	30	0	0	26	96	0	6	2	92	169	164	661
1966	92	30	40	32	0	75	126	73	1	163	203	196	1033
1967	197	104	0	0	35	61	0	114	190	203	108	158	1171
1968	127	7	38	79	0	51	45	14	89	169	169	164	952
1969	154	30	15	0	0	0	0	203	143	186	95	148	974
1970	120	1	153	145	0	62	35	37	89	169	203	179	1193
1971	154	0	0	0	105	26	0	113	103	197	96	148	941
1972	113	14	31	53	16	203	0	17	89	92	203	164	996
1973	154	0	0	0	0	25	43	107	38	171	169	164	871
1974	57	74	0	139	9	0	46	163	196	203	104	149	1142
1975	109	0	31	42	0	0	19	121	196	203	101	155	977
1976	126	31	53	151	6	12	11	15	89	203	169	119	986
1977	46	30	6	6	6	15	98	6	122	203	125	60	723
1978	15	6	43	0	0	0	0	0	2	92	92	164	415
1979	85	0	0	6	6	6	6	6	0	92	169	164	540
1980	154	23	0	0	0	60	35	48	89	92	169	164	833
1981	92	89	0	6	6	0	6	6	89	169	184	179	827
1982	77	0	0	41	0	83	0	95	60	193	97	148	793
1983	149	37	0	0	0	65	69	191	196	203	154	173	1237
1984	126	129	0	102	0	50	19	56	89	92	169	164	996
1985	0	102	54	106	16	6	14	57	104	203	203	149	1014
1986	92	45	15	15	0	0	129	49	89	169	172	164	939
1987	92	30	7	6	6	0	15	137	92	203	203	196	987
1988	61	30	15	15	14	34	39	15	123	200	154	104	805
1989	15	6	6	6	6	6	6	40	45	182	154	89	561
1990	46	30	15	6	6	6	29	6	60	138	154	60	555
1991	15	6	6	6	6	0	0	0	15	92	92	60	298
1992	15	6	6	6	0	0	0	6	98	154	93	60	444
1993	15	6	6	6	6	6	0	0	0	0	92	1	138
Avg.	83	30	18	27	12	24	25	47	84	149	143	135	776
Min.	0	0	0	0	0	0	0	0	0	0	92	1	138
Max.	203	129	153	151	154	203	157	203	196	203	203	196	1515

Trinity

No Action [EWA], Trinity Flow (TAF)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1922	18	18	18	18	17	18	18	98	34	28	28	27	340
1923	18	18	18	18	17	18	18	98	34	28	28	27	340
1924	18	18	18	18	17	18	18	98	34	28	28	27	341
1925	18	18	18	18	17	18	18	98	34	28	28	27	340
1926	18	18	18	18	17	18	18	98	34	28	28	27	340
1927	18	18	18	18	17	18	18	98	34	28	28	27	340
1928	18	18	18	18	17	35	18	98	34	28	28	27	358
1929	18	18	18	18	17	18	18	98	34	28	28	27	340
1930	18	18	18	18	17	18	18	98	34	28	28	27	340
1931	18	18	18	18	17	18	18	98	34	28	28	27	340
1932	18	18	18	18	17	18	18	98	34	28	28	27	341
1933	18	18	18	18	17	18	18	98	34	28	28	27	340
1934	18	18	18	18	17	18	18	98	34	28	28	27	340
1935	18	18	18	18	17	18	18	98	34	28	28	27	340
1936	18	18	18	18	17	18	18	98	34	28	28	27	341
1937	18	18	18	18	17	18	18	98	34	28	28	27	340
1938	18	18	18	18	17	18	18	98	34	28	28	27	340
1939	18	18	18	18	17	18	18	98	34	28	28	27	340
1940	18	18	18	18	17	18	18	98	34	28	28	27	341
1941	18	18	18	18	24	273	162	203	107	120	28	27	1016
1942	18	18	275	164	134	18	18	98	34	28	28	27	861
1943	18	18	18	71	17	18	18	98	34	28	28	27	393
1944	18	18	18	18	17	18	18	98	34	28	28	27	341
1945	18	18	18	18	17	18	18	98	34	28	28	27	340
1946	18	18	18	18	17	18	18	98	34	28	28	27	340
1947	18	18	18	18	17	18	18	98	34	28	28	27	340
1948	18	18	18	18	17	18	18	98	34	28	28	27	341
1949	18	18	18	18	17	18	18	98	34	28	28	27	340
1950	18	18	18	18	17	18	18	98	34	28	28	27	340
1951	18	18	18	18	17	18	18	98	34	28	28	27	340
1952	18	18	18	18	17	18	18	98	34	40	28	27	353
1953	18	18	18	280	17	18	18	98	34	66	28	27	640
1954	18	18	18	18	130	18	18	98	34	28	28	27	454
1955	18	18	18	18	17	18	18	98	34	28	28	27	340
1956	18	18	18	18	32	18	18	98	34	28	28	27	355
1957	18	18	18	18	17	18	18	98	34	28	28	27	340
1958	27	18	18	18	333	188	102	225	63	54	28	27	1101
1959	18	18	18	18	17	18	18	98	34	28	28	27	340
1960	18	18	18	18	17	18	18	98	34	28	28	27	341
1961	18	18	18	18	17	18	18	98	34	28	28	27	340
1962	18	18	18	18	17	18	18	98	34	28	28	27	340
1963	18	18	18	18	17	18	73	98	34	28	28	27	396
1964	18	18	18	18	17	18	18	98	34	28	28	27	341
1965	18	18	26	77	17	18	18	98	34	28	28	27	407
1966	18	18	18	18	17	18	18	98	34	28	28	27	340
1967	18	18	18	18	17	18	18	98	34	31	28	27	344
1968	18	18	18	18	149	18	18	98	34	28	28	27	473
1969	18	18	18	18	17	18	18	178	34	28	28	27	421
1970	18	18	82	369	73	18	18	98	34	28	28	27	811
1971	18	18	18	18	17	18	18	98	34	28	28	27	340
1972	18	18	18	18	17	46	18	98	34	28	28	27	369
1973	18	18	18	52	71	18	18	98	34	28	28	27	428
1974	18	357	261	369	17	221	18	98	48	39	28	27	1501
1975	18	18	18	18	17	95	18	98	49	30	28	27	434
1976	18	18	18	18	17	18	18	98	34	28	28	27	341
1977	18	18	18	18	17	18	18	98	34	28	28	27	340
1978	18	18	18	19	17	18	18	98	34	28	28	27	341
1979	18	18	18	18	17	18	18	98	34	28	28	27	340
1980	18	18	18	60	220	18	18	98	34	28	28	27	585
1981	18	18	18	18	17	18	18	98	34	28	28	27	340
1982	18	18	98	18	176	18	60	98	34	28	28	27	622
1983	18	18	158	181	181	369	18	269	294	211	28	27	1771
1984	18	18	313	18	17	18	18	98	34	28	28	27	636
1985	18	18	18	18	17	18	18	98	34	28	28	27	340
1986	18	18	18	18	17	18	18	98	34	28	28	27	340
1987	18	18	18	18	17	18	18	98	34	28	28	27	340
1988	18	18	18	18	17	18	18	98	34	28	28	27	341
1989	18	18	18	18	17	18	18	98	34	28	28	27	340
1990	18	18	18	18	17	18	18	98	34	28	28	27	340
1991	18	18	18	18	17	18	18	98	34	28	28	27	340
1992	18	18	18	18	17	18	18	98	34	28	28	27	341
1993	18	18	18	18	17	18	18	98	34	28	28	27	340
Avg.	19	23	34	39	35	34	22	105	40	33	28	27	436
Min.	18	18	18	18	17	18	18	98	34	28	28	27	340
Max.	27	357	313	369	333	369	162	269	294	211	28	27	1771

Trinity

No Action [EWA], Tracy Export (TAF)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1922	270	243	260	185	236	263	174	92	179	282	279	266	2729
1923	268	253	260	134	141	162	152	118	179	283	280	267	2494
1924	268	253	260	260	206	49	48	76	48	49	105	167	1789
1925	153	103	240	237	226	49	163	129	152	171	172	263	2058
1926	228	181	163	260	235	136	48	49	50	114	139	217	1819
1927	95	251	259	259	235	222	175	140	179	283	280	267	2645
1928	265	253	260	260	244	263	163	69	179	282	279	262	2779
1929	230	246	240	260	206	58	48	49	87	162	160	177	1923
1930	192	115	259	259	192	261	100	105	100	107	105	204	1999
1931	219	147	84	184	167	65	48	49	48	49	153	158	1371
1932	131	91	259	259	243	116	113	126	108	141	188	256	2031
1933	229	93	48	47	60	37	48	55	48	49	37	173	923
1934	188	52	259	257	43	60	48	49	48	37	37	128	1204
1935	82	226	184	259	115	259	152	49	153	101	275	260	2116
1936	131	115	196	259	243	189	150	92	160	219	277	264	2296
1937	202	142	253	260	190	125	93	49	139	277	276	262	2268
1938	248	252	163	49	47	102	89	92	179	282	279	266	2048
1939	267	253	94	113	138	143	111	124	132	254	217	234	2079
1940	133	122	131	260	244	261	152	118	179	278	276	263	2416
1941	257	162	259	260	235	257	175	140	179	283	280	267	2754
1942	269	253	260	174	189	163	152	49	179	281	279	266	2513
1943	267	253	260	94	209	86	159	92	151	282	280	266	2399
1944	268	196	260	260	244	263	111	49	179	280	278	265	2652
1945	165	253	260	260	236	263	149	140	179	282	279	266	2731
1946	268	253	260	260	236	201	118	118	179	281	278	266	2716
1947	253	253	260	260	236	262	109	102	179	280	260	265	2718
1948	152	178	180	260	244	208	152	118	179	281	278	266	2494
1949	267	219	243	260	176	261	107	118	155	281	278	266	2630
1950	200	253	159	185	236	261	143	49	147	277	276	262	2447
1951	264	252	259	252	100	163	153	92	147	282	279	266	2509
1952	268	221	260	185	244	263	152	49	179	280	278	266	2644
1953	267	253	260	104	128	111	144	69	179	281	279	266	2339
1954	267	253	260	260	236	263	163	129	178	282	279	266	2835
1955	252	253	260	260	172	142	103	114	175	237	226	233	2427
1956	193	252	184	185	244	263	175	92	179	282	280	266	2596
1957	268	253	260	260	236	237	160	69	179	282	279	266	2748
1958	268	253	185	185	236	263	152	49	179	282	279	266	2595
1959	267	253	260	136	138	161	108	121	179	282	280	254	2438
1960	195	230	159	185	227	236	48	49	107	275	274	198	2182
1961	178	251	239	242	235	249	96	99	179	281	271	239	2560
1962	207	253	260	194	236	263	120	69	141	280	278	265	2565
1963	266	253	260	260	236	240	162	140	179	283	281	267	2825
1964	269	254	260	260	166	145	48	110	117	277	276	232	2414
1965	154	244	259	260	235	263	152	118	179	283	280	267	2692
1966	268	253	260	260	236	263	129	69	179	282	279	263	2741
1967	219	253	260	185	236	263	175	92	179	281	279	266	2687
1968	267	253	227	109	134	162	133	117	143	283	280	251	2358
1969	223	253	260	260	236	262	122	49	179	282	279	266	2671
1970	268	252	94	96	101	161	157	140	179	283	280	253	2264
1971	260	253	236	260	236	263	163	129	179	282	280	266	2807
1972	268	253	260	260	244	263	98	103	179	280	278	241	2726
1973	254	253	260	185	236	263	144	49	143	281	279	266	2612
1974	267	253	185	185	236	263	175	92	178	281	279	266	2660
1975	267	253	260	185	236	263	152	49	179	281	279	266	2669
1976	267	253	260	260	148	147	48	78	96	49	104	172	1881
1977	148	91	49	157	44	49	48	49	89	242	192	167	1324
1978	184	85	259	184	234	263	89	92	179	282	280	266	2398
1979	268	186	159	260	232	167	143	118	179	283	280	267	2540
1980	268	235	260	260	244	252	122	92	160	282	280	266	2722
1981	268	218	260	130	145	161	142	118	168	283	280	250	2422
1982	218	253	185	185	236	262	152	49	179	279	277	265	2540
1983	266	215	49	49	63	103	89	92	179	282	279	266	1931
1984	267	130	75	94	136	162	136	49	132	281	279	265	2005
1985	267	253	260	260	203	173	48	116	141	281	278	266	2545
1986	213	174	185	185	236	262	175	92	156	273	277	265	2493
1987	266	213	254	260	129	122	102	95	178	253	218	217	2306
1988	168	213	259	260	244	49	82	87	48	57	89	174	1730
1989	191	150	174	218	85	259	138	118	140	244	265	219	2201
1990	233	232	247	260	218	146	48	49	48	49	67	141	1737
1991	181	72	49	112	65	260	48	49	71	52	137	254	1349
1992	181	108	123	165	243	218	98	87	48	49	108	177	1606
1993	187	169	257	185	235	263	163	69	179	281	278	266	2530
Avg.	227	211	216	209	194	195	121	88	147	236	242	244	2331
Min.	82	52	48	47	43	37	48	49	48	37	37	128	923
Max.	270	254	260	260	244	263	175	140	179	283	281	267	2835

Trinity

No Action [EWA], Banks Export (TAF)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1922	214	177	327	468	472	465	200	224	397	441	415	352	4153
1923	326	297	334	496	269	246	176	146	210	441	441	389	3771
1924	308	141	329	301	206	18	18	76	18	18	275	118	1827
1925	137	147	240	237	256	18	173	140	161	110	21	258	1899
1926	113	98	163	311	302	94	164	114	139	379	296	173	2347
1927	206	397	322	332	456	448	204	220	270	329	411	303	3898
1928	296	397	434	455	358	442	192	69	180	269	435	299	3828
1929	195	191	240	343	206	112	42	18	72	245	229	94	1987
1930	68	18	315	324	192	318	100	105	81	413	351	177	2461
1931	126	47	78	242	129	78	18	43	64	296	109	87	1317
1932	70	80	331	358	349	291	64	126	304	136	343	223	2675
1933	112	161	145	215	295	301	78	72	132	153	18	64	1747
1934	91	63	293	292	318	75	18	18	39	197	205	157	1766
1935	116	202	184	361	236	446	180	20	359	441	410	304	3260
1936	306	170	241	449	485	465	196	171	301	441	405	300	3930
1937	143	129	254	412	472	465	180	174	322	374	339	276	3541
1938	189	397	265	509	472	465	204	224	397	411	411	427	4372
1939	411	308	434	456	180	177	83	124	95	441	406	321	3437
1940	226	161	181	367	482	465	180	162	267	441	441	319	3694
1941	287	154	442	511	472	465	204	224	397	272	411	427	4266
1942	411	298	460	523	404	427	180	201	397	238	411	427	4377
1943	411	397	447	491	422	423	204	130	276	124	411	318	4054
1944	222	135	251	336	329	316	111	115	195	441	425	343	3220
1945	239	397	321	273	472	427	149	155	234	441	415	348	3873
1946	243	393	338	509	220	338	118	135	247	441	441	370	3794
1947	291	252	323	237	318	254	109	96	176	441	364	314	3177
1948	210	221	180	290	120	208	179	201	319	441	441	370	3181
1949	208	170	243	282	176	324	107	113	237	290	264	289	2704
1950	43	116	159	269	422	249	143	141	347	441	441	327	3099
1951	375	397	351	523	472	426	153	183	263	375	441	338	4297
1952	263	281	442	523	482	465	180	201	363	377	393	427	4396
1953	411	342	395	180	297	442	144	205	397	210	411	427	3859
1954	389	397	362	445	413	437	192	198	159	437	384	397	4209
1955	300	372	318	449	124	142	91	114	190	220	80	202	2604
1956	92	229	277	296	485	465	177	224	299	411	411	427	3792
1957	411	229	192	370	416	452	160	69	244	200	394	305	3441
1958	411	397	430	451	434	465	180	201	397	296	411	427	4502
1959	411	256	314	453	252	107	108	121	250	411	441	324	3448
1960	249	96	216	353	273	275	18	111	227	385	208	271	2681
1961	56	267	239	242	294	216	96	69	61	441	359	299	2640
1962	198	205	275	161	472	423	120	67	288	376	393	360	3337
1963	411	397	316	448	431	438	204	224	269	266	411	417	4233
1964	411	397	336	445	124	145	42	110	232	441	411	395	3489
1965	194	316	333	523	472	318	180	121	196	232	430	322	3637
1966	229	397	467	508	282	444	129	69	202	441	441	329	3939
1967	242	396	329	477	430	463	204	224	397	441	436	427	4467
1968	411	358	432	393	381	402	133	117	143	302	441	323	3837
1969	242	258	321	523	472	465	180	201	363	222	411	427	4085
1970	411	383	438	384	371	403	157	145	224	330	441	349	4037
1971	333	397	236	459	118	434	171	212	329	411	411	427	3939
1972	411	330	431	446	264	427	98	103	129	331	373	274	3616
1973	209	397	317	460	466	465	144	154	334	401	409	353	4110
1974	411	397	263	523	458	465	204	224	273	344	411	427	4399
1975	411	354	432	450	470	465	177	201	366	411	411	427	4577
1976	411	397	431	373	183	175	42	78	59	402	381	244	3176
1977	191	180	110	157	63	72	39	43	86	80	281	96	1397
1978	36	82	283	282	472	465	89	222	282	441	415	371	3441
1979	326	153	430	489	259	465	143	143	251	362	405	302	3728
1980	241	276	320	523	485	465	179	181	301	258	411	356	3997
1981	297	87	302	454	239	445	142	118	168	441	407	330	3431
1982	242	397	261	523	472	465	180	201	397	411	411	427	4388
1983	411	397	472	347	201	219	204	92	231	441	441	427	3884
1984	345	207	137	445	398	410	136	128	301	326	441	397	3673
1985	328	397	433	385	203	173	42	116	200	441	422	397	3538
1986	289	288	261	455	472	465	203	169	290	411	411	347	4061
1987	277	63	151	316	229	238	102	20	178	441	391	346	2753
1988	181	123	316	324	115	66	82	87	20	153	18	68	1555
1989	40	159	174	218	69	317	138	119	194	441	411	331	2612
1990	336	92	269	435	131	191	18	79	18	54	255	119	1996
1991	80	18	80	104	67	322	42	43	18	190	18	63	1045
1992	70	24	123	165	316	218	98	87	20	162	29	206	1518
1993	33	33	257	296	468	457	192	212	397	441	409	322	3519
Avg.	253	246	299	381	326	335	135	136	231	336	357	312	3346
Min.	33	18	78	104	63	18	18	18	18	18	18	63	1045
Max.	411	397	472	523	485	465	204	224	397	441	441	427	4577

Trinity

No Action [EWA], Delta Inflows (TAF)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1922	815	742	1320	1240	2665	2312	1862	3507	2610	1509	1124	949	20656
1923	918	988	2224	2181	1170	1165	1859	1363	1109	1395	1145	1007	16524
1924	910	882	930	971	1048	746	562	587	634	725	743	561	9299
1925	578	603	954	885	4045	1782	1686	1180	1067	863	628	799	15072
1926	697	614	714	1195	2583	984	1715	1016	795	1125	846	682	12967
1927	711	1613	1380	2101	7770	3035	3242	1944	1282	1498	1126	874	26575
1928	903	1244	1164	1592	1581	6680	1916	1316	1023	1334	1160	862	20774
1929	815	844	907	927	1055	881	593	644	725	921	847	558	9716
1930	588	515	1278	1477	1182	2207	933	911	789	1102	946	661	12588
1931	674	594	599	976	748	605	601	537	641	902	699	534	8110
1932	558	513	1540	1570	1552	1162	956	1022	1299	870	1028	784	12856
1933	702	609	653	995	788	966	836	611	791	759	560	530	8800
1934	575	531	1079	1305	1001	931	807	589	736	769	655	577	9555
1935	565	804	755	2212	1002	2009	3486	1847	1470	1244	1150	877	17421
1936	837	656	789	2707	4682	2270	1815	1401	1315	1378	1144	866	19859
1937	730	663	867	1039	2902	3194	1941	1682	1315	1347	1082	839	17604
1938	787	1587	4426	2260	8206	10683	4955	4980	3478	1477	1140	1271	45249
1939	1473	896	1067	1003	901	1109	921	997	828	1297	1103	852	12447
1940	768	630	677	2447	3935	7025	4494	1545	1272	1511	1169	893	26366
1941	885	844	3252	6318	7185	6185	4821	3197	1720	1343	1118	1132	38000
1942	1050	880	4404	5265	8150	2001	3369	2752	2129	1307	1140	1197	33644
1943	1128	1200	2100	5723	3702	5819	2171	1700	1220	1219	1133	898	28011
1944	831	747	852	1043	1700	1655	1064	1025	1066	1314	1128	935	13360
1945	860	1038	1203	961	3086	1965	1236	1223	1246	1434	1145	943	16339
1946	826	1174	4666	3512	1825	1540	1150	1240	1215	1410	1173	976	20706
1947	939	898	1148	867	1228	1471	1043	882	1011	1316	1093	889	12786
1948	784	730	765	1102	1038	1188	1900	1980	1421	1411	1169	976	14464
1949	851	790	956	831	834	3263	1022	1103	1120	1162	940	852	13724
1950	687	699	734	1468	2228	1458	1454	1312	1412	1418	1167	903	14940
1951	997	3458	6286	4555	4328	2235	1287	1527	1171	1457	1160	927	29388
1952	859	995	3158	5796	4879	4636	4582	4950	3167	1438	1124	1507	37092
1953	1479	916	2985	6640	1642	1577	1321	1896	1758	1386	1118	1264	23983
1954	1006	1156	967	2295	3666	3386	2787	1816	961	1507	1092	1019	21658
1955	943	1084	1641	1349	934	854	970	1014	1043	1035	754	725	12346
1956	702	830	6287	10456	5395	2817	1582	3006	1623	1467	1131	1312	36607
1957	1161	823	801	1081	2200	3212	1514	1312	1209	1278	1112	877	16580
1958	1508	1007	1571	2585	10359	6287	6209	3734	2679	1343	1135	1414	39829
1959	1414	849	919	2464	3292	1595	880	971	1224	1427	1163	886	17084
1960	788	814	714	923	1882	1459	832	983	954	1276	919	769	12313
1961	699	835	1092	862	2056	1326	887	851	897	1327	1116	826	12775
1962	849	816	1117	718	3160	1958	1026	1092	1224	1345	1113	961	15379
1963	2323	1067	1809	1127	4386	2256	5508	2324	1347	1418	1132	1051	25748
1964	1168	1830	938	1598	970	873	952	968	996	1308	1164	964	13730
1965	694	979	5273	7574	2303	1781	3106	1804	1069	1434	1130	903	28050
1966	844	1585	1351	2275	1758	2087	1142	1074	1087	1384	1168	908	16663
1967	914	1010	2786	3156	3347	4092	3574	3953	3467	1580	1168	1481	30528
1968	1446	942	1168	2019	3869	2567	1187	919	991	1308	1113	880	18409
1969	892	883	1648	7798	7821	4373	3877	4725	2882	1291	1154	1328	38672
1970	1534	976	3954	13136	5142	2750	1337	1112	1149	1614	1172	925	34803
1971	928	1271	4196	3329	1787	3042	1651	2059	1448	1583	1134	1269	23698
1972	1041	916	1228	1271	1622	2348	901	891	1248	1293	1092	792	14643
1973	832	1352	1717	5349	5366	4068	1471	1453	1362	1459	1131	950	26509
1974	1042	3934	4451	8413	2672	7216	4602	1995	1527	1382	1140	1526	39900
1975	1266	943	1182	1098	4069	5895	1881	2299	1813	1452	1118	1362	24377
1976	1327	1078	1134	974	911	1096	723	618	665	971	856	703	11056
1977	688	595	644	613	527	572	650	475	744	1006	838	536	7888
1978	580	513	1075	4346	3527	4572	3079	1964	1577	1513	1158	978	24884
1979	957	742	1000	1733	2713	2538	1463	1336	1347	1322	1118	872	17142
1980	893	921	1344	6968	7901	4003	1614	1503	1317	1289	1124	956	29832
1981	912	681	1014	1573	1689	2375	1300	935	960	1324	1178	890	14830
1982	839	2236	5713	5063	6034	5878	8595	3655	1995	1456	1125	1574	44165
1983	2081	2862	5637	6622	9988	15615	5541	5153	5568	2646	1509	2041	65264
1984	1947	5092	9746	4565	2665	2666	1366	1171	1237	1607	1162	1017	34241
1985	913	2186	1559	994	1038	1080	989	1032	972	1312	1167	1018	14261
1986	874	812	1210	1657	11846	9581	1904	1371	1275	1456	1250	941	34177
1987	888	647	779	1001	1269	1724	954	803	1015	1269	1054	864	12266
1988	827	651	1273	1885	1023	670	708	717	720	755	537	532	10299
1989	584	672	731	905	599	2966	1393	1066	955	1307	1194	843	13217
1990	932	803	864	1314	971	960	766	619	570	687	771	553	9809
1991	553	508	566	504	551	2236	991	705	538	778	619	623	9173
1992	556	508	531	772	2143	1422	904	718	716	735	572	683	10260
1993	573	519	1005	4122	3564	3153	2668	2404	1854	1508	1146	903	23418
Avg.	940	1081	1923	2773	3162	2973	2015	1654	1376	1293	1050	945	21185
Min.	553	508	531	504	527	572	562	475	538	687	537	530	7888
Max.	2323	5092	9746	13136	11846	15615	8595	5153	5568	2646	1509	2041	65264

Trinity

No Action [EWA], Total Delta Outflow (TAF)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1922	246	268	724	683	2127	1551	1399	3045	1771	492	246	212	12765
1923	246	398	1783	1653	736	681	1500	952	495	400	246	254	9343
1924	246	419	277	414	623	621	381	248	313	411	198	179	4329
1925	236	302	485	445	3711	1672	1324	831	512	307	272	185	10283
1926	271	278	328	654	2158	673	1480	693	293	307	215	179	7530
1927	330	944	733	1567	7255	2318	2816	1436	578	596	246	193	19012
1928	272	543	443	916	969	6010	1470	1011	392	499	246	182	12953
1929	294	365	406	343	633	657	409	402	359	246	274	179	4567
1930	241	321	660	964	831	1627	650	570	346	307	318	179	7015
1931	246	340	367	592	452	394	403	283	293	251	239	179	4039
1932	266	289	1072	1012	1059	692	677	614	608	307	301	179	7075
1933	262	286	405	802	409	595	598	352	360	246	306	179	4799
1934	207	346	498	766	710	712	595	345	410	246	218	179	5233
1935	277	333	360	1717	634	1353	3169	1626	660	400	246	179	10953
1936	316	304	296	2084	4203	1568	1387	988	602	400	246	179	12573
1937	291	320	324	431	2400	2780	1583	1286	589	400	254	179	10837
1938	258	886	4000	1770	8004	10238	4592	4504	2622	492	246	458	38070
1939	711	268	472	441	571	762	598	575	320	307	279	179	5483
1940	318	280	300	1992	3472	6341	4085	1103	526	492	246	198	19354
1941	246	461	2626	5763	6641	5467	4450	2703	882	492	246	318	30295
1942	285	268	3688	4752	7594	1379	3055	2380	1275	492	246	386	25799
1943	354	504	1357	5291	3082	5341	1741	1314	531	524	246	188	20473
1944	246	348	284	460	1225	1011	768	710	438	307	215	195	6207
1945	370	346	610	440	2448	1306	828	777	544	400	246	202	8517
1946	246	468	4113	2753	1352	955	802	833	519	400	246	217	12903
1947	301	349	522	369	681	935	705	492	392	307	276	179	5507
1948	356	268	339	543	645	752	1541	1556	684	400	246	225	7555
1949	291	330	431	303	485	2720	699	708	449	307	215	185	7124
1950	351	268	361	1086	1585	910	1071	950	648	400	246	208	8082
1951	287	2790	5789	3897	3782	1606	899	1112	493	511	246	203	21616
1952	247	444	2526	5384	4155	3964	4197	4537	2386	492	246	690	29267
1953	699	268	2377	6429	1182	966	966	1493	950	574	246	449	16597
1954	254	444	277	1597	3013	2680	2350	1322	365	492	246	238	13279
1955	290	406	1047	756	633	512	726	650	419	307	246	179	6171
1956	326	292	6010	10250	4661	2018	1168	2554	869	492	246	514	29401
1957	401	268	277	457	1568	2487	1120	1085	517	505	246	196	9127
1958	761	287	912	2098	9970	5684	5929	3353	1860	492	246	600	32191
1959	635	268	277	1902	2970	1255	540	547	508	431	246	244	9823
1960	246	415	277	419	1434	899	678	674	333	307	233	179	6094
1961	368	287	554	460	1512	843	604	538	369	307	297	179	6317
1962	347	315	522	369	2694	1236	675	789	509	400	246	217	8321
1963	1620	350	1207	535	3779	1608	5205	1840	641	595	246	256	17881
1964	412	1136	277	966	644	517	747	577	420	307	285	224	6512
1965	271	372	4741	6907	1571	1149	2736	1405	446	645	246	204	20693
1966	246	903	629	1562	1248	1312	759	754	437	400	246	200	8698
1967	354	338	2227	2822	2659	3408	3242	3490	2659	565	246	669	22679
1968	670	268	446	1572	3365	1982	816	518	418	427	246	184	10913
1969	337	324	1045	7314	7326	3602	3493	4299	2091	492	246	510	31078
1970	779	276	3406	12930	4670	2132	917	636	480	702	246	196	27370
1971	246	621	3833	2637	1405	2305	1230	1593	680	601	246	453	15848
1972	268	268	507	572	1095	1566	601	490	662	400	246	179	6851
1973	315	748	1150	5036	4835	3350	1079	1059	590	492	246	214	19114
1974	295	3273	4059	7790	1951	6501	4168	1514	806	492	246	704	31799
1975	499	268	437	459	3438	5234	1486	1880	985	492	246	541	15965
1976	582	357	369	325	548	674	529	246	244	246	240	186	4547
1977	254	267	426	300	382	376	422	267	307	400	184	179	3763
1978	266	294	519	4185	2919	3939	2861	1486	848	492	251	217	18277
1979	246	353	339	1117	2359	1878	1097	910	628	400	246	179	9750
1980	308	351	760	6347	7380	3258	1234	1088	605	492	246	219	22289
1981	246	305	394	1030	1288	1779	917	527	328	307	291	199	7611
1982	306	1568	5290	4629	5356	5330	8261	3241	1175	492	246	804	36697
1983	1336	2309	5155	6510	9921	15588	5251	4828	4889	1648	593	1240	59269
1984	1241	4751	9642	4022	2132	2036	999	807	532	710	246	224	27342
1985	248	1554	851	369	622	751	793	610	345	307	280	254	6984
1986	283	317	753	1101	11467	8923	1449	951	556	492	359	234	26885
1987	246	300	311	426	929	1364	626	494	386	307	251	179	5820
1988	393	268	675	1384	639	484	453	392	410	246	238	179	5760
1989	258	312	339	468	436	2385	991	644	351	307	312	223	7025
1990	283	422	277	642	633	549	586	407	238	293	261	179	4769
1991	205	352	377	277	391	1679	799	470	241	246	280	179	5494
1992	230	310	223	447	1702	984	608	356	398	246	236	179	5918
1993	272	249	514	4030	3053	2441	2221	2000	1050	492	246	179	16746
Avg.	374	575	1393	2274	2700	2434	1683	1274	734	433	257	275	14406
Min.	205	249	223	277	382	376	381	246	238	246	184	179	3763
Max.	1620	4751	9642	12930	11467	15588	8261	4828	4889	1648	593	1240	59269

Trinity

No Action [EWA], CVP Delivery North of Delta (TAF)
(sum of CALSIM variables D300, D8, D9, D302, D167A_IMI, D167B_IMI, D162_IMI, D168B, D168C_FRWP, and Del_CVP_Total_N)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1922	95	40	33	29	28	29	399	459	557	567	506	273	3014
1923	58	40	34	29	28	97	284	486	540	577	510	186	2869
1924	95	49	34	29	28	55	316	353	385	388	336	168	2235
1925	33	29	24	21	20	24	247	346	513	562	500	232	2550
1926	110	39	32	27	26	56	164	402	523	528	463	257	2628
1927	58	37	30	25	25	31	336	462	531	577	512	273	2900
1928	65	40	34	29	28	25	283	466	542	552	495	265	2823
1929	108	40	33	29	28	36	340	439	406	483	433	235	2609
1930	97	52	30	25	24	22	249	397	519	523	467	223	2629
1931	95	37	30	25	25	68	327	308	353	400	348	173	2190
1932	67	31	25	22	21	42	296	321	405	422	377	204	2232
1933	89	40	29	25	25	48	328	329	394	398	346	173	2223
1934	60	45	27	23	22	34	299	355	404	424	368	183	2245
1935	65	32	27	23	22	22	140	422	545	549	491	262	2601
1936	69	42	32	27	26	30	285	417	472	539	485	255	2680
1937	106	57	32	27	27	24	273	454	489	534	478	261	2763
1938	70	39	32	27	26	26	252	440	572	578	512	235	2810
1939	71	44	34	29	51	116	442	398	507	509	459	210	2868
1940	82	52	31	26	25	25	292	397	564	576	510	267	2848
1941	66	40	33	29	28	26	146	342	559	587	519	276	2651
1942	68	40	34	29	28	26	153	384	573	587	519	272	2712
1943	105	40	34	29	28	26	263	471	557	577	512	274	2916
1944	107	43	34	29	28	38	324	404	515	546	489	265	2820
1945	79	38	31	26	25	25	342	401	524	579	512	274	2858
1946	46	40	33	29	28	35	418	466	548	544	495	260	2942
1947	104	40	34	29	28	25	344	449	477	551	490	266	2837
1948	46	38	31	26	36	48	136	303	487	585	515	250	2502
1949	89	43	33	29	29	24	336	418	553	558	498	264	2874
1950	116	41	33	29	28	33	351	452	513	526	470	238	2828
1951	46	39	32	27	26	39	400	400	566	572	508	269	2925
1952	54	40	34	29	28	26	314	471	516	571	510	268	2860
1953	117	40	34	29	28	57	301	440	533	576	472	272	2900
1954	101	40	34	29	28	24	246	459	545	572	459	266	2804
1955	106	39	32	27	26	71	314	443	511	516	462	219	2764
1956	91	38	31	26	25	67	362	397	544	576	510	246	2913
1957	69	56	34	29	28	52	354	411	576	585	517	151	2862
1958	51	46	34	29	28	26	157	376	526	565	511	269	2617
1959	110	55	34	29	28	45	428	497	545	549	483	134	2936
1960	111	56	31	26	25	23	310	386	499	503	451	244	2666
1961	98	37	30	25	25	22	320	445	523	552	488	240	2804
1962	106	38	31	26	25	24	372	472	540	566	500	259	2960
1963	43	39	32	27	26	26	149	400	568	586	518	273	2686
1964	63	40	34	29	28	80	422	441	466	501	444	222	2770
1965	60	37	30	25	25	60	251	482	567	576	441	273	2826
1966	118	40	33	29	28	44	406	479	531	535	479	257	2981
1967	111	39	32	27	26	26	136	445	477	583	515	272	2688
1968	109	40	34	29	28	24	360	469	522	570	453	268	2905
1969	77	39	32	27	26	27	335	493	546	566	507	268	2941
1970	80	42	34	29	28	25	384	483	503	546	489	263	2903
1971	74	39	32	27	26	51	440	406	538	559	499	261	2951
1972	109	41	34	29	31	122	405	450	506	532	476	209	2941
1973	48	38	31	26	26	26	344	478	567	572	509	257	2923
1974	57	40	34	29	28	26	265	476	560	499	513	275	2800
1975	71	41	34	29	28	26	290	484	571	565	501	274	2912
1976	48	44	34	29	52	145	338	426	457	466	371	201	2610
1977	94	38	28	23	34	90	358	266	397	402	351	125	2206
1978	77	29	24	21	20	26	202	457	571	580	512	224	2744
1979	121	40	34	29	28	26	308	476	573	579	506	259	2977
1980	53	40	34	29	28	26	309	443	538	567	511	268	2846
1981	105	51	34	29	28	23	284	427	565	570	505	239	2860
1982	47	38	31	26	25	26	179	465	521	589	521	182	2651
1983	45	40	34	29	28	26	158	420	549	584	499	230	2641
1984	98	40	34	29	28	50	413	496	531	552	470	259	2999
1985	61	39	32	27	26	24	356	486	553	565	496	193	2855
1986	84	39	32	27	26	24	280	439	544	548	491	202	2736
1987	107	52	33	28	27	23	356	461	512	515	462	250	2826
1988	86	37	30	25	24	77	296	352	439	479	429	232	2505
1989	97	35	28	23	29	24	333	491	523	556	491	86	2717
1990	56	40	32	27	26	53	385	263	475	481	414	225	2477
1991	94	41	29	24	28	21	219	331	403	425	378	204	2198
1992	70	37	27	24	23	21	230	381	403	451	404	217	2288
1993	45	38	27	23	22	26	312	345	493	579	506	274	2687
Avg.	80	41	32	27	27	40	302	422	513	538	474	237	2732
Min.	33	29	24	21	20	21	136	263	353	388	336	86	2190
Max.	121	57	34	29	52	145	442	497	576	589	521	276	3014

Trinity

No Action [EWA], CVP Delivery So w/ CVC (TAF)
(equals CALSIM variable CVPTotalDel)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1922	204	123	107	137	166	150	187	305	439	538	453	277	3086
1923	192	114	95	116	141	160	195	310	456	562	456	285	3082
1924	195	117	99	122	148	78	87	126	165	174	168	135	1612
1925	112	61	36	29	39	135	158	238	348	413	358	236	2162
1926	173	99	75	84	105	121	140	193	277	315	284	205	2069
1927	159	89	61	60	76	157	195	316	470	581	486	288	2938
1928	198	119	101	126	153	148	175	294	429	525	443	273	2984
1929	190	113	93	113	137	108	123	173	239	263	244	188	1984
1930	151	83	52	47	61	124	151	213	303	352	312	216	2065
1931	164	93	66	69	87	75	83	120	156	162	158	131	1363
1932	110	59	34	25	35	96	110	153	216	245	222	159	1466
1933	123	70	48	47	60	79	91	126	174	188	178	140	1325
1934	114	63	39	32	43	97	112	162	221	252	227	161	1523
1935	124	71	50	49	62	92	120	224	311	363	320	220	2006
1936	166	94	68	72	90	148	176	257	363	434	374	243	2484
1937	176	102	78	89	111	123	164	239	336	396	345	230	2390
1938	170	97	72	80	100	151	191	299	430	526	444	274	2835
1939	190	113	93	113	137	141	181	266	387	467	399	254	2743
1940	181	106	84	98	120	125	148	243	350	416	360	234	2464
1941	173	99	75	85	105	159	195	324	470	581	486	291	3042
1942	198	119	101	126	153	161	195	294	421	514	435	270	2986
1943	188	112	92	110	134	155	195	310	448	551	463	281	3038
1944	193	116	97	119	144	152	180	268	391	473	404	256	2793
1945	182	107	85	99	122	153	187	308	445	547	460	277	2972
1946	193	115	96	118	143	149	177	287	418	509	424	268	2898
1947	188	111	91	109	132	131	184	272	396	479	408	258	2759
1948	183	107	86	101	124	108	156	280	407	494	420	263	2729
1949	185	109	88	105	128	126	186	277	408	495	421	263	2793
1950	185	110	88	105	128	125	164	234	335	395	345	230	2444
1951	170	97	72	80	99	161	189	296	435	534	450	276	2859
1952	191	114	94	115	139	146	179	284	406	493	419	263	2844
1953	185	109	88	105	128	157	188	291	423	516	437	268	2895
1954	189	112	92	111	135	148	181	295	431	528	445	274	2940
1955	190	113	94	113	138	146	176	255	362	433	373	242	2636
1956	176	102	78	89	110	152	189	308	448	551	463	281	2947
1957	193	116	97	119	144	161	189	300	435	533	450	276	3014
1958	191	114	94	115	139	150	190	300	432	528	446	274	2974
1959	190	114	94	114	138	160	187	306	447	549	450	293	3040
1960	193	116	97	119	144	108	142	200	282	322	289	207	2218
1961	160	90	62	62	78	139	194	291	417	508	430	268	2698
1962	187	111	91	108	132	150	184	267	394	477	407	257	2766
1963	183	107	85	100	123	158	194	322	476	590	493	291	3123
1964	199	120	102	129	156	139	165	236	338	400	348	232	2563
1965	171	98	73	81	101	149	177	313	461	569	477	287	2956
1966	196	118	99	124	150	154	185	297	432	529	446	275	3004
1967	191	114	94	114	138	145	176	293	420	513	434	269	2901
1968	188	112	91	110	134	160	187	311	454	560	470	284	3060
1969	195	117	98	121	147	151	195	302	434	532	449	276	3017
1970	191	114	94	115	139	159	189	316	463	572	479	288	3120
1971	196	118	100	124	151	154	183	307	449	552	438	293	3066
1972	194	116	97	119	145	147	180	281	402	487	415	261	2844
1973	184	109	87	103	126	158	195	293	420	512	434	269	2888
1974	188	112	91	109	133	148	186	297	427	522	441	272	2927
1975	190	113	93	112	136	156	195	294	421	514	435	270	2929
1976	188	112	92	110	134	108	122	172	238	261	243	187	1967
1977	151	83	52	46	61	87	98	140	184	213	193	146	1453
1978	117	65	42	37	49	152	195	310	448	551	463	279	2708
1979	193	116	97	119	144	166	195	315	456	561	471	283	3116
1980	196	117	98	122	148	152	195	310	448	551	463	281	3080
1981	193	116	97	119	144	160	189	305	450	553	465	282	3074
1982	194	116	97	120	145	136	167	267	379	456	391	250	2719
1983	179	105	82	95	117	151	190	298	428	524	443	273	2885
1984	190	113	93	112	137	160	189	285	418	510	432	268	2908
1985	188	111	91	109	133	153	187	283	413	502	379	313	2862
1986	187	110	90	107	130	133	170	271	385	464	397	253	2697
1987	181	106	83	97	119	120	188	269	390	471	402	255	2682
1988	182	106	84	99	121	102	114	166	219	235	223	178	1829
1989	147	79	48	39	53	92	172	251	354	422	365	239	2261
1990	174	100	76	86	107	95	105	153	199	207	202	169	1673
1991	143	76	43	32	45	83	102	147	197	219	202	150	1439
1992	119	67	44	40	52	104	143	208	294	353	304	193	1921
1993	138	81	64	74	91	146	181	286	409	498	423	264	2655
Avg.	176	103	82	95	117	136	168	261	375	453	386	247	2600
Min.	110	59	34	25	35	75	83	120	156	162	158	131	1325
Max.	204	123	107	137	166	166	195	324	476	590	493	313	3123

Trinity

No Action [EWA], X2_PRV (KM)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	
1922	74.9	83.2	85.0	78.2	76.4	66.4	66.3	66.8	61.2	63.3	74.1	82.9	
1923	86.7	87.0	83.2	70.7	67.2	71.5	74.2	68.8	70.8	76.2	79.9	84.8	
1924	85.9	86.8	82.7	84.8	82.4	78.0	77.1	80.3	84.9	84.4	82.3	87.3	
1925	89.4	88.2	85.7	81.5	80.8	63.5	64.8	66.7	71.2	76.1	81.9	84.7	
1926	88.3	86.8	85.9	84.6	78.9	67.0	72.9	68.5	73.1	81.0	83.5	87.0	
1927	89.3	85.7	76.1	75.2	69.1	54.5	59.3	59.1	64.5	73.0	75.8	83.5	
1928	87.6	86.6	80.7	80.6	75.0	72.2	57.8	63.6	68.6	77.3	78.5	84.4	
1929	88.3	86.2	83.6	82.2	83.0	77.8	76.6	79.6	80.9	82.0	85.5	85.8	
1930	89.0	87.9	85.1	79.0	74.0	72.8	68.0	73.2	76.2	80.7	83.4	84.0	
1931	88.4	87.6	84.6	83.3	79.2	79.1	81.0	81.1	84.2	84.6	86.2	87.1	
1932	89.4	87.3	85.7	75.5	72.5	70.7	73.9	74.8	76.1	76.4	82.0	83.9	
1933	88.3	87.1	85.8	82.9	76.7	79.1	77.8	77.1	81.1	82.1	85.5	85.0	
1934	88.7	89.0	84.9	81.1	76.5	74.8	75.0	76.2	81.0	81.0	85.2	87.5	
1935	89.5	87.1	84.6	83.4	71.1	73.9	69.8	61.7	64.4	71.9	78.5	84.3	
1936	88.5	85.7	84.8	85.0	70.1	59.3	63.9	66.1	69.6	74.3	79.3	84.6	
1937	88.6	86.4	84.7	84.3	81.9	67.2	62.1	64.4	67.1	73.7	79.0	84.3	
1938	88.5	87.3	77.2	62.5	64.0	52.1	47.1	51.4	53.2	57.7	72.2	82.3	
1939	80.6	76.9	82.9	80.8	80.6	77.8	75.5	76.3	77.1	81.6	83.7	85.1	
1940	88.7	85.7	85.5	85.1	70.5	60.9	53.7	54.4	65.0	73.8	77.5	84.0	
1941	87.6	87.3	82.2	67.4	56.5	51.1	51.6	53.1	57.7	67.5	75.4	83.3	
1942	83.7	84.9	85.6	65.9	57.5	50.4	61.9	59.4	60.7	65.7	74.8	83.2	
1943	82.2	82.8	80.0	71.8	58.6	57.7	53.9	61.1	65.8	74.0	77.1	83.9	
1944	87.9	87.5	84.4	85.2	81.7	72.6	71.6	73.1	74.5	78.4	82.6	86.7	
1945	88.6	84.5	83.5	79.0	80.1	66.5	67.6	71.2	73.2	76.3	79.9	84.8	
1946	87.7	87.4	82.1	63.9	61.1	64.8	69.5	72.1	72.9	76.5	80.0	84.8	
1947	87.1	85.6	83.8	80.3	81.8	76.9	73.6	74.4	77.7	80.3	83.2	85.0	
1948	88.7	84.9	85.5	84.2	80.1	77.0	75.3	69.0	67.1	72.5	78.7	84.4	
1949	86.7	85.8	84.2	81.9	83.9	80.1	66.5	72.2	74.2	78.1	82.5	86.7	
1950	89.0	85.1	85.6	83.7	74.7	68.0	70.9	70.3	71.3	74.3	79.3	84.6	
1951	87.4	86.1	68.0	56.7	56.0	55.3	62.4	68.9	69.6	75.9	77.9	84.2	
1952	87.4	87.2	82.4	67.8	57.2	55.2	55.4	54.8	54.2	58.7	72.6	82.4	
1953	77.5	76.0	82.6	68.3	56.0	64.2	69.2	70.6	67.9	70.3	75.2	83.3	
1954	81.0	84.9	81.7	84.5	72.0	62.2	60.7	61.0	65.7	76.9	78.5	84.4	
1955	86.3	85.6	82.6	74.6	74.5	75.0	77.6	75.5	75.9	79.2	82.9	85.8	
1956	89.0	85.6	85.1	62.0	50.4	52.1	59.6	66.0	62.3	69.1	76.0	83.5	
1957	80.1	81.1	84.3	85.4	81.8	70.5	64.0	67.7	69.4	75.4	77.8	84.1	
1958	87.7	78.7	83.0	75.8	67.0	51.4	51.4	50.8	55.3	61.0	73.3	82.7	
1959	78.6	77.1	83.0	84.9	70.8	61.9	66.4	74.1	76.8	78.0	79.9	84.8	
1960	86.2	86.9	82.8	84.9	82.4	71.6	72.2	74.2	75.2	80.7	83.4	86.4	
1961	89.1	84.8	85.0	80.3	80.1	70.2	72.2	75.1	77.3	80.6	83.3	84.5	
1962	88.5	85.0	84.3	80.5	81.9	66.3	68.0	72.9	73.6	76.9	80.1	84.9	
1963	87.1	72.7	79.5	72.5	76.4	62.0	64.5	56.1	61.6	71.2	75.2	83.3	
1964	85.4	82.7	73.7	81.9	75.0	75.3	77.6	75.3	76.8	79.4	83.0	84.7	
1965	86.9	86.4	83.5	63.3	53.8	61.3	66.9	61.8	65.5	75.3	75.9	83.5	
1966	87.2	87.2	77.0	76.7	69.6	68.2	68.1	72.1	73.7	78.1	80.5	85.0	
1967	87.8	84.6	83.7	69.2	62.6	60.1	58.2	57.7	57.2	58.9	71.5	82.1	
1968	77.6	76.4	82.8	81.2	71.0	61.3	62.7	69.7	75.8	79.1	80.3	85.0	
1969	88.4	85.2	84.2	75.1	57.2	50.6	54.6	55.9	55.0	60.0	73.0	82.5	
1970	79.8	76.0	82.4	65.5	49.7	51.6	59.0	67.6	73.5	77.3	75.9	83.5	
1971	87.5	87.3	79.9	63.8	61.3	64.6	62.6	66.6	66.1	72.3	75.5	83.4	
1972	81.0	84.5	85.4	81.1	78.7	72.5	68.2	73.9	77.6	76.2	79.9	84.8	
1973	88.6	85.8	78.0	72.4	59.2	54.4	56.4	65.5	68.9	74.3	77.7	84.1	
1974	87.0	85.8	66.6	59.0	51.5	58.8	52.8	54.0	62.4	69.7	76.2	83.6	
1975	77.7	78.7	83.5	81.6	80.6	64.0	56.2	63.0	63.7	68.6	75.8	83.5	
1976	79.7	78.1	81.1	82.1	83.4	79.3	76.9	77.7	84.1	86.0	86.8	87.3	
1977	89.1	87.6	86.5	82.8	84.2	82.1	82.3	81.2	84.6	84.4	82.6	87.9	
1978	89.6	87.4	85.7	81.0	63.4	59.7	56.9	58.2	63.9	69.8	76.2	83.5	
1979	86.7	87.0	84.1	83.8	74.5	64.9	64.3	68.0	70.9	74.4	79.3	84.6	
1980	88.6	85.9	83.8	77.4	59.1	51.4	55.7	64.3	68.3	73.9	77.5	84.0	
1981	86.8	87.1	85.3	83.0	74.8	69.7	66.3	70.0	75.7	81.0	83.5	84.7	
1982	87.8	85.7	72.3	58.8	55.4	52.4	52.2	48.6	54.8	64.3	74.4	83.0	
1983	76.5	70.7	64.4	56.4	52.0	46.5	42.1	48.7	51.8	52.4	61.2	71.9	
1984	69.6	69.0	58.3	49.6	53.5	59.1	61.8	67.9	71.8	76.0	75.4	83.3	
1985	86.4	86.9	72.7	72.9	79.4	76.8	75.2	74.1	75.9	80.7	83.4	85.0	
1986	86.0	85.7	84.5	77.8	72.6	52.2	48.2	60.6	68.1	74.4	77.7	81.2	
1987	85.4	86.6	85.2	84.8	82.2	74.6	69.9	74.1	77.6	80.3	83.3	85.8	
1988	88.9	84.2	85.3	78.9	71.2	74.1	77.7	79.2	81.0	81.0	85.2	86.8	
1989	89.3	87.5	85.2	84.1	81.3	80.1	67.5	69.8	74.1	79.9	83.1	84.1	
1990	86.7	86.0	82.4	84.7	79.0	76.5	77.6	77.1	80.1	84.9	85.1	86.1	
1991	89.0	89.2	84.9	83.2	85.0	82.2	70.8	72.6	77.5	83.9	86.1	85.9	
1992	89.0	88.3	85.6	87.4	82.7	70.4	71.1	74.7	80.3	81.0	85.2	86.8	
1993	89.3	87.1	86.8	81.4	63.9	59.5	60.5	61.3	62.7	67.8	75.5	83.4	
Avg.	86.0	84.5	82.0	76.7	71.1	66.1	65.6	67.6	70.4	74.9	79.3	84.4	
Min.	69.6	69.0	58.3	49.6	49.7	46.5	42.1	48.6	51.8	52.4	61.2	71.9	
Max.	89.6	89.2	86.8	87.4	85.0	82.2	82.3	81.2	84.9	86.0	86.8	87.9	

Revised Mechanical Restoration

Trinity

Revised Mechanical Restoration [EWA], Trinity Storage (TAF)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1922	1782	1679	1666	1663	1685	1735	1834	1962	2032	1919	1796	1603
1923	1502	1414	1424	1450	1473	1525	1640	1601	1581	1362	1163	990
1924	936	902	886	872	930	935	918	839	714	564	443	356
1925	334	403	445	453	719	854	1160	1248	1190	1029	869	768
1926	743	737	756	757	901	1003	1222	1182	1115	936	753	669
1927	642	798	993	1111	1349	1527	1764	1863	1928	1841	1727	1541
1928	1435	1493	1511	1568	1677	1884	2050	2033	1920	1796	1564	1375
1929	1281	1257	1248	1225	1241	1290	1308	1353	1286	1111	883	752
1930	720	703	831	847	946	1072	1172	1140	1103	928	762	679
1931	647	633	624	632	651	709	757	739	686	570	450	364
1932	333	320	317	330	351	504	593	672	700	592	475	390
1933	357	349	341	339	340	457	610	654	747	655	540	458
1934	425	411	414	470	554	711	819	790	678	560	441	357
1935	309	368	399	434	518	579	792	885	908	739	621	538
1936	509	498	495	602	737	855	1036	1020	1008	886	755	674
1937	641	624	608	594	592	698	923	1122	1209	1090	961	849
1938	794	936	1155	1252	1409	1670	1985	2308	2340	2270	2150	1975
1939	1850	1850	1847	1778	1774	1876	1948	1893	1778	1565	1350	1129
1940	1020	939	993	1159	1485	1787	2023	2054	1931	1739	1543	1360
1941	1273	1254	1393	1613	1863	2100	2300	2420	2447	2270	2150	1975
1942	1850	1850	1850	1900	2000	1987	2203	2372	2447	2270	2150	1975
1943	1850	1850	1850	1900	2000	2100	2293	2240	2238	2123	2003	1813
1944	1710	1720	1714	1665	1708	1776	1814	1881	1834	1627	1432	1257
1945	1164	1166	1232	1285	1451	1505	1650	1668	1683	1569	1374	1229
1946	1187	1242	1433	1563	1619	1748	1980	2077	1976	1878	1678	1491
1947	1400	1393	1406	1397	1449	1568	1652	1616	1591	1387	1178	1004
1948	972	959	951	1134	1156	1181	1374	1413	1511	1415	1304	1245
1949	1237	1244	1248	1240	1273	1488	1760	1820	1754	1639	1446	1302
1950	1210	1178	1160	1177	1225	1347	1502	1562	1563	1379	1229	1087
1951	1149	1265	1522	1613	1833	1937	2125	2160	2028	1914	1720	1531
1952	1370	1376	1523	1582	1772	1938	2295	2420	2447	2270	2150	1975
1953	1850	1845	1850	1900	1943	2071	2287	2355	2447	2270	2150	1975
1954	1850	1850	1850	1900	2000	2100	2300	2311	2195	2092	1905	1724
1955	1621	1671	1727	1746	1747	1782	1834	1887	1848	1663	1471	1331
1956	1238	1222	1530	1864	2000	2099	2292	2420	2422	2270	2150	1975
1957	1850	1850	1813	1796	1957	2100	2183	2253	2295	2180	1985	1802
1958	1850	1850	1850	1900	2059	2100	2300	2420	2447	2270	2150	1975
1959	1850	1850	1818	1900	2000	2012	2149	2092	2011	1779	1549	1332
1960	1239	1201	1180	1179	1313	1492	1620	1609	1646	1457	1309	1136
1961	1046	1026	1107	1138	1361	1489	1648	1672	1730	1621	1430	1257
1962	1164	1143	1165	1170	1304	1380	1608	1583	1585	1473	1334	1192
1963	1298	1350	1523	1564	1859	1938	2215	2348	2330	2219	2096	1904
1964	1850	1850	1841	1900	1888	1918	1943	1896	1828	1625	1423	1257
1965	1173	1180	1716	1900	1971	1956	2200	2218	2195	2095	1913	1731
1966	1624	1712	1753	1835	1904	2100	2300	2372	2378	2196	1976	1763
1967	1598	1606	1749	1864	2000	2100	2221	2420	2447	2270	2150	1975
1968	1850	1850	1834	1844	2000	2100	2183	2128	2034	1838	1645	1461
1969	1374	1370	1429	1573	1698	1860	2203	2420	2436	2270	2150	1975
1970	1850	1850	1850	1900	2000	2080	2145	2146	2038	1851	1637	1430
1971	1340	1446	1577	1811	1917	2100	2292	2420	2447	2270	2150	1975
1972	1850	1850	1842	1900	2000	2100	2259	2250	2187	2069	1842	1650
1973	1493	1532	1642	1802	1957	2082	2265	2407	2395	2270	2064	1879
1974	1805	1850	1850	1900	2000	2100	2300	2420	2447	2270	2150	1975
1975	1850	1849	1840	1827	1924	2100	2236	2420	2447	2270	2150	1975
1976	1850	1850	1837	1703	1737	1784	1870	1908	1834	1616	1431	1290
1977	1225	1190	1173	1162	1155	1141	1096	1058	923	692	537	467
1978	444	468	626	1027	1212	1499	1707	1871	1913	1847	1737	1578
1979	1470	1467	1463	1485	1539	1688	1814	1956	1986	1870	1670	1483
1980	1420	1455	1525	1754	2000	2083	2233	2249	2147	2058	1861	1672
1981	1562	1554	1600	1707	1846	1972	2088	2075	1989	1792	1559	1348
1982	1266	1510	1841	1900	2000	2100	2300	2394	2305	2207	2092	1975
1983	1850	1850	1850	1900	2000	2100	2300	2420	2447	2270	2150	1975
1984	1850	1850	1850	1900	1998	2100	2224	2289	2191	2091	1900	1714
1985	1703	1831	1850	1777	1805	1861	2006	1960	1873	1645	1414	1241
1986	1138	1088	1089	1208	1692	2034	2090	2078	1958	1767	1571	1388
1987	1334	1298	1295	1314	1399	1618	1770	1693	1601	1376	1146	920
1988	837	799	968	1038	1118	1193	1281	1286	1241	1032	852	717
1989	680	716	729	751	776	1120	1335	1272	1217	1063	897	790
1990	803	775	766	825	846	931	987	1009	996	826	642	557
1991	520	501	483	472	476	554	620	661	668	561	447	364
1992	331	315	306	313	452	595	831	880	818	653	533	447
1993	415	408	426	481	620	992	1212	1503	1636	1647	1537	1510
Avg.	1248	1257	1309	1367	1474	1595	1753	1806	1783	1632	1470	1317
Min.	309	315	306	313	340	457	593	654	668	560	441	356
Max.	1850	1850	1850	1900	2059	2100	2300	2420	2447	2270	2150	1975

Trinity

Revised Mechanical Restoration [EWA], Whiskeytown Storage (TAF)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	
1922	217	206	206	206	206	217	240	240	240	240	240	235	
1923	217	206	206	206	206	217	240	240	240	240	240	235	
1924	217	206	206	206	206	217	238	240	240	240	240	235	
1925	217	206	206	180	206	217	240	240	240	240	240	235	
1926	217	206	206	206	206	217	240	240	240	240	240	235	
1927	217	206	206	206	206	217	240	240	240	240	240	235	
1928	217	206	206	206	206	217	240	240	240	240	240	235	
1929	217	206	206	206	206	217	240	240	240	240	240	235	
1930	217	206	206	206	206	217	240	240	240	240	240	235	
1931	217	206	206	206	206	212	218	214	240	240	240	235	
1932	217	206	206	206	206	205	204	213	215	188	210	235	
1933	217	206	206	206	206	217	233	232	240	240	240	235	
1934	217	206	206	206	206	217	228	240	240	240	240	187	
1935	180	196	206	206	206	217	240	238	240	240	240	235	
1936	217	206	206	206	206	205	227	237	240	240	240	235	
1937	217	206	206	206	206	217	240	240	240	240	240	235	
1938	217	206	206	206	206	217	240	240	240	240	240	235	
1939	217	206	206	206	206	217	240	240	240	240	240	235	
1940	217	206	206	206	206	217	240	240	240	240	240	235	
1941	217	206	206	206	206	217	240	240	240	240	240	235	
1942	217	206	206	206	206	217	240	240	240	240	240	235	
1943	217	206	206	206	206	217	240	240	240	240	240	235	
1944	217	206	206	206	206	217	240	240	240	240	240	235	
1945	217	206	206	206	206	217	240	240	240	240	240	235	
1946	217	206	206	206	206	217	240	240	240	240	240	235	
1947	217	206	206	206	206	217	240	240	240	240	240	235	
1948	217	206	206	206	206	217	240	240	240	240	240	235	
1949	217	206	206	206	206	217	240	240	240	240	240	235	
1950	217	206	206	206	206	217	240	240	240	240	240	235	
1951	217	206	206	206	206	217	240	240	240	240	240	235	
1952	217	206	206	206	206	217	240	240	240	240	240	235	
1953	217	206	206	206	206	217	240	240	240	240	240	235	
1954	217	206	206	206	206	217	240	240	240	240	240	235	
1955	217	206	206	206	206	217	240	240	240	240	240	235	
1956	217	206	206	206	206	217	240	240	240	240	240	235	
1957	217	206	206	206	206	217	240	240	240	240	240	235	
1958	217	206	206	206	240	217	240	240	240	240	240	235	
1959	217	206	206	206	206	217	240	240	240	240	240	235	
1960	217	206	206	206	206	217	240	240	240	240	240	235	
1961	217	206	206	206	206	217	240	240	240	240	240	235	
1962	217	206	206	206	206	217	240	240	240	240	240	235	
1963	217	206	206	206	206	217	240	240	240	240	240	235	
1964	217	206	206	206	206	217	240	240	240	240	240	235	
1965	217	206	206	206	206	217	240	240	240	240	240	235	
1966	217	206	206	206	206	217	240	238	240	240	240	235	
1967	217	206	206	206	206	217	240	240	240	240	240	235	
1968	217	206	206	206	206	217	240	240	240	240	240	235	
1969	217	206	206	206	206	217	240	240	240	240	240	235	
1970	217	206	206	206	206	217	240	240	240	240	240	235	
1971	217	206	206	206	206	217	240	240	240	240	240	235	
1972	217	206	206	206	206	217	240	240	240	240	240	235	
1973	217	206	206	206	206	217	240	240	240	240	240	235	
1974	217	206	206	206	206	217	240	240	240	240	240	235	
1975	217	206	206	206	206	217	240	240	240	240	240	235	
1976	217	206	206	206	206	217	240	240	240	240	240	235	
1977	217	206	206	206	206	217	240	240	240	240	240	235	
1978	217	206	206	206	206	217	240	240	238	240	240	235	
1979	217	206	206	206	206	217	240	240	240	240	240	235	
1980	217	206	206	206	206	217	240	240	240	240	240	235	
1981	217	206	206	206	206	217	240	240	240	240	240	235	
1982	217	206	206	206	206	217	240	240	240	240	240	235	
1983	217	206	206	206	206	217	240	240	240	240	240	235	
1984	217	206	206	206	206	217	240	240	240	240	240	235	
1985	217	206	206	206	206	217	240	240	240	240	240	235	
1986	217	206	206	206	206	217	240	240	240	240	240	235	
1987	217	206	206	206	206	217	240	240	240	240	240	235	
1988	217	206	206	206	206	217	240	240	240	240	240	235	
1989	217	206	206	206	206	217	240	240	240	240	240	235	
1990	217	206	206	206	206	215	217	240	240	234	240	235	
1991	217	206	206	206	206	217	227	229	240	240	240	235	
1992	217	206	206	206	206	217	240	240	240	240	240	235	
1993	217	206	206	206	206	217	240	240	240	240	240	235	
Avg.	216	206	206	206	206	217	238	239	240	239	240	234	
Min.	180	196	206	180	206	205	204	213	215	188	210	187	
Max.	217	206	206	206	240	217	240	240	240	240	240	235	

Trinity

Revised Mechanical Restoration [EWA], Shasta Storage (TAF)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1922	2806	2890	2995	3099	3459	3841	4315	4444	4096	3612	3158	3017
1923	3059	3205	3336	3535	3663	3791	4091	3820	3402	2942	2557	2528
1924	2494	2414	2369	2390	2540	2448	2195	1883	1508	952	684	596
1925	631	787	888	1083	2327	2538	3197	3263	3032	2666	2332	2216
1926	2156	2158	2161	2204	2925	3127	3416	3267	2919	2486	2216	2097
1927	2098	2581	3090	3629	3462	4094	4552	4552	4244	3626	3189	3075
1928	3089	3252	3327	3592	4067	3965	4463	4252	3895	3200	2846	2743
1929	2684	2712	2737	2832	3027	3204	3266	3128	2928	2457	2156	2062
1930	1927	1838	2361	2568	2946	3428	3590	3484	3104	2700	2378	2262
1931	2216	2217	2203	2280	2367	2537	2284	2003	1645	1194	796	685
1932	625	618	821	968	1097	1531	1690	1876	1700	1431	1138	1002
1933	950	948	940	972	1011	1604	1748	1814	1700	1333	1031	906
1934	824	800	930	1231	1561	1822	1835	1664	1323	919	649	595
1935	577	678	715	1018	1347	1735	2731	2946	2639	2335	1976	1836
1936	1830	1805	1814	2448	3335	3695	3918	3791	3601	3180	2780	2605
1937	2493	2408	2330	2311	2407	3055	3707	3839	3668	3200	2804	2637
1938	2616	3175	3310	3668	3560	3416	4058	4552	4467	4112	3700	3400
1939	3250	3252	3361	3557	3689	4090	3899	3616	3133	2555	2056	2038
1940	2037	2019	2112	2991	3252	3435	4161	4115	3780	3273	2901	2819
1941	2840	2864	3293	3317	3423	3940	4456	4552	4500	4150	3700	3400
1942	3250	3200	3316	3389	3516	3938	4552	4552	4494	4091	3700	3400
1943	3250	3252	3356	3541	3848	4118	4552	4521	4248	3708	3289	3191
1944	3200	3189	3179	3309	3615	3926	3921	3814	3553	3022	2646	2564
1945	2524	2723	3024	3215	3948	4258	4426	4425	4127	3555	3182	3028
1946	3078	3252	3265	3622	3609	4005	4206	4132	3808	3299	2958	2881
1947	2813	2877	2968	2982	3250	3773	3934	3572	3326	2784	2351	2279
1948	2404	2465	2455	3012	2804	3120	4021	4382	4387	4006	3605	3400
1949	3250	3188	3189	3194	3390	4071	4392	4345	3997	3331	2962	2828
1950	2738	2675	2623	2902	3318	3766	4103	4041	3749	3365	3029	2969
1951	3200	3252	3322	3624	3794	4237	4326	4345	3985	3323	2955	2846
1952	2967	3044	3306	3604	3739	4022	4290	4552	4450	4145	3700	3400
1953	3250	3201	3345	3366	3753	4226	4552	4552	4500	4128	3700	3400
1954	3250	3252	3364	3552	3661	4106	4546	4330	4128	3421	3194	3189
1955	3234	3252	3360	3482	3607	3776	3917	3994	3615	3109	2803	2756
1956	2742	2773	3252	3252	3288	4012	4528	4552	4373	4087	3700	3400
1957	3250	3200	3241	3367	3675	4129	4210	4473	4185	3562	3217	3302
1958	3250	3252	3338	3531	3252	3416	4173	4552	4500	4150	3700	3400
1959	3250	3200	3258	3648	3777	4102	4163	3949	3324	2775	2380	2487
1960	2439	2246	2235	2437	3163	3860	4051	4048	3768	3200	2754	2724
1961	2722	2880	3350	3563	3914	4280	4378	4356	4024	3185	2677	2620
1962	2505	2454	2743	2865	3675	4206	4485	4376	4024	3362	2962	2876
1963	3250	3252	3349	3514	3944	4018	4137	4446	4222	3698	3363	3367
1964	3250	3252	3333	3705	3923	4086	3909	3695	3478	2974	2582	2541
1965	2548	2717	3252	3368	3809	3959	4500	4420	4088	3486	3256	3216
1966	3200	3252	3340	3725	4037	4229	4552	4404	3755	3200	2825	2767
1967	2702	3138	3335	3551	3920	4033	4479	4552	4500	4150	3700	3400
1968	3250	3213	3315	3612	3654	4248	4252	4116	3659	3073	2826	2775
1969	2799	2834	3156	3358	3480	4030	4434	4552	4378	3930	3546	3400
1970	3250	3252	3317	3252	3431	4104	4099	3970	3703	2941	2651	2632
1971	2731	3250	3319	3515	3661	3873	4360	4552	4500	4114	3700	3400
1972	3250	3200	3338	3714	3979	4249	4488	4375	3877	3200	2853	2876
1973	3061	3252	3346	3552	3636	4162	4448	4457	4038	3376	3096	3081
1974	3214	3252	3267	3252	3694	3416	4289	4552	4452	4150	3700	3400
1975	3250	3209	3336	3509	3936	3756	4347	4552	4500	4150	3700	3400
1976	3250	3252	3328	3543	3728	3962	4053	3886	3487	3136	3064	3087
1977	3076	3146	3047	3054	3048	3052	2652	2517	1990	1194	763	728
1978	566	614	1118	3034	3567	4000	4552	4552	4208	3603	3239	3301
1979	3207	3201	3194	3352	3712	4227	4398	4428	3837	3200	2954	2925
1980	3012	3192	3342	3528	3292	4047	4356	4293	3977	3535	3239	3227
1981	3200	3158	3250	3558	3974	4256	4400	4155	3573	2984	2593	2586
1982	2660	3252	3276	3616	3530	3953	4094	4369	4244	3944	3673	3400
1983	3250	3252	3328	3371	3252	3417	4074	4552	4500	4150	3700	3400
1984	3250	3252	3285	3650	4005	4246	4344	4297	4054	3442	3250	3270
1985	3250	3252	3360	3559	3750	3961	4069	3717	3200	2674	2301	2301
1986	2340	2406	2571	3149	3252	3534	3937	3920	3581	3266	2978	3087
1987	3117	3128	3132	3261	3601	4298	4138	3807	3200	2683	2330	2287
1988	2159	2144	2606	3048	3062	3177	3195	3175	2642	2239	1978	1880
1989	1762	1973	2075	2183	2297	3685	4076	3861	3496	2925	2524	2553
1990	2658	2542	2486	2722	2742	2986	2834	2952	2783	2347	2145	2129
1991	2030	1983	1969	1977	2013	2443	2565	2485	2203	1896	1678	1619
1992	1537	1412	1413	1459	2116	2562	2772	2462	2042	1617	1224	1025
1993	939	844	1081	1736	2473	3937	4552	4552	4500	3863	3591	3400
Avg.	2622	2674	2798	3036	3286	3646	3926	3908	3618	3126	2771	2666
Min.	566	614	715	968	1011	1531	1690	1664	1323	919	649	595
Max.	3250	3252	3364	3725	4067	4298	4552	4552	4500	4150	3700	3400

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Revised Mechanical Restoration [EWA], Trinity Import (TAF)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1922	203	104	31	15	6	6	20	6	4	92	92	164	743
1923	92	89	8	6	6	12	19	70	45	203	172	149	870
1924	46	30	15	15	6	6	22	22	97	120	92	60	531
1925	15	6	6	44	6	6	6	6	60	154	138	89	536
1926	15	6	6	6	6	12	6	6	60	154	154	60	489
1927	15	6	6	6	0	6	0	0	2	92	92	164	390
1928	92	0	6	6	6	0	7	14	89	92	203	164	680
1929	77	30	15	35	14	15	22	15	89	154	200	104	770
1930	15	6	6	6	6	6	24	6	47	154	138	60	474
1931	15	6	6	6	6	6	0	0	59	92	92	60	348
1932	15	6	6	0	0	0	0	0	17	92	92	60	289
1933	15	6	6	0	0	0	0	0	60	93	92	60	332
1934	15	6	6	6	6	0	0	25	105	94	92	60	415
1935	37	6	6	6	0	0	0	0	15	154	92	60	375
1936	15	6	6	6	6	0	6	6	45	108	108	60	371
1937	15	6	6	6	6	0	0	6	45	123	108	89	410
1938	46	6	0	0	0	0	0	0	0	63	96	151	362
1939	119	15	34	87	23	6	24	47	104	184	184	193	1022
1940	92	71	15	15	0	0	15	15	89	169	169	164	815
1941	77	30	0	0	0	0	0	203	115	203	120	162	909
1942	114	17	0	0	0	98	0	0	35	193	99	152	708
1943	110	26	65	0	22	72	19	3	5	92	92	164	669
1944	92	0	8	58	6	6	27	15	89	193	169	149	813
1945	77	30	15	6	0	6	18	6	0	92	169	119	539
1946	46	0	0	0	6	0	6	6	89	92	176	164	585
1947	77	30	15	15	14	6	24	15	74	186	184	149	790
1948	61	30	15	15	6	15	6	15	45	92	92	40	434
1949	0	0	4	8	6	0	6	6	89	92	169	119	500
1950	77	30	15	15	14	6	15	15	45	169	123	119	643
1951	46	0	0	0	0	6	22	6	89	92	169	164	595
1952	154	30	0	0	0	0	0	95	54	203	103	153	791
1953	110	0	36	0	81	0	9	0	39	203	107	155	740
1954	116	83	54	35	0	139	146	69	89	92	169	164	1156
1955	92	0	0	6	33	6	3	15	89	169	169	119	702
1956	77	30	0	0	0	52	82	122	4	145	99	152	762
1957	114	5	45	22	0	33	53	6	0	92	169	164	704
1958	43	80	101	108	154	0	0	203	71	203	112	155	1230
1959	111	0	32	99	4	120	62	15	89	202	203	196	1136
1960	77	30	15	15	14	15	17	15	45	169	123	149	685
1961	77	30	14	6	0	0	13	6	45	92	169	149	600
1962	77	30	15	15	0	6	24	6	45	92	123	119	553
1963	0	0	0	6	0	0	0	15	2	92	92	164	372
1964	51	118	52	21	65	12	24	15	104	192	184	149	988
1965	77	30	0	0	26	94	0	6	2	92	169	164	659
1966	92	0	0	0	0	10	126	0	3	169	203	196	799
1967	154	104	0	0	1	61	0	31	112	200	108	158	929
1968	123	7	38	79	0	51	45	6	89	169	169	164	940
1969	77	30	15	0	0	0	0	191	0	153	95	148	710
1970	115	1	154	145	0	69	28	15	89	169	184	179	1149
1971	77	30	0	0	36	13	0	30	26	190	96	148	645
1972	109	14	31	53	16	203	0	6	89	92	203	164	980
1973	154	0	0	0	0	0	30	31	0	113	174	164	666
1974	92	29	0	139	9	0	46	128	57	193	104	149	947
1975	104	0	31	42	0	0	19	38	134	199	101	155	823
1976	122	31	53	151	6	12	11	15	89	203	169	119	981
1977	46	30	6	6	7	15	46	6	127	203	134	60	686
1978	15	6	41	0	0	0	0	0	0	92	92	164	411
1979	92	0	0	6	6	6	6	6	0	100	169	164	555
1980	77	30	0	0	0	60	35	6	89	92	169	164	721
1981	92	0	0	6	6	0	6	6	89	169	198	179	751
1982	77	0	0	32	0	83	0	64	44	92	92	90	574
1983	145	37	0	0	0	65	69	191	196	203	154	173	1233
1984	121	129	0	102	0	50	19	7	89	92	169	164	942
1985	0	0	36	106	16	1	24	38	104	203	203	149	879
1986	92	45	15	15	0	0	111	15	89	169	169	164	885
1987	46	30	6	6	6	0	15	102	105	203	203	195	916
1988	61	30	6	15	6	15	13	6	111	200	154	104	722
1989	15	6	6	6	6	6	6	15	45	123	138	89	462
1990	15	30	7	6	6	6	6	6	60	154	154	60	508
1991	15	6	6	6	6	0	0	0	15	92	92	60	298
1992	15	6	6	0	0	0	0	6	83	154	92	60	422
1993	15	6	6	6	6	6	0	0	0	0	92	1	138
Avg.	70	24	16	23	10	21	20	29	60	141	139	130	683
Min.	0	0	0	0	0	0	0	0	0	0	92	1	138
Max.	203	129	154	151	154	203	146	203	196	203	203	196	1233

Trinity

Revised Mechanical Restoration [EWA], Trinity Flow (TAF)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1922	23	18	18	18	17	18	32	124	28	28	28	27	379
1923	23	18	18	18	17	18	32	124	28	28	28	27	379
1924	23	18	18	18	17	18	36	80	30	28	28	27	341
1925	23	18	18	18	17	18	18	181	112	34	28	27	512
1926	23	18	18	18	17	18	32	124	28	28	28	27	379
1927	23	18	18	18	17	18	18	181	112	34	28	27	512
1928	23	18	18	18	17	18	18	198	63	38	28	27	485
1929	23	18	18	18	17	18	36	80	30	28	28	27	340
1930	23	18	18	18	17	18	32	124	28	28	28	27	379
1931	23	18	18	18	17	18	36	80	30	28	28	27	340
1932	23	18	18	18	17	18	32	124	28	28	28	27	379
1933	23	18	18	18	17	18	32	124	28	28	28	27	379
1934	23	18	18	18	17	18	36	80	30	28	28	27	340
1935	23	18	18	18	17	18	32	124	28	28	28	27	379
1936	23	18	18	18	17	18	18	198	63	38	28	27	485
1937	23	18	18	18	17	18	32	124	28	28	28	27	379
1938	23	18	18	18	17	18	18	133	188	49	28	27	555
1939	23	18	18	18	17	18	36	80	30	28	28	27	340
1940	23	18	18	18	17	18	18	181	112	34	28	27	513
1941	23	18	18	18	17	136	162	203	188	120	28	27	957
1942	23	18	275	164	134	18	18	181	112	34	28	27	1032
1943	23	18	18	71	17	18	18	198	63	38	28	27	537
1944	23	18	18	18	17	18	36	80	30	28	28	27	341
1945	23	18	18	18	17	18	18	198	63	38	28	27	485
1946	23	18	18	18	17	18	18	181	112	34	28	27	512
1947	23	18	18	18	17	18	32	124	28	28	28	27	379
1948	23	18	18	18	17	18	18	198	63	38	28	27	485
1949	23	18	18	18	17	18	18	198	63	38	28	27	485
1950	23	18	18	18	17	18	32	124	28	28	28	27	379
1951	23	18	18	18	17	18	18	181	112	34	28	27	512
1952	23	18	18	18	17	18	18	181	112	40	28	27	518
1953	23	18	18	280	17	18	18	181	112	66	28	27	805
1954	23	18	18	18	130	18	18	181	112	34	28	27	625
1955	23	18	18	18	17	18	32	124	28	28	28	27	379
1956	23	18	18	18	19	18	18	133	188	49	28	27	557
1957	23	18	18	18	17	18	18	198	63	38	28	27	485
1958	23	18	18	18	333	188	102	225	188	54	28	27	1222
1959	23	18	18	18	17	18	18	198	63	38	28	27	485
1960	23	18	18	18	17	18	18	198	63	38	28	27	485
1961	23	18	18	18	17	18	18	198	63	38	28	27	485
1962	23	18	18	18	17	18	18	198	63	38	28	27	485
1963	23	18	18	18	17	18	18	181	112	34	28	27	512
1964	23	18	18	18	17	18	32	124	28	28	28	27	379
1965	23	18	26	49	17	18	18	181	112	34	28	27	551
1966	23	18	18	18	17	18	18	198	63	38	28	27	485
1967	23	18	18	18	17	18	18	181	112	34	28	27	512
1968	23	18	18	18	149	18	18	198	63	38	28	27	617
1969	23	18	18	18	17	18	18	133	188	49	28	27	555
1970	23	18	81	369	73	18	18	181	112	34	28	27	981
1971	23	18	18	18	17	18	18	181	112	34	28	27	512
1972	23	18	18	18	17	46	18	198	63	38	28	27	513
1973	23	18	18	18	17	18	18	181	112	34	28	27	512
1974	23	357	261	369	17	221	18	133	188	49	28	27	1690
1975	23	18	18	18	17	95	18	181	112	34	28	27	588
1976	23	18	18	18	17	18	32	124	28	28	28	27	379
1977	23	18	18	18	17	18	36	80	30	28	28	27	340
1978	23	18	18	19	17	18	18	133	188	49	28	27	556
1979	23	18	18	18	17	18	32	124	28	28	28	27	379
1980	23	18	18	18	74	18	18	181	112	34	28	27	569
1981	23	18	18	18	17	18	32	124	28	28	28	27	379
1982	23	18	18	18	176	18	60	133	188	49	28	27	757
1983	23	18	158	181	181	369	18	269	294	211	28	27	1776
1984	23	18	313	18	17	18	18	181	112	34	28	27	807
1985	23	18	18	18	17	18	32	124	28	28	28	27	379
1986	23	18	18	18	17	18	18	181	112	34	28	27	512
1987	23	18	18	18	17	18	32	124	28	28	28	27	379
1988	23	18	18	18	17	18	32	124	28	28	28	27	379
1989	23	18	18	18	17	18	18	198	63	38	28	27	485
1990	23	18	18	18	17	18	32	124	28	28	28	27	379
1991	23	18	18	18	17	18	36	80	30	28	28	27	340
1992	23	18	18	18	17	18	32	124	28	28	28	27	379
1993	23	18	18	18	17	18	18	181	112	34	28	27	512
Avg.	23	23	32	37	32	32	28	156	80	38	28	27	535
Min.	23	18	18	18	17	18	18	80	28	28	28	27	340
Max.	23	357	313	369	333	369	162	269	294	211	28	27	1776

Trinity

Revised Mechanical Restoration [EWA], Tracy Export (TAF)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1922	270	243	260	185	236	263	174	92	179	282	279	266	2729
1923	268	253	260	134	141	162	152	118	179	283	280	267	2494
1924	268	253	260	260	206	49	48	76	48	49	68	168	1752
1925	155	104	239	243	166	49	163	129	139	171	163	262	1984
1926	228	181	166	185	235	147	152	49	48	49	49	189	1676
1927	165	251	259	259	201	163	175	140	179	283	280	267	2622
1928	267	253	260	260	244	263	152	118	179	280	259	266	2799
1929	227	224	260	260	206	78	48	49	87	109	116	177	1841
1930	191	111	259	259	192	261	100	104	106	103	94	202	1981
1931	216	168	91	184	167	65	48	49	48	49	116	153	1354
1932	106	98	259	259	243	136	110	126	108	141	163	255	2003
1933	229	82	47	44	57	37	48	49	48	49	37	173	900
1934	188	60	259	218	41	77	48	49	48	37	37	128	1190
1935	77	231	185	259	115	259	128	52	153	101	275	260	2095
1936	131	116	194	259	243	152	145	49	141	142	276	263	2113
1937	204	155	240	260	235	151	88	92	139	263	275	261	2362
1938	253	252	74	49	44	102	48	49	179	281	278	266	1875
1939	267	154	88	105	128	140	111	69	107	279	244	236	1928
1940	127	117	185	260	244	262	175	140	179	279	277	265	2509
1941	257	175	259	260	235	263	152	118	179	283	280	267	2727
1942	268	253	241	185	236	264	175	92	179	282	279	266	2721
1943	268	253	260	164	217	86	152	49	133	282	279	266	2408
1944	267	200	256	260	227	246	89	92	139	279	277	265	2596
1945	158	252	259	260	235	263	125	118	179	282	279	266	2676
1946	268	253	260	260	236	201	142	140	179	282	279	266	2763
1947	267	253	260	260	230	261	108	49	104	279	277	264	2611
1948	138	177	178	260	244	208	152	118	179	281	278	266	2478
1949	267	222	246	260	173	244	48	49	122	279	277	265	2450
1950	203	233	133	185	235	255	143	49	146	275	274	259	2392
1951	263	252	259	50	85	163	129	118	179	283	280	266	2324
1952	268	253	260	260	244	263	175	92	179	282	279	266	2822
1953	268	253	252	116	142	147	144	69	175	281	279	266	2391
1954	267	253	260	238	236	263	163	129	179	282	279	266	2815
1955	257	253	260	260	183	143	101	114	176	127	167	235	2276
1956	176	252	259	185	244	234	152	118	179	283	280	267	2627
1957	269	253	260	260	174	164	159	69	179	283	280	267	2617
1958	269	253	185	185	236	263	175	92	179	282	279	266	2663
1959	267	253	260	134	137	161	108	121	179	282	280	266	2448
1960	195	225	75	185	227	236	48	49	107	274	265	190	2075
1961	163	243	242	241	235	205	96	49	100	280	278	234	2367
1962	193	251	260	199	236	263	120	129	179	281	279	266	2653
1963	267	253	260	260	236	263	152	118	179	283	280	266	2815
1964	268	253	260	260	166	145	48	110	138	227	276	240	2391
1965	150	246	259	260	235	263	175	140	179	283	281	267	2737
1966	269	253	260	260	236	263	129	69	179	281	279	259	2737
1967	217	253	260	185	236	263	152	49	179	280	278	266	2616
1968	266	253	207	103	127	162	133	117	143	283	280	251	2325
1969	223	253	260	260	236	262	122	92	179	282	280	266	2715
1970	268	253	108	100	105	161	128	118	154	282	280	248	2205
1971	260	253	260	260	236	263	163	69	179	282	280	266	2772
1972	268	253	260	260	244	263	98	103	179	280	278	241	2726
1973	255	253	260	185	236	263	168	92	166	282	279	266	2705
1974	268	253	260	260	236	263	152	49	163	281	279	266	2729
1975	267	253	185	260	236	263	175	92	179	282	279	266	2738
1976	268	253	260	260	148	147	48	49	82	49	112	176	1851
1977	144	95	49	156	44	49	48	49	88	223	207	167	1319
1978	188	79	259	184	234	263	125	49	172	282	279	266	2381
1979	268	195	130	260	188	166	167	140	179	283	280	267	2521
1980	269	224	260	260	244	262	122	49	179	282	279	266	2695
1981	268	215	195	114	139	161	142	118	168	283	280	250	2332
1982	213	253	185	185	236	262	175	140	179	281	279	266	2653
1983	267	253	49	49	80	103	48	49	179	280	277	265	1898
1984	266	84	66	80	119	162	164	92	142	282	279	266	2001
1985	268	253	235	260	203	234	112	116	143	280	278	265	2646
1986	199	174	260	185	236	262	152	49	179	132	278	265	2370
1987	266	217	254	260	179	120	100	96	175	198	184	223	2270
1988	178	214	188	260	164	49	48	86	106	84	121	170	1668
1989	143	165	164	227	83	259	137	49	126	206	276	215	2051
1990	227	229	237	260	218	146	48	49	48	49	63	142	1715
1991	181	71	49	113	59	243	48	49	76	52	153	254	1347
1992	180	121	121	167	243	218	48	87	48	49	81	175	1537
1993	187	169	257	184	235	263	163	69	179	281	278	266	2531
Avg.	226	210	213	208	192	196	120	86	145	228	239	244	2307
Min.	77	60	47	44	41	37	48	49	48	37	37	128	900
Max.	270	253	260	260	244	264	175	140	179	283	281	267	2822

Trinity

Revised Mechanical Restoration [EWA], Banks Export (TAF)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1922	214	177	327	468	472	465	200	224	397	441	415	352	4153
1923	326	297	334	496	269	246	176	146	210	441	441	389	3771
1924	309	141	337	299	206	18	18	76	18	18	276	118	1834
1925	135	147	239	243	235	18	173	140	190	105	20	258	1906
1926	120	91	166	255	302	147	166	112	140	376	256	244	2373
1927	124	397	322	447	456	448	204	220	270	283	411	303	3886
1928	290	397	434	455	357	442	180	145	155	208	265	295	3625
1929	195	193	271	290	206	119	42	18	72	245	112	100	1863
1930	75	18	315	324	192	429	100	104	34	411	313	254	2569
1931	101	54	70	244	129	77	18	57	64	317	119	91	1340
1932	104	60	331	358	344	271	46	126	304	358	44	222	2567
1933	114	156	151	214	298	301	78	76	18	177	18	64	1666
1934	94	36	298	438	321	71	18	18	43	218	204	159	1918
1935	119	194	185	361	236	446	204	20	359	441	409	309	3285
1936	304	171	241	449	485	465	172	148	327	441	404	301	3909
1937	125	137	242	416	472	465	204	197	87	398	441	303	3486
1938	203	397	232	509	472	465	180	201	397	411	411	427	4306
1939	411	379	434	456	180	249	80	69	117	438	410	319	3543
1940	228	138	202	367	482	465	204	187	259	441	415	317	3706
1941	245	165	442	511	472	465	180	201	377	411	411	427	4308
1942	411	330	241	459	472	438	204	224	397	236	411	427	4250
1943	411	397	447	497	422	423	180	133	303	115	411	319	4057
1944	214	115	259	338	280	333	132	135	237	441	411	332	3227
1945	237	397	321	264	472	410	125	134	270	441	441	328	3841
1946	328	367	338	509	205	336	142	157	248	441	441	397	3908
1947	278	241	323	226	230	250	108	41	141	441	411	315	3005
1948	206	203	178	298	120	208	179	201	283	441	441	374	3135
1949	216	164	246	284	173	286	108	123	269	337	268	290	2764
1950	46	104	106	269	421	255	143	142	344	441	441	308	3023
1951	336	397	348	523	472	456	129	160	165	348	441	374	4150
1952	309	316	442	523	482	465	204	224	363	351	380	427	4486
1953	411	346	384	389	271	406	144	203	391	260	411	427	4043
1954	385	397	360	238	413	437	192	197	158	433	421	397	4029
1955	295	357	429	449	124	143	93	114	190	277	63	201	2734
1956	91	235	351	296	485	465	153	201	297	411	411	427	3823
1957	411	228	348	226	416	452	159	69	244	275	413	306	3547
1958	411	397	430	451	434	465	204	224	397	297	411	427	4550
1959	411	265	323	455	252	107	108	121	245	411	441	341	3480
1960	254	103	185	353	273	275	18	112	227	372	257	278	2706
1961	67	247	242	241	294	205	96	18	144	343	358	275	2531
1962	196	191	276	155	472	412	120	67	185	396	441	387	3300
1963	411	397	316	449	431	438	180	201	269	231	411	336	4071
1964	411	397	332	445	124	145	42	110	191	441	411	374	3422
1965	209	318	333	523	472	310	204	123	196	242	427	328	3684
1966	198	397	467	508	282	444	129	69	202	441	441	322	3902
1967	239	397	329	477	430	463	180	201	397	441	435	427	4417
1968	411	358	432	393	381	402	133	117	143	301	441	323	3836
1969	242	258	321	523	472	465	204	224	363	223	411	427	4132
1970	411	380	439	384	371	403	128	123	233	323	441	368	4004
1971	326	397	438	459	127	434	172	69	303	411	411	427	3974
1972	411	329	431	446	264	427	98	103	128	333	376	274	3619
1973	209	397	317	460	466	465	168	176	319	405	410	340	4132
1974	336	397	322	523	458	465	180	199	393	314	411	427	4426
1975	411	354	431	450	470	458	201	224	344	411	411	427	4593
1976	411	397	431	373	183	175	42	77	77	394	342	240	3142
1977	189	177	110	156	63	72	40	43	79	100	248	91	1369
1978	38	77	292	282	472	465	180	200	397	133	411	371	3319
1979	312	195	430	489	267	465	167	165	250	356	398	302	3793
1980	251	278	320	523	485	465	156	158	227	441	415	379	4098
1981	355	87	384	454	237	445	142	118	168	441	401	331	3564
1982	263	397	261	523	472	465	204	224	397	411	411	427	4456
1983	411	397	472	367	201	219	180	43	231	441	441	427	3831
1984	386	207	249	347	376	408	164	150	170	337	441	397	3632
1985	332	397	235	390	203	147	112	116	191	441	441	397	3404
1986	288	284	320	455	472	465	179	146	200	172	411	358	3751
1987	276	71	144	317	243	237	100	23	175	441	411	337	2774
1988	167	133	188	437	85	34	42	86	152	175	54	85	1638
1989	58	174	164	227	69	317	137	43	222	441	411	356	2620
1990	345	172	260	435	131	157	18	78	18	71	245	161	2092
1991	75	28	80	106	63	285	42	43	70	178	18	63	1050
1992	66	18	120	167	316	218	42	87	21	162	26	225	1467
1993	35	31	257	296	468	457	192	212	397	441	410	322	3521
Avg.	253	248	302	381	324	335	135	131	226	336	351	315	3338
Min.	35	18	70	106	63	18	18	18	18	18	18	63	1050
Max.	411	397	472	523	485	465	204	224	397	441	441	427	4593

Trinity

Revised Mechanical Restoration [EWA], Delta Inflows (TAF)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1922	815	742	1320	1240	2665	2312	1862	3507	2610	1509	1124	949	20656
1923	918	988	2224	2181	1170	1165	1859	1363	1109	1395	1145	1008	16525
1924	910	883	938	971	1048	746	562	587	634	725	706	561	9272
1925	580	602	954	900	4037	1782	1685	1178	1084	859	631	799	15092
1926	697	614	714	1195	2583	985	1738	989	800	1057	740	725	12837
1927	681	1653	1294	2101	7859	3034	3242	1945	1282	1447	1126	874	26538
1928	895	1246	1164	1592	1581	6736	1958	1439	1058	1264	969	860	20762
1929	811	804	880	901	1055	879	594	643	725	868	697	564	9422
1930	583	515	1277	1474	1179	2207	931	906	780	1095	869	736	12553
1931	665	600	601	983	725	606	602	538	661	918	684	535	8118
1932	558	509	1539	1570	1540	1162	956	1023	1299	1093	739	783	12770
1933	702	609	653	995	787	966	837	611	676	783	555	530	8704
1934	575	518	1078	1305	1001	932	808	591	740	790	654	580	9573
1935	563	804	755	2212	1002	2009	3486	1849	1464	1244	1149	882	17418
1936	837	656	791	2707	4682	2254	1814	1396	1334	1301	1142	866	19780
1937	716	666	867	1038	2895	3191	1939	1682	1081	1356	1175	865	17471
1938	794	1587	4496	2260	8204	10683	4955	4954	3357	1476	1139	1268	45172
1939	1444	868	1067	1001	900	1109	917	891	834	1319	1136	853	12340
1940	760	611	755	2458	3911	7035	4494	1571	1265	1512	1143	894	26408
1941	844	850	3239	6334	7226	6184	4821	3197	1696	1482	1153	1218	38244
1942	1044	913	4234	5267	8150	2001	3369	2717	2009	1307	1140	1196	33348
1943	1122	1193	2099	5722	3702	5818	2170	1700	1244	1213	1132	898	28011
1944	822	723	868	1042	1699	1651	1034	995	1072	1313	1118	916	13253
1945	852	1034	1199	972	3124	1914	1238	1235	1280	1434	1171	912	16366
1946	917	1177	4628	3421	1822	1533	1149	1242	1216	1411	1173	1019	20708
1947	932	879	1137	857	1195	1457	1027	827	911	1314	1175	889	12601
1948	730	736	756	1103	1038	1188	1904	1996	1479	1411	1169	982	14493
1949	850	793	954	833	834	3253	1031	1112	1116	1208	950	852	13787
1950	687	667	669	1445	2228	1458	1457	1323	1399	1416	1165	871	14786
1951	966	3434	6249	4560	4327	2235	1285	1525	980	1517	1160	984	29221
1952	905	1068	2982	5801	4879	4585	4425	4862	3140	1414	1112	1493	36666
1953	1474	921	2979	6641	1643	1576	1320	1877	1616	1420	1118	1260	23844
1954	1001	1115	966	2294	3666	3386	2786	1814	961	1504	1130	1019	21642
1955	940	1068	1641	1349	945	861	945	1015	1043	982	672	725	12185
1956	688	824	6356	10455	5395	2816	1582	2970	1622	1467	1132	1276	36585
1957	1154	822	959	941	2177	3212	1513	1312	1208	1380	1132	879	16689
1958	1350	1012	1569	2522	10343	6286	6208	3733	2553	1345	1134	1380	39434
1959	1382	858	928	2471	3291	1594	880	972	1208	1436	1163	933	17117
1960	793	793	680	922	1881	1459	832	988	953	1261	974	767	12305
1961	676	820	1086	858	2096	1325	887	795	872	1229	1117	797	12558
1962	815	809	1114	717	3117	1928	1026	1093	1039	1402	1163	1003	15225
1963	2199	1070	1807	1127	4415	2276	5488	2324	1346	1372	1131	925	25480
1964	1066	1832	934	1595	969	871	953	969	970	1258	1165	943	13524
1965	709	981	5338	7573	2303	1773	3114	1834	1070	1444	1127	913	28177
1966	814	1542	1325	2229	1758	2021	1143	1075	1087	1384	1168	891	16436
1967	916	1007	2689	3157	3316	4092	3574	3870	3391	1579	1167	1480	30238
1968	1442	942	1167	2018	3868	2567	1187	919	992	1306	1113	880	18402
1969	893	883	1648	7713	7822	4372	3877	4712	2862	1293	1154	1172	38400
1970	1538	973	3953	13135	5142	2781	1277	1112	1105	1626	1172	946	34758
1971	921	1246	4195	3328	1807	2942	1663	1963	1375	1694	1134	1251	23519
1972	1041	915	1225	1259	1622	2348	901	892	1246	1295	1096	791	14631
1973	832	1352	1713	5348	5365	4042	1471	1451	1385	1463	1133	931	26486
1974	926	3836	4449	8411	2671	7216	4601	1959	1589	1352	1140	1404	39553
1975	1205	942	1181	1097	4069	5894	1880	2216	1753	1453	1119	1361	24170
1976	1322	1072	1133	974	911	1096	723	600	663	963	821	703	10981
1977	688	588	653	612	527	572	652	475	729	1022	820	531	7870
1978	578	513	1074	4362	3531	4572	3058	1967	1691	1204	1149	979	24676
1979	941	763	1025	1733	2682	2538	1461	1333	1359	1317	1112	872	17135
1980	904	908	1307	6902	7900	4002	1613	1503	1157	1472	1216	990	29875
1981	970	681	1027	1515	1668	2338	1301	935	961	1324	1170	891	14781
1982	862	2252	5648	5054	6034	5878	8595	3654	1996	1459	1127	1496	44056
1983	2079	2859	5636	6622	9987	15614	5541	5154	5570	2648	1507	2041	65258
1984	1943	5092	9745	4563	2664	2665	1421	1167	1106	1563	1163	1019	34110
1985	921	2084	1541	999	1038	1080	1080	1032	954	1311	1199	1018	14257
1986	862	811	1209	1657	11810	9580	1904	1371	1081	1076	1137	958	33457
1987	887	647	779	1000	1268	1924	926	816	996	1213	1035	860	12352
1988	825	663	1273	1886	914	638	708	708	907	803	593	544	10462
1989	584	675	730	905	598	3000	1389	922	992	1269	1180	875	13120
1990	944	853	845	1315	971	959	765	616	570	703	763	595	9901
1991	554	508	509	507	549	2235	991	705	591	766	634	622	9172
1992	556	508	530	772	2143	1422	861	718	712	735	551	701	10209
1993	572	519	1004	4130	3563	3119	2660	2404	1853	1508	1147	903	23383
Avg.	930	1076	1916	2765	3160	2971	2013	1644	1354	1288	1042	943	21101
Min.	554	508	509	507	527	572	562	475	570	703	551	530	7870
Max.	2199	5092	9745	13135	11810	15614	8595	5154	5570	2648	1507	2041	65258

Trinity

Revised Mechanical Restoration [EWA], Total Delta Outflow (TAF)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1922	246	268	724	683	2127	1551	1399	3045	1771	492	246	212	12765
1923	246	398	1783	1653	736	681	1501	952	495	400	246	254	9344
1924	246	420	277	416	623	621	381	248	313	411	196	179	4330
1925	237	299	486	449	3785	1671	1323	829	512	307	285	185	10370
1926	264	286	323	785	2159	610	1397	669	299	307	240	179	7518
1927	311	984	647	1452	7377	2377	2816	1437	578	591	246	193	19010
1928	269	546	443	916	968	6066	1536	1010	452	492	246	181	13123
1929	294	345	328	371	633	628	410	402	359	246	284	179	4479
1930	231	326	659	960	828	1516	649	566	379	307	290	179	6890
1931	265	319	370	598	429	395	403	269	314	246	251	179	4038
1932	258	300	1070	1011	1051	692	698	614	608	307	335	179	7123
1933	260	301	400	805	409	595	598	354	359	246	301	179	4807
1934	204	352	492	659	710	701	595	346	410	246	218	179	5113
1935	277	335	358	1717	634	1353	3169	1626	654	400	246	179	10947
1936	318	302	300	2084	4203	1590	1414	1049	615	400	246	179	12698
1937	294	301	349	426	2347	2751	1562	1220	590	400	246	179	10665
1938	246	885	4192	1770	8004	10238	4658	4543	2501	492	246	456	38231
1939	683	268	478	448	580	692	599	578	329	307	281	179	5420
1940	314	289	304	2003	3449	6351	4037	1083	526	492	246	199	19292
1941	246	450	2613	5778	6683	5460	4498	2748	878	492	281	404	30530
1942	280	268	3755	4807	7479	1267	3008	2280	1155	492	246	384	25421
1943	347	497	1357	5214	3074	5340	1771	1354	547	528	246	188	20463
1944	246	340	295	458	1291	1008	738	617	441	307	220	188	6150
1945	372	344	607	461	2486	1273	877	832	543	400	246	191	8632
1946	254	498	4075	2661	1365	950	754	790	520	400	246	232	12744
1947	293	341	512	369	742	926	691	545	402	307	295	179	5603
1948	319	293	333	536	645	752	1545	1572	779	400	246	227	7647
1949	283	338	424	304	491	2766	767	776	446	307	222	185	7308
1950	344	268	374	1063	1585	909	1073	960	640	400	246	197	8059
1951	296	2766	5755	4105	3796	1576	945	1106	369	597	246	223	21779
1952	246	450	2349	5314	4154	3913	3992	4384	2358	492	246	675	28573
1953	693	268	2389	6208	1195	965	965	1476	818	557	246	445	16224
1954	252	403	278	1827	3012	2680	2349	1321	365	492	246	238	13463
1955	287	405	937	755	633	517	701	651	419	307	240	179	6031
1956	330	280	5931	10249	4661	2047	1216	2516	870	492	246	478	29316
1957	394	268	279	461	1608	2559	1119	1086	517	531	246	197	9263
1958	601	292	910	2035	9953	5684	5880	3287	1734	492	246	566	31681
1959	604	268	277	1909	2971	1255	539	548	498	440	246	260	9814
1960	246	394	357	418	1434	899	678	680	333	307	247	179	6171
1961	349	300	542	458	1552	897	604	583	340	307	292	179	6402
1962	330	324	518	369	2651	1217	675	730	389	435	246	232	8116
1963	1494	353	1205	534	3808	1604	5219	1884	639	584	246	212	17784
1964	311	1139	277	964	644	516	749	577	413	307	287	216	6399
1965	274	369	4806	6907	1571	1149	2697	1411	446	645	246	207	20729
1966	246	860	603	1516	1248	1246	760	755	438	400	246	195	8512
1967	361	335	2129	2823	2629	3408	3289	3472	2583	566	246	668	22510
1968	667	268	465	1578	3371	1982	816	518	419	426	246	184	10940
1969	338	323	1044	7229	7326	3601	3468	4221	2070	492	246	354	30714
1970	782	275	3391	12924	4665	2162	914	681	451	722	246	203	27417
1971	246	596	3606	2636	1416	2206	1241	1700	632	712	246	434	15669
1972	267	268	504	561	1094	1566	601	490	661	400	246	179	6836
1973	315	748	1146	5035	4835	3325	1031	993	605	492	246	208	18977
1974	252	3175	3922	7713	1950	6500	4215	1546	762	492	246	582	31356
1975	438	268	513	383	3438	5240	1438	1731	948	492	246	540	15673
1976	576	351	369	325	548	674	530	259	238	246	235	186	4537
1977	260	259	435	300	382	376	422	267	300	415	184	179	3778
1978	259	304	510	4200	2922	3939	2712	1553	853	492	246	217	18208
1979	246	322	392	1117	2365	1880	1048	862	641	400	246	179	9697
1980	310	347	723	6281	7379	3248	1258	1153	501	492	334	231	22258
1981	246	308	390	988	1275	1742	917	527	328	307	288	199	7517
1982	313	1584	5225	4621	5356	5330	8213	3127	1177	492	246	725	36407
1983	1333	2269	5154	6489	9903	15588	5316	4921	4890	1652	593	1242	59349
1984	1196	4797	9540	4133	2170	2037	997	737	523	655	246	224	27255
1985	251	1452	1057	369	621	717	748	610	333	307	292	253	7012
1986	284	319	618	1102	11432	8922	1496	1016	431	492	246	240	26596
1987	246	288	318	425	865	1567	604	503	375	307	246	179	5922
1988	396	268	874	1272	639	484	527	385	406	246	227	179	5901
1989	288	285	357	450	436	2419	988	644	375	307	286	234	7070
1990	292	395	277	643	633	582	585	404	238	293	265	179	4787
1991	210	342	320	277	399	1733	799	470	238	246	279	179	5491
1992	234	304	228	444	1702	984	671	355	394	246	247	179	5987
1993	269	251	512	4039	3053	2406	2212	2000	1050	492	246	179	16709
Avg.	365	569	1386	2267	2703	2432	1681	1270	719	436	258	270	14355
Min.	204	251	228	277	382	376	381	248	238	246	184	179	3778
Max.	1494	4797	9540	12924	11432	15588	8213	4921	4890	1652	593	1242	59349

Trinity

Revised Mechanical Restoration [EWA], CVP Delivery North of Delta (TAF)
(sum of CALSIM variables D300, D8, D9, D302, D167A_IMI, D167B_IMI, D162_IMI, D168B, D168C_FRWP, and Del_CVP_Total_N)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1922	95	40	33	29	28	29	399	459	557	567	506	273	3014
1923	58	40	34	29	28	97	282	486	539	575	510	186	2863
1924	95	49	33	29	28	55	314	350	383	385	334	167	2222
1925	33	29	24	20	20	24	246	345	511	560	498	232	2541
1926	110	39	32	27	26	55	162	395	515	519	456	252	2589
1927	57	37	30	25	24	31	336	462	531	577	512	273	2897
1928	65	40	34	29	28	24	277	455	530	540	484	263	2769
1929	106	40	33	28	27	36	338	437	404	481	430	234	2593
1930	97	52	30	25	24	22	248	396	517	521	465	222	2618
1931	95	37	30	25	25	68	327	308	353	400	348	173	2189
1932	67	31	25	22	21	41	295	320	403	420	375	203	2223
1933	88	40	29	25	25	48	326	328	392	396	345	172	2213
1934	60	44	27	23	22	34	297	353	401	421	366	182	2231
1935	65	32	27	23	22	22	140	423	545	550	492	262	2603
1936	69	42	32	27	26	30	283	415	469	536	482	254	2665
1937	105	56	32	27	26	24	271	451	485	530	475	260	2744
1938	70	39	32	27	26	26	252	440	572	578	512	235	2810
1939	71	44	34	29	51	116	440	397	505	506	457	209	2857
1940	82	52	31	26	25	25	292	397	564	576	510	267	2846
1941	66	40	33	29	28	26	146	342	559	587	519	276	2650
1942	68	40	34	29	28	26	153	384	573	587	519	272	2712
1943	105	40	34	29	28	26	263	471	557	577	512	274	2916
1944	107	43	34	29	28	37	318	396	505	536	480	261	2772
1945	78	38	31	26	25	25	342	401	523	579	512	274	2853
1946	46	40	33	29	28	34	415	462	543	540	491	260	2922
1947	103	40	33	29	28	25	337	439	467	539	480	262	2782
1948	45	38	31	26	35	48	136	303	487	585	515	250	2499
1949	89	43	33	29	29	24	328	407	538	543	485	261	2809
1950	113	41	33	28	27	32	344	444	504	516	461	234	2778
1951	46	39	32	27	26	39	400	400	566	572	508	269	2924
1952	54	40	34	29	28	26	314	471	516	571	510	268	2860
1953	117	40	34	29	28	57	301	440	533	576	472	272	2900
1954	101	40	34	29	28	24	246	459	545	572	459	266	2804
1955	106	39	32	27	26	70	309	436	503	508	455	215	2725
1956	90	37	30	25	25	67	362	397	544	576	510	246	2911
1957	69	56	34	29	28	52	354	411	576	585	517	151	2862
1958	51	46	34	29	28	26	157	376	526	565	511	269	2617
1959	110	55	34	29	28	45	428	497	545	549	483	134	2936
1960	111	56	31	26	25	22	306	380	492	496	445	241	2632
1961	97	37	30	25	24	22	314	436	513	541	478	238	2756
1962	104	38	31	26	25	23	372	472	540	566	500	259	2957
1963	43	39	32	27	26	26	149	400	568	586	518	273	2686
1964	63	40	34	29	28	80	422	441	466	501	444	222	2769
1965	60	37	30	25	25	60	250	482	566	575	440	273	2824
1966	118	40	33	29	28	44	406	479	531	535	479	257	2981
1967	111	39	32	27	26	26	136	445	477	583	515	272	2688
1968	109	40	34	29	28	24	360	469	522	570	453	268	2905
1969	77	39	32	27	26	27	335	493	546	566	507	268	2941
1970	80	42	34	29	28	25	381	479	499	541	485	262	2884
1971	74	39	32	27	26	51	440	406	538	559	499	261	2951
1972	109	41	34	29	31	121	403	448	504	530	474	208	2931
1973	48	38	31	26	25	26	344	478	567	572	509	257	2922
1974	57	40	34	29	28	26	265	476	560	499	513	275	2800
1975	71	41	34	29	28	26	290	484	571	565	501	274	2912
1976	48	44	34	29	52	144	337	425	456	465	371	201	2606
1977	94	38	28	23	34	89	356	265	396	401	349	124	2199
1978	77	29	24	21	20	26	202	457	571	580	512	224	2744
1979	121	40	34	29	28	26	308	476	573	579	506	259	2977
1980	53	40	34	29	28	26	309	443	538	567	511	268	2846
1981	105	51	34	29	28	23	284	427	565	570	505	239	2860
1982	47	38	31	26	25	26	179	465	521	589	521	182	2651
1983	45	40	34	29	28	26	158	420	549	584	499	230	2641
1984	98	40	34	29	28	50	413	496	531	552	470	259	2999
1985	61	39	32	27	26	23	354	485	550	562	496	193	2846
1986	84	39	32	27	26	24	281	440	546	550	493	203	2743
1987	108	52	33	28	28	23	352	455	506	509	456	247	2796
1988	85	36	30	25	24	77	295	351	437	477	427	231	2495
1989	97	35	28	23	29	24	331	488	520	553	489	86	2703
1990	56	39	32	27	26	53	383	262	473	479	412	224	2465
1991	93	41	29	24	28	21	218	330	402	424	377	204	2190
1992	70	37	27	23	23	21	229	379	402	449	403	217	2279
1993	44	38	27	23	22	26	312	345	493	579	506	274	2687
Avg.	80	41	32	27	27	40	301	420	511	535	472	236	2722
Min.	33	29	24	20	20	21	136	262	353	385	334	86	2189
Max.	121	56	34	29	52	144	440	497	576	589	521	276	3014

Trinity

Revised Mechanical Restoration [EWA], CVP Delivery So w/ CVC (TAF)
(equals CALSIM variable CVPTotalDel)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1922	204	123	107	137	166	150	187	305	439	538	453	277	3086
1923	192	114	95	116	141	160	195	310	456	562	456	285	3082
1924	195	117	99	122	148	75	83	120	155	161	158	131	1562
1925	110	59	34	25	35	133	155	233	340	402	350	232	2108
1926	171	98	73	81	101	112	128	176	250	278	256	193	1916
1927	154	85	55	50	66	161	195	316	470	581	486	288	2905
1928	198	119	101	126	153	147	173	275	398	482	411	259	2841
1929	183	108	86	102	125	106	119	168	231	252	236	184	1899
1930	149	81	50	44	58	122	147	208	295	340	303	213	2012
1931	163	92	64	66	84	75	83	120	155	161	158	131	1350
1932	110	59	34	25	35	94	107	149	210	236	215	156	1431
1933	122	69	47	45	57	79	89	123	168	179	171	137	1286
1934	113	62	37	30	41	94	108	155	211	239	217	157	1463
1935	122	69	47	45	58	92	120	226	314	366	322	221	2003
1936	166	94	68	72	91	144	171	250	352	419	363	238	2429
1937	174	100	76	85	106	120	158	231	322	377	331	224	2303
1938	168	95	69	75	94	152	192	285	407	495	420	263	2715
1939	185	109	88	105	128	138	178	260	379	456	391	250	2669
1940	179	105	82	95	117	128	154	259	375	450	386	245	2574
1941	178	104	81	93	115	157	193	313	453	557	468	283	2996
1942	194	116	98	121	146	165	195	306	441	541	456	278	3059
1943	192	115	96	117	142	155	195	301	432	529	447	275	2995
1944	191	114	94	114	138	150	174	255	371	444	382	246	2673
1945	177	103	80	92	114	153	188	302	434	532	449	273	2896
1946	191	114	94	114	139	149	177	294	429	525	439	273	2939
1947	190	113	93	113	137	127	177	253	366	438	377	244	2630
1948	177	102	79	90	112	109	156	285	414	505	428	267	2724
1949	187	111	90	108	131	121	182	257	376	451	387	249	2650
1950	179	104	81	94	116	116	148	210	297	343	305	214	2208
1951	163	92	65	67	85	161	189	306	451	554	449	281	2862
1952	194	116	97	120	146	151	185	306	440	540	455	278	3028
1953	192	115	95	116	141	157	188	290	423	516	437	270	2942
1954	189	112	92	111	134	153	187	303	445	547	460	280	3012
1955	193	115	96	118	143	138	163	236	333	392	342	229	2500
1956	170	97	72	79	99	158	189	319	465	574	481	289	2990
1957	197	118	100	125	151	163	189	317	462	571	478	288	3159
1958	196	118	100	124	150	143	180	299	429	524	443	273	2979
1959	190	113	93	113	137	160	187	306	447	549	449	293	3037
1960	193	116	97	119	144	101	131	184	257	287	263	196	2086
1961	155	86	56	53	68	134	193	281	401	485	413	260	2585
1962	184	108	87	103	126	150	184	288	427	521	441	272	2890
1963	190	113	93	112	136	154	188	307	451	556	467	280	3045
1964	194	116	98	120	146	140	165	235	338	399	348	231	2530
1965	171	98	73	80	101	147	175	322	475	588	491	293	3014
1966	199	119	102	128	155	151	180	290	422	514	435	270	2966
1967	188	112	92	110	134	145	177	282	403	489	416	261	2810
1968	184	109	87	104	127	160	187	311	454	560	470	284	3036
1969	195	117	98	121	147	151	195	310	448	551	463	281	3076
1970	193	116	97	119	144	159	189	305	446	549	461	281	3060
1971	193	116	97	119	144	154	183	307	449	552	424	307	3044
1972	194	116	97	119	145	147	180	281	402	487	414	261	2843
1973	184	108	87	103	126	158	195	305	440	540	455	276	2976
1974	194	115	95	116	141	154	195	297	426	521	440	272	2967
1975	189	113	93	112	136	158	195	306	441	542	456	279	3019
1976	192	115	96	117	142	107	121	170	234	256	239	185	1974
1977	150	82	51	45	59	85	95	136	175	202	187	144	1412
1978	116	64	41	35	46	153	195	302	434	532	449	273	2640
1979	191	114	94	115	139	164	195	320	463	572	479	288	3134
1980	196	118	100	124	151	151	195	302	434	532	449	276	3028
1981	191	114	94	115	139	160	189	305	450	553	465	282	3057
1982	194	116	97	120	145	136	166	296	425	519	439	271	2924
1983	189	113	92	111	135	145	183	272	387	467	399	254	2746
1984	181	106	84	98	120	160	189	298	439	538	453	277	2944
1985	192	115	95	116	141	147	180	271	395	477	407	257	2792
1986	183	107	85	100	123	140	178	274	390	471	403	255	2710
1987	182	106	84	99	121	118	177	253	366	438	377	244	2565
1988	176	102	79	90	112	99	111	161	212	225	216	175	1759
1989	145	78	46	37	50	92	167	244	343	406	353	233	2196
1990	172	98	74	82	103	92	102	148	191	197	194	165	1619
1991	141	75	41	30	42	87	99	144	193	213	197	148	1410
1992	118	66	43	39	50	101	140	203	288	344	296	190	1879
1993	137	80	63	71	88	147	184	290	415	506	429	267	2677
Avg.	176	103	81	94	115	135	166	259	372	447	382	245	2574
Min.	110	59	34	25	35	75	83	120	155	161	158	131	1286
Max.	204	123	107	137	166	165	195	322	475	588	491	307	3159

Trinity

Revised Mechanical Restoration [EWA], X2_PRV (KM)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	
1922	74.9	83.2	85.0	78.2	76.4	66.4	66.3	66.8	61.2	63.3	74.1	82.9	
1923	86.7	87.0	83.2	70.7	67.2	71.5	74.2	68.8	70.8	76.2	79.9	84.8	
1924	85.9	86.8	82.7	84.8	82.4	78.0	77.1	80.3	84.9	84.3	82.3	87.3	
1925	89.5	88.2	85.8	81.5	80.7	63.4	64.7	66.7	71.2	76.1	81.9	84.3	
1926	88.2	87.0	85.7	84.6	77.5	66.6	73.5	69.1	73.6	81.0	83.5	86.2	
1927	89.1	86.0	75.9	76.1	70.0	54.7	59.2	59.1	64.5	73.0	75.8	83.5	
1928	87.6	86.7	80.7	80.6	75.0	72.2	57.7	63.2	68.5	76.2	78.3	84.3	
1929	88.4	86.2	84.0	84.0	83.0	77.8	76.9	79.7	81.0	82.0	85.5	85.5	
1930	88.9	88.2	85.1	79.0	74.1	72.8	68.6	73.4	76.3	80.1	83.2	84.6	
1931	88.6	87.1	84.9	83.3	79.1	79.5	81.1	81.2	84.5	84.2	86.2	86.7	
1932	89.3	87.5	85.5	75.4	72.5	70.7	73.9	74.6	76.1	76.4	81.9	83.1	
1933	88.1	87.1	85.4	82.9	76.7	79.1	77.8	77.1	81.1	82.0	85.5	85.1	
1934	88.7	89.1	84.8	81.1	77.7	75.2	75.2	76.3	81.0	81.0	85.2	87.5	
1935	89.5	87.1	84.5	83.5	71.1	73.9	69.8	61.7	64.4	72.0	78.5	84.4	
1936	88.5	85.7	84.9	84.9	70.1	59.3	63.8	65.9	69.1	74.0	79.2	84.6	
1937	88.6	86.3	85.1	83.8	81.9	67.4	62.2	64.6	67.5	73.8	79.1	84.5	
1938	88.5	87.6	77.3	62.2	63.9	52.1	47.1	51.3	53.1	58.0	72.3	82.3	
1939	80.6	77.2	83.0	80.7	80.5	77.7	76.2	76.5	77.2	81.4	83.6	85.0	
1940	88.7	85.8	85.3	85.0	70.4	60.9	53.7	54.5	65.1	73.9	77.5	84.0	
1941	87.6	87.3	82.4	67.5	56.6	51.1	51.6	53.0	57.5	67.5	75.4	82.3	
1942	81.6	84.4	85.4	65.7	57.4	50.5	62.6	59.7	61.1	66.6	75.1	83.3	
1943	82.2	82.9	80.2	71.8	58.8	57.7	54.0	60.9	65.5	73.7	76.9	83.8	
1944	87.9	87.4	84.5	84.9	81.7	72.2	71.5	73.4	75.6	78.7	82.7	86.6	
1945	88.8	84.6	83.5	79.1	79.7	66.2	67.7	70.8	72.5	76.1	79.8	84.8	
1946	88.1	87.3	81.6	63.8	61.3	64.8	69.5	72.6	73.5	76.7	80.0	84.9	
1947	86.6	85.7	84.0	80.5	81.9	76.2	73.4	74.5	76.9	79.8	83.1	84.5	
1948	88.5	85.6	85.1	84.2	80.2	77.0	75.3	69.0	67.0	71.5	78.3	84.3	
1949	86.6	85.9	84.1	82.0	83.9	80.0	66.3	71.4	73.2	77.8	82.4	86.4	
1950	88.9	85.2	85.6	83.5	74.8	68.1	70.9	70.3	71.2	74.4	79.3	84.6	
1951	87.8	86.0	68.0	56.8	55.7	55.1	62.5	68.5	69.6	78.1	77.4	84.0	
1952	86.7	87.0	82.3	68.3	57.5	55.3	55.5	55.2	54.6	59.0	72.6	82.4	
1953	77.7	76.1	82.7	68.3	56.3	64.2	69.2	70.6	68.0	71.5	75.8	83.5	
1954	81.2	85.0	82.5	84.7	71.0	61.9	60.6	60.9	65.7	76.9	78.5	84.4	
1955	86.3	85.7	82.6	75.5	74.8	75.1	77.5	75.8	76.0	79.2	82.9	86.0	
1956	89.0	85.5	85.4	62.2	50.4	52.1	59.5	65.6	62.3	69.1	76.0	83.5	
1957	80.7	81.5	84.4	85.3	81.8	70.3	63.7	67.6	69.4	75.4	77.5	84.0	
1958	87.6	80.5	83.4	75.9	67.3	51.5	51.4	50.9	55.4	61.6	73.5	82.7	
1959	79.1	77.7	83.2	85.0	70.8	61.9	66.4	74.1	76.8	78.1	79.8	84.8	
1960	85.7	86.7	83.2	83.0	81.8	71.4	72.1	74.2	75.2	80.7	83.4	85.9	
1961	89.0	85.1	84.7	80.3	80.2	70.0	71.7	75.0	76.6	81.0	83.5	84.7	
1962	88.6	85.4	84.3	80.5	81.9	66.5	68.2	73.0	74.2	79.2	80.2	84.9	
1963	86.7	73.2	79.6	72.5	76.5	61.9	64.5	56.1	61.4	71.2	75.3	83.3	
1964	86.8	85.3	74.6	82.2	75.1	75.4	77.6	75.3	76.8	79.6	83.0	84.7	
1965	87.1	86.3	83.6	63.2	53.8	61.3	66.9	61.9	65.5	75.3	75.9	83.5	
1966	87.0	87.2	77.3	77.1	70.0	68.3	68.6	72.2	73.7	78.1	80.5	85.0	
1967	88.0	84.5	83.7	69.5	62.7	60.2	58.2	57.6	57.2	59.1	71.6	82.1	
1968	77.6	76.4	82.8	80.9	70.9	61.3	62.7	69.7	75.8	79.1	80.3	85.0	
1969	88.4	85.2	84.2	75.1	57.3	50.6	54.6	56.0	55.2	60.1	73.0	82.6	
1970	82.6	76.8	82.7	65.6	49.8	51.6	58.9	67.6	73.0	77.6	75.8	83.5	
1971	87.2	87.2	80.2	64.3	61.5	64.6	63.0	66.6	65.6	72.7	74.3	83.0	
1972	81.2	84.6	85.5	81.1	78.9	72.5	68.2	73.9	77.6	76.2	79.9	84.8	
1973	88.6	85.8	78.0	72.4	59.2	54.4	56.5	65.9	69.5	74.3	77.7	84.1	
1974	87.2	87.0	67.3	59.5	51.7	58.9	52.8	53.9	62.2	70.1	76.3	83.6	
1975	79.2	80.2	84.0	80.5	81.6	64.4	56.3	63.3	64.4	69.1	76.0	83.5	
1976	79.7	78.2	81.3	82.2	83.4	79.3	76.9	77.7	83.7	86.1	86.8	87.4	
1977	89.2	87.4	86.7	82.6	84.2	82.1	82.3	81.2	84.6	84.6	82.3	87.8	
1978	89.6	87.6	85.5	81.0	63.4	59.7	56.9	58.6	63.7	69.7	76.2	83.6	
1979	86.7	87.1	84.8	82.9	74.2	64.8	64.3	68.3	71.4	74.4	79.3	84.6	
1980	88.6	85.9	83.9	77.9	59.3	51.5	55.7	64.1	67.8	75.1	77.9	81.8	
1981	85.7	86.7	85.1	83.0	75.2	69.9	66.5	70.1	75.8	81.0	83.5	84.8	
1982	87.8	85.5	72.1	58.8	55.4	52.4	52.2	48.6	55.1	64.4	74.4	83.0	
1983	77.3	71.0	64.6	56.5	52.1	46.6	42.1	48.6	51.6	52.4	61.2	71.9	
1984	69.5	69.3	58.3	49.7	53.3	58.9	61.7	67.9	72.5	76.3	76.1	83.6	
1985	86.5	86.8	73.2	71.5	78.9	76.6	75.5	74.6	76.1	81.0	83.5	84.7	
1986	85.9	85.7	84.5	79.3	73.1	52.4	48.3	60.4	67.5	76.2	78.3	84.3	
1987	86.2	86.9	85.6	84.7	82.2	75.2	69.1	74.1	77.4	80.5	83.3	85.9	
1988	89.0	84.2	85.3	76.9	71.2	74.1	77.7	78.0	80.8	81.0	85.2	87.2	
1989	89.4	86.7	85.7	83.8	81.5	80.2	67.4	69.8	74.1	79.4	83.0	84.7	
1990	86.5	85.7	82.8	84.9	79.1	76.5	77.1	77.0	80.1	84.9	85.1	85.9	
1991	89.0	89.0	85.0	84.5	85.4	82.1	70.6	72.5	77.4	84.0	86.2	85.9	
1992	89.0	88.2	85.7	87.3	82.7	70.4	71.1	74.0	80.1	81.0	85.2	86.5	
1993	89.2	87.2	86.8	81.5	63.9	59.5	60.6	61.4	62.7	67.8	75.5	83.4	
Avg.	86.1	84.7	82.1	76.7	71.2	66.1	65.6	67.6	70.4	75.1	79.3	84.3	
Min.	69.5	69.3	58.3	49.7	49.8	46.6	42.1	48.6	51.6	52.4	61.2	71.9	
Max.	89.6	89.1	86.8	87.3	85.4	82.1	82.3	81.2	84.9	86.1	86.8	87.8	

Modified Percent

Trinity

Mod Percent [EWA], Trinity Storage (TAF)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	
1922	1787	1724	1717	1713	1736	1786	1868	1947	1928	1815	1692	1544	
1923	1464	1432	1432	1459	1482	1539	1625	1579	1523	1307	1135	1022	
1924	952	918	902	898	955	961	906	823	695	572	451	365	
1925	347	414	446	464	730	865	1102	1194	1172	1029	869	797	
1926	777	768	778	778	923	1025	1228	1201	1140	977	795	710	
1927	689	842	1027	1145	1383	1560	1773	1855	1928	1841	1727	1585	
1928	1531	1586	1594	1651	1766	1973	2112	2103	2017	1903	1671	1526	
1929	1433	1408	1400	1250	1266	1315	1334	1366	1312	1152	970	839	
1930	812	792	910	927	1025	1151	1225	1206	1157	997	831	748	
1931	716	702	692	701	720	778	826	788	724	608	487	402	
1932	376	360	348	360	381	534	598	647	655	547	430	346	
1933	318	307	290	288	288	405	547	590	642	547	433	351	
1934	324	307	301	363	452	609	692	665	602	488	369	285	
1935	241	302	324	365	449	510	678	733	733	627	509	427	
1936	403	389	377	484	619	737	888	912	932	819	735	653	
1937	625	605	581	566	564	670	886	1010	1024	915	786	719	
1938	701	839	1049	1146	1303	1564	1823	1987	2062	2064	1948	1920	
1939	1850	1850	1847	1778	1774	1876	1948	1888	1775	1593	1374	1242	
1940	1027	940	985	1150	1476	1778	1973	2022	1954	1766	1616	1477	
1941	1395	1373	1503	1723	1973	2100	2300	2420	2447	2270	2150	1975	
1942	1850	1850	1850	1900	2000	1987	2162	2316	2390	2270	2150	1975	
1943	1850	1850	1850	1900	2000	2100	2257	2265	2276	2170	2051	1860	
1944	1809	1816	1789	1682	1725	1793	1815	1826	1803	1595	1429	1255	
1945	1197	1197	1253	1297	1463	1516	1638	1688	1715	1610	1461	1316	
1946	1279	1331	1513	1643	1698	1827	2018	2107	2047	1953	1733	1590	
1947	1504	1495	1498	1489	1541	1660	1733	1697	1654	1512	1284	1154	
1948	1127	1111	1093	1276	1298	1324	1467	1532	1566	1565	1453	1381	
1949	1378	1382	1377	1369	1401	1617	1830	1899	1877	1771	1613	1469	
1950	1382	1344	1307	1324	1372	1494	1610	1645	1614	1474	1324	1212	
1951	1279	1392	1640	1730	1951	2055	2200	2260	2184	2075	1880	1735	
1952	1656	1659	1796	1855	2000	2100	2300	2420	2447	2270	2150	1975	
1953	1850	1842	1850	1900	1943	2071	2261	2326	2440	2270	2150	1975	
1954	1850	1850	1850	1900	2000	2100	2300	2311	2249	2150	1963	1781	
1955	1730	1777	1824	1778	1773	1808	1852	1881	1854	1715	1569	1400	
1956	1342	1323	1622	1900	2000	2099	2280	2401	2447	2270	2150	1975	
1957	1850	1850	1811	1795	1956	2100	2178	2261	2285	2179	1983	1800	
1958	1850	1850	1850	1900	2059	2100	2300	2420	2447	2270	2150	1975	
1959	1850	1847	1815	1900	2000	2012	2140	2103	2035	1812	1582	1365	
1960	1308	1267	1237	1236	1370	1549	1656	1695	1694	1557	1371	1257	
1961	1203	1180	1250	1281	1504	1632	1775	1849	1870	1724	1500	1327	
1962	1269	1245	1258	1262	1397	1473	1679	1704	1669	1565	1426	1284	
1963	1394	1443	1608	1648	1943	2022	2257	2389	2419	2270	2146	1975	
1964	1850	1850	1839	1900	1888	1919	1940	1816	1653	1489	1318	1212	
1965	1165	1168	1703	1900	1971	1970	2172	2207	2233	2137	1955	1773	
1966	1718	1803	1834	1900	1968	2100	2300	2381	2396	2224	2004	1791	
1967	1613	1692	1826	1900	2000	2100	2203	2414	2447	2270	2150	1975	
1968	1850	1850	1833	1843	2000	2100	2178	2190	2115	1929	1736	1596	
1969	1514	1507	1557	1701	1826	1987	2278	2420	2447	2270	2150	1975	
1970	1850	1848	1850	1900	2000	2080	2143	2186	2125	1943	1716	1538	
1971	1454	1556	1678	1900	1935	2100	2262	2420	2447	2270	2150	1975	
1972	1850	1850	1840	1900	2000	2100	2239	2284	2221	2113	1885	1738	
1973	1663	1670	1770	1900	2000	2100	2261	2401	2424	2270	2064	1878	
1974	1845	1850	1850	1900	2000	2100	2300	2415	2447	2270	2150	1975	
1975	1850	1846	1837	1824	1922	2100	2221	2420	2447	2270	2150	1975	
1976	1850	1850	1835	1700	1733	1780	1858	1875	1841	1623	1484	1343	
1977	1278	1243	1226	1206	1192	1179	1086	1035	899	668	529	459	
1978	441	463	623	1023	1208	1495	1674	1761	1862	1810	1699	1585	
1979	1529	1523	1509	1532	1585	1734	1826	1914	1923	1815	1661	1519	
1980	1461	1493	1548	1776	2000	2083	2226	2260	2211	2125	1928	1739	
1981	1680	1669	1700	1805	1944	2070	2156	2145	2055	1858	1619	1439	
1982	1361	1602	1850	1900	2000	2100	2296	2348	2308	2226	2111	1975	
1983	1850	1850	1850	1900	2000	2100	2300	2420	2447	2270	2150	1975	
1984	1850	1850	1850	1900	1998	2100	2200	2280	2215	2118	1927	1741	
1985	1735	1850	1850	1776	1805	1861	2017	1969	1904	1676	1445	1227	
1986	1160	1122	1114	1232	1716	2058	2090	2112	2034	1848	1662	1523	
1987	1443	1405	1391	1410	1495	1707	1870	1794	1675	1451	1221	993	
1988	916	875	1034	1104	1184	1259	1357	1348	1284	1118	937	802	
1989	771	803	807	829	854	1198	1368	1365	1335	1143	977	870	
1990	888	881	862	921	942	1025	1070	1117	1042	888	765	679	
1991	642	622	605	594	598	676	741	769	759	652	537	454	
1992	426	407	388	389	528	671	916	941	865	729	609	523	
1993	496	486	494	550	688	1060	1251	1518	1561	1570	1460	1434	
Avg.	1300	1309	1353	1405	1509	1626	1762	1812	1792	1652	1495	1356	
Min.	241	302	290	288	288	405	547	590	602	488	369	285	
Max.	1850	1850	1850	1900	2059	2100	2300	2420	2447	2270	2150	1975	

Trinity

Mod Percent [EWA], Whiskeytown Storage(TAF)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	
1922	217	206	206	206	206	217	240	240	240	240	240	235	
1923	217	206	206	206	206	217	240	240	240	240	240	235	
1924	217	206	206	206	206	217	240	240	240	240	240	235	
1925	217	206	206	180	206	217	240	240	240	240	240	235	
1926	217	206	206	206	206	217	240	240	240	240	240	235	
1927	217	206	206	206	206	217	240	240	240	240	240	235	
1928	217	206	206	206	206	217	240	240	240	240	240	235	
1929	217	206	206	206	206	217	240	240	240	240	240	235	
1930	217	206	206	206	206	217	240	240	240	240	240	235	
1931	217	206	204	206	206	212	215	214	240	240	240	235	
1932	217	206	206	206	206	205	204	213	229	240	240	235	
1933	217	206	206	206	206	217	233	232	240	240	240	235	
1934	217	206	206	206	206	205	216	216	240	240	240	186	
1935	180	191	200	206	206	217	240	238	240	240	240	235	
1936	217	206	206	206	206	205	221	231	240	240	240	235	
1937	217	206	206	206	206	217	240	240	240	240	240	235	
1938	217	206	206	206	206	217	240	240	240	240	240	235	
1939	217	206	206	206	206	217	240	240	240	240	240	235	
1940	217	206	206	206	206	217	240	240	240	240	240	235	
1941	217	206	206	206	206	217	240	240	240	240	240	235	
1942	217	206	206	206	206	217	240	240	240	240	240	235	
1943	217	206	206	206	206	217	240	240	240	240	240	235	
1944	217	206	206	206	206	217	240	240	240	240	240	235	
1945	217	206	206	206	206	217	240	240	240	240	240	235	
1946	217	206	206	206	206	217	240	240	240	240	240	235	
1947	217	206	206	206	206	217	240	240	240	240	240	235	
1948	217	206	206	206	206	217	240	240	240	240	240	235	
1949	217	206	206	206	206	217	240	240	240	240	240	235	
1950	217	206	206	206	206	217	240	240	240	240	240	235	
1951	217	206	206	206	206	217	240	240	240	240	240	235	
1952	217	206	206	206	206	217	240	240	240	240	240	235	
1953	217	206	206	206	206	217	240	240	240	240	240	235	
1954	217	206	206	206	206	217	240	240	240	240	240	235	
1955	217	206	206	206	206	217	240	240	240	240	240	235	
1956	217	206	206	206	206	217	240	240	240	240	240	235	
1957	217	206	206	206	206	217	240	240	240	240	240	235	
1958	217	206	206	206	240	217	240	240	240	240	240	235	
1959	217	206	206	206	206	217	240	240	240	240	240	235	
1960	217	206	206	206	206	217	240	240	240	240	240	235	
1961	217	206	206	206	206	217	240	240	240	240	240	235	
1962	217	206	206	206	206	217	240	240	240	240	240	235	
1963	217	206	206	206	206	217	240	240	240	240	240	235	
1964	217	206	206	206	206	217	240	240	240	240	240	235	
1965	217	206	206	206	206	217	240	240	240	240	240	235	
1966	217	206	206	206	206	217	240	240	240	240	240	235	
1967	217	206	206	206	206	217	240	240	240	240	240	235	
1968	217	206	206	206	206	217	240	240	240	240	240	235	
1969	217	206	206	206	206	217	240	240	240	240	240	235	
1970	217	206	206	206	206	217	240	240	240	240	240	235	
1971	217	206	206	206	206	217	240	240	240	240	240	235	
1972	217	206	206	206	206	217	240	240	240	240	240	235	
1973	217	206	206	206	206	217	240	240	240	240	240	235	
1974	217	206	206	206	206	217	240	240	240	240	240	235	
1975	217	206	206	206	206	217	240	240	240	240	240	235	
1976	217	206	206	206	206	217	240	240	240	240	240	235	
1977	217	206	206	206	206	217	240	240	240	240	240	235	
1978	217	206	206	206	206	217	240	240	240	240	240	235	
1979	217	206	206	206	206	217	240	240	240	240	240	235	
1980	217	206	206	206	206	217	240	240	240	240	240	235	
1981	217	206	206	206	206	217	240	240	240	240	240	235	
1982	217	206	206	206	206	217	240	240	240	240	240	235	
1983	217	206	206	206	206	217	240	240	240	240	240	235	
1984	217	206	206	206	206	217	240	240	240	240	240	235	
1985	217	206	206	206	206	217	240	240	240	240	240	235	
1986	217	206	206	206	206	217	240	240	240	240	240	235	
1987	217	206	206	206	206	217	240	240	240	240	240	235	
1988	217	206	206	206	206	217	240	240	240	240	240	235	
1989	217	206	206	206	206	217	240	240	240	240	240	235	
1990	217	206	206	206	206	217	240	240	240	240	240	235	
1991	217	206	206	206	206	217	227	224	233	240	240	235	
1992	217	206	206	206	206	217	240	240	240	240	240	235	
1993	217	206	206	206	206	217	240	240	240	240	240	235	
Avg.	216	206	206	206	206	216	238	238	240	240	240	234	
Min.	180	191	200	180	206	205	204	213	229	240	240	186	
Max.	217	206	206	206	240	217	240	240	240	240	240	235	

Trinity

Mod Percent [EWA], Shasta Storage (TAF)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1922	2806	2848	2937	3041	3401	3783	4260	4393	4086	3602	3148	2963
1923	2991	3078	3209	3408	3536	3659	3963	3686	3304	2846	2437	2349
1924	2331	2279	2235	2246	2392	2369	2153	1833	1442	1001	730	634
1925	668	824	925	1111	2355	2565	3223	3288	3097	2721	2390	2244
1926	2184	2186	2189	2231	2952	3154	3443	3291	2908	2459	2180	2061
1927	2022	2505	3011	3550	3462	4094	4552	4552	4244	3623	3185	3027
1928	2996	3252	3363	3639	4099	3965	4463	4274	3914	3200	2824	2676
1929	2617	2634	2649	2869	3064	3241	3321	3203	2948	2485	2157	2084
1930	1942	1852	2375	2579	2957	3439	3601	3493	3125	2730	2409	2294
1931	2247	2245	2231	2302	2386	2554	2307	2029	1681	1231	840	747
1932	650	643	846	993	1122	1555	1719	1909	1713	1411	1145	1049
1933	997	995	986	1018	1058	1651	1826	1895	1738	1369	1062	942
1934	869	832	962	1256	1582	1854	1870	1691	1299	900	619	567
1935	550	652	689	980	1308	1697	2693	2911	2608	2247	1892	1754
1936	1748	1722	1732	2366	3253	3613	3838	3718	3496	3096	2654	2480
1937	2369	2284	2207	2188	2286	2934	3589	3730	3593	3200	2841	2661
1938	2610	3169	3310	3668	3560	3416	4058	4552	4467	4056	3690	3400
1939	3250	3252	3361	3557	3689	4090	3899	3609	3124	2516	2021	1914
1940	2030	2020	2114	2992	3252	3435	4161	4115	3780	3273	2855	2729
1941	2749	2773	3293	3317	3423	3940	4456	4552	4500	4150	3700	3400
1942	3250	3200	3316	3389	3516	3938	4552	4552	4459	4150	3700	3400
1943	3250	3252	3356	3541	3848	4118	4552	4521	4248	3708	3289	3190
1944	3165	3155	3157	3345	3651	3962	3957	3848	3542	3013	2614	2532
1945	2472	2680	2990	3190	3948	4258	4426	4434	4137	3564	3145	2991
1946	3044	3252	3265	3622	3610	4006	4205	4129	3802	3292	2968	2845
1947	2781	2840	2925	2939	3207	3731	3893	3538	3251	2647	2286	2202
1948	2316	2391	2432	3005	2799	3115	4024	4385	4402	3932	3531	3400
1949	3250	3200	3201	3206	3402	4071	4392	4345	3946	3247	2850	2716
1950	2625	2557	2511	2790	3206	3655	3995	3942	3651	3221	2885	2795
1951	3126	3252	3322	3624	3794	4237	4326	4354	3994	3328	2960	2808
1952	2853	2952	3306	3604	3739	4022	4290	4552	4426	4133	3700	3400
1953	3250	3201	3345	3366	3753	4226	4552	4552	4500	4119	3700	3400
1954	3250	3252	3364	3552	3661	4106	4546	4315	4112	3405	3178	3173
1955	3173	3252	3360	3546	3671	3840	3977	4049	3619	3073	2696	2676
1956	2623	2651	3252	3252	3288	4012	4492	4552	4386	4137	3700	3400
1957	3250	3200	3236	3363	3675	4129	4195	4468	4180	3557	3212	3298
1958	3250	3252	3338	3531	3252	3416	4173	4552	4500	4150	3700	3400
1959	3250	3200	3249	3648	3777	4102	4142	3959	3333	2785	2390	2468
1960	2389	2258	2247	2449	3175	3872	4053	4050	3772	3169	2745	2642
1961	2586	2729	3196	3406	3914	4280	4372	4346	3919	3149	2686	2632
1962	2481	2425	2713	2832	3675	4175	4453	4345	3993	3325	2926	2840
1963	3250	3252	3349	3514	3944	4018	4137	4465	4240	3759	3425	3400
1964	3250	3252	3326	3705	3923	4087	3910	3697	3457	2910	2501	2401
1965	2384	2556	3252	3368	3809	4015	4500	4423	4094	3492	3259	3226
1966	3200	3252	3340	3725	4037	4229	4552	4416	3764	3200	2826	2775
1967	2727	3089	3335	3551	3920	4033	4479	4552	4500	4150	3700	3400
1968	3250	3211	3309	3607	3654	4248	4239	4103	3646	3061	2814	2718
1969	2743	2777	3099	3358	3480	4030	4434	4552	4415	3993	3608	3400
1970	3250	3252	3317	3252	3431	4104	4092	3965	3673	2930	2662	2614
1971	2705	3224	3319	3515	3728	3873	4368	4552	4500	4117	3700	3400
1972	3250	3200	3330	3714	3979	4249	4488	4376	3879	3200	2853	2832
1973	2941	3248	3346	3552	3636	4162	4437	4423	4004	3375	3095	3087
1974	3185	3252	3267	3252	3694	3416	4289	4503	4426	4150	3700	3400
1975	3250	3209	3326	3499	3936	3756	4343	4552	4463	4150	3700	3400
1976	3250	3252	3321	3538	3722	3956	4047	3880	3438	3088	2978	3008
1977	2995	3066	2966	2982	2983	2986	2635	2500	1958	1182	747	712
1978	562	611	1103	3020	3567	4000	4552	4552	4208	3605	3241	3258
1979	3200	3199	3192	3351	3710	4225	4396	4426	3839	3194	2904	2832
1980	2924	3104	3260	3528	3292	4047	4336	4280	3964	3522	3226	3214
1981	3181	3142	3239	3549	3965	4256	4400	4154	3573	2984	2610	2574
1982	2644	3252	3276	3616	3530	3953	4094	4312	4238	3938	3667	3400
1983	3250	3252	3328	3371	3252	3417	4074	4552	4500	4150	3700	3400
1984	3250	3252	3285	3650	4005	4246	4344	4304	4061	3449	3257	3280
1985	3250	3252	3360	3559	3750	3961	4070	3721	3195	2670	2297	2307
1986	2316	2368	2534	3112	3252	3534	3937	3925	3586	3200	2898	2962
1987	3028	3039	3045	3174	3514	4250	4049	3783	3200	2683	2320	2267
1988	2109	2103	2566	3008	2943	3057	3077	3072	2675	2289	1971	1871
1989	1728	1939	2041	2149	2263	3647	4037	3770	3402	2866	2502	2535
1990	2642	2573	2517	2753	2804	3049	2895	3040	2869	2410	2088	2020
1991	1916	1837	1807	1815	1851	2281	2418	2343	2063	1749	1532	1473
1992	1432	1341	1342	1394	2052	2498	2709	2432	2028	1577	1189	995
1993	920	835	1072	1727	2463	3927	4552	4552	4500	3865	3593	3400
Avg.	2587	2644	2776	3020	3275	3636	3915	3898	3606	3113	2753	2635
Min.	550	611	689	980	1058	1555	1719	1691	1299	900	619	567
Max.	3250	3252	3364	3725	4099	4280	4552	4552	4500	4150	3700	3400

Trinity

Mod Percent [EWA], Trinity Import (TAF)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1922	203	62	15	15	6	6	20	6	45	92	92	119	681
1923	77	30	8	6	6	6	19	62	74	199	145	89	722
1924	61	30	15	6	6	6	58	13	84	92	92	60	525
1925	15	6	6	34	6	6	6	6	60	138	138	60	481
1926	15	6	6	6	6	12	6	6	60	138	154	60	474
1927	15	6	6	6	0	6	0	0	2	92	92	119	345
1928	46	0	6	6	0	0	7	45	89	92	203	119	614
1929	77	30	15	160	14	15	22	15	60	138	154	104	804
1930	15	6	6	6	6	6	24	6	58	138	138	60	470
1931	15	6	6	6	6	6	0	6	53	92	92	60	349
1932	15	6	6	0	0	0	0	0	15	92	92	60	286
1933	15	6	6	0	0	0	0	0	15	92	92	60	286
1934	15	6	6	0	0	0	0	0	66	92	92	60	337
1935	39	0	6	0	0	0	0	0	15	92	92	60	304
1936	15	6	6	6	6	0	0	6	15	108	61	60	289
1937	15	6	6	6	6	0	0	6	45	108	108	45	350
1938	15	6	0	0	0	0	0	0	0	7	92	5	125
1939	64	15	34	87	23	6	24	39	86	154	188	104	825
1940	203	74	15	15	0	0	15	15	89	169	123	119	838
1941	77	30	0	0	0	0	0	87	106	203	120	162	784
1942	120	14	0	0	0	98	0	0	0	135	99	152	618
1943	115	23	56	0	22	72	19	3	5	92	92	164	662
1944	46	0	20	117	6	6	27	15	45	194	140	149	764
1945	46	30	15	15	0	6	18	6	0	92	123	119	471
1946	46	0	0	0	6	0	6	6	89	92	196	119	560
1947	77	30	15	15	14	6	24	24	74	123	203	104	710
1948	61	30	15	15	6	15	15	15	45	1	92	54	364
1949	0	0	4	8	6	0	6	6	45	92	133	119	420
1950	77	32	25	15	14	6	15	15	45	123	123	89	580
1951	46	0	0	0	0	6	22	6	89	92	169	119	550
1952	77	30	0	0	0	66	98	56	30	203	103	153	815
1953	115	0	24	0	81	0	9	0	0	203	107	155	694
1954	121	80	45	35	0	139	88	60	89	92	169	164	1082
1955	46	0	0	70	39	6	3	15	45	123	123	149	619
1956	46	30	0	0	0	52	46	0	13	185	99	152	622
1957	119	2	37	21	0	33	38	15	0	92	169	164	691
1958	47	77	92	108	154	0	0	115	75	203	112	155	1137
1959	117	0	23	97	4	120	41	47	89	203	203	196	1140
1960	46	30	15	15	14	15	17	15	45	125	161	89	589
1961	46	30	15	6	0	0	7	6	45	137	202	149	643
1962	46	30	15	15	0	6	24	6	45	92	123	119	522
1963	0	0	0	6	0	0	0	34	2	135	92	143	413
1964	127	115	45	18	64	12	24	15	74	140	154	89	879
1965	46	30	0	0	26	80	0	6	2	92	169	164	615
1966	46	0	0	16	0	75	76	11	1	169	203	196	793
1967	172	30	0	41	37	61	0	0	64	193	108	158	864
1968	128	4	30	79	0	51	32	6	89	169	169	119	877
1969	77	30	15	0	0	0	0	145	36	179	95	148	726
1970	120	0	154	145	0	69	19	15	89	169	197	149	1126
1971	77	30	0	0	106	31	0	2	33	191	96	148	713
1972	114	11	24	51	16	203	0	6	89	92	203	119	929
1973	77	30	0	0	0	25	18	8	0	147	175	164	643
1974	57	69	0	139	9	0	16	22	77	203	104	149	846
1975	109	0	21	41	0	0	15	5	67	199	101	155	715
1976	127	28	46	153	6	11	11	15	45	203	123	119	886
1977	46	30	6	15	14	15	93	6	112	203	118	60	718
1978	15	6	31	0	0	0	0	0	2	92	92	119	358
1979	46	0	0	6	6	6	6	6	0	92	123	119	410
1980	77	30	6	0	0	60	15	12	89	92	169	164	713
1981	46	0	6	8	6	0	6	6	89	169	203	149	688
1982	77	0	0	40	0	83	0	8	89	92	92	109	591
1983	150	34	0	0	0	65	36	187	175	203	154	173	1176
1984	127	126	0	102	0	50	19	13	89	92	169	164	950
1985	0	10	45	106	16	1	24	41	74	203	203	193	917
1986	61	30	15	15	0	0	110	22	89	169	159	119	790
1987	77	30	7	6	6	6	15	86	129	203	203	196	964
1988	61	30	6	15	6	15	13	15	97	154	154	104	671
1989	15	6	6	6	6	6	6	15	45	171	138	89	510
1990	15	6	7	6	6	8	27	6	60	138	92	60	431
1991	15	6	6	6	6	0	0	0	15	92	92	60	298
1992	15	6	6	6	0	0	0	6	95	125	92	60	411
1993	15	6	6	6	6	6	0	0	0	0	92	0	138
Avg.	64	21	15	27	11	23	18	21	54	133	134	116	638
Min.	0	0	0	0	0	0	0	0	0	0	61	0	125
Max.	203	126	154	160	154	203	110	187	175	203	203	196	1176

Trinity

Mod Percent [EWA], Trinity Flow (TAF)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1922	18	21	28	19	17	18	48	174	76	29	28	27	501
1923	18	21	28	19	17	18	61	138	35	28	28	27	437
1924	23	18	18	18	17	18	36	92	47	28	28	27	370
1925	18	21	28	19	17	18	87	177	76	32	28	27	547
1926	18	21	28	19	17	18	48	111	22	27	28	27	381
1927	18	21	28	19	17	18	43	197	104	34	28	27	553
1928	18	21	28	19	17	18	45	159	37	27	28	27	442
1929	23	18	18	18	17	18	36	92	47	28	28	27	369
1930	18	21	28	19	17	18	58	111	29	27	28	27	398
1931	23	18	18	18	17	18	36	92	47	28	28	27	369
1932	18	21	28	19	17	18	57	155	49	28	28	27	464
1933	18	21	28	19	17	18	44	124	113	32	28	27	489
1934	18	21	28	19	17	18	62	103	21	27	28	27	386
1935	18	21	28	19	17	18	78	162	51	27	28	27	493
1936	18	21	28	19	17	18	55	159	61	30	28	27	479
1937	18	21	28	19	17	18	42	199	102	34	28	27	551
1938	18	21	28	19	17	18	75	292	146	34	28	27	721
1939	23	18	18	18	17	18	36	92	47	28	28	27	369
1940	18	21	28	19	17	18	59	162	59	29	28	27	484
1941	18	21	28	19	17	246	162	318	197	120	28	27	1199
1942	18	21	275	164	134	18	60	195	149	35	28	27	1123
1943	18	21	28	71	17	18	54	137	51	28	28	27	496
1944	18	21	28	19	17	18	51	136	50	28	28	27	440
1945	18	21	28	19	17	18	41	166	52	29	28	27	462
1946	18	21	28	19	17	18	59	189	71	30	28	27	523
1947	18	21	28	19	17	18	43	115	46	28	28	27	406
1948	18	21	28	19	17	18	58	172	128	33	28	27	566
1949	18	21	28	19	17	18	76	189	65	28	28	27	532
1950	18	21	28	19	17	18	71	149	59	29	28	27	482
1951	18	21	28	19	17	18	60	155	56	29	28	27	474
1952	18	21	28	19	63	18	76	225	136	40	28	27	697
1953	18	21	28	280	17	18	43	185	129	58	28	27	851
1954	18	21	28	19	130	18	76	190	58	30	28	27	641
1955	18	21	28	19	17	18	39	149	59	27	28	27	450
1956	18	21	28	74	55	18	66	262	135	34	28	27	765
1957	18	21	28	19	17	18	38	176	82	29	28	27	499
1958	18	21	28	19	333	188	102	313	184	54	28	27	1314
1959	18	21	28	19	17	18	48	147	50	29	28	27	447
1960	18	21	28	19	17	18	39	148	100	30	28	27	492
1961	18	21	28	19	17	18	39	148	100	30	28	27	491
1962	18	21	28	19	17	18	39	148	100	30	28	27	491
1963	18	21	28	19	17	18	59	163	64	29	28	27	490
1964	18	21	28	19	17	18	36	200	154	41	28	27	606
1965	18	21	28	36	17	18	59	163	64	29	28	27	508
1966	18	21	28	19	17	18	68	178	56	29	28	27	505
1967	18	21	28	19	17	18	36	200	154	41	28	27	605
1968	18	21	28	19	147	18	36	131	45	28	28	27	544
1969	18	21	28	19	17	18	71	253	141	34	28	27	673
1970	18	21	79	369	73	18	30	138	65	29	28	27	894
1971	18	21	28	31	17	18	47	179	105	33	28	27	552
1972	18	21	28	19	17	46	37	144	63	29	28	27	476
1973	18	21	28	49	71	18	51	206	78	29	28	27	623
1974	18	357	261	369	17	221	48	244	162	39	28	27	1791
1975	18	21	28	19	17	92	37	198	179	33	28	27	696
1976	18	21	28	19	17	18	41	145	32	27	28	27	421
1977	23	18	18	18	17	18	36	92	47	28	28	27	369
1978	18	21	28	19	17	18	47	210	127	35	28	27	594
1979	18	21	28	19	17	18	66	178	49	28	28	27	496
1980	18	21	28	19	96	18	45	157	59	31	28	27	546
1981	18	21	28	19	17	18	62	121	32	27	28	27	417
1982	18	21	102	19	176	18	65	232	93	34	28	27	831
1983	18	21	158	181	181	369	50	274	316	211	28	27	1832
1984	18	21	313	19	17	18	42	159	80	31	28	27	772
1985	18	21	28	19	17	18	22	121	36	27	28	27	381
1986	18	21	28	19	17	18	44	140	71	28	28	27	457
1987	18	21	28	19	17	18	22	140	29	27	28	27	391
1988	18	21	28	19	17	18	22	128	60	31	28	27	416
1989	18	21	28	19	17	18	62	138	38	27	28	27	440
1990	18	21	28	19	17	18	22	99	88	28	28	27	412
1991	23	18	18	18	17	18	36	92	47	28	28	27	369
1992	18	21	28	19	17	18	22	148	29	27	28	27	401
1993	18	21	28	19	17	18	47	204	202	37	28	27	665
Avg.	18	25	41	39	34	33	52	166	83	35	28	27	581
Min.	18	18	18	18	17	18	22	92	21	27	28	27	369
Max.	23	357	313	369	333	369	162	318	316	211	28	27	1832

Trinity

Mod Percent [EWA], Tracy Export (TAF)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1922	270	243	260	185	236	263	174	92	179	282	279	266	2729
1923	268	253	260	134	141	162	152	118	179	283	280	267	2494
1924	268	143	202	260	213	49	48	76	48	37	122	171	1636
1925	168	111	190	237	234	49	67	129	106	172	210	261	1934
1926	224	182	164	259	235	231	152	49	86	49	49	188	1869
1927	221	251	259	259	103	163	175	140	179	283	280	267	2580
1928	264	253	260	260	244	263	152	118	179	281	278	265	2815
1929	227	231	260	260	206	68	48	49	87	86	99	177	1797
1930	191	111	259	259	192	261	100	104	72	91	93	202	1935
1931	217	190	82	184	168	66	48	49	48	49	100	146	1346
1932	138	80	259	259	243	122	101	69	108	144	160	253	1935
1933	186	66	42	37	44	41	48	49	48	49	37	173	819
1934	187	72	259	221	41	60	48	49	48	37	37	132	1190
1935	106	189	195	259	112	139	117	60	157	102	274	259	1971
1936	132	113	199	259	166	142	140	49	179	127	276	262	2044
1937	203	139	259	260	165	111	82	124	179	177	218	260	2177
1938	241	252	116	49	44	102	48	49	179	281	278	266	1904
1939	267	156	89	105	129	139	111	69	104	275	236	237	1917
1940	124	117	187	260	244	262	175	140	179	279	277	265	2508
1941	257	177	259	260	235	263	152	118	179	283	280	267	2729
1942	268	253	241	260	236	205	175	92	179	261	279	266	2717
1943	268	253	260	174	217	86	152	49	133	282	279	266	2418
1944	267	203	250	260	227	246	89	92	139	279	277	265	2594
1945	154	252	259	260	235	263	125	118	179	282	279	266	2673
1946	266	253	260	260	236	200	142	140	179	282	279	266	2761
1947	267	253	260	260	230	261	108	103	136	274	238	265	2654
1948	132	178	129	260	244	208	152	118	179	280	278	265	2422
1949	266	217	241	260	176	261	48	49	179	280	278	265	2518
1950	203	243	144	185	236	255	143	49	146	275	274	259	2412
1951	199	252	259	165	85	163	129	118	179	283	280	266	2376
1952	268	253	260	260	244	263	175	92	179	282	279	266	2822
1953	268	253	216	116	142	147	144	69	172	281	279	266	2352
1954	267	253	260	238	236	263	163	129	179	282	279	266	2815
1955	257	253	260	260	183	142	101	114	174	153	189	234	2321
1956	182	252	259	185	244	243	152	118	179	283	280	267	2642
1957	269	253	260	260	173	164	159	69	179	283	280	267	2616
1958	269	253	185	185	236	262	175	92	179	281	279	266	2663
1959	267	253	260	131	137	161	108	122	179	282	280	266	2445
1960	195	177	158	260	227	236	48	49	107	275	270	198	2200
1961	185	251	244	242	235	205	96	98	179	281	275	240	2531
1962	197	253	260	203	236	263	120	129	179	281	279	266	2664
1963	267	253	260	260	236	263	152	118	179	283	280	266	2815
1964	268	253	260	260	166	143	48	110	114	232	276	248	2377
1965	138	252	259	260	235	208	175	140	179	283	280	267	2676
1966	269	253	260	260	236	263	125	69	179	281	278	256	2729
1967	215	253	260	185	236	263	152	49	179	280	278	266	2614
1968	266	253	207	104	128	162	133	117	143	283	280	251	2326
1969	223	253	260	260	236	262	122	92	179	282	280	266	2715
1970	268	253	108	100	105	161	128	118	179	282	279	247	2229
1971	260	253	260	260	236	263	163	69	179	282	280	266	2772
1972	268	253	260	260	244	263	98	103	179	280	278	242	2727
1973	254	253	260	185	236	263	168	92	166	282	279	266	2704
1974	268	253	260	260	236	263	152	49	163	281	279	266	2729
1975	267	253	260	185	236	263	175	92	179	282	279	266	2738
1976	268	253	260	260	149	147	48	49	82	49	98	182	1844
1977	144	95	49	156	44	49	48	49	88	209	195	167	1294
1978	184	81	259	184	234	259	122	49	172	282	279	266	2371
1979	268	204	106	260	236	163	167	140	179	283	280	267	2552
1980	269	224	260	260	244	262	122	49	179	282	279	266	2695
1981	268	220	229	114	139	161	142	118	168	283	280	249	2372
1982	215	253	185	185	236	262	175	140	179	281	279	266	2655
1983	267	253	49	49	80	103	48	49	179	280	277	265	1899
1984	266	84	66	80	119	162	164	92	142	282	279	263	1998
1985	268	253	235	260	203	234	112	116	123	280	278	265	2626
1986	201	175	185	260	236	262	152	49	137	222	278	265	2422
1987	266	210	165	260	236	194	104	49	155	192	187	224	2242
1988	179	214	184	260	244	49	86	86	48	49	107	169	1674
1989	181	145	176	217	83	259	138	118	141	217	229	215	2119
1990	224	232	259	260	163	169	48	49	48	49	66	144	1710
1991	183	123	49	112	62	260	48	49	71	52	64	254	1328
1992	181	80	127	167	243	218	98	49	48	49	69	172	1501
1993	184	138	259	184	235	263	163	69	179	280	278	266	2499
Avg.	227	207	212	213	191	194	120	87	146	227	236	244	2304
Min.	106	66	42	37	41	41	48	49	48	37	37	132	819
Max.	270	253	260	260	244	263	175	140	179	283	280	267	2822

Trinity

Mod Percent [EWA], Banks Export (TAF)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1922	214	177	327	468	472	465	200	224	397	441	415	352	4153
1923	324	297	334	496	269	184	175	146	210	441	441	389	3707
1924	317	129	360	258	213	18	18	76	18	18	268	103	1796
1925	129	149	190	237	314	18	67	140	186	103	24	259	1817
1926	84	109	164	307	239	98	160	112	149	361	276	148	2207
1927	132	397	322	332	456	448	204	220	270	334	411	303	3830
1928	286	359	434	455	360	442	180	149	159	235	273	294	3627
1929	195	191	282	291	206	115	42	18	68	245	57	93	1802
1930	78	18	315	324	192	429	100	104	32	409	294	254	2549
1931	79	61	107	245	129	78	18	57	74	331	135	98	1412
1932	77	86	331	358	347	285	71	126	18	400	404	219	2722
1933	168	156	151	204	236	297	79	77	18	153	18	64	1624
1934	101	18	302	438	321	75	18	18	18	154	31	163	1658
1935	116	190	195	361	239	446	204	20	354	441	406	296	3267
1936	307	168	240	449	485	465	172	148	216	441	415	302	3809
1937	251	123	267	384	472	465	204	196	272	363	308	304	3610
1938	196	397	247	509	472	465	180	201	397	411	411	427	4314
1939	411	376	434	456	180	177	79	119	108	441	404	318	3503
1940	228	132	204	367	482	465	204	187	260	441	415	317	3702
1941	245	158	442	511	472	465	180	201	363	411	411	427	4287
1942	411	327	241	523	472	205	204	224	397	346	411	427	4189
1943	411	397	447	496	422	423	180	132	303	115	411	319	4055
1944	202	114	261	343	280	333	132	135	237	441	411	347	3234
1945	213	397	321	264	472	410	125	133	239	441	415	330	3761
1946	239	371	338	509	234	329	142	157	248	441	441	387	3836
1947	278	246	323	226	230	247	108	97	168	441	397	314	3076
1948	207	230	153	284	120	208	179	201	319	441	441	334	3120
1949	196	169	241	282	176	324	108	118	181	316	288	289	2689
1950	45	104	133	269	422	255	143	142	344	441	434	308	3039
1951	304	397	351	523	472	460	129	159	165	350	441	375	4127
1952	309	315	442	523	482	465	204	224	363	339	374	427	4468
1953	411	346	396	389	271	405	144	203	381	268	411	427	4051
1954	388	397	332	238	413	437	192	198	158	432	421	397	4004
1955	295	326	429	449	124	142	91	114	191	250	83	201	2695
1956	88	240	351	296	485	465	153	201	298	411	411	427	3827
1957	411	225	354	222	416	452	159	69	244	277	414	306	3548
1958	411	397	430	451	434	465	204	224	397	297	411	427	4549
1959	411	265	323	455	251	107	108	122	245	411	441	354	3492
1960	256	114	213	307	273	275	18	111	227	367	228	246	2634
1961	60	253	244	242	294	205	96	48	31	418	359	298	2548
1962	197	194	280	155	472	423	120	67	185	389	441	381	3305
1963	411	397	316	449	431	438	180	201	269	231	411	397	4132
1964	411	397	334	445	124	143	42	110	235	441	411	353	3445
1965	186	319	333	389	472	294	204	119	196	295	434	320	3561
1966	163	397	467	508	282	444	125	69	204	441	441	317	3859
1967	236	397	329	477	430	463	180	201	397	441	434	427	4414
1968	411	356	432	393	381	402	133	117	143	300	441	323	3833
1969	241	258	321	523	472	465	204	224	363	223	411	427	4131
1970	411	380	439	384	371	403	128	123	209	338	441	372	3998
1971	333	397	438	459	106	434	171	69	306	411	411	427	3962
1972	411	320	431	446	264	427	98	103	127	324	377	274	3600
1973	209	397	317	460	466	465	168	176	319	405	410	336	4127
1974	336	397	322	523	458	465	180	194	394	306	411	427	4413
1975	411	354	432	450	470	441	201	224	334	411	411	427	4566
1976	411	397	431	373	183	175	42	77	74	391	338	236	3128
1977	187	174	110	156	62	73	42	43	82	98	252	91	1369
1978	42	78	290	282	472	465	180	200	397	134	411	371	3323
1979	230	194	430	489	329	465	167	165	246	355	386	302	3758
1980	249	278	320	523	485	465	156	158	227	441	415	379	4096
1981	315	92	329	454	237	445	142	118	168	441	411	331	3483
1982	272	397	261	523	472	465	204	224	397	411	411	427	4465
1983	411	397	472	367	201	219	180	43	231	441	441	427	3831
1984	386	207	249	347	376	408	164	150	170	337	441	397	3632
1985	332	397	235	390	203	147	112	116	211	441	441	397	3423
1986	287	286	261	455	472	465	179	146	317	411	411	345	4036
1987	274	59	165	391	250	237	104	20	121	439	414	339	2815
1988	201	128	184	324	105	36	86	86	22	208	28	59	1467
1989	51	160	176	217	69	317	138	119	194	441	411	341	2633
1990	346	102	268	435	130	169	18	78	18	18	269	218	2069
1991	58	18	71	105	65	322	42	43	18	191	18	63	1015
1992	97	18	127	167	316	218	98	18	18	161	22	204	1463
1993	54	27	284	296	468	457	192	212	397	441	409	322	3561
Avg.	251	246	303	376	325	330	136	133	218	341	351	313	3323
Min.	42	18	71	105	62	18	18	18	18	18	18	59	1015
Max.	411	397	472	523	485	465	204	224	397	441	441	427	4566

Trinity

Mod Percent [EWA], Delta Inflows (TAF)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1922	815	742	1320	1240	2665	2312	1859	3503	2610	1509	1124	949	20649
1923	916	988	2224	2181	1170	1165	1855	1363	1108	1395	1145	1008	16518
1924	919	729	904	938	1089	746	560	587	636	709	740	549	9106
1925	599	601	953	885	4051	1782	1685	1182	1040	858	621	799	15056
1926	697	616	714	1195	2584	986	1668	995	848	1042	821	628	12792
1927	681	1628	1308	2101	7761	3036	3242	1944	1282	1517	1126	874	26500
1928	883	1154	1133	1581	1588	6723	1957	1442	1063	1292	997	858	20673
1929	811	815	890	901	1055	879	594	641	720	845	630	557	9339
1930	583	515	1277	1477	1180	2207	932	907	744	1081	817	737	12457
1931	665	605	644	988	757	609	601	538	672	932	693	535	8238
1932	558	529	1539	1570	1549	1163	956	1023	1012	1138	1105	778	12919
1933	698	608	653	1010	801	965	837	610	676	759	563	530	8710
1934	575	518	1077	1305	1001	931	808	590	714	725	517	588	9349
1935	555	784	755	2196	1002	2009	3497	1840	1457	1244	1146	867	17352
1936	837	656	785	2707	4682	2305	1813	1393	1126	1286	1153	866	19608
1937	838	665	855	1038	2908	3192	1939	1679	1286	1236	985	865	17485
1938	795	1585	4508	2259	8204	10683	4954	4954	3359	1476	1139	1114	45029
1939	1397	866	1064	1000	899	1109	916	946	807	1319	1128	852	12303
1940	750	614	756	2458	3912	7036	4494	1571	1267	1512	1143	894	26407
1941	843	853	3145	6336	7226	6184	4820	3081	1691	1482	1151	1217	38029
1942	1049	910	4235	5267	8150	2001	3369	2717	2009	1396	1140	1217	33460
1943	1127	1140	2090	5722	3702	5817	2169	1699	1244	1213	1132	898	27953
1944	810	721	869	1042	1699	1651	1034	995	1072	1313	1118	939	13264
1945	811	1026	1191	967	3099	1915	1238	1225	1249	1434	1145	916	16214
1946	825	1144	4661	3511	1840	1512	1149	1242	1216	1411	1173	1003	20686
1947	934	891	1142	857	1195	1448	1025	889	983	1310	1101	889	12664
1948	752	739	679	1090	1038	1187	1903	1997	1421	1410	1169	921	14306
1949	854	777	953	830	833	3271	1026	1107	1085	1188	964	851	13739
1950	687	676	702	1457	2228	1458	1454	1321	1399	1416	1158	871	14828
1951	867	3366	6257	4557	4326	2234	1285	1515	980	1523	1160	985	29056
1952	905	1067	2863	5802	4878	4650	4522	4822	3142	1402	1107	1488	36647
1953	1479	920	2967	6641	1642	1576	1320	1877	1577	1439	1118	1260	23816
1954	1006	1094	957	2295	3665	3386	2728	1824	961	1503	1130	1019	21567
1955	938	1027	1643	1348	945	855	947	1018	1043	980	707	725	12175
1956	698	825	6216	10457	5394	2816	1582	2813	1624	1467	1132	1274	36297
1957	1161	819	963	939	2174	3211	1513	1311	1208	1382	1133	879	16691
1958	1349	1009	1560	2522	10343	6286	6207	3644	2560	1344	1134	1369	39329
1959	1387	857	928	2459	3291	1595	879	973	1209	1435	1163	953	17129
1960	795	732	711	921	1881	1459	832	983	954	1257	939	744	12207
1961	697	833	1091	862	1939	1328	887	833	855	1304	1128	826	12583
1962	821	818	1114	721	3077	1959	1026	1093	1038	1393	1163	993	15216
1963	2163	1072	1807	1126	4415	2276	5487	2324	1346	1371	1131	1020	25538
1964	1175	1824	937	1587	969	838	968	965	997	1262	1159	922	13602
1965	682	979	5103	7575	2302	1703	3173	1821	1070	1539	1134	901	27981
1966	779	1519	1324	2244	1758	2085	1091	1073	1092	1383	1167	880	16397
1967	917	1007	2649	3199	3351	4092	3574	3839	3344	1574	1166	1479	30191
1968	1448	940	1165	2016	3864	2567	1187	919	992	1305	1113	880	18394
1969	892	883	1648	7658	7822	4372	3876	4666	2862	1293	1154	1234	38360
1970	1540	973	3953	13135	5142	2781	1277	1112	1105	1642	1172	950	34782
1971	929	1245	4169	3329	1786	3028	1654	1944	1383	1690	1134	1252	23542
1972	1041	912	1226	1256	1622	2347	901	892	1245	1285	1096	791	14615
1973	831	1267	1725	5347	5364	4067	1471	1451	1385	1463	1133	924	26427
1974	926	3851	4449	8411	2671	7216	4570	1903	1589	1343	1140	1397	39466
1975	1208	942	1181	1097	4058	5894	1880	2179	1725	1453	1119	1359	24096
1976	1326	1035	1134	974	911	1096	723	600	660	960	812	698	10929
1977	688	584	654	612	526	573	653	475	733	1001	813	531	7844
1978	578	513	1074	4353	3516	4572	3070	1967	1691	1205	1149	979	24666
1979	860	751	1048	1732	2668	2537	1461	1332	1356	1316	1100	872	17033
1980	902	907	1307	6821	7901	4001	1613	1501	1157	1472	1216	990	29789
1981	929	681	1026	1515	1667	2329	1301	935	961	1324	1183	891	14741
1982	875	2237	5652	5063	6034	5878	8595	3654	1992	1459	1127	1509	44074
1983	2083	2856	5636	6622	9987	15614	5509	5150	5548	2648	1507	2041	65201
1984	1948	5088	9745	4563	2664	2665	1421	1167	1106	1563	1163	1014	34107
1985	921	2094	1551	999	1038	1080	1079	1032	954	1311	1199	1018	14276
1986	863	811	1208	1655	11797	9580	1903	1371	1298	1405	1203	938	34033
1987	884	647	779	1001	1268	1708	985	706	943	1205	1044	864	12033
1988	854	657	1274	1885	995	640	766	702	722	802	565	518	10379
1989	584	673	731	905	598	3022	1391	1065	955	1280	1144	853	13202
1990	944	790	876	1322	916	961	766	611	570	653	787	654	9849
1991	560	508	526	505	549	2236	976	705	538	780	595	623	9101
1992	556	508	531	771	2142	1422	905	628	708	734	548	677	10129
1993	566	519	1004	4104	3563	3175	2650	2409	1853	1508	1146	903	23399
Avg.	928	1066	1908	2764	3157	2972	2013	1636	1345	1293	1041	940	21063
Min.	555	508	526	505	526	573	560	475	538	653	517	518	7844
Max.	2163	5088	9745	13135	11797	15614	8595	5150	5548	2648	1507	2041	65201

Trinity

Mod Percent [EWA], Total Delta Outflow (TAF)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1922	246	268	724	683	2127	1551	1397	3041	1771	492	246	212	12758
1923	246	397	1783	1653	736	744	1497	952	494	400	246	254	9402
1924	246	389	277	424	651	620	380	248	315	407	184	179	4318
1925	250	289	584	445	3651	1672	1527	833	506	307	224	186	10474
1926	304	268	326	658	2222	576	1333	674	301	307	301	179	7449
1927	247	960	661	1567	7378	2378	2815	1436	578	610	246	193	19071
1928	265	492	412	905	973	6053	1535	1010	454	492	246	181	13017
1929	294	351	328	370	633	642	410	400	359	246	290	179	4502
1930	228	325	659	963	829	1516	649	566	378	307	258	179	6859
1931	287	294	385	602	460	397	402	269	314	246	260	179	4096
1932	253	311	1071	1011	1057	692	683	672	607	307	344	179	7187
1933	246	317	405	837	496	595	597	353	359	246	309	179	4940
1934	197	359	487	656	710	712	595	346	410	246	253	179	5150
1935	243	362	338	1702	634	1473	3192	1609	649	400	246	179	11024
1936	314	307	291	2084	4280	1651	1419	1046	480	400	246	179	12696
1937	290	331	293	459	2431	2791	1567	1185	570	400	246	179	10740
1938	266	884	4147	1769	8004	10238	4658	4542	2502	492	246	302	38050
1939	636	268	474	445	578	765	598	583	314	307	287	179	5434
1940	307	295	300	2004	3450	6352	4037	1083	528	492	246	199	19292
1941	246	451	2519	5780	6682	5460	4498	2632	887	492	279	403	30327
1942	285	268	3756	4668	7479	1559	3007	2280	1155	492	246	406	25600
1943	352	444	1348	5206	3074	5340	1770	1354	547	528	246	188	20397
1944	246	337	301	453	1291	1009	738	617	441	307	220	197	6155
1945	358	335	599	456	2460	1273	876	823	543	400	246	193	8563
1946	252	461	4108	2751	1353	937	753	790	520	400	246	226	12797
1947	294	348	517	369	742	920	690	498	413	307	274	179	5552
1948	347	268	330	536	645	752	1544	1573	685	400	246	206	7530
1949	307	321	432	303	484	2729	762	776	446	307	215	184	7267
1950	346	268	370	1075	1585	910	1070	958	640	400	246	197	8065
1951	293	2698	5760	3986	3794	1571	945	1097	369	601	246	223	21585
1952	246	449	2230	5315	4153	3978	4088	4344	2360	492	246	670	28572
1953	698	268	2400	6208	1194	965	965	1475	793	568	246	446	16226
1954	254	382	297	1827	3012	2680	2291	1330	365	492	246	238	13414
1955	287	395	939	755	633	513	705	653	419	307	233	179	6016
1956	336	276	5791	10251	4660	2038	1216	2358	871	492	246	475	29010
1957	400	268	277	463	1604	2558	1119	1084	517	531	246	197	9264
1958	601	289	901	2035	9953	5684	5880	3199	1740	492	246	556	31576
1959	608	268	277	1899	2972	1255	539	549	498	439	246	267	9817
1960	246	368	277	388	1433	898	678	675	333	307	237	179	6019
1961	355	300	544	460	1395	899	604	542	357	307	304	179	6246
1962	331	328	514	369	2611	1237	675	730	389	432	246	229	8092
1963	1459	354	1205	534	3808	1605	5219	1884	639	584	246	245	17782
1964	420	1130	277	956	644	487	764	575	420	307	281	209	6469
1965	284	361	4571	7043	1570	1149	2756	1402	446	687	246	203	20718
1966	246	837	602	1532	1248	1311	717	753	441	400	246	191	8523
1967	367	335	2090	2865	2664	3407	3289	3441	2536	561	246	668	22468
1968	672	268	462	1575	3366	1982	816	518	419	426	246	184	10934
1969	337	323	1044	7175	7327	3601	3468	4176	2070	492	246	416	30675
1970	784	275	3391	12924	4665	2162	914	681	451	724	246	205	27423
1971	246	595	3580	2637	1417	2291	1232	1681	637	708	246	436	15705
1972	268	274	505	557	1095	1566	601	490	661	400	246	179	6840
1973	314	663	1159	5034	4834	3350	1031	992	605	492	246	205	18924
1974	253	3190	3922	7713	1949	6500	4185	1495	762	492	246	575	31281
1975	441	268	436	458	3428	5257	1438	1694	929	492	246	538	15625
1976	581	314	369	325	547	674	530	259	238	246	245	179	4506
1977	263	257	436	300	382	376	422	267	301	411	184	179	3777
1978	259	302	512	4192	2908	3942	2728	1553	853	492	246	217	18204
1979	246	302	438	1116	2240	1882	1048	862	641	400	246	179	9599
1980	310	347	723	6200	7380	3247	1257	1152	501	492	334	231	22174
1981	246	298	410	988	1274	1733	917	527	328	307	292	199	7519
1982	314	1569	5229	4629	5356	5330	8213	3127	1172	492	246	738	36414
1983	1337	2266	5154	6489	9902	15588	5284	4917	4868	1652	592	1242	59291
1984	1202	4794	9540	4133	2170	2036	997	737	523	655	246	223	27255
1985	251	1462	1066	369	622	717	748	610	333	307	292	253	7031
1986	285	316	750	1024	11419	8922	1496	1016	571	492	311	233	26836
1987	246	307	385	351	801	1277	653	442	393	307	248	179	5589
1988	390	268	883	1385	621	484	502	379	410	246	239	179	5985
1989	257	318	335	471	436	2441	989	643	351	307	297	226	7071
1990	294	400	277	650	633	550	586	400	238	295	262	179	4763
1991	231	301	345	277	393	1678	784	470	242	246	329	179	5474
1992	203	345	216	441	1701	983	609	372	392	246	259	179	5946
1993	246	285	483	4013	3053	2462	2203	2005	1050	492	246	179	16717
Avg.	365	564	1378	2266	2699	2439	1682	1260	717	437	260	268	14334
Min.	197	257	216	277	382	376	380	248	238	246	184	179	3777
Max.	1459	4794	9540	12924	11419	15588	8213	4917	4868	1652	592	1242	59291

Trinity

Mod Percent [EWA], CVP Delivery North of Delta (TAF)
(sum of CALSIM variables D300, D8, D9, D302, D167A_IMI, D167B_IMI, D162_IMI, D168B, D168C_FRWP, and Del_CVP_Total_N)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1922	95	40	33	29	28	29	399	459	557	567	506	273	3014
1923	58	40	34	29	28	96	279	484	533	569	508	185	2842
1924	95	49	33	29	28	55	315	352	384	387	336	167	2229
1925	33	29	24	20	20	24	245	343	508	556	494	231	2526
1926	110	39	32	27	26	55	162	396	517	521	457	253	2596
1927	58	37	30	25	24	31	336	462	531	577	512	273	2898
1928	65	40	34	29	28	25	279	458	533	544	487	264	2784
1929	106	40	33	28	27	35	335	433	400	476	426	231	2571
1930	96	52	29	24	23	22	248	396	517	521	464	222	2614
1931	95	37	30	25	25	68	327	308	353	400	348	173	2189
1932	67	31	25	22	21	41	290	315	397	413	369	199	2190
1933	87	39	28	25	24	48	326	328	392	396	344	172	2208
1934	60	44	27	23	22	34	293	347	395	415	360	179	2199
1935	64	32	26	23	22	22	139	420	541	545	488	260	2583
1936	69	42	32	27	26	30	281	412	465	532	479	253	2647
1937	105	56	32	27	26	23	270	448	482	526	472	258	2725
1938	70	39	32	27	26	26	252	440	572	578	512	235	2809
1939	71	44	34	29	51	116	439	396	504	505	456	208	2851
1940	82	52	31	26	25	25	292	397	564	576	510	267	2845
1941	66	40	33	29	28	26	146	342	559	587	519	276	2650
1942	68	40	34	29	28	26	153	384	573	587	519	272	2712
1943	105	40	34	29	28	26	263	471	557	577	512	274	2916
1944	107	43	34	29	28	38	319	397	506	537	481	261	2777
1945	78	38	31	26	25	25	342	401	523	579	512	274	2853
1946	46	40	33	29	28	34	417	465	546	542	493	260	2935
1947	104	40	33	29	28	25	338	440	468	540	481	263	2790
1948	45	38	31	26	35	48	136	303	487	585	515	250	2499
1949	89	43	33	29	29	24	332	413	546	551	492	263	2843
1950	115	41	33	29	28	32	344	444	504	516	462	234	2782
1951	46	39	32	27	26	39	400	400	566	572	508	269	2924
1952	54	40	34	29	28	26	314	471	516	571	510	268	2860
1953	117	40	34	29	28	57	301	440	533	576	472	272	2900
1954	101	40	34	29	28	24	246	459	545	572	459	266	2804
1955	106	39	32	27	26	71	311	438	505	510	457	216	2738
1956	91	37	30	25	25	67	362	397	544	576	510	246	2911
1957	69	56	34	29	28	52	354	411	576	585	517	151	2862
1958	51	46	34	29	28	26	157	376	526	565	511	269	2617
1959	110	55	34	29	28	45	428	497	545	549	483	134	2936
1960	111	56	31	26	25	23	310	386	500	503	452	245	2667
1961	98	37	30	25	25	22	317	441	518	546	483	239	2782
1962	105	38	31	26	25	24	372	472	540	566	500	259	2958
1963	43	39	32	27	26	26	149	400	568	586	518	273	2686
1964	63	40	34	29	28	80	422	440	465	500	444	222	2766
1965	60	37	30	25	25	60	250	482	563	571	440	272	2815
1966	118	40	33	29	28	44	406	479	531	535	479	257	2980
1967	111	39	32	27	26	26	136	445	477	583	515	272	2688
1968	109	40	34	29	28	24	360	469	522	570	453	268	2905
1969	77	39	32	27	26	27	335	493	546	566	507	268	2941
1970	80	42	34	29	28	25	380	478	498	540	484	262	2879
1971	74	39	32	27	26	51	440	406	538	559	499	261	2951
1972	109	41	34	29	31	121	403	447	503	529	473	208	2926
1973	48	38	31	26	25	26	344	478	567	572	509	257	2922
1974	57	40	34	29	28	26	265	476	560	499	513	275	2800
1975	71	41	34	29	28	26	290	484	571	565	501	274	2912
1976	48	44	34	29	52	144	336	425	455	464	370	201	2602
1977	94	38	28	23	34	89	355	264	394	399	349	124	2193
1978	77	29	24	21	20	26	202	457	571	580	512	224	2743
1979	121	40	34	29	28	26	308	476	573	579	506	259	2977
1980	53	40	34	29	28	26	309	443	538	567	511	268	2846
1981	105	51	34	29	28	23	284	427	565	570	505	239	2860
1982	47	38	31	26	25	26	179	465	521	589	521	182	2651
1983	45	40	34	29	28	26	158	420	549	584	499	230	2641
1984	98	40	34	29	28	50	413	496	531	552	470	259	2999
1985	61	39	32	27	26	23	353	485	549	561	496	193	2844
1986	84	39	32	27	26	24	281	441	546	550	493	203	2745
1987	108	52	33	28	28	23	352	456	507	510	457	247	2800
1988	85	36	30	25	24	77	294	350	436	476	426	231	2488
1989	96	35	28	23	29	24	331	488	520	553	489	86	2702
1990	56	39	32	27	26	53	383	262	473	479	412	224	2465
1991	93	41	29	24	28	21	219	331	403	425	378	204	2196
1992	70	37	27	24	23	20	228	377	399	447	401	216	2269
1993	44	38	27	23	22	26	312	345	493	579	506	274	2687
Avg.	80	41	32	27	27	40	301	420	511	535	472	236	2721
Min.	33	29	24	20	20	20	136	262	353	387	336	86	2189
Max.	121	56	34	29	52	144	440	497	576	589	521	276	3014

Trinity

Mod Percent [EWA], CVP Delivery So w/ CVC (TAF)
(equals CALSIM variable CVPTotalDel)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1922	204	123	107	137	166	150	187	305	439	538	453	277	3086
1923	192	114	95	116	141	160	195	310	456	562	456	285	3082
1924	195	117	99	122	148	77	85	123	161	169	164	133	1593
1925	111	60	36	27	38	129	150	225	326	383	336	226	2047
1926	168	96	70	77	96	114	130	179	255	284	261	195	1925
1927	155	86	56	52	67	161	195	316	470	581	486	288	2912
1928	198	119	101	126	153	147	172	282	409	497	422	264	2890
1929	186	110	89	106	129	100	113	158	216	230	220	177	1832
1930	146	79	47	38	52	121	147	207	294	338	302	212	1983
1931	162	92	64	66	83	75	83	120	155	161	158	131	1349
1932	110	59	34	25	35	86	97	135	188	207	192	146	1316
1933	117	65	42	37	48	79	88	122	168	178	171	137	1252
1934	113	61	37	30	40	86	97	141	188	207	192	146	1338
1935	117	65	42	37	48	92	113	217	299	346	307	215	1898
1936	163	92	65	67	85	140	166	242	339	401	349	232	2343
1937	171	98	73	81	101	110	152	222	308	358	316	218	2208
1938	165	94	67	70	89	152	193	286	409	497	422	264	2707
1939	186	110	89	106	129	137	176	258	375	451	387	248	2651
1940	178	104	81	94	115	129	154	260	376	452	388	246	2577
1941	179	104	81	94	116	157	193	313	452	557	467	283	2996
1942	194	116	98	120	146	165	195	306	441	541	456	278	3058
1943	192	115	96	117	142	155	195	301	432	529	447	275	2995
1944	191	114	94	114	138	150	176	257	374	450	386	248	2691
1945	178	104	81	93	115	152	188	301	433	531	448	272	2898
1946	191	114	94	114	139	149	177	294	429	525	440	273	2938
1947	190	113	93	113	137	125	180	257	372	446	383	247	2657
1948	178	103	80	92	114	108	153	272	395	478	408	258	2639
1949	183	107	86	101	123	123	188	265	389	470	401	255	2691
1950	181	106	84	99	121	116	149	211	298	345	306	214	2231
1951	163	92	65	67	85	161	189	306	451	554	449	281	2863
1952	194	116	97	120	146	151	185	306	440	540	455	278	3028
1953	192	115	95	116	141	157	188	290	423	516	437	270	2942
1954	189	112	92	111	134	153	187	303	444	546	459	280	3010
1955	193	115	96	118	143	141	168	243	344	408	354	234	2556
1956	172	98	74	83	103	158	189	319	465	574	481	289	3004
1957	197	118	100	125	151	163	189	317	463	571	478	288	3159
1958	196	118	100	124	150	142	179	298	427	522	442	272	2971
1959	190	113	93	112	136	160	187	306	447	549	449	294	3035
1960	193	116	97	119	144	105	142	201	283	324	291	208	2223
1961	160	90	62	62	79	136	194	293	419	511	433	269	2710
1962	188	112	91	109	133	150	183	286	425	519	439	271	2907
1963	189	113	92	111	135	154	188	307	451	556	467	283	3046
1964	194	116	98	120	146	139	164	234	335	396	345	230	2517
1965	170	97	72	80	100	146	174	320	473	585	489	292	2997
1966	198	119	102	127	154	148	177	285	414	504	427	266	2922
1967	187	111	90	107	131	146	178	283	405	492	418	262	2810
1968	185	109	88	104	127	160	187	311	454	560	470	284	3039
1969	195	117	98	121	147	151	195	310	448	551	463	281	3076
1970	193	116	97	119	144	159	189	302	442	542	457	279	3039
1971	192	115	96	117	142	154	183	307	449	552	429	303	3039
1972	194	116	97	119	145	147	180	279	398	482	410	259	2826
1973	183	108	86	102	124	159	195	305	440	539	454	276	2972
1974	194	115	95	116	141	154	195	297	426	521	440	272	2967
1975	189	113	93	112	136	159	195	306	441	542	456	279	3020
1976	192	115	96	117	142	106	119	168	231	251	235	184	1955
1977	149	81	50	44	58	83	93	133	179	194	183	142	1391
1978	115	64	40	34	45	152	195	302	434	532	449	273	2634
1979	191	114	94	115	139	161	195	320	463	572	479	288	3131
1980	196	118	100	124	151	151	195	302	434	532	449	276	3028
1981	191	114	94	115	139	160	189	305	450	553	465	282	3057
1982	194	116	97	120	145	136	167	296	425	520	440	272	2927
1983	189	113	93	111	135	145	183	272	387	466	399	254	2746
1984	181	106	84	98	120	160	189	298	439	538	453	277	2944
1985	192	115	95	116	141	147	180	272	395	478	408	258	2795
1986	183	107	86	101	123	140	178	275	391	473	404	256	2717
1987	182	107	85	99	122	119	179	255	369	442	380	245	2584
1988	177	103	80	91	113	97	109	158	207	218	210	173	1736
1989	144	77	45	35	48	92	167	244	343	406	352	233	2187
1990	172	98	74	82	103	92	102	148	191	197	194	165	1618
1991	141	75	41	30	42	89	101	146	197	219	201	150	1432
1992	119	67	44	40	52	93	136	198	278	331	287	187	1832
1993	135	79	61	68	84	145	179	283	404	490	417	262	2607
Avg.	175	103	81	94	115	134	166	258	370	446	381	245	2566
Min.	110	59	34	25	35	75	83	120	155	161	158	131	1252
Max.	204	123	107	137	166	165	195	320	473	585	489	303	3159

Trinity

Mod Percent [EWA], X2_PRV (KM)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	
1922	74.9	83.2	85.0	78.2	76.4	66.4	66.3	66.8	61.2	63.3	74.1	82.9	
1923	86.7	87.0	83.2	70.7	67.2	71.5	73.6	68.6	70.7	76.2	79.9	84.8	
1924	85.9	86.8	83.3	85.0	82.3	77.6	77.0	80.3	84.9	84.3	82.4	87.8	
1925	89.6	87.9	85.9	80.2	80.4	63.5	64.8	65.6	70.8	76.0	81.8	86.2	
1926	88.8	86.1	85.9	84.6	78.8	66.8	74.0	69.7	73.7	81.0	83.5	84.4	
1927	88.5	87.6	76.6	76.2	69.4	54.5	59.1	59.1	64.5	73.0	75.6	83.4	
1928	87.6	86.8	81.5	81.4	75.3	72.3	57.8	63.3	68.5	76.1	78.3	84.3	
1929	88.4	86.2	83.9	83.9	83.0	77.8	76.8	79.6	81.0	82.0	85.5	85.4	
1930	88.8	88.3	85.2	79.0	74.0	72.8	68.5	73.4	76.3	80.1	83.2	85.5	
1931	88.9	86.6	85.4	83.2	79.0	78.9	80.8	81.1	84.5	84.2	86.2	86.5	
1932	89.2	87.6	85.3	75.3	72.5	70.7	73.9	74.8	75.4	76.2	81.9	82.9	
1933	88.0	87.5	85.1	82.7	76.3	77.5	77.2	76.9	81.1	82.0	85.5	84.9	
1934	88.7	89.4	84.8	81.2	77.7	75.2	75.1	76.2	81.0	81.0	85.2	86.3	
1935	89.1	87.9	84.2	83.8	71.3	74.0	69.1	61.4	64.4	72.0	78.5	84.4	
1936	88.5	85.8	84.8	85.1	70.1	59.2	63.4	65.7	69.1	75.9	79.8	84.8	
1937	88.6	86.4	84.4	85.0	81.7	67.1	62.0	64.5	67.7	74.1	79.2	84.6	
1938	88.6	87.1	77.1	62.2	63.9	52.1	47.1	51.3	53.1	58.0	72.3	82.3	
1939	83.8	78.8	83.6	81.0	80.6	77.7	75.4	76.3	77.0	81.8	83.7	84.9	
1940	88.7	86.0	85.2	85.0	70.4	60.9	53.7	54.5	65.1	73.9	77.5	84.0	
1941	87.6	87.3	82.4	67.8	56.6	51.1	51.6	53.0	57.8	67.5	75.4	82.4	
1942	81.6	84.2	85.3	65.7	57.6	50.5	61.0	59.2	61.0	66.5	75.1	83.2	
1943	81.8	82.7	81.0	72.1	58.9	57.8	54.0	60.9	65.5	73.7	76.9	83.8	
1944	87.9	87.4	84.6	84.8	81.7	72.2	71.5	73.4	75.6	78.7	82.7	86.6	
1945	88.5	84.8	83.8	79.3	79.9	66.4	67.8	70.8	72.6	76.1	79.8	84.8	
1946	88.0	87.3	82.2	64.0	61.1	64.8	69.6	72.6	73.5	76.7	80.1	84.9	
1947	86.8	85.7	83.8	80.4	81.9	76.2	73.5	74.6	77.7	79.8	83.1	85.0	
1948	88.7	85.1	85.6	84.4	80.3	77.1	75.3	69.0	67.0	72.5	78.7	84.4	
1949	87.4	85.6	84.4	82.0	83.9	80.2	66.5	71.5	73.3	77.8	82.4	86.7	
1950	89.0	85.2	85.6	83.6	74.7	68.1	70.9	70.3	71.3	74.4	79.3	84.6	
1951	87.8	86.1	68.2	56.8	55.9	55.2	62.5	68.5	69.6	78.1	77.4	84.0	
1952	86.6	87.0	82.3	68.7	57.6	55.3	55.4	55.0	54.6	59.0	72.6	82.4	
1953	77.7	76.1	82.7	68.3	56.3	64.2	69.2	70.6	68.0	71.7	75.7	83.4	
1954	81.2	85.0	82.9	84.3	70.9	61.9	60.6	61.1	65.7	76.9	78.5	84.4	
1955	86.3	85.7	82.8	75.5	74.8	75.1	77.6	75.7	76.0	79.2	82.9	86.2	
1956	89.1	85.4	85.5	62.4	50.5	52.1	59.5	65.6	62.8	69.3	76.0	83.5	
1957	80.7	81.4	84.4	85.4	81.8	70.3	63.7	67.6	69.4	75.4	77.4	84.0	
1958	87.6	80.5	83.5	76.0	67.4	51.6	51.5	50.9	55.6	61.6	73.5	82.7	
1959	79.2	77.7	83.2	85.0	70.8	62.0	66.4	74.1	76.8	78.1	79.8	84.8	
1960	85.5	86.7	83.7	85.2	83.1	71.8	72.2	74.3	75.2	80.7	83.4	86.2	
1961	89.1	85.0	84.7	80.3	80.1	70.8	71.9	75.1	77.2	80.8	83.4	84.4	
1962	88.5	85.3	84.1	80.5	81.9	66.6	68.1	72.9	74.2	79.2	80.3	84.9	
1963	86.8	73.4	79.6	72.6	76.5	61.9	64.5	56.1	61.4	71.2	75.3	83.3	
1964	85.7	82.6	73.8	81.9	75.1	75.3	78.1	75.3	76.8	79.4	83.0	84.8	
1965	87.4	86.2	83.7	63.7	53.8	61.3	66.9	61.8	65.5	75.3	75.4	83.4	
1966	87.2	87.2	77.6	77.2	69.9	68.3	68.2	72.5	73.8	78.1	80.5	85.0	
1967	88.2	84.5	83.7	69.7	62.6	60.1	58.2	57.6	57.3	59.3	71.7	82.1	
1968	77.6	76.4	82.8	80.9	70.9	61.3	62.7	69.7	75.8	79.1	80.4	85.0	
1969	88.4	85.2	84.2	75.1	57.4	50.6	54.7	56.0	55.3	60.2	73.0	82.6	
1970	81.4	76.4	82.6	65.6	49.8	51.6	58.9	67.6	73.0	77.6	75.8	83.5	
1971	87.1	87.2	80.2	64.4	61.5	64.6	62.7	66.6	65.7	72.6	74.3	83.0	
1972	81.2	84.6	85.3	81.1	78.9	72.5	68.2	73.9	77.6	76.2	79.9	84.8	
1973	88.6	85.8	78.9	72.6	59.3	54.4	56.5	65.9	69.5	74.3	77.7	84.1	
1974	87.3	87.0	67.3	59.4	51.7	58.9	52.8	54.0	62.5	70.2	76.3	83.6	
1975	79.3	80.1	84.0	81.8	80.7	64.1	56.2	63.2	64.6	69.3	76.0	83.6	
1976	79.8	78.2	82.1	82.4	83.5	79.4	76.9	77.7	83.7	86.1	86.8	87.1	
1977	89.4	87.4	86.7	82.7	84.2	82.1	82.3	81.2	84.6	84.6	82.4	87.8	
1978	89.6	87.6	85.5	81.0	63.5	59.7	56.9	58.6	63.7	69.7	76.2	83.6	
1979	86.7	87.1	85.3	82.2	74.0	65.2	64.4	68.4	71.4	74.4	79.3	84.6	
1980	88.6	85.9	83.9	77.9	59.4	51.5	55.7	64.1	67.8	75.1	77.9	81.8	
1981	85.7	86.7	85.3	82.7	75.1	69.8	66.6	70.1	75.8	81.0	83.5	84.7	
1982	87.7	85.5	72.2	58.9	55.4	52.4	52.2	48.6	55.1	64.5	74.4	83.0	
1983	77.2	70.9	64.6	56.5	52.1	46.6	42.1	48.7	51.6	52.4	61.2	71.9	
1984	69.5	69.3	58.3	49.7	53.3	58.9	61.7	67.9	72.5	76.3	76.1	83.6	
1985	86.5	86.8	73.2	71.4	78.9	76.6	75.5	74.6	76.1	81.0	83.5	84.7	
1986	85.9	85.7	84.5	77.8	73.2	52.4	48.3	60.4	67.5	74.1	77.6	82.2	
1987	85.7	86.7	85.1	83.1	83.1	76.0	70.9	74.1	78.4	80.5	83.3	85.9	
1988	89.0	84.3	85.3	76.8	70.6	74.1	77.7	78.4	81.0	81.0	85.2	86.8	
1989	89.3	87.5	85.1	84.1	81.2	80.1	67.3	69.8	74.1	79.9	83.1	84.4	
1990	86.7	85.7	82.7	84.8	79.0	76.5	77.5	77.1	80.2	84.9	85.1	86.0	
1991	89.0	88.3	85.8	84.1	85.3	82.2	70.9	72.7	77.5	83.9	86.1	84.6	
1992	88.6	89.1	85.0	87.5	82.8	70.4	71.1	74.7	79.9	81.0	85.2	86.2	
1993	89.1	87.8	86.0	81.6	64.0	59.5	60.5	61.4	62.7	67.8	75.5	83.4	
Avg.	86.1	84.7	82.2	76.8	71.2	66.1	65.6	67.6	70.5	75.1	79.3	84.3	
Min.	69.5	69.3	58.3	49.7	49.8	46.6	42.1	48.6	51.6	52.4	61.2	71.9	
Max.	89.6	89.4	86.7	87.5	85.3	82.2	82.3	81.2	84.9	86.1	86.8	87.8	

Preferred Flow

Trinity

Pref Flow [EWA], Trinity Storage (TAF)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1922	1782	1724	1725	1722	1745	1794	1893	1966	1976	1864	1741	1592
1923	1507	1478	1488	1514	1537	1595	1709	1638	1599	1380	1161	1077
1924	1053	1043	1036	930	973	973	916	834	704	582	507	465
1925	457	526	557	477	748	889	1186	1172	1120	1003	898	820
1926	794	788	807	808	952	1054	1273	1177	1119	974	830	746
1927	719	875	1070	1187	1425	1603	1831	1821	1850	1729	1616	1474
1928	1415	1473	1491	1548	1663	1869	2024	1962	1831	1678	1446	1332
1929	1269	1245	1236	1171	1195	1253	1272	1313	1259	1101	969	882
1930	820	799	927	943	1042	1167	1267	1179	1118	999	895	811
1931	779	765	753	762	781	838	880	841	752	617	531	489
1932	473	467	470	435	456	608	698	721	717	609	532	483
1933	458	452	448	445	446	563	716	704	789	688	593	547
1934	530	522	531	592	682	818	842	816	700	580	506	442
1935	383	447	484	525	610	670	884	914	918	810	692	653
1936	639	634	637	751	885	1003	1160	1090	1045	939	854	772
1937	739	722	707	692	696	801	1021	1163	1261	1157	1073	991
1938	967	1108	1327	1424	1581	1842	2150	2324	2269	2237	2120	1975
1939	1850	1850	1847	1778	1774	1876	1948	1889	1763	1582	1396	1265
1940	1045	924	988	1162	1488	1790	2017	1954	1839	1659	1510	1400
1941	1344	1325	1464	1684	1934	2100	2300	2420	2447	2270	2150	1975
1942	1850	1850	1850	1900	2000	1987	2194	2254	2326	2270	2150	1975
1943	1850	1850	1850	1900	2000	2100	2281	2172	2104	1960	1841	1696
1944	1639	1619	1613	1617	1660	1728	1765	1820	1771	1563	1383	1268
1945	1206	1208	1273	1327	1493	1547	1680	1645	1597	1454	1321	1206
1946	1164	1219	1410	1540	1595	1725	1947	1942	1848	1686	1515	1402
1947	1342	1336	1348	1339	1391	1502	1585	1494	1480	1286	1085	947
1948	961	972	973	1165	1187	1222	1404	1398	1434	1308	1197	1149
1949	1141	1148	1152	1145	1183	1399	1658	1666	1582	1438	1307	1194
1950	1163	1155	1146	1173	1229	1351	1505	1510	1492	1369	1235	1123
1951	1216	1331	1589	1679	1900	2004	2182	2114	1952	1805	1657	1513
1952	1459	1465	1612	1671	1861	2027	2300	2412	2447	2270	2150	1975
1953	1850	1845	1850	1900	1943	2071	2278	2237	2330	2270	2150	1975
1954	1850	1850	1850	1900	2000	2100	2300	2272	2125	1989	1802	1665
1955	1608	1629	1685	1704	1732	1767	1819	1817	1803	1664	1518	1408
1956	1346	1330	1638	1900	2000	2099	2290	2392	2311	2194	2081	1975
1957	1850	1850	1813	1796	1957	2100	2180	2197	2177	2032	1837	1699
1958	1790	1850	1850	1900	2059	2100	2300	2420	2431	2270	2150	1975
1959	1850	1850	1818	1900	2000	2012	2145	2045	1945	1714	1506	1289
1960	1227	1189	1177	1186	1328	1507	1624	1569	1543	1386	1231	1117
1961	1089	1093	1182	1219	1442	1570	1714	1684	1681	1542	1385	1272
1962	1209	1188	1220	1224	1358	1435	1651	1572	1511	1371	1247	1136
1963	1226	1277	1451	1492	1787	1866	2133	2173	2118	1974	1851	1704
1964	1701	1819	1834	1900	1888	1918	1915	1812	1756	1562	1388	1281
1965	1213	1220	1756	1900	1971	1961	2195	2110	2050	1915	1780	1643
1966	1583	1671	1711	1794	1862	2069	2300	2312	2256	2045	1825	1660
1967	1553	1635	1778	1893	2000	2100	2211	2333	2434	2270	2150	1975
1968	1850	1850	1834	1844	2000	2100	2180	2071	1915	1717	1570	1401
1969	1345	1341	1400	1544	1669	1831	2167	2420	2349	2225	2109	1975
1970	1850	1850	1850	1900	2000	2080	2144	2051	1912	1688	1505	1387
1971	1328	1434	1565	1800	1915	2100	2282	2332	2345	2270	2150	1975
1972	1850	1850	1842	1900	2000	2100	2247	2185	2059	1912	1752	1605
1973	1525	1535	1644	1804	1959	2084	2263	2328	2278	2141	1941	1800
1974	1742	1850	1850	1900	2000	2100	2300	2400	2394	2270	2150	1975
1975	1850	1849	1840	1827	1924	2100	2231	2344	2447	2270	2150	1975
1976	1850	1850	1837	1703	1737	1784	1870	1853	1804	1586	1447	1336
1977	1271	1236	1219	1199	1192	1179	1071	1020	885	654	525	500
1978	492	500	629	1030	1215	1501	1702	1719	1674	1590	1481	1397
1979	1336	1332	1328	1351	1404	1554	1680	1767	1778	1671	1517	1405
1980	1373	1408	1472	1701	2000	2083	2231	2144	2012	1890	1739	1595
1981	1531	1508	1548	1655	1795	1921	2037	1967	1908	1757	1519	1398
1982	1318	1562	1850	1900	2000	2100	2300	2311	2179	2063	1948	1921
1983	1850	1850	1850	1900	2000	2100	2300	2420	2447	2270	2150	1975
1984	1850	1850	1850	1900	1998	2100	2215	2178	2050	1916	1772	1631
1985	1574	1702	1756	1747	1778	1834	1980	1900	1806	1578	1348	1168
1986	1112	1101	1111	1239	1723	2065	2096	1990	1877	1681	1525	1416
1987	1362	1327	1314	1324	1409	1621	1773	1695	1514	1290	1061	916
1988	879	865	1034	1112	1192	1277	1346	1286	1237	1074	932	832
1989	776	811	825	846	871	1215	1418	1311	1193	1036	924	846
1990	859	855	846	905	925	1009	1044	1010	1008	900	777	691
1991	669	655	644	639	649	727	792	819	798	690	621	582
1992	564	554	550	558	697	839	1074	1067	935	754	615	542
1993	525	520	544	606	750	1127	1332	1514	1609	1587	1476	1450
Avg.	1271	1287	1340	1395	1503	1624	1772	1769	1722	1577	1437	1321
Min.	383	447	448	435	446	563	698	704	700	580	506	442
Max.	1850	1850	1850	1900	2059	2100	2300	2420	2447	2270	2150	1975

Trinity

Pref Flow [EWA], Whiskeytown Storage (TAF)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	
	1922	217	206	206	206	206	217	240	240	240	240	240	235
	1923	217	206	206	206	206	217	240	240	240	240	240	235
	1924	217	206	205	206	206	217	240	240	240	240	240	207
	1925	203	206	206	180	206	217	240	240	240	240	240	235
	1926	217	206	206	206	206	217	240	240	240	240	240	235
	1927	217	206	206	206	206	217	240	240	238	240	240	235
	1928	217	206	206	206	206	217	240	240	240	240	240	235
	1929	217	206	206	206	206	217	240	240	240	240	240	235
	1930	217	206	206	206	206	217	240	240	240	240	240	235
	1931	217	206	206	206	206	217	227	232	240	240	240	235
	1932	217	195	193	180	186	209	208	216	240	240	180	180
	1933	180	180	180	180	182	202	218	224	240	240	240	235
	1934	217	206	206	206	206	217	240	240	240	240	240	180
	1935	180	191	194	206	206	217	240	240	240	240	240	235
	1936	217	206	202	206	206	205	240	240	240	240	240	235
	1937	217	206	204	205	206	217	240	240	240	240	240	235
	1938	217	206	206	206	206	217	240	240	240	240	240	235
	1939	217	206	206	206	206	217	240	240	240	240	240	235
	1940	217	206	206	206	206	217	240	238	240	240	240	235
	1941	217	206	206	206	206	217	240	240	240	240	240	235
	1942	217	206	206	206	206	217	240	240	240	240	240	235
	1943	217	206	206	206	206	217	240	237	240	240	240	235
	1944	217	206	206	206	206	217	240	240	240	240	240	235
	1945	217	206	206	206	206	217	240	237	232	240	240	235
	1946	217	206	206	206	206	217	240	238	240	240	240	235
	1947	217	206	206	206	206	217	240	240	240	240	240	235
	1948	217	206	206	206	206	217	240	240	240	240	240	235
	1949	217	206	206	206	206	217	240	238	240	240	240	235
	1950	217	206	206	206	206	217	240	240	240	240	240	235
	1951	217	206	206	206	206	217	240	240	240	240	240	235
	1952	217	206	206	206	206	217	240	240	240	240	240	235
	1953	217	206	206	206	206	217	240	240	240	240	240	235
	1954	217	206	206	206	206	217	240	240	240	240	240	235
	1955	217	206	206	206	206	217	240	240	240	240	240	235
	1956	217	206	206	206	206	217	240	240	236	240	240	235
	1957	217	206	206	206	206	217	240	240	240	240	240	235
	1958	217	206	206	206	240	217	240	240	240	240	240	235
	1959	217	206	206	206	206	217	240	238	240	240	240	235
	1960	217	206	206	206	206	217	240	240	240	240	240	235
	1961	217	206	206	206	206	217	240	238	240	240	240	235
	1962	217	206	206	206	206	217	240	237	240	240	240	235
	1963	217	206	206	206	206	217	240	240	240	240	240	235
	1964	217	206	206	206	206	217	240	240	240	240	240	235
	1965	217	206	206	206	206	217	240	240	240	240	240	235
	1966	217	206	206	206	206	217	240	238	240	240	240	235
	1967	217	206	206	206	206	217	240	240	240	240	240	235
	1968	217	206	206	206	206	217	240	238	240	240	240	235
	1969	217	206	206	206	206	217	240	240	240	240	240	235
	1970	217	206	206	206	206	217	240	239	240	240	240	235
	1971	217	206	206	206	206	217	240	240	240	240	240	235
	1972	217	206	206	206	206	217	240	238	240	240	240	235
	1973	217	206	206	206	206	217	240	240	240	240	240	235
	1974	217	206	206	206	206	217	240	240	240	240	240	235
	1975	217	206	206	206	206	217	240	240	240	240	240	235
	1976	217	206	206	206	206	217	240	240	240	240	240	235
	1977	217	206	206	206	206	217	240	240	240	240	240	235
	1978	203	206	206	206	206	217	240	240	238	240	240	235
	1979	217	206	206	206	206	217	240	240	240	240	240	235
	1980	217	206	206	206	206	217	240	240	240	240	240	235
	1981	217	206	206	206	206	217	240	240	240	240	240	235
	1982	217	206	206	206	206	217	240	240	238	240	240	235
	1983	217	206	206	206	206	217	240	240	240	240	240	235
	1984	217	206	206	206	206	217	240	236	240	240	240	235
	1985	217	206	206	206	206	217	240	240	240	240	240	235
	1986	217	206	206	206	206	217	240	239	240	240	240	235
	1987	217	206	206	206	206	217	240	240	240	240	240	235
	1988	217	206	206	206	206	217	240	240	240	240	240	235
	1989	217	206	206	206	206	217	240	239	240	240	240	235
	1990	217	206	206	206	206	217	240	240	240	239	240	235
	1991	217	206	201	200	202	217	231	228	240	240	240	235
	1992	217	206	206	206	206	217	240	240	240	240	240	235
	1993	217	206	206	206	206	217	240	240	240	240	240	235
Avg.		216	205	205	205	206	217	239	239	240	240	239	233
Min.		180	180	180	180	182	202	208	216	232	239	180	180
Max.		217	206	206	206	240	217	240	240	240	240	240	235

Trinity

Pref Flow [EWA], Shasta Storage (TAF)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1922	2806	2846	2935	3040	3400	3781	4258	4392	4085	3600	3147	2961
1923	2990	3077	3208	3407	3535	3658	3962	3669	3256	2800	2437	2319
1924	2255	2180	2127	2240	2399	2400	2188	1866	1471	1040	693	607
1925	612	747	860	1143	2381	2589	3246	3303	3066	2628	2241	2102
1926	2043	2045	2047	2090	2817	3022	3317	3172	2798	2344	2037	1919
1927	1903	2387	2893	3432	3462	4094	4552	4552	4243	3621	3183	3024
1928	2994	3252	3363	3639	4099	3965	4463	4242	3874	3200	2853	2707
1929	2650	2626	2626	2752	2939	3106	3188	3061	2819	2396	2043	1911
1930	1836	1757	2280	2485	2857	3332	3492	3387	3053	2618	2274	2194
1931	2150	2149	2135	2209	2293	2455	2190	1902	1584	1141	810	665
1932	625	631	822	1036	1152	1562	1742	1949	1777	1503	1281	1159
1933	1096	1081	1069	1094	1131	1715	1848	1906	1771	1412	1086	930
1934	843	803	926	1221	1546	1827	1915	1744	1396	999	685	618
1935	605	706	743	1031	1357	1745	2741	2960	2654	2290	1931	1747
1936	1725	1694	1702	2325	3212	3572	3799	3685	3471	3015	2570	2396
1937	2285	2200	2124	2103	2195	2846	3509	3657	3491	3147	2745	2579
1938	2532	3090	3310	3668	3560	3416	4058	4552	4467	4056	3690	3400
1939	3250	3252	3361	3557	3689	4090	3901	3610	3109	2500	1989	1880
1940	1977	1999	2149	3029	3252	3435	4161	4102	3720	3193	2777	2621
1941	2611	2635	3293	3317	3423	3940	4456	4552	4494	4150	3700	3400
1942	3250	3200	3316	3389	3516	3938	4552	4552	4459	4057	3686	3400
1943	3250	3252	3356	3541	3848	4118	4552	4521	4248	3708	3289	3146
1944	3121	3140	3130	3208	3514	3825	3825	3723	3454	2969	2620	2484
1945	2472	2695	3010	3201	3948	4258	4426	4422	4129	3546	3112	2928
1946	2985	3252	3265	3622	3595	3991	4195	4120	3753	3278	2911	2761
1947	2686	2755	2863	2878	3146	3678	3843	3486	3202	2651	2269	2179
1948	2271	2322	2354	2918	2714	3020	3923	4277	4289	3911	3510	3370
1949	3250	3187	3189	3194	3384	4071	4392	4341	3950	3284	2871	2709
1950	2558	2472	2411	2684	3094	3546	3893	3847	3561	3183	2840	2751
1951	3054	3252	3322	3624	3794	4237	4325	4348	3980	3314	2899	2750
1952	2769	2884	3306	3604	3739	4022	4290	4552	4404	4107	3700	3400
1953	3250	3200	3345	3366	3753	4226	4552	4552	4500	4000	3682	3400
1954	3250	3252	3364	3552	3661	4106	4546	4260	4050	3319	3093	3044
1955	3052	3219	3360	3482	3571	3739	3883	3962	3534	3051	2700	2623
1956	2596	2638	3252	3252	3288	4012	4522	4552	4376	4031	3700	3400
1957	3250	3200	3241	3367	3675	4129	4201	4459	4171	3550	3199	3241
1958	3250	3245	3338	3531	3252	3416	4173	4552	4500	4146	3700	3400
1959	3250	3200	3258	3648	3777	4103	4155	3928	3263	2681	2264	2429
1960	2307	2204	2183	2376	3094	3791	3985	3973	3693	3073	2598	2543
1961	2483	2618	3080	3283	3914	4280	4378	4350	4026	3201	2659	2538
1962	2411	2360	2639	2752	3675	4175	4452	4341	3986	3316	2901	2785
1963	3214	3252	3349	3514	3944	4006	4137	4431	4206	3682	3348	3307
1964	3250	3252	3310	3705	3923	4086	3762	3539	3305	2846	2461	2362
1965	2358	2530	3252	3368	3809	3976	4500	4416	4086	3484	3208	3133
1966	3119	3252	3340	3725	4037	4229	4552	4406	3729	3179	2795	2737
1967	2606	2968	3335	3551	3920	4033	4479	4552	4500	4150	3700	3400
1968	3250	3212	3315	3612	3654	4248	4243	4103	3643	3033	2740	2674
1969	2668	2703	3025	3358	3480	4030	4434	4552	4383	3873	3484	3400
1970	3250	3252	3317	3252	3431	4104	4093	3953	3678	2950	2633	2525
1971	2600	3123	3319	3515	3654	3873	4359	4552	4493	3968	3629	3400
1972	3250	3200	3338	3714	3979	4249	4494	4393	3889	3200	2843	2834
1973	2944	3250	3346	3552	3636	4162	4443	4421	4002	3322	3037	2979
1974	3102	3252	3267	3252	3694	3416	4289	4480	4330	4067	3700	3400
1975	3250	3208	3336	3509	3936	3756	4343	4552	4416	4150	3700	3400
1976	3250	3252	3328	3543	3728	3962	4053	3886	3442	3093	2981	2981
1977	2963	3033	2935	2951	2946	2949	2612	2477	1933	1169	718	668
1978	550	595	1128	3044	3567	4000	4552	4552	4208	3609	3245	3242
1979	3200	3199	3192	3351	3702	4208	4379	4411	3826	3182	2893	2791
1980	2854	3035	3191	3528	3292	4047	4349	4280	3956	3515	3173	3115
1981	3088	3064	3162	3470	3886	4256	4400	4154	3527	2892	2518	2423
1982	2500	3252	3276	3616	3530	3953	4094	4304	4143	3853	3583	3400
1983	3250	3252	3328	3371	3252	3417	4074	4552	4500	4150	3700	3400
1984	3250	3252	3285	3650	4005	4246	4344	4294	4039	3427	3189	3167
1985	3203	3252	3360	3494	3683	3895	4006	3635	3131	2609	2238	2247
1986	2249	2277	2434	3002	3252	3534	3954	3924	3544	3175	2850	2888
1987	2928	2939	2953	3092	3432	4168	3971	3675	3137	2664	2381	2254
1988	2075	2047	2509	2941	2916	3025	3046	3033	2637	2229	1919	1775
1989	1671	1882	1984	2095	2209	3594	3982	3706	3340	2745	2343	2367
1990	2487	2456	2404	2644	2657	2902	2750	2901	2699	2199	1941	1863
1991	1749	1681	1667	1670	1698	2125	2276	2220	1968	1681	1382	1300
1992	1205	1080	1076	1122	1779	2226	2462	2189	1821	1416	1065	863
1993	755	725	956	1605	2336	3794	4430	4552	4500	3864	3592	3400
Avg.	2537	2603	2744	2988	3245	3607	3888	3868	3571	3075	2713	2585
Min.	550	595	743	1031	1131	1562	1742	1744	1396	999	685	607
Max.	3250	3252	3364	3725	4099	4280	4552	4552	4500	4150	3700	3400

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Pref Flow [EWA], Trinity Import (TAF)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1922	203	60	15	16	6	6	20	6	45	92	92	119	680
1923	77	30	8	6	6	6	19	46	45	203	192	60	697
1924	15	6	6	108	20	12	61	12	85	92	45	15	479
1925	0	6	18	131	0	0	6	0	15	77	83	67	403
1926	15	6	6	6	6	12	6	6	31	119	115	60	388
1927	15	6	6	6	0	6	0	0	0	92	92	119	343
1928	46	0	6	6	0	0	7	0	45	92	203	89	495
1929	46	30	15	76	6	6	22	6	60	138	103	60	568
1930	44	10	6	6	6	6	24	6	52	97	77	60	394
1931	15	6	8	6	6	6	6	7	79	110	58	15	322
1932	0	0	0	47	0	0	0	0	30	92	52	23	244
1933	7	4	3	0	0	0	0	0	48	102	72	23	259
1934	0	0	0	0	0	21	84	9	92	96	47	39	388
1935	48	0	0	0	0	0	0	6	15	92	92	15	269
1936	0	0	0	0	6	0	19	0	15	61	61	60	222
1937	15	6	6	6	0	0	6	6	15	108	61	60	289
1938	15	6	0	0	0	0	0	0	0	7	92	121	242
1939	119	15	34	87	23	6	24	38	98	154	154	104	857
1940	203	110	6	6	0	0	15	0	45	123	123	89	720
1941	46	30	0	0	0	0	0	124	28	203	120	162	713
1942	114	17	0	0	0	98	0	0	0	38	99	152	519
1943	110	26	65	0	22	72	19	0	8	92	92	119	624
1944	46	30	8	6	6	6	27	15	74	195	154	89	657
1945	46	30	15	6	0	6	18	0	0	92	108	89	411
1946	46	0	0	0	6	0	6	0	45	123	148	89	462
1947	46	30	15	15	14	15	24	15	45	176	177	113	686
1948	15	6	6	6	6	6	6	0	45	92	92	30	310
1949	0	0	4	8	0	0	6	0	45	92	108	89	352
1950	15	6	6	6	6	6	15	15	45	108	108	89	425
1951	15	0	0	0	0	6	22	0	82	92	123	119	459
1952	46	30	0	0	0	0	74	0	7	175	103	153	587
1953	110	0	36	0	81	0	9	0	0	84	107	155	582
1954	116	83	54	35	0	139	136	0	82	92	169	119	1025
1955	46	30	0	6	6	6	3	15	45	123	123	89	492
1956	46	30	0	0	0	52	76	0	0	92	91	84	471
1957	114	5	45	22	0	33	45	0	0	92	169	119	645
1958	0	20	101	108	154	0	0	146	0	173	112	155	970
1959	111	0	32	99	4	120	54	0	45	173	181	196	1016
1960	46	30	6	6	6	15	17	0	45	108	130	89	498
1961	15	6	6	0	0	0	16	0	45	92	135	89	405
1962	46	30	6	15	0	6	24	0	45	92	108	89	461
1963	15	0	0	6	0	0	0	0	2	92	92	119	327
1964	0	0	29	14	65	12	52	15	74	183	157	89	690
1965	61	30	0	0	26	90	0	0	2	92	123	119	543
1966	46	0	0	0	0	0	83	0	3	169	203	149	653
1967	96	30	0	0	30	61	0	0	0	153	108	158	637
1968	123	7	38	79	0	51	37	0	89	142	123	149	838
1969	46	30	15	0	0	0	0	6	0	92	92	107	389
1970	115	1	155	145	0	69	20	0	82	173	154	89	1004
1971	46	30	0	0	26	11	0	0	2	54	96	148	413
1972	109	14	31	53	16	203	0	0	89	92	136	119	863
1973	77	30	0	0	0	0	24	0	0	92	169	119	511
1974	77	0	0	139	9	0	39	0	2	122	104	149	642
1975	104	0	31	42	0	0	15	0	20	165	101	155	633
1976	122	31	53	151	6	12	11	15	45	203	123	89	861
1977	46	30	6	15	7	15	108	6	111	203	108	15	671
1978	0	22	71	0	0	0	0	0	0	92	92	89	367
1979	46	0	0	6	6	6	6	6	0	92	123	89	381
1980	46	30	6	0	0	60	28	0	82	92	123	119	585
1981	46	15	6	6	6	0	6	6	45	123	203	89	551
1982	74	0	0	41	0	83	0	0	0	92	92	0	382
1983	91	37	0	0	0	65	61	179	196	203	154	173	1159
1984	121	129	0	102	0	50	19	0	82	92	123	119	837
1985	46	0	0	41	14	1	24	15	92	203	203	156	796
1986	45	6	6	6	0	0	128	0	45	141	129	89	594
1987	46	30	15	15	6	6	15	49	173	203	203	114	875
1988	15	6	6	6	6	6	31	15	96	154	115	69	526
1989	35	6	6	6	6	6	6	0	45	96	85	60	357
1990	15	6	7	6	6	8	27	6	29	92	92	60	354
1991	0	0	0	0	0	0	0	0	27	92	46	15	180
1992	0	0	0	0	0	0	0	6	133	168	111	47	465
1993	0	4	0	0	0	0	6	0	0	0	92	1	103
Avg.	53	17	14	24	9	21	23	11	43	118	117	94	545
Min.	0	0	0	0	0	0	0	0	0	0	45	0	103
Max.	203	129	155	151	154	203	136	179	196	203	203	196	1159

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Pref Flow [EWA], Trinity Flow (TAF)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1922	23	18	18	18	17	18	32	180	47	28	28	27	453
1923	23	18	18	18	17	18	32	180	47	28	28	27	453
1924	23	18	18	18	17	18	36	92	47	28	28	27	370
1925	23	18	18	18	17	18	27	290	150	68	28	27	702
1926	23	18	18	18	17	18	32	180	47	28	28	27	453
1927	23	18	18	18	17	18	27	290	150	68	28	27	702
1928	23	18	18	18	17	18	29	258	126	68	28	27	649
1929	23	18	18	18	17	18	36	92	47	28	28	27	369
1930	23	18	18	18	17	18	32	180	47	28	28	27	453
1931	23	18	18	18	17	18	36	92	47	28	28	27	369
1932	23	18	18	18	17	18	32	180	47	28	28	27	454
1933	23	18	18	18	17	18	32	180	47	28	28	27	453
1934	23	18	18	18	17	18	36	92	47	28	28	27	369
1935	23	18	18	18	17	18	32	180	47	28	28	27	453
1936	23	18	18	18	17	18	29	258	126	68	28	27	649
1937	23	18	18	18	17	18	32	180	47	28	28	27	453
1938	23	18	18	18	17	18	25	281	275	68	28	27	817
1939	23	18	18	18	17	18	36	92	47	28	28	27	369
1940	23	18	18	18	17	18	27	290	150	68	28	27	703
1941	23	18	18	18	17	207	162	281	275	120	28	27	1194
1942	23	18	275	164	134	18	27	290	150	68	28	27	1222
1943	23	18	18	71	17	18	29	258	126	68	28	27	700
1944	23	18	18	18	17	18	36	92	47	28	28	27	370
1945	23	18	18	18	17	18	29	258	126	68	28	27	648
1946	23	18	18	18	17	18	27	290	150	68	28	27	702
1947	23	18	18	18	17	18	32	180	47	28	28	27	453
1948	23	18	18	18	17	18	29	258	126	68	28	27	649
1949	23	18	18	18	17	18	29	258	126	68	28	27	648
1950	23	18	18	18	17	18	32	180	47	28	28	27	453
1951	23	18	18	18	17	18	27	290	150	68	28	27	702
1952	23	18	18	18	17	18	27	290	150	68	28	27	703
1953	23	18	18	280	17	18	27	290	150	68	28	27	964
1954	23	18	18	18	130	18	27	290	150	68	28	27	815
1955	23	18	18	18	17	18	32	180	47	28	28	27	453
1956	23	18	18	90	55	18	25	281	275	68	28	27	926
1957	23	18	18	18	17	18	29	258	126	68	28	27	648
1958	23	18	18	18	333	188	102	281	275	68	28	27	1380
1959	23	18	18	18	17	18	29	258	126	68	28	27	648
1960	23	18	18	18	17	18	29	258	126	68	28	27	649
1961	23	18	18	18	17	18	29	258	126	68	28	27	648
1962	23	18	18	18	17	18	29	258	126	68	28	27	648
1963	23	18	18	18	17	18	27	290	150	68	28	27	702
1964	23	18	18	18	17	18	32	180	47	28	28	27	454
1965	23	18	26	89	17	18	27	290	150	68	28	27	781
1966	23	18	18	18	17	18	29	258	126	68	28	27	648
1967	23	18	18	18	17	18	27	290	150	68	28	27	702
1968	23	18	18	18	149	18	29	258	126	68	28	27	780
1969	23	18	18	18	17	18	25	281	275	68	28	27	817
1970	23	18	80	369	73	18	27	290	150	68	28	27	1170
1971	23	18	18	18	17	18	27	290	150	68	28	27	702
1972	23	18	18	18	17	46	29	258	126	68	28	27	676
1973	23	18	18	18	17	18	27	290	150	68	28	27	702
1974	23	323	261	369	17	221	25	281	275	68	28	27	1918
1975	23	18	18	18	17	94	27	290	150	68	28	27	778
1976	23	18	18	18	17	18	32	180	47	28	28	27	454
1977	23	18	18	18	17	18	36	92	47	28	28	27	369
1978	23	18	18	19	17	18	25	281	275	68	28	27	817
1979	23	18	18	18	17	18	32	180	47	28	28	27	453
1980	23	18	18	18	21	18	27	290	150	68	28	27	706
1981	23	18	18	18	17	18	32	180	47	28	28	27	453
1982	23	18	62	18	176	18	60	281	275	68	28	27	1054
1983	23	18	158	181	181	369	25	281	294	211	28	27	1795
1984	23	18	313	18	17	18	27	290	150	68	28	27	998
1985	23	18	18	18	17	18	32	180	47	28	28	27	453
1986	23	18	18	18	17	18	27	290	150	68	28	27	702
1987	23	18	18	18	17	18	32	180	47	28	28	27	453
1988	23	18	18	18	17	18	32	180	47	28	28	27	454
1989	23	18	18	18	17	18	29	258	126	68	28	27	648
1990	23	18	18	18	17	18	32	180	47	28	28	27	453
1991	23	18	18	18	17	18	36	92	47	28	28	27	369
1992	23	18	18	18	17	18	32	180	47	28	28	27	454
1993	23	18	18	18	17	18	27	290	150	68	28	27	702
Avg.	23	22	33	39	32	33	33	229	121	55	28	27	674
Min.	23	18	18	18	17	18	25	92	47	28	28	27	369
Max.	23	323	313	369	333	369	162	290	294	211	28	27	1918

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Pref Flow [EWA], Tracy Export (TAF)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1922	270	243	260	185	236	263	174	92	179	282	279	266	2729
1923	268	253	260	134	141	162	152	118	166	283	280	267	2481
1924	245	133	194	260	213	49	48	75	48	37	152	159	1613
1925	170	107	193	237	234	49	163	69	115	172	201	262	1973
1926	227	182	162	184	235	232	152	49	52	50	49	189	1764
1927	194	251	259	259	132	163	175	140	179	283	280	267	2581
1928	261	253	260	260	244	263	152	118	179	280	241	241	2750
1929	201	253	259	260	206	72	48	49	69	65	83	167	1732
1930	191	108	184	184	219	260	101	104	93	93	104	190	1830
1931	217	181	165	240	141	93	48	49	48	49	45	143	1418
1932	67	102	259	184	243	203	120	69	92	128	192	253	1912
1933	229	96	40	34	46	37	48	56	48	49	37	173	892
1934	188	72	259	202	41	72	48	49	48	37	37	131	1183
1935	72	230	186	184	124	259	143	53	154	101	275	260	2041
1936	131	115	196	259	242	146	143	49	141	133	276	263	2095
1937	200	146	222	260	235	138	82	92	138	129	260	260	2161
1938	249	252	184	49	82	85	122	49	179	282	279	266	2078
1939	268	179	94	114	139	137	67	69	117	279	242	237	1943
1940	121	129	144	260	244	261	175	140	179	253	277	264	2448
1941	256	193	259	260	235	263	152	118	179	283	280	267	2744
1942	268	253	260	260	236	167	175	92	179	245	279	266	2681
1943	268	253	260	167	217	86	152	49	133	282	279	266	2411
1944	267	203	250	260	227	245	89	92	138	239	209	262	2482
1945	139	252	259	260	235	263	125	118	169	282	279	266	2647
1946	266	253	260	260	236	200	142	140	179	282	279	266	2761
1947	267	253	260	260	218	250	48	49	106	262	249	262	2484
1948	114	178	128	260	244	208	152	118	179	280	278	266	2403
1949	251	216	255	260	176	261	48	49	122	280	277	265	2460
1950	212	233	134	185	236	255	142	49	146	213	274	258	2336
1951	198	251	259	128	77	163	129	118	179	283	280	266	2330
1952	268	253	260	260	244	263	175	92	179	282	279	266	2822
1953	268	253	157	116	142	148	144	69	172	281	279	266	2295
1954	267	253	260	238	236	263	163	129	150	282	279	266	2787
1955	251	229	260	260	194	143	101	114	174	79	136	237	2178
1956	167	252	259	184	243	220	152	118	179	283	280	267	2602
1957	269	253	260	260	174	164	159	69	179	283	280	267	2617
1958	269	253	185	185	236	262	175	92	179	281	279	266	2662
1959	267	253	228	112	136	161	108	122	179	282	280	229	2356
1960	219	147	72	185	227	236	48	49	107	273	270	186	2019
1961	190	238	259	238	235	185	96	49	89	280	278	236	2374
1962	187	235	260	209	236	263	120	129	166	281	279	266	2629
1963	267	253	260	260	236	263	152	118	179	283	280	266	2815
1964	268	253	260	260	166	144	130	49	102	212	275	245	2366
1965	149	252	259	259	235	256	175	140	179	283	281	267	2735
1966	269	253	260	260	236	263	126	129	179	281	278	238	2771
1967	215	253	185	185	236	262	152	49	179	280	277	265	2537
1968	266	253	228	98	121	162	133	117	143	283	280	251	2333
1969	223	253	260	260	236	262	122	92	179	282	280	266	2715
1970	268	253	109	100	105	160	128	118	154	282	279	245	2203
1971	253	253	260	260	236	263	163	69	179	282	280	266	2764
1972	268	253	260	260	244	263	97	102	179	280	276	232	2713
1973	255	253	260	185	236	263	168	92	166	282	279	266	2704
1974	268	253	260	260	236	263	152	49	163	281	279	266	2729
1975	267	253	260	260	202	163	175	92	179	282	279	266	2679
1976	268	253	260	260	150	147	48	49	82	49	98	182	1846
1977	148	96	49	156	44	49	48	49	88	199	183	167	1276
1978	182	81	259	184	234	259	122	49	172	282	279	266	2369
1979	268	208	103	260	236	161	167	140	179	283	280	267	2549
1980	269	223	260	260	244	261	122	49	179	282	279	266	2694
1981	268	221	228	114	139	161	142	118	168	283	280	249	2372
1982	208	253	185	185	236	262	175	92	179	280	278	265	2599
1983	266	231	49	49	69	103	48	49	179	280	278	266	1866
1984	266	99	69	85	125	162	164	92	142	282	279	266	2031
1985	268	253	235	260	203	233	112	116	137	280	278	265	2640
1986	200	173	185	185	236	262	152	49	137	183	277	265	2302
1987	265	210	166	260	235	197	104	49	108	131	137	213	2076
1988	172	214	195	260	244	49	83	87	48	66	120	176	1713
1989	172	148	173	218	83	259	138	118	141	214	224	213	2102
1990	212	184	238	185	218	146	48	49	53	49	65	151	1597
1991	182	88	54	107	60	260	48	49	71	74	182	242	1417
1992	181	106	120	161	243	218	48	70	48	49	74	170	1487
1993	188	125	253	184	235	263	163	69	179	280	278	266	2482
Avg.	224	207	209	206	194	195	122	84	141	221	236	242	2280
Min.	67	72	40	34	41	37	48	49	48	37	37	131	892
Max.	270	253	260	260	244	263	175	140	179	283	281	267	2822

Trinity

Pref Flow [EWA], Banks Export (TAF)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1922	214	177	327	468	472	465	200	224	397	441	415	352	4153
1923	324	297	334	496	269	184	175	146	270	441	441	362	3740
1924	289	133	312	265	213	18	18	75	18	18	262	89	1712
1925	131	146	193	237	314	18	173	69	181	104	22	259	1848
1926	89	109	162	238	302	101	160	112	142	374	273	147	2209
1927	151	397	322	332	456	448	204	220	270	333	411	303	3848
1928	292	360	434	455	360	442	180	149	161	188	270	299	3592
1929	187	203	284	309	206	117	42	18	58	191	38	66	1719
1930	85	18	259	263	219	429	101	104	120	405	297	241	2542
1931	66	84	165	240	141	118	18	43	68	155	274	102	1473
1932	147	54	331	280	343	203	120	125	262	103	18	219	2206
1933	99	174	140	444	135	301	78	73	18	153	18	65	1699
1934	101	18	293	277	321	76	18	18	36	286	128	165	1736
1935	122	196	186	282	227	446	204	20	359	441	408	304	3194
1936	305	169	245	449	485	465	172	148	327	441	441	301	3949
1937	252	136	222	309	472	465	204	196	97	383	408	262	3407
1938	231	397	273	509	472	465	180	201	397	411	411	427	4376
1939	411	353	434	456	180	177	35	118	218	417	401	318	3518
1940	225	147	180	367	482	465	204	187	260	441	415	318	3690
1941	247	164	442	511	472	465	180	201	281	411	411	427	4214
1942	411	330	460	523	396	205	204	224	397	345	411	427	4333
1943	411	397	447	496	422	423	180	132	303	115	411	319	4055
1944	202	113	261	343	280	333	132	135	237	441	441	321	3240
1945	233	397	321	396	472	410	125	134	279	441	441	334	3986
1946	321	293	338	509	270	318	142	157	248	441	441	397	3875
1947	274	246	323	231	230	250	108	79	149	441	399	317	3048
1948	200	196	149	294	121	208	179	201	280	441	441	325	3036
1949	240	170	255	282	176	324	108	123	269	338	254	289	2830
1950	50	104	103	269	422	255	142	145	343	441	415	309	2999
1951	306	397	351	523	472	464	129	159	165	352	441	376	4135
1952	309	315	442	523	482	465	204	224	363	313	362	427	4429
1953	411	346	434	389	273	404	144	203	381	268	411	427	4090
1954	384	397	259	238	413	437	192	198	201	404	421	397	3942
1955	296	322	429	449	124	143	93	114	191	258	83	198	2700
1956	90	242	351	296	485	465	153	201	298	411	411	427	3830
1957	411	225	354	245	416	452	159	69	244	265	408	305	3552
1958	411	373	430	451	434	465	204	224	397	284	411	427	4511
1959	411	264	355	455	251	107	108	122	239	411	441	298	3463
1960	258	113	183	352	424	275	18	111	227	389	361	228	2938
1961	86	196	265	238	294	206	96	18	31	421	363	303	2517
1962	197	192	295	155	472	424	120	67	249	427	408	379	3385
1963	411	397	316	449	431	438	180	201	269	231	411	336	4072
1964	354	397	333	445	124	144	130	43	213	441	411	361	3396
1965	189	302	333	523	472	294	204	121	196	239	429	328	3630
1966	137	397	467	508	282	441	126	137	221	395	355	313	3777
1967	230	397	266	477	430	463	180	201	397	441	435	427	4347
1968	411	358	432	393	381	402	133	117	143	299	441	323	3833
1969	241	258	321	523	472	465	204	224	363	223	411	427	4131
1970	411	378	440	384	371	403	128	123	233	302	441	379	3993
1971	325	397	438	459	104	434	172	69	298	411	411	427	3945
1972	411	327	431	446	264	427	97	102	128	343	357	284	3617
1973	207	397	317	460	466	465	168	176	319	409	410	341	4135
1974	332	397	322	523	458	465	180	194	394	263	411	427	4367
1975	411	354	432	450	470	427	201	224	334	411	411	427	4552
1976	411	389	431	361	183	175	42	77	81	383	316	231	3079
1977	183	171	110	156	56	73	37	43	82	117	271	91	1391
1978	42	80	288	282	472	465	180	200	397	125	411	365	3308
1979	214	176	430	489	349	465	167	165	244	354	387	302	3740
1980	245	278	320	523	485	465	156	158	227	441	415	379	4092
1981	309	92	327	454	237	445	142	118	168	441	411	331	3477
1982	268	397	261	523	472	465	204	224	397	411	411	427	4461
1983	411	397	472	358	201	219	180	43	231	441	441	427	3822
1984	395	207	249	347	376	408	164	150	170	337	441	391	3633
1985	341	397	235	390	203	147	112	116	197	441	441	397	3418
1986	291	287	261	455	472	465	179	146	317	411	411	344	4041
1987	270	56	166	391	250	236	104	19	139	433	413	323	2800
1988	183	133	195	324	105	39	83	87	18	211	23	74	1476
1989	53	163	173	218	69	317	138	119	194	441	411	348	2645
1990	344	105	259	435	130	157	18	77	18	29	261	144	1977
1991	76	18	81	96	62	322	42	43	18	182	18	61	1018
1992	73	18	116	161	316	218	42	18	19	160	28	224	1393
1993	25	89	253	296	468	457	192	212	397	441	408	322	3562
Avg.	251	244	303	377	326	329	137	131	226	333	350	309	3317
Min.	25	18	81	96	56	18	18	18	18	18	18	61	1018
Max.	411	397	472	523	485	465	204	224	397	441	441	427	4552

Trinity

Pref Flow [EWA], Delta Inflows (TAF)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1922	815	742	1320	1240	2665	2312	1859	3502	2610	1509	1124	949	20649
1923	916	988	2224	2181	1170	1165	1855	1363	1245	1395	1145	966	16613
1924	868	714	847	938	1089	746	560	586	636	708	763	524	8981
1925	601	601	953	885	4052	1782	1686	1183	1033	858	621	799	15053
1926	697	616	714	1195	2578	984	1663	989	808	1056	803	628	12732
1927	681	1632	1290	2101	7640	3037	3241	1944	1282	1516	1126	874	26364
1928	890	1152	1133	1581	1588	6714	1958	1443	1066	1244	957	837	20561
1929	772	857	901	911	1055	879	594	641	693	770	592	520	9184
1930	583	515	1276	1476	1180	2213	938	908	848	1080	820	712	12548
1931	667	605	707	950	728	654	603	539	659	883	716	535	8247
1932	558	509	1537	1569	1536	1163	1031	1007	1240	825	692	776	12443
1933	701	604	628	995	787	965	836	611	676	759	563	530	8655
1934	575	518	1059	1306	1001	933	808	590	732	857	585	589	9552
1935	562	804	755	2212	1001	2009	3498	1849	1464	1244	1148	877	17424
1936	837	656	793	2709	4682	2240	1811	1387	1336	1292	1179	865	19787
1937	847	665	794	1040	2893	3189	1937	1670	1067	1208	1126	823	17258
1938	817	1584	4421	2260	8203	10682	4954	4953	3356	1477	1140	1231	45079
1939	1448	866	1067	1001	900	1110	872	935	956	1298	1102	852	12408
1940	785	611	678	2450	3948	7034	4494	1571	1267	1486	1143	894	26359
1941	847	867	2993	6332	7225	6183	4820	3118	1606	1482	1119	1216	37810
1942	1043	913	4184	5267	8150	2001	3369	2717	2009	1378	1140	1207	33378
1943	1121	1142	2099	5722	3702	5817	2169	1699	1244	1213	1132	898	27956
1944	810	720	869	1042	1699	1652	1034	995	1072	1273	1076	896	13139
1945	840	1036	1185	1012	3097	1914	1238	1235	1280	1434	1172	921	16365
1946	902	1083	4633	3417	1890	1478	1149	1241	1216	1411	1173	1019	20611
1947	927	888	1138	861	1198	1426	1029	815	936	1298	1117	889	12521
1948	716	706	675	1089	1038	1187	1894	1989	1470	1410	1169	907	14250
1949	891	806	953	830	833	3248	1033	1115	1116	1210	948	852	13835
1950	687	667	669	1426	2226	1455	1451	1358	1396	1354	1138	870	14696
1951	863	3294	6277	4559	4325	2233	1285	1515	980	1526	1160	986	29003
1952	905	1066	2771	5803	4877	4584	4498	4765	3143	1376	1094	1475	36356
1953	1473	920	2978	6640	1642	1575	1319	1876	1576	1440	1118	1256	23815
1954	998	1077	884	2287	3665	3386	2776	1816	1004	1475	1130	1019	21517
1955	931	989	1613	1347	955	861	945	1016	1043	914	654	725	11993
1956	682	821	6204	10456	5394	2816	1582	2843	1623	1467	1132	1211	36229
1957	1156	819	986	940	2155	3212	1513	1311	1208	1367	1127	877	16671
1958	1247	963	1562	2521	10350	6286	6207	3675	2483	1331	1134	1340	39099
1959	1382	857	928	2471	3291	1593	879	981	1193	1441	1163	809	16988
1960	858	699	680	920	1880	1459	832	985	954	1277	1125	713	12382
1961	676	819	1086	849	1808	1330	887	805	747	1306	1148	826	12288
1962	785	825	1113	727	2997	1960	1026	1093	1186	1398	1130	990	15231
1963	2155	1035	1809	1125	4341	2288	5474	2324	1346	1372	1131	925	25327
1964	955	1720	935	1562	969	869	1304	878	898	1243	1175	930	13438
1965	679	978	5107	7575	2302	1751	3132	1830	1070	1446	1129	913	27912
1966	753	1468	1328	2225	1757	2010	1100	1141	1141	1336	1080	845	16185
1967	928	1006	2505	3160	3397	4090	3574	3839	3279	1538	1167	1477	29960
1968	1443	942	1167	2018	3868	2567	1187	919	992	1302	1113	880	18396
1969	891	882	1648	7585	7823	4372	3876	4527	2862	1293	1154	1068	37981
1970	1544	970	3952	13134	5141	2780	1277	1112	1105	1600	1171	958	34745
1971	914	1243	4067	3330	1789	2932	1664	1932	1359	1698	1134	1200	23261
1972	1041	914	1225	1151	1622	2347	896	878	1253	1305	1074	791	14499
1973	830	1266	1727	5294	5364	4041	1471	1450	1385	1467	1133	932	26360
1974	920	3688	4451	8410	2670	7215	4593	1903	1589	1301	1140	1385	39265
1975	1083	942	1180	1096	4068	5894	1880	2173	1725	1453	1119	1330	23943
1976	1320	988	1133	973	911	1096	723	600	667	952	791	693	10848
1977	688	580	652	612	520	574	649	475	735	1008	819	531	7842
1978	578	513	1073	4327	3541	4589	3079	1966	1691	1196	1149	969	24671
1979	844	731	1052	1731	2693	2547	1460	1332	1354	1314	1101	872	17031
1980	897	907	1307	6761	7902	4001	1613	1502	1157	1472	1216	990	29724
1981	924	681	1026	1515	1667	2250	1302	935	962	1324	1182	891	14658
1982	860	2093	5665	5062	6033	5877	8595	3654	1992	1457	1148	1316	43753
1983	2031	2856	5633	6620	9986	15614	5533	5141	5569	2647	1507	2041	65178
1984	1942	5091	9745	4562	2663	2664	1421	1166	1106	1563	1163	1009	34097
1985	934	2037	1506	999	1037	1080	1078	1032	954	1311	1199	1018	14184
1986	859	811	1208	1646	11641	9582	1904	1372	1296	1366	1177	936	33798
1987	880	647	779	1000	1268	1708	985	703	911	1137	971	836	11827
1988	834	664	1292	1897	993	643	724	713	718	822	570	541	10410
1989	584	674	730	902	598	2995	1392	1066	956	1277	1136	861	13170
1990	925	732	845	1304	971	958	765	606	575	664	779	587	9709
1991	557	508	508	492	548	2235	960	690	534	792	663	608	9095
1992	555	508	512	756	2143	1422	837	627	713	733	532	695	10034
1993	576	519	1008	4127	3562	3169	2645	2282	1857	1508	1145	903	23299
Avg.	921	1053	1894	2756	3151	2967	2017	1631	1350	1280	1036	925	20981
Min.	555	508	508	492	520	574	560	475	534	664	532	520	7842
Max.	2155	5091	9745	13134	11641	15614	8595	5141	5569	2647	1507	2041	65178

Trinity

Pref Flow [EWA], Total Delta Outflow (TAF)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1922	246	268	724	683	2127	1551	1397	3041	1771	492	246	212	12758
1923	246	397	1783	1653	736	744	1497	952	583	400	246	239	9476
1924	246	380	277	417	651	620	380	247	315	407	184	179	4302
1925	247	296	579	445	3652	1672	1324	964	494	307	235	186	10402
1926	295	268	330	802	2154	570	1329	669	302	307	286	179	7489
1927	256	964	643	1567	7228	2380	2814	1436	578	610	246	193	18915
1928	267	489	412	905	973	6043	1536	1010	454	492	246	179	13006
1929	288	359	337	361	633	636	410	400	359	246	286	179	4494
1930	221	328	789	1098	775	1523	654	567	372	307	247	179	7061
1931	302	280	306	513	446	376	405	284	309	373	199	179	3972
1932	253	301	1069	1163	1049	692	690	658	607	307	287	179	7254
1933	276	268	393	585	582	595	597	351	359	246	309	179	4740
1934	197	359	478	836	710	701	595	345	410	246	225	179	5281
1935	279	335	357	1871	633	1353	3166	1625	653	400	246	179	11097
1936	317	305	297	2086	4204	1581	1413	1041	616	400	246	179	12684
1937	302	311	313	534	2346	2761	1565	1209	567	400	246	179	10732
1938	246	883	3966	1770	7966	10255	4583	4542	2500	492	246	418	37867
1939	686	268	471	438	569	767	642	573	340	307	258	179	5498
1940	348	268	290	1995	3485	6350	4037	1082	528	492	246	199	19319
1941	249	447	2367	5776	6681	5459	4497	2669	884	492	247	403	30172
1942	280	268	3468	4668	7555	1596	3007	2280	1155	492	246	396	25410
1943	346	446	1356	5212	3074	5340	1770	1354	547	528	246	188	20407
1944	246	337	301	453	1291	1009	738	617	441	307	215	181	6136
1945	383	346	593	369	2459	1273	877	832	543	400	246	195	8515
1946	246	477	4080	2657	1367	914	754	789	520	400	246	232	12683
1947	291	344	513	369	756	906	753	496	417	307	276	179	5607
1948	335	268	332	527	645	752	1535	1565	773	400	246	200	7577
1949	314	350	403	303	485	2706	769	779	446	307	234	185	7282
1950	331	268	377	1044	1582	907	1068	991	638	400	246	196	8048
1951	287	2626	5780	4026	3801	1567	945	1097	369	602	246	224	21571
1952	246	449	2138	5316	4153	3912	4064	4286	2361	492	246	658	28321
1953	691	268	2432	6208	1193	964	965	1475	793	568	246	441	16244
1954	251	365	297	1819	3012	2680	2339	1322	393	492	246	238	13454
1955	283	386	908	754	633	517	701	652	419	307	232	179	5971
1956	333	271	5779	10251	4660	2061	1215	2388	870	492	246	413	28979
1957	396	268	300	441	1585	2559	1119	1085	517	529	246	196	9239
1958	498	268	904	2034	9961	5683	5879	3230	1664	492	246	527	31385
1959	604	268	277	1931	2972	1254	539	556	488	445	246	217	9795
1960	282	367	363	417	1281	898	678	676	333	307	289	179	6072
1961	304	356	502	453	1264	922	604	592	339	307	318	179	6139
1962	305	355	499	369	2531	1238	675	730	485	400	246	228	8061
1963	1451	318	1207	533	3734	1617	5206	1884	639	584	246	212	17631
1964	257	1027	277	930	644	515	928	615	356	307	297	212	6364
1965	266	377	4576	6909	1570	1151	2715	1409	446	650	246	207	20520
1966	246	786	605	1513	1248	1239	724	695	472	400	246	179	8352
1967	384	334	2083	2826	2710	3407	3289	3441	2472	526	246	666	22382
1968	668	268	444	1582	3376	1982	816	518	420	425	246	184	10929
1969	338	323	1044	7102	7328	3601	3468	4036	2070	492	246	250	30297
1970	788	274	3388	12923	4664	2162	915	681	451	718	246	208	27417
1971	246	593	3478	2638	1421	2196	1241	1669	622	716	246	383	15448
1972	267	268	504	453	1094	1566	596	479	668	400	246	179	6720
1973	315	662	1160	4980	4834	3324	1031	992	605	492	246	208	18849
1974	250	3027	3924	7712	1949	6499	4208	1495	762	492	246	563	31127
1975	316	268	435	383	3471	5371	1438	1688	930	492	246	509	15546
1976	575	275	369	337	546	674	530	259	238	246	247	179	4473
1977	261	256	434	300	382	376	422	267	303	408	184	179	3771
1978	261	300	513	4166	2932	3960	2737	1553	853	492	246	213	18226
1979	246	297	446	1115	2246	1894	1047	862	641	400	246	179	9618
1980	309	347	723	6140	7381	3248	1257	1153	501	492	334	231	22114
1981	246	297	412	988	1274	1654	919	527	329	307	291	199	7442
1982	311	1424	5242	4628	5355	5329	8213	3175	1172	492	268	545	36154
1983	1285	2288	5151	6497	9912	15587	5308	4909	4889	1650	593	1241	59311
1984	1187	4782	9536	4127	2163	2036	997	737	523	655	246	221	27211
1985	255	1406	1022	369	621	717	747	610	333	307	292	254	6933
1986	278	317	750	1090	11262	8924	1496	1017	570	492	286	232	26716
1987	246	310	383	351	801	1275	653	441	391	307	226	179	5564
1988	395	268	879	1397	619	484	467	389	410	246	235	179	5967
1989	263	311	339	464	436	2414	990	643	352	307	294	229	7043
1990	288	383	277	707	633	581	585	395	238	295	263	179	4824
1991	211	335	313	277	398	1678	767	454	238	246	279	179	5376
1992	227	318	215	439	1702	983	647	351	397	246	232	179	5936
1993	282	236	525	4036	3052	2456	2197	1879	1053	492	246	179	16633
Avg.	360	553	1367	2264	2689	2433	1682	1259	720	437	257	260	14282
Min.	197	236	215	277	382	376	380	247	238	246	184	179	3771
Max.	1451	4782	9536	12923	11262	15587	8213	4909	4889	1650	593	1241	59311

Trinity

Pref Flow [EWA], CVP Delivery North of Delta (TAF)
(sum of CALSIM variables D300, D8, D9, D302, D167A_IMI, D167B_IMI, D162_IMI, D168B, D168C_FRWP, and Del_CVP_Total_N)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1922	95	40	33	29	28	29	399	459	557	567	506	273	3014
1923	58	40	34	29	28	96	280	485	534	570	509	185	2847
1924	95	49	33	29	28	55	315	352	384	387	336	167	2229
1925	33	29	24	20	20	24	245	343	509	557	495	232	2531
1926	110	39	32	27	26	55	161	394	514	518	455	252	2583
1927	57	37	30	25	24	31	336	462	531	577	512	273	2897
1928	65	40	34	29	28	24	276	452	527	537	481	261	2752
1929	105	40	33	28	27	35	334	432	399	475	425	231	2564
1930	96	51	29	24	23	22	243	388	507	511	455	218	2568
1931	93	37	30	25	24	69	332	313	358	406	353	176	2217
1932	68	31	26	22	21	40	289	313	395	411	367	198	2181
1933	86	39	28	25	24	48	326	328	392	396	345	172	2208
1934	60	44	27	23	22	34	294	348	396	416	361	180	2204
1935	64	32	26	23	22	22	142	423	545	549	492	262	2602
1936	69	42	32	27	26	30	282	413	467	535	481	254	2659
1937	105	56	32	27	26	24	269	448	482	526	472	258	2725
1938	70	39	32	27	26	26	252	440	572	578	512	235	2809
1939	71	44	34	29	51	115	438	395	503	504	455	208	2845
1940	81	52	31	26	25	25	292	397	564	576	510	267	2845
1941	66	40	33	29	28	26	146	342	559	587	519	276	2650
1942	68	40	34	29	28	26	153	384	573	587	519	272	2712
1943	105	40	34	29	28	26	263	471	557	577	512	274	2916
1944	107	43	34	29	28	37	313	389	497	527	472	256	2731
1945	77	37	30	25	25	25	342	401	524	579	512	274	2851
1946	46	40	33	29	28	34	412	459	540	536	487	259	2903
1947	103	40	33	29	28	25	331	432	459	531	472	258	2741
1948	45	37	30	25	35	48	136	302	487	585	514	250	2494
1949	89	43	33	29	29	24	325	404	534	539	481	260	2789
1950	112	40	33	28	27	32	341	439	499	511	457	232	2752
1951	46	39	32	27	26	39	400	400	566	572	508	269	2924
1952	54	40	34	29	28	26	314	471	516	571	510	268	2860
1953	117	40	34	29	28	57	301	440	533	576	472	272	2900
1954	101	40	34	29	28	24	246	459	545	572	459	266	2804
1955	106	39	32	27	26	70	307	432	499	504	452	214	2706
1956	90	37	30	25	25	67	362	397	544	576	510	246	2910
1957	69	56	34	29	28	52	354	411	576	585	517	151	2862
1958	51	46	34	29	28	26	157	376	526	565	511	269	2617
1959	110	55	34	29	28	45	428	497	545	549	483	134	2936
1960	111	56	31	26	25	22	304	377	489	492	442	239	2614
1961	96	37	30	25	24	22	315	437	514	542	480	238	2759
1962	104	38	31	26	25	23	371	472	540	566	500	259	2956
1963	43	39	32	27	26	26	149	400	568	586	518	273	2686
1964	63	40	34	29	28	80	421	439	464	499	443	221	2760
1965	60	37	30	25	25	60	250	482	564	573	440	272	2818
1966	118	40	33	29	28	44	406	479	531	535	479	257	2980
1967	111	39	32	27	26	26	136	445	477	583	515	272	2688
1968	109	40	34	29	28	24	360	469	522	570	453	268	2905
1969	77	39	32	27	26	27	335	493	546	566	507	268	2941
1970	80	42	34	29	28	25	379	476	497	539	483	262	2872
1971	74	39	32	27	26	51	440	406	538	559	499	261	2950
1972	109	41	34	29	31	121	402	446	502	527	472	207	2919
1973	48	38	31	26	25	26	344	478	567	572	509	257	2922
1974	57	40	34	29	28	26	265	476	560	499	513	275	2800
1975	71	41	34	29	28	26	290	484	571	565	501	274	2912
1976	48	44	34	29	52	144	337	425	456	465	370	201	2603
1977	94	38	28	23	34	89	355	264	394	399	349	124	2193
1978	77	29	24	21	20	26	202	457	571	580	512	224	2743
1979	121	40	34	29	28	25	308	475	572	578	505	258	2971
1980	53	40	33	29	28	26	309	443	538	567	511	268	2846
1981	105	51	34	29	28	23	284	427	565	570	505	239	2860
1982	47	38	31	26	25	26	179	465	521	589	521	182	2651
1983	45	40	34	29	28	26	158	420	549	584	499	230	2641
1984	98	40	34	29	28	50	413	496	531	552	470	259	2999
1985	61	39	32	27	26	23	350	482	543	556	492	192	2821
1986	84	39	32	27	26	24	278	436	540	545	488	202	2720
1987	107	51	32	28	27	23	346	447	498	501	449	243	2753
1988	84	36	29	25	24	77	297	353	440	481	430	233	2509
1989	97	35	28	23	29	24	330	486	519	551	487	86	2695
1990	56	39	32	27	26	53	383	262	473	479	412	224	2465
1991	93	41	29	24	28	21	216	327	399	421	374	202	2176
1992	70	37	27	23	23	20	227	376	398	445	399	215	2259
1993	44	38	27	23	22	25	312	345	493	579	506	274	2687
Avg.	80	41	31	27	27	40	300	419	509	534	471	236	2714
Min.	33	29	24	20	20	20	136	262	358	387	336	86	2176
Max.	121	56	34	29	52	144	440	497	576	589	521	276	3014

Trinity

Pref Flow [EWA], CVP Delivery So w/ CVC (TAF)
(equals CALSIM variable CVPTotalDel)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1922	204	123	107	137	166	150	187	305	439	538	453	277	3086
1923	192	114	95	116	141	160	195	310	456	562	443	293	3078
1924	195	117	99	122	148	77	85	123	161	169	164	133	1593
1925	111	60	36	27	38	130	151	227	331	389	340	228	2068
1926	169	97	71	78	98	111	126	174	246	273	252	191	1886
1927	153	84	54	49	64	161	195	316	470	581	486	288	2901
1928	198	119	101	126	153	146	172	267	386	466	398	253	2786
1929	181	106	83	98	120	99	111	156	212	226	216	175	1784
1930	145	78	46	37	51	110	131	185	258	289	264	197	1792
1931	155	86	57	53	69	82	93	134	178	192	181	141	1421
1932	115	63	39	33	44	84	94	131	181	197	185	143	1310
1933	116	64	40	35	46	79	89	123	168	179	171	137	1247
1934	113	62	37	30	41	88	99	143	192	212	196	148	1360
1935	118	66	43	38	50	92	129	225	313	364	321	220	1980
1936	166	94	68	72	91	143	169	247	348	413	358	236	2405
1937	173	99	75	84	105	114	152	222	308	357	316	218	2222
1938	165	93	67	70	89	155	195	302	434	532	449	276	2827
1939	191	114	94	115	139	136	174	255	370	444	382	246	2660
1940	177	103	80	92	114	127	151	255	369	442	381	243	2534
1941	177	103	80	92	113	158	193	314	454	559	469	284	2995
1942	195	117	98	121	147	166	195	306	441	541	456	278	3060
1943	192	115	96	117	142	155	195	301	432	529	447	275	2995
1944	191	114	94	114	138	141	161	237	342	404	351	233	2519
1945	171	98	73	82	102	154	191	306	441	541	455	275	2889
1946	192	115	95	117	142	149	177	295	430	526	437	274	2947
1947	190	113	93	113	137	120	163	232	333	392	342	229	2458
1948	170	97	72	79	99	103	149	276	401	486	414	260	2603
1949	184	108	87	103	126	118	187	265	388	469	401	254	2690
1950	181	106	84	98	121	111	140	198	279	317	286	206	2128
1951	160	90	61	61	77	161	189	306	451	554	449	281	2839
1952	194	116	97	120	146	151	185	306	440	540	455	278	3028
1953	192	115	95	116	141	157	188	290	423	516	437	270	2942
1954	189	112	92	111	134	153	187	303	445	546	459	280	3010
1955	193	115	96	118	143	133	156	226	317	370	326	222	2416
1956	167	95	69	73	92	158	189	319	465	574	481	289	2970
1957	197	118	100	125	151	163	189	317	462	570	478	287	3158
1958	196	118	100	124	150	142	179	297	427	521	441	272	2967
1959	190	113	93	112	136	160	187	306	447	549	451	292	3034
1960	193	116	97	119	144	96	126	177	245	271	251	190	2024
1961	153	84	54	49	64	134	195	283	405	492	418	262	2592
1962	185	109	88	104	127	150	184	287	426	521	440	272	2894
1963	189	113	93	112	136	154	188	307	452	556	467	280	3048
1964	194	116	98	120	146	137	162	231	330	389	340	228	2491
1965	169	97	71	78	98	145	173	322	476	589	492	293	3003
1966	199	120	102	128	156	147	176	283	411	499	424	265	2909
1967	186	110	89	106	130	141	171	273	389	469	401	255	2718
1968	181	106	84	98	121	160	187	311	454	560	470	284	3016
1969	195	117	98	121	147	151	195	310	448	551	463	281	3076
1970	193	116	97	119	144	159	189	299	436	534	450	276	3012
1971	191	114	95	115	140	154	183	307	449	552	428	304	3031
1972	194	116	97	119	145	147	180	276	393	475	405	257	2804
1973	182	107	85	100	123	159	195	305	440	540	454	276	2965
1974	194	115	95	116	141	155	195	297	426	521	440	272	2967
1975	189	113	93	112	136	162	195	306	441	542	456	279	3023
1976	192	115	96	117	142	106	120	169	232	252	236	184	1960
1977	150	82	51	44	58	83	93	133	179	194	183	142	1391
1978	115	63	40	34	45	152	195	302	434	532	449	273	2633
1979	191	114	94	115	139	159	195	320	463	571	478	288	3125
1980	196	118	100	124	150	151	195	302	434	532	449	276	3027
1981	191	114	94	115	139	160	189	305	450	553	465	282	3057
1982	194	116	97	120	145	135	166	278	397	480	409	258	2795
1983	183	108	86	101	124	150	189	281	402	487	414	261	2786
1984	184	108	87	103	126	160	189	298	439	538	453	277	2965
1985	192	115	95	116	141	147	180	271	395	478	407	257	2793
1986	183	107	85	101	123	134	170	263	373	448	385	248	2621
1987	178	104	81	93	115	116	163	232	333	393	343	229	2379
1988	170	97	72	79	99	103	116	169	224	242	228	181	1779
1989	148	80	49	41	55	92	164	239	335	395	345	230	2174
1990	170	97	72	80	100	92	102	148	191	197	194	165	1609
1991	141	75	41	30	42	85	95	137	183	200	187	144	1360
1992	116	64	41	35	46	91	133	193	272	322	280	184	1777
1993	134	78	60	66	82	145	177	280	400	485	413	260	2578
Avg.	175	102	80	92	113	133	164	255	367	440	377	243	2541
Min.	111	60	36	27	38	77	85	123	161	169	164	133	1247
Max.	204	123	107	137	166	166	195	322	476	589	492	304	3158

Trinity

Pref Flow [EWA], X2_PRV (KM)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	
1922	74.9	83.2	85.0	78.2	76.4	66.4	66.3	66.8	61.2	63.3	74.1	82.9	
1923	86.7	87.0	83.2	70.7	67.2	71.5	73.6	68.6	70.7	74.9	79.5	84.7	
1924	86.3	86.9	83.5	85.1	82.5	77.7	77.0	80.3	84.9	84.3	82.4	87.8	
1925	89.6	88.0	85.8	80.2	80.4	63.5	64.8	66.7	70.0	76.0	81.8	85.8	
1926	88.7	86.3	86.0	84.6	77.3	66.5	74.0	69.7	73.8	81.0	83.5	84.8	
1927	88.6	87.4	76.5	76.4	69.5	54.7	59.2	59.1	64.5	73.0	75.6	83.4	
1928	87.6	86.7	81.5	81.4	75.3	72.3	57.8	63.3	68.5	76.1	78.3	84.3	
1929	88.5	86.4	83.8	83.7	83.1	77.8	76.9	79.6	81.0	82.0	85.5	85.5	
1930	88.9	88.6	85.2	77.6	72.6	72.8	68.5	73.3	76.3	80.2	83.2	85.9	
1931	89.0	86.2	85.6	85.0	80.8	79.8	81.5	81.3	84.1	84.2	83.0	87.5	
1932	89.5	87.7	85.6	75.4	71.4	70.4	73.8	74.7	75.6	76.2	81.9	84.3	
1933	88.5	86.7	86.2	83.3	79.3	77.2	77.2	76.9	81.1	82.0	85.5	84.9	
1934	88.7	89.4	84.8	81.3	75.9	74.6	75.0	76.2	81.0	81.0	85.2	87.2	
1935	89.4	87.0	84.5	83.5	70.4	73.7	69.7	61.6	64.4	72.0	78.5	84.4	
1936	88.5	85.7	84.8	85.0	70.1	59.3	63.8	65.9	69.2	74.0	79.2	84.6	
1937	88.6	86.1	84.8	84.6	80.4	66.9	62.0	64.5	67.6	74.1	79.2	84.6	
1938	88.6	87.7	77.3	62.7	64.0	52.2	47.1	51.4	53.1	58.0	72.3	82.3	
1939	81.3	77.4	83.1	80.9	80.7	77.9	75.4	75.7	77.0	81.1	83.5	85.6	
1940	88.9	85.1	85.6	85.4	70.6	60.9	53.7	54.5	65.1	73.9	77.5	84.0	
1941	87.6	87.2	82.4	68.3	56.8	51.2	51.6	53.0	57.7	67.5	75.4	83.3	
1942	81.9	84.5	85.4	66.3	57.8	50.5	60.9	59.1	60.9	66.5	75.1	83.2	
1943	82.0	82.9	81.0	72.1	58.8	57.8	54.0	60.9	65.5	73.7	76.9	83.8	
1944	87.9	87.4	84.6	84.8	81.7	72.2	71.5	73.4	75.6	78.7	82.7	86.8	
1945	89.1	84.5	83.4	79.2	81.5	66.9	68.0	70.9	72.5	76.1	79.8	84.8	
1946	88.0	87.5	82.0	64.0	61.3	64.8	69.8	72.7	73.5	76.7	80.1	84.9	
1947	86.6	85.7	83.9	80.5	81.9	76.1	73.6	73.9	77.5	79.7	83.0	85.0	
1948	88.7	85.3	85.7	84.4	80.5	77.1	75.3	69.0	67.1	71.6	78.4	84.3	
1949	87.6	85.5	83.7	82.3	84.0	80.2	66.5	71.4	73.2	77.8	82.4	86.0	
1950	88.8	85.4	85.7	83.5	74.9	68.1	70.9	70.4	71.0	74.3	79.3	84.6	
1951	87.8	86.2	68.5	56.9	55.8	55.2	62.5	68.5	69.6	78.1	77.4	84.0	
1952	86.6	87.0	82.3	69.0	57.7	55.4	55.6	55.1	54.8	59.0	72.6	82.4	
1953	77.9	76.2	82.7	68.2	56.2	64.2	69.2	70.6	68.0	71.7	75.7	83.4	
1954	81.2	85.1	83.2	84.5	71.0	61.9	60.6	61.0	65.7	76.3	78.3	84.3	
1955	86.2	85.8	83.1	75.8	74.9	75.1	77.6	75.8	76.0	79.2	82.9	86.2	
1956	89.1	85.5	85.7	62.5	50.5	52.1	59.4	65.6	62.7	69.2	76.0	83.5	
1957	81.8	81.8	84.5	84.8	82.0	70.4	63.8	67.7	69.4	75.4	77.5	84.0	
1958	87.6	81.9	84.6	76.4	67.5	51.6	51.5	50.9	55.6	61.9	73.6	82.8	
1959	79.7	77.9	83.2	85.0	70.7	61.9	66.4	74.1	76.7	78.3	79.7	84.8	
1960	87.1	86.1	83.5	83.0	81.8	72.3	72.4	74.3	75.2	80.7	83.4	84.7	
1961	88.6	86.0	83.7	80.6	80.4	71.6	72.0	75.1	76.5	81.0	83.5	84.0	
1962	88.4	85.9	83.7	80.6	82.0	66.8	68.1	73.0	74.2	77.5	80.3	84.9	
1963	86.8	73.5	80.5	72.8	76.6	62.1	64.5	56.1	61.4	71.2	75.3	83.3	
1964	86.8	86.8	75.9	82.6	75.5	75.5	77.7	73.7	75.7	80.4	83.3	84.5	
1965	87.2	86.6	83.5	63.6	53.9	61.3	66.9	61.9	65.5	75.3	75.9	83.5	
1966	87.1	87.2	78.0	77.3	70.0	68.4	68.6	72.6	74.5	77.8	80.4	85.0	
1967	88.7	84.3	83.7	69.7	62.7	60.0	58.2	57.6	57.3	59.5	72.3	82.3	
1968	77.7	76.4	82.8	81.2	71.0	61.3	62.7	69.7	75.8	79.1	80.4	85.0	
1969	88.4	85.2	84.2	75.1	57.5	50.7	54.7	56.0	55.5	60.2	73.1	82.6	
1970	85.3	77.7	83.0	65.7	49.8	51.6	58.9	67.6	73.0	77.6	75.9	83.5	
1971	87.0	87.2	80.2	64.6	61.6	64.6	63.0	66.6	65.8	72.8	74.3	83.0	
1972	82.2	84.9	85.6	81.2	80.5	73.1	68.4	74.0	77.8	76.2	79.9	84.8	
1973	88.6	85.8	78.9	72.6	59.4	54.5	56.5	65.9	69.5	74.3	77.7	84.1	
1974	87.2	87.1	67.7	59.6	51.7	58.9	52.8	53.9	62.5	70.2	76.3	83.6	
1975	79.4	82.7	84.8	82.1	82.1	64.5	56.1	63.2	64.6	69.4	76.0	83.6	
1976	80.2	78.4	83.2	82.8	83.4	79.3	76.9	77.7	83.7	86.1	86.8	87.1	
1977	89.4	87.5	86.7	82.7	84.2	82.1	82.3	81.2	84.6	84.5	82.5	87.9	
1978	89.6	87.5	85.5	81.0	63.5	59.7	56.9	58.5	63.7	69.7	76.2	83.6	
1979	86.9	87.1	85.5	82.1	73.9	65.1	64.3	68.4	71.4	74.4	79.3	84.6	
1980	88.6	85.9	83.9	77.9	59.5	51.5	55.7	64.1	67.8	75.1	77.9	81.8	
1981	85.7	86.7	85.4	82.6	75.1	69.8	66.9	70.2	75.8	81.0	83.5	84.7	
1982	87.7	85.6	73.0	59.1	55.5	52.4	52.2	48.6	54.9	64.4	74.4	82.4	
1983	79.3	71.9	64.9	56.6	52.1	46.6	42.1	48.6	51.6	52.4	61.2	71.9	
1984	69.5	69.4	58.4	49.7	53.3	58.9	61.7	67.9	72.5	76.3	76.1	83.6	
1985	86.6	86.7	73.4	71.8	79.0	76.7	75.5	74.6	76.1	81.0	83.5	84.7	
1986	85.9	85.8	84.6	77.8	72.7	52.4	48.3	60.4	67.5	74.1	77.6	82.9	
1987	86.0	86.8	85.1	83.1	83.1	76.0	70.9	74.1	78.5	80.5	83.3	86.6	
1988	89.2	84.2	85.3	76.8	70.5	74.1	77.7	78.9	81.0	81.0	85.2	86.9	
1989	89.3	87.4	85.2	84.1	81.3	80.1	67.4	69.8	74.1	79.9	83.1	84.5	
1990	86.6	85.8	83.1	85.0	78.4	76.3	77.0	77.0	80.2	84.9	85.1	86.0	
1991	89.0	89.0	85.2	84.7	85.5	82.2	70.8	72.9	77.8	84.1	86.2	85.9	
1992	89.0	88.4	85.4	87.6	82.9	70.5	71.1	74.3	80.2	81.0	85.2	87.0	
1993	89.3	86.9	87.1	81.4	63.9	59.5	60.5	61.4	63.2	67.9	75.6	83.4	
Avg.	86.3	84.8	82.3	76.8	71.2	66.1	65.6	67.6	70.4	75.0	79.3	84.4	
Min.	69.5	69.4	58.4	49.7	49.8	46.6	42.1	48.6	51.6	52.4	61.2	71.9	
Max.	89.6	89.4	87.1	87.6	85.5	82.2	82.3	81.3	84.9	86.1	86.8	87.9	

70 Percent

Trinity

70 Percent [EWA], Trinity Storage (TAF)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	
1922	1782	1722	1720	1689	1657	1597	1610	1739	1764	1734	1628	1594	
1923	1585	1582	1578	1599	1596	1598	1627	1561	1410	1217	1102	1078	
1924	1048	1010	989	847	879	834	819	724	606	512	348	322	
1925	314	390	437	489	750	869	1031	1066	1038	954	830	765	
1926	755	735	671	584	615	622	762	723	674	649	622	597	
1927	586	743	930	1043	1251	1378	1466	1506	1544	1543	1522	1476	
1928	1462	1500	1430	1399	1391	1490	1518	1551	1497	1471	1240	1193	
1929	1177	1177	1166	1044	1014	966	987	1031	1032	931	809	740	
1930	724	713	846	869	963	1072	1087	1055	993	892	772	720	
1931	704	691	674	678	672	679	708	672	608	515	344	318	
1932	302	295	298	310	322	452	456	529	530	514	427	402	
1933	384	377	361	348	319	379	447	484	593	557	512	489	
1934	472	460	455	505	565	665	753	713	609	505	307	283	
1935	272	337	373	415	489	527	656	742	736	720	694	670	
1936	656	647	636	738	848	908	957	982	985	979	955	932	
1937	914	897	876	831	776	770	910	1107	1195	1194	1140	1101	
1938	1092	1235	1440	1526	1653	1857	1985	2125	2072	2008	1971	1943	
1939	1850	1784	1705	1569	1441	1362	1416	1391	1321	1130	942	835	
1940	818	808	877	1058	1374	1654	1755	1742	1680	1588	1475	1405	
1941	1395	1385	1436	1562	1693	1941	2098	2308	2364	2270	2150	1975	
1942	1850	1786	1850	1897	1971	1867	1934	2043	2124	2126	2096	1975	
1943	1850	1850	1826	1834	1837	1901	1955	1938	1907	1883	1841	1732	
1944	1721	1726	1704	1551	1540	1499	1517	1582	1611	1412	1238	1097	
1945	1081	1113	1193	1252	1409	1446	1453	1511	1498	1485	1425	1399	
1946	1402	1452	1631	1725	1727	1744	1827	1871	1827	1713	1508	1450	
1947	1435	1438	1374	1278	1224	1242	1243	1216	1222	1083	941	846	
1948	875	888	875	1063	1060	1044	1104	1193	1308	1312	1293	1275	
1949	1256	1258	1250	1205	1185	1289	1426	1527	1522	1498	1405	1372	
1950	1242	1235	1214	1209	1213	1226	1297	1366	1367	1352	1303	1280	
1951	1388	1499	1743	1822	2000	2053	2090	2071	1997	1872	1701	1650	
1952	1631	1647	1705	1670	1737	1796	2002	2163	2215	2232	2150	1975	
1953	1850	1825	1778	1900	1905	1926	1991	2000	2102	2147	2127	1975	
1954	1850	1850	1814	1805	1899	2030	2226	2216	2158	2137	2053	1975	
1955	1761	1791	1759	1689	1604	1532	1499	1562	1567	1444	1298	1206	
1956	1165	1174	1468	1791	1897	1991	2075	2143	2064	2004	1976	1953	
1957	1850	1773	1667	1521	1538	1530	1526	1638	1653	1640	1616	1595	
1958	1686	1760	1850	1900	2059	2100	2197	2418	2430	2270	2150	1975	
1959	1850	1768	1654	1687	1648	1595	1631	1626	1577	1359	1169	1114	
1960	1077	1036	1019	996	1084	1167	1160	1200	1254	1158	1037	956	
1961	944	948	1032	1032	1197	1213	1239	1305	1380	1341	1230	1207	
1962	1190	1194	1221	1199	1275	1246	1335	1352	1369	1359	1337	1314	
1963	1417	1464	1626	1635	1872	1839	1966	2055	2008	1983	1931	1837	
1964	1800	1850	1802	1788	1717	1653	1614	1576	1555	1360	1144	1003	
1965	997	1029	1560	1763	1829	1852	1946	1910	1861	1839	1809	1746	
1966	1718	1786	1738	1726	1675	1775	1962	2069	2046	1884	1682	1637	
1967	1500	1606	1738	1816	1895	1944	1915	2086	2196	2204	2150	1975	
1968	1850	1837	1770	1765	1929	1973	1951	1937	1903	1683	1553	1531	
1969	1500	1490	1554	1660	1727	1776	1933	2159	2090	2027	1997	1964	
1970	1850	1769	1850	1900	1913	1876	1810	1767	1719	1511	1389	1295	
1971	1282	1398	1440	1581	1603	1692	1733	1833	1857	1864	1839	1812	
1972	1795	1789	1724	1741	1734	1957	1977	2009	2006	1875	1680	1652	
1973	1609	1643	1741	1865	1961	1974	2036	2151	2110	2091	1900	1784	
1974	1759	1850	1850	1900	1890	2085	2145	2210	2208	2170	2147	1975	
1975	1850	1768	1684	1564	1518	1585	1590	1754	1884	1900	1880	1861	
1976	1850	1850	1798	1624	1540	1485	1486	1525	1494	1301	1270	1248	
1977	1229	1220	1189	1168	1049	994	917	868	726	545	438	428	
1978	420	450	650	1050	1226	1490	1511	1494	1451	1428	1408	1413	
1979	1390	1305	1196	1076	992	962	1010	1154	1142	1129	1100	1079	
1980	1093	1154	1210	1427	1699	1785	1816	1779	1736	1733	1634	1550	
1981	1532	1504	1462	1481	1507	1525	1559	1546	1507	1315	1281	1250	
1982	1245	1484	1801	1880	2000	2100	2155	2132	2001	1940	1907	1880	
1983	1850	1805	1840	1900	2000	2100	2181	2420	2447	2270	2150	1975	
1984	1850	1850	1850	1853	1802	1769	1744	1757	1714	1690	1628	1601	
1985	1589	1698	1663	1602	1527	1476	1536	1522	1473	1249	1020	893	
1986	882	873	875	998	1453	1738	1744	1688	1629	1492	1361	1342	
1987	1334	1308	1218	1145	1117	1228	1296	1293	1130	958	842	769	
1988	748	735	896	970	1025	1053	1056	1060	1042	931	805	725	
1989	704	741	746	763	764	1057	1138	1125	1086	965	869	830	
1990	858	855	835	863	830	811	788	809	812	744	671	633	
1991	611	593	567	551	532	552	598	621	627	580	539	515	
1992	498	487	483	491	620	739	889	937	796	639	513	487	
1993	470	465	474	525	639	960	1030	1262	1366	1372	1354	1328	
Avg.	1255	1266	1297	1322	1373	1429	1483	1531	1514	1436	1341	1280	
Min.	272	295	298	310	319	379	447	484	530	505	307	283	
Max.	1850	1850	1850	1900	2059	2100	2226	2420	2447	2270	2150	1975	

Trinity

70 Percent [EWA], Whiskeytown Storage+A54 (TAF)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	
1922	217	206	206	206	206	217	240	240	240	240	240	235	
1923	217	206	206	206	206	217	240	240	240	240	240	203	
1924	180	180	180	206	206	217	216	234	240	240	180	179	
1925	180	194	199	180	206	217	240	240	240	240	240	235	
1926	217	206	206	206	206	205	240	237	231	223	218	214	
1927	212	206	206	206	206	217	240	240	238	230	221	235	
1928	217	206	206	206	206	217	240	240	240	240	240	235	
1929	217	206	206	206	206	213	214	209	216	240	240	235	
1930	217	206	206	206	206	217	240	238	240	240	240	235	
1931	217	206	201	205	205	204	215	213	240	240	180	179	
1932	179	180	180	185	191	190	190	198	200	197	180	180	
1933	180	180	180	180	182	202	218	224	232	240	240	224	
1934	180	180	181	199	206	205	216	235	240	240	180	180	
1935	180	191	194	206	206	217	240	238	235	228	223	219	
1936	217	206	202	206	206	205	221	225	223	220	215	212	
1937	209	204	198	198	199	217	240	238	238	234	240	235	
1938	217	206	206	206	206	217	240	240	240	240	240	235	
1939	217	206	206	206	206	217	240	228	240	240	240	235	
1940	217	206	206	206	206	217	240	238	239	240	240	235	
1941	217	206	206	206	206	217	240	240	240	240	240	235	
1942	217	206	206	206	206	217	240	240	240	240	240	235	
1943	217	206	206	206	206	217	240	240	240	240	240	235	
1944	217	206	206	206	206	217	240	233	231	240	240	235	
1945	217	206	206	206	206	217	240	237	232	222	240	230	
1946	217	206	206	206	206	217	240	238	240	240	240	235	
1947	217	206	206	206	206	217	240	230	229	240	240	235	
1948	217	206	206	206	204	212	240	240	238	231	223	213	
1949	217	206	206	206	206	217	240	238	239	240	240	235	
1950	217	206	206	206	206	217	240	234	232	227	240	235	
1951	217	206	206	206	206	217	240	240	240	240	240	235	
1952	217	206	206	206	206	217	240	240	240	240	240	235	
1953	217	206	206	206	206	217	240	240	240	240	240	235	
1954	217	206	206	206	206	217	240	240	240	240	240	235	
1955	217	206	206	206	206	217	240	240	240	240	240	235	
1956	217	206	206	206	206	217	240	240	238	240	240	235	
1957	217	206	206	206	206	217	240	240	240	238	235	235	
1958	217	206	206	206	240	217	240	240	240	240	240	235	
1959	217	206	206	206	206	217	240	238	240	240	240	235	
1960	217	206	203	206	206	217	240	240	236	240	240	235	
1961	217	206	206	206	206	217	240	240	240	240	240	235	
1962	217	206	206	206	206	217	240	237	231	221	218	209	
1963	217	206	206	206	206	217	240	240	240	240	240	235	
1964	217	206	206	206	206	217	240	239	240	240	240	235	
1965	217	206	206	206	206	217	240	240	238	240	240	235	
1966	217	206	206	206	206	217	240	238	240	240	240	235	
1967	217	206	206	206	206	217	240	240	240	240	240	235	
1968	217	206	206	206	206	217	240	238	240	240	240	235	
1969	217	206	206	206	206	217	240	240	240	240	240	235	
1970	217	206	206	206	206	217	240	240	240	240	240	235	
1971	217	206	206	206	206	217	240	240	239	240	240	235	
1972	217	206	206	206	206	217	240	238	240	240	240	235	
1973	217	206	206	206	206	217	240	240	240	240	240	235	
1974	217	206	206	206	206	217	240	240	238	240	240	235	
1975	217	206	206	206	206	217	240	240	240	240	240	235	
1976	217	206	206	206	206	217	240	240	240	240	240	235	
1977	217	206	206	206	206	213	240	240	240	240	180	180	
1978	180	181	206	206	206	217	240	240	238	232	224	223	
1979	217	206	206	206	206	217	230	240	240	236	231	225	
1980	217	206	206	206	206	217	240	240	240	240	240	235	
1981	217	206	206	206	206	217	240	238	240	240	240	235	
1982	217	206	206	206	206	217	240	240	238	240	240	235	
1983	217	206	206	206	206	217	240	240	240	240	240	235	
1984	217	206	206	206	206	217	240	236	238	240	240	235	
1985	217	206	206	206	206	217	240	238	240	240	240	235	
1986	217	206	206	206	206	217	240	239	237	240	240	235	
1987	217	206	206	206	206	217	240	240	240	240	240	235	
1988	217	206	206	206	206	217	240	238	240	240	240	235	
1989	217	206	206	206	206	217	240	240	232	240	240	235	
1990	217	206	206	206	204	207	203	222	229	240	240	235	
1991	217	206	201	200	200	217	231	233	237	240	240	235	
1992	217	206	206	206	206	217	240	240	240	240	240	235	
1993	217	206	206	206	206	217	240	240	240	240	240	235	
Avg.	213	204	204	205	206	215	237	237	237	238	234	229	
Min.	179	180	180	180	182	190	190	198	200	197	180	179	
Max.	217	206	206	206	240	217	240	240	240	240	240	235	

Trinity

70 Percent [EWA], Shasta Storage (TAF)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1922	2806	2842	2925	3019	3376	3755	4233	4362	4015	3449	2979	2680
1923	2648	2706	2837	3030	3155	3276	3593	3349	3031	2559	2099	1963
1924	1912	1848	1812	1933	2078	2104	1856	1524	1124	718	592	550
1925	551	653	742	904	2126	2333	3002	3076	2797	2389	2061	1941
1926	1899	1925	1970	2012	2733	2939	3218	3084	2715	2187	1800	1643
1927	1633	2106	2610	3142	3462	4088	4552	4552	4243	3577	3058	2785
1928	2715	2979	3117	3387	3855	3965	4463	4242	3833	3107	2786	2575
1929	2471	2428	2419	2565	2749	2914	2999	2877	2612	2160	1838	1695
1930	1530	1472	1989	2194	2567	3039	3210	3127	2733	2317	1958	1813
1931	1752	1746	1732	1802	1887	2062	1835	1555	1202	741	590	550
1932	550	550	725	867	991	1424	1603	1810	1632	1269	1017	889
1933	820	804	792	800	837	1422	1631	1695	1538	1124	763	643
1934	639	622	721	998	1315	1588	1605	1425	1085	677	576	550
1935	550	635	672	957	1286	1675	2670	2890	2576	2130	1689	1491
1936	1453	1421	1430	2053	2938	3298	3533	3422	3197	2691	2191	1957
1937	1816	1719	1693	1674	1766	2411	3084	3261	3086	2649	2217	2009
1938	1987	2539	3310	3668	3560	3416	4058	4552	4467	4056	3606	3400
1939	3250	3252	3336	3450	3564	3960	3813	3540	2995	2476	2138	2037
1940	1961	1891	2036	2910	3252	3435	4146	4088	3662	3045	2590	2395
1941	2339	2333	3233	3317	3423	3940	4456	4552	4466	4150	3700	3400
1942	3250	3200	3316	3389	3516	3843	4476	4552	4459	3871	3402	3262
1943	3250	3252	3356	3541	3848	4118	4552	4521	4247	3623	3127	2948
1944	2877	2866	2861	3057	3357	3666	3666	3555	3217	2746	2394	2283
1945	2234	2427	2727	2912	3682	3986	4166	4183	3895	3246	2722	2456
1946	2476	2770	3265	3622	3607	4003	4199	4117	3701	3200	2862	2655
1947	2533	2602	2698	2706	2960	3478	3646	3321	3010	2521	2201	2108
1948	2190	2234	2266	2824	2625	2928	3822	4184	4162	3698	3213	3050
1949	2972	2942	2943	2948	3139	4071	4388	4337	3899	3151	2697	2454
1950	2423	2360	2301	2566	2969	3415	3762	3719	3427	2985	2581	2437
1951	2744	3160	3322	3624	3794	4230	4318	4332	3884	3197	2804	2593
1952	2587	2693	3306	3604	3739	4022	4290	4552	4397	3947	3567	3400
1953	3250	3200	3345	3366	3672	4145	4480	4552	4500	3917	3499	3400
1954	3250	3252	3352	3552	3661	4106	4546	4267	3975	3200	2847	2737
1955	2905	3046	3347	3485	3547	3715	3804	3871	3404	2816	2452	2363
1956	2320	2422	3252	3252	3288	3992	4438	4552	4377	3944	3524	3350
1957	3250	3200	3210	3319	3675	4129	4168	4428	4141	3448	2967	2913
1958	3052	3189	3338	3531	3252	3416	4173	4512	4481	4120	3700	3400
1959	3250	3200	3236	3648	3777	3984	4006	3779	3161	2622	2161	2075
1960	1962	1891	1882	2085	2806	3491	3695	3710	3378	2803	2385	2296
1961	2183	2290	2734	2941	3662	4202	4300	4261	3810	3053	2574	2387
1962	2201	2306	2614	2735	3675	4169	4450	4343	3960	3264	2759	2558
1963	2961	3079	3349	3509	3944	4092	4137	4431	4206	3531	3123	3056
1964	3061	3252	3284	3691	3851	4003	3630	3391	3094	2606	2259	2195
1965	2142	2285	3252	3368	3784	3897	4500	4411	4084	3395	3010	2862
1966	2830	3187	3338	3725	4037	4229	4552	4410	3723	3162	2751	2570
1967	2488	2820	3335	3551	3920	4033	4479	4552	4500	4062	3697	3400
1968	3250	3208	3280	3500	3654	4207	4179	4039	3421	2888	2581	2373
1969	2368	2487	2833	3358	3480	4030	4434	4552	4383	3792	3314	3180
1970	3250	3252	3317	3252	3431	4066	4048	3906	3524	2827	2464	2333
1971	2365	2858	3319	3515	3580	3873	4360	4552	4493	3911	3478	3390
1972	3250	3195	3302	3648	3979	4249	4510	4413	3783	3193	2768	2637
1973	2718	2995	3317	3552	3636	4162	4418	4397	3977	3212	2918	2844
1974	2944	3252	3267	3252	3694	3416	4289	4480	4329	3948	3581	3400
1975	3250	3200	3296	3428	3936	3756	4328	4552	4399	3977	3578	3400
1976	3250	3238	3265	3426	3605	3834	3927	3762	3276	2907	2707	2641
1977	2561	2592	2503	2510	2586	2582	2192	2051	1513	851	550	550
1978	550	555	985	2901	3567	4000	4552	4552	4208	3518	3070	2977
1979	2882	2881	2874	3027	3372	3873	4053	4096	3528	3040	2689	2533
1980	2560	2720	2873	3528	3292	3987	4268	4206	3803	3269	2876	2760
1981	2708	2671	2762	3065	3475	4081	4229	3977	3302	2711	2123	1939
1982	1989	2903	3276	3616	3530	3953	4094	4304	4143	3766	3412	3293
1983	3250	3252	3328	3371	3252	3417	4074	4552	4500	4150	3700	3400
1984	3250	3252	3285	3650	4005	4246	4340	4289	3960	3263	2946	2813
1985	2824	3252	3360	3453	3628	3840	3955	3576	3024	2503	2134	2091
1986	2061	2083	2234	2796	3252	3534	3838	3810	3390	3011	2665	2615
1987	2628	2611	2615	2742	3077	3807	3703	3375	2843	2395	2087	1963
1988	1832	1859	2374	2805	2956	3069	3085	3074	2565	2079	1771	1621
1989	1480	1685	1781	1886	1995	3377	3771	3560	3196	2616	2224	2236
1990	2351	2384	2391	2632	2666	2920	2767	2891	2653	2096	1790	1646
1991	1533	1472	1452	1455	1486	1910	2073	1996	1713	1343	1029	899
1992	845	744	740	786	1444	1891	2149	1904	1531	1122	709	598
1993	614	595	826	1475	2206	3664	4299	4482	4492	3851	3488	3330
Avg.	2340	2428	2614	2859	3132	3502	3780	3766	3445	2914	2530	2384
Min.	550	550	672	786	837	1422	1603	1425	1085	677	550	550
Max.	3250	3252	3360	3725	4037	4249	4552	4552	4500	4150	3700	3400

Trinity

70 Percent [EWA], Trinity Import (TAF)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1922	203	56	8	5	2	4	20	0	4	10	75	5	393
1923	0	0	8	0	2	4	19	89	132	177	89	0	520
1924	22	29	7	132	0	0	0	20	80	65	135	0	489
1925	0	0	0	0	0	0	0	0	0	70	103	53	226
1926	0	0	0	0	0	0	0	0	0	0	0	0	0
1927	0	0	0	0	0	0	0	0	0	0	0	24	24
1928	0	0	6	0	0	0	7	0	2	4	203	22	244
1929	0	0	6	96	2	0	0	0	11	81	95	42	334
1930	0	0	0	0	0	0	24	0	27	79	93	28	250
1931	0	0	0	0	0	0	0	0	59	70	144	0	272
1932	0	0	0	0	0	0	0	0	0	0	63	0	63
1933	0	0	0	0	0	0	0	0	0	37	22	0	59
1934	0	0	0	0	0	0	0	19	87	80	172	0	357
1935	0	0	0	0	0	0	0	0	0	0	0	0	0
1936	0	0	0	0	0	0	0	0	0	0	0	0	0
1937	0	0	0	0	0	0	0	0	0	4	32	15	51
1938	0	0	0	0	0	0	0	0	0	7	10	5	21
1939	82	0	5	3	4	2	24	0	50	165	159	81	577
1940	0	0	0	0	0	0	0	0	0	63	86	49	198
1941	0	0	0	0	0	0	0	0	0	141	116	162	418
1942	109	0	0	0	0	3	0	0	0	7	9	99	227
1943	109	6	0	0	0	0	19	3	5	10	16	83	251
1944	0	0	13	125	0	4	27	0	4	186	148	116	622
1945	0	0	0	0	0	0	18	0	0	0	34	0	53
1946	0	0	0	0	0	0	5	0	3	102	182	35	326
1947	0	0	3	9	0	0	23	0	0	122	118	71	347
1948	0	0	5	0	0	0	0	0	0	0	0	0	5
1949	11	0	4	8	0	0	2	0	0	11	69	8	114
1950	115	0	6	0	0	3	14	0	0	0	22	0	160
1951	0	0	0	0	0	0	22	0	2	97	146	25	292
1952	11	0	0	0	0	0	0	0	0	7	65	153	236
1953	109	0	0	0	0	0	9	0	0	6	8	132	264
1954	116	63	1	0	0	0	0	30	2	3	65	60	341
1955	203	0	0	0	0	6	3	0	0	107	124	72	515
1956	25	0	0	0	0	0	3	0	0	4	3	0	36
1957	88	0	9	2	0	0	2	0	0	0	0	2	104
1958	0	0	1	70	154	0	0	11	0	140	108	155	640
1959	106	0	9	0	0	0	24	0	29	199	165	35	567
1960	21	28	0	0	0	0	14	0	0	85	98	57	303
1961	0	0	0	0	0	0	7	0	0	32	90	0	128
1962	0	0	0	3	0	0	24	0	0	0	6	0	34
1963	2	0	0	0	0	0	0	0	2	0	21	66	92
1964	32	49	2	0	0	0	2	0	14	184	200	124	607
1965	0	0	0	0	0	0	0	0	0	0	7	18	45	70
1966	13	0	0	0	0	0	0	0	3	159	186	28	390
1967	126	0	0	0	0	0	0	0	0	8	42	158	335
1968	122	0	0	0	0	0	11	0	0	203	107	0	443
1969	21	30	0	0	0	0	0	0	0	0	3	6	61
1970	100	0	31	145	0	0	10	0	0	184	94	65	629
1971	0	0	0	0	0	0	0	0	1	0	3	0	4
1972	0	0	0	0	0	0	0	0	0	114	172	0	286
1973	39	0	0	0	0	0	0	0	0	1	160	94	294
1974	44	0	0	139	0	0	0	0	0	5	2	147	337
1975	99	0	0	0	0	0	0	0	2	0	2	0	104
1976	7	11	3	97	0	7	11	8	3	178	16	0	342
1977	0	0	5	6	89	0	58	0	123	154	86	0	523
1978	0	0	0	0	0	0	0	0	0	0	0	0	0
1979	3	0	0	0	0	0	0	0	0	0	0	0	3
1980	0	0	0	0	0	0	4	0	2	0	72	59	137
1981	0	0	0	0	0	0	3	0	0	165	0	0	168
1982	0	0	0	0	0	26	0	0	0	6	8	0	39
1983	44	0	0	0	0	65	0	26	196	203	150	173	858
1984	116	47	0	0	0	0	19	0	6	11	41	5	245
1985	0	0	0	0	0	1	24	0	23	200	203	104	555
1986	0	0	0	0	0	0	12	0	0	109	105	0	225
1987	0	0	4	5	0	0	15	24	132	151	92	42	463
1988	0	0	0	0	0	6	13	0	41	102	100	49	310
1989	0	0	0	0	0	0	1	0	0	99	69	20	190
1990	0	0	7	0	0	0	0	0	0	52	43	12	114
1991	0	0	0	0	0	0	0	0	6	32	19	0	57
1992	0	0	0	0	0	0	0	1	117	145	98	0	361
1993	0	0	0	0	0	0	0	0	0	0	0	1	1
Avg.	29	4	2	12	4	2	7	3	16	64	72	39	254
Min.	0	0	0	0	0	0	0	0	0	0	0	0	0
Max.	203	63	31	145	154	65	58	89	196	203	203	173	858

Trinity

70 Percent [EWA], Trinity Flow (TAF)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1922	23	23	30	56	75	130	118	131	72	28	28	27	741
1923	23	22	33	30	46	76	118	131	72	28	28	27	633
1924	23	22	33	30	48	76	55	97	41	28	28	27	507
1925	23	18	19	18	26	41	168	241	142	41	28	27	792
1926	23	38	107	112	136	126	118	131	72	28	28	27	946
1927	23	22	33	30	46	76	168	241	142	41	28	27	876
1928	23	38	107	112	141	126	157	164	93	30	28	27	1045
1929	23	23	30	56	75	130	55	97	41	28	28	27	612
1930	23	18	19	18	26	41	118	131	72	28	28	27	549
1931	23	22	33	30	46	76	55	97	41	28	28	27	505
1932	23	18	19	18	27	41	118	131	72	28	28	27	550
1933	23	22	33	30	46	76	118	131	72	28	28	27	633
1934	23	22	33	30	46	76	55	97	41	28	28	27	505
1935	23	18	19	18	26	41	118	131	72	28	28	27	549
1936	23	22	33	30	48	76	157	164	93	30	28	27	729
1937	23	23	30	56	75	130	118	131	72	28	28	27	741
1938	23	22	33	30	46	76	205	316	274	100	32	27	1182
1939	28	99	123	167	160	204	55	97	41	28	28	27	1058
1940	23	18	19	18	27	41	168	241	142	41	28	27	793
1941	23	38	107	112	136	126	205	316	274	100	32	27	1495
1942	28	99	211	167	160	204	168	241	142	41	28	27	1517
1943	23	38	107	112	136	126	157	164	93	30	28	27	1040
1944	23	23	30	56	78	130	55	97	41	28	28	27	615
1945	23	18	19	18	26	41	157	164	93	30	28	27	643
1946	23	23	30	56	75	130	168	241	142	41	28	27	983
1947	23	38	107	112	136	126	118	131	72	28	28	27	946
1948	23	22	33	30	48	76	157	164	93	30	28	27	729
1949	23	23	30	56	75	130	157	164	93	30	28	27	834
1950	23	23	30	56	75	130	118	131	72	28	28	27	741
1951	23	22	33	30	59	76	168	241	142	41	28	27	888
1952	23	38	107	112	141	126	168	241	142	41	28	27	1194
1953	23	38	107	208	136	126	168	241	142	41	28	27	1284
1954	23	38	107	112	136	126	168	241	142	41	28	27	1189
1955	23	38	107	112	136	126	118	131	72	28	28	27	946
1956	23	22	33	30	48	76	205	316	274	100	32	27	1184
1957	28	99	123	167	160	204	157	164	93	30	28	27	1280
1958	23	23	30	56	333	188	205	316	274	100	32	27	1606
1959	28	99	123	167	160	204	157	164	93	30	28	27	1280
1960	23	23	30	56	78	130	157	164	93	30	28	27	837
1961	23	23	30	56	75	130	157	164	93	30	28	27	834
1962	23	23	30	56	75	130	157	164	93	30	28	27	834
1963	23	23	30	56	75	130	168	241	142	41	28	27	983
1964	23	38	107	112	141	126	118	131	72	28	28	27	951
1965	23	22	33	30	46	76	168	241	142	41	28	27	876
1966	23	38	107	112	136	126	157	164	93	30	28	27	1040
1967	23	23	30	56	75	130	168	241	142	41	28	27	983
1968	23	38	107	112	141	126	157	164	93	30	28	27	1045
1969	23	23	30	56	75	130	205	316	274	100	32	27	1289
1970	28	99	123	369	160	204	168	241	142	41	28	27	1630
1971	23	38	107	112	136	126	168	241	142	41	28	27	1189
1972	23	38	107	112	141	126	157	164	93	30	28	27	1045
1973	23	23	30	56	75	130	168	241	142	41	28	27	983
1974	23	340	261	369	136	126	205	316	274	100	32	27	2208
1975	28	99	123	167	160	204	168	241	142	41	28	27	1429
1976	23	38	107	112	141	126	118	131	72	28	28	27	951
1977	23	22	33	30	46	76	55	97	41	28	28	27	505
1978	23	18	19	19	26	41	205	316	274	100	32	27	1098
1979	28	99	123	167	160	204	118	131	72	28	28	27	1186
1980	23	22	33	30	48	76	168	241	142	41	28	27	878
1981	23	38	107	112	136	126	118	131	72	28	28	27	946
1982	23	22	33	30	156	76	205	316	274	100	32	27	1292
1983	28	99	123	170	181	369	205	316	294	211	32	27	2055
1984	28	99	313	167	166	204	168	241	142	41	28	27	1624
1985	23	38	107	112	136	126	118	131	72	28	28	27	946
1986	23	22	33	30	46	76	168	241	142	41	28	27	876
1987	23	38	107	112	136	126	118	131	72	28	28	27	946
1988	23	22	33	30	48	76	118	131	72	28	28	27	635
1989	23	22	33	30	46	76	157	164	93	30	28	27	727
1990	23	23	30	56	75	130	118	131	72	28	28	27	741
1991	23	22	33	30	46	76	55	97	41	28	28	27	505
1992	23	18	19	18	27	41	118	131	72	28	28	27	550
1993	23	22	33	30	46	76	168	241	142	41	28	27	876
Avg.	24	40	67	81	95	116	144	188	118	43	28	27	970
Min.	23	18	19	18	26	41	55	97	41	28	28	27	505
Max.	28	340	313	369	333	369	205	316	294	211	32	27	2208

Trinity

70 Percent [EWA], Tracy Export (TAF)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1922	270	243	260	185	236	263	174	92	179	282	279	266	2729
1923	268	253	260	117	157	162	152	49	136	281	279	266	2380
1924	258	126	177	260	212	49	48	75	48	37	138	165	1592
1925	148	92	235	237	234	49	163	129	129	144	148	260	1969
1926	227	177	158	259	235	140	152	49	48	49	49	177	1721
1927	131	250	259	165	12	163	175	140	179	283	280	267	2304
1928	252	253	260	260	244	262	152	118	179	258	222	241	2701
1929	201	252	234	260	206	117	48	49	48	49	49	163	1675
1930	191	67	259	259	189	236	100	49	68	72	124	204	1817
1931	218	189	49	259	168	71	48	49	48	37	55	110	1300
1932	117	45	259	259	237	146	97	125	92	129	184	253	1941
1933	128	65	40	33	44	39	37	49	48	49	37	124	692
1934	128	54	259	259	112	60	48	49	36	37	37	133	1210
1935	64	176	200	259	107	207	113	49	152	103	274	259	1962
1936	137	103	206	259	154	144	142	49	179	126	276	263	2038
1937	205	140	231	260	225	110	75	92	140	131	274	258	2140
1938	214	251	60	49	44	102	48	49	179	280	278	266	1821
1939	266	151	87	103	109	118	67	69	118	142	134	212	1577
1940	113	130	143	259	243	262	175	140	179	280	278	265	2467
1941	250	200	260	260	236	263	152	118	179	282	279	266	2744
1942	268	253	260	260	191	163	175	92	179	282	279	266	2668
1943	268	253	260	143	217	86	152	49	133	282	279	266	2386
1944	267	203	252	260	227	245	132	92	139	222	199	263	2500
1945	131	252	259	185	235	263	124	118	169	281	279	266	2561
1946	265	253	260	260	235	199	142	140	179	282	279	266	2758
1947	267	253	260	260	231	250	105	96	121	127	144	259	2374
1948	87	177	146	258	243	208	152	118	179	281	278	266	2392
1949	231	232	260	260	170	260	108	118	179	280	274	266	2637
1950	208	219	120	185	236	255	143	49	179	184	271	256	2305
1951	168	251	259	66	68	163	129	118	179	283	280	266	2228
1952	268	253	260	260	244	263	175	140	179	283	280	267	2872
1953	269	253	148	126	153	145	143	69	172	281	279	266	2303
1954	267	253	260	260	236	263	163	129	179	282	279	266	2837
1955	245	240	260	260	194	162	105	113	176	182	181	234	2351
1956	169	164	259	260	244	207	152	118	179	270	280	267	2567
1957	269	253	208	260	209	167	160	69	179	283	280	266	2602
1958	268	217	243	185	236	262	175	92	179	281	278	266	2682
1959	267	253	166	106	129	161	108	124	179	282	280	244	2298
1960	193	116	146	260	244	254	48	49	107	233	245	189	2084
1961	156	239	237	241	235	183	97	97	170	225	227	222	2329
1962	178	98	257	157	235	262	120	69	140	278	243	263	2299
1963	264	252	259	260	235	162	152	118	179	283	280	267	2710
1964	269	253	260	260	166	144	131	49	103	261	276	213	2385
1965	162	252	259	260	235	224	175	140	179	283	280	267	2715
1966	268	253	260	260	236	263	119	129	179	281	279	242	2769
1967	199	253	185	185	236	262	152	49	179	279	277	265	2520
1968	266	252	94	95	118	162	133	117	179	283	280	251	2230
1969	196	220	185	185	218	248	89	92	179	279	277	265	2433
1970	265	188	80	74	77	161	129	118	179	282	274	244	2070
1971	198	253	260	260	236	263	163	69	179	282	280	266	2709
1972	268	253	260	260	213	263	48	102	179	280	278	231	2634
1973	244	253	260	185	236	263	168	92	166	282	279	266	2693
1974	268	253	260	260	236	263	152	49	163	281	279	266	2729
1975	267	253	260	260	194	163	175	92	179	282	279	266	2671
1976	268	253	260	260	151	149	48	49	87	49	76	168	1817
1977	164	100	49	156	44	49	48	49	89	89	183	89	1110
1978	64	109	255	184	234	263	48	49	172	282	279	266	2205
1979	268	198	113	260	236	215	167	140	179	130	233	264	2401
1980	265	230	259	260	143	86	122	118	179	283	280	267	2491
1981	269	221	260	260	175	159	142	118	169	283	280	244	2580
1982	177	253	185	185	236	262	175	92	179	280	277	265	2566
1983	266	224	49	49	66	103	48	49	179	280	278	266	1857
1984	266	100	70	85	126	162	165	92	142	282	279	266	2034
1985	268	253	235	260	203	232	112	116	141	280	278	243	2620
1986	177	171	185	185	236	262	152	49	179	162	277	264	2297
1987	265	215	210	260	235	113	48	69	80	74	82	148	1800
1988	159	158	187	259	54	49	81	87	107	100	112	171	1526
1989	159	149	172	219	83	259	137	49	108	208	221	207	1972
1990	168	142	179	259	218	145	48	49	59	58	87	159	1571
1991	146	143	1	115	60	260	48	49	76	96	199	178	1370
1992	181	100	120	164	243	218	48	49	48	49	37	50	1306
1993	113	36	259	184	235	263	163	69	179	282	279	266	2327
Avg.	212	196	203	211	187	187	119	86	144	213	228	235	2221
Min.	64	36	1	33	12	39	37	49	36	37	37	50	692
Max.	270	253	260	260	244	263	175	140	179	283	280	267	2872

Trinity

70 Percent [EWA], Banks Export (TAF)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1922	214	177	327	468	472	465	200	224	397	441	415	352	4153
1923	308	302	334	496	253	184	174	146	314	441	441	316	3710
1924	300	122	320	274	212	18	18	75	18	18	242	103	1722
1925	131	146	235	237	314	18	172	139	95	103	18	238	1848
1926	113	97	158	311	302	140	155	43	141	390	337	144	2331
1927	203	397	322	272	457	448	204	220	254	324	411	303	3816
1928	301	376	434	455	356	442	180	149	171	190	275	297	3627
1929	194	198	234	333	206	121	42	18	18	170	38	111	1681
1930	85	65	315	324	189	429	100	102	18	402	313	251	2592
1931	58	88	120	284	126	77	18	56	47	305	310	138	1628
1932	92	100	331	358	237	261	44	125	303	153	18	219	2240
1933	201	206	145	412	131	299	42	43	18	160	38	122	1817
1934	162	33	295	325	250	75	18	18	18	154	18	96	1462
1935	181	168	200	361	244	446	204	20	357	441	407	253	3282
1936	314	159	250	449	485	465	171	147	217	441	415	301	3815
1937	224	124	246	383	472	465	204	193	116	394	441	305	3567
1938	238	397	226	509	472	465	180	201	397	411	411	405	4313
1939	411	361	434	456	173	177	18	115	202	430	425	313	3516
1940	228	146	192	367	481	465	204	187	262	441	415	397	3785
1941	284	196	328	511	472	465	180	201	283	411	411	427	4170
1942	407	312	460	523	403	427	204	224	397	238	411	374	4380
1943	377	397	447	523	422	423	180	127	303	118	411	319	4048
1944	202	118	255	343	280	331	132	135	237	441	441	323	3239
1945	232	397	321	343	472	414	124	132	280	441	419	322	3898
1946	237	308	338	509	261	311	142	157	248	441	441	387	3779
1947	288	245	323	234	231	250	105	37	145	441	411	294	3005
1948	199	216	157	258	121	208	178	201	276	441	441	325	3021
1949	173	159	281	299	170	324	108	122	191	278	254	289	2648
1950	48	105	107	269	422	255	143	142	250	441	402	287	2871
1951	301	397	351	523	472	464	129	160	165	387	441	379	4169
1952	309	314	442	523	482	465	204	224	363	298	329	427	4381
1953	411	342	440	419	255	406	143	197	381	274	411	416	4094
1954	391	283	236	445	306	437	192	201	158	423	398	395	3866
1955	287	277	318	449	123	134	86	113	190	278	61	201	2516
1956	98	234	351	389	485	465	152	201	390	411	411	393	3979
1957	411	219	273	348	416	452	160	69	244	252	377	295	3515
1958	411	237	243	451	434	465	204	224	397	258	411	427	4162
1959	411	255	406	453	238	99	108	124	250	411	441	314	3509
1960	274	116	213	289	315	254	18	109	221	344	254	296	2702
1961	62	266	237	241	294	183	97	18	70	335	338	267	2408
1962	192	188	257	153	351	424	120	65	287	441	441	376	3295
1963	411	370	316	448	431	438	180	201	270	266	411	336	4078
1964	335	397	336	445	124	144	131	43	211	441	411	330	3349
1965	182	329	333	389	472	288	204	118	196	250	441	309	3511
1966	161	397	467	508	276	440	119	137	224	392	366	309	3795
1967	232	397	266	477	430	463	180	201	397	418	411	427	4301
1968	411	353	432	443	217	443	133	117	218	323	419	324	3833
1969	234	238	262	523	472	441	204	224	363	218	411	398	3988
1970	411	397	421	384	371	403	129	123	211	307	441	382	3980
1971	332	397	438	459	141	434	172	69	298	411	411	397	3959
1972	411	182	431	446	213	427	42	102	147	372	419	283	3474
1973	212	397	317	460	466	465	168	176	319	414	410	353	4158
1974	326	397	322	523	458	465	180	194	394	263	411	427	4361
1975	411	281	426	450	470	436	201	224	334	411	411	419	4474
1976	411	375	409	317	182	175	42	76	127	372	334	218	3038
1977	172	167	110	156	56	72	42	43	86	108	240	169	1422
1978	114	92	255	282	472	465	42	199	397	199	411	363	3292
1979	212	216	430	489	351	465	167	164	250	270	390	304	3708
1980	229	247	320	523	485	465	155	157	227	441	415	375	4040
1981	287	94	289	454	248	445	142	118	169	441	400	344	3433
1982	225	397	261	523	472	465	204	224	397	411	411	427	4418
1983	411	397	472	355	201	219	180	43	231	441	441	427	3819
1984	399	207	249	347	376	408	165	150	169	336	441	397	3645
1985	332	397	235	390	203	147	112	116	193	441	441	397	3405
1986	290	288	261	455	472	465	179	146	200	145	411	345	3659
1987	251	72	205	324	250	235	91	38	268	441	410	300	2884
1988	154	124	187	324	89	35	81	87	18	232	58	83	1473
1989	59	166	172	219	69	317	137	43	230	441	411	322	2586
1990	328	130	225	435	129	187	18	77	18	18	289	276	2130
1991	48	78	18	121	75	322	42	43	73	186	18	62	1087
1992	73	18	116	164	316	218	42	18	18	159	38	228	1408
1993	168	46	297	296	468	457	192	212	397	441	411	322	3708
Avg.	253	240	294	385	315	333	132	129	224	328	348	309	3291
Min.	48	18	18	121	56	18	18	18	18	18	18	62	1087
Max.	411	397	472	523	485	465	204	224	397	441	441	427	4474

Trinity

70 Percent [EWA], Delta Inflows (TAF)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1922	815	742	1320	1240	2665	2312	1858	3500	2610	1509	1124	949	20646
1923	901	989	2224	2181	1170	1165	1844	1363	1285	1393	1144	895	16554
1924	892	721	838	922	1083	746	562	586	636	709	729	544	8968
1925	576	577	952	884	4017	1782	1669	1170	981	830	596	769	14801
1926	697	610	688	1206	2538	981	1608	916	804	1071	847	614	12579
1927	680	1620	1298	2101	7352	3041	3233	1944	1357	1440	1126	874	26066
1928	904	1146	1106	1582	1578	6399	1961	1444	1062	1224	943	836	20183
1929	780	847	901	910	1054	878	596	644	631	733	559	560	9094
1930	583	515	1278	1469	1157	2209	927	881	702	1055	838	736	12351
1931	670	605	654	981	751	601	602	537	642	1066	753	538	8402
1932	560	507	1503	1568	1456	1162	942	1007	1281	874	695	777	12332
1933	701	605	649	1009	800	965	788	611	673	765	584	539	8687
1934	575	518	1058	1304	999	930	807	589	702	725	521	522	9250
1935	554	781	727	2179	1001	2008	3448	1846	1461	1245	1147	824	17220
1936	837	656	788	2706	4678	2252	1802	1383	1129	1285	1153	865	19534
1937	810	665	794	1036	2906	3187	1923	1643	1092	1220	1174	865	17315
1938	789	1583	3770	2267	8199	10680	4953	4952	3356	1476	1139	1029	44194
1939	1419	847	1061	996	898	1110	822	904	964	1174	975	822	11991
1940	809	610	676	2430	3826	7049	4492	1570	1277	1513	1143	1018	26413
1941	888	829	2781	6266	7068	6183	4819	2993	1618	1482	1118	1174	37217
1942	1037	894	4126	5266	8149	2000	3349	2641	2011	1308	1140	983	32906
1943	992	1161	2032	5721	3677	5744	2167	1697	1244	1219	1132	898	27683
1944	810	726	864	1042	1699	1646	1033	995	1073	1256	1066	899	13109
1945	828	1036	1184	959	3068	1926	1228	1214	1281	1433	1148	902	16208
1946	826	1059	4152	3507	1887	1457	1149	1241	1216	1411	1173	1002	20081
1947	943	893	1144	865	1199	1425	997	817	955	1162	978	863	12242
1948	720	723	666	1088	1038	1188	1886	1978	1462	1411	1169	906	14235
1949	772	838	1010	857	839	2895	1028	1110	1098	1150	936	852	13385
1950	687	653	669	1408	2228	1458	1454	1328	1223	1325	1123	832	14388
1951	841	3182	6227	4557	4322	2232	1285	1523	980	1579	1160	991	28878
1952	905	1066	2500	5806	4875	4582	4422	4765	3141	1361	1063	1314	35800
1953	1478	916	2940	6640	1642	1573	1309	1804	1578	1452	1118	1047	23498
1954	1010	1051	841	2232	3664	3246	2640	1849	961	1494	1106	1016	21110
1955	912	945	1453	1331	954	845	996	1004	1043	1038	701	725	11947
1956	674	726	5296	10906	5388	2783	1572	2758	1622	1454	1132	1014	35325
1957	1093	813	934	935	2139	3178	1515	1308	1209	1352	1096	862	16434
1958	1117	805	1412	2478	10349	6283	6205	3578	2465	1304	1134	1309	38438
1959	1373	847	917	2340	3287	1591	879	998	1223	1420	1164	858	16896
1960	832	670	698	889	1872	1452	832	956	948	1192	937	784	12064
1961	676	814	1097	858	1726	1158	888	830	877	1165	1019	777	11886
1962	811	596	1089	702	2980	1958	1026	1091	1222	1409	1127	981	14990
1963	2187	956	1640	1127	4324	2200	5562	2321	1346	1451	1132	926	25173
1964	927	1582	939	1534	969	868	1307	878	897	1291	1178	834	13205
1965	721	1000	4885	7578	2300	1713	3052	1839	1070	1471	1141	883	27652
1966	776	1297	1319	2224	1734	2008	1016	1140	1153	1334	1092	846	15938
1967	908	1007	2325	3162	3374	4029	3574	3838	3279	1481	1142	1479	29598
1968	1437	937	1159	2014	3834	2488	1192	919	1151	1301	1090	883	18405
1969	864	800	1614	7311	7824	4370	3876	4522	2864	1284	1152	1018	37499
1970	1311	980	3821	13133	5139	2748	1280	1112	1112	1604	1167	961	34367
1971	865	1240	3851	3332	1835	2824	1665	1932	1359	1701	1134	1019	22758
1972	1041	904	1218	1105	1328	2149	881	879	1328	1333	1137	791	14095
1973	822	1267	1466	5203	5362	4039	1470	1449	1386	1472	1132	951	26020
1974	911	3485	4453	8408	2660	7215	4554	1903	1589	1301	1140	1269	38887
1975	1057	869	1178	1095	3986	5895	1879	2158	1725	1453	1119	1052	23466
1976	1218	967	1106	970	909	1095	724	594	718	941	791	665	10696
1977	688	588	636	613	520	572	654	476	749	853	788	531	7668
1978	535	528	1067	4319	3396	4572	2838	1956	1688	1270	1149	966	24284
1979	842	779	1046	1731	2637	2547	1458	1317	1360	1078	1058	872	16726
1980	845	897	1327	6461	7914	3998	1609	1494	1158	1473	1210	985	29371
1981	903	681	1025	1551	1676	2015	1302	935	965	1324	1167	904	14448
1982	758	1914	5402	5023	6030	5818	8595	3653	1992	1457	1151	1252	43044
1983	1880	2826	5630	6617	9985	15612	5471	4989	5571	2645	1503	2040	64768
1984	1937	5010	9746	4459	2663	2612	1430	1165	1106	1564	1163	1019	33873
1985	920	1655	1516	999	1035	1078	1077	1032	954	1311	1199	983	13759
1986	838	811	1207	1643	11448	9584	1903	1373	1082	1080	1136	936	33042
1987	861	647	809	999	1267	1862	877	777	993	1089	905	750	11836
1988	775	594	1232	1878	795	640	705	718	778	877	598	544	10134
1989	584	673	730	901	598	2975	1382	924	965	1271	1116	812	12930
1990	888	659	751	1296	969	948	766	605	582	667	800	727	9659
1991	576	508	516	524	560	2235	946	705	594	818	674	546	9204
1992	556	508	512	755	2142	1422	825	607	713	732	566	579	9917
1993	557	518	1004	4152	3559	2873	2641	2232	1798	1509	1149	903	22895
Avg.	899	1021	1826	2746	3124	2934	2000	1617	1349	1266	1025	896	20703
Min.	535	507	512	524	520	572	562	476	582	667	521	522	7668
Max.	2187	5010	9746	13133	11448	15612	8595	4989	5571	2645	1503	2040	64768

Trinity

70 Percent [EWA], Total Delta Outflow (TAF)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1922	246	268	724	683	2127	1551	1396	3039	1771	492	246	212	12755
1923	246	394	1783	1669	736	744	1487	1021	609	400	246	214	9548
1924	247	404	277	392	647	620	381	247	315	407	184	179	4300
1925	244	287	492	445	3617	1672	1309	822	514	307	267	179	10154
1926	271	280	314	665	2113	620	1277	664	303	307	266	179	7259
1927	266	952	651	1722	7059	2383	2806	1436	669	543	246	193	18926
1928	281	467	385	906	967	5729	1538	1010	440	492	246	179	12640
1929	290	354	412	337	632	586	412	403	359	246	288	179	4498
1930	221	321	661	956	812	1544	645	598	354	307	229	179	6827
1931	311	268	414	481	457	385	404	269	311	418	189	179	4087
1932	259	310	1034	1009	1081	692	700	603	608	307	297	179	7080
1933	275	268	410	632	600	595	597	387	356	246	310	179	4855
1934	196	361	476	729	710	712	595	345	410	246	271	179	5230
1935	220	394	301	1685	633	1404	3146	1625	654	400	246	179	10886
1936	302	327	277	2084	4288	1596	1406	1037	482	400	246	179	12622
1937	287	330	281	457	2369	2787	1559	1184	571	400	246	179	10649
1938	246	882	3486	1778	8000	10235	4656	4541	2499	492	246	240	37301
1939	658	268	473	444	604	787	609	545	363	307	215	179	5450
1940	378	268	277	1975	3364	6365	4036	1081	536	492	246	242	19259
1941	259	366	2268	5711	6524	5459	4496	2544	894	492	246	360	29617
1942	277	268	3410	4667	7591	1377	2988	2204	1156	492	246	225	24902
1943	250	465	1289	5208	3049	5267	1768	1357	547	531	246	188	20165
1944	246	338	299	453	1290	1005	695	617	442	307	215	182	6089
1945	379	346	592	444	2430	1281	868	813	543	400	246	188	8531
1946	255	439	3599	2748	1374	901	754	790	520	400	246	226	12251
1947	294	351	518	369	745	905	666	493	424	307	230	179	5481
1948	369	268	296	562	645	752	1527	1554	769	400	246	201	7590
1949	282	378	431	312	502	2353	704	708	449	307	225	185	6836
1950	337	268	387	1026	1584	909	1070	964	525	400	246	183	7900
1951	300	2515	5730	4086	3808	1565	945	1104	369	619	246	226	21513
1952	246	450	1867	5319	4151	3911	3989	4239	2359	492	246	496	27763
1953	696	268	2397	6168	1198	963	956	1410	794	575	246	244	15914
1954	255	453	277	1535	3117	2539	2204	1354	365	492	246	237	13075
1955	280	377	860	737	633	491	755	642	419	307	257	179	5937
1956	315	271	4871	10533	4654	2041	1206	2304	777	492	246	250	27960
1957	332	268	380	333	1534	2523	1120	1082	518	526	246	191	9053
1958	368	281	883	1991	9959	5680	5877	3133	1646	492	246	496	31053
1959	595	268	277	1809	2988	1259	539	570	507	424	246	234	9714
1960	266	366	277	374	1366	894	678	651	334	307	235	179	5926
1961	361	279	563	458	1182	773	605	569	349	307	265	179	5892
1962	345	268	515	398	2635	1237	675	789	508	400	246	224	8240
1963	1486	268	1038	536	3718	1630	5294	1881	639	628	246	212	17576
1964	247	889	277	903	644	514	931	615	356	307	300	179	6160
1965	302	372	4353	7046	1568	1151	2635	1421	446	664	246	197	20400
1966	246	616	597	1511	1230	1238	654	693	481	400	246	179	8090
1967	378	335	1903	2828	2686	3345	3289	3440	2472	492	246	669	22082
1968	662	268	570	1532	3510	1861	820	518	468	400	246	185	11041
1969	343	293	1143	6903	7346	3637	3501	4031	2072	492	246	230	30239
1970	558	331	3304	12948	4690	2129	917	681	455	717	246	209	27185
1971	246	590	3262	2640	1430	2088	1242	1669	622	719	246	233	14986
1972	268	404	495	407	883	1368	686	481	724	400	246	179	6538
1973	312	663	899	4890	4831	3322	1030	991	606	492	246	215	18497
1974	247	2824	3926	7710	1939	6499	4168	1495	762	492	246	446	30754
1975	290	268	439	382	3397	5362	1437	1673	930	492	246	240	15154
1976	472	268	363	377	543	671	531	253	238	246	250	179	4392
1977	256	265	419	300	382	376	422	268	311	371	184	179	3732
1978	265	275	542	4158	2788	3939	2709	1544	851	492	246	212	18021
1979	246	314	431	1115	2188	1840	1045	848	641	400	246	179	9492
1980	276	361	743	5840	7495	3420	1253	1076	502	492	327	229	22015
1981	246	295	418	878	1235	1421	919	527	331	307	287	204	7068
1982	282	1245	4979	4589	5352	5270	8212	3174	1172	492	271	481	35521
1983	1134	2263	5148	6497	9914	15586	5246	4756	4891	1649	588	1240	58913
1984	1177	4699	9537	4024	2163	1983	1004	736	523	656	246	224	26972
1985	251	1024	1031	369	619	716	746	610	333	307	292	242	6541
1986	281	319	749	1087	11069	8927	1495	1018	431	492	246	232	26346
1987	246	289	331	417	801	1514	615	476	372	307	219	179	5765
1988	378	268	835	1378	626	484	451	393	410	246	236	179	5883
1989	271	308	341	462	436	2394	982	646	357	307	277	212	6993
1990	312	327	277	624	633	541	586	394	238	301	235	179	4646
1991	294	221	437	277	396	1677	754	470	238	246	273	179	5462
1992	227	325	215	433	1701	983	636	352	398	246	293	179	5986
1993	195	369	471	4060	3050	2160	2194	1829	995	492	246	179	16238
Avg.	349	535	1314	2242	2681	2405	1673	1246	717	436	254	238	14089
Min.	195	221	215	277	382	376	381	247	238	246	184	179	3732
Max.	1486	4699	9537	12948	11069	15586	8212	4756	4891	1649	588	1240	58913

Trinity

70 Percent [EWA], CVP Delivery North of Delta (TAF)
(sum of CALSIM variables D300, D8, D9, D302, D167A_IMI, D167B_IMI, D162_IMI, D168B, D168C_FRWP, and Del_CVP_Total_N)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1922	95	40	33	29	28	29	399	459	557	567	506	273	3014
1923	58	40	34	29	28	95	276	479	528	564	503	185	2819
1924	94	49	33	29	28	55	316	353	385	388	336	67	2133
1925	33	29	24	21	20	24	244	339	502	550	489	231	2505
1926	109	39	32	27	26	52	156	380	496	500	439	243	2499
1927	55	36	29	24	23	31	336	462	531	577	512	273	2890
1928	65	40	34	29	28	24	274	449	523	533	478	259	2736
1929	104	39	32	28	27	35	330	426	394	469	420	228	2531
1930	94	51	29	24	23	22	246	391	511	515	460	220	2586
1931	94	37	30	25	25	68	327	308	353	400	348	73	2088
1932	30	31	25	22	21	40	288	313	394	410	366	198	2138
1933	86	39	28	25	24	48	326	328	392	396	345	172	2208
1934	60	44	27	23	22	34	293	347	395	415	360	53	2072
1935	33	32	26	23	22	22	138	419	541	545	488	260	2548
1936	69	42	32	27	26	30	282	413	467	534	480	253	2655
1937	105	56	32	27	26	23	267	443	478	521	467	255	2701
1938	70	39	32	27	26	26	252	440	572	578	512	235	2809
1939	71	44	34	29	51	114	424	382	487	488	440	202	2764
1940	80	51	30	25	24	26	292	398	565	576	510	267	2844
1941	66	40	34	29	28	26	146	342	559	587	519	276	2651
1942	68	40	34	29	28	26	153	384	573	587	519	272	2712
1943	105	40	34	29	28	26	263	471	557	577	512	274	2916
1944	107	43	34	29	28	37	314	390	498	528	473	257	2735
1945	77	37	30	25	25	24	339	400	520	574	510	273	2835
1946	46	40	33	29	28	35	417	465	546	543	494	260	2936
1947	104	40	33	29	28	25	327	426	453	524	466	255	2710
1948	45	37	30	25	35	47	136	302	487	584	514	250	2492
1949	89	43	33	29	29	23	327	406	537	542	484	261	2802
1950	113	41	33	28	27	31	336	433	493	504	451	228	2719
1951	45	38	31	27	26	39	400	400	566	572	508	269	2922
1952	54	40	34	29	28	26	314	471	516	571	510	268	2860
1953	117	40	34	29	28	57	301	440	533	576	472	272	2900
1954	101	40	34	29	28	24	246	459	545	572	459	266	2804
1955	106	39	32	27	26	70	310	437	504	509	456	216	2731
1956	90	37	30	25	25	67	362	397	544	576	510	246	2911
1957	69	56	34	29	28	52	352	409	574	582	516	151	2852
1958	51	46	33	29	28	26	157	376	526	565	511	269	2616
1959	110	55	34	29	28	45	428	497	545	549	483	134	2936
1960	111	56	31	26	25	22	305	380	491	495	444	240	2628
1961	97	37	30	25	24	22	308	428	503	531	470	235	2709
1962	102	37	30	26	25	23	366	466	532	558	494	259	2918
1963	43	39	32	27	26	26	149	400	568	586	518	273	2686
1964	63	40	34	29	28	80	422	441	465	500	444	222	2767
1965	60	37	30	25	25	61	252	480	559	567	439	271	2805
1966	117	40	33	29	28	44	406	479	531	535	479	257	2980
1967	111	39	32	27	26	26	136	445	477	583	515	272	2688
1968	109	40	34	29	28	24	360	469	522	570	453	268	2904
1969	77	39	32	27	26	27	335	493	546	566	507	268	2941
1970	80	42	34	29	28	25	379	476	496	538	482	261	2868
1971	74	39	32	27	26	50	440	406	538	559	499	261	2950
1972	109	41	34	29	31	121	402	446	502	527	472	207	2919
1973	48	38	31	26	25	26	344	478	567	572	509	257	2922
1974	57	40	34	29	28	26	265	476	560	499	513	275	2800
1975	71	41	34	29	28	26	290	484	571	565	501	274	2912
1976	48	44	34	29	52	143	334	421	451	460	367	199	2580
1977	93	38	28	23	34	89	355	264	394	399	348	124	2192
1978	76	29	24	21	20	26	202	457	571	580	512	224	2742
1979	121	40	34	29	28	24	295	460	548	552	489	252	2871
1980	51	39	32	27	27	26	309	443	538	567	511	268	2839
1981	105	51	34	29	28	23	284	427	564	570	505	238	2856
1982	47	38	31	26	25	26	179	465	521	589	521	182	2651
1983	45	40	34	29	28	26	158	420	549	584	499	230	2641
1984	98	40	34	29	28	50	413	496	531	552	470	259	2999
1985	61	39	32	27	26	23	345	475	536	548	486	192	2789
1986	83	39	32	27	26	24	277	434	537	542	485	201	2705
1987	106	51	32	27	27	23	336	433	482	485	435	235	2675
1988	82	36	29	25	24	76	291	347	432	472	422	228	2464
1989	96	34	28	23	29	24	327	482	514	546	483	86	2671
1990	56	39	32	27	26	53	383	262	473	479	412	224	2465
1991	93	41	29	24	28	21	219	331	403	425	378	204	2196
1992	70	37	27	24	23	20	218	359	381	426	382	205	2173
1993	44	37	26	23	22	25	312	345	493	579	506	274	2685
Avg.	79	41	31	27	27	40	298	417	507	531	469	230	2697
Min.	30	29	24	21	20	20	136	262	353	388	336	53	2072
Max.	121	56	34	29	52	143	440	497	574	589	521	276	3014

Trinity

70 Percent [EWA], CVP Delivery So w/ CVC (TAF)
(equals CALSIM variable CVPTotalDel)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1922	204	123	107	137	166	150	187	305	439	538	453	277	3086
1923	192	114	95	116	141	160	195	288	421	514	435	270	2940
1924	188	112	92	110	134	78	87	126	165	175	168	135	1569
1925	112	61	37	29	39	126	146	212	306	355	314	217	1954
1926	165	93	66	70	88	92	102	139	191	197	194	166	1563
1927	141	75	41	30	42	161	195	316	470	581	486	288	2825
1928	198	119	101	126	153	135	172	260	375	450	386	248	2725
1929	178	104	81	94	115	92	102	142	191	197	194	165	1657
1930	141	75	41	30	42	115	138	195	273	310	280	204	1844
1931	159	89	60	59	75	75	83	120	155	161	158	131	1323
1932	110	59	34	25	35	83	93	129	179	194	182	142	1266
1933	115	63	40	34	45	79	89	123	168	179	171	137	1243
1934	113	62	37	30	40	86	97	141	188	207	192	146	1339
1935	117	65	42	37	48	92	109	215	297	342	305	214	1883
1936	163	92	65	67	84	142	168	246	346	410	356	235	2373
1937	172	99	74	83	104	108	144	210	289	331	296	210	2121
1938	161	91	63	64	81	150	190	282	403	489	416	261	2652
1939	184	109	87	104	127	128	146	214	305	353	313	217	2286
1940	164	93	66	69	87	134	161	270	392	474	405	256	2573
1941	182	107	85	100	122	154	189	307	443	544	458	279	2971
1942	193	115	96	117	143	162	195	306	441	541	456	278	3043
1943	192	115	96	117	142	155	195	301	432	529	447	275	2995
1944	191	114	94	114	138	142	163	239	345	409	355	234	2537
1945	172	99	74	83	103	146	183	293	421	513	435	267	2789
1946	188	112	91	110	134	149	177	295	430	526	436	274	2921
1947	190	113	93	113	137	113	150	213	303	351	311	216	2305
1948	164	93	66	69	87	92	147	284	414	504	427	266	2613
1949	187	111	90	107	131	108	183	273	402	487	415	261	2754
1950	184	108	87	103	126	106	130	183	255	284	261	195	2022
1951	155	86	56	52	67	161	189	306	451	554	462	280	2818
1952	194	116	97	120	146	151	185	323	469	580	485	290	3156
1953	197	119	101	126	153	157	188	290	422	516	436	270	2976
1954	189	112	92	110	134	153	187	303	445	546	460	280	3010
1955	193	115	96	118	143	140	165	239	338	399	348	231	2525
1956	171	98	73	81	101	161	189	319	465	574	481	289	2999
1957	197	118	100	125	151	165	189	310	452	556	467	283	3113
1958	194	116	98	120	146	141	172	286	410	498	423	264	2868
1959	186	110	89	106	129	160	187	306	447	549	448	294	3010
1960	193	116	97	119	144	92	130	183	254	284	261	195	2067
1961	155	86	56	52	67	124	177	258	365	437	376	244	2398
1962	176	102	79	90	112	134	161	234	343	407	353	234	2424
1963	172	98	74	82	103	161	194	317	467	577	483	287	3014
1964	197	118	101	125	152	139	164	234	336	397	346	230	2540
1965	170	97	72	80	100	151	180	310	456	562	471	285	2934
1966	195	117	98	122	148	152	182	292	425	520	440	272	2963
1967	189	113	93	111	136	138	167	268	380	458	392	251	2695
1968	180	105	82	95	118	160	187	311	455	560	470	284	3005
1969	195	117	98	121	147	132	165	261	370	444	382	246	2679
1970	177	103	80	92	114	159	189	296	432	528	446	274	2891
1971	190	114	94	114	138	154	183	307	449	552	428	304	3026
1972	194	116	97	119	145	147	180	275	392	474	405	256	2802
1973	182	107	85	100	122	158	195	305	440	540	455	276	2963
1974	194	115	95	116	141	156	195	297	426	521	440	272	2968
1975	189	113	93	112	136	162	195	306	441	542	456	279	3023
1976	192	115	96	117	142	100	112	157	214	228	218	176	1867
1977	146	78	47	38	51	83	93	133	179	194	183	135	1360
1978	63	63	40	34	45	155	195	302	434	532	449	273	2586
1979	191	114	94	115	139	134	176	256	363	433	373	242	2630
1980	176	102	78	89	110	155	195	324	470	581	486	291	3056
1981	198	119	101	126	153	158	189	305	450	553	465	282	3099
1982	194	116	97	120	145	133	162	273	388	468	400	254	2751
1983	181	106	84	98	121	150	190	282	403	488	416	261	2780
1984	184	109	87	103	126	160	189	298	439	538	454	278	2967
1985	192	115	95	116	141	147	179	271	395	477	407	257	2792
1986	183	107	85	101	123	131	165	257	364	435	375	243	2569
1987	176	102	78	90	111	107	136	192	269	303	275	201	2041
1988	158	88	59	57	73	92	102	148	191	197	194	165	1526
1989	141	75	41	30	42	92	156	227	316	368	324	222	2033
1990	166	95	68	73	92	92	102	148	191	197	194	165	1585
1991	141	75	41	30	42	89	101	146	197	219	201	150	1432
1992	119	67	44	40	52	91	103	149	202	225	207	152	1451
1993	120	67	45	42	54	151	189	298	429	524	443	271	2634
Avg.	172	100	77	88	109	131	160	249	356	426	366	238	2475
Min.	63	59	34	25	35	75	83	120	155	161	158	131	1243
Max.	204	123	107	137	166	165	195	324	470	581	486	304	3156

Trinity

70 Percent [EWA], X2_PRV (KM)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	
1922	74.9	83.2	85.0	78.2	76.4	66.4	66.3	66.8	61.2	63.3	74.1	82.9	
1923	86.7	87.0	83.3	70.7	67.1	71.5	73.6	68.7	70.2	74.4	79.3	84.6	
1924	87.2	87.2	83.1	85.0	82.9	77.9	77.1	80.3	84.9	84.3	82.4	87.8	
1925	89.6	88.1	86.0	81.5	80.8	63.7	64.8	66.8	71.3	76.1	81.9	84.8	
1926	88.6	86.9	85.9	84.9	78.8	67.2	73.6	69.9	73.9	81.0	83.5	85.4	
1927	88.8	87.1	76.6	76.3	68.7	54.6	59.1	59.1	64.5	71.8	76.1	83.6	
1928	87.6	86.3	81.8	82.0	75.5	72.4	58.2	63.4	68.6	76.4	78.4	84.3	
1929	88.5	86.4	83.9	82.2	83.1	77.9	77.5	79.8	81.0	82.0	85.5	85.5	
1930	88.8	88.6	85.4	79.0	74.1	73.0	68.5	73.4	75.9	80.5	83.3	86.5	
1931	89.2	86.1	85.9	82.8	80.6	79.5	81.3	81.2	84.6	84.3	82.2	87.6	
1932	89.5	87.6	85.3	75.6	72.6	70.6	73.8	74.6	76.2	76.4	82.0	84.0	
1933	88.4	86.8	86.2	82.9	78.6	76.8	77.0	76.8	80.3	81.9	85.5	84.9	
1934	88.6	89.4	84.7	81.3	77.0	74.9	75.0	76.2	81.0	81.0	85.2	85.8	
1935	89.0	88.6	83.8	84.6	71.6	74.1	69.5	61.6	64.4	72.0	78.5	84.4	
1936	88.5	86.0	84.4	85.4	70.2	59.2	63.7	65.9	69.2	75.9	79.8	84.8	
1937	88.6	86.5	84.5	85.3	81.8	67.3	62.1	64.6	67.7	74.1	79.2	84.6	
1938	88.6	87.7	77.3	63.6	64.3	52.2	47.2	51.3	53.1	58.0	72.3	82.3	
1939	85.6	79.1	83.7	81.0	80.7	77.4	75.1	76.0	77.5	80.8	83.4	87.0	
1940	89.3	84.6	85.5	85.7	70.8	61.3	53.8	54.6	65.2	73.8	77.5	84.0	
1941	86.0	86.4	83.7	69.0	57.1	51.4	51.7	53.1	58.1	67.5	75.4	83.4	
1942	82.8	84.8	85.5	66.5	57.9	50.5	62.0	59.5	61.3	66.6	75.1	83.3	
1943	86.4	86.8	81.9	72.8	59.1	57.9	54.1	61.0	65.5	73.7	76.9	83.8	
1944	87.9	87.4	84.6	84.9	81.8	72.2	71.5	73.9	75.8	78.7	82.7	86.8	
1945	89.1	84.5	83.5	79.2	80.1	66.5	67.8	70.9	72.7	76.1	79.9	84.8	
1946	88.2	87.3	82.5	65.1	61.5	64.8	69.9	72.7	73.5	76.7	80.1	84.9	
1947	86.8	85.7	83.7	80.4	81.9	76.2	73.6	74.9	77.8	79.7	83.0	86.3	
1948	89.1	84.7	85.5	85.2	80.2	77.0	75.3	69.1	67.1	71.6	78.4	84.3	
1949	87.6	86.3	83.4	81.7	83.6	79.8	67.5	72.4	74.3	78.1	82.5	86.4	
1950	88.9	85.3	85.7	83.2	75.0	68.1	70.9	70.4	71.2	75.9	79.8	84.8	
1951	88.4	86.1	68.8	57.0	55.8	55.1	62.5	68.5	69.6	78.1	77.1	83.9	
1952	86.5	87.0	82.3	70.1	58.0	55.5	55.6	55.2	54.9	59.0	72.7	82.4	
1953	80.0	76.9	82.9	68.4	56.3	64.2	69.2	70.6	68.4	71.8	75.7	83.4	
1954	85.8	86.5	82.0	84.6	72.3	62.1	61.1	61.6	65.7	76.9	78.5	84.4	
1955	86.3	85.9	83.3	76.3	75.2	75.3	78.0	75.3	76.0	79.2	82.9	85.5	
1956	88.8	85.9	85.8	63.8	50.8	52.2	59.5	65.7	63.0	70.2	76.3	83.6	
1957	85.7	84.4	85.4	83.3	83.6	71.2	64.1	67.8	69.5	75.4	77.5	84.0	
1958	87.9	84.3	85.0	76.7	67.7	51.7	51.5	50.9	55.8	62.1	73.7	82.8	
1959	80.1	78.1	83.3	85.0	71.2	62.0	66.4	74.1	76.5	77.9	80.0	84.8	
1960	86.6	86.4	83.7	85.1	83.3	72.3	72.4	74.3	75.5	80.8	83.4	86.3	
1961	89.1	84.9	85.2	80.2	80.2	72.1	73.5	75.6	77.0	80.9	83.4	85.4	
1962	88.8	85.2	85.6	81.0	81.5	66.4	68.0	72.9	73.6	76.9	80.1	84.9	
1963	86.9	73.3	81.8	74.4	77.0	62.3	64.5	56.0	61.4	71.2	74.8	83.1	
1964	86.8	87.0	77.1	83.0	75.9	75.6	77.8	73.7	75.7	80.4	83.3	84.4	
1965	88.5	86.1	83.4	63.9	53.9	61.3	66.9	62.1	65.5	75.3	75.7	83.4	
1966	87.4	87.3	80.0	78.0	70.3	68.5	68.7	73.4	74.7	77.7	80.4	85.0	
1967	88.7	84.4	83.7	70.4	63.0	60.2	58.3	57.6	57.3	59.5	72.8	82.5	
1968	77.7	76.5	82.8	79.3	70.6	60.9	63.1	69.8	75.8	78.3	80.6	85.0	
1969	88.4	85.1	84.9	74.7	57.5	50.7	54.6	55.9	55.5	60.2	73.1	82.6	
1970	85.9	80.5	82.5	65.8	49.8	51.6	59.0	67.6	73.0	77.6	75.8	83.5	
1971	87.0	87.1	80.2	65.1	61.8	64.6	63.4	66.7	65.8	72.8	74.3	83.0	
1972	86.0	86.2	82.8	80.4	81.1	74.9	70.0	73.5	77.6	75.5	79.7	84.7	
1973	88.6	85.8	78.9	74.6	60.1	54.7	56.6	66.0	69.6	74.3	77.7	84.1	
1974	87.0	87.1	68.2	59.7	51.8	59.0	52.9	54.0	62.5	70.2	76.3	83.6	
1975	81.2	84.0	85.3	82.1	82.2	64.7	56.2	63.3	64.7	69.4	76.1	83.6	
1976	86.0	81.8	84.5	83.3	82.7	79.1	76.9	77.7	83.9	86.1	86.9	87.0	
1977	89.3	87.6	86.5	82.9	84.3	82.1	82.3	81.2	84.6	84.3	83.1	88.1	
1978	89.7	87.5	86.2	80.8	63.4	60.0	57.0	58.7	63.8	69.8	76.2	83.6	
1979	86.9	87.1	85.0	82.2	74.0	65.3	64.6	68.5	71.6	74.5	79.3	84.6	
1980	88.6	86.8	83.9	77.6	59.8	51.5	55.3	64.0	68.3	75.3	78.0	82.0	
1981	85.8	86.7	85.4	82.6	75.9	70.4	68.2	70.6	75.9	81.0	83.5	84.8	
1982	87.6	86.3	74.2	59.9	55.8	52.5	52.4	48.6	55.0	64.4	74.4	82.3	
1983	80.2	73.2	65.4	56.7	52.1	46.6	42.1	48.7	51.9	52.5	61.2	72.0	
1984	69.6	69.4	58.5	49.8	53.5	59.0	62.0	67.9	72.5	76.3	76.1	83.6	
1985	86.5	86.8	75.9	72.5	79.3	76.8	75.6	74.6	76.1	81.0	83.5	84.7	
1986	86.3	85.9	84.5	77.8	72.7	52.5	48.3	60.4	67.5	76.2	78.3	84.3	
1987	86.4	87.0	85.7	84.4	82.2	75.8	69.5	74.1	77.9	80.7	83.4	86.9	
1988	89.3	84.6	85.5	77.3	70.7	74.1	77.7	79.2	81.0	81.0	85.2	86.8	
1989	89.3	87.2	85.2	84.0	81.3	80.1	67.4	69.9	74.1	79.8	83.1	84.9	
1990	87.4	85.4	84.2	85.3	79.5	76.6	77.7	77.2	80.3	84.9	84.9	86.8	
1991	89.3	86.5	87.6	82.9	84.9	82.0	70.8	73.0	77.6	84.1	86.2	86.1	
1992	89.0	88.4	85.2	87.6	83.0	70.5	71.1	74.4	80.3	81.0	85.2	85.2	
1993	88.8	89.5	84.6	81.4	63.8	59.5	61.5	61.7	63.5	68.5	75.8	83.5	
Avg.	86.8	85.2	82.6	77.1	71.4	66.2	65.8	67.7	70.5	75.1	79.3	84.5	
Min.	69.6	69.4	58.5	49.8	49.8	46.6	42.1	48.6	51.9	52.5	61.2	72.0	
Max.	89.7	89.5	87.6	87.6	84.9	82.1	82.3	81.2	84.9	86.1	86.9	88.1	

Maximum Flow

Trinity

Max Flow [EWA], Trinity Storage (TAF)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1922	1850	1850	1850	1728	1606	1497	1501	1607	1591	1522	1477	1445
1923	1441	1442	1460	1480	1416	1375	1394	1396	1330	1265	1222	1195
1924	1191	1186	1186	1175	1141	1049	1070	1020	902	843	785	748
1925	744	819	867	919	1190	1330	1419	1327	1273	1199	1156	1142
1926	1136	1136	1160	1034	1033	981	1091	1029	931	856	812	784
1927	777	939	1140	1251	1395	1475	1490	1404	1418	1359	1319	1295
1928	1286	1344	1369	1298	1258	1299	1308	1272	1194	1123	1085	1059
1929	1047	1052	1059	937	817	715	775	844	779	733	679	644
1930	632	621	754	777	881	1013	1023	968	887	817	774	747
1931	735	727	724	726	657	617	683	672	589	538	482	447
1932	436	429	432	444	466	618	593	643	597	531	491	463
1933	449	448	446	431	338	351	390	405	467	420	383	358
1934	345	338	347	396	392	445	572	576	481	431	377	343
1935	337	402	439	480	564	625	724	787	734	670	629	602
1936	592	588	591	692	736	749	772	727	705	650	615	592
1937	579	568	559	416	270	240	352	530	573	531	496	472
1938	469	616	835	920	984	1140	1154	757	758	708	688	673
1939	673	689	715	566	437	380	498	502	408	359	306	273
1940	262	252	322	503	830	1133	1162	1025	941	856	813	794
1941	789	800	939	1026	1126	1316	1358	1031	1140	1191	1193	1187
1942	1181	1199	1451	1481	1548	1467	1462	1447	1504	1458	1419	1396
1943	1386	1412	1477	1445	1418	1424	1471	1388	1337	1276	1239	1213
1944	1207	1217	1220	1096	990	899	982	1075	1031	993	941	908
1945	896	929	1009	1069	1235	1295	1294	1283	1244	1181	1144	1118
1946	1126	1181	1372	1369	1280	1243	1259	1179	1115	1048	1007	983
1947	974	998	1025	899	815	775	770	724	685	622	584	558
1948	592	609	617	803	734	671	705	727	816	773	744	726
1949	723	730	739	606	494	545	659	694	665	605	573	550
1950	541	539	536	435	347	310	368	418	377	318	282	259
1951	374	490	748	825	953	960	948	807	715	634	594	570
1952	569	605	752	677	713	714	850	889	920	892	860	840
1953	831	826	867	1045	1020	983	986	873	954	951	923	905
1954	902	986	1040	991	1055	1128	1253	1151	1072	1001	967	950
1955	945	995	1052	942	827	703	645	688	651	591	557	537
1956	526	540	849	1170	1211	1258	1230	762	737	687	671	656
1957	652	657	660	499	511	523	498	544	537	480	448	432
1958	529	610	711	736	1216	1262	1244	939	1005	992	987	975
1959	967	967	963	978	933	901	937	865	820	754	719	700
1960	689	681	676	557	550	579	561	535	564	507	475	451
1961	444	453	549	452	526	489	497	496	548	495	465	443
1962	432	441	479	365	350	267	356	307	302	248	240	240
1963	352	404	578	491	637	550	606	574	509	433	389	365
1964	368	487	530	476	374	252	240	240	240	240	240	240
1965	240	277	813	1015	1019	995	1017	859	788	720	693	676
1966	668	757	797	746	665	707	870	911	868	820	796	781
1967	776	887	1031	1012	999	995	894	943	1032	994	968	952
1968	956	963	985	941	1073	1059	1024	944	886	823	791	771
1969	766	792	867	877	853	849	891	581	567	512	494	477
1970	474	475	686	1066	1073	1057	929	764	695	618	573	546
1971	539	674	806	907	898	929	899	876	879	833	795	770
1972	759	774	797	774	736	902	898	864	838	776	745	718
1973	721	761	870	897	902	862	853	847	785	715	669	649
1974	674	1086	1328	1734	1694	1831	1774	1301	1351	1321	1307	1288
1975	1272	1272	1288	1151	1099	1185	1118	1158	1268	1228	1193	1173
1976	1175	1207	1247	1131	1015	908	892	920	847	787	758	735
1977	722	717	706	689	597	494	514	491	397	344	297	278
1978	275	306	505	906	1091	1378	1283	727	737	718	704	716
1979	706	703	694	557	467	457	476	600	545	486	445	423
1980	443	508	578	795	1001	1040	1004	844	781	725	681	658
1981	646	639	685	664	660	621	631	599	518	446	402	370
1982	371	615	947	1025	1191	1270	1210	651	575	526	509	491
1983	517	554	688	735	849	1200	1166	894	1191	1333	1369	1374
1984	1375	1504	1793	1780	1722	1709	1629	1517	1456	1385	1346	1322
1985	1317	1445	1499	1398	1293	1184	1240	1204	1133	1061	1020	993
1986	987	982	998	1120	1511	1749	1694	1513	1429	1343	1297	1277
1987	1274	1268	1270	1162	1103	1155	1209	1208	1130	1060	1019	984
1988	967	959	1134	1206	1196	1182	1168	1150	1125	1066	1024	990
1989	972	1014	1033	1048	986	1231	1286	1204	1137	1064	1024	1004
1990	1036	1038	1036	967	843	769	717	717	673	609	564	535
1991	518	505	493	476	393	366	450	499	433	392	343	311
1992	298	288	285	292	432	574	695	722	652	591	548	518
1993	506	505	529	578	629	903	900	1007	1087	1035	1000	974
Avg.	763	801	882	892	906	932	951	884	859	807	773	750
Min.	240	252	285	292	270	240	240	240	240	240	240	240
Max.	1850	1850	1850	1780	1722	1831	1774	1607	1591	1522	1477	1445

Trinity

Max Flow [EWA], Whiskeytown Storage (TAF)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1922	217	206	198	192	190	197	200	204	200	191	180	179
1923	180	180	180	181	180	189	195	192	186	183	180	180
1924	180	180	180	181	194	193	192	190	180	178	176	175
1925	177	191	196	180	206	217	240	240	240	237	233	180
1926	180	180	180	180	206	205	240	234	228	220	180	180
1927	180	206	206	206	206	217	240	240	238	236	233	229
1928	217	206	203	206	206	217	233	240	238	234	229	225
1929	216	206	200	197	198	208	212	210	206	198	193	190
1930	188	182	205	206	206	217	216	214	209	201	180	180
1931	180	180	180	185	184	202	213	211	210	180	178	177
1932	177	178	180	180	180	180	180	189	190	180	178	178
1933	178	179	180	181	181	200	217	218	226	224	221	186
1934	180	180	181	199	198	217	228	228	226	180	178	177
1935	179	189	193	206	206	217	240	240	240	236	231	227
1936	217	206	202	206	206	205	221	225	223	217	209	206
1937	203	198	192	192	193	211	240	238	240	235	228	221
1938	217	206	206	206	206	217	240	240	240	236	230	223
1939	217	206	206	206	206	217	226	220	214	206	198	195
1940	192	187	194	206	206	217	240	238	239	235	231	227
1941	217	206	206	206	206	217	240	240	240	240	238	235
1942	217	206	206	206	206	214	240	240	240	233	224	216
1943	208	204	204	206	206	217	221	218	213	203	194	185
1944	180	180	180	180	193	203	203	199	196	187	180	179
1945	180	185	192	192	206	217	225	225	220	216	212	209
1946	203	206	206	206	206	217	235	233	232	229	224	221
1947	213	206	206	199	206	217	216	209	211	205	199	195
1948	195	192	190	206	206	217	240	240	238	237	235	231
1949	217	206	202	196	202	217	240	238	236	230	224	217
1950	212	206	203	206	206	217	232	232	227	219	212	205
1951	217	206	206	206	206	217	224	239	237	230	224	217
1952	213	206	206	206	206	217	240	240	240	236	230	222
1953	214	206	206	206	206	217	234	240	240	237	230	222
1954	215	206	206	206	206	217	240	240	238	229	220	213
1955	206	206	206	206	206	211	232	240	240	237	233	229
1956	217	206	206	206	206	217	237	240	238	236	233	229
1957	217	206	203	203	206	217	238	240	240	238	235	233
1958	217	206	206	206	206	217	240	240	240	233	224	215
1959	207	201	194	206	206	217	216	214	213	206	202	200
1960	195	191	188	187	206	217	229	238	237	231	224	219
1961	214	206	206	206	206	217	230	229	226	221	214	209
1962	204	206	206	206	206	217	216	214	212	205	202	199
1963	208	206	206	206	206	217	240	240	238	240	238	235
1964	217	206	206	206	206	205	205	203	196	187	180	179
1965	179	180	206	206	206	217	240	240	238	233	229	225
1966	217	206	206	206	206	217	240	238	234	226	220	215
1967	206	206	206	206	206	217	240	240	240	232	223	222
1968	217	206	206	206	206	217	223	221	229	240	240	234
1969	217	206	206	206	206	217	240	240	240	240	237	235
1970	217	206	206	206	206	217	224	226	224	227	229	227
1971	217	206	206	206	206	217	240	240	240	240	237	235
1972	217	206	206	206	206	217	240	238	240	240	240	235
1973	217	206	206	206	206	217	240	240	240	240	238	235
1974	217	206	206	206	206	217	240	240	238	235	233	232
1975	217	206	206	206	206	217	240	240	238	238	236	233
1976	217	206	206	201	205	209	222	214	214	212	213	211
1977	214	206	201	197	198	205	207	215	220	180	180	180
1978	180	181	206	206	206	217	240	240	238	235	230	229
1979	217	206	206	206	206	217	233	240	240	239	237	234
1980	217	206	206	206	206	217	239	240	238	237	235	234
1981	217	206	206	206	206	217	234	232	236	233	231	229
1982	217	206	206	206	206	217	240	240	238	237	233	231
1983	217	206	206	206	206	217	240	240	240	240	239	235
1984	217	206	206	206	206	217	221	217	213	205	196	185
1985	181	206	206	206	206	216	225	223	221	217	213	212
1986	211	206	206	206	206	217	228	228	222	217	207	203
1987	197	194	190	185	202	217	225	226	223	220	215	180
1988	180	180	206	206	206	212	221	220	224	218	218	219
1989	217	206	206	180	180	217	236	235	227	226	180	180
1990	180	180	180	199	204	212	214	239	240	239	236	233
1991	217	206	201	200	202	217	231	233	230	226	180	180
1992	179	180	180	190	206	217	240	240	240	240	180	180
1993	180	180	202	206	206	217	240	240	240	240	240	234
Avg.	204	199	200	201	203	214	229	229	228	223	216	211
Min.	177	178	180	180	180	180	180	189	180	178	176	175
Max.	217	206	206	206	206	217	240	240	240	240	240	235

Trinity

Max Flow [EWA], Shasta Storage (TAF)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1922	2603	2583	2666	2761	3118	3497	3983	4130	3785	3221	2688	2382
1923	2360	2417	2548	2741	2866	2988	3311	3031	2639	2024	1553	1439
1924	1379	1317	1305	1303	1437	1475	1230	902	550	550	550	550
1925	551	653	742	901	2123	2327	2996	3071	2804	2286	1816	1680
1926	1595	1576	1622	1665	2336	2540	2825	2703	2330	1853	1524	1387
1927	1377	1795	2299	2832	3462	4088	4552	4552	4240	3530	3000	2719
1928	2641	2908	3047	3313	3782	3965	4463	4241	3835	3109	2640	2407
1929	2292	2338	2392	2458	2641	2807	2887	2760	2494	2001	1591	1404
1930	1225	1163	1658	1862	2235	2708	2885	2826	2473	2049	1700	1578
1931	1546	1513	1499	1569	1654	1812	1586	1305	945	558	550	550
1932	550	550	725	896	1025	1458	1601	1779	1580	1228	1075	928
1933	835	811	800	807	846	1432	1638	1705	1546	1058	674	595
1934	556	550	649	926	1252	1505	1519	1337	914	571	550	550
1935	550	635	672	956	1284	1673	2669	2890	2570	2116	1671	1469
1936	1436	1401	1409	2033	2917	3278	3514	3400	3172	2667	2169	1932
1937	1789	1689	1663	1644	1736	2380	3050	3230	3086	2681	2266	2075
1938	2033	2590	3310	3668	3560	3416	4058	4552	4470	4053	3598	3400
1939	3250	3252	3334	3449	3563	3964	3856	3601	3092	2538	2120	1987
1940	1961	1905	2042	2907	3252	3435	4146	4088	3662	2998	2463	2216
1941	2151	2143	3043	3317	3423	3940	4456	4552	4466	4054	3597	3350
1942	3212	3238	3316	3389	3516	3843	4473	4552	4459	3870	3399	3163
1943	3103	3192	3356	3541	3848	4118	4552	4521	4256	3637	3138	2881
1944	2797	2774	2755	2825	3115	3424	3460	3385	3092	2610	2168	1973
1945	1936	2117	2409	2598	3357	3664	3857	3900	3652	3033	2536	2294
1946	2330	2614	3265	3622	3703	4099	4304	4235	3833	3245	2743	2505
1947	2375	2455	2549	2553	2804	3324	3504	3180	2915	2354	1927	1766
1948	1853	1892	1924	2473	2500	2804	3711	4099	4103	3644	3186	3047
1949	2981	3018	3082	3098	3285	4071	4389	4341	3952	3203	2732	2520
1950	2394	2365	2340	2617	3025	3474	3820	3772	3486	3052	2650	2508
1951	2785	3205	3322	3624	3794	4237	4367	4367	3973	3252	2772	2571
1952	2548	2751	3306	3604	3739	4022	4290	4552	4400	3948	3508	3360
1953	3250	3230	3345	3366	3675	4150	4485	4552	4500	3930	3516	3366
1954	3200	3252	3354	3552	3661	4106	4546	4297	4007	3200	2806	2640
1955	2594	2723	3023	3164	3262	3431	3659	3731	3270	2741	2368	2288
1956	2253	2359	3252	3252	3288	3992	4438	4552	4376	3942	3521	3345
1957	3250	3252	3256	3365	3675	4129	4177	4434	4203	3709	3213	3135
1958	3250	3252	3338	3531	3252	3416	4173	4504	4476	4015	3652	3400
1959	3250	3200	3237	3648	3777	3986	4058	3887	3201	2493	1996	2008
1960	1879	1792	1811	2018	2720	3409	3615	3631	3315	2726	2280	2168
1961	2051	2161	2612	2822	3541	4077	4232	4228	3871	3199	2813	2676
1962	2477	2468	2744	2857	3675	4175	4489	4408	4075	3397	2937	2767
1963	3156	3252	3349	3515	3944	4118	4137	4428	4202	3525	3098	2961
1964	2944	3252	3350	3705	3867	4005	3903	3760	3498	2964	2592	2396
1965	2303	2436	3252	3368	3784	3996	4500	4463	4194	3735	3377	3229
1966	3155	3252	3346	3725	4037	4229	4552	4446	3877	3162	2617	2441
1967	2253	2578	3288	3551	3920	4033	4479	4552	4500	4061	3661	3400
1968	3250	3209	3281	3503	3654	4179	4165	4057	3548	2836	2531	2366
1969	2384	2476	2824	3358	3480	4030	4434	4552	4386	3791	3315	3171
1970	3158	3233	3317	3252	3431	4038	4032	3936	3656	2957	2562	2403
1971	2432	2927	3319	3515	3847	3873	4405	4552	4500	3975	3565	3400
1972	3250	3200	3310	3659	3979	4249	4527	4427	3976	3271	2835	2777
1973	2817	3097	3346	3552	3636	4162	4421	4403	4006	3298	2866	2698
1974	2767	3252	3267	3252	3694	3416	4289	4480	4328	3975	3609	3400
1975	3250	3252	3352	3483	3936	3756	4328	4552	4398	3976	3576	3400
1976	3250	3228	3255	3323	3498	3728	3822	3665	3200	2470	2308	2258
1977	2137	2149	2164	2193	2177	2171	1753	1605	985	550	550	550
1978	550	556	990	2906	3567	4000	4552	4552	4206	3516	3063	2974
1979	2881	2878	2868	3024	3373	3876	4056	4102	3542	3094	2782	2654
1980	2686	2848	3004	3528	3292	3990	4271	4211	3822	3200	2742	2567
1981	2516	2478	2576	2884	3292	3895	4051	3846	3247	2505	2079	1931
1982	1975	2889	3276	3616	3530	3953	4094	4307	4149	3767	3408	3289
1983	3250	3252	3328	3371	3252	3417	4074	4552	4500	4150	3700	3400
1984	3250	3252	3285	3650	4005	4246	4351	4305	3982	3239	2878	2754
1985	2759	3162	3360	3470	3645	3857	3996	3656	3092	2410	1880	1762
1986	1745	1790	1975	2543	3252	3534	3838	3808	3393	2921	2481	2430
1987	2443	2418	2421	2549	2867	3593	3496	3214	2532	1951	1575	1475
1988	1370	1383	1865	2303	2441	2552	2569	2561	2071	1545	1143	941
1989	791	998	1094	1250	1359	2692	3102	2888	2530	2015	1696	1700
1990	1804	1832	1839	2067	2161	2428	2267	2476	2219	1600	1167	1035
1991	913	878	864	868	897	1325	1489	1434	1175	808	590	550
1992	550	550	550	570	1205	1653	1911	1587	1094	589	550	550
1993	550	550	735	1380	2111	3573	4210	4402	4420	3784	3420	3259
Avg.	2236	2328	2515	2756	3040	3406	3693	3688	3379	2833	2443	2293
Min.	550	550	550	570	846	1325	1230	902	550	550	550	550
Max.	3250	3252	3360	3725	4037	4249	4552	4552	4500	4150	3700	3400

Trinity

Max Flow [EWA], Trinity Import (TAF)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1922	0	0	0	0	0	0	0	0	0	0	0	0	0
1923	0	0	0	0	0	0	0	0	0	0	0	0	0
1924	0	0	0	0	0	0	0	0	0	0	0	0	0
1925	0	0	0	0	0	0	0	0	0	0	0	0	0
1926	0	0	0	0	0	0	0	0	0	0	0	0	0
1927	0	0	0	0	0	0	0	0	0	0	0	0	0
1928	0	0	0	0	0	0	0	0	0	0	0	0	0
1929	0	0	0	0	0	0	0	0	0	0	0	0	0
1930	0	0	0	0	0	0	0	0	0	0	0	0	0
1931	0	0	0	0	0	0	0	0	0	0	0	0	0
1932	0	0	0	0	0	0	0	0	0	0	0	0	0
1933	0	0	0	0	0	0	0	0	0	0	0	0	0
1934	0	0	0	0	0	0	0	0	0	0	0	0	0
1935	0	0	0	0	0	0	0	0	0	0	0	0	0
1936	0	0	0	0	0	0	0	0	0	0	0	0	0
1937	0	0	0	0	0	0	0	0	0	0	0	0	0
1938	0	0	0	0	0	0	0	0	0	0	0	0	0
1939	0	0	0	0	0	0	0	0	0	0	0	0	0
1940	0	0	0	0	0	0	0	0	0	0	0	0	0
1941	0	0	0	0	0	0	0	0	0	0	0	0	0
1942	0	0	0	0	0	0	0	0	0	0	0	0	0
1943	0	0	0	0	0	0	0	0	0	0	0	0	0
1944	0	0	0	0	0	0	0	0	0	0	0	0	0
1945	0	0	0	0	0	0	0	0	0	0	0	0	0
1946	0	0	0	0	0	0	0	0	0	0	0	0	0
1947	0	0	0	0	0	0	0	0	0	0	0	0	0
1948	0	0	0	0	0	0	0	0	0	0	0	0	0
1949	0	0	0	0	0	0	0	0	0	0	0	0	0
1950	0	0	0	0	0	0	0	0	0	0	0	0	0
1951	0	0	0	0	0	0	0	0	0	0	0	0	0
1952	0	0	0	0	0	0	0	0	0	0	0	0	0
1953	0	0	0	0	0	0	0	0	0	0	0	0	0
1954	0	0	0	0	0	0	0	0	0	0	0	0	0
1955	0	0	0	0	0	0	0	0	0	0	0	0	0
1956	0	0	0	0	0	0	0	0	0	0	0	0	0
1957	0	0	0	0	0	0	0	0	0	0	0	0	0
1958	0	0	0	0	0	0	0	0	0	0	0	0	0
1959	0	0	0	0	0	0	0	0	0	0	0	0	0
1960	0	0	0	0	0	0	0	0	0	0	0	0	0
1961	0	0	0	0	0	0	0	0	0	0	0	0	0
1962	0	0	0	0	0	0	0	0	0	0	0	0	0
1963	0	0	0	0	0	0	0	0	0	0	0	0	0
1964	0	0	0	0	0	0	0	0	0	0	0	0	0
1965	0	0	0	0	0	0	0	0	0	0	0	0	0
1966	0	0	0	0	0	0	0	0	0	0	0	0	0
1967	0	0	0	0	0	0	0	0	0	0	0	0	0
1968	0	0	0	0	0	0	0	0	0	0	0	0	0
1969	0	0	0	0	0	0	0	0	0	0	0	0	0
1970	0	0	0	0	0	0	0	0	0	0	0	0	0
1971	0	0	0	0	0	0	0	0	0	0	0	0	0
1972	0	0	0	0	0	0	0	0	0	0	0	0	0
1973	0	0	0	0	0	0	0	0	0	0	0	0	0
1974	0	0	0	0	0	0	0	0	0	0	0	0	0
1975	0	0	0	0	0	0	0	0	0	0	0	0	0
1976	0	0	0	0	0	0	0	0	0	0	0	0	0
1977	0	0	0	0	0	0	0	0	0	0	0	0	0
1978	0	0	0	0	0	0	0	0	0	0	0	0	0
1979	0	0	0	0	0	0	0	0	0	0	0	0	0
1980	0	0	0	0	0	0	0	0	0	0	0	0	0
1981	0	0	0	0	0	0	0	0	0	0	0	0	0
1982	0	0	0	0	0	0	0	0	0	0	0	0	0
1983	0	0	0	0	0	0	0	0	0	0	0	0	0
1984	0	0	0	0	0	0	0	0	0	0	0	0	0
1985	0	0	0	0	0	0	0	0	0	0	0	0	0
1986	0	0	0	0	0	0	0	0	0	0	0	0	0
1987	0	0	0	0	0	0	0	0	0	0	0	0	0
1988	0	0	0	0	0	0	0	0	0	0	0	0	0
1989	0	0	0	0	0	0	0	0	0	0	0	0	0
1990	0	0	0	0	0	0	0	0	0	0	0	0	0
1991	0	0	0	0	0	0	0	0	0	0	0	0	0
1992	0	0	0	0	0	0	0	0	0	0	0	0	0
1993	0	0	0	0	0	0	0	0	0	0	0	0	0
Avg.	0	0	0	0	0	0	0	0	0	0	0	0	0
Min.	0	0	0	0	0	0	0	0	0	0	0	0	0
Max.	0	0	0	0	0	0	0	0	0	0	0	0	0

Trinity

Max Flow [EWA], Trinity Flow (TAF)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1922	157	20	36	152	167	184	147	153	119	78	43	30	1286
1923	18	18	18	31	110	123	147	153	119	78	43	30	889
1924	18	18	18	31	114	123	18	72	119	55	55	36	678
1925	18	18	18	18	17	18	241	366	167	100	48	28	1059
1926	18	18	18	152	167	184	147	153	119	78	43	30	1128
1927	18	18	18	31	110	123	241	366	167	100	48	28	1269
1928	18	18	18	152	173	184	183	233	120	80	40	28	1249
1929	18	18	18	152	167	184	18	72	119	55	55	36	913
1930	18	18	18	18	17	18	147	153	119	78	43	30	678
1931	18	18	18	31	110	123	18	72	119	55	55	36	674
1932	18	18	18	18	17	18	147	153	119	78	43	30	679
1933	18	18	18	31	110	123	147	153	119	78	43	30	889
1934	18	18	18	31	110	123	18	72	119	55	55	36	674
1935	18	18	18	18	17	18	147	153	119	78	43	30	678
1936	18	18	18	31	114	123	183	233	120	80	40	28	1008
1937	18	18	18	152	167	155	147	153	119	78	43	30	1098
1938	18	18	18	31	110	123	321	856	225	100	29	22	1872
1939	18	18	24	184	167	184	18	72	119	55	55	36	951
1940	18	18	18	18	17	18	241	366	167	100	48	28	1059
1941	18	18	18	152	167	184	321	856	225	100	29	22	2111
1942	18	18	24	184	167	184	241	366	167	100	48	28	1546
1943	18	18	18	152	167	184	183	233	120	80	40	28	1243
1944	18	18	18	152	173	184	18	72	119	55	55	36	919
1945	18	18	18	18	17	18	183	233	120	80	40	28	794
1946	18	18	18	152	167	184	241	366	167	100	48	28	1509
1947	18	18	18	152	167	184	147	153	119	78	43	30	1128
1948	18	18	18	31	114	123	183	233	120	80	40	28	1008
1949	18	18	18	152	167	184	183	233	120	80	40	28	1243
1950	18	18	18	152	167	184	147	153	119	78	43	30	1128
1951	18	18	18	31	110	123	241	366	167	100	48	28	1269
1952	18	18	18	152	173	184	241	366	167	100	48	28	1515
1953	18	18	18	152	167	184	241	366	167	100	48	28	1509
1954	18	18	18	152	167	184	241	366	167	100	48	28	1509
1955	18	18	18	152	167	184	147	153	119	78	43	30	1128
1956	18	18	18	31	114	123	321	856	225	100	29	22	1875
1957	18	18	24	184	167	184	183	233	120	80	40	28	1281
1958	18	18	18	152	167	184	321	856	225	100	29	22	2111
1959	18	18	24	184	167	184	183	233	120	80	40	28	1281
1960	18	18	18	152	173	184	183	233	120	80	40	28	1249
1961	18	18	18	152	167	184	183	233	120	80	40	28	1243
1962	18	18	18	152	167	184	183	233	120	80	25	8	1208
1963	18	18	18	152	167	184	241	366	167	100	48	28	1509
1964	18	18	18	152	173	184	96	98	71	25	17	14	884
1965	18	18	26	31	110	123	241	366	167	100	48	28	1277
1966	18	18	18	152	167	184	183	233	120	80	40	28	1243
1967	18	18	18	152	167	184	241	366	167	100	48	28	1509
1968	18	18	18	152	173	184	183	233	120	80	40	28	1249
1969	18	18	18	152	167	184	321	856	225	100	29	22	2111
1970	18	18	24	184	167	184	241	366	167	100	48	28	1546
1971	18	18	18	152	167	184	241	366	167	100	48	28	1509
1972	18	18	18	152	173	184	183	233	120	80	40	28	1249
1973	18	18	18	152	167	184	241	366	167	100	48	28	1509
1974	18	20	18	152	167	184	321	856	225	100	29	22	2113
1975	18	18	24	184	167	184	241	366	167	100	48	28	1546
1976	18	18	18	152	173	184	147	153	119	78	43	30	1134
1977	18	18	18	31	110	123	18	72	119	55	55	36	674
1978	18	18	18	19	17	18	321	856	225	100	29	22	1661
1979	18	18	24	184	167	184	147	153	119	78	43	30	1166
1980	18	18	18	31	114	123	241	366	167	100	48	28	1273
1981	18	18	18	152	167	184	147	153	119	78	43	30	1128
1982	18	18	18	31	110	123	321	856	225	100	29	22	1872
1983	18	18	24	184	167	184	321	856	225	100	29	22	2149
1984	18	18	24	184	173	184	241	366	167	100	48	28	1552
1985	18	18	18	152	167	184	147	153	119	78	43	30	1128
1986	18	18	18	31	110	123	241	366	167	100	48	28	1269
1987	18	18	18	152	167	184	147	153	119	78	43	30	1128
1988	18	18	18	31	114	123	147	153	119	78	43	30	892
1989	18	18	18	31	110	123	183	233	120	80	40	28	1004
1990	18	18	18	152	167	184	147	153	119	78	43	30	1128
1991	18	18	18	31	110	123	18	72	119	55	55	36	674
1992	18	18	18	18	17	18	147	153	119	78	43	30	679
1993	18	18	18	31	110	123	241	366	167	100	48	28	1269
Avg.	20	18	19	108	135	149	187	307	145	84	43	28	1244
Min.	18	18	18	18	17	18	18	72	71	25	17	8	674
Max.	157	20	36	184	173	184	321	856	225	100	55	36	2149

Trinity

Max Flow [EWA], Tracy Export (TAF)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1922	270	243	260	260	236	227	148	92	179	282	280	266	2743
1923	268	253	185	185	205	204	48	49	132	278	276	263	2346
1924	225	115	161	260	211	37	48	76	36	4	20	67	1258
1925	165	78	185	227	234	49	163	69	126	196	211	262	1966
1926	219	184	152	260	235	224	152	49	48	49	49	168	1787
1927	177	251	259	185	15	163	175	140	179	283	280	267	2373
1928	260	253	260	260	244	262	152	118	179	200	177	263	2626
1929	197	204	212	260	205	58	48	49	48	49	49	163	1542
1930	191	65	184	184	211	259	99	49	48	49	125	165	1629
1931	219	190	124	235	171	89	48	49	36	37	31	36	1264
1932	37	83	259	259	232	143	102	69	109	145	117	254	1809
1933	228	77	42	37	44	37	36	49	48	49	37	127	811
1934	178	53	259	243	36	79	48	49	36	37	8	36	1060
1935	37	189	188	259	109	259	175	49	179	104	274	259	2082
1936	137	109	202	259	165	143	141	49	141	126	276	262	2011
1937	205	148	212	260	235	116	66	92	131	102	267	257	2090
1938	213	251	49	49	44	102	48	49	179	281	278	266	1810
1939	267	164	49	49	113	93	48	69	48	49	81	182	1212
1940	63	129	140	259	243	263	175	140	179	265	279	266	2400
1941	259	182	260	260	236	263	152	118	179	282	279	266	2733
1942	267	253	260	260	193	164	175	92	179	282	279	266	2670
1943	268	253	260	180	142	85	152	49	133	282	279	266	2348
1944	267	210	249	260	227	244	89	92	101	98	170	258	2265
1945	67	251	259	184	235	233	124	49	136	259	277	265	2340
1946	231	252	259	260	110	200	142	140	179	281	279	266	2599
1947	267	209	260	260	231	249	107	49	106	112	164	198	2213
1948	74	195	142	259	165	216	152	49	179	278	277	264	2249
1949	193	137	230	260	168	260	48	49	122	277	144	262	2150
1950	224	190	101	185	235	254	144	49	142	185	268	254	2230
1951	174	251	56	49	44	141	48	49	126	279	277	265	1760
1952	266	210	259	260	244	263	150	92	179	282	280	266	2751
1953	268	253	97	49	214	116	143	69	173	281	278	266	2208
1954	267	253	260	260	236	218	163	69	125	282	279	266	2677
1955	244	242	260	260	189	153	48	110	176	49	49	182	1960
1956	191	189	259	259	167	92	152	118	179	255	280	267	2406
1957	269	253	196	260	236	175	160	69	179	155	275	261	2488
1958	264	252	149	49	124	161	122	92	179	282	280	266	2220
1959	268	253	134	119	145	158	107	122	179	239	209	195	2126
1960	174	107	49	185	226	238	48	49	103	200	196	168	1742
1961	178	234	250	184	234	107	48	49	94	142	116	192	1828
1962	161	197	259	159	235	262	118	69	136	278	176	259	2309
1963	265	252	259	260	235	161	152	118	179	283	280	267	2710
1964	269	253	260	260	159	124	48	49	106	104	145	228	2006
1965	108	251	259	259	192	129	155	102	179	122	276	263	2294
1966	265	252	184	185	235	142	67	69	125	279	273	229	2306
1967	182	252	259	185	235	263	152	49	179	281	278	266	2580
1968	267	253	118	104	128	148	133	69	122	221	194	239	1997
1969	195	240	184	185	218	248	89	92	179	281	278	266	2454
1970	267	220	88	49	128	136	128	49	115	145	238	261	1826
1971	199	252	259	259	56	263	163	69	179	263	278	266	2506
1972	266	253	260	260	232	216	48	103	67	167	158	259	2287
1973	259	252	259	184	79	160	168	92	153	280	278	266	2430
1974	266	253	260	185	236	256	152	49	163	281	279	266	2646
1975	267	253	260	260	236	225	175	92	179	282	279	266	2775
1976	268	253	185	260	152	149	48	49	48	49	78	143	1682
1977	199	99	111	137	44	49	48	49	53	4	51	85	929
1978	62	110	248	184	234	203	152	49	172	282	279	266	2241
1979	268	200	109	260	236	226	156	140	179	96	206	260	2335
1980	263	230	184	102	188	84	122	49	141	281	278	266	2189
1981	267	221	246	108	114	112	67	69	117	205	222	262	2009
1982	139	252	184	184	235	263	175	92	179	282	279	266	2531
1983	268	253	49	49	84	103	48	49	179	280	278	265	1905
1984	266	92	68	49	155	161	163	92	150	282	279	266	2024
1985	268	253	260	260	202	173	48	116	120	279	277	209	2465
1986	174	154	184	185	235	262	152	118	167	154	276	264	2325
1987	265	216	253	248	109	102	48	49	65	60	49	169	1633
1988	157	158	259	259	46	49	81	87	48	49	120	168	1483
1989	166	151	171	216	82	259	136	118	92	108	134	175	1808
1990	164	143	137	259	188	156	48	49	82	49	134	168	1577
1991	184	74	41	106	60	259	48	49	71	37	111	218	1259
1992	178	60	111	156	243	218	98	49	48	37	10	36	1243
1993	99	36	259	184	235	262	163	69	179	280	278	266	2309
Avg.	210	195	192	198	176	175	110	75	130	187	206	227	2081
Min.	37	36	41	37	15	37	36	49	36	4	8	36	811
Max.	270	253	260	260	244	263	175	140	179	283	280	267	2775

Trinity

Max Flow [EWA], Banks Export (TAF)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1922	214	177	327	468	472	465	199	224	397	441	415	351	4151
1923	280	301	269	496	205	204	174	143	301	441	441	326	3582
1924	249	139	301	256	211	18	18	76	18	18	277	185	1768
1925	130	141	185	227	314	18	172	69	184	105	25	259	1828
1926	86	108	152	299	302	93	161	110	141	378	244	224	2299
1927	115	397	322	447	457	448	204	220	270	285	411	303	3878
1928	292	360	434	455	356	442	180	138	165	200	232	292	3547
1929	185	185	212	323	205	110	42	18	69	173	38	93	1654
1930	83	69	259	263	211	429	99	100	18	391	288	220	2430
1931	68	109	147	235	178	68	18	43	78	299	309	317	1868
1932	150	92	331	358	232	181	56	126	18	367	165	214	2289
1933	126	149	148	211	288	300	42	76	18	194	18	110	1681
1934	111	32	296	287	325	66	18	18	23	233	141	193	1742
1935	176	180	188	361	242	444	204	20	250	441	401	287	3195
1936	311	162	244	449	485	465	171	147	327	441	403	302	3907
1937	144	130	236	408	472	465	204	193	18	407	419	307	3403
1938	254	397	222	509	472	465	180	201	397	411	411	396	4317
1939	411	351	434	456	161	176	22	117	223	420	425	265	3462
1940	225	146	178	366	481	465	204	187	262	441	413	317	3686
1941	234	181	442	511	472	465	180	201	283	411	411	330	4122
1942	349	102	460	523	468	429	204	224	397	238	411	374	4179
1943	325	397	447	523	393	405	180	127	303	114	411	318	3943
1944	203	99	268	341	280	334	130	132	272	441	441	350	3292
1945	221	397	321	350	472	438	124	130	312	439	441	304	3951
1946	326	269	338	508	159	341	142	158	247	441	441	395	3767
1947	246	218	323	310	231	249	107	30	181	430	339	286	2952
1948	185	192	146	270	17	216	177	197	304	441	441	323	2909
1949	253	190	230	267	168	324	109	124	269	341	189	265	2730
1950	88	79	107	269	421	254	144	146	332	441	398	287	2966
1951	297	397	229	523	472	464	126	162	281	366	441	318	4077
1952	247	279	442	523	482	465	204	224	363	296	329	427	4281
1953	411	312	440	399	193	434	143	197	384	255	411	364	3941
1954	312	212	429	445	306	437	192	195	240	375	414	393	3950
1955	293	277	318	449	122	153	87	110	191	255	43	193	2491
1956	119	190	351	389	485	465	152	201	390	355	411	403	3911
1957	378	138	389	337	416	452	160	69	243	191	388	304	3465
1958	411	335	430	451	426	426	204	224	397	223	411	427	4366
1959	411	250	344	453	254	98	107	122	238	396	441	291	3406
1960	226	122	169	351	273	274	18	109	178	368	358	271	2716
1961	78	226	250	208	294	183	42	18	80	350	270	232	2230
1962	181	178	259	159	472	421	118	49	275	441	441	375	3370
1963	411	375	316	448	431	438	180	201	270	263	411	336	4081
1964	331	397	325	445	121	153	42	106	211	441	415	315	3301
1965	169	383	333	389	472	292	204	114	196	130	432	342	3457
1966	181	397	467	508	261	444	67	134	233	400	359	322	3772
1967	242	393	329	477	430	463	180	201	397	416	411	427	4367
1968	411	354	432	447	221	443	133	116	184	311	359	315	3725
1969	217	232	262	523	472	444	204	224	363	220	411	397	3968
1970	411	342	447	367	405	425	128	121	250	259	435	386	3976
1971	283	397	438	459	17	434	169	69	301	411	411	397	3786
1972	411	119	431	446	232	427	42	103	128	283	391	256	3267
1973	220	397	317	460	461	408	168	177	192	410	401	333	3945
1974	315	397	434	523	458	429	180	194	394	330	411	427	4492
1975	358	199	376	450	470	465	201	224	334	411	411	416	4313
1976	411	373	413	370	182	175	42	76	52	210	386	258	2947
1977	163	156	127	137	47	60	42	43	83	96	227	173	1352
1978	141	96	248	282	472	203	180	199	397	126	411	359	3115
1979	212	212	430	489	351	465	167	165	250	265	385	308	3698
1980	232	244	262	523	485	465	155	158	328	220	411	356	3839
1981	280	91	301	454	227	445	142	115	217	379	356	307	3314
1982	234	397	261	523	472	465	204	224	397	411	411	427	4426
1983	411	397	472	371	201	219	180	43	231	441	441	427	3835
1984	390	207	249	347	403	204	163	150	273	354	441	394	3574
1985	335	397	433	386	202	173	42	116	222	441	411	397	3555
1986	285	295	261	455	472	465	179	147	274	411	411	345	4000
1987	239	68	138	336	222	430	18	30	64	426	406	255	2631
1988	170	124	316	324	80	34	81	87	19	175	18	56	1484
1989	57	163	171	216	68	317	136	119	237	441	416	313	2654
1990	280	154	195	435	230	156	18	43	79	18	209	111	1927
1991	54	66	74	93	61	322	42	43	18	181	18	84	1058
1992	74	72	103	156	315	218	98	18	18	154	42	176	1445
1993	175	37	294	296	468	457	192	212	397	441	409	323	3702
Avg.	243	231	301	383	316	328	131	130	227	322	345	305	3260
Min.	54	32	74	93	17	18	18	18	18	18	18	56	1058
Max.	411	397	472	523	485	465	204	224	397	441	441	427	4492

Trinity

Max Flow [EWA], Delta Inflows (TAF)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1922	815	742	1320	1240	2665	2312	1851	3481	2610	1510	1124	948	20619
1923	873	980	2221	2181	1168	1164	1841	1336	1237	1390	1141	906	16438
1924	807	692	802	920	1080	734	561	593	617	686	656	528	8675
1925	576	567	911	857	3999	1782	1663	1160	1050	883	621	799	14867
1926	697	616	662	1189	2551	984	1681	970	805	1059	721	684	12619
1927	680	1605	1279	2044	7079	3043	3228	1941	1282	1449	1126	874	25628
1928	890	1141	1101	1580	1576	6439	1960	1432	1043	1176	855	852	20044
1929	768	753	841	896	1047	871	594	641	682	735	558	543	8930
1930	583	515	1277	1467	1140	2209	926	863	691	1021	804	665	12161
1931	673	640	629	926	774	604	604	538	650	1063	726	643	8469
1932	557	507	1495	1548	1417	1159	956	1023	1012	1105	813	772	12366
1933	697	608	644	990	783	962	788	611	677	800	569	530	8658
1934	575	518	1056	1285	997	929	808	590	708	805	570	522	9361
1935	555	773	720	2174	1001	2003	3436	1865	1341	1246	1141	859	17115
1936	836	656	783	2696	4675	2349	1798	1383	1336	1285	1141	866	19804
1937	732	663	794	1033	2895	3186	1921	1644	984	1204	1144	865	17064
1938	805	1579	3796	2264	8198	10678	4950	4950	3351	1476	1139	1016	44201
1939	1324	850	1053	989	890	1106	792	923	901	1071	923	744	11566
1940	707	610	674	2427	3820	7111	4491	1569	1281	1497	1143	894	26225
1941	834	829	2774	6112	7223	6179	4817	2992	1618	1481	1124	915	36899
1942	948	794	4059	5259	8144	1997	3347	2636	2009	1309	1140	983	32625
1943	935	1053	1975	5717	3672	5741	2165	1697	1244	1217	1132	897	27444
1944	812	712	878	1042	1693	1650	1003	968	1070	1133	1037	932	12929
1945	729	1029	1186	966	3083	1909	1219	1192	1279	1407	1169	874	16043
1946	871	1055	3994	3333	1692	1546	1149	1252	1216	1410	1173	1015	19708
1947	896	790	1103	941	1201	1421	1022	789	941	1136	910	794	11943
1948	680	717	650	1092	857	1230	1870	1929	1377	1408	1168	901	13879
1949	841	706	891	815	826	3149	1040	1121	1116	1210	823	818	13357
1950	686	636	652	1400	2220	1450	1466	1366	1353	1326	1115	831	14502
1951	840	3071	6258	4565	4321	2226	1255	1541	1161	1436	1158	895	28728
1952	850	970	2598	5739	4873	4581	4421	4764	3137	1359	1062	1144	35498
1953	1329	886	2965	6634	1636	1569	1312	1806	1588	1423	1118	966	23233
1954	921	972	1058	1982	3662	3244	2639	1784	1042	1444	1122	1012	20883
1955	916	946	1453	1327	949	871	867	969	1046	883	599	664	11489
1956	673	750	5209	10905	5388	2782	1571	2754	1622	1383	1132	1030	35197
1957	993	766	1062	928	2106	3177	1515	1326	1207	1129	1103	869	16180
1958	1135	937	1465	2470	10237	6250	6204	3572	2459	1271	1135	1117	38252
1959	1119	843	906	2327	3285	1585	865	982	1188	1363	1092	745	16300
1960	783	648	623	914	1897	1460	832	957	902	1183	1016	739	11954
1961	676	808	1089	841	1719	1160	784	805	806	1102	791	711	11291
1962	803	685	1111	705	3108	1949	1010	1075	1173	1410	1061	973	15063
1963	2232	966	1811	1116	4472	2173	5589	2324	1346	1449	1132	925	25536
1964	922	1411	928	1585	959	882	874	922	944	1134	986	833	12380
1965	708	970	5165	7574	2299	1615	3165	1777	1069	1166	1128	929	27564
1966	792	1531	1362	2232	1735	2010	1037	1115	1051	1340	1079	845	16129
1967	882	1004	2188	3118	3360	4026	3572	3836	3277	1480	1143	1281	29167
1968	1321	938	1152	2008	3836	2513	1191	907	1010	1227	944	855	17902
1969	836	819	1618	7435	7824	4370	3876	4531	2863	1288	1153	1018	37632
1970	1321	895	3761	12985	5137	2774	1279	1088	1043	1425	1124	993	33824
1971	817	1213	3898	3330	1531	3199	1627	1996	1370	1659	1133	1018	22792
1972	1039	900	1217	1101	1459	2149	881	895	1115	1131	990	790	13668
1973	831	1259	1605	5390	5359	4039	1469	1464	1242	1466	1122	920	26167
1974	897	3388	4453	8267	2660	7213	4552	1901	1590	1373	1140	1164	38599
1975	961	800	1152	1091	4038	5896	1879	2156	1725	1453	1119	1048	23319
1976	1208	965	1111	969	907	1094	725	590	628	1002	779	680	10658
1977	687	604	544	593	514	561	653	481	705	737	644	531	7255
1978	561	513	1061	4315	3398	4569	2883	1954	1690	1197	1149	959	24250
1979	842	772	1050	1726	2648	2542	1457	1327	1360	1038	1025	872	16659
1980	846	890	1334	6590	7913	3994	1607	1500	1341	1250	1123	955	29344
1981	894	681	1010	1544	1684	2016	1298	904	953	1183	1018	873	14058
1982	784	1943	5444	5021	6041	5790	8592	3647	1985	1459	1161	1247	43116
1983	1829	2827	5627	6615	9982	15546	5470	4961	5373	2446	1357	1866	63899
1984	1819	4962	9740	4455	2658	2605	1406	1167	1208	1683	1163	1014	33879
1985	925	1643	1425	994	1033	1076	960	1035	976	1310	1151	931	13458
1986	844	797	1173	1560	11168	9586	1899	1373	1259	1337	1201	936	33133
1987	848	647	776	998	1266	1706	845	687	861	1060	865	725	11284
1988	748	594	1211	1869	795	638	705	720	719	769	553	514	9835
1989	584	672	728	884	596	3080	1368	1068	941	1170	1016	748	12856
1990	864	625	721	1281	1040	951	766	520	666	697	763	571	9464
1991	564	508	510	487	546	2203	951	690	534	760	590	608	8950
1992	556	508	490	726	2139	1419	907	609	714	715	518	513	9814
1993	557	496	999	4088	3555	2869	2635	2222	1785	1508	1146	903	22762
Avg.	874	1005	1823	2732	3112	2942	1991	1613	1335	1233	993	867	20522
Min.	555	496	490	487	514	561	561	481	534	686	518	513	7255
Max.	2232	4962	9740	12985	11168	15546	8592	4961	5373	2446	1357	1866	63899

Trinity

Max Flow [EWA], Total Delta Outflow (TAF)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1922	246	268	724	608	2128	1588	1415	3019	1771	492	246	211	12716
1923	246	385	1920	1601	734	681	1589	996	578	400	246	218	9595
1924	246	369	277	408	644	620	381	253	308	418	194	179	4296
1925	229	296	551	438	3599	1672	1303	941	498	307	222	185	10241
1926	307	268	300	659	2126	586	1345	651	304	307	232	179	7265
1927	309	937	632	1469	6783	2385	2802	1433	578	591	246	193	18357
1928	269	477	380	904	965	5770	1537	1010	428	492	246	179	12658
1929	290	321	396	332	628	649	410	400	359	246	286	179	4495
1930	223	320	790	1090	750	1520	644	582	363	307	219	179	6987
1931	304	282	288	499	425	378	406	282	301	421	187	179	3951
1932	279	280	1027	989	1053	772	698	672	607	307	335	179	7197
1933	246	314	400	810	426	593	598	354	359	246	315	179	4838
1934	197	364	472	764	708	701	595	346	410	246	225	179	5207
1935	253	360	318	1679	633	1349	3072	1644	615	400	246	179	10748
1936	305	318	281	2074	4274	1694	1404	1036	616	400	246	179	12825
1937	288	313	310	429	2347	2780	1567	1186	571	400	246	179	10615
1938	246	878	3527	1774	7998	10233	4653	4539	2494	492	246	235	37315
1939	562	268	503	491	604	809	594	563	350	307	215	179	5444
1940	328	268	292	1973	3359	6426	4034	1081	540	492	246	199	19238
1941	246	399	2148	5556	6679	5455	4494	2543	894	492	253	199	29358
1942	246	378	3343	4661	7520	1372	2986	2199	1155	492	246	225	24821
1943	246	357	1232	5168	3149	5284	1766	1357	547	533	246	188	20070
1944	246	335	304	453	1285	1008	710	592	443	307	215	194	6092
1945	355	339	594	444	2445	1270	861	862	543	400	246	179	8538
1946	247	474	3442	2574	1406	959	753	800	520	400	246	230	12050
1947	288	319	477	369	746	903	687	519	389	307	215	179	5397
1948	355	268	296	554	645	779	1512	1578	656	400	246	199	7488
1949	309	308	392	303	493	2607	775	784	446	307	307	179	7212
1950	281	305	390	1018	1577	905	1081	998	610	400	246	183	7993
1951	297	2404	6086	4111	3831	1581	999	1190	487	500	246	192	21924
1952	255	432	1965	5252	4149	3909	4013	4286	2356	492	246	326	27681
1953	547	268	2473	6259	1194	961	959	1411	800	565	246	216	15898
1954	246	446	301	1285	3115	2583	2203	1354	418	492	246	236	12925
1955	280	375	860	733	633	508	682	613	421	307	304	179	5895
1956	271	314	4784	10532	4730	2155	1205	2300	777	492	246	256	28062
1957	265	302	404	338	1474	2513	1121	1099	516	492	246	193	8963
1958	391	280	842	2119	9969	5787	5929	3126	1640	492	246	303	31125
1959	339	268	359	1782	2954	1258	527	557	485	425	246	195	9395
1960	285	347	343	412	1450	899	678	651	334	307	257	179	6142
1961	324	319	530	530	1175	851	605	592	344	312	215	179	5976
1962	366	268	533	392	2643	1231	662	789	476	400	246	221	8227
1963	1529	271	1210	524	3866	1604	5320	1884	639	629	246	212	17935
1964	246	717	277	954	644	540	670	597	400	307	235	179	5764
1965	356	290	4634	7042	1610	1143	2768	1400	446	639	246	213	20787
1966	246	851	715	1595	1246	1357	779	730	424	400	246	179	8766
1967	359	336	1629	2784	2673	3342	3287	3438	2469	492	246	470	21526
1968	545	268	539	1513	3498	1901	820	555	418	400	246	179	10880
1969	335	299	1148	7027	7347	3633	3501	4041	2071	492	246	230	30371
1970	566	268	3210	12842	4603	2158	917	727	411	723	246	220	26890
1971	246	565	3310	2639	1430	2463	1207	1733	629	697	246	232	15396
1972	267	463	494	404	977	1414	687	494	643	400	246	179	6666
1973	299	657	1039	5077	4991	3482	1030	1004	602	492	246	204	19121
1974	246	2728	3815	7645	1939	6539	4166	1493	763	498	246	342	30419
1975	246	281	464	378	3408	5273	1437	1672	930	492	246	238	15065
1976	462	268	439	324	542	671	532	251	262	470	184	179	4584
1977	230	292	248	320	385	377	422	273	307	354	184	179	3572
1978	266	255	551	4155	2790	4259	2511	1541	852	492	246	210	18127
1979	246	309	438	1110	2199	1823	1055	857	641	400	246	179	9502
1980	276	357	884	6128	7449	3418	1252	1151	621	492	246	219	22493
1981	246	298	405	1024	1325	1469	990	547	323	307	241	193	7369
1982	338	1276	5022	4588	5364	5242	8210	3167	1166	492	279	476	35619
1983	1082	2236	5145	6478	9893	15520	5245	4728	4693	1450	442	1067	57979
1984	1069	4660	9533	4055	2100	2181	984	738	513	757	246	223	27059
1985	252	1011	717	369	618	748	764	612	348	307	275	224	6245
1986	295	315	716	1005	10789	8928	1492	950	546	492	311	232	26071
1987	246	292	322	416	954	1174	656	414	460	307	215	179	5635
1988	337	268	613	1369	643	484	450	394	410	246	223	179	5616
1989	265	307	341	453	436	2498	970	645	343	307	259	190	7016
1990	341	268	319	610	633	565	586	343	238	339	231	179	4649
1991	237	301	335	277	397	1646	758	454	238	251	276	179	5348
1992	229	309	215	420	1698	981	610	353	399	246	268	179	5908
1993	202	357	468	3997	3046	2156	2188	1819	982	492	246	179	16131
Avg.	336	530	1315	2241	2680	2430	1674	1253	715	437	249	221	14080
Min.	197	255	215	277	385	377	381	251	238	246	184	179	3572
Max.	1529	4660	9533	12842	10789	15520	8210	4728	4693	1450	442	1067	57979

Trinity

Max Flow [EWA], CVP Delivery North of Delta (TAF)
(sum of CALSIM variables D300, D8, D9, D302, D167A_IMI, D167B_IMI, D162_IMI, D168B, D168C_FRWP, and Del_CVP_Total_N)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1922	95	40	33	29	28	28	398	458	556	566	505	273	3009
1923	58	40	33	29	28	92	262	457	505	539	481	180	2704
1924	91	47	32	27	26	55	314	350	372	95	84	62	1555
1925	33	29	24	20	20	24	246	345	511	559	497	232	2540
1926	100	39	32	27	26	53	157	382	499	503	441	218	2477
1927	56	36	29	24	23	31	336	462	531	577	512	273	2891
1928	65	40	34	29	28	24	270	443	517	527	471	256	2703
1929	103	39	32	27	26	35	330	426	394	469	420	228	2528
1930	94	51	29	24	23	21	237	377	493	497	443	212	2500
1931	91	36	29	24	23	68	327	308	353	400	89	53	1802
1932	30	31	25	22	21	41	290	315	397	414	164	199	1950
1933	87	39	28	25	24	47	323	325	388	392	341	170	2190
1934	59	44	26	23	22	34	293	347	395	415	89	53	1798
1935	33	32	26	23	22	22	139	420	541	545	488	260	2551
1936	69	42	32	27	26	30	282	412	466	533	479	253	2651
1937	105	56	32	27	26	22	264	438	472	515	461	252	2671
1938	70	39	32	27	26	26	252	440	572	578	512	235	2808
1939	71	44	34	29	51	107	400	362	460	461	416	191	2624
1940	76	49	29	24	23	25	291	396	563	574	508	266	2824
1941	66	40	33	29	28	26	146	342	559	587	519	276	2650
1942	68	40	34	29	28	26	153	384	573	587	519	272	2712
1943	105	40	34	29	28	26	258	466	547	565	507	272	2876
1944	106	43	33	29	28	36	304	377	482	511	458	249	2656
1945	75	37	30	25	25	24	331	392	508	560	501	270	2779
1946	45	40	33	28	27	34	404	450	529	526	478	254	2848
1947	101	40	33	29	28	25	324	422	449	519	462	253	2684
1948	45	37	30	25	35	47	130	298	481	577	508	246	2460
1949	86	41	32	27	27	23	314	390	516	521	465	251	2696
1950	109	39	32	27	26	31	331	427	486	498	445	225	2676
1951	45	38	31	26	25	37	378	382	536	543	485	263	2789
1952	53	40	33	28	27	26	314	471	516	571	510	268	2855
1953	117	40	34	29	28	54	293	436	523	564	467	271	2855
1954	100	40	33	29	28	23	245	458	544	569	458	265	2791
1955	106	39	32	27	26	68	297	418	483	487	437	207	2625
1956	88	37	30	25	24	67	362	397	544	576	510	246	2907
1957	69	56	34	29	28	49	331	389	543	550	492	147	2715
1958	49	45	32	27	26	26	157	376	526	565	511	269	2608
1959	110	55	34	29	28	44	406	471	517	521	459	130	2803
1960	107	54	31	26	25	22	294	365	472	476	427	230	2529
1961	93	36	29	24	23	22	295	409	481	507	449	225	2591
1962	99	37	30	25	24	23	348	442	505	529	469	249	2781
1963	42	37	31	26	25	25	149	400	568	585	517	273	2677
1964	63	40	33	29	28	77	400	418	442	475	422	211	2638
1965	58	37	30	25	24	59	243	452	527	535	414	261	2666
1966	111	39	32	27	26	42	384	452	502	506	453	244	2820
1967	106	38	31	26	25	26	136	445	477	583	515	272	2680
1968	109	40	34	29	28	23	338	445	491	535	431	260	2761
1969	74	37	31	26	25	27	333	491	542	562	504	267	2919
1970	79	42	33	29	28	24	358	448	469	508	455	246	2719
1971	71	37	30	25	25	48	420	388	515	534	477	253	2823
1972	105	40	33	28	30	115	382	425	478	502	449	197	2785
1973	47	37	30	25	25	25	329	459	542	546	489	253	2808
1974	56	40	33	28	27	26	265	476	560	499	513	275	2797
1975	71	41	34	29	28	26	288	483	571	563	501	274	2907
1976	48	44	33	29	52	141	329	415	445	454	362	196	2550
1977	92	38	28	23	34	88	350	261	388	393	70	123	1887
1978	35	29	24	20	20	26	202	457	571	580	512	224	2701
1979	121	40	34	29	28	24	287	447	533	537	475	248	2803
1980	50	39	32	27	26	25	298	432	520	547	498	265	2761
1981	102	50	33	28	27	22	268	406	533	537	481	233	2722
1982	46	37	30	25	24	26	179	465	521	589	521	182	2646
1983	45	40	34	29	28	26	158	420	549	584	499	230	2641
1984	98	40	34	29	28	49	408	489	524	544	463	258	2964
1985	60	39	32	27	26	23	338	465	525	537	476	190	2736
1986	82	38	31	26	25	24	276	432	536	540	484	200	2693
1987	106	51	32	27	27	23	334	431	480	483	433	234	2662
1988	82	36	29	24	24	76	291	347	432	472	422	228	2463
1989	96	34	28	23	29	24	324	477	509	541	478	85	2647
1990	56	39	32	27	26	53	383	262	473	479	412	224	2464
1991	93	41	29	24	28	21	213	323	394	415	369	144	2093
1992	50	23	27	23	22	20	218	359	381	426	157	117	1824
1993	35	29	26	23	22	25	312	345	493	579	506	274	2668
Avg.	77	40	31	26	27	39	292	409	497	517	440	224	2619
Min.	30	23	24	20	20	20	130	261	353	95	70	53	1555
Max.	121	56	34	29	52	141	420	491	573	589	521	276	3009

Trinity

Max Flow [EWA], CVP Delivery So w/ CVC (TAF)
(equals CALSIM variable CVPTotalDel)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1922	204	123	107	137	166	156	195	310	448	551	463	279	3137
1923	193	116	97	119	144	143	170	242	349	414	359	236	2583
1924	173	99	75	84	105	75	83	120	155	161	158	131	1418
1925	110	59	34	25	35	132	155	233	339	400	348	232	2103
1926	171	98	73	81	101	95	106	144	200	209	203	169	1649
1927	143	76	43	33	46	161	195	316	470	581	486	288	2837
1928	198	119	101	126	153	132	163	246	352	419	362	238	2609
1929	173	100	76	85	106	92	102	142	191	197	194	165	1625
1930	141	75	41	30	42	92	112	157	215	230	219	177	1531
1931	146	79	47	38	52	75	83	120	155	161	158	131	1243
1932	110	59	34	25	35	87	98	136	190	209	194	147	1326
1933	117	65	42	38	49	75	83	114	155	161	158	131	1189
1934	110	59	34	25	35	86	97	141	188	207	192	146	1321
1935	117	65	42	37	48	92	113	216	299	345	307	214	1895
1936	163	92	65	67	85	141	167	244	343	406	353	233	2359
1937	172	98	74	82	103	92	135	196	266	300	273	200	1990
1938	157	88	59	56	72	153	194	288	412	501	426	266	2672
1939	186	110	89	107	130	96	102	149	203	213	206	171	1763
1940	143	77	44	34	47	145	177	293	428	524	443	270	2625
1941	190	113	93	112	137	150	183	299	429	525	444	273	2949
1942	190	113	93	113	137	162	195	306	441	541	456	278	3027
1943	192	115	96	117	142	154	195	301	432	529	447	275	2994
1944	191	114	94	114	138	122	135	197	279	318	286	206	2193
1945	160	90	61	61	77	134	185	269	382	460	394	252	2524
1946	180	105	83	96	118	149	177	293	426	521	440	272	2860
1947	189	113	93	112	136	104	141	200	281	321	289	207	2187
1948	160	90	62	61	78	92	111	250	360	430	371	241	2308
1949	175	101	78	88	110	111	163	230	333	392	342	229	2350
1950	170	97	72	79	98	95	120	169	233	255	238	185	1810
1951	150	82	51	44	59	155	180	264	384	463	396	252	2480
1952	180	105	83	97	119	156	191	310	448	551	463	281	2985
1953	193	116	97	119	144	147	186	287	417	508	431	268	2913
1954	187	111	91	109	132	149	195	294	431	527	445	274	2945
1955	190	113	94	113	138	113	129	185	253	282	259	194	2063
1956	154	85	56	51	67	162	189	319	465	574	481	289	2891
1957	197	118	100	125	151	132	156	233	330	388	339	228	2498
1958	169	97	71	78	97	159	195	310	448	551	463	281	2919
1959	193	116	97	119	144	157	180	269	389	470	401	255	2790
1960	181	106	84	99	121	92	102	143	191	197	194	165	1677
1961	141	75	41	30	42	111	139	202	276	314	283	205	1860
1962	159	89	61	60	76	130	174	244	358	427	369	240	2387
1963	175	101	77	88	109	158	194	317	467	577	483	287	3030
1964	197	118	101	125	152	108	122	172	237	260	242	187	2022
1965	151	83	52	46	61	129	150	242	349	414	359	236	2271
1966	173	99	75	84	105	155	178	265	383	462	395	252	2626
1967	180	105	83	97	119	146	179	285	407	494	420	263	2777
1968	185	109	88	105	128	147	168	252	361	432	372	242	2589
1969	176	101	78	89	110	144	181	285	407	494	420	263	2747
1970	185	109	88	105	128	135	154	227	323	379	333	225	2392
1971	168	96	70	76	95	151	183	279	405	491	418	262	2693
1972	185	109	88	104	127	127	148	215	296	342	304	213	2257
1973	163	92	65	66	84	159	194	283	405	491	418	262	2683
1974	185	109	88	104	127	162	195	297	426	521	440	272	2926
1975	189	113	93	112	136	160	195	306	441	542	456	279	3021
1976	192	115	96	117	142	92	102	143	191	197	194	165	1747
1977	141	75	41	30	42	75	83	118	155	161	116	83	1119
1978	61	59	34	25	35	161	195	302	434	532	449	273	2561
1979	191	114	94	115	139	125	154	224	311	361	319	219	2365
1980	166	94	67	71	90	153	195	290	416	506	429	267	2743
1981	187	111	90	108	132	123	157	230	331	389	340	228	2425
1982	169	97	71	78	98	147	184	304	438	538	453	277	2854
1983	192	114	95	116	141	148	186	277	395	477	407	257	2804
1984	183	107	85	100	123	160	189	298	439	539	454	278	2956
1985	192	115	95	116	141	143	179	264	383	462	387	260	2738
1986	180	105	83	97	119	131	172	253	358	427	369	240	2534
1987	175	101	77	87	109	101	132	186	260	291	266	197	1982
1988	156	87	57	54	70	92	102	148	191	197	194	165	1513
1989	141	75	41	30	42	92	146	213	293	337	301	212	1924
1990	162	92	64	65	83	92	102	148	191	197	194	165	1557
1991	141	75	41	30	42	78	87	126	165	174	168	135	1261
1992	112	61	36	29	39	82	103	149	202	225	207	152	1398
1993	120	67	45	42	54	140	176	278	397	481	410	259	2469
Avg.	167	96	72	80	99	126	153	233	331	391	340	226	2312
Min.	61	59	34	25	35	75	83	114	155	161	116	83	1119
Max.	204	123	107	137	166	162	195	319	470	581	486	289	3137

Trinity

Max Flow [EWA], X2_PRV (KM)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	
1922	74.9	83.2	85.0	78.2	77.3	66.7	66.2	66.7	61.2	63.3	74.1	82.9	
1923	86.7	87.0	83.5	70.2	67.3	71.5	74.3	68.4	70.3	74.9	79.4	84.7	
1924	87.0	87.2	83.8	85.2	82.7	77.8	77.0	80.3	84.7	84.4	82.2	87.4	
1925	89.5	88.5	86.0	80.6	80.6	63.7	64.8	66.8	70.2	76.0	81.8	86.2	
1926	88.8	86.0	85.9	85.3	79.0	67.2	74.0	69.6	74.0	81.0	83.5	86.4	
1927	89.2	86.1	76.3	76.4	70.0	55.4	59.4	59.2	64.5	73.0	75.8	83.5	
1928	87.6	86.6	81.7	82.1	75.5	72.4	58.2	63.4	68.6	76.6	78.4	84.3	
1929	88.5	86.4	84.6	82.7	83.4	78.0	76.8	79.6	81.0	82.0	85.5	85.5	
1930	88.9	88.5	85.4	77.7	72.7	73.1	68.6	73.5	76.1	80.3	83.2	86.8	
1931	89.3	86.3	85.6	85.5	81.2	80.3	81.6	81.3	84.2	84.4	82.2	87.7	
1932	89.6	87.0	85.9	75.8	72.8	70.8	73.1	74.3	75.3	76.1	81.9	83.1	
1933	88.1	87.5	85.2	82.8	76.6	78.8	77.7	77.0	81.1	82.0	85.5	84.8	
1934	88.6	89.4	84.7	81.4	76.6	74.9	75.1	76.2	81.0	81.0	85.2	87.2	
1935	89.4	87.7	84.2	84.3	71.5	74.0	69.8	61.9	64.4	72.4	78.7	84.4	
1936	88.5	86.0	84.6	85.3	70.3	59.3	63.3	65.8	69.2	74.0	79.2	84.6	
1937	88.6	86.4	84.9	84.7	82.1	67.5	62.2	64.6	67.7	74.1	79.2	84.6	
1938	88.6	87.7	77.3	63.6	64.3	52.2	47.2	51.3	53.1	58.0	72.3	82.3	
1939	85.7	80.4	84.1	80.7	79.8	77.1	74.8	76.1	77.2	81.0	83.5	87.0	
1940	89.3	85.7	85.8	85.4	70.7	61.2	53.7	54.5	65.2	73.7	77.5	84.0	
1941	87.5	87.3	83.3	69.3	57.4	51.4	51.7	53.1	58.1	67.5	75.4	83.1	
1942	87.2	87.2	83.7	66.0	57.7	50.5	62.0	59.6	61.4	66.6	75.2	83.3	
1943	86.4	86.9	84.0	73.8	59.5	57.8	54.1	61.0	65.5	73.7	76.9	83.8	
1944	87.9	87.4	84.7	84.8	81.7	72.2	71.5	73.7	76.0	78.8	82.7	86.8	
1945	88.6	84.9	83.7	79.3	80.1	66.5	67.8	71.0	72.3	76.0	79.8	84.8	
1946	88.6	87.7	82.1	65.3	62.0	64.8	69.4	72.6	73.4	76.7	80.0	84.9	
1947	86.7	85.8	84.5	81.3	82.1	76.3	73.7	74.6	77.4	80.2	83.2	86.9	
1948	89.3	85.1	85.6	85.3	80.4	77.1	75.0	69.1	67.0	72.8	78.8	84.4	
1949	87.7	85.6	84.7	82.8	84.2	80.1	66.8	71.5	73.2	77.8	82.4	83.9	
1950	88.3	86.6	85.1	83.0	74.9	68.2	71.0	70.3	70.9	74.7	79.4	84.6	
1951	88.4	86.2	69.1	56.7	55.6	55.0	62.4	68.1	68.9	75.7	78.0	84.2	
1952	87.9	87.1	82.6	69.8	58.0	55.5	55.6	55.2	54.8	59.0	72.7	82.4	
1953	83.2	79.8	83.9	68.4	56.2	64.2	69.2	70.6	68.4	71.7	75.8	83.5	
1954	86.7	87.1	82.3	84.1	73.5	62.5	61.1	61.6	65.7	75.9	78.2	84.3	
1955	86.3	85.9	83.3	76.3	75.3	75.3	77.7	76.0	76.5	79.3	82.9	84.2	
1956	88.4	86.9	85.0	63.7	50.7	52.1	59.1	65.5	63.0	70.2	76.3	83.6	
1957	85.5	86.1	85.0	82.7	83.3	71.4	64.2	67.8	69.4	75.4	78.0	84.2	
1958	87.8	83.9	84.9	77.0	67.4	51.5	51.3	50.8	55.8	62.1	73.7	82.8	
1959	83.9	83.7	85.1	83.6	70.9	62.0	66.4	74.3	76.7	78.3	80.1	84.9	
1960	88.0	86.3	84.0	83.6	82.1	71.4	72.1	74.2	75.5	80.8	83.4	85.6	
1961	88.9	85.6	84.4	80.4	79.1	71.8	72.6	75.3	76.6	80.9	83.3	87.0	
1962	89.3	84.9	85.5	80.7	81.5	66.4	68.0	73.1	73.6	77.5	80.3	84.9	
1963	87.0	73.1	81.6	73.2	76.8	61.9	64.5	56.0	61.4	71.2	74.8	83.1	
1964	86.8	87.1	78.7	83.5	75.6	75.5	77.4	76.0	76.8	79.8	83.1	86.2	
1965	89.1	85.0	85.0	64.0	53.9	61.1	66.9	61.7	65.5	75.3	76.0	83.5	
1966	86.9	87.1	77.4	75.8	69.1	68.1	67.8	71.8	73.8	78.4	80.6	85.0	
1967	88.7	84.8	83.8	71.6	63.5	60.4	58.4	57.6	57.3	59.5	72.8	82.5	
1968	80.5	78.9	83.6	80.0	70.9	61.0	62.9	69.8	75.3	79.0	80.8	85.1	
1969	88.7	85.3	84.8	74.6	57.4	50.6	54.6	55.9	55.5	60.2	73.1	82.6	
1970	85.9	80.4	84.1	66.5	50.1	51.8	59.0	67.6	72.5	78.2	76.0	83.5	
1971	86.6	87.0	80.5	65.1	61.8	64.6	62.1	66.5	65.5	72.6	74.5	83.0	
1972	86.0	86.2	81.8	80.1	81.1	74.1	69.5	73.3	77.3	76.4	79.9	84.8	
1973	88.6	86.2	79.1	73.5	59.5	54.3	56.1	65.8	69.4	74.3	77.7	84.1	
1974	87.4	87.3	68.5	60.1	52.0	59.1	52.8	54.0	62.5	70.2	76.2	83.6	
1975	83.3	85.9	85.5	81.8	82.1	64.6	56.3	63.3	64.7	69.4	76.1	83.6	
1976	86.0	82.0	84.6	81.9	83.4	79.4	77.0	77.7	83.9	85.4	81.7	87.6	
1977	89.5	88.5	86.1	86.8	85.1	82.3	82.3	81.2	84.4	84.4	83.5	88.2	
1978	89.7	87.5	86.8	80.9	63.5	60.0	56.4	59.1	63.9	69.8	76.2	83.6	
1979	87.0	87.1	85.2	82.1	74.0	65.3	64.7	68.4	71.5	74.5	79.3	84.6	
1980	88.6	86.8	84.0	76.3	59.0	51.3	55.3	64.0	67.8	73.5	77.4	84.0	
1981	86.8	87.1	85.5	82.8	74.8	69.5	67.7	69.9	75.4	81.0	83.5	86.1	
1982	88.5	85.2	73.7	59.7	55.7	52.5	52.4	48.7	55.0	64.5	74.4	82.1	
1983	80.2	73.6	65.6	56.8	52.2	46.6	42.1	48.7	51.9	52.8	62.3	74.6	
1984	71.6	70.8	59.0	49.9	53.5	59.2	61.3	67.8	72.4	76.5	75.1	83.2	
1985	86.4	86.8	76.0	75.3	80.2	77.1	75.4	74.4	76.0	80.6	83.3	85.1	
1986	87.0	85.7	84.6	78.2	73.5	52.9	48.4	60.4	68.1	74.6	77.8	82.3	
1987	85.8	86.7	85.5	84.6	82.3	74.4	71.0	74.1	78.9	79.5	83.0	86.8	
1988	89.3	85.5	85.7	79.7	71.6	74.2	77.8	79.2	81.0	81.0	85.2	87.3	
1989	89.4	87.4	85.3	84.1	81.5	80.2	67.1	69.9	74.1	80.1	83.2	85.5	
1990	88.4	85.1	85.6	84.7	79.4	76.6	77.4	77.1	81.3	85.3	84.1	86.7	
1991	89.2	88.2	85.7	84.4	85.4	82.2	71.0	73.0	77.9	84.1	86.1	85.9	
1992	89.0	88.3	85.6	87.7	83.3	70.6	71.2	74.7	80.3	81.0	85.2	85.9	
1993	89.0	89.3	84.8	81.5	64.0	59.5	61.5	61.8	63.5	68.6	75.8	83.5	
Avg.	87.2	85.5	82.7	77.1	71.4	66.2	65.7	67.6	70.5	75.0	79.2	84.6	
Min.	71.6	70.8	59.0	49.9	50.1	46.6	42.1	48.7	51.9	52.8	62.3	74.6	
Max.	89.7	89.4	86.8	87.7	85.4	82.3	82.3	81.3	84.7	85.4	86.1	88.2	

Cumulative

Trinity

Cumulative [EWA], Trinity Storage (TAF)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1922	1782	1715	1714	1711	1725	1775	1874	1937	1947	1835	1682	1533
1923	1479	1450	1453	1470	1493	1551	1665	1588	1444	1251	1086	1003
1924	979	969	962	914	956	940	881	796	665	547	494	367
1925	360	436	484	435	706	847	1144	1130	1078	961	832	761
1926	735	729	748	749	899	1001	1220	1124	1060	908	755	671
1927	660	821	1016	1134	1372	1550	1778	1768	1798	1676	1563	1422
1928	1362	1406	1424	1480	1590	1797	1943	1880	1750	1597	1410	1295
1929	1232	1208	1199	1166	1190	1248	1267	1309	1255	1081	944	856
1930	805	788	916	932	1031	1156	1256	1168	1098	978	864	781
1931	749	735	723	732	756	814	856	804	715	574	500	400
1932	352	329	330	342	364	516	606	629	641	553	444	391
1933	362	356	351	349	350	467	620	608	702	611	535	498
1934	480	473	482	543	633	769	797	770	649	526	401	269
1935	240	305	342	383	467	528	742	779	784	676	636	597
1936	583	578	581	695	835	946	1107	1037	993	887	787	705
1937	672	661	652	643	647	752	978	1121	1219	1115	1016	934
1938	910	1051	1270	1361	1518	1779	2087	2262	2205	2177	2061	1975
1939	1850	1848	1831	1752	1731	1837	1913	1851	1693	1462	1229	1059
1940	1027	1011	1074	1249	1575	1877	2104	2041	1925	1745	1593	1424
1941	1368	1349	1488	1708	1958	2100	2300	2420	2447	2270	2150	1975
1942	1850	1844	1850	1900	2000	1975	2176	2236	2306	2270	2150	1975
1943	1850	1850	1850	1900	2000	2100	2281	2172	2101	1957	1838	1693
1944	1636	1616	1610	1600	1643	1711	1748	1803	1754	1564	1384	1269
1945	1191	1217	1283	1327	1487	1541	1675	1639	1547	1404	1271	1157
1946	1145	1194	1385	1516	1571	1696	1911	1905	1811	1650	1478	1366
1947	1305	1299	1311	1303	1355	1465	1550	1459	1430	1254	1088	960
1948	973	984	985	1178	1200	1234	1416	1410	1446	1320	1209	1180
1949	1156	1164	1164	1157	1195	1411	1670	1678	1594	1450	1319	1206
1950	1145	1136	1124	1151	1207	1329	1483	1488	1470	1348	1213	1101
1951	1195	1310	1568	1658	1879	1982	2161	2093	1931	1783	1636	1491
1952	1438	1444	1591	1650	1840	2006	2300	2412	2447	2270	2150	1975
1953	1850	1845	1850	1900	1933	2054	2261	2220	2313	2270	2150	1975
1954	1850	1842	1838	1900	2000	2100	2300	2272	2125	1989	1802	1665
1955	1608	1629	1685	1710	1699	1725	1768	1766	1752	1534	1374	1264
1956	1202	1186	1494	1828	1965	2077	2268	2370	2289	2172	2059	1975
1957	1850	1843	1802	1783	1944	2100	2166	2183	2160	2016	1821	1683
1958	1774	1850	1850	1900	2059	2100	2300	2420	2430	2270	2150	1975
1959	1850	1841	1804	1900	2000	1992	2122	2022	1922	1691	1494	1278
1960	1201	1162	1148	1156	1298	1477	1594	1539	1514	1352	1189	1105
1961	1077	1080	1170	1201	1424	1552	1696	1666	1662	1524	1394	1281
1962	1218	1197	1229	1233	1368	1444	1660	1582	1521	1380	1257	1145
1963	1235	1287	1460	1501	1796	1875	2142	2182	2124	1980	1857	1711
1964	1672	1790	1824	1872	1854	1889	1890	1787	1731	1532	1370	1264
1965	1196	1226	1762	1900	1969	1953	2188	2102	2036	1902	1767	1630
1966	1570	1658	1698	1781	1849	2056	2300	2312	2245	2034	1814	1649
1967	1561	1643	1786	1900	2000	2100	2211	2333	2434	2270	2150	1975
1968	1850	1850	1828	1834	2000	2081	2154	2046	1933	1731	1554	1385
1969	1329	1325	1384	1528	1653	1815	2151	2411	2339	2216	2099	1975
1970	1850	1850	1850	1900	2000	2067	2114	2022	1920	1723	1566	1389
1971	1330	1436	1567	1801	1926	2100	2282	2332	2345	2270	2150	1975
1972	1850	1842	1832	1878	1989	2100	2240	2178	2052	1905	1699	1552
1973	1472	1482	1585	1745	1900	2025	2222	2287	2237	2100	1888	1747
1974	1719	1850	1850	1900	2000	2100	2300	2400	2394	2270	2150	1975
1975	1850	1849	1835	1821	1918	2100	2231	2344	2447	2270	2150	1975
1976	1850	1850	1834	1689	1703	1755	1841	1824	1746	1528	1374	1262
1977	1198	1186	1167	1157	1133	1111	973	923	794	618	509	483
1978	375	405	605	1006	1191	1477	1678	1695	1650	1567	1457	1373
1979	1312	1309	1299	1322	1375	1524	1646	1724	1692	1554	1401	1289
1980	1257	1292	1347	1576	1878	2015	2184	2097	1965	1843	1693	1549
1981	1485	1448	1478	1585	1725	1851	1961	1892	1832	1682	1493	1372
1982	1300	1521	1850	1900	2000	2100	2300	2311	2179	2063	1948	1863
1983	1850	1850	1850	1900	2000	2100	2300	2420	2447	2270	2150	1975
1984	1850	1850	1850	1900	1992	2100	2215	2178	2050	1916	1772	1631
1985	1574	1702	1756	1730	1740	1780	1926	1846	1717	1490	1260	1077
1986	1051	1039	1050	1178	1662	2004	2079	1973	1860	1668	1499	1391
1987	1336	1301	1288	1298	1383	1596	1739	1653	1458	1234	1005	873
1988	837	822	992	1070	1150	1223	1288	1237	1192	1052	889	786
1989	732	767	781	802	827	1171	1375	1268	1150	1012	908	831
1990	843	840	831	890	910	996	1029	995	995	886	763	677
1991	655	642	630	626	635	713	778	806	782	674	612	573
1992	556	545	542	549	688	830	1065	1058	923	730	586	537
1993	520	519	542	604	748	1120	1331	1512	1607	1585	1475	1448
Avg.	1242	1260	1314	1371	1479	1598	1747	1743	1693	1548	1409	1289
Min.	240	305	330	342	350	467	606	608	641	526	401	269
Max.	1850	1850	1850	1900	2059	2100	2300	2420	2447	2270	2150	1975

Trinity

Cumulative [EWA], Whiskeytown Storage (TAF)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	
1922	217	206	206	206	206	217	240	240	240	240	240	235	
1923	217	206	206	206	206	217	240	240	240	240	240	235	
1924	217	206	202	206	206	217	240	240	240	240	180	180	
1925	181	194	200	180	206	217	240	240	240	240	240	235	
1926	217	206	206	206	206	217	240	240	240	240	240	235	
1927	217	206	206	206	206	217	240	240	238	240	240	235	
1928	217	206	206	206	206	217	240	238	240	240	240	235	
1929	217	206	206	206	206	217	240	240	240	240	240	235	
1930	217	206	206	206	206	217	240	240	240	240	240	235	
1931	217	206	206	206	206	217	227	240	240	240	202	180	
1932	180	180	180	185	191	214	213	220	235	180	180	180	
1933	180	180	180	181	181	200	217	221	240	240	240	235	
1934	217	196	197	196	206	217	240	240	240	240	180	180	
1935	180	191	194	206	206	217	240	240	240	240	240	235	
1936	217	206	202	206	206	212	240	240	240	240	240	235	
1937	217	206	198	192	188	200	240	240	240	240	240	235	
1938	217	206	206	206	206	217	240	240	240	240	240	235	
1939	217	206	206	206	206	217	240	240	240	240	240	235	
1940	217	206	206	206	206	217	240	239	240	240	240	235	
1941	217	206	206	206	206	217	240	240	240	240	240	235	
1942	217	206	206	206	206	217	240	240	240	240	240	235	
1943	217	206	206	206	206	217	240	237	240	240	240	235	
1944	217	206	206	206	206	217	240	240	240	240	240	235	
1945	217	206	206	206	206	217	240	237	240	240	240	235	
1946	217	206	206	206	206	217	240	236	240	240	240	235	
1947	217	206	206	206	206	217	240	240	240	240	240	235	
1948	217	206	206	206	206	217	240	240	240	240	240	235	
1949	217	206	206	206	206	217	240	238	240	240	240	235	
1950	217	206	206	206	206	217	240	240	240	240	240	235	
1951	217	206	206	206	206	217	240	240	240	240	240	235	
1952	217	206	206	206	206	217	240	240	240	240	240	235	
1953	217	206	206	206	206	217	240	240	240	240	240	235	
1954	217	206	206	206	206	217	240	240	240	240	240	235	
1955	217	206	206	206	206	217	240	240	240	240	240	235	
1956	217	206	206	206	206	217	240	240	233	240	240	235	
1957	217	206	206	206	206	217	240	240	240	240	240	235	
1958	217	206	206	206	240	217	240	240	240	240	240	235	
1959	217	206	206	206	206	217	240	234	240	240	240	235	
1960	217	206	206	206	206	217	240	240	240	240	240	235	
1961	217	206	206	206	206	217	240	238	240	240	240	235	
1962	217	206	206	206	206	217	240	237	240	240	240	235	
1963	217	206	206	206	206	217	240	240	240	240	240	235	
1964	217	206	206	206	206	217	240	240	240	240	240	235	
1965	217	206	206	206	206	217	240	240	240	240	240	235	
1966	217	206	206	206	206	217	240	236	240	240	240	235	
1967	217	206	206	206	206	217	240	240	240	240	240	235	
1968	217	206	206	206	206	217	240	238	240	240	240	235	
1969	217	206	206	206	206	217	240	240	240	240	240	235	
1970	217	206	206	206	206	217	240	239	240	240	240	235	
1971	217	206	206	206	206	217	240	240	240	240	240	235	
1972	217	206	206	206	206	217	240	238	240	240	240	235	
1973	217	206	206	206	206	217	240	240	240	240	240	235	
1974	217	206	206	206	206	217	240	240	240	240	240	235	
1975	217	206	206	206	206	217	240	240	240	240	240	235	
1976	217	206	206	206	206	217	240	240	240	240	240	235	
1977	217	206	206	206	206	217	240	240	240	240	240	235	
1978	180	181	206	206	206	217	240	240	236	240	240	235	
1979	217	206	206	206	206	217	240	240	240	240	240	235	
1980	217	206	206	206	206	217	240	240	240	240	240	235	
1981	217	206	206	206	206	217	240	240	240	240	240	235	
1982	217	206	206	206	206	217	240	240	238	240	240	235	
1983	217	206	206	206	206	217	240	240	240	240	240	235	
1984	217	206	206	206	206	217	240	236	240	240	240	235	
1985	217	206	206	206	206	217	240	240	240	240	240	235	
1986	217	206	206	206	206	217	240	239	240	240	240	235	
1987	217	206	206	206	206	217	240	240	240	240	240	235	
1988	217	206	206	206	206	217	240	240	240	240	240	235	
1989	217	206	206	206	206	217	240	239	240	240	240	235	
1990	217	206	206	206	206	215	240	240	240	240	240	235	
1991	217	206	198	191	188	217	223	218	240	240	240	235	
1992	217	206	206	206	206	217	240	240	240	240	240	235	
1993	217	206	206	206	206	217	240	240	240	240	240	235	
Avg.	214	204	205	204	205	216	239	239	240	239	237	232	
Min.	180	180	180	180	181	200	213	218	233	180	180	180	
Max.	217	206	206	206	240	217	240	240	240	240	240	235	

Trinity

Cumulative [EWA], Shasta Storage (TAF)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1922	2806	2822	2897	2991	3290	3595	4074	4232	3927	3442	3020	2835
1923	2836	2849	2938	3146	3204	3251	3561	3323	3066	2658	2290	2203
1924	2173	2127	2124	2182	2339	2276	2061	1746	1334	887	648	599
1925	596	702	791	1038	2276	2457	3120	3179	2939	2435	2068	1924
1926	1866	1868	1916	1959	2674	2866	3161	3030	2665	2213	1866	1764
1927	1709	2184	2690	3164	3462	4035	4552	4552	4243	3642	3204	3045
1928	3020	3211	3300	3576	3970	3965	4463	4268	3897	3256	2880	2732
1929	2639	2634	2642	2745	2932	3099	3098	2968	2720	2317	1965	1823
1930	1780	1768	2288	2485	2845	3282	3432	3331	2969	2539	2168	2054
1931	1982	1968	1954	2028	2107	2269	1987	1704	1409	945	650	612
1932	593	584	760	902	1025	1435	1599	1790	1596	1333	1059	927
1933	855	840	828	852	892	1476	1661	1727	1583	1200	840	681
1934	641	639	755	1050	1365	1646	1747	1595	1214	769	592	561
1935	550	635	672	957	1286	1675	2670	2890	2588	2226	1794	1612
1936	1591	1560	1568	2192	3076	3358	3579	3474	3263	2817	2391	2218
1937	2108	2018	1956	1935	2027	2671	3312	3472	3308	2955	2569	2404
1938	2359	2877	3310	3641	3560	3416	4058	4552	4466	4049	3592	3400
1939	3250	3195	3305	3500	3580	3977	3762	3480	3045	2506	2173	2101
1940	2028	1948	2092	2970	3252	3435	4143	4079	3698	3115	2697	2602
1941	2592	2602	3293	3317	3423	3940	4456	4552	4485	4150	3641	3400
1942	3250	3183	3316	3389	3516	3894	4531	4552	4459	3999	3625	3400
1943	3250	3252	3356	3541	3848	4118	4552	4521	4250	3653	3231	3090
1944	3065	3074	3069	3163	3398	3632	3633	3538	3250	2869	2533	2397
1945	2409	2559	2849	3049	3755	3988	4168	4185	3933	3369	2936	2754
1946	2777	3002	3265	3622	3608	3998	4208	4132	3760	3268	2898	2747
1947	2673	2690	2729	2741	2961	3437	3599	3281	3064	2583	2283	2207
1948	2303	2323	2347	2911	2745	3070	3970	4325	4341	3960	3558	3400
1949	3177	3147	3134	3128	3249	4071	4392	4341	3947	3285	2870	2707
1950	2608	2546	2479	2732	3094	3467	3805	3759	3472	3094	2749	2661
1951	2944	3252	3322	3624	3794	4181	4268	4286	3918	3267	2853	2735
1952	2741	2897	3306	3604	3739	4022	4290	4552	4401	4150	3700	3400
1953	3250	3217	3345	3366	3714	4116	4452	4552	4500	3918	3597	3400
1954	3250	3178	3321	3552	3661	4106	4546	4308	4100	3496	3142	3083
1955	3025	3143	3360	3461	3487	3656	3730	3799	3388	2899	2574	2499
1956	2474	2536	3252	3252	3288	3944	4457	4552	4376	4026	3695	3400
1957	3250	3181	3203	3311	3675	4129	4159	4411	4129	3524	3146	3182
1958	3250	3238	3338	3531	3252	3416	4173	4552	4500	4150	3700	3400
1959	3250	3175	3211	3648	3777	4041	4096	3873	3257	2682	2165	2326
1960	2204	2131	2129	2332	3049	3682	3877	3876	3523	2965	2543	2464
1961	2415	2506	2948	3158	3801	4280	4333	4249	3818	3153	2521	2410
1962	2363	2344	2650	2703	3675	4120	4396	4285	3930	3303	2854	2737
1963	3149	3193	3349	3459	3944	4071	4137	4422	4200	3614	3277	3238
1964	3250	3252	3276	3649	3832	3931	3710	3496	3259	2815	2466	2362
1965	2372	2472	3252	3368	3803	3946	4500	4457	4131	3527	3229	3153
1966	3131	3252	3326	3725	4037	4229	4552	4409	3851	3298	2844	2777
1967	2674	2980	3335	3551	3920	4033	4479	4552	4500	4150	3700	3400
1968	3250	3210	3295	3577	3654	4191	4177	4037	3548	2981	2639	2557
1969	2568	2631	2959	3358	3480	4030	4434	4552	4383	4020	3638	3400
1970	3250	3247	3317	3252	3431	4061	4007	3865	3576	3027	2634	2471
1971	2502	2960	3319	3515	3695	3873	4369	4552	4492	3919	3577	3400
1972	3250	3178	3304	3648	3959	4249	4455	4327	3808	3166	2756	2730
1973	2826	3058	3336	3552	3636	4162	4421	4394	3975	3361	3090	3041
1974	3132	3252	3267	3252	3694	3416	4289	4480	4329	4099	3700	3400
1975	3250	3200	3319	3482	3936	3756	4343	4552	4416	4150	3700	3400
1976	3250	3252	3318	3522	3657	3887	3971	3811	3292	2870	2799	2732
1977	2743	2722	2712	2740	2719	2707	2402	2259	1728	1124	637	584
1978	550	572	1008	2925	3567	4000	4552	4552	4210	3698	3337	3322
1979	3200	3140	3091	3229	3510	3940	4117	4167	3674	3166	2848	2736
1980	2786	2898	3013	3528	3292	3938	4223	4166	3843	3401	3058	3002
1981	2983	2975	3068	3365	3773	4256	4397	4149	3518	2881	2389	2291
1982	2364	3252	3276	3616	3530	3953	4094	4304	4140	3849	3471	3400
1983	3250	3252	3328	3371	3252	3417	4074	4552	4500	4150	3700	3400
1984	3250	3252	3285	3650	3995	4246	4336	4285	4030	3428	3159	3138
1985	3184	3252	3360	3456	3588	3730	3844	3482	3064	2542	2121	2132
1986	2095	2123	2292	2850	3252	3534	3903	3870	3486	3139	2819	2854
1987	2882	2876	2888	3026	3358	4084	3845	3549	3030	2511	2225	2122
1988	2056	2035	2540	2940	2855	2915	2955	2942	2527	2023	1724	1587
1989	1507	1716	1815	1920	2029	3410	3795	3578	3216	2679	2323	2341
1990	2455	2449	2430	2662	2557	2823	2676	2832	2618	2110	1835	1744
1991	1701	1698	1668	1672	1699	2104	2258	2187	1908	1582	1282	1179
1992	1165	1123	1119	1165	1822	2268	2497	2217	1826	1368	976	865
1993	801	798	1029	1678	2408	3875	4497	4552	4500	3909	3637	3400
Avg.	2482	2540	2693	2933	3188	3535	3812	3798	3504	3023	2651	2529
Min.	550	572	672	852	892	1435	1599	1595	1214	769	592	561
Max.	3250	3252	3360	3725	4037	4280	4552	4552	4500	4150	3700	3400

Trinity

Cumulative [EWA], Trinity Import (TAF)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1922	203	68	18	15	14	6	20	15	45	92	123	119	739
1923	46	30	15	15	6	6	19	52	150	177	138	60	714
1924	15	6	6	50	21	29	62	16	87	88	24	99	503
1925	0	0	0	101	0	0	6	0	15	77	108	60	366
1926	15	6	6	6	0	12	6	6	38	127	124	60	406
1927	0	0	6	6	0	6	0	0	0	92	92	119	322
1928	46	15	6	6	6	0	16	0	45	92	159	89	481
1929	46	30	15	44	6	6	22	6	60	154	108	61	558
1930	34	6	6	6	6	6	24	6	61	98	86	60	399
1931	15	6	8	6	0	6	6	20	79	117	46	73	382
1932	33	15	2	0	0	0	0	0	15	72	85	27	250
1933	11	4	3	0	0	0	0	0	40	92	53	15	218
1934	0	0	0	0	0	21	81	11	97	99	98	107	514
1935	28	0	0	0	0	0	0	0	15	92	15	15	165
1936	0	0	0	0	0	6	15	0	15	61	77	60	234
1937	15	0	0	0	0	0	0	6	15	108	77	60	280
1938	15	6	0	6	0	0	0	0	1	3	92	62	186
1939	119	17	48	97	41	2	20	41	131	203	203	142	1064
1940	15	6	6	6	0	0	15	0	45	123	125	149	490
1941	46	30	0	0	0	0	0	124	28	203	120	162	713
1942	114	24	0	0	0	110	6	0	2	18	99	152	525
1943	110	26	65	0	22	72	19	0	11	92	92	119	627
1944	46	30	8	21	6	6	27	15	74	177	154	89	653
1945	61	6	15	15	6	6	18	0	45	92	108	89	462
1946	15	6	0	0	6	4	14	0	45	123	148	89	450
1947	46	30	15	15	14	15	23	15	60	159	141	104	638
1948	15	6	6	6	6	6	6	0	45	92	92	11	292
1949	15	0	7	8	0	0	6	0	45	92	108	89	371
1950	46	6	9	6	6	6	15	15	45	108	108	89	459
1951	15	0	0	0	0	6	22	0	82	92	123	119	459
1952	46	30	0	0	0	0	0	0	7	175	103	153	513
1953	110	0	36	0	92	6	9	0	0	67	107	155	582
1954	116	91	58	23	0	139	136	0	82	92	169	119	1025
1955	46	30	0	0	45	15	12	15	45	203	138	89	638
1956	46	30	0	0	0	39	76	0	0	92	92	61	436
1957	114	12	49	24	0	21	59	0	2	92	169	119	662
1958	0	3	101	108	154	0	0	146	1	172	112	155	953
1959	111	9	37	86	4	140	58	0	45	173	169	196	1028
1960	61	30	9	6	6	15	17	0	45	112	138	60	500
1961	15	6	6	6	0	0	16	0	45	92	108	89	383
1962	46	30	6	15	0	6	24	0	45	92	108	89	461
1963	15	0	0	6	0	0	0	0	5	92	92	119	330
1964	36	0	9	32	71	8	48	15	74	188	145	89	714
1965	61	6	0	0	28	95	0	0	8	92	123	119	532
1966	46	0	0	0	0	0	70	0	14	169	203	149	651
1967	77	30	0	1	37	5	0	0	0	153	108	158	569
1968	123	7	44	84	0	70	43	0	45	146	154	149	865
1969	46	30	15	0	0	0	0	0	0	92	92	98	374
1970	115	1	14	145	1	81	37	0	45	146	127	149	862
1971	46	30	0	0	16	22	0	0	2	54	96	148	414
1972	109	22	33	65	6	203	7	0	89	92	183	119	928
1973	77	30	6	0	0	0	6	0	0	92	181	120	512
1974	46	0	0	139	9	0	39	0	2	122	104	149	611
1975	104	0	36	43	0	0	15	0	20	165	101	155	639
1976	122	31	56	162	25	7	11	15	74	203	138	89	935
1977	46	6	8	6	24	23	138	6	106	148	88	15	616
1978	100	0	0	0	0	0	0	0	0	92	92	89	374
1979	46	0	6	6	6	6	10	15	45	123	123	89	475
1980	46	30	15	0	0	6	6	0	82	92	123	119	519
1981	46	30	15	6	6	0	12	6	45	123	154	89	532
1982	67	22	0	41	0	83	0	0	0	92	92	58	455
1983	32	37	0	0	0	65	61	179	196	203	154	173	1101
1984	121	129	0	102	6	44	19	0	82	92	123	119	837
1985	46	0	0	58	35	17	23	15	128	203	203	159	888
1986	15	6	6	6	0	0	84	0	45	137	142	89	530
1987	46	30	15	15	6	6	24	56	188	203	203	100	893
1988	15	6	6	6	6	18	35	6	92	132	136	72	531
1989	33	6	6	6	6	6	6	0	45	77	77	60	327
1990	15	6	7	6	6	6	29	6	27	93	92	60	353
1991	0	0	0	0	0	0	0	0	29	92	39	15	176
1992	0	0	0	0	0	0	0	6	136	181	116	22	462
1993	0	0	0	0	0	6	0	0	0	0	92	1	99
Avg.	50	16	12	23	10	21	22	12	47	118	117	97	545
Min.	0	0	0	0	0	0	0	0	0	0	15	1	99
Max.	203	129	101	162	154	203	138	179	196	203	203	196	1101

Trinity

Cumulative [EWA], Trinity Flow (TAF)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1922	23	18	18	18	17	18	32	180	47	28	28	27	453
1923	23	18	18	18	17	18	32	180	47	28	28	27	453
1924	23	18	18	18	17	18	36	92	47	28	28	27	370
1925	23	18	18	18	17	18	27	290	150	68	28	27	702
1926	23	18	18	18	17	18	32	180	47	28	28	27	453
1927	23	18	18	18	17	18	27	290	150	68	28	27	702
1928	23	18	18	18	17	18	29	258	126	68	28	27	649
1929	23	18	18	18	17	18	36	92	47	28	28	27	369
1930	23	18	18	18	17	18	32	180	47	28	28	27	453
1931	23	18	18	18	17	18	36	92	47	28	28	27	369
1932	23	18	18	18	17	18	32	180	47	28	28	27	454
1933	23	18	18	18	17	18	32	180	47	28	28	27	453
1934	23	18	18	18	17	18	36	92	47	28	28	27	369
1935	14	18	18	18	17	18	32	180	47	28	28	27	444
1936	23	18	18	18	17	18	29	258	126	68	28	27	649
1937	23	18	18	18	17	18	32	180	47	28	28	27	453
1938	23	18	18	18	17	18	25	281	275	68	28	27	817
1939	23	18	18	18	17	18	36	92	47	28	28	27	369
1940	23	18	18	18	17	18	27	290	150	68	28	27	703
1941	23	18	18	18	17	231	162	281	275	120	28	27	1218
1942	23	18	269	164	134	18	27	290	150	68	28	27	1216
1943	23	18	18	71	17	18	29	258	126	68	28	27	700
1944	23	18	18	18	17	18	36	92	47	28	28	27	370
1945	23	18	18	18	17	18	29	258	126	68	28	27	648
1946	23	18	18	18	17	18	27	290	150	68	28	27	702
1947	23	18	18	18	17	18	32	180	47	28	28	27	453
1948	23	18	18	18	17	18	29	258	126	68	28	27	649
1949	23	18	18	18	17	18	29	258	126	68	28	27	648
1950	23	18	18	18	17	18	32	180	47	28	28	27	453
1951	23	18	18	18	17	18	27	290	150	68	28	27	702
1952	23	18	18	18	17	18	81	290	150	68	28	27	756
1953	23	18	18	280	17	18	27	290	150	68	28	27	964
1954	23	18	18	18	130	18	27	290	150	68	28	27	815
1955	23	18	18	18	17	18	32	180	47	28	28	27	453
1956	23	18	18	18	17	18	25	281	275	68	28	27	817
1957	23	18	18	18	17	18	29	258	126	68	28	27	648
1958	23	18	18	18	333	188	102	281	275	68	28	27	1380
1959	23	18	18	18	17	18	29	258	126	68	28	27	648
1960	23	18	18	18	17	18	29	258	126	68	28	27	649
1961	23	18	18	18	17	18	29	258	126	68	28	27	648
1962	23	18	18	18	17	18	29	258	126	68	28	27	648
1963	23	18	18	18	17	18	27	290	150	68	28	27	702
1964	23	18	18	18	17	18	32	180	47	28	28	27	454
1965	23	18	26	95	17	18	27	290	150	68	28	27	787
1966	23	18	18	18	17	18	29	258	126	68	28	27	648
1967	23	18	18	18	17	74	27	290	150	68	28	27	758
1968	23	18	18	18	138	18	29	258	126	68	28	27	769
1969	23	18	18	18	17	18	25	281	275	68	28	27	817
1970	23	18	220	369	72	18	27	290	150	68	28	27	1310
1971	23	18	18	18	17	18	27	290	150	68	28	27	702
1972	23	18	18	18	17	35	29	258	126	68	28	27	665
1973	23	18	18	18	17	18	27	290	150	68	28	27	702
1974	23	301	261	369	17	221	25	281	275	68	28	27	1895
1975	23	18	18	18	17	88	27	290	150	68	28	27	772
1976	23	18	18	18	17	18	32	180	47	28	28	27	454
1977	23	18	18	18	17	18	36	92	47	28	28	27	369
1978	23	18	18	19	17	18	25	281	275	68	28	27	817
1979	23	18	18	18	17	18	32	180	47	28	28	27	453
1980	23	18	18	18	17	18	27	290	150	68	28	27	703
1981	23	18	18	18	17	18	32	180	47	28	28	27	453
1982	23	18	21	18	176	18	60	281	275	68	28	27	1013
1983	23	18	158	181	181	369	25	281	294	211	28	27	1795
1984	23	18	313	18	17	18	27	290	150	68	28	27	998
1985	23	18	18	18	17	18	32	180	47	28	28	27	453
1986	23	18	18	18	17	18	27	290	150	68	28	27	702
1987	23	18	18	18	17	18	32	180	47	28	28	27	453
1988	23	18	18	18	17	18	32	180	47	28	28	27	454
1989	23	18	18	18	17	18	29	258	126	68	28	27	648
1990	23	18	18	18	17	18	32	180	47	28	28	27	453
1991	23	18	18	18	17	18	36	92	47	28	28	27	369
1992	23	18	18	18	17	18	32	180	47	28	28	27	454
1993	23	18	18	18	17	18	27	290	150	68	28	27	702
Avg.	23	22	34	38	31	33	34	229	121	55	28	27	675
Min.	14	18	18	18	17	18	25	92	47	28	28	27	369
Max.	23	301	313	369	333	369	162	290	294	211	28	27	1895

Trinity

Cumulative [EWA], Tracy Export (TAF)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1922	237	274	258	258	230	283	166	92	179	283	247	274	2781
1923	255	274	258	258	233	213	152	49	179	255	233	262	2619
1924	186	136	154	235	233	49	67	71	48	37	37	170	1423
1925	179	89	257	258	219	49	163	69	122	219	80	269	1973
1926	229	181	166	258	255	225	123	49	48	49	49	177	1809
1927	221	274	258	100	27	169	175	92	179	283	283	274	2334
1928	169	274	258	258	240	283	152	118	179	241	195	243	2608
1929	203	269	258	244	234	72	78	49	49	49	49	168	1724
1930	193	68	258	258	219	213	100	49	94	93	94	234	1872
1931	211	152	140	234	197	75	48	49	48	37	37	135	1361
1932	153	71	258	258	265	96	116	69	105	134	193	249	1966
1933	229	129	42	37	49	77	36	49	48	49	37	173	953
1934	149	43	258	184	36	48	48	49	48	37	37	132	1067
1935	128	172	216	258	120	98	106	49	158	116	274	209	1904
1936	169	164	138	258	183	142	140	49	147	144	276	260	2071
1937	232	160	227	258	181	108	80	121	175	131	175	274	2121
1938	277	274	115	49	44	155	160	239	179	283	283	274	2331
1939	283	260	175	112	216	120	114	69	104	140	93	219	1905
1940	147	177	54	258	240	283	175	92	179	283	266	274	2427
1941	218	258	258	258	230	283	207	160	173	283	283	274	2884
1942	283	274	258	175	116	248	175	92	179	283	283	274	2639
1943	283	274	258	283	232	183	152	49	147	283	281	274	2698
1944	283	242	238	245	265	283	127	92	131	120	95	249	2367
1945	213	274	258	258	255	171	121	49	179	281	279	274	2612
1946	256	253	258	258	217	151	144	92	179	283	282	260	2633
1947	213	274	258	258	255	255	105	49	143	130	92	259	2292
1948	202	218	150	234	246	191	152	49	179	281	283	258	2443
1949	262	214	258	235	208	283	109	118	179	280	223	241	2608
1950	239	240	244	258	255	263	143	49	147	214	274	271	2596
1951	221	274	145	49	55	199	128	49	179	283	283	245	2110
1952	263	253	258	258	240	283	208	199	179	283	283	274	2979
1953	283	254	167	112	141	168	140	69	179	283	281	274	2351
1954	283	274	258	258	230	283	163	69	170	283	248	264	2782
1955	226	274	258	258	255	142	106	49	179	227	94	214	2282
1956	243	260	258	258	241	174	150	49	147	241	283	274	2578
1957	283	274	219	258	230	283	160	129	179	283	245	267	2808
1958	283	274	258	258	255	283	158	193	179	283	283	274	2980
1959	283	250	258	283	230	166	107	69	179	280	274	180	2558
1960	229	93	85	235	265	264	48	49	147	192	125	149	1880
1961	216	251	258	251	255	110	97	99	179	283	223	230	2452
1962	136	156	255	258	255	283	123	69	179	283	277	241	2514
1963	283	274	258	258	247	220	152	49	179	283	283	274	2757
1964	283	274	258	258	195	167	77	49	103	213	192	226	2295
1965	203	252	258	258	230	247	175	92	179	283	283	274	2734
1966	283	274	258	258	255	282	125	69	179	283	281	239	2786
1967	218	274	258	258	230	283	218	204	179	283	283	274	2961
1968	283	274	228	112	209	165	133	69	179	283	265	218	2415
1969	232	271	258	258	230	283	161	240	179	283	281	274	2949
1970	283	268	142	93	100	197	128	49	147	165	283	274	2130
1971	261	274	258	258	229	283	163	69	179	283	283	274	2813
1972	283	274	258	258	265	283	100	49	179	283	263	248	2742
1973	233	274	258	283	230	246	167	92	162	283	267	267	2761
1974	269	274	258	258	230	283	152	49	147	283	283	274	2759
1975	283	274	258	258	255	283	175	92	160	283	283	274	2878
1976	283	274	258	249	210	161	82	49	78	68	78	145	1934
1977	175	188	49	110	44	49	48	49	67	184	175	139	1278
1978	188	77	258	283	202	111	154	194	179	283	278	274	2480
1979	283	262	171	258	255	214	163	92	158	250	250	206	2562
1980	283	273	258	258	240	214	149	49	179	283	281	274	2739
1981	270	228	258	258	255	283	137	69	169	281	204	215	2627
1982	283	274	258	258	230	283	193	218	179	283	283	274	3014
1983	283	274	111	93	100	162	160	239	179	283	283	267	2434
1984	133	89	64	93	140	243	165	92	179	283	283	266	2030
1985	252	274	258	258	255	283	101	49	147	283	274	205	2640
1986	225	136	258	258	255	283	109	140	169	169	277	274	2552
1987	283	261	205	72	158	110	106	49	91	99	72	190	1695
1988	177	239	258	258	218	49	81	49	48	49	49	168	1644
1989	190	126	198	234	118	283	138	49	137	159	138	199	1969
1990	208	230	134	258	255	150	48	49	48	49	49	140	1618
1991	182	64	116	71	60	283	103	49	101	49	50	178	1306
1992	181	66	77	209	265	224	98	49	48	49	37	77	1379
1993	189	40	258	258	230	194	163	69	152	283	280	274	2389
Avg.	232	219	215	223	205	201	130	85	145	214	209	235	2313
Min.	128	40	42	37	27	48	36	49	48	37	37	77	953
Max.	283	274	258	283	265	283	218	240	179	283	283	274	3014

Trinity

Cumulative [EWA], Banks Export (TAF)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1922	328	224	498	479	447	523	202	92	506	508	92	363	4263
1923	360	371	498	498	233	213	179	143	208	523	514	326	4065
1924	403	160	312	220	233	18	18	26	18	22	218	68	1717
1925	134	138	302	251	310	18	167	69	182	189	25	164	1949
1926	145	69	145	389	472	70	156	49	115	443	268	149	2472
1927	131	506	498	459	289	410	229	92	278	268	433	336	3930
1928	411	436	429	498	358	523	188	153	186	217	285	283	3967
1929	195	207	260	261	229	149	78	18	70	198	26	65	1757
1930	83	68	387	498	219	428	100	49	63	459	377	227	2958
1931	133	51	49	252	110	61	18	37	46	115	286	98	1256
1932	78	76	498	498	284	247	103	69	172	384	18	153	2580
1933	136	89	300	235	234	241	80	49	18	200	27	69	1678
1934	146	47	338	454	226	58	18	18	18	187	19	102	1630
1935	135	169	202	498	230	332	229	20	194	474	419	403	3304
1936	345	172	362	498	489	434	173	49	283	484	433	256	3978
1937	178	120	329	361	472	523	240	171	214	233	322	224	3385
1938	197	506	498	498	383	413	323	333	506	492	340	384	4871
1939	523	253	452	402	237	268	114	18	127	425	458	315	3591
1940	227	143	280	498	464	523	229	92	166	520	505	279	3926
1941	400	146	498	498	447	523	261	285	285	492	368	411	4613
1942	395	267	498	378	345	416	229	92	506	197	460	435	4219
1943	466	427	494	398	346	425	202	49	158	250	499	336	4050
1944	244	146	331	303	489	282	127	92	246	504	438	288	3489
1945	270	374	496	256	472	488	121	137	272	477	375	276	4013
1946	295	344	498	498	161	375	144	92	248	523	509	285	3972
1947	392	223	468	160	316	255	105	18	164	478	272	215	3068
1948	187	184	171	280	17	191	182	49	318	513	444	321	2859
1949	401	199	310	179	208	523	109	94	156	305	207	224	2915
1950	88	133	141	498	472	263	143	49	301	493	432	263	3276
1951	330	506	498	464	348	427	128	49	163	335	523	334	4105
1952	371	303	498	498	464	523	262	215	451	470	441	506	5000
1953	523	144	217	344	278	411	140	69	387	322	400	472	3707
1954	370	413	191	498	447	523	218	193	170	478	407	392	4297
1955	378	304	498	498	147	148	90	49	172	262	21	216	2782
1956	121	180	498	498	391	440	150	49	444	179	450	491	3890
1957	481	239	205	318	447	523	160	154	257	342	465	304	3894
1958	498	272	498	498	385	487	301	203	505	492	454	506	5098
1959	523	250	254	431	376	93	107	69	153	394	496	320	3467
1960	278	108	315	229	489	264	18	49	79	483	84	153	2548
1961	124	184	396	243	472	288	97	18	165	433	138	219	2778
1962	219	191	386	124	472	383	123	53	152	471	520	345	3439
1963	523	390	498	496	415	417	206	49	271	209	464	378	4315
1964	376	506	310	498	132	134	116	101	218	523	460	248	3621
1965	174	328	498	498	447	288	229	124	254	170	496	334	3840
1966	208	506	498	498	365	391	125	69	142	393	446	320	3960
1967	302	351	498	498	447	523	284	224	506	492	461	506	5091
1968	523	345	387	348	384	406	133	69	149	241	440	321	3746
1969	293	265	498	498	447	411	252	264	362	451	147	506	4393
1970	523	293	266	339	346	424	128	49	128	257	523	444	3720
1971	346	506	498	498	17	523	171	69	302	467	455	440	4291
1972	391	282	476	430	293	523	100	103	207	402	342	245	3794
1973	271	506	498	380	345	426	167	92	228	445	399	304	4062
1974	338	506	498	498	447	523	206	194	374	411	492	506	4992
1975	410	266	385	415	392	456	202	92	467	459	492	506	4542
1976	523	364	323	177	210	211	82	49	112	175	447	347	3020
1977	157	192	176	125	127	42	18	24	18	28	238	105	1251
1978	64	67	368	426	192	330	293	204	250	523	181	366	3264
1979	300	143	366	498	472	453	163	92	189	433	320	298	3727
1980	275	271	498	498	464	350	153	49	240	523	127	392	3838
1981	316	106	275	498	324	461	137	117	169	486	339	346	3574
1982	257	506	498	498	447	523	379	330	452	492	320	506	5207
1983	523	451	352	189	172	279	198	158	231	523	523	249	3847
1984	222	187	204	322	351	443	165	92	171	256	523	316	3251
1985	394	506	498	359	255	124	101	49	130	523	492	399	3829
1986	357	274	491	498	399	501	255	140	192	469	137	303	4016
1987	239	60	199	419	401	335	106	23	96	401	402	241	2921
1988	172	123	370	498	68	31	81	18	18	265	18	53	1715
1989	82	144	173	180	56	523	138	49	118	461	350	368	2643
1990	277	150	336	479	165	150	18	49	18	39	282	113	2076
1991	96	18	62	51	58	466	103	49	18	35	206	66	1229
1992	113	35	62	181	489	248	98	18	49	205	83	190	1772
1993	94	88	326	498	426	384	218	69	466	499	350	306	3722
Avg.	289	251	366	391	326	347	157	94	218	368	339	300	3445
Min.	64	18	49	51	17	18	18	18	18	22	18	53	1229
Max.	523	506	498	498	489	523	379	333	506	523	523	506	5207

Trinity

Cumulative [EWA], Delta Inflows (TAF)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1922	887	822	1344	1207	2649	2509	1887	3484	2862	1567	759	977	20954
1923	944	1087	2378	2349	1332	1213	1899	1329	1104	1450	1244	903	17232
1924	912	746	811	909	1034	737	550	532	643	697	654	522	8747
1925	596	594	999	907	3956	1791	1611	1213	1041	992	599	694	14992
1926	700	635	698	1231	2593	990	1613	916	781	1127	883	610	12776
1927	681	1582	1282	2144	7215	3067	3191	1993	1305	1492	1149	936	26036
1928	888	1257	1128	1569	1697	6543	2006	1447	1057	1237	925	819	20573
1929	769	883	917	904	1027	854	664	644	698	762	554	515	9191
1930	592	523	1238	1459	1180	2122	937	868	746	1133	992	732	12521
1931	674	596	586	902	738	579	614	515	643	837	729	518	7931
1932	554	507	1503	1563	1439	1112	976	1021	1165	1125	749	693	12409
1933	701	610	698	1009	754	962	832	578	686	789	577	529	8726
1934	576	520	1034	1295	970	885	808	588	725	753	538	523	9214
1935	560	782	736	2139	998	1931	3428	1844	1289	1292	1146	939	17085
1936	883	713	888	2624	4712	2303	1824	1379	1230	1346	1272	805	19978
1937	744	707	911	1031	2822	3370	1984	1688	1219	1071	992	791	17330
1938	800	1672	4010	2394	8241	10663	4963	4990	3426	1560	1073	1010	44802
1939	1440	849	1042	999	1003	1105	953	857	827	1188	957	819	12038
1940	819	653	678	2418	3865	7111	4515	1488	1081	1597	1263	848	26335
1941	949	953	2828	6446	7255	6174	4833	3117	1619	1571	1141	1051	37936
1942	1042	943	4116	5269	8173	2021	3390	2707	2009	1289	1192	1088	33240
1943	1152	1073	2114	5715	3708	5825	2178	1702	1099	1362	1222	936	28085
1944	858	810	924	1033	1765	1612	969	1041	1074	1230	1075	833	13223
1945	829	1123	1225	922	3112	1986	1192	1266	1285	1481	1177	843	16442
1946	864	1136	4466	3331	1796	1500	1183	1263	1219	1497	1237	836	20329
1947	993	983	1185	841	1268	1451	998	798	941	1203	847	772	12282
1948	750	790	668	1021	943	1091	1939	1981	1419	1495	1179	890	14165
1949	1108	792	999	836	924	2985	1036	1087	1066	1191	879	745	13648
1950	688	778	729	1427	2231	1503	1454	1306	1280	1417	1290	820	14924
1951	866	3182	6336	4854	4369	2279	1270	1534	976	1518	1243	890	29317
1952	972	1055	2810	5645	4908	4601	4436	4773	3156	1534	1175	1315	36380
1953	1407	899	2988	6636	1699	1653	1281	1771	1615	1561	1108	1145	23763
1954	1002	1161	855	2212	3649	3382	2784	1763	968	1552	1082	1007	21416
1955	993	1018	1490	1306	1052	827	1005	990	1029	1072	657	709	12148
1956	714	845	6043	10576	5371	2820	1544	2842	1711	1206	1180	1175	36027
1957	1173	856	848	1045	2114	3205	1517	1339	1244	1422	1150	876	16788
1958	1201	1000	1581	2506	10175	6350	6227	3688	2499	1542	1180	1305	39255
1959	1255	840	965	2385	3289	1618	867	908	1025	1497	1199	768	16618
1960	869	653	742	892	1955	1505	833	943	860	1301	795	589	11938
1961	683	899	1124	836	1786	1134	899	852	980	1358	915	725	12191
1962	700	804	1062	749	2826	1903	1061	1085	1018	1509	1227	899	14843
1963	2208	1021	1739	1226	4632	2186	5641	2264	1344	1479	1187	1001	25929
1964	1012	1643	950	1601	1014	860	1128	868	917	1331	1140	751	13215
1965	704	1077	4951	7721	2290	1743	3126	1790	1236	1342	1197	933	28111
1966	828	1420	1295	2213	1770	1922	1094	1090	940	1383	1160	858	15974
1967	938	1051	2498	3152	3513	4091	3593	3834	3287	1557	1197	1425	30136
1968	1513	950	1195	2031	3920	2551	1188	877	993	1252	1082	826	18380
1969	975	903	1648	7635	7819	4390	3884	4535	2857	1524	891	1206	38267
1970	1453	953	3807	13132	5141	2839	1275	1159	877	1483	1255	1102	34476
1971	932	1265	3915	3331	1727	3156	1651	1927	1373	1752	1180	1096	23306
1972	1034	941	1228	1171	1505	2328	934	891	1351	1374	1067	758	14581
1973	862	1378	1508	5167	5441	4071	1457	1466	1275	1506	1108	876	26116
1974	929	3698	4453	8387	2661	7193	4602	1903	1489	1470	1238	1367	39391
1975	1065	875	1189	1112	4034	5955	1890	2168	1832	1505	1202	1318	24144
1976	1313	981	970	901	933	1059	716	574	755	974	832	755	10765
1977	697	710	593	563	593	540	630	456	643	893	790	514	7622
1978	574	513	1075	4268	3373	4509	3011	1982	1573	1595	949	982	24405
1979	925	788	972	1683	2823	2601	1417	1357	1251	1372	1014	798	17000
1980	912	1022	1403	6571	8028	4045	1575	1472	1195	1556	918	1022	29720
1981	923	700	1043	1498	1651	2120	1240	919	967	1367	1100	861	14390
1982	861	2032	5754	5100	6054	5836	8602	3672	1998	1553	1157	1205	43823
1983	1805	2833	5636	6614	9987	15619	5541	5147	5582	2641	1509	2045	64958
1984	1975	5056	9747	4564	2683	2652	1438	1188	1117	1489	1247	893	34049
1985	993	2023	1491	1031	1132	1156	938	1006	890	1400	1238	928	14226
1986	941	786	1218	1571	11710	9692	1913	1371	1196	1421	960	887	33668
1987	856	705	793	992	1235	1661	1001	728	835	1087	879	720	11493
1988	772	687	1193	1899	971	644	698	626	723	864	563	514	10154
1989	583	687	714	925	622	3121	1396	934	918	1225	898	870	12893
1990	908	727	881	1304	1048	857	777	586	580	677	791	547	9683
1991	556	514	495	459	530	2129	974	665	574	658	723	547	8824
1992	555	510	548	715	2058	1344	908	609	749	776	593	566	9933
1993	578	520	962	4233	3509	3150	2652	2272	1884	1568	1076	889	23292
Avg.	930	1074	1873	2754	3153	2962	2015	1618	1331	1318	1019	881	20927
Min.	554	507	495	459	530	540	550	456	574	658	538	514	7622
Max.	2208	5056	9747	13132	11710	15619	8602	5147	5582	2641	1509	2045	64958

Trinity

Cumulative [EWA], Total Delta Outflow (TAF)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1922	246	268	568	551	2135	1668	1435	3157	1916	492	246	231	12912
1923	262	409	1766	1682	834	709	1537	989	489	400	322	228	9626
1924	246	380	277	455	550	621	351	252	322	387	228	179	4247
1925	220	316	452	431	3577	1672	1254	992	493	307	332	179	10227
1926	246	325	325	609	1975	603	1305	656	304	309	383	179	7219
1927	246	784	458	1629	7064	2438	2739	1661	592	639	246	224	18720
1928	249	507	401	840	1082	5772	1576	1009	415	492	246	179	12768
1929	284	372	376	415	548	587	413	404	359	246	304	179	4486
1930	222	319	543	776	769	1474	660	635	326	317	361	179	6581
1931	246	330	323	453	426	379	406	270	315	374	208	179	3908
1932	237	312	875	868	985	701	666	731	607	307	339	179	6806
1933	246	323	302	803	444	616	597	351	360	246	318	179	4785
1934	196	365	412	667	783	701	595	345	410	246	300	179	5198
1935	212	403	294	1513	633	1538	3095	1620	639	400	246	214	10808
1936	294	308	328	1954	4291	1671	1423	1134	546	400	351	179	12877
1937	246	354	317	474	2330	2907	1576	1222	564	400	283	179	10852
1938	246	843	3391	1903	8123	10220	4411	4257	2460	492	246	231	36822
1939	551	268	346	489	535	683	596	591	302	327	215	179	5083
1940	364	268	277	1832	3423	6342	4011	1138	435	492	288	192	19062
1941	246	480	2150	5895	6741	5366	4374	2545	896	492	309	247	29741
1942	289	328	3366	4902	7748	1324	3004	2405	1048	512	246	268	25439
1943	317	317	1319	5189	3140	5248	1757	1440	531	539	246	203	20246
1944	246	363	298	495	1108	975	640	702	440	307	350	179	6101
1945	267	436	457	419	2453	1346	816	927	542	400	325	179	8566
1946	246	478	3746	2572	1393	927	781	925	518	400	246	179	12411
1947	302	439	413	419	697	914	666	536	364	307	307	179	5544
1948	292	324	277	493	645	676	1556	1778	681	400	250	205	7575
1949	367	308	388	432	504	2214	710	708	449	307	277	179	6845
1950	278	344	284	742	1515	924	1048	1030	562	400	387	190	7704
1951	246	2388	5797	4445	3985	1611	933	1299	362	609	246	200	22119
1952	268	457	2115	5175	4200	3851	3913	4196	2286	492	246	411	27609
1953	499	451	2653	6253	1242	1013	932	1500	812	644	246	288	16533
1954	263	420	324	1467	2954	2564	2322	1334	365	492	246	243	12994
1955	301	393	707	653	633	474	757	752	415	307	345	179	5914
1956	269	358	5476	10083	4735	2128	1174	2611	841	492	246	312	28724
1957	322	268	349	479	1459	2354	1122	970	534	501	248	201	8807
1958	360	372	773	1902	9812	5702	5820	3166	1578	492	246	405	30627
1959	349	268	387	1694	2751	1286	528	586	402	516	246	215	9226
1960	265	379	277	458	1248	920	678	694	332	327	397	179	6153
1961	246	432	407	418	1041	709	606	585	344	332	373	179	5671
1962	246	414	359	369	2341	1186	680	790	400	452	246	206	7687
1963	1375	278	947	585	4031	1579	5348	2048	633	712	246	247	18027
1964	287	830	302	904	644	487	818	544	364	307	314	179	5981
1965	263	460	4248	7068	1574	1148	2683	1413	550	603	246	222	20479
1966	246	601	534	1512	1155	1180	718	768	347	441	246	196	7944
1967	319	405	1762	2714	2809	3327	3138	3258	2371	492	246	526	21368
1968	608	268	515	1628	3337	1957	818	568	376	430	246	179	10929
1969	360	320	869	7168	7343	3646	3389	3857	2065	492	246	302	30058
1970	571	327	3387	12970	4691	2167	913	867	330	760	246	268	27497
1971	246	495	3259	2590	1446	2309	1229	1668	626	711	246	269	15094
1972	272	326	470	475	914	1421	627	541	682	400	279	179	6586
1973	307	645	748	4825	5030	3410	1019	1091	587	492	246	195	18595
1974	264	2907	3743	7714	1954	6400	4191	1495	697	511	259	456	30591
1975	283	268	493	431	3460	5284	1447	1815	920	492	246	410	15549
1976	440	273	314	462	481	583	447	254	285	458	184	179	4360
1977	273	264	302	325	383	376	422	269	297	400	199	179	3689
1978	233	323	441	3871	3071	4150	2521	1419	863	492	290	239	17913
1979	246	334	362	1060	2222	1904	1011	1008	613	400	256	179	9593
1980	292	419	632	5965	7524	3452	1196	1231	521	492	324	251	22298
1981	246	299	449	769	1041	1378	867	558	327	307	374	202	6816
1982	260	1242	5011	4608	5405	5199	8027	2960	1125	492	356	347	35032
1983	933	2172	5214	6619	9913	15476	5187	4609	4904	1563	513	1423	58527
1984	1527	4778	9594	4146	2191	1905	1011	817	492	658	246	190	27556
1985	286	1268	709	419	602	764	629	714	322	307	301	235	6556
1986	282	351	456	889	11371	8975	1464	930	560	492	337	214	26319
1987	246	322	333	498	693	1210	666	460	373	307	224	179	5510
1988	341	268	537	1215	643	485	446	410	405	246	318	179	5493
1989	216	368	298	508	435	2308	988	646	393	307	219	230	6916
1990	340	284	337	586	633	486	587	407	238	300	281	179	4657
1991	191	368	259	326	385	1414	666	426	238	290	294	179	5036
1992	190	346	350	331	1423	869	617	355	401	246	276	179	5583
1993	217	325	404	3871	3040	2567	2173	2014	1028	492	246	195	16572
Avg.	329	556	1273	2227	2676	2400	1649	1282	701	446	282	240	14060
Min.	190	264	259	325	383	376	351	252	238	246	184	179	3689
Max.	1527	4778	9594	12970	11371	15476	8027	4609	4904	1563	513	1423	58527

Trinity

Cumulative [EWA], CVP Delivery North of Delta (TAF)
(sum of CALSIM variables D300, D8, D9, D302, D167A_IMI, D167B_IMI, D162_IMI, D168B, D168C_FRWP, and Del_CVP_Total_N)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1922	97	43	34	29	28	30	402	462	561	572	511	276	3044
1923	60	43	34	29	28	95	272	472	520	556	497	187	2792
1924	94	50	33	28	27	69	329	366	396	396	345	176	2311
1925	36	29	24	21	20	27	251	351	517	565	499	232	2571
1926	111	39	32	27	26	67	173	402	519	520	456	257	2629
1927	66	45	31	24	24	33	340	466	535	582	517	276	2940
1928	66	43	34	29	28	25	281	460	534	545	488	264	2796
1929	106	40	33	28	27	49	347	444	409	483	433	238	2637
1930	102	51	29	24	23	37	264	412	532	532	474	232	2713
1931	104	47	38	26	25	74	339	319	362	408	354	176	2272
1932	68	31	26	22	21	44	296	321	403	416	370	200	2220
1933	87	39	28	25	24	62	338	340	401	403	352	180	2279
1934	66	44	26	23	22	47	308	362	410	426	370	189	2294
1935	69	40	27	23	22	24	140	426	548	551	491	261	2622
1936	70	42	32	27	26	33	287	418	472	538	481	253	2678
1937	105	56	32	27	26	26	274	453	487	531	473	258	2747
1938	71	39	32	27	26	27	255	444	576	583	517	238	2835
1939	73	46	34	29	50	124	444	404	510	512	463	217	2907
1940	91	62	40	35	30	27	295	401	569	581	515	270	2917
1941	68	43	34	29	28	27	149	346	563	592	524	279	2680
1942	69	43	34	29	28	28	156	388	577	592	524	275	2741
1943	106	43	34	29	28	28	267	474	561	582	517	277	2945
1944	109	45	34	29	28	40	316	392	499	528	470	255	2743
1945	77	38	30	26	25	26	343	404	526	580	516	276	2867
1946	48	43	34	29	28	36	418	466	547	544	495	263	2949
1947	105	43	34	29	28	28	333	433	461	531	470	257	2751
1948	46	38	30	26	35	49	139	306	492	591	520	253	2524
1949	90	45	34	29	29	24	333	413	543	548	490	263	2840
1950	113	41	34	28	27	35	347	447	508	519	461	233	2794
1951	47	39	32	27	26	40	403	404	570	577	513	272	2950
1952	56	43	34	29	28	28	317	475	520	576	515	271	2889
1953	118	43	34	29	28	59	304	444	537	581	477	275	2929
1954	103	43	34	29	28	26	250	465	551	580	466	271	2846
1955	109	41	33	27	26	74	316	443	511	515	459	217	2772
1956	92	38	30	26	25	68	365	401	548	581	515	249	2938
1957	71	58	34	29	28	54	357	414	580	590	522	154	2892
1958	53	49	34	29	28	27	160	379	530	570	516	272	2647
1959	111	57	34	29	28	57	442	512	560	566	500	148	3044
1960	124	68	42	36	35	35	323	399	511	511	454	243	2780
1961	97	37	30	25	25	23	320	442	519	547	485	241	2792
1962	105	39	32	26	25	35	386	487	555	583	517	273	3063
1963	55	51	42	37	35	27	153	404	572	591	523	276	2766
1964	64	43	34	29	28	92	436	456	481	516	452	223	2853
1965	61	38	30	26	25	63	256	486	571	582	446	276	2859
1966	120	43	34	29	28	46	411	484	538	542	487	262	3023
1967	114	41	33	27	26	28	140	448	481	588	520	275	2721
1968	111	43	34	29	28	36	374	483	537	586	469	282	3010
1969	89	51	42	27	26	29	339	497	550	571	512	271	3003
1970	81	44	34	29	28	27	382	479	501	543	488	265	2901
1971	77	41	33	27	26	52	443	410	542	564	504	264	2984
1972	111	43	34	29	31	125	417	465	522	548	491	216	3030
1973	50	40	32	27	26	27	347	482	571	577	514	260	2953
1974	58	43	34	29	28	27	268	480	564	504	518	278	2830
1975	72	43	34	29	28	27	293	487	575	570	506	277	2942
1976	50	46	34	29	52	159	355	444	475	480	383	213	2720
1977	105	46	28	23	35	104	370	279	407	409	358	134	2297
1978	86	31	24	21	20	33	205	461	575	585	517	227	2786
1979	122	43	34	29	28	36	316	486	579	585	517	269	3044
1980	64	50	34	28	28	28	313	447	542	572	516	271	2892
1981	106	53	34	29	28	35	298	442	580	587	522	253	2967
1982	60	48	32	27	26	27	182	468	525	594	527	185	2701
1983	47	43	34	29	28	27	161	423	553	589	504	233	2671
1984	100	43	34	29	28	52	418	502	537	559	477	263	3041
1985	64	41	33	27	26	25	351	481	543	557	494	197	2839
1986	86	41	33	27	26	25	286	446	551	555	498	204	2778
1987	108	53	33	28	27	35	359	461	511	514	459	252	2839
1988	94	46	39	30	24	91	309	365	449	487	437	240	2611
1989	97	35	28	23	29	26	334	490	523	554	487	86	2711
1990	56	39	32	27	26	64	398	278	489	489	422	233	2554
1991	94	41	29	24	28	37	235	347	417	436	389	214	2291
1992	80	41	27	24	23	33	237	375	397	442	393	211	2282
1993	45	38	27	23	22	27	315	349	497	584	511	276	2714
Avg.	83	44	33	27	27	45	307	426	516	541	477	240	2767
Min.	36	29	24	21	20	23	139	278	362	396	345	86	2220
Max.	124	68	42	37	52	159	444	512	580	594	527	282	3063

Trinity

Cumulative [EWA], CVP Delivery So w/ CVC (TAF)
(equals CALSIM variable CVPTotalDel)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1922	318	137	107	137	166	174	213	332	483	559	459	270	3355
1923	306	120	104	131	158	158	189	270	393	448	378	229	2885
1924	249	123	85	100	123	75	83	120	155	165	158	131	1565
1925	110	59	34	25	35	131	153	233	338	444	328	211	2102
1926	171	98	73	81	101	99	111	154	216	238	216	174	1730
1927	146	79	47	38	52	167	203	315	464	536	443	265	2756
1928	286	128	100	125	151	139	184	269	392	491	419	229	2911
1929	182	107	85	100	122	95	106	148	200	219	202	168	1733
1930	143	76	43	33	46	118	144	205	289	358	283	197	1934
1931	161	91	63	64	81	82	92	133	177	197	177	138	1456
1932	115	63	39	33	44	86	98	135	188	216	188	142	1348
1933	117	65	42	37	49	75	83	114	155	166	158	131	1192
1934	110	59	34	25	35	85	96	139	186	212	186	141	1309
1935	117	65	41	36	47	92	102	217	300	332	293	210	1852
1936	198	92	65	68	85	141	166	243	341	383	330	244	2357
1937	201	98	73	82	102	106	150	218	302	346	306	228	2212
1938	164	93	66	68	86	192	236	344	502	583	477	262	3072
1939	204	239	119	137	166	127	161	236	341	423	360	221	2734
1940	171	98	73	81	102	146	181	280	409	467	392	246	2646
1941	263	110	89	106	129	172	203	336	489	566	505	258	3226
1942	223	182	105	133	161	175	214	337	490	568	466	259	3312
1943	201	122	103	133	161	182	221	331	480	571	457	307	3269
1944	252	120	103	130	157	134	152	223	320	357	312	238	2500
1945	188	95	69	75	94	151	199	295	424	486	406	252	2733
1946	271	112	92	111	135	150	180	292	425	487	407	240	2902
1947	285	113	92	111	135	113	152	221	306	402	303	202	2436
1948	165	93	66	70	88	104	155	283	407	465	391	249	2536
1949	259	109	88	105	128	111	195	276	405	551	389	233	2850
1950	185	109	88	104	127	117	143	208	286	314	299	230	2211
1951	161	91	63	63	80	167	198	298	438	503	419	286	2765
1952	250	114	95	116	140	189	236	344	502	583	480	263	3312
1953	327	123	107	137	166	163	198	317	465	537	443	251	3234
1954	243	184	100	125	151	165	203	309	454	523	433	266	3158
1955	284	117	98	121	147	140	165	241	338	445	327	211	2634
1956	171	98	73	80	101	170	201	310	451	520	431	247	2853
1957	194	223	98	120	146	174	198	316	462	533	473	319	3255
1958	196	127	100	124	150	177	218	344	502	583	477	262	3258
1959	204	251	107	137	166	165	191	293	426	511	435	297	3184
1960	189	113	93	112	136	93	134	188	263	308	274	189	2091
1961	156	87	58	55	71	128	191	278	397	513	414	230	2580
1962	183	108	86	101	124	155	190	278	412	471	395	275	2780
1963	186	110	89	107	130	171	203	309	455	524	434	261	2981
1964	214	117	174	121	147	138	163	232	332	372	322	271	2604
1965	170	97	72	79	98	154	184	323	468	596	446	294	2978
1966	213	118	101	126	152	167	194	294	431	495	413	302	3005
1967	228	113	94	113	138	192	236	344	502	583	477	262	3281
1968	204	208	111	137	166	163	191	298	434	520	436	311	3180
1969	191	114	94	114	139	192	236	344	502	603	504	262	3295
1970	204	172	139	137	166	162	198	292	425	473	362	359	3088
1971	219	113	93	111	135	162	194	304	445	512	425	245	2958
1972	218	194	96	118	143	167	199	292	418	544	436	237	3063
1973	188	111	91	109	133	177	203	319	462	534	441	279	3047
1974	279	118	100	124	150	170	213	321	466	538	444	251	3173
1975	201	227	100	125	152	167	204	320	464	536	442	251	3189
1976	197	145	185	124	151	110	126	177	245	291	243	183	2177
1977	152	84	54	49	64	81	91	131	174	194	175	137	1385
1978	114	63	39	32	43	182	229	344	502	583	477	284	2890
1979	290	142	107	137	166	147	200	291	417	480	402	313	3092
1980	200	111	91	108	132	184	223	343	501	582	476	262	3213
1981	331	123	107	137	166	158	189	280	409	468	412	305	3085
1982	186	110	89	106	129	192	233	344	502	583	477	262	3211
1983	204	121	114	137	166	192	236	344	502	711	477	262	3465
1984	204	123	107	137	166	167	198	313	462	533	441	280	3131
1985	270	118	100	124	150	146	192	283	412	471	396	274	2935
1986	239	110	90	107	130	142	187	273	389	442	444	239	2792
1987	181	106	84	98	121	108	158	224	320	414	323	206	2345
1988	167	95	69	75	94	97	108	157	205	229	207	170	1674
1989	144	77	45	35	48	92	160	233	325	365	316	266	2105
1990	168	96	70	76	96	92	102	148	191	197	194	165	1597
1991	141	75	41	30	42	89	101	146	196	229	195	144	1429
1992	119	67	44	40	52	90	118	170	234	293	230	157	1613
1993	127	73	53	54	67	164	203	314	453	523	433	262	2725
Avg.	201	116	85	96	118	142	174	263	378	444	369	238	2624
Min.	110	59	34	25	35	75	83	114	155	165	158	131	1192
Max.	331	251	185	137	166	192	236	344	502	711	505	359	3465

Trinity

Cumulative [EWA], X2_PRV (KM)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	
1922	74.9	83.2	85.0	80.1	78.7	67.1	65.9	66.5	60.8	62.6	73.8	82.8	
1923	86.0	86.3	82.8	70.7	67.0	70.5	73.6	68.5	70.4	76.2	79.9	82.7	
1924	86.1	86.8	83.5	85.1	81.8	78.8	77.3	81.0	85.0	84.2	82.7	86.3	
1925	89.1	88.7	85.5	82.0	81.2	63.9	64.9	67.2	69.9	76.0	81.8	83.1	
1926	88.1	87.5	84.9	84.3	79.3	67.9	74.0	69.8	74.0	81.0	83.4	82.6	
1927	87.9	87.4	78.1	79.5	70.2	55.1	59.1	59.3	63.4	72.4	75.0	83.2	
1928	86.4	86.8	81.3	81.5	75.9	71.6	57.9	63.1	68.5	76.8	78.5	84.4	
1929	88.5	86.5	83.6	82.8	81.8	78.5	77.7	79.9	81.0	82.0	85.5	85.0	
1930	88.7	88.5	85.4	80.5	76.2	74.1	69.2	73.5	75.4	80.9	83.2	82.9	
1931	88.0	87.5	84.8	84.3	81.6	80.4	81.7	81.3	84.6	84.2	83.0	87.1	
1932	89.4	88.2	85.5	76.9	74.2	71.8	74.1	75.0	74.9	76.0	81.8	83.0	
1933	88.0	87.5	85.0	84.9	77.4	78.7	77.4	76.9	81.1	82.0	85.5	84.7	
1934	88.6	89.4	84.7	82.4	78.0	74.5	75.0	76.2	81.0	81.0	85.2	85.0	
1935	88.7	88.9	83.7	84.7	72.5	74.3	68.9	61.6	64.4	72.1	78.6	84.4	
1936	87.1	85.8	84.8	84.2	70.3	59.3	63.4	65.7	68.4	74.7	79.4	81.9	
1937	87.7	87.4	84.2	84.3	81.2	67.2	61.7	64.4	67.4	74.1	79.2	83.5	
1938	88.2	87.5	77.6	64.0	63.9	52.0	47.1	51.7	53.7	58.3	72.4	82.4	
1939	85.9	80.6	84.1	83.6	80.7	78.4	76.5	76.7	77.0	82.0	83.3	87.0	
1940	89.3	84.9	85.6	85.8	71.3	61.3	53.8	54.6	64.8	75.2	78.0	83.0	
1941	87.5	87.3	81.9	68.8	56.8	51.1	51.7	53.3	58.2	67.5	75.4	81.6	
1942	85.1	85.3	84.1	66.1	57.4	50.2	62.2	59.6	60.7	67.2	75.0	83.2	
1943	85.0	84.5	84.1	73.3	59.3	57.8	54.1	61.0	65.1	73.8	76.8	83.8	
1944	87.3	87.2	84.0	84.7	81.0	73.1	72.0	74.7	75.1	78.5	82.7	83.0	
1945	88.0	86.9	82.5	80.9	81.1	66.8	67.5	71.3	71.8	75.9	79.8	82.6	
1946	87.9	87.4	81.9	64.6	61.8	64.8	69.7	72.4	72.2	76.3	79.9	84.8	
1947	88.6	86.1	82.1	81.6	81.3	76.5	73.6	74.9	77.2	80.7	83.4	84.3	
1948	88.4	86.3	84.6	85.4	81.3	77.4	76.2	69.2	66.2	72.3	78.6	84.3	
1949	87.4	84.2	84.2	82.7	81.4	79.0	67.7	72.4	74.3	78.1	82.5	84.8	
1950	88.6	86.7	84.2	85.1	78.1	69.5	71.3	70.6	70.8	75.2	79.6	81.2	
1951	87.0	87.1	69.5	57.2	55.2	54.6	62.1	68.5	68.3	77.8	77.2	83.9	
1952	87.5	86.7	82.0	69.0	57.9	55.3	55.7	55.4	55.0	59.3	72.8	82.5	
1953	81.5	79.9	79.9	66.6	55.6	63.7	68.6	70.7	67.9	71.5	74.7	83.1	
1954	84.4	85.8	82.4	83.5	72.3	62.5	61.1	61.2	65.7	76.9	78.5	84.4	
1955	86.1	85.3	82.8	77.7	76.6	75.7	78.4	75.5	74.8	78.9	82.8	83.2	
1956	88.1	86.8	84.0	62.4	50.6	52.0	59.1	65.8	62.1	69.3	76.0	83.5	
1957	83.9	84.1	85.3	83.9	81.0	70.8	64.5	67.9	70.4	75.5	77.9	84.1	
1958	87.5	84.4	82.9	77.0	68.2	51.9	51.6	51.0	55.8	62.4	73.8	82.8	
1959	81.7	82.7	84.8	83.0	71.0	62.6	66.5	74.3	76.3	79.6	79.1	84.5	
1960	87.1	86.6	83.4	85.1	81.7	72.5	72.3	74.3	75.0	80.7	82.9	82.1	
1961	87.7	87.4	82.7	81.9	81.4	73.5	74.6	75.9	76.9	81.0	82.9	82.6	
1962	87.9	87.4	83.0	83.0	82.7	67.7	68.8	73.1	73.6	78.8	79.8	84.8	
1963	87.5	74.1	81.7	75.1	76.6	61.5	64.5	55.9	60.7	71.0	73.8	82.8	
1964	85.5	85.5	77.1	82.3	75.6	75.5	78.1	74.8	77.0	80.6	83.3	84.1	
1965	88.4	87.1	82.1	63.7	53.8	61.2	66.9	62.0	65.5	73.7	75.9	83.5	
1966	86.5	87.0	80.0	78.9	70.6	69.1	69.3	72.9	73.8	79.9	80.4	85.0	
1967	88.0	85.5	82.6	70.6	63.4	59.9	58.3	58.0	57.8	60.0	73.0	82.5	
1968	79.6	77.8	83.2	80.2	70.4	61.2	62.8	69.7	75.1	79.7	80.5	85.0	
1969	88.7	84.8	84.1	76.5	57.9	50.8	54.6	56.2	55.9	60.4	73.1	82.6	
1970	83.9	79.7	82.3	65.5	49.7	51.5	58.8	67.6	71.1	79.4	76.0	83.5	
1971	85.1	86.5	81.4	65.5	62.0	64.6	62.6	66.6	65.8	72.8	74.3	83.0	
1972	84.9	85.7	84.3	81.3	80.2	74.3	69.5	74.0	76.8	75.7	79.7	83.8	
1973	88.3	85.9	79.1	76.0	60.7	54.6	56.4	66.0	68.8	74.3	77.7	84.1	
1974	87.7	86.9	67.9	60.0	51.9	59.0	53.0	54.0	62.5	70.9	76.3	83.2	
1975	80.9	84.1	85.3	81.3	80.9	64.1	56.1	63.2	64.0	69.2	76.0	83.5	
1976	81.8	81.0	84.1	84.3	81.4	79.7	78.1	79.4	84.4	84.9	81.7	87.6	
1977	89.5	87.2	86.4	85.4	84.5	82.1	82.3	81.2	84.5	84.6	82.6	87.3	
1978	89.5	88.4	85.3	82.1	64.4	59.6	56.5	59.1	64.5	69.9	76.2	82.3	
1979	85.6	86.7	84.4	83.3	74.7	65.5	64.4	68.6	70.3	74.4	79.3	84.3	
1980	88.5	86.3	82.6	78.5	59.9	51.5	55.3	64.4	67.4	74.7	77.8	82.0	
1981	85.1	86.5	85.2	82.0	76.8	71.9	69.0	71.3	75.7	81.0	83.5	82.8	
1982	87.0	86.7	74.4	59.9	55.8	52.4	52.4	48.8	55.6	64.9	74.6	80.2	
1983	82.0	75.3	66.4	57.0	52.1	46.6	42.1	48.8	52.2	52.5	61.7	73.2	
1984	68.9	67.2	57.7	49.4	53.2	58.8	62.2	67.9	71.7	76.6	76.2	83.6	
1985	87.8	86.2	74.1	74.8	79.1	76.9	75.1	75.8	75.3	81.0	83.5	84.4	
1986	86.4	85.9	83.8	81.4	75.4	53.2	48.5	60.6	68.3	74.5	77.7	81.7	
1987	86.2	86.9	84.8	84.1	80.8	76.4	71.4	74.2	78.1	80.8	83.4	86.7	
1988	89.2	85.4	85.7	80.7	72.8	74.6	77.9	79.3	80.7	81.0	85.2	84.6	
1989	88.6	88.7	84.4	84.8	80.9	80.0	67.7	69.9	74.1	79.1	82.8	86.7	
1990	87.3	84.7	85.1	84.1	79.5	76.7	78.5	77.4	80.2	84.9	84.9	85.4	
1991	88.8	89.7	84.7	86.0	84.7	82.2	72.1	74.4	78.8	84.5	85.1	85.1	
1992	88.7	89.7	85.2	83.8	83.8	72.1	72.6	75.1	80.4	81.0	85.2	85.6	
1993	88.9	88.7	85.3	82.8	64.6	59.8	60.2	61.4	62.6	67.9	75.6	83.4	
Avg.	86.5	85.5	82.2	77.6	71.6	66.4	65.9	67.8	70.3	75.2	79.2	83.7	
Min.	68.9	67.2	57.7	49.4	49.7	46.6	42.1	48.8	52.2	52.5	61.7	73.2	
Max.	89.5	89.7	86.4	86.0	84.7	82.2	82.3	81.3	85.0	84.9	85.5	87.6	

CEQA Mitigation Measures

APPENDIX A
CEQA MITIGATION MEASURES

The Trinity County Board of Supervisors submitted scoping comments to the Bureau of Reclamation on the Supplemental EIS for Trinity River Mainstem Fishery Restoration on May 21, 2002. Specifically, the Board asked that the SEIS examine 3 mitigation measures to reduce water resources impacts. The three mitigation measures were as follows:

1. A reduction in the 200-250 cubic feet per second (cfs) dilution/mobilization flows from the Spring Creek Powerplant into the Spring Creek arm of Keswick Reservoir that are currently used to dilute and mobilize acid mine drainage (AMD) from the Spring Creek Debris Dam and Iron Mountain Mine (IMM). Comments from the California Department of Fish and Game and the Central Valley Regional Water Quality Control Board indicate that, without compromising water quality, such a reduction may save up to 50,000 acre-feet of Trinity Lake storage, especially during drier years.

2. Full analysis and consideration of a program to retire waterlogged lands in the San Luis Unit of the CVP and other drainage problem areas in the western San Joaquin Valley and Tulare Basin, primarily in the Westlands Water District, with the water and power savings to be credited to the Trinity River, thereby eliminating impacts to Trinity Lake, CVP Power Customers, and other CVP water contractors (see below).

3. Consideration and analysis of the potential to use Safety of Dams (SOD) releases into the Trinity River in lieu of spring fishery releases. This analysis should consider the future frequency and magnitude of SOD releases under the Preferred Alternative, and the biological implications of higher flows in the winter, instead of higher flows in May and June, as would occur under the December 2000 ROD.

The proposed mitigation measures and their feasibility are discussed below. The analysis of these potential mitigation measures is pursuant to CEQA, not NEPA.

REDUCTION IN 200 cfs DILUTION FLOWS FOR ACID MINE DRAINAGE

While the CALSIM modeling for this SEIS/EIR assumes a constant 200 cfs release through the Spring Creek Tunnel for dilution and mobilization of AMD from IMM, real time CVP operations do not reflect that modeling assumption. The 200 cfs year-round release is based on a pre-Superfund dilution rate of AMD from IMM. The U.S. Environmental Protection Agency's Superfund work at IMM had previously contained 80-85% of the AMD. A combination of the IMM Superfund work, other mine remedial work upstream of Shasta Dam and the Shasta Dam Temperature Control Device (Shasta TCD) have provided Reclamation with much greater flexibility to meet water quality standards in the Sacramento River for AMD metals such as copper without a constant 200 cfs release from the Spring Creek Tunnel.

USEPA recently completed the Slickrock Creek Operative Unit of the IMM Superfund Site (Slickrock Unit). A dedication is planned in May 2004. The Slickrock Unit consists of a collection reservoir, conveyance system and treatment plant expansion which is expected to cumulative provide approximately 95% to 99% containment of AMD and metals from IMM.

Additionally, there are metal contaminants in Shasta Reservoir from other mines upstream of Shasta Dam. The Shasta TCD allows selective release of contaminated layers of water in the reservoir to ensure that water quality standards are being met. Furthermore, remediation work is ongoing at those mines to reduce metal contamination at the source.

For the reasons listed above, this mitigation measure is not considered feasible because real time operations of the CVP do not currently include a 200 cfs release from the Spring Creek Tunnel into the Spring Creek Arm of Keswick Reservoir. However, the fact that the modeling assumption used does not reflect actual CVP operations means that there is additional flexibility in CVP operations, and that other impacts identified may not be as significant as the modeling indicates.

LAND RETIREMENT MITIGATION MEASURE

Trinity County's proposed mitigation measure is to retire drainage-impacted lands in the San Luis Unit of the CVP. The water savings would provide mitigation for impacts to recreation at Trinity Lake by increasing storage, and to use any energy savings from reduced Delta pumping with CVP Project Use Power as mitigation for impacts to CVP power customers.

BACKGROUND

There is a direct relationship between the damming and diversion of the Trinity River and irrigation of the San Luis Unit of the CVP. State Water Permits issued to the Bureau of Reclamation by the State Water Board in 1959 were based on U.S. Bureau of Reclamation map No. 416-208-341 (see attached). Exhibit 17 <http://www.snowcrest.net/tcrcd/exhibita.htm> shows the 1959 expansion of the CVP Place of Use (POU) in the San Luis Unit associated with the Bureau of Reclamation's 7 state water permits to store and divert Trinity River water.

The maps show the expansion included more than half of the acreage within Westlands, including the areas with soils highest in selenium concentrations. The 1959 expanded CVP service area also includes many of the areas that Westlands has identified as having high groundwater and being desirable for land retirement (see map on page 2 of "*Why Land Retirement Makes Sense"* Westlands Water District, 2002 <http://westlandswater.org/drainage/drainage1.htm>).

Both the House (H.R. Rep. No. 602, 84th Cong., 1st sess. 4-5 (1955) and Senate committee reports (S. Rep. No. 1154, 84 Cong., 1st Sess. 5 (1955) for the 1955 Trinity River Act (P.L. 84-386) identified the San Luis Unit as one of the three areas targeted to receive Trinity River water. Westlands signed its contract for CVP water in 1963, the same year that the late President John F. Kennedy dedicated the Trinity River Division (TRD) of the CVP. Westlands actively supported passage of the Trinity River Act of 1955 through participation in the California Committee for Trinity River Development (Sayles, 1978).

Now that it is recognized that these lands have severe drainage problems, the Trinity County Board of Supervisors believes that the problem areas should be retired and the water should be returned to the county of origin, Trinity Lake and the Trinity River. Such a scenario would be consistent with the land retirement provisions of the Central Valley Project Improvement Act (Section 3408h, Public Law 102-575), which states: .

> *3408**(h) LAND RETIREMENT. -***
>
> *(1) The Secretary is authorized to purchase from willing sellers land and associated water rights and other property interests identified in paragraph (h) (2) which receives Central Valley Project water under a contract executed with the United States, and to target such purchases to areas deemed most beneficial to the overall purchase program, including the purposes of this title.*
>
> *(2) The Secretary is authorized to purchase, under the authority of paragraph (h) (i), and pursuant to such rules and regulations as may be adopted or promulgated to implement the provisions of this subsection, agricultural land which, in the opinion of the Secretary -*
>
> > *(A) would, if permanently retired from irrigation, improve water conservation by a district, or improve the quality of an irrigation district's agricultural wastewater and assist the district in implementing the provisions of a water conservation plan approved under section 210 of the Reclamation Reform Act of 1982 and agricultural wastewater management activities developed pursuant to recommendations specific to water conservation, drainage source reduction, and land retirement contained in the final report of the San Joaquin Valley Drainage Program (September, 1990) ; or*
> >
> > *(B) are no longer suitable for sustained agricultural production because of permanent damage resulting from severe drainage or agricultural wastewater management problems, groundwater withdrawals, or other causes.*

METHODOLOGY

Table 1 portrays a rough estimate of the potential water savings associated with the retirement of lands within the San Luis Unit of the Central Valley Project that are expected to require drainage service by the year 2050. The purpose of this analysis is to estimate an amount of CVP water that could be obtained from the retirement of drainage-impacted lands in the San Luis Unit. The water savings would then be dedicated to increase Trinity Lake storage to offset instream fishery flows as prescribed in the ROD for the Trinity River. The reduction in

project use power needs would also reduce power demands to help mitigate impacts to CVP power customers from loss of generation from implementing the Trinity ROD.

Table 1 was derived by obtaining acreage information for each district through Chris Eacock at the Bureau of Reclamation (USBR) in Fresno. The number of acres requiring drainage by 2050 was taken from estimates in the San Luis Drainage Feature Evaluation, Plan Formulation Report, USBR, December 2002 (pages 2-5 and 2-6). The maximum water savings associated with the retirement of these lands was calculated by multiplying the maximum contract amounts for each district by the percent of that district requiring drainage. Contract amounts were taken from a list of CVP contracts provided by Reclamation. Each district's total contract amount was calculated by adding all of its water contracts if more than one contract exists.

.

TABLE 1

District	Acres	Acres Requiring Drainage	% of District Requiring Drainage Service	Max Contract Amount (af)	Max Water Savings (af)	2002 Deliveries (af)	2002 Water Savings (af)
Broadview Water District	9,515	9,515	100.00%	27,000	27,000	18,588	18,588
Panoche Water District	39,292	27,000	68.72%	94,000	64,593	66,743	45,863
Westlands Water District	604,000	298,000	49.34%	1,154,198	569,455	776,631	383,172
Charleston Drainage District (portion of San Luis WD with drainage problems)	4,314	3,000	69.54%	8,130	5,654	Not avail	Not avail
Pacheco Water District	5,175	5,000	96.62%	10,080	9,739	7,137	6,896
Total	658,416	342,515	NA	1,293,408	676,441	859,099	454,519

The San Luis Drainage Feature Evaluation EIS is now considering land retirement as an alternative to completion of the San Luis Drain or construction of evaporation ponds and a treatment plant. The full impacts of retiring 200,000 acres of drainage-impacted lands in the San Luis Unit will be analyzed in that EIS.

It is the position of Trinity County that retirement of drainage-impacted lands in the San Luis Unit of the CVP is a feasible mitigation measure to reduce water supply and power impacts of implementing the Trinity ROD.

USE OF SAFETY OF DAMS RELEASES

The concept of using Safety of Dams releases in winter months in lieu of spring and summer flows was a common comment on the 1999 DEIS/EIR for Trinity River

Mainstem Fishery Restoration. The Thematic Response "Increasing Effectiveness of Releases by Accounting for Storm Flows" (page D2-39) addresses this issue. There is the potential through the AEAM program to synchronize peak releases with storm flows to achieve geomorphic objectives. However, spring biological objectives such as meeting smolt temperature criteria and preventing riparian seedling germination low on alternate bar surfaces would not be met by winter SOD releases. The thematic response leaves open the possibility of using SOD releases to achieve geomorphic objectives, but based only on sound scientific information and within a science-based AEAM program, once the AEAM program is developed, channel rehabilitation projects are implemented, and as our understanding of potential for redd scour improves.

This proposed mitigation measure is not feasible at this time, but has some potential as part of a fully developed AEAM program in the future.

Fishery Resources Technical Appendix B

Fishery Resources

Fishery Resources

Appendix B

Trinity River Mainstem
Fishery Restoration

Appendix B

1.0 FISHERY RESOURCES

Fishery resources include fish populations, their habitats, and the harvest of those populations. Extensive fishery resources are found within the Trinity River Basin, Lower Klamath River Basin/Coastal Area, and Central Valley. Many of the fish species found within the lower Klamath River Basin are also found within the Trinity River Basin. The coastal areas adjacent to the Klamath River Basin contain marine species as well as provide essential habitat for maturing and adult anadromous fish species that return to the Klamath and Trinity River Basins. The Trinity River Basin consists of the mainstem Trinity River, its numerous tributaries, high mountain lakes, and Trinity and Lewiston Reservoirs. In addition, within the Trinity River Basin, the Trinity River Salmon and Steelhead Hatchery (TRSSH) is intended to mitigate for the reduced salmon and steelhead production resulting from the loss of habitat upstream of Lewiston Dam by releasing chinook and coho salmon and steelhead young into the mainstem Trinity River. Table B-1 (all tables and figures are located at end of this appendix) summarizes the impacts to fishery resources (compared to No Action) associated with each alternative.

The following discussion describes the affected environment and the environmental consequences of the project on anadromous salmonid species, other native anadromous species, resident native species, non-native species, and reservoir species. Anadromous species spend their early life stages in fresh water, migrate to the ocean for maturation, and return to their natal stream to spawn. Resident species, on the other hand, spend their entire lives in the freshwater rivers or reservoirs of the affected project areas. A list of fish species found within the Trinity River Basin, including the Trinity and Lewiston Reservoirs, is shown in Table B-1. Species commonly found in other geographic areas of the affected project area are noted and discussed in those sections.

1.1 ANADROMOUS SALMONID SPECIES

1.1.1 Affected Environment

Native anadromous salmonid species currently found in the Trinity River Basin and the Lower Klamath River Basin/Coastal Areas includes spring, and fall chinook salmon (*Oncoryhnchus tshawytscha*), coho salmon (*O. kisutch*), and steelhead (*O. mykiss irideus*). In addition, coastal cutthroat trout (*O. clarki clarki*) are found in the Lower Klamath River Basin/Coastal Area. In the Central Valley, chinook salmon (fall, late-fall, spring, and winter) and winter steelhead, but not coho salmon and cutthroat trout, constitute the native anadromous salmonids in that geographical area.

1.1.1.1 Trinity River Basin

This section discusses the current status of anadromous salmonid resources and their habitats in the mainstem Trinity River, downstream of Lewiston Reservoir, and the factors influencing these resources. The following native anadromous salmonids are found in the mainstem Trinity River and its tributaries: fall and spring chinook salmon, coho salmon, and winter and summer steelhead (Table B-1). A description of sportfishing activity along the Trinity River was presented in the Recreation Technical Appendix D of the 1999 DEIS/DEIR.

Habitat Characteristics and Requirements. The anadromous salmonids native to the Trinity River Basin have similar life history characteristics. These species all begin life in fresh water as eggs and alevins (larval fish), which are hatched in gravely riffle area in the mainstem Trinity River or in its tributaries. Figure B-1 illustrates the generalized life history of anadromous salmon and steelhead. The time spent in fresh water as incubating eggs and alevins, or rearing fry (earliest free swimming life stage) and juveniles (pre-emigrating immature fish), and emigrating smolts (juveniles physiologically adapting for life in the marine environment) varies with each species, as does the time spent maturing in salt water before returning to their natal stream to spawn (reproduce). The generalized temporal distribution of chinook and coho salmon and steelhead is shown on Figure B-2.

Habitat needs of anadromous salmonids are similar, but each species does differ somewhat in its freshwater habitat needs. These differences are important and have implications from a resource management standpoint. Specific life history information for anadromous salmonids are provided in Table B-2. (A more detailed discussion of chinook, coho, and steelhead life cycles in the Trinity River can be found in Frederiksen, Kamine, and Associates, 1980, or U.S. Fish and Wildlife Service and Hoopa Valley Tribe, 1999.)

Adequate flows, temperatures, water depths and velocities, appropriate spawning and rearing substrates (e.g., riverbed gravels), and availability of instream cover and food are critical for the production of all anadromous salmonid fish. Spring chinook salmon and summer steelhead also need long-term adult holding habitat, in which pool size and depth, temperature, cover, and proximity to spawning gravel are important requirements. Newly emerged fry and juveniles of all species require rearing habitat with low velocities, open cobble substrate, and cool water temperatures. Emigration of smolts to the ocean and the immigration of adults require adequately timed flows with the appropriate temperature, depth, and velocity.

Populations. The following discussion considers population estimates of the anadromous salmonids in the mainstem Trinity River. A key to understanding anadromous fish populations is the concept of "escapement." Annual spawner escapement is defined as the number of fish of a particular species that successfully return from the ocean ("escape" harvest and natural mortality) to spawn within a specific river. For the purposes of this document, inriver spawner escapement refers to the number of returning fish (adult and jacks) that physically spawn in the river. Hatchery escapement refers to the number of adults and jacks that return from the ocean to the TRSSH where they are artificially spawned.

Other terms used in this discussion include the following:

- Naturally produced—refers to the progeny of fish that physically spawned in the river or its tributaries, without human intervention.

- Hatchery produced—refers to the progeny of fish that were spawned and raised at the TRSSH.
- Jacks (sometimes referred to as "grilse")—refers to sexually mature fish that return as 2-year old fish to spawn; nearly all jacks are male.
- Half-pounders—refers to sexually immature steelhead, which after residing in fresh water for up to 3 years and salt water for less than 1 year return to fresh water, but not for the intent purpose of spawning; half-pounders subsequently return to the ocean and make their spawning migration months to years later.
- Run size—the total estimated annual number of adults and jacks, including inriver spawner escapement and hatchery escapement, as well as inriver harvest by tribal fisheries and inriver sport anglers. Annual estimates of fall chinook salmon run size in the Trinity River Basin have been compiled by the California Department of Fish and Game (CDFG) since 1978, as a part of the Klamath Basin Fall Chinook Salmon Spawner Escapement Estimates (California Department of Fish and Game, 2003). (Attachment B1, Table B1-1). In addition, since 1977, fall and spring chinook salmon, coho salmon, and adult winter steelhead (in some years) run size, spawner escapement, and angler harvest have been estimated by CDFG. These run size estimates are derived in part from data collected at fish counting weirs are installed annually near Willow Creek and usually Junction City on the mainstem Trinity River. CDFG, Hoopa Valley Tribe (HVT), U.S. Fish and Wildlife Service (Service), and U.S. Forest Service (USFS) have also conducted annual summer steelhead surveys in several tributaries to the mainstem Trinity River to estimate the population of this species.

Trinity River Restoration Program Goals. The 1983 Environmental Impact Statement (EIS) on the Trinity River Basin Fish and Wildlife Management Program (U.S. Fish and Wildlife Service, 1983) documented the inriver spawner escapement goals and the TRSSH production goals established by the Trinity River Basin Fish and Wildlife Restoration Program (TRRP) as escapement numbers that could be met once restoration was completed. The inriver goals represent the total number of naturally produced adult spawners (excluding jacks) for the Trinity River Basin below Lewiston Dam and exclude fish caught by the fisheries. The hatchery goals represent numbers of adult fish needed by the hatchery, exclusive of fisheries for chinook and coho salmon (an undefined inriver harvest is included in the Restoration Program goal for hatchery steelhead). A summary of these restoration goals are shown as Table B-3.

Because the project purpose is the restoration and maintenance of the natural production of anadromous salmonids below Lewiston Dam, the following discussions concern the inriver spawner escapement goals (adults only) and the numbers of fish returns (jacks and adults) that were naturally produced. Restoration and maintenance of natural production implies that the fish spawning inriver began their life as eggs in the river (i.e., were not raised in the hatchery), and that a sufficient percentage of their eggs spawned in the river survive to return as adults to spawn; in other words, naturally producing populations are self-sustaining.

"Inriver spawner escapement," for the purposes of this report, is the number of returning fish that physically spawn in the river, which in reality consists of two factions: naturally produced fish and hatchery-produced fish. This term is analogous to the term "natural spawner

escapement" used by CDFG. However, we chose not to use the CDFG term because it is confusing in discussions pertaining to naturally and hatchery-produced fish. "Total basin escapement" refers to the total number of fish that spawned inriver plus those fish that were spawned at the TRSSH.

Hatchery-produced fish are not considered to contribute towards the inriver spawner escapement goals of the Trinity River Restoration Program, although their offspring do (i.e., if hatchery-produced fish spawn inriver and their offspring survive to return to spawn, these offspring are naturally produced by definition [see "natural production" in glossary]. The best available data indicate that large numbers of hatchery-produced fish spawn inriver. Typically, more fish spawn inriver than are spawned at the hatchery, and relatively fewer inriver eggs survive to return as adults. Assuming that hatchery and naturally produced fish are subject to the same environmental conditions after the hatchery releases its fish (typically as smolts), the relatively low returns of naturally produced fish are likely indicative of low survival rates of young freshwater life stages (eggs, fry, and/or juvenile fish).

Spring Chinook Salmon. Fisheries investigations conducted during 1942 through 1946, prior to the construction of the Trinity and Lewiston Dams, identified spring, summer, and fall chinook salmon populations in the Trinity River above the North Fork Trinity River (North Fork) confluence (Moffett and Smith, 1950). In 1955 an inriver spawner escapement estimate of 3,000 spring, 5,000 summer, and 24,000 fall chinook salmon upstream of Lewiston was reported by CDFG (California Department of Fish and Game/U.S. Fish and Wildlife Service, 1956). Contrary to these previous reports, Hubbell (1973) stated that review of data collected up to that time (1973) indicated that only spring and fall chinook salmon existed in the Trinity River, and since that time only estimates of spring and fall chinook salmon have been made by CDFG.

The Service (1983) estimated that prior to the construction of the dams, the average annual mainstem Trinity River spring chinook spawner escapement between the North Fork and Lewiston was approximately 3,500 adults. An additional 300-3,000 spring chinook were estimated to spawn annually upstream of Lewiston. For the years during 1978 through 2002, CDFG estimated that total spring chinook spawner escapements, upstream of the Junction City weir, have averaged approximately 16,000 and have ranged from approximately 2,000-55,000 fish (Attachment B1, Table B1-2). It must be noted that these estimates include hatchery fish spawned at the TRSSH and all spring chinook salmon (hatchery- and naturally produced fish) that spawned in the river. In recent years, estimates of the proportion of hatchery-produced and naturally produced fish contributing to the inriver spring chinook spawner escapement have been made (U.S. Fish and Wildlife Service, 1998 and CDFG, 2003). Escapement estimates for the years 1982 through 2002 (excluding 1983 and 1995) indicated that an average of approximately 82 percent (approximately 14,000) of the in-river spawner escapement of Trinity River spring chinook salmon were hatchery produced (Table B-5). Conversely, only 18 percent (approximately 3,217 annually) were naturally produced, which represents approximately 53 percent of the TRRP goal of 6,000 natural spring chinook in the Trinity River.

Fall Chinook Salmon. Annual pre-dam estimates averaged 45,600 fall chinook salmon, based on studies conducted during 1944, 1945, 1954, 1955, and 1963. Although limited in duration, these pre-dam estimates were the best numerical estimates available from the

pre-dam era for the mainstem Trinity River upstream of the North Fork confluence. A review of the literature indicates that, before the construction of Lewiston Dam, approximately 50 percent of the mainstem Trinity River fall chinook salmon above the North Fork confluence spawned above Lewiston (Moffett and Smith, 1950; Gibbs, 1956; LaFaunce, 1965). Fifty percent of the pre-dam average of 45,600 would represent approximately 23,250 adults and jacks in the Trinity River upstream of Lewiston, and 22,350 adults and jacks from the North Fork to Lewiston prior to construction of the dams (Table B-4).

CDFG's 1978 through 2002 fall chinook salmon run-size estimates for the Trinity River Basin upstream of the Willow Creek weir have averaged approximately 43,000 adults and jacks (Table B-5) and ranged from approximately 9,200 (1991) to 148,000 (1986). These estimates are shown in Attachment B1, Table B1-3. These estimates include inriver spawner escapements, TRSSH hatchery returns, and harvest (inriver anglers and tribal) for the entire Trinity River Basin above the Willow Creek weir. As shown in Table B-5, the average annual Trinity basin in-river spawner escapement estimate is approximately 39,600 fall chinook. However, as previously discussed, these estimates include a component of hatchery-produced chinook salmon that spawn in the Trinity River and not at TRSSH. Table B-5 provides an estimate of Trinity River naturally and hatchery-produced fall chinook salmon spawner escapement for the years 1982 through 2002 (Figure B-3). CDFG's post-dam inriver spawner escapement estimates for the Trinity River Basin upstream of the Willow Creek weir from 1982 through 2002 averaged 30,400 fall chinook salmon, of which an average of 12,047 fish are naturally-produced fish. Naturally produced fish have ranged from 10-94 percent of inriver spawner escapements, with an average of 42 percent (Table B-5).

Comparisons between pre- and post-dam averages are problematic because: 1) few pre-dam estimates exist, 2) pre-dam estimates typically represent fish spawning in the river above the North Fork, while post-dam estimates are above Willow Creek, and 3) post-dam estimates are only for the river below Lewiston and are confounded by large numbers of hatchery-produced fish that spawn in natural areas (recent changes have been enacted to reduce competition of hatchery-produced fish with naturally produced spawners).

Comparisons between pre-dam escapements and the TRRP inriver spawner escapement goals are also problematic because the inriver goals represent the numbers of fish that could be produced in the entire Trinity River Basin below Lewiston Dam once successful restoration is completed, whereas the pre-dam numbers are sporadic and limited to the Trinity River above the North Fork. Because of these problems, the following discussions focus on the current post-dam estimates relative to the TRRP inriver spawner escapement goals as an indicator. This is a conservative indicator because the TRRP goals represent adult returns and the numbers for naturally produced fish include jacks and adults (adult only information was not available).

According to the TRRP goals, the hatchery is to produce 9,000 returning fall chinook spawners for the hatchery, and the river below Lewiston is supposed to produce 62,000 naturally produced fall chinook spawners. Both these goals are exclusive of harvest.

The 1982-2002 mean annual estimated naturally produced spawner escapement upstream of Willow Creek is 12,047, approximately 19 percent of the restoration goal of 62,000 naturally produced fall chinook salmon for the Trinity River Basin (Table B-4). These estimates

indicate that a significant improvement in escapement must be made to meet the Trinity River restoration goals for fall chinook salmon. A complete summary of the Trinity River fall chinook salmon run sizes, in-river and hatchery escapements, angler harvests, and estimated proportions of naturally and hatchery-produced fish contributing to the inriver spawner escapements for the Trinity River for 1977 through 2002 are shown in Attachment B1, Table B1-3 (California Department of Fish and Game, 2003.

There were large runs of fall chinook salmon in the mainstem Trinity River during 1986 through 1989, and again in 1995 as compared to other years since 1977 (Attachment B1, Table B1-3). These years greatly influenced the long-term mean inriver spawner escapement estimates for the fall chinook salmon in the Trinity River. The large spawner escapements for the years 1986-1989 may have been related to wetter water years during brood years beginning in the 1983 water year. Wetter than normal water years and associated increases in streamflow may have resulted in improved habitat conditions during those brood years. These improvements in stream flows and habitat conditions may have also resulted in significant increases in smolt production and smolt out-migration success during those brood years. This in turn may have resulted in increased run sizes and spawner escapements beginning in the fall of 1986 and continuing through 1989. Harvest restrictions, particularly since 1985, and improved ocean conditions and survival may have also contributed to greater runs and spawner escapements during 1986-1989 and in 1995.

Coho Salmon. Coho salmon populations were historically much smaller than chinook salmon in the Trinity River. Holmberg (1972) reported that the estimated number of coho salmon in the Trinity Basin was approximately 8,000. An average annual pre-dam spawner escapement of approximately 5,000 adult coho above Lewiston was cited by CDFG and Service (1956). After construction of Lewiston Dam, coho in-river escapement estimates below Lewiston ranged from approximately 460-2,100 during 1969 through 1971 (Smith, 1975; Rogers, 1972; and Rogers, 1982). Leidy and Leidy (1984) reported that the returns to Trinity River Hatchery for the period 1973-1980 averaged 3,300 adults. The total Trinity River basin run size estimate for 1977 through 2002 has averaged 16,500 adult coho (CDFG, 2003) (Table B-5**).**

Averages for CDFG's annual coho run-size, inriver spawner escapement, TRSSH escapements, angler harvest, and proportions of naturally and hatchery-produced spawners contributing to the inriver spawner escapement estimates for the years 1977 through 2002 are shown in Table B-5. Since 1978, CDFG has estimated that coho inriver escapements have ranged from approximately 850 (1993) to 55,700 (1987) (Attachment B1, Table B1-4), with an annual average of 16,100 coho salmon (adults and jacks) upstream of the Willow Creek weir. These total basin escapement estimates indicate that recent post-dam spawner escapement may be as great or greater than the "pre-dam" estimates. However, like those estimates for spring and fall chinook salmon, these estimates include both TRSSH escapement and hatchery-produced adults that spawned in the river.

Estimates of the naturally produced coho salmon spawning in the mainstem Trinity River upstream of the Willow Creek weir for the years 1991-1995, and 1997-2002 have been made (CDFG, 2003). Table B-5 shows the average estimated spawner escapement of naturally and hatchery-produced coho salmon for those years. Since 1991 naturally produced coho salmon spawning in the Trinity River upstream of the Willow Creek weir averaged approximately

582 fish, ranging from 0-19 percent of the total annual escapement (an annual average of 7 percent). Approximately 93 percent (11,332) of the coho salmon spawning in-river are produced by the hatchery.

The estimated 582 naturally produced coho spawning in the mainstem Trinity River upstream of the Willow Creek weir represents approximately 42 percent of the restoration program spawner escapement goal of 1,400 for naturally produced adult coho (Table B-3).

Steelhead. Winter steelhead spawner escapements within the Trinity River and its tributaries upstream of Lewiston prior to the construction of the dams were estimated to range from approximately 6,900-24,000 adults (California Department of Fish and Game/U.S. Fish and Wildlife Service, 1956).

Winter steelhead spawner escapement estimates have been highly variable in the Trinity River and its tributaries since 1963. The 1964 steelhead spawner escapement estimate was approximately 8,000 fish (LaFaunce, 1965). A spawner escapement estimate of approximately 1,000 steelhead was made for the year 1972 (Rogers, 1973).

From 1980 through 2002 (for the years in which data is available), the estimated total basin escapement of winter steelhead spawning upstream of the Willow Creek weir has ranged from approximately 2,750 (1992) to 33,700 (1989) (Attachment B1, Table B1-5) and has averaged approximately 9,400 (California Department of Fish and Game, 2003). However, weir data is typically available for fall and early winter period only. Estimates for the remaining winter portion of the escapement are unavailable because increased river flows render weirs inoperable. Estimates of naturally produced winter steelhead for the years 1980, 1982, and 1992 to 1995 and 2002 were made by the CDFG (2003). On the average for those years, approximately 4,700 naturally produced winter steelhead spawned in the Trinity River upstream of the Willow Creek weir (Table B-5). However, this average is largely influenced by the 1980 and 1982 years. The average naturally produced inriver escapement for 1980 and 1982 was 10,675, while the average escapement for 1992-1995 and 2002 was approximately 2,326 adults. The overall average (4,711) represents approximately 12 percent of the restoration goal of 40,000 adult steelhead, while the 1992-1995 and 2002 average represents 6 percent of this goal (Table B-5). The latter average is more likely to represent the current status of the Trinity River steelhead population, because it is more recent, and fairly consistent from year to year. The data available for winter steelhead hatchery and inriver spawner escapements for the years since 1977 are shown in Attachment B1, Table B1-5.

Adult summer steelhead primarily hold in the headwaters of mainstem Trinity tributaries during the summer months, and subsequently spawn in the following late winter/early spring. Average annual summer steelhead inriver spawner escapements for the Trinity River upstream of Lewiston, prior to the construction of the dams, were estimated to average 8,000 adults (California Department of Fish and Game /U.S. Fish and Wildlife Service, 1956). In recent years, CDFG, Service, USFS, and HVT have conducted population surveys for these fish in the North Fork, South Fork, Canyon Creek, and New River tributaries and the upper Trinity River. Population estimates have ranged from a low of 20 adults in the South Fork in 1985 to 1,037 adult summer steelhead in the North Fork in 1991 (California Department of Fish and Game, 1997, unpublished). The estimated mean annual populations of summer steelhead from 1980-1996 are: 460 (North Fork), 40 (South Fork), 15 (Canyon

Creek), 11 (upper Trinity River), and 404 (New River). Summaries of those estimates are shown in Attachment B1, Table B1-6 of the Fishery Technical Appendix to the 1999 DEIS/DRIR.

The steelhead of the Trinity River are characterized by the unique "half-pounder" phase of their life history. An immature steelhead that returns to fresh water from the ocean during July-September after remaining in the ocean only a few months is referred to as a "half-pounder"(U.S. National Marine Fisheries Service, 1994). This phase includes the summer migration in which it does not spawn, followed by winter or spring emigration back to the ocean. These fish are typically 12-14 inches in length and are rarely greater than 16 inches (ACWA, 1995). Half-pounders are highly sought after by sportfishers.

Species Listed and Proposed for Listing under the Endangered Species Act (ESA). After a coast-wide status review by the U.S. National Marine Fisheries Service (NOAA-Fisheries), the Southern Oregon/Northern California evolutionarily significant unit (ESU) naturally produced coho salmon was proposed for listing as threatened on July 25, 1995. Under the ESA, an ESU is a population (or group of populations) that:

- Is substantially reproductively isolated from other nonspecific population units
- Represents an important component in the evolutionary legacy of the species

On October 24, 1996, NOAA-Fisheries extended the period of review and final determination of this ESU's proposed listing for 6 months until April 25, 1997. On June 5, 1997, NOAA-Fisheries announced its final action that this species would be listed as threatened in the California range of its distribution, which includes the Trinity and Klamath River Basins.

Additionally under the ESA, the Klamath Mountains Province ESU steelhead, which includes stocks from the Trinity River, were proposed for listing as threatened on March 16, 1995. On July 31, 1996, NOAA-Fisheries determined that this species warranted listing as a threatened species under ESA, but the decision to list the species was deferred on August 11, 1997, for 6 months to gather more scientific information. A final ruling on its status was made on April 4, 2001, when NOAA-Fisheries determined that this species did not warrant listing as threatened at that time.

Factors Influencing Trinity River Basin's Anadromous Salmonid Populations.
Trinity River Salmon and Steelhead Hatchery. TRSSH was constructed by the U.S. Bureau of Reclamation (Reclamation) in 1963 and is operated by CDFG to mitigate for the loss of salmonid habitat and production above Lewiston Dam due to construction of the Trinity River Division (TRD) of the Central Valley Project (CVP). The hatchery was modernized in 1991 as part of the TRRP. The TRSSH's current goals are to produce sufficient juveniles to provide for returns to the hatchery (exclusive of harvest) of 12,000 chinook salmon (3,000 spring; 9,000 fall); 2,100 coho salmon; and 10,000 steelhead. Fingerling and yearling production of chinook, coho, and steelhead at the TRSSH (and its predecessor facilities) from 1958 through 1996 are summarized in Attachment B1, Table B1-7 of the 1999 DEIS/DEIR Fishery Appendix. Since that time (January, 1997) the TRSSH has operated under new stocking goals and constraints criteria. These goals and constraints are summarized in Table B-6.

Hatchery operations, including the magnitude and the timing of hatchery releases and the subsequent return of adult hatchery-produced fish, can directly affect the behavior, growth, survival, and ultimate success of naturally produced salmon and steelhead. Factors such as competition, predation, and disease organisms transmitted by hatchery-produced fish may adversely affect naturally produced anadromous salmonids within the Trinity River Basin. In a 1991 study of hatchery- and naturally produced juvenile chinook, coho, and steelhead, TRSSH coho juveniles were found to be in poor health resulting from bacteria kidney disease (Foote and Walker, 1992). The diseased coho juveniles may have influenced smolt survival of several naturally produced Trinity River Basin salmonid stocks (Foote and Walker, 1992).

Annual numbers (adults and jacks) of chinook, coho, and steelhead entering TRSSH (or its predecessor facilities) since 1958 are shown on Figure B-4. Since the beginning of operations, there have been two periods of significantly increased numbers of chinook returning to the TRSSH (Figure B-4). The numbers of chinook salmon trapped at the TRSSH peaked in 1988 with more than 20,000 fall and 16,000 spring chinook entering TRSSH. More than 23,000 coho entered the TRSSH in 1987-1988. Except as noted above, since the peaks of the 1980s, TRSSH returns of chinook and coho salmon have generally decreased. Since operations began, the numbers of steelhead entering the TRSSH have varied widely, ranging from 13 fish in 1976-1977 to nearly 7,000 in 1964-1965 (Figure B-4). Since 1990, there have been less than 1,000 adult steelhead trapped annually at the hatchery.

Introductions of Klamath River fall chinook salmon juveniles raised from eggs reared at the TRSSH were made into the Trinity River during 1971, 1977, and 1983 (California Department of Fish and Game, TRSSH Reports: 1971, 1977, and 1983) (Table B-7). Since 1983, no additional fall chinook salmon genetic stocks have been introduced into the Trinity River Basin.

Native Trinity River coho salmon stocks have been potentially intermingled with four out-of-basin coho stocks introduced by the TRSSH since 1965 (Table B-7). Coho salmon juveniles, reared from eggs at the TRSSH, from the Eel and Noyo Rivers (California) were introduced into the Trinity River in 1965 and 1970, respectively (California Department of Fish and Game, TRSSH Reports: 1965 and 1970). Juvenile coho salmon from genetic strains from Alsea River Hatchery (Oregon) were introduced into the Trinity River in 1970 and 1971 (California Department of Fish and Game, TRSSH Reports: 1970 and 1971). Juvenile coho salmon from the Cascade Hatchery (Oregon) were also introduced in 1970. No other coho salmon stocks from out-of-basin sources have been introduced into the Trinity River since 1971. The impact of these introductions are not understood at the present time.

Native Trinity River winter steelhead stocks may also have been intermingled with introduced steelhead from outside the Trinity River Basin (Table B-7). In 1963, American River (California) fall steelhead fry were received and reared at the TRSSH until they were planted into the Trinity River in the spring of 1964 (California Department of Fish and Game, TRSSH Report 65-5). Juvenile winter steelhead reared from eggs received from the Cowlitz River Hatchery (Washington) in 1969, and juveniles from the Roaring River Hatchery (Oregon) were planted into the Trinity River at China Slide in 1970 and 1971 (California Department of Fish and Game, TRSSH Reports 70-19 and 72-4). Winter steelhead fry and juveniles reared from eggs transferred from the CDFG's Iron Gate Hatchery on the Klamath

River were released at TRSSH beginning in 1971 and continued yearly through 1987 (California Department of Fish and Game, TRSSH Reports: 1970-1988) (Table B-7).

Summer steelhead stocks from two hatchery sources outside the Trinity River Basin have been introduced into the basin: Cedar Creek Hatchery (California) and Skamania Hatchery (Washington) were introduced into the Trinity River from eggs reared to fry or juveniles and released at the TRSSH during 1971 through 1975. (Table B-7) (California Department of Fish and Game, TRSSH Reports: 1971-1976).

The precise impacts on natural anadromous populations downstream of Lewiston from releases of salmonids from the TRSSH are unknown. Hatchery fish pose six primary threats to naturally produced fish (Hilborn,1992):

- Direct competition for food
- Predation of hatchery-produced fish on naturally-produced fish
- Genetic dilution of native fish stocks by hatchery fish allowed to spawn inriver
- Increased fishing pressure on naturally produced stocks due to hatchery production
- Disease transmission from hatchery-produced fish to naturally produced fish
- Direct competition for habitat

Recent concerns involving the potential impacts of hatchery operations on the naturally producing stocks of the Klamath Basin (including the Trinity River) prompted the CDFG to hold a workshop to address these concerns and revise their hatchery operation procedures. New hatchery operating procedures were instituted in 1997 to minimize the potential impacts of hatchery-produced fish on naturally producing stocks.

Recently adopted TRSSH operations designed to minimize impacts include:

- All mature salmon returning to the hatchery are processed and destroyed, in order to reduce the occurrence of hatchery stock spawning with natural stocks. Allowing all hatchery fish (including surplus spawners) entry to the hatchery also reduces competition between hatchery- and naturally produced stocks for appropriate spawning sites. Steelhead are spawned and returned to the river because, unlike salmon, they are capable of spawning in subsequent years.

- Juvenile salmonids from TRSSH are released to mimic natural out-migration patterns at Lewiston prior to dam construction, which are slightly delayed relative to outmigrating naturally produced juveniles in the river reach below Lewiston (Table B-6).

- Hatchery production goals are not to be exceeded (Table B-6).

Fish Harvest. The harvest of Klamath River Basin fall chinook salmon (including Trinity River Basin) is managed jointly by the CDFG, Oregon Department of Fish and Wildlife, California Fish and Game Commission, (Commission) Yurok Tribe, HVT, NOAA-Fisheries, and Bureau of Indian Affairs (BIA). The Pacific Fishery Management Council (PFMC) and the Klamath Fishery Management Council (KFMC) are allocation forums for the ocean and ocean/in-river fisheries, respectively. The mixed-stock ocean population is harvested by commercial and sport fisheries; and the in-river population is harvested by tribal (ceremonial, subsistence, and commercial) and sport fisheries. Chinook salmon harvest (both spring and fall runs) includes both naturally and hatchery-produced fish. Coho harvest in the ocean

commercial troll fishery has been prohibited in California and Oregon, and reduced in Washington, since 1994. Coho harvest has also been prohibited in the California ocean sport fishery, and reduced in Oregon. Coho harvest is allowed in the tribal in-river fisheries and currently occurs as incidental take during the harvest of chinook salmon. Steelhead are rarely caught in the ocean commercial and sport fisheries, but are harvested by the in-river tribal and sport fisheries. Frederiksen, Kamine, and Associates (1980) stated that ocean harvest of naturally produced salmon stocks had been sufficient to have caused steady declines in Trinity River spawner escapements at the time of their report. Historically, Klamath/Trinity River chinook and coho populations have been harvested in the ocean from Monterey County, California, to the Oregon/Washington border. Ocean harvest of naturally produced salmon may have been sufficient in the late 1970s to cause declines in Klamath River Basin (including Trinity River) populations, but fall chinook harvest management restrictions implemented since 1986 have decreased harvest impacts to levels believed to be sustainable, based on the best available data. A description of sportfishing activity along the Trinity River is presented in the Recreation Resources Technical Appendix D of the 1999 DEIS/DEIR. Information on tribal fisheries is presented in the Tribal Trust section (3.6) of the 1999 DEIS/DEIR.

Habitat Conditions. Reduced river flow due to the construction and operation of the TRD, combined with excessive watershed erosion, large-scale gold dredging, and other harmful land management activities, have caused major changes in the inriver habitat conditions of the Trinity River (U.S. Fish and Wildlife Service, 1994) since the construction of the Trinity and Lewiston Dams. Factors that have resulted in adverse effects on fish habitat (Frederiksen, Kamine, and Associates, 1980) include the following:

- Obstruction to the river reaches upstream of Lewiston Dam
- Changes in natural flow regime in both quantity and timing
- Changes in water temperature.
- Changes in river channel geomorphology and restriction of river meandering
- Changes in substrate composition, addition of fine sediments, and restriction of gravel recruitment

The quantity and quality of anadromous fish habitat have been seriously reduced since construction of the TRD. The dams blocked fish access to 59 miles of chinook salmon habitat, 109 miles of steelhead habitat, and an undetermined amount of coho salmon habitat (U.S. Fish and Wildlife Service, 1983). Much of this habitat was prime spawning and rearing habitat. In the case of chinook salmon, this habitat represented 50 percent of the spawning habitat in the Trinity Basin. Furthermore, elimination of the upstream reaches, which were dominated by snowmelt and hydrologically different from the river habitats downstream of Lewiston, greatly reduced the diversity of the entire river system, thereby reducing habitat choices for salmonids.

Reduced river flows and disruption of the sediment flow in the mainstem (post-TRD), as well as altered watersheds (both pre- and post-dam), have altered geomorphic processes, particularly in the mainstem above the confluence of the North Fork. For the first 21 years of TRD operations, Trinity River flows were only 21 percent of natural flows. Perhaps more signifi-

cantly, the peak winter and spring flows were eliminated or greatly reduced. The harmful effects of the reduced flows were manifested in several ways, including changes to channel geomorphology, substrate composition, and water temperatures. Ultimately, the reduction in flows has lead to a reduction in habitat, as evidenced by sand filling in holding pools of adult salmonids, increased fine sediment accumulation in river substrates, and increased channelization of the mainstem (which has made the river banks more vertical and does not allow lateral movement of the channel within the floodplain). The effects of these processes have significantly reduced total wetted habitat and salmonid spawning and rearing habitat area and suitability in the mainstem Trinity River below Lewiston Dam (Frederiksen, Kamine, and Associates, 1980). For example, spawning habitat losses have been estimated to be 80 percent in the first 2 miles below Grass Valley Creek, and at 50 percent in the next 6 miles since construction of Lewiston Dam (California Resources Agency, 1980).

Since the completion of the dams, the degradation of habitat, beginning downstream of Lewiston and adversely affecting approximately 40 river miles (RM) downstream to the North Fork, has generally been accompanied by a decline in salmonid populations (Frederiksen, Kamine, and Associates, 1980). Shallow riffles have been replaced by glides and deeper water habitats, resulting in reduction in total habitat areas suitable for the production of food organisms (Frederiksen, Kamine, and Associates, 1980). Reduced river flows and changes in sediment input are the primary factors in changes to channel geomorphology and, therefore, the degradation of fish habitat. The altered channel geomorphology includes a reduction in the number and quality of alternate bar sequences. Important salmonid habitats associated with alternate bars include: pools that provide cover from predators and cool resting places for juveniles and adults; gravelly riffles where adults typically spawn; open gravel/cobble bars that create shallow, low-velocity zones important for emerging fry; and slack water habitats for rearing juveniles.

Since TRD operation, the Trinity River has become channelized, i.e., the river banks have become more vertical, and there is little lateral movement of the channel within the floodplain. The static nature of the altered river has allowed the root systems of riparian plants to encroach into the river channel. The roots bind spawning gravel and encourage the formation of sand berms along the river banks. This encroachment of riparian vegetation and subsequent berm formation further narrows the channel and reduces shallow, low-velocity salmonid rearing habitat and habitat diversity (see the Geomorphic Environment section [3.2] of the 1999 DEIS/DEIR for additional information).

Changes in substrate composition have occurred because of increases in fine sediment (from increased watershed erosion and attenuation of sediment-transporting flows) and the reduction of coarse sediment (e.g., gravel) recruitment (due to the dams). Fine sediment fills in spaces between gravels and cobbles, which inhibits the percolation of water through these areas. This accumulation of fine sediment decreases survival of eggs and sac-fry and decreases the amount of habitat for overwintering juvenile coho and steelhead (which burrow between gravels and cobbles). Fine sediment accumulation may have also impacted habitat for aquatic invertebrates, which are the primary food source for juvenile salmonids.

Seasonal changes in water temperature and turbidities since the construction of the TRD, particularly in the reach from Lewiston to the North Fork, have been observed (Frederiksen, Kamine, and Associates, 1980). On the average, and prior to the construction of the TRD,

water temperatures in the Lewiston-to-North Fork reach of the mainstem Trinity River were warmer than current water temperatures during the migration, holding, and spawning periods of spring chinook salmon. Temperature conditions in the Trinity River during the late summer baseflow periods have been more favorable (cooler) to rearing salmonids than those prior to the construction of the TRD because of an overall increase in summer baseflow. (For more information on flows and temperatures, see the Water Resources section [3.3] of the 1999 DEIS/DEIR.) These changes in water temperatures have implications on the temporal and geographic distribution and life history attributes of the fish resources in the Trinity River.

Construction and operation of the TRD changed the thermal diversity available to Trinity River anadromous salmonids. The dams blocked access to the cool upstream reaches that are dominated by snowmelt runoff and remain cool throughout the year. Prior to the dam, these areas provided important juvenile rearing and adult holding habitats for salmonids when the majority of the lower mainstem habitats (i.e., below Lewiston) had likely become too warm. The upstream tributaries (dominated by snowmelt) provided increased flows and decreased temperatures during the spring and early summer that aided smolt emigration through much of the mainstem. Because these habitats are now blocked by the TRD, and much of the snowmelt is retained in the TRD reservoirs, it is necessary to artificially maintain cooler temperatures below the dam than those that existed prior to the dam. In other words, the mainstem below the dam must now function thermally like the upstream reaches and tributaries (for anadromous salmonids). Exacerbating the problem is the decrease in geomorphic diversity below the dam. Prior to the TRD, water temperatures in the deep mainstem pools stratified; bottom layers were documented as much as 7 degrees Fahrenheit (°F) cooler than upper layers (Moffett and Smith, 1950). The cool temperatures at the bottom of the pools provided important thermal refugia for migrating adult and rearing juvenile salmonids. The altered flow regime and channel geomorphology decreased or eliminated the temperature stratification in pools in the summer/early fall months. Although average post-dam monthly water temperatures at Lewiston are cooler than pre-dam temperatures during June-November, this benefit has not fully compensated for the lost thermal diversity in the system (i.e., above the dams) or for the reduction in stratified pools.

The Trinity River also has a significant influence on the water temperatures in the Klamath River downstream of it's confluence at Weitchpec. Cool water releases from Lewiston Dan during the warm months can benefit anadromous species and their habitats not only within the Trinity River, assisting in rearing, immigration, and smolt outmigration, but also benefits the Klamath fishery. In 2002, low flow conditions in the Lower Klamath River, warm water temperatures, and an above average fall run Chinook salmon escapement combined to create conditions favorable to an epizootic outbreak resulting in a huge fish die-off (TRPP, 2003). At a hearing in response to this die-off, Federal District Court Judge Oliver Wanger directed the Department of the Interior to determine what actions would be necessary to "assure against the risk of fish losses that occurred…." (in 2002). Subsequently, in April, 2003 a ruling also allowed Reclamation to use an additional 50,000 acre-feet of water from the Trinity River Division of the CVP to prevent a recurrence of the September, 2002 fish die-off. In a summary report of the monitoring of that flow release, the Trinity River Restoration Program concluded that the implementation of the 2003 Trinity River Fall Flows Action Plan was successful in reducing the risk of a major die-off event in 2003. A memorandum outlining the methodology and results of the flow releases made by Reclamation during the

late-summer of 2003 in response to these orders are attached to this Appendix as Attachment B2.

Finally, in it's investigation on the causes of decline and strategies for recovery of the endangered and threatened fishes in the Klamath River Basin, the National Academy of Sciences final report (NAS, 2003) recommended: "That it is vital that management of the Trinity River, including releases from Lewiston Dam be viewed in the context of the entire Klamath watershed" (NAS,2003). Furthermore the Report states: "While it may be attractive to use Trinity flows to influence conditions in the Lower Klamath River, it must not occur at the expense of the Trinity River restoration goals" (NAS, 2003).

Food Production. During the freshwater phase of their life history, the major food source of anadromous salmonids are aquatic benthic macroinvertebrate (insect) organisms. The production of these organisms occurs on the constantly submerged (wetted) portions of a streambed (Frederiksen, Kamine, and Associates, 1980). The particle size and substrate material of the wetted streambed can greatly affect the production of this food source. Boles (1980) found that when a riffle in the Junction City reach of the Trinity was flushed of its load of granite sand, a marked increase in productivity, biomass, and diversity of benthic organisms occurred.

Food production capability within the mainstem Trinity River was good and compared favorably with that of the North Fork and the Smith River, which have not been impacted by siltation and water diversions (Frederiksen, Kamine, and Associates, 1980). Results of aquatic insect studies, which monitored the mainstem Trinity River upstream of the North Fork confluence, indicated that over the course of the multi-year study, improvements have occurred in the biotic condition indices (BCI) measured at six sampling locations, but habitat conditions could be improved (Mangum, 1995). These results indicated that good to excellent potential food conditions exist at the study sites monitored downstream of Lewiston, particularly for larger juvenile fish (Mangum, 1995). From these investigations it appears that benthic food production may not be a major factor in limiting fish production in the mainstem Trinity River at the current time.

Habitat Restoration Projects. Since the early 1980s, the Trinity River Basin Fish and Wildlife Restoration Program conducted a variety of restoration activities in the mainstem Trinity River and its tributaries. Some activities conducted in tributaries include watershed restoration work as well as habitat enhancement projects, and dam construction and pool dredging in Grass Valley Creek to decrease the amount of fine sediment entering the mainstem Trinity River. Restoration activities that have been implemented in the mainstem include gravel placement, pool dredging, and construction of several channel rehabilitation projects (side channels and bank rehabilitation of point bars).

The Trinity River Basin Fish and Wildlife Restoration Program constructed twenty-seven channel rehabilitation projects on the mainstem Trinity River between Lewiston Dam and the North Fork: 18 side-channel projects and 9 bank rehabilitation projects (also known as feathered-edge projects). Monitoring documented chinook salmon spawning within the constructed side-channels. Observations also indicate that the side-channels are used extensively during the spring by rearing chinook salmon juveniles.

The remaining nine projects were bank rehabilitation projects between Lewiston Dam and the North Fork Trinity River. The projects were constructed by physically removing vegetated sand berms along the bank to restore the channel to a pre-dam configuration. Channel rehabilitation sites are significantly wider and shallower than corresponding control sites at intermediate and high flows. Along with promoting formation of alluvial features characteristic of unregulated rivers, channel rehabilitation projects have been shown to increase the amount and diversity of habitat for adult and juvenile salmon and steelhead. During recent investigations, salmonid fry habitat indexes were greater at rehabilitation sites than at corresponding control sites. Catch per effort for chinook salmon fry was also greater at rehabilitation sites than at control sites, suggesting greater habitat use at these sites. Spawning surveys at project locations have also shown high use of these areas by spawning chinook salmon.

1.1.1.2 Lower Klamath River Basin

The Klamath River is California's second largest river, with an average annual water yield in excess of 13 million acre-feet (maf). Like the Trinity Basin, the lower Klamath River Basin provides habitat for anadromous spring and fall chinook salmon, coho salmon, and steelhead. In addition, coastal cutthroat trout frequent the lower reaches of the basin. All anadromous fish from the Trinity Basin must migrate through the lower Klamath Basin and estuary. The estuary at the mouth of the Klamath is an important rearing and migration area for these anadromous species. Approximately 80 percent of the Native American salmon gill-net fishery occurs within the lower Klamath River, as well as a sport fishery for chinook and coho salmon, steelhead, and coastal cutthroat trout. A description of sportfishing activity along the lower Klamath River is presented in the Recreation Technical Appendix D in the 1999 DEIS/DEIR.

Habitat Characteristics and Requirements. Habitat requirements and characteristics for anadromous salmonids in the lower Klamath River Basin are similar to those discussed for the Trinity River Basin (refer to Trinity River Basin Habitat Characteristics and Requirements). The lower Klamath River Basin provides significant seasonal habitat for anadromous salmonids. Causes for the decline of the numbers of salmonids in the Klamath River Basin have been attributed to land use, water diversions, harvest, ocean conditions, dams, and inriver habitat conditions (California Department of Fish and Game, 1992b). Some of these activities are thought to have degraded juvenile salmonid rearing and nursery habitats (California Department of Fish and Game, 1997.).

Water quality of the Klamath River has been negatively effected by nutrient-rich agricultural runoff. Runoff from the upper Klamath Basin (including reservoirs) contains many inorganic compounds that lead to large plankton blooms, which can make the river turbid in appearance. As evidenced by field crews above Weitchpec during 1997, warm water and high phytoplankton abundance can also periodically lead to low dissolved oxygen levels, which can have a negative effect on fish survival. With increasing distance from Iron Gate Dam, however, the water quality improves through dilution by tributaries, including the Trinity River, largest of tributaries (see Water Quality).

CDFG (1992a, 1992b, 1993a, 1993b, 1994a, 1994b, and 1995) has been conducting investigations to describe fish habitats and monitor water quality in the lower Klamath River and

estuary. Their findings have determined that seasonal habitat changes occur as plant growth (especially algae) and fine sediments gradually increase in the summer and fall seasons due to decreased river flows and increased water temperatures. A sand bar occasionally closes the estuary and impounds the outflow of the Klamath River during this time. Salt water dominates the estuary during these months of high biological productivity, and a resulting salt wedge provides thermal refuge for rearing salmonids during the warm summer and fall months.

Populations. Since 1978, CDFG has compiled the inriver and hatchery spawner escapements and Indian net and angler harvests for fall chinook salmon for the Klamath Basin including the lower Klamath and Trinity River Basins. These estimates are compiled annually and are referred to as the "mega-table" (Attachment B1, Table B1-1). Harvest (ocean and inriver combined) of fall chinook salmon is managed for a 33-34 percent escapement for all brood years, or a minimum inriver spawner escapement level (floor) of 35,000 fall chinook salmon adults, whichever is greater. These harvest goals were established in 1989 by the PFMC on the recommendation of the Klamath River Technical Advisory Team (PFMC, 1997). Factors influencing the anadromous salmonid populations inhabiting the Klamath River Basin include: Iron Gate Hatchery operations, harvest (both inriver tribal and sports fisheries, and ocean commercial and sport fisheries), freshwater habitat conditions (including flows from the Trinity and upper Klamath River and its major tributaries, such as the Shasta and Scott Rivers), and ocean productivity conditions.

A description of sportfishing activity along the lower Klamath River is presented in the Recreation Resources Technical Appendix D of the 1999 DEIS/DEIR. Information on tribal fisheries is presented in the Tribal Trust section (3.6) of the 1999 DEIS/DEIR.

1.1.1.3 Coastal Area

The coastal area adjacent to the Klamath River Basin provides habitat for the maturing and adult life stages of the anadromous salmonids found in the lower Klamath and Trinity River Basins. Habitat conditions in this coastal near shore and ocean environment are subject to natural productivity as affected by physical and biological oceanic processes, atmospheric weather, and climate patterns. The influence of humans on anadromous salmonid populations in the coastal areas adjacent to the Klamath River Basin is primarily a result of commercial and recreational harvest activities. The 1999 DEIS/DEIR described recent ocean sport and commercial salmon fishing activity for the six study regions along the California and Oregon coast that could be affected by the project.

1.1.1.4 Central Valley

Habitat Characteristics and Requirements. The Central Valley of California provides essential habitat for the freshwater life stages for chinook salmon as well as steelhead. Within the Central Valley, the Sacramento and San Joaquin Rivers provide corridors for the anadromous salmonids resources found within the valley. The Sacramento River is the largest river system in California and produces more than 90 percent of the Central Valley salmon and steelhead. The Sacramento River supports four runs (races) of chinook salmon: fall, late-fall, winter, and spring. Fall chinook is the predominant salmon in the Central Valley. Fall steelhead are also found in the Central Valley with almost the entire population

restricted to the Sacramento River system. Unlike the Trinity and Klamath River Basins, the Central Valley is not known to contain coho salmon or cutthroat trout. Estimates of the abundance of the chinook salmon and steelhead populations found in the Central Valley are shown in Tables B1-8 and B1-9 in Attachment B1 of the 1999 DEIS/DEIR Fishery Appendix.

Limiting Factors. Major limiting factors in the Central Valley that have affected anadromous salmonids (U.S. Fish and Wildlife Service, 1995) include the following:

- Diversions, such as the Red Bluff Diversion Dam/Tehama-Colusa Canal; the Glen-Colusa Irrigation District Canal; the Anderson-Cottonwood Irrigation District Canal; and hundreds of small unscreened diversions throughout the Sacramento and San Joaquin Rivers and the Sacramento-San Joaquin River Delta (Delta)
- Blockage of habitat by major dams (i.e. Shasta Dam)
- Water diversions at the state and federal pumps in the Delta
- Increased water temperatures within the Central Valley rivers and the Delta
- Habitat loss and degradation in the rivers and the Delta
- Industrial, municipal, agricultural, and mining waste discharge that degrades water quality
- Predation by introduced species
- Inadequate instream flows within the rivers and reduced outflows in the Delta

Approximately 25 percent of all warmwater and anadromous sportfishing and 80 percent of the state's commercial fishery are dependent on species that live in or migrate through the Delta. Most of the state's anadromous fish, including several state Species of Special Concern, inhabit the waters of the Delta.

Delta outflow plays a key role in influencing the abundance and distribution of fish and invertebrates in San Francisco Bay through changes to salinity, currents, nutrient levels, and pollutant concentrations. The response of organisms to Delta outflow is species and life-stage dependent. The effect of Delta outflow on San Francisco Bay aquatic organisms is determined by timing, magnitude, and duration of the outflow. Fluctuations in water temperature also play an influential role in the productivity of the Bay. The San Francisco Bay provides essential migration and rearing habitat for the anadromous salmonid species of the Central Valley. These species migrate through the bay on their way to and from the ocean as well as rear on their way out of the system.

Species Listed or Proposed for Listing under the Endangered Species Act (ESA) or the California Endangered Species Act (CESA). Special-status anadromous salmonids found in the Central Valley include the federal and State of California endangered winter chinook salmon. Winter chinook salmon were listed endangered under the California Endangered Species Act (CESA) in 1989 and were declared threatened by NOAA-Fisheries on November 5, 1990. NOAA-Fisheries reclassified winter chinook salmon as endangered on January 4, 1994. On June 16, 1993, NOAA-Fisheries published the final rule designating the critical

habitat for this species as the Sacramento River from Keswick Dam (Shasta County) to Chipps Island at the westward margin of the Delta. In addition, all waters westward of Chipps Island to Carquinez Bridge, all of San Pablo Bay, and San Francisco Bay north of the San Francisco/Oakland Bay Bridge were designated as critical habitat for winter chinook salmon (U.S. National Marine Fisheries Service, 1997).

The Central Valley ESU steelhead was proposed for listing as threatened under the federal ESA March 16, 1995. On July 31, 1996, NOAA-Fisheries determined that this species warranted listing as a threatened species under ESA, but the decision to list the species was deferred on August 11, 1997, for 6 months to gather more scientific information. A final ruling on its status resulted in the listing of this species as threatened on May 18, 1998.

In April of 1996, the Commission rejected a petition submitted to list the Sacramento River spring chinook salmon as an endangered species under CESA. However, in February 1997, the State of California Superior Court in San Francisco ruled that the Commission committed an error in their finding that the listing of the Sacramento River spring chinook salmon as endangered was not warranted. This resulted in the conclusion by the Commission that the species should be listed as a candidate for endangered status and required CDFG to submit a report to the Commission within one year indicating whether the species should be listed. The State of California listed Sacramento River spring chinook salmon as threatened on February 6, 1999.

In March 9, 1998, NOAA-Fisheries proposed spring chinook salmon ESU as endangered, and fall and late-fall chinook salmon ESU's were proposed as threatened in the Central Valley. On September 9, 1999, NOAA-Fisheries announced that the Central Valley spring chinook ESU was listed as threatened on or about November 15, 1999. The fall/late-fall ESU remains a Federal candidate species.

1.1.2 Environmental Consequences

1.1.2.1 Methodology

Trinity River Basin. The salmon pre-smolt production model (SALMOD) developed for the Trinity River (Williamson, et al., 1993) was previously evaluated as a tool for assessing the effects of project alternatives on anadromous salmonids. For the purposes of the 1999 Draft Environmental Impact Statement/Environmental Impact Report (DEIS/DEIR) it was determined that the SALMOD model is not useful in distinguishing project alternatives because SALMOD was developed only for the uppermost 25-mile reach of the mainstem Trinity River downstream of Lewiston to Dutch Creek; only chinook salmon are modeled; the model covers a limited time-frame (from September 2 to June 9); and the model uses current channel configuration and conditions. Because of these limitations, an alternative methodology was developed and used to determine effects of project alternatives on salmonid fish resources for the 1999 DEIS/DEIR. This methodology was also used in the analysis of impacts and benefits to anadromous salmonids in the Trinity River in this SEIS. In addition to the methodology used in the 1999 DEIS/DEIR, a supplemental and more robust analysis of the effects of river flows and resulting water temperatures on the smolt life-stages of anadromous salmonids was conducted.

The following assumptions were used in the SEIS/SEIR analysis of environmental consequences:

- The TRSSH would be operated as it is currently, and operations would not affect natural production of anadromous salmonids.
- All anadromous salmonid species would respond similarly to actions of any one particular project alternative except as noted below.
- In the year 2020, any rehabilitation sites and/or watershed work would be completed, and the river system processes would be functioning at the full level of their ability within the given flow regime(s); and anadromous fish populations, although not constant from year to year due to varying environmental conditions (especially oceanic factors), would be at their long-term average.
- Except as noted, the analysis assumed the historic distribution of Trinity River Basin water-year class as shown in Attachment B3.

Trinity River System Attribute Analysis Method (TRSAAM). To evaluate the environmental consequences of the proposed project alternatives on anadromous salmonid fish habitat in the Trinity River Basin, the Trinity River System Attribute Analysis Method (TRSAAM) was employed. This approach was based on the fundamentals and relationships of key river system characteristics and functions (McBain and Trush, 1997). In the Trinity River Flow Evaluation Report (U.S. Fish and Wildlife Service and Hoopa Valley Tribe, 1999), 10 river system habitat attributes (attributes) were identified as essential to the integrity of a healthy fluvial river system. The members of Trinity River EIS/EIR Fisheries and Channel Rehabilitation Technical Team (TRFCRTT) convened numerous times and developed and agreed upon an evaluation methodology that employed these 10 fluvial geomorphic attributes. An additional attribute specific to water temperature and habitat requirements was salmonids was identified and included in the analysis conducted for the 1999 DEIS/DEIR, with objectives and threshold criteria developed for the purposes of assessment. For the SEIS this analysis was replaced with an analysis of water temperature suitability for anadromous salmonid smolts (see description below).

In the DEIS/DEIR, the 11 river system attributes were evaluated in meeting threshold criteria for objectives of a healthy river for each project alternative and the No Action Alternative. Threshold criterion for meeting each of the attribute's objectives was identified from investigations conducted on the Trinity River in recent years. These studies included McBain and Trush (1997); Wilcock, et al., (1995); Trinity Restoration Associates (1993); and Zedonis and Newcomb (1997). The attributes, objectives, and their thresholds evaluated in this SEIS are shown in Table B-8. A summary of the methods are shown in Attachment B3 of Fishery Technical Appendix B to the 1999 DEIS/DEIR. The assumptions for the TRSAAM method are summarized below:

- If actions are made that move closer to meeting or that meet desirable system attributes, fish production will increase.
- All attributes were weighted equally for evaluation of fish production.
- Attributes provide and maintain habitat for all freshwater life stages of anadromous salmonids.

- Decline of one attribute can negate the benefits to fish of all other attributes (i.e., habitat diversity, water quality).
- Changes in fish numbers are not linearly correlated with flow.
- Only set flow release schedules were evaluated (uncontrolled spills were not assessed).
- Sediment-related attributes are limited to mainstem Trinity River channel upstream of Indian Creek confluence.
- The 70 Percent Inflow Alternative is based on weekly flow scheduled as seen in Attachment B4) and not average flow schedules by water-year classes used for other impact assessment.
- Current harvest management practices are sustainable.
- Probability of occurrence for Trinity River water-year classes used for the analysis was based on flows at Lewiston (pre-dam) and inflows to Trinity Lake (post-dam) (Attachment B3); these are as follows: extremely wet = 0.12; wet = 0.28; normal = 0.20; dry = 0.28; and critically dry = 0.12.

For the 1999 DEIS/DEIR the TRFCRTT determined that the objectives of the Attribute No.1 (1998) were contained in portions of other river system attributes, and by scoring objectives 1 through 4 for this attribute, a "double-counting" of objectives would occur. Therefore, for Attribute 1, objectives 1 through 4 (Table B-8) were not analyzed as part of the TRSAAM evaluation for the DEIS/DEIR nor this SEIS/EIR. Additionally, objectives 1 through 4 of Attribute 11 were not scored for the SEIS, as it was determined that it was desirable and necessary to evaluate the effects of water temperature outside this TRAASM methodology. The remainder of the attribute objectives presented in Service and HVT (1999) were used to evaluate each project alternative. In summary, for the SEIS, for each project alternative, a total of 35 objectives were evaluated for the 9 fluvial river system attributes.

TRSAAM Attribute Scoring. For impact analysis for the 1999 DEIS/DEIR the TRFCRTT developed a scoring system for evaluating the performance of each project alternative in meeting all of the attribute objectives. Using the same approach and scoring system, for this SEIS, the following was employed: a numerical 2 was assigned to an objective that always or nearly always met an identified threshold (e.g., flows > 6,000 cfs and achieved the frequency of that threshold); a numerical 1 was assigned to an objective that sometimes exceeded that threshold; and a numerical 0 was assigned to an objective that never or nearly never exceeded that threshold (less than 10 percent of the time). Using this system, each of the 35 objectives were assigned a score of "2," "1," or "0." Because of the difficulty in assessing the relative importance of each attribute objective, an assumption was made that all attribute objectives were equally important. Therefore, there was no attempt to differentially weight the relative contributions of each objective when summarizing an alternative's total score. This assumption is likely incorrect but unavoidable. For example, even if all other habitat attributes were optimized, the inability to provide suitable water temperatures would prevent successful restoration to the fishery. In that example water temperature and microhabitat conditions would act to constrain any beneficial restoration gained from other habitat objectives. However, for this analysis and to facilitate scoring of attributes, all objectives were treated as equally important in meeting the attributes of a healthy and functioning fluvial system.

In summary, for each project alternative, a maximum total score of 70 was possible if all 35 objective thresholds were always or nearly always met (a score of 2 X 35 objectives = 70). Using this process, the Maximum Flow, Flow Evaluation, Revised Mechanical Restoration, and Modified Percent Inflow Alternatives were assessed by assigning a total score to the 11 river system attributes assuming that flows met or exceeded the attribute objective thresholds and identified frequencies using the historic water-year class frequencies. For the 70 Percent Inflow alternative the assessment was made using representative median water years to assess the ability of this alternative to meet the attribute objective thresholds and identified frequencies. Finally, for the No Action, and the Mechanical Restoration project alternatives, which do not have water-year class dependent flow schedules, attribute assessment and scoring were made by assessing the ability of this alternative to meet the attribute objective thresholds and identified frequencies using the flow schedules as shown in Attachment B4.

Water Temperature and Microhabitat Attribute Evaluation. In the 1999 DEIS/DEIR and as part of the habitat attribute analysis (above), mainstem Trinity River water temperatures were evaluated as to their ability in meeting two temperature objectives These two temperature objectives were: flows sufficient in quantity, on average, to meet salmonid smolt emigration temperature requirements during normal hydro-meteorological conditions (Attribute 11, Objective No.1); and flow volumes (450 cubic feet per second [cfs]) sufficient to meet State Water Quality Control Board (SWQCB) temperature objectives for the Trinity River upstream of the North Fork (Attribute 11, Objective No.2).

To assess the impacts of water temperature on populations of salmonids in the Mainstem Trinity River for this SEIS an evaluation of the temperature-flow relationships and suitability for the smolt lifestages of steelhead, coho and chinook salmon were conducted (see description below). This analysis replaced the water temperature and microhabitat attribute evaluation previously conducted in the TRAASM Analysis. The role of water temperature acting to limiting the success of a population of salmonids were determined to be of significant biological importance and outside the evaluation of purely physical habitat conditions (e.g. channel migration frequency).

Assessment of Temperature Influences on Potential Salmonid Smolt Production in the Trinity River.

The object of this analysis was to assess, evaluate, and discriminate differences (if any) between proposed project alternatives with regards to the effects of water temperature on the smolting success of anadromous salmonids in the mainstem Trinity River. Water temperature is crucial to the success of salmonid populations. In order to assess temperature effects on smolt outmigration as a potentially limiting factor, the evaluation of water temperature effects was removed from TRSAAM and evaluated independently. Adverse water temperature conditions could result in large losses of sensitive salmonid life-stages (i.e. smolts) irregardless of other habitat conditions within the watershed. Due to it's importance to survival during out-migration and recruitment to the population, a detailed evaluation of the effects of water temperature on emigrating smolts for the three principal salmonid species, Chinook and coho salmon and steelhead, in the Trinity River was conducted.

Salmonid smolt temperature indices were developed to evaluate the impacts of changing water temperatures on successful smolt outmigration. While the index is called a smolt survival index, the term refers to an index of indirect smolt survival as opposed to an index of direct acute lethality. It is recognized that not all smolts of a given cohort would be expected to perish at the upper marginal temperature thresholds provided in Table 9. However, it would be expected that at these temperature thresholds smolts would likely revert to a non-migratory lifestage (parr) and attempt to rear in the river. Given that scenario, these parr may be considered potentially lost to that years' recruitment and therefore don't "survive".

This analysis focused on potential smolt survivability, based on smolt lifestage specific temperature threshold criteria (Table B-9) identified for these species in the Trinity river (Zedonis and Newcomb, 1997). Also, smolt emigration timing (TRFES, 1999), specific river flows, flow/temperature relationship estimates, and smolt temperature survival estimates were also used to calculate these indices. These factors were used to calculate an annual smolt survival suitability index (S.I.) for each species for each alternative and No Action. These indices, predicting smolt out-migration success at Weitchpec were then compared to distinguish performance of proposed project alternatives in meeting for the water temperature needs of the anadromous salmonids in the Trinity River. Furthermore the influence of differing flow regimes and resulting water temperatures on Chinook salmon smolts and resulting harvest and spawning escapement were evaluated using a Chinook salmon life cycle model. The methodology and results of these analyses are found as Attachment B5 to this Fishery Appendix.

Harvest Factors and Allocations. In the 1999 DEIS/DEIR, harvest to escapement ratios (harvest factors) were generated for chinook salmon, coho salmon, and steelhead so that harvest levels based on estimated spawner escapements could be generated. (See Attachment B6 of the 1999 DEIS/DEIR Fishery Technical Appendix for methods and data used to generate harvest factors.) From this analysis, allocation estimates for total harvest, tribal harvest, commercial (ocean) harvest, ocean sport harvest, and inriver sport harvest were made.

However, for this SEIS/SEIR, the results of a Chinook salmon harvest index calculated from the smolt temperature suitability analyses replaced the escapement estimates presented in the 1999 EIS/EIR in an attempt to distinguish project alternatives. The methodology and results of these analyses are also found as Attachment B6 to this Fishery Appendix. Chinook salmon production was evaluated by using an existing harvest/escapement model that is commonly used for evaluations in the Klamath Management Zone. Use of the harvest/ escapement model allowed for analysis of various smolt survival rates on the relative numbers of adult fish between alternatives. The harvest/escapement model used in this analysis is specific to chinook salmon life cycle uses life history parameters (age specific survival, maturity rates, harvest rates, etc.) as developed for Trinity (or Klamath Basin) Chinook salmon. This model utilized alternative-specific annual smolt survival indexes generated by this document. Because no similar model exists for the steelhead and coho, Chinook is the only species that underwent this evaluation.

Evaluation of Sediment Transport and Augmentation Needs. The flow and sediment management actions in each alternative benefits and impacts the sediment regime on the Trinity River. Actions are necessary to balance the coarse sediment budget by transporting

Rush Creek sediments at a rate equal to input, and by augmenting coarse sediment immediately downstream from Lewiston Dam to compensate that transported by the high flow release hydrograph. To assess the ability of each alternative to accomplish sediment transport and the needs for augmentation an analysis was conducted based on field derived measurements conducted on the upper mainstem Trinity River. As a comparative tool, fine and coarse sediment transport was computed for each alternative and for each water year for that alternative. The weighted annual fine and coarse sediment transport rates for the Lewiston and Limekiln gaging stations as reported in the TRFES (Service and Hoopa Valley Tribe, 1999) were averaged and summarized for the analysis. The implications of the computed fine and coarse sediment transport rates were considered in light of: (1) ability to transport and route coarse sediment delivered from tributaries, (2) coarse sediment imbalance in the reach immediately downstream of Lewiston Dam, which would require compensating coarse sediment introduction (augmentation) to maintain coarse sediment storage, and (3) ability to transport large volumes of fine sediment, which would reduce fine sediment storage in the mainstem Trinity River. The details of the methodology are found as Attachment B9 of this Fishery Resources Appendix.

Assessment of Riparian Vegetation Regeneration. The seed dispersal timing of desirable woody riparian species (black cottonwood, Fremont cottonwood, shiny willow) on Trinity River floodplains occurs in the late spring and early summer months, corresponding to the historic snowmelt hydrograph of the Trinity River. Successful plant initiation requires that: (1) a higher elevation bar, scour channel, or floodplain surface be exposed and wetted during the seed dispersal period, (2) the surface be exposed and moist for a short duration to allow seed germination, (3) the subsurface capillary fringe declines at a rate less than the root growth rate of the initiating seedling, and (4) when the flow recession transitions into the summer baseflow period, the seedling roots are at the summer baseflow capillary fringe (Mahoney and Rood 1992, Segelquist et al. 1993, Amlin and Rood 2002, McBride, et al. 1988. Riparian recruitment on floodplains and other higher elevation surfaces during Extremely Wet years, and perhaps some Wet water years, is an appropriate riparian restoration objective for the future.

To assess the ability of each alternative to provide conditions conducive to riparian seed dispersal and riparian forest regeneration along the mainstem Trinity River, the stage-discharge curve at the Lewiston gaging station, and assumptions of target floodplain surface for riparian inundation, the hydrograph for each alternative was evaluated for riparian initiation. The hydrographs for Extremely Wet and Wet water years were plotted, and the receding hydrograph necessary for riparian initiation was also plotted. For the 70 percent Inflow Alternative and Modified Percent Inflow Alternative, median Extremely Wet and Wet years were used from the 1912-2002 period of record. Detailed methodology for this analysis is found as Attachment B9 of this Fishery Resources Appendix.

Lower Klamath River Basin. There were no quantitative methods available to directly evaluate the effects of project alternatives on the anadromous salmonid resources within the lower Klamath River. For this reason, several assumptions were made to assist in assessing changes or effects of alternatives on anadromous salmonid resources.

These assumptions included:

- Increased coldwater releases to the Trinity River could reduce Klamath River temperatures during mid-May through late-June to a small degree and are beneficial for emigrating and immigrating salmonids (U.S. Fish and Wildlife Service and Hoopa Valley Tribe, 1999).
- Increases in flows in the Trinity River would improve habitat conditions and river system health.
- Mechanical restoration of riverine habitats within the Trinity River would not affect anadromous salmonids in the Klamath River Basin.
- Watershed protection in the Trinity River would improve habitat conditions and system health in the Klamath River Basin.

Using these assumptions, a qualitative assessment of the effects of project alternatives, as compared to No Action, was made.

Coastal Area. In the 1999 DEIS/DEIR changes in ocean salmon populations from Trinity River stocks were analyzed. For the methodology of that analysis see the Fishery Technical Appendix of the 1999 DEIS/DEIR. For this SEIS/SEIR, no analysis of changes in ocean population were intended nor conducted.

Central Valley. The effects of each project alternative on the anadromous salmonids in the Sacramento River were evaluated using Reclamation's Sacramento River Salmon Mortality Model, (LSACTEMC) (U.S. Bureau of Reclamation, 1991). For each project alternative, monthly water temperatures for the Sacramento River were estimated using Reclamation's Sacramento River Basin Temperature Model (LSALSRC3) (U.S. Bureau of Reclamation, 1990-1991). For the purpose of the water temperature analysis, it was assumed that the Shasta Temperature Control Device (STCD) would operate as designed. Estimated monthly temperature data from Reclamation's temperature model were input into Reclamation's salmon mortality model. Spatial and temporal spawning distributions for each of the four chinook salmon species found in the Sacramento River were also input into the salmon mortality model. Updated spawning distributions for winter chinook salmon from the years 1990 through 2002) were used in the salmon mortality model. From the salmon mortality model, losses of chinook salmon eggs and fry were estimated for all four species of chinook salmon spawning in the Sacramento River from Keswick Dam to Woodson Bridge.

There was no similar temperature mortality model available to estimate effects of project alternatives to steelhead in the Sacramento River. To evaluate the effects of project alternatives on steelhead spawning in the Sacramento River, it was assumed that estimated losses of steelhead eggs or fry would be similar to those estimated for late-fall chinook salmon using the LSACTEMC model. It was assumed that the peak of steelhead spawning in the Sacramento River is February (Hallock, 1989), and subsequent steelhead egg and fry incubation occurs at times similar to those for late-fall chinook salmon (Vogel and Marine, 1992) within the mainstem Sacramento River. It was recognized that the actual number of steelhead spawning in the mainstem Sacramento River is likely to be much less than those spawning in tributaries to the Sacramento River (Hallock, 1989). Therefore, any actual adverse effects on steelhead populations, as a result of changes in water temperatures from

project alternatives, would likely be much less than that estimated using late-fall chinook salmon mortality as a surrogate analysis.

1.1.2.2 Significance Criteria

Effects are considered significant for anadromous salmonids if they result in any of the following:

- Potential for reductions in the number, or restrictions of the range, of an endangered or threatened anadromous salmonid species or an anadromous salmonid species that is a candidate for state listing or proposed for federal listing as endangered or threatened
- Potential for substantial reductions in the habitat of any anadromous salmonid species other than those that are listed as threatened or endangered or are candidates (CESA) or proposed (ESA) for threatened or endangered status
- Potential for causing an anadromous salmonid population to drop below self-sustaining levels
- Substantial adverse effect, either directly or through habitat modifications, on any anadromous salmonid species identified as a sensitive or special-status species in local or regional plans, policies, or regulations by the California Department of Fish and Game, the U.S. Fish and Wildlife Service, or the National Marine Fisheries Service
- Substantial interference with the movement of any anadromous salmonid species
- A conflict with, or violation of, the provisions of an adopted Habitat Conservation Plan, Natural Community Conservation Plan, or other approved local, regional, or state habitat conservation plan relating to the protection of anadromous salmonid species
- Mortality of state or federally listed anadromous salmonid species, or anadromous salmonid species that are candidates for listing (CESA) or proposed for listing (ESA)
- Reductions in the size of an anadromous salmonid species population sufficient to jeopardize its long-term persistence
- Temporary impacts to habitats such that anadromous salmonid species suffer increased mortality or lowered reproductive success that jeopardizes the long-term persistence of those local populations
- Permanent loss of essential habitat of a listed species or special-status anadromous salmonid species
- Reduction in the quantity or quality of habitats in which anadromous salmonid populations occur sufficient to reduce the long-term abundance and productivity of local populations.

Ocean sport and commercial salmon fishing levels have varied considerably from year to year over the past 30 years within each region. Some variation in activity and harvest levels is normal; however, substantial reductions, especially in harvest levels, can adversely affect the industries that rely on salmon harvests. Ocean sport and commercial salmon harvests

were not specifically analyzed for the SEIS. Benefits to salmon harvest from implementation of the alternatives considered in the SEIS would fall within the range of those for the alternatives considered in the 1999 DEIS/DEIR. It is likely for any of the project alternatives considered in this SEIS, salmon harvest levels would be potentially greater than under no action conditions. This would result in beneficial economic effects within the sportfishing and commercial harvesting sector.

1.1.2.3 Results

Summary. The results of the comparisons of the No Action Alternative to each project alternative are summarized in Table B-19. Compared to the No Action Alternative, the Maximum Flow, Flow Evaluation, 70 Percent Inflow, Revised Mechanical Restoration, and Modified Percent Inflow Alternatives would all result in highly beneficial habitat conditions for anadromous salmonid species in the Trinity River as measured using the TRAASM methodology. The Mechanical Restoration Alternative would result in only modest benefits to these species in the Trinity River Basin using the TRAASM methodology. Using the supplemental analysis of water temperature-salmonid smolt outmigration, and sediment transport estimates the alternatives were further evaluated. The results indicated that the water temperature conditions for smolt outmigration, as reflected in the Smolt Suitability Indices (SI), were best for the Maximum Flow, Flow Evaluation, 70 Percent Inflow, Revised Mechanical, and Modified Percent Inflow alternatives, (in that order). The result of the Chinook Salmon Harvest index analyses also indicated that the improvement in harvestable Chinook salmon increased from 1,427 percent to 370 percent over that for No Action (in the same order of the alternatives given above). Additionally, the sediment transport analyses indicated that the: 70 Percent Inflow, Flow Evaluation, Modified Percent Inflow and Revised Mechanical Restoration Alternatives would provide beneficial coarse and fine sediment transport conditions (in the order of alternatives given).

The results of the sediment transport and augmentation analysis determined that the Flow Evaluation Alternative provided a desirable balance of fine and coarse sediment transport along with a moderate level of gravel augmentation. The Maximum Flow and the 70 Percent Inflow alternatives increase fine and coarse sediment transport volumes of up to approximately 90 to greater than 200 fold over that over No Action but would require a huge gravel augmentation program to provide sustained salmonid spawning substrates. The Modified Percent and Revised Mechanical were intermediate in their capacity to transport fine and coarse sediments and the need for gravel augmentation when compared to No Action and the Flow evaluation (see Table 2 and discussion in Attachment B9).

The Results of the riparian regeneration analysis indicated that the Flow Evaluation Alternative, 70 Percent Inflow Alternative, Maximum Flow Alternative, and the Revised Mechanical Alternative all would provide hydrographs during Extremely Wet years that would likely result in riparian initiation on the floodplains. The Modified Percent Inflow Alternative and No Action Alternative all have recession limbs steeper than that required to initiate riparian vegetation and therefore would not act to promote riparian vegetative regeneration on the upper mainstem Trinity River floodplain (see Table 3 and the discussion in Attachment B9 to this Fishery Resources Appendix).

Except for the Mechanical Restoration Alternative, for which there would be no change in habitat benefits, all of the remaining alternatives would benefit, to some degree, native anadromous salmonid species in the Klamath River Basin compared to the No Action Alternative. These benefits would be principally due to increased flows and in some cases somewhat cooler water temperatures in the Klamath River downstream of its confluence with the Trinity River.

The Maximum Flow, 70 Percent Inflow, Flow Evaluation, Revised Mechanical Restoration, and Modified Percent Inflow Alternatives all may negatively impact some of the native anadromous salmonid species including either Winter and/or Spring-run Chinook salmon in the Central Valley. For any impacts to Fall Chinook salmon, re-operation of the CVP are measures likely adequate to mitigate to less than significant any adverse effects in the Central Valley from implementing the Maximum Flow, Flow Evaluation, Modified Percent Inflow 70 Percent Inflow, Revised Mechanical Restoration, and Modified Percent Inflow Alternatives.

Adverse impacts from the implementation of the Maximum Flow, Flow Evaluation, Modified Percent Inflow, and the 70 Percent of Inflow Alternatives to federal and state listed endangered Winter-run Chinook salmon, in any water year in which the drawdown of Shasta Reservoir results in storage levels of less than 1.9 maf on September 30th, it would be necessary to re-consult with NOAA-Fisheries under terms of the 1993 Winter-Run Chinook Biological Opinion (NMFS-Fisheries, 1993). This re-consultation would result in operations that would attempt to minimize any losses to these species. Formal consultation with NOAA-Fisheries would be continued, as necessary, in order to operationally meet the Reasonable and Prudent Alternatives (RPAs) and Reasonable and Prudent Measures (RPMs) stipulated in the 1993 Biological Opinion for this species.

In the case of adverse impacts from the Maximum Flow, Flow Evaluation Alternative, Modified Percent Inflow, revised Mechanical Restoration and the 70 Percent of Inflow Alternatives to federal and state listed threatened Spring-run Chinook salmon, continued operation of the Cross-Channel gates in the Delta in consultation with NOAA-Fisheries would offset, mitigate and minimize any incremental losses of these species attributed to those alternatives.

1.1.2.4 No Action Alternative

Trinity River Basin. The results of the TRSAAM scoring for all attribute objectives for the No Action Alternative are shown in Table B-10. The individual scoring worksheets are shown in Attachment B6. The assumptions and rationale for scoring each attribute objective is shown in Attachment B7. A summary of the total score of the attributes for all project alternatives is shown in Table B-11. Attachment B5 provides details of the analysis of smolt outmigration temperature effects for the mainstem Trinity River for the project alternatives. Attachment B9 provides details of the sediment transport and riparian revegetation analysis for the mainstem Trinity River.

As shown in Table B-11, the No Action Alternative scored only 4 of the total possible 70 attribute objectives points believed necessary for a restored fluvial river system. For 32 of the 35 attribute objectives, thresholds were rated as never or nearly never exceeded (Table B-12). For only two objectives (attribute 2-objectives 4 and 5) did the proposed No

Action Alternative sometimes meet the attribute objective thresholds. For only one objectives did the No Action Alternative always or nearly always meet attribute objective thresholds. Those objective thresholds that were always or nearly always met were groundwater recharge of gravel bars (attribute 10-objective 1 (Table B-12).

Furthermore, the results of the detailed salmonid smolt temperature suitability analysis indicated that water temperature conditions in the mainstem Trinity River would likely result in allowing only approximately 41 percent, 84 percent, and 60 percent, of chinook and coho salmon, and steelhead smolts (respectively) to successfully emigrate (Table B-13). The receding limb of the spring hydrograph for the No Action alternative (Attachment B4) has insufficient stream flows throughout the out-migration months of June and July to ensure adequate cool water for those smolts leaving the Trinity river at Weichpec during that period. The effect of increased water temperatures on steelhead smolts may be less critical to their overall survival as smolts of this species could be expected to reverse their physiological condition (smoltification), allowing them to remain in-river as parr (rearing juvenile lifestage). Parr steelhead are significantly less vulnerable to increased water temperature, and therefore would not necessarily be entirely lost to the population. However, this effect would delay and would be an adverse impact, changing the timing of their entrance into the ocean. Should this occur, an indirect index of overall survivability for steelhead parr may be a more appropriate index for water temperature effects and the index of smolt suitability may be an index of direct water temperature impacts to steelhead. For the results of the analysis see Table B-13.

The weighted average sediment transport for No action is summarized in Table 1 of Attachment B9. The fine and coarse sediment transport rates for the Lewiston and Limekiln gaging stations as reported in the TRFES were averaged for the results shown in Table 1 in Attachment B9. For the No Action Alternative coarse and fine sediment transport is approximately 680 yd^3 and 230 yd^3 respectively. The benefits and deficiencies in sediment transport and augmentation for this alternative are summarized in Table 2 of Attachment B9. The No Action Alternative has a recession limb of the hyrodograph steeper than that required to initiate riparian vegetation on floodplains (See Table 3, Figure 1, and discussion in Attachment B9). Therefore, No Action is not conductive to riparian regeneration during any water year type.

The No Action Alternative performed poorly in meeting the habitat smolt temperature, sediment transport, and riparian revegetation requirements necessary for restoring anadromous salmonids in the mainstem Trinity River. These results indicate that, under the No Action Alternative, fishery habitat in the mainstem Trinity River in the year 2020 would not provide the conditions necessary to allow salmonid stocks, including federal threatened coho salmon, to recover to pre-dam population levels. The consequences of reduced rates of smolt out-migration for Chinook and coho salmon during their normal emigration periods are significant annual reductions in their respective year class recruitment, significant impedance in recovery of coho salmon, and generally impede the overall restoration of the anadromous fisheries in the Trinity River.

The results of the salmonid smolt temperature suitability analysis indicated that there were significant deficiencies in the performance of the No Action Alternative, compared to the proposed alternatives in meeting the biological needs for these species. A summary of that

analysis and the evaluation of the differences between the No Action alternative and the other alternatives for the Chinook harvest index are seen in Table B-14.

Furthermore, it is likely that habitat conditions would continue to deteriorate under the No Action Alternative, resulting in lower populations of these species in the year 2020 for the No Action Alternative.

Lower Klamath River Basin. As discussed in the methodology section, the assumptions were that improvements in water temperature conditions and increases in flows in the Trinity River would result in more favorable conditions in the lower Klamath River, thus benefiting anadromous salmonids within the lower Klamath River and estuary. Habitat conditions for the No Action Alternative would remain the same as currently found in the lower Klamath River and estuary; therefore, anadromous salmonid populations would remain unchanged under the No Action Alternative.

Central Valley. A summary of the estimated average annual losses of early life stages of Chinook salmon from Reclamation's LSACTEMC is shown in Table B-16. Tables of annual estimated mortalities for fall, late-fall, winter, and spring Chinook salmon for the No Action Alternative are shown in Attachment B8. In Table B-16, estimates of average annual simulated losses of Chinook salmon for the entire simulation period (1922-1993) are presented.

From this evaluation for the No Action Alternative for the entire period of simulation, annual losses of Chinook early life stages averaged 18 percent for fall run and 24 percent for spring run (Table B-16). Late-fall and federally and state endangered winter Chinook salmon losses were estimated to be much less than those for fall and spring Chinook and averaged from 1 to 8 percent for the entire 1922-1993 simulation period (Table B-16).

Using estimated losses of late-fall Chinook salmon as an estimate for steelhead losses, approximately 1 percent of these fish may be lost annually under the No Action Alternative (Table B-16).

1.1.2.5 Maximum Flow Alternative

Trinity River Basin. The results of the TRSAAM analysis for all attribute objectives for the Maximum Flow Alternative are shown in Table B-10. The individual scoring worksheets are shown in Attachment B6. The assumptions and rationale for scoring each attribute objective is shown in Attachment B7. A summary of the total score of the attributes for all project alternatives is shown in Table B-11. Fisheries Attachment B5 provides details of the analysis of smolt outmigration temperature effects for the mainstem Trinity River for the project alternatives. Results of the salmonid smolt outmigration temperature suitability analysis are summarized and shown in Table B-13. Detailed results of the sediment transport and riparian revegetation analysis is found in Attachment B9.

As shown in Table B-11, the Maximum Flow Alternative was scored 58 of the total possible 70 attribute objectives points believed necessary to restore the Trinity River fluvial river system. Only 3 of the 35 attribute objectives thresholds were rated as never or nearly never exceeded (Table B-12). Six of the 35 attributes were scored as sometimes meeting threshold criteria. Twenty-six of the 35 attribute objectives were scored as always or nearly always

exceeding objective thresholds for the Maximum Flow Alternative (Table B-12). Compared to No Action, the Maximum Flow Alternative excelled in meeting the river system and habitat requirements necessary for restoring naturally produced anadromous salmonids in the mainstem Trinity River. Table B-15 summarizes the percent change in river system health and habitat conditions for anadromous salmonids for the Maximum Flow Alternative compared to No Action. These results indicate that river system health and habitat conditions would be expected to improve approximately 1,350 percent under the Maximum Flow Alternative as compared to the No Action Alternative, using the TRSAAM scores as a measure of comparison (Table B-15).

The salmonid smolt temperature suitability analysis indicated that, on average, water temperature conditions would be suitable for allowing approximately 76 percent, 99 percent, and 81 percent of Chinook, coho, and steelhead smolts, respectively, to successfully migrate out of the Trinity River at Weitchpec (Table B-13; Figures B5a through B5c). These indices represent improvements of 86 percent, 18 percent and 35 percent respectively, from No Action Alternative (Tables 6 through 8, Attachment 6). The Chinook Salmon Production index, a measure of the potential in harvest production is 1,427 percent greater, approximately a 14-fold increase over the No Action Alternative (Table 9 of Attachment 6). The summary of the changes in the instream release volumes, anadromous salmonid smolt temperature survival indices, and Chinook Harvest Index from the No Action Alternative are shown in Table B-14.

For the Maximum Flow alternative, the estimated annual coarse and fine sediment transport volumes are estimated to be very large, and are approximately 156,000 yd^3 and 21,500 yd^3 respectively (Table 1 Attachment B9). The huge volume of coarse sediment transported by this alternative would require a much larger gravel augmentation program to keep coarse sediment volumes balanced in the mainstem Trinity River. The benefits and deficiencies in sediment transport and augmentation for this alternative are summarized in Table 2 of Attachment B9. The recession limbs of the hydrograph during Extremely Wet and Wet years would likely result in riparian initiation on floodplains and initiate riparian regeneration during those water years (See Table 3 and Figures 2 and 3, and discussion in Attachment B9).

These results indicate that, compared to the No Action Alternative, fishery habitat in the mainstem Trinity River in the year 2020 would greatly improve under the Maximum Flow Alternative (Table B-19). This project alternative would result in highly beneficial improvements in river system and habitat conditions, including significantly improving water temperature conditions for outmigrating smolts. These conditions would allow naturally produced anadromous salmonid populations, including federal threatened coho salmon, to greatly increase over those expected for No Action (Table B-14).

Lower Klamath River Basin. As discussed in the methodology section, the assumptions were that improvements in water temperature conditions and increases in flows in the Trinity River would result in more favorable conditions in the lower Klamath River, thus benefiting anadromous salmonids within the lower Klamath River and estuary. Increases in flows to the Trinity River from approximately 122 thousand acre-feet (taf) (critically dry water year) up to 1,800 taf (extremely wet water year) would benefit habitat conditions in the lower Klamath River and estuary. In their evaluation of the Flow Evaluation Alternative, the

Service and Hoopa Valley Tribe (1999) found that increases in flow in the Trinity River resulting from spring reservoir releases, dependent on timing and magnitude, can decrease or maintain water temperatures in the Klamath River downstream of the confluence. The temperature benefits determined from the evaluation of the Flow Evaluation Alternative would likely occur as a result of increased discharges in the Trinity and into the Klamath River for the Maximum Flow Alternative as well. Decreased water temperatures and increased flows would enhance habitat conditions and reduce travel time in the lower Klamath River during a critical period of out-migration of anadromous salmonid smolts.

Beneficial habitat conditions, as a result of more optimal temperatures and increased flows, would likely improve survival rates of outmigrating smolts and enhance the probability of their successful passage to the ocean. An additional benefit to anadromous salmonids in the lower Klamath River and estuary would result from improved rearing conditions for juveniles that will rear in the river for an additional year before out-migrating. Coho salmon and steelhead would particularly benefit from improvements in rearing conditions in the lower Klamath River and estuary due to their life history characteristic of smolting and out-migrating during the second year of their lives. For these reasons, it is likely that anadromous salmonids in the Klamath River as well as the Trinity River Basin would benefit. These benefits would result in increased populations under the Maximum Flow Alternative.

Central Valley. A summary of the estimated average annual losses of early life stages of Chinook salmon for the Maximum Flow Alternative from Reclamation's LSACTEMC is shown in Table B-16. Tables of annual estimated mortalities for fall, late-fall, winter, and spring chinook salmon for the Maximum Flow Alternative are shown in Attachment B8.

From this evaluation, the Maximum Flow Alternative for the historic simulated period of 1922 through 1993 increased water temperatures in the Sacramento River resulted in an estimated annual average loss of 27 percent of fall Chinook early life stages (Table B-16), an increase over the No Action Alternative of 9 percent (Table B-17).The estimated losses for late-fall chinook were nearly unchanged from those estimated for this species under the No Action Alternative (less than approximately 1 percent) (Table B-16). The average annual losses for endangered winter chinook were estimated to be 16 percent for the 1922-1993 simulation period (Table B-16).

Increased water temperatures in the Sacramento River resulted in an estimated annual average loss of 55 percent of spring chinook early life stages (Table B-16), an increase over the No Action Alternative of 31 percent percent (Table B-17).For endangered winter chinook salmon, these estimates represent an increase in annual average losses of 8 percent greater than those estimated for the No Action Alternative for the 1922-1993 period of simulation (Table B-17). Reviewing the estimated losses of winter chinook salmon in Attachment B8 revealed that the majority of estimated losses for this species, compared to the No Action Alternative, resulted from extremely high mortalities during a number of critically dry water years (1924, 1931 through 1934, 1977, and 1988 through 1992). For any water year in which the drawdown of Shasta Reservoir results in levels of less than 1.9 maf at the end of September 30th, it would be necessary to re-consult with NOAA-Fisheries under terms of the 1993 Winter-Run Chinook Biological Opinion (U.S. Fish and Wildlife Service, 1993). This

re-consultation would result in operations that would attempt to minimize any losses to these species.

Using the estimated average annual losses of late-fall chinook salmon as an estimate for steelhead losses in the upper Sacramento River, approximately 1 percent of these fish may be lost annually for the Maximum Flow Alternative (Table B-16). This estimate is unchanged from that for the No Action Alternative (Table B-17).

In summary, the estimated losses resulting from increases in water temperature on the early life stages of chinook salmon and steelhead in the Sacramento River for the Maximum Flow Alternative were compared to No Action. The results of this evaluation ranged from no change to an 31 percent increase in average annual losses for the 1922-1993 period of simulation (Table B-18). For the most part these incremental increases in losses are small compared to the No Action Alternative. However, the estimated increased losses of fall, spring, and winter- run chinook salmon in the Sacramento River are considered significant and represent adverse effects compared to the No Action Alternative.

The results of the evaluation of the Maximum Flow Alternative on the anadromous salmonids within the Sacramento River are summarized in Table B-18.

The results of the evaluation of the Maximum Flow Alternative on the anadromous salmonids of the affected area (Trinity and Klamath Basins and the Central Valley) are summarized in Table B-19.

1.1.2.6 Flow Evaluation Alternative

Trinity River Basin. The results of the TRSAAM analysis for all attribute objectives for the Flow Evaluation Alternative are shown in Table B-10. The individual scoring worksheets are shown in Attachment B6. The assumptions and rationale for scoring each attribute objective is shown in Fisheries Attachment B7. A summary of the total score of the attributes for all project alternatives is shown in Table B-11. Fisheries Attachment B5 provides details of the analysis of smolt outmigration temperature effects for the mainstem Trinity River for the project alternatives. Results of the salmonid smolt outmigration temperature suitability analysis are summarized and shown in Table B-13.

As shown in Table B-11, the Flow Evaluation Alternative was scored 49 of the total possible 70 attribute objective points believed necessary to restore the Trinity River fluvial river system. Eight of the 35 attribute objectives were determined to never or nearly never exceed threshold criteria (Table B-12). Five of the 35 attribute objectives were found to sometimes exceed thresholds. Twenty-two of the 35 attribute objectives were scored as always or nearly always exceeding objective thresholds for the Flow Evaluation Alternative (Table B-12). While this alternative was not as effective as the Maximum Flow Alternative in meeting the objectives of the TRAASM Attributes, compared to No Action, the Flow Evaluation Alternative excelled in meeting the river system and habitat requirements necessary for restoring naturally produced anadromous salmonids in the mainstem Trinity River. Table B-15 summarizes the percent change in river system health and habitat conditions for anadromous salmonids for the Flow Evaluation Alternative compared to No Action. These results indicate that river system health and habitat conditions would be expected to improve approximately 1,125 percent, approximately an 11-fold increase, under the Flow Evaluation

Alternative as compared to the No Action Alternative, using the TRSAAM scores as a measure of comparison (Table B-15).

The salmonid smolt temperature suitability analysis indicated that, on average, water temperature conditions would be suitable for allowing approximately 60 percent, 95 percent, and 80 percent of Chinook, coho, and steelhead smolts, respectively, to successfully migrate out of the Trinity River from April 9th to August 27th at Weitchpec (Table B-13; Figures B5a through B5c). These increases over No Action, ranged from 47 percent (Chinook), 13 percent (coho); to 33 percent (steelhead) (Tables 6 through 8, Attachment 6). The Chinook Salmon Production index, a measure of the potential in harvest production is 919 percent greater, approximately an 9-fold increase over the No Action Alternative (Table 9 of Attachment 6). Compared to the No Action Alternative, the Flow Evaluation Alternative had an estimated annual Chinook Salmon Harvest Index greater than approximately 40,000 adults. The summary of the changes in the instream release volumes, anadromous salmonid smolt temperature survival indices, and Chinook Harvest Index from the No Action Alternative are shown in Table B-14.

The analysis of fine and coarse sediment transport in the upper mainstem Trinity River for the Flow Evaluation alternative is found in Attachment B9 of this Fishery Resources Appendix. For this alternative, the estimated annual coarse and fine sediment transport volumes are balanced, from 8-12 fold greater than to those for No Action and are approximately 8,570 yd^3 and 1,870^3 respectively (Table 1 Attachment B9). The benefits and deficiencies in sediment transport and augmentation for this alternative are summarized in Table 2 of Attachment B9. The recession limbs of the hydrograph during Extremely Wet years would likely result in riparian initiation on floodplains and initiate riparian regeneration during those water years. The recession limbs of the hydrograph during Extremely Wet years would likely result in riparian initiation on floodplains and initiate riparian regeneration during those water years (See Table 3, Figures 1 through 9, and discussion in Attachment B9).

The Flow Evaluation alternative would provide the instream flows necessary to meet these sediment transport processes, would notably reduce fine sediment storage, and improve coarse sediment balance, as well as minimize coarse sediment augmentation.

These results indicate that, compared to the No Action Alternative, fishery habitat, water temperature conditions, sediment transport, and riparian revegetation conditions in the mainstem Trinity River in the year 2020 would greatly improve under the Flow Evaluation Alternative (Table B-19). This alternative would result in highly beneficial improvements in river system and habitat conditions allowing naturally produced anadromous salmonid populations to greatly increase over those expected under No Action (Table B-14).

Lower Klamath River Basin. The Flow Evaluation Alternative would result in improved water temperature conditions and increases in Trinity River flows, both of which would result in more favorable conditions in the lower Klamath River. These improved conditions would benefit anadromous salmonids within the lower Klamath River and estuary. An annual increase in Trinity River flows, from approximately 28 taf (critically dry water year) to approximately 475 taf (extremely wet water year), would likely improve habitat conditions in the lower Klamath River and estuary in most years. In their evaluation of the Flow Evaluation Alternative, the Hoopa Valley Tribe and Service (1999) predicted that increases in

flow in the Trinity River would reduce water temperatures in the Klamath River downstream of their confluence. These improvements would enhance habitat conditions and reduce travel time in the lower Klamath River during a critical period of out-migration of salmonid smolts.

Beneficial habitat conditions, as a result of more optimal temperatures and increased flows, would likely improve survival rates of out-migrating smolts and enhance the probability of their successful passage to the ocean. An additional benefit to anadromous salmonids in the lower Klamath River and estuary would result from improved rearing conditions for juveniles that will rear in the river for an additional year before out-migrating (U.S. Fish and Wildlife Service, 1998). Like the Maximum Flow Alternative, coho salmon and steelhead would particularly benefit from improvements in rearing conditions in the lower Klamath River and estuary due to their life history characteristics of smolting and out-migrating during the second year of their lives. For these reasons, it is likely that anadromous salmonids in the Klamath River and Trinity River Basin would benefit. These benefits would likely result in very large increases in salmonid populations with this Alternative.

Central Valley. A summary of the estimated average annual losses of early life stages of chinook salmon for the Flow Evaluation Alternative from Reclamation's LSACTEMC is shown in Table B-16. Tables of annual estimated mortalities for fall, late-fall, winter, and spring chinook salmon for the Flow Evaluation Alternative are shown in Attachment B8.

From this evaluation for the Flow Evaluation Alternative for the historic simulated period of 1922 through 1993, increased water temperatures in the Sacramento River resulted in an estimated annual average loss of 21 percent for fall chinook early life stages (Table B-16); an annual increase over the No Action Alternative of 3 percent (Table B-17).Average annual losses of late-fall and winter chinook salmon were estimated to be substantially less than those for spring chinook and averaged less than 2 percent for late-fall chinook. This estimated average annual loss for late-fall chinook was unchanged from that estimated for this species under the No Action Alternative.

For the historic simulated period of 1922 through 1993, increased water temperatures in the Sacramento River resulted in an estimated annual average loss of 32 percent of spring chinook early life stages (Table B-16); an annual increase over the No Action Alternative of 8 percent (Table B-17). The average annual losses for endangered winter chinook were estimated to be approximately 9 percent for the entire 1922-1993 simulation period (Table B-16). For endangered winter chinook salmon, these estimates represent a small net increase (less than 1 percent) in annual average losses compared to the No Action Alternative (Table B-17).

For any water year in which the drawdown of Shasta Reservoir results in levels of less than 1.9 maf at the end of September 30th, it would be necessary to re-consult with NOAA-Fisheries under terms of the 1993 Winter-Run Chinook Biological Opinion (U.S. Fish and Wildlife Service, 1993). This re-consultation would result in operations which would attempt to minimize losses to these species.

Using the estimated average annual losses of late-fall chinook salmon as an estimate for steelhead losses in the upper Sacramento River, approximately 2 percent of these fish may be lost annually for the Flow Evaluation Alternative (Table B-16). This estimate is only slightly greater than that for the No Action Alternative (Table B-17).

In summary, the estimated losses resulting from increases in water temperature on the early life stages of chinook salmon and steelhead in the Sacramento River for the Flow Evaluation Alternative were compared to No Action. The results of this evaluation ranged from no change to a 8 percent increase in average annual losses for the 1922-1993 period of simulation, depending on species (Table B-18). Many of the increases in losses are small as compared to the No Action Alternative and may be within the limits of precision of the model used to estimate them. However, the estimated losses for fall, winter, and spring run chinook salmon in the Sacramento River are considered significant and represent adverse effects compared to the No Action Alternative. The results of the evaluation of the Flow Evaluation Alternative on the anadromous salmonids within the Sacramento River are summarized in Table B-18.

The results of the evaluation of the Flow Evaluation Alternative on the anadromous salmonids of the affected area (Trinity and Klamath Basins and the Central Valley) are summarized in Table B-19.

1.1.2.7 70 Percent Inflow Alternative

Trinity River Basin. The results of the TRSAAM analysis for all attribute objectives for the 70 Percent Inflow Alternative are shown in Table B-10. The individual scoring worksheets are shown in Attachment B6. The assumptions and rationale for scoring each attribute objective is shown in Attachment B7. A summary of the total score of the attributes for all project alternatives is shown in Table B-11. Fisheries Attachment B5 provides details of the analysis of smolt outmigration temperature effects for the mainstem Trinity River for the project alternatives. Results of the salmonid smolt outmigration temperature suitability analysis are summarized and shown in Table B-13.

As shown in Table B-11, the 70 Percent Inflow Alternative was scored 50 out of the total possible 70 attribute objective points believed necessary to restore the Trinity River fluvial river system. A majority of the attribute objectives (19 of the 35) were determined to always exceed threshold criteria for this alternative (Table B-12). Twelve of the 35 attribute objectives were found to sometimes exceed objective thresholds. Only four of the 35 attribute objectives were scored as never or nearly never meeting objective thresholds for this alternative (Table B-12).

On further evaluation using the smolt temperature suitability analysis, water temperature conditions for the 70 Percent Inflow Alternative would, on average, would allow approximately 54 percent, 94 percent, and 74 percent of Chinook, coho, and steelhead smolts (respectively) to successfully migrate out of the Trinity River at Weitchpec from April 9th through August 27th (Table B-13; Figures B5a through B5c). These increases over No Action, ranged from 33 percent (Chinook), 23 percent (steelhead); to 12 percent (coho) (Tables 6 through 8, Attachment 6). The Chinook Salmon Production index, a measure of the potential in harvest production is 755 percent greater, or an increase of approximately 6-fold over the No Action Alternative (Table 9 of Attachment 6).

These results indicate that, compared to the No Action Alternative, fishery habitat in the mainstem Trinity River in the year 2020 would improve under the 70 Percent Inflow Alternative Table B-19). This alternative would result in highly beneficial improvements in river system and habitat conditions allowing naturally produced anadromous salmonid

populations to significantly increase over those expected under No Action. Table B-15 summarizes the estimated changes in river system health and habitat conditions for anadromous salmonids for the 70 Percent Inflow Alternative compared to No Action. These results indicate that habitat conditions would be expected to improve approximately 1150 percent under the 70 Percent Inflow Alternative as compared to the No Action Alternative, using the TRSAAM scores as a measure of comparison (Table B-15).

The analysis of the estimated fine and coarse sediment transport in the upper mainstem Trinity River for the 70 Percent Inflow alternative is shown in Attachment B9. For this alternative, it was estimated that the weighted annual average transport of coarse sediments (> 8mm) for both Lewiston and Limekiln Gulch combined, would be approximately 17,000 cubic yards, or approximately 97 percent greater than that for the Flow Evaluation Alternative (Table 1, Attachment B9). The weighted annual average transport of fine sediment for this alternative was estimated to be approximately 3,200 cubic yards. The 70 Percent Inflow alternative would provide the instream flows necessary to meet these sediment transport processes, would notably reduce fine sediment storage, and also greatly increase coarse material transport. However, to rehabilitate and not maintain mainstem Trinity River morphology, coarse bed material augmentation must meet or exceed transport capacity (FWS, 1999). Therefore, the estimated volume of coarse bed material augmentation would proportionally be much greater (on average, 97 percent greater) for the 70 Percent Inflow alternative as compared to the Flow Evaluation. This additional level of augmentation would necessitate a greater cost for and coarse bed material augmentation program.

The benefits and deficiencies in sediment transport and augmentation for this alternative are summarized in Table 2 of Attachment B9. The recession limbs of the hydrograph during Extremely Wet and Wet water years would likely result in riparian initiation on floodplains and initiate riparian regeneration during those water years (See table 3, Figures 4 and 5 and discussion in Attachment B9).

Significant improvements in river system habitats would benefit anadromous salmonid populations as compared to No Action. However this alternative, compared to the Maximum Flow and the Flow Evaluation Alternatives, would not perform as well in providing cool water temperatures for outmigrating smolts, especially after July 1st. This reduction would act to depress the overall recovery of anadromous salmonids in the mainstem Trinity River compared to the Maximum Flow and the Flow Evaluation alternatives. The Chinook Harvest Index for the 70 Percent Inflow alternative indicates that the average annual number of harvestable adult Chinook salmon may be reduced from approximately 9,500 to 38,000 adults from the estimates for the Flow Evaluation and the Maximum Flow alternatives respectively (Table 9, Attachment 6). The summary of the changes in the instream release volumes, anadromous salmonid smolt temperature survival indices, and Chinook Harvest Index from the No Action Alternative are shown in Table B-14.

Lower Klamath River Basin. The 70 Percent Inflow Alternative would result in improved water temperature conditions and increased Trinity River flows in many water years. In these years, increased annual flows (and improved water temperature conditions during smolt out-migration) could result in improved habitat conditions in the lower Klamath River and estuary (Table B-19). Compared to the No Action alternative, these improvements may

result in significant benefits and improvements in populations of anadromous salmonids under the 70 Percent Inflow Alternative.

Central Valley. A summary of the estimated average annual losses of early life stages of chinook salmon for the 70 Percent Inflow Alternative from Reclamation's is shown in Table B-16. Tables of annual estimated mortalities for fall, late-fall, winter, and spring chinook salmon for this Alternative are shown in Attachment B8.

From this evaluation, for the historic simulated period of 1922 through 1993, increased water temperatures in the Sacramento River resulted in an estimated annual average loss of 25 percent of fall chinook salmon early life stages; an increase of approximately 7 percent annually from the No Action Alternative (Table B-17).

Average annual losses of late-fall chinook salmon were estimated to be approximately 2 percent for the 1922-1993 simulation period (Table B-16). These estimated losses for late-fall chinook were unchanged (less than 1 percent) from those estimated for this species under the No Action Alternative (Table B-17).

Increased water temperatures in the Sacramento River resulted in an estimated annual average loss of 47 percent for threatened spring chinook early life stages (Table B-16); an increase of approximately 23 percent annually from the No Action Alternative (Table B-17). The average annual losses for endangered winter chinook were estimated to be 11 percent for the 1922-1993 simulation period (Table B-16). For endangered winter chinook salmon, these estimates represent an increase of 3 percent in annual average losses from those estimated for the No Action Alternative (Table B-17). For any water year in which the drawdown of Shasta Reservoir results in levels of less than 1.9 maf at the end of September 30th, it would be necessary to re-consult with NOAA-Fisheries under terms of the 1993 Winter-Run Chinook Biological Opinion (U.S. Fish and Wildlife Service, 1993). This re-consultation would result in operations which would attempt to minimize losses to these species. Using the estimated average annual losses of late-fall chinook salmon as an estimate for steelhead losses in the upper Sacramento River, approximately 2 percent of these fish may be lost annually for the 70 Percent Inflow Alternative (Table B-16). This estimate is numerically unchanged from that for the No Action Alternative (Table B-17).

In summary, the estimated losses resulting from increases in water temperature on the early life stages of chinook salmon and steelhead in the Sacramento River for this alternative were compared to No Action. The results of this evaluation ranged from no change to a 23 percent increase in average annual losses for the 1922-1993 period of simulation, depending on species (Table B-18). These increases in losses are relatively small as compared to the No Action Alternative. However, these estimated losses in fall, winter and spring-run chinook salmon in the Sacramento River are considered significant and represent adverse effects from the No Action alternative. The results of the evaluation of the 70 Percent Inflow Alternative on the anadromous salmonids within the Sacramento River are summarized in Table B-18.

The results of the evaluation of the 70 Percent Inflow Alternative on the anadromous salmonids of the affected area (Trinity and Klamath Basins and the Central Valley) are summarized in Table B-19.

1.1.2.8 Mechanical Restoration Alternative

Trinity River Basin. The results of the TRSAAM analysis for all attribute objectives for the Mechanical Restoration Alternative are shown in Table B-10. The individual scoring worksheets are shown in Attachment B6. The assumptions and rationale for scoring each attribute objective is shown in Attachment B7. A summary of the total score of the attributes for all project alternatives is shown in Table B-11. Fisheries Attachment B5 provides details of the analysis of smolt outmigration temperature effects for the mainstem Trinity River for the project alternatives. Results of the salmonid smolt outmigration temperature suitability analysis are summarized and shown in Table B-13.

As shown in Table B-11, the Mechanical Restoration Alternative was scored 13 out of the total possible 70 attribute objectives points believed necessary to restore the Trinity River fluvial river system. A majority of the attribute objectives (25 of the 35) were determined to never or nearly never exceed threshold criteria for this alternative (Table B-12). Seven of the 35 attribute objectives were found to sometimes exceed objective thresholds. Only 3 of the 35 attribute objectives were scored as always or nearly always exceeding objective thresholds for this alternative (Table B-12). One of the objectives which was determined to always or nearly always exceed threshold criteria was that for Attribute 8 in which periodic removal of large deposits of tributary delta materials and construction and rehabilitation of side channels would be accomplished by mechanical means.

Similar to conditions in the No Action alternative, the consequences of reduced rates of smolt out-migration for Chinook and coho salmon during their normal emigration periods are significant. As the flows under this alternative would be the same as the No Action Alternative the water temperature conditions for the Mechanical Restoration Alternative would also remain the same and, on average, allow only approximately 41 percent, 84 percent, and 60 percent of Chinook, coho, and steelhead smolts (respectively) to successfully migrate out of the Trinity River at Weitchpec from April 9th through August 27th (Table B-13). Annual reductions in their respective year class recruitment, significant impedance in recovery of coho salmon, and generally impedance of the overall restoration of the anadromous fisheries in the Trinity River would result from poor water temperature conditions for outmigrating salmonid smolts (Table 13).

The total weighted average sediment transport for the Lewiston and Limekiln gaging stations for the Mechanical Restoration Alternative is the same as that for the No action alternative and is summarized in Table 1 in Attachment B9. The coarse and fine sediment transport is approximately 680 yd^3 and 230 yd^3 respectively. The benefits and deficiencies in sediment transport and augmentation for this alternative are summarized in Table 2 of Attachment B9. This alternative has the same recession limb of the hyrodograph as the No Action alternative and is steeper than that required to initiate riparian vegetation on floodplains (See Table 3, Figure 1 and the discussion in Attachment B9). This alternative is not conductive to riparian regeneration during any water year type.

This alternative was determined to provide some benefit in meeting river system attribute objectives compared to the No Action Alternative, but much less than that for the all the other alternatives considered. The Mechanical Restoration Alternative was not effective, as compared to those alternatives in meeting the river system and habitat requirements necessary for substantially restoring naturally produced anadromous salmonids in the mainstem

Trinity River. Table B-15 summarizes the estimated changes in river system health and habitat conditions for anadromous salmonids for the Mechanical Restoration Alternative compared to No Action. These results indicate that conditions would be expected to improve approximately 225 percent under this alternative as compared to the No Action Alternative, using the TRSAAM scores as a measure of comparison (Table B-15). However, these measures of habitat improvement must be tempered with the results of the smolt temperature suitability analysis (Attachment B5). That analysis indicated that water temperature conditions for smolt migration may be inadequate, especially for chinook salmon and steelhead, and may potentially limit fishery restoration for anadromous salmonids in the Trinity River (Table B-14). The estimated Harvest Index for the Mechanical Restoration alternative, which would have the same Harvest Index (approximately 4,400 fall Chinook salmon adults) as the No Action alternative (see Attachment B5, Table 9).

Compared to No Action, fishery habitat in the mainstem Trinity River in the year 2020 would be expected to improve only slightly under the Mechanical Restoration Alternative (Table B-19). Small and localized beneficial improvements in river system health and function would result in small benefits to naturally produced anadromous salmonid populations as compared to No Action.

Lower Klamath River Basin. As discussed in the No Action Alternative, the assumptions were that improvements in water temperature conditions and increases in flows in the Trinity River would result in more favorable conditions in the lower Klamath River, thus benefiting anadromous salmonids within the lower Klamath River and estuary. The only changes in habitat conditions in the Trinity River Basin in the Mechanical Restoration Alternative are through mechanical means. Therefore, no benefits resulting from increased flows or cool water temperatures would be expected in the lower Klamath River and estuary under the Mechanical Restoration Alternative. Habitat conditions under this alternative would remain the same as No Action for the lower Klamath River and estuary. Anadromous salmonid populations would likely remain unchanged under this project alternative.

Central Valley. There would be no changes to anadromous salmonid species or their habitats in the Central Valley as a result of implementing this alternative.

1.1.2.9 Revised Mechanical Restoration Alternative

Trinity River Basin. The results of the TRSAAM analysis for all attribute objectives for the Revised Mechanical Restoration Alternative are shown in Table B-10. The individual scoring worksheets are shown in Attachment B6. The assumptions and rationale for scoring each attribute objective is shown in Attachment B7. A summary of the total score of the attributes for all project alternatives is shown in Table B-11. Fisheries Attachment B5 provides details of the analysis of smolt outmigration temperature effects for the mainstem Trinity River for the project alternatives. Results of the salmonid smolt outmigration temperature suitability analysis are summarized and shown in Table B-13.

As shown in Table B-11, the Revised Mechanical Restoration Alternative was scored 37 out of the total possible 70 attribute objective points believed necessary to restore the Trinity River fluvial river system. A large number of the attribute objectives (14 of the 35) were determined to always exceed threshold criteria for this alternative (Table B-12). Nine of the 35 attribute objectives were found to sometimes exceed objective thresholds. Twelve of the

35 attribute objectives were scored as never or nearly never meeting objective thresholds for this alternative (Table B-12).

On further evaluation using the smolt temperature suitability analysis, water temperature conditions for the Revised Mechanical Restoration Alternative would, on average, allow approximately 51 percent, 91 percent, and 67 percent of Chinook, coho, and steelhead smolts (respectively) to successfully migrate out of the Trinity River at Weitchpec from April 9th through August 27th (Table B-13 and Figures B5a through B5c). These increases over No Action, ranged from 23 percent (Chinook), 8 percent (coho); to 12 percent (steelhead) (Tables 6 through 9, Attachment 6). The Chinook Salmon Production index, a measure of the potential in harvest production is 634 percent greater, or an increase of approximately 6-fold over the No Action Alternative (Table 9 of Attachment 6). The summary of the changes in the instream release volumes, anadromous salmonid smolt temperature survival indices, and Chinook Harvest Index from the No Action Alternative are shown in Table B-14

These results indicate that, compared to the No Action Alternative, fishery habitat in the mainstem Trinity River in the year 2020 would improve somewhat under the this alternative (Table B-19). The alternative would result in beneficial improvements in river system and habitat conditions allowing naturally produced anadromous salmonid populations to increase over those expected under No Action. Table B-15 summarizes the estimated changes in river system health and habitat conditions for anadromous salmonids for the Revised Mechanical Alternative compared to No Action. These results indicate that conditions would be expected to improve approximately 825 percent under the alternative as compared to the No Action Alternative, using the TRSAAM scores as a measure of comparison (Table B-15).

The analysis of the estimated fine and coarse sediment transport in the upper mainstem Trinity River for the Revised Mechanical Restoration alternative is shown in Attachment B9. For this alternative, it was estimated that the weighted annual average transport of coarse sediments (> 8mm) for both Lewiston and Limekiln Gulch combined, would be approximately 1,100 cubic yards, or approximately 88 percent less than that for the Flow Evaluation Alternative (Table 1 of Attachment B9). The weighted annual average transport of fine sediment for this alternative was estimated to be approximately 400 cubic yards. The Revised Mechanical Restoration alternative would not generally provide the instream flows necessary to meet sediment transport processes. This alternative would not notably reduce fine sediment storage, or increase coarse material transport.

The benefits and deficiencies in sediment transport and augmentation for this alternative are summarized in Table 2 of Attachment B9. For the Revised Mechanical Restoration alternative the recession limbs of the hydrograph during Extremely Wet and Wet years would likely result in riparian initiation on floodplains and initiate riparian regeneration during those water years (See Table 3, Figures 6 and 7, and discussion in Attachment B9).

Improvements in habitat conditions for native anadromous salmonids in the mainstem Trinity River, as measured by the TRAASM score, must also be tempered with the results of the smolt temperature suitability analysis. That analysis indicated that, while there is measured improvement in water temperature for smolt migration over the No Action Alternative, this improvement may not be sufficiently robust to optimize smolt emigration and limit fish population recovery and restoration in the Trinity River. This alternative, compared to the Maximum Flow and the Flow Evaluation Alternatives, would not provide perform as nearly

well in providing cool water temperatures for outmigrating smolts, especially after July 1st (Table B-14). The Chinook harvest index for the Revised Mechanical Restoration alternative also indicates that the average annual number of harvestable adult Chinook salmon may be reduced from approximately 12,500-24,000 adults (depending on the assumption of the level of restoration for the Revised Mechanical Restoration alternative) to approximately 34,500-46,000 adults from those estimates for the Flow Evaluation and the Maximum Flow alternative respectively (Table B-14; and Attachment B5).

Lower Klamath River Basin. The Revised Mechanical Restoration Alternative would result in somewhat improved water temperature conditions and increased Trinity River flows in many water years compared to No Action. In these years, increased annual flows (and improved water temperature conditions during smolt out-migration could result in some modest improvements in habitat conditions in the lower Klamath River and estuary. These benefits may result in only modest increases to populations under this alternative during those years.

Central Valley. A summary of the estimated average annual losses of early life stages of chinook salmon for the Revised Mechanical Restoration Alternative from Reclamation's LSACTEMC is shown in Table B-16. Tables of annual estimated mortalities for fall, late-fall, winter, and spring chinook salmon for this Alternative are shown in Attachment B8.

From this evaluation for this alternative, for the historic simulated period of 1922 through 1993, increased water temperatures in the Sacramento River resulted in an estimated annual average loss of 18 percent of fall chinook early life stages, 1 percent greater than the No Action Alternative (Table B-17). Average annual losses of late-fall were estimated to average approximately 1 percent for the 1922-1993 simulation period (Table B-16). These estimated losses for late-fall chinook were also unchanged from those estimated for this species under the No Action Alternative (Table B-17).

Increased water temperatures in the Sacramento River resulted in an estimated annual average loss of approximately 25 percent of threatened spring chinook early life stages (Table B-16), a change of 1 percent from the No Action Alternative (Table B-17). The average annual losses for endangered winter chinook were estimated to be 8 percent for the 1922-1993 simulation period (Table B-16), also virtually unchanged from those estimated for the No Action Alternative (Table B-17).

Using the estimated average annual losses of late-fall chinook salmon as an estimate for steelhead losses in the upper Sacramento River, approximately 1 percent of these fish would be lost annually for the Revised Mechanical Restoration Alternative (Table B-16). This estimate is unchanged from that for the No Action Alternative (Table B-17).

In summary, the estimated losses resulting from increases in water temperature on the early life stages of chinook salmon and steelhead in the Sacramento River for the Revised Mechanical Restoration Alternative were compared to No Action. The results of this evaluation resulted in small changes in average annual losses for the 1922-1993 period of simulation, for fall and spring chinook salmon species. These estimated losses of fall and spring chinook salmon are considered significant and represent adverse effects as compared to the No Action Alternative. The results of the evaluation of this alternative on the anadromous salmonids within the Sacramento River are summarized in Table B-18.

The results of the evaluation of the Revised Mechanical Restoration Alternative on the anadromous salmonids of the affected area (Trinity and Klamath Basins and the Central Valley) are summarized in Table B-19.

1.1.2.10 Modified Percent Inflow Alternative

Trinity River Basin. The results of the TRSAAM analysis for all attribute objectives for the Modified Percent Inflow Alternative are shown in Table B-10. The individual scoring worksheets are shown in Attachment B6. The assumptions and rationale for scoring each attribute objective is shown in Attachment B7. A summary of the total score of the attributes for all project alternatives is shown in Table B-11. Fisheries Attachment B5 provides details of the analysis of smolt outmigration temperature effects for the mainstem Trinity River for the project alternatives. Results of the salmonid smolt outmigration temperature suitability analysis are summarized and shown in Table B-13.

As shown in Table B-11, this Alternative was scored 51 out of the total possible 70 attribute objective points believed necessary to restore the Trinity River fluvial river system. A large number of the attribute objectives (23 of the 35) were determined to always exceed threshold criteria for this alternative (Table B-12). Five of the 35 attribute objectives sometimes exceeded objective thresholds. However, seven of the 35 attribute objectives were scored as never or nearly never meeting objective thresholds for this alternative (Table B-12).

On further evaluation using the smolt temperature suitability analysis, water temperature conditions for the Modified Percent Inflow Alternative would, on average, allow approximately 49 percent, 91 percent, and 58 percent of Chinook, coho, and steelhead smolts (respectively) to successfully migrate out of the Trinity River at Weitchpec from April 9th through August 27th (Table B-13 and Figures B5a through B5c). These increases over No Action, ranged from 21 percent (Chinook), to 8 percent (coho) and decreased 3 percent for steelhead (Tables 3 through 5, Attachment 6). The Chinook Salmon Production index, a measure of the potential in harvest production is 606 percent greater, or an increase of approximately 6-fold over the No Action Alternative (Table 9 of Attachment 6).

These results indicate that, compared to the No Action Alternative, fishery habitat in the mainstem Trinity River in the year 2020 would greatly improve under this alternative Table B-19). The alternative would result in beneficial improvements in river system and habitat conditions allowing naturally produced anadromous salmonid populations to increase over those expected under No Action. Table B-15 summarizes the estimated changes in river system health and habitat conditions for anadromous salmonids for this Alternative compared to No Action. These results indicate that habitat conditions would be expected to improve approximately 783 percent under the alternative as compared to the No Action Alternative, using the TRSAAM scores as a measure of comparison (Table B-15).

The analysis of the estimated fine and coarse sediment transport in the upper mainstem Trinity River for the Modified Percent Inflow alternative is shown in Attachment B9. For this alternative, it was estimated that the weighted annual average transport of coarse sediments (> 8mm) for both Lewiston and Limekiln Gulch combined, would be approximately 5,400 cubic yards, or approximately 37 percent less than that for the Flow Evaluation Alternative. The weighted annual average transport of fine sediment for this alternative was also estimated to be only approximately 1,100 cubic yards, 41 percent less

than that estimated for the Flow Evaluation alternative. The Modified Percent Inflow alternative would partially provide some of the instream flows necessary to meet sediment transport processes, would reduce fine sediment storage somewhat, and increase coarse material transport over that for the No Action Alternative. However these improvements would be approximately 40-50 percent less than those estimated for the Flow Evaluation alternative, resulting in a lesser overall benefit to mainstem Trinity River morphology.

The benefits and deficiencies in sediment transport and augmentation for this alternative are summarized in Table 2 of Attachment B9. The Modified Percent Inflow Alternative generally have recession limbs steeper than that required to initiate riparian vegetation on floodplains. Because the analyses for the Modified Percent Inflow Alternative uses the median years to represent an Extremely Wet and a Wet water years type, the median year does not represent all years for those two water year classes. Therefore, there could be individual years within the period of record where the recession limbs are sufficient to initiate riparian vegetation. (See Table 3, Figures 8 and 9, and discussion in Attachment B9).

In addition, these measures of habitat improvement must be tempered with the results of the smolt temperature suitability analysis. That analysis indicated that, while there is measured improvement in water temperature for smolt migration over the No Action Alternative, these improvements may not be adequate and inhibit the rate of fishery recovery in the Trinity River. The Modified Percent Inflow alternative, compared to the Maximum Flow and the Flow Evaluation Alternatives, would not perform as well in providing cool water temperatures for outmigrating smolts, especially after July 1st (Table B-14). The Chinook Harvest Index for the Modified Percent Inflow alternative also indicates that the average annual number of harvestable adult Chinook salmon may be reduced from approximately 18.000 to 47,000 adults from the estimates for the Flow Evaluation and the Maximum Flow alternatives respectively (Table 9, Attachment 6). The summary of the changes in the instream release volumes, anadromous salmonid smolt temperature survival indices, and Chinook Harvest Index from the No Action Alternative are shown in Table B-14.

Lower Klamath River Basin. Compared to the No Action Alternative, the Modified Percent Inflow Alternative would result in improvements in water temperature conditions and increased Trinity River flows in many water years. In these years, increased annual flows (and improved water temperature conditions during smolt out-migration could result in improvements in habitat conditions in the lower Klamath River and estuary. These benefits would result in increases to populations under this alternative (Table B-16).

Central Valley. A summary of the estimated average annual losses of early life stages of chinook salmon for this Alternative from Reclamation's LSACTEMC is shown in Table B-16. Tables of annual estimated mortalities for fall, late-fall, winter, and spring chinook salmon for this Alternative are shown in Attachment B8.

From this evaluation for the Modified Percent Inflow Alternative, for the historic simulated period of 1922 through 1993, increased water temperatures in the Sacramento River resulted in an estimated annual average loss of 19 percent of fall chinook early life stages (Table B-16); an increase of approximately 2 percent annually from the No Action Alternative (Table B-17). Annual losses of late-fall chinook salmon were estimated to be approximately 1 percent for the 1922-1993 simulation period (Table B-16). These estimated

losses were unchanged from those estimated for this species under the No Action Alternative (B-16).

Increased water temperatures in the Sacramento River resulted in an estimated annual average loss of 27 percent of threatened spring chinook early life stages (Table B-16); an increase of approximately 4 percent annually from the No Action Alternative (Table B-17). The average annual losses for endangered winter chinook were estimated to be 8 percent for the 1922-1993 simulation period (Table B-16). These estimates represent a small increase (slightly less than ½ of 1 percent) that those estimated for the No Action Alternative (Table B-17).

Using the estimated average annual losses of late-fall chinook salmon as an estimate for steelhead losses in the upper Sacramento River, approximately 1 percent of these fish may be lost annually for this Alternative (Table B-16). This estimate is unchanged from that for the No Action Alternative(Table B-17).

In summary, the estimated losses resulting from increases in water temperature on the early life stages of chinook salmon and steelhead in the Sacramento River for the Modified Percent Inflow Alternative were compared to No Action. The results of this evaluation ranged from no change to approximately 4 percent increase in average annual losses for the 1922-1993 period of simulation, depending on species (Table B-18). These increases in losses are small as compared to the No Action Alternative and may be within the limits of precision of the model used to estimate them. However, these estimated losses in fall, and spring-run chinook salmon in the Sacramento River are considered significant and represent adverse effects from the Modified Percent Inflow Alternative. The results of the evaluation of this Alternative on the anadromous salmonids within the Sacramento River are summarized in Table B-18.

The results of the evaluation of the modified Percent Inflow Alternative on the anadromous salmonids of the affected area (Trinity and Klamath Basins and the Central Valley) are summarized in Table B-19.

1.1.2.11 Existing Conditions versus Preferred (Flow Evaluation) Alternative

Trinity River Basin and Lower Klamath River Basin. The No Action Alternative is, by definition, projected into the year 2020. Existing Conditions are representative of current conditions (2001 level of development). For CEQA purposes, the Preferred (Flow Evaluation) Alternative, which is also projected into the year 2020, must be compared to Existing Conditions. This comparison should be consistent with analyses performed to compare action alternatives to the No Action Alternative. The No Action Alternative and Existing Conditions have the same volume of water releases to the Trinity River, and are modeled on similar release schedules. The TRSAAM cannot detect temporal changes for the same release schedule; hence, the TRSAAM analysis results in the same number of estimated fish for both the No Action and Existing Conditions. The only difference between the No Action Alternative and Existing Conditions for fishery resources is the passage of time (~20 years).

Although the river and its fish habitats would continue to gradually degrade under the No Action Alternative, the majority of the degradation occurred in the decade immediately following dam construction. Therefore, naturally producing anadromous salmonid populations are not expected to substantially change from existing conditions versus the projected numbers for the No Action Alternative. The change that would occur over this 20-year period under the 340 taf water volume will not significantly improve conditions in the Trinity River, river health, or the diversity of fish habitats, and correspondingly will result in, at best, status quo fish populations, and likely somewhat reduced populations.

Implementation of the Preferred Alternative would substantially restore the diverse fish habitats necessary for restoration and maintenance of anadromous salmonid populations compared to existing conditions. Because the Preferred Alternative also includes the watershed protection component of the Mechanical Restoration Alternative, it would likely accelerate and enhance the improvements in habitat and the resultant increases in salmonid production. The Preferred Alternative would also benefit the lower Klamath River beyond the benefits accrued by either the Flow Evaluation Alternative or Revised Mechanical Restoration Alternative individually, due to increased flow releases and improved watershed conditions.

The TRSAAM was only intended to show relative differences between the alternatives after the passage of time (i.e., projected conditions in the year 2020). Existing Conditions is not an alternative, but represents today's conditions with today's environment. No Action conditions are predicted to be slightly worse than what exist today (Existing Conditions), because the volume of water available is not sufficient to manage for a healthy river. The Preferred Alternative has additional measures to improve fish habitat than the Flow Evaluation Alternative alone, so the Preferred Alternative will be better at improving fish habitats and increasing the fish populations that depend on those habitats.

If these four scenarios were ranked for conditions that promote river health, habitat restoration, and naturally producing fish populations, beginning with the best conditions for fishery resources, the ranking would be:

1. Preferred Alternative
2. Flow Evaluation
3. Existing Conditions
4. No Action

Because of the similarity between the Preferred Alternative and the Flow Evaluation Alternative, and the similarity between Existing Conditions and the No Action Alternative, and their relative rankings to one another, it seems appropriate to conclude that the amount of improvement of the Preferred Alternative over Existing Conditions (1 vs. 3) will be similar to the improvement of the Flow Evaluation Alternative over the No Action Alternative (2 vs. 4).

This is the most consistent and logical way to compare, given the following limitations:

1. There was no way to use the TRSAAM to show differences between these No Action and Existing Conditions.
2. Using the actual escapement data for comparison with modeled results from the TRSAAM analysis is inconsistent with alternative assessment methodologies.

The TRSAAM was only intended to show relative differences between the alternatives after the passage of time (i.e., projected conditions in the year 2020).

Central Valley. A summary of the estimated average annual losses of early life stages of chinook salmon for the Preferred Alternative and existing conditions from Reclamation's LSACTEMC Model are shown in Table B-18. Tables of annual estimated mortalities for fall, late-fall, winter, and spring chinook salmon for the Flow Evaluation Alternative and existing conditions are shown in Attachment B8.

Increased water temperatures in the Sacramento River resulted in an estimated annual average loss of 21 percent of fall chinook early life stages for the Preferred Alternative (Table B-15), an increase over existing conditions of 3 percent (Table B-17). Average annual losses of late-fall chinook salmon were estimated to be approximately 1 percent for the simulation period (Table B-15). The estimated average annual loss of late-fall chinook was unchanged from that estimated for this species under the existing conditions (Table B-17).

Increased water temperatures in the Sacramento River resulted in an estimated annual average loss of nearly 32 percent of spring chinook early life stages for the Preferred Alternative (Table B-16), an increase over existing conditions of approximately 8 percent, (Table B-17). For the Preferred Alternative, the average annual loss of winter chinook was estimated to be approximately 9 percent for the 1922-1993 simulation period (Table B-15). This estimate represents an increase in annual average loss of less than approximately 1 percent greater than those estimated for existing conditions (Table B-17).

Reviewing the annual estimated losses of winter chinook salmon in Attachment B8 revealed that the majority of the estimated loss of this species, compared to existing conditions, resulted from extremely high mortalities during three critically dry water years (1933, 1934, and 1977). For any water year during which the drawdown of Shasta Reservoir results in levels of less than 1.9 maf at the end of September 30, it would be necessary to re-consult with NOAA-Fisheries under terms of the 1993 Winter-Run Chinook Biological Opinion (NMFS, 1993). This re-consultation would result in operations that would attempt to minimize losses to these salmonid species.

Using the estimated average annual losses of late-fall chinook salmon as an estimate for steelhead losses in the upper Sacramento River, approximately 1 percent of these fish may be lost annually for the Preferred Alternative (Table B-16). This estimate is less than 1 percent greater that that estimated for existing conditions Table B-17.

In summary, the estimated losses resulting from increases in water temperature on the early life stages of chinook salmon and steelhead in the Sacramento River for the Preferred Alternative were compared to existing conditions. The results of this evaluation from no change to a 8 percent increase in average annual losses for the 1922-1993 period of simulation, depending on species (Table B-18). These increases in losses are small as compared to existing conditions and may be within the limits of precision of the model used to estimate them. However, the estimated losses of chinook salmon in the Sacramento River for the Preferred Alternative are considered significant and represent adverse effects compared to the existing conditions.

The results of the evaluation of impacts of anadromous salmonids within the Trinity and Klamath River Basins, and the Central Valley, for the Preferred Alternative as compared to existing conditions are summarized in Table B-18.

1.2 OTHER NATIVE ANADROMOUS FISH

1.2.1 Affected Environment

Other native anadromous fish species (non-salmonids) found in the areas affected by the project include: white sturgeon (*Acipenser transmontanus*), green sturgeon (*A. medirostris*), Pacific lamprey (*Lampetra tridentata*), and candlefish (eulachon) (*Thaleichthys pacificus*).

1.2.1.1 Trinity River Basin

Native, non-salmonid, anadromous species found in the Trinity River Basin are listed in Table B-1. These species include: white and green sturgeon and Pacific lamprey. As stated previously, anadromous species spend their early life stages in fresh water, migrate to the ocean for maturation, and return to their natal stream to spawn.

Habitat Characteristics and Requirements. Life history characteristics and habitat requirements for green sturgeon and Pacific lamprey in the Trinity River Basin are less precisely known than those for anadromous salmonids. However, life history information and habitat requirements for these species in other river systems have been established. This information is summarized and shown in Table B-20. Green sturgeon are thought to spend less time in fresh water as compared to white sturgeon (Moyle et al., 1995). Migrating green sturgeon move into the Klamath Basin in late February through July and spawn in spring and early summer. Sturgeon require water depths greater than 9 feet (Galbreath, 1979) and water temperatures of approximately 58°F. (Kolhorst, 1976). After spawning, the adhesive eggs of sturgeon settle to the river bottom and attach to substrates. Excessive fine sediment can decrease the adhesiveness of sturgeon eggs, preventing their attachment on the bottom following spawning (Conte, et al. 1988). Rearing requirements for juvenile sturgeon are generally unknown except that juvenile green sturgeon remain within fresh water environments until they emigrate to the estuary sometime during summer through fall and leave the estuary before they are 2 years of age (Moyle, et al., 1995).

Pacific lamprey are somewhat unique in that they have a larval life stage (ammocoete) which remains buried in soft substrates for as long as 5 years before emergence and emigration. Generalized life history and habitat characteristics for Pacific lamprey are summarized in Table B-20.

Populations. While the numbers of non-salmonid native anadromous species residing in the Trinity and Klamath River Basins is generally unknown, it has been established that these basins contain the largest spawning population of green sturgeon in California. Apparently, only small runs of white sturgeon occur in the Klamath and Trinity River Basins. In the Trinity Basin, spawning green sturgeon are known to occur in the mainstem upstream to at least as far as Gray's Falls, near Burnt Ranch. Historically, green sturgeon were also known

to use the South Fork. Since the large flood in 1964, this species was apparently eliminated due to the loss of suitable sturgeon habitat in the South Fork (Moyle, et al., 1995).

The only population information generally available for sturgeon is the green sturgeon harvest estimated annually from the Native American net harvests in the spring and early summer. Typical green sturgeon catches reported for the Yurok tribal harvest in the Klamath River have ranged from 158 adult green sturgeon in 1987 to 810 in 1981 with a mean of 349 in 1987 (Moyle, et al., 1995). Yurok tribal harvest for 1990 and 1991 were 239 and 309 fish, respectively. These estimates do not account, however, for tribal harvest in the Trinity River Basin by the Hoopa Valley Tribe. Some juvenile green sturgeon have been captured during annual surveys in the mainstem Trinity as far as Big Bar.

1.2.1.2 Lower Klamath River Basin

In addition to the native non-salmonid anadromous species found in the Trinity River Basin (Table B-1), eulachon are known to occur in the lower Klamath River. The non-salmonid anadromous species found in the lower Klamath River Basin include: white and green sturgeon, Pacific lamprey, and candlefish.

Life history characteristics and habitat requirements for green sturgeon, white sturgeon, and Pacific lamprey are previously described for those species found in the Trinity River (Table B-20). The populations of sturgeon and lamprey found in the lower Klamath River Basin is unknown. The only information available for these species is the number of green sturgeon harvested annually in the Native American net harvests. See discussion in Trinity River Basin section above.

The main population of eulachon in California occurs in the Klamath River (Moyle, et al., 1995). These native anadromous species spend most of their lives in salt water, migrating into the Klamath in March and April. Eulachon penetrate no more than approximately 6-8 miles upstream of the mouth of the Klamath River. Mass spawning occurs following their arrival during nighttime hours. After hatching, the larvae are swept downstream to the ocean immediately. Eulachon populations in the Klamath estuary have been severely depressed since the mid-1980s.

1.2.1.3 Coastal Area

The coastal area adjacent to the Klamath River Basin provides rearing and foraging habitat for the maturing and adult life stages of the native non-salmonid anadromous species found in the lower Klamath and Trinity River Basins. Habitat conditions in this coastal near shore and ocean environment are subject to natural productivity as affected by physical and biological oceanic processes, weather, and climate patterns. Except indirectly, humans generally do not affect populations of these species in the coastal areas adjacent to the Klamath River Basin as there is no commercial and little, if any, recreational harvest of these species. Factors affecting the abundance of these species in the coastal areas adjacent to the project are likely to be the result of natural factors.

1.2.1.4 Central Valley

The native non-salmonid anadromous fish in the Central Valley include the green sturgeon and white sturgeon, and Pacific lamprey. Life history and habitat characteristics have previously been described in the Klamath and Trinity River Basin discussion above.

The estimated population of adult white sturgeon in the Central Valley for the period of 1967-1991 has been estimated to be approximately 64,000 fish with a low of 28,000 estimated for the year 1990 (Mills and Fisher, 1993) (Attachment B1, Table B1-10 of the 1999 DEIS/DEIR Fishery Technical Appendix). Adult green sturgeon abundance for the same interval has been estimated to be approximately 870 fish (Mills and Fisher, 1994). There are no estimates of Pacific lamprey in the Central Valley.

The factors affecting the abundance of native non-salmonid anadromous fish in the Central Valley include: inadequate stream flows and temperatures in the Sacramento and San Joaquin Rivers, water export/inadequate outflows in the Delta, entrainment losses at water diversions, lack of abundant food, poor water quality, predation by and competition from introduced species, and lack of suitable spawning and rearing habitat. (U.S. Fish and Wildlife Service, 1995).

1.2.2 Environmental Consequences

1.2.2.1 Methodology

Trinity River Basin. There are no direct methods to assess the effects of project alternatives on other native anadromous fish species in the Trinity River. To evaluate the effects of the project on these species the following assumptions were made:

- Increased coldwater releases to the Trinity River are not harmful for other native emigrating and immigrating anadromous fish species.
- Increases in stream flows in the Trinity River would improve habitat conditions and river system health for other native anadromous fish species within the Trinity River.
- Mechanical restoration of riverine habitats within the Trinity River would not affect other native anadromous fish species within the Trinity River.
- Watershed protection activities in the Trinity River would improve habitat conditions and river system health for other native anadromous fish species within the Trinity River.

In summary, for the purposes of this analysis, it was assumed that any benefits or adverse effects on native anadromous fish species in the Trinity River would be the same as those for naturally produced anadromous salmonid species. Using these assumptions, a qualitative assessment of the effects of project alternatives, as compared to No Action, was made.

Lower Klamath River Basin. There were no methods available to directly measure or evaluate the effects of project alternatives on other native anadromous fish resources within the lower Klamath River. For this reason, several assumptions were made to assist in assessing the effects of project alternatives on these resources. These assumptions were:

- Increased coldwater releases to the Trinity River reduce Klamath River temperatures during mid-May through late-June (U.S. Fish and Wildlife Service, 1998) and are not harmful for native non-salmonid anadromous fish.
- Increases in stream flows in the Trinity River would improve habitat conditions and river system health for other native anadromous fish within the lower Klamath River and estuary.
- Mechanical restoration of riverine habitats within the Trinity River would not affect other native anadromous fish species within the lower Klamath River.
- Watershed protection activities in the Trinity River would improve habitat conditions and river system health for other native anadromous fishery resources in the lower Klamath River.

In summary, for the purposes of this analysis, it was assumed that any benefits or adverse effects on native anadromous fish species in the Klamath River would be the same as those for naturally produced anadromous salmonid species in the Klamath River. Using these assumptions, a qualitative assessment of the effects of each project alternative, as compared to No Action, was made.

Coastal Area. There were no methods readily available to estimate or directly measure any effect of project alternatives on other native anadromous species inhabiting Coastal Area. It was assumed that there would be no measurable or incremental effect on food availability, rates of predation or survival, or other ecological consequences to other native anadromous fish species in the adjacent Coastal Areas as a result of any of the project alternatives. Therefore, it was assumed that there would be no likely measurable effects.

Central Valley. There are no direct methods for estimating the effects of project alternatives on native non-salmonid anadromous fish species in the Central Valley. For the purpose of estimating effects of the project alternatives, it was assumed that any adverse effects or benefits to naturally produced anadromous salmonid species in the Central Valley from changes in stream flows resulting in reduced habitat area would similarly effect or benefit other native anadromous fishery resources.

To evaluate the potential effects of the project alternatives on other native anadromous fish species in the Central Valley, a comparison of the annual flows at various locations in the Sacramento River (and Delta) was conducted. Total annual discharges for each alternative for Keswick, Grimes, Verona, inflow into the Delta, and outflow from the Delta were compared to the No Action Alternative to determine potential changes in habitat for other native anadromous fish species. It was assumed that decreases in monthly average stream flows or inflows and outflows in the Delta greater than 10 percent of those for the No Action Alternative would be sufficient to reduce habitat quality and/or quantity for other native anadromous fish in the Central Valley. The evaluation was focused on the middle and lower

portions of the Sacramento River and Delta as this region provides the majority of spawning and rearing habitats for species such as sturgeon in the Central Valley.

1.2.2.2 Significance Criteria

Effects are considered significant for native anadromous fish (other than salmonids) if they result in any of the following:

- Potential for reductions in the number, or restrictions of the range, of an endangered or threatened native anadromous species or a native anadromous species that is a candidate for state listing or proposed for federal listing as endangered or threatened
- Potential for substantial reductions in the habitat of any native anadromous species other than those that are listed as threatened or endangered or are candidates (CESA) or proposed (ESA) for threatened or endangered status
- Potential for causing a native anadromous fish population to drop below self-sustaining levels
- Substantial adverse effect, either directly or through habitat modifications, on any native anadromous fish species identified as a sensitive or special-status species in local or regional plans, policies, or regulations by the California Department of Fish and Game, the U.S. Fish and Wildlife Service, or the National Marine Fisheries Service
- Substantial interference with the movement of any native anadromous fish species
- A conflict with, or violation of, the provisions of an adopted Habitat Conservation Plan, Natural Community Conservation Plan, or other approved local, regional, or state habitat conservation plan relating to the protection of native anadromous fish species
- Mortality of state or federally listed anadromous species, or species that are candidates for listing (CESA) or proposed for listing (ESA)
- Reductions in the size of a native anadromous species' population sufficient to jeopardize its long-term persistence
- Temporary impacts to habitats such that native anadromous species suffer increased mortality or lowered reproductive success that jeopardizes the long-term persistence of those local populations
- Permanent loss of essential habitat of a listed species or special-status native anadromous fish species
- Reduction in the quantity or quality of habitats in which native anadromous populations occur sufficient to reduce the long-term abundance and productivity of local populations

1.2.2.3 Results

Summary. The results of the comparisons of the No Action Alternative to each project alternative are summarized in Table B-19. Compared to the No Action Alternative, the Maximum Flow, Flow Evaluation, 70 Percent Inflow, Revised Mechanical Restoration, and

Modified Percent Inflow Alternatives would all result in highly beneficial habitat conditions for other anadromous species in the Trinity River. The Mechanical Restoration Alternative would result in only modest benefits to these species in the Trinity River Basin. Except for the Mechanical Restoration Alternative, all of the alternative would benefit other anadromous species in the Klamath River Basin to some extent. This benefit would be principally due to increased flows and somewhat cooler water temperatures in the Klamath River downstream of its confluence with the Trinity River.

The Maximum Flow, Alternative may adversely impact other anadromous species in the Central Valley. In the Central Valley, there would be no measures to mitigate, to less than significant, the adverse effects to native resident species from implementing from implementing the Maximum Flow, Alternative.

1.2.2.4 No Action Alternative

Trinity River Basin. As stated in the methodology section, it was assumed that increased coldwater releases to the Trinity River would not harm other native anadromous as well as naturally produced anadromous salmonid species. Increased stream flows in the Trinity River would provide river system benefits resulting in improved habitat conditions for the other native anadromous fish species. Mechanical habitat restoration and watershed sediment management activities on the mainstem Trinity River would improve habitat conditions and benefit other native anadromous fish species in the Trinity River Basin. Thus, it was assumed that any benefits or adverse effects on native anadromous fish species in the Trinity River would be the same as those for naturally produced anadromous salmonid species. Using these assumptions, the assessment of the effects of the No Action Alternative on other anadromous species was made.

The No Action Alternative performed poorly in meeting the river system attributes and habitat requirements necessary for restoring naturally produced anadromous salmonids in the mainstem Trinity River (Tables B-10 and B-11). TRSAAM results indicate that, under the No Action Alternative, fishery habitat in the mainstem Trinity River in the year 2020 would also not likely provide the conditions necessary to allow other native anadromous stocks to recover to pre-dam population levels.

Lower Klamath River Basin/Coastal Area. It was assumed that any benefits or adverse effects on native anadromous fish species in the Klamath River would be the same as those for naturally produced anadromous salmonid species in the Klamath River. Using these assumptions, a qualitative assessment of the effects of the No Action Alternative was made. As shown in Tables B-10 and B-11, the No Action Alternative performed poorly in meeting the river system attributes and habitat requirements necessary for restoring naturally produced anadromous salmonids in the mainstem Trinity River. TRSAAM results indicate that, under the No Action Alternative, fishery habitat in the mainstem Trinity River in the year 2020 would also not likely provide the conditions necessary to provide sufficient benefits to other native anadromous species in the lower Klamath River and estuary to restore populations to pre-dam levels.

Central Valley. The other native anadromous fish in the Central Valley that may be affected by the project are green and white sturgeon and Pacific lamprey. All of these species are primarily found in the middle to lower reaches of the Sacramento River, the Delta, and the

lower reaches of the San Joaquin River. For the simulated period 1922-1993, the average annual discharge of the Sacramento River as estimated at Grimes and Verona was approximately 11,300 cfs and 19,300 cfs, respectively (Table B-21). Total average annual inflow and outflows for the Delta are approximately 29,200 cfs and 19,900 cfs, respectively (Tables B-22 and B-23). Habitat quantity and quality for the other native anadromous species in the Central Valley areas affected by the project alternatives are directly effected by the volume and quality of water moving through this region. The changes, from No Action, in estimated average yearly and monthly Sacramento River discharges and Delta inflows and outflows were used to qualitatively evaluate changes in habitat for these species. This is necessary as there are no specific habitat/discharge relationships known for these species for the Sacramento River or Delta..

1.2.2.5 Maximum Flow Alternative

Trinity River Basin. The results of the TRSAAM analysis for all attribute objectives for the Maximum Flow Alternative are shown in Table B-10 and are summarized in Table B-11. As shown in these tables, the Maximum Flow Alternative was scored 58 of the total possible 70 attribute objectives points believed necessary to restore the Trinity River fluvial river system. Compared to No Action, the Maximum Flow Alternative excelled in meeting the river system and habitat requirements necessary for restoring naturally produced anadromous salmonids in the mainstem Trinity River. This would also greatly enhance habitat conditions for other anadromous fish species in the Trinity Basin (Table B-19). These results indicate that river system health and habitat conditions would be expected to improve approximately 1350 percent under the Maximum Flow Alternative as compared to No Action, using the TRSAAM scores as a measure of comparison (Table B-15). These results indicate that, compared to the No Action Alternative, fishery habitat in the mainstem Trinity River in the year 2020 would greatly improve under the Maximum Flow Alternative and would likely result in large increases in other native anadromous fish populations as compared to those expected from the No Action Alternative.

Lower Klamath River Basin/Coastal Area. Improvements in water temperature conditions and increases in flows in the Trinity River would result in more favorable conditions in the lower Klamath River, thus benefiting other anadromous species within the lower Klamath River and estuary. Increases in flows to the Trinity River would increase habitat quantity and benefit habitat conditions in the lower Klamath River and estuary. Increases in flow in the Trinity River resulting from spring reservoir releases would improve temperature conditions in the Klamath River downstream of the confluence. This alternative would provide habitat conditions more suitable to other native anadromous fish species than the No Action Alternative.

Beneficial habitat conditions, as a result of more optimal temperatures and increased flows, would likely improve survival rates for young life stages of other native anadromous species and enhance the probability of their successful passage to the ocean. Improved habitat conditions for juveniles rearing in the lower Klamath River and estuary would also likely occur (Table B-19). These benefits would likely result in increased populations under the Maximum Flow Alternative.

Central Valley. It was assumed that decreases in monthly average stream flows greater than 10 percent of those for the No Action Alternative during months critical to spawning and early rearing (February through August) would significantly diminish habitat quality and quantity for other native anadromous species in the Central Valley. Increases in flows greater than 10 percent of those for the No Action Alternative during February through August were considered beneficial to these species. For the simulated period 1922-1993, the average annual discharge of the Sacramento River at Keswick, Grimes, and Verona for the Maximum Flow Alternative is approximately 7,693, 10,500, and 18,400 cfs, respectively (Table B-21). For the Maximum Flow Alternative, the total average annual discharges in the upper and middle reaches of the Sacramento River decreased approximately 12 and 9 percent at Keswick and Grimes respectively (Table B-24). The monthly average flows diminished from 12 to up to 21 percent for some months (July through November) compared to the No Action Alternative (Table B-24). The total average annual discharges in the lower reach of the Sacramento River decreased by approximately 6 percent at Verona compared to those discharges estimated for the No Action Alternative (Table B-24). Flows at Verona decreased from 10 up to 13 percent (September through November) compared to the No Action Alternative. Considering the magnitude of the decreases in some of the monthly average discharges, it is likely that reductions in habitat quantity and quality would be sufficient to adversely affect other anadromous species in the lower Sacramento River.

The average annual inflow and outflow in the Delta for the Maximum Flow Alternative is estimated to be approximately 28,300 and 19,400 cfs, respectively (Tables B-22 and B-23). These flows are approximately 4 percent less, on average, than those for the No Action Alternative (Tables B-25 and B-26).

There would be substantial numbers of months in many years in which reductions in Sacramento River flows would be significantly less than those for the No Action Alternative. These reductions in flow and resulting habitat quality and quantity may result in significant impacts to other native anadromous species in the Central Valley (Table B-19).

1.2.2.6 Flow Evaluation Alternative

Trinity River Basin. The results of the TRSAAM analysis for all attribute objectives for the Maximum Flow Alternative are shown in Table B-10 and are summarized in Table B-11. As shown in these tables, the Flow Evaluation Alternative was scored 49 of the total possible 70 attribute objectives points believed necessary to restore the Trinity River fluvial river system. Compared to No Action, the Flow Evaluation Alternative provided greatly improved river system and habitat conditions necessary for restoring naturally produced anadromous salmonids in the mainstem Trinity River. These improvements would also greatly enhance habitat conditions for other native anadromous fish species in the Trinity Basin. The results indicate that river system health and habitat conditions would be expected to improve approximately 1,125 percent under the Flow Evaluation Alternative as compared to No Action, using the TRSAAM scores as a measure of comparison (Table B-15). These results indicate that, compared to the No Action Alternative, fishery habitat in the mainstem Trinity River in the year 2020 would greatly improve under the Flow Evaluation Alternative (Table B-19) and would likely result in increases in other native anadromous populations compared to those expected from the No Action Alternative.

Lower Klamath River Basin/Coastal Area. For the Flow Evaluation Alternative, improvements in water temperature conditions and increases in flows in the Trinity River would likely result in more favorable conditions in the lower Klamath River and estuary, thus benefiting other native anadromous species. An annual increase in Trinity River flows would likely improve habitat conditions in the lower Klamath River and estuary in most years (Table B-19). Increases in flow in the Trinity River resulting from spring Lewiston Dam releases would greatly improve temperature and habitat conditions in the Klamath River downstream of the confluence with the Trinity River (U.S. Fish and Wildlife Service, 1998).

Beneficial habitat conditions, as a result of cooler summer water temperatures and increased flows, would likely improve survival rates for young life stages of other native anadromous species and enhance the probability of their successful passage to the ocean. Improved habitat conditions for juveniles rearing in the lower Klamath River and estuary would likely occur. These benefits would likely result in increased populations of these species for the Flow Evaluation Alternative.

Central Valley. It was assumed that decreases in monthly average stream flows greater than 10 percent of those for the No Action Alternative would significantly diminish habitat quality and quantity for other native anadromous species in the Central Valley. Increases in flows greater than 10 percent of those for the No Action Alternative were considered beneficial to these species. For the simulated period 1922-1993, the average annual discharge of the Sacramento River at Keswick, Grimes, and Verona for the Flow Evaluation Alternative is approximately 8,703, 11,000, and 19,000 cfs, respectively (Table B-21). For this alternative, the total average annual discharges in the upper and middle reach of the Sacramento River decreased approximately 4 and 3 percent at Keswick and Grimes, respectively, and monthly average flows ranged from no change to a decrease of 6 percent compared to the No Action Alternative (Table B-24). The total average discharges in the lower reach of the Sacramento River decreased by approximately 2 percent at Verona compared to those discharges estimated for the No Action Alternative (Table B-24). Average monthly flows at Verona decreased up to 4 percent compared to the No Action Alternative. Considering the magnitude of the decreases in the annual monthly discharges, it is likely that reductions in habitat quantity and quality would be insufficient to adversely affect other anadromous species in the mid and lowermost reaches of the Sacramento River.

The average annual inflow and outflow in the Delta for the Flow Evaluation Alternative is estimated to be approximately 28,900 and 19,700 cfs, respectively (Tables B-23 and B-23). These flows are approximately 1 percent less, on average, than those for the No Action Alternative (Tables B-25 and B-26).

The yearly average inflows to or outflows from the Delta would not be significantly less than those for No Action (Tables B-25 and B-26). These reductions in flow and resulting habitat quality and quantity would not result in significant impacts to other native anadromous species in the Sacramento River and/or the Delta for this Alternative (Table B-19).

1.2.2.7 70 Percent Inflow Alternative

Trinity River Basin. The results of the TRSAAM analysis for all attribute objectives for the 70 Percent Inflow Alternative are shown in Table B-10 and are summarized in Table B-11. As shown in these tables, the 70 Percent Inflow Alternative was scored 51 of the total

possible 70 attribute objectives points believed necessary to restore the Trinity River fluvial river system. Compared to No Action, this alternative provided significantly beneficial improvement to river system and habitat conditions necessary for restoring anadromous salmonids species in the mainstem Trinity River (Table B-19). These expected improvements would likely provide significant benefits to habitat conditions for other native anadromous fish species in the Trinity Basin. The TRSAAM analysis indicated that river system health and habitat conditions improved approximately 1,175 percent for the 70 Percent Inflow Alternative as compared to No Action (Table B-15). These results indicate that, compared to the No Action Alternative, fishery habitat in the mainstem Trinity River in the year 2020 would improve under the 70 Percent Inflow Alternative and would likely result in increases in other native anadromous fish populations as compared to the No Action Alternative.

Lower Klamath River Basin/Coastal Area. The 70 Percent Inflow Alternative would result in improved water temperature conditions and increased Trinity River flows in many water years. In these years, increased annual flows (and improved water temperature conditions) could result in improved habitat conditions in the lower Klamath River and estuary (Table B-19). These improvements may result in significant improvements to populations of other native anadromous salmonids under the 70 Percent Inflow Alternative.

Central Valley. It was assumed that decreases in monthly average stream flows greater than 10 percent of those for the No Action Alternative would significantly diminish habitat quality and quantity for other native anadromous species in the Central Valley. Increases in flows greater than 10 percent of those for the No Action Alternative were considered beneficial to these species. For the simulated period 1922-1993, the average annual discharge of the Sacramento River at Keswick, Grimes, and Verona for the 70 Percent Inflow Alternative is approximately 8,007, 10,700, and 18,700 cfs, respectively (Table B-21). For this Alternative, the total average annual discharges in the upper and middle reach of the Sacramento River decreased approximately 9 and 6 percent at Keswick and Grimes respectively, and the range of monthly average flows decreased 1 to 8 percent compared to the No Action Alternative (Table B-24). The total average annual discharges in the lower reach of the Sacramento River decreased by approximately 4 percent at Verona compared to those discharges estimated for the No Action Alternative (Table B-24). Average monthly flows at Verona decreased from 1 percent (January, February, and April) to 8 percent (November) as compared to the No Action Alternative (Table B-24). Considering the magnitude of the decreases ($\geq$10 percent less than No Action) in the monthly average discharges at Grimes from September through November, reductions in habitat quantity and quality may be sufficient to adversely affect other anadromous species in the lower Sacramento River.

The average annual inflow and outflow in the Delta for the 70 Percent Inflow Alternative is estimated to be approximately 28,600 and 19,400 cfs, respectively (Tables B-22 and B-23). These flows are approximately 3 percent less, on average annually, than those for the No Action Alternative (Tables B-25 and B-26).

The monthly flows in the Sacramento River and inflows to and outflows from the Delta would not be significantly less, on average, than those for the No Action Alternative. The reductions in discharges and outflows would result in significant reductions in habitat quality

or quantity and therefore significant impacts to other native anadromous species would occur in the Central Valley (Table B-19).

1.2.2.8 Mechanical Restoration Alternative

Trinity River Basin. The results of the TRSAAM analysis for all attribute objectives for the Mechanical Restoration Alternative are shown in Table B-10 and summarized in Table B-11. As shown in these tables, this alternative was scored 13 out of the total possible 70 attribute objectives points believed necessary to restore the Trinity River fluvial river system. A majority of the attribute objectives were determined to never or nearly never exceed threshold criteria for this alternative. This alternative was determined to provide only some small benefit in meeting river system attribute objectives compared to the No Action Alternative. These results indicate that conditions would be expected to improve approximately 225 percent under this alternative as compared to No Action, using the TRSAAM scores as a measure of comparison (Table B-15). Small and localized beneficial improvements in river system health and function would likely result in only small benefits to other native anadromous fish populations as compared to No Action (Table B-19).

Lower Klamath River Basin/Coastal Area. The only changes in habitat conditions in the Trinity River Basin under the Mechanical Restoration Alternative are through mechanical means. Therefore, no benefits resulting from increased flows or cool water temperature would be expected in the lower Klamath River and estuary under the Mechanical Restoration Alternative. Habitat conditions for this Alternative would remain unchanged from No Action for the lower Klamath River and estuary. Other native anadromous fish populations in the lower Klamath River would likely remain unchanged under this project alternative (Table B-19).

Central Valley. This alternative would not affect habitats for other native anadromous fish species in the Central Valley and therefore would result in no change from the No Action Alternative (Table B-19).

1.2.2.9 Revised Mechanical Restoration Alternative

Trinity River Basin. The results of the TRSAAM analysis for all attribute objectives for the Revised Mechanical Restoration Alternative are shown in Table B-10 and summarized in Table B-11. As shown in these tables, this alternative was scored 37 out of the total possible 70 attribute objectives points believed necessary to restore the Trinity River fluvial river system. While many of the attribute objectives were determined to never or nearly never exceed threshold criteria for this alternative there were substantial improvements in habitat due to increased flows and physical mechanical enhancements. This alternative was determined to be largely beneficial in meeting river system attribute objectives compared to the No Action Alternative (Table B-19). These results indicate that conditions would be expected to improve approximately 825 percent under this alternative as compared to No Action, using the TRSAAM scores as a measure of comparison (Table B-15). Beneficial improvements in river system health and function would result in benefits to other native anadromous fish populations as compared to No Action.

Lower Klamath River Basin/Coastal Area. The changes in habitat conditions in the Trinity River Basin under the Revised Mechanical Restoration Alternative are largely through mechanical means with some benefits from increase flow releases. This Alternative would result in some improvements water temperature conditions and increased Trinity River flows in all but critically dry water years. In those years with increased annual flows (and improved water temperature conditions) could result in some improvements in habitat conditions in the lower Klamath River and estuary. These benefits to habitat condition may result in modest benefits to populations of other native anadromous fish under this alternative (Table B-19).

Central Valley. It was assumed that decreases in monthly average stream flows greater than 10 percent of those for the No Action Alternative would significantly diminish habitat quality and quantity for other native anadromous species in the Central Valley. Increases in flows greater than 10 percent of those for the No Action Alternative were considered beneficial to these species. For the simulated period 1922-1993, the average annual discharge of the Sacramento River at Keswick, Grimes, and Verona for this alternative is approximately 8,574, 11,200, and 19,200 cfs, respectively (Table B-21). For this alternative, the total average annual discharge in the upper and middle reaches of the Sacramento River decreased approximately 1 percent at Keswick and Grimes, and the changes in the monthly average flows ranged from no change in January through April to a decrease of 3 percent in October and June compared to the No Action Alternative (Table B-24). The total average annual discharges in the lower reach of the Sacramento River also decreased by approximately 1 percent at Verona compared to those discharges estimated for the No Action Alternative (Table B-24). The changes in the average monthly flows at Verona ranged from no change (December through April and September) to a decrease of 3 percent in June as compared to the No Action Alternative. Considering the magnitude of the decreases ($\geq$10 percent less than No Action) in the annual and monthly average discharges, it is likely that reductions in habitat quantity and quality would not be sufficient to adversely affect other anadromous species in the lower Sacramento River.

The average annual inflow and outflow in the Delta for the Revised Mechanical Restoration Alternative is estimated to be approximately 29,100 and 19,800 cfs, respectively (Tables B-22 and B-23). These flows are approximately 1 percent less, on average, than those for the No Action Alternative (Tables B-25 and B-26).

These changes would not result in significant adverse impacts to these species in the lower Sacramento River/Delta for this Alternative (Table B-19).

1.2.2.10 Modified Percent Inflow Alternative

Trinity River Basin. The results of the TRSAAM analysis for all attribute objectives for the Modified Percent Inflow Alternative are shown in Table B-10 and are summarized in Table B-11. As shown in these tables, this alternative was scored 51 of the total possible 70 attribute objectives points believed necessary to restore the Trinity River fluvial river system. Compared to No Action, this alternative provided significantly beneficial improvements to river system and habitat conditions necessary for restoring anadromous salmonids species in the mainstem Trinity River (Table B-15). These expected improvements would likely provide large improvements in habitat conditions for other native

anadromous fish species in the Trinity Basin (Table B-19). The TRSAAM analysis indicated that river system health and habitat conditions improved approximately 1,175 percent for this Alternative as compared to No Action (Table B-15). These results indicate that, compared to the No Action Alternative, fishery habitat in the mainstem Trinity River in the year 2020 would greatly improve under the Modified Percent Inflow Alternative and would likely result in increases in other native anadromous fish populations as compared to the No Action Alternative.

Lower Klamath River Basin/Coastal Area. The Modified Percent Inflow Alternative would result in improved water temperature conditions and increased Trinity River flows in most water years. In these years, increased annual flows (and improved water temperature) would result in improved habitat conditions in the lower Klamath River and estuary. These improvements would result in benefits to other native anadromous fish populations under the Modified Percent Inflow Alternative (Table B-19).

Central Valley. It was assumed that decreases in monthly average stream flows greater than 10 percent of those for the No Action Alternative would significantly diminish habitat quality and quantity for other native anadromous species in the Central Valley. Increases in flows greater than 10 percent of those for the No Action Alternative were considered beneficial to these species. For the simulated period 1922-1993, the average annual discharge of the Sacramento River at Keswick, Grimes, and Verona for the Modified Percent Inflow Alternative is approximately 8,514, 11,200, and 19,200 cfs, respectively (Table B-21). For this alternative, the total average annual discharge in the upper and middle reaches of the Sacramento River decreased approximately 2 percent, and the changes in monthly average flows ranged from no change percent to a decrease of 4 percent compared to the No Action Alternative (Table B-24). The total average annual discharge in the lower reach of the Sacramento River (Verona) decreased by approximately 1 percent compared those estimated for the No Action Alternative (Table B-24). Average monthly flows at Verona ranged from no change to a decrease of 4 percent (June) as compared to the No Action Alternative. Considering the magnitude of the decreases ($\geq$10 percent less than No Action) in the annual and monthly average discharges, it is likely that reductions in habitat quantity and quality not would be sufficient to adversely affect other anadromous species in the lower Sacramento River.

The average annual inflow and outflow in the Delta for the Modified Percent Inflow Alternative is estimated to be approximately 29,000 and 19,800 cfs, respectively (Tables B-22 and B-23). These flows are approximately 1 percent less, on an annual average, than those for the No Action Alternative (Tables B-25 and B-26).

None of the monthly flows in the Sacramento River and/or inflows to or from the Delta would be significantly less, on average, than those for the No Action Alternative. For the Modified Percent Inflow Alternative, no reductions in inflows and outflows would be sufficient so as to result in adverse effects to other native anadromous species in the Delta (Table B-19).

1.2.2.11 Existing Conditions versus Preferred (Flow Evaluation) Alternative

Trinity River Basin and Lower Klamath River Basin/Coastal Area. Implementation of the Preferred (Flow Evaluation) Alternative would substantially restore the diverse fish habitats necessary for restoration and maintenance of native anadromous fish populations compared to existing conditions. The degree of improvement is similar to that of the Flow Evaluation alternative over the No Action Alternative, even though the No Action Alternative is projected into the year 2020. Although the river and its fish habitats would continue to gradually degrade under the No Action Alternative, the majority of the degradation occurred in the decade immediately following dam construction. Therefore, native anadromous fish populations are not expected to substantially change from existing conditions versus the projected numbers for the No Action Alternative (the TRSAAM was not designed to detect temporal changes for the same release conditions). Because the Preferred Alternative also includes the watershed protection component of the Mechanical Restoration Alternative, it would likely accelerate and enhance the improvements in habitat and the resultant increases in fish production. The Preferred Alternative would also benefit the Klamath River beyond the benefits accrued by either the Flow Evaluation Alternative or Mechanical Restoration Alternative individually, due to increased flow releases and improved watershed conditions. The Preferred Alternative would likely impact native anadromous fish in the Central Valley similar to the impacts of the Flow Evaluation compared to the No Action Alternative.

Central Valley. It was assumed that decreases in monthly average stream flows greater than 10 percent of those for existing conditions during months critical to spawning and rearing (February through August) would significantly diminish habitat quality and quantity for other native anadromous species in the Central Valley. Increases in flows greater than 10 percent of those for existing conditions were considered beneficial to these species. For existing conditions (for the simulated period 1922-1993), the average annual discharge in the Sacramento River as estimated for Keswick, Grimes, and Verona is approximately 8,703, 11,300, and 19,300 cfs, respectively (Table B-21). For the Preferred Alternative (Flow Evaluation Alternative), for the simulated period 1922-1993, the average annual discharge in the Sacramento River as estimated for Keswick, Grimes, and Verona is approximately 8,387, 11,000, and 19,000 cfs, respectively (Table B-21). The estimated changes in the average annual Sacramento River flows for Keswick, Grimes, and Verona for the Preferred Alternative as compared to existing conditions are shown in Table B-24. Changes in the estimated average annual Sacramento River flows at Keswick and Grimes for the Preferred Alternative averaged approximately 4 percent less and ranged from no change up to nearly 10 percent less compared to existing conditions (Table B-24). These decreases in stream flows would likely be insufficient to result in significant losses in habitat for other native anadromous species residing in the middle and lower reaches of the Sacramento River.

For the Preferred Alternative, the total average annual discharge (in cfs) for the lower reach of the Sacramento River at Verona decreased by an average of approximately 2 percent and ranged from no change to a decrease of 4 percent compared to existing conditions (Table B-24). Considering the magnitude of these decreases in annual discharges, it is not likely that the quantity and quality of other native anadromous species' habitats would be significantly impacted in the lower Sacramento River reach.

For existing conditions, the total average annual inflow and outflows for the Delta are approximately 29,300 and 20,000 cfs, respectively (Tables B-22 and B-23). For the Preferred Alternative, the total average annual inflow and outflow for the Delta are approximately 28,900 and 19,700 cfs, respectively (Tables B-22 and B-23). The annual average decrease in Delta inflows and outflows for the Preferred Alternative are 2 percent and 3 percent, respectively, as compared to existing conditions.

On average, there would be no significant numbers of years in which inflows to the Delta would be significantly less than those for existing conditions. These changes would not result in significant impacts to other native anadromous species in the Delta (Table B-19).

1.3 RESIDENT NATIVE FISH

1.3.1 Affected Environment

1.3.1.1 Trinity River Basin

Resident native fish species found in the Trinity River Basin are listed in Table B-1. These species include gamefish: rainbow trout (*Oncorhynchus mykiss*); and non-gamefish: speckled dace (*Rhinichthys osculus*), Klamath smallscale sucker (*Catostomus rimiculus*), and coast range sculpin (*Cottus aleuticus*).

Rainbow trout in the Trinity River Basin are found in the mainstem Trinity River, its tributaries, and the Trinity River Basin reservoirs. This species is the nonanadromous form of the steelhead that are found in cool, swift waters throughout the basin. This species spawns in the tributaries and possibly the mainstem Trinity River in suitable riffle areas primarily during February through late May. Eggs incubate starting in February and generally hatch no later than late June. The Trinity River sport fishery for rainbow trout may include juvenile steelhead and salmon, as well as rainbow trout (Frederiksen, Kamine, and Associates, 1980).

Speckled dace and Klamath smallscale sucker are common within the Trinity and Klamath River Basins. Smallscale suckers prefer deep, quiet pools of the mainstem rivers and tributaries. They are presumed to spawn in the tributary streams in these basins during the spring months (Moyle, 1976). Speckled dace are the most widely distributed freshwater fish in the western United States. They inhabit cool, slow, rocky-bottomed streams and rivers where they browse on small invertebrate prey organisms. This species is found in small groups that feed extensively at night in the Trinity River (Moyle, 1976). Coast range sculpins are generally less abundant and widely distributed than other sculpins (Moyle, 1976). They are typically found in swift gravel areas in the lower reaches of coastal rivers and streams. They are active at night and thought to be predatory on small insect larvae, clams, and snails. The abundance of these species and the factors affecting their abundance within the Trinity River Basin is not well understood.

1.3.1.2 Lower Klamath River Basin

In addition to the native resident species found in the Trinity River Basin, marbled sculpin *(Cottus klamathensis),* prickly sculpin (*Cottus asper*), threespine stickleback *(Gasterosteous aculeatus),* staghorn sculpin *(Leptocottus armatus),* longfin smelt (*Spirinchus thaleichthys*), and starry flounder *(Platichthys stellatus)* are known to occur in the lower Klamath River Basin (Moyle, 1976). Except for marbled sculpins, these fish are species that range into estuarine, marine, and adjacent freshwater habitats. Other marine species such as topsmelt, shiner perch, arrow goby, and sharpnose sculpin may occasionally occur in the lower Klamath River estuary. The abundance and distribution of all of these species and the factors affecting their abundance in the lower Klamath River Basin are not known.

Non-native species know to occur in the Lower Klamath are similar to those found in upstream areas including the reservoirs. Some of these species include yellow perch, black crappie, green sunfish, golden shiner, and brown bullhead.

Specific information on the life history characteristics and habitat requirements for longfin smelt in the lower Klamath River Basin is generally unknown. However, these requirements are known for the Delta estuary (see discussion in the Central Valley section below). The population of longfin smelt found in the Klamath River estuary is small and of uncertain status (Moyle, et al., 1995). In November 1992, two individual longfin smelt were collected in the Klamath River estuary (Moyle, et al., 1995). The factors that limit longfin smelt abundance in the Klamath estuary are unknown. It is likely however, that the reduction in Klamath and Trinity Basin river flows have adversely affected this species just as Delta outflow reductions have impacted this species' population in the Delta.

1.3.1.3 Coastal Area

Numerous native marine species are found in tidepool, and nearshore habitats in the coastal area adjacent to the lower Klamath River Basin. There are as many as 250 species of tide-pool and nearshore fish in the coastal water of California (Fitch and Lavenberg, 1973), most of which would be expected to occur in the coastal waters adjacent to the project. Important recreational species include representatives from the following families: halibut and sanddab (*Bothidae*), herring (*Clupidae*), surf perch (*Embiotocidae*), lingcod and greenling (*Hexagrammidae*), smelt (*Osmeridae*), sole and flounder, (*Pleuroectidae*), and rockcod (*Scorpaenidae*).

In addition, important commercial fisheries exist for numerous coastal marine fish harvested from waters adjacent to the project area. These species include the following: flatfish, (dover, english, petrale, and rex sole, and California halibut); roundfish, (sablefish-black cod and Pacific hake or whiting); rockfish (*genus Sebastes, Sebastolobus,* and *Scorpaena* including black, calico, blackgill, canary, and widow rockfish, Pacific ocean perch, bocaccio, chilepepper, and thornyhead); albacore tuna; and lingcod. Most or all of these species are landed in Eureka and Crescent City, California, and Brookings, Oregon.

1.3.1.4 Central Valley

Many of the same species found in the lower Klamath and Trinity River Basins also occur in the Central Valley. In addition to the species shown in Table B-1, the following native resident species occur (Moyle, 1976): Pacific brook lamprey, hardhead, hitch, blackfish, California roach, Sacramento squawfish, Sacramento splittail, Sacramento sucker, tule perch, prickly sculpin, longfin smelt, and Delta smelt.

A longfin smelt population abundance index is annually estimated by the CDFG. For the period for of 1967 through 1991 this index has ranged from greater than 80,000 adult fish (1967) to less than 1,000 fish during the drought years of 1988 through 1991 (U.S. Bureau of Reclamation, 1997). Spawning-aged fish begin moving into upper areas of their distribution in the Suisun Bay and the middle and lower Delta in late summer. Some spawning may occur as early as November and continue until June, and takes place in freshwater habitats containing sandy-gravel substrates, rock, and vegetation. In the Delta, most spawning occurs in February through April (Moyle, et al., 1995). Most longfin smelt die following spawning. Newly hatched larvae are subject to being transported downstream into brackish waters because of their preference for the upper water column. Therefore, increased river outflows greatly influence longfin smelt larval survival rates as the larvae are quickly transported to more productive estuarine environments.

Delta smelt are found in the upper Sacramento-San Joaquin estuary and were listed as threatened by federal and state governments in 1993 (U.S. Fish and Wildlife Service, 1994). This species is rarely found in habitats where the salinity is greater than 10-12 parts-per-thousand (ppt) and prefers salinity of approximately 2 ppt. A target salinity of 2 ppt occurring within Suisun Bay and the western Delta during the months of February through June (inclusive) is thought to provide habitat conditions conducive to the survival and recovery of this species (USFWS, 1995). The salinity target is referred to X2 and is an approximate location in Suisun Bay and the western Delta, calculated (in Kilometers) upstream of the Golden Gate Bridge. Delta smelt occur in the Sacramento River downstream of Isleton and in the San Joaquin downstream of Mossdale. Adults move upstream into fresh water during January through July to spawn downstream of Sacramento in the Sacramento River and in the Mokelumne River and the freshwater sloughs of the Delta. Spawning can occur at temperatures ranging from 45-62°F. Reduction of Delta outflows, high Delta outflows, losses to entrainment at water diversions, changes in food organisms, toxic substances, disease, competition, predation, and loss of genetic integrity in the Delta are suspected causes in the population decline of Delta smelt (U.S. Fish and Wildlife Service, 1995).

Sacramento splittail are found only in California's Sacramento–San Joaquin Delta and Central Valley rivers. Presently, this species is restricted to the Delta, Suisun Bay, and Suisun and Napa Marshes (U.S. Fish and Wildlife Service, 1999). These fish are members of the minnow family and grow up to 16 inches long and live up to 7 years (U.S. Fish and Wildlife Service, 1999). Peak spawning of this species occurs during March through May but can occur from January through June. Splittail populations were found to have declined as much as 62 percent over the last 20 years. Threats to splittail occur primarily as a result of water-development projects. Activities that could harm splittail include: diversion of water, levee maintenance, dredging and discharge of dredge materials, and discharges of toxic

materials into their habitat (U.S. Fish and Wildlife Service, 1999). This species was listed as federally threatened under ESA on March 10, 1999, by the Service (1999). However, USFWS's final decision to list the Sacramento splittail was subsequently challenged and on June 23, 2000, the Federal Eastern District Court of California found the final rule to be unlawful, and remanded the determination back for a re-evaluation of the final decision. After a thorough review and consideration of all the best scientific and commercial information available, USFWS removed the Sacramento splittail from the list of threatened species effective September 22, 2003 (*Fed. Reg. 68 (183), 55139-55166*).

1.3.2 Environmental Consequences

1.3.2.1 Methodology

Trinity River Basin. There are no direct methods to assess the effects of project alternatives on resident native fish species in the Trinity River. To evaluate the effects of the project on these species, the following assumptions were made:

- Increased coldwater releases to the Trinity River are not harmful for resident native fish species.
- Increases in Trinity River flows would improve habitat conditions and river system health for resident native fish species within the Trinity River.
- Mechanical restoration of riverine habitat within the Trinity River would not affect resident native fish species within the Trinity River.
- Watershed protection activities in the Trinity River would improve habitat conditions and river system health for resident native fish species within the Trinity River.

In summary, for the purposes of this analysis, it was assumed that any benefits or adverse effects on resident native fish species in the Trinity River would be the same as those for naturally produced anadromous salmonid species. Using these assumptions, a qualitative assessment of the effects of project alternatives, as compared to No Action, was made.

Lower Klamath River Basin. There were no methods available to directly evaluate the effects of project alternatives on other native fish species within the lower Klamath River. For this reason, several assumptions were made to assist in assessing changes or effects of project alternatives on these resources. These assumptions were:

- Increased coldwater releases to the Trinity River reduce Klamath River temperatures during mid-May through late-June (U.S. Fish and Wildlife Service, 1998) and are not harmful to other resident native fish.
- Increases in stream flows in the Trinity River would improve habitat conditions and river system health for resident native fish within the lower Klamath River and estuary.

- Mechanical restoration of riverine habitats within the Trinity River would not affect resident native fish species within the lower Klamath River.
- Watershed protection activities in the Trinity River would improve habitat conditions and river system health for resident native fishery resources in the lower Klamath River.

In summary, for the purposes of this analysis, it was assumed that any benefits or adverse effects on resident native fish species in the Klamath River would be the same as those benefits or effects on naturally produced anadromous salmonid species in the Klamath River. Using these assumptions, a qualitative assessment of the effects of project alternatives, as compared to No Action, was made.

Coastal Area. There were no methods readily available to estimate or directly measure any effect of project alternatives on other native fish species inhabiting Coastal Area. It was assumed that there would be no measurable or incremental effect on food availability, rates of predation or survival, or other ecological consequences to other native resident fish species in the adjacent Coastal Areas as a result of any of the project alternatives. Therefore, it was assumed that there would be no likely measurable effects.

Central Valley. For the purpose of estimating effects of the project alternatives on resident native fish species in the Central Valley, it was assumed that any adverse effects or benefits to naturally produced anadromous species in the Central Valley would similarly effect or benefit resident native fishery resources. Sacramento River flows, Delta inflow and outflow, ratio of Delta inflow to exports, and position of X2 in the Delta were evaluated. X2 refers to the calculated 2 part-per-thousand (2ppt) salinity position, in kilometers from the Golden Gate Bridge. X2 (2 ppt salinity) is believed optimal for maximizing native Delta smelt.

To evaluate the potential effects of the project alternatives on native resident fish species in the Central Valley, a comparison of the annual flows at various locations in the Sacramento River and Delta was conducted. For each project alternative, for the Sacramento River, average annual and monthly flows in cfs at Keswick, Grimes, and Verona were compared to flows for the No Action Alternative. Total annual and monthly inflows into the Delta, outflows from the Delta, the ratio of Delta inflow to exports. We evacuated the changes in the position of X2 as compared to the No Action Alternative were used to determine potential changes in the habitat and impacts to Delta smelt.

1.3.2.2 Significance Criteria

Effects are considered significant for resident native fish species if they result in any of the following:

- Potential for reductions in the number, or restrictions of the range, of an endangered or threatened resident native fish species or a resident native fish species that is a candidate for listing as threatened
- Potential for substantial reductions in the habitat of any resident native fish species other than those that are listed as threatened or endangered or are candidates for threatened or endangered status
- Potential for causing a resident native fish population to drop below self-sustaining levels

- Substantial adverse effect, either directly or through habitat modifications, on any resident native fish species identified as a sensitive or special status species in local or regional plans, policies, or regulations by the California Department of Fish and Game, the U.S. Fish and Wildlife Service, or the National Marine Fisheries Service
- Substantial interference with the movement of any resident native fish species
- A conflict with, or violation of, the provisions of an adopted Habitat Conservation Plan, Natural Community Conservation Plan, or other approved local, regional, or state habitat conservation plan relating to the protection of resident native fish species
- Direct mortality (losses) of state or federally listed resident native fish species, or species that are candidates for listing (CESA) or proposed for listing (ESA)
- Reductions in the size of a special-status resident native fish species population sufficient to jeopardize its long-term persistence
- Temporary impacts to habitats such that listed or special-status species suffer increased mortality or lowered reproductive success that jeopardizes the long-term persistence of those local populations
- Permanent loss of essential habitat of a listed species or special-status fish species
- Reduction in the quantity or quality of habitats in which resident native fish populations occur sufficient to affect the abundance and productivity of local populations

1.3.2.3 Results

Summary. Compared to the No Action Alternative, all the alternatives considered would result in beneficial habitat conditions for resident native species in the Trinity River. However, the Mechanical Restoration Alternative would result in rather small incremental habitat benefits for resident native species in the Trinity River Basin. Except for the Mechanical Restoration Alternative, all the alternatives would also benefit resident native species in the Klamath River Basin to some extent. These benefits would principally stem from increased flows, somewhat cooler water temperatures in the Klamath River Basin downstream its confluence with the Trinity River, and watershed restoration actions within the Trinity Basin. In the Central Valley only the 70 percent inflow and the Maximum Flow Alternative may have potential for adverse impacts to habitat quantity and quality for resident native species, principally due to reductions of flows in the upper Sacramento River for native species and habitat for Delta smelt in Sacramento-San Joaquin River Delta.

In the Central Valley, there would be no measures to mitigate, to less than significant, the adverse effects to native resident species and Delta smelt from implementing the maximum flow and 10 percent inflow alternatives would be to re-operate the Central Valley Project, including changing the pattern or increasing stream flows in the Sacramento River, inflows to the Delta, increasing Delta outflows, or reducing Delta exports.

1.3.2.4 No Action Alternative

Trinity River Basin. As stated in the methodology section, it was assumed that increased coldwater releases to the Trinity River would not harm resident native fish species. Increased stream flows in the Trinity River would provide river system benefits resulting in improved habitat conditions for the resident native species as well as anadromous species. Mechanical habitat restoration and watershed activities on the mainstem Trinity River were also assumed to improve habitat conditions and benefit resident native fish species in the Trinity River Basin. Thus, any benefits or adverse effects on resident native species in the Trinity River would be the same as those for naturally produced anadromous species. Using these assumptions, a qualitative assessment of the effects of the No Action Alternative was made.

As previously discussed, the No Action Alternative performed poorly in meeting the river system and habitat requirements necessary for restoring naturally produced anadromous salmonids in the mainstem Trinity River (Tables B-10 and B-11). TRSAAM results indicate that, under the No Action Alternative, fishery habitats in the mainstem Trinity River in the year 2020 would not likely provide the conditions necessary to allow resident native species to recover to pre-dam population levels.

Lower Klamath River Basin/Coastal Area. It was assumed that any benefits or adverse effects on resident native fish species in the Klamath River would be the same as those for naturally produced anadromous salmonid species in the Klamath River. Using these assumptions, a qualitative assessment of the effects of the No Action Alternative was made. As shown in Tables B-10 and B-11, the No Action Alternative performed poorly in meeting the river system attributes and habitat requirements necessary for restoring naturally produced anadromous salmonids in the mainstem Trinity River. TRSAAM results indicate that, under the No Action Alternative, fishery habitat in the mainstem Trinity River in the year 2020 would also not likely provide the conditions necessary to provide benefits to resident native species in the lower Klamath River and estuary.

These results indicate that, under the No Action Alternative, fishery habitat in the mainstem Trinity River in the year 2020 would not likely provide the flow, temperature, and habitat conditions necessary to restore populations of resident native fish species in the lower Klamath River and estuary to pre-dam levels.

Central Valley. The resident native fish species in the Central Valley have evolved in an environment in which wide ranges of conditions, including water temperatures and flows, fluctuate widely both within and between years. Habitat quantity and quality for native resident species in the Sacramento River and Delta areas are affected by the quantity and quality of water moving through this region. Populations of these species in the portions of the Central Valley affected by operations of the TRD (Sacramento River and the Delta) would be expected to largely fluctuate in response to any changes in environmental conditions (e.g., flows, temperatures, and salinity).

For the simulated period 1922-1993, the average annual discharge of the Sacramento River as estimated at Keswick, Grimes, and Verona was approximately 8,700 cfs; 11,300 cfs; and 19,300 cfs, respectively (Table B-21). Total average annual inflow and outflows for the Delta are approximately 29,200 cfs and 19,900 cfs, respectively (Tables B-22 and B-23). For

the simulated period, the average monthly position of the X2 position, in Kilometers (KM) from the Golden Gate Bridge, during the months of February through June (inclusive) ranges from 65.7 KM (April) to 71.3 KM (February) (Table B-27; and Attachment B10).

1.3.2.5 Maximum Flow Alternative

Trinity River Basin. As previously discussed, the results of the TRSAAM analysis for all attribute objectives for the Maximum Flow Alternative are shown in Table B-10 and are summarized in Table B-11. As shown in these tables, the Maximum Flow Alternative was scored 58 of the total possible 70 attribute objectives points believed necessary to restore the Trinity River fluvial river system. Compared to No Action, the Maximum Flow Alternative excelled in meeting the river system and habitat requirements necessary for restoring naturally produced anadromous salmonids in the mainstem Trinity River. This would also greatly enhance habitat conditions for resident native fish species in the Trinity Basin. These results indicate that river system health and habitat conditions improved approximately 1350 percent under the Maximum Flow Alternative as compared to No Action, using the TRSAAM scores as a measure of comparison (Table B-15). These results indicate that, compared to the No Action Alternative, fishery habitat in the mainstem Trinity River in the year 2020 would greatly improve under the Maximum Flow Alternative and would likely result in large increases in resident native fish populations compared to those expected from the No Action Alternative (Table B-19).

Lower Klamath River Basin/Coastal Area. Improvements in water temperature conditions and increases in flows in the Trinity River would result in more favorable conditions in the lower Klamath River, thus benefiting resident native species within the lower Klamath River and estuary. Increases in flows to the Trinity River would increase habitat quantity and benefit habitat conditions in the lower Klamath River and estuary. Increases in flow in the Trinity River resulting from spring reservoir releases would improve temperature conditions in the Klamath River downstream of the confluence.

Beneficial habitat conditions, as a result of more optimal temperatures and increased flows, would likely improve survival rates for young life stages of resident native species. Improved habitat conditions would benefit juveniles rearing and adults occupying the lower Klamath River and estuary (Table B-19). These benefits would likely result in increased populations of resident native species under the Maximum Flow Alternative.

Central Valley. It was assumed that decreases in monthly average flows in the Sacramento River and Delta greater than 10 percent of those for the No Action Alternative during the months critical to spawning and early rearing (February through June) would significantly diminish habitat quality and quantity for resident native species in the Central Valley. Increases in stream flows greater than 10 percent of those for No Action during those months were considered beneficial to these species for the maximum flow alternative. For the simulated period 1922-1993, the average annual discharge in the Sacramento River as estimated for Keswick, Grimes, and Verona is approximately 7,700 cfs; 10,500 cfs; and 18,400 cfs, respectively (Table B-21). The estimated changes in the average annual Sacramento River flows for Keswick and Grimes for the Maximum Flow Alternative as compared to No Action are shown in Table B-24. Changes in the estimated average annual Sacramento River flows at Keswick (upper reach of the river) for the Maximum Flow

Alternative decreased an average of approximately 12 percent. Changes in the estimated average annual Sacramento River flows at Grimes (middle reach of the river) for the Maximum Flow Alternative decreased an average of approximately 9 percent compared to No Action Alternative (Table B-24). These changes in stream flows would likely result in significant losses of habitat for resident native species residing in the Keswick reach of the Sacramento River only.

For this alternative, the total average annual discharge (in cfs) for the lower reach of the Sacramento River at Verona decreased an average of approximately 6 percent compared to No Action Alternative (Table B-24). Considering the magnitude of the decreases in annual discharges, it is not likely that reductions in habitat quantity and quality may be sufficient to significantly reduce habitat and adversely affect native resident species in the lower Sacramento River reaches.

The average annual inflow and outflow in the Delta for the Maximum Flow Alternative is estimated to be approximately 28,300 and 19,400 cfs, respectively (Tables B-22 and B-23). These flows are approximately 4 percent less, on average, that those for the No Action Alternative (Tables B-25 and B-26).

For the months critical to life stages of Delta Smelt in the Delta (February through June), Delta inflows ranges from 1 percent (March) to 3 percent (June) (Table B-25). For the same months critical to these species in the Delta, the Delta outflows ranges from 0 percent (March) to 3 percent (June) (Table B-26). The maximum ratio of Delta inflows to exports, (35 percent for February through June and 65 percent for July through January), were not violated for any year simulated for the Maximum Flow Alternative.

Calculated positions of X2 in the Delta, as measured from the Golden Gate Bridge, are shown in Table B-27 and in Attachment B10. During the months of February through June, the average monthly X2 position ranged from 65.8 KM (April) to 71.6 KM (February) (Table B-27). During these months, X2 moved 0.3 kilometers or less for the years simulated (a change of 0.4 percent or less relative to that for No Action) (Table B-28). A summary of the evaluation of the frequency and the direction of changes of X2 position in the Delta are found as Attachment B10. The analysis of the frequency and direction of movement of the predicted X2 position in the Delta are shown in Table B-29 and in Attachment B10.

Of the 72 years (1922-1993) analyzed for the months from February through June for the Maximum Flow Alternative, a total of 55 months (15.3 percent) movement of the predicted X2 location was greater that 0.5 KM upstream (east) of the position predicted for the No Action alternative. Additionally, 23 months (6.4 percent) movement of the predicted X2 position was greater than 0.5 KM downstream (west) of the predicted X2 position for the No Action alternative. The overall conclusion from this analysis is, that while there are both movements of X2 greater than 0.5 KM eastward (15.3 percent of the months) and westward (6.4 percent of the months), on the balance for the vast majority of months these movements would not significantly reduce habitat quantity or quality sufficiently to adversely affect Delta smelt or other native resident species in the Delta.

On an average annual basis the monthly ratio of Delta inflows to exports in the Delta would not significantly change for the Max Flow Alternative. The changes in streamflows in the lower Sacramento or Delta inflows or outflows would not significantly reduce habitat for

resident native species in the Central Valley, (Table B-19) reduction in streamflows in the Keswick Research of the upper Sacramento River would reduce habitat for native resident species (but not Delta smelt). There are no measures to mitigate these impacts to resident native species.

1.3.2.6 Flow Evaluation Alternative

Trinity River Basin. As previously discussed, the results of the TRSAAM analysis for all attribute objectives for the Flow Evaluation Alternative are shown in Table B-10 and are summarized in Table B-11. As shown in these tables, the Flow Evaluation Alternative was scored 49 of the total possible 70 attribute objectives points believed necessary to restore the Trinity River fluvial river system. Compared to No Action, this alternative greatly improved conditions necessary for restoring naturally produced anadromous salmonids in the mainstem Trinity River. This alternative would also greatly enhance habitat conditions for resident native fish species in the Trinity Basin. These results indicate that river system health and habitat conditions would be expected to improve approximately 1125 percent under the Flow Evaluation Alternative as compared to No Action, using the TRSAAM scores as a measure of comparison (Table B-15). These results indicate that, compared to the No Action Alternative, fishery habitat in the mainstem Trinity River in the year 2020 would greatly improve with this alternative (Table B-19) and would likely result in large increases in resident native fish populations compared to those expected from the No Action Alternative.

Lower Klamath River Basin/Coastal Area. Improvements in water temperature conditions and increases in flows in the Trinity River would result in more favorable conditions in the lower Klamath River, thus benefiting resident native species within the lower Klamath River and estuary. Annual increases in Trinity River flows, from approximately 28 taf (critically dry water year) to approximately 475 taf (extremely wet water year), would likely improve habitat conditions in the lower Klamath River and estuary in most years. Increases in flow in the Trinity River resulting from spring Lewiston Dam releases would greatly improve temperature and habitat conditions in the Klamath River downstream of the confluence with the Trinity River (U.S. Fish and Wildlife Service, 1998).

Beneficial habitat conditions, as a result of more optimal temperatures and increased flows, would likely improve survival rates for young life stages of resident native species. Improved habitat conditions would benefit juveniles rearing and adults occupying the lower Klamath River and estuary (Table B-19). These benefits would likely result in increased populations of resident native species under the Flow Evaluation Alternative.

Central Valley. It was assumed that decreases in monthly average flows greater than 10 percent of those for the No Action Alternative during months critical to spawning and rearing (February through June) would significantly diminish habitat quality and quantity for resident native species in the Central Valley. Increases in stream flows greater than 10 percent of those for No Action during these months were considered beneficial to these species. For the flow evaluation alternative, the simulated period 1922-1993, the average annual discharge in the Sacramento River as estimated for Keswick, Grimes, and Verona is approximately 8,400 cfs; 11,000 cfs; and 19,000 cfs, respectively (Table B-21). The estimated changes in the average annual Sacramento River flows for Keswick and Grimes for the Flow Evaluation Alternative as compared to No Action are shown in Table B-24.

Changes in the estimated average annual Sacramento River flow at Keswick (upper reach of the river) for the Flow Evaluation Alternative decreased an average of 4 percent. Changes in the estimated average annual Sacramento River flows at Grimes (middle reach of the river) for the Flow Evaluation Alternative decreased on an average of approximately 3 percent compared to the No Action Alternative (Table B-24). These reductions in stream flows would not likely result in significant losses of habitat for resident native species residing in the upper and middle reaches of the Sacramento River.

For this alternative, the total average annual discharge (in cfs) for the lower reach of the Sacramento River at Verona decreased an average of approximately 2 percent compared to the average annual discharge estimated for the No Action Alternative (Table B-24). Considering the magnitude of the decreases in annual discharges, it is not likely that reductions in habitat quantity and quality would be sufficient to significantly reduce habitat and adversely affect resident native species in the lower Sacramento River.

The average annual inflow and outflow in the Delta for the Flow Evaluation Alternative is estimated to be approximately 28,900 and 19,700 cfs, respectively (Tables B-22 and B-23). These flows are approximately 1 percent less, on average, that those for the No Action Alternative (Tables B-25 and B-26).

For the months critical to life stages of Delta smelt (February through June), ranges from 0 percent (February through April) to 2 percent (June). For the months critical to these species in the Delta, outflows 0 percent (February, March, and April) to 2 percent (June). The compliance target maximum ratio of Delta inflows to exports were not violated for any year simulated for the Flow Evaluation Alternative.

Calculated positions of X2 in the Delta, as measured from the Golden Gate Bridge, are shown in Table B-27. During the months of February through June the average monthly X2 position ranged from 65.8 KM (April) to 71.4 KM (February) (Table B-27). During these months, X2 moved 0.1 kilometers or less for the years simulated (a change of 0.1 percent or less relative to that for No Action) (Table B-28). A summary of the evaluation of the frequency and the direction of changes of X2 position in the Delta are found in Table B-29 and in Attachment B10.

Of the 72 years (1922-1993) analyzed for the months from February through June for the Flow Evaluation alternative, a total of 35 months (9.7 percent) movement of the predicted X2 location was greater that 0.5 KM upstream (east) of the position predicted for the No Action alternative. Additionally, 29 months (8.1 percent) movement of the predicted X2 position was greater than 0.5 KM downstream (west) of the predicted X2 position for the No Action alternative. The overall conclusion from this analysis is, that while there are both movements of X2 greater than 0.5 KM eastward (9.7 percent of the months) and westward (8.1 percent of the months), on the balance for the vast majority of months (≥90 percent) these movements would not likely reduce habitat quantity or quality sufficiently to adversely affect Delta smelt or other native resident species in the Delta.

On an average annual basis, the monthly ratio of Delta inflows to exports in the Delta would not significantly change for the Flow Evaluation Alternative compared to No Action. The changes in streamflows, or Delta inflows and outflows would not significantly reduce habitat for resident native species in the Central Valley (Table B-19).

1.3.2.7 70 Percent Inflow Alternative

Trinity River Basin. The results of the TRSAAM analysis for all attribute objectives for the 70 Percent Inflow Alternative are shown in Table B-10 and are summarized in Table B-11. As shown in these tables, the 70 Percent Inflow Alternative was scored 50 of the total possible 70 attribute objectives points believed necessary to restore the Trinity River fluvial river system. Compared to No Action, this alternative provided significant benefits to habitat conditions necessary for restoring anadromous salmonids species in the mainstem Trinity River. These expected improvements would also provide significant benefits to habitat conditions for resident native fish species in the Trinity Basin (Table B-19). The TRSAAM analysis indicated that river system health and habitat conditions improved approximately 1,150 percent for the 70 Percent Inflow Alternative as compared to No Action (Table B-15). These results indicate that, compared to the No Action Alternative, fishery habitat in the mainstem Trinity River in the year 2020 would improve under this alternative and would likely result in increases in resident native fish populations as compared to the No Action Alternative.

Lower Klamath River Basin/Coastal Area. The 70 Percent Inflow Alternative would result in improved water temperature conditions and increased Trinity River flows in many water years. In those years, increased annual flows (and improved water temperature conditions would result in improved habitat conditions in the lower Klamath River and estuary (Table B-19). These improvements would result in benefits to other resident native fish populations under the 70 Percent Inflow Alternative.

Central Valley. It was assumed that decreases in monthly average flows greater than 10 percent of those for the No Action Alternative during months critical to spawning and rearing (February through June) would significantly diminish habitat quality and quantity for resident native species in the Central Valley. Increases in stream flows greater than 10 percent of those for No Action during those months were considered beneficial to these species. For the simulated period 1922-1993, the average annual discharge in the Sacramento River as estimated for Keswick, Grimes, and Verona is approximately 8,000 cfs; 10,700 cfs; and 18,700 cfs, respectively (Table B-21). The estimated changes in the average annual Sacramento River flows for Keswick and Grimes for the 70 Percent Inflow Alternative as compared to No Action are shown in Table B-24. Changes in the estimated average annual Sacramento River flows at Keswick (upper reach of the river) for the 70 Percent Inflow Alternative decreased an average of 9 percent. Changes in the estimated average annual Sacramento River flows at Grimes (middle reach of the river) for this Alternative decreased an average of 6 percent compared to the No Action Alternative (Table B-24). These reductions in stream flows would not likely result in significant losses of habitat for resident native species residing in the upper and middle reaches of the Sacramento River.

For this alternative, the total average annual discharge (in cfs) for the lower reach of the Sacramento River at Verona decreased approximately 4 percent compared to the average annual discharge estimated for the No Action Alternative (Table B-24). Considering the magnitude of the decreases in annual discharges, it is not likely that reductions in habitat quantity and quality would be sufficient to significantly reduce habitat and adversely affect resident native species in the lower reaches of Sacramento River.

The average annual inflow and outflow in the Delta for the 70 Percent Inflow Alternative is estimated to be approximately 28,600 and 19,400 cfs, respectively (Tables B-22 and B-23). These flows are approximately 3 percent less, on average, that those for the No Action Alternative (Tables B-25 and B-26).

For the months critical to life stages of Delta smelt (February through June), Delta inflows ranges from 1 to 2 percent less than those for No Action (Table B-25). Similarly, for the months critical to these species in the Delta, it was determined that Delta outflows ranges from 1 to 2 percent less than those for No Action. The maximum ratio of Delta inflows to exports were not violated for any year simulated for the this Alternative.

Calculated positions of X2 in the Delta, as measured from the Golden Gate Bridge, are shown in Table B-27. During the months of February through June the average monthly X2 position ranged from 65.9 KM (April) to 71.6 KM (February) (Table B-27). During the months of February through June, X2 moved 0.3 kilometers or less for the years simulated (a change of 0.4 percent or less relative to that for No Action) (Table B-28). A summary of the evaluation of the frequency and the direction of changes of X2 position in the Delta are found in Table B-29 and in Attachment B10.

Of the 72 years (1922-1993) analyzed for the months from February through June for the 70 Percent Inflow Alternative, a total of 54 months (15 percent) movement of the predicted X2 location was greater that 0.5 KM upstream (east) of the position predicted for the No Action alternative. Additionally, 12 months (3.3 percent) movement of the predicted X2 position was greater than 0.5 KM downstream (west) of the predicted X2 position for the No Action alternative. The overall conclusion from this analysis is, there are both movements of X2 greater than 0.5 KM eastward (15 percent of the months) and westward (3.3 percent of the months). However, on the balance greater than 10 percent of all months X2 movement would likely reduce habitat quantity or quality sufficiently to adversely affect Delta smelt or other native resident species in the Delta.

On an average annual basis, the monthly ratio of Delta inflows to exports, would not significantly change for the 70 Percent Inflow Alternative. The number and magnitude of habitat changes may result in impacts to Delta smelt (Table B-19). There are no measures to mitigate these impacts to Delta smelt.

1.3.2.8 Mechanical Restoration Alternative

Trinity River Basin. The results of the TRSAAM analysis for all attribute objectives for the Mechanical Restoration Alternative are shown in Table B-10 and summarized in Table B-11. As shown in these tables, the Mechanical Restoration Alternative was scored 13 out of the total possible 70 attribute objectives points believed necessary to restore the Trinity River fluvial river system. A majority of the attribute objectives were determined to never or nearly never exceed threshold criteria for this alternative. This alternative was determined to provide only small benefits in meeting river system attribute objectives compared to the No Action Alternative (Table B-19). These results indicate that conditions would be expected to improve approximately 225 percent under this alternative as compared to No Action, using the TRSAAM scores as a measure of comparison (Table B-15). Small and localized beneficial improvements in river system health and function would result in only small benefits to resident native fish populations as compared to No Action.

Lower Klamath River Basin/Coastal Area. The only changes in habitat conditions in the Trinity River Basin in the Mechanical Restoration Alternative are through mechanical means. Therefore, no benefits resulting from increased flows or cool water temperature would be expected in the lower Klamath River and estuary under the Mechanical Restoration Alternative. Habitat conditions for this alternative would remain the same as No Action for the lower Klamath River and estuary (Table B-19). It is likely that resident native fish populations in the lower Klamath River would remain unchanged under this project alternative.

Central Valley. This alternative would not affect habitats for resident native fish species in the Central Valley and therefore would result in no change from the No Action Alternative (Table B-19).

1.3.2.9 Revised Mechanical Restoration Alternative

Trinity River Basin. The results of the TRSAAM analysis for all attribute objectives for the Revised Mechanical Restoration Alternative are shown in Table B-10 and are summarized in Table B-11. As shown in these tables, this alternative was scored 37 of the total possible 70 attribute objectives points believed necessary to restore the Trinity River fluvial river system. Compared to No Action, this alternative provided some improvement to river system and habitat conditions necessary for restoring anadromous salmonid species in the mainstem Trinity River. These expected improvements would be moderately beneficial and improve habitat conditions for resident native fish species in the Trinity Basin (Table B-19). The TRSAAM analysis indicated that river system health and habitat conditions improved approximately 825 percent for this Alternative as compared to No Action (Table B-15). These results indicate that, compared to the No Action Alternative, fishery habitats in the mainstem Trinity River in the year 2020 would improve under this alternative and would likely result in increased resident native fish populations as compared to the No Action Alternative.

Lower Klamath River Basin/Coastal Area. The Revised Mechanical Alternative would result in some improvement in water temperature conditions and increased Trinity River flows in some water years. In those years, increased flows during spring and early summer months could result in improved habitat conditions in the lower Klamath River and estuary (Table B-19). However, in dry and critically dry water years, water temperature conditions in the Trinity River would be either similar or less beneficial to resident native species as compared to temperatures for No Action. Populations of resident native species in the lower Klamath River and estuary may benefit somewhat from implementation of this alternative.

Central Valley. It was assumed that decreases in monthly average flows greater than 10 percent of those for the No Action Alternative during the months critical to spawning and rearing (February through June) would significantly diminish habitat quality and quantity for resident native species in the Central Valley. Increases in stream flows greater than 10 percent of those for No Action during these months were considered beneficial to these species. For the simulated period 1922-1993, the average annual discharge in the Sacramento River as estimated for Keswick, Grimes, and Verona is approximately 8,600 cfs; 11,200 cfs; and 19,200 cfs, respectively (Table B-21). The estimated changes in the average annual Sacramento River flows for Keswick and Grimes for the Revised Mechanical

Restoration Alternative as compared to No Action are approximately 1 percent less than No Action and are shown in Table B-24. Changes in the estimated average monthly Sacramento River flows at Keswick, Grimes, and Verona (upper, middle and lower reaches of the river respectively) ranged from no change to a 3 percent decrease compared to the No Action Alternative (Table B-24).These reductions in stream flows would not likely result in significant losses of habitat for resident native species residing in these reaches of the Sacramento River.

The average annual inflow and outflow in the Delta for the Revised Mechanical Restoration Alternative is estimated to be approximately 29,100 and 19,800 cfs, respectively (Tables B-22 and B-23). These annual flows are approximately 1 percent less, on average, and range from no change to a 3 percent decrease compared to those for the No Action Alternative (Tables B-25 and B-26). For the months critical to life stages of Delta smelt (February through June), Delta inflows range from 0 to 2 percent less than those for No Action (Table B-25) for the months critical to life stages of Delta smelt Delta outflows range from 0 to 2 percent less than those for No Action (Table B-26). The maximum ratio of Delta inflows to exports were not violated for any year simulated for the Revised Mechanical Restoration Alternative.

Calculated positions of X2 in the Delta, as measured from the Golden Gate Bridge, are shown in Table B-27. The average monthly position of X2 remained relatively unchanged compared to the No Action Alternative for the period of simulation (Table B-28). During the months of February through June the average monthly X2 position ranged from 65.8 KM (April) to 71.3 KM (February) (Table B-27). Overall, during the months of February through June, X2 did not significantly move, relative to No Action, during the years simulated (Table B-28). A summary of the evaluation of the frequency and the direction of changes of X2 position in the Delta are found in Table B-29 and as Attachment B10.

Of the 72 years (1922-1993) analyzed for the months from February through June for the Revised Mechanical Restoration alternative, a total of 17 months (4.7 percent) movement of the predicted X2 location was greater that 0.5 KM upstream (east) of the position predicted for the No Action alternative. Additionally, 14 months (3.9 percent) movement of the predicted X2 position was greater than 0.5 KM downstream (west) of the predicted X2 position for the No Action alternative. The overall conclusion from this analysis is, that while there are both movements of X2 greater than 0.5 KM eastward (4.7 percent of the months) and westward (3.3 percent of the months), on the balance for the vast majority of months (≥95 percent) these movements would not likely reduce habitat quantity or quality sufficiently to adversely affect Delta smelt or other native resident species in the Delta.

On an average annual basis the monthly ratio of Delta inflows to exports, and the position of X2 in the Delta would not significantly change for the Revised Mechanical Restoration Alternative. No impacts to habitat quantity and quality for resident native species would occur in the Sacramento River or in the Delta (Table B-19).

1.3.2.10 Modified Percent Inflow Alternative

Trinity River Basin. The results of the TRSAAM analysis for all attribute objectives for the Modified Percent Inflow Alternative are shown in Table B-10 and are summarized in

Table B-11. As shown in these tables, this Alternative was scored 51 of the total possible 70 attribute objectives points believed necessary to restore the Trinity River fluvial river system. Compared to No Action, this alternative provided significantly beneficial improvements to river system and habitat conditions necessary for restoring anadromous salmonids species in the mainstem Trinity River. These expected improvements would likely provide large benefits to habitat conditions for resident native fish species in the Trinity Basin (Table B-19). The TRSAAM analysis indicated that river system health and habitat conditions improved approximately 1125 percent for this Alternative as compared to No Action (Table B-15). These results indicate that, compared to the No Action Alternative, fishery habitat in the mainstem Trinity River in the year 2020 would greatly improve under the Modified Percent Inflow Alternative and would likely result in increases in resident native fish populations as compared to the No Action Alternative.

Lower Klamath River Basin/Coastal Area. The Modified Percent Inflow Alternative would result in improved water temperature conditions and increased Trinity River flows in most water years. In these years, increased annual flows (and improved water temperature conditions would result in improved habitat conditions in the lower Klamath River and estuary (Table B-19). These improvements would result in benefits to resident native fish populations under this Alternative.

Central Valley. It was assumed that decreases in monthly average stream flows greater than 10 percent of those for the No Action Alternative during months critical to spawning and rearing (February through June) would significantly diminish habitat quality and quantity for resident native species in the Central Valley. Increases in flows greater than 10 percent of those for the No Action Alternative during those months were considered beneficial to these species. For the simulated period 1922-1993, the average annual discharge of the Sacramento River at Keswick, Grimes, and Verona for the Modified Percent Inflow Alternative is approximately 8,500, 11,100 and 19,100 cfs, respectively (Table B-21). For this Alternative, the total average annual discharges in the lower and middle reach of the Sacramento River decreased approximately 2 percent at Keswick and Grimes, and the monthly average flows ranged from no change (March at Keswick; January through March at Grimes) to 4 percent (November and May at Keswick; and June at Grimes) compared to the No Action Alternative (Table B-24). The total average annual discharges in the lower reach of the Sacramento River (Verona) decreased by approximately 1 percent compared to those discharges estimated for the No Action Alternative (Table B-24). Average monthly flows at Verona ranged from no change (January through April, and July) to 4 percent (June) as compared to the No Action Alternative. Considering the magnitude of the decreases in the annual and monthly average discharges, it is unlikely that reductions in habitat quantity and quality would be sufficient to adversely affect resident native species in the Sacramento River.

On an average annual basis, inflow and outflow in the Delta for the Modified Percent Inflow Alternative is estimated to be approximately 29,000 and 19,800 cfs, respectively (Tables B-22 and B-23). These flows are approximately 1 percent less, on average, than those for the No Action Alternative (Tables B-25 and B-26). Delta inflows and outflows during months critical to Delta smelt range from 0 to 2 percent less than No Action. (Tables B-25 and B-26). The allowable maximum ratio of Delta inflows to exports were not violated for any year simulated for the Modified Percent Inflow Alternative.

Calculated positions of X2 in the Delta, as measured from the Golden Gate Bridge, are shown in Table B-27. The average monthly position of X2 remained relatively unchanged compared to the No Action Alternative for the period of simulation (Table B-28). During the months of February through June the average monthly X2 position ranged from 65.7 KM (April) to 71.3 KM (February). On the average, for the months of February through June, X2 did not appreciably move (≤0.1 KM), relative to No Action, during the years simulated (Table B-28). A summary of the evaluation of the frequency and the direction of changes of X2 position in the Delta are found in Table B-29 and as Attachment B10.

Of the 72 years (1922-1993) analyzed for the months from February through June for the Modified Percent Inflow alternative, a total of 23 months (6.4 percent) movement of the predicted X2 location was greater that 0.5 KM upstream (east) of the position predicted for the No Action alternative. Additionally, 19 months (5.3 percent) movement of the predicted X2 position was greater than 0.5 KM downstream (west) of the predicted X2 position for the No Action alternative. The overall conclusion from this analysis is, that while there are both movements of X2 greater than 0.5 KM eastward (6.4 percent of the months) and westward (5.3 percent of the months), on the balance for the vast majority of months (≥93 percent) these movements would not likely reduce habitat quantity or quality sufficiently to adversely affect Delta smelt or other native resident species in the Delta.

On an average annual basis, the monthly ratio of Delta inflows to exports, and the position of X2 in the Delta would not significantly change for the Modified Percent Inflow Alternative. The magnitude of these changes would not result in impacts to habitat quantity and quality for resident native species in the Sacramento River or in the Delta (Table B-19).

1.3.2.11 Existing Conditions versus Preferred (Flow Evaluation) Alternative

Trinity River Basin and Lower Klamath River Basin/Coastal Area. Trinity River impacts of the Preferred (Flow Evaluation) Alternative compared to existing conditions for resident native fish would be similar to the impacts of the Flow Evaluation alternative compared to the No Action conditions in the year 2020. However, the watershed protection component of the Preferred Alternative would benefit resident native fish by reducing sediment inputs to the Trinity River.

Central Valley. It was assumed that decreases in monthly average stream flows greater than 10 percent of those for existing conditions during the months critical to spawning and rearing (February through June) would significantly diminish habitat quality and quantity for resident native species in the Central Valley. Increases in flows greater than 10 percent of those for existing conditions during those months were considered beneficial to these species. For existing conditions (for the simulated period 1922-1993), the average annual discharge in the Sacramento River as estimated for Keswick, Grimes, and Verona is approximately 8,700 cfs; 11,300 cfs; and 19,300 cfs, respectively (Table B-21). For the Preferred Alternative (Flow Evaluation Alternative), for the simulated period 1922-1993, the average annual discharge in the Sacramento River as estimated for Keswick, Grimes, and Verona is approximately 8,400 cfs; 11,000 cfs; and 19,000 cfs, respectively (Table B-21). The estimated changes in the average annual Sacramento River flows for Keswick and Grimes for the Preferred Alternative as compared to existing conditions are shown in Table B-24.

Changes in the estimated average annual Sacramento River flows at Grimes (middle reach of the river) for the Preferred Alternative averaged approximately 4 percent less and ranged from no change to 8 percent less compared to existing conditions (Table B-24).

For the Preferred Alternative, the total average annual discharge (in cfs) for the lower reach of the Sacramento River (Verona) decreased by an average of approximately 2 percent and ranged from an increase of 1 percent to a decrease of 4 percent compared to existing conditions (Table B-24). Considering the magnitude of these decreases in annual discharges, it is not likely that the quantity and quality of resident native species' habitats would be significantly impacted in the lower Sacramento River reach.

For existing conditions, the total average annual inflow and outflows for the Delta are approximately 29,300 and 20,000 cfs, respectively (Tables B-22 and B-23). For the Preferred Alternative, the total average annual inflow and outflow for the Delta are approximately 28,900 and 19,700 cfs, respectively (Tables B-21 and B-22). The annual average change in Delta inflows and outflows for the Preferred Alternative are 2 percent and 3 percent, respectively, as compared to existing conditions (Tables B-25 and B-26).

The maximum allowable ratio of Delta inflows to exports were not violated for any year simulated for the Preferred Alternative.

Calculated positions of X2 in the Delta, as measured from the Golden Gate Bridge, are shown in Table B-27. During the months of February through June, X2 moved 0.1 kilometers or less for the years simulated (a change of 0.1 percent or less relative to that for existing conditions) (Table B-28). During the months of February through June the average monthly X2 position ranged from 65.6 KM (April) to 71.2 KM (February) (Table B-27). A summary of the evaluation of the frequency and the direction of changes of X2 position in the Delta are found in Table B-29 and as Attachment B10.

Of the 72 years (1922-1993) analyzed for the months from February through June for the Preferred alternative, compared to existing conditions a total of 45 months (12.2 percent) movement of the predicted X2 location was greater that 0.5 KM upstream (east) of the position predicted for the existing conditions. Additionally, 39 months (10.8 percent) movement of the predicted X2 position was greater than 0.5 KM downstream (west) of the predicted X2 position for existing conditions. The overall conclusion from this analysis is, that while there are both movements of X2 greater than 0.5 KM eastward (12.2 percent of the months) and westward (10.8 percent of the months), on the balance for the vast majority of months (≥95 percent) these movements would not likely reduce habitat quantity or quality sufficiently to adversely affect Delta smelt or other native resident species in the Delta.

On an annual average basis the monthly ratio of Delta inflows to exports, and the position of X2 in the Delta would not significantly change for the Preferred Alternative as compared to existing conditions. However, there would be, in many years, months critical to sensitive Delta species in which inflows to the Delta may be less than those for existing conditions. These changes would not result in impacts to habitat quantity and quality for resident native species in the Delta (Table B-19).

1.4 NON-NATIVE FISH

1.4.1 Affected Environment

1.4.1.1 Trinity River Basin and Lower Klamath River Basin/Coastal Area

Non-native fish species found in the Trinity River Basin are listed in Table B-1. Non-native species are identified in this table as "introduced" species. Except for the species found in the reservoirs, the following discussion primarily provides information on: American shad (*Alosa sapidissima*), brown trout (*Salmo trutta*), and brook trout (*Salvelinus fontinalis*). Other non-native species found in the reservoirs are discussed in the Reservoir section.

Of the introduced species, striped bass has only been recently reported from the Trinity and Klamath River Basins (Gilroy, pers. comm.). Small numbers of other introduced fish including golden shiners, which may have been inadvertently introduced into Trinity Lake, are occasionally found in the Trinity River downstream of the Lewiston Dam (Aguilar, pers. comm.). American shad are known to occur in the lowermost portions of the Trinity River Basin and primarily in the lower Klamath River Basin. The abundance of all of these species in the Trinity and lower Klamath River Basins is unknown.

American shad were introduced to California from the eastern United States beginning with introductions into the Sacramento River in 1871 through 1881 (Moyle, 1976). This anadromous species has since established populations in the Sacramento and its southernmost tributaries and the San Joaquin River Basin, including the Mokelumne and Stanislaus Rivers. In addition, populations in the Russian, Eel, Klamath, and Trinity River Basins have become established. The adults of this species move into the estuary or fresh water in late spring or early summer and spawn upriver soon thereafter.

Brown trout have been known to occur in the Trinity River for decades. This species spawns in the fall in small- to medium-sized tributary streams but may spawn in larger riverine habitats. Migration to breeding areas begins in late summer and early fall, and spawning occurs in late October to early November. This species is known for predatory habits and is suspected to prey on naturally produced salmonid fry emerging from spawning gravels (Frederiksen, Kamine, and Associates, 1980).

Trinity River Basin brown trout (Loch Leven strain) were first introduced in 1911 (Frederiksen, Kamine, and Associates, 1980). Anadromous forms of brown trout were propagated in the TRSSH until 1977 when this practice was discontinued due to the small numbers and the lack of anadromous characteristics of the brown trout entering the TRSSH (TRSSH Report, 1979). Small numbers of small brown trout continued to enter the TRSSH from September to December each year until 1982, but these fish were not propagated after the 1976 brood year (California Department of Fish and Game, TRSSH Reports, 1979-1982).

Brook trout were first introduced into the Trinity River in 1909 (Frederiksen, Kamine, and Associates, 1980). This species provides a significant sport fishery in the tributary streams and high elevation lakes of the Trinity River Basin. Its life cycle and habitat requirements are similar to that of brown trout, with the exception of its preference for smaller and colder headwater streams; and it is less predatory than brown trout. After establishing in a

watershed, this species is known to flourish at the expense of other less competitive salmonid species.

Factors which affect the abundance of these species in the Trinity and lower Klamath River Basins are generally unknown but may be similar to those factors affecting naturally produced anadromous species discussed previously.

1.4.1.2 Central Valley

There have been a large number of fish species introduced into the Central Valley. CDFG estimates at least 50 species of fish have been introduced at one time or another into the Delta and San Francisco Bay estuary. Moyle (1976) estimated that of 79 total species in the Central Valley, 32 were introduced species. Principal introduced gamefish species include: catfish (*Icaluridae*), including channel and white catfish; American shad (*Clupeidae*); and bass and sunfish (*Centrarchidae*), including black and white crappie, green and bluegill sunfish, and largemouth, smallmouth, and striped bass. American shad and striped bass are recreationally important gamefish in the lower Sacramento River and Delta and constitute major sport fisheries in the Central Valley. Notable non-gamefish include: threadfin shad, goldfish, carp, golden shiner, and fathead minnow (*Cyprinidae*); mosquitofish (*Poecilidae*); and yellowfin goby (*Gobiidae*) (Moyle, 1976).

1.4.2 Environmental Consequences

1.4.2.1 Methodology

Trinity River Basin. There are no direct methods to assess the effects of project alternatives on non-native fish species in the Trinity River. To evaluate the effects of the project on these species, the following assumptions were made:

- Increased coldwater releases to the Trinity River are beneficial for coldwater non-native fish species or are not adverse for warmwater tolerant non-native species.
- Increases in the Trinity River stream flows would improve habitat conditions and river system health for other non-native fish species within the Trinity River.
- Mechanical restoration of riverine habitat within the Trinity River would not affect non-native fish species within the Trinity River.
- Watershed protection activities in the Trinity River would improve habitat conditions and river system health for non-native fish species within the Trinity River.

In summary, for the purposes of this analysis, it was assumed that any benefits or adverse effects on non-native fish species in the Trinity River would be the same as those for naturally produced anadromous salmonid species. Using these assumptions, a qualitative assessment of the effects of project alternatives, as compared to No Action, was made.

Lower Klamath River Basin. There were no tools available to directly evaluate the effects of project alternatives on other non-native fish resources within the lower Klamath River. For this reason, several assumptions were made to assist in assessing changes or effects of project alternatives on these resources. These assumptions were:

- Increased coldwater releases to the Trinity River reduce Klamath River temperatures during mid-May through late-June (U.S. Fish and Wildlife Service, 1998) and are not harmful for coldwater non-native fish.
- Increases in Trinity River stream flows would improve habitat conditions and river system health for other non-native fish within the lower Klamath River and estuary.
- Mechanical restoration of riverine habitats within the Trinity River would not affect other non-native fish species within the lower Klamath River.
- Watershed protection activities in the Trinity River would improve habitat conditions and river system health for other non-native fish resources in the lower Klamath River.

In summary, for the purposes of this analysis, it was assumed that any benefits or adverse effects on non-native fish species in the Klamath River would be the same as those for naturally produced anadromous salmonid species in the Klamath River. Using these assumptions, a qualitative assessment of the effects of project alternatives, as compared to No Action, was made.

Coastal Area. It was assumed there would be no measurable effects to other non-native fish in the Coastal Areas. Furthermore, it was assumed that there would be no density-dependent effect of changes on food availability, rates of predation or survival, or other ecological consequences on other non-native fish in the adjacent Coastal Areas as a result of any of the project alternatives.

Central Valley. There are no direct methods for estimating the effects of project alternatives on non-native fish species in the Central Valley. For the purpose of estimating effects of the project alternatives, it was assumed that any adverse effects or benefits to other native anadromous and resident species in the Central Valley would similarly effect or benefit non-native fish species.

To evaluate the potential effects of the project alternatives on non-native fish species in the Central Valley, a comparison of the annual flows at various locations in the Sacramento River and Delta was conducted. For each project alternative, for the Sacramento River, average annual and average monthly discharges in cfs at Keswick, Grimes, and Verona were compared to flows for the No Action Alternative. Total annual outflow from the Delta, ratio of inflow to exports were evaluated. Position of X2 in the Delta were compared to the No Action Alternative to determine potential changes in habitat for non-native fish species principally striped bass.

It was assumed that decreases in monthly average stream flows greater than 10 percent of those for the No Action Alternative would significantly diminish habitat quality and quantity for non-native species in the Central Valley. Increases in flows greater than 10 percent of those for the No Action Alternative were considered beneficial to these species.

1.4.2.2 Significance Criteria

Effects are considered significant for non-native fish species if they result in any of the following:

- Potential for reductions in the number, or restrictions of the range, of an endangered or threatened non-native fish species or a non-native fish species that is a candidate for state listing or proposed for federal listing as endangered or threatened
- Potential for substantial reductions in the habitat of any non-resident fish species other than those that are listed as threatened or endangered or are candidates (CESA) or proposed (ESA) for threatened or endangered status
- Potential for causing non-native fish population to drop below self-sustaining levels
- Substantial adverse effect, either directly or through habitat modifications, on any non-native fish species identified as a sensitive or special-status species in local or regional plans, policies, or regulations by the California Department of Fish and Game, the U.S. Fish and Wildlife Service, or the National Marine Fisheries Service
- Substantial interference with the movement of any non-native fish species
- A conflict with, or violation of, the provisions of an adopted Habitat Conservation Plan, Natural Community Conservation Plan, or other approved local, regional, or state habitat conservation plan relating to the protection of non-native fish species
- Mortality of state or federally listed non-native fish species, or non-native fish species that are candidates for listing (CESA) or proposed for listing (ESA)
- Reductions in the size of a non-native fish species' population sufficient to jeopardize is long-term persistence
- Temporary impacts to habitats such that listed or special-status species suffer increased mortality or lowered reproductive success that jeopardizes the long-term persistence of those local populations
- Permanent loss of essential habitat of a listed species or special-status fish species
- Reduction in the quantity or quality of habitats in which non-native fish populations occur sufficient to affect the abundance and productivity of local populations

1.4.2.3 Results

Summary. The results of the comparisons of the No Action Alternative to each project alternative are summarized in Table B-19. Compared to the No Action Alternative, all the Alternatives would benefit non-native species in the Trinity River and the Klamath River Basin. Except for the maximum flow and the 70 percent alternatives proposed alternatives would not adversely affect non-native fish species including striped bass and American Shad in the Central Valley.

In the Central Valley, there would be no measures to mitigate, to less than significant, the adverse effects to non-native resident species from implementing the maximum flow or 70 percent inflow alternatives.

1.4.2.4 No Action Alternative

Trinity River Basin. The effects on non-native species from the No Action Alternative would be similar to those for resident native species: increased stream flows in the Trinity River would provide river system benefits resulting in improved habitat conditions for the non-native species. Mechanical habitat restoration and watershed activities on the mainstem Trinity River would also improve habitat conditions and benefit non-native fish species in the Trinity River Basin. Thus, any benefits or adverse effects on non-native species in the Trinity River would be similar to those for native resident species.

The No Action Alternative performed poorly in meeting the river system and habitat requirements necessary for restoring naturally produced anadromous salmonids or other anadromous and resident native fish species in the mainstem Trinity River (Tables B-10 and B-11). TRSAAM results indicate that, under the No Action Alternative, fishery habitats in the mainstem Trinity River in the year 2020 would not likely provide or enhance the habitat conditions necessary to allow non-native species to flourish.

Lower Klamath River Basin/Coastal Area. The benefits or adverse effects on non-native fish species in the Klamath River would be the same as those for native species. As shown in Tables B-10 and B-11, the No Action Alternative performed poorly in meeting the river system and habitat requirements necessary for restoring native species in the mainstem Trinity River. These results indicate that, under the No Action Alternative, fishery habitat in the mainstem Trinity River in the year 2020 would also not likely enhance or restore the habitat conditions necessary to optimize non-native species' populations in the lower Klamath River and estuary.

These results indicate that, under the No Action Alternative, fishery habitat in the mainstem Trinity River in the year 2020 would not likely provide the flow, temperature, and habitat conditions necessary to provide benefits to populations of non-native fish species in the lower Klamath River and estuary.

Central Valley. Habitat quantity and quality for non-native resident species in the Central Valley areas are affected by the quantity and quality of water moving through this region. Similar to resident native species, populations of non-native species in the portions of the Central Valley affected by operations of the TRD (Sacramento River and the Delta) would be expected to largely fluctuate in response to any changes in environmental conditions (e.g., flows and temperatures).

For the simulated period 1922-1993, the average annual discharge of the Sacramento River as estimated at Keswick, Grimes, and Verona was approximately 8,700 cfs; 11,300 cfs; and 19,300 cfs, respectively (Table B-21). Total average annual inflow and outflows for the Delta are approximately 29,200 cfs and 19,900 cfs, respectively (Tables B-22 and B-23). The average yearly estimates of Sacramento River discharges and Delta inflows and outflows can only be used to qualitatively evaluate changes in habitat for these species.

1.4.2.5 Maximum Flow Alternative

Trinity River Basin. The results of the TRSAAM analysis for all attribute objectives for the Maximum Flow Alternative are shown in Table B-10 and are summarized in Table B-11. As shown in these tables, the Maximum Flow Alternative was scored 58 of the total possible 70 attribute objectives points believed necessary to restore the Trinity River fluvial river system. Compared to No Action, the Maximum Flow Alternative excelled in meeting the river system and habitat requirements necessary for restoring many naturally produced anadromous salmonids in the mainstem Trinity River. This would also likely enhance habitat conditions for non-native fish species in the Trinity Basin. Cooler water temperature in the spring and early summer may positively affect coldwater species such as brown trout, but may negatively affect growth and development of American shad in the Trinity River Basin. For most species, as compared to the No Action Alternative, river system health and fishery habitat in the mainstem Trinity River in the year 2020 would greatly improve under the Maximum Flow Alternative (Table B-19). This would likely result in increases in non-native fish populations, particularly brown trout, compared to those expected from the No Action Alternative.

Lower Klamath River Basin/Coastal Area. Improvements in habitat conditions and increases in flows in the Trinity River would result in more favorable conditions in the lower Klamath River, thus generally benefiting non-native species within the lower Klamath River and estuary. Increases in flows to the Trinity River would increase habitat quantity and benefit habitat conditions for cold-water non-native species in the lower Klamath River and estuary. Increases in flow in the Trinity River resulting from spring reservoir releases would provide cooler water temperature conditions in the Klamath River downstream of the confluence. However, this may negatively affect growth of species such as American shad and striped bass in the lower Klamath River and estuary.

Beneficial habitat conditions, as a result of more optimal temperatures and increased flows, would likely improve survival rates for young life stages of coldwater species such as brown trout. Improved habitat conditions would benefit juveniles rearing and adults of coldwater non-native species occupying the lower Klamath River and estuary (Table B-19). These benefits may result in increased populations of brown trout under the Maximum Flow Alternative.

Central Valley. It was assumed that decreases in monthly average stream flows greater than 10 percent of those for the No Action Alternative would significantly diminish habitat quality and quantity for non-native species, including striped bass and American shad, in the Central Valley. Increases in flows greater than 10 percent of those for the No Action Alternative were considered beneficial to these species. For the simulated period 1922-1993, the average annual discharge of the Sacramento River at Keswick, Grimes, and Verona for the Maximum Flow Alternative are approximately 7,700; 10,500; and 18,400 cfs, respectively (Table B-21). For the Maximum Flow Alternative, the total average annual discharges in the upper and middle reaches of the Sacramento River decreased approximately 12 and 9 percent at Keswick and Grimes respectively. The range of monthly average flows diminished from 5 to 22 percent at Keswick and 2 to 21 percent at Grimes (Table B-24). These average monthly flows included reductions of up to 9 percent (Keswick) and 8 percent (Grimes) for the months of May and June, important months for spawning for striped bass and American shad

and up to 12 percent in July, important months for larval and fry rearing for striped bass and American shad (Table B-24). These flow reductions may result in reductions in habitat for non-native species including striped bass and American shad in the upper reaches of the Sacramento River.

The total average annual discharges in the lower reach of the Sacramento River decreased by approximately 6 percent at Verona compared to those discharges estimated for the No Action Alternative (Table B-24). Average monthly flows at Verona decreased from 1 to 13 percent compared to the No Action Alternative and included average reductions of 4, 5, and 7 percent in May, June, and July respectively. Considering the magnitude of the decreases in some of the monthly average discharges important to striped bass and American shad, it is un-likely that reductions in habitat quantity and quality may be sufficient to potentially impact some non-native species in the lower most reach of the Sacramento River.

The average annual inflow and outflow in the Delta for the Maximum Flow Alternative is estimated to be approximately 28,300 and 19,400 cfs, respectively (Tables B-22 and B-23). These flows are approximately 4 percent less, on average, than those for the No Action Alternative (Tables B-25 and B-26).

For the months important for recreationally important striped bass in the Delta (February through June), Delta inflows ranged from 1 to 3 percent less than those for No Action. For these months, Delta outflows ranged from 0 to 3 percent less than those for No Action. However, the target compliance ratio of Delta inflows to exports, 35 percent for February through June and 65 percent for July through January, were not violated for any year simulated for the Maximum Flow Alternative.

Calculated positions of X2 in the Delta, as measured from the Golden Gate Bridge, are shown in Table B-27. The average monthly position of X2 moved 0.3 kilometers or less for the period of simulation (approximately 0.4 percent or less relative to the No Action Alternative). During the months of February through June the average monthly X2 position ranged from 65.8 KM (April) to 71.6 KM (February) (Table B-27). During these months, X2 moved 0.3 kilometers or less for the years simulated (a change of 0.4 percent or less relative to that for No Action) (Table B-28). A summary of the evaluation of the frequency and the direction of changes of X2 position in the Delta are found in Table B-29 and in Attachment B10.

Of the 72 years (1922-1993) analyzed for the months from February through June for the Maximum Flow Alternative, a total of 55 months (15.3 percent) movement of the predicted X2 location was greater that 0.5 KM upstream (east) of the position predicted for the No Action alternative. Additionally, 23 months (6.4 percent) movement of the predicted X2 position was greater than 0.5 KM downstream (west) of the predicted X2 position for the No Action alternative. The overall conclusion from this analysis is, that while there are both movements of X2 greater than 0.5 KM eastward (15.3 percent of the months) and westward (6.4 percent of the months), on the balance for the vast majority of months these movements would not likely reduce habitat quantity or quality sufficiently to adversely affect non-native resident species in the Delta.

The monthly ratio of Delta inflows to exports in the Delta would not significantly changed for the Max Flow Alternative.

On the average, the monthly ratio of Delta inflows to exports, and the position of X2 in the Delta would not significantly change for the Maximum Flow Alternative. However, there would be reductions in flows in the Sacramento River that may affect striped bass and American shad, particularly during May and June when these species are migrating and spawning (Table B-19). There are no measures sufficient to mitigate to less than significant, these impacts in the Central Valley.

1.4.2.6 Flow Evaluation Alternative

Trinity River Basin. The results of the TRSAAM analysis for all attribute objectives for the Flow Evaluation Alternative are shown in Table B-10 and are summarized in Table B-11. As shown in these tables, this alternative was scored 49 of the total possible 70 attribute objectives points believed necessary to restore the Trinity River fluvial river system. Compared to No Action, the Flow Evaluation Alternative excelled in meeting the river system and habitat requirements necessary for restoring naturally produced anadromous salmonids in the mainstem Trinity River. This would also likely enhance habitat conditions for many non-native, especially cold-water fish species in the Trinity Basin. Cooler water temperature in the spring and early summer may, however, negatively affect growth and development of American shad in the Trinity River Basin. For most species, as compared to the No Action Alternative, river system health and fishery habitat in the mainstem Trinity River in the year 2020 would greatly improve under the Flow Evaluation Alternative (Table B-19). This would likely result in increases in non-native fish populations, particularly brown trout, compared to those expected from the No Action Alternative.

Lower Klamath River Basin/Coastal Area. Improvements in habitat conditions and increases in flows in the Trinity River would result in more favorable conditions in the lower Klamath River, thus benefiting non-native cold-water species within the lower Klamath River and estuary. Increases in flows to the Trinity River would increase habitat quantity and benefit habitat conditions in the lower Klamath River and estuary. Increases in flow in the Trinity River resulting from spring reservoir releases would provide cooler water temperature conditions in the Klamath River downstream of the confluence. However, this may negatively affect growth of species such as American shad and striped bass in the lower Klamath River and estuary.

Beneficial habitat conditions, as a result of more optimal temperatures and increased flows, would likely improve survival rates for young life stages of coldwater species such as brown trout. Improved habitat conditions would benefit juveniles rearing and adults of many of these species occupying the lower Klamath River and estuary (Table B-19). These benefits may result in increased populations of brown trout for the Flow Evaluation Alternative.

Central Valley. It was assumed that decreases in monthly average stream flows greater than 10 percent of those for the No Action Alternative would significantly diminish habitat quality and quantity for non-native species, including striped bass and American shad, in the Central Valley. Increases in flows greater than 10 percent of those for the No Action Alternative were considered beneficial to these species. For the simulated period 1922-1993, the average annual discharge of the Sacramento River at Keswick, Grimes, and Verona for the Flow Evaluation Alternative are approximately 8,400; 11,000; and 19,000 cfs, respectively (Table B-21). For this alternative, the total average annual discharges in the upper and

middle reaches of the Sacramento River decreased approximately 4 percent at Keswick and Grimes. The average monthly flows decreased 1 to 8 percent at Keswick and from no change to 6 percent at Grimes (Table B-24). These flow reductions are insufficient to result in habitat reductions for non-native species in the upper reaches of the Sacramento River.

The total average annual discharges in the lower reach of the Sacramento River decreased by approximately 2 percent at Verona compared to those discharges estimated for the No Action Alternative (Table B-24). The average monthly flows at Verona decreased up to 4 percent compared to the No Action Alternative. Considering the magnitude of the decreases in average annual and monthly discharges at these Sacramento River locations significant reductions in habitat quantity and quality are unlikely and no impacts to non-native species, including striped bass and American shad, would be expected to occur in the Sacramento River.

The average annual inflow and outflow in the Delta for the Flow Evaluation Alternative is estimated to be approximately 28,900 and 19,700 cfs, respectively (Tables B-22 and B-23). These flows are approximately 1 percent less, on average, than those for the No Action Alternative (Tables B-25 and B-25).

For the months important for recreationally important striped bass in the Delta (February through June), Delta inflows range from 0 to 2 percent less than No Action(Table B-25). Similarly, Delta outflows ranged from 0 to 2 percent less than No Action (Table-B-26). The maximum ratio of Delta inflows to exports, 35 percent for February through June and 65 percent for July through January, were not violated for any year simulated for the Flow Evaluation Alternative.

Calculated positions of X2 in the Delta, as measured from the Golden Gate Bridge, are shown in Table B-27. During the months of February through June the average monthly X2 position ranged from 65.8 KM (April) to 71.4 KM (February) (Table B-27). During these months, X2 moved 0.1 kilometers or less for the years simulated (a change of 0.1 percent or less relative to that for No Action) (Table B-28). A summary of the evaluation of the frequency and the direction of changes of X2 position in the Delta are found in Table B-29 and in Attachment B10.

Of the 72 years (1922-1993) analyzed for the months from February through June for the Flow Evaluation alternative, a total of 35 months (9.7 percent) movement of the predicted X2 location was greater that 0.5 KM upstream (east) of the position predicted for the No Action alternative. Additionally, 29 months (8.1 percent) movement of the predicted X2 position was greater than 0.5 KM downstream (west) of the predicted X2 position for the No Action alternative. The overall conclusion from this analysis is, that while there are both movements of X2 greater than 0.5 KM eastward (9.7 percent of the months) and westward (8.1 percent of the months), on the balance for the vast majority of months (≥90 percent) these movements would not likely reduce habitat quantity or quality sufficiently to adversely affect non-native resident species in the Delta.

On average, the monthly ratio of Delta inflows to exports in the Delta nor X2 position in the Delta would not significantly change for the Flow Evaluation Alternative. There would be no impacts to non-native species in the Central Valley from implementing the Flow Evaluation Alternative (Table B-19).

1.4.2.7 70 Percent Inflow Alternative

Trinity River Basin. The results of the TRSAAM analysis for all attribute objectives for the 70 Percent Inflow Alternative are shown in Table B-10 and are summarized in Table B-11. As shown in these tables, the 70 Percent Inflow Alternative was scored 50 of the total possible 70 attribute objectives points believed necessary to restore the Trinity River fluvial river system. Compared to No Action, this alternative provided significant improvement to river system and habitat conditions necessary for restoring anadromous salmonids species in the mainstem Trinity River. These expected improvements would also provide significant benefits to habitat conditions for most non-native, especially cold-water, fish species in the Trinity Basin. Cooler water temperature in the spring and early summer may, however, negatively affect growth and development of American shad in the Trinity River Basin. These results indicated that, compared to the No Action Alternative, fishery habitat in the mainstem Trinity River in the year 2020 would significantly improve under the 70 Percent Inflow Alternative and would may result in increases in populations of non-native species, particularly brown trout, as compared to the No Action Alternative.

Lower Klamath River Basin/Coastal Area. The 70 Percent Inflow Alternative would result in somewhat cooler water temperature conditions and increased Trinity River flows in many water years. In these years, increased annual flows and cooler water temperature conditions during spring and early summer could result in improved habitat conditions in the lower Klamath River and estuary for non-native species such as brown trout. However, species such as American shad and striped bass may not benefit from these cooler water temperatures. In many dry and critically dry water years, annual discharges would be less than those for the No Action Alternative. During these years, water temperature and habitat conditions in the Trinity River would be either similar or less beneficial to brown trout, but may be more beneficial to striped bass and American shad compared to conditions for the No Action Alternative.

Central Valley. It was assumed that decreases in monthly average stream flows greater than 10 percent of those for the No Action Alternative would significantly diminish habitat quality and quantity for non-native species, including striped bass and American shad, in the Central Valley. Increases in flows greater than 10 percent of those for the No Action Alternative were considered beneficial to these species for the 70 Percent Inflow alternative. For the simulated period 1922-1993, the average annual discharge of the Sacramento River at Keswick, Grimes, and Verona for the 70 Percent Inflow Alternative are approximately 8,000; 10,700; and 18,700cfs, respectively (Table B-21). For this alternative, the total average annual discharges in the upper and middle reaches of the Sacramento River decreased approximately 9 percent at Keswick and 6 percent at Grimes (Table B-24). The average monthly flows ranged from a decrease of 3 to 18 percent at Keswick and a decrease of 1 to 14 percent at Grimes (Table B-24). These average monthly flows included reductions of up to 7 percent (Keswick) and 6 percent (Grimes) for the months of May and June, important months for spawning and up to 8 percent in July, important months for larval and fry rearing for striped bass and American shad (Table B-24).

The total average annual discharge in the lower reach of the Sacramento River decreased by approximately 4 percent at Verona compared to those discharges estimated for the No Action Alternative (Table B-24). The average monthly flows at Verona decreased from 1 to

7 percent compared to the No Action Alternative. Considering the magnitude of the decreases of average monthly flows at those locations on the Sacramento River, there would likely be no significant reductions in habitat quantity and quality nor impacts to non-native species, including striped bass and American shad, in the Sacramento River.

The average annual inflow and outflow in the Delta for the 70 Percent Inflow Alternative is estimated to be approximately 28,600 and 19,400 cfs, respectively (Tables B-22 and B-23). These annual flows are approximately 3 percent less, on average, than those for the No Action Alternative (Tables B-25 and B-26).

For the months important for recreationally important striped bass in the Delta (February through June), inflows range from 1 to 2 percent less than No Action (Table B-25). Similarly, Delta outflows range from 1 to 2 percent less than No Action (Table B-26). However, the maximum ratio of Delta inflows to exports, 35 percent for February through June and 65 percent for July through January, were not violated for any year simulated for the 70 Percent Inflow Alternative.

Calculated positions of X2 in the Delta, as measured from the Golden Gate Bridge, are shown in Table B-27. The average monthly position of X2 moved 0.3 kilometers or less for the period of simulation (approximately 0.4 percent or less relative to the No Action Alternative) (Table B-28). During the months of February through June the average monthly X2 position ranged from 65.9 KM (April) to 71.6 KM (February) (Table B-27). During these months, X2 moved 0.3 kilometers or less for the years simulated (a change of 0.4 percent or less relative to that for No Action) (Table B-28). A summary of the evaluation of the frequency and the direction of changes of X2 position in the Delta are found in Table B-29 and in Attachment B10.

Of the 72 years (1922-1993) analyzed for the months from February through June for the 70 Percent Inflow Alternative, a total of 54 months (15 percent) movement of the predicted X2 location was greater that 0.5 KM upstream (east) of the position predicted for the No Action alternative. Additionally, 12 months (3.3 percent) movement of the predicted X2 position was greater than 0.5 KM downstream (west) of the predicted X2 position for the No Action alternative. The overall conclusion from this analysis is, that there are both movements of X2 greater than 0.5 KM eastward (15 percent of the months) and westward (3.3 percent of the months), and on the balance these movements would likely reduce habitat quantity or quality sufficiently to adversely affect non-native resident species in the Delta.

On average, the monthly ratio of Delta inflows to exports, would not significantly change for the 70 Percent Inflow Alternative. However, X2 position in many months would significantly impact non-native species habitat in the Delta, (Table B-19), important for striped bass and American shad. There are no measures sufficient to mitigate, to less than significant, these impacts in the Central Valley

1.4.2.8 Mechanical Restoration Alternative

Trinity River Basin. The results of the TRSAAM analysis for all attribute objectives for the Mechanical Restoration Alternative are shown in Table B-10 and summarized in Table B-11. As shown in these tables, the Mechanical Restoration Alternative was scored 13 out of the total possible 70 attribute objectives points believed necessary to restore the Trinity River

fluvial river system. A majority of the attribute objectives were determined to never or nearly never exceed threshold criteria for this alternative. This alternative was determined to provide only some small benefit in meeting river system attribute objectives compared to the No Action Alternative. Small and localized beneficial improvements in river system health and function would result in only small benefits to non-native fish populations as compared to No Action.

Lower Klamath River Basin/Coastal Area. The only changes in habitat conditions in the Trinity River Basin in the Mechanical Restoration Alternative are through mechanical means. Therefore, no benefits resulting from increased flows or cool water temperature would be expected in the lower Klamath River and estuary under the Mechanical Restoration Alternative. Habitat conditions for this alternative would remain the same as No Action for the lower Klamath River and estuary. It is likely that non-native fish populations in the lower Klamath River would remain unchanged under this project alternative.

Central Valley. This alternative would not affect habitats for non-native fish species in the Central Valley and therefore would result in no change from the No Action Alternative.

1.4.2.9 Revised Mechanical Restoration Alternative

Trinity River Basin. The results of the TRSAAM analysis for all attribute objectives for the Revised Mechanic Restoration Alternative are shown in Table B-10 and are summarized in Table B-11. As shown in these tables, the Revised Mechanical Restoration Alternative was scored 37 of the total possible 70 attribute objectives points believed necessary to restore the Trinity River fluvial river system. Compared to No Action, this alternative provided improvement to river system and habitat conditions necessary for restoring anadromous salmonids species in the mainstem Trinity River. These expected improvements would also provide benefits to habitat conditions for non-native cold-water fish species such as brown trout in the Trinity Basin. Cooler water temperature in the spring and early summer may, however, negatively affect growth and development of American shad in the Trinity River Basin. These results indicated that, compared to the No Action Alternative, fishery habitat conditions in the mainstem Trinity River in the year 2020 would generally improve under the Revised Mechanical Restoration Alternative and would likely result in increases in populations of non-native cold-water species as compared to the No Action Alternative.

Lower Klamath River Basin/Coastal Area. Revised Mechanical Restoration Alternative would result in cooler water temperature conditions and increased Trinity River flows in some water years. In these years, increased annual flows and cooler water temperature conditions during spring and early summer could result in improved habitat conditions in the lower Klamath River and estuary for non-native species such as brown trout. However, species such as American shad may not benefit from these cooler water temperatures. In many dry and critically dry water years, annual discharges may be less than those for the No Action Alternative. During these years, water temperature and habitat conditions in the Trinity River would be either similar or less beneficial to brown trout, but may be more beneficial to American shad and striped bass compared to conditions for the No Action Alternative. In general, populations of non-native cold-water species in the lower Klamath River and estuary would benefit somewhat by this alternative.

Central Valley. It was assumed that decreases in monthly average stream flows greater than 10 percent of those for the No Action Alternative would significantly diminish habitat quality and quantity for non-native species, including striped bass and American shad, in the Central Valley. Increases in flows greater than 10 percent of those for the No Action Alternative were considered beneficial to these species for the Revised Mechanical Restoration Alternative. For the simulated period 1922-1993, the average annual discharge of the Sacramento River at Keswick, Grimes, and Verona for the Revised Mechanical Restoration Alternative are approximately 8,600, 11,200, and 19,200cfs, respectively (Table B-21). For this alternative, the total average annual discharges in these upper and middle reaches of the Sacramento River decreased approximately 1 percent at both Keswick and Grimes (Table B-24). The average monthly flows ranged from no change to a decrease of 3 percent at both Keswick and Grimes (Table B-24).

The total average annual discharge in the lower reach of the Sacramento River also decreased by approximately 1 percent at Verona compared to those discharges estimated for the No Action Alternative (Table B-24). The average monthly flows at Verona ranged from no change to a 3 percent decrease compared to the No Action Alternative. Considering the magnitude of the decreases of average monthly flows at Keswick and Grimes, there would not likely be significant reductions in habitat quantity and quality or impacts non-native species, including striped bass and American shad, in the Sacramento River.

The average annual inflow and outflow in the Delta for the Revised Mechanical Restoration Alternative is estimated to be approximately 29,100 and 19,800 cfs, respectively (Tables B-22 and B-23). These flows are approximately 1 percent less, on average, than those for the No Action Alternative (Tables B-25 and B-26). For the months important for recreationally important striped bass in the Delta (February through June), Delta inflows range from 0 to 2 percent less than those for No Action (Table B-25). Similarly, Delta outflows range from 0 to 2 percent less than those for No Action (Table B-26). The maximum ratio of Delta inflows to exports, 35 percent for February through June and 65 percent for July through January, were not violated for any year simulated for the Revised Mechanical Restoration Alternative.

Calculated positions of X2 in the Delta, as measured from the Golden Gate Bridge, are shown in Table B-27. During the months of February through June the average monthly X2 position ranged from 65.6 KM (April) to 71.3 KM (February) (Table B-27). A summary of the evaluation of the frequency and the direction of changes of X2 position in the Delta are found in Table B-29 and as Attachment B10.

Of the 72 years (1922-1993) analyzed for the months from February through June for the Revised Mechanical Restoration alternative, a total of 17 months (4.7 percent) movement of the predicted X2 location was greater that 0.5 KM upstream (east) of the position predicted for the No Action alternative. Additionally, 14 months (3.9 percent) movement of the predicted X2 position was greater than 0.5 KM downstream (west) of the predicted X2 position for the No Action alternative. The overall conclusion from this analysis is, that there are both movements of X2 greater than 0.5 KM eastward (4.7 percent of the months) and westward (3.3 percent of the months), and the balance these movements would not likely reduce habitat quantity or quality sufficiently to adversely affect non-native resident species in the Delta.

On average, the monthly compliance target ratio of Delta inflows to exports, and the position of X2 in the Delta would not significantly change for the Revised Mechanical Alternative. The frequency and magnitude of these changes would not result in reductions in habitat conditions for striped bass and American shad (Table B-19).

1.4.2.10 Modified Percent Inflow Alternative

Trinity River Basin. The results of the TRSAAM analysis for all attribute objectives for the Modified Percent Inflow Alternative are shown in Table B-10 and are summarized in Table B-11. As shown in these tables, the Modified Percent Inflow Alternative was scored 51 of the total possible 70 attribute objectives points believed necessary to restore the Trinity River fluvial river system. Compared to No Action, this alternative provided significant improvement to river system and habitat conditions necessary for restoring anadromous salmonids species in the mainstem Trinity River. Cooler water temperature in the spring and early summer may, however, may negatively affect growth and development of American shad in the Trinity River Basin. The expected improvements would provide significant benefits to habitat conditions for non-native cold-water fish species especially brown trout in the Trinity Basin. These results indicated that, compared to the No Action Alternative, fishery habitat in the mainstem Trinity River in the year 2020 would significantly improve under the Modified Percent Inflow Alternative and would likely result in increases in populations of non-native species as compared to the No Action Alternative.

Lower Klamath River Basin/Coastal Area. The Modified Percent Inflow Alternative would result in somewhat cooler water temperature conditions and increased Trinity River flows in many water years. In these years, increased annual flows and cooler water temperature conditions during spring and early summer could result in improved habitat conditions in the lower Klamath River and estuary for non-native cold-water species such as brown trout. However, species such as American shad may not benefit from these cooler water temperatures. In many dry and critically dry water years, annual discharges may be less than those for the No Action Alternative. During these years, water temperature and habitat conditions in the Trinity River would be either similar or less beneficial to brown trout, but may be more beneficial to American shad and striped bass compared to conditions for the No Action Alternative. In general, populations of non-native species in the lower Klamath River and estuary would likely benefit by this alternative.

Central Valley. It was assumed that decreases in monthly average stream flows greater than 10 percent of those for the No Action Alternative would significantly diminish habitat quality and quantity for non-native species, including striped bass and American shad, in the Central Valley. Increases in flows greater than 10 percent of those for the No Action Alternative were considered beneficial to these species for the Modified Percent Inflow Alternative. For the simulated period 1922-1993, the average annual discharge of the Sacramento River at Keswick, Grimes, and Verona for this Alternative are approximately 8,500; 11,100; and 19,100 cfs, respectively (Table B-21). For this alternative, the total average annual discharges in the upper and middle reaches of the Sacramento River decreased approximately 2 percent at Keswick and Grimes (Table B-24). The average monthly flows ranged from an decrease of 1 to 5 percent at Keswick and no change to a decrease or 4 percent at Grimes (Table B-24).

The total average annual discharge in the lower reach of the Sacramento River decreased by approximately 1 percent at Verona compared to those discharges estimated for the No Action Alternative (Table B-24). The average monthly flows at Verona ranged from no change to a decrease of 3 percent compared to the No Action Alternative. Considering the magnitude of the decreases of average monthly flows at Keswick and Grimes, and Verona there likely would no significant reduction in habitat quantity and quality. There likely would no significant impacts non-native species, including striped bass and American shad, in the Sacramento River.

The average annual inflow and outflow in the Delta for the Modified Percent Inflow Alternative is estimated to be approximately 29,000 and 19,800 cfs, respectively (Tables B-22 and B-23). These flows are approximately 1 percent less, on average, than those for the No Action Alternative (Tables B-25 and B-26). For the months important for recreationally important striped bass in the Delta (February through June), Delta inflows range from 0 to 2 percent less than those for No Action (Table B-25). Similarly, Delta outflows range from 0 to 2 percent less than those for No Action (Table B-26). The maximum compliance target ratio of Delta inflows to exports, 35 percent for February through June and 65 percent for July through January, were not violated for any year simulated for the Modified Percent Inflow Alternative.

Calculated positions of X2 in the Delta, as measured from the Golden Gate Bridge, are shown in Table B-27. During the months of February through June the average monthly X2 position ranged from 65.6 KM (April) to 71.3 KM (February) (Table B-27). On the average, for the months of February through June, X2 did not appreciably move (≤0.1 KM), relative to No Action, during the years simulated (Table B-28). A summary of the evaluation of the frequency and the direction of changes of X2 position in the Delta are found in Table B-29 and in Attachment B10.

Of the 72 years (1922-1993) analyzed for the months from February through June for the Modified Percent Inflow alternative, a total of 23 months (6.4 percent) movement of the predicted X2 location was greater that 0.5 KM upstream (east) of the position predicted for the No Action alternative. Additionally, 19 months (5.3 percent) movement of the predicted X2 position was greater than 0.5 KM downstream (west) of the predicted X2 position for the No Action alternative. The overall conclusion from this analysis is, that there are both movements of X2 greater than 0.5 KM eastward (6.4 percent of the months) and westward (5.3 percent of the months), and on the balance for the vast majority of months (≥93 percent) these movements would not likely reduce habitat quantity or quality sufficiently to adversely affect non-native resident species in the Delta.

On an average annual basis, the monthly ratio of Delta inflows to exports, and the position of X2 in the Delta would not significantly change for the Modified Percent Inflow Alternative. The frequency and magnitude of these changes would not result in reductions in habitat conditions for striped bass and American shad (Table B-19).

1.4.2.10 Existing Conditions versus Preferred (Flow Evaluation) Alternative

Trinity River Basin and Lower Klamath River Basin/Coastal Area. Trinity River impacts of the Preferred (Flow Evaluation) Alternative compared to existing conditions for resident non-native fish would be similar to the impacts of the Flow Evaluation Alternative compared to the No Action conditions in the year 2020. However, the watershed protection component of the Preferred Alternative would benefit non-native fish by reducing sediment inputs to the Trinity River.

Central Valley. It was assumed that decreases in monthly average stream flows greater than 10 percent of those for existing conditions would significantly diminish habitat quality and quantity for non-native species, including striped bass and American shad, in the Central Valley. Increases in flows greater than 10 percent of those for existing conditions were considered beneficial to these species. For existing conditions (for the simulated period 1922-1993), the average annual discharge in the Sacramento River as estimated for Keswick, Grimes, and Verona are approximately 8,700; 11,300; and 19,300 cfs, respectively (Table B-21). For the Preferred Alternative, for the simulated period 1922-1993, the average annual discharge in the Sacramento River as estimated for Keswick, Grimes, and Verona are approximately 8,400; 11,000, and 19,000, respectively (Table B-21). The estimated changes in the average annual Sacramento River flows for Keswick, Grimes, and Verona for the Preferred Alternative as compared to existing conditions are shown in Table B-24. Changes in the estimated average annual Sacramento River flows at Keswick (upper reach of the river) and Grimes (middle reach of the river) for the Preferred Alternative each averaged approximately 4 percent less than Existing Conditions. Flows ranged from 1 to 10 percent less (Keswick) and no change to 8 percent less (Grimes) compared to existing conditions (Table B-24). These decreases in stream flows would not likely result in significant reduction in habitat for striped bass and American shad migration and spawning within the upper and middle reaches of the Sacramento River during their presence.

For the Preferred Alternative, the total average annual discharge (in cfs) for the lower reach of the Sacramento River at Verona decreased by an average of approximately 2 percent and ranged from an increase of 1 percent to a decrease of 4 percent compared to existing conditions (Table B-24). Considering the magnitude of these decreases in annual discharges, it is not likely that the quantity and quality of non-native species' (including striped bass and American shad) habitats would be significantly impacted in the lower Sacramento River reach.

For existing conditions, the total average annual inflow and outflows for the Delta are approximately 29,300 and 20,000 cfs, respectively (Tables B-22 and B-23). For the Preferred Alternative, the total average annual inflow and outflow for the Delta are approximately 28,900 and 19,700 cfs, respectively (Tables B-22 and B-23). The annual average change in Delta inflows and outflows for the Preferred Alternative are 2 percent and 3 percent, respectively, as compared to existing conditions.

For the months important for recreationally important striped bass in the Delta (February through June), Delta inflows ranged from 0 to 3 percent less than those for existing conditions (Table B-25). For these months, Delta outflows range are less than 3 less 10 percent than those for existing conditions (Table B-26). The maximum compliance target

ratio of Delta inflows to exports, 35 percent for February through June and 65 percent for July through January, were not violated for any year simulated for the Flow Evaluation Alternative.

Calculated positions of X2 in the Delta, as measured from the Golden Gate Bridge, are shown in Table B-27. During the months of February through June, X2 moved 0.1 kilometers or less for the years simulated (a change of 0.1 percent or less relative to that for existing conditions) (Table B-28). During the months of February through June the average monthly X2 position ranged from 65.6 KM (April) to 71.2 KM (February) (Table B-27). A summary of the evaluation of the frequency and the direction of changes of X2 position in the Delta are found in Table B-29 and in Attachment B10.

Of the 72 years (1922-1993) analyzed for the months from February through June for the Preferred alternative, a total of 26 months (7.2 percent) movement of the predicted X2 location was greater that 0.5 KM upstream (east) of the position predicted for the Existing Conditions. Additionally, 40 months (4.2 percent) movement of the predicted X2 position was greater than 0.5 KM downstream (west) of the predicted X2 position for Existing conditions. The overall conclusion from this analysis is, that there are both movements of X2 greater than 0.5 KM eastward (7.2 percent of the months) and westward (4.2 percent of the months), and on the balance for the vast majority of months (≥92 percent) these movements would not likely reduce habitat quantity or quality sufficiently to adversely affect non-native resident species in the Delta.

On an annual average basis the monthly ratio of Delta inflows to exports, and the position of X2 in the Delta would not significantly change for the Preferred Alternative as compared to existing conditions. These changes would not result in reduction in habitat quantity and quality for resident non-native species in the Delta (Table B-19).

1.5 RESERVOIRS

1.5.1 Affected Environment

1.5.1.1 Trinity River Basin (Trinity Lake and Lewiston Reservoirs)

Fish species found in the Lewiston Reservoirs and Trinity Lake are listed in Table B-2. Non-native reservoir species are identified in this table as “introduced” species. These reservoir fish include warmwater species: largemouth bass (*Micropterus salmoides*), small-mouth bass (*M. dolomieu*), green sunfish (*Lepomis cyanellus*), white catfish (*Ameiurus catus*), and black bullhead (*Ameiurus melus*). Coldwater reservoir fish include: kokanee salmon (*Oncorhynchus nerka*), rainbow trout (*O. mykiss*), brown trout (*Salmo trutta*), and brook trout (*Salvelinus fontinalus*). Native species, including speckled dace, coast range sculpin, Klamath smallscale sucker, and river lamprey, inhabit both Trinity Lake and Lewiston Reservoir.

1.5.1.2 Reservoir Fish Populations and Habitat Conditions

Trinity Lake is located on the mainstem of the Trinity River, and is fed by Trinity and East Fork Trinity Rivers, Swift Creek, Stuart Fork, East Fork Stuart Fork, and ephemeral and intermittent streams (Larson & Associates, 1984). The fisheries in Trinity Lake include both coldwater and warmwater species. Trinity Lake supports a trophy smallmouth bass fishery and provides significant sport fishing for largemouth bass, as well as trout, kokanee, and other sportfish species. As is typical with most reservoirs, Trinity Lake is characterized by steep sides, with the upper one-fifth of the reservoir containing gentle slopes (Coleman, 1978). The maximum surface area of the reservoir is 16,500 acres, with an irregular shoreline of about 145 miles. Trinity Lake is considered relatively unproductive, with low standing crops of zooplankton. Thermal stratification occurs between May and November, while during the remainder of the year, the reservoir is relatively isothermal (i.e., water temperature is the same at all depths). The banks of Trinity Lake have high erosion potential and, under windy conditions, contribute to high turbidity in the littoral areas (Coleman, 1978).

Lewiston Reservoir is principally a trout fishery. Its total storage capacity is 14,600 af, covering about 610 acres, banded by 15 miles of shoreline. Because Lewiston Reservoir is fairly shallow, thermal stratification can develop quickly when the discharge from Trinity Lake is low. Diversions to Carr Powerplant are intermittent, which results in large, rapid swings in surface temperatures and reservoir elevations in Lewiston Reservoir.

1.5.1.3 Habitat and Life History Characteristics of Principal Species

Habitat conditions and food production for smallmouth bass in Trinity Lake appear to be nearly ideal. The cool water and the high percentage of gravel-rubble bottom found in Trinity Lake have resulted in record-sized smallmouth bass being taken (Frederiksen, Kamine, and Associates, 1980). This species requires clean sand, gravel, or debris-littered bottoms to spawn beginning in April at depths of 1-3 feet up to 23 feet. Optimal water temperatures for spawning are from 55-61°F. Optimal temperatures for growth and survival are approximately 68-81°F. Food organisms for young smallmouth bass include crustaceans, insects, and fish fry. Larger smallmouth feed extensively on fish, frogs, and crayfish.

Largemouth bass were also introduced into Trinity Lake, although not as successfully as smallmouth bass. Largemouth bass spawn, beginning in April and continuing though June, when water temperatures reach 61°F. Spawning occurs at depths of 3-6 feet on sand, gravel, or debris-littered bottom substrates. If nests are submerged under 15 feet or greater, egg mortality approaches 100 percent (Stuber et al., 1982). Largemouth bass fry feed primarily on rotifers and crustaceans. After reaching 2-3 inches in length they feed on aquatic insects and fish fry. Optimal growth and survival occurs at water temperatures of 68-86°F.

Kokanee salmon are the non-anadromous (land-locked) form of sockeye salmon and have become well established in both Trinity and Lewiston Reservoirs. This species has flourished in Trinity Lake (Frederiksen, Kamine, and Associates, 1980). This zooplankton feeding species makes its spawning migration into streams tributary to the reservoirs between early August and February. They prefer spawning in water temperatures of between 43 and 55°F.

Rainbow trout are the most abundant salmonid species found in Trinity Lake and Lewiston Reservoir. The cold, deep water of these reservoirs provides suitable rearing habitat for this species, although they do not spawn in the reservoirs. Like kokanee salmon, rainbow trout can spawn in streams tributary to Trinity and Lewiston Reservoirs. Rainbow trout usually spawn in the spring months, with specific timing dependent on reservoir elevations and water temperatures. Juvenile trout migrate out of the spawning streams to enter the reservoir to forage and mature. Benthic invertebrates and zooplankton are the preferred prey food of rainbow trout, but terrestrial insects are consumed if other food is scarce. Rainbow trout more than 12 inches in length are predatory and can consume small fish. Optimum temperatures for growth and for completion of most stages of their life histories are between 55 and 70°F. (Moyle, 1976).

Variable numbers of hatchery trout are stocked by CDFG into Trinity Lake and Lewiston Reservoir each year to support the sport fishery in these reservoirs. The timing and numbers of planted fish are dependent upon several factors including: water temperature, availability of hatchery fish, and reservoir surface acreage.

1.5.1.4 Factors Affecting Abundance

Fluctuating water level is frequently identified as the main adverse condition affecting reservoir fish production. Limited cover availability, associated with surface level fluctuation, has also been identified as a primary environmental problem limiting fish production in reservoirs. Rising reservoir elevations may submerge active largemouth bass nests during spring months. Severe drawdown of Trinity Lake may adversely affect both smallmouth and largemouth bass production in some years.

Temperatures within the reservoirs are dependent on season and reservoir storage conditions. Generally, temperatures are adequate in providing conditions required to sustain reservoir fisheries. However, the cool water temperature conditions in Trinity Lake may not have been optimal for largemouth bass (Frederiksen, Kamine, and Associates, 1980). Cold water in Trinity Lake, resulting in low zooplankton production and competition for food with Trinity Lake rainbow trout, may be responsible for the stunted size (6-8 inches) of kokanee salmon (Moyle, 1976; Coleman, 1978).

Except for periodic input of sediments from logging or road building activities in the watershed above the reservoirs, water quality in the reservoirs would not be expected to limit the fisheries within them.

The effects of fishing on reservoir fish communities are not well understood, although overfishing of naturally reproducing populations of reservoir game fish seldom seems to limit populations (Moyle, 1976).

Central Valley. The Central Valley contains numerous reservoirs containing both coldwater and warmwater sport fisheries. The principal reservoirs include: Shasta Lake and Keswick Reservoir, Whiskeytown Reservoir, Lake Oroville, Folsom Lake, and San Luis Reservoir. However, all major tributary streams to the Sacramento and San Joaquin Rivers in the Central Valley contain at least one or more reservoir. Each of these provide habitat for game and non-game fish species. The following discussion describes the fisheries in the principal Central Valley reservoirs most closely associated with and adjacent to the project area.

Shasta Lake. Waters from the McCloud, Pit, and Sacramento Rivers and tributaries are impounded by Shasta Dam. Discharges from Shasta Lake greatly influence temperatures in the upper Sacramento River below the dam. Shasta Lake is an outstanding fishery resource, with both coldwater and warmwater species. Coldwater sportfish include chinook and kokanee salmon and rainbow and brown trout. The warmwater gamefish species include largemouth and smallmouth bass, spotted bass, sunfish, black crappie, channel and white catfish, and bullhead.

Keswick Reservoir. Keswick Reservoir is a re-regulation reservoir immediately downstream of the Spring Creek Tunnel and Shasta Dam. The water quality within this reservoir, at times, can be greatly influenced by discharges of acid mine drainage and heavy metal inputs from the Spring Creek Debris Dam discharge and other mine waste discharges within the watershed. Gamefish found in Keswick Reservoir include chinook and kokanee salmon, rainbow and brown trout, largemouth and smallmouth bass, and sunfish species. Many of these species have been introduced, and most of the coldwater species are supplemented with periodic hatchery stocking by CDFG.

Whiskeytown Reservoir. Trinity River water is delivered to Whiskeytown Reservoir from Lewiston Reservoir via the Clear Creek Tunnel. Gamefish species found in Whiskeytown Reservoir include rainbow and brown trout, kokanee salmon, largemouth bass, crappie, sunfish, catfish, and bullhead.

Lake Oroville. Lake Oroville is a State Department of Water Resources (DWR) storage reservoir on the Feather River. Water is delivered out of the Reservoir to Thermolito forebay/afterbays and from there to downstream users. Drawdown averages approximately 75 feet per year. Both warmwater and coldwater sportfisheries ("two story fishery") exist in Lake Oroville. Bass fishing is a popular sport and is recognized as a top bass angling fishery in the Western U.S. Species include spotted bass, largemouth, redeye, and smallmouth bass. In addition, black crappie, white crappie, and channel catfish up to 25 pounds are commonly caught in Lake Oroville. The principal coldwater species are planted brown trout and Chinook salmon. Brown trout up to 15 pounds and Chinook salmon up to 19+ pounds have been caught in Lake Oroville in recent years.

San Luis Reservoir. San Luis Reservoir principally serves to store and deliver water received from the Delta diversions for delivery to farmland in western Merced, Fresno, and Kings Counties. Due to water deliveries from this reservoir, drawdown averaging in excess of 60 feet occurs annually. In excess of 30 species of fish are known to or have occurred in San Luis Reservoir. These species were introduced principally by transport as larvae or fry from the Delta via the California Aqueduct. CDFG has periodically stocked catfish and bass into this reservoir, but the principal gamefish has been striped bass.

Folsom Lake. Folsom Lake is a Reclamation facility which impounds the American River near Sacramento California. Folsom contains a warmwater fishery consisting of largemouth and smallmouth bass, sunfish, and catfish. The coldwater fishery in Folsom is for rainbow trout stocked by CDFG on an annual basis.

1.5.2 Environmental Consequences

1.5.2.1 Methodology

Trinity River Basin.

Reservoir operations affect reservoir fish populations by changing reservoir water surface elevations and reservoir surface areas. For the 1999 DEIS/DEIR the Reservoir Habitat Assessment Model (RHAM) (Jones and Stokes Associates, 1999) spreadsheet method was used to assess the changes in reservoir habitat in Trinity Lake and Lewiston Reservoir. For the methodology and results of those analyses see B-17 of the Fishery Technical Appendix to the 1999 DEIS/DEIR. Reservoir fluctuations can strongly affect both the spawning and rearing life stages of bass species. Nests exposed to the air by receding reservoir levels become desiccated. Changing reservoir elevations can force fry and juvenile bass to move to less desirable habitats, increasing their vulnerability and loss to predators. Periods of reservoir bank substrate exposure affects habitat quality (plant community structure). Thus, reservoir water level fluctuations affects habitat quantity, and substrate exposure over some period of time affects habitat quality.

For this SEIS/SEIR the impacts of operations and the effects of fluctuating reservoirs on warmwater fish communities in Trinity Lake was qualitatively assessed by comparing the changes in surface area for each alternative to the No Action alternative. Mean reservoir surface area (in acres) for the months critical to principal warmwater reservoir species' spawning and rearing lifestages (March through July) for the historic simulation period of 1922-1993 were compared to evaluate operational changes affecting those species.

Trinity Reservoir

It was not possible to describe the effects of reservoir operations on coldwater fish communities except in a qualitative manner. Therefore, the evaluation on the effects of reservoir operations on coldwater species for Trinity Lake was determined based on knowledge of these species' habitat requirements. Lewiston Reservoir elevations and surface areas were not modeled for this SEIS/SEIR and therefore any effect of reservoir fluctuation on fisheries were unable to be assessed. However, Lewiston Reservoir is principally a coldwater fishery, and supplemented with hatchery planting. Therefore, operational effects of reservoir fluctuations on the warmwater fishery is likely irrelevant.

Central Valley. To qualitatively assess effects on reservoir species in the Central Valley, a comparison of changes in surface areas of Shasta Lake, Lake Oroville, and Folsom Lake and Whiskeytown, and San Luis Reservoirs comparing each alternative to the No Action Alternative was conducted. Mean reservoir surface area (in acres) for the months critical to principal warmwater reservoir species' spawning and rearing (March through July) for the historic simulation period of 1922-1993 were compared to evaluate operational changes affecting those species.

1.5.2.2 Significance Criteria

For this analysis, an impact on reservoir fisheries was considered significant when an alternative would:

- Potential for reductions in the number, or restrictions of the range, of an endangered or threatened reservoir fish or a reservoir fish that is a candidate for state listing or proposed for federal listing as endangered or threatened
- Potential for substantial reductions in the habitat of any reservoir fish other than those that are listed as endangered or threatened or are candidates (CESA) or proposed (ESA) for endangered or threatened status
- Potential for causing a reservoir fish population to drop below self-sustaining levels
- Substantial adverse effect, either directly or through habitat modifications, on any reservoir fish identified as a sensitive or special status species in local or regional plans, policies, or regulations
- Substantial interference with the movement of any reservoir fish
- A conflict with, or violation of, the provisions of an adopted Habitat Conservation Plan, Natural Community Conservation Plan, or other approved local, regional, or state habitat conservation plan relating to the protection of reservoir fish
- Mortality of state or federally listed reservoir fish, or species that are candidates for listing (CESA) or proposed for listing (ESA)
- Reductions in the size of a reservoir fish population sufficient to jeopardize its long-term persistence
- Temporary impacts to habitats such that reservoir fish suffer increased mortality or lowered reproductive success that jeopardizes the long-term persistence of those local populations
- Permanent loss of essential habitat of a listed species or special-status reservoir fish
- Reduction in the quantity or quality of habitats in which reservoir fish populations occur sufficient to reduce the long-term abundance and productivity of local populations

For the Trinity River Basin Reservoirs, significance thresholds are phrased in either qualitative or quantitative terms, indicating potential changes from the No Action Alternative. Changes in hydrology and reservoir operations result in variability in reservoir surface area as a surrogate for habitat area.

For all Trinity Basin and Central Valley Reservoirs, decreases in reservoir surface areas greater than 10 percent of those for No Action during key warmwater reservoir fish's spawning and rearing months (March through July) were considered sufficient to significantly reduce spawning and rearing habitats. For those warmwater reservoir species, changes greater than 10 percent would constitute a significant adverse impact. Increases in reservoir surface areas greater than 10 percent of those for No Action during those key

months were considered sufficient to significantly increase spawning and rearing habitats for reservoir species. For those reservoir species, this would be considered a significant benefit.

1.5.2.3 Results

Summary. The results of the comparisons of the No Action Alternative to each project alternative are summarized in Table B-19. The average monthly surface area for Trinity Lake are summarized as shown in Table B-30. For coldwater reservoir species, none of the project alternatives would significantly affect those species in Trinity Lake. The Maximum Flow and the 70 percent Inflow Alternatives would likely result in significant reductions in Trinity Lake surface area and spawning and rearing habitats for warmwater species during March through July. These reductions would result in reductions in habitat for warmwater species and possibly adversely effect the warmwater fishery in Trinity Lake (Table B-37). A summary of the changes in reservoir surface acres and percent change for all alternatives and all reservoirs are shown in Tables B-37 through B-43 and summarized for the months of March through July in Table B-44.

None of the project alternatives would adversely affect, to a significant extent, any reservoir fishery in the Central Valley compared to No Action.

Comparing the Preferred Alternative to existing conditions resulted in no significant differences and no impacts to reservoir fisheries in the Trinity/Klamath River Basins or the Central Valley. There was, however, a significant decrease in San Luis Reservoir storage for SWP operations for the Preferred Alternative when compared to Existing Conditions (Table B-43). This may result in adverse conditions in that reservoir for warmwater fisheries.

To reduce the impact on warmwater fish species to a less-than-significant level, Reclamation should implement a smallmouth and largemouth bass stocking program. This program would be similar to the existing stocking program for coldwater species in many of the reservoirs in the Central Valley.

1.5.2.4 No Action Alternative

Trinity Lake/Trinity River Basin.

Warmwater Species. On the average, surface acreage in Trinity Lake average approximately 12,000 acre annually (Table B-30) for the No Action Alternative. The months with the greatest storage (March through July) and the greatest surface acreage are the same months which are important for spawning and rearing of warmwater species in Trinity Lake.

Lewiston Reservoir. Coldwater fish habitat conditions under the No Action Alternative fluctuates because Lewiston Reservoir would continue to be operated as a re-regulating reservoir, and the CDFG's fish planting program is assumed to continue.

Central Valley. Simulated Central Valley reservoir surface areas in acres by month and their annual averages for the period 1922-1993 are shown in Tables B-30 through B-36. Similar to case for Trinity Lake, maximum storage and reservoir surface acreage occurs during months which are important to spawning and rearing lifestages of warmwater fishes in the Central Valley reservoirs.

1.5.2.5 Maximum Flow Alternative

Trinity Lake.

Warmwater Species. Under the Maximum Flow Alternative, Trinity Lake would be drawn down more frequently and to lower levels resulting in lower surface areas than under the No Action Alternative (Table B-30). Lake surface area, on an annual basis would diminish to approximately 7,900 acres (Table B-30). This is an average annual reduction of approximately 34 percent (Table B-37). The reduction of surface area ranged from 33 to 41 percent during the months of March through July as compared to No Action (Table B-37). The resulting reservoir fluctuations and reduced surface area would generally result in a decrease in habitat availability and an adverse effect to warmwater species.

Conditions for largemouth and smallmouth bass spawning and rearing under the Maximum Flow Alternative would be adversely affected during March through July with a reduction of nearly 5,500 surface acres of the Lake during those months on the average.

The change in operations under this alternative would result in significant adverse impacts (Table B-19) on both largemouth and smallmouth bass populations because these species support an important sport fishery in Trinity Lake and have economic and social value to the region.

To reduce the impact on warmwater fish species to a less-than-significant level, Reclamation should implement a smallmouth and largemouth bass stocking program. This program would be similar to the existing stocking program for coldwater species.

Coldwater Species. Under the Maximum Flow Alternative, Trinity Lake elevations would frequently be lower than those of the No Action Alternative, reducing the amount of habitat available to coldwater fish (Table B-30). Although coldwater fish species may be adversely affected, this impact would likely be less than significant because trout populations are currently supplemented by hatchery production and stocking. Any necessary adjustments to the stocking frequency and intensity would need to be determined on the basis of creel census surveys conducted by the CDFG. No additional mitigation would be necessary.

Lewiston Reservoir. Coldwater fish habitat conditions at Lewiston Reservoir under the Maximum Flow Alternative are expected to be the same as those under the No Action Alternative. Because Lewiston Reservoir would continue to be operated as a re-regulating reservoir and the coldwater fish stocking program is assumed to continue, no impacts on coldwater fisheries are expected under the Maximum Flow Alternative.

Central Valley. The average monthly reservoir surface areas in acres for the Maximum Flow Alternative for Whiskeytown, Shasta, Oroville, Folsom, and San Luis Reservoirs are shown in Tables B-31 through B-36. The percent differences in monthly surface area for these reservoirs are shown in Tables B-38 through B-43. Summaries of the expected changes in reservoir surface area for March through July, as compared to No Action are shown in Table B-44.

There would be no significant changes in the average monthly surface area of Whiskeytown Reservoir for the Maximum Flow Alternative during March through July compared the No Action Alternative (Table B-38). The change in monthly surface area of Shasta Lake would

range from a decrease of approximately 1,260 to 1,840 acres during March through July (Table B-39) compared to the No Action Alternative, a decrease of 5 to 8 percent (Table B-39). The average monthly surface area for Lake Oroville ranged from a decrease of approximately 10 to 50 acres during March through July (Table B-40) compared to No Action, an increase of less than 1 percent (Table B-40). The change in monthly surface area of Folsom Lake would range, on average, from a decrease of approximately 30 to 130 acres during March through July (Table B-41) compared to the No Action Alternative, a decrease of less than 1 percent (Table B-41).

Finally, the changes in average monthly storage in San Luis Reservoir (for CVP operations) would range, on average, from an increase of approximately 5 to 50 TAF during March through July (Table B-42), an increase of approximately 1 to 16 percent (Table B-42) compared to the No Action Alternative. The average monthly storage in San Luis Reservoir (for SWP operations) area would decrease approximately 15 acres during March through July (Table B-43) a decrease of approximately 2 to 4 percent (Table B-44) compared to the No Action Alternative. The small changes in reservoir surface areas or storage would not result in significant reductions in reservoir habitats or impacts to warmwater reservoir fish populations in the Central Valley. The small but significant increase of up to approximately 15 percent in San Luis Reservoir (SWP operation) surface area during June and July may provide beneficial rearing conditions for young warmwater fishes in this reservoir.

1.5.2.6 Flow Evaluation Alternative

Trinity Lake/Trinity River Basin.

Warmwater Species. Under the Flow Evaluation Alternative, Trinity Lake would be drawn down similarly to conditions under the No Action Alternative (Table B-30). Lake surface area, on an annual basis would only diminish to approximately 11,700 acres. This is an average annual reduction of approximately 3 percent with reductions of surface acres ranging from 1 to 6 percent during the months of March through July as compared to No Action (Table B-37). The resulting reservoir fluctuations and reduced surface area would not result in a significant decrease in habitat availability for warmwater species.

Habitat conditions for largemouth and smallmouth bass spawning and rearing under the Flow Evaluation Alternative would be not be adversely affected during March through July. A reduction of approximately 90 to 700 surface acres of Trinity Lake would occur during those months on the average (Table B-37).

Impacts on warmwater species are considered less than significant because habitats for largemouth and smallmouth bass would diminish less than 10 percent on average (Table B-37).

Coldwater Species. Under this alternative, Trinity Lake elevations and surface areas would be similar to those under the No Action Alternative (Table B-30). On an annual basis, the amount of habitat area available for fish year round would be similar to that for the No Action Alternative. Therefore, coldwater fish in Trinity Lake are un-likely to be adversely affected by this alternative.

Lewiston Reservoir. Coldwater fish habitat conditions at Lewiston Reservoir under the Flow Evaluation Alternative are expected to be nearly the same as those under the No Action Alternative. Because Lewiston Reservoir would continue to be operated as a re-regulating reservoir and the coldwater fish stocking program is assumed to continue, no impacts on coldwater fisheries are expected under the Flow Evaluation Alternative.

Central Valley. For the Flow Evaluation Alternative, the average monthly reservoir surface areas in acres for Shasta, Oroville, and Folsom Lakes and Whiskeytown and San Luis Reservoirs are shown in Tables B-30 through B-36. The differences in monthly and average surface area, from No Action, for these reservoirs are shown in Tables B-38 through B-43. The summaries of the expected changes in reservoir conditions, as compared to No Action from March through July, are shown in Table B-44.

There would be no significant changes in the average monthly surface area of Whiskeytown Reservoir for the Flow Evaluation Alternative during March through July compared the No Action Alternative (Table B-38). The small changes in monthly surface area of Lake Shasta during March through July would range from a decrease of approximately 250 to 400 acres during March through July (Table B-39) compared to the No Action Alternative, a decrease of less than 2 percent. Monthly Lake Oroville surface areas ranged from a decrease of approximately 20 to 60 acres during March through July (Table B-40) compared to No Action, an decrease of less than 1 percent. Monthly Folsom Lake surface area ranged from a decrease of approximately 25 to an increase of approximately 20 acres during March through July (Table B-41) compared to No Action, a change of less than ±1 percent.

The average changes in San Luis Reservoir (CVP operations) average monthly surface area would range from a decrease of approximately of 6 acres to increase of 2 acres during March through July (Table B-42) a change of approximately less than ±1 percent (Table B-42) compared to the No Action Alternative. The change in average monthly surface area in San Luis Reservoir (SWP operations) would range ±8 acres or less from March through July (Table B-43). This is a decrease of less than approximately ±2 percent compared to the No Action Alternative (Table B-43). The small changes in surface areas within all of these reservoirs would not result in significant reductions in reservoir habitats quantity or impacts to warmwater reservoir fish populations in the Central Valley.

1.5.2.7 70 Percent Inflow Alternative

Trinity Lake/Trinity River Basin.

Warmwater Species. Under the 70 Percent Inflow Alternative, Trinity Lake would be drawn down somewhat more than conditions under the No Action Alternative (Table B-30). The annual average Trinity Lake surface area would diminish by approximately 1,000 acres to a surface area of approximately 11,000 acres. This is an average annual reduction of approximately 8 percent with reductions of surface area ranging from 9 to 13 percent during the months of March through July as compared to No Action (Table B-37). The resulting reservoir fluctuations and reduced surface area may result in a decrease in habitat availability for warmwater species and an adverse impact to that fishery. Habitat area for largemouth and smallmouth bass spawning and rearing under the 70 Percent Inflow Alternative would decrease during March through July by approximately 1,100 to 1,800 surface acres (Table B-37).

Coldwater Species. Under the 70 Percent of Inflow Alternative, Trinity Lake elevations would frequently be lower and surface area less than those of the No Action Alternative, reducing the amount of habitat available to coldwater fish (Table B-30). Although coldwater fish species may be adversely affected, this impact would likely be less than significant because trout populations are currently supplemented by hatchery production. Any necessary adjustments to the stocking frequency and intensity would need to be determined on the basis of creel census surveys conducted by the CDFG. No additional mitigation would be necessary.

Lewiston Reservoir. Coldwater fish habitat conditions at Lewiston Reservoir under the 70 Percent Inflow Alternative are expected to be the same as those under the No Action Alternative. Because Lewiston Reservoir would continue to be operated as a re-regulating reservoir with a coldwater fish stocking program assumed to continue, no impacts on coldwater fisheries are expected under the this alternative.

Central Valley. The average monthly reservoir surface areas in acres for the 70 Percent Inflow Alternative for Whiskeytown, Shasta, Oroville, Folsom, and San Luis Reservoirs are shown in Tables B-30 through B-36. The differences in mean monthly surface area from No Action for these reservoirs are shown in Tables B-38 through B-43. The summary of the expected changes in reservoir conditions, as compared to No Action from March through July, are shown in Table B-44.

There would be no significant changes in the average monthly surface area of Whiskeytown Reservoir for the 70 Percent Inflow Alternative during March through July compared the No Action Alternative (Table B-38). The change in monthly surface area of Shasta Lake would range from a decrease of approximately 800 to 1,300 acres during March through July (Table B-39) compared to the No Action Alternative, a decrease of 3 to 6 percent (Table B-39). The monthly surface area for Oroville Reservoir ranged from a decrease of approximately 25 to 70 acres during March through July (Table B-40) compared to No Action, a decrease of less than 1 percent (Table B-40). The change in monthly surface area of Folsom Lake would decrease approximately 5 to 80 acres during March through July compared to the No Action Alternative, a decrease of less than 1 percent (Table B-41).

Finally, the changes in average monthly surface area in San Luis Reservoir (for CVP operations) would range, on average, approximately ± 10 to 20 acres during March through July (Table B-42), a change of less than approximately ±1 to 4 percent (Table B-42) compared to the No Action Alternative. The average monthly surface area in San Luis Reservoir (for SWP operations) area would decrease, on average, approximately 15 to 25 acres during March through July (Table B-43) a decrease of approximately 2 to 6 percent (Table B-43) compared to the No Action Alternative.

The small changes in reservoir surface areas would not result in significant reductions in reservoir habitats or impacts to warmwater reservoir fish populations in the Central Valley.

1.5.2.8 Mechanical Restoration Alternative

Reservoir storage and flows under the Mechanical Restoration Alternative would be identical to those under the No Action Alternative. Therefore, habitat conditions for warmwater and

coldwater fish species at Trinity Lake and coldwater fish species at Lewiston Reservoir would be the same as under the No Action Alternative.

This alternative would not affect operations on the Central Valley reservoirs and therefore would not result in any affects on reservoir habitats or fish populations within these reservoirs.

1.5.2.9 Revised Mechanical Restoration Alternative

Trinity Lake/Trinity River Basin.

Warmwater Species. Under the Revised Mechanical Restoration Alternative, Trinity Lake would be drawn down slightly more than conditions under the No Action Alternative (Table B-30). The annual average Trinity Lake surface area would diminish by approximately 400 acres to approximately 11,600 acres. This is an average annual reduction of approximately 3 percent with reductions of surface acres ranging from 2 to 4 percent during the months of March through July as compared to No Action (Table B-37). The resulting reservoir fluctuations and reduced surface area would not result in a significant decrease in habitat availability for warmwater species. There would likely be no adverse impact to that fishery from this alternative.

Conditions for largemouth and smallmouth bass spawning and rearing under the Revised Mechanical Restoration Alternative would not be adversely affected during March through July with a reduction of only 250 to 500 surface acres of the Lake during those months on the average (Table B-37).

Coldwater Species. Because changes in surface area would be minimal under this alternative relative to the No Action Alternative, and because the existing coldwater fish stocking program would continue, no impacts on coldwater fish species are expected under this alternative.

Lewiston Reservoir. Coldwater fish habitat conditions at Lewiston Reservoir under the Revised Mechanical Restoration Alternative are expected to be the same as those under the No Action Alternative. Because Lewiston Reservoir would continue to be operated as a re-regulating reservoir and the coldwater fish hatchery stocking program is assumed to continue, no impacts on coldwater fisheries are expected under the Revised Mechanical Restoration Alternative.

Central Valley. The average monthly reservoir surface areas in acres for the Revised Mechanical Restoration Alternative for Shasta Lake, Lake Oroville, and Folsom Lake and Whiskeytown and San Luis Reservoirs are shown in Tables B-30 through B-36. The differences in mean monthly surface area from No Action for these reservoirs are shown in Tables B-38 through B-43. The summary of the expected changes in reservoir conditions, as compared to No Action from March through July, are shown in Table B-44.

There would be no significant changes in the average monthly surface area of Whiskeytown Reservoir for the Revised Mechanical Restoration Alternative during March through July compared the No Action Alternative (Table B-38). The change in monthly surface area of Lake Shasta would range from a decrease of approximately 85 to 160 acres during March through July (Table B-39) compared to the No Action Alternative, a decrease of less than

1 percent (Table B-39). The monthly surface area for Lake Oroville increased approximately 10 to 50 acres during March through July (Table B-40) compared to No Action, an increase of less than 1 percent (Table B-40). The change in monthly surface area of Folsom Lake would diminish, on average, less than approximately 30 acres during March through July (Table B-41) compared to the No Action Alternative, a decrease of less than 1 percent (Table B-41).

The average monthly storage in San Luis Reservoir (for CVP operations) would change, on average, less than 5 TAF during March through July (Table B-42), less than approximately 1 percent (Table B-3) compared to the No Action Alternative. The average monthly storage in San Luis Reservoir (for SWP operations) area would decrease, on average, less than approximately 15 TAF during March through July (Table B-43), less than 3 percent (Table B-43) compared to No Action.

For this alternative the small changes in reservoir surface areas and storage would not result in significant reductions in reservoir habitats or adverse impacts to warmwater reservoir fish populations in the Central Valley.

1.5.2.10 Modified Percent Inflow

Trinity Lake/Trinity River Basin.

Warmwater Species. Under the Modified Percent Inflow Alternative, Trinity Lake would be drawn down slightly more than conditions under the No Action Alternative (Table B-30). The annual average Trinity Lake surface area would diminish by approximately 350 acres compared to No Action. This is an average annual reduction of approximately 3 percent. Surface acre reductions ranged from 2 to 4 percent during the months of March through July as compared to No Action (Table B-37). The resulting reservoir fluctuations and reduced surface area would not result in a significant decreases in habitat availability for warmwater species. There would likely be no adverse impact to that fishery. Conditions for largemouth and smallmouth bass spawning and rearing under the Modified Percent Inflow Alternative would not be adversely affected during March through July with a reduction of approximately 180 to 550 surface acres during those months on the average (Table B-37).

Coldwater Species. Because changes in surface area would be minimal under this alternative relative to the No Action Alternative, and because the existing coldwater fish stocking program would continue, no impacts on coldwater fish species are expected under this alternative.

Lewiston Reservoir. Coldwater fish habitat conditions at Lewiston Reservoir under the Modified Percent Inflow Alternative are expected to be the same as those under the No Action Alternative. Because Lewiston Reservoir would continue to be operated as a re-regulating reservoir and the coldwater fish stocking program is assumed to continue, no impacts on coldwater fisheries are expected under the Modified Percent Inflow Alternative.

Central Valley. The average monthly reservoir surface areas in acres for the Modified Percent Inflow Alternative for Lake Shasta, Lake Oroville, and Folsom Lake, and Whiskeytown, and San Luis Reservoirs are shown in Tables B-30 through B-36. The differences in surface area from No Action for these reservoirs are shown in Tables B-38

through B-43. The summary of the expected changes in reservoir conditions, as compared to No Action from March through July, are shown in Table B-44.

There would be no significant changes in the average monthly surface area of Whiskeytown Reservoir for the Modified Percent Inflow Alternative during March through July compared the No Action Alternative (Table B-38). The change in monthly surface area of Shasta Lake would range from a decrease of approximately 160 to 250 acres during March through July (Table B-39) compared to the No Action Alternative, a decrease of less than approximately 1 percent (Table B-39). The monthly surface area for Lake Oroville ranged from a increase of approximately 15 to 55 acres during March through July (Table B-40) compared to No Action, a increase of less than 1 percent (Table B-40). The changes in monthly surface area of Folsom Lake would range from a decrease of 30 acres to an increase of 35 acres during March through July (Table B-41) compared to the No Action Alternative, changes of less than ±1 percent (Table B-41).

The changes in average monthly storage in San Luis Reservoir (for CVP operations) would change, on average, less than 10 TAF during March through July (Table B-42), less than approximately 2 percent (Table B-42). The average monthly storage in San Luis Reservoir (for SWP operations) would decrease, on average, approximately less than 10 TAF during March through July (Table B-43) a decrease of less than approximately 4 percent (Table B-43.

The small changes in reservoir surface areas would not result in significant reductions in reservoir habitats or impacts to warmwater reservoir fish populations in the Central Valley for this alternative.

1.5.2.11 Existing Conditions versus Preferred (Flow Evaluation) Alternative

Trinity Lake/Trinity River Basin. The difference between existing conditions and the Preferred Alternative would be nearly identical to the difference between the Flow Evaluation Alternative and No Action. The average surface area for Trinity Lake would be similar for Preferred Conditions compared to existing conditions (Table B-30).

Warmwater Species. Trinity Lake would rarely be lower under the Preferred Alternative than under existing conditions. Largemouth and smallmouth bass spawning and rearing conditions would not be significantly different between the Preferred Alternative and existing conditions during May through July.

Impacts on largemouth and smallmouth bass are considered less than significant because the percent difference in Trinity Lake surface area between the Preferred Alternative and Existing Conditions is less than approximately 5 percent (<700 acres) during March through July (Table B-37).

Coldwater Species. Under the Preferred Alternative, Trinity Lake elevations would typically be similar to those under existing conditions, resulting in similar amounts of habitat area available for fish year round. Coldwater fish are neither likely to be adversely nor beneficially affected by the Preferred Alternative compared to existing conditions.

Lewiston Reservoir. Coldwater fish habitat conditions in Lewiston Reservoir under the Preferred Alternative are expected to be the same as those under existing conditions. Because Lewiston Reservoir would continue to be operated as a re-regulating reservoir and the coldwater fish stocking program is assumed to continue, no impacts on coldwater fisheries are expected under the Preferred Alternative.

Central Valley. The average monthly reservoir surface areas in acres for the Preferred Alternative for Lake Shasta, Lake Oroville, and Folsom Lake, and Whiskeytown and San Luis Reservoirs are shown in Tables B-30 through B-36. Summaries of the expected changes in reservoir area, as compared to existing conditions on a monthly basis, are shown in Tables B-38 through B-43.

The surface area of Whiskeytown Reservoir for the Preferred Alternative during March through July would range from an increase of 3 to a decrease of 3 acres, on average, compared the No Action Alternative (Table B-38) a change of less than 0.1 percent (Table B-38). The ranges in average monthly surface area of Lake Shasta would decrease on the average approximately 200 to 350 acres during March through July compared to the No Action Alternative, a reduction of less than 2 percent (Table B-39). The average monthly decreases in Lake Oroville's surface area for the Preferred Alternative would range from approximately 210 to 230 acres during March through July compared to No Action (Table B-40), a decrease of less than 2 percent (Table B-40). The decreases in monthly Folsom Lake surface areas would range from approximately 10 to 190 acres during March through July compared to No Action (Table B-41), a decrease of less than approximately 2 percent (Table B-42). Finally, the changes in average monthly San Luis Reservoir storage (CVP operations) would range, on average, from an increase of approximately 12 to 35 TAF from March through July compared to the No Action Alternative (Table B-42). These changes represent a difference of up to 6 percent increase in the reservoir storage compared to No Action (Table B-42). The changes in average monthly San Luis Reservoir storage (SWP operations) would range, on average, from a decrease of approximately 20 to 100 TAF from March through July compared to the No Action Alternative (Table B-43). These changes represent a decrease of up to nearly 17 percent of the reservoir storage compared to No Action in May (Table B-43). The apparent net change in storage of San Luis Reservoir's from the combined operations of the CVP and the SWP would result in an approximate reduction of approximately 10 percent.

1.5.2.12 Fisheries Cumulative Effects

Impacts Relative to the Preferred Alternative. Except for fall, winter, and spring-run Chinook salmon, the cumulative effects of the implementation of the Trinity Preferred alternative and CVP OCAP alternative would result in relatively small (less than 1 percent) increases in losses of early lifestages of Sacramento River chinook salmon. Cumulative effects would result in fall and winter chinook salmon losses increasing an additional 1 percent over the Preferred Alternative alone due to increased water temperatures in the upper Sacramento River (Table B-17). Cumulative effects would result in Spring-run Chinook salmon losses increasing an additional 3 percent over the Preferred Alternative alone due to increased water temperatures in the upper Sacramento River (Table B-17). These additional losses would be significant.

The cumulative effects of the implementation of the Trinity Preferred alternative and the CVP OCAP alternative on Delta species would also be generally minor compared to the Trinity Preferred alternative alone. The average absolute change in the position of X2 (in KM) in the Delta during February through June would be less than 0.3 KM, a relative change of less than 0.4 percent (Table B-28). These changes are likely not sufficient in magnitude to result in adverse effects to Delta smelt and other native or important gamefish in the Delta. The changes in the position of X2 would not generally be sufficiently large enough to transport larvae and juvenile smelt and other species into areas where they would be subject to increased entrainment at the Delta Pumps. These changes in X2 position may however, potentially affect Delta species by more frequently relocating them into less productive areas or areas of lower habitat value within the Delta (Table B-29). The position of X2 in the Delta would move eastward greater than 26 percent of the months from February through June compared to the Trinity Preferred Alternative (Table B-29). These changes may result in adverse effects to these species.

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Tables

Table B-1
Fish Species Found in the Trinity River Basin

Name		Aquatic Environment				
Common	**Scientific**	**Introduced**	**Trinity River and Major Tributaries**	**Lewiston Reservoir**	**Trinity Reservoir**	**Status**
Anadromous						
Pacific lamprey	*Lampetra tridentata*		X	X	X	--/--
American shad	*Alosa sapidissima*	X	X			--/--
Chinook salmon (spring and fall runs)	*Oncorhynchus tshawytscha*		X			--/--
Coho salmon[a]	*Oncorhynchus kisutch*	X[b]	X			FT[c] /--
Steelhead[d] (sum-mer and winter runs)	*Oncorhynchus mykiss irideus*	X[e]	X			--/--
Brown trout[f]	*Salmo trutta*	X	X			--/--
White sturgeon	*Acipenser transmontanus*		X			--/--
Green sturgeon	*Acipenser medirostris*		X			--/--
Eulachon	*Thaleichthys pacificus*		X			--/--
Resident						
Rainbow trout	*Oncorhynchus mykiss*		X[g]	X	X	--/--
Brown trout	*Salmo trutta*	X	X	X	X	--/--
Brook trout	*Salvelinus fontinalis*	X	X	X		--/--
Kokanee	*Oncorhynchus nerka*	X		X	X	--/--
Speckled dace	*Rhinichthys osculus*		X	X	X	--/--
Klamath smallscale sucker	*Catostomus rimiculus*		X	X	X	--/--
Coast range sculpin	*Cottus aleuticus*		X	X	X	--/--
Smallmouth bass	*Micropterus dolomieu*	X	X		X	--/--
Largemouth bass	*Micropterus salmoides*	X			X	--/--
Green sunfish	*Lepomis cyanellus*	X			X	--/--
Brown bullhead	*Ameiurus nebulosus*	X			X	--/--

[a] Southern Oregon/Northern California Evolutionary Significant Unit (ESU) coho salmon was listed as Threatened by NOAA Fisheries in 1997.
[b] TRSSH coho stocks include introductions from stocks from Oregon, as well as other California watersheds.
[c] Federal threatened.
[d] Klamath Mountains Province Evolutionary Significant Unit (ESU) steelhead was proposed for as Threatened but was found to not warrant listing (U.S. National Marine Fisheries Service, 2001).
[e] TRSSH steelhead stocks include introductions from stocks from Washington and Oregon, as well as other California watersheds.
[f] Historically were suspected to be anadromous; current status is uncertain (Fry, 1973 as cited by Moyle, 1976).
[g] Stocked into Lewiston and Trinity Reservoirs by CDFG and since transported downstream into Trinity River.

Table B-2
Life History and Habitat Characteristics of Anadromous Salmonid Fish in the Trinity River Basin

Name	Migration	Spawning	Rearing	Rearing Habitat Description
Chinook (spring)	Spring-Summer	Early Fall	Winter-Spring-Summer	Shallow, slow-moving waters adjacent to higher water velocities for feeding.
Chinook (fall)	Fall	Fall	Spring-Summer-Fall	Shallow, slow-moving waters adjacent to higher water velocities for feeding.
Steelhead (winter)	Fall-winter	February-April	Year round	Areas of clean cobble where there is refuge from high velocities; juveniles overwinter for 1-2 or more years.
Steelhead (summer)	Spring-Summer	February-April	Year round	Areas of clean cobble where there is refuge from high velocities; juveniles overwinter for 1-2 or more years.

Table B-3
Inriver and Hatchery Restoration Goals for the Trinity River

Species	Inriver Goals	Hatchery Goals	Total
Fall chinook salmon	62,000	9,000	71,000
Spring chinook salmon	6,000	3,000	9,000
Coho salmon	1,400	2,100	3,500
Steelhead	40,000	10,000	50,000

Table B-4
Estimated Fall Chinook Salmon Inriver Spawner Escapement for the Trinity River

	Pre-dam (<1964)		Post-dam (1982-2002)	
Area	**Mean**	**Range**	**Mean**	**Range**
Above Lewiston	23,250	9,000-37,800	N/A[a]	N/A
Below Lewiston[b]	22,350	10,000-37,800	31,850[c]	5,250-113,000[c]
Total	45,600[d]	19,000-75,600	31,850	5,250 113,000
Total of naturally produced fish (total minus hatchery-produced fish spawning inriver)[c]	N/A	N/A	12,050	2,350-41,400

[a] N/A= Not applicable
[b] North Fork to Lewiston
[c] Upstream of Willow Creek to Lewiston, exclusive of fish returning to hatchery
[d] Upstream of the North Fork confluence for years 1944, 1945, 1955, 1956, and 1963

Table B-5
Post-dam Chinook and Coho Salmon and Winter Steelhead Run-size, Spawning Escapement, and Angler Harvest Estimates for the Mainstem Trinity River[a]

Species	Run-size Estimate	Total Basin Escapement	Inriver Spawner Escapement	TRSSH Hatchery Escapement	Inriver Angler Harvest	Naturally Produced Inriver Spawner Escapement	Hatchery-produced Inriver Spawner Escapement
Years	1977-2002					1982-2002	
Fall Chinook	43,016	39,664	30,214	9,450	3,352	12,047	30,377
Years	1978-1982, 1984-1994, 1996-2002			1977-2002		1982,1984-1994, 1996-2002	
Spring Chinook	17,770	15,854	10,971	4,757	1,916	3,217	14,135
Years	1977-2002					1991-1995, 1997-2002	
Coho	16,567	16,095	10,330	5,765	473	582	11,332
Years	1980, 1982-1984, 1988-2002			1977-2002	1980, 1982-1984, 1989-2002	1980, 1982, 1992-1995, 2002	
Winter Steelhead	10,395	9,378	7,880	1,464	1,073	4,711	2,549
Years	1992-2002					1992-1995, 2002	
Winter Steelhead	7,150	6,780	5,139	1,641	370	2,326	2,354

[a] (personal communication, W. Sinnen, DFG, 2003)

Table B-6

Trinity River Salmon and Steelhead Hatchery Operational Rearing and Stocking Goals and Constraints Criteria for Salmonid Species

Species	Egg Allotment	Release Type	Number	Minimum Release Size	Target Release Dates[a]
Spring Chinook		Smolt	1,000,000	90 to a lb.	June 1 to 15
	3,000,000	Yearling	400,000		October 1 to 15
Fall Chinook		Smolt	2,000,000	90 to a lb.	June 1 to 15
	6,000,000	Yearling	900,000		October 1 to 15
Coho	1,200,000	Yearling	500,000	10-20 to a lb.	March 15 to May 1
Steelhead	2,000,000	Yearling	800,000	6 inches[b]	March 15 to May 1

[a] If unusual circumstances dictate, releases may deviate from the target release dates on approval from the Regional Manager.

[b] Steelhead less than 6 inches fork length shall be held at the hatchery for an additional year and released as 2-year-old fish between March 15 and May 1 of the following year.

Source: From Final Goals and Constraints for Iron Gate and Trinity River hatcheries, January 7, 1997.

Table B-7
Trinity River Salmon and Steelhead Hatchery (TRSSH) Salmonid Introductions into the Trinity River since 1963

	Species and Source:			
Year Planted	**Chinook (Fall)**	**Coho**	**Steelhead (Winter)**	**Steelhead (Summer)**
1963	none	none	American River Hatchery	none
1965	none	Eel River, CA	none	none
1970	none	Cascade, OR	Cowlitz River, WA	none
		Noyo River,CA		
		Alsea River, OR		
1971	Iron Gate Hatchery	Alsea River, OR	Roaring River, OR	Eel River
			Iron Gate Hatchery	Washougal River, WA
1972	none	none	none	Eel River
				Washougal River, WA
1973	none	none	none	Eel River
1974	none	none	none	Eel River
				Washougal River, WA
1975	none	none	Iron Gate Hatchery	none
1976	none	none	Iron Gate Hatchery	Washougal River, WA
1977	Iron Gate Hatchery	none	Iron Gate Hatchery	none
1978	none	none	Iron Gate Hatchery	none
1979	none	none	Iron Gate Hatchery	none
1980	none	none	Iron Gate Hatchery	none
1981	none	none	Iron Gate Hatchery	none
1982	none	none	Iron Gate Hatchery	none
1983	Iron Gate Hatchery	none	Iron Gate Hatchery	none
1984	none	none	Iron Gate Hatchery	none
1985	none	none	Iron Gate Hatchery	none
1986	none	none	Iron Gate Hatchery	none
1987	none	none	Iron Gate Hatchery	none

Source: CDFG Trinity River Hatchery Records, 1963-1994

Table B-8
Trinity River Ecosystem Attributes, Objectives, and Thresholds

Attribute Number	River System Attribute Description	Objective Number	River System Objectives Description	River System Objective Threshold
1	Spatially complex channel geomorphology	1	Restore alluvial channel (able to form its own bed, particle, and bank dimensions)	Dependent on an integration of all attributes
		2	Create and/or maintain structural complexity of alternate bar sequences	Dependent on an integration of all attributes
		3	Create and maintain functional floodplains	Dependent on an integration of all attributes
		4	Increase diversity of channelbed particle size	
		5	Greater topographic complexity in side channels	
2	Flows and water quality are predictably unpredictable	1	Provide inter- and intra-annual flow variation for summer baseflows (July 1-October 1)	Based on flow schedule's emulation of pre-dam hydrograph components
		2	Provide inter- and intra-annual flow variation for winter baseflows (January 1-April 1)	Based on flow schedule's emulation of pre-dam hydrograph components
		3	Provide inter- and intra-annual flow variation for winter flood (October 1-April 30)	Based on flow schedule's emulation of pre-dam hydrograph components
		4	Provide inter- and intra-annual flow variation for snowmelt peak floods (April1-June 30)	Based on flow schedule's emulation of pre-dam hydrograph components
		5	Provide inter- and intra-annual flow variation for snowmelt recession (May 1-July 31)	Based on flow schedule's emulation of pre-dam hydrograph components
3	Frequently mobilized channelbed surface	1	Exceed incipient motion for mobile active channel alluvial features (median bars, pool tails, spawning gravel deposits) every 2 of 3 years	Bed mobilization of the mobile active channel features occurs > 3,000 cfs
		2	Achieve incipient motion for most channelbed surfaces (riffles, face of point bars) every 2 of 3 years	Bed mobilization of most of the channelbed surface occurs > 6,000 cfs (Target Value)
		3	Exceed threshold for transporting sand through most pools every 2 of 3 years	Transport of substantial volumes of sand through pools requires flows > 3,000 cfs
4	Periodic channelbed scour and fill	1	Scour/redeposit spawning gravel deposits (at least 2 D_{84} thicknesses) every 2-3 years	Bed scour (> 2 D_{84} particle thickness) in mobile active channel features occurs at > 6,000 cfs
		2	Scour/redeposit faces of alternate bars (at least 2 D_{84} thicknesses) every 3-5 years	Bed scour (> 2 D_{84} particle thickness) on face of alternate bar surfaces occurs at > 8,500 cfs
		3	Deposit fine sediment onto upper alternate bar and floodplain surfaces every 2-3 years	Bed scour (> 2 D_{84} particle thickness) on face of alternate bar surfaces occurs at > 6,000 cfs
		4	Maintain scour channels on alternate bar surfaces every 3-5 years	Bed scour (> 2 D_{84} particle thickness) in mobile active channel features occurs at > 8,500 cfs
5	Balanced fine and coarse sediment budgets	1	Reduce fine sediment storage in mainstem	Ability of combined flow magnitude and duration to transport fine sediment through the system
		2	Maintain coarse sediment budget in the mainstem	Ability of combined flow magnitude and duration to achieve zero net coarse sediment budget
		3	Route mobilized D84 gravel through alternate bar sequences every 2 of 3 years	Exceeded by flows greater than 6,000 cfs
		4	Prevent excessive aggradation of tributary-derived material in the mainstem	Mechanically excavated and distributed downstream and/or maintained by flows; distribution of delta begins at flows > 6,000 cfs; coarser particles require flows > 14,000 cfs
6	Periodic channel migration	1	Channel migrates in alluvial reaches	Requires partial removal of riparian berm and flows greater than 6,000 cfs
		2	Maintain channel geometry as channel migrates	Requires adequate coarse sediment supply and flows greater than 6,000 cfs
		3	Create channel avulsions every 10 years	Flows must be greater than 30,000 cfs for channel avulsions
7	Functional floodplain	1	Inundate the floodplain on average every 2 to 3 years	Flows greater than 6,000 cfs
		2	Encourage local floodplain surface scour and deposition by infrequent (every 3-5 years) but larger floods	Flows greater than 8,500 cfs
		3	Floodplain construction keeps pace with floodplain loss on opposite bank	Requires fine sediment supply and flows greater than 6,000 cfs and depths > 1' on floodplain
8	Infrequent channel resetting floods	1	Major reorganization of alternate bar sequences every 10-20 years	Flows estimated to be greater than 30,000 cfs
		2	Remove upstream bedload impedance by distributing tributary delta materials	Flows estimated to be greater than 24,000 cfs
		3	Infrequent (once in 5-10 years) deep scour on floodplain surfaces	Flows greater than 24,000 cfs
		4	Construct and maintain/rejuvenate side channels	Flows estimated to be greater than 11,000 cfs or mechanically maintained side channels
		5	Deposit fine sediment on lower terrace surfaces	Flows greater than 11,000-14,000 cfs causing inundation of pre-dam floodplains (which now function as terraces)
9	Self-sustaining diverse riparian plant communities	1	Prevent seedling germination on lower bar surfaces	Bar inundation of seed dispersal period (1,500-2,000 cfs) in June and July
		2	Scour or remove most initiating seedlings (0- to 1-year old plants)	Surficial bed scour on lower bar surfaces requires flows greater than 6,000 cfs, or mechanical removal
		3	Scour of most established seedling (2- to 3-year old plants)	Deep bed scour on bar surfaces requires flows greater than 8,500-14,000 cfs
		4	Periodic removal of individual mature riparian trees at least every 10 years	Individual alder trees require at least 14,000 cfs; widespread removal of alders requires >30,000 cfs; or mechanical removal of mature riparian alders
		5	Seed deposition on floodplains every 2-3 years	Floodplain access begins at 5,000-6,000 cfs; flows needed May 5th to June 5th
10	Naturally fluctuating groundwater table	1	Groundwater recharge of gravel bars	Exceed by flows greater than 1,500-2,000 cfs
		2	Groundwater recharge of floodplains and off-channel wetland habitats	Exceeded by flows greater than 6,000 cfs
		3	Groundwater recharge of terraces and associated wetland habitats	Flows greater than 10,000-14,000 cfs

Table B-9

Water Temperature Requirements and Approximate Emigration Dates for Steelhead and Coho and Chinook Salmon Smolts

Species	Approximate Date of 80 Perent Emigration	Optimal (ºF)	Marginal (ºF)	Unsuitable (ºF)
Steelhead	May 22	42.8-55.4	55.4-59	>59
Coho salmon	June 4	50-59	59-62.9	>62.6
Chinook salmon	July 9	50-62.6	62.6-68	>68

Source: U.S. Fish and Wildlife Service and Hoopa Valley Tribe, 1999

Table B-10
Scoring Results of the Trinity River System Attribute Analysis (TRSAAM) Evaluation

Attribute Number	Objective Number	Alternative							
		No Action	Maximum Flow	Flow Evaluation	70% Inflow	Mechanical Restoration	Revised Mechanical Restoration	Mod. % inflow	Existing Conditions
1	1	NS	NS	NS	NS	NS	NS	NS	NS
	2	NS	NS	NS	NS	NS	NS	NS	NS
	3	NS	NS	NS	NS	NS	NS	NS	NS
	4	NS	NS	NS	NS	NS	NS	NS	NS
	5	NS	NS	NS	NS	NS	NS	NS	NS
	subtotal score	NS	NS	NS	NS	NS	NS	NS	NS
2	1	0	0	0	2	0	0	0	0
	2	0	0	0	2	0	0	0	0
	3	0	0	0	1	0	0	0	0
	4	1	2	2	2	1	2	2	1
	5	1	2	2	2	1	2	2	1
	subtotal score	2	4	4	9	2	4	4	2
3	1	0	2	2	2	0	2	2	0
	2	0	2	2	2	0	2	2	0
	3	0	2	2	2	1	2	2	0
	subtotal score	0	6	6	6	1	6	6	0
4	1	0	2	2	2	0	2	2	0
	2	0	1	2	1	0	0	2	0
	3	0	2	2	2	0	1	2	0
	4	0	1	2	1	0	0	2	0
	subtotal score	0	6	8	6	0	3	8	0
5	1	0	2	2	2	1	2	2	0
	2	0	2	2	1	0	1	2	0
	3	0	2	2	2	0	2	2	0
	4	0	2	2	2	0	2	2	0
	subtotal score	0	8	8	7	1	7	8	0
6	1	0	1	1	1	0	1	1	0
	2	0	2	2	2	0	1	2	0
	3	0	2	0	0	0	0	0	0
	subtotal score	0	5	3	3	0	2	3	0
7	1	0	2	2	2	0	1	2	0
	2	0	1	2	1	0	0	2	0
	3	0	2	2	2	0	0	2	0
	subtotal score	0	5	6	5	0	1	6	0
8	1	0	2	0	0	0	0	0	0
	2	0	2	2	2	2	2	2	0
	3	0	2	0	0	0	0	0	0
	4	0	2	1	1	2	2	2	0
	5	0	2	0	1	0	0	0	0
	subtotal score	0	10	3	4	4	4	4	0
9	1	0	1	1	1	0	1	1	0
	2	0	2	2	2	1	1	2	0
	3	0	2	1	1	1	1	1	0
	4	0	2	0	0	1	1	1	0
	5	0	2	2	2	0	2	2	0
	subtotal score	0	9	6	6	3	6	7	0
10	1	2	2	2	2	2	2	2	2
	2	0	2	2	1	0	2	2	0
	3	0	1	1	1	0	0	1	0
	subtotal score	2	5	5	4	2	4	5	2
Grand Total		**4**	**58**	**49**	**50**	**13**	**37**	**51**	**4**

NS = Not scored
2 = Always or nearly always exceeds thresholds
1 = Sometimes exceeds thresholds
0 = Never or rarely exceeds thresholds

Table B-11
Summary of Trinity River System Attribute Scoring from TRSAAM Evaluation

Attribute Number	Ecosystem Attribute Description	No Action	Maximum Flow	Flow Evaluation	70% Inflow	Mechanical Restoration	Revised Mechanical Restoration	Mod. % inflow	Existing Conditions
1	Spatially complex channel geomorphology	NS	NS	NS	NS	NS	NS	NS	NS
2	Flows and water quality are predictably unpredictable	2	4	4	9	2	4	4	2
3	Frequently mobilized channelbed surface	0	6	6	6	1	6	6	0
4	Periodic channelbed scour and fill	0	6	8	6	0	3	8	0
5	Balanced fine and coarse sediment budgets	0	8	8	7	1	7	8	0
6	Periodic channel migration	0	5	3	3	0	2	3	0
7	Functional floodplain	0	5	6	5	0	1	6	0
8	Infrequent channel resetting floods	0	10	3	4	4	4	4	0
9	Self-sustaining diverse riparian plant communities	0	9	6	6	3	6	7	0
10	Naturally fluctuating groundwater table	2	5	5	4	2	4	5	2
	Total Score	**4**	**58**	**49**	**50**	**13**	**37**	**51**	**4**

NS = Not scored

Table B-12
Summary of the Results of the Analysis of Trinity River System Attribute Performance for Each of the Proposed Project Alternatives

River System Attribute	River System Objective	Project Alternative							
		No Action	Maximum Flow	Flow Evaluation	70% Inflow	Mechanical Restoration	Revised Mechanical Restoration	Mod. % inflow	Existing Conditions
Spatially complex channel geomorphology	Restore alluvial channel (self-forming bed particle and bank dimensions)	NS	NS	NS	NS	NS	NS	NS	NS
	Create and/or maintain structural complexity of alternate bar sequences	NS	NS	NS	NS	NS	NS	NS	NS
	Create and maintain functional floodplains	NS	NS	NS	NS	NS	NS	NS	NS
	Increase diversity of channelbed particle size	NS	NS	NS	NS	NS	NS	NS	NS
	Greater topographic complexity in side channels	NS	NS	NS	NS	NS	NS	NS	NS
Flows and water quality are predictably unpredictable	Provide inter- and intra-annual flow variation for summer baseflows (July 1-October 1)	N	N	N	A	N	N	N	N
	Provide inter- and intra-annual flow variation for winter baseflows (January 1-April 1)	N	N	N	A	N	N	N	N
	Provide inter- and intra-annual flow variation for winter flood (October 1-April 30)	N	N	N	S	N	N	N	N
	Provide inter- and intra-annual flow variation for snowmelt peak floods (April 1-June 30)	S	A	A	A	S	A	A	S
	Provide inter- and intra-annual flow variation for snowmelt recession (May 1-July 31)	S	A	A	A	S	A	A	S
Frequently mobilized channelbed surface	Exceed incipient motion for mobile, active channel alluvial features (median bars, pool tails, spawning gravel deposits) every 2 of 3 years	N	A	A	A	N	A	A	N
	Achieve incipient motion for most of channelbed surface (riffles, face of point bars) every 2 of 3 years	N	A	A	A	N	A	A	N
	Exceed threshold for transporting sand through most pools every 2 of 3 years	N	A	A	A	S	A	A	N
Periodic channelbed scour and fill	Scour/redeposit spawning gravel deposits (at least 2 D_{84} thicknesses) every 2-3 years	N	A	A	A	N	A	A	N
	Scour/redeposit faces of alternate bars (at least 2 D_{84} thicknesses) every 3-5 years	N	S	A	S	N	N	A	N
	Deposit fine sediment onto upper alternate bar and floodplain surfaces every 2-3 years	N	A	A	A	N	S	A	N
	Maintain scour channels on alternate bar surfaces every 3-5 years	N	S	A	S	N	N	A	N
Balanced fine and coarse sediment budgets	Reduce fine sediment storage in mainstem	N	A	A	A	S	A	A	N
	Maintain coarse sediment budget in the mainstem	N	A	A	S	N	S	A	N
	Route mobilized D_{84} gravel through alternate bar sequences every 2 of 3 years	N	A	A	A	N	A	A	N
	Prevent excessive aggradation of tributary-derived material in the mainstem	N	A	A	A	N	A	A	N
Periodic channel migration	Channel migrates in alluvial reaches	N	S	S	S	N	S	S	N
	Maintain channel geometry as channel migrates	N	A	A	A	N	S	A	N
	Create channel avulsions every 10 years	N	A	N	N	N	N	N	N
Functional floodplain	Inundate the floodplain on average every 2 or 3 years	N	A	A	A	N	S	A	N
	Encourage local floodplain surface scour and deposition by infrequent (every 3-5 years) but larger floods	N	S	A	S	N	N	A	N
	Floodplain construction keeps pace with floodplain loss on opposite bank	N	A	A	A	N	N	A	N
Infrequent channel resetting floods	Major reorganization of alternate bar sequences every 10-20 years	N	A	N	N	N	N	N	N
	Remove upstream bedload impedance by distributing tributary delta materials	N	A	A	A	A	A	A	N
	Infrequent (once every 5-10 years) deep scour on floodplain surfaces	N	A	N	N	N	N	N	N
	Construct and maintain/rejuvenate side channels	N	A	S	S	A	A	A	N
	Deposit fine sediment on lower terrace surfaces	N	A	N	S	N	N	N	N
Self-sustaining diverse riparian plant communities	Prevent seedling germination on lower bar surfaces	N	S	S	S	N	S	S	N
	Scour of most initiating seedlings (0- to 1-year old plants)	N	A	A	A	S	S	A	N
	Scour of most established seedling (2- to 3-year old plants)	N	A	S	S	S	S	S	N
	Periodic removal of individual mature riparian trees at least every 10 years	N	A	N	N	S	S	S	N
	Seed deposition on floodplains every 2-3 years	N	A	A	A	N	A	A	N
Naturally fluctuating groundwater table	Groundwater recharge of gravel bars	A	A	A	A	A	A	A	A
	Groundwater recharge of floodplains and off-channel wetland habitats	N	A	A	S	N	A	A	N
	Groundwater recharge of terraces and associated wetland habitats	N	S	S	S	N	N	S	N

Table B-13
Summary of Salmonid Smolt Temperature Suitability/Survivability Analysis Results

Alternative:	Average Index (%):			
	Chinook (smolt suitability)	Coho (smolt suitability)	Steelhead (smolt suitability)	Steelhead (parr survivability)
No Action	41%	84%	60%	88%
Mechanaical Restoration	41%	84%	60%	88%
Maximum Flow	76%	99%	81%	96%
Flow Evaluation	60%	95%	80%	95%
70 % Inflow	54%	94%	74%	93%
Revised Mechanical Restoration	51%	91%	67%	91%
Modified % Inflow	49%	91%	58%	92%

Table B-14
Percentage Change from No Action Alternative for Instream Release Volumes, Steelhead Survival Index, Coho Survival Index, Chinook Survival Index, and Chinook Harvest for Each Alternative

Measure/Assumption	Revised Mechanical A	Revised Mechanical B	Flow Evaluation	Mod. Percent Inflow	70% Inflow	Maximum Flow
Instream Volumes	34%	34%	75%	47%	175%	260%
Assumption of Increase in Habitat Conditions	50%	100%	100%	100%	100%	100%
Steelhead Survival Index	12%	12%	33%	-3%	23%	35%
Coho Survival Index	8%	8%	13%	8%	12%	18%
Chinook Survival Index	23%	23%	47%	21%	33%	86%
Increase to Chinook Harvest Index	370%	634%	919%	606%	755%	1427%

Table B-15
Summary of Change in Trinity River Fluvial River System Health (TRAASM results) from No Action

Parameter	Alternative							
	No Action	**Maximum Flow**	**Flow Evaluation**	**70% Inflow**	**Mechanical Restoration**	**Revised Mechanical Restoration**	**Modified % Inflow**	**Pref. Alt. Compared to Exist.Conds.**
Total Score	**4**	**58**	**49**	**50**	**13**	**37**	**51**	**49**
Possible Score	70	70	70	70	70	70	70	70
Percent of Maximum	6	83	70	71	19	53	73	70
Percent Change from No Action	0	1350	1125	1150	225	825	1175	1125
Qualitative Rating[a]	**--**	**HB**	**HB**	**HB**	**B**	**HB**	**HB**	**HB**

[a] Rating based on following scale:
nc = no change from No Action attribute score
B = beneficial change (>No Action score but less than 5 times the No Action score)
HB = highly beneficial change (equal to or greater than 5 times the No Action score)

Table B-16
Summary of Estimated Average Annual Losses of Early Life Stages of Chinook Salmon and Steelhead in the Upper Sacramento River (Version 1 revised)

	Simulated Average Loss (Percent)								
Species	**No Action**	**Maximum Flow**	**Flow Evaluation**	**70 % Inflow**	**Mechanical Restoration**	**Revised Mechanical Restoration**	**Modified % Inflow**	**Exist. Cond.**	**Cumulative (OCAP Future)**
Fall chinook	17.5	26.6	20.6	24.7	17.5	18.2	19.1	17.4	21.4
Late-fall chinook	1.4	1.8	1.6	1.8	1.4	1.4	1.5	1.4	1.6
Winter chinook	8.0	16.5	8.6	11.2	8.0	8.5	8.5	7.8	10.0
Spring chinook	23.9	55.0	31.8	47.2	23.9	25.3	27.5	24.1	34.4
Steelhead	1.4	1.8	1.6	1.8	1.4	1.4	1.5	1.4	1.6

Table B-17

Change in Temperature-related Losses (%)[a] to Early Life Stages of Salmonids in the Sacramento River

Species	Maximum Flow	Flow Evaluation	70 % Inflow	Mechanical Restoration	Revised Mechanical Restoration	Modified % Inflow	Exist. Cond. vs. Pref. Flow	Cumul. Effects vs. Pref Flow
Fall chinook	9	3.0	7	0	1	2	3	1
Late-fall chinook	0	0.2	0	0	0	0	0	0
Winter chinook	8	0.6	3	0	0	0	1	1
Spring chinook	31	7.8	23	0	1	4	8	3
Steelhead	0	0.2	0	0	0	0	0	0

a Estimated average annual losses rounded to the nearest percentile for the 1922-1993 simulation period.

Table B-18
Summary of Percent Change from No Action for Each Project Alternative for Estimated Losses of Early Life Stages of Anadromous Salmonids in the Sacramento River

Species	Maximum Flow	Flow Evaluation	70 % Inflow	Mechanical Restoration	Revised Mechanical Restoration	Modified % Inflow	Pref. Alt. Vs. Exist.Conds.[a]
Fall chinook							
Percent loss change[b]	9	3	7	0	1	2	3
Results[c]	A	A	A	NC	A	A	A
Late-fall chinook							
Percent loss change[b]	0	0	0	0	0	0	0
Results[c]	NC	NC	NC	NC	NC	NC	NC
Winter chinook							
Percent loss change[b]	8	1	3	0	0	0	1
Results[c]	A	A	A	NC	NC	NC	A
Spring chinook							
Percent loss change[b]	31	8	23	0	1	4	8
Results[c]	A	A	A	NC	A	A	A
Steelhead							
Percent loss change[b]	0	0	0	0	0	0	0
Results[c]	NC	NC	NC	NC	NC	NC	NC

[a] Compared to the preferred alternative.
[b] Average annual losses estimated for the entire 1922-1993 simulation period (negative value = lower losses than No Action).
[c] NC = no change; A = significantly adverse effect; B = beneficial effect.

Table B-19
Summary of Impact Analysis for Fisheries Resources (Comparing Each Alternative to the No Action Alternative)

Resource Concern	Geographical Area	Alternative						
		Maximum Flow	Flow Evaluation	70 % Inflow	Mechanical Restoration	Revised Mechanical Restoration	Modified % Inflow	Preferred Alternative Compared to Existing Conditions
Native anadromous salmonids	Trinity River Basin	**HB**	**HB**	**HB**	**B**	**HB**	**HB**	**HB**
	Lower Klamath Basin	**B**	**B**	**B**	**nc**	**B**	**B**	**B**
	Central Valley	**A**	**A**	**A**	**nc**	**nc**	**A**	**A**
Other native anadromous species	Trinity River Basin	**HB**	**HB**	**HB**	**B**	**HB**	**HB**	**HB**
	Lower Klamath Basin	**B**	**B**	**B**	**nc**	**B**	**B**	**B**
	Central Valley	**A**	**A**	**A**	**nc**	**A**	**A**	**A**
Resident native species	Trinity River Basin	**B**	**B**	**B**	**B**	**B**	**B**	**B**
	Lower Klamath Basin	**B**	**B**	**B**	**nc**	**B**	**B**	**B**
	Central Valley	**A**	**A**	**A**	**nc**	**A**	**A**	**A**
Non-native species	Trinity River Basin	**B**	**B**	**B**	**B**	**B**	**B**	**B**
	Lower Klamath Basin	**B**	**B**	**B**	**nc**	**B**	**B**	**B**
	Central Valley	**A**	**A**	**A**	**nc**	**A**	**A**	**A**
Reservoir species-Trinity Basin	Warmwater Species	**A**	**nc**	**A**	**nc**	**nc**	**nc**	**nc**
	Coldwater Species	**nc**	**nc**	**nc**	**nc**	**nc**	**nc**	**nc**
Reservoir species-Central Valley	All Species	**nc**	**nc**	**nc**	**nc**	**nc**	**nc**	**nc**

A = adverse change
nc = no change
B = benefical change
HB = highly beneficial change

Table B-20
Life History and Habitat Characteristics of Non-salmonid Native Anadromous Fish in the Project Affected Area

Name	Migration	Spawning	Rearing	Rearing Habitat Descriptions
Pacific lamprey	April-July	Spring-early summer	Year round	Developing larvae burrow into silty river-bottom substrates, where they remain for 4-5 years before emigrating to the ocean.
Sturgeon (green and white sturgeon)	February- July	March –July	Year round	Juveniles inhabit estuarine environments for 4-6 years before migrating to the ocean.
Eulachon	March-April	March-April	--	Adhesive eggs anchored to bottom until hatched; larvae quickly transported to ocean.

Table B-21
Average Monthly Flows (cfs) in the Sacramento River at Keswick, Grimes, and Verona (1922-1993)

	Alternative																							
	No Action			Maximum Flow			Flow Evaluation			70% Inflow			Mechanical Restoration			Revised Mechanical Restoration			Modified % Inflow			Existing Conditions		
Location	Keswick	Grimes	Verona	Keswick	Grimes	Verona	Keswick	Grimes	Verona	Keswick	Grimes	Verona	Keswick	Grimes	Verona	Keswick	Grimes	Verona	Keswick	Grimes	Verona	Keswick	Grimes	Verona
Month																								
October	5,928	6,643	10,416	4,767	5,453	9,208	5,552	6,262	10,068	5,099	5,822	9,712	5,928	6,643	10,416	5,758	6,468	10,234	5,737	6,449	10,210	6,038	6,723	10,482
November	5,444	8,169	12,524	4,272	7,029	11,236	5,035	7,792	12,046	4,455	7,232	11,498	5,444	8,169	12,524	5,386	8,116	12,420	5,252	7,984	12,268	5,604	8,212	12,525
December	7,138	13,627	21,560	5,795	12,668	20,212	6,751	13,344	21,158	5,822	12,751	20,272	7,138	13,627	21,560	7,050	13,541	21,476	6,903	13,462	21,372	7,124	13,546	21,507
January	7,892	16,387	29,293	7,481	16,130	28,835	7,778	16,336	29,151	7,538	16,190	29,013	7,892	16,387	29,293	7,851	16,361	29,195	7,822	16,357	29,212	7,872	16,342	29,352
February	10,133	19,890	35,114	9,354	19,414	34,539	9,940	19,757	34,989	9,589	19,560	34,653	10,133	19,890	35,114	10,090	19,845	35,079	10,026	19,807	35,032	10,139	19,846	35,101
March	8,105	16,691	30,693	7,657	16,279	30,251	8,009	16,599	30,576	7,599	16,218	30,122	8,105	16,691	30,693	8,053	16,643	30,653	8,084	16,668	30,651	8,135	16,662	30,469
April	7,213	12,282	21,063	6,807	11,981	20,611	7,153	12,265	21,097	6,970	12,076	20,825	7,213	12,282	21,063	7,134	12,228	21,022	7,118	12,211	20,999	7,309	12,282	20,895
May	8,809	8,959	16,365	7,988	8,296	15,712	8,396	8,594	15,994	8,172	8,384	15,766	8,809	8,959	16,365	8,639	8,822	16,207	8,485	8,662	16,081	8,741	9,002	16,310
June	11,135	8,642	14,702	10,261	7,991	13,982	10,673	8,245	14,270	10,669	8,264	14,213	11,135	8,642	14,702	10,847	8,386	14,311	10,797	8,337	14,153	11,152	8,850	14,661
July	13,921	9,965	15,127	12,414	8,745	14,141	13,373	9,484	14,846	13,075	9,217	14,584	13,921	9,965	15,127	13,676	9,758	15,023	13,561	9,643	15,092	13,960	10,277	15,045
August	11,279	7,761	13,186	9,611	6,501	12,289	10,882	7,416	12,981	10,596	7,157	12,803	11,279	7,761	13,186	11,104	7,613	13,094	11,110	7,619	13,104	10,982	7,722	13,190
September	7,444	6,472	11,462	5,910	5,082	10,028	7,101	6,149	11,105	6,494	5,597	10,648	7,444	6,472	11,462	7,299	6,336	11,412	7,278	6,306	11,349	7,380	6,575	11,614
average	**8,703**	**11,290**	**19,292**	**7,693**	**10,464**	**18,420**	**8,387**	**11,020**	**19,023**	**8,007**	**10,706**	**18,675**	**8,703**	**11,290**	**19,292**	**8,574**	**11,177**	**19,177**	**8,514**	**11,125**	**19,127**	**8,703**	**11,337**	**19,263**

Table B-22
Average Monthly Delta Inflow (CFS) for 1922 to 1993.

Month	No Action	Maximum Flow	Flow Evaluation	70 % Inflow	Mechanical Resstoration	Revised Mechanical Restoration	Modified % Inflow	Existing Conditions
	Monthly Inflow	Monthly Inflow	Monthly Inflow	Monthly Inflow	Monthly Inflow	Monthly Inflow	Monthly Inflow	Monthly Inflow
October	15,297	14,215	14,982	14,640	15,297	15,129	15,101	15,374
November	18,101	16,842	17,638	17,095	18,101	18,027	17,851	18,028
December	31,091	29,482	30,620	29,527	31,091	30,978	30,851	30,970
January	44,697	44,032	44,434	44,272	44,697	44,577	44,556	45,005
February	56,107	55,235	55,915	55,445	56,107	56,066	56,016	56,229
March	47,937	47,445	47,835	47,282	47,937	47,904	47,915	47,796
April	33,597	33,195	33,628	33,353	33,597	33,555	33,568	33,390
May	26,675	26,027	26,305	26,084	26,675	26,512	26,389	26,697
June	22,987	22,318	22,561	22,539	22,987	22,621	22,471	23,216
July	21,060	20,102	20,848	20,619	21,060	20,983	21,062	21,170
August	17,096	16,160	16,868	16,689	17,096	16,959	16,948	17,169
September	15,897	14,549	15,571	15,084	15,897	15,859	15,808	16,453
Total	**29,212**	**28,300**	**28,934**	**28,552**	**29,212**	**29,097**	**29,045**	**29,291**

Table B-23
Average Monthly Delta Outflow (CFS) for 1922 to 1993.

Month	No Action	Maximum Flow	Flow Evaluation	70 % Inflow	Mechanical Restoration	Revised Mechanical Restoration	Modified % Inflow	Existing Conditions
	Monthly Outflow	Monthly Outflow	Monthly Outflow	Monthly Outflow	Monthly Outflow	Monthly Outflow	Monthly Outflow	Monthly Outflow
October	6,061	5,440	5,833	5,657	6,061	5,909	5,914	6,219
November	9,614	8,881	9,251	8,953	9,614	9,528	9,431	9,592
December	22,421	21,163	22,008	21,150	22,421	22,304	22,185	22,618
January	36,568	36,045	36,411	36,051	36,568	36,459	36,436	36,785
February	47,894	47,524	47,713	47,526	47,894	47,928	47,888	48,226
March	39,195	39,132	39,180	38,724	39,195	39,154	39,267	39,305
April	28,033	27,875	28,004	27,860	28,033	27,988	28,009	27,947
May	20,520	20,180	20,289	20,071	20,520	20,461	20,295	20,685
June	12,218	11,908	11,993	11,934	12,218	11,976	11,934	12,307
July	7,047	7,108	7,112	7,100	7,047	7,093	7,107	7,199
August	4,162	4,030	4,161	4,120	4,162	4,178	4,212	4,140
September	4,612	3,702	4,371	3,998	4,612	4,527	4,503	4,990
Average	**19,862**	**19,416**	**19,694**	**19,429**	**19,862**	**19,792**	**19,765**	**20,001**

Table B-24
Comparison of the Average Monthly Flows in the Sacramento River (CFS) from 1922 to 1993.

	Maximum Flow			Flow Evaluation			70% Inflow			Mechanical Restoration			Revised Mechanical Restoration			Modified % Inflow			Existing Conditions		
	Average Absolute Change from No Action Alternative[a] (percent)			Average Absolute Change from No Action Alternative[a] (percent)			Average Absolute Change from No Action[a] (percent)			Average Absolute Change from No Action Alternative[a] (percent)			Average Absolute Change from No Action Alternative[a] (percent)			Average Absolute Change from No Action Alternative[a] (percent)			Average Absolute Change of Preferred Alternative from Existing Conditions[a] (percent)		
Month	**Keswick**	**Grimes**	**Verona**	**Keswick**	**Grimes**	**Verona**	**Keswick**	**Grimes**	**Verona**	**Keswick**	**Grimes**	**Verona**	**Keswick**	**Grimes**	**Verona**	**Keswick**	**Grimes**	**Verona**	**Keswick**	**Grimes**	**Verona**
October	-20	-18	-12	-6	-6	-3	-14	-12	-7	0	0	0	-3	-3	-2	-3	-3	-2	-8	-7	-4
November	-22	-14	-10	-8	-5	-4	-18	-11	-8	0	0	0	-1	-1	-1	-4	-2	-2	-10	-5	-4
December	-19	-7	-6	-5	-2	-2	-18	-6	-6	0	0	0	-1	-1	0	-3	-1	-1	-5	-1	-2
January	-5	-2	-2	-1	0	0	-4	-1	-1	0	0	0	-1	0	0	-1	0	0	-1	0	-1
February	-8	-2	-2	-2	-1	0	-5	-2	-1	0	0	0	0	0	0	-1	0	0	-2	0	0
March	-6	-2	-1	-1	-1	0	-6	-3	-2	0	0	0	-1	0	0	0	0	0	-2	0	0
April	-6	-2	-2	-1	0	0	-3	-2	-1	0	0	0	-1	0	0	-1	-1	0	-2	0	1
May	-9	-7	-4	-5	-4	-2	-7	-6	-4	0	0	0	-2	-2	-1	-4	-3	-2	-4	-5	-2
June	-8	-8	-5	-4	-5	-3	-4	-4	-3	0	0	0	-3	-3	-3	-3	-4	-4	-4	-7	-3
July	-11	-12	-7	-4	-5	-2	-6	-8	-4	0	0	0	-2	-2	-1	-3	-3	0	-4	-8	-1
August	-15	-16	-7	-4	-4	-2	-6	-8	-3	0	0	0	-2	-2	-1	-1	-2	-1	-1	-4	-2
September	-21	-21	-13	-5	-5	-3	-13	-14	-7	0	0	0	-2	-2	0	-2	-3	-1	-4	-6	-4
Average	-12	-9	-6	-4	-3	-2	-9	-6	-4	0	0	0	-1	-1	-1	-2	-2	-1	-4	-4	-2

[a] Change relative to the No Action Alternative. Values represent the average change for the 73 years modeled, rather than the difference between the 73-year average flow values for each month under these two cases.

Table B-25

Percent Change in the Average Monthly Inflows (cfs) to the Delta (1922-1993) [a]

Compared to No Action Alternative

Month	Maximum Flow	Flow Evaluation	70 % Inflow	Mechanical Restoration	Revised Mechanical Restoration	Modified % Inflow	Preferred vs. Exist. Cond.
October	-7	-2	-4	0	-1	-1	-3
November	-7	-3	-6	0	0	-1	-2
December	-5	-2	-5	0	0	-1	-1
January	-1	-1	-1	0	0	0	-1
February	-2	0	-1	0	0	0	-1
March	-1	0	-1	0	0	0	0
April	-1	0	-1	0	0	0	1
May	-2	-1	-2	0	-1	-1	-1
June	-3	-2	-2	0	-2	-2	-3
July	-5	-1	-2	0	0	0	-2
August	-5	-1	-2	0	-1	-1	-2
September	-8	-2	-5	0	0	-1	-5
Average	-4	-1	-3	0	-1	-1	-2

[a] Areas shaded are values for months critical for senstitive species in the Delta.

Table B-26

Percent Change in the Average Monthly Outflows (CFS) from the Delta (1922-1993) [a]

Compared to No Action Alternative							
Month	**Maximum Flow**	**Flow Evaluation**	**70% Inflow**	**Mechanical Restoration**	**Revised Mechanical Restoration**	**Modified % Inflow**	**Preferred vs. Exist. Cond.**
October	-10	-4	-7	0	-3	-2	-6
November	-8	-4	-7	0	-1	-2	-4
December	-6	-2	-6	0	-1	-1	-3
January	-1	0	-1	0	0	0	-1
February	-1	0	-1	0	0	0	-1
March	0	0	-1	0	0	0	0
April	-1	0	-1	0	0	0	0
May	-2	-1	-2	0	0	-1	-2
June	-3	-2	-2	0	-2	-2	-3
July	1	1	1	0	1	1	-1
August	-3	0	-1	0	0	1	1
September	-20	-5	-13	0	-2	-2	-12
Average	-4	-1	-3	0	-1	-1	-3

[a]Areas shaded are values for months critical for senstitive species in the Delta.

Table B-27

Estimated Monthly Average Position of X2 in the Delta (in km from the Golden Gate Bridge) for the Period 1922-1993[a]

	Alternative								
Month	**No Action**	**Maximum Flow**	**Flow Evaluation**	**70% Inflow**	**Mechanical Restoration**	**Revised Mechanical Restoration**	**Modified % Inflow**	**Existing Conditions**	**OCAP Cumulative**
October	86.0	87.2	86.3	86.8	86.0	86.1	86.1	85.5	86.5
November	84.6	85.5	84.9	85.2	84.6	84.7	84.7	84.3	85.5
December	82.0	82.7	82.4	82.6	82.0	82.1	82.2	82.0	82.2
January	76.8	77.2	76.9	77.1	76.8	76.8	76.9	76.7	77.6
February	71.3	71.6	71.4	71.6	71.3	71.3	71.3	71.2	71.6
March	66.2	66.3	66.2	66.3	66.2	66.2	66.1	66.1	66.4
April	65.7	65.8	65.8	65.9	65.7	65.8	65.7	65.6	65.9
May	67.7	67.7	67.7	67.8	67.7	67.7	67.7	67.6	67.8
June	70.5	70.6	70.6	70.7	70.5	70.5	70.6	70.4	70.3
July	75.1	75.2	75.1	75.2	75.1	75.2	75.2	75.0	75.2
August	79.3	79.3	79.3	79.3	79.3	79.3	79.3	79.2	79.2
September	84.4	84.6	84.4	84.5	84.4	84.4	84.3	84.4	83.7

[a] Areas shaded are values for months critical for sensitive species in the Delta.

Table B-28
Estimated Average Monthly Change in Delta X2 Position (KM) from the No Action Alternative for the Period 1922-1993

	Maximum Flow		Flow Evaluation		70 Percent Inflow		Mechanical Restoration		Revised Mechanical Restoration		Modified Percent Inflow		Existing Conditions Compared to Preferred Alternative		Cumulative Effects Compared to Preferred Alternative	
Month	**Average Absolute Change (km)**	**Average Relative Change (Percent)**	**Average Absolute Change (km)**	**Average Relative Change (Percent)**	**Average Absolute Change (km)**	**Average Relative Change (Percent)**	**Average Absolute Change (km)**	**Average Relative Change (Percent)**	**Average Absolute Change (km)**	**Average Relative Change (Percent)**	**Average Absolute Change (km)**	**Average Relative Change (Percent)**	**Average Absolute Change (km)**	**Average Relative Change (Percent)**	**Average Absolute Change (km)**	**Average Relative Change (Percent)**
October	-1.1	-1.3	-0.2	-0.3	-0.8	-0.9	0.0	0.0	-0.1	-0.1	-0.1	-0.1	-0.8	-0.9	0.2	0.2
November	-1.0	-1.1	-0.3	-0.3	-0.6	-0.7	0.0	0.0	-0.1	-0.2	0.0	-0.1	-0.5	-0.6	0.7	0.8
December	-0.7	-0.8	-0.3	-0.4	-0.6	-0.7	0.0	0.0	-0.1	-0.1	0.0	-0.1	-0.4	-0.4	-0.2	-0.2
January	-0.4	-0.6	-0.1	-0.2	-0.4	-0.5	0.0	0.0	0.0	0.0	0.0	-0.1	-0.2	-0.2	0.7	0.9
February	-0.3	-0.4	-0.1	-0.1	-0.3	-0.4	0.0	0.0	0.0	0.0	0.0	-0.1	0.0	0.0	0.2	0.3
March	-0.1	-0.2	0.0	-0.1	-0.1	-0.2	0.0	0.0	0.0	0.0	0.0	-0.1	0.0	-0.1	0.2	0.3
April	-0.1	-0.1	0.0	-0.1	-0.2	-0.3	0.0	0.0	0.0	0.0	0.0	-0.1	0.0	0.0	0.2	0.2
May	-0.1	-0.1	0.0	0.0	-0.1	-0.1	0.0	0.0	0.0	0.0	0.0	-0.1	0.1	0.1	0.2	0.2
June	-0.1	-0.1	0.0	0.0	-0.1	-0.2	0.0	0.0	0.0	0.0	0.0	-0.1	-0.1	-0.1	-0.3	-0.4
July	-0.1	-0.1	-0.1	-0.1	-0.2	-0.2	0.0	0.0	-0.1	-0.2	0.0	-0.1	-0.1	-0.1	0.1	0.1
August	0.1	0.1	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-0.1	-0.1	-0.1	-0.1	-0.2
September	-0.2	-0.2	0.0	0.0	-0.1	-0.1	0.0	0.0	0.0	0.0	0.0	-0.1	0.0	0.0	-0.7	-0.9
Mean Annual Change (km)	-0.3	-0.4	-0.1	-0.1	-0.3	-0.4	0.0	0.0	0.0	-0.1	0.0	-0.1	-0.2	-0.2	0.1	0.1

Table 29
Summary of the Change in X2 Position in the Delta compared to the No Action Alternative (1922-1993)

Alternative	Max Flow	Flow Eval	70% inflow	Mechanical	Enhanced Mech	Mod. % Inflow	Pref. vs. Exist. Cond.	OCAP Cumulative vs Preferred (2020)
	Compared to No Action Alternative							
February								
# years > 0.5 Km upstream	20	8	18	0	3	5	9	30
% years > 0.5km upstream	27.8%	11.1%	25.0%	0.0%	4.2%	6.9%	12.5%	41.7%
# years > 0.5 Km downstream	3	11	1	0	3	4	7	14
% years > 0.5km downstream	4.2%	15.3%	1.4%	0.0%	4.2%	5.6%	9.7%	19.4%
March								
# years > 0.5 Km upstream	7	5	7	0	1	2	6	21
% years > 0.5km upstream	9.7%	6.9%	9.7%	0.0%	1.4%	2.8%	8.3%	29.2%
# years > 0.5 Km downstream	2	2	2	0	1	2	8	5
% years > 0.5km downstream	2.8%	2.8%	2.8%	0.0%	1.4%	2.8%	11.1%	6.9%
April								
# years > 0.5 Km upstream	8	5	9	0	4	2	5	20
% years > 0.5km upstream	11.1%	6.9%	12.5%	0.0%	5.6%	2.8%	6.9%	27.8%
# years > 0.5 Km downstream	5	4	2	0	1	4	6	2
% years > 0.5km downstream	6.9%	5.6%	2.8%	0.0%	1.4%	5.6%	8.3%	2.8%
May								
# years > 0.5 Km upstream	6	4	6	0	2	3	10	12
% years > 0.5km upstream	8.3%	5.6%	8.3%	0.0%	2.8%	4.2%	13.9%	16.7%
# years > 0.5 Km downstream	3	4	2	0	2	3	8	0
% years > 0.5km downstream	4.2%	5.6%	2.8%	0.0%	2.8%	4.2%	11.1%	0.0%
June								
# years > 0.5 Km upstream	14	13	14	0	7	11	14	11
% years > 0.5km upstream	19.4%	18.1%	19.4%	0.0%	9.7%	15.3%	19.4%	15.3%
# years > 0.5 Km downstream	10	8	5	0	7	6	10	23
% years > 0.5km downstream	13.9%	11.1%	6.9%	0.0%	9.7%	8.3%	13.9%	31.9%
All Months (Feb-June)								
# months > 0.5 Km upstream	**55**	**35**	**54**	**0**	**17**	**23**	**44**	**94**
% months > 0.5km upstream	**15.3%**	**9.7%**	**15.0%**	**0.0%**	**4.7%**	**6.4%**	**12.2%**	**26.1%**
# months > 0.5 Km downstream	**23**	**29**	**12**	**0**	**14**	**19**	**39**	**44**
% months > 0.5km downstream	**6.4%**	**8.1%**	**3.3%**	**0.0%**	**3.9%**	**5.3%**	**10.8%**	**12.2%**

Table B-30

Estimated Average Monthly Surface Area of Trinity Lake (Acres) for the Period 1922-1993[a]

	Alternative							
Month	**No Action**	**Maximum Flow**	**Flow Evaluation**	**70% Inflow**	**Mechanical Restoration**	**Revised Mechanical Restoration**	**Modified % Inflow**	**Existing Conditions**
October	10,703	7,259	10,429	10,279	10,703	10,252	10,532	10,679
November	10,709	7,517	10,511	10,351	10,709	10,296	10,578	10,702
December	10,996	8,119	10,824	10,540	10,996	10,607	10,834	10,984
January	11,269	8,131	11,118	10,680	11,269	10,927	11,122	11,244
February	11,808	8,214	11,700	10,967	11,808	11,510	11,677	11,775
March	12,419	8,342	12,326	11,257	12,419	12,146	12,304	12,388
April	13,166	8,491	13,037	11,542	13,166	12,917	12,942	13,146
May	13,523	8,101	12,988	11,776	13,523	13,126	13,144	13,505
June	13,461	7,903	12,756	11,675	13,461	13,006	13,029	13,442
July	12,729	7,545	12,028	11,241	12,729	12,263	12,348	12,711
August	11,896	7,298	11,295	10,683	11,896	11,416	11,538	11,885
September	11,070	7,135	10,654	10,345	11,070	10,585	10,803	11,055
Average	12,062	7,902	11,728	10,999	12,062	11,679	11,823	12,042

[a] months critical to principal warmwater reservoir species' spawning and rearing (March through July).

Table B-31

Estimated Average Monthly Surface Area of Whiskeytown Reservoir (Acres) for the Period 1922-1993

	Alternative							
Month	**No Action**	**Maximum Flow**	**Flow Evaluation**	**70% Inflow**	**Mechanical Restoration**	**Revised Mechanical Restoration**	**Modified % Inflow**	**Existing Conditions**
October	3,073	2,922	3,059	3,031	3,073	3,068	3,068	3,073
November	2,923	2,857	2,916	2,903	2,923	2,922	2,921	2,923
December	2,923	2,865	2,915	2,904	2,923	2,923	2,922	2,923
January	2,919	2,872	2,912	2,910	2,919	2,919	2,919	2,919
February	2,927	2,893	2,921	2,920	2,927	2,927	2,927	2,927
March	3,031	3,000	3,031	3,020	3,031	3,032	3,031	3,034
April	3,259	3,155	3,261	3,238	3,259	3,254	3,255	3,258
May	3,233	3,146	3,232	3,215	3,233	3,233	3,228	3,233
June	3,241	3,133	3,241	3,221	3,241	3,239	3,241	3,242
July	3,240	3,087	3,241	3,224	3,240	3,234	3,242	3,241
August	3,241	3,028	3,236	3,195	3,241	3,237	3,241	3,241
September	3,207	2,981	3,192	3,151	3,207	3,203	3,203	3,207
Average	3,101	2,995	3,096	3,078	3,101	3,099	3,100	3,102

Table B-32
Estimated Average Monthly Surface Area of Shasta Lake (Acres) for the Period 1922-1993

	Alternative							
Month	No Action	Maximum Flow	Flow Evaluation	70% Inflow	Mechanical Restoration	Revised Mechanical Restoration	Modified % Inflow	Existing Conditions
October	20,487	18,162	19,923	18,798	20,487	20,391	20,202	20,529
November	20,784	18,679	20,286	19,283	20,784	20,672	20,514	20,754
December	21,476	19,763	21,087	20,344	21,476	21,382	21,268	21,454
January	22,901	21,183	22,530	21,780	22,901	22,791	22,710	22,880
February	24,227	22,757	23,923	23,282	24,227	24,132	24,073	24,224
March	26,048	24,681	25,747	25,200	26,048	25,953	25,898	26,017
April	27,199	25,939	26,937	26,407	27,199	27,114	27,066	27,151
May	27,066	25,798	26,752	26,236	27,066	26,941	26,900	27,034
June	25,735	24,255	25,338	24,667	25,735	25,575	25,509	25,690
July	23,295	21,454	22,893	21,998	23,295	23,160	23,086	23,228
August	21,279	19,248	20,853	19,802	21,279	21,172	21,071	21,304
September	20,657	18,349	20,101	18,915	20,657	20,558	20,388	20,720
Average	23,430	21,689	23,031	22,226	23,430	23,320	23,224	23,415

Table B-33
Estimated Average Monthly Surface Area of Lake Oroville (Acres) for the Period 1922-1993

	Alternative							
Month	**No Action**	**Maximum Flow**	**Flow Evaluation**	**70% Inflow**	**Mechanical Restoration**	**Revised Mechanical Restoration**	**Modified % Inflow**	**Existing Conditions**
October	10,512	10,515	10,459	10,369	10,512	10,513	10,475	10,626
November	10,706	10,709	10,666	10,563	10,706	10,717	10,681	10,816
December	11,133	11,130	11,094	10,998	11,133	11,138	11,097	11,212
January	11,691	11,740	11,673	11,601	11,691	11,712	11,666	11,753
February	12,349	12,382	12,331	12,268	12,349	12,368	12,323	12,366
March	12,985	13,006	12,968	12,934	12,985	12,997	12,961	12,981
April	13,843	13,890	13,816	13,790	13,843	13,854	13,818	13,852
May	14,192	14,231	14,166	14,145	14,192	14,208	14,166	14,200
June	13,488	13,540	13,471	13,464	13,488	13,530	13,511	13,567
July	12,165	12,176	12,109	12,095	12,165	12,194	12,132	12,342
August	10,961	10,946	10,884	10,856	10,961	10,981	10,917	11,143
September	10,639	10,657	10,593	10,526	10,639	10,639	10,599	10,771
Average	12,055	12,077	12,019	11,967	12,055	12,071	12,029	12,136

Table B-34
Estimated Average Monthly Surface Area of Folsom Lake (Acres) for the Period 1922-1993

	Alternative							
Month	**No Action**	**Maximum Flow**	**Flow Evaluation**	**70% Inflow**	**Mechanical Restoration**	**Revised Mechanical Restoration**	**Modified % Inflow**	**Existing Conditions**
October	7,346	7,151	7,295	7,201	7,346	7,329	7,334	7,611
November	7,351	7,142	7,292	7,214	7,351	7,321	7,347	7,502
December	7,408	7,363	7,385	7,411	7,408	7,389	7,427	7,495
January	7,616	7,599	7,649	7,622	7,616	7,602	7,648	7,625
February	7,785	7,756	7,798	7,765	7,785	7,776	7,817	7,804
March	8,631	8,601	8,639	8,608	8,631	8,624	8,652	8,651
April	9,532	9,475	9,544	9,526	9,532	9,531	9,540	9,603
May	10,007	9,960	10,019	9,997	10,007	10,007	10,015	10,093
June	9,625	9,552	9,645	9,602	9,625	9,617	9,622	9,746
July	8,489	8,357	8,465	8,406	8,489	8,463	8,464	8,655
August	7,878	7,746	7,875	7,798	7,878	7,882	7,875	8,150
September	7,440	7,310	7,422	7,331	7,440	7,437	7,443	7,660
Average	8,259	8,168	8,252	8,207	8,259	8,248	8,265	8,383

Table B-35
Estimated Average Monthly Storage (TAF) for San Luis Reservoir (CVP operations) for the Period 1922-1993

	Alternative							
Month	**No Action**	**Maximum Flow**	**Flow Evaluation**	**70% Inflow**	**Mechanical Restoration**	**Revised Mechanical Restoration**	**Modified % Inflow**	**Existing Conditions**
October	316	357	316	318	316	323	323	307
November	431	459	429	421	431	437	435	421
December	576	588	568	557	576	581	577	557
January	701	720	691	692	701	705	708	687
February	790	806	783	783	790	792	795	773
March	856	862	852	846	856	858	861	833
April	818	828	818	813	818	822	825	787
May	663	688	665	668	663	667	672	630
June	470	522	472	490	470	475	481	445
July	314	363	309	327	314	313	316	297
August	209	258	205	224	209	206	207	190
September	259	307	263	272	259	265	267	247
Average	534	563	531	534	534	537	539	514

Table B-36
Estimated Average Monthly Storage (TAF) in San Luis Reservoir (SWP operations) for the Period 1922-1993

	Alternative							
Month	**No Action**	**Maximum Flow**	**Flow Evaluation**	**70% Inflow**	**Mechanical Restoration**	**Revised Mechanical Restoration**	**Modified % Inflow**	**Existing Conditions**
October	306	291	303	300	306	301	307	352
November	330	310	327	323	330	326	332	385
December	394	385	397	388	394	393	400	455
January	597	594	592	586	597	595	594	664
February	707	697	705	689	707	707	703	776
March	766	753	762	750	766	766	760	838
April	610	596	611	594	610	611	607	713
May	453	438	454	437	453	452	452	545
June	422	407	414	398	422	410	401	467
July	305	292	304	288	305	299	301	323
August	268	255	265	250	268	262	267	287
September	290	284	288	280	290	286	290	316
Average	454	442	452	440	454	451	451	510

Table B-37
Comparison of Trinity Lake Water Surface Area (Acres) for the Simulated Period 1922-1993

	Compared to No Action Alternative													
	Maximum Flow		Flow Evaluation		70 Percent Inflow		Mechanical Restoration		Revised Mechanical Restoration		Modified % Inflow		Pref. Alt. vs. Ex. Cond.	
Month	Percent Change in Surface Area	Change in Area (acres)	Percent Change in Surface Area	Change in Area (acres)	Percent Change in Surface Area	Change in Area (acres)	Percent Change in Surface Area	Change in Area (acres)	Percent Change in Surface Area	Change in Area (acres)	Percent Change in Surface Area	Change in Area (acres)	Percent Change in Surface Area	Change in Area (acres)
October	-32	-3444	-3	-274	-4	-425	0	0	-4	-452	-2	-171	-2	-250
November	-30	-3191	-2	-197	-3	-358	0	0	-4	-413	-1	-131	-2	-190
December	-26	-2877	-2	-172	-4	-456	0	0	-4	-388	-1	-162	-1	-160
January	-28	-3138	-1	-151	-5	-589	0	0	-3	-342	-1	-146	-1	-126
February	-30	-3594	-1	-109	-7	-841	0	0	-3	-298	-1	-131	-1	-75
March	-33	-4077	-1	-93	-9	-1162	0	0	-2	-273	-1	-115	0	-61
April	-36	-4675	-1	-129	-12	-1624	0	0	-2	-249	-2	-224	-1	-109
May	-40	-5421	-4	-535	-13	-1747	0	0	-3	-397	-3	-379	-4	-517
June	-41	-5557	-5	-705	-13	-1786	0	0	-3	-455	-3	-432	-5	-686
July	-41	-5184	-6	-701	-12	-1488	0	0	-4	-466	-3	-381	-5	-683
August	-39	-4598	-5	-601	-10	-1213	0	0	-4	-480	-3	-358	-5	-590
September	-36	-3935	-4	-416	-7	-726	0	0	-4	-485	-2	-267	-4	-401
Average	-34	-4141	-3	-340	-8	-1035	0	0	-3	-391	-2	-241	-3	-321

Table B-38
Comparison of Whiskeytown Reservoir Water Surface Area (Acres) for the Simulated Period 1922-1993

	Compared to No Action Alternative													
	Maximum Flow		Flow Evaluation		70 Percent Inflow		Mechanical Restoration		Revised Mechanical Restoration		Modified % Inflow		Pref. Alt. vs. Ex. Cond.	
Month	Percent Change in Surface Area	Change in Area (acres)	Percent Change in Surface Area	Change in Area (acres)	Percent Change in Surface Area	Change in Area (acres)	Percent Change in Surface Area	Change in Area (acres)	Percent Change in Surface Area	Change in Area (acres)	Percent Change in Surface Area	Change in Area (acres)	Percent Change in Surface Area	Change in Area (acres)
October	-5	-150	0	-14	-1	-42	0	0	0	-5	0	-4	0	-14
November	-2	-66	0	-7	-1	-20	0	0	0	-1	0	-2	0	-7
December	-2	-58	0	-8	-1	-19	0	0	0	0	0	-1	0	-8
January	-2	-48	0	-8	0	-9	0	0	0	0	0	0	0	-8
February	-1	-35	0	-6	0	-7	0	0	0	0	0	0	0	-6
March	-1	-30	0	0	0	-10	0	0	0	2	0	0	0	-3
April	-3	-104	0	2	-1	-22	0	0	0	-5	0	-5	0	3
May	-3	-87	0	-1	-1	-18	0	0	0	0	0	-5	0	-2
June	-3	-108	0	0	-1	-20	0	0	0	-3	0	-1	0	-1
July	-5	-153	0	1	-1	-17	0	0	0	-6	0	2	0	0
August	-7	-214	0	-6	-1	-47	0	0	0	-4	0	0	0	-6
September	-7	-226	0	-15	-2	-57	0	0	0	-4	0	-5	0	-15
Average	-3	-107	0	-5	-1	-24	0	0	0	-2	0	-2	0	-5

Table B-39
Comparison of Shasta Lake Water Surface Area (Acres) for the Simulated Period 1922-1993

	Compared to No Action Alternative												Pref. Alt. vs. Ex. Cond.	
	Maximum Flow		Flow Evaluation		70 Percent Inflow		Mechanical Restoration		Revised Mechanical Restoration		Modified % Inflow			
Month	Percent Change in Surface Area	Change in Area (acres)	Percent Change in Surface Area	Change in Area (acres)	Percent Change in Surface Area	Change in Area (acres)	Percent Change in Surface Area	Change in Area (acres)	Percent Change in Surface Area	Change in Area (acres)	Percent Change in Surface Area	Change in Area (acres)	Percent Change in Surface Area	Change in Area (acres)
October	-11	-2324	-3	-563	-8	-1689	0	0	0	-96	-1	-284	-3	-606
November	-10	-2105	-2	-498	-7	-1501	0	0	-1	-113	-1	-270	-2	-468
December	-8	-1712	-2	-389	-5	-1132	0	0	0	-94	-1	-207	-2	-367
January	-8	-1718	-2	-372	-5	-1121	0	0	0	-110	-1	-191	-2	-351
February	-6	-1470	-1	-304	-4	-946	0	0	0	-95	-1	-154	-1	-301
March	-5	-1367	-1	-301	-3	-848	0	0	0	-95	-1	-150	-1	-271
April	-5	-1259	-1	-262	-3	-791	0	0	0	-85	0	-132	-1	-214
May	-5	-1268	-1	-315	-3	-831	0	0	0	-126	-1	-167	-1	-282
June	-6	-1480	-2	-397	-4	-1068	0	0	-1	-160	-1	-225	-1	-352
July	-8	-1841	-2	-402	-6	-1297	0	0	-1	-134	-1	-208	-1	-336
August	-10	-2031	-2	-426	-7	-1478	0	0	-1	-108	-1	-208	-2	-451
September	-11	-2308	-3	-556	-8	-1743	0	0	0	-99	-1	-269	-3	-619
Average	-8	-1740	-2	-399	-5	-1204	0	0	0	-110	-1	-206	-2	-385

Table B-40
Comparison of Lake Oroville Water Surface Area (Acres) for the Simulated Period 1922-1993

Month	Compared to No Action Alternative												Pref. Alt. vs. Ex. Cond.	
	Maximum Flow		Flow Evaluation		70 Percent Inflow		Mechanical Restoration		Revised Mechanical Restoration		Modified % Inflow			
	Percent Change in Surface Area	Change in Area (acres)	Percent Change in Surface Area	Change in Area (acres)	Percent Change in Surface Area	Change in Area (acres)	Percent Change in Surface Area	Change in Area (acres)	Percent Change in Surface Area	Change in Area (acres)	Percent Change in Surface Area	Change in Area (acres)	Percent Change in Surface Area	Change in Area (acres)
October	0	3	-1	-54	-1	-143	0	0	0	1	0	-37	-2	-167
November	0	3	0	-40	-1	-143	0	0	0	11	0	-25	-1	-150
December	0	-3	0	-39	-1	-135	0	0	0	5	0	-36	-1	-118
January	0	50	0	-18	-1	-90	0	0	0	21	0	-25	-1	-80
February	0	33	0	-18	-1	-81	0	0	0	19	0	-26	0	-35
March	0	22	0	-17	0	-51	0	0	0	13	0	-24	0	-12
April	0	47	0	-26	0	-53	0	0	0	11	0	-25	0	-36
May	0	39	0	-26	0	-47	0	0	0	16	0	-26	0	-33
June	0	52	0	-16	0	-23	0	0	0	43	0	23	-1	-95
July	0	11	0	-57	-1	-70	0	0	0	28	0	-34	-2	-234
August	0	-14	-1	-76	-1	-105	0	0	0	20	0	-44	-2	-259
September	0	19	0	-46	-1	-113	0	0	0	1	0	-39	-2	-178
Average	0	22	0	-36	-1	-88	0	0	0	16	0	-26	-1	-117

Table B-41

Comparison of Folsom Lake Water Surface Area (Acres) for the Simulated Period 1922-1993

	Compared to No Action Alternative												Pref. Alt. vs. Ex. Cond.	
	Maximum Flow		Flow Evaluation		70 Percent Inflow		Mechanical Restoration		Revised Mechanical Restoration		Modified % Inflow			
Month	Percent Change in Surface Area	Change in Area (acres)	Percent Change in Surface Area	Change in Area (acres)	Percent Change in Surface Area	Change in Area (acres)	Percent Change in Surface Area	Change in Area (acres)	Percent Change in Surface Area	Change in Area (acres)	Percent Change in Surface Area	Change in Area (acres)	Percent Change in Surface Area	Change in Area (acres)
October	-3	-195	-1	-51	-2	-145	0	0	0	-17	-0.2	-12	-4	-316
November	-3	-209	-1	-59	-2	-137	0	0	0	-29	-0.1	-4	-3	-210
December	-1	-45	0	-23	0	3	0	0	0	-19	0.3	19	-1	-110
January	0	-17	0	34	0	7	0	0	0	-14	0.4	33	0	25
February	0	-30	0	13	0	-20	0	0	0	-10	0.4	31	0	-5
March	0	-30	0	8	0	-23	0	0	0	-7	0.2	21	0	-12
April	-1	-57	0	12	0	-6	0	0	0	-1	0.1	7	-1	-59
May	0	-47	0	12	0	-10	0	0	0	0	0.1	8	-1	-74
June	-1	-72	0	20	0	-23	0	0	0	-8	0.0	-3	-1	-101
July	-2	-132	0	-24	-1	-83	0	0	0	-26	-0.3	-25	-2	-190
August	-2	-132	0	-3	-1	-80	0	0	0	4	0.0	-3	-3	-275
September	-2	-130	0	-18	-1	-109	0	0	0	-3	0.0	3	-3	-239
Average	-1	-91	0	-7	-1	-52	0	0	0	-11	0.1	6	-2	-131

Table B-42
Comparison of Estimated Average Monthly Storage (taf) in San Luis Reservoir (CVP operations) for 1922-1993

Compared to No Action Alternative

Month	Maximum Flow		Flow Evaluation		70 Percent Inflow		Mechanical Restoration		Revised Mechanical Restoration		Modified % Inflow		Existing Conditions	
	Percent Change in Acre Feet	Change in TAF	Percent Change in Acre Feet	Change in TAF	Percent Change in Acre Feet	Change in TAF	Percent Change in Acre Feet	Change in TAF	Percent Change in Acre Feet	Change in TAF	Percent Change in Acre Feet	Change in TAF	Percent Change in Acre Feet	Change in TAF
October	12.7	40	0	0	1	2	0	0	2	6	2	7	3	9
November	6.5	28	-1	-2	-2	-10	0	0	1	6	1	4	2	8
December	2.2	13	-1	-8	-3	-19	0	0	1	5	0	1	2	11
January	2.7	19	-1	-10	-1	-9	0	0	1	4	1	7	1	5
February	2.0	16	-1	-7	-1	-7	0	0	0	2	1	5	1	10
March	0.7	6	-1	-4	-1	-11	0	0	0	2	1	5	2	19
April	1.2	10	0	0	-1	-5	0	0	0	3	1	6	4	31
May	3.8	25	0	2	1	5	0	0	1	4	1	9	6	35
June	11.0	52	0	2	4	19	0	0	1	5	2	11	6	27
July	15.6	49	-2	-6	4	13	0	0	0	-1	0	1	4	12
August	23.6	49	-2	-4	7	15	0	0	-1	-3	-1	-2	8	14
September	18.7	48	2	4	5	14	0	0	2	6	3	9	6	16
Average	8.4	30	-1	-3	1	1	0	0	1	3	1	5	4	16

Table B-43
Comparison of Estimated Average Monthly Storage (taf) in San Luis Reservoir (SWP operations) for 1922-1993

Compared to No Action Alternative

Month	Maximum Flow		Flow Evaluation		70 Percent Inflow		Mechanical Restoration		Revised Mechanical Restoration		Modified % Inflow		Pref. Alt. vs. Ex. Cond.	
	Percent Change in Acre Feet	Change in TAF	Percent Change in Acre Feet	Change in TAF	Percent Change in Acre Feet	Change in TAF	Percent Change in Acre Feet	Change in TAF	Percent Change in Acre Feet	Change in TAF	Percent Change in Acre Feet	Change in TAF	Percent Change in Acre Feet	Change in TAF
October	-5	-14	-1	-3	-2	-6	0	0	-2	-5	0	1	-14	-49
November	-6	-20	-1	-3	-2	-7	0	0	-1	-4	1	3	-15	-58
December	-2	-9	1	4	-1	-6	0	0	0	-1	2	6	-13	-58
January	-1	-3	-1	-4	-2	-11	0	0	0	-1	0	-3	-11	-72
February	-1	-11	0	-2	-3	-19	0	0	0	-1	-1	-4	-9	-71
March	-2	-13	0	-4	-2	-16	0	0	0	0	-1	-5	-9	-76
April	-2	-13	0	1	-3	-15	0	0	0	1	0	-3	-14	-102
May	-3	-15	0	2	-3	-15	0	0	0	0	0	-1	-17	-90
June	-4	-16	-2	-8	-6	-24	0	0	-3	-13	-5	-22	-11	-53
July	-4	-13	0	-1	-6	-17	0	0	-2	-6	-1	-4	-6	-19
August	-5	-13	-1	-4	-7	-18	0	0	-2	-6	-1	-1	-8	-22
September	-2	-6	-1	-3	-3	-10	0	0	-1	-4	0	0	-9	-28
Average	-3	-12	-1	-2	-3	-14	0	0	-1	-3	-1	-3	-11	-58

Table B-44
Summary of the Comparison of Changes in Reservoir Surface Area/Storage during Key Warmwater Fish Spawning and Rearing Months (March through July) for 1922 to 1993

	Compared to No Action Alternative												Pref. Alt. vs. Ex. Cond.	
	Maximum Flow		Flow Evaluation		70 % Inflow		Mechanical Restoration		Revised Mechanical Restoration		Modified % Inflow			
	Range of Mean Changes in Reservoir Area (March through July)													
Reservoir	**Percent**	**Acres**	**Percent**	**Acres**	**Percent**	**Acres**	**Percent**	**Acres**	**Percent**	**Acres**	**Percent**	**Acres**	**Percent**	**Acres**
Trinity	-32.8 to -41.3	-4077 to -5557	-0.7 to -5.5	-93 to -705	-9.4 to 13.3	-1162 to -1786	0	0	-1.9 to -3.7	-249 to -466	-1 to -3	-115 to - 432	-0.6 to -5.4	-18 to -31
Whiskeytown	-1.0 to -4.7	-30 to -153	0.0 to + 0.1	-1 to +2	-0.3 to -0.7	-10 to -22	0	0	-0.2 to + 0.1	-6 to +2	0	-5 to 2	+0.0 to -0.5	-1 to +3
Shasta	-4.6 to -7.9	-1259 to -1841	-1.0 to -1.7	-262 to -402	-2.8 to -5.6	-791 to -1297	0	0	-0.3 to - 0.6	-85 to -160	0 to -1	-284 to -132	-0.8 to -3.0	-30 to -66
Oroville	+0.1 to +0.4	+11 to + 52	-0.1 to -0.5	-16 to -0.1	-0.2 to -0.6	-23 to -70	0	0	+0.1 to + 0.3	+11 to +43	0	-44 to 23	-0.1 to -2.3	-4 to +177
Folsom	-0.3 to -1.6	-30 to -132	-0.3 to +0.2	+8 to -24	-0.1 to -1.0	-6 to -83	0	0	-0.3 to 0.0	0 to -26	0	-29 to 4	-01 to -4.1	+20 to +166
	Range of Mean Changes in Reservoir Storage (March through July)													
Reservoir	**Percent**	**TAF**	**Percent**	**TAF**	**Percent**	**TAF**	**Percent**	**TAF**	**Percent**	**TAF**	**Percent**	**TAF**	**Percent**	**TAF**
San Luis (CVP)	+0.7 to +15.6	+6 to +49	0.0 to -1.8	0 to -6	-1.2 to +4.1	-11 to +19	0	0	-0.5 to +1.0	-1 to +5	-1 to 3	-2 to 11	+0.7 to +7.5	-17 to -33
San Luis (SWP)	-1.6 to -4.2	-13 to -16	-2.0 to +0.3	-8 to +2	-2.0 to -5.6	-15 to -24	0	0	-3.0 to 0.0	-13 to +1	-5 to 2	-22 to 6	-6.0 to -16.6	+18 to + 103

Figures

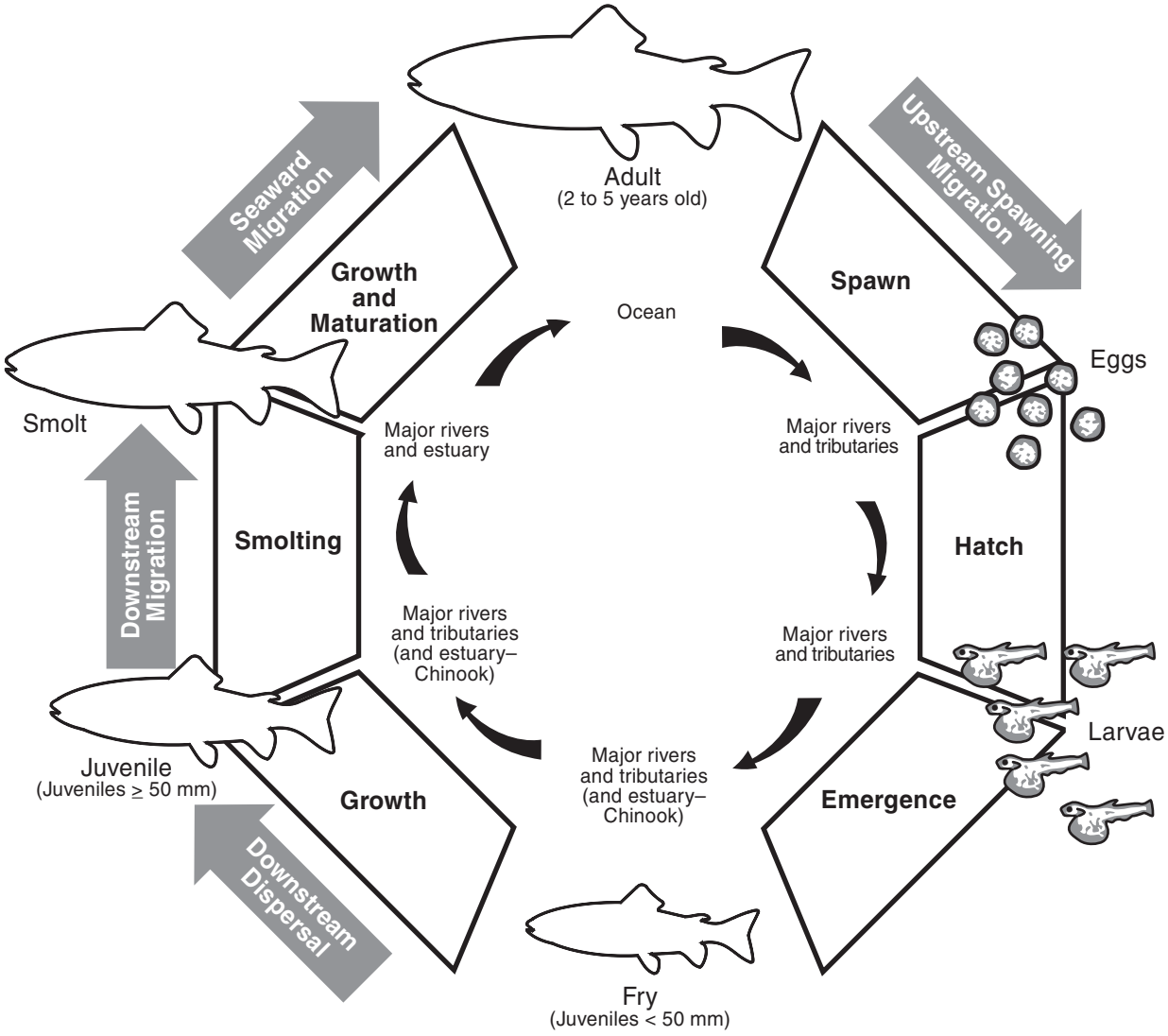


FIGURE B-1
GENERAL LIFE HISTORY
OF ANADROMOUS SALMONIDS
TRINITY RIVER FISHERY RESTORATION SUPPLEMENTAL EIS/EIR

W022004007RDD_05 (4/12/04)

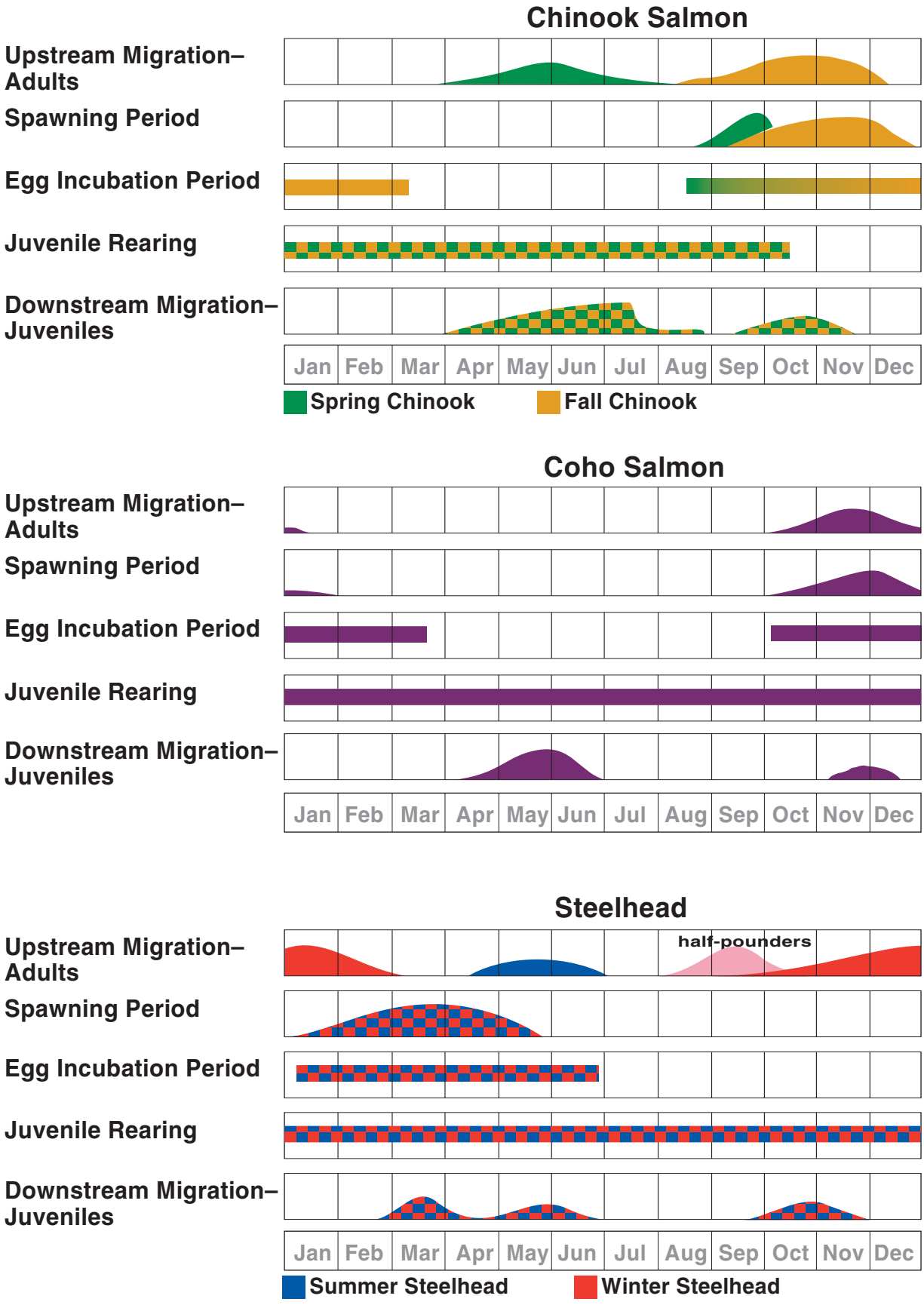


FIGURE B-2
TEMPORAL DISTRIBUTION
OF ANADROMOUS SALMONID
TRINITY RIVER FISHERY RESTORATION SUPPLEMENTAL EIS/EIR

W022004007RDD_06 (4/12/04)

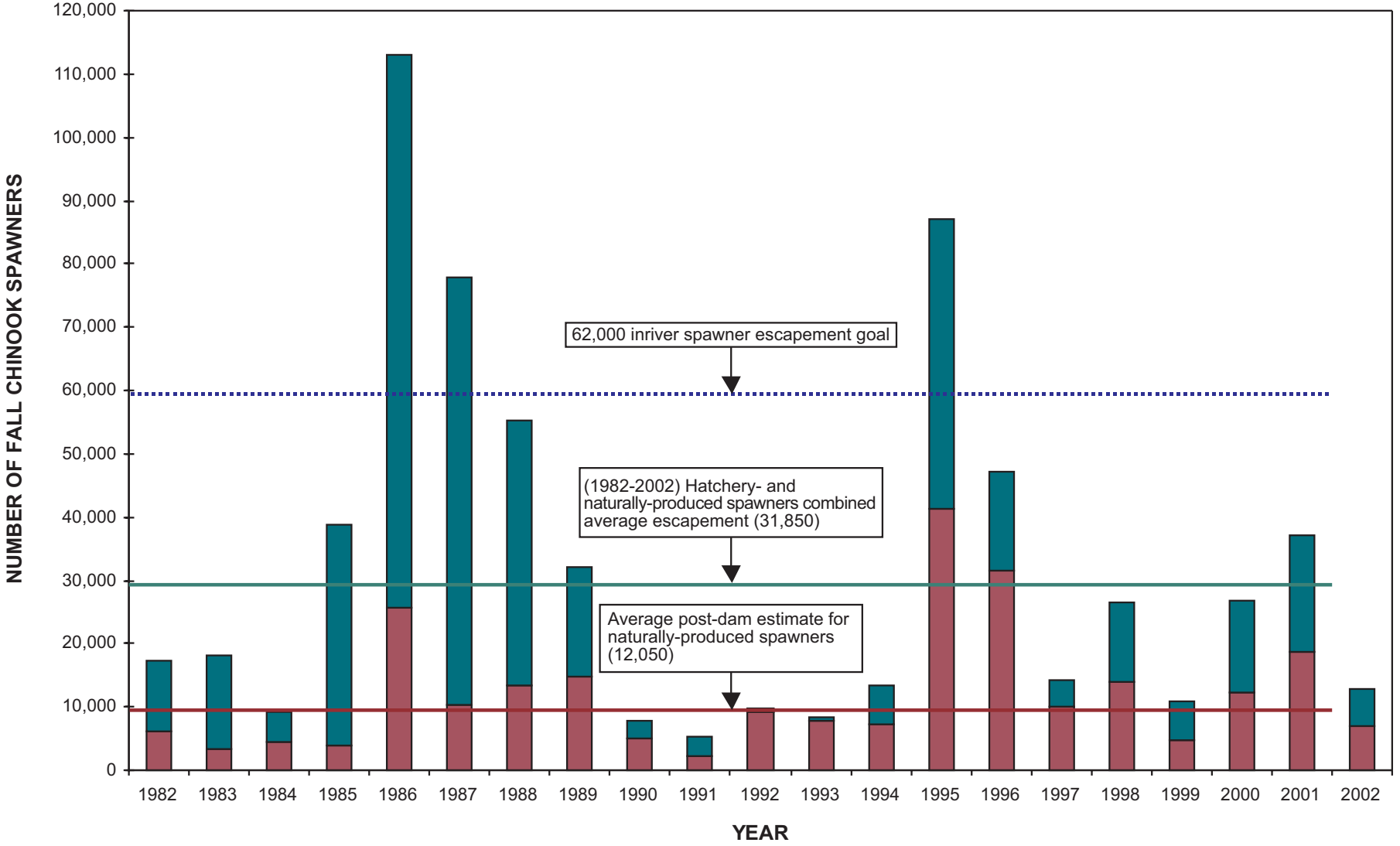
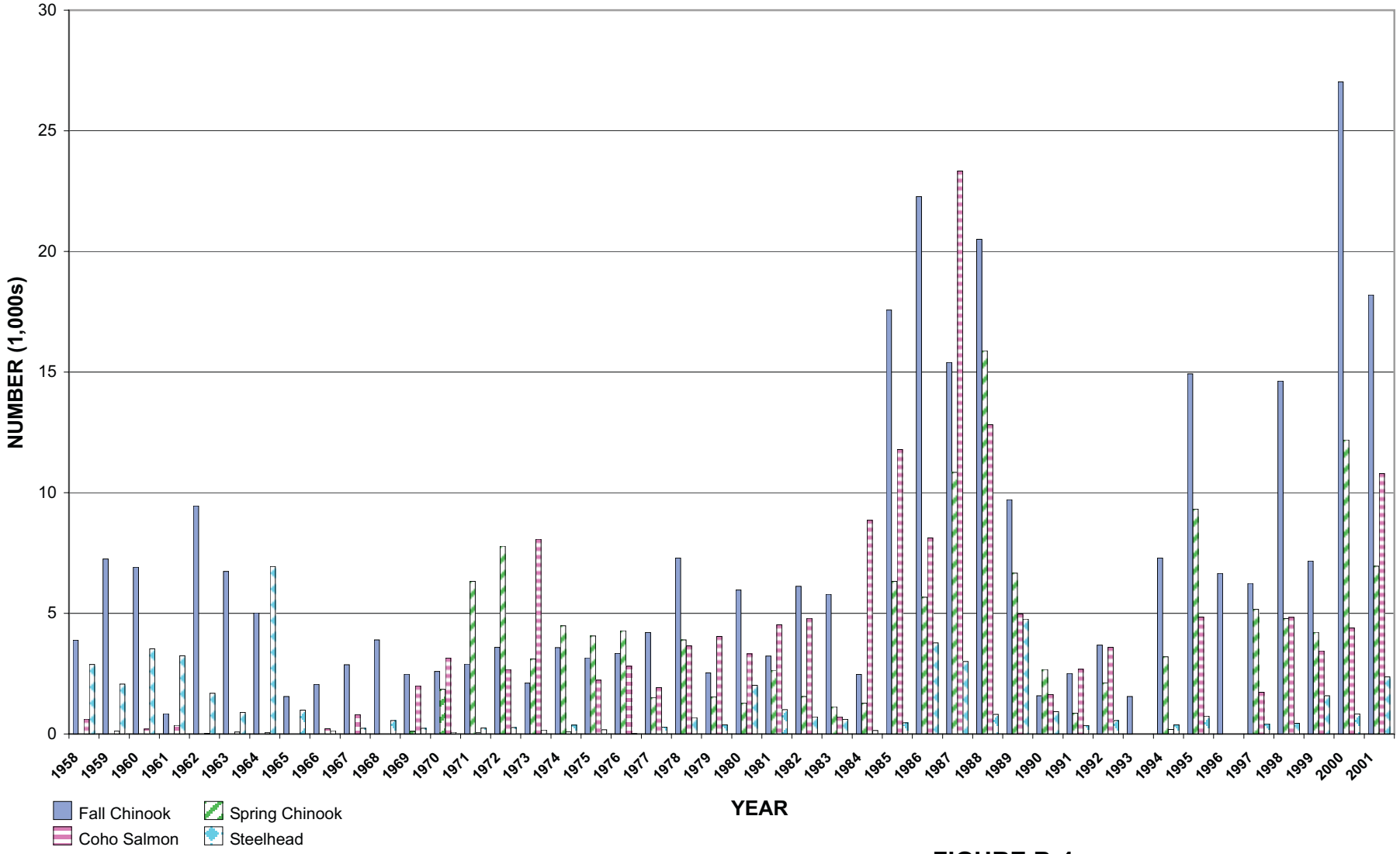


FIGURE B-3
FALL CHINOOK SPAWNER ESCAPEMENT IN THE TRINITY RIVER (1982-2002)
TRINITY RIVER FISHERY RESTORATION SUPPLEMENTAL EIS/EIR

W022004007RDD_08 (4/12/04)



(a) 1993 and 1996 Data Missing for Coho and Steelhead; 1958-1968, 1993, and 1996 for Spring Chinook

FIGURE B-4
NUMBER (ADULTS AND JACKS) OF CHINOOK AND COHO SALMON AND STEELHEAD ENTERING TRSSH (1958-2001)[a]
TRINITY RIVER FISHERY RESTORATION SUPPLEMENTAL EIS/EIR

W022004007RDD_03 (4/12/04)

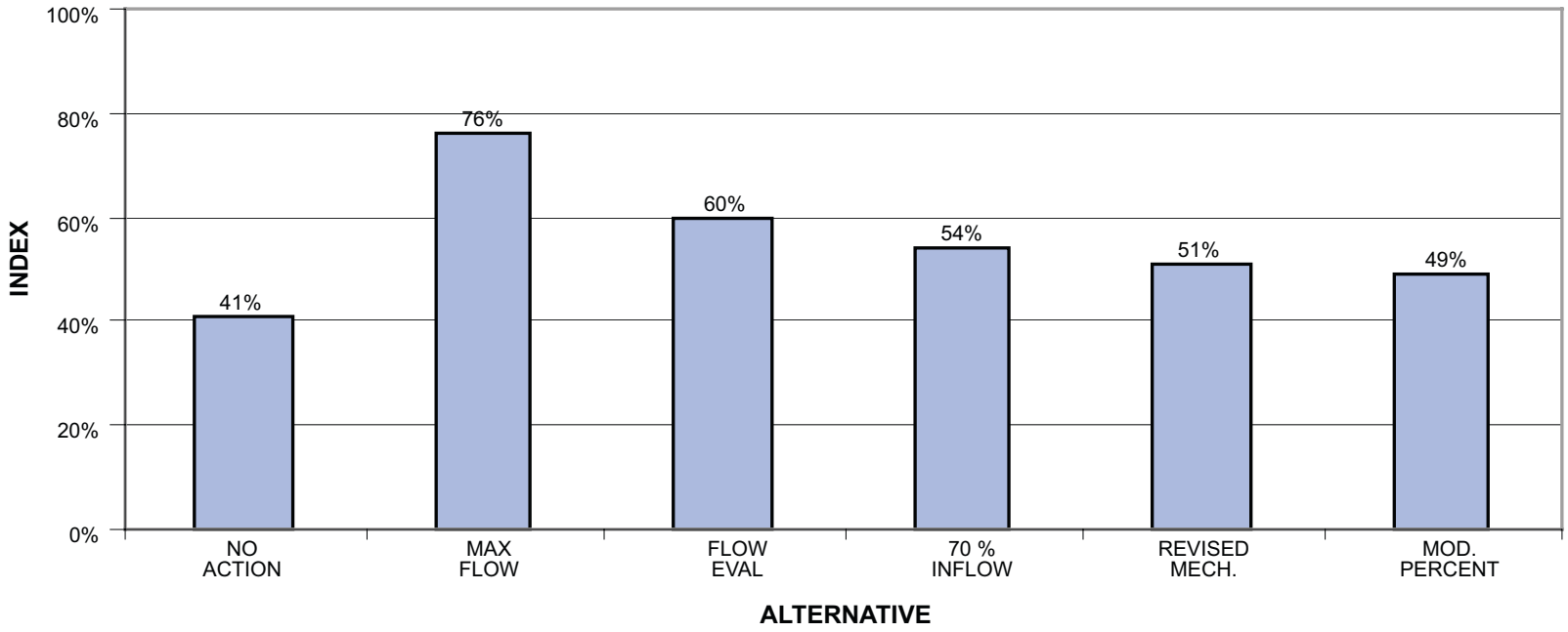


FIGURE B-5A
TRINITY RIVER CHINOOK SMOLT TEMPERATURE SUITABILITY INDICES
TRINITY RIVER FISHERY RESTORATION SUPPLEMENTAL EIS/EIR

W022004007RDD_04 (4/12/04)

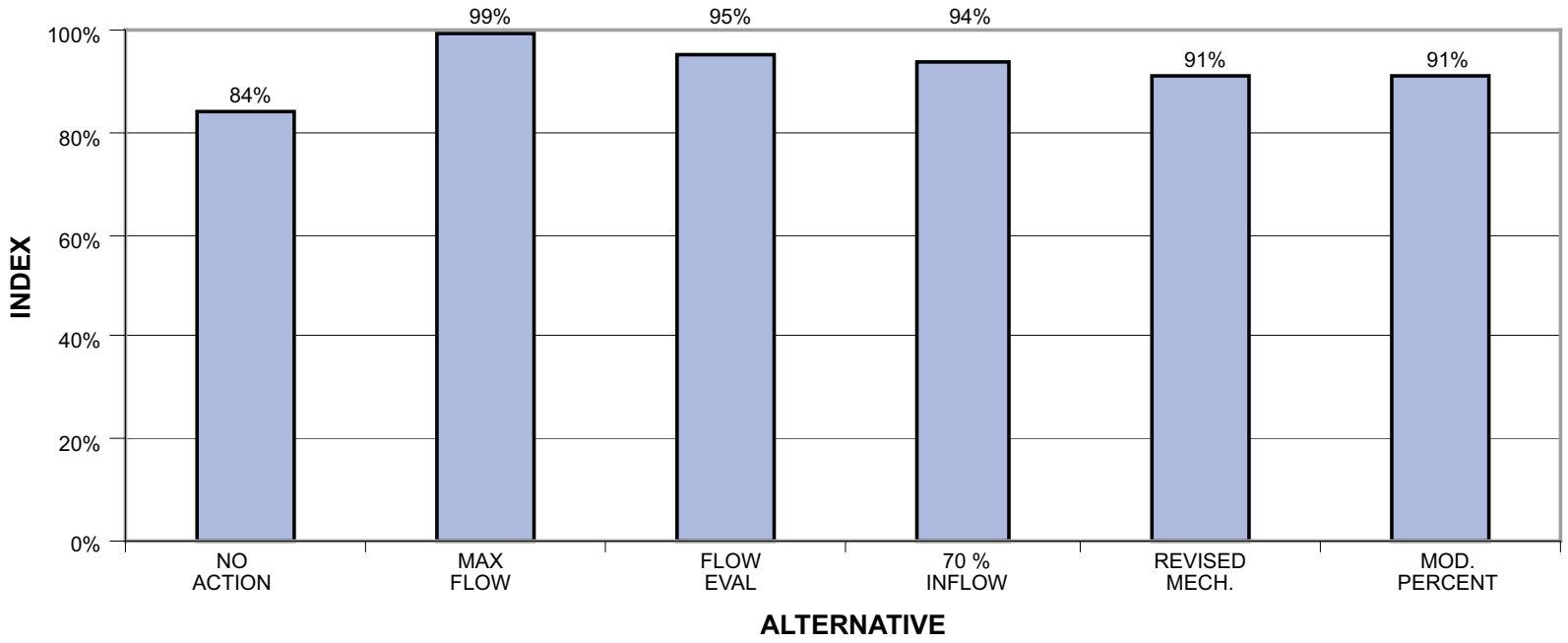


FIGURE B-5B
TRINITY RIVER COHO SMOLT
TEMPERATURE SUITABILITY INDICES
TRINITY RIVER FISHERY RESTORATION SUPPLEMENTAL EIS/EIR

W022004007RDD_09 (4/12/04)

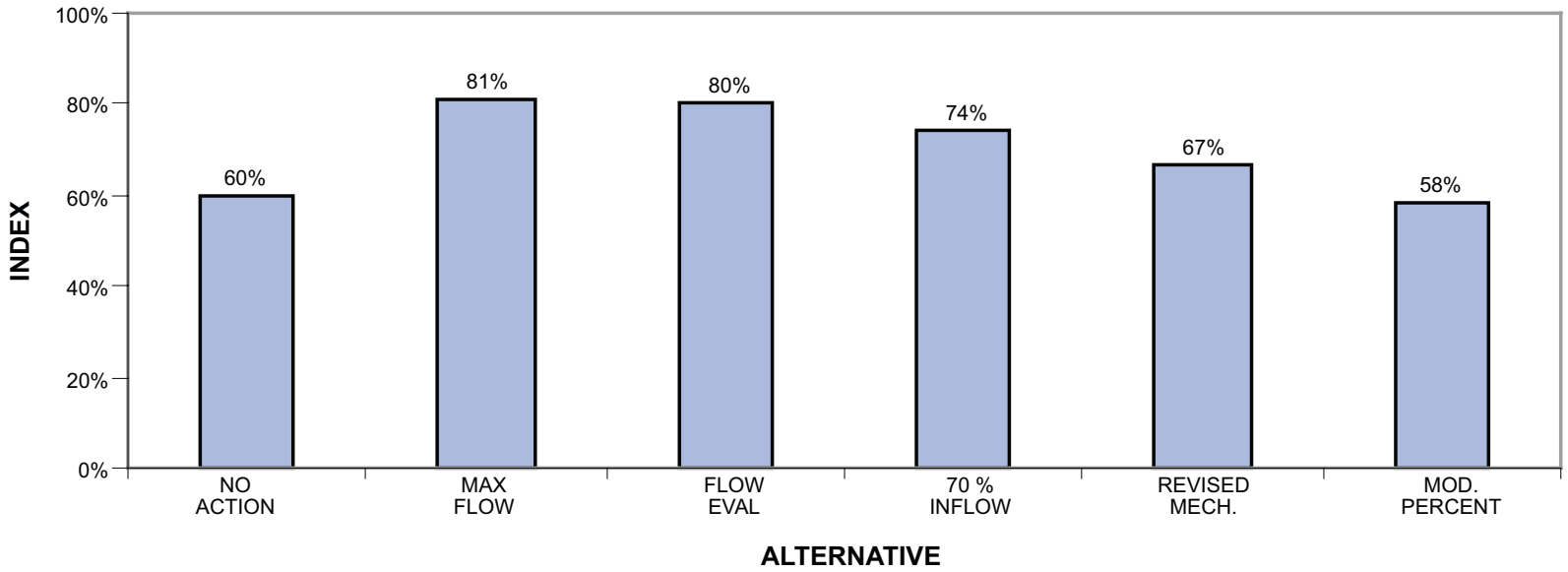


FIGURE B-5C
TRINITY RIVER STEELHEAD SMOLT
TEMPERATURE SUITABILITY, SURVIVABILITY INDICES
TRINITY RIVER FISHERY RESTORATION SUPPLEMENTAL EIS/EIR

W022004007RDD_10 (4/12/04)

Attachment B1
Chinook and Coho Salmon and Steelhead Run-size, Spawner Escapements, Angler Harvest, and Origin of Spawner Estimates.

Table B1-1.
Klamath River Basin Fall Chinook Salmon Spawner Escapement, In-river Harvest and Run-size Estimates, 1978-2002 a

SPAWNER ESCAPEMENT

	1978			1979			1980		
Hatchery Spawners	Grilse	Adults	Totals	Grilse	Adults	Totals	Grilse	Adults	Totals
Iron Gate Hatchery (IGH)	915	6,925	7,840	257	2,301	2,558	451	2,412	2,863
Trinity River Hatchery (TRH)	1,325	6,034	7,359	964	1,335	2,299	2,256	4,099	6,355
Subtotals	2,240	12,959	15,199	1,221	3,636	4,857	2,707	6,511	9,218
Natural Spawners									
Trinity River basin (above Willow Creek, excluding TRH)	4,712	31,052	35,764	3,936	8,028	11,964	16,837	7,700	24,537
Salmon River basin	1,400	2,600	4,000	150	1,000	1,150	200	800	1,000
Scott River basin	1,909	3,423	5,332	428	3,396	3,824	2,245	2,032	4,277
Shasta River basin	6,707	12,024	18,731	1,040	7,111	8,151	4,334	3,762	8,096
Bogus Creek basin	651	4,928	5,579	494	5,444	5,938	1,749	3,321	5,070
Main Stem Klamath River (excluding IGH)	300	1,700	2,000	466	4,190	4,656	867	2,468	3,335
Misc. Klamath tributaries (above Hoopa and Yurok Reservations)	735	2,765	3,500	147	1,068	1,215	500	1,000	1,500
Hoopa and Yurok Reservation tribs.	-- b/	-- b/	-- b/	100 c/	400 c/	500 c/	250 c/	400 c/	650 c/
Subtotals	16,414	58,492	74,906	6,761	30,637	37,398	26,982	21,483	48,465
Total Spawner Escapement	18,654	71,451	90,105	7,982	34,273	42,255	29,689	27,994	57,683

IN-RIVER HARVEST

	1978			1979			1980		
Angler Harvest	Grilse	Adults	Totals	Grilse	Adults	Totals	Grilse	Adults	Totals
Klamath River (below Hwy 101 bridge)	122	854	976	216	484	700	835	727	1,562
Trinity River basin (above Willow Creek)	-- d/	-- d/	-- d/	765	1,157	1,922	2,456	998	3,454
Balance of Klamath system	1,960	840	2,800	1,200	500	1,700	2,600	2,771	5,371
Subtotals	2,082	1,694	3,776	2,181	2,141	4,322	5,891	4,496	10,387
Indian Net Harvest e/									
Klamath River (below Hwy 101 bridge)	--	--	--	--	--	--	495	9,605	10,100
Klamath River (Hwy 101 to Trinity mouth)	--	--	--	--	--	--	272	1,528	1,800
Trinity River (Hoopa Reservation)	--	--	--	--	--	--	220	880	1,100
Subtotals	1,800	18,200	20,000	1,350	13,650	15,000	987	12,013	13,000
Total In-river Harvest	3,882	19,894	23,776	3,531	15,791	19,322	6,878	16,509	23,387

IN-RIVER RUN

	1978			1979			1980		
Totals	Grilse	Adults	Totals	Grilse	Adults	Totals	Grilse	Adults	Totals
In-river Harvest and Escapement	22,536	91,345	113,881	11,513	50,064	61,577	36,567	44,503	81,070
Angling Mortality (2% of harvest) f/	42	34	76	44	43	87	118	90	208
Net Mortality (8% of harvest) f/	144	1,456	1,600	108	1,092	1,200	79	961	1,040
Total In-river Run	22,722	92,835	115,557	11,665	51,199	62,864	36,764	45,554	82,318

(continued next page)

Klamath River Basin Fall Chinook Salmon Spawner Escapement, In-river Harvest and Run-size Estimates 1978-2002 a/

SPAWNER ESCAPEMENT

	1981			1982			1983		
Hatchery Spawners	Grilse	Adults	Totals	Grilse	Adults	Totals	Grilse	Adults	Totals
Iron Gate Hatchery (IGH)	540	2,055	2,595	1,833	8,353	10,186	514	8,371	8,885
Trinity River Hatchery (TRH)	1,004	2,370	3,374	4,235	2,058	6,293	271	5,494	5,765
Subtotals	1,544	4,425	5,969	6,068	10,411	16,479	785	13,865	14,650
Natural Spawners									
Trinity River basin (above Willow Creek, excluding TRH)	5,906	15,340	21,246	8,149	9,274	17,423	853	17,284	18,137
Salmon River basin	450	750	1,200	300	1,000	1,300	75	1,200	1,275
Scott River basin	3,409	3,147	6,556	4,350	5,826	10,176	170	3,398	3,568
Shasta River basin	4,330	7,890	12,220	1,922	6,533	8,455	753	3,119	3,872
Bogus Creek basin	912	2,730	3,642	2,325	4,818	7,143	335	2,713	3,048
Main Stem Klamath River (excluding IGH)	1,000	3,000	4,000	1,000	3,000	4,000	200	1,800	2,000
Misc. Klamath tributaries (above Hoopa and Yurok Reservations)	500	1,000	1,500	600	1,500	2,100	140	1,270	1,410
Hoopa and Yurok Reservation tribs.	-- b/	-- b/	-- b/	-- b/	-- b/	-- b/	-- b/	-- b/	-- b/
Subtotals	16,507	33,857	50,364	18,646	31,951	50,597	2,526	30,784	33,310
Total Spawner Escapement	18,051	38,282	56,333	24,714	42,362	67,076	3,311	44,649	47,960

IN-RIVER HARVEST

	1981			1982			1983		
Angler Harvest	Grilse	Adults	Totals	Grilse	Adults	Totals	Grilse	Adults	Totals
Klamath River (below Hwy 101 bridge)	536	1,714	2,250	1,252	3,539	4,791	60	750	810
Trinity River basin (above Willow Creek)	1,456	3,174	4,630	2,554	2,321	4,875	116	2,360	2,476
Balance of Klamath system	5,260	1,095	6,355	8,678	2,479	11,157	175	1,125	1,300
Subtotals	7,252	5,983	13,235	12,484	8,339	20,823	351	4,235	4,586
Indian Net Harvest e/									
Klamath River (below Hwy 101 bridge)	912	23,097	24,009	290	4,547	4,837	12	800	812
Klamath River (Hwy 101 to Trinity mouth)	1,104	8,405	9,509	1,195	8,424	9,619	121	5,700	5,821
Trinity River (Hoopa Reservation)	449	1,531	1,980	314	1,511	1,825	30	1,390	1,420
Subtotals	2,465	33,033	35,498	1,799	14,482	16,281	163	7,890	8,053
Total In-river Harvest	9,717	39,016	48,733	14,283	22,821	37,104	514	12,125	12,639

IN-RIVER RUN

	1981			1982			1983		
Totals	Grilse	Adults	Totals	Grilse	Adults	Totals	Grilse	Adults	Totals
In-river Harvest and Escapement	27,768	77,298	105,066	38,997	65,183	104,180	3,825	56,774	60,599
Angling Mortality (2% of harvest) f/	145	120	265	250	167	417	7	85	92
Net Mortality (8% of harvest) f/	197	2,643	2,840	144	1,159	1,303	13	631	644
Total In-river Run	28,110	80,061	108,171	39,391	66,509	105,900	3,845	57,490	61,335

(continued next page)

Klamath River Basin Fall Chinook Salmon Spawner Escapement, In-river Harvest and Run-size Estimates
1978-2002 a/

SPAWNER ESCAPEMENT

	1984			1985			1986		
Hatchery Spawners	Grilse	Adults	Totals	Grilse	Adults	Totals	Grilse	Adults	Totals
Iron Gate Hatchery (IGH)	764	5,330	6,094	2,159	19,951	22,110	1,461	17,096	18,557
Trinity River Hatchery (TRH)	766	2,166	2,932	18,166	2,583	20,749	3,609	15,795	19,404
Subtotals	1,530	7,496	9,026	20,325	22,534	42,859	5,070	32,891	37,961
Natural Spawners									
Trinity River basin (above Willow Creek, excluding TRH)	3,416	5,654	9,070	29,454	9,217	38,671	20,459	92,548	113,007
Salmon River basin	216 g/	1,226 g/	1,442 g/	905	2,259	3,164	949	2,716	3,665
Scott River basin	358	1,443	1,801	1,357	3,051	4,408	4,865	3,176	8,041
Shasta River basin	480	2,362	2,842	2,227	2,897	5,124	683	3,274	3,957
Bogus Creek basin	465	3,039	3,504	1,156	3,491	4,647	1,184	6,124	7,308
Main Stem Klamath River (excluding IGH)	200	1,350	1,550	156	468	624	196	603	799
Misc. Klamath tributaries (above Hoopa and Yurok Reservations)	150	990	1,140	646	4,214	4,860	606	4,919	5,525
Hoopa and Yurok Reservation tribs.	-- b/	-- b/	-- b/	50 h/	80 h/	130 h/	-- b/	-- b/	-- b/
Subtotals	5,285	16,064	21,349	35,951	25,677	61,628	28,942	113,360	142,302
Total Spawner Escapement	6,815	23,560	30,375	56,276	48,211	104,487	34,012	146,251	180,263

IN-RIVER HARVEST

	1984			1985			1986		
Angler Harvest	Grilse	Adults	Totals	Grilse	Adults	Totals	Grilse	Adults	Totals
Klamath River (below Hwy 101 bridge)	175	548	723	1,479	2,427 i/	3,906	704	2,456	3,160
Trinity River basin (above Willow Creek)	393	736	1,129	5,442	154 i/	5,596	3,438	12,039	15,477
Balance of Klamath system	384	2,056	2,440	4,274	1,001 i/	5,275	5,266	6,532	11,798
Subtotals	952	3,340	4,292	11,195	3,582 i/	14,777	9,408	21,027	30,435
Indian Net Harvest e/									
Klamath River (below Hwy 101 bridge)	132	11,878	12,010	132	5,700	5,832	191	15,286	15,477
Klamath River (Hwy 101 to Trinity mouth)	183	5,622	5,805	476	3,925	4,401	377	5,033	5,410
Trinity River (Hoopa Reservation)	140	1,170	1,310	947 j/	1,941 j/	2,888 j/	286	4,808	5,094
Subtotals	455	18,670	19,125	1,555	11,566	13,121	854	25,127	25,981
Total In-river Harvest	1,407	22,010	23,417	12,750	15,148	27,898	10,262	46,154	56,416

IN-RIVER RUN

	1984			1985			1986		
Totals	Grilse	Adults	Totals	Grilse	Adults	Totals	Grilse	Adults	Totals
In-river Harvest and Escapement	8,222	45,570	53,792	69,026	63,359	132,385	44,274	192,405	236,679
Angling Mortality (2% of harvest) f/	19	67	86	224	72	296	188	421	609
Net Mortality (8% of harvest) f/	36	1,494	1,530	124	925	1,049	68	2,010	2,078
Total In-river Run	8,277	47,131	55,408	69,374	64,356	133,730	44,530	194,836	239,366

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Klamath River Basin Fall Chinook Salmon Spawner Escapement, In-river Harvest and Run-size Estimates
1978-2002 a/

SPAWNER ESCAPEMENT

	1987			1988			1989		
Hatchery Spawners	Grilse	Adults	Totals	Grilse	Adults	Totals	Grilse	Adults	Totals
Iron Gate Hatchery (IGH)	1,825	15,189	17,014	609	16,106	16,715	831	10,859	11,690
Trinity River Hatchery (TRH)	2,453	13,934	16,387	4,752	17,352	22,104	239	11,132	11,371
Subtotals	4,278	29,123	33,401	5,361	33,458	38,819	1,070	21,991	23,061
Natural Spawners									
Trinity River basin (above Willow Creek, excluding TRH)	5,949	71,920	77,869	10,626	44,616	55,242	2,543	29,445	31,988
Salmon River basin	118	3,832	3,950	327	3,273	3,600	695	2,915	3,610
Scott River basin	797	7,769	8,566	473	4,727	5,200	1,188	3,000	4,188
Shasta River basin	398	4,299	4,697	256	2,586	2,842	137	1,440	1,577
Bogus Creek basin	1,208	9,748	10,956	225	16,215	16,440	444	2,218	2,662
Main Stem Klamath River (excluding IGH)	65	863	928	164	2,982	3,146	214	1,011	1,225
Misc. Klamath tributaries (above Hoopa and Yurok Reservations)	237	3,286	3,523	418	4,167	4,585	248	3,239	3,487
Hoopa and Yurok Reservation tribs.	-- b/	-- b/	-- b/	55 k/	820 k/	875 k/	40 k/	600 k/	640 k/
Subtotals	8,772	101,717	110,489	12,544	79,386	91,930	5,509	43,868	49,377
Total Spawner Escapement	13,050	130,840	143,890	17,905	112,844	130,749	6,579	65,859	72,438

IN-RIVER HARVEST

	1987			1988			1989		
Angler Harvest	Grilse	Adults	Totals	Grilse	Adults	Totals	Grilse	Adults	Totals
Klamath River (below Hwy 101 bridge)	146	2,455	2,601	124	3,367	3,491	137	1,328	1,465
Trinity River basin (above Willow Creek)	923	9,433	10,356	2,735	9,341	12,076	209	3,054	3,263
Balance of Klamath system	4,367	8,281	12,648	2,552	9,495	12,047	1,921	4,393	6,314
Subtotals	5,436	20,169	25,605	5,411	22,203	27,614	2,267	8,775	11,042
Indian Net Harvest e/									
Klamath River (below Hwy 101 bridge)	36	39,978	40,014	138	36,914	37,052	0	37,130	37,130
Klamath River (Hwy 101 to Trinity mouth)	117	8,136	8,253	173	9,667	9,840	120	4,961	5,081
Trinity River (Hoopa Reservation)	262	4,982	5,244	267	5,070	5,337	71	3,474	3,545
Subtotals	415	53,096	53,511	578	51,651	52,229	191	45,565	45,756
Total In-river Harvest	5,851	73,265	79,116	5,989	73,854	79,843	2,458	54,340	56,798

IN-RIVER RUN

	1987			1988			1989		
Totals	Grilse	Adults	Totals	Grilse	Adults	Totals	Grilse	Adults	Totals
In-river Harvest and Escapement	18,901	204,105	223,006	23,894	186,698	210,592	9,037	120,199	129,236
Angling Mortality (2% of harvest) f/	109	403	512	108	444	552	45	176	221
Net Mortality (8% of harvest) f/	33	4,248	4,281	46	4,132	4,178	15	3,645	3,660
Total In-river Run	19,043	208,756	227,799	24,048	191,274	215,322	9,097	124,020	133,117

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Klamath River Basin Fall Chinook Salmon Spawner Escapement, In-river Harvest and Run-size Estimates 1978-2002 a/

SPAWNER ESCAPEMENT

	1990			1991			1992		
Hatchery Spawners	Grilse	Adults	Totals	Grilse	Adults	Totals	Grilse	Adults	Totals
Iron Gate Hatchery (IGH)	321	6,704	7,025	65	4,002	4,067	3,737	3,581	7,318
Trinity River Hatchery (TRH)	371	1,348	1,719	205	2,482	2,687	211	3,779	3,990
Subtotals	692	8,052	8,744	270	6,484	6,754	3,948	7,360	11,308
Natural Spawners									
Trinity River basin									
(above Willow Creek, excluding TRH)	241	7,682	7,923	382	4,867	5,249	2,563	7,139	9,702
Salmon River basin	596 l/	4,071 l/	4,667 l/	143	1,337	1,480	547	778	1,325
Scott River basin	236	1,379	1,615	146	2,019	2,165	965	1,873	2,838
Shasta River basin	118	415	533	10	716	726	66	520	586
Bogus Creek basin	53	732	785	20	1,261	1,281	556	598	1,154
Main Stem Klamath River									
(excluding IGH)	59	505	564	8	572	580	234	366	600
Misc. Klamath tributaries									
(above Hoopa and Yurok Reservations)	30	694	724	9	495	504	153	280	433
Hoopa and Yurok Reservation tribs.	17 k/	118 k/	135 k/	0 k/	382 k/	382 k/	59 k/	474 k/	533 k/
Subtotals	1,350	15,596	16,946	718	11,649	12,367	5,143	12,028	17,171
Total Spawner Escapement	2,042	23,648	25,690	988	18,133	19,121	9,091	19,388	28,479

IN-RIVER HARVEST

	1990			1991			1992		
Angler Harvest	Grilse	Adults	Totals	Grilse	Adults	Totals	Grilse	Adults	Totals
Klamath River (below Hwy 101 bridge)	58	291	349	19	314	333	13	20	33
Trinity River basin (above Willow Creek)	22	328	350	94	1,177	1,271	158	314	472
Balance of Klamath system	2,020	2,934	4,954	573	1,892	2,465	3,949	668	4,617
Subtotals	2,100	3,553	5,653	686	3,383	4,069	4,120	1,002	5,122
Indian Net Harvest e/									
Klamath River (below Hwy 101 bridge)	13	3,648	3,661	7	3,902	3,909	124	1,152	1,276
Klamath River (Hwy 101 to Trinity mouth)	141	3,447	3,588	25	5,016	5,041	200	3,687	3,887
Trinity River (Hoopa Reservation)	36	811	847	30	1,280	1,310	42	946	988
Subtotals	190	7,906	8,096	62	10,198	10,260	366	5,785	6,151
Total In-river Harvest	2,290	11,459	13,749	748	13,581	14,329	4,486	6,787	11,273

IN-RIVER RUN

	1990			1991			1992		
Totals	Grilse	Adults	Totals	Grilse	Adults	Totals	Grilse	Adults	Totals
In-river Harvest and Escapement	4,332	35,107	39,439	1,736	31,714	33,450	13,577	26,175	39,752
Angling Mortality (2% of harvest) f/	42	71	113	14	68	82	82	20	102
Net Mortality (8% of harvest) f/	15	632	647	5	816	821	29	463	492
Total In-river Run	4,389	35,810	40,199	1,755	32,598	34,353	13,688	26,658	40,346

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Klamath River Basin Fall Chinook Salmon Spawner Escapement, In-river Harvest and Run-size Estimates 1978-2002 a/

SPAWNER ESCAPEMENT

	1993			1994			1995		
Hatchery Spawners	Grilse	Adults	Totals	Grilse	Adults	Totals	Grilse	Adults	Totals
Iron Gate Hatchery (IGH)	883	20,828	21,711	758	11,475 m/	12,233	259	13,749 m/	14,008
Trinity River Hatchery (TRH)	736	815	1,551	4,442	3,264	7,706	76	15,178	15,254
Subtotals	1,619	21,643	23,262	5,200	14,739	19,939	335	28,927	29,262
Natural Spawners									
Trinity River basin (above Willow Creek, excluding TRH)	2,465	5,905	8,370	2,505	10,906	13,411	9,262	77,876	87,138
Salmon River basin	456	3,077	3,533	277	3,216	3,493	1,335	4,140	5,475
Scott River basin	265	5,035	5,300	505	2,358	2,863	3,279	11,198	14,477
Shasta River basin	85	1,341	1,426	1,840	3,363	5,203	695	12,816	13,511
Bogus Creek basin	431	3,285	3,716	443	7,817	8,260	1,207	45,225	46,432
Main Stem Klamath River (excluding IGH)	31 n/	647 n/	678 n/	625 n/	3,249 n/	3,874 n/	768 n/	6,472 n/	7,240 n/
Misc. Klamath tributaries (above Hoopa and Yurok Reservations)	92	2,470	2,562	50	1,202	1,252	744 o/	3,654 o/	4,398 o/
Hoopa and Yurok Reservation tribs.	0 h/	98 h/	98 h/	0 h/	222 h/	222 h/	34 p/	413 p/	447 p/
Subtotals	3,825	21,858	25,683	6,245	32,333	38,578	17,324	161,794	179,118
Total Spawner Escapement	5,444	43,501	48,945	11,445	47,072	58,517	17,659	190,721	208,380

IN-RIVER HARVEST

	1993			1994			1995		
Angler Harvest	Grilse	Adults	Totals	Grilse	Adults	Totals	Grilse	Adults	Totals
Klamath River (below Hwy 101 bridge)	23	669	692	246	662	908	323	956	1,279
Trinity River basin (above Willow Creek)	172	391	563	547	260	807	554	2,779	3,333
Balance of Klamath system	1,730	2,112	3,842	1,763	910	2,673	3,543	2,346 q/	5,889
Subtotals	1,925	3,172	5,097	2,556	1,832	4,388	4,420	6,081	10,501
Indian Net Harvest e/									
Klamath River (below Hwy 101 bridge)	62	3,017	3,079	81	4,362	4,443	137	5,119	5,256
Klamath River (Hwy 101 to Trinity mouth)	80	5,127	5,207	118	5,064	5,182	152	7,055	7,207
Trinity River (Hoopa Reservation)	33	1,492	1,525	94	2,266	2,360	268	3,383	3,651
Subtotals	175	9,636	9,811	293	11,692	11,985	557	15,557	16,114
Total In-river Harvest	2,100	12,808	14,908	2,849	13,524	16,373	4,977	21,638	26,615

IN-RIVER RUN

	1993			1994			1995		
Totals	Grilse	Adults	Totals	Grilse	Adults	Totals	Grilse	Adults	Totals
In-river Harvest and Escapement	7,544	56,309	63,853	14,294	60,596	74,890	22,636	212,359	234,995
Angling Mortality (2% of harvest) f/	39	63	102	51	37	88	88	122	210
Net Mortality (8% of harvest) f/	14	771	785	23	935	958	45	1,245	1,290
Total In-river Run	7,597	57,143	64,740	14,368	61,568	75,936	22,769	213,726	236,495

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Klamath River Basin Fall Chinook Salmon Spawner Escapement, In-river Harvest and Run-size Estimates 1978-2002 a/

SPAWNER ESCAPEMENT

	1996			1997			1998		
Hatchery Spawners	Grilse	Adults	Totals	Grilse	Adults	Totals	Grilse	Adults	Totals
Iron Gate Hatchery (IGH)	543	13,622	14,165	452	13,275	13,727	403	14,923	15,326
Trinity River Hatchery (TRH)	249	6,411	6,660	820	5,387	6,207	192	14,296	14,488
Subtotals	792	20,033	20,825	1,272	18,662	19,934	595	29,219	29,814
Natural Spawners									
Trinity River basin									
(above Willow Creek, excluding TRH)	4,478	42,646	47,124	2,845	11,507	14,352	1,974	24,460	26,434
Salmon River basin	274	5,189	5,463	217	5,783	6,000	116	1,337	1,453
Scott River basin	145	11,952	12,097	277	8,284	8,561	266	3,061	3,327
Shasta River basin	46	1,404	1,450	334	1,667	2,001	76	2,466	2,542
Bogus Creek basin	377	10,420	10,797	221	9,809	10,030	205	6,630	6,835
Main Stem Klamath River									
(excluding IGH)	218 n/	2,790 n/	3,008 n/	104 n/	3,472 n/	3,576 n/	109 n/	2,913 n/	3,022 n/
Misc. Klamath-Trinity tributaries									
(above Hoopa and Yurok Reservations)	581 o/	5,804 o/	6,385 o/	174 o/	5,174 o/	5,348 o/	83 o/	1,232 o/	1,315 o/
Hoopa and Yurok Reservation tribs.	55 p/	1,121 p/	1,176 p/	53 p/	448 p/	501 p/	26 p/	389 p/	415 p/
Subtotals	6,174	81,326	87,500	4,225	46,144	50,369	2,855	42,488	45,343
Total Spawner Escapement	6,966	101,359	108,325	5,497	64,806	70,303	3,450	71,707	75,157

IN-RIVER HARVEST

	1996			1997			1998		
Angler Harvest	Grilse	Adults	Totals	Grilse	Adults	Totals	Grilse	Adults	Totals
Klamath River (below Hwy 101 bridge)	100	3,110	3,210	49	2,182	2,231	124	1,603	1,727
Klamath River (Hwy 101 to Coon Cr Falls)	1,128	4,052	5,180	1,226	512	1,738	406	1,270	1,676
Trinity River basin (above Willow Creek)	331	1,214	1,545 r/	353	1,331	1,684 s/	275	3,262	3,537 u/
Balance of Klamath system	753	4,390	5,143	781	1,651	2,432 t/	303	1,575	1,878 v/
Subtotals	2,312	12,766	15,078	2,409	5,676	8,085	1,108	7,710 x/	8,818
Indian Net Harvest e/									
Klamath River (below Hwy 101 bridge)	163	49,113	49,276	21	5,574	5,595	16	3,454	3,470
Klamath River (Hwy 101 to Trinity mouth)	19	4,593	4,612	8	5,275	5,283	32	5,198	5,230
Trinity River (Hoopa Reservation)	8	2,770	2,778	6	1,238	1,244	5	1,535	1,540
Subtotals	190	56,476	56,666	35	12,087	12,122	53	10,187	10,240
Total In-river Harvest	2,502	69,242	71,744	2,444	17,763	20,207	1,161	17,897	19,058

IN-RIVER RUN

	1996			1997			1998		
Totals	Grilse	Adults	Totals	Grilse	Adults	Totals	Grilse	Adults	Totals
In-river Harvest and Escapement	9,468	170,601	180,069	7,941	82,569	90,510	4,611	89,604	94,215
Angling Mortality (2% of harvest) f/	46	255	301	48	114	162	22	154	176
Net Mortality (8% of harvest) f/	15	4518	4533	3	967	970	4	815	819
Total In-river Run	9,529	175,374	184,903	7,992	83,650	91,642	4,637	90,573	95,210

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Klamath River Basin Fall Chinook Salmon Spawner Escapement, In-river Harvest and Run-size Estimates
1978-2002 a/

SPAWNER ESCAPEMENT

	1999			2000			2001		
Hatchery Spawners	Grilse	Adults	Totals	Grilse	Adults	Totals	Grilse	Adults	Totals
Iron Gate Hatchery (IGH)	4,830	9,290	14,120	839	71,635	72,474	1,364	37,204	38,568
Trinity River Hatchery (TRH)	2,027	5,037	7,064	1,070	25,976	27,046	267	17,908	18,175
Subtotals	6,857	14,327	21,184	1,909	97,611	99,520	1,631	55,112	56,743
Natural Spawners									
Trinity River basin									
(above Willow Creek, excluding TRH)	4,154	6,753	10,907	3,376	23,468	26,844	1,336	35,991	37,327 cc/
Salmon River basin	110	670	780	228	1,544	1,772	743	2,607	3,350
Scott River basin	563	3,021	3,584	524	5,729	6,253	744	5,398	6,142
Shasta River basin	1,901	1,296	3,197	1,271	11,025	12,296	2,641	8,452	11,093
Bogus Creek basin	2,628	3,537	6,165	373	34,678	35,051	648	11,927	12,575
Main Stem Klamath River n/									
(excluding IGH)	630	1,978	2,608	184	3,271	3,455	1,016	9,832	10,848
Misc. Klamath-Trinity tributaries o/									
(above Hoopa and Yurok Reservations)	251	777	1,028	261	2,051	2,312	565	2,969	3,534
Hoopa and Yurok Reservation tribs. p/	210	425	635	177	962	1,139	54	657	711
Subtotals	10,447	18,457	28,904	6,394	82,728	89,122	7,747	77,833	85,580
Total Spawner Escapement	17,304	32,784	50,088	8,303	180,339	188,642	9,378	132,945	142,323

IN-RIVER HARVEST

	1999			2000			2001		
Angler Harvest	Grilse	Adults	Totals	Grilse	Adults	Totals	Grilse	Adults	Totals
Klamath River (below Hwy 101 bridge)	37	177	214	108	1,190	1,298	298	4,620	4,918
Klamath River (Hwy 101 to Coon Cr Falls)	869 y/	1,112 y/	1,981 y/	972	1,006	1,978	825	1,960	2,785
Klamath River (Coon Cr Falls to IGH)	138 z/	571 z/	709 z/	117	1,549	1,666 bb/	242	3,041	3,283
Trinity River basin above Weitchpec aa/	572	422	994	385	1,905	2,290	135	2,513	2,648
Subtotals	1616	2282	3898	1582	5650	7232	1,500	12,134	13,634
Indian Net Harvest e/									
Klamath River (below Hwy 101 bridge)	126	4,387	4,513	35	17,278	17,313	261	28,967	29,228
Klamath River (Hwy 101 to Trinity mouth)	49	7,295	7,344	140	6,175	6,315	78	4,724	4,802
Trinity River (Hoopa Reservation)	96	2,978	3,074	128	5,962	6,090	60	4,954	5,014
Subtotals	271	14,660	14,931	303	29,415	29,718	399	38,645	39,044
Total In-river Harvest	1,887	16,942	18,829	1,885	35,065	36,950	1,899	50,779	52,678

IN-RIVER RUN

	1999			2000			2001		
Totals	Grilse	Adults	Totals	Grilse	Adults	Totals	Grilse	Adults	Totals
In-river Harvest and Escapement	19,191	49,726	68,917	10,188	215,404	225,592	11,277	183,724	195,001
Angling Mortality (2% of harvest) f/	32	46	78	32	113	145	30	243	273
Net Mortality (8% of harvest) f/	22	1173	1195	24	2353	2377	32	3,092	3,124
Total In-river Run	19,245	50,945	70,190	10,244	217,870	228,114	11,339	187,059	198,398

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Klamath River Basin Fall Chinook Salmon Spawner Escapement, In-river Harvest and Run-size Estimates 1978-2002 a/

SPAWNER ESCAPEMENT

	2002			2003			2004		
Hatchery Spawners	Grilse	Adults	Totals	Grilse	Adults	Totals	Grilse	Adults	Totals
Iron Gate Hatchery (IGH)	1,296	23,665	24,961						
Trinity River Hatchery (TRH)	1,034	3,515	4,549						
Hatchery Spawner Subtotals:	**2,330**	**27,180**	**29,510**						
Natural Spawners									
Main Stem Klamath River n/ (excluding IGH)	658	21,650	22,308						
Shasta River basin	386	6,432	6,818						
Scott River basin	47	4,261	4,308						
Salmon River basin	72	2,486	2,558						
Bogus Creek basin	305	17,529	17,834						
Misc. Klamath tributaries o/ (above Yurok Reservation)	44	1,344	1,388						
Yurok Reservation tribs. (Klamath River) p/	12	339	351						
Klamath Natural Spawner Subtotals:	**1,524**	**54,041**	**55,565**						
Main Stem Trinity River dd/ (excluding TRH)	2,257	11,075	13,332						
Misc. Trinity tributaries o/ (above Hoopa Reservation)	66	324	390						
Hoopa Reservation tribs. (Trinity River) p/	42	206	248						
Trinity Natural Spawner Subtotals:	**2,365**	**11,605**	**13,970**						
Natural Spawner Subtotals:	**3,889**	**65,646**	**69,535**						
Total Spawner Escapement	**6,219**	**92,826**	**99,045**						

IN-RIVER HARVEST

	2002			2003			2004		
Angler Harvest	Grilse	Adults	Totals	Grilse	Adults	Totals	Grilse	Adults	Totals
Klamath River (below Hwy 101 bridge)	274	3,285	3,559						
Klamath River (Hwy 101 to Coon Cr Falls)	283	3,269	3,552						
Klamath River (Coon Cr Falls to IGH)	93	3,216	3,309						
Trinity River basin above Weitchpec aa/	221	640	861						
Angler Harvest Subtotals:	**871**	**10,410**	**11,281**						
Indian Net Harvest e/									
Klamath River (below Hwy 101 bridge)	17	19,701	19,718						
Klamath River (Hwy 101 to Trinity mouth)	41	3,257	3,298						
Trinity River (Hoopa Reservation)	68	1,168	1,236						
Indian Net Harvest Subtotals:	**126**	**24,126**	**24,252**						
Total In-river Harvest	**997**	**34,536**	**35,533**						

IN-RIVER RUN

	2002			2003			2004		
Totals	Grilse	Adults	Totals	Grilse	Adults	Totals	Grilse	Adults	Totals
In-river Harvest and Escapement	7,216	127,362	134,578						
Angling Mortality (2% of harvest) f/	17	209	226						
Net Mortality (8% of harvest) f/	10	1,930	1,940						
Fish Die Off ee/	2,003	30,550	32,553						
Total In-river Run	**9,246**	**160,051**	**169,297**						

(continued next page)

Year	Grilse	Adults	Total						
1978	22,722	92,835	115,557						
1979	11,665	51,199	62,864						
1980	36,764	45,554	82,318						**Total**
1981	28,110	80,061	108,171						**82-'02**
1982	39,391	66,509	105,900						105900
1983	3,845	57,490	61,335						61335
1984	8,277	47,131	55,408						55408
1985	69,374	64,356	133,730						133730
1986	44,530	194,836	239,366						239366
1987	19,043	208,756	227,799						227799
1988	24,048	191,274	215,322						215322
1989	9,097	124,020	133,117						133117
1990	4,389	35,810	40,199						40199
1991	1,755	32,598	34,353						34353
1992	13,688	26,658	40,346						40346
1993	7,597	57,143	64,740						64740
1994	14,368	61,568	75,936						75936
1995	22,769	213,726	236,495						236495
1996	9,529	175,374	184,903						184903
1997	7,992	83,650	91,642	% of all previous years					91642
1998	4,637	90,573	95,210	0.250413	0.88472				95210
1999	19,245	50,945	70,190	1.039292	0.497632	0.5806			70190
2000	10,244	217,870	228,114	0.553209	2.128161	1.886921			228114
2001	11,339	187,059	198,398	0.612342	1.827198	1.641115			198398
2002	9,246	160,051	169,297						169297
Average:	18,517	102,375	120,892 *					**avg.**	128657.1

* In-River Runs from 1978 to Present Year-1

Klamath River Basin Fall-Run Chinook Salmon Run-size Estimates, 1978-2002

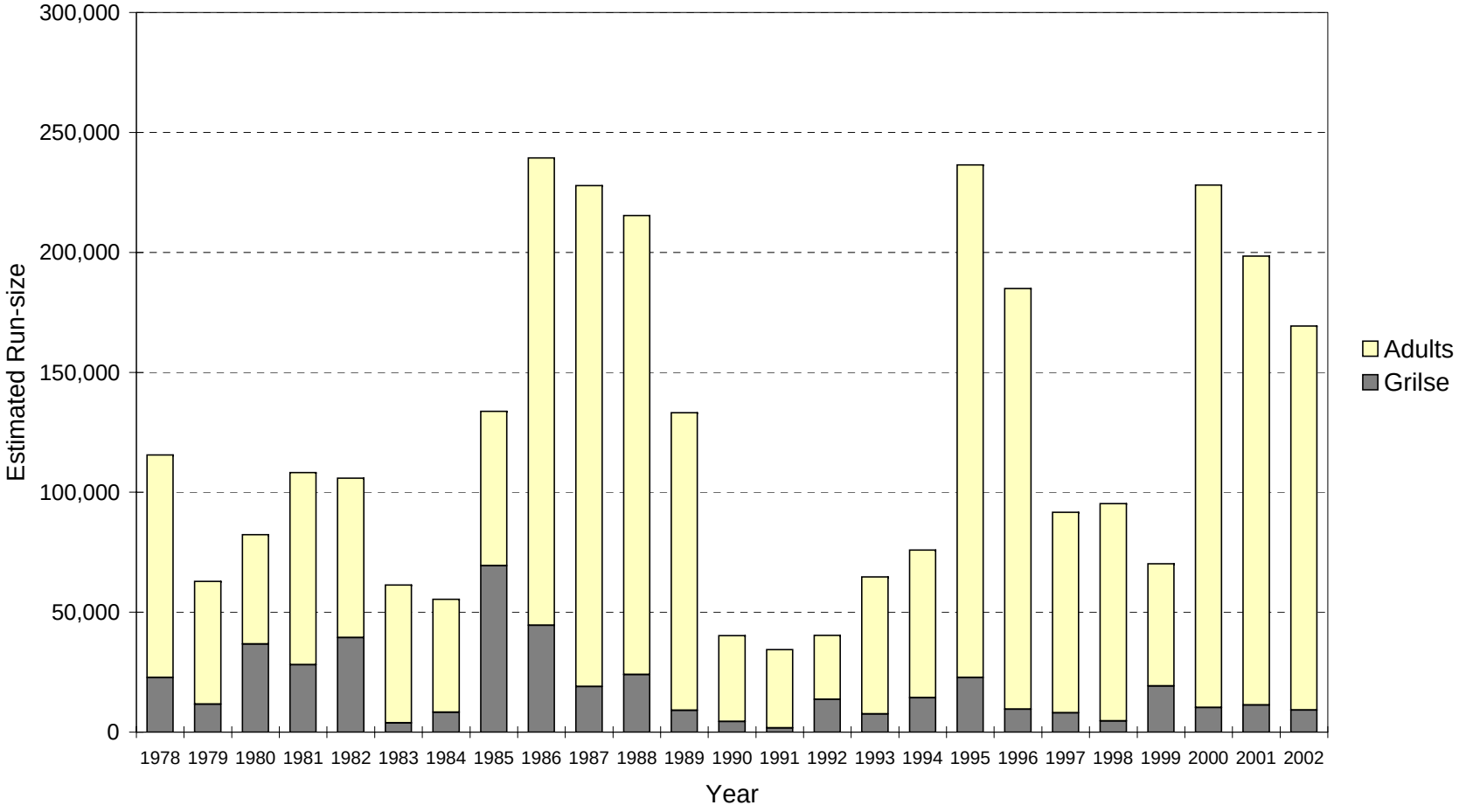

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Table B1-2

Estimated Trinity River Spring Chinook Run-size, Spawning Escapement, Angler Harvest, and Origin of Spawners Upstream of Junction City Weir (1977-2002) (W. Sinnen, CDFG, personal communication, 2003).

Year	Run Size Estimate	Total Basin Escapement	Inriver Spawner Escapement	Angler Harvest	TRSSH Escapement	TRFH Ad Clip Rate	JCW Ad Clip Rate	% Hatchery	Hatchery Produced Inriver Escapement	Natural Produced Inriver Escapement	Inriver % Natural
1977					1,509						
1978	19,006	18,246	14,413	760	3,833						
1979	8,077	6,779	5,008	1298	1,771						
1980	4,250	3,826	2,926	424	900						
1981	8,260	6,104	3,604	2156	2,500						
1982	6,387	5,631	4,255	756	1,376	0.753	0.489	64.9%	3,657	1,974	46%
1983					1,158						
1984	2,720	2,306	1,494	414	812	0.319	0.028	8.8%	202	2,104	141%
1985	9,712	8,849	5,696	863	3,153	0.24	0.223	92.9%	8,222	627	11%
1986	30,421	26,250	17,706	4171	8,544	0.097	0.174	100.0%	26,250	0	0%
1987	50,874	41,513	31,660	9361	9,853	0.138	0.135	97.8%	40,611	902	3%
1988	62,692	53,852	39,570	8840	14,282	0.13	0.115	88.5%	47,638	6,214	16%
1989	26,306	23,676	18,676	2630	5,000	0.145	0.131	90.3%	21,390	2,286	12%
1990	6,388	5,543	3,006	845	2,537	0.149	0.125	83.9%	4,650	893	30%
1991	2,381	2,045	1,360	336	685	0.088	0.061	69.3%	1,418	627	46%
1992	4,030	3,732	1,886	298	1,846	0.118	0.069	58.5%	2,182	1,550	82%
1993	5,232	4,809	2,148	423	2,661	0.083	0.091	100.0%	4,809	0	0%
1994	6,788	6,334	3,447	454	2,887	0.22	0.17	77.3%	4,894	1,440	42%
1995 a/					8,722						
1996	23,416	21,903	16,653	1513	5,250	0.168	0.113	67.3%	14,750	7,153	43%
1997	20,039	18,709	13,592	1330	5,117	0.124	0.064	51.8%	9,688	9,021	66%
1998	16,167	14,487	9,624	1680	4,863	0.160	0.117	72.8%	10,550	3,937	41%
1999	11,293	10,626	6,408	667	4,218	0.198	0.145	73.1%	7,765	2,861	45%
2000	26,082	24,275	12,110	1807	12,165	0.236	0.195	82.7%	20,081	4,194	35%
2001	19,621	18,457	11,462	1164	6,995	0.259	0.189	73.1%	13,489	4,968	43%
2002 b/	38,565	36,690	25,633	1875	11,057	0.211	0.152	71.7%	26,320	10,370	40%
Years		**('78-'82, '84-'94, '96-'02)**			**('77-'02)**					**('82,'84-94, '96-'02)**	
Average	**17,770**	**15,854**	**10,971**	**1,916**	**4,757**				**14,135**	**3,217**	**39.1%**
Min	**2,381**	**2,045**	**1,360**	**298**	**685**				**202**	**0**	**0.0%**
Max	**62,692**	**53,852**	**39,570**	**9,361**	**14,282**				**47,638**	**10,370**	**100.0%**

a/ the Junction City weir was not operated in 1995

b/ all data from 2002 is preliminary

Table B1-3

Estimated Trinity River Fall Chinook Salmon Run-size, Spawning Escapement, Angler Harvest, and Origin of Spawners Upstream of Junction City Weir (1977-2002) (W. Sinnen, DFG, personal communication, 2003)

Year	Run Size Estimate	Total Basin Escapement	Inriver Spawner Escapement	TRSSH Escapement	Angler Harvest	WCW Ad Clip Rate	TRFH Ad Clip Rate	Basin % Hatchery	Hatchery Produced Inriver Escapement	Natural Produced Inriver Escapement	Total Inriver spawners	Inriver % Natural
1977	32,914	27,450	23,238	4,212	5,464							35.6%
1978	43,123	43,123	35,764	7,359	0							17.8%
1979	16,185	14,263	11,964	2,299	1,922							49.2%
1980	34,346	30,892	24,537	6,355	3,454							9.7%
1981	29,250	24,620	21,246	3,374	4,630							22.7%
1982	28,591	23,716	17,423	6,293	4,875	0.161	0.218	73.9%	17,515	6,201	17,423	35.6%
1983	26,378	23,902	18,137	5,765	2,476	0.128	0.148	86.5%	20,672	3,230	18,137	17.8%
1984	13,131	12,002	9,070	2,932	1,129	0.081	0.129	62.8%	7,536	4,466	9,070	49.2%
1985	65,016	59,420	38,671	20,749	5,596	0.192	0.205	93.7%	55,652	3,768	38,671	9.7%
1986	147,888	132,411	113,007	19,404	15,477	0.216	0.268	80.6%	106,719	25,692	113,007	22.7%
1987	104,612	94,256	77,869	16,387	10,356	0.197	0.221	89.1%	84,020	10,236	77,869	13.1%
1988	89,422	77,346	55,242	22,104	12,076	0.111	0.134	82.8%	64,070	13,276	55,242	24.0%
1989	46,622	43,359	31,988	11,371	3,263	0.068	0.103	66.0%	28,625	14,734	31,988	46.1%
1990	9,992	9,642	7,923	1,719	350	0.060	0.128	46.9%	4,520	5,122	7,923	64.7%
1991	9,207	7,936	5,249	2,687	1,271	0.083	0.118	70.3%	5,582	2,354	5,249	44.8%
1992	14,164	13,692	9,702	3,990	472	0.039	0.118	33.1%	4,525	9,167	9,702	94.5%
1993	10,485	9,921	8,370	1,551	563	0.040	0.182	22.0%	2,180	7,741	8,370	92.5%
1994	21,924	21,117	13,411	7,706	807	0.084	0.128	65.6%	13,858	7,259	13,411	54.1%
1995	105,725	102,392	87,138	15,254	3,333	0.059	0.099	59.6%	61,021	41,371	87,138	47.5%
1996	55,646	53,784	47,124	6,660	1,862	0.048	0.115	41.5%	22,338	31,446	47,124	66.7%
1997	21,347	20,559	14,352	6,207	788	0.075	0.148	50.6%	10,396	10,163	14,352	70.8%
1998	43,189	40,922	26,434	14,488	2,267	0.070	0.106	65.8%	26,928	13,994	26,434	52.9%
1999	18,516	17,971	10,907	7,064	545	0.101	0.138	73.6%	13,234	4,737	10,907	43.4%
2000	55,473	53,890	26,844	27,046	1,583	0.176	0.228	77.4%	41,686	12,204	26,844	45.5%
2001	57,109	55,241	37,066	18,175	1,868	0.196	0.297	66.0%	36,477	18,764	37,066	50.6%
2002 a/	18,156	17,429	12,876	4,553	727	0.126	0.212	59.4%	10,359	7,070	12,876	54.9%
Years:			**(1977-2002)**							**(1982-2002)**		
Average	**43,016**	**39,664**	**30,214**	**9,450**	**3,352**			**65.1%**	**30,377**	**12,047**	**31,848**	**42.3%**
Min	**9,207**	**7,936**	**5,249**	**1,551**	**0**			**22.0%**	**2,180**	**2,354**	**5,249**	**9.7%**
Max	**147,888**	**132,411**	**113,007**	**27,046**	**15,477**			**93.7%**	**106,719**	**41,371**	**113,007**	**94.5%**

a/ all data from 2002 is preliminary

Table B1-4

Estimated Trinty River Coho Salmon Run-size, Spawning Escapement, Angler Harvest, and Origin of Spawners Upstream of Willow Creek Weir (1977-2002). (W.

Year	Run Size Estimate	Total Basin Escapement	Inriver Spawner Escapement	TRSSH Escapement	TRFH Ad Clip Rate	WCW Ad Clip Rate	Basin % Hatchery	Angler Harvest	Hatchery Produced Inriver Escapement	Natural Produced Inriver Escapement	% Natural
1977	3,858	3,709	1,781	1,928				149			
1978	9,132	9,132	5,477	3,655				0			
1979	11,624	10,797	7,262	3,535				827			
1980	6,094	6,094	2,771	3,323				0			
1981	10,970	10,004	5,481	4,523				966			
1982	11,529	11,053	6,255	4,798				476			
1983	1,971	1,789	1,083	706				182			
1984	19,694	18,020	9,159	8,861				1674			
1985	38,933	38,170	26,384	11,786				763			
1986	27,972	27,272	19,281	7,991				700			
1987	59,079	55,711	32,373	23,338				3368			
1988	38,904	36,943	24,127	12,816				1961			
1989	18,752	18,452	13,482	4,970				300			
1990	3,897	3,850	2,215	1,635				47			0%
1991	9,124	9,015	6,327	2,688	0.003	0.003	100.0%	109	9,015	0	0%
1992	10,339	10,315	6,733	3,582	0.100	0.091	91.0%	24	9,387	928	14%
1993	5,621	5,557	3,440	2,117	0.136	0.134	98.5%	64	5,475	82	2%
1994	852	852	558	294	0.061	0.070	100.0%	0	852	0	0%
1995	16,111	15,817	11,050	4,767	0.097	0.104	100.0%	294	15,817	0	0%
1996	36,660	36,412	26,457	9,955				248			
1997	7,935	7,893	6,135	1,758	0.981	0.918	93.6%	42	7,386	507	8%
1998	12,480	12,480	7,489	4,991	0.975	0.931	95.5%	0	11,923	557	7%
1999	5,535	5,437	1,930	3,507	0.968	0.904	93.4%	98	5,076	361	19%
2000	15,532	15,532	11,145	4,387	0.985	0.966	98.0%	0	15,225	307	3%
2001	32,140	32,140	21,359	10,781	0.988	0.895	90.6%	0	29,124	3,016	14%
2002 a/	16,016	16,016	8,818	7,198	0.986	0.946	96.0%	0	15,370	646	7%
Years:				**('77-'02)**					**('91-'95, '97-'02)**		
Average:	**16,567**	**16,095**	**10,330**	**5,765**				**473**	**11,332**	**582**	**7%**
Min:	**852**	**852**	**558**	**294**				**0**	**852**	**0**	**0%**
Max:	**59,079**	**55,711**	**32,373**	**23,338**				**3,368**	**29,124**	**3,016**	**19%**

a/ all data from 2002 is preliminary

Table B1-5

Estimated Trinty River Winter Steelhead Run-size, Spawning Escapement, Angler Harvest, and Origin of Spawners Upstream of the Willow Creek Weir (1977-2002). (W. Sinnen, CDFG, personal commumication, 2003)

Year	Run Size	Total Basin Escapement	Inriver Spawners	Angler Harvest	TRSSH Escapement	Hatchery Produced Inriver Escapement	Natural Produced Inriver Escapement	% Hatchery Origin	% Natural Origin
1977					285				
1978					683				
1979					382				
1980	25,094	21,568	19,563	3,526	2,005	5,101	14,462	26%	74%
1981					1,004				
1982	10,532	8,573	7,860	1,959	713	971	6,889	12%	88%
1983	8,605	7,260	6,661	1,345	599				
1984	7,833	6,572	6,430	1,261	142				
1985					461				
1986					3,780				
1987					3,007				
1988	12,743	12,743	11,926		817				
1989	37,276	33,698	28,933	3,578	4,765				
1990	5,348	4,118	3,188	1,230	930				
1991	11,417	9,077	8,631	2,340	446				
1992	3,046	2,754	2,299	292	455	759	1,540	33%	67%
1993	3,243	2,862	1,977	381	885	801	1,176	41%	59%
1994	4,244	3,699	3,288	545	411	878	2,410	27%	73%
1995	4,288	3,996	3,291	292	705	1,424	1,867	43%	57%
1996	10,435	9,842	5,830	593	4,012				
1997	5,212	4,696	4,267	516	429				
1998	2,972	2,904	2,463	68	441				
1999	5,470	5,388	3,817	82	1,571				
2000	8,042	7,865	7,097	177	768				
2001	12,638	12,271	9,938	367	2,333				
2002 a/	19,058	18,302	12,264	756	6,038	7,907	4,636	64%	38%
Years:		**('80,82-'84,'88-'02)**		**('80,'82-'84,'89-'02)**	**('77-'02)**		**('80,'82,'92-'95,'02)**		
Average:	**10,395**	**9,378**	**7,880**	**1,073**	**1,464**	**2,549**	**4,711**	**35%**	**65%**
Min:	**2,972**	**2,754**	**1,977**	**68**	**142**	**759**	**1,176**	**12%**	**38%**
Max:	**37,276**	**33,698**	**28,933**	**3,578**	**6,038**	**7,907**	**14,462**	**64%**	**88%**
Average('92-'95, '02)	**6,776**	**6,323**	**4,624**	**453**	**1,699**	**2,354**	**2,326**	**42%**	**59%**

a/ all data from 2002 is preliminary

Attachment B2
Memorandum from Daryl Peterson, Trinity Restoration Program: "Preliminary Results from Monitoring the Trinity River Fall Flows Action Plan"

Trinity River Restoration Program

P.O. Box 1300, 1313 South Main Street, Weaverville, California 96093
Telephone: 530-623-1800, Fax: 530-623-5944

NC-156

MEMORANDUM

TO: Mike Ryan, Northern California Area Manager
Russell Smith, Environmental Resources Division Chief

FROM: Daryl Peterson, Trinity River Restoration Program, Technical Modeling Branch Chief

SUBJECT: Preliminary Results From Monitoring the Trinity River Fall Flows Action Plan

CC: Doug Schleusner, Executive Director, Trinity River Restoration Program

Introduction

In a March 5, 2003 court hearing, Judge Oliver Wanger directed the Department of the Interior to determine what actions would be necessary to "assure against the risk of fish losses that occurred late in the season last year." Judge Wanger subsequently issued a ruling on April 4, 2003 allowing Reclamation to use an additional 50,000 af from the Trinity River Division of the Central Valley Project "at its reasonable discretion" to prevent a recurrence of the September 2002 fish die-off.

In fall of 2003 an Action Plan was developed that recommended increased Trinity River flows to reduce the likelihood, and potentially reduce the severity, of a fish die-off occurring during the fall run Chinook salmon migration. The Action Plan provided flows known to be adequate for unimpaired salmon migration through the lower Klamath River. It was expected that increasing flows would reduce or eliminate adverse in-river conditions that contributed to the adult fish die-off of 2002.

An initial presentation of increased late-summer Trinity River dam release options and request for written comments was given at the TMC meeting on June 26, 2003. Written comments were received through July 18, 2003. A technical workgroup of state, federal, and tribal biologists was convened on July 23 and 24, 2003, to consider comments received and evaluate alternatives. That group developed a revised alternative, the Action Plan Flows option, that addresses these concerns. Additional updates were provided to a broadly representative group of stakeholders on July 29, 2003, at a TAMWG meeting in Weaverville, California, and a TMC conference call on July 30, 2003. A letter of support for the proposed action was forwarded directly to the Secretary of the Interior from the TMC and TAMWG in a letter dated August 8, 2003.

The need for implementing the Action Plan was both biological and legal in nature. In 2002, low flow conditions in the lower Klamath River, warm water temperatures, and an above average fall run Chinook salmon escapement combined to create conditions favorable to an epizootic outbreak resulting in a fish die-off. Biological consequences of a die-off in two consecutive years would substantially impact present efforts to restore the native Trinity River anadromous fish community and fishery. Reductions in the Trinity River fish

population would also affect Tribal fishery harvest opportunities, ocean harvest levels, recreational fishing, as well as public perception and recovery mandates. Last year's loss of 3 year-old and a potential loss of 4 year-old fish from the 1999 brood year affect the population structure, and may impede recovery goals authorized by the Trinity River Division Central Valley Project Act of 1955 (P.L. 84-386), the Trinity River Basin Fish and Wildlife Act of 1984 (P.L. 98-541), and the Central Valley Project Improvement Act of 1992 (P.L. 102-575), for naturally produced fall run Chinook salmon.

Projected flow conditions and a large fall run Chinook salmon escapement on the lower Klamath River in 2003 were similar to conditions that existed during the die-off in 2002. The two triggers established for initiating the preventive flow release (low flow and a large return of fall run Chinook salmon) were met as of August 20, 2003. Therefore, Reclamation implemented the release schedule proposed in the Action Plan as a preventative means to reduce the likelihood of another fish die-off in 2003.

Methods

The Action Plan used a conservative risk management approach to avert another fish die-off in 2003. The Action Plan had two flow components. The first component was a preventative flow release, using 33,000 acre-ft (af) of water. The preventative flow was intended to reduce the likelihood of a large scale fish die-off by ensuring adequate conditions for adult upstream migration though the lower Klamath River. The second component was an emergency response flow release, using an additional 17,000 af of water. This flow would be implemented to decrease the severity of a fish die-off if real-time monitoring indicated a rapid spread of the incidence and severity of the disease Ich.

Implementing components of the Action Plan were dependant on separate triggers for initiating preventive and emergency response flow releases. Triggers for initiating the preventive flow release were: (1) a fall run Chinook salmon population size estimate of greater than 110,000 for the Klamath Basin, and (2) a flow of less than 3,000 cfs in the lower Klamath River. Triggers for initiating the emergency response flow release would have been an estimated doubling in less than 7 days of either the incidence (proportion of fish infected) or severity (number of parasites per gill) of Ich. Evaluation of emergency action triggers were based on real-time monitoring of disease incidence conducted by the U.S. Fish & Wildlife Service, Fish Health Center, the Yurok Tribe, the Karuk Tribe and California Department of Fish & Game.

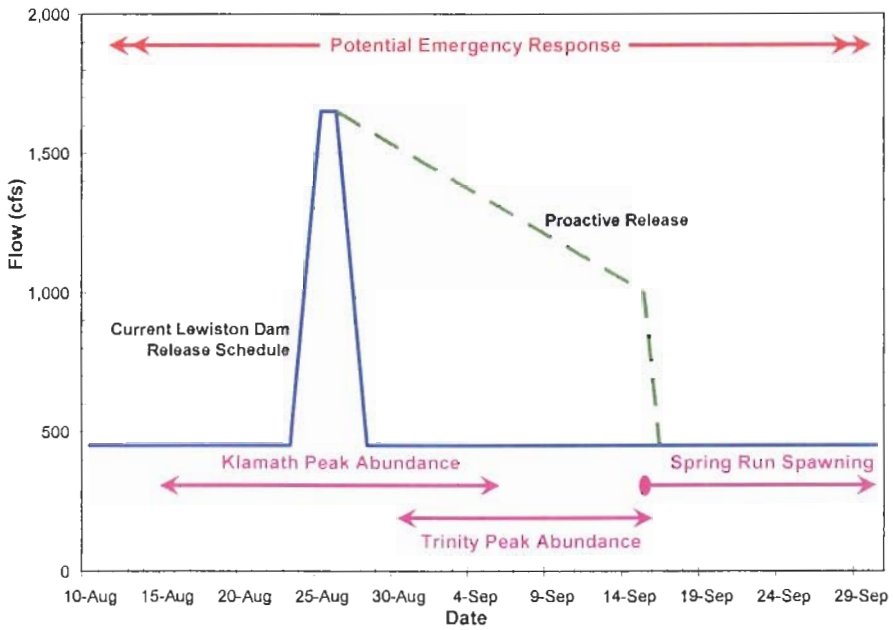


Figure 1. Daily Flow Schedule for Preventative Component of Action Plan.

Existing monitoring programs managed by the U.S. Fish & Wildlife Service, California Department of Fish & Game, the Hoopa Valley Tribe, the Yurok Tribe and the Karuk Tribe assessed the physical and biological effects associated with the Action Plan. Monitoring activities included weir counts, carcass and redd surveys, water temperature, water quality, angler and tribal harvest rates and adult salmon radio tracking, as well as disease incidence and severity from the real-time monitoring used as the trigger for the emergency action component of the Action Plan. Refugia dives and float surveys upstream of the Trinity River confluence were also conducted to evaluate the possibility of unintended effects on Klamath mainstem migrating adults.

Results

Results reported in this memo are preliminary and have not been peer reviewed for consistency with other findings and are subject to revision.

Figures 2, and 3 summarize results of key monitoring to assess effectiveness of the Action Plan release schedule. Additional information on run timing and migration patterns from weir operation, angler and tribal harvest and radio tracking studies is currently being prepared and will be reported in subsequent revisions of this memo.

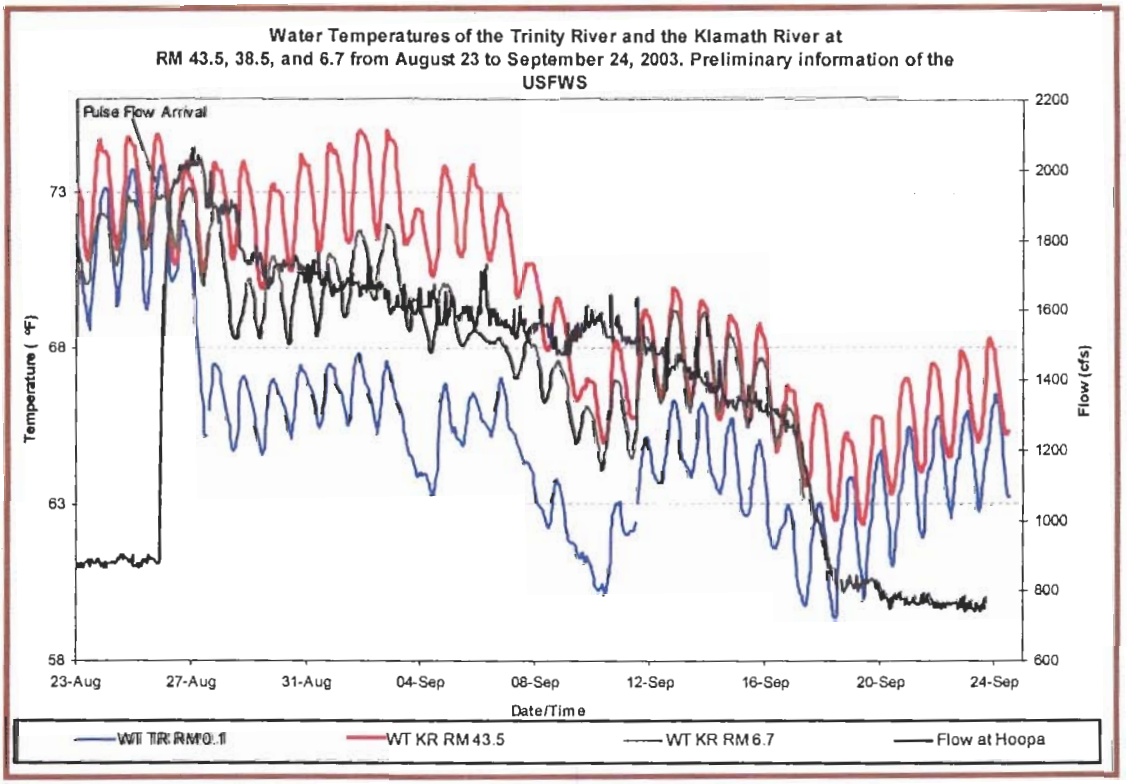


Figure 2. Trinity River flows reduce lower Klamath River water temperatures during the preventative action release schedule. River flow at Hoopa (black) during the fall of 2003, water temperature for the lower Trinity River near Hoopa (blue), Klamath River above Weitchpec (red) and lower Klamath River below the Trinity River confluence (green). Water temperatures above 71.6F inhibit adult Klamath Basin Chinook salmon migration. Preliminary data from Paul Zedonis, Fish & Wildlife Service, Arcata Field Office.

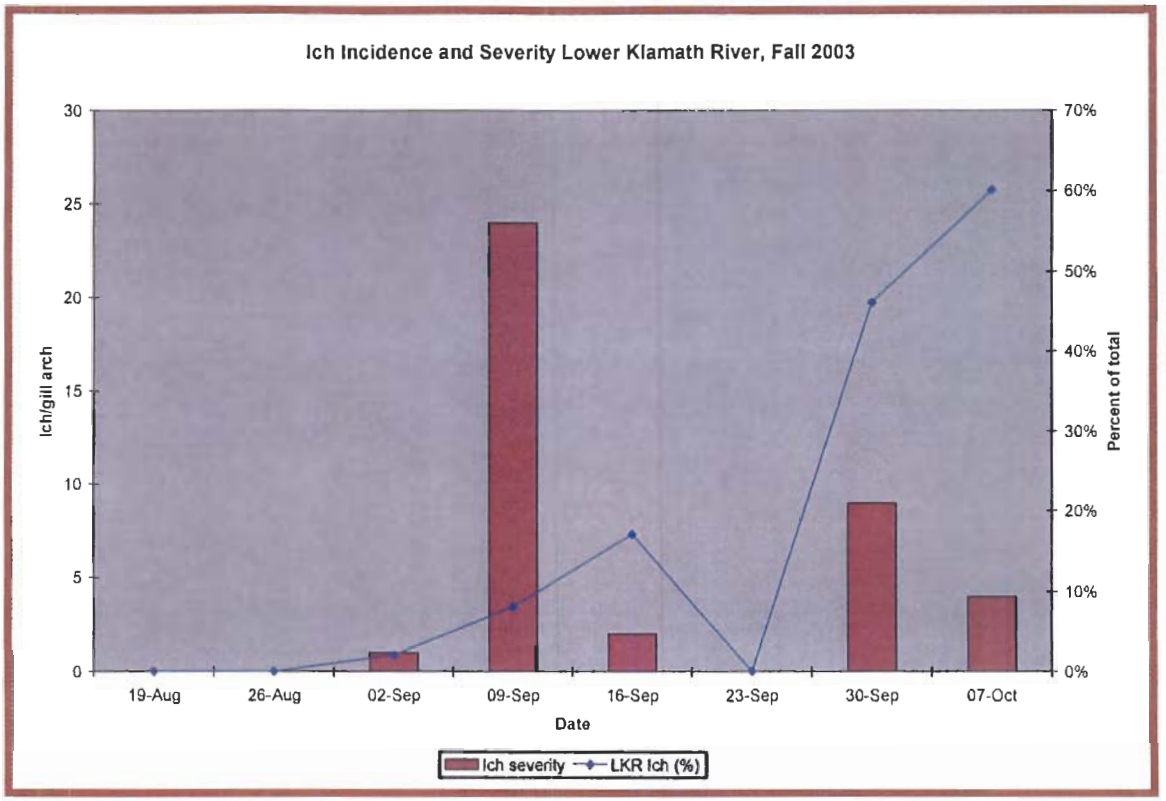


Figure 3. Incidence and severity of Ich (*Ichthyophthirius multifiliis*) on fall run Chinook salmon in the lower Klamath River during the fall of 2003. Disease incidence is reported as proportion of sampled fish with parasites (blue line). Severity is reported as the number of parasites per gill arch (red bars). Standard deviations not reported. Low value for incidence on 23 September is due to low sample size (n=10). Severity values greater than 30 parasites /gill arch is considered to a lower threshold for notable physiological stress. Preliminary data from Scott Foott, Fish & Wildlife Service, Fish Health Center, Red Bluff, Ca.

In addition, two preliminary conclusions from radio tracking studies to understand use of thermal refugia by adult Chinook salmon are relevant to the Trinity River fall flows (Josh Strange, University of Washington pers. com.).

- temperatures above 22C (71.6F) inhibit adult Chinook salmon migration and
- Fish die-off prevention flows from Trinity Dam substantially lowered temperatures in the lower Trinity and Klamath Rivers. During these higher flows thermal refugia use and migration delays were minimal among tagged Chinook salmon.

Conclusions

Monitoring results indicate that implementing the 2003 Trinity River Fall Flows Action Plan was successful in reducing the risk of a major die-off event. No observations of significant adult mortality were noted and the preventative flow schedule maintained water temperatures and flow magnitudes known to provide adequate fish migration in the lower Klamath River, specifically water temperatures were kept below 22C and flows near Klamath, Ca. (Terwar gage) greater than 3000 cfs.

Fall run Chinook salmon migration was unimpeded. Radio tracking of tagged fish demonstrated that migration delays were minimal. Congregations of large numbers of fish at known thermal refugia areas and

below critical riffles and rapids were not noted by divers. Observations of fish above the confluence of the Trinity River did not note any negative migration, or health effects to Klamath mainstem Chinook salmon due to these artificially increased flows.

Emergency response flows were not called for although monitoring revealed disease incidence increased throughout the sample period and a doubling did occur. Incidence of Ich did not exceed 20% (10% was assumed to be an acceptable background value) until late September by this time the majority of the fish had migrated out of the lower Klamath and monitoring indicated that disease severity was kept at a low level and therefore did not pose a threat to the physiological health of infected fish.

Spring run Chinook salmon spawning was not affected in the upper Trinity River by the preventative flow schedule. Weekly redd counts in the Trinity River immediately below Lewiston Dam indicate that minimal spawning occurred before September 15, 2003. Lewiston Dam releases returned to the normal (450 cfs) on September 16, 2003. Those redds noted were not threatened by de-watering following flow reductions. Anecdotal reports indicate that fish condition was excellent throughout the run (Loren Everest, Forest Service, Trinity River Management Unit pers. com.).

Attachment B3
Trinity River Basin Water Year Type Classifications

TRINITY RIVER MAINSTEM FISHERY RESTORATION SEIS/R

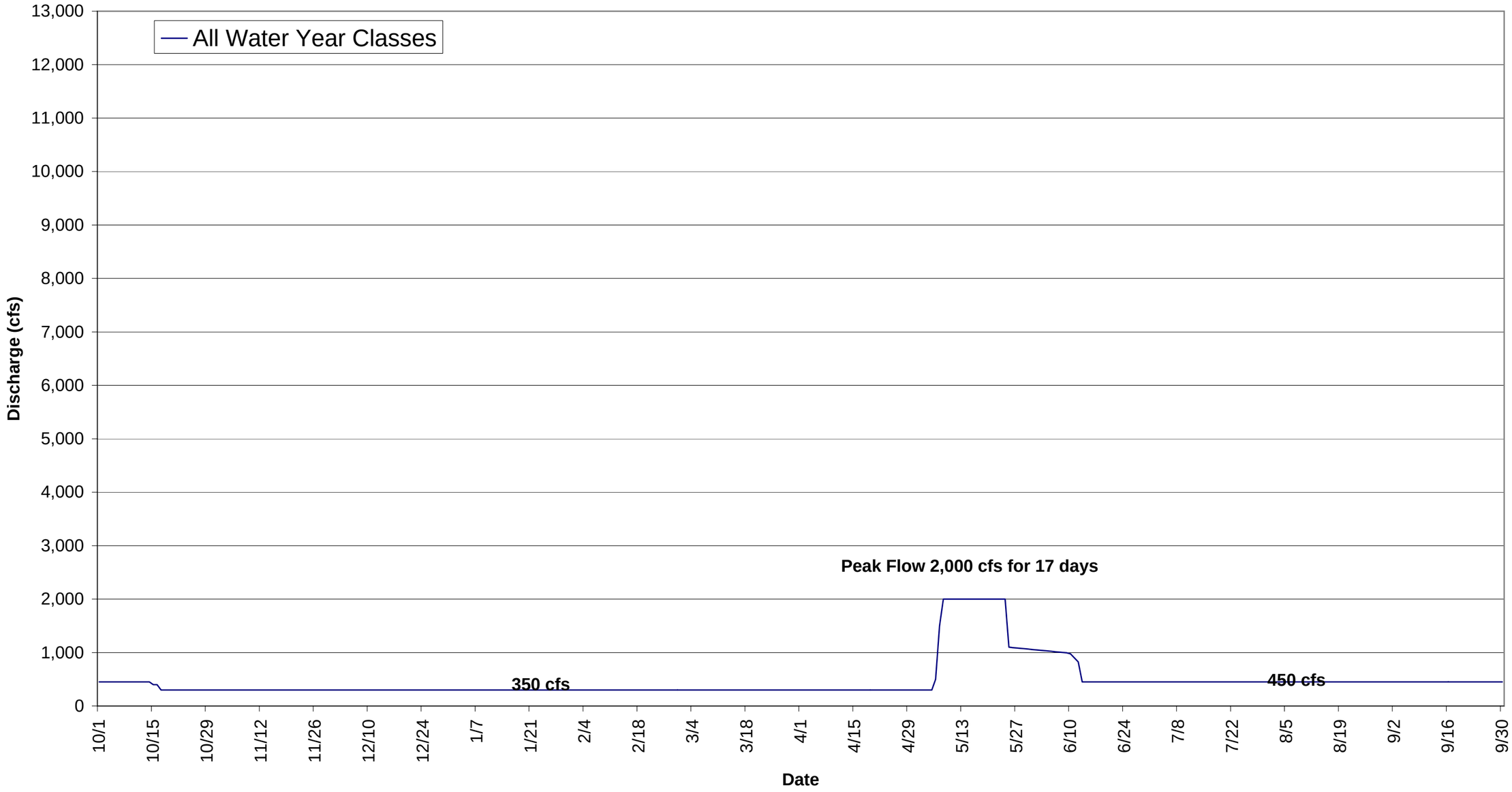
TRINITY RIVER BASIN WATER YEAR TYPE DESIGNATIONS

YEAR	CATEGORY	YEAR TYPE
1973	2	Wet
1974	1	Extremely Wet
1975	2	Wet
1976	4	Dry
1977	5	Critically Dry
1978	1	Extremely Wet
1979	4	Dry
1980	2	Wet
1981	4	Dry
1982	1	Extremely Wet
1983	1	Extremely Wet
1984	2	Wet
1985	4	Dry
1986	2	Wet
1987	4	Dry
1988	4	Dry
1989	3	Normal
1990	4	Dry
1991	5	Critically Dry
1992	4	Dry
1993	2	Wet
1994	5	Critically Dry
1995	1	Extremely Wet
1996	2	Wet
1997	2	Wet
1998	1	Extremely Wet
1999	2	Wet
2000	2	Wet
2001	4	Dry
2002	3	Normal

Attachment B4
Weekly Flows Schedules and Hydrographs for Proposed Alternatives

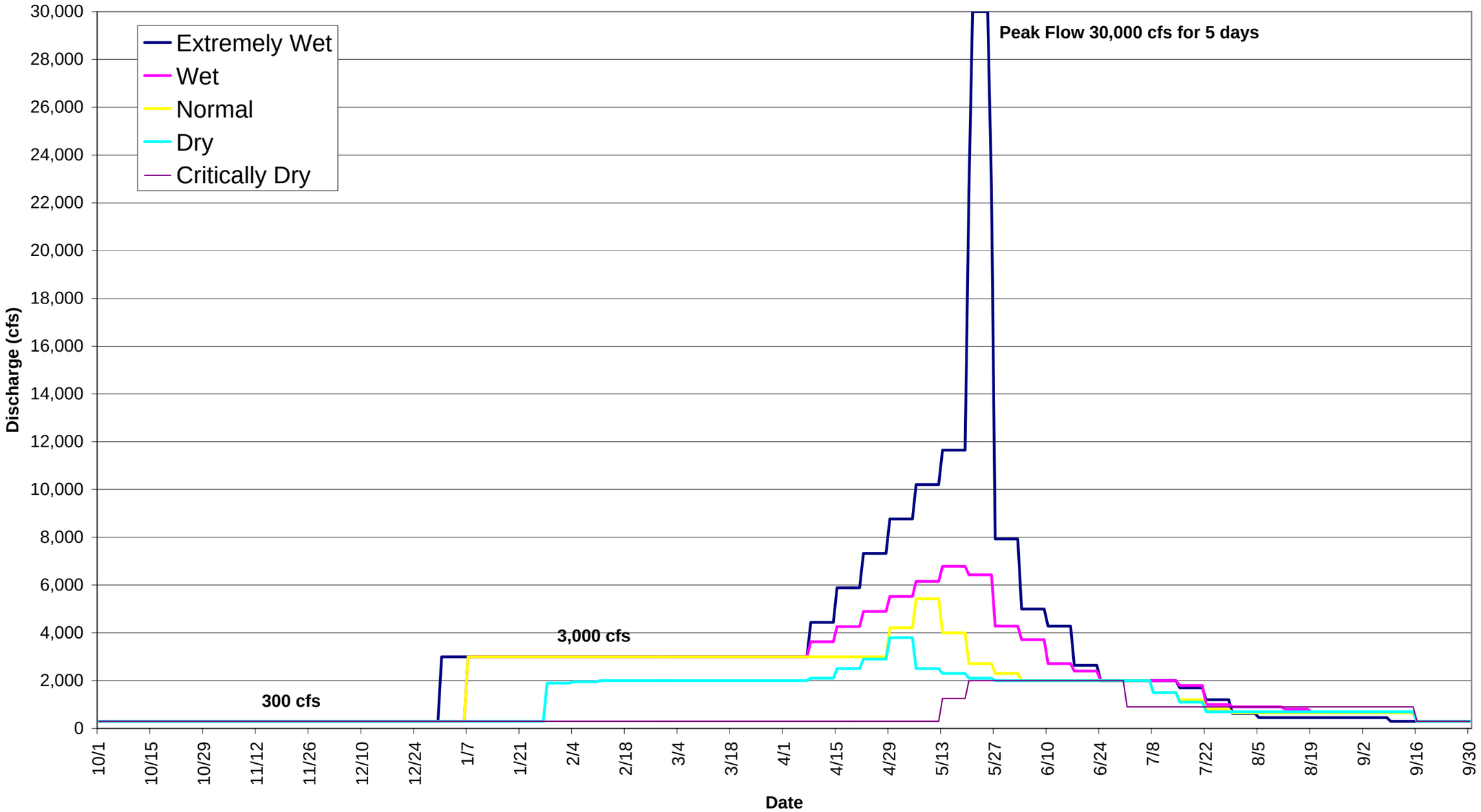
No Action Alternative		
		Flows (cfs)
Week Beginning	Week	All Water Year Classes
01-Oct	1	450
08-Oct	2	450
15-Oct	3	400
22-Oct	4	300
29-Oct	5	300
05-Nov	6	300
12-Nov	7	300
19-Nov	8	300
26-Nov	9	300
03-Dec	10	300
10-Dec	11	300
17-Dec	12	300
24-Dec	13	300
31-Dec	14	300
07-Jan	15	300
14-Jan	16	300
21-Jan	17	300
28-Jan	18	300
04-Feb	19	300
11-Feb	20	300
18-Feb	21	300
25-Feb	22	300
04-Mar	23	300
11-Mar	24	300
18-Mar	25	300
25-Mar	26	300
01-Apr	27	300
08-Apr	28	300
15-Apr	29	300
22-Apr	30	300
29-Apr	31	300
06-May	32	1714
13-May	33	2000
20-May	34	1741
27-May	35	1065
03-Jun	36	1016
10-Jun	37	643
17-Jun	38	450
24-Jun	39	450
01-Jul	40	450
08-Jul	41	450
15-Jul	42	450
22-Jul	43	450
29-Jul	44	450
05-Aug	45	450
12-Aug	46	450
19-Aug	47	450
26-Aug	48	450
02-Sep	49	450
09-Sep	50	450
16-Sep	51	450
23-Sep	52	450
	Acre Feet	341,871

No Action Alternative Hydrograph



Maximum Flow Alternative						
	Flows (cfs)	Water Year Types				
Week Beginning	Week	Extremely Wet	Wet	Normal	Dry	Critically Dry
01-Oct	1	300	300	300	300	300
08-Oct	2	300	300	300	300	300
15-Oct	3	300	300	300	300	300
22-Oct	4	300	300	300	300	300
29-Oct	5	300	300	300	300	300
05-Nov	6	300	300	300	300	300
12-Nov	7	300	300	300	300	300
19-Nov	8	300	300	300	300	300
26-Nov	9	300	300	300	300	300
03-Dec	10	300	300	300	300	300
10-Dec	11	300	300	300	300	300
17-Dec	12	300	300	300	300	300
24-Dec	13	300	300	300	300	300
31-Dec	14	3000	300	300	300	300
07-Jan	15	3000	3000	3000	300	300
14-Jan	16	3000	3000	3000	300	300
21-Jan	17	3000	3000	3000	300	300
28-Jan	18	3000	3000	3000	1900	300
04-Feb	19	3000	3000	3000	1950	300
11-Feb	20	3000	3000	3000	2000	300
18-Feb	21	3000	3000	3000	2000	300
25-Feb	22	3000	3000	3000	2000	300
04-Mar	23	3000	3000	3000	2000	300
11-Mar	24	3000	3000	3000	2000	300
18-Mar	25	3000	3000	3000	2000	300
25-Mar	26	3000	3000	3000	2000	300
01-Apr	27	3000	3000	3000	2000	300
08-Apr	28	4441	3631	3000	2100	300
15-Apr	29	5882	4262	3000	2500	300
22-Apr	30	7323	4893	3000	2900	300
29-Apr	31	8764	5524	4215	3800	300
06-May	32	10,205	6155	5429	2500	300
13-May	33	11,643	6786	4000	2300	1250
20-May	34	22500	6429	2714	2100	2000
27-May	35	7929	4286	2300	2000	2000
03-Jun	36	5000	3714	2000	2000	2000
10-Jun	37	4286	2714	2000	2000	2000
17-Jun	38	2643	2400	2000	2000	2000
24-Jun	39	2000	2000	2000	2000	2000
01-Jul	40	2000	2000	2000	2000	900
08-Jul	41	2000	2000	1500	1500	900
15-Jul	42	1700	1800	1200	1100	900
22-Jul	43	1200	1000	800	700	900
29-Jul	44	629	900	650	700	900
05-Aug	45	450	900	650	700	900
12-Aug	46	450	800	650	700	900
19-Aug	47	450	670	650	700	900
26-Aug	48	450	650	650	700	900
02-Sep	49	450	650	650	700	900
09-Sep	50	300	650	650	700	900
16-Sep	51	300	300	300	300	300
23-Sep	52	300	300	300	300	300
	Acre Feet	2,146,443	1,508,624	1,243,351	888,496	463,636

Maximum Flow Alternative Hydrograph



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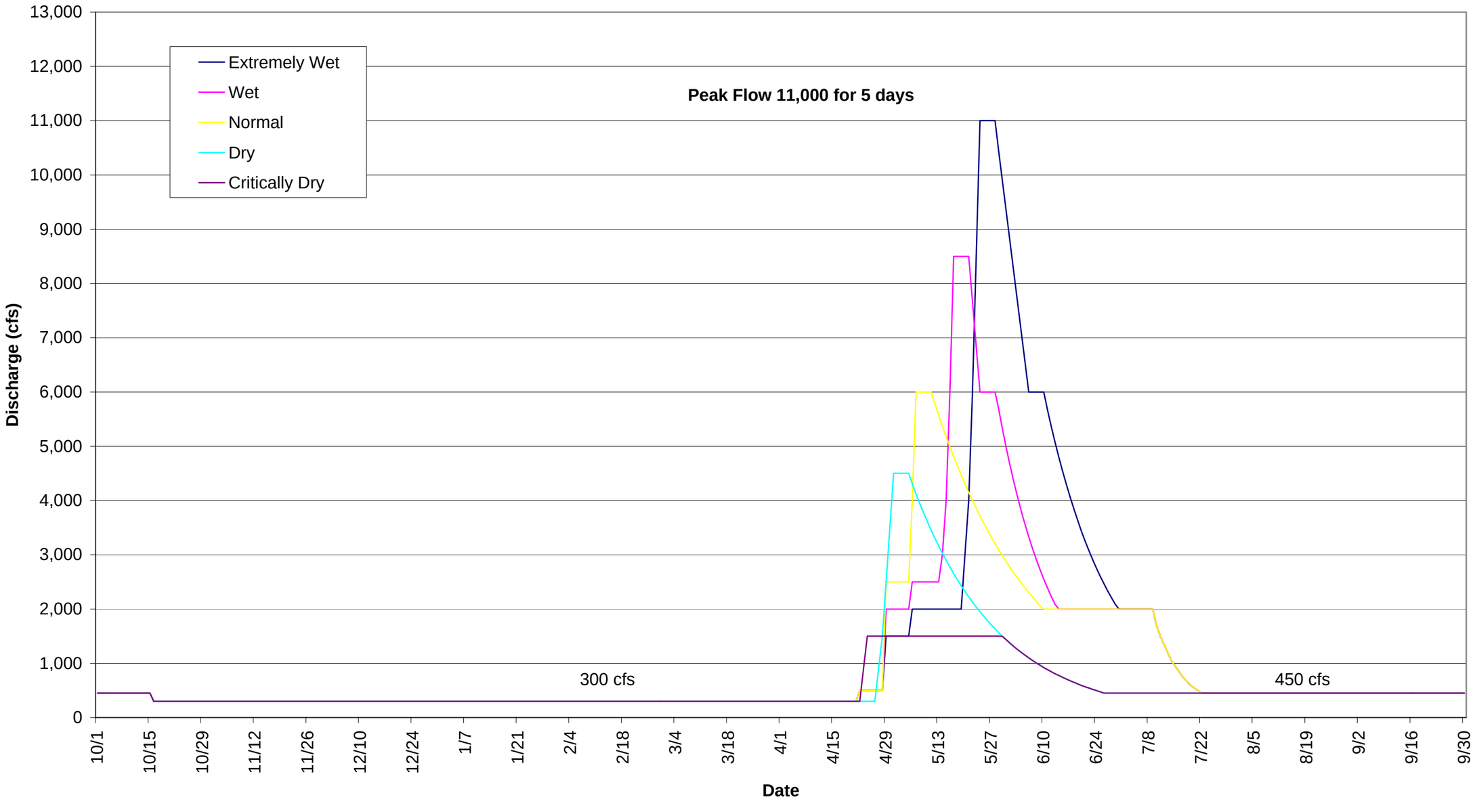
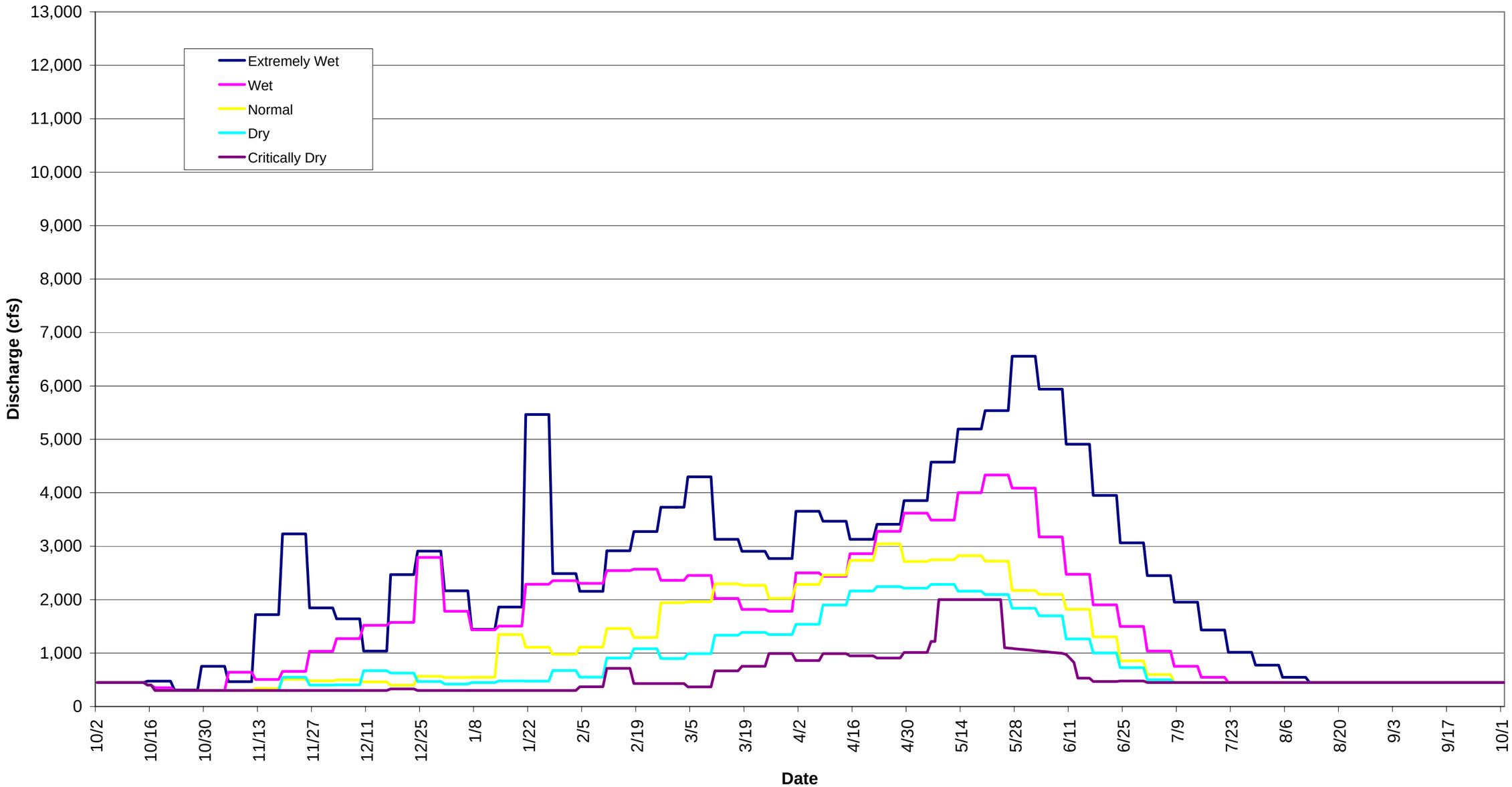
Flow Evaluation Alternative						
	Flows (cfs)	Water Year Types				
Week Beginning	Week	xtremely W	Wet	Normal	Dry	Critically Dry
01-Oct	1	450	450	450	450	450
08-Oct	2	450	450	450	450	450
15-Oct	3	450	450	450	450	450
22-Oct	4	300	300	300	300	300
29-Oct	5	300	300	300	300	300
05-Nov	6	300	300	300	300	300
12-Nov	7	300	300	300	300	300
19-Nov	8	300	300	300	300	300
26-Nov	9	300	300	300	300	300
03-Dec	10	300	300	300	300	300
10-Dec	11	300	300	300	300	300
17-Dec	12	300	300	300	300	300
24-Dec	13	300	300	300	300	300
31-Dec	14	300	300	300	300	300
07-Jan	15	300	300	300	300	300
14-Jan	16	300	300	300	300	300
21-Jan	17	300	300	300	300	300
28-Jan	18	300	300	300	300	300
04-Feb	19	300	300	300	300	300
11-Feb	20	300	300	300	300	300
18-Feb	21	300	300	300	300	300
25-Feb	22	300	300	300	300	300
04-Mar	23	300	300	300	300	300
11-Mar	24	300	300	300	300	300
18-Mar	25	300	300	300	300	300
25-Mar	26	300	300	300	300	300
01-Apr	27	300	300	300	300	300
08-Apr	28	300	300	300	300	300
15-Apr	29	300	300	300	300	300
22-Apr	30	500	500	500	300	300
29-Apr	31	1,500	2,000	2,500	2,500	1,500
06-May	32	2,000	2,500	4,000	4,500	1,500
13-May	33	2,000	2,500	5,574	3,164	1,500
20-May	34	3,000	8,500	4,307	2,325	1,500
27-May	35	11,000	6,000	3,328	1,708	1,500
03-Jun	36	7,667	4,072	2,572	1,255	1,255
10-Jun	37	6,000	2,550	2,000	922	922
17-Jun	38	4,064	2,000	2,000	678	678
24-Jun	39	2,759	2,000	2,000	498	498
01-Jul	40	2,000	2,000	2,000	450	450
08-Jul	41	2,000	2,000	2,000	450	450
15-Jul	42	950	950	950	450	450
22-Jul	43	450	450	450	450	450
29-Jul	44	450	450	450	450	450
05-Aug	45	450	450	450	450	450
12-Aug	46	450	450	450	450	450
19-Aug	47	450	450	450	450	450
26-Aug	48	450	450	450	450	450
02-Sep	49	450	450	450	450	450
09-Sep	50	450	450	450	450	450
16-Sep	51	450	450	450	450	450
23-Sep	52	450	450	450	450	450
	Acre Feet	816,653	702,258	648,079	453,416	369,269

Flow Evaluation Alternative Hydrograph



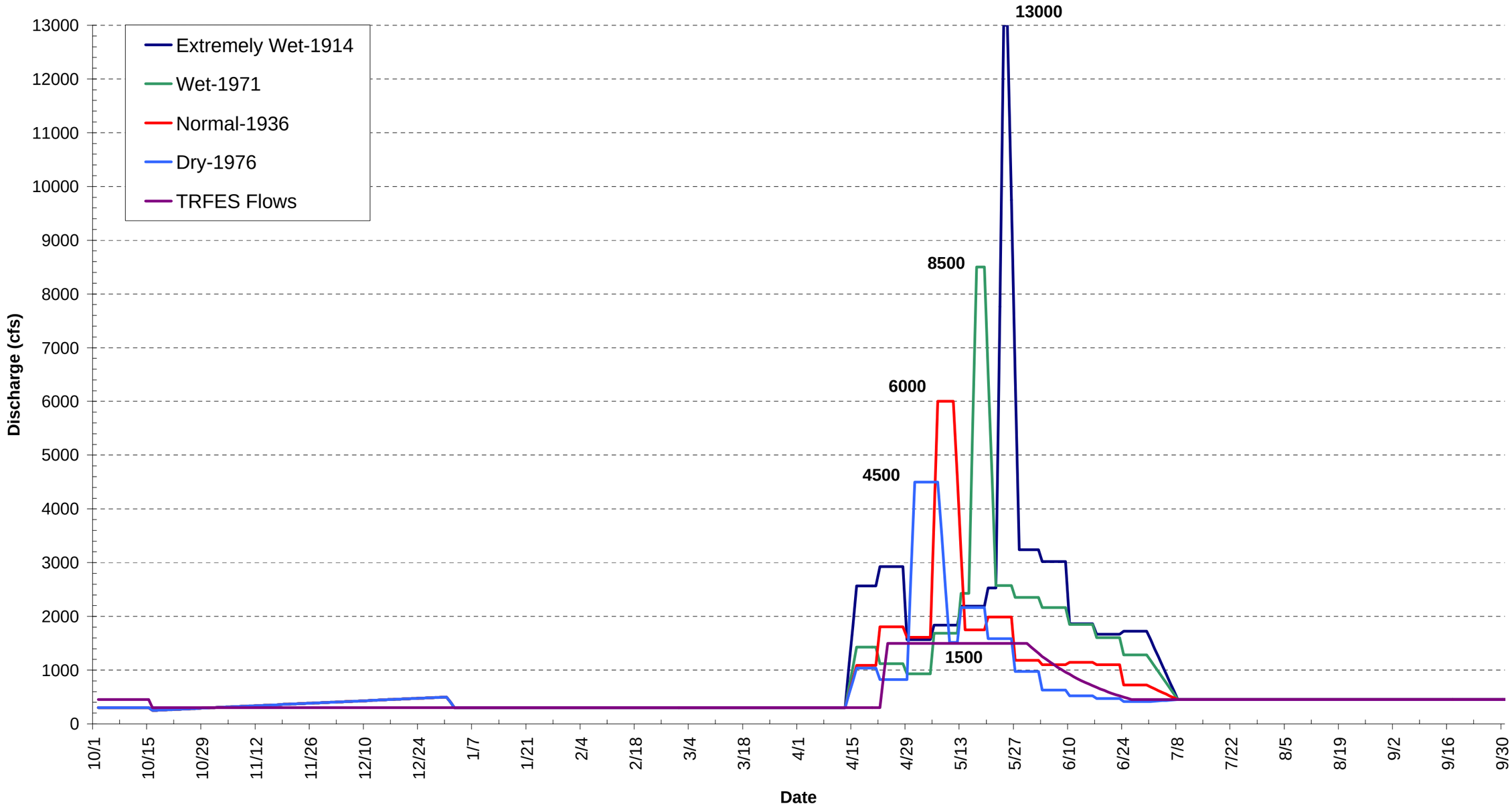
70 Percent Inflow Alternative						
	Flows	Representative Median Water Year Types:				
Week Beginning	Week	Extremely Wet	Wet	Normal	Dry	Critically Dry
1-Oct	1	450	450	450	450	450
8-Oct	2	450	450	450	450	450
15-Oct	3	474	400	400	400	400
22-Oct	4	310	300	300	300	300
29-Oct	5	751	300	300	300	300
5-Nov	6	466	641	300	300	300
12-Nov	7	1719	506	340	300	300
19-Nov	8	3229	656	509	546	300
26-Nov	9	1846	1033	481	403	300
3-Dec	10	1640	1271	497	406	300
10-Dec	11	1038	1519	460	670	300
17-Dec	12	2468	1575	397	627	327
24-Dec	13	2907	2791	567	469	300
31-Dec	14	2167	1783	544	422	300
7-Jan	15	1446	1435	548	448	300
14-Jan	16	1862	1503	1348	478	300
21-Jan	17	5465	2287	1110	474	300
28-Jan	18	2487	2354	977	672	300
4-Feb	19	2154	2303	1111	550	371
11-Feb	20	2916	2545	1461	908	714
18-Feb	21	3276	2571	1292	1080	431
25-Feb	22	3731	2361	1943	898	429
4-Mar	23	4298	2452	1960	989	368
11-Mar	24	3129	2023	2294	1335	667
18-Mar	25	2905	1817	2268	1386	751
25-Mar	26	2769	1782	2023	1348	992
1-Apr	27	3652	2501	2286	1540	859
8-Apr	28	3469	2438	2461	1899	989
15-Apr	29	3129	2861	2735	2161	949
22-Apr	30	3411	3278	3045	2244	907
29-Apr	31	3854	3619	2714	2216	1012
6-May	32	4573	3490	2746	2286	1218
13-May	33	5194	4002	2823	2160	2000
20-May	34	5537	4333	2721	2097	2000
27-May	35	6554	4086	2172	1839	1086
3-Jun	36	5940	3173	2100	1696	1037
10-Jun	37	4909	2475	1822	1265	975
17-Jun	38	3950	1904	1304	1003	467
24-Jun	39	3064	1500	854	728	478
1-Jul	40	2450	1038	599	499	450
8-Jul	41	1953	753	450	450	450
15-Jul	42	1432	548	450	450	450
22-Jul	43	1013	450	450	450	450
29-Jul	44	775	450	450	450	450
5-Aug	45	546	450	450	450	450
12-Aug	46	450	450	450	450	450
19-Aug	47	450	450	450	450	450
26-Aug	48	450	450	450	450	450
2-Sep	49	450	450	450	450	450
9-Sep	50	450	450	450	450	450
16-Sep	51	450	450	450	450	450
23-Sep	52	450	450	450	450	450
Representative	Acre Feet	1,735,062	1,188,913	834,469	633,539	421,239

Hydrograph for 70 Percent Inflow Alternative (representative water years)



Modified Percent Inflow (Representative Years)						
		Extremely Wet	Wet	Normal	Dry	Critically Dry
Week Beginning:	Week	1914	1971	1936	1976	(TRFES)
1-Oct	1	300	300	300	300	450
8-Oct	2	300	300	300	300	450
15-Oct	3	300	300	300	300	450
22-Oct	4	270	270	270	270	300
29-Oct	5	293	293	293	293	300
5-Nov	6	316	316	316	316	300
12-Nov	7	339	339	339	339	300
19-Nov	8	362	362	362	362	300
26-Nov	9	385	385	385	385	300
3-Dec	10	408	408	408	408	300
10-Dec	11	431	431	431	431	300
17-Dec	12	454	454	454	454	300
24-Dec	13	477	477	477	477	300
31-Dec	14	500	500	500	500	300
7-Jan	15	300	300	300	300	300
14-Jan	16	300	300	300	300	300
21-Jan	17	300	300	300	300	300
28-Jan	18	300	300	300	300	300
4-Feb	19	300	300	300	300	300
11-Feb	20	300	300	300	300	300
18-Feb	21	300	300	300	300	300
25-Feb	22	300	300	300	300	300
4-Mar	23	300	300	300	300	300
11-Mar	24	300	300	300	300	300
18-Mar	25	300	300	300	300	300
25-Mar	26	300	300	300	300	300
1-Apr	27	300	300	300	300	300
8-Apr	28	300	300	300	300	300
15-Apr	29	1,813	1,052	825	790	300
22-Apr	30	2,927	1,121	1,806	821	300
29-Apr	31	1,568	931	1,613	2,661	1,500
6-May	32	1,836	1,684	3,807	4,500	1,500
13-May	33	2,192	2,426	6,000	2,167	1,500
20-May	34	2,530	8,500	1,986	1,587	1,500
27-May	35	13,000	2,355	1,181	973	1,500
3-Jun	36	3,019	2,166	1,102	632	1,255
10-Jun	37	1,864	1,851	1,145	522	922
17-Jun	38	1,666	1,602	1,099	472	678
24-Jun	39	1,724	1,281	721	413	498
1-Jul	40	1,564	1,177	688	450	450
8-Jul	41	450	450	450	450	450
15-Jul	42	450	450	450	450	450
22-Jul	43	450	450	450	450	450
29-Jul	44	450	450	450	450	450
5-Aug	45	450	450	450	450	450
12-Aug	46	450	450	450	450	450
19-Aug	47	450	450	450	450	450
26-Aug	48	450	450	450	450	450
2-Sep	49	450	450	450	450	450
9-Sep	50	450	450	450	450	450
16-Sep	51	450	450	450	450	450
23-Sep	52	450	450	450	450	450
Representative	Acre Feet	640,905	539,688	478,559	420,182	369,269

Hydrograph for Modified Percent Inflow Alternative (five repesentative water years)



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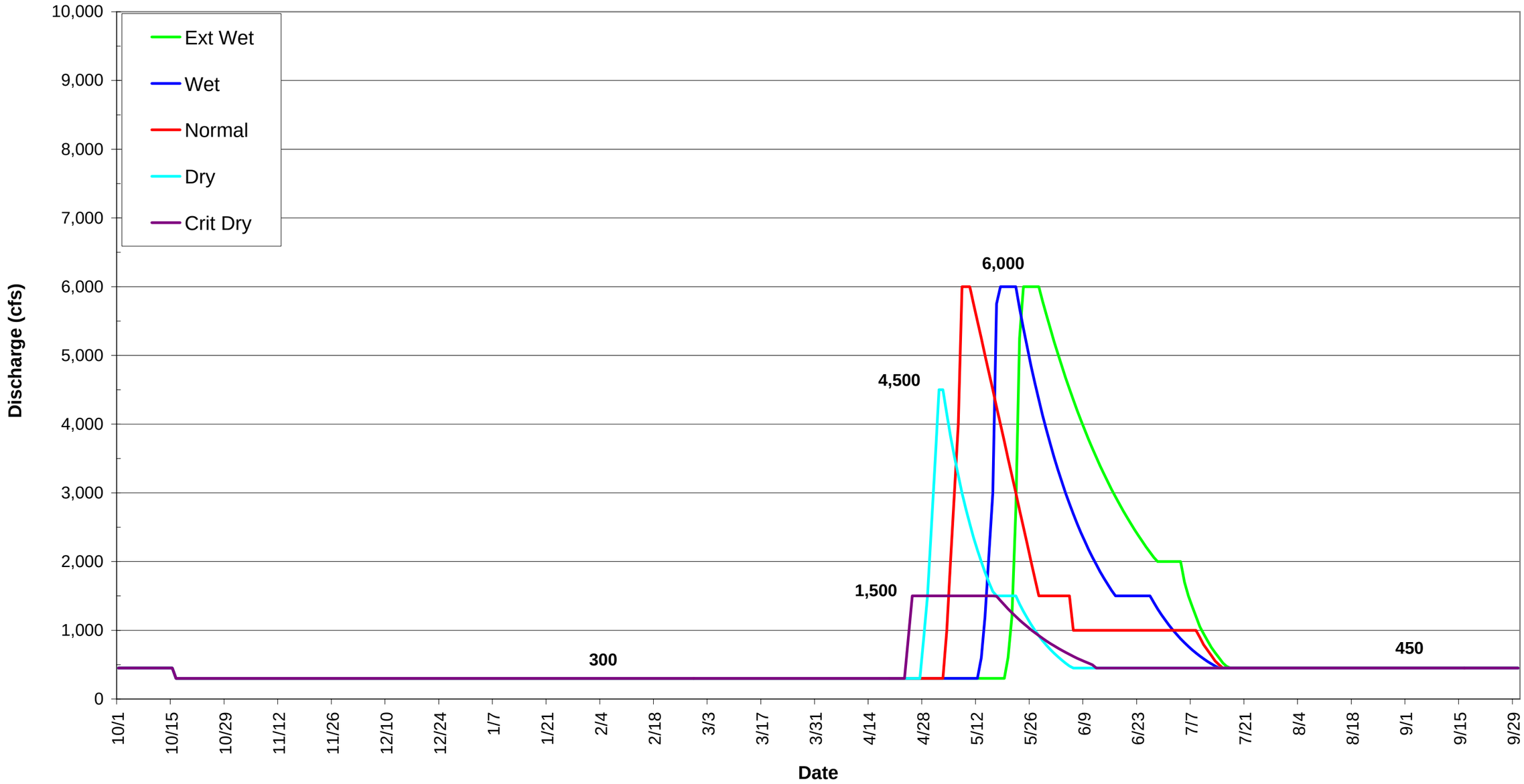
Revised Mechanical Alternative						
Week Beginning:	Week	Extremely Wet	Wet	Normal	Dry	Critically Dry
1-Oct	1	450	450	450	450	450
8-Oct	2	450	450	450	450	450
15-Oct	3	450	450	450	450	450
22-Oct	4	300	300	300	300	300
29-Oct	5	300	300	300	300	300
5-Nov	6	300	300	300	300	300
12-Nov	7	300	300	300	300	300
19-Nov	8	300	300	300	300	300
26-Nov	9	300	300	300	300	300
3-Dec	10	300	300	300	300	300
10-Dec	11	300	300	300	300	300
17-Dec	12	300	300	300	300	300
24-Dec	13	300	300	300	300	300
31-Dec	14	300	300	300	300	300
7-Jan	15	300	300	300	300	300
14-Jan	16	300	300	300	300	300
21-Jan	17	300	300	300	300	300
28-Jan	18	300	300	300	300	300
4-Feb	19	300	300	300	300	300
11-Feb	20	300	300	300	300	300
18-Feb	21	300	300	300	300	300
25-Feb	22	300	300	300	300	300
4-Mar	23	300	300	300	300	300
11-Mar	24	300	300	300	300	300
18-Mar	25	300	300	300	300	300
25-Mar	26	300	300	300	300	300
1-Apr	27	300	300	300	300	300
8-Apr	28	300	300	300	300	300
15-Apr	29	300	300	300	300	300
22-Apr	30	300	300	300	300	300
29-Apr	31	300	300	300	1500	1500
6-May	32	300	300	3000	3527	1500
13-May	33	300	600	5250	1998	1500
20-May	34	600	6000	3500	1500	1312
27-May	35	6000	4594	1750	999	964
3-Jun	36	4845	3161	1500	566	708
10-Jun	37	3776	2175	1000	450	521
17-Jun	38	2942	1500	1000	450	450
24-Jun	39	2293	1500	1000	450	450
1-Jul	40	2000	1072	1000	450	450
8-Jul	41	1,200	670	1,000	450	450
15-Jul	42	525	450	450	450	450
22-Jul	43	450	450	450	450	450
29-Jul	44	450	450	450	450	450
5-Aug	45	450	450	450	450	450
12-Aug	46	450	450	450	450	450
19-Aug	47	450	450	450	450	450
26-Aug	48	450	450	450	450	450
2-Sep	49	450	450	450	450	450
9-Sep	50	450	450	450	450	450
16-Sep	51	450	450	450	450	450
23-Sep	52	450	450	450	450	450
	Acre feet	554,961	511,622	484,324	378,301	339,761

Hydrographs for the Revised Mechanical Alternative



TRINITY RIVER MAINSTEM FISHERY RESTORATION SEIS/R

TRINITY RIVER BASIN WATER YEAR TYPE DESIGNATIONS

YEAR	CATEGORY	YEAR TYPE
1912	3	Normal
1913	3	Normal
1914	1	Extremely Wet
1915	1	Extremely Wet
1916	2	Wet
1917	4	Dry
1918	5	Critically Dry
1919	3	Normal
1920	5	Critically Dry
1921	2	Wet
1922	4	Dry
1923	4	Dry
1924	5	Critically Dry
1925	2	Wet
1926	4	Dry
1927	2	Wet
1928	3	Normal
1929	5	Critically Dry
1930	4	Dry
1931	5	Critically Dry
1932	4	Dry
1933	4	Dry
1934	4	Dry
1935	4	Dry
1936	3	Normal
1937	4	Dry
1938	1	Extremely Wet
1939	5	Critically Dry
1940	2	Wet
1941	1	Extremely Wet
1942	2	Wet
1943	3	Normal
1944	4	Dry
1945	3	Normal
1946	2	Wet
1947	4	Dry
1948	3	Normal
1949	3	Normal
1950	4	Dry
1951	2	Wet
1952	2	Wet
1953	2	Wet
1954	2	Wet
1955	4	Dry
1956	1	Extremely Wet
1957	3	Normal
1958	1	Extremely Wet
1959	3	Normal
1960	3	Normal
1965	2	Wet
1966	3	Normal
1967	2	Wet
1968	3	Normal
1969	2	Wet
1970	2	Wet
1971	2	Wet
1972	3	Normal

YEAR TYPE	CATEGORY	NO. YEARS	PROBABILITY
EXTREMELY WET	1	12	0.12
WET	2	26	0.28
NORMAL	3	17	0.2
DRY	4	23	0.28
CRITICALLY DRY	5	9	0.12
		87	

Attachment B5
Smolt Survival and Harvest Assessment

PUBLIC DRAFT – March 1, 2004

Assessment of Temperature Influences on Potential Salmonid Smolt Production and Harvest of Chinook Salmon of the Trinity River

Introduction

The 1999 EIS/EIR included a model referred to as the Trinity River System Attribute Analysis Methodology (TRSAAM) for comparison of the relative restoration potential of the Trinity River fishery resources between alternatives (Trinity River DEIS/R, Appendix B, 1999). The Supplemental EIS/EIR (SEIS/EIR) that is currently being developed includes several alternatives that were in the 1999 EIS/EIR in addition to several other new alternatives that were developed following a Court Ruling that found the 1999 EIS/EIR did not evaluate a sufficient range of alternatives. The SEIS/EIR includes the addition of one new alternative (the 70 Percent Inflow Alternative) and changes to two previous alternatives (Mechanical Restoration and Percent Inflow alternatives) that respond to specific findings of the court with regard to the practicality of the alternatives. To reflect these changes the alternatives have been re-named the Revised Mechanical Restoration Alternative and the Modified Percent Inflow Alternative.

As part of the preparation of the SEIS/EIR, all of the alternatives were re-evaluated with TRSAAM to determine the relative restoration potential of the alternatives. Results from the updated TRSAAM analysis narrowed the relative differences between several alternatives, notably the new alternatives developed in response to the court's findings. The narrowing in relative difference was most evident in the comparisons between Modified Percent Inflow, Flow Evaluation and the 70 Percent Inflow alternatives. TRSAAM results are presented below in Table 1.

Table 1
Initial TRSAAM Results for SEIS/EIR for each Alternative

Alternative	**TRSAAM Result**	**Percent of Possible**
No Action	6	8%
Revised Mechanical	39	53%
Modified Percent Inflow	53	72%
Flow Evaluation	52	70%
70 Percent Inflow	53	72%
Maximum Flow	60	81%

As previously noted, in the 1999 EIS/EIR the TRSAAM results indicated a greater spread between alternatives. The 1999 EIS/EIR interpreted the TRSAAM scores to be representative of likely levels of spawning escapement that would be expected under the alternatives.

Originally, the SEIS/EIR intended to replicate that analysis. However, in reviewing preliminary results for the SEIS/EIR, it was determined that the close grouping of several

of the alternatives had exceeded the ability of TRSAAM to differentiate alternatives – particularly between the Modified Percent Inflow, Flow Evaluation and 70 Percent Inflow alternatives. Detailed scrutiny of the alternatives indicated that, generally, the differences between alternatives was in the ability to mobilize fine and coarse sediment, vegetation maintenance on river terraces, and provision of suitable temperatures for smolt outmigration. Discussion of the differences in the alternatives' ability to mobilize and transport coarse and fine sediment materials and to achieve riparian recruitment on the river floodplain is provided in the Fishery Technical Appendix.

If water temperatures are suitable, salmonid smolts are likely to be more successful in reaching the ocean – ultimately increasing the numbers of subsequent spawners returning as adults. In order to assess temperature effects on smolt outmigration as a potentially limiting factor, water temperature was removed from TRSAAM analysis and evaluated independently. Ultimately, water temperature was determined to be a potential limiting factor such that even if the physical habitat was very abundant and of great quality that fish (salmonid smolts) still had to depart the Trinity River during the window of suitable temperatures, or be subject to increased mortality.

The purpose of this document is two-fold. First, it compares temperature-dependent survival indexes of steelhead, coho, and Chinook salmon smolts by alternative. The smolt temperature indices were developed to evaluate the impacts of changing water flows and subsequent water temperatures on successful smolt outmigration. While the index is called a smolt survival index, the term refers to an index of indirect smolt survival as opposed to an index of direct acute lethality. It is recognized that not all smolts of a given cohort would be expected to perish at the upper marginal temperature thresholds provided in Table 3. However, it would be expected that at the temperature thresholds shown in Table 3, smolts would likely revert to a non-migratory lifestage (parr) and attempt to rear in the river. Given that scenario, these parr may be considered potentially lost to that years' recruitment and would likely be subject to very low survival rates prior to the following year's outmigration period.

Secondarily, the analyses in this evaluation uses a suite of models to provide a relative index of harvestable Chinook salmon to further compare and contrast alternatives.

Methods

Instream Flow Release

Lewiston Dam release volumes varied by alternative (Table 2). Average annual volumes dedicated for fishery restoration range from 340 thousand acre-feet (TAF) in the No Action Alternative to 1,225 TAF for the Maximum Flow Alternative. Each alternative is comprised of five water year classes that are based on probability of recurrence and different annual allocations, except the No Action Alternative that uses the same release schedule across year types. Hydrographs for these alternatives during the active period of salmonid smolt emigration are shown in Figures 1 through 6 (found at the end of this assessment).

Table 2
Instream Release Volumes (thousands of acre-feet) by Water Year Type for Each Alternative.

Water Year Class	Probability	No Action	Revised Mechanical	Mod. Percent Flow	Flow Evaluation	70% Inflow	Maximum Flow
Critically Dry	0.12	340	340	369	369	421	463
Dry	0.28	340	380	438	453	632	889
Normal	0.20	340	485	483	647	833	1,206
Wet	0.28	340	513	540	701	1,187	1,508
Extremely Wet	0.12	340	556	720	815	1,732	2,146
Weighted Mean		340	455	501	595	934	1,225
Difference from No Action			115	161	255	594	885
% Change from No Action			34%	47%	75%	175%	260%
% of Total Yield		28%	37%	41%	49%	76%[1]	100%

[1]This alternative has a floor of 340 ac ft/year and has minimum flow releases during certain times of year that increases the total yield beyond the 70% of total on average.

Water Temperature

Estimates of the average weekly water temperatures of the Trinity River at Weitchpec, CA, were used in determining the survival of salmonid smolts departing the Trinity River. Temperature-flow relationships for a median atmospheric year were used to estimate weekly water temperatures at Weitchpec (USFWS and HVT 1999; Trinity River EIS/EIR 2000). A series of annual release schedules for each alternative was developed based on historical hydrology to determine water year classifications for water years 1912 through 2002 (excluding WY 1961 to WY1964 while the TRD was being constructed).

Smolt Outmigration Timing

Timing of smolt outmigration for steelhead, coho salmon, and Chinook salmon was estimated based on empirical juvenile trapping data collected at the USFWS Willow Creek trapping site for the period of 1992 to 2001, excluding 2000. This data set represented the most comprehensive and contemporary information on salmonid emigration in the Trinity River, and supersedes the information used in the original Flow Evaluation Study (USFWS and HVT, 1999). Emigration data for each species was necessary to identify weekly proportions of the emigrants exiting the Trinity River during times of variable thermal regimes. The weekly proportions of total catch were normalized for Julian weeks 15 to 35 (April 9 to August 27), corresponding to the smolt temperature evaluation period. The temporal distribution of smolt outmigration for Chinook salmon, coho salmon, and steelhead is shown as Figure 7.

Smolt Survival

This evaluation concentrates on the alternatives effects on the smolt life stage of salmonids in the Trinity River. This life-stage, in particular, is reported to be very temperature-sensitive and in the absence of appropriately cold water smolts may not survive entry to seawater and thus not return to the river as an adult spawner (USFWS and HVT, 1999).

The literature-derived temperature thresholds identified in the Flow Evaluation (USFWS and HVT 1999) were used to calculate survival indexes for alternatives and are shown in Table 3. The TRFE recommended these temperature thresholds for each species because they supported relatively good growth while extending the physiological readiness of juveniles (i.e. the smoltification process) to successfully survive in seawater (USFWS and HVT 1999). Temperatures that support good growth further enhances a juvenile's ability grow to a larger size which enhances its chances of survival in seawater. (Clarke and Shelbourn, 1985). In the absence of appropriate thermal regimes, salmonid smolts may revert to the non-migratory parr lifestage and be forced to rear in freshwater during the summer (Folmar and Dickhoff, 1980, Wedemeyer et al., 1980). Survival of parr, however, may be jeopardized if they are subjected to poor water quality, competition or predators (Cada et al., 1997). Diseases in particular are of major concern for fish departing the Trinity River and entering the lower Klamath River, which harbors debilitating and lethal diseases (i.e. *Ceratomyxa shasta* and *Columnaris sp*.) for juvenile and adult salmonids (Guillen 2003).

Smolt survival was based on the estimated average weekly water temperatures of the Trinity River at Weitchpec. It was assumed that if a smolt reached Weitchpec and the temperature was below the upper bound of the optimal smolt temperature range (Table 3) that there was 100% survival (i.e.: for steelhead, this would be 55.4 degrees F). When temperatures exceeded the upper bound of the optimal range, it was assumed that survival declined linearly until reaching 0% at the upper bound of the marginal range (for steelhead, this would be 59 degrees F). The linear temperature-survival relationship was developed as a tool to compare alternatives that include a range of flows (and thus a range of temperatures).

Table 3
Optimal and Marginal Salmonid Smolt Temperature Criteria (USFWS and HVT, 1999, Table 5.11)

Species	Optimal Temperature (F)	Marginal Temperature (F)
Steelhead	42.8-55.4	55.4-59.0
Coho Salmon	50.0-59.0	59.0-62.6
Chinook Salmon	50.0-62.6	62.6-68.0

Survival Index

A weekly survival index (SI) was calculated for each species by multiplying the weekly proportions (P) of the populations outmigrating past Weitchpec by the species specific survival (S) for that week (Equations 1a, b, c).

$SI(sth)_i$ = steelhead survival index during week i = $S(sth)_i * P(sth)_i$ Equation 1a
$SI(coho)_i$ = coho survival index during week i = $S(coho)_i * P(coho)_i$ Equation 1b
$SI(chin)_i$ = Chinook survival index during week i = $S(chin)_i * P(chin)_i$ Equation 1c

$S(sth)_i$ = steelhead survival during week i
$S(coho)_i$ = coho survival during week i
$S(chin)_i$ = Chinook survival during week i

$P(sth)_i$ = proportion of steelhead outmigrating during week i
$P(coho)_i$ = proportion of coho outmigrating during week i
$P(chin)_i$ = proportion of Chinook outmigrating during week i

The annual smolt survival index was estimated by summing the weekly survival indexes (Equation 2).

$$\text{Smolt Survival Index} = \sum (SI(species)i) \quad \text{Equation 2}$$

Chinook Salmon Production Analysis

As part of this evaluation, Chinook salmon production was further evaluated by using a harvest/escapement model (HEM). Parameters used in this model were consistent with harvest assessment parameters used in models utilized for management of Klamath Basin Chinook salmon ocean and inriver fisheries. The HEM used in this analysis is specific to the Chinook salmon life cycle that uses life history parameters (age specific survival, maturity rates, harvest rates, etc.) as developed for Trinity (or Klamath Basin) Chinook salmon. Use of the HEM generated an index of harvestable salmon (HI) specific to each alternative and water year type and allowed for comparison between alternatives. Because no similar model exists for the steelhead and coho, Chinook is the only species that underwent this evaluation.

To isolate the influence of smolt survival on Chinook salmon production, ocean and inriver harvest rates were adjusted to produce a constant number of adult spawners across alternatives. This allowed for the assumption that a fixed number of smolts for a given number of spawners would be produced from the upper Trinity River to outmigrate to the ocean. Varying juvenile Chinook salmon production is expected for a given number of spawners due to different levels of instream restoration for the alternatives. A juvenile Chinook salmon production model, SALMOD (Williamson et al., 1993), was developed for the Trinity River and used to evaluate the influence of varying flow schedules and habitat restoration actions on juvenile Chinook salmon production. Information generated from SALMOD for the TRFE was used to seed the Chinook harvest/ escapement model (USFWS and HVT, 1999, Table 5.23).

The HEM was used to test the sensitivity of two parameters. and these included: 1) varying the number of spawners that seed the available habitat of the Trinity River from Lewiston to Dutch Creek (i.e. either 33,000 or 68,000 salmon), and 2) adjusting the amount of rearing habitat that an alternative is likely to create (Table 4). *(Note: the level of habitat created or restored for the Revised Mechanical Restoration is problematic in that if it is assumed that full restoration would occur, then a habitat value similar to the other alternatives [e.g. Flow Evaluation] which scored a TRAASM score of greater than 70% of possible could be given; if on the other hand this alternative could only obtain habitat restoration of 50% of possible, then a much lower habitat value would be assumed. Therefore, two levels of habitat restoration were evaluated for this alternative. It is likely that the habitat benefit from this alternative lies somewhere between the two levels selected for this analysis).*

Table 4
Parameters Used in the Sensitivity Analysis

Alternative Scenario	**Rearing Habitat Improvement**	**Predicted Pre-Smolt Production in the Trinity River prior to outmigration (Millions)**	
		33,000 Spawners	**68,000 Spawners**
No Action	0	2.959	2.976
Revised Mechanical A [1]	50%	3.748	4.462
Revised Mechanical B [1]	100%	4.537	5.948
Modified Percent Inflow	100%	4.537	5.948
Flow Evaluation	100%	4.537	5.948
70% Inflow	100%	4.537	5.948
Max Flow	100%	4.537	5.948

[1] Habitat and resultant production of smolts was varied under the Revised Mechanical Alternative to assess the sensitivity of the analysis to habitat assumptions for this alternative

Two levels of spawning escapement and resulting smolt production were used for this analysis. For the first evaluation, it was assumed that 2.959 million smolts would be produced by a spawning escapement of 33,000 adults for the No Action alternative (Table 4). For all alternatives with significant levels of channel rehabilitation and/or high flows to achieve fluvial processes, it was assumed that a two-fold increase in habitat (i.e. 100% increase) would result in 4.537 million smolts being produced by 33,000 spawners. The Revised Mechanical Restoration alternative was evaluated with two levels of smolt production. For the first evaluation (Revised Mechanical-A), it was assumed that the channel rehabilitation activities would increase smolt production to a level 1/2 way between the No Action and other alternatives that contained channel rehabilitation and/or fluvial process flows. Under this alternative 33,000 spawners would produce 3.748 million smolts. For the second evaluation (Revised Mechanical-B) it was assumed that

smolt production would equal 4.537 million, similar to the Flow Evaluation, MPI, 70% Inflow, and Maximum Flow alternatives.

A second parallel analysis, using smolt production produced by 68,000 spawners was also conducted (Table 4). For these analyses, it was assumed that smolt production would equal 2.077 million for the No Action alternative, 4.462 million for the Revised Mechanical-A, and 5.948 for Revised Mechanical-B, MPI, Flow Evaluation, 70%, and Maximum Flow alternatives

For WY 1961-1964, the construction years for which smolt survival indexes were not calculated, mean survival index values for corresponding water year types were used. Mean annual harvest (ocean and inriver) indexes were calculated for each alternative. Harvest values generated by this exercise are only an index of Trinity River naturally produced fish and do not account for harvest of hatchery produced Chinook salmon or harvest in the mixed stock fisheries (river and ocean).

Results

Smolt Survival Indexes

Steelhead

The mean steelhead smolt SI (all WYs) ranged from 0.600 for the No Action alternative to 0.810 for the Maximum Flow alternative, a 35% increase compared to the No Action alternative (Table 5, Figure 8). The survival index for the Flow Evaluation alternative (0.800) was similar to that of the Maximum Flow, a 33% increase compared to the No Action alternative. The index values shown in Table 5, in some cases, seem counter intuitive. For example the Smolt Index for the Flow Evaluation Alternative is slightly lower than that for the No Action during critically dry years.

On inspection of the hydrographs in Figure 3 (Flow Evaluation) and Figure 1 (No Action) it is apparent why this occurs. For all water year types for the No Action alternative release flows ramp up to and hold at 2,000 cfs during Julian week 19 (May 6th) and remains at that level until Julian week 21 (approximately May 25th). On the other hand the releases during critical dry years for the Flow Evaluation alternative for example, ramp up to only1,500 cfs during week 17 and are held at that level through Julian week 22 (approximately May 31st). Julian week 20 corresponds to the peak of steelhead outmigration (Figure 7). As a result, a slightly lower index was calculated for Flow Evaluation compared to the No Action alternative, but only for this water year type (Table 5). A similar circumstance occurs for the Maximum Flow alternative during week 20 when flows are ramped up to 1,250 cfs during that week (Figure 2) as opposed to 2,000 cfs for the No Action alternative (Figure 1). The slightly smaller release during the peak of steelhead outmigration results in a slightly lower smolt SI during critically dry water years. In summary, the timing AND the magnitude of the flow releases and their overlap with the timing of out migrating smolts greatly affects the resulting index of survival for these species. This is true for all salmonid species and alternatives assessed.

Table 5
Steelhead Smolt Survival Indexes by Water Year Type for each Alternative

Water Year Class	No Action	Revised Mechanical	Flow Evaluation	MPI	70% Inflow	Maximum Flow
Critically Dry	0.600	0.547	0.558	0.439	0.525	0.535
Dry	0.600	0.590	0.652	0.475	0.657	0.685
Normal	0.600	0.695	0.835	0.535	0.731	0.763
Wet	0.600	0.762	0.929	0.624	0.816	0.956
Extremely Wet	0.600	0.714	0.918	0.820	0.945	0.981
Mean (all WYs)	0.600	0.670	0.800	0.580	0.740	0.810
Difference from No Action		0.070	0.200	-0.020	0.140	0.210
% Change from No Action		12%	33%	-3%	23%	35%

Coho Salmon

Mean coho salmon smolt SI (all WYs) ranged from 0.840 for the No Action alternative to 0.990 for the Maximum Flow alternative, an 18% increase compared to the No Action alternative (Table 6, Figure 9). All other alternatives has coho salmon smolt survival indexes greater than 0.910 including Flow Evaluation alternative which has an index of 0.950, an increase of 13% over the No Action alternative.

Table 6
Coho Salmon Smolt Survival Indexes by Water Year Type for Each Alternative

Water Year Class	No Action	Revised Mechanical	Flow Evaluation	MPI	70% Inflow	Maximum Flow
Critically Dry	0.840	0.822	0.867	0.867	0.813	0.981
Dry	0.840	0.815	0.871	0.863	0.904	0.981
Normal	0.840	0.898	0.989	0.903	0.949	0.981
Wet	0.840	0.979	0.991	0.947	0.973	0.993
Extremely Wet	0.840	0.990	0.995	0.989	0.996	0.993
Mean (all Wys)	0.840	0.910	0.950	0.910	0.940	0.990
Difference from No Action		0.070	0.110	0.070	0.100	0.150
% Change from No Action		8%	13%	8%	12%	18%

Chinook Salmon

Mean Chinook salmon smolt SI (all WYs) ranged from 0.410 for the No Action alternative to 0.764 for the Maximum Flow alternative (Table 7, Figure 10). Compared to the No Action alternative, the percentage increase of the other alternatives ranged from 20.5 % increase for the MPI alternative to 86.3 % increase for the Maximum Flow alternative. The Flow Evaluation alternative index increased 46.8% compared to the No Action alternative.

Table 7
Chinook Salmon Smolt Survival Indexes by Water Year Type for each Alternative

Water Year Class	No Action	Revised Mechanical	Flow Evaluation	MPI	70% Inflow	Maximum Flow
Critically Dry	0.410	0.387	0.443	0.443	0.394	0.677
Dry	0.410	0.385	0.443	0.438	0.474	0.729
Normal	0.410	0.540	0.694	0.476	0.516	0.734
Wet	0.410	0.568	0.694	0.526	0.586	0.827
Extremely Wet	0.410	0.643	0.694	0.594	0.745	0.805
Mean (all Wys)	0.410	0.506	0.602	0.494	0.545	0.764
SI Difference from No Action		0.096	0.192	0.084	0.135	0.354
% Change from No Action		23%	47%	21%	33%	86%

Chinook Salmon Harvest

Mean HI (Brood Years 1912-2002) of naturally produced Trinity River Chinook salmon ranged from 4,400 fish for the No Action alternative to 66,600 fish for the Maximum Flow alternative under the 33,000 spawner scenario (Table 8). Compared to the No Action alternative, all alternatives had increased harvest indexes (> 370% increase). The Flow Evaluation alternative resulted in the second largest harvest index increase with greater than a 10-fold increase (919%).

Table 8
Chinook Salmon Harvest Index for each Alternative using the Assumption of 33,000 Spawners for Seeding the System as well as 33, 000 adult Spawners

	Alternative						
	No Action	**Revised Mechanical A**	**Revised Mechanical B**	**Flow Evaluation**	**MPI**	**70% Inflow**	**Maximum Flow**
	33,000 scenario	**33,000 scenario**	**33,000 scenario**	**33,000 scenario**	**33,000 scenario**	**33,000 scenario**	**33,000 scenario**
Harvest Index	4,364	20,506	32,013	44,486	30,794	37,311	66,646
Harvest Difference from No Action	--	16,142	27,649	40,122	26,430	32,947	62,282
% Change from No Action	--	370%	634%	919%	606%	755%	1427%

Under the 68,000 spawner scenario, mean harvest indexes (Brood Years 1912-2002) of naturally produced Trinity River Chinook salmon ranged from zero fish for the No Action alternative to 61,600 fish for the Maximum Flow alternative (Table 9). The No Action and Revised Mechanical A alternatives were not able to produce enough pre-smolts and suitable temperatures during emigration to even achieve 68,000 adult spawners and so the harvest index was zero. This inability to even maintain a self-sustaining spawning population is the result of density dependent factors influencing the number of smolts produced per adult spawner. Under this scenario, freshwater habitat is over-seeded which results in higher levels of freshwater mortality due to habitat bottlenecks than under the 33,000 spawning escapement scenario.

Table 9
Chinook Salmon Harvest Index for each Alternative Using the Assumption of 68,000 Spawners for Seeding the System as well as 68, 000 Adult Spawners

	Alternative						
	No Action	**Revised Mechanical A**	**Revised Mechanical B**	**Flow Evaluation**	**MPI**	**70% Inflow**	**Maximum Flow**
	68,000 scenario	**68,000 scenario**	**68,000 scenario**	**68,000 scenario**	**68,000 scenario**	**68,000 scenario**	**68,000 scenario**
Harvest Index	0	0	16,426	32,705	14,847	23,339	61,661
Harvest Difference from No Action	--	0	NA	NA	NA	NA	NA
% Change from No Action	--	0	NA	NA	NA	NA	NA

Summary

Survival Indexes

Temperature regimes resulting from different flows during the salmonid smolt out-migration period had varying affects on the smolt survival index depending on species and alternative. Proportional increases in mean survival index (all water years combined) between the No Action and action alternatives were the smallest for coho salmon smolts, ranging from an 8% increase for the Revised Mechanical alternative to an 18% increase for the Maximum Flow alternative (Table 11). Changes in steelhead smolt survival index, compared to the No Action alternative, ranged from a 3% reduction (Modified Percent Inflow) to a 35% increase (Maximum Flow). Changes in smolt survival indexes were greatest for Chinook salmon, ranging from 21% (MPI) to 86% (Maximum Flow). Chinook salmon harvest indices increased substantially for all alternatives and were greatest for the Maximum Flow alternative (1427%) and the Flow Evaluation alternative (919%) (Figure 11).

Table 11
Percentage Change from No Action Alternative for Instream Release Volumes, Steelhead, Coho, and Chinook Survival Index, and Chinook Harvest Index for Each Alternative

	Revised Mechanical A	**Revised Mechanical B**	**Flow Evaluation**	**MPI**	**70% Inflow**	**Maximum Flow**
Instream Volumes	34%	34%	75%	47%	175%	260%
Steelhead Survival Index	12%	12%	33%	-3%	23%	35%
Coho Survival Index	8%	8%	13%	8%	12%	18%
Chinook Survival Index	23%	23%	45%	21%	32%	86%
Increase to Chinook Harvest Index (33 K)	370%	634%	919%	606%	755%	1427%
Increase in Numbers of Harvestable Chinook (68K)	NA	NA	NA	NA	NA	NA

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Figure 1. Hydrograph of Flow Releases for the No Action Alternative during the active Period of Steelhead, Coho and Chinook Salmon Smolt Emigration.

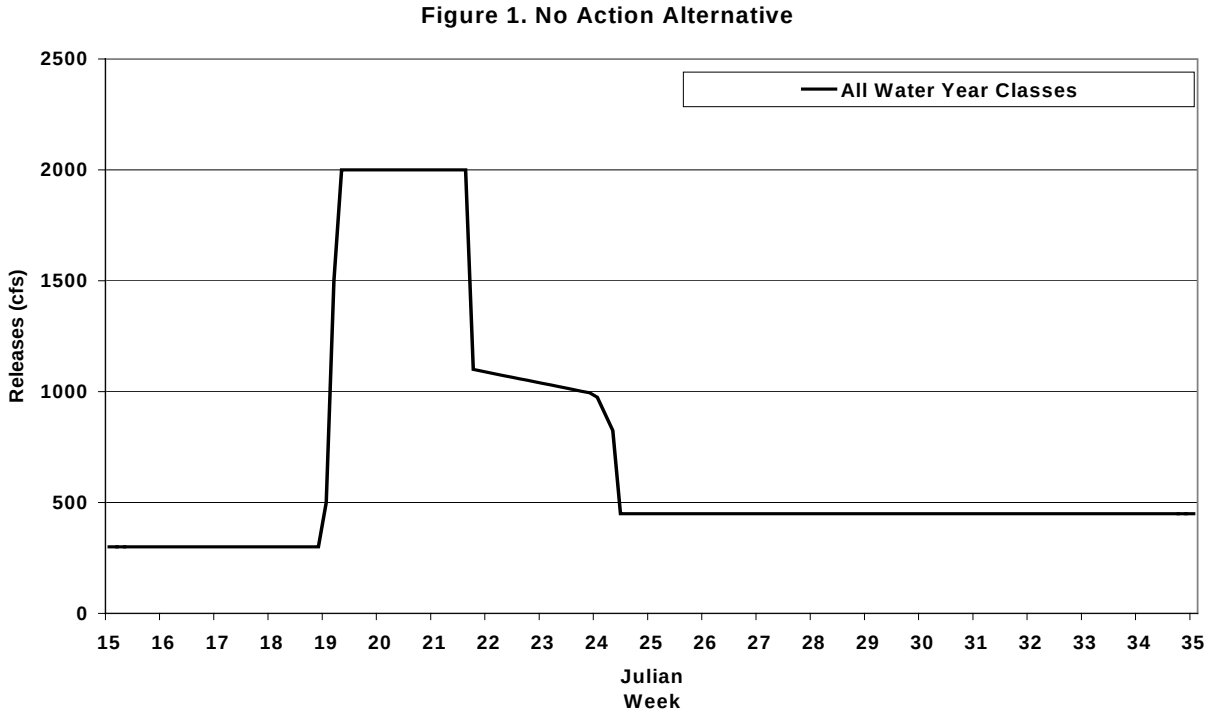


Figure 2. Hydrograph of Flow Releases for the Maximum Flow Alternative during the active Period of Steelhead, Coho and Chinook Salmon Smolt Emigration.

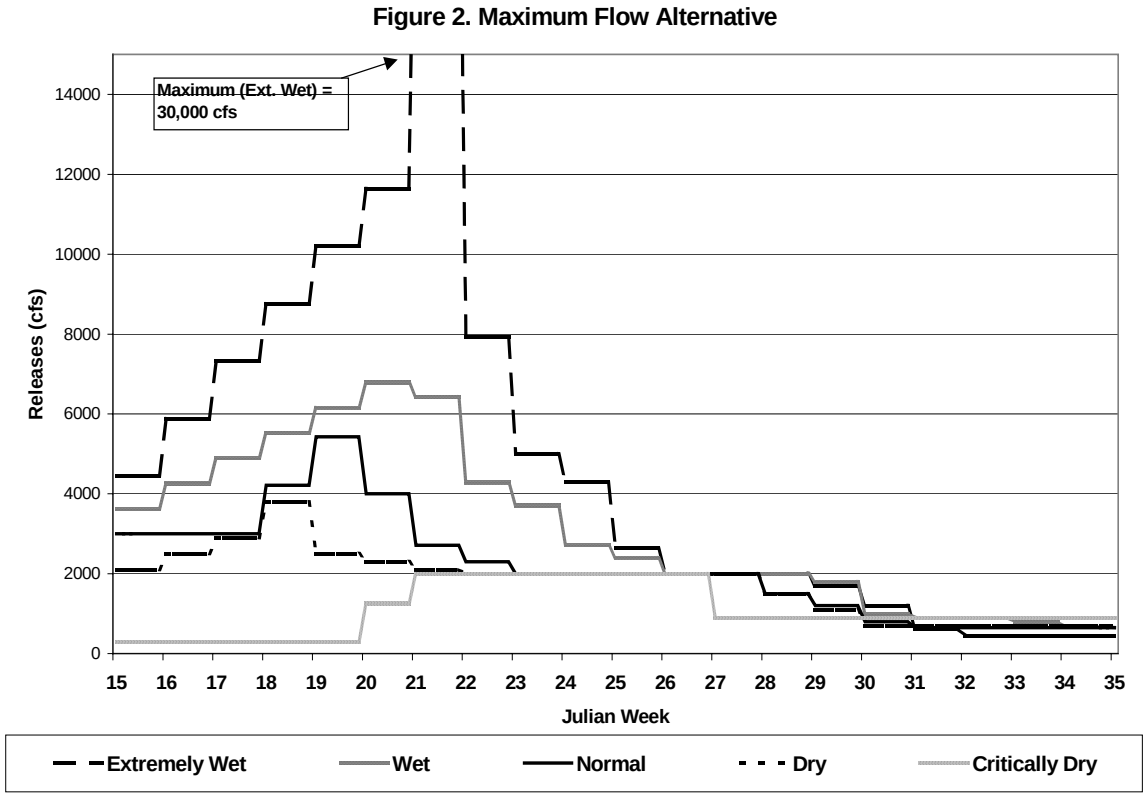


Figure 3. Hydrograph of Flow Releases for the Flow Evaluation Alternative during the active Period of Steelhead, Coho and Chinook Salmon Smolt Emigration.

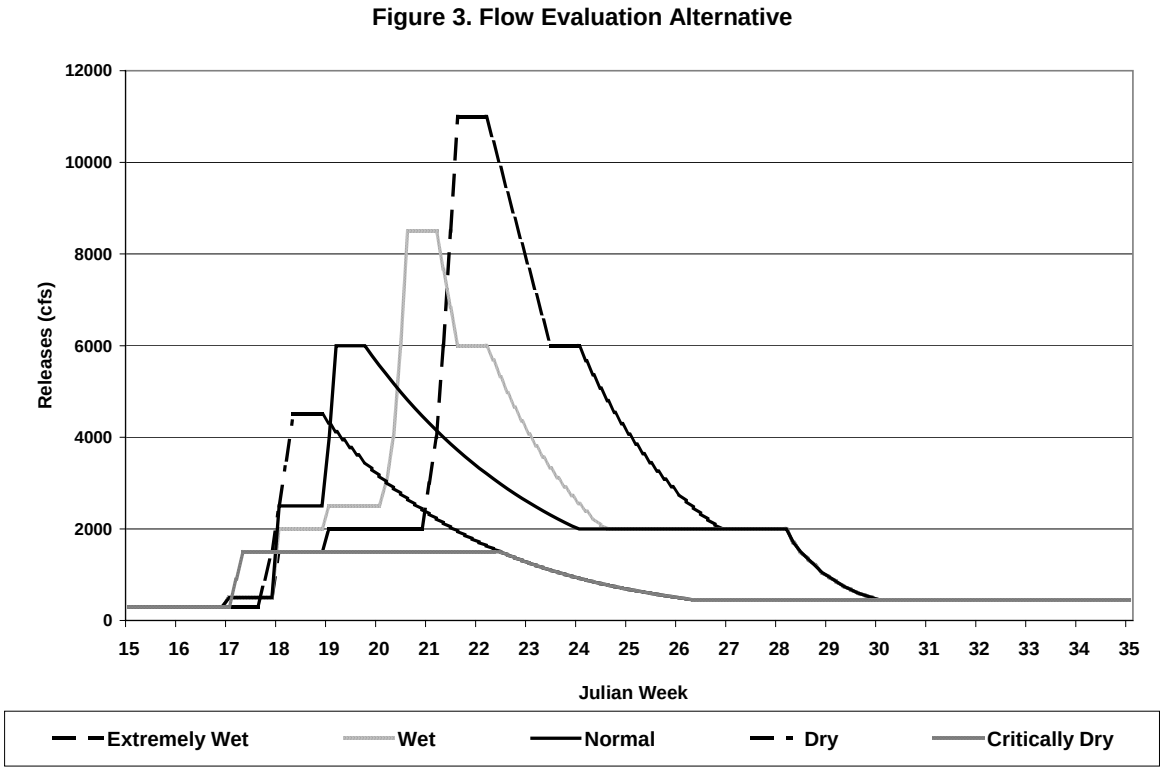


Figure 4. Hydrograph of Flow Releases for the 70 Percent Inflow Alternative during the active Period of Steelhead, Coho and Chinook Salmon Smolt Emigration.

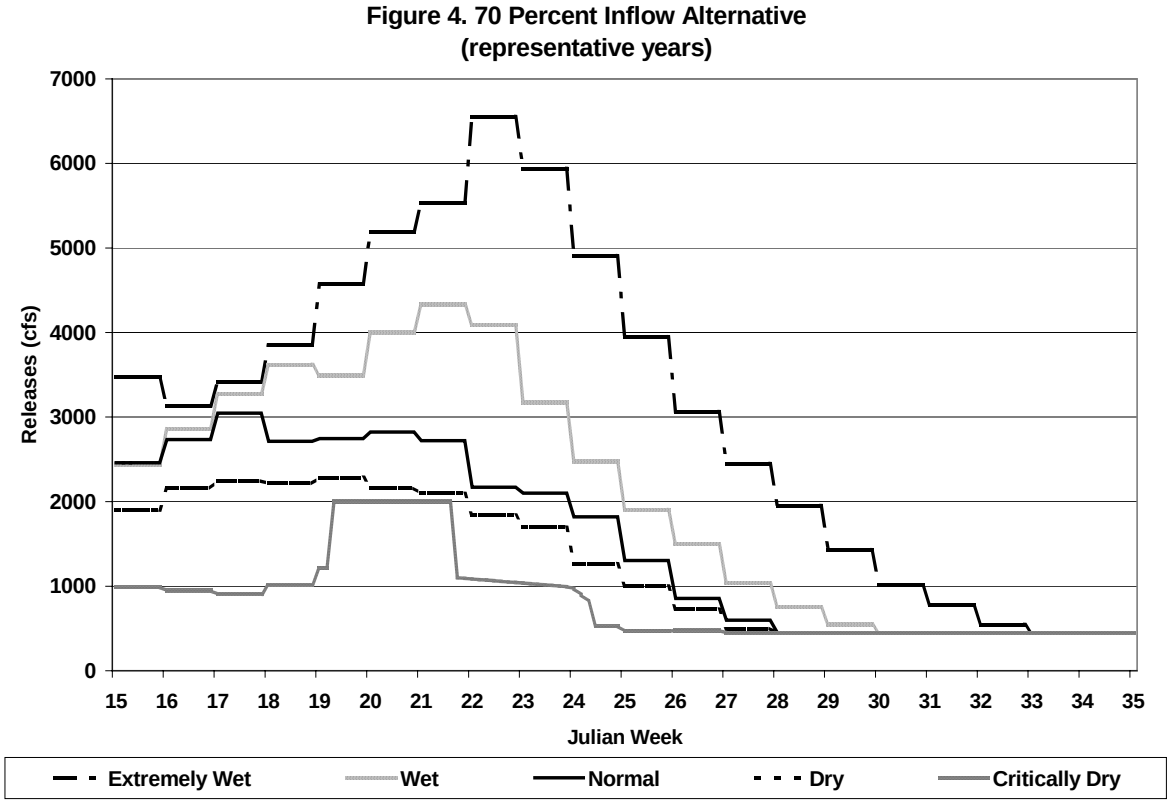


Figure 5. Hydrograph of Flow Releases for the Revised Mechanical Restoration Alternative during the active Period of Steelhead, Coho and Chinook Salmon Smolt Emigration.

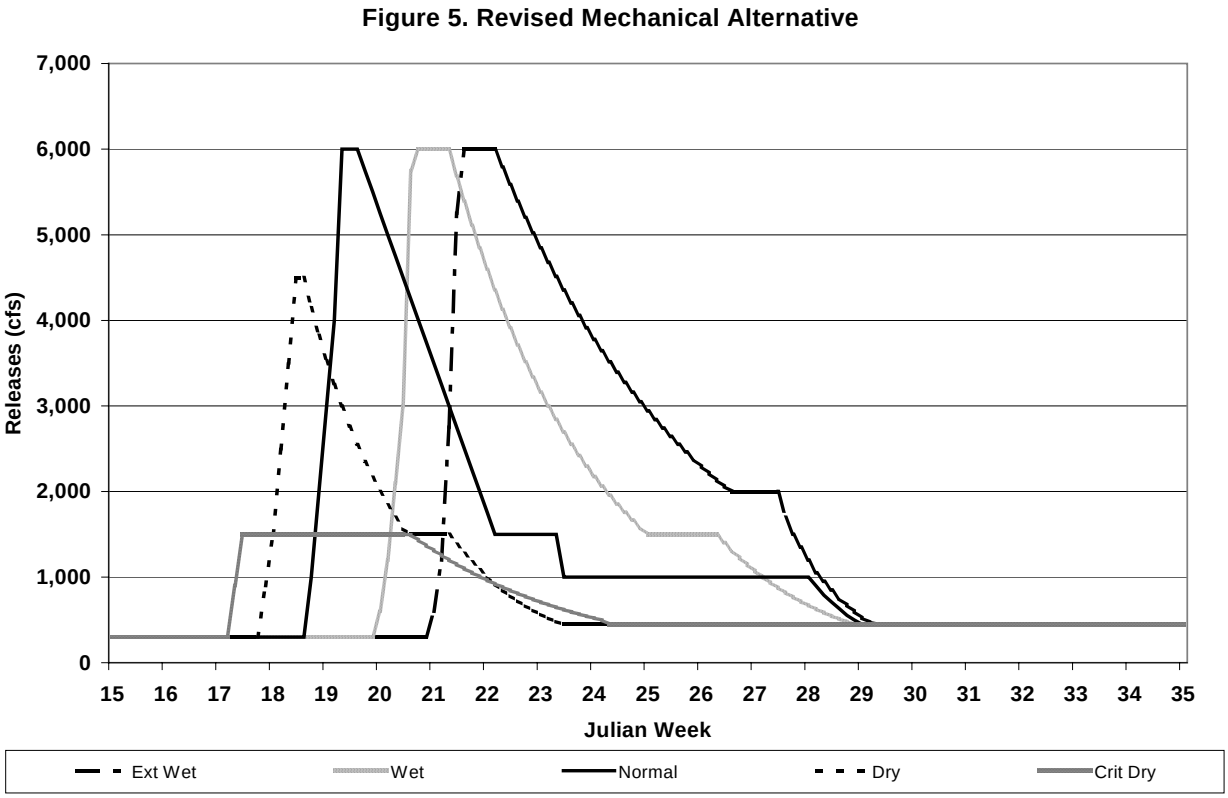


Figure 6. Hydrograph of Flow Releases for the Modified Percent Inflow Alternative during the active Period of Steelhead, Coho and Chinook Salmon Smolt Emigration.

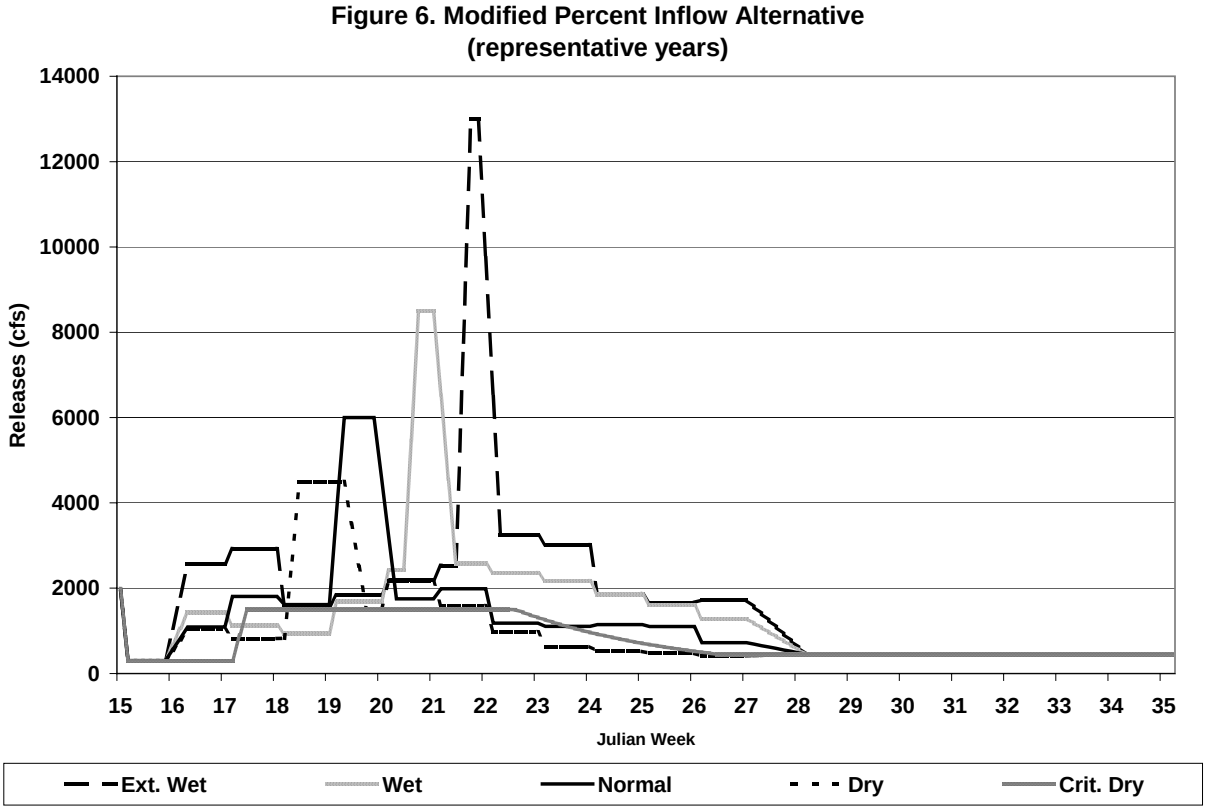


Figure 7. Mean weekly proportions of juvenile salmonid smolts outmigrating from the Trinity River, 1992-1999, 2001, at Willow Creek, CA.

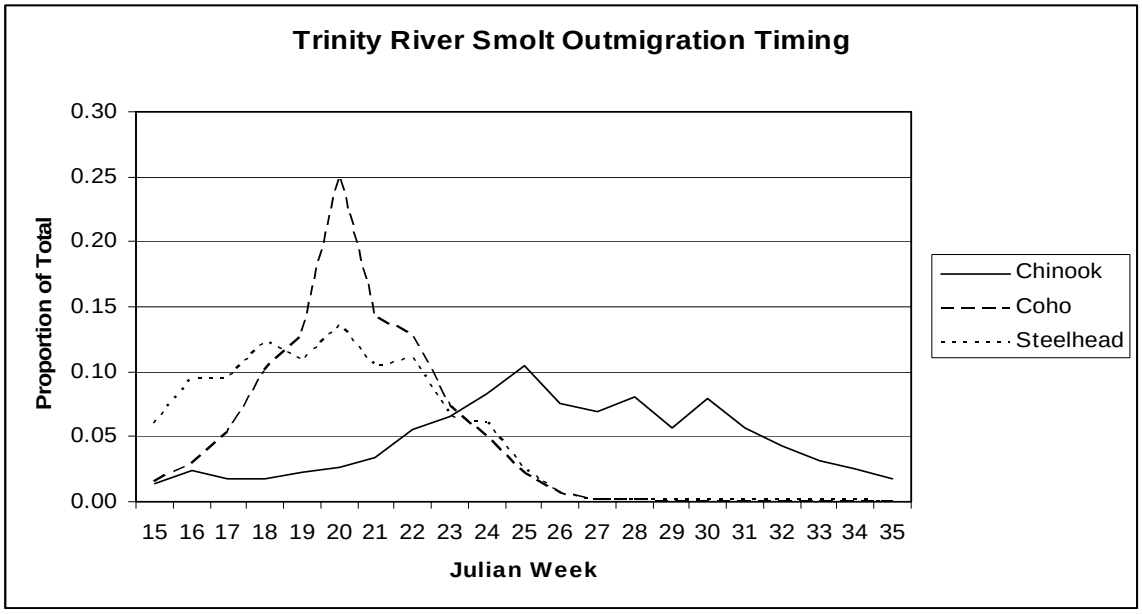


Figure 8. Steelhead Smolt Survival Suitability Indices by alternative

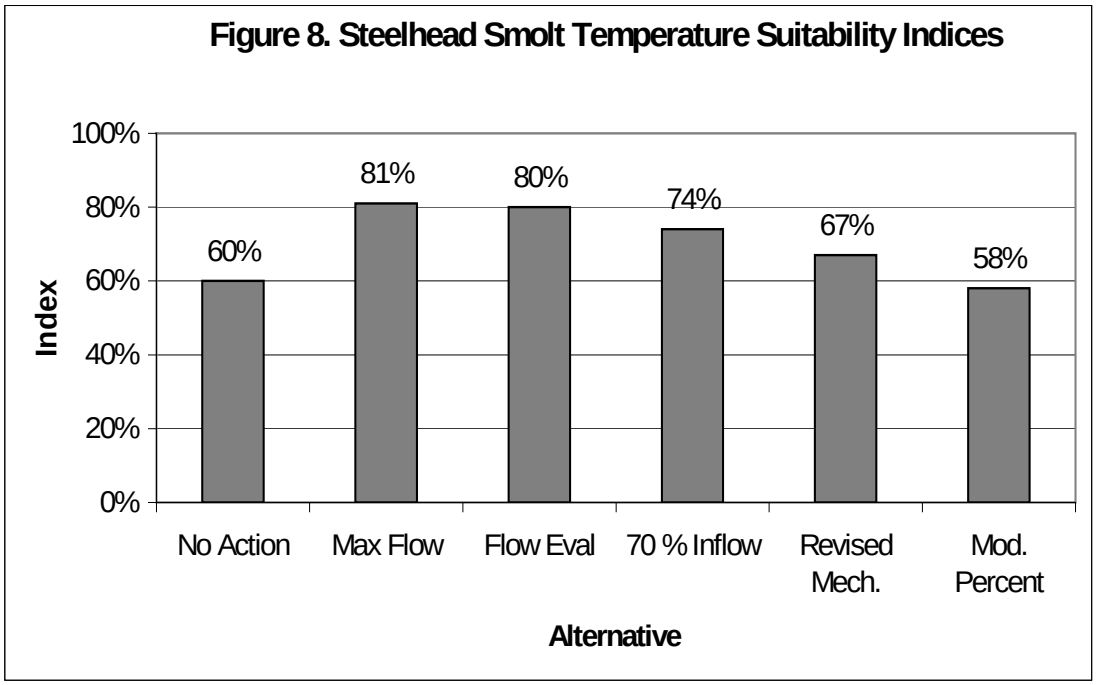


Figure 9. Mean Coho Salmon Smolt Survival Indices By Alternative.

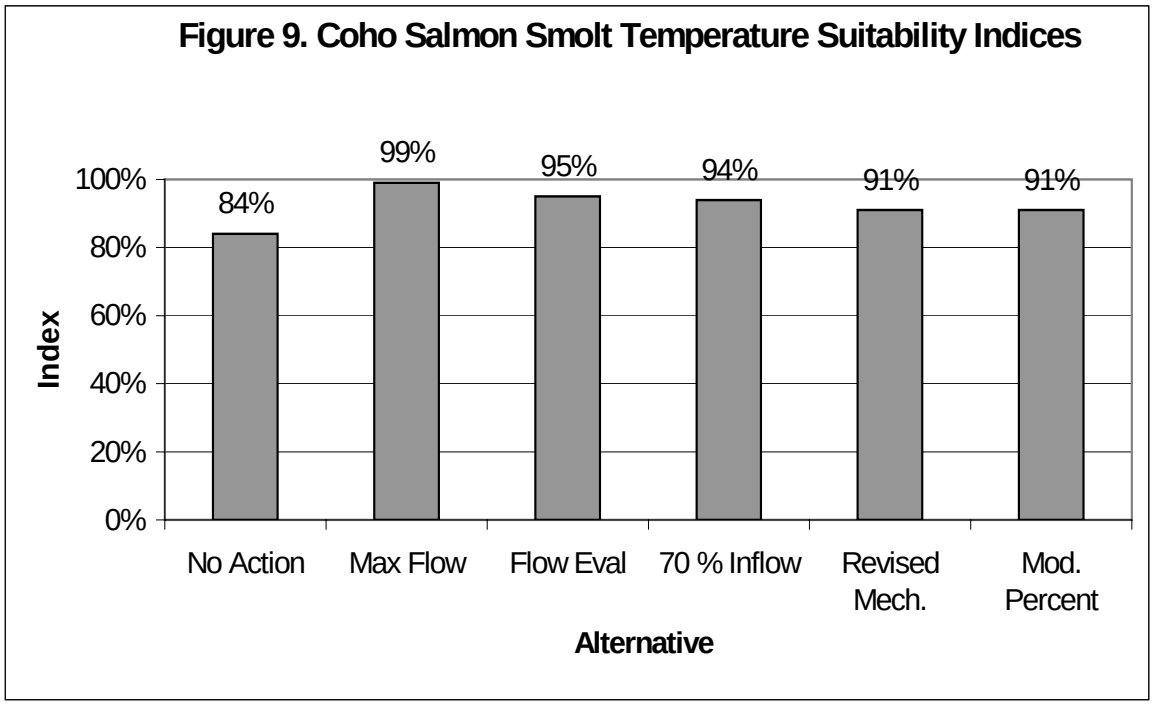


Figure 10. Percentage Change of the Chinook Salmon Smolt Survival Index Compared to the No Action Alternative.

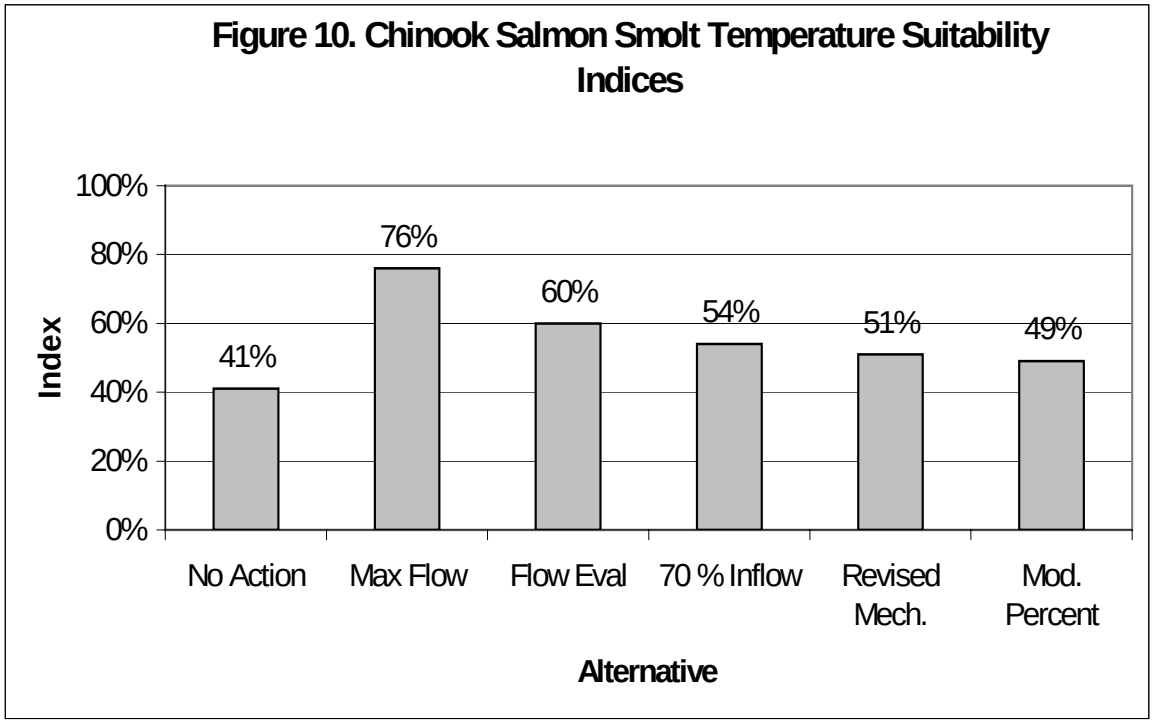
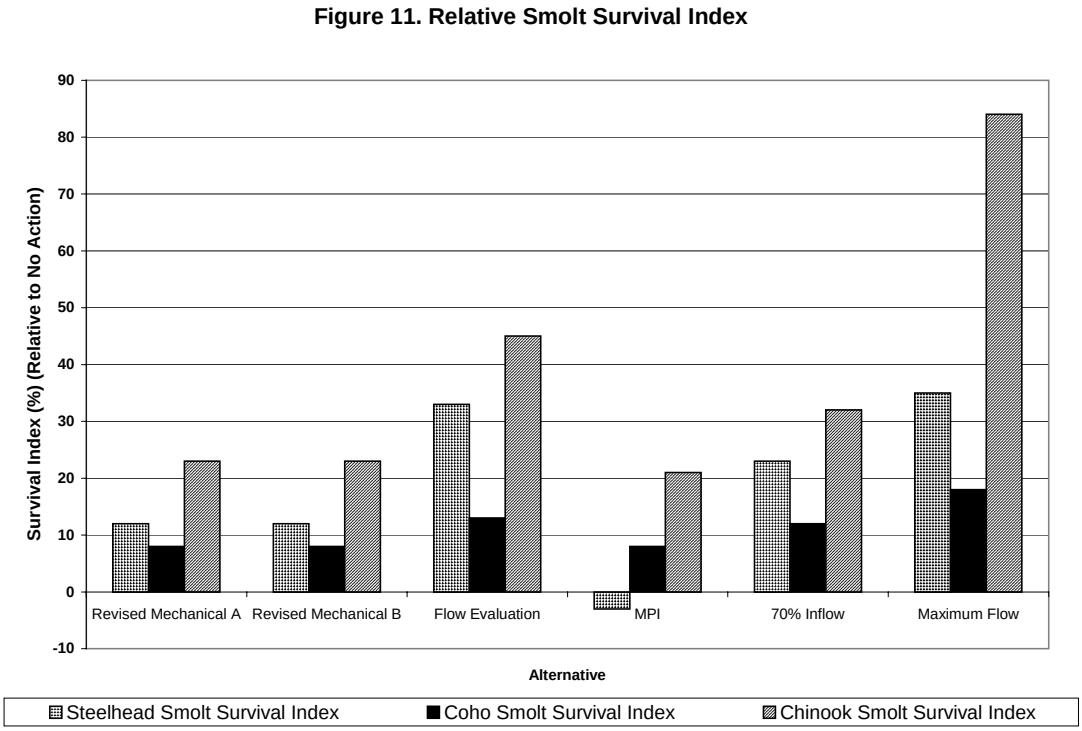


Figure 11.
Relative Changes in Smolt Survival Indices.



Attachment B6
TRAASM Scoring Worksheets

	ATTRIBUTE #1 Spatially complex channel geomorphology							
	OBJECTIVE	**No Action**	**Maxflow**	**FlowEval**	**Mech Rest**	**70% Inflow**	**Revised Mech**	**Mod. % Inflow**
1	Restore alluvial channel (able to form its own bed, particle, and bank dimensions)	NS	NS	NS	NS	NS	NS	NS
2	Create and/or maintain structural complexity of alternate bar sequences	NS	NS	NS	NS	NS	NS	NS
3	Create and maintain functional floodplains	NS	NS	NS	NS	NS	NS	NS
4	Increase diversity of channelbed particle size	NS	NS	NS	NS	NS	NS	NS
5	Greater topographic complexity in side channels	NS	NS	NS	NS	NS	NS	NS
	Sum of the Alternative	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**
Thresholds:								
1,2, 3	Dependent on an integration of all attributes							
Scorir	These objectives are dependent on the integration of all other attributes and therefore the Fish Tech Team did not attempt to assess these objectives to eliminate "double counting"							

	ATTRIBUTE #2 Flows and water quality are predictably unpredictable							
	OBJECTIVE	**No Action**	**Maxflow**	**FlowEval**	**Mech Rest**	**70% Inflow**	**Revised Mech**	**Mod. % Inflow**
1	Provide inter- and intra-annual flow variation for summer baseflows (July 1-October 1)	0	0	0	0	2	0	0
2	Provide inter- and intra-annual flow variation for winter baseflows (January 1-April 1)	0	0	0	0	2	0	0
3	Provide inter- and intra-annual flow variation for winter flood (October 1-April 30)	0	0	0	0	1	0	0
4	Provide inter- and intra-annual flow variation for snowmelt peak floods (April1-June 30)	1	2	2	1	2	2	2
5	Provide inter- and intra-annual flow variation for snowmelt recession (May 1-July 31)	1	2	2	1	2	2	2
	Sum of the Alternative	**2**	**4**	**4**	**2**	**9**	**4**	**4**

Thresholds:

1-5 Based on flow schedule's emulation of pre-dam hydrograph components

Scoring:

"2" presence of natural AND variable hydrograph components*
"1" presence of natural OR variable hydrograph components
"0" natural and variable hydrograph components absent

* natural components follow the same relative magnitude, trends and timing of pre-dam hydrograph components of the hydrograph are variable when magnitudes vary throughout the season and year

	ATTRIBUTE #3 Frequently mobilized channelbed surface							
	OBJECTIVE	**No Action**	**Maxflow**	**FlowEval**	**Mech Rest**	**70% Inflow**	**Revised Mech**	**Mod. % Inflow**
1	Exceed incipient motion for mobile active channel alluvial features (median bars, pool tails, spawning gravel deposits) every 2 of 3 years	0	2	2	0	2	2	2
2	Achieve incipient motion for most channelbed surfaces (riffles, face of point bars) every 2 of 3 years	0	2	2	0	2	2	2
3	Exceed threshold for transporting sand through most pools every 2 of 3 years	0	2	2	1	2	2	2
	Sum of the Alternative	**0**	**6**	**6**	**1**	**6**	**6**	**6**
Thresholds:								
1	Bed surface mobilization of the mobile active channel alluvial features occurs >3,000 cfs							
2	Bed surface mobilization of most of the channel bed surface occurs >6,000 cfs							
3	Transport of substantial volumes of sand through pools requires flows >3,000 cfs							
Scoring:								
	"2" Always or nearly always exceeds threshold							
	"1" sometimes exceeds threshold							
	"0" never or nearly never exceeds thresholds							

	ATTRIBUTE #4 Periodic channelbed scour and fill							
	OBJECTIVE	**No Action**	**Maxflow**	**FlowEval**	**Mech Rest**	**70% Inflow**	**Revised Mech**	**Mod. % Inflow**
1	Scour/redeposit spawning gravel deposits (at least 2 D84 thicknesses) every 2-3 years	0	2	2	0	2	2	2
2	Scour/redeposit faces of alternate bars (at least 2 D84 thicknesses) every 3-5 years	0	1	2	0	1	0	2
3	Deposit fine sediment onto upper alternate bar and floodplain surfaces every 2-3 years	0	2	2	0	2	1	2
4	Maintain scour channels on alternate bar surfaces every 3-5 years	0	1	2	0	1	0	2
	Sum of the Alternative	**0**	**6**	**8**	**0**	**6**	**3**	**8**
Thresholds:								
1	Bed scour (>2 D84 particle thickness) in mobile active channel features occurs >6,000 cfs							
2, 4	Bed Scour (>2 D84 thickness) on face of alternate bar surfaces begins to occur at 8,500 cfs							
3	Bed scour (>2 D84 particle thickness) in mobile active channel features occurs >6,000 cfs and with depths of 1 foot and greater on floodplain surfaces							
Scoring:								
	"2" always or nearly always exceeds threshold							
	"1" sometimes exceeds threshold							
	"0" never or nearly never exceeds threshold							

	ATTRIBUTE #5 Balanced fine and coarse sediment budgets							
	OBJECTIVE	**No Action**	**Maxflow**	**FlowEval**	**Mech Rest**	**70% Inflow**	**Revised Mech**	**Mod. % Inflow**
1	Reduce fine sediment storage in mainstem	0	2	2	1	2	2	2
2	Maintain coarse sediment budget in the mainstem	0	2	2	0	1	1	2
3	Route mobilized D84 gravel through alternate bar sequences every 2 of 3 years	0	2	2	0	2	2	2
4	Prevent excessive aggradation of tributary-derived material in the mainstem	0	2	2	0	2	2	2
	Sum of the Alternative	**0**	**8**	**8**	**1**	**7**	**7**	**8**

Thresholds:

1	Ability of combined flow magnitude and duration to transpost fine sediments through the system
2	Ability of combined flow magnitude and duration to achive ZERO net coarse sediment budget
3	Exceeded by flows greater than 6,000 cfs
4	Mechanically excavated and distributed downstream and/or maintained by flows; distribution of delta begins at > 6,000 cfs but coarser particles require flows >14,000 cfs

Scoring:

1	Alternatives were scored relative to each other, "2" moved the most fine sediment, "0" the least
2	Alternative closest to ZERO net supply scored "2", other over/under supplies were scored relative to this alternative, where "1" was the next best range, and "0" was the most over/under supply
3, 4	"2" always or nearly always exceeds threshold "1" sometimes exceeds threshold "0" never or nearly never exceeds threshold

	ATTRIBUTE #6 Periodic channel migration							
	OBJECTIVE	**No Action**	**Maxflow**	**FlowEval**	**Mech Rest**	**70% Inflow**	**Revised Mech**	**Mod. % Inflow**
1	Channel migrates in alluvial reaches	0	1	1	0	1	1	1
2	Maintain channel geometry as channel migrates	0	2	2	0	2	1	2
3	Create channel avulsions every 10 years	0	2	0	0	0	0	0
	Sum of the Alternative	**0**	**5**	**3**	**0**	**3**	**2**	**3**
Thresholds:								
1	Requires partial removal of riparian berm and estimate >6,000 cfs flow							
2	Requires adequate coarse sediment supply and estimated >6,000 cfs flow							
3	Flows must be greater than 30,000 cfs for channel avulsions							
Scoring:								
	"2" always or nearly always exceeds threshold							
	"1" sometimes exceeds threshold							
	"0" never or nearly never exceeds threshold							

	ATTRIBUTE #7 Functional floodplain							
	OBJECTIVE	**No Action**	**Maxflow**	**FlowEval**	**Mech Rest**	**70% Inflow**	**Revised Mech**	**Mod. % Inflow**
1	Inundate the floodplain on average every 2 to 3 years	0	2	2	0	2	1	2
2	Encourage local floodplain surface scour and deposition by infrequent (every 3-5 years) but larger floods	0	1	2	0	1	0	2
3	Floodplain construction keeps pace with floodplain loss on opposite bank	0	2	2	0	2	0	2
	Sum of the Alternative	**0**	**5**	**6**	**0**	**5**	**1**	**6**
Thresholds:								
1	Flows greater than 6,000 cfs							
2	Flows greater than 8,500 cfs							
3	Requires fine sediment supply and flows greater than 6,000 cfs and depths > 1' on floodplain							
Scoring:								
	"2" always or nearly always exceeds threshold							
	"1" sometimes exceeds threshold							
	"0" never or nearly never exceeds threshold							

	ATTRIBUTE #8 Infrequent channel resetting floods							
	OBJECTIVE	**No Action**	**Maxflow**	**FlowEval**	**Mech Rest**	**70% Inflow**	**Revised Mech**	**Mod. % Inflow**
1	Major reorganization of alternate bar sequences every 10-20 years	0	2	0	0	0	0	0
2	Remove upstream bedload impedance by distributing tributary delta materials	0	2	2	2	2	2	2
3	Infrequent (once in 5-10 years) deep scour on floodplain surfaces	0	2	0	0	0	0	0
4	Construct and maintain/rejuvenate side channels	0	2	1	2	1	2	2
5	Deposit fine sediment on lower terrace surfaces	0	2	0	0	1	0	0
	Sum of the Alternative	**0**	**10**	**3**	**4**	**4**	**4**	**4**
Thresholds:								
1	Flows estimated to be greater than 30,000 cfs							
2	Flows estimated to be greater than 14,000 cfs and balance coarse sediment budget							
3	Flows greater than 24,000 cfs							
4	Flows estimated to be > 11,000 cfs OR mechanically maitained side channels							
5	Flows greater than 11,000-14,000 cfs causing innundation of pre-dam flood plains (now functioning as terraces)							
Scoring:								
	"2" always or nearly always exceeds threshold							
	"1" sometimes exceeds threshold							
	"0" never or nearly never exceeds threshold							

	ATTRIBUTE #9 Self-sustaining diverse riparian plant communities							
	OBJECTIVE	**No Action**	**Maxflow**	**FlowEval**	**Mech Rest**	**70% Inflow**	**Revised Mech**	**Mod. % Inflow**
1	Prevent seedling germination on lower bar surfaces	0	1	1	0	1	1	1
2	Scour or remove most initiating seedlings (0- to 1-year old plants)	0	2	2	1	2	1	2
3	Scour of most established seedling (2- to 3-year old plants)	0	2	1	1	1	1	1
4	Periodic removal of individual mature riparian trees at least every 10 years	0	2	0	1	0	1	1
5	Seed deposition on floodplains every 2-3 years	0	2	2	0	2	2	2
	Sum of the Alternative	**0**	**9**	**6**	**3**	**6**	**6**	**7**
Thresholds:								
1	Bar innundation of seed dispersal period (1,500 cfs-2,000 cfs) in June and July							
2	Surficial bed scour on lower bar surfaces require flows greater than 6,000 cfs OR hand and/o mechanical removal							
3	Deep bed scour or bar surfaces requires flows greater than 8,500 to 14,000 cfs							
4	Individual exposed alder trees require at least 14,000 cfs, widespread removal of alder trees requires over 30,000 cfs OR mature riparian alders are mechanically removed							
5	Floodplain access begins at 5,000-6,000 cfs; flows needed May 5th to June 5th							
Scoring:								
	"2" always or nearly always exceeds threshold							
	"1" sometimes exceeds threshold							
	"0" never or nearly never exceeds threshold							

	ATTRIBUTE #10 Naturally fluctuating groundwater table							
	OBJECTIVE	**No Action**	**Maxflow**	**FlowEval**	**Mech Rest**	**70% Inflow**	**Revised Mech**	**Mod. % Inflow**
1	Groundwater recharge of gravel bars	2	2	2	2	2	2	2
2	Groundwater recharge of floodplains and off-channel wetland habitats	0	2	2	0	1	2	2
3	Groundwater recharge of terraces and associated wetland habitats	0	1	1	0	1	0	1
	Sum of the Alternative	**2**	**5**	**5**	**2**	**4**	**4**	**5**
Thresholds:								
	Exceeded by flows greater than 1,500-2,000 cfs							
	Exceeded by flows greater than 6,000 cfs							
	Flows greater than 10,000 to 14,000 cfs							
Scoring:								
	"2" always or nearly always exceeds threshold							
	"1" sometimes exceeds threshold							
	"0" never or nearly never exceeds threshold							

Attachment B7
Assumptions and Rationale for TRAASM Scores

TRINITY RIVER SEIS FISH AND CHANNEL RESTORATION TEAM-TRAASM SCORING RATIONALE

ASSUMPTIONS:

- If actions are made to improve habitat conditions that move closer to meeting or that meet the objectives of the "Healthy River" Attributes, fish production will increase,
- All Attributes were weighted equally important in the analysis of the Attributes,
- These Attributes provide and maintain habitat for all freshwater lifestages of anadromous salmonids,
- Changes in fish numbers are not linearly correlated with flow,
- Only scheduled flows were considered in scoring the attributes, no "safety of dam release" flows were assessed,
- Sediment related Attributes were only considered for the mainstem Trinity River upriver from Indian Creek confluence,
- The 70 percent Inflow and the Modified Inflow alternatives were based on historic inflows to the reservoir and not average flow schedules by water year type used for other impact assessment
- The impacts of water temperature on anadromous salmonids were evaluated outside the TRAASM methodology (see Attachment 6)

Attribute # 1, all Objectives

As the objectives under Attribute #1 depend on the integration of all the remaining 10 attributes, none of the Alternatives were scored (to eliminate potential double counting).

Attribute # 2

Objective 1

"0" was scored for all alternatives except the 70 Percent of inflow alternative. All the remaining alternatives have summer flows maintained to meet State Regional water quality standards and therefore there is no inter- and intra-annual variation.

"2" was scored for the 70 Percent Inflow alternative as this alternative allows for inter and intra-annual variation of flow releases during summer (above a "floor of 300 cfs) based on the in-flow to Trinity Reservoir.

Objective 2

"0" was scored for all alternatives except the 70 Percent of inflow alternative. All the remaining alternatives have winter flows maintained at minimum flow releases and therefore there is no inter- and intra-annual variation.

None of the alternative scored a "1" for this Objective.

"2" was scored for the 70 Percent Inflow alternative as this alternative allows for inter and intra-annual variation of flow releases during winter base flow period based on the in-flow to Trinity Reservoir.

Objective 3

"0" was scored for all alternatives except the 70 Percent of inflow alternative. All the remaining alternatives eliminate winter flood flows, maintaining minimum flow releases and therefore there is no inter- and intra-annual variation.

"1" was scored for the 70 Percent Inflow alternative as this alternative allows for inter and intra-annual variation of flow releases during winter flood flow period based on the in-flow to Trinity Reservoir but at a much smaller magnitude that historic hydrograph (a "cap" of 70% of in-flow to the Trinity Reservoir).

Objective 4

None of the alternatives scored a "0" as all provide at least some annual variation of snow-melt peak flows.

"1" was scored for No Action and Mechanical Restoration alternatives as these alternatives allow for a snowmelt peak flow each year (not variable between years however).

"2" was scored for the remaining alternatives as all have peaks of flows during the winter within a year and peaks that vary between years depending on water year type.

Objective 5

None of the alternatives scored a "0" as all provide at least some inter and intra-annual variation of snow-melt recession flows.

"1" was scored for No Action and Mechanical Restoration alternatives as these alternatives allow for a variable snow-melt (descending limb) hydrograph within each year (not variable between years however).

"2" was scored for the remaining alternatives as all have descending limb hydrographs within each year and are variable depending on water year type.

Attribute 2

Objective 1

"0" was scored for No Action and Mechanical Restoration alternatives as the threshold of flows greater that 3,000 cfs is never met.

"2" was scored for the remaining alternative as all had flows greater than the threshold of 3,000 cfs for at least 2 out of 3 years.

Objective 2

"0" was scored for No Action and Mechanical Restoration alternatives as the threshold of flows greater that 6,000 cfs is never met.

"2" was scored for the remaining alternative as all had flows greater than the threshold of 6,000 cfs for at least 2 out of 3 years.

Objective 3

"0" was scored for No Action as the threshold of flows greater that 3,000 cfs is never met.

"1" was scored for Mechanical Restoration as the objective may partially be met through additional mechanical dredging and fine sediment reduction input measures beyond that for the No Action alternative.

"2" was scored for the remaining alternative as all had flows greater than the threshold of 6,000 cfs for at least 2 out of 3 years.

Attribute 4

Objective 1

"0" was scored for No Action and Mechanical as flows greater than 6,000 cfs are never met.

"2" was scored for the remaining alternatives as all meet and exceed the 6,000 cfs threshold in at least 2 out of 3 years.

Objective 2

"0" was scored for No Action and Mechanical as flows greater than 8,500 cfs are never met.

"1" was scored for Maximum Flow and 70 Percent Inflow alternatives as these alternatives meet the threshold of 8,500 cfs only in extremely wet water years.

"2" was scored for the Flow Evaluation and Modified Percent Inflow alternatives as they meet the 8,500 cfs threshold in extremely wet and wet water year types.

Objective 3

"0" was scored for No Action and Mechanical as flows greater than 6,000 cfs are never met.

"1" was scored for Revised Mechanical alternative as this alternatives meets but doesn't exceed the minimum threshold of 6,000 cfs in 3 of 5 years and depths on the floodplain are minimal and much less than 1 foot.

"2" was scored for the remaining alternatives as all meet and greatly exceed the 6,000 cfs threshold in at least 2 out of 3 years.

Objective 4

"0" was scored for No Action and Mechanical as flows greater than 8,500 cfs are never met.

"1" was scored for Maximum Flow and 70 Percent Inflow alternatives as these alternatives meet the threshold of 8,500 cfs only in extremely wet water years.

"2" was scored for the Flow Evaluation and Modified Percent Inflow alternatives as they meet the 8,500 cfs threshold in extremely wet and wet water year types.

Attribute 5

Objective 1

"0" was scored for No Action as this alternative would be expected to move the least volume of fine sediment.

"1" was scored for Mechanical Restoration as this alternative were reduce fine sediment storage in the mainstem by additional mechanical dredging and fine sediment reduction input measures beyond that for the No Action alternative.

"2" was scored for the remaining alternatives all demonstrate the ability to reduce the accumulation and transport fine sediments through the system.

Objective 2

"0" was scored for the No Action and Mechanical Restoration alternatives as these have flow releases insufficient to route coarse sediment through the system resulting in large surpluses of coarse sediments over time.

"1" was scored for the 70 Percent and Revised Mechanical alternatives as these alternatives were "intermediate" in achieving a zero net supply of coarse sediment relative to the alternatives that resulted in either a large over or under supply of coarse sediments.

"2" was scored for the Maximum Flow, Flow Evaluation, and the Modified Percent Inflow alternatives as these were the best in meeting a zero net balance of coarse sediments relative to the other alternatives considering both flows and gravel augmentation.

Objective 3

"0" was scored for No Action and Mechanical Restoration alternative as these alternatives never reach the threshold of 6,000 cfs flow releases to route coarse sediment through alternate bar sequences.

"2" was scored for the remaining alternatives as all always or nearly always reach and/or exceed the threshold of 6,000 cfs flow releases in 3 out of 5 years to route coarse sediments through alternate bar sequences.

Objective 4

"0" was scored for No Action and Mechanical Restoration alternative as these alternatives never reach the threshold of 6,000 cfs flow releases to prevent coarse sediment aggradation of tributary-derived sediment in the mainstem.

"2" was scored for the remaining alternatives as all always or nearly always reach the threshold of 6,000 cfs to 14,000 cfs flow releases in 3 out of 5 years and/or would use additional mechanical excavation measures to prevent coarse sediment aggradation of tributary-derived sediment in the mainstem.

Attribute 6

Objective 1

"0" was scored for No Action and Mechanical Restoration alternatives as flows greater than 6,000 cfs are never met.

"1" was scored for the remaining alternatives as all meet the 6,000 cfs threshold to initiate channel migration but insufficient flow duration to maintain rate of channel migration.

None of the alternatives was scored a "2" as none met the duration of flows sufficient to maintain rate of channel migration.

Objective 2

"0" was scores for No Action and Mechanical Restoration alternatives as flows greater than 6,000 cfs are never met.

"1" was scored for the Revised Mechanical Restoration alternative as it meets the 6,000 cfs threshold to maintain channel geometry but insufficient to route coarse sediment through system.

"2" was scored for the remaining alternatives as flows are equal to or greater than 6,000 cfs are met to maintain channel geometry and also sufficiently routes course sediment through the system.

Objective 3

"0" was scored for all but the Maximum Flow alternative since none have scheduled releases of 30,000 cfs or greater.

"2" was scored for the Maximum Flow alternative as 30,000 cfs is scheduled for the first 3 extremely wet water years.

Attribute 7

Objective 1

"0" was scored for No Action and Mechanical Restoration as either of these alternatives ever exceed the threshold of 6,000 cfs.

"1" was scored for Revised Mechanical Restoration since this alternative meets the minimum of 6,000 cfs scheduled releases meet, but are no greater than, 6,000 cfs for widespread floodplain inundation.

"2" was scored for the remaining alternatives since the releases are greater than 6,000 cfs in greater than 2 out of 3 years.

Objective 2

"0" was scored for No Action, Mechanical Restoration, and Revised Mechanical Restoration alternative as these alternatives never reach 8,500 cfs required to encourage floodplain scour.

"1" was scored for Maximum Flow and 70 Percent Inflow alternatives as neither of these alternative provide scheduled releases of 8,500 cfs with sufficient frequency to meet the objective of 3 out of 5 years.

"2" was scored for the Flow Evaluation and Modified Percent Inflow alternatives as these alternatives exceed releases of greater than 8,500 cfs with sufficient frequency (>3 out of 5 years).

Objective 3

"0" was scored for No Action, Mechanical Restoration, and Revised Mechanical Restoration alternative as these alternatives never reach 6,000 cfs or exceed 6,000 cfs with sufficient depths greater than 1 foot on the floodplain required to encourage floodplain construction.

"2" was scored for the remaining alternatives as the threshold of 6,000 cfs and greater, with greater than 1 foot depth on the are met with sufficient frequency to provide fine sediment supply for floodplain construction.

Attribute 8

Objective 1

"0" was scored for all alternatives because none have scheduled releases of 30,000 cfs.

Objective 2

"0" was scored for No Action alternative as no schedules flows reach or exceed 14,000 cfs nor mechanical means would be used to accomplish objective.

"2" was scored for all action alternatives; Maximum flow because releases greater than 14,000 cfs would be provided; the remaining alternatives would use mechanical means to accomplish the objective.

Objective 3

"0" was scored for all but the Maximum flow alternative because schedule flow releases for those alternatives would never meet or exceed 14,000 cfs required to accomplish the objective.

"2" was scored for the Maximum Flow alternative because flow releases in excess of 14,000 cfs would occur at least once per 10 years.

Objective 4

"0" was scored by the No action alternative because the scheduled releases would not meet or exceed the 11,000 cfs threshold to meet the objective.

"1" was scored for the Flow Evaluation alternative because the scheduled flows up to 11,000 cfs in extremely wet water years (12% of years) may be sufficiently frequent to maintain the constructed side channels; the 70 Percent Flow alternative may provide adequate flows (>11,000 cfs) in sufficient number of years to maintain side channels and would use additional mechanical means for maintenance.

"2" was scored for the Maximum Flow alternative because scheduled releases up to 30,000 cfs in extremely wet water years are expected to construct and maintain side channels; the remaining alternatives would use mechanical means to construct and maintain side channels in order to meet this objective.

Objective 5

"0" was scored for No Action, Flow Evaluation, Mechanical Restoration, Revised Mechanical Restoration, and Modified Percent Inflow alternatives because scheduled flow releases never exceed 11,000 cfs.

"1" was scored for the 70 Percent of Inflow alternative as this alternative may provide adequate flows (>11,000 cfs) in sufficient number of years to deposit some fine sediments on the floodplain.

"2" was scored for the Maximum Flow Alternative because scheduled releases up to 30,000 cfs in extremely wet water years are expected to deposit fine sediments onto the floodplain.

Attribute 9

Objective 1

"0" was scored for the No Action and Mechanical Restoration Alternatives as neither of these alternatives provided flows >1,500-2,000 cfs in June and July thereby leaving bar surfaces exposed and allow seedling germination.

"1" was scored for all of the remaining alternatives as thee all had at least some period for at least some years where the scheduled flow releases were >1,500-2,000 cfs providing at least partial bar surface inundation and prevention of germination .

No Alternative always provided flows at >1,500-2000 cfs throughout June and July.

Objective 2

"0" was scored for No Action as no flows are scheduled for 6,000 cfs or greater nor are there mechanical methods used to remove initiating seedling plants.

"1" was scored for Mechanical Restoration, and Revised Mechanical Restoration alternatives because these alternatives rely only on mechanical means to remove initiating seedling on channel restoration sites only.

"2" was scored for the Flow Evaluation, the 70 Percent Inflow and Maximum Flow alternatives as these alternatives provide scheduled releases of greater that 6,000 cfs with sufficient frequency to scour initiating seedlings off of lower bar surfaces; the Modified Percent Inflow alternative would provide sufficiently frequent flows at or greater than 6,000 cfs and would provide mechanical seedling removal in spots.

Objective 3

"0" was scored for No Action as no flows are scheduled for 8,500 cfs or greater to 14,000 nor are there mechanical methods used to remove 2-3 year old plants.

"1" was scored for Flow Evaluation, 70 Percent Inflow, and Modified Percent Inflow alternatives provide flows that meet or exceed the 8,500 cfs threshold but not with sufficient frequency to scour most of the 2-3 year old plants along the channel. The Mechanical and Revised Mechanical Restoration alternatives do not provide adequate flows but rely on mechanical means to remove plants at specific locations, but not along the entire reach of channel.

"2" was scored for the Maximum Flow alternative because the scheduled flows of up to 30,000 cfs would be highly efficient at removing most established 2-3 plants along large segments of the channel.

Objective 4

"0 " was scored for the No Action, Flow Evaluation, and the 70 Percent alternatives as these alternatives don't have scheduled flow releases greater than 14,000 cfs.

"1" was scored for the Mechanical and the Revised Mechanical Restoration Alternatives because they would mechanically remove mature riparian trees at lease in some locations along the channel.

"2" was scored for the Maximum Flow alternative because flows greater than 14,000 and up to 30,000 cfs would be scheduled for extremely wet water years and would be highly effective in removing mature riparian trees along large segments of the channel.

Objective 5

"0" was scored for the No Action and the Mechanical Restoration Alternatives because those alternatives do not have scheduled releases greater than 5,000 to 6,000 cfs every 2-3 years during May to June to disperse seeds onto the floodplains.

"2" was scored for the Maximum Flow, Flow Evaluation, 70 Percent Inflow, Revised Mechanical Restoration, and the Modified Percent Inflow Alternatives as they all had scheduled flows greater than 5,000 to 6,000 cfs at least 1 of every 3 years (33%).

Attribute 10

Objective 1

"2" was scored by all alternatives as they all have scheduled flow releases greater than 1,500 to 2,000 cfs in all years.

Objective 2

"0" was scored for No Action and the Mechanical Restoration alternatives because these alternatives never have scheduled released greater than 6,000 cfs.

"1" was scored for the 70 Percent Inflow alternative because the frequency of years where scheduled flows equal or exceed 6,000 cfs is inadequate for completely recharging floodplains and off-channel wetlands habitats.

"2" was scored for the Maximum Flow, Flow Evaluation, Revised Mechanical Restoration, 70 Percent Inflow, and Modified Percent Inflow alternatives as the frequency years in which flows exceeding 6,000 cfs are sufficient to completely recharge floodplains and off-channel wetlands habitats.

Objective 3

"0" was scored for the No Action, Mechanical Restoration and the Revised Mechanical Restoration alternatives because scheduled flow releases for these alternative never exceed the threshold of 10,000 cfs needed to recharge the groundwater of terraces and associated wetland habitats.

"1" was scored for the Maximum Flow, Flow Evaluation, 70 Percent Inflow, and Modified Percent Inflow alternatives because many years scheduled flow releases exceed the 10,000 cfs threshold needed to recharge the groundwater of terraces and associated wetland habitats.

No alternatives were score a "2" as none always or nearly always had scheduled release flows of greater than 10,000 cfs.

Attachment B8
Tables of Annual Estimates of Chinook Salmon Mortalities in the Sacramento River

Sacramento River Salmon (Fall, Late-fall, Winter,Spring) Loss (%)

No Action Alternative (version 1 revised)

Year	Sac Index	Fall	Late Fall	Winter	Spring
1927	1	12.5	0.8	0.1	4.4
1938	1	13.2	1.5	0.3	6.8
1941	1	11.1	1.3	0.2	2.9
1942	1	9.7	0.7	0.1	2.6
1943	1	11.4	0.5	0.1	5.1
1952	1	6.9	0.7	0.2	2.0
1953	1	9.1	0.3	0.1	2.5
1956	1	9.8	2.0	0.3	2.9
1958	1	21.8	4.5	0.2	13.0
1963	1	13.7	0.9	0.3	10.1
1965	1	13.6	0.8	0.3	6.2
1967	1	21.4	3.0	0.2	9.6
1969	1	8.0	1.8	0.2	2.9
1970	1	15.1	0.7	0.2	14.8
1971	1	10.3	0.8	0.2	5.2
1974	1	13.8	1.7	0.2	4.0
1975	1	14.0	0.7	0.2	7.1
1982	1	1.5	0.8	0.2	2.4
1983	1	16.0	0.6	0.1	5.5
1984	1	10.3	0.4	0.6	5.4
1986	1	8.5	0.4	0.4	4.1
1922	2	7.0	0.4	0.2	2.4
1928	2	10.8	0.5	0.3	7.0
1940	2	13.3	1.3	0.3	6.0
1951	2	6.5	0.3	0.1	2.4
1954	2	13.4	0.6	0.1	7.3
1957	2	12.2	0.5	0.2	9.1
1973	2	5.3	1.0	0.3	4.2
1978	2	13.7	0.8	1.1	4.8
1980	2	6.5	0.2	0.1	1.6
1993	2	12.1	0.5	0.2	3.4
1923	3	13.4	1.4	1.5	3.4
1935	3	31.0	2.4	3.2	92.7
1936	3	31.8	4.5	1.8	38.7
1937	3	6.5	0.6	0.2	3.2
1945	3	14.6	0.5	0.1	4.6
1946	3	4.2	0.3	0.1	1.1
1948	3	9.1	0.5	0.3	4.5
1950	3	3.0	0.6	0.2	2.2
1959	3	35.6	4.7	0.8	65.5
1962	3	22.3	2.4	0.2	19.3
1966	3	14.7	0.5	0.1	11.1
1968	3	15.4	0.7	0.3	15.4
1972	3	10.9	0.3	0.3	7.4
1979	3	9.9	0.5	0.2	5.4
1925	4	20.4	1.2	0.4	23.6
1926	4	30.4	2.8	4.8	77.6
1930	4	16.9	1.7	1.4	7.5
1932	4	40.0	4.3	46.2	99.9
1939	4	24.8	2.3	0.3	29.1
1944	4	17.7	0.5	0.3	11.3
1947	4	21.0	1.1	0.8	24.9
1949	4	2.4	0.7	0.1	0.4
1955	4	15.2	0.9	0.2	7.2
1960	4	18.4	0.7	0.4	15.1
1961	4	23.1	1.4	0.2	23.2
1964	4	19.3	0.5	0.1	14.5
1981	4	12.4	0.5	0.2	8.7
1985	4	10.6	0.4	0.1	2.8
1987	4	25.9	1.3	0.1	32.8
1989	4	15.5	0.9	0.1	7.5
1924	5	29.6	1.1	98.7	96.5
1929	5	35.9	5.8	0.6	33.2
1931	5	36.2	2.0	87.8	99.2
1933	5	42.3	4.1	58.9	100.0
1934	5	36.0	2.9	100.0	99.0
1976	5	20.0	3.2	0.4	19.4
1977	5	36.6	1.3	93.6	99.2
1988	5	32.9	1.4	0.8	88.1
1990	5	29.3	1.7	0.6	63.4
1991	5	36.1	2.4	1.8	95.9
1992	5	37.5	2.1	62.1	99.4
Average		17.5	1.4	8.03	23.9

Sacramento River Salmon Mortality (%)

(Version 1 with revised Spawning Distributions*)

2001 Exist Cond

40-30-30 YRT		Fall	Late Fall	Winter	Spring
Wet	AVG	11.7	1.2	0.2	5.3
	MED	11.1	0.8	0.2	4.8
	MAX	21.7	4.5	0.6	12.7
	MIN	1.6	0.3	0.1	1.9
Above Normal	AVG	9.6	0.6	0.3	4.7
	MED	10.5	0.6	0.2	4.5
	MAX	14.2	1.0	1.1	8.8
	MIN	4.8	0.2	0.1	1.8
Below Normal	AVG	16.0	1.5	0.6	19.2
	MED	13.8	0.6	0.2	6.1
	MAX	35.5	4.9	2.2	85.8
	MIN	2.9	0.3	0.1	1.1
Dry	AVG	19.0	1.4	2.9	22.4
	MED	18.7	1.0	0.2	15.5
	MAX	39.9	4.6	37.3	99.8
	MIN	2.2	0.4	0.1	0.4
Critical	AVG	34.9	2.5	45.6	86.1
	MED	37.0	2.1	23.4	99.3
	MAX	43.2	5.8	99.4	100.0
	MIN	19.7	1.1	0.4	20.5

2020 No Act

40-30-30 YRT		Fall	Late Fall	Winter	Spring
Wet	AVG	12.0	1.2	0.2	5.7
	MED	11.4	0.8	0.2	5.1
	MAX	21.8	4.5	0.6	14.8
	MIN	1.5	0.3	0.1	2.0
Above Normal	AVG	10.1	0.6	0.3	4.8
	MED	11.5	0.5	0.2	4.5
	MAX	13.7	1.3	1.1	9.1
	MIN	5.3	0.2	0.1	1.6
Below Normal	AVG	15.9	1.4	0.7	19.6
	MED	14.0	0.6	0.2	6.4
	MAX	35.6	4.7	3.2	92.7
	MIN	3.0	0.3	0.1	1.1
Dry	AVG	19.6	1.3	3.5	24.1
	MED	18.8	1.0	0.2	14.8
	MAX	40.0	4.3	46.2	99.9
	MIN	2.4	0.4	0.1	0.4
Critical	AVG	33.8	2.5	45.9	81.2
	MED	36.0	2.1	58.9	96.5
	MAX	42.3	5.8	100.0	100.0
	MIN	20.0	1.1	0.4	19.4

Difference = 2020 No Act - 2001 Exist Cond

40-30-30 YRT		Fall	Late Fall	Winter	Spring
Wet	AVG	0.3	0.0	0.0	0.4
	MED	0.2	0.0	0.0	0.3
	MAX	0.1	0.0	0.0	2.1
	MIN	-0.1	0.0	0.0	0.2
Above Normal	AVG	0.4	0.0	0.0	0.1
	MED	0.9	-0.1	0.0	0.0
	MAX	-0.5	0.3	0.0	0.3
	MIN	0.6	0.0	0.0	-0.2
Below Normal	AVG	-0.1	0.0	0.1	0.4
	MED	0.2	-0.1	0.0	0.3
	MAX	0.0	-0.2	1.0	6.9
	MIN	0.1	0.0	0.0	0.0
Dry	AVG	0.6	0.0	0.6	1.8
	MED	0.1	0.0	0.0	-0.7
	MAX	0.1	-0.3	8.9	0.0
	MIN	0.1	0.0	0.0	0.0
Critical	AVG	-1.1	0.0	0.3	-4.9
	MED	-1.0	0.0	35.5	-2.7
	MAX	-0.9	0.0	0.6	0.0
	MIN	0.3	0.0	0.0	-1.0

No Action: Sacramento River Salmon Mortality (%) for Critical Water Years

Year	Sac Index	Fall	Late Fall	**Winter**	Spring
1924	5	29.6	1.1	**98.7**	96.5
1929	5	35.9	5.8	**0.6**	33.2
1931	5	36.2	2.0	**87.8**	99.2
1933	5	42.3	4.1	**58.9**	100.0
1934	5	36.0	2.9	**100.0**	99.0
1976	5	20.0	3.2	**0.4**	19.4
1977	5	36.6	1.3	**93.6**	99.2
1988	5	32.9	1.4	**0.8**	88.1
1990	5	29.3	1.7	**0.6**	63.4
1991	5	36.1	2.4	**1.8**	95.9
1992	5	37.5	2.1	**62.1**	99.4
	Average	33.8	2.5	**45.9**	81.2

Sacramento River Salmon (Fall, Late-fall, Winter,Spring) Loss (%)

Maximum Flow Alternative (version 1 revised)

Year	Sac Index	Fall	Late Fall	Winter	Spring
1927	1	23.7	1.1	0.1	27.0
1938	1	19.0	1.8	0.4	16.3
1941	1	14.7	1.5	0.3	5.2
1942	1	17.0	1.0	0.2	6.2
1943	1	20.1	1.0	0.1	16.8
1952	1	11.0	0.8	0.2	3.0
1953	1	14.9	0.6	0.2	6.6
1956	1	14.0	2.1	0.4	3.8
1958	1	26.8	5.3	0.4	25.8
1963	1	24.1	1.2	0.3	38.1
1965	1	17.4	1.1	2.1	7.9
1967	1	25.6	3.2	0.3	16.3
1969	1	14.4	2.3	0.2	3.1
1970	1	29.5	1.5	2.2	79.0
1971	1	14.9	1.0	0.2	7.1
1974	1	17.3	1.8	0.4	7.3
1975	1	19.1	1.1	0.3	17.2
1982	1	4.3	0.7	0.2	2.4
1983	1	19.9	1.1	0.2	11.0
1984	1	20.9	0.6	1.1	27.7
1986	1	24.8	1.4	0.5	35.4
1922	2	25.6	1.2	0.5	51.9
1928	2	28.9	1.5	0.7	73.3
1940	2	32.0	2.1	3.1	95.2
1951	2	20.1	0.8	0.2	14.2
1954	2	27.5	1.1	0.6	62.1
1957	2	17.2	1.0	0.2	12.1
1973	2	17.2	1.2	0.3	9.4
1978	2	24.5	1.7	1.0	16.6
1980	2	15.5	0.6	0.1	3.8
1993	2	14.9	0.7	0.3	5.7
1923	3	36.0	2.3	24.5	99.0
1935	3	34.7	2.4	25.0	98.8
1936	3	47.6	6.3	5.1	100.0
1937	3	22.6	1.4	0.4	24.5
1945	3	30.6	1.2	0.8	79.3
1946	3	17.9	0.7	0.1	11.1
1948	3	14.0	0.6	0.3	7.6
1950	3	6.3	0.8	0.3	3.1
1959	3	43.0	5.1	26.9	100.0
1962	3	27.2	2.5	0.3	44.4
1966	3	37.5	2.3	4.7	99.7
1968	3	31.7	1.6	4.2	92.2
1972	3	21.3	0.7	2.5	23.3
1979	3	17.6	0.6	0.3	14.7
1925	4	32.7	1.7	4.9	97.2
1926	4	37.3	2.3	27.7	99.4
1930	4	34.4	2.6	5.6	98.1
1932	4	40.1	4.2	80.7	99.9
1939	4	37.8	4.3	3.9	99.4
1944	4	33.6	1.3	2.5	96.5
1947	4	32.2	1.7	17.9	97.2
1949	4	9.0	1.9	0.2	0.4
1955	4	31.5	1.5	1.4	84.0
1960	4	35.1	1.5	5.0	99.1
1961	4	29.7	1.8	0.5	66.1
1964	4	28.8	1.2	0.3	59.8
1981	4	26.0	0.7	4.0	81.5
1985	4	29.4	0.9	10.1	95.3
1987	4	38.6	2.1	27.7	99.8
1989	4	29.3	1.3	8.9	93.1
1924	5	29.6	2.4	100.0	96.7
1929	5	46.7	6.4	16.0	100.0
1931	5	34.2	1.8	100.0	98.6
1933	5	40.4	3.2	95.9	99.9
1934	5	35.1	2.7	100.0	98.7
1976	5	37.7	4.9	3.4	98.9
1977	5	34.7	1.1	100.0	98.4
1988	5	38.5	1.4	79.3	99.7
1990	5	36.6	2.0	80.0	99.2
1991	5	38.0	1.7	100.0	99.4
1992	5	34.8	1.5	100.0	98.4
Average		26.6	1.8	16.5	55.0

Sacramento River Salmon Mortality (%)

(Version 1 with revised Spawning Distributions*)

No Action

40-30-30 YRT		Fall	Late Fall	Winter	Spring
Wet	AVG	12.0	1.2	0.2	5.7
	MED	11.4	0.8	0.2	5.1
	MAX	21.8	4.5	0.6	14.8
	MIN	1.5	0.3	0.1	2.0
Above Normal	AVG	10.1	0.6	0.3	4.8
	MED	11.5	0.5	0.2	4.5
	MAX	13.7	1.3	1.1	9.1
	MIN	5.3	0.2	0.1	1.6
Below Normal	AVG	15.9	1.4	0.7	19.6
	MED	14.0	0.6	0.2	6.4
	MAX	35.6	4.7	3.2	92.7
	MIN	3.0	0.3	0.1	1.1
Dry	AVG	19.6	1.3	3.5	24.1
	MED	18.8	1.0	0.2	14.8
	MAX	40.0	4.3	46.2	99.9
	MIN	2.4	0.4	0.1	0.4
Critical	AVG	33.8	2.5	45.9	81.2
	MED	36.0	2.1	58.9	96.5
	MAX	42.3	5.8	100.0	100.0
	MIN	20.0	1.1	0.4	19.4

Max Flow Alt

40-30-30 YRT		Fall	Late Fall	Winter	Spring
Wet	AVG	18.7	1.5	0.5	17.3
	MED	19.0	1.1	0.3	11.0
	MAX	29.5	5.3	2.2	79.0
	MIN	4.3	0.6	0.1	2.4
Above Normal	AVG	22.3	1.2	0.7	34.4
	MED	22.3	1.2	0.4	15.4
	MAX	32.0	2.1	3.1	95.2
	MIN	14.9	0.6	0.1	3.8
Below Normal	AVG	27.7	2.0	6.8	57.0
	MED	28.9	1.5	1.7	61.8
	MAX	47.6	6.3	26.9	100.0
	MIN	6.3	0.6	0.1	3.1
Dry	AVG	31.6	1.9	12.6	85.4
	MED	32.5	1.7	4.9	96.8
	MAX	40.1	4.3	80.7	99.9
	MIN	9.0	0.7	0.2	0.4
Critical	AVG	36.9	2.7	79.5	98.9
	MED	36.6	2.0	100.0	98.9
	MAX	46.7	6.4	100.0	100.0
	MIN	29.6	1.1	3.4	96.7

Difference = Max Flow Alt - No Action

40-30-30 YRT		Fall	Late Fall	Winter	Spring
Wet	AVG	6.8	0.3	0.3	11.6
	MED	7.7	0.3	0.1	5.9
	MAX	7.7	0.8	1.6	64.2
	MIN	2.8	0.3	0.0	0.3
Above Normal	AVG	12.3	0.6	0.4	29.6
	MED	10.8	0.7	0.2	10.9
	MAX	18.3	0.9	2.0	86.1
	MIN	9.6	0.4	0.0	2.2
Below Normal	AVG	11.8	0.6	6.2	37.4
	MED	14.9	0.9	1.4	55.4
	MAX	12.0	1.6	23.7	7.3
	MIN	3.2	0.4	0.0	2.0
Dry	AVG	12.0	0.6	9.1	61.3
	MED	13.6	0.7	4.7	82.1
	MAX	0.1	0.0	34.5	0.1
	MIN	6.6	0.3	0.1	-0.1
Critical	AVG	3.1	0.1	33.6	17.7
	MED	0.7	0.0	41.1	2.4
	MAX	4.4	0.6	0.0	0.0
	MIN	9.6	0.0	3.0	77.3

Maximum Flow: Sacramento River Salmon Mortality (%) for Critical Water Years

Year	Sac Index	Fall	Late Fall	**Winter**	Spring
1924	5	29.6	2.4	**100.0**	96.7
1929	5	46.7	6.4	**16.0**	100.0
1931	5	34.2	1.8	**100.0**	98.6
1933	5	40.4	3.2	**95.9**	99.9
1934	5	35.1	2.7	**100.0**	98.7
1976	5	37.7	4.9	**3.4**	98.9
1977	5	34.7	1.1	**100.0**	98.4
1988	5	38.5	1.4	**79.3**	99.7
1990	5	36.6	2.0	**80.0**	99.2
1991	5	38.0	1.7	**100.0**	99.4
1992	5	34.8	1.5	**100.0**	98.4
	Average	36.9	2.7	**79.5**	98.9

Sacramento River Salmon (Fall, Late-fall, Winter,Spring) Loss (%)

Preferred Flow (version 1 revised)

Year	Sac Index	Fall	Late Fall	Winter	Spring
1927	1	15.5	0.9	0.1	6.5
1938	1	14.1	1.6	0.4	8.6
1941	1	11.1	1.4	0.2	3.3
1942	1	10.2	0.8	0.2	3.1
1943	1	13.5	0.6	0.1	6.3
1952	1	7.2	0.9	0.3	2.9
1953	1	9.8	0.3	0.1	3.4
1956	1	11.1	2.1	0.3	4.0
1958	1	22.0	4.7	0.3	13.8
1963	1	19.3	1.3	0.3	20.0
1965	1	17.7	1.0	0.3	9.6
1967	1	21.6	3.1	0.2	9.9
1969	1	10.0	1.9	0.2	3.9
1970	1	24.2	1.1	0.3	35.0
1971	1	12.1	1.0	0.2	6.6
1974	1	14.2	1.9	0.4	6.3
1975	1	14.2	0.9	0.3	8.0
1982	1	3.2	0.7	0.2	3.0
1983	1	16.1	0.6	0.1	5.6
1984	1	11.4	0.4	0.6	6.7
1986	1	12.7	0.7	0.5	5.5
1922	2	8.8	0.5	0.2	2.9
1928	2	18.2	1.1	0.3	13.9
1940	2	20.5	1.6	0.4	18.4
1951	2	11.7	0.6	0.1	2.6
1954	2	16.9	0.6	0.1	13.0
1957	2	17.9	1.0	0.2	14.3
1973	2	8.9	0.9	0.3	4.2
1978	2	19.5	1.2	1.1	9.2
1980	2	7.3	0.2	0.1	1.9
1993	2	12.6	0.5	0.2	3.7
1923	3	20.3	2.0	2.3	10.6
1935	3	33.9	2.5	9.0	98.4
1936	3	38.8	5.4	1.9	75.2
1937	3	8.2	0.9	0.3	4.5
1945	3	17.4	0.6	0.1	8.6
1946	3	9.8	0.4	0.1	2.2
1948	3	10.4	0.5	0.2	4.8
1950	3	5.2	0.7	0.3	3.4
1959	3	36.4	4.5	1.2	82.6
1962	3	26.2	2.5	0.2	38.5
1966	3	24.4	1.3	0.2	27.3
1968	3	23.8	1.2	0.3	30.6
1972	3	16.2	0.5	0.3	13.3
1979	3	15.3	0.6	0.2	9.9
1925	4	27.0	1.5	0.7	59.5
1926	4	33.8	2.3	2.6	96.2
1930	4	21.6	2.0	0.3	15.8
1932	4	40.1	4.6	35.7	99.9
1939	4	19.4	0.9	1.2	48.2
1944	4	19.9	0.6	0.5	15.9
1947	4	26.2	1.5	1.2	52.6
1949	4	5.1	1.4	0.1	0.4
1955	4	19.8	1.2	0.3	15.0
1960	4	27.7	1.1	0.7	59.3
1961	4	30.7	1.8	0.7	78.2
1964	4	24.1	0.7	0.2	30.7
1981	4	16.2	0.5	0.2	17.6
1985	4	14.2	0.6	0.1	5.5
1987	4	25.9	1.6	0.1	33.1
1989	4	22.1	1.2	0.2	26.5
1924	5	29.6	1.1	99.1	96.7
1929	5	38.0	5.8	0.2	53.4
1931	5	35.2	1.8	93.9	98.9
1933	5	42.6	4.2	59.8	100.0
1934	5	35.7	2.7	100.0	99.0
1976	5	21.3	3.5	0.4	22.2
1977	5	36.5	1.2	94.5	99.1
1988	5	35.7	1.4	2.8	99.0
1990	5	35.3	2.0	4.4	98.7
1991	5	39.3	2.7	17.0	99.8
1992	5	37.3	2.1	79.1	99.4
Average		20.6	1.6	8.63	31.8

Sacramento River Salmon Mortality (%)

(Version 1 with revised Spawning Distributions*)

No Action

40-30-30 YRT		Fall	Late Fall	Winter	Spring
Wet	AVG	12.0	1.2	0.2	5.7
	MED	11.4	0.8	0.2	5.1
	MAX	21.8	4.5	0.6	14.8
	MIN	1.5	0.3	0.1	2.0
Above Normal	AVG	10.1	0.6	0.3	4.8
	MED	11.5	0.5	0.2	4.5
	MAX	13.7	1.3	1.1	9.1
	MIN	5.3	0.2	0.1	1.6
Below Normal	AVG	15.9	1.4	0.7	19.6
	MED	14.0	0.6	0.2	6.4
	MAX	35.6	4.7	3.2	92.7
	MIN	3.0	0.3	0.1	1.1
Dry	AVG	19.6	1.3	3.5	24.1
	MED	18.8	1.0	0.2	14.8
	MAX	40.0	4.3	46.2	99.9
	MIN	2.4	0.4	0.1	0.4
Critical	AVG	33.8	2.5	45.9	81.2
	MED	36.0	2.1	58.9	96.5
	MAX	42.3	5.8	100.0	100.0
	MIN	20.0	1.1	0.4	19.4

Pref Flow Alt

40-30-30 YRT		Fall	Late Fall	Winter	Spring
Wet	AVG	13.9	1.3	0.3	8.2
	MED	13.5	1.0	0.3	6.3
	MAX	24.2	4.7	0.6	35.0
	MIN	3.2	0.3	0.1	2.9
Above Normal	AVG	14.2	0.8	0.3	8.4
	MED	14.7	0.8	0.2	6.7
	MAX	20.5	1.6	1.1	18.4
	MIN	7.3	0.2	0.1	1.9
Below Normal	AVG	20.5	1.7	1.2	29.3
	MED	18.9	1.1	0.3	12.0
	MAX	38.8	5.4	9.0	98.4
	MIN	5.2	0.4	0.1	2.2
Dry	AVG	23.4	1.5	2.8	40.9
	MED	23.1	1.3	0.4	31.9
	MAX	40.1	4.6	35.7	99.9
	MIN	5.1	0.5	0.1	0.4
Critical	AVG	35.1	2.6	50.1	87.8
	MED	35.7	2.1	59.8	99.0
	MAX	42.6	5.8	100.0	100.0
	MIN	21.3	1.1	0.2	22.2

Difference = Pref Flow Alt - No Action

40-30-30 YRT		Fall	Late Fall	Winter	Spring
Wet	AVG	1.9	0.1	0.0	2.5
	MED	2.1	0.2	0.1	1.2
	MAX	2.4	0.2	0.0	20.2
	MIN	1.7	0.0	0.0	0.9
Above Normal	AVG	4.1	0.2	0.0	3.6
	MED	3.2	0.3	0.0	2.2
	MAX	6.8	0.4	0.0	9.3
	MIN	2.0	0.0	0.0	0.3
Below Normal	AVG	4.6	0.3	0.5	9.7
	MED	4.8	0.5	0.1	5.6
	MAX	3.2	0.7	5.8	5.7
	MIN	2.1	0.2	0.0	1.1
Dry	AVG	3.8	0.1	-0.7	16.8
	MED	4.2	0.3	0.1	17.1
	MAX	0.1	0.3	-10.5	0.0
	MIN	2.7	0.1	0.0	0.0
Critical	AVG	1.3	0.1	4.2	6.6
	MED	-0.2	0.0	0.9	2.4
	MAX	0.4	0.0	0.0	0.0
	MIN	1.3	-0.1	-0.2	2.7

Preferred Flow: Sacramento River Salmon Mortality (%) for Critical Water Years

Year	Sac Index	Fall	Late Fall	**Winter**	Spring
1924	5	29.6	1.1	**99.1**	96.7
1929	5	38.0	5.8	**0.2**	53.4
1931	5	35.2	1.8	**93.9**	98.9
1933	5	42.6	4.2	**59.8**	100.0
1934	5	35.7	2.7	**100.0**	99.0
1976	5	21.3	3.5	**0.4**	22.2
1977	5	36.5	1.2	**94.5**	99.1
1988	5	35.7	1.4	**2.8**	99.0
1990	5	35.3	2.0	**4.4**	98.7
1991	5	39.3	2.7	**17.0**	99.8
1992	5	37.3	2.1	**79.1**	99.4
Average		35.1	2.6	**50.1**	87.8

Sacramento River Salmon (Fall, Late-fall, Winter,Spring) Loss (%)

70 Percent Inflow Alternative (version 1 revised)

Year	Sac Index	Fall	Late Fall	Winter	Spring
1927	1	21.6	1.1	0.1	18.2
1938	1	16.7	1.7	0.4	13.4
1941	1	11.4	1.5	0.3	3.7
1942	1	12.1	0.8	0.2	3.4
1943	1	17.5	0.9	0.1	10.6
1952	1	7.7	0.9	0.2	2.7
1953	1	10.9	0.4	0.2	3.7
1956	1	11.8	2.2	0.4	3.7
1958	1	22.2	5.2	0.3	14.5
1963	1	22.4	1.3	0.3	28.2
1965	1	23.2	1.1	1.5	22.3
1967	1	21.3	3.1	0.3	9.8
1969	1	12.1	2.2	0.2	2.8
1970	1	31.6	1.7	2.7	92.0
1971	1	15.9	1.0	0.2	9.4
1974	1	15.1	1.9	0.3	5.8
1975	1	18.8	1.1	0.3	16.6
1982	1	4.1	0.7	0.2	2.4
1983	1	16.2	0.8	0.1	5.9
1984	1	18.5	0.6	1.1	18.0
1986	1	20.3	1.2	0.5	16.4
1922	2	17.1	0.9	0.2	9.5
1928	2	24.0	1.5	0.3	28.9
1940	2	28.8	2.1	0.8	69.4
1951	2	17.9	0.9	0.1	9.5
1954	2	13.4	0.3	0.1	21.0
1957	2	22.3	1.0	0.3	36.4
1973	2	12.5	1.0	0.3	4.7
1978	2	24.9	1.7	1.0	17.8
1980	2	13.2	0.6	0.1	1.8
1993	2	13.9	0.6	0.3	4.3
1923	3	28.4	2.2	2.8	55.7
1935	3	35.5	2.5	24.3	99.1
1936	3	47.4	6.3	4.7	100.0
1937	3	23.4	1.5	0.4	26.1
1945	3	27.4	0.9	0.3	49.2
1946	3	14.1	0.6	0.1	4.1
1948	3	14.8	0.8	0.2	7.4
1950	3	6.4	0.8	0.3	3.0
1959	3	41.5	4.6	12.5	99.9
1962	3	29.6	2.3	0.6	66.4
1966	3	27.7	1.7	0.6	56.4
1968	3	31.1	1.6	3.2	88.9
1972	3	23.9	0.9	2.5	37.9
1979	3	19.8	0.7	0.3	18.4
1925	4	29.1	1.6	1.5	82.9
1926	4	37.1	2.1	16.8	99.4
1930	4	31.1	2.5	1.0	83.7
1932	4	39.8	4.3	49.6	99.9
1939	4	36.0	4.1	1.3	94.7
1944	4	25.5	0.9	0.6	36.0
1947	4	28.8	1.7	2.6	78.6
1949	4	7.7	2.0	0.1	0.3
1955	4	27.8	1.5	0.4	51.7
1960	4	32.7	1.4	2.2	94.8
1961	4	35.0	1.8	2.3	99.1
1964	4	30.3	1.2	0.4	72.6
1981	4	26.7	0.7	4.2	83.7
1985	4	21.7	0.7	0.1	26.1
1987	4	35.8	1.9	2.2	99.2
1989	4	24.2	1.3	0.3	40.9
1924	5	29.7	1.0	100.0	96.9
1929	5	45.3	6.4	1.8	99.9
1931	5	34.4	1.7	100.0	98.6
1933	5	39.0	3.0	89.9	99.4
1934	5	35.2	2.7	100.0	98.8
1976	5	29.8	4.7	0.5	45.1
1977	5	34.7	1.0	100.0	98.4
1988	5	38.3	1.7	10.1	99.7
1990	5	37.3	2.1	14.3	99.4
1991	5	38.5	2.1	36.2	99.5
1992	5	35.5	1.9	98.4	98.7
Average		24.7	1.8	11.2	47.2

Sacramento River Salmon Mortality (%)

(Version 1 with revised Spawning Distributions*)

No Action

40-30-30 YRT		Fall	Late Fall	Winter	Spring
Wet	AVG	12.0	1.2	0.2	5.7
	MED	11.4	0.8	0.2	5.1
	MAX	21.8	4.5	0.6	14.8
	MIN	1.5	0.3	0.1	2.0
Above Normal	AVG	10.1	0.6	0.3	4.8
	MED	11.5	0.5	0.2	4.5
	MAX	13.7	1.3	1.1	9.1
	MIN	5.3	0.2	0.1	1.6
Below Normal	AVG	15.9	1.4	0.7	19.6
	MED	14.0	0.6	0.2	6.4
	MAX	35.6	4.7	3.2	92.7
	MIN	3.0	0.3	0.1	1.1
Dry	AVG	19.6	1.3	3.5	24.1
	MED	18.8	1.0	0.2	14.8
	MAX	40.0	4.3	46.2	99.9
	MIN	2.4	0.4	0.1	0.4
Critical	AVG	33.8	2.5	45.9	81.2
	MED	36.0	2.1	58.9	96.5
	MAX	42.3	5.8	100.0	100.0
	MIN	20.0	1.1	0.4	19.4

70 Perc Alt

40-30-30 YRT		Fall	Late Fall	Winter	Spring
Wet	AVG	16.7	1.5	0.5	14.4
	MED	16.7	1.1	0.3	9.8
	MAX	31.6	5.2	2.7	92.0
	MIN	4.1	0.4	0.1	2.4
Above Normal	AVG	18.8	1.1	0.3	20.3
	MED	17.5	0.9	0.3	13.7
	MAX	28.8	2.1	1.0	69.4
	MIN	12.5	0.3	0.1	1.8
Below Normal	AVG	26.5	2.0	3.8	50.9
	MED	27.5	1.5	0.6	52.4
	MAX	47.4	6.3	24.3	100.0
	MIN	6.4	0.6	0.1	3.0
Dry	AVG	29.3	1.9	5.4	71.5
	MED	29.7	1.6	1.4	83.3
	MAX	39.8	4.3	49.6	99.9
	MIN	7.7	0.7	0.1	0.3
Critical	AVG	36.2	2.6	59.2	94.1
	MED	35.5	2.1	89.9	98.8
	MAX	45.3	6.4	100.0	99.9
	MIN	29.7	1.0	0.5	45.1

Difference = 70 Perc Alt - No Action

40-30-30 YRT		Fall	Late Fall	Winter	Spring
Wet	AVG	4.7	0.3	0.2	8.8
	MED	5.4	0.3	0.1	4.7
	MAX	9.8	0.6	2.1	77.2
	MIN	2.6	0.1	0.0	0.4
Above Normal	AVG	8.7	0.5	0.1	15.5
	MED	6.0	0.4	0.1	9.2
	MAX	15.1	0.9	-0.1	60.3
	MIN	7.2	0.1	0.0	0.2
Below Normal	AVG	10.6	0.5	3.1	31.3
	MED	13.5	0.9	0.4	46.0
	MAX	11.9	1.6	21.1	7.3
	MIN	3.4	0.3	0.0	1.9
Dry	AVG	9.7	0.5	1.9	47.3
	MED	10.9	0.6	1.2	68.5
	MAX	-0.2	0.0	3.4	0.0
	MIN	5.4	0.3	0.0	-0.2
Critical	AVG	2.3	0.0	13.3	12.8
	MED	-0.4	0.0	31.0	2.2
	MAX	3.0	0.6	0.0	-0.1
	MIN	9.7	-0.2	0.0	25.6

70 Percent Inflow: Sacramento River Salmon Mortality (%) for Critical Water Years

Year	Sac Index	Fall	Late Fall	**Winter**	Spring
1924	5	29.7	1.0	**100.0**	96.9
1929	5	45.3	6.4	**1.8**	99.9
1931	5	34.4	1.7	**100.0**	98.6
1933	5	39.0	3.0	**89.9**	99.4
1934	5	35.2	2.7	**100.0**	98.8
1976	5	29.8	4.7	**0.5**	45.1
1977	5	34.7	1.0	**100.0**	98.4
1988	5	38.3	1.7	**10.1**	99.7
1990	5	37.3	2.1	**14.3**	99.4
1991	5	38.5	2.1	**36.2**	99.5
1992	5	35.5	1.9	**98.4**	98.7
Average		36.2	2.6	**59.2**	94.1

Sacramento River Salmon (Fall, Late-fall, Winter,Spring) Loss (%)

Revised Mechanical Alternative (version 1 revised)

Year	Sac Index	Fall	Late Fall	Winter	Spring
1927	1	12.4	0.8	0.1	4.3
1938	1	13.6	1.6	0.4	7.9
1941	1	11.2	1.3	0.2	3.0
1942	1	9.9	0.8	0.2	2.7
1943	1	11.1	0.5	0.1	4.9
1952	1	6.9	0.8	0.2	2.4
1953	1	9.3	0.3	0.1	2.6
1956	1	10.1	2.0	0.3	3.5
1958	1	22.0	4.6	0.2	13.5
1963	1	17.1	0.9	0.3	17.1
1965	1	14.6	0.9	0.3	6.4
1967	1	21.4	3.0	0.2	9.8
1969	1	8.9	1.8	0.1	3.1
1970	1	19.0	0.9	0.2	17.5
1971	1	10.5	0.9	0.2	5.5
1974	1	14.0	1.8	0.3	4.7
1975	1	14.2	0.8	0.2	7.5
1982	1	2.2	0.7	0.2	3.2
1983	1	16.1	0.6	0.1	5.6
1984	1	10.6	0.4	0.6	5.7
1986	1	8.4	0.4	0.5	4.4
1922	2	7.0	0.4	0.2	2.4
1928	2	14.8	0.9	0.3	8.2
1940	2	13.5	1.2	0.3	6.1
1951	2	6.5	0.4	0.1	2.2
1954	2	13.1	0.6	0.1	7.7
1957	2	15.9	0.7	0.2	11.2
1973	2	7.1	0.9	0.3	4.2
1978	2	15.8	1.0	1.1	6.2
1980	2	5.8	0.2	0.1	1.8
1993	2	12.3	0.5	0.2	3.5
1923	3	14.1	1.4	1.5	4.4
1935	3	32.2	2.5	5.0	96.3
1936	3	33.0	4.7	1.8	44.1
1937	3	7.5	0.7	0.2	3.6
1945	3	15.5	0.6	0.1	5.6
1946	3	6.4	0.3	0.1	1.5
1948	3	9.4	0.5	0.2	4.2
1950	3	3.9	0.6	0.2	2.9
1959	3	35.1	4.6	0.9	62.9
1962	3	24.8	2.5	0.2	27.4
1966	3	17.3	0.6	0.2	13.0
1968	3	19.6	1.0	0.3	19.3
1972	3	10.8	0.3	0.3	7.3
1979	3	11.7	0.5	0.2	5.7
1925	4	23.9	1.4	0.5	35.4
1926	4	30.6	2.3	1.2	78.0
1930	4	18.9	1.9	0.6	10.1
1932	4	39.9	4.2	54.4	99.9
1939	4	24.5	2.2	0.3	28.1
1944	4	16.9	0.5	0.3	10.5
1947	4	21.2	1.2	1.3	26.0
1949	4	3.0	0.7	0.1	0.4
1955	4	15.3	0.9	0.2	8.4
1960	4	19.3	0.7	0.4	17.9
1961	4	26.6	1.6	0.2	42.4
1964	4	19.1	0.5	0.1	14.5
1981	4	12.3	0.5	0.2	8.6
1985	4	10.5	0.4	0.1	2.8
1987	4	22.4	1.2	0.1	16.0
1989	4	17.7	1.2	0.2	11.3
1924	5	29.6	1.1	99.6	96.6
1929	5	34.5	5.6	0.6	31.7
1931	5	35.8	1.9	92.1	99.1
1933	5	42.4	4.1	73.0	100.0
1934	5	35.8	3.2	100.0	99.0
1976	5	19.4	3.2	0.4	19.0
1977	5	36.8	1.5	93.4	99.2
1988	5	34.3	1.5	2.7	95.7
1990	5	31.8	1.8	1.4	85.8
1991	5	37.0	2.6	3.0	98.7
1992	5	37.6	2.1	68.3	99.4
Average		18.2	1.4	8.5	25.3

Sacramento River Salmon Mortality (%)

(Version 1 with revised Spawning Distributions*)

No Action

40-30-30 YRT		Fall	Late Fall	Winter	Spring
Wet	AVG	12.0	1.2	0.2	5.7
	MED	11.4	0.8	0.2	5.1
	MAX	21.8	4.5	0.6	14.8
	MIN	1.5	0.3	0.1	2.0
Above Normal	AVG	10.1	0.6	0.3	4.8
	MED	11.5	0.5	0.2	4.5
	MAX	13.7	1.3	1.1	9.1
	MIN	5.3	0.2	0.1	1.6
Below Normal	AVG	15.9	1.4	0.7	19.6
	MED	14.0	0.6	0.2	6.4
	MAX	35.6	4.7	3.2	92.7
	MIN	3.0	0.3	0.1	1.1
Dry	AVG	19.6	1.3	3.5	24.1
	MED	18.8	1.0	0.2	14.8
	MAX	40.0	4.3	46.2	99.9
	MIN	2.4	0.4	0.1	0.4
Critical	AVG	33.8	2.5	45.9	81.2
	MED	36.0	2.1	58.9	96.5
	MAX	42.3	5.8	100.0	100.0
	MIN	20.0	1.1	0.4	19.4

Revised Mech. Alt

40-30-30 YRT		Fall	Late Fall	Winter	Spring
Wet	AVG	12.5	1.2	0.3	6.4
	MED	11.2	0.9	0.2	4.9
	MAX	22.0	4.6	0.6	17.5
	MIN	2.2	0.3	0.1	2.4
Above Normal	AVG	11.2	0.7	0.3	5.3
	MED	12.7	0.7	0.2	5.1
	MAX	15.9	1.2	1.1	11.2
	MIN	5.8	0.2	0.1	1.8
Below Normal	AVG	17.2	1.5	0.8	21.3
	MED	14.8	0.7	0.2	6.5
	MAX	35.1	4.7	5.0	96.3
	MIN	3.9	0.3	0.1	1.5
Dry	AVG	20.1	1.3	3.8	25.6
	MED	19.2	1.2	0.3	15.3
	MAX	39.9	4.2	54.4	99.9
	MIN	3.0	0.4	0.1	0.4
Critical	AVG	34.1	2.6	48.6	84.0
	MED	35.8	2.1	68.3	98.7
	MAX	42.4	5.6	100.0	100.0
	MIN	19.4	1.1	0.4	19.0

Difference = Revised Mech. Alt.- No Action

40-30-30 YRT		Fall	Late Fall	Winter	Spring
Wet	AVG	0.6	0.0	0.0	0.8
	MED	-0.2	0.1	0.0	-0.2
	MAX	0.2	0.0	0.0	2.8
	MIN	0.7	0.0	0.0	0.4
Above Normal	AVG	1.1	0.1	0.0	0.5
	MED	1.2	0.2	0.0	0.7
	MAX	2.2	0.0	0.0	2.1
	MIN	0.4	0.0	0.0	0.2
Below Normal	AVG	1.4	0.1	0.1	1.7
	MED	0.8	0.1	0.0	0.0
	MAX	-0.5	0.0	1.8	3.6
	MIN	0.8	0.1	0.0	0.4
Dry	AVG	0.5	0.0	0.3	1.5
	MED	0.4	0.2	0.0	0.5
	MAX	-0.1	-0.1	8.2	0.0
	MIN	0.6	0.0	0.0	0.0
Critical	AVG	0.2	0.1	2.7	2.8
	MED	-0.2	0.0	9.5	2.2
	MAX	0.1	-0.2	0.0	0.0
	MIN	-0.6	0.0	0.0	-0.5

Revised Mechanical:Sacramento River Salmon Mortality (%) for Critical Water Years

Year	Sac Index	Fall	Late Fall	**Winter**	Spring
1924	5	29.6	1.1	**99.6**	96.6
1929	5	34.5	5.6	**0.6**	31.7
1931	5	35.8	1.9	**92.1**	99.1
1933	5	42.4	4.1	**73.0**	100.0
1934	5	35.8	3.2	**100.0**	99.0
1976	5	19.4	3.2	**0.4**	19.0
1977	5	36.8	1.5	**93.4**	99.2
1988	5	34.3	1.5	**2.7**	95.7
1990	5	31.8	1.8	**1.4**	85.8
1991	5	37.0	2.6	**3.0**	98.7
1992	5	37.6	2.1	**68.3**	99.4
	Average	34.1	2.6	**48.6**	84.0

Sacramento River Salmon (Fall, Late-fall, Winter,Spring) Loss (%)

Modifed Percent Inflow Alternative (version 1 revised)

Year	Sac Index	Fall	Late Fall	Winter	Spring
1927	1	15.2	0.9	0.1	6.2
1938	1	16.9	1.8	0.4	11.9
1941	1	11.2	1.4	0.2	3.1
1942	1	9.8	0.8	0.2	3.0
1943	1	12.8	0.6	0.1	5.3
1952	1	7.1	0.8	0.2	2.6
1953	1	9.2	0.3	0.1	2.5
1956	1	9.8	2.1	0.3	3.3
1958	1	21.8	4.8	0.3	13.4
1963	1	15.2	0.8	0.3	15.0
1965	1	16.0	1.0	0.4	7.2
1967	1	21.4	3.1	0.2	9.8
1969	1	8.4	1.9	0.2	3.1
1970	1	19.6	0.9	0.2	19.6
1971	1	10.5	0.9	0.2	5.5
1974	1	13.7	1.9	0.4	5.1
1975	1	14.1	0.9	0.2	7.7
1982	1	2.1	0.8	0.2	3.2
1983	1	16.0	0.6	0.1	5.5
1984	1	10.5	0.4	0.6	5.9
1986	1	9.8	0.5	0.5	4.4
1922	2	8.8	0.5	0.2	2.9
1928	2	16.9	1.0	0.3	11.7
1940	2	15.6	1.4	0.4	9.1
1951	2	9.3	0.5	0.1	2.4
1954	2	15.0	0.7	0.1	8.7
1957	2	15.7	0.7	0.2	11.0
1973	2	7.5	0.9	0.3	4.1
1978	2	18.2	1.1	1.1	7.8
1980	2	6.4	0.2	0.1	1.9
1993	2	12.3	0.5	0.2	3.4
1923	3	16.7	1.6	2.3	7.6
1935	3	33.8	2.6	9.8	98.4
1936	3	37.0	5.3	1.8	63.0
1937	3	7.4	0.8	0.3	5.0
1945	3	16.1	0.6	0.1	6.5
1946	3	7.3	0.3	0.1	1.6
1948	3	10.2	0.5	0.2	4.4
1950	3	4.8	0.7	0.2	2.8
1959	3	36.1	4.6	0.9	78.1
1962	3	25.2	2.6	0.2	29.0
1966	3	17.1	1.0	0.1	12.4
1968	3	21.3	1.0	0.3	25.2
1972	3	15.8	0.4	0.3	12.1
1979	3	13.2	0.5	0.2	7.8
1925	4	23.1	1.4	0.5	31.5
1926	4	31.7	2.3	1.8	86.4
1930	4	18.1	1.9	0.8	8.9
1932	4	40.1	4.4	50.2	99.9
1939	4	19.0	1.5	0.9	43.7
1944	4	18.9	0.6	0.3	13.5
1947	4	23.2	1.2	1.5	42.8
1949	4	3.7	1.0	0.1	0.4
1955	4	18.3	1.1	0.2	11.5
1960	4	23.0	0.9	0.4	27.0
1961	4	27.4	1.6	0.2	46.2
1964	4	24.8	0.8	0.1	33.9
1981	4	13.0	0.5	0.2	9.9
1985	4	11.6	0.5	0.1	2.5
1987	4	22.3	1.2	0.1	16.0
1989	4	16.6	1.0	0.2	9.5
1924	5	29.8	1.1	99.4	96.8
1929	5	34.3	5.5	0.7	31.0
1931	5	36.2	2.0	89.7	99.2
1933	5	42.9	4.4	62.4	100.0
1934	5	35.7	2.8	100.0	99.0
1976	5	20.6	3.4	0.4	21.3
1977	5	36.8	1.3	93.5	99.2
1988	5	34.5	1.4	1.3	97.0
1990	5	33.1	2.0	2.1	93.6
1991	5	37.8	2.5	4.8	99.4
1992	5	37.3	2.1	72.6	99.3
Average		19.1	1.5	8.5	27.5

Sacramento River Salmon Mortality (%)

(Version 1 with revised Spawning Distributions*)

No Action

40-30-30 YRT		Fall	Late Fall	Winter	Spring
Wet	AVG	12.0	1.2	0.2	5.7
	MED	11.4	0.8	0.2	5.1
	MAX	21.8	4.5	0.6	14.8
	MIN	1.5	0.3	0.1	2.0
Above Normal	AVG	10.1	0.6	0.3	4.8
	MED	11.5	0.5	0.2	4.5
	MAX	13.7	1.3	1.1	9.1
	MIN	5.3	0.2	0.1	1.6
Below Normal	AVG	15.9	1.4	0.7	19.6
	MED	14.0	0.6	0.2	6.4
	MAX	35.6	4.7	3.2	92.7
	MIN	3.0	0.3	0.1	1.1
Dry	AVG	19.6	1.3	3.5	24.1
	MED	18.8	1.0	0.2	14.8
	MAX	40.0	4.3	46.2	99.9
	MIN	2.4	0.4	0.1	0.4
Critical	AVG	33.8	2.5	45.9	81.2
	MED	36.0	2.1	58.9	96.5
	MAX	42.3	5.8	100.0	100.0
	MIN	20.0	1.1	0.4	19.4

Mod Perc Alt

40-30-30 YRT		Fall	Late Fall	Winter	Spring
Wet	AVG	12.9	1.3	0.3	6.8
	MED	12.8	0.9	0.2	5.5
	MAX	21.8	4.8	0.6	19.6
	MIN	2.1	0.3	0.1	2.5
Above Normal	AVG	12.6	0.7	0.3	6.3
	MED	13.6	0.7	0.2	6.0
	MAX	18.2	1.4	1.1	11.7
	MIN	6.4	0.2	0.1	1.9
Below Normal	AVG	18.7	1.6	1.2	25.3
	MED	16.4	0.9	0.3	10.0
	MAX	37.0	5.3	9.8	98.4
	MIN	4.8	0.3	0.1	1.6
Dry	AVG	20.9	1.4	3.6	30.2
	MED	20.6	1.2	0.3	21.5
	MAX	40.1	4.4	50.2	99.9
	MIN	3.7	0.5	0.1	0.4
Critical	AVG	34.5	2.6	47.9	85.1
	MED	35.7	2.1	62.4	99.0
	MAX	42.9	5.5	100.0	100.0
	MIN	20.6	1.1	0.4	21.3

Difference = Mod Perc Alt - No Action

40-30-30 YRT		Fall	Late Fall	Winter	Spring
Wet	AVG	0.9	0.1	0.0	1.2
	MED	1.4	0.1	0.0	0.4
	MAX	0.0	0.3	0.0	4.9
	MIN	0.6	0.0	0.0	0.5
Above Normal	AVG	2.5	0.1	0.0	1.5
	MED	2.2	0.2	0.0	1.5
	MAX	4.5	0.1	0.0	2.6
	MIN	1.0	0.0	0.0	0.3
Below Normal	AVG	2.8	0.2	0.5	5.7
	MED	2.4	0.3	0.0	3.5
	MAX	1.4	0.6	6.6	5.7
	MIN	1.8	0.1	0.0	0.5
Dry	AVG	1.3	0.0	0.1	6.1
	MED	1.8	0.1	0.0	6.8
	MAX	0.1	0.1	3.9	0.0
	MIN	1.4	0.0	0.0	0.0
Critical	AVG	0.6	0.0	2.0	3.9
	MED	-0.2	0.1	3.5	2.4
	MAX	0.7	-0.3	0.0	0.0
	MIN	0.6	0.0	0.0	1.9

Modified Percent Inflow: Sacramento River Salmon Mortality (%) for Critical Water Years

Year	Sac Index	Fall	Late Fall	**Winter**	Spring
1924	5	29.8	1.1	**99.4**	96.8
1929	5	34.3	5.5	**0.7**	31.0
1931	5	36.2	2.0	**89.7**	99.2
1933	5	42.9	4.4	**62.4**	100.0
1934	5	35.7	2.8	**100.0**	99.0
1976	5	20.6	3.4	**0.4**	21.3
1977	5	36.8	1.3	**93.5**	99.2
1988	5	34.5	1.4	**1.3**	97.0
1990	5	33.1	2.0	**2.1**	93.6
1991	5	37.8	2.5	**4.8**	99.4
1992	5	37.3	2.1	**72.6**	99.3
	Average	34.5	2.6	**47.9**	85.1

Sacramento River Salmon (Fall, Late-fall, Winter,Spring) Loss (%)

Existing Conditions (version 1 revised)

Year	Sac Index	Fall	Late Fall	Winter	Spring
1927	1	11.1	0.8	0.1	4.1
1938	1	13.2	1.4	0.2	6.8
1941	1	11.1	1.2	0.2	2.9
1942	1	9.7	0.7	0.1	2.4
1943	1	10.8	0.5	0.1	4.8
1952	1	6.5	0.6	0.1	1.9
1953	1	9.1	0.3	0.1	2.6
1956	1	9.5	2.0	0.2	2.6
1958	1	21.7	4.5	0.2	12.7
1963	1	12.9	0.8	0.3	8.7
1965	1	12.9	0.8	0.3	5.6
1967	1	21.4	3.0	0.1	9.5
1969	1	7.9	1.8	0.1	2.9
1970	1	13.9	0.8	0.2	11.7
1971	1	10.3	0.8	0.2	5.2
1974	1	13.6	1.7	0.2	3.9
1975	1	14.0	0.7	0.2	6.9
1982	1	1.6	0.7	0.2	2.1
1983	1	16.0	0.6	0.1	5.4
1984	1	9.5	0.4	0.6	5.4
1986	1	8.6	0.4	0.4	3.6
1922	2	5.9	0.4	0.2	2.3
1928	2	11.3	0.9	0.3	6.5
1940	2	9.8	1.0	0.3	6.2
1951	2	6.3	0.3	0.1	2.4
1954	2	14.0	0.7	0.1	7.0
1957	2	11.9	0.5	0.2	8.8
1973	2	4.8	0.9	0.3	4.2
1978	2	14.2	0.9	1.1	4.7
1980	2	6.3	0.2	0.1	1.8
1993	2	11.9	0.5	0.2	3.2
1923	3	14.0	1.4	1.6	4.2
1935	3	30.0	2.3	2.2	85.8
1936	3	34.0	4.9	1.5	47.1
1937	3	6.3	0.6	0.2	3.7
1945	3	13.7	0.5	0.1	3.8
1946	3	4.2	0.3	0.1	1.1
1948	3	9.9	0.5	0.2	3.7
1950	3	2.9	0.5	0.2	1.9
1959	3	35.5	4.7	0.8	62.3
1962	3	21.1	2.4	0.2	16.6
1966	3	16.2	0.6	0.2	12.1
1968	3	15.4	0.8	0.3	14.5
1972	3	10.7	0.3	0.3	7.2
1979	3	10.6	0.5	0.2	5.0
1925	4	19.7	1.2	0.4	21.7
1926	4	29.9	2.8	4.8	72.7
1930	4	16.6	1.7	0.5	8.6
1932	4	39.9	4.6	37.3	99.8
1939	4	23.9	2.6	0.3	23.8
1944	4	16.5	0.4	0.3	9.9
1947	4	18.5	1.0	1.1	18.4
1949	4	2.2	0.7	0.1	0.4
1955	4	16.9	1.0	0.2	8.8
1960	4	18.9	0.7	0.4	17.0
1961	4	23.2	1.5	0.1	23.1
1964	4	19.4	0.6	0.1	14.0
1981	4	9.3	0.4	0.2	8.0
1985	4	10.0	0.4	0.1	1.9
1987	4	23.6	1.2	0.1	20.9
1989	4	15.6	1.0	0.2	8.9
1924	5	29.9	1.1	99.4	96.7
1929	5	37.8	5.8	1.2	51.6
1931	5	35.6	1.9	95.0	99.0
1933	5	43.2	4.5	23.4	100.0
1934	5	36.8	2.5	96.3	99.3
1976	5	19.7	2.6	0.4	20.5
1977	5	37.0	1.6	93.0	99.3
1988	5	37.6	1.6	5.1	99.6
1990	5	31.4	1.8	1.0	82.4
1991	5	37.9	2.5	4.8	99.5
1992	5	37.5	2.1	81.9	99.4
Average		17.4	1.4	7.8	24.1

Sacramento River Salmon Mortality (%)

(Version 1 with revised Spawning Distributions*)

2001 Exist Cond

40-30-30 YRT		Fall	Late Fall	Winter	Spring
Wet	AVG	11.7	1.2	0.2	5.3
	MED	11.1	0.8	0.2	4.8
	MAX	21.7	4.5	0.6	12.7
	MIN	1.6	0.3	0.1	1.9
Above Normal	AVG	9.6	0.6	0.3	4.7
	MED	10.5	0.6	0.2	4.5
	MAX	14.2	1.0	1.1	8.8
	MIN	4.8	0.2	0.1	1.8
Below Normal	AVG	16.0	1.5	0.6	19.2
	MED	13.8	0.6	0.2	6.1
	MAX	35.5	4.9	2.2	85.8
	MIN	2.9	0.3	0.1	1.1
Dry	AVG	19.0	1.4	2.9	22.4
	MED	18.7	1.0	0.2	15.5
	MAX	39.9	4.6	37.3	99.8
	MIN	2.2	0.4	0.1	0.4
Critical	AVG	34.9	2.5	45.6	86.1
	MED	37.0	2.1	23.4	99.3
	MAX	43.2	5.8	99.4	100.0
	MIN	19.7	1.1	0.4	20.5

2020 No Act

40-30-30 YRT		Fall	Late Fall	Winter	Spring
Wet	AVG	12.0	1.2	0.2	5.7
	MED	11.4	0.8	0.2	5.1
	MAX	21.8	4.5	0.6	14.8
	MIN	1.5	0.3	0.1	2.0
Above Normal	AVG	10.1	0.6	0.3	4.8
	MED	11.5	0.5	0.2	4.5
	MAX	13.7	1.3	1.1	9.1
	MIN	5.3	0.2	0.1	1.6
Below Normal	AVG	15.9	1.4	0.7	19.6
	MED	14.0	0.6	0.2	6.4
	MAX	35.6	4.7	3.2	92.7
	MIN	3.0	0.3	0.1	1.1
Dry	AVG	19.6	1.3	3.5	24.1
	MED	18.8	1.0	0.2	14.8
	MAX	40.0	4.3	46.2	99.9
	MIN	2.4	0.4	0.1	0.4
Critical	AVG	33.8	2.5	45.9	81.2
	MED	36.0	2.1	58.9	96.5
	MAX	42.3	5.8	100.0	100.0
	MIN	20.0	1.1	0.4	19.4

Difference = 2020 No Act - 2001 Exist Cond

40-30-30 YRT		Fall	Late Fall	Winter	Spring
Wet	AVG	0.3	0.0	0.0	0.4
	MED	0.2	0.0	0.0	0.3
	MAX	0.1	0.0	0.0	2.1
	MIN	-0.1	0.0	0.0	0.2
Above Normal	AVG	0.4	0.0	0.0	0.1
	MED	0.9	-0.1	0.0	0.0
	MAX	-0.5	0.3	0.0	0.3
	MIN	0.6	0.0	0.0	-0.2
Below Normal	AVG	-0.1	0.0	0.1	0.4
	MED	0.2	-0.1	0.0	0.3
	MAX	0.0	-0.2	1.0	6.9
	MIN	0.1	0.0	0.0	0.0
Dry	AVG	0.6	0.0	0.6	1.8
	MED	0.1	0.0	0.0	-0.7
	MAX	0.1	-0.3	8.9	0.0
	MIN	0.1	0.0	0.0	0.0
Critical	AVG	-1.1	0.0	0.3	-4.9
	MED	-1.0	0.0	35.5	-2.7
	MAX	-0.9	0.0	0.6	0.0
	MIN	0.3	0.0	0.0	-1.0

Existing Conditions: Sacramento River Salmon Mortality (%) in Critical Water Years

Year	Sac Index	Fall	Late Fall	**Winter**	Spring
1924	5	29.9	1.1	**99.4**	96.7
1929	5	37.8	5.8	**1.2**	51.6
1931	5	35.6	1.9	**95.0**	99.0
1933	5	43.2	4.5	**23.4**	100.0
1934	5	36.8	2.5	**96.3**	99.3
1976	5	19.7	2.6	**0.4**	20.5
1977	5	37.0	1.6	**93.0**	99.3
1988	5	37.6	1.6	**5.1**	99.6
1990	5	31.4	1.8	**1.0**	82.4
1991	5	37.9	2.5	**4.8**	99.5
1992	5	37.5	2.1	**81.9**	99.4
Average		34.9	2.5	**45.6**	86.1

Sacramento River Salmon (Fall, Late-fall, Winter,Spring) Loss (%)

OCAP Preferred Alternative

Year	Sac Index	Fall	Late Fall	Winter	Spring
1927	1	15.2	0.9	0.1	5.8
1938	1	16.1	1.7	0.3	12.4
1941	1	11.7	1.4	0.3	3.3
1942	1	10.4	0.8	0.2	2.9
1943	1	14.8	0.7	0.1	8.3
1952	1	7.0	0.9	0.3	2.9
1953	1	10.4	0.4	0.1	3.4
1956	1	10.9	2.1	0.3	4.0
1958	1	22.1	4.7	0.3	13.6
1963	1	20.4	1.3	0.4	23.8
1965	1	17.6	1.1	0.4	8.8
1967	1	21.6	3.1	0.2	9.9
1969	1	9.1	2.3	0.2	4.1
1970	1	23.5	1.2	0.3	27.8
1971	1	12.2	0.9	0.2	6.8
1974	1	14.1	1.9	0.4	6.2
1975	1	14.1	0.9	0.3	7.8
1982	1	4.0	0.7	0.2	2.5
1983	1	16.0	0.6	0.1	5.6
1984	1	12.5	0.4	0.6	7.2
1986	1	13.8	0.8	0.5	6.4
1922	2	11.8	0.7	0.2	3.8
1928	2	18.4	1.2	0.4	13.9
1940	2	19.7	1.6	0.4	16.0
1951	2	12.4	0.6	0.1	3.6
1954	2	16.8	0.7	0.1	11.3
1957	2	18.5	1.0	0.2	15.4
1973	2	8.6	0.9	0.3	4.2
1978	2	17.0	1.2	1.1	6.4
1980	2	7.9	0.2	0.1	2.0
1993	2	12.1	0.6	0.2	3.4
1923	3	20.3	1.9	2.1	13.6
1935	3	34.4	2.5	16.4	98.7
1936	3	43.4	5.9	2.9	94.6
1937	3	12.3	1.2	0.3	5.2
1945	3	20.5	0.8	0.1	14.3
1946	3	10.3	0.5	0.1	2.3
1948	3	9.6	0.5	0.3	4.6
1950	3	5.2	0.7	0.3	3.5
1959	3	36.7	4.3	1.4	88.4
1962	3	26.8	2.5	0.2	41.2
1966	3	24.1	1.5	0.2	23.8
1968	3	25.4	1.3	0.4	40.0
1972	3	18.2	0.6	0.3	16.8
1979	3	15.1	0.6	0.2	8.8
1925	4	29.5	1.6	1.8	86.0
1926	4	36.5	2.5	6.3	99.4
1930	4	25.6	2.3	0.2	29.9
1932	4	39.9	4.2	69.7	99.9
1939	4	32.4	3.8	0.5	65.0
1944	4	20.3	0.7	0.6	17.6
1947	4	26.0	1.6	0.8	50.9
1949	4	5.1	1.3	0.1	0.4
1955	4	22.7	1.2	0.3	22.9
1960	4	28.6	1.2	1.0	64.7
1961	4	31.5	1.8	1.2	87.6
1964	4	24.1	0.9	0.2	29.1
1981	4	18.7	0.5	0.2	27.8
1985	4	17.7	0.7	0.1	10.9
1987	4	29.6	1.7	0.2	59.5
1989	4	22.0	1.2	0.2	27.3
1924	5	29.5	1.1	100.0	96.5
1929	5	37.0	5.6	0.3	69.0
1931	5	34.8	1.7	99.0	98.8
1933	5	41.2	3.6	86.4	100.0
1934	5	35.5	2.8	100.0	98.9
1976	5	25.7	4.3	0.4	26.2
1977	5	35.7	1.1	96.9	98.8
1988	5	37.4	1.6	7.3	99.5
1990	5	35.7	2.0	8.2	99.0
1991	5	38.7	2.3	21.0	99.6
1992	5	37.0	2.0	85.6	99.3
Average		21.4	1.6	10.0	34.4

Sacramento River Salmon Mortality (%)

(Version 1 with revised Spawning Distributions*)

No Action (Trinity No Action)

40-30-30 YRT		Fall	Late Fall	Winter	Spring
Wet	AVG	12.0	1.2	0.2	5.7
	MED	11.4	0.8	0.2	5.1
	MAX	21.8	4.5	0.6	14.8
	MIN	1.5	0.3	0.1	2.0
Above Normal	AVG	10.1	0.6	0.3	4.8
	MED	11.5	0.5	0.2	4.5
	MAX	13.7	1.3	1.1	9.1
	MIN	5.3	0.2	0.1	1.6
Below Normal	AVG	15.9	1.4	0.7	19.6
	MED	14.0	0.6	0.2	6.4
	MAX	35.6	4.7	3.2	92.7
	MIN	3.0	0.3	0.1	1.1
Dry	AVG	19.6	1.3	3.5	24.1
	MED	18.8	1.0	0.2	14.8
	MAX	40.0	4.3	46.2	99.9
	MIN	2.4	0.4	0.1	0.4
Critical	AVG	33.8	2.5	45.9	81.2
	MED	36.0	2.1	58.9	96.5
	MAX	42.3	5.8	100.0	100.0
	MIN	20.0	1.1	0.4	19.4

OCAP Future EWA

40-30-30 YRT		Fall	Late Fall	Winter	Spring
Wet	AVG	14.2	1.4	0.3	8.3
	MED	14.1	0.9	0.3	6.4
	MAX	23.5	4.7	0.6	27.8
	MIN	4.0	0.4	0.1	2.5
Above Normal	AVG	14.3	0.9	0.3	8.0
	MED	14.6	0.8	0.2	5.3
	MAX	19.7	1.6	1.1	16.0
	MIN	7.9	0.2	0.1	2.0
Below Normal	AVG	21.6	1.8	1.8	32.6
	MED	20.4	1.2	0.3	15.5
	MAX	43.4	5.9	16.4	98.7
	MIN	5.2	0.5	0.1	2.3
Dry	AVG	25.6	1.7	5.2	48.7
	MED	25.8	1.4	0.4	40.4
	MAX	39.9	4.2	69.7	99.9
	MIN	5.1	0.5	0.1	0.4
Critical	AVG	35.3	2.6	55.0	89.6
	MED	35.7	2.0	85.6	98.9
	MAX	41.2	5.6	100.0	100.0
	MIN	25.7	1.1	0.3	26.2

Difference = OCAP Future EWA - No Action

40-30-30 YRT		Fall	Late Fall	Winter	Spring
Wet	AVG	2.2	0.2	0.0	2.6
	MED	2.8	0.1	0.1	1.3
	MAX	1.7	0.2	0.0	13.1
	MIN	2.5	0.1	0.0	0.4
Above Normal	AVG	4.2	0.3	0.0	3.2
	MED	3.1	0.3	0.0	0.8
	MAX	6.0	0.3	0.0	6.9
	MIN	2.6	0.1	0.0	0.4
Below Normal	AVG	5.7	0.3	1.1	12.9
	MED	6.4	0.6	0.1	9.1
	MAX	7.8	1.2	13.2	6.0
	MIN	2.2	0.2	0.0	1.2
Dry	AVG	6.0	0.4	1.7	24.6
	MED	7.0	0.4	0.2	25.6
	MAX	-0.1	-0.1	23.4	0.0
	MIN	2.7	0.1	0.0	0.0
Critical	AVG	1.4	0.0	9.1	8.4
	MED	-0.3	-0.1	26.7	2.3
	MAX	-1.0	-0.2	0.0	0.0
	MIN	5.7	-0.1	-0.1	6.8

Attachment B9
Evaluation of Riparian Vegetation and Sediment Transport for All Alternatives

Evaluation of Riparian Vegetation and Sediment Transport for all Alternatives

Sediment management considerations

Trinity and Lewiston dams alter fine and coarse sediment supply and storage downstream of Lewiston Dam, as well as reduce the fine and coarse sediment transport capability via reduced high flows. Overall, this has caused: (1) coarse sediment supply and storage to be in deficit, primarily between Lewiston Dam and Indian Creek, (2) local long-term accumulation of coarse sediment at the Rush Creek, Grass Valley Creek, and Indian Creek deltas, and (3) accumulation of fine sediment storage in the channel, particularly downstream of Grass Valley Creek. Efforts have been made to increase coarse sediment storage (e.g., gravel introduction), as well as reduce fine sediment supply (e.g., dredging, sediment traps, and watershed rehabilitation). The flow and sediment management actions in each alternative benefits and impacts the sediment regime on the Trinity River. The Preferred Alternative attempts to balance the coarse sediment budget by transporting Rush Creek sediments at a rate equal to input, and by augmenting coarse sediment immediately downstream from Lewiston Dam to compensate that transported by the high flow release hydrograph. Additionally, the Preferred Alternative attempts to transport fine sediment at a rate greater than input from tributaries to reduce fine sediment storage in the mainstem Trinity River. Watershed rehabilitation and continued operation of sediment traps in Grass Valley Creek is also included in the Preferred Alternative.

As a comparative tool, fine and coarse sediment transport was computed for each alternative and for each water year for that alternative. The weighted average sediment transport for each alternative is summarized in Table 1. The fine and coarse sediment transport rates for the Lewiston and Limekiln gaging stations as reported in the TRFES were averaged for the results shown in Table 1. The largest flow where sediment transport was measured was 6,000 cfs, so the computed sediment transport from those alternatives with flow magnitudes significantly greater than 6,000 cfs should be considered relative magnitudes, not absolute magnitudes.

Table 1. Summary of weighted average annual fine and coarse sediment transport for differing alternatives.

ALTERNATIVE	Weighted average coarse sediment transport	% different from Preferred Alternative	Weighted average fine sediment transport	% different from Preferred Alternative
Preferred alternative	8,570 yd^3	0%	1,870 yd^3	0%
70% inflow	16,900 yd^3	+97%	3,220 yd^3	+72%
Maximum Flow[a]	156,000 yd^3	+1,700%	21,500 yd^3	+1,050%
Modified Percent Inflow	5,370 yd^3	-37%	1,100 yd^3	-41%
Revised Mechanical	1,070 yd^3	-88%	370 yd^3	-80%
No Action	680 yd^3	-92%	230 yd^3	-88%

[a] rating curve is extended far beyond measured data, resulting in abnormally large predictions of sediment transport. Results should be considered qualitatively "very large".

The implications of the computed fine and coarse sediment transport rates are considered in light of: (1) ability to transport and route coarse sediment delivered from tributaries, (2) coarse sediment imbalance in the reach immediately downstream of Lewiston Dam, which would require compensating coarse sediment introduction to maintain coarse sediment storage, and (3) ability to transport large volumes of fine sediment, which would reduce fine sediment storage in the mainstem Trinity River. These results are summarized for both fine and coarse sediment (Table 2).

Riparian regeneration considerations

The seed dispersal timing of target woody riparian species (black cottonwood, Fremont cottonwood, shiny willow) desired to be regenerated on Trinity River floodplains occurs in the late spring and early summer months, corresponding to the historic snowmelt hydrograph of the Trinity River. Successful plant initiation requires that: (1) a higher elevation bar, scour channel, or floodplain surface be exposed and wetted during the seed dispersal period, (2) the surface be exposed and moist for a short duration to allow seed germination (usually created by fine sediment deposition and/or scouring of annual plants), (3) the subsurface capillary fringe declines at a rate less than the root growth rate of the initiating seedling, and (4) when the flow recession transitions into the summer baseflow period, the seedling roots are at the summer baseflow capillary fringe (Mahoney and Rood 1992, Segelquist et al. 1993, Amlin and Rood 2002, McBride, et al. 1988). Riparian initiation modelers initially assume that, for coarse alluvial sediment, the capillary fringe on higher elevation bars, scour channels, or floodplains is approximated by the water surface elevation of the river. Black cottonwood is often used as a target riparian indicator species. Black cottonwood has an approximate maximum root growth rate of 2.5 cm/day (0.082 ft/day); therefore, recession rates from the spring peak flow greater than 2.5 cm/day will likely prevent riparian initiation and establishment (Mahoney and Rood, 1998). Under natural conditions, cottonwood recruitment is infrequent, and usually occurs during abnormally wet years (Merigliano 1996, Mahoney and Rood 1998). Therefore, riparian recruitment on floodplains and other higher elevation surfaces during Extremely Wet years, and perhaps some Wet water years, is an appropriate riparian restoration objective for the future.

Using the stage-discharge curve at the Lewiston gaging station and assuming a target floodplain surface for riparian initiation being inundated at 6,000 cfs, the annual hydrograph for each alternative was evaluated for riparian initiation. The simulated snowmelt hydrograph release occurs during the cottonwood seed dispersal period (may-June) for all Alternatives, and a groundwater recession rate of 2.5 cm/day is assumed as the threshold for plant survival and plant desiccation. It is also assumed that the shallow groundwater table elevation is identical to the water surface in the river on each day.

The hydrographs for Extremely Wet and Wet water years were plotted, and the receding hydrograph necessary for riparian initiation is also plotted (See figures 1 through 9). For the 70% Inflow Alternative and Modified Percent Inflow Alternative, median Extremely Wet and Wet years were used from the 1912-2002 period of record. For each alternative, if the solid line (hydrograph for that alternative) is under the dashed line (hydrograph

needed to cause riparian initiation), the recession limb of that alternative is too steep to recruit black cottonwood (See Figures 1 through 9). Of the alternatives, the Preferred Alternative, 70% Inflow Alternative, Maximum Flow Alternative, and the Revised Mechanical Alternative provide hydrographs during Extremely Wet years that would likely result in riparian initiation on floodplains (Table 3). The Modified Percent Inflow Alternative and No Action Alternative all have recession limbs steeper than that required to initiate riparian vegetation on floodplains. Because the analyses for the Modified Percent Inflow Alternative use the median years for Extremely Wet and Wet water years, the median year does not represent all years for those two water years classes, and there could be an individual year within the record where the recession limb is sufficient to initiate riparian vegetation. Testing this would require an analysis of all Extremely Wet and Wet water years within the period of record, which was not done.

Table 2. Summary of impacts and benefits to fine and coarse sediment regime for differing alternatives.

Alternative	Transport tributary coarse sediments	Coarse sediment deficit	Fine sediment deficit
Preferred Alternative	Transports coarse sediment from Rush Creek at rate equal to input, may not be able to transport largest boulders contributed from Rush Creek. Mechanical means would be required to remove these larger particles.	Would cause moderate coarse sediment deficit, to be replaced by moderate amounts of mechanically introduced coarse sediments.	Moderate volume of fine sediment reduction, causing moderate deficit if Grass Valley Creek sediment traps are maintained.
70% inflow	Larger peak flow magnitude (up to 19,000 cfs) would transport greater volumes of coarse sediment from Rush Creek, and would be better able to transport largest boulders contributed from Rush Creek.	Larger peak flow magnitude (up to 19,000 cfs) would create larger coarse sediment deficit below Lewiston Dam, requiring greater augmentation to maintain coarse sediment storage.	Larger peak flow magnitude (up to 19,000 cfs) would create larger fine sediment deficit below Lewiston Dam, improving aquatic habitat and depositing more fine sediment on floodplains.
Maximum Flow[a]	Larger peak flow magnitude (30,000 cfs) would transport greater volumes of coarse sediment from Rush Creek, and would be better able to transport largest boulders contributed from Rush Creek.	Larger peak flow magnitude (30,000 cfs) would create very large coarse sediment deficit below Lewiston Dam, requiring greater augmentation to maintain coarse sediment storage.	Larger peak flow magnitude (30,000 cfs) would create larger fine sediment deficit below Lewiston Dam, improving aquatic habitat and depositing more fine sediment on floodplains.
Modified Percent Inflow	Larger peak flow magnitude (13,000 cfs) and shorter duration of flow would transport lower volumes of coarse sediment from Rush Creek, but the larger magnitude would be better able to transport largest boulders contributed from Rush Creek.	Larger peak flow magnitude (13,000 cfs) and shorter duration would create a smaller coarse sediment deficit below Lewiston Dam, requiring less augmentation to maintain coarse sediment storage.	Larger peak flow magnitude (13,000 cfs) but of shorter duration would not transport as much fine sediment as Preferred Alternative, reducing fine sediment deficit or possibly allowing fine sediment accumulation below Lewiston Dam.
Revised Mechanical	Unable to transport coarse sediment from Rush Creek at rate equal to input, and will not be able to transport largest boulders contributed from Rush Creek. Mechanical means would be required to remove these larger particles and accumulations of smaller delta particles.	Would cause small coarse sediment deficit, to be replaced by small amounts of mechanically introduced coarse sediments.	Much lower fine sediment transport rates than Preferred Alternative, fine sediments may accumulate in channel without additional fine sediment supply reduction efforts (in addition to Grass Valley Creek sediment traps).
No Action	Unable to transport coarse sediment from Rush Creek at rate equal to input, and will	Would cause small coarse sediment deficit, to be replaced by small	Much lower fine sediment transport rates than Preferred Alternative, fine sediments may

	not be able to transport largest boulders contributed from Rush Creek. Mechanical means would be required to remove these larger particles and accumulations of smaller delta particles.	amounts of mechanically introduced coarse sediments.	accumulate in channel without additional fine sediment supply reduction efforts (in addition to Grass Valley Creek sediment traps).

Table 3. Summary of riparian regeneration evaluation for variety of alternatives, assuming target floodplains are inundated at 6,000 cfs.

Alternative	Natural riparian initiation?	Explanation
Preferred alternative	Yes	Riparian initiation occurs on Extremely Wet years, recession is slightly too steep on Wet and Normal years for riparian initiation, fine sediment deposition would occur in Extremely Wet and Wet water years.
70% inflow	Yes	Riparian initiation likely occurs on most Extremely Wet and Wet years; high flows up to 19,000 cfs would deposit fine sediment during Extremely Wet and Wet water years.
Maximum Flow	Yes	Riparian initiation occurs on Extremely Wet years, recession is slightly too steep on Wet and Normal years for riparian initiation, fine sediment deposition would occur in Extremely Wet and Wet water years.
Modified Percent Inflow	No	Recession rate too steep for riparian initiation in median Extremely Wet and Wet water years; however, fine sediment deposition would occur in Extremely Wet and Wet water years.
Revised Mechanical	Yes	Riparian initiation occurs on Extremely Wet and Wet years, no overbank fine sediment deposition except during safety of dams releases or tributary floods in downstream reaches.
No Action	No	Releases identical for all water years, recession rate too steep for riparian initiation, no overbank fine sediment deposition except during safety of dams releases or tributary floods in downstream reaches.

Figure 1.
Example hydrograph of No Action Alternative (all years) and EXTREMELY WET water year for the Preferred Alternative, showing ability for riparian regeneration on floodplains using a 2.5 cm/day recession criteria at Lewiston USGS station

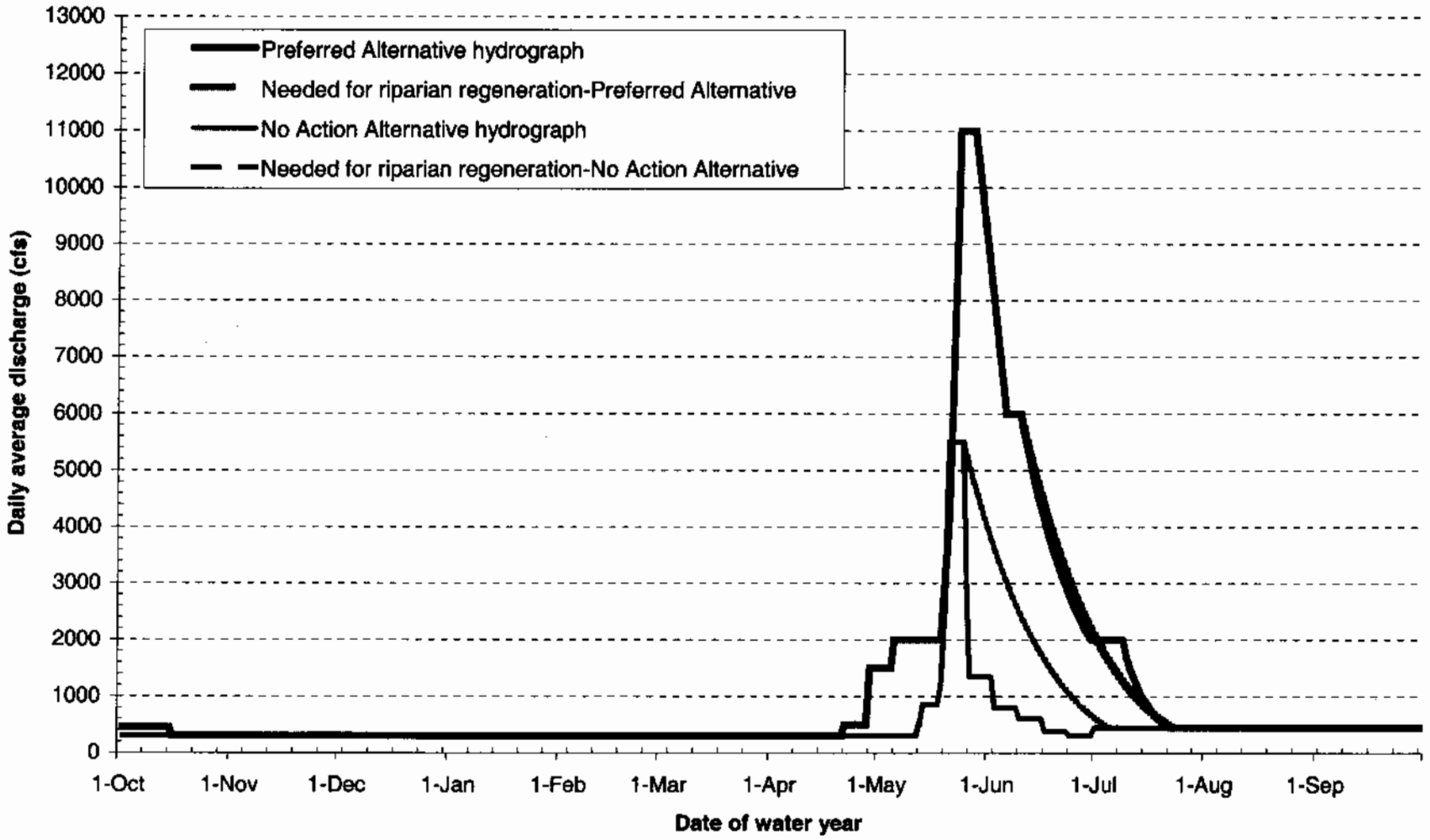


Figure 2.
Example hydrograph of EXTREMELY WET water year for Maximum Flow Alternative and Preferred Alternative, showing ability for riparian regeneration on floodplains using a 2.5 cm/day recession criteria at Lewiston USGS station

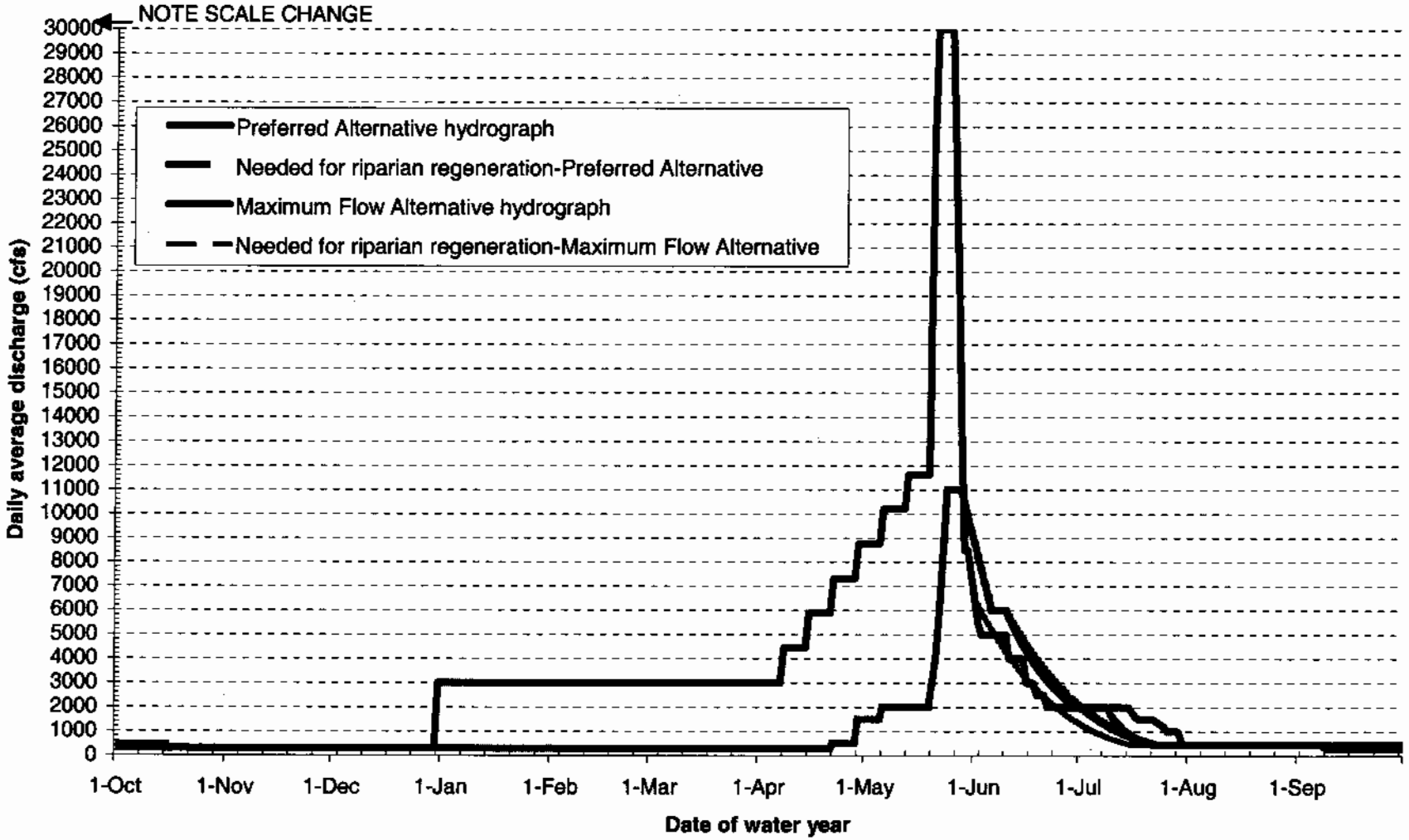


Figure 3.
Example hydrograph of WET water year for Maximum Flow Alternative and Preferred Alternative, showing ability for riparian regeneration on floodplains using a 2.5 cm/day recession criteria at Lewiston USGS station

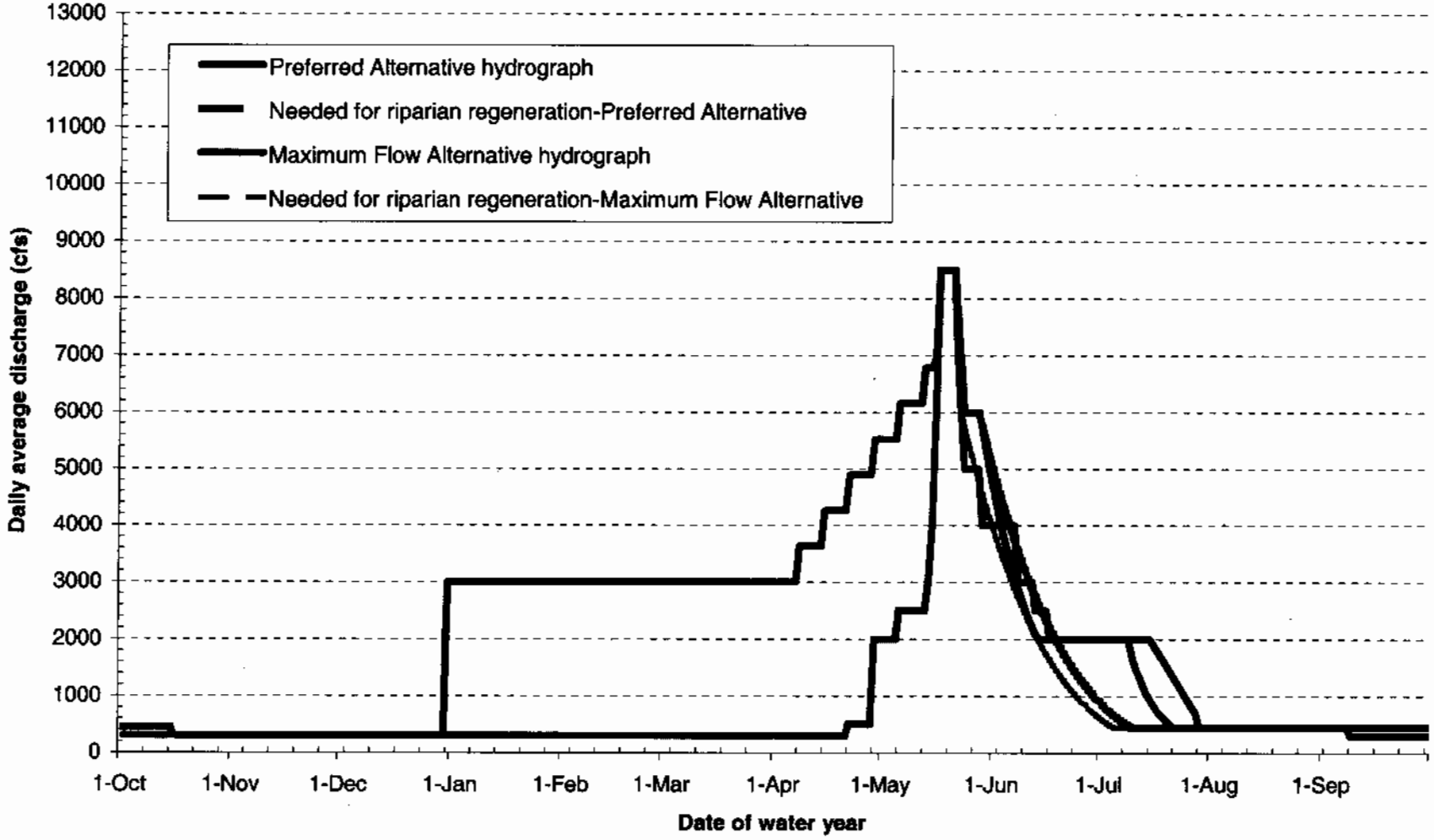


Figure 4.
Example hydrograph of EXTREMELY WET water years for 70 Percent Inflow Alternative and Preferred Alternative showing ability for riparian regeneration on floodplains using a 2.5 cm/day recession criteria at Lewiston USGS station

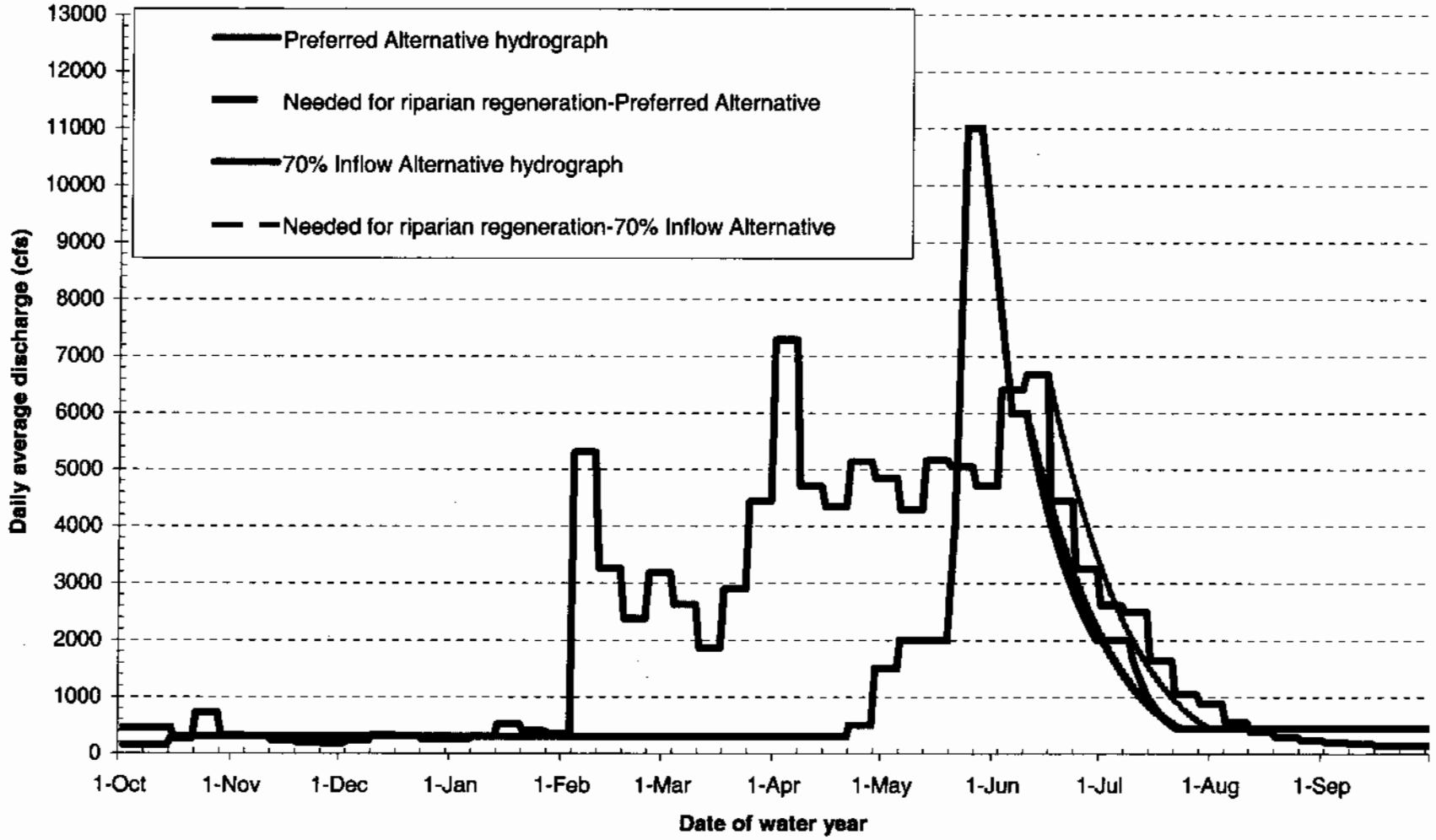


Figure 5.
Example hydrograph of WET water years for 70 Percent Inflow Alternative and Preferred Alternative showing ability for riparian regeneration on floodplains using a 2.5 cm/day recession criteria at Lewiston USGS station

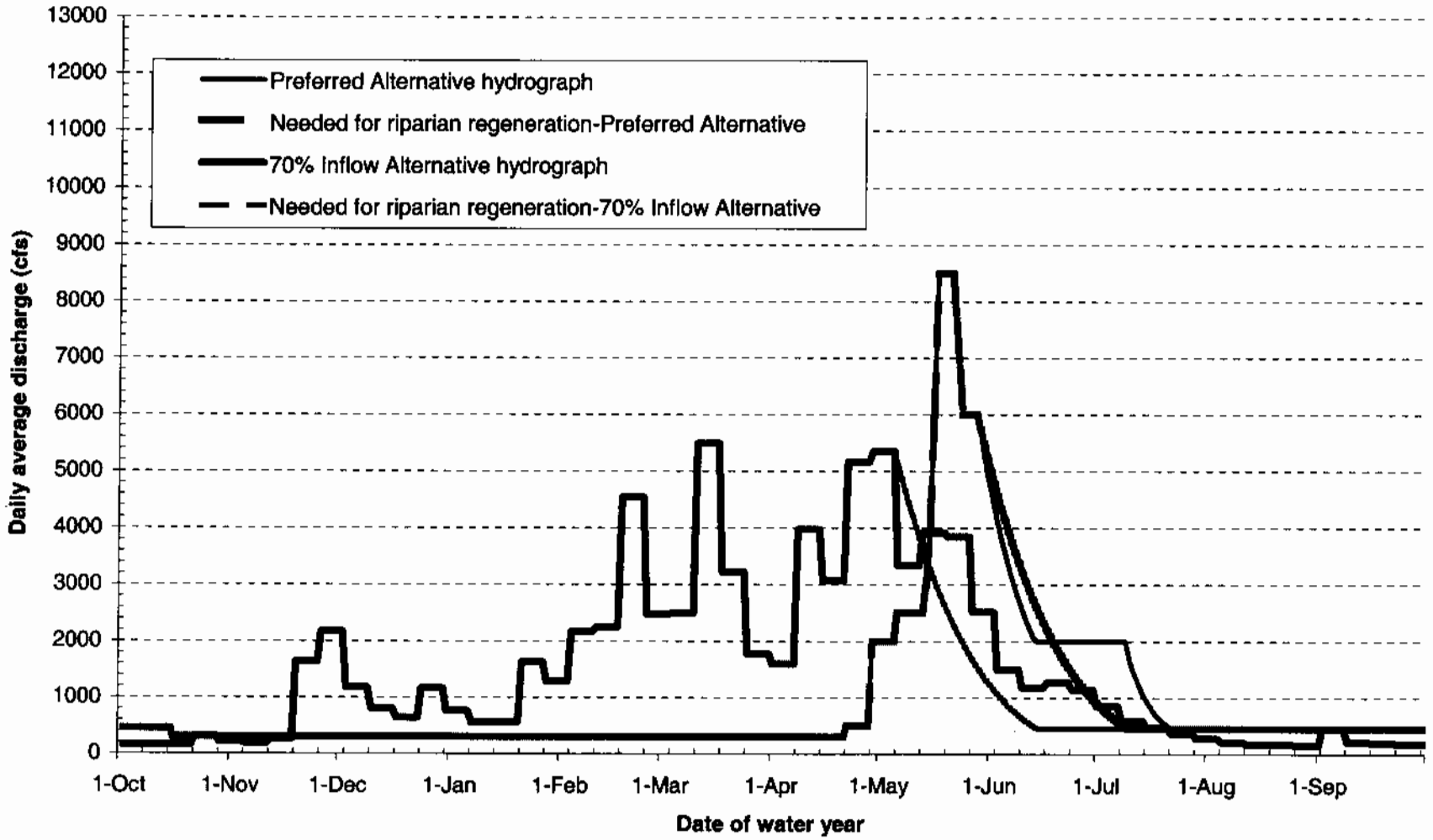
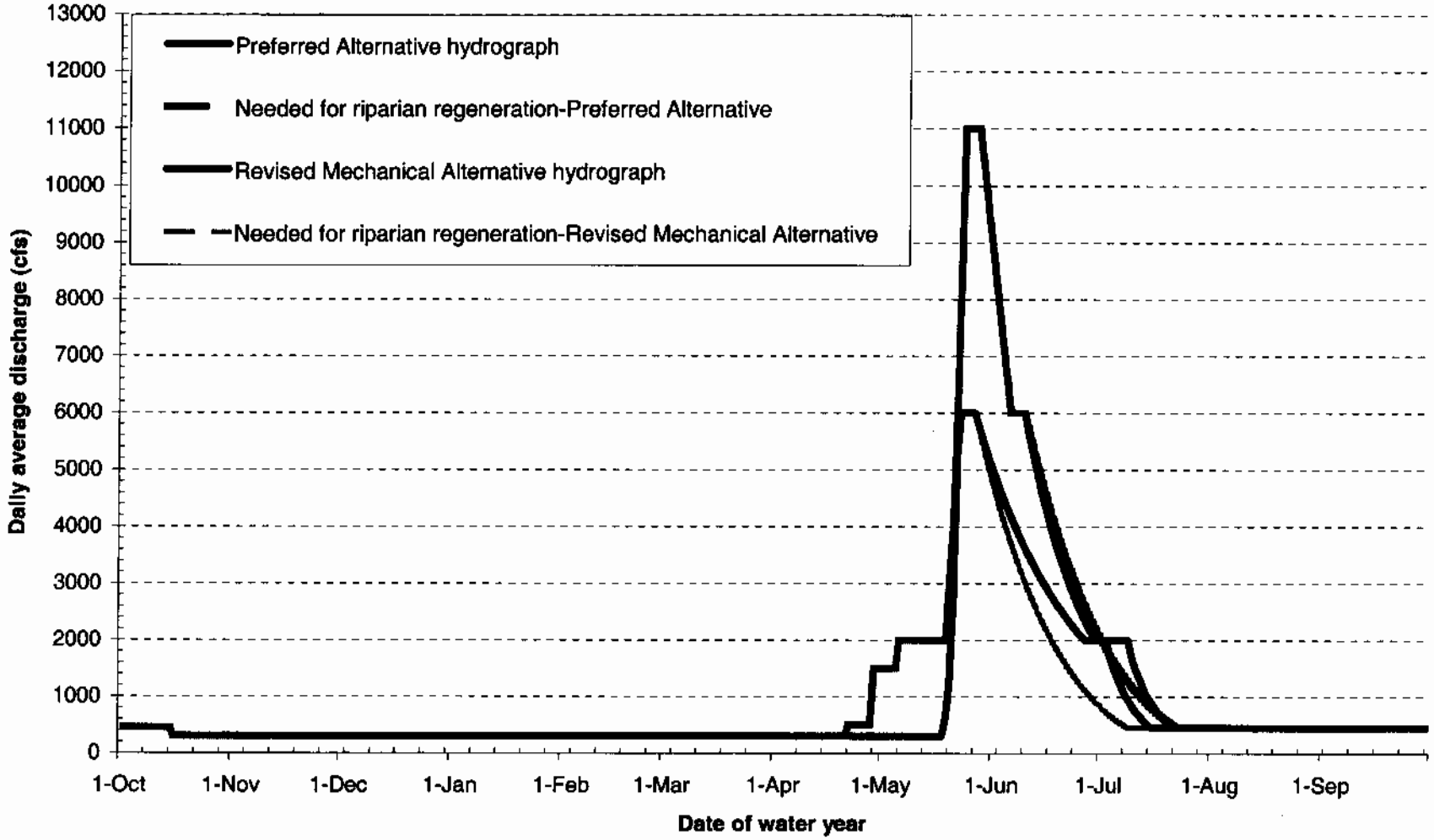


Figure 6.
Example hydrograph of EXTREMELY WET water years for Revised Mechanical Alternative and Flow Evaluation Study showing ability for riparian regeneration on floodplains using a 2.5 cm/day recession criteria at Lewiston USGS station



DRAFT SEIS EXT. WET REVISED MECH.

Figure 7.
Example hydrograph of WET water year for Revised Mechanical Alternative and Preferred Alternative, showing ability for riparian regeneration on floodplains using a 2.5 cm/day recession criteria at Lewiston USGS station

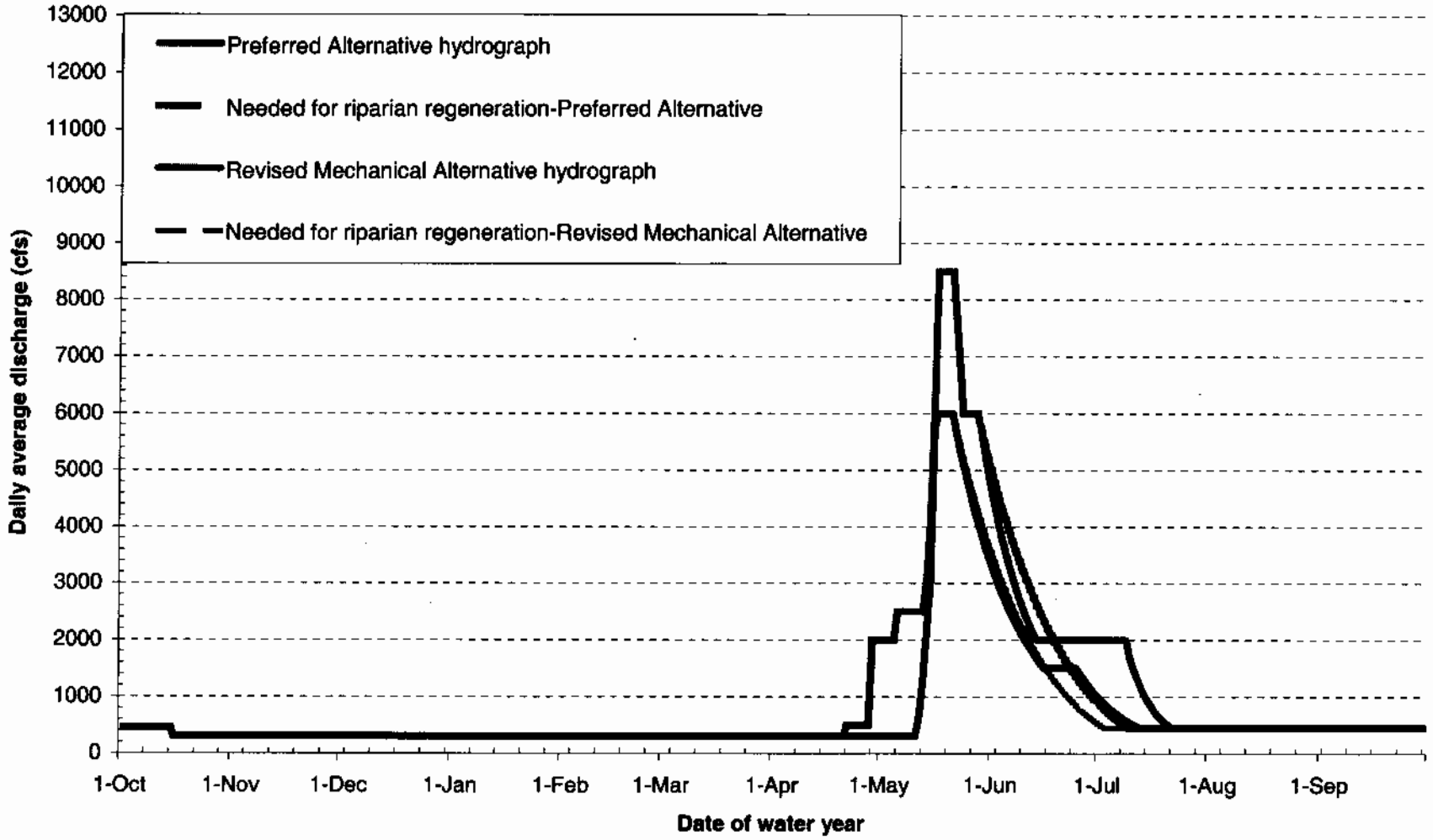


Figure 8.
Example hydrograph of EXTREMELY WET water years for Modified Percent Inflow Alternative and Preferred Alternative showing ability for riparian regeneration on floodplains using a 2.5 cm/day recession criteria at Lewiston USGS station

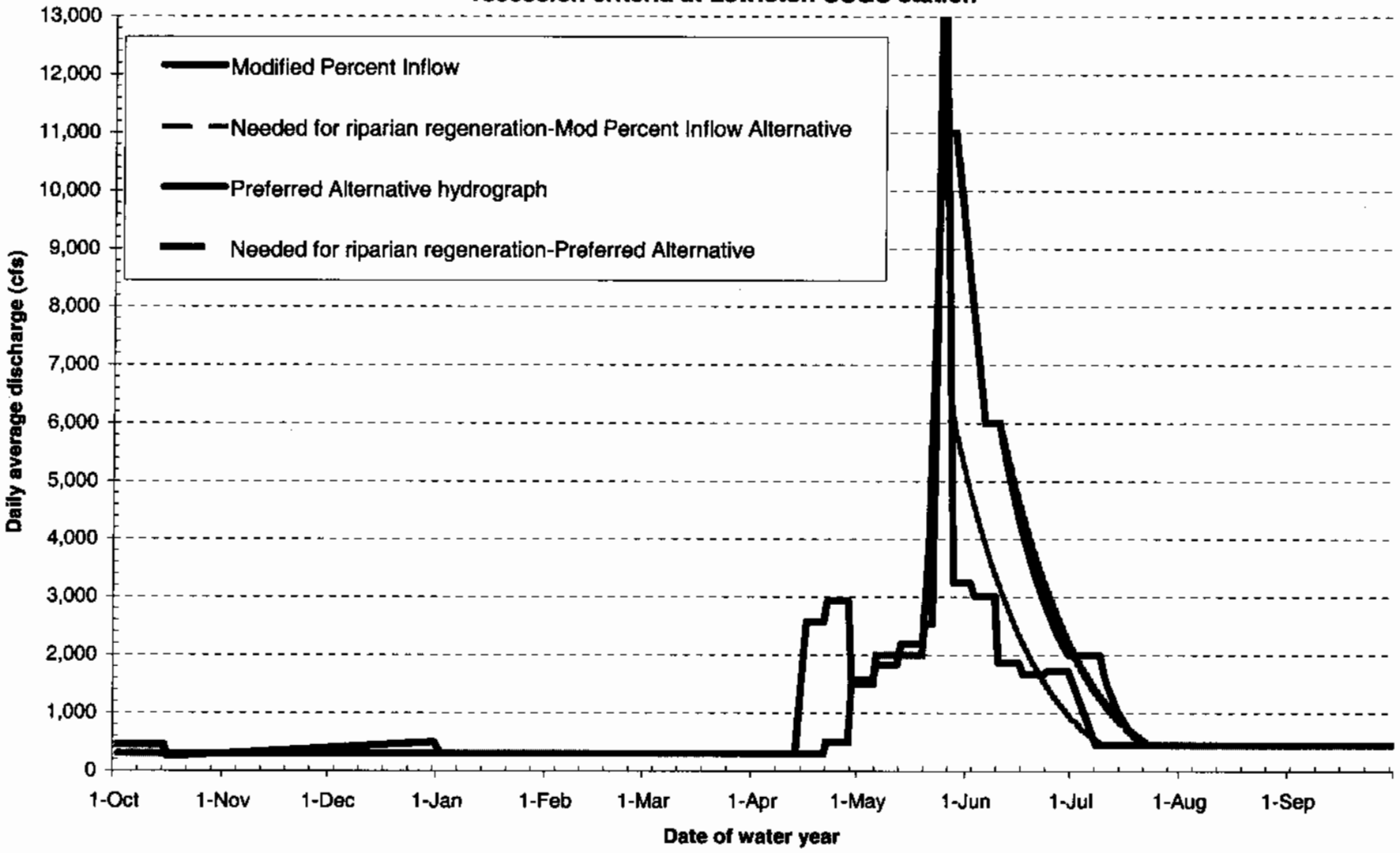
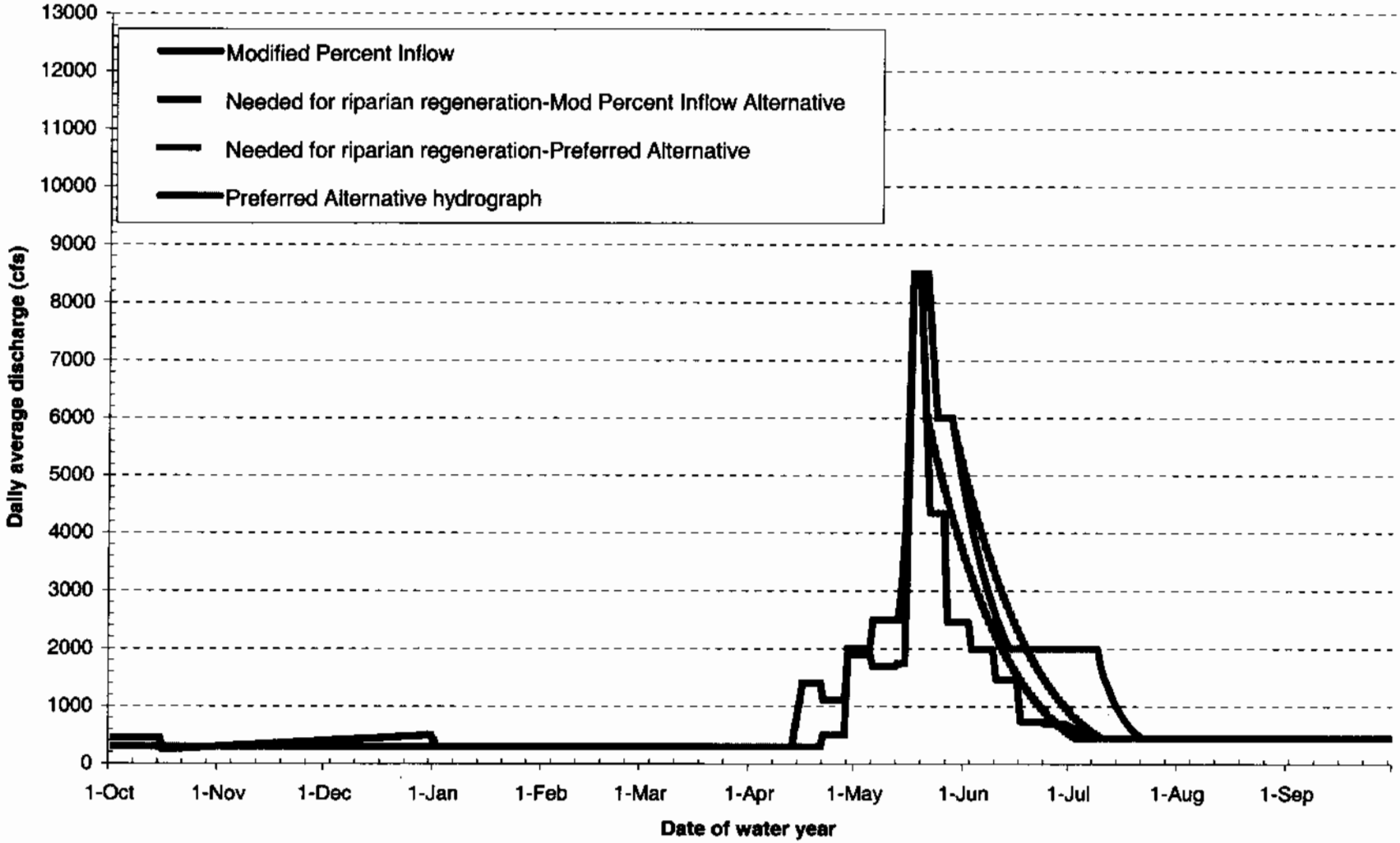


Figure 9.
Example hydrograph of WET water years for Modified Percent Inflow Alternative and Preferred Alternative showing ability for riparian regeneration on floodplains using a 2.5 cm/day recession criteria at Lewiston USGS station



Attachment B10
Analysis of the Frequency and Direction of Changes of the Predicted Position of X2 in the Sacramento-San Joaquin River Delta

Summary of the Change in X2 Position in the Delta compared to the No Action Alternative (1922-1993).

	Compared to No Action Alternative						Pref. vs. Exist. Cond.
Alternative	Max Flow	Flow Eval	70% inflow	Mechanical	Revised Mech	Mod. % Inflow	
February							
# years > 0.5 Km upstream	20	8	18	0	3	5	4
% years > 0.5km upstream	27.8%	11.1%	25.0%	0.0%	4.2%	6.9%	5.6%
# years > 0.5 Km downstream	3	11	1	0	3	4	1
% years > 0.5km downstream	4.2%	15.3%	1.4%	0.0%	4.2%	5.6%	1.4%
March							
# years > 0.5 Km upstream	7	5	7	0	1	2	3
% years > 0.5km upstream	9.7%	6.9%	9.7%	0.0%	1.4%	2.8%	4.2%
# years > 0.5 Km downstream	2	2	2	0	1	2	2
% years > 0.5km downstream	2.8%	2.8%	2.8%	0.0%	1.4%	2.8%	2.8%
April							
# years > 0.5 Km upstream	8	5	9	0	4	2	5
% years > 0.5km upstream	11.1%	6.9%	12.5%	0.0%	5.6%	2.8%	6.9%
# years > 0.5 Km downstream	5	4	2	0	1	4	1
% years > 0.5km downstream	6.9%	5.6%	2.8%	0.0%	1.4%	5.6%	1.4%
May							
# years > 0.5 Km upstream	6	4	6	0	2	3	4
% years > 0.5km upstream	8.3%	5.6%	8.3%	0.0%	2.8%	4.2%	5.6%
# years > 0.5 Km downstream	3	4	2	0	2	3	4
% years > 0.5km downstream	4.2%	5.6%	2.8%	0.0%	2.8%	4.2%	5.6%
June							
# years > 0.5 Km upstream	14	13	14	0	7	11	10
% years > 0.5km upstream	19.4%	18.1%	19.4%	0.0%	9.7%	15.3%	13.9%
# years > 0.5 Km downstream	10	8	5	0	7	6	7
% years > 0.5km downstream	13.9%	11.1%	6.9%	0.0%	9.7%	8.3%	9.7%
All months (Feb-June)							
# years > 0.5 Km upstream	55	35	54	0	17	23	26
% years > 0.5km upstream	15.3%	9.7%	15.0%	0.0%	4.7%	6.4%	7.2%
# years > 0.5 Km downstream	23	29	12	0	14	19	15
% years > 0.5km downstream	6.4%	8.1%	3.3%	0.0%	3.9%	5.3%	4.2%

Changes in X2 Position Compared to No Action for all Alternatives

February

Year	No Action (Km)	Max. Flow (Km)[1]	difference	Flow Eval. (Km)[1]	difference	70% inflow (Km)[1]	difference	Mech. Rest. (Km)[1]	difference	Revised Mech. (Km)[1]	difference	Mod. % Inflow (Km)[1]	difference	Existing Conditions (2001)	Difference (vs. Pref. Alt. 2001)
1922	76.43	77.32	0.89	76.43	0.00	76.43	0.00	76.43	0.00	76.43	0.00	76.43	0.00	66.89	0.00
1923	67.20	67.29	0.08	67.20	0.00	67.14	-0.07	67.20	0.00	67.20	0.00	67.20	0.00	69.75	0.00
1924	82.45	82.67	0.22	82.48	0.03	82.91	0.47	82.45	0.00	82.41	-0.03	82.33	-0.12	77.79	0.35
1925	80.80	80.63	-0.17	80.36	-0.44	80.81	0.01	80.80	0.00	80.73	-0.06	80.35	-0.44	63.68	0.08
1926	78.85	79.02	0.16	77.28	-1.57	78.84	-0.01	78.85	0.00	77.47	-1.38	78.82	-0.03	67.11	-0.16
1927	69.09	69.98	0.89	69.46	0.37	68.71	-0.38	69.09	0.00	69.96	0.87	69.40	0.31	54.65	0.42
1928	74.96	75.55	0.59	75.32	0.36	75.50	0.55	74.96	0.00	74.96	0.00	75.31	0.36	71.69	0.01
1929	83.01	83.43	0.42	83.11	0.09	83.14	0.12	83.01	0.00	82.99	-0.02	83.00	-0.02	78.21	-0.17
1930	74.04	72.67	-1.37	72.59	-1.44	74.12	0.09	74.04	0.00	74.07	0.03	74.05	0.01	72.62	-0.10
1931	79.19	81.22	2.03	80.85	1.66	80.63	1.44	79.19	0.00	79.13	-0.05	79.03	-0.16	80.22	0.13
1932	72.52	72.81	0.30	71.44	-1.08	72.58	0.06	72.52	0.00	72.50	-0.01	72.47	-0.05	70.37	0.11
1933	76.75	76.64	-0.11	79.28	2.54	78.58	1.83	76.75	0.00	76.70	-0.04	76.34	-0.41	78.21	1.26
1934	76.48	76.61	0.12	75.90	-0.58	76.96	0.47	76.48	0.00	77.65	1.17	77.71	1.23	74.73	-0.17
1935	71.08	71.52	0.44	70.43	-0.65	71.59	0.51	71.08	0.00	71.09	0.01	71.27	0.19	74.01	0.04
1936	70.11	70.26	0.15	70.09	-0.02	70.23	0.13	70.11	0.00	70.08	-0.03	70.15	0.04	59.38	-0.09
1937	81.93	82.11	0.17	80.39	-1.54	81.83	-0.10	81.93	0.00	81.90	-0.03	81.70	-0.23	67.17	-0.05
1938	64.00	64.32	0.32	64.03	0.04	64.33	0.33	64.00	0.00	63.89	-0.10	63.90	-0.09	51.99	0.00
1939	80.63	79.78	-0.86	80.71	0.08	80.66	0.03	80.63	0.00	80.50	-0.13	80.62	-0.02	79.42	-0.28
1940	70.49	70.67	0.17	70.58	0.09	70.76	0.26	70.49	0.00	70.40	-0.10	70.41	-0.08	60.92	0.04
1941	56.54	57.45	0.90	56.81	0.27	57.14	0.60	56.54	0.00	56.56	0.01	56.65	0.10	50.99	0.08
1942	57.53	57.72	0.19	57.81	0.28	57.86	0.33	57.53	0.00	57.38	-0.15	57.60	0.07	50.31	-0.07
1943	58.62	59.48	0.86	58.85	0.22	59.08	0.46	58.62	0.00	58.75	0.13	58.87	0.24	57.39	-0.01
1944	81.74	81.72	-0.02	81.75	0.01	81.76	0.03	81.74	0.00	81.71	-0.03	81.75	0.01	72.86	-0.17
1945	80.06	80.09	0.03	81.49	1.43	80.07	0.01	80.06	0.00	79.72	-0.34	79.88	-0.18	66.19	-0.03
1946	61.07	62.03	0.96	61.35	0.28	61.47	0.40	61.07	0.00	61.30	0.23	61.09	0.02	64.80	0.00
1947	81.84	82.15	0.31	81.90	0.06	81.86	0.02	81.84	0.00	81.91	0.07	81.87	0.03	76.06	0.29
1948	80.15	80.35	0.20	80.46	0.31	80.22	0.07	80.15	0.00	80.25	0.10	80.32	0.17	76.95	0.03
1949	83.88	84.17	0.29	83.99	0.11	83.56	-0.32	83.88	0.00	83.89	0.01	83.89	0.02	80.99	0.01
1950	74.69	74.94	0.25	74.90	0.21	74.96	0.27	74.69	0.00	74.77	0.07	74.71	0.01	68.01	0.13
1951	56.03	55.62	-0.41	55.84	-0.19	55.78	-0.25	56.03	0.00	55.65	-0.38	55.90	-0.13	55.33	-0.39
1952	57.19	58.03	0.84	57.69	0.500	58.02	0.83	57.19	0.00	57.45	0.26	57.58	0.39	55.10	0.13
1953	56.01	56.24	0.24	56.22	0.22	56.33	0.33	56.01	0.00	56.26	0.26	56.25	0.25	63.62	0.55
1954	71.98	73.50	1.52	70.98	-1.00	72.32	0.34	71.98	0.00	71.02	-0.96	70.90	-1.08	62.10	0.33
1955	74.47	75.27	0.80	74.90	0.43	75.23	0.76	74.47	0.00	74.76	0.29	74.78	0.32	74.93	0.15
1956	50.37	50.71	0.35	50.52	0.16	50.75	0.39	50.37	0.00	50.43	0.07	50.50	0.13	52.04	0.05
1957	81.85	83.29	1.44	81.96	0.11	83.60	1.75	81.85	0.00	81.78	-0.07	81.76	-0.09	70.49	-0.27
1958	67.03	67.36	0.33	67.47	0.43	67.73	0.70	67.03	0.00	67.32	0.29	67.36	0.32	51.39	0.13
1959	70.78	70.86	0.07	70.69	-0.09	71.20	0.42	70.78	0.00	70.78	-0.01	70.82	0.03	62.06	-0.07
1960	82.37	82.08	-0.29	81.79	-0.58	83.32	0.95	82.37	0.00	81.77	-0.60	83.05	0.68	71.50	0.66
1961	80.13	79.11	-1.02	80.36	0.23	80.15	0.02	80.13	0.00	80.19	0.06	80.15	0.02	70.60	1.06
1962	81.90	81.51	-0.39	81.95	0.05	81.50	-0.41	81.90	0.00	81.92	0.01	81.92	0.02	66.47	0.39
1963	76.43	76.80	0.37	76.56	0.13	77.04	0.61	76.43	0.00	76.45	0.02	76.46	0.03	61.94	0.34
1964	74.98	75.61	0.63	75.50	0.52	75.86	0.88	74.98	0.00	75.09	0.11	75.07	0.08	74.94	0.29
1965	53.81	53.88	0.07	53.90	0.08	53.87	0.05	53.81	0.00	53.79	-0.03	53.77	-0.04	61.23	0.03
1966	69.58	69.15	-0.44	70.04	0.46	70.29	0.71	69.58	0.00	69.96	0.37	69.91	0.32	68.40	0.14
1967	62.59	63.49	0.90	62.75	0.16	62.97	0.38	62.59	0.00	62.70	0.11	62.64	0.05	59.94	0.17
1968	71.02	70.92	-0.10	70.98	-0.04	70.61	-0.41	71.02	0.00	70.89	-0.13	70.92	-0.10	61.36	0.00
1969	57.25	57.39	0.14	57.48	0.23	57.54	0.29	57.25	0.00	57.34	0.09	57.40	0.15	50.61	0.11
1970	49.72	50.10	0.38	49.80	0.08	49.80	0.08	49.72	0.00	49.77	0.05	49.75	0.03	51.43	-0.01
1971	61.34	61.77	0.43	61.62	0.27	61.77	0.43	61.34	0.00	61.53	0.19	61.54	0.20	64.60	0.00
1972	78.73	81.08	2.35	80.55	1.82	81.12	2.39	78.73	0.00	78.90	0.17	78.93	0.20	72.45	0.27
1973	59.20	59.51	0.31	59.36	0.16	60.14	0.95	59.20	0.00	59.21	0.01	59.28	0.09	54.20	0.07
1974	51.47	51.97	0.504	51.74	0.27	51.80	0.33	51.47	0.00	51.70	0.23	51.70	0.23	58.91	0.07
1975	80.59	82.14	1.55	82.13	1.54	82.17	1.59	80.59	0.00	81.62	1.03	80.65	0.06	64.17	-0.10
1976	83.40	83.36	-0.03	83.35	-0.04	82.66	-0.74	83.40	0.00	83.42	0.02	83.51	0.11	80.69	-1.09
1977	84.24	85.06	0.82	84.22	-0.02	84.29	0.05	84.24	0.00	84.21	-0.03	84.21	-0.03	82.31	-0.17
1978	63.44	63.47	0.03	63.50	0.05	63.44	0.00	63.44	0.00	63.44	-0.01	63.45	0.01	59.71	0.40
1979	74.48	74.00	-0.48	73.94	-0.53	73.99	-0.49	74.48	0.00	74.19	-0.29	73.97	-0.51	63.71	0.05
1980	59.09	59.00	-0.10	59.49	0.39	59.79	0.70	59.09	0.00	59.31	0.21	59.41	0.32	51.41	0.07
1981	74.84	74.83	0.00	75.06	0.22	75.93	1.09	74.84	0.00	75.16	0.32	75.07	0.23	69.51	0.23
1982	55.40	55.75	0.35	55.50	0.10	55.83	0.43	55.40	0.00	55.43	0.03	55.42	0.02	52.03	0.02
1983	52.00	52.17	0.17	52.07	0.07	52.13	0.12	52.00	0.00	52.05	0.05	52.05	0.05	46.49	-0.01
1984	53.47	53.51	0.05	53.30	-0.16	53.51	0.05	53.47	0.00	53.29	-0.18	53.29	-0.18	58.64	0.01
1985	79.43	80.21	0.78	79.05	-0.38	79.29	-0.14	79.43	0.00	78.94	-0.49	78.91	-0.52	76.99	0.11
1986	72.62	73.46	0.83	72.71	0.09	72.73	0.11	72.62	0.00	73.11	0.49	73.19	0.56	52.17	0.01
1987	82.19	82.32	0.12	83.14	0.95	82.25	0.05	82.19	0.00	82.21	0.02	83.13	0.94	76.03	0.12
1988	71.23	71.60	0.37	70.50	-0.73	70.74	-0.49	71.23	0.00	71.22	-0.01	70.55	-0.68	74.25	0.03
1989	81.26	81.51	0.25	81.32	0.05	81.35	0.08	81.26	0.00	81.48	0.22	81.23	-0.03	80.11	0.12
1990	79.04	79.43	0.39	78.39	-0.66	79.46	0.41	79.04	0.00	79.08	0.03	78.98	-0.06	76.62	-0.32
1991	84.98	85.38	0.39	85.48	0.497	84.90	-0.08	84.98	0.00	85.41	0.43	85.30	0.32	81.89	0.22
1992	82.70	83.27	0.57	82.92	0.21	83.00	0.30	82.70	0.00	82.72	0.01	82.82	0.12	70.73	0.10
1993	63.89	63.96	0.08	63.85	-0.03	63.81	-0.08	63.89	0.00	63.87	-0.01	63.98	0.10	59.46	0.01
count > + 0.5 Km			20		8		18		0		3		5		4
% > + 0.5km			27.8%		11.1%		25.0%		0.0%		4.2%		6.9%		5.6%
count > - 0.5 Km			3		11		1		0		3		4		1
% > - 0.5km			4.2%		15.3%		1.4%		0.0%		4.2%		5.6%		1.4%
Avg.	71.12	71.45	0.33	71.22	0.10	71.44	0.32	71.12	0.00	71.15	0.03	71.17	0.05	66.05	0.08
Min.	49.72	50.10	-1.37	49.80	-1.57	49.80	-0.74	49.72	0.00	49.77	-1.38	49.75	-1.08	46.49	-1.09
Max.	84.98	85.38	2.35	85.48	2.54	84.90	2.39	84.98	0.00	85.41	1.17	85.30	1.23	82.31	1.26

(1) Compared to No Action

Changes in X2 Position for all Alternatives
March

Year	No Action (Km)	Max. Flow (Km)[1]	difference	Flow Eval. (Km)[1]	difference	70% inflow (Km)[1]	difference	Mech. Rest. (Km)[1]	difference	Revised Mech. (Km)[1]	difference	Mod. % Inflow (Km)[1]	difference	Existing Conditions (2001)	Difference (vs. Pref. Alt. 2001)
1922	66.36	66.65	0.29	66.36	0.00	66.36	0.00	66.36	0.00	66.36	0.00	66.36	0.00	65.7	0.00
1923	71.47	71.51	0.04	71.47	0.00	71.45	-0.02	71.47	0.00	71.47	0.00	71.47	0.00	74.1	0.00
1924	78.01	77.83	-0.18	77.69	-0.32	77.88	-0.13	78.01	0.00	78.00	-0.01	77.64	-0.37	77.0	0.11
1925	63.53	63.71	0.18	63.51	-0.02	63.73	0.20	63.53	0.00	63.35	-0.17	63.51	-0.02	64.8	0.03
1926	67.04	67.21	0.17	66.54	-0.499	67.20	0.16	67.04	0.00	66.59	-0.46	66.81	-0.23	73.6	0.01
1927	54.55	55.35	**0.81**	54.70	0.15	54.63	0.09	54.55	0.00	54.71	0.16	54.52	-0.03	59.3	0.10
1928	72.17	72.39	0.22	72.26	0.09	72.37	0.20	72.17	0.00	72.18	0.00	72.26	0.08	57.3	0.01
1929	77.81	78.01	0.20	77.84	0.03	77.86	0.04	77.81	0.00	77.81	-0.01	77.80	-0.01	77.3	-0.02
1930	72.78	73.12	0.34	72.84	0.06	72.98	0.20	72.78	0.00	72.82	0.03	72.80	0.02	68.1	-0.03
1931	79.13	80.28	**1.15**	79.78	**0.65**	79.52	0.39	79.13	0.00	79.51	0.38	78.95	-0.19	81.5	0.21
1932	70.69	70.84	0.15	70.41	-0.28	70.55	-0.14	70.69	0.00	70.74	0.05	70.69	0.00	73.9	0.03
1933	79.11	78.76	-0.35	77.23	**-1.88**	76.76	**-2.34**	79.11	0.00	79.09	-0.01	77.48	**-1.62**	77.4	0.42
1934	74.78	74.85	0.07	74.59	-0.19	74.95	0.16	74.78	0.00	75.17	0.38	75.19	0.40	75.1	-0.06
1935	73.89	74.04	0.15	73.68	-0.21	74.06	0.18	73.89	0.00	73.89	0.00	73.95	0.06	70.2	0.01
1936	59.34	59.26	-0.08	59.33	-0.01	59.22	-0.11	59.34	0.00	59.33	-0.01	59.21	-0.13	63.7	-0.03
1937	67.24	67.47	0.23	66.91	-0.33	67.31	0.07	67.24	0.00	67.40	0.16	67.06	-0.17	62.0	-0.31
1938	52.13	52.24	0.11	52.17	0.05	52.24	0.11	52.13	0.00	52.09	-0.03	52.10	-0.03	47.1	0.00
1939	77.82	77.11	**-0.71**	77.87	0.06	77.40	-0.41	77.82	0.00	77.66	-0.15	77.72	-0.10	76.8	-0.15
1940	60.93	61.24	0.31	60.93	0.00	61.26	0.33	60.93	0.00	60.95	0.02	60.95	0.02	53.6	0.15
1941	51.11	51.37	0.25	51.16	0.04	51.45	0.33	51.11	0.00	51.07	-0.04	51.10	-0.01	51.5	0.04
1942	50.41	50.55	0.14	50.54	0.13	50.52	0.11	50.41	0.00	50.48	0.07	50.55	0.14	60.8	**0.88**
1943	57.68	57.80	0.12	57.77	0.09	57.91	0.23	57.68	0.00	57.74	0.06	57.78	0.10	53.8	0.00
1944	72.60	72.23	-0.37	72.20	-0.40	72.21	-0.39	72.60	0.00	72.19	-0.41	72.20	-0.40	71.3	**0.81**
1945	66.47	66.49	0.02	66.91	0.43	66.53	0.06	66.47	0.00	66.24	-0.23	66.38	-0.10	67.8	-0.13
1946	64.80	64.81	0.02	64.80	0.00	64.80	0.01	64.80	0.00	64.80	0.00	64.80	0.00	69.1	0.01
1947	76.87	76.27	**-0.60**	76.08	**-0.78**	76.18	**-0.68**	76.87	0.00	76.23	**-0.64**	76.21	**-0.65**	73.5	0.42
1948	77.00	77.07	0.07	77.10	0.10	77.02	0.02	77.00	0.00	77.03	0.03	77.06	0.06	76.0	0.03
1949	80.14	80.10	-0.04	80.18	0.04	79.77	-0.37	80.14	0.00	80.05	-0.09	80.15	0.01	67.1	-0.18
1950	68.05	68.17	0.12	68.13	0.08	68.14	0.09	68.05	0.00	68.07	0.02	68.05	0.01	71.1	0.05
1951	55.26	55.03	-0.23	55.16	-0.10	55.13	-0.13	55.26	0.00	55.11	-0.15	55.19	-0.07	62.8	-0.37
1952	55.19	55.48	0.29	55.36	0.17	55.47	0.28	55.19	0.00	55.28	0.09	55.32	0.13	55.4	0.17
1953	64.17	64.17	0.00	64.17	0.00	64.17	0.00	64.17	0.00	64.17	0.00	64.17	0.00	69.1	0.18
1954	62.23	62.48	0.24	61.91	-0.33	62.08	-0.15	62.23	0.00	61.92	-0.31	61.88	-0.35	60.8	0.11
1955	75.01	75.27	0.26	75.15	0.14	75.26	0.25	75.01	0.00	75.10	0.10	75.11	0.10	78.2	-0.03
1956	52.07	52.07	0.00	52.12	0.05	52.21	0.14	52.07	0.00	52.09	0.02	52.12	0.04	59.6	**-0.61**
1957	70.48	71.42	**0.95**	70.43	-0.05	71.21	**0.74**	70.48	0.00	70.26	-0.21	70.27	-0.21	63.8	-0.09
1958	51.44	51.55	0.11	51.59	0.15	51.68	0.24	51.44	0.00	51.55	0.11	51.56	0.12	51.3	0.05
1959	61.95	62.02	0.07	61.92	-0.03	62.04	0.09	61.95	0.00	61.95	0.00	61.96	0.01	66.4	0.00
1960	71.60	71.42	-0.18	72.27	**0.68**	72.28	**0.69**	71.60	0.00	71.40	-0.19	71.83	0.23	71.8	0.22
1961	70.19	71.78	**1.59**	71.64	**1.45**	72.08	**1.89**	70.19	0.00	70.01	-0.18	70.81	**0.62**	72.4	0.19
1962	66.34	66.36	0.02	66.84	0.49	66.38	0.04	66.34	0.00	66.47	0.13	66.59	0.25	68.1	-0.01
1963	61.95	61.90	-0.05	62.09	0.14	62.28	0.33	61.95	0.00	61.90	-0.05	61.91	-0.05	64.5	0.00
1964	75.32	75.52	0.20	75.48	0.17	75.60	0.29	75.32	0.00	75.35	0.04	75.34	0.03	76.9	0.43
1965	61.27	61.10	-0.16	61.30	0.04	61.30	0.03	61.27	0.00	61.26	-0.01	61.26	-0.01	66.9	0.00
1966	68.20	68.07	-0.13	68.35	0.15	68.54	0.34	68.20	0.00	68.32	0.12	68.31	0.11	68.5	0.38
1967	60.11	60.37	0.26	60.02	-0.09	60.16	0.05	60.11	0.00	60.24	0.13	60.11	0.00	58.0	0.06
1968	61.34	61.01	-0.33	61.30	-0.04	60.88	-0.46	61.34	0.00	61.28	-0.06	61.30	-0.04	62.9	0.00
1969	50.59	50.62	0.02	50.67	0.07	50.67	0.07	50.59	0.00	50.62	0.03	50.64	0.05	54.6	0.08
1970	51.58	51.81	0.24	51.61	0.04	51.57	-0.01	51.58	0.00	51.60	0.03	51.60	0.02	58.8	-0.09
1971	64.59	64.60	0.00	64.60	0.00	64.60	0.00	64.59	0.00	64.60	0.00	64.60	0.00	62.3	0.12
1972	72.48	74.11	**1.64**	73.07	**0.60**	74.91	**2.43**	72.48	0.00	72.53	0.06	72.54	0.06	68.2	0.09
1973	54.42	54.28	-0.14	54.47	0.06	54.73	0.32	54.42	0.00	54.42	0.00	54.45	0.03	56.0	0.38
1974	58.84	59.05	0.21	58.94	0.10	59.00	0.16	58.84	0.00	58.92	0.08	58.92	0.08	52.6	0.34
1975	64.04	64.62	**0.58**	64.48	0.43	64.66	**0.61**	64.04	0.00	64.38	0.34	64.09	0.05	56.2	-0.03
1976	79.30	79.38	0.08	79.33	0.02	79.13	-0.17	79.30	0.00	79.32	0.01	79.36	0.06	77.9	**-0.78**
1977	82.09	82.29	0.20	82.08	0.00	82.10	0.01	82.09	0.00	82.08	-0.01	82.08	-0.01	82.3	-0.04
1978	59.68	60.03	0.35	59.66	-0.02	60.03	0.35	59.68	0.00	59.67	-0.01	59.71	0.03	57.0	0.13
1979	64.93	65.31	0.38	65.13	0.20	65.34	0.42	64.93	0.00	64.81	-0.11	65.16	0.23	64.0	0.01
1980	51.41	51.31	-0.10	51.54	0.13	51.52	0.11	51.41	0.00	51.48	0.07	51.51	0.10	55.7	0.03
1981	69.68	69.46	-0.22	69.84	0.16	70.36	**0.68**	69.68	0.00	69.87	0.18	69.84	0.16	66.6	**0.92**
1982	52.39	52.49	0.10	52.42	0.03	52.53	0.15	52.39	0.00	52.40	0.01	52.40	0.01	52.6	0.01
1983	46.55	46.63	0.08	46.58	0.03	46.59	0.05	46.55	0.00	46.58	0.03	46.58	0.03	42.0	0.00
1984	59.08	59.21	0.13	58.92	-0.17	58.99	-0.09	59.08	0.00	58.89	-0.19	58.89	-0.19	61.5	0.01
1985	76.77	77.07	0.30	76.66	-0.11	76.75	-0.02	76.77	0.00	76.61	-0.16	76.60	-0.17	76.1	0.06
1986	52.20	52.94	**0.74**	52.37	0.17	52.50	0.31	52.20	0.00	52.38	0.18	52.42	0.22	48.1	0.06
1987	74.60	74.44	-0.16	76.05	**1.45**	75.76	**1.16**	74.60	0.00	75.15	**0.56**	76.04	**1.44**	70.9	0.03
1988	74.15	74.21	0.07	74.14	0.00	74.14	0.00	74.15	0.00	74.15	0.00	74.14	0.00	77.8	0.01
1989	80.10	80.17	0.07	80.11	0.01	80.12	0.02	80.10	0.00	80.16	0.06	80.09	-0.01	67.1	0.04
1990	76.51	76.63	0.13	76.29	-0.22	76.64	0.14	76.51	0.00	76.52	0.01	76.49	-0.02	77.3	0.42
1991	82.15	82.16	0.00	82.17	0.02	82.02	-0.14	82.15	0.00	82.13	-0.03	82.21	0.05	70.7	0.32
1992	70.40	70.60	0.20	70.47	0.07	70.50	0.10	70.40	0.00	70.40	0.00	70.44	0.04	71.6	0.04
1993	59.48	59.52	0.04	59.47	-0.01	59.46	-0.02	59.48	0.00	59.47	0.00	59.51	0.03	60.7	-0.07
count			**7**		**5**		**7**		**0**		**1**		**2**		**3**
% > +0.5km			**9.7%**		**6.9%**		**9.7%**		**0.0%**		**1.4%**		**2.8%**		**4.2%**
count > - 0.5 Km			**2**		**2**		**2**		**0**		**1**		**2**		**2**
% > - 0.5km			**2.8%**		**2.8%**		**2.8%**		**0.0%**		**1.4%**		**2.8%**		**2.8%**
Avg.	66.06	66.20	0.15	66.10	0.04	66.19	0.13	66.06	0.00	66.05	0.00	66.06	0.00	65.64	0.07
Min.	46.55	46.63	-0.71	46.58	-1.88	46.59	-2.34	46.55	0.00	46.58	-0.64	46.58	-1.62	42.03	-0.78
Max.	82.15	82.29	1.64	82.17	1.45	82.10	2.43	82.15	0.00	82.13	0.56	82.21	1.44	82.33	0.92

(1) = Compared to No Action

Changes in X2 Position Compared to No Action for all Alternatives

April

Year	No Action (Km)	Max. Flow (Km)[1]	difference	Flow Eval. (Km)[1]	difference	70% inflow (Km)[1]	difference	Mech. Rest. (Km)[1]	difference	Revised Mech. (Km)[1]	difference	Mod. % Inflow (Km)[1]	difference	Existing Conditions (2001)	Difference (vs. Pref. Alt. 2001)
1922	66.26	66.18	-0.08	66.26	0.00	66.26	0.00	66.26	0.00	66.26	0.00	66.26	0.00	66.28	0.01
1923	74.24	74.26	0.02	73.57	-0.67	73.56	-0.68	74.24	0.00	74.24	0.00	73.57	-0.67	68.77	0.02
1924	77.10	77.05	-0.06	77.00	-0.10	77.06	-0.04	77.10	0.00	77.10	0.00	76.99	-0.12	80.24	0.00
1925	64.76	64.82	0.06	64.75	-0.01	64.82	0.07	64.76	0.00	64.70	-0.06	64.75	-0.01	66.94	0.00
1926	72.89	74.00	1.11	74.00	1.11	73.56	0.68	72.89	0.00	73.49	0.60	74.00	1.11	69.86	0.05
1927	59.31	59.36	0.05	59.16	-0.15	59.12	-0.18	59.31	0.00	59.17	-0.14	59.10	-0.20	59.18	0.04
1928	57.78	58.17	0.39	57.77	-0.01	58.21	0.43	57.78	0.00	57.71	-0.07	57.76	-0.03	63.00	-0.04
1929	76.60	76.76	0.16	76.85	0.25	77.49	0.89	76.60	0.00	76.94	0.34	76.77	0.17	79.75	0.00
1930	68.00	68.63	0.63	68.53	0.53	68.47	0.47	68.00	0.00	68.55	0.55	68.55	0.55	73.77	0.00
1931	80.95	81.64	0.69	81.52	0.57	81.25	0.30	80.95	0.00	81.06	0.11	80.84	-0.12	81.25	0.05
1932	73.87	73.08	-0.79	73.77	-0.10	73.82	-0.05	73.87	0.00	73.89	0.02	73.87	0.00	74.95	0.01
1933	77.78	77.70	-0.08	77.16	-0.62	77.02	-0.76	77.78	0.00	77.77	0.00	77.25	-0.53	76.95	0.13
1934	74.99	75.13	0.14	75.05	0.06	75.04	0.05	74.99	0.00	75.24	0.25	75.12	0.13	76.22	-0.02
1935	69.77	69.85	0.07	69.71	-0.07	69.55	-0.23	69.77	0.00	69.77	0.00	69.15	-0.63	61.87	-0.07
1936	63.87	63.26	-0.62	63.81	-0.06	63.70	-0.17	63.87	0.00	63.77	-0.11	63.44	-0.44	66.05	0.01
1937	62.08	62.15	0.07	62.02	-0.06	62.08	0.00	62.08	0.00	62.21	0.13	61.99	-0.09	64.43	-0.16
1938	47.13	47.17	0.04	47.13	0.00	47.17	0.04	47.13	0.00	47.12	-0.01	47.12	-0.01	51.43	0.00
1939	75.46	74.77	-0.69	75.43	-0.03	75.08	-0.38	75.46	0.00	76.15	0.69	75.40	-0.06	76.47	0.23
1940	53.69	53.69	0.00	53.68	-0.01	53.76	0.08	53.69	0.00	53.68	0.00	53.68	-0.01	54.50	0.05
1941	51.61	51.71	0.10	51.63	0.02	51.73	0.12	51.61	0.00	51.60	0.00	51.61	0.01	53.04	0.02
1942	61.93	62.02	0.09	60.85	-1.08	61.98	0.04	61.93	0.00	62.60	0.67	61.04	-0.89	59.18	0.29
1943	53.94	54.06	0.12	53.97	0.03	54.12	0.18	53.94	0.00	53.96	0.02	53.97	0.03	61.03	0.00
1944	71.59	71.49	-0.10	71.47	-0.12	71.50	-0.09	71.59	0.00	71.47	-0.12	71.47	-0.11	73.91	0.31
1945	67.61	67.84	0.22	67.95	0.34	67.79	0.17	67.61	0.00	67.74	0.12	67.78	0.16	71.29	-0.02
1946	69.47	69.44	-0.03	69.80	0.33	69.91	0.45	69.47	0.00	69.50	0.04	69.62	0.15	72.50	0.00
1947	73.58	73.66	0.08	73.57	-0.01	73.61	0.02	73.58	0.00	73.45	-0.14	73.49	-0.09	74.71	0.24
1948	75.30	75.05	-0.25	75.33	0.04	75.31	0.01	75.30	0.00	75.31	0.01	75.32	0.02	69.40	0.03
1949	66.47	66.78	0.31	66.52	0.05	67.46	0.99	66.47	0.00	66.31	-0.16	66.45	-0.02	72.49	-0.19
1950	70.90	70.98	0.08	70.95	0.05	70.94	0.03	70.90	0.00	70.91	0.01	70.91	0.00	70.56	0.00
1951	62.35	62.40	0.04	62.51	0.16	62.51	0.15	62.35	0.00	62.45	0.10	62.50	0.15	68.66	-0.12
1952	55.41	55.61	0.20	55.56	0.16	55.60	0.20	55.41	0.00	55.53	0.13	55.42	0.02	54.87	-0.19
1953	69.17	69.21	0.04	69.18	0.01	69.19	0.02	69.17	0.00	69.18	0.00	69.18	0.01	69.66	1.20
1954	60.71	61.08	0.36	60.61	-0.11	61.08	0.36	60.71	0.00	60.61	-0.10	60.60	-0.11	60.99	0.07
1955	77.60	77.74	0.14	77.55	-0.04	77.99	0.39	77.60	0.00	77.55	-0.05	77.62	0.02	75.33	0.27
1956	59.56	59.06	-0.501	59.42	-0.14	59.52	-0.04	59.56	0.00	59.46	-0.10	59.50	-0.06	65.97	-0.20
1957	63.99	64.22	0.23	63.76	-0.23	64.12	0.13	63.99	0.00	63.70	-0.29	63.71	-0.29	67.67	-0.03
1958	51.41	51.31	-0.10	51.46	0.05	51.50	0.08	51.41	0.00	51.45	0.04	51.45	0.04	50.93	0.02
1959	66.44	66.44	0.00	66.44	0.00	66.44	0.00	66.44	0.00	66.44	0.00	66.44	0.00	74.29	0.00
1960	72.16	72.10	-0.06	72.38	0.22	72.42	0.26	72.16	0.00	72.10	-0.06	72.24	0.08	74.14	0.07
1961	72.19	72.64	0.45	71.98	-0.21	73.47	1.28	72.19	0.00	71.66	-0.53	71.90	-0.29	75.21	0.06
1962	67.99	68.03	0.04	68.14	0.15	68.00	0.01	67.99	0.00	68.16	0.16	68.07	0.08	73.02	0.00
1963	64.54	64.54	0.00	64.54	0.00	64.54	0.00	64.54	0.00	64.54	0.00	64.54	0.00	56.23	0.04
1964	77.61	77.36	-0.26	77.71	0.10	77.75	0.14	77.61	0.00	77.65	0.04	78.08	0.47	75.88	-0.09
1965	66.89	66.88	-0.01	66.89	0.00	66.89	0.00	66.89	0.00	66.89	0.00	66.89	0.00	62.09	-0.01
1966	68.15	67.85	-0.30	68.63	0.49	68.70	0.56	68.15	0.00	68.58	0.43	68.19	0.04	71.31	0.60
1967	58.18	58.41	0.23	58.15	-0.03	58.34	0.16	58.18	0.00	58.22	0.04	58.18	0.00	57.62	0.02
1968	62.73	62.95	0.21	62.72	-0.01	63.07	0.33	62.73	0.00	62.72	-0.02	62.72	-0.01	69.77	0.00
1969	54.63	54.58	-0.06	54.66	0.03	54.58	-0.05	54.63	0.00	54.64	0.01	54.65	0.02	55.72	0.03
1970	58.98	58.96	-0.02	58.88	-0.10	58.98	0.01	58.98	0.00	58.88	-0.10	58.87	-0.10	67.60	-0.01
1971	62.64	62.14	-0.51	63.02	0.37	63.41	0.76	62.64	0.00	62.98	0.34	62.69	0.05	66.56	-0.85
1972	68.19	69.51	1.32	68.39	0.20	70.03	1.83	68.19	0.00	68.21	0.02	68.22	0.02	74.00	0.00
1973	56.44	56.10	-0.34	56.52	0.08	56.61	0.17	56.44	0.00	56.50	0.06	56.45	0.01	65.86	0.13
1974	52.81	52.84	0.02	52.85	0.03	52.87	0.05	52.81	0.00	52.84	0.03	52.84	0.03	53.81	0.13
1975	56.18	56.31	0.13	56.12	-0.06	56.19	0.02	56.18	0.00	56.28	0.10	56.16	-0.02	62.58	1.00
1976	76.89	76.95	0.06	76.90	0.01	76.87	-0.02	76.89	0.00	76.89	0.00	76.91	0.02	78.00	0.39
1977	82.28	82.32	0.05	82.28	0.00	82.28	0.00	82.28	0.00	82.28	0.00	82.28	0.00	81.21	-0.01
1978	56.93	56.44	-0.48	56.88	-0.05	57.04	0.11	56.93	0.00	56.92	0.00	56.93	0.00	58.72	0.05
1979	64.32	64.68	0.35	64.33	0.00	64.62	0.29	64.32	0.00	64.28	-0.04	64.38	0.06	67.83	0.02
1980	55.67	55.27	-0.40	55.74	0.07	55.34	-0.34	55.67	0.00	55.72	0.05	55.73	0.06	64.26	0.02
1981	66.30	67.69	1.39	66.91	0.61	68.24	1.94	66.30	0.00	66.52	0.22	66.55	0.25	69.62	1.44
1982	52.22	52.38	0.16	52.23	0.01	52.35	0.13	52.22	0.00	52.22	0.00	52.22	0.00	48.45	0.00
1983	42.08	42.14	0.06	42.09	0.01	42.09	0.02	42.08	0.00	42.09	0.01	42.09	0.01	48.61	0.01
1984	61.79	61.30	-0.49	61.74	-0.06	61.96	0.17	61.79	0.00	61.72	-0.07	61.72	-0.07	67.86	0.00
1985	75.23	75.36	0.13	75.55	0.32	75.59	0.36	75.23	0.00	75.53	0.30	75.53	0.30	74.97	0.02
1986	48.21	48.44	0.24	48.26	0.05	48.30	0.10	48.21	0.00	48.27	0.06	48.28	0.07	60.38	0.02
1987	69.94	71.04	1.10	70.94	0.99	69.53	-0.42	69.94	0.00	69.06	-0.88	70.92	0.98	74.14	0.00
1988	77.75	77.76	0.02	77.74	0.00	77.74	0.00	77.75	0.00	77.75	0.00	77.74	0.00	78.56	1.21
1989	67.47	67.13	-0.33	67.38	-0.09	67.45	-0.02	67.47	0.00	67.38	-0.09	67.29	-0.18	69.45	0.02
1990	77.55	77.37	-0.18	77.04	-0.51	77.70	0.15	77.55	0.00	77.10	-0.45	77.53	-0.02	77.07	0.13
1991	70.83	70.98	0.15	70.84	0.01	70.79	-0.04	70.83	0.00	70.58	-0.25	70.85	0.02	73.31	0.43
1992	71.07	71.16	0.09	71.10	0.02	71.11	0.04	71.07	0.00	71.08	0.00	71.09	0.02	74.81	0.01
1993	60.53	61.49	0.96	60.48	-0.05	61.46	0.93	60.53	0.00	60.64	0.11	60.47	-0.06	61.37	-0.02
count			8		5		9		0		4		2		5
% > +0.5km			11.1%		6.9%		12.5%		0.0%		5.6%		2.8%		6.9%
count > - 0.5 Km			5		4		2		0		1		4		1
% > - 0.5km			6.9%		5.6%		2.8%		0.0%		1.4%		5.6%		1.4%
Avg.	65.60	65.68	0.08	65.63	0.04	65.77	0.18	65.60	0.00	65.62	0.03	65.60	0.00	67.62	0.10
Min.	42.08	42.14	-0.79	42.09	-1.08	42.09	-0.76	42.08	0.00	42.09	-0.88	42.09	-0.89	48.45	-0.85
Max.	82.28	82.32	1.39	82.28	1.11	82.28	1.94	82.28	0.00	82.28	0.69	82.28	1.11	81.25	1.44

(1) = Compared to No Action

Changes in X2 Position Compared to No Action for all Alternatives

May

Year	No Action (Km)	Max. Flow (Km)[1]	difference	Flow Eval. (Km)[1]	difference	70% inflow (Km)[1]	difference	Mech. Rest. (Km)[1]	difference	Revised Mech. (Km)[1]	difference	Mod. % Inflow (Km)[1]	difference	Existing Conditions (2001)	Difference (vs. Pref. Alt. 2001)
1922	66.77	66.65	-0.11	66.78	0.01	66.78	0.02	66.77	0.00	66.77	0.00	66.78	0.01	60.77	0.01
1923	68.85	68.41	-0.43	68.64	-0.20	68.69	-0.16	68.85	0.00	68.85	0.00	68.64	-0.20	70.25	-0.49
1924	80.29	80.28	0.00	80.28	0.00	80.28	0.00	80.29	0.00	80.29	0.00	80.28	-0.01	84.76	-0.02
1925	66.70	66.84	0.14	66.69	0.00	66.81	0.11	66.70	0.00	66.68	-0.01	65.60	-1.09	70.82	-0.04
1926	68.51	69.60	1.10	69.70	1.19	69.86	1.35	68.51	0.00	69.15	0.64	69.67	1.17	73.55	0.38
1927	59.13	59.18	0.05	59.08	-0.05	59.09	-0.03	59.13	0.00	59.08	-0.05	59.06	-0.07	64.27	0.01
1928	63.61	63.39	-0.22	63.27	-0.34	63.40	-0.21	63.61	0.00	63.25	-0.36	63.27	-0.34	68.46	-0.01
1929	79.58	79.62	0.04	79.65	0.07	79.81	0.23	79.58	0.00	79.67	0.09	79.62	0.04	81.00	0.00
1930	73.21	73.49	0.28	73.33	0.12	73.43	0.22	73.21	0.00	73.41	0.20	73.40	0.19	75.87	-0.01
1931	81.13	81.30	0.17	81.27	0.14	81.20	0.07	81.13	0.00	81.15	0.03	81.10	-0.03	84.18	0.07
1932	74.82	74.34	-0.49	74.65	-0.17	74.55	-0.27	74.82	0.00	74.60	-0.22	74.75	-0.07	74.56	0.63
1933	77.06	77.04	-0.02	76.87	-0.19	76.82	-0.24	77.06	0.00	77.06	0.00	76.89	-0.17	81.11	0.03
1934	76.19	76.23	0.05	76.20	0.02	76.20	0.02	76.19	0.00	76.26	0.08	76.23	0.04	81.00	0.00
1935	61.65	61.91	0.26	61.64	-0.01	61.63	-0.02	61.65	0.00	61.65	0.00	61.39	-0.26	64.36	0.00
1936	66.05	65.76	-0.30	65.89	-0.17	65.89	-0.16	66.05	0.00	65.87	-0.18	65.74	-0.32	69.03	0.15
1937	64.45	64.55	0.10	64.52	0.07	64.56	0.11	64.45	0.00	64.60	0.15	64.50	0.05	67.99	-0.15
1938	51.38	51.30	-0.09	51.40	0.02	51.29	-0.09	51.38	0.00	51.27	-0.11	51.27	-0.11	53.00	0.03
1939	76.29	76.12	-0.18	75.74	-0.55	76.03	-0.26	76.29	0.00	76.52	0.22	76.27	-0.02	76.83	0.42
1940	54.43	54.53	0.10	54.52	0.09	54.55	0.12	54.43	0.00	54.52	0.09	54.52	0.09	65.04	0.01
1941	53.09	53.05	-0.04	53.02	-0.07	53.05	-0.04	53.09	0.00	53.01	-0.08	53.01	-0.08	57.58	0.23
1942	59.36	59.57	0.20	59.13	-0.23	59.55	0.19	59.36	0.00	59.70	0.34	59.19	-0.17	60.82	0.21
1943	61.05	60.98	-0.07	60.94	-0.12	60.99	-0.06	61.05	0.00	60.93	-0.12	60.94	-0.12	65.59	0.00
1944	73.11	73.69	0.57	73.38	0.26	73.85	0.74	73.11	0.00	73.38	0.26	73.38	0.27	75.52	0.45
1945	71.23	71.00	-0.23	70.91	-0.33	70.93	-0.31	71.23	0.00	70.83	-0.40	70.85	-0.39	72.17	0.01
1946	72.08	72.55	0.47	72.67	0.58	72.70	0.62	72.08	0.00	72.57	0.49	72.61	0.53	73.16	0.00
1947	74.43	74.64	0.22	73.91	-0.52	74.86	0.44	74.43	0.00	74.52	0.10	74.56	0.13	77.62	-0.77
1948	68.99	69.05	0.06	69.03	0.04	69.06	0.07	68.99	0.00	68.97	-0.02	68.98	-0.01	66.88	-0.01
1949	72.15	71.46	-0.69	71.44	-0.72	72.42	0.27	72.15	0.00	71.39	-0.76	71.48	-0.67	74.27	-0.06
1950	70.34	70.29	-0.04	70.38	0.04	70.35	0.02	70.34	0.00	70.32	-0.01	70.34	0.01	71.14	-0.12
1951	68.88	68.08	-0.79	68.55	-0.33	68.54	-0.33	68.88	0.00	68.52	-0.35	68.54	-0.34	68.78	0.43
1952	54.79	55.20	0.41	55.09	0.30	55.24	0.45	54.79	0.00	55.21	0.43	54.99	0.21	54.12	0.48
1953	70.56	70.63	0.07	70.58	0.01	70.65	0.08	70.56	0.00	70.57	0.01	70.57	0.01	67.61	0.48
1954	60.97	61.59	0.61	60.97	0.00	61.58	0.61	60.97	0.00	60.94	-0.03	61.13	0.16	65.72	0.00
1955	75.51	76.04	0.53	75.77	0.26	75.34	-0.17	75.51	0.00	75.76	0.25	75.75	0.23	76.40	0.07
1956	65.95	65.55	-0.40	65.60	-0.35	65.69	-0.26	65.95	0.00	65.61	-0.34	65.63	-0.32	62.05	0.40
1957	67.73	67.80	0.07	67.66	-0.07	67.77	0.04	67.73	0.00	67.64	-0.09	67.64	-0.09	70.23	0.00
1958	50.83	50.80	-0.03	50.91	0.08	50.93	0.09	50.83	0.00	50.91	0.07	50.91	0.08	55.40	0.14
1959	74.13	74.30	0.18	74.13	0.01	74.14	0.01	74.13	0.00	74.13	0.00	74.13	0.00	76.76	-0.18
1960	74.25	74.23	-0.02	74.32	0.07	74.34	0.09	74.25	0.00	74.23	-0.02	74.28	0.03	75.60	-0.02
1961	75.15	75.29	0.14	75.08	-0.07	75.55	0.41	75.15	0.00	74.98	-0.17	75.05	-0.09	77.02	0.32
1962	72.92	73.08	0.17	72.97	0.05	72.92	0.01	72.92	0.00	72.97	0.06	72.94	0.03	74.20	0.00
1963	56.13	55.96	-0.17	56.13	0.00	56.00	-0.13	56.13	0.00	56.11	-0.02	56.11	-0.02	61.20	0.01
1964	75.29	76.05	0.75	73.67	-1.63	73.66	-1.63	75.29	0.00	75.29	0.00	75.28	-0.01	75.88	0.57
1965	61.83	61.74	-0.09	61.89	0.06	62.12	0.29	61.83	0.00	61.94	0.11	61.78	-0.05	65.54	0.00
1966	72.07	71.78	-0.29	72.59	0.52	73.40	1.33	72.07	0.00	72.21	0.14	72.52	0.45	74.21	0.19
1967	57.68	57.65	-0.03	57.56	-0.12	57.62	-0.06	57.68	0.00	57.58	-0.10	57.57	-0.11	57.04	0.26
1968	69.74	69.78	0.04	69.74	0.00	69.81	0.07	69.74	0.00	69.74	0.00	69.74	0.00	75.85	0.01
1969	55.94	55.91	-0.04	56.01	0.06	55.91	-0.03	55.94	0.00	56.00	0.06	56.00	0.06	54.95	0.35
1970	67.62	67.61	0.00	67.61	-0.01	67.62	0.00	67.62	0.00	67.61	-0.01	67.61	-0.01	73.20	-0.75
1971	66.57	66.54	-0.03	66.63	0.05	66.75	0.17	66.57	0.00	66.61	0.04	66.57	0.00	65.16	0.94
1972	73.88	73.29	-0.60	74.00	0.12	73.46	-0.42	73.88	0.00	73.89	0.00	73.89	0.00	77.77	0.00
1973	65.54	65.79	0.24	65.92	0.37	65.95	0.41	65.54	0.00	65.91	0.36	65.90	0.35	69.12	0.06
1974	53.99	54.00	0.01	53.93	-0.06	54.01	0.02	53.99	0.00	53.91	-0.08	53.97	-0.02	62.02	0.46
1975	63.00	63.30	0.30	63.24	0.23	63.26	0.26	63.00	0.00	63.29	0.28	63.25	0.25	63.48	0.85
1976	77.70	77.68	-0.02	77.70	0.00	77.67	-0.03	77.70	0.00	77.70	0.00	77.70	0.00	84.19	0.12
1977	81.20	81.21	0.01	81.20	0.00	81.20	0.00	81.20	0.00	81.20	0.00	81.20	0.00	84.59	0.01
1978	58.22	59.07	0.84	58.55	0.32	58.68	0.46	58.22	0.00	58.63	0.41	58.59	0.37	63.64	0.01
1979	68.00	68.41	0.42	68.35	0.36	68.46	0.47	68.00	0.00	68.33	0.34	68.37	0.37	70.58	0.04
1980	64.26	64.02	-0.24	64.14	-0.12	64.03	-0.23	64.26	0.00	64.13	-0.13	64.13	-0.12	68.02	0.496
1981	70.02	69.89	-0.13	70.20	0.19	70.64	0.62	70.02	0.00	70.09	0.07	70.10	0.08	75.59	-0.82
1982	48.55	48.65	0.10	48.60	0.05	48.64	0.09	48.55	0.00	48.60	0.05	48.60	0.05	55.56	-0.13
1983	48.70	48.73	0.03	48.62	-0.08	48.71	0.01	48.70	0.00	48.61	-0.09	48.66	-0.04	51.59	0.02
1984	67.89	67.84	-0.05	67.88	-0.01	67.90	0.02	67.89	0.00	67.88	-0.01	67.88	-0.01	72.36	0.00
1985	74.06	74.39	0.33	74.62	0.56	74.64	0.58	74.06	0.00	74.60	0.54	74.60	0.54	75.92	0.18
1986	60.58	60.43	-0.15	60.35	-0.23	60.37	-0.21	60.58	0.00	60.35	-0.22	60.36	-0.22	68.33	-0.55
1987	74.13	74.14	0.01	74.14	0.01	74.13	0.00	74.13	0.00	74.13	0.00	74.14	0.01	77.70	-0.01
1988	79.17	79.23	0.06	78.95	-0.22	79.21	0.05	79.17	0.00	78.02	-1.15	78.38	-0.78	80.76	0.24
1989	69.80	69.86	0.05	69.78	-0.02	69.87	0.06	69.80	0.00	69.80	0.00	69.76	-0.04	74.13	0.00
1990	77.14	77.08	-0.06	76.98	-0.16	77.19	0.05	77.14	0.00	77.00	-0.14	77.13	-0.01	81.54	0.25
1991	72.56	73.01	0.45	72.87	0.31	72.99	0.43	72.56	0.00	72.48	-0.08	72.71	0.15	78.01	0.14
1992	74.73	74.73	0.00	74.26	-0.47	74.41	-0.32	74.73	0.00	73.97	-0.76	74.73	0.00	79.51	0.36
1993	61.35	61.78	0.43	61.41	0.06	61.74	0.40	61.35	0.00	61.41	0.06	61.39	0.04	63.66	-0.35
count			6		4		6		0		2		3		4
% > +0.5km			8.3%		5.6%		8.3%		0.0%		2.8%		4.2%		5.6%
count > - 0.5 Km			3		4		2		0		2		3		4
% > - 0.5km			4.2%		5.6%		2.8%		0.0%		2.8%		4.2%		5.6%
Avg.	67.57	67.62	0.06	67.56	-0.01	67.66	0.09	67.57	0.00	67.57	0.00	67.56	-0.01	70.37	0.08
Min.	48.55	48.65	0.10	48.60	0.05	48.64	0.09	48.55	0.00	48.60	0.05	48.60	0.05	51.59	-0.82
Max.	81.20	81.30	0.10	81.27	0.07	81.20	0.00	81.20	0.00	81.20	0.00	81.20	0.00	84.76	0.94

(1) = Compared to No Action

Changes in X2 Position Compared to No Action for all Alternatives

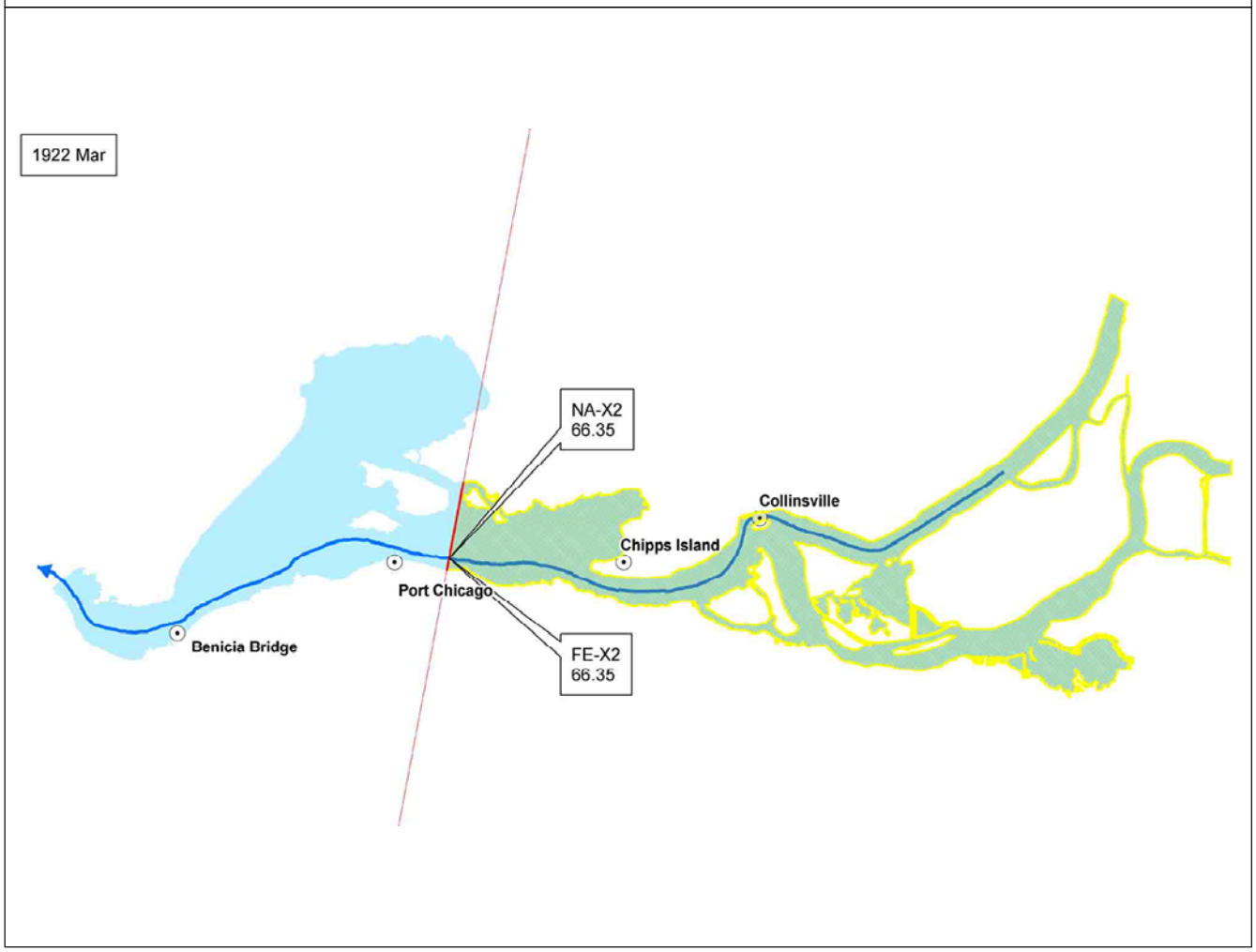
June

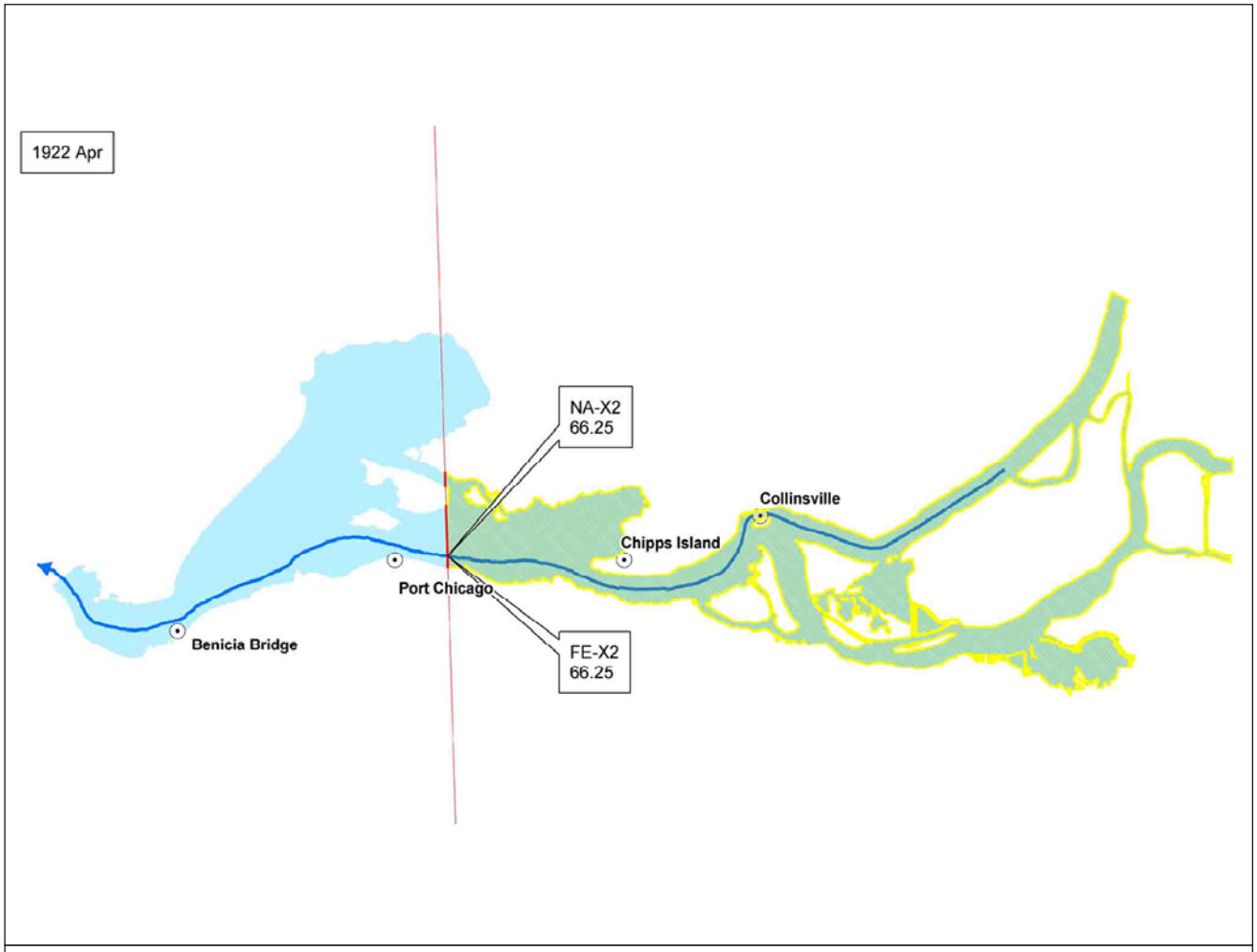
Year	No Action (Km)	Max. Flow (Km)[1]	difference	Flow Eval. (Km)[1]	difference	70% inflow (Km)[1]	difference	Mech. Rest. (Km)[1]	difference	Revised Mech. (Km)[1]	difference	Mod. % Inflow (Km)[1]	difference	Existing Conditions (2001)	Difference (vs. Pref. Alt. 2001)
1922	61.22	61.25	0.03	61.24	0.02	61.24	0.02	61.22	0.00	61.22	0.00	61.24	0.01	61.57	0.00
1923	70.82	70.33	-0.48	70.75	-0.07	70.23	-0.58	70.82	0.00	70.82	0.00	70.75	-0.07	76.17	-1.69
1924	84.89	84.73	-0.16	84.89	0.01	84.91	0.02	84.89	0.00	84.89	0.00	84.88	-0.01	84.43	0.04
1925	71.16	70.25	-0.91	70.01	-1.14	71.28	0.12	71.16	0.00	71.17	0.01	70.78	-0.38	76.04	0.00
1926	73.14	73.98	0.84	73.80	0.66	73.91	0.77	73.14	0.00	73.62	0.49	73.74	0.60	81.00	0.00
1927	64.48	64.51	0.03	64.46	-0.02	64.47	-0.01	64.48	0.00	64.46	-0.02	64.46	-0.02	72.72	0.00
1928	68.64	68.57	-0.06	68.54	-0.10	68.58	-0.06	68.64	0.00	68.53	-0.11	68.54	-0.10	78.25	0.00
1929	80.94	81.00	0.06	81.00	0.06	81.00	0.06	80.94	0.00	80.97	0.03	81.00	0.06	82.02	0.00
1930	76.19	76.11	-0.07	76.26	0.08	75.88	-0.30	76.19	0.00	76.30	0.12	76.29	0.11	80.21	-0.01
1931	84.15	84.21	0.06	84.15	0.00	84.55	0.40	84.15	0.00	84.53	0.38	84.52	0.37	84.55	-0.02
1932	76.14	75.29	-0.85	75.56	-0.58	76.19	0.06	76.14	0.00	76.06	-0.07	75.43	-0.71	75.90	0.20
1933	81.14	81.10	-0.04	81.09	-0.04	80.33	-0.81	81.14	0.00	81.09	-0.05	81.07	-0.07	82.05	0.01
1934	81.00	81.00	0.00	81.00	0.00	81.00	0.00	81.00	0.00	81.00	0.00	81.00	0.00	81.00	0.00
1935	64.35	64.36	0.00	64.35	0.00	64.35	0.00	64.35	0.00	64.35	0.00	64.35	0.00	71.89	-0.02
1936	69.62	69.15	-0.46	69.16	-0.46	69.20	-0.42	69.62	0.00	69.10	-0.52	69.08	-0.54	75.88	0.02
1937	67.07	67.73	0.65	67.56	0.49	67.74	0.67	67.07	0.00	67.52	0.45	67.71	0.64	74.12	0.00
1938	53.18	53.09	-0.09	53.12	-0.06	53.09	-0.09	53.18	0.00	53.08	-0.10	53.08	-0.10	57.49	0.38
1939	77.13	77.23	0.11	76.97	-0.16	77.45	0.33	77.13	0.00	77.16	0.03	77.01	-0.12	81.86	-0.17
1940	64.96	65.15	0.19	65.14	0.17	65.16	0.19	64.96	0.00	65.14	0.17	65.14	0.17	74.17	0.22
1941	57.65	58.11	0.45	57.73	0.07	58.11	0.45	57.65	0.00	57.50	-0.15	57.83	0.18	67.47	0.02
1942	60.69	61.36	0.67	60.94	0.25	61.33	0.65	60.69	0.00	61.13	0.44	60.96	0.27	65.54	0.81
1943	65.79	65.52	-0.27	65.52	-0.27	65.53	-0.27	65.79	0.00	65.52	-0.27	65.52	-0.27	75.97	-2.21
1944	74.47	76.04	1.57	75.63	1.16	75.79	1.32	74.47	0.00	75.63	1.16	75.63	1.17	78.11	0.66
1945	73.16	72.29	-0.87	72.52	-0.64	72.71	-0.45	73.16	0.00	72.50	-0.66	72.59	-0.57	75.97	0.00
1946	72.90	73.37	0.47	73.51	0.61	73.52	0.62	72.90	0.00	73.47	0.57	73.48	0.58	76.62	0.00
1947	77.70	77.37	-0.33	77.47	-0.23	77.84	0.13	77.70	0.00	76.95	-0.76	77.65	-0.05	79.81	0.07
1948	67.10	67.01	-0.09	67.07	-0.03	67.13	0.03	67.10	0.00	67.01	-0.08	67.01	-0.08	72.23	0.08
1949	74.17	73.16	-1.01	73.20	-0.97	74.26	0.09	74.17	0.00	73.22	-0.96	73.25	-0.92	78.10	-0.02
1950	71.33	70.93	-0.40	71.01	-0.32	71.21	-0.11	71.33	0.00	71.24	-0.09	71.26	-0.07	74.27	0.00
1951	69.64	68.86	-0.78	69.63	-0.01	69.58	-0.06	69.64	0.00	69.56	-0.08	69.63	-0.01	75.49	0.59
1952	54.24	54.81	0.57	54.77	0.53	54.91	0.67	54.24	0.00	54.64	0.40	54.64	0.40	58.57	0.23
1953	67.93	68.39	0.45	68.03	0.10	68.40	0.47	67.93	0.00	68.02	0.09	68.02	0.09	69.66	1.66
1954	65.72	65.74	0.02	65.72	0.00	65.74	0.02	65.72	0.00	65.72	0.00	65.72	0.01	76.89	-0.85
1955	75.93	76.54	0.62	75.99	0.07	75.96	0.04	75.93	0.00	75.99	0.07	75.96	0.04	79.31	0.02
1956	62.30	62.98	0.67	62.70	0.40	63.01	0.71	62.30	0.00	62.31	0.01	62.81	0.51	69.80	0.18
1957	69.45	69.37	-0.07	69.43	-0.02	69.48	0.04	69.45	0.00	69.42	-0.03	69.43	-0.02	75.49	0.00
1958	55.26	55.79	0.53	55.57	0.31	55.81	0.55	55.26	0.00	55.44	0.18	55.65	0.39	60.80	0.87
1959	76.79	76.72	-0.07	76.68	-0.12	76.49	-0.31	76.79	0.00	76.78	-0.02	76.77	-0.03	77.81	-0.09
1960	75.23	75.49	0.26	75.24	0.00	75.54	0.30	75.23	0.00	75.16	-0.07	75.23	0.00	80.80	0.00
1961	77.26	76.56	-0.70	76.50	-0.76	76.96	-0.30	77.26	0.00	76.59	-0.67	77.16	-0.10	81.00	-1.32
1962	73.59	73.64	0.06	74.20	0.62	73.59	0.00	73.59	0.00	74.20	0.62	74.19	0.61	79.19	-1.34
1963	61.60	61.36	-0.24	61.42	-0.18	61.39	-0.21	61.60	0.00	61.41	-0.19	61.41	-0.19	71.14	0.00
1964	76.77	76.76	-0.01	75.75	-1.02	75.74	-1.03	76.77	0.00	76.76	-0.01	76.79	0.02	80.05	-0.39
1965	65.53	65.53	0.00	65.53	0.00	65.54	0.01	65.53	0.00	65.54	0.00	65.53	0.00	75.29	0.00
1966	73.66	73.81	0.15	74.46	0.80	74.74	1.09	73.66	0.00	73.70	0.04	73.82	0.16	77.26	0.01
1967	57.20	57.30	0.11	57.27	0.07	57.29	0.09	57.20	0.00	57.21	0.01	57.27	0.07	58.70	0.64
1968	75.77	75.26	-0.51	75.77	0.00	75.80	0.03	75.77	0.00	75.77	0.00	75.77	0.00	77.82	-0.13
1969	55.03	55.49	0.46	55.54	0.505	55.51	0.48	55.03	0.00	55.19	0.16	55.27	0.24	59.97	0.25
1970	73.50	72.48	-1.02	72.98	-0.52	72.99	-0.52	73.50	0.00	72.98	-0.52	72.98	-0.52	77.63	0.60
1971	66.13	65.47	-0.65	65.78	-0.34	65.83	-0.30	66.13	0.00	65.64	-0.48	65.71	-0.41	71.65	1.04
1972	77.56	77.31	-0.25	77.77	0.20	77.57	0.01	77.56	0.00	77.56	0.00	77.55	-0.01	76.24	-0.05
1973	68.92	69.40	0.49	69.54	0.63	69.56	0.64	68.92	0.00	69.53	0.62	69.53	0.62	74.26	0.00
1974	62.39	62.50	0.11	62.47	0.08	62.50	0.11	62.39	0.00	62.21	-0.18	62.48	0.09	69.34	0.78
1975	63.69	64.68	1.00	64.59	0.90	64.67	0.98	63.69	0.00	64.41	0.72	64.56	0.88	68.33	0.85
1976	84.09	83.94	-0.15	83.69	-0.40	83.85	-0.24	84.09	0.00	83.70	-0.39	83.70	-0.40	85.42	0.47
1977	84.61	84.45	-0.17	84.60	-0.01	84.58	-0.03	84.61	0.00	84.61	-0.01	84.61	-0.01	84.59	-0.11
1978	63.92	63.92	0.00	63.69	-0.23	63.78	-0.14	63.92	0.00	63.72	-0.21	63.70	-0.22	69.62	0.00
1979	70.88	71.48	0.59	71.42	0.54	71.57	0.69	70.88	0.00	71.41	0.52	71.42	0.54	74.42	0.00
1980	68.29	67.78	-0.51	67.81	-0.48	68.30	0.01	68.29	0.00	67.80	-0.49	67.81	-0.48	74.94	0.16
1981	75.74	75.40	-0.34	75.80	0.06	75.94	0.20	75.74	0.00	75.76	0.03	75.77	0.03	81.00	0.00
1982	54.77	54.98	0.21	54.95	0.17	54.96	0.19	54.77	0.00	55.06	0.29	55.06	0.29	63.99	-0.01
1983	51.77	51.94	0.17	51.62	-0.15	51.89	0.12	51.77	0.00	51.59	-0.18	51.61	-0.15	52.27	0.01
1984	71.77	72.44	0.68	72.46	0.69	72.48	0.71	71.77	0.00	72.46	0.69	72.46	0.69	76.59	0.00
1985	75.94	76.02	0.08	76.13	0.19	76.13	0.19	75.94	0.00	76.12	0.18	76.12	0.18	80.78	-0.13
1986	68.12	68.08	-0.04	67.53	-0.59	67.53	-0.59	68.12	0.00	67.53	-0.58	67.54	-0.58	74.46	-0.56
1987	77.59	78.93	1.35	78.45	0.87	77.86	0.27	77.59	0.00	77.44	-0.15	78.44	0.85	80.86	0.14
1988	81.00	80.98	-0.02	80.99	-0.01	81.00	0.00	81.00	0.00	80.77	-0.23	81.00	0.00	81.00	0.00
1989	74.13	74.13	0.00	74.13	0.00	74.13	0.00	74.13	0.00	74.13	0.00	74.13	0.00	80.28	-0.59
1990	80.05	81.34	1.29	80.23	0.18	80.31	0.26	80.05	0.00	80.06	0.00	80.19	0.13	85.27	-0.04
1991	77.45	77.86	0.40	77.81	0.35	77.59	0.14	77.45	0.00	77.42	-0.03	77.50	0.05	84.19	0.05
1992	80.29	80.34	0.05	80.23	-0.06	80.27	-0.02	80.29	0.00	80.05	-0.24	79.94	-0.35	81.00	0.00
1993	62.67	63.54	0.87	63.17	0.50	63.49	0.82	62.67	0.00	62.69	0.02	62.66	0.00	68.31	-0.10
count			14		13		14		0		7		11		10
% > +0.5km			19.4%		18.1%		19.4%		0.0%		9.7%		15.3%		13.9%
count > - 0.5 Km			10		8		5		0		7		6		7
% > - 0.5km			13.9%		11.1%		6.9%		0.0%		9.7%		8.3%		9.7%
Avg.	70.41	70.47	0.07	70.44	0.03	70.53	0.12	70.41	0.00	70.41	0.00	70.46	0.05	74.96	4.52
Min.	51.77	51.94	0.17	51.62	-0.15	51.89	0.12	51.77	0.00	51.59	-0.18	51.61	-0.15	52.27	0.66
Max.	84.89	84.73	-0.16	84.89	0.01	84.91	0.02	84.89	0.00	84.89	0.00	84.88	-0.01	85.42	0.53

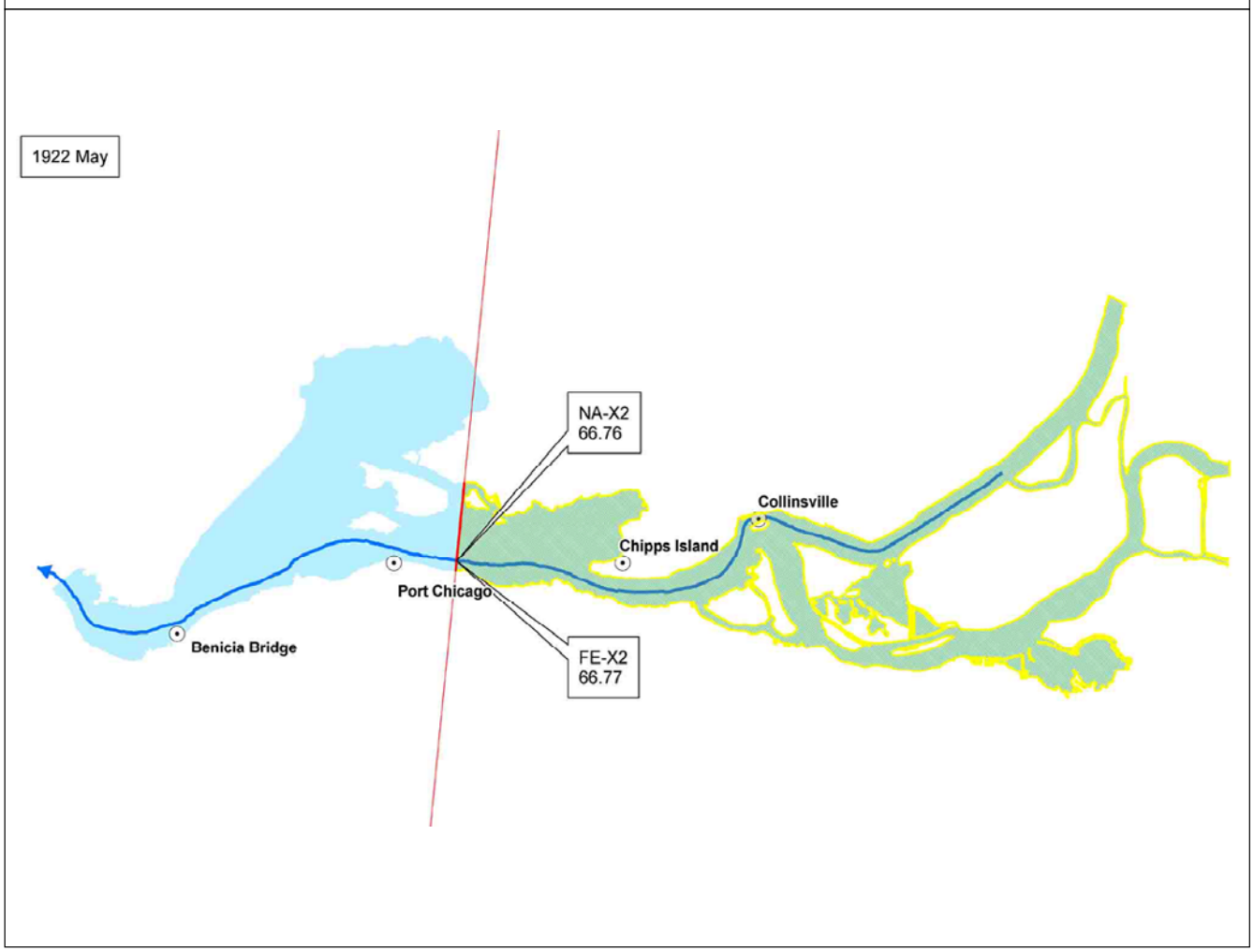
(1) = Compared to No Action

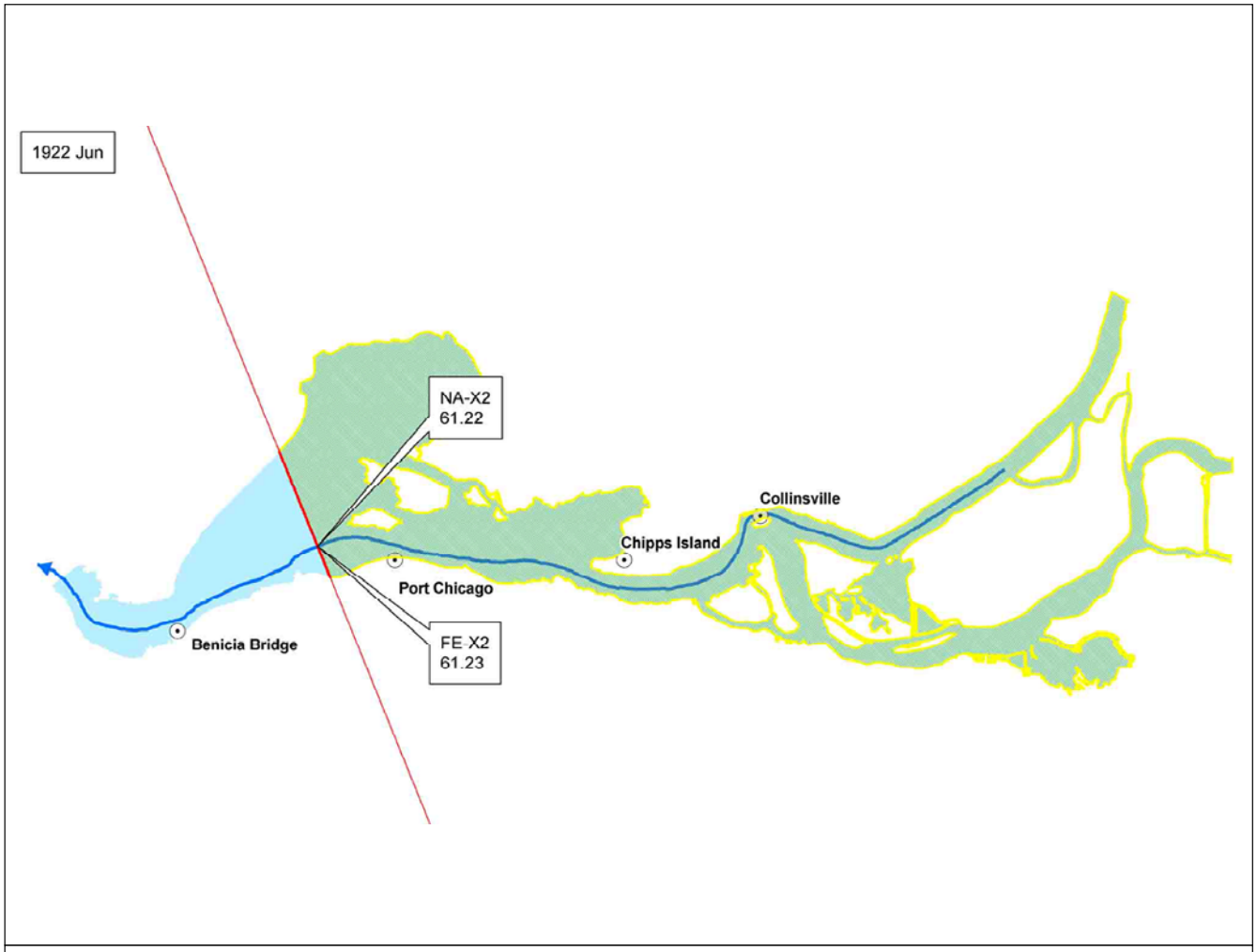
Relative X2 Position No Action versus Preferred Alternatives

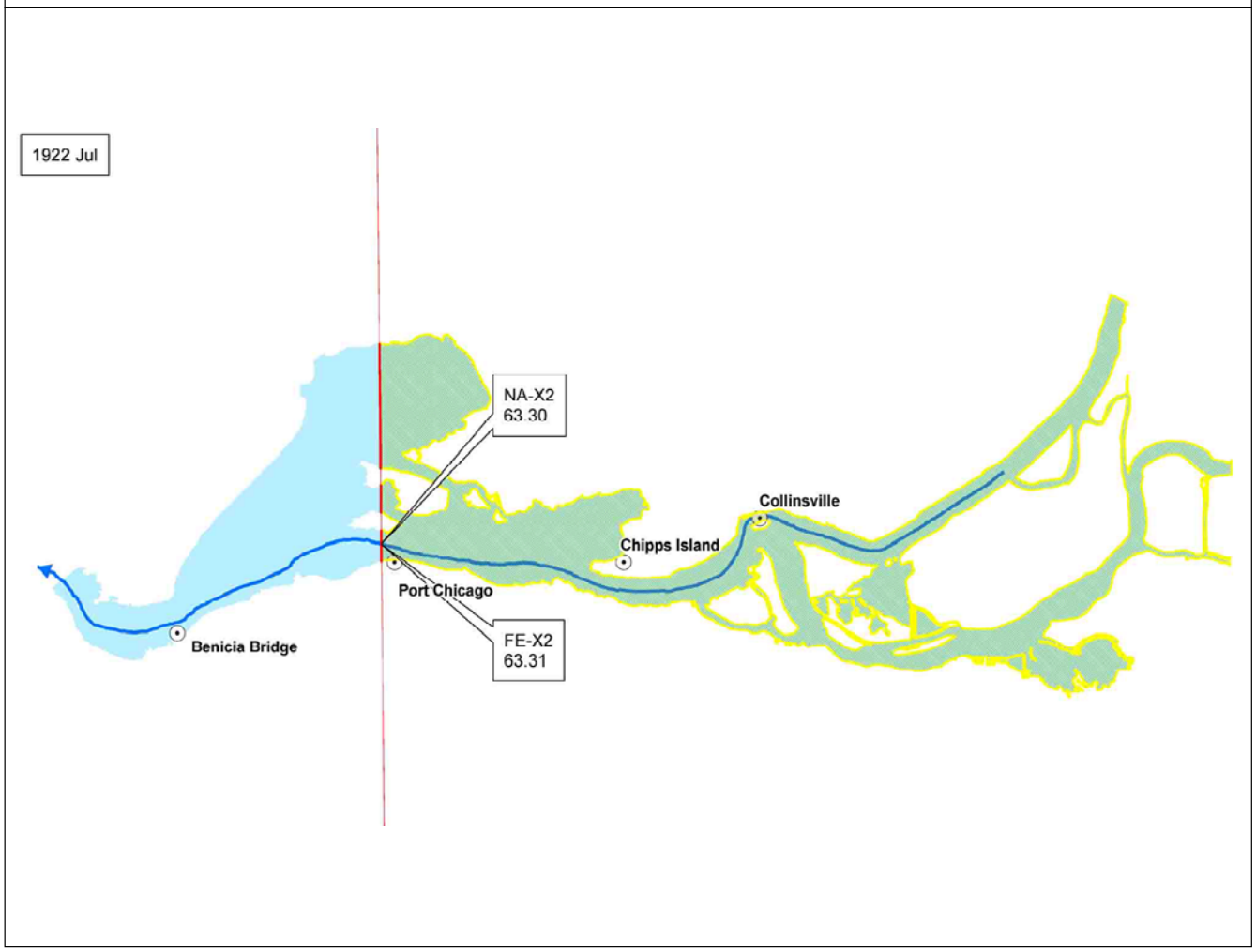

1922 Feb
NA-X2
76.43
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
76.43

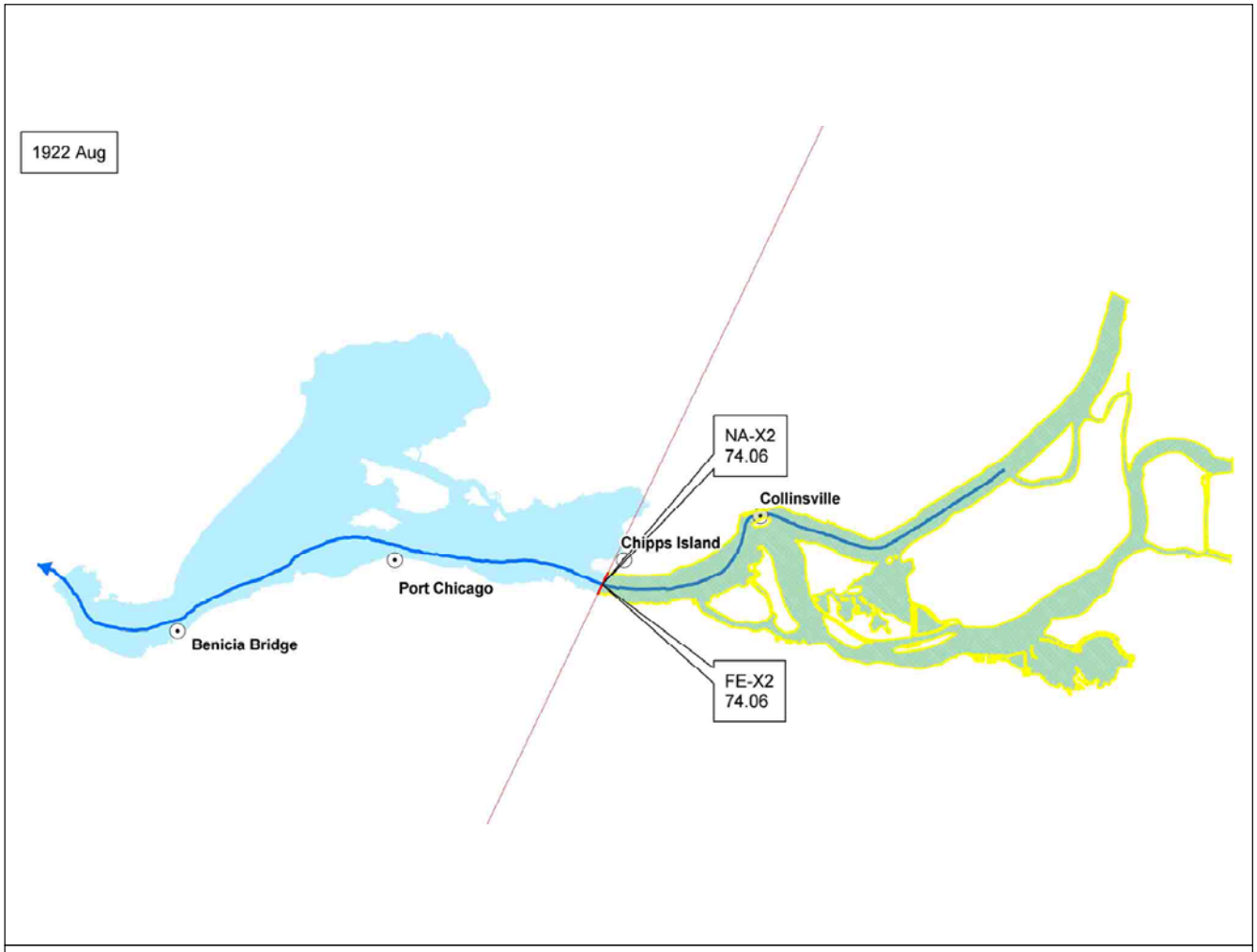

1922 Mar
NA-X2
66.35
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
66.35


1922 Apr
NA-X2
66.25
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
66.25

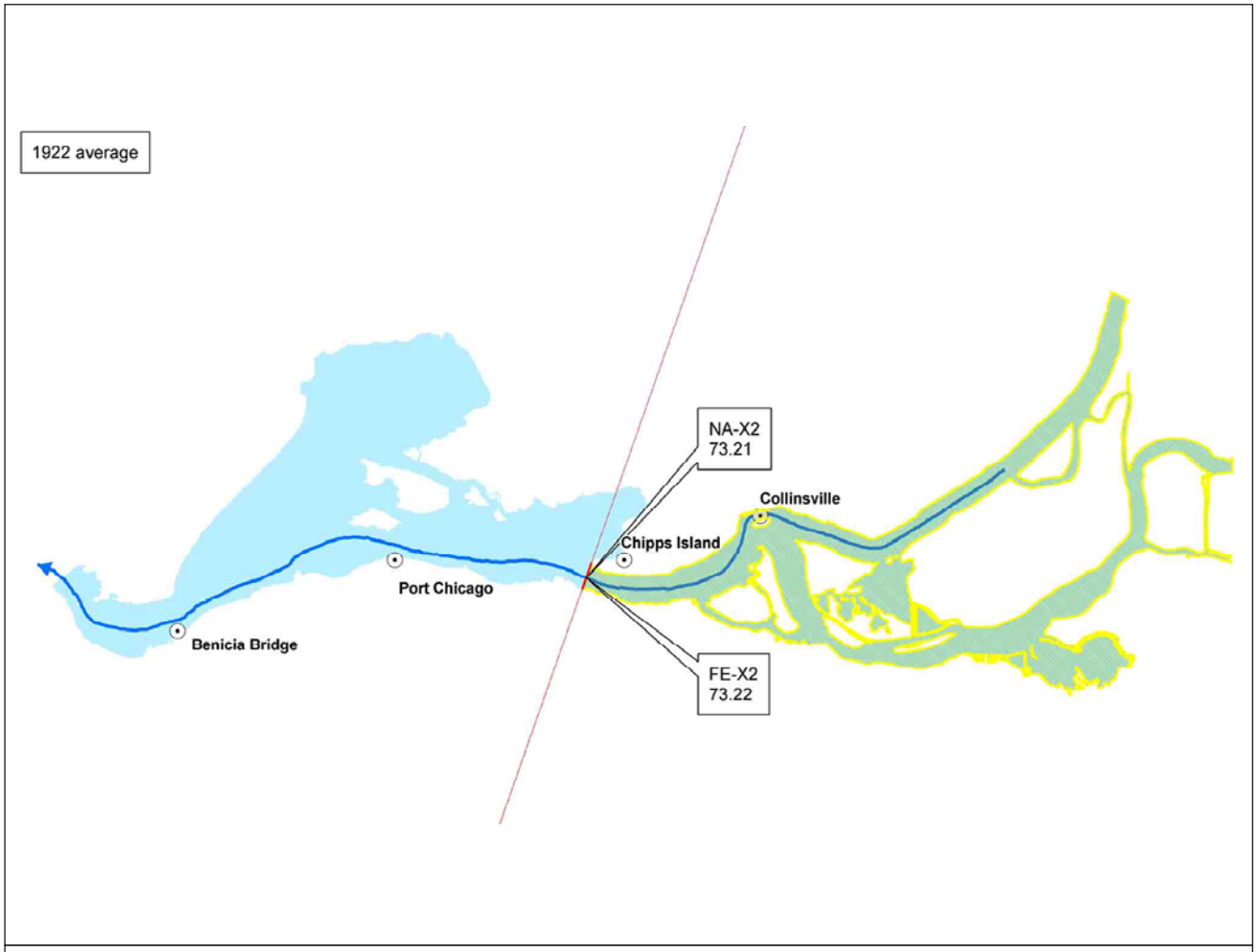

1922 May
NA-X2
66.76
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
66.77

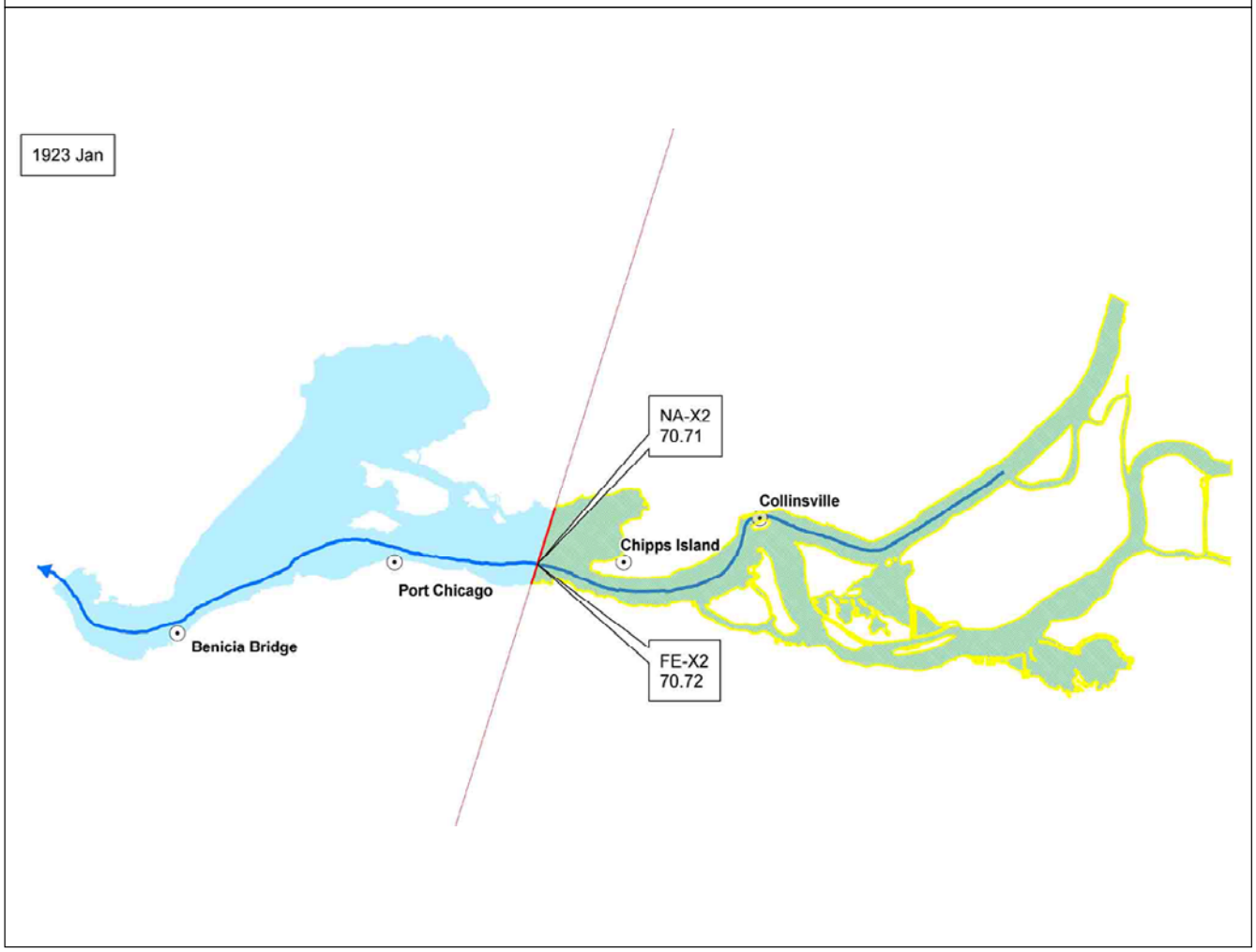

1922 Jun
NA-X2
61.22
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
61.23

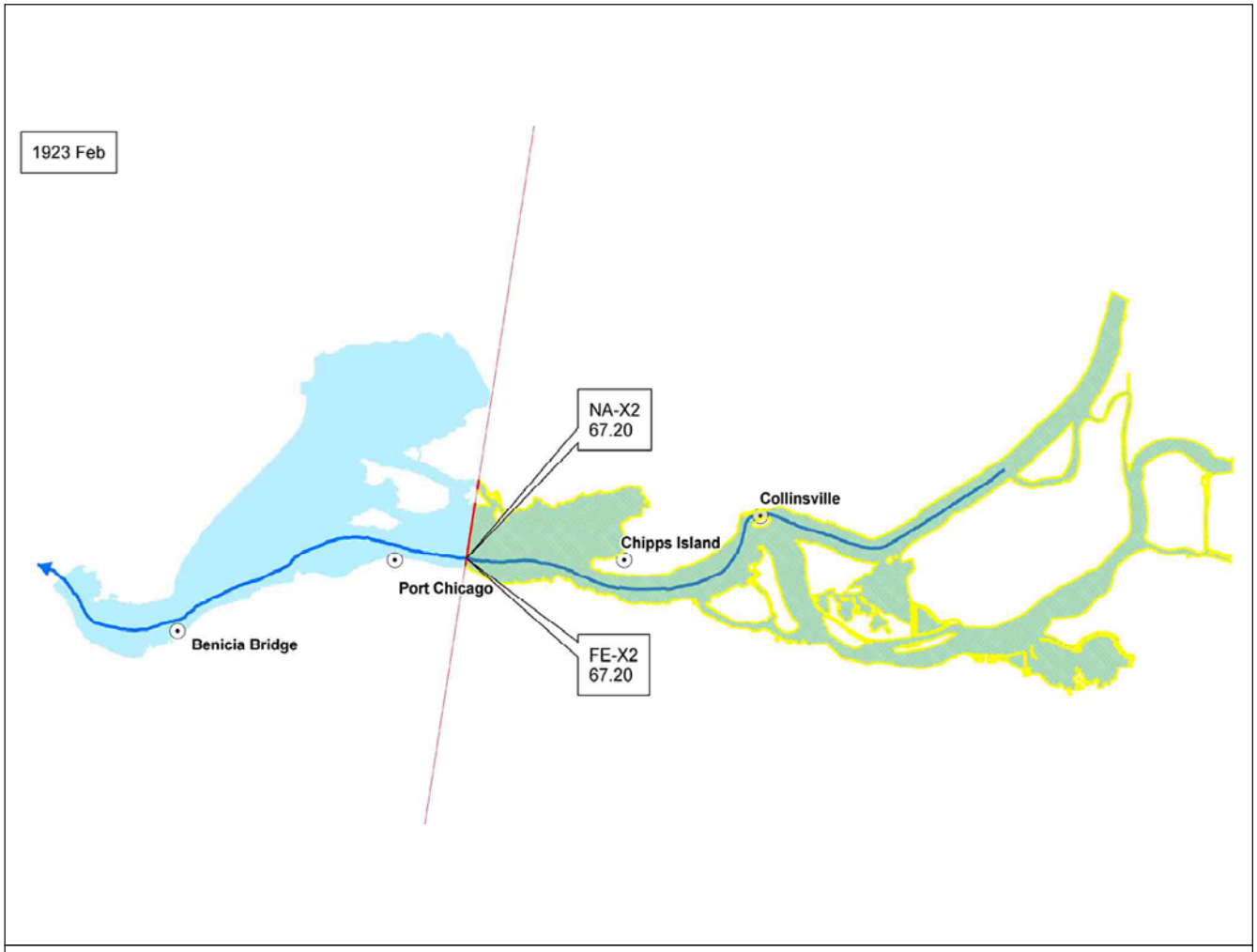

1922 Jul
NA-X2
63.30
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
63.31

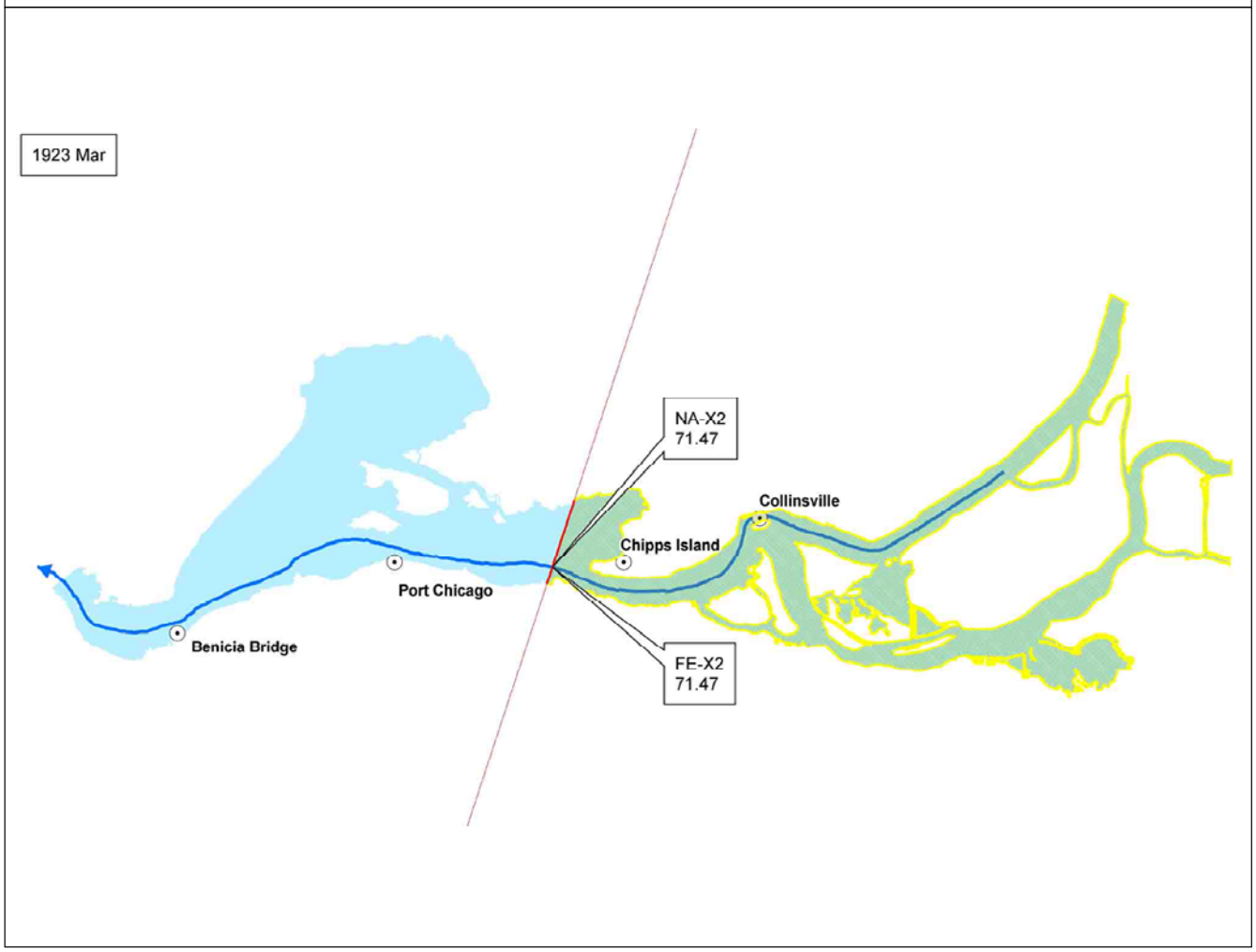

1922 Aug
NA-X2
74.06
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
74.06

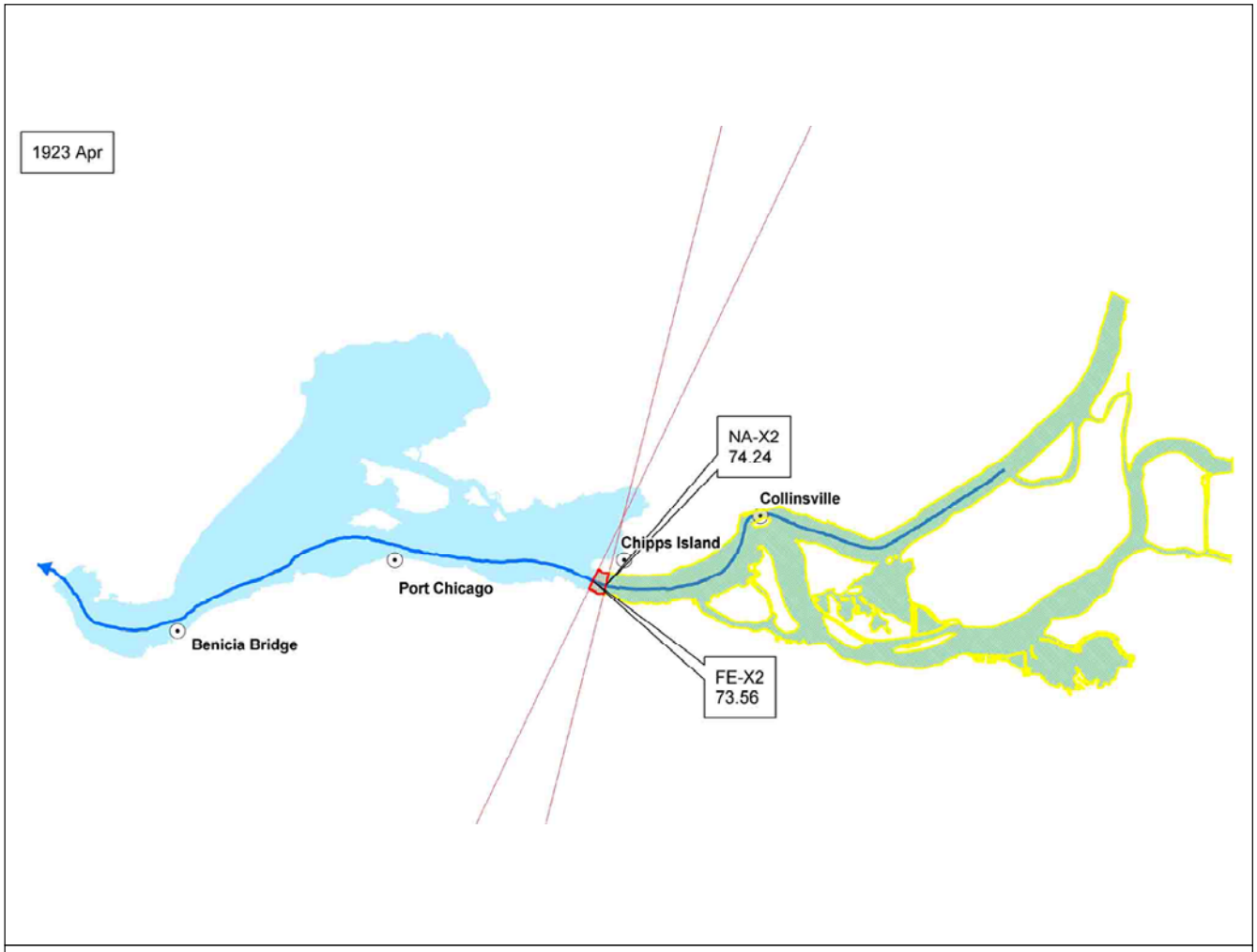

1922 Sep
NA-X2
82.90
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
82.90

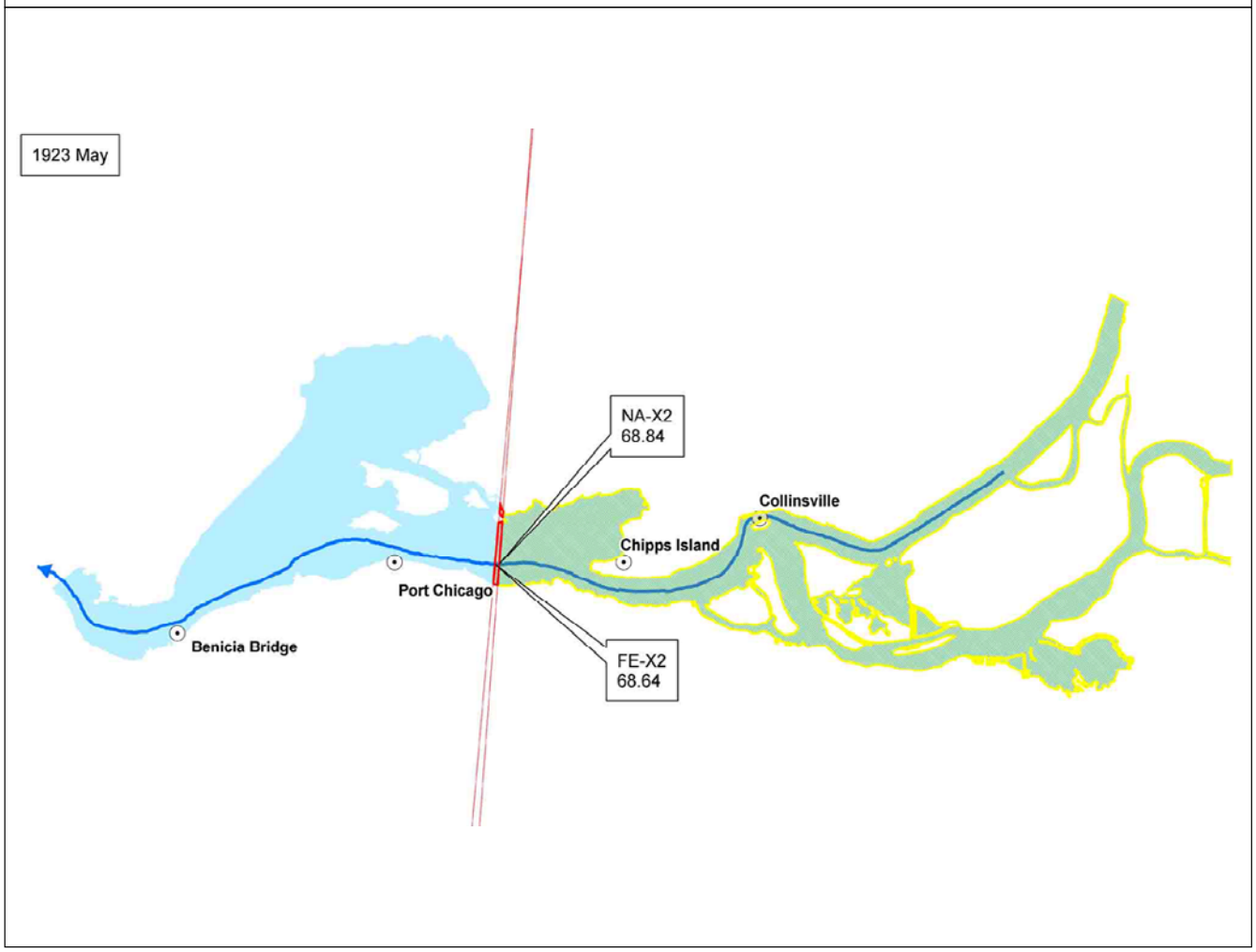

1922 average
NA-X2
73.21
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
73.22


1923 Jan
NA-X2
70.71
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
70.72


1923 Feb
NA-X2
67.20
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
67.20


1923 Mar
NA-X2
71.47
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
71.47


1923 Apr
NA-X2
74.24
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
73.56

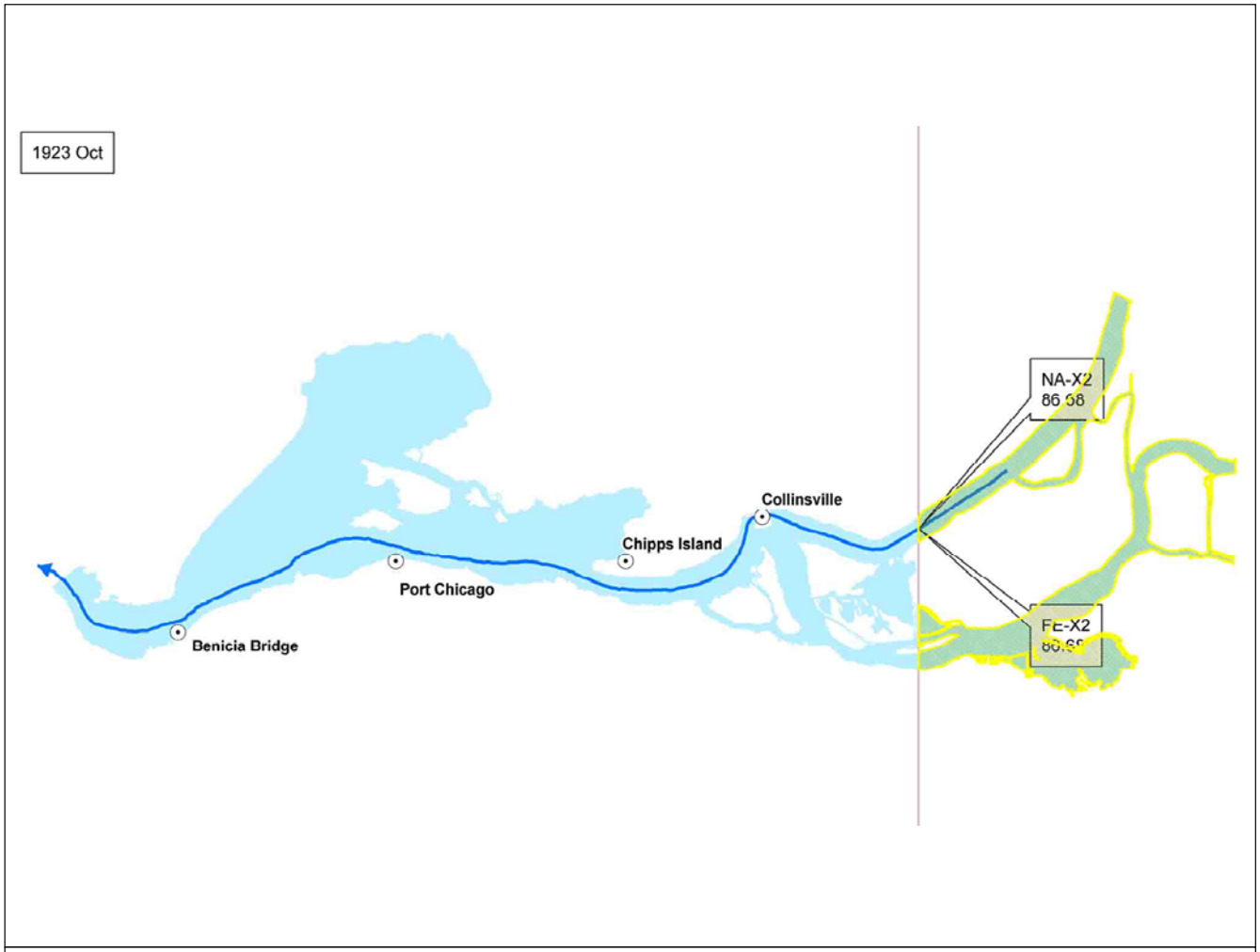

1923 May
NA-X2
68.84
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
68.64

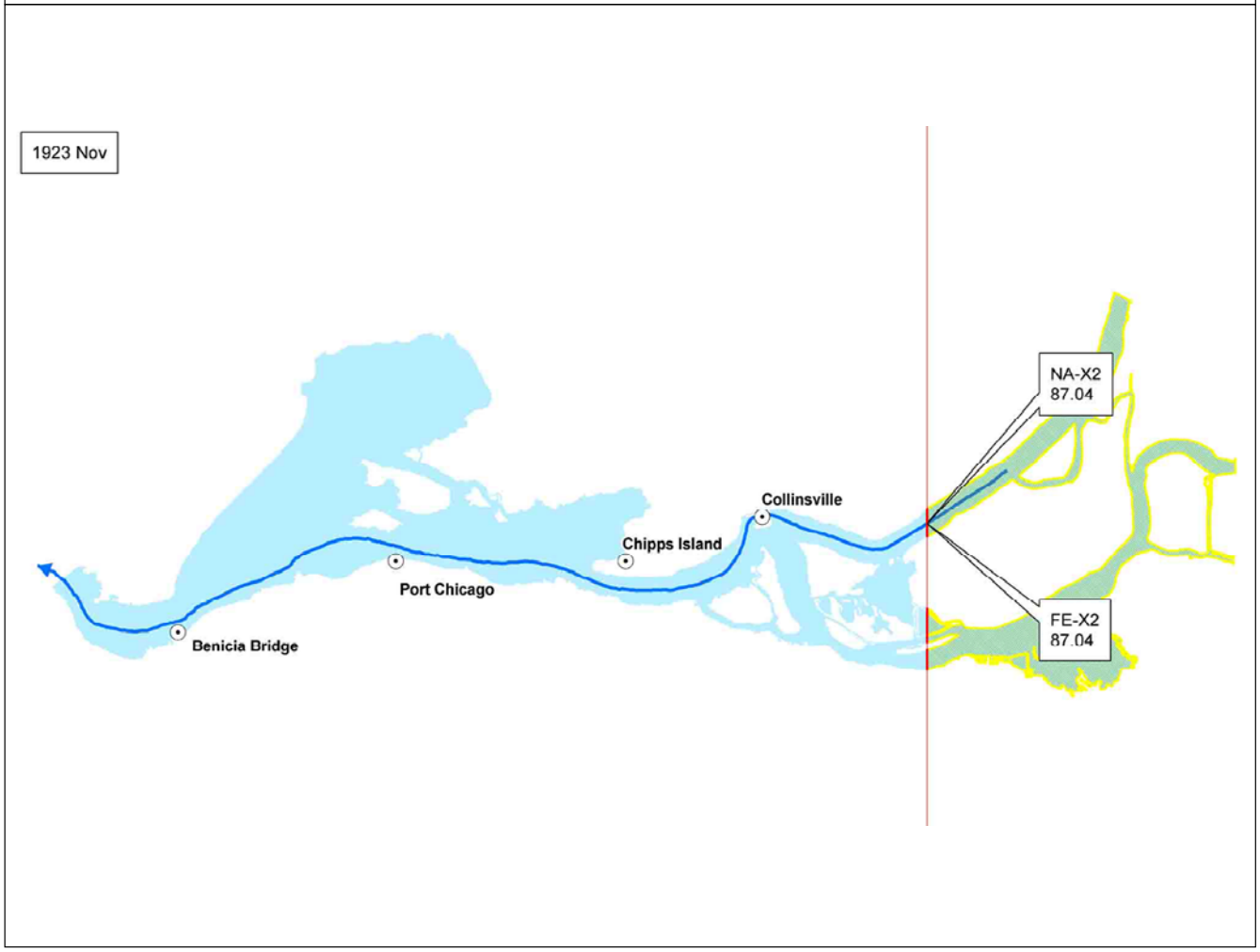

1923 Jun
NA-X2
70.81
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
70.74


1923 Jul
NA-X2
76.22
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
74.94

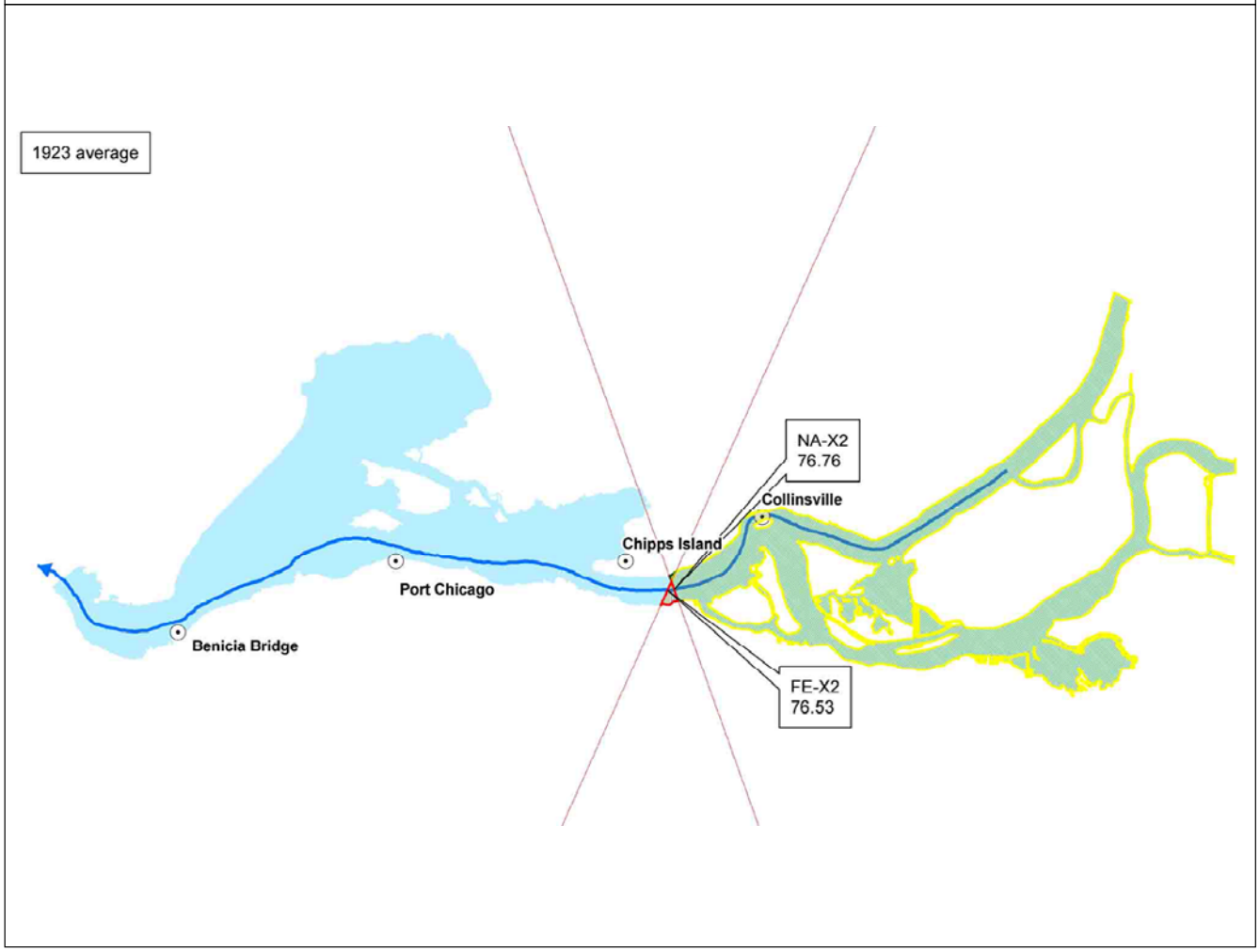

1923 Aug
NA-X2
79.88
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
79.46

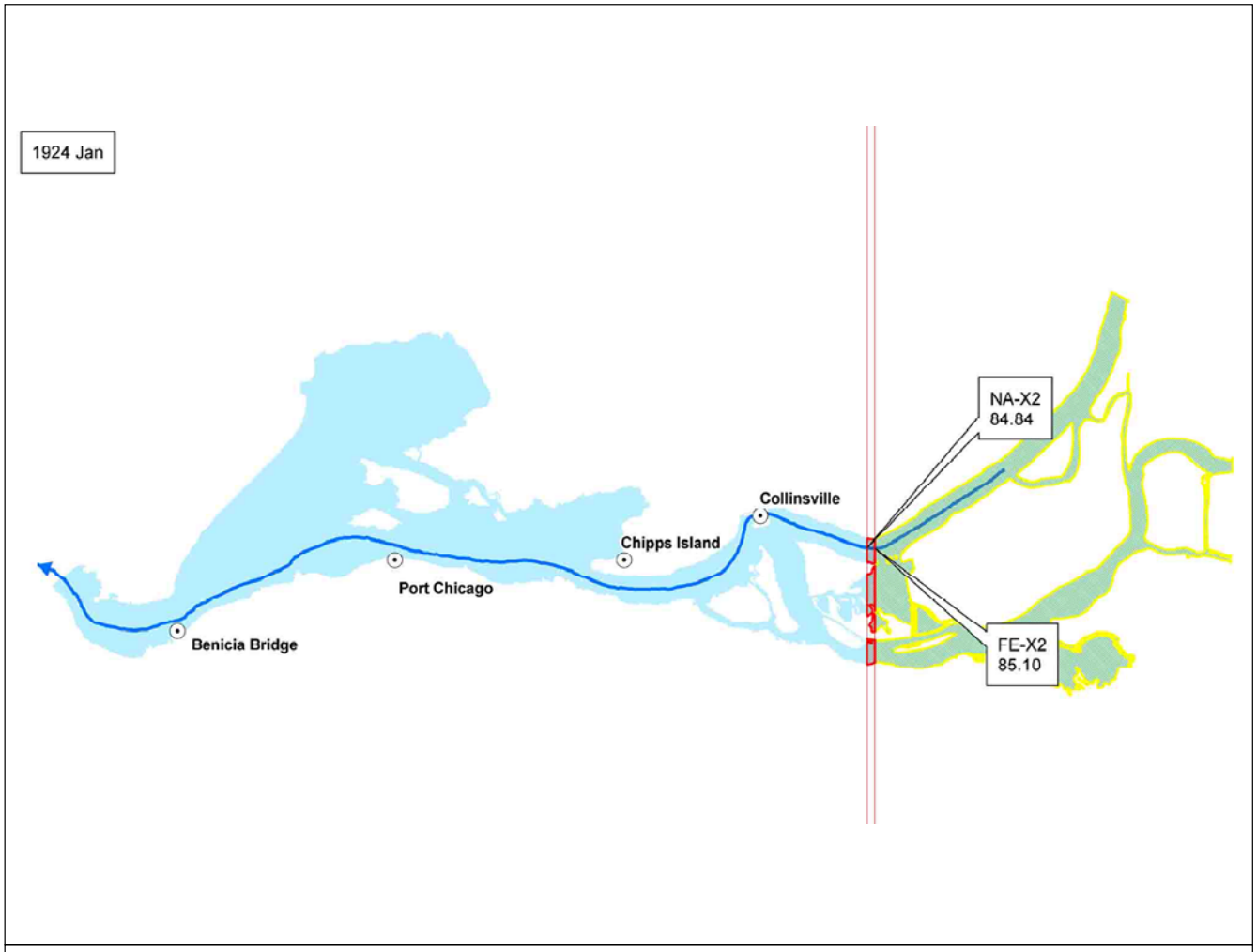

1923 Sep
NA-X2
84.81
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
84.67

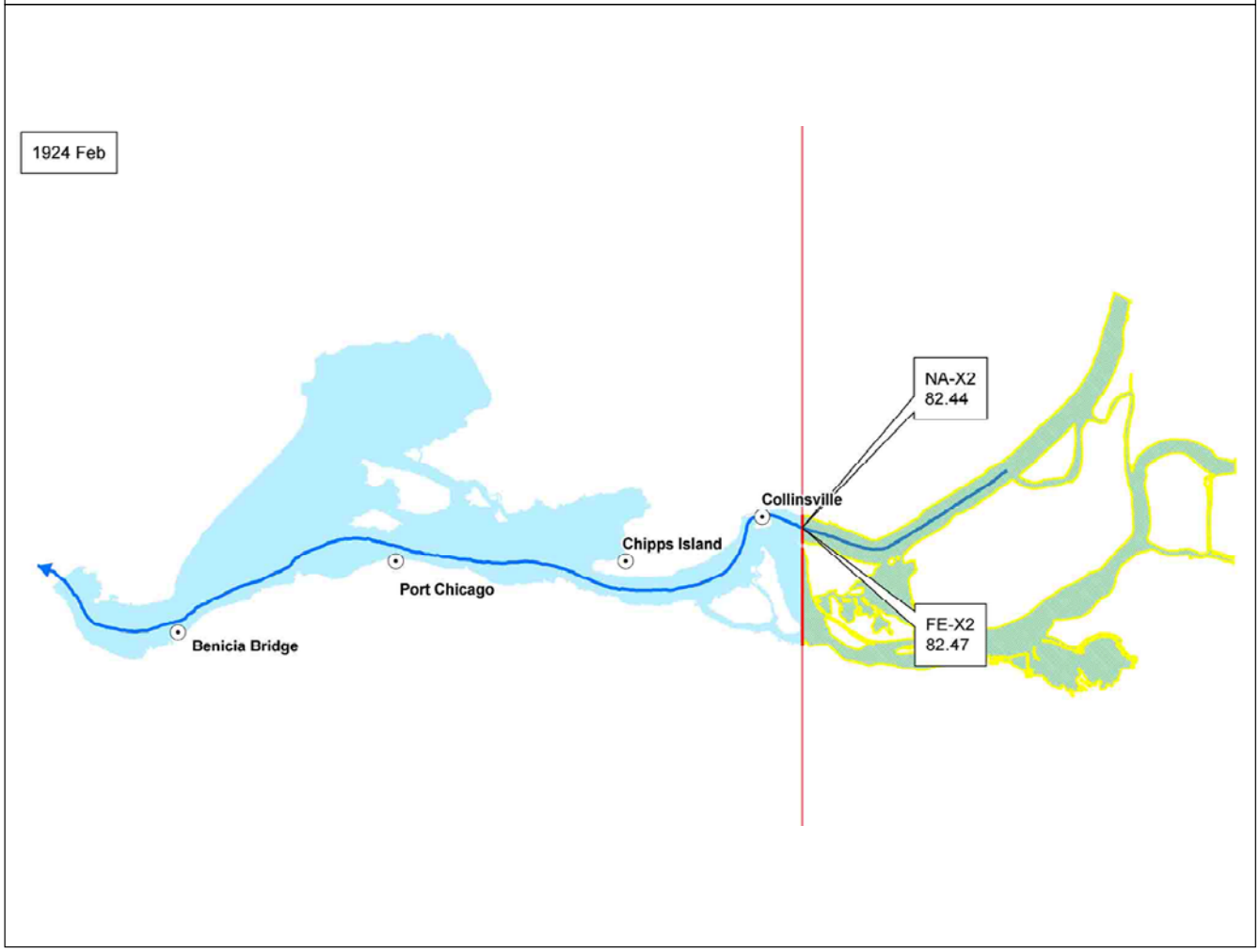

1923 Oct
NA-X2
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2


1923 Nov
NA-X2
87.04
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
87.04


1923 Dec
NA-X2
83.22
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
83.23


1923 average
NA-X2
76.76
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
76.53

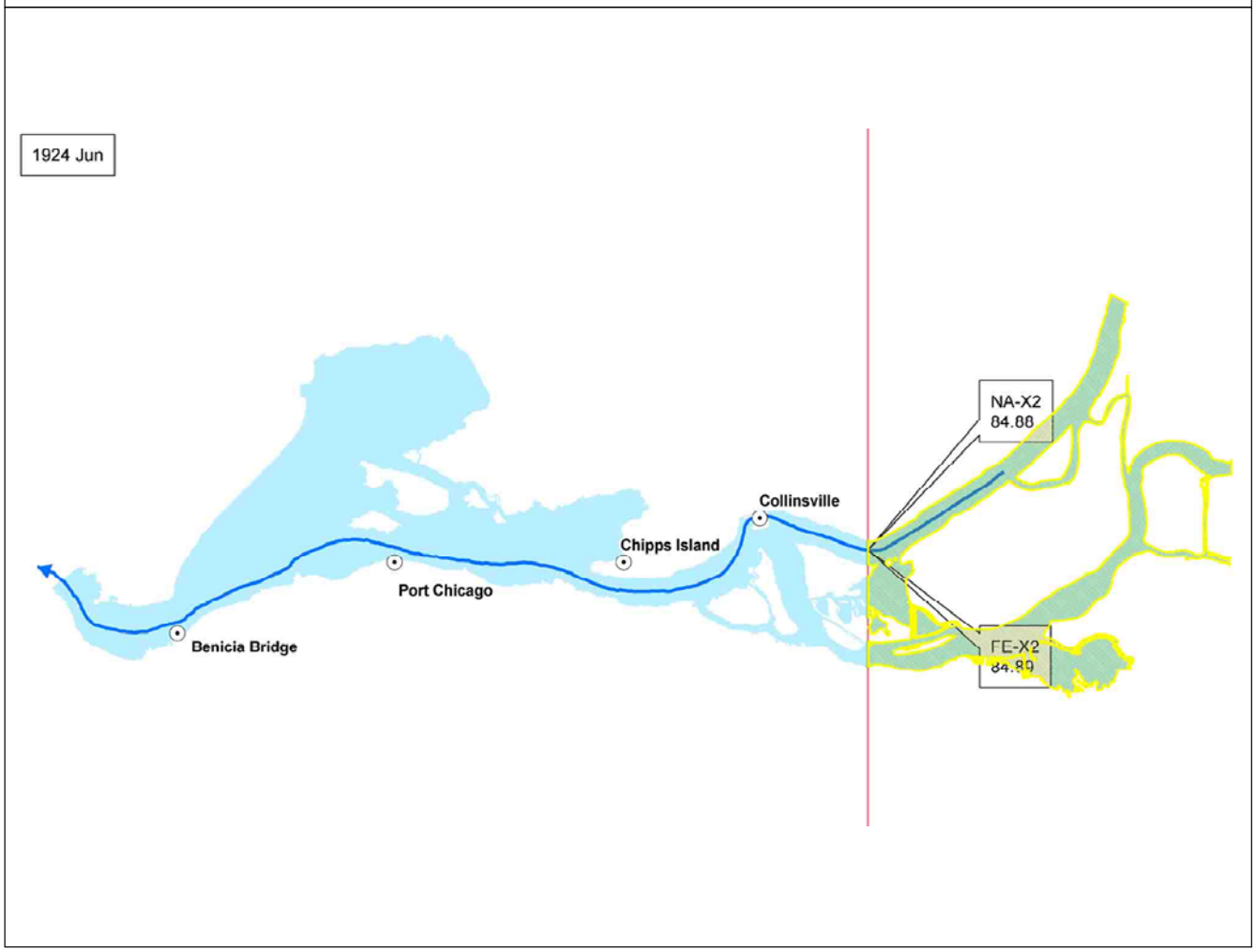

1924 Jan
NA-X2
84.84
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
85.10

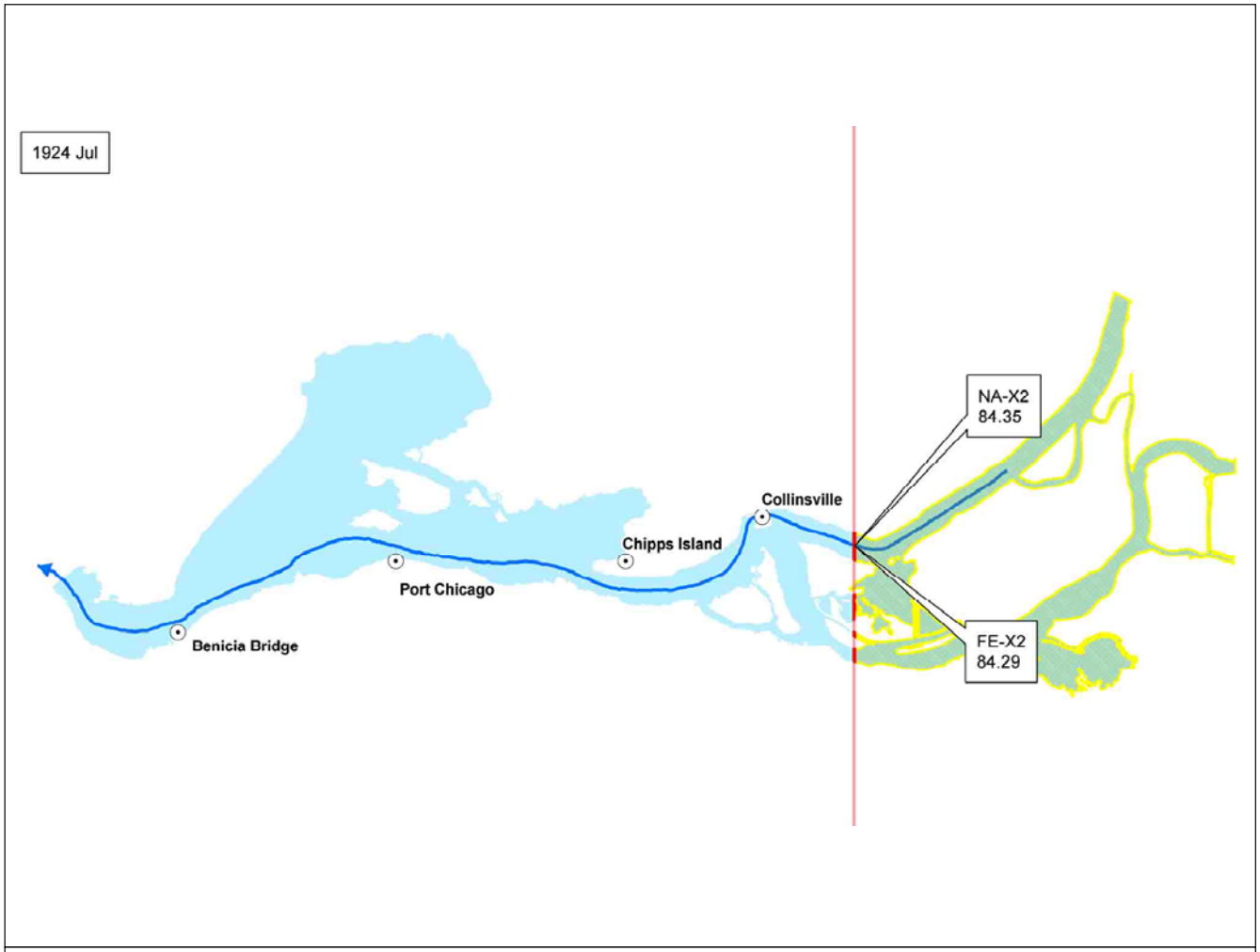

1924 Feb
NA-X2
82.44
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
82.47


1924 Mar
NA-X2
78.01
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
77.69

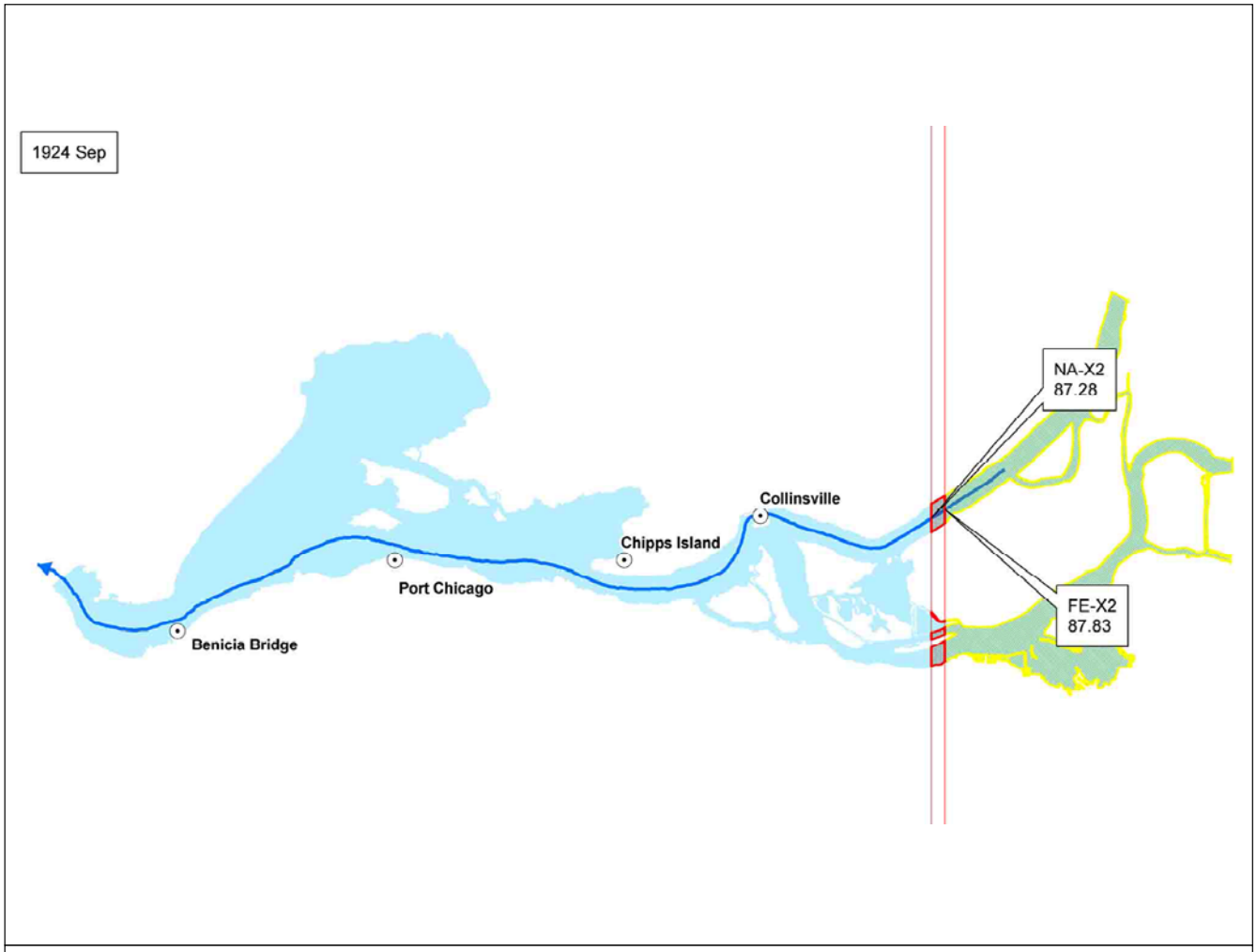

1924 Apr
NA-X2
77.10
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
77.00


1924 May
NA-X2
80.28
Collinsville
Chipps Island
Port Chicago
Benicia Bridge

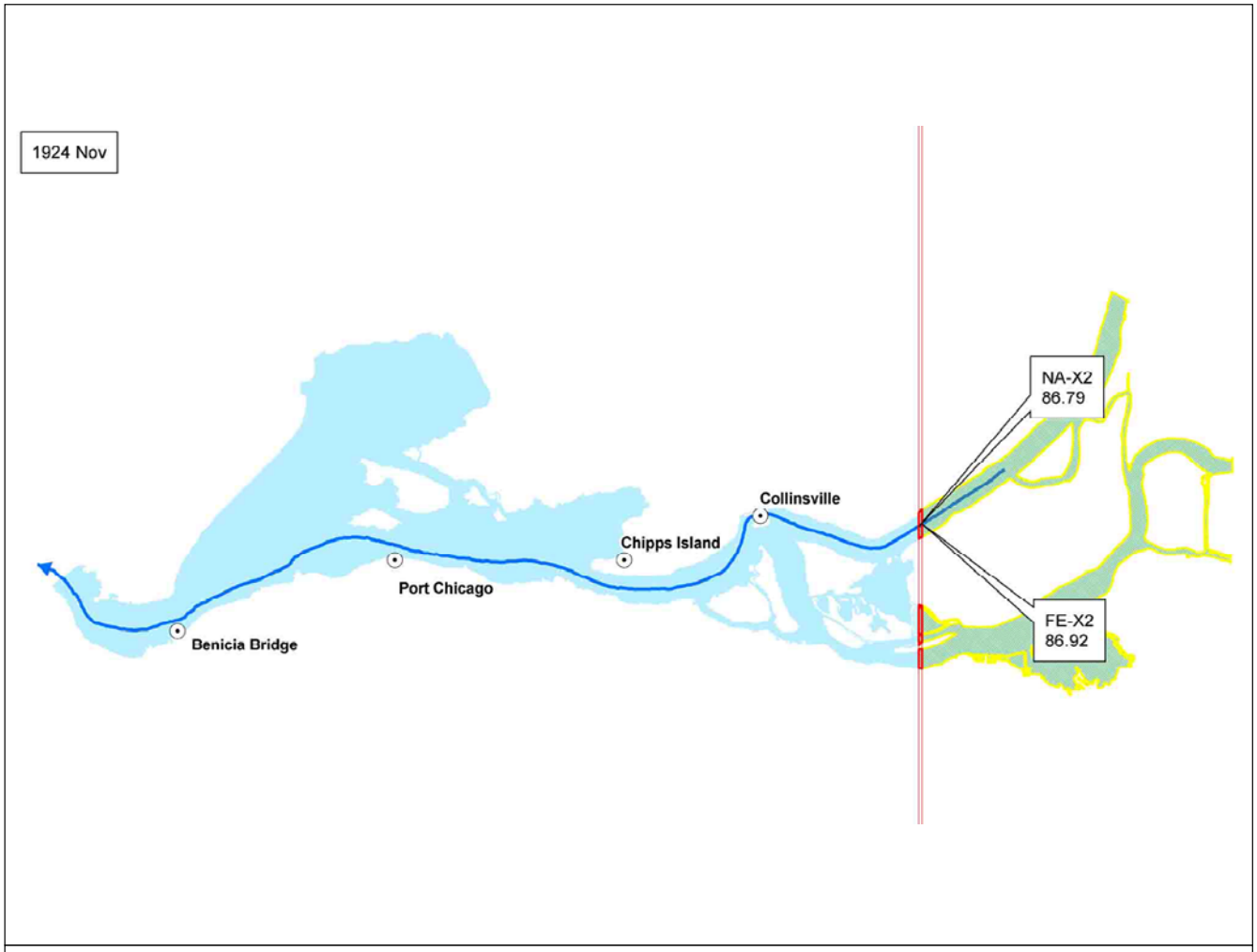

1924 Jun
NA-X2
84.88
Collinsville
Chipps Island
Port Chicago
Benicia Bridge


1924 Jul
NA-X2
84.35
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
84.29


1924 Aug
NA-X2
82.33
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
82.40

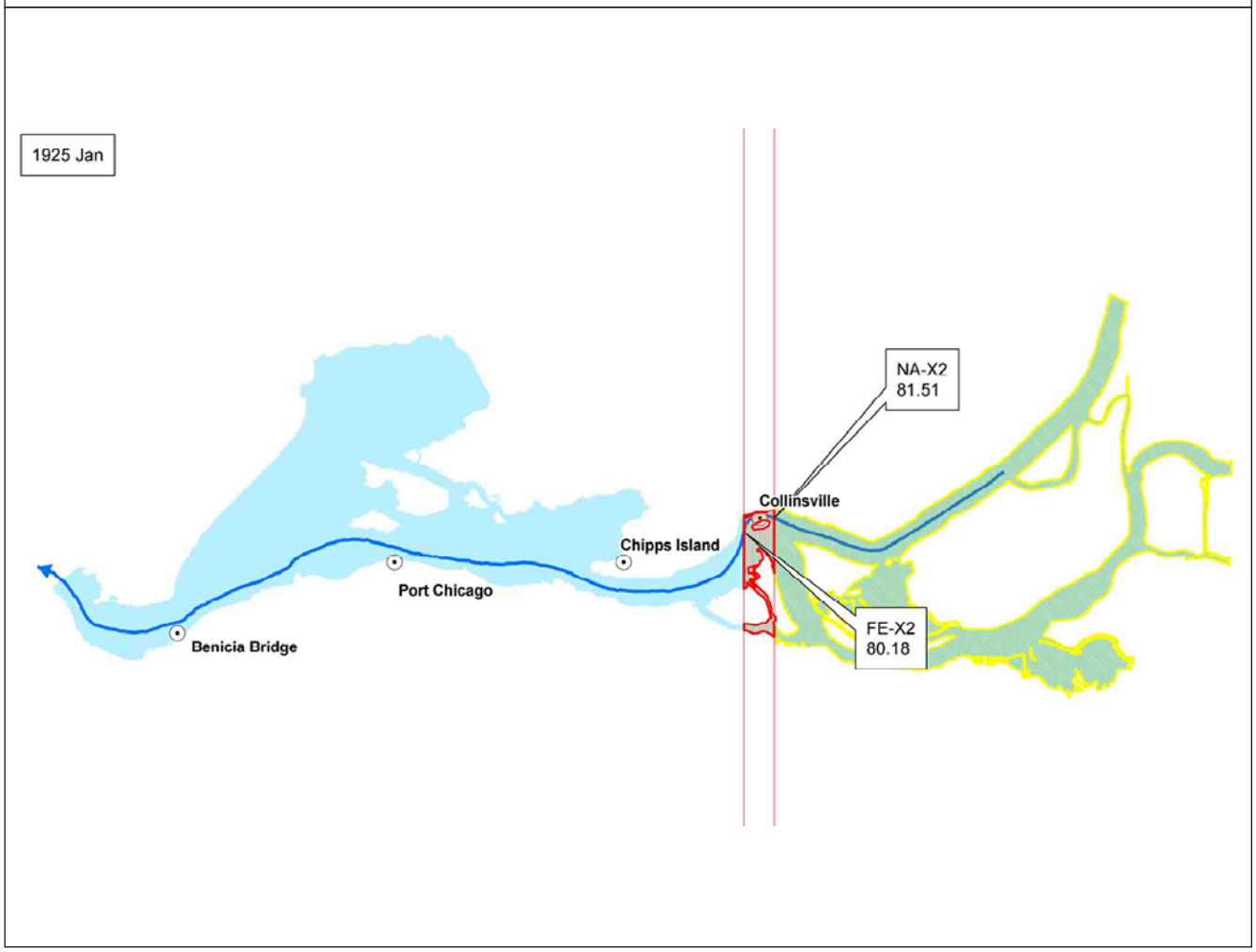

1924 Sep
NA-X2
87.28
Collinsville
Chipps Island
Port Chicago
FE-X2
87.83
Benicia Bridge


1924 Oct
NA-X2
85.93
Collinsville
Chipps Island
Port Chicago
FE-X2
86.34
Benicia Bridge

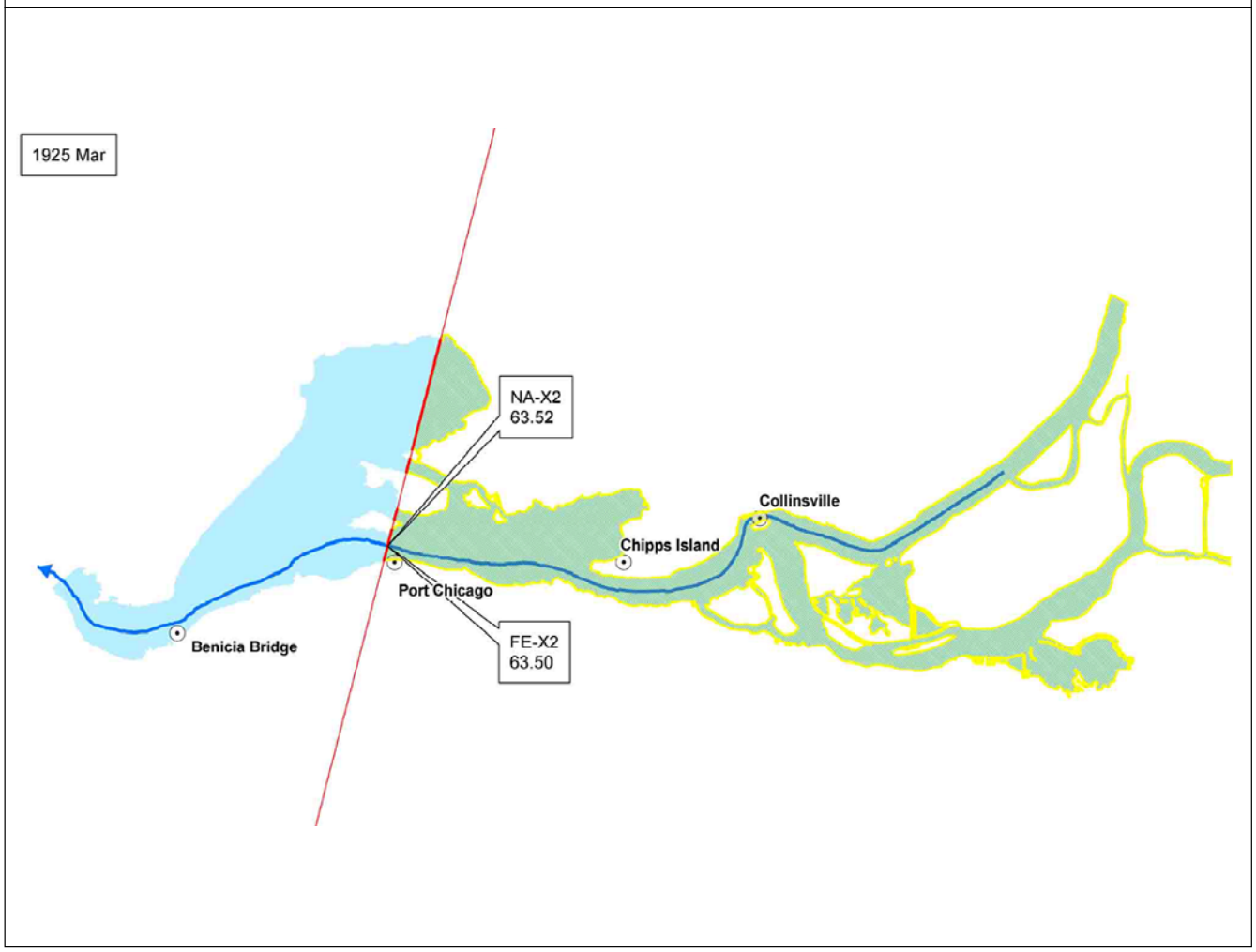

1924 Nov
NA-X2
86.79
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
86.92

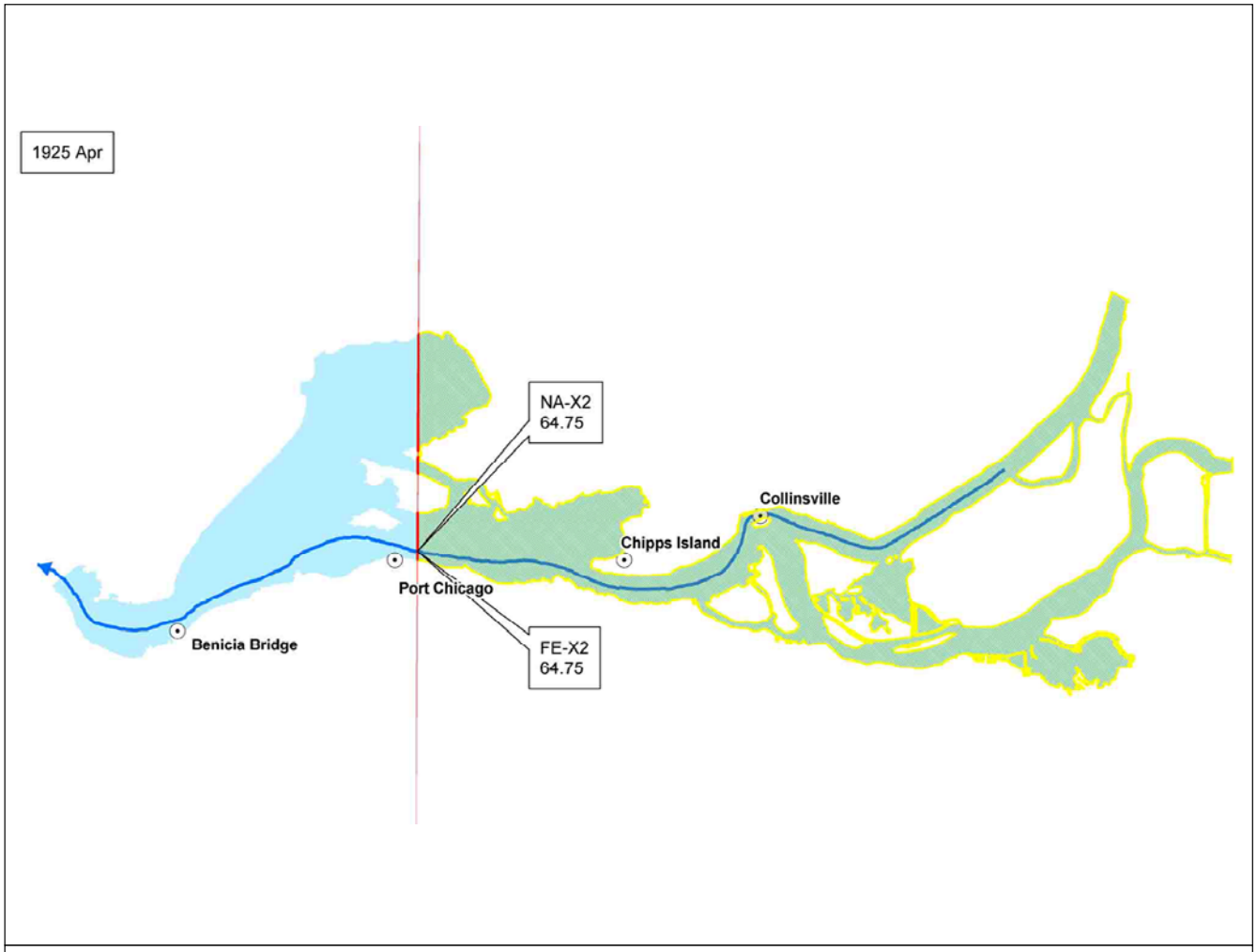

1924 Dec
NA-X2
82.73
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
83.54

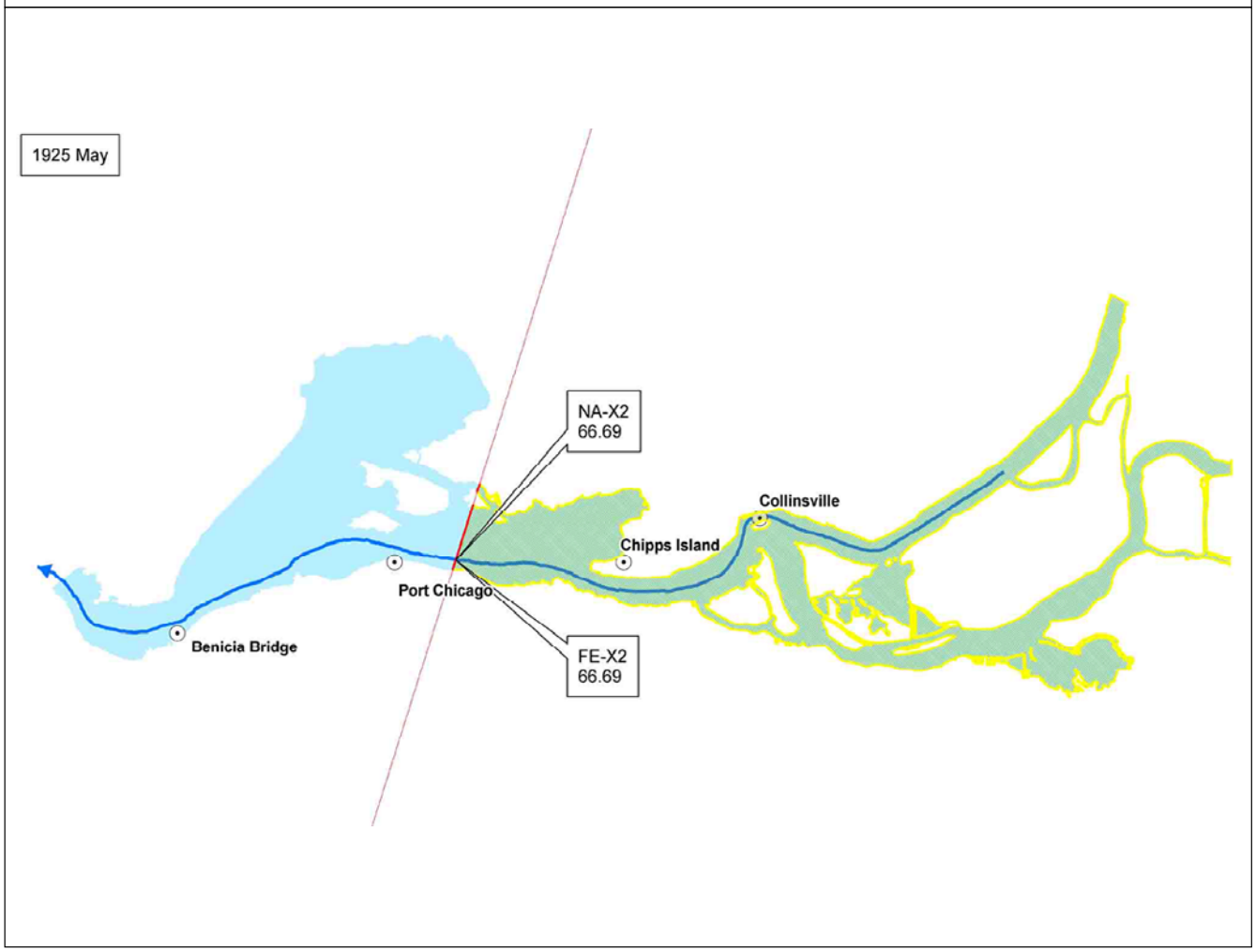

1924 average
NA-X2
83.08
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
83.23

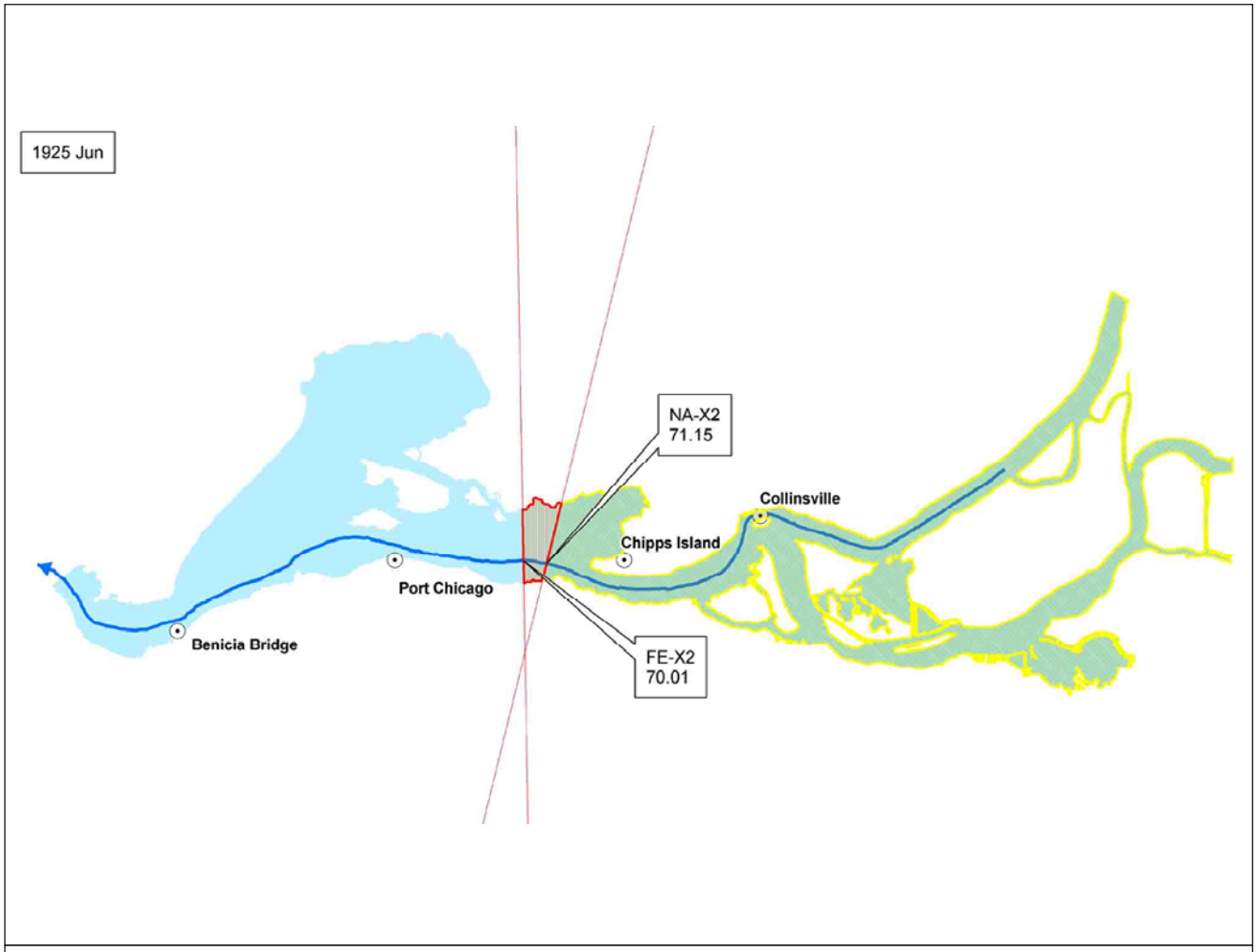

1925 Jan
NA-X2
81.51
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
80.18

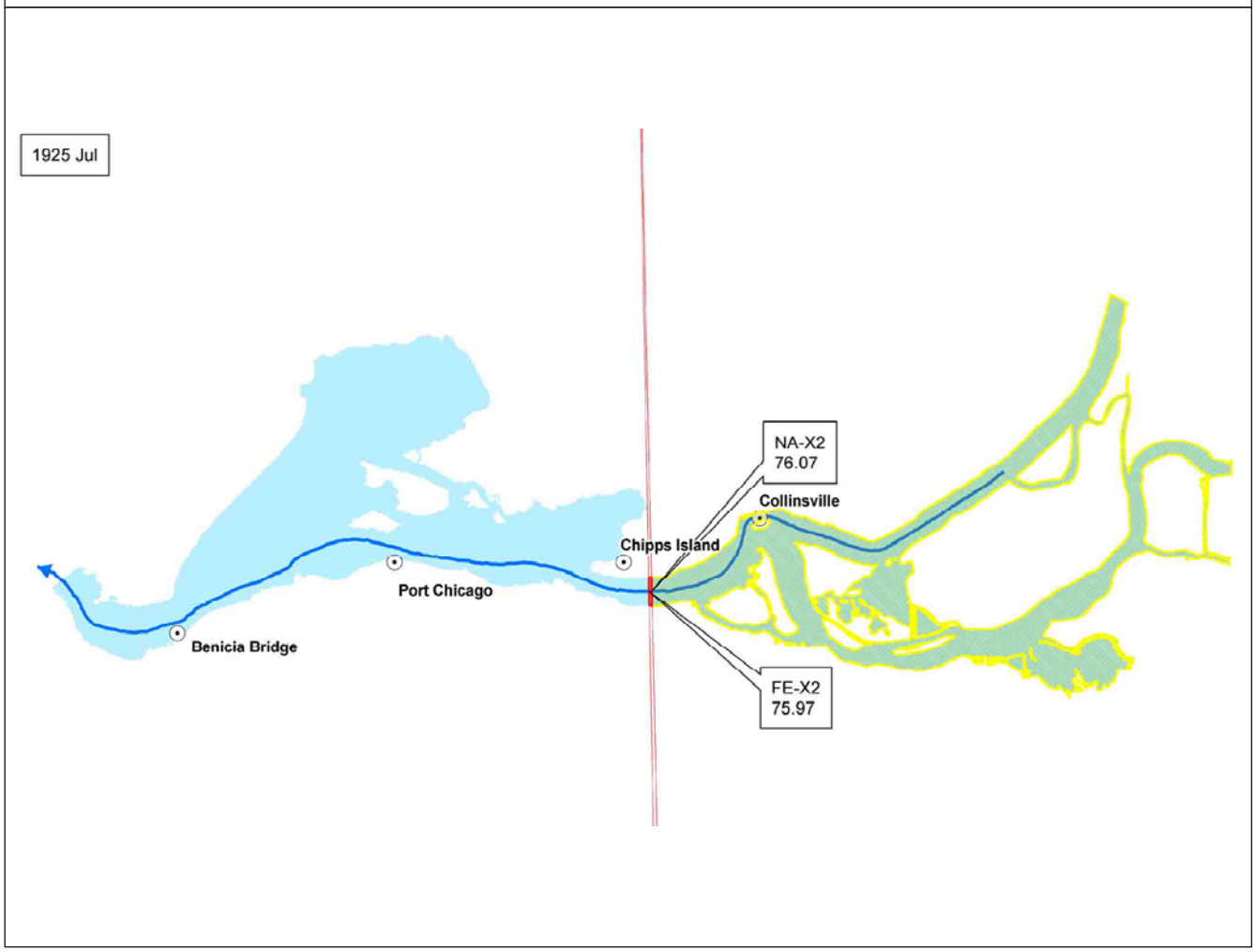

1925 Feb
NA-X2
80.79
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
80.36


1925 Mar
NA-X2
63.52
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
63.50


1925 Apr
NA-X2
64.75
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
64.75


1925 May
NA-X2
66.69
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
66.69

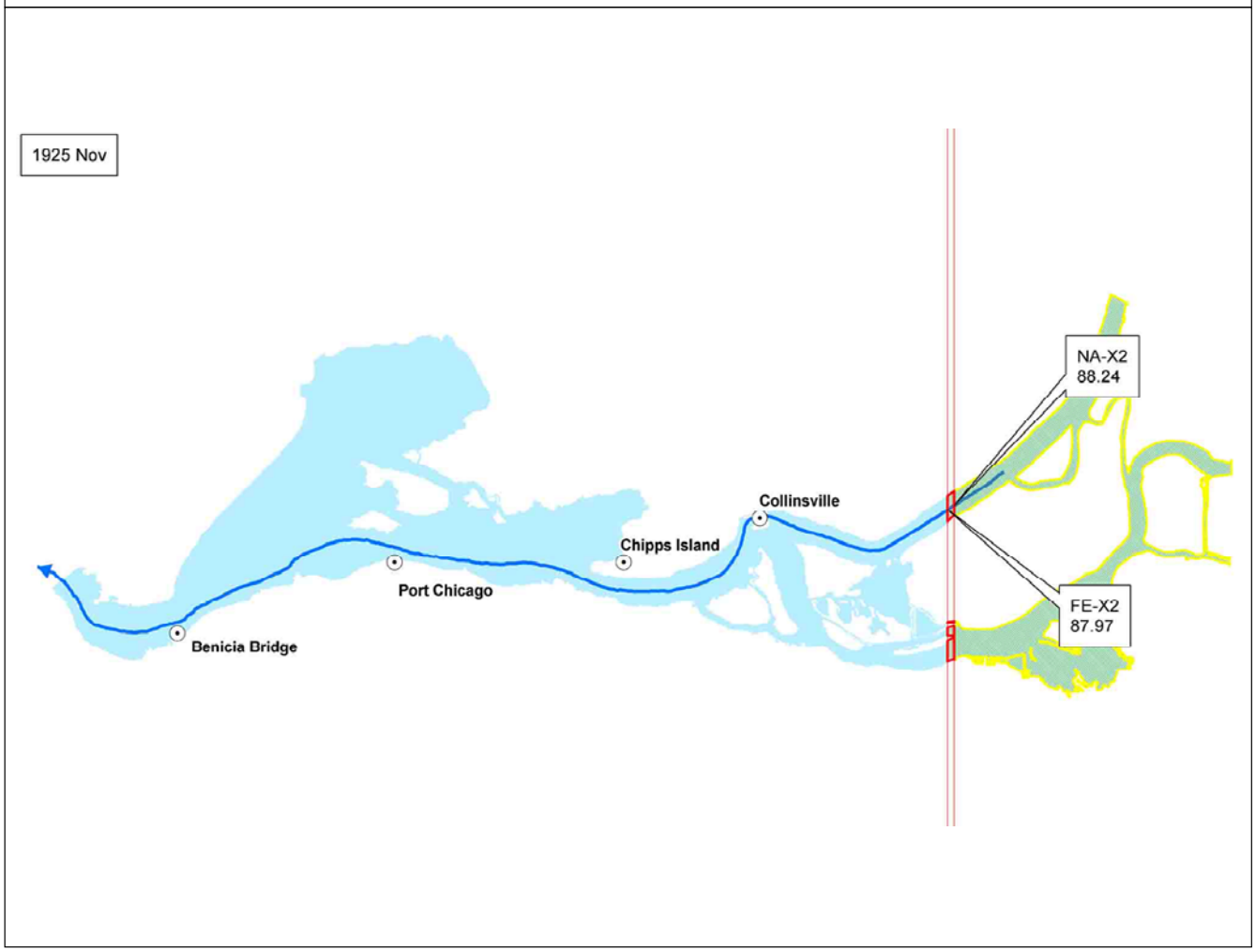

1925 Jun
NA-X2
71.15
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
70.01


1925 Jul
NA-X2
76.07
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
75.97


1925 Aug
NA-X2
81.85
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
81.81


1925 Sep
NA-X2
84.69
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
85.77

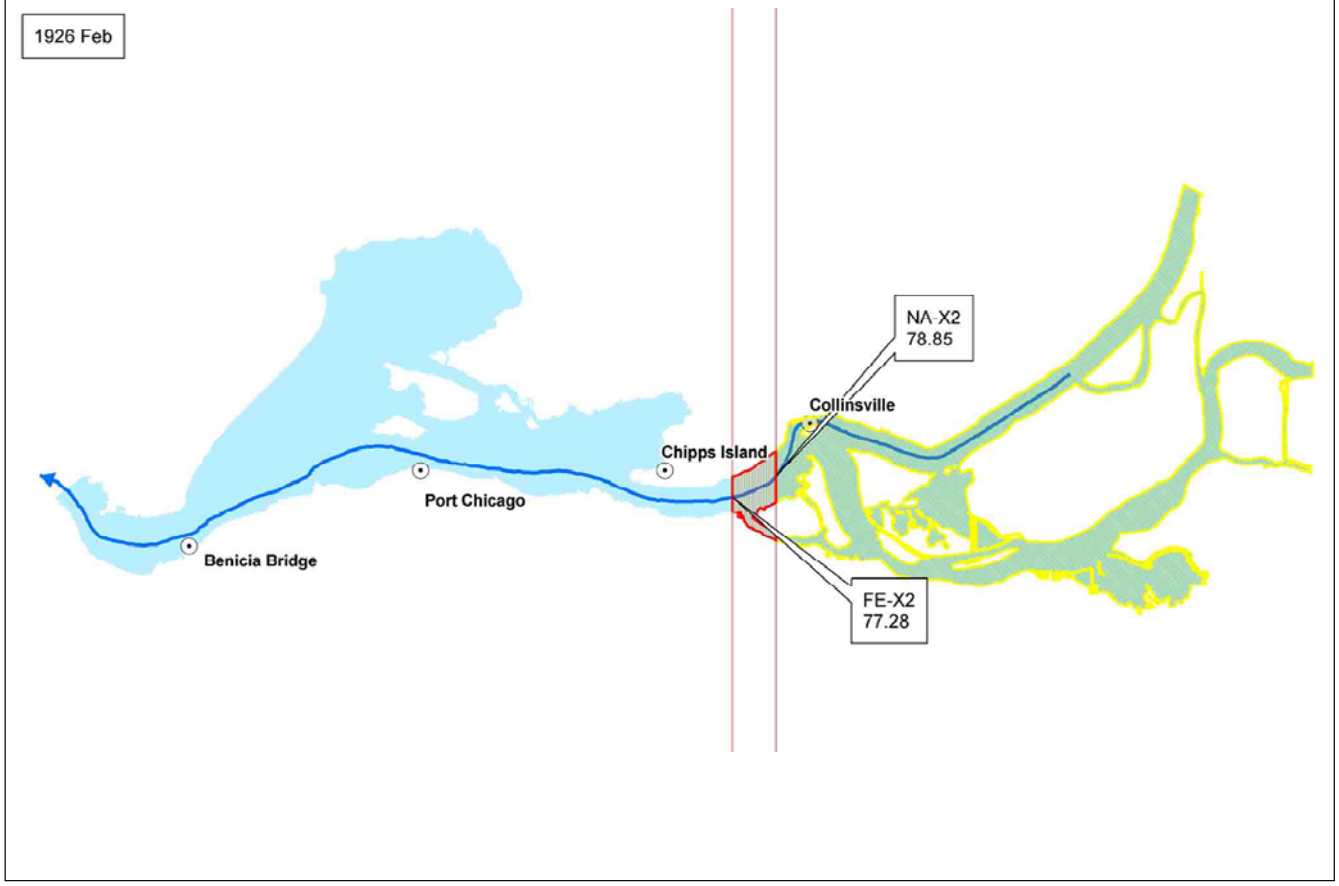

1925 Oct
NA-X2
89.44
Collinsville
Chipps Island
Port Chicago
FE-X2
89.62
Benicia Bridge


1925 Nov
NA-X2
88.24
Collinsville
Chipps Island
Port Chicago
FE-X2
87.97
Benicia Bridge

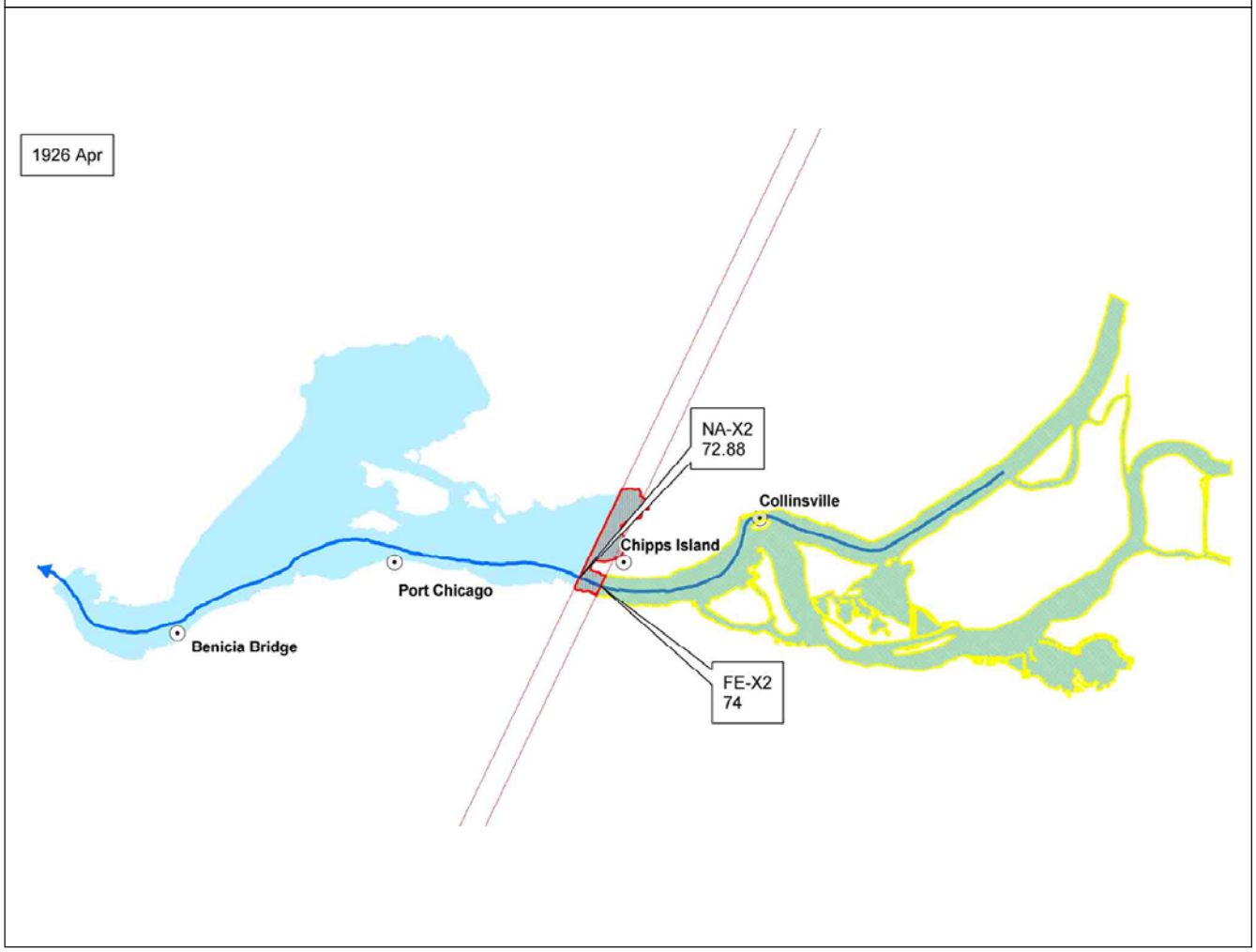

1925 Dec
NA-X2
85.73
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
85.78

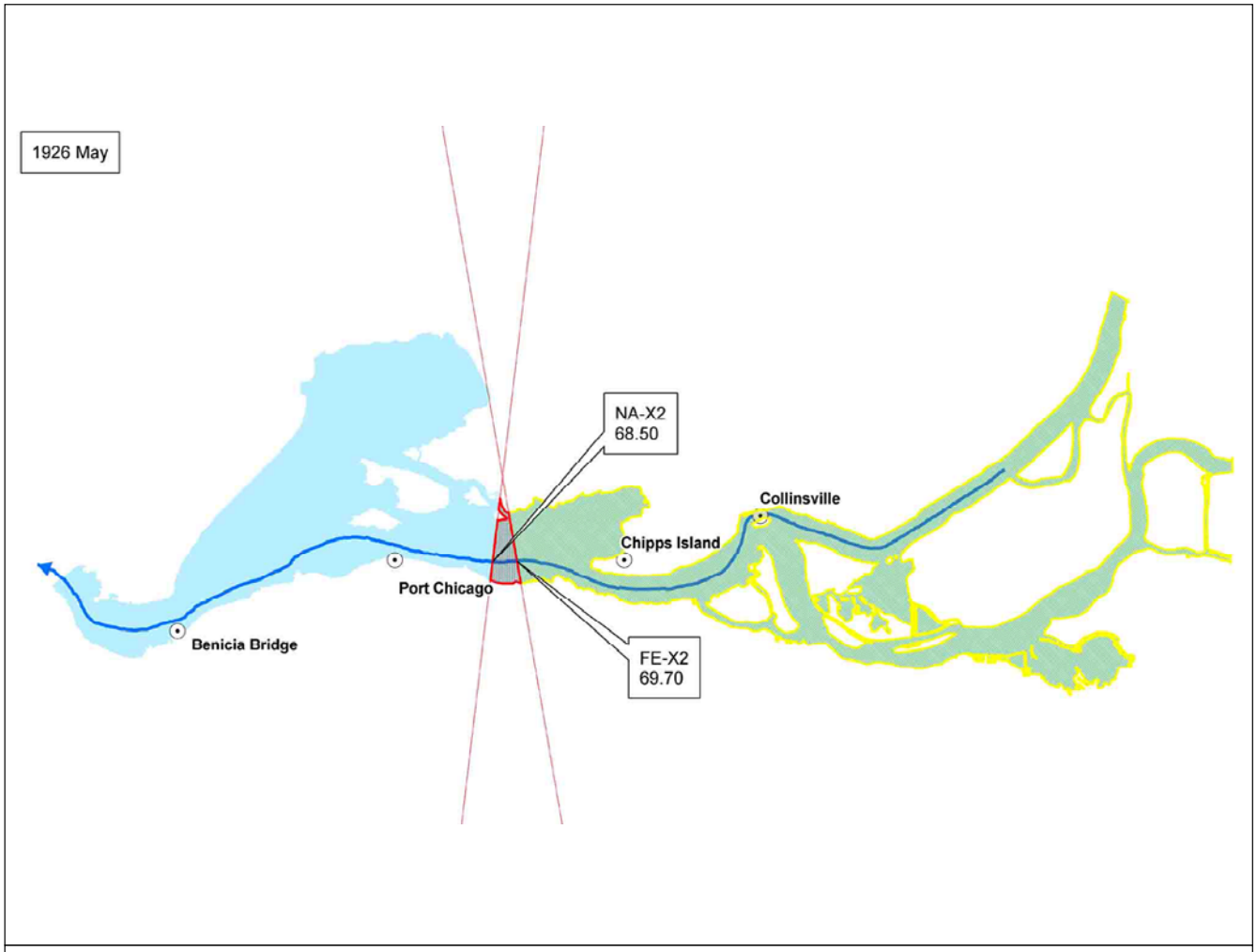

1925 average
NA-X2
77.87
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
77.70

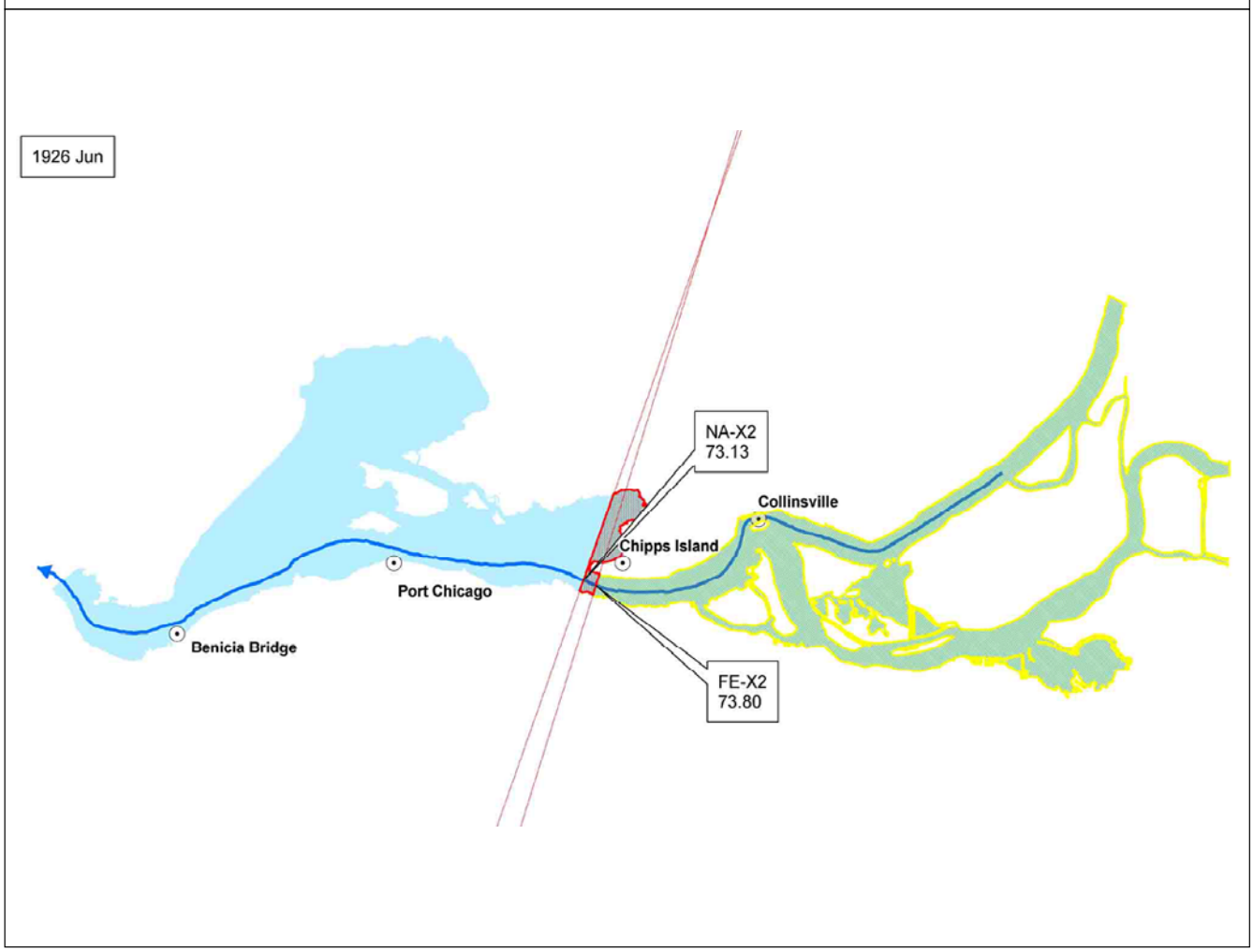

1926 Jan
NA-X2
84.56
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2

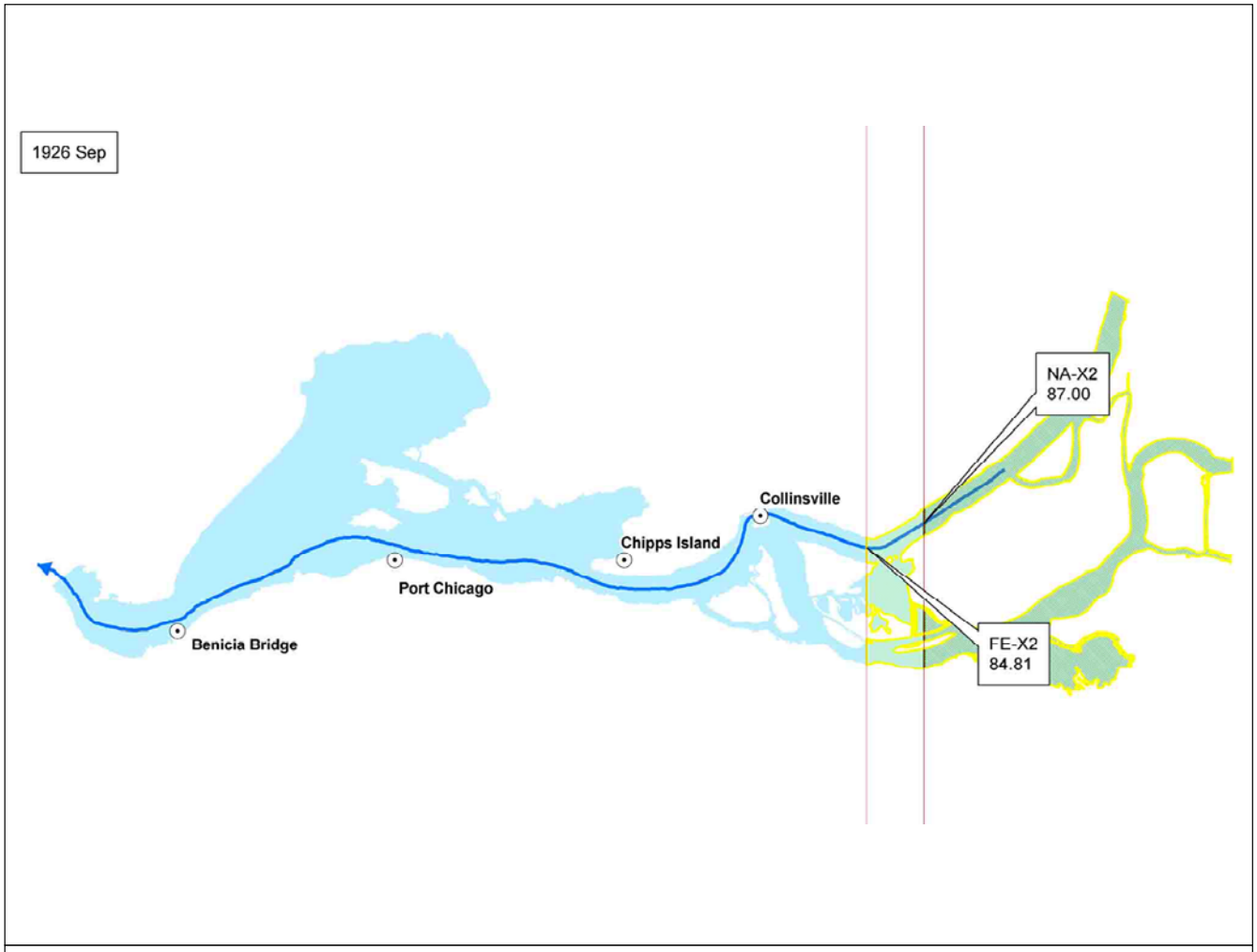

1926 Feb
NA-X2
78.85
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
77.28

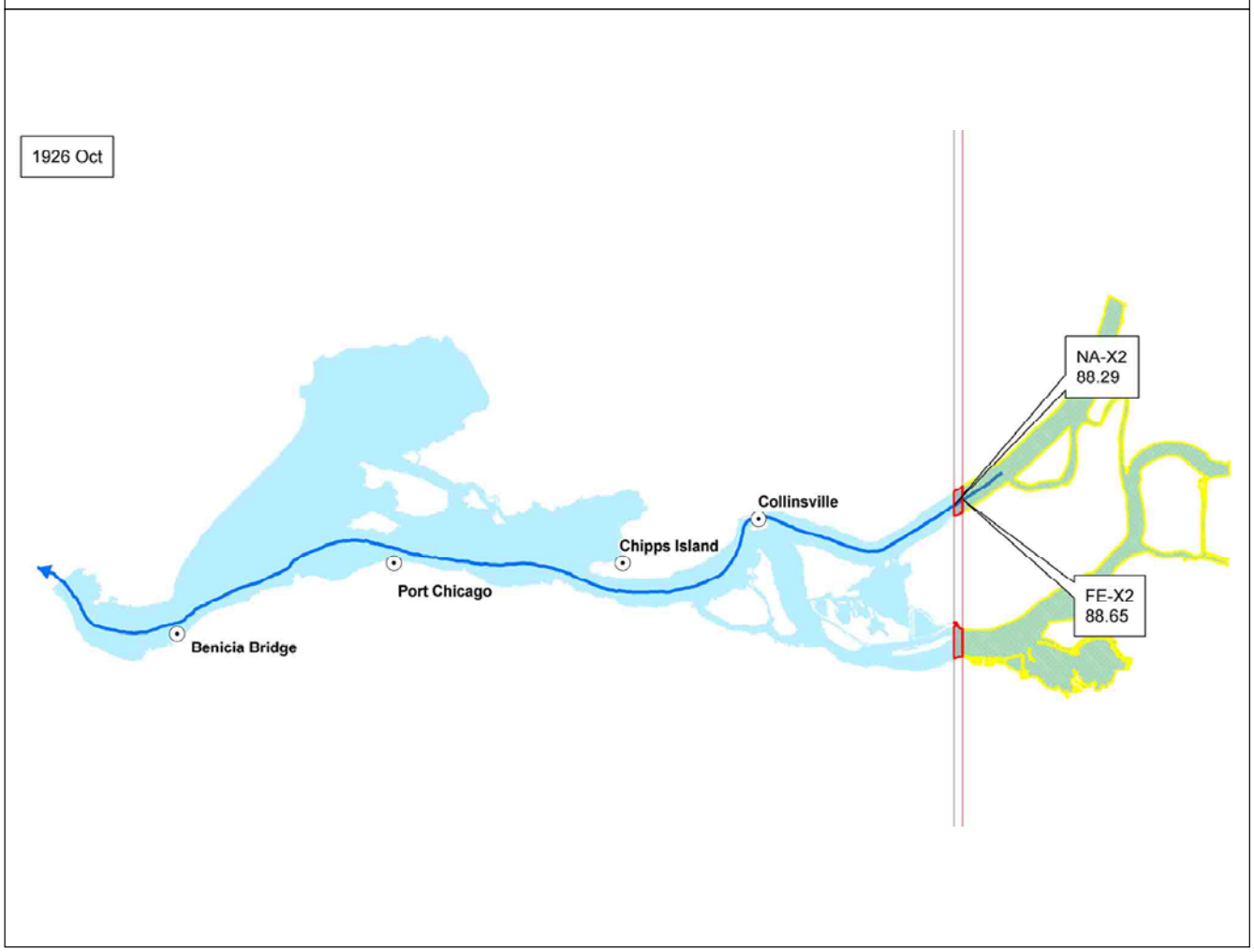

1926 Mar
NA-X2
67.04
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
66.54

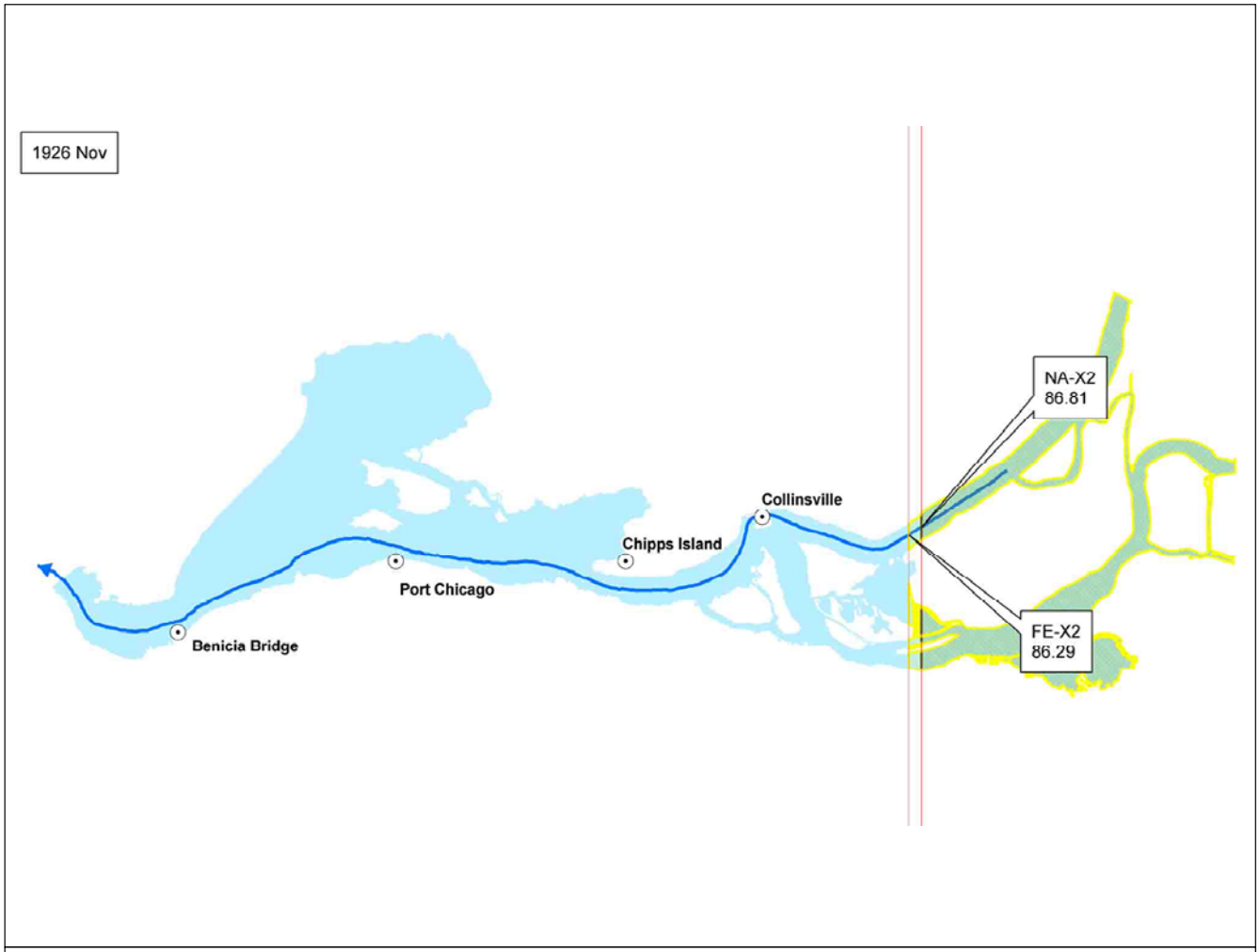

1926 Apr
NA-X2
72.88
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
74


1926 May
NA-X2
68.50
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
69.70


1926 Jun
NA-X2
73.13
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
73.80

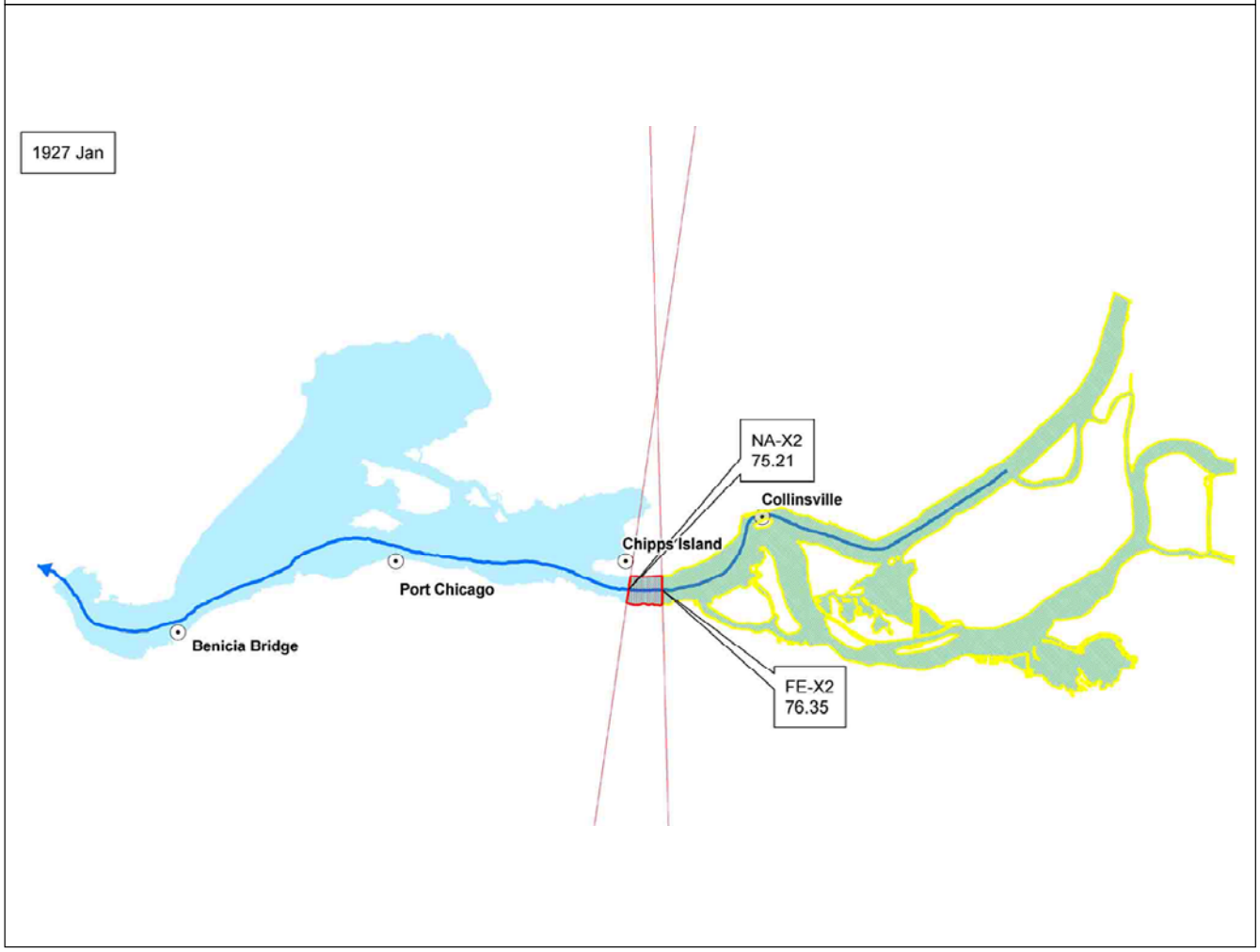

1926 Sep
NA-X2
87.00
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
84.81


1926 Oct
NA-X2
88.29
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
88.65


1926 Nov
NA-X2
86.81
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
86.29


1926 Dec
NA-X2
85.88
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
86.00


1926 average
NA-X2
79.78
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
79.67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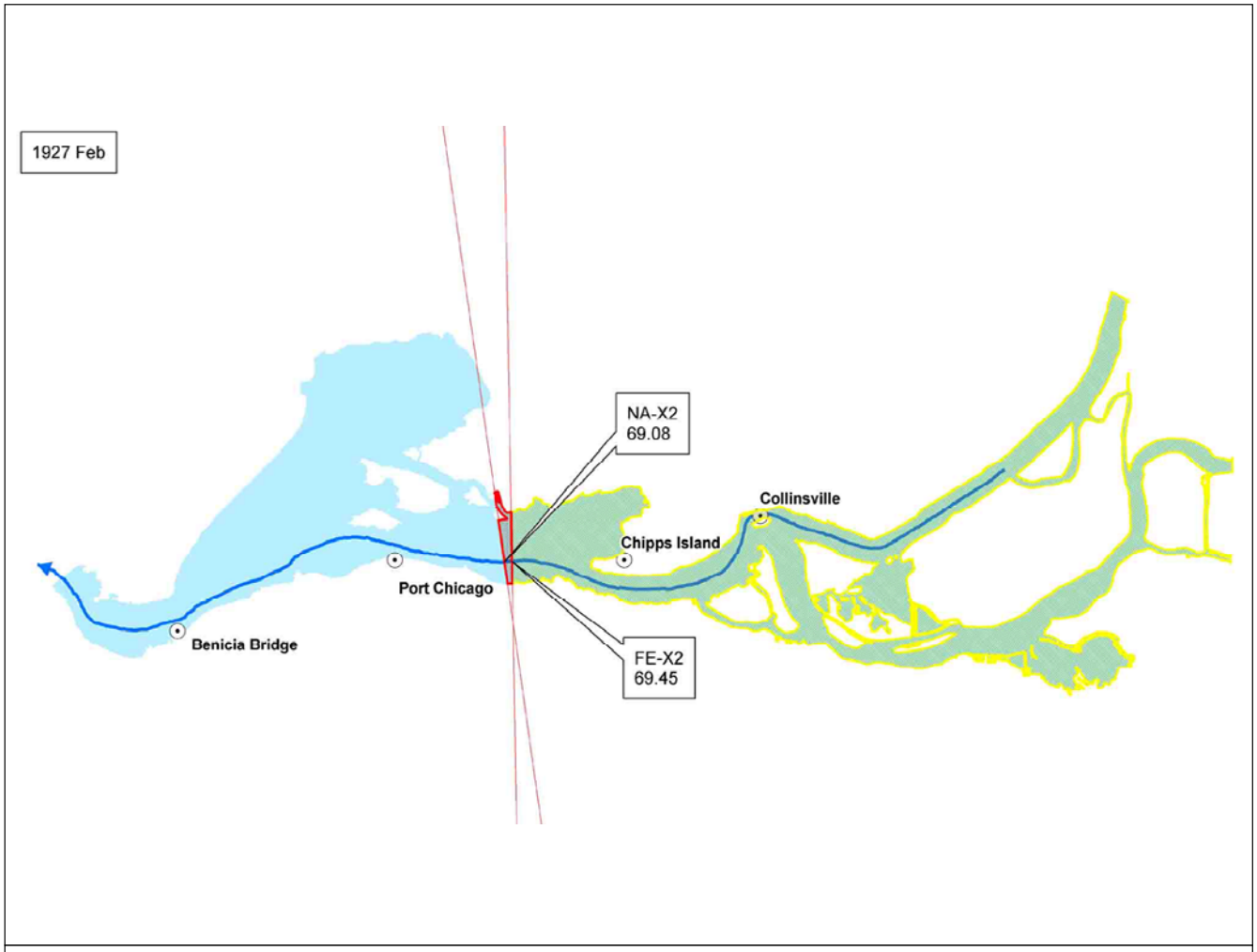
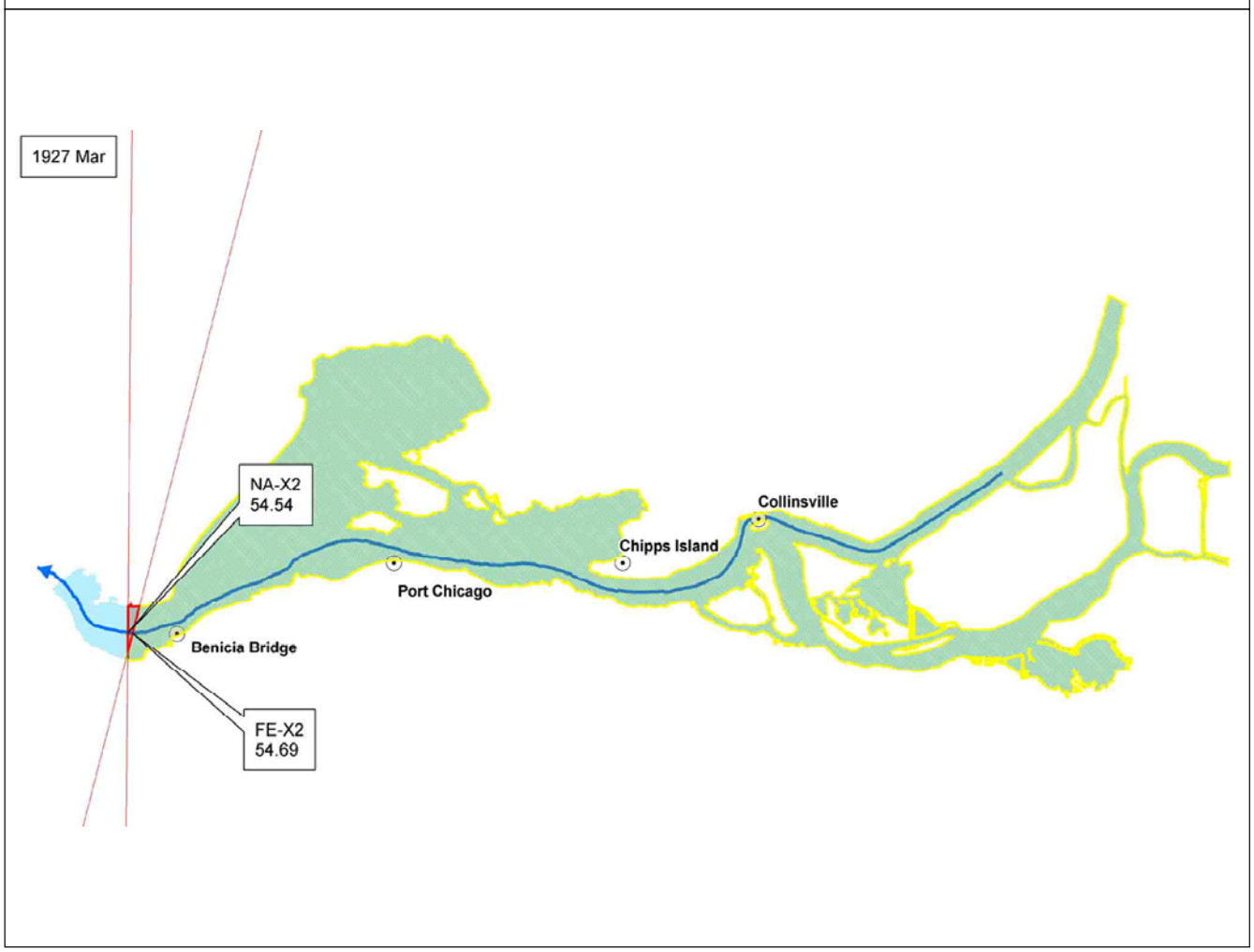
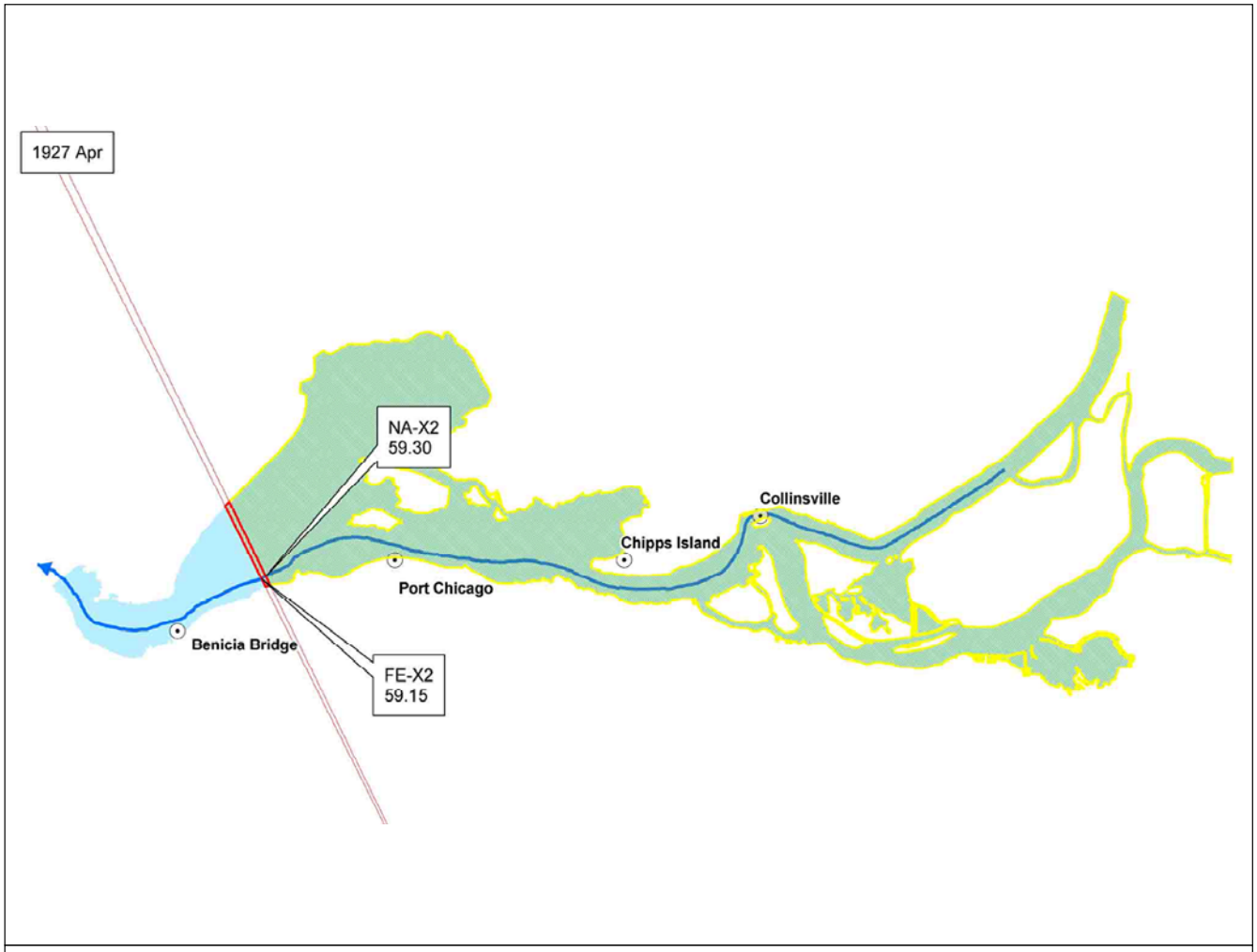
NA-X2
75.21
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
76.35


1927 Feb
NA-X2
69.08
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
69.45


1927 Mar
NA-X2
54.54
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
54.69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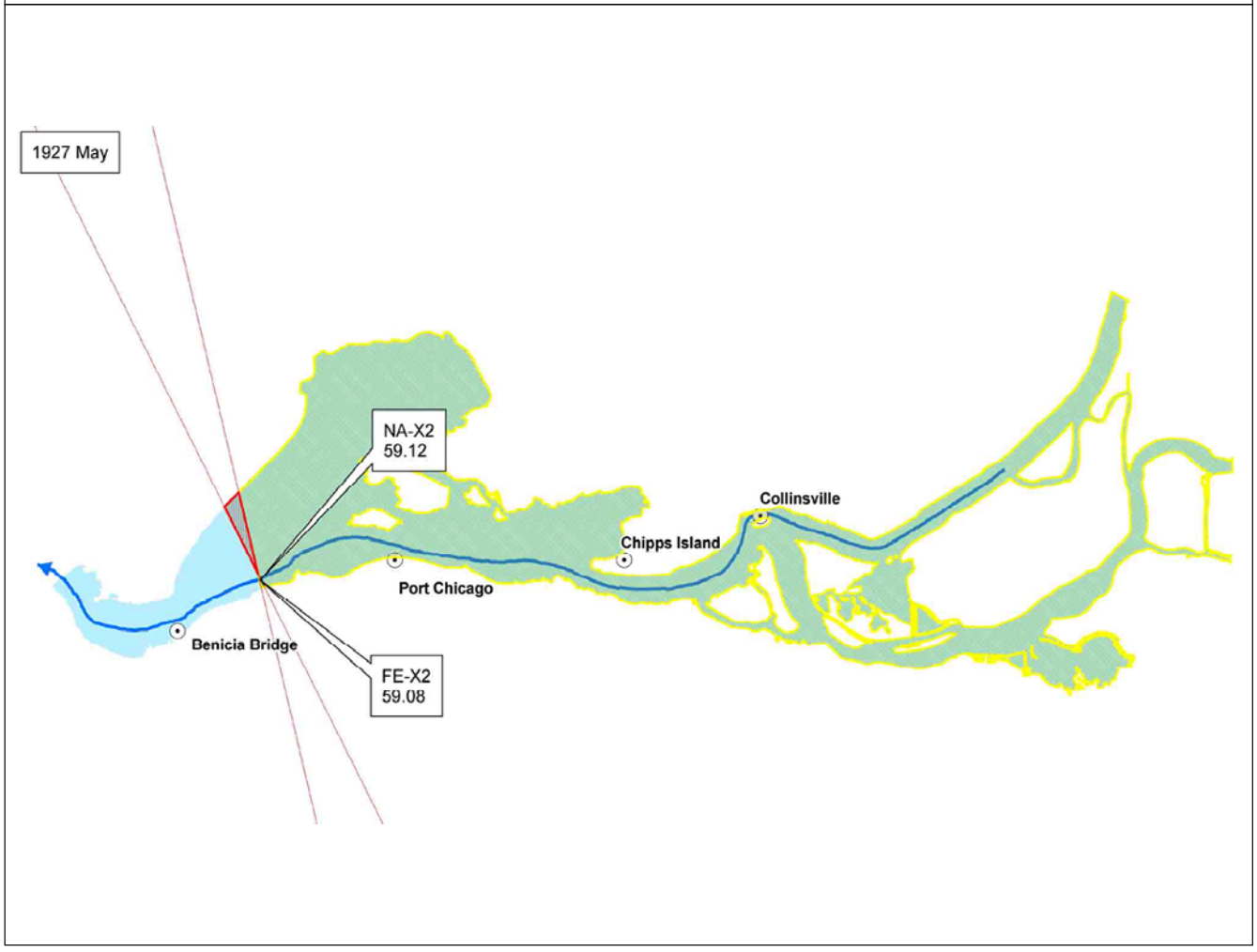
NA-X2
59.30
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
59.15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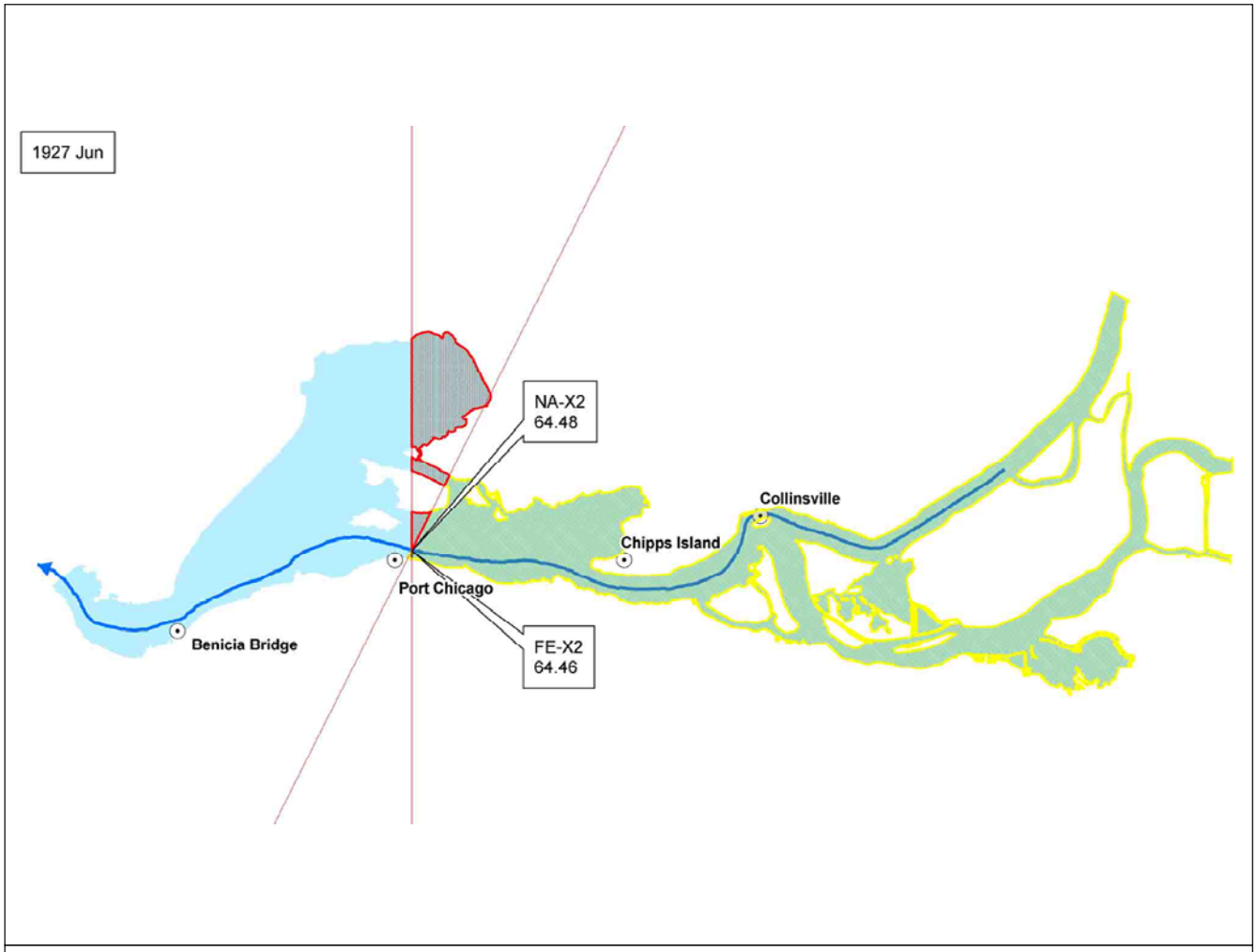
NA-X2
59.12
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
59.08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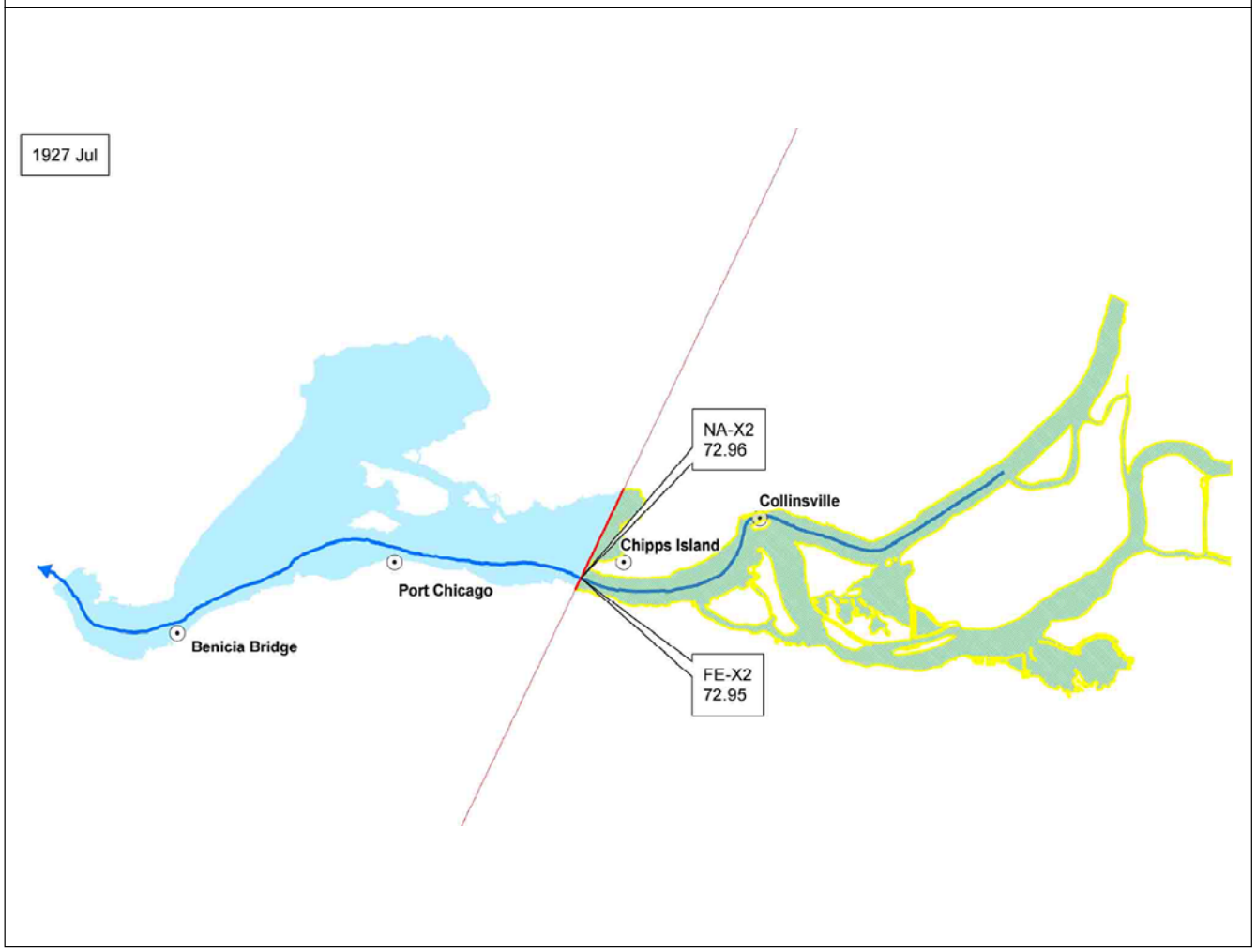
NA-X2
64.48
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
64.46

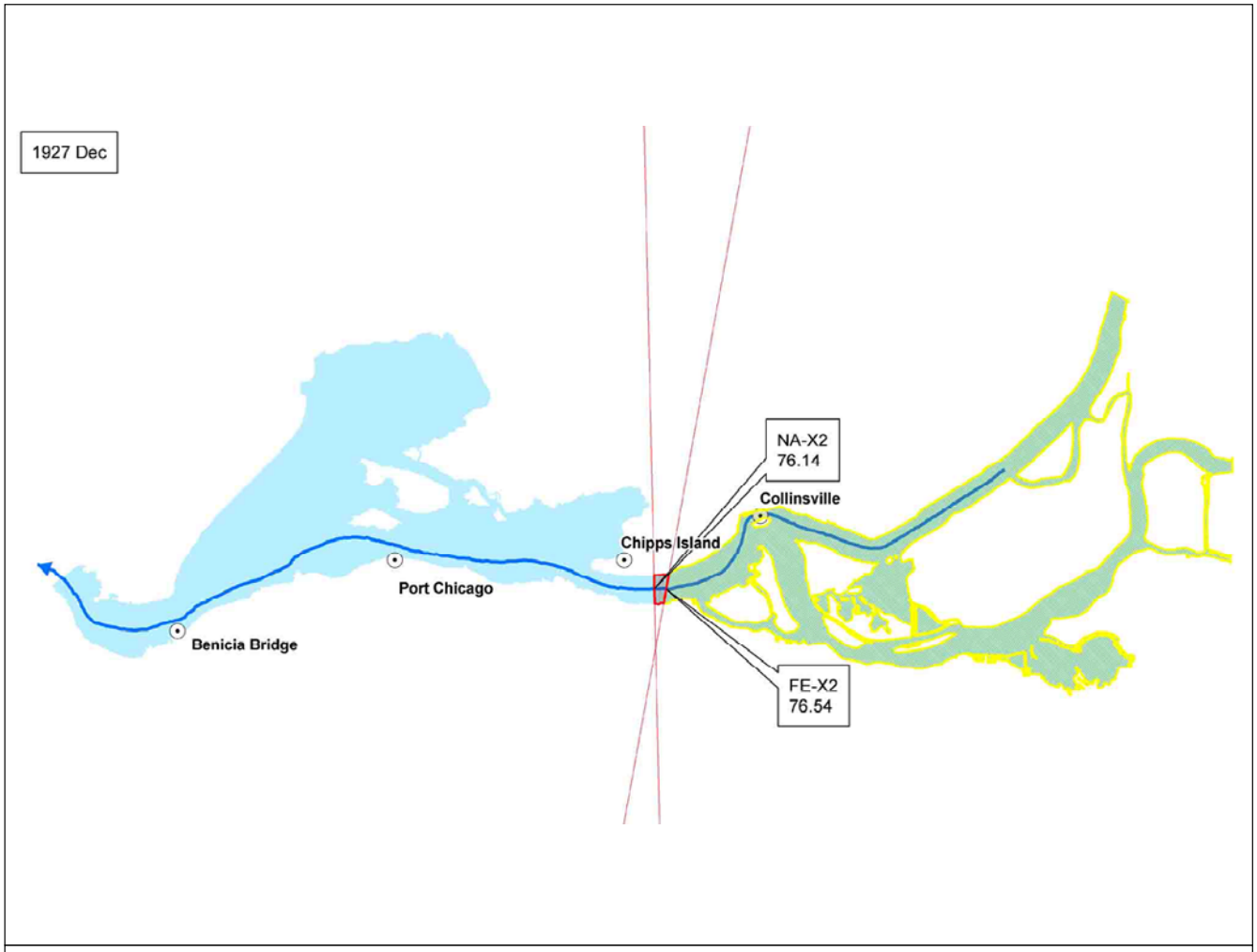

1927 Jul
NA-X2
72.96
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
72.95


1927 Aug
NA-X2
75.75
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
75.57

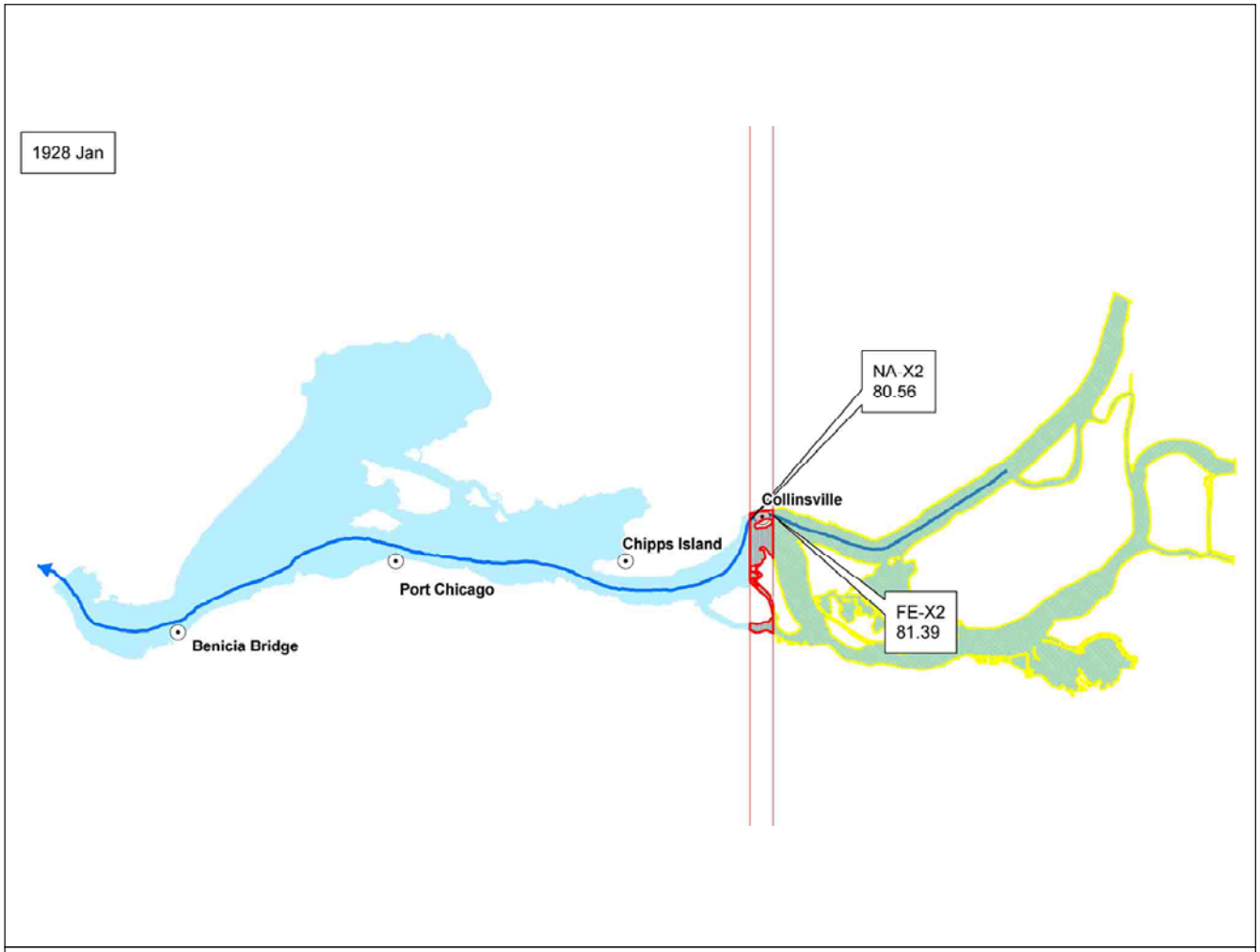

1927 Sep
NA-X2
83.45
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
83.39

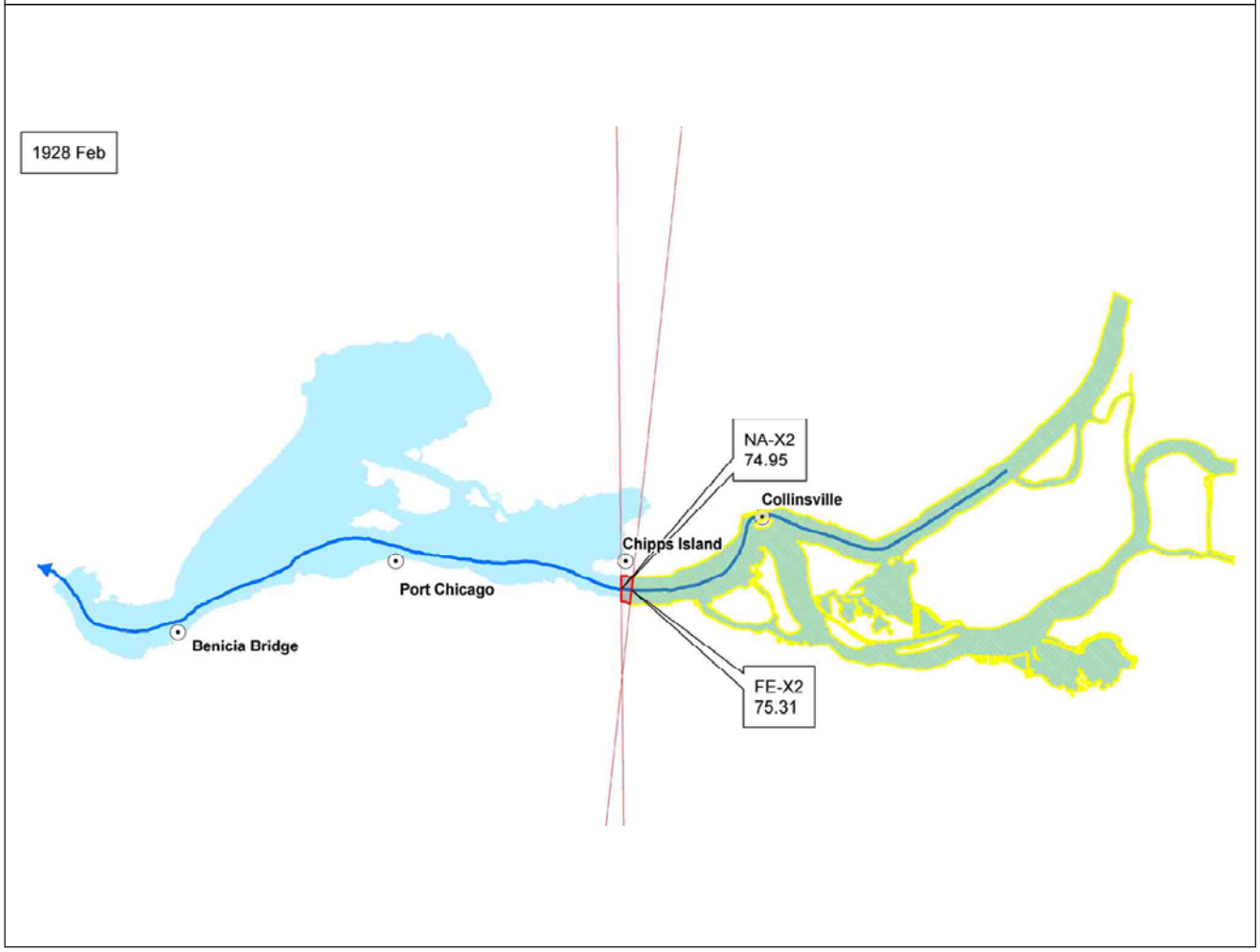

1927 Oct
NA-X2
89.34
FF-X2
88.63
Collinsville
Chipps Island
Port Chicago
Benicia Bridge

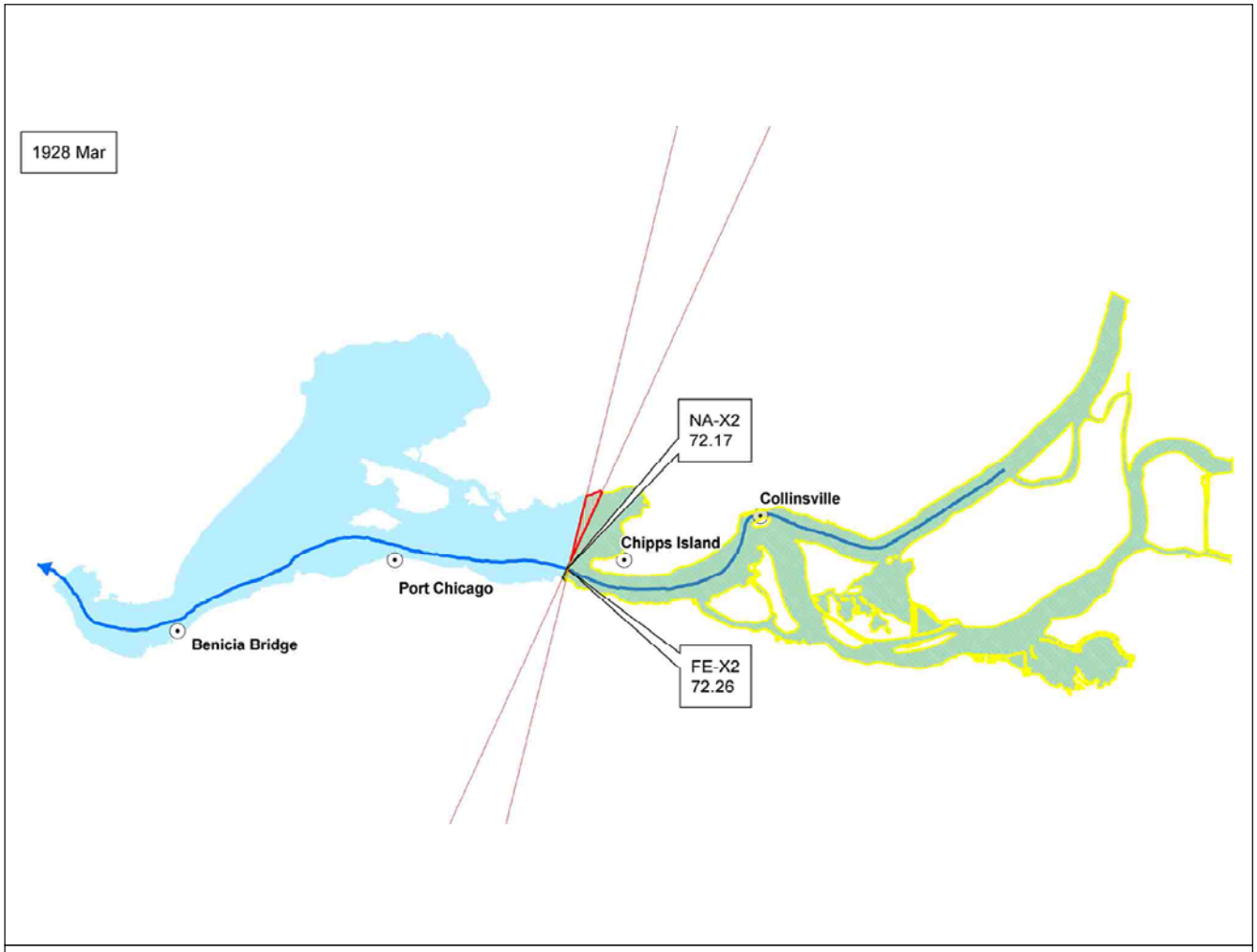

1927 Nov
NA-X2
85.66
FE-X2
87.38
Collinsville
Chipps Island
Port Chicago
Benicia Bridge

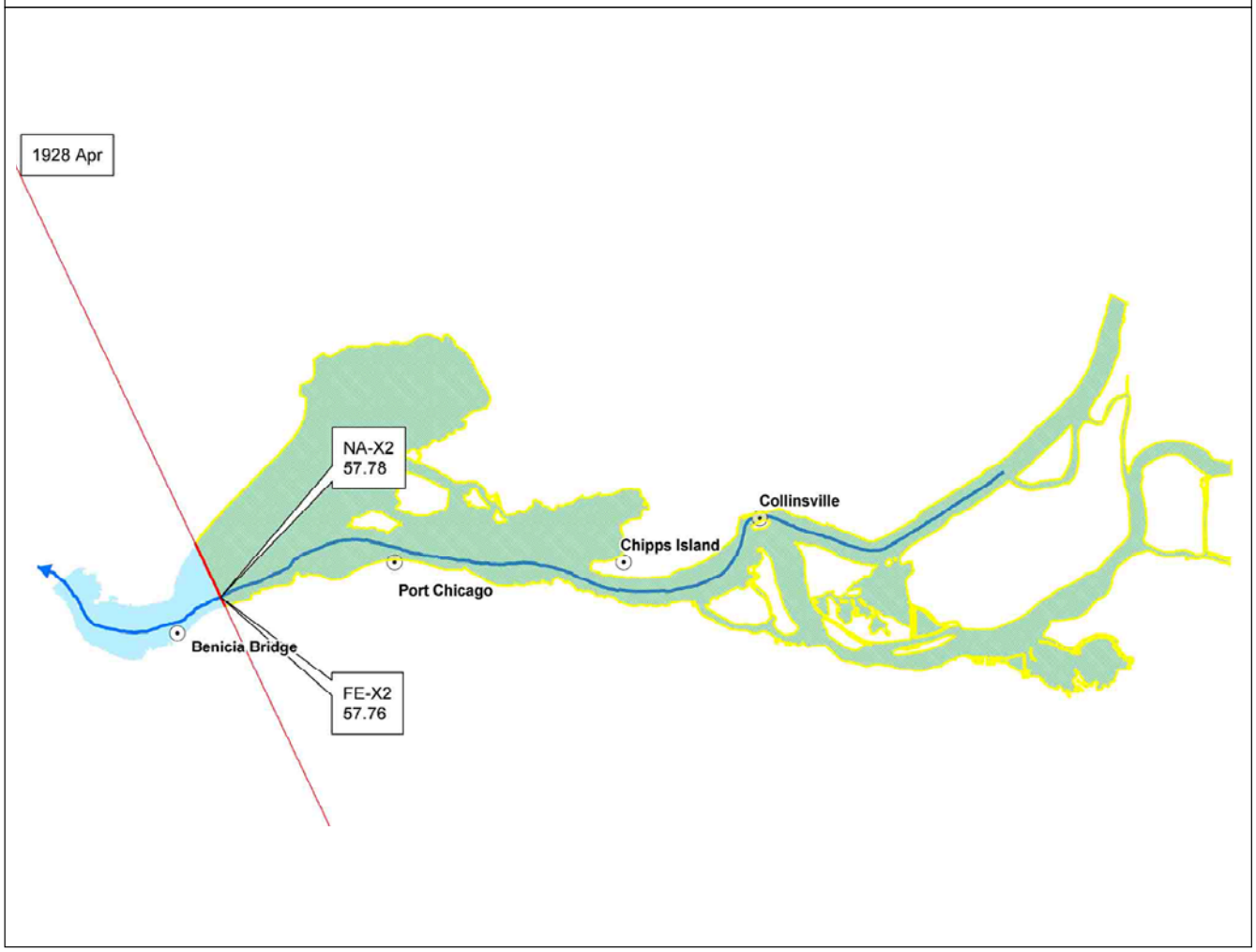

1927 Dec
NA-X2
76.14
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
76.54


1927 average
NA-X2
72.09
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
72.30


1928 Jan
NA-X2
80.56
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
81.39


1928 Feb
NA-X2
74.95
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
75.31


1928 Mar
NA-X2
72.17
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
72.26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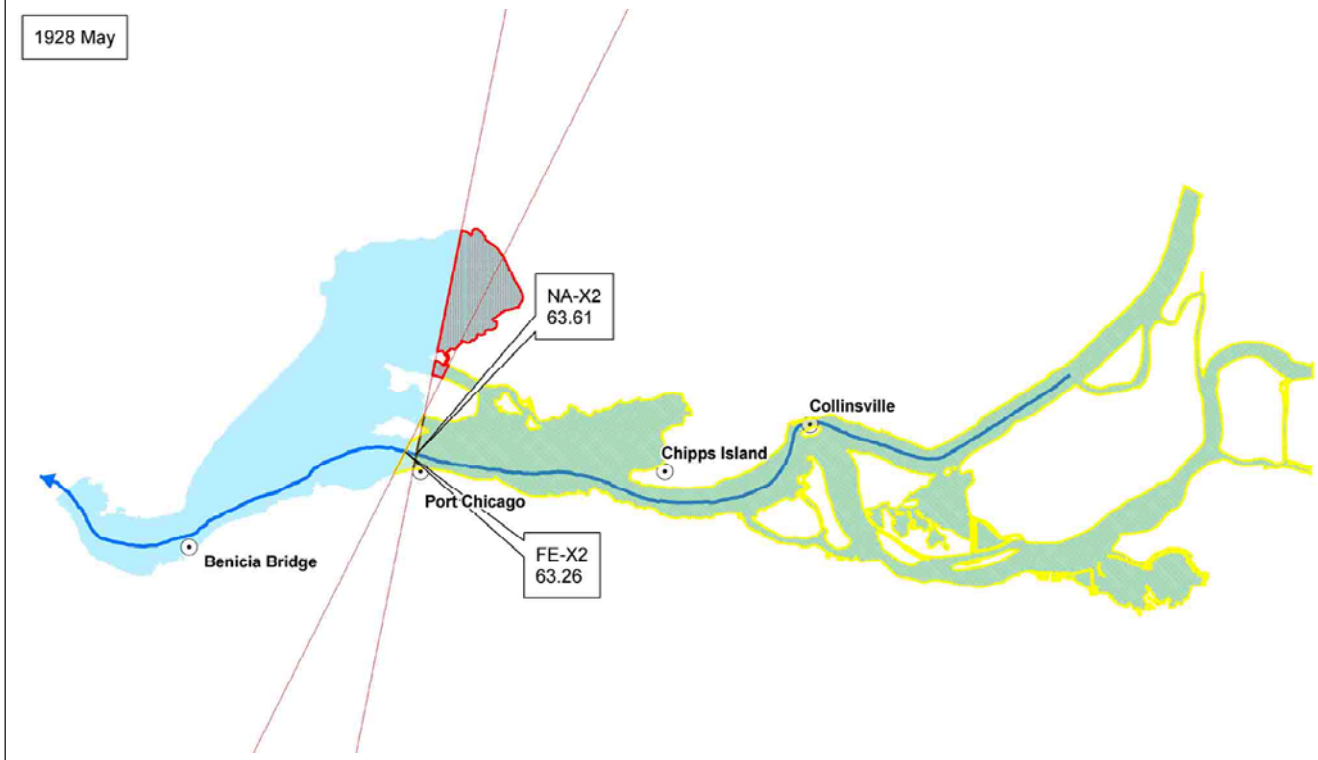
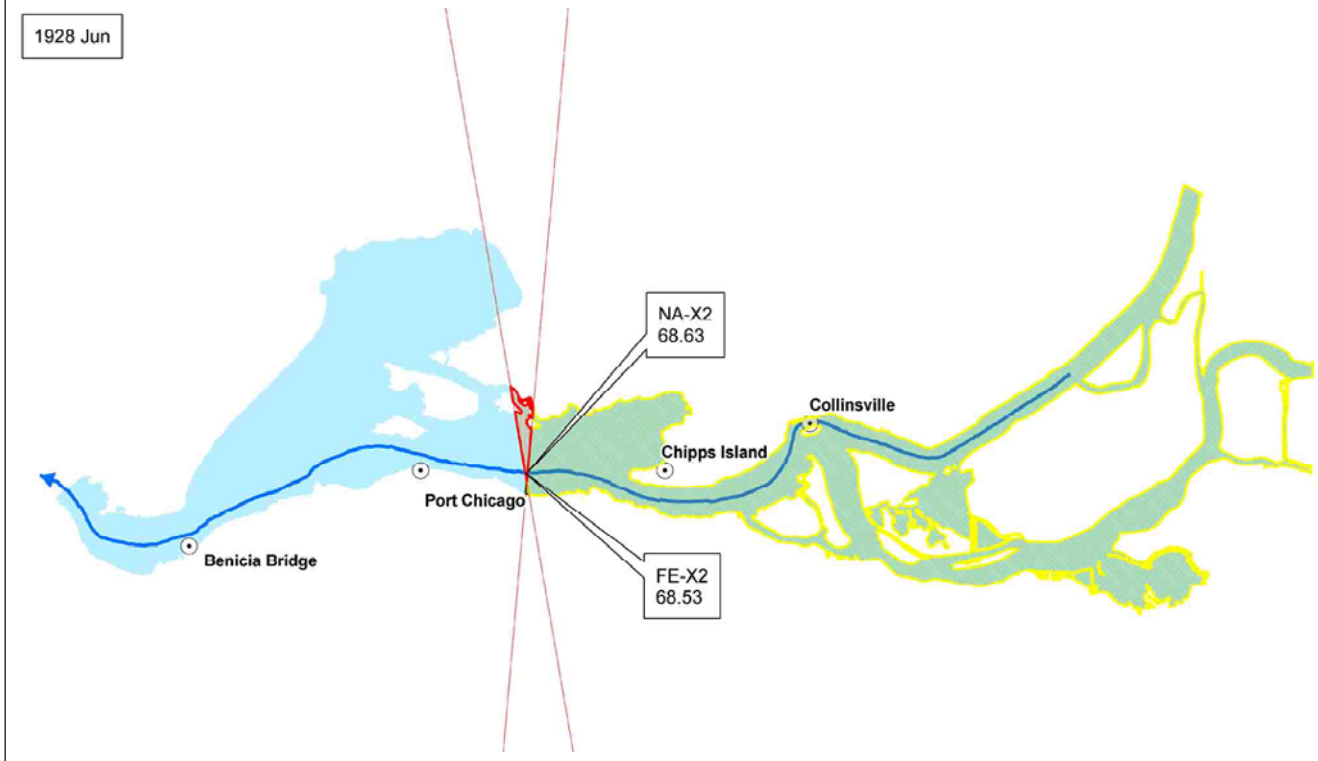
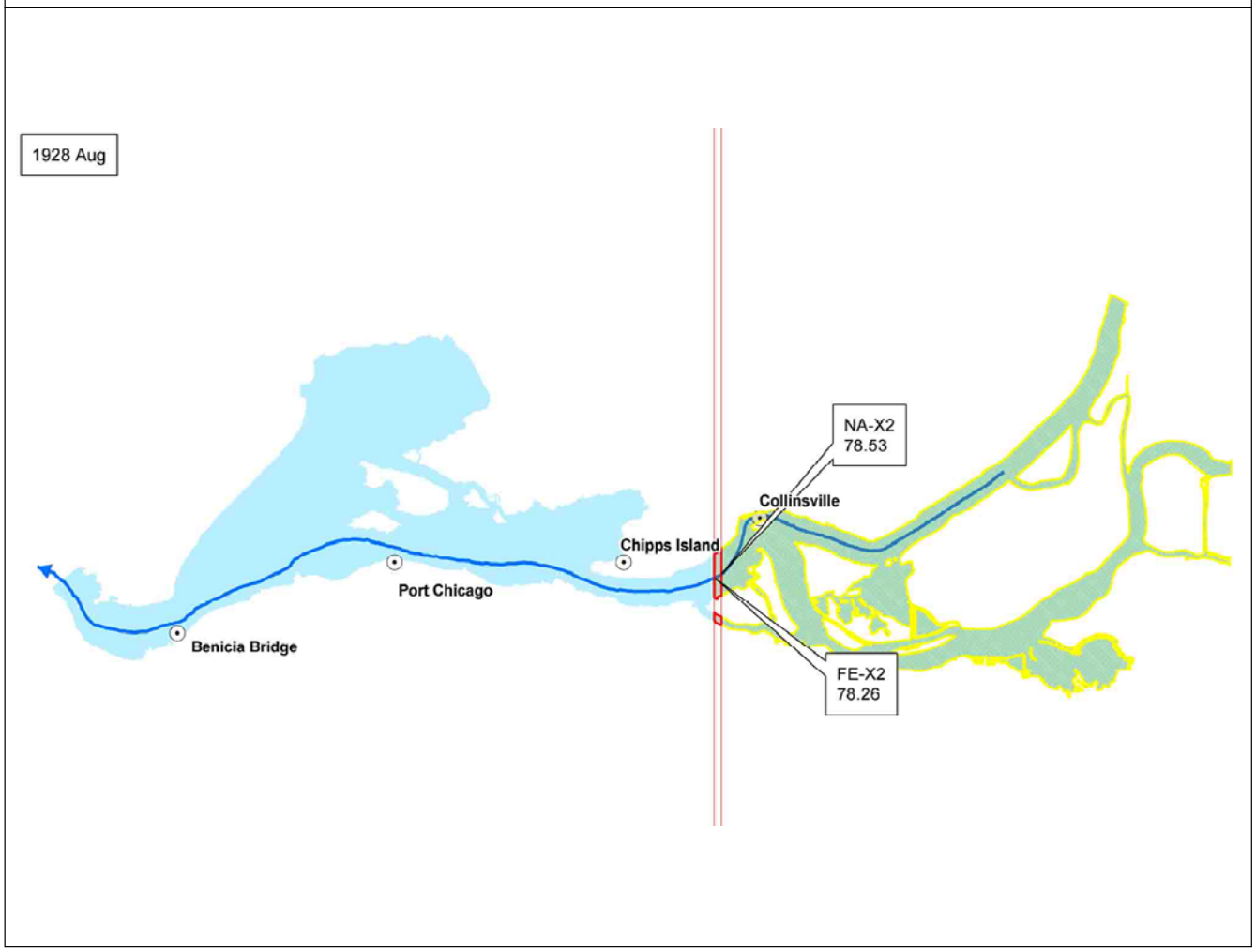
NA-X2
57.78
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
57.76

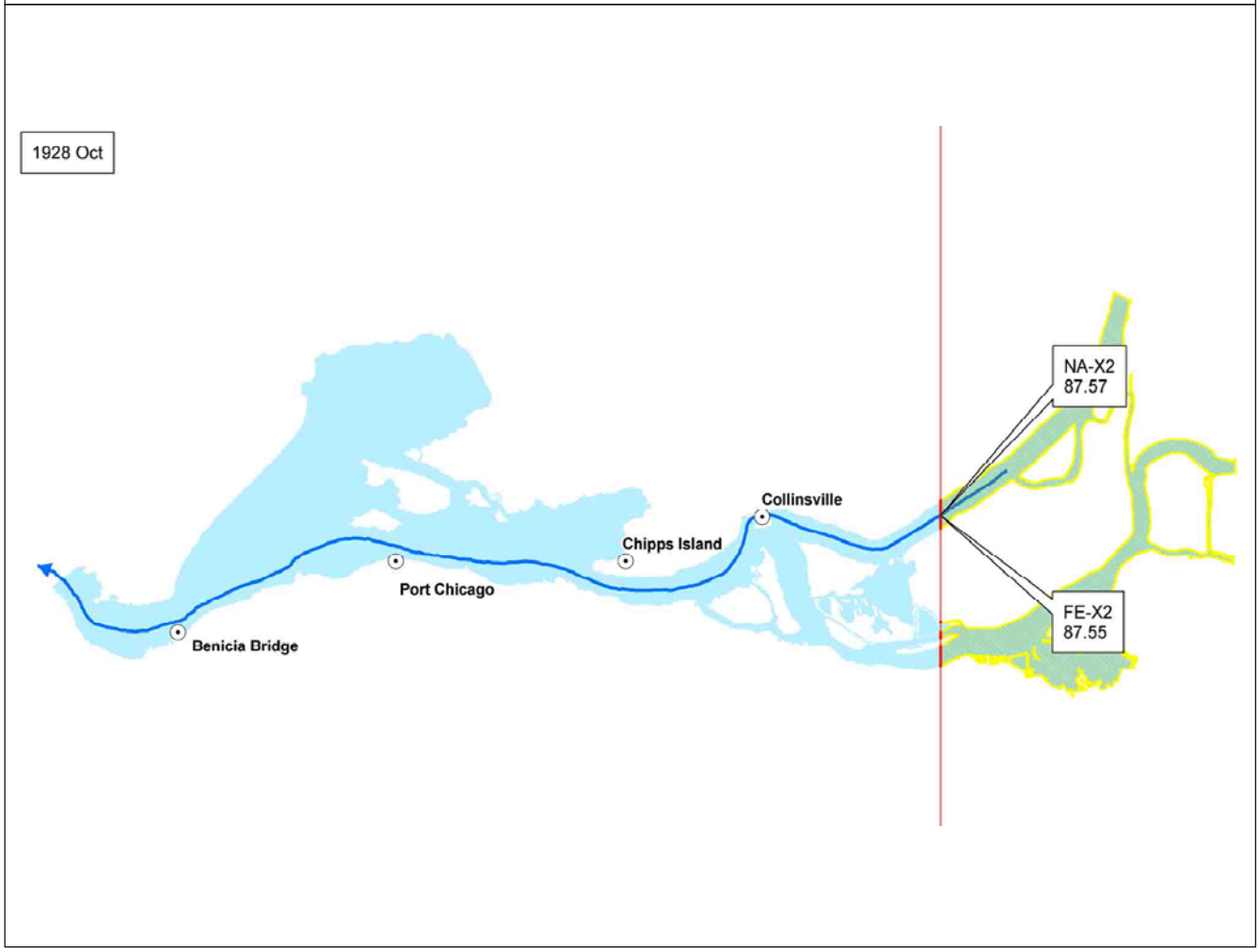

1928 May
NA-X2
63.61
Collinsville
Chipps Island
Port Chicago
FE-X2
63.26
Benicia Bridge


1928 Jun
NA-X2
68.63
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
68.53


1928 Jul
NA-X2
77.29
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
76.13


1928 Aug
NA-X2
78.53
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
78.26


1928 Sep
NA-X2
84.36
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
84.27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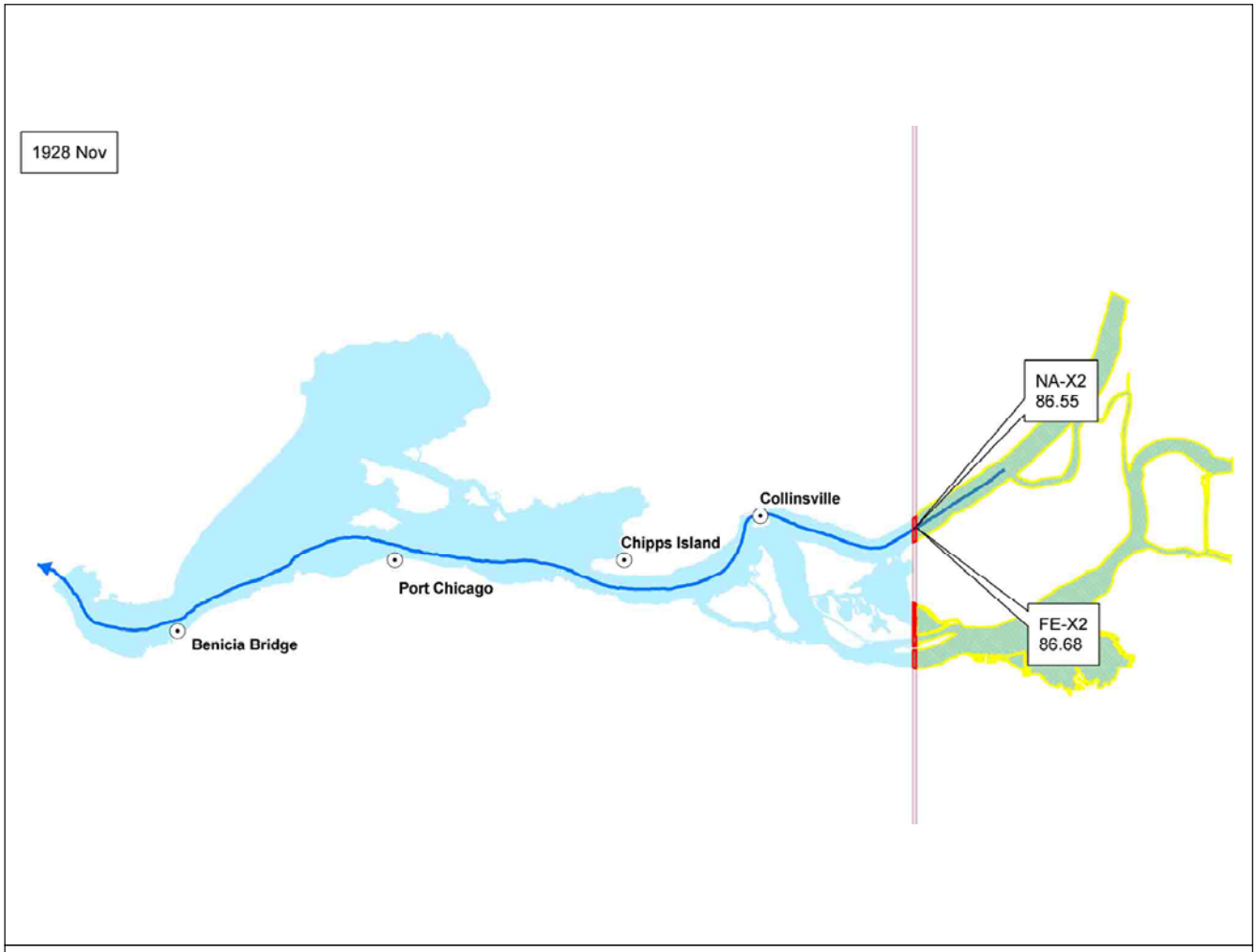
NA-X2
87.57
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
87.55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NA-X2
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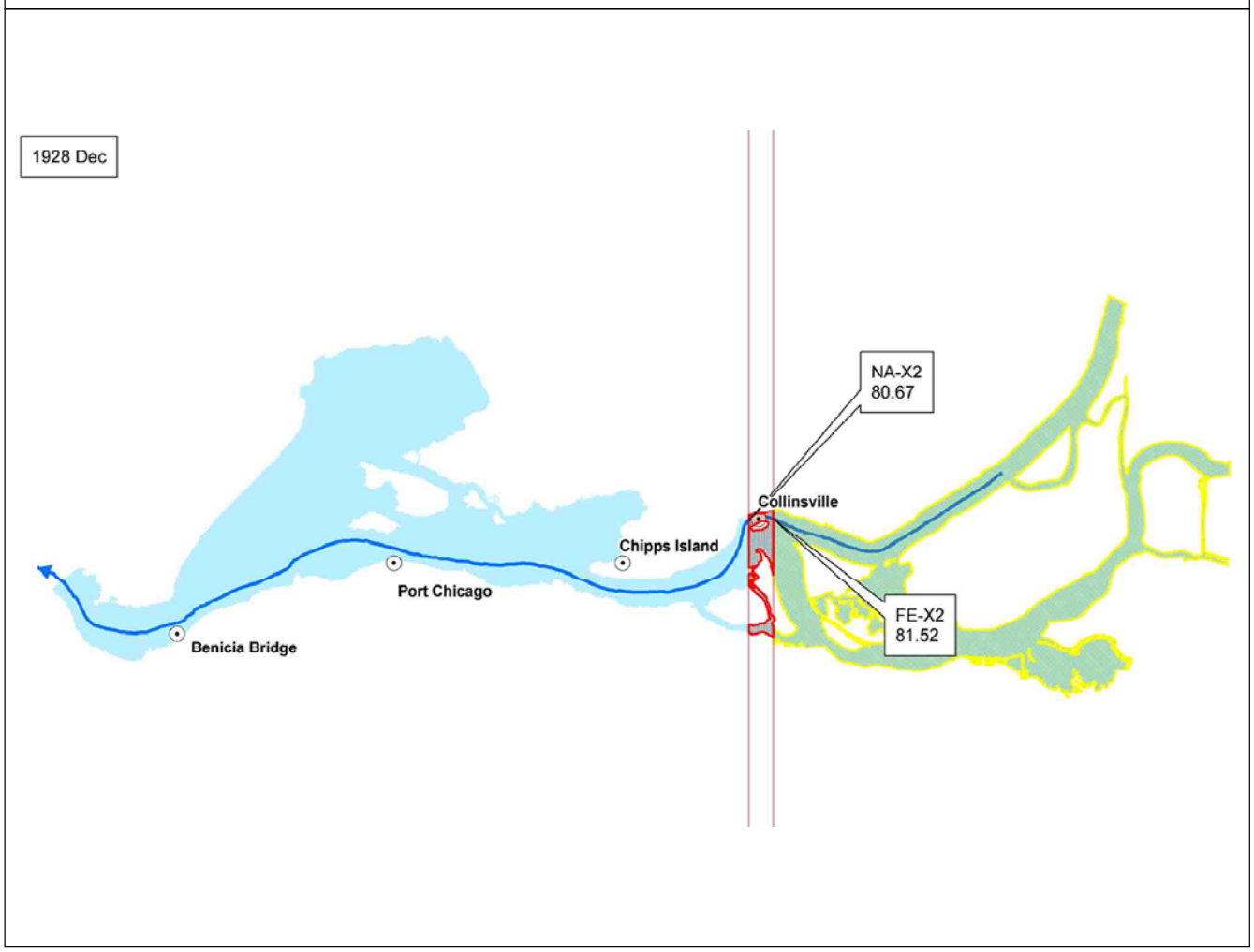
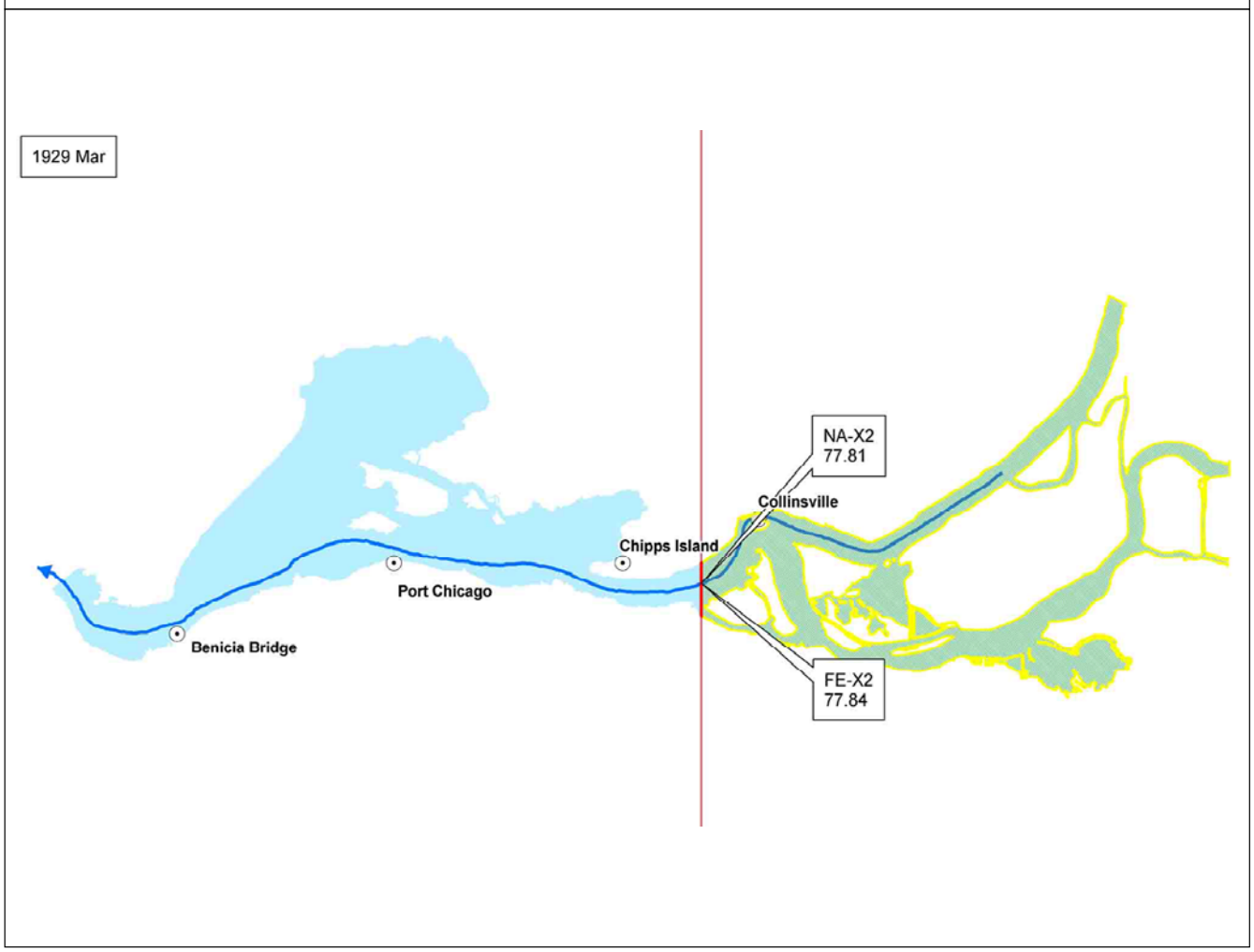
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
86.68

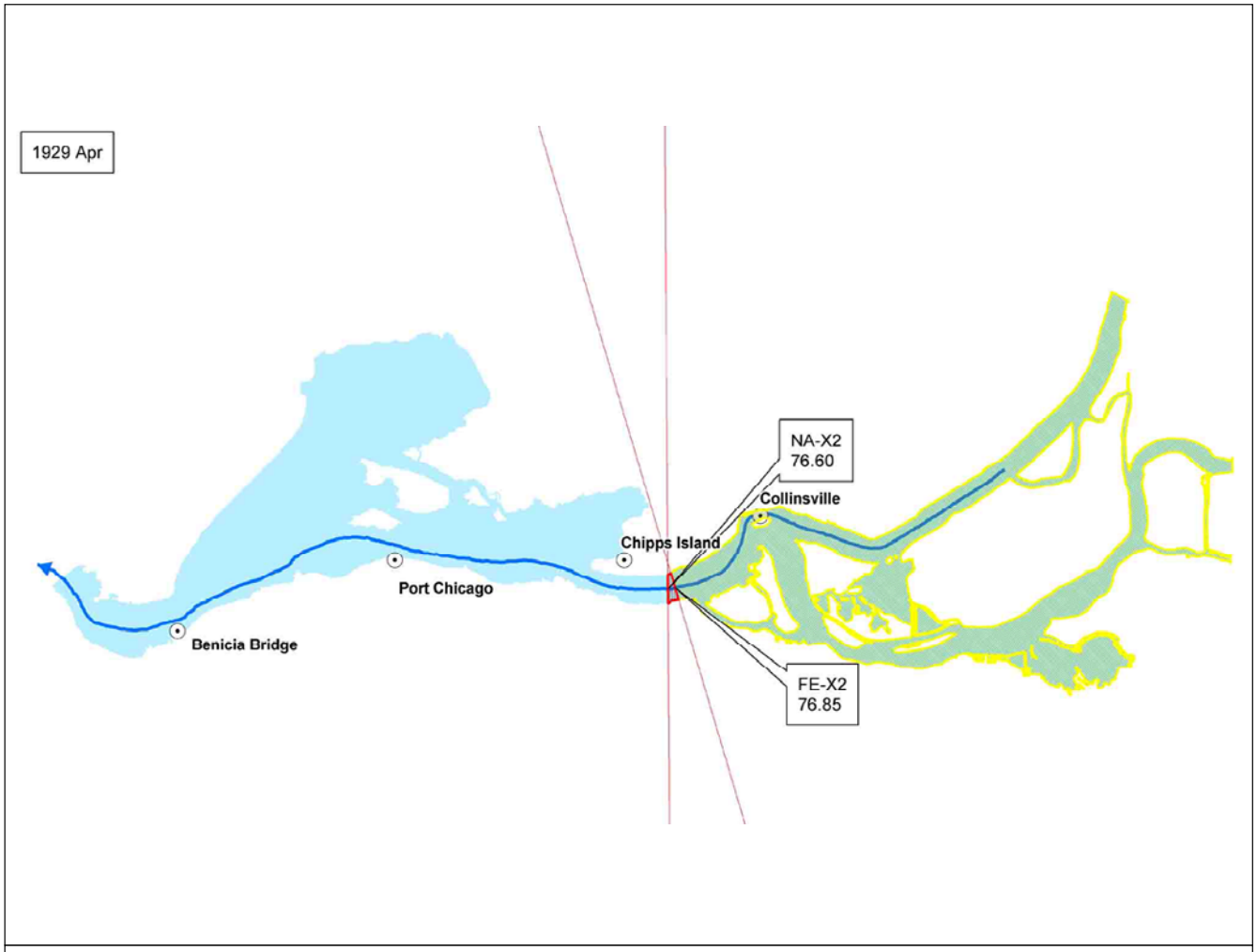

1928 Dec
NA-X2
80.67
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
81.52


1928 average
NA-X2
76.06
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
76.08


1929 Jan
NA-X2
82.18
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
83.68

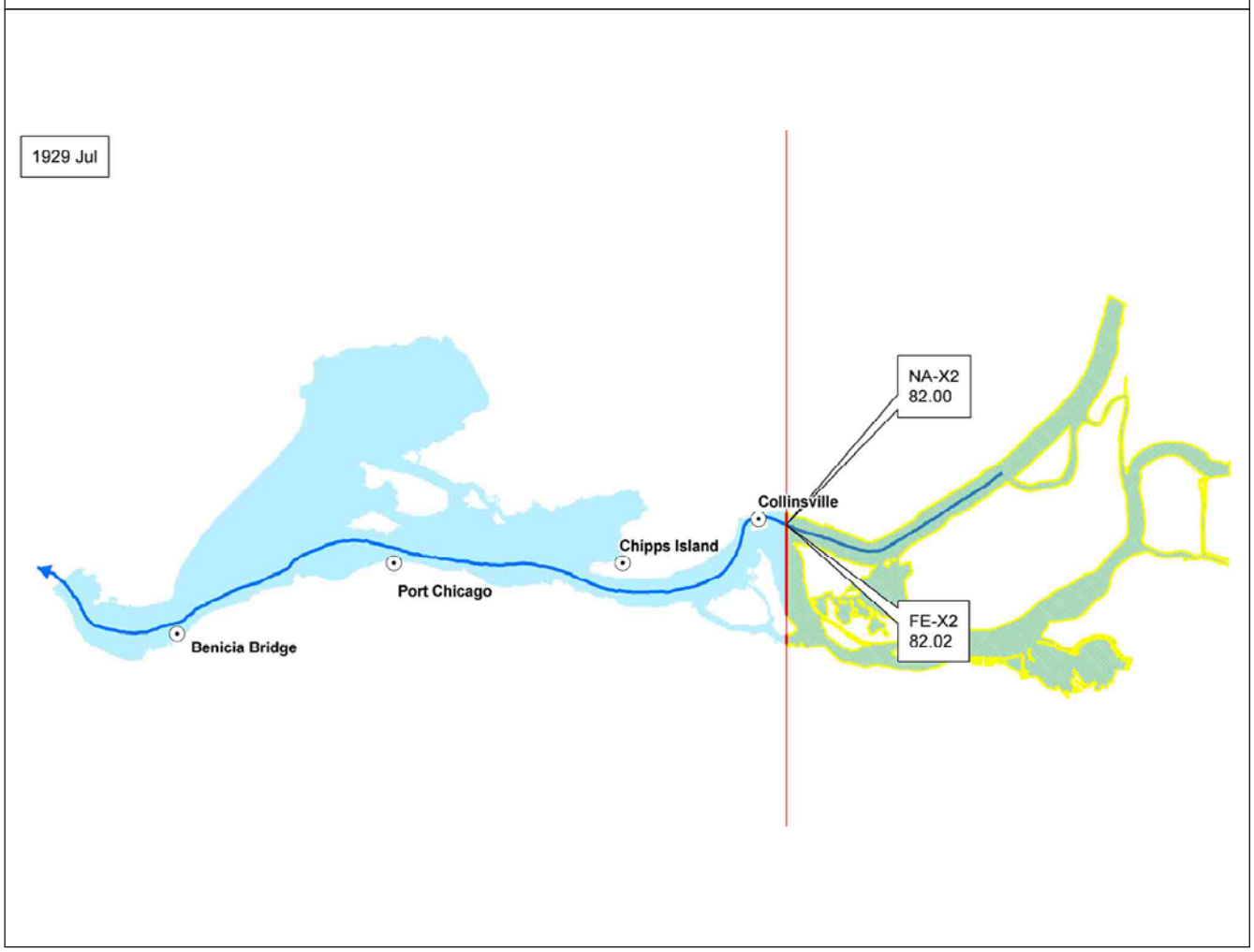

1929 Feb
NA-X2
83.01
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
83.10


1929 Mar
NA-X2
77.81
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
77.84


1929 Apr
NA-X2
76.60
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
76.85


1929 May
NA-X2
79.58
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
79.64

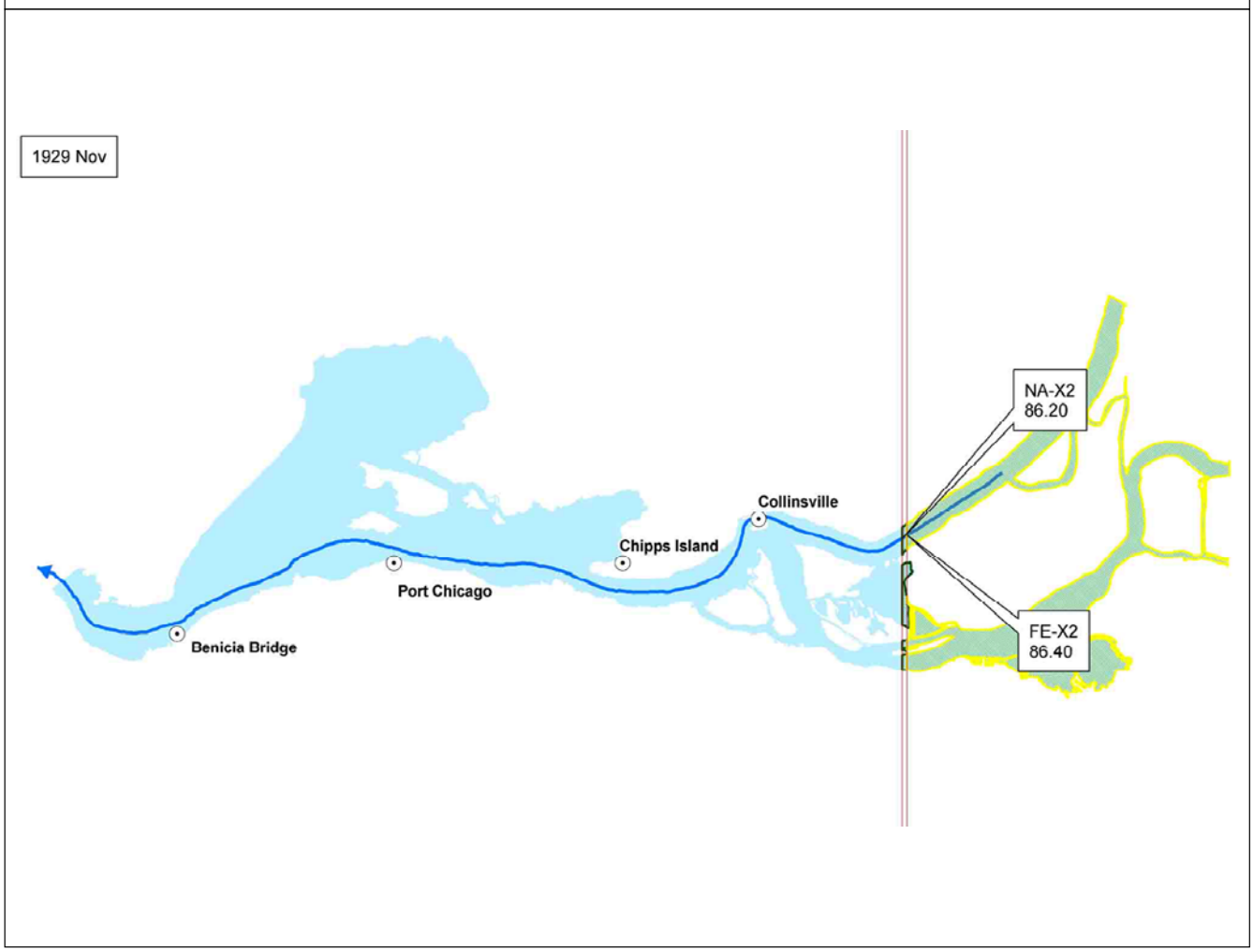

1929 Jun
NA-X2
80.93
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
81


1929 Jul
NA-X2
82.00
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
82.02


1929 Aug
NA-X2
85.50
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
85.51


1929 Sep
NA-X2
85.81
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
85.48

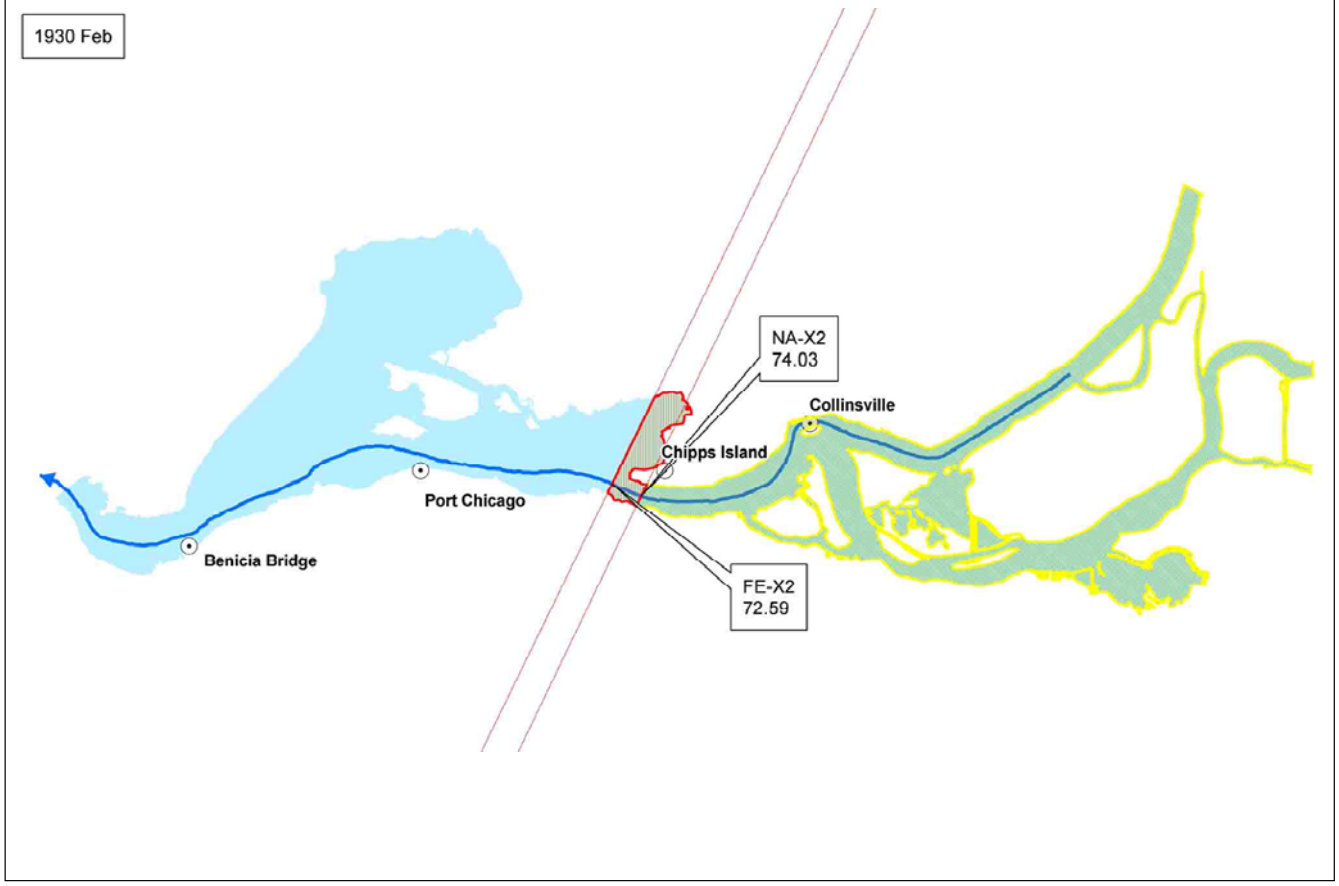

1929 Oct
NA-X2
88.34
FE-X2
88.45
Collinsville
Chipps Island
Port Chicago
Benicia Bridge


1929 Nov
NA-X2
86.20
FE-X2
86.40
Collinsville
Chipps Island
Port Chicago
Benicia Bridge


1929 Dec
NA-X2
83.60
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
83.80


1929 average
NA-X2
82.63
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
82.81


1930 Jan
NA-X2
78.96
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
77.61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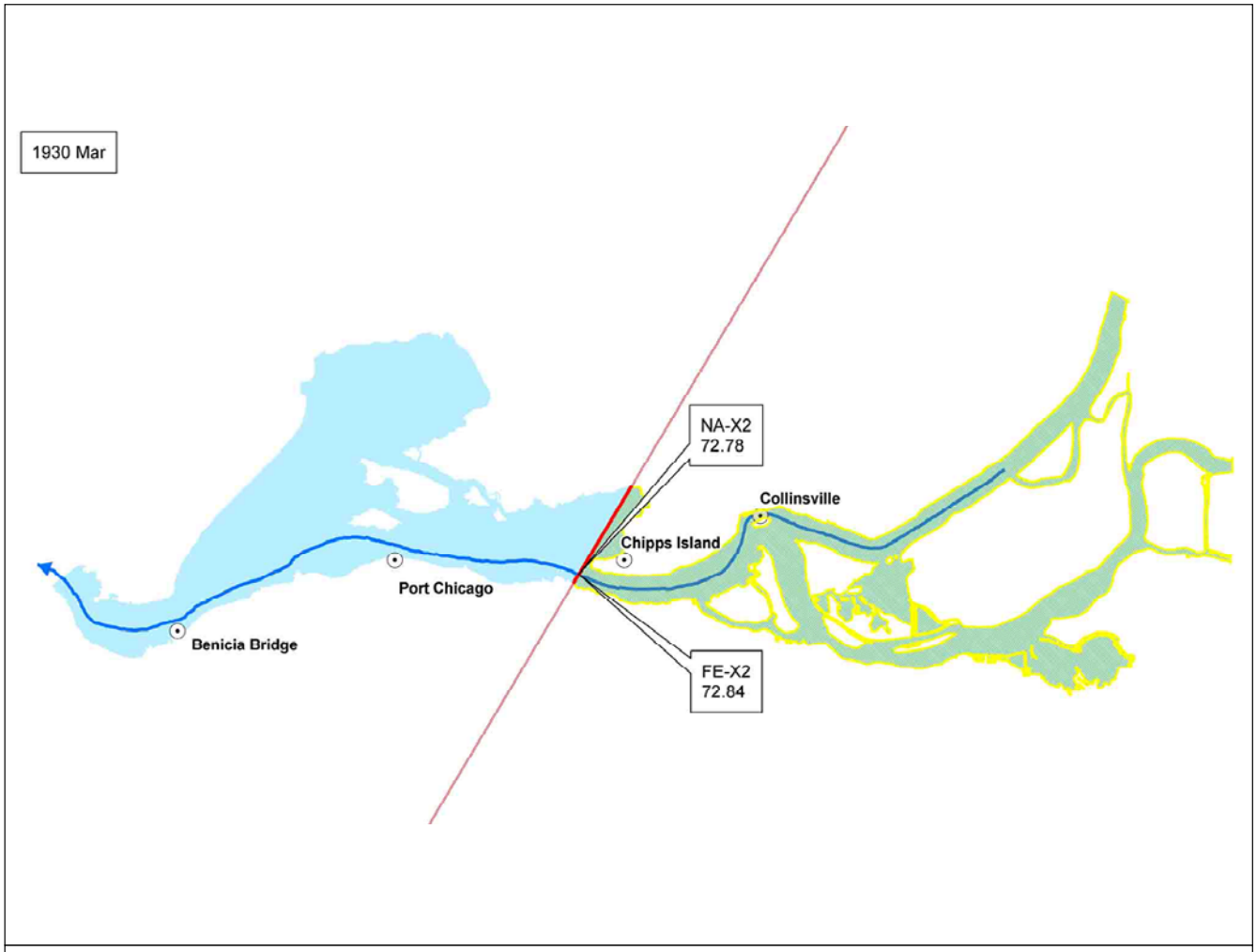
NA-X2
74.03
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
72.59


1930 Mar
NA-X2
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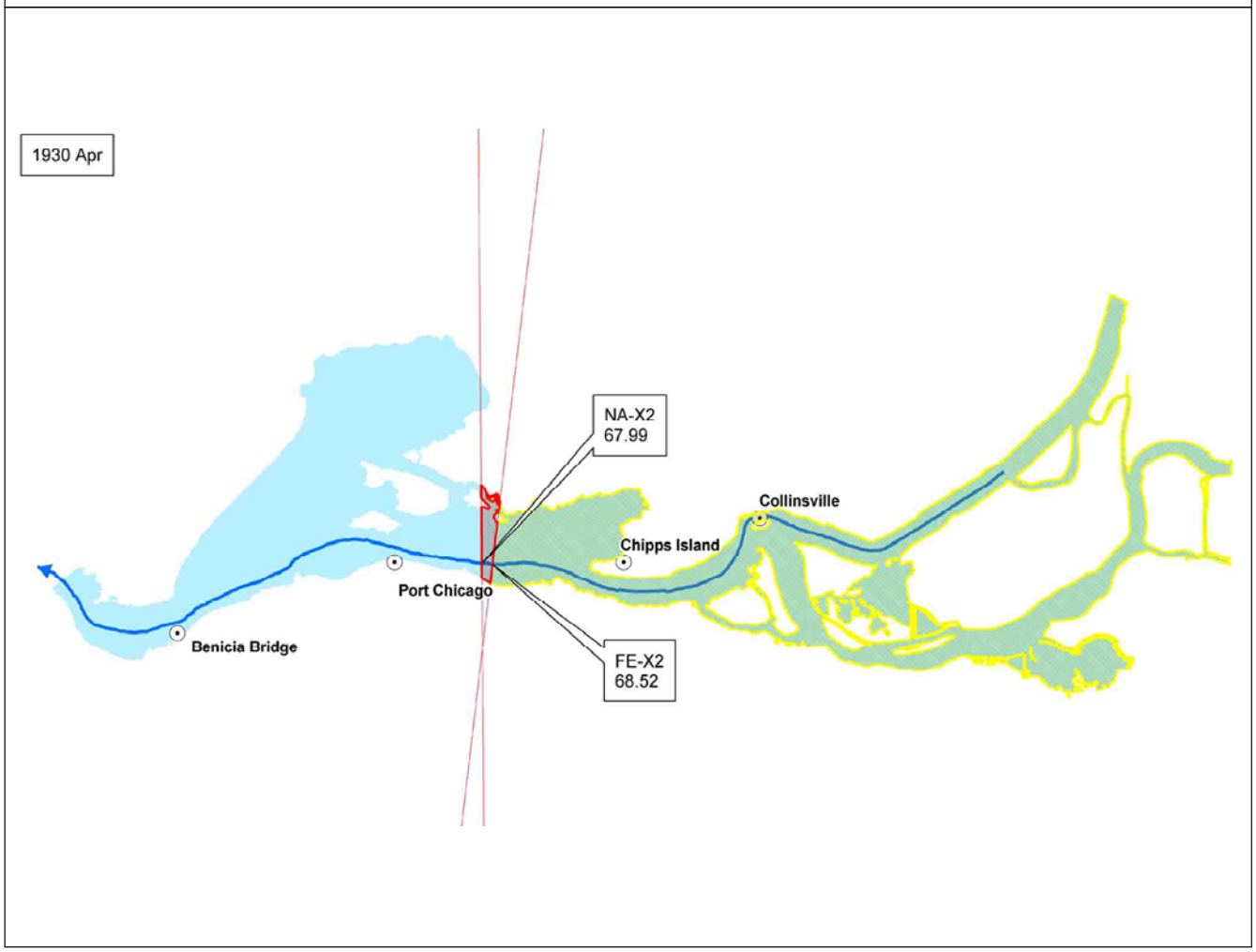
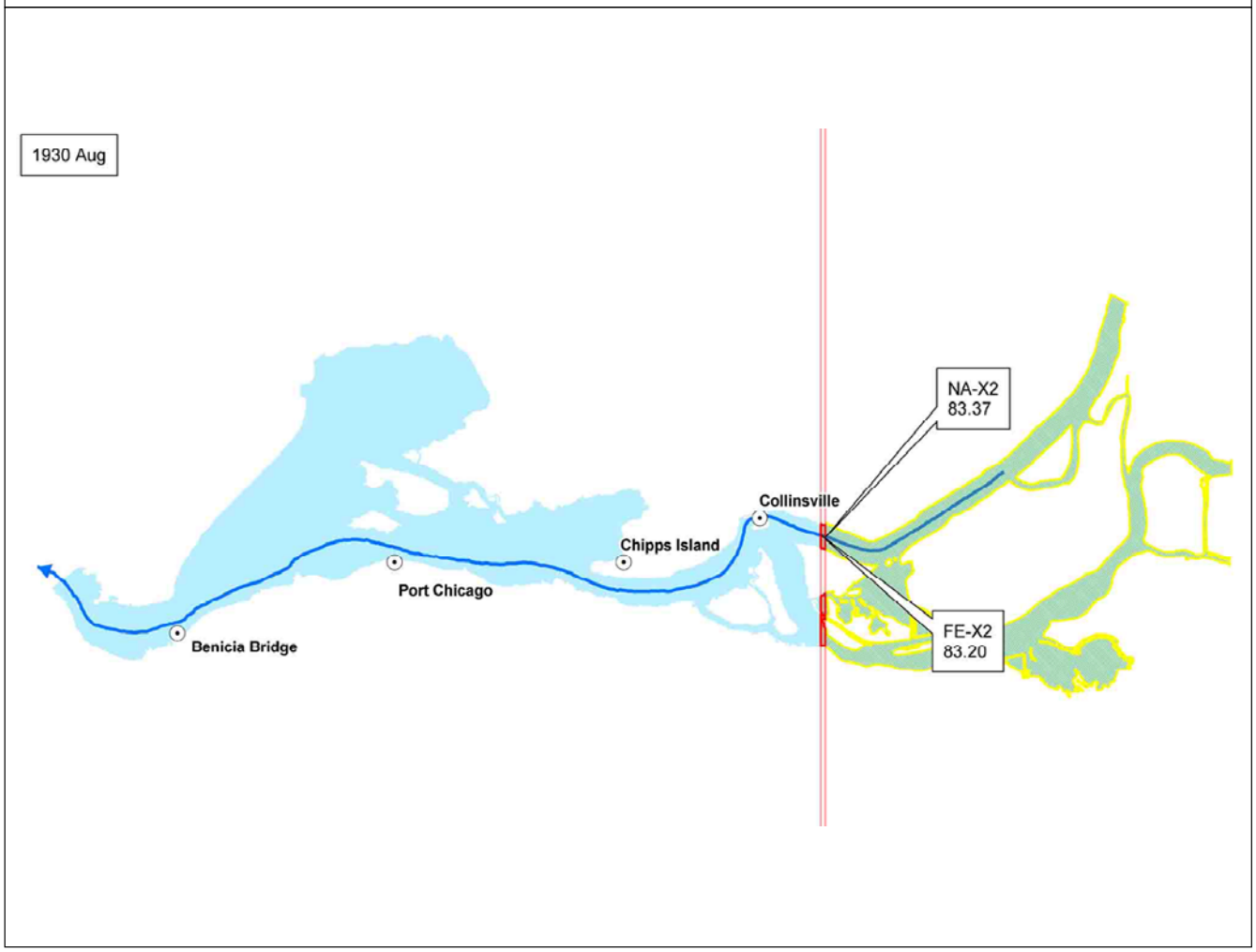
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
72.84


1930 Apr
NA-X2
67.99
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
68.52

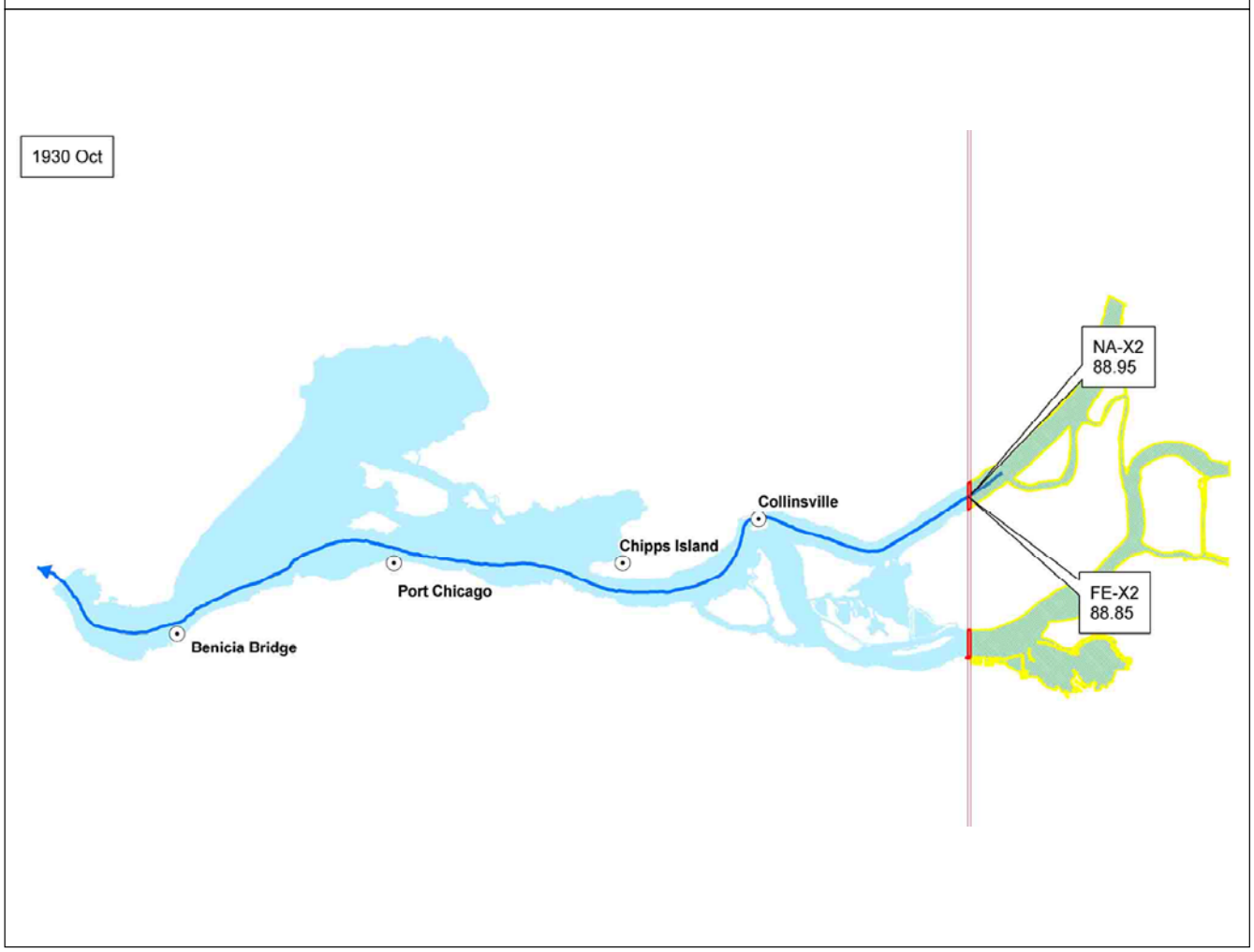

1930 May
NA-X2
73.21
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
73.33


1930 Jun
NA-X2
76.18
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
76.26


1930 Jul
NA-X2
80.72
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
80.20


1930 Aug
NA-X2
83.37
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
83.20


1930 Sep
NA-X2
83.97
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
85.85


1930 Oct
NA-X2
88.95
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
88.85


1930 Nov
NA-X2
87.92
FE-X2
88.57
Collinsville
Chipps Island
Port Chicago
Benicia Bridge


1930 Dec
NA-X2
85.14
FE-X2
85.20
Collinsville
Chipps Island
Port Chicago
Benicia Bridge


1930 average
NA-X2
79.44
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
79.42

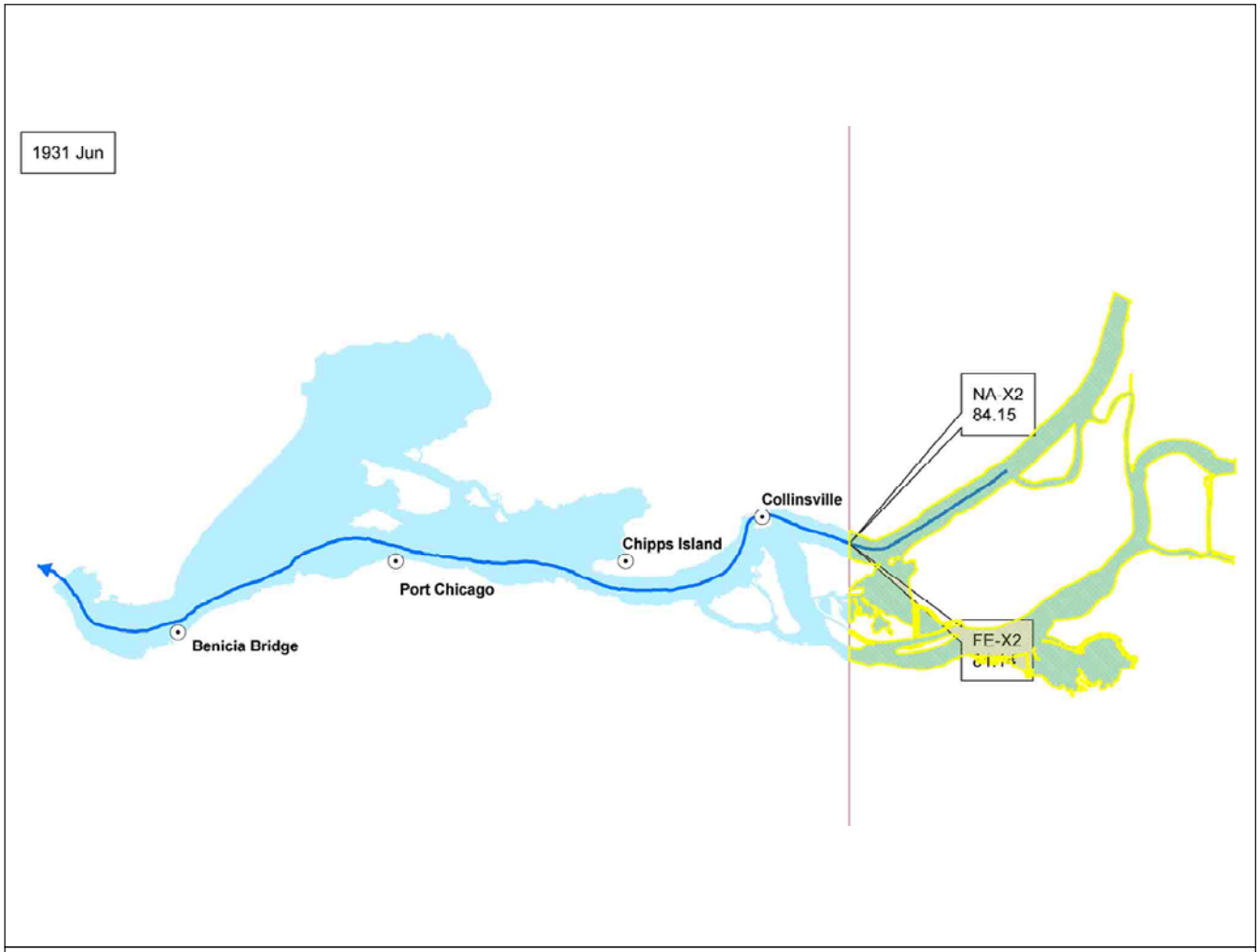

1931 Jan
NA-X2
83.28
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
85.01


1931 Feb
NA-X2
79.18
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
80.84

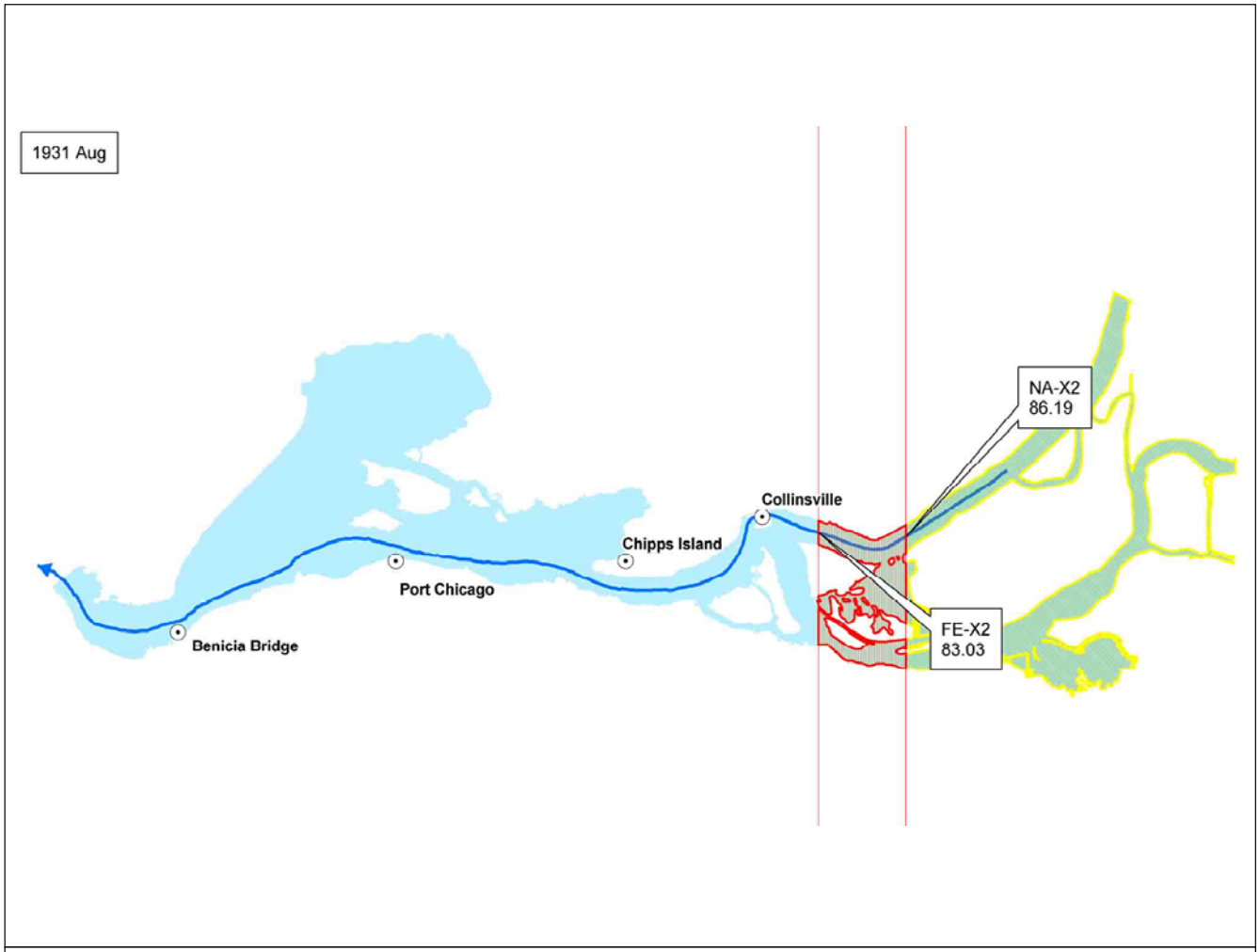

1931 Mar
NA-X2
79.13
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
79.78

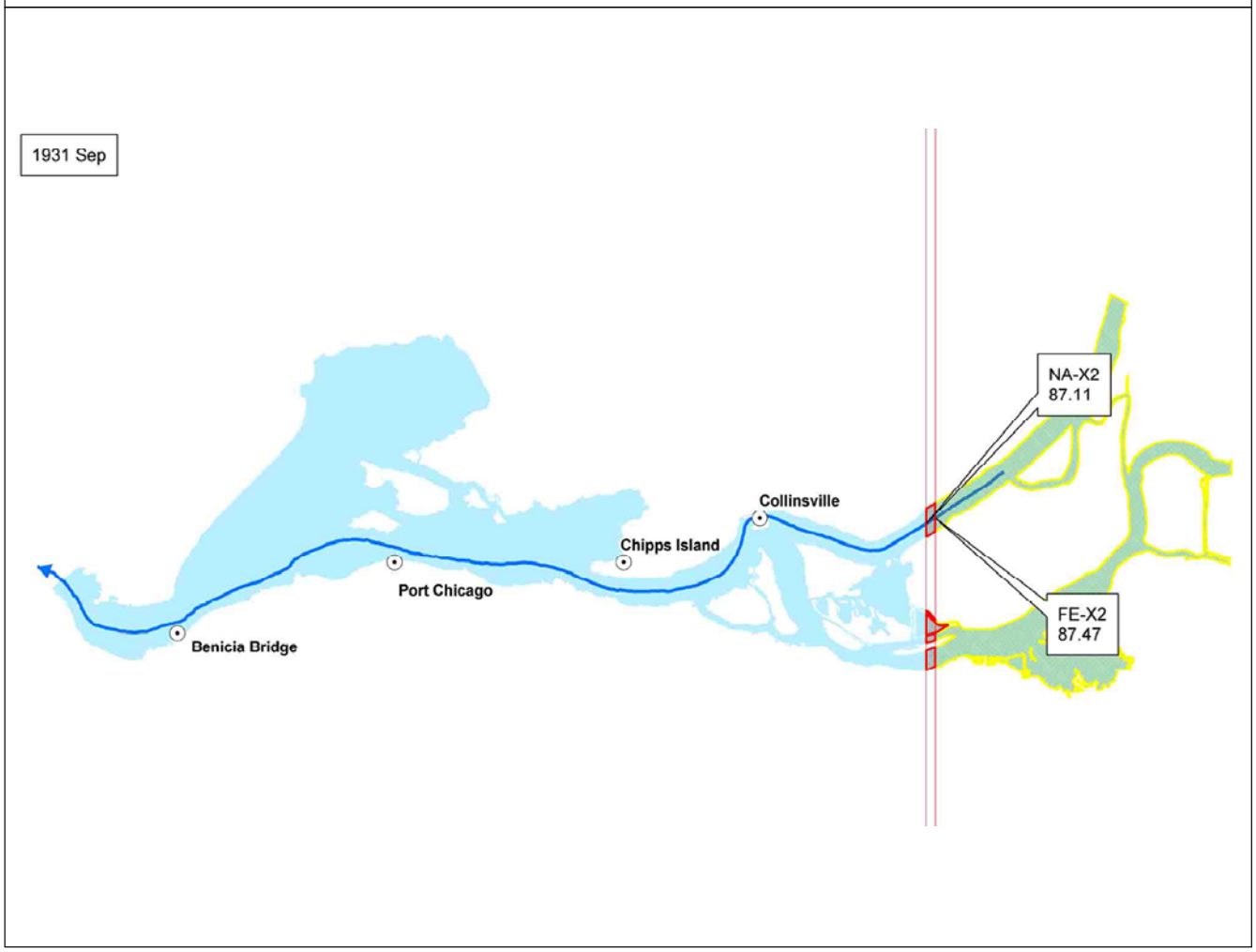

1931 Apr
NA-X2
80.95
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
81.52


1931 May
NA-X2
81.12
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
81.26

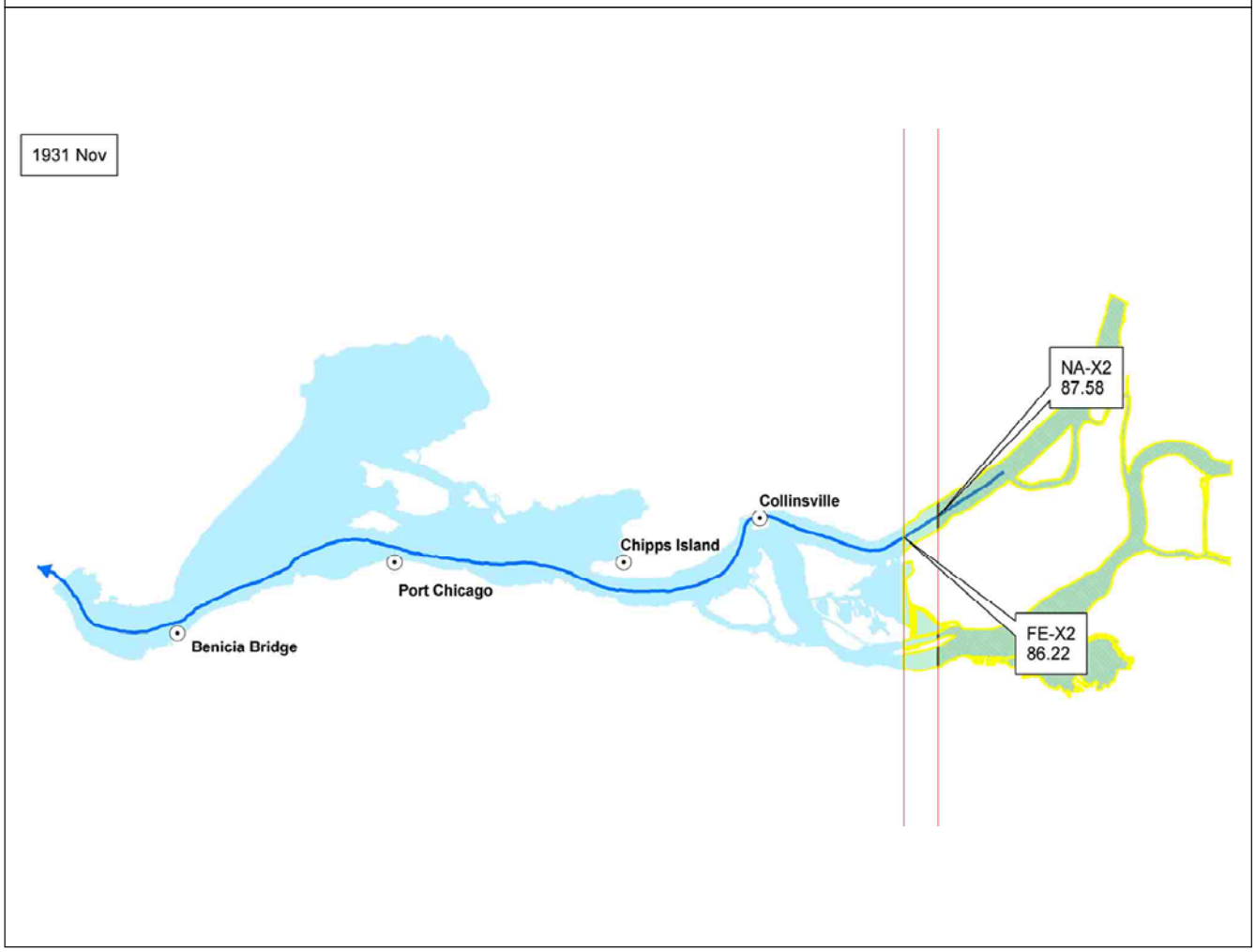

1931 Jun
NA-X2
84.15
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2


1931 Jul
NA-X2
84.61
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
84.21


1931 Aug
NA-X2
86.19
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
83.03

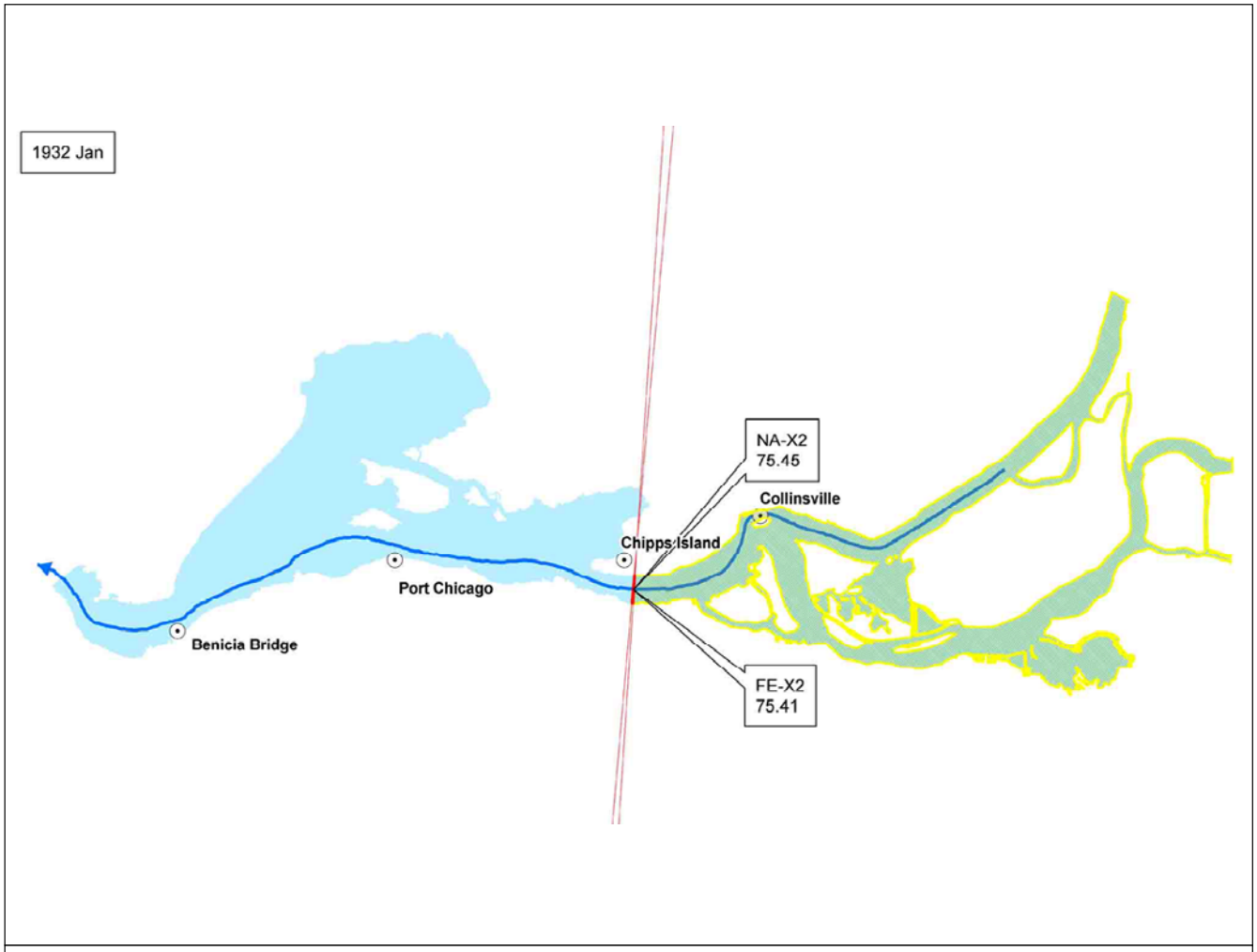

1931 Sep
NA-X2
87.11
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
87.47


1931 Oct
NA-X2
88.35
FE-X2
88.97
Collinsville
Chipps Island
Port Chicago
Benicia Bridge


1931 Nov
NA-X2
87.58
FE-X2
86.22
Collinsville
Chipps Island
Port Chicago
Benicia Bridge


1931 Dec
NA-X2
84.59
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
85.64


1931 average
NA-X2
83.85
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
84.01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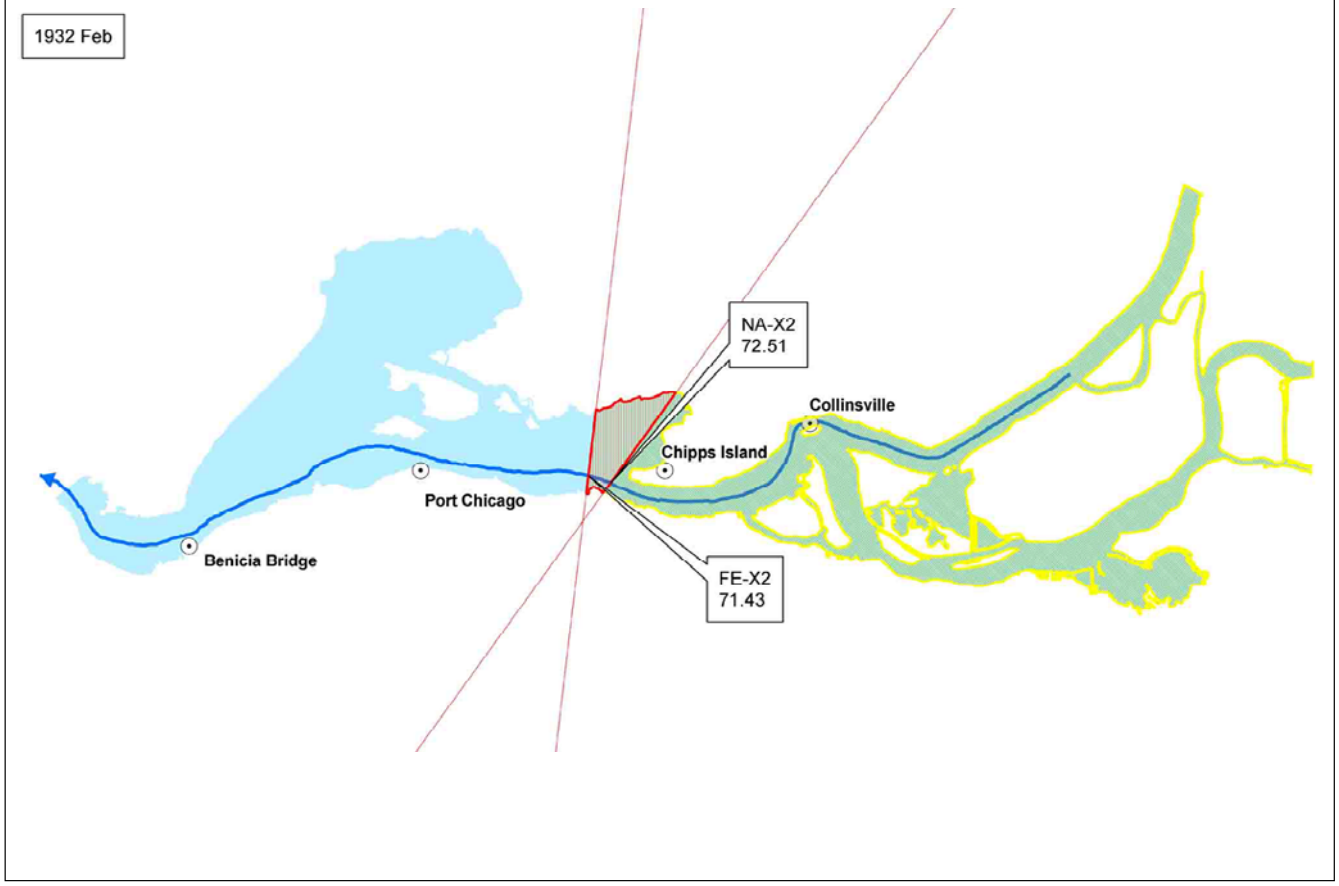
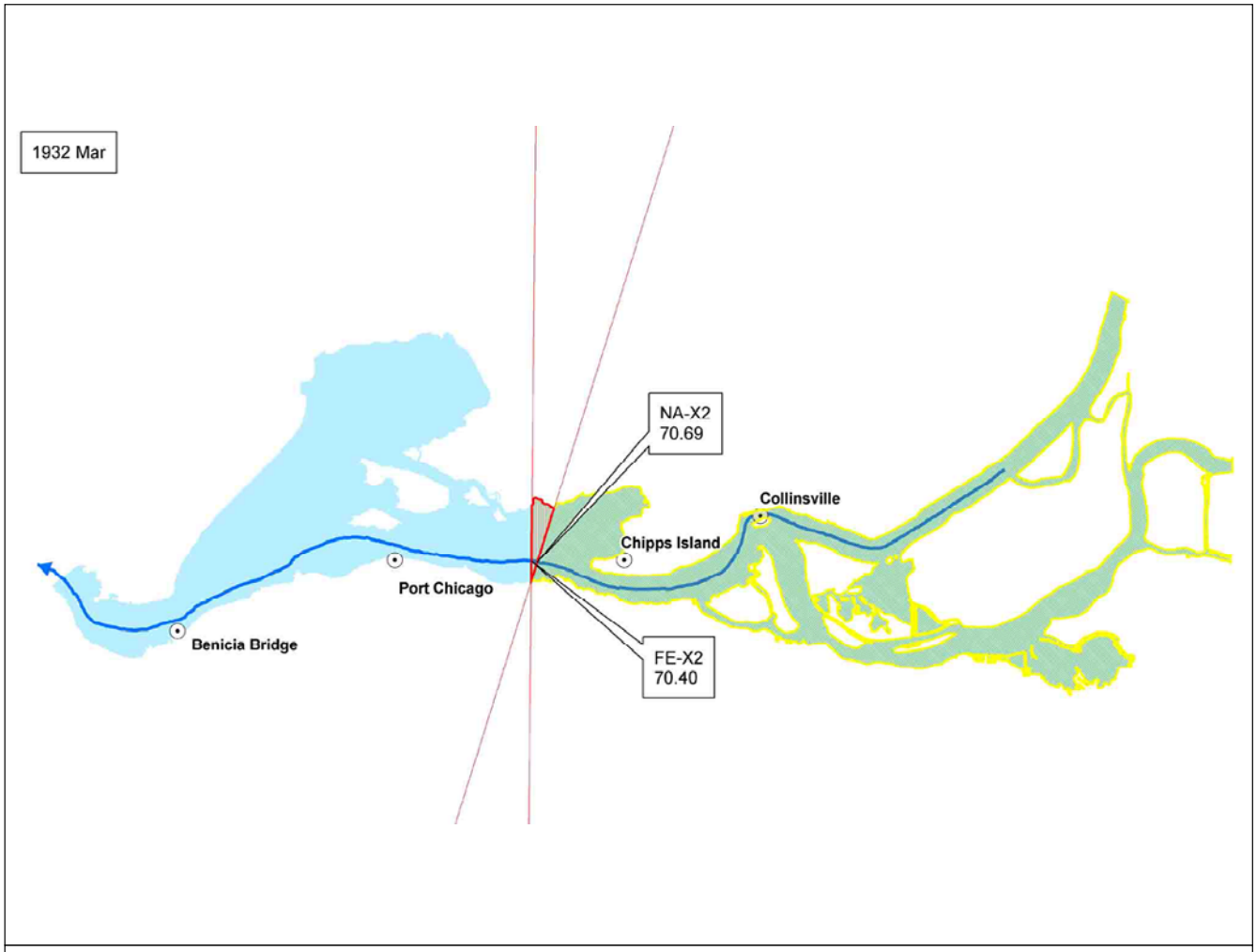
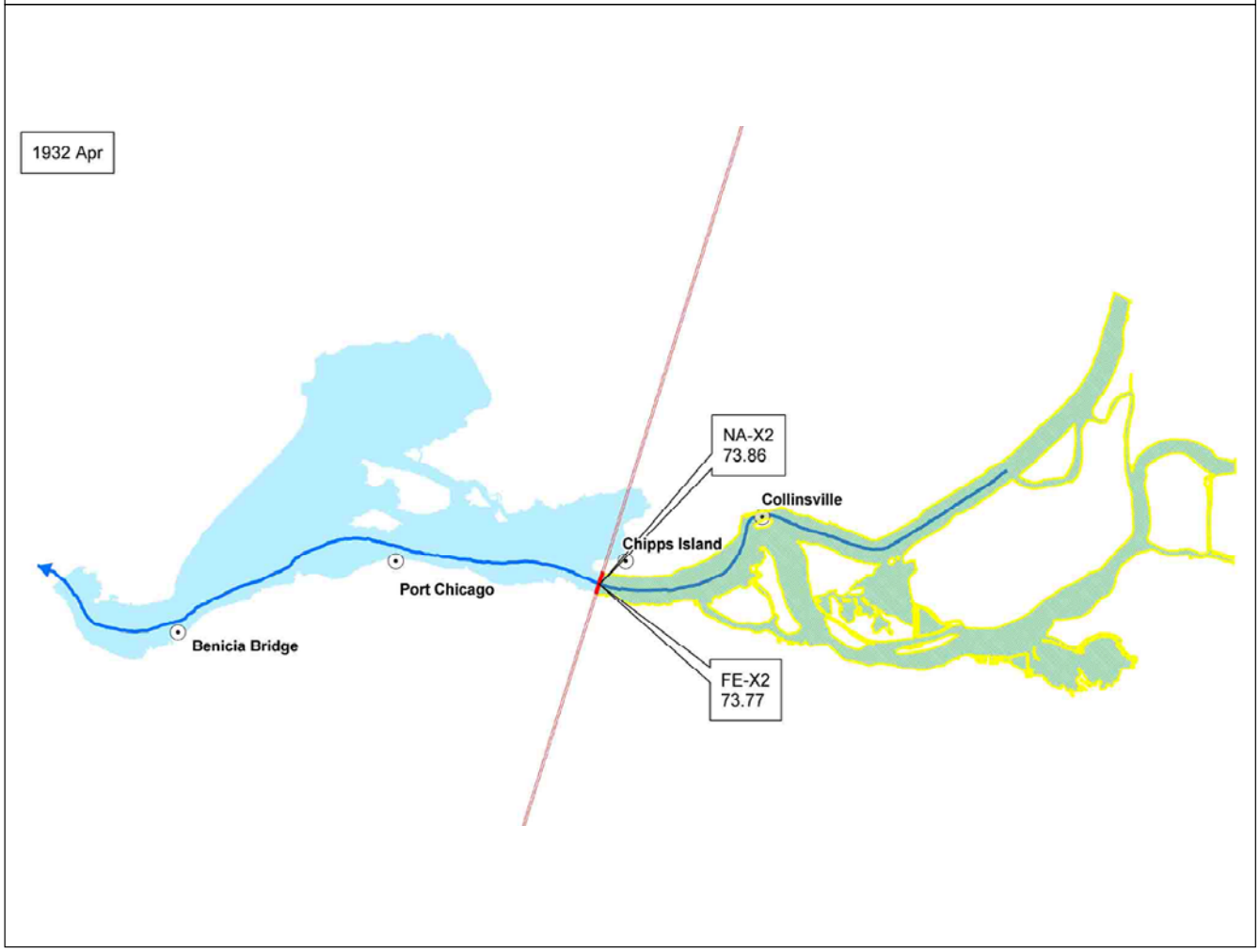
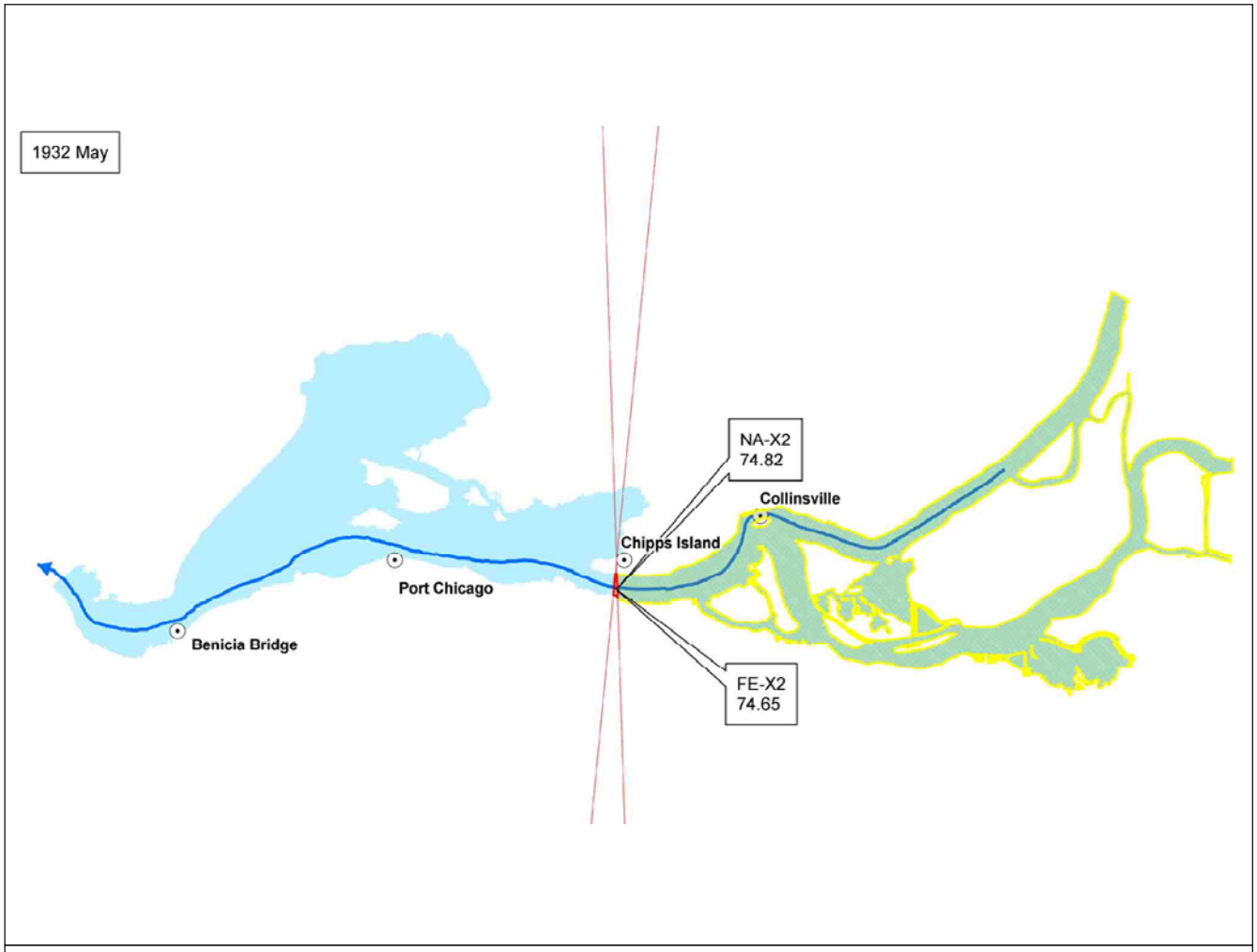
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
75.41


1932 Feb
NA-X2
72.51
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
71.43


1932 Mar
NA-X2
70.69
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
70.40


1932 Apr
NA-X2
73.86
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
73.77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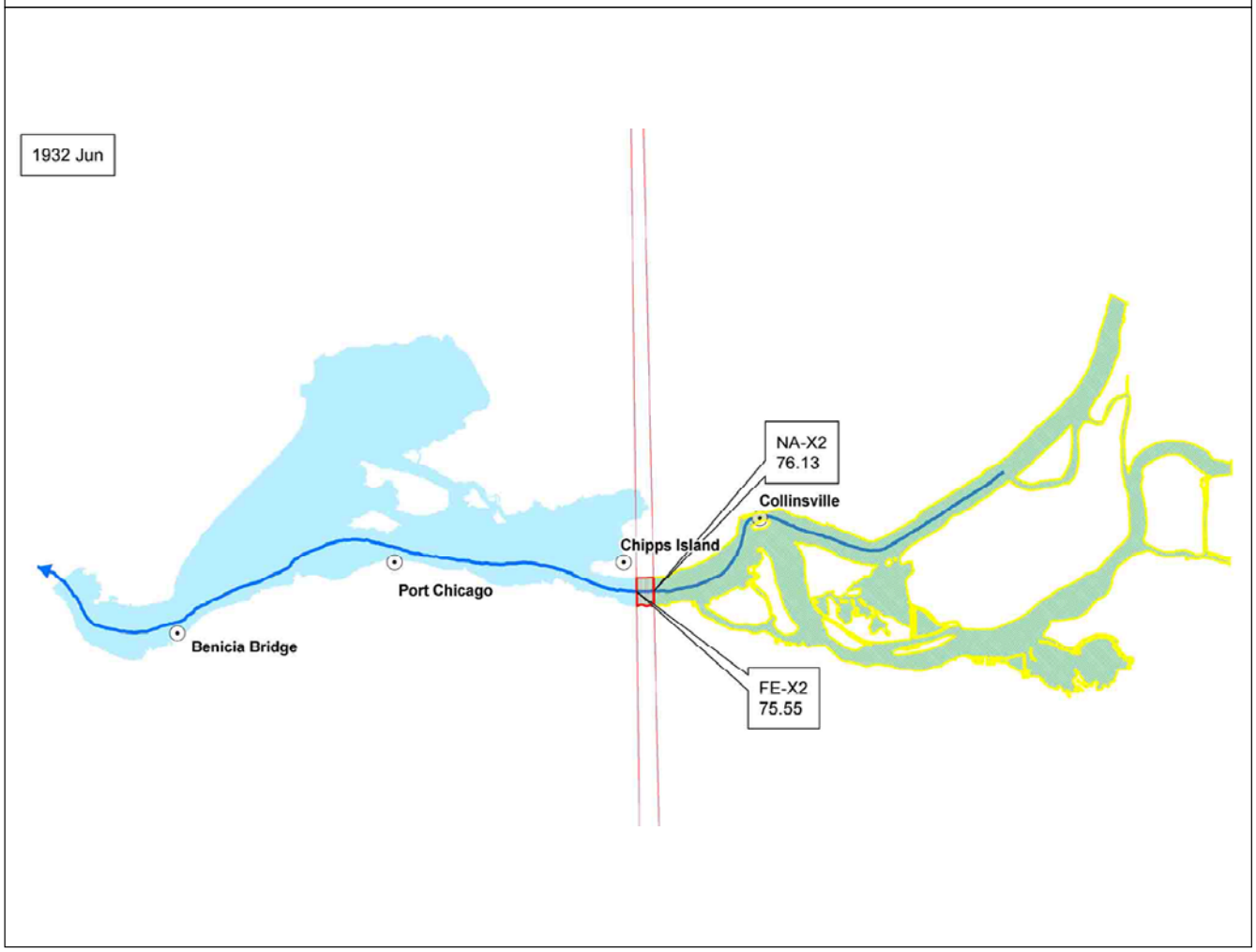
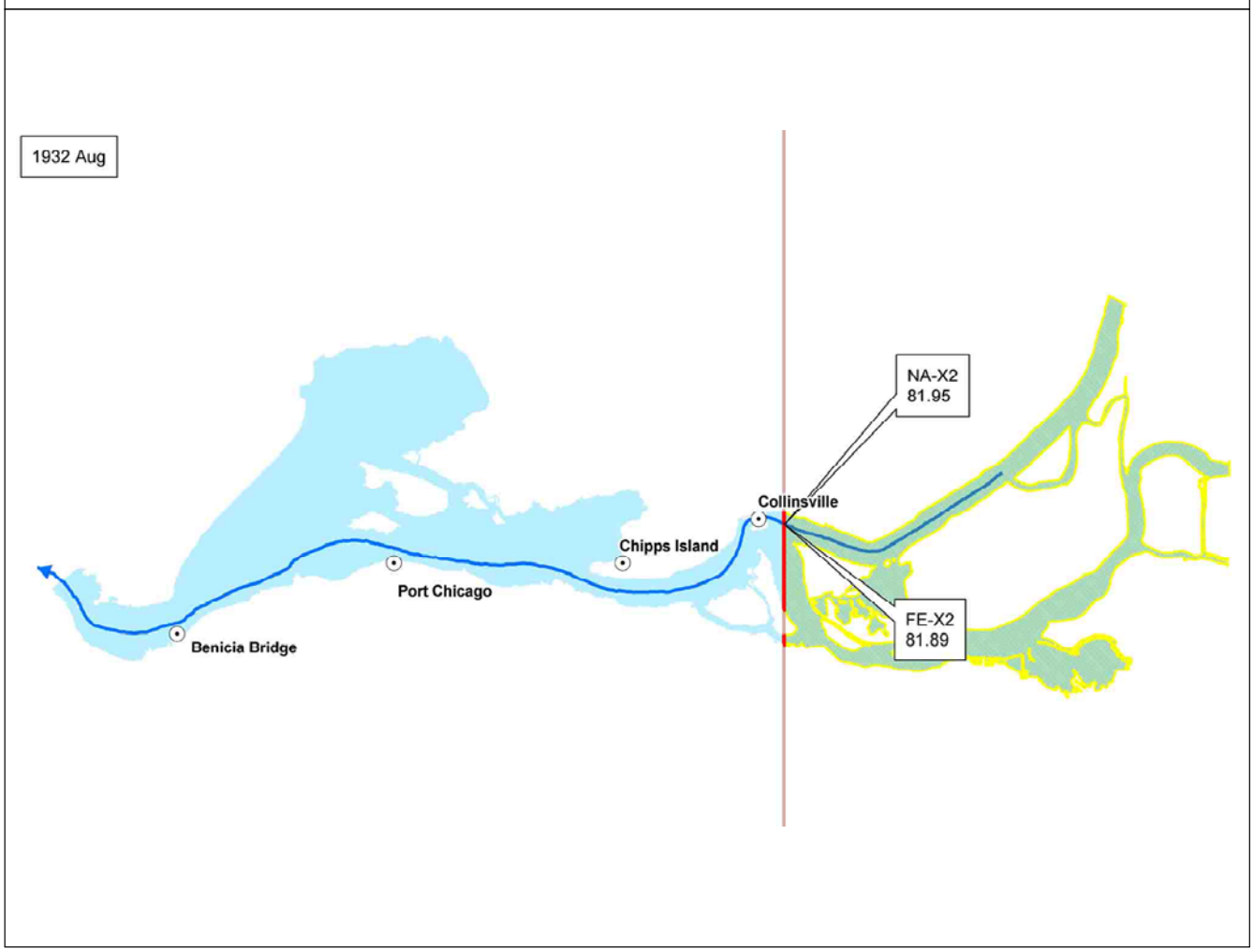
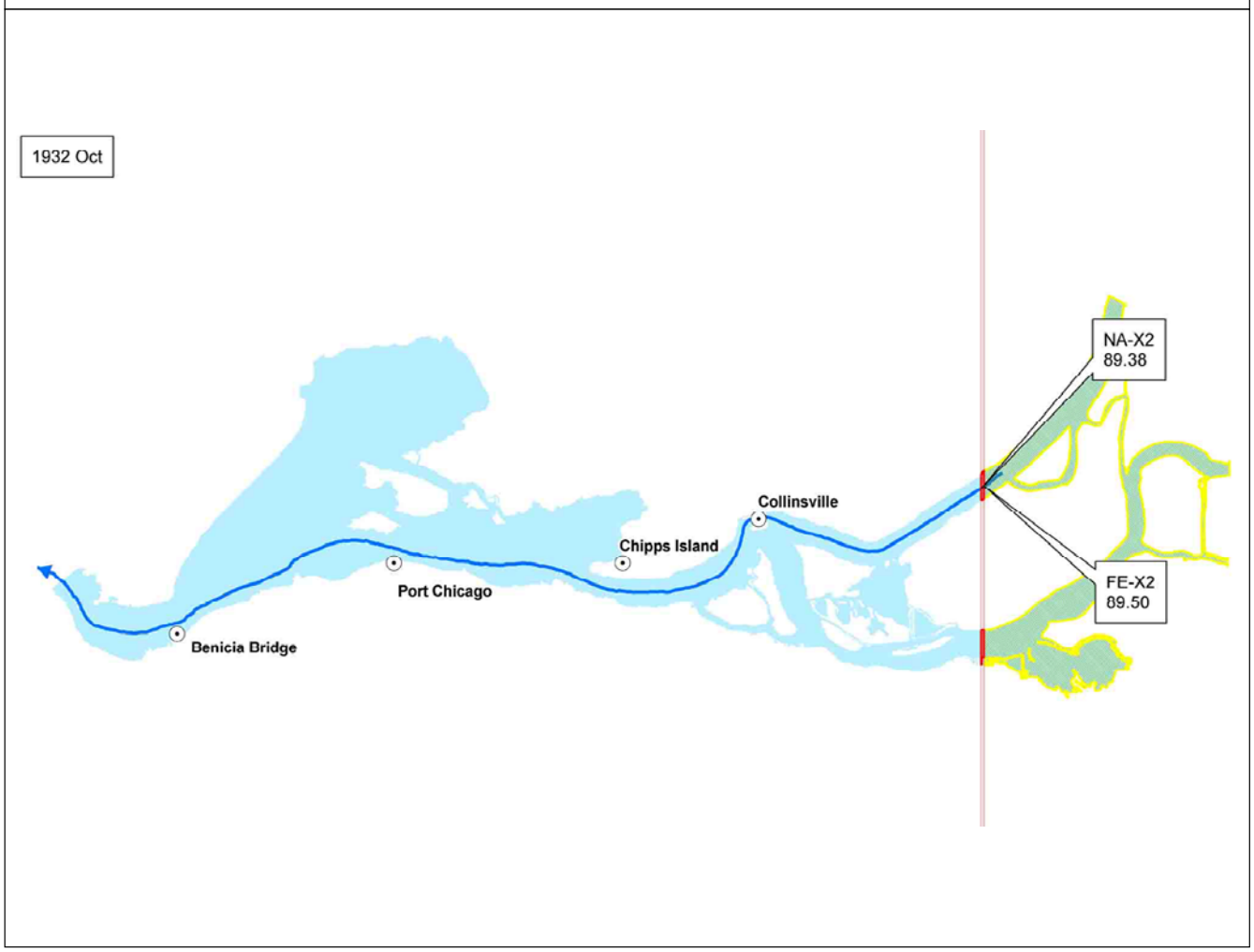
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
74.65


1932 Jun
NA-X2
76.13
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
75.55


1932 Jul
NA-X2
76.39
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
76.21


1932 Aug
NA-X2
81.95
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
81.89


1932 Sep
NA-X2
83.94
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
84.29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NA-X2
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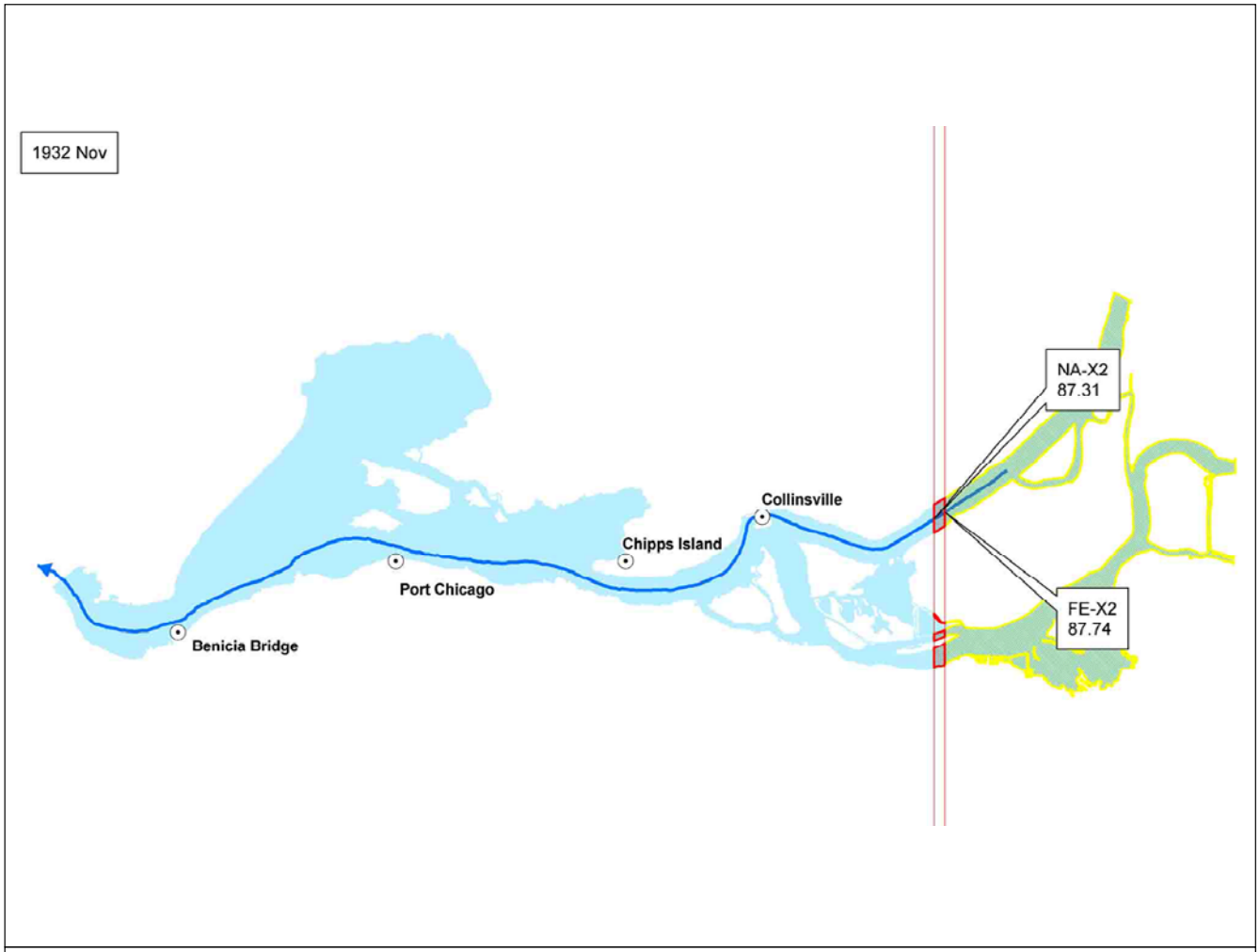
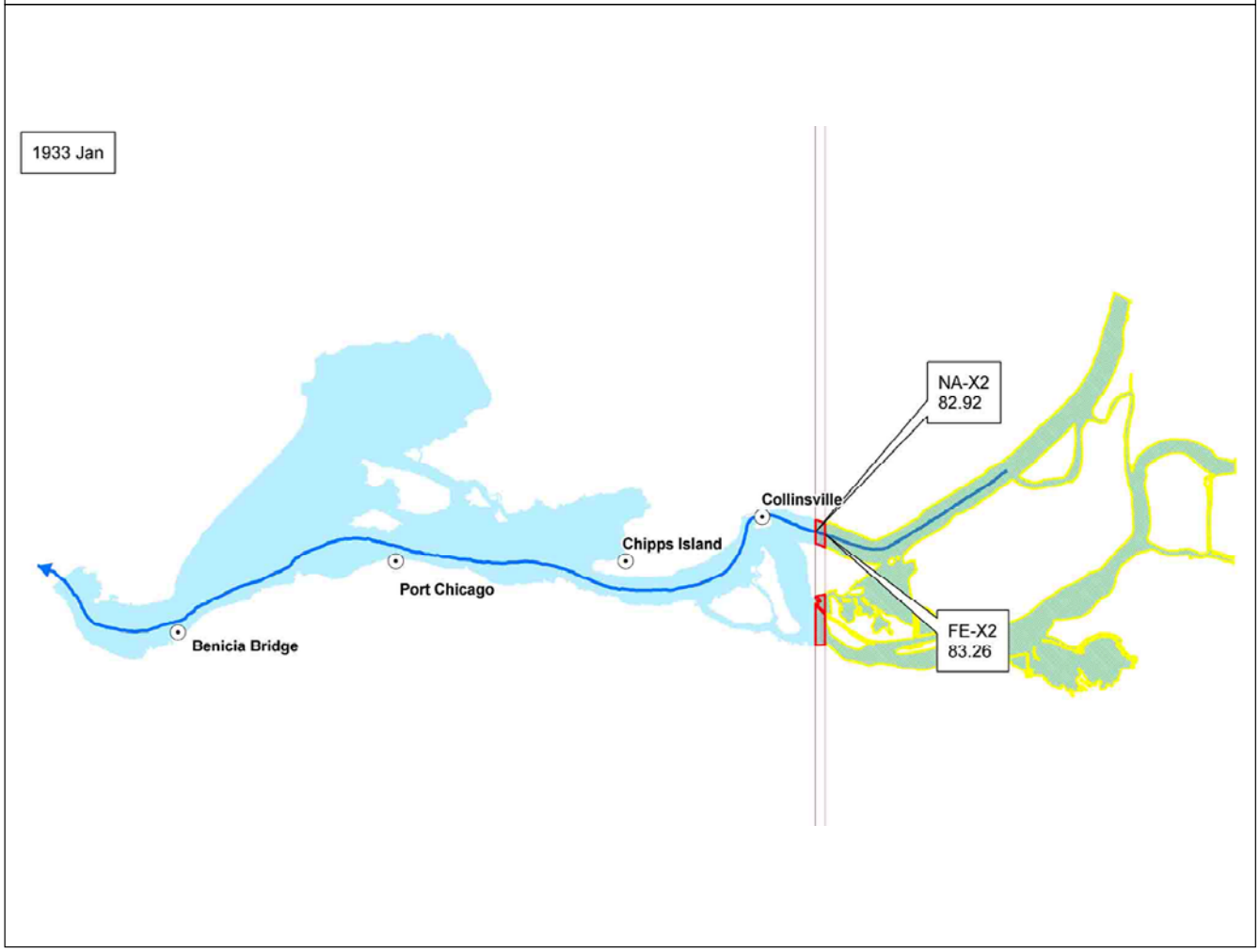
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
89.50


1932 Nov
NA-X2
87.31
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
87.74


1932 Dec
NA-X2
85.74
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
85.58

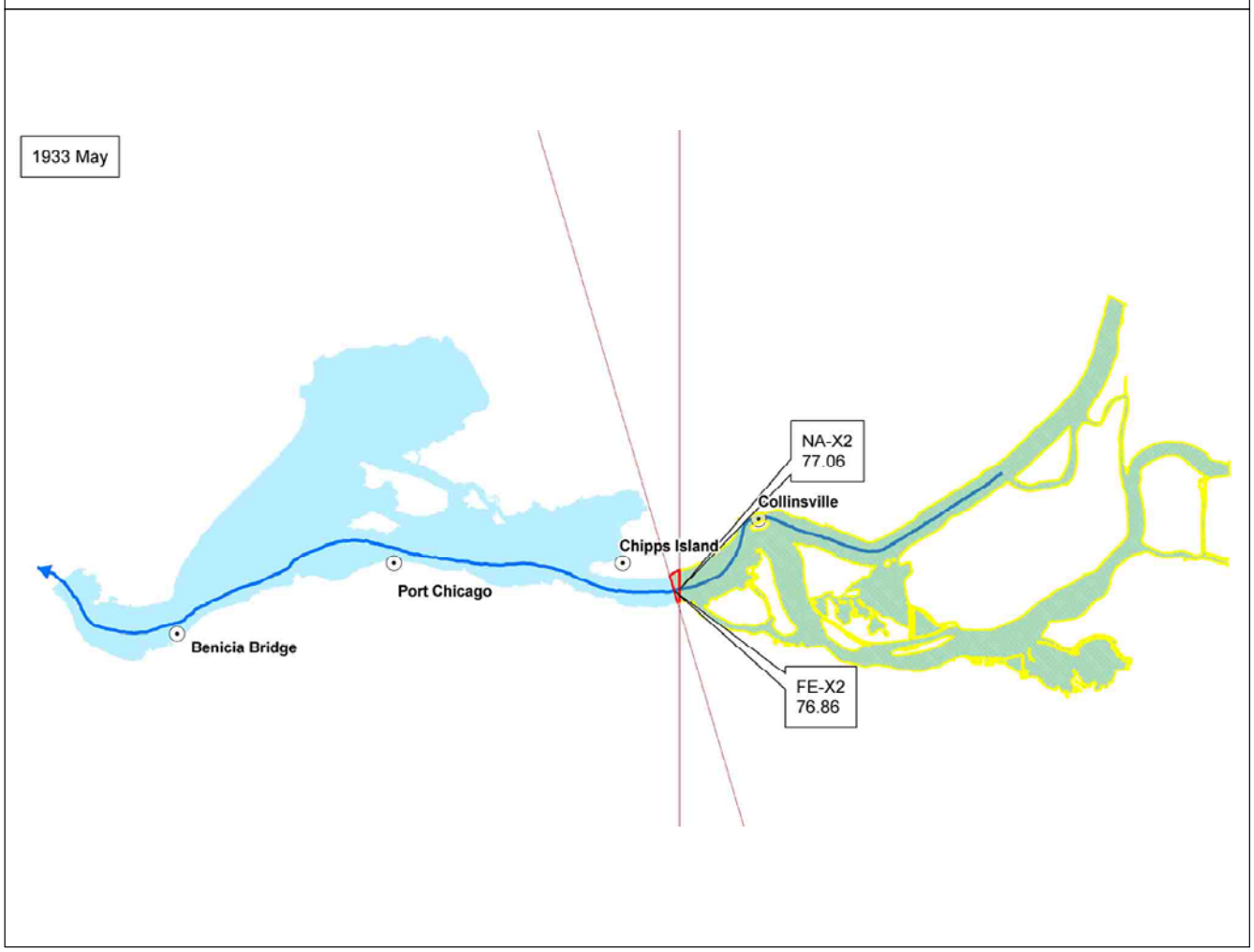

1932 average
NA-X2
79.01
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
78.87


1933 Jan
NA-X2
82.92
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
83.26

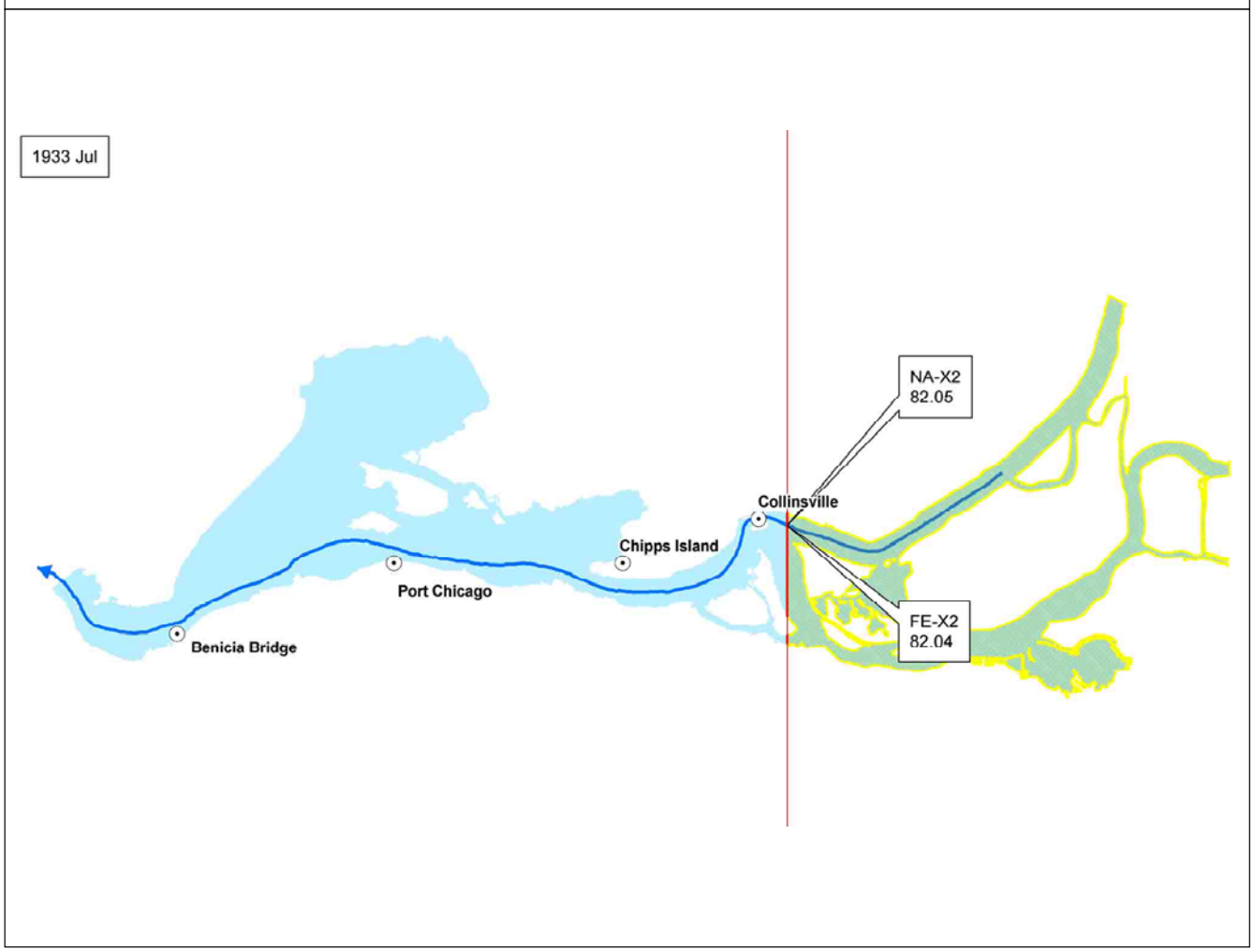

1933 Feb
NA-X2
76.74
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
79.28


1933 Mar
NA-X2
79.10
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
77.22


1933 Apr
NA-X2
77.77
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
77.16


1933 May
NA-X2
77.06
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
76.86


1933 Jun
NA-X2
81.13
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
81.09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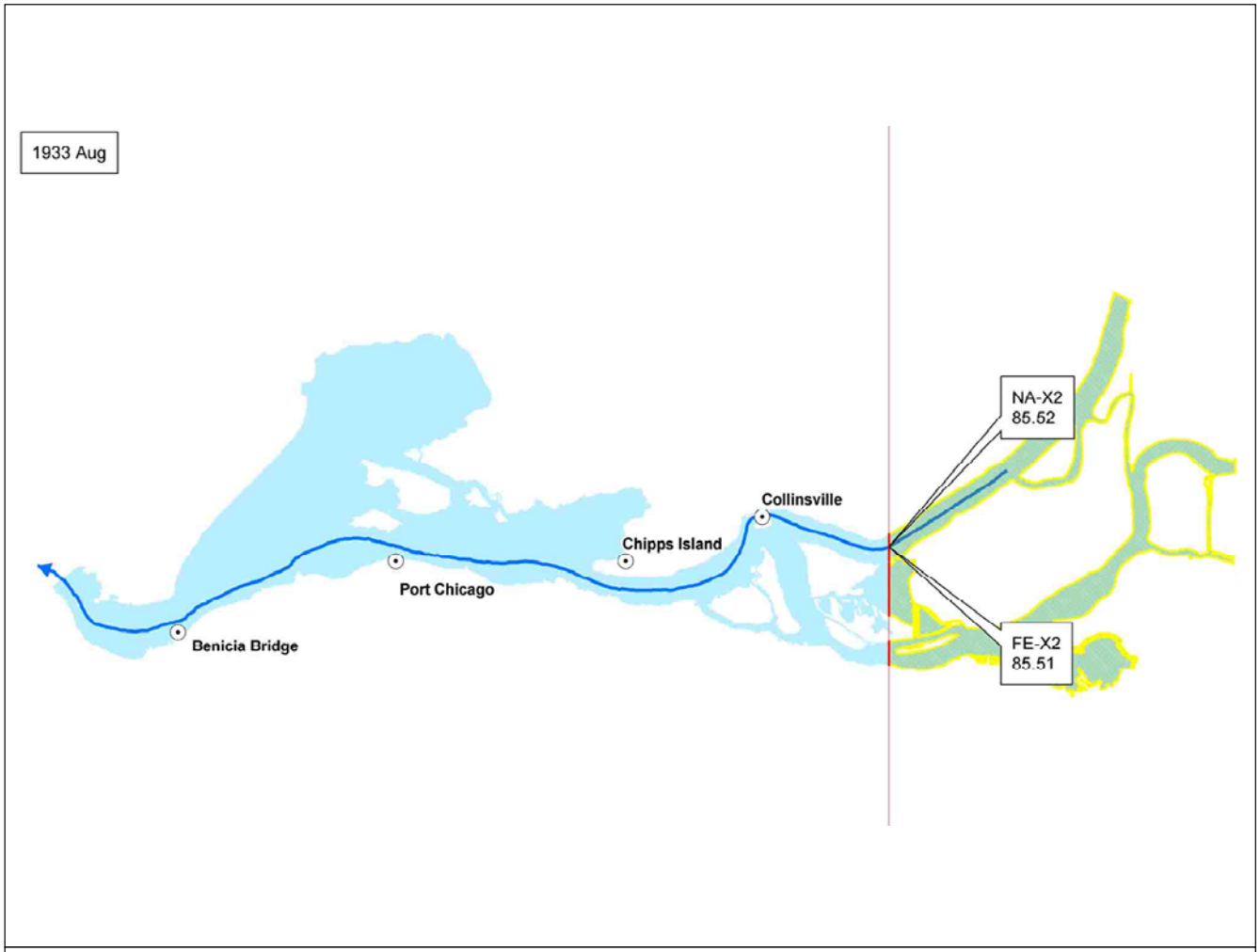
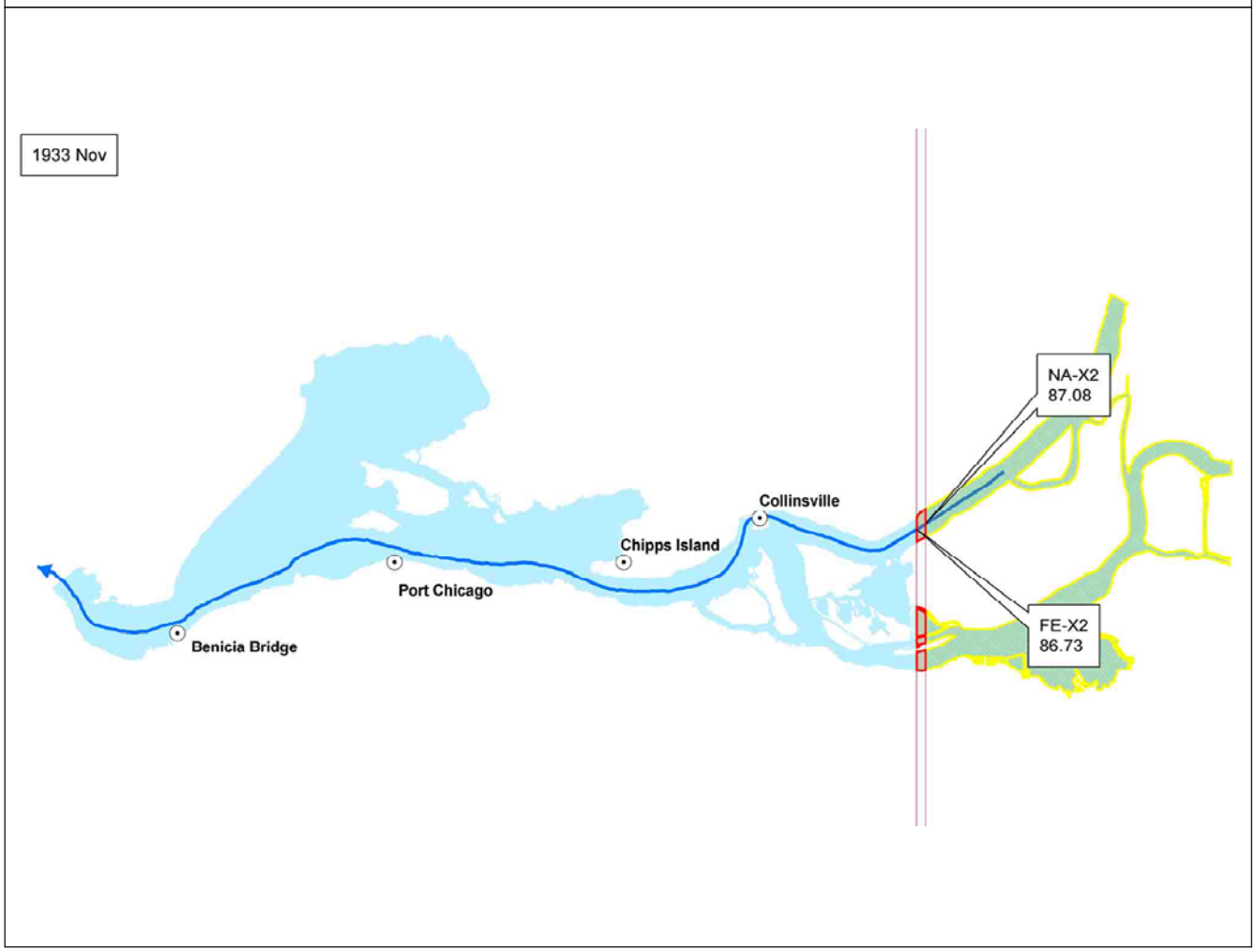
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
82.04


1933 Aug
NA-X2
85.52
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
85.51


1933 Sep
NA-X2
84.97
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
84.90


1933 Oct
NA-X2
88.34
FE-X2
88.46
Collinsville
Chipps Island
Port Chicago
Benicia Bridge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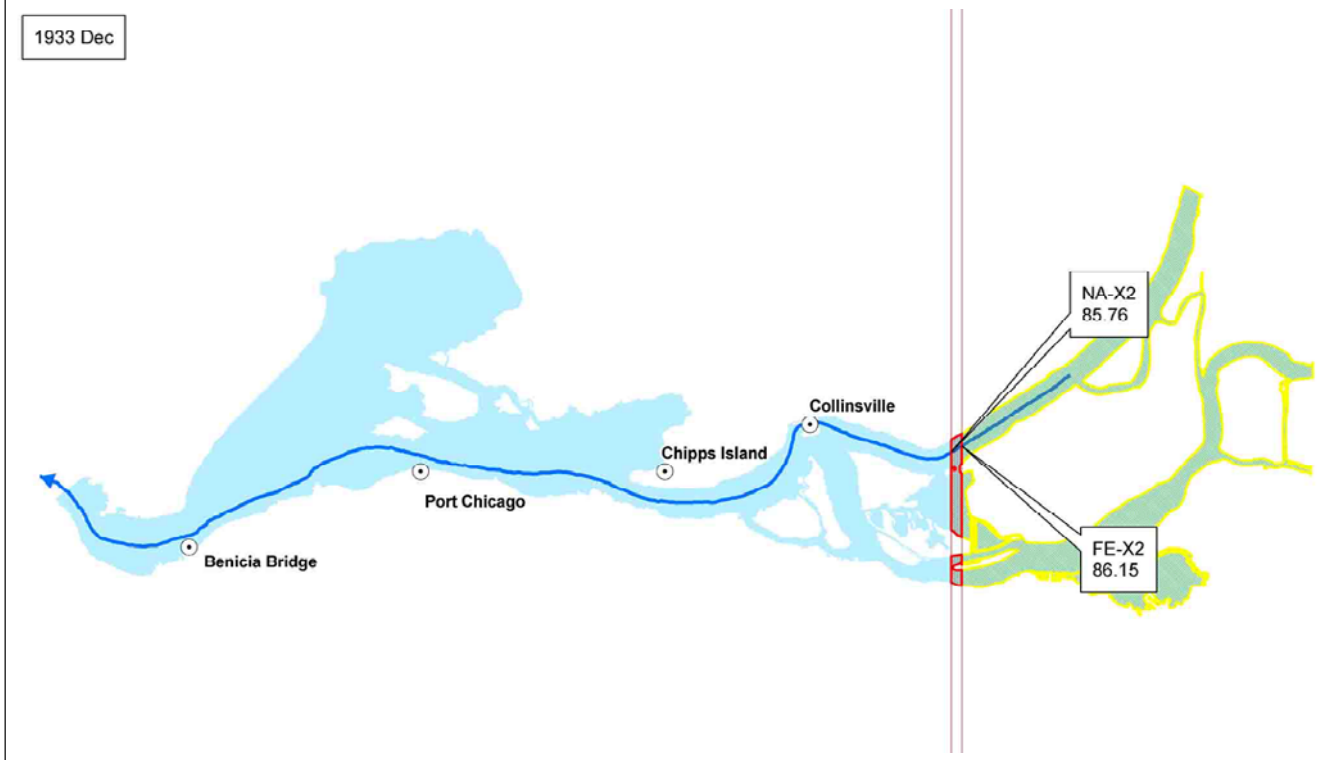
87.08
FE-X2
86.73
Collinsville
Chipps Island
Port Chicago
Benicia Bridge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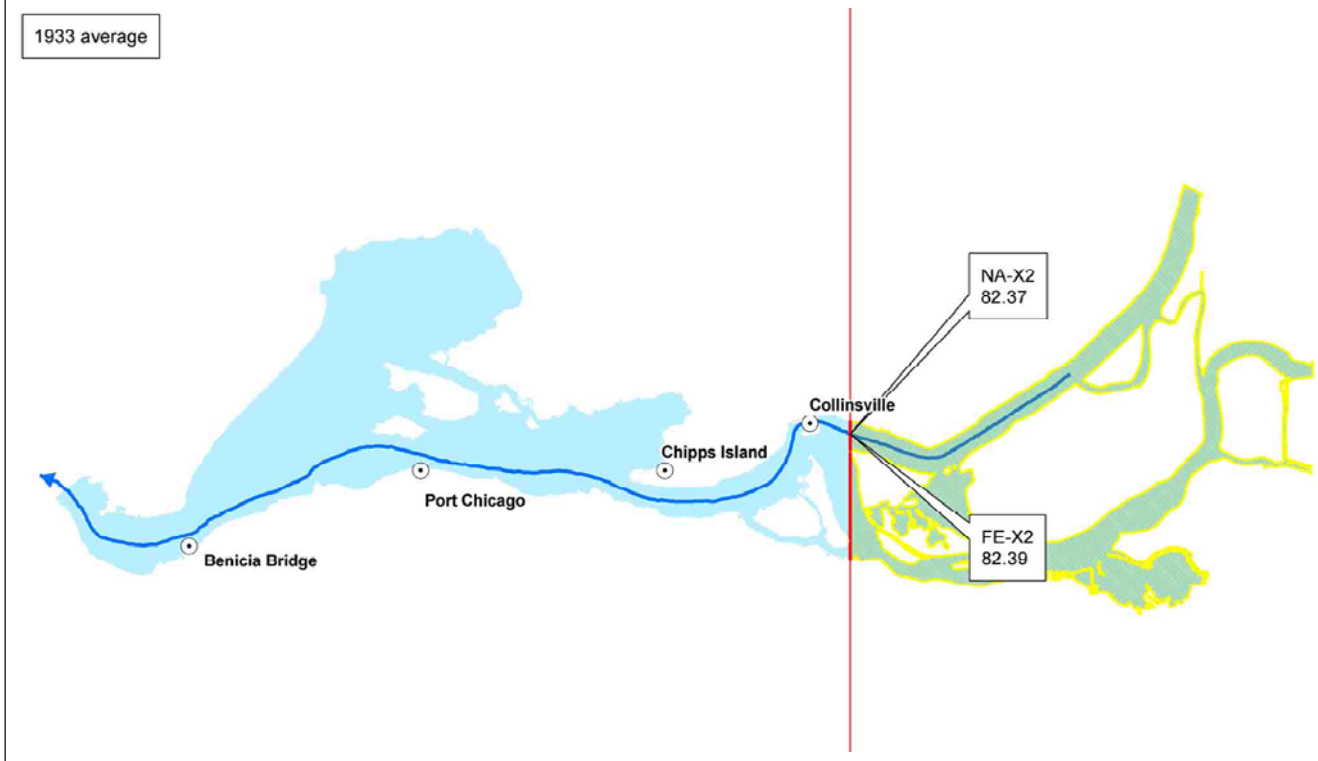
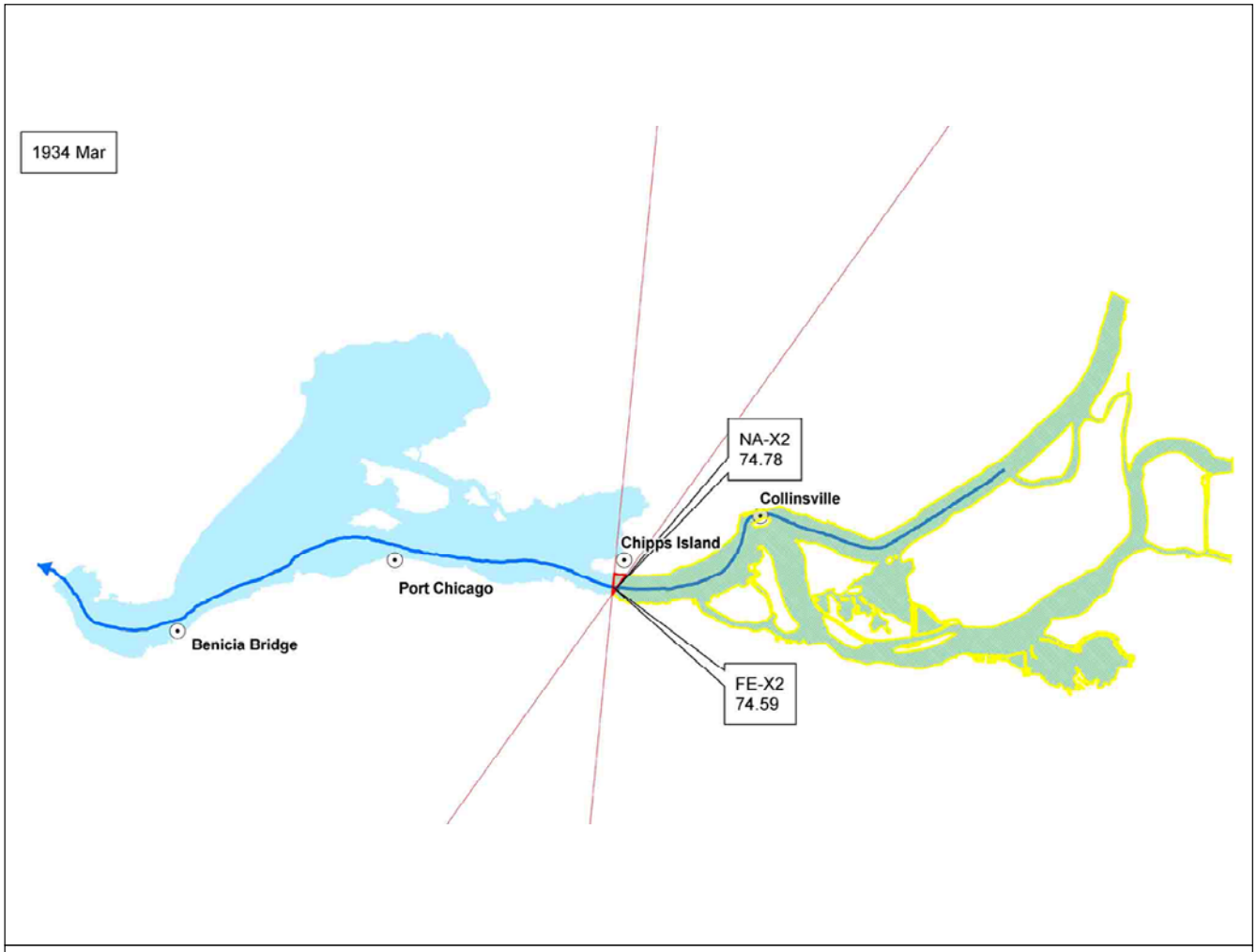
85.76
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
86.15


1933 average
NA-X2
82.37
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
82.39


1934 Jan
NA-X2
81.05
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
81.32


1934 Feb
NA-X2
76.48
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
75.90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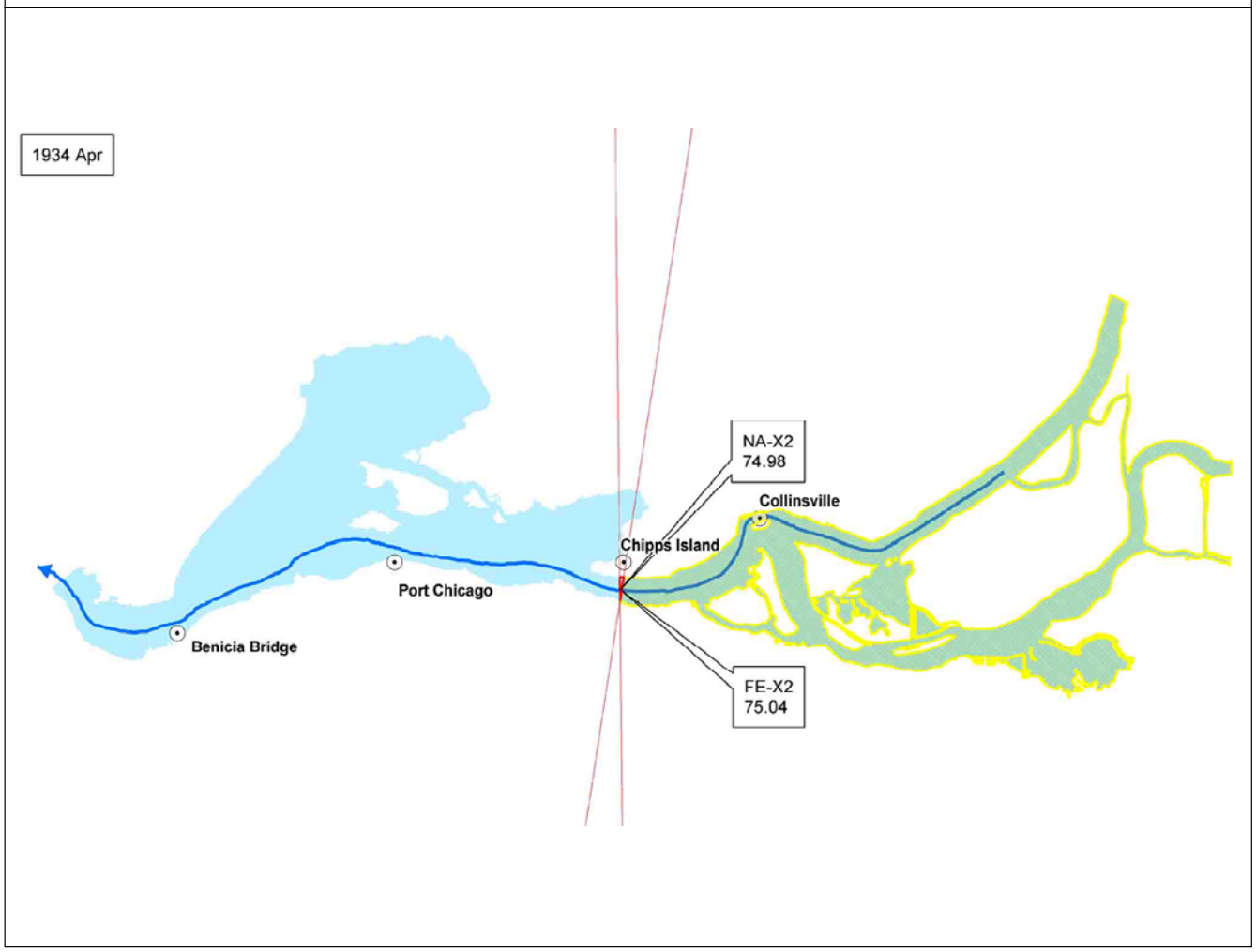
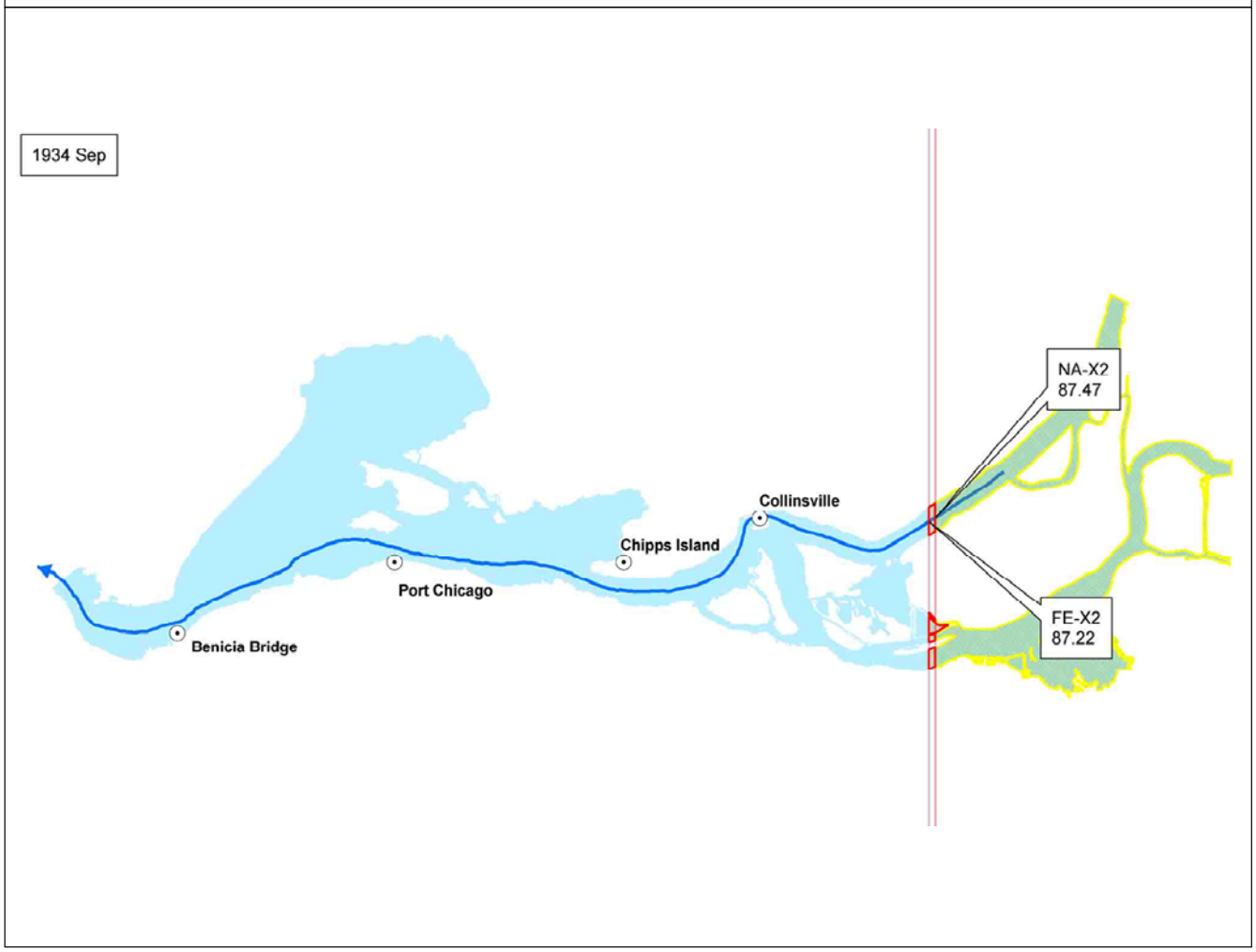
NA-X2
74.78
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
74.59


1934 Apr
NA-X2
74.98
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
75.04


1934 May
NA-X2
76.18
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
76.20


1934 Sep
NA-X2
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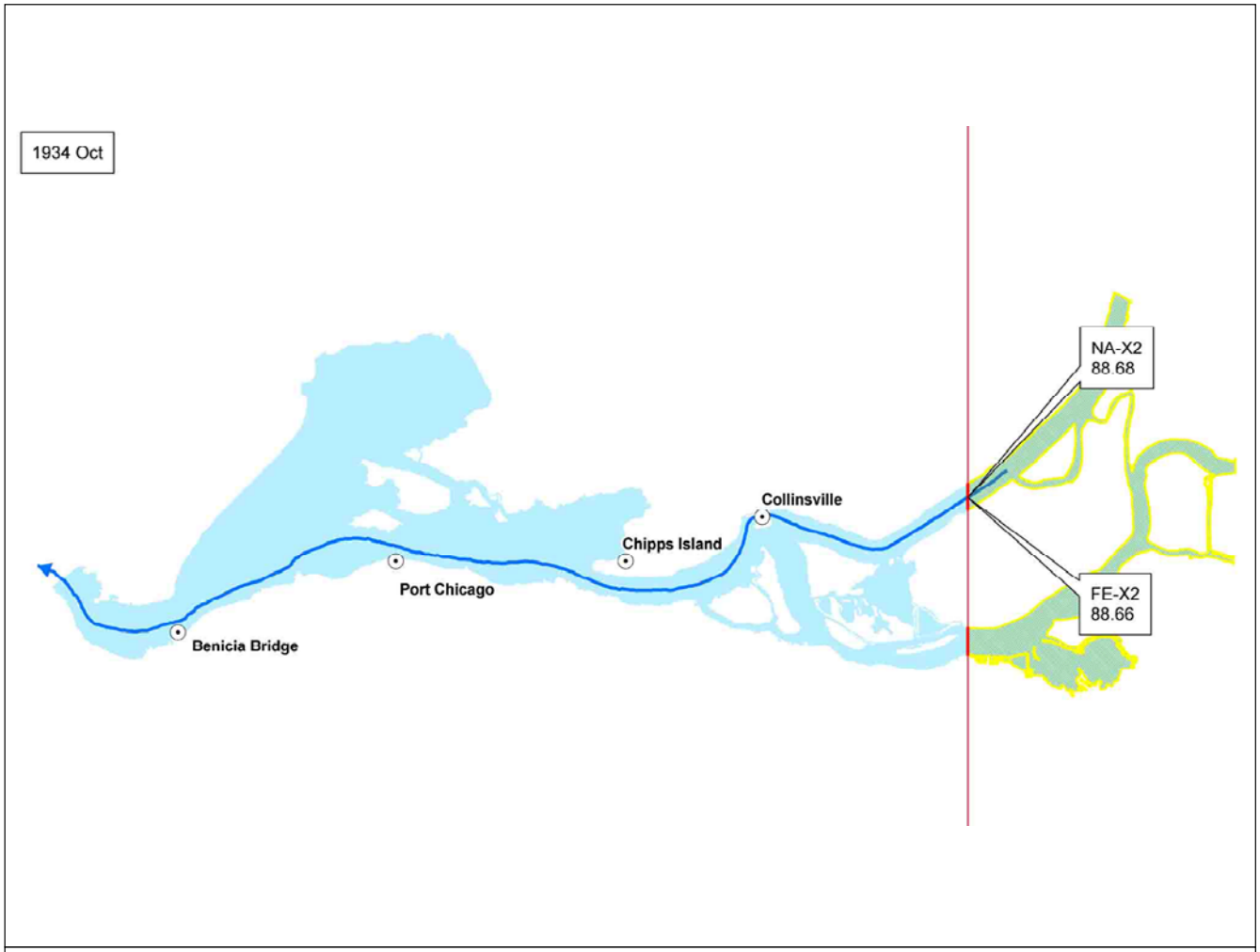
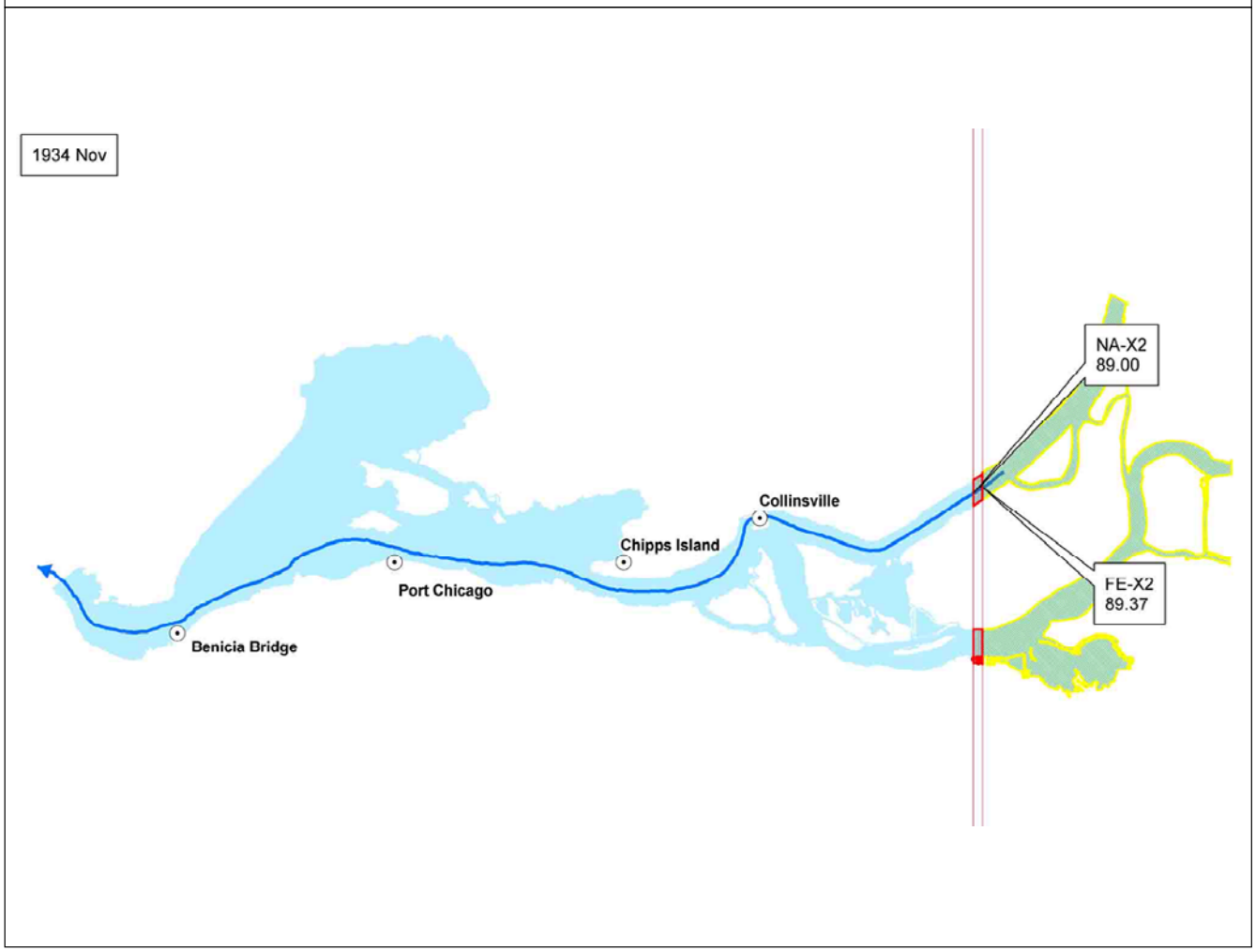
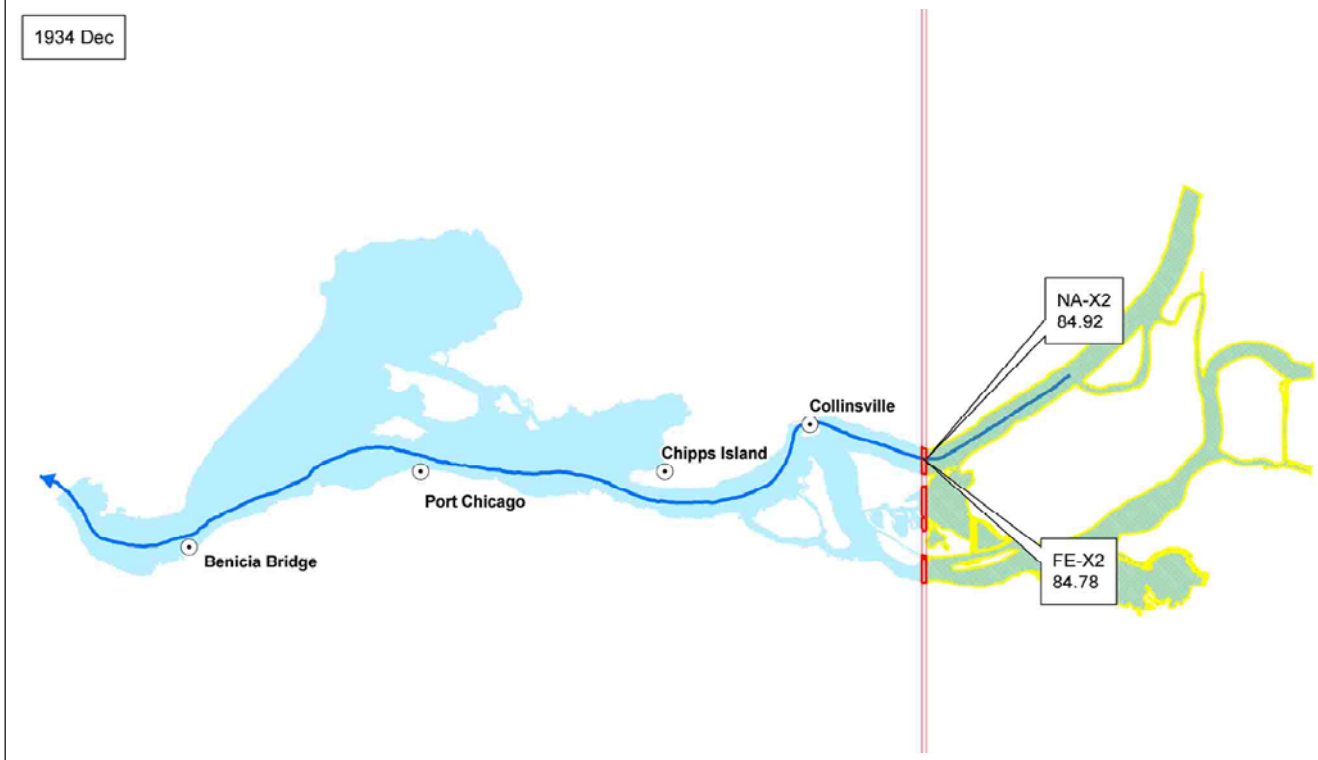
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
87.22


1934 Oct
NA-X2
88.68
FE-X2
88.66
Collinsville
Chipps Island
Port Chicago
Benicia Bridge


1934 Nov
NA-X2
89.00
FE-X2
89.37
Collinsville
Chipps Island
Port Chicago
Benicia Bridge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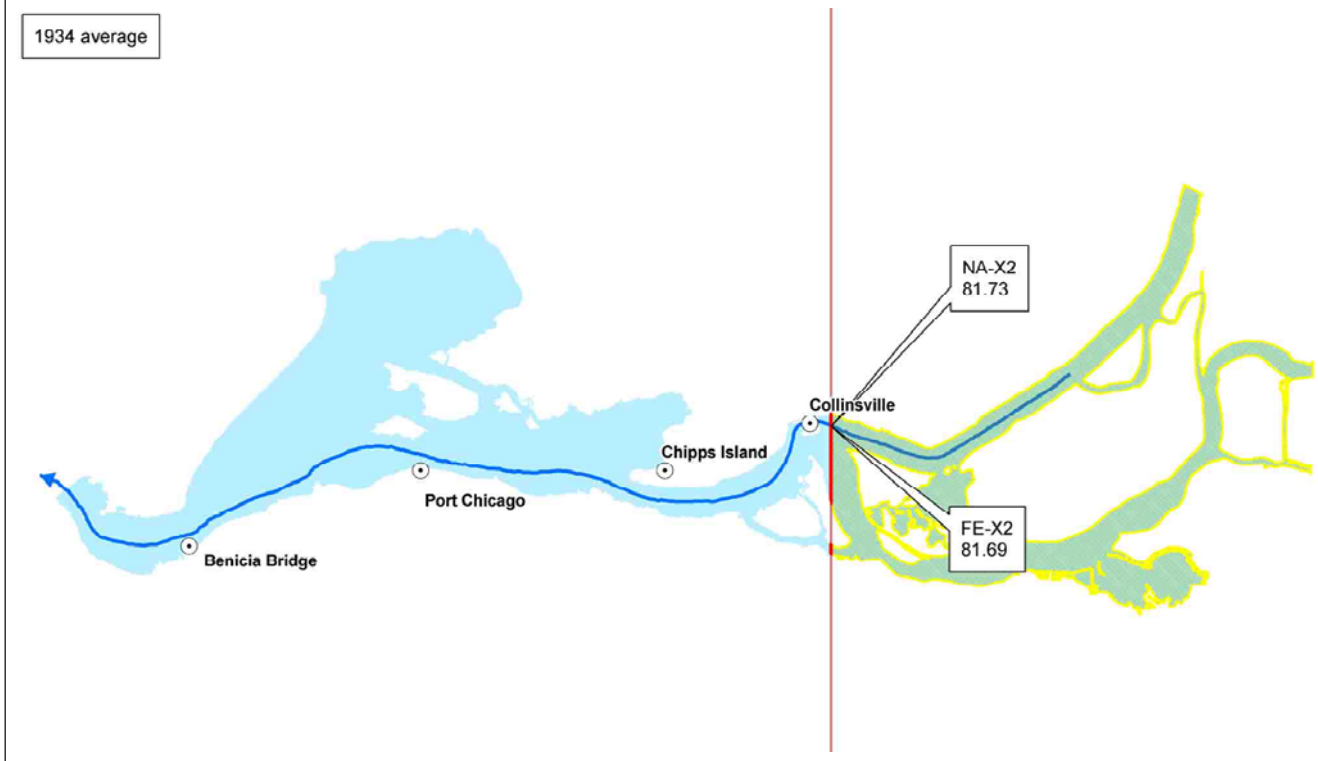
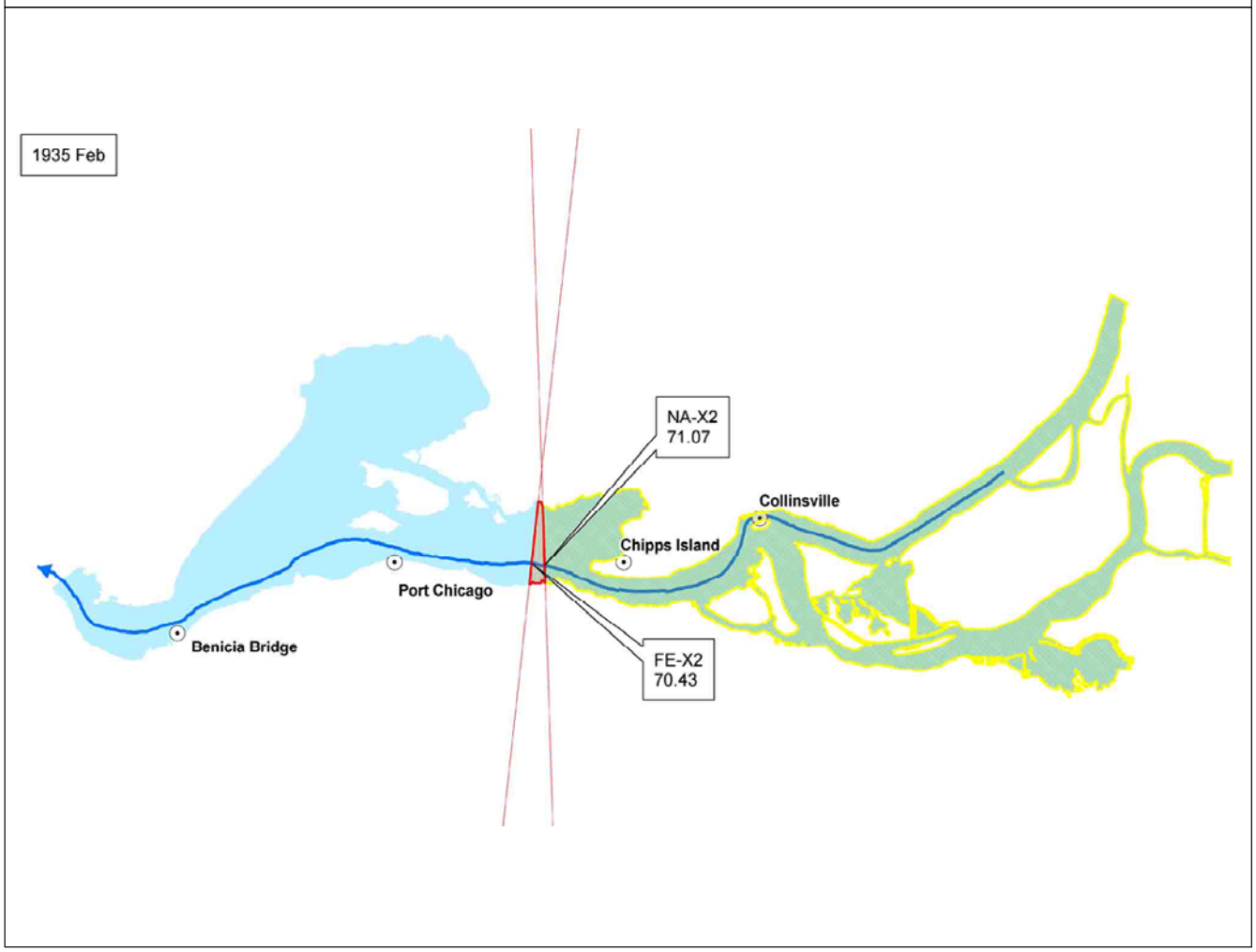
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
84.78


1934 average
NA-X2
81.73
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
81.69


1935 Jan
NA-X2
83.43
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
83.46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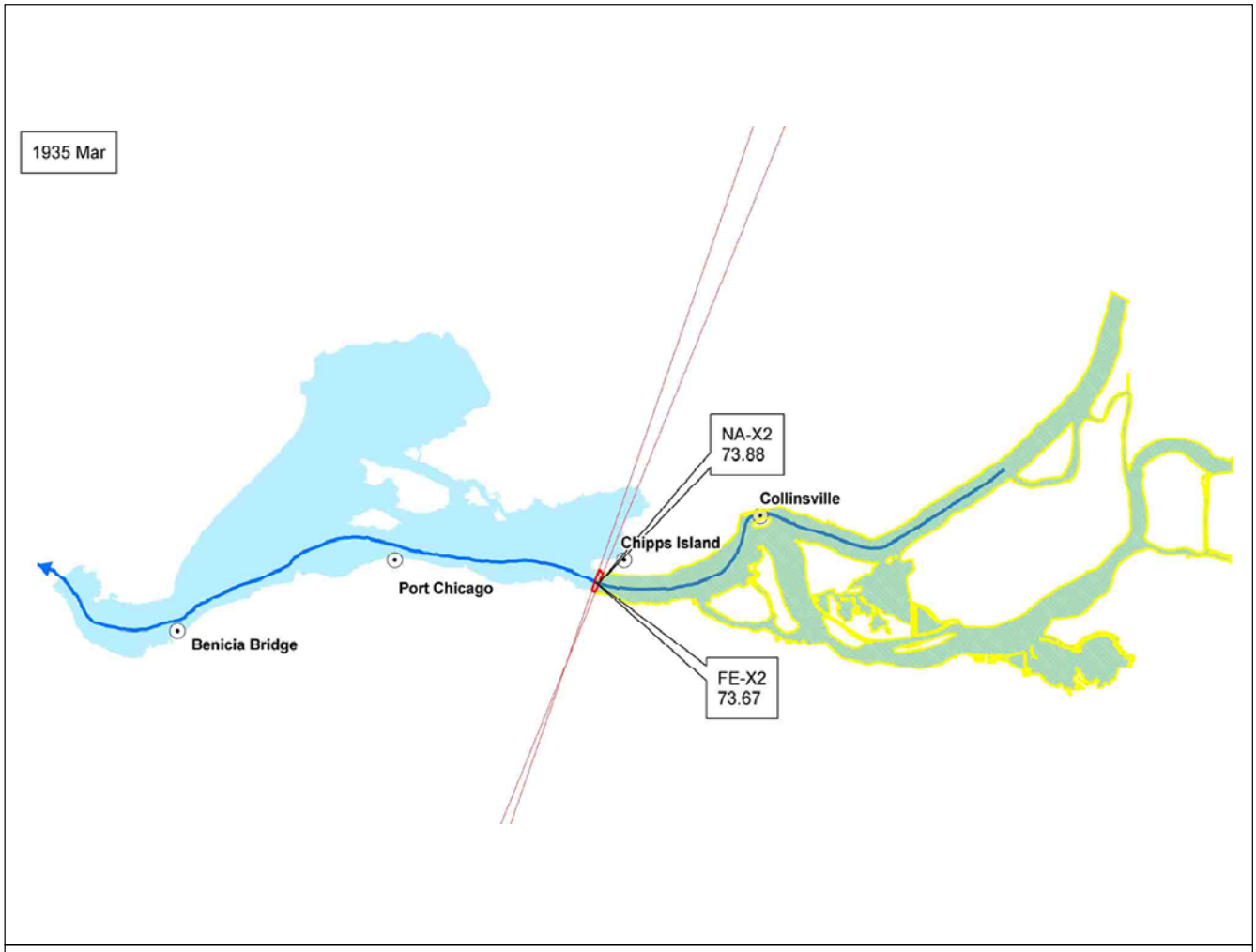
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
70.43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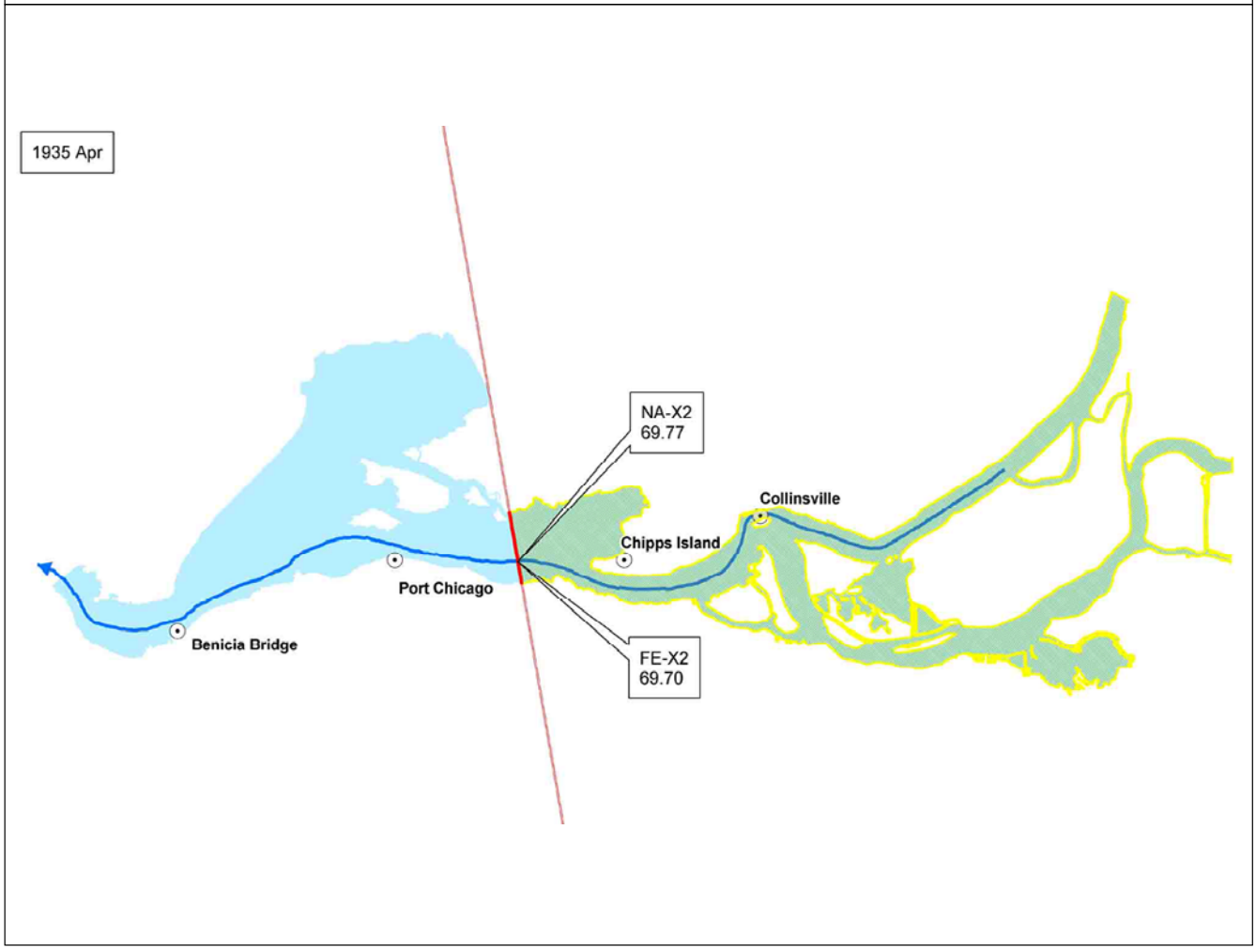
73.88
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
73.67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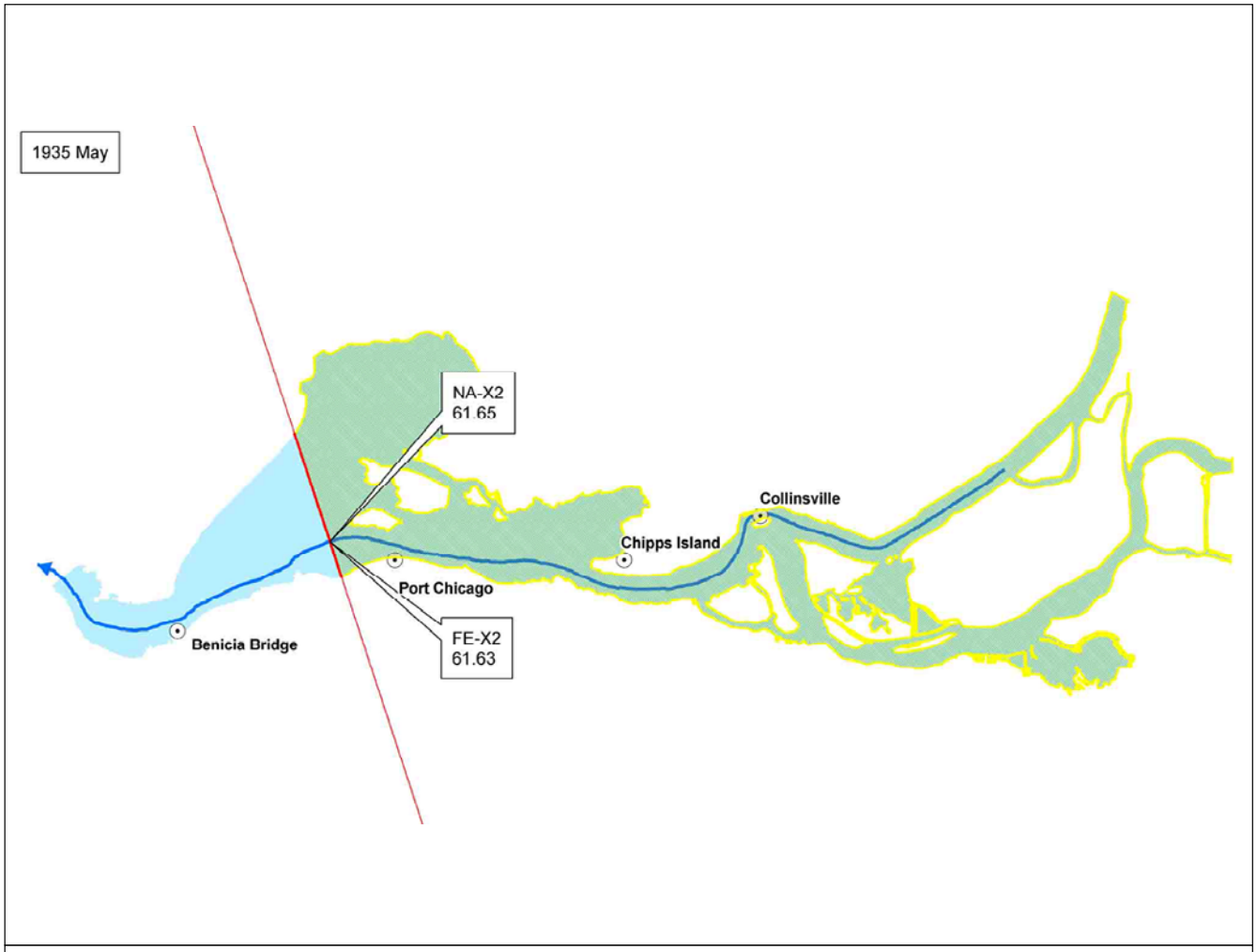
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
69.70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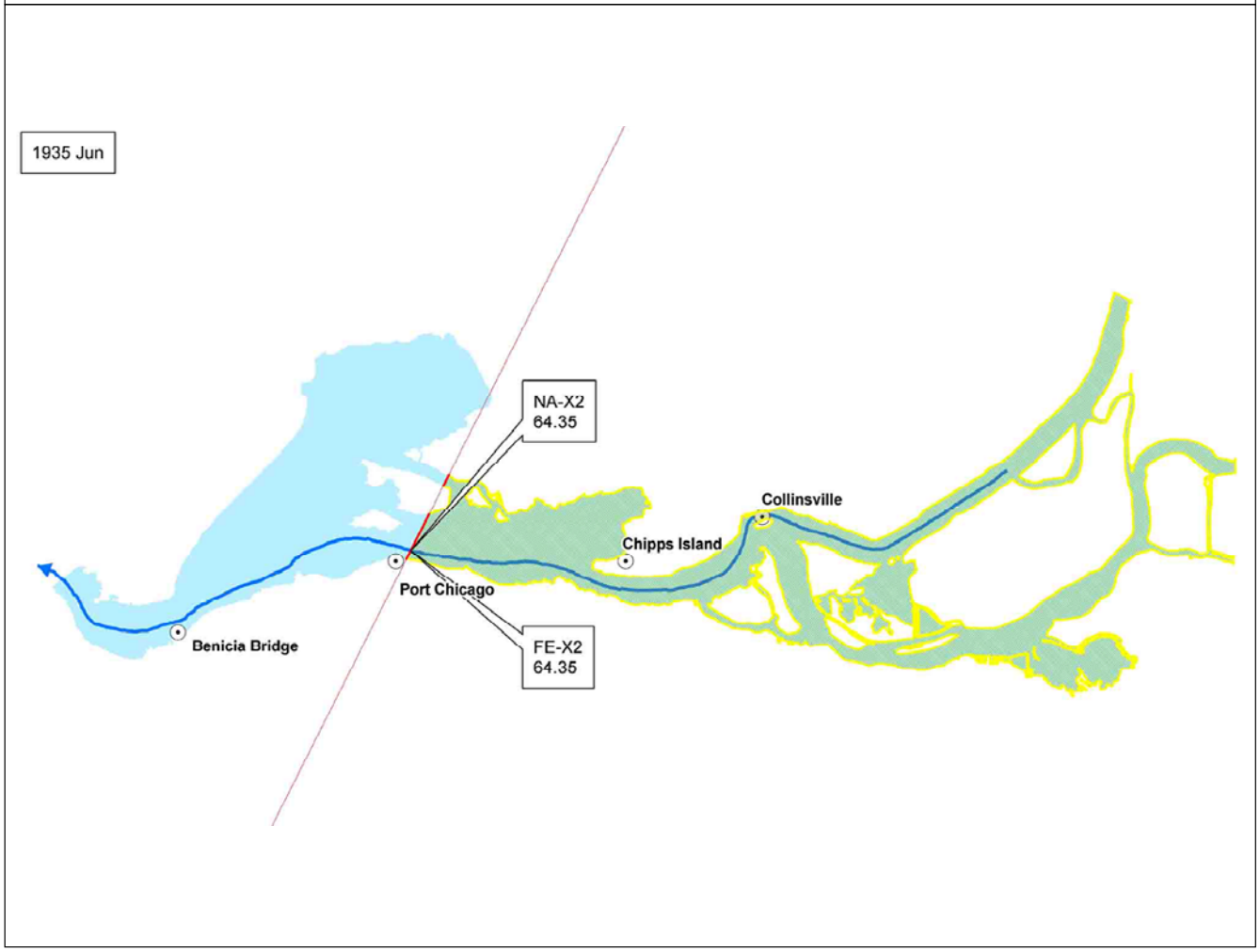
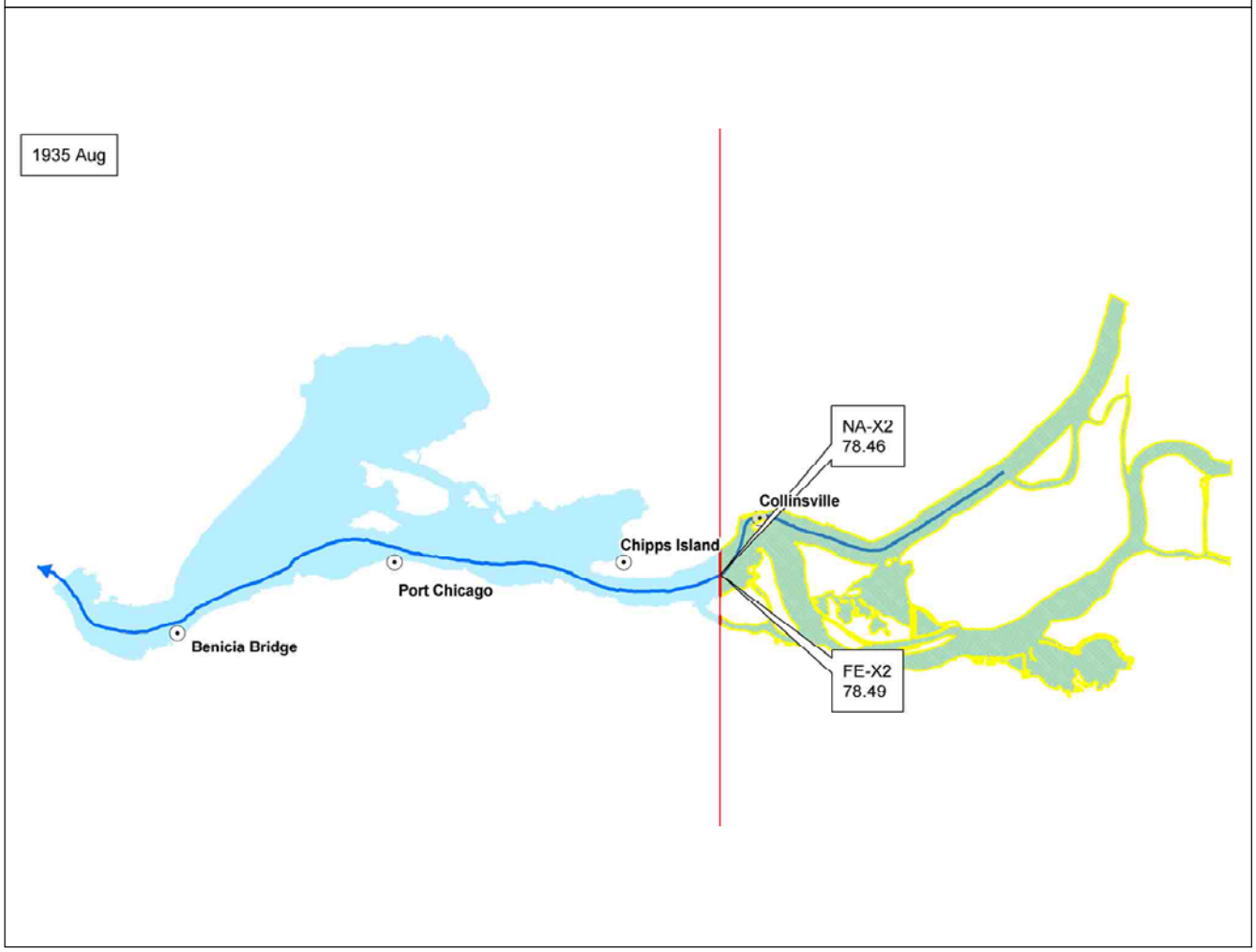
NA-X2
61.65
Collinsville
Chipps Island
Port Chicago
FE-X2
61.63
Benicia Bridge


1935 Jun
NA-X2
64.35
Collinsville
Chipps Island
Port Chicago
FE-X2
64.35
Benicia Bridge


1935 Jul
NA-X2
71.89
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
71.98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NA-X2
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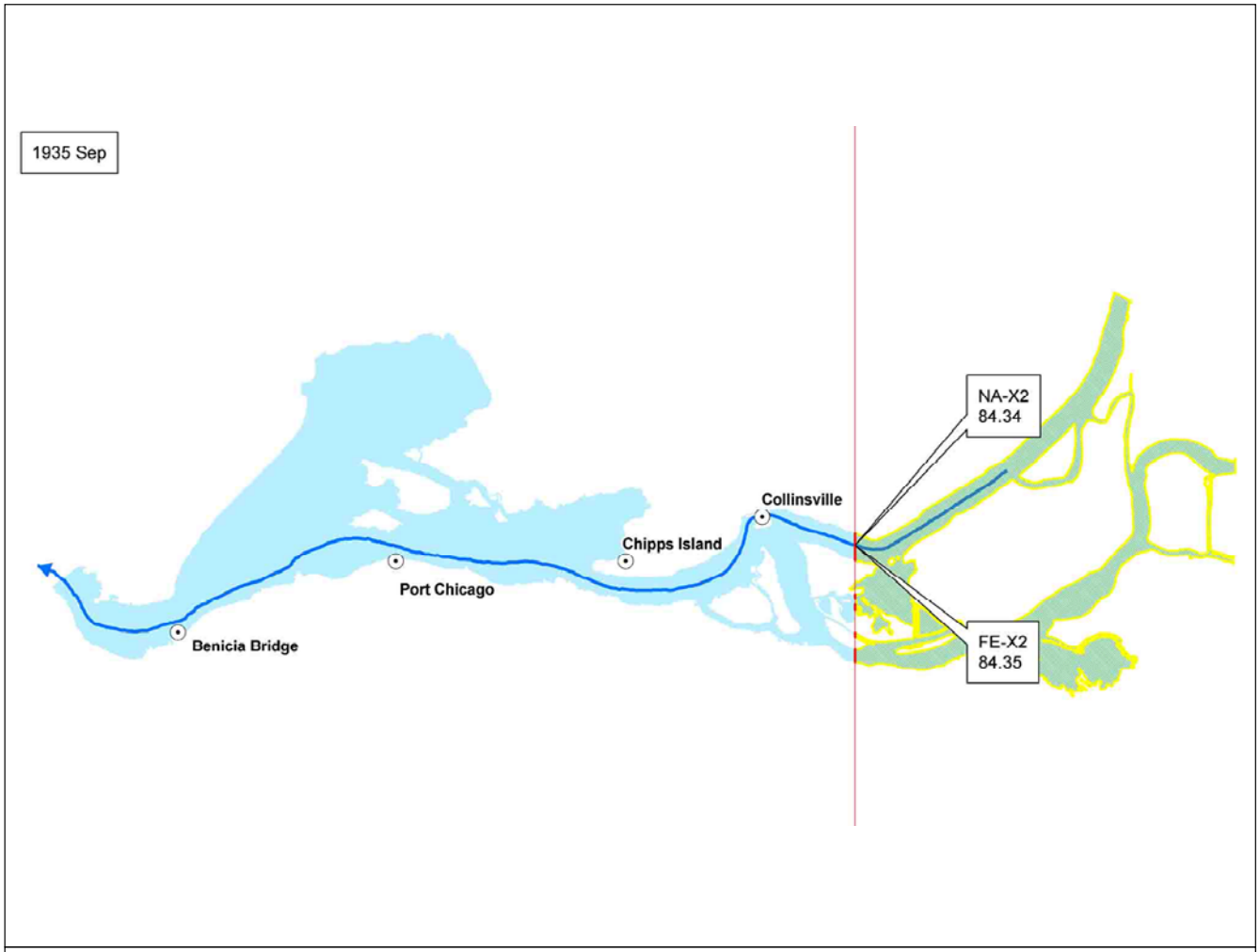
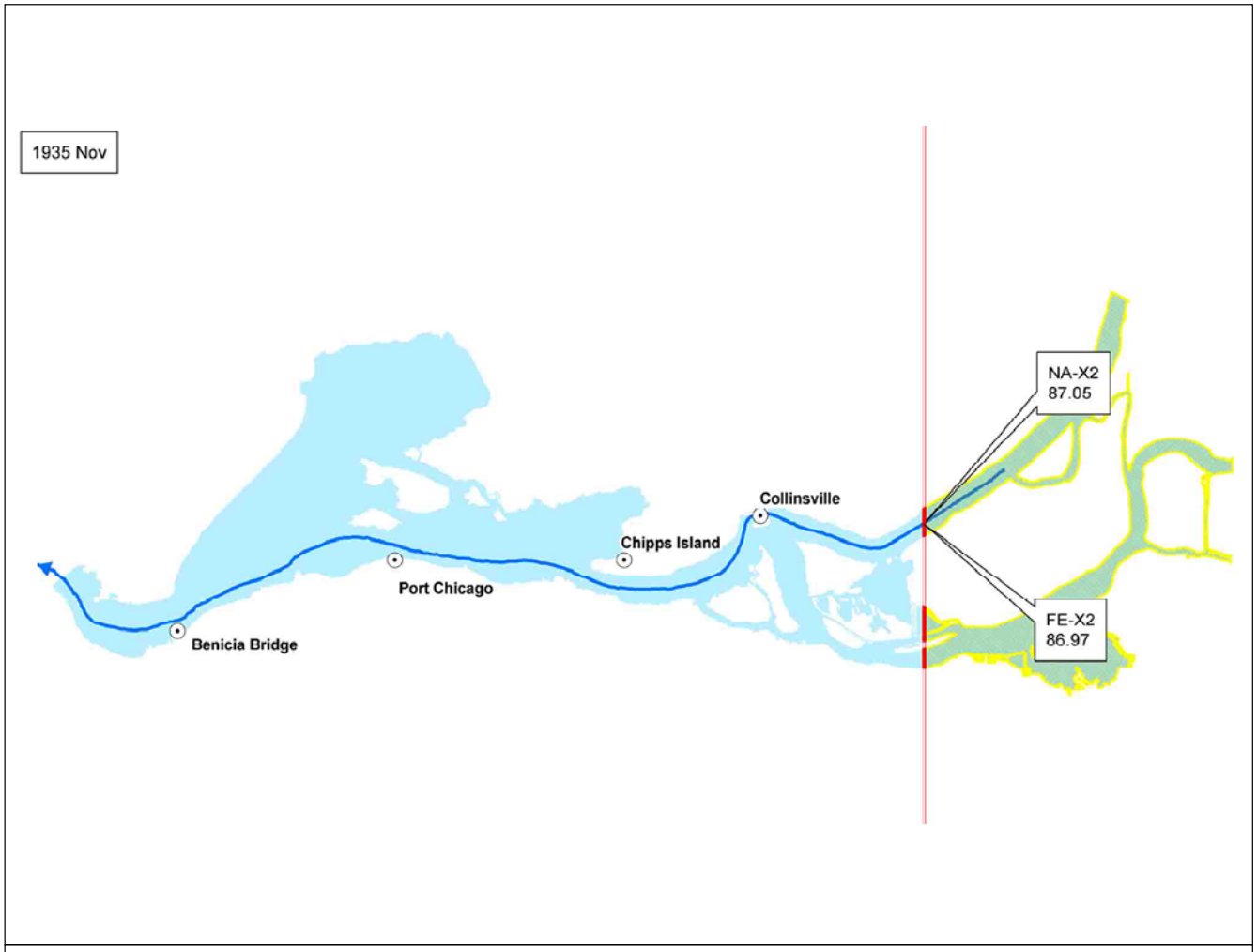
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
78.49


1935 Sep
NA-X2
84.34
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
84.35


1935 Oct
NA-X2
89.50
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
89.42


1935 Nov
NA-X2
87.05
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
86.97


1935 Dec
NA-X2
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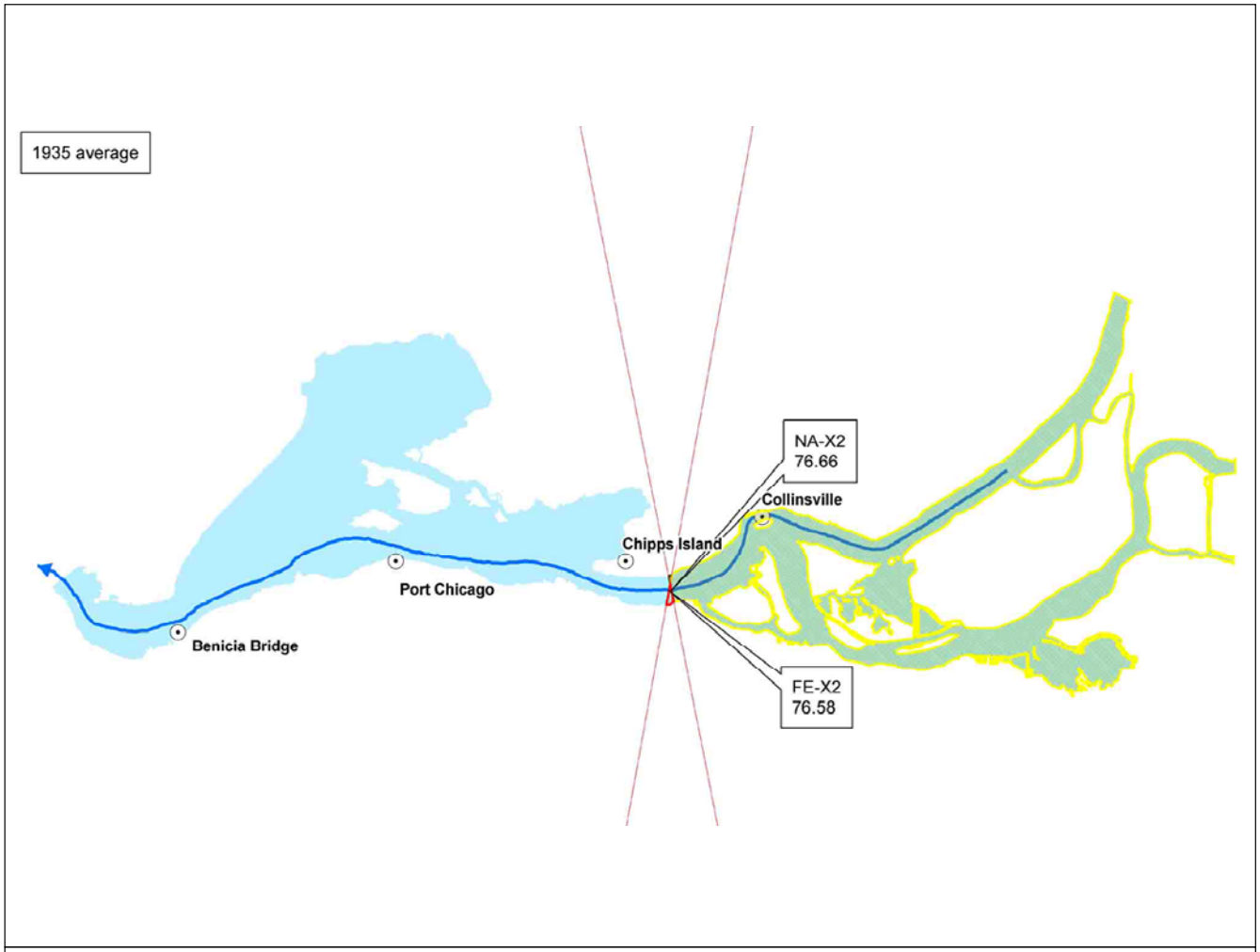
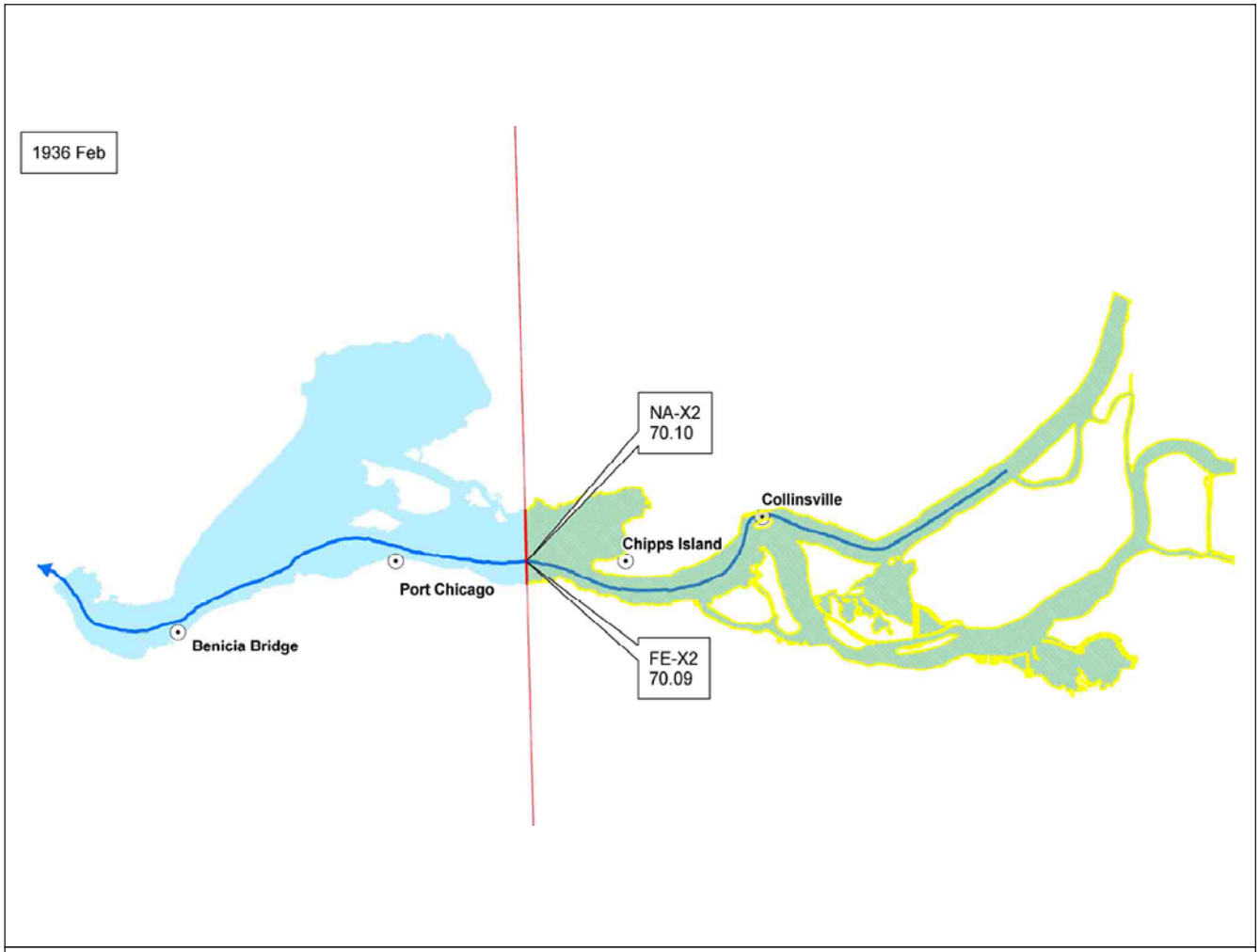
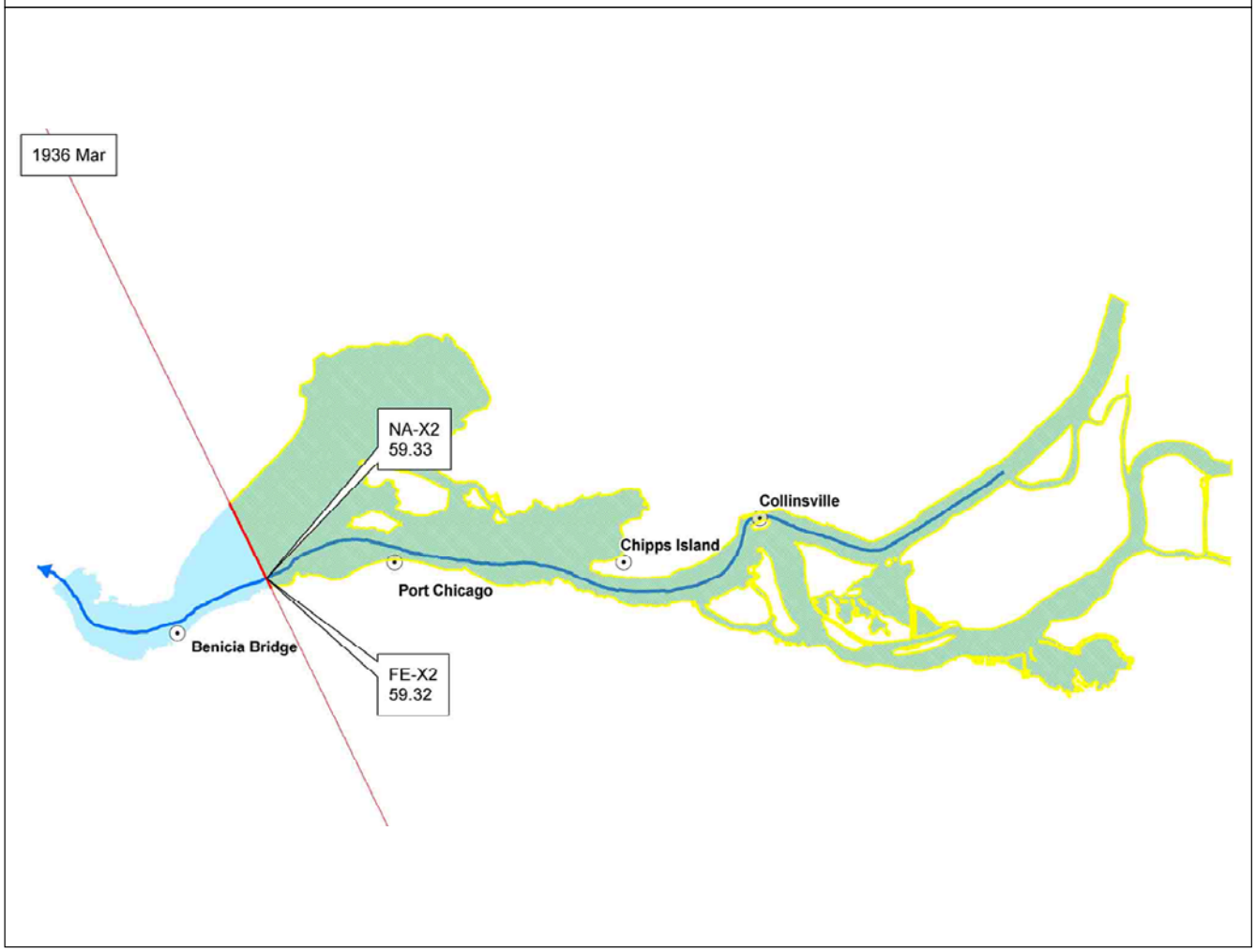
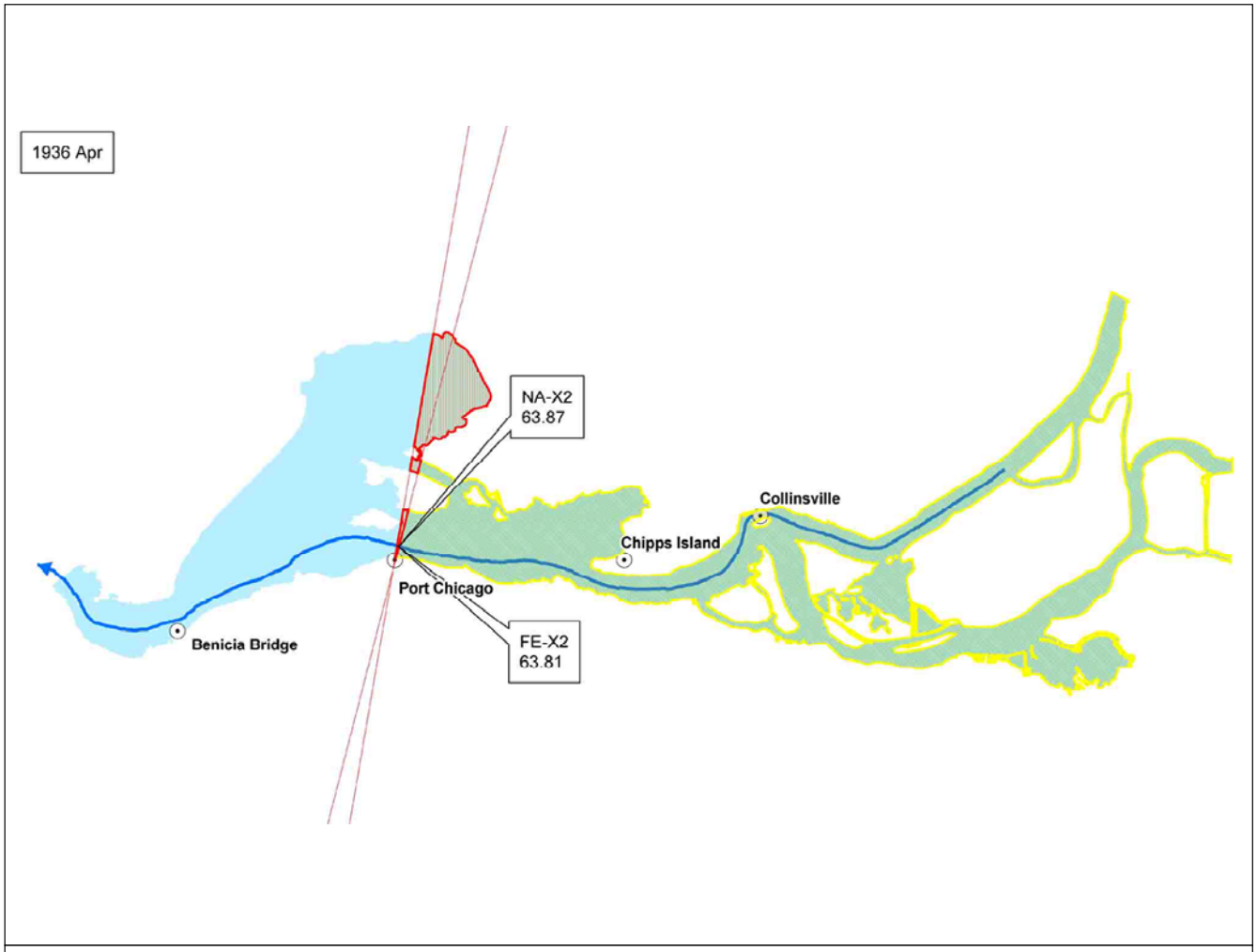
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
84.51

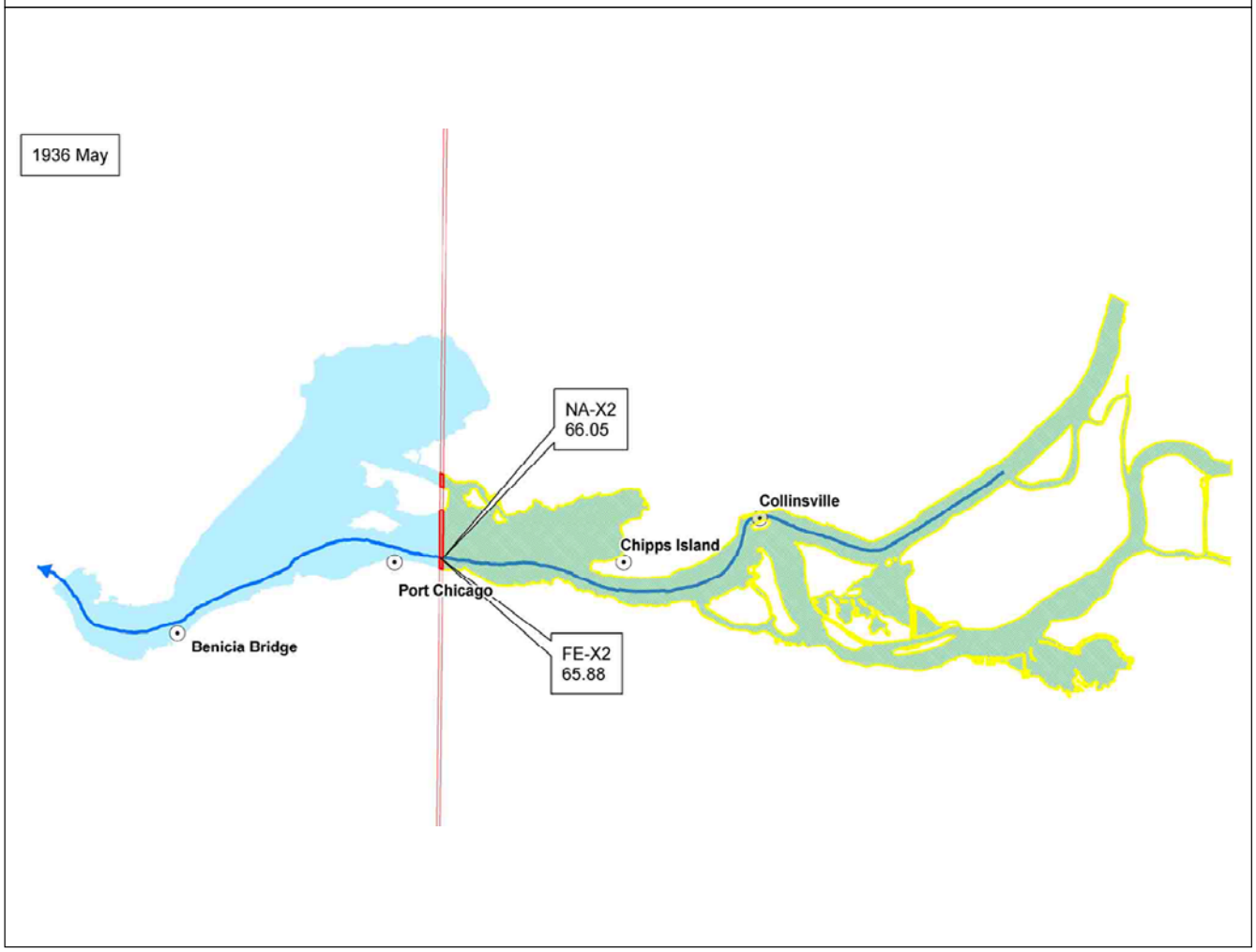

1935 average
NA-X2
76.66
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
76.58

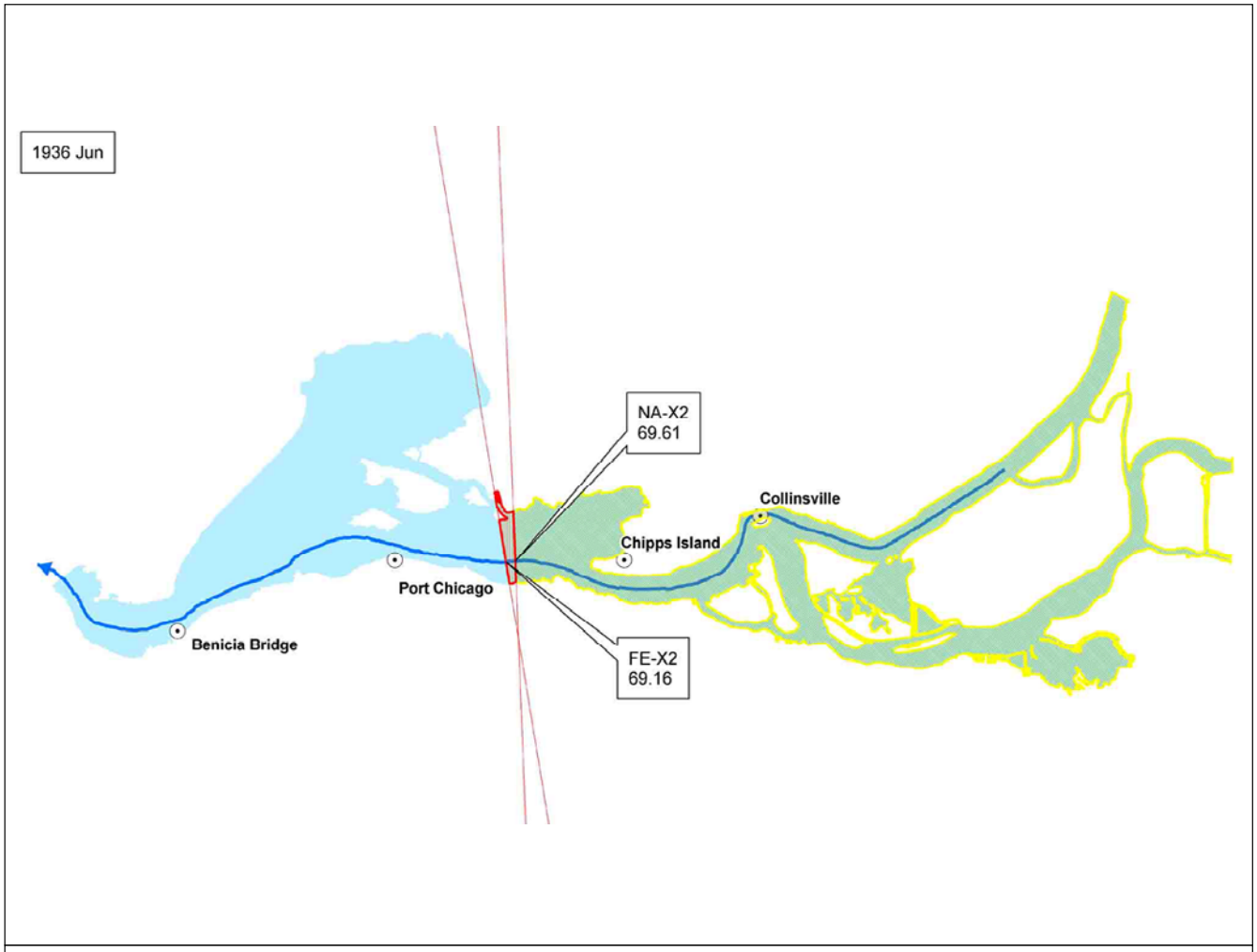

1936 Jan
NA-X2
85.00
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
84.97

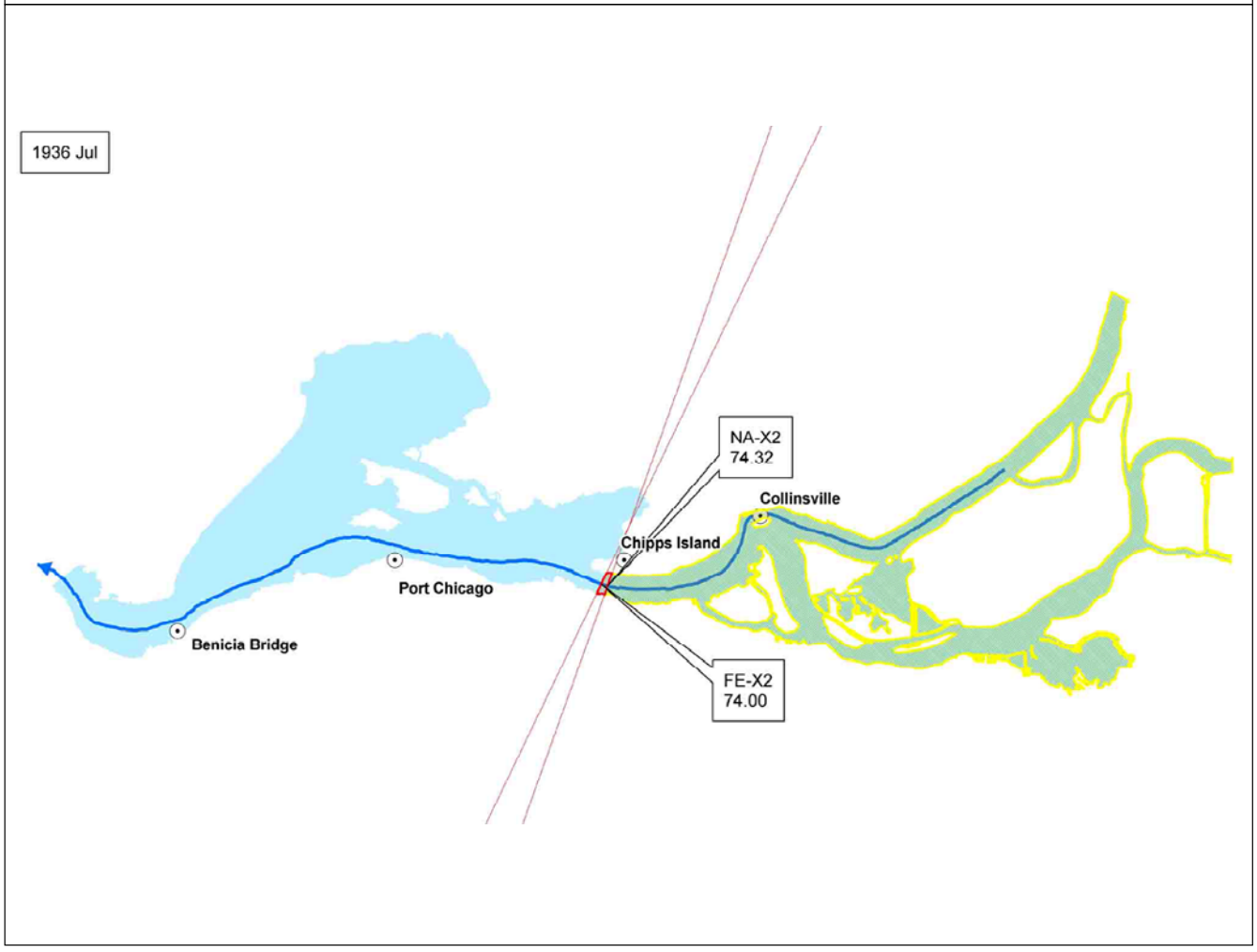

1936 Feb
NA-X2
70.10
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
70.09


1936 Mar
NA-X2
59.33
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
59.32


1936 Apr
NA-X2
63.87
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
63.81


1936 May
NA-X2
66.05
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
65.88


1936 Jun
NA-X2
69.61
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
69.16

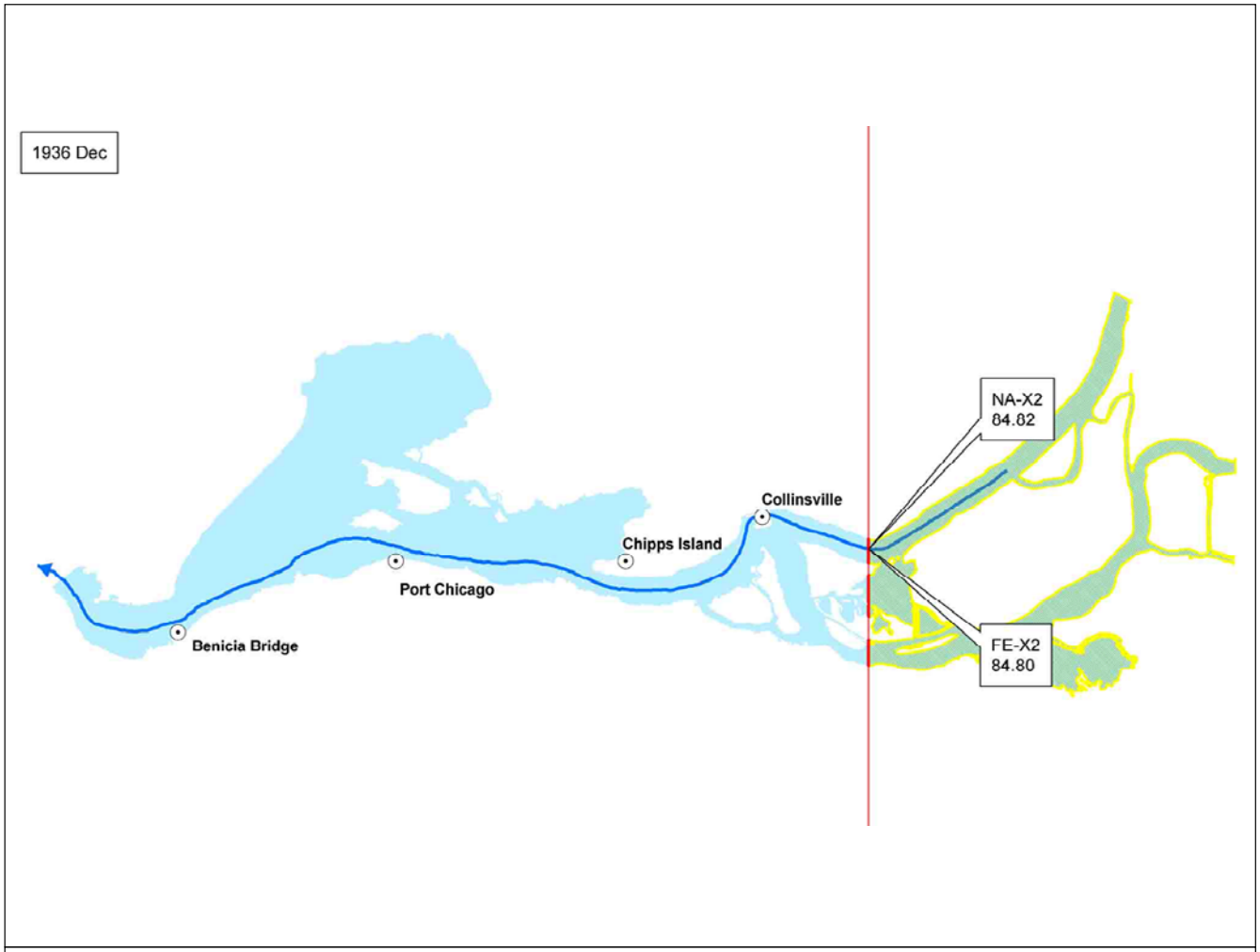

1936 Jul
NA-X2
74.32
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
74.00

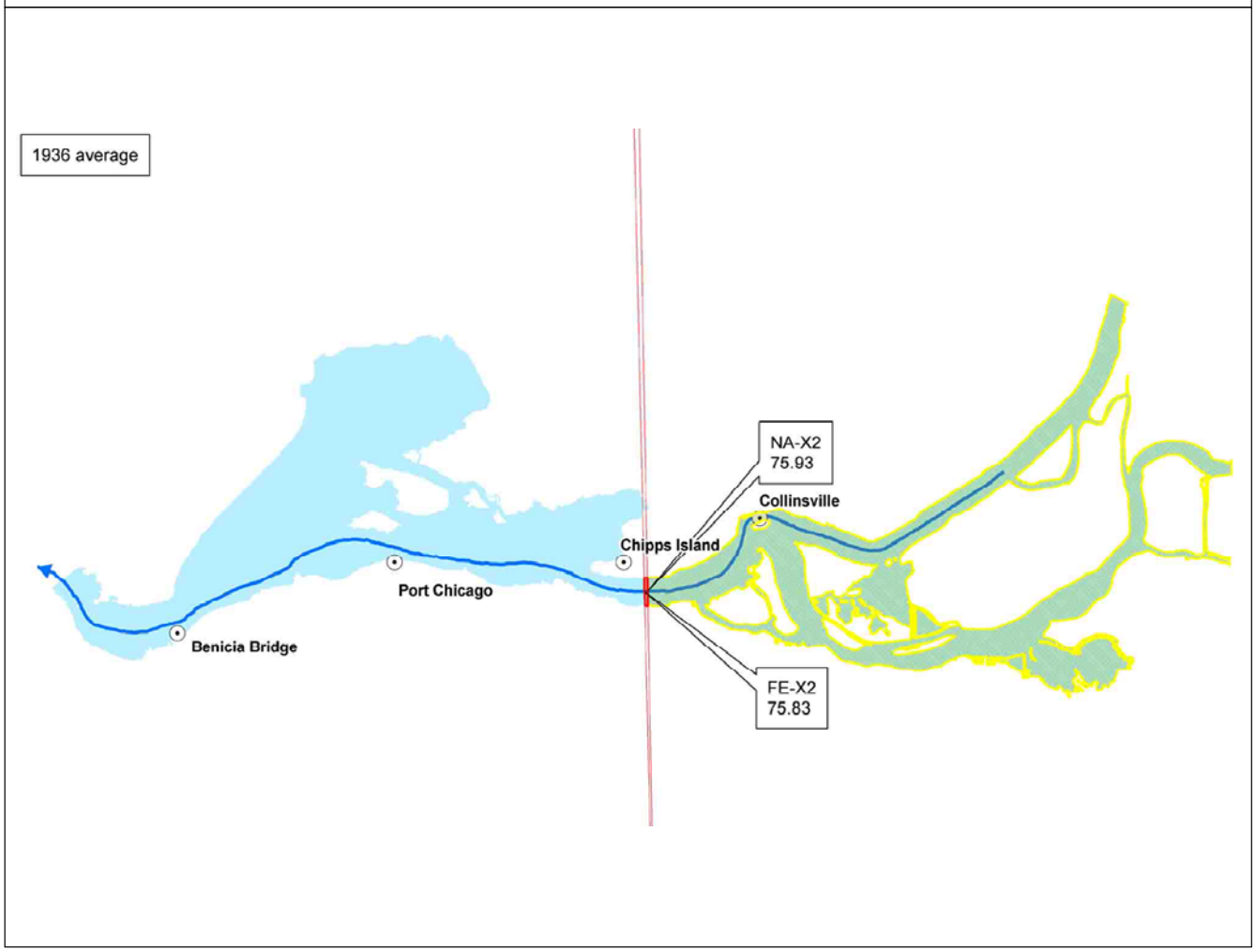

1936 Aug
NA-X2
79.26
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
79.16


1936 Sep
NA-X2
84.60
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
84.57

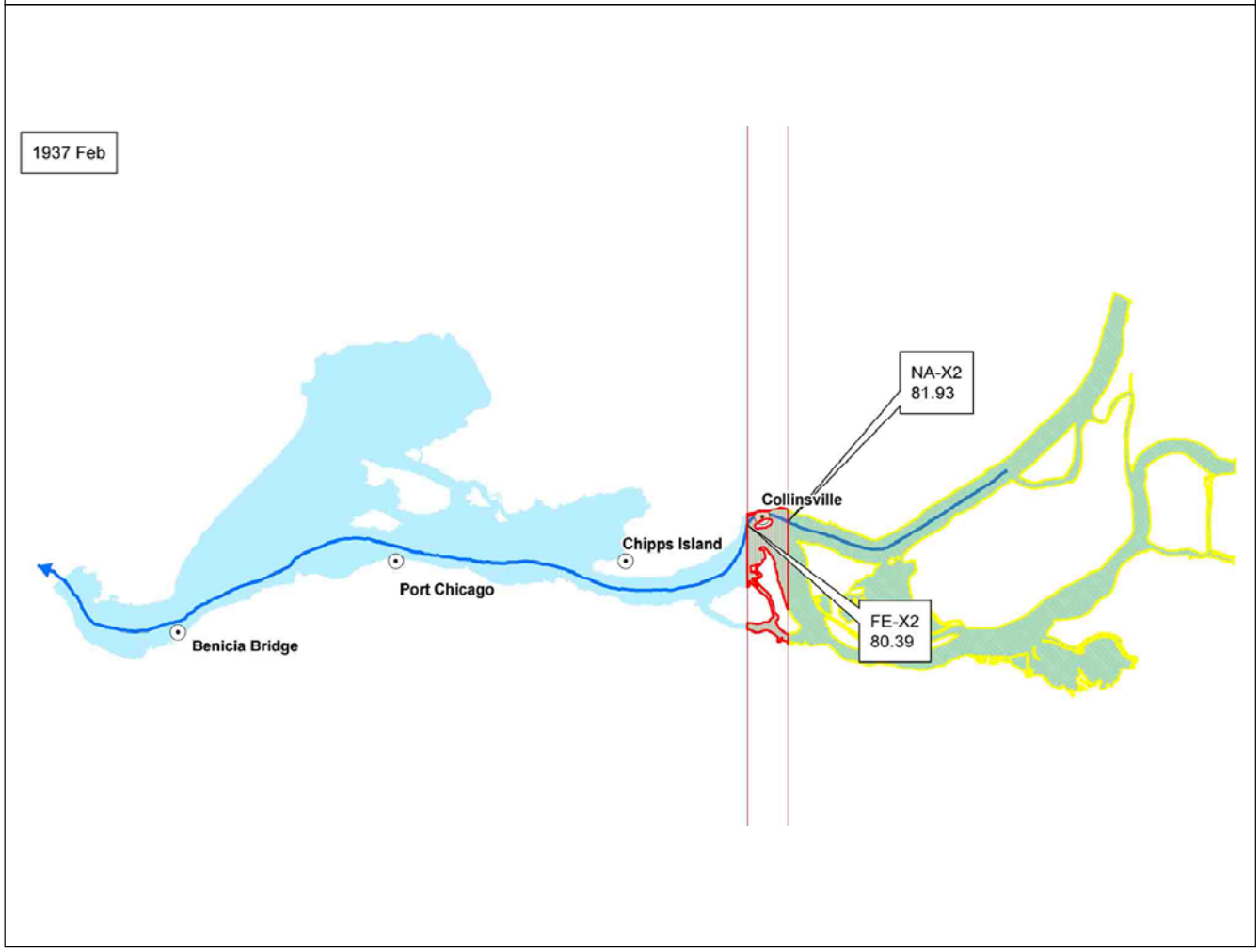

1936 Oct
NA-X2
88.47
FE-X2
88.48
Collinsville
Chipps Island
Port Chicago
Benicia Bridge

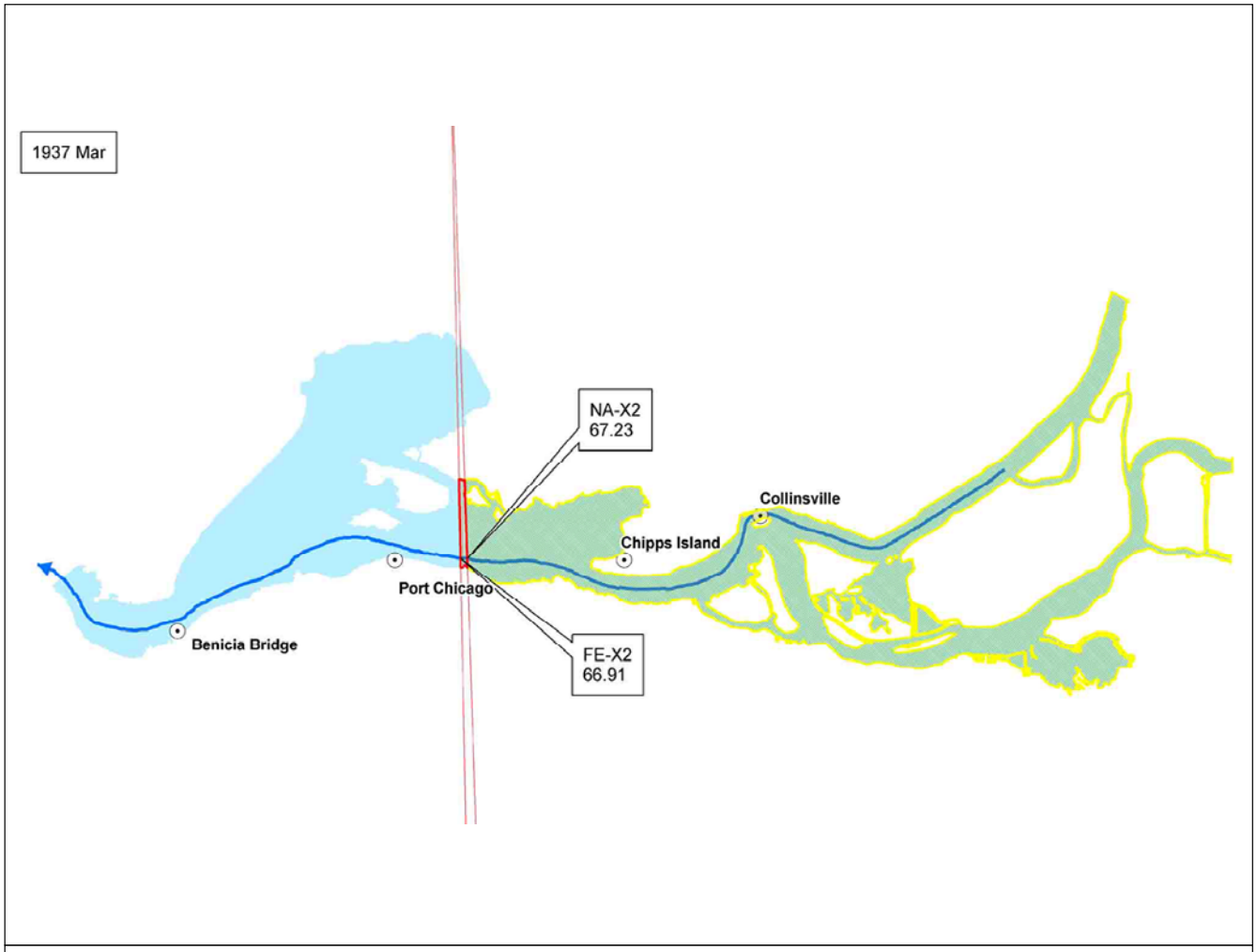

1936 Nov
NA-X2
85.70
FE-X2
85.69
Collinsville
Chipps Island
Port Chicago
Benicia Bridge

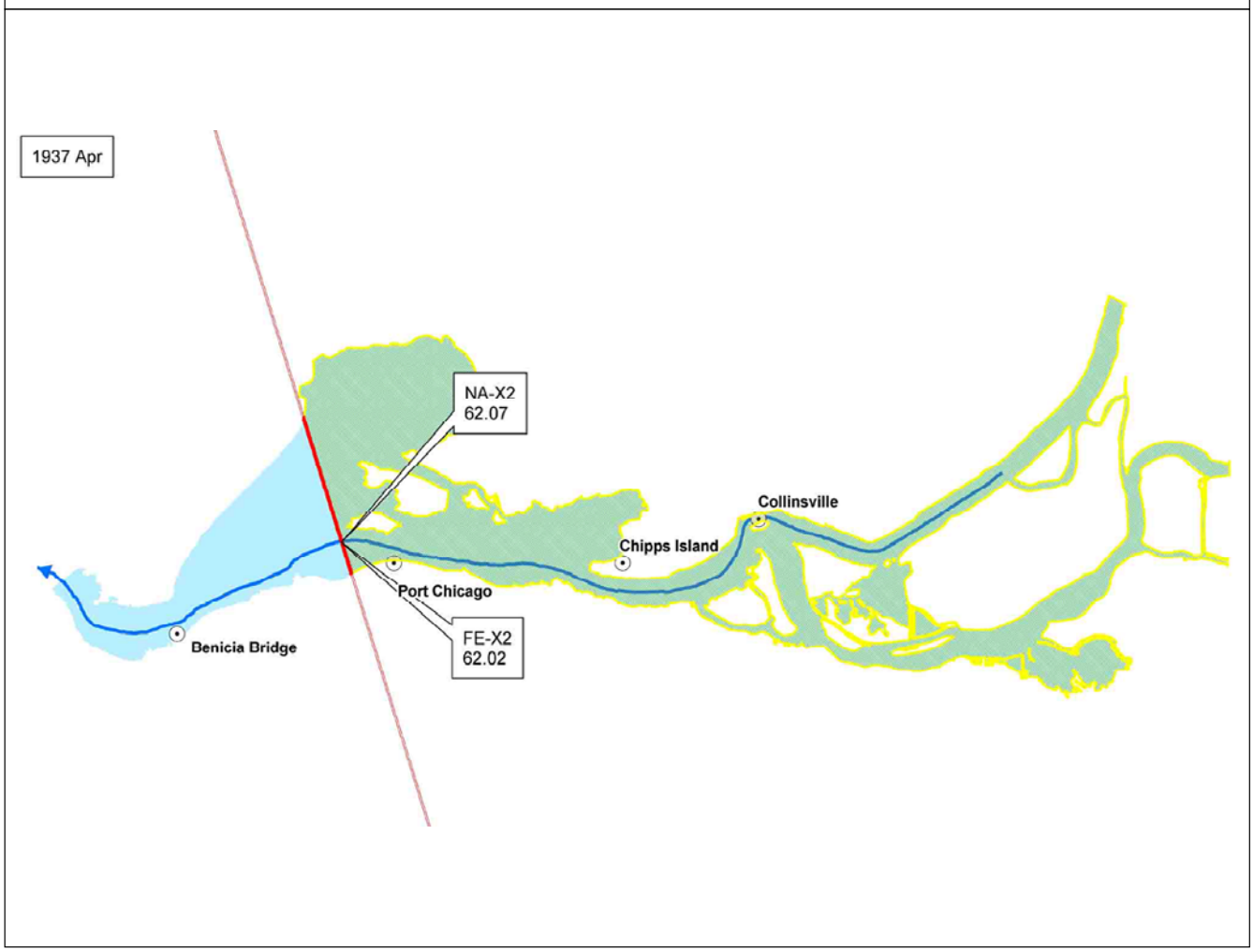

1936 Dec
NA-X2
84.82
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
84.80

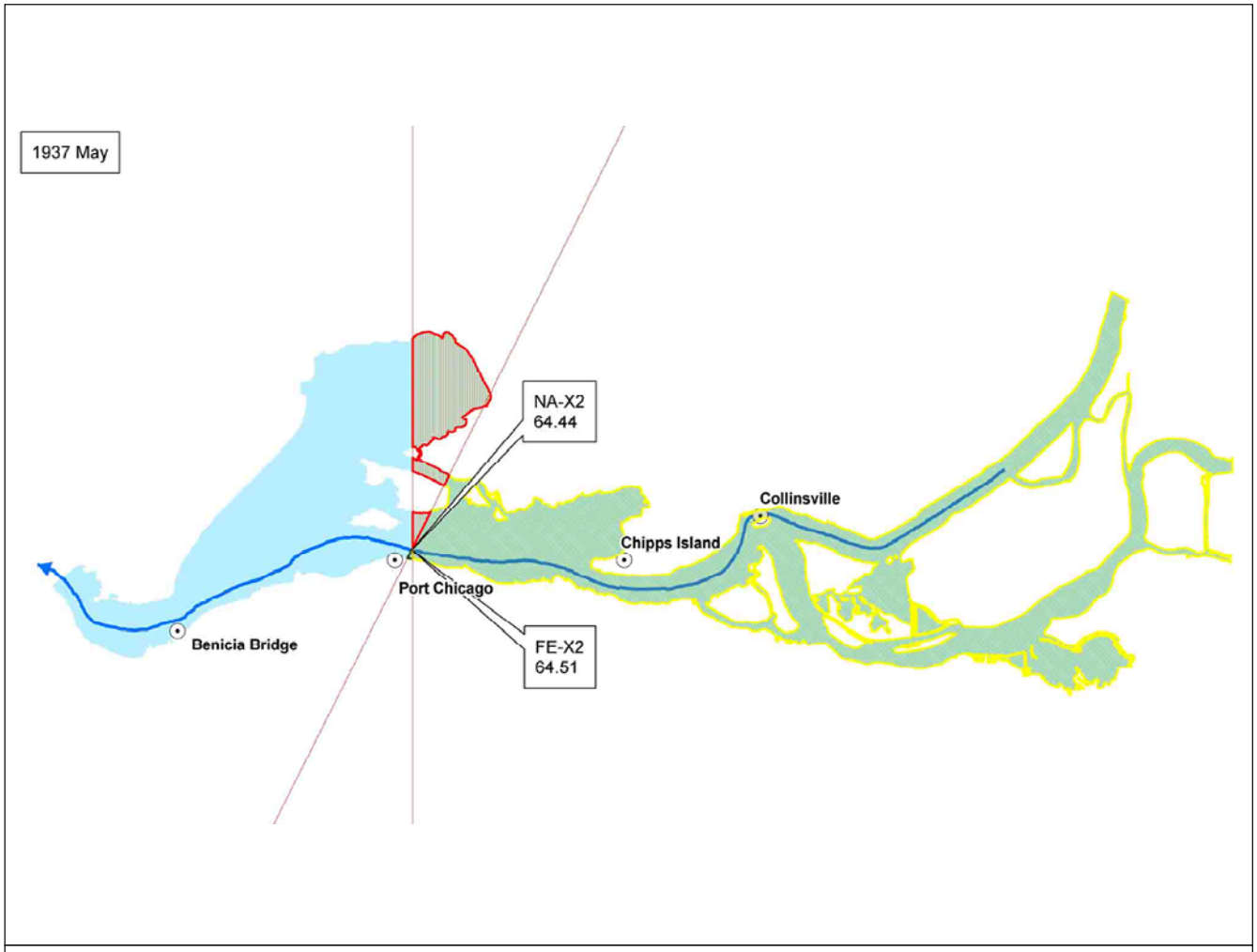

1936 average
NA-X2
75.93
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
75.83

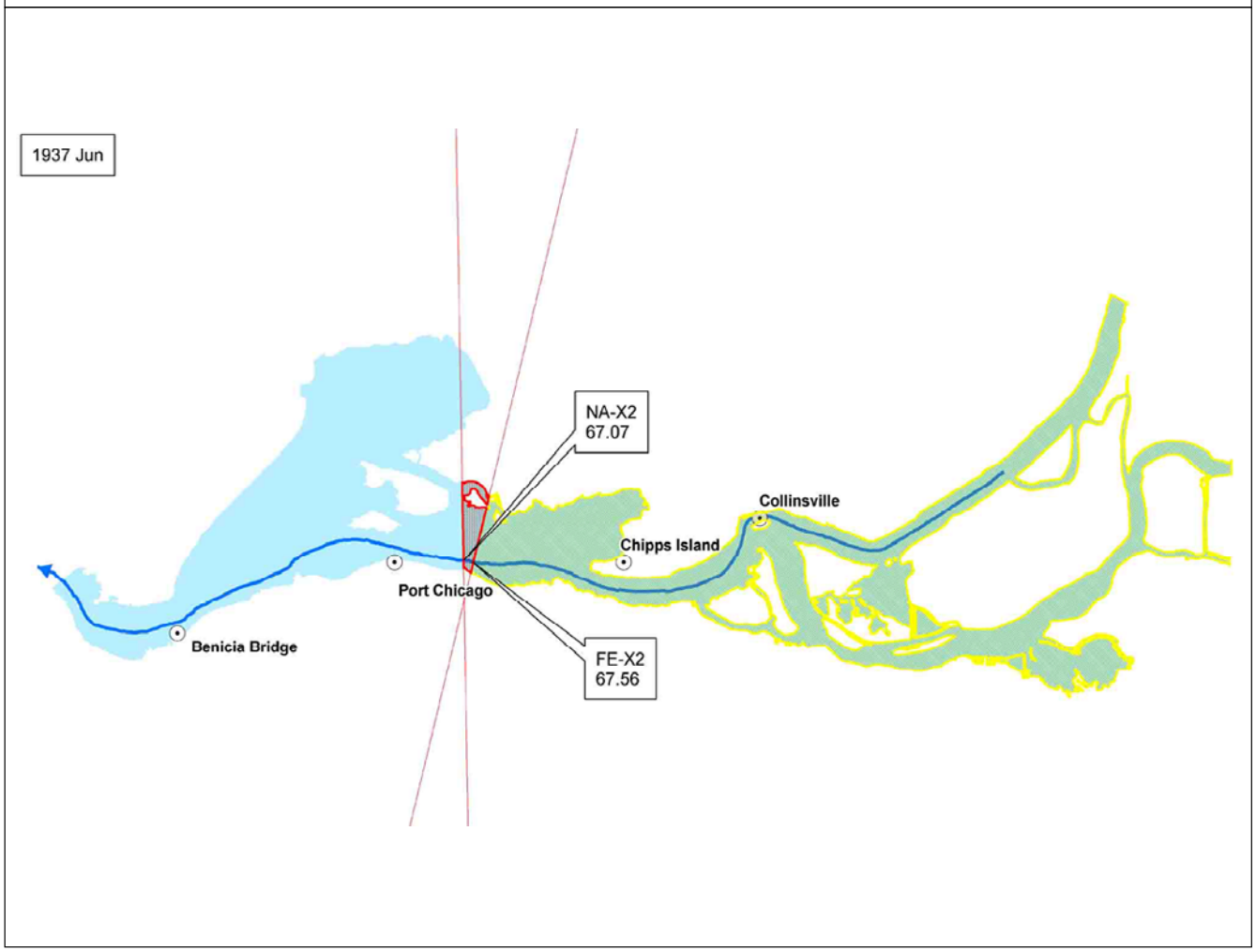

1937 Jan
NA-X2
84.25
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
84.56

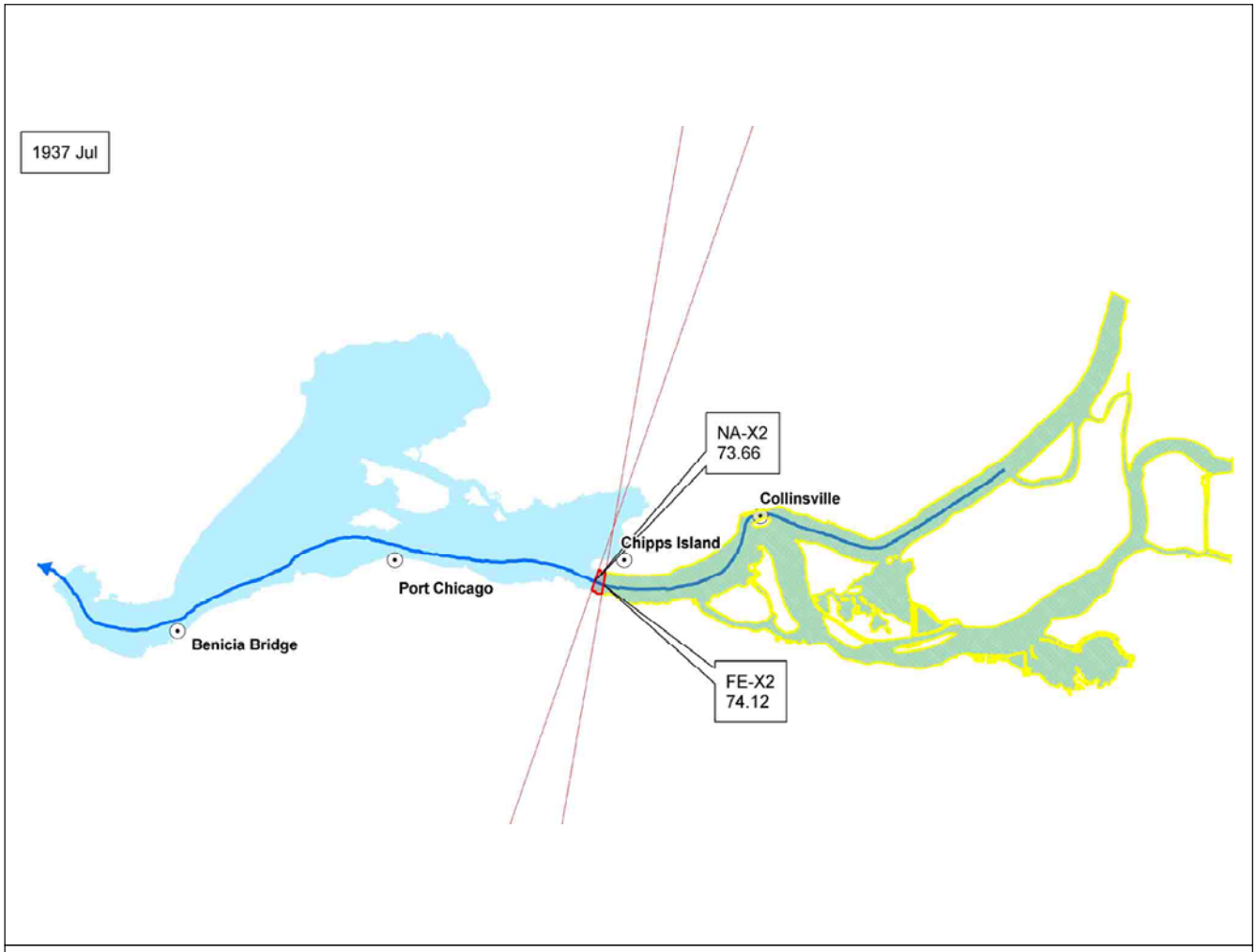

1937 Feb
NA-X2
81.93
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
80.39


1937 Mar
NA-X2
67.23
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
66.91


1937 Apr
NA-X2
62.07
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
62.02

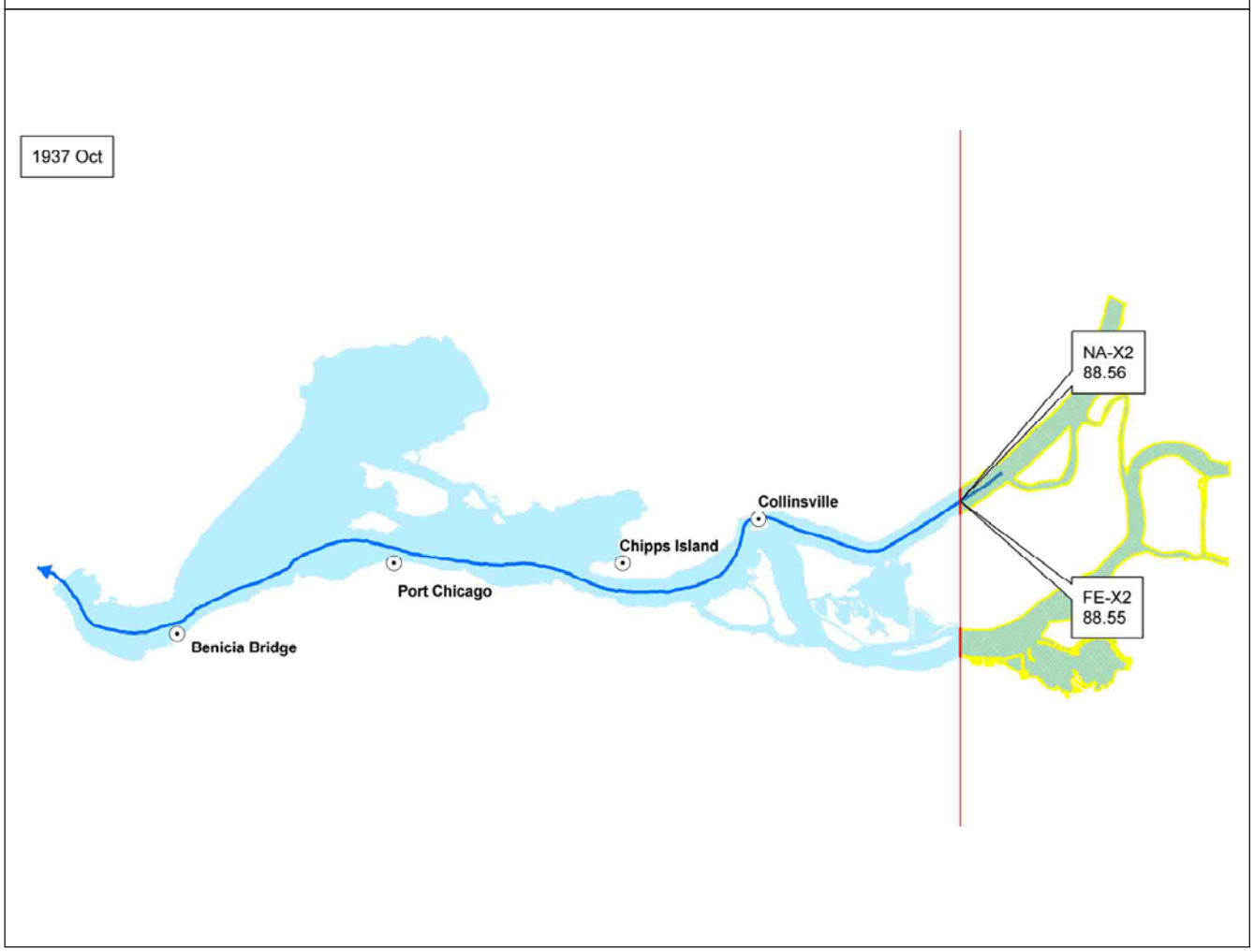

1937 May
NA-X2
64.44
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
64.51


1937 Jun
NA-X2
67.07
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
67.56


1937 Jul
NA-X2
73.66
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
74.12

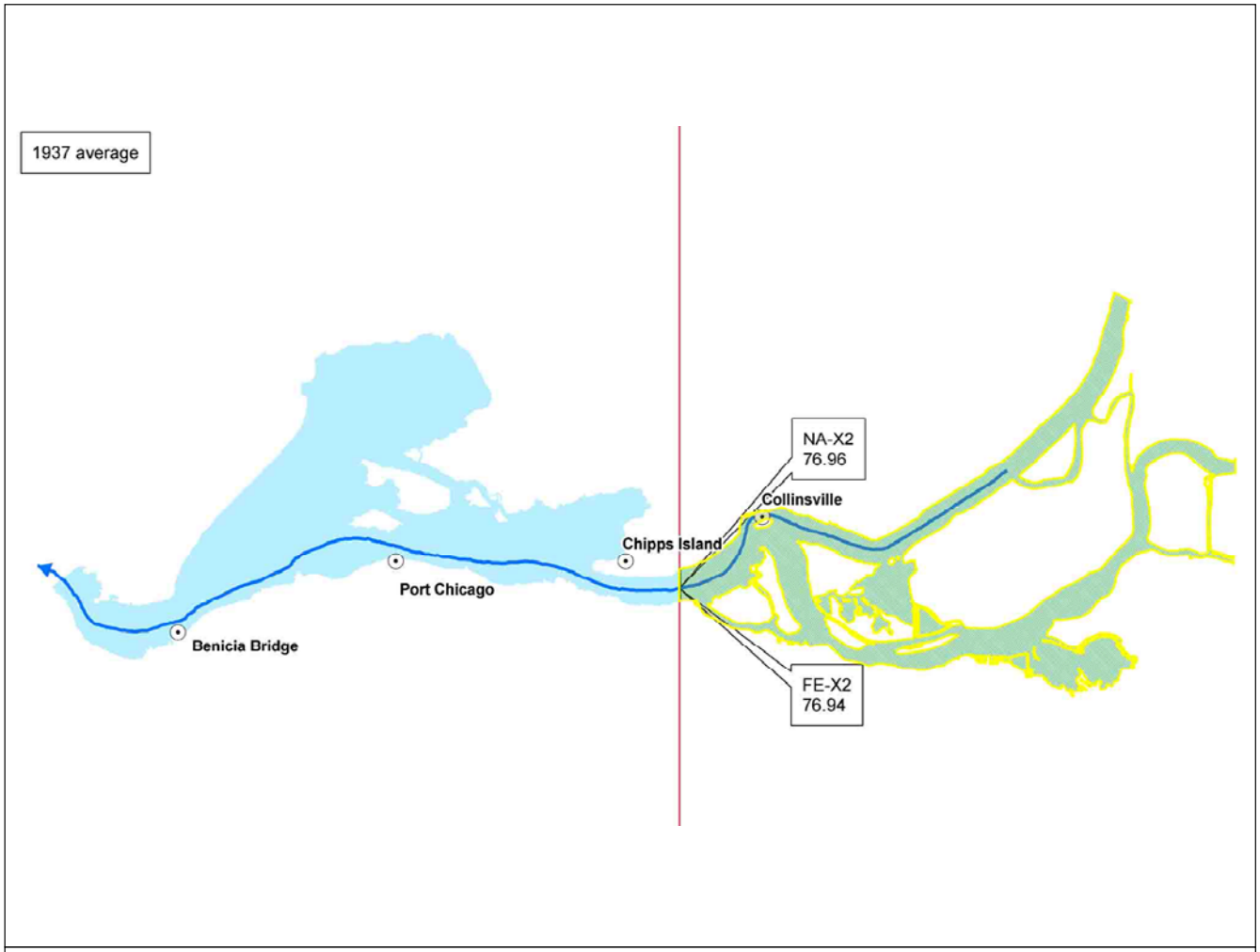

1937 Aug
NA-X2
79.04
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
79.19

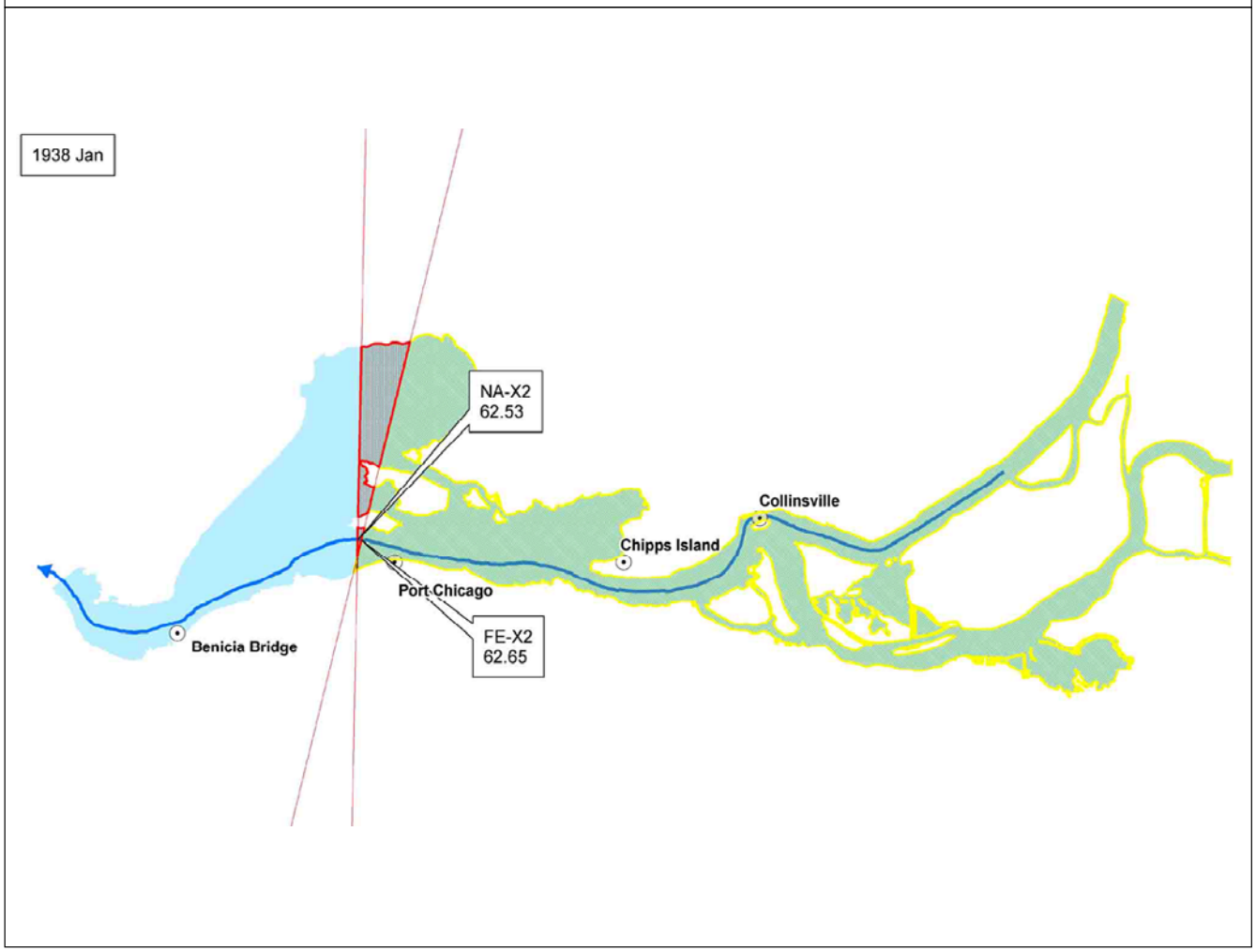

1937 Sep
NA-X2
84.27
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
84.58

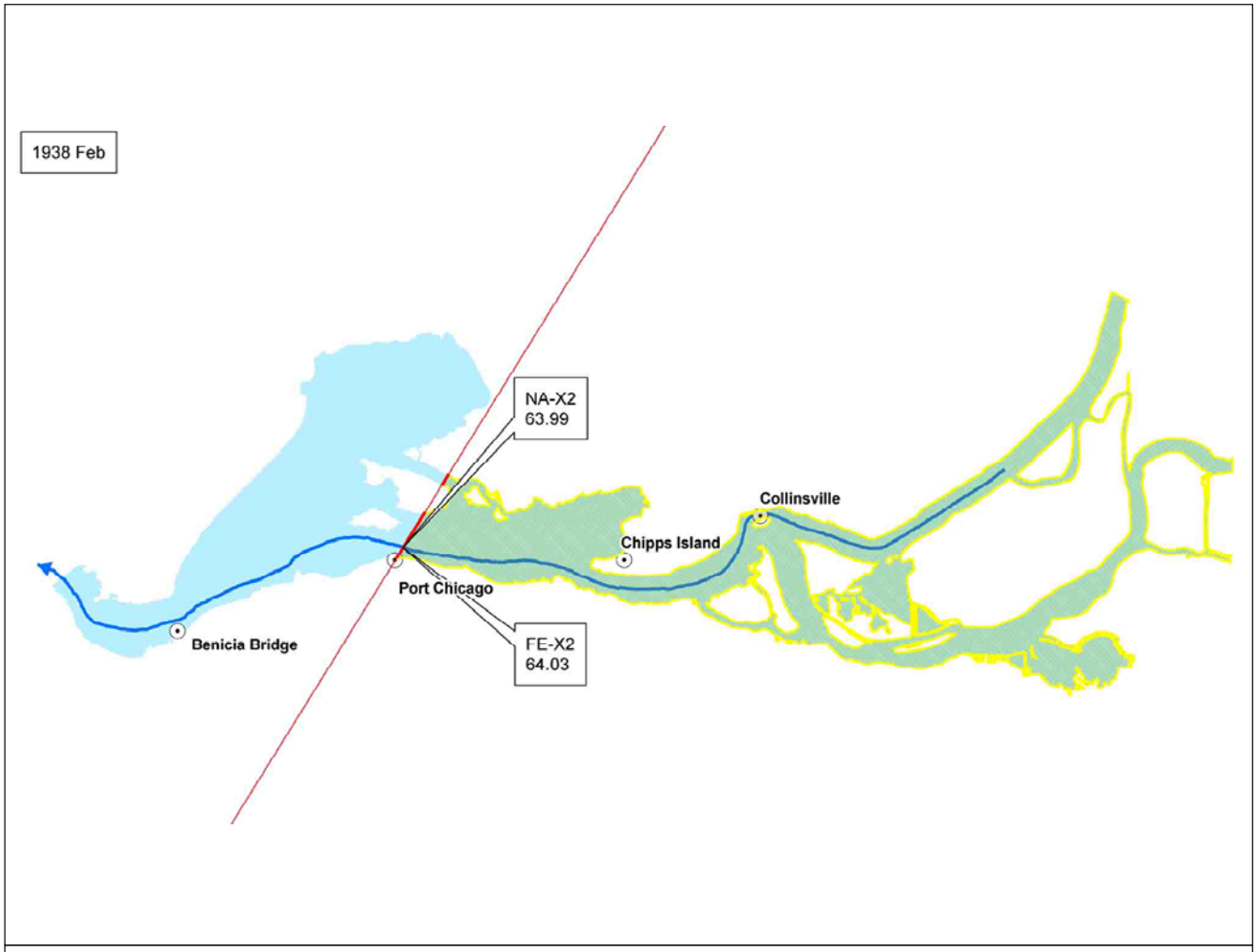

1937 Oct
NA-X2
88.56
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
88.55

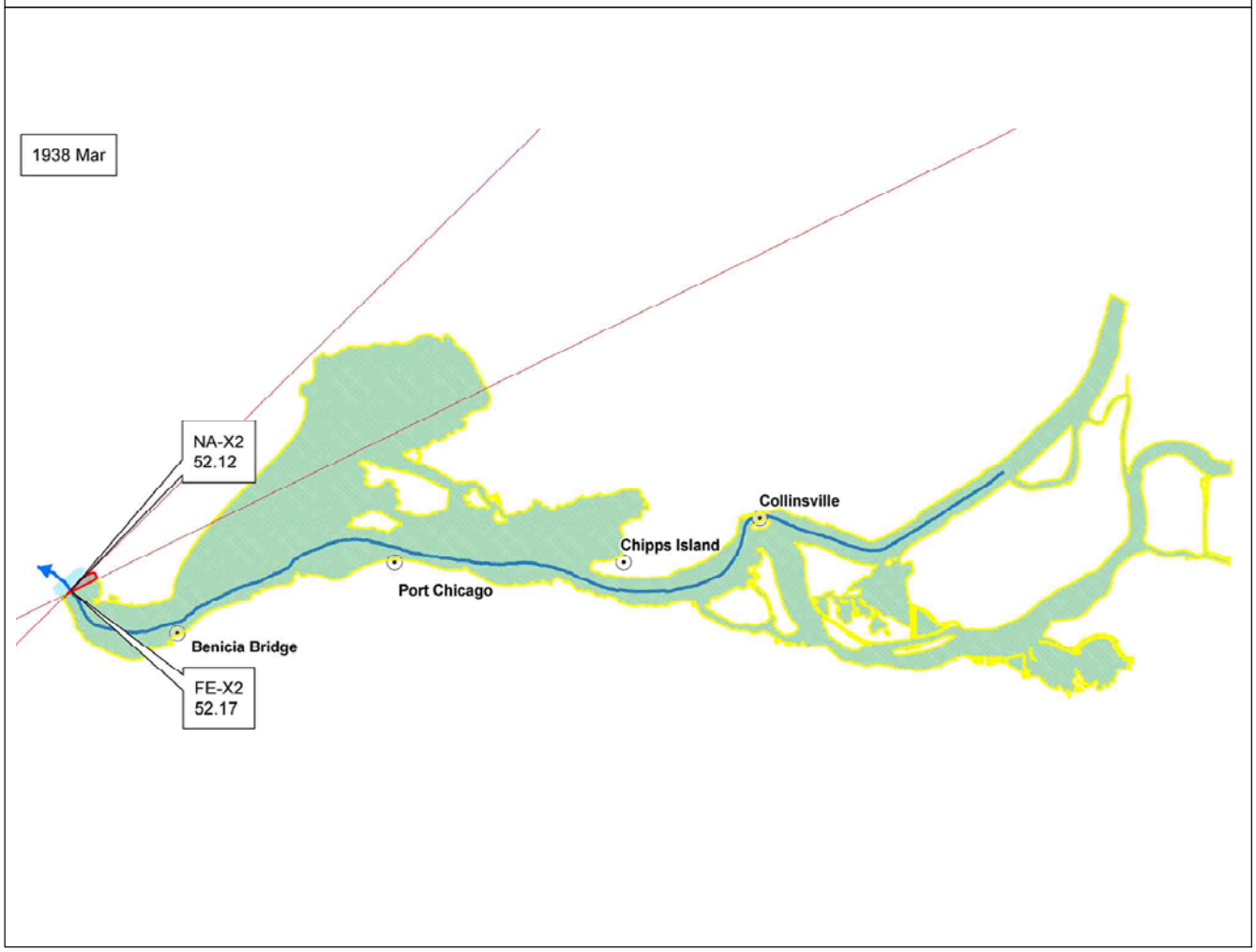

1937 Nov
NA-X2
86.36
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
86.08

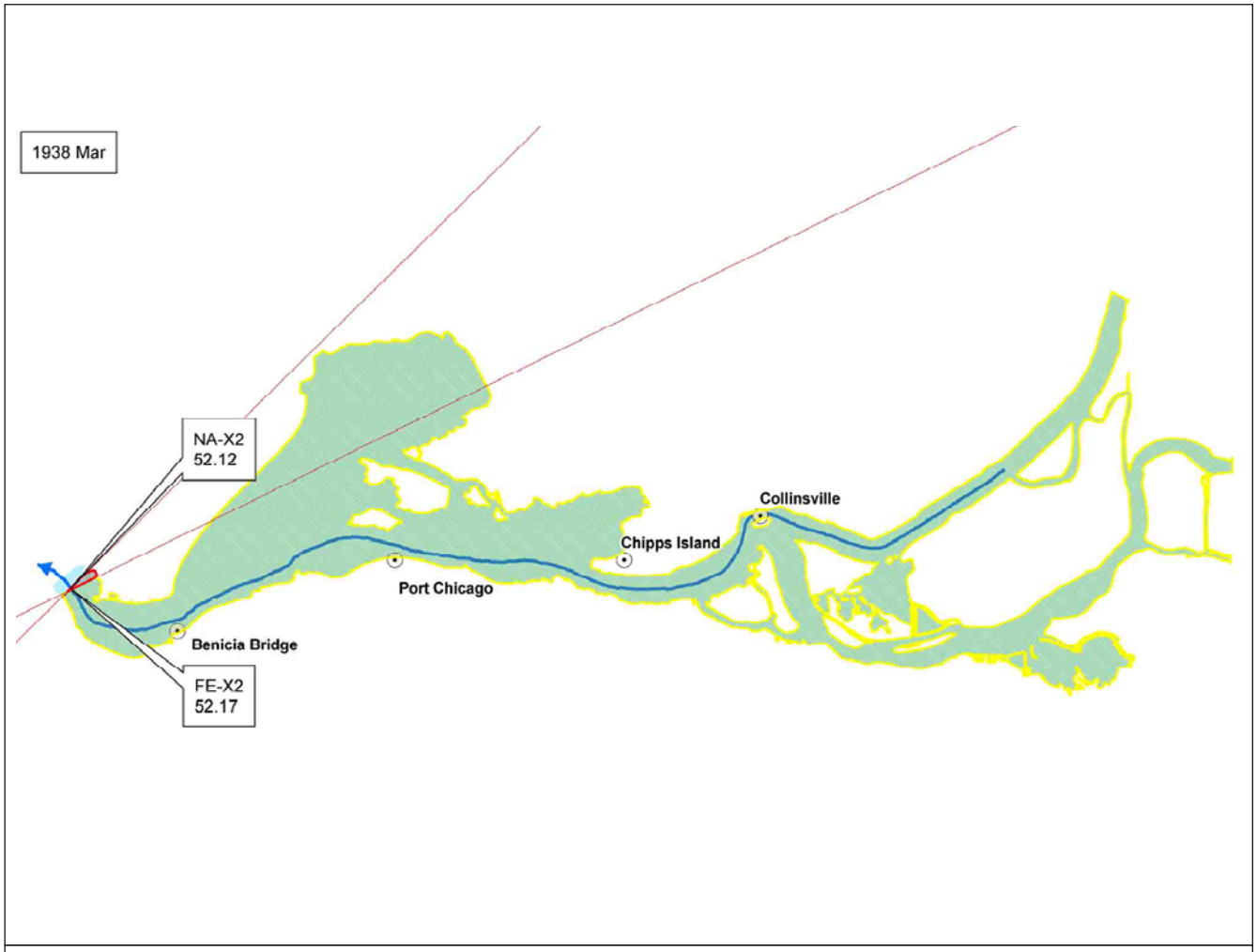

1937 Dec
NA-X2
84.65
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
84.79

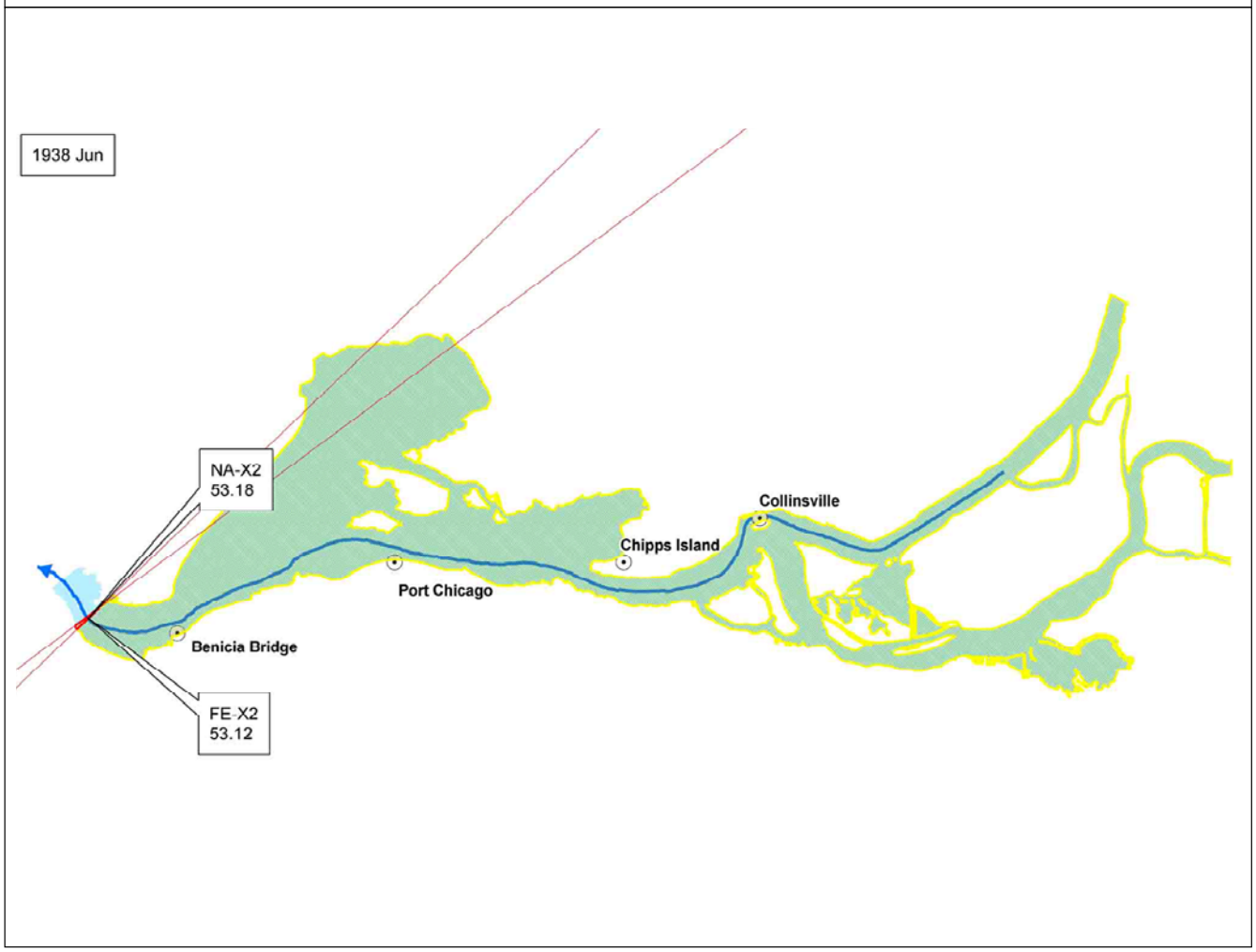

1937 average
NA-X2
76.96
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
76.94

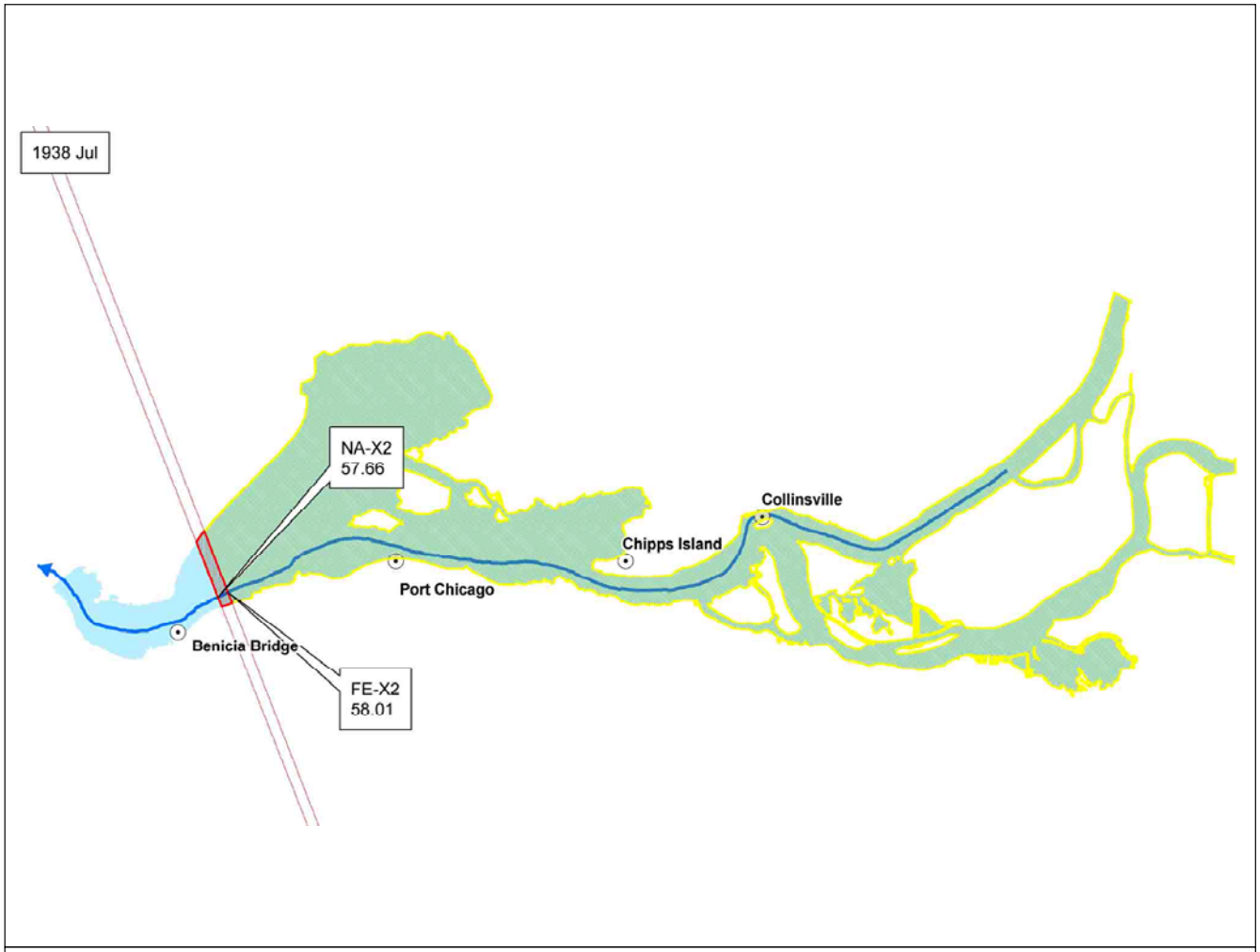

1938 Jan
NA-X2
62.53
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
62.65


1938 Feb
NA-X2
63.99
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
64.03


1938 Mar
NA-X2
52.12
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
52.17


1938 Mar
NA-X2
52.12
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
52.17


1938 Jun
NA-X2
53.18
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
53.12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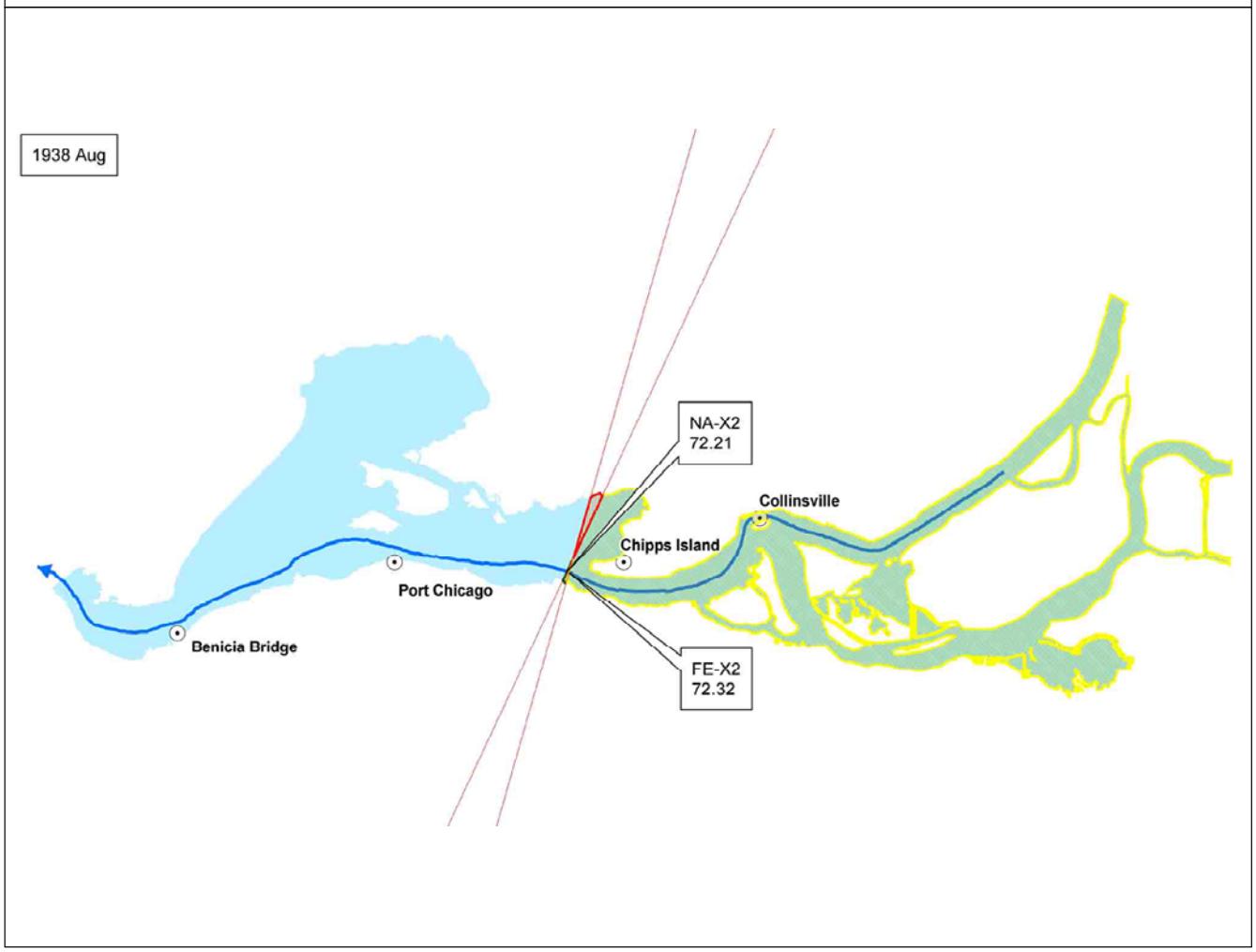
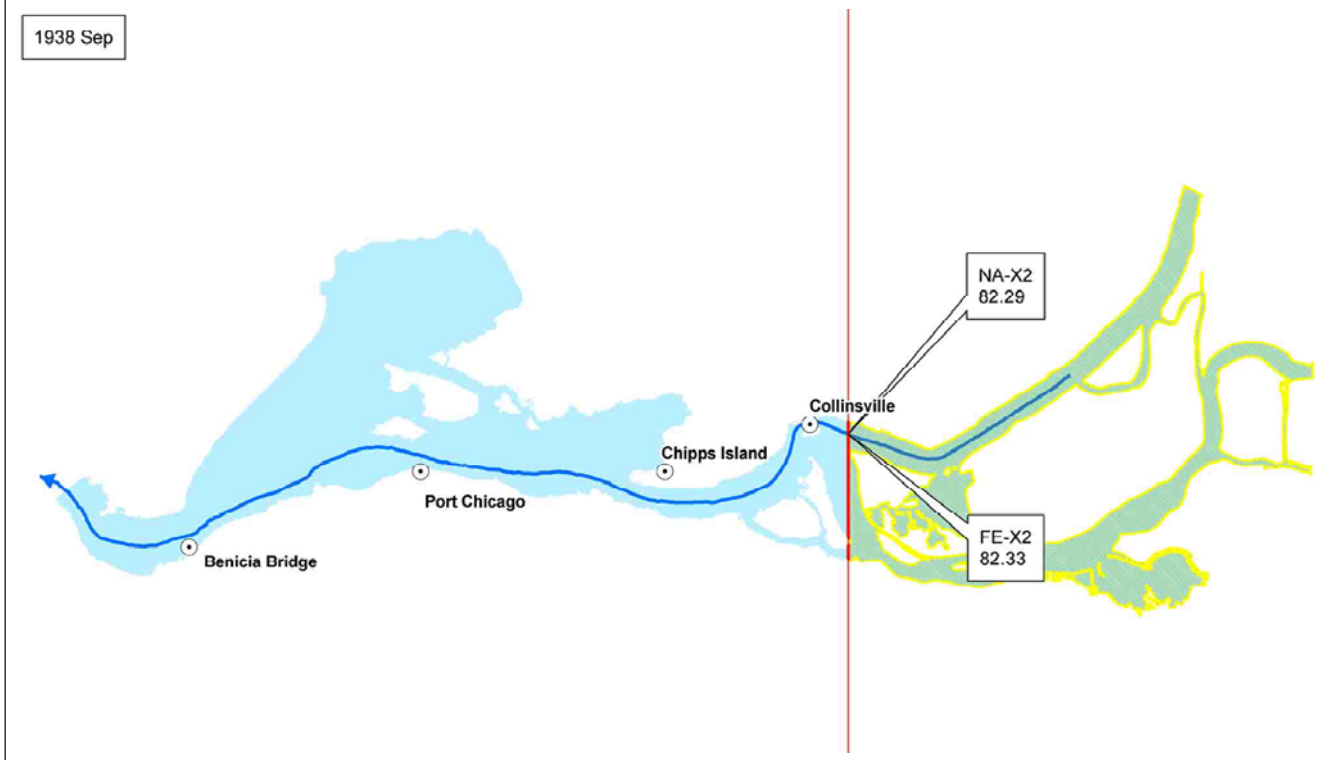
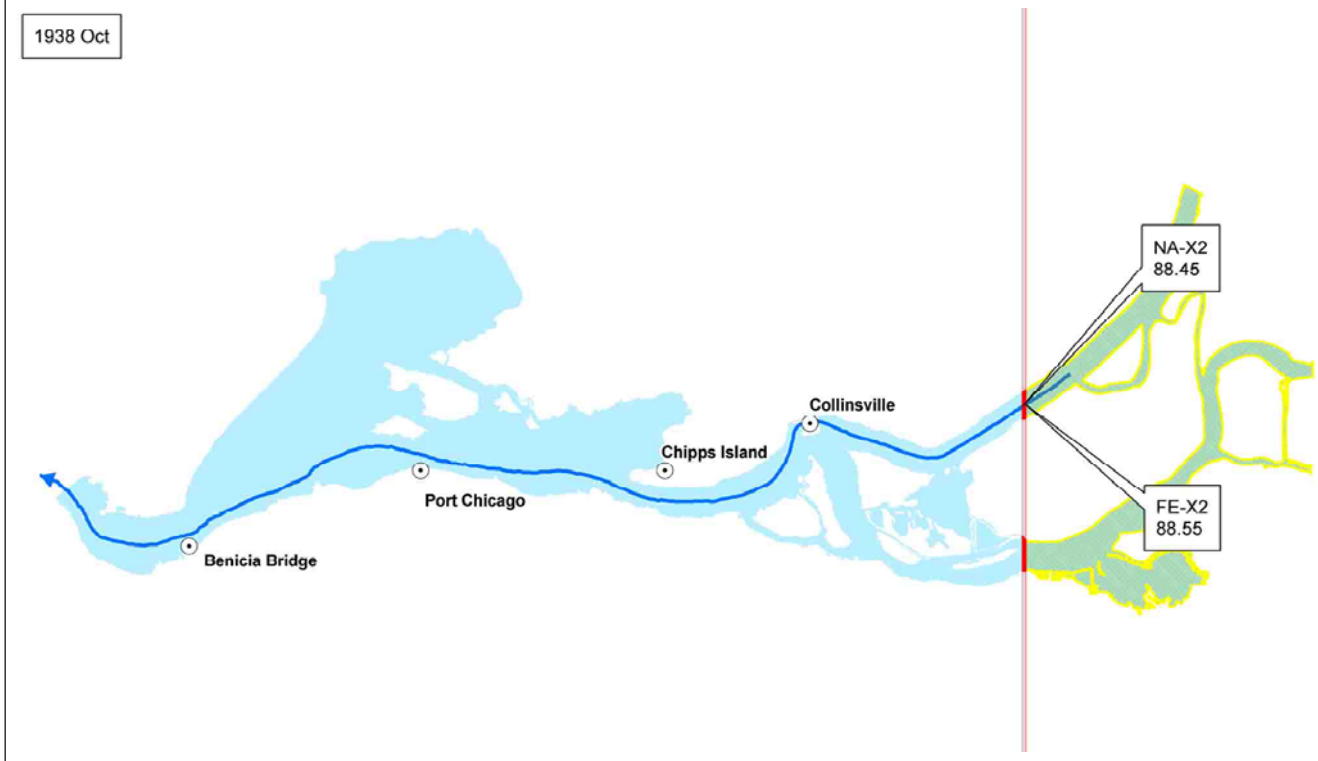
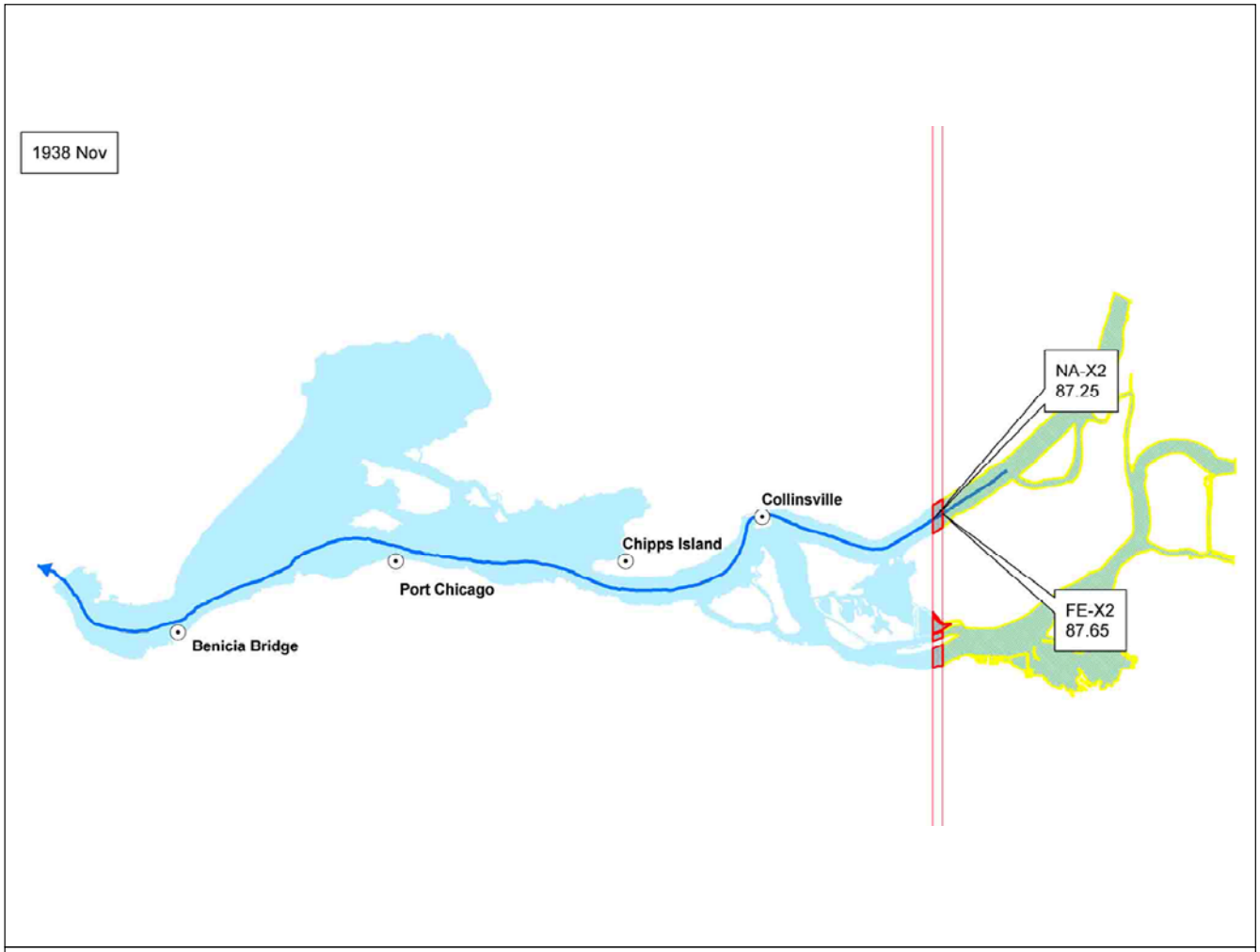
NA-X2
57.66
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
58.01

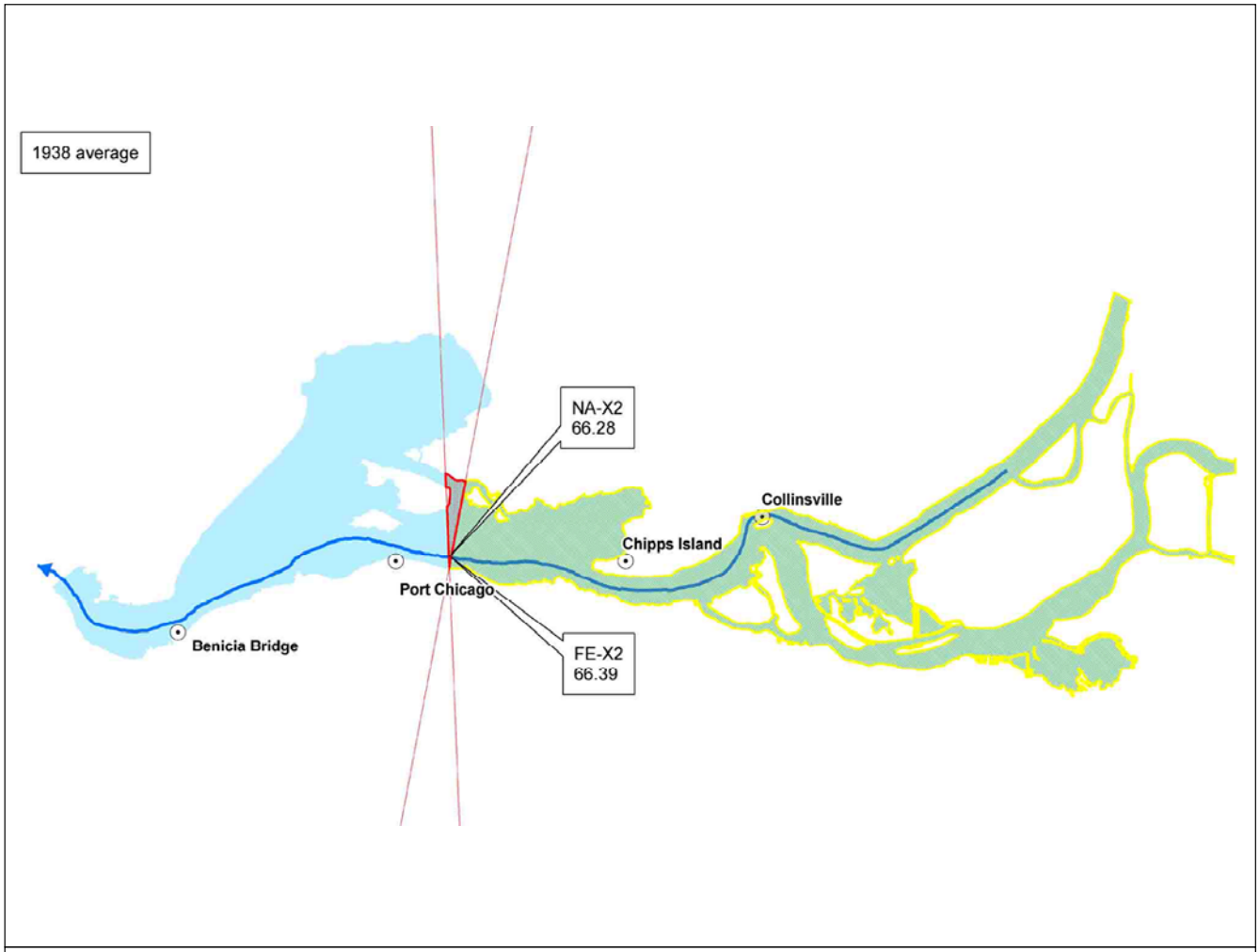

1938 Aug
NA-X2
72.21
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
72.32


1938 Sep
NA-X2
82.29
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
82.33

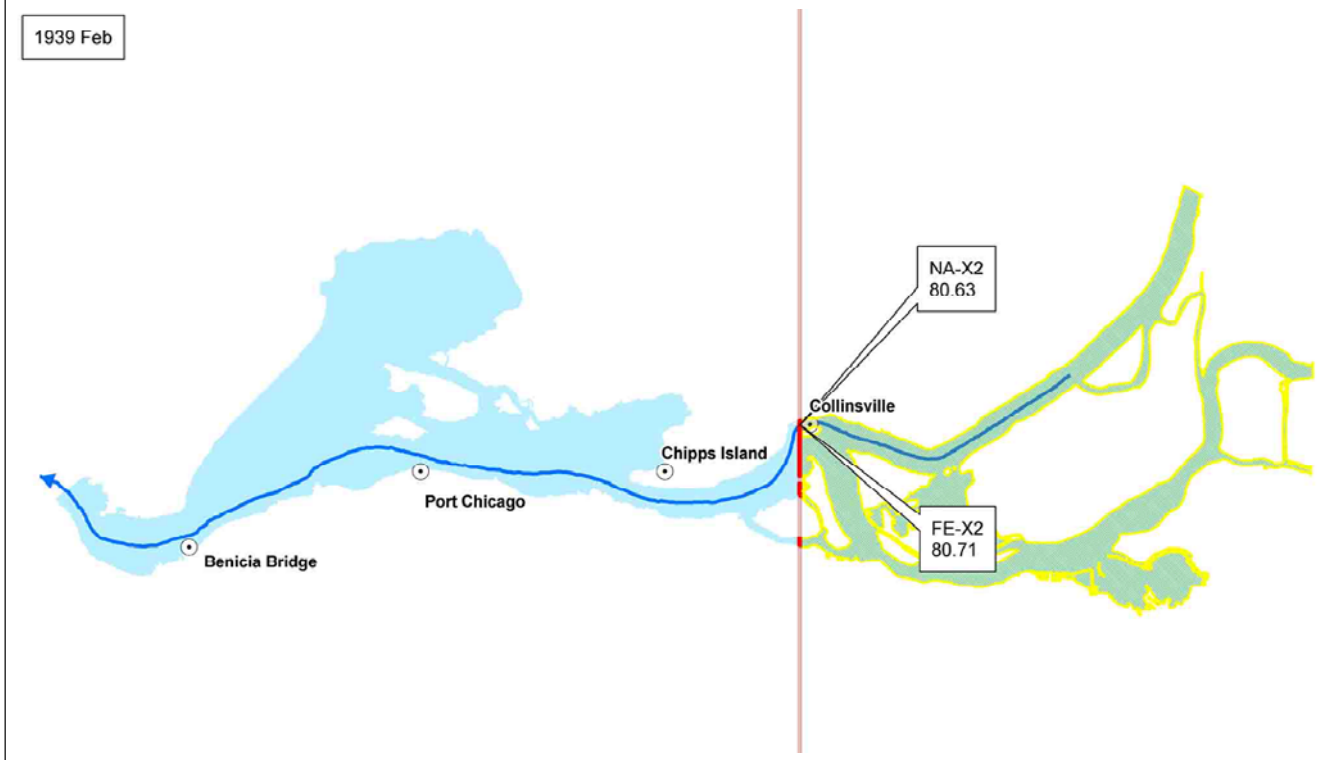

1938 Oct
NA-X2
88.45
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
88.55

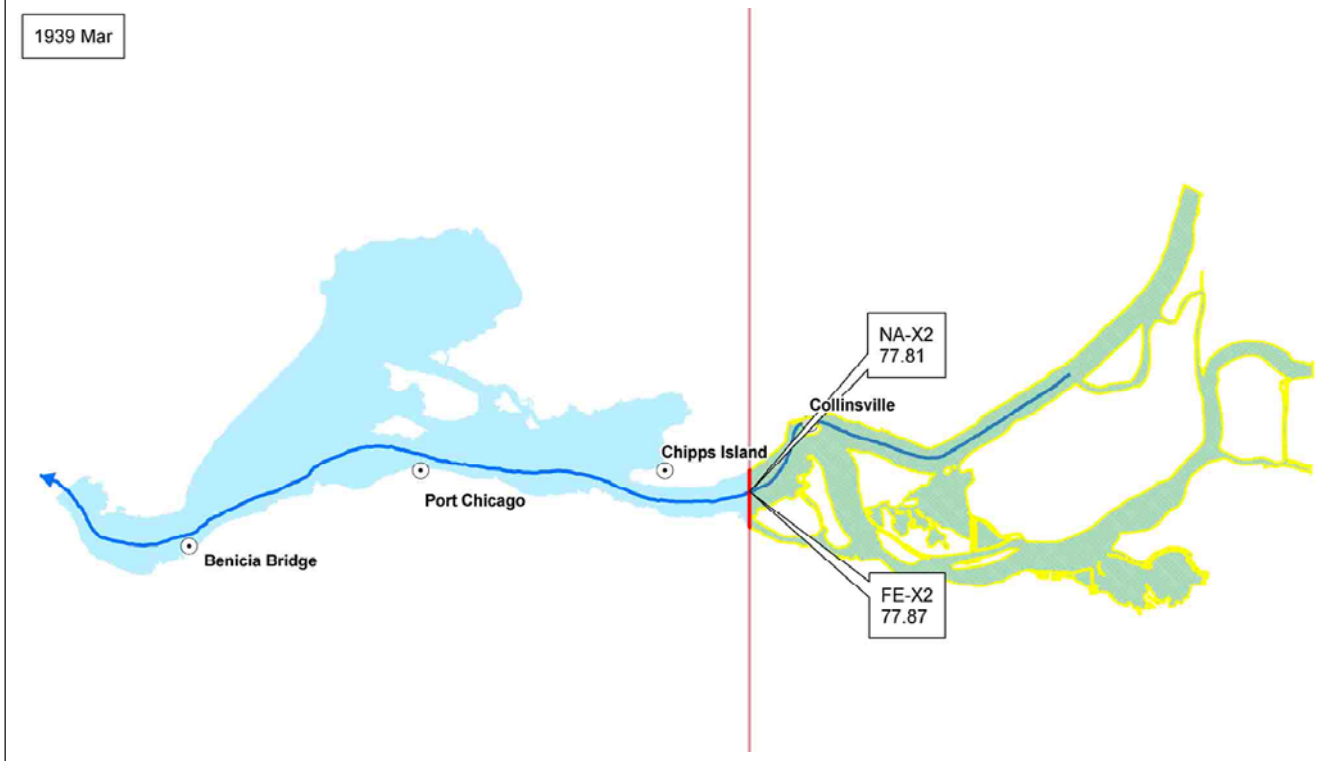

1938 Nov
NA-X2
87.25
Collinsville
Chipps Island
Port Chicago
FE-X2
87.65
Benicia Bridge

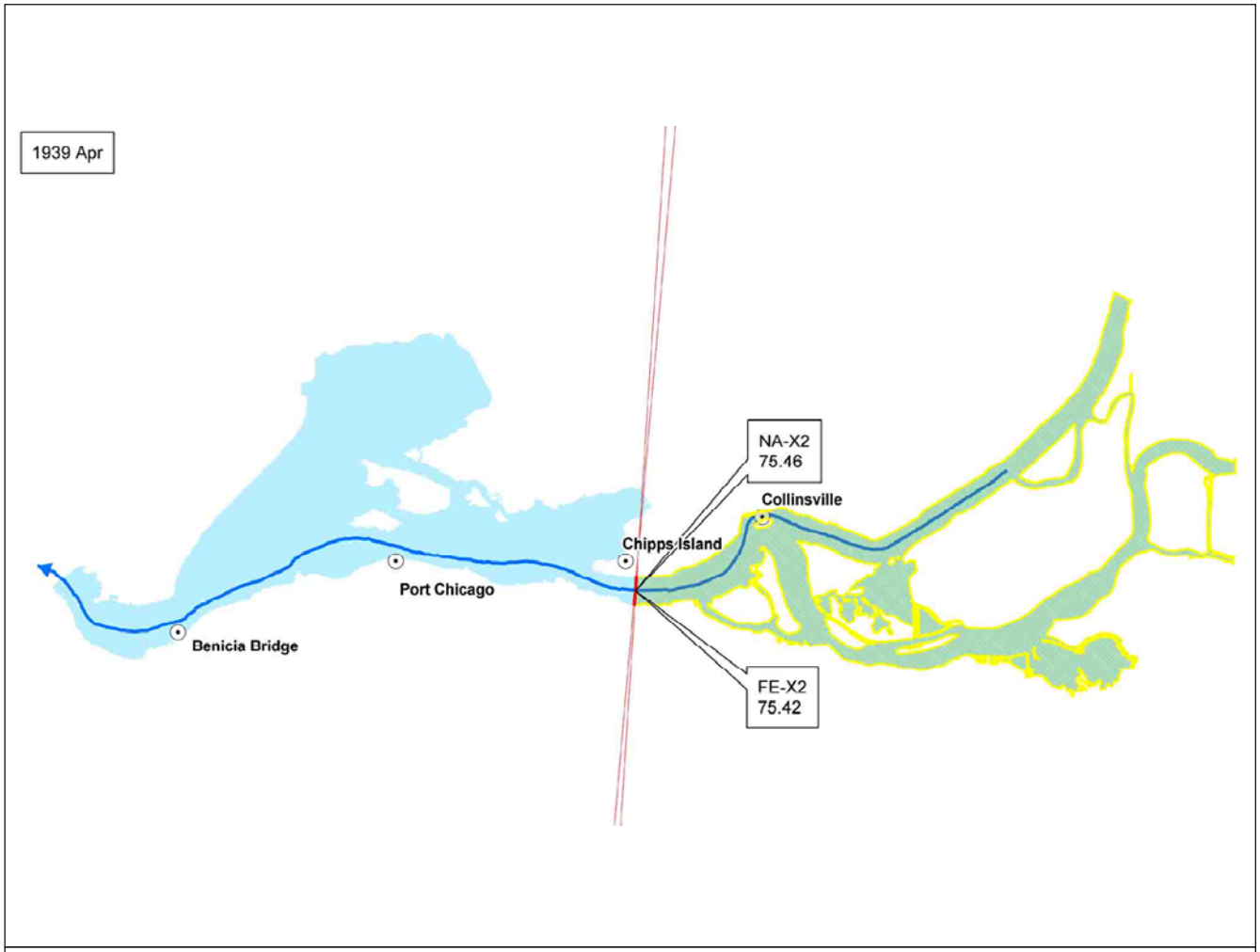

1938 Dec
NA-X2
77.15
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
77.30

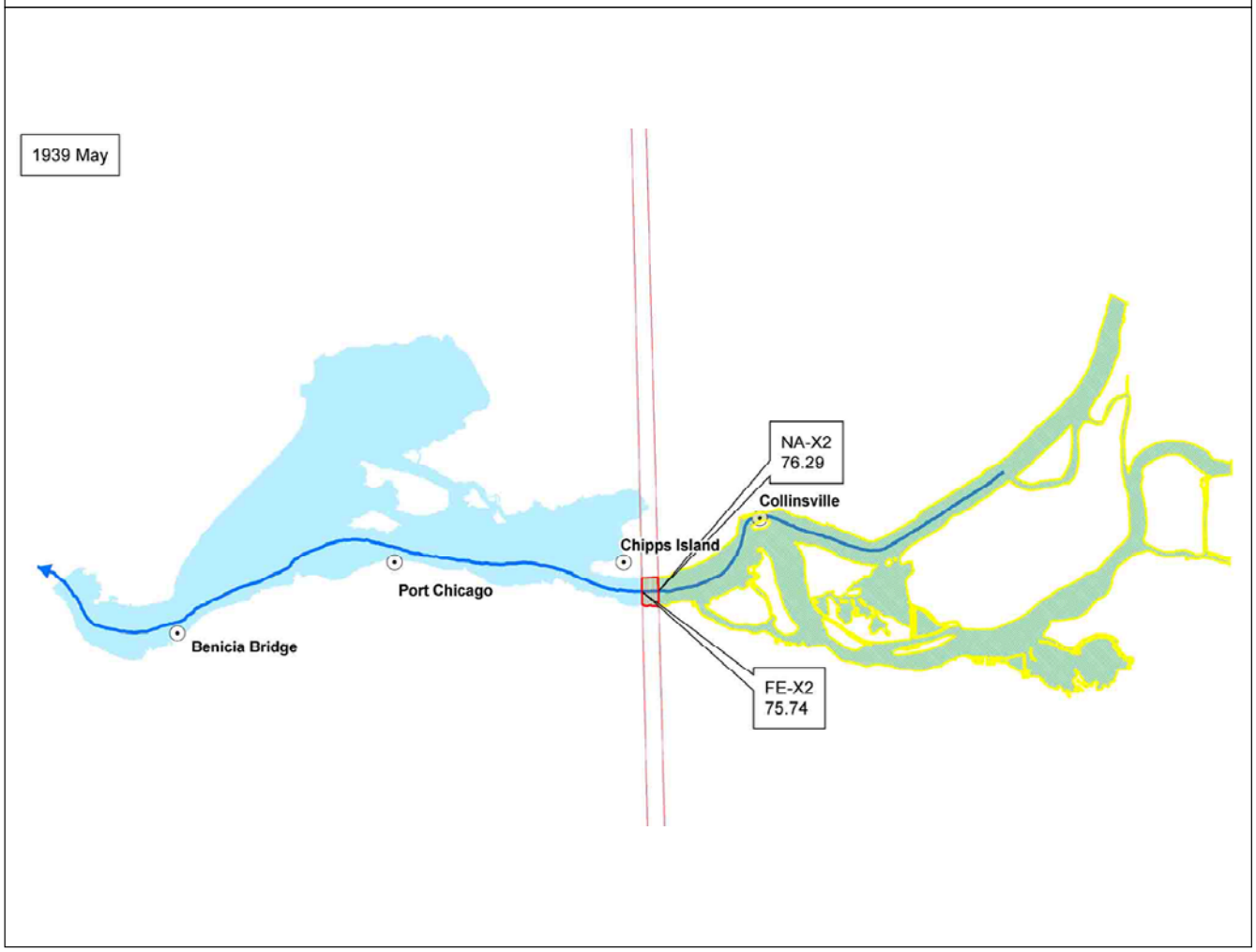

1938 average
NA-X2
66.28
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
66.39

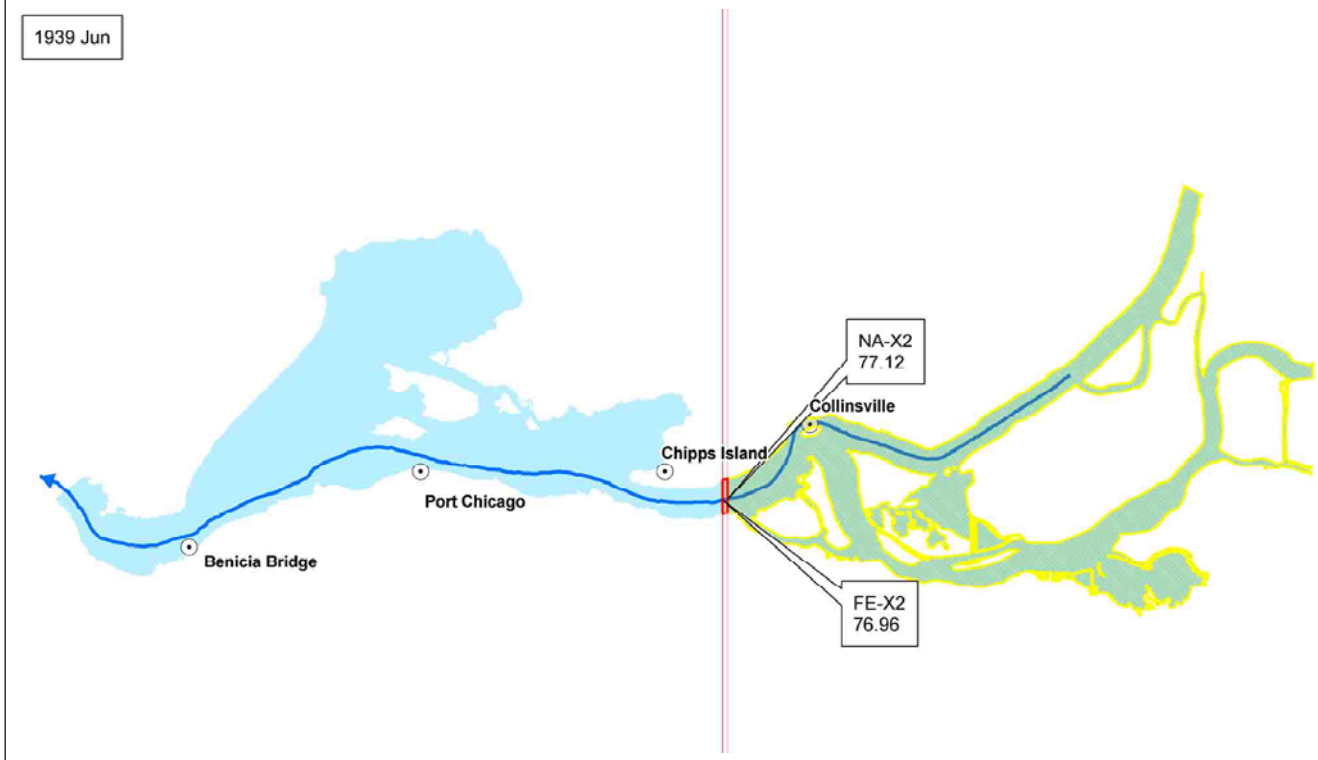

1939 Jan
NA-X2
80.80
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
80.87

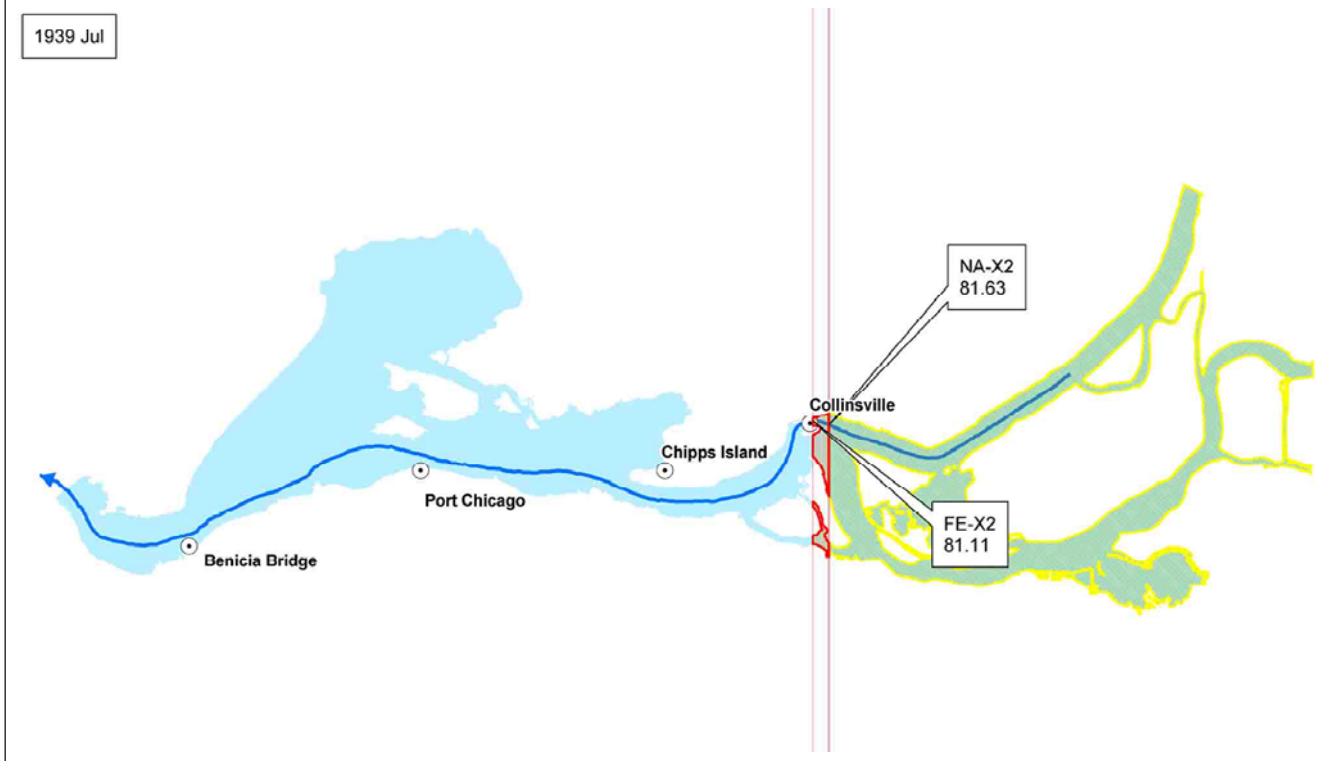

1939 Feb
NA-X2
80.63
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
80.71


1939 Mar
NA-X2
77.81
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
77.87

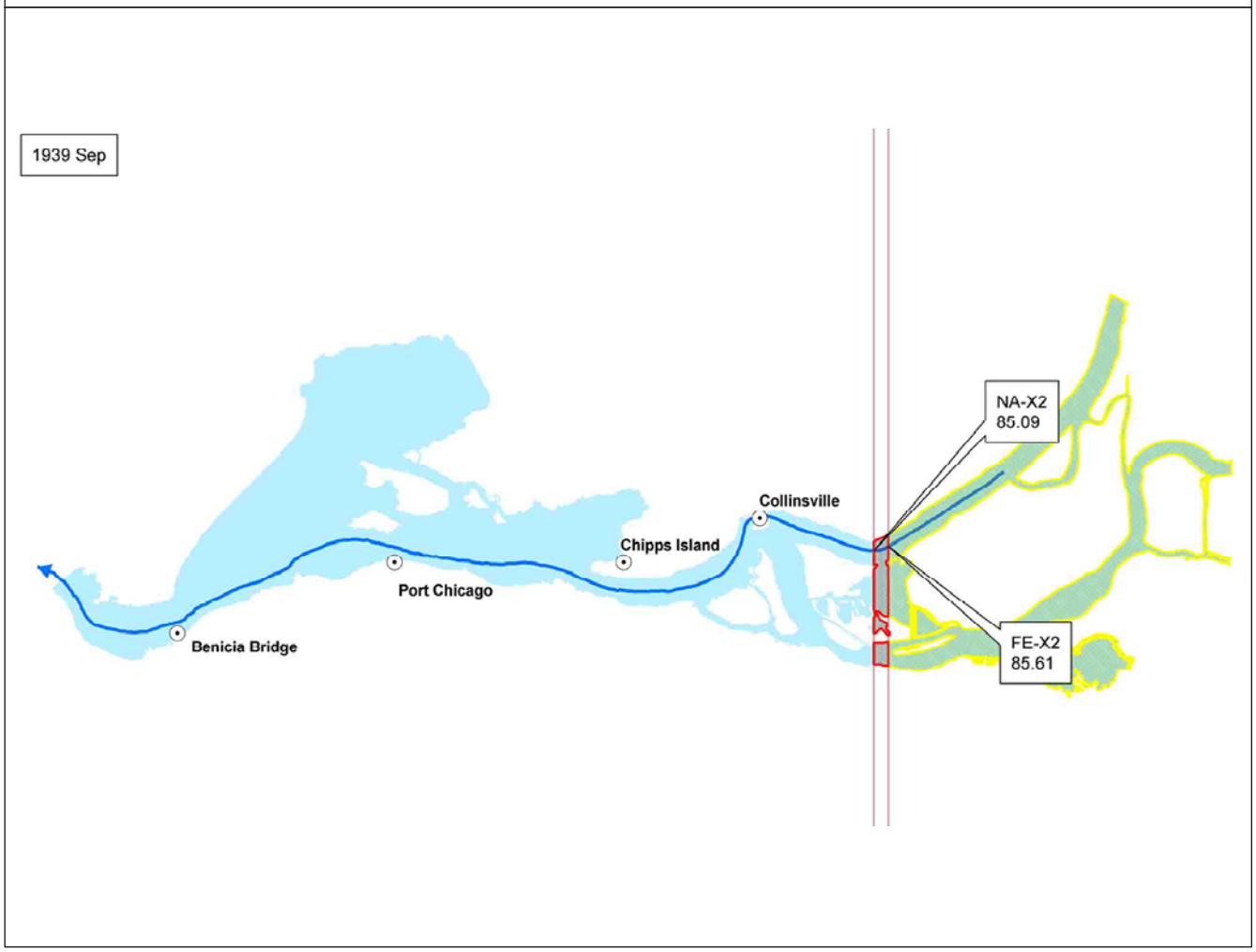

1939 Apr
NA-X2
75.46
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
75.42


1939 May
NA-X2
76.29
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
75.74

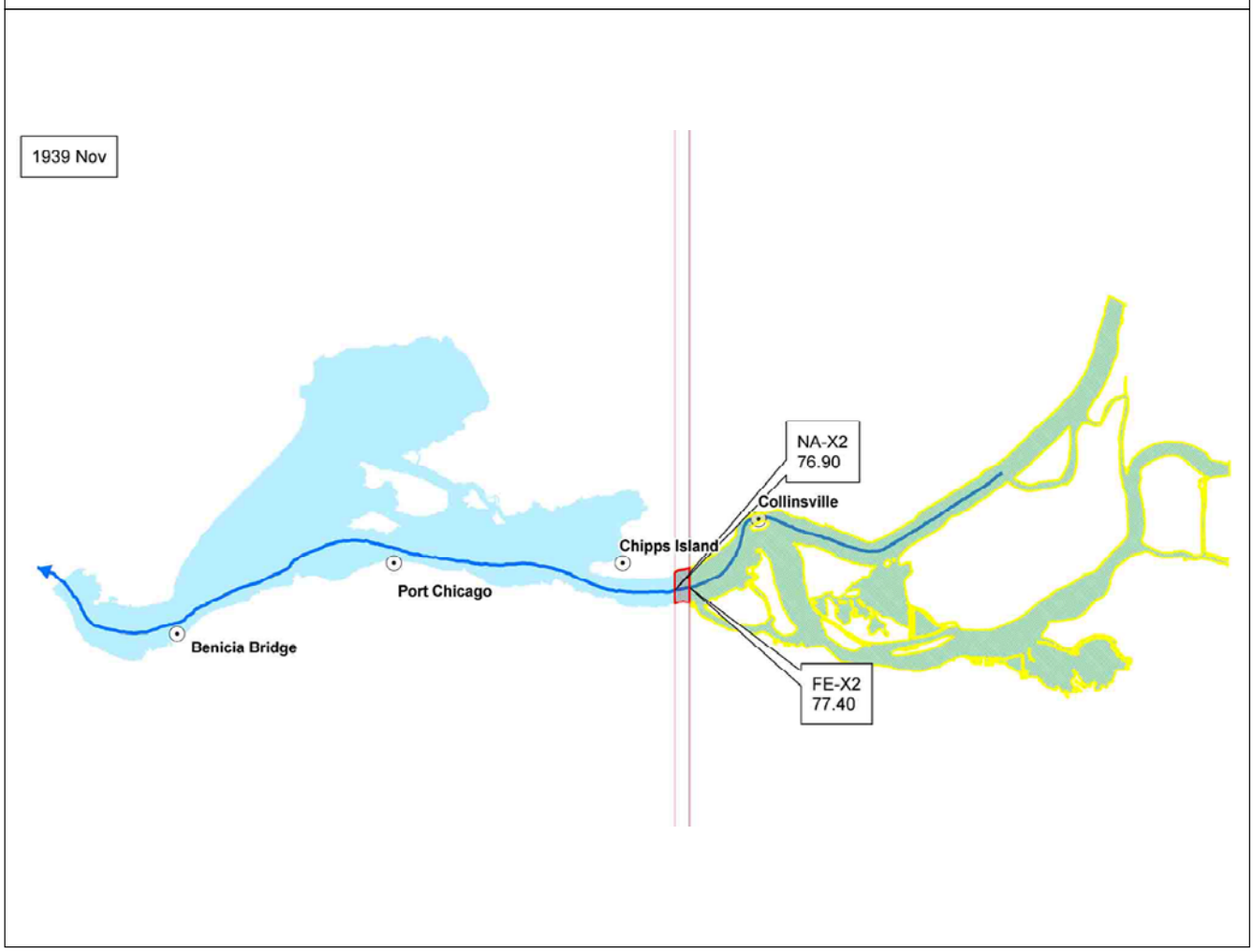

1939 Jun
NA-X2
77.12
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
76.96


1939 Jul
NA-X2
81.63
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
81.11


1939 Aug
NA-X2
83.67
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
83.50

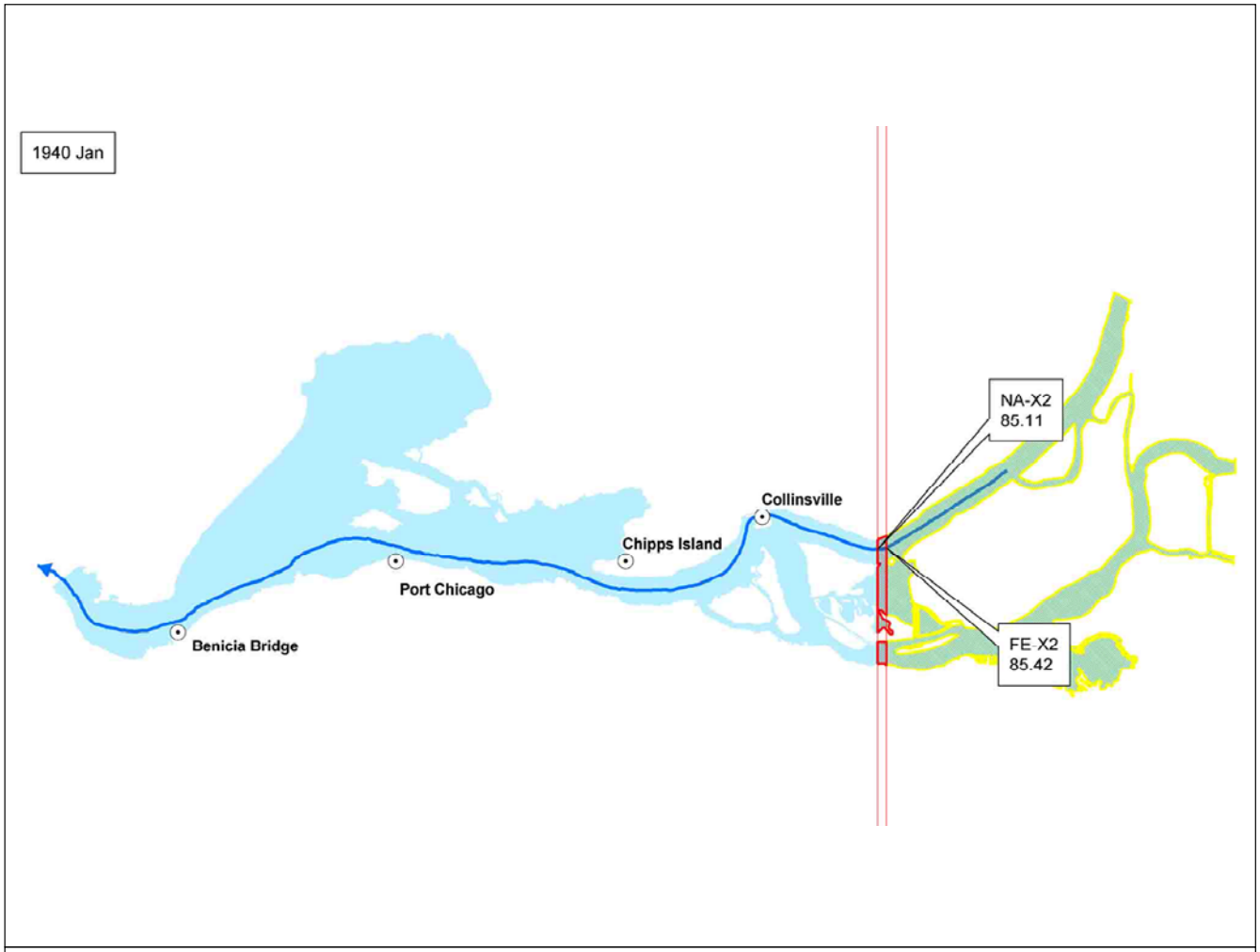

1939 Sep
NA-X2
85.09
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
85.61

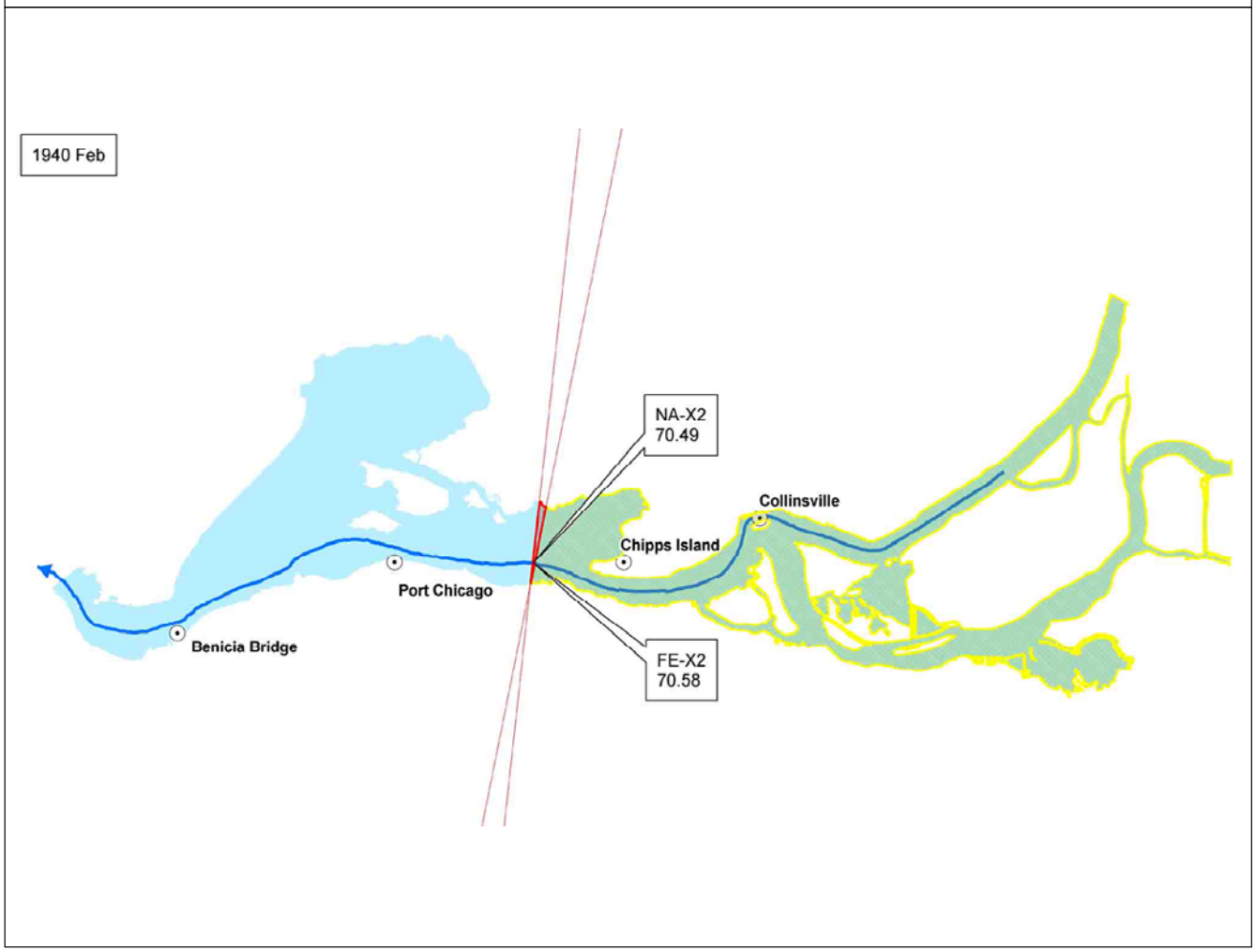

1939 Oct
NA-X2
80.57
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
81.28

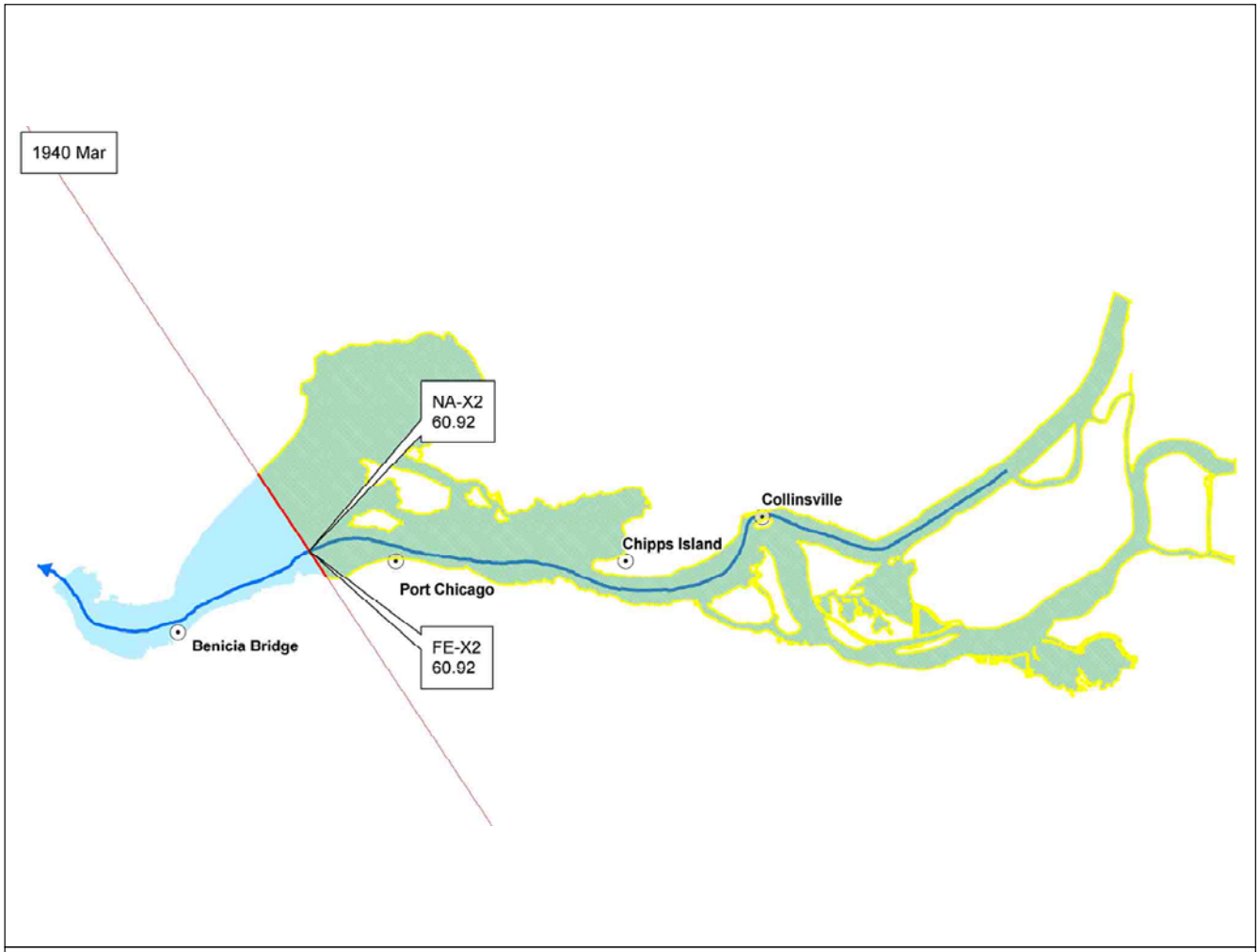

1939 Nov
NA-X2
76.90
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
77.40

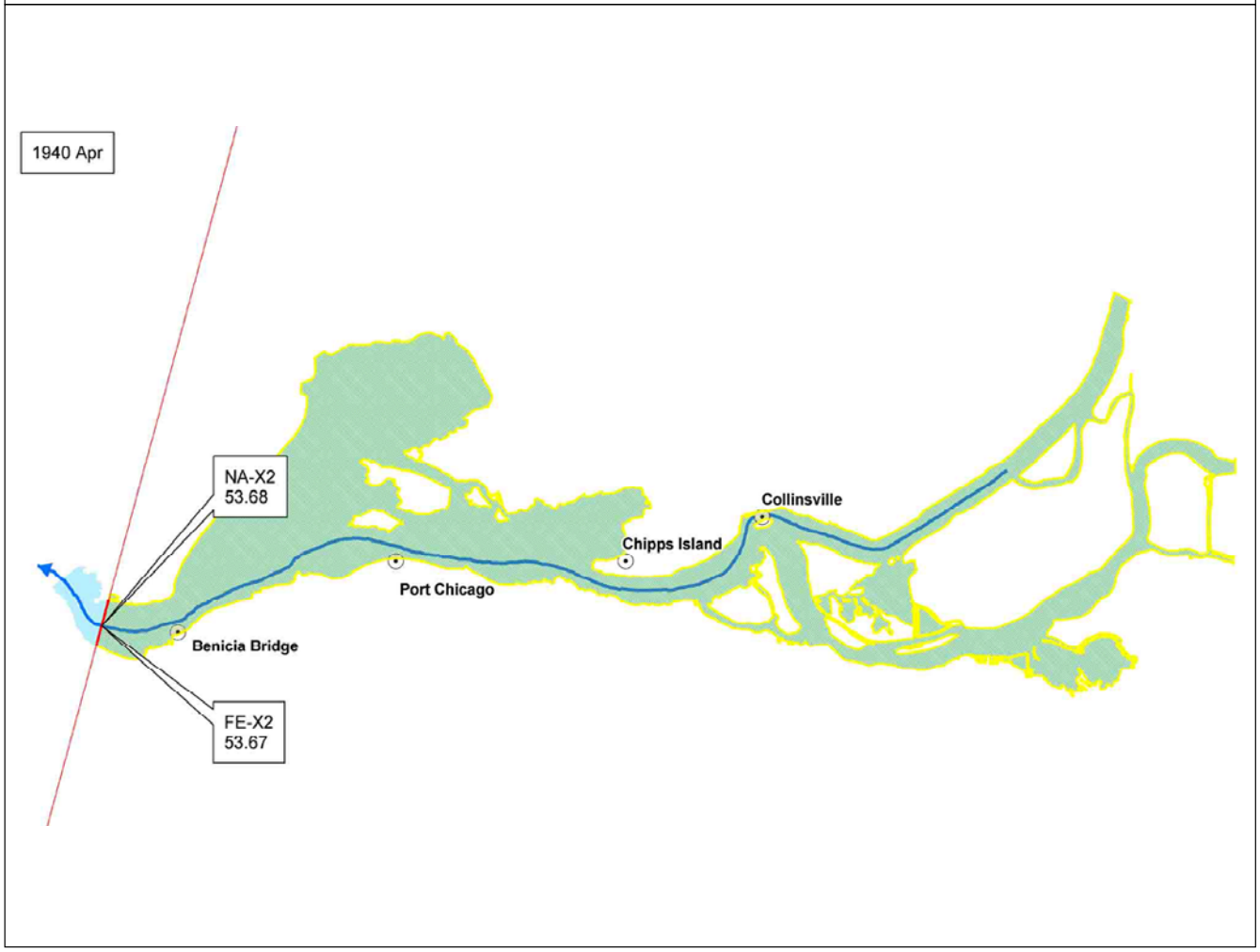

1939 Dec
NA-X2
82.92
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
83.09

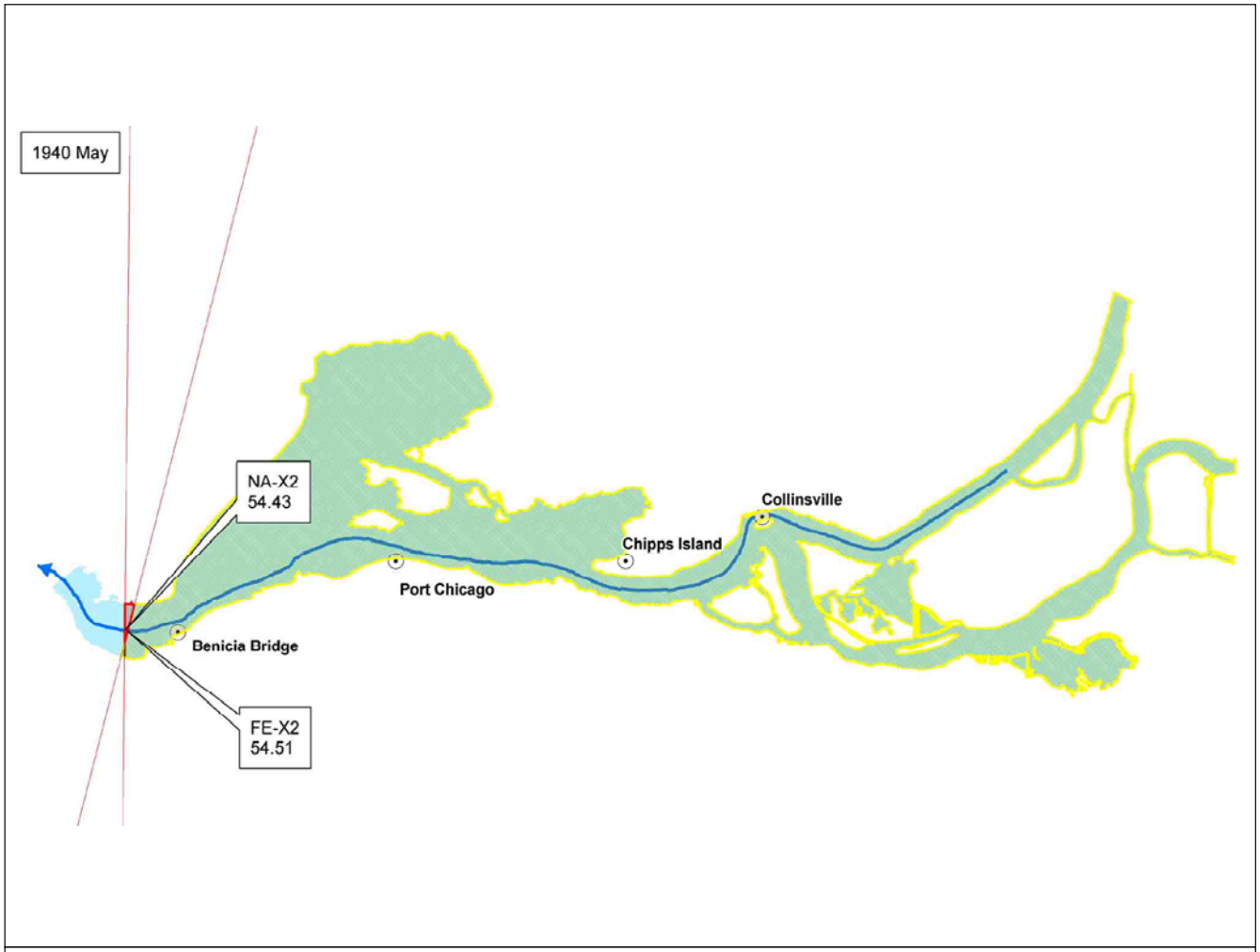

1939 average
NA-X2
79.91
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
79.96

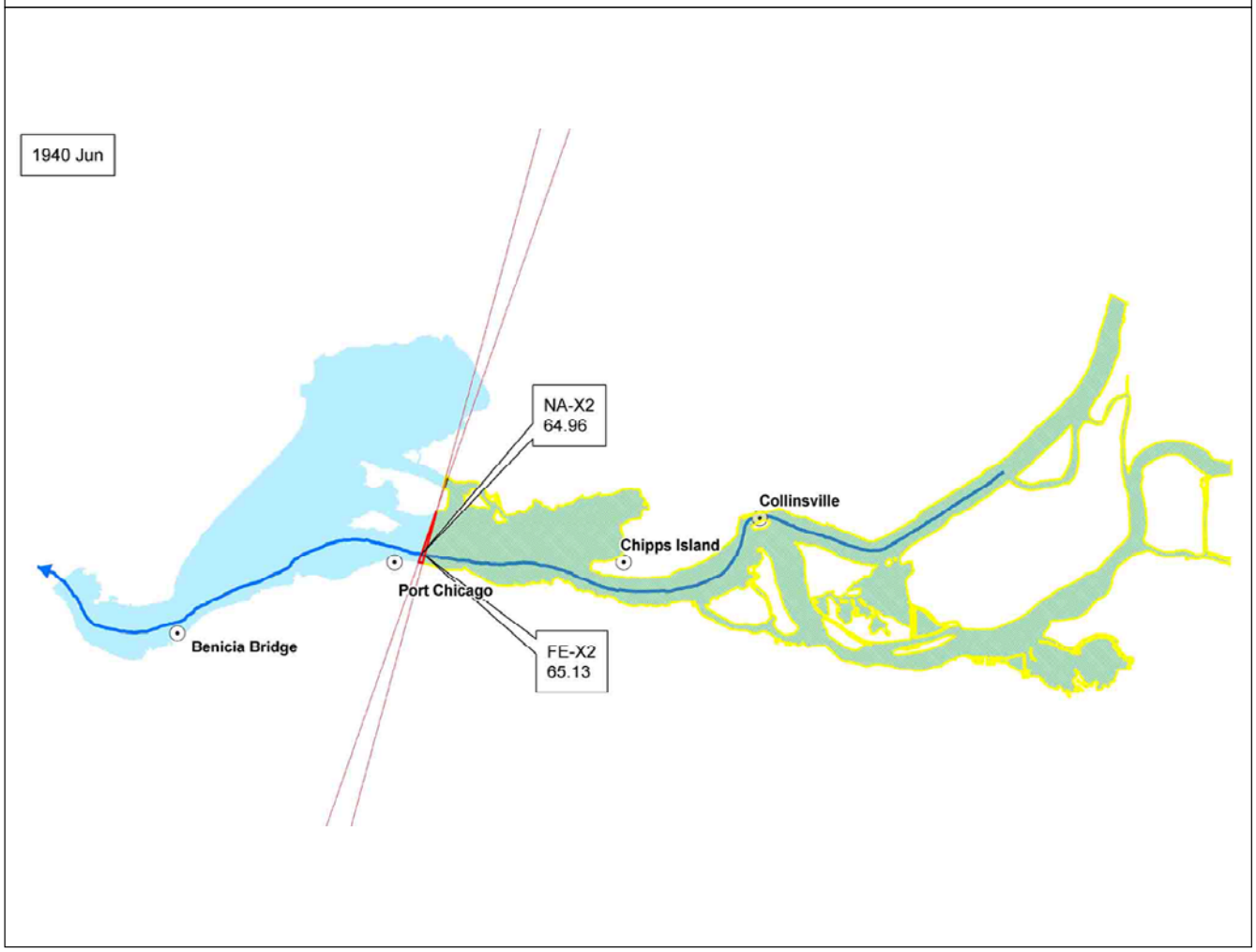

1940 Jan
NA-X2
85.11
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
85.42

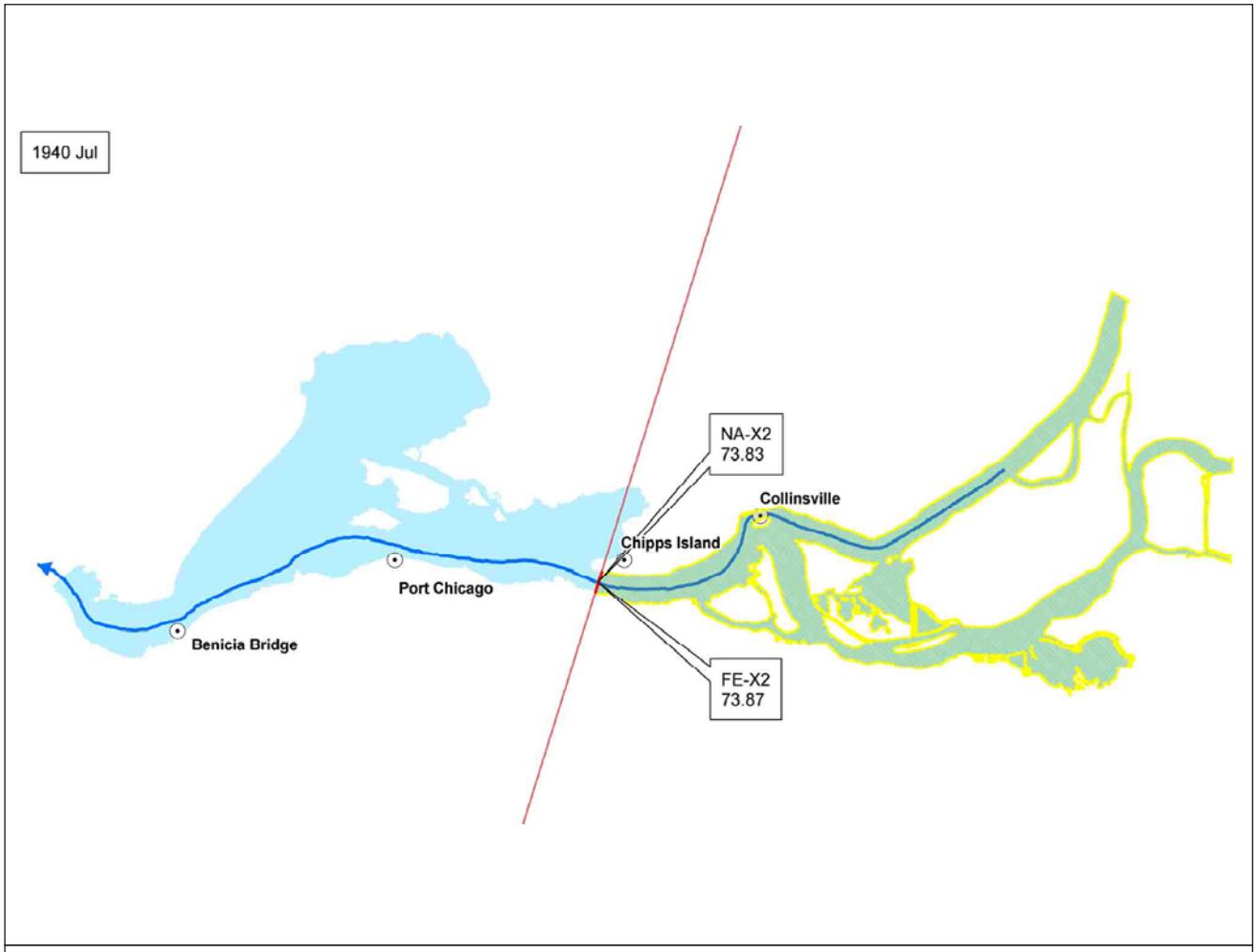

1940 Feb
NA-X2
70.49
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
70.58


1940 Mar
NA-X2
60.92
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
60.92


1940 Apr
NA-X2
53.68
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
53.67

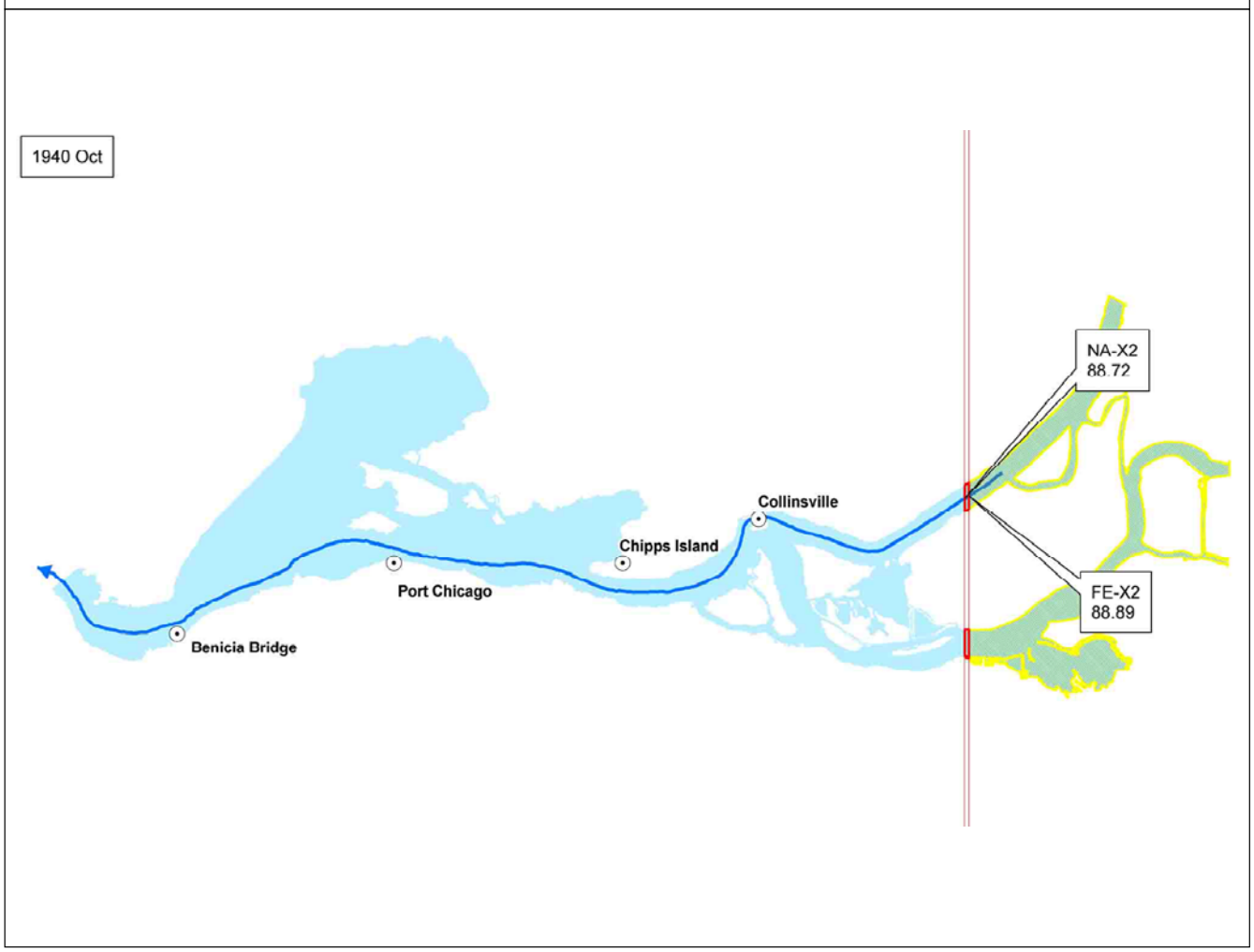

1940 May
NA-X2
54.43
FE-X2
54.51
Benicia Bridge
Port Chicago
Chipps Island
Collinsville


1940 Jun
NA-X2
64.96
FE-X2
65.13
Benicia Bridge
Port Chicago
Chipps Island
Collinsville

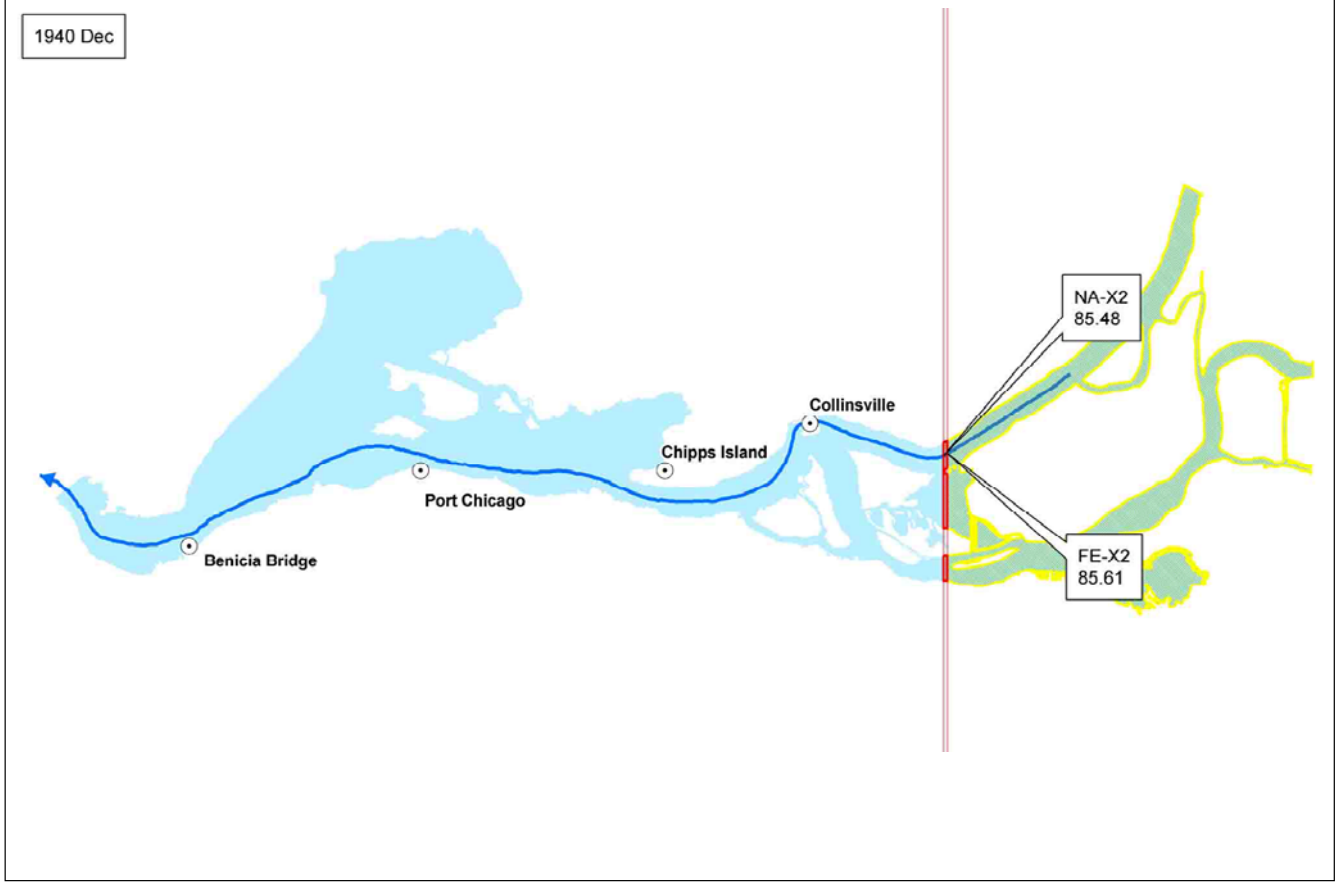

1940 Jul
NA-X2
73.83
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
73.87

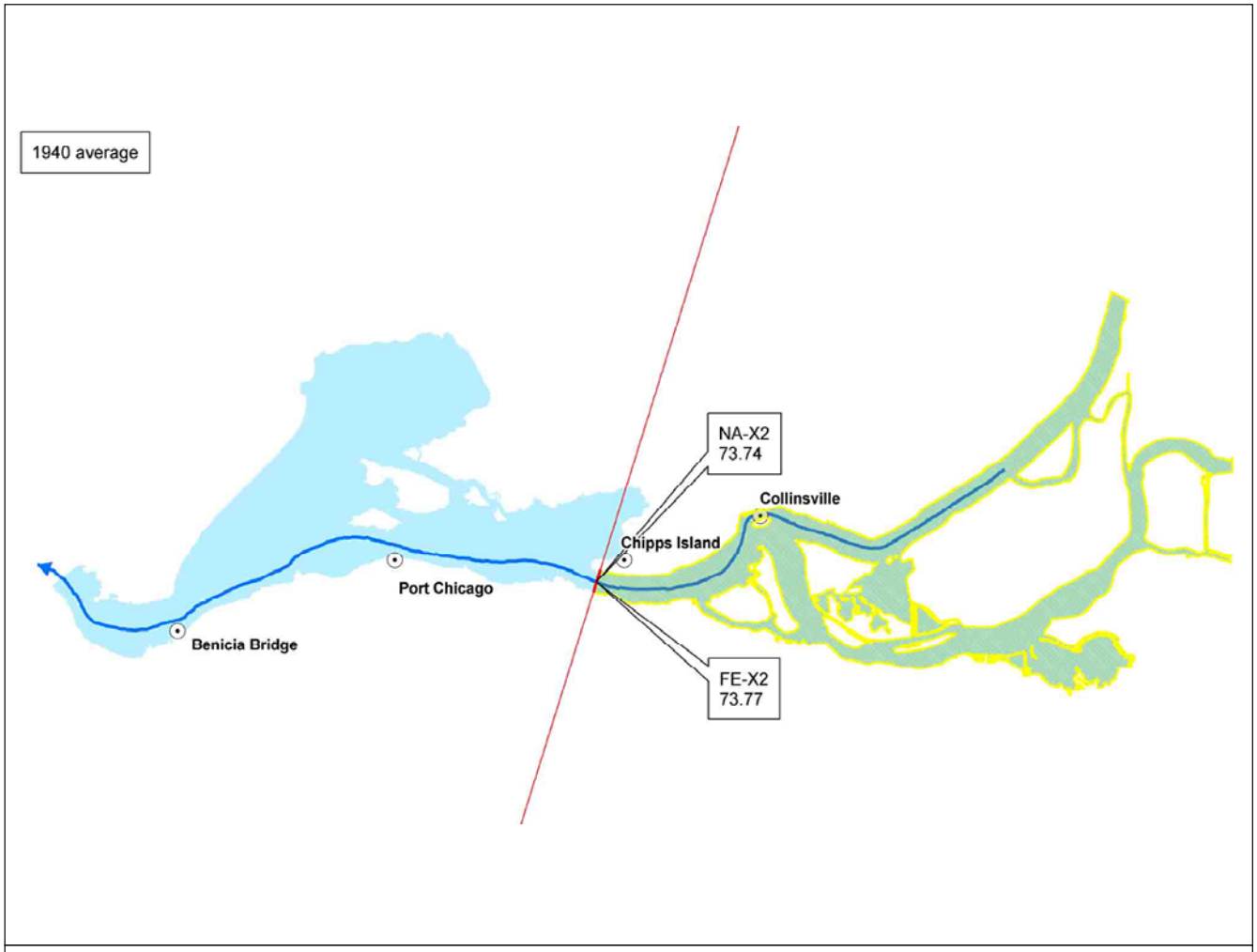

1940 Aug
NA-X2
77.51
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
77.52

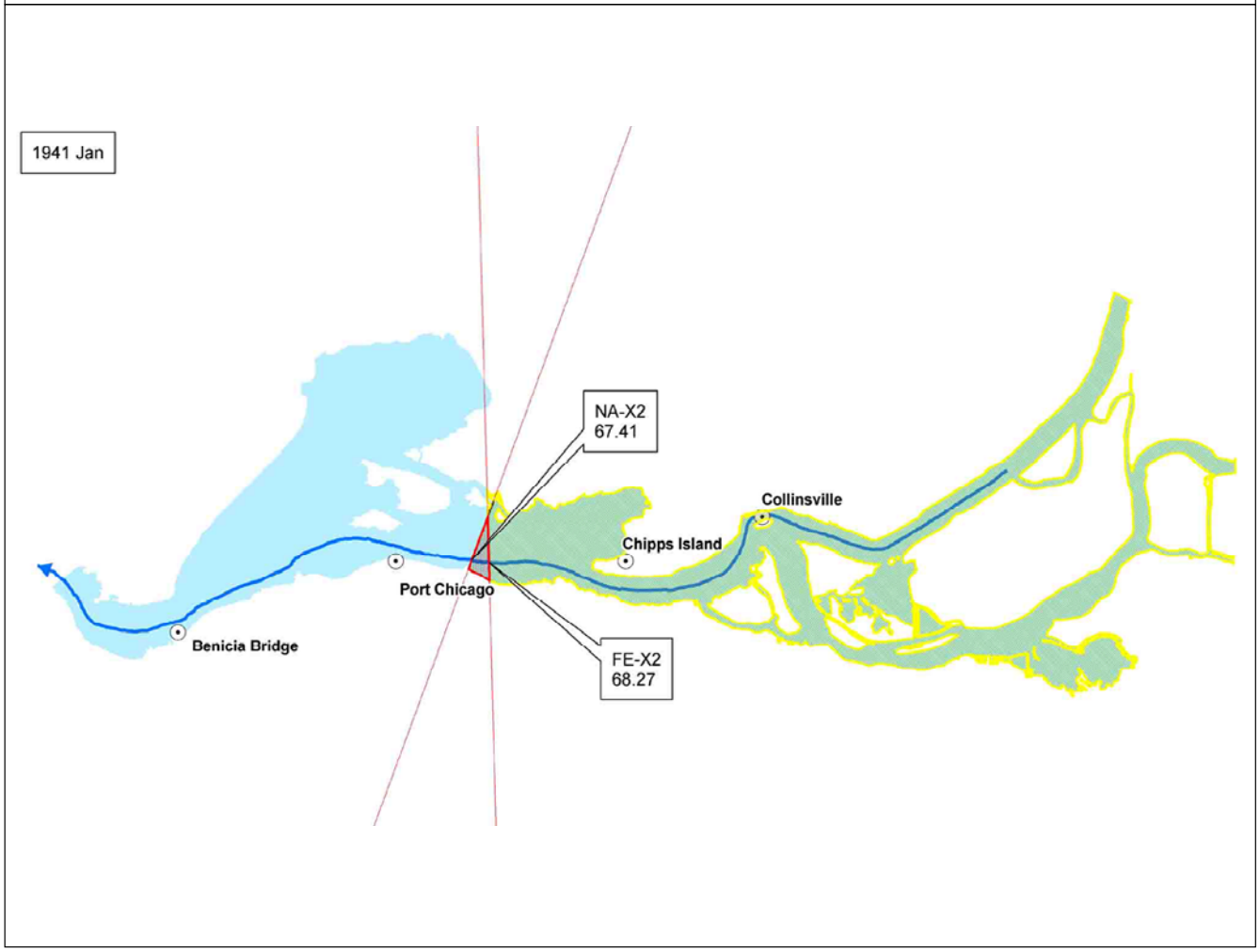

1940 Sep
NA-X2
84.03
FE-X2
84.03
Collinsville
Chipps Island
Port Chicago
Benicia Bridge

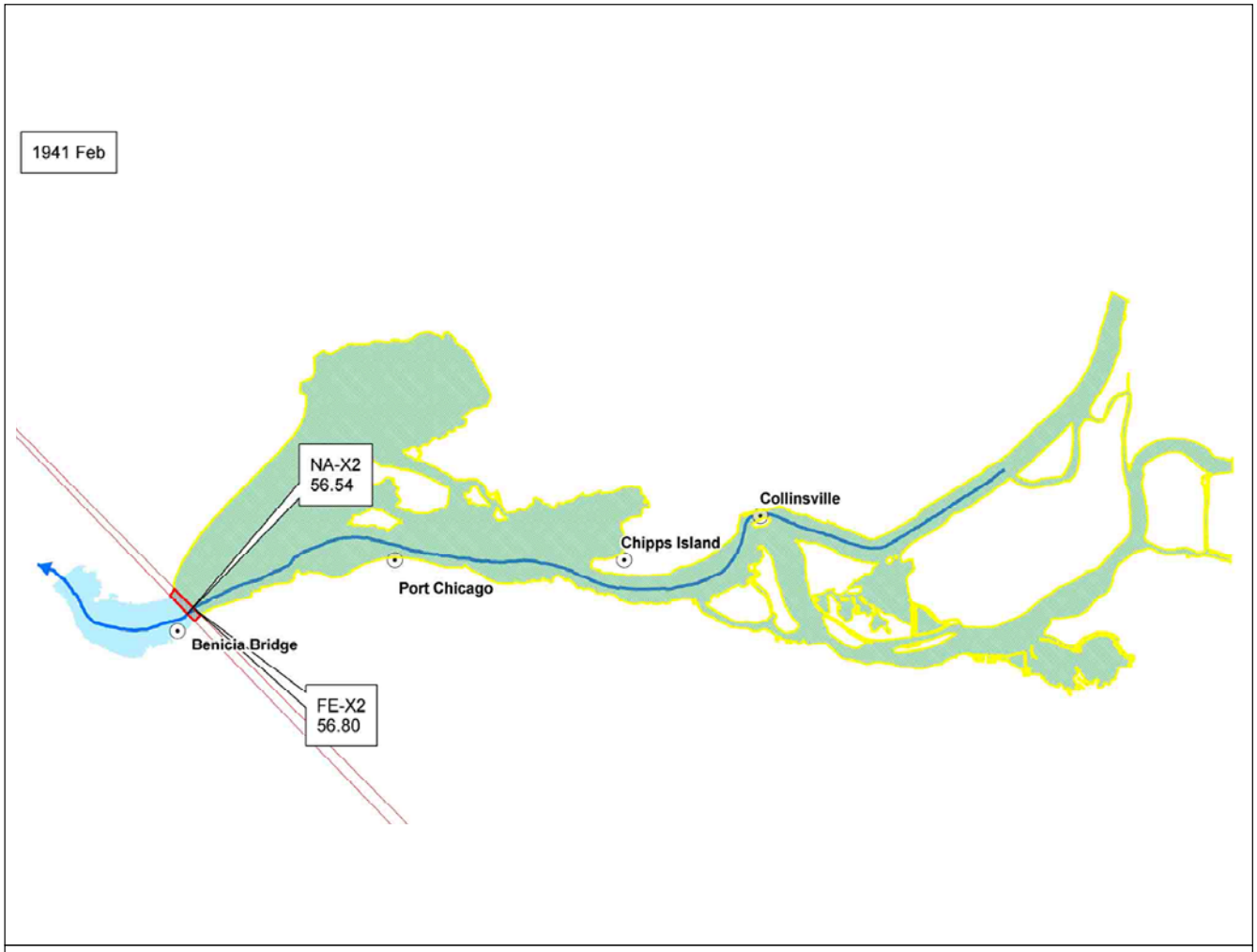

1940 Oct
NA-X2
88.72
FE-X2
88.89
Collinsville
Chipps Island
Port Chicago
Benicia Bridge

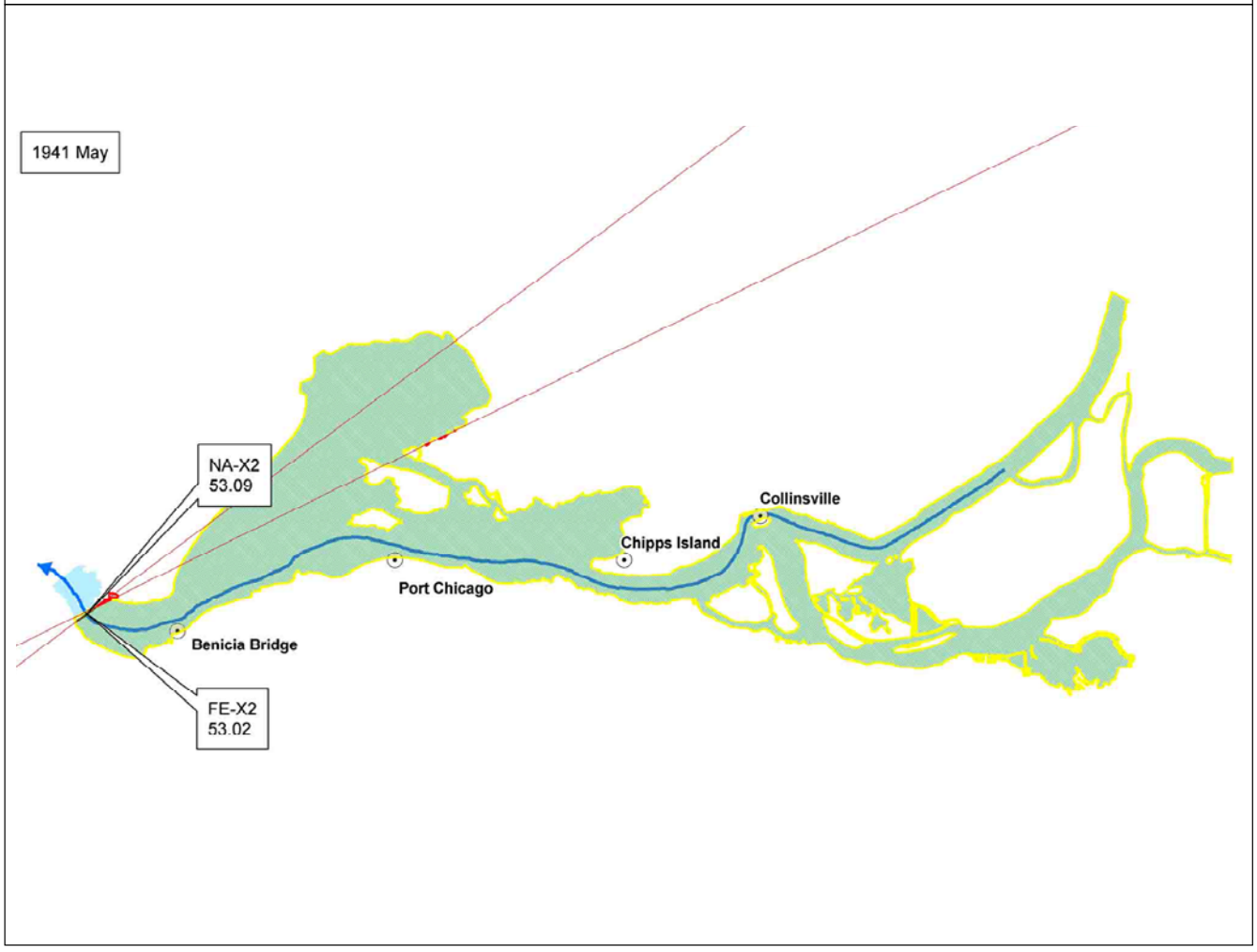

1940 Nov
NA-X2
85.74
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
85.10

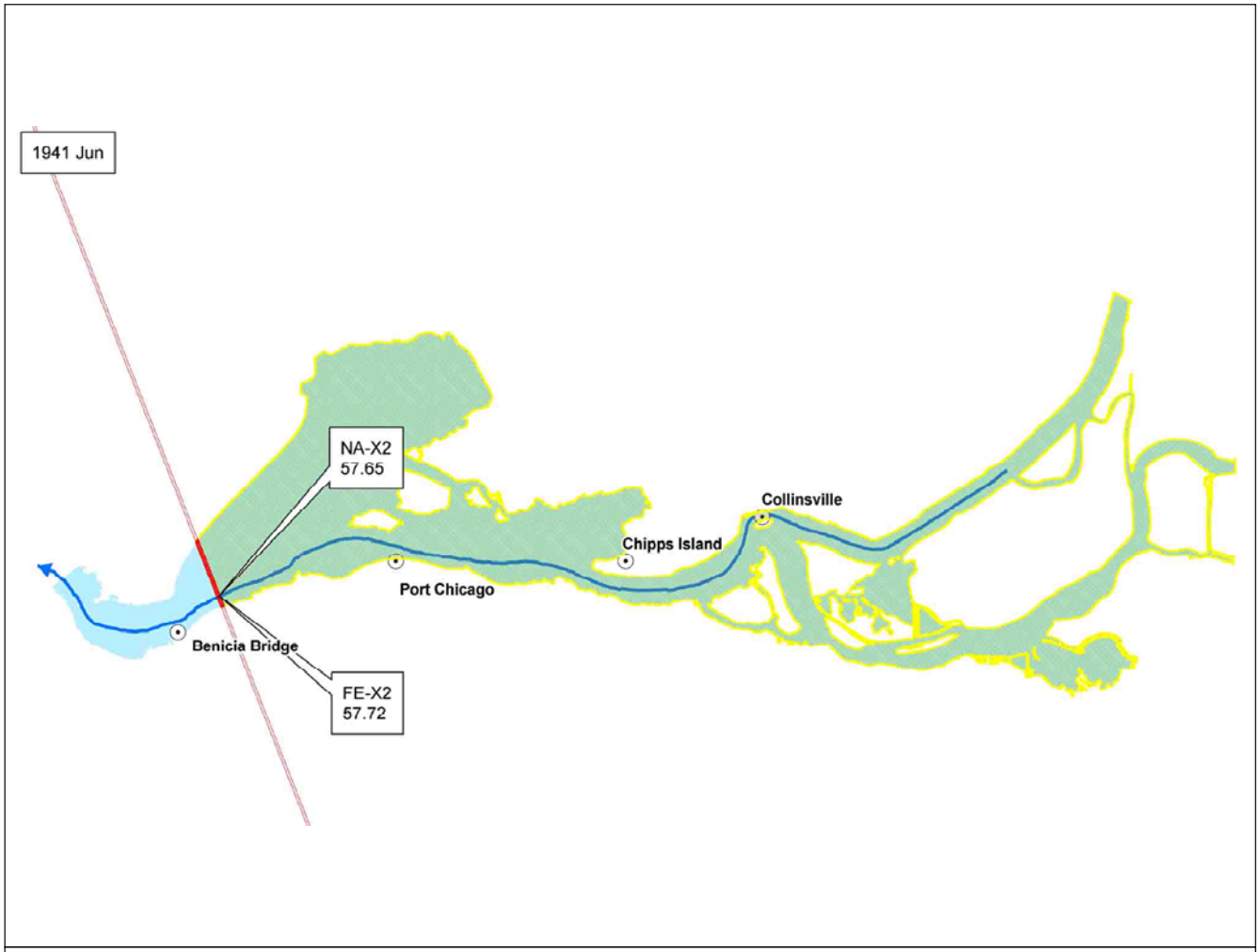

1940 Dec
NA-X2
85.48
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
85.61

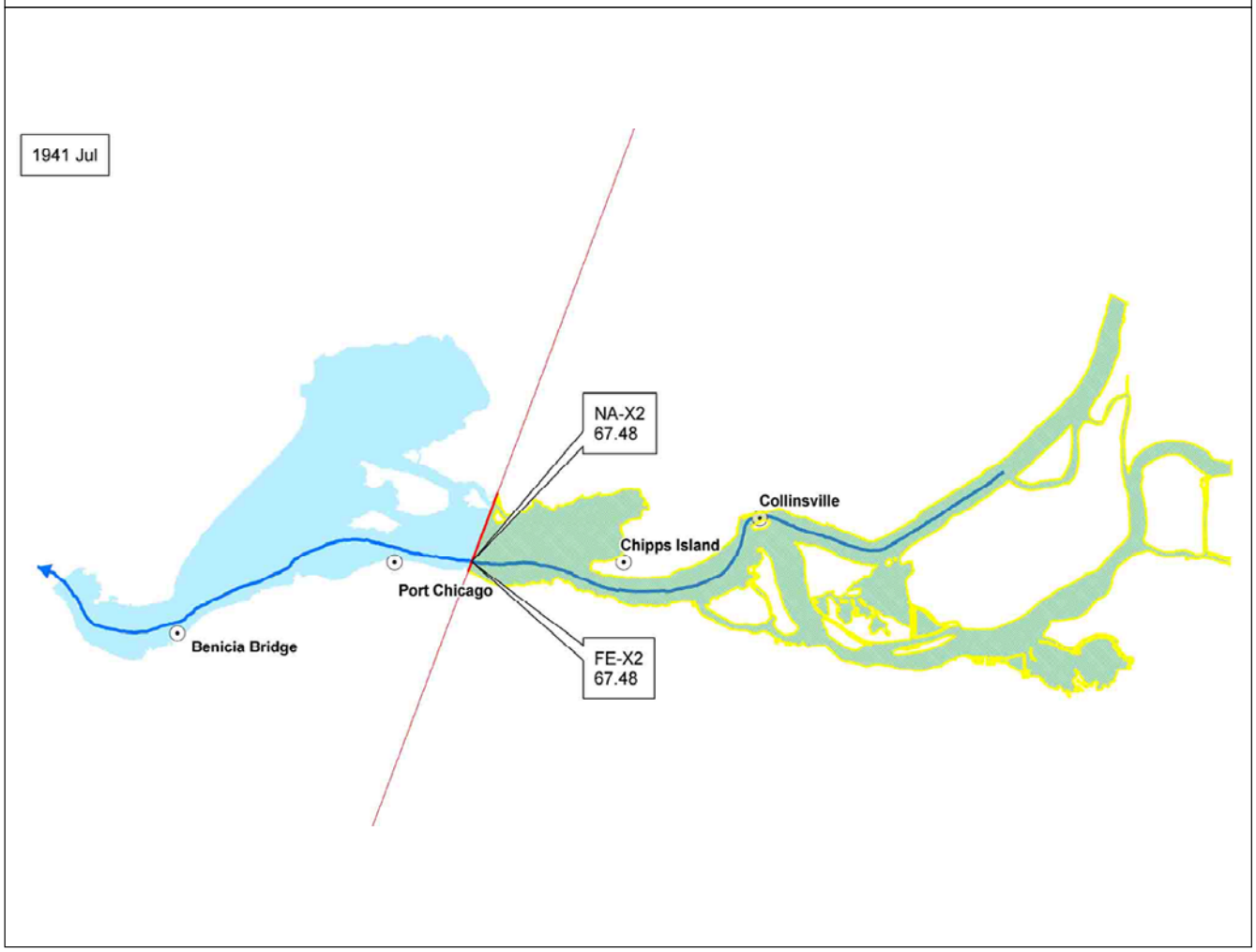

1940 average
NA-X2
73.74
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
73.77

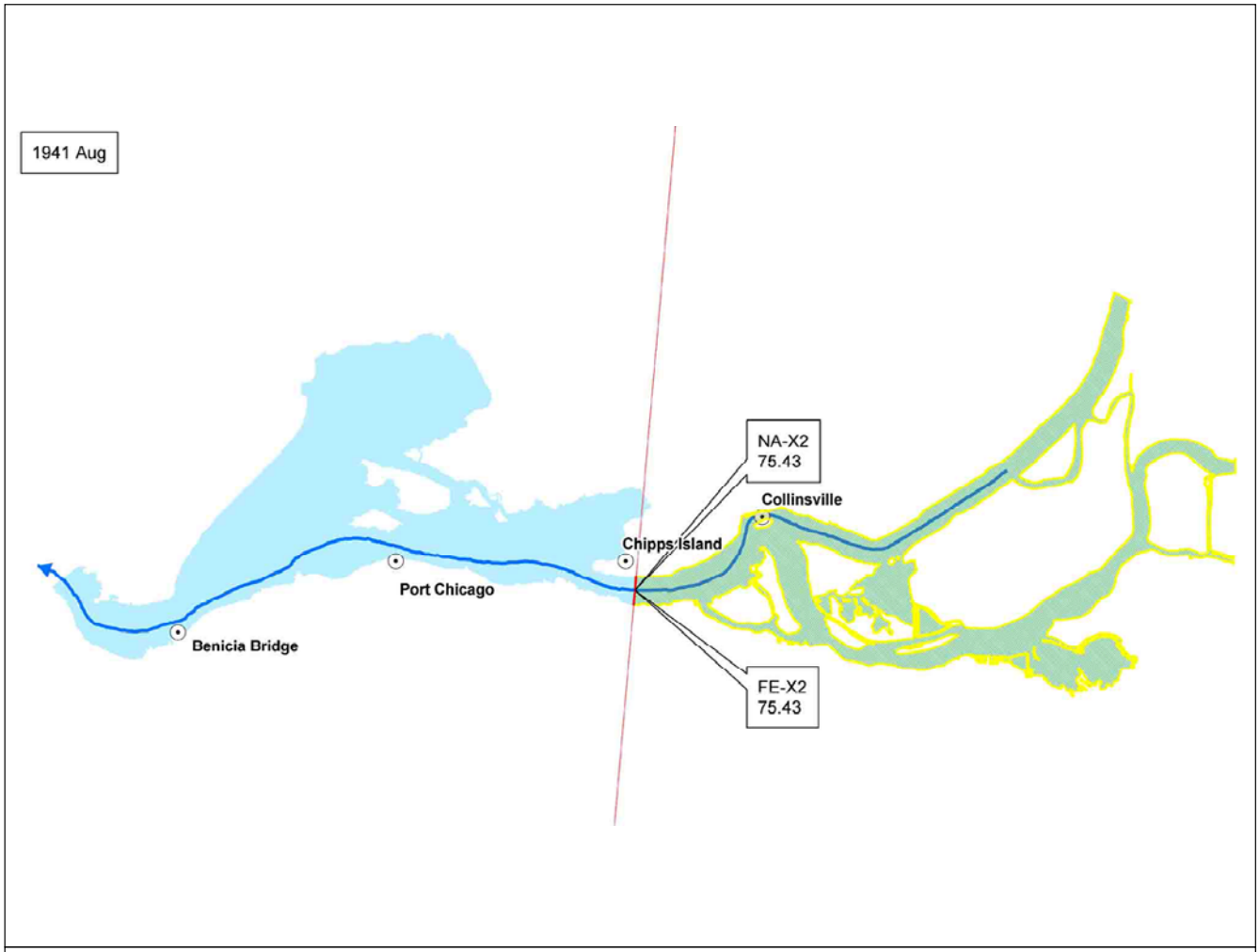

1941 Jan
NA-X2
67.41
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
68.27


1941 Feb
NA-X2
56.54
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
56.80

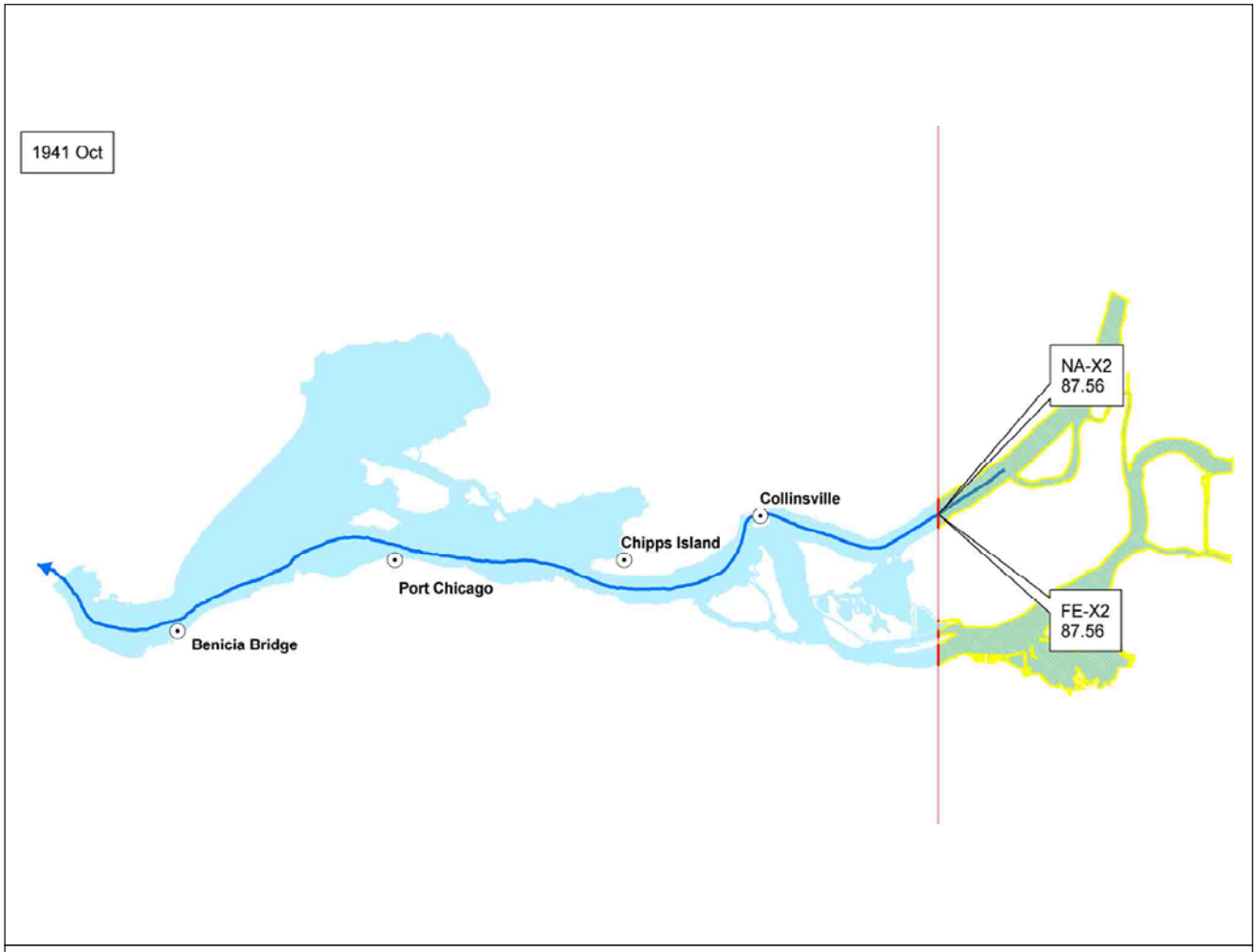

1941 May
NA-X2
53.09
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
53.02

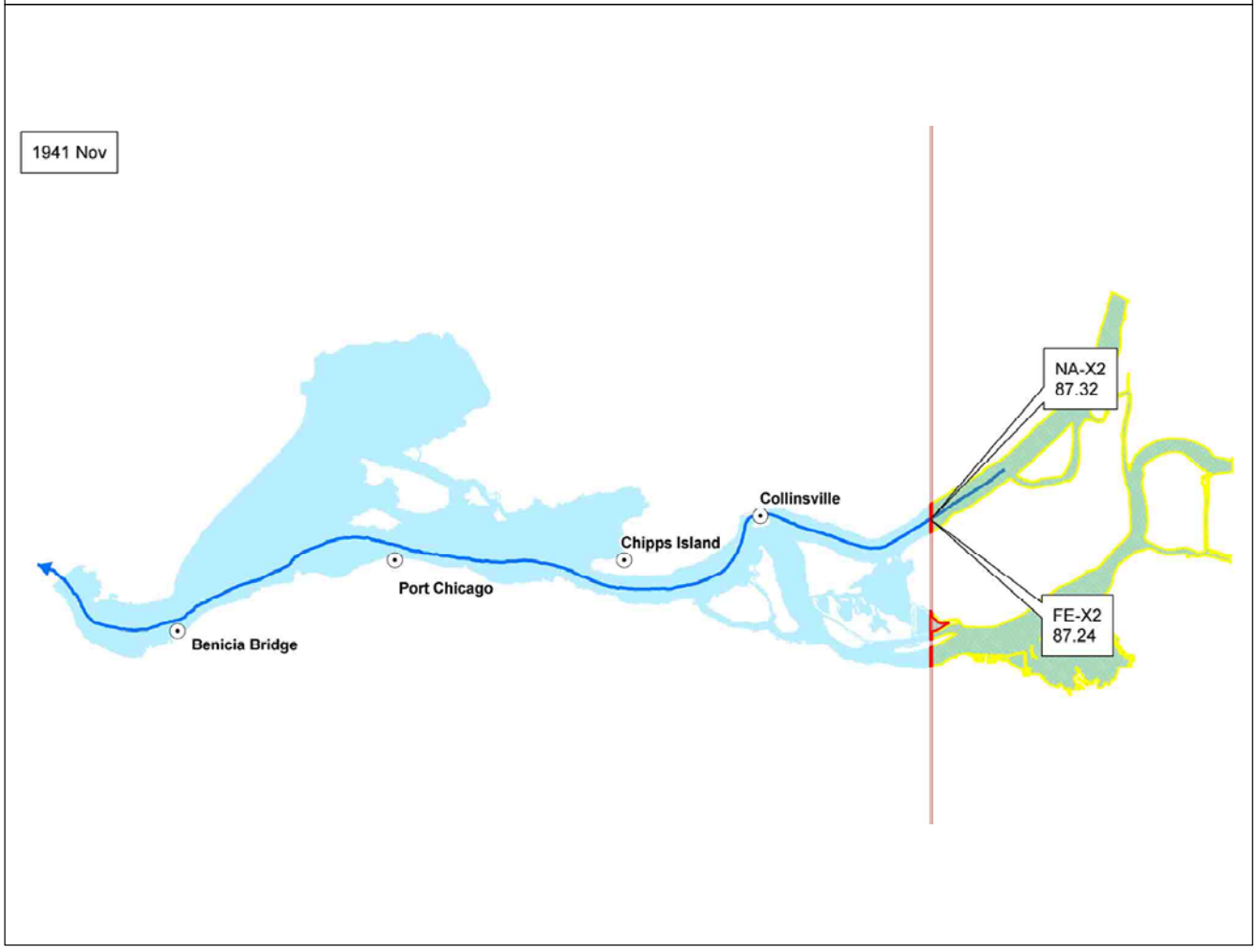

1941 Jun
NA-X2
57.65
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
57.72


1941 Jul
NA-X2
67.48
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
67.48

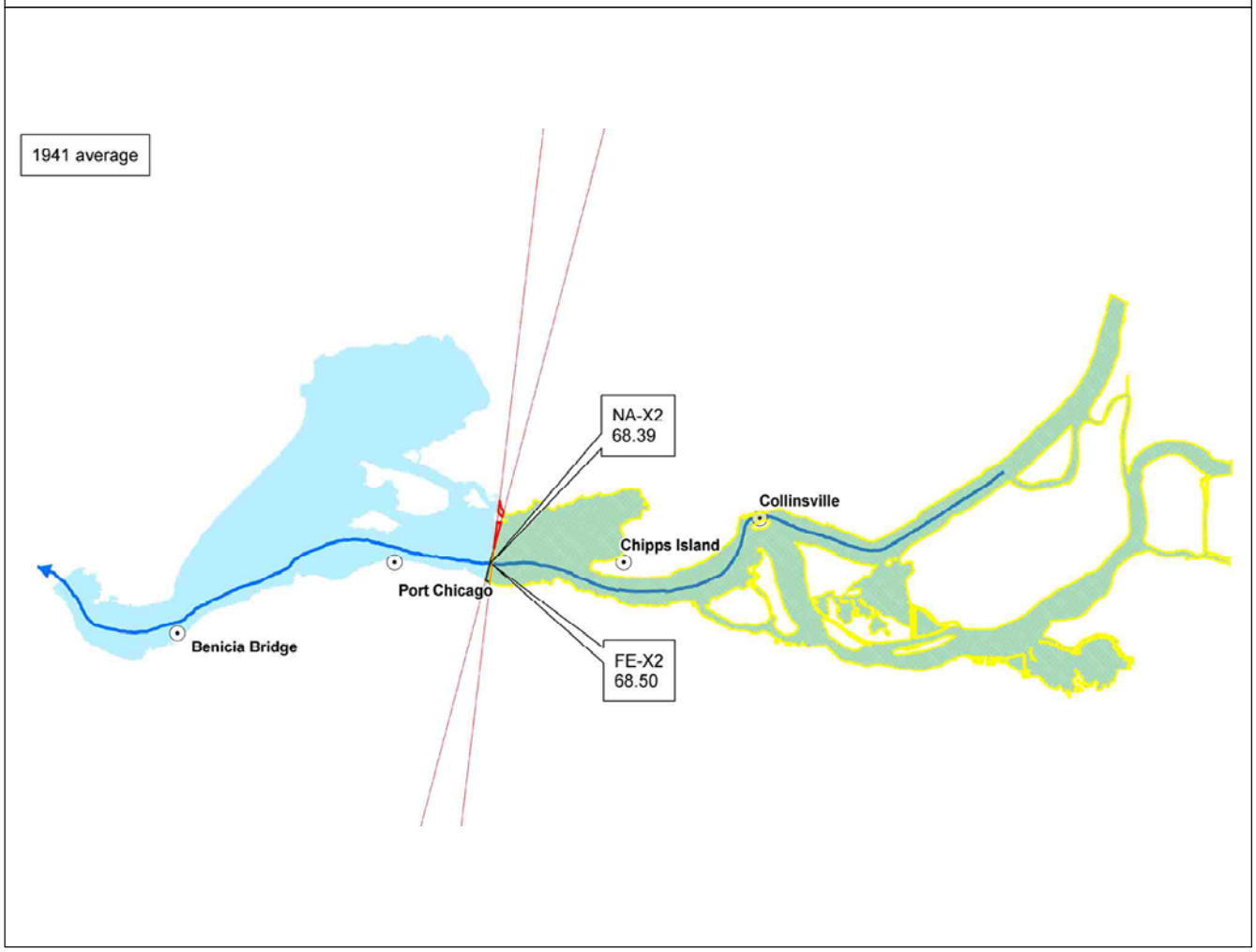

1941 Aug
NA-X2
75.43
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
75.43

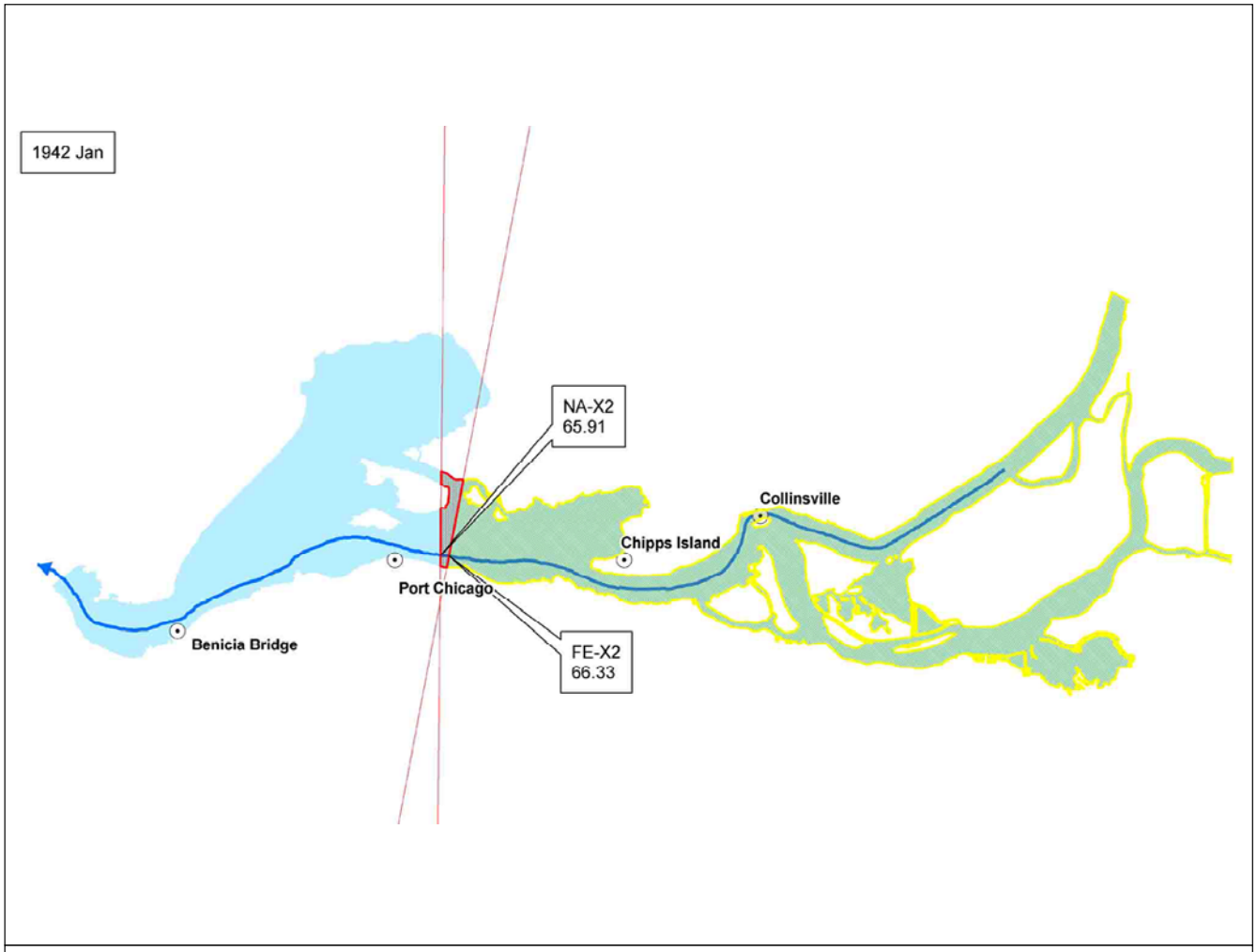

1941 Sep
NA-X2
83.34
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
83.30

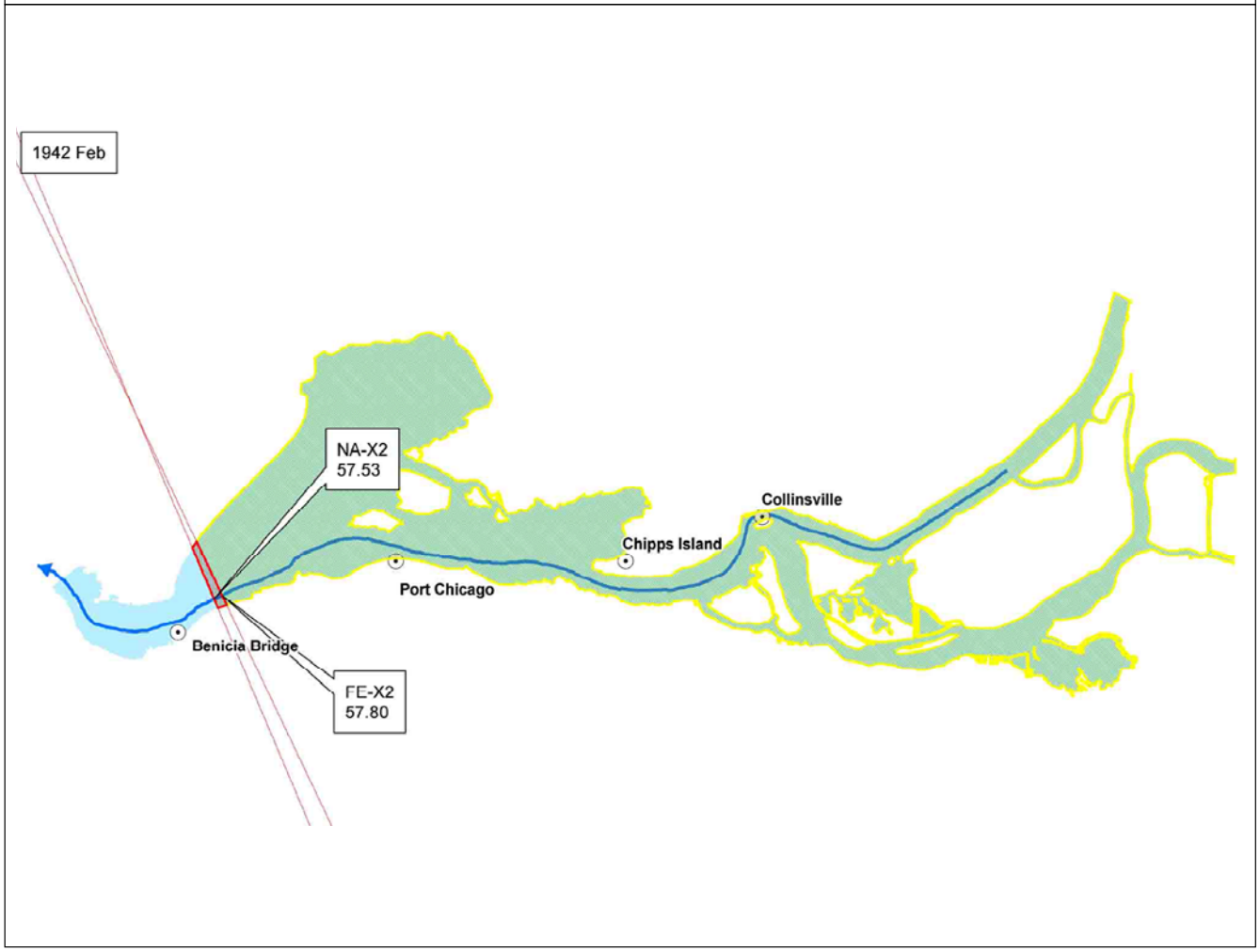

1941 Oct
NA-X2
87.56
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
87.56

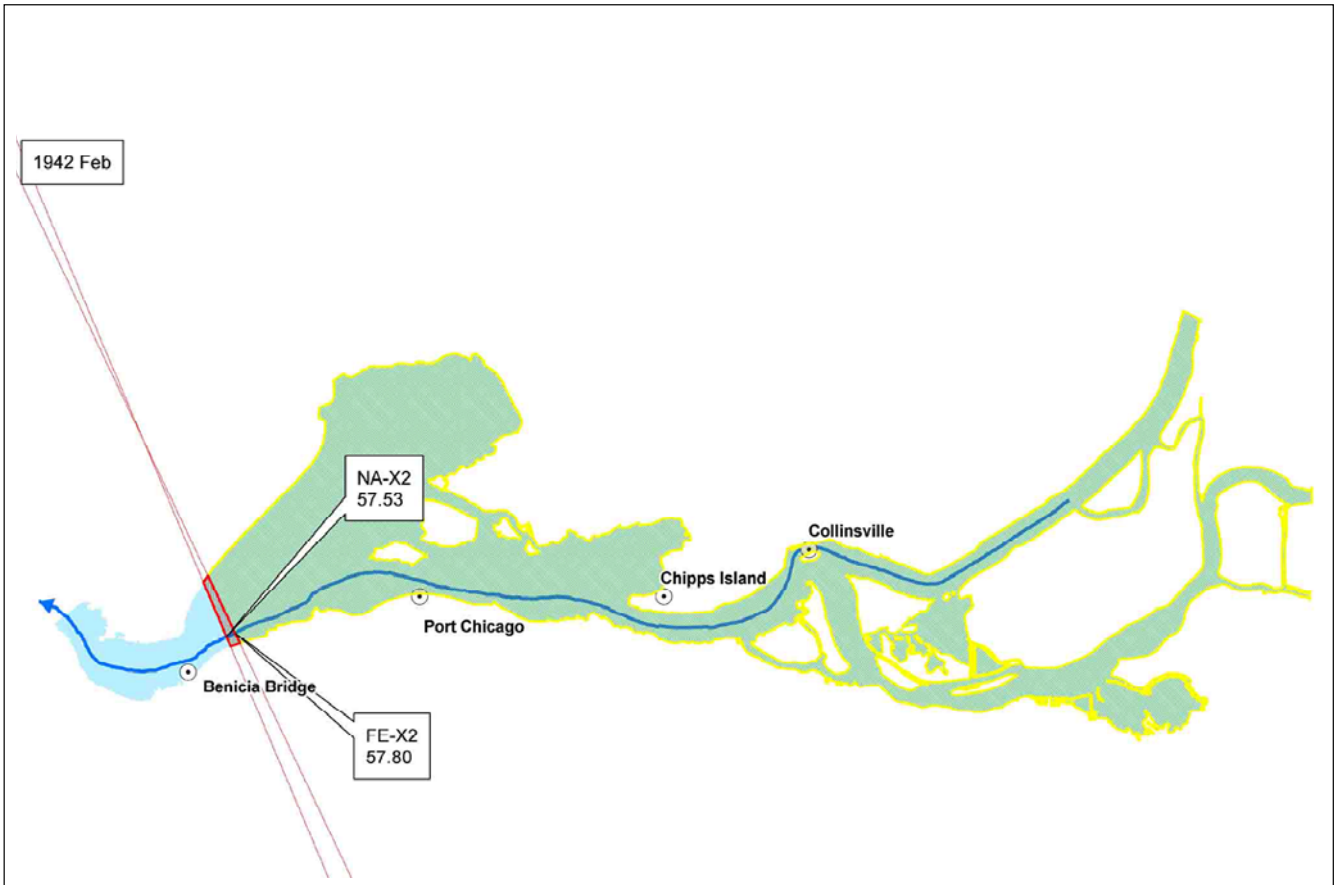

1941 Nov
NA-X2
87.32
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
87.24

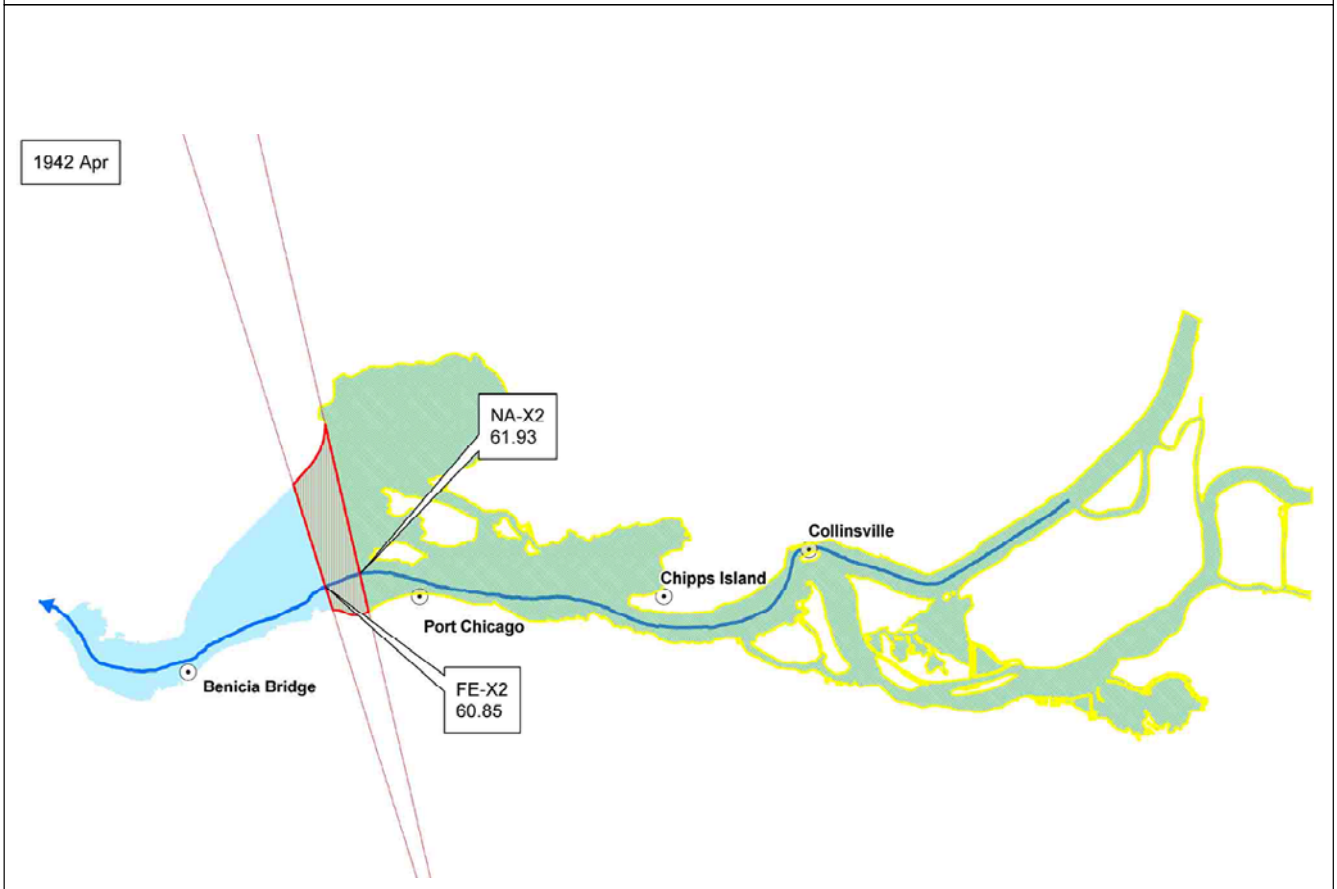

1941 Dec
NA-X2
82.18
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
82.39

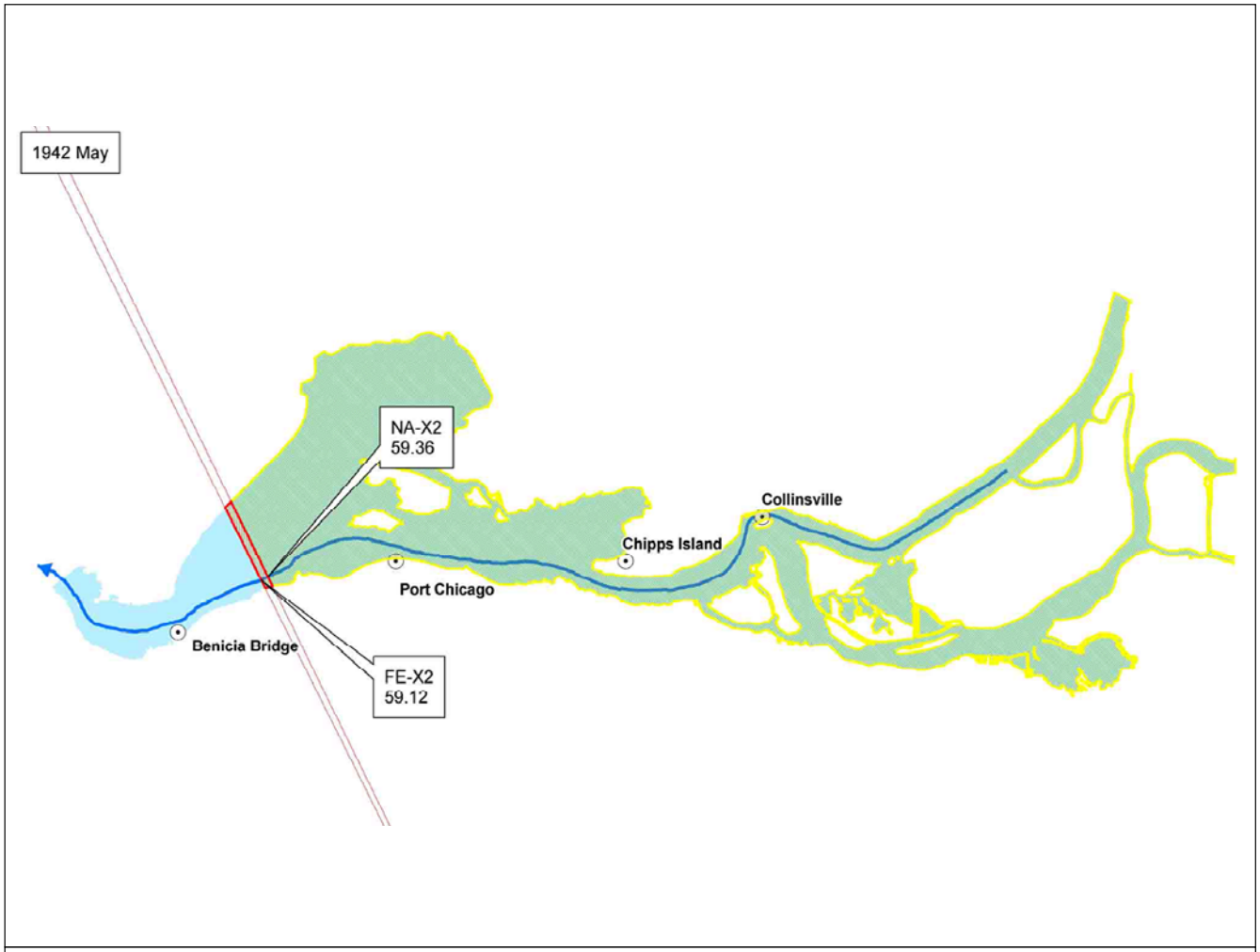

1941 average
NA-X2
68.39
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
68.50

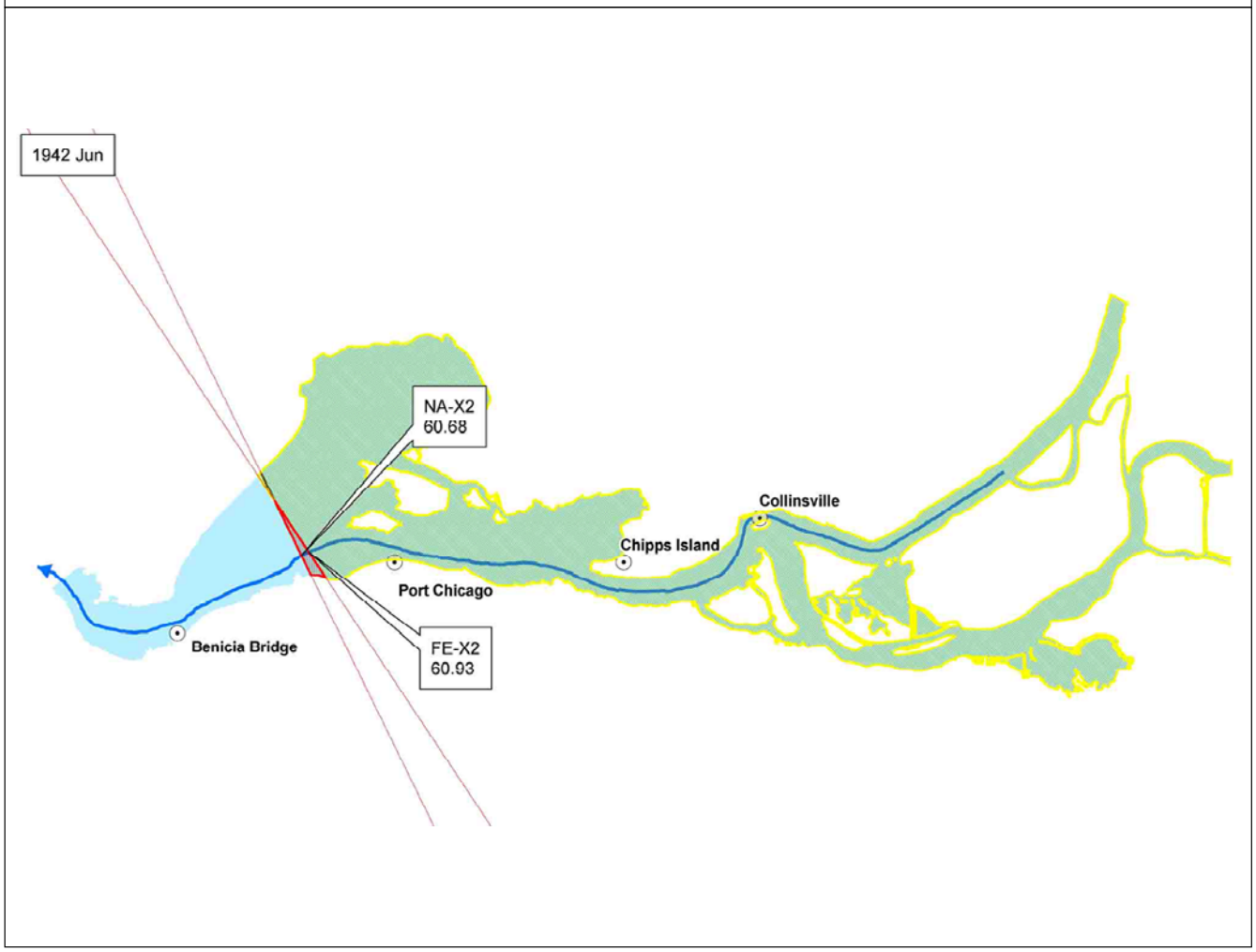

1942 Jan
NA-X2
65.91
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
66.33

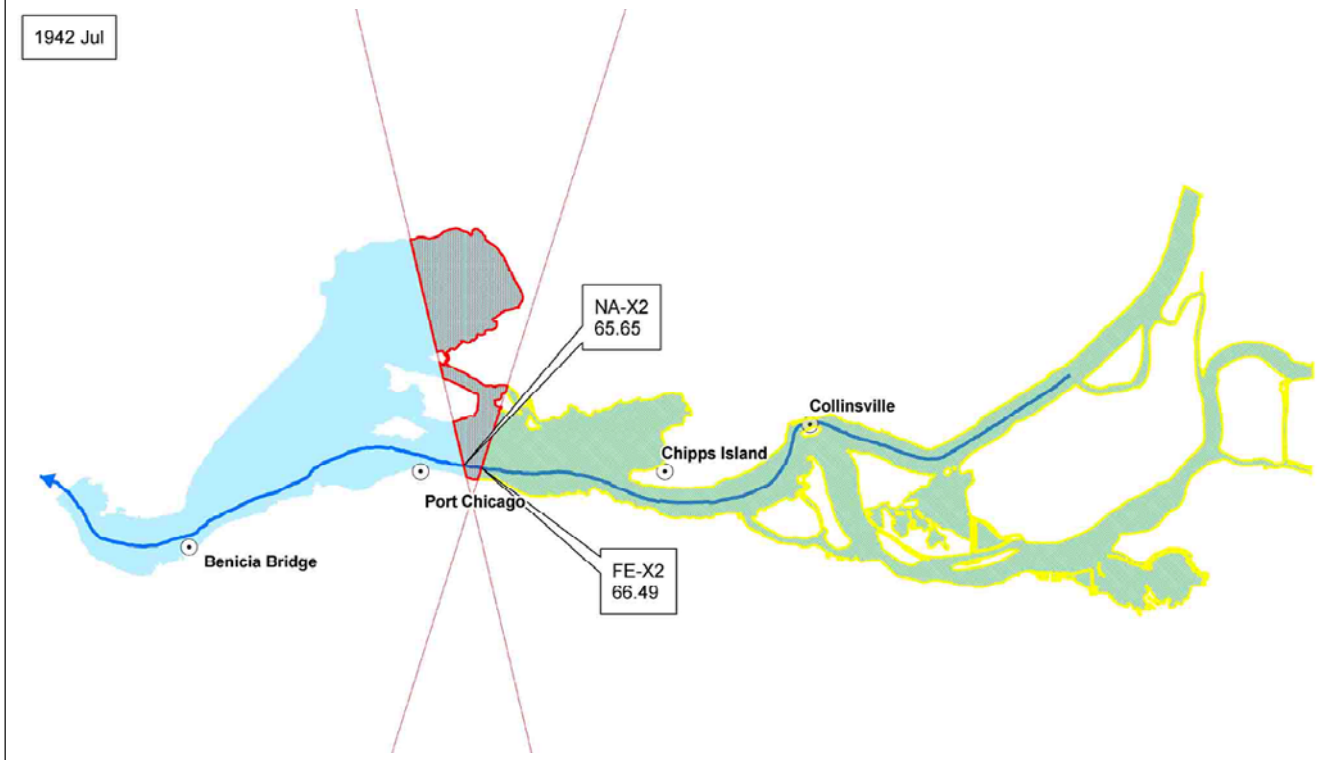

1942 Feb
NA-X2
57.53
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
57.80

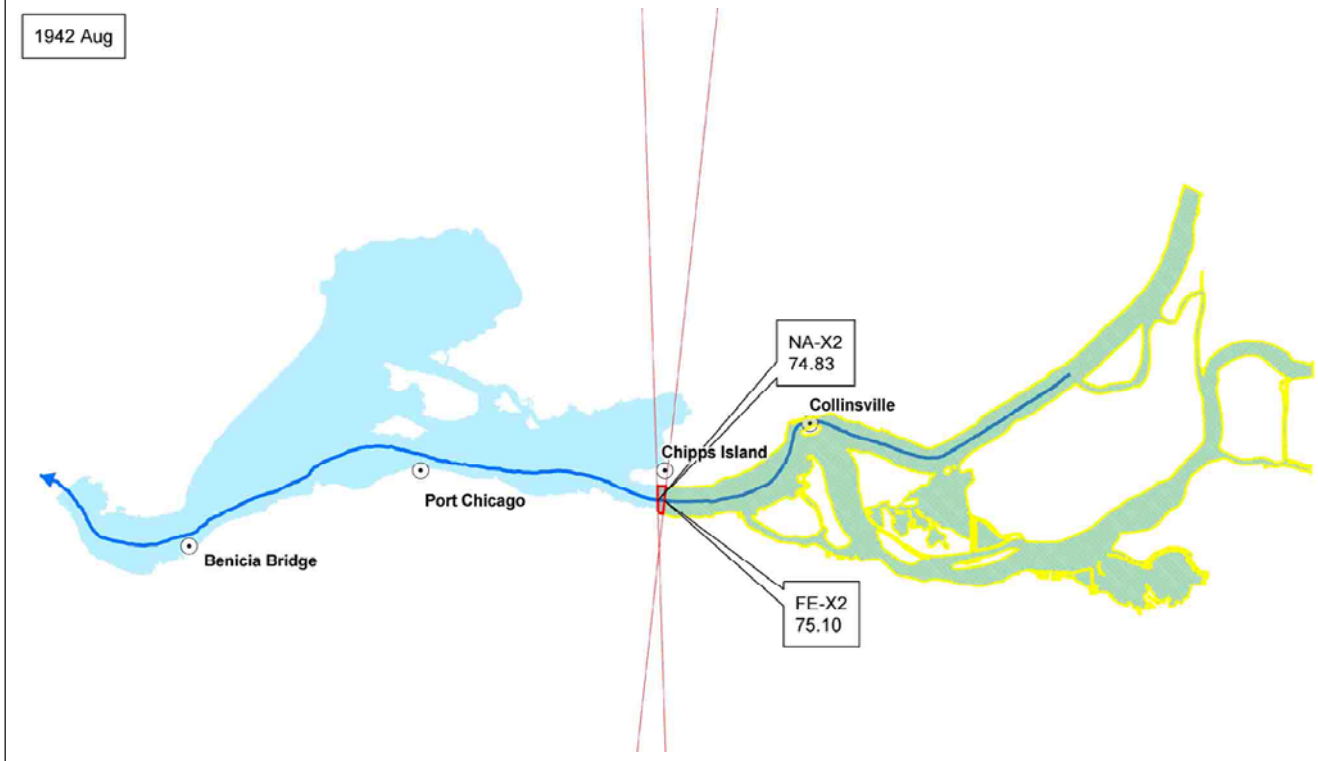

1942 Feb
NA-X2
57.53
FE-X2
57.80
Collinsville
Chipps Island
Port Chicago
Benicia Bridge


1942 Apr
NA-X2
61.93
FE-X2
60.85
Collinsville
Chipps Island
Port Chicago
Benicia Bridge


1942 May
NA-X2
59.36
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
59.12

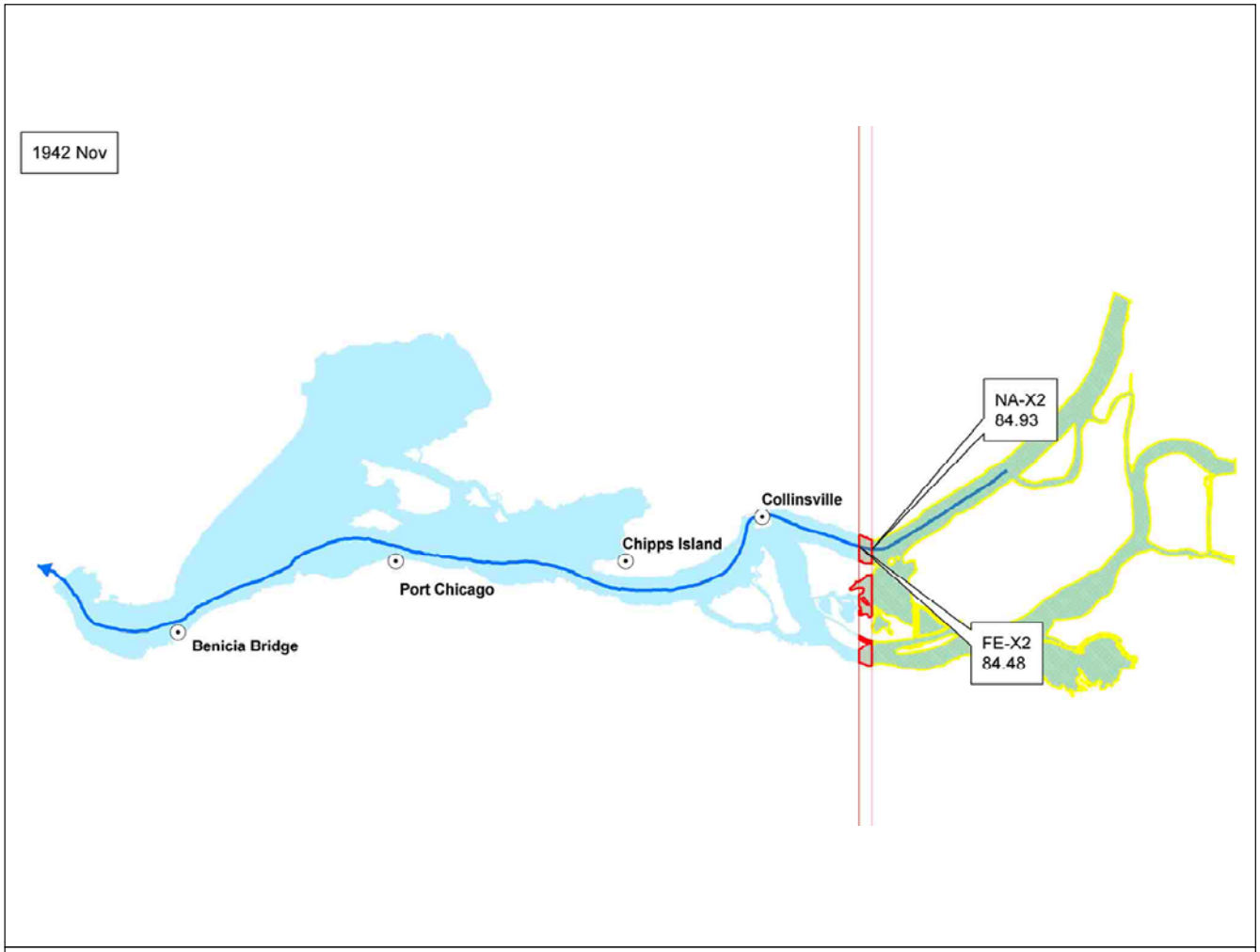

1942 Jun
NA-X2
60.68
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
60.93


1942 Jul
NA-X2
65.65
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
66.49


1942 Aug
NA-X2
74.83
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
75.10

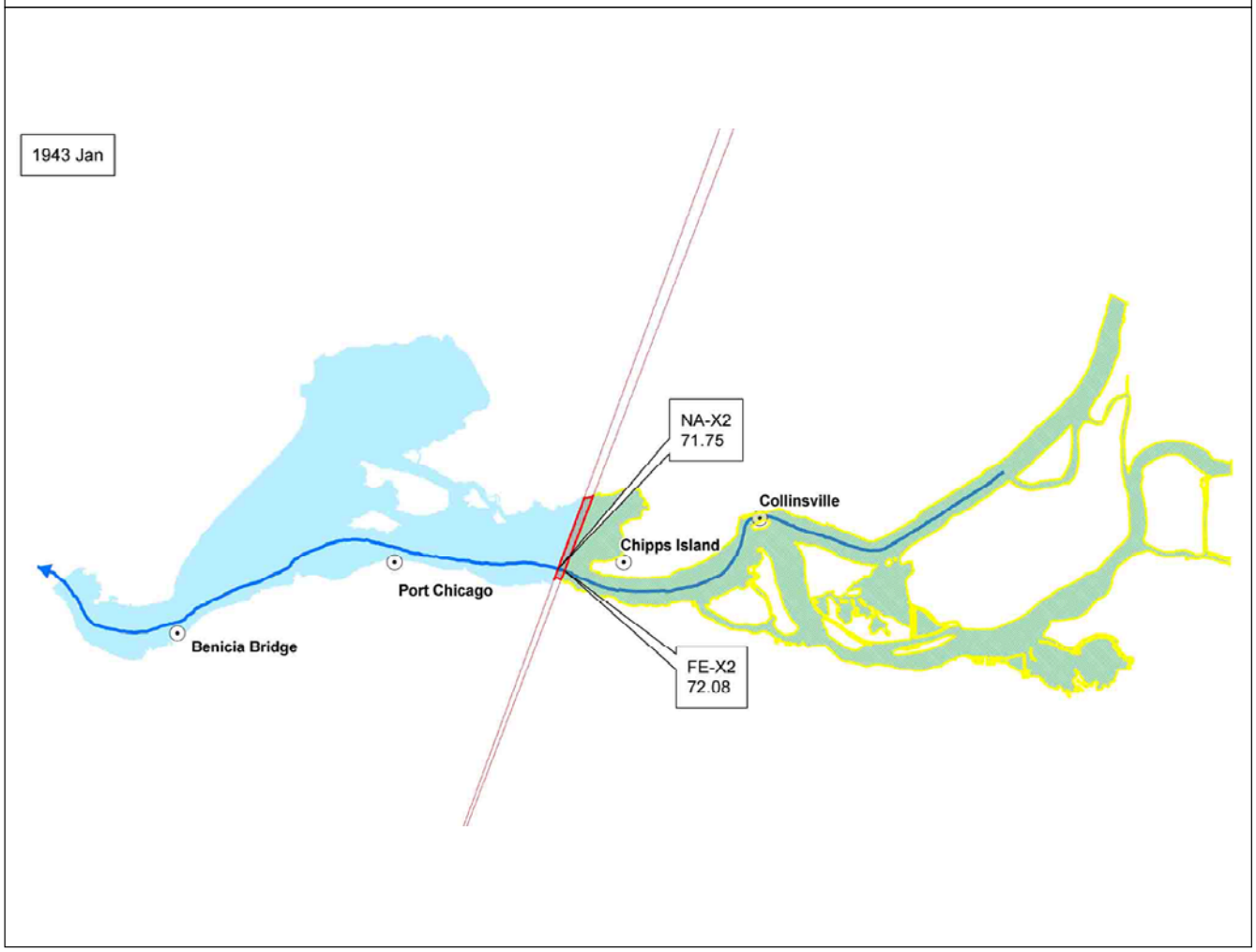

1942 Sep
NA-X2
83.15
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
83.24

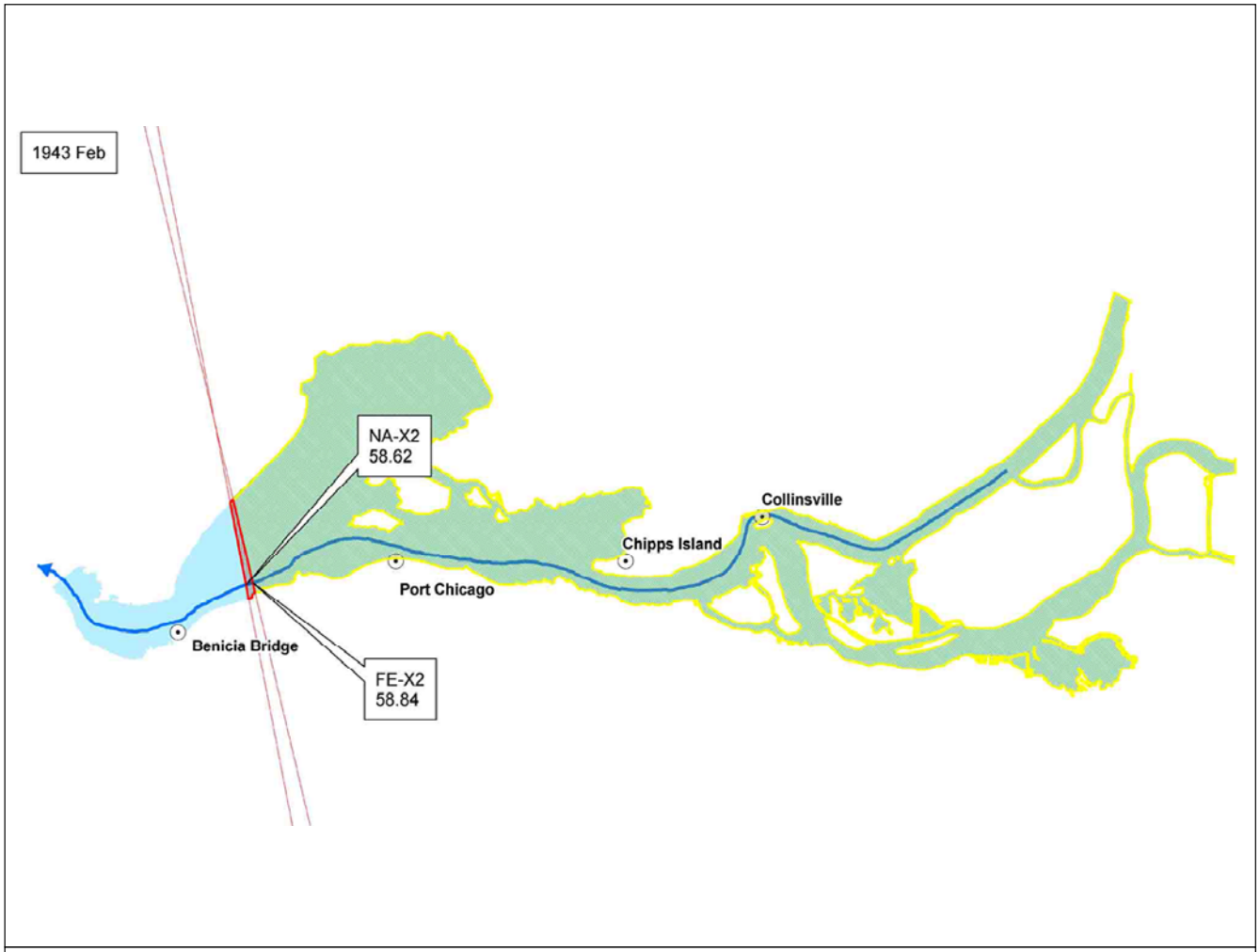

1942 Oct
NA-X2
83.72
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
81.90

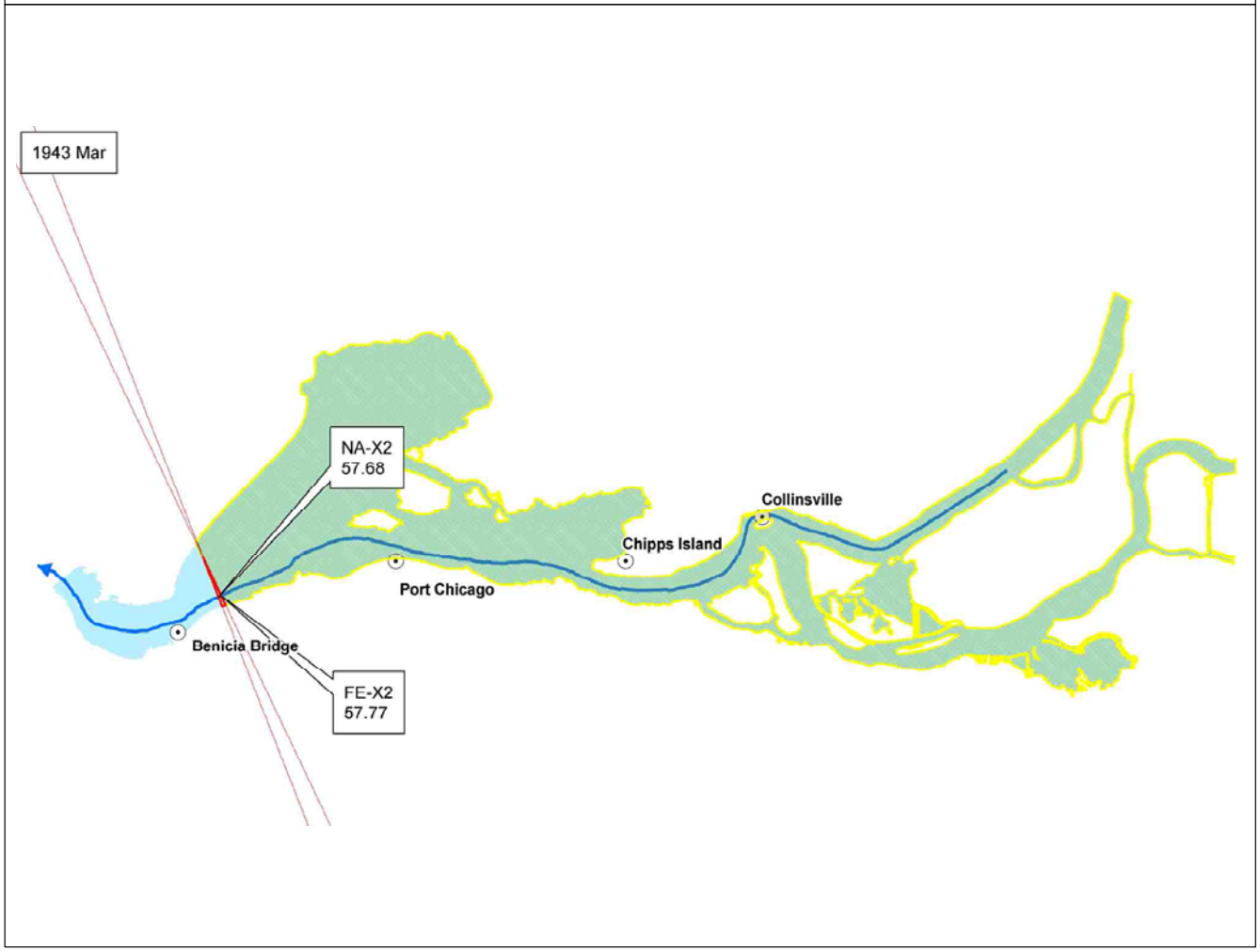

1942 Nov
NA-X2
84.93
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
84.48

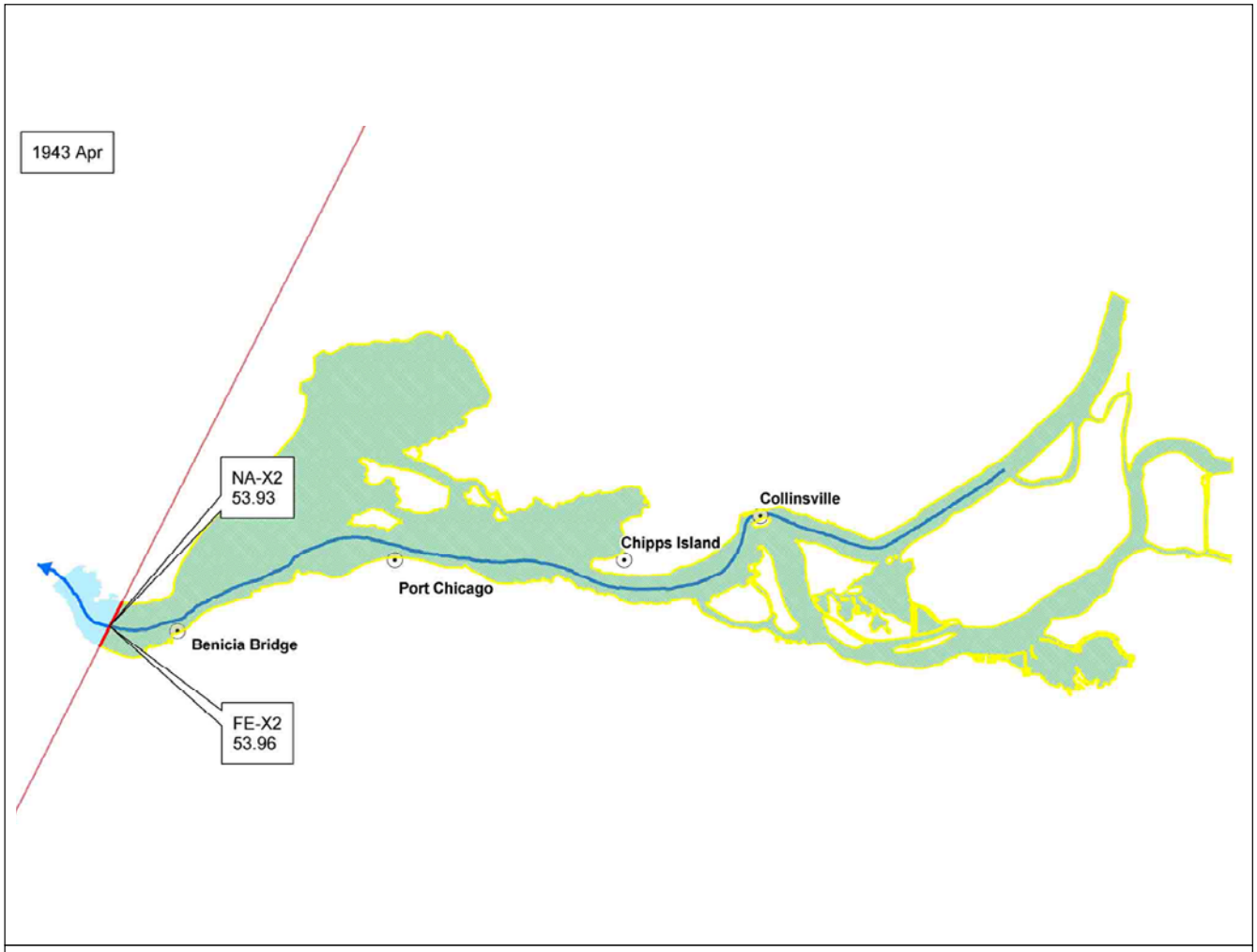

1942 Dec
NA-X2
85.56
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
85.41

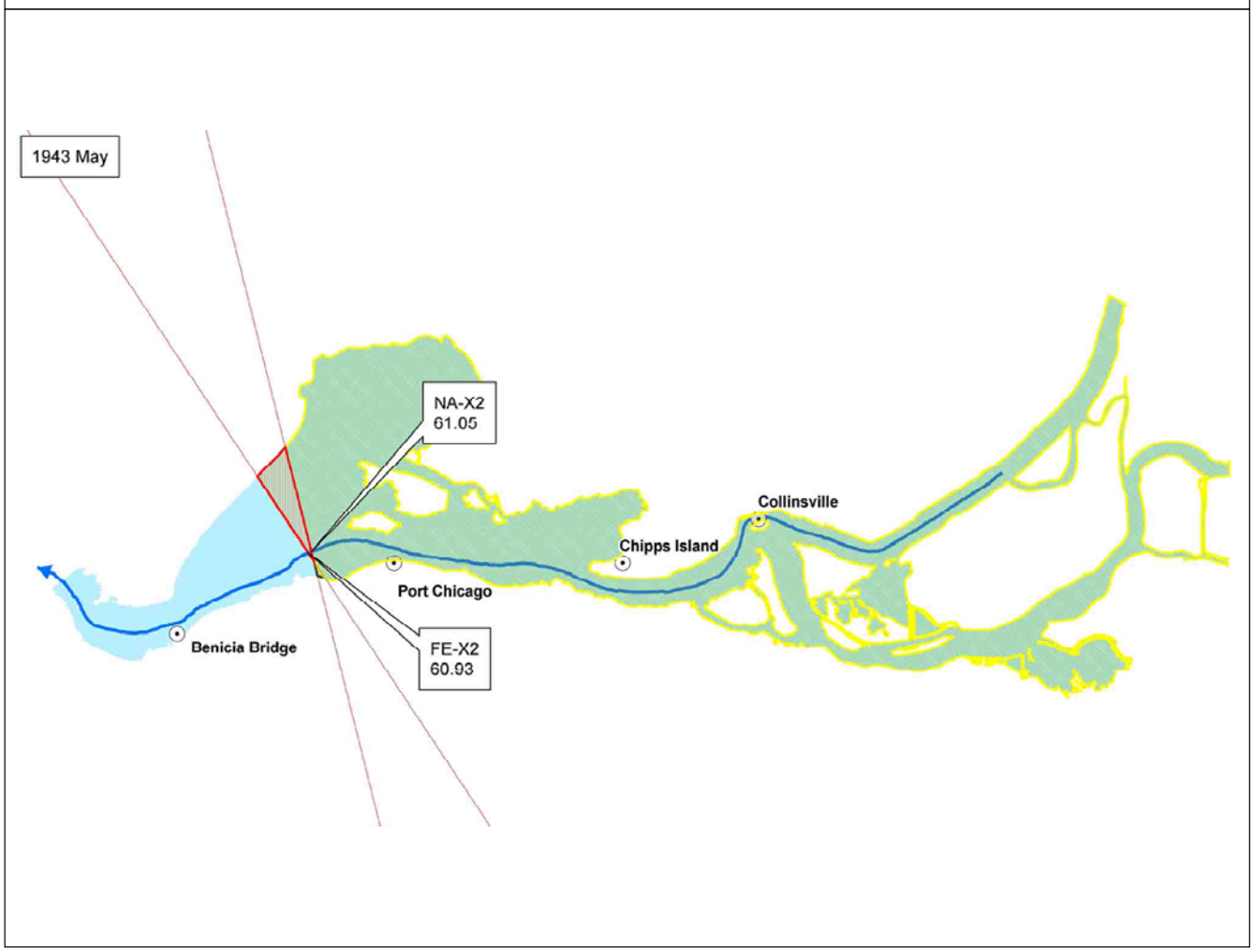

1942 average
NA-X2
69.47
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
69.35


1943 Jan
NA-X2
71.75
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
72.08

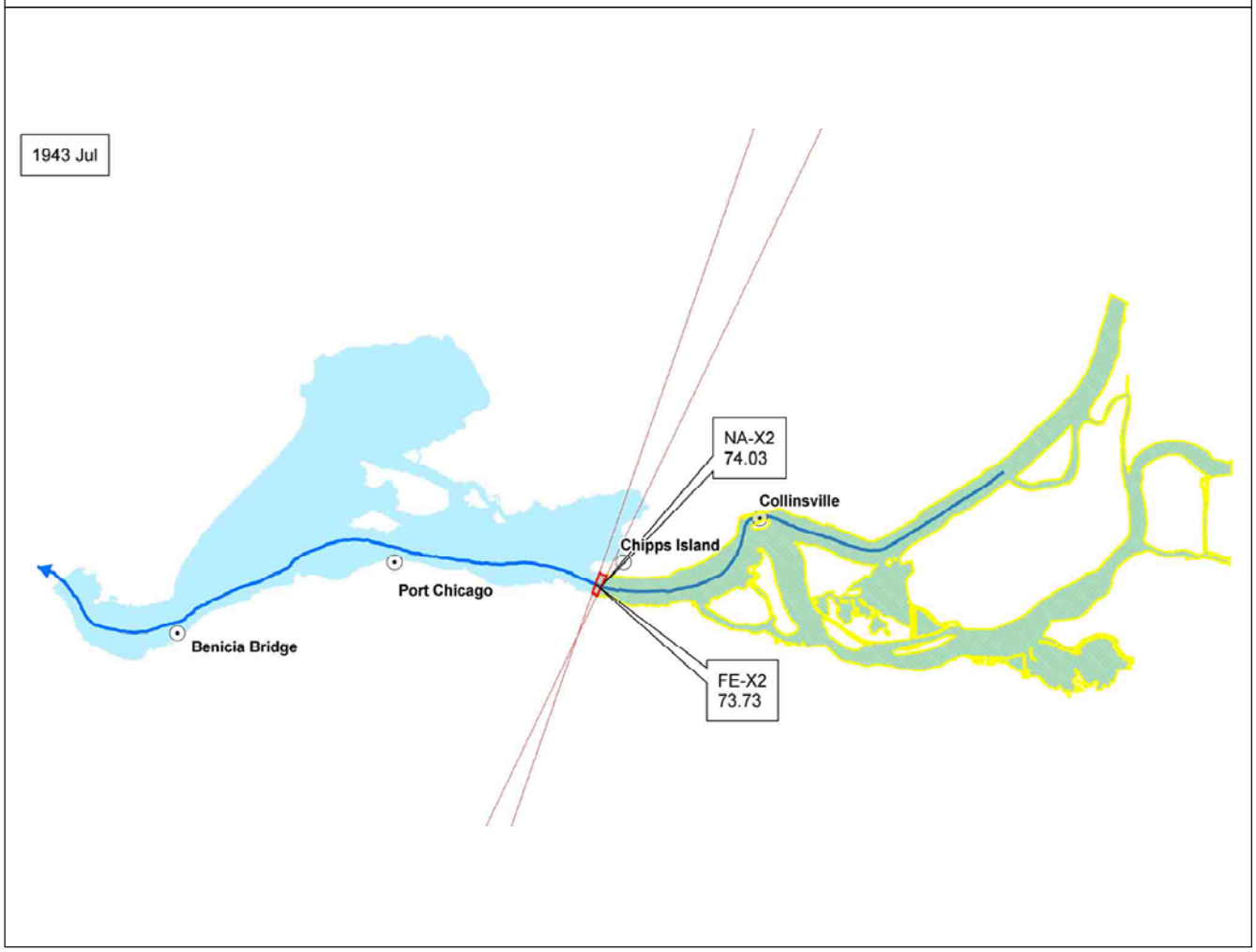

1943 Feb
NA-X2
58.62
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
58.84


1943 Mar
NA-X2
57.68
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
57.77


1943 Apr
NA-X2
53.93
FE-X2
53.96
Benicia Bridge
Port Chicago
Chipps Island
Collinsville

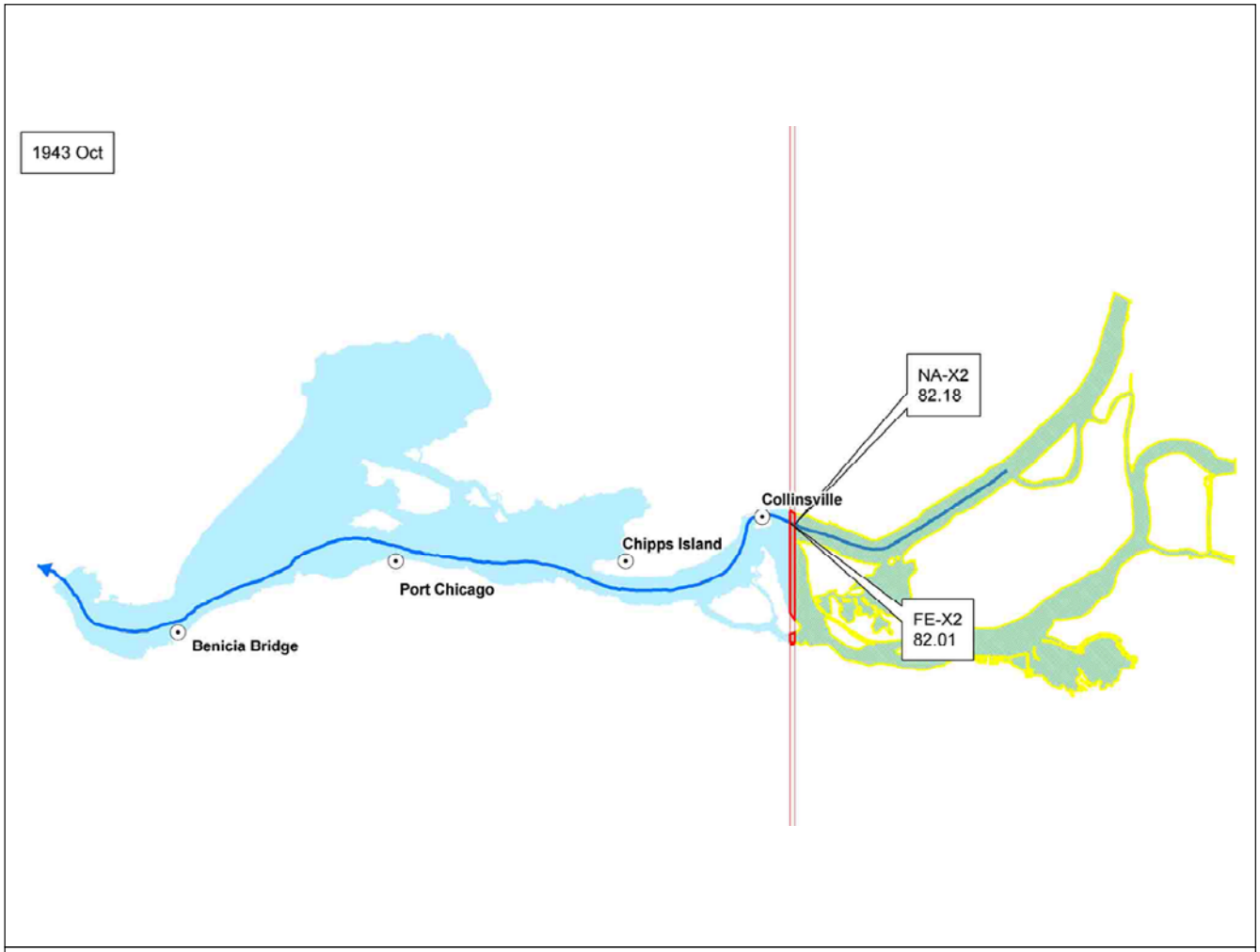

1943 May
NA-X2
61.05
FE-X2
60.93
Benicia Bridge
Port Chicago
Chipps Island
Collinsville


1943 Jun
NA-X2
65.79
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
65.52


1943 Jul
NA-X2
74.03
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
73.73

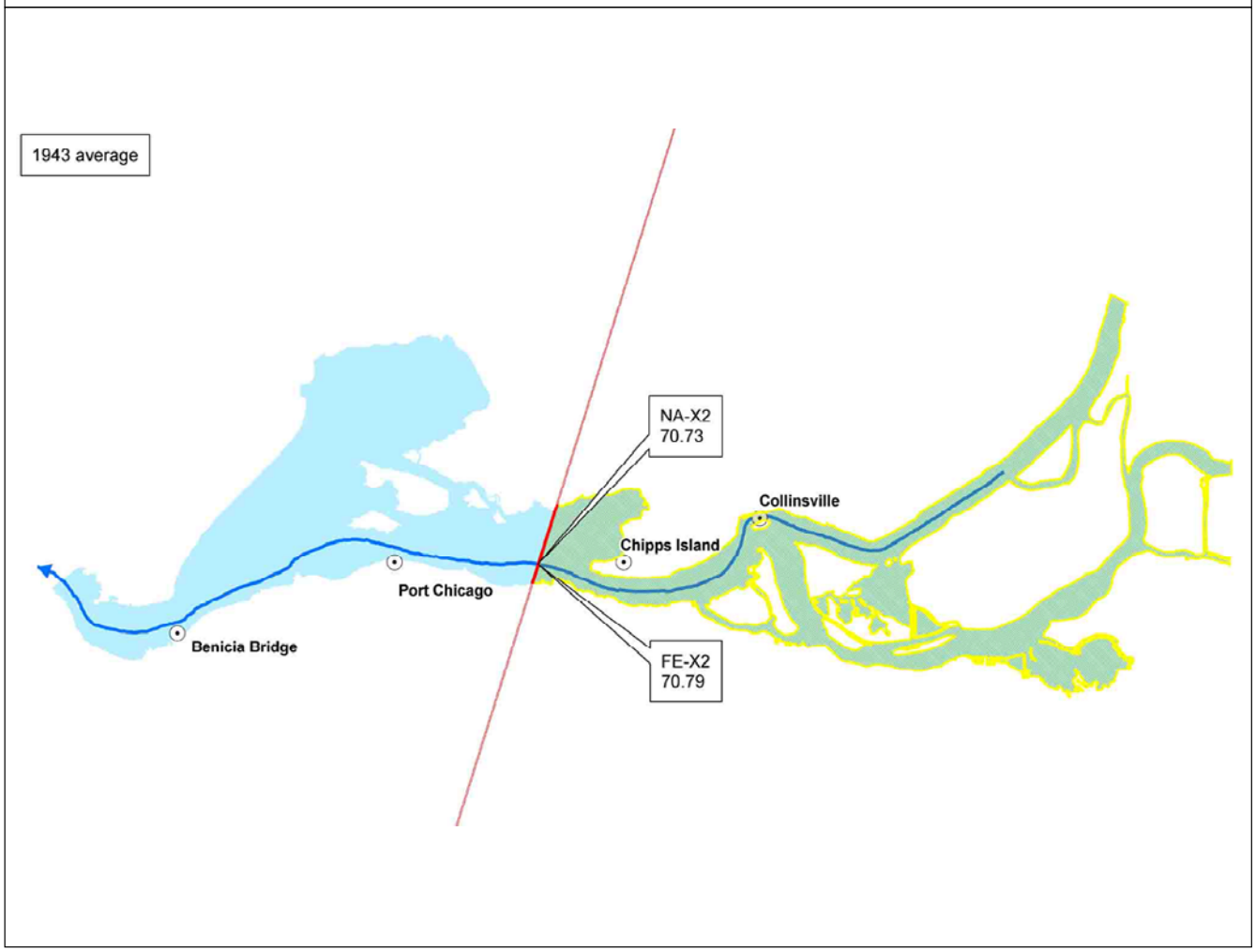

1943 Aug
NA-X2
77.09
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
76.93

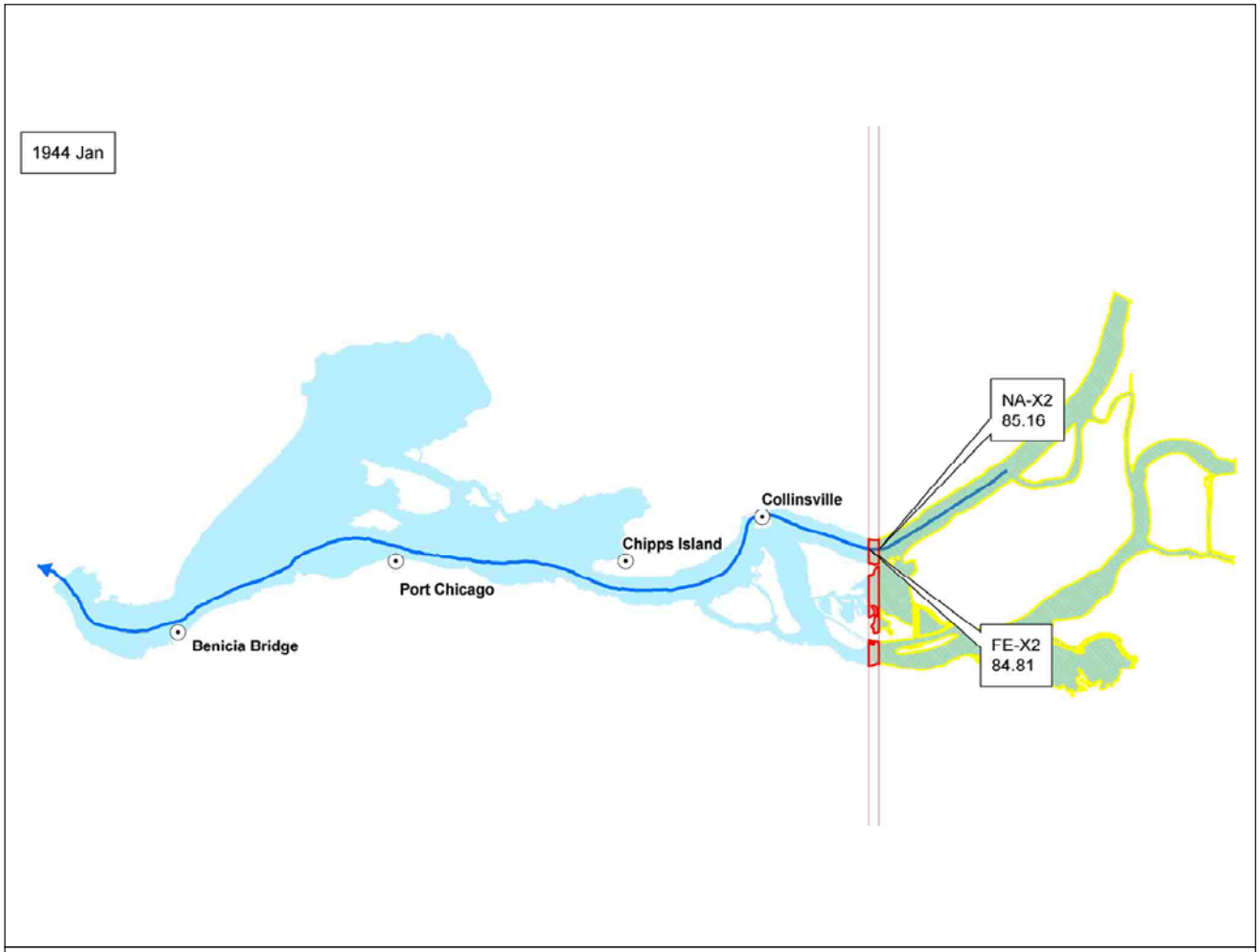

1943 Sep
NA-X2
83.89
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
83.84


1943 Oct
NA-X2
82.18
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
82.01

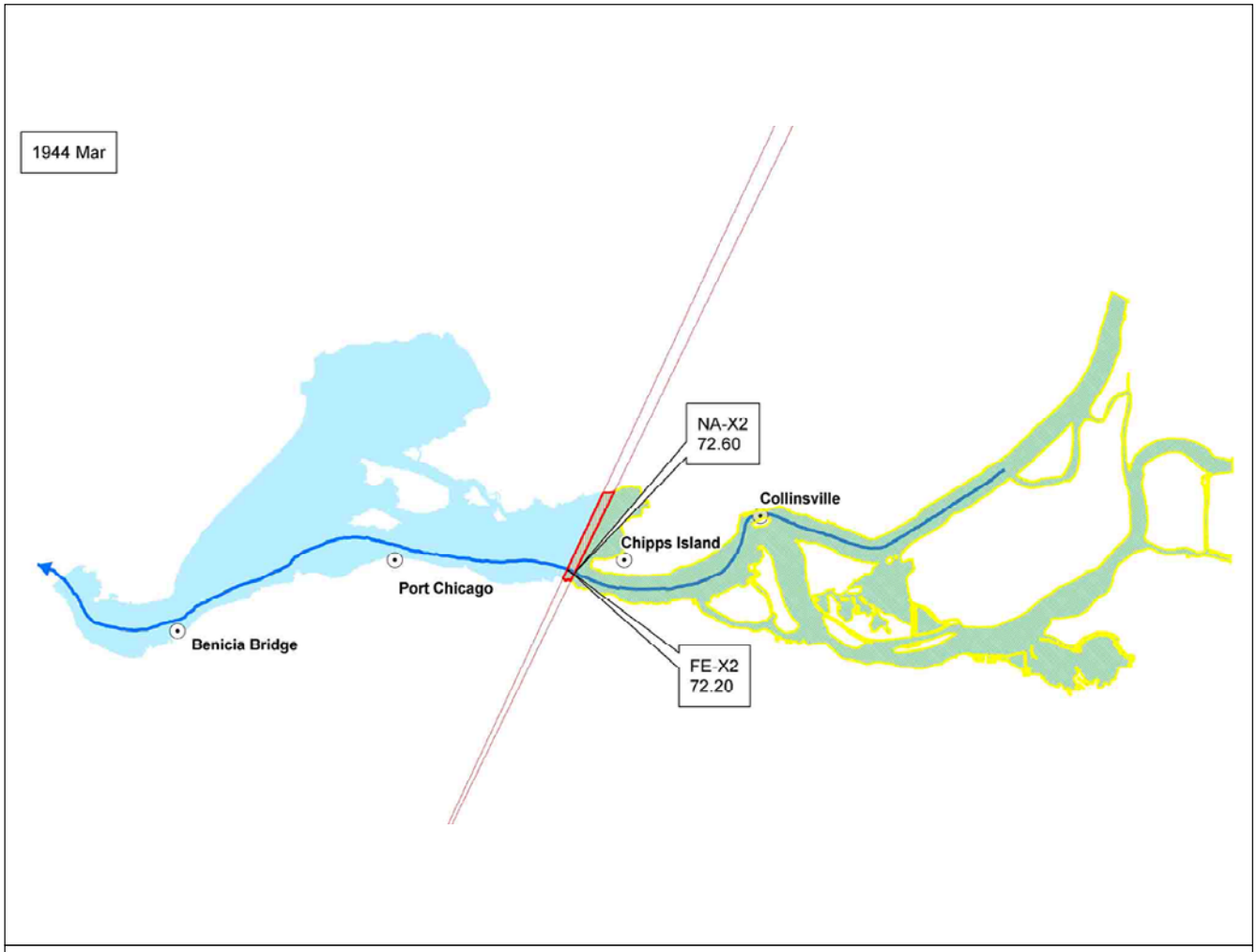

1943 Nov
NA-X2
82.76
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
82.88

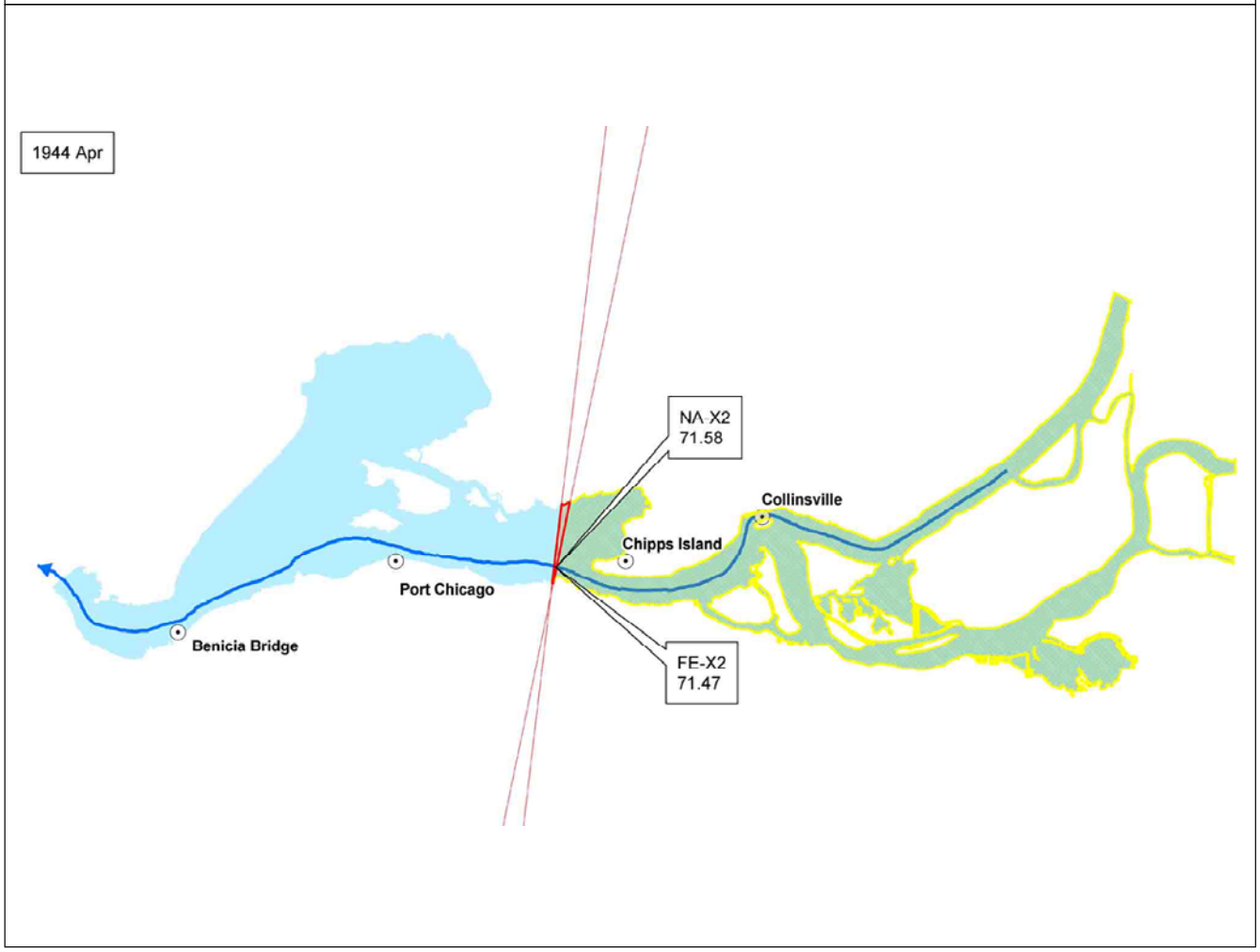

1943 Dec
NA-X2
79.99
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
80.97

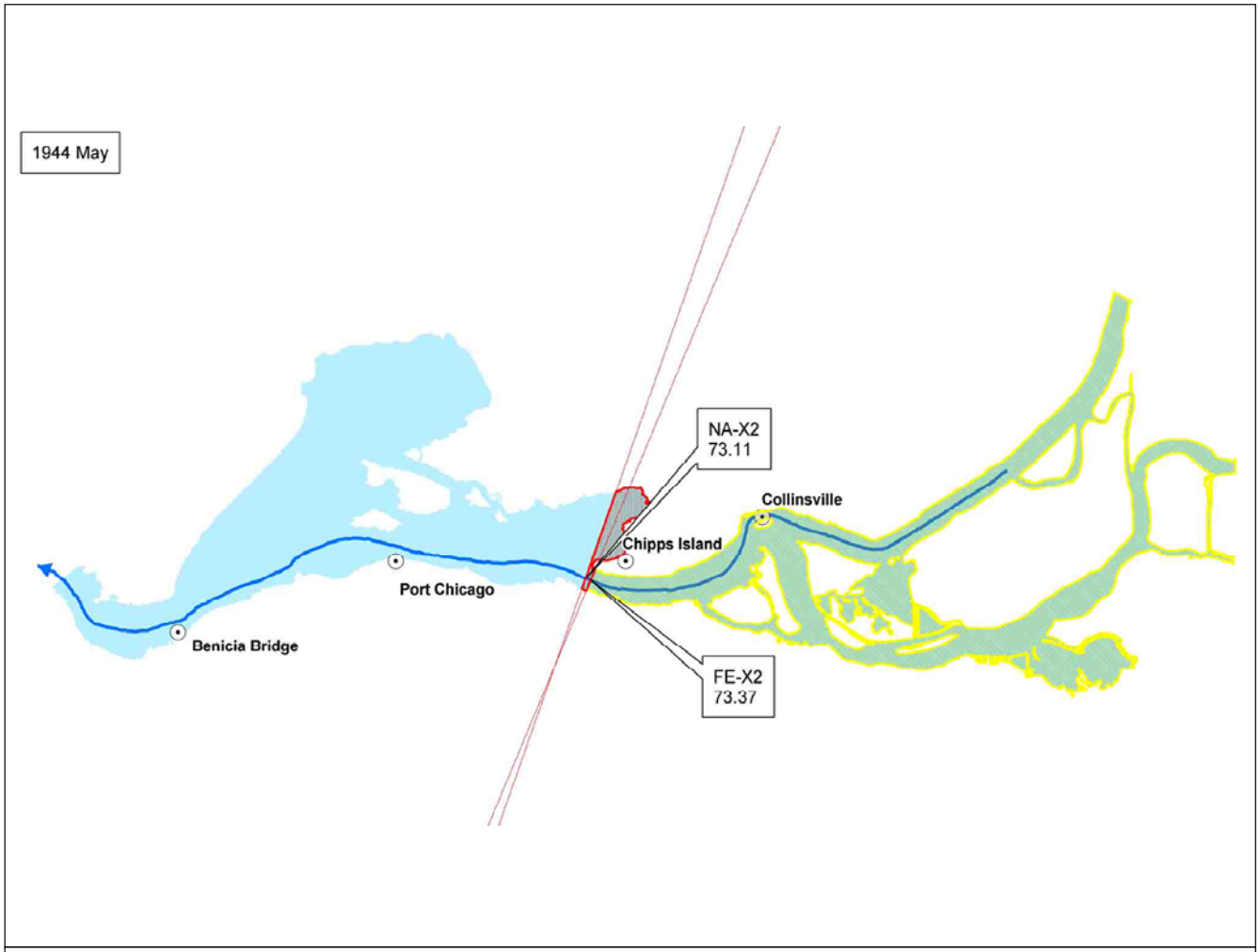

1943 average
NA-X2
70.73
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
70.79

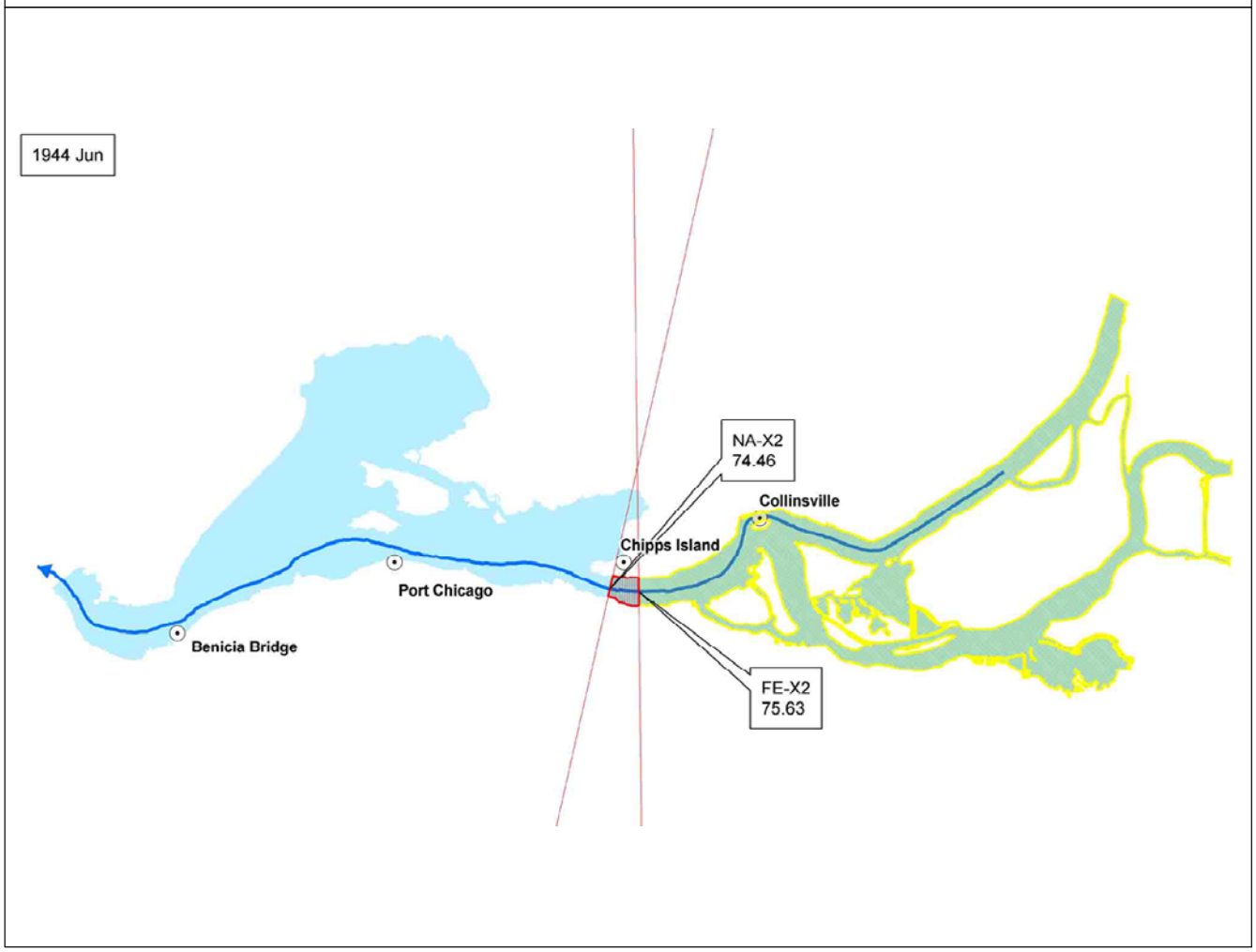

1944 Jan
NA-X2
85.16
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
84.81


1944 Feb
NA-X2
81.73
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
81.74


1944 Mar
NA-X2
72.60
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
72.20


1944 Apr
NA-X2
71.58
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
71.47

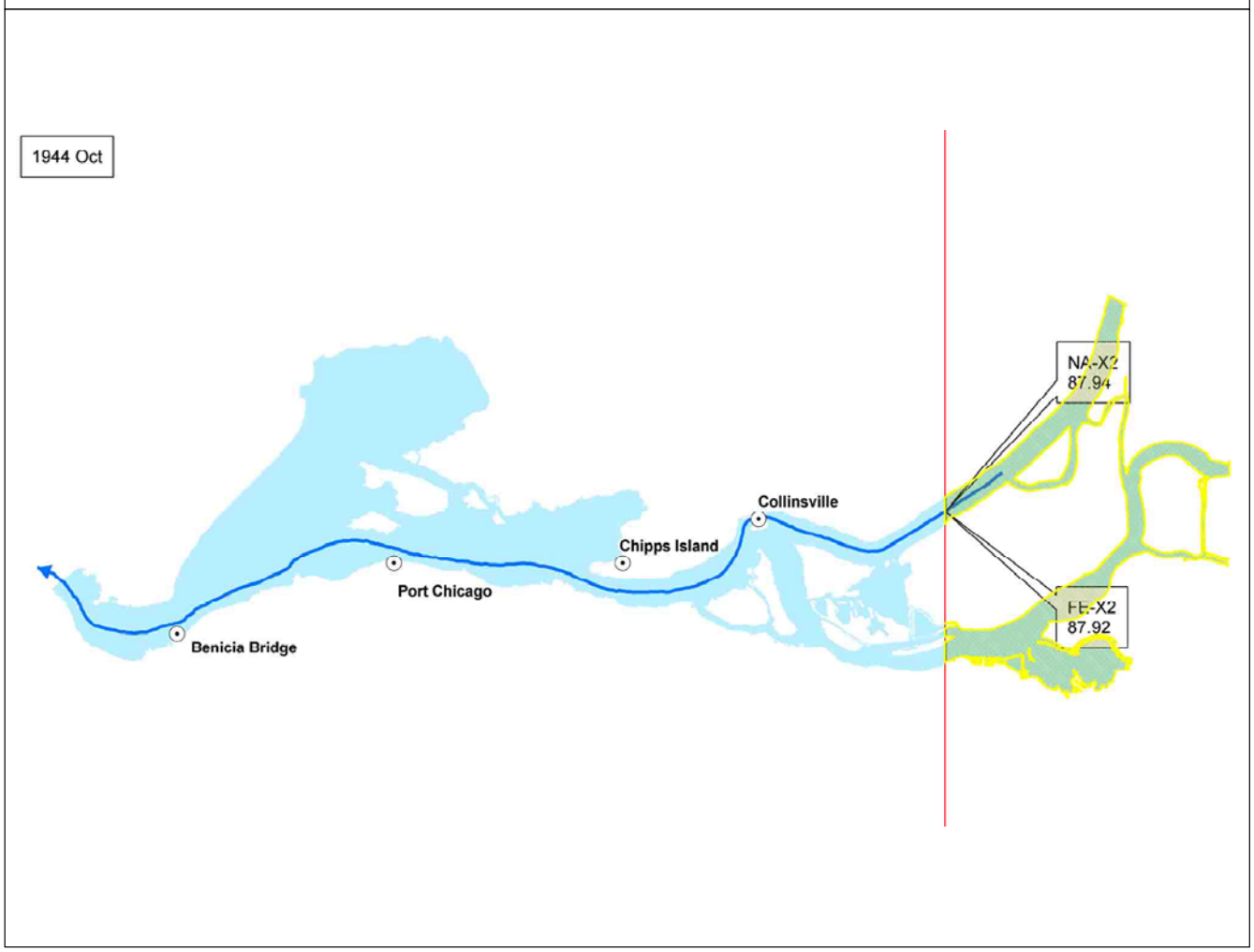

1944 May
NA-X2
73.11
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
73.37

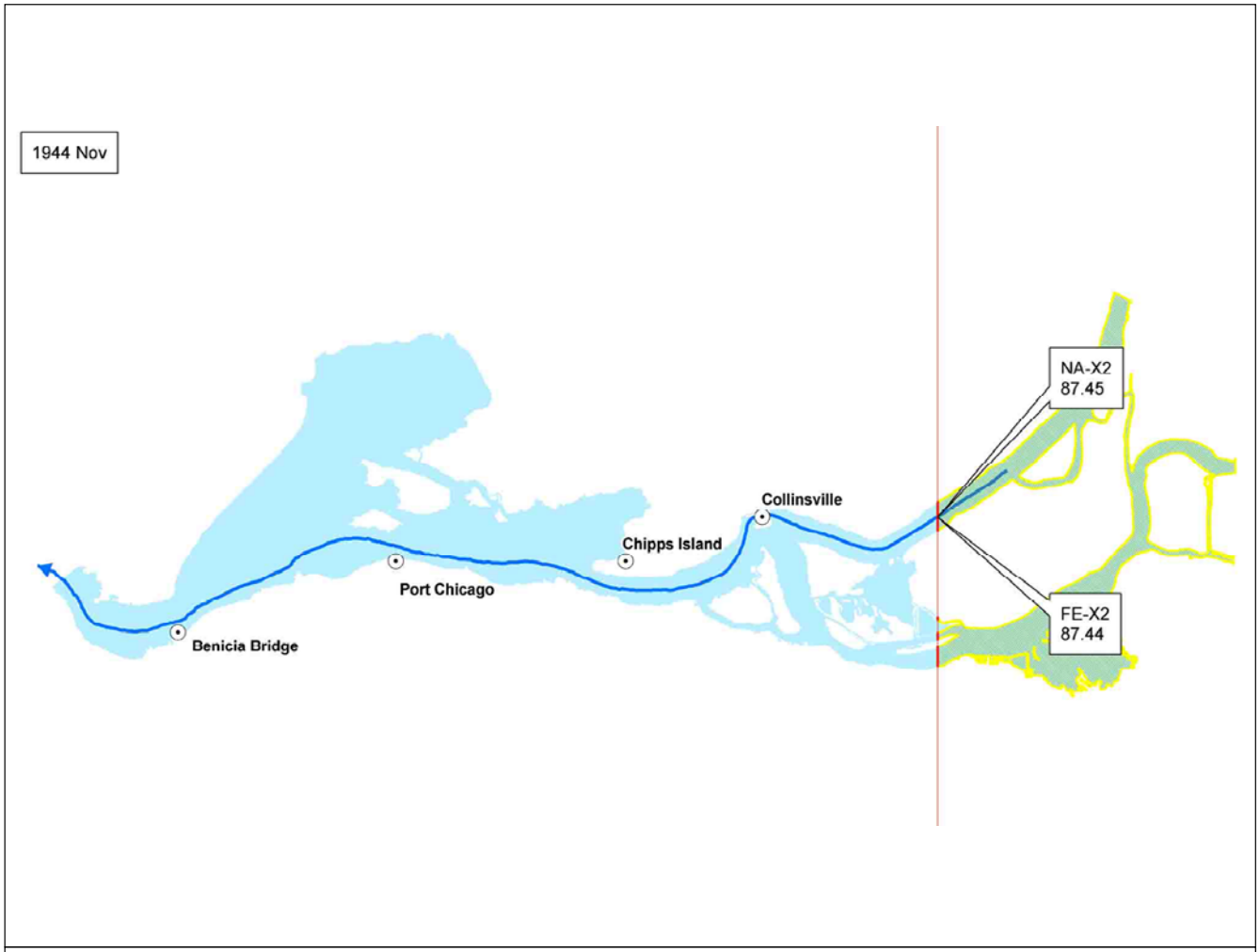

1944 Jun
NA-X2
74.46
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
75.63


1944 Jul
NA-X2
78.36
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
78.68

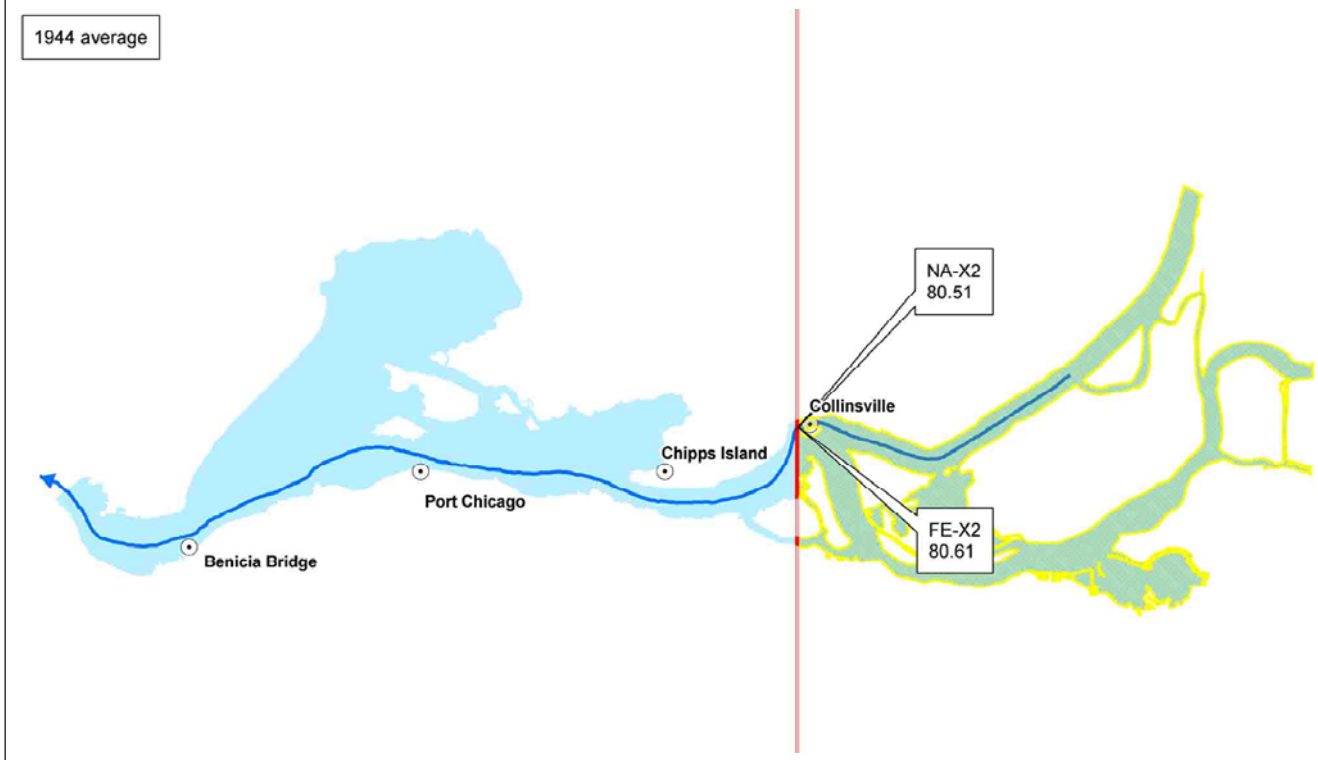

1944 Aug
NA-X2
82.60
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
82.70

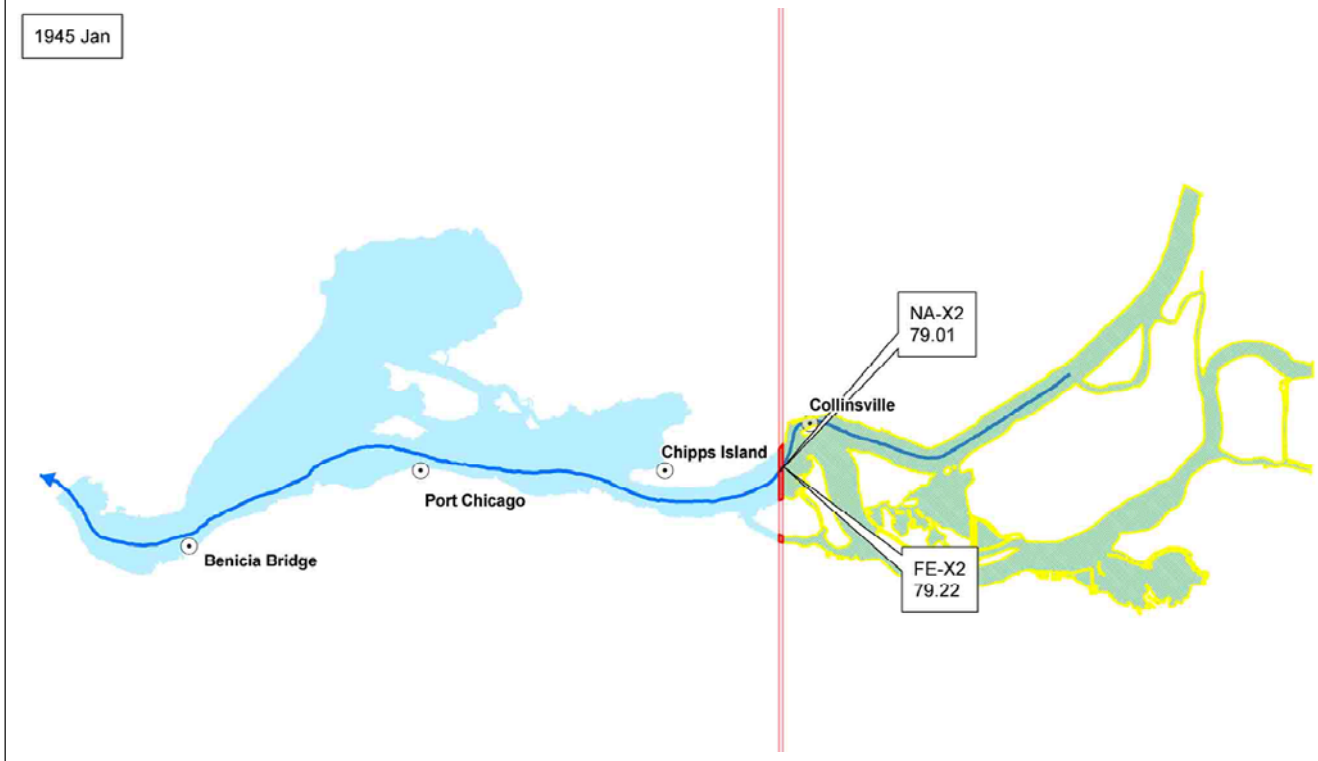

1944 Sep
NA-X2
86.72
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
86.75


1944 Oct
NA-X2
87.94
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
87.92

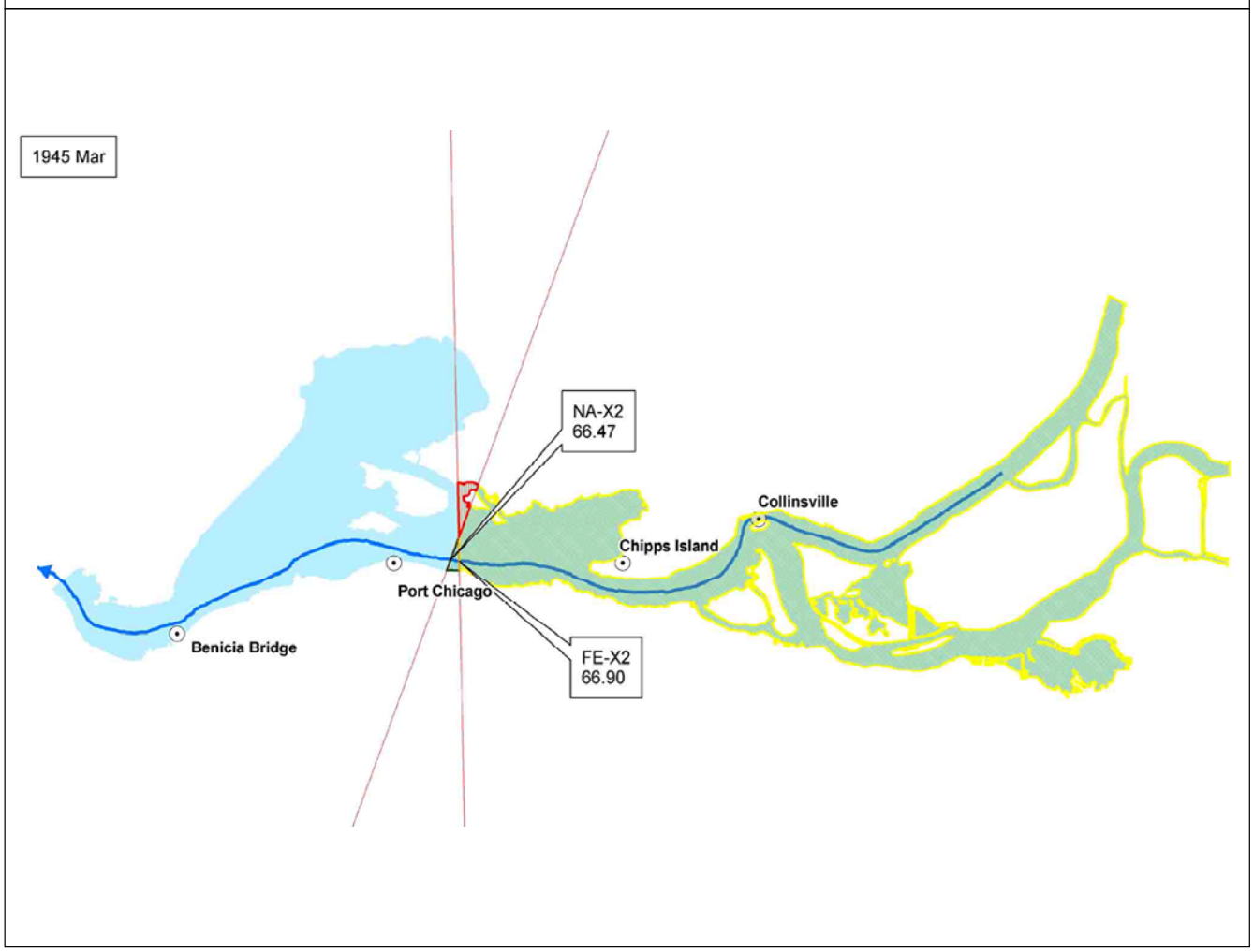

1944 Nov
NA-X2
87.45
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
87.44

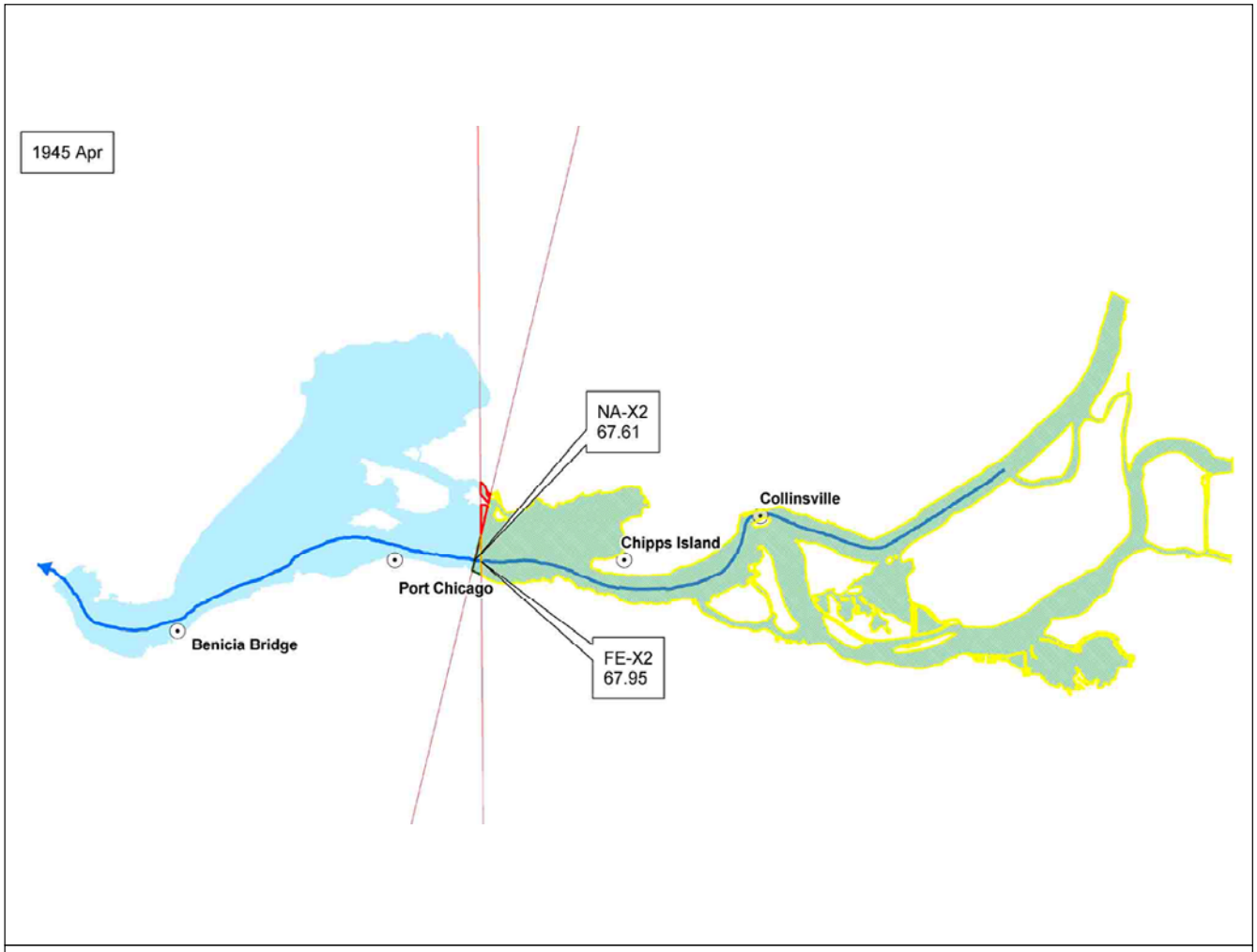

1944 Dec
NA-X2
84.37
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
84.62

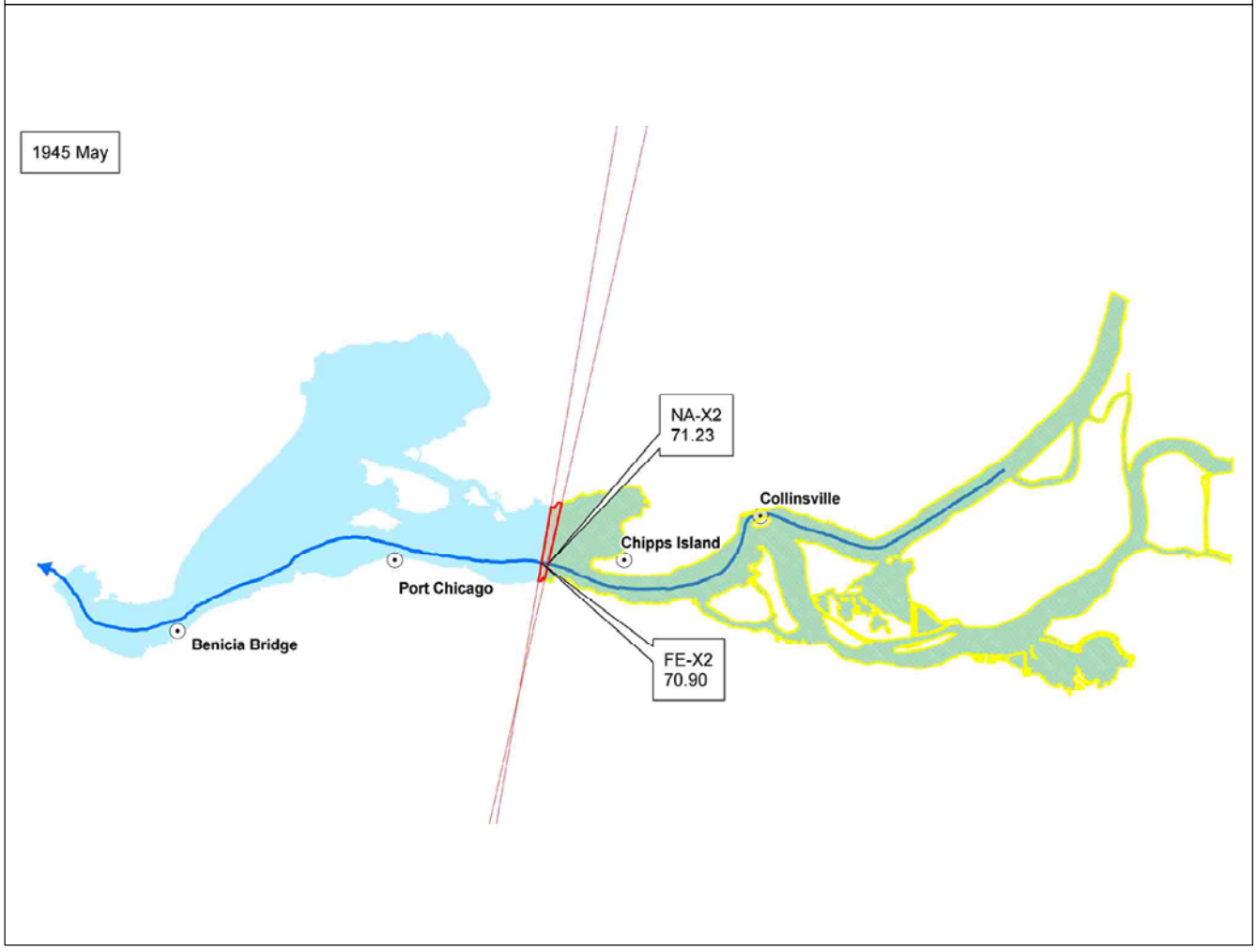

1944 average
NA-X2
80.51
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
80.61

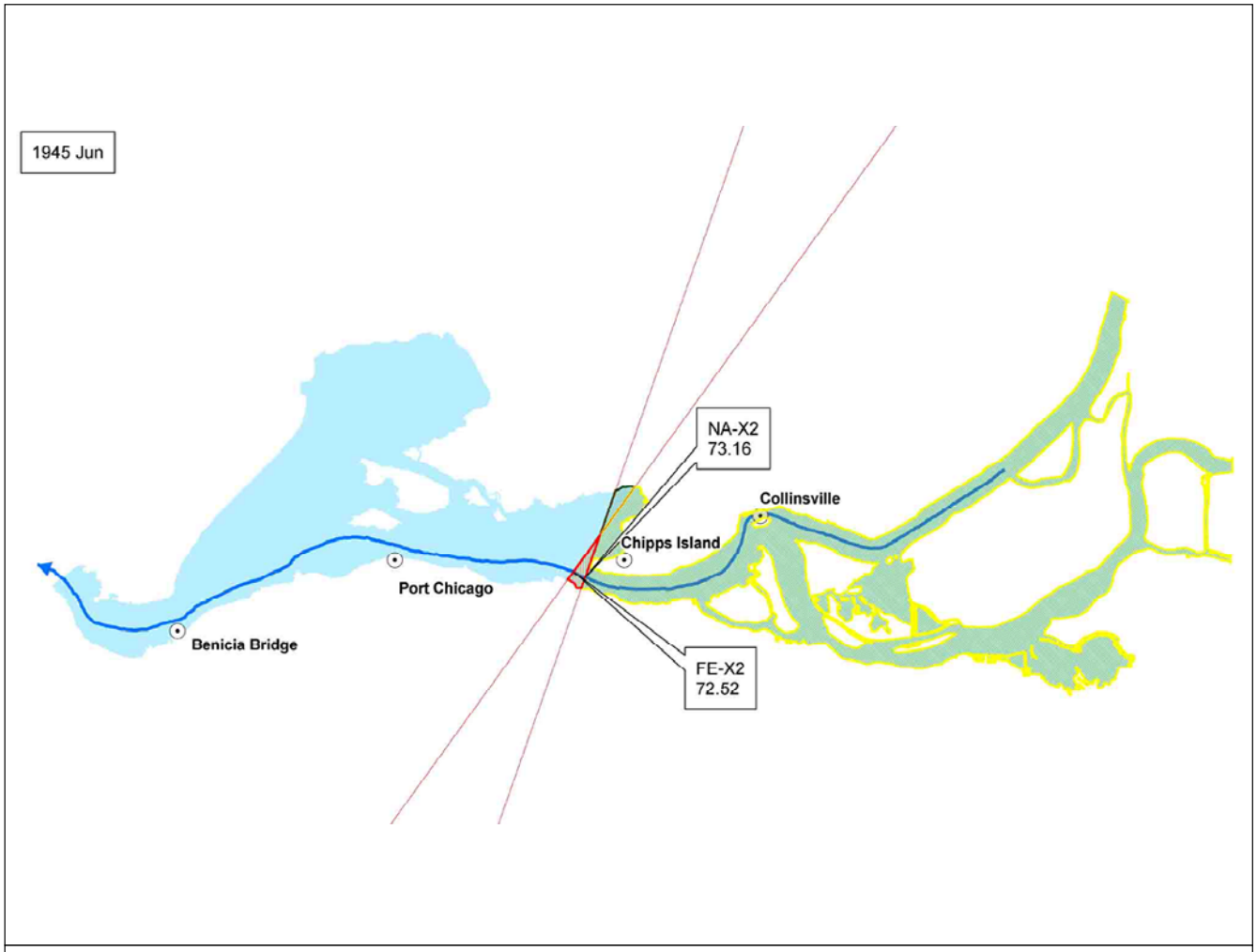

1945 Jan
NA-X2
79.01
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
79.22

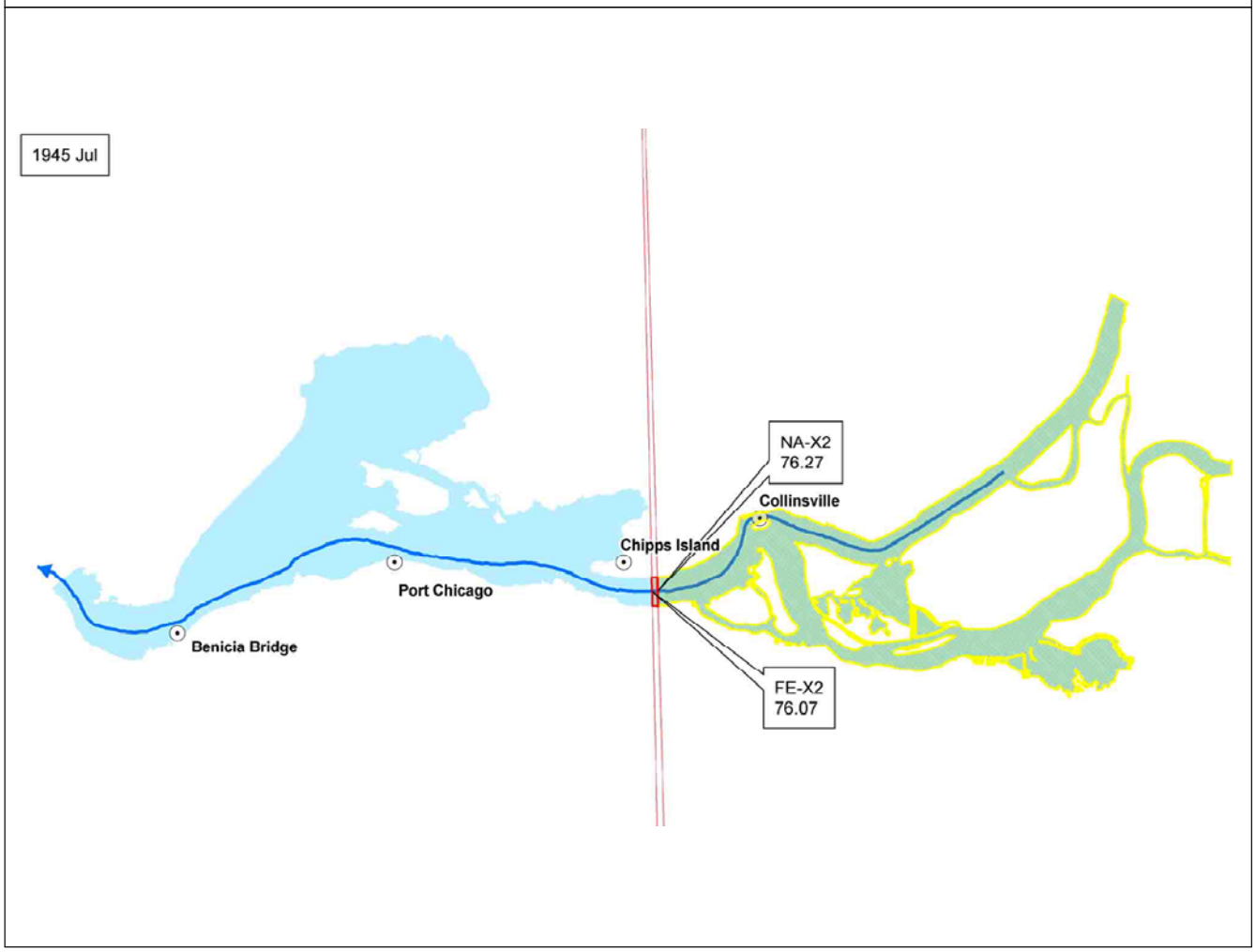

1945 Feb
NA-X2
80.05
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
81.48


1945 Mar
NA-X2
66.47
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
66.90


1945 Apr
NA-X2
67.61
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
67.95


1945 May
NA-X2
71.23
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
70.90


1945 Jun
NA-X2
73.16
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
72.52

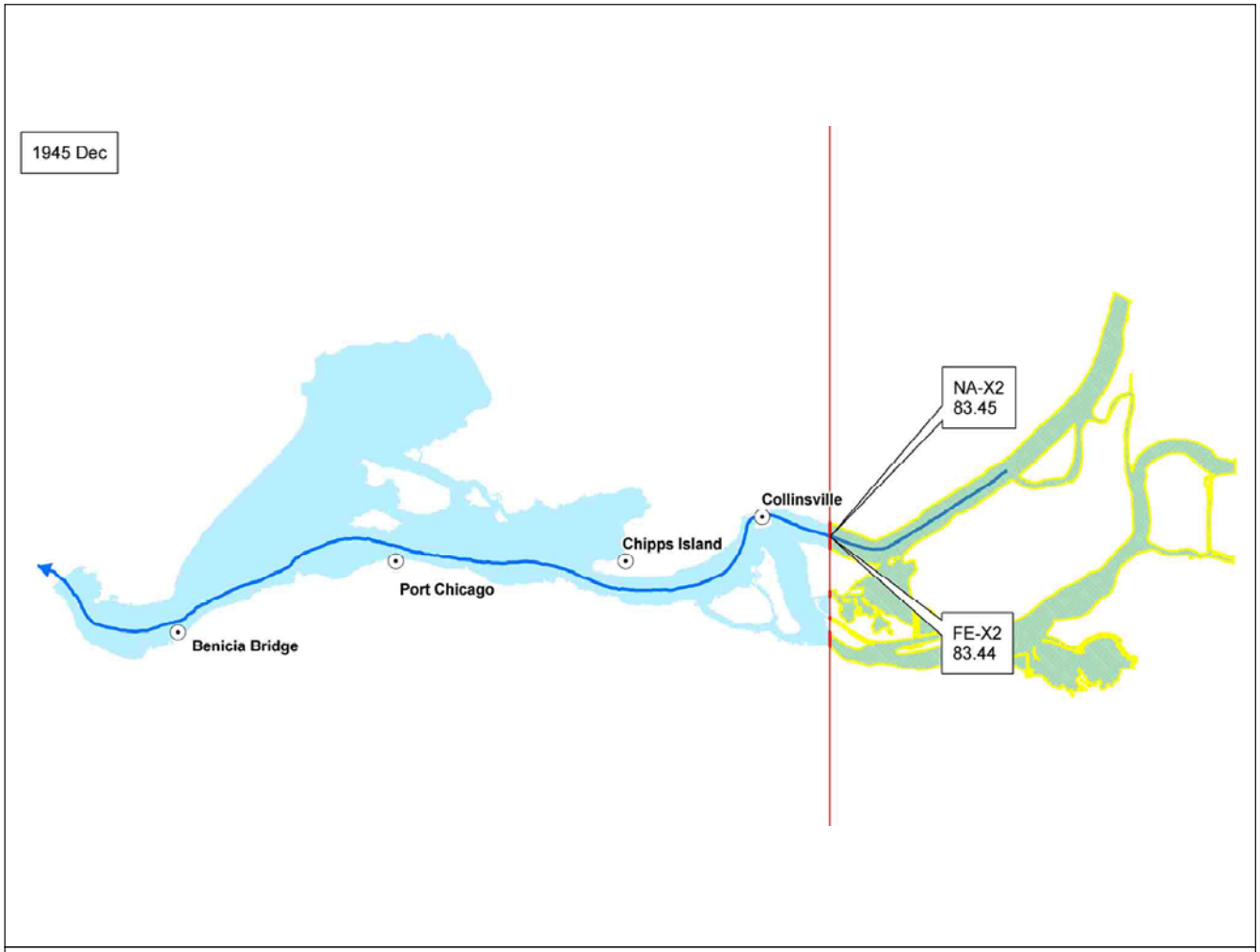

1945 Jul
NA-X2
76.27
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
76.07


1945 Aug
NA-X2
79.90
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
79.83

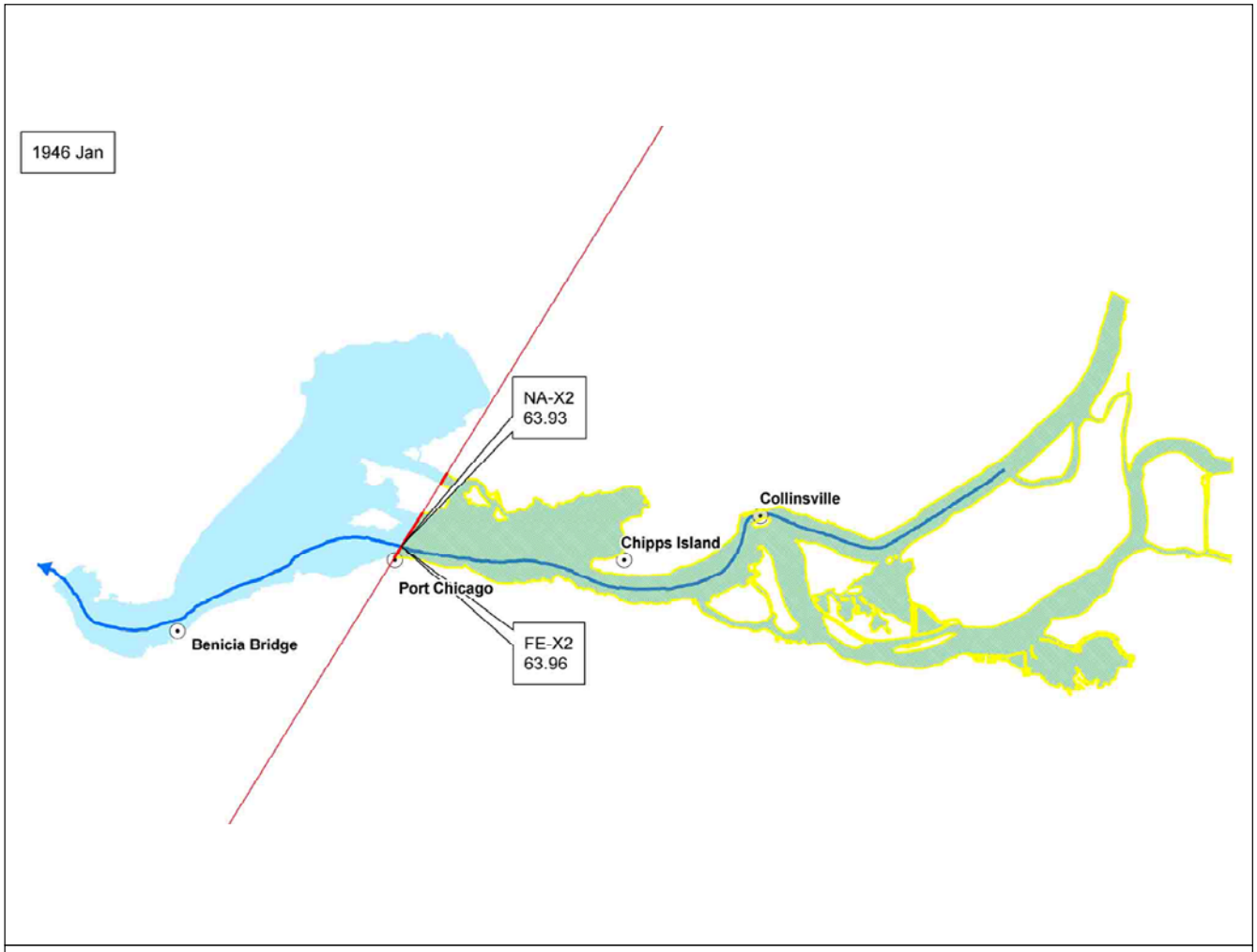

1945 Sep
NA-X2
84.81
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
84.79


1945 Oct
NA-X2
88.58
FE-X2
89.14
Collinsville
Chipps Island
Port Chicago
Benicia Bridge


1945 Nov
NA-X2
84.53
FE-X2
84.45
Collinsville
Chipps Island
Port Chicago
Benicia Bridge


1945 Dec
NA-X2
83.45
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
83.44


1945 average
NA-X2
77.92
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
78.06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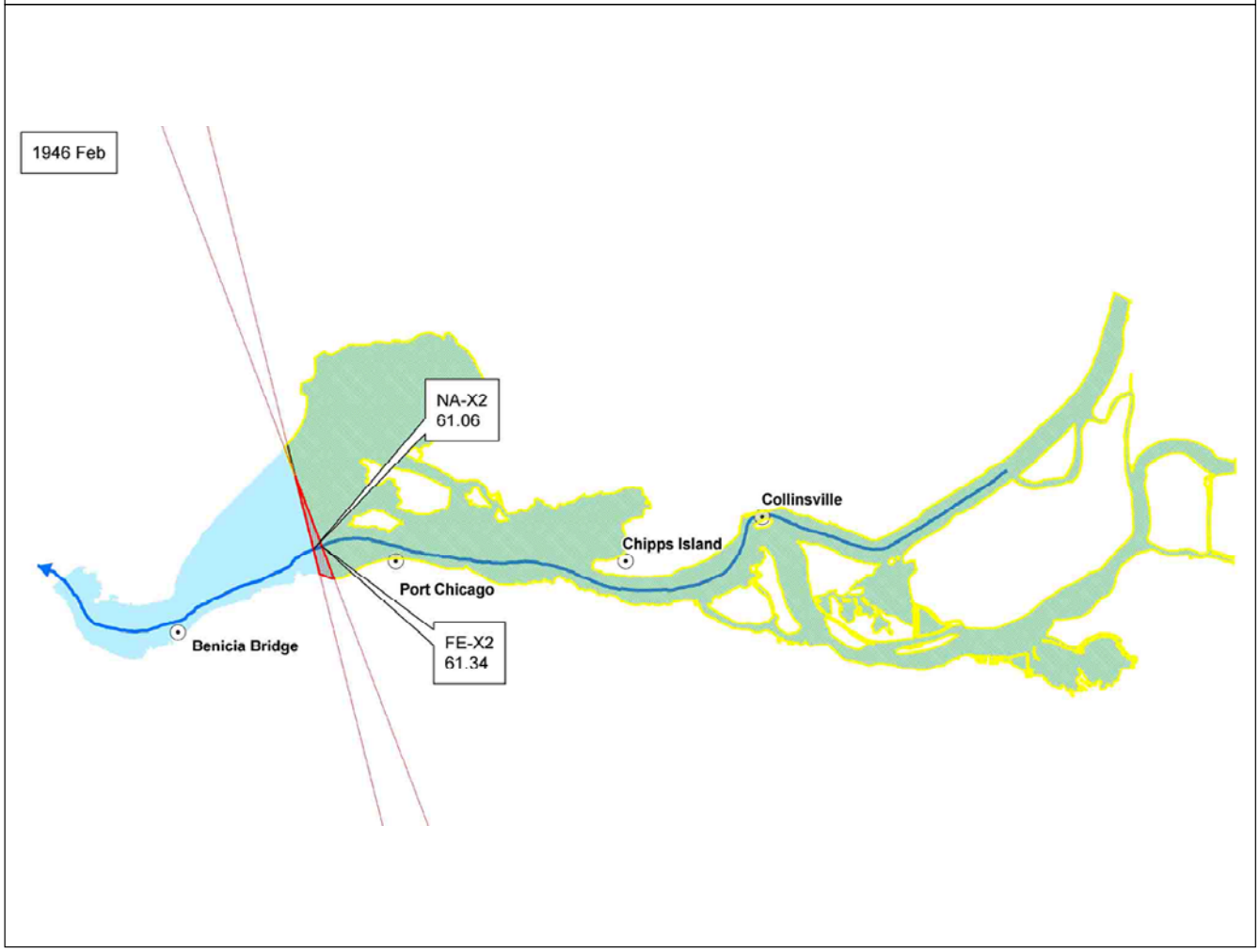
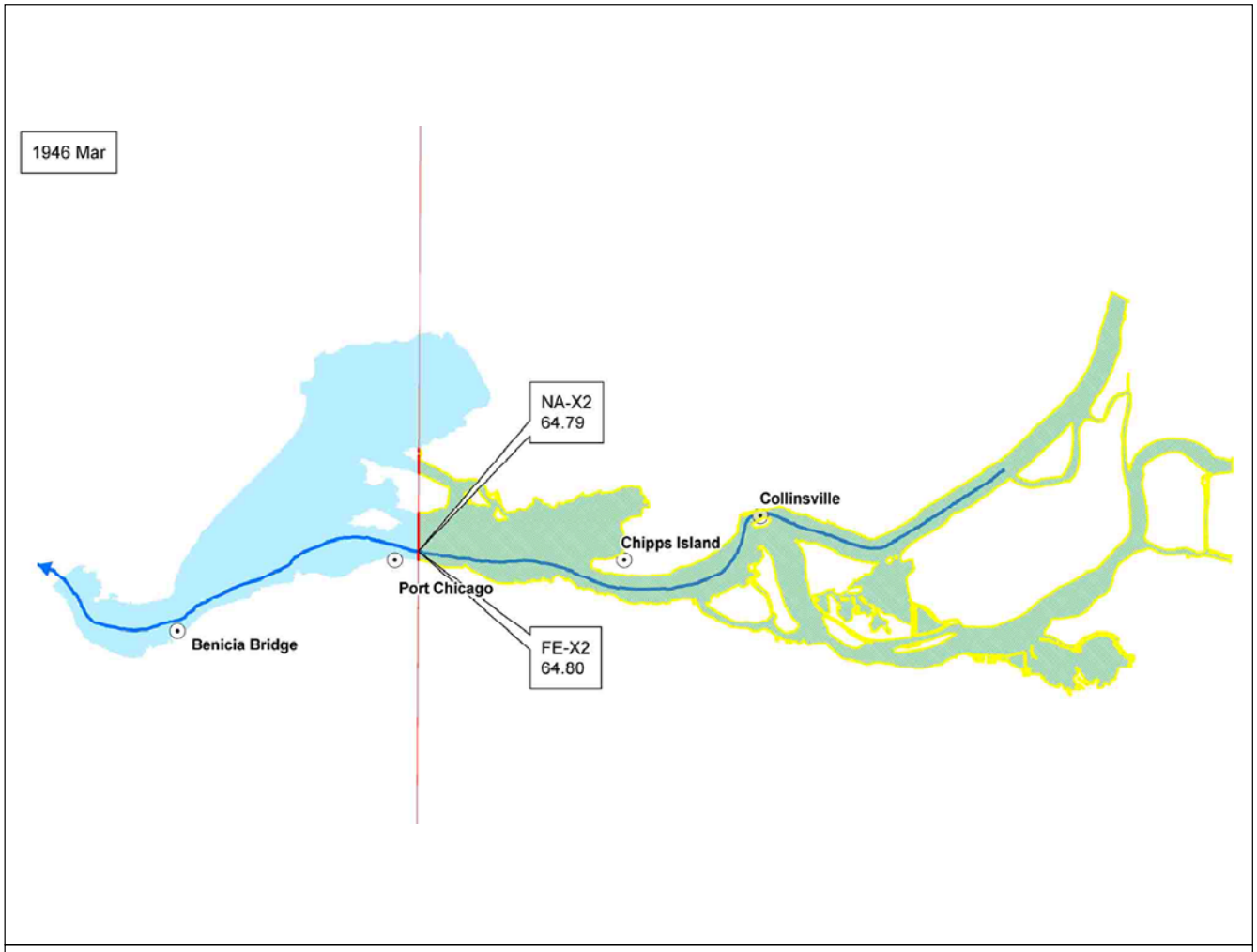
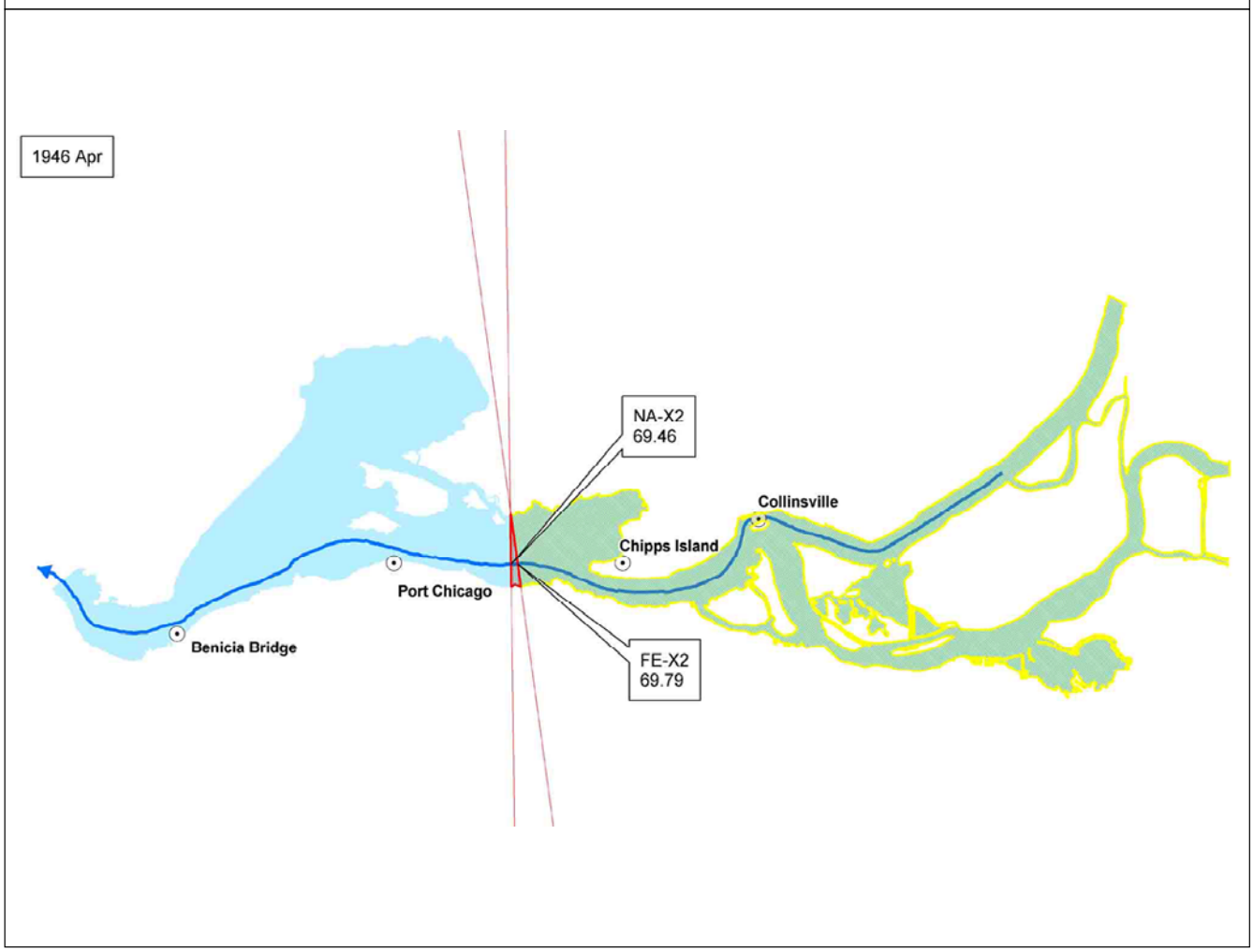
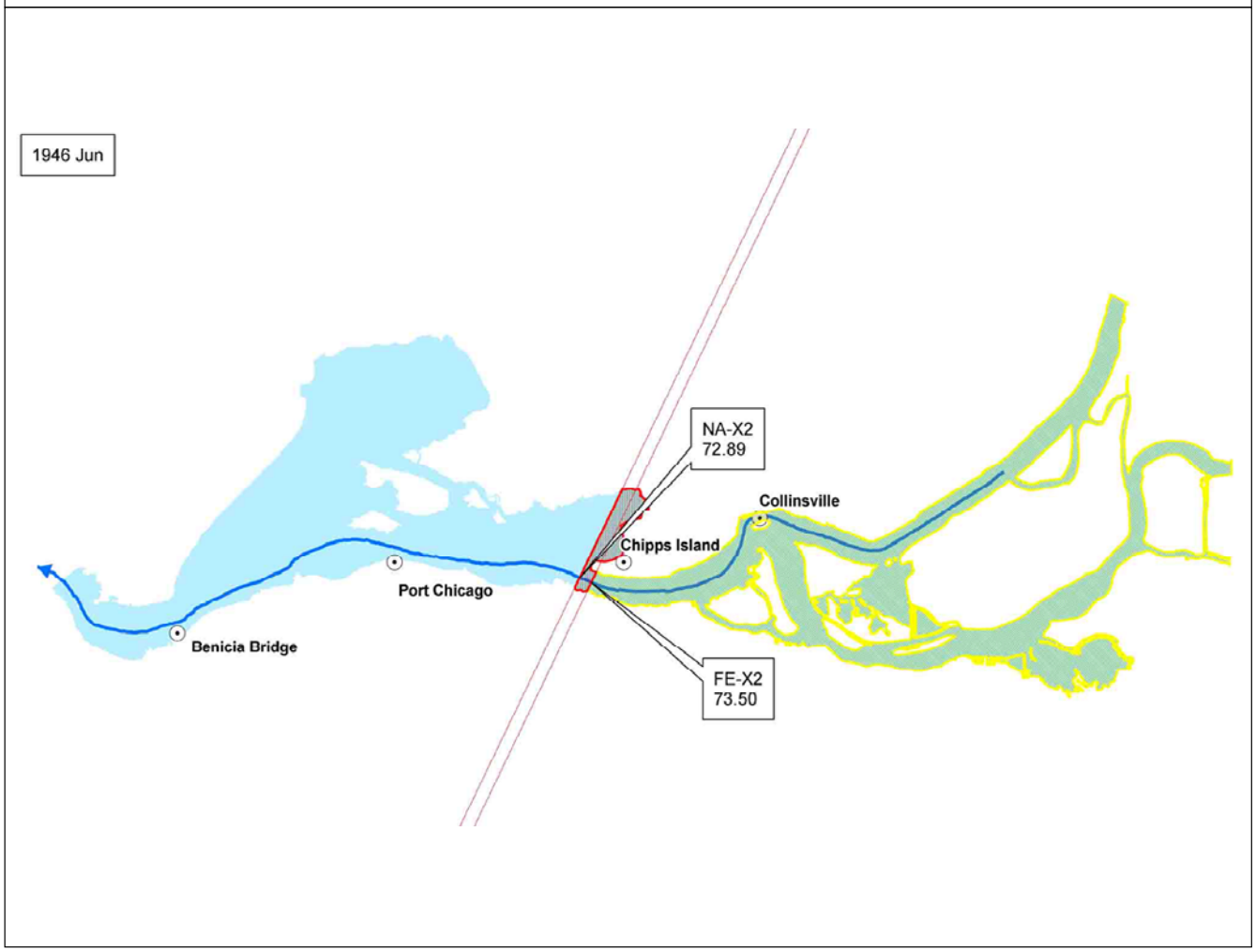
NA-X2
63.93
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
63.96

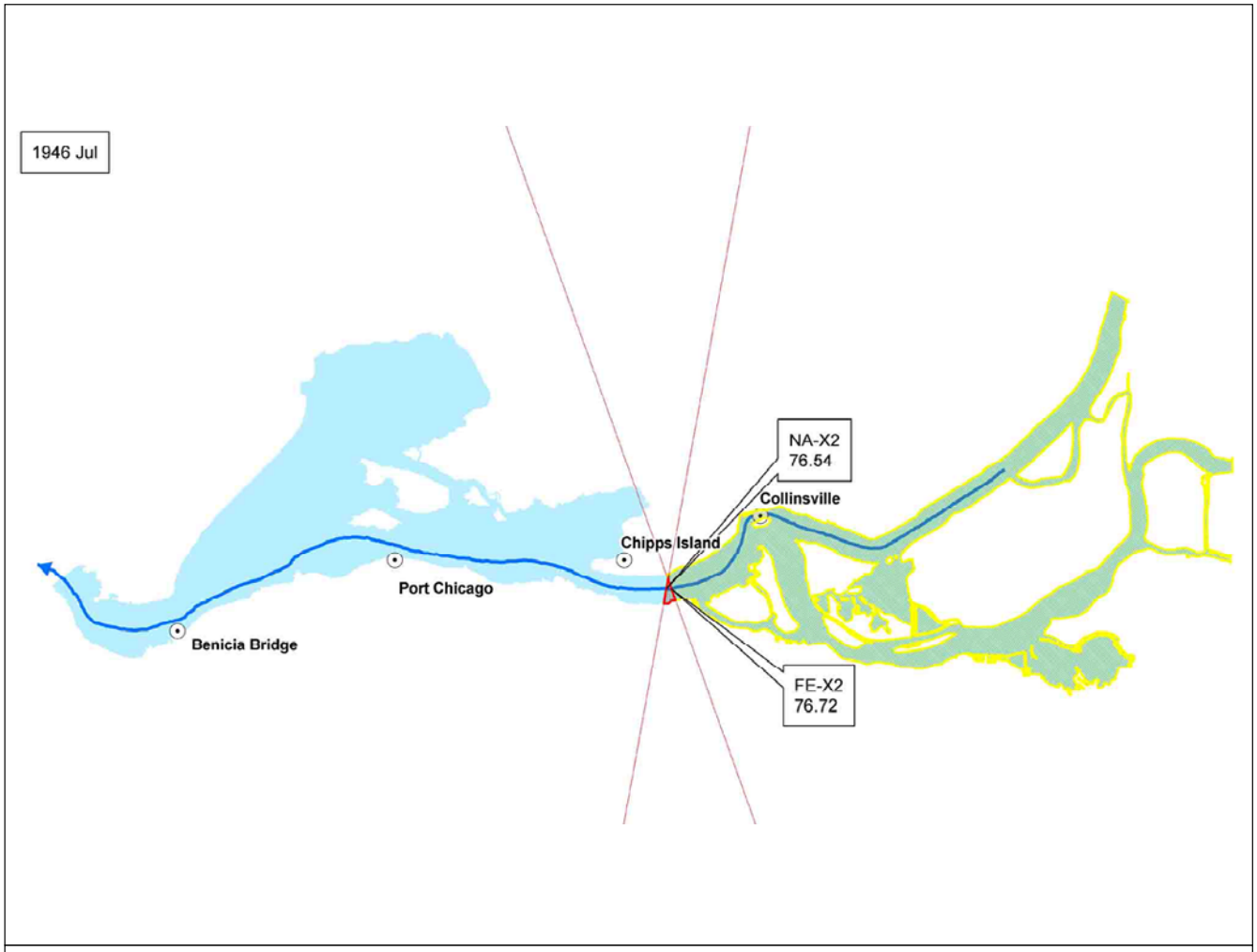

1946 Feb
NA-X2
61.06
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
61.34


1946 Mar
NA-X2
64.79
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
64.80

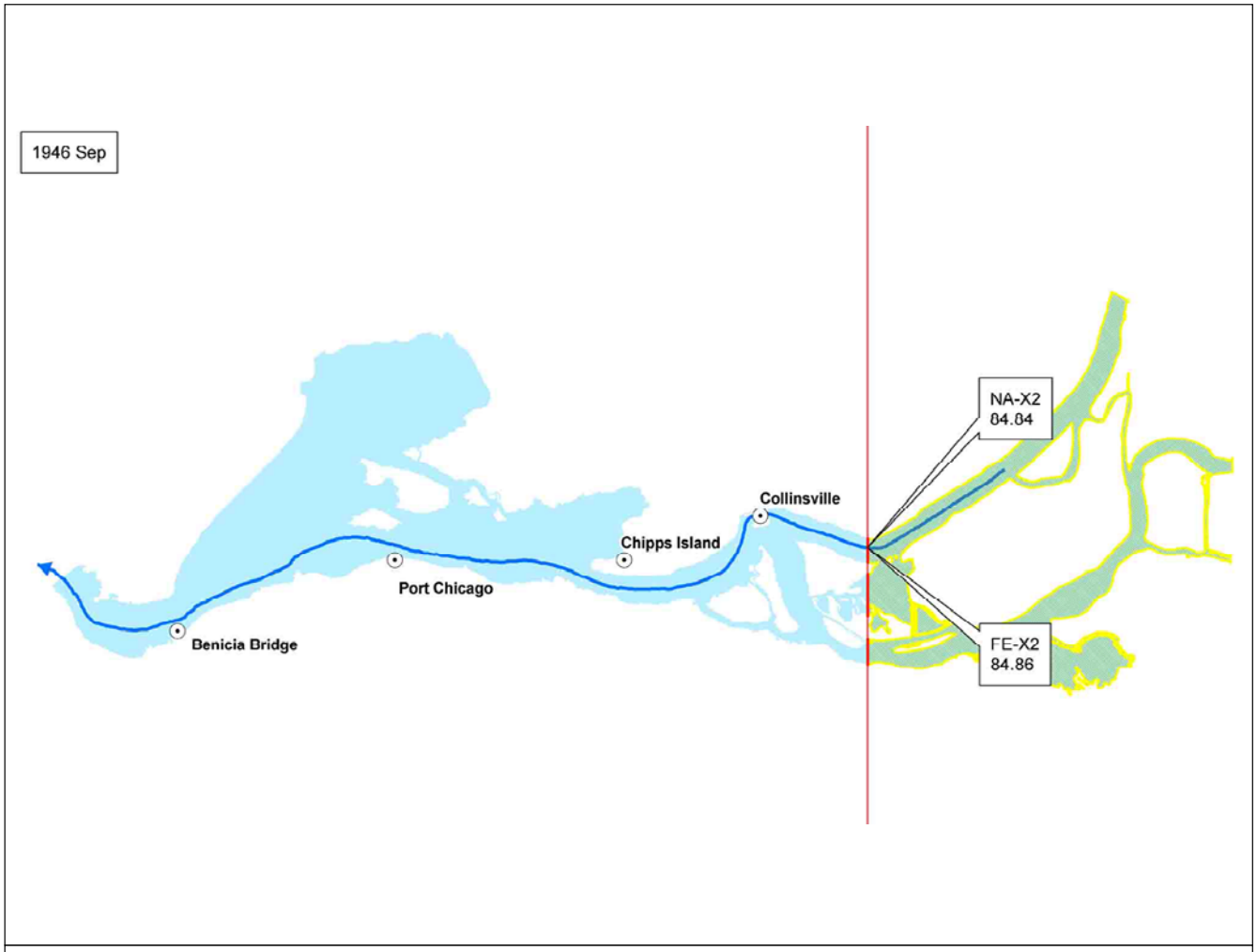

1946 Apr
NA-X2
69.46
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
69.79

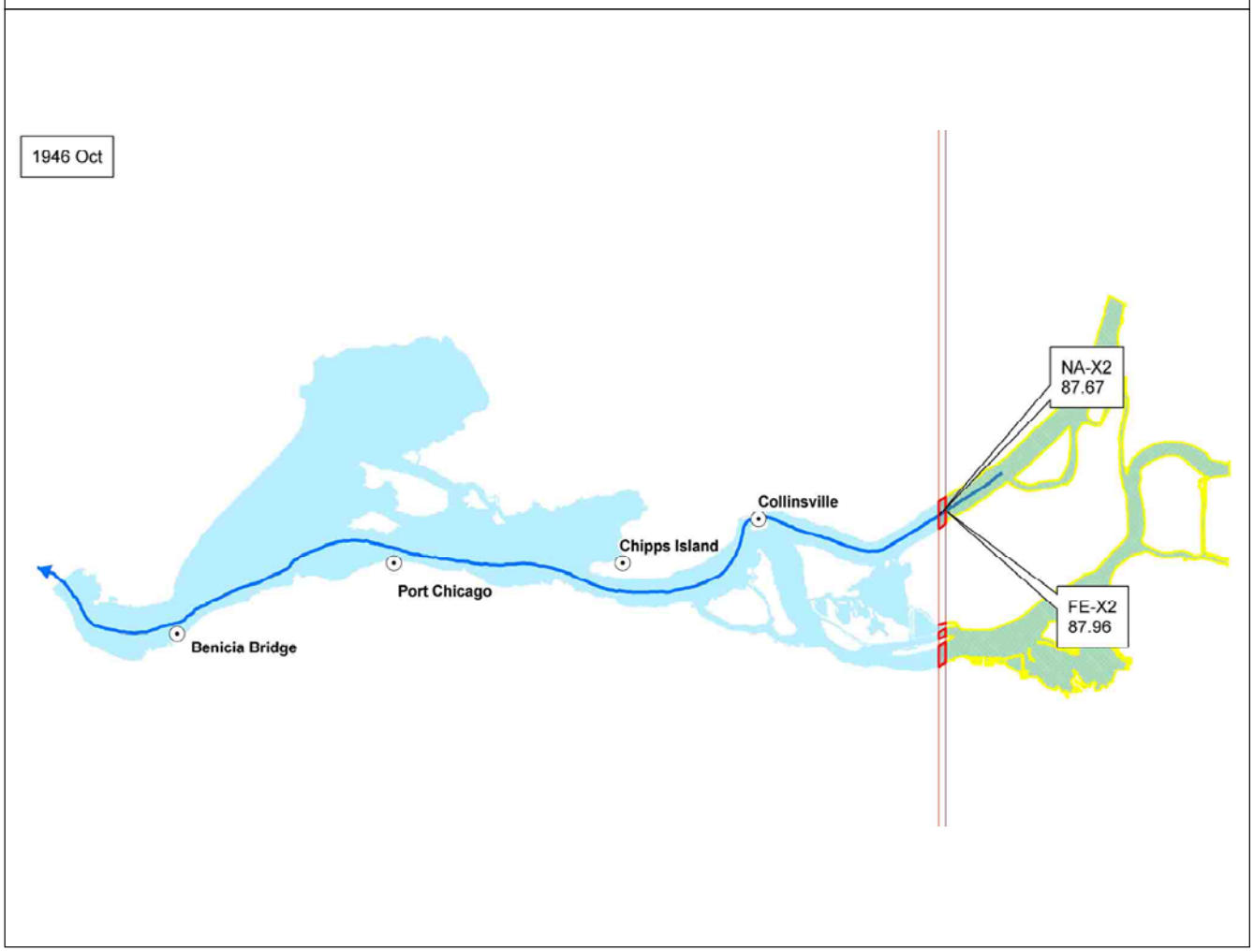

1946 May
NA-X2
72.08
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
72.66

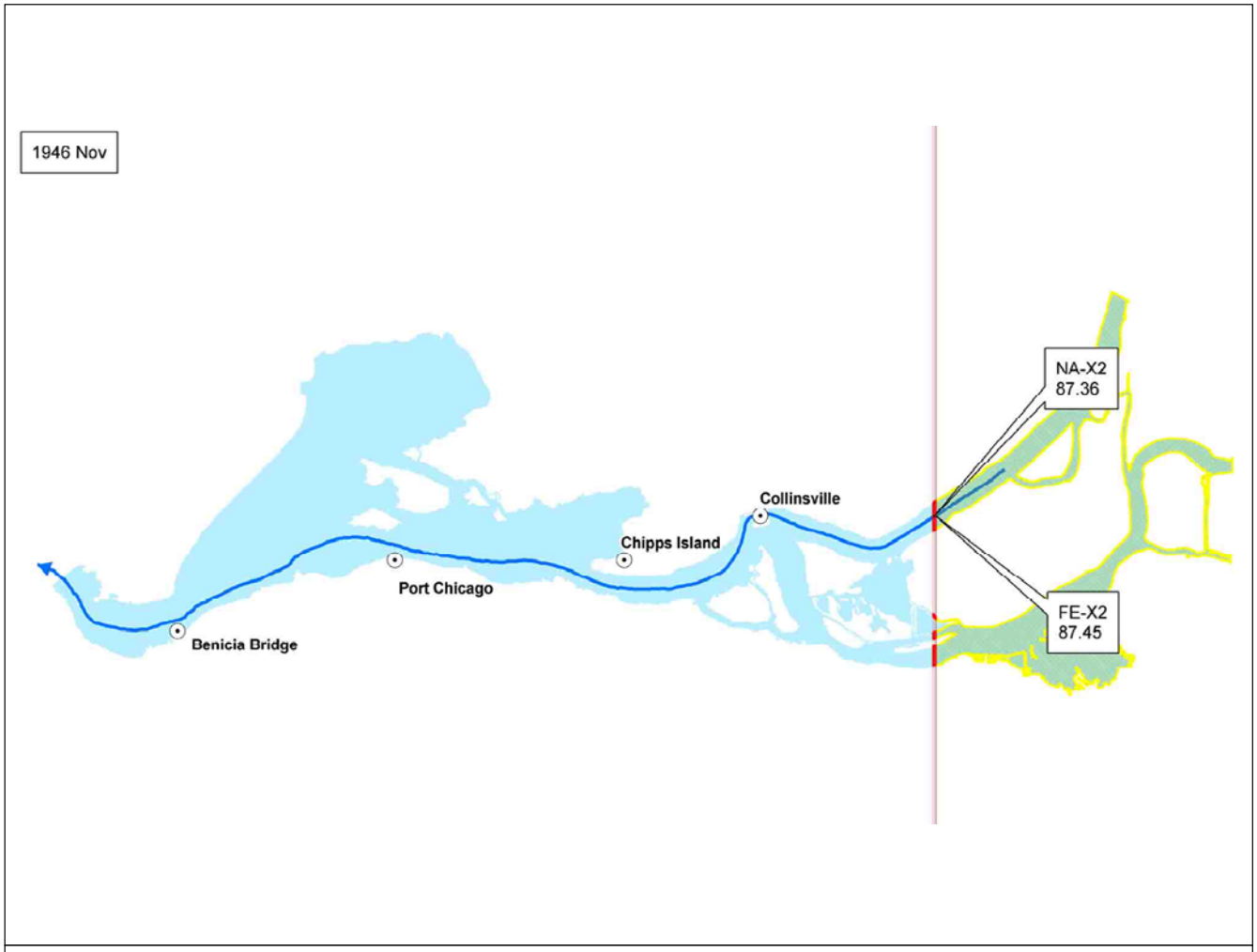

1946 Jun
NA-X2
72.89
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
73.50

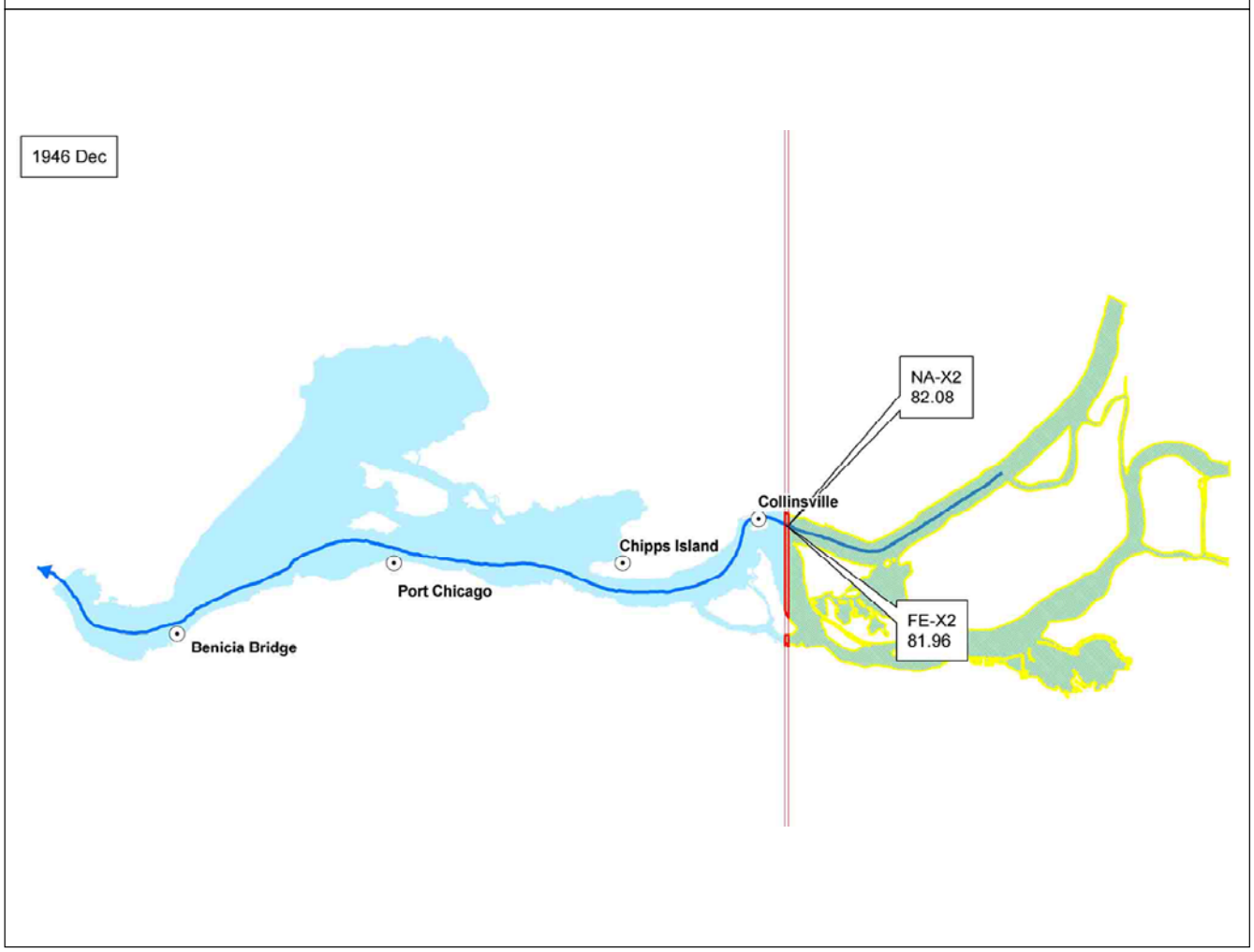

1946 Jul
NA-X2
76.54
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
76.72

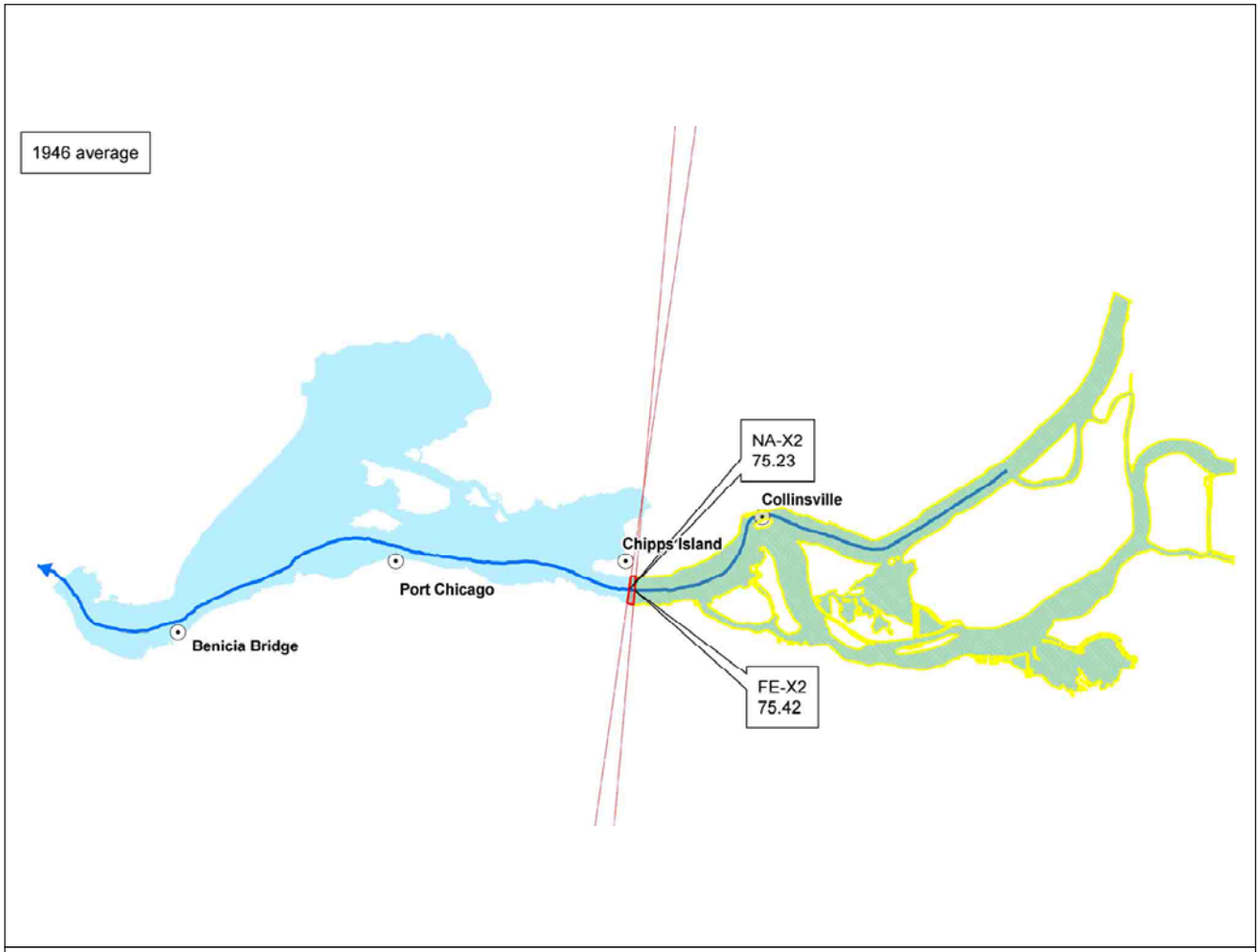

1946 Aug
NA-X2
79.99
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
80.05


1946 Sep
NA-X2
84.84
FE-X2
84.86
Collinsville
Chipps Island
Port Chicago
Benicia Bridge


1946 Oct
NA-X2
87.67
FE-X2
87.96
Collinsville
Chipps Island
Port Chicago
Benicia Bridge

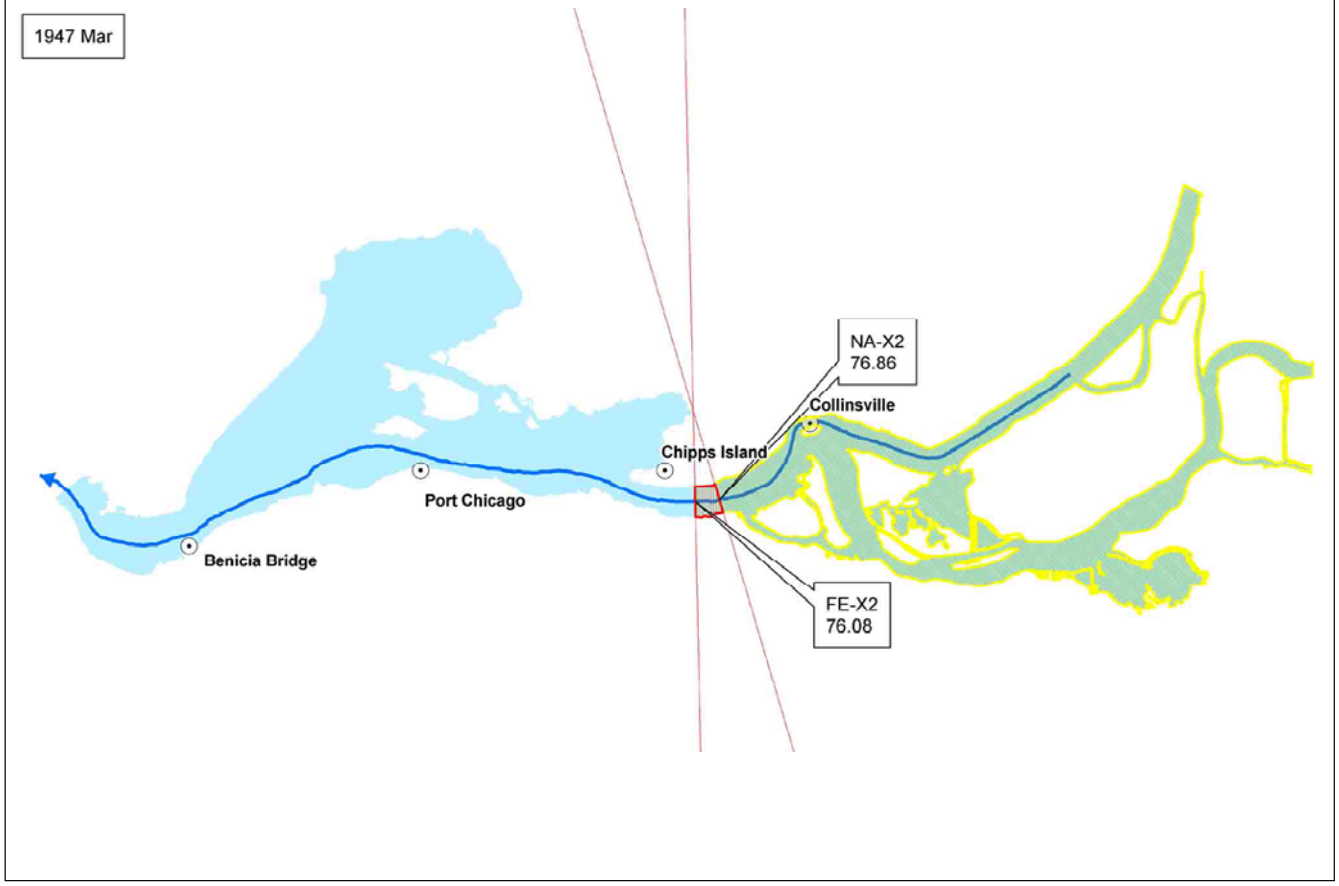

1946 Nov
NA-X2
87.36
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
87.45

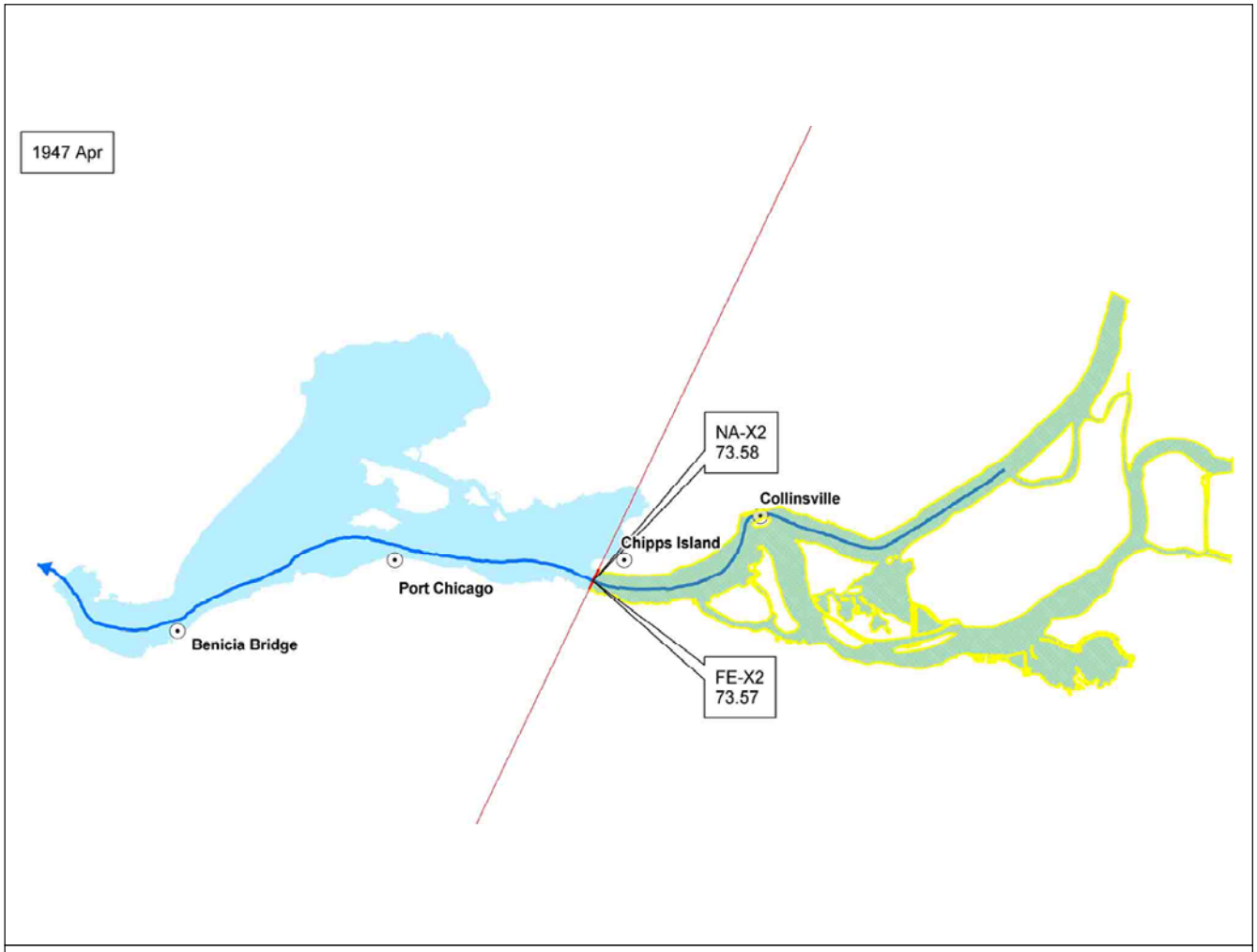

1946 Dec
NA-X2
82.08
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
81.96

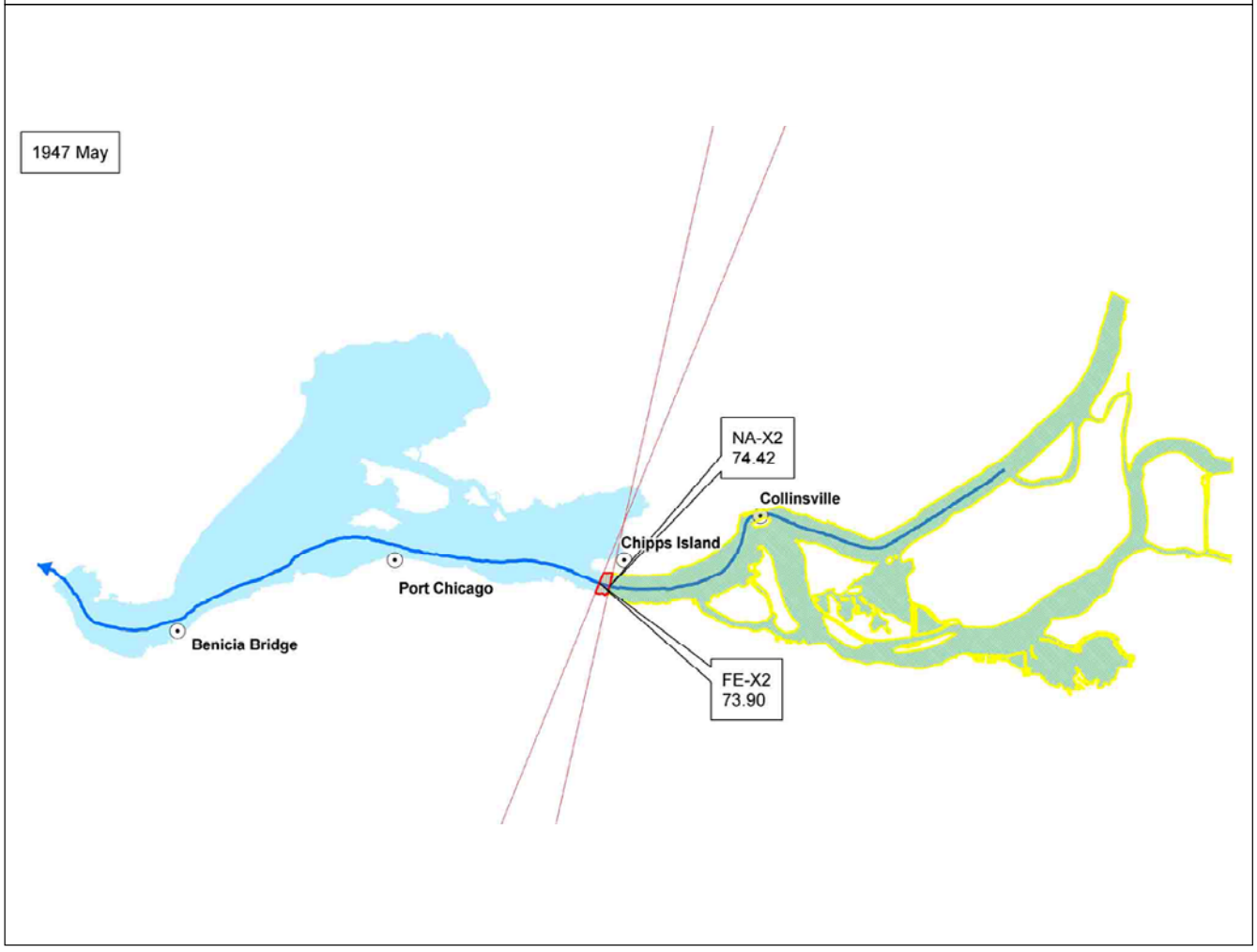

1946 average
NA-X2
75.23
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
75.42


1947 Jan
NA-X2
80.30
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
80.49


1947 Feb
NA X2
81.84
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
81.90


1947 Mar
NA-X2
76.86
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
76.08


1947 Apr
NA-X2
73.58
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
73.57

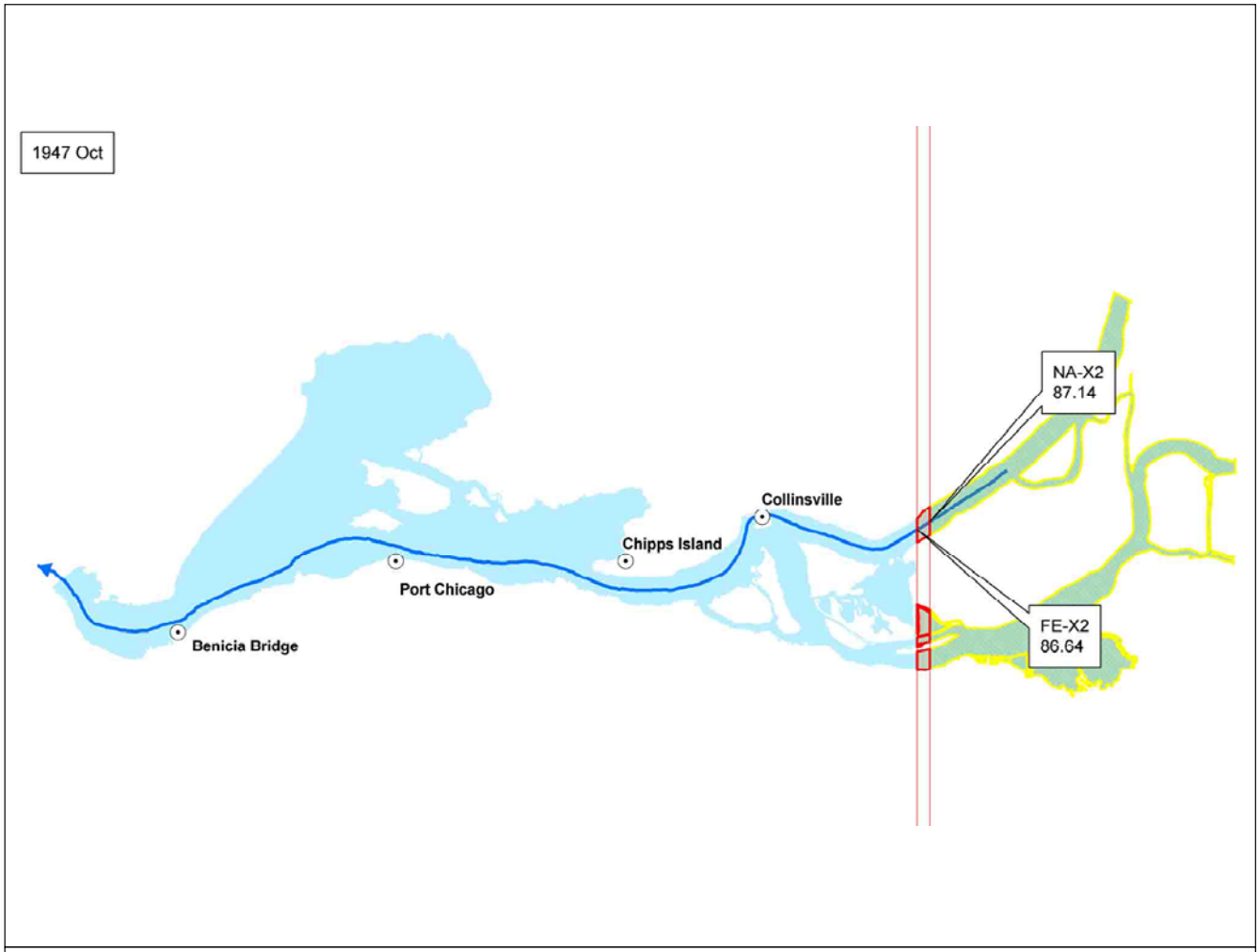

1947 May
NA-X2
74.42
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
73.90


1947 Jun
NA-X2
77.70
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
77.46


1947 Jul
NA-X2
80.27
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FF-X2
79.72


1947 Aug
NA-X2
83.22
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
83.04


1947 Sep
NA-X2
85.02
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
84.96


1947 Oct
NA-X2
87.14
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
86.64


1947 Nov
NA-X2
85.64
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
85.73

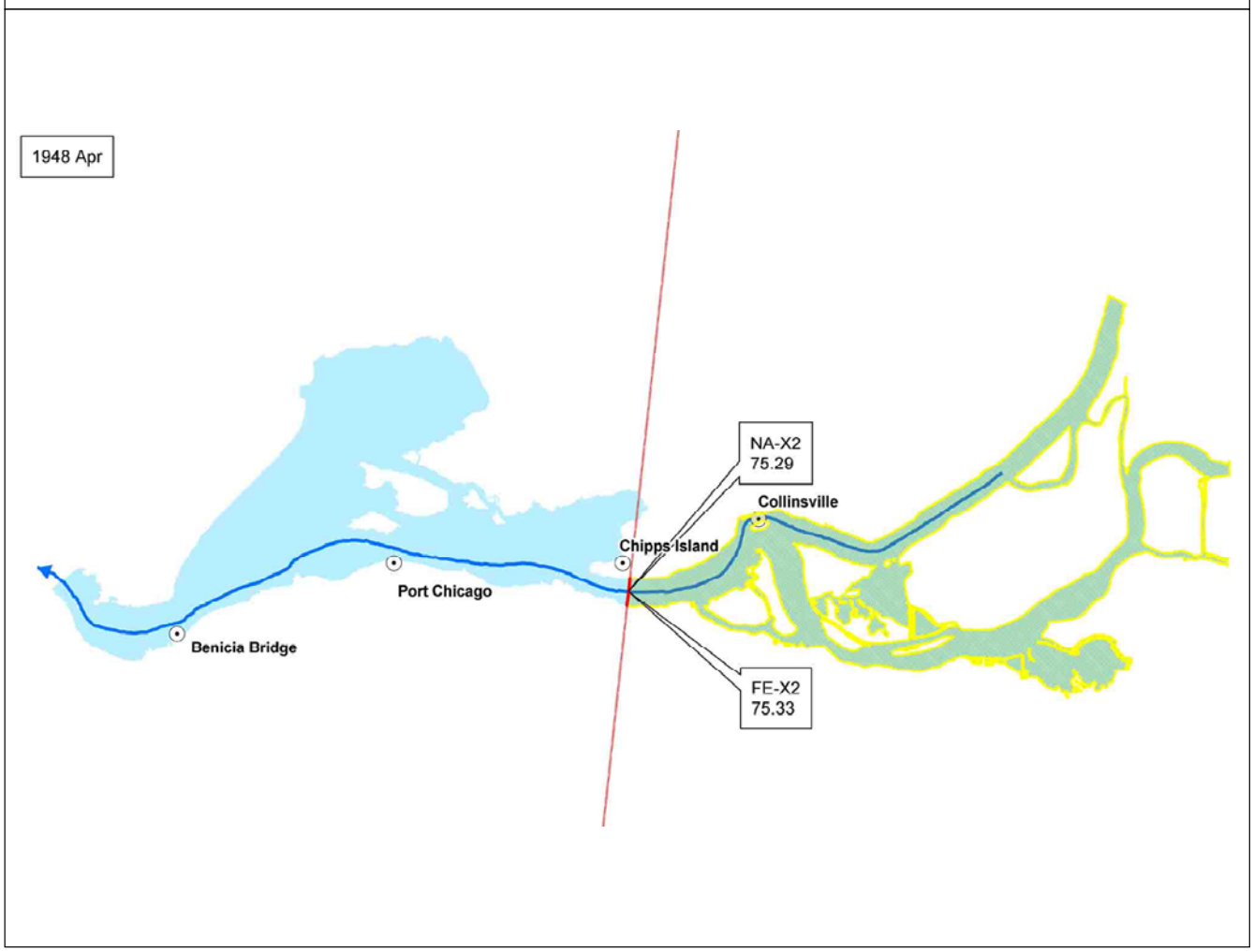

1947 Dec
NA-X2
83.76
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
83.89


1947 average
NA-X2
80.81
Collinsville
Chipps Island
Port Chicago
Benicia Bridge


1948 Jan
NA-X2
84.20
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
84.40


1948 Feb
NA-X2
80.14
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
80.45


1948 Mar
NA-X2
76.99
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
77.10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NA-X2
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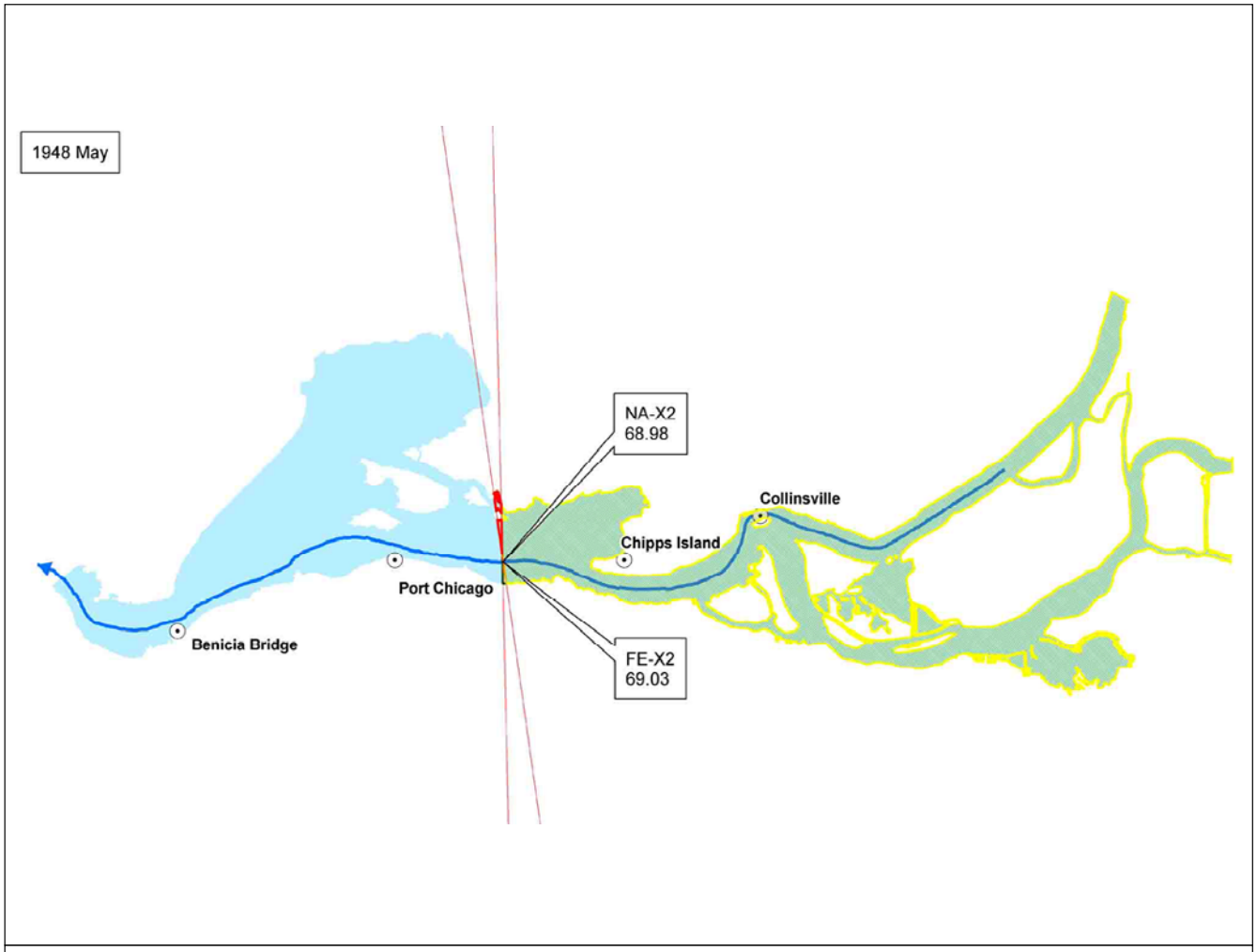
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
75.33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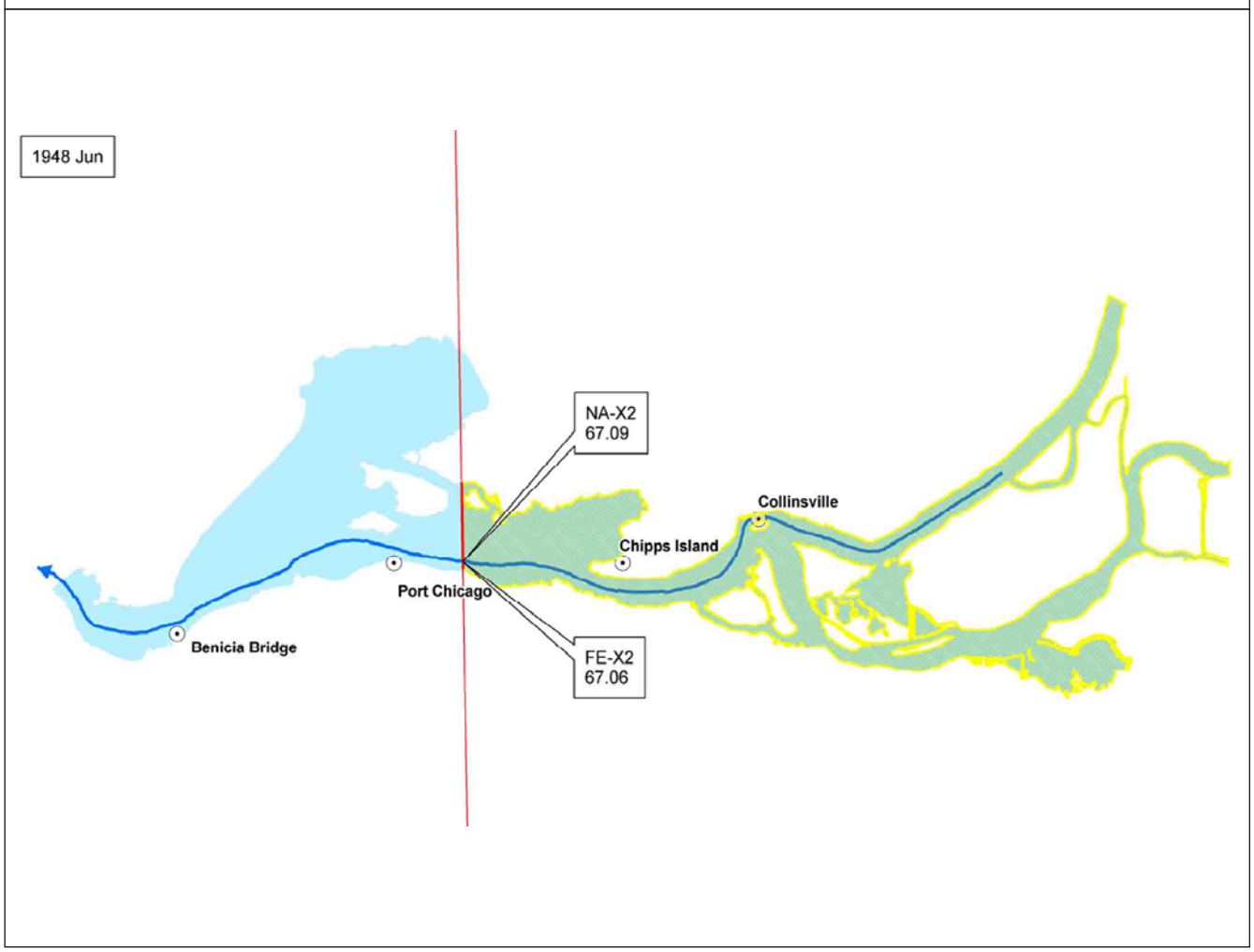
NA-X2
68.98
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
69.03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NA-X2
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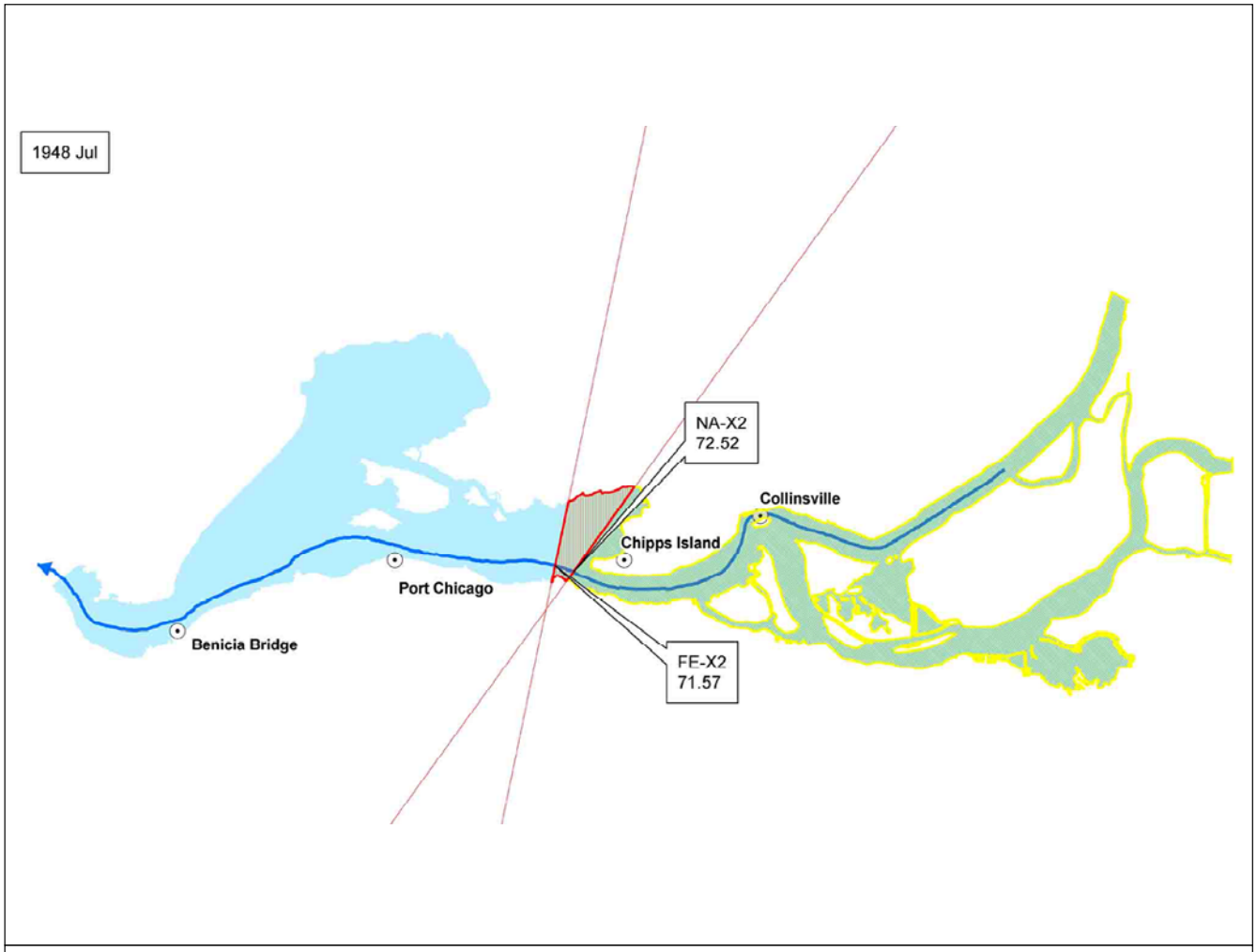
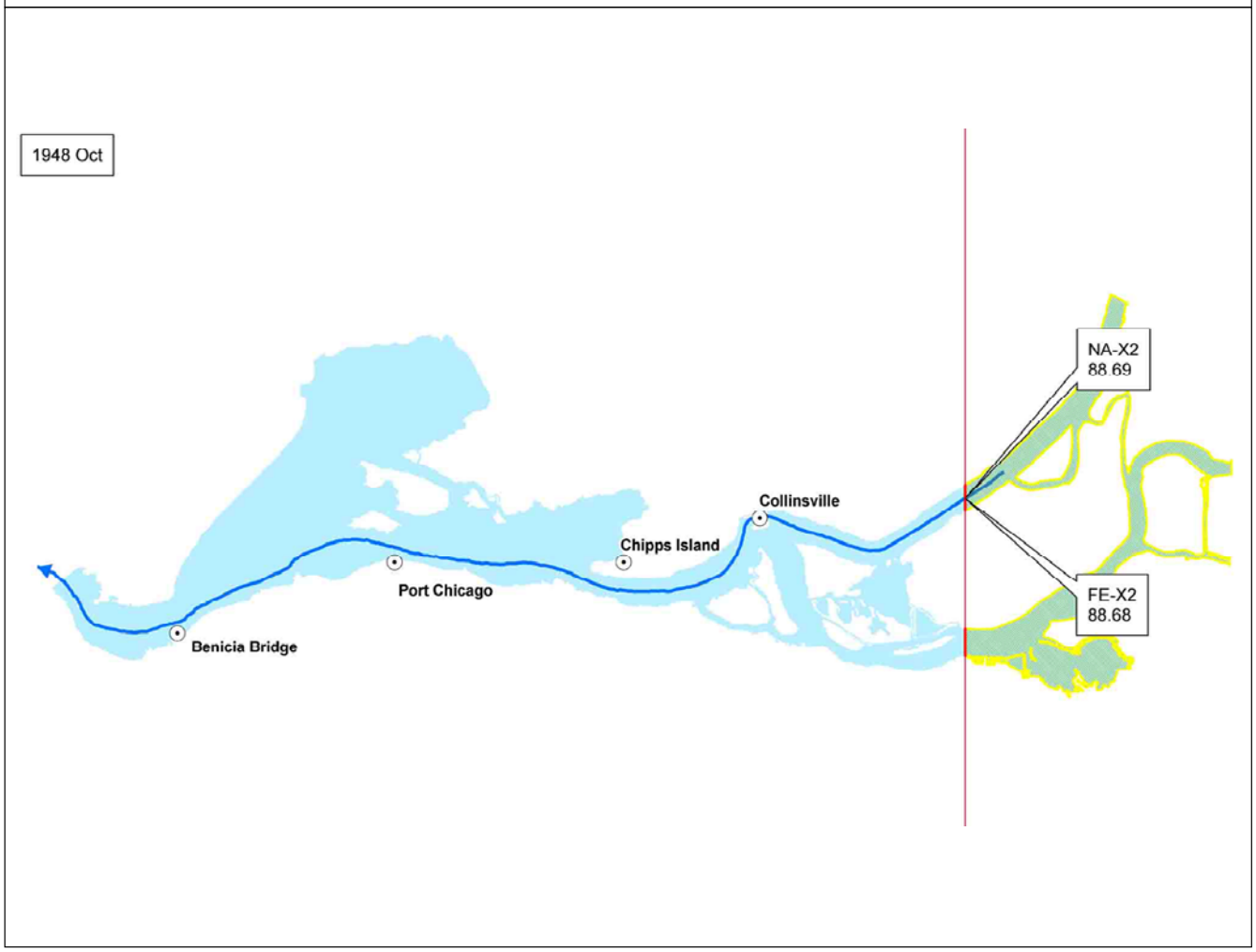
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
67.06


1948 Jul
NA-X2
72.52
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
71.57


1948 Aug
NA-X2
78.67
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
78.36


1948 Sep
NA-X2
84.41
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
84.31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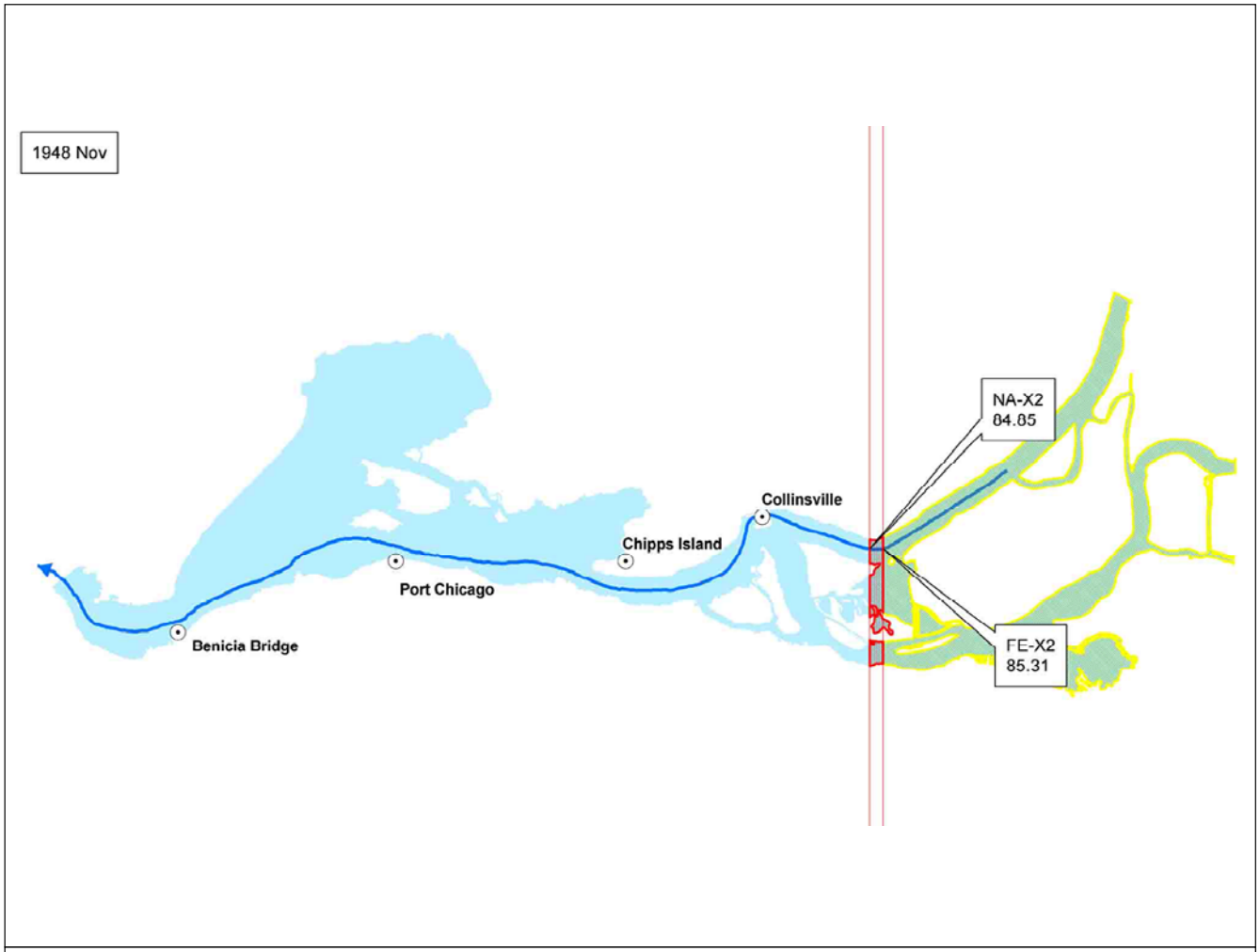
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
88.68


1948 Nov
NA-X2
84.85
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
85.31


1948 Dec
NA-X2
85.53
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
85.68

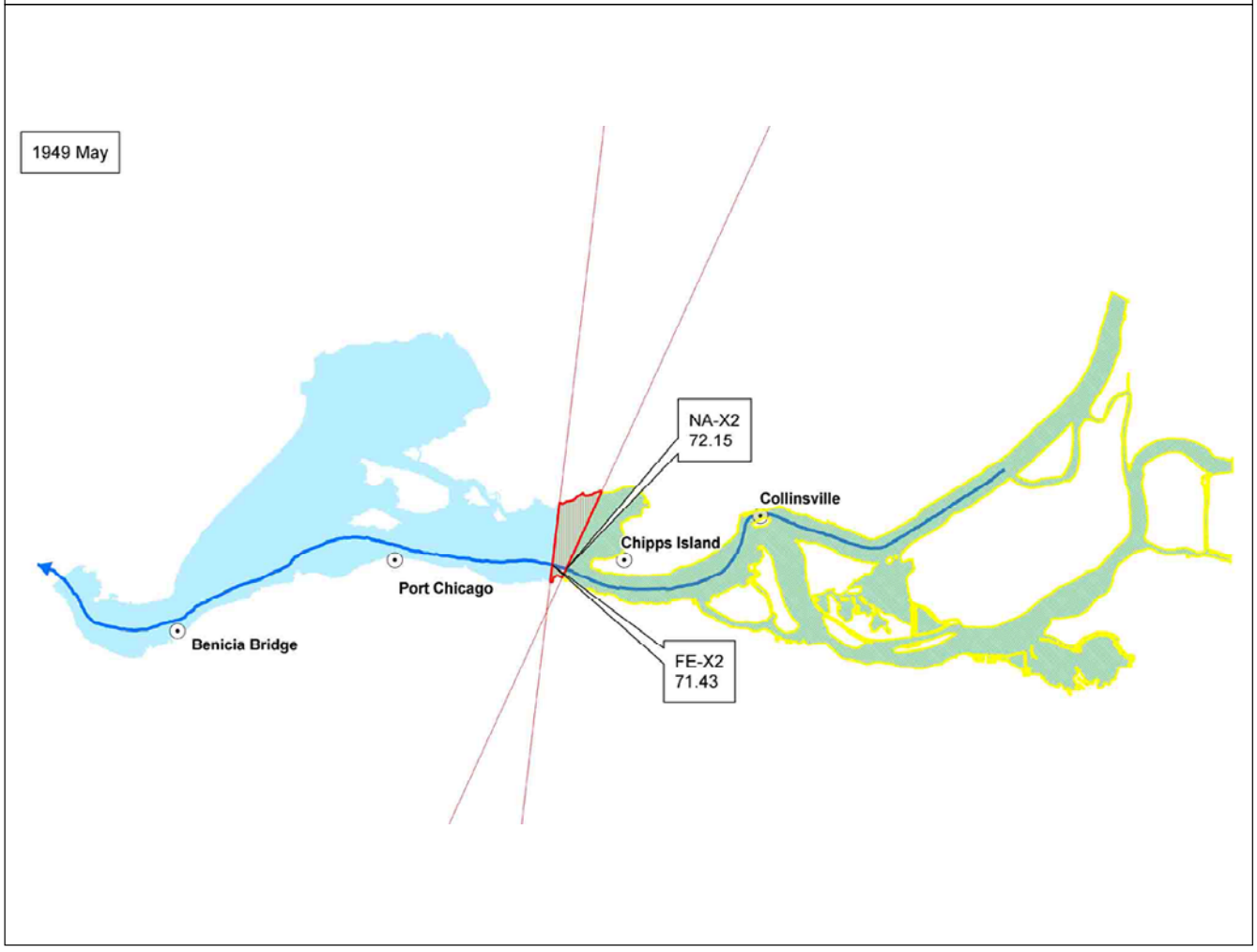

1948 average
NA-X2
78.95
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
78.94


1949 Jan
NA-X2
81.92
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
82.26


1949 Feb
NA-X2
83.87
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
83.99


1949 Mar
NA-X2
80.13
Collinsville
Chipps Island
Port Chicago
Benicia Bridge


1949 Apr
NA-X2
66.46
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
66.52


1949 May
NA-X2
72.15
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
71.43


1949 Jun
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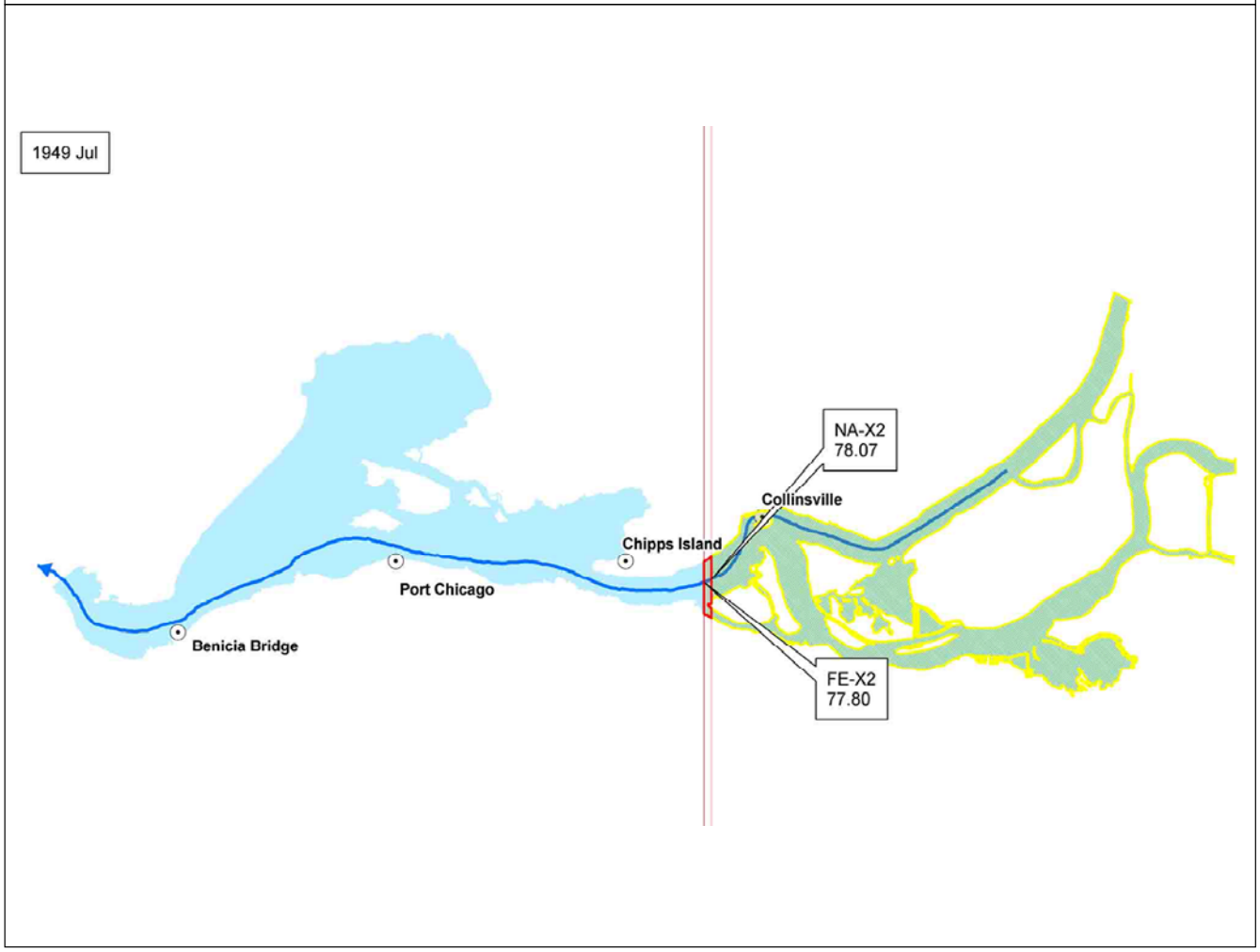
74.17
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
73.20


1949 Jul
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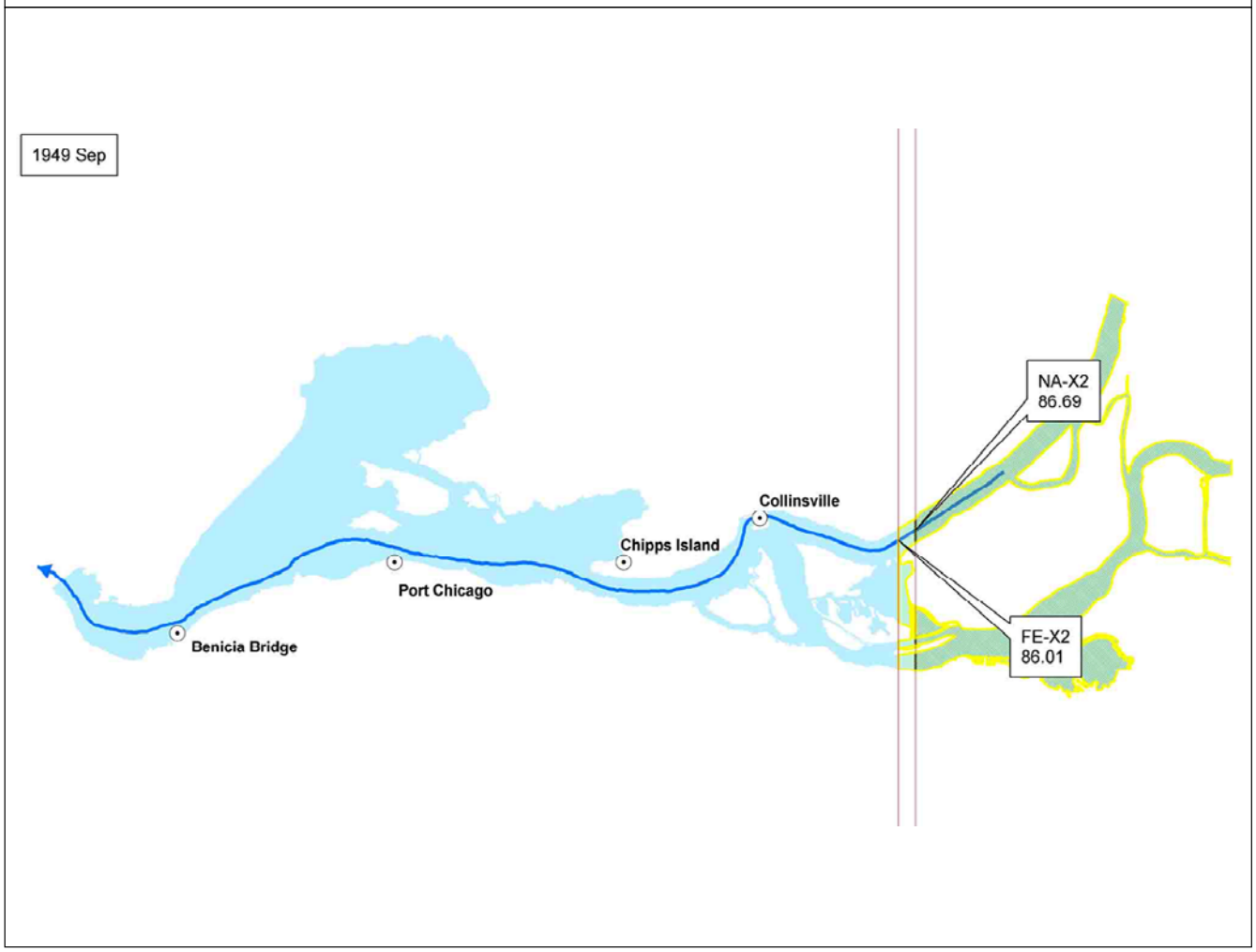
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
77.80


1949 Aug
NA-X2
82.50
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
82.41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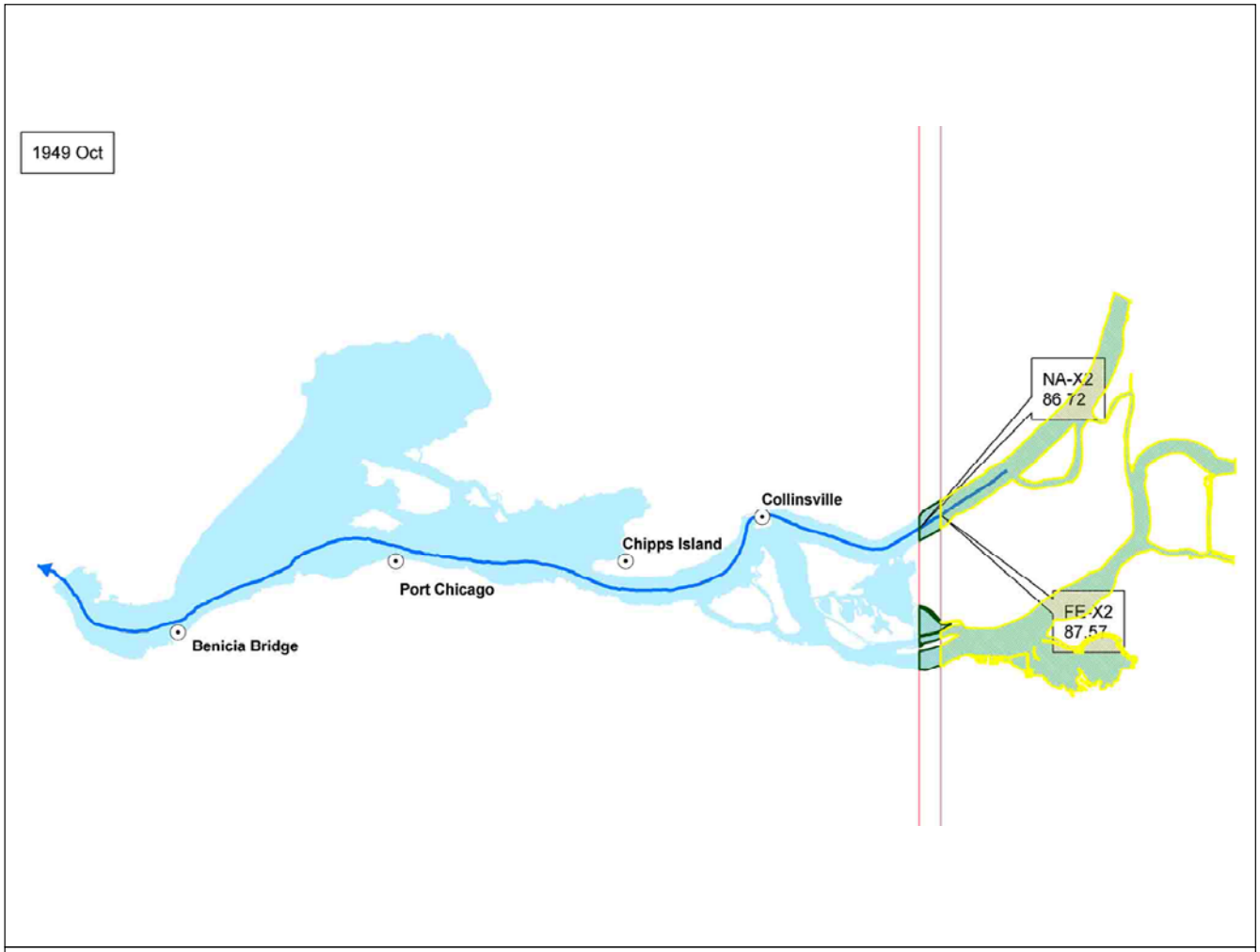
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
86.01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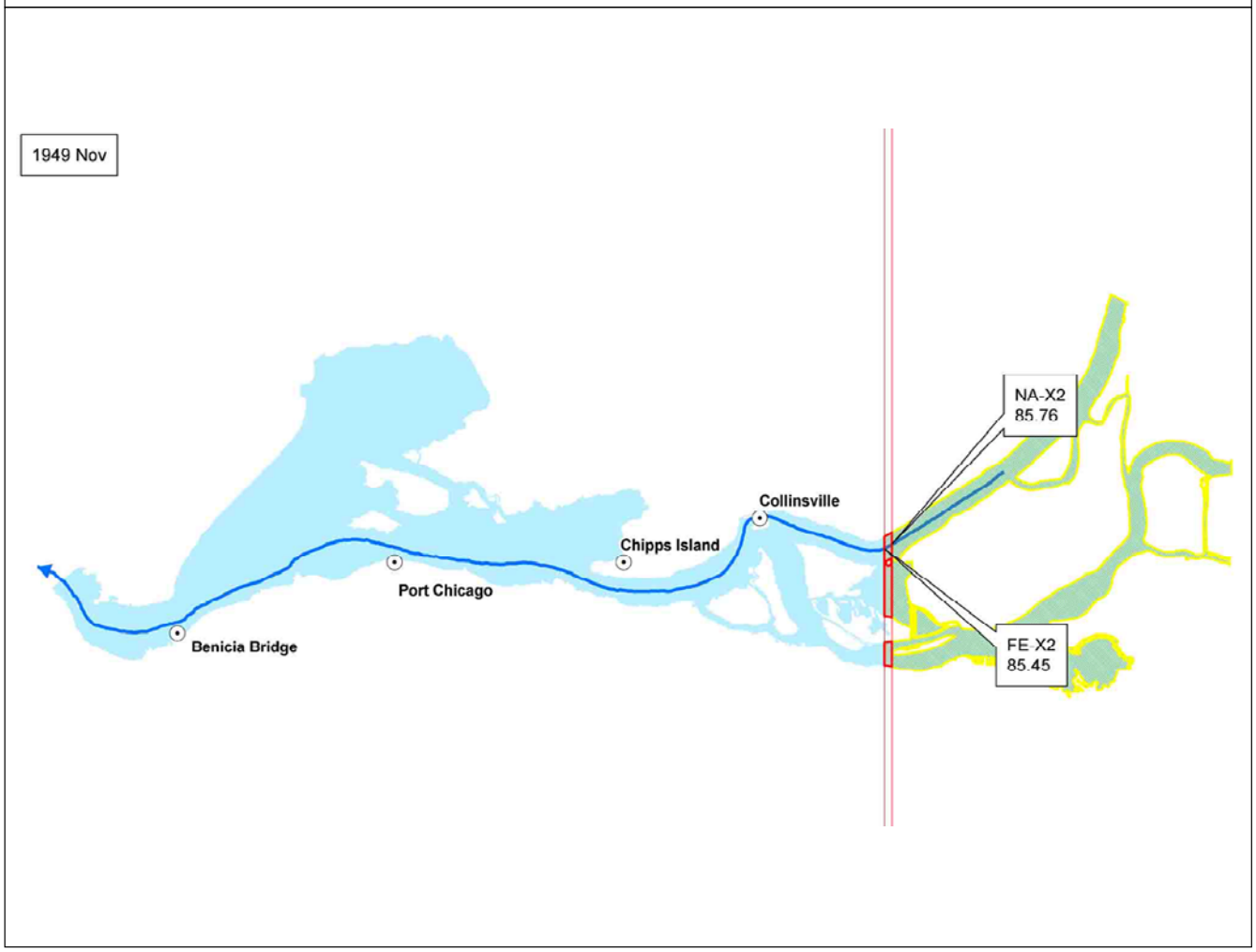
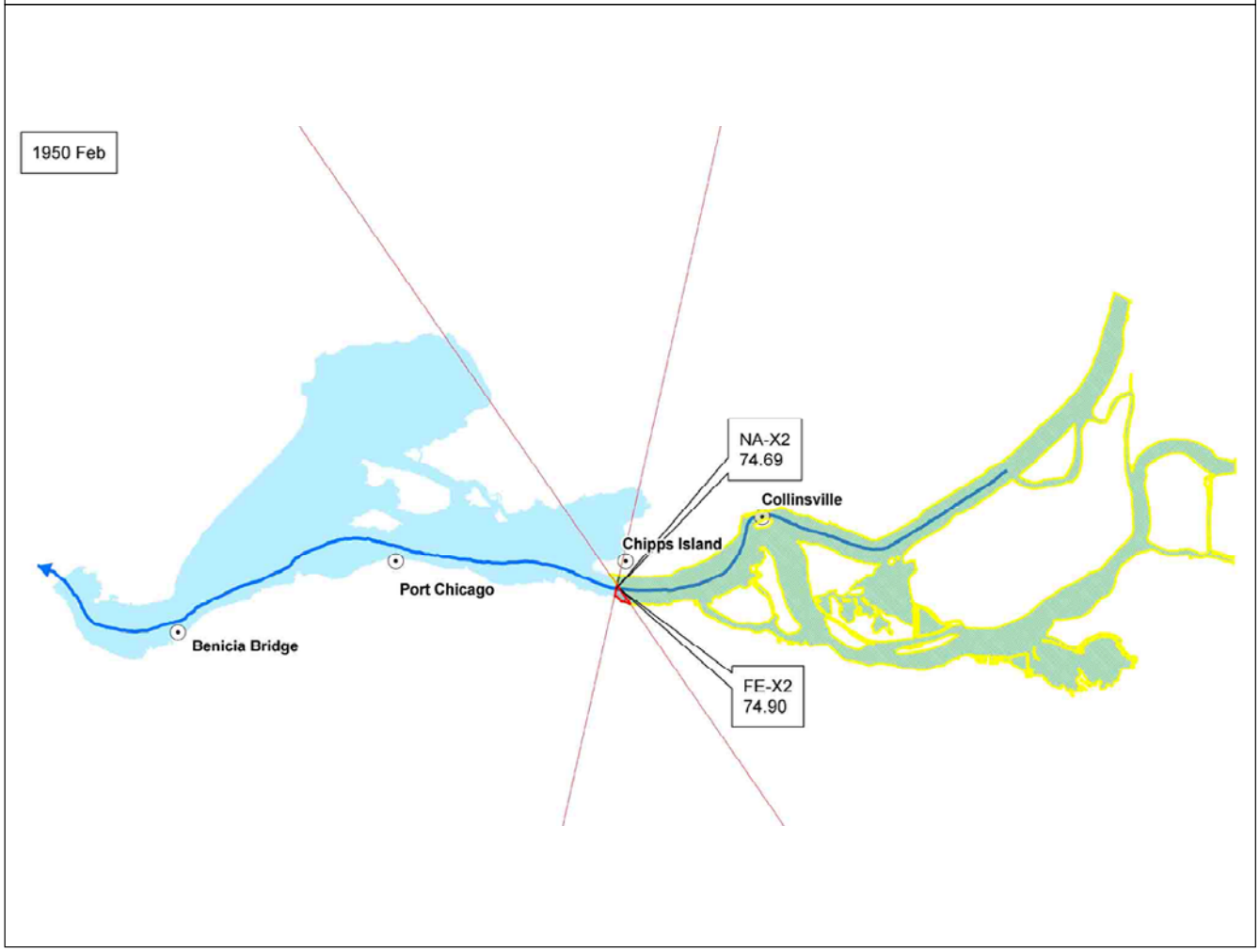
NA-X2
86.72
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
87.57

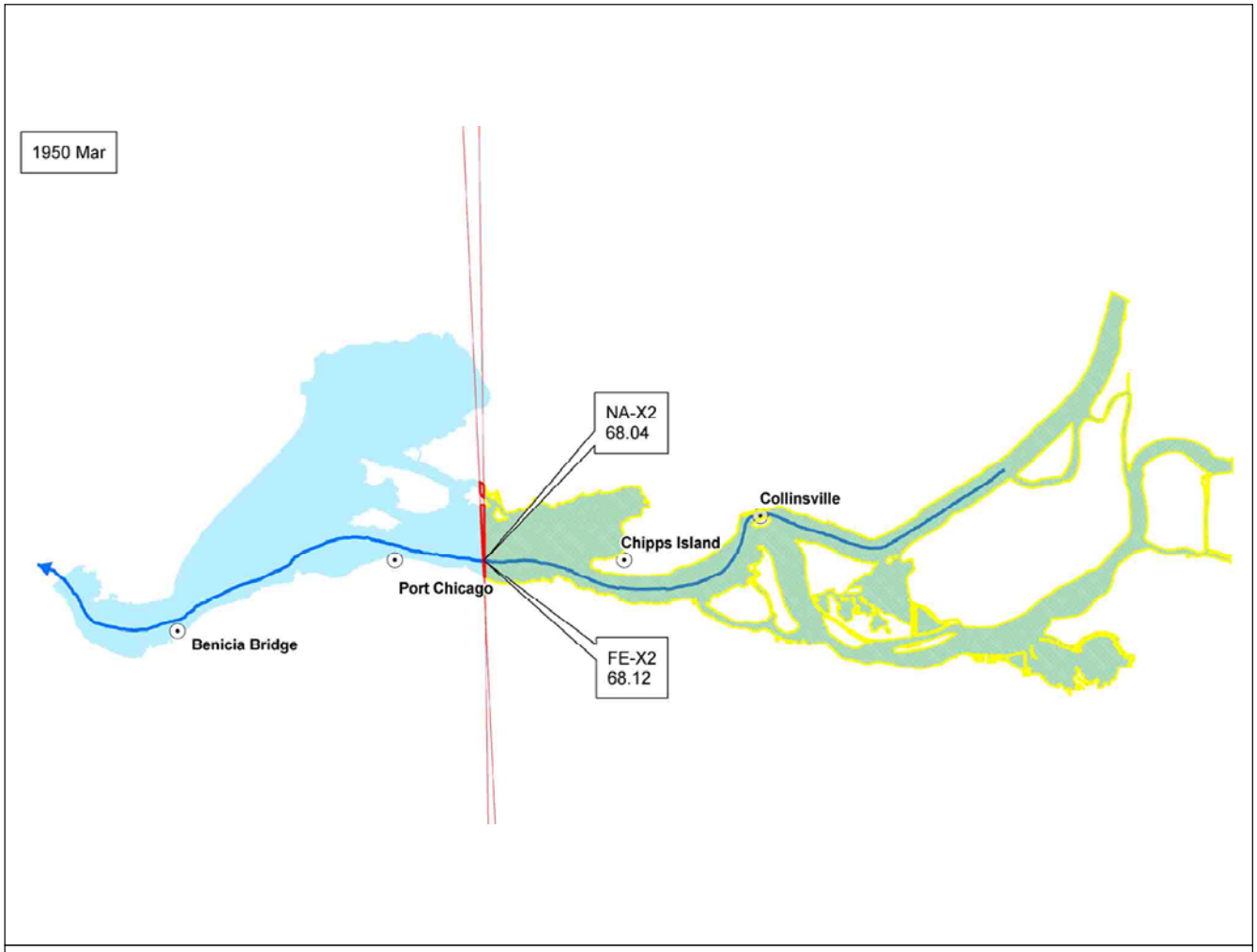

1949 Nov
NA-X2
85.76
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
85.45


1949 Dec
NA-X2
84.22
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
83.68


1949 average
NA-X2
80.22
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
80.04


1950 Jan
NA-X2
83.74
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
83.45


1950 Feb
NA-X2
74.69
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
74.90


1950 Mar
NA-X2
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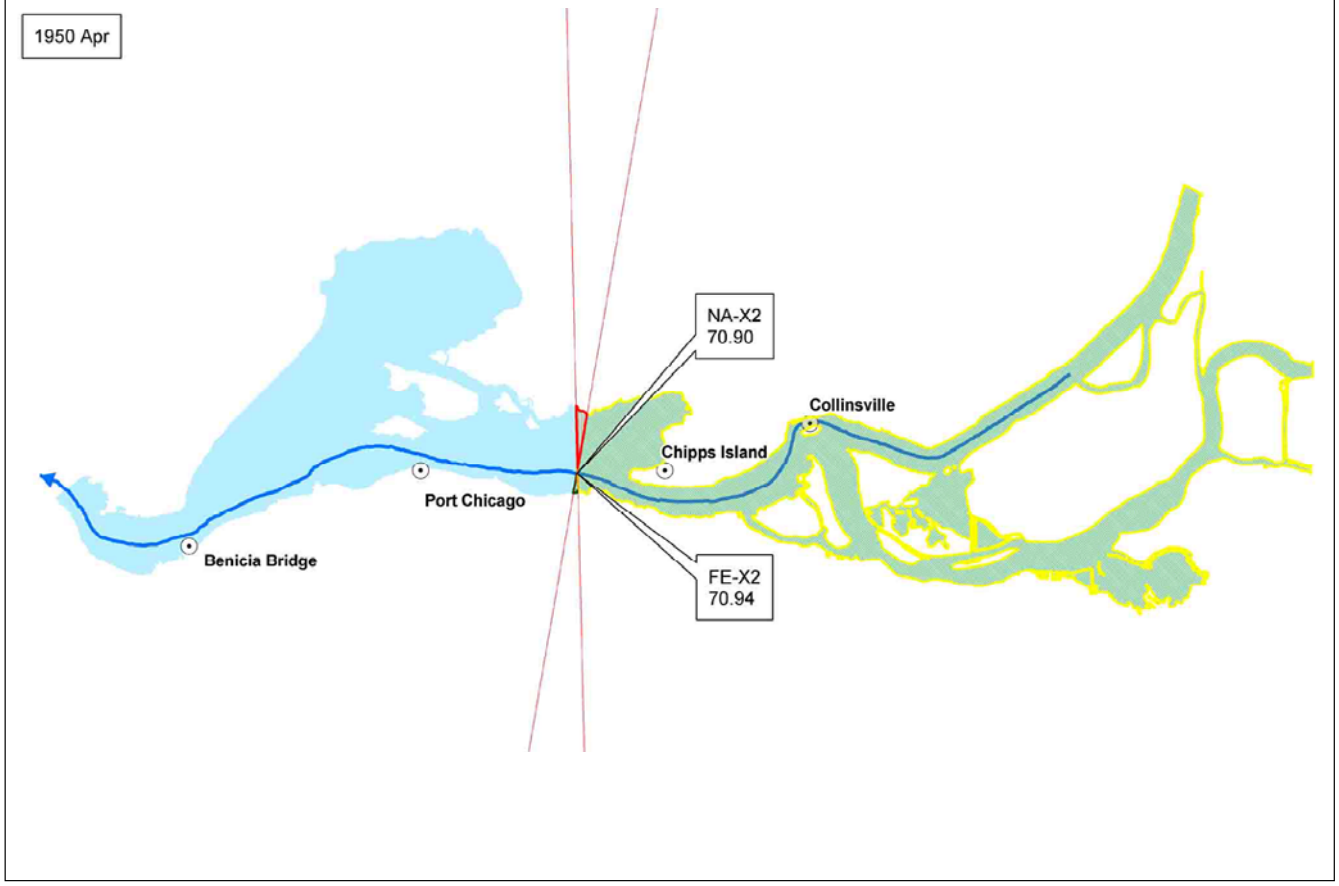
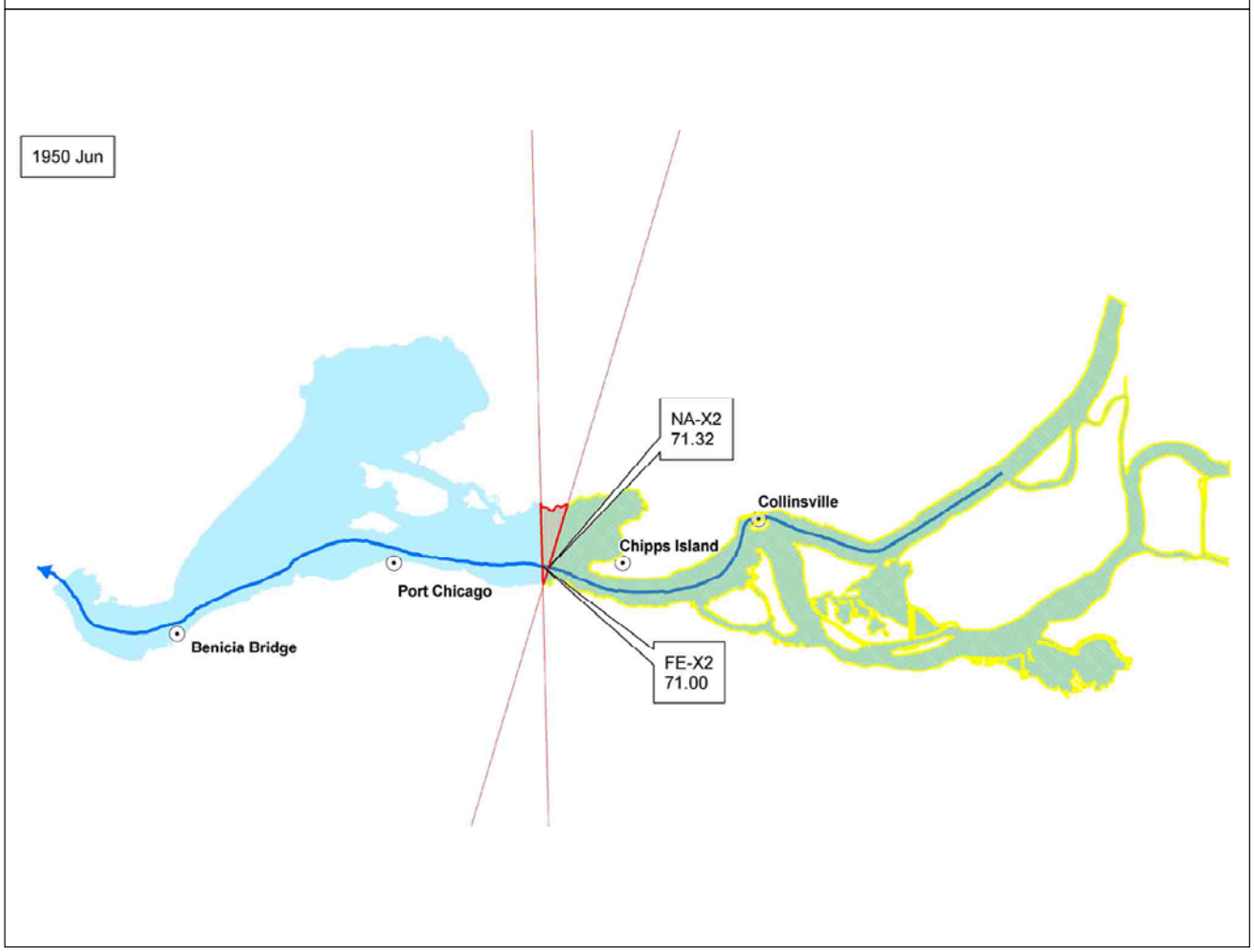
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
68.12


1950 Apr
NA-X2
70.90
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
70.94


1950 May
NA-X2
70.33
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
70.37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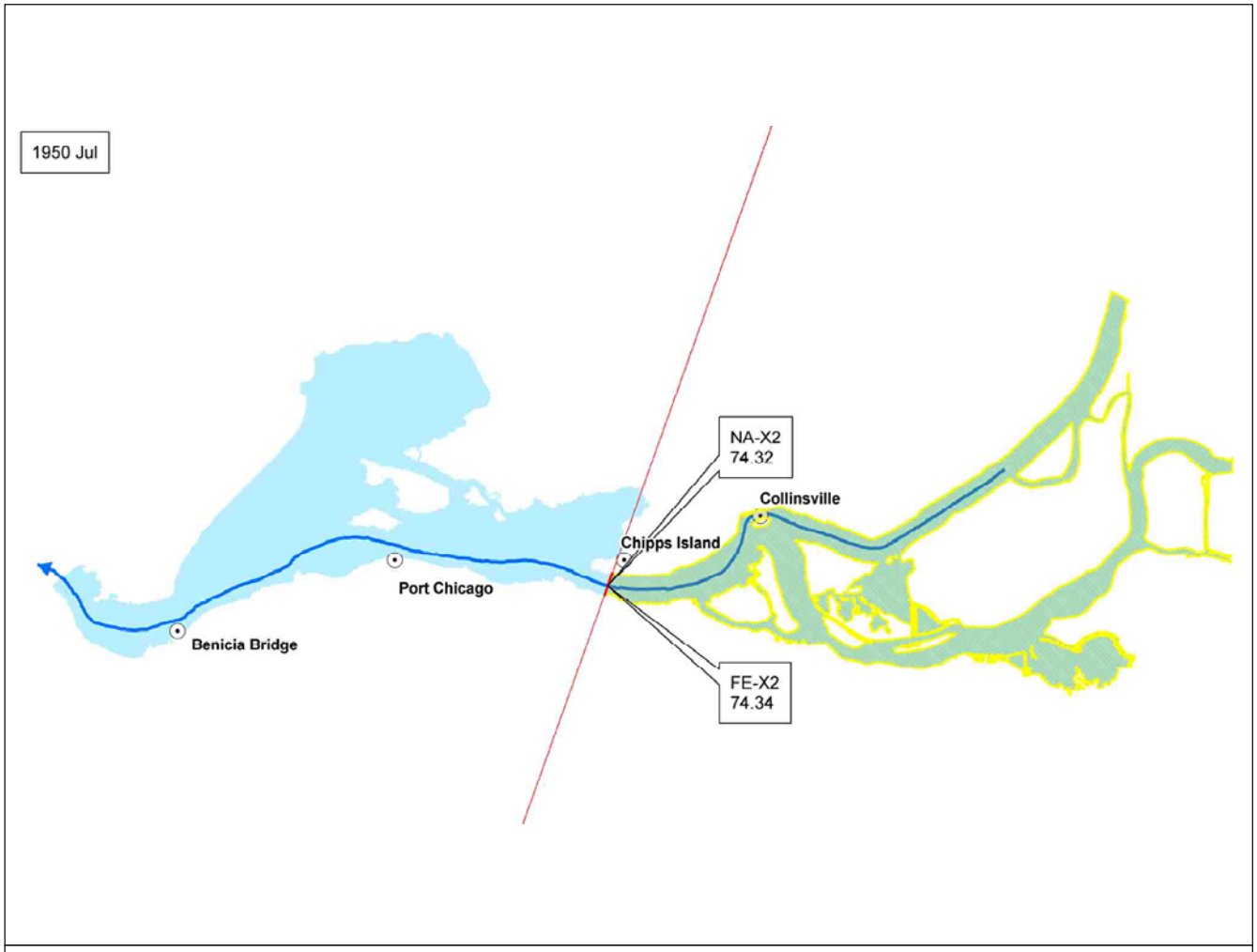
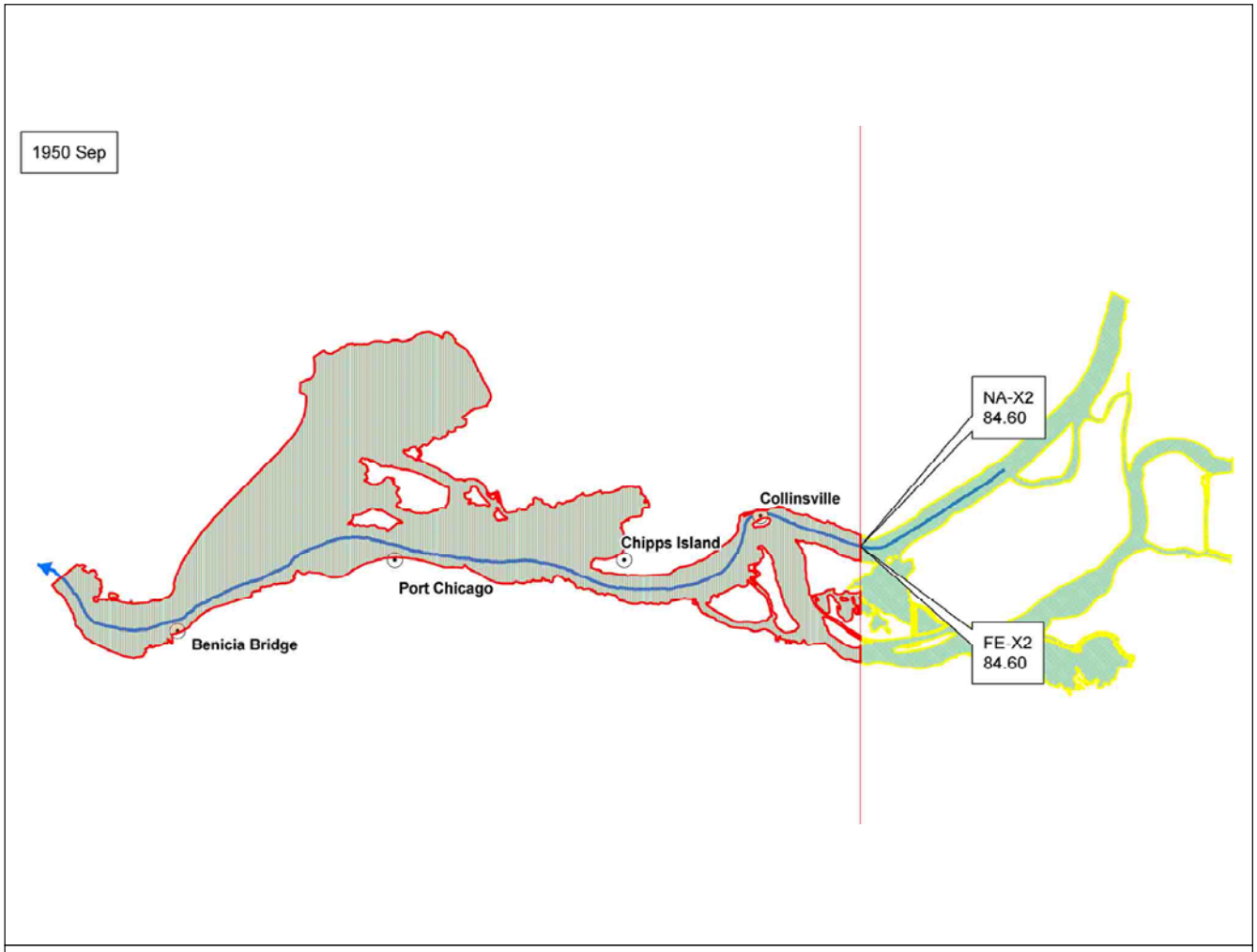
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
71.00


1950 Jul
NA-X2
74.32
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
74.34


1950 Aug
NA-X2
79.26
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
79.27


1950 Sep
NA-X2
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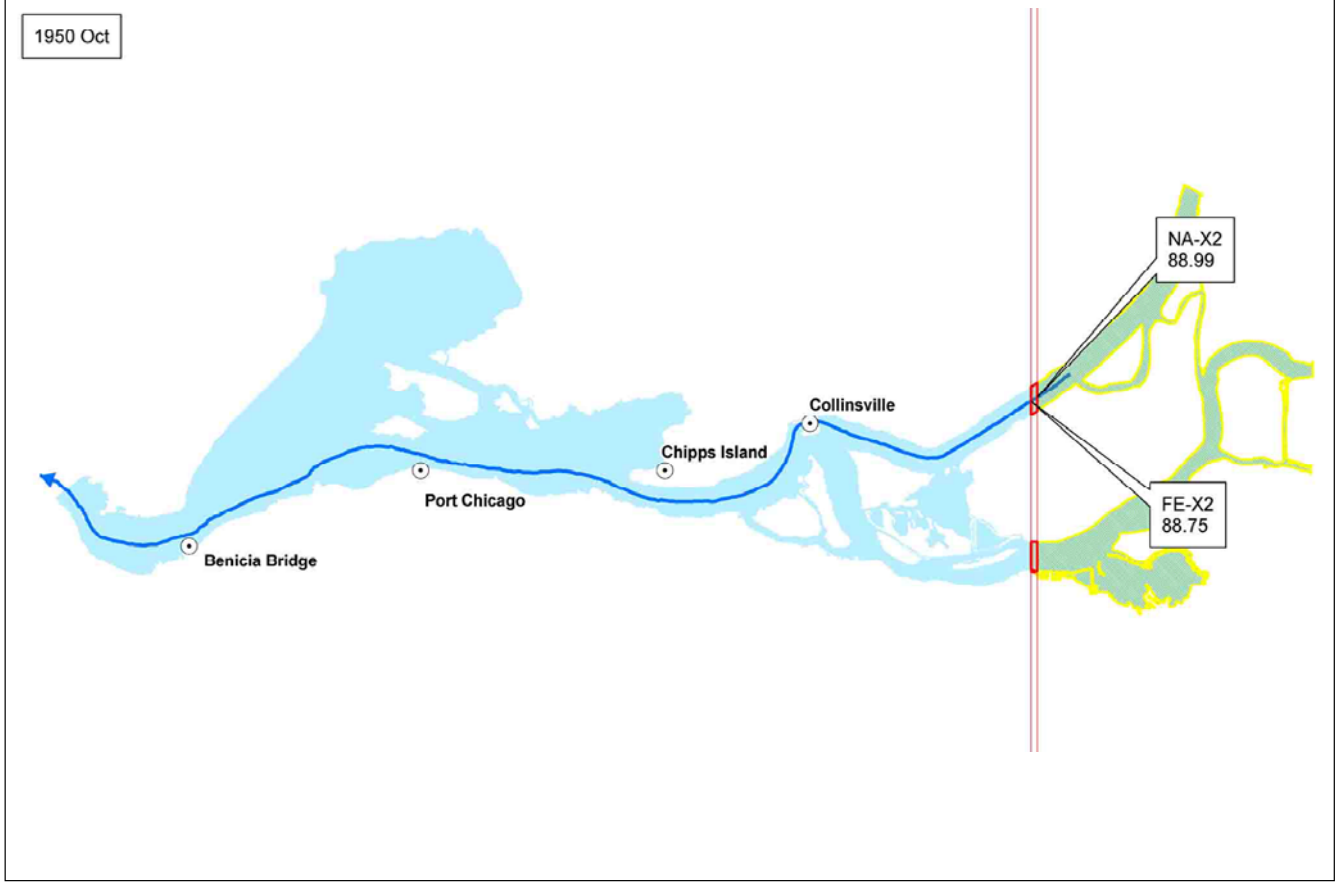
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
84.60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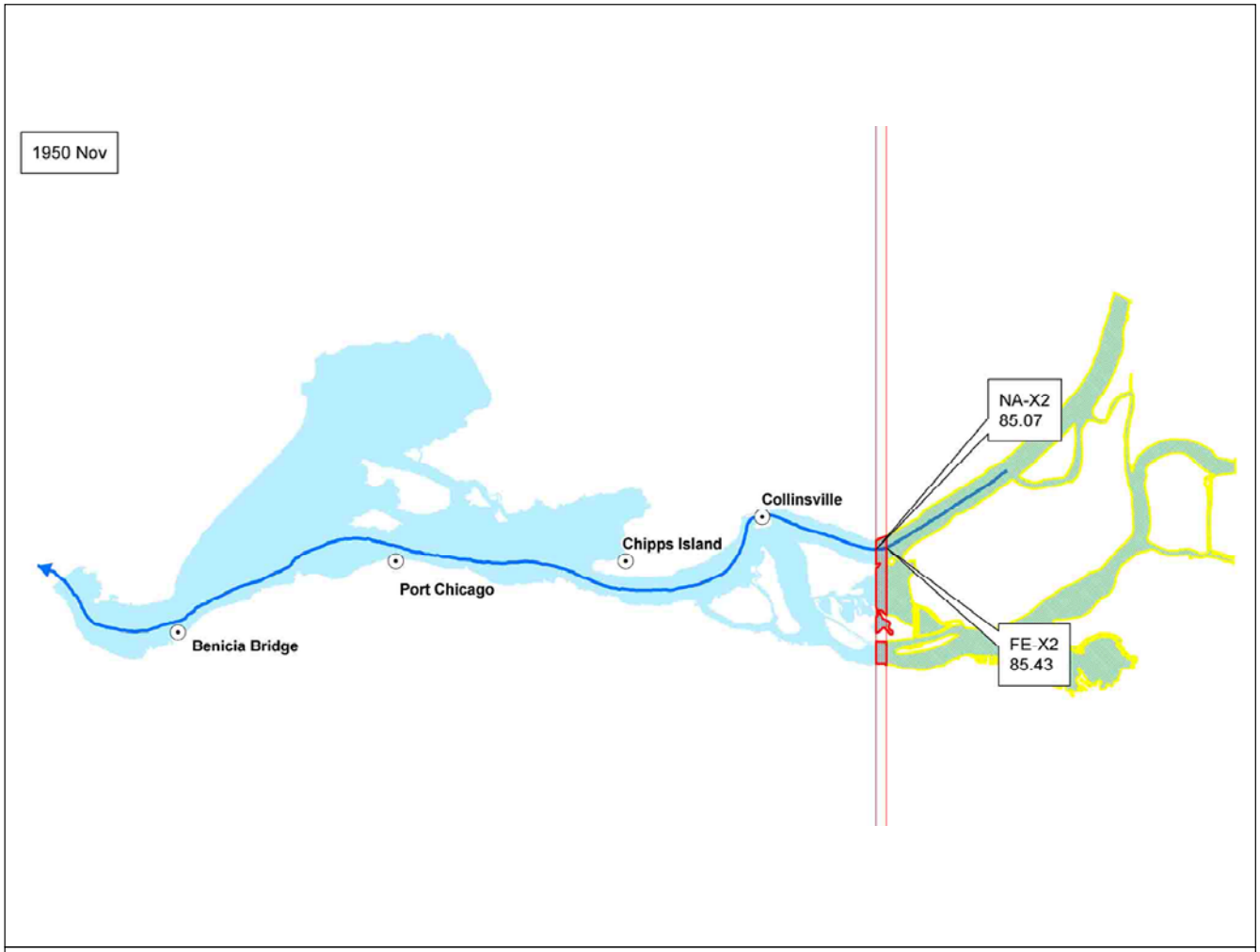
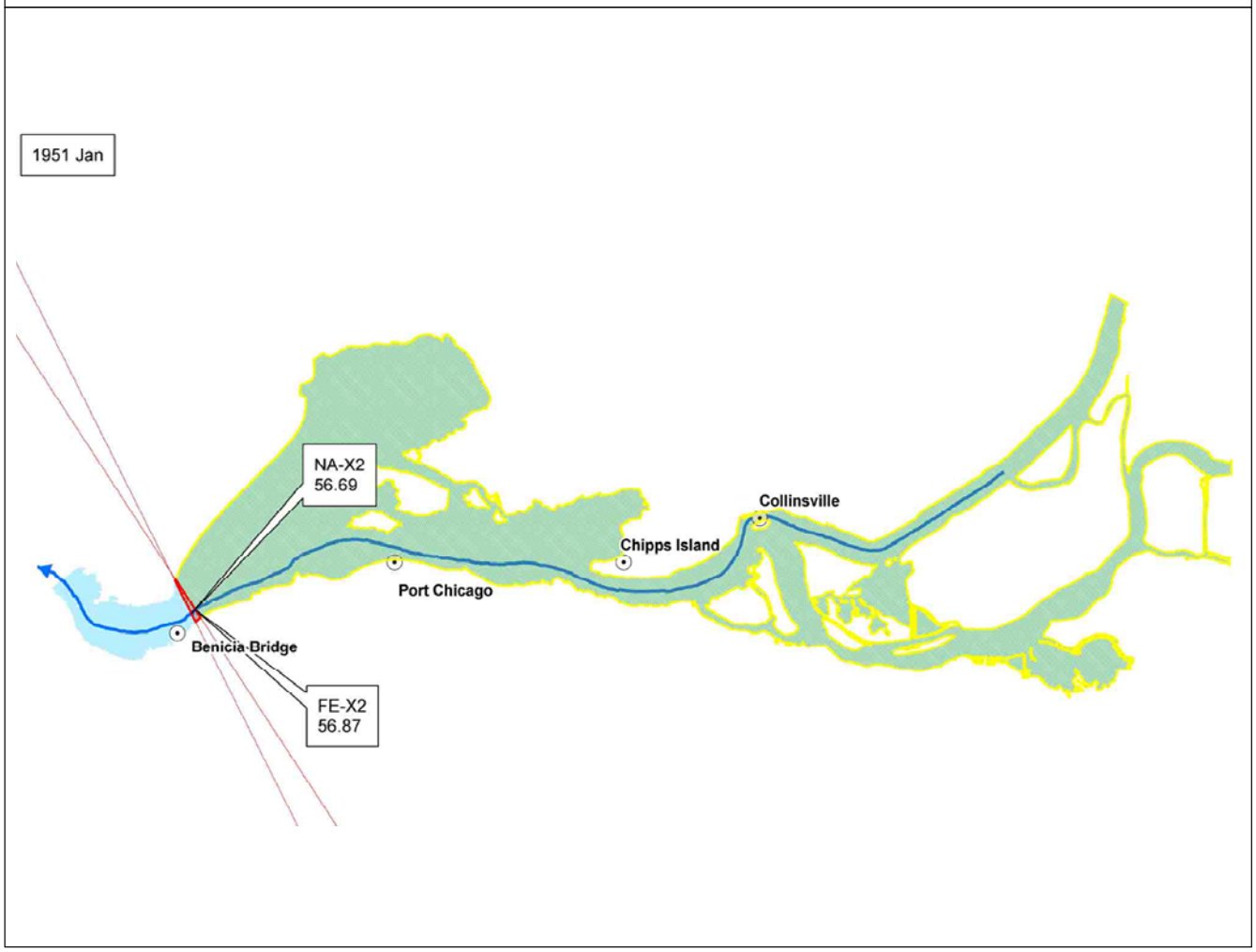
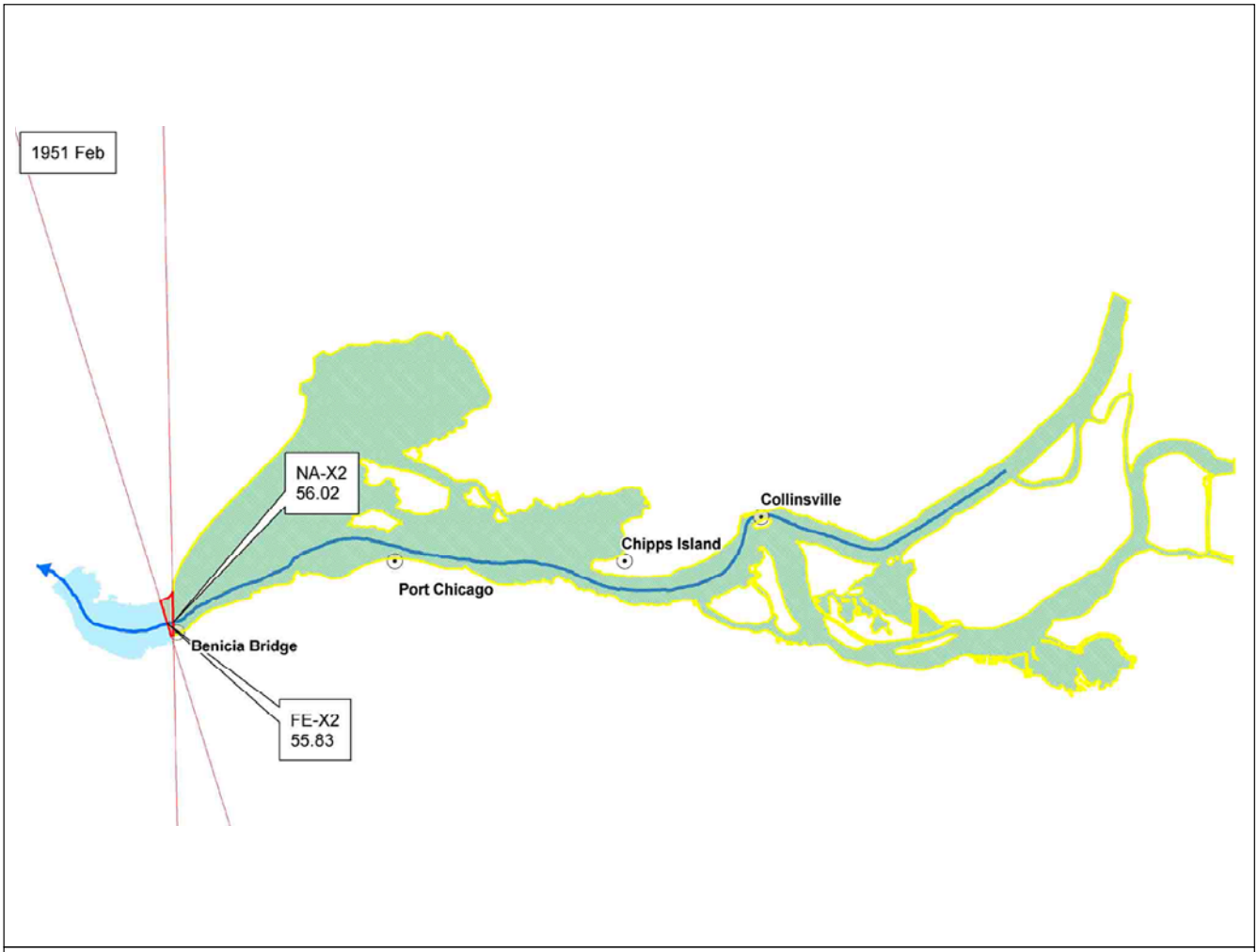
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
88.75

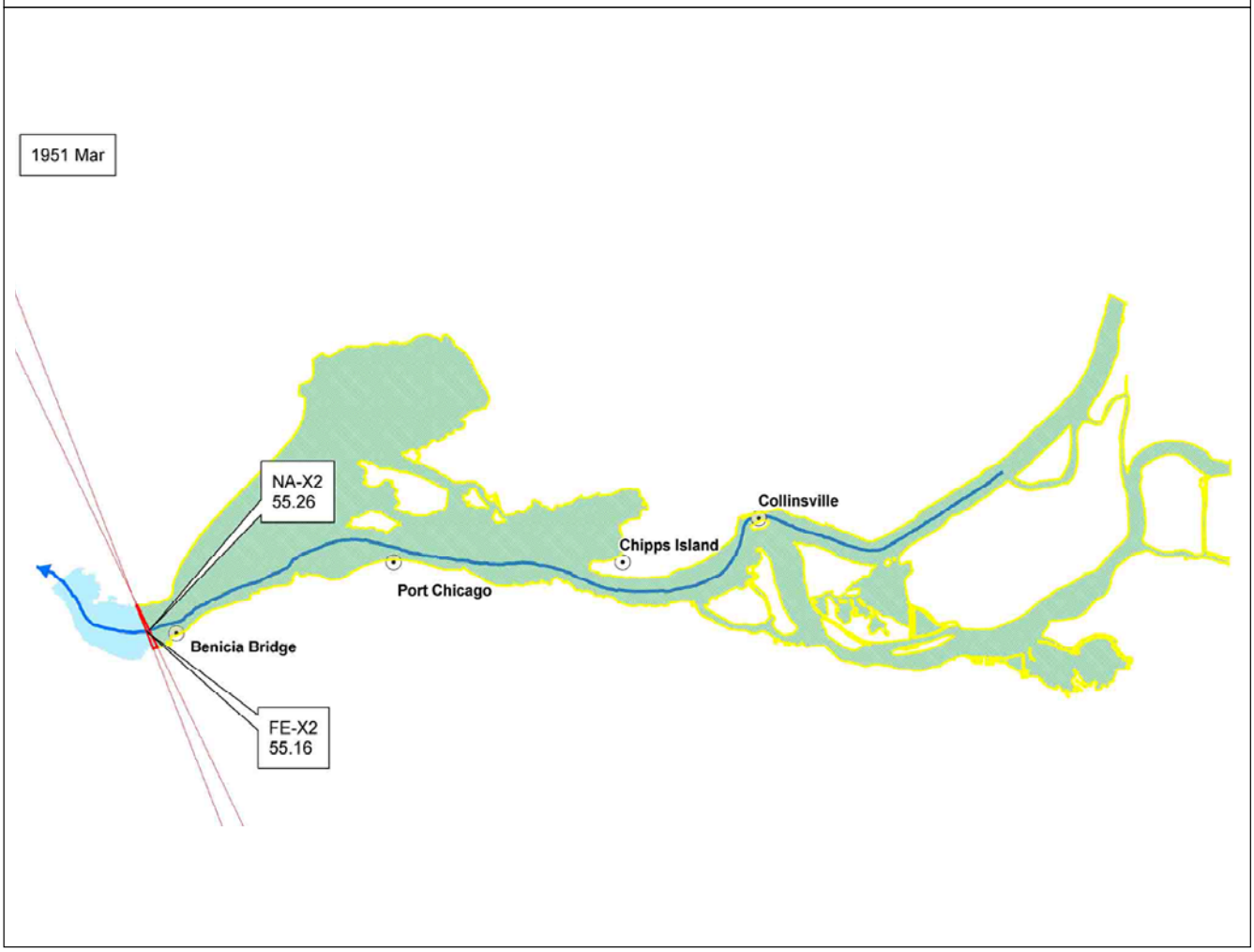

1950 Nov
NA-X2
85.07
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
85.43

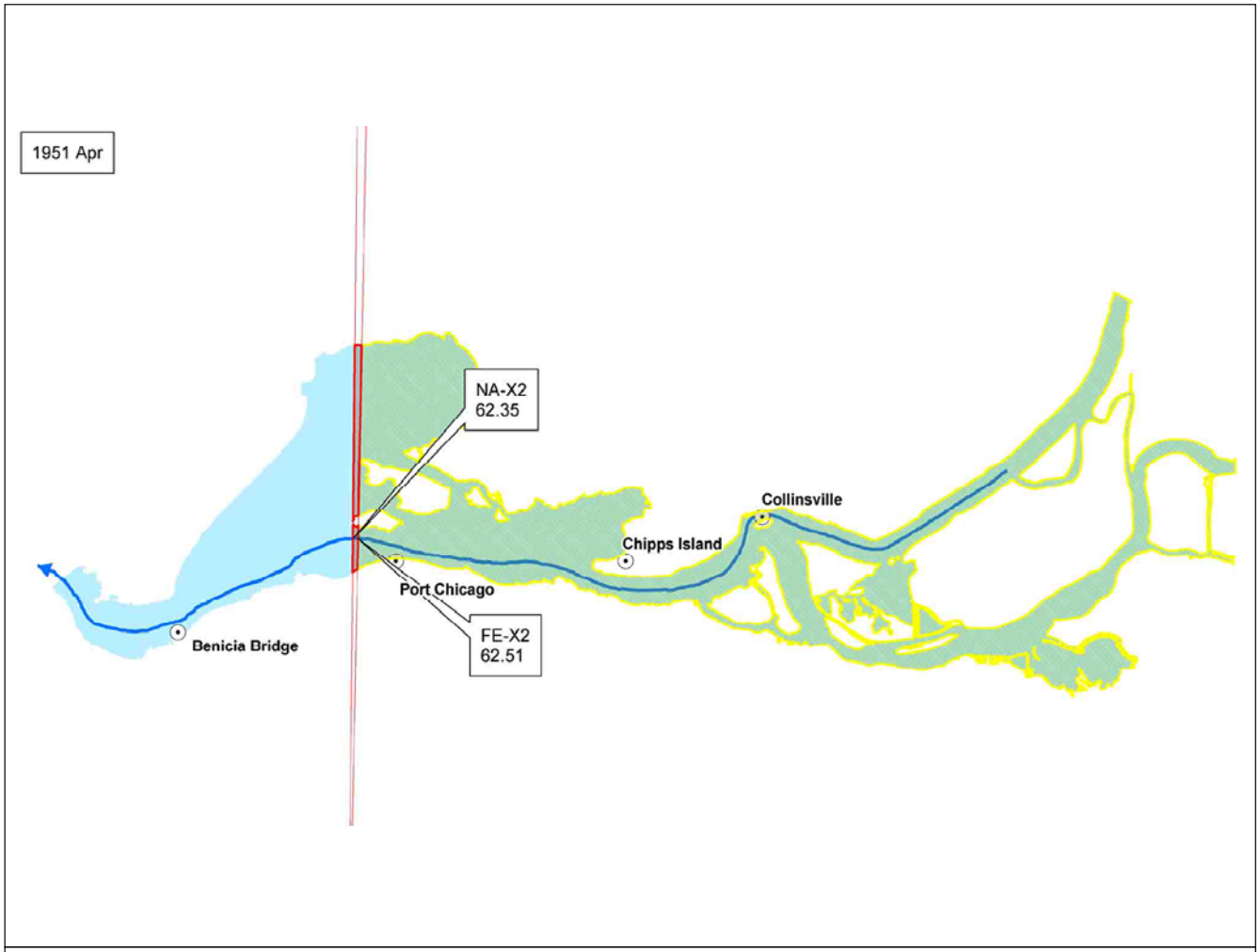

1950 Dec
NA-X2
85.60
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FF-X2
85.72

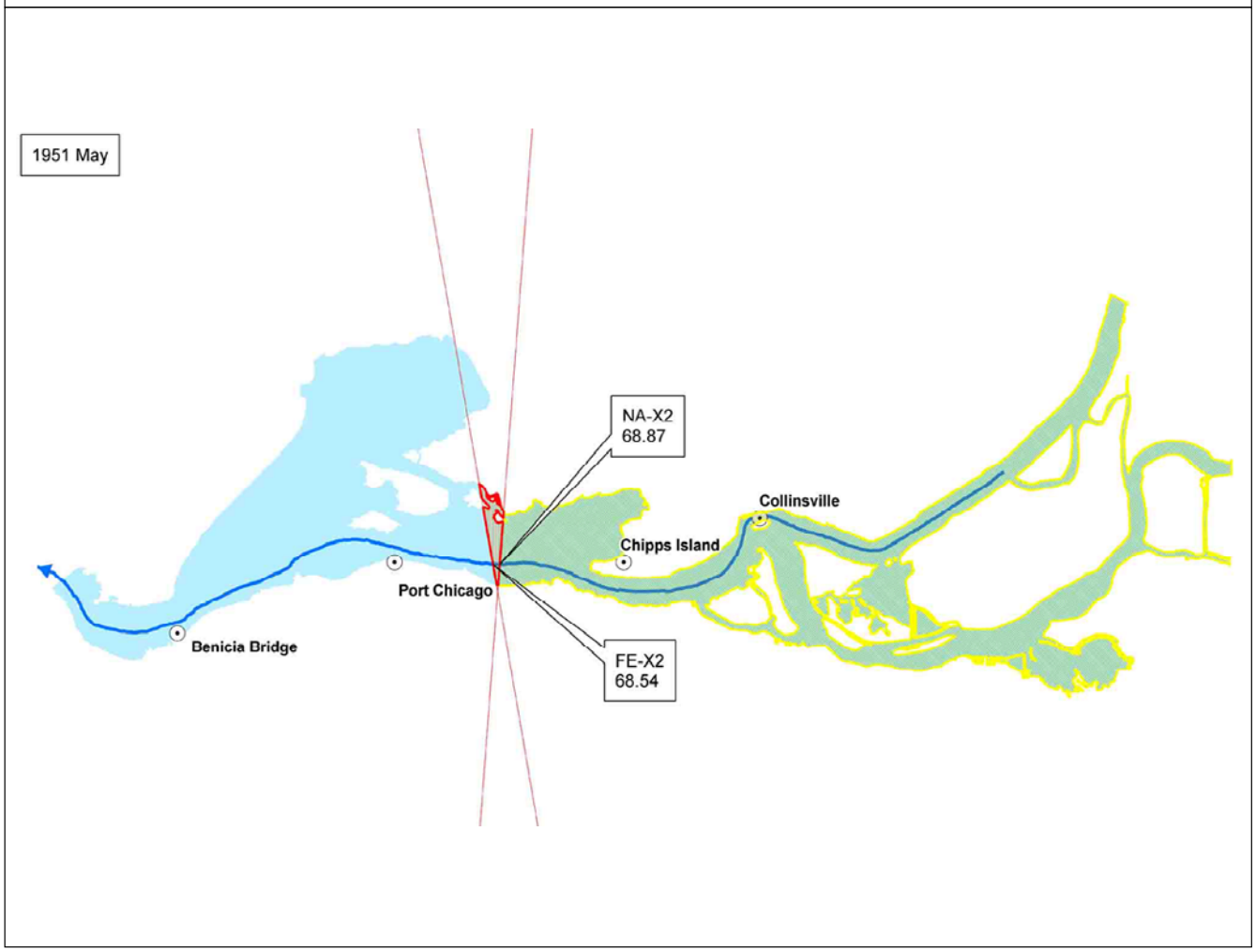

1950 average
NA-X2
78.07
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
78.08


1951 Jan
NA-X2
56.69
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
56.87


1951 Feb
NA-X2
56.02
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
55.83


1951 Mar
NA-X2
55.26
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
55.16


1951 Apr
NA-X2
62.35
Collinsville
Chipps Island
Port Chicago
FE-X2
62.51
Benicia Bridge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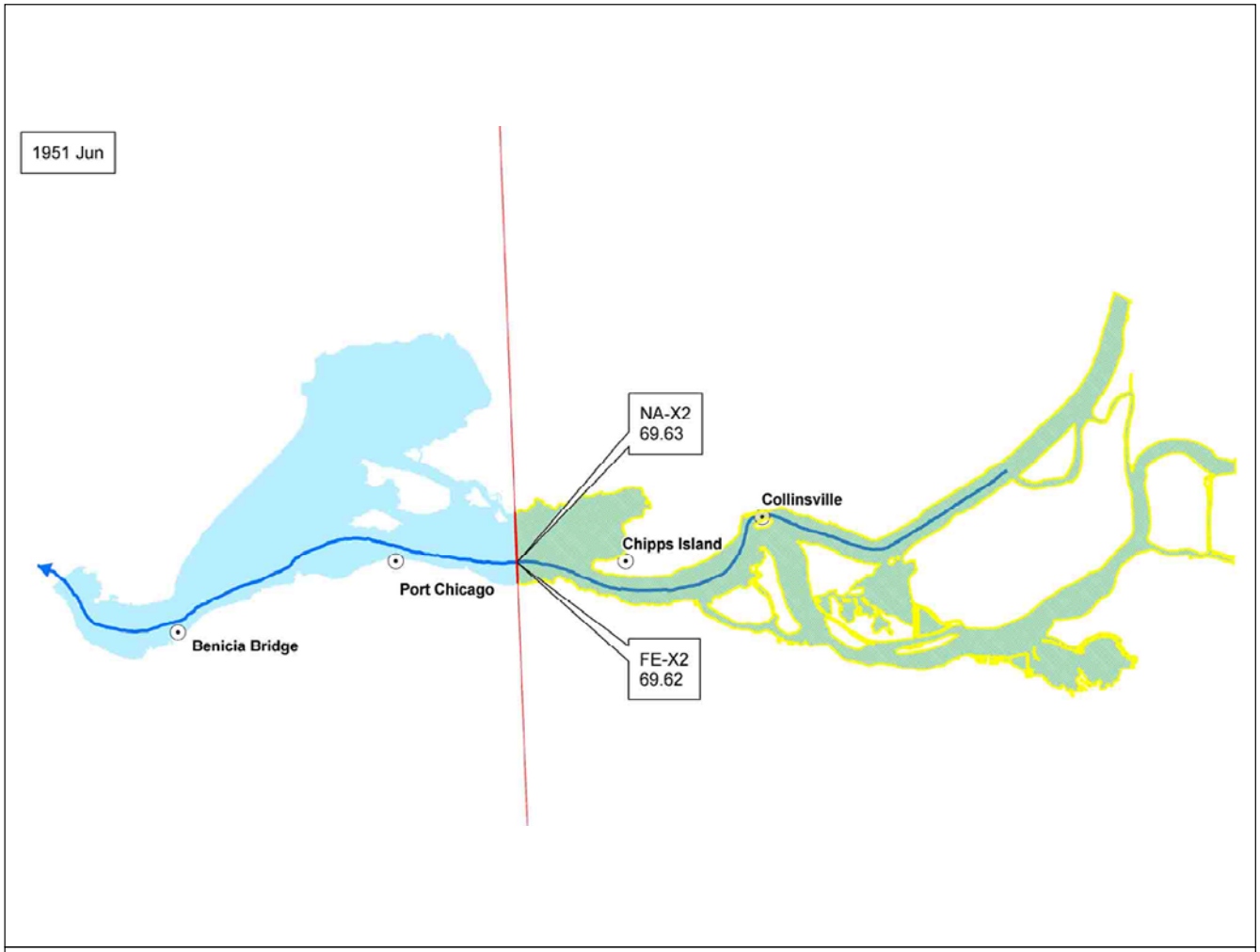
NA-X2
68.87
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
68.54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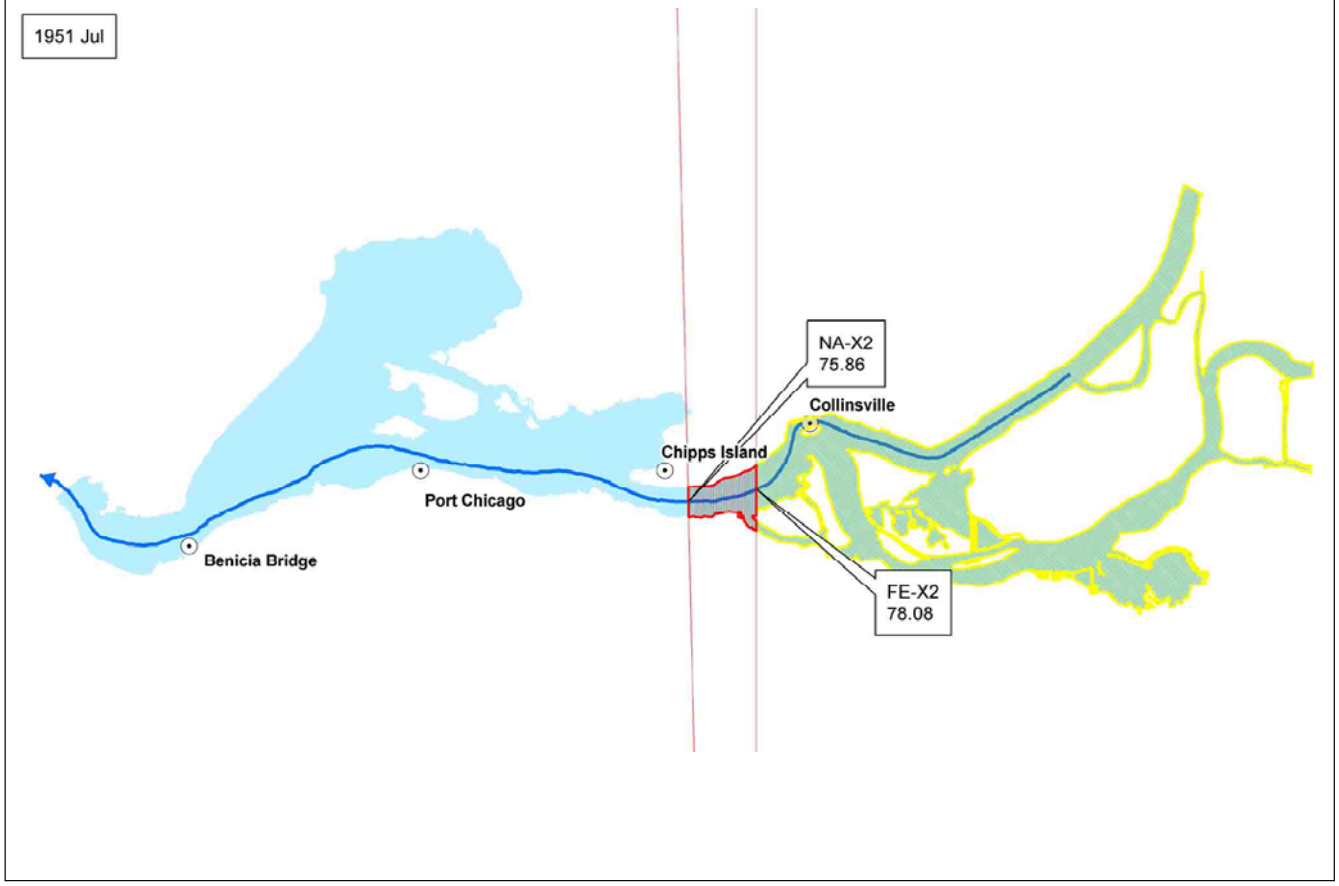
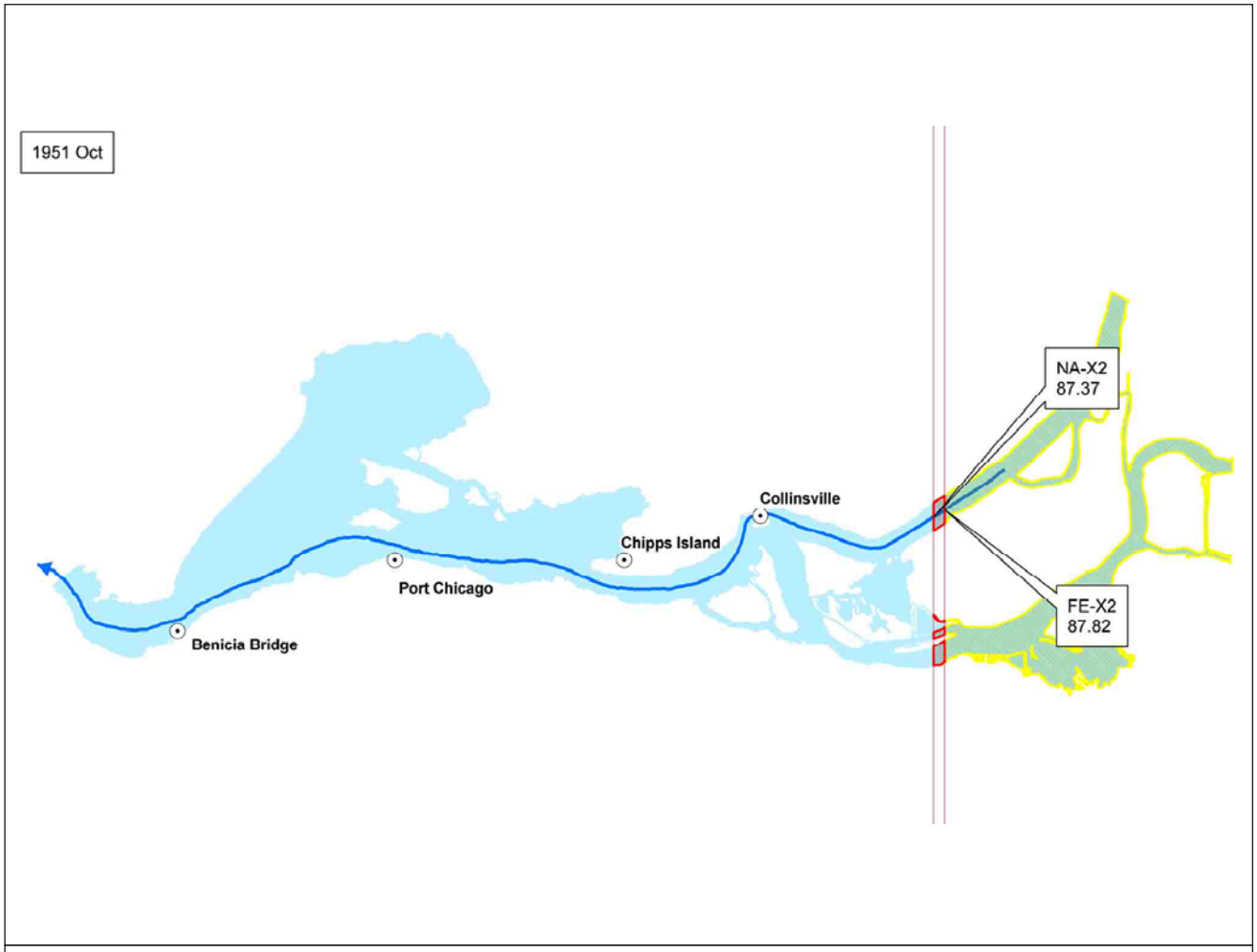
NA-X2
69.63
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
69.62

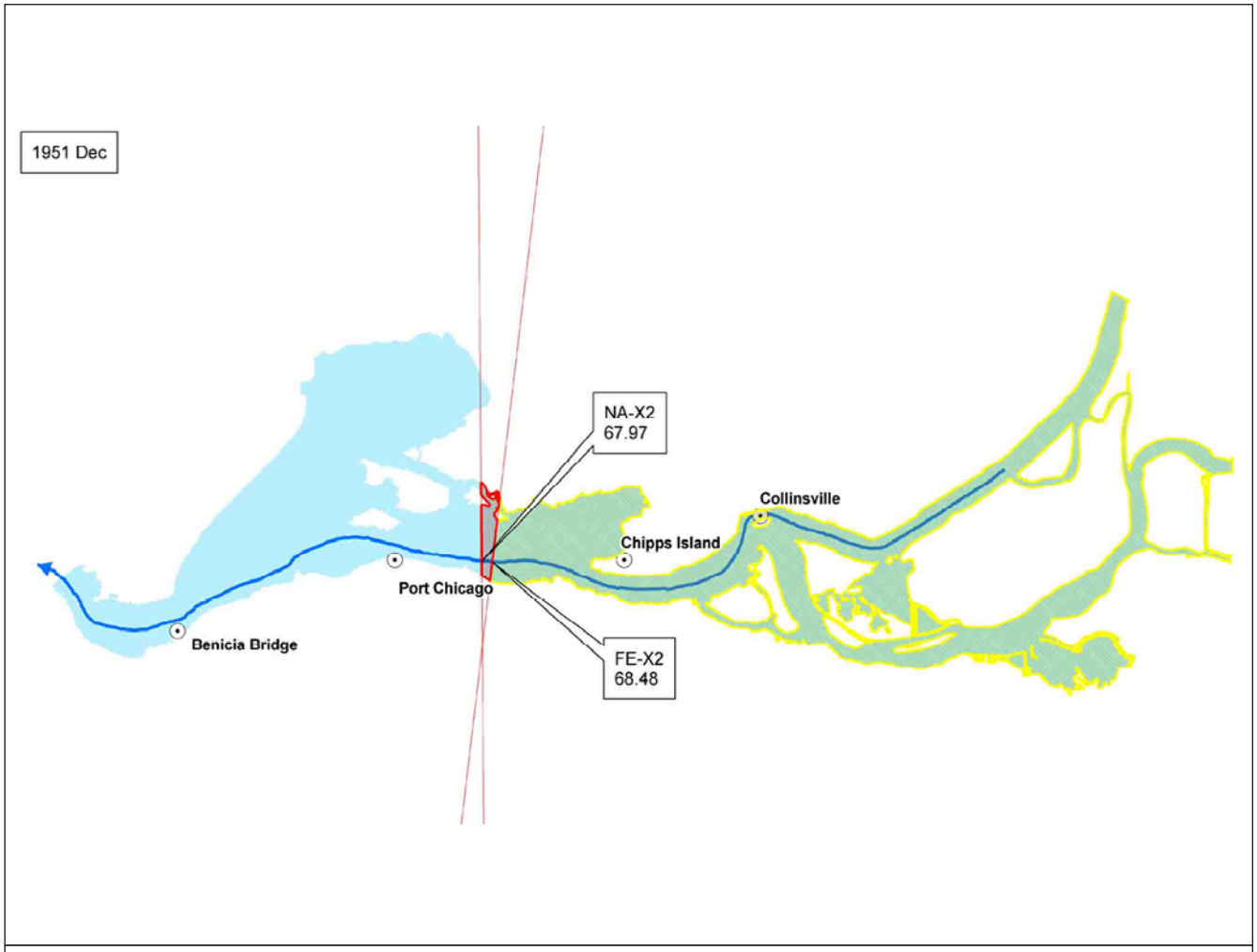

1951 Jul
NA-X2
75.86
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
78.08

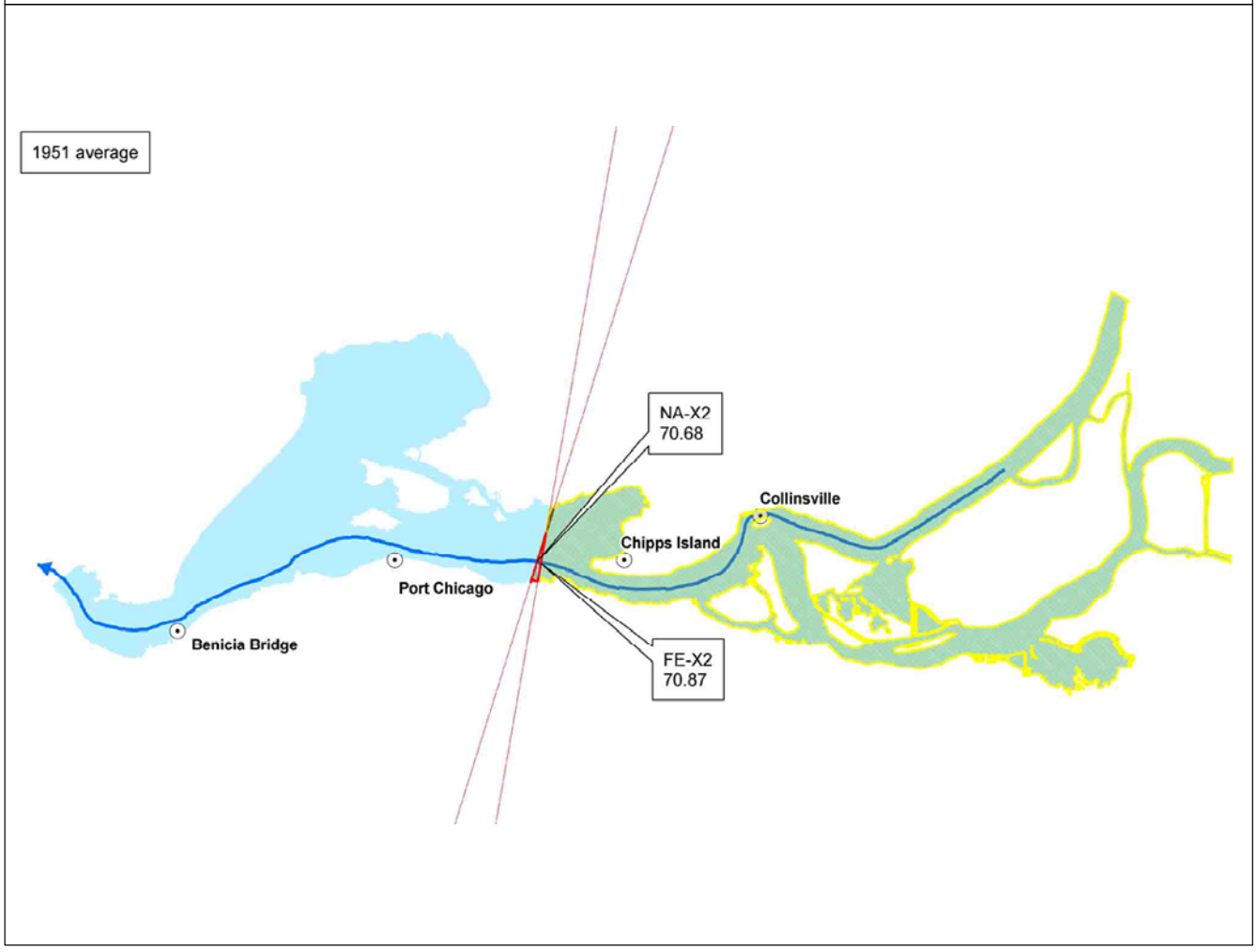

1951 Aug
NA-X2
77.88
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
77.35

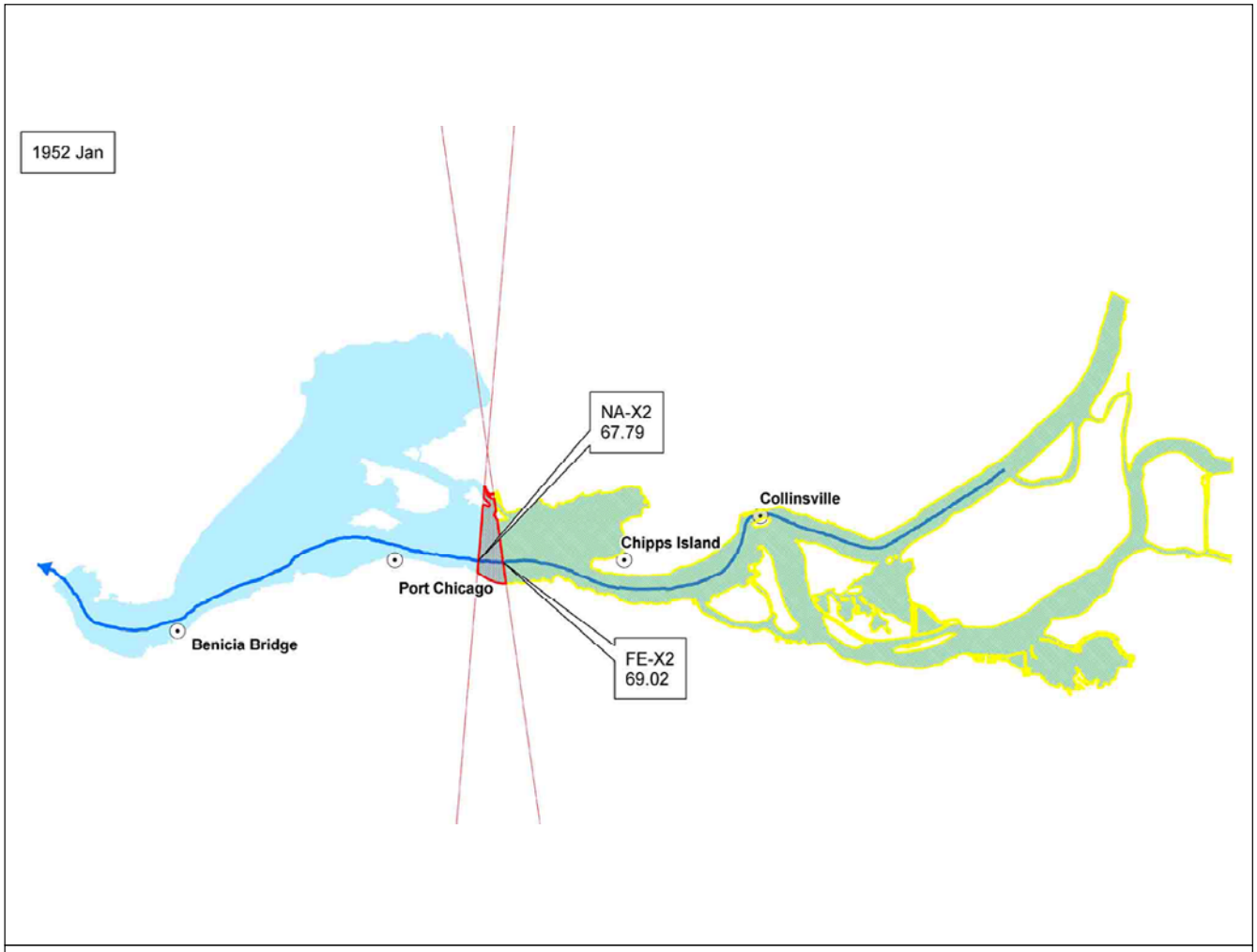

1951 Sep
NA-X2
84.15
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
83.98

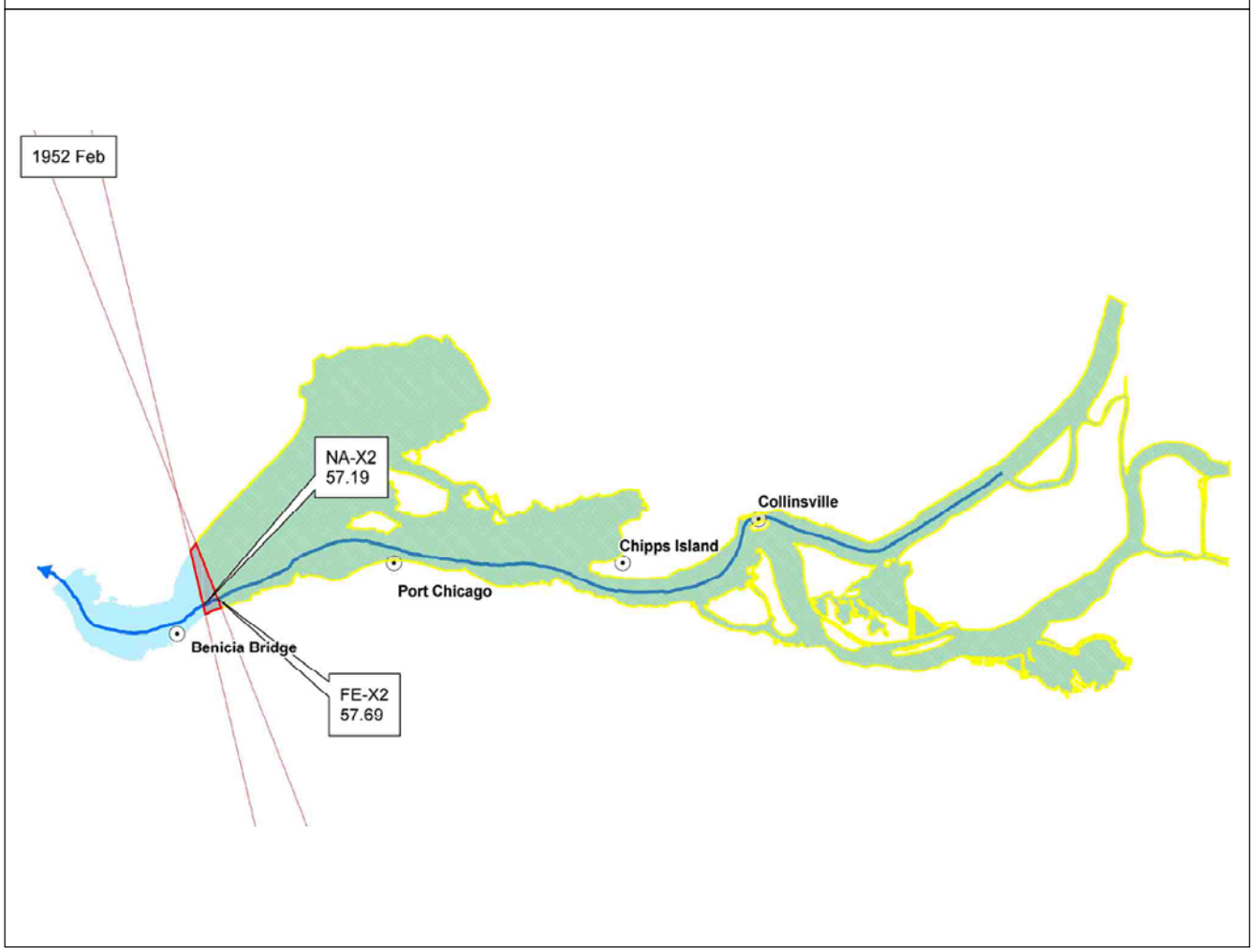

1951 Oct
NA-X2
87.37
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
87.82


1951 Nov
NA-X2
86.08
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
86.22


1951 Dec
NA-X2
67.97
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
68.48


1951 average
NA-X2
70.68
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
70.87


1952 Jan
NA-X2
67.79
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
69.02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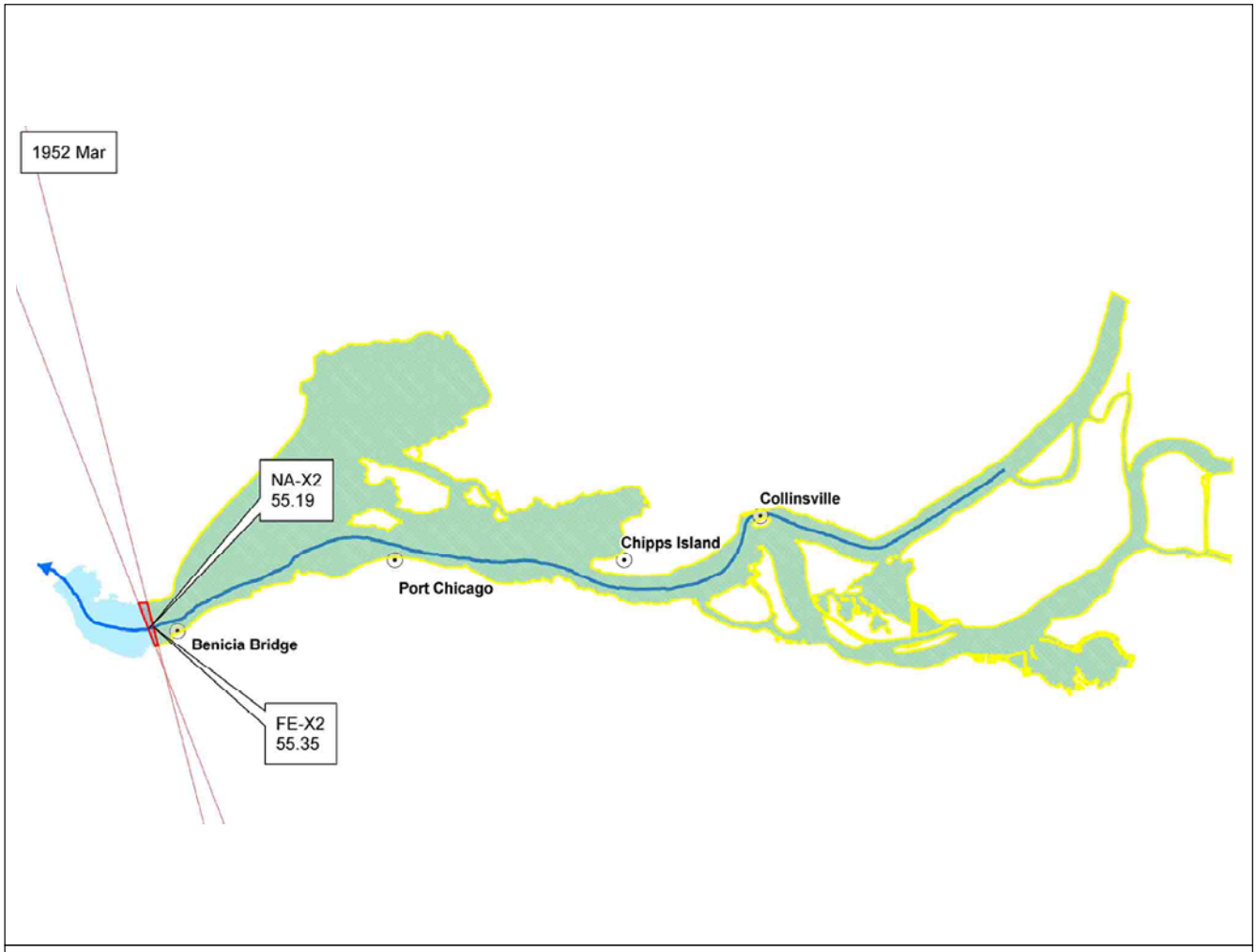
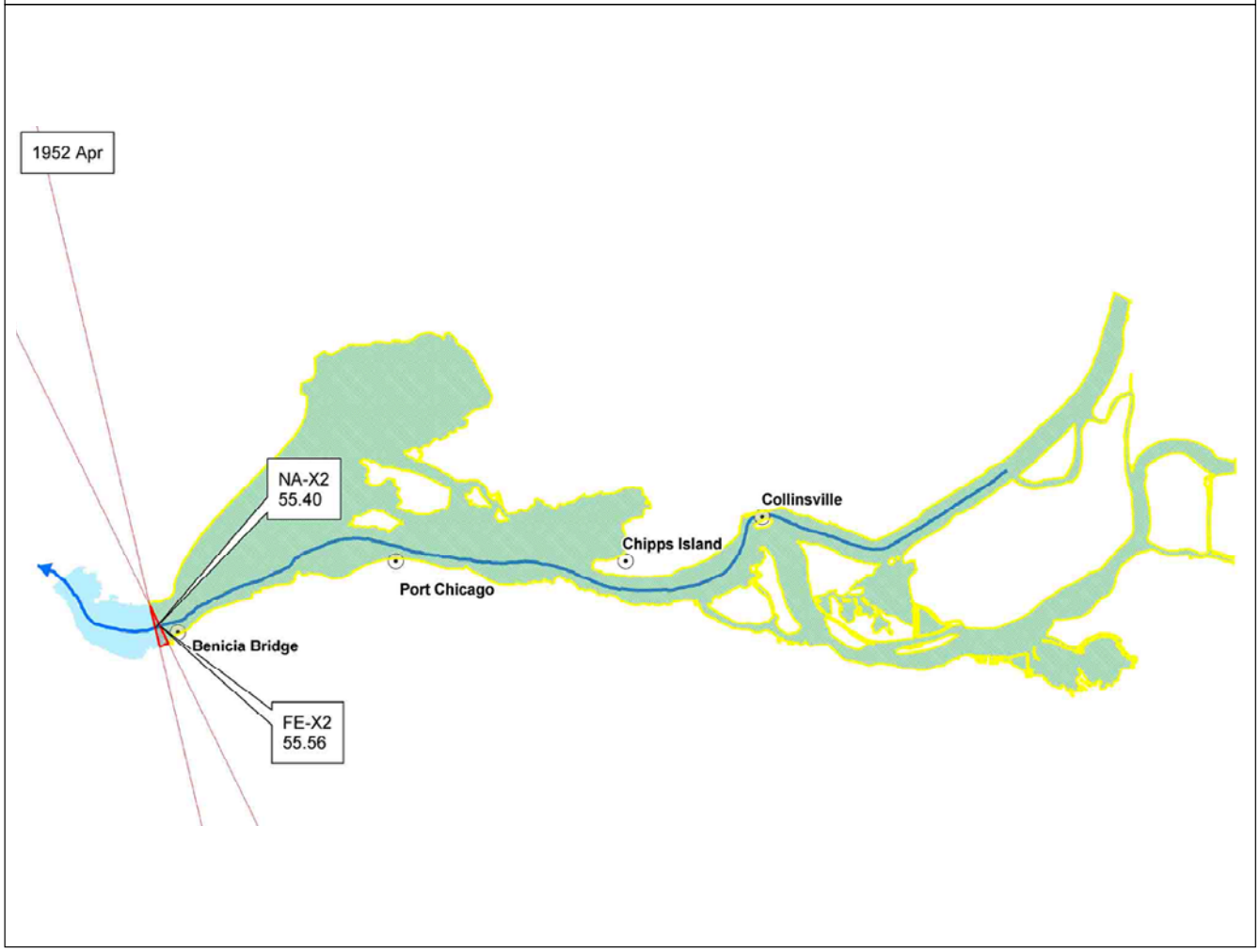
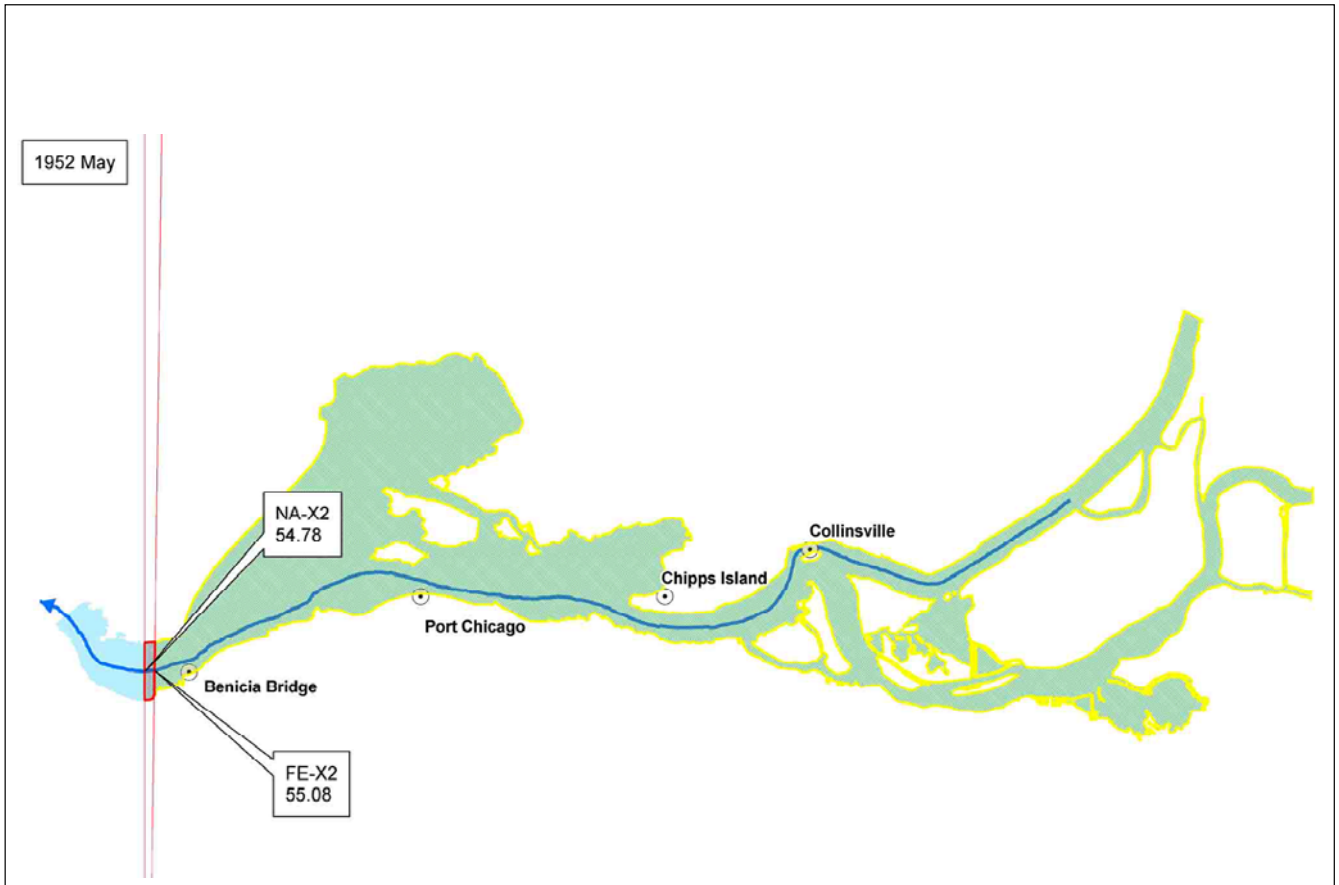
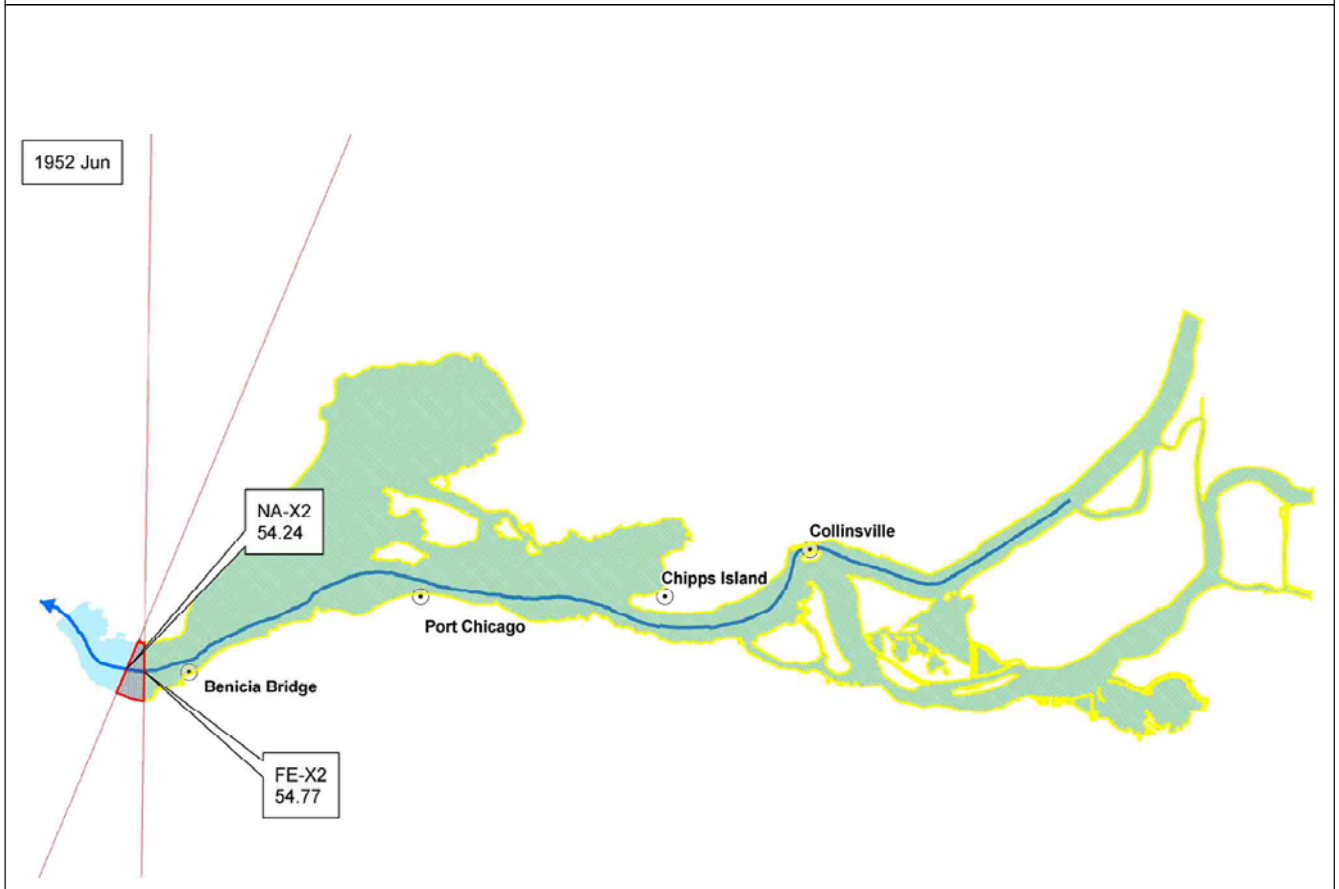
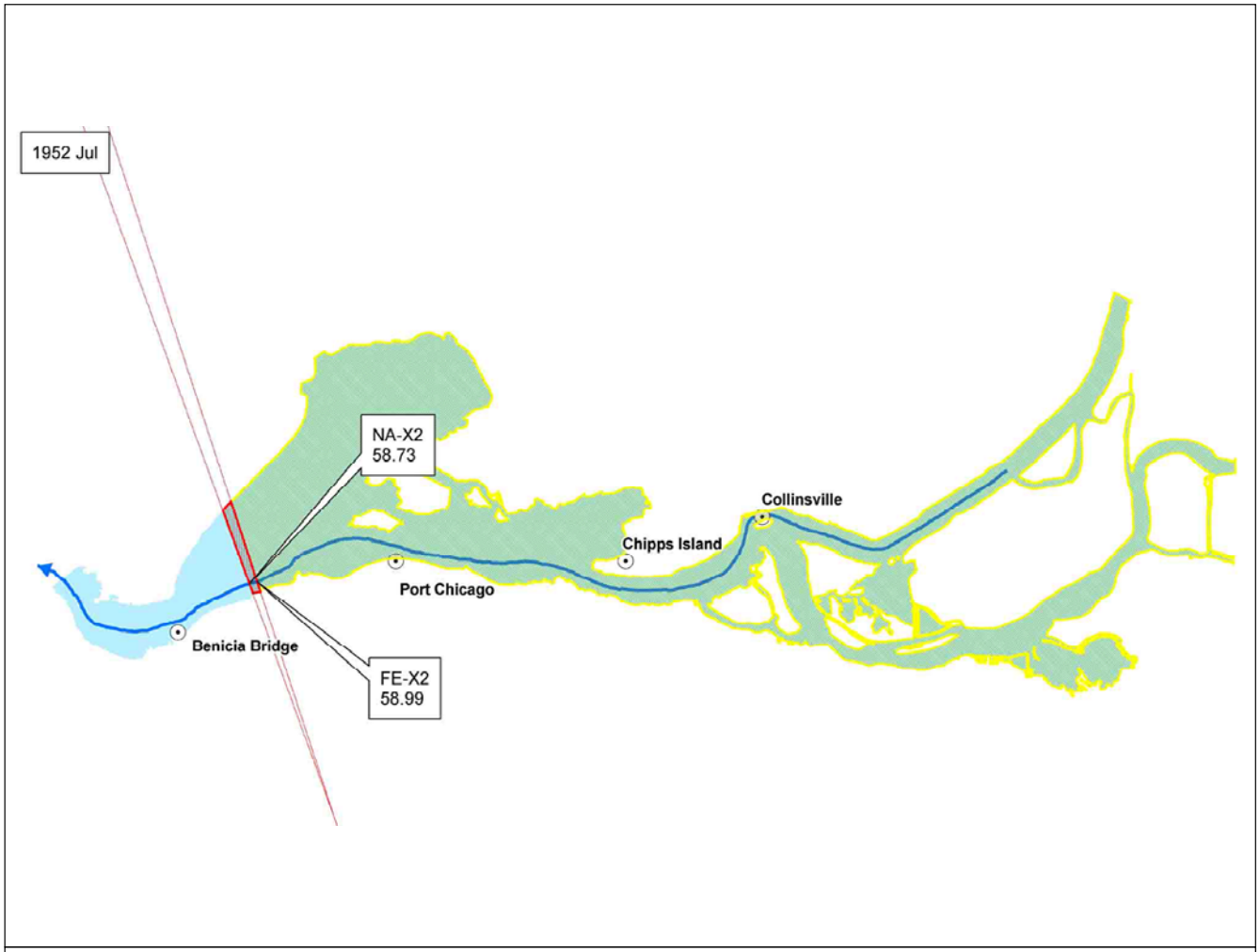
NA-X2
57.19
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
57.69


1952 Mar
NA-X2
55.19
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
55.35


1952 Apr
NA-X2
55.40
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
55.56


1952 May
NA-X2
54.78
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
55.08


1952 Jun
NA-X2
54.24
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
54.77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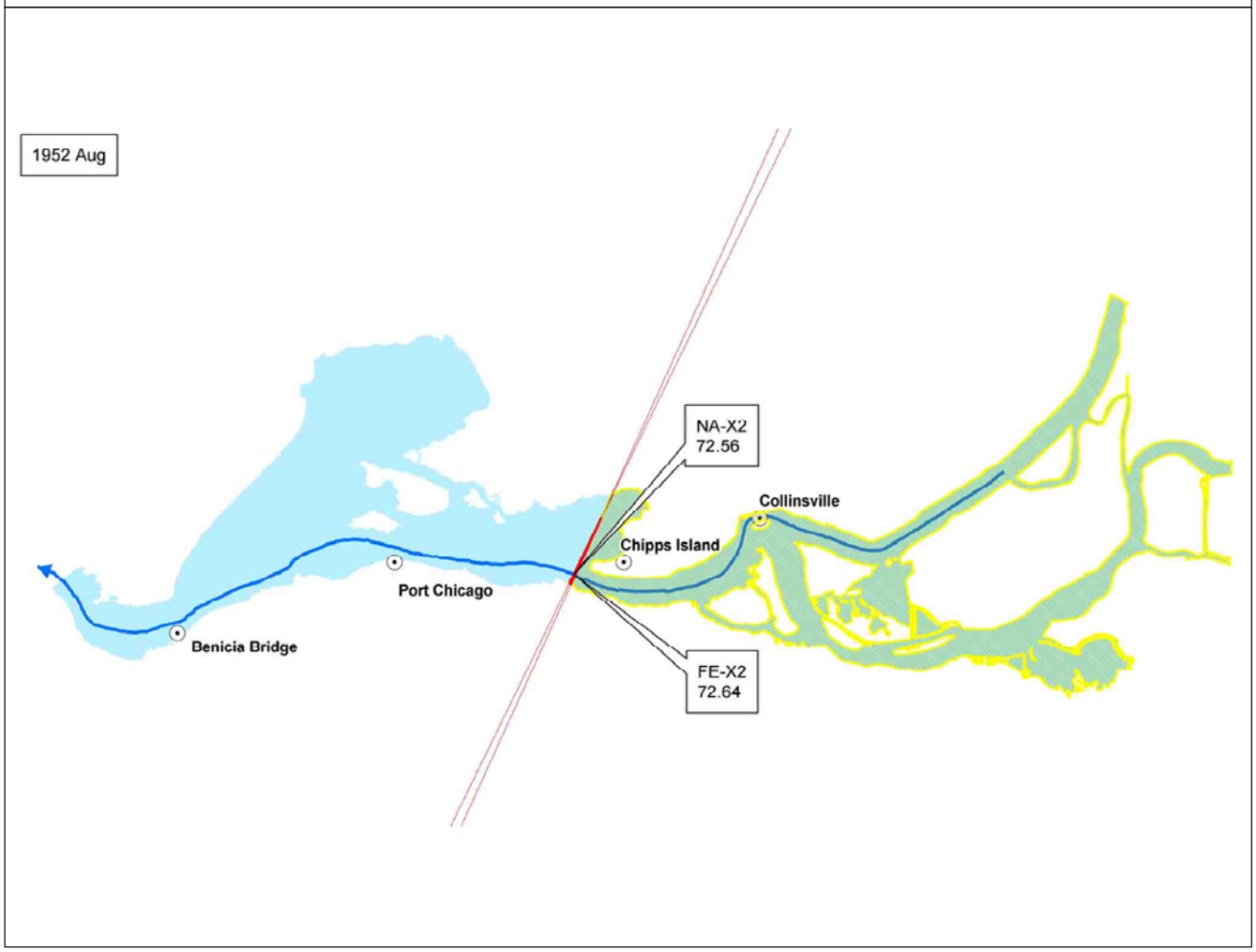
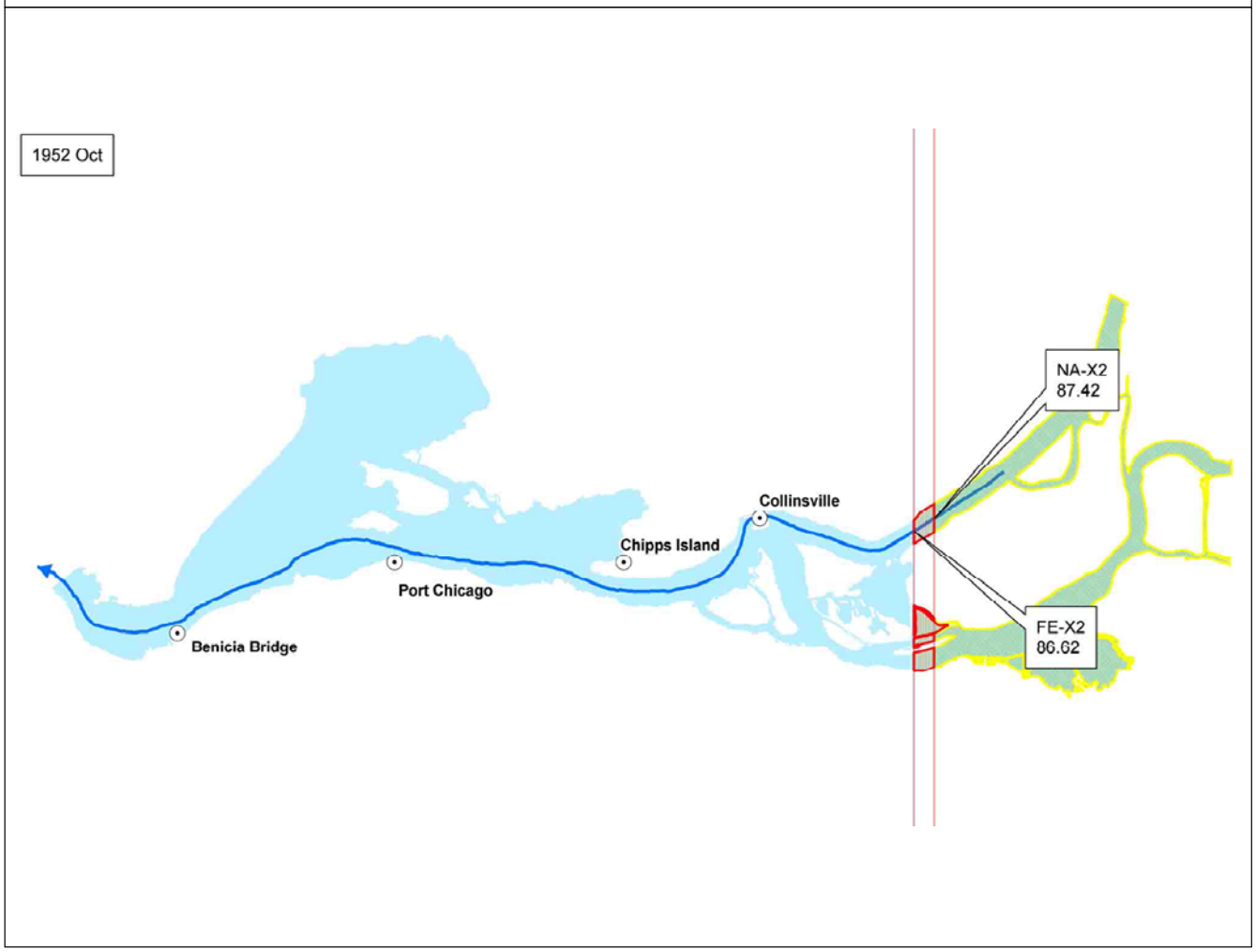
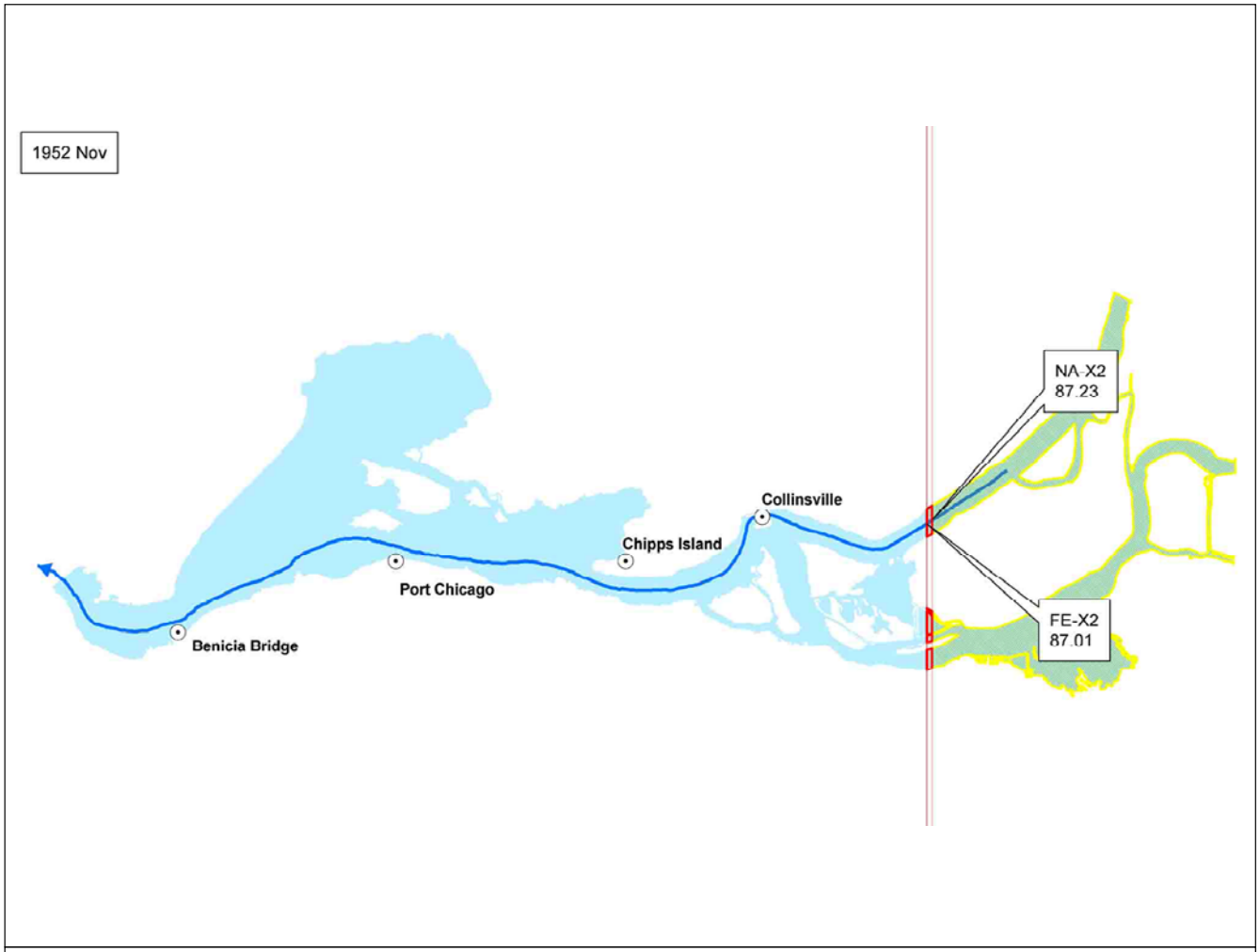
NA-X2
58.73
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
58.99

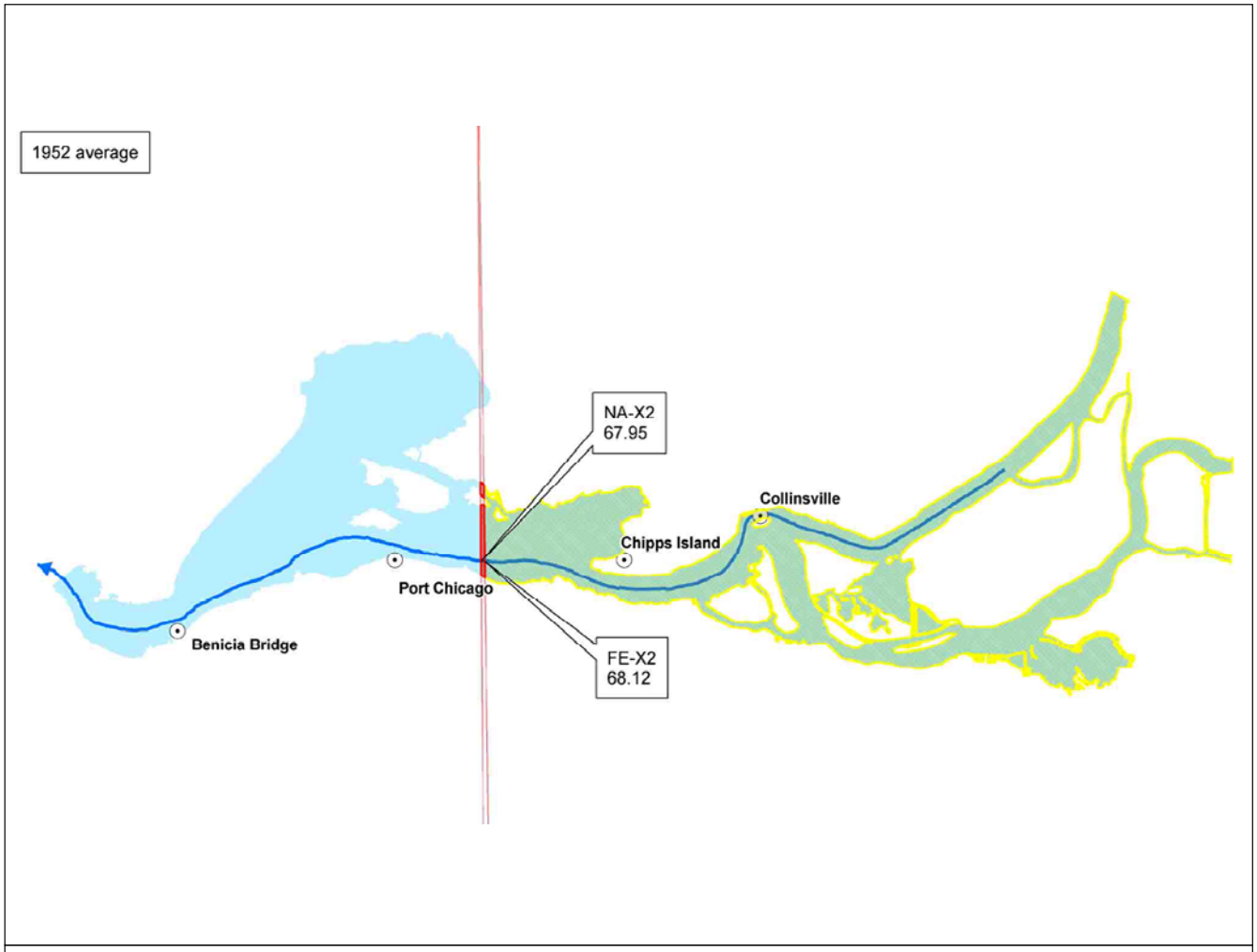

1952 Aug
NA-X2
72.56
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
72.64

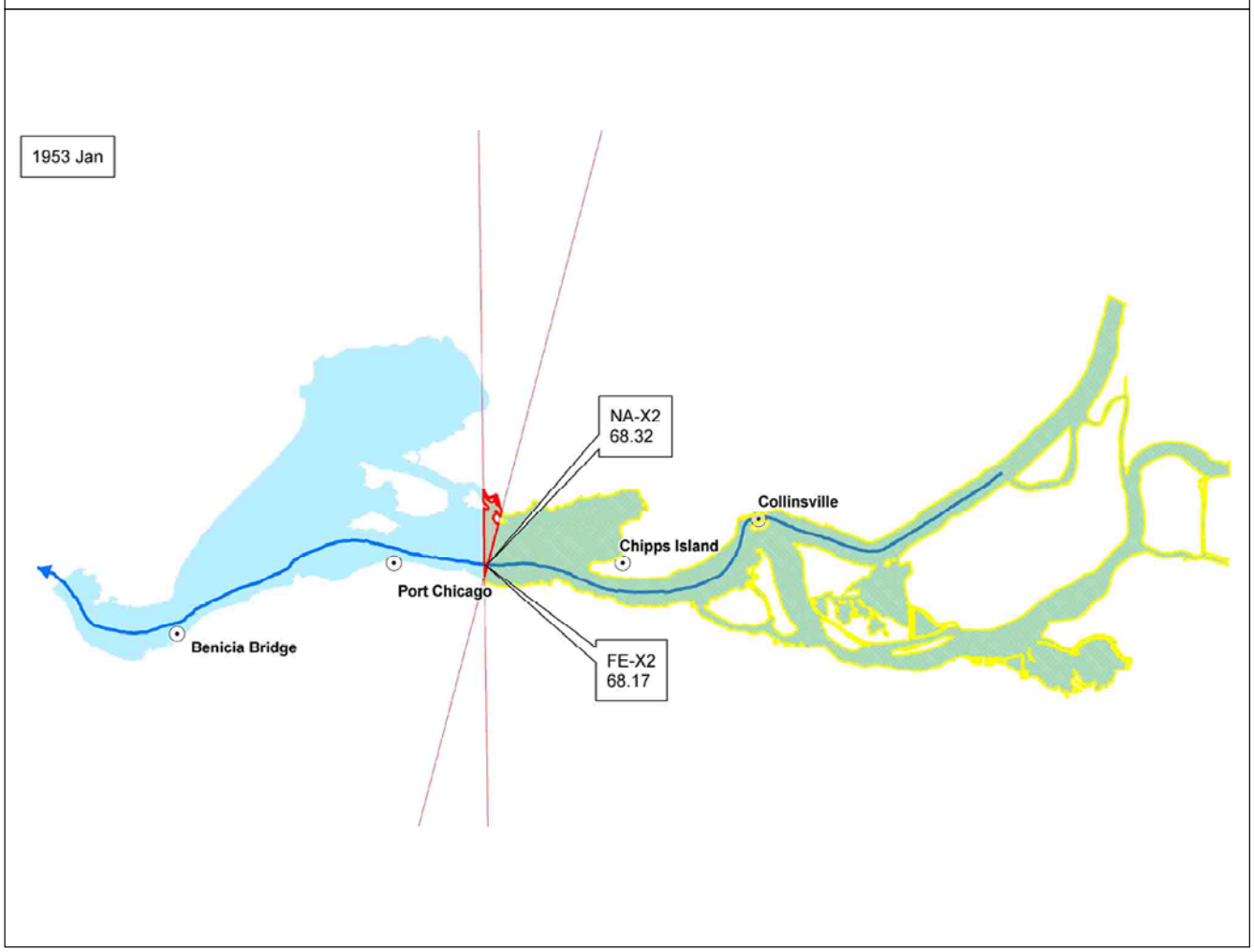

1952 Sep
NA-X2
82.41
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
82.43

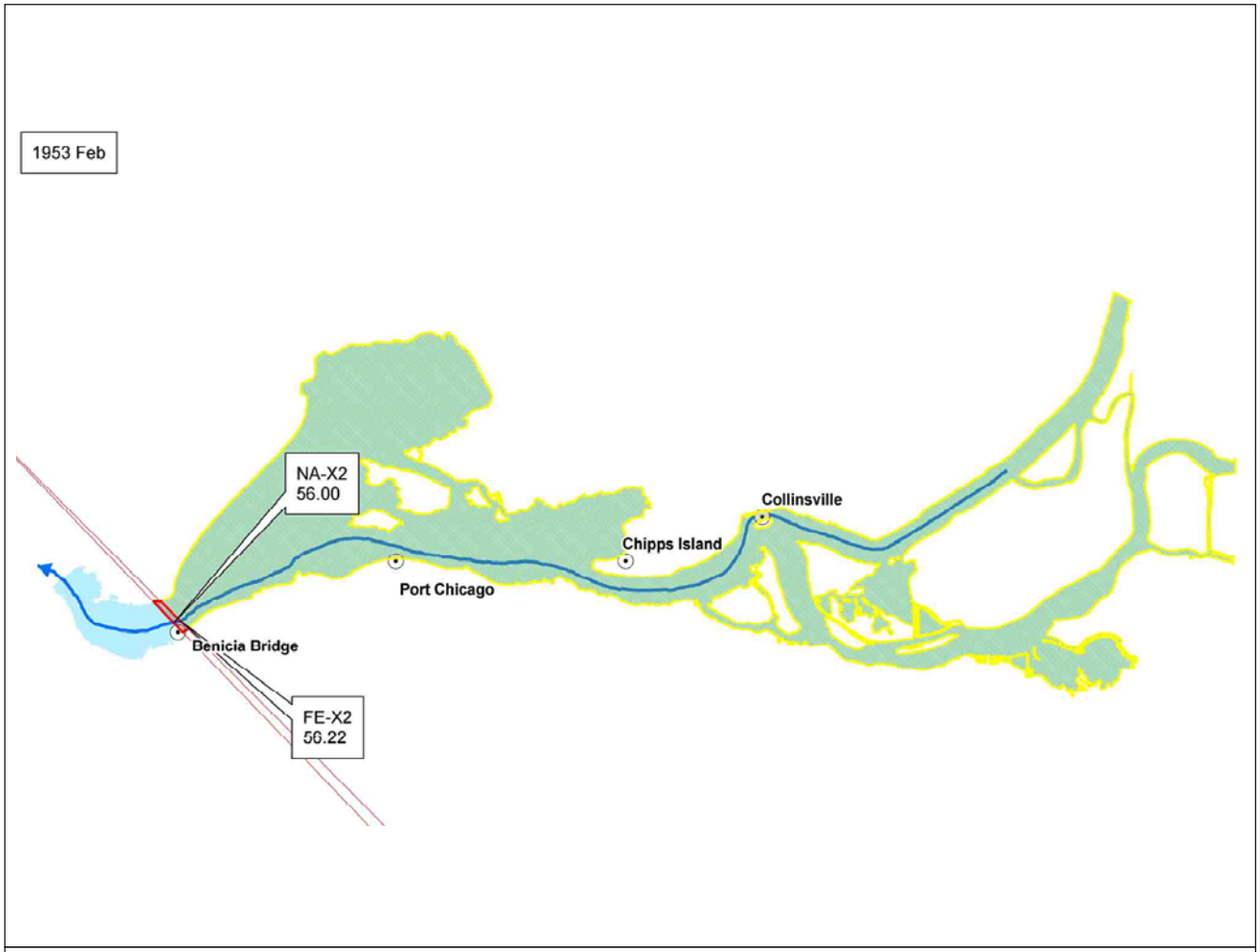

1952 Oct
NA-X2
87.42
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
86.62

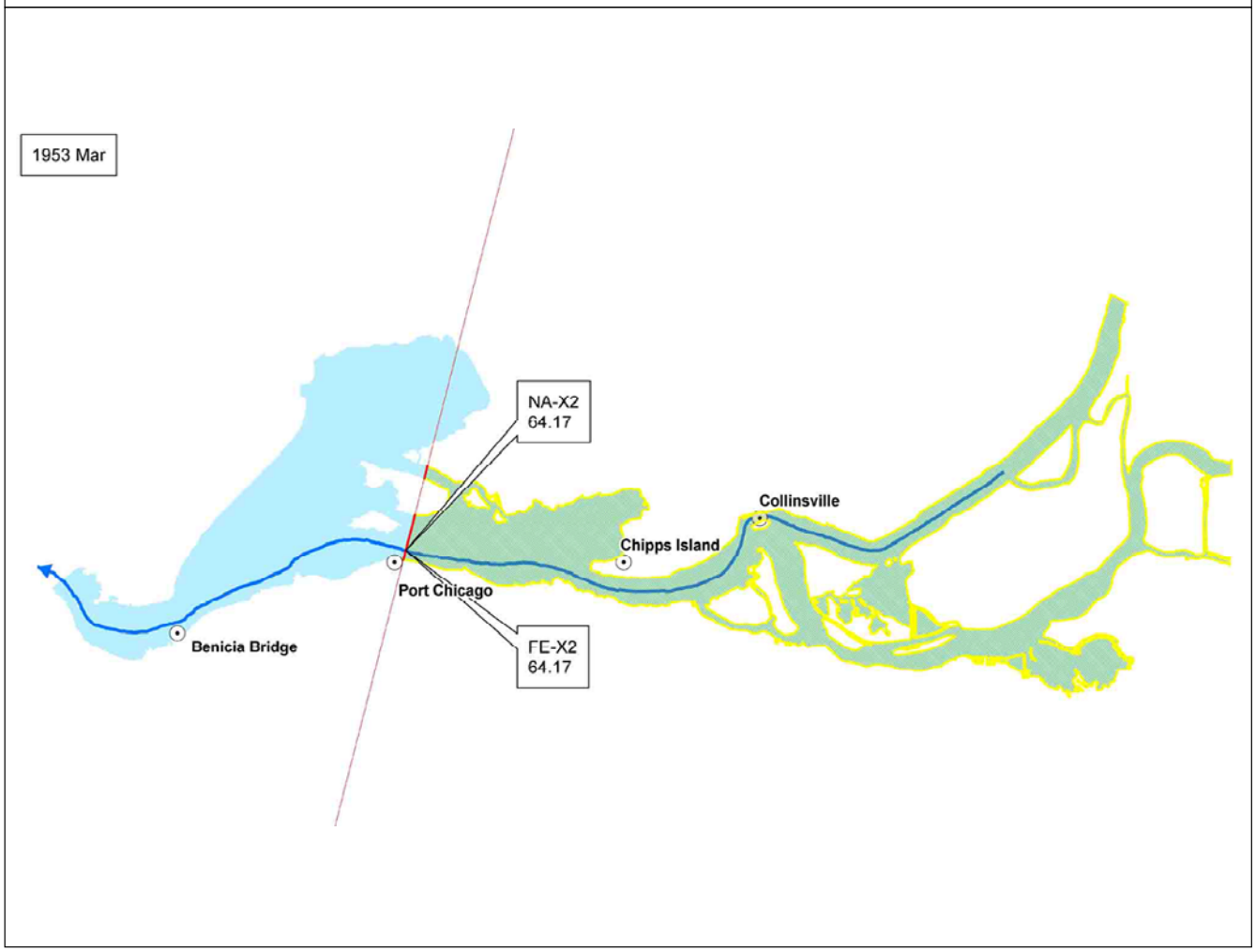

1952 Nov
NA-X2
87.23
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
87.01

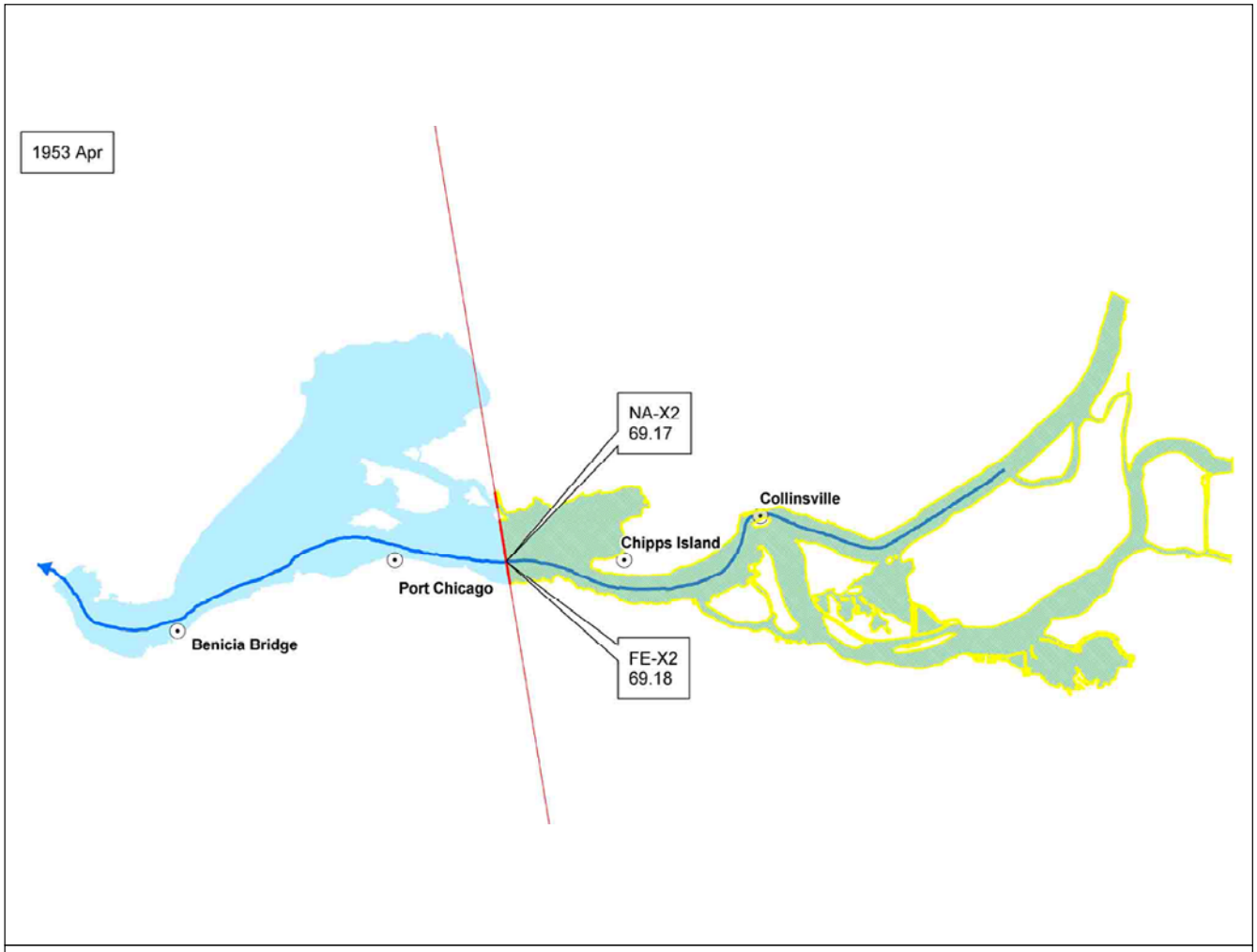

1952 Dec
NA-X2
82.44
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
82.28


1952 average
NA-X2
67.95
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
68.12


1953 Jan
NA-X2
68.32
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
68.17


1953 Feb
NA-X2
56.00
FE-X2
56.22
Collinsville
Chipps Island
Port Chicago
Benicia Bridge


1953 Mar
NA-X2
64.17
FE-X2
64.17
Collinsville
Chipps Island
Port Chicago
Benicia Bridge


1953 Apr
NA-X2
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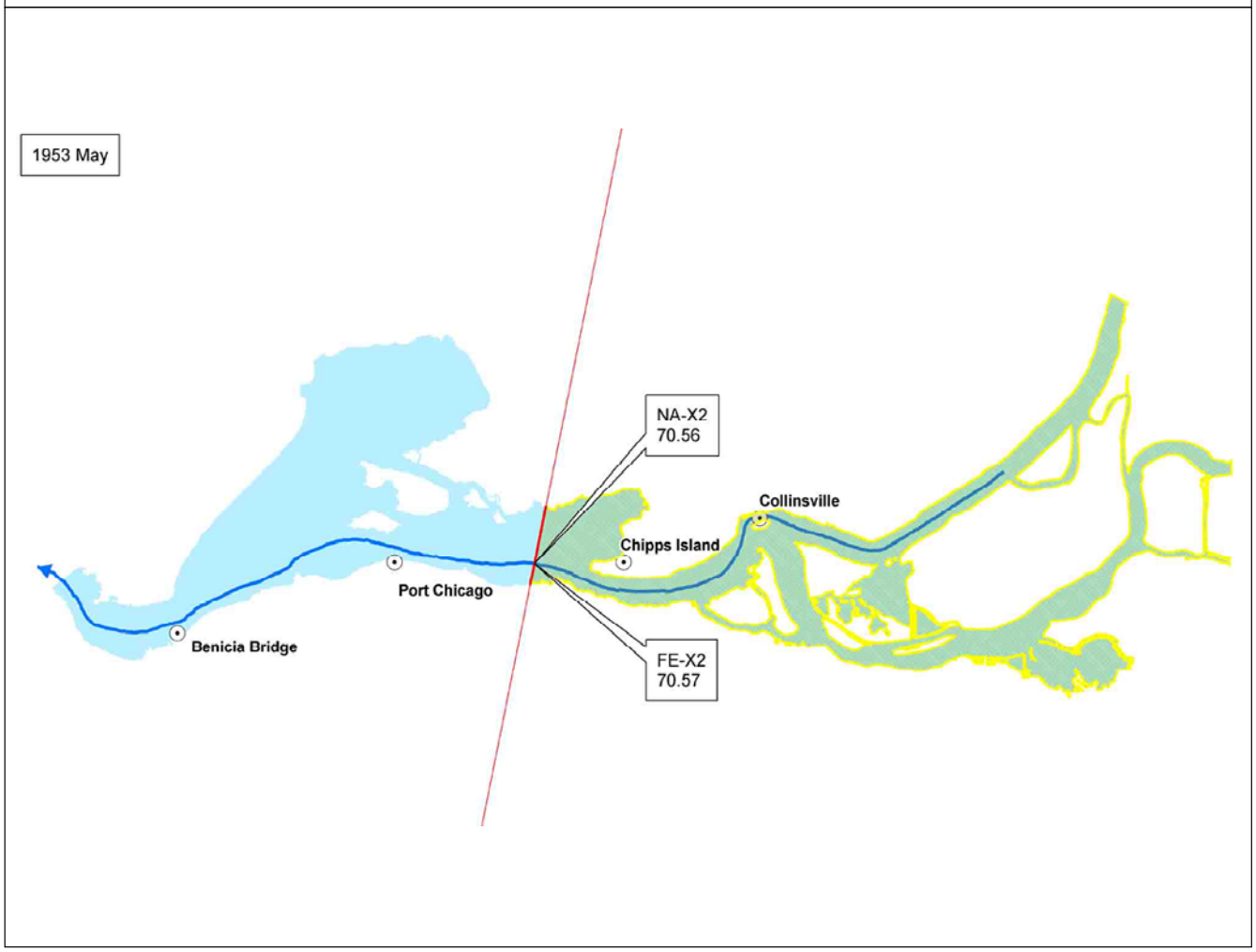
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
69.18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NA-X2
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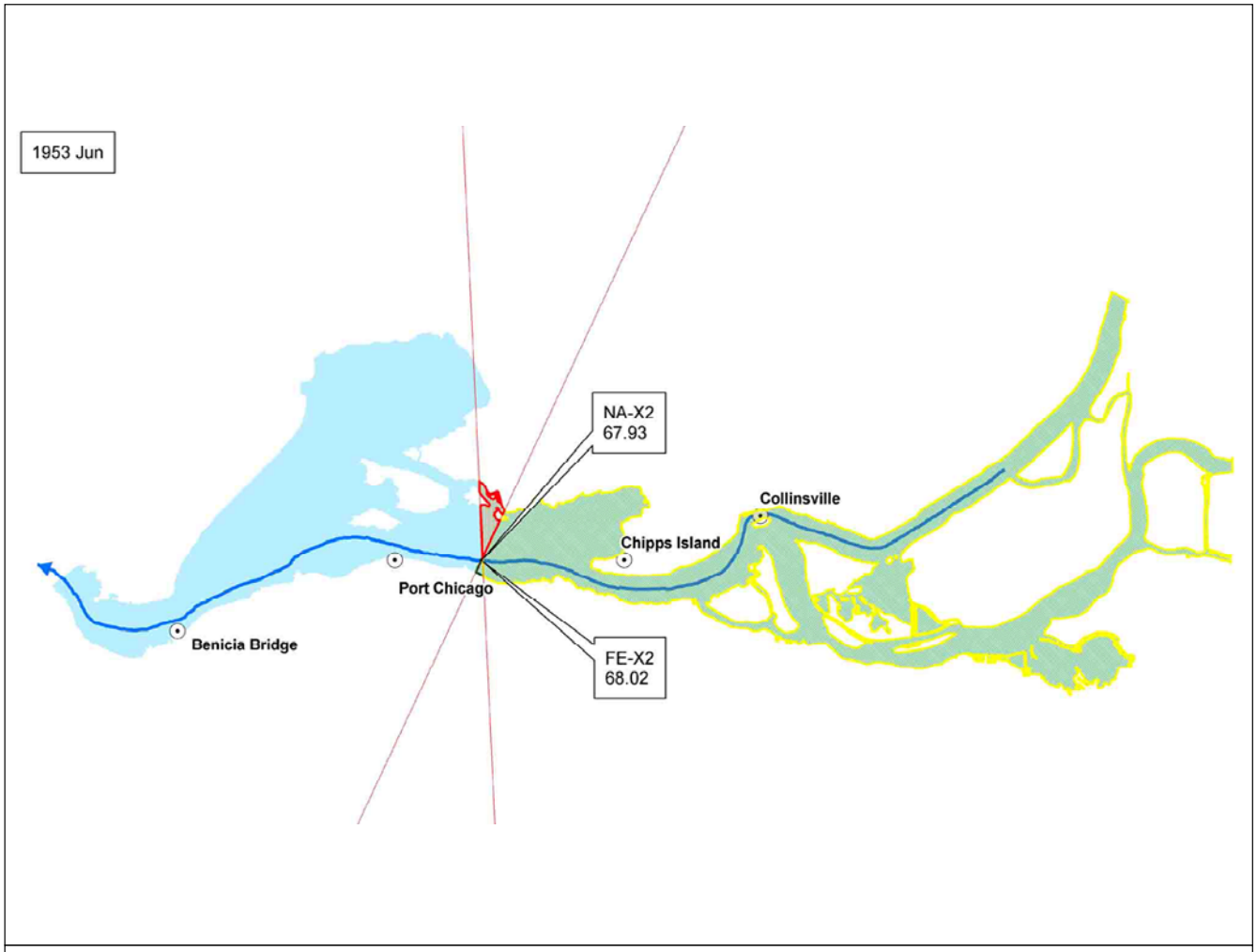
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
70.57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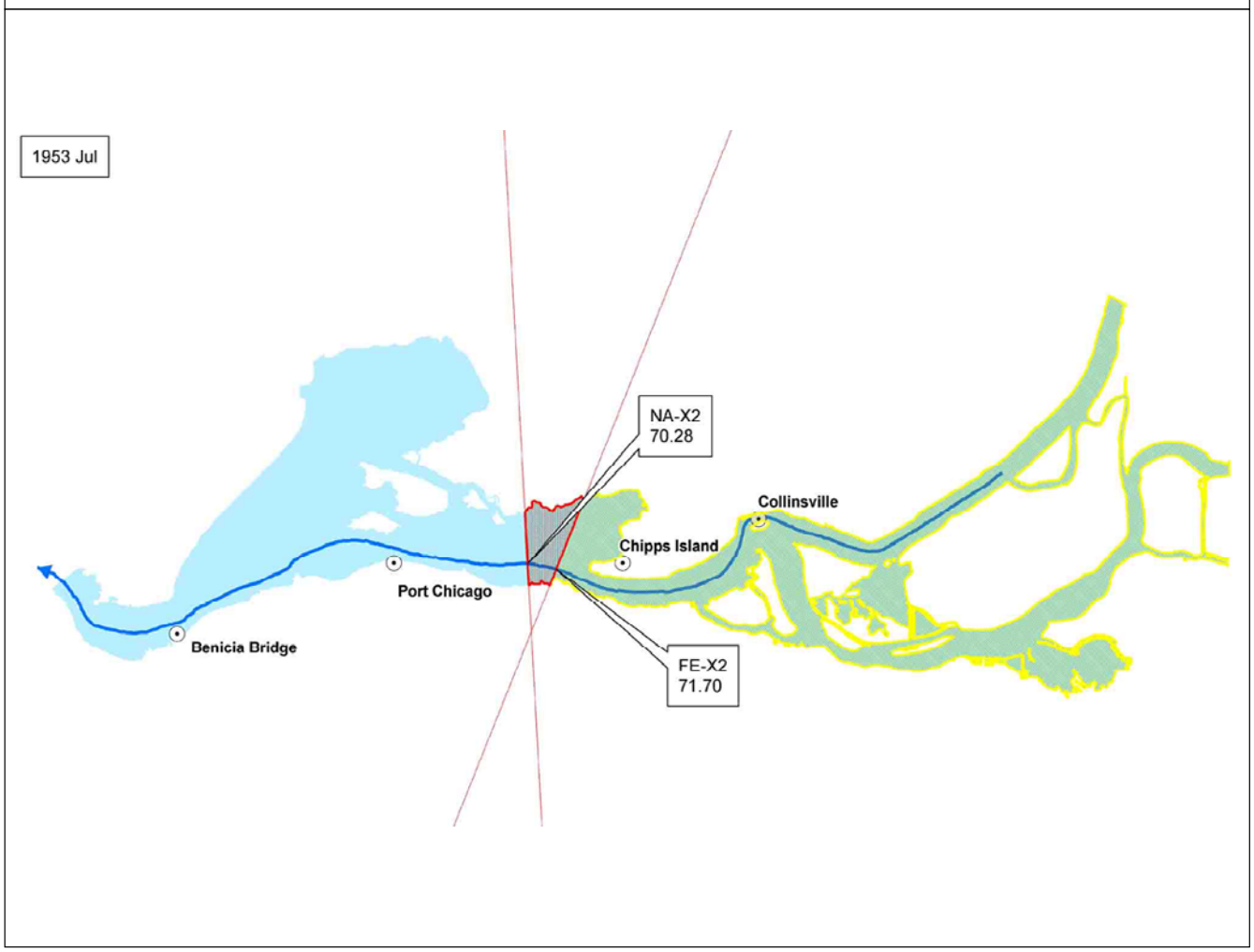
NA-X2
67.93
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
68.02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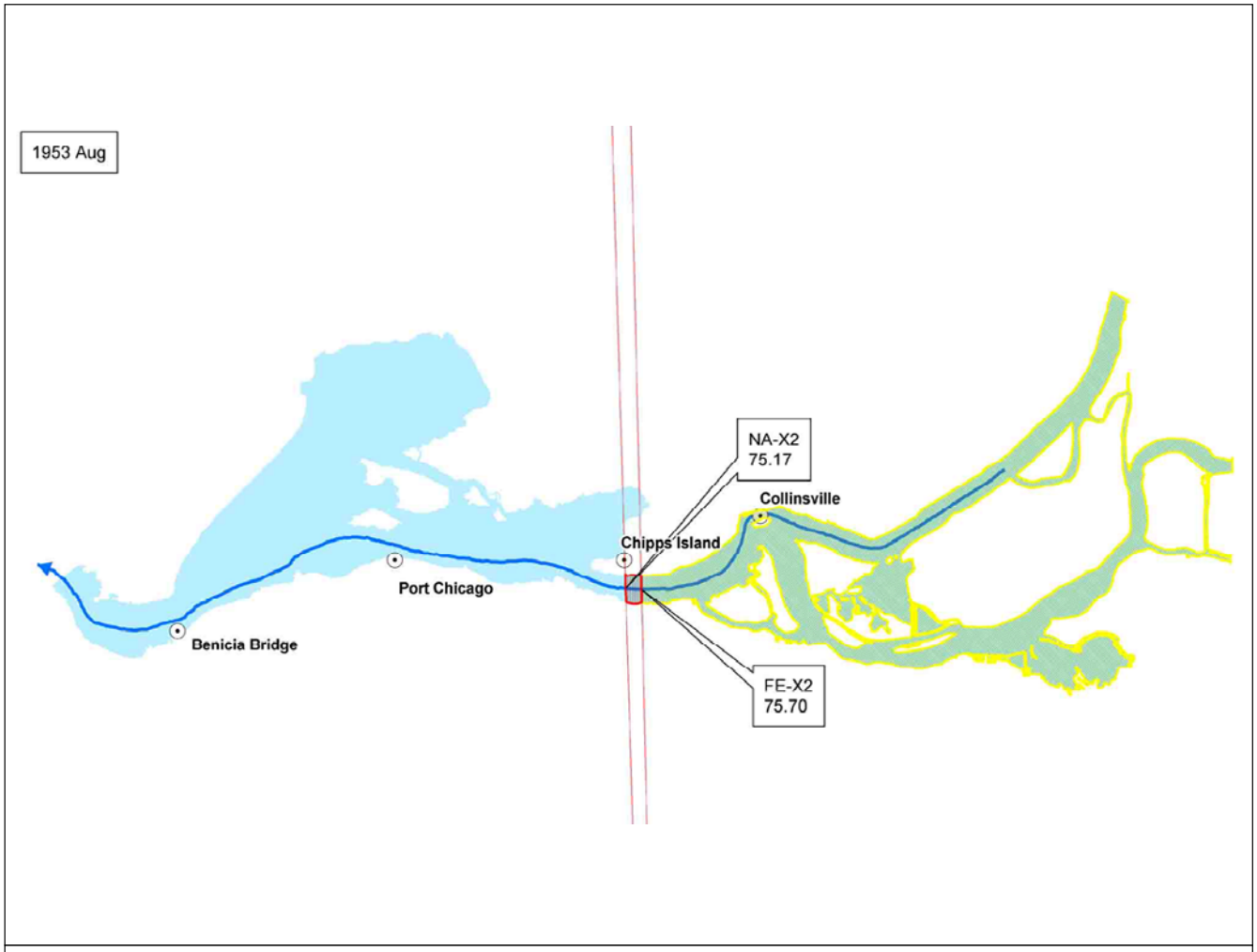
NA-X2
70.28
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
71.70


1953 Aug
NA-X2
75.17
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
75.70


1953 Sep
NA-X2
83.26
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
83.44

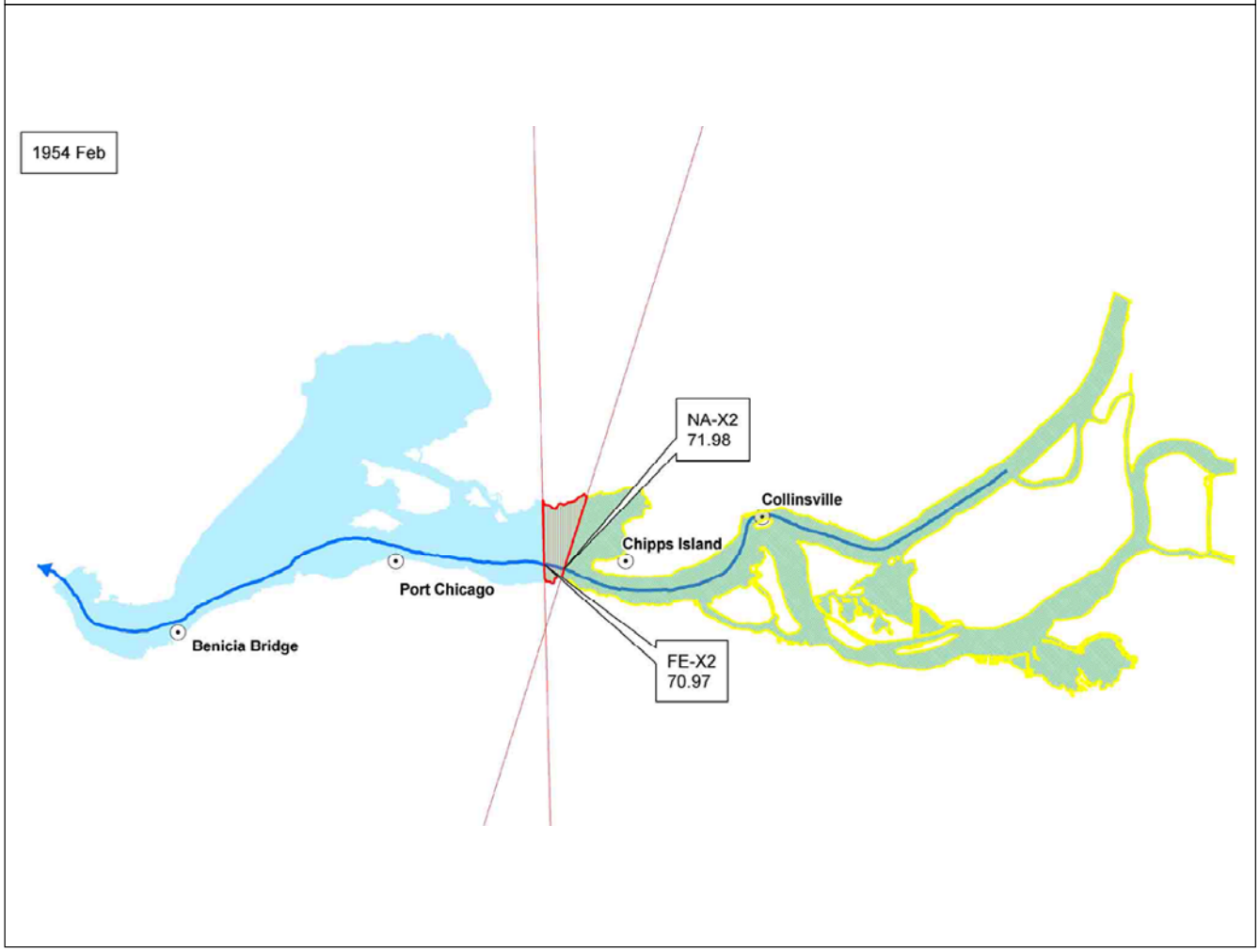

1953 Oct
NA-X2
77.48
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
77.85


1953 Nov
NA-X2
76.01
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
76.22


1953 Dec
NA-X2
82.63
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
82.70


1953 average
NA-X2
71.75
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
71.99


1954 Jan
NA-X2
84.49
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
84.47


1954 Feb
NA-X2
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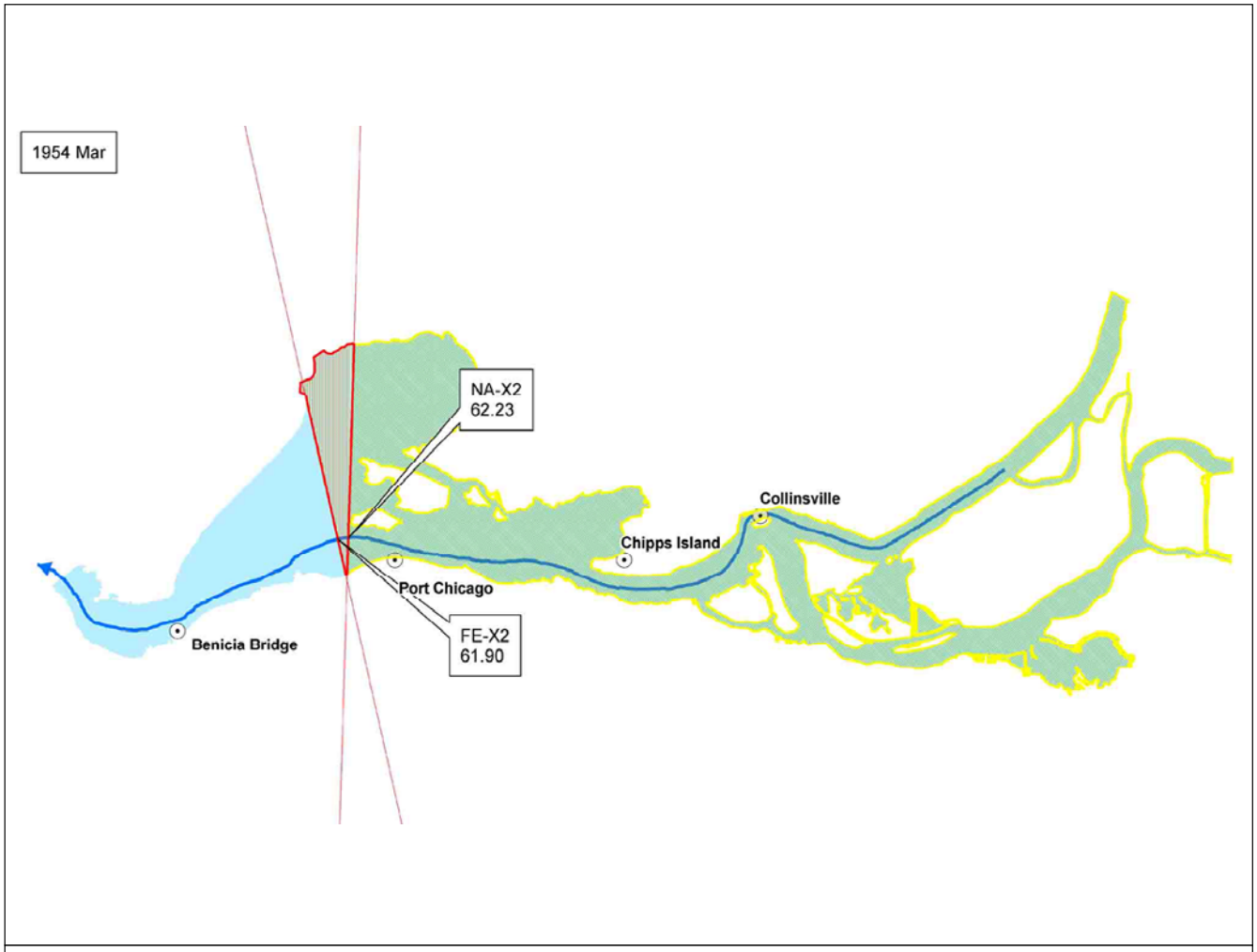
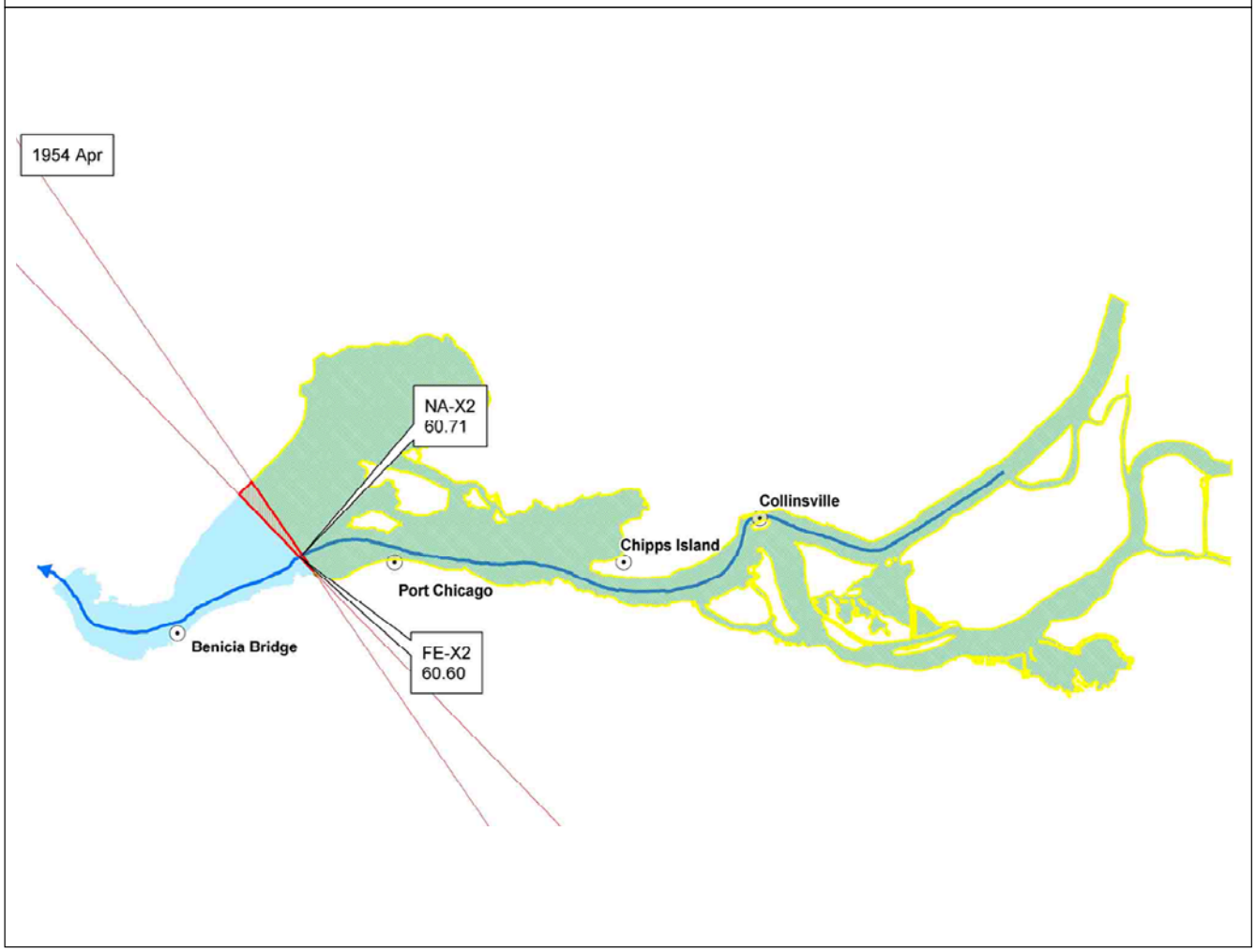
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
70.97


1954 Mar
NA-X2
62.23
Collinsville
Chipps Island
Port Chicago
FE-X2
61.90
Benicia Bridge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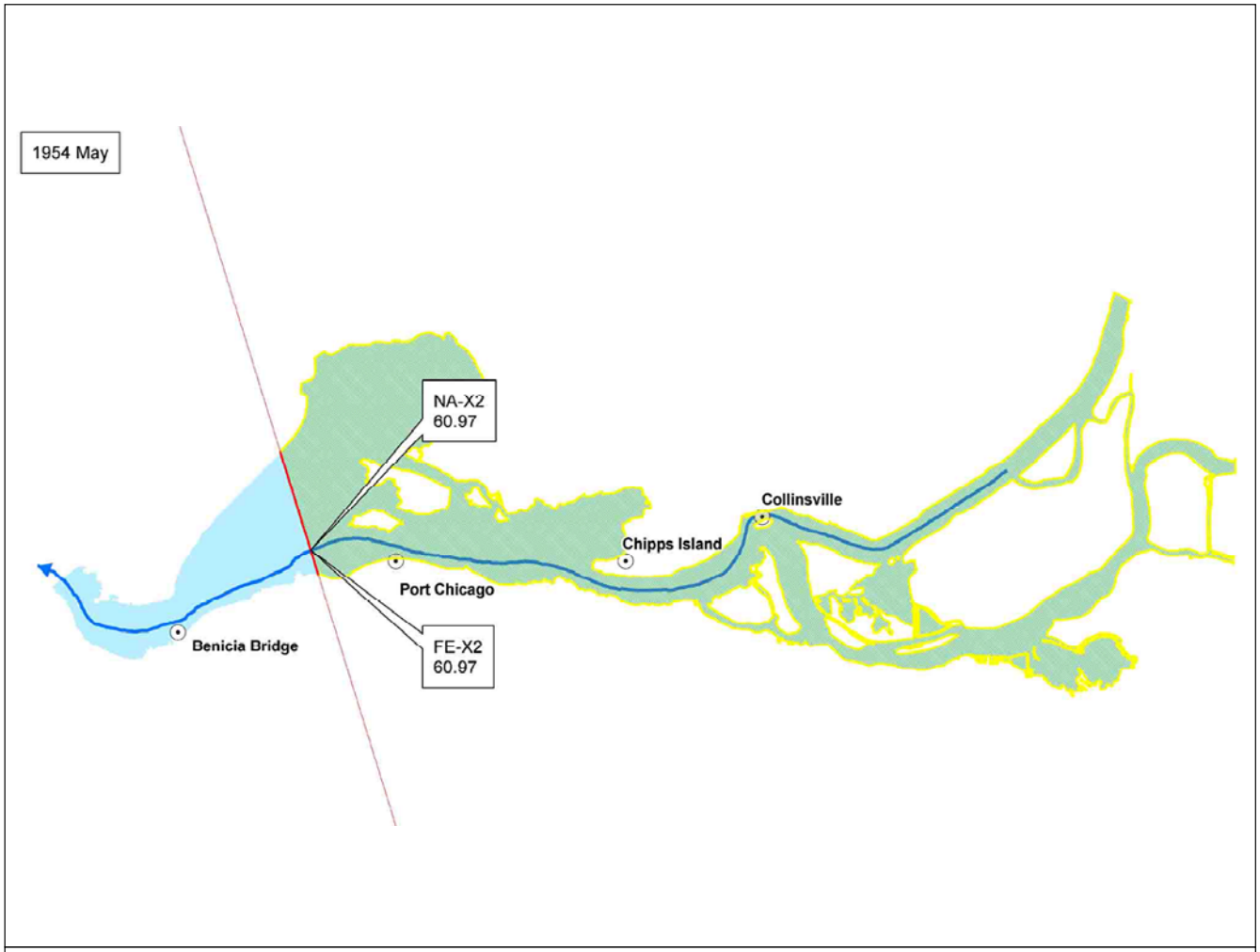
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
60.60


1954 May
NA-X2
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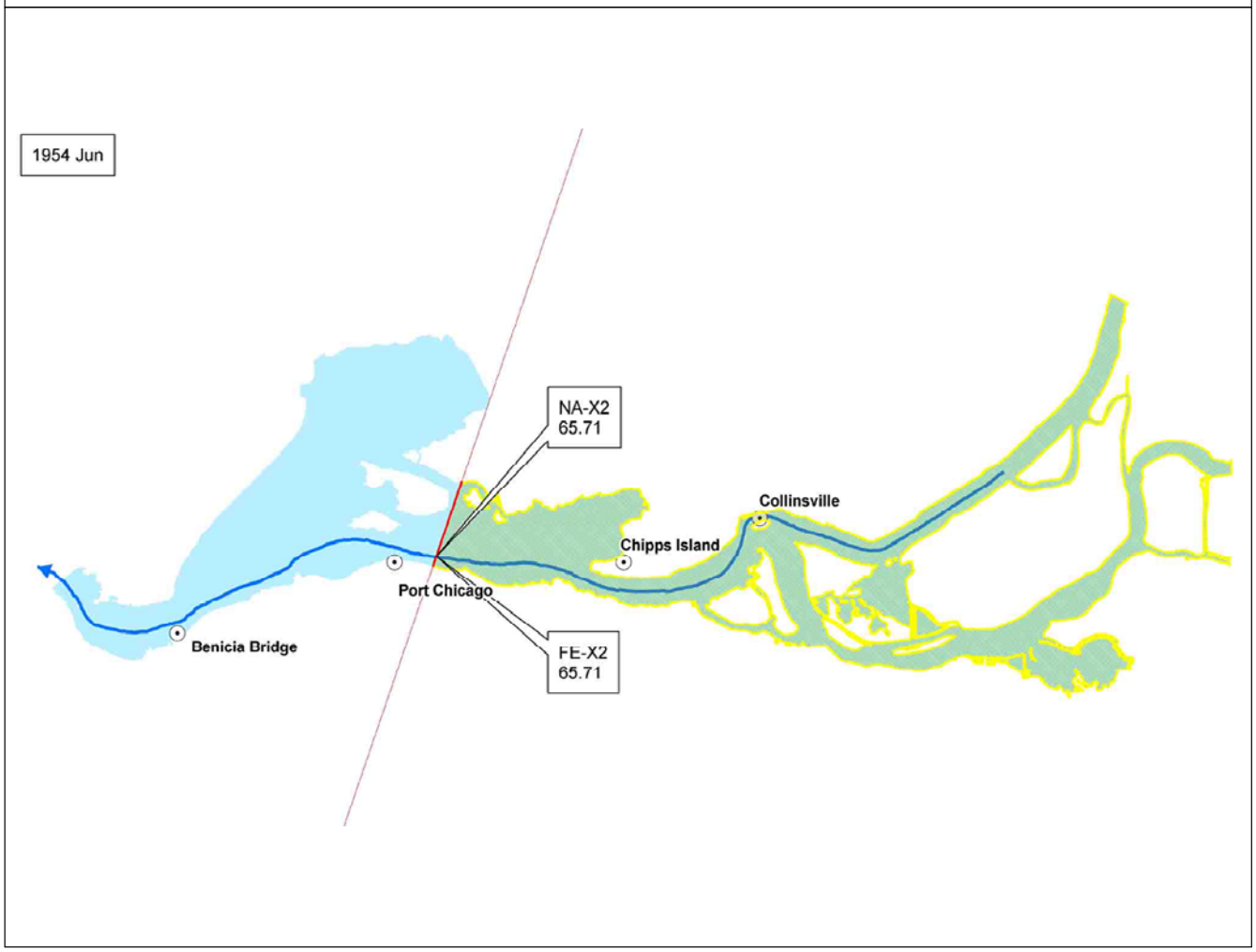
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
60.97

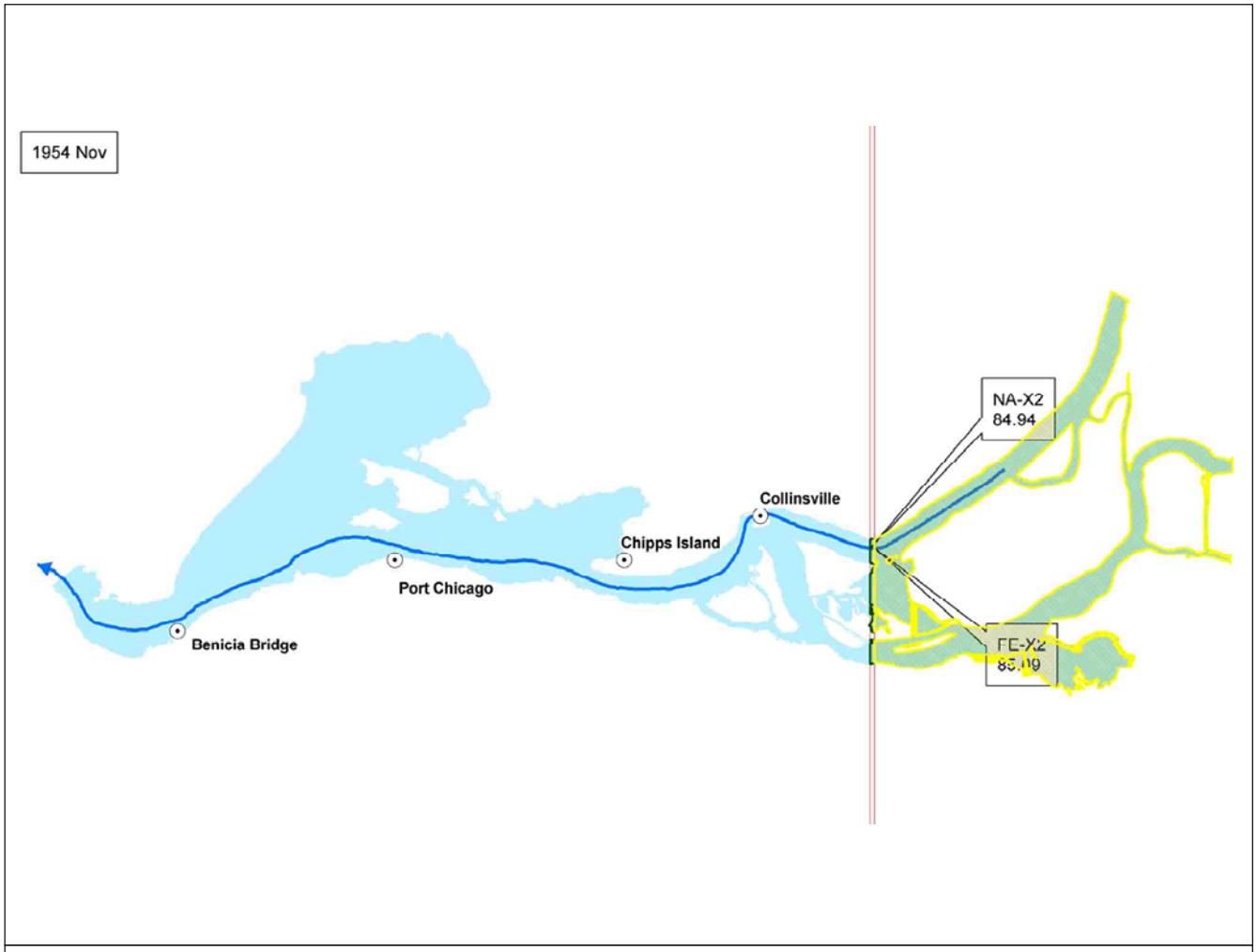

1954 Jun
NA-X2
65.71
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
65.71

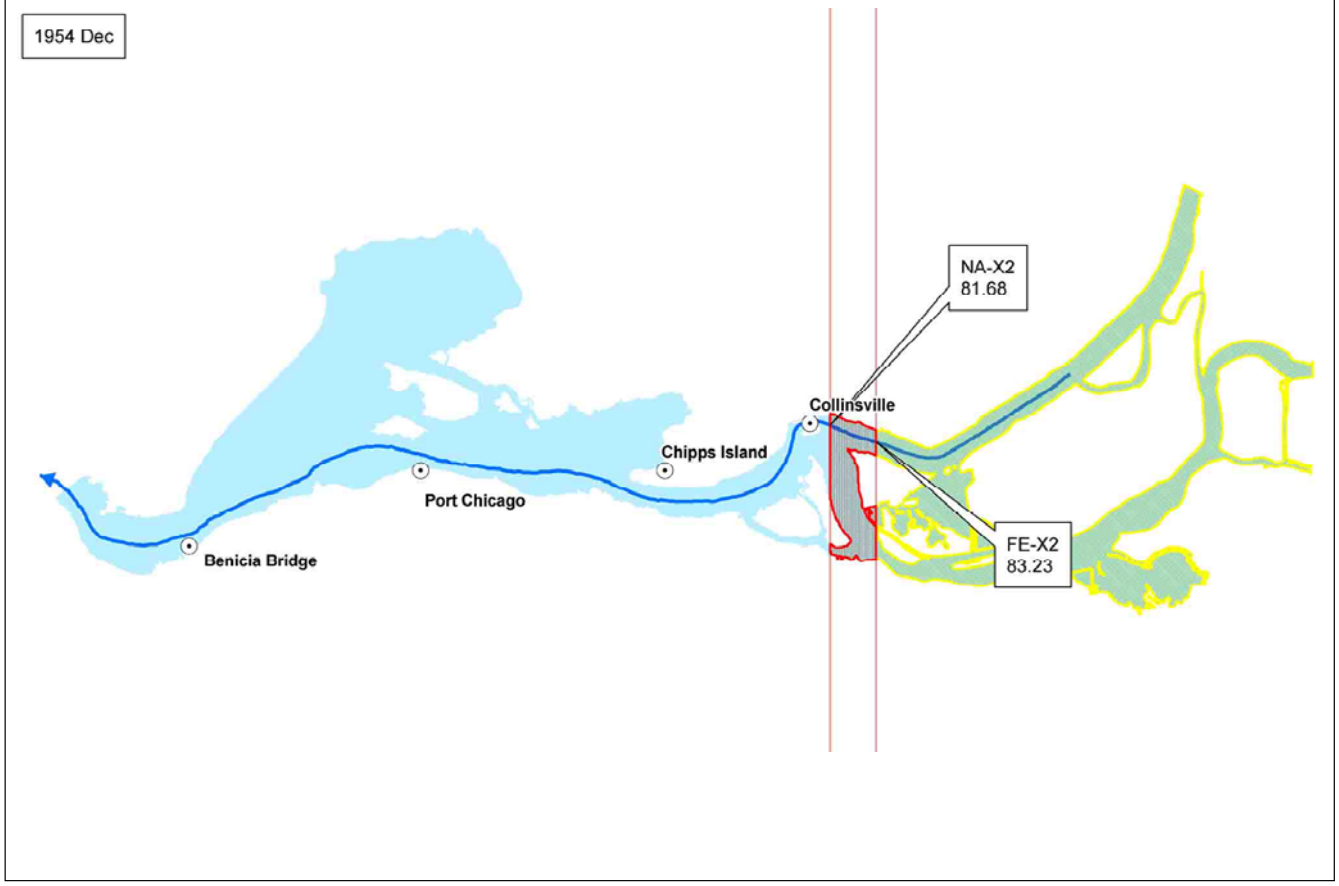

1954 Jul
NA-X2
76.88
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
76.32


1954 Aug
NA-X2
78.51
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
78.33


1954 Sep
NA-X2
84.36
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
84.30


1954 Oct
NA-X2
81.04
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
81.24


1954 Nov
NA-X2
84.94
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2


1954 Dec
NA-X2
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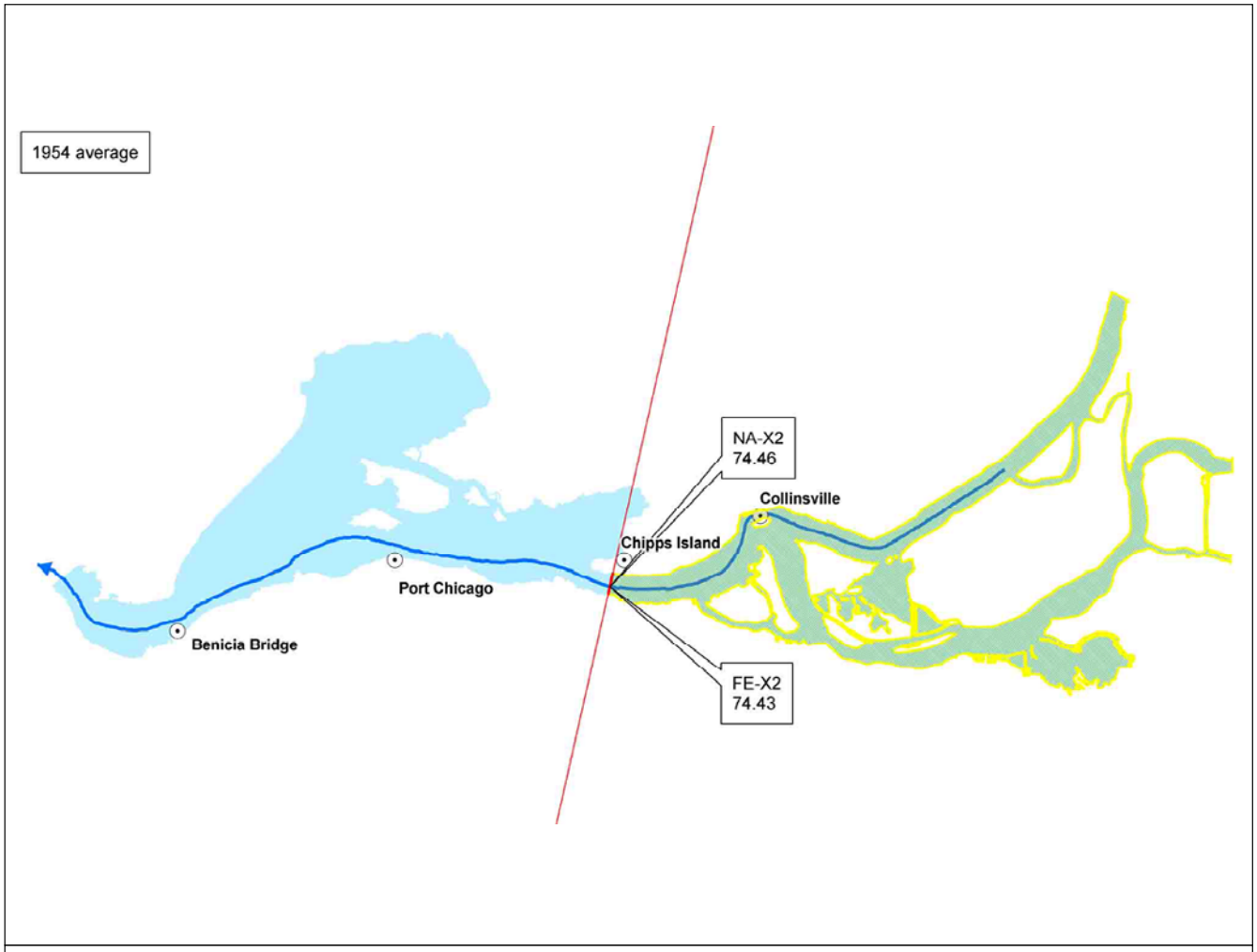
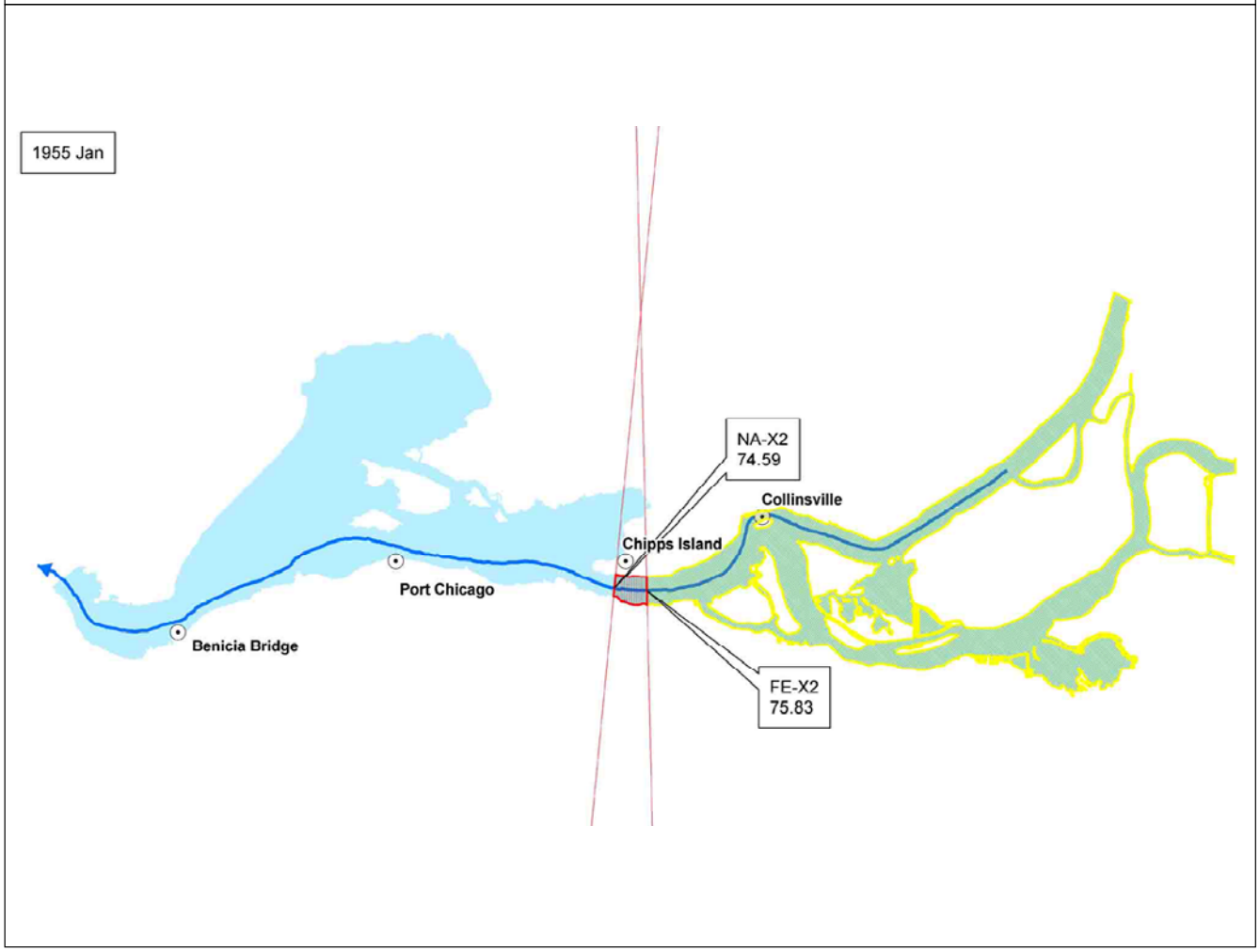
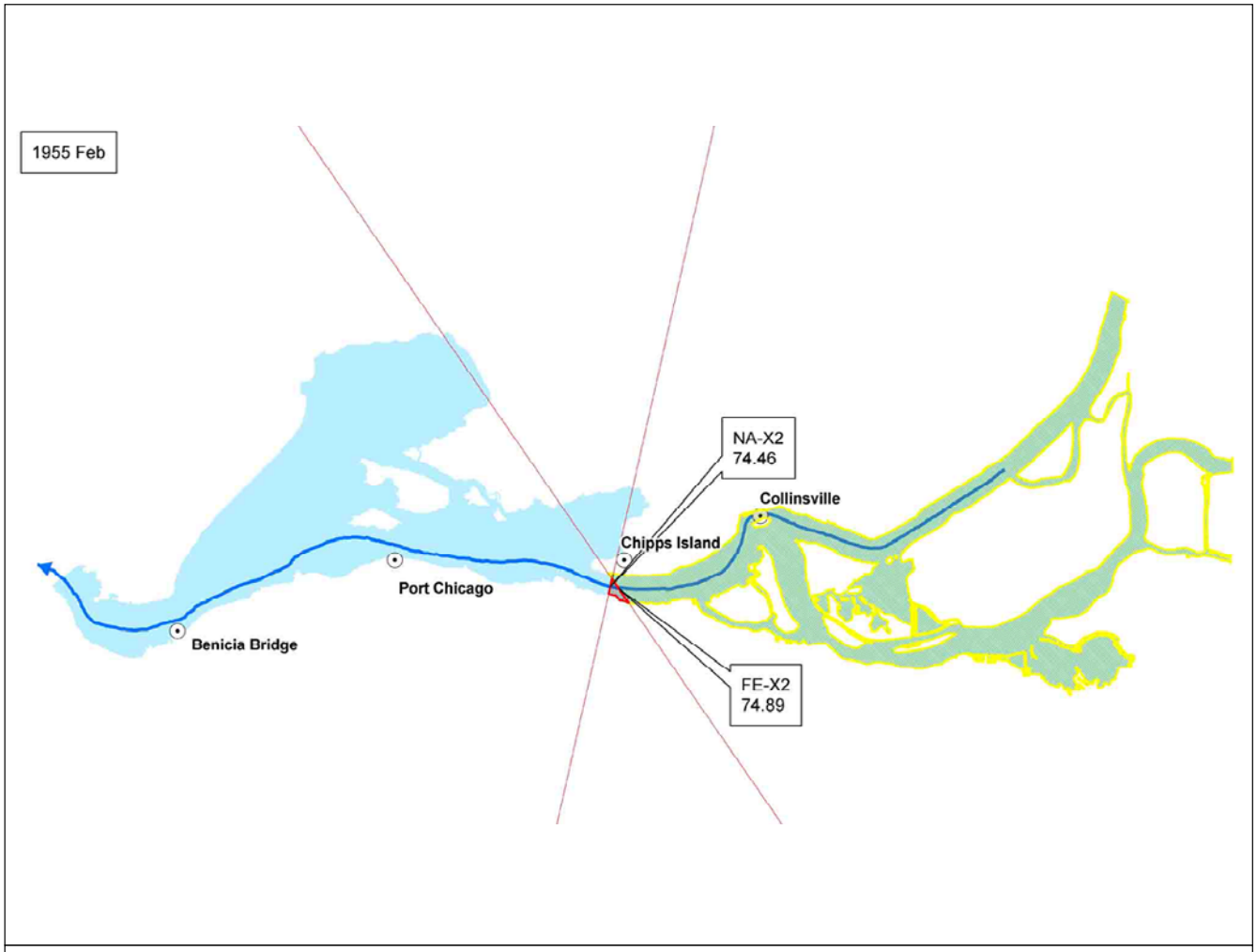
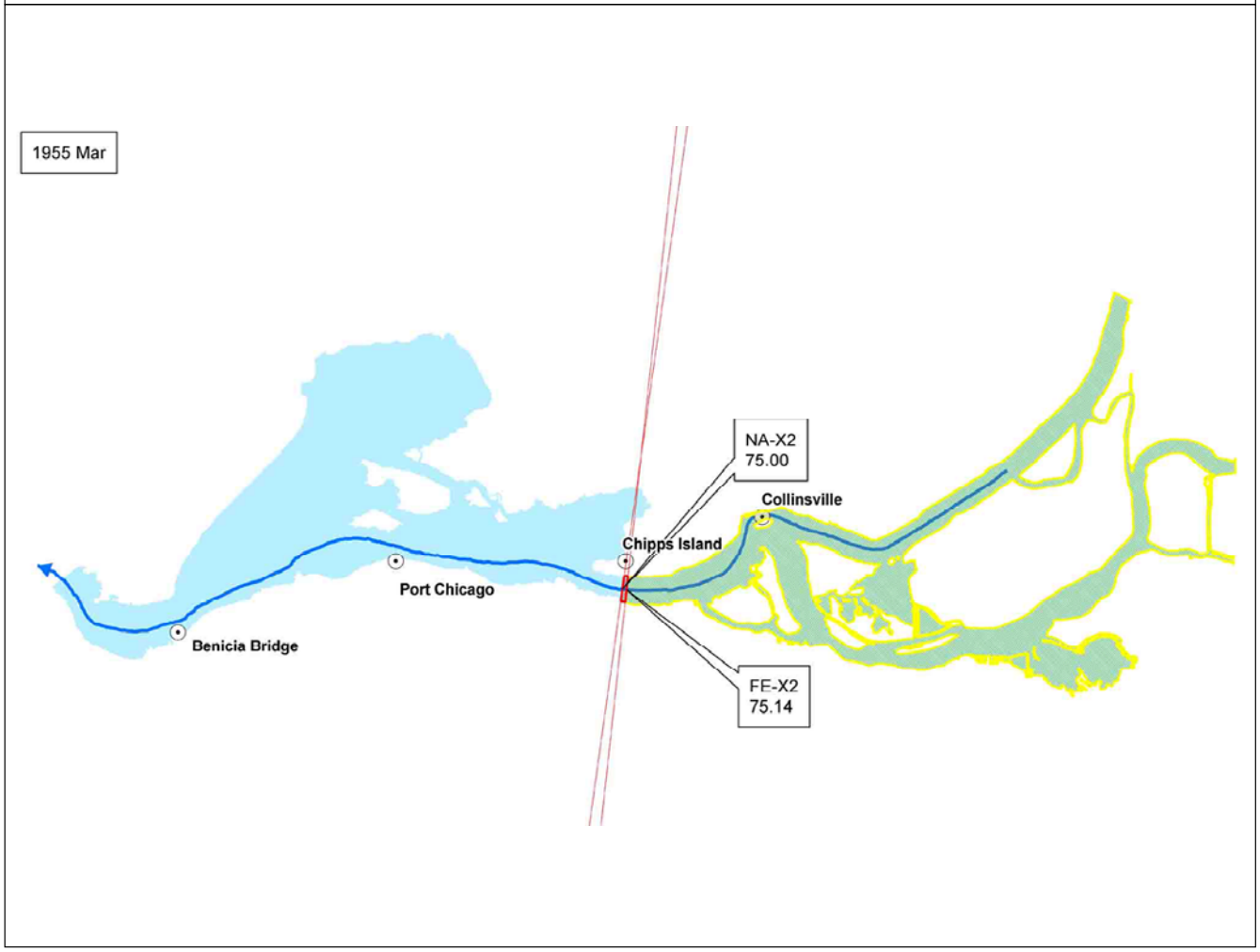
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
83.23

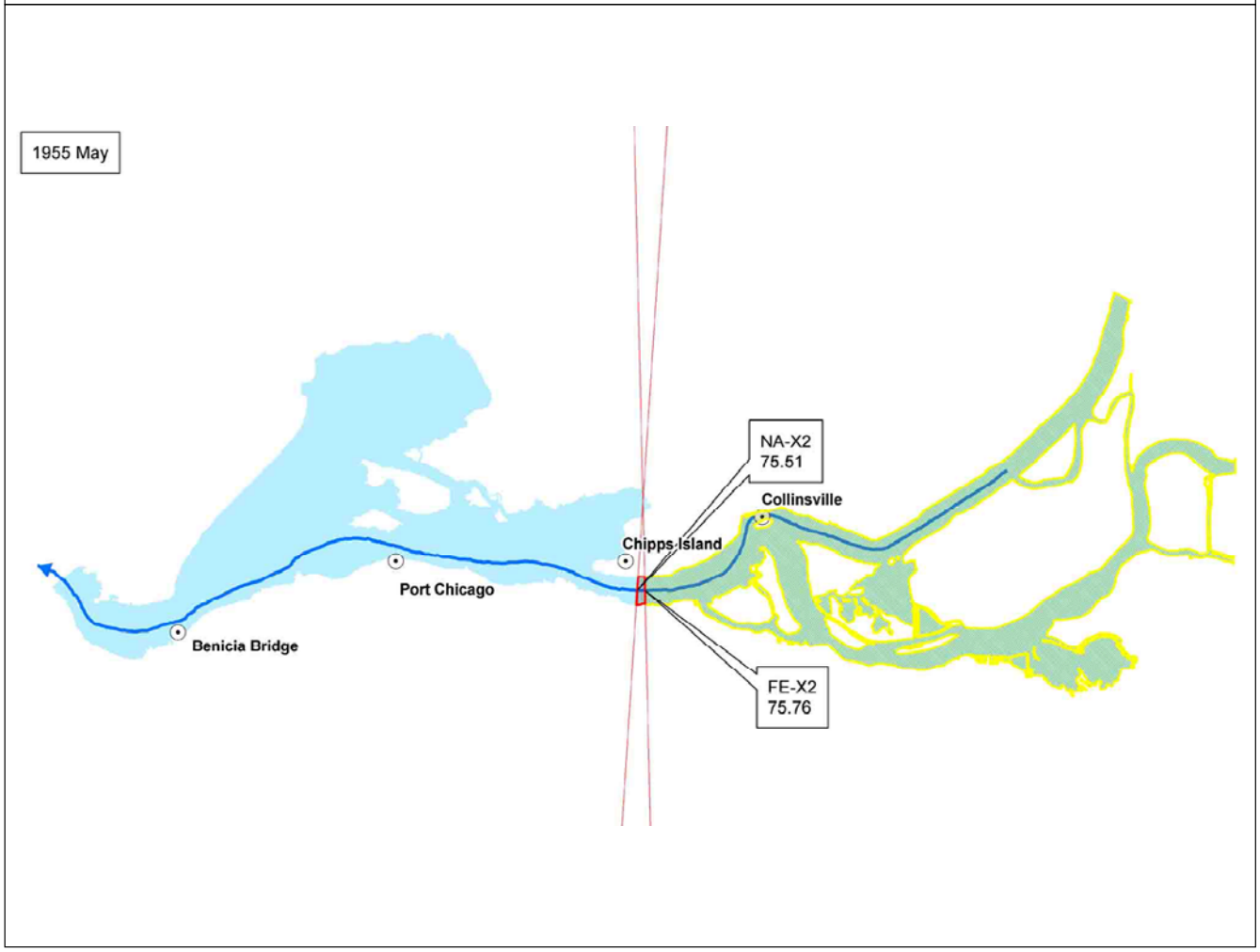

1954 average
NA-X2
74.46
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
74.43


1955 Jan
NA-X2
74.59
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
75.83


1955 Feb
NA-X2
74.46
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
74.89


1955 Mar
NA-X2
75.00
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
75.14

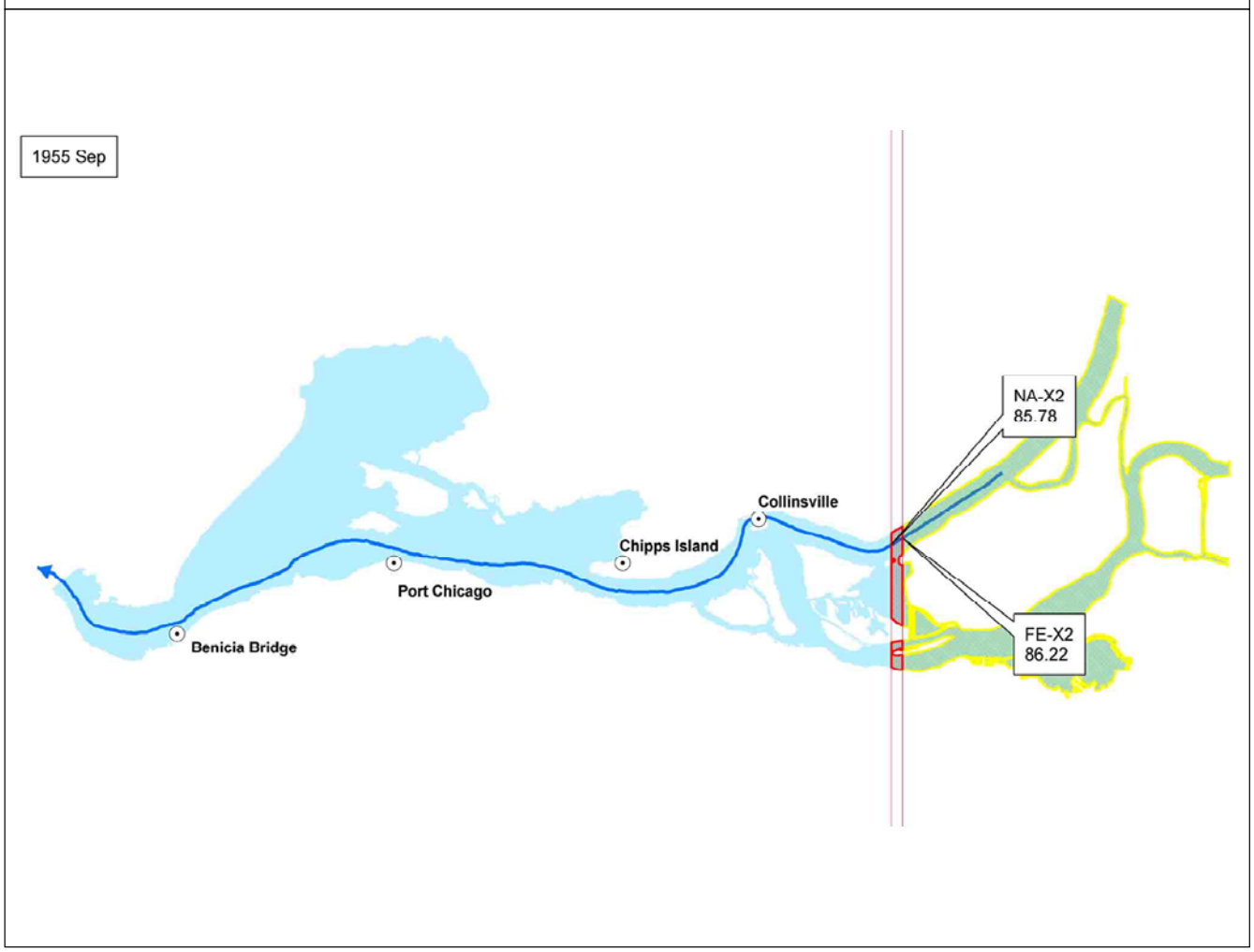

1955 Apr
NA-X2
77.59
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
77.55


1955 May
NA-X2
75.51
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
75.76

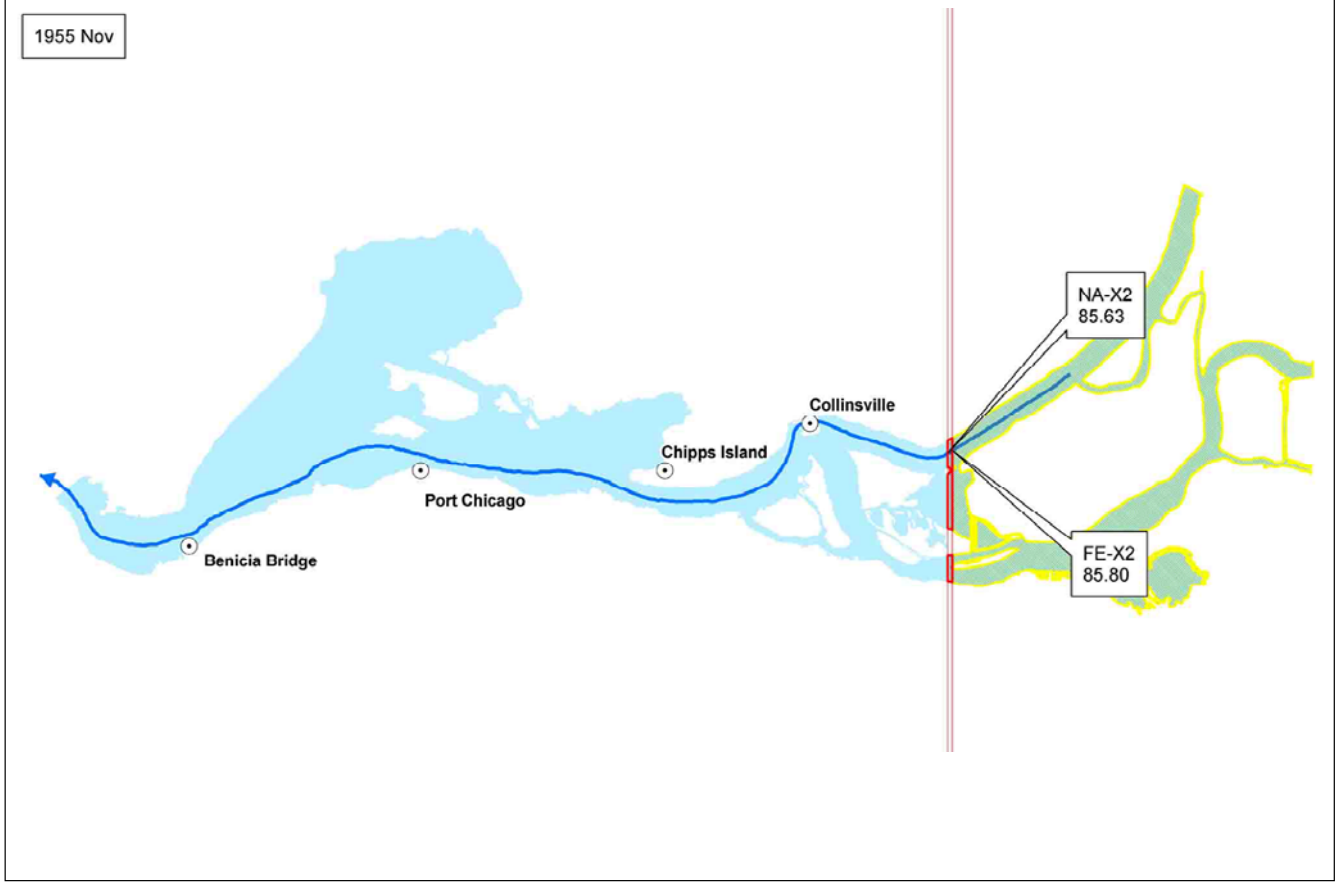

1955 Jun
NA-X2
75.92
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
75.99


1955 Jul
NA-X2
79.18
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
79.20


1955 Aug
NA-X2
82.86
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
82.87

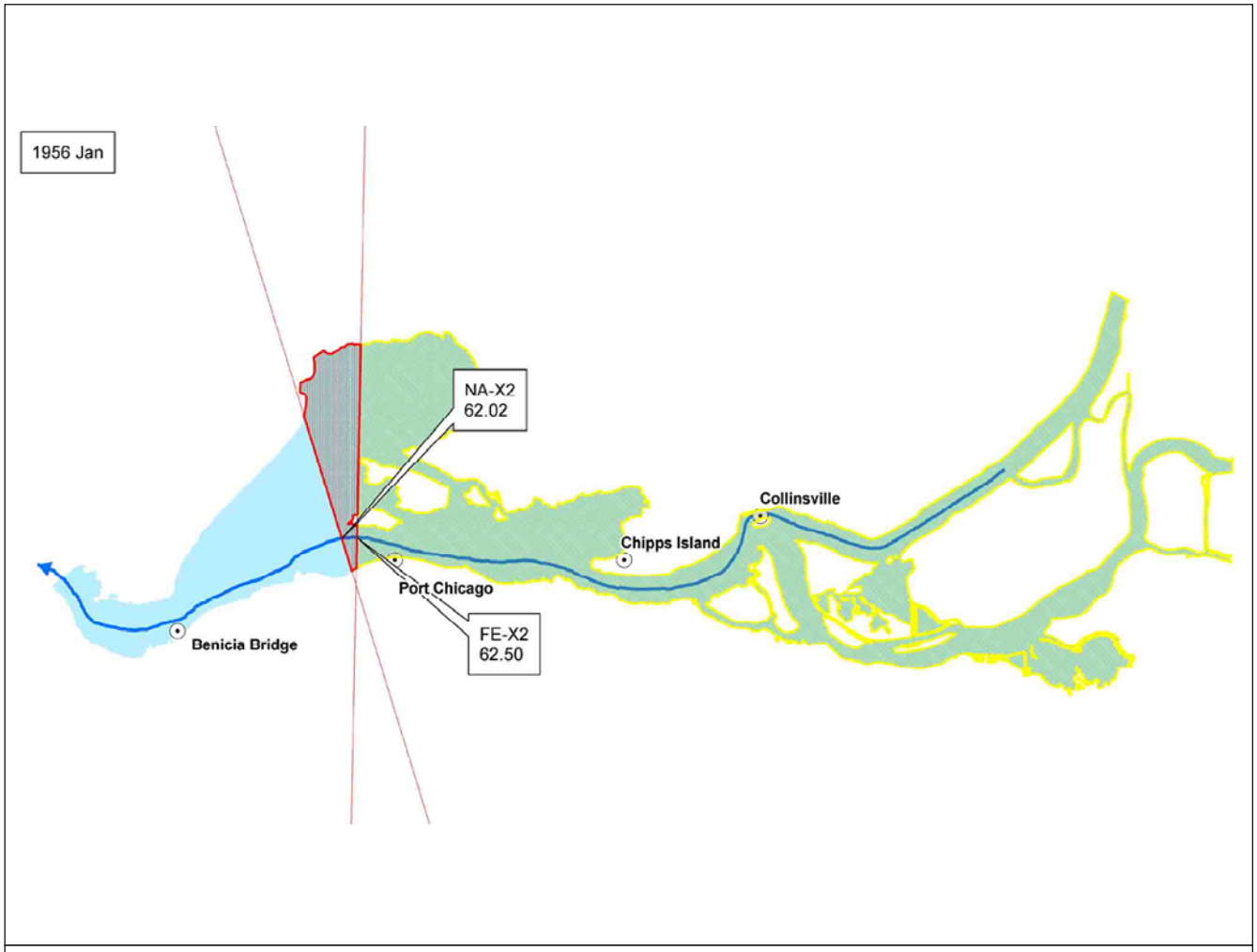

1955 Sep
NA-X2
85.78
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
86.22


1955 Oct
NA-X2
86.27
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
86.24


1955 Nov
NA-X2
85.63
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
85.80


1955 Dec
NA-X2
82.59
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
83.05


1955 average
NA-X2
79.62
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
79.88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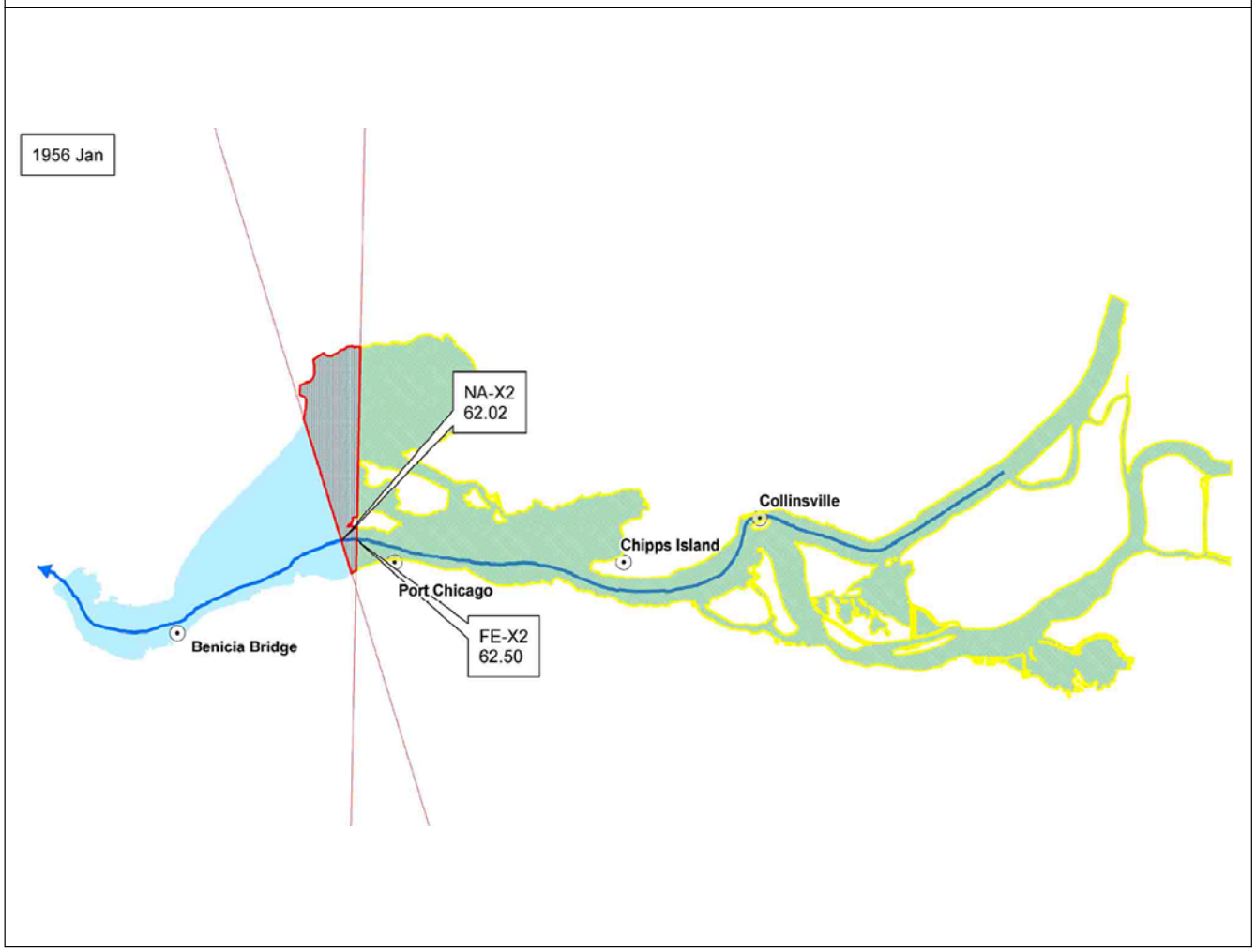
Collinsville
Chipps Island
Port Chicago
FE-X2
62.50
Benicia Bridge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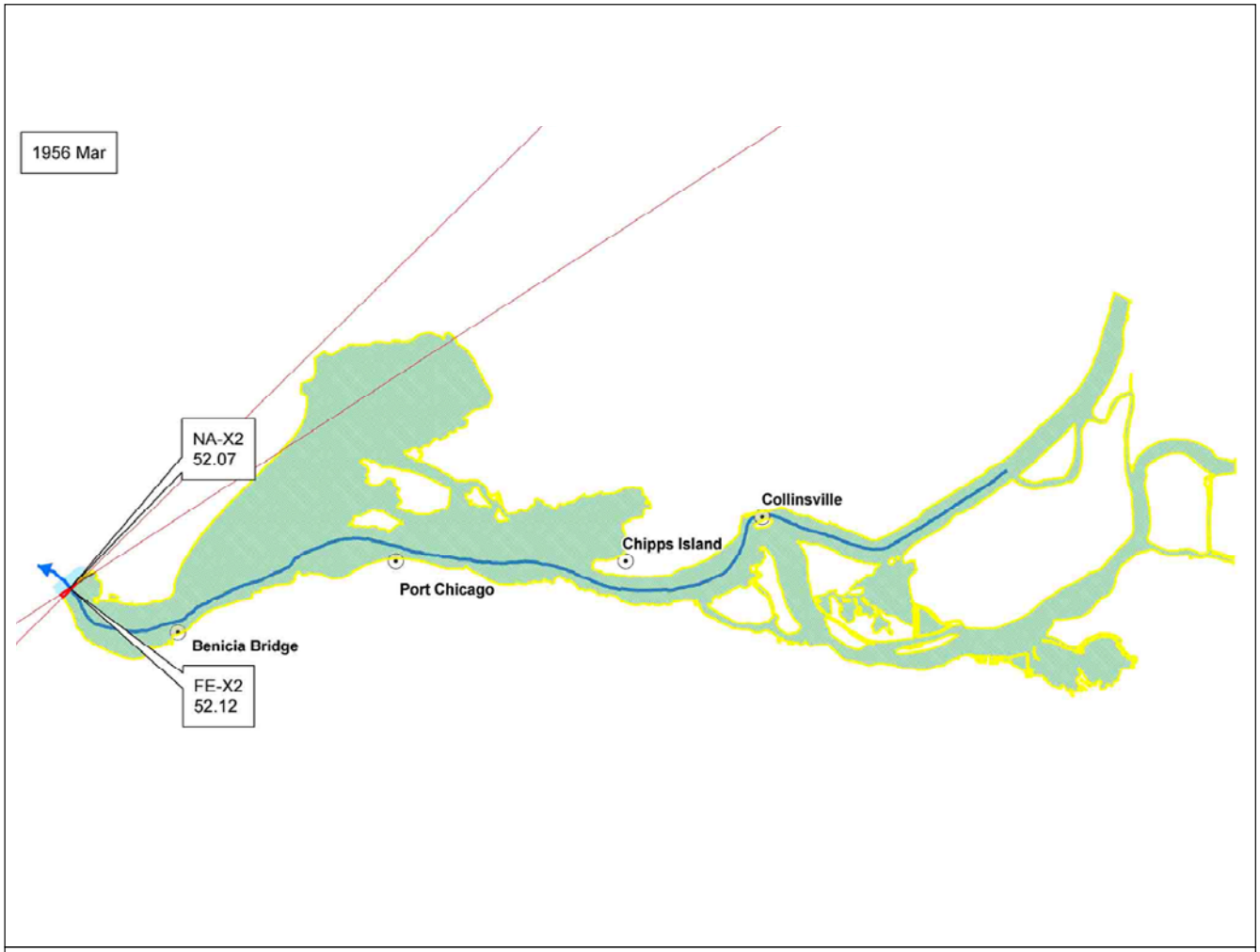
Collinsville
Chipps Island
Port Chicago
FE-X2
62.50
Benicia Bridge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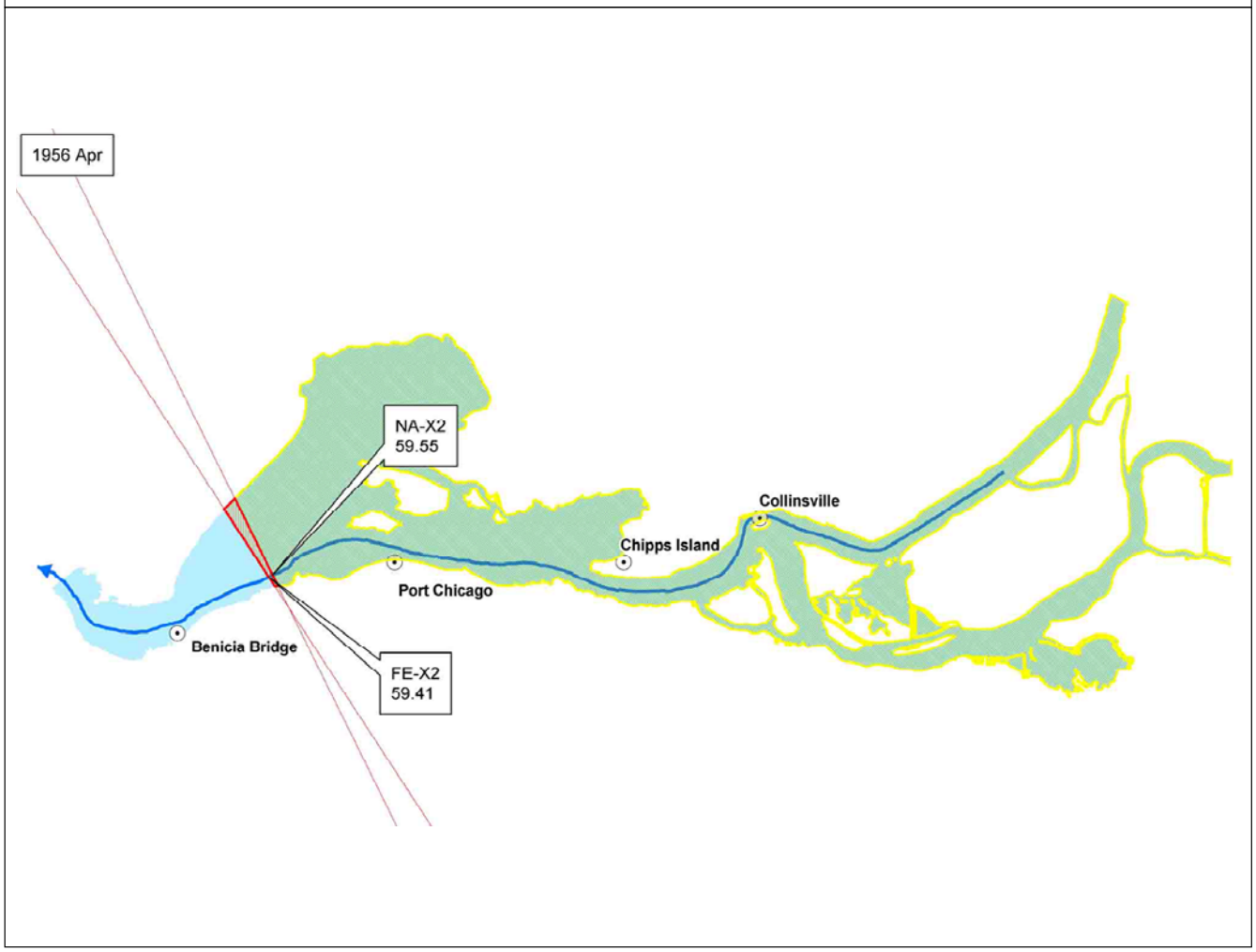
NA-X2
52.07
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
52.12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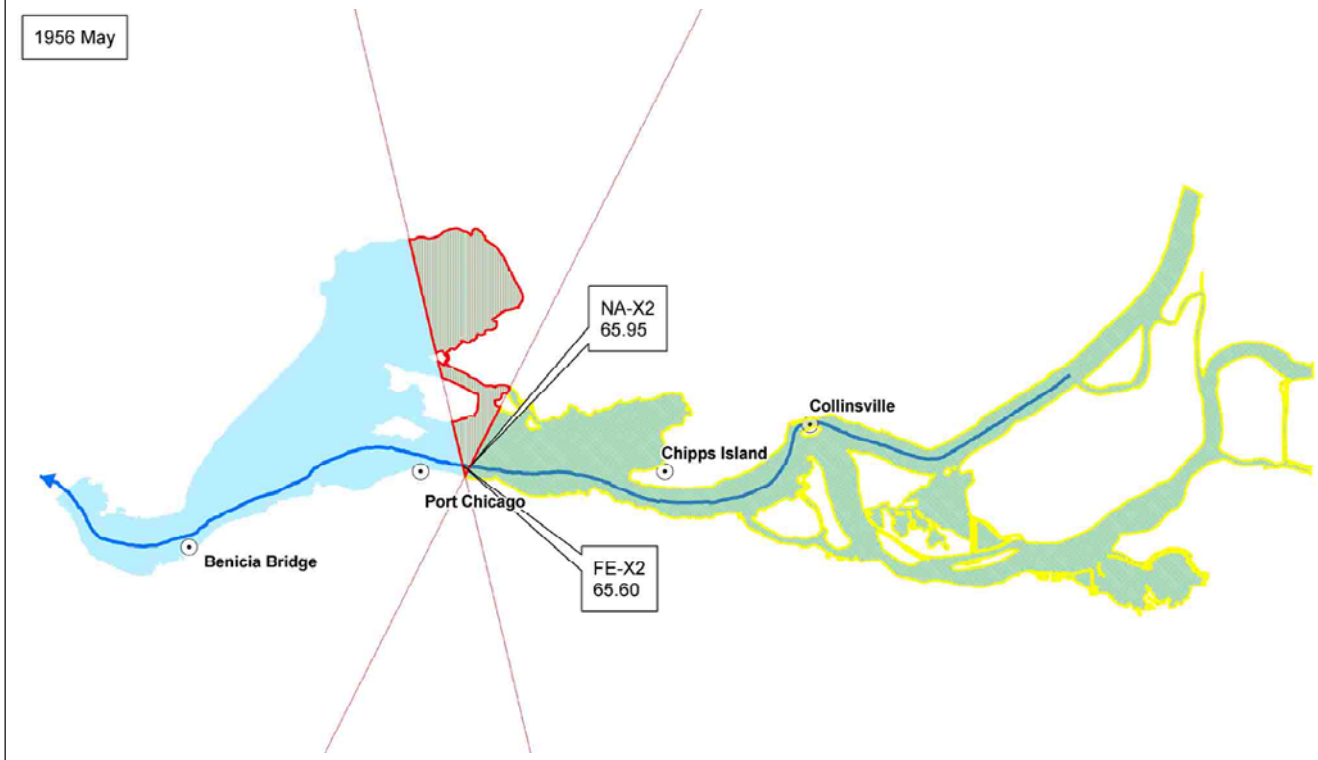
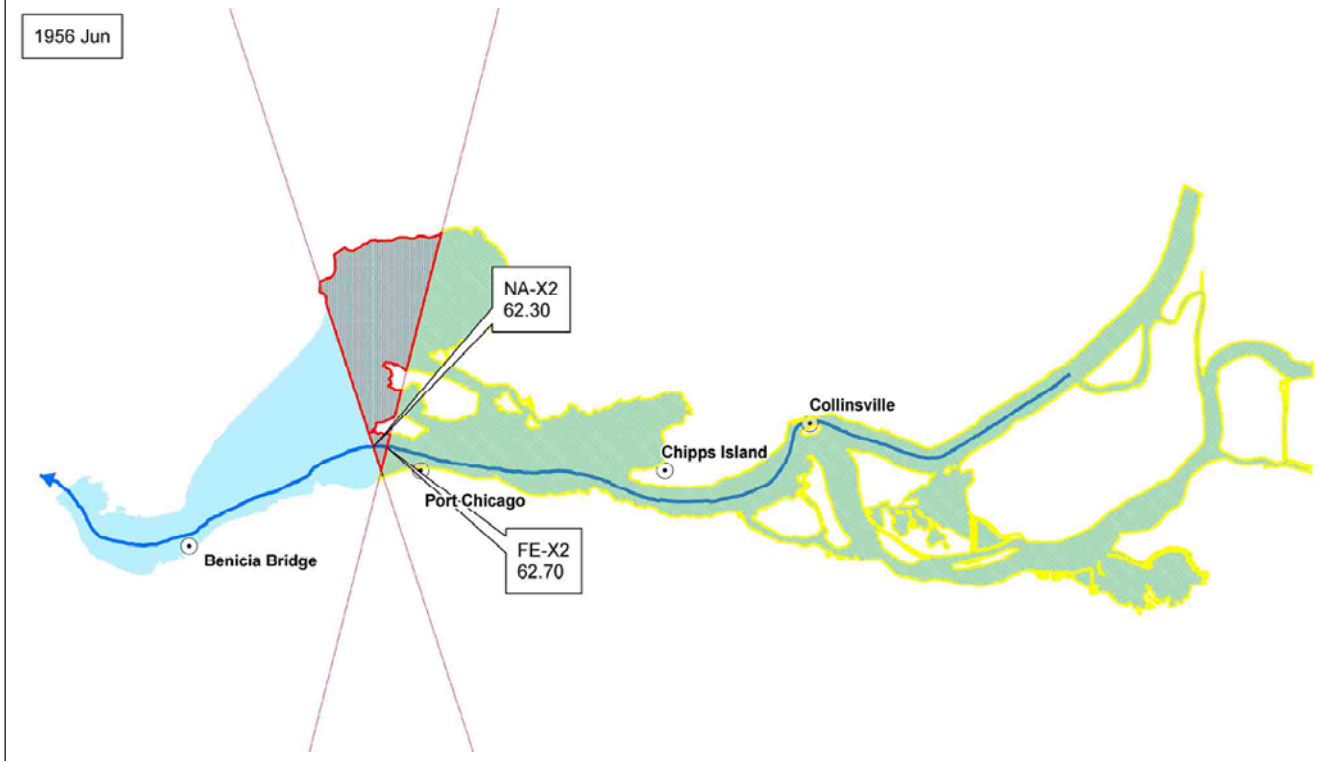
59.55
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
59.41


1956 May
NA-X2
65.95
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
65.60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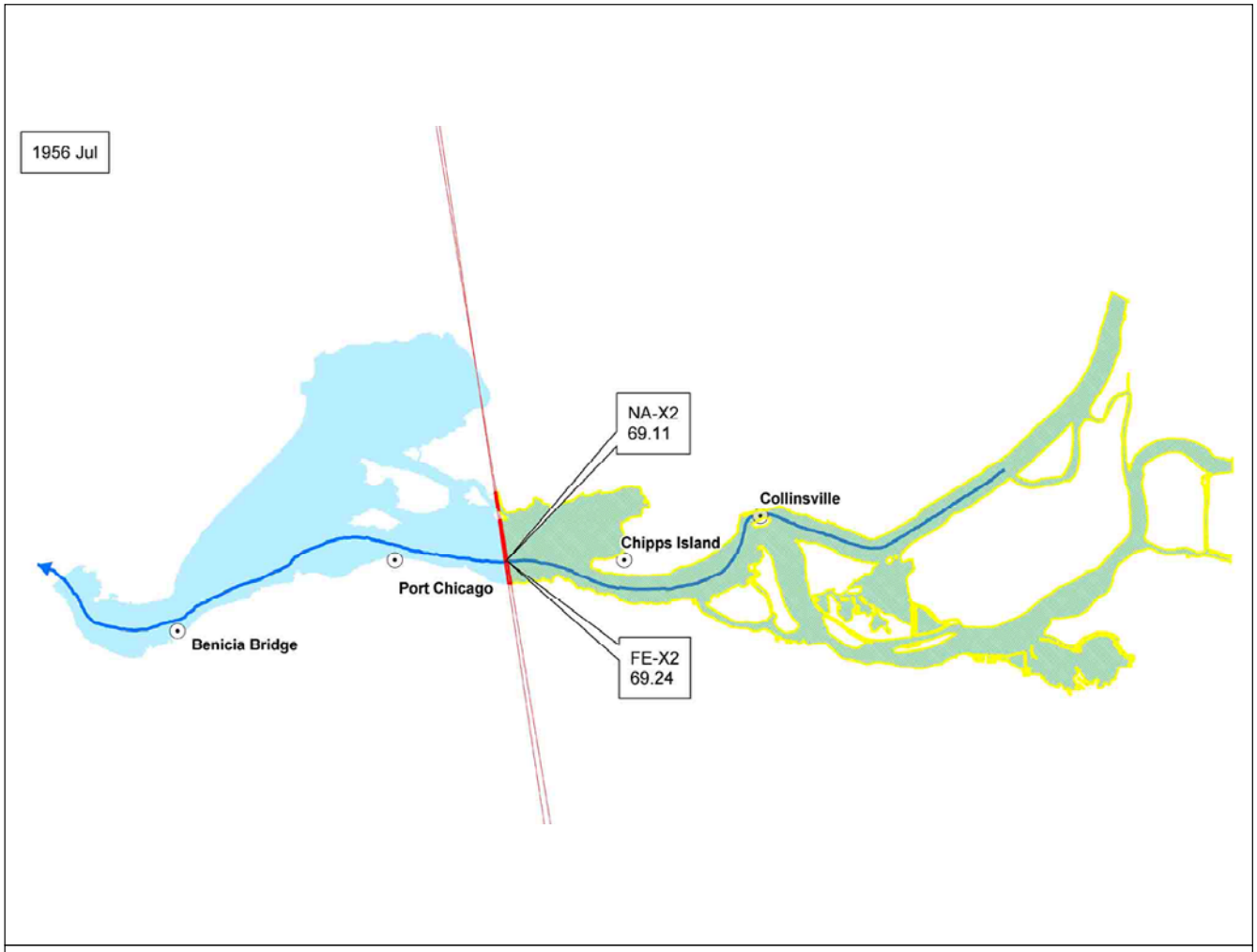
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
62.70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NA-X2
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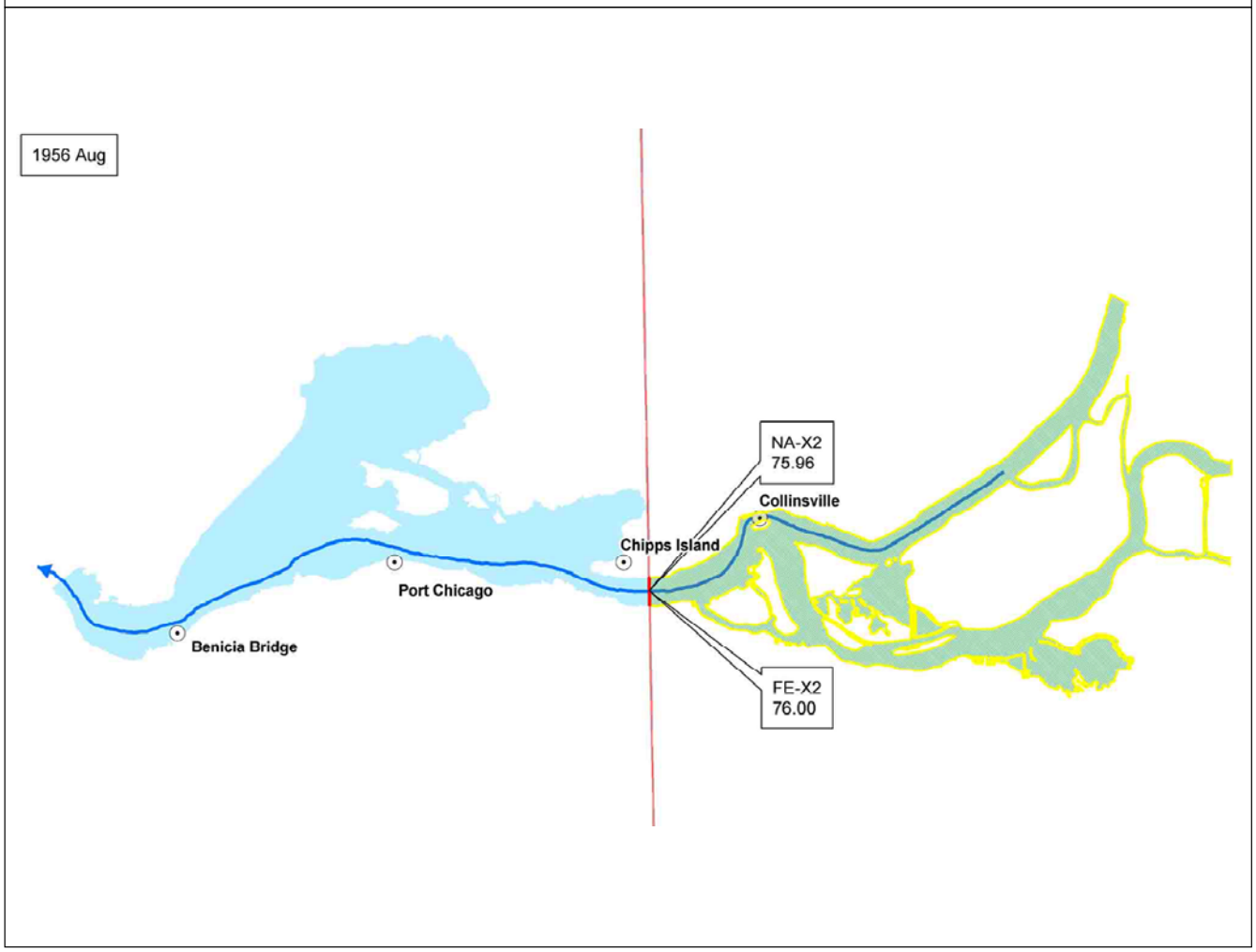
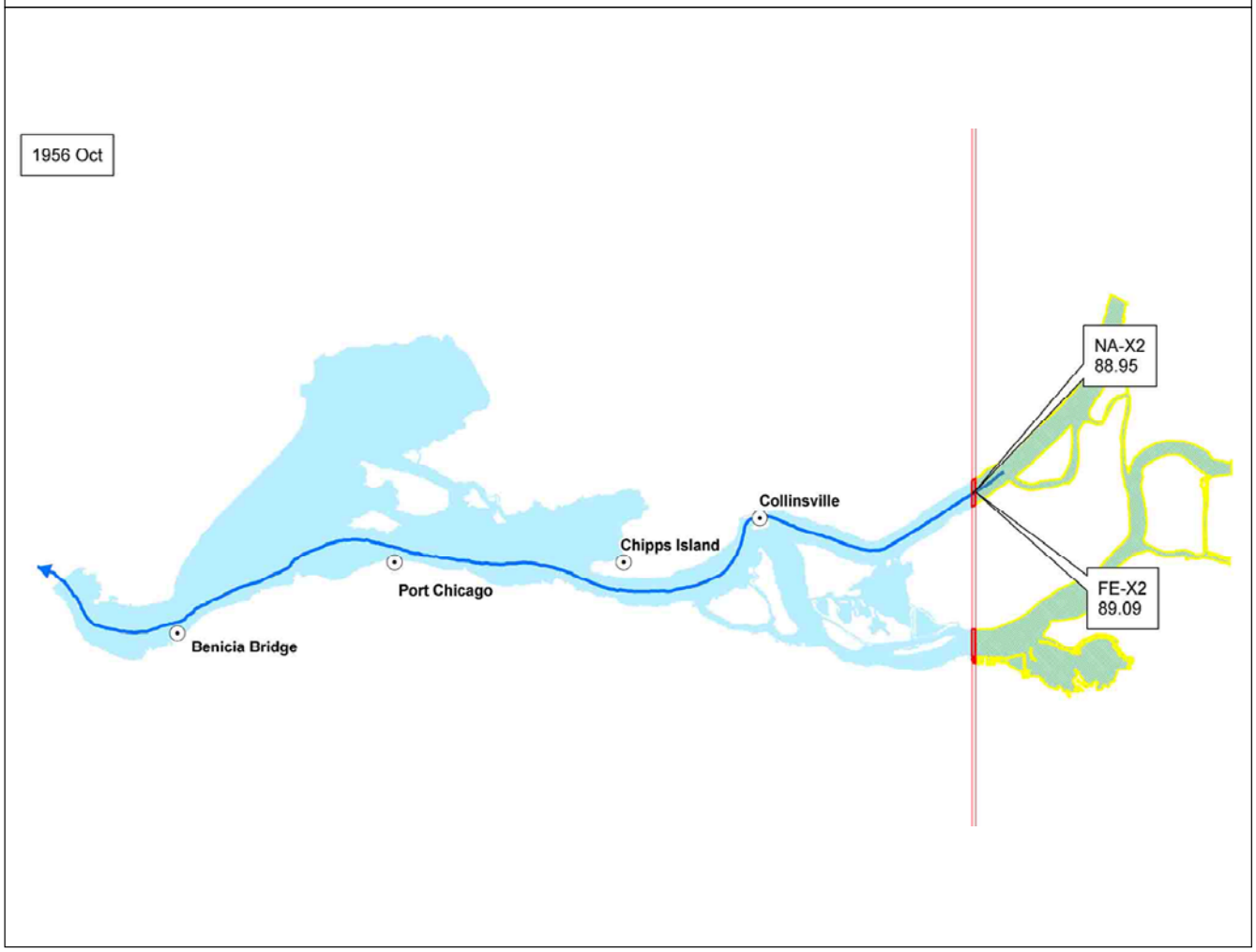
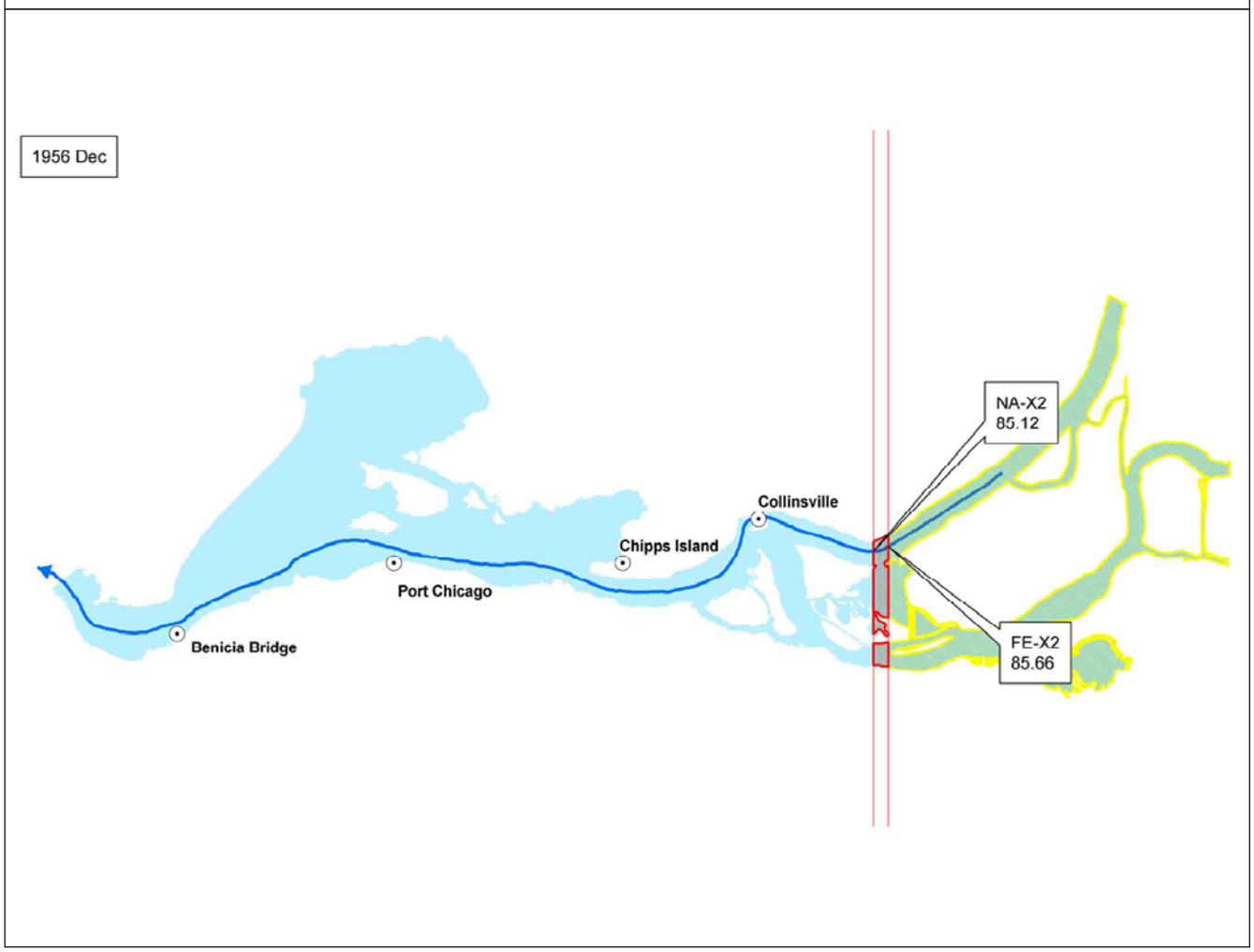
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
69.24


1956 Aug
NA-X2
75.96
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
76.00


1956 Sep
NA-X2
83.52
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
83.53


1956 Oct
NA-X2
88.95
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
89.09


1956 Nov
NA-X2
85.62
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
85.49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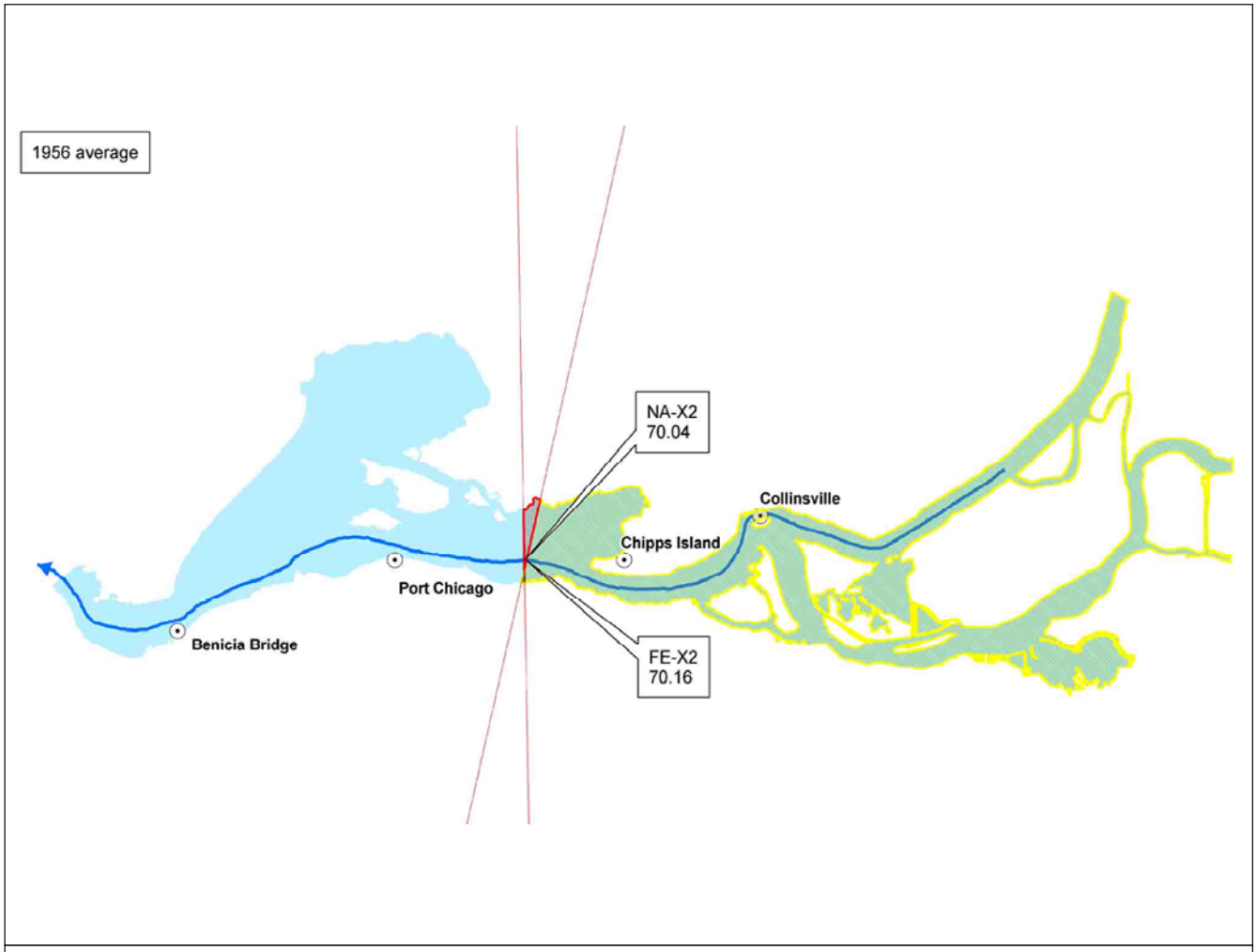
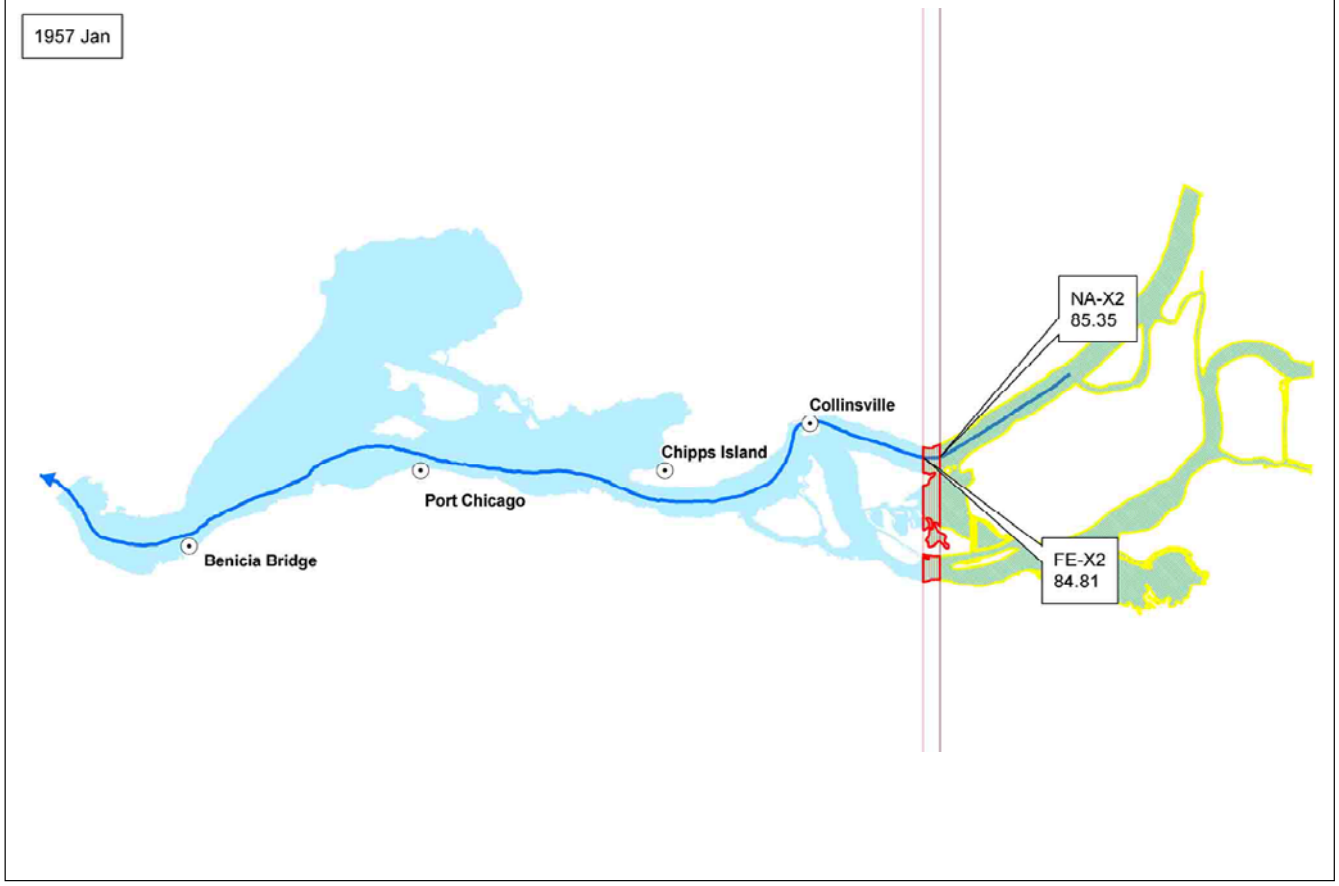
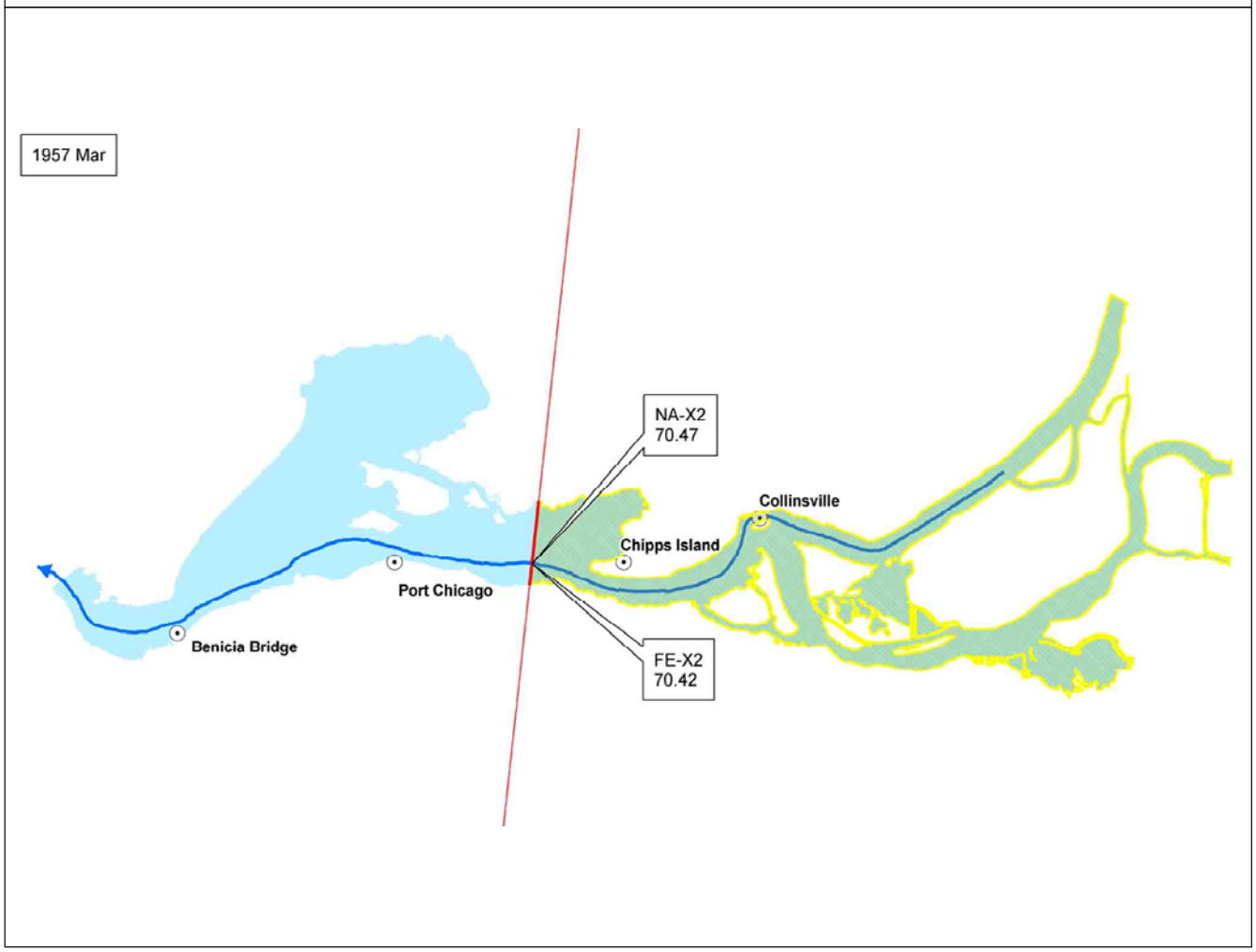
NA-X2
85.12
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
85.66


1956 average
NA-X2
70.04
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
70.16


1957 Jan
NA-X2
85.35
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
84.81


1957 Feb
NA-X2
81.84
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
81.95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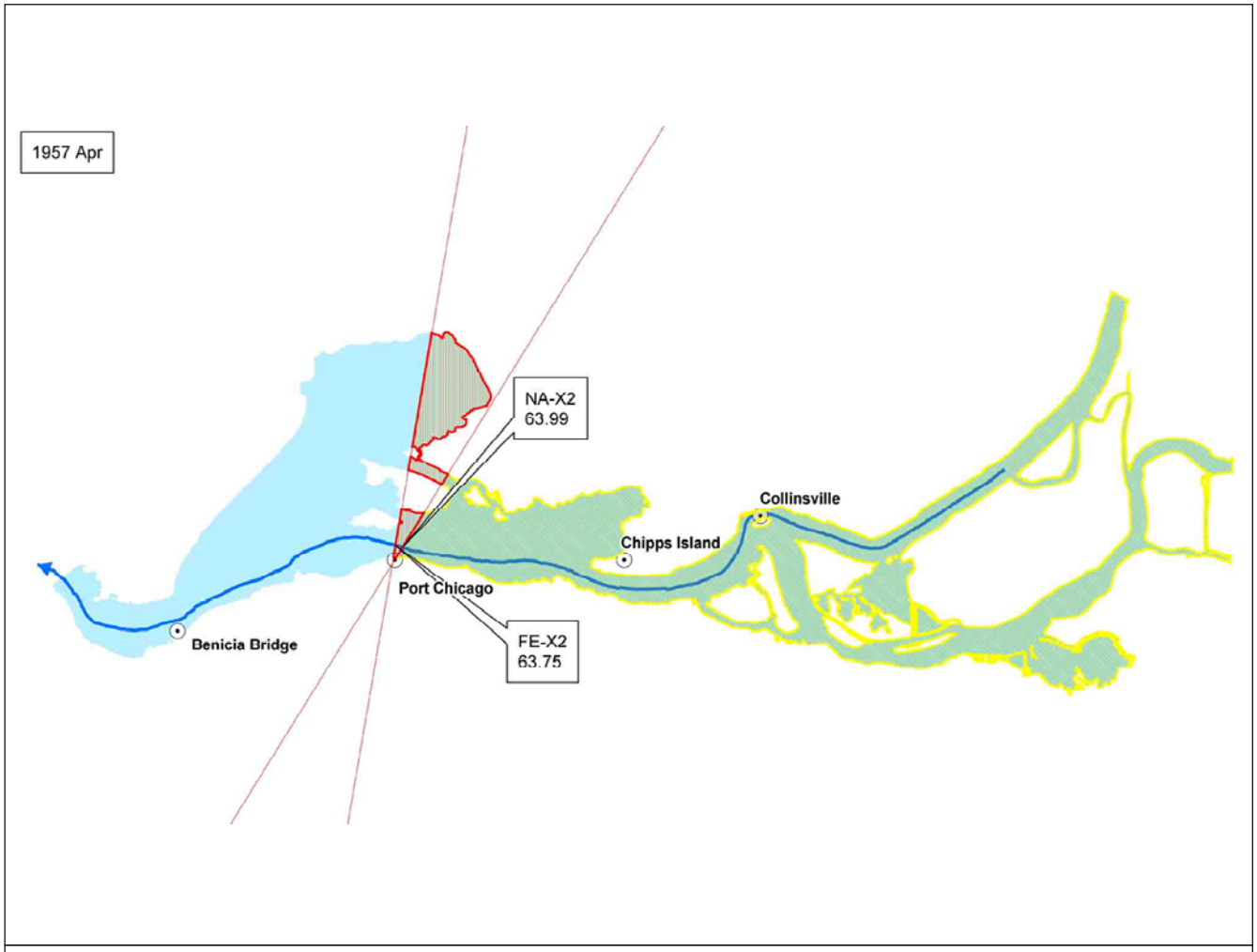
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
70.42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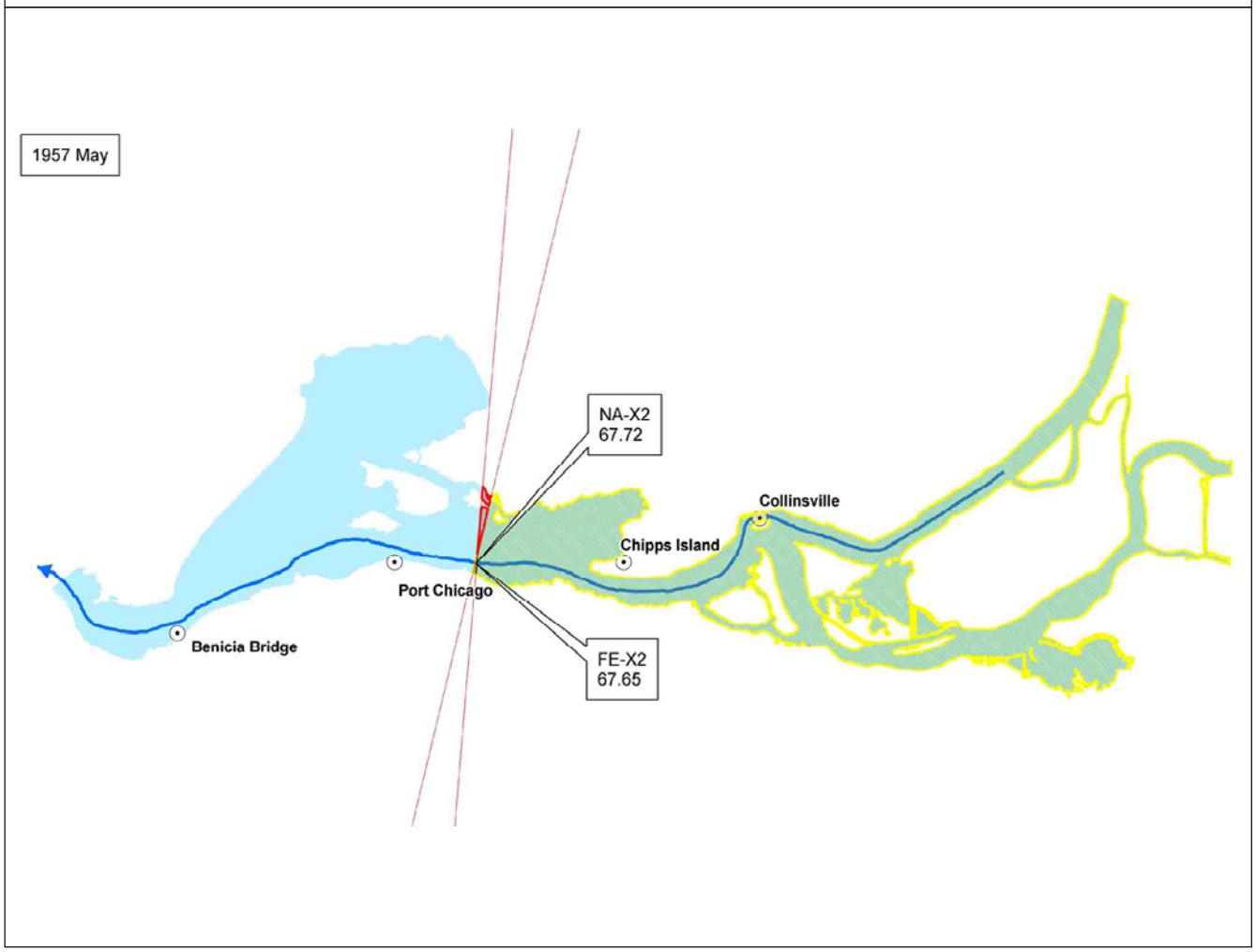
NA-X2
63.99
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
63.75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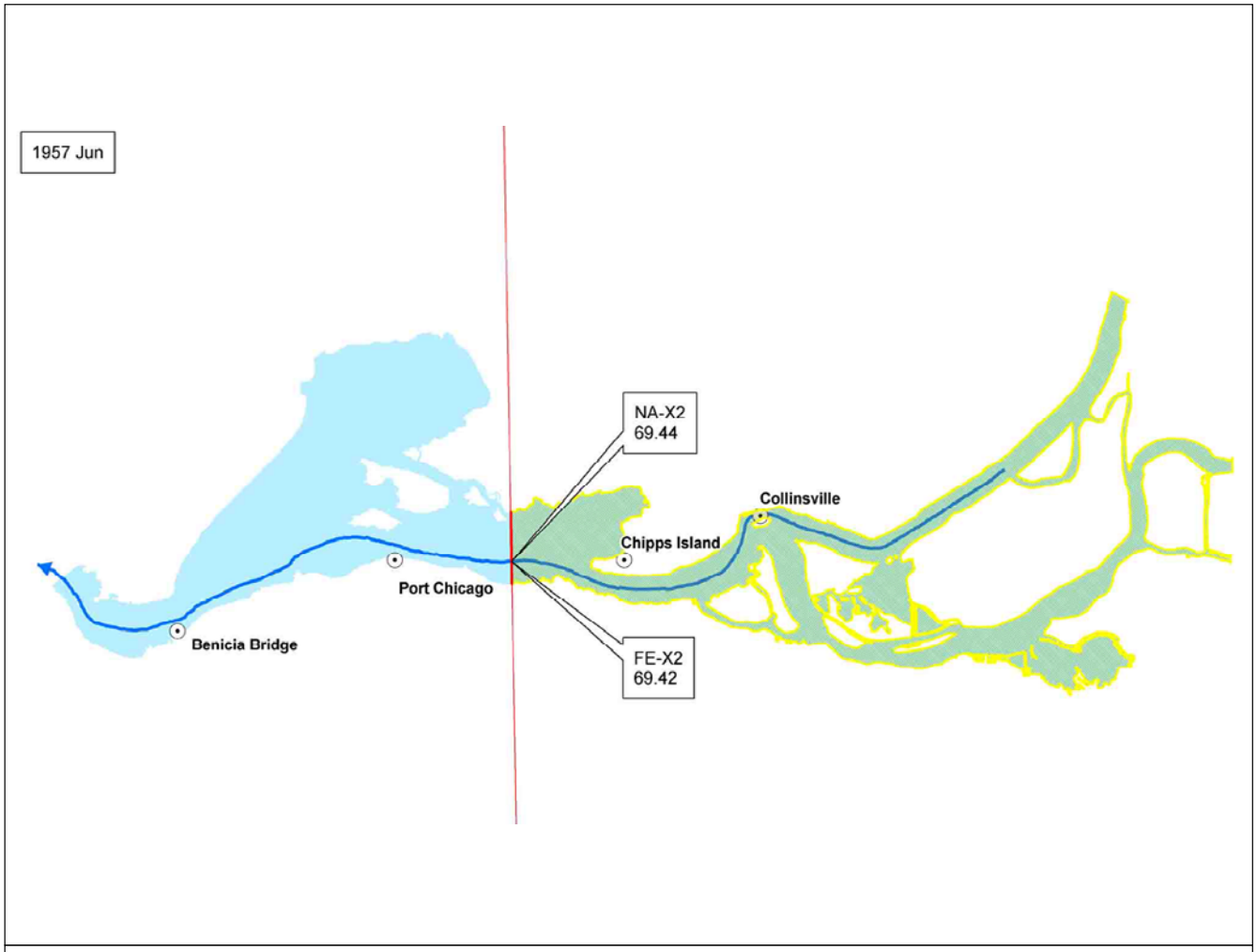
NA-X2
67.72
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
67.65


1957 Jun
NA-X2
69.44
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
69.42


1957 Jul
NA-X2
75.43
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
75.43

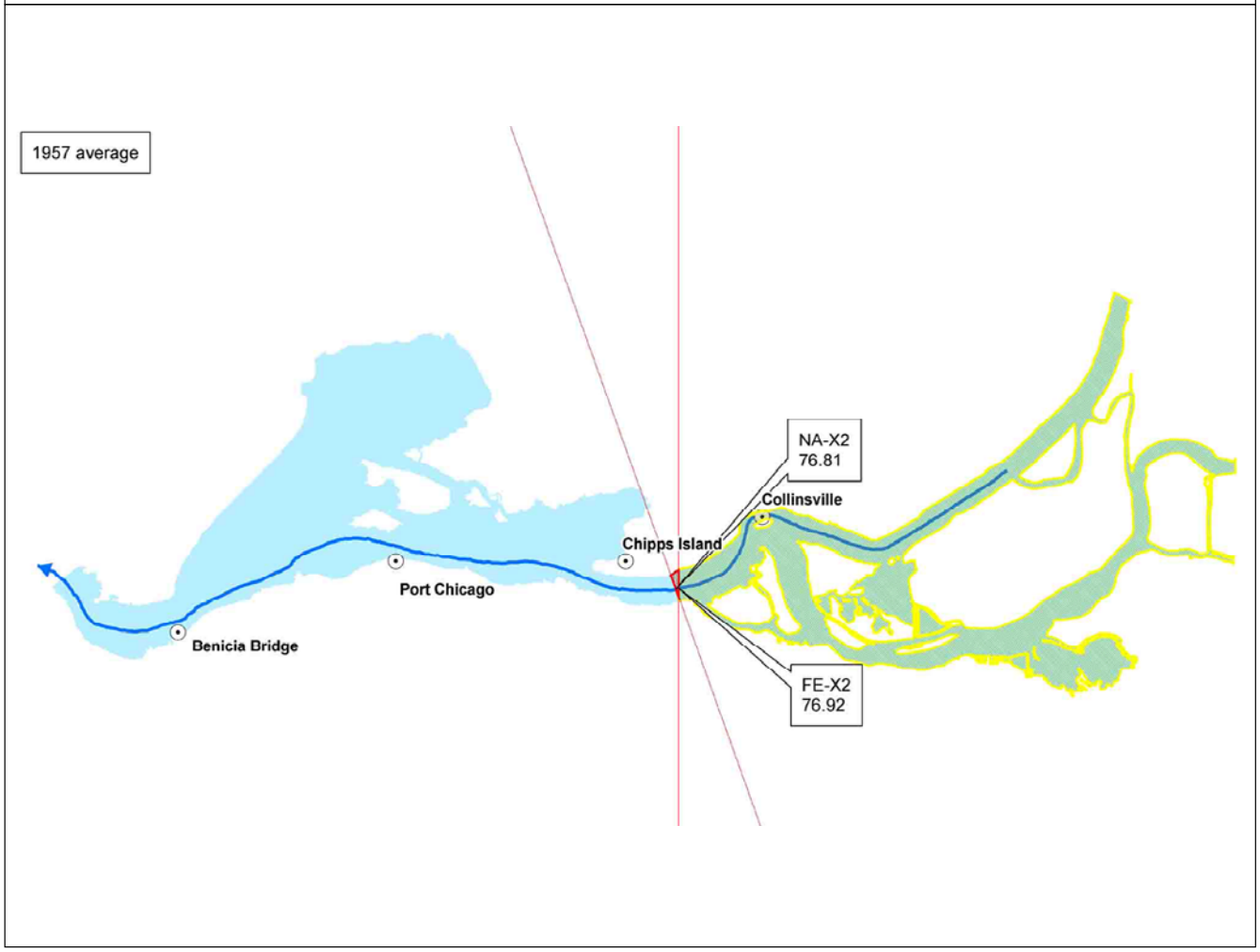

1957 Aug
NA-X2
77.83
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
77.48


1957 Sep
NA-X2
84.13
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
84.02


1957 Oct
NA-X2
80.10
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
81.79

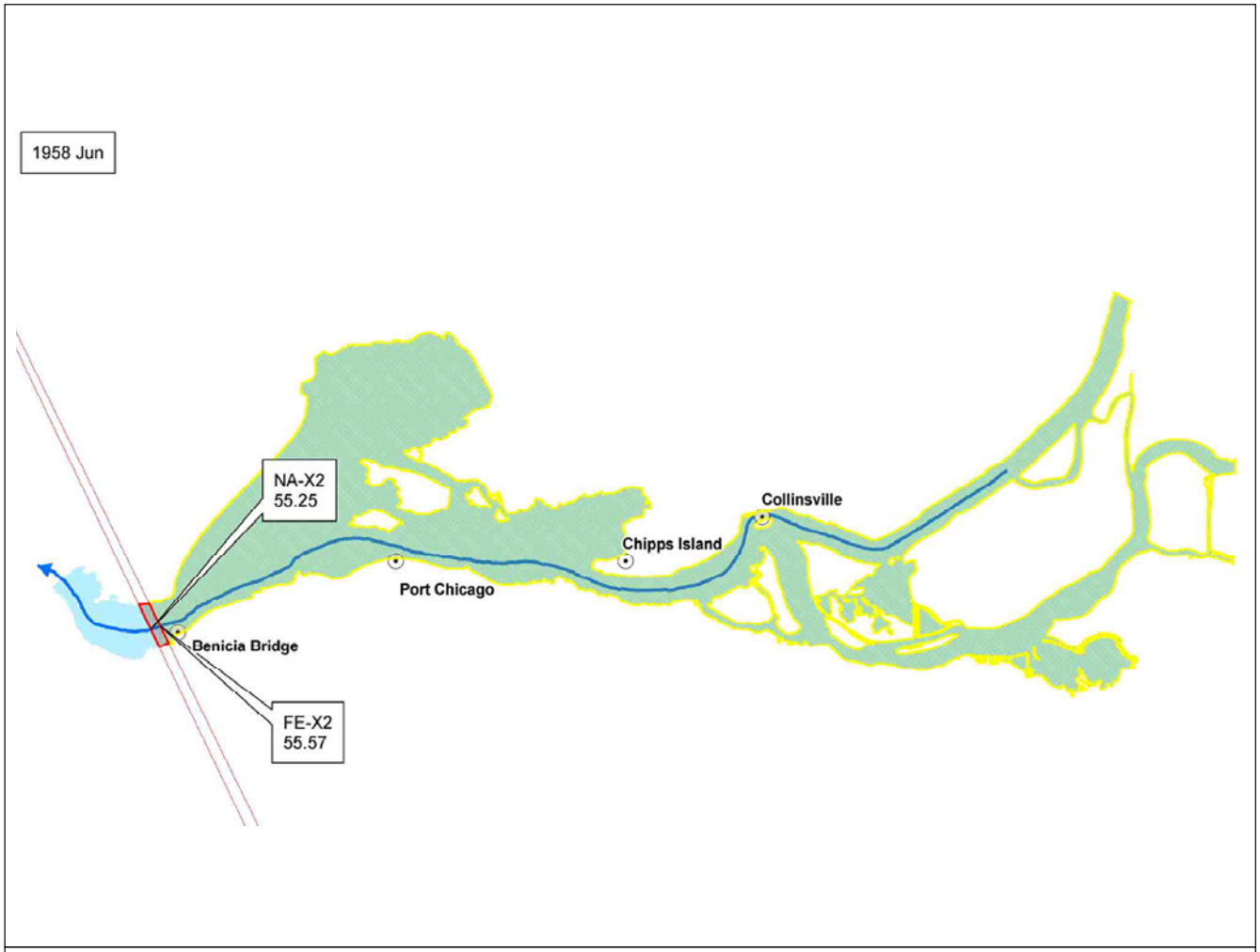

1957 Nov
NA-X2
81.12
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
81.78


1957 Dec
NA-X2
84.31
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
84.52


1957 average
NA-X2
76.81
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
76.92


1958 Jan
NA-X2
75.77
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
76.37


1958 Feb
NA-X2
67.03
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
67.46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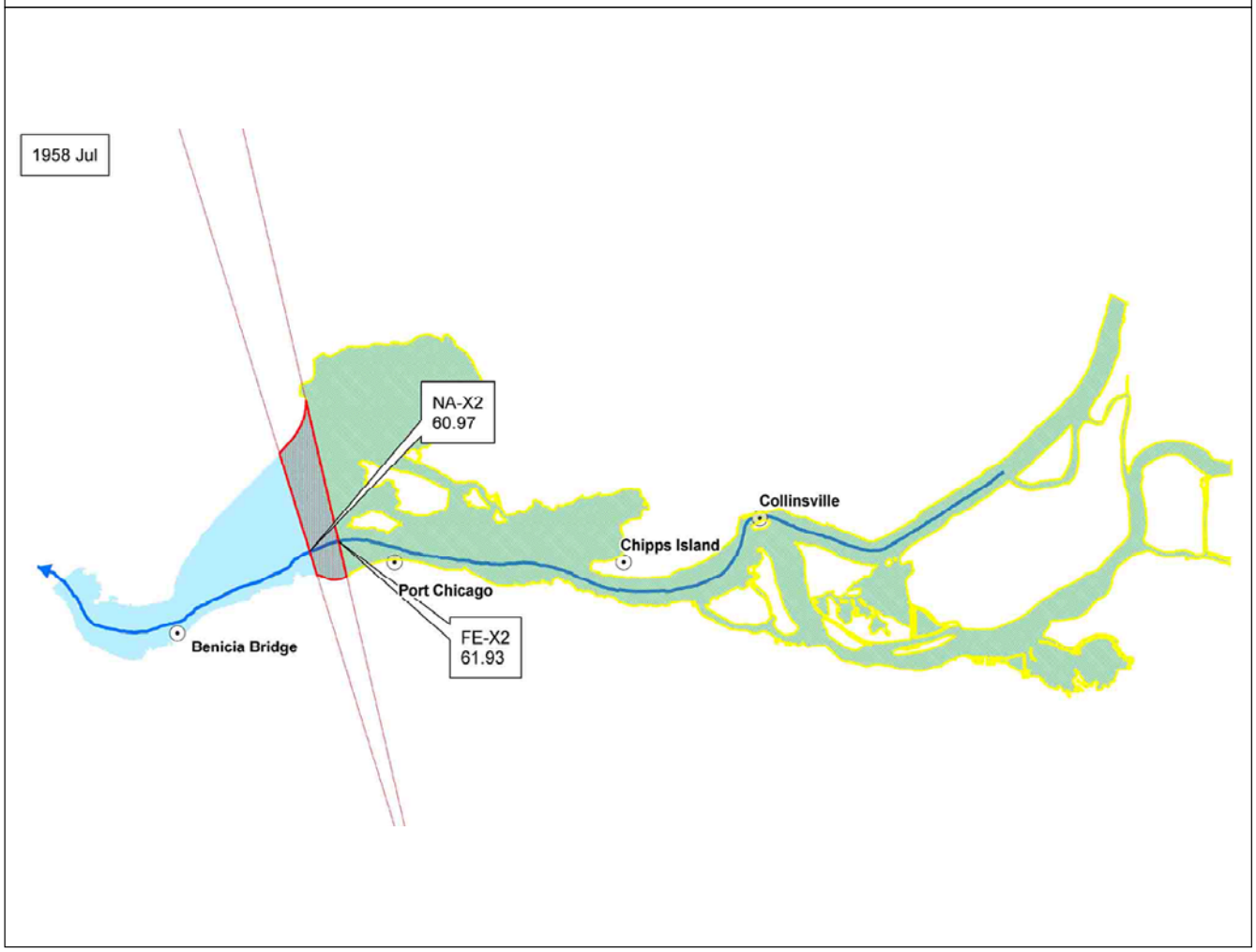
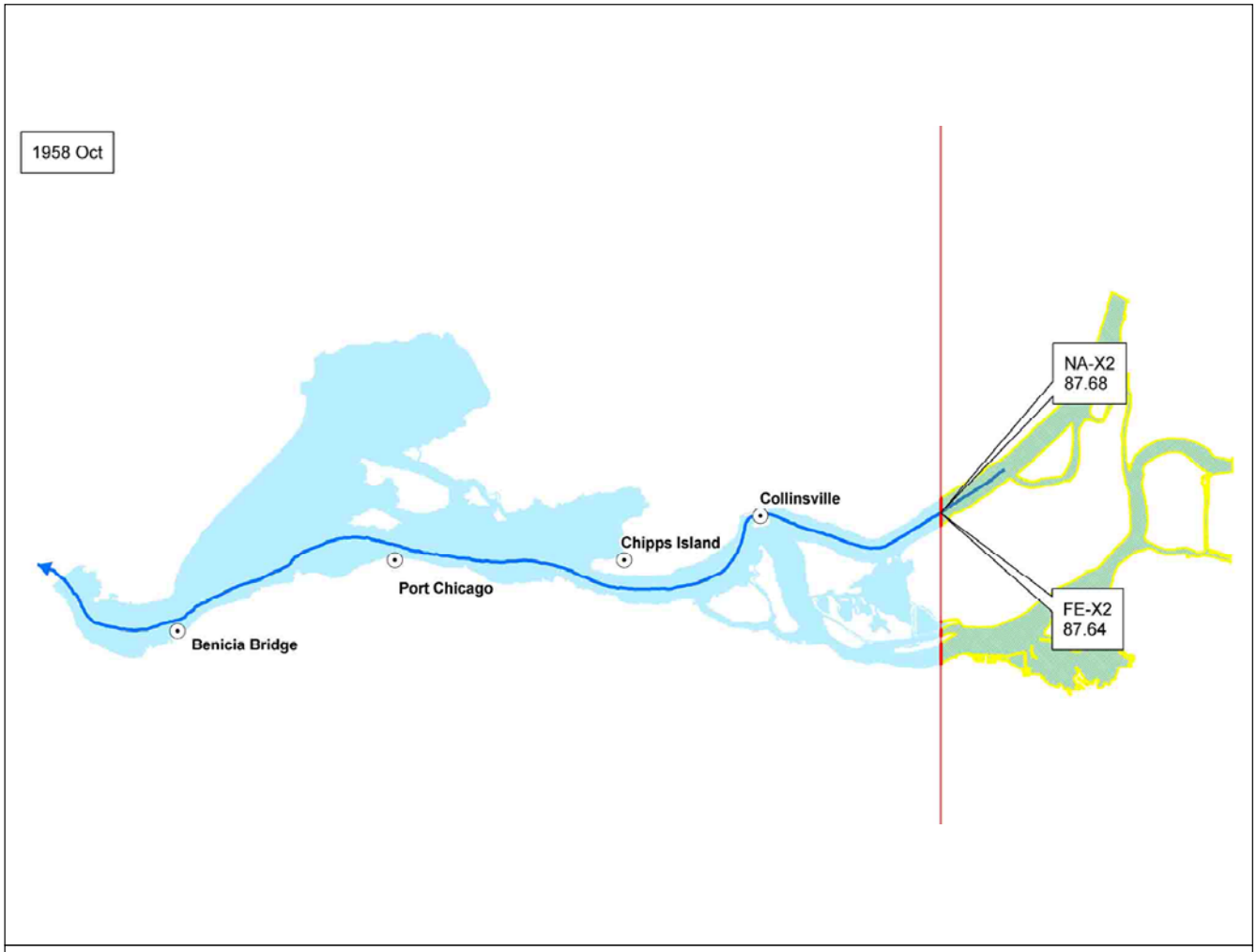
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
55.57


1958 Jul
NA-X2
60.97
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
61.93


1958 Aug
NA-X2
73.29
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
73.61


1958 Sep
NA-X2
82.65
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
82.75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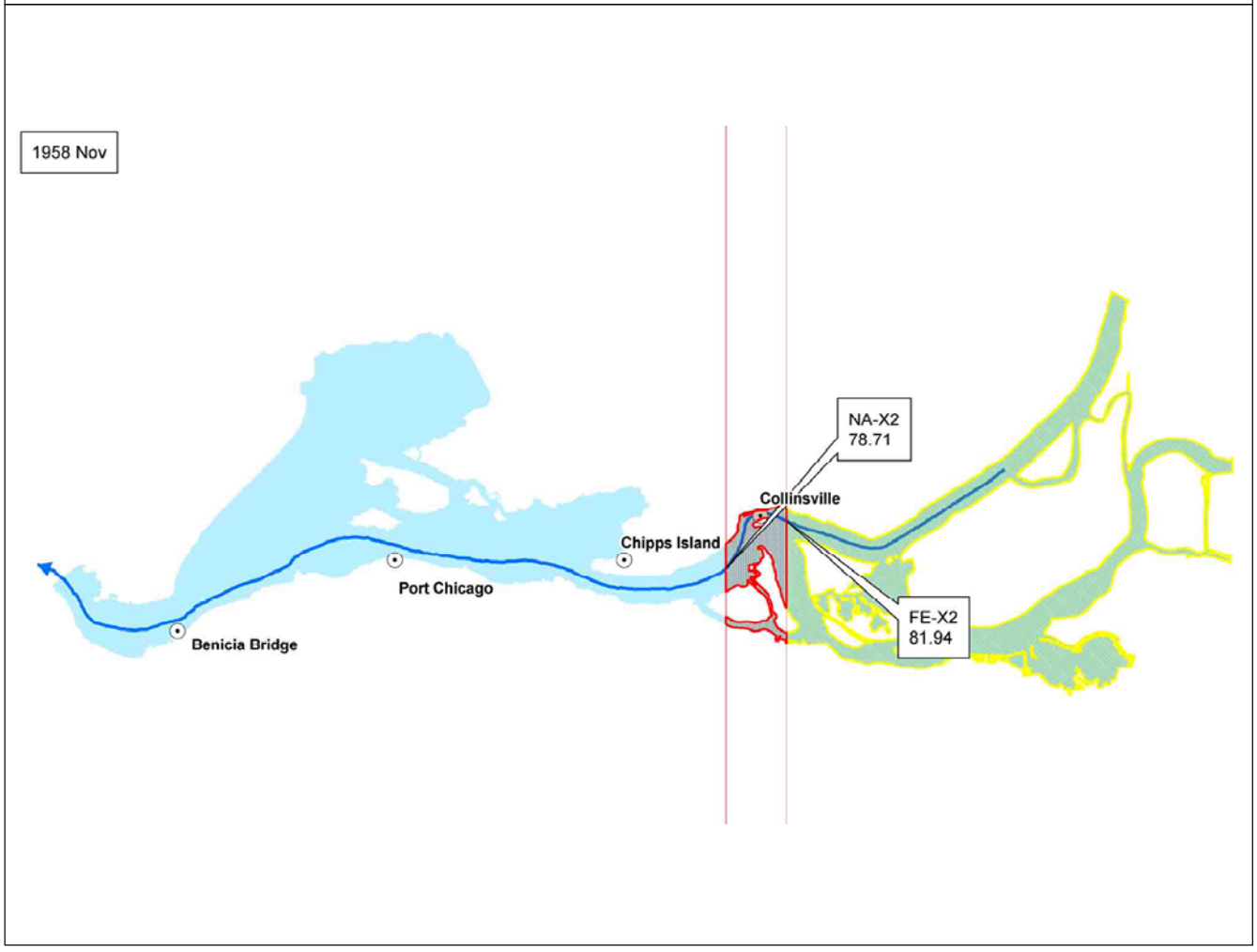
NA-X2
87.68
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
87.64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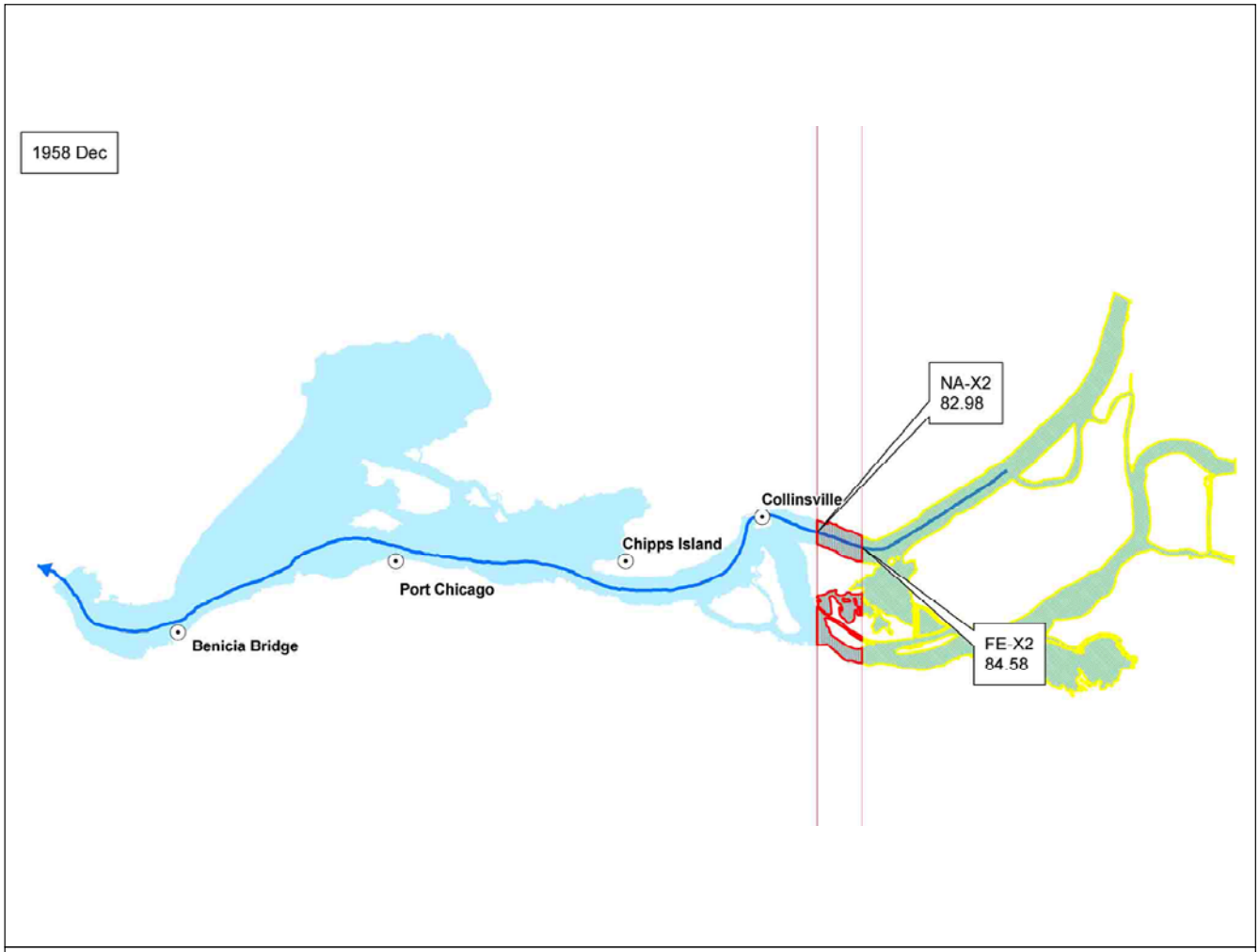
NA-X2
78.71
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
81.94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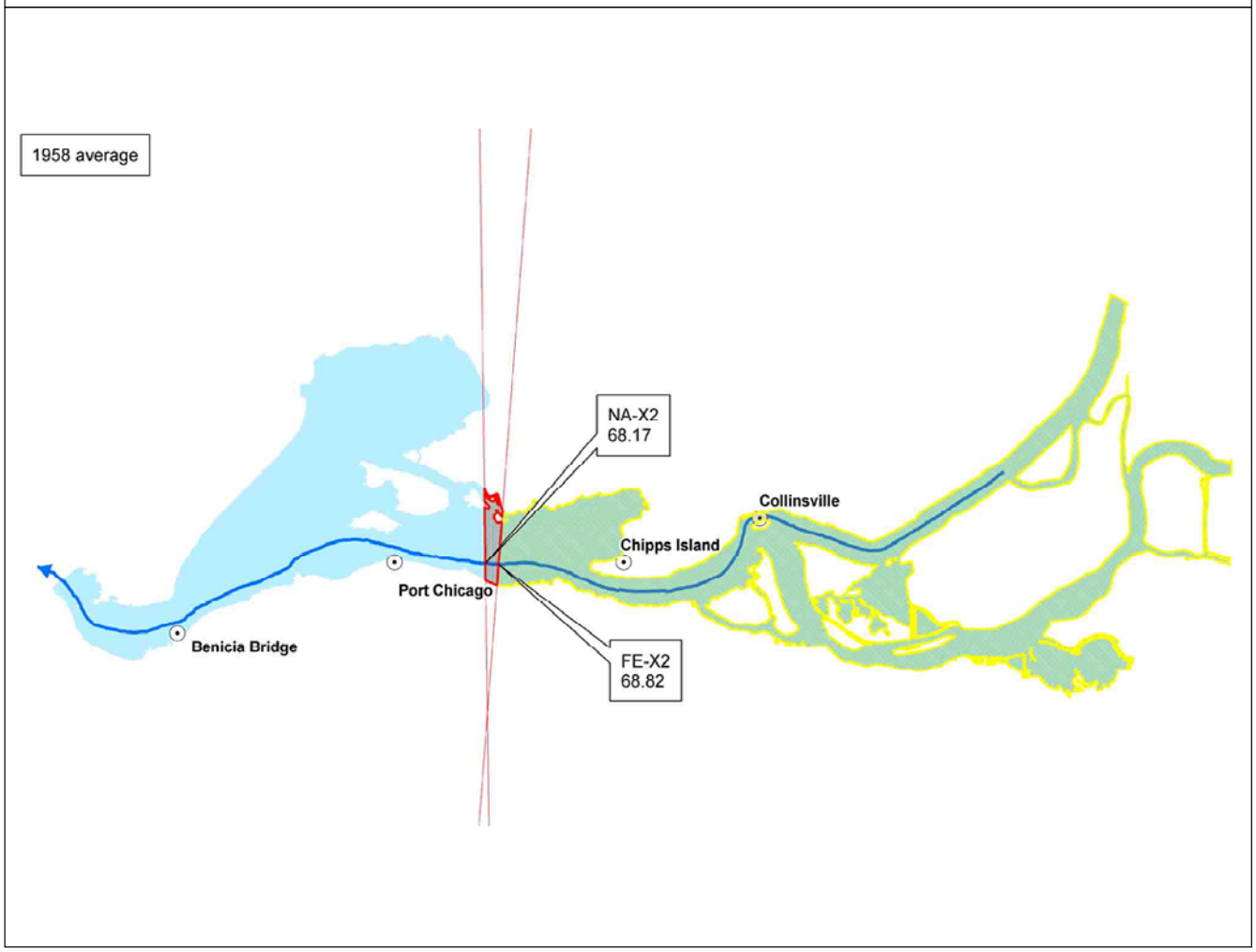
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
84.58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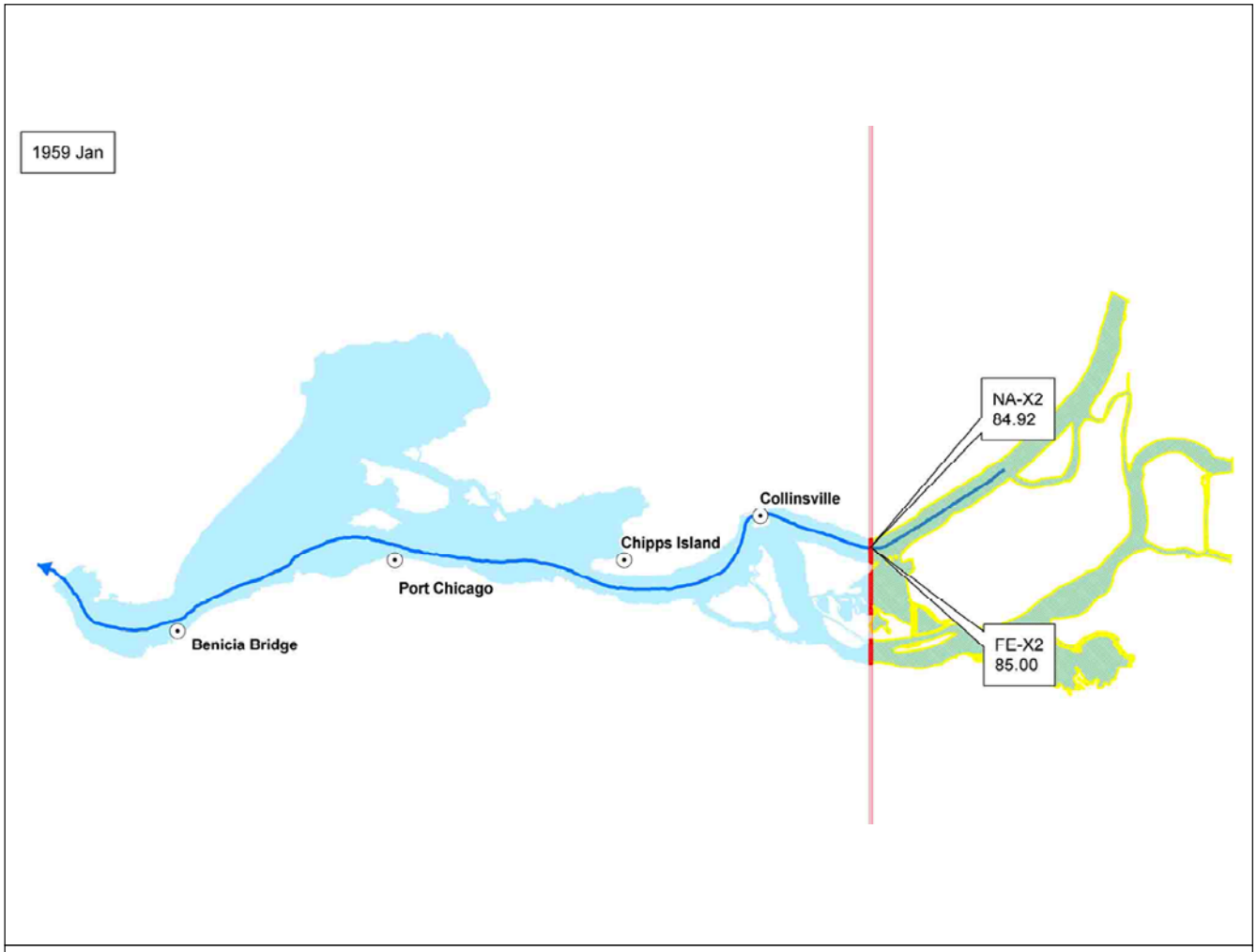
NA-X2
68.17
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
68.82


1959 Jan
NA-X2
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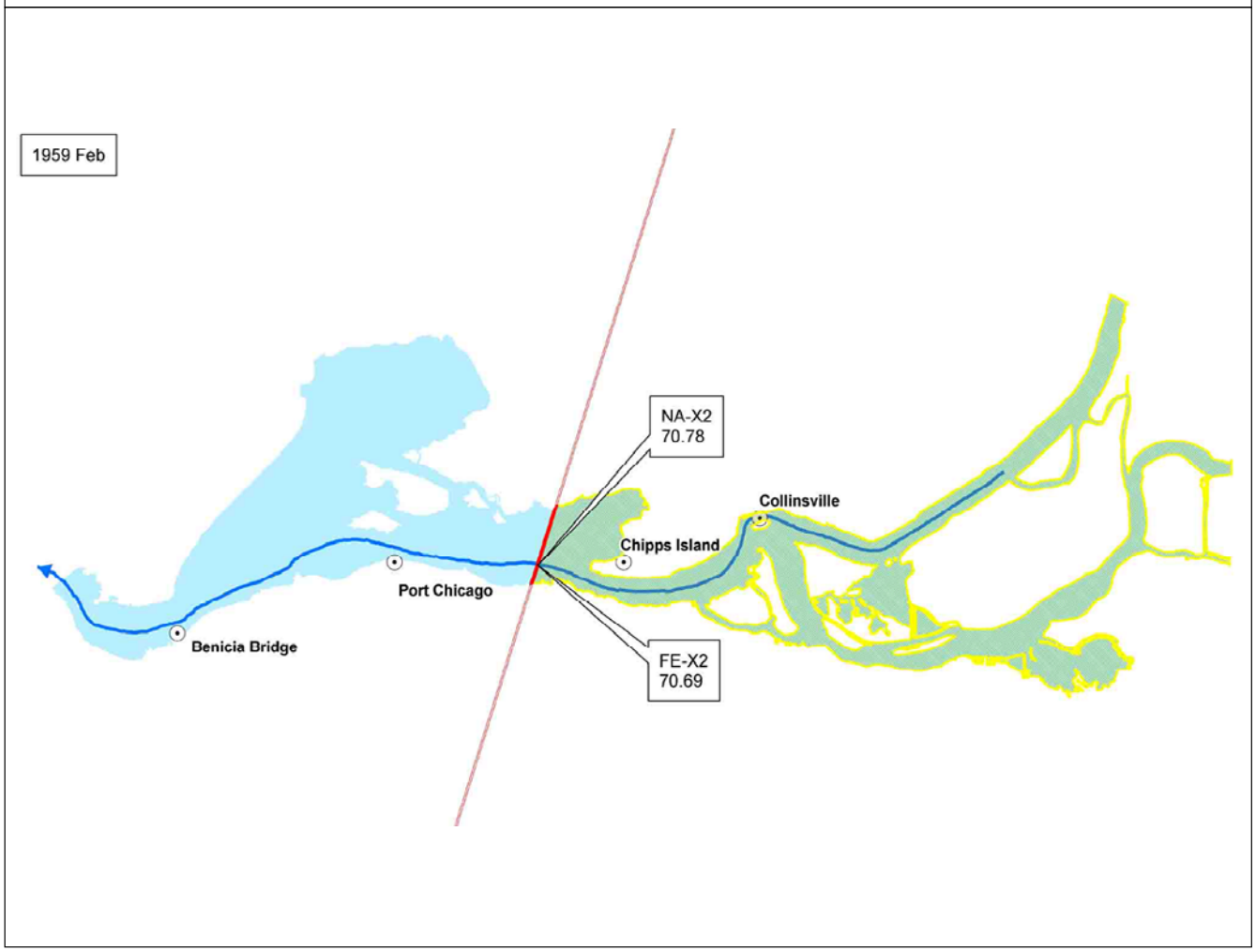
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
85.00


1959 Feb
NA-X2
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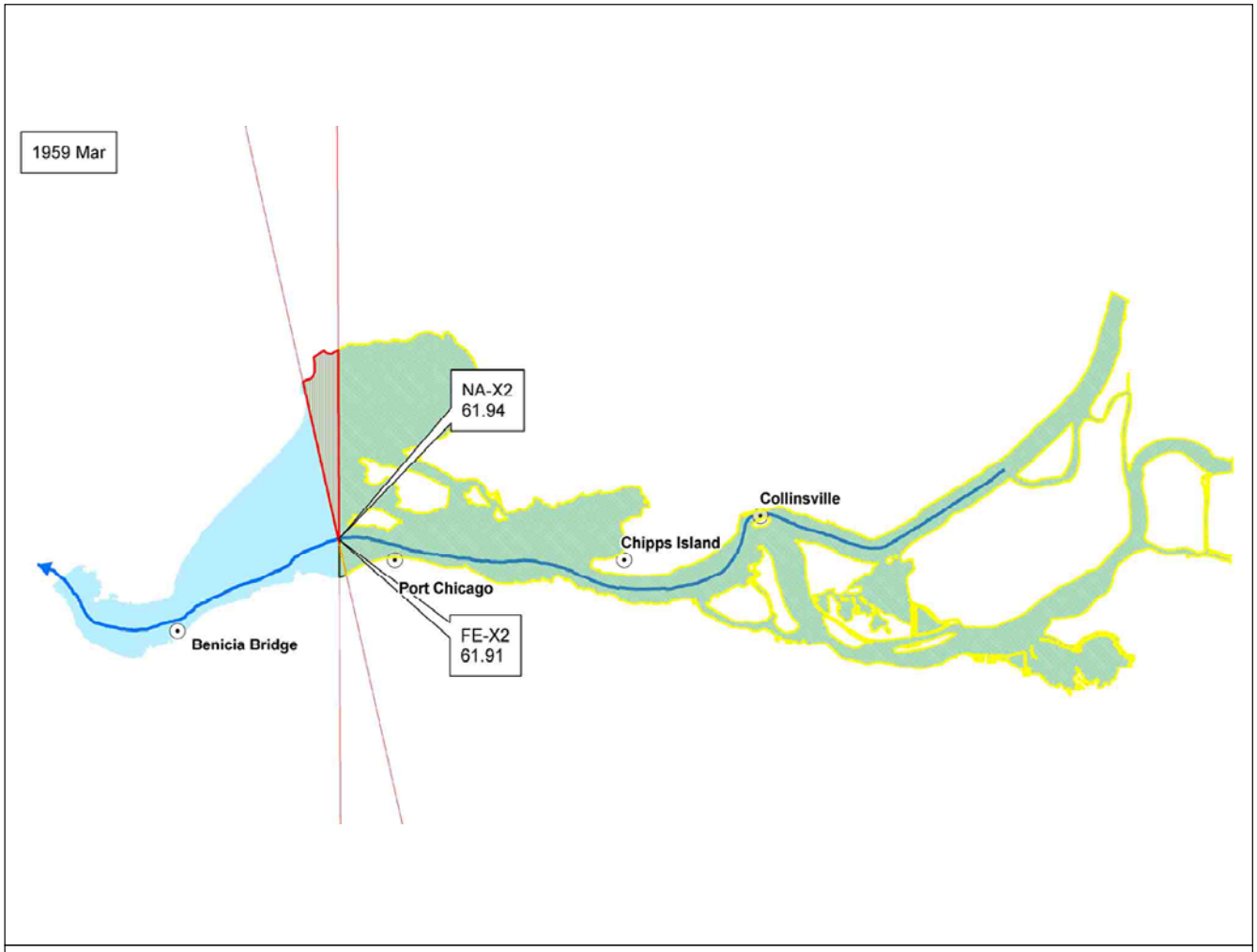
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
70.69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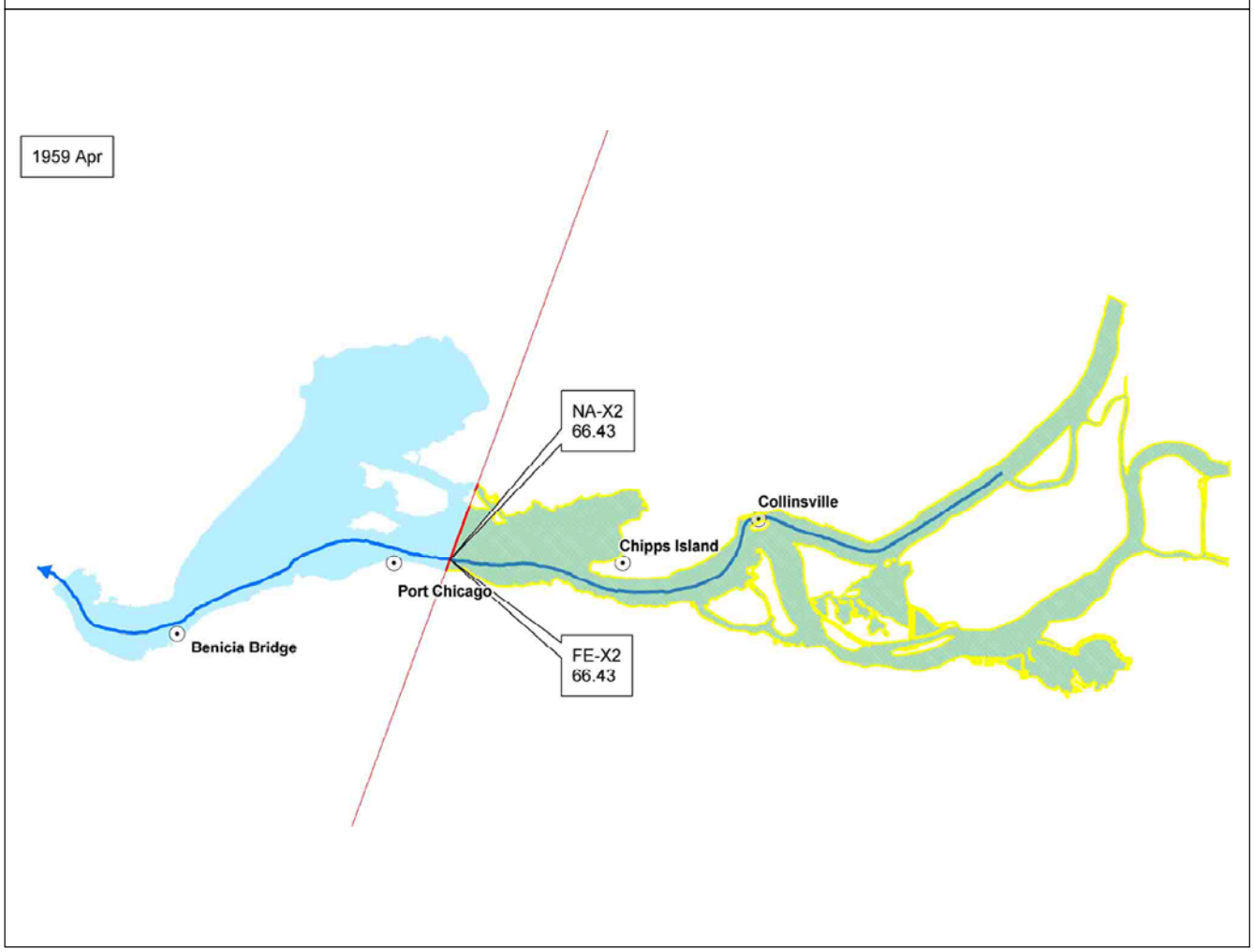
Collinsville
Chipps Island
Port Chicago
FE-X2
61.91
Benicia Bridge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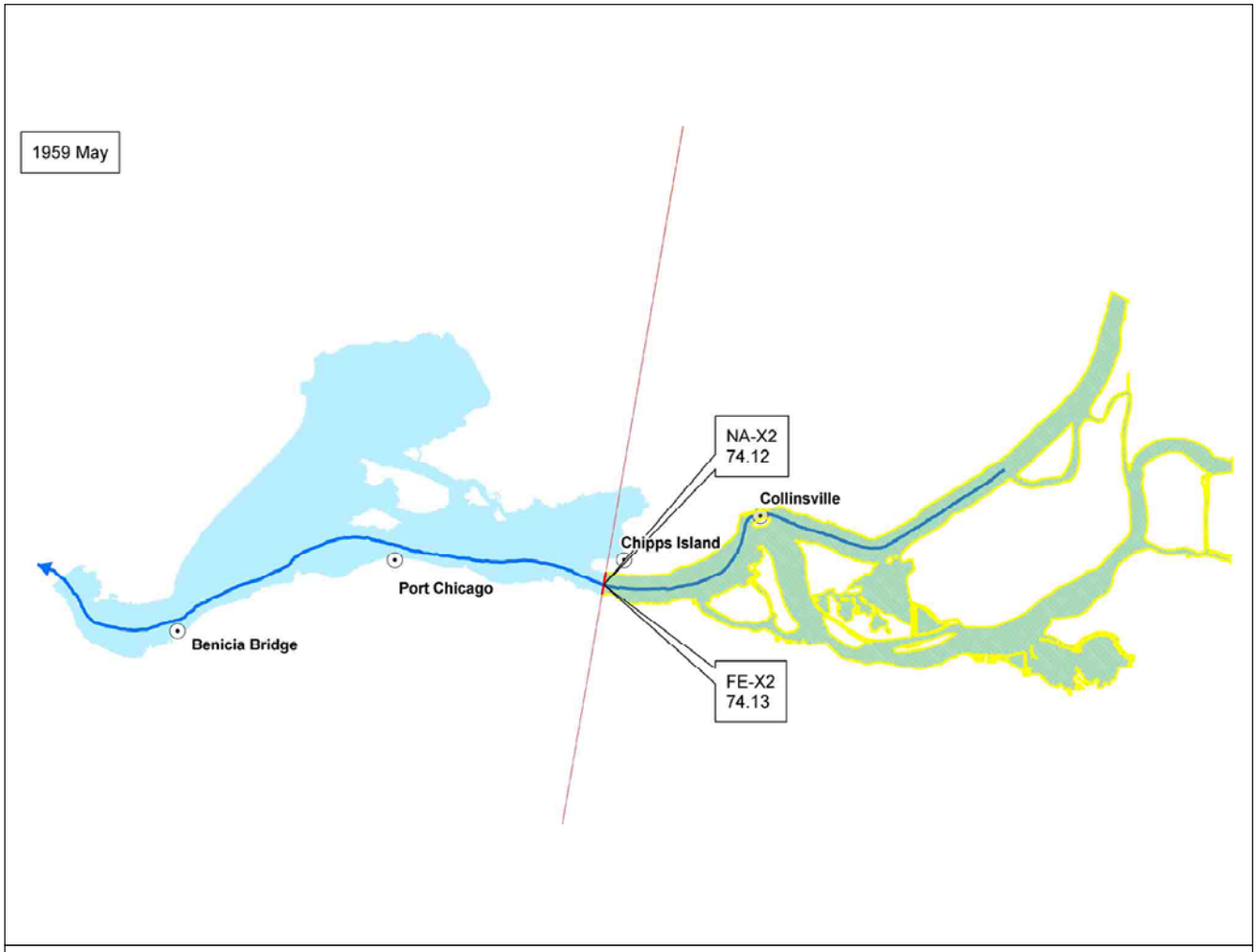
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
66.43

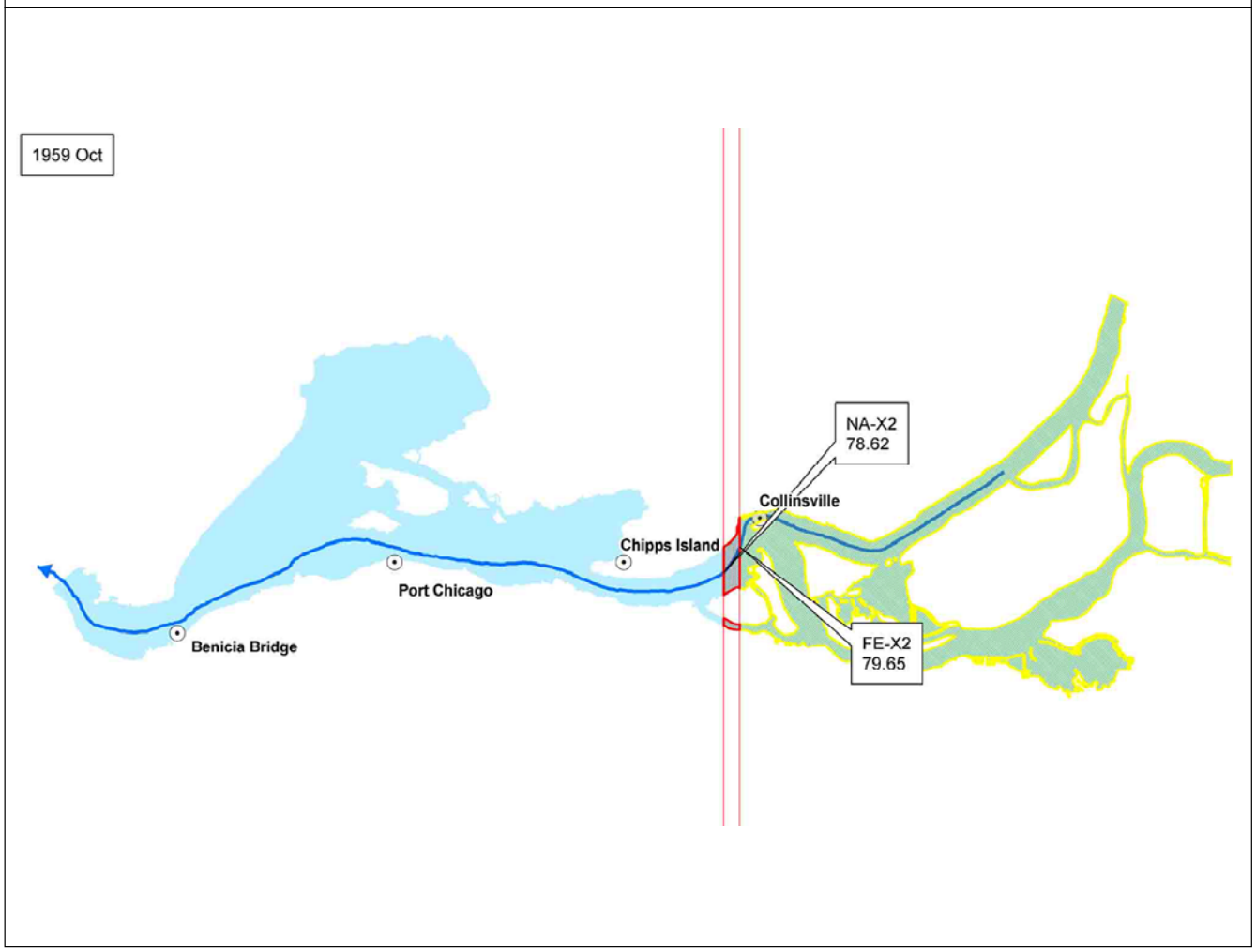

1959 May
NA-X2
74.12
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
74.13


1959 Jun
NA-X2
76.79
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
76.67


1959 Jul
NA-X2
77.98
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
78.25


1959 Aug
NA-X2
79.87
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
79.72


1959 Sep
NA-X2
84.80
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
84.75


1959 Oct
NA-X2
78.62
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
79.65


1959 Nov
NA-X2
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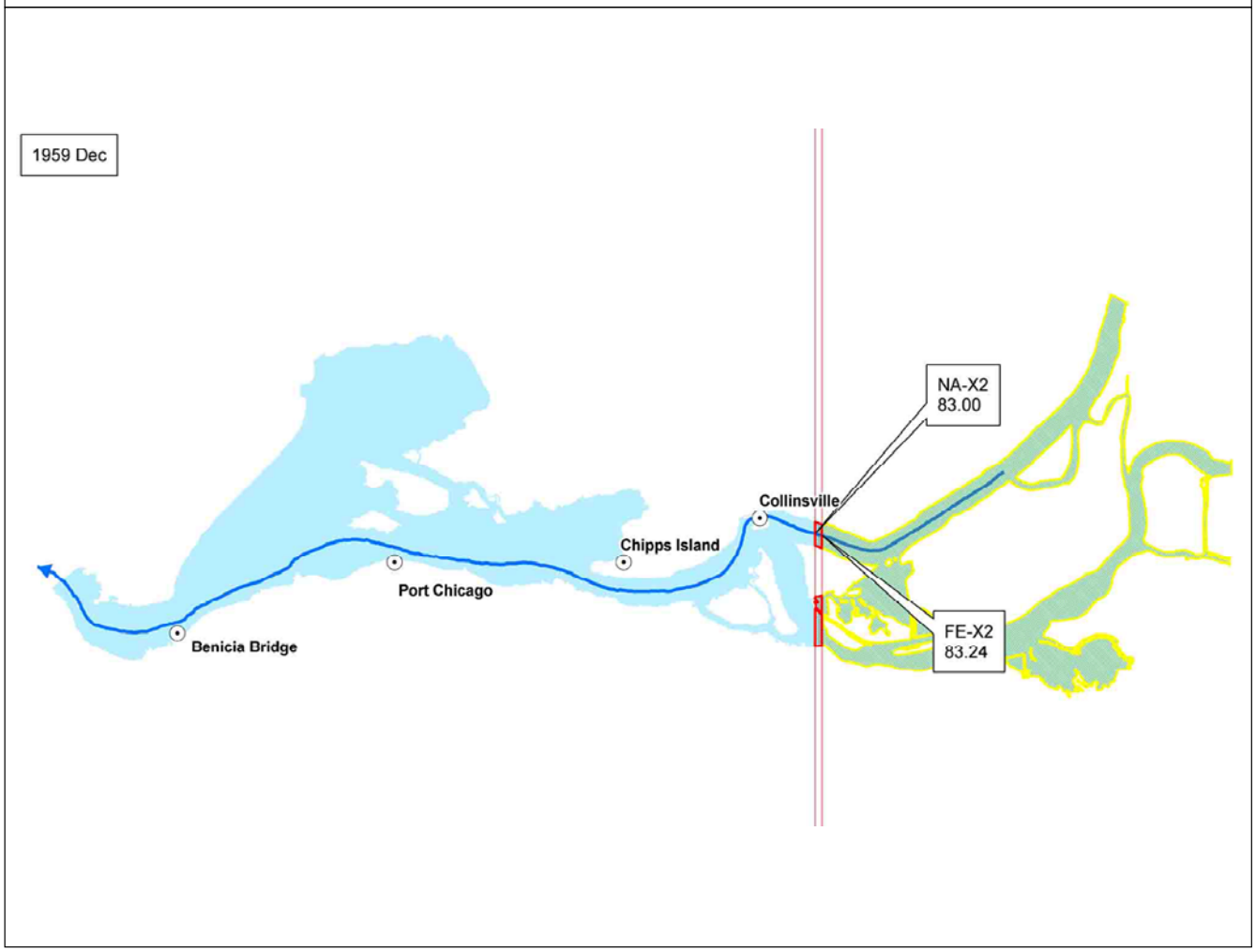
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
77.85


1959 Dec
NA-X2
83.00
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
83.24

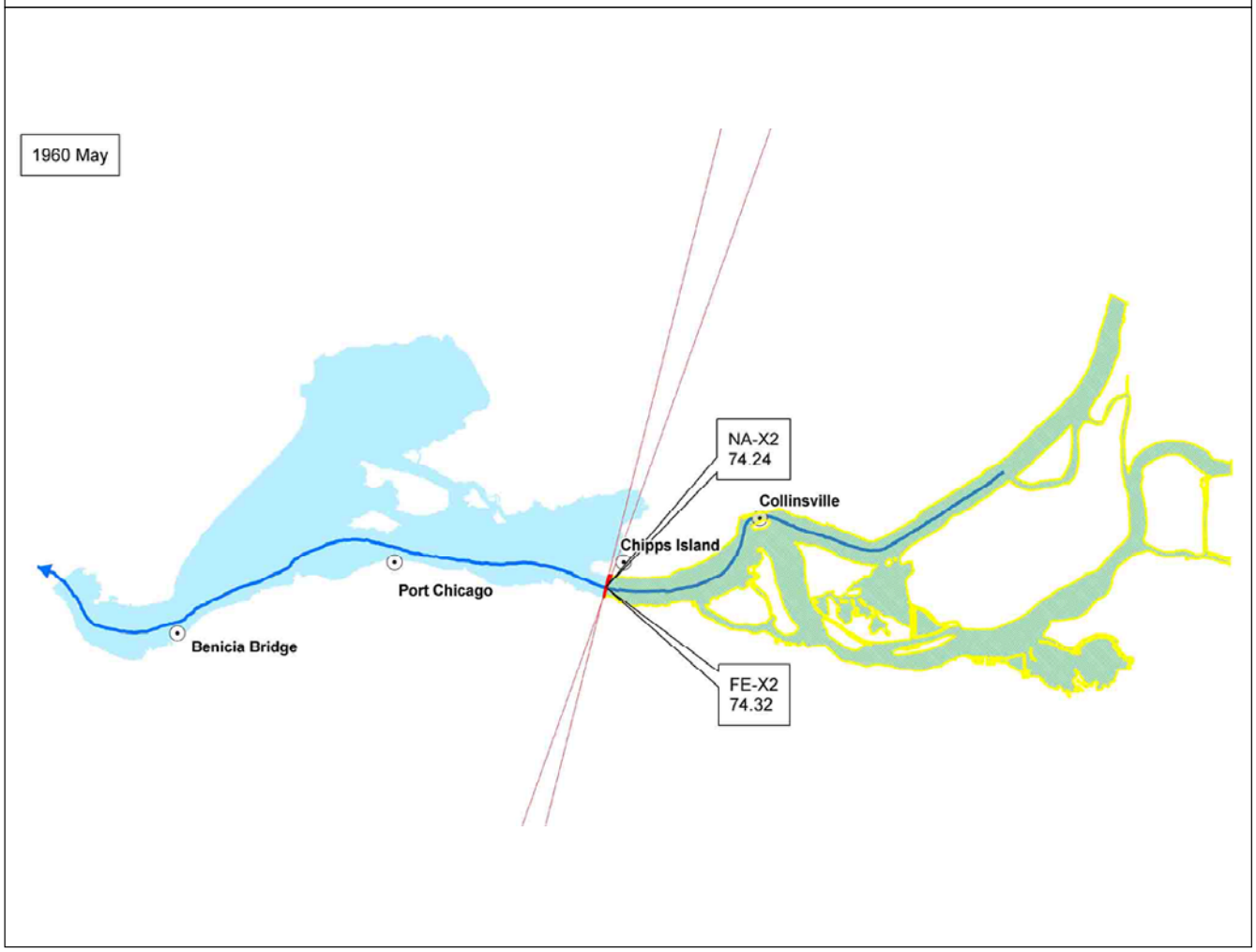

1959 average
NA-X2
76.37
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
76.53


1960 Jan
NA-X2
84.87
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
83.02


1960 Feb
NA-X2
82.36
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
81.79


1960 Mar
NA-X2
71.59
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
72.27


1960 Apr
NA-X2
72.15
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
72.38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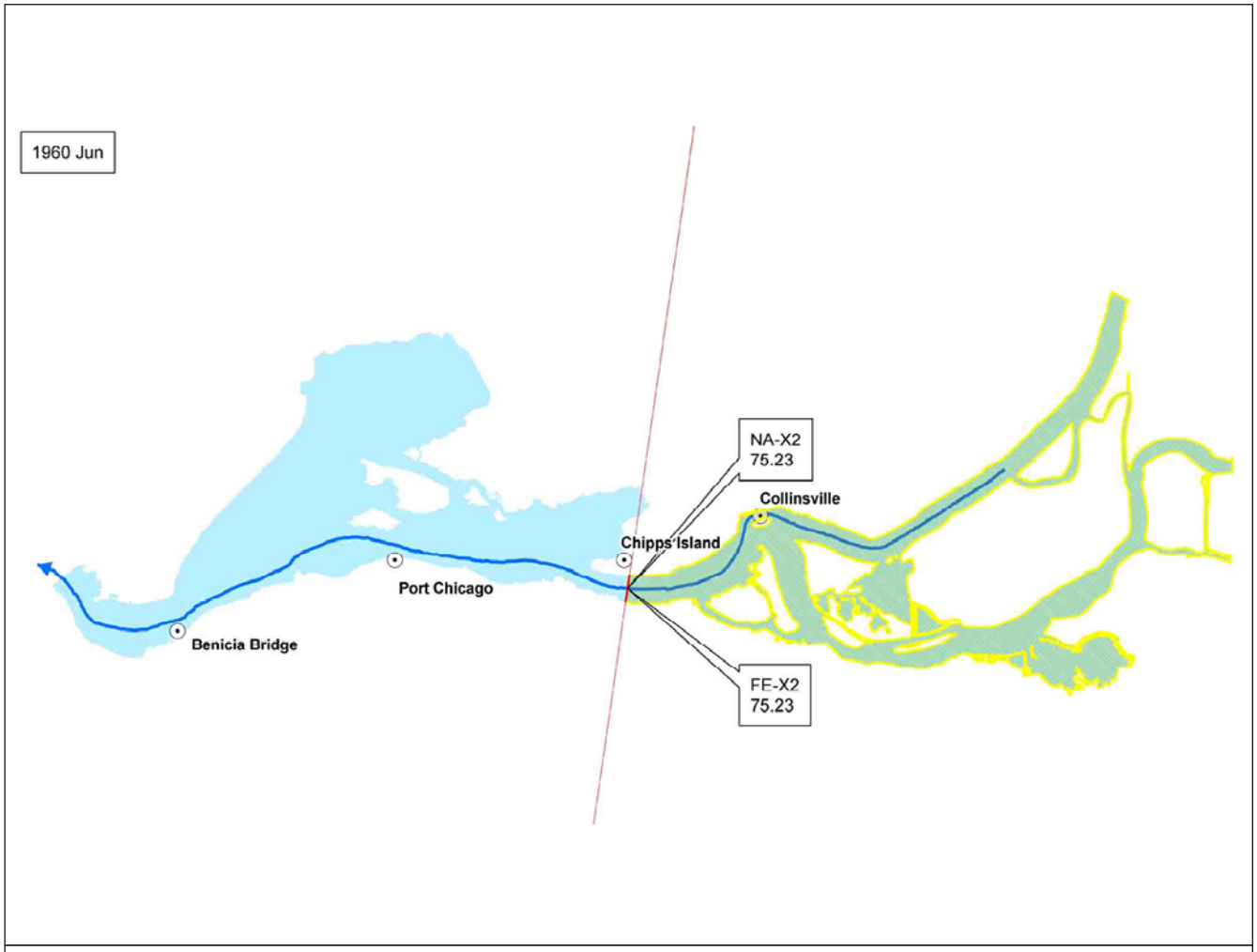
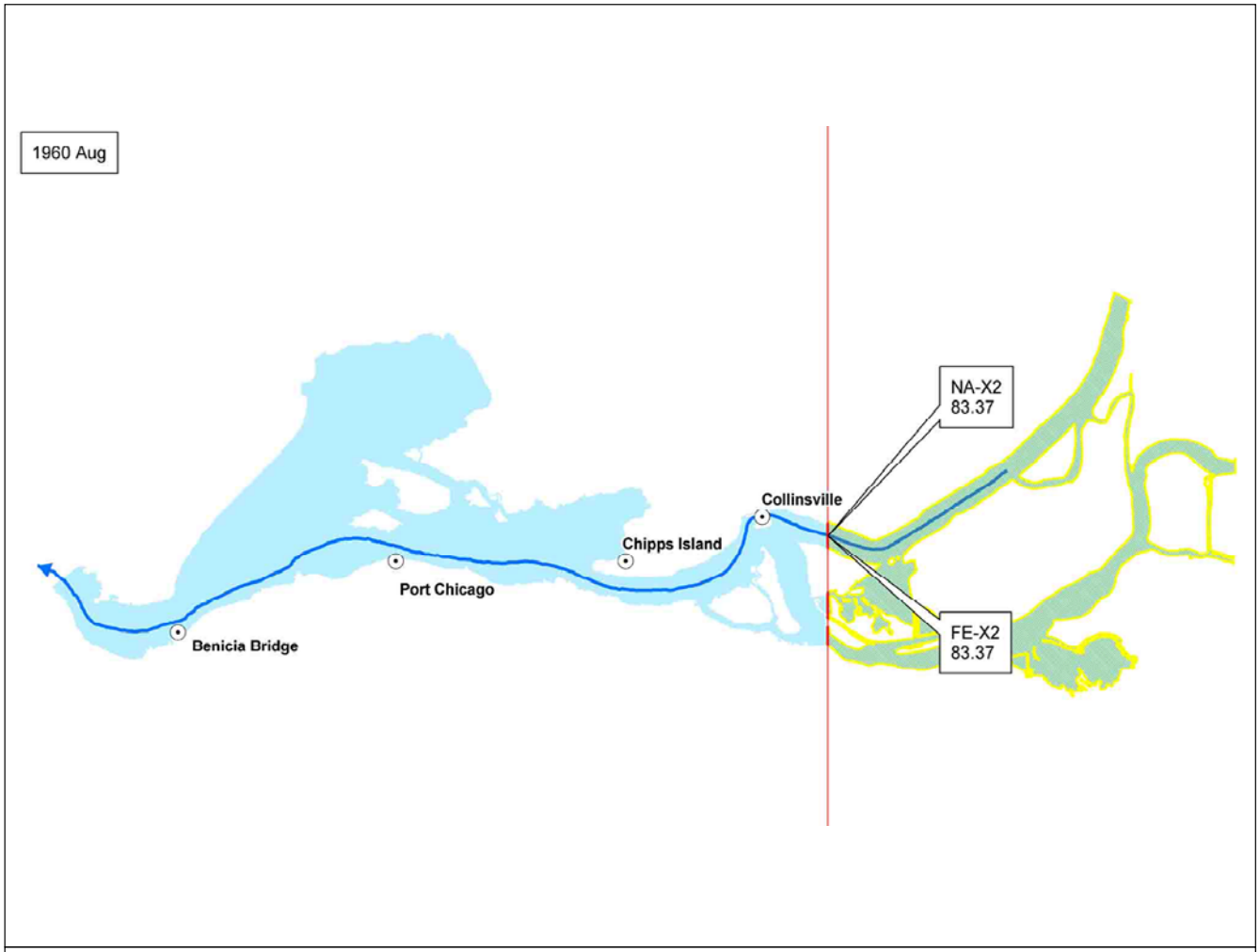
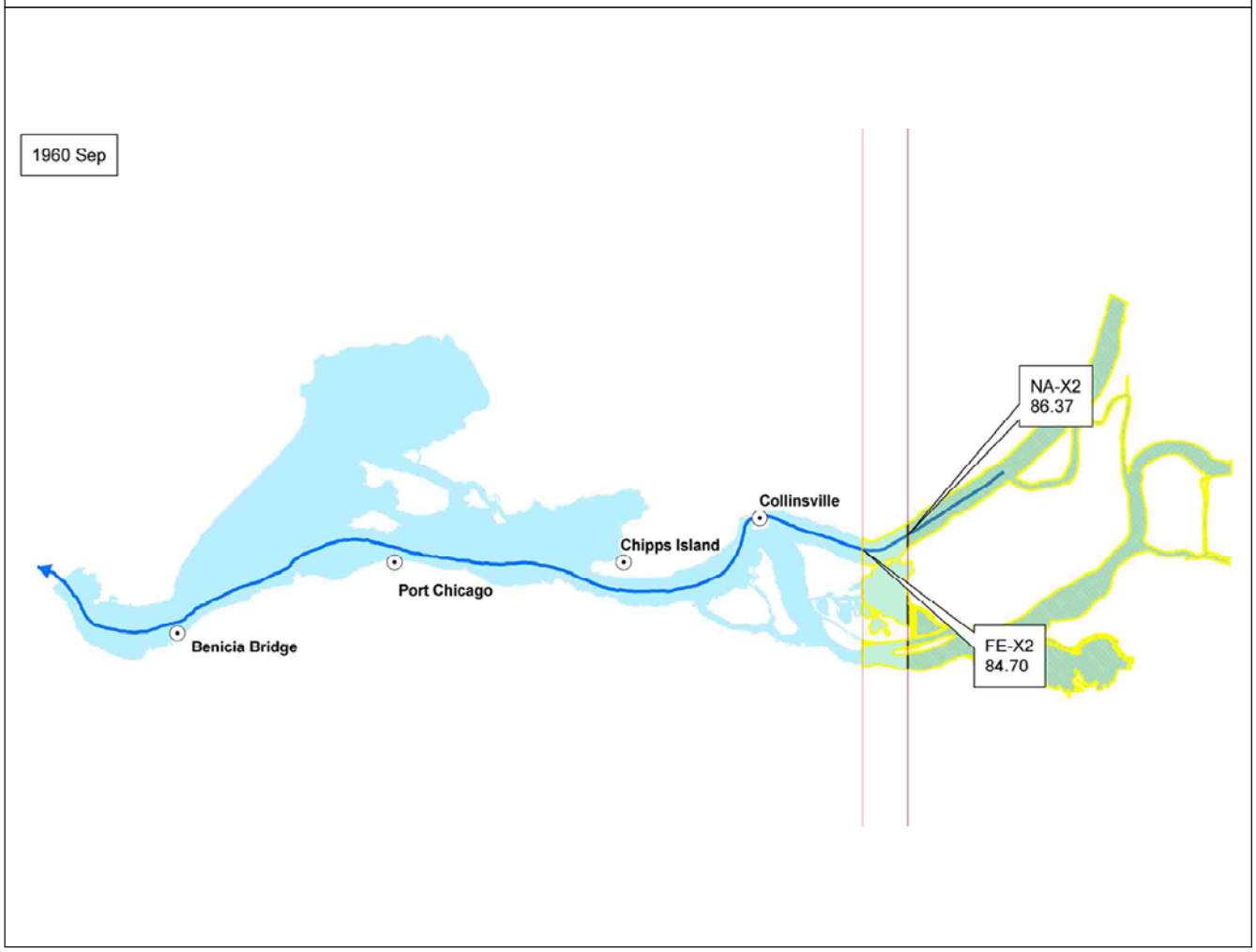
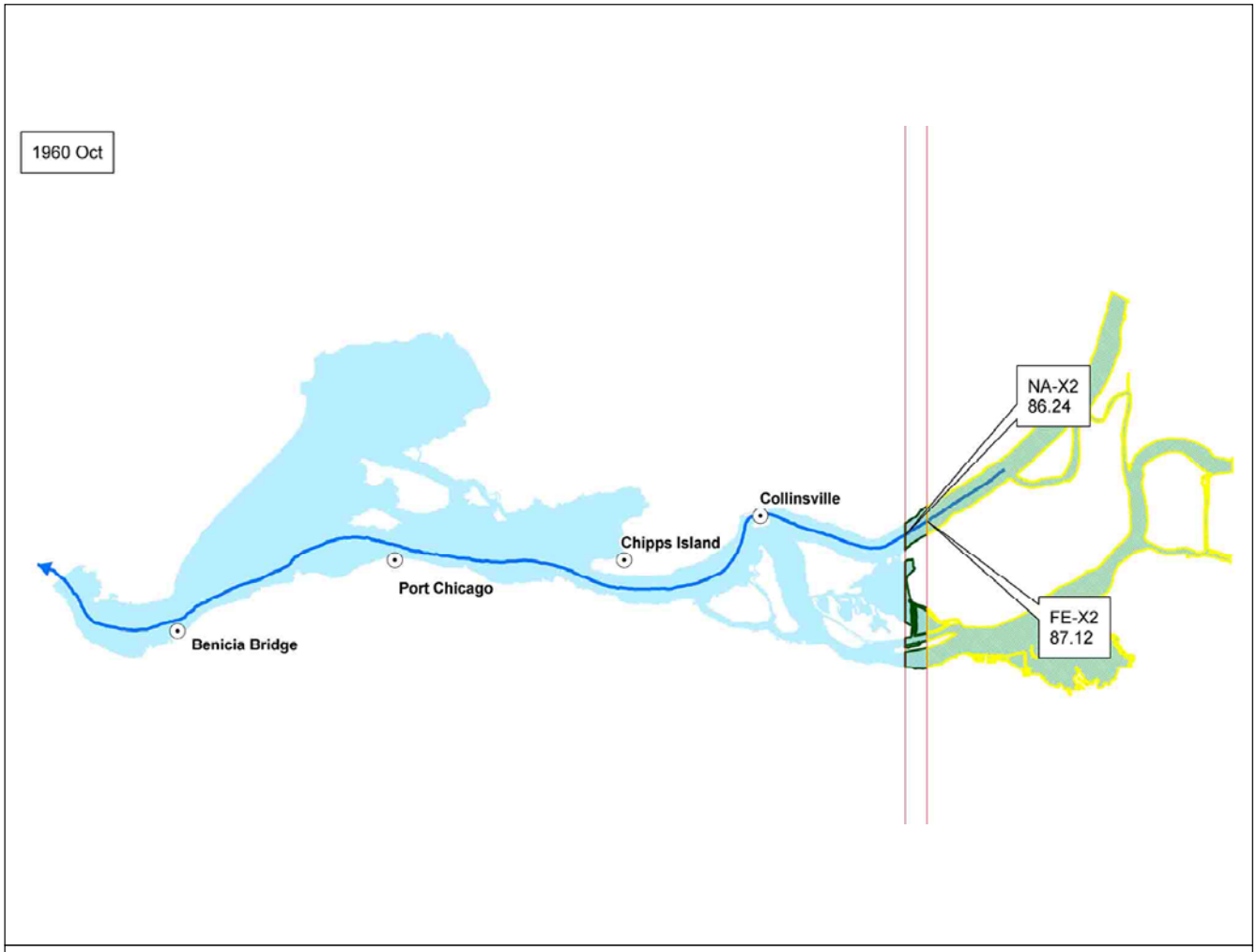
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
74.32

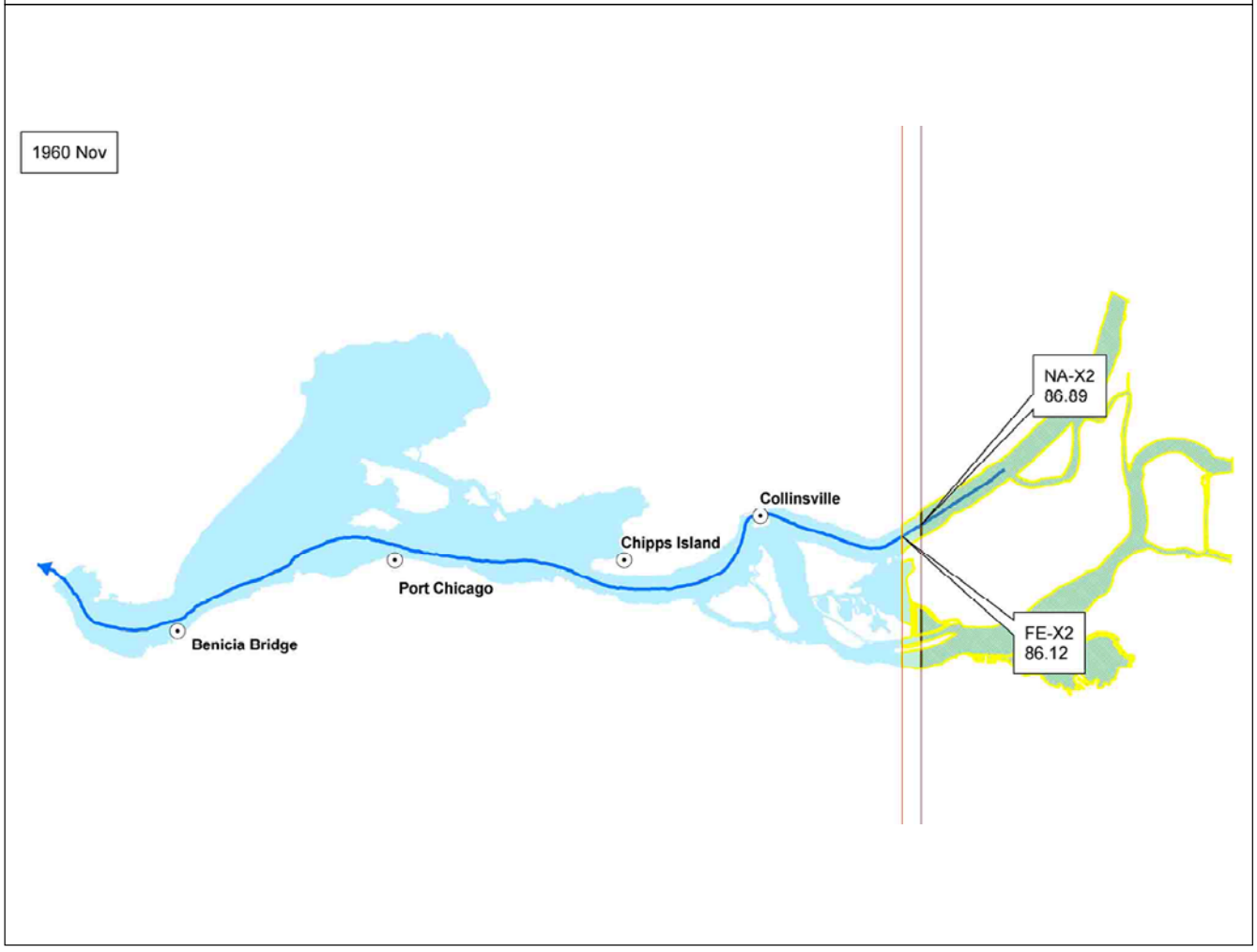

1960 Jun
NA-X2
75.23
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
75.23

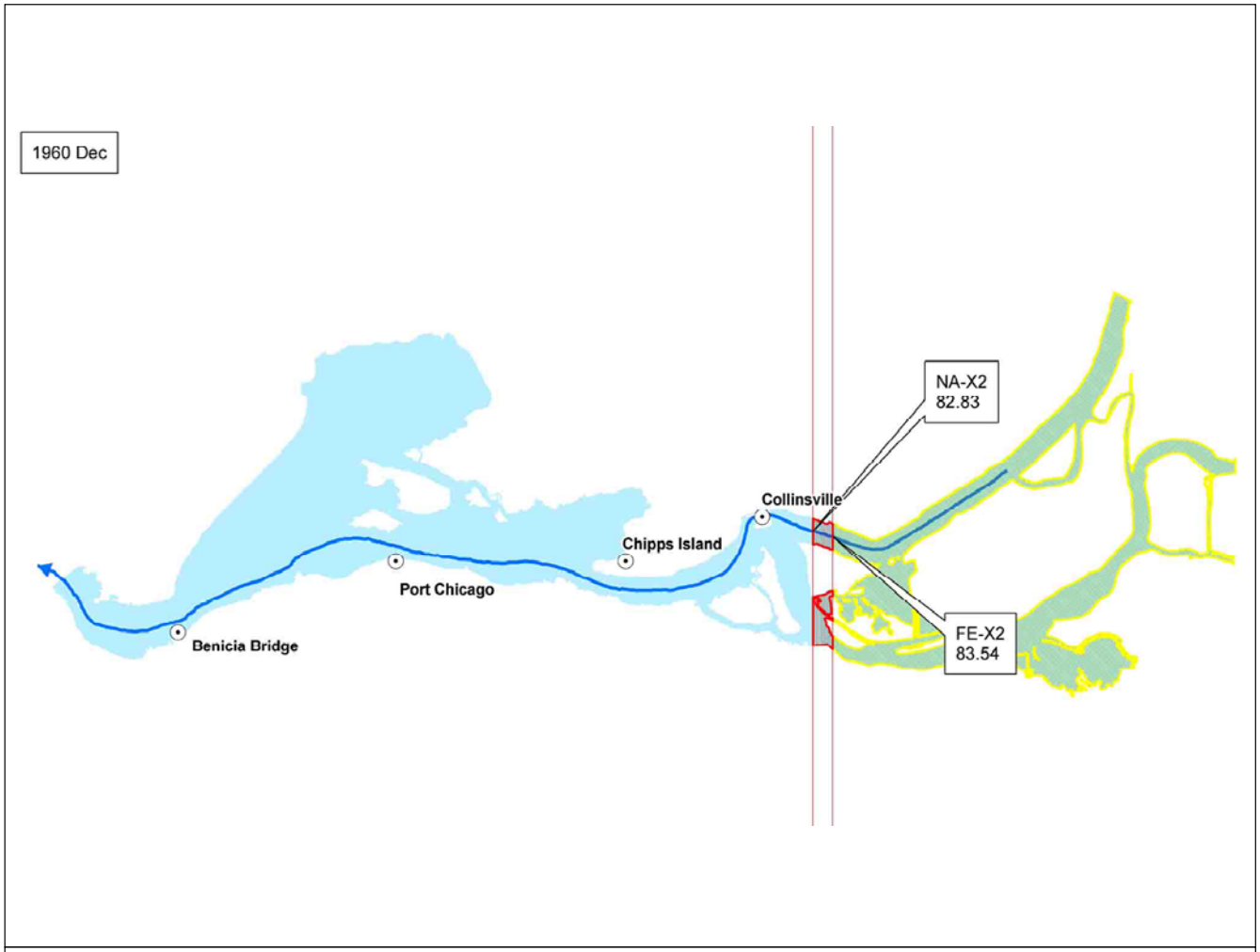

1960 Jul
NA-X2
80.71
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
80.71


1960 Aug
NA-X2
83.37
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
83.37


1960 Sep
NA-X2
86.37
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
84.70


1960 Oct
NA-X2
86.24
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
87.12


1960 Nov
NA-X2
86.09
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
86.12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NA-X2
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Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
83.54


1960 average
NA-X2
80.57
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
80.38


1961 Jan
NA-X2
80.25
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
80.60


1961 Feb
NA-X2
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Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
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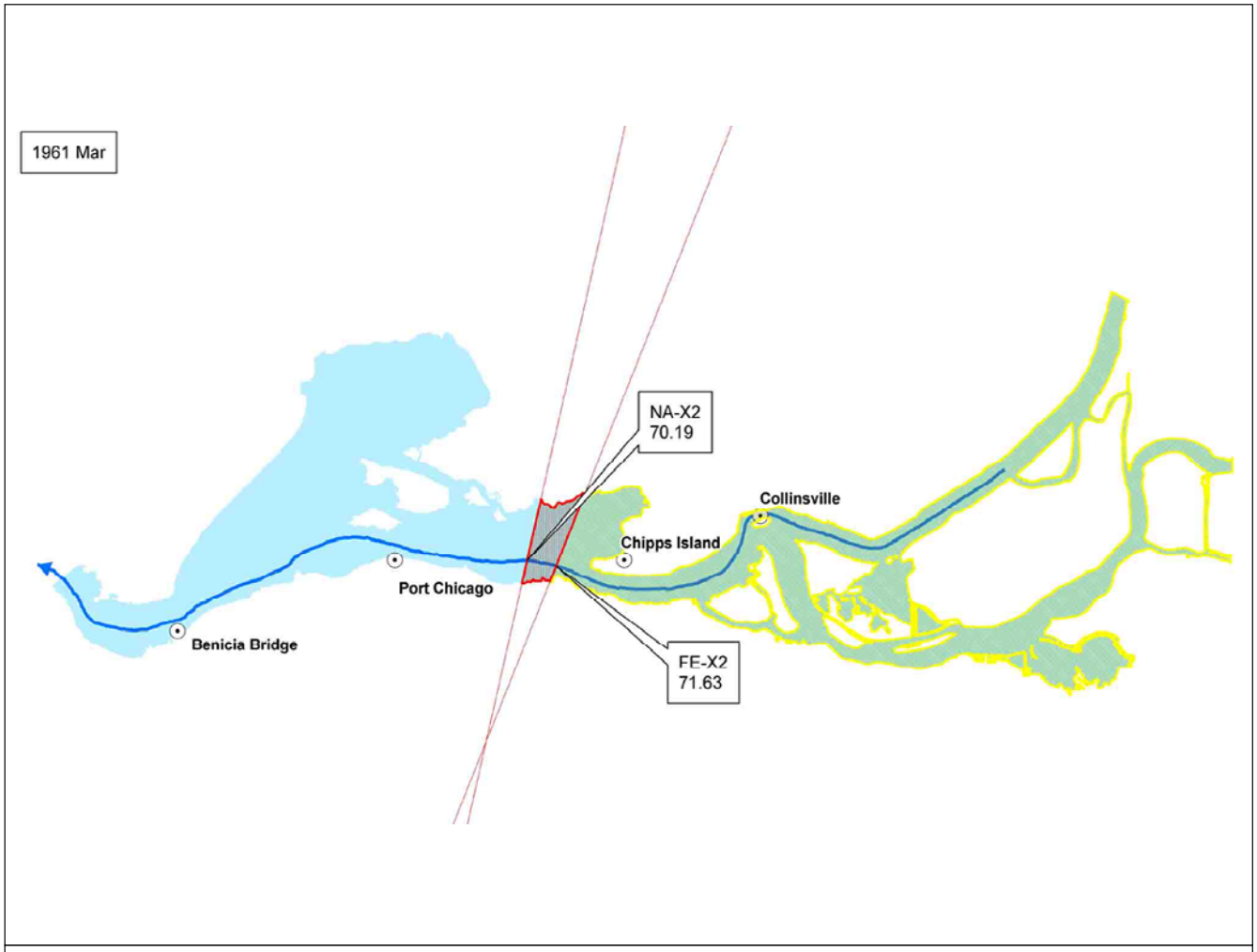
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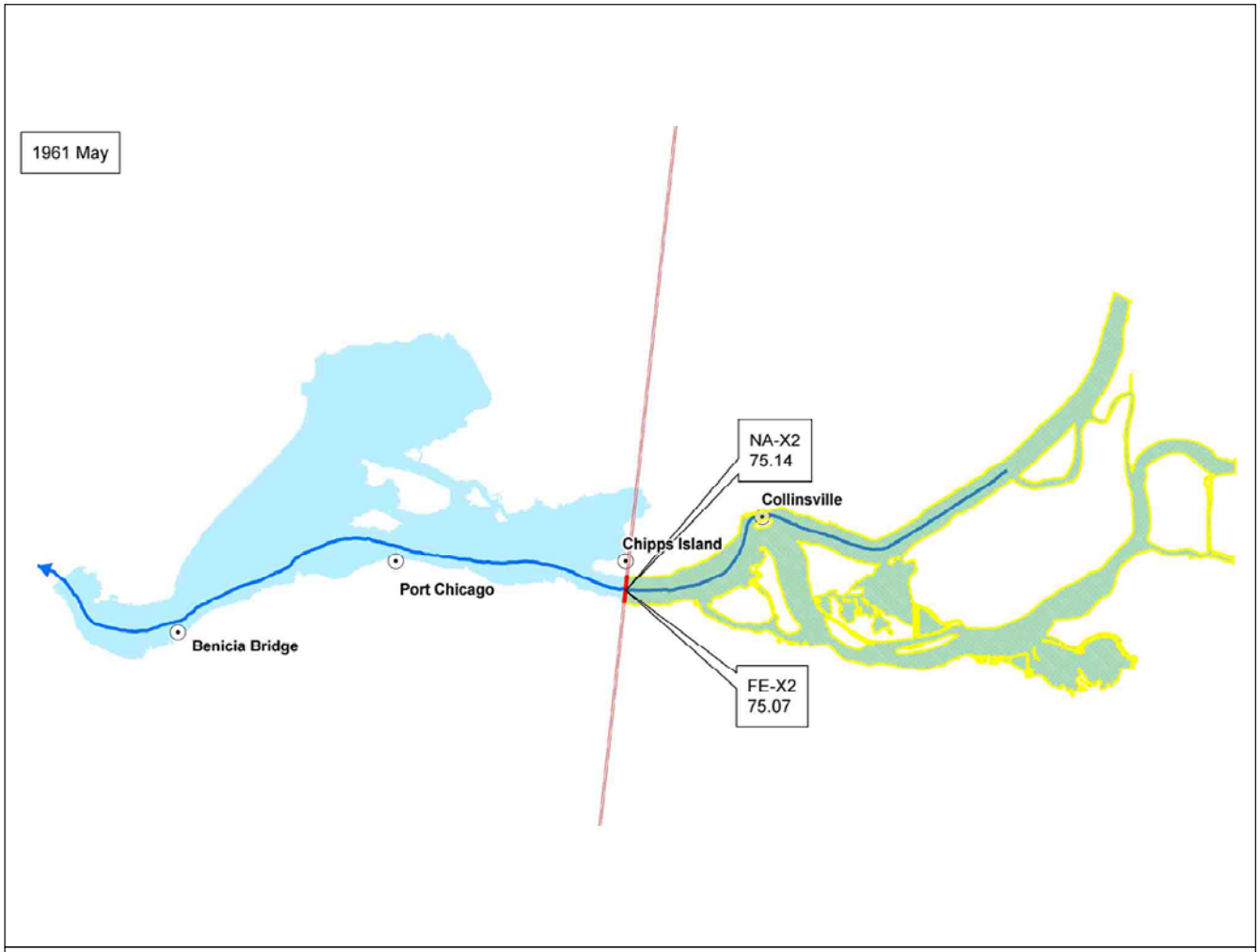
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
71.63


1961 Apr
NA-X2
72.19
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
71.97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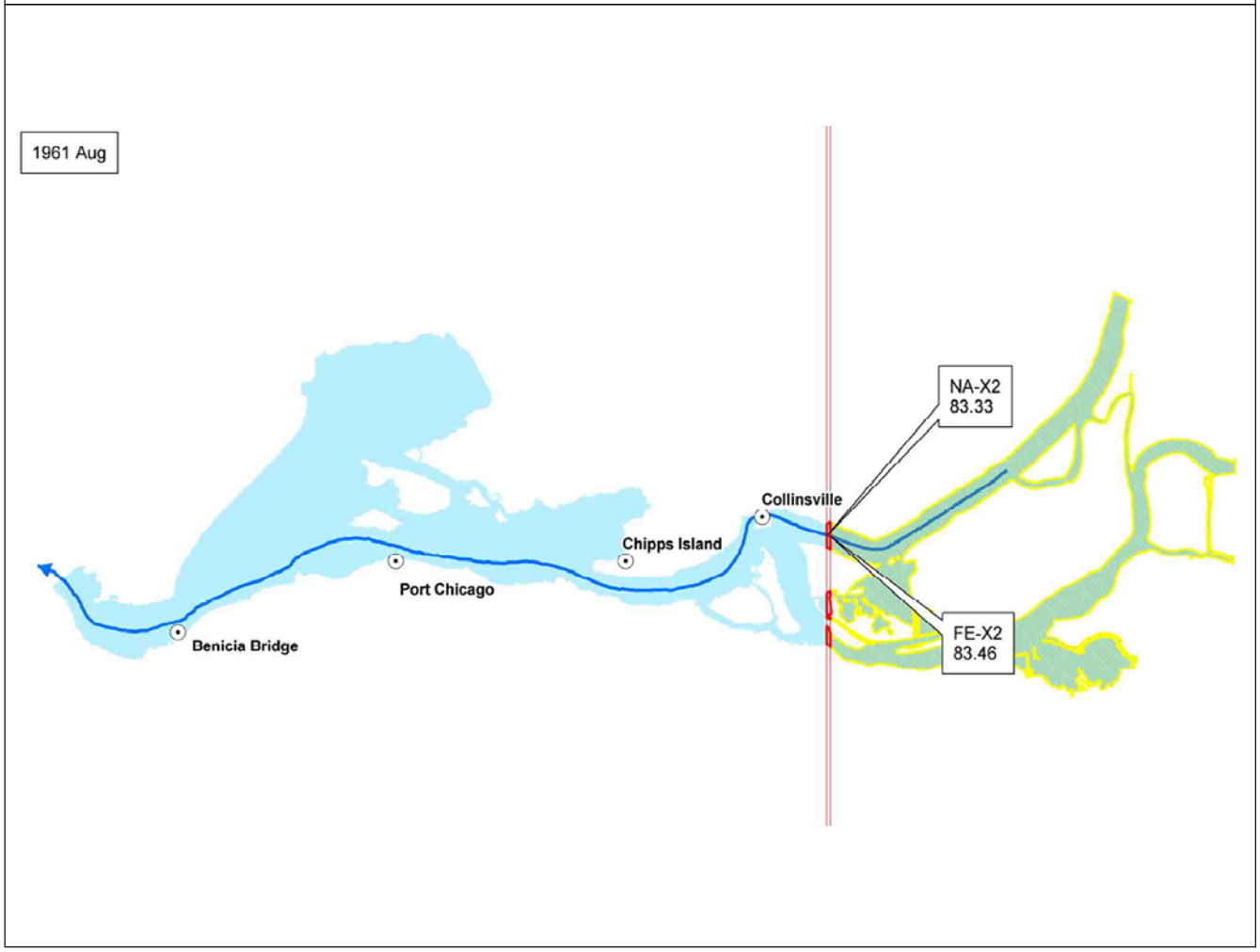
NA-X2
75.14
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
75.07


1961 Jun
NA-X2
77.26
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
76.50


1961 Jul
NA-X2
80.59
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
81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NA-X2
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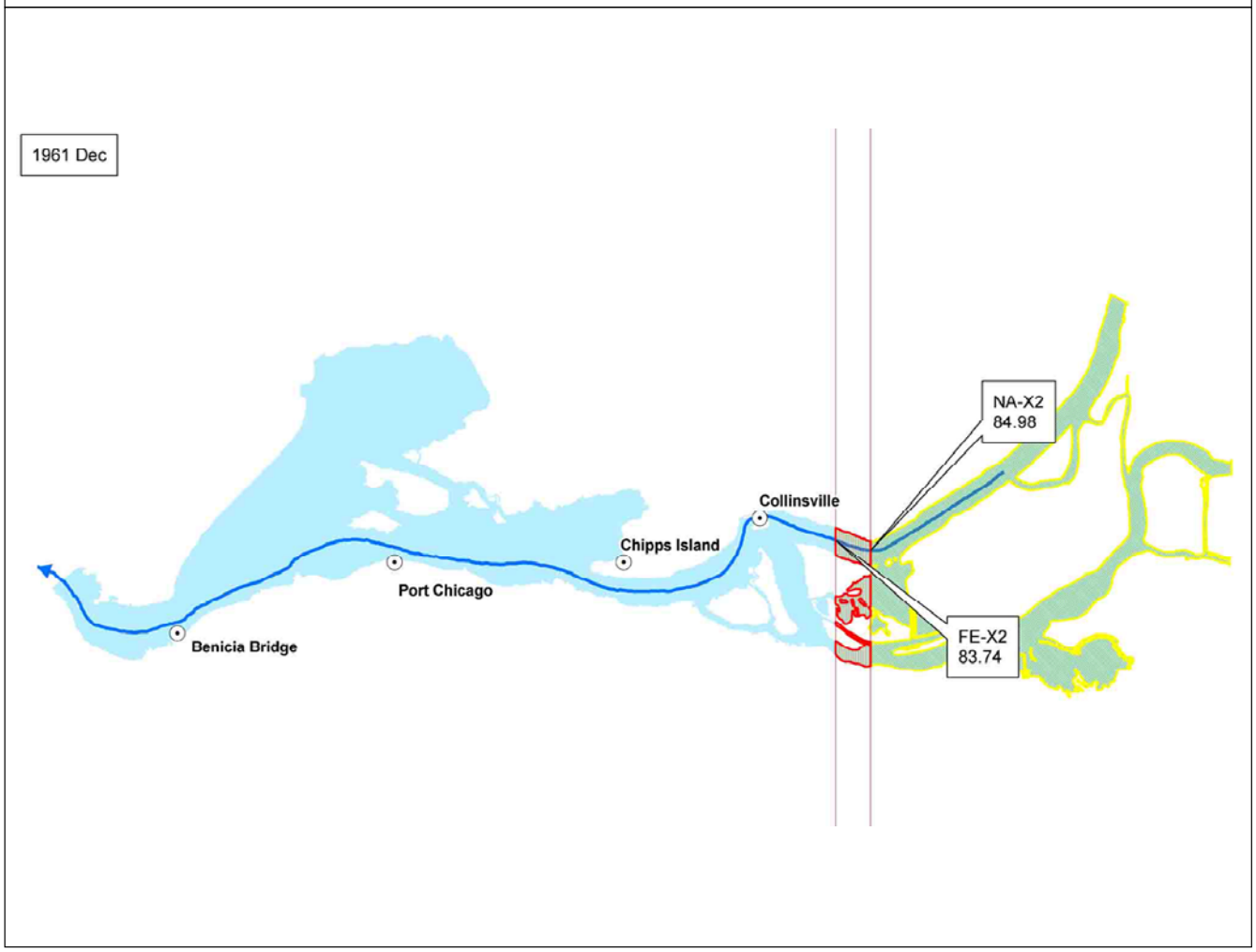
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
83.46


1961 Sep
NA-X2
84.50
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
84.01


1961 Oct
NA-X2
89.14
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
88.59


1961 Nov
NA-X2
84.75
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
86.04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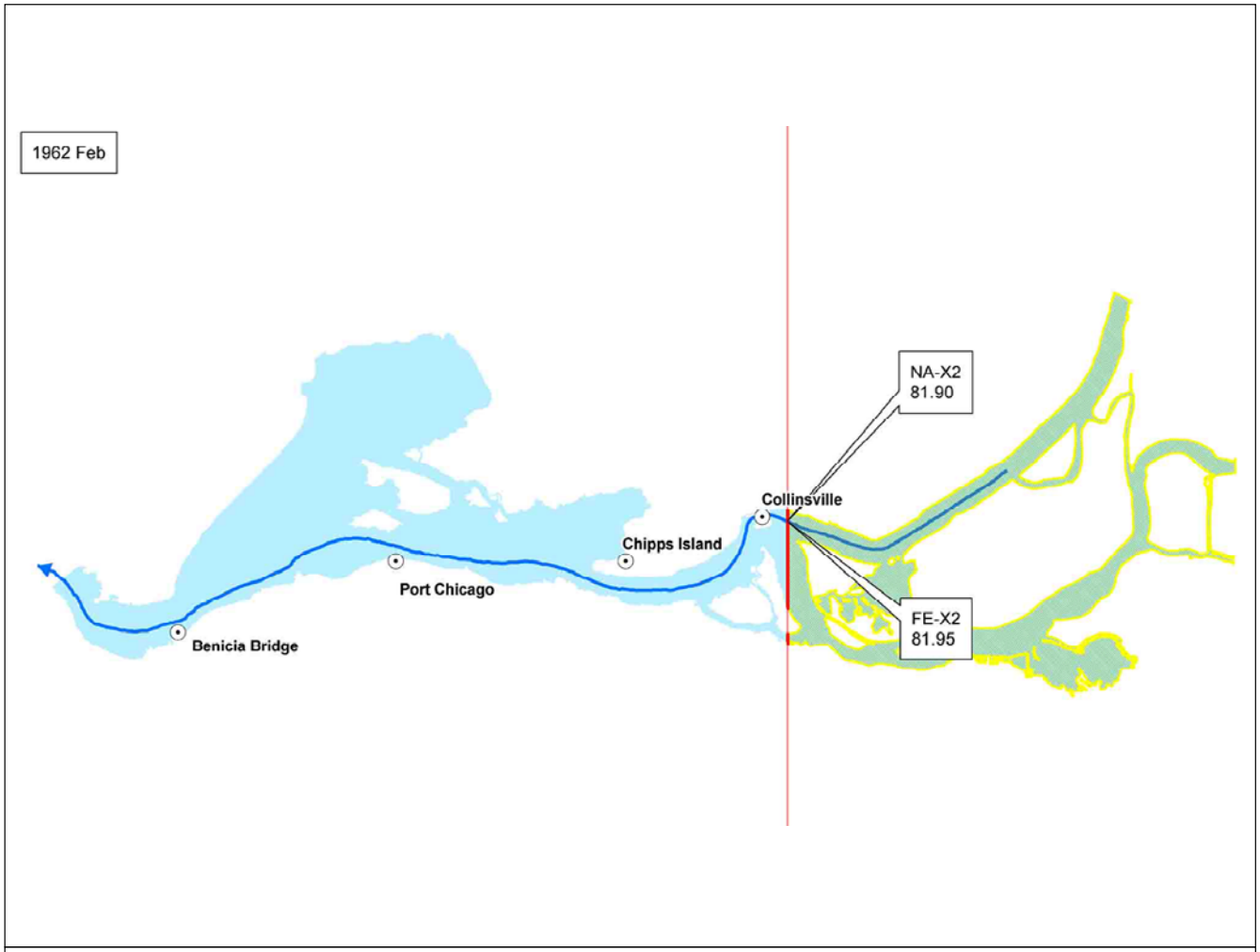
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
83.74


1961 average
NA-X2
80.20
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
80.25


1962 Jan
NA-X2
80.50
Collinsville
Chipps Island
Port Chicago
Benicia Bridge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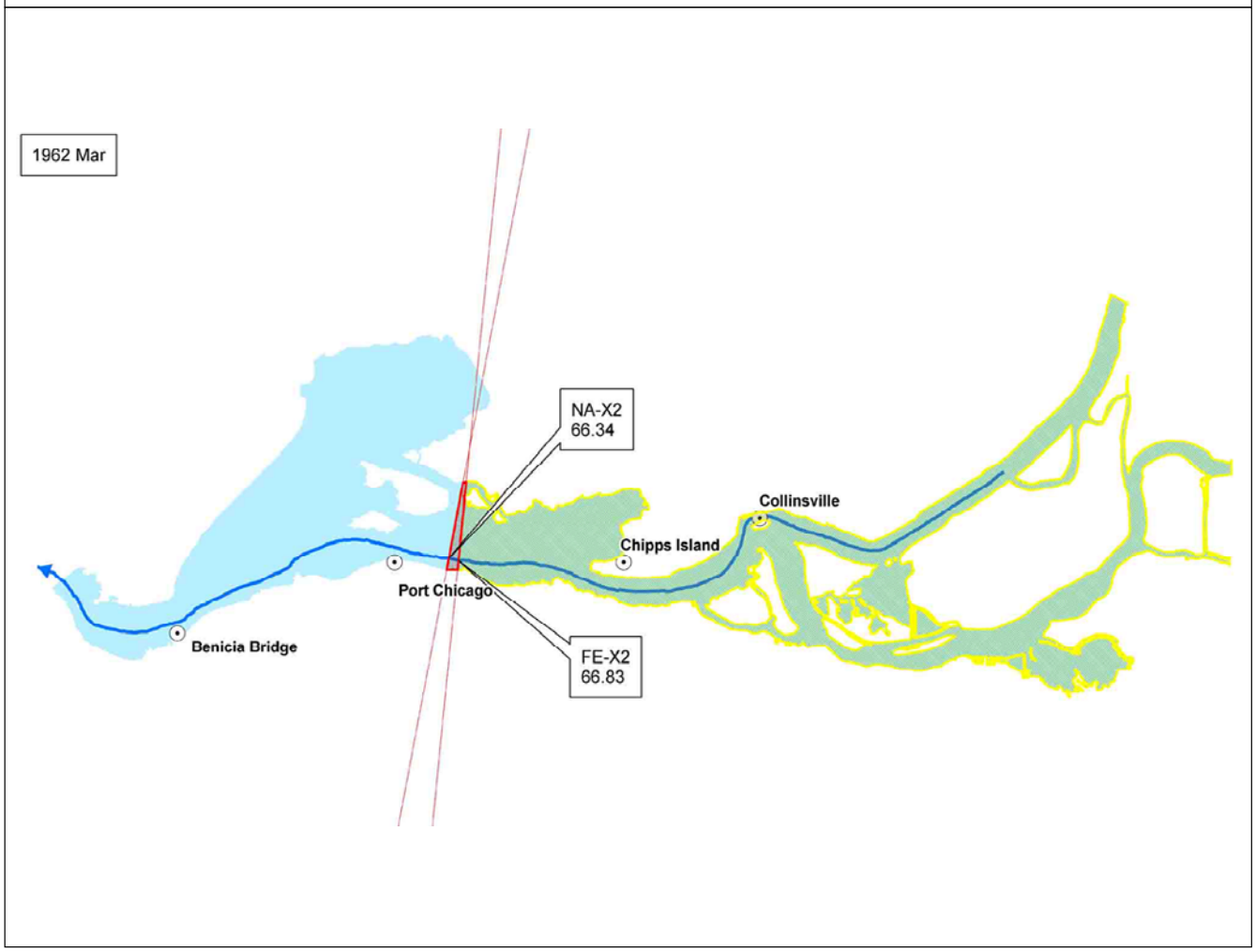
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
81.95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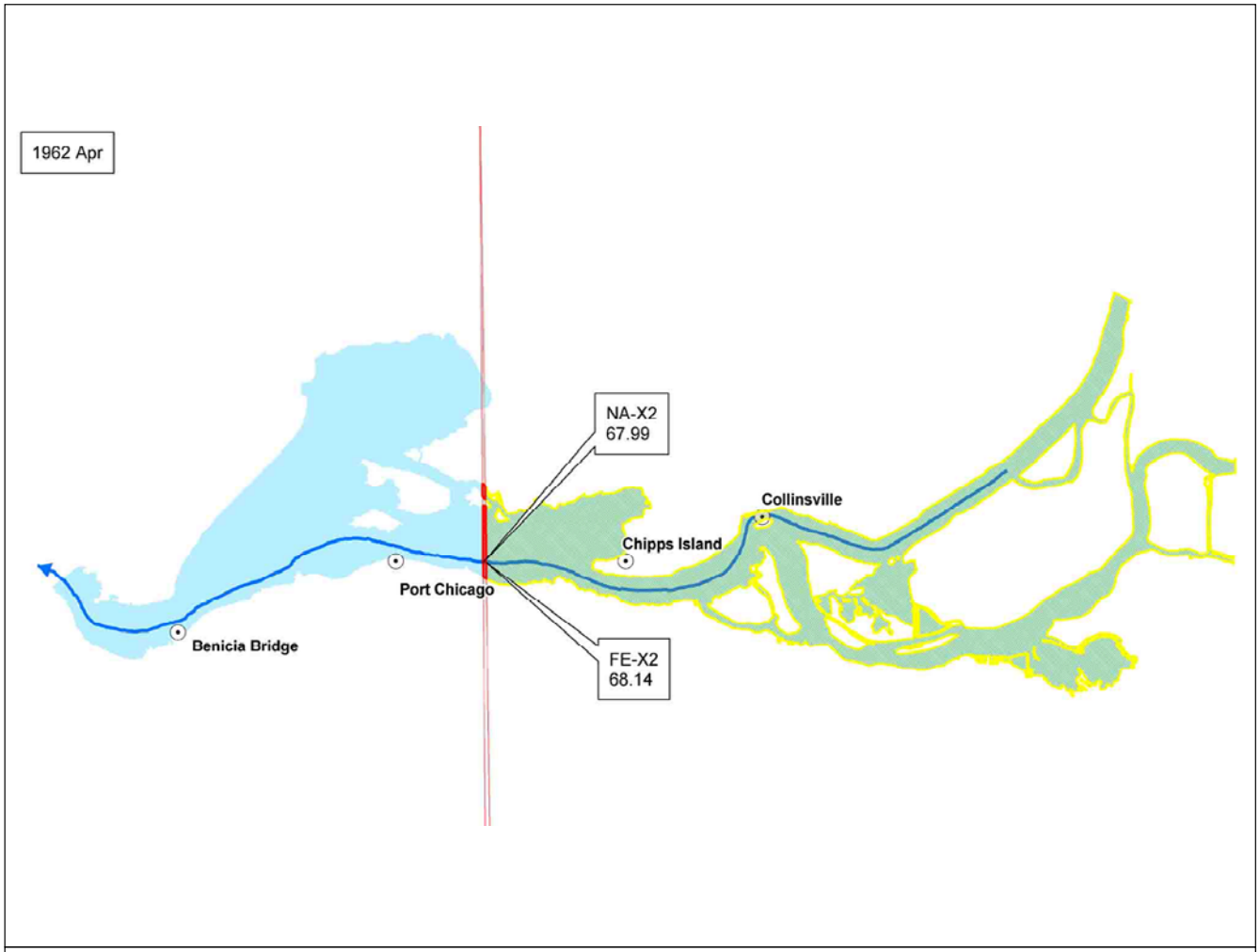
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
66.83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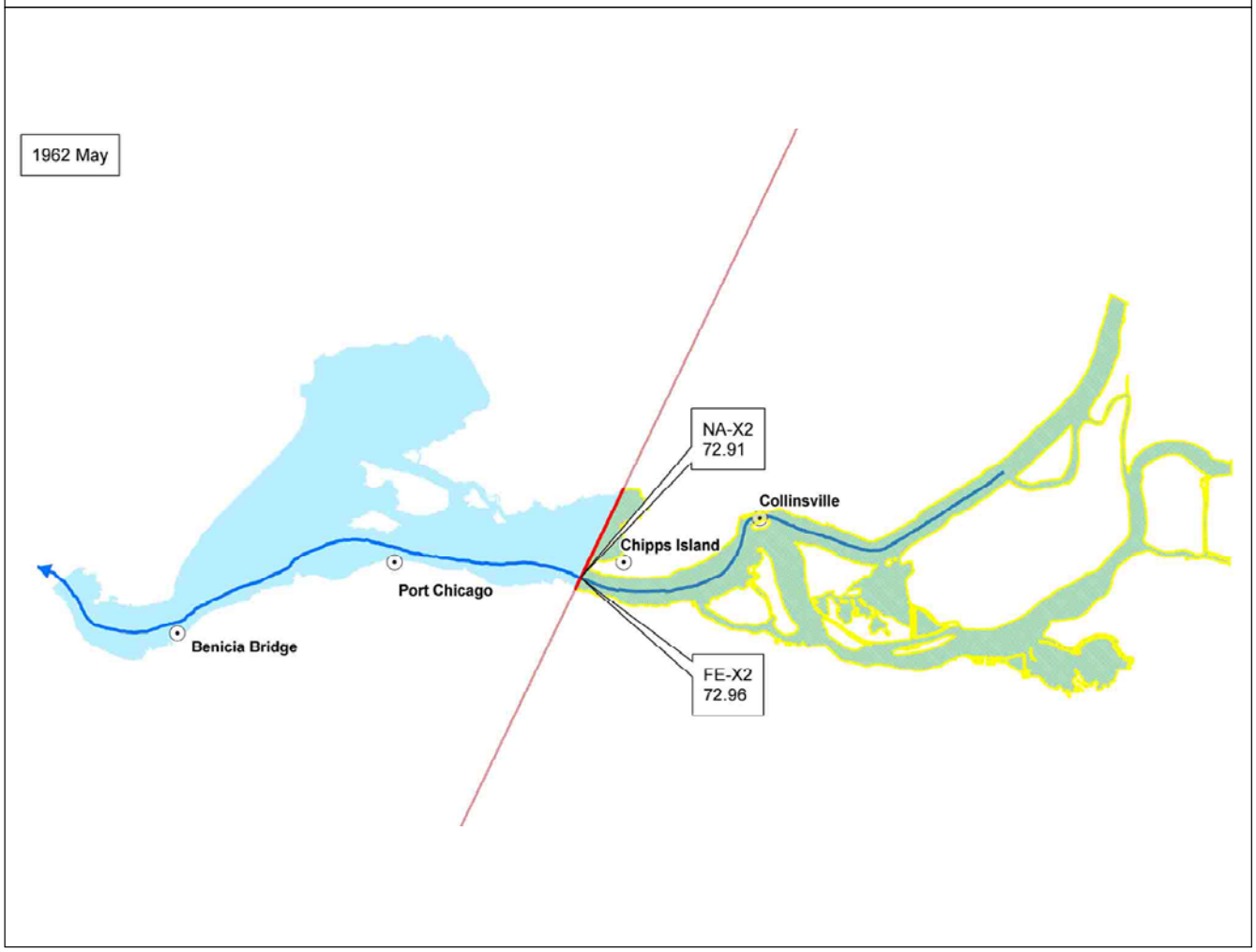
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
68.14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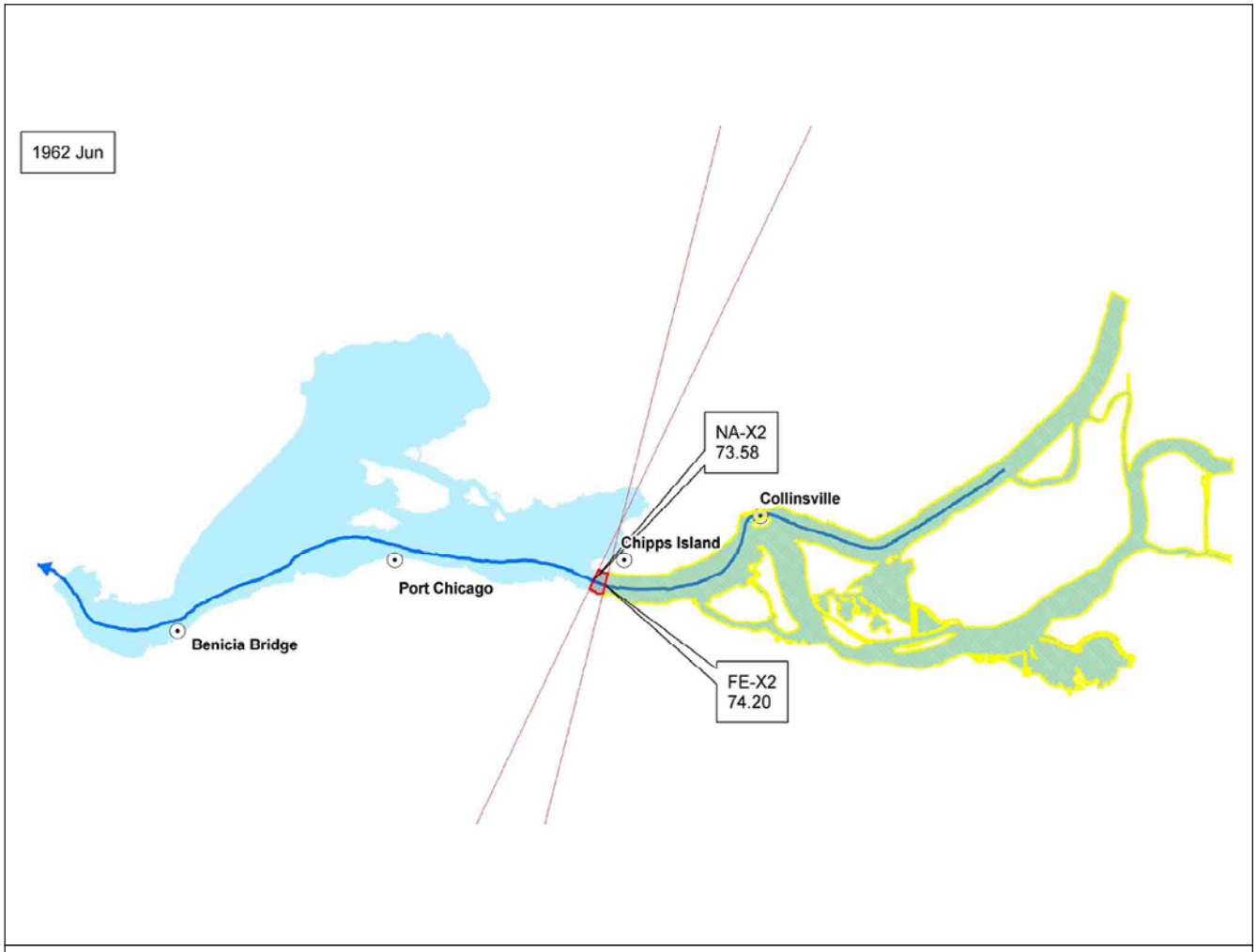
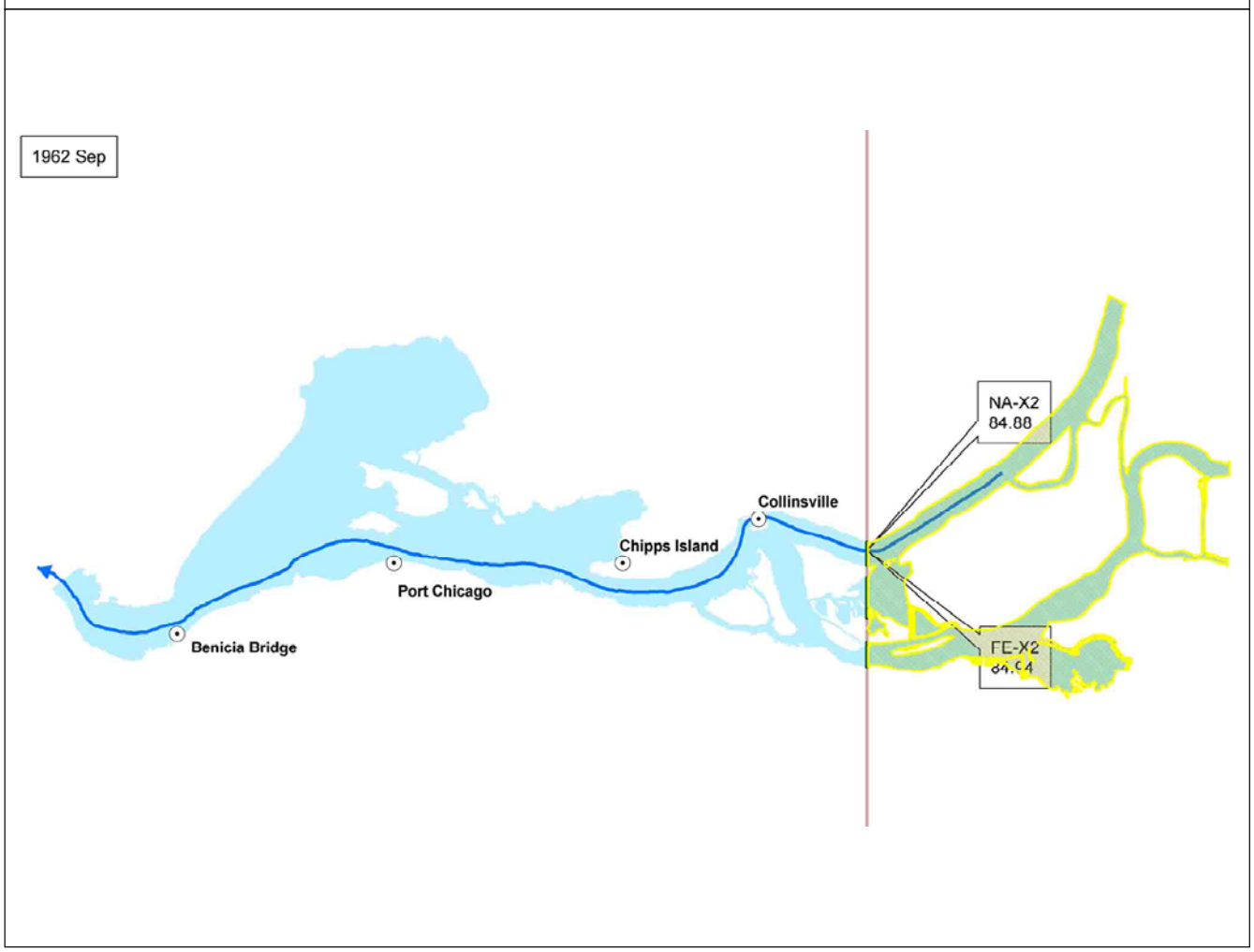
Port Chicago
Benicia Bridge
FE-X2
72.96

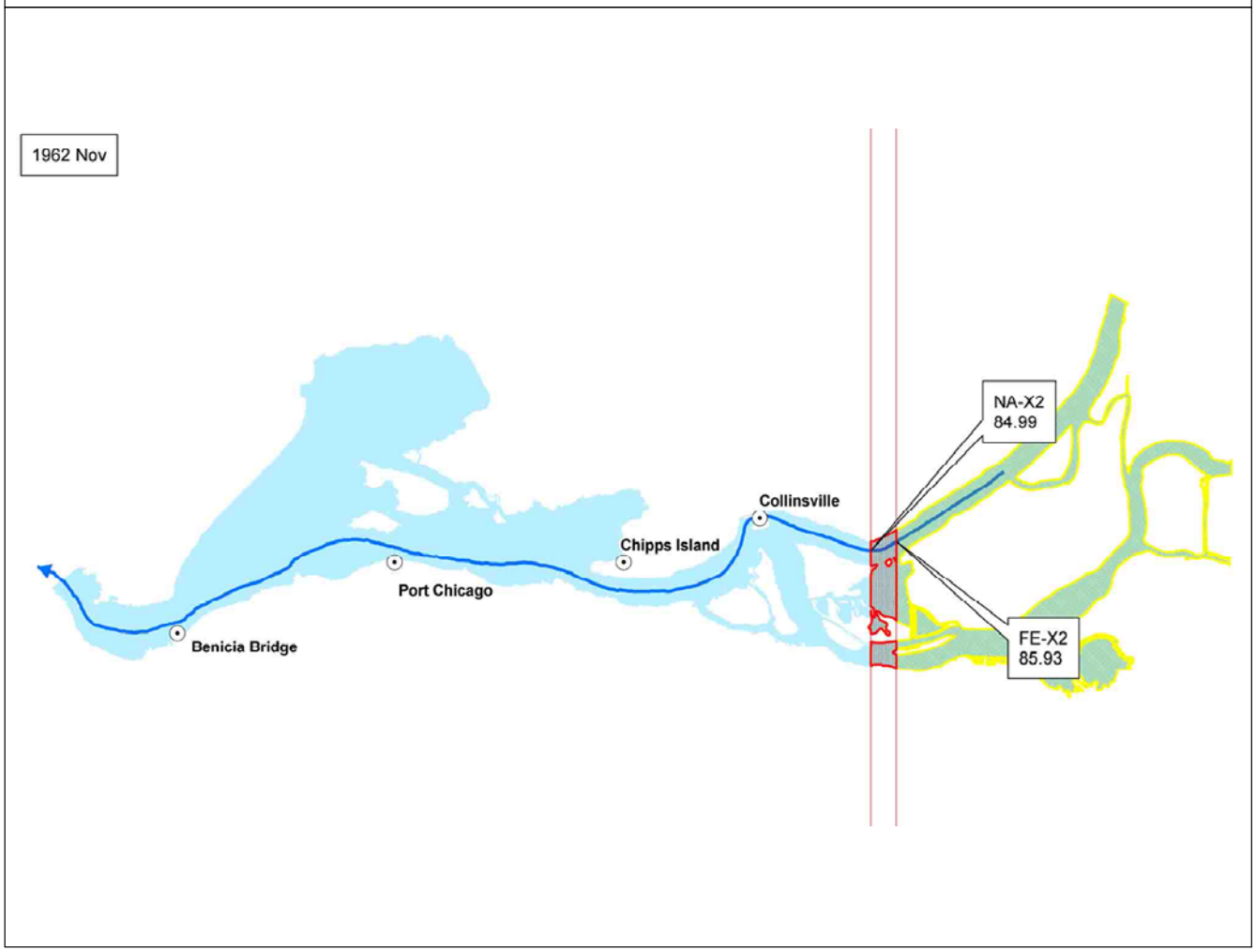

1962 Jun
NA-X2
73.58
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
74.20


1962 Jul
NA-X2
76.91
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
77.49


1962 Aug
NA-X2
80.11
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
80.30


1962 Sep
NA-X2
84.88
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2


1962 Oct
NA-X2
88.52
Collinsville
Chipps Island
Port Chicago
FE-X2
88.36
Benicia Bridge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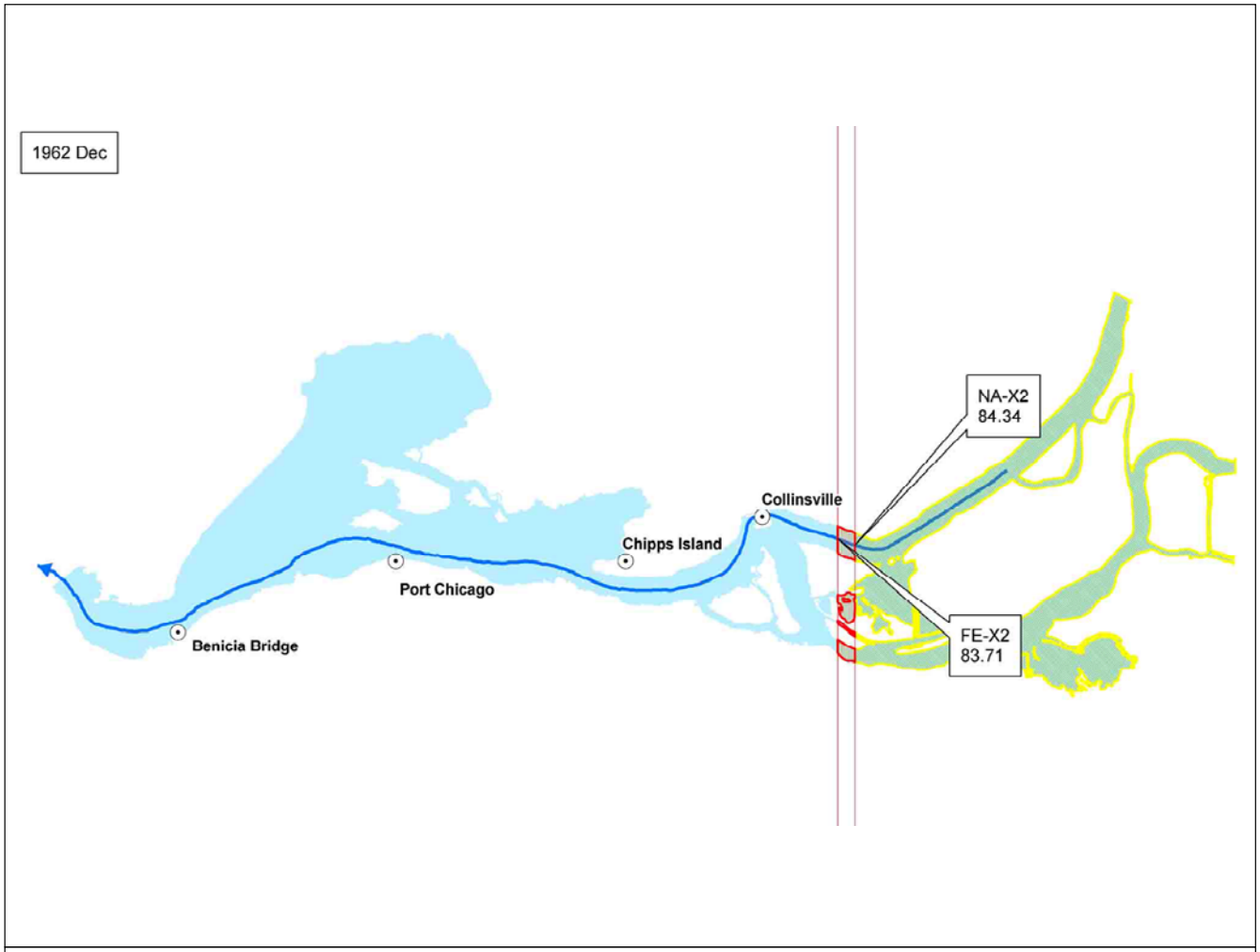
Collinsville
Chipps Island
Port Chicago
FE-X2
85.93
Benicia Bridge


1962 Dec
NA-X2
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Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
83.71


1962 average
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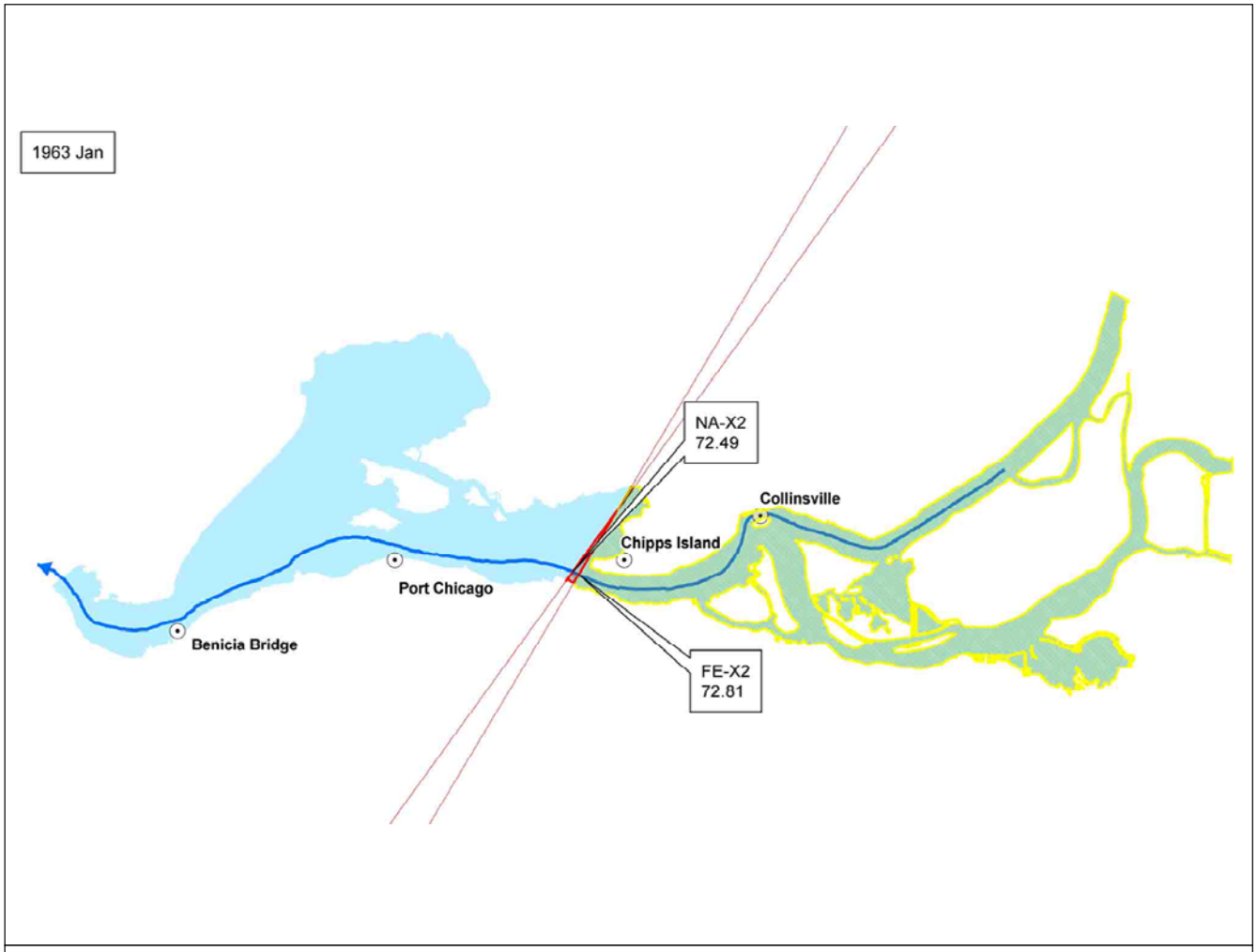
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
78.79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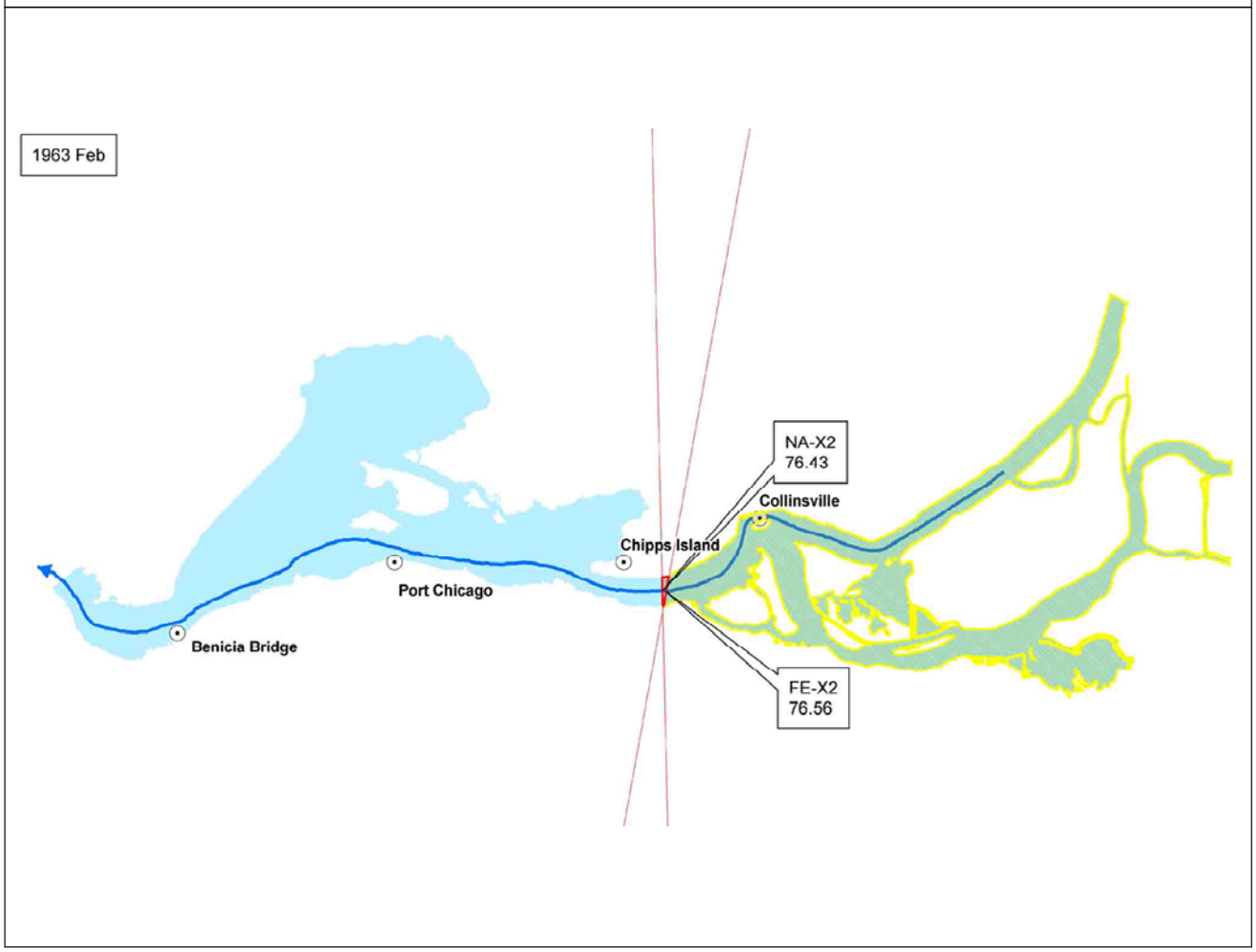
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
72.81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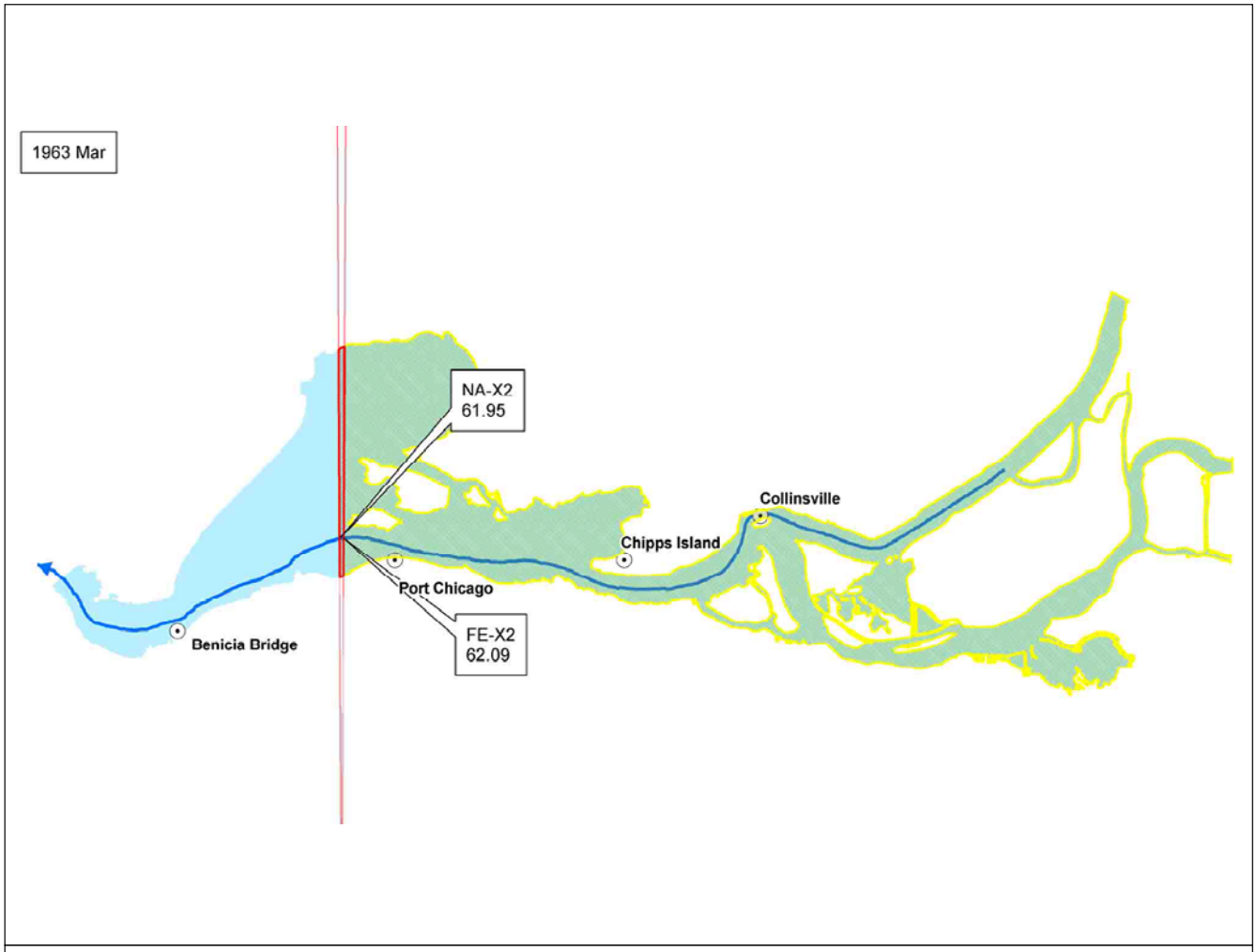
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
76.56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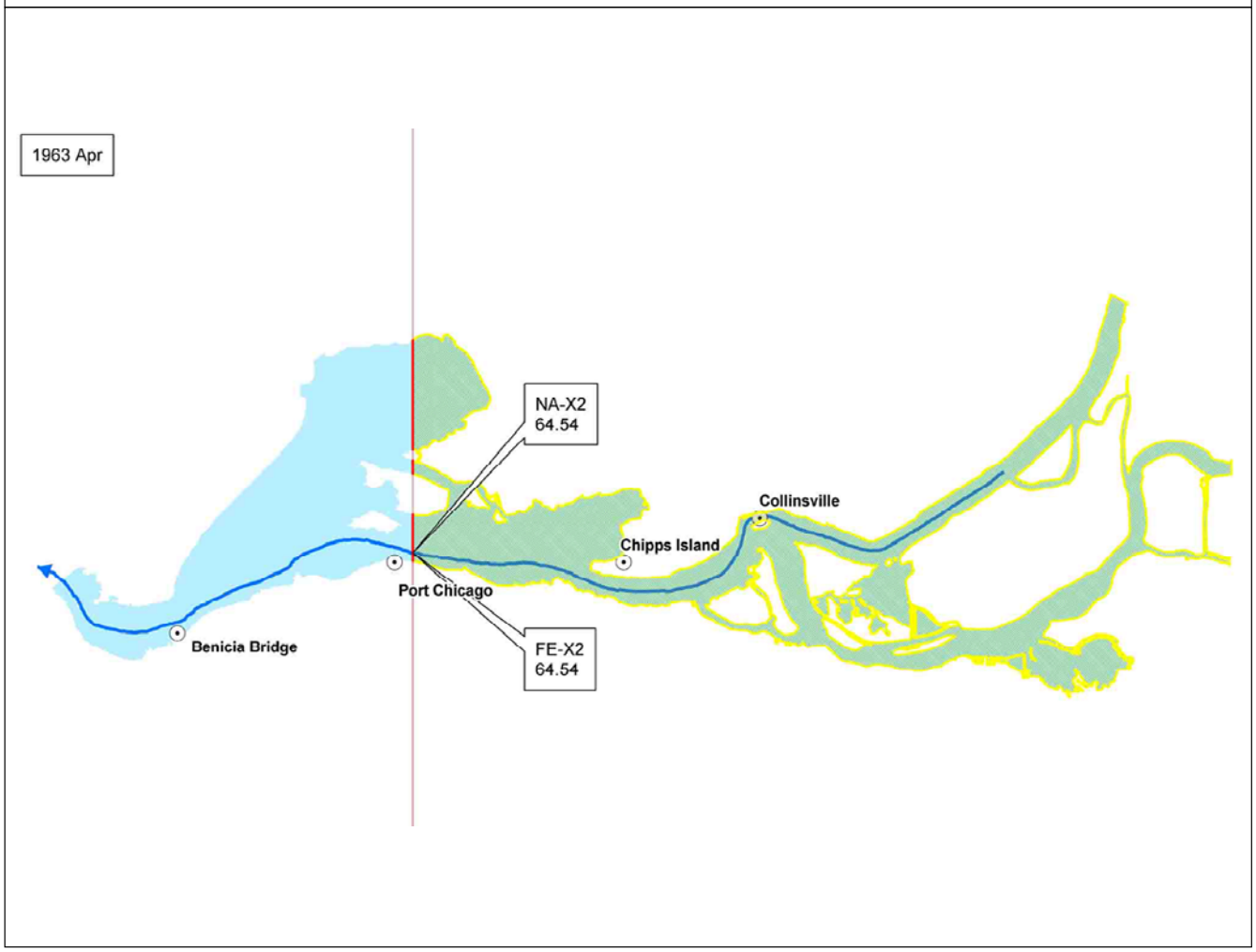
Collinsville
Chipps Island
Port Chicago
FE-X2
62.09
Benicia Bridge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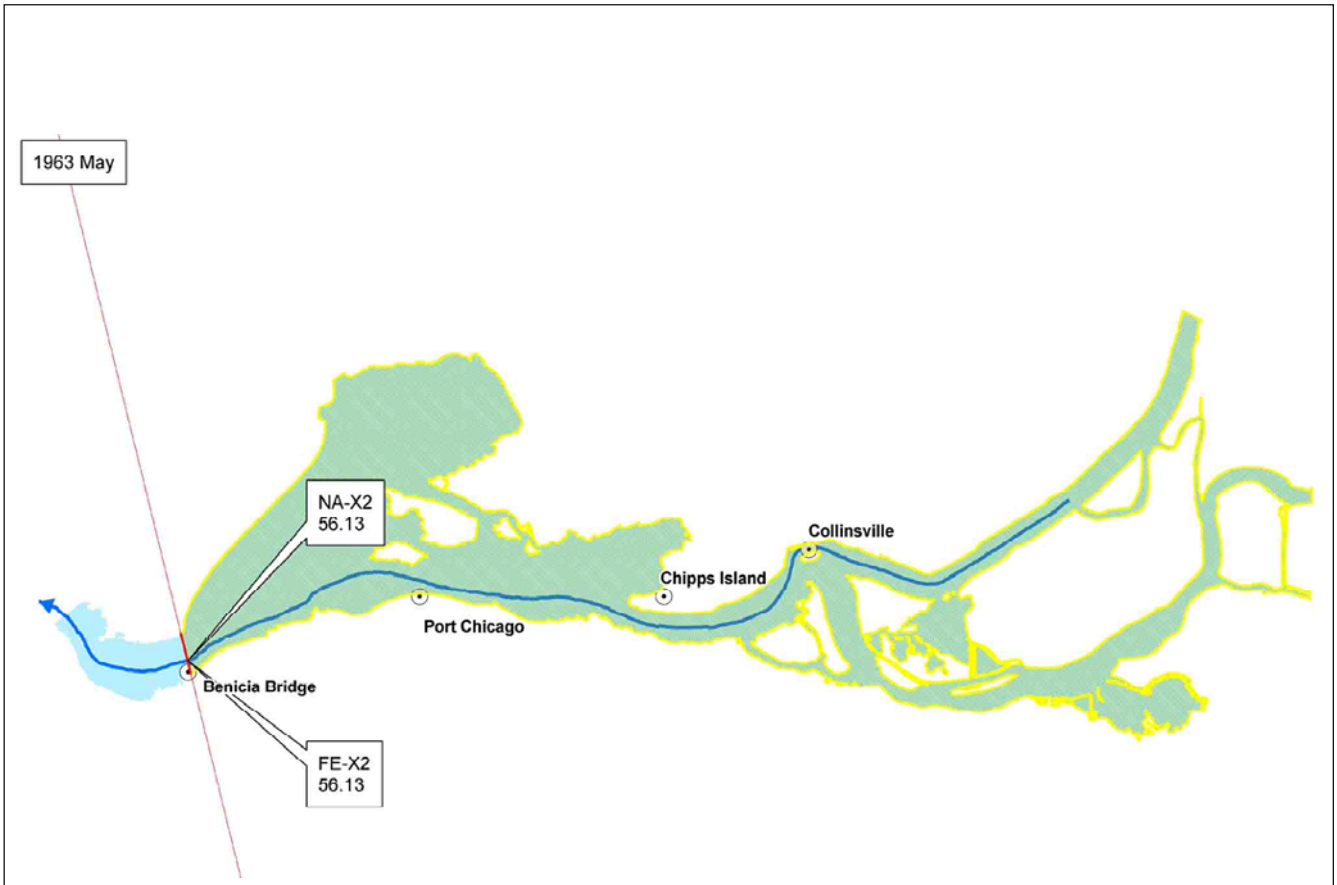
Collinsville
Chipps Island
Port Chicago
FE-X2
64.54
Benicia Bridge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NA-X2
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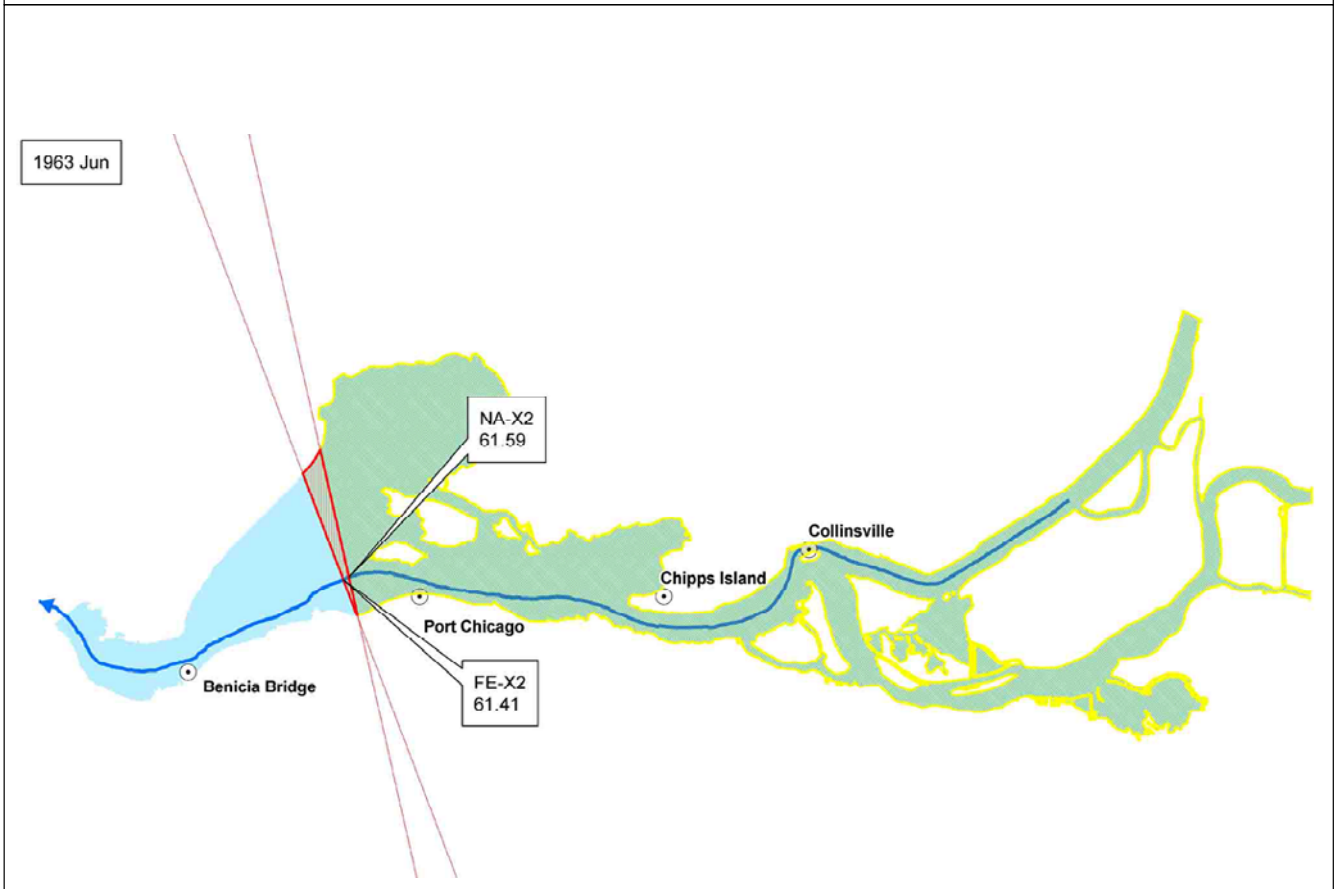
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
56.13


1963 Jun
NA-X2
61.59
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
61.41


1963 Jul
NA-X2
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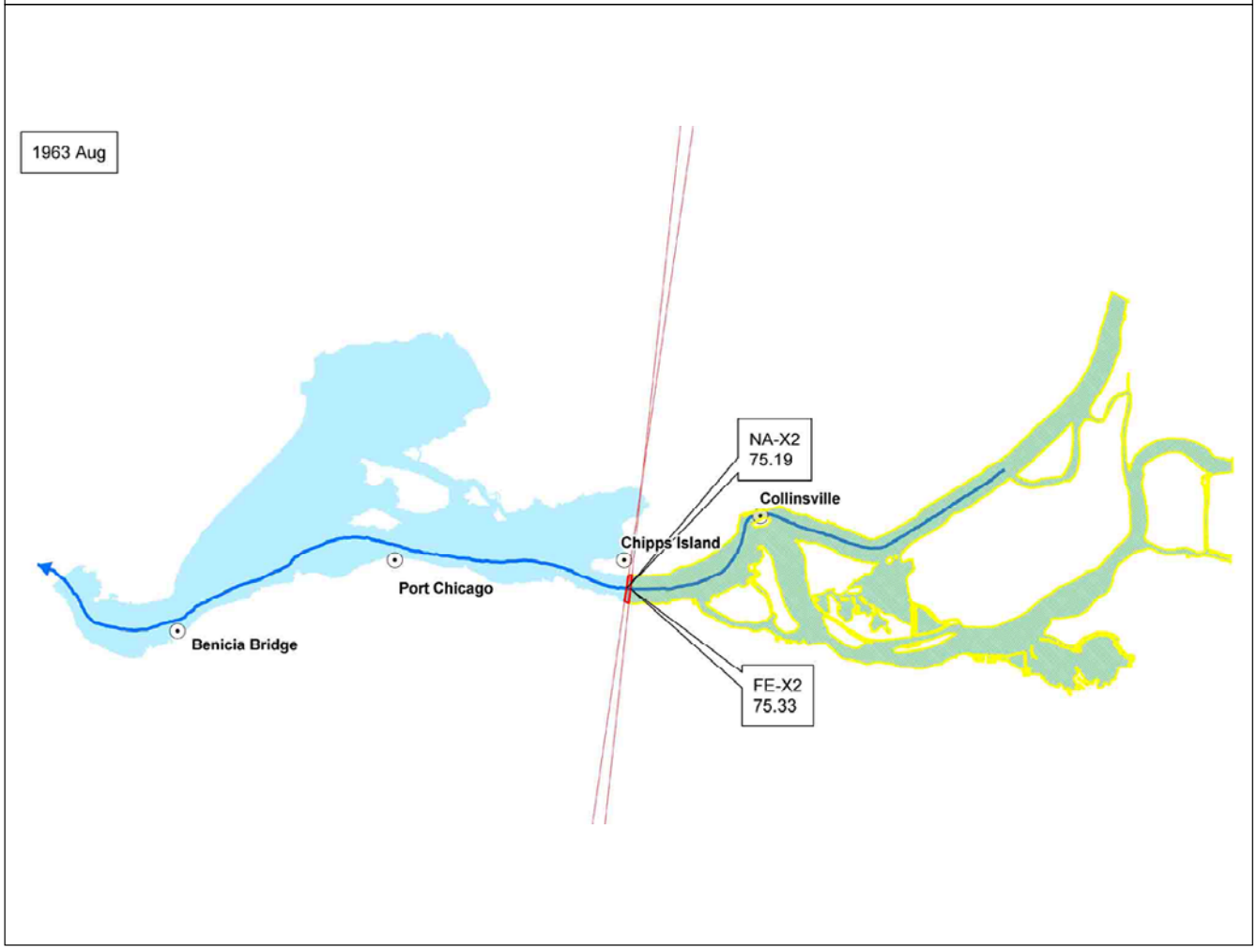
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
71.18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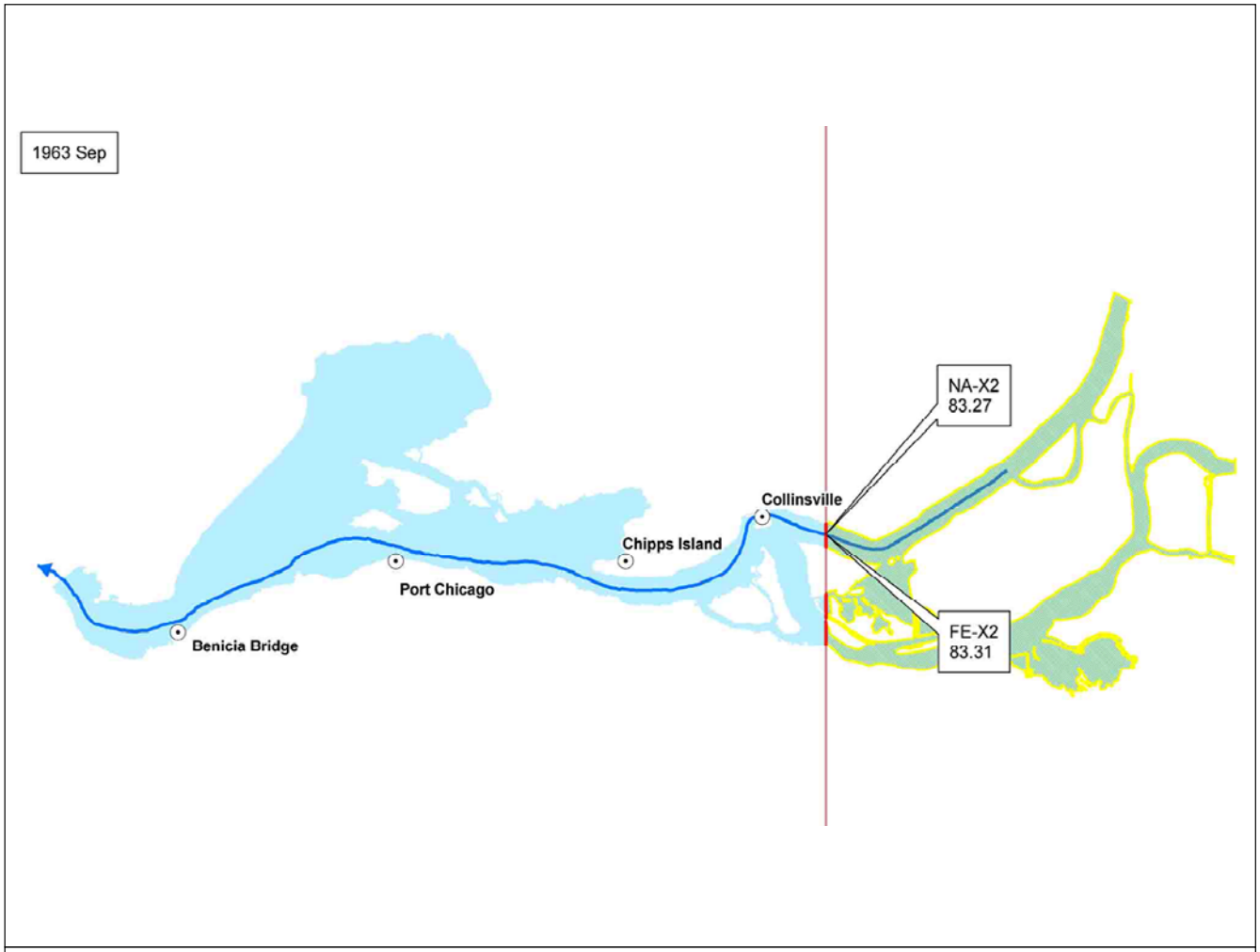
Port Chicago
Benicia Bridge
FE-X2
75.33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NA-X2
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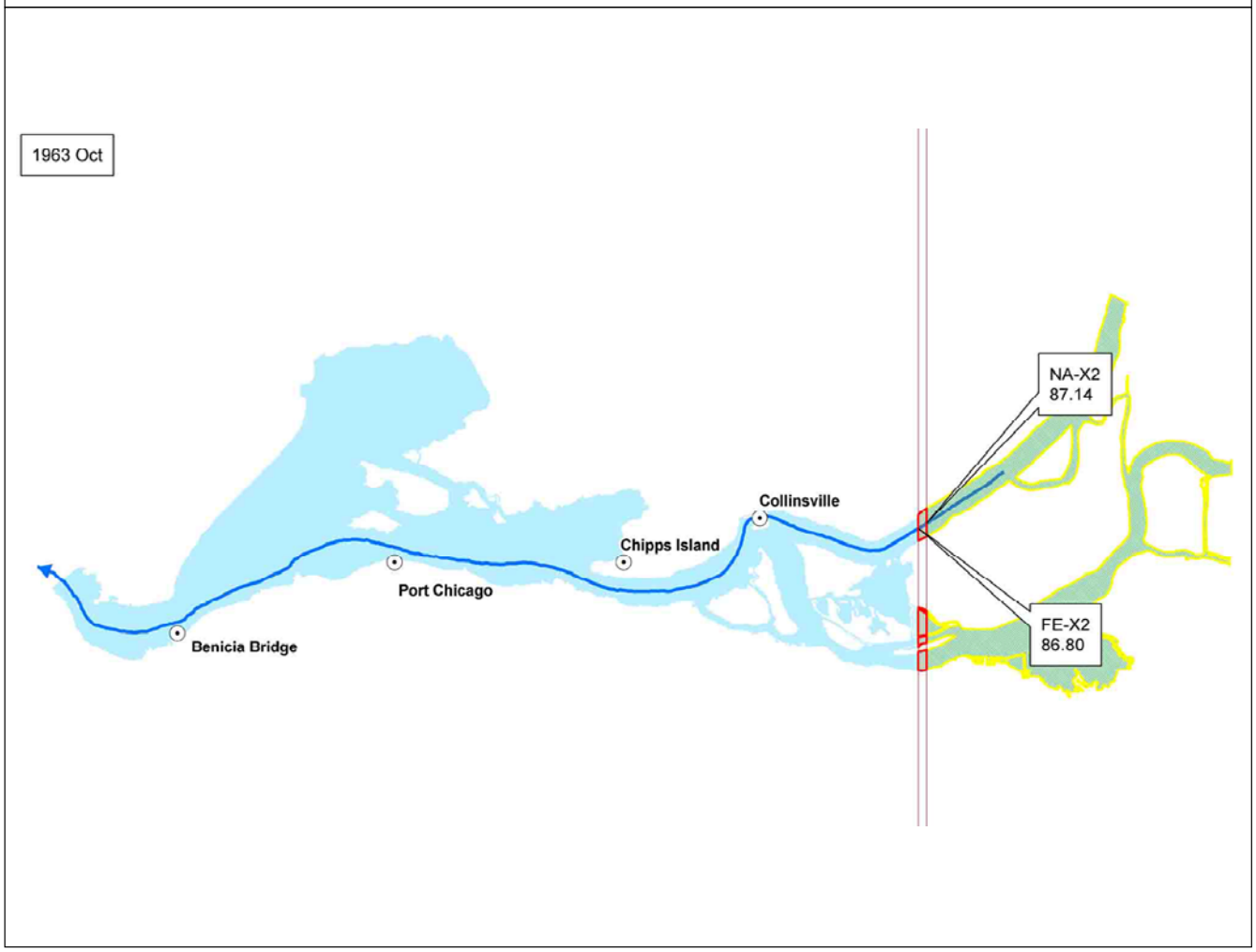
Port Chicago
Benicia Bridge
FE-X2
83.31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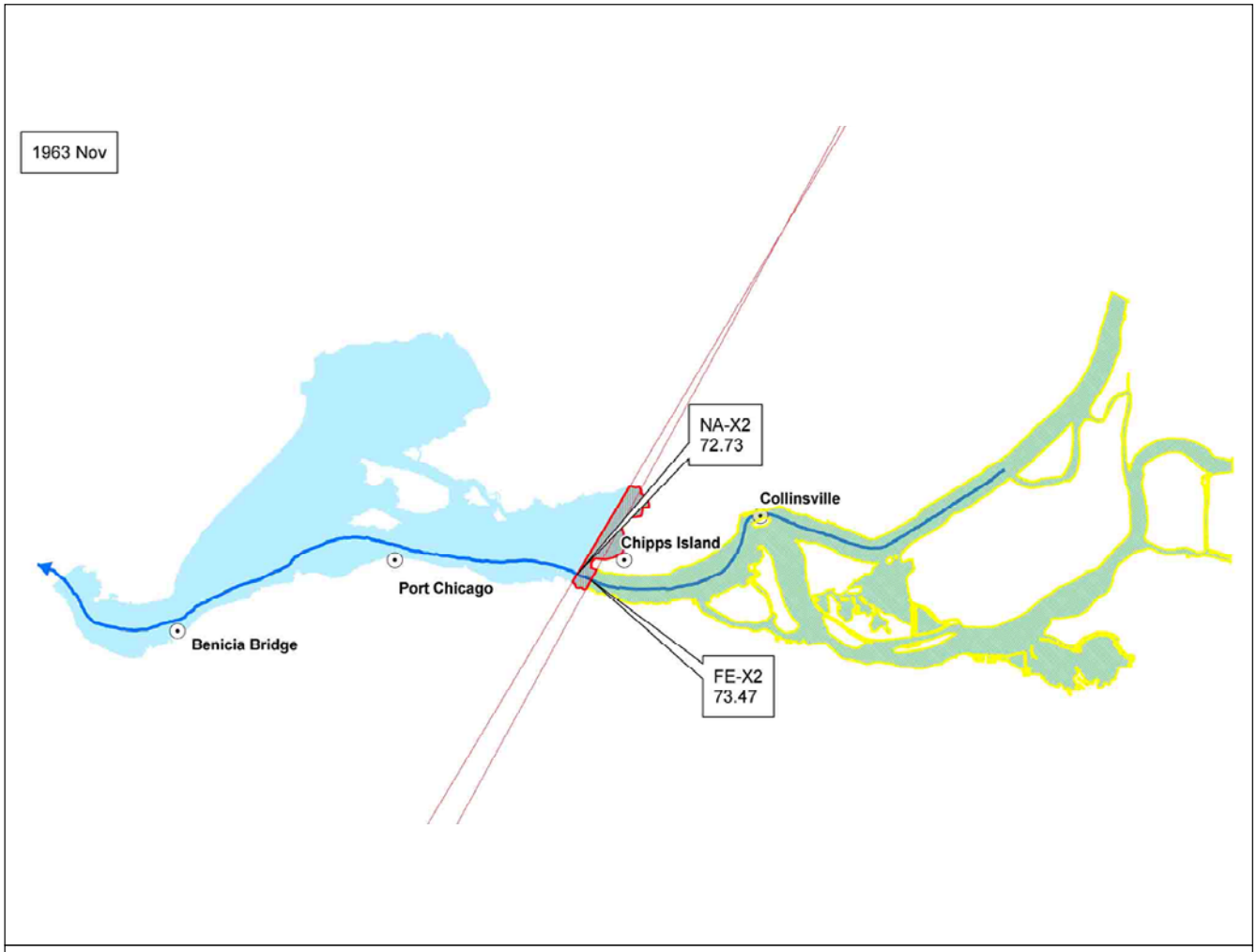
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
86.80


1963 Nov
NA-X2
72.73
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
73.47


1963 Dec
NA-X2
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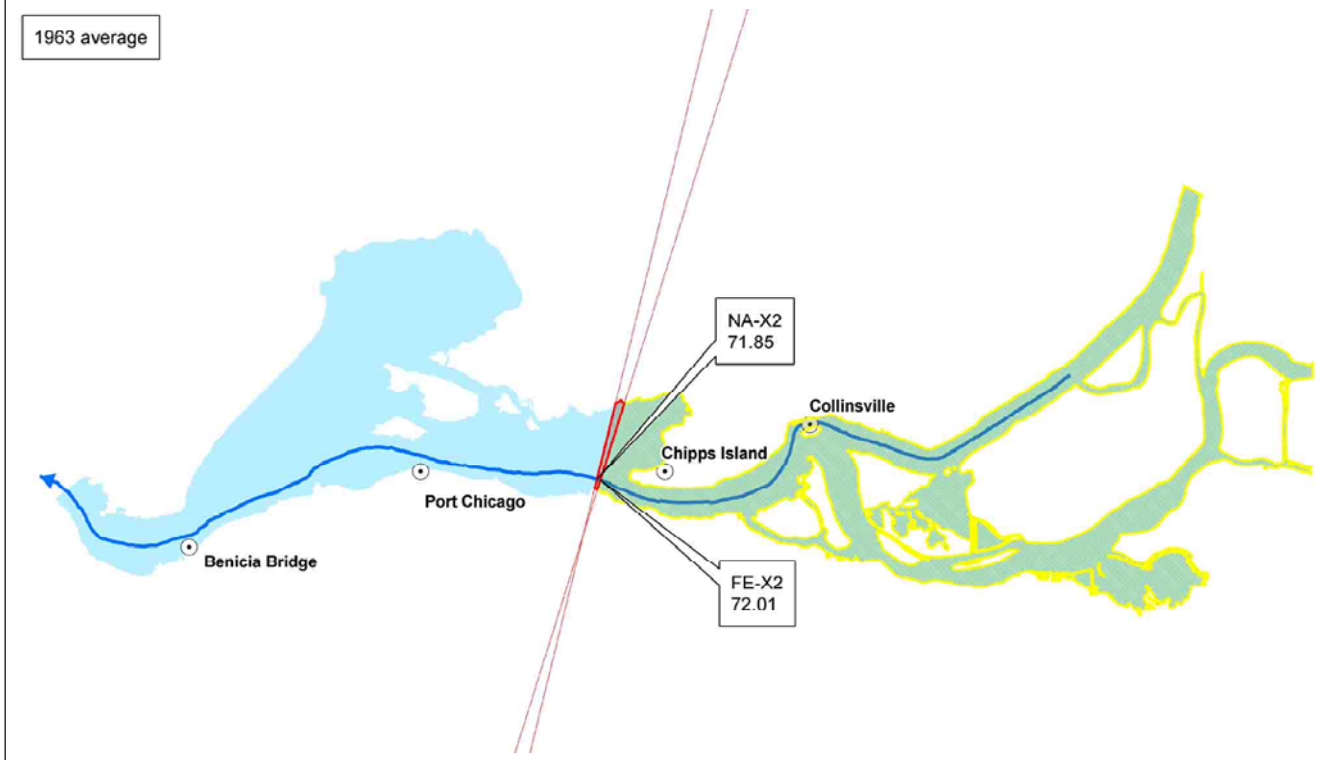
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
80.48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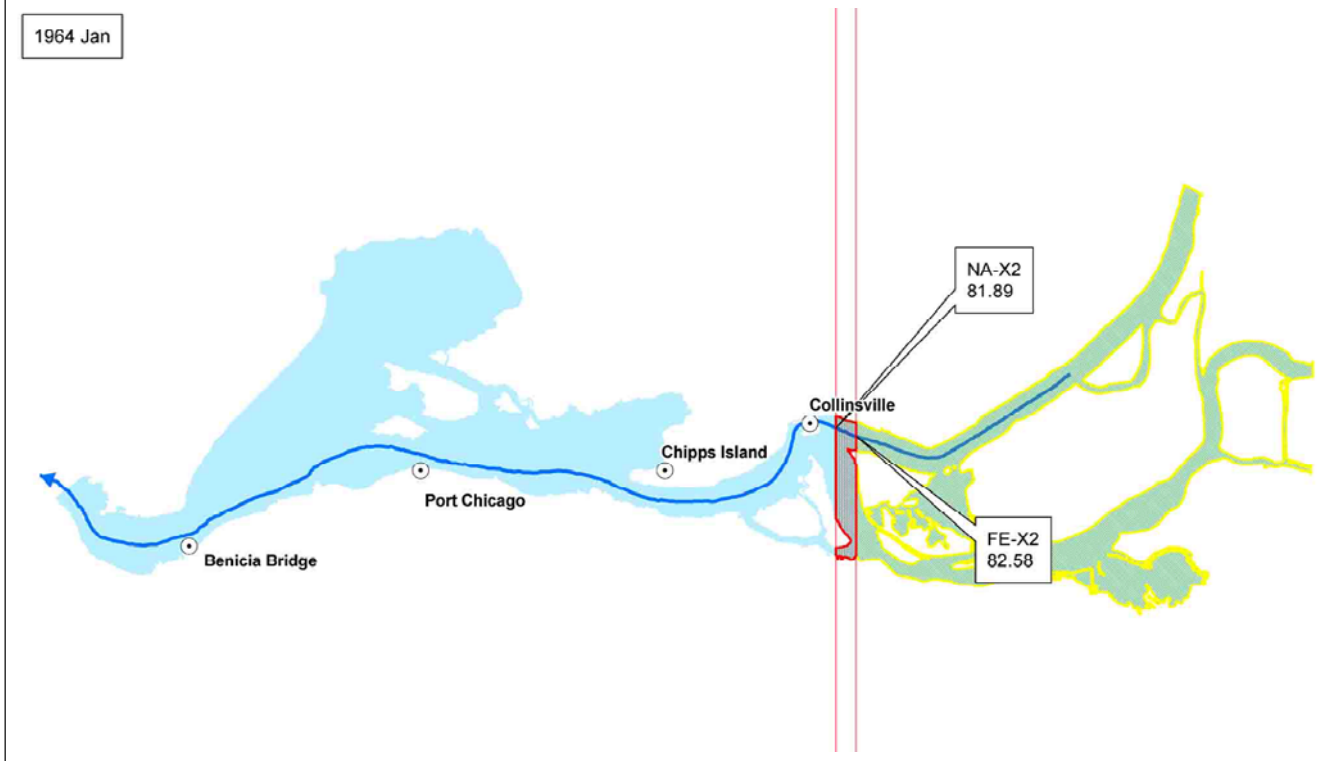
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
72.01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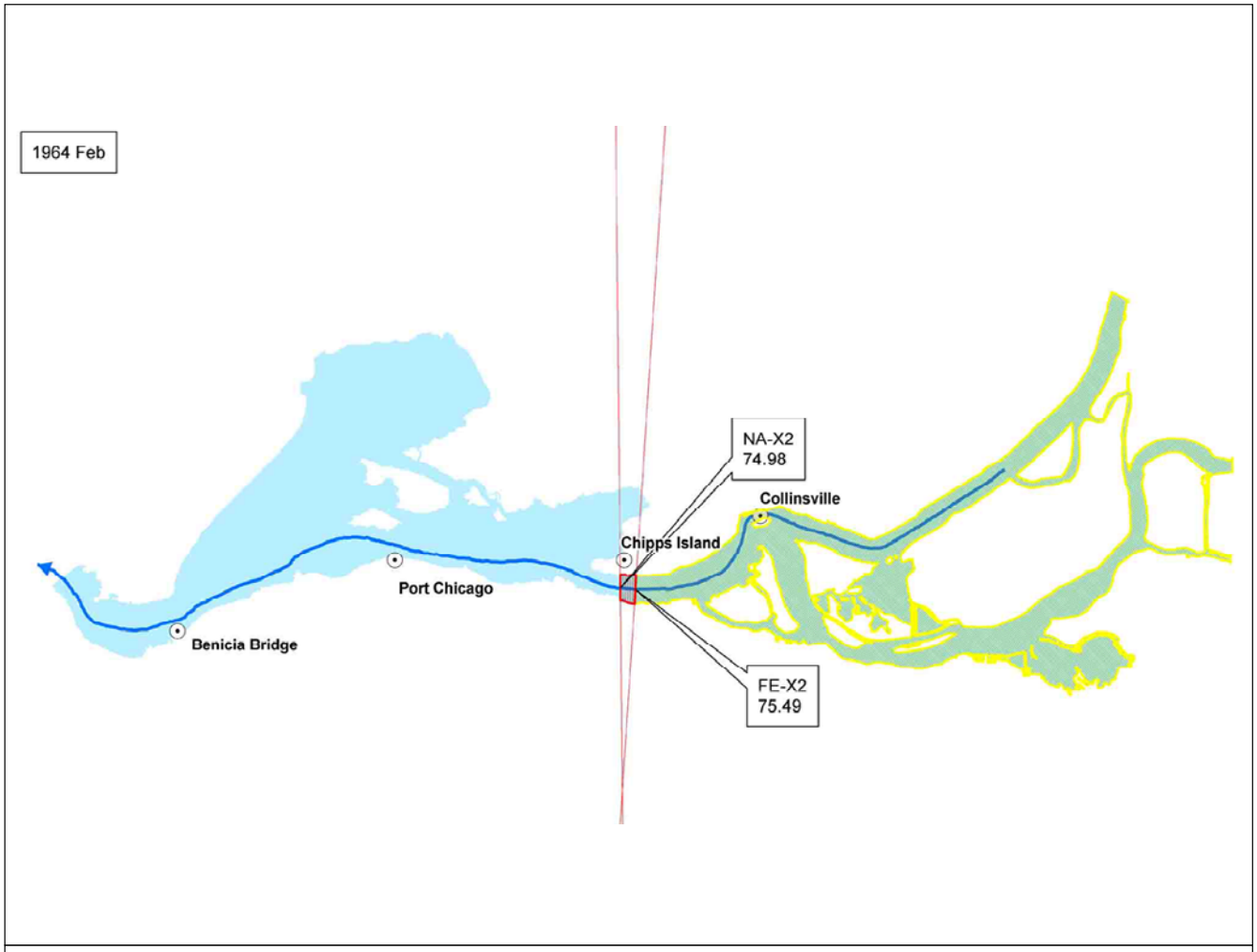
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
82.58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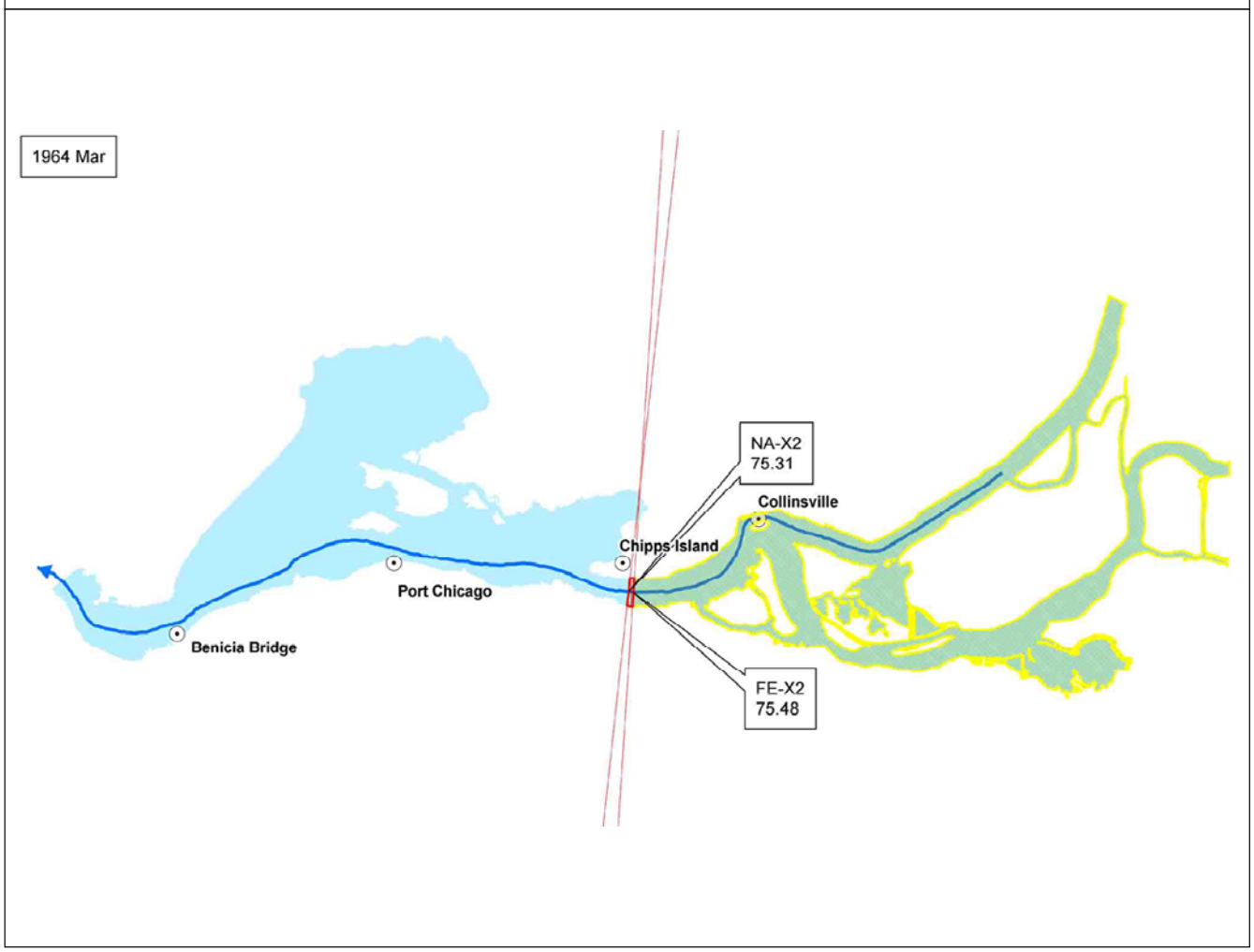
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
75.49


1964 Mar
NA-X2
75.31
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
75.48


1964 Apr
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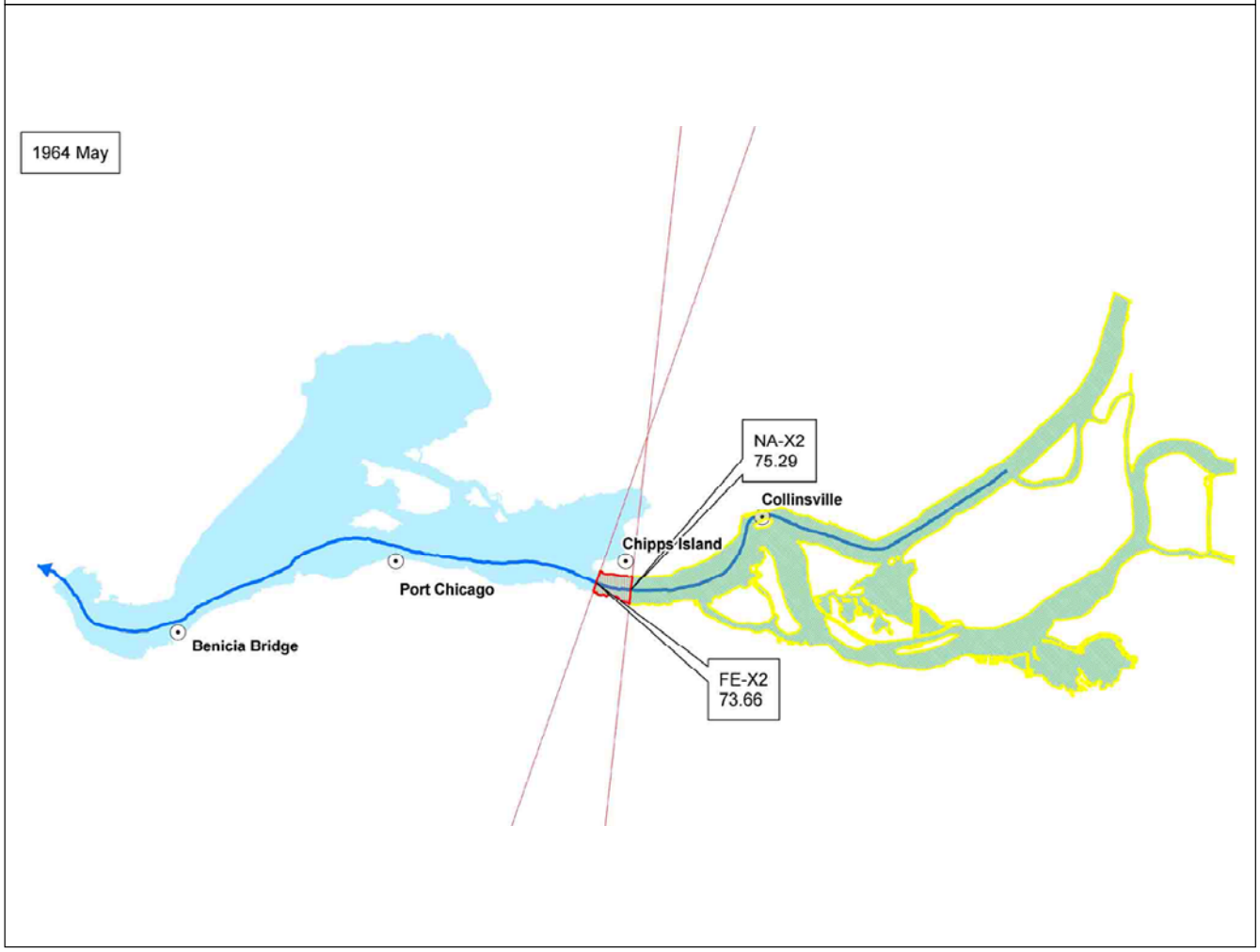
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
77.70


1964 May
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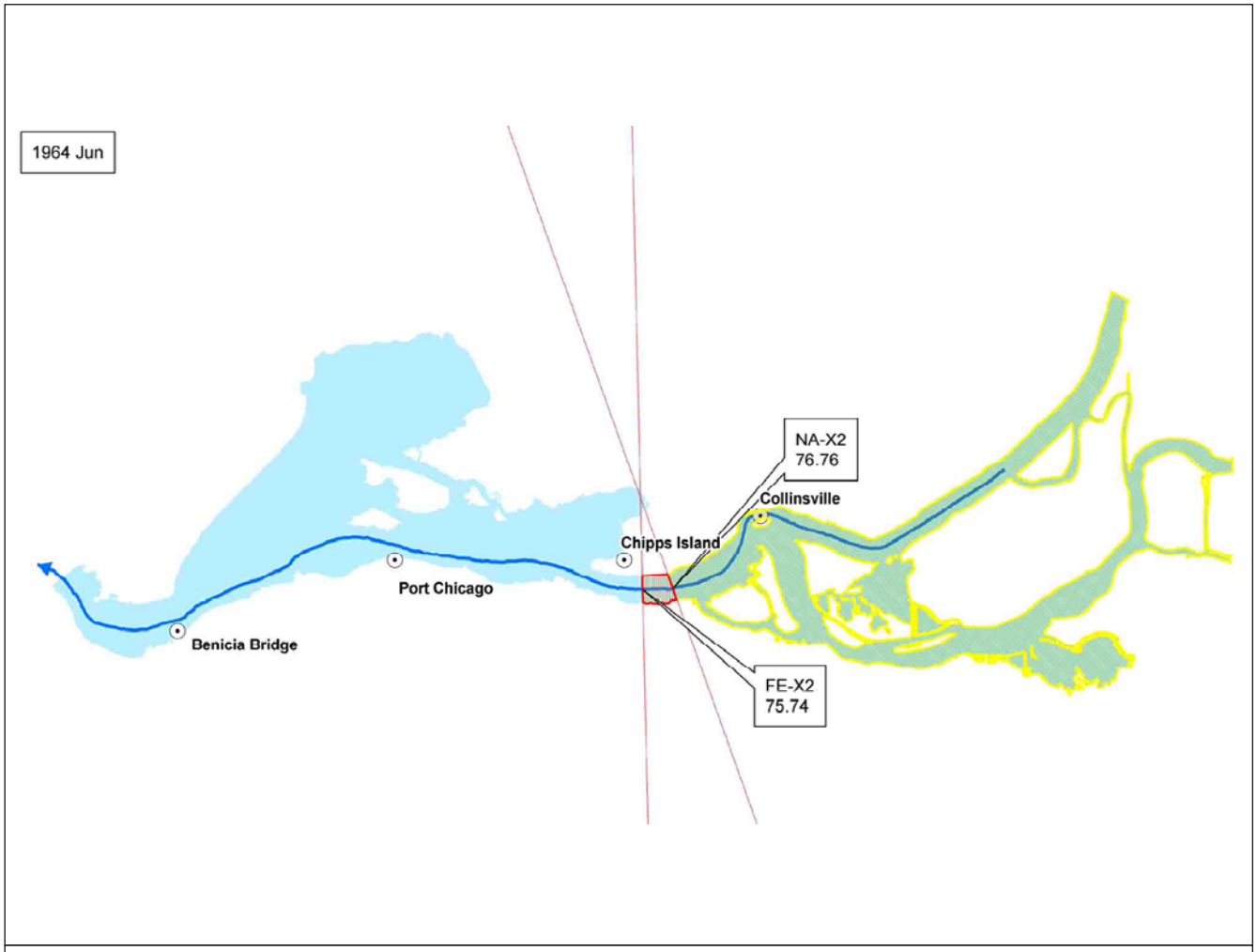
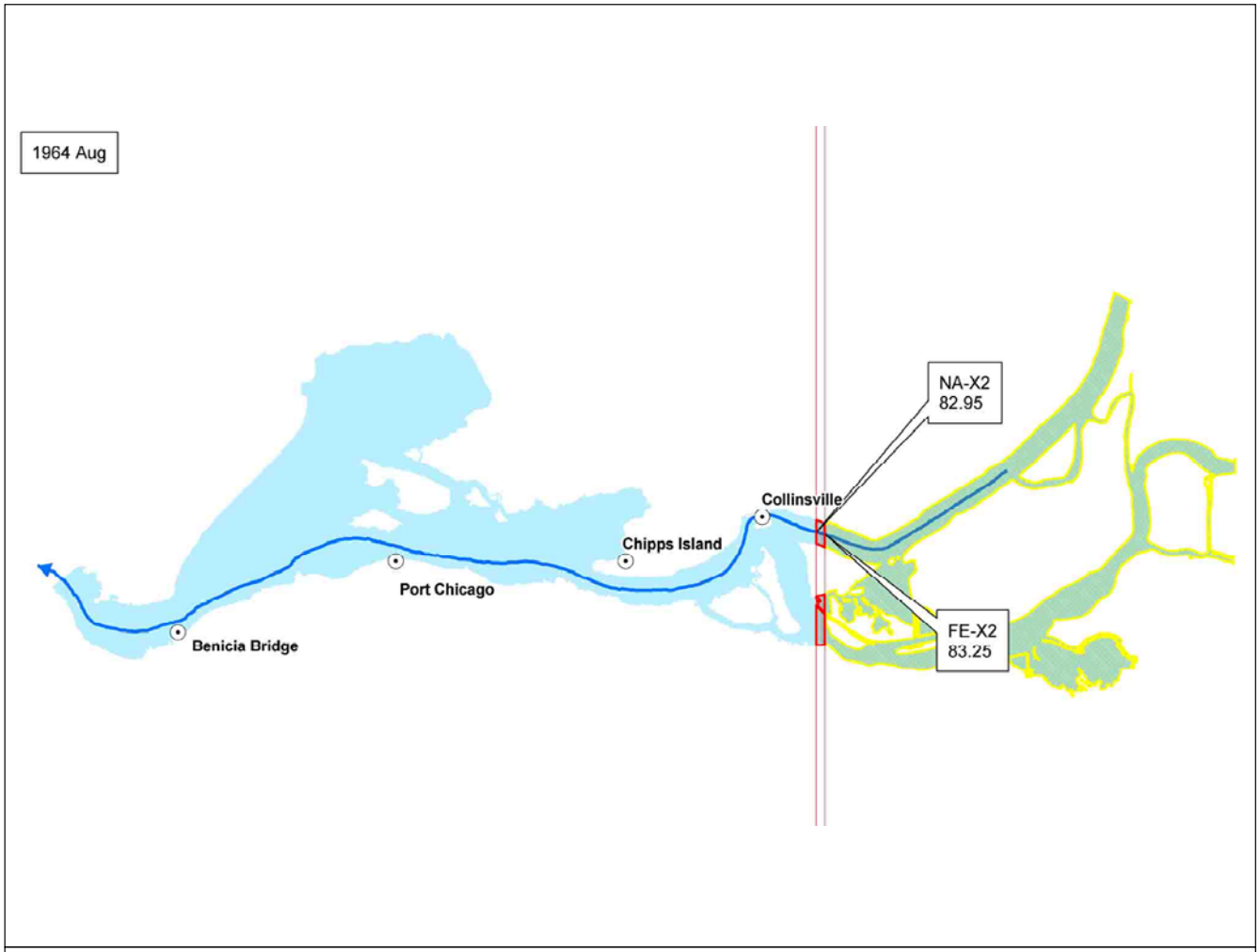
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
73.66


1964 Jun
NA-X2
76.76
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
75.74

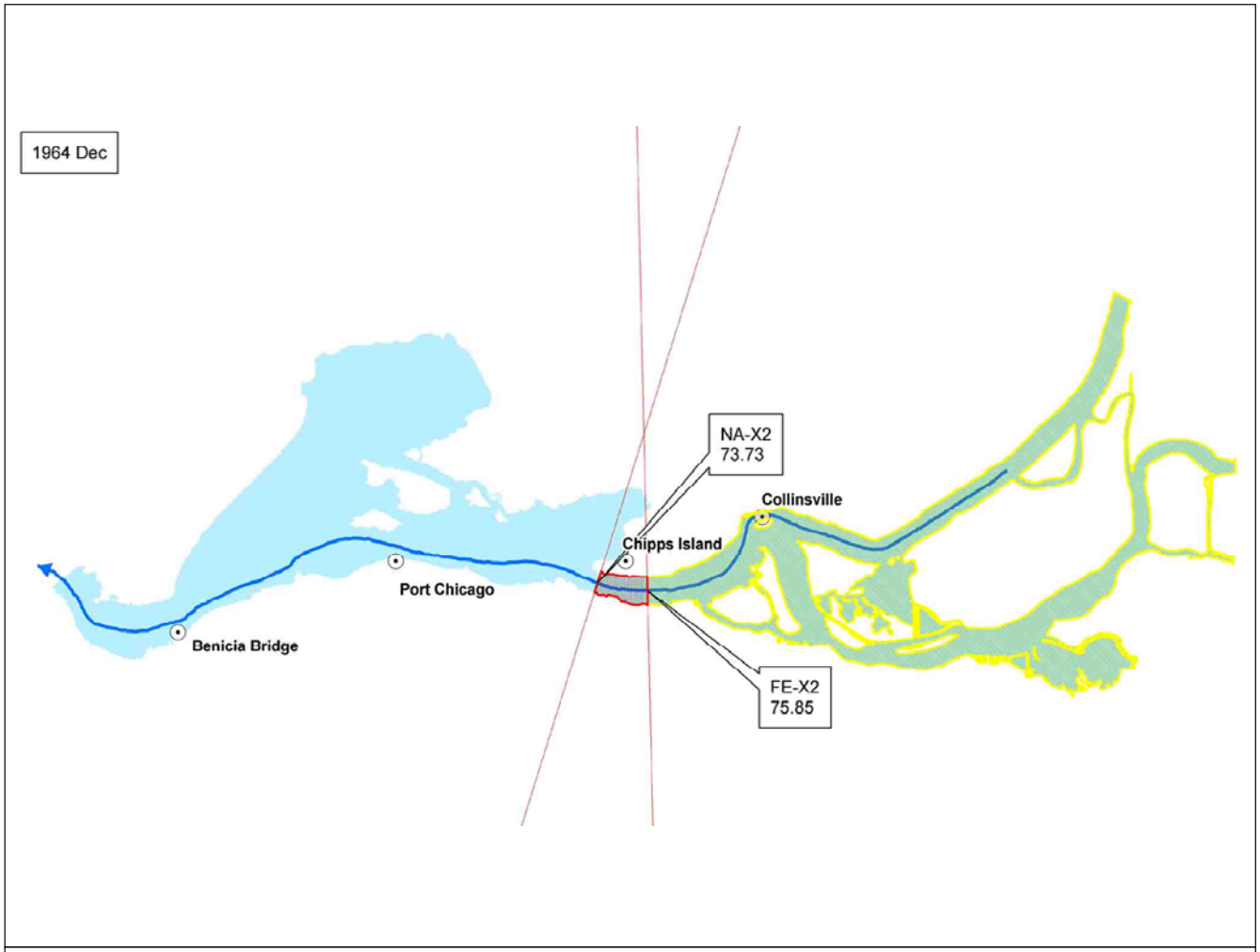

1964 Jul
NA-X2
79.44
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
80.36


1964 Aug
NA-X2
82.95
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
83.25


1964 Sep
NA-X2
84.68
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
84.48


1964 Oct
NA-X2
85.36
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
86.82


1964 Nov
NA-X2
82.65
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
86.75


1964 Dec
NA-X2
73.73
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
75.85


1964 average
NA-X2
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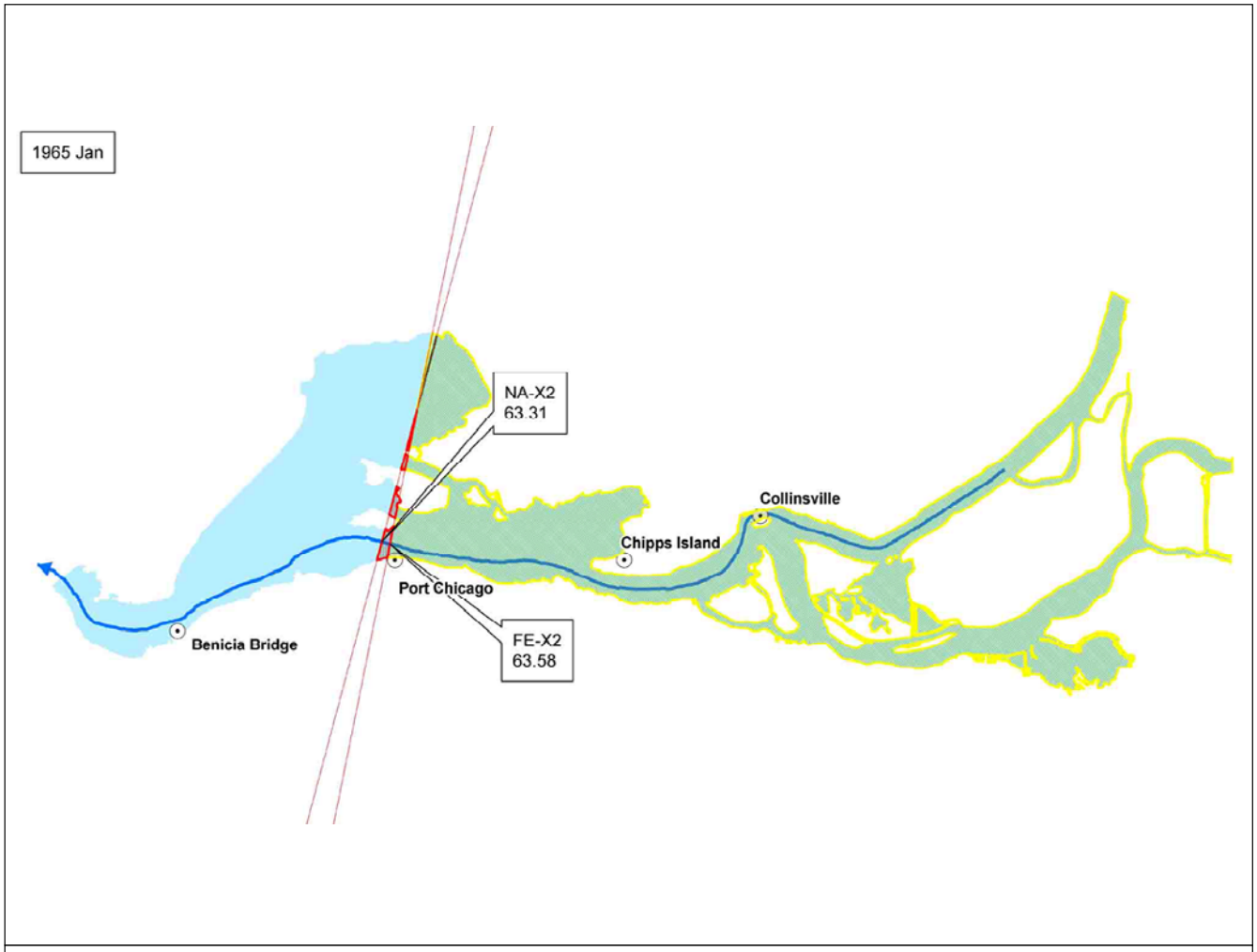
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
79.85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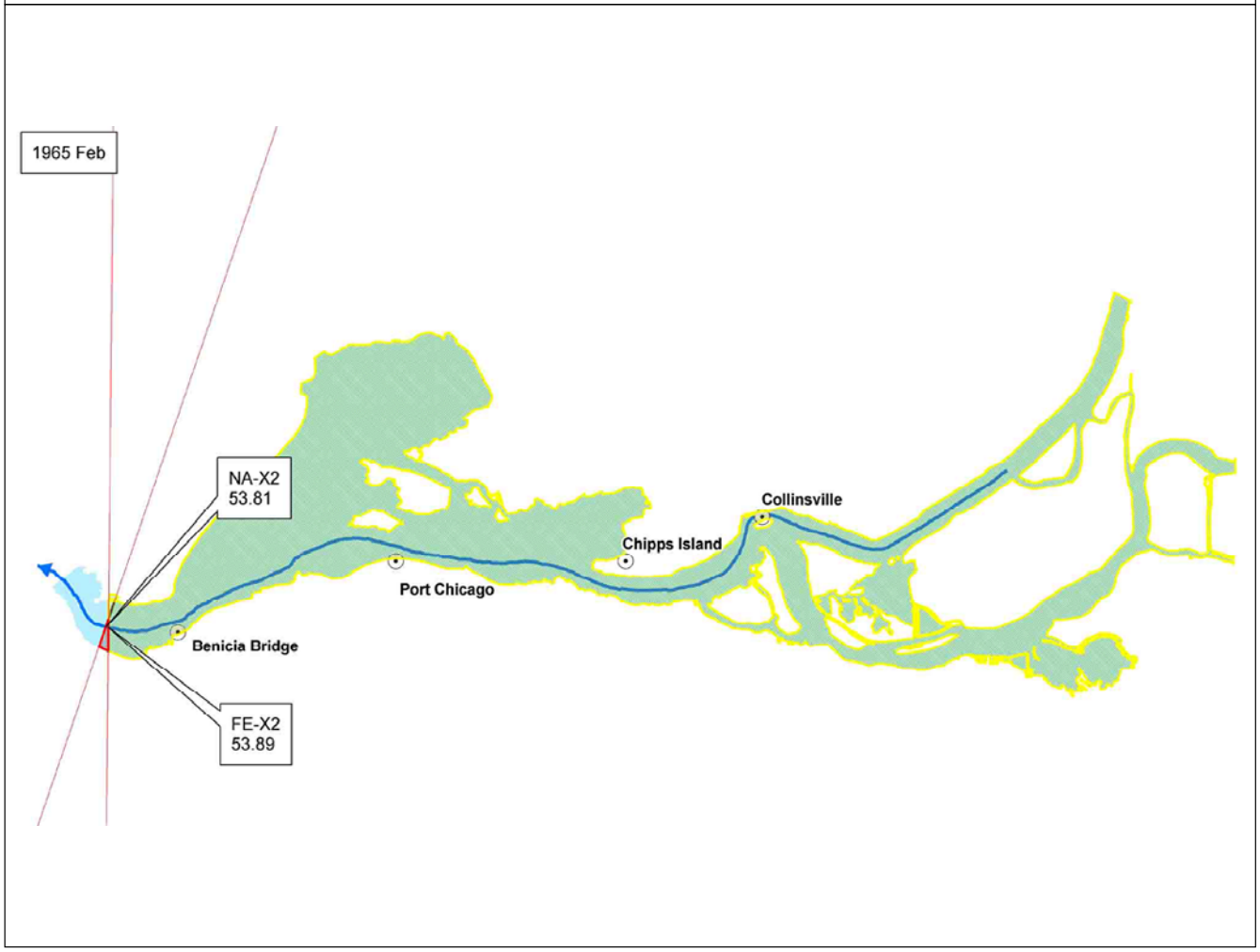
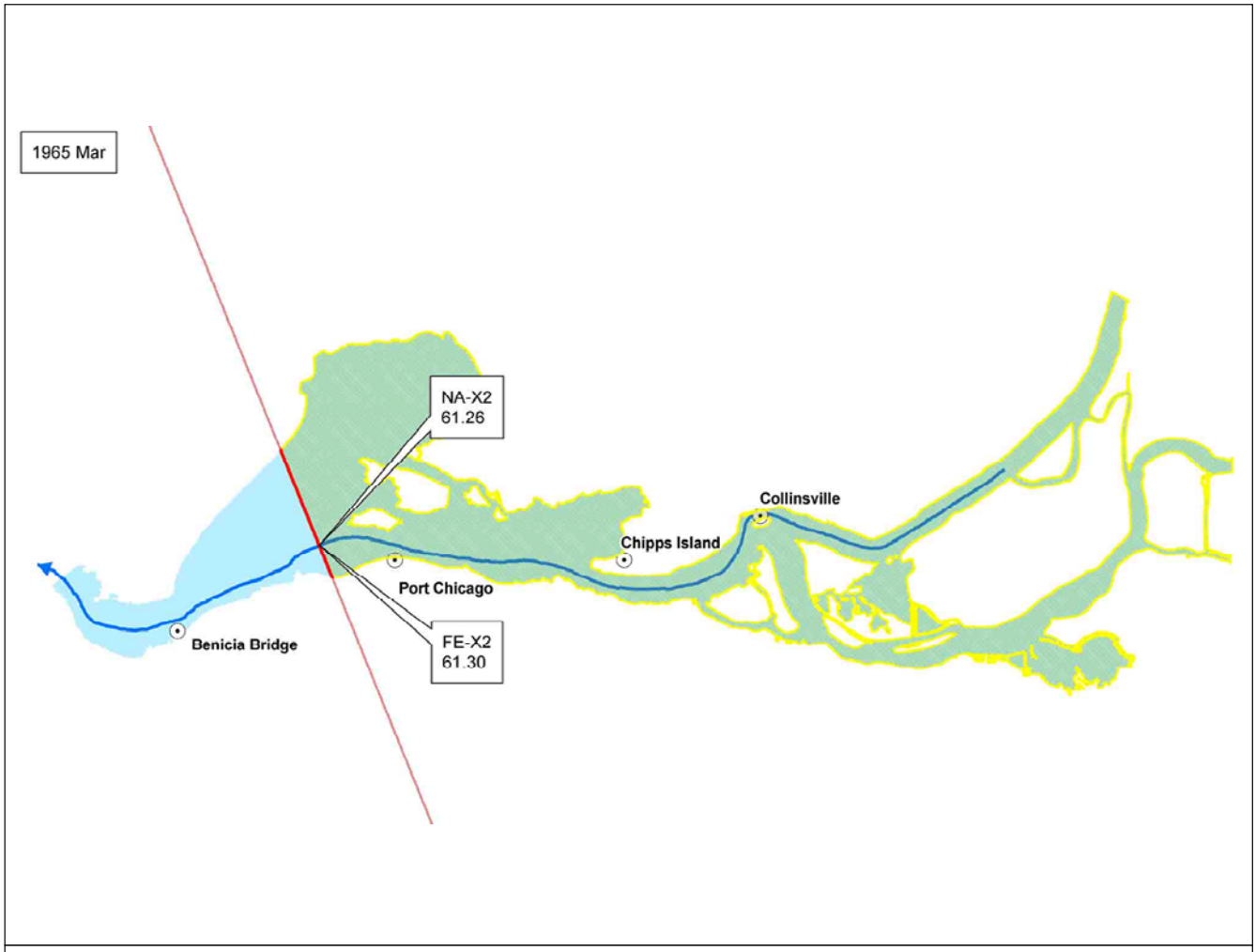
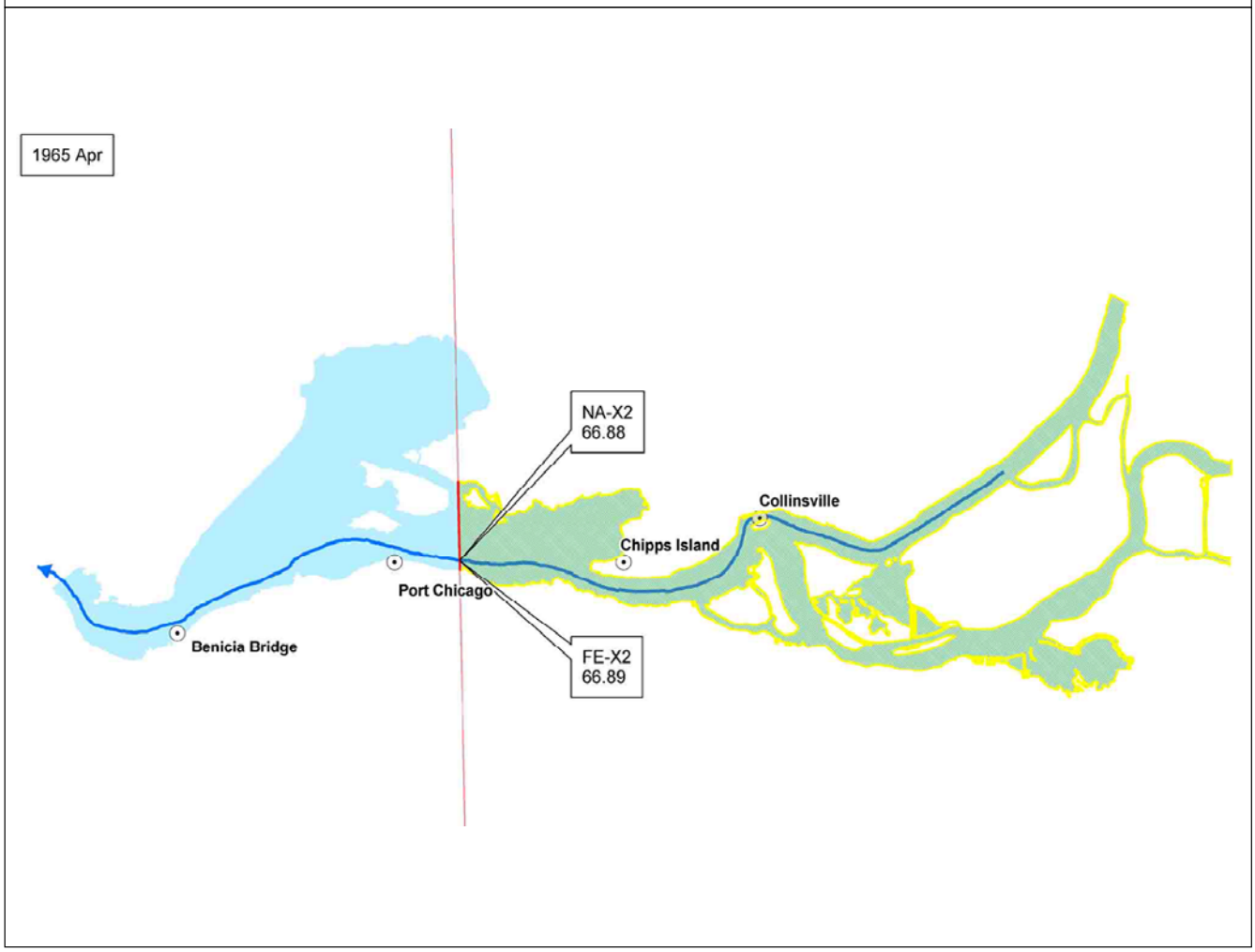
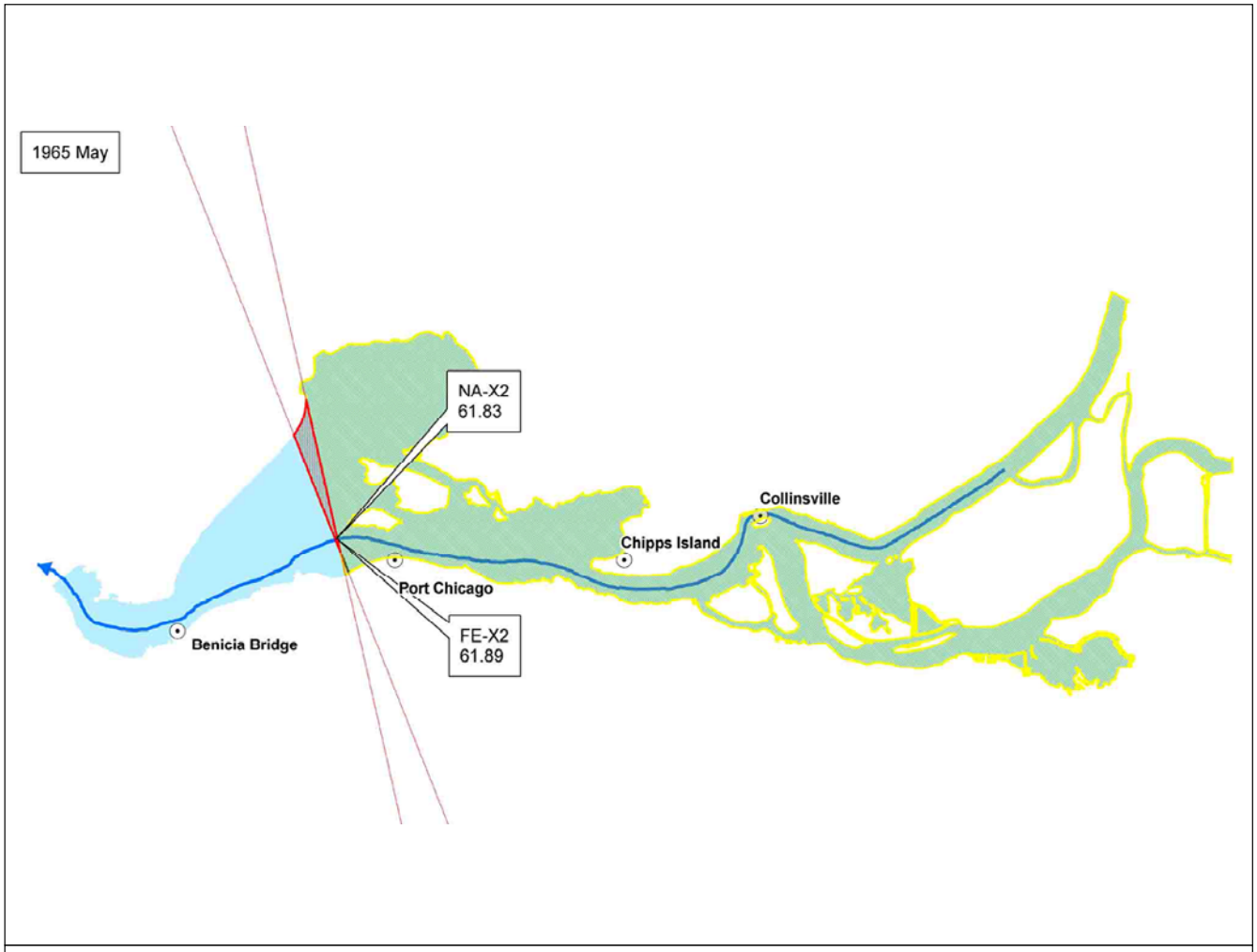
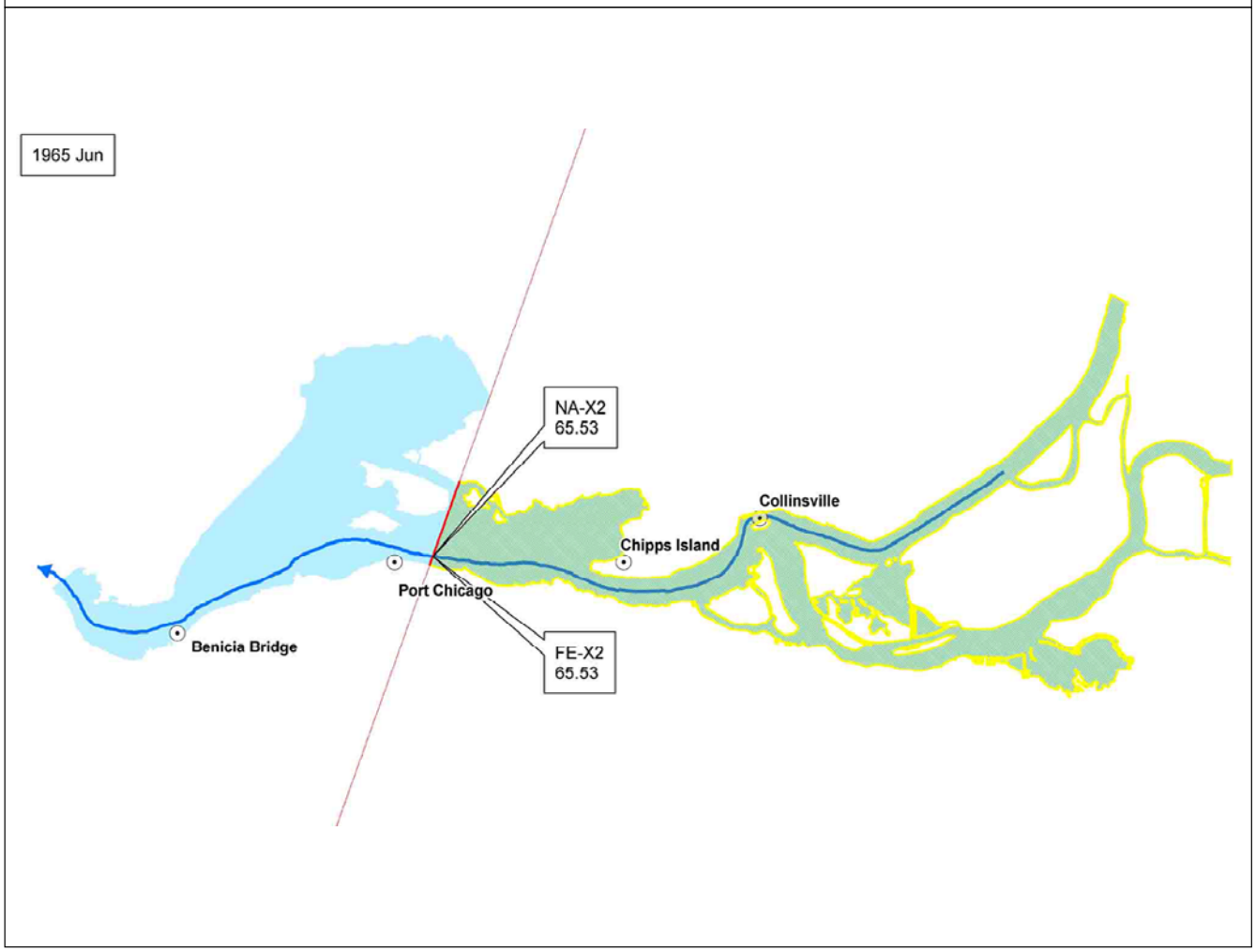
NA-X2
63.31
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
63.58


1965 Feb
NA-X2
53.81
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
53.89


1965 Mar
NA-X2
61.26
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
61.30


1965 Apr
NA-X2
66.88
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
66.89


1965 May
NA-X2
61.83
Collinsville
Chipps Island
Port Chicago
FE-X2
61.89
Benicia Bridge


1965 Jun
NA-X2
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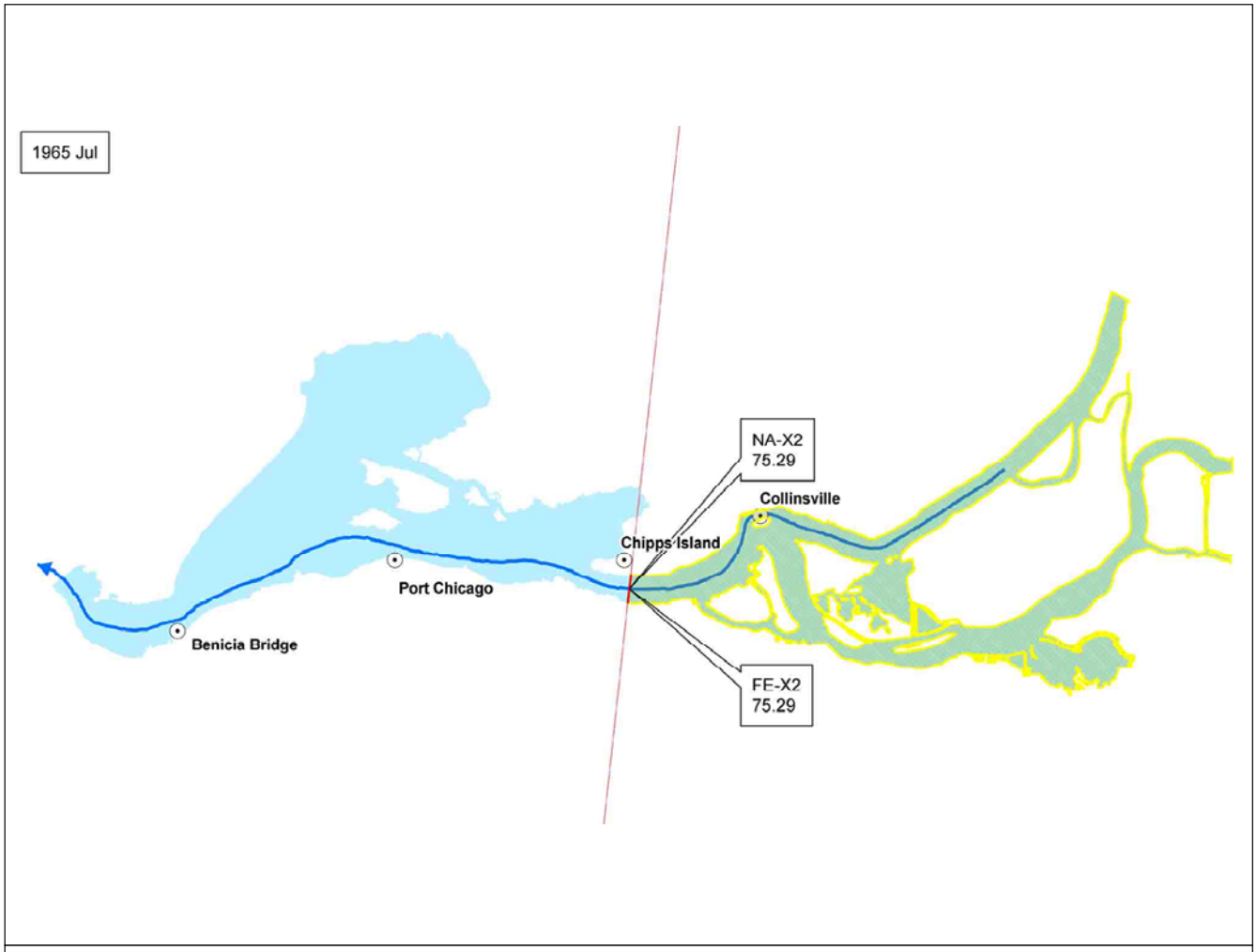
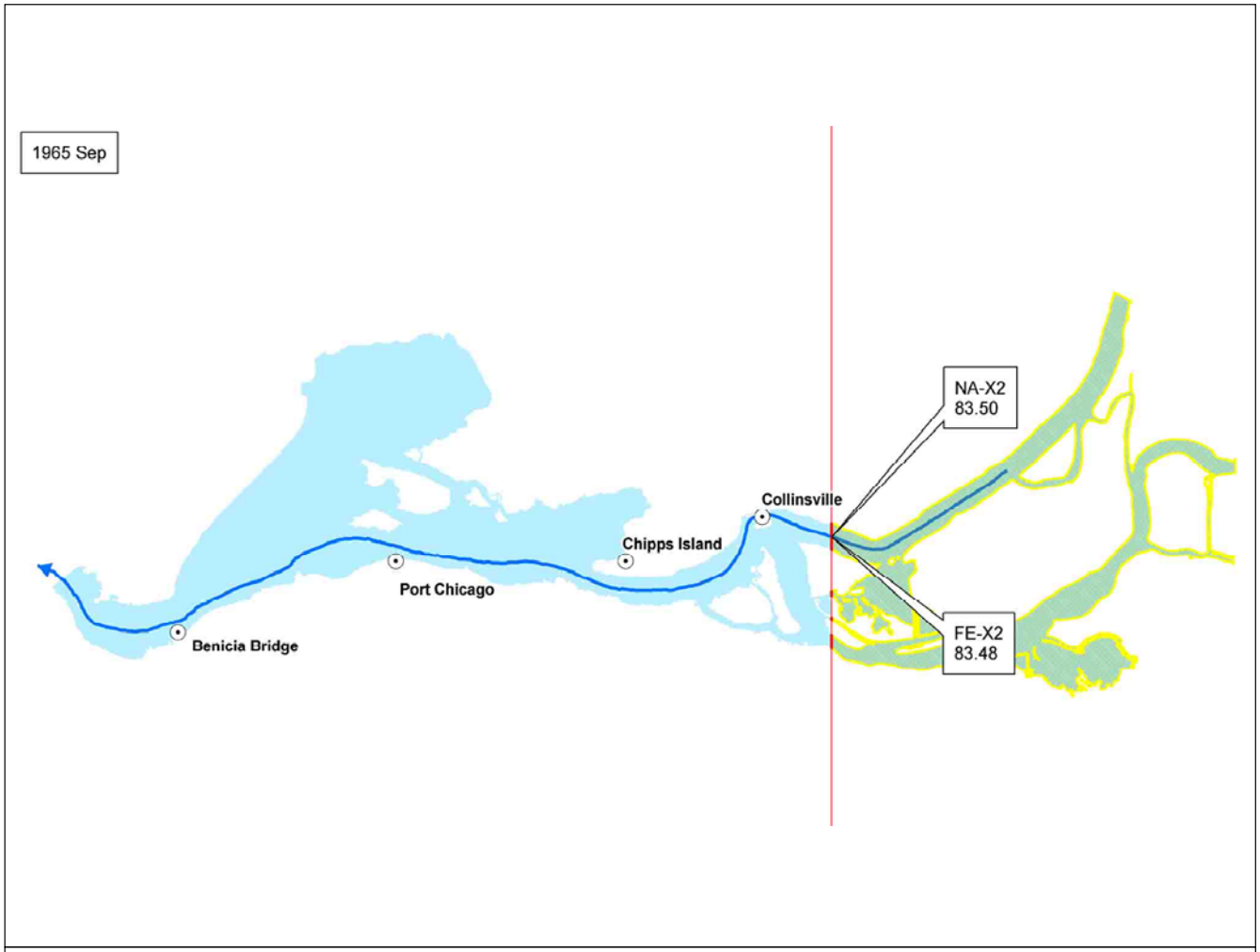
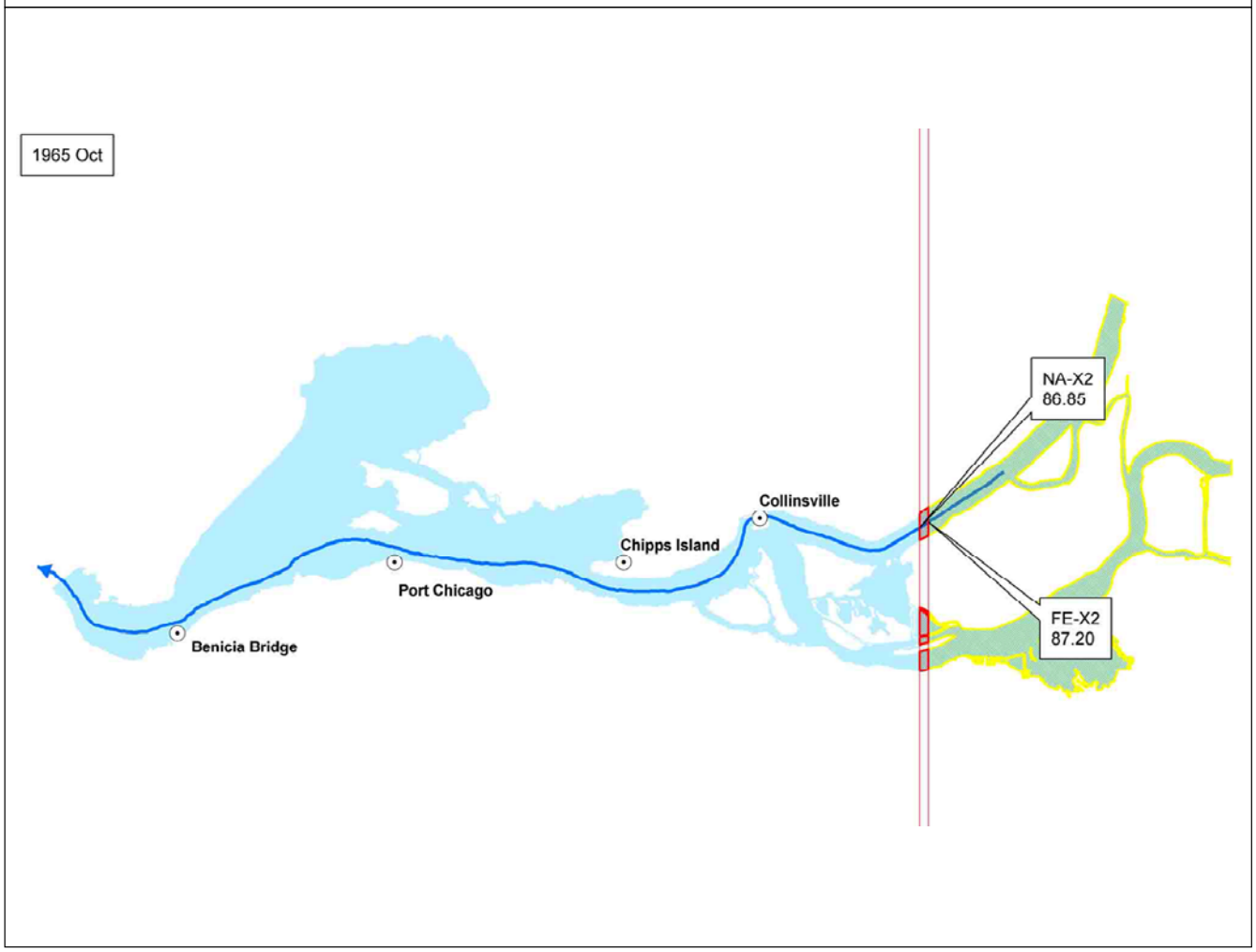
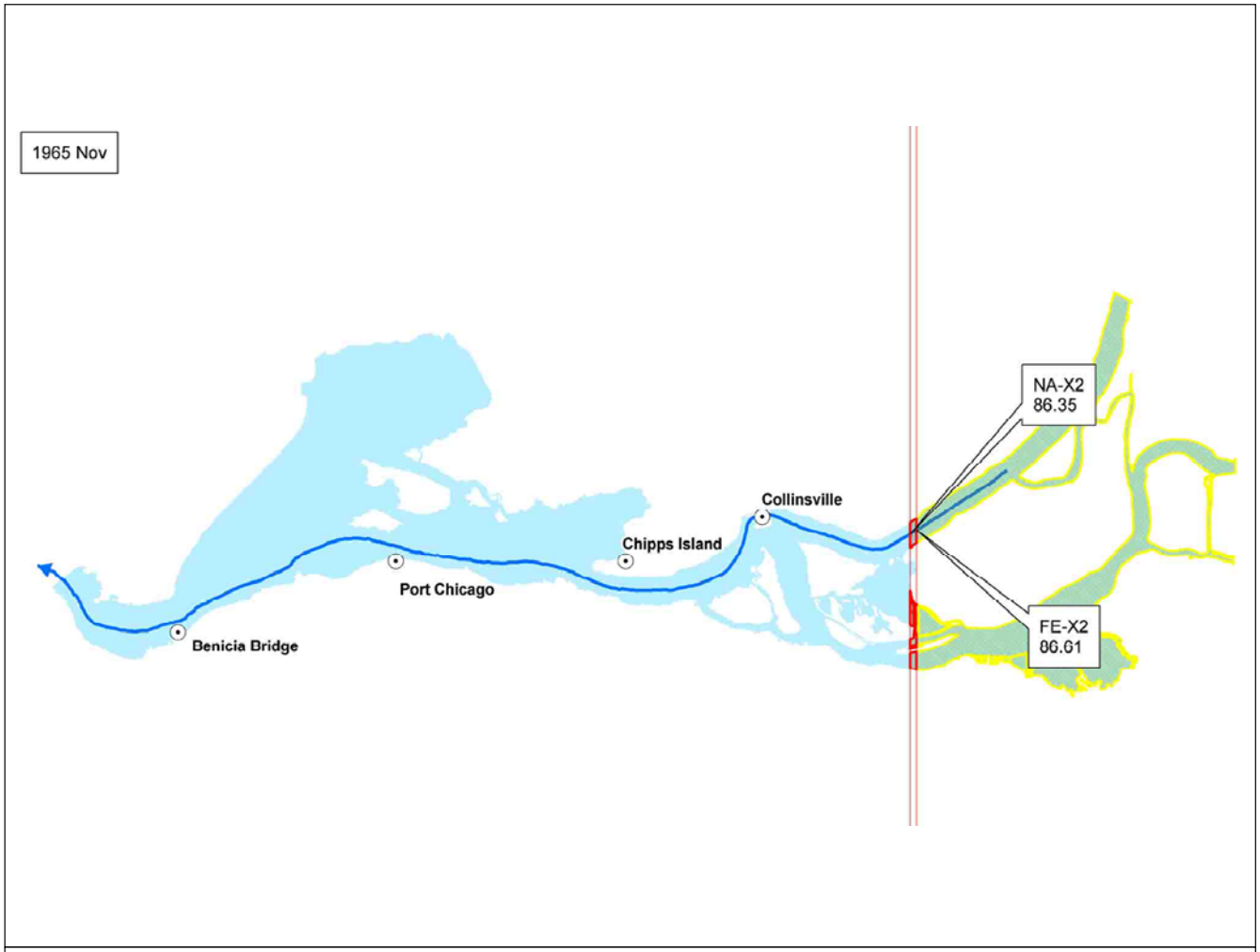
Collinsville
Chipps Island
Port Chicago
FE-X2
65.53
Benicia Bridge


1965 Jul
NA-X2
75.29
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
75.29

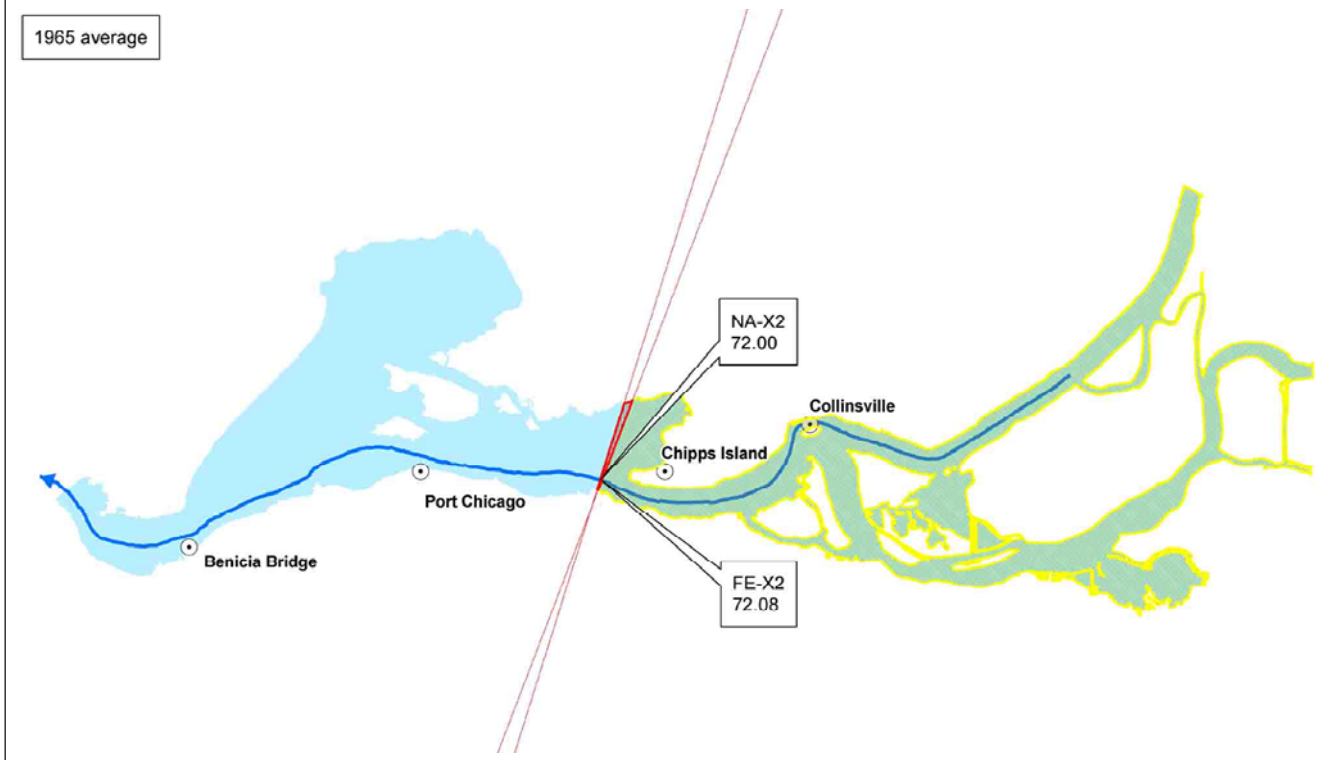

1965 Aug
NA-X2
75.91
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
75.85

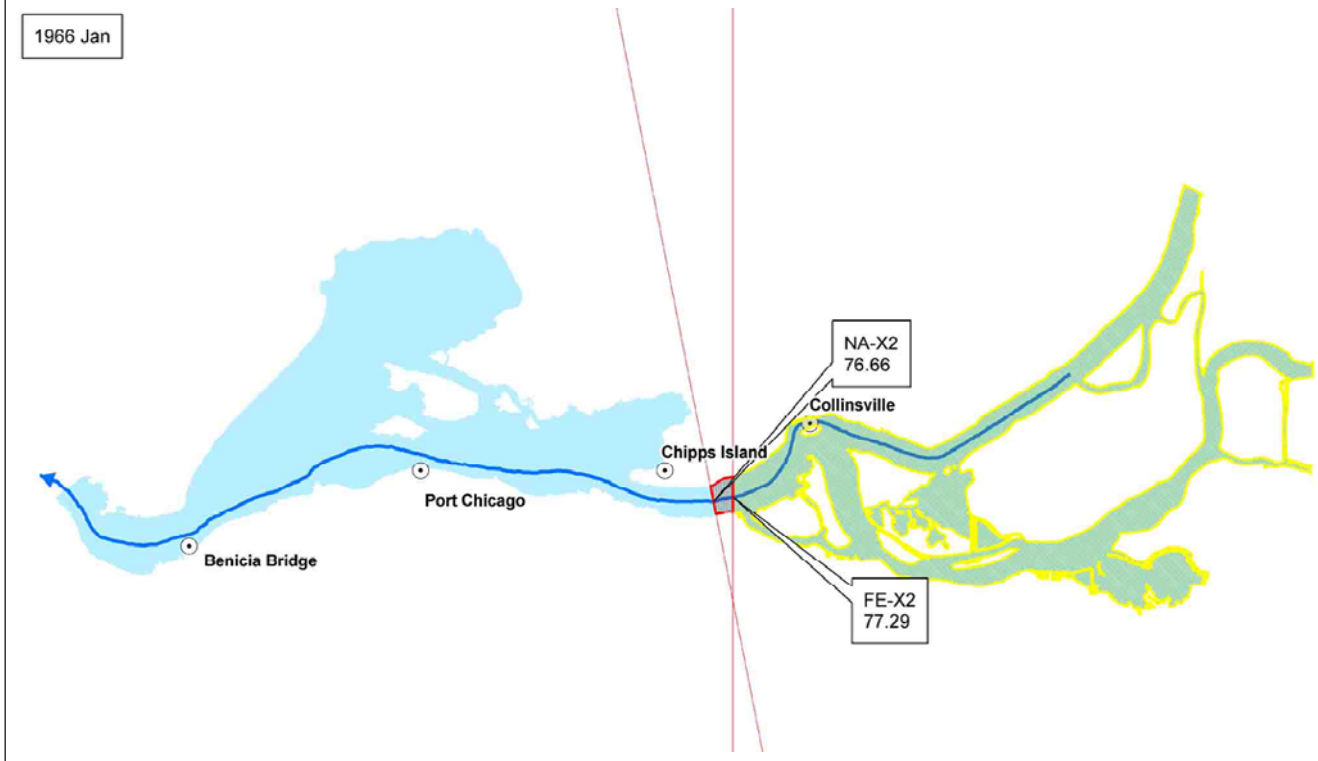

1965 Sep
NA-X2
83.50
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
83.48

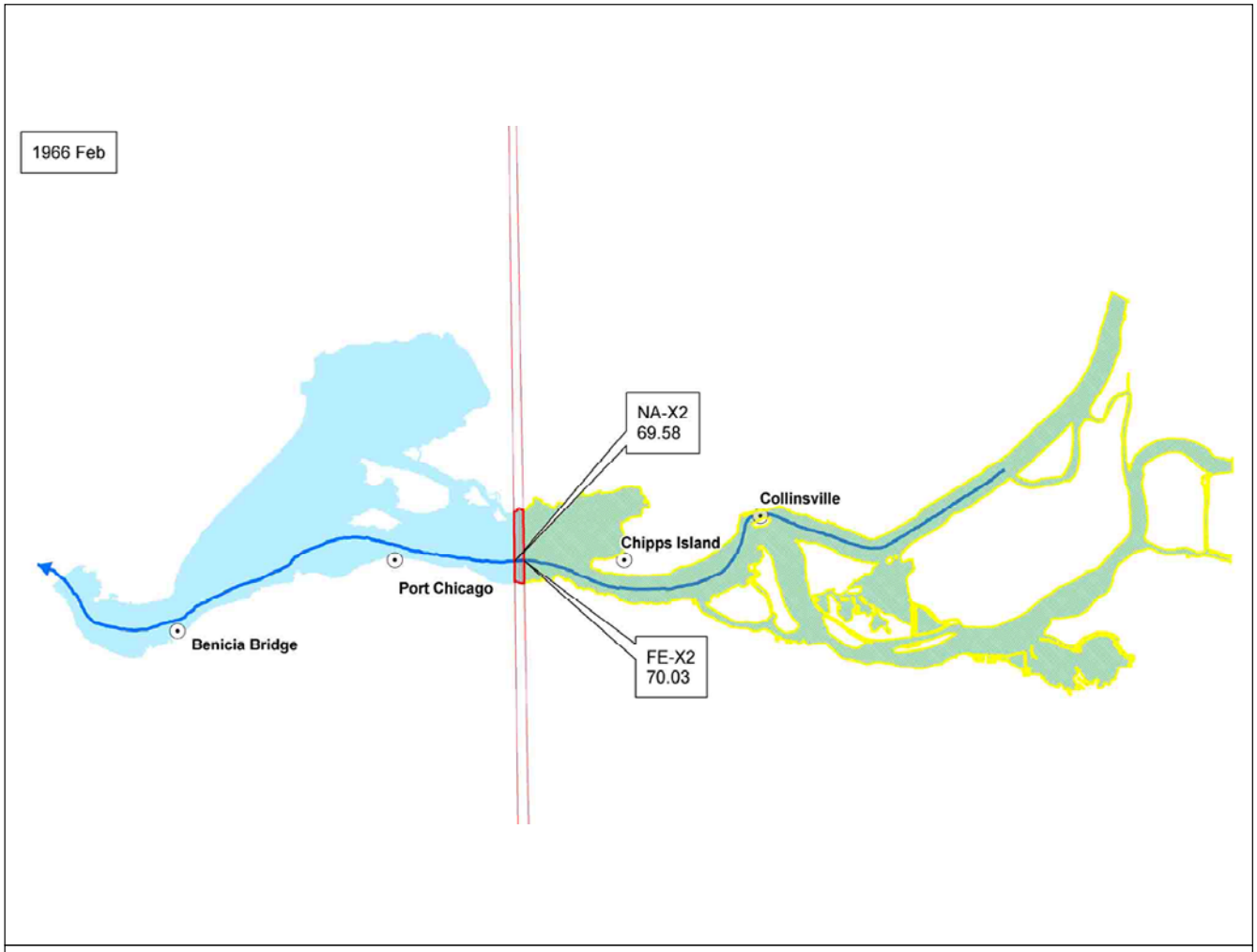

1965 Oct
NA-X2
86.85
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
87.20

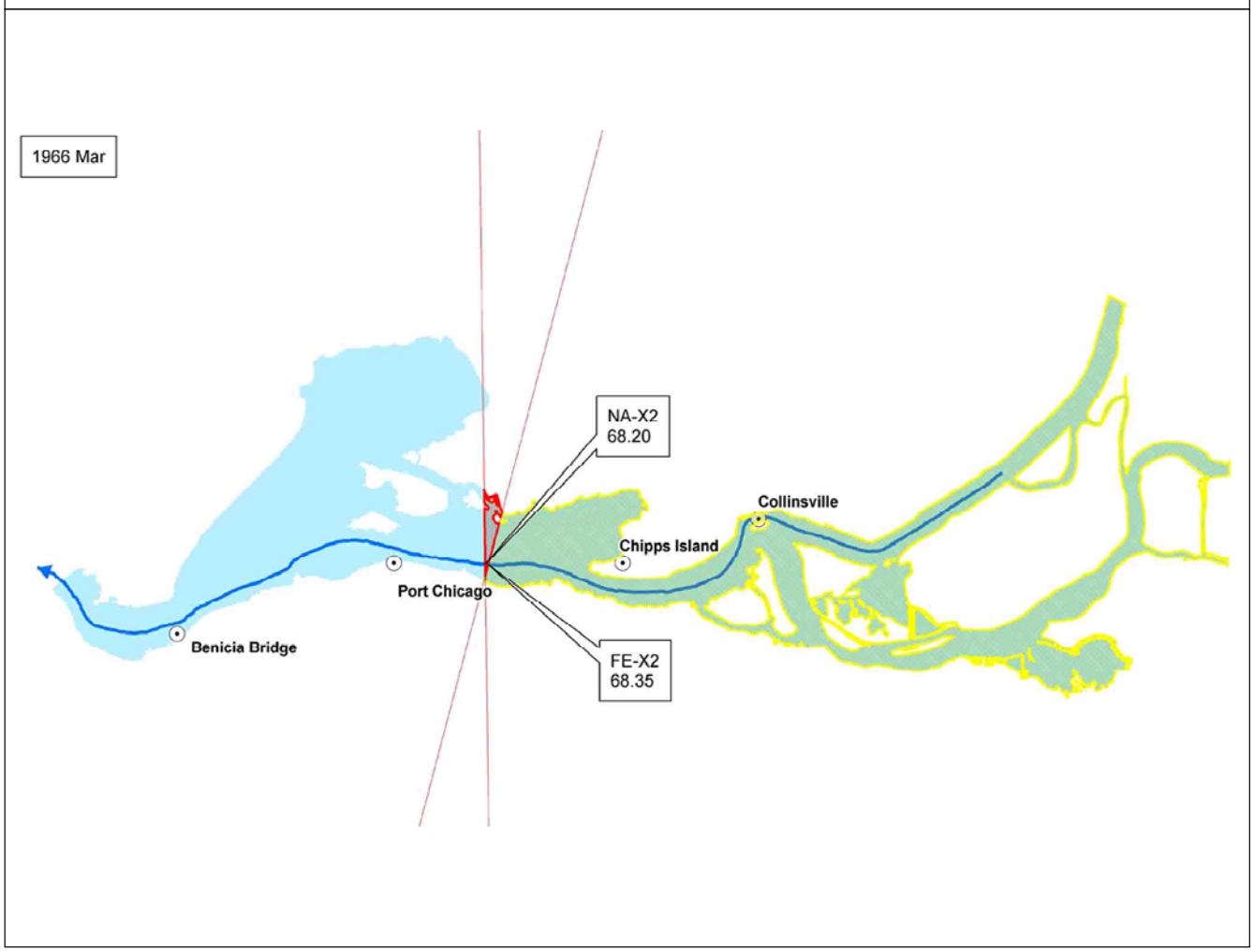

1965 Nov
NA-X2
86.35
FE-X2
86.61
Collinsville
Chipps Island
Port Chicago
Benicia Bridge

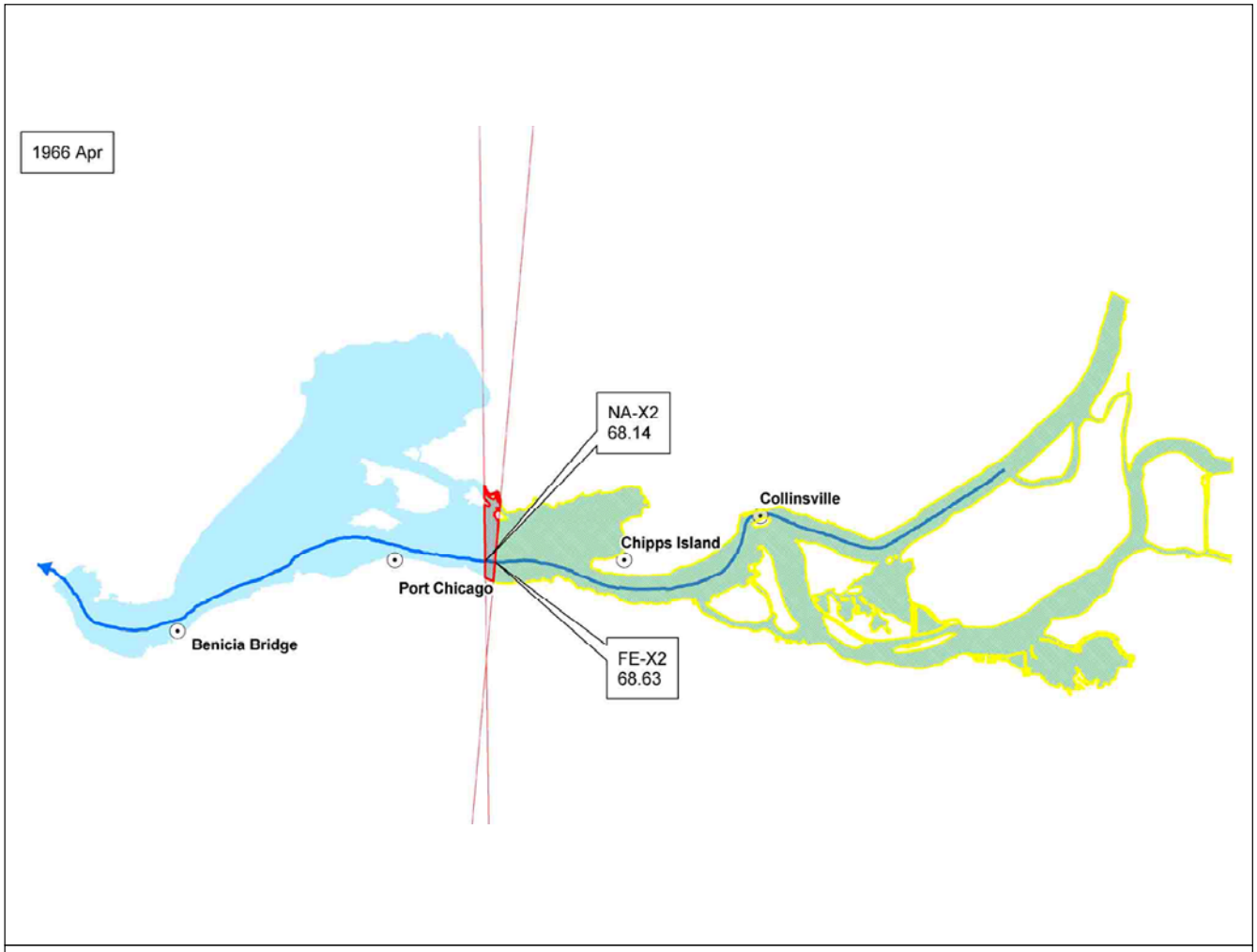

1965 Dec
NA-X2
83.51
FE-X2
83.48
Collinsville
Chipps Island
Port Chicago
Benicia Bridge

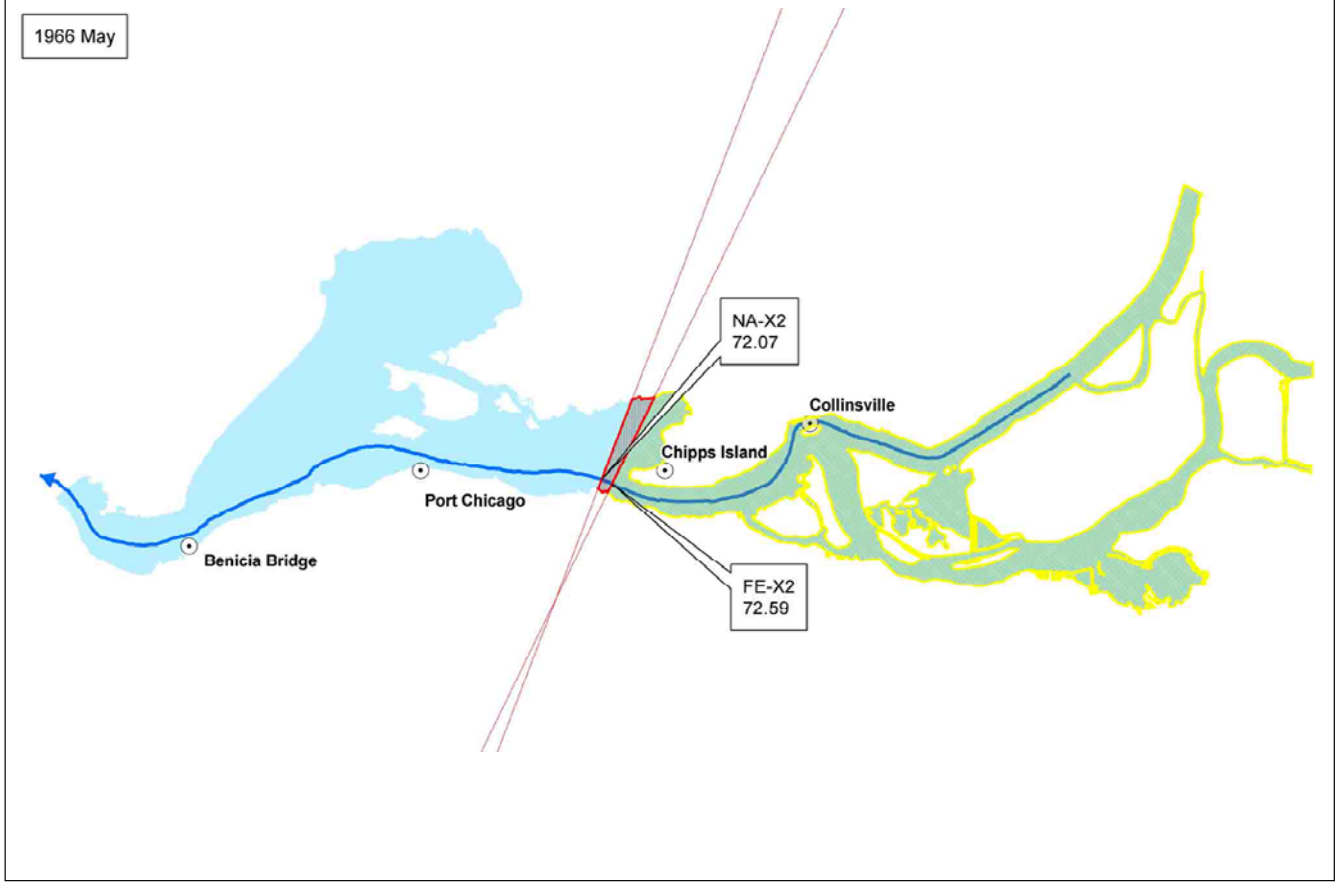

1965 average
NA-X2
72.00
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
72.08

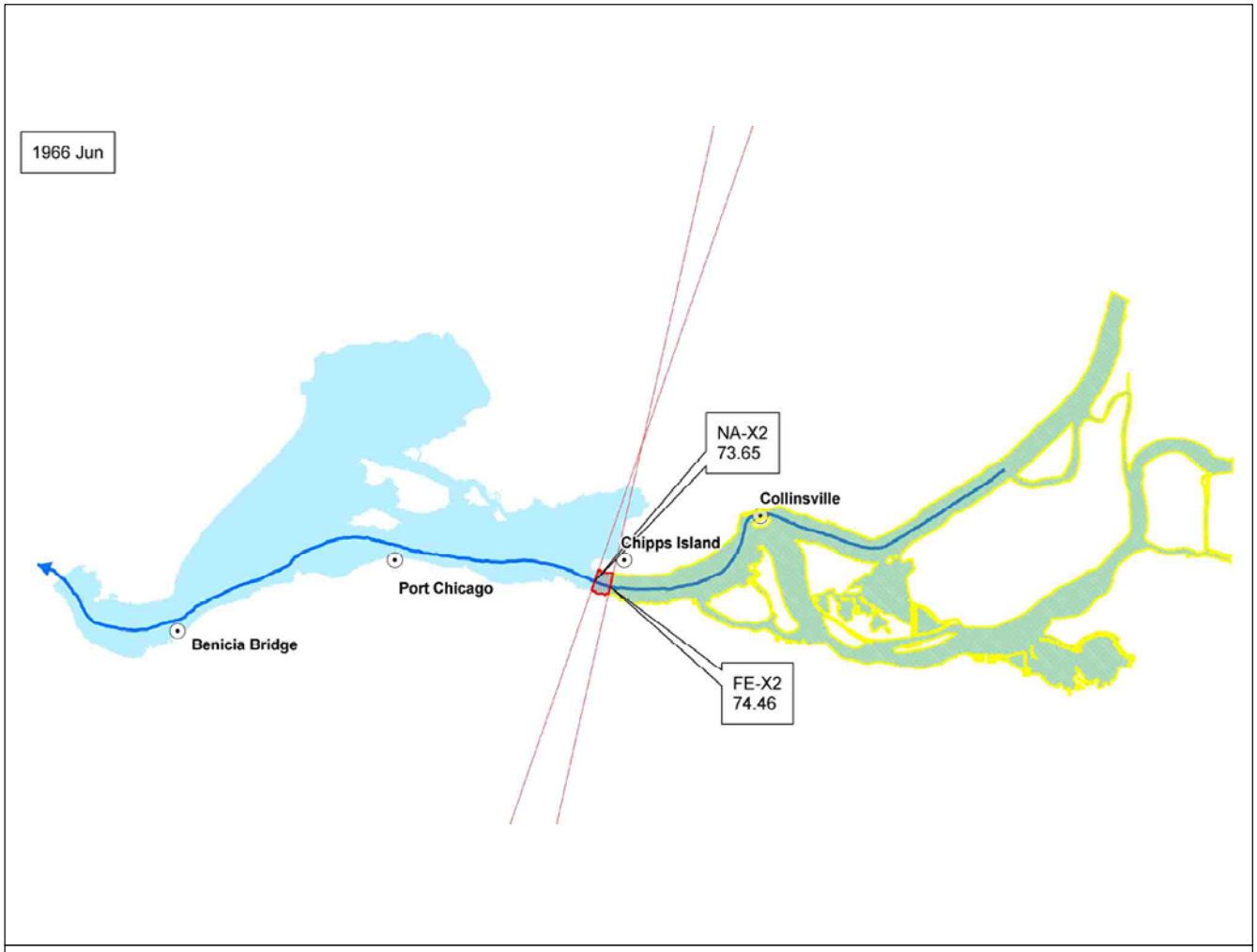

1966 Jan
NA-X2
76.66
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
77.29


1966 Feb
NA-X2
69.58
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
70.03


1966 Mar
NA-X2
68.20
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
68.35


1966 Apr
NA-X2
68.14
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
68.63


1966 May
NA-X2
72.07
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
72.59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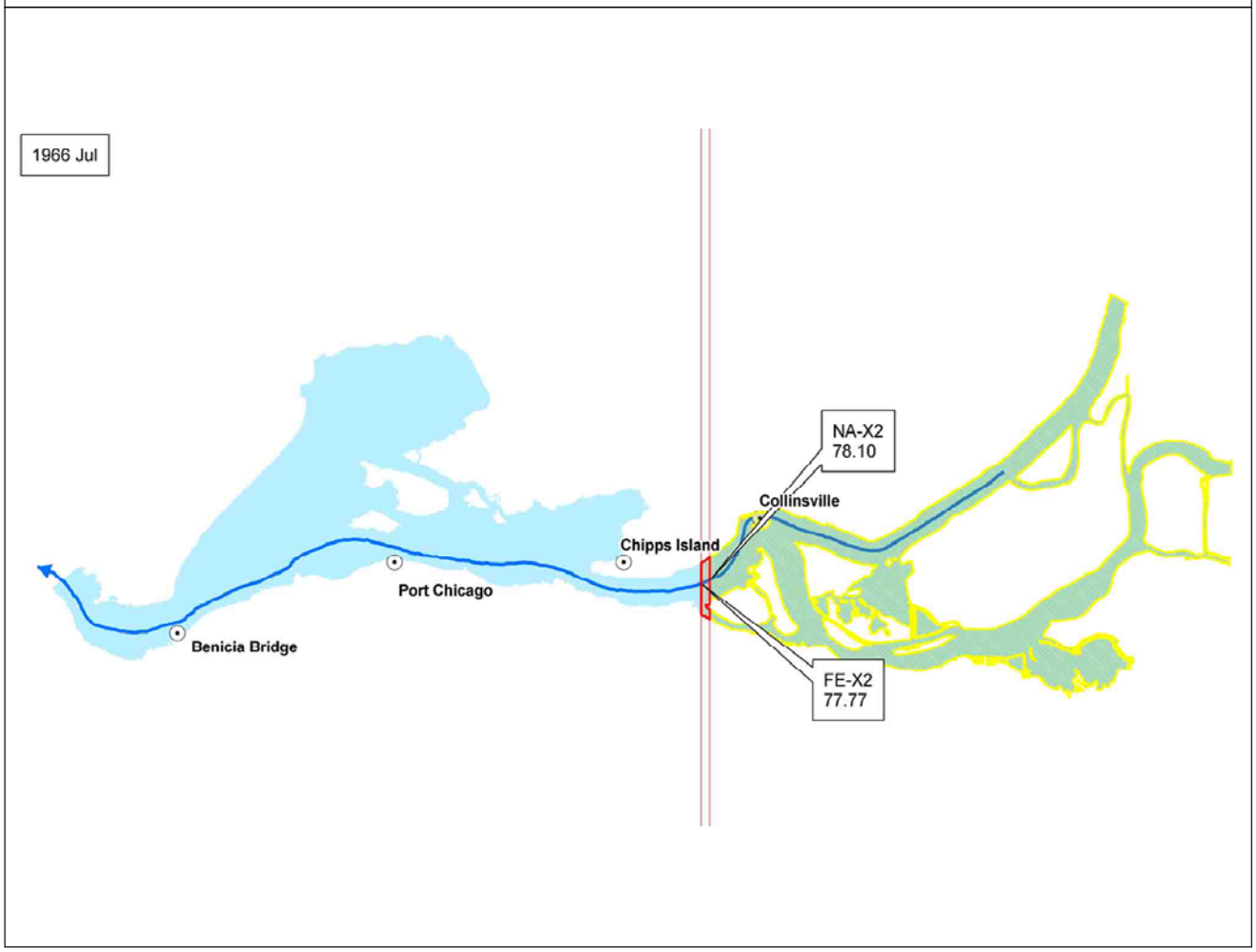
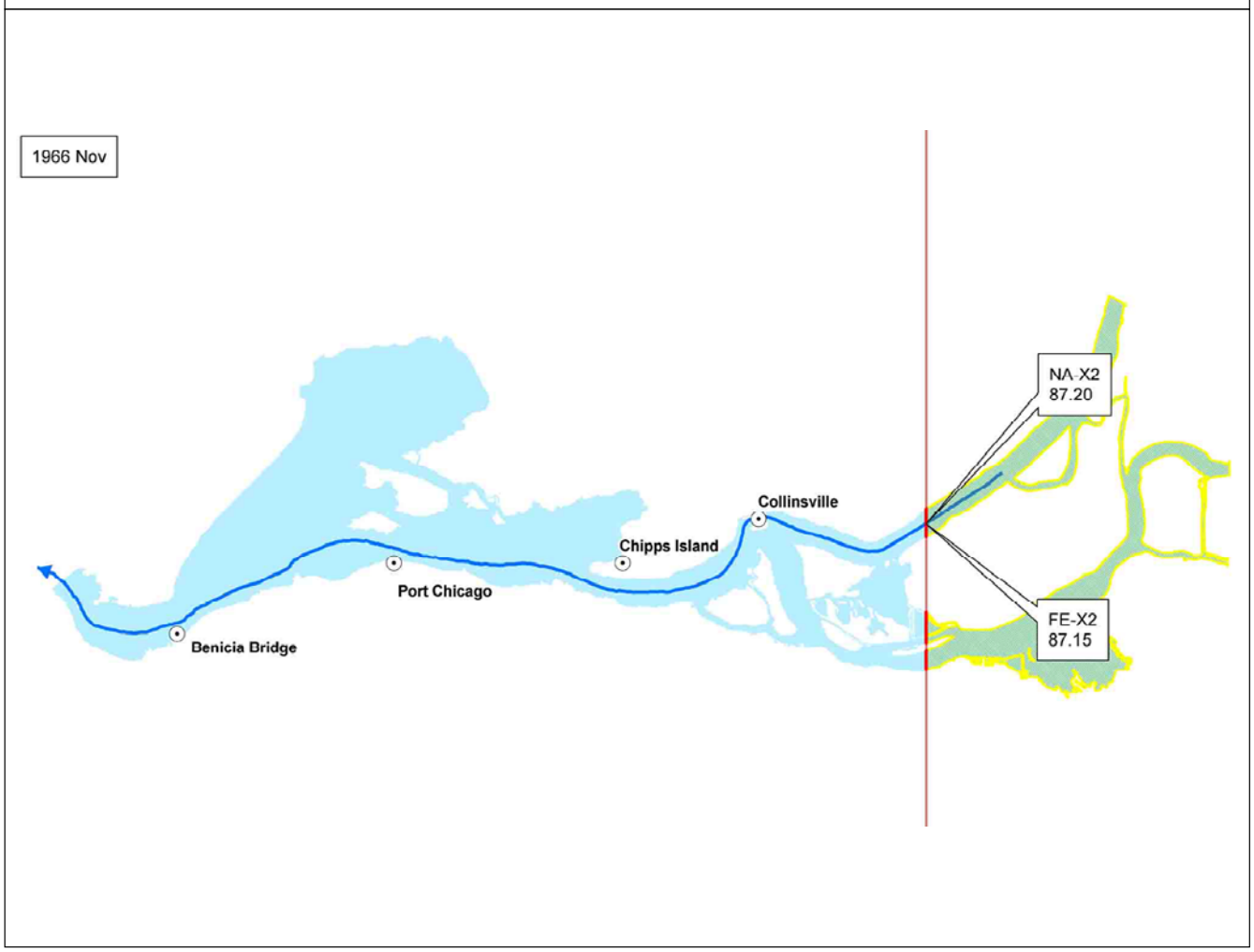
NA-X2
73.65
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
74.46


1966 Jul
NA-X2
78.10
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
77.77

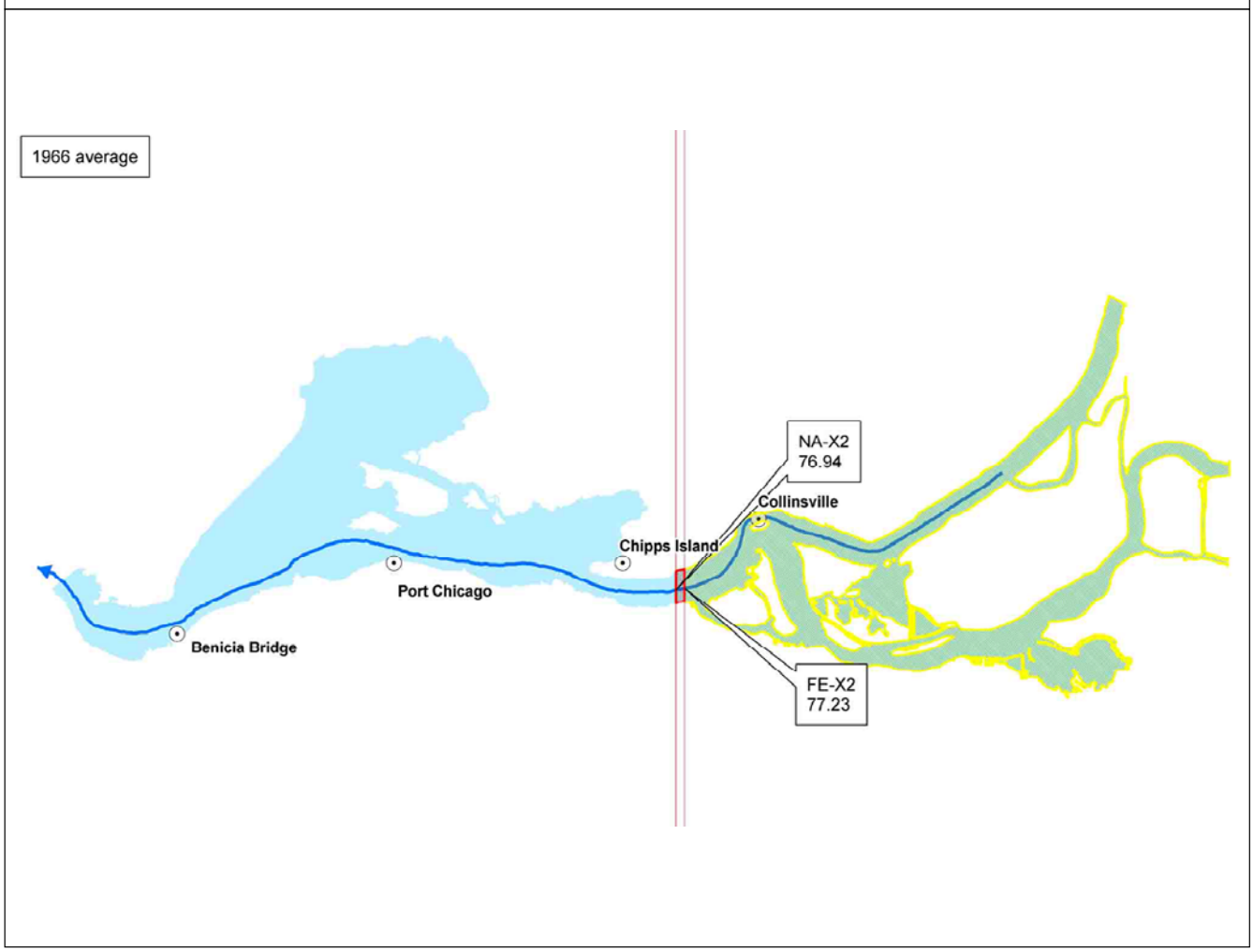

1966 Aug
NA-X2
80.50
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
80.39

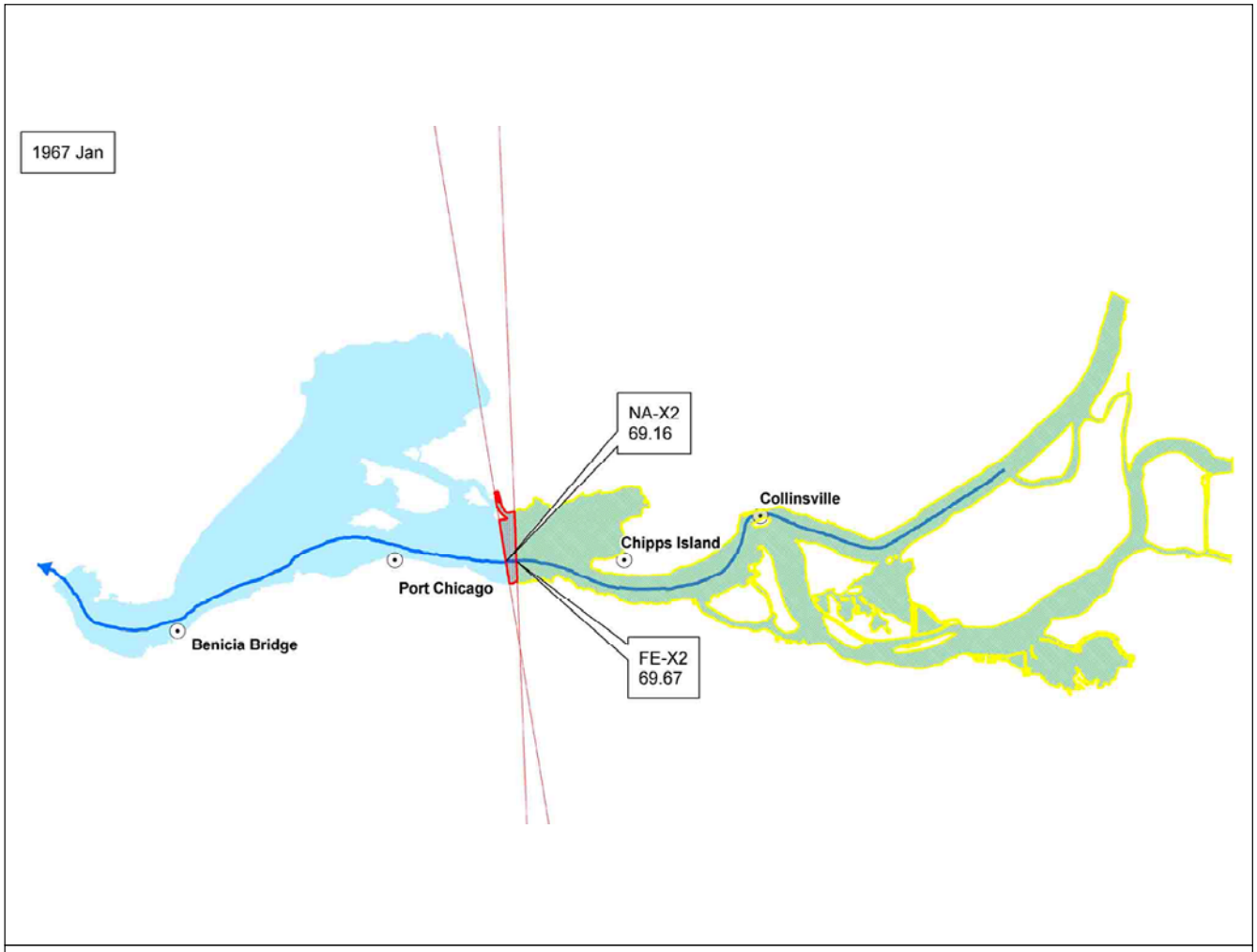

1966 Sep
NA-X2
85.01
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
84.97

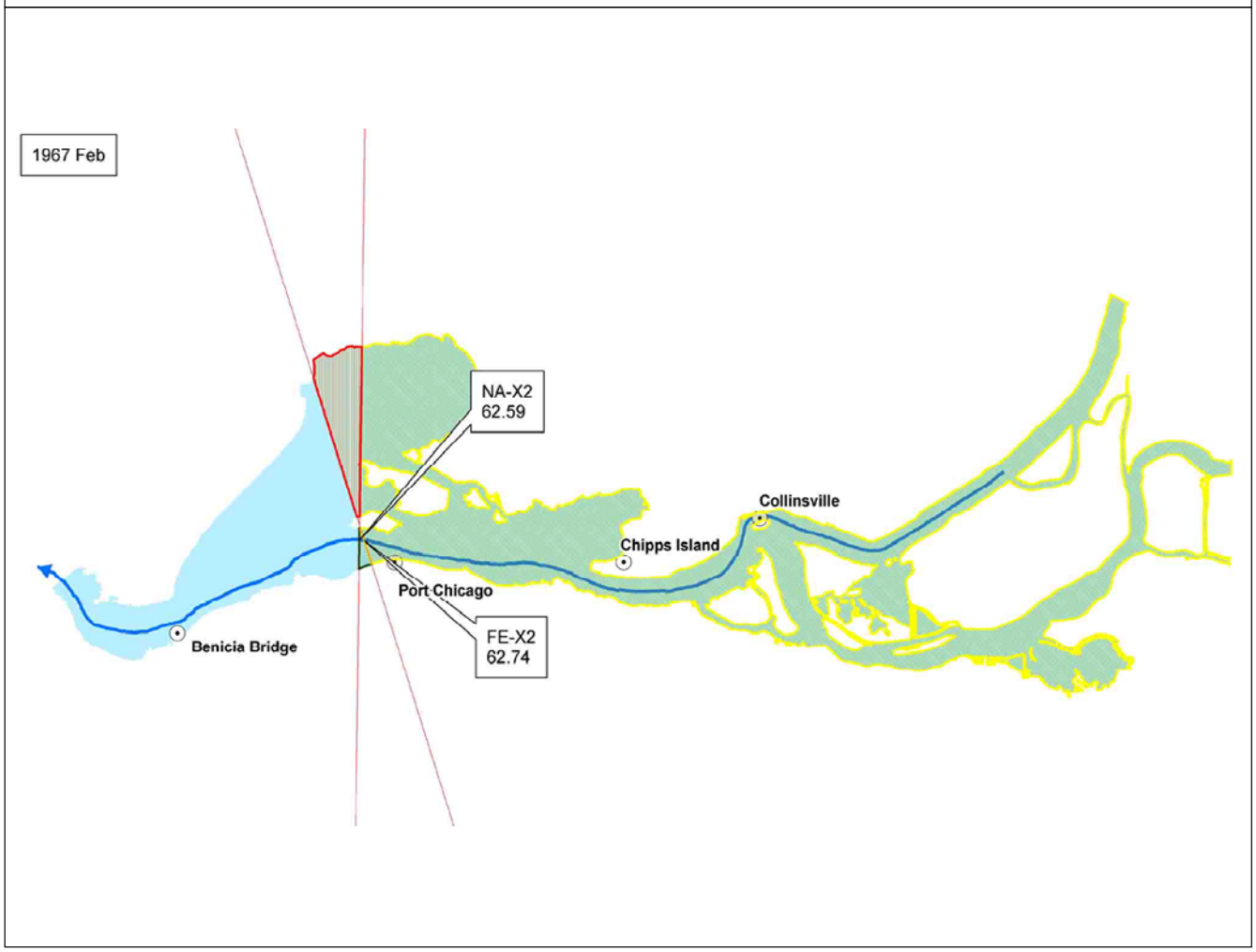

1966 Oct
NA-X2
87.17
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
87.05

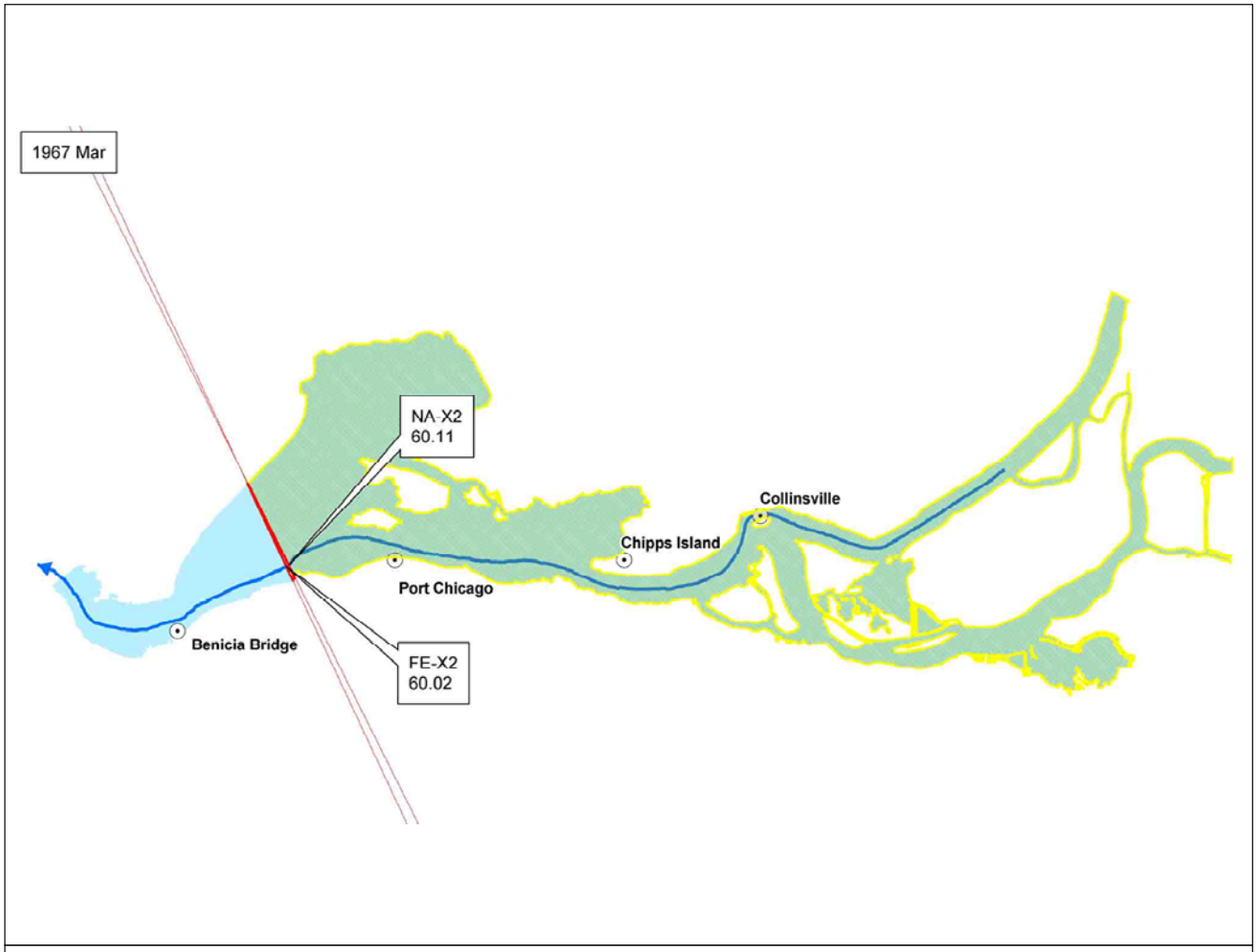

1966 Nov
NA-X2
87.20
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
87.15


1966 Dec
NA-X2
76.98
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
78.03


1966 average
NA-X2
76.94
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
77.23


1967 Jan
NA-X2
69.16
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
69.67


1967 Feb
NA-X2
62.59
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
62.74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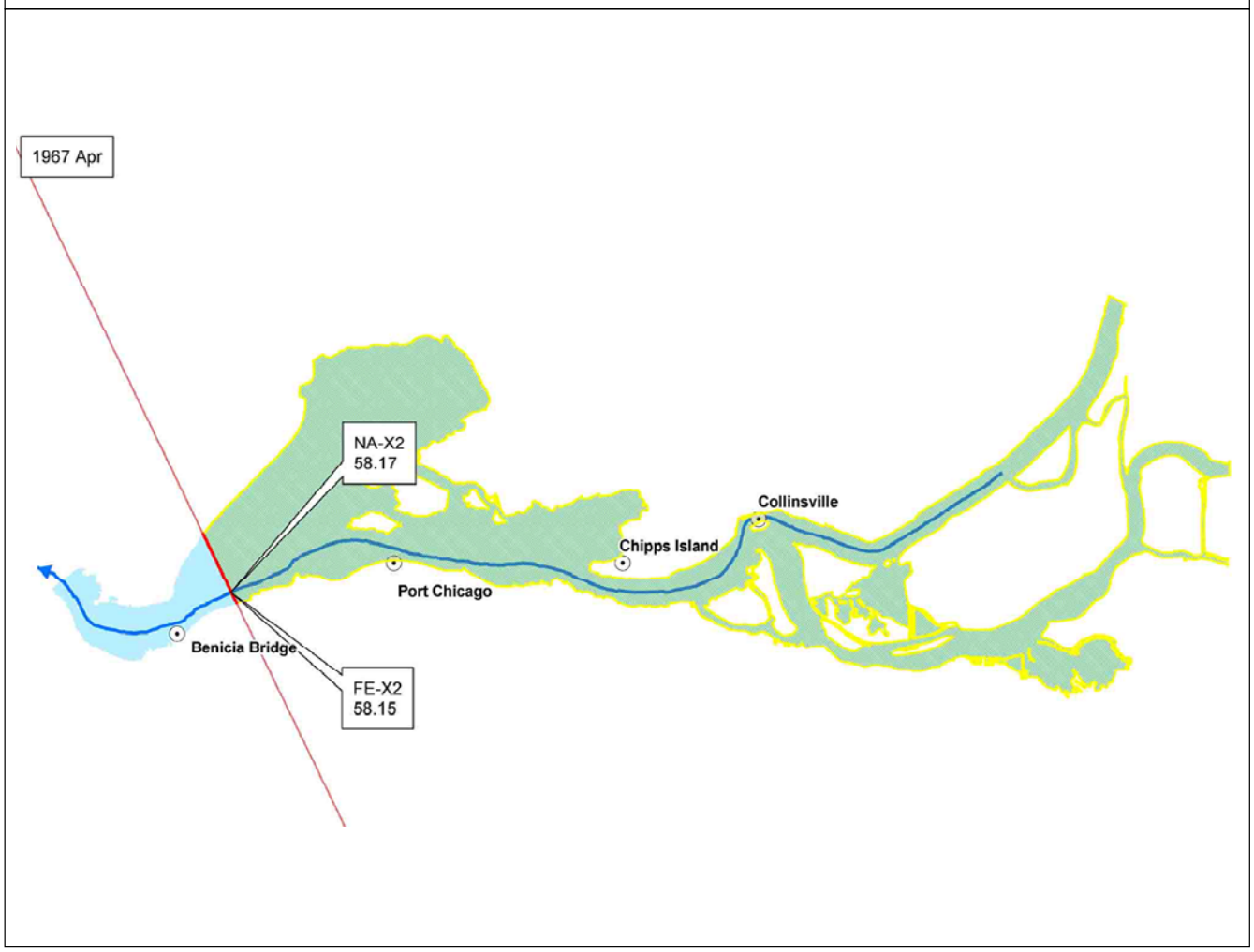
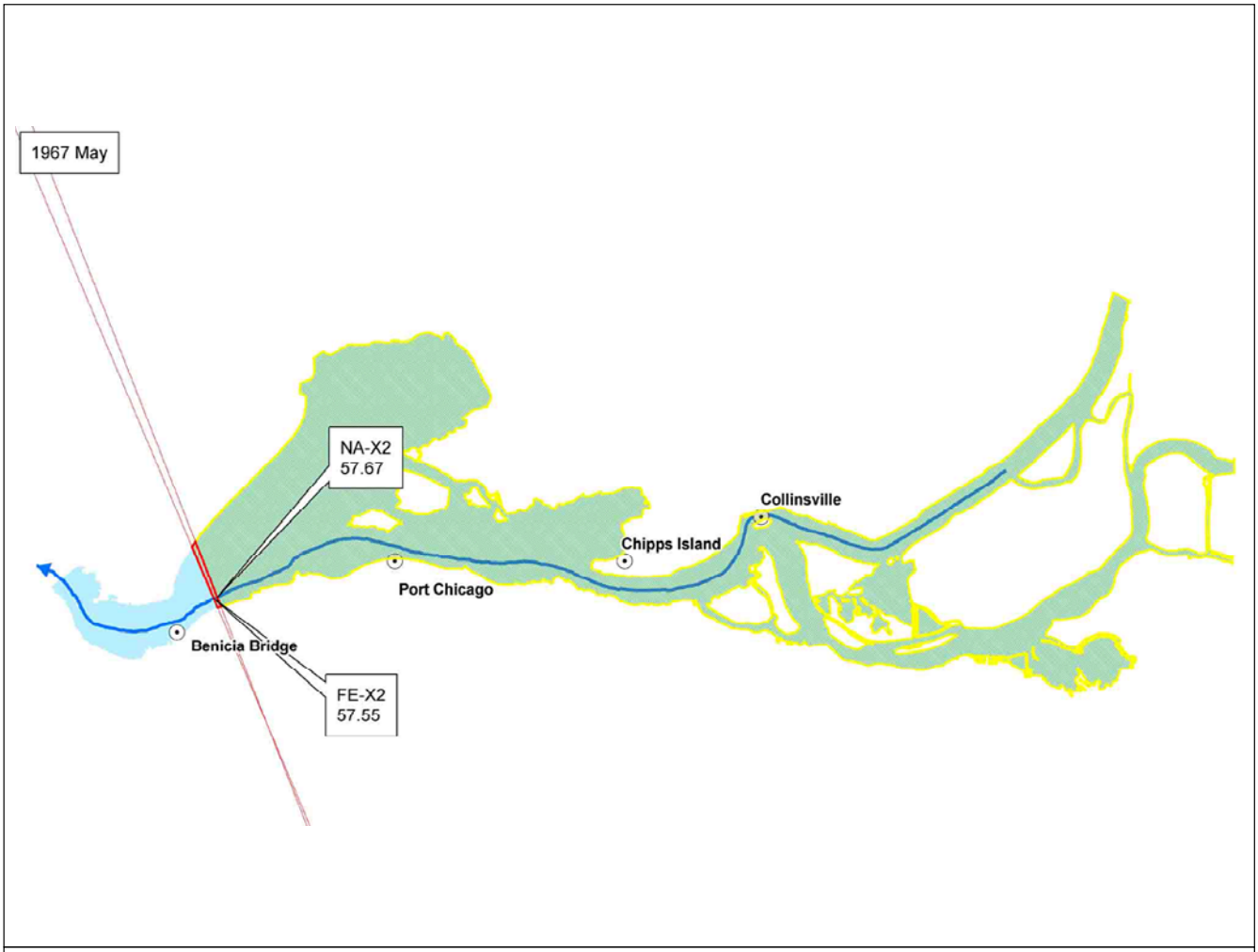
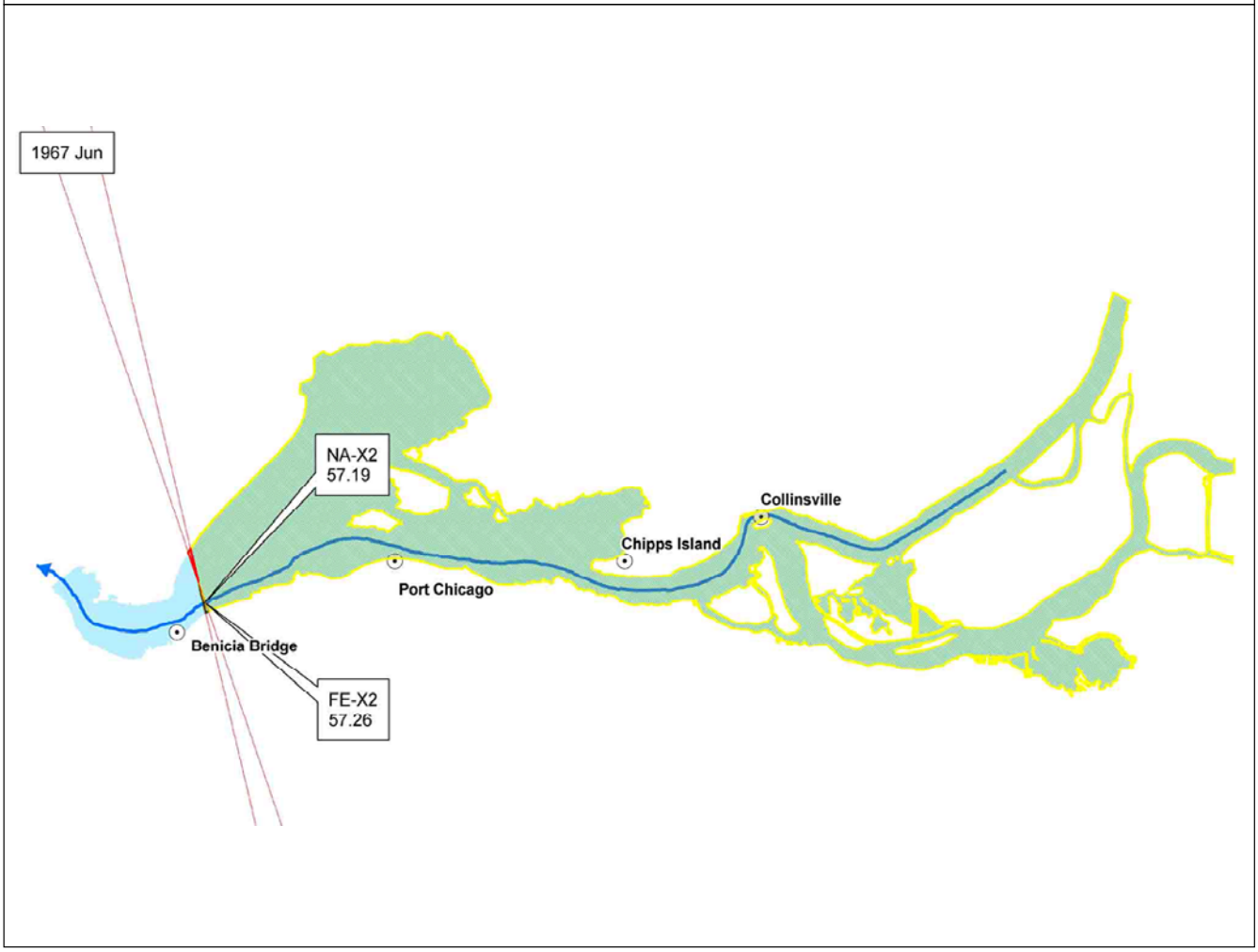
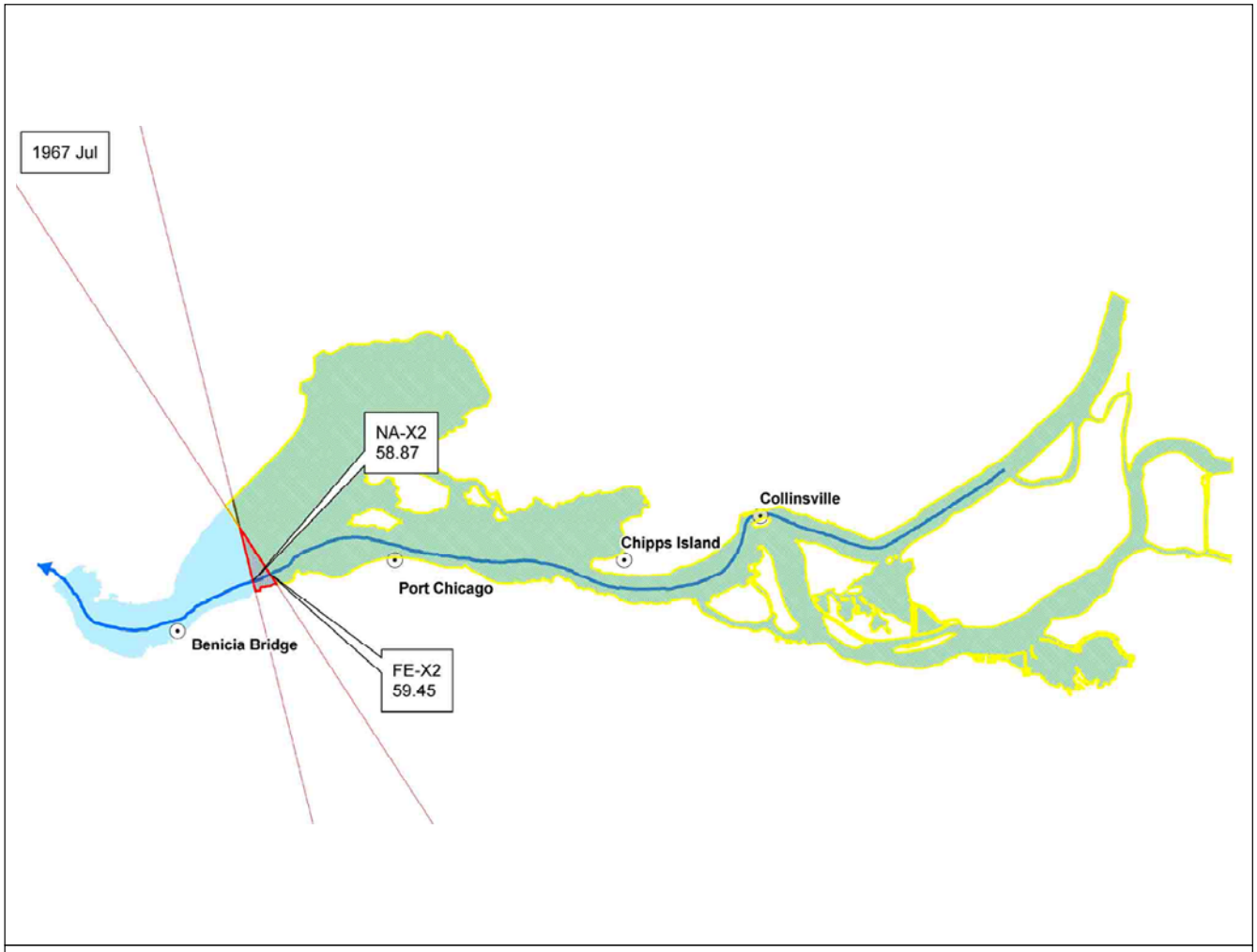
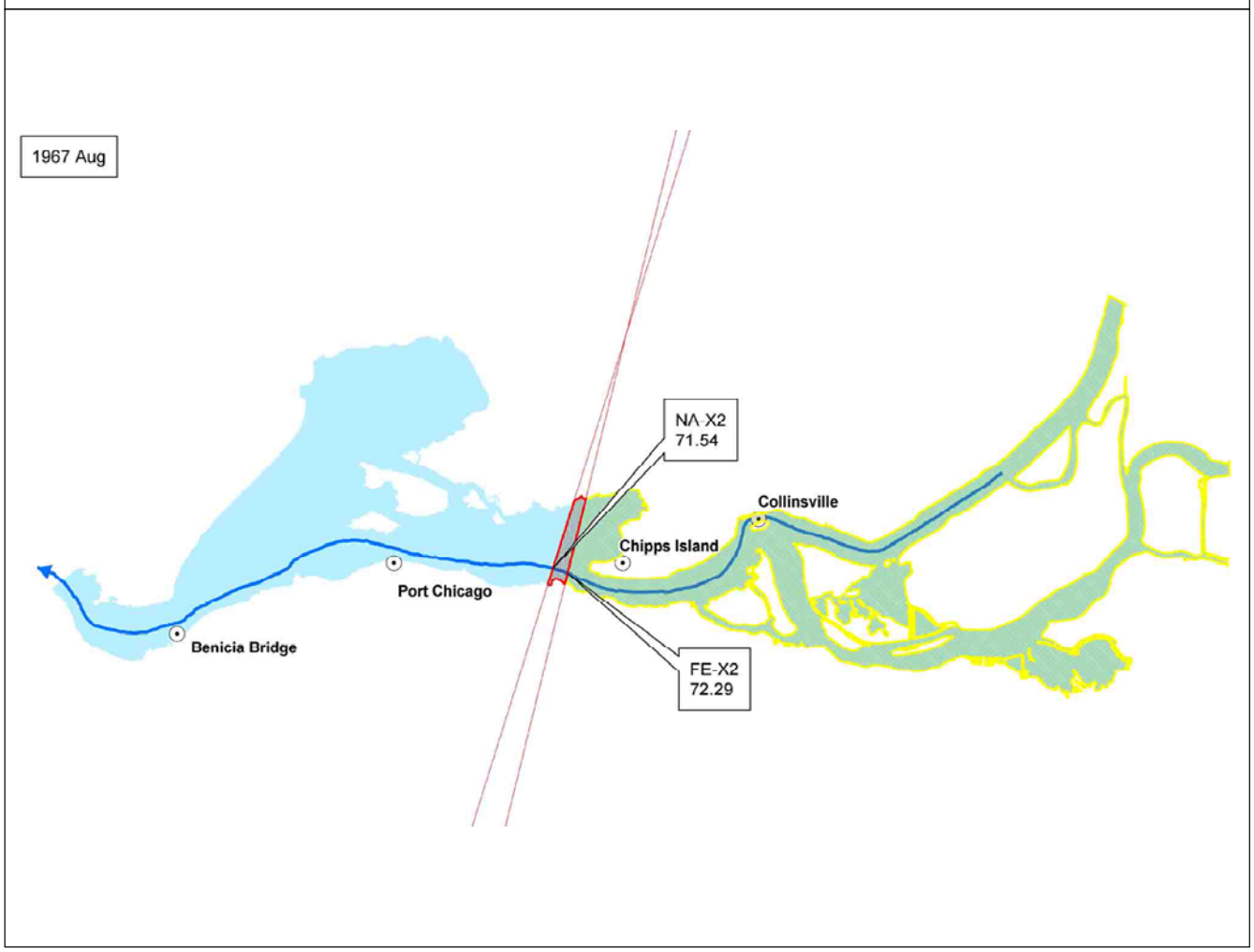
NA-X2
60.11
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
60.02


1967 Apr
NA-X2
58.17
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
58.15

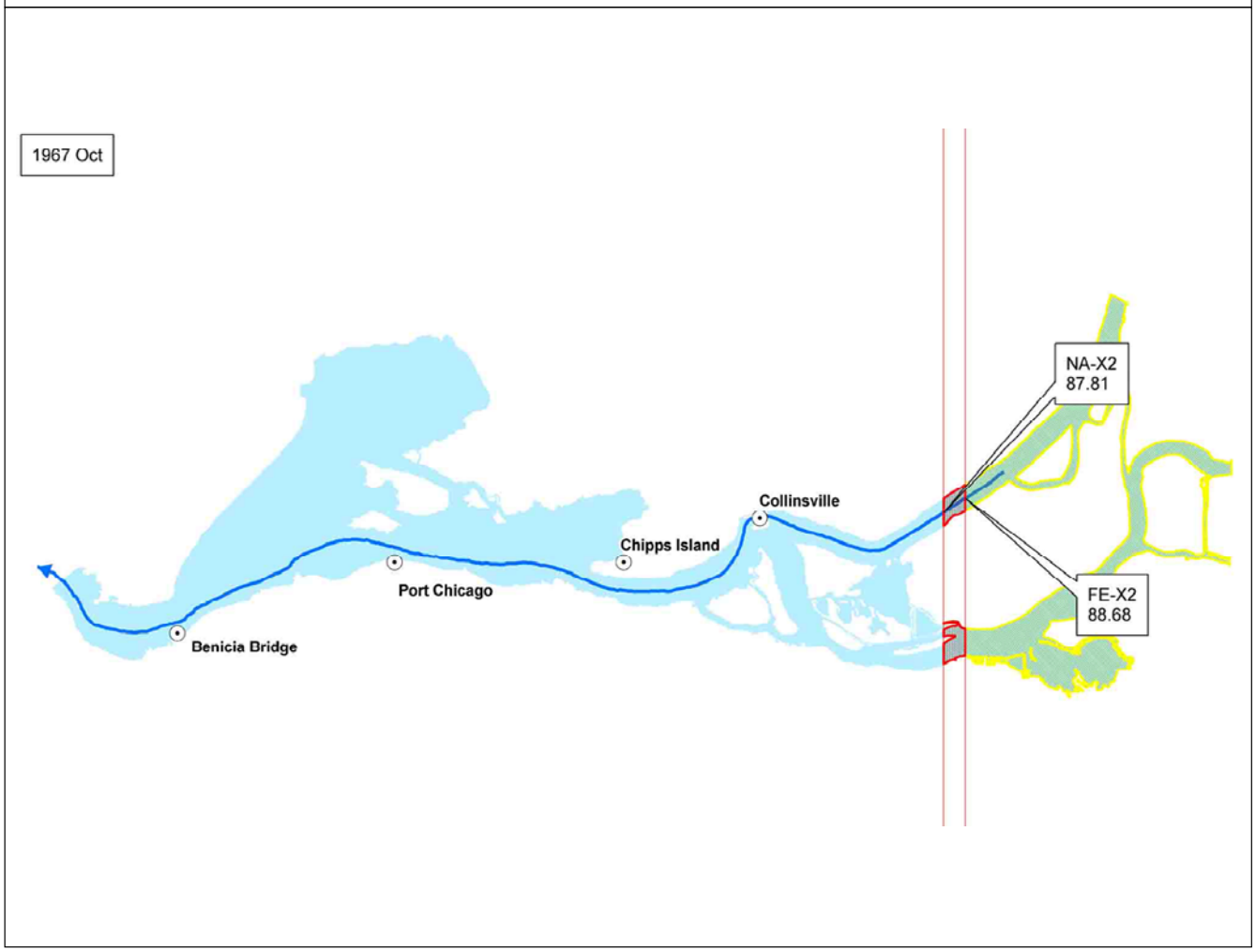

1967 May
NA-X2
57.67
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
57.55

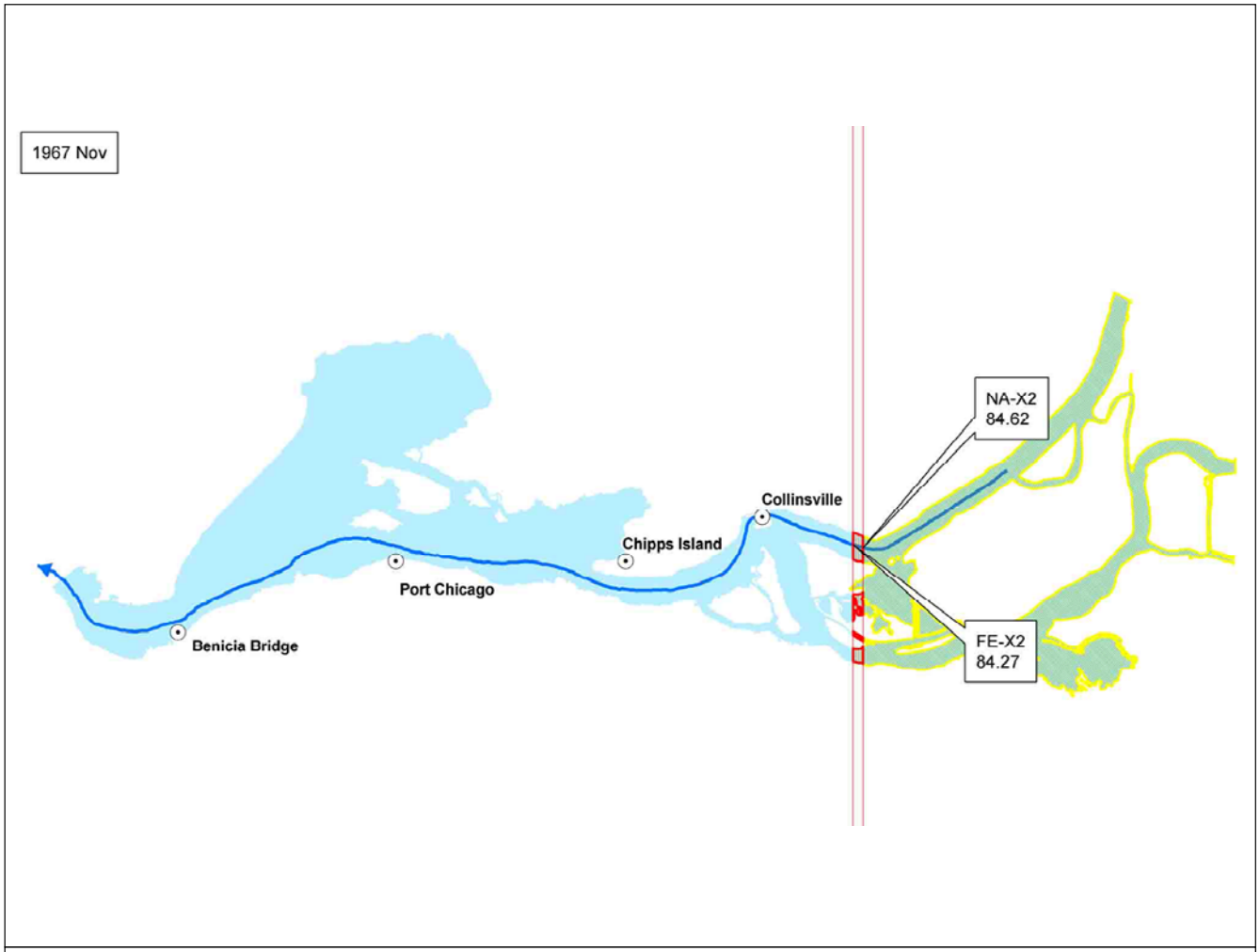

1967 Jun
NA-X2
57.19
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
57.26


1967 Jul
NA-X2
58.87
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
59.45


1967 Aug
NA X2
71.54
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
72.29


1967 Sep
NA-X2
82.07
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
82.32

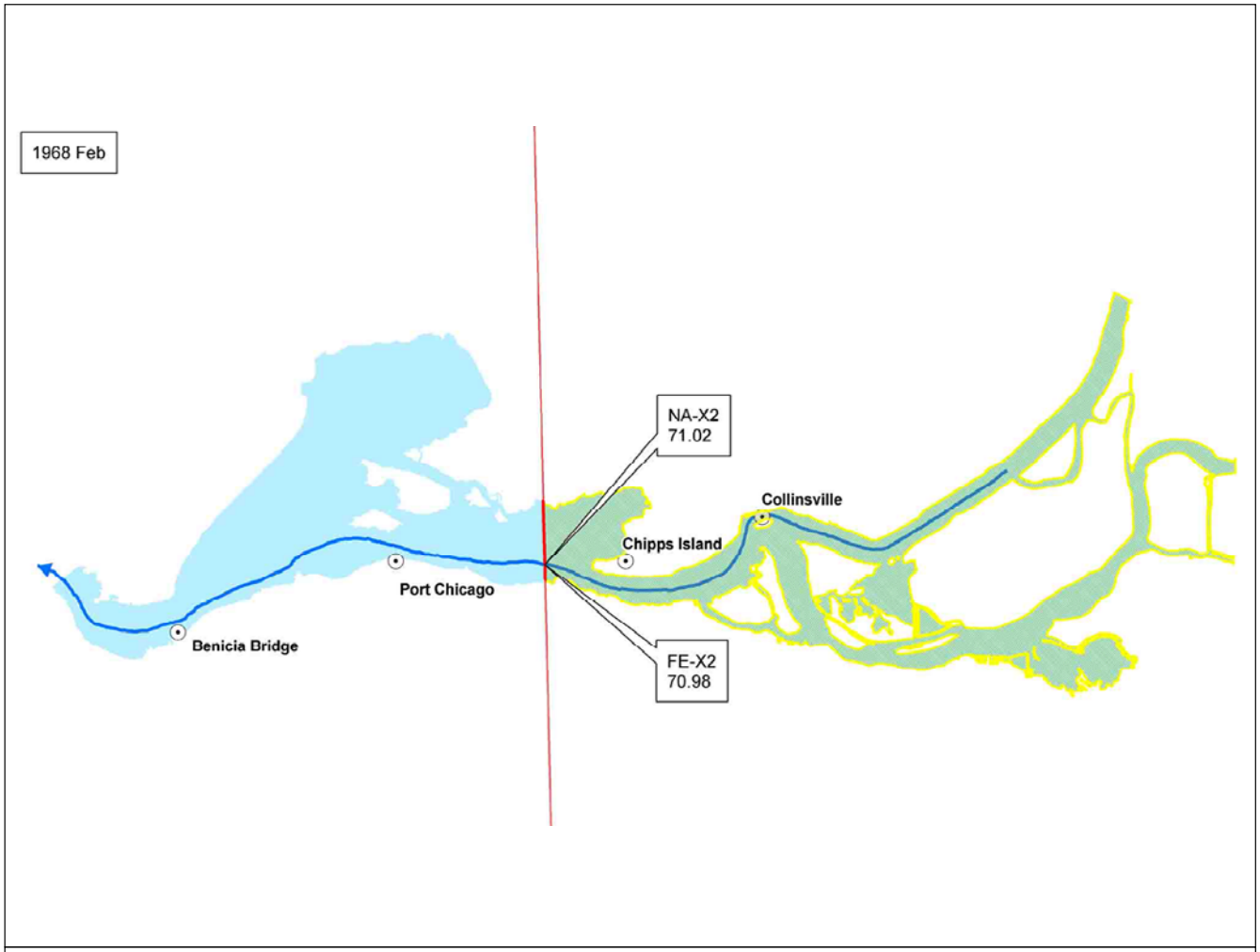

1967 Oct
NA-X2
87.81
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
88.68

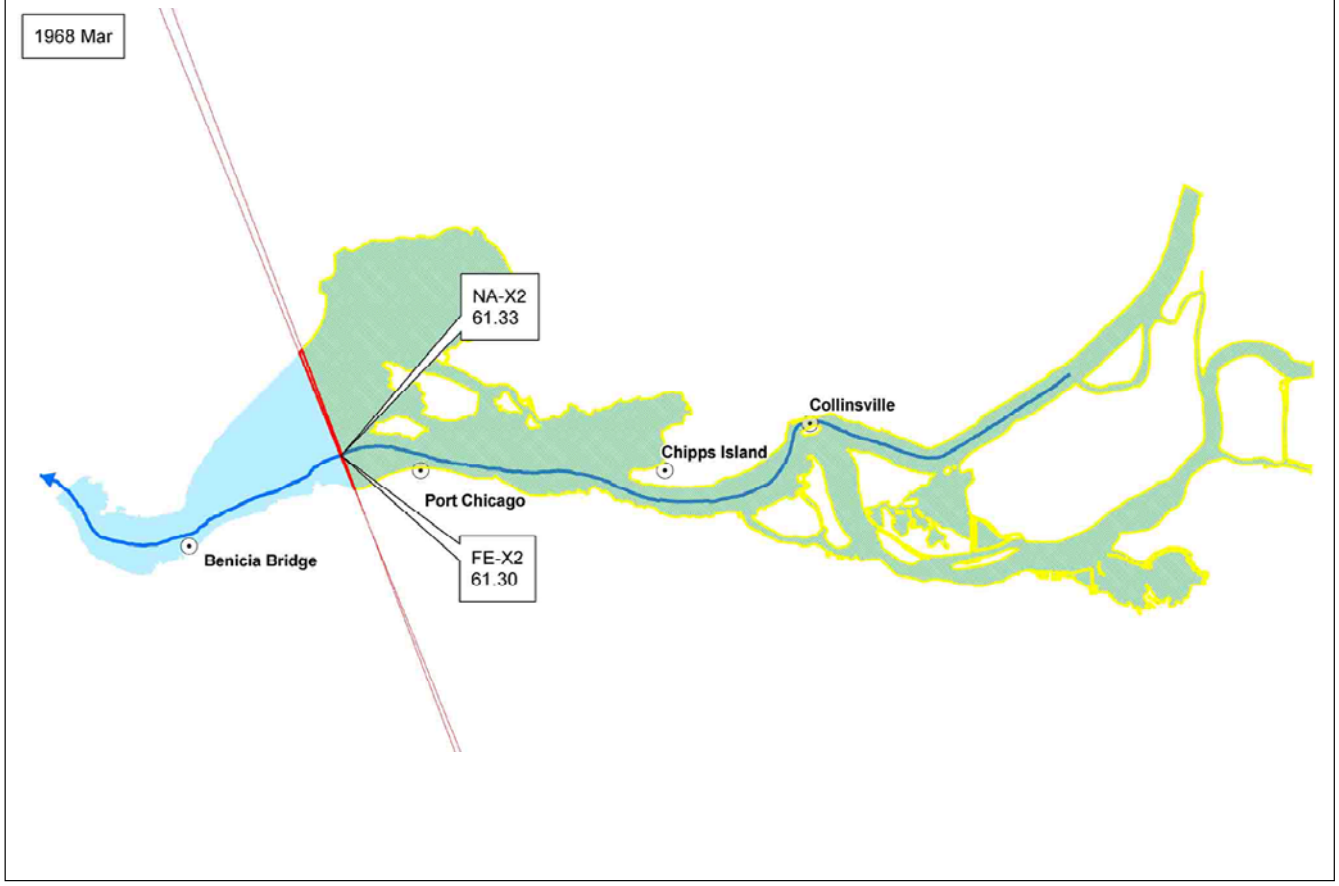

1967 Nov
NA-X2
84.62
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
84.27

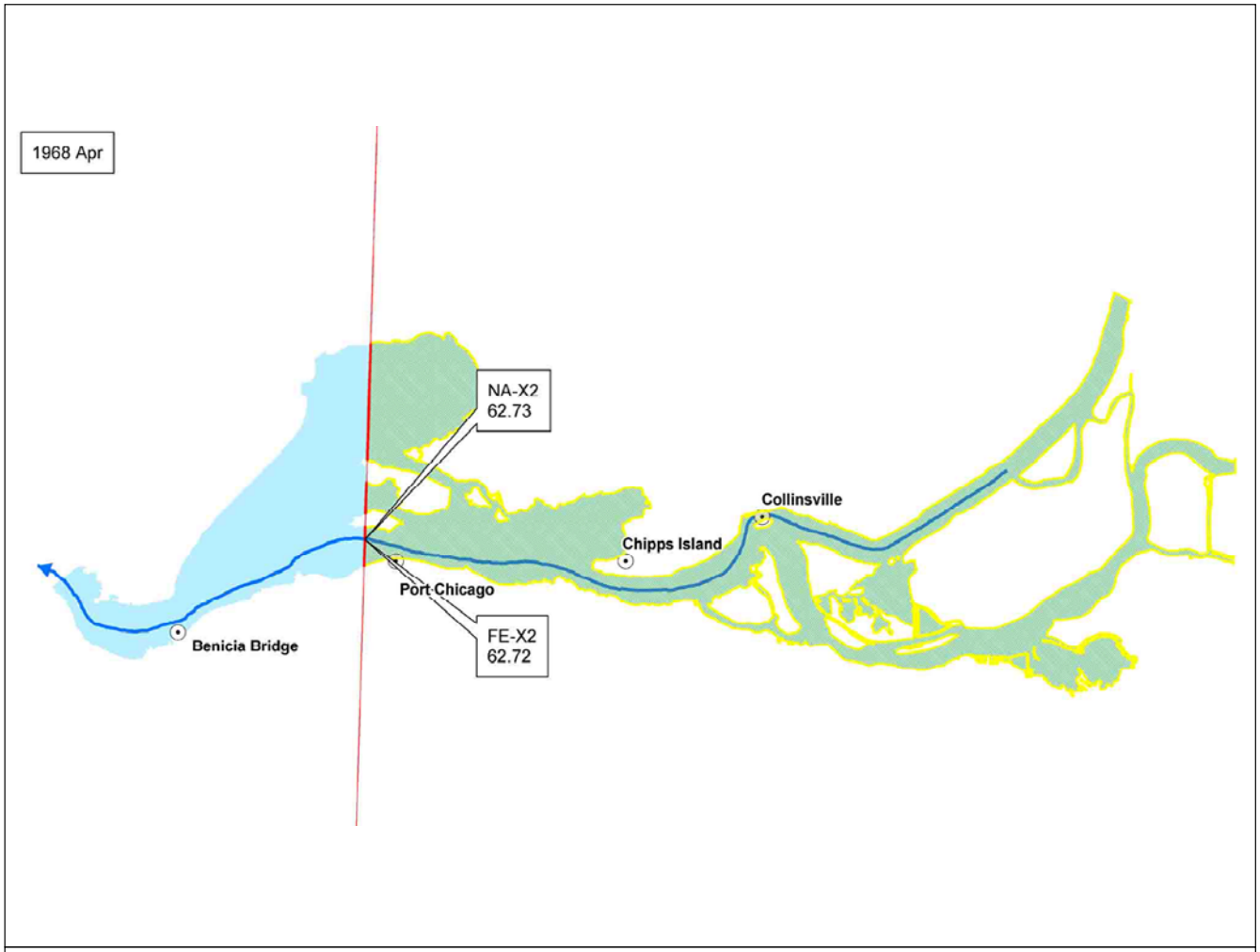

1967 Dec
NA-X2
83.66
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
83.65


1967 average
NA-X2
69.45
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
69.67


1968 Jan
NA-X2
81.19
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
81.23


1968 Feb
NA-X2
71.02
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
70.98


1968 Mar
NA-X2
61.33
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
61.30


1968 Apr
NA-X2
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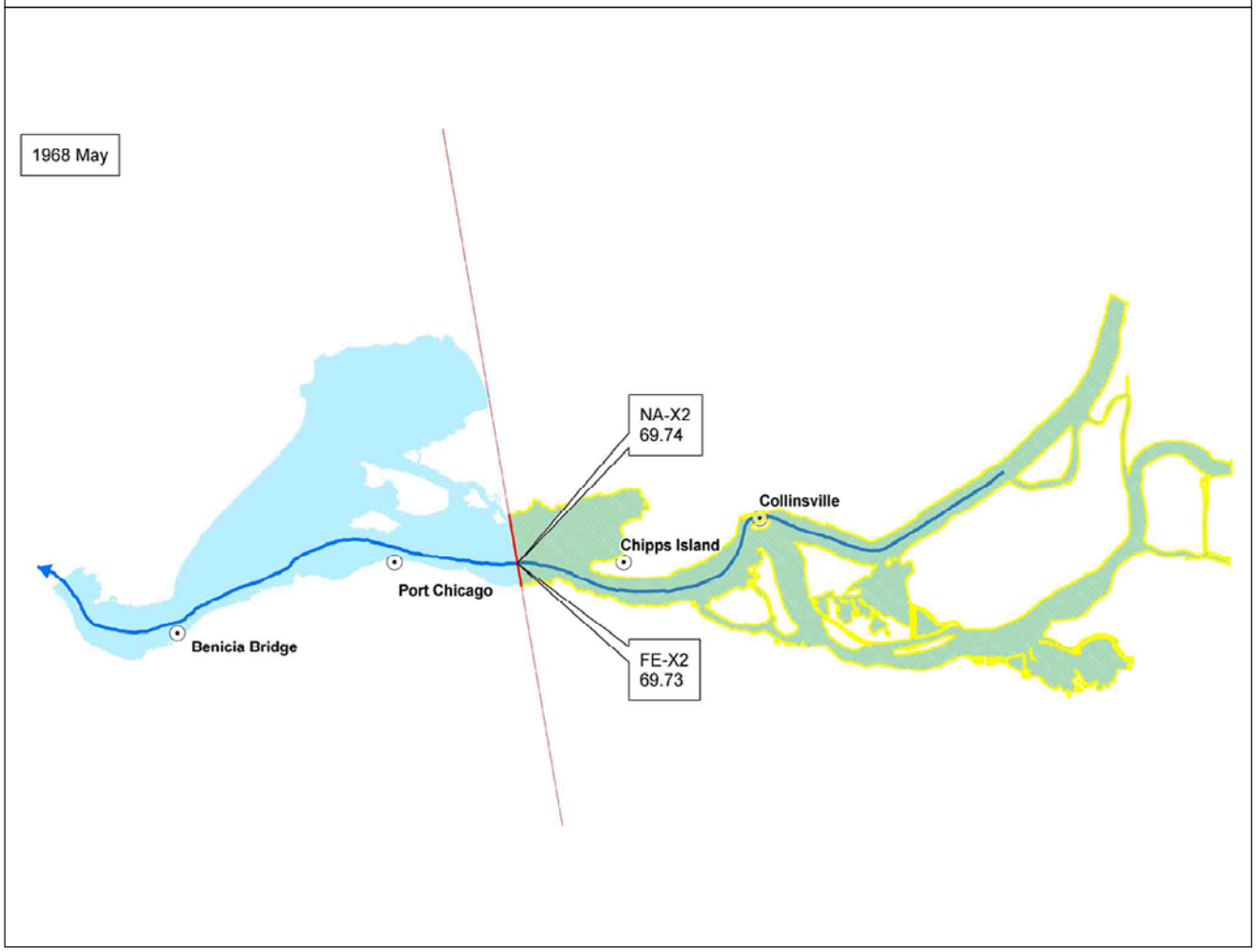
Collinsville
Chipps Island
Port Chicago
FE-X2
62.72
Benicia Bridge


1968 May
NA-X2
69.74
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
69.73


1968 Jun
NA-X2
75.77
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
75.77


1968 Jul
NA-X2
79.14
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
79.11

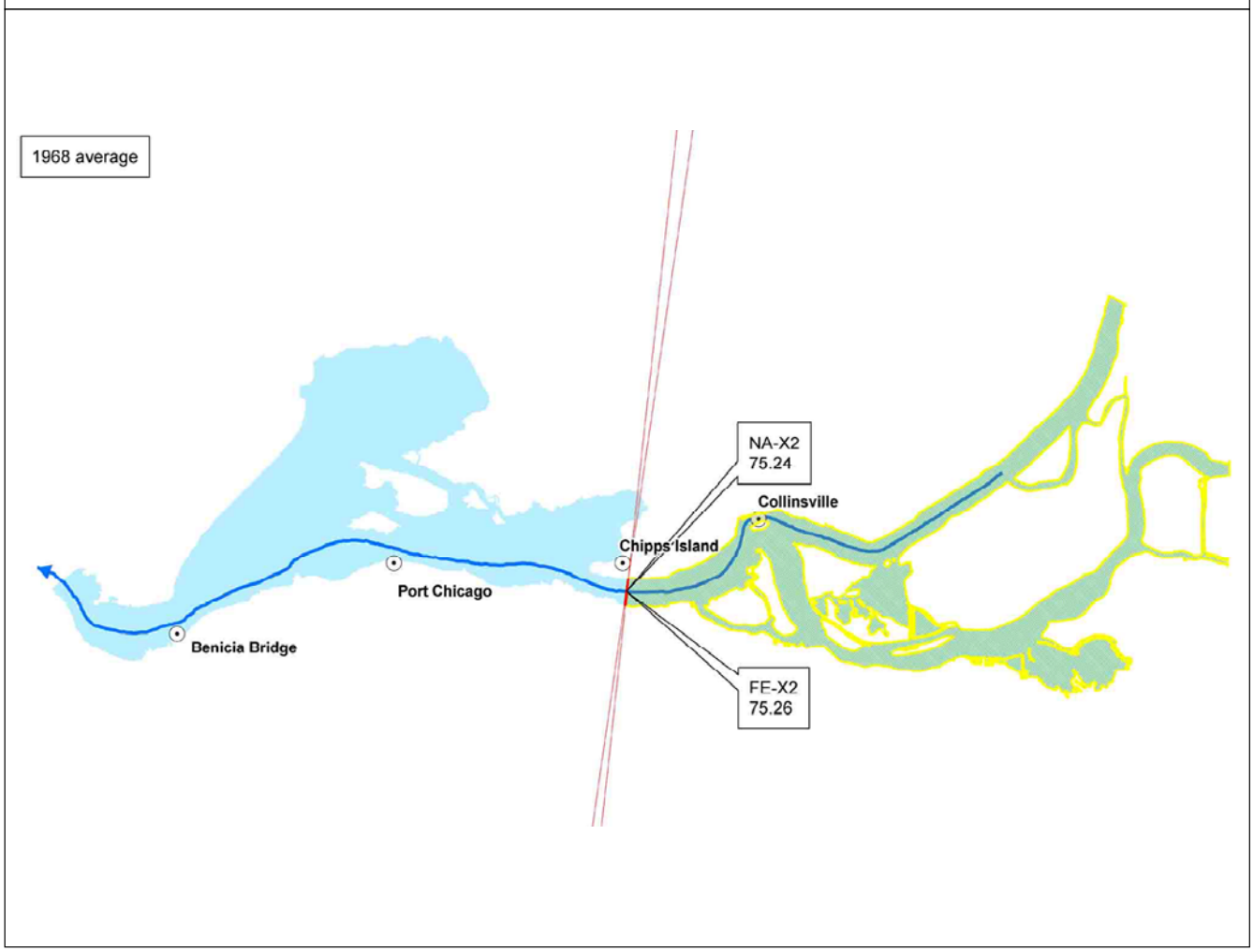

1968 Aug
NA-X2
80.33
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
80.37


1968 Sep
NA-X2
84.95
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
84.96


1968 Oct
NA-X2
77.60
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
77.71


1968 Nov
NA-X2
76.37
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
76.44


1968 Dec
NA-X2
82.75
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
82.77


1968 average
NA-X2
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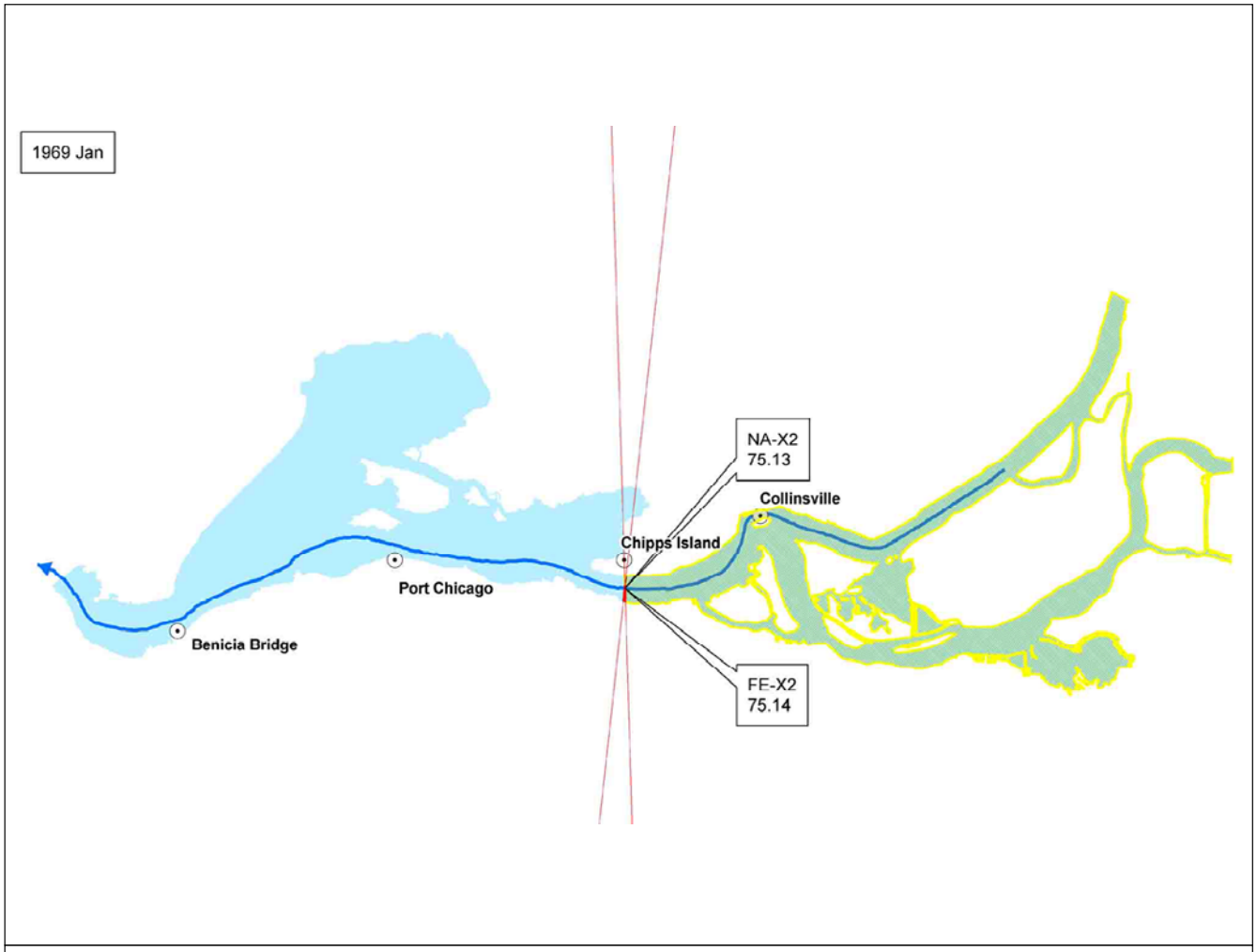
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
75.26


1969 Jan
NA-X2
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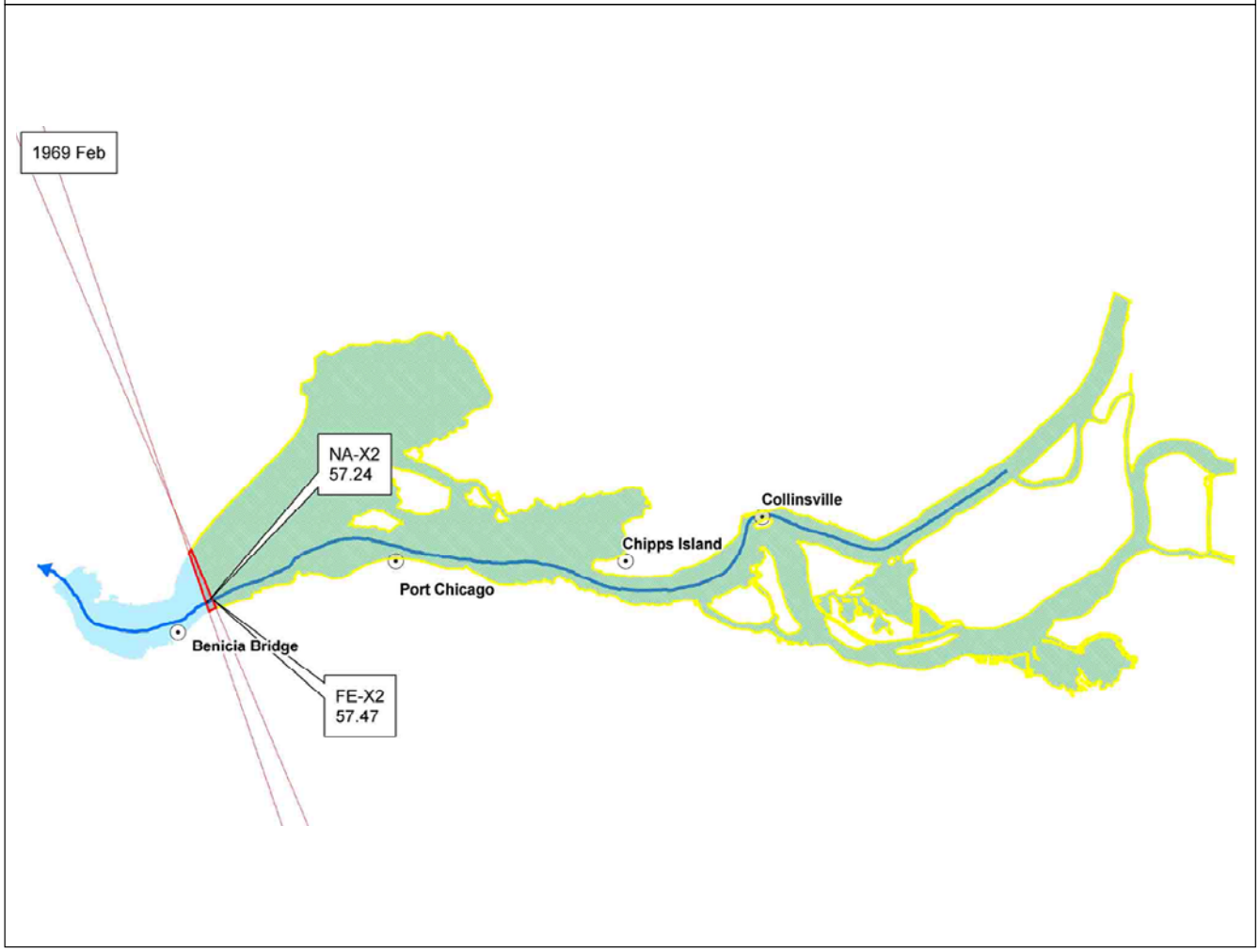
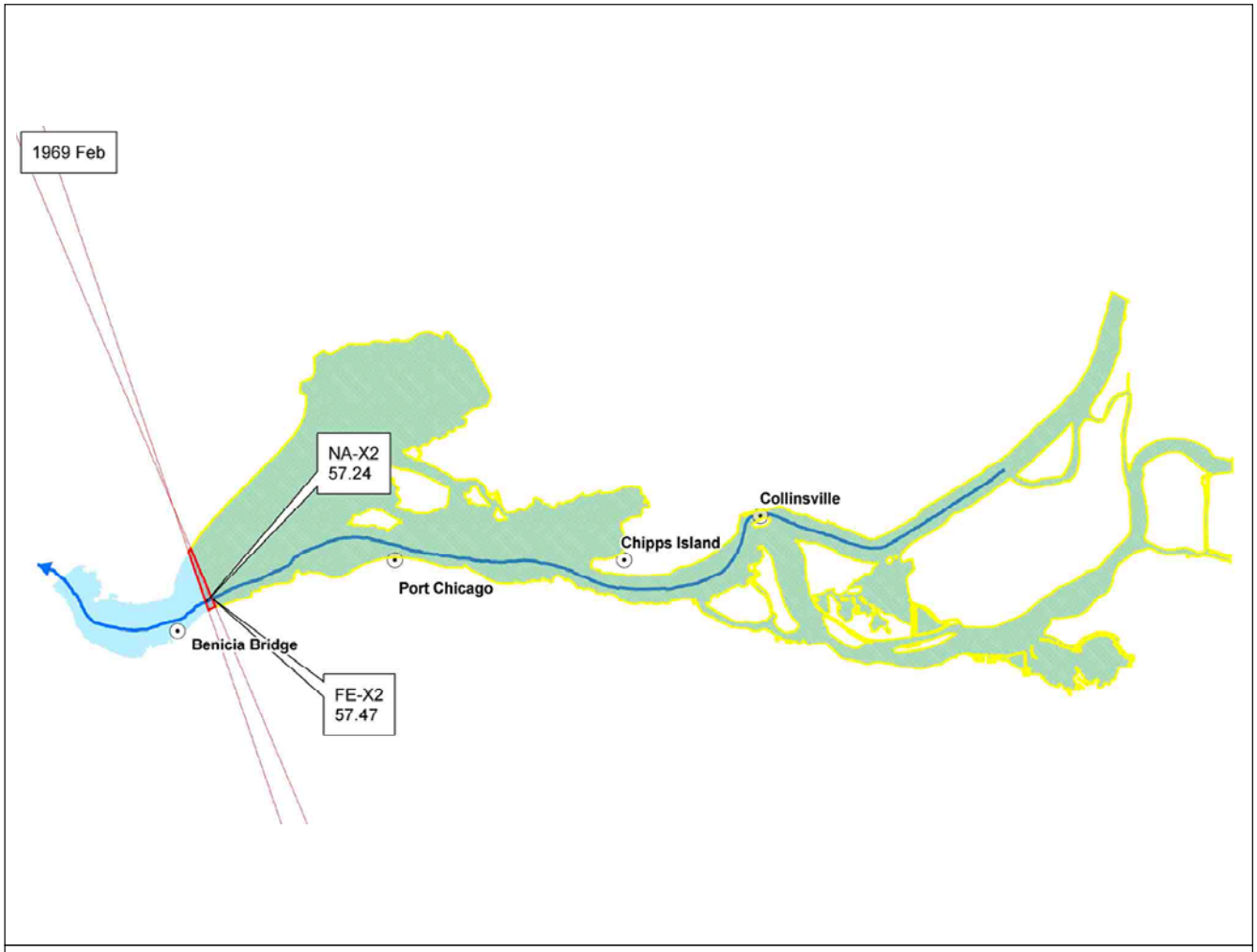
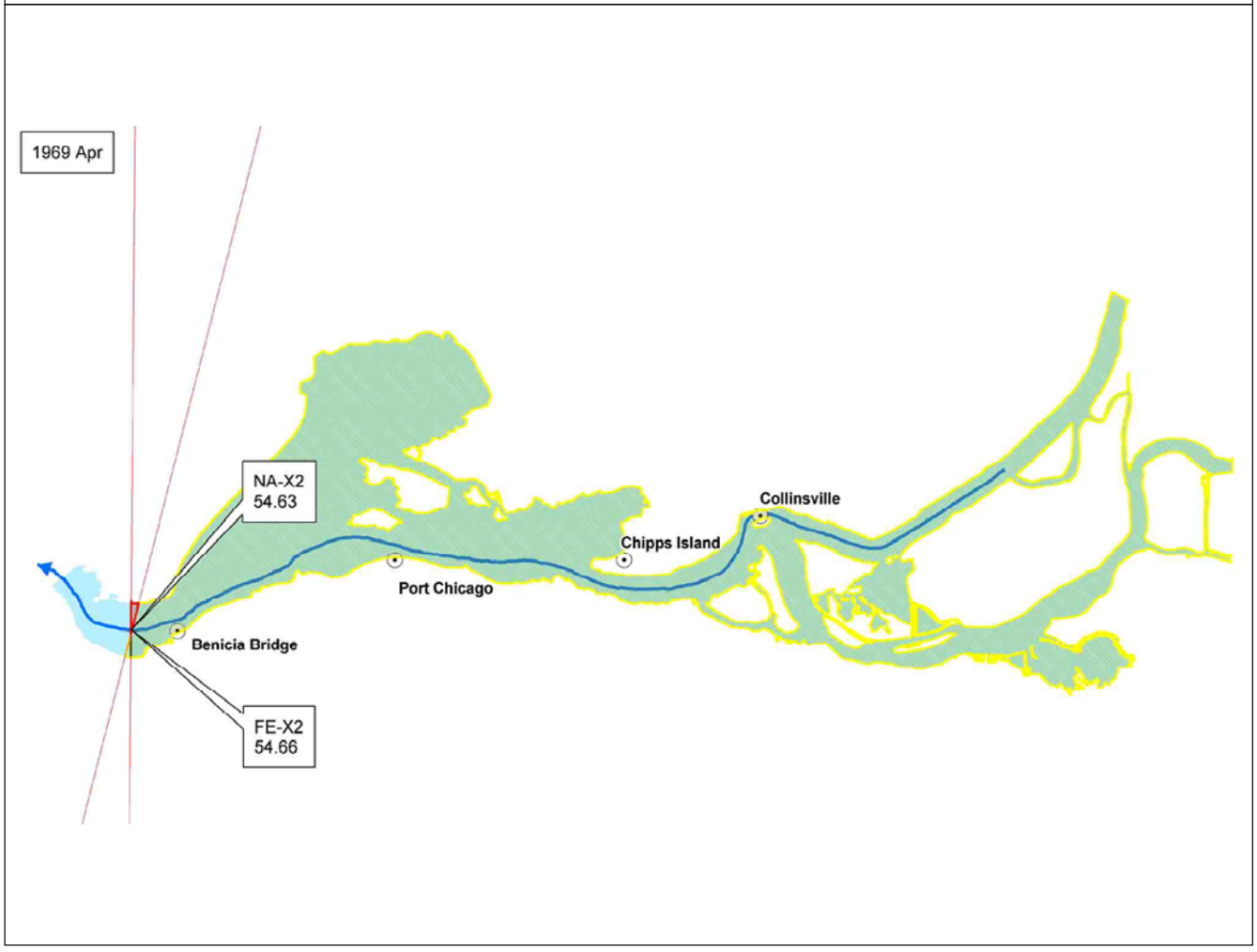
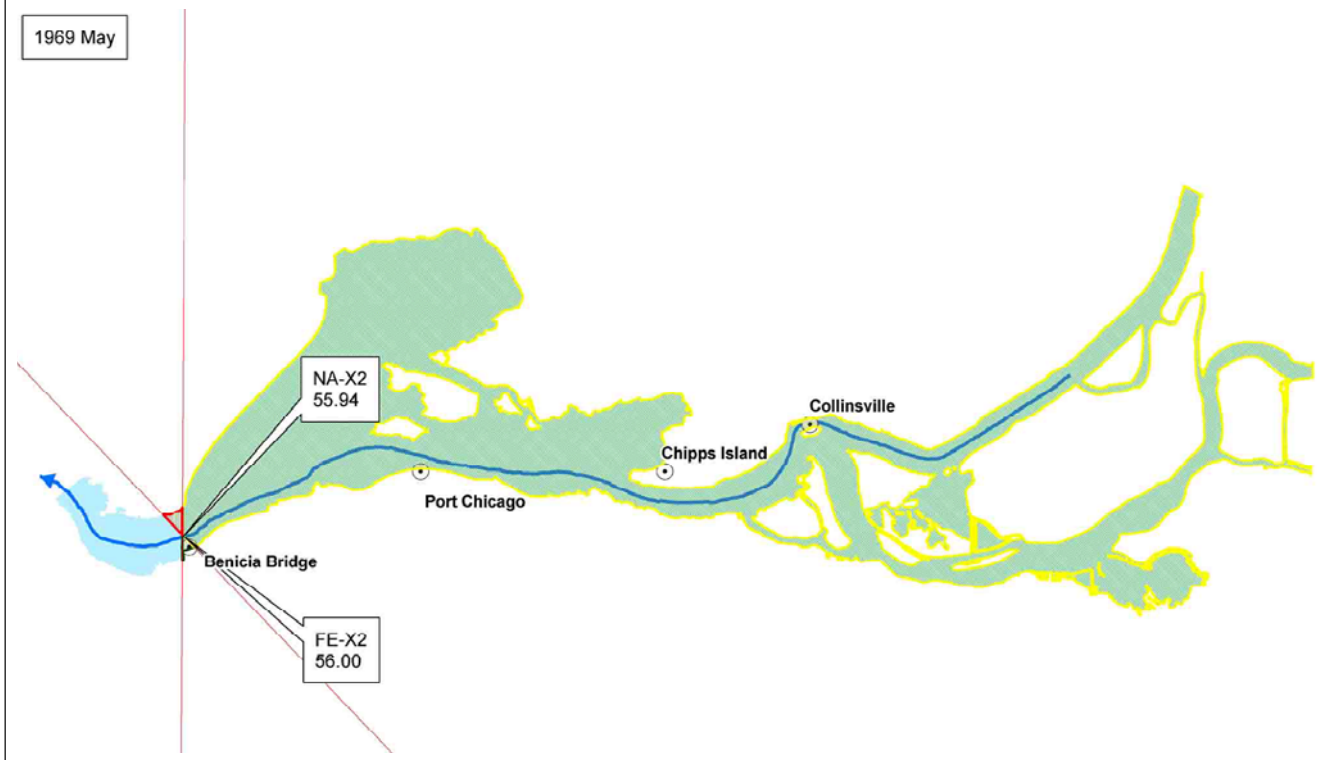
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
75.14


1969 Feb
NA-X2
57.24
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
57.47


1969 Feb
NA-X2
57.24
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
57.47


1969 Apr
NA-X2
54.63
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
54.66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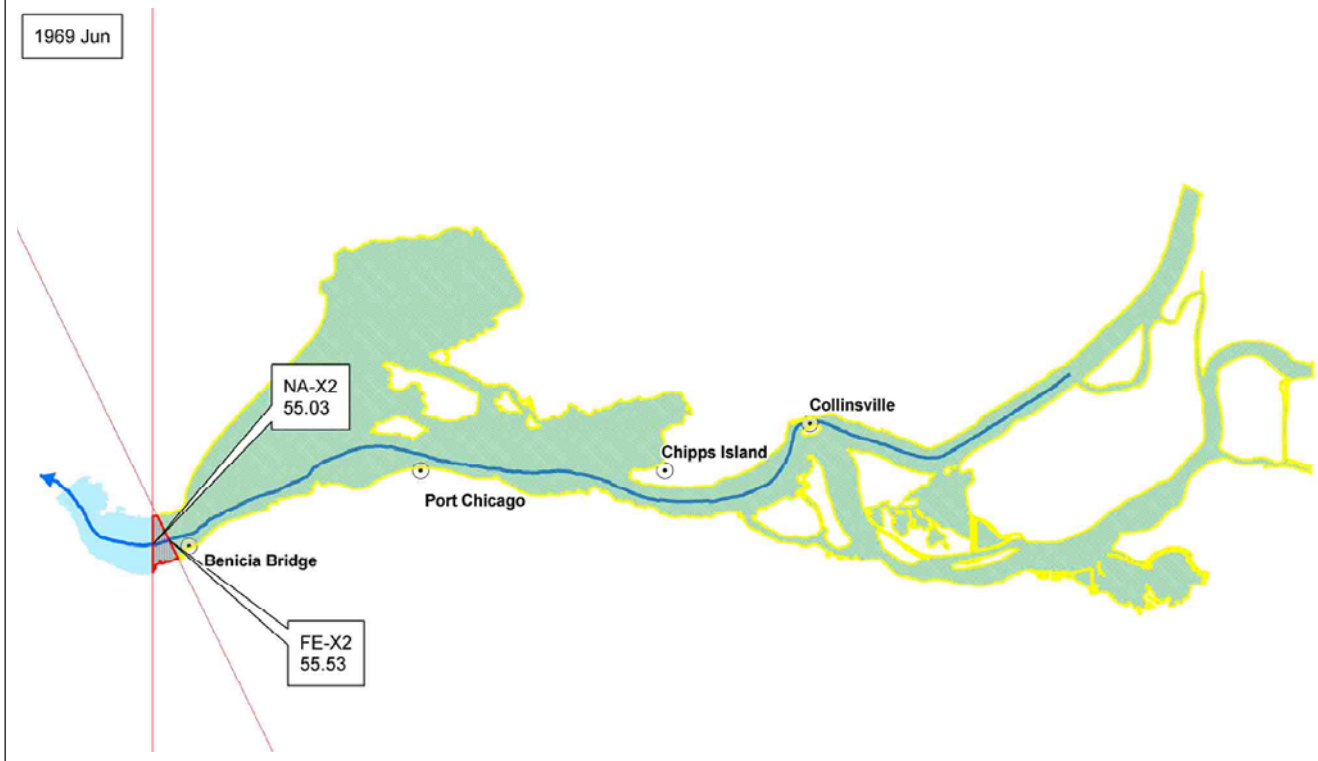
NA-X2
55.94
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
56.00


1969 Jun
NA-X2
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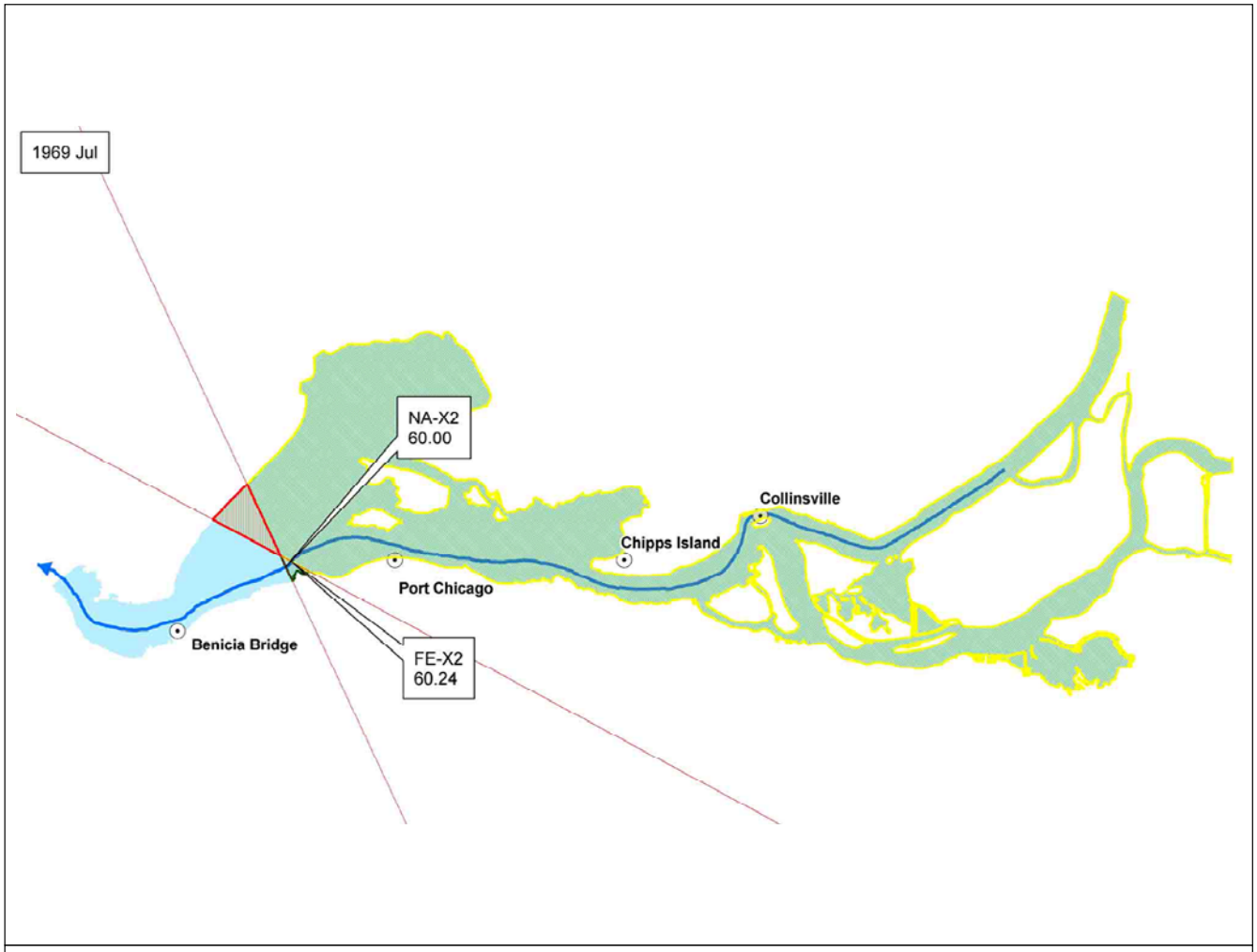
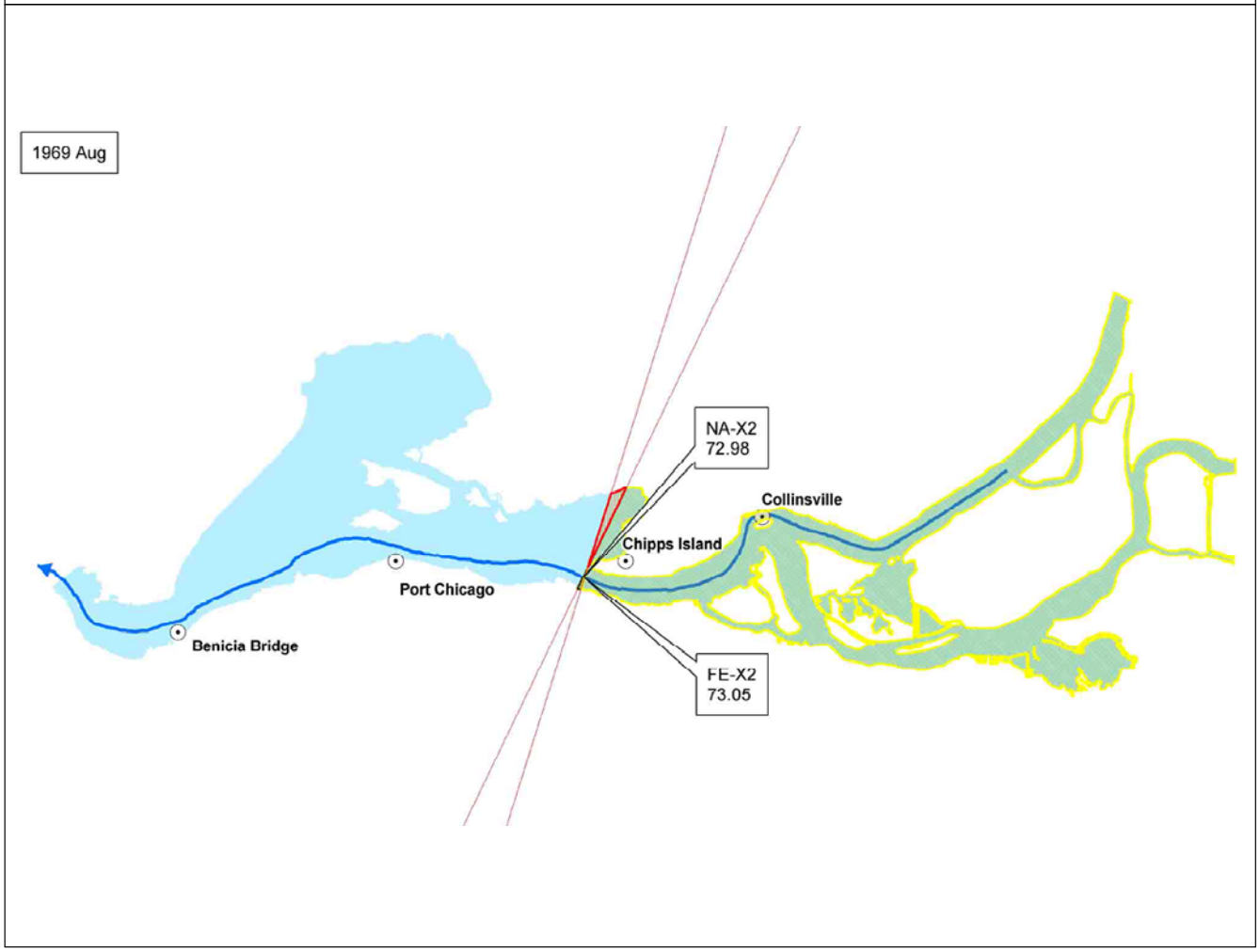
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
55.53


1969 Jul
NA-X2
60.00
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
60.24

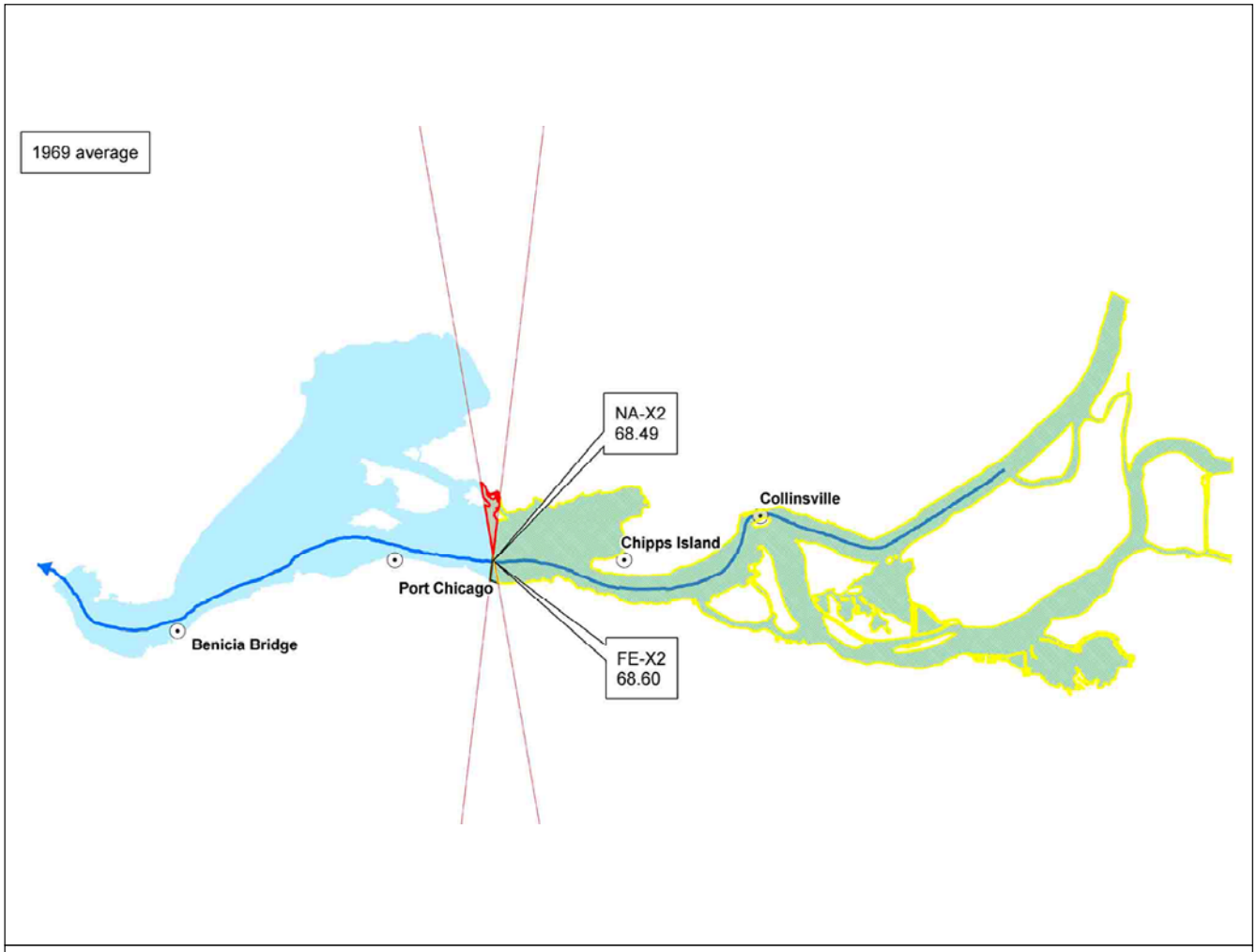

1969 Aug
NA-X2
72.98
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
73.05

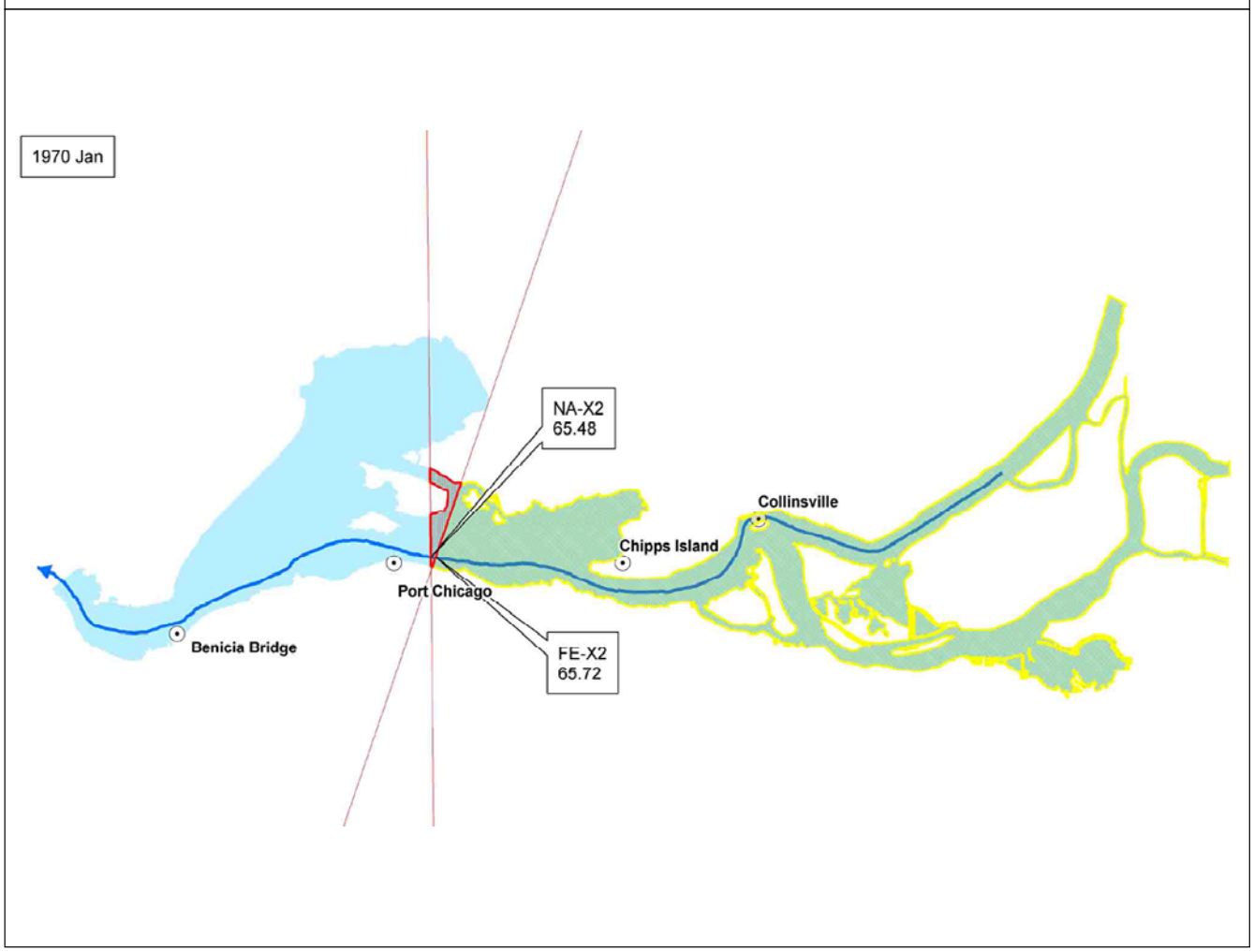

1969 Sep
NA-X2
82.54
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
82.57


1969 Oct
NA-X2
88.43
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
88.44

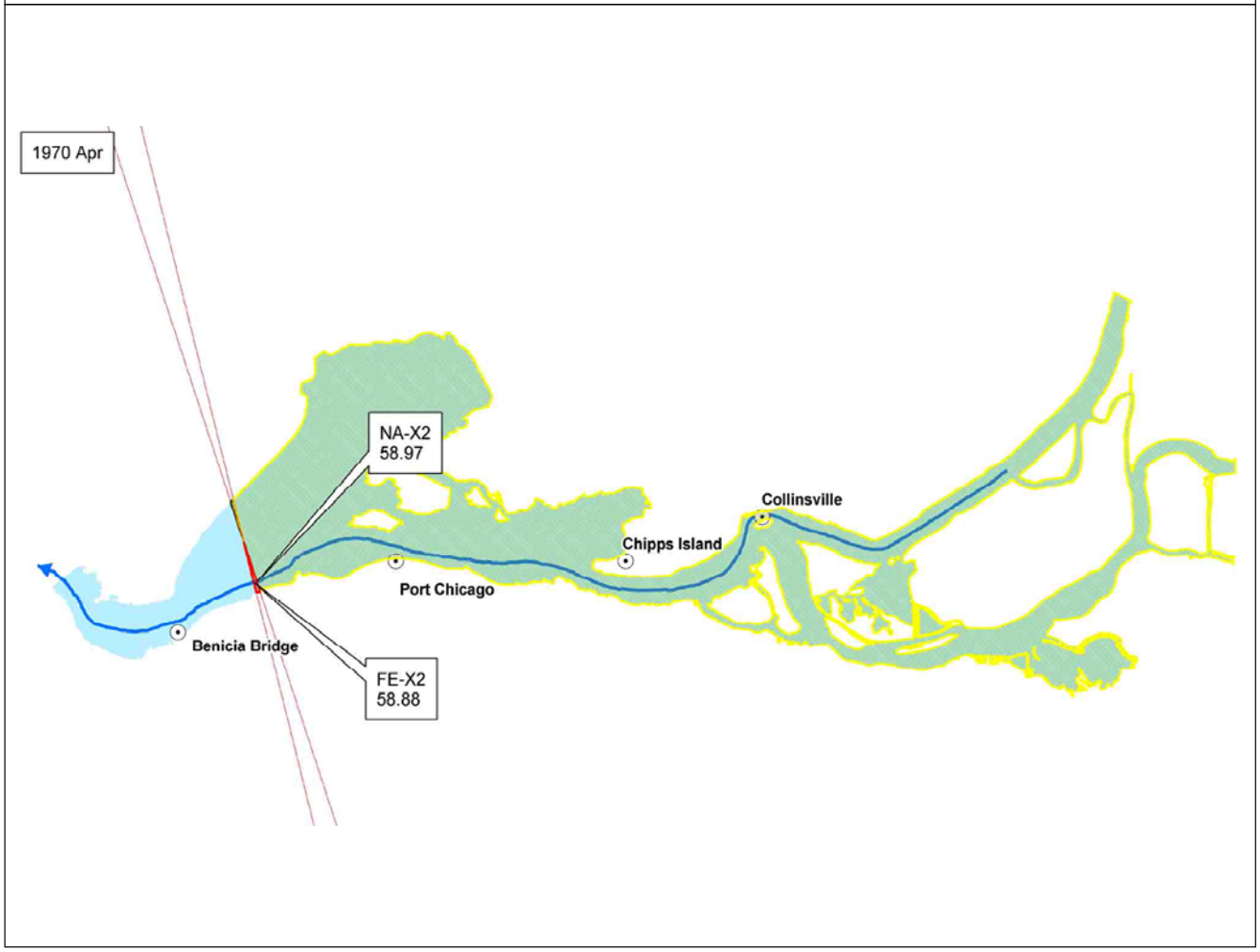

1969 Nov
NA-X2
85.19
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
85.18

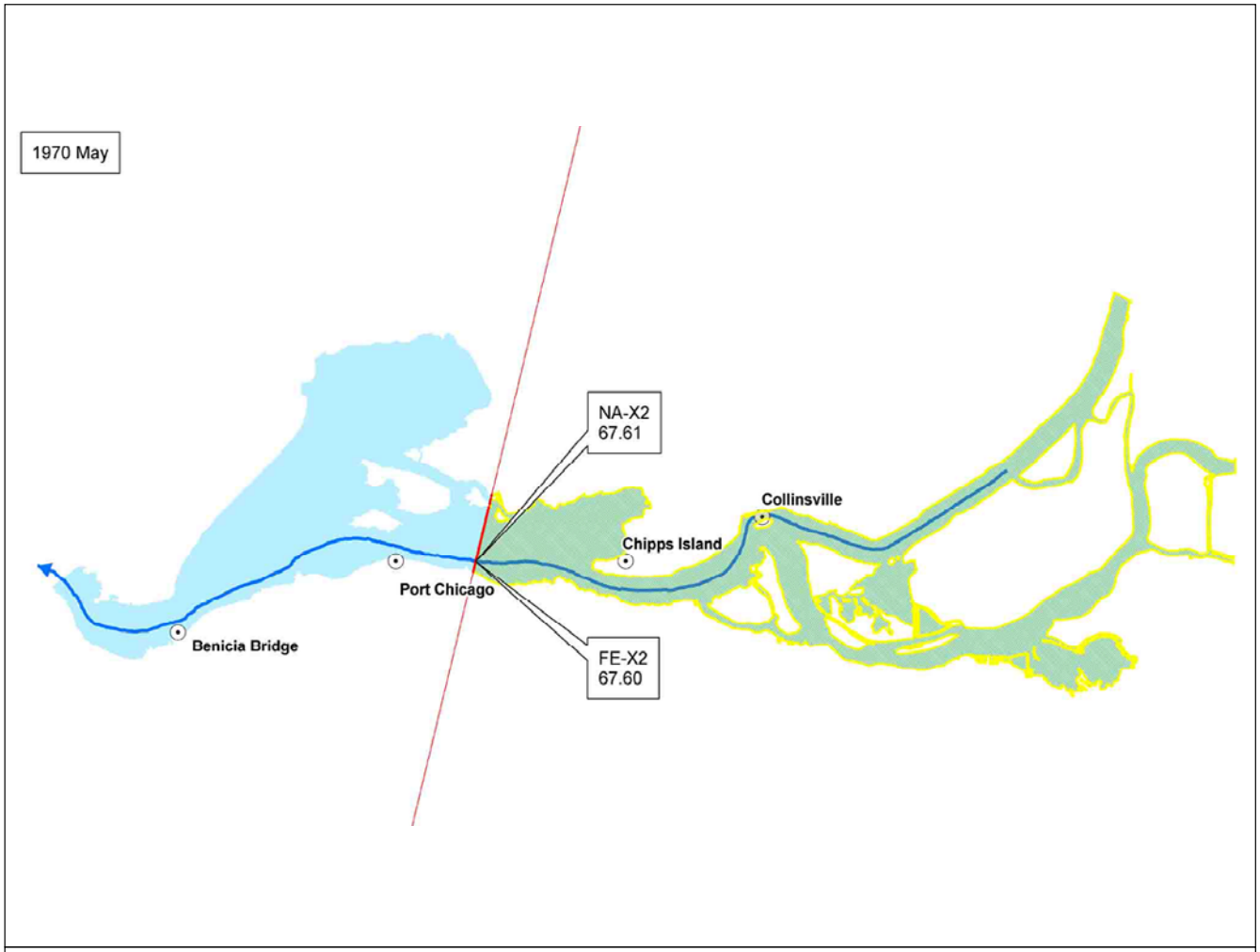

1969 Dec
NA-X2
84.19
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
84.21

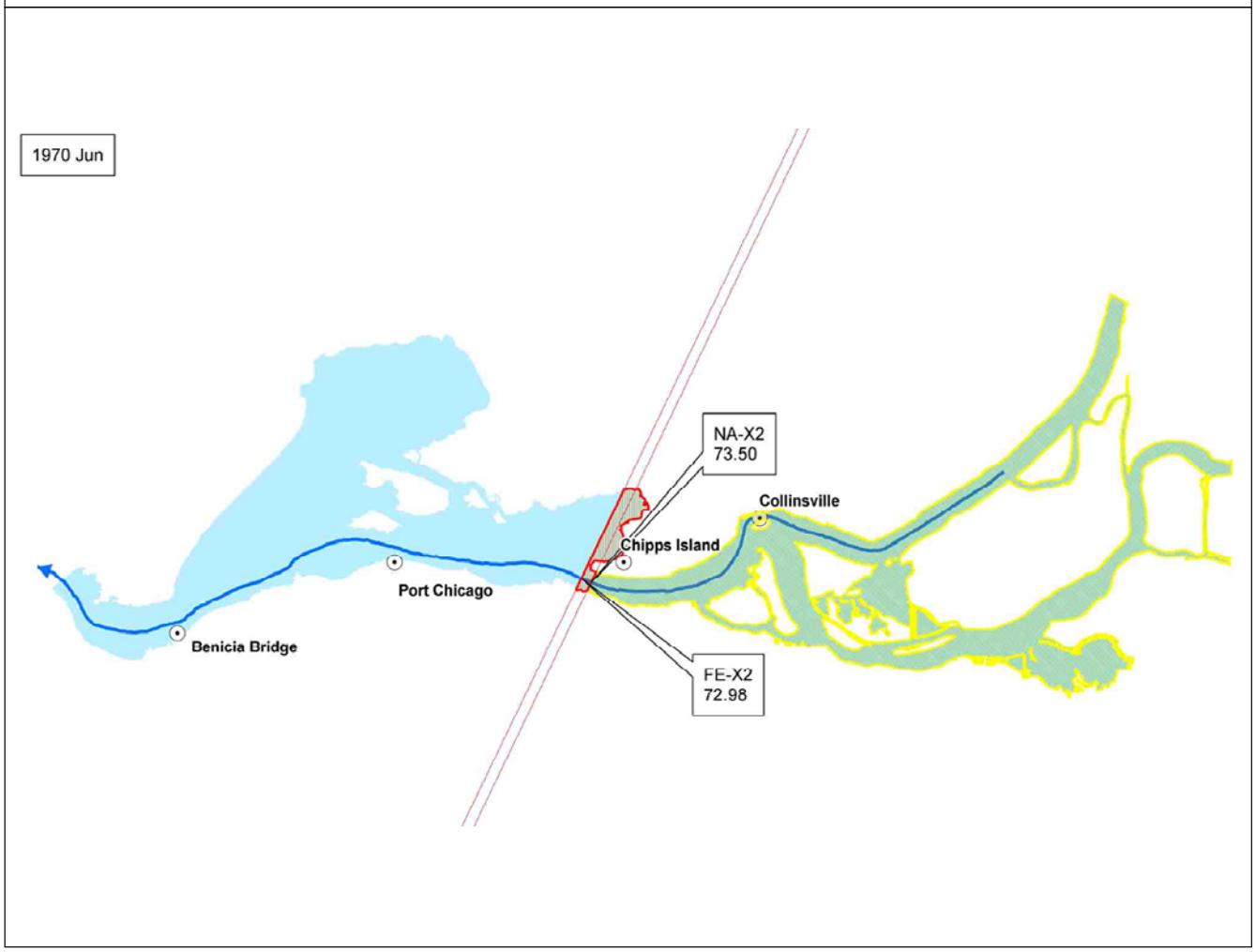

1969 average
NA-X2
68.49
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
68.60


1970 Jan
NA-X2
65.48
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
65.72

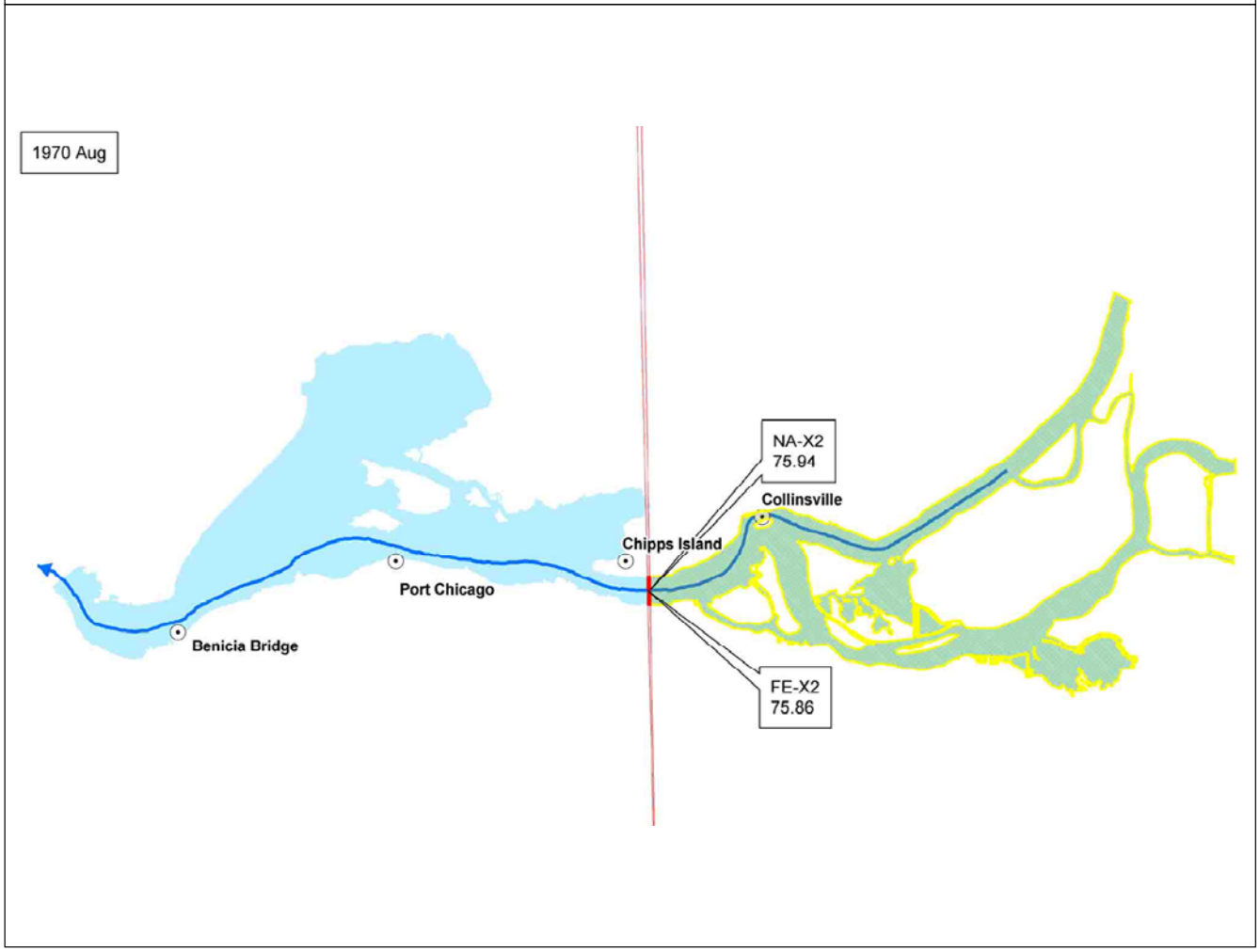

1970 Jan
NA-X2
65.48
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
65.72


1970 Apr
NA-X2
58.97
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
58.88

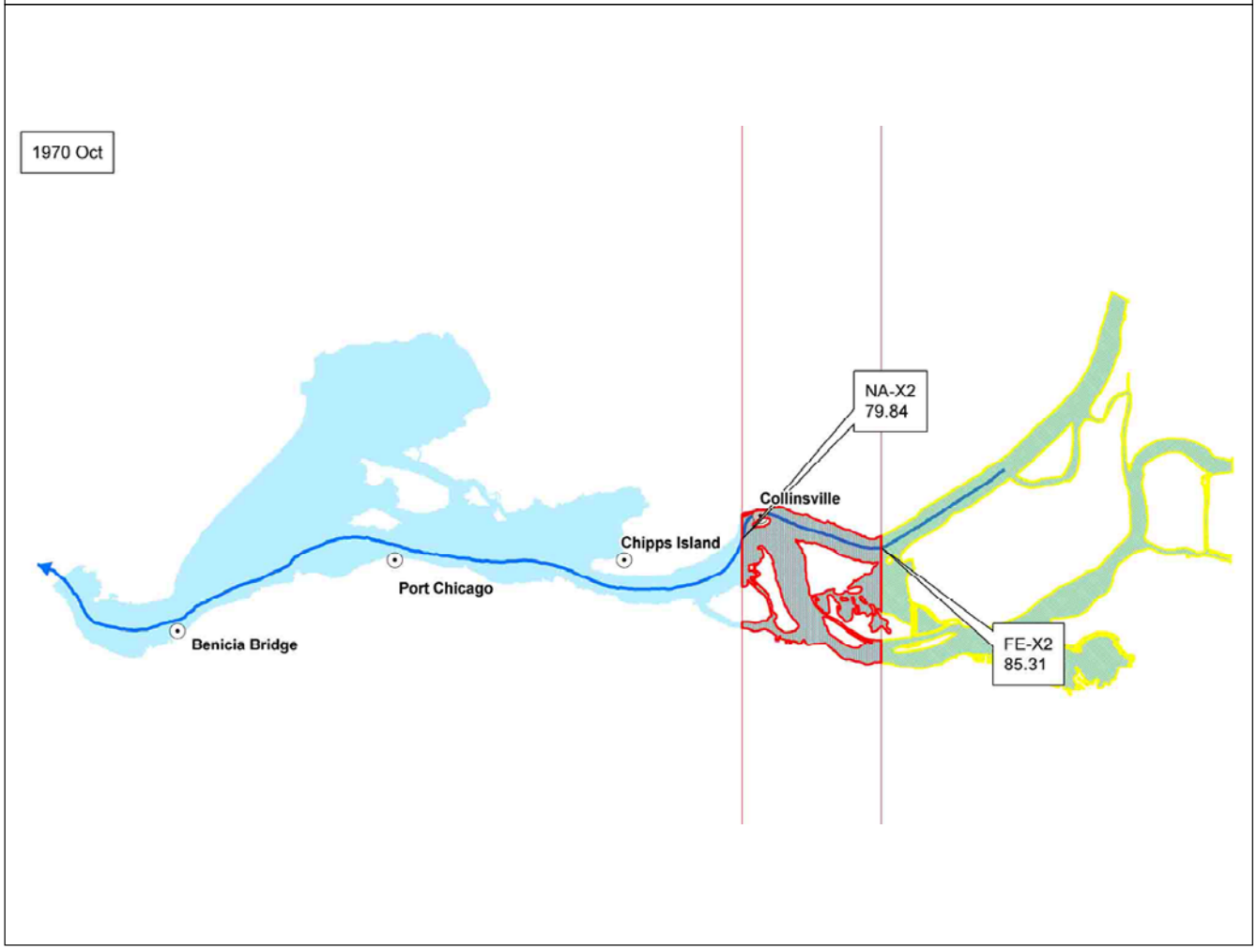

1970 May
NA-X2
67.61
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
67.60


1970 Jun
NA-X2
73.50
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
72.98


1970 Jul
NA-X2
77.34
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
77.64


1970 Aug
NA-X2
75.94
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
75.86


1970 Sep
NA-X2
83.51
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
83.49


1970 Oct
NA-X2
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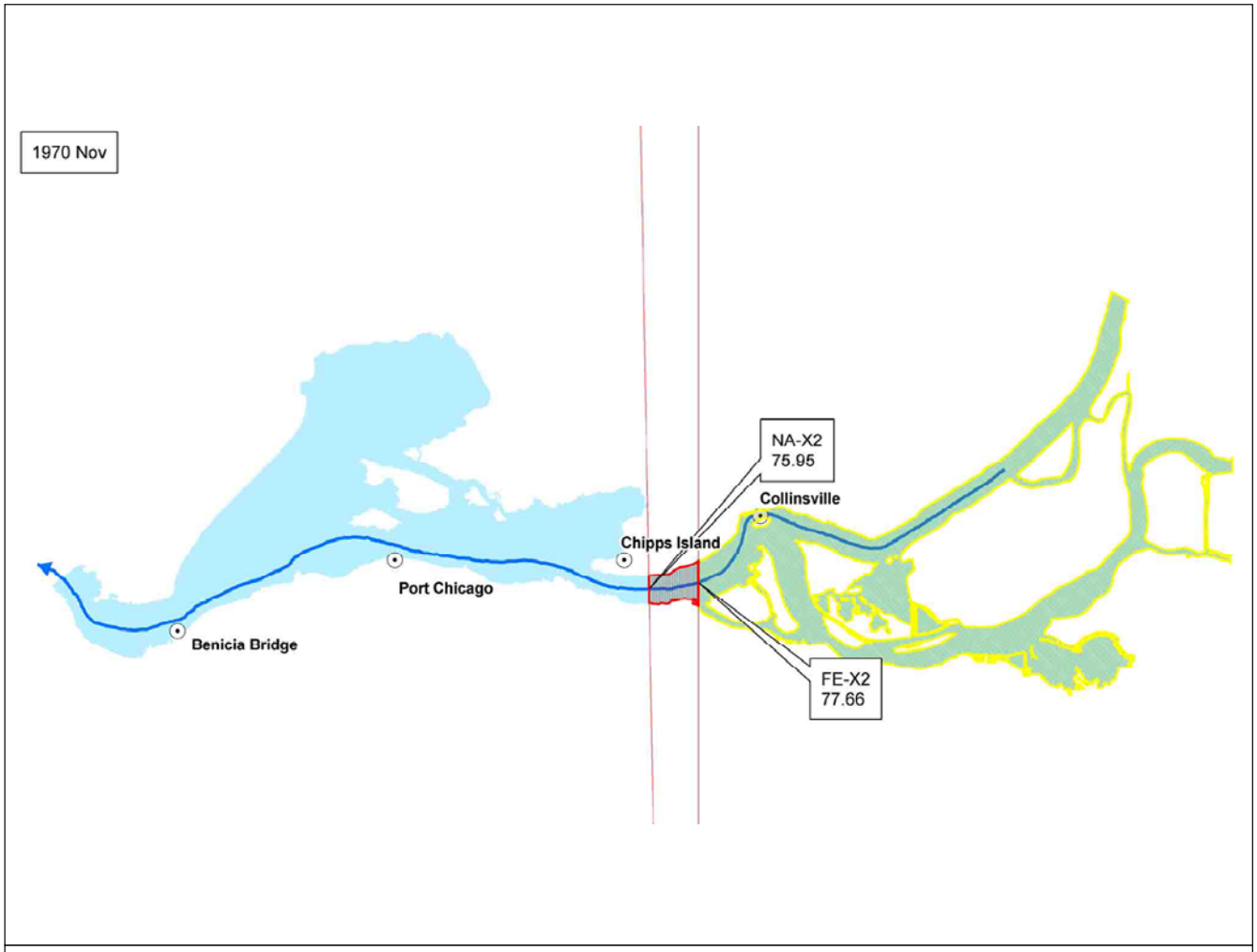
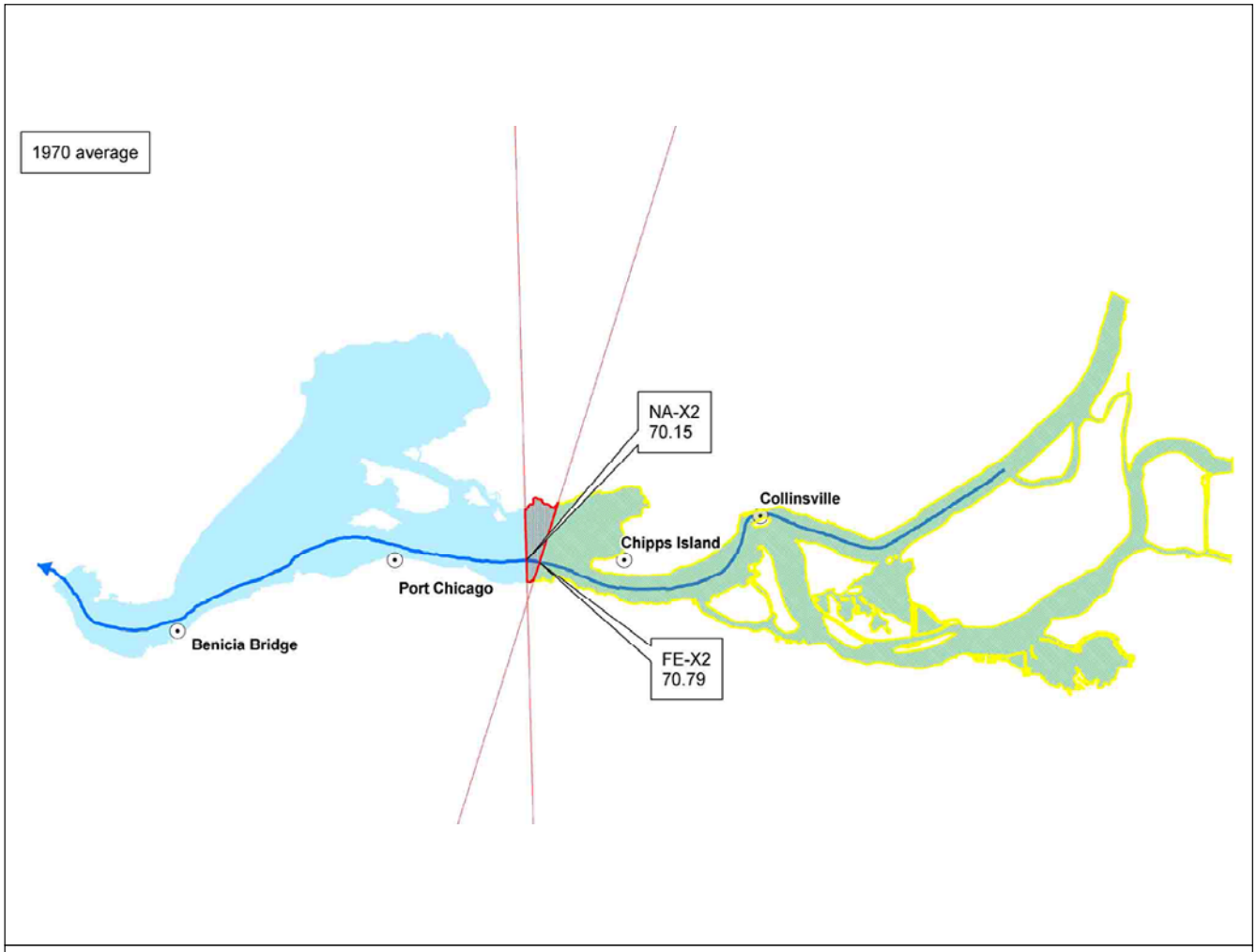
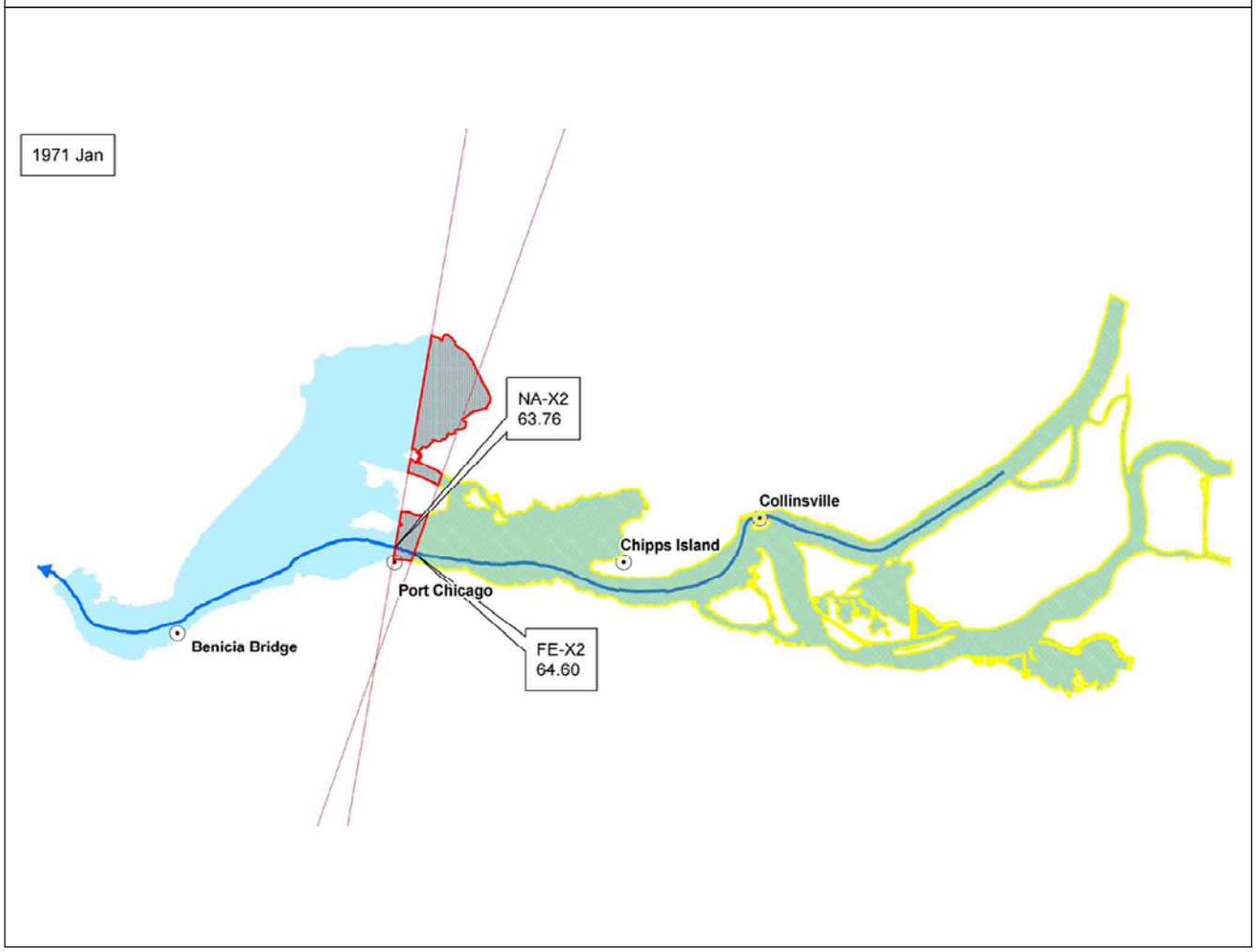
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
85.31


1970 Nov
NA-X2
75.95
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
77.66


1970 Dec
NA-X2
82.37
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
83.00


1970 average
NA-X2
70.15
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
70.79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NA-X2
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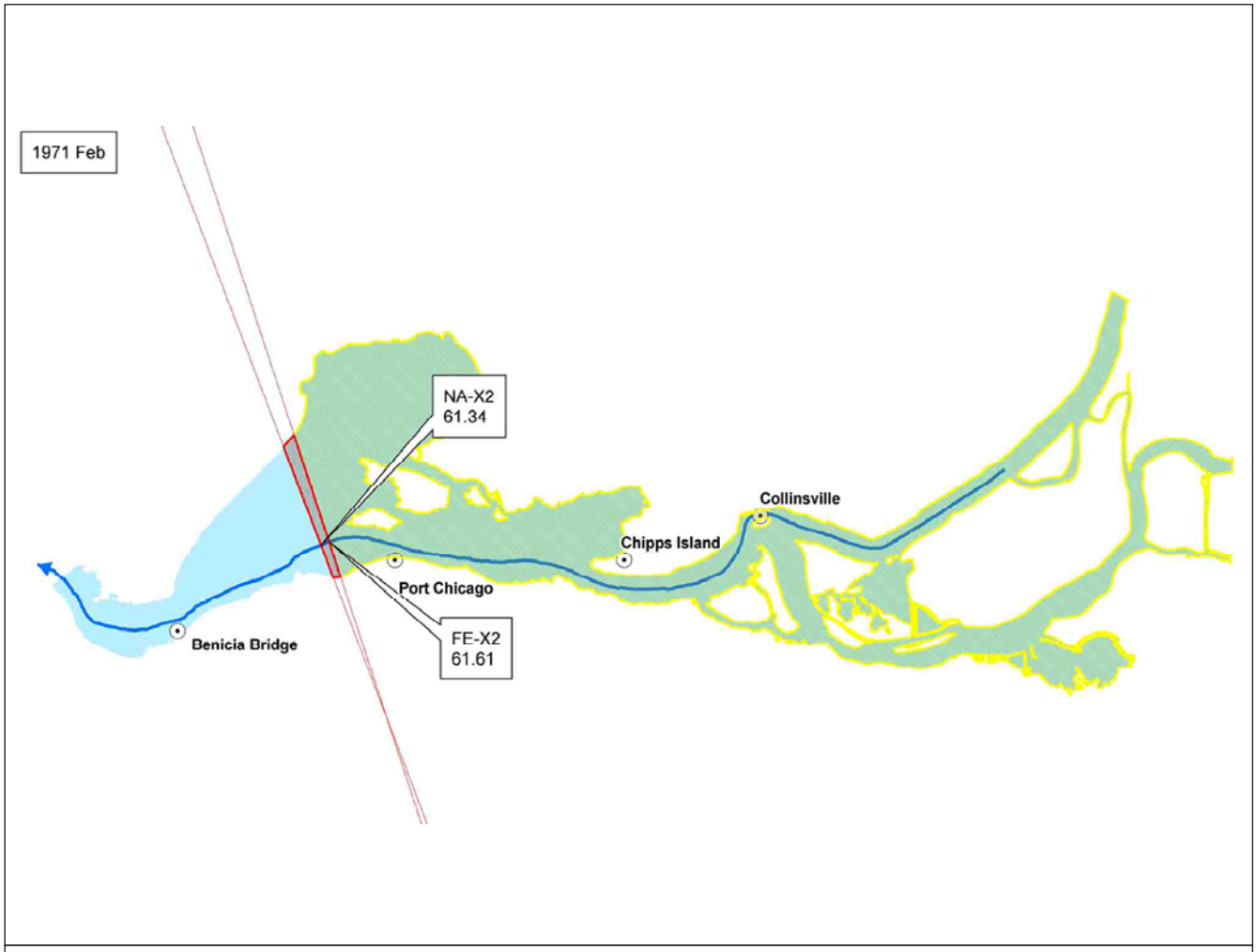
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
64.60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NA-X2
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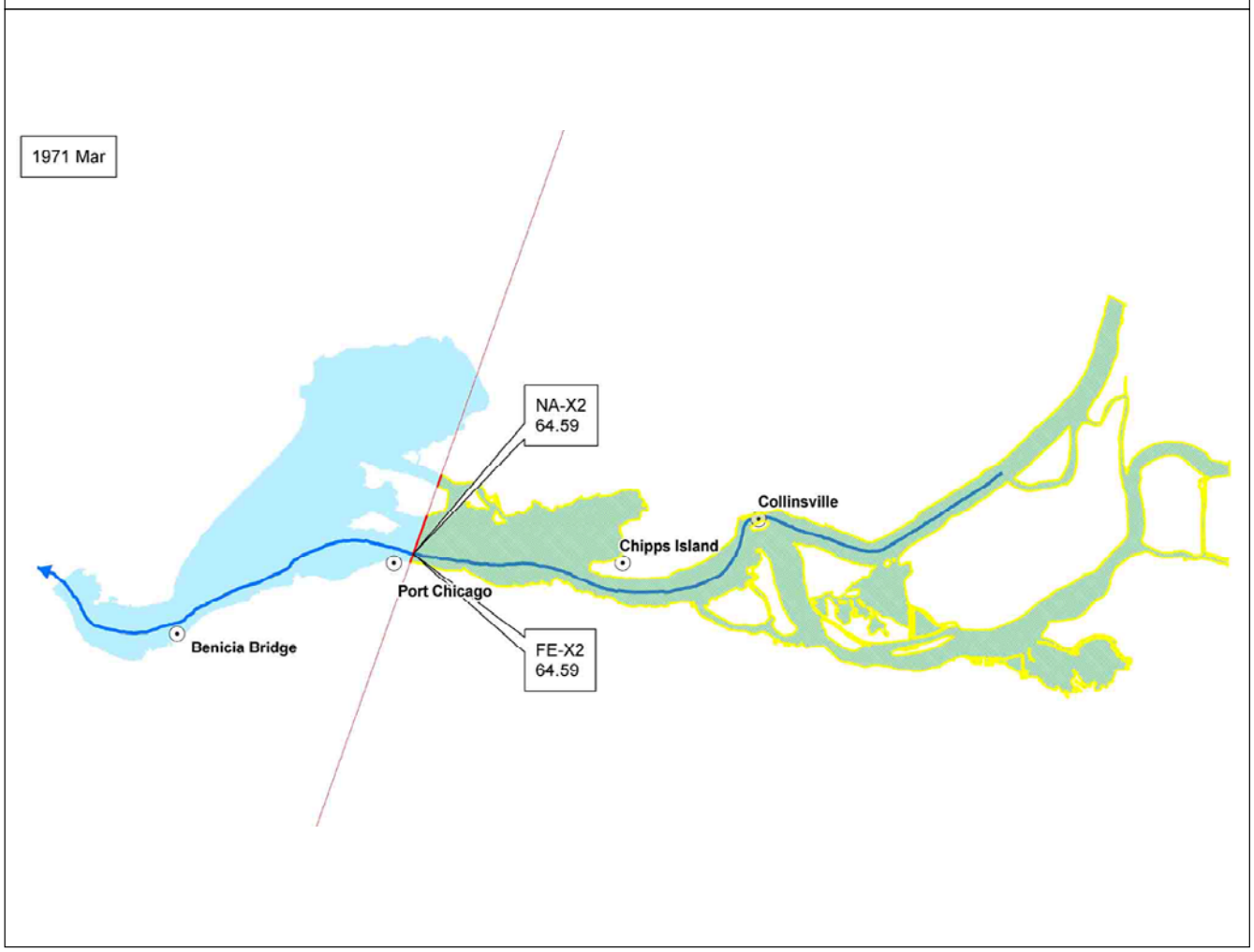
Collinsville
Chipps Island
Port Chicago
FE-X2
61.61
Benicia Bridge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NA-X2
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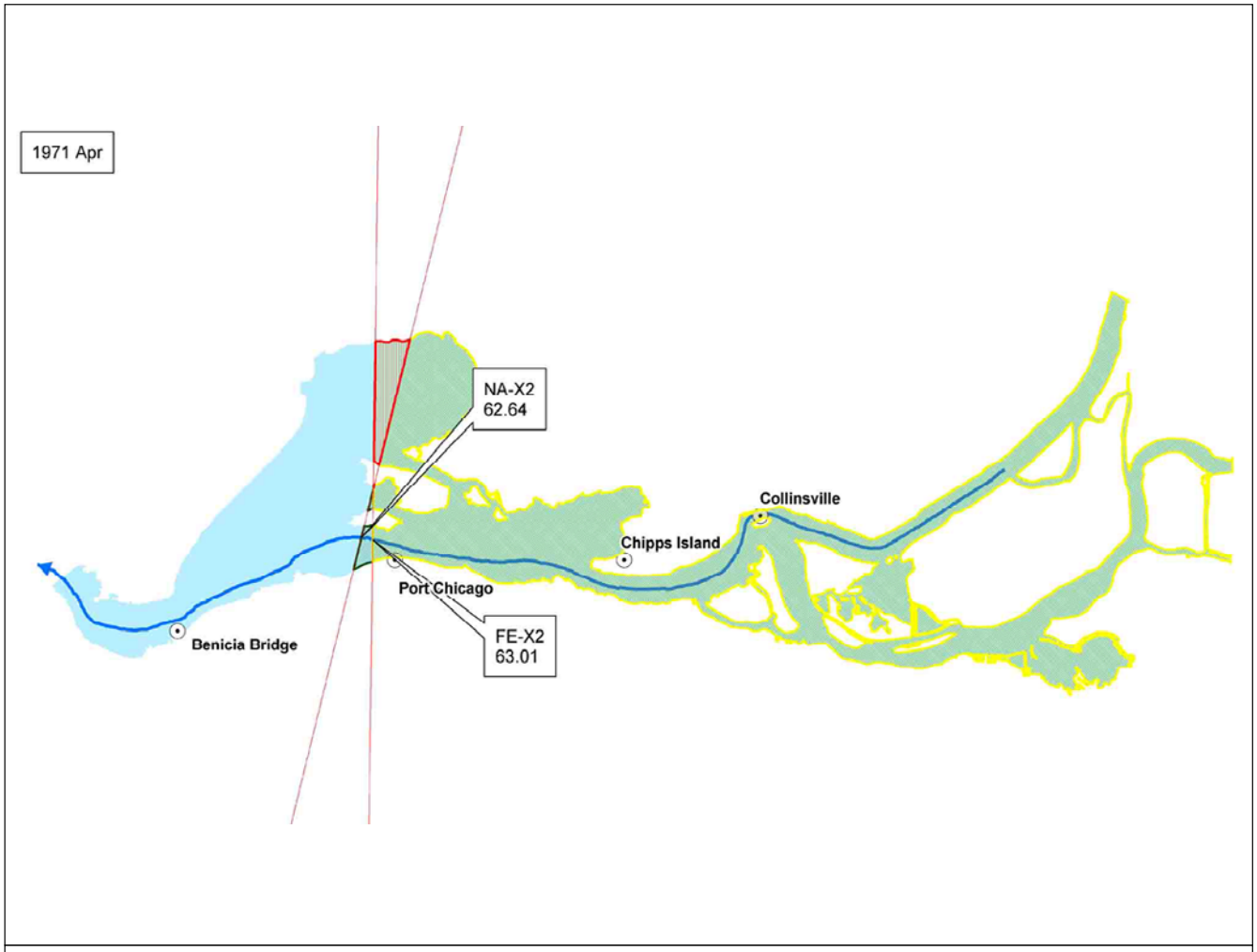
Collinsville
Chipps Island
Port Chicago
FE-X2
64.59
Benicia Bridge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NA-X2
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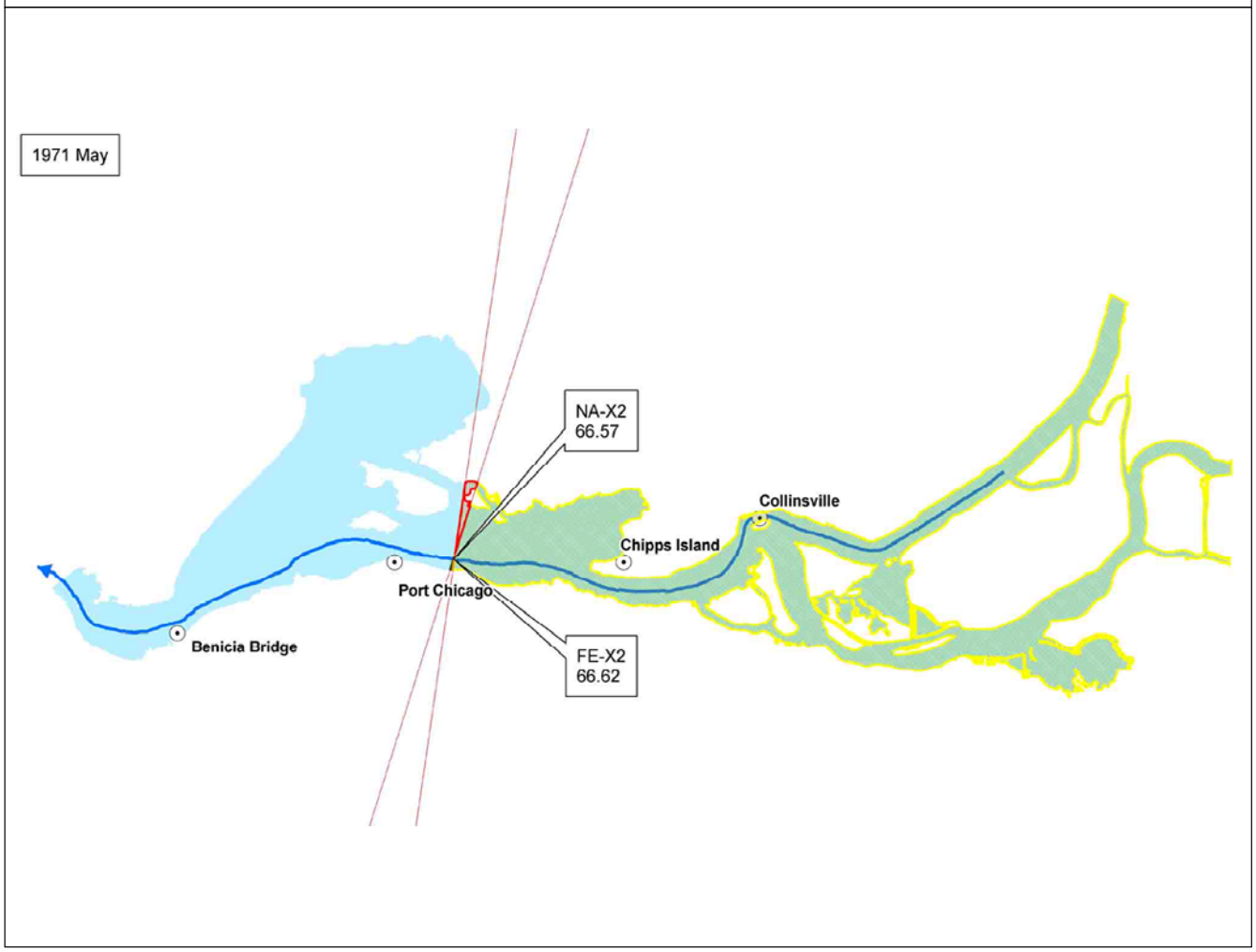
Collinsville
Chipps Island
Port Chicago
FE-X2
63.01
Benicia Bridge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NA-X2
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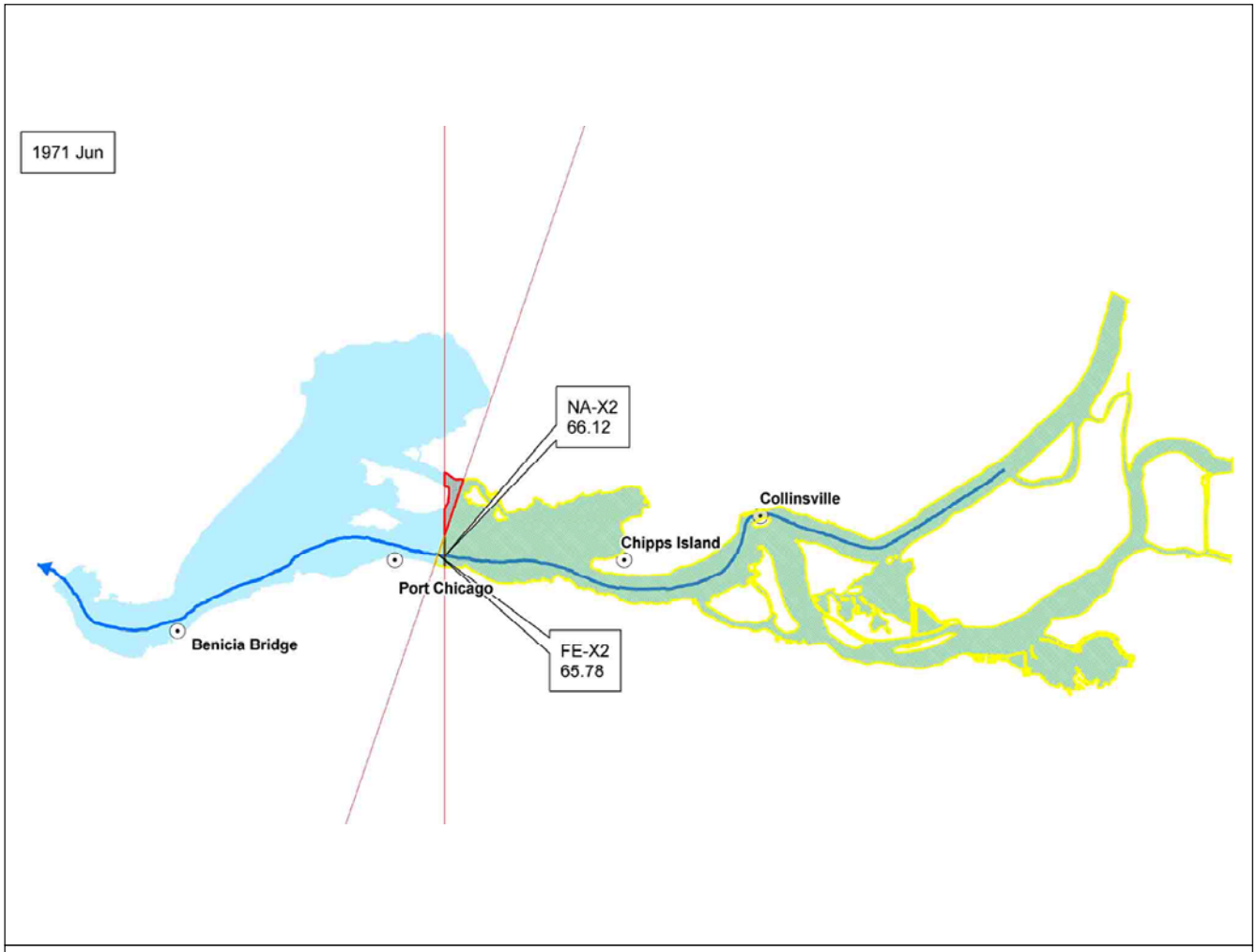
Collinsville
Chipps Island
Port Chicago
FE-X2
66.62
Benicia Bridge


1971 Jun
NA-X2
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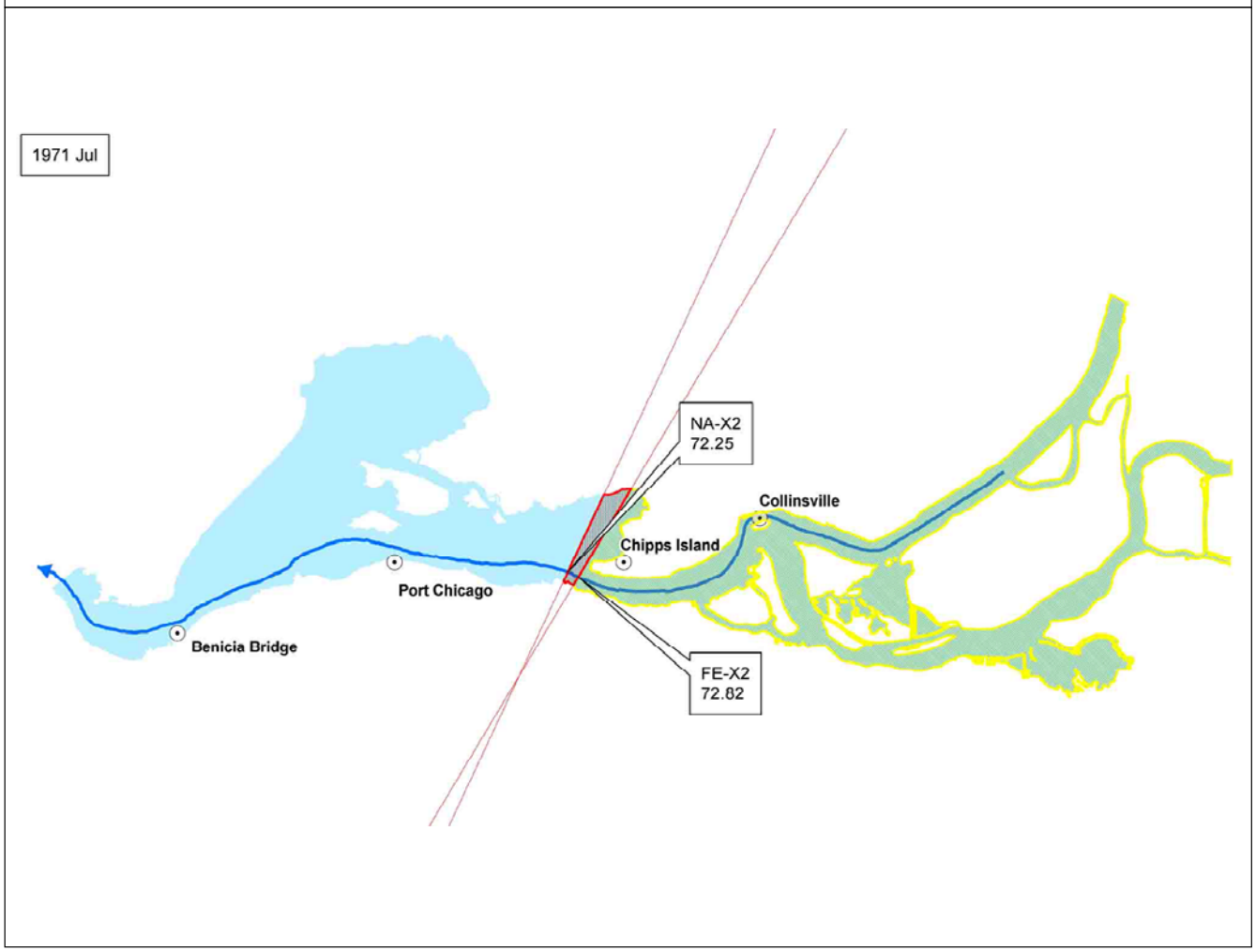
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
65.78


1971 Jul
NA-X2
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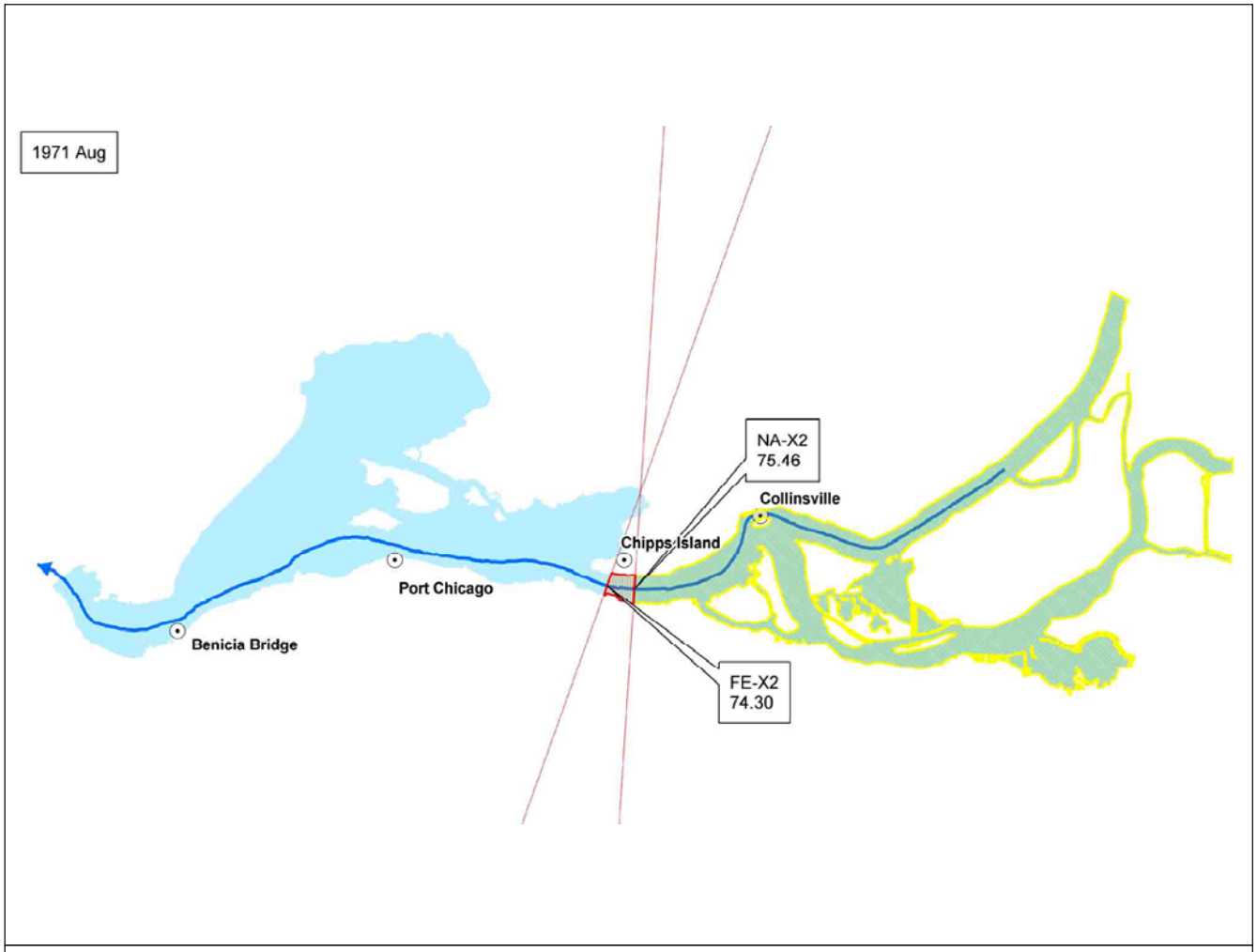
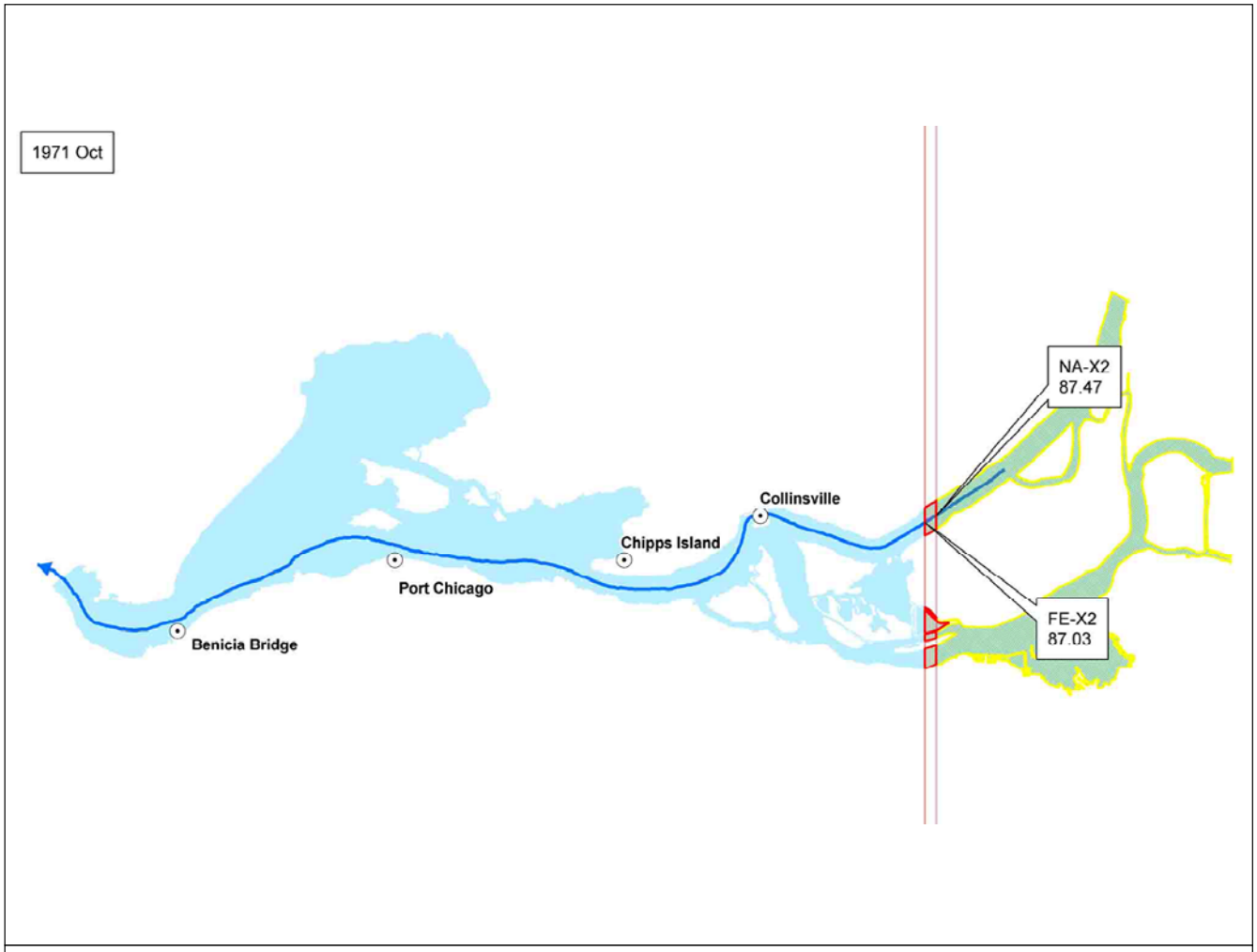
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
72.82


1971 Aug
NA-X2
75.46
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
74.30


1971 Sep
NA-X2
83.36
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
82.98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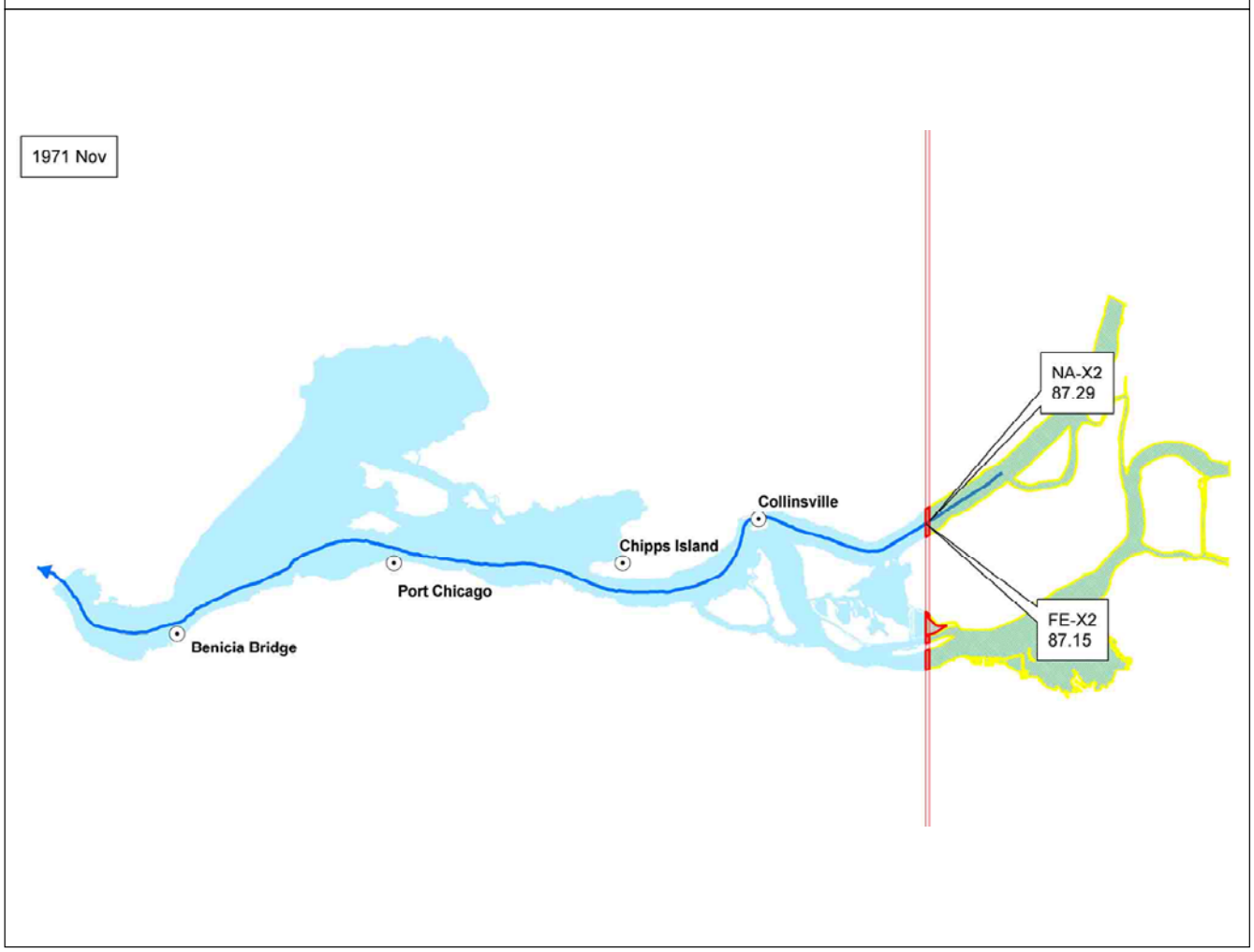
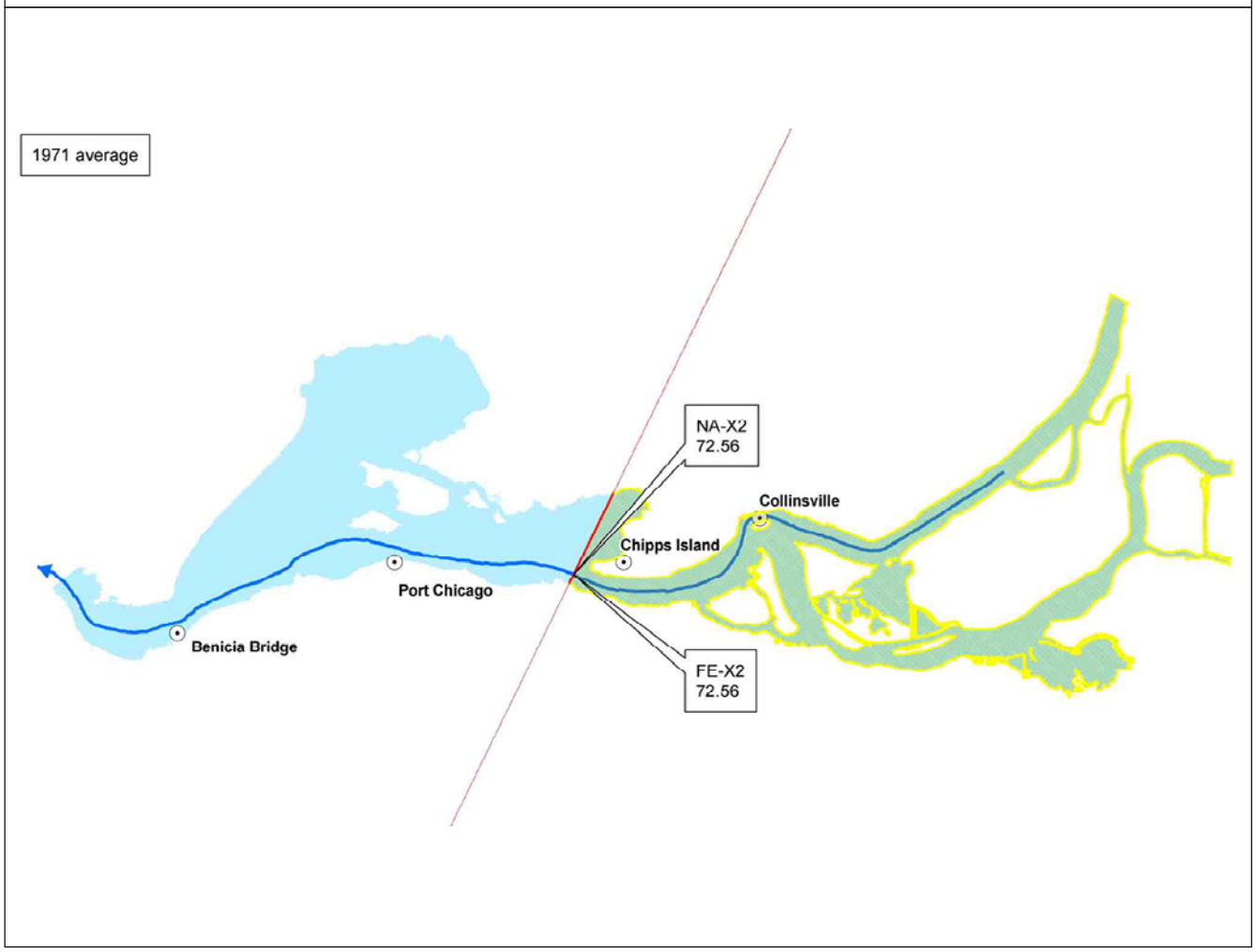
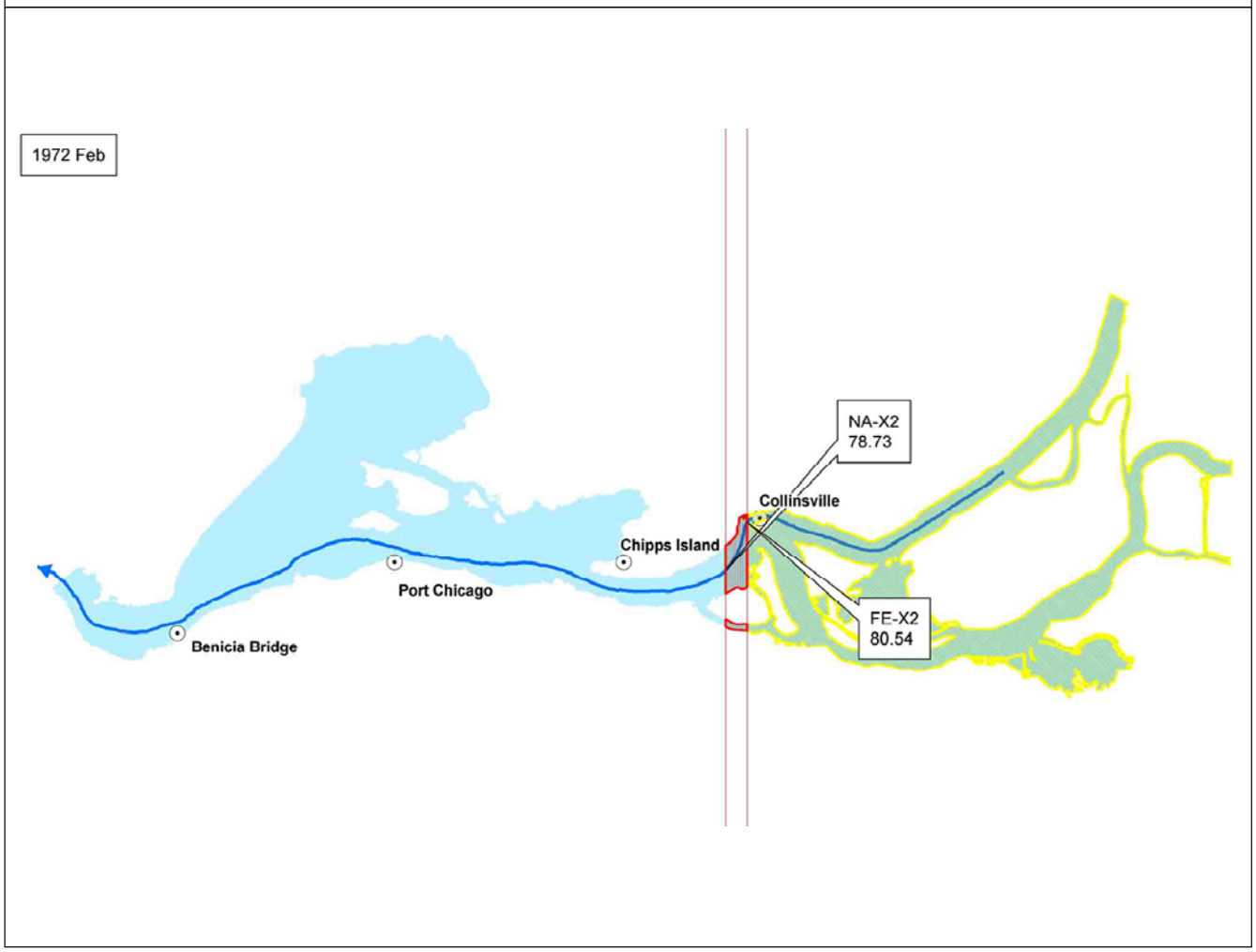
NA-X2
87.47
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
87.03

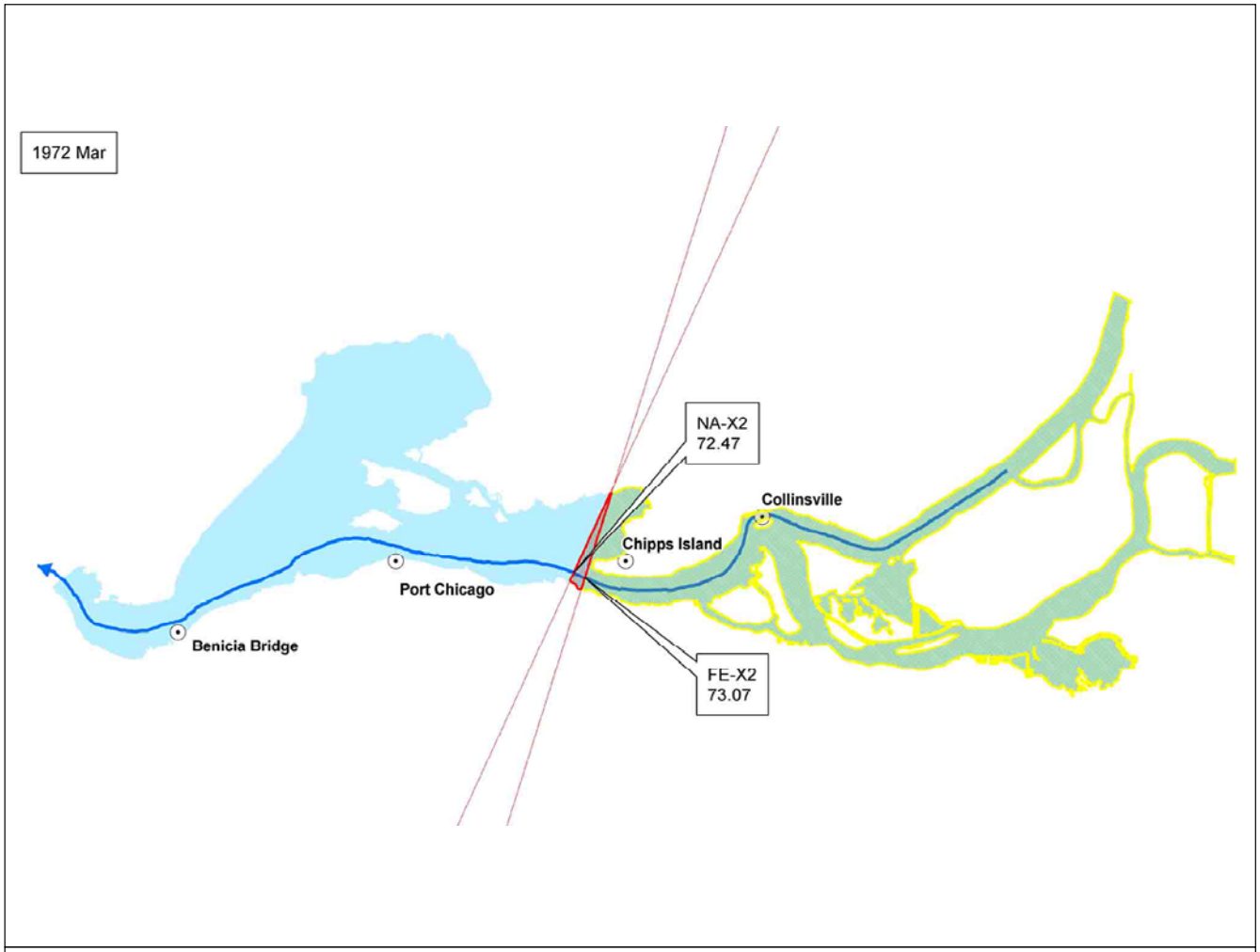

1971 Nov
NA-X2
87.29
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
87.15

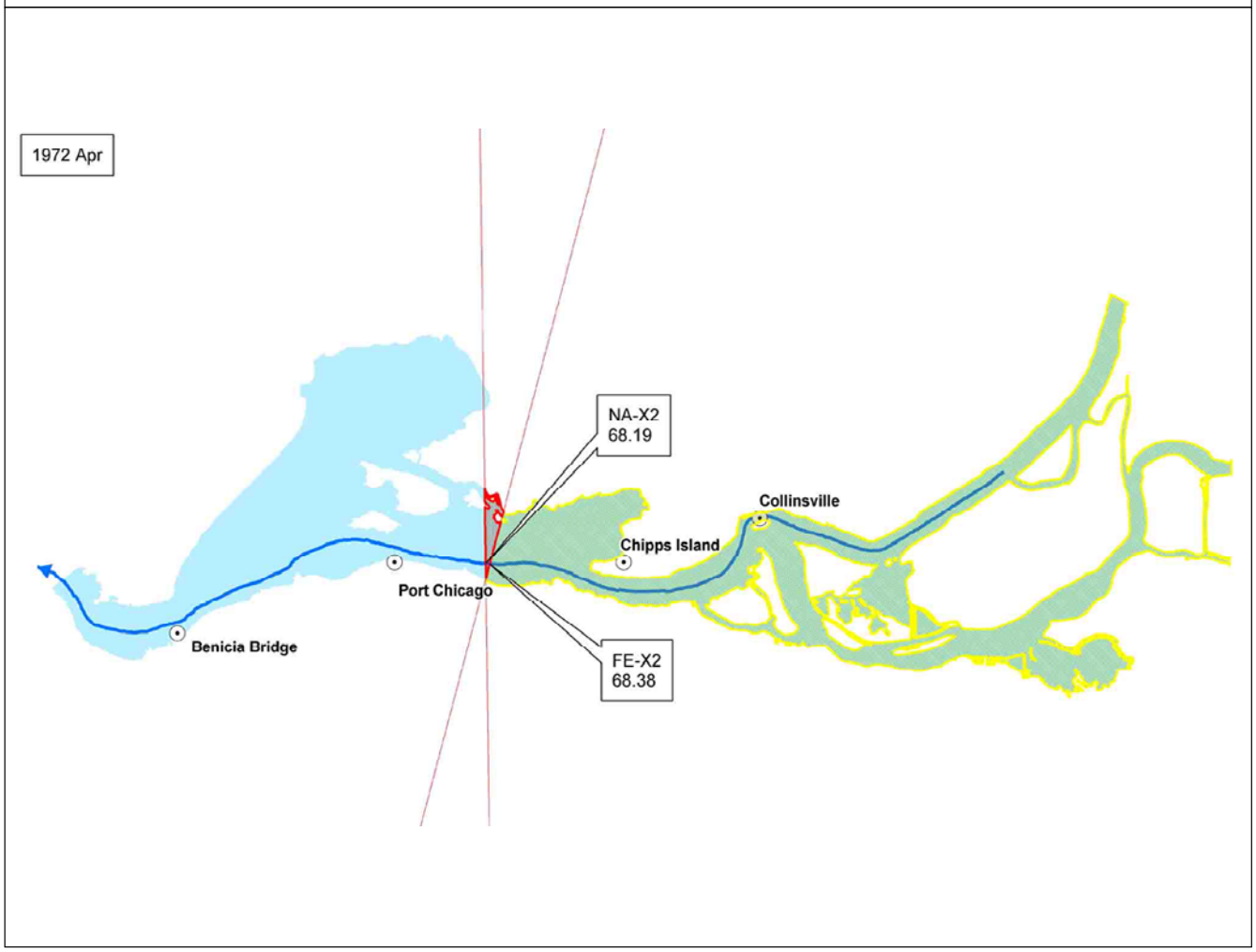

1971 Dec
NA-X2
79.89
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
80.19


1971 average
NA-X2
72.56
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
72.56


1972 Jan
NA-X2
81.07
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
81.17


1972 Feb
NA-X2
78.73
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
80.54


1972 Mar
NA-X2
72.47
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
73.07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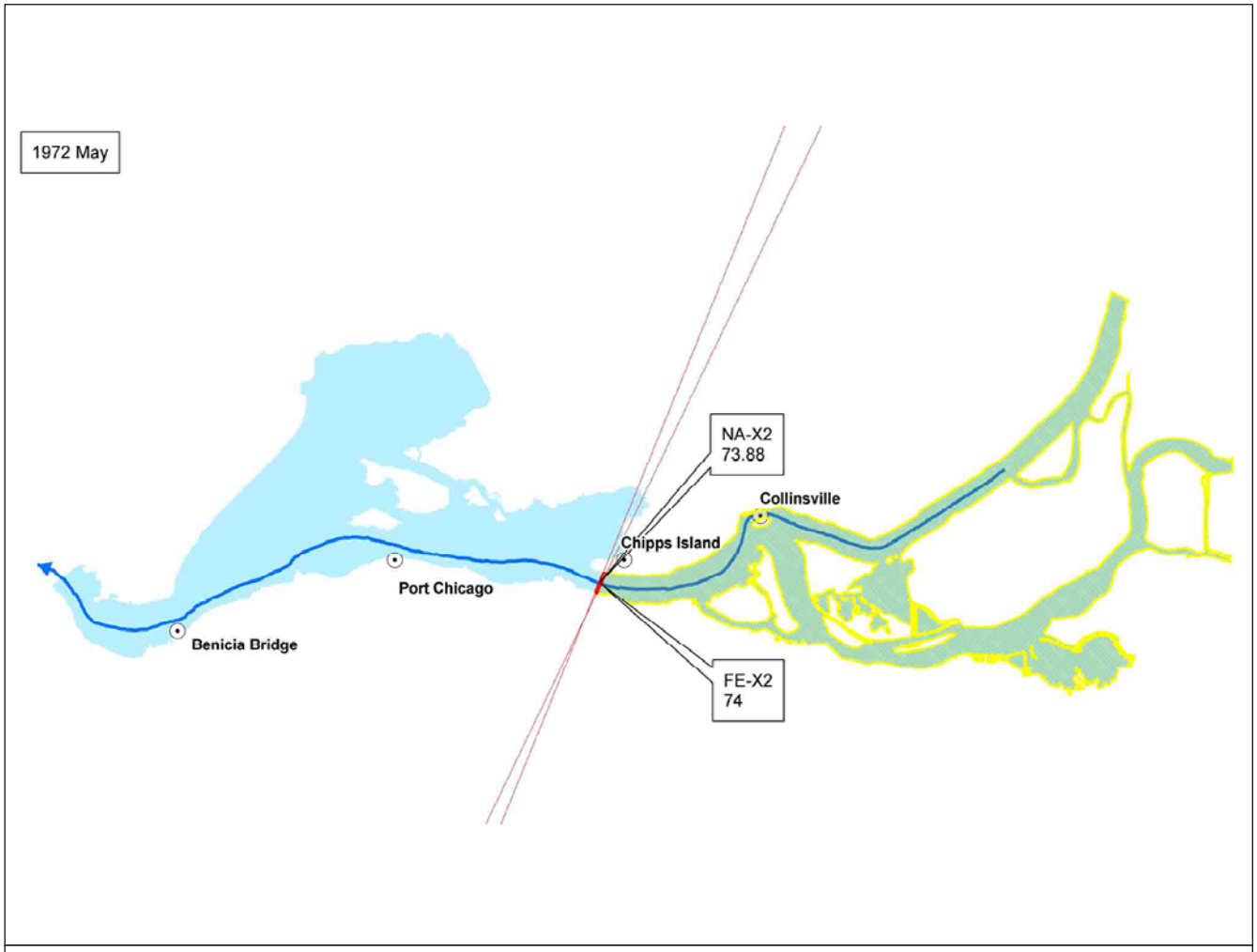
NA-X2
68.19
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
68.38


1972 May
NA-X2
73.88
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
74

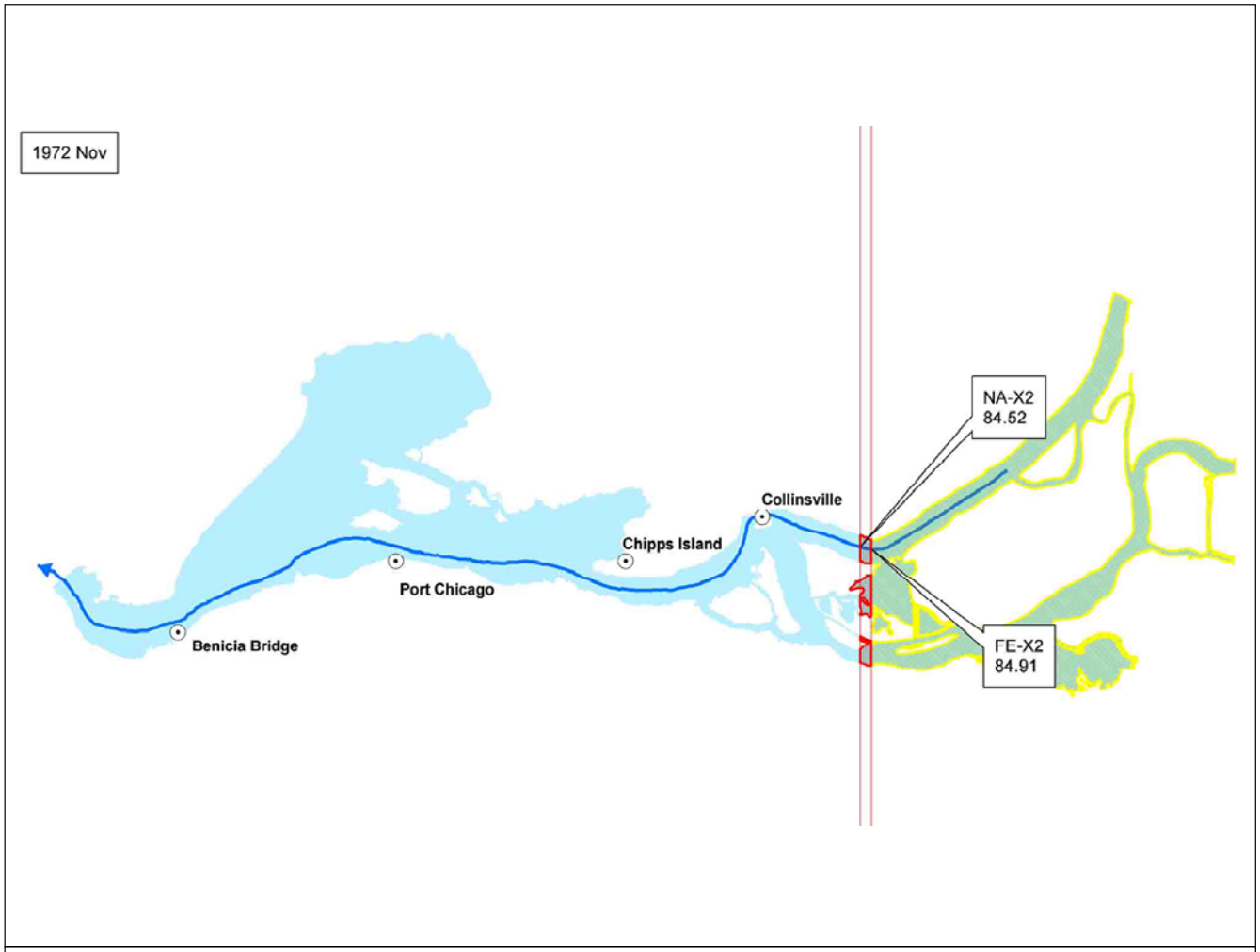

1972 Jun
NA-X2
77.56
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
77.76


1972 Jul
NA-X2
76.21
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
76.20


1972 Aug
NA-X2
79.88
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
79.88

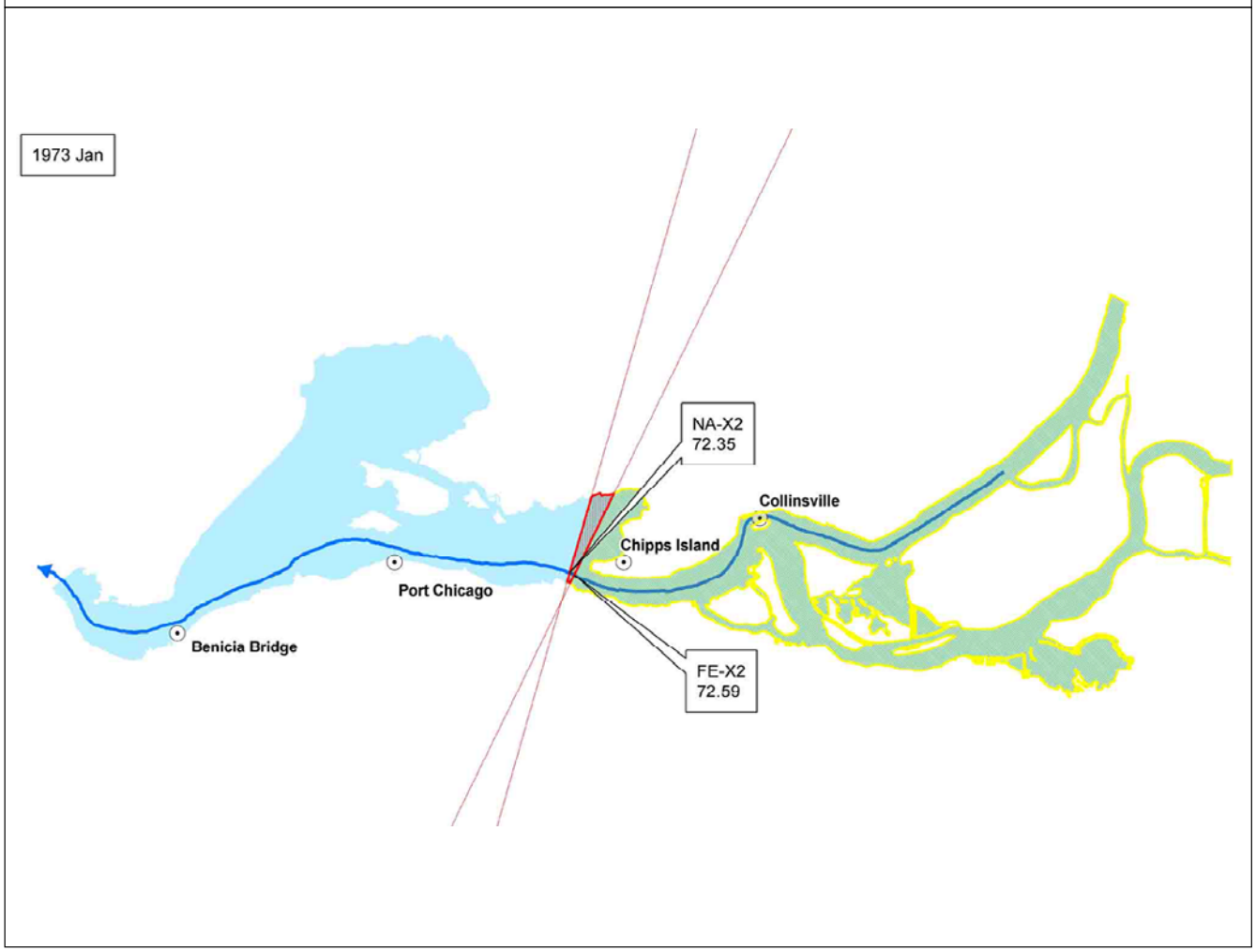

1972 Sep
NA-X2
84.80
FE-X2
84.80
Collinsville
Chipps Island
Port Chicago
Benicia Bridge

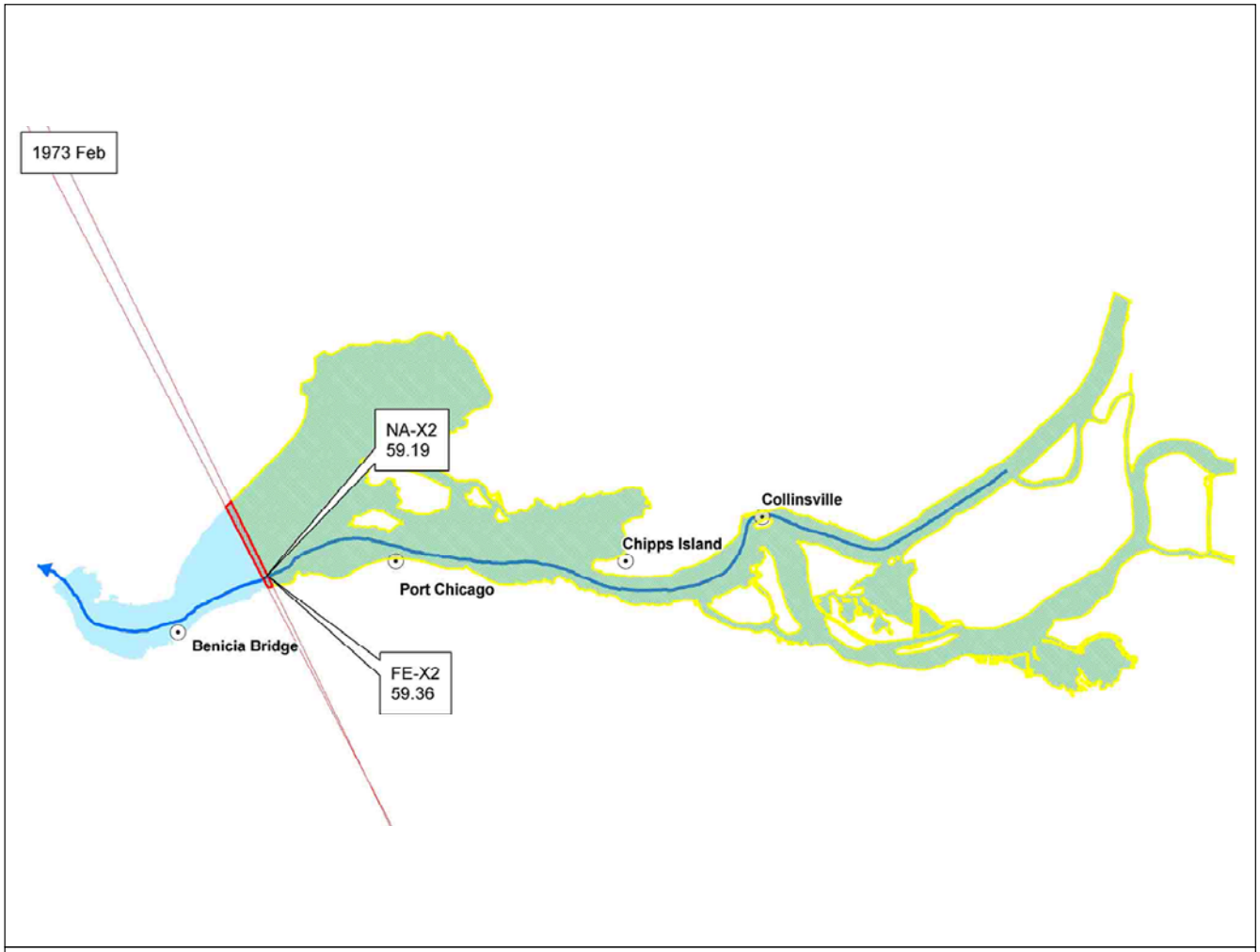

1972 Oct
NA-X2
81.01
FE-X2
82.17
Collinsville
Chipps Island
Port Chicago
Benicia Bridge


1972 Nov
NA-X2
84.52
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
84.91


1972 Dec
NA-X2
85.42
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
85.55


1972 average
NA-X2
78.65
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
79.04


1973 Jan
NA-X2
72.35
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
72.59


1973 Feb
NA-X2
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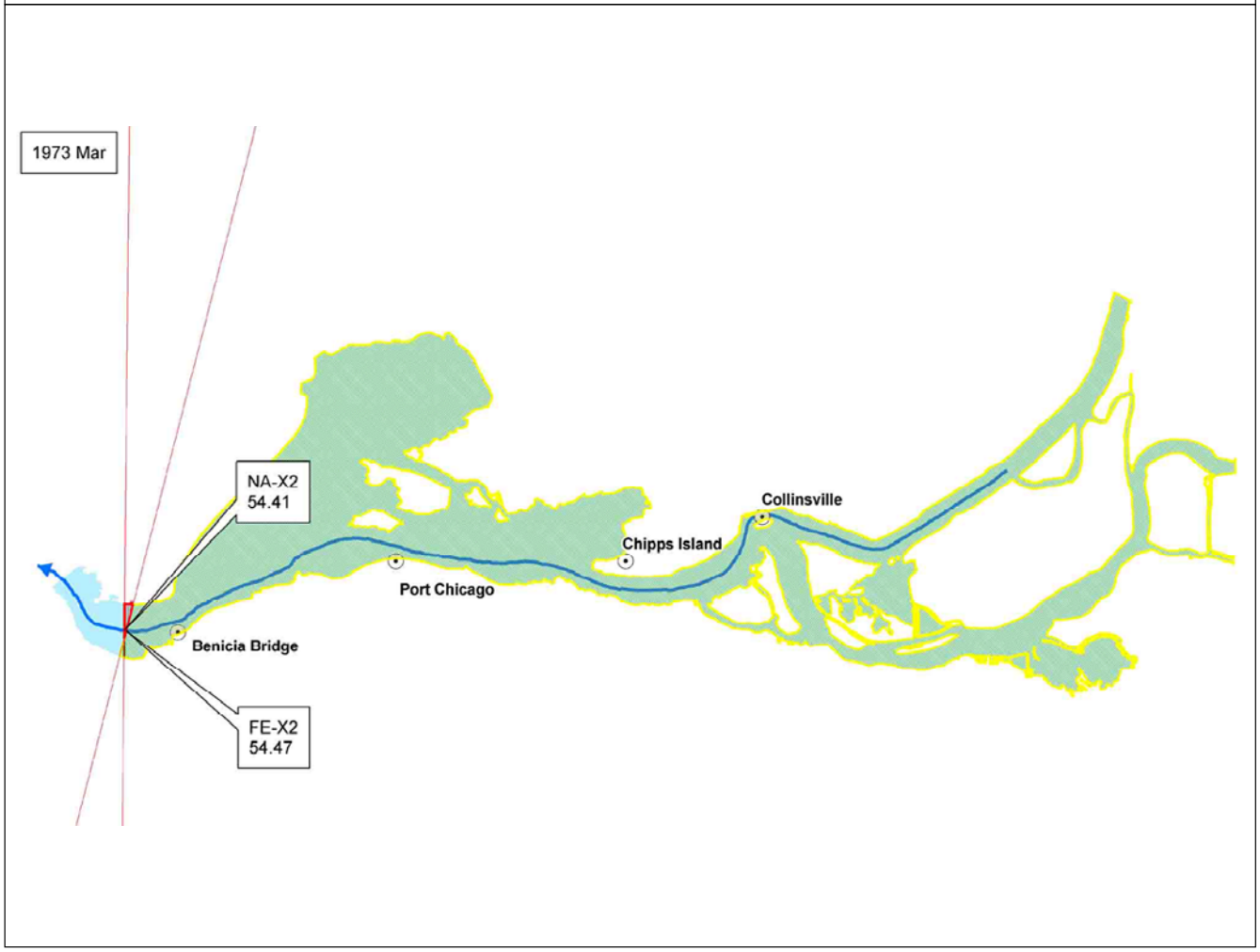
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
59.36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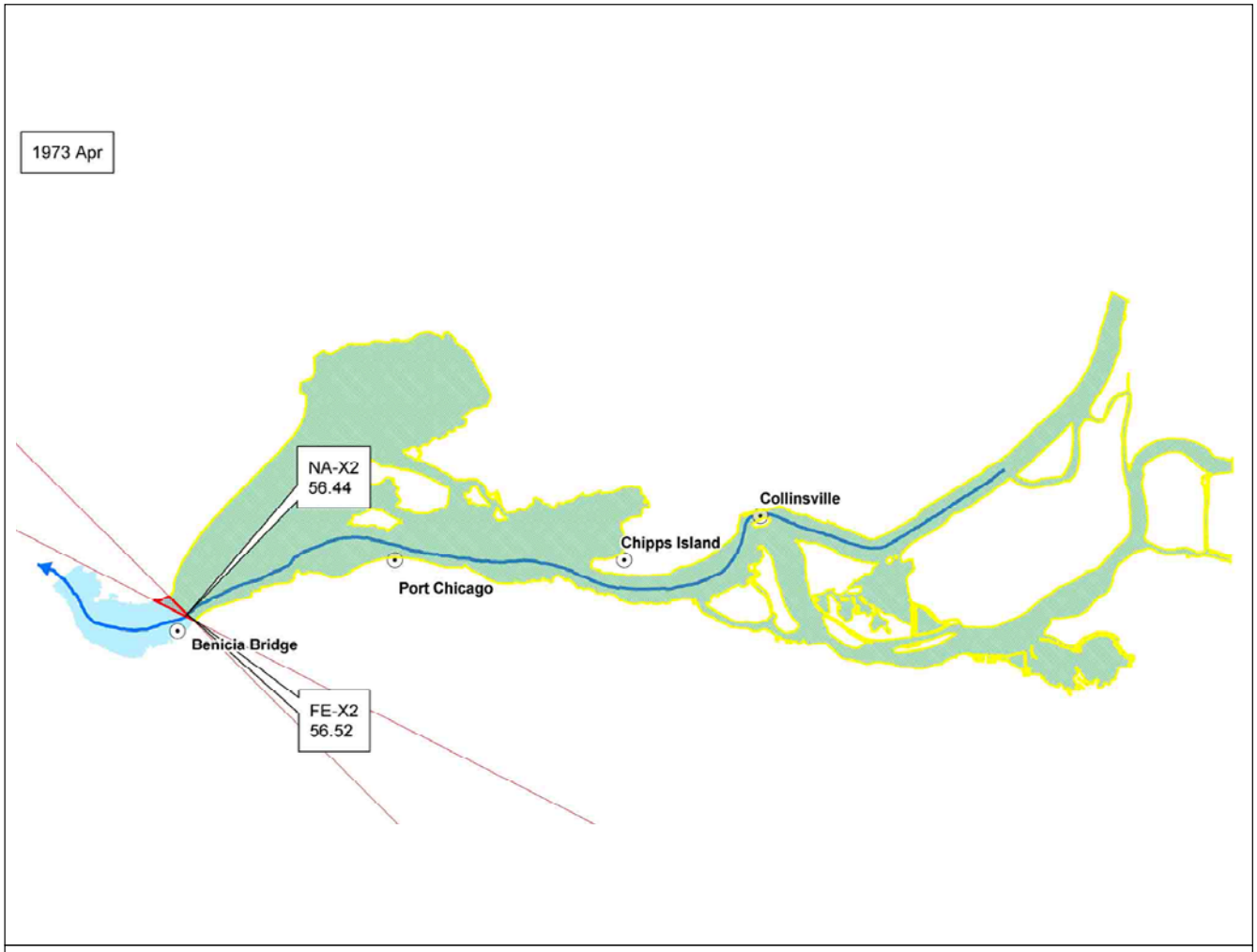
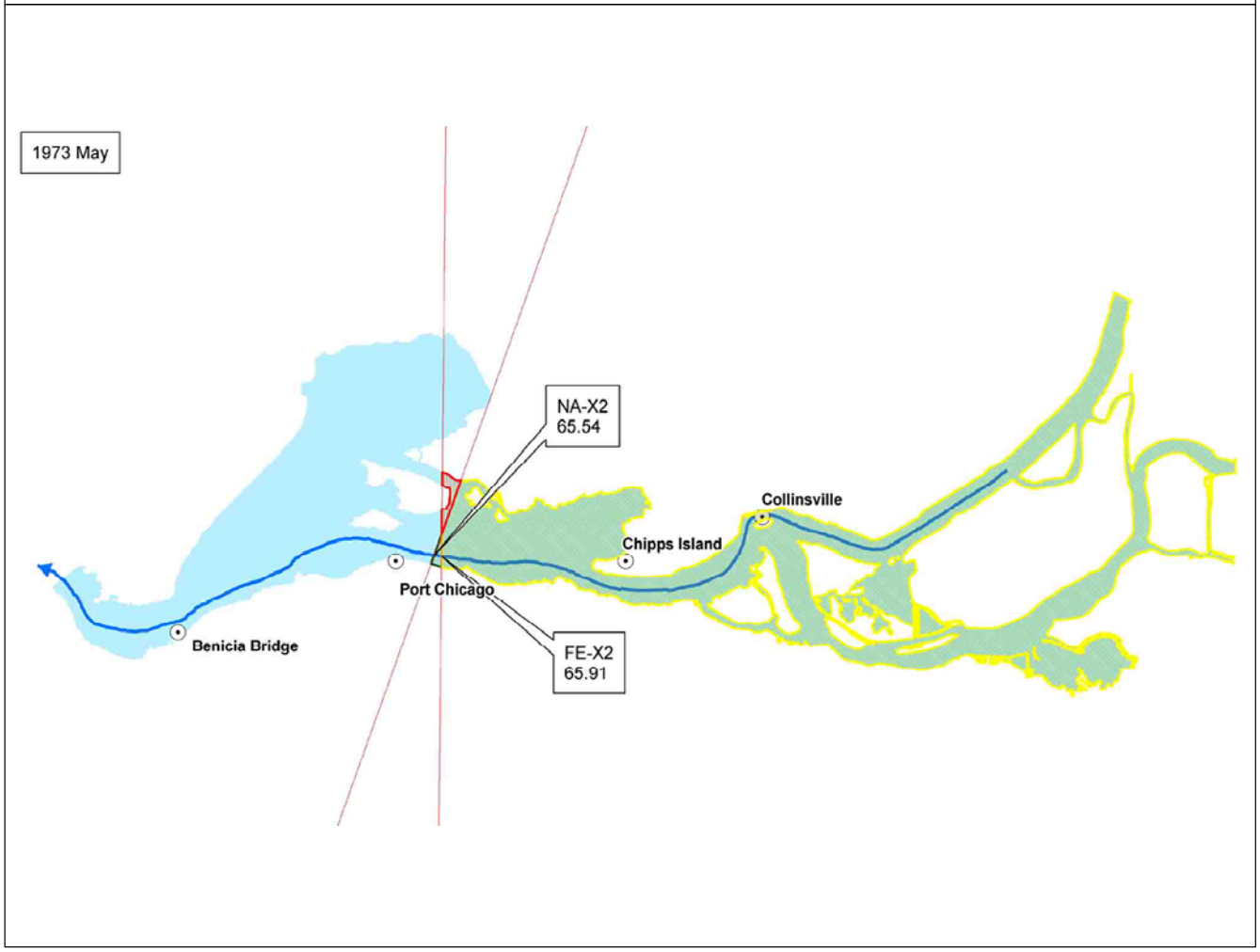
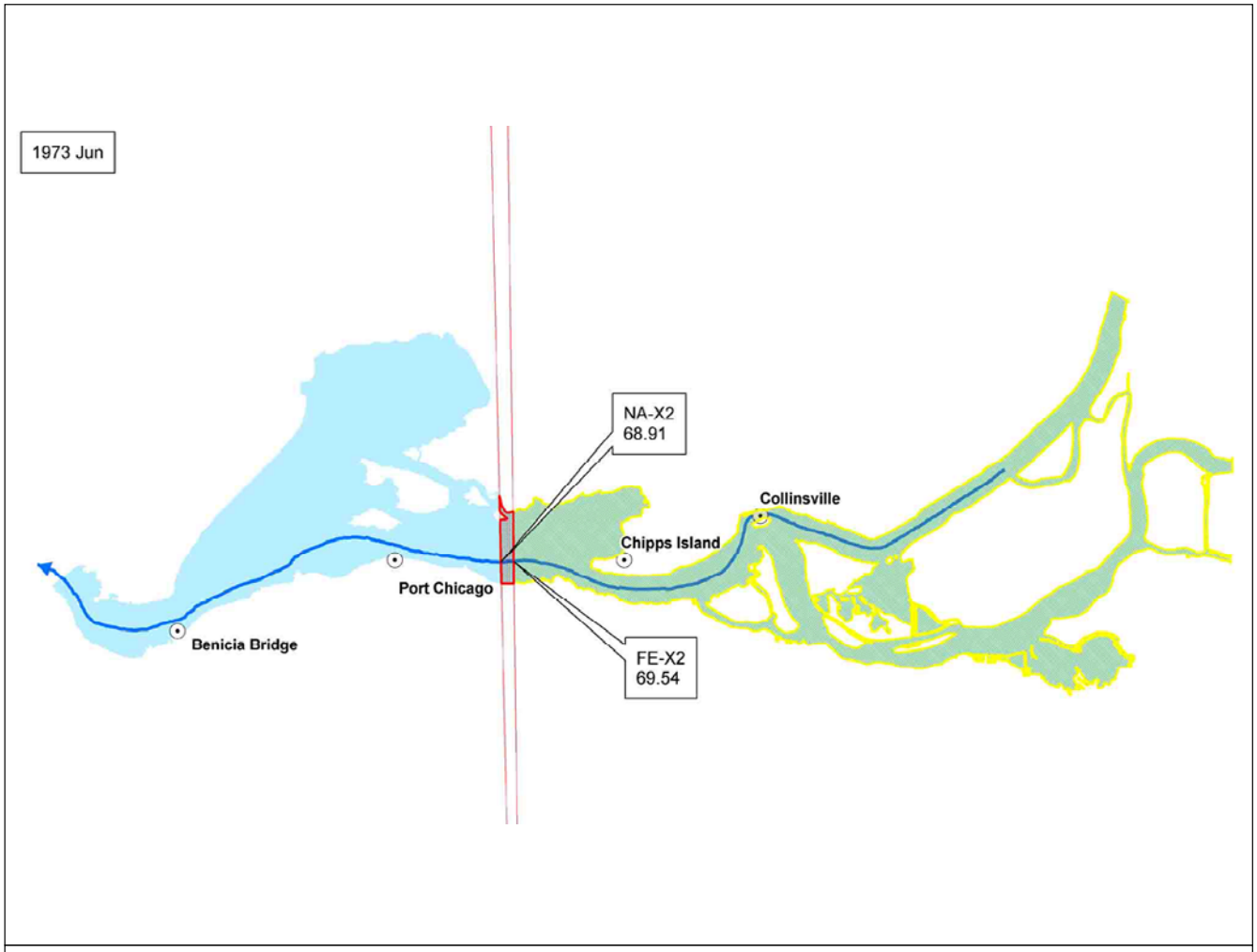
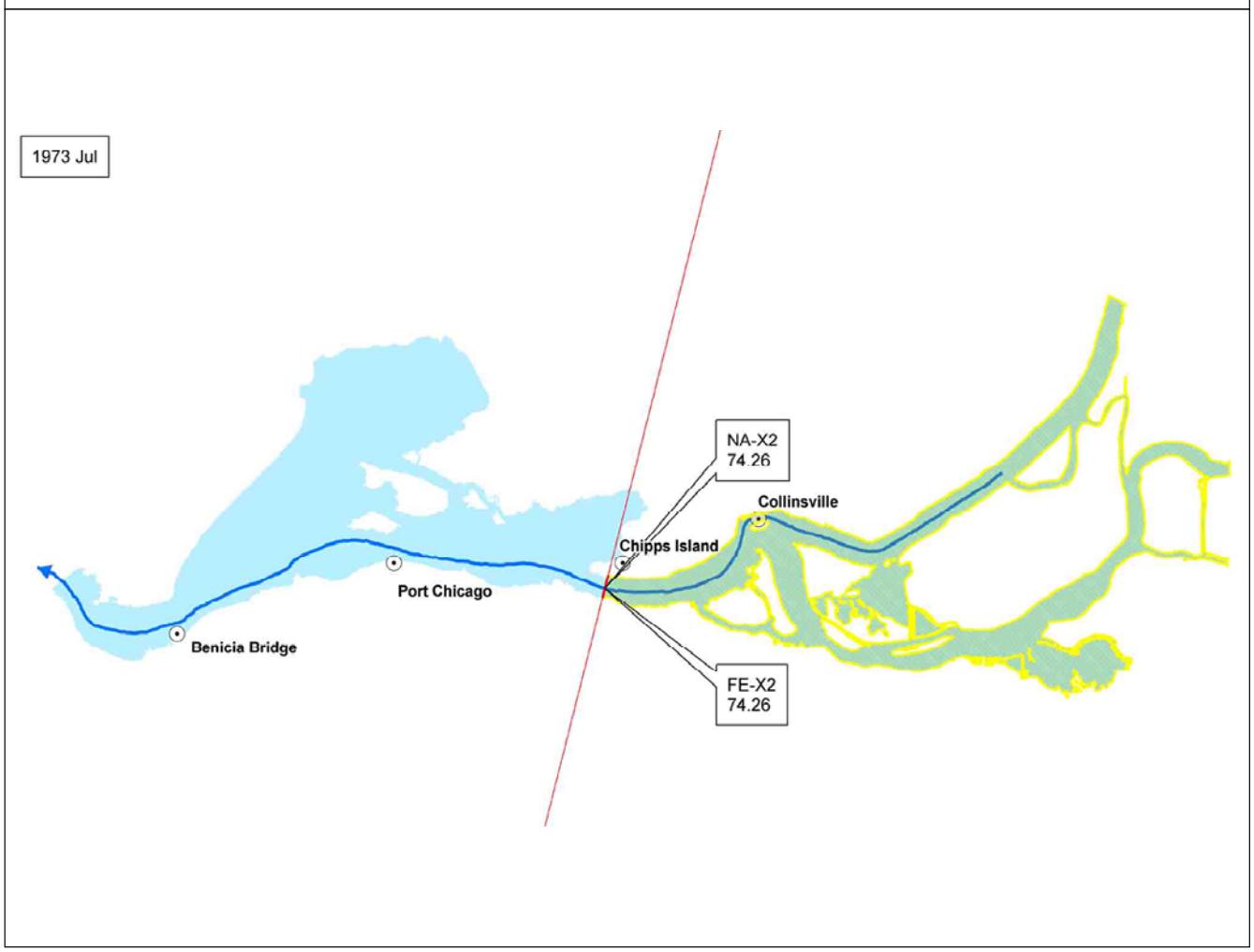
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
54.47


1973 Apr
NA-X2
56.44
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
56.52


1973 May
NA-X2
65.54
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
65.91


1973 Jun
NA-X2
68.91
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
69.54


1973 Jul
NA-X2
74.26
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
74.26


1973 Aug
NA-X2
77.65
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
77.65

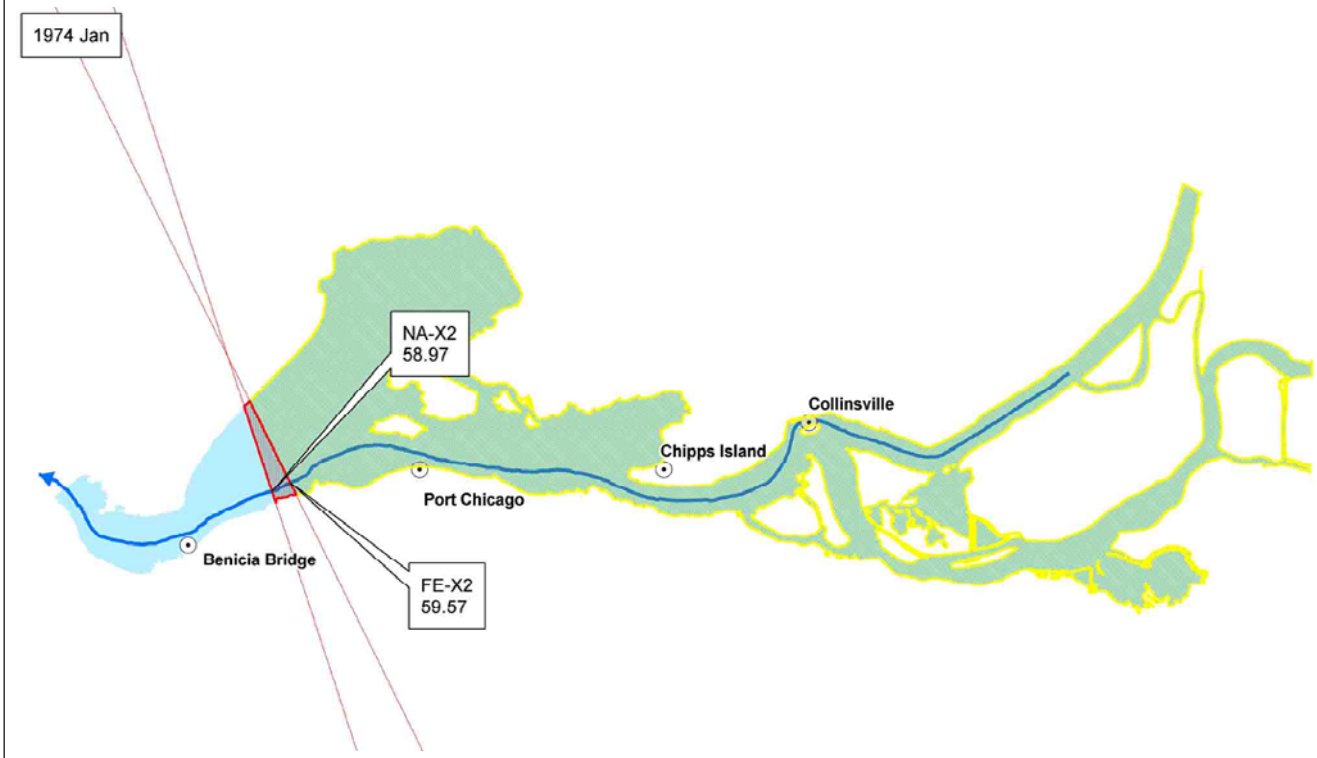

1973 Sep
NA-X2
84.07
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
84.07


1973 Oct
NA-X2
88.62
FE-X2
88.62
Collinsville
Chipps Island
Port Chicago
Benicia Bridge

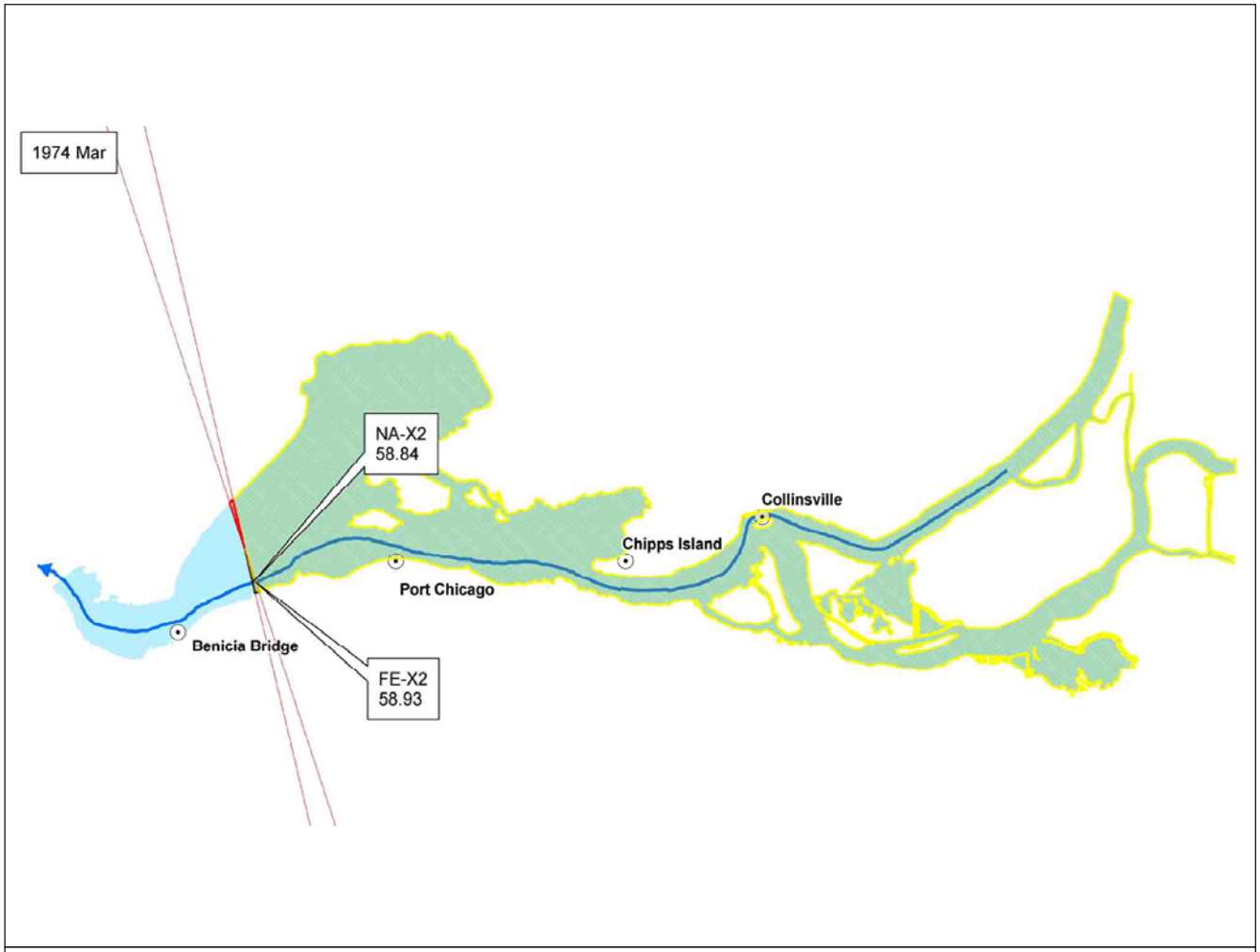

1973 Nov
NA-X2
85.77
FE-X2
85.78
Collinsville
Chipps Island
Port Chicago
Benicia Bridge


1973 Dec
NA-X2
77.96
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
78.90


1973 average
NA-X2
72.10
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
72.31


1974 Jan
NA-X2
58.97
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
59.57


1974 Feb
NA-X2
51.46
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
51.74


1974 Mar
NA-X2
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FE-X2
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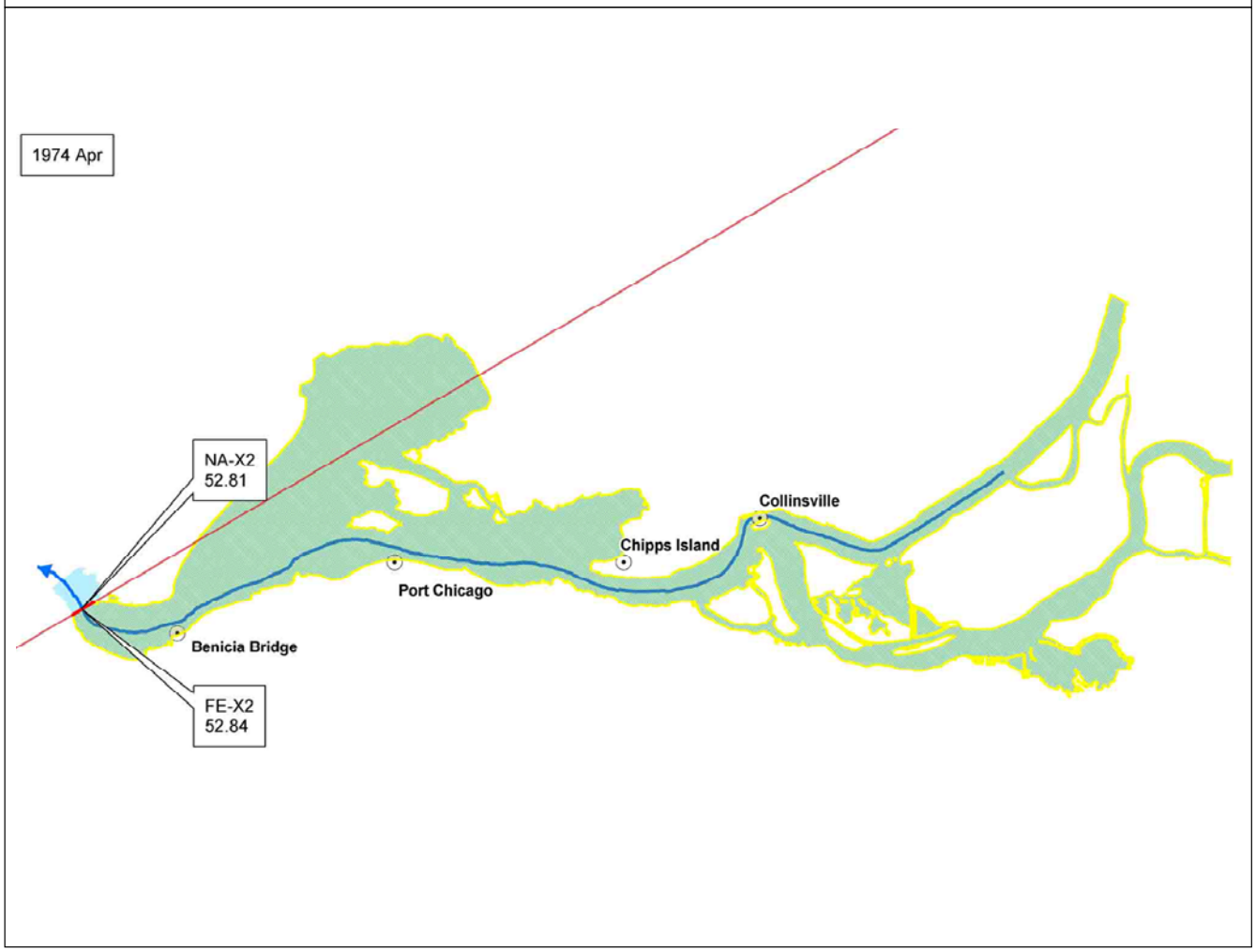
Collinsville
Chipps Island
Port Chicago
Benicia Bridge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NA-X2
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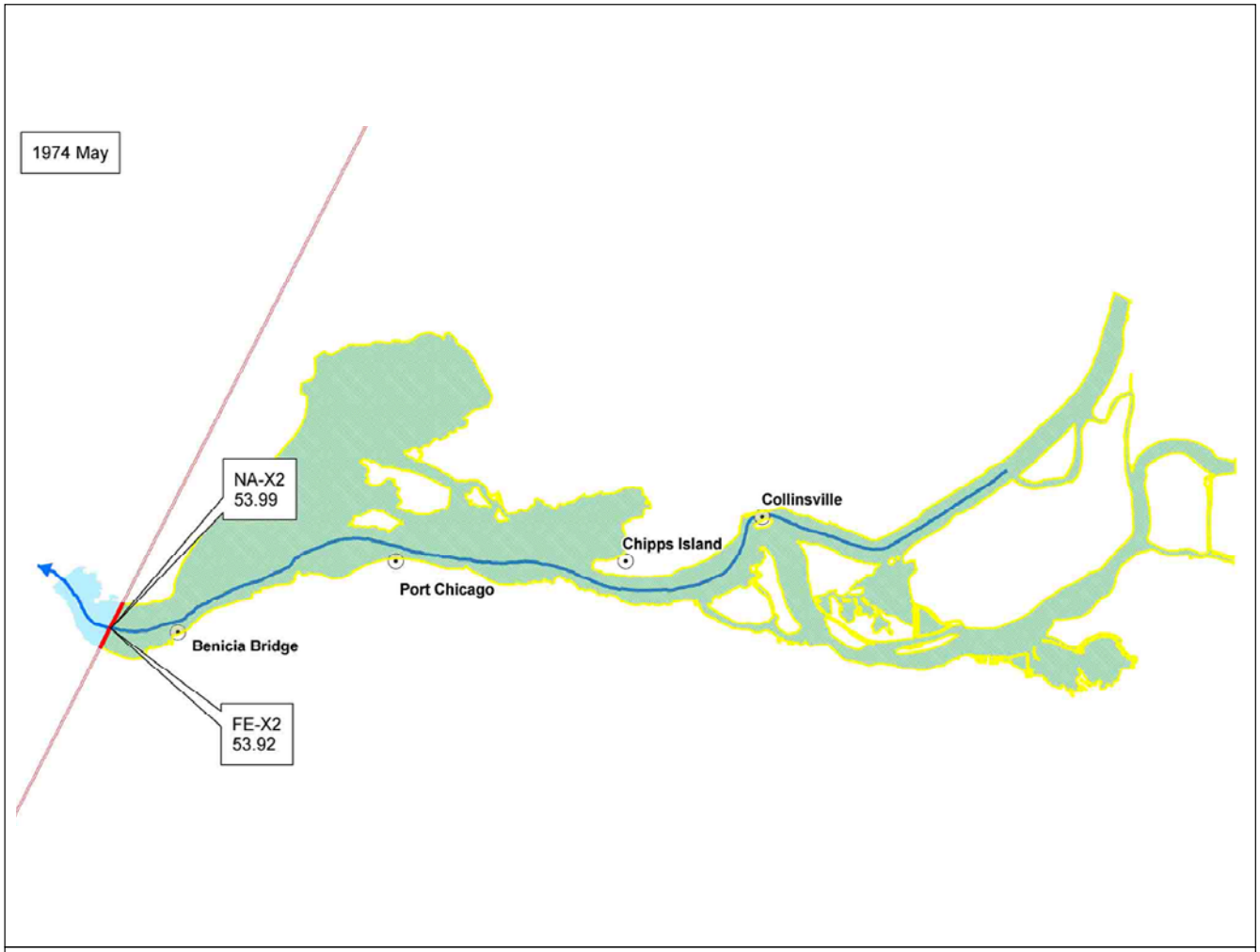
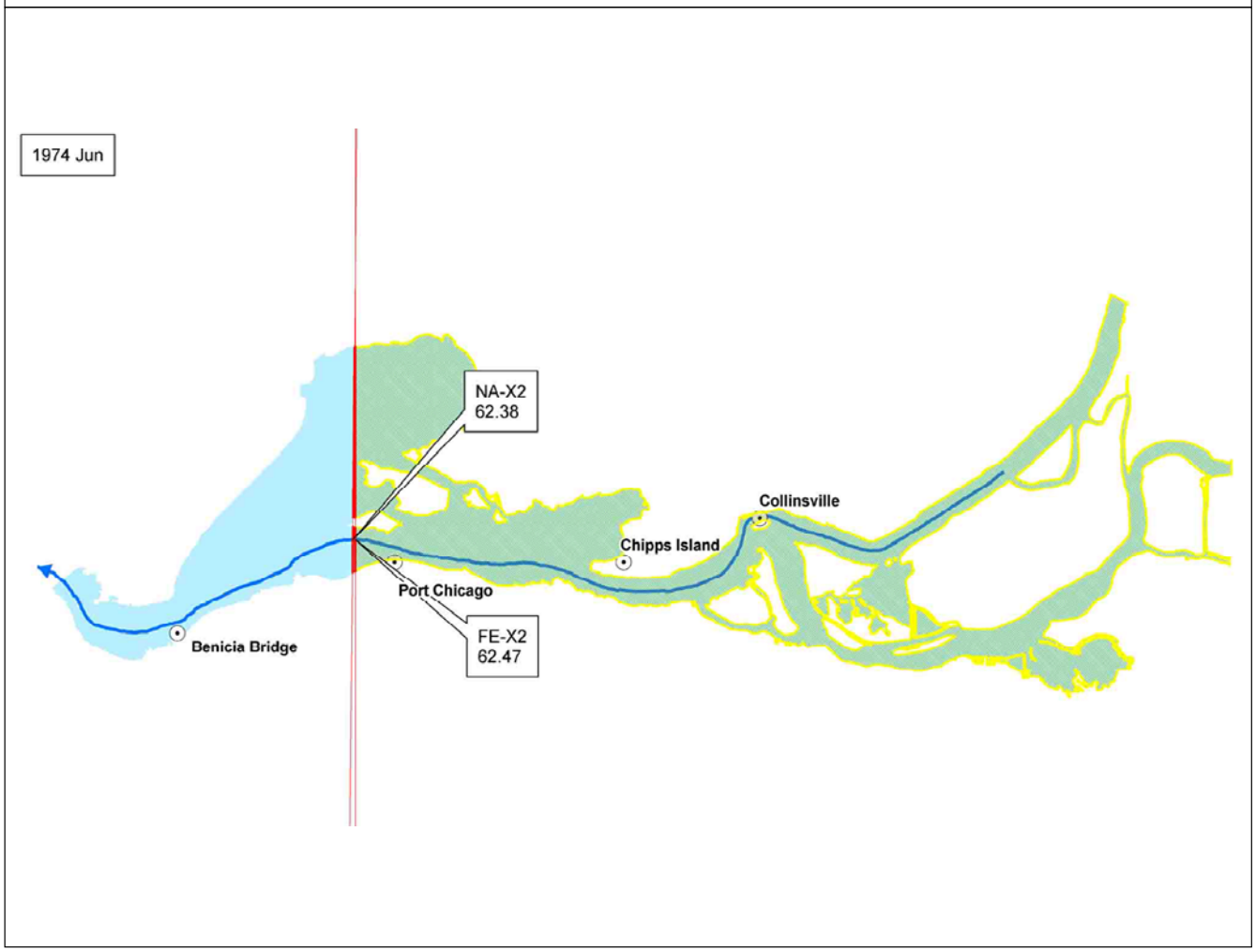
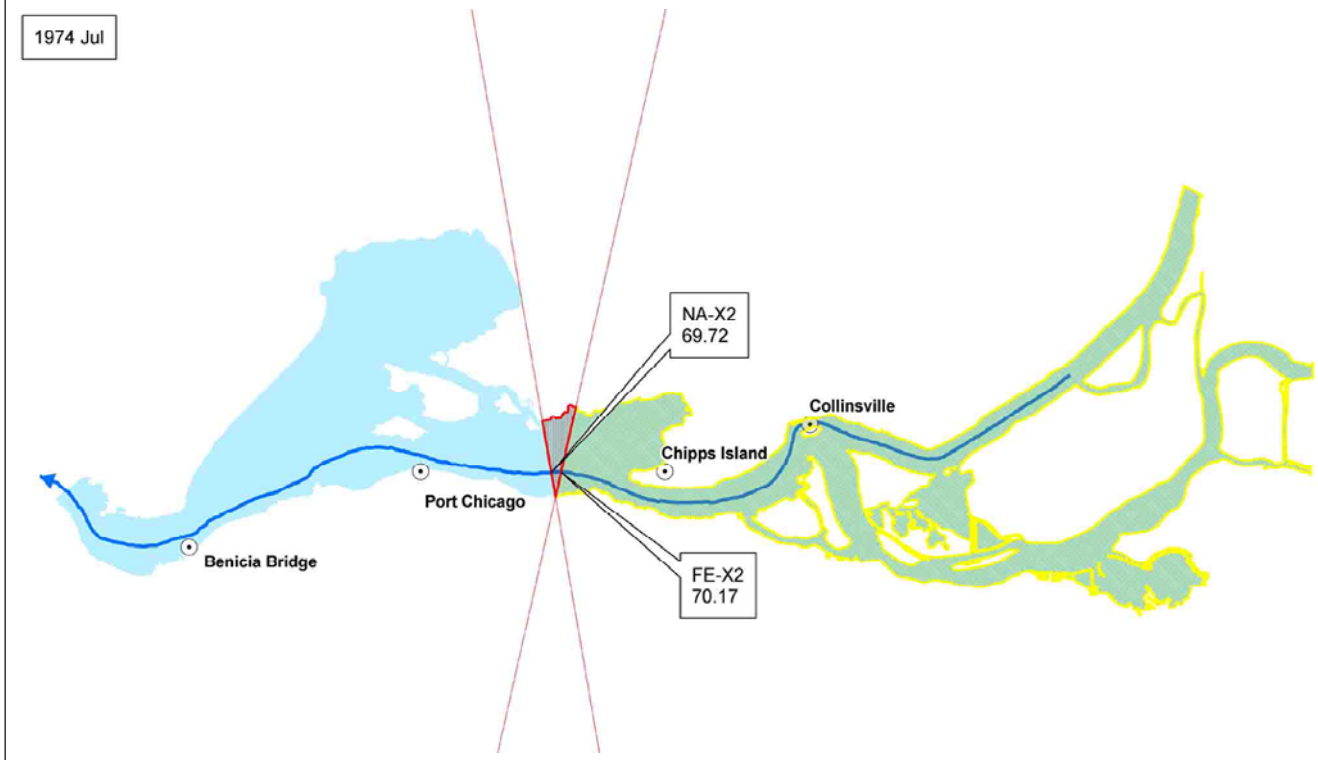
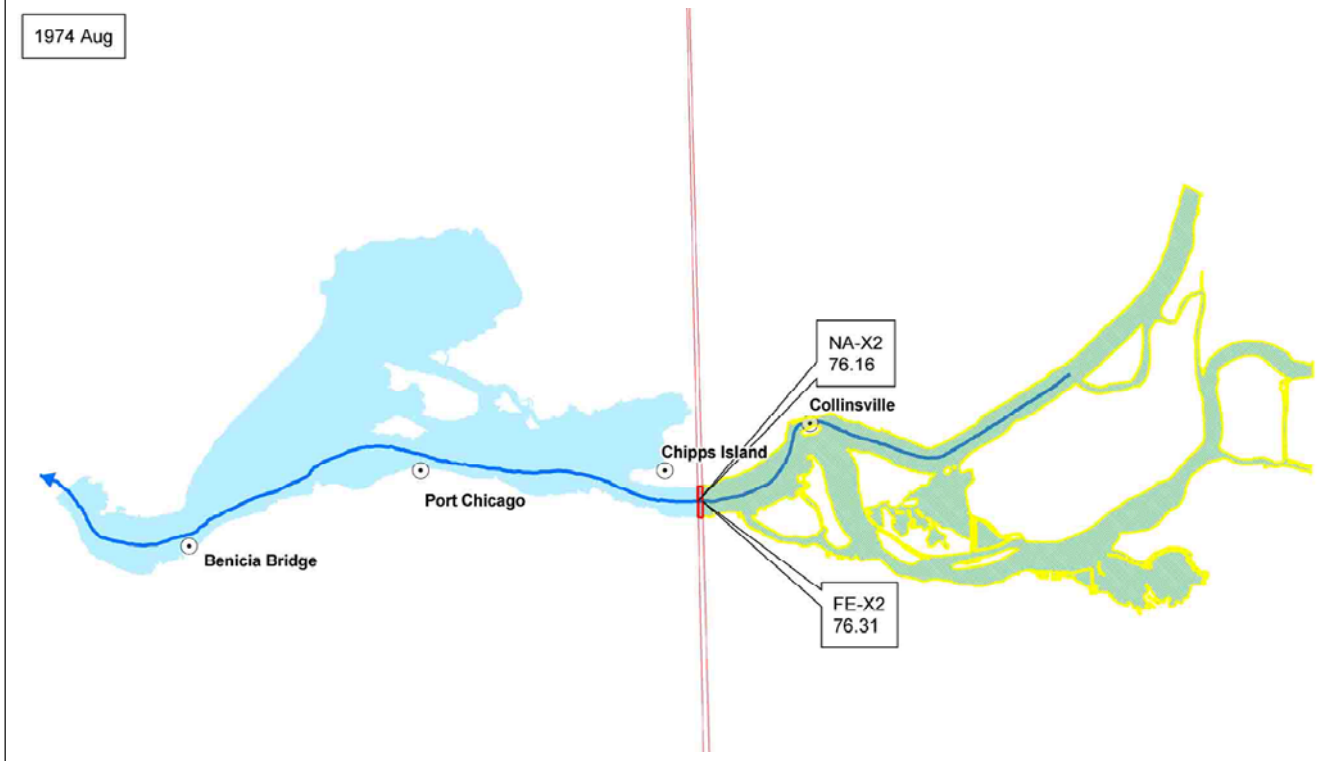
FE-X2
52.84
Collinsville
Chipps Island
Port Chicago
Benicia Bridge

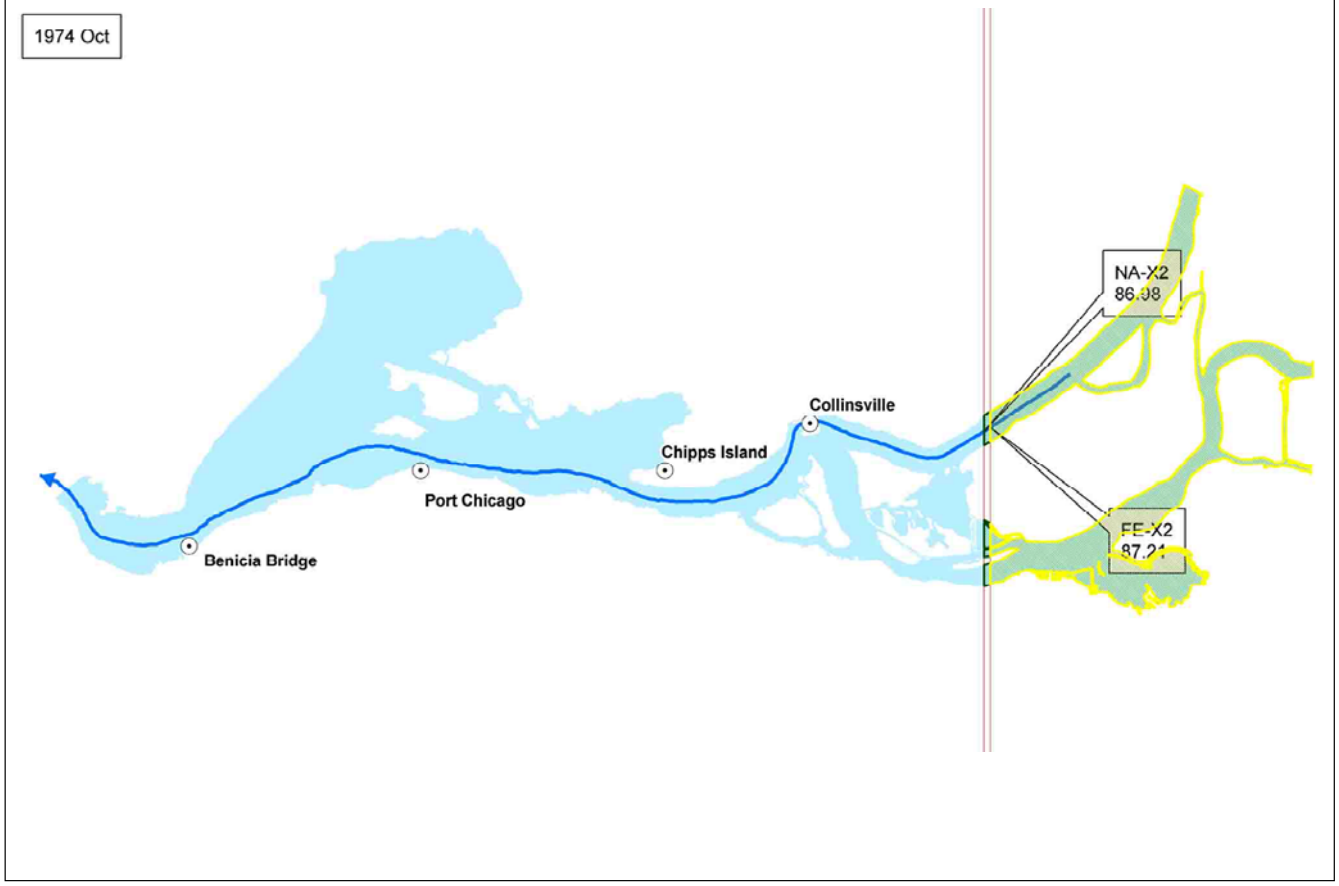

1974 May
NA-X2
53.99
FE-X2
53.92
Benicia Bridge
Port Chicago
Chipps Island
Collinsville


1974 Jun
NA-X2
62.38
FE-X2
62.47
Benicia Bridge
Port Chicago
Chipps Island
Collinsville

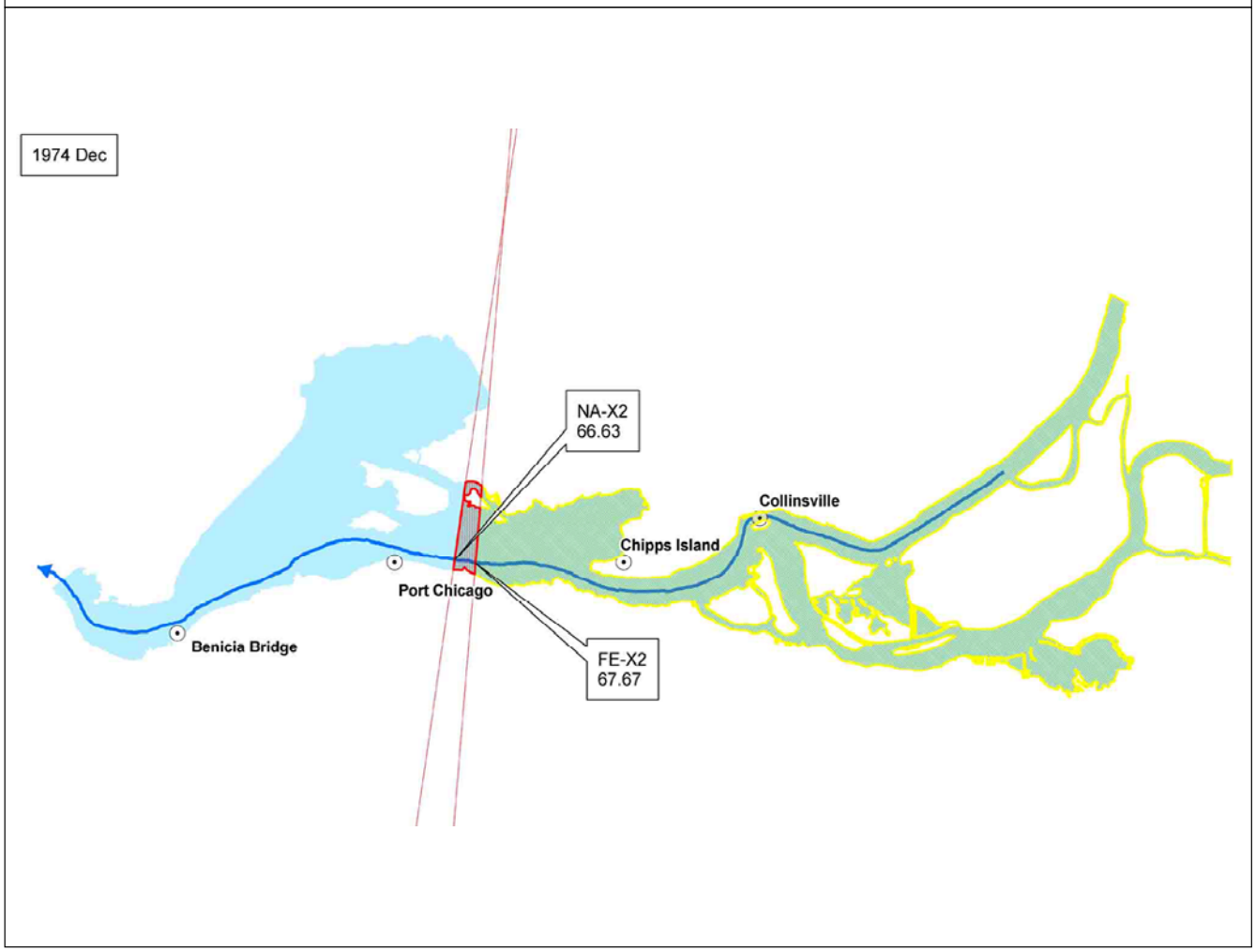

1974 Jul
NA-X2
69.72
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
70.17


1974 Aug
NA-X2
76.16
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
76.31

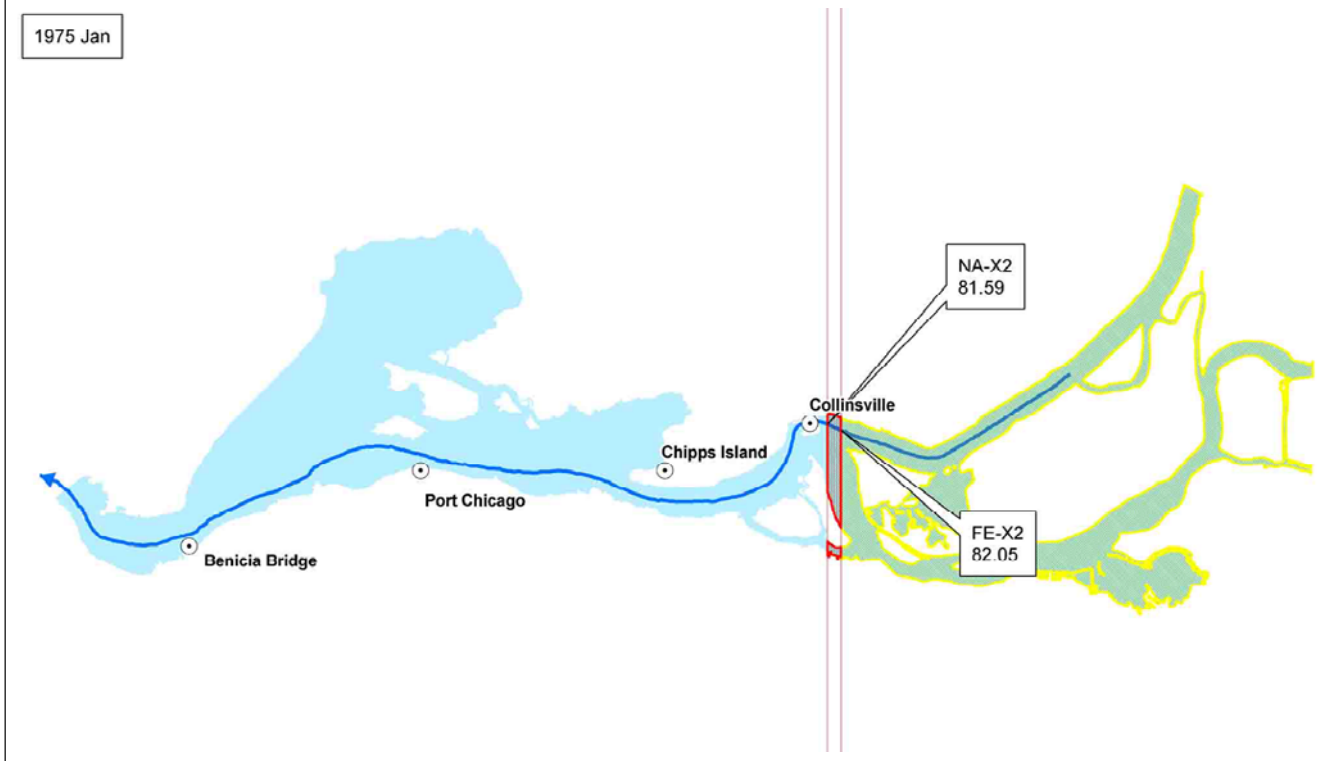

1974 Sep
NA-X2
83.59
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
83.63

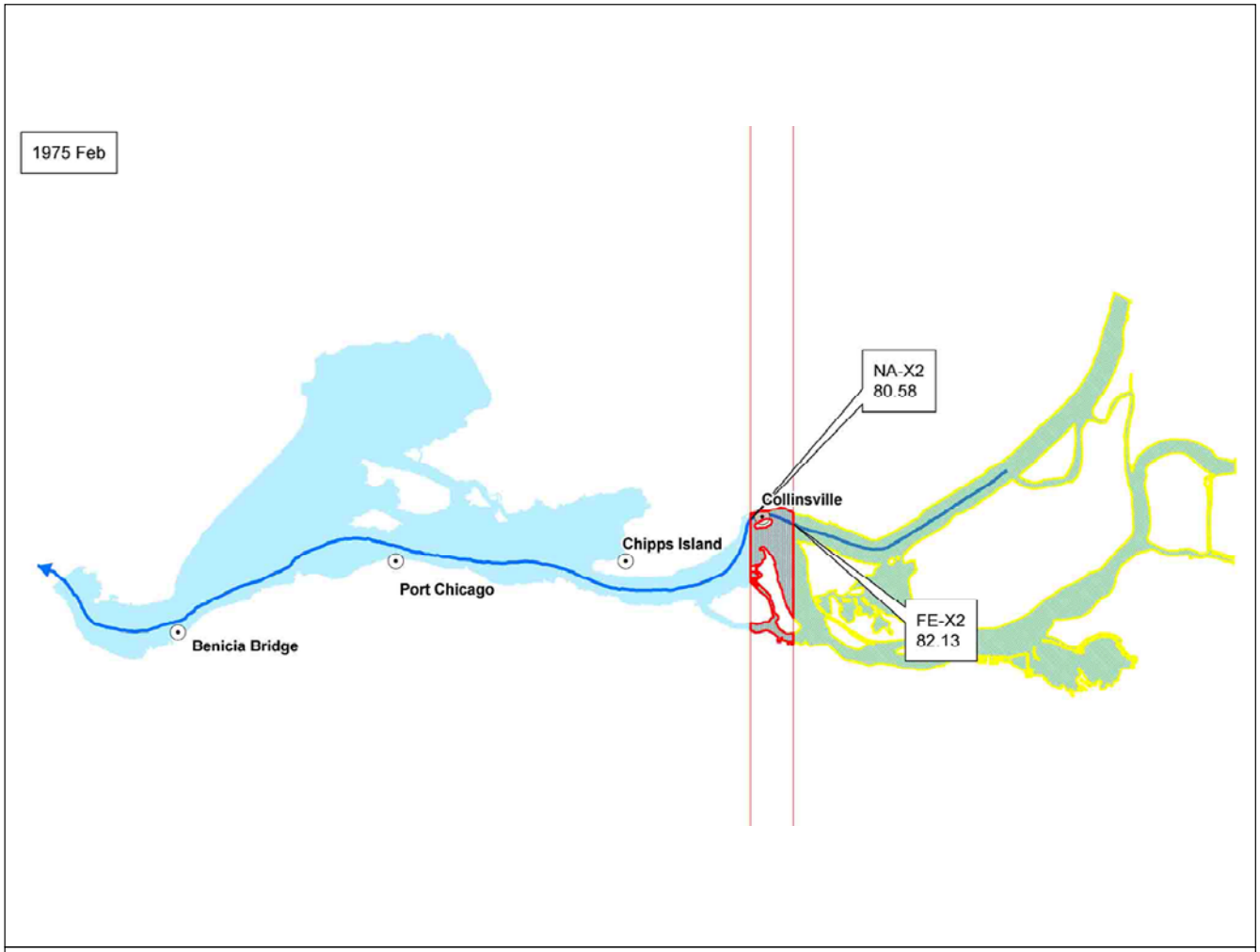

1974 Oct
NA-X2
Collinsville
Chipps Island
Port Chicago
Benicia Bridge

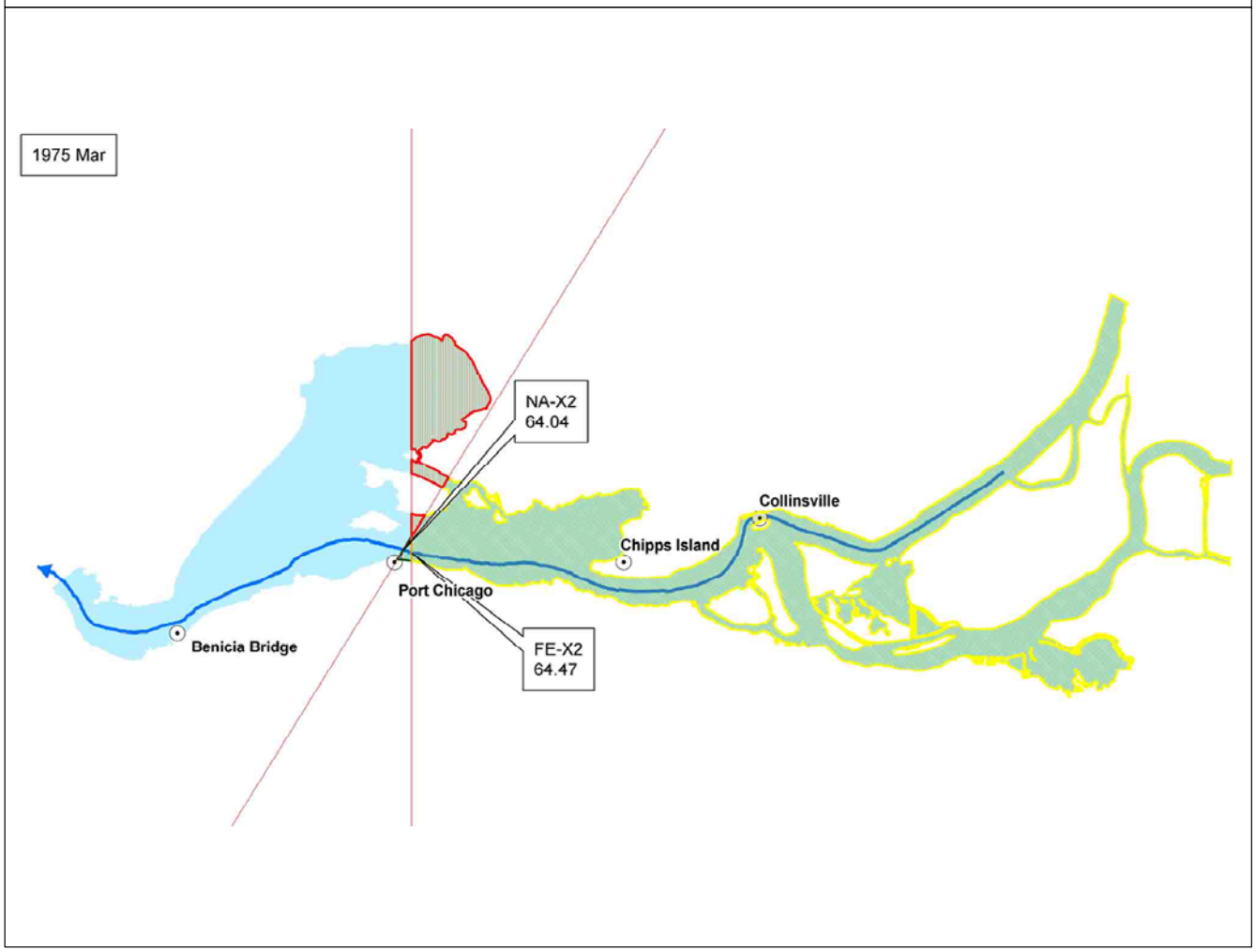

1974 Nov
NA-X2
85.75
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
87.07

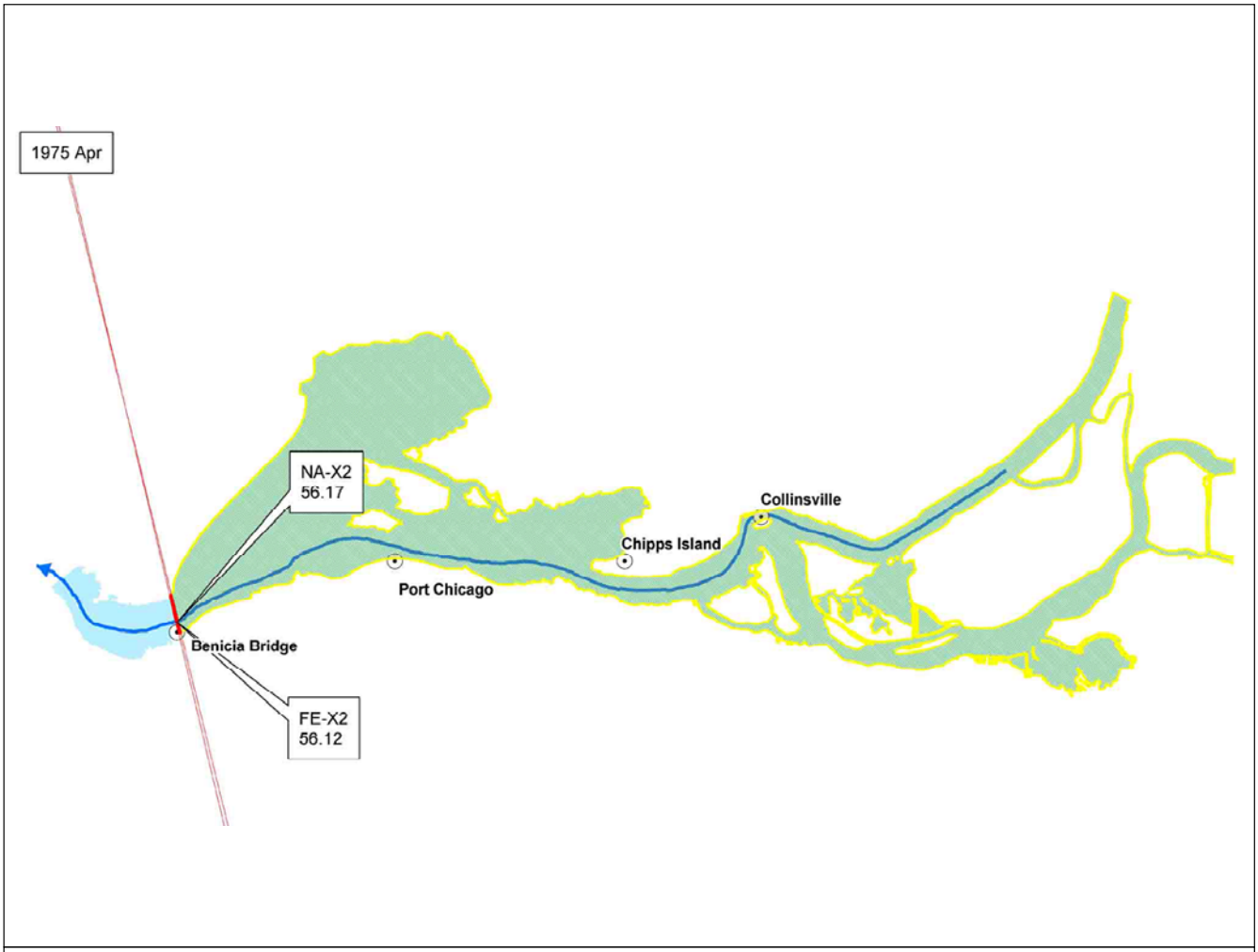

1974 Dec
NA-X2
66.63
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
67.67

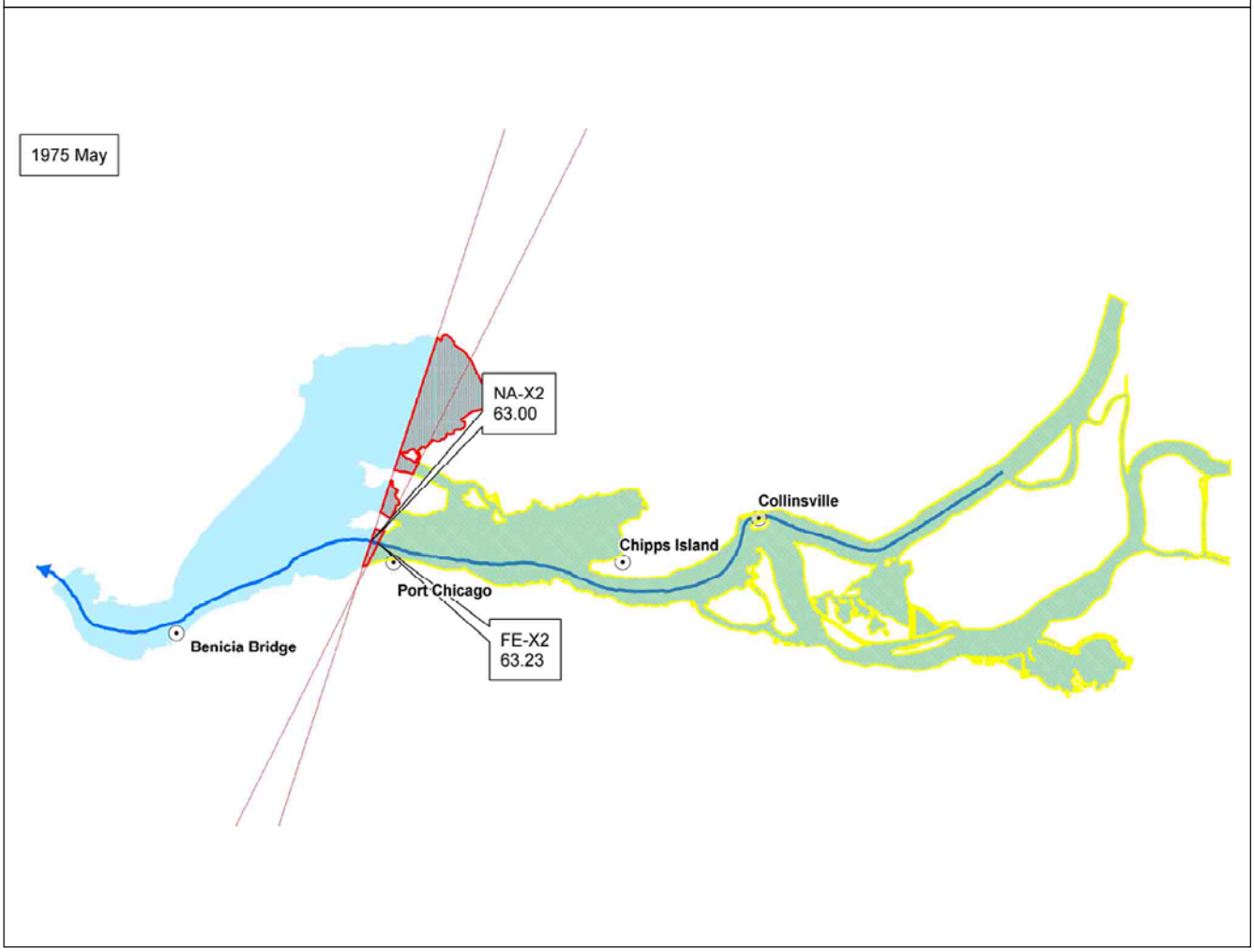

1974 average
NA-X2
67.27
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
67.63


1975 Jan
NA-X2
81.59
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
82.05


1975 Feb
NA-X2
80.58
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
82.13


1975 Mar
NA-X2
64.04
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
64.47


1975 Apr
NA-X2
56.17
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
56.12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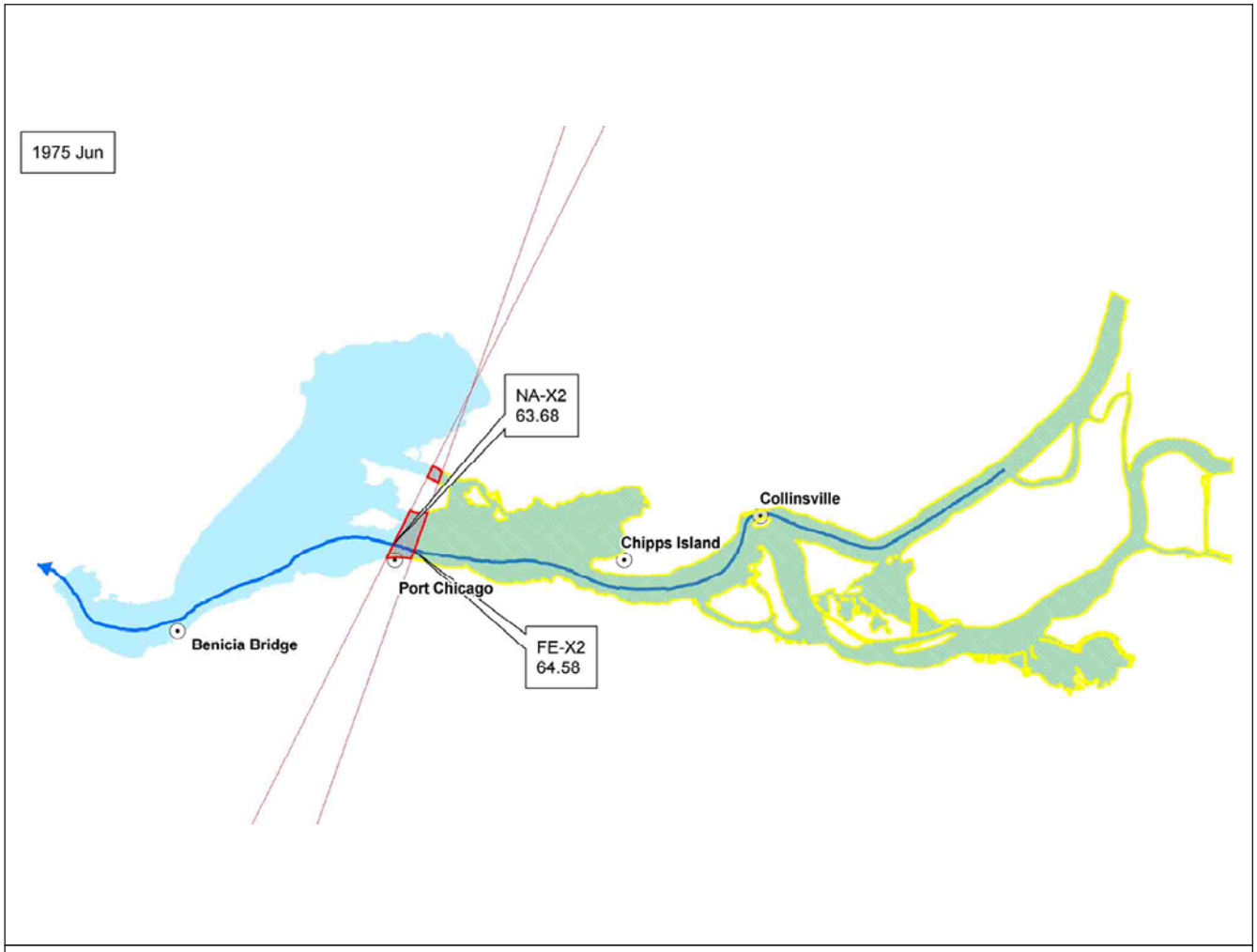
NA-X2
63.00
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
63.23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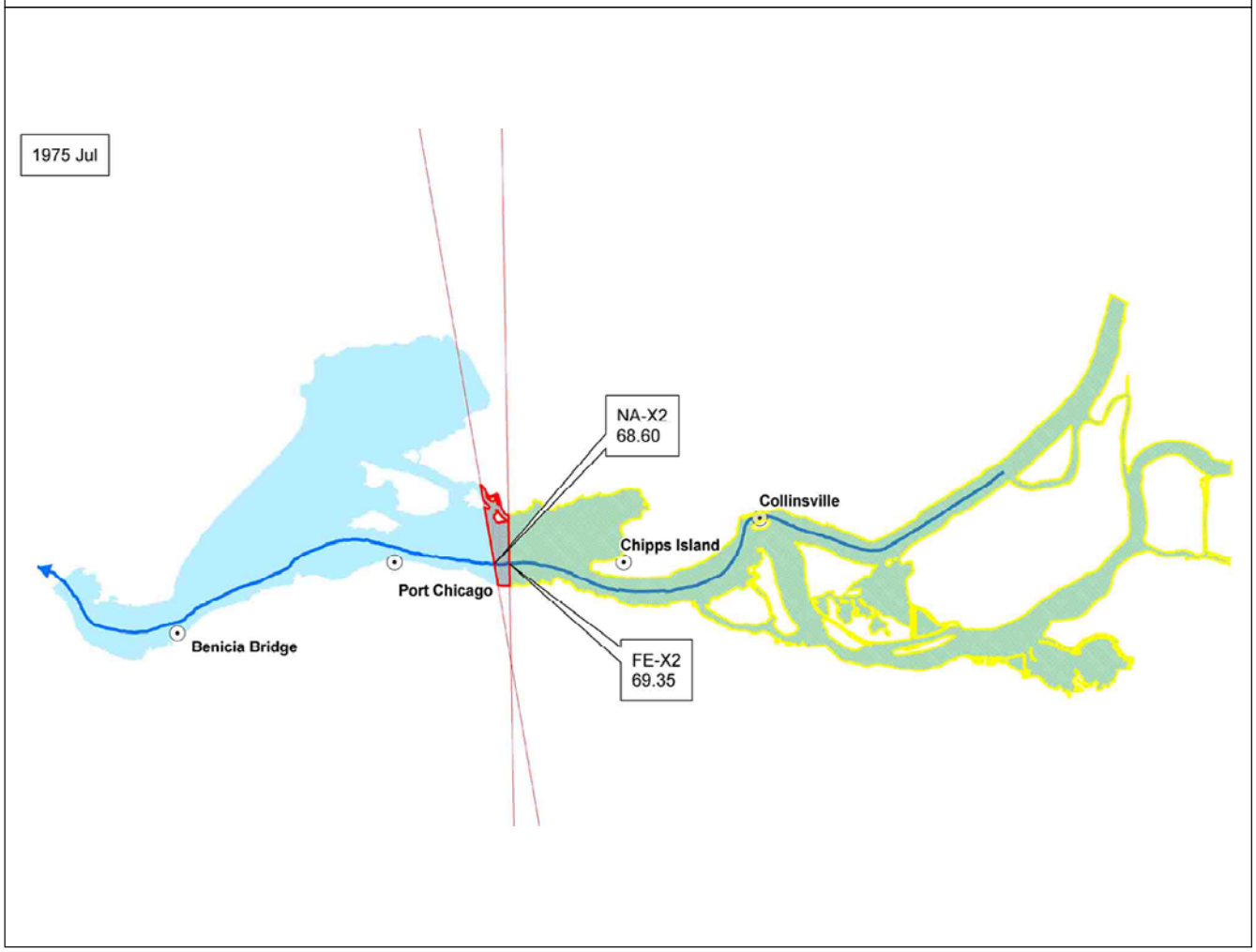
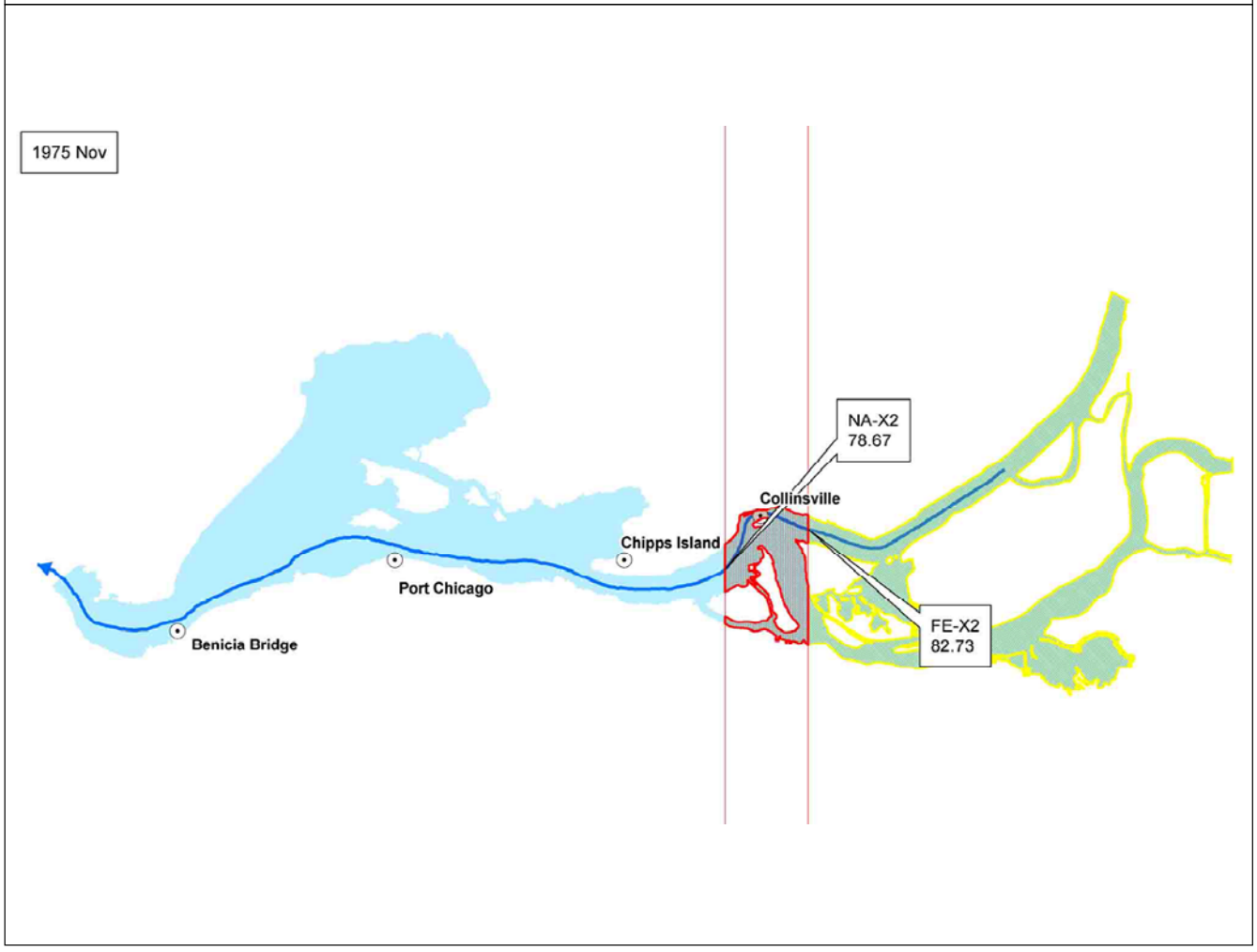
NA-X2
63.68
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
64.58


1975 Jul
NA-X2
68.60
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
69.35


1975 Aug
NA-X2
75.80
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
76.04


1975 Sep
NA-X2
83.47
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
83.55


1975 Oct
NA-X2
77.71
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
79.44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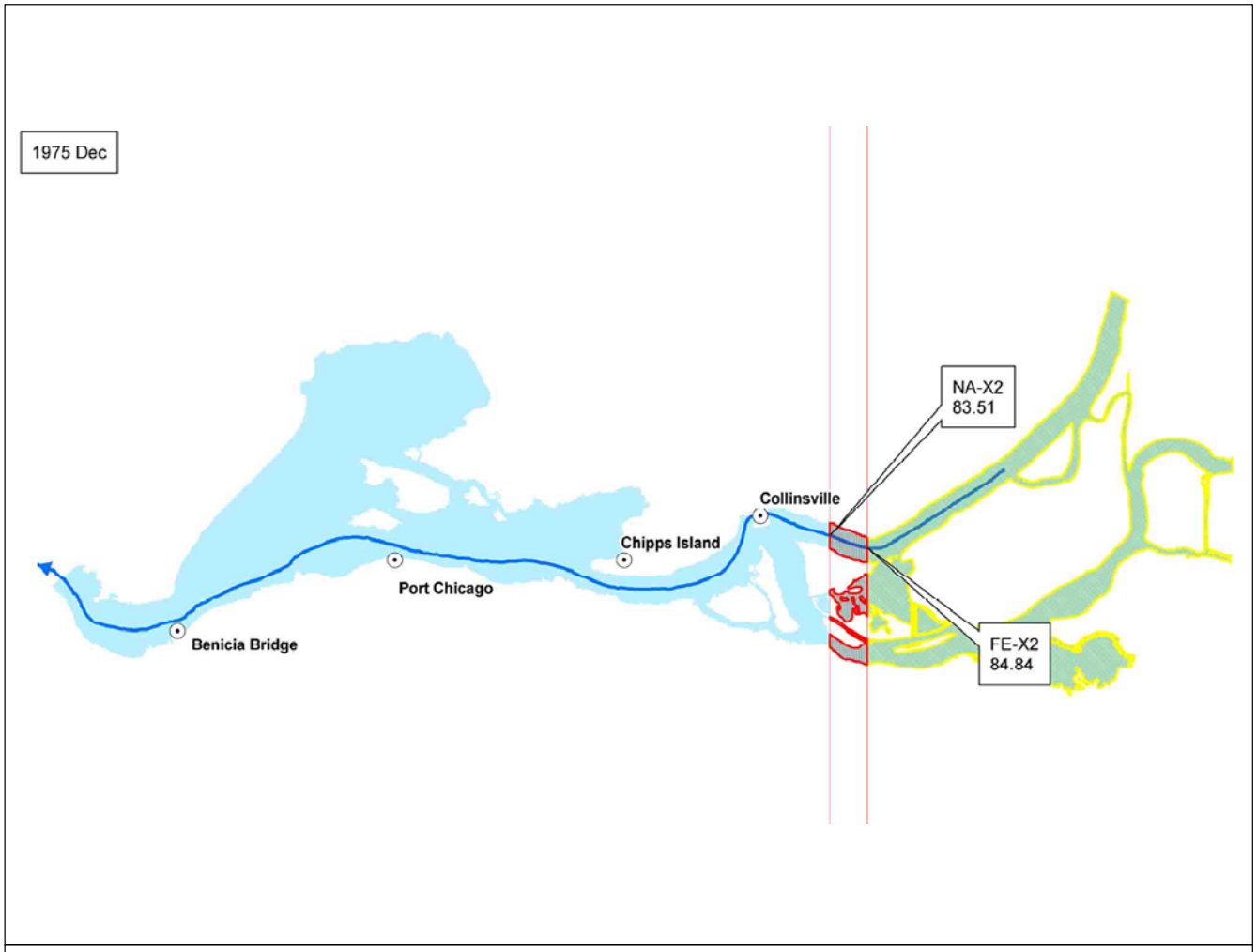
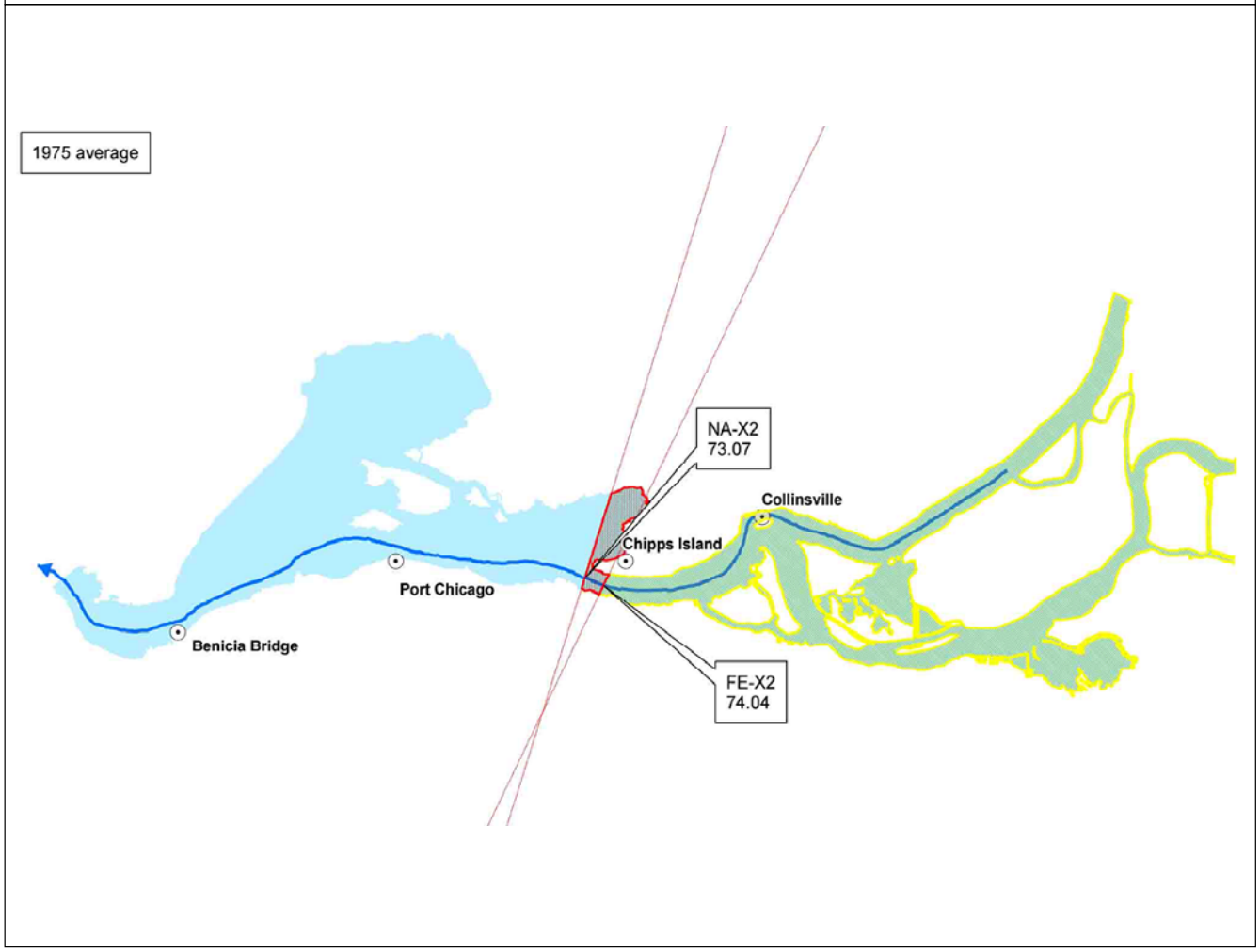
NA-X2
78.67
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
82.73

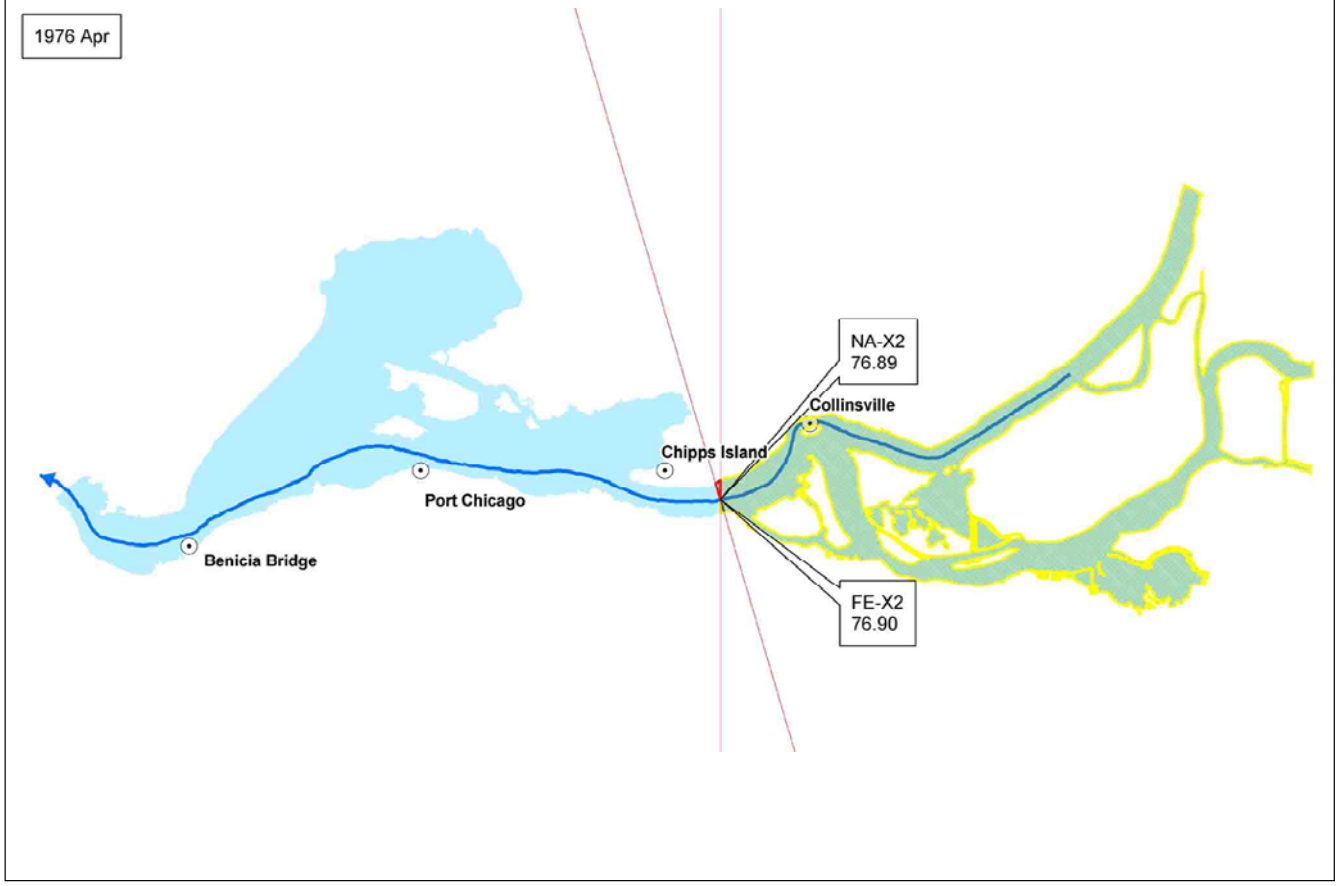

1975 Dec
NA-X2
83.51
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
84.84


1975 average
NA-X2
73.07
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
74.04

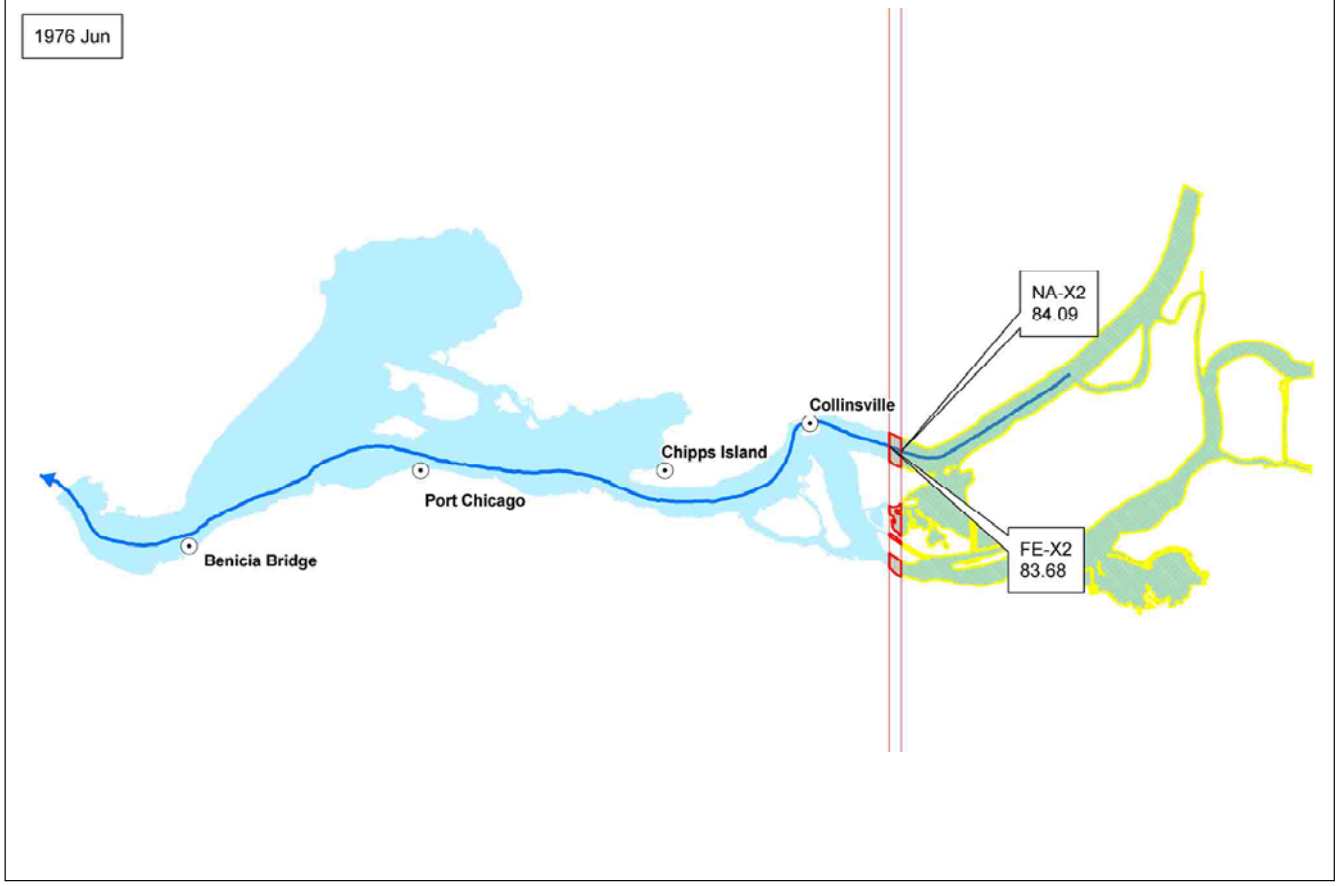

1976 Jan
NA-X2
82.10
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
82.79


1976 Feb
NA-X2
83.39
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
83.35


1976 Mar
NA-X2
79.30
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
79.32


1976 Apr
NA-X2
76.89
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
76.90


1976 May
NA-X2
77.70
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
77.69


1976 Jun
NA-X2
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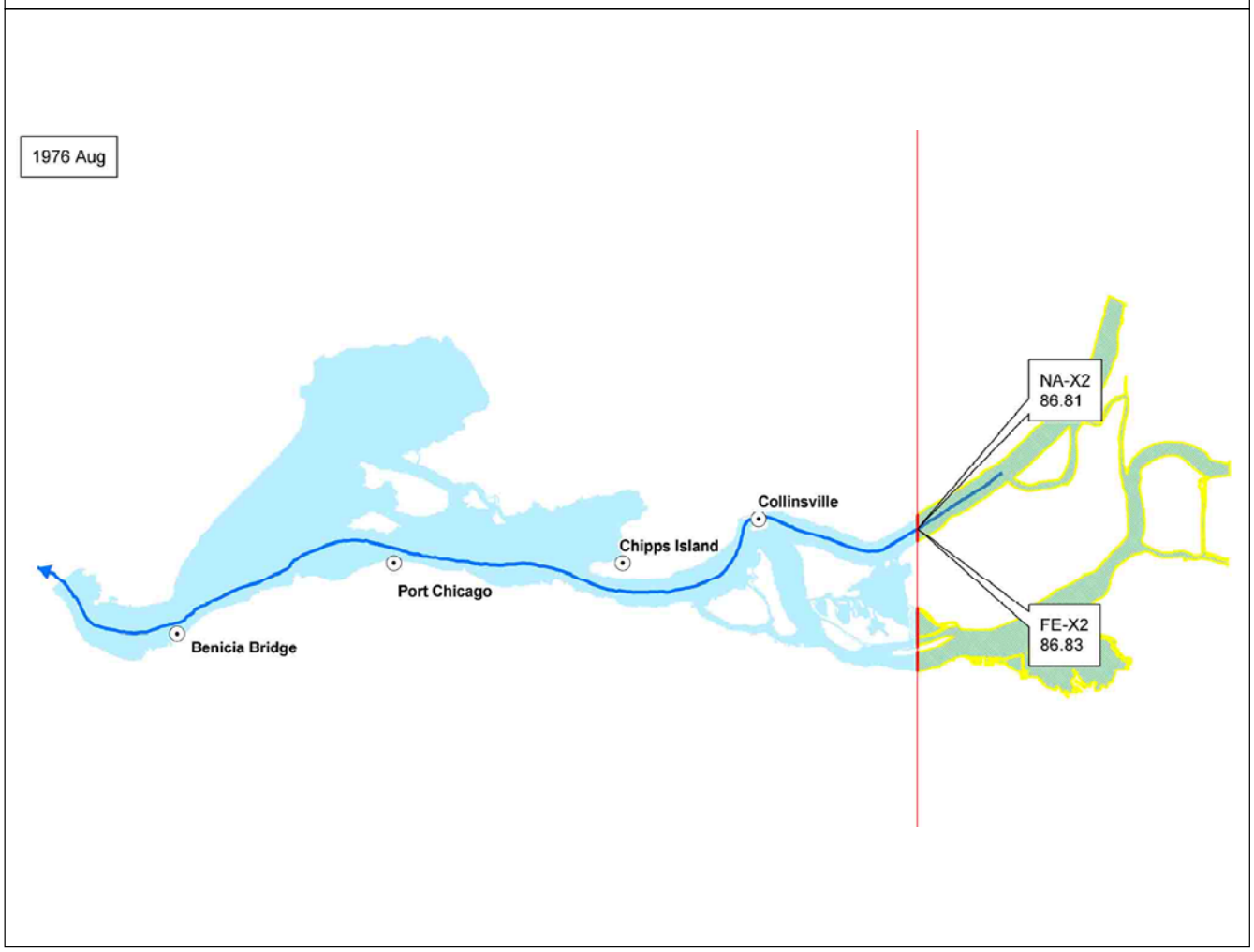
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
83.68


1976 Jul
NA-X2
86.00
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
86.05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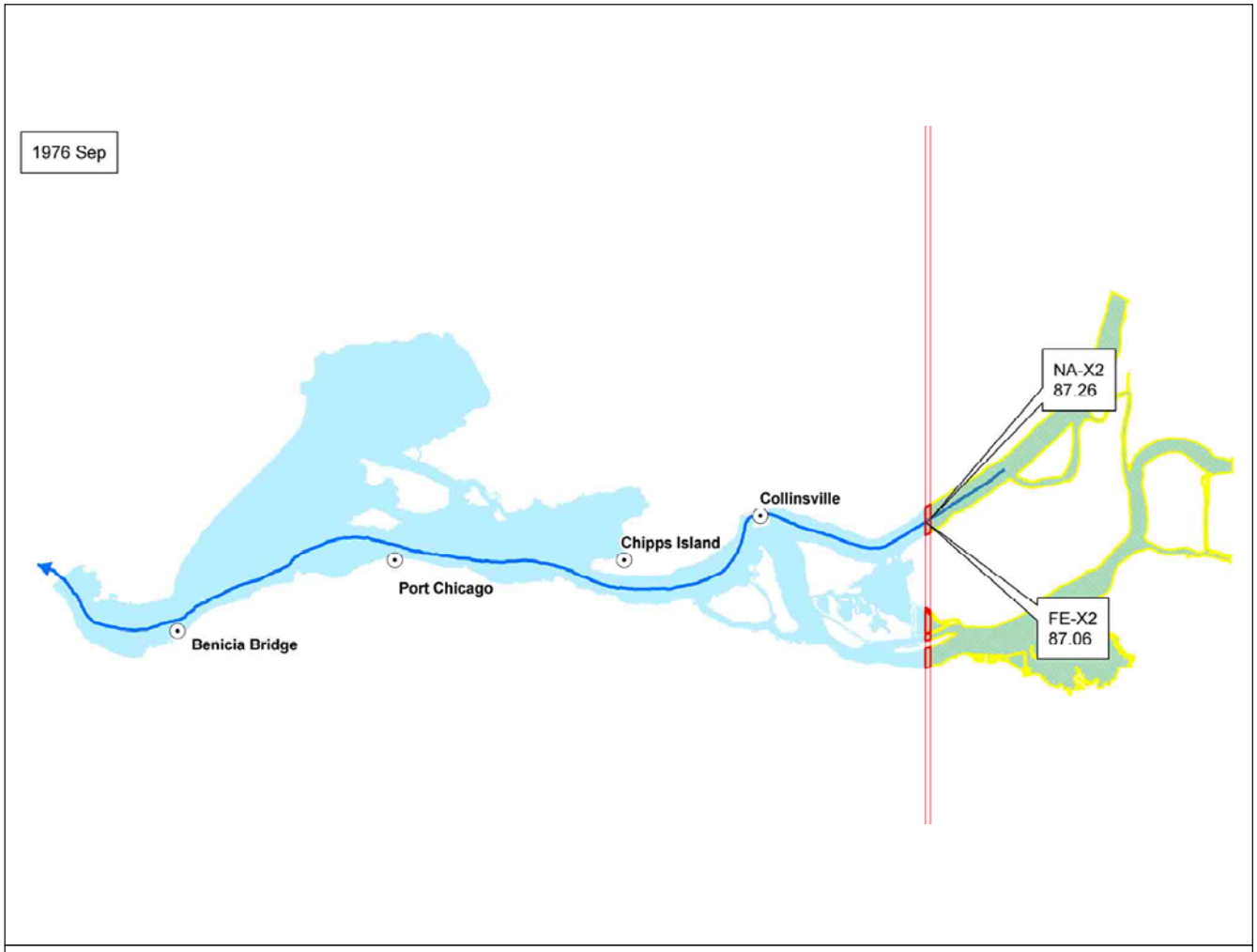
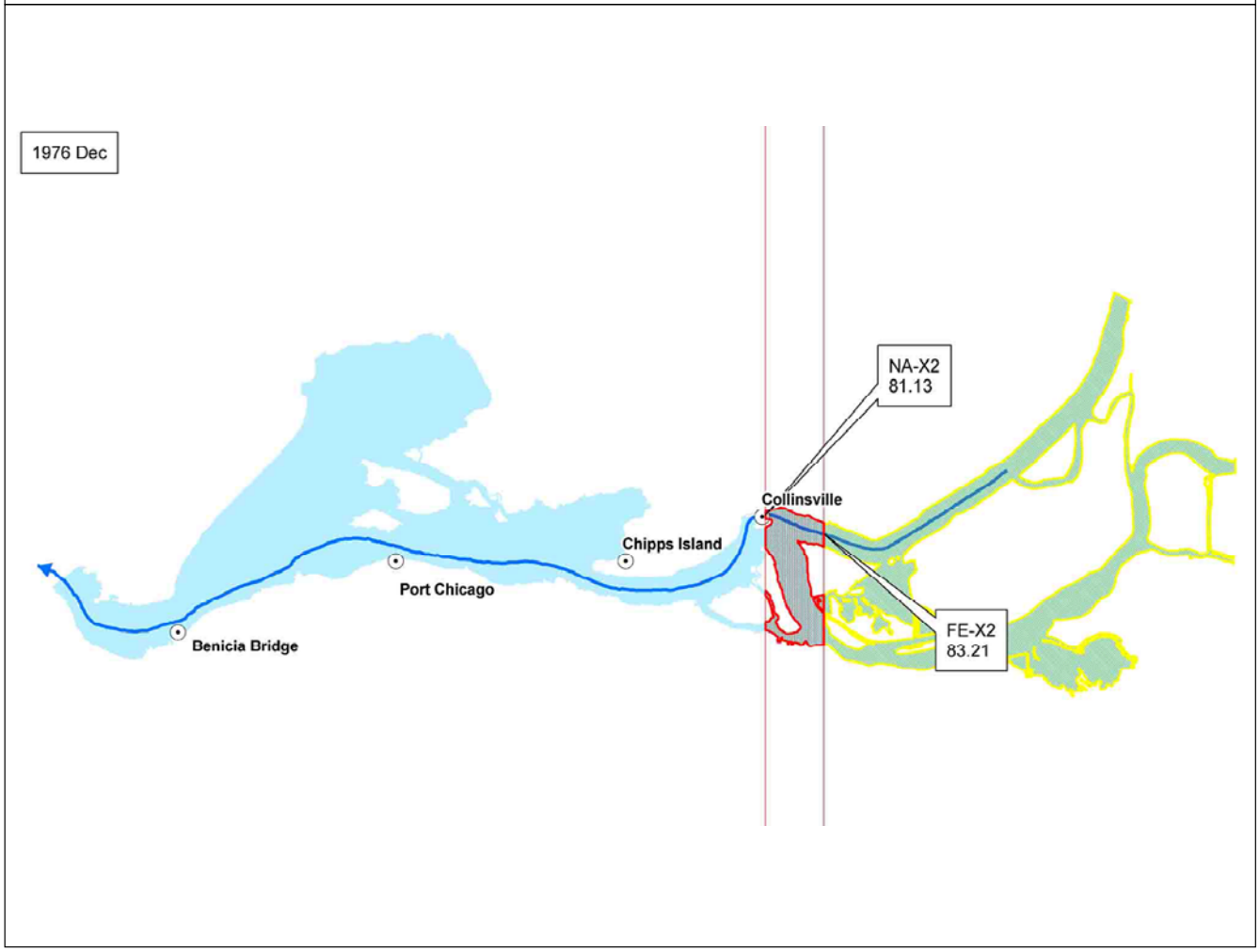
NA-X2
86.81
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
86.83


1976 Sep
NA-X2
87.26
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
87.06


1976 Oct
NA-X2
79.68
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
80.18

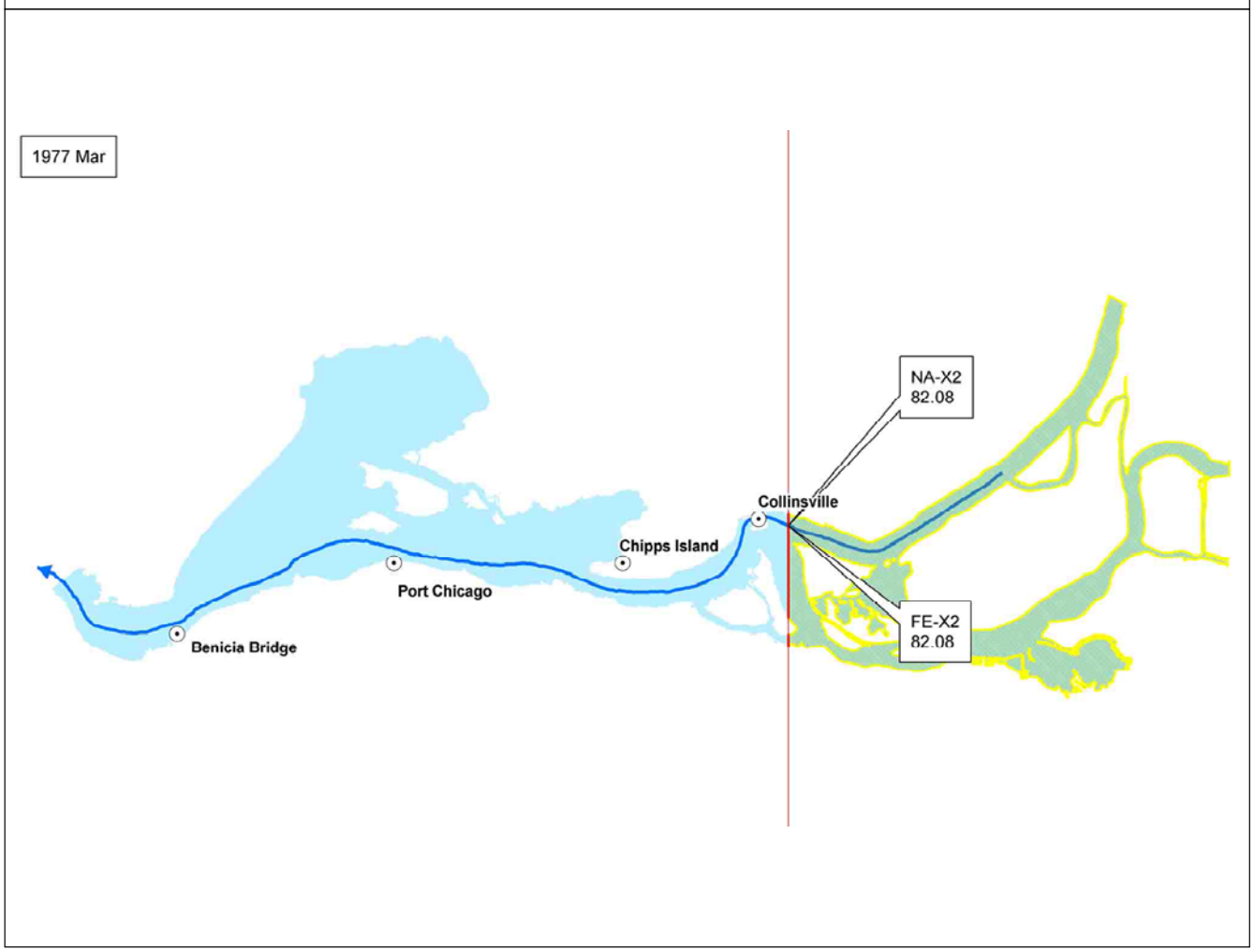

1976 Nov
NA-X2
78.14
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
78.40


1976 Dec
NA-X2
81.13
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
83.21


1976 average
NA-X2
81.87
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
82.12


1977 Jan
NA-X2
82.75
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
82.70


1977 Feb
NA-X2
84.23
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
84.22


1977 Mar
NA-X2
82.08
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
82.08

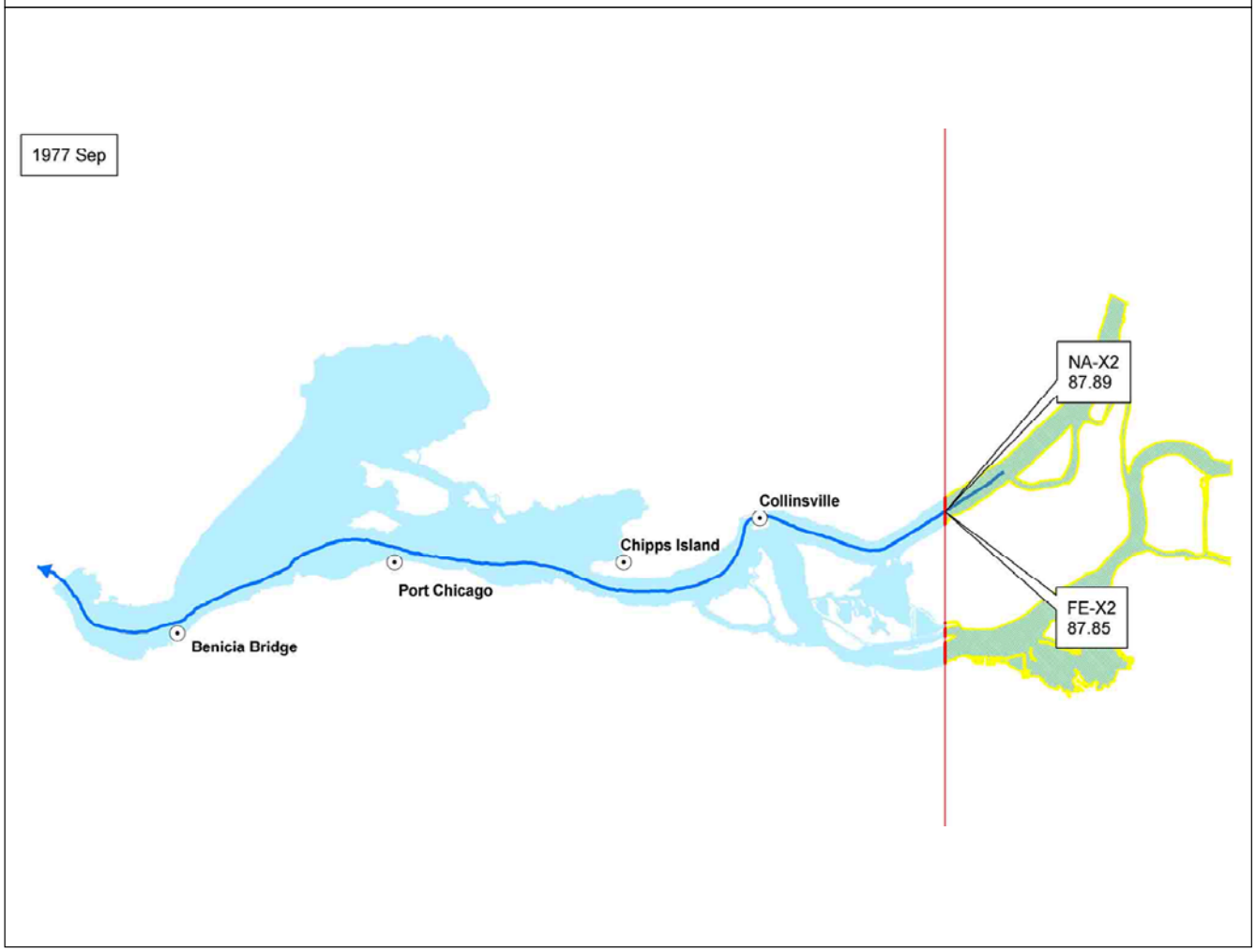

1977 Apr
NA-X2
82.27
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
82.27


1977 May
NA-X2
81.19
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
81.19


1977 Jun
NA-X2
84.61
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
84.60


1977 Jul
NA-X2
84.40
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
84.51


1977 Aug
NA-X2
82.57
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
82.45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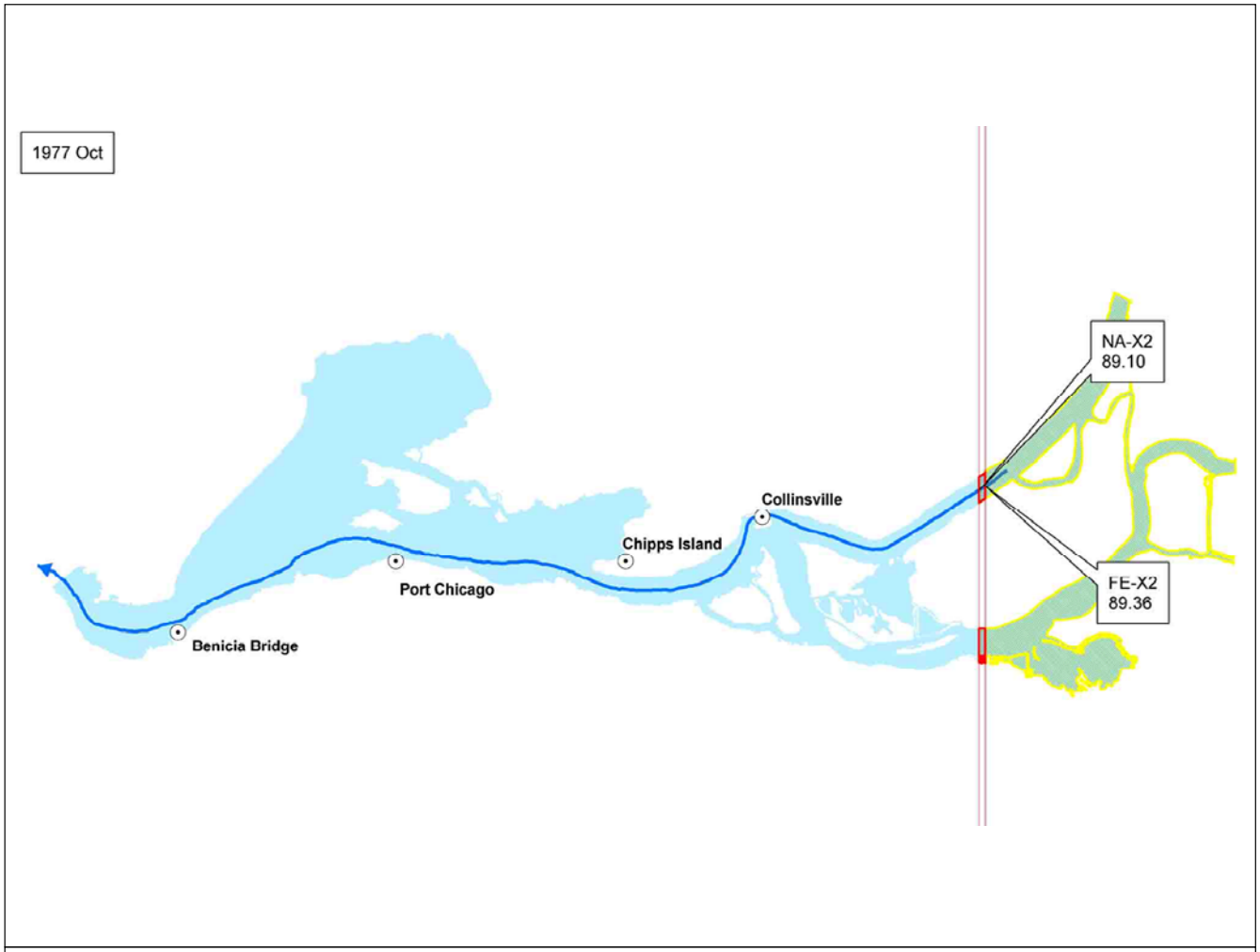
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
87.85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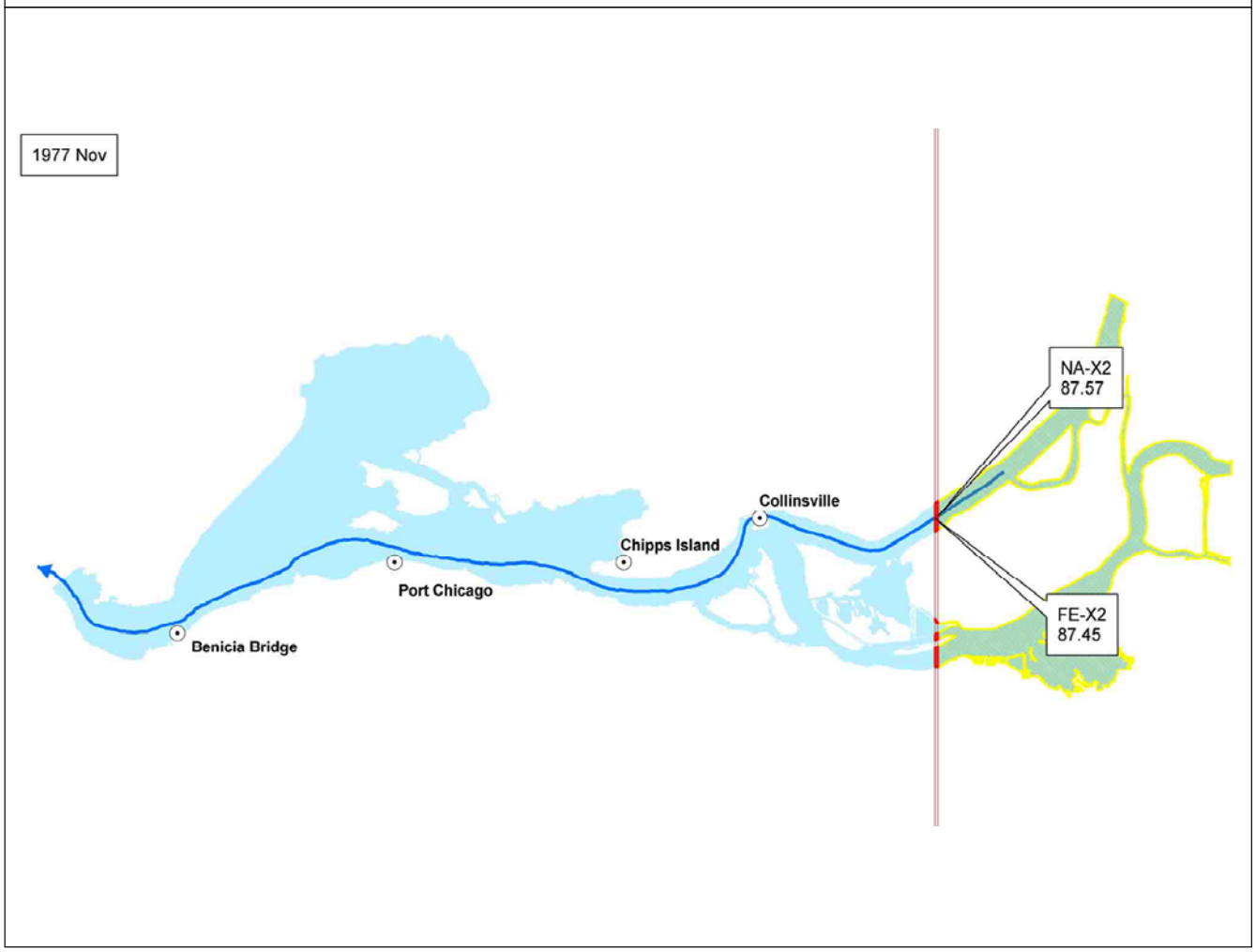
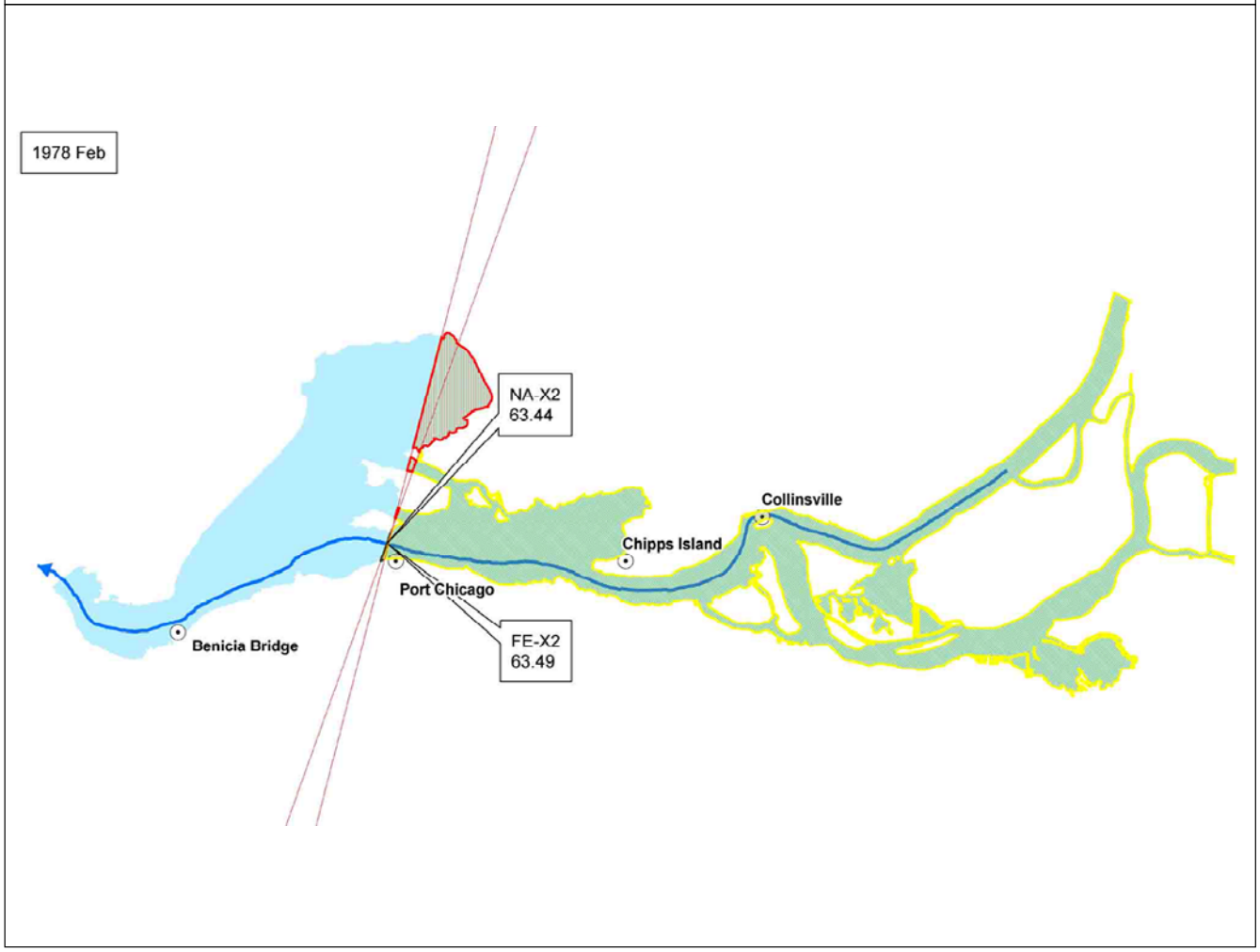
FE-X2
89.36
Collinsville
Chipps Island
Port Chicago
Benicia Bridge

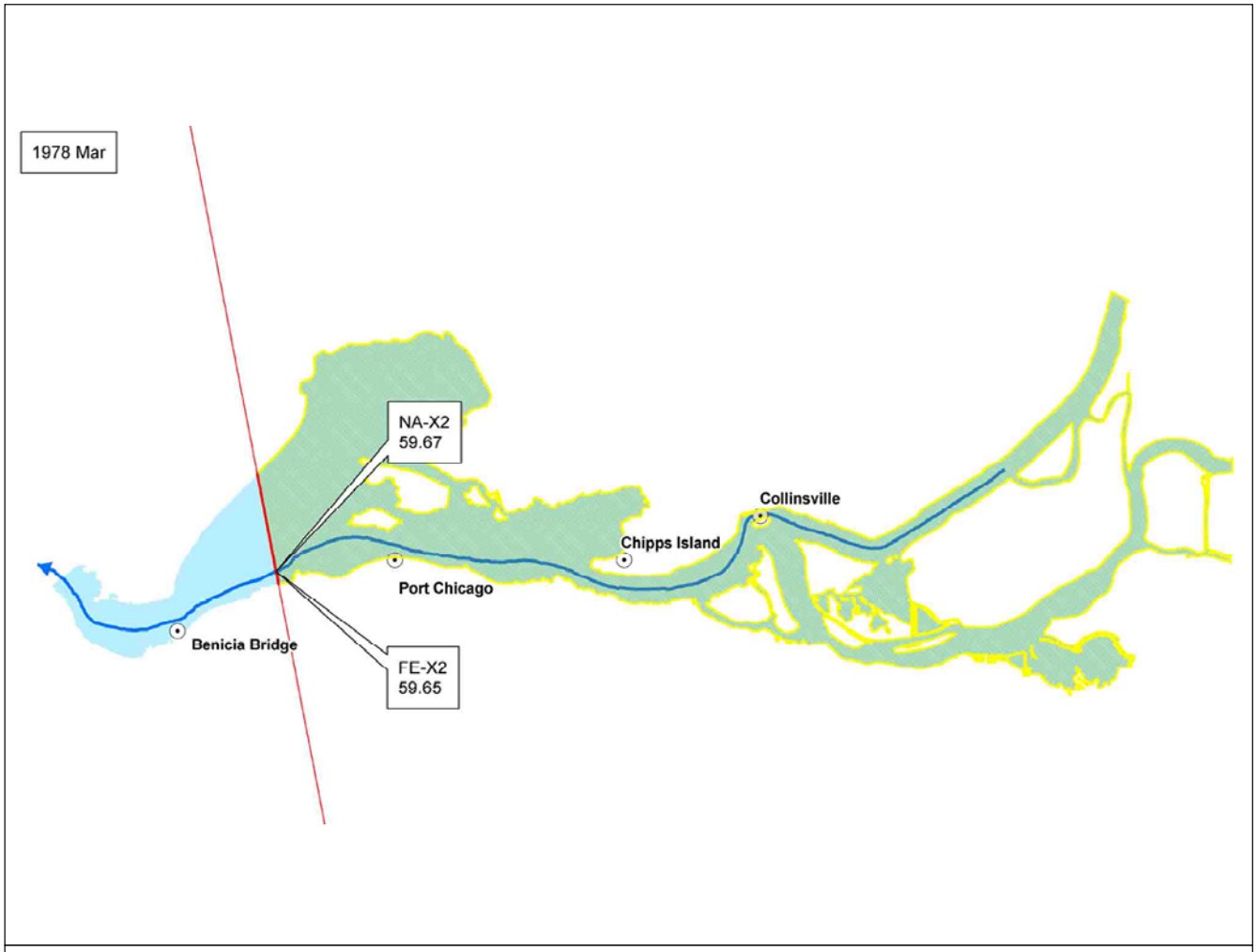

1977 Nov
NA-X2
87.57
FE-X2
87.45
Collinsville
Chipps Island
Port Chicago
Benicia Bridge

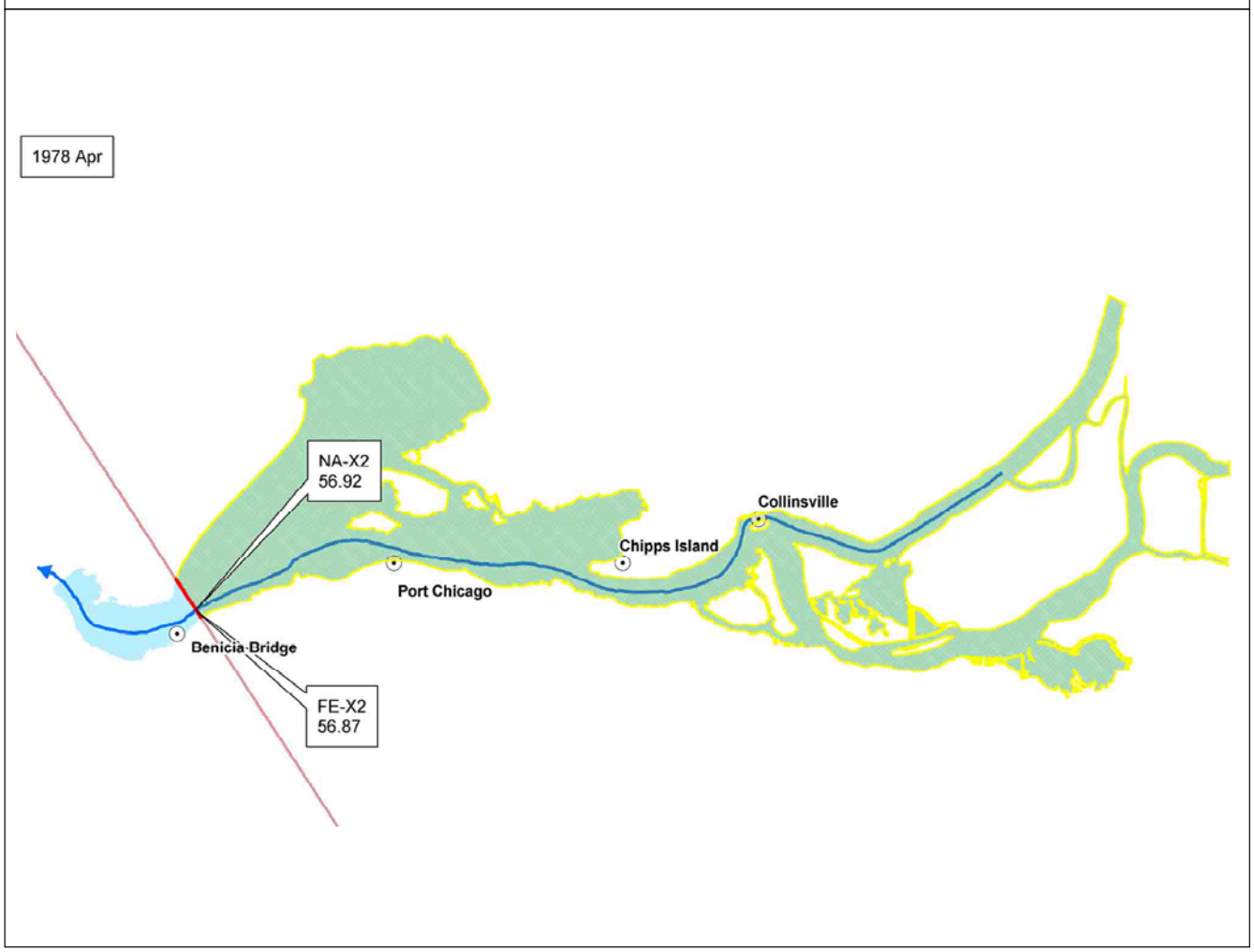

1977 Dec
NA-X2
86.45
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
86.72

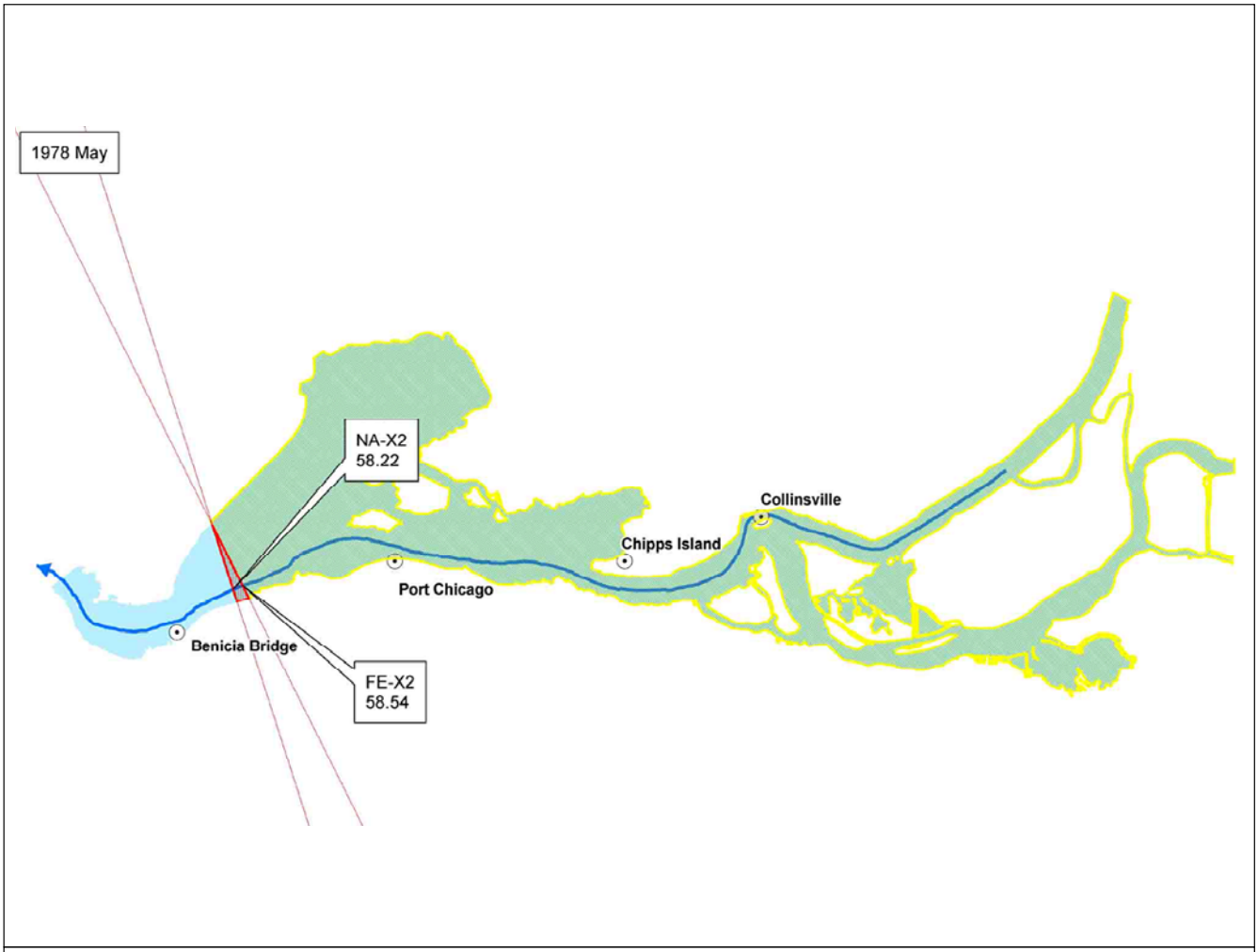

1977 average
NA-X2
84.59
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
84.62


1978 Jan
NA-X2
80.97
Collinsville
Chipps Island
Port Chicago
FE-X2
81.03
Benicia Bridge


1978 Feb
NA-X2
63.44
Collinsville
Chipps Island
Port Chicago
FE-X2
63.49
Benicia Bridge


1978 Mar
NA-X2
59.67
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
59.65


1978 Apr
NA-X2
56.92
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
56.87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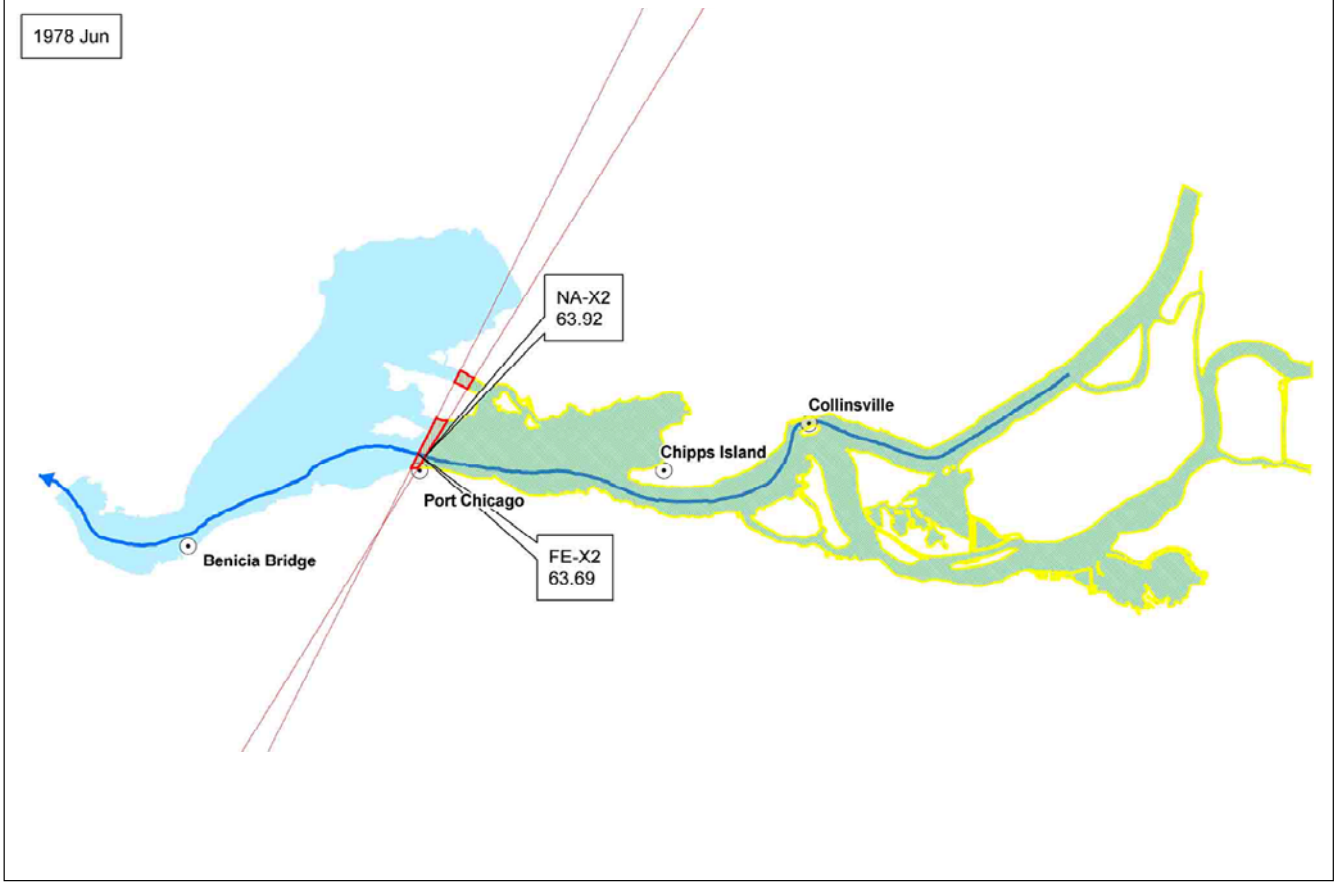
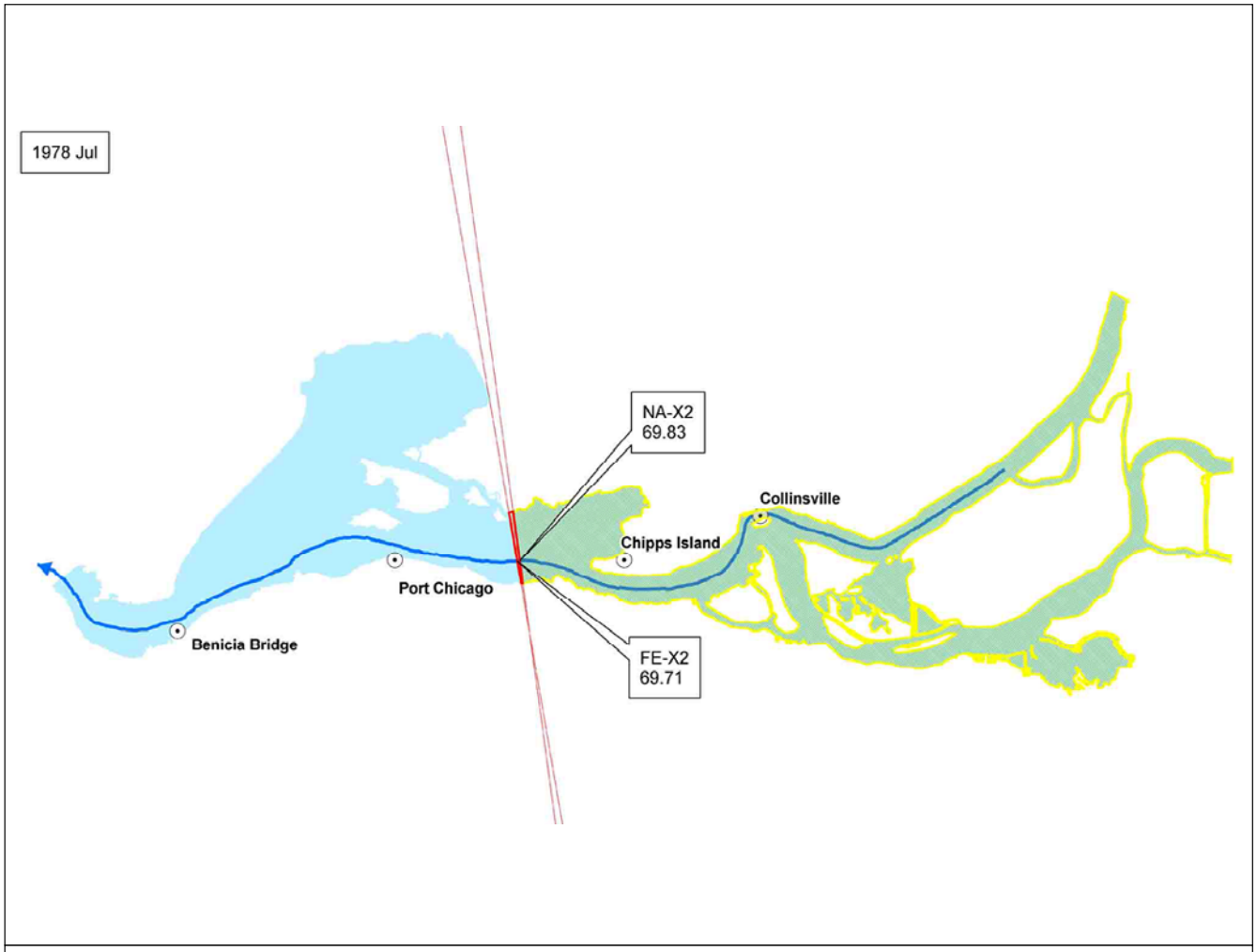
NA-X2
58.22
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
58.54


1978 Jun
NA-X2
63.92
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
63.69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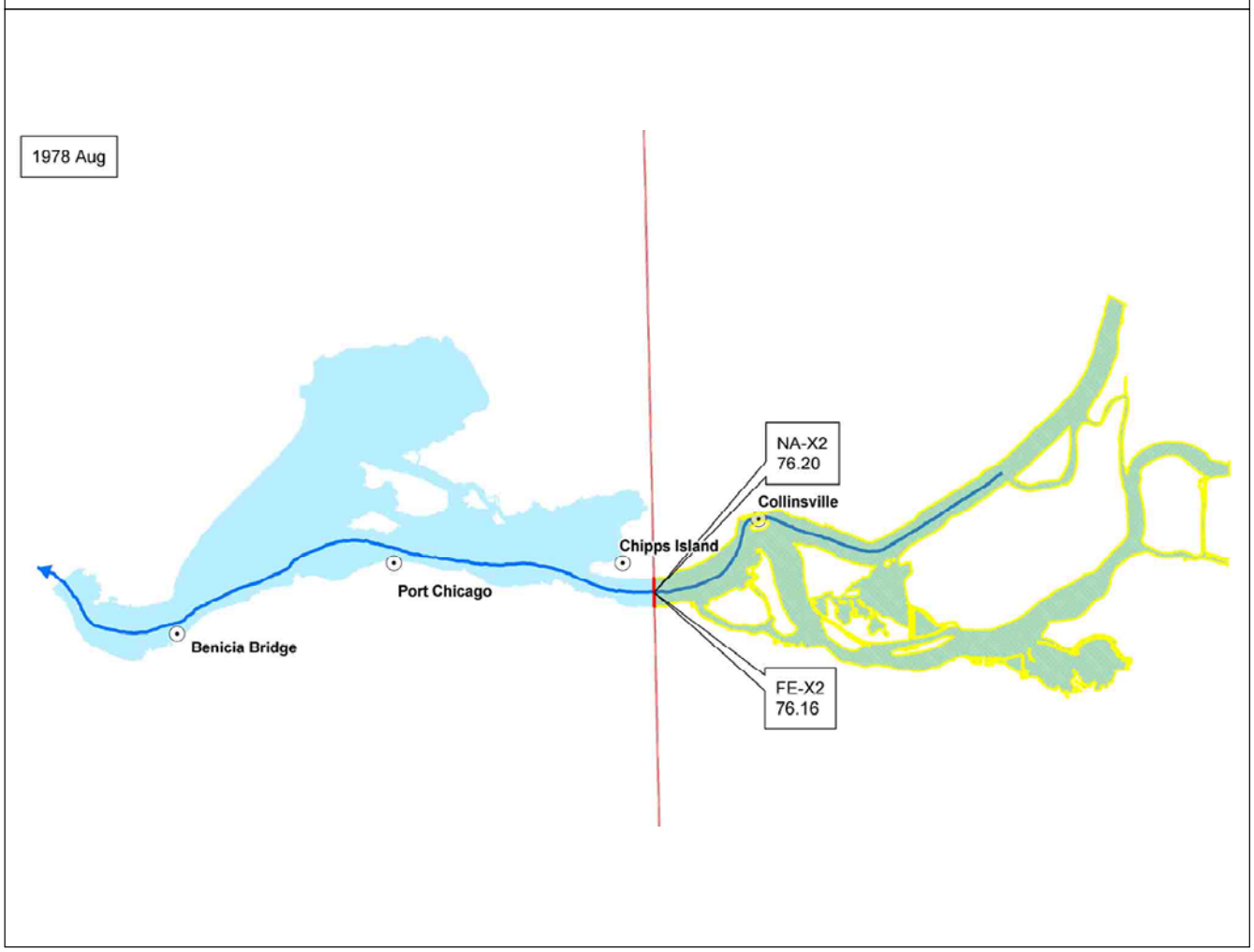
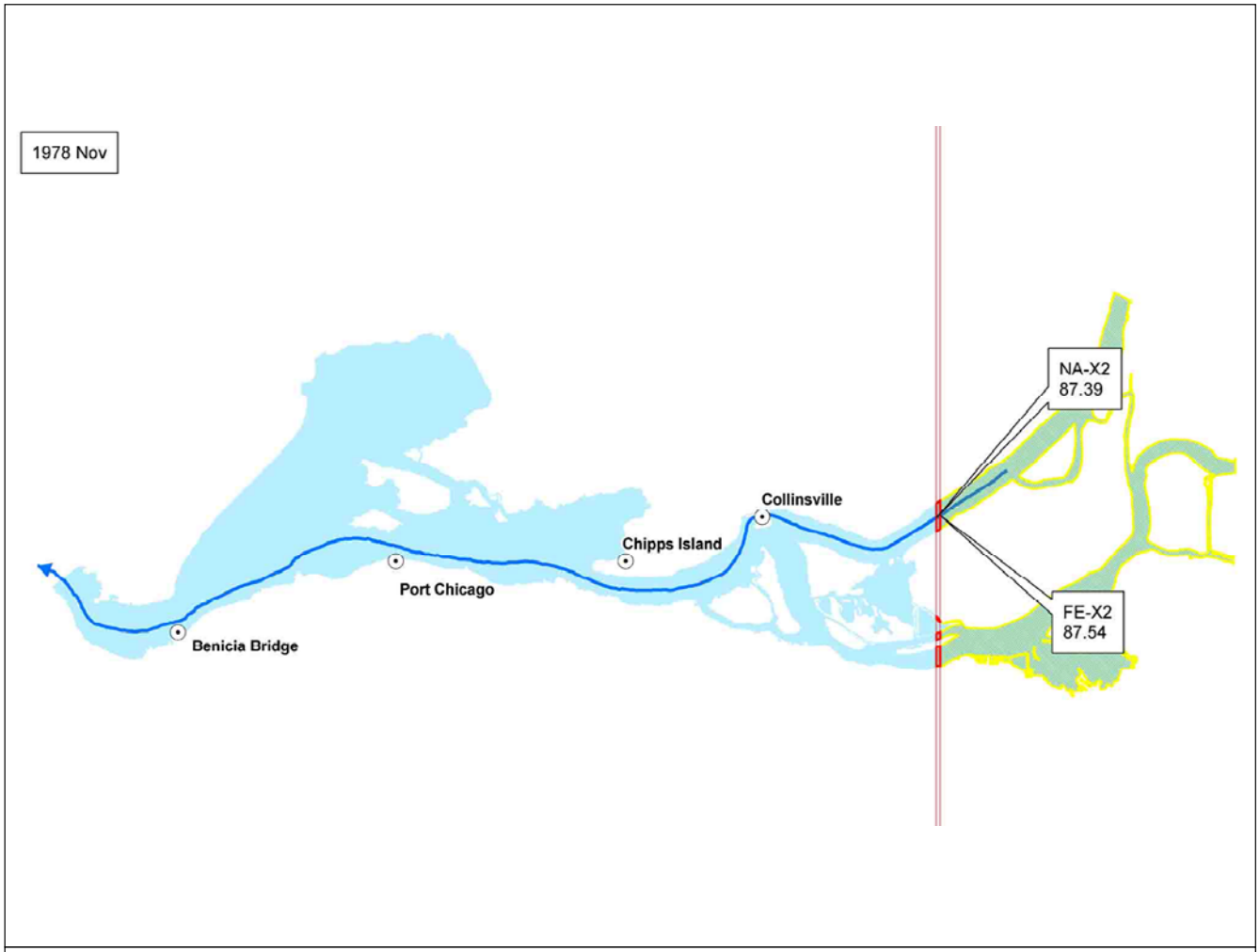
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
69.71

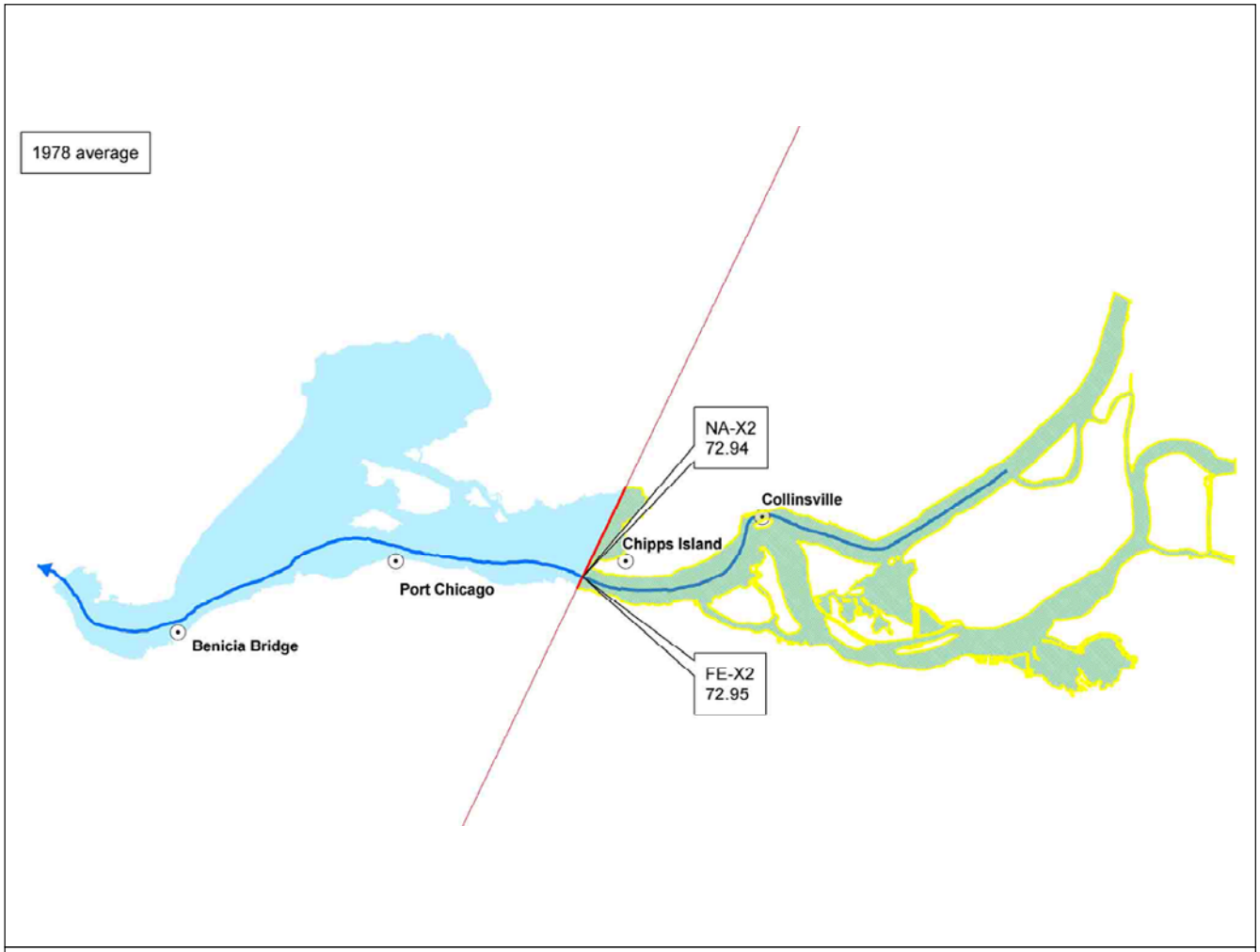

1978 Aug
NA-X2
76.20
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
76.16


1978 Sep
NA-X2
83.45
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
83.59

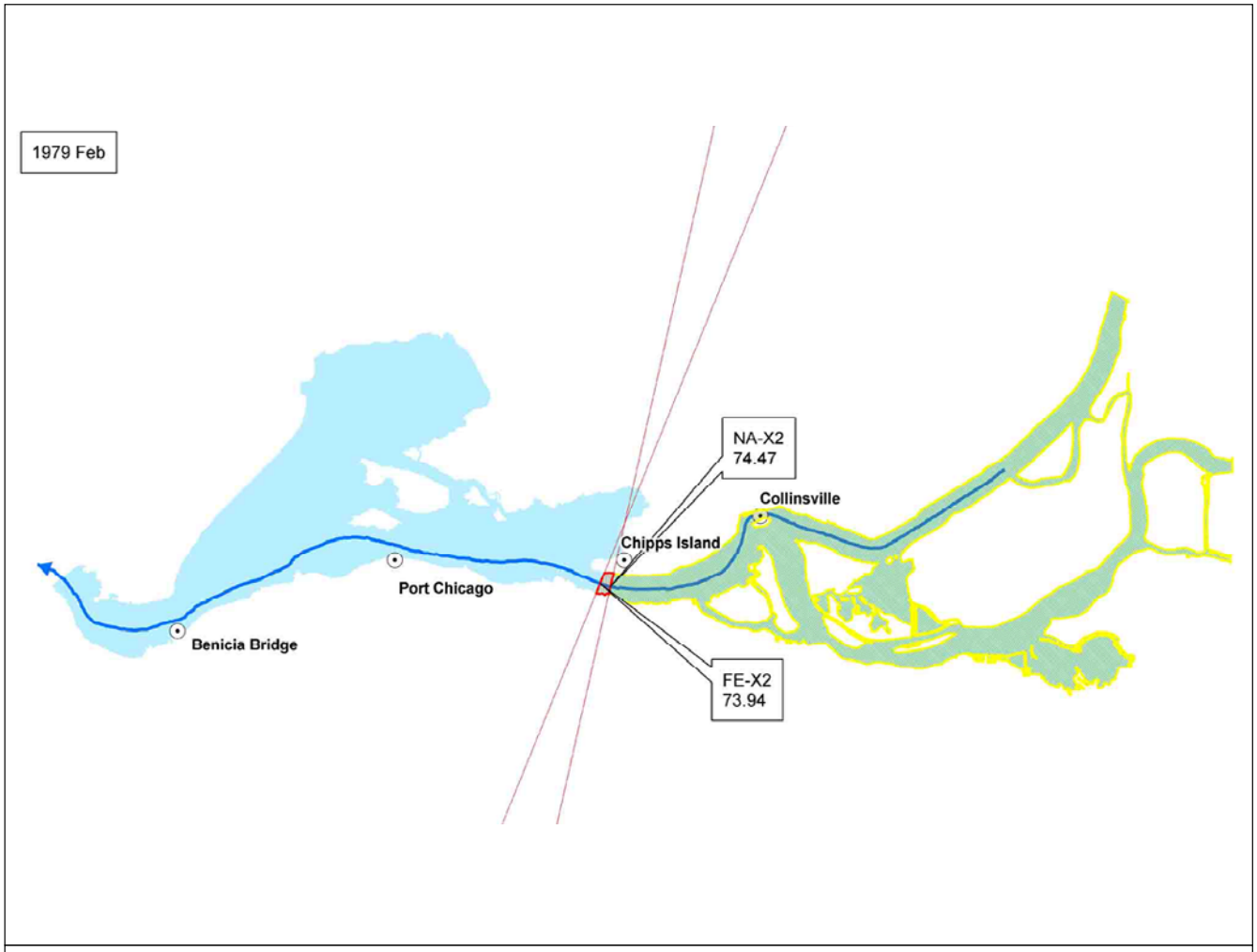

1978 Oct
NA-X2
89.64
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
89.62


1978 Nov
NA-X2
87.39
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
87.54


1978 Dec
NA-X2
85.65
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
85.54


1978 average
NA-X2
72.94
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
72.95


1979 Jan
NA-X2
83.75
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
82.08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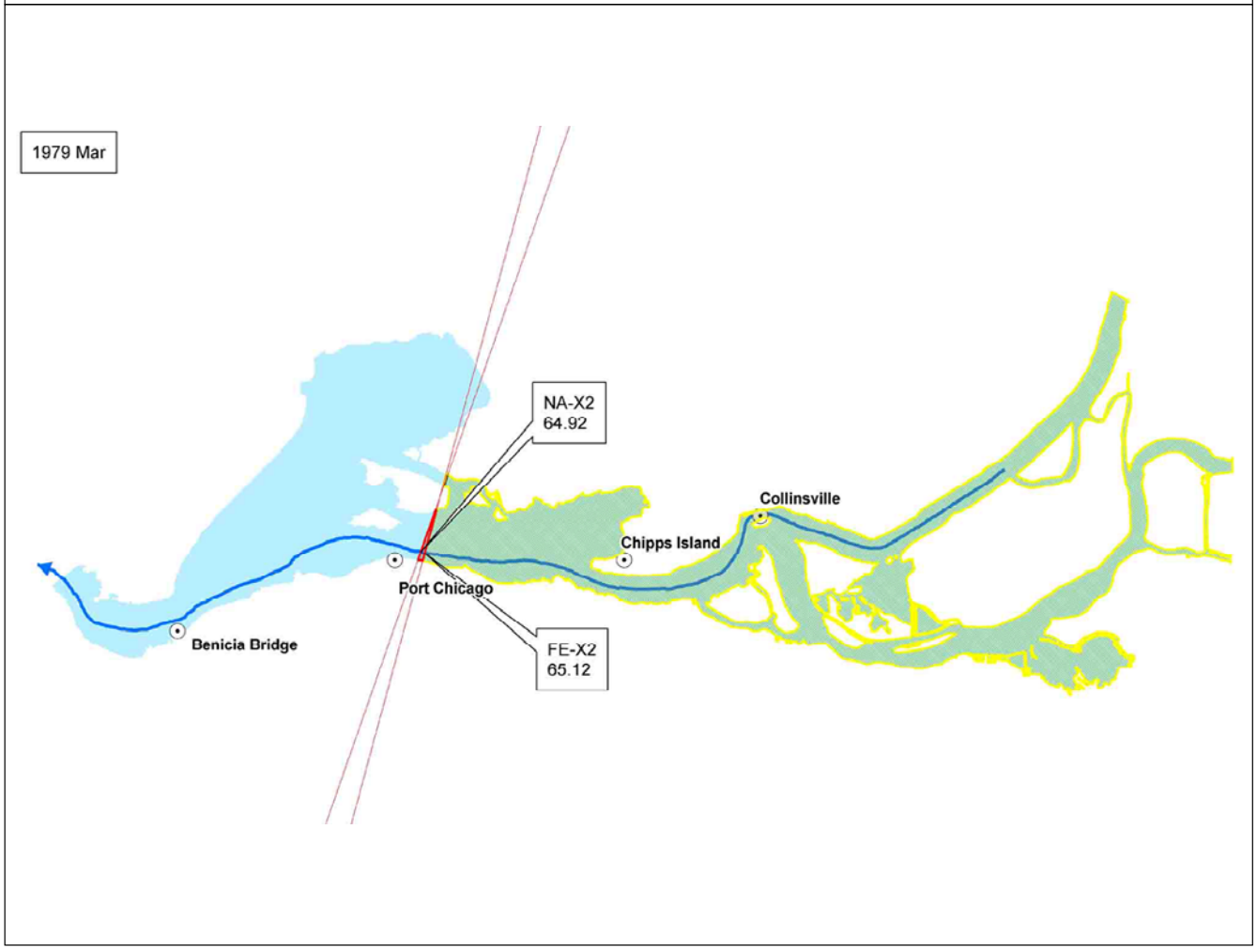
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
73.94


1979 Mar
NA-X2
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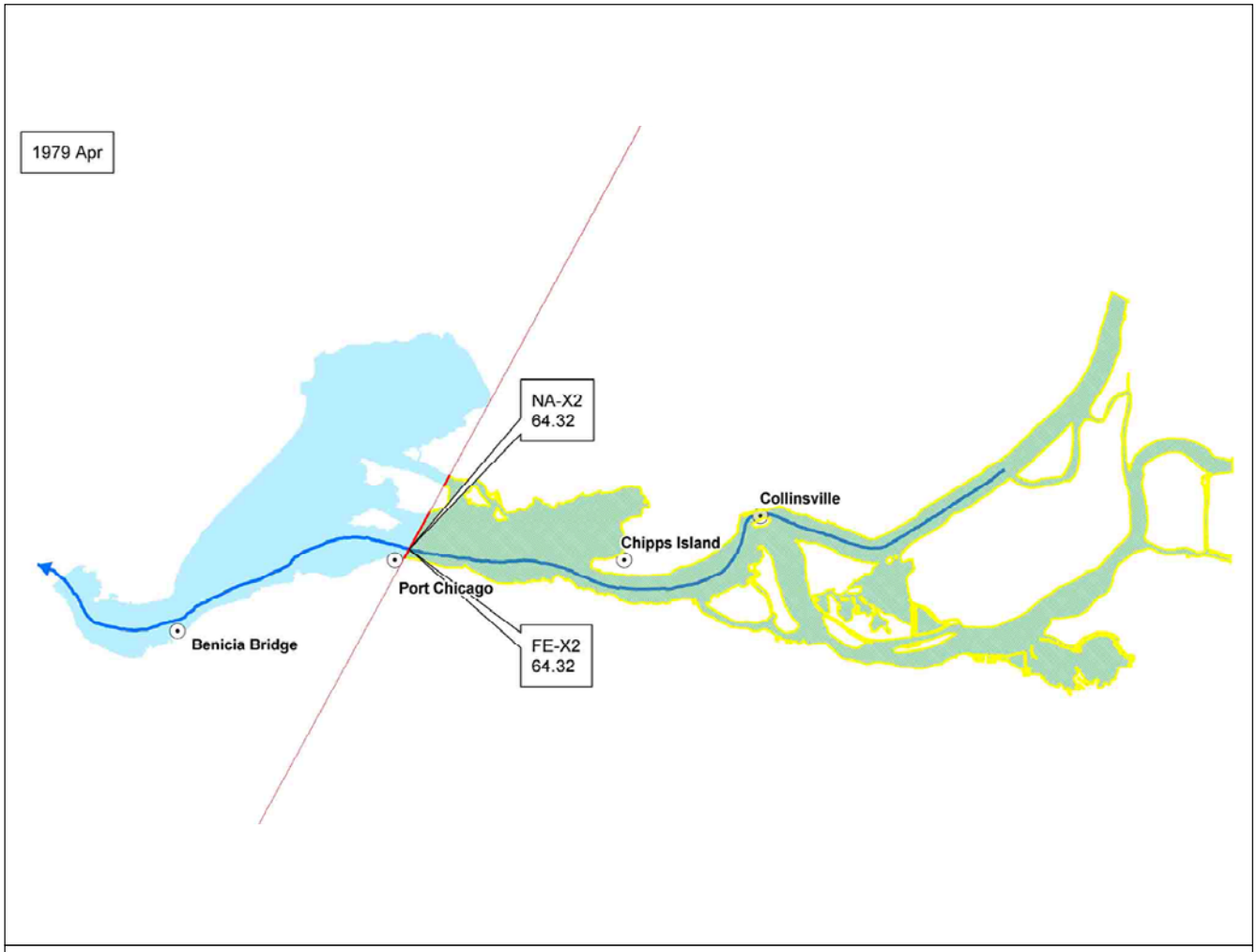
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
65.12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NA-X2
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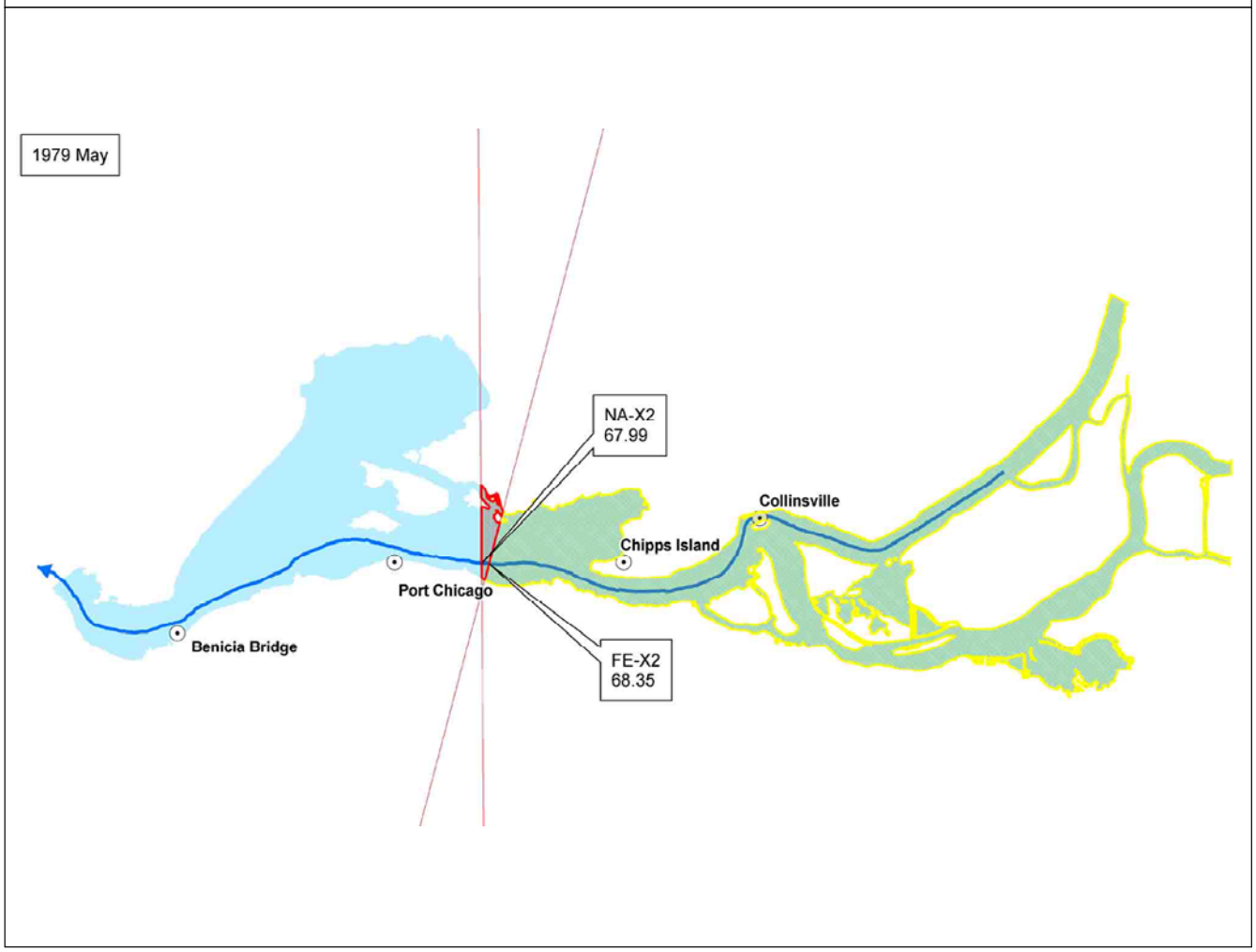
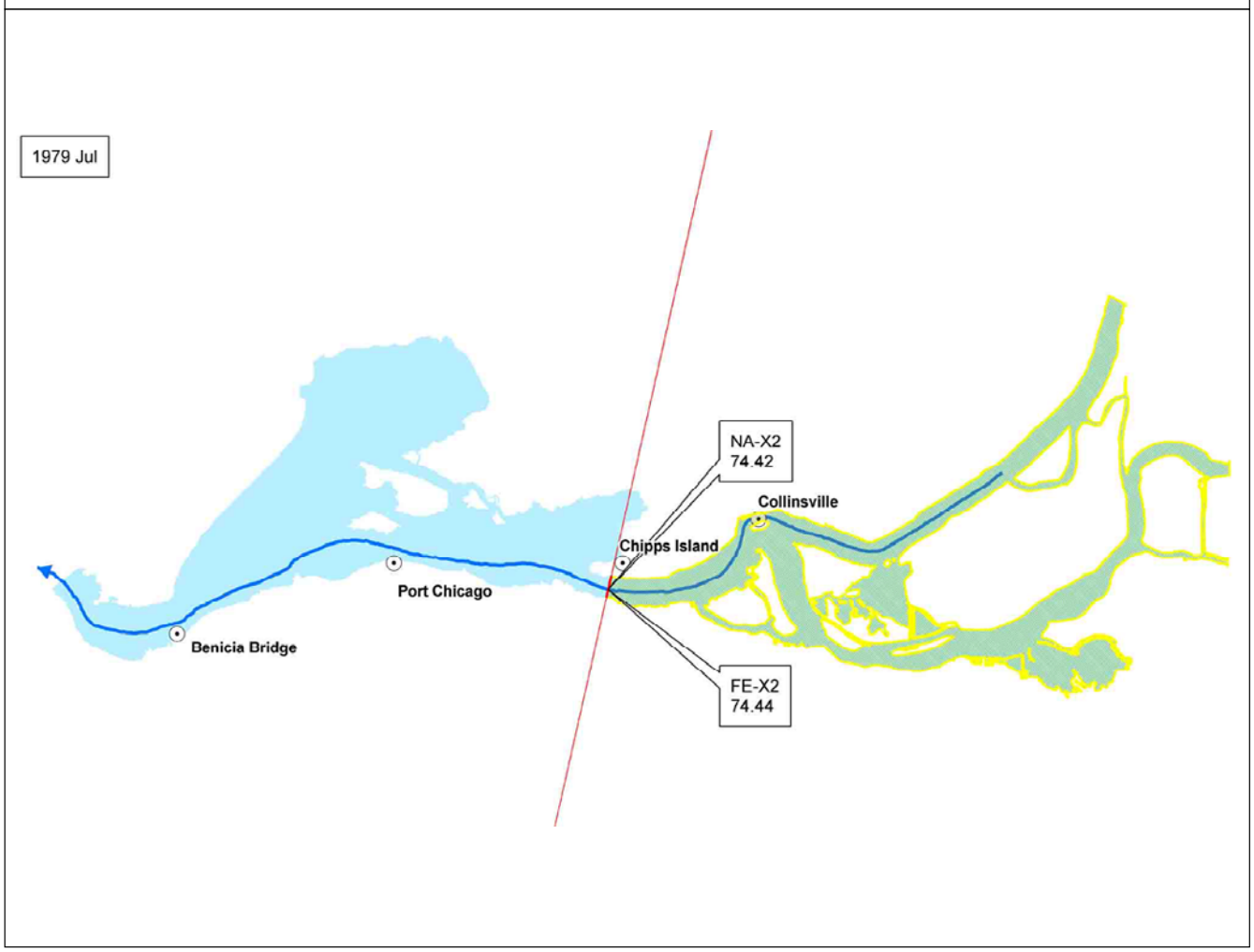
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
64.32

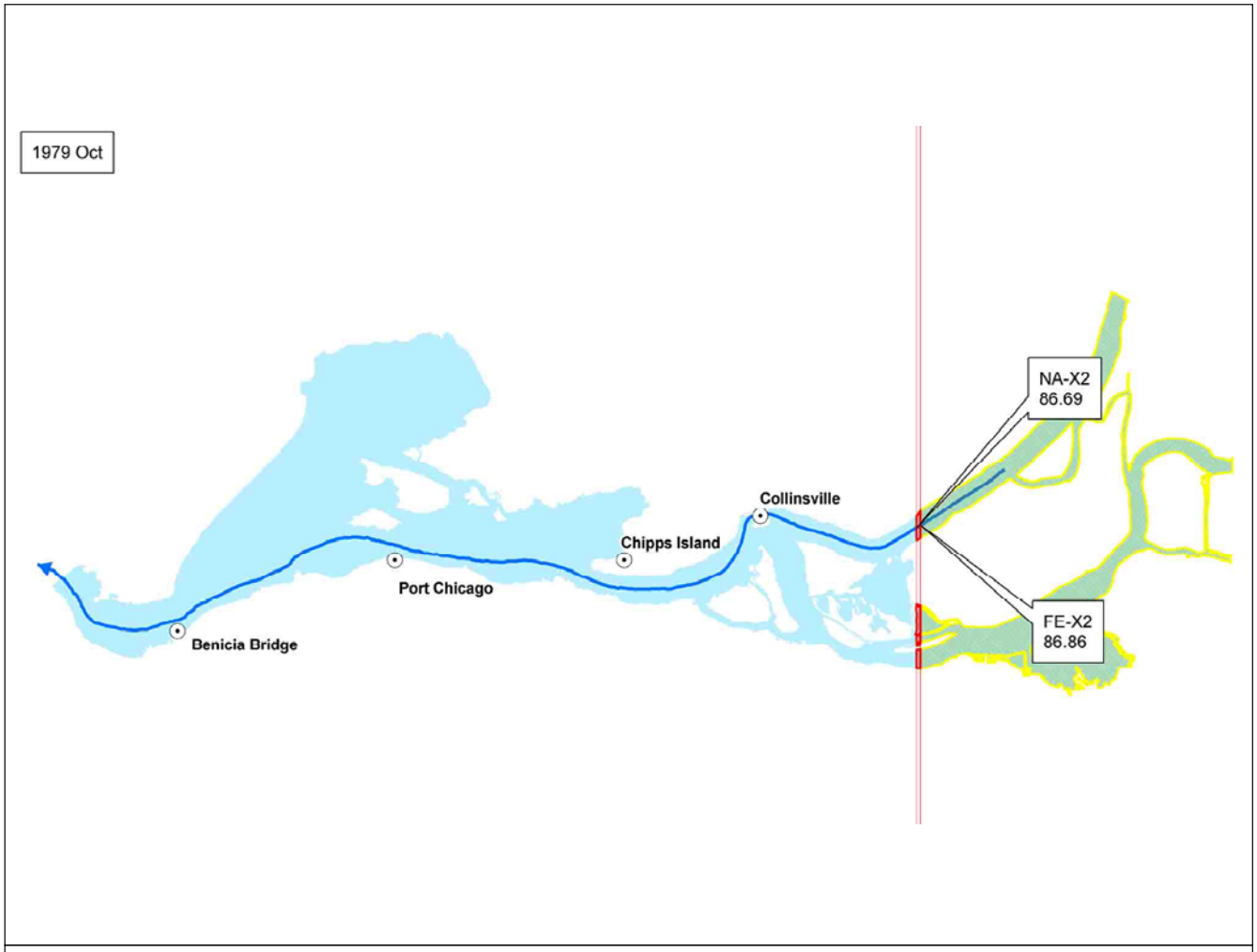

1979 May
NA-X2
67.99
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
68.35


1979 Jun
NA-X2
70.88
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
71.41


1979 Jul
NA-X2
74.42
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
74.44


1979 Aug
NA-X2
79.29
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
79.30


1979 Sep
NA-X2
84.61
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
84.61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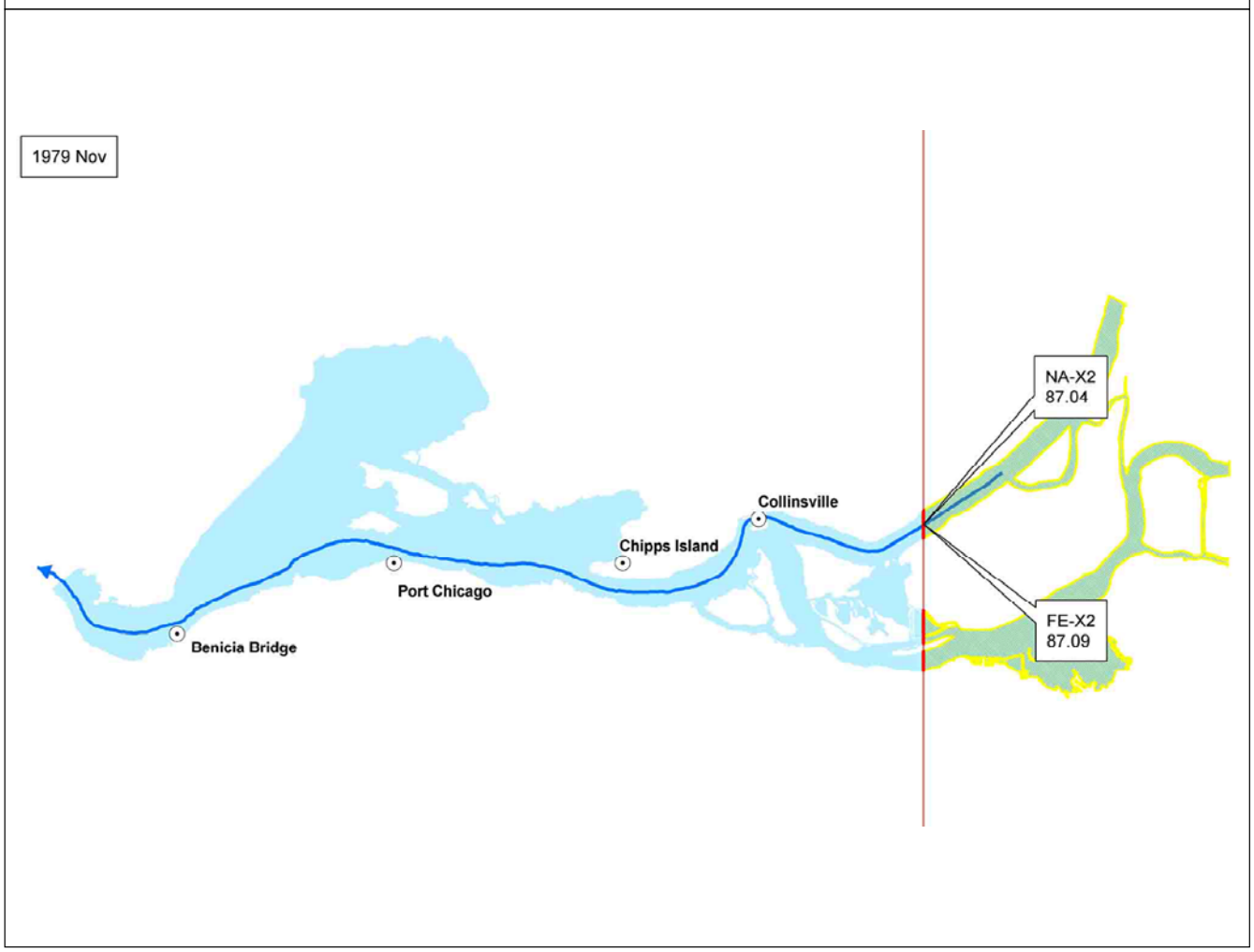
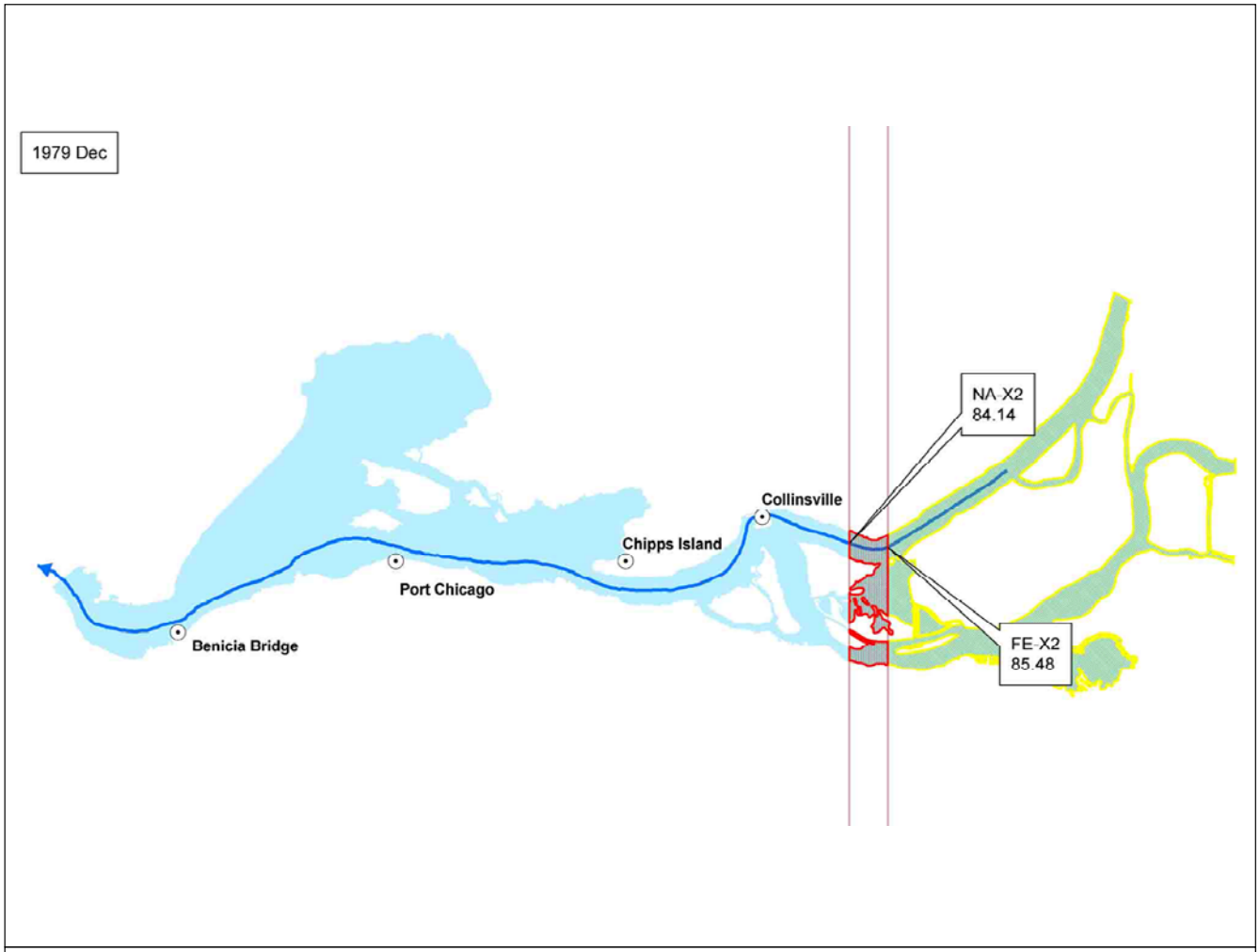
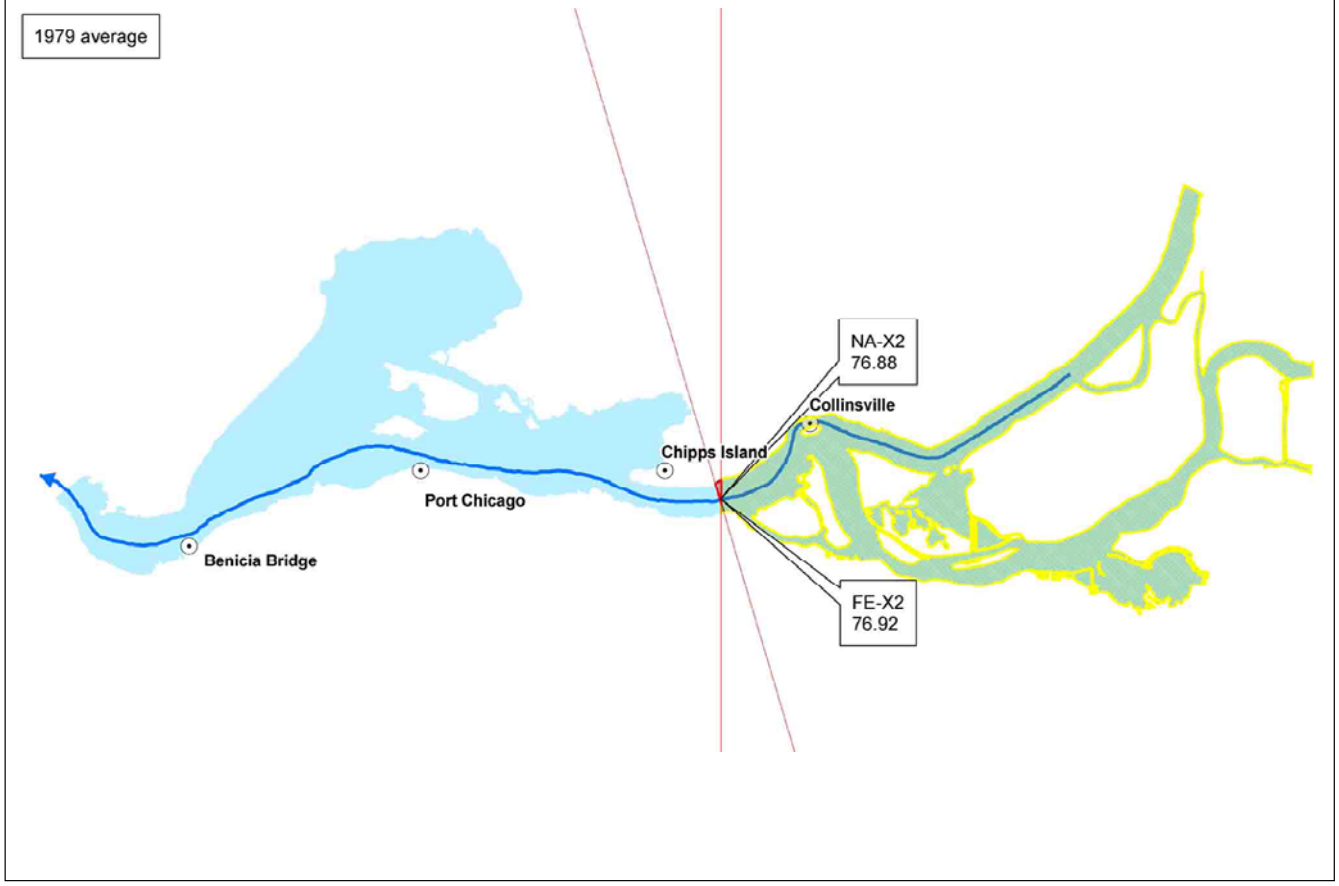
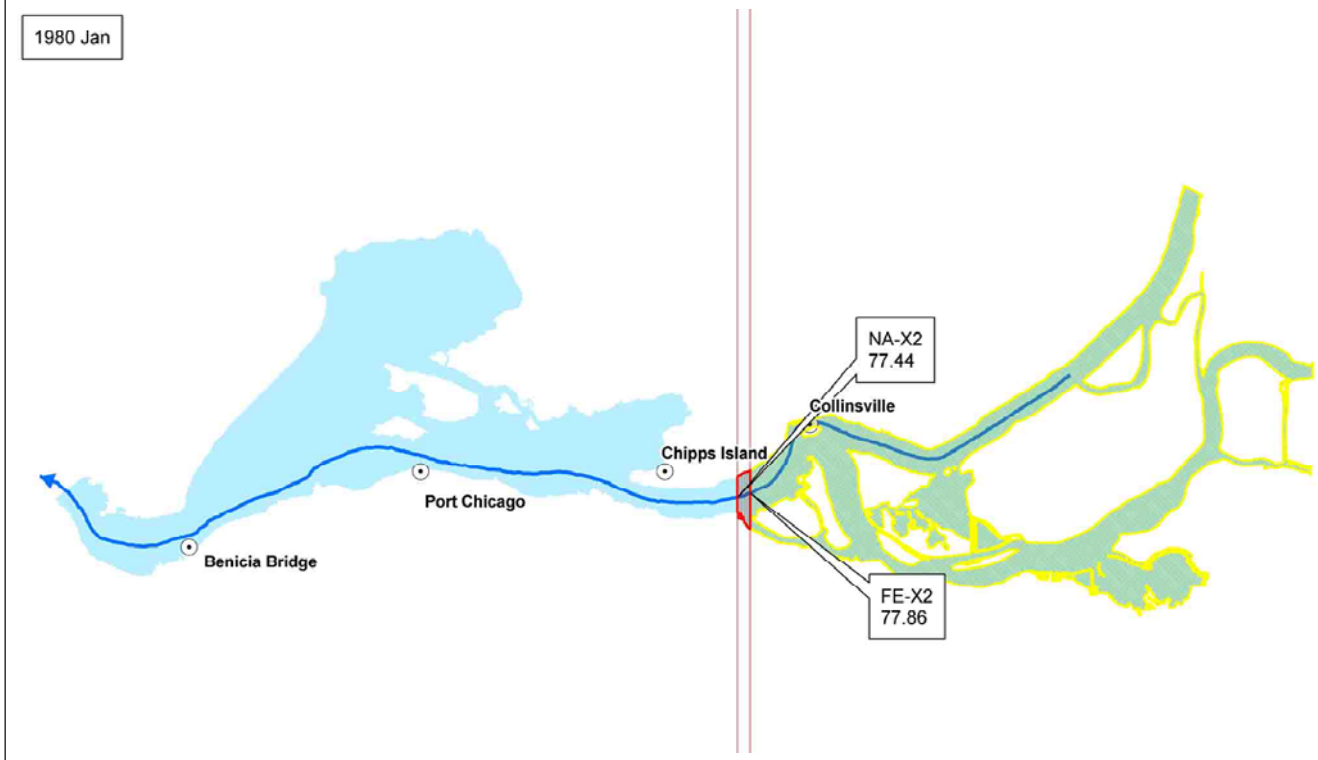
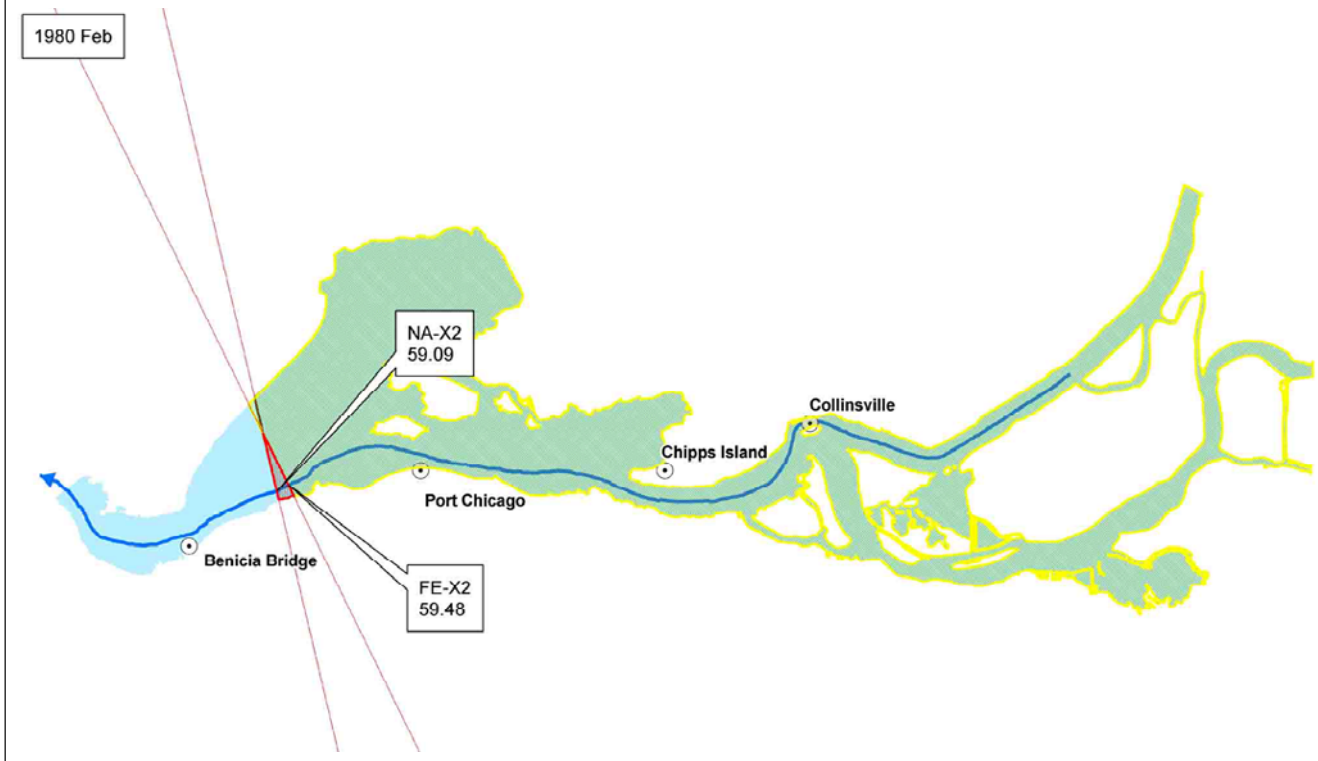
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
86.86

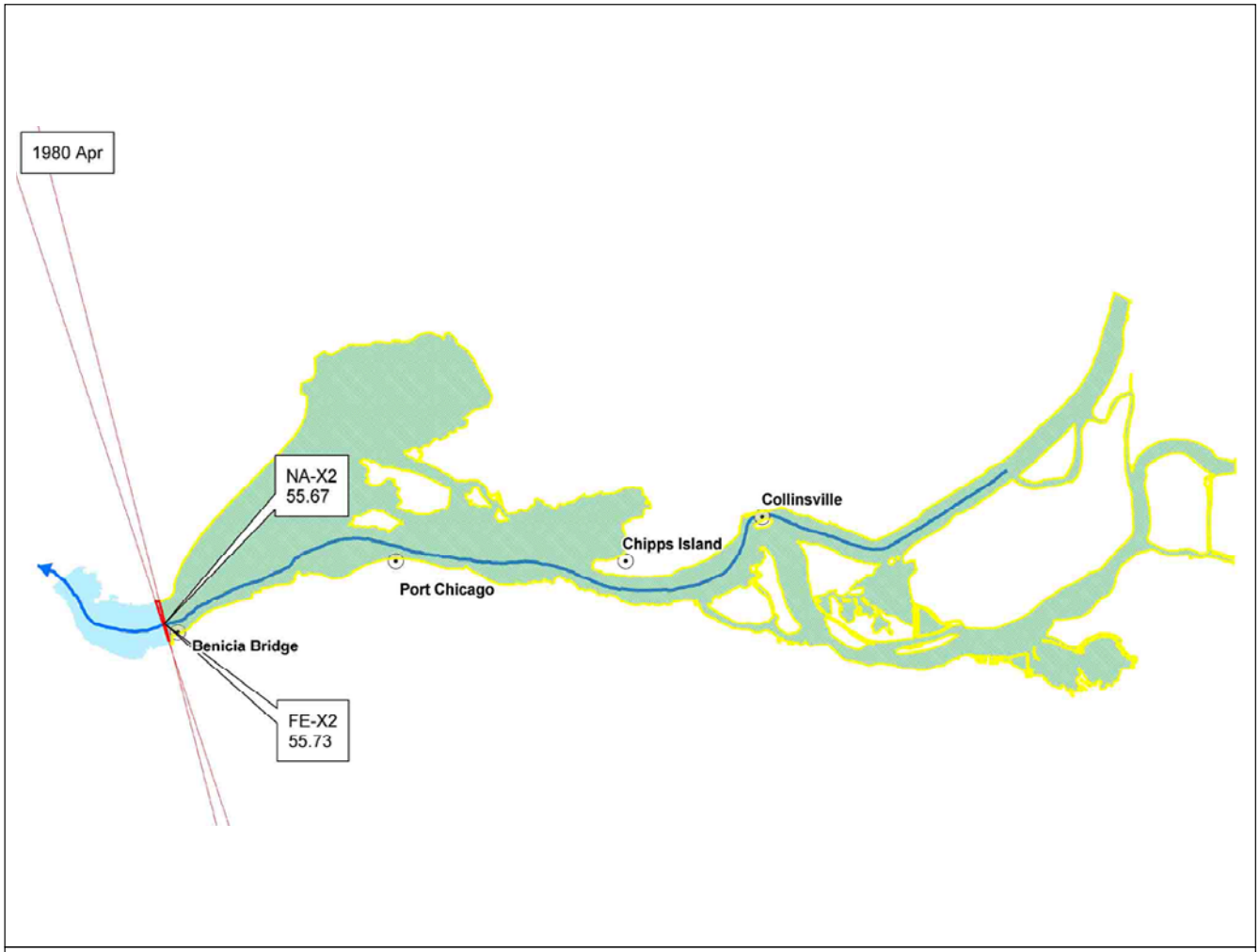

1979 Nov
NA-X2
87.04
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
87.09

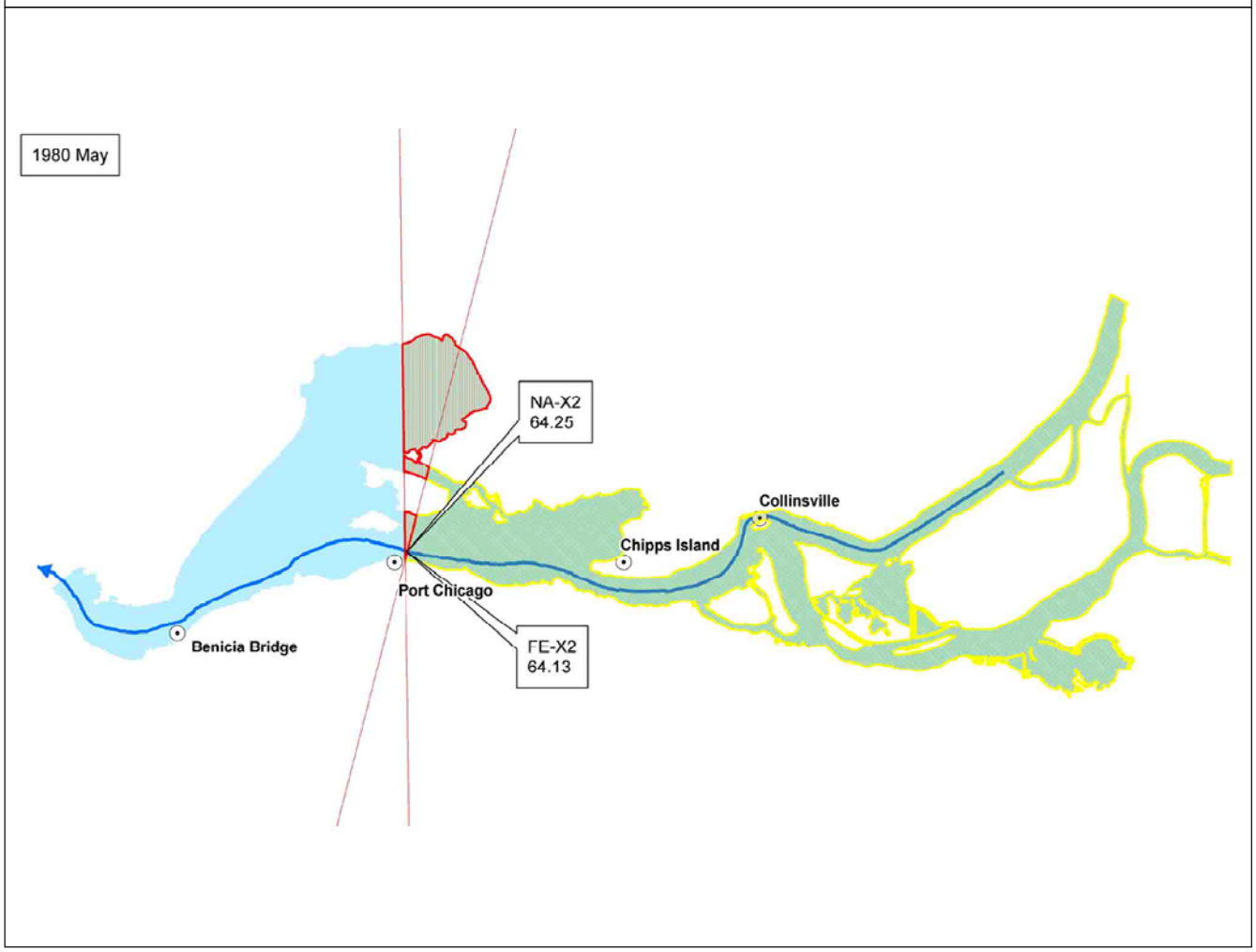

1979 Dec
NA-X2
84.14
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
85.48

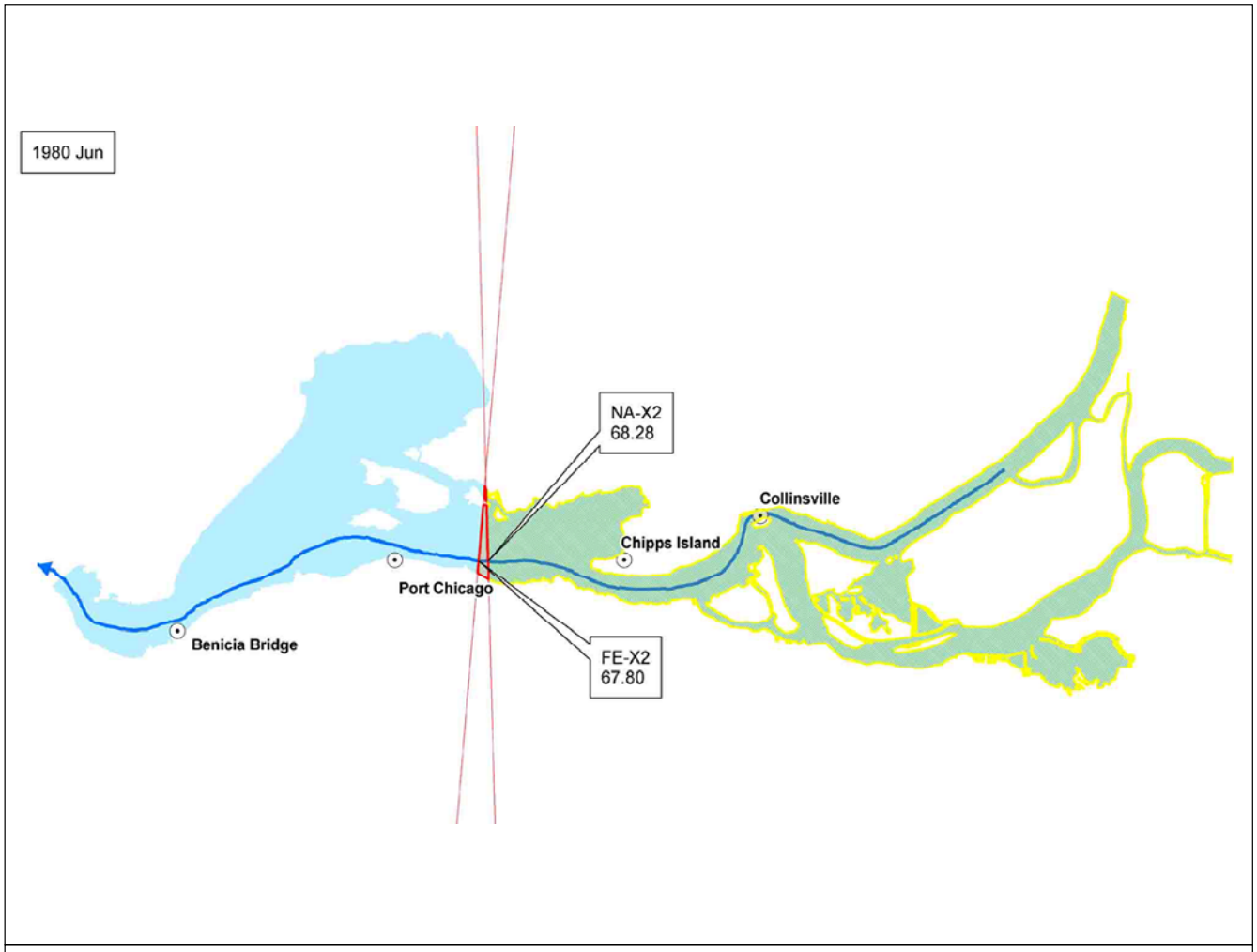

1979 average
NA-X2
76.88
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
76.92

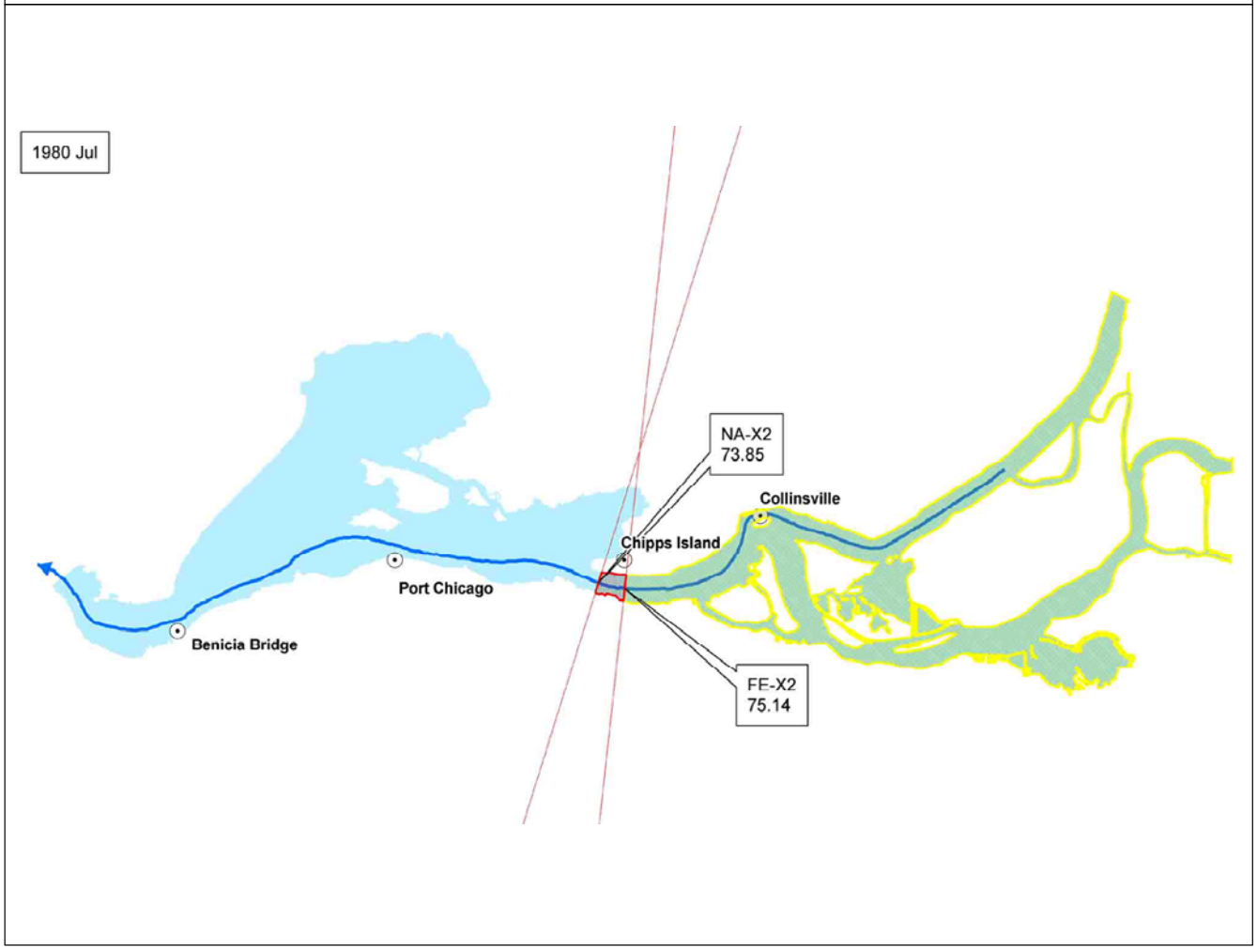

1980 Jan
NA-X2
77.44
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
77.86

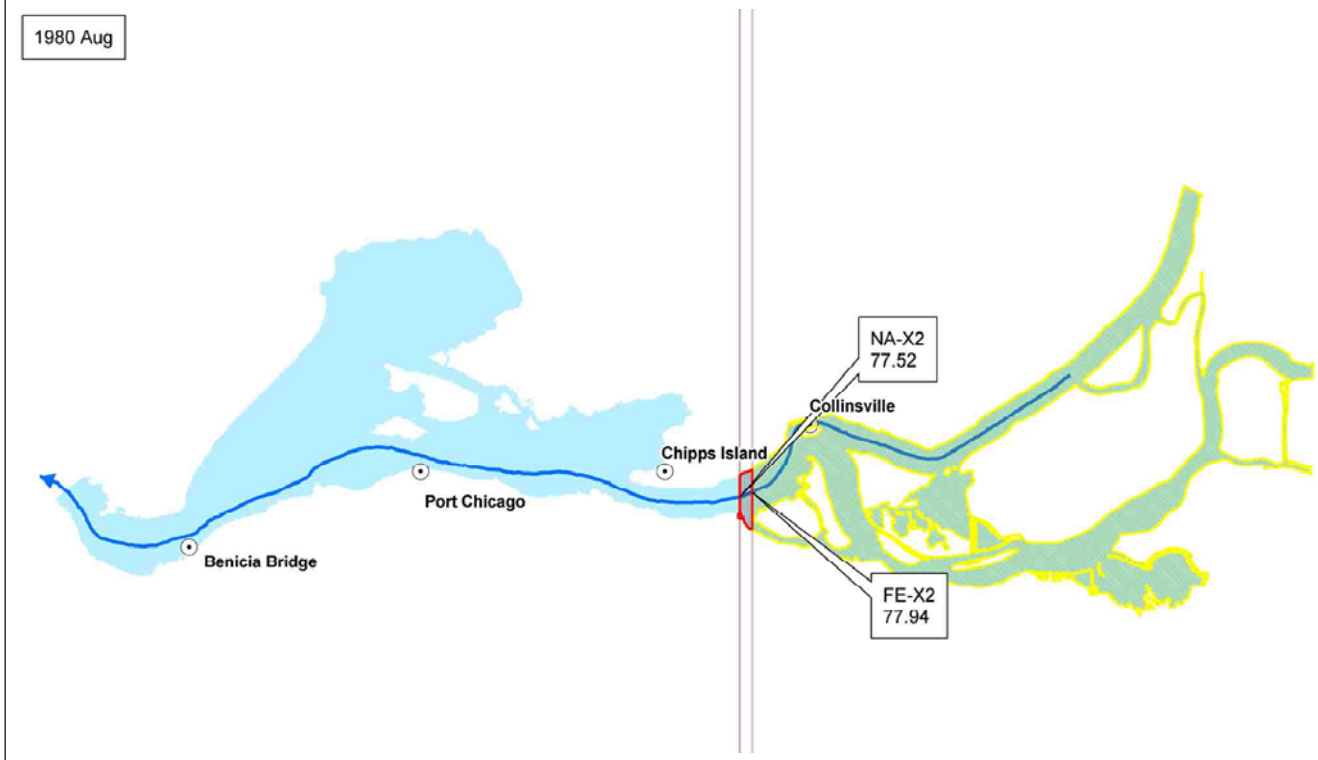

1980 Feb
NA-X2
59.09
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
59.48

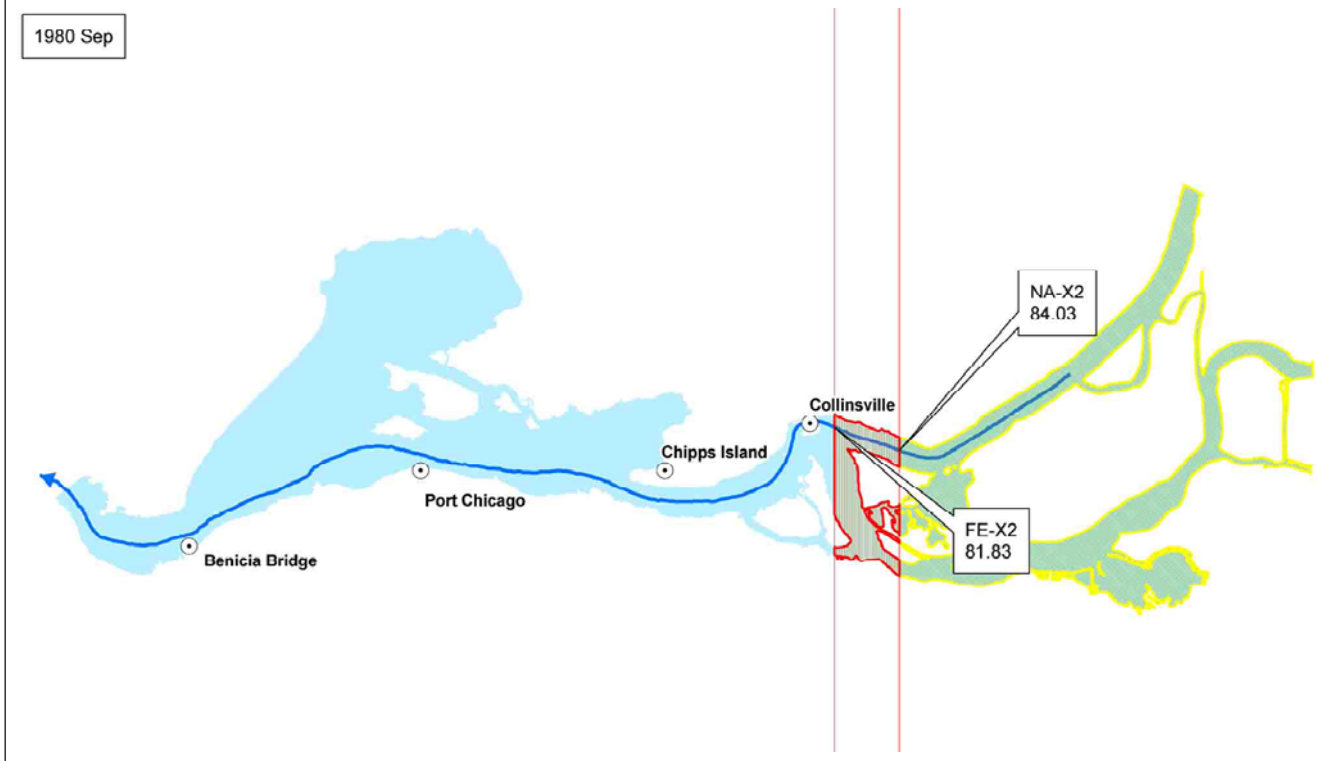

1980 Apr
NA-X2
55.67
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
55.73


1980 May
NA-X2
64.25
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
64.13


1980 Jun
NA-X2
68.28
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
67.80


1980 Jul
NA-X2
73.85
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
75.14

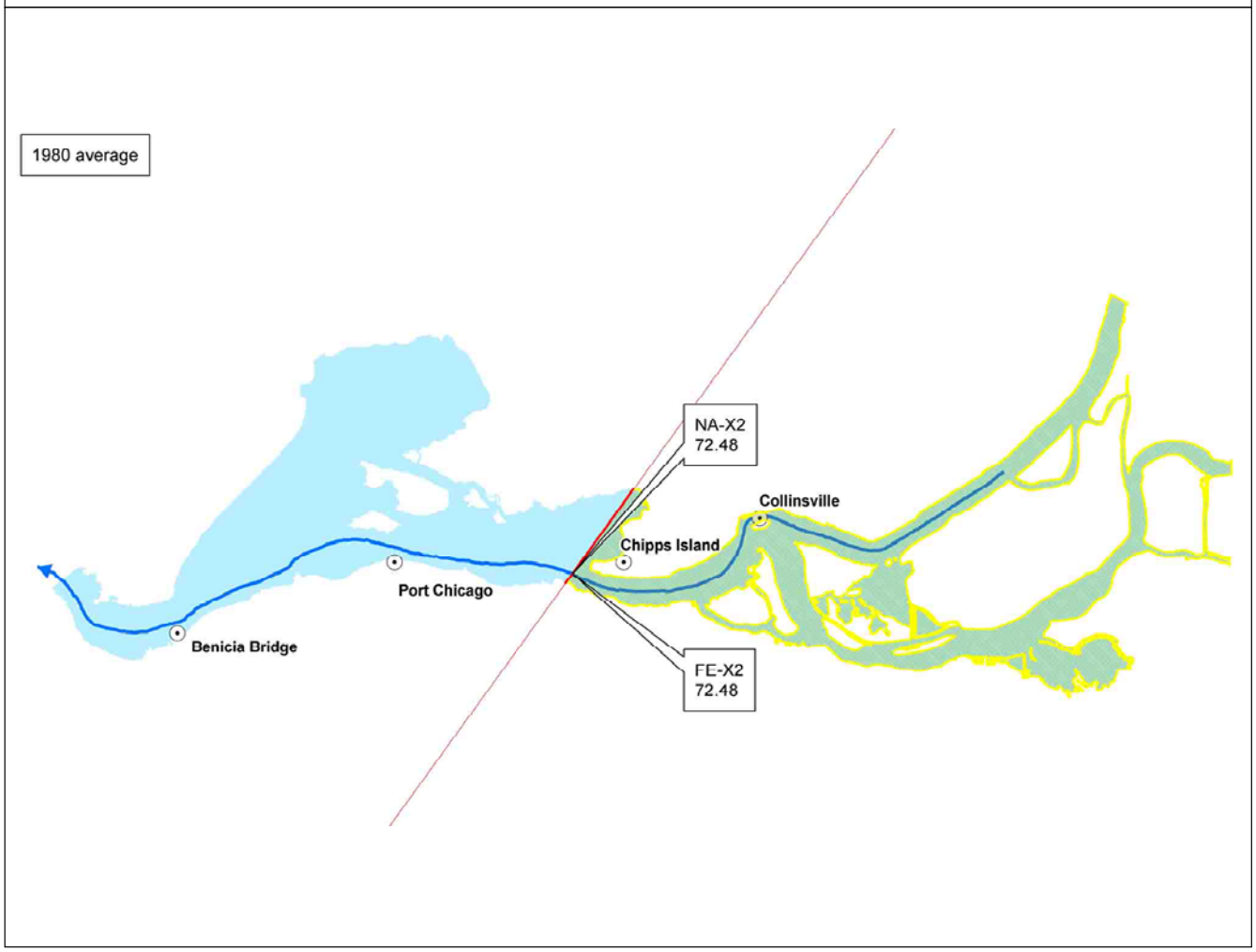

1980 Aug
NA-X2
77.52
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
77.94


1980 Sep
NA-X2
84.03
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
81.83

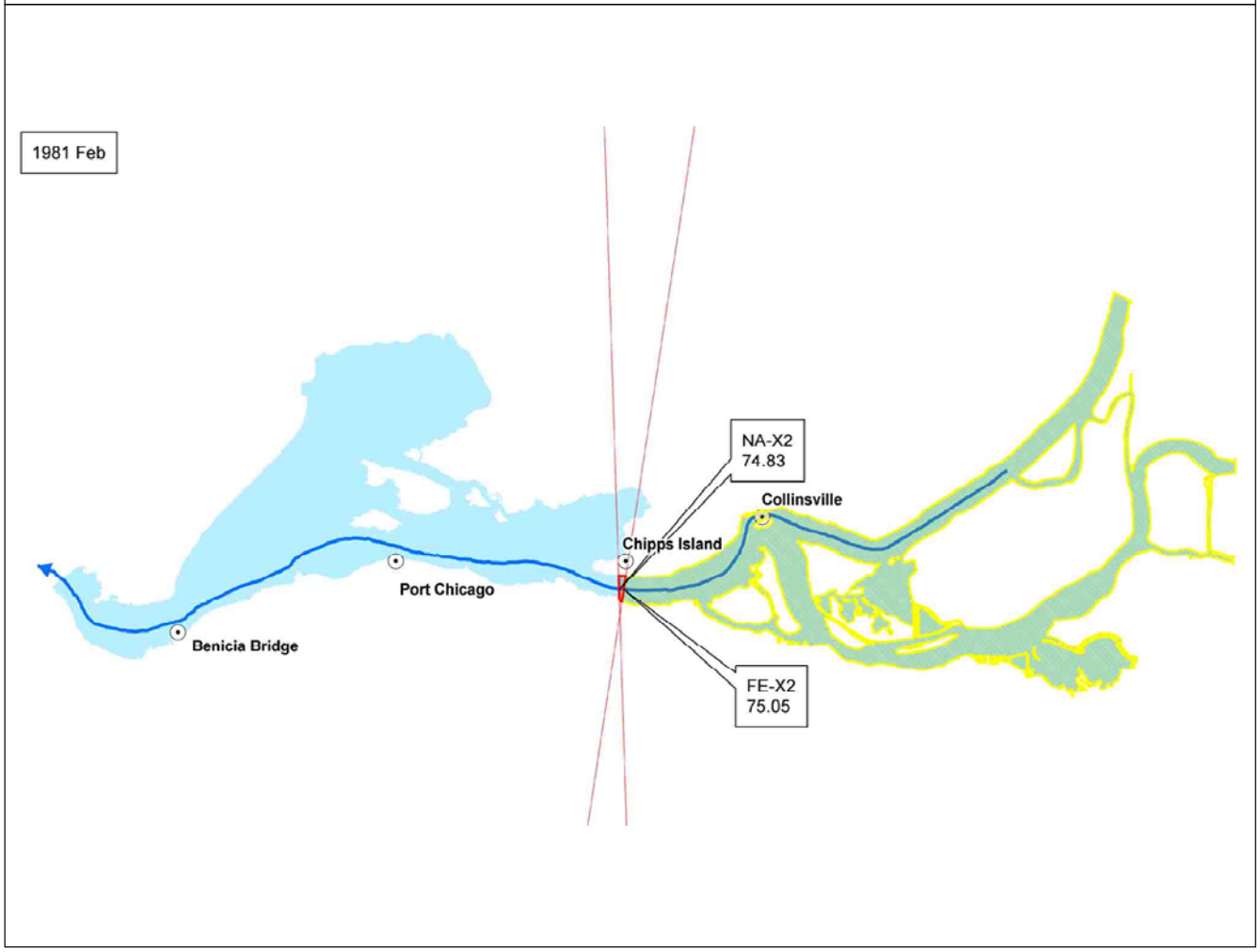

1980 Oct
NA-X2
88.56
Collinsville
Chipps Island
Port Chicago
FE-X2
88.56
Benicia Bridge

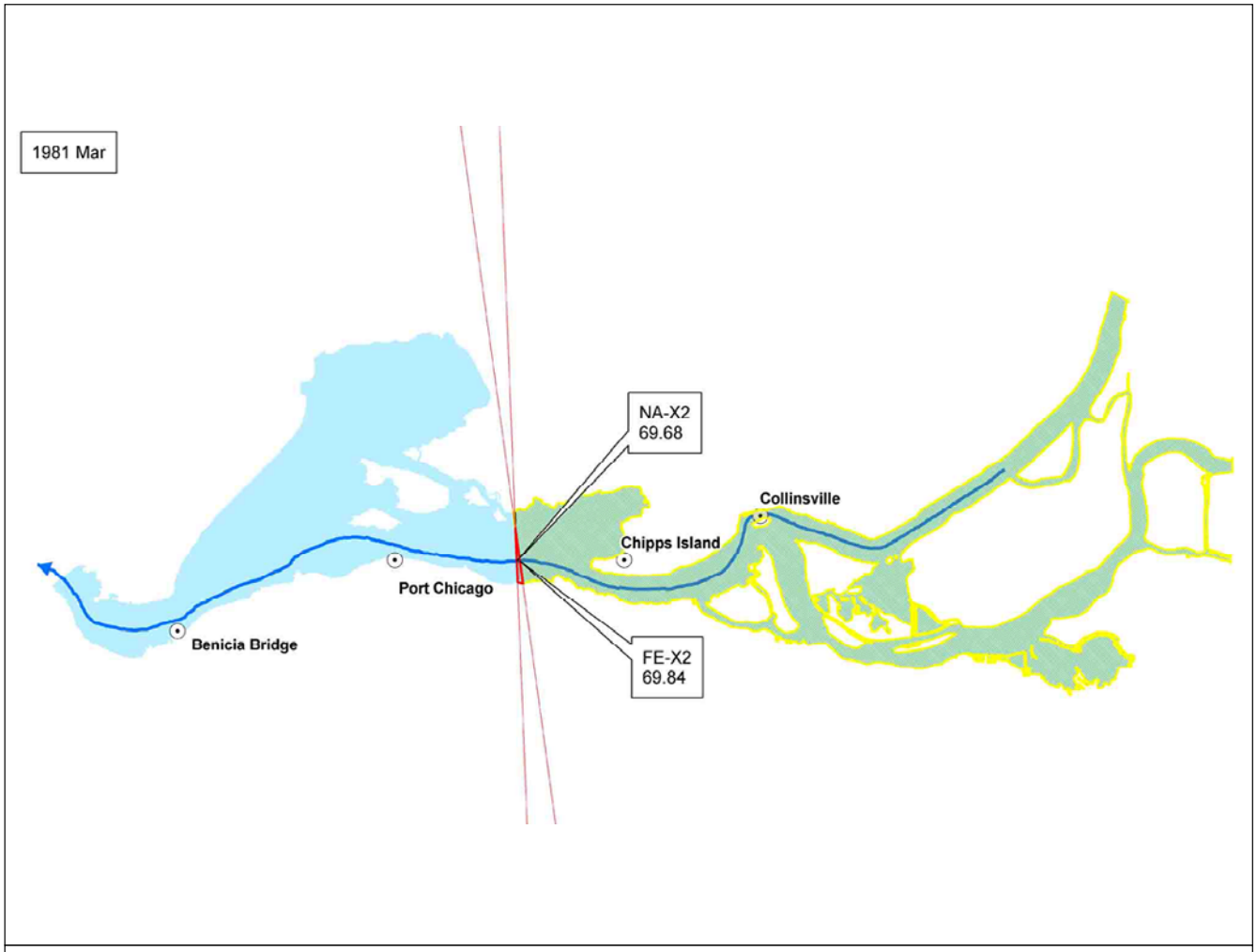

1980 Nov
NA-X2
85.92
Collinsville
Chipps Island
Port Chicago
FE-X2
85.90
Benicia Bridge

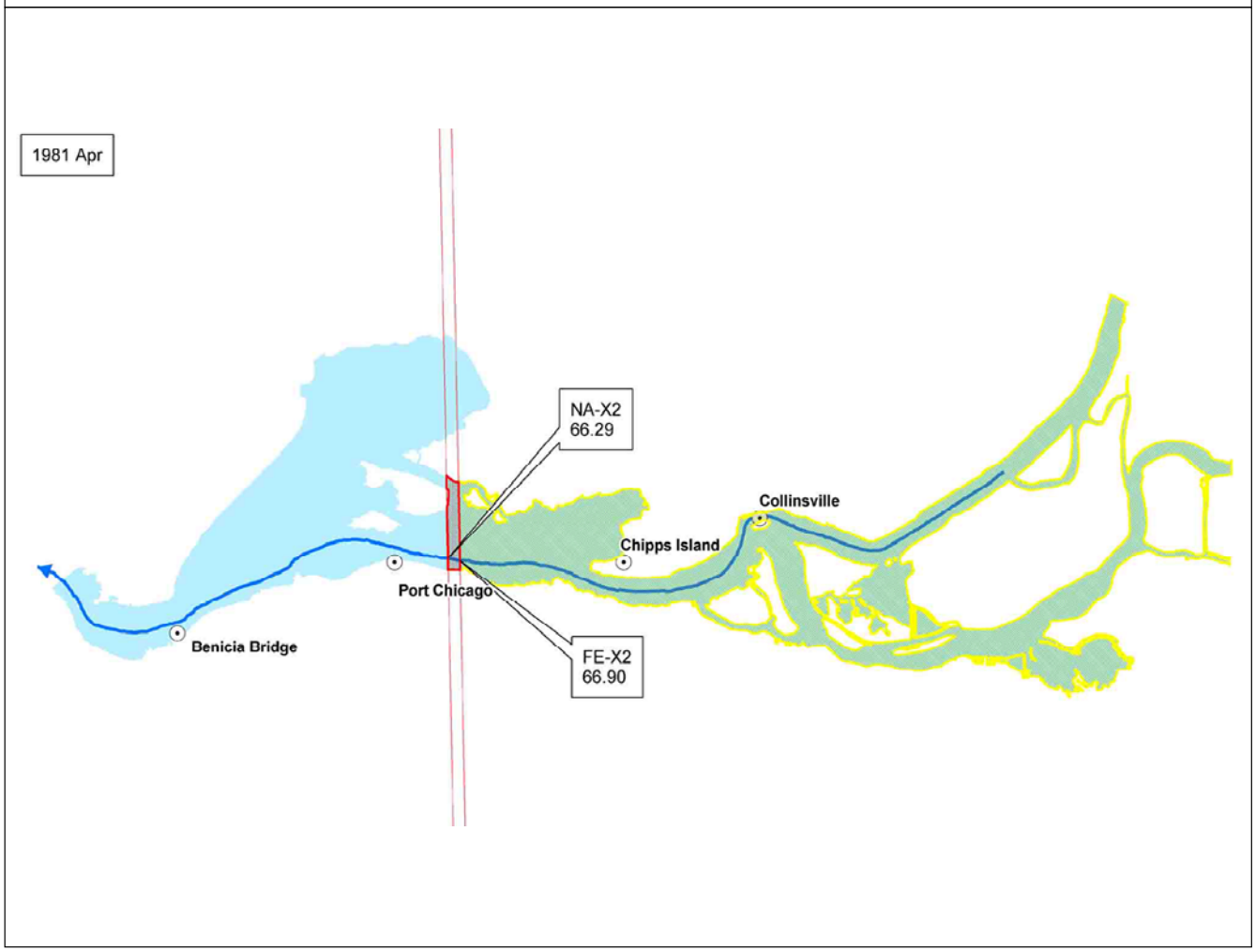

1980 Dec
NA-X2
83.80
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
83.90

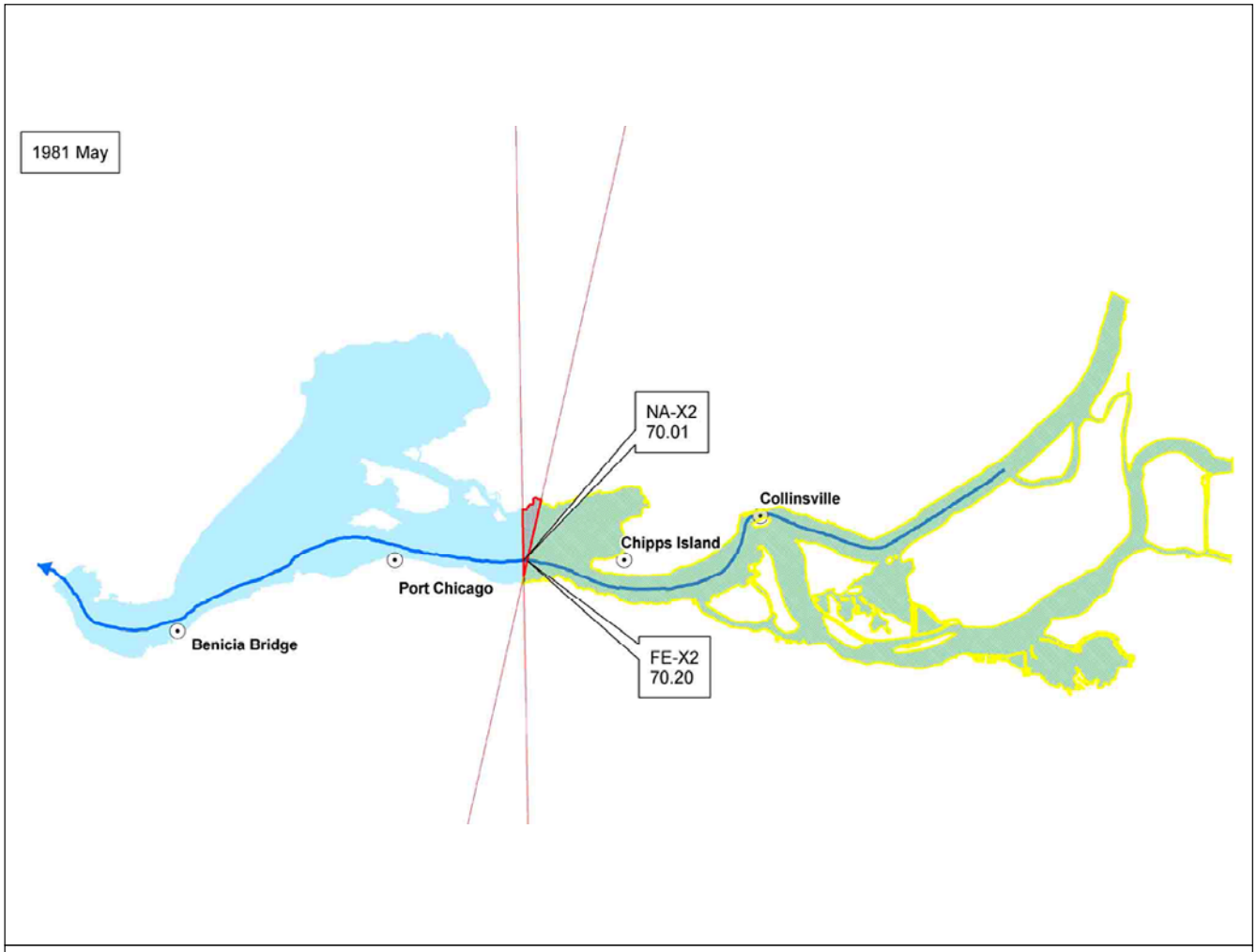

1980 average
NA-X2
72.48
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
72.48

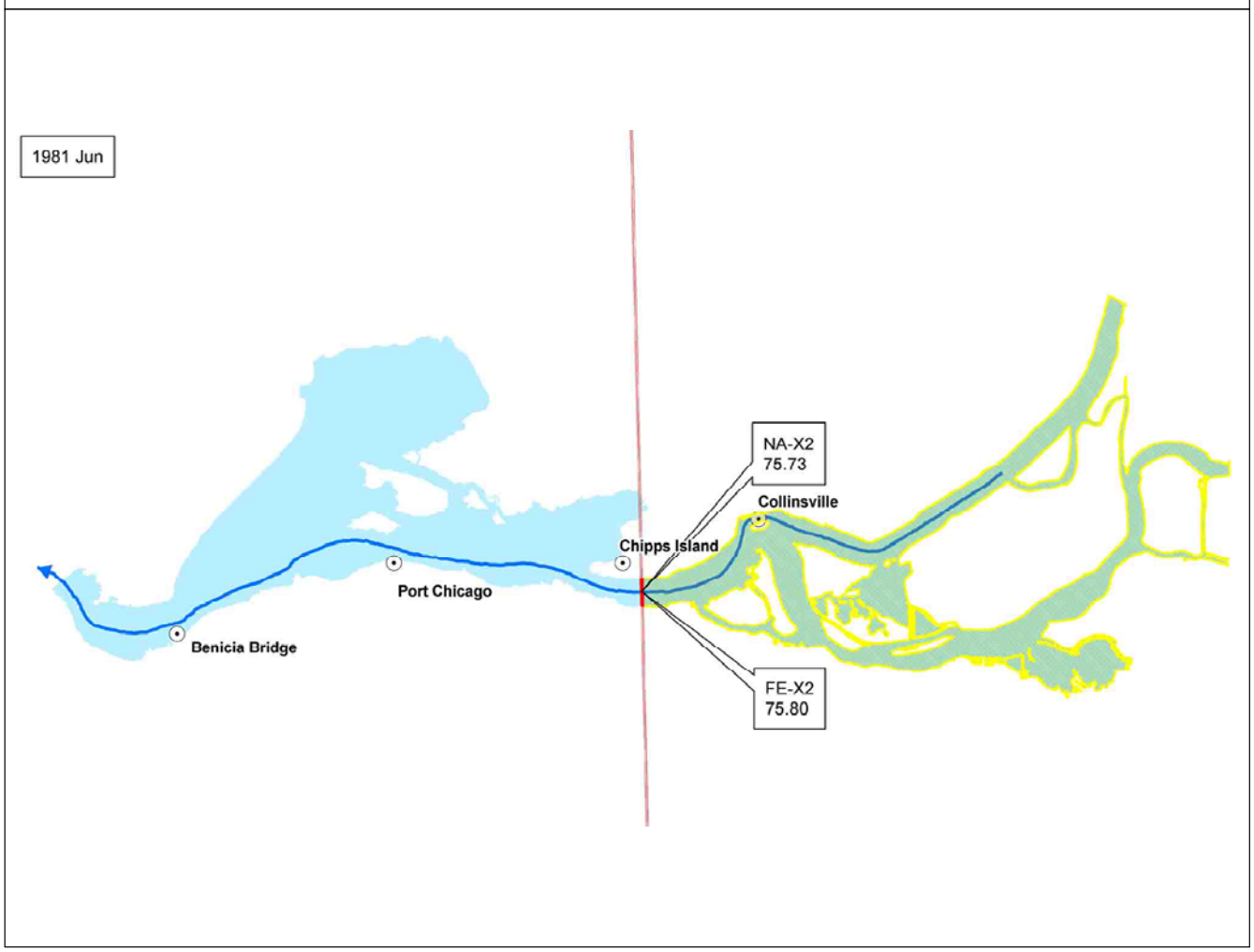

1981 Jan
NA-X2
82.95
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
82.63

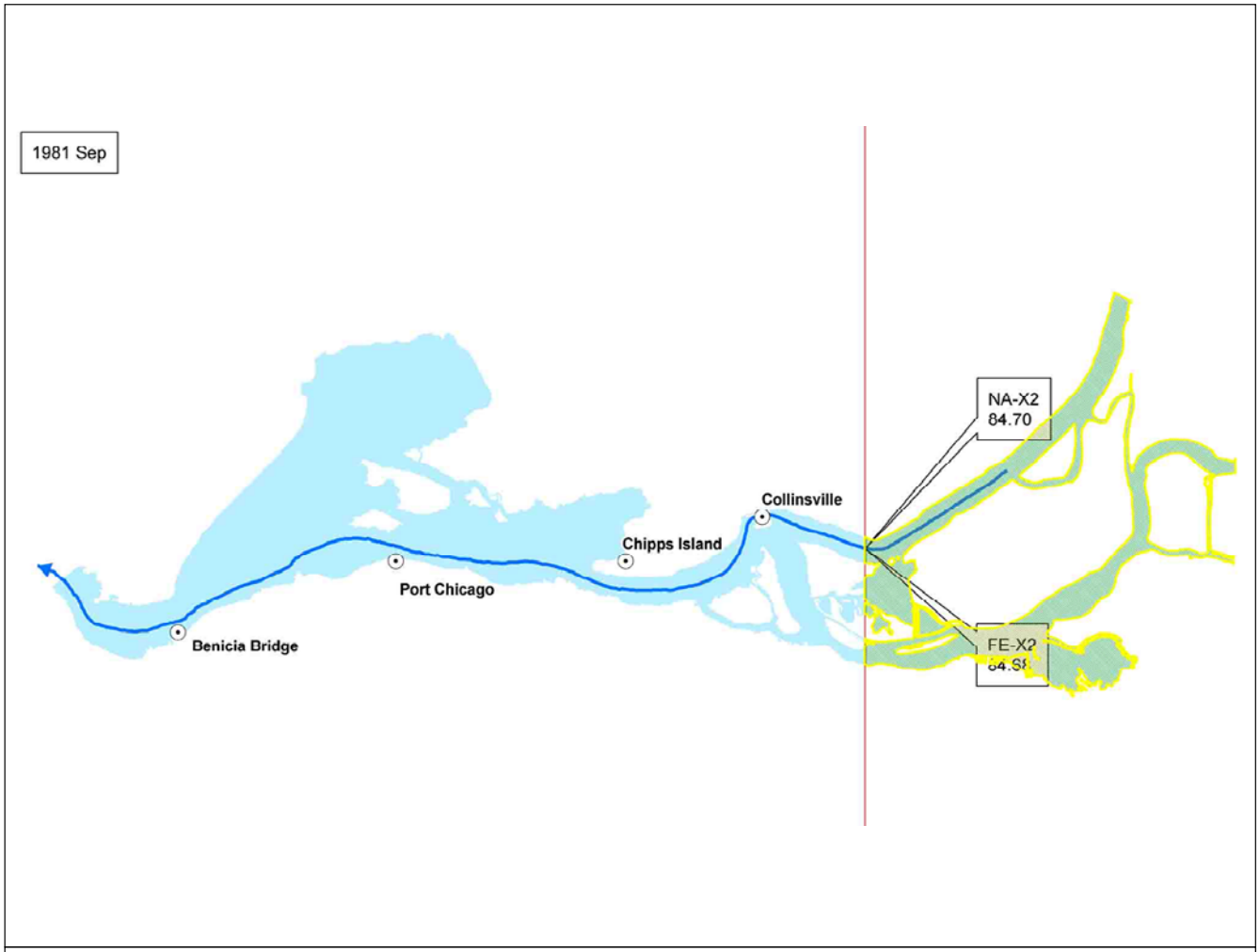

1981 Feb
NA-X2
74.83
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
75.05

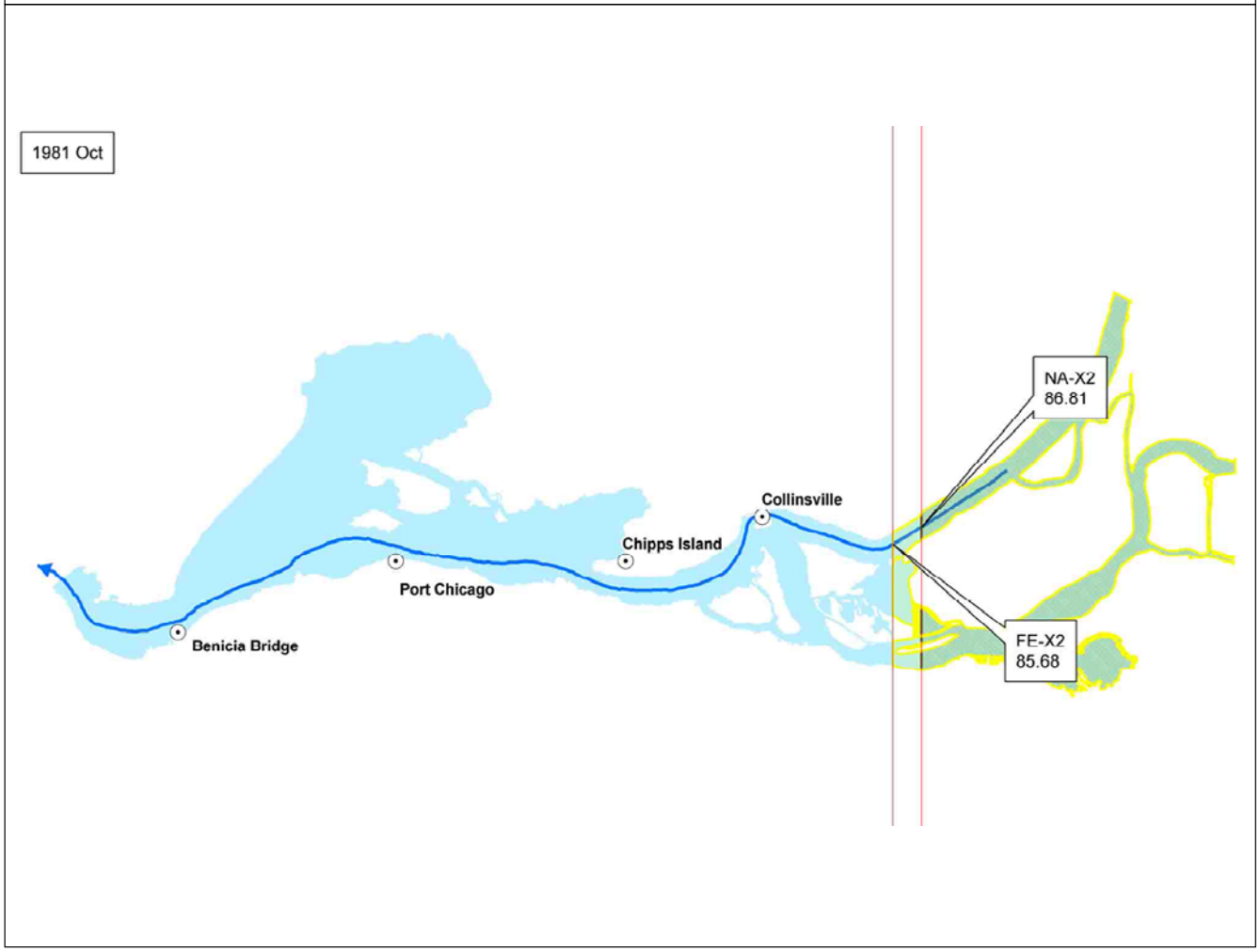

1981 Mar
NA-X2
69.68
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
69.84


1981 Apr
NA-X2
66.29
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
66.90


1981 May
NA-X2
70.01
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
70.20


1981 Jun
NA-X2
75.73
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
75.80

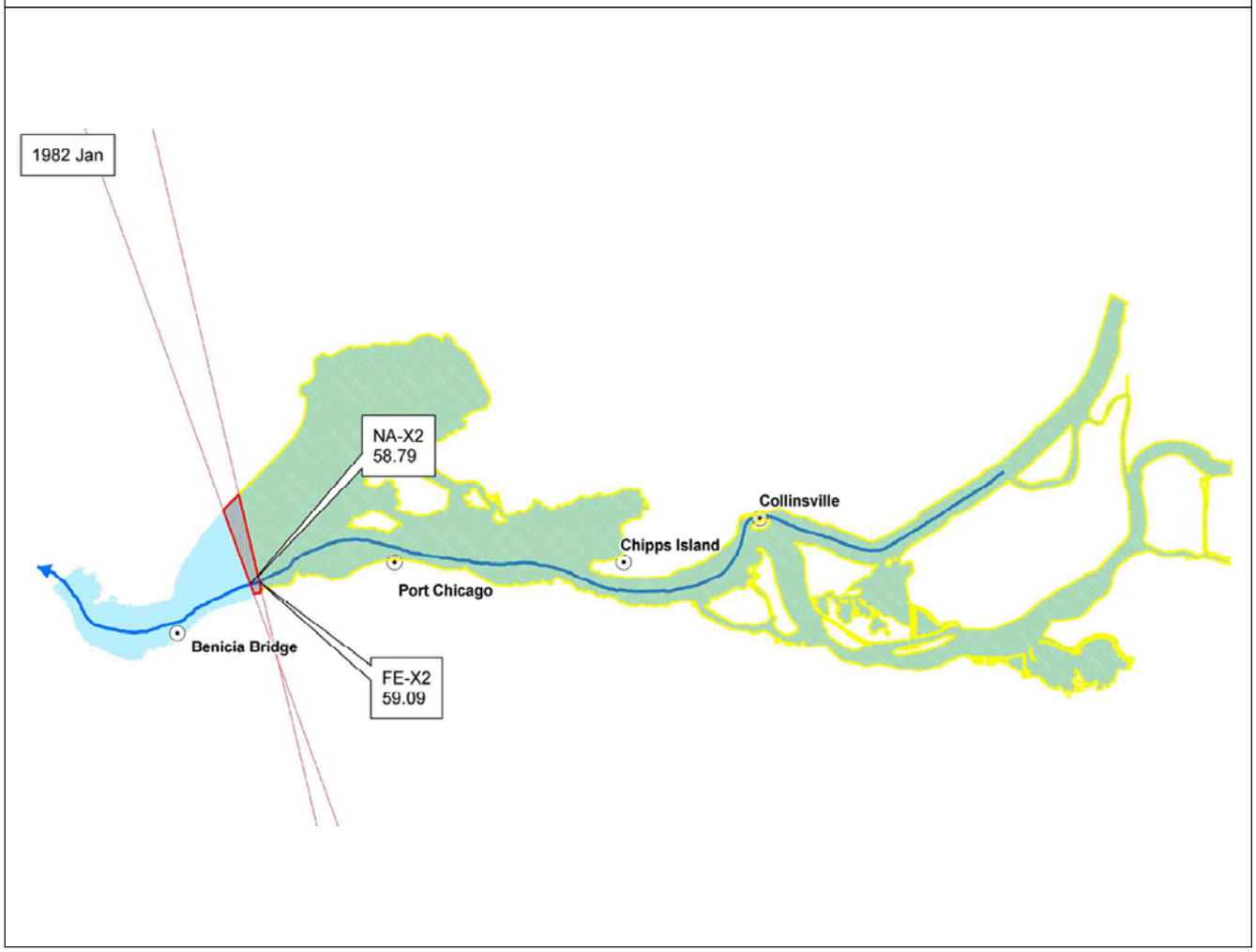

1981 Sep
NA-X2
84.70
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2

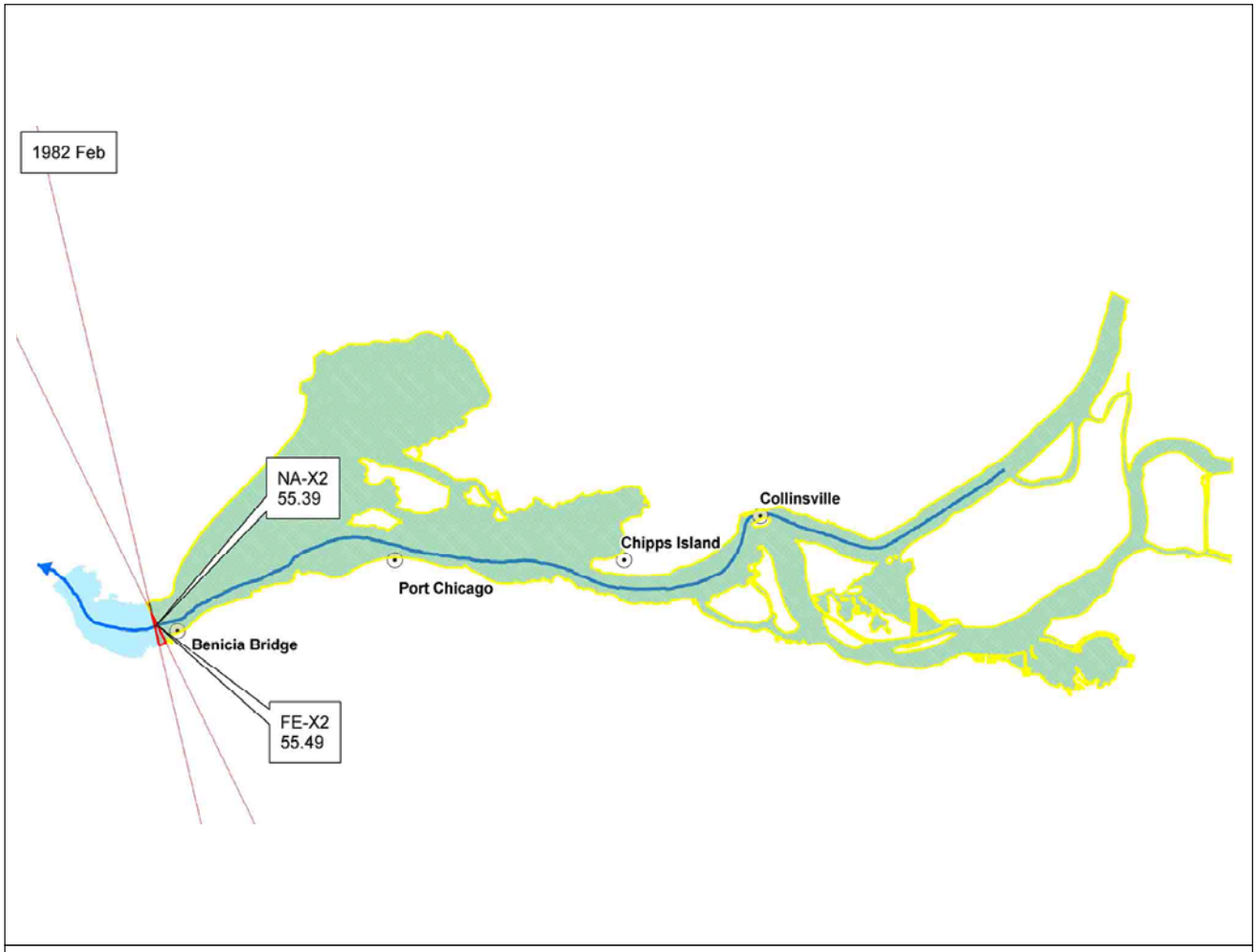

1981 Oct
NA-X2
86.81
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
85.68

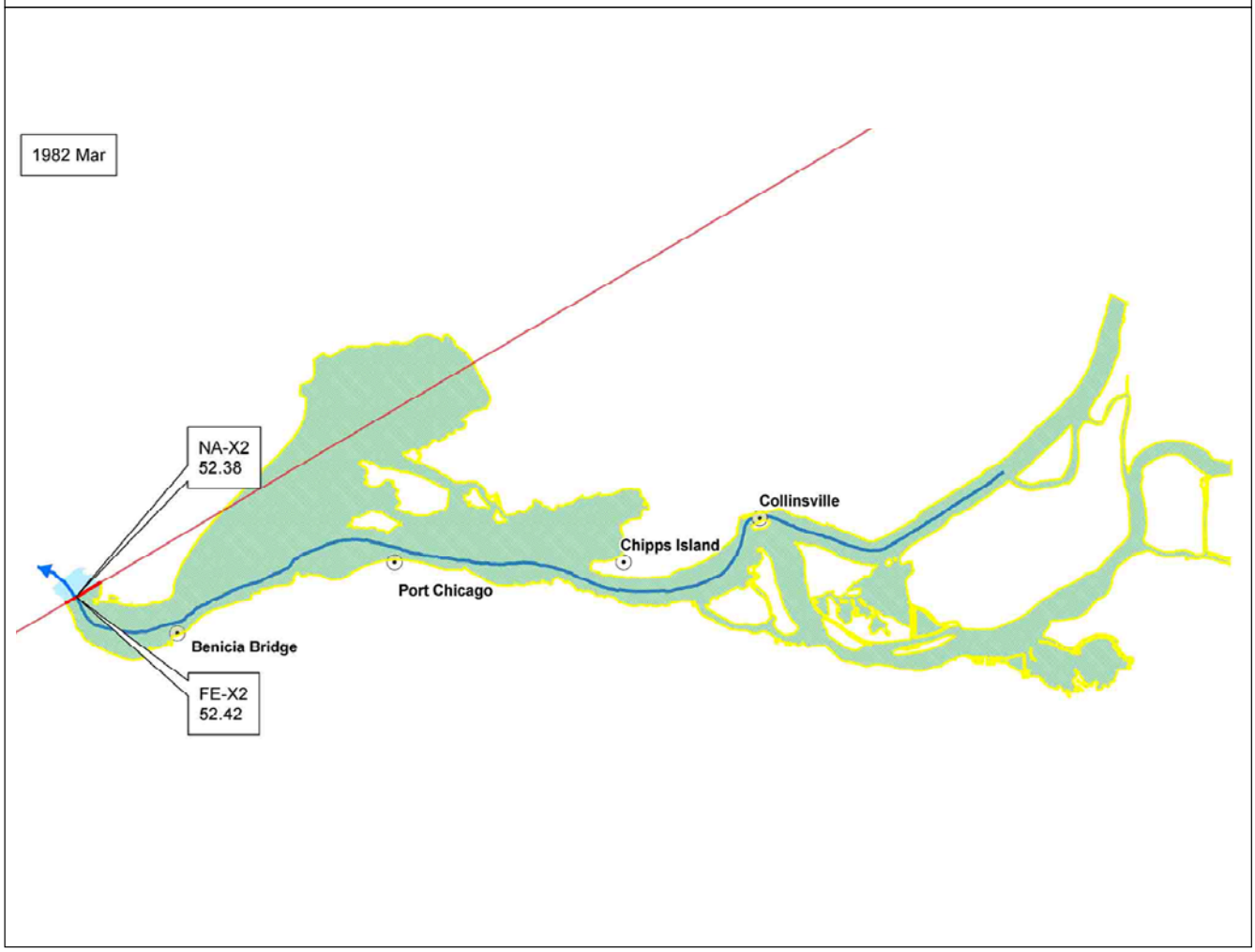

1981 Nov
NA-X2
87.08
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
86.70

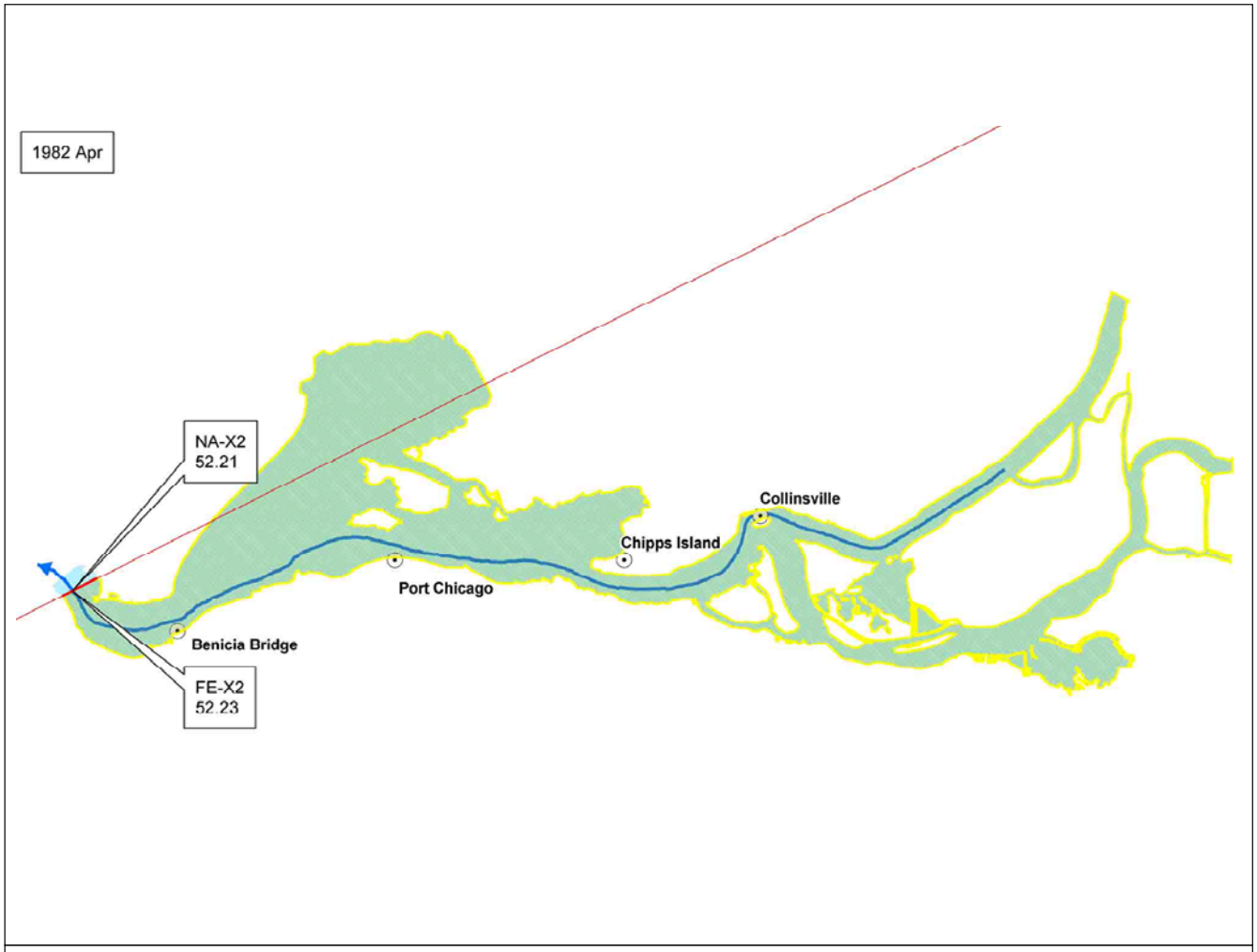

1981 Dec
NA-X2
85.26
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
85.35

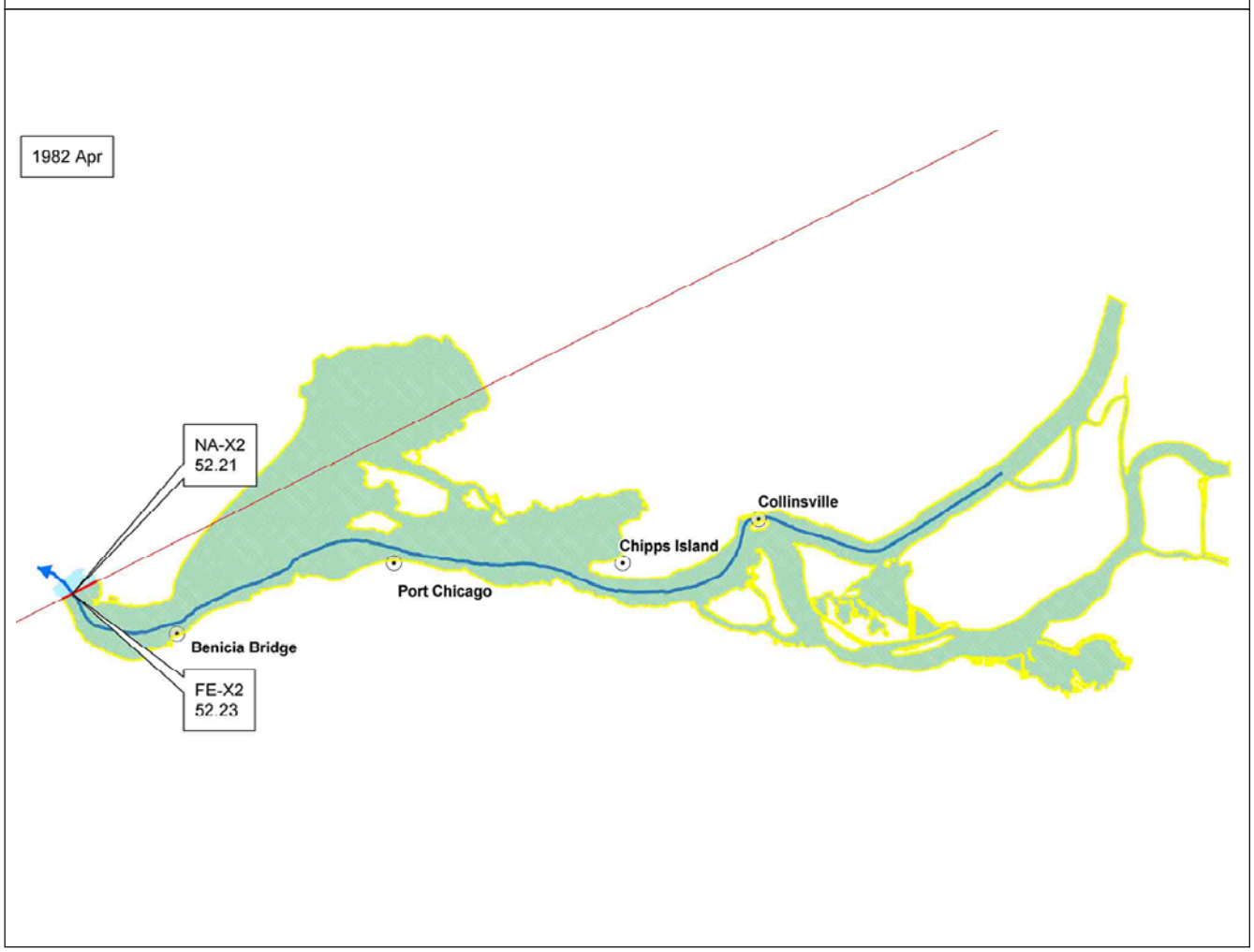

1981 average
NA-X2
78.98
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
78.94

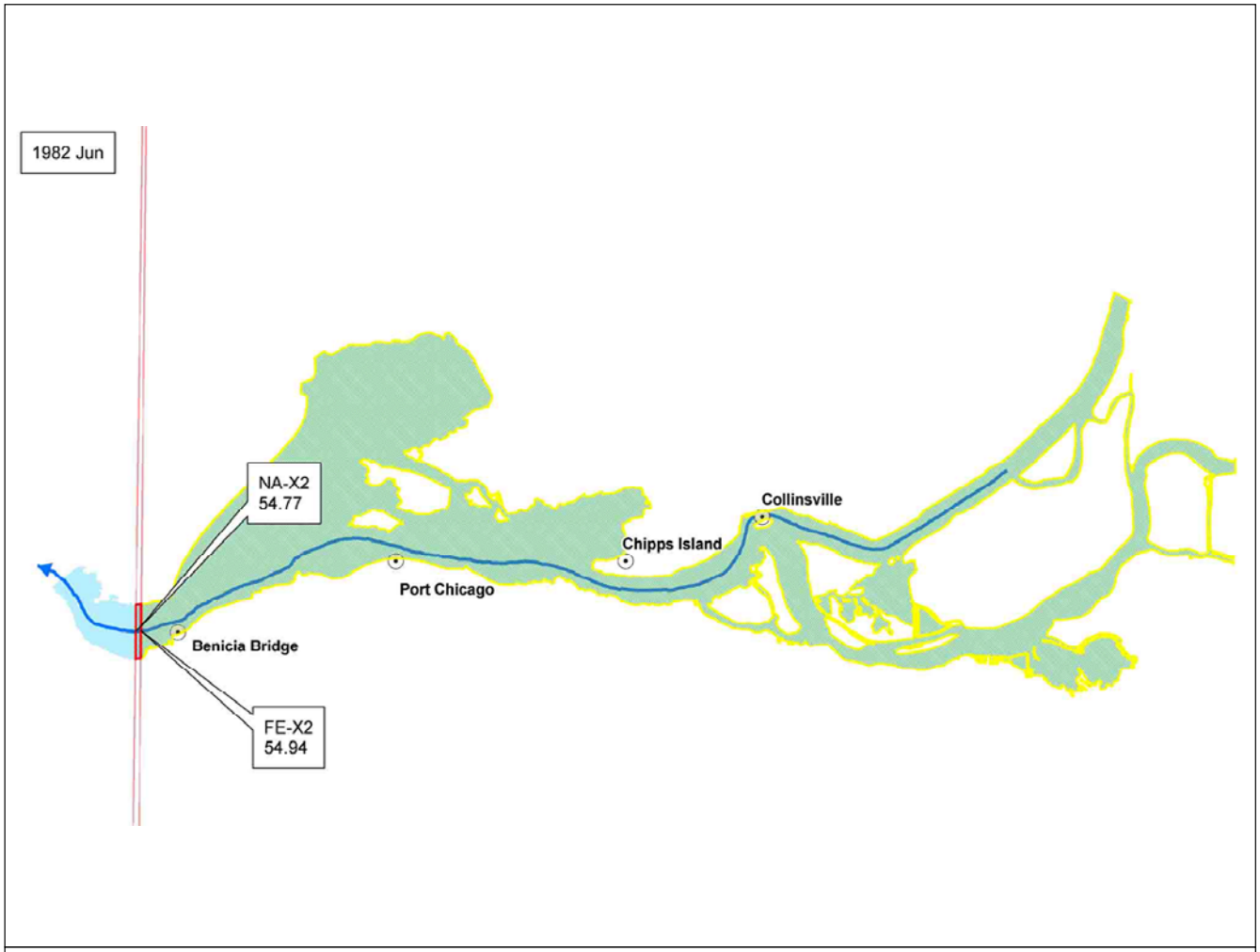

1982 Jan
NA-X2
58.79
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
59.09

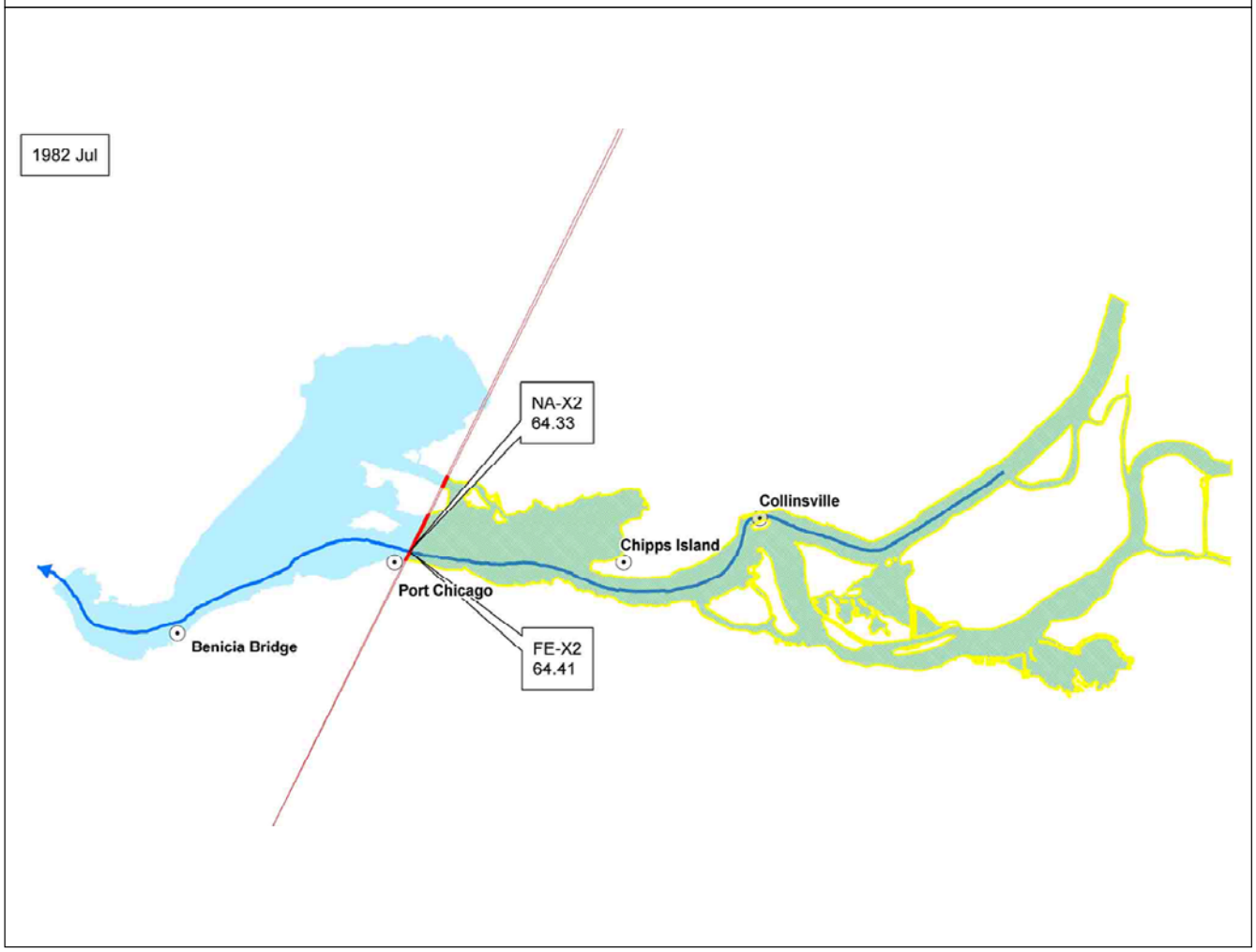

1982 Feb
NA-X2
55.39
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
55.49


1982 Mar
NA-X2
52.38
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
52.42


1982 Apr
NA-X2
52.21
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
52.23

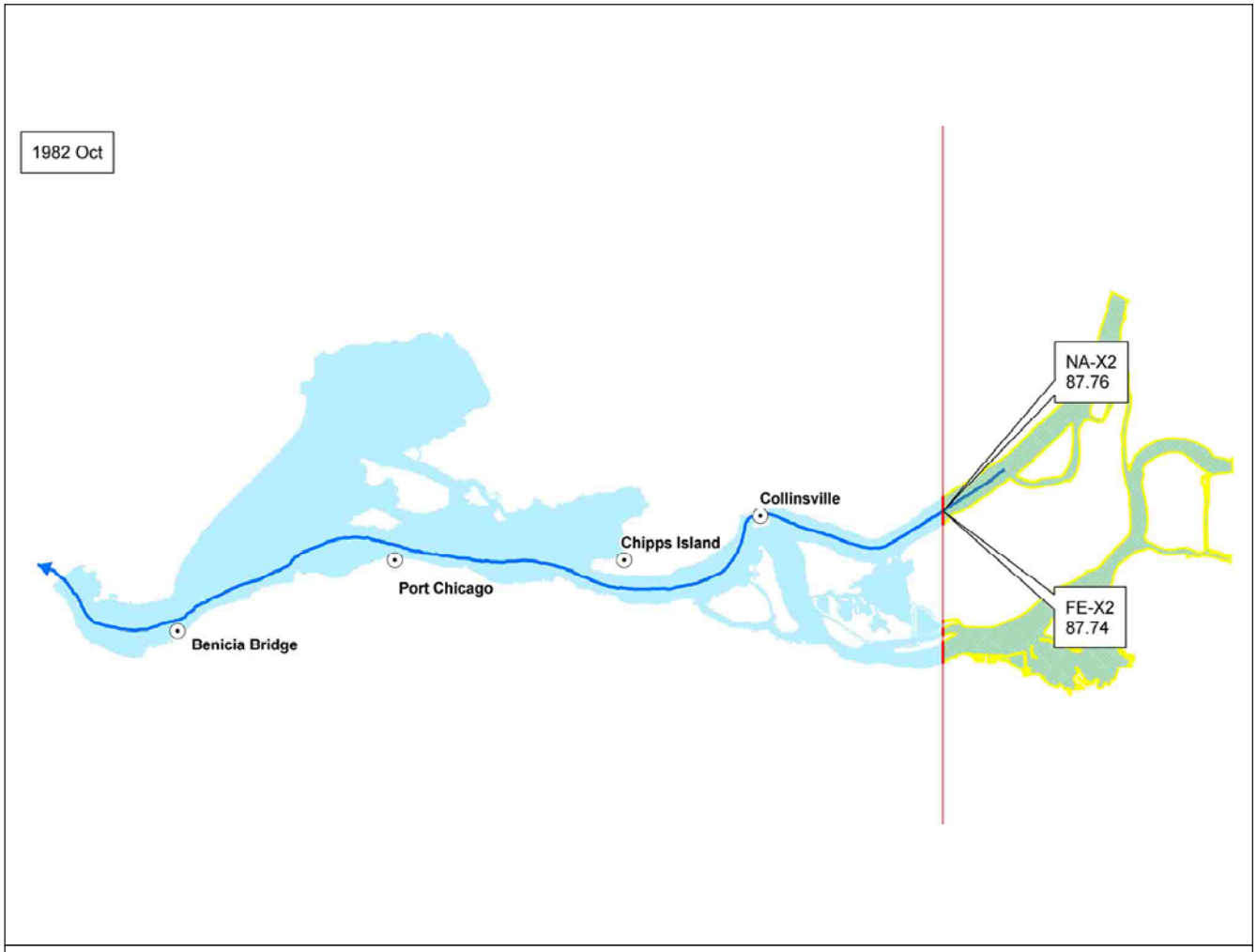

1982 Apr
NA-X2
52.21
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
52.23


1982 Jun
NA-X2
54.77
FE-X2
54.94
Benicia Bridge
Port Chicago
Chipps Island
Collinsville


1982 Jul
NA-X2
64.33
FE-X2
64.41
Benicia Bridge
Port Chicago
Chipps Island
Collinsville

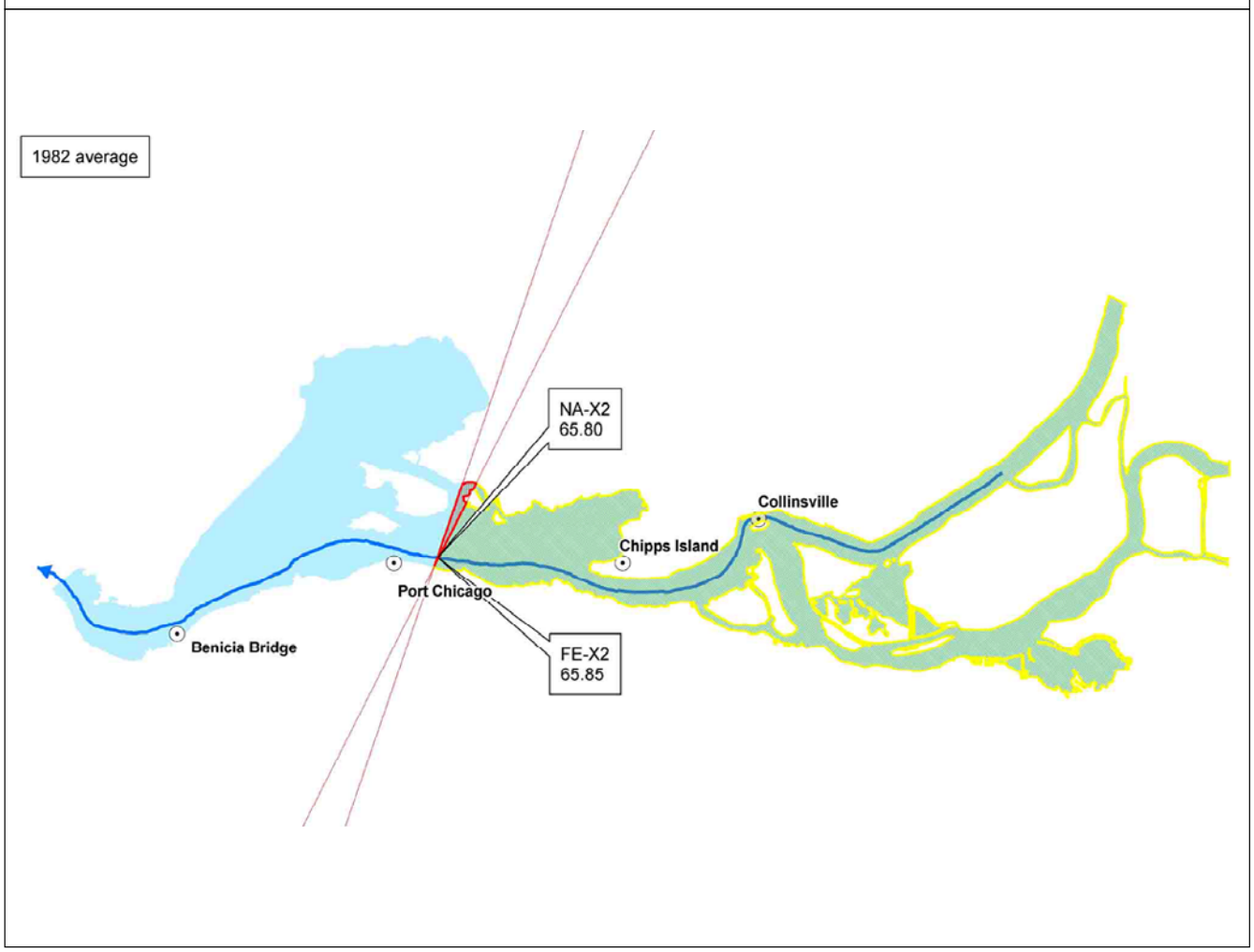

1982 Aug
NA-X2
74.40
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
74.42

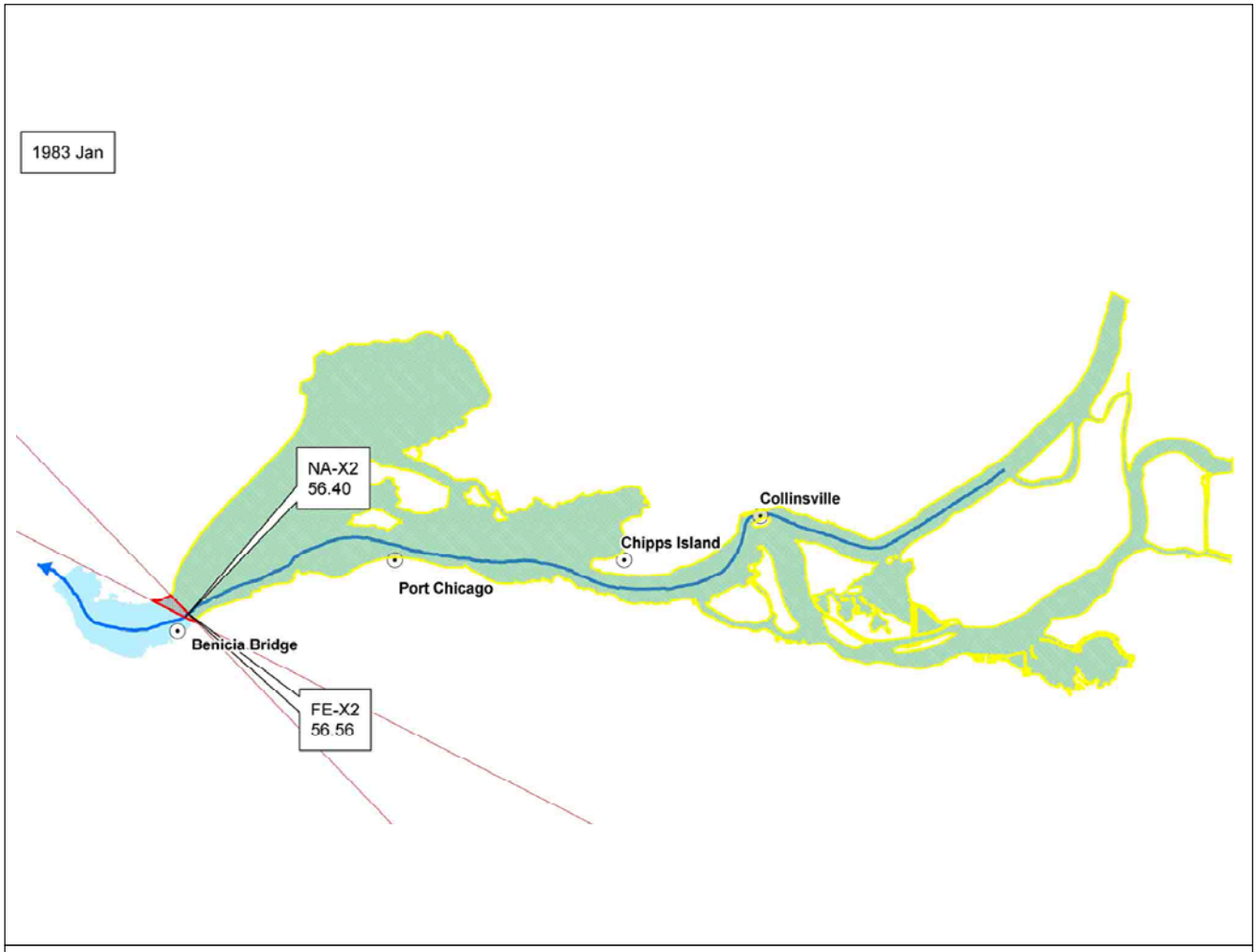

1982 Sep
NA-X2
83.01
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
82.35

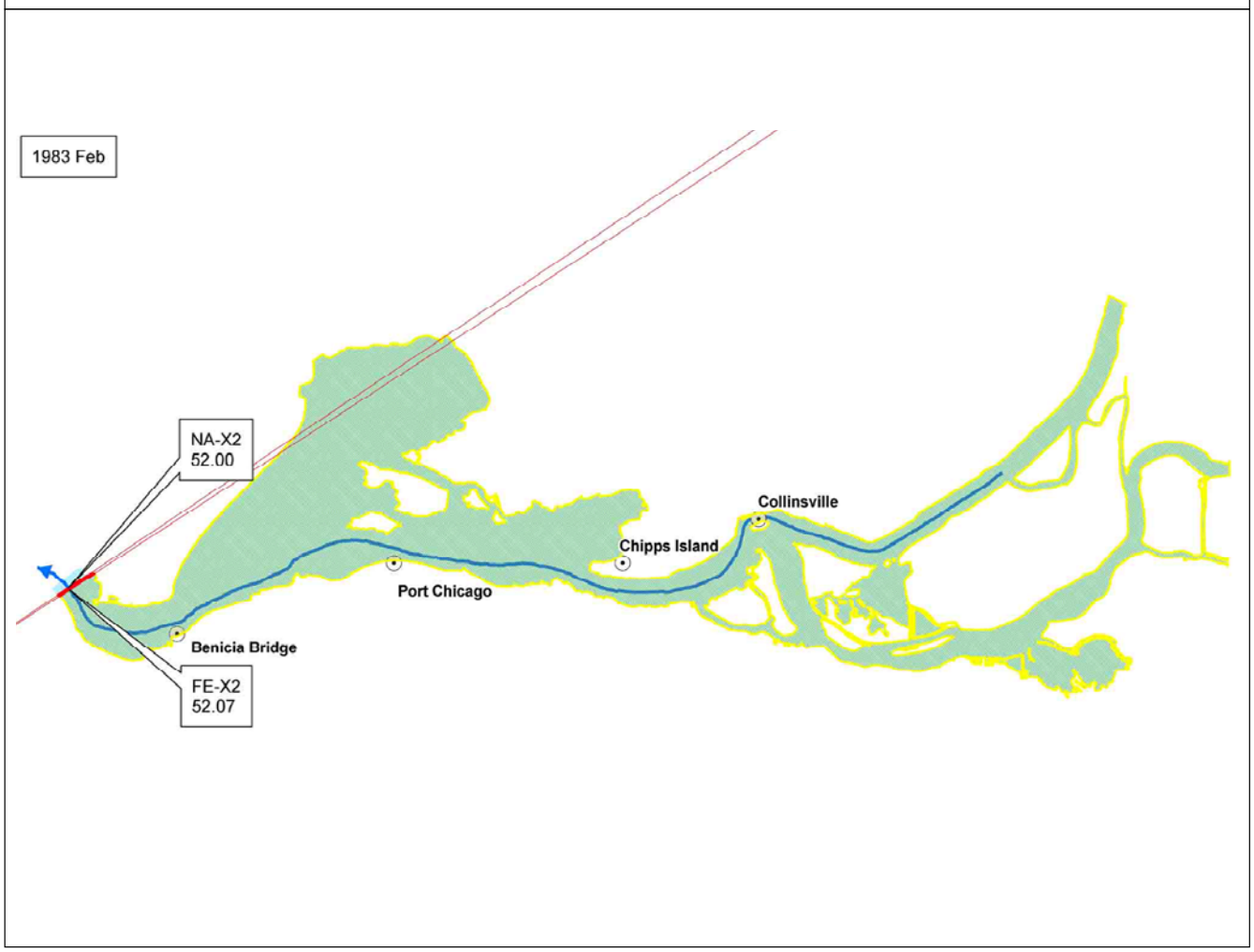

1982 Oct
NA-X2
87.76
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
87.74

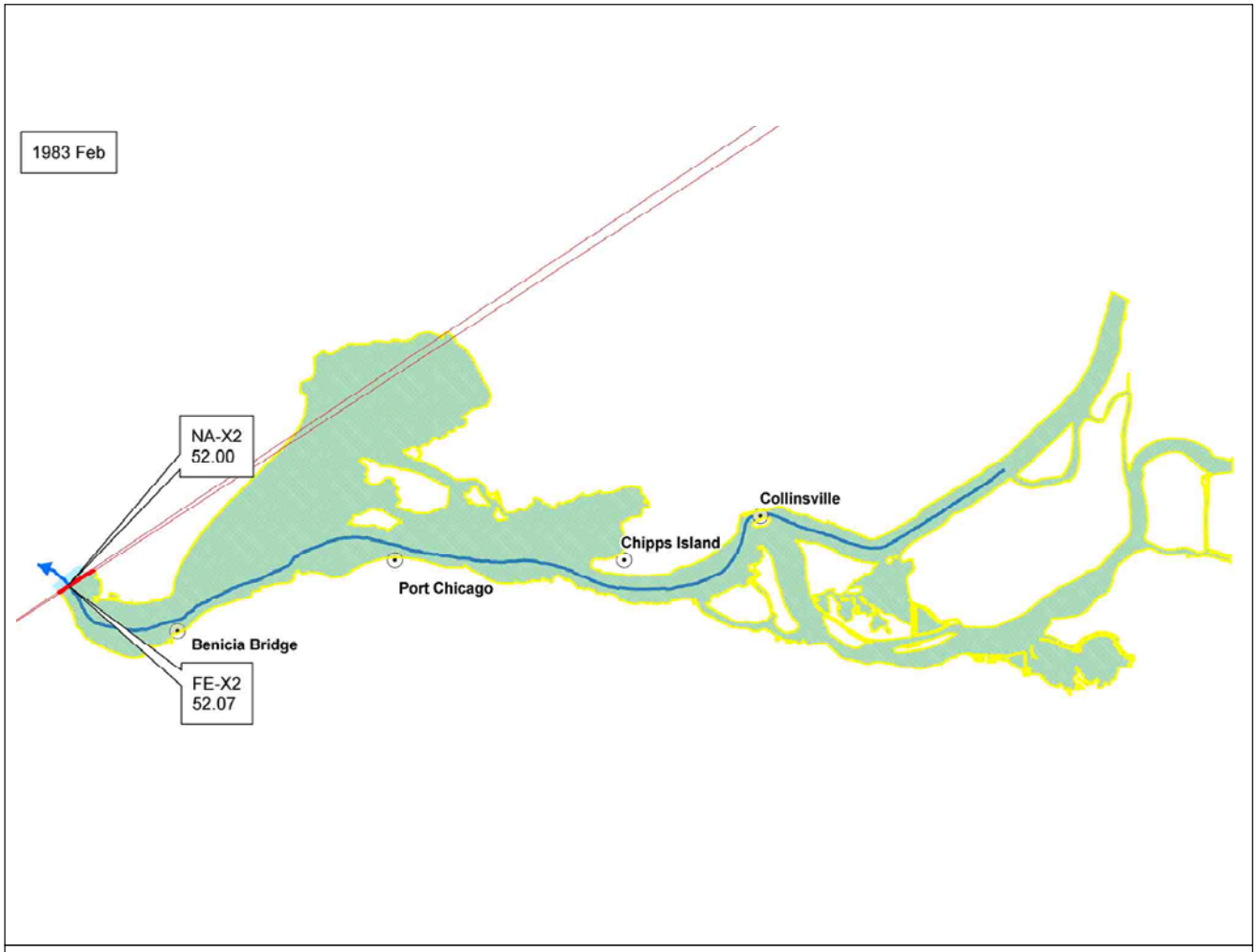

1982 Nov
NA-X2
85.72
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
85.59

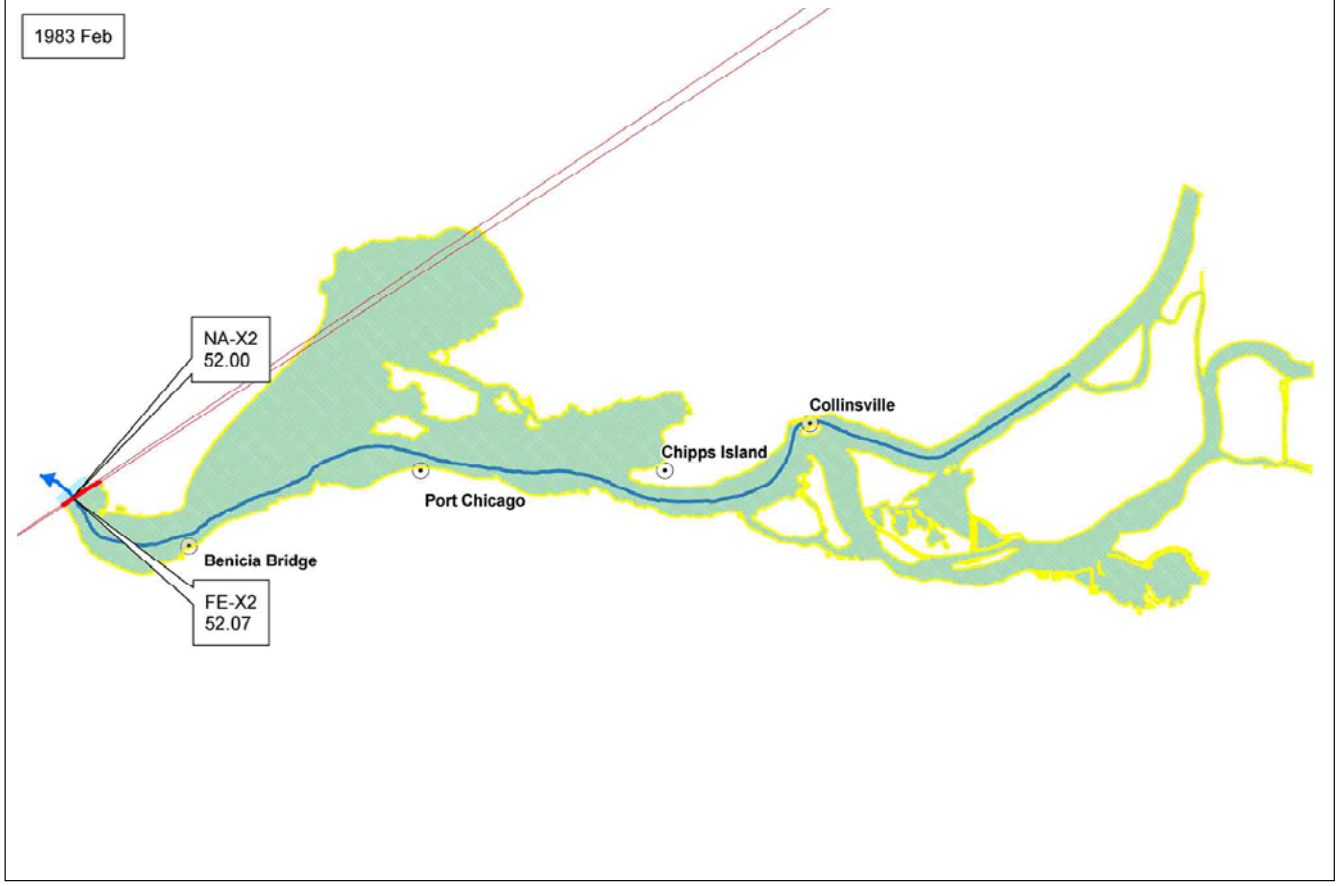

1982 Dec
NA-X2
72.27
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
72.96

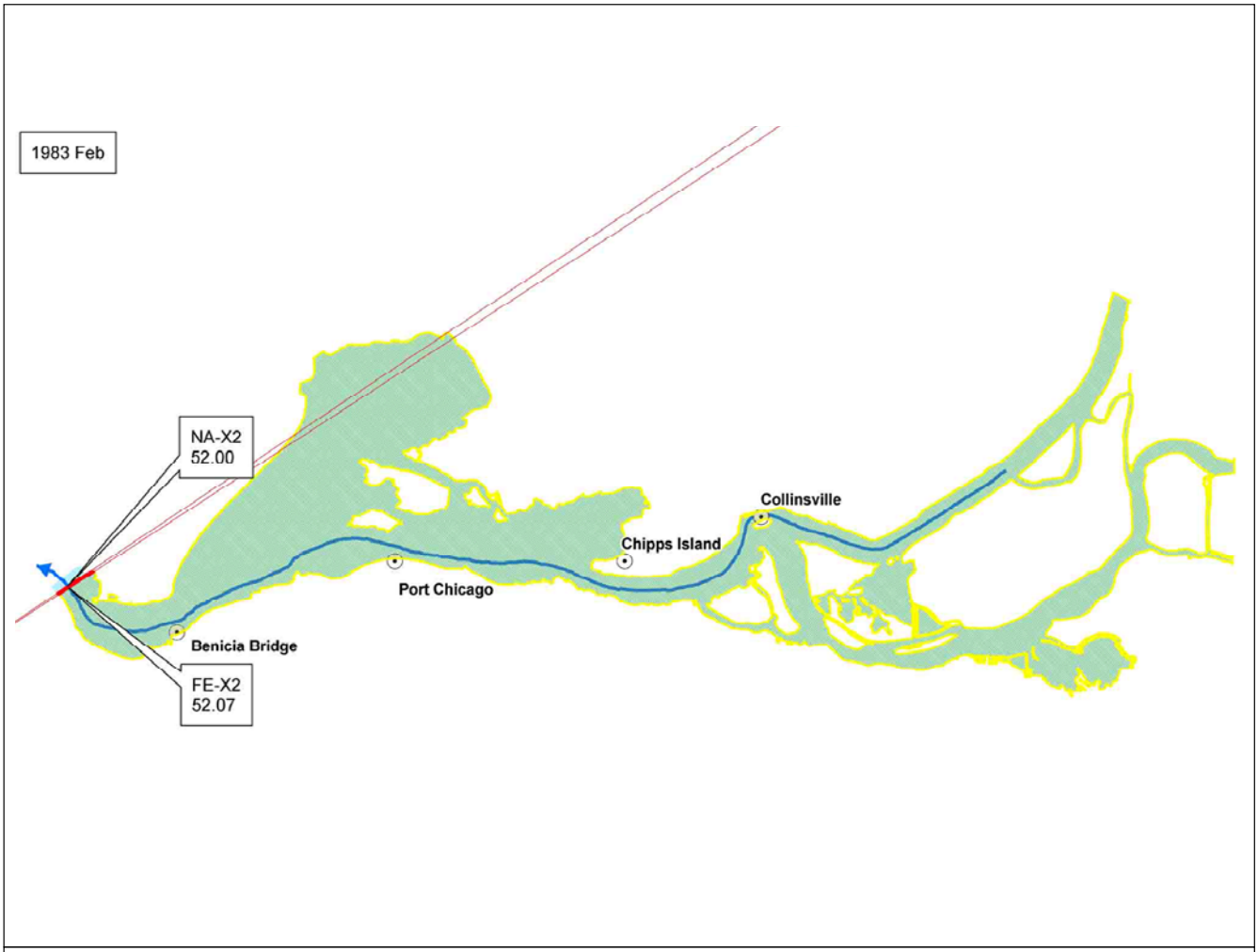

1982 average
NA-X2
65.80
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
65.85

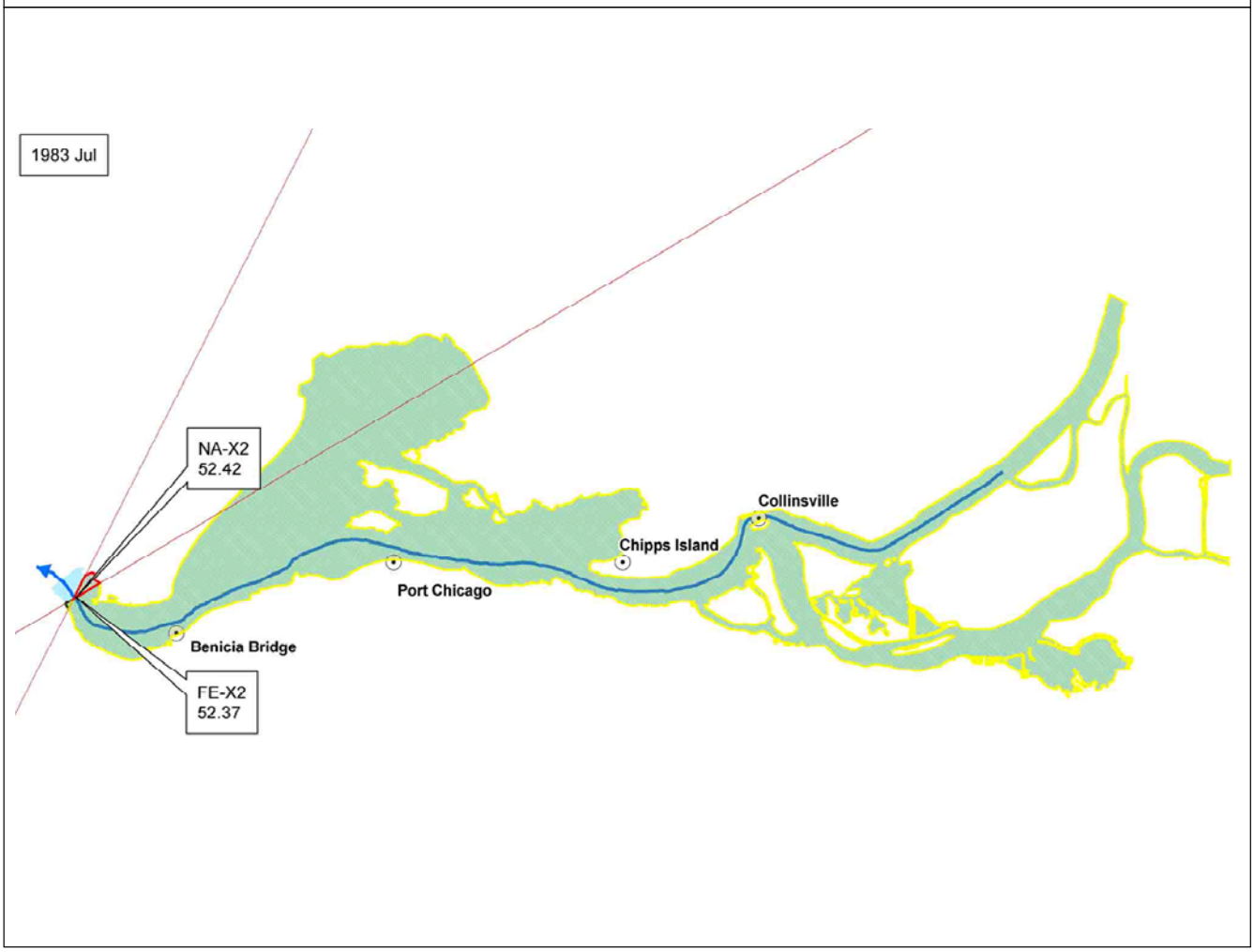

1983 Jan
NA-X2
56.40
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
56.56

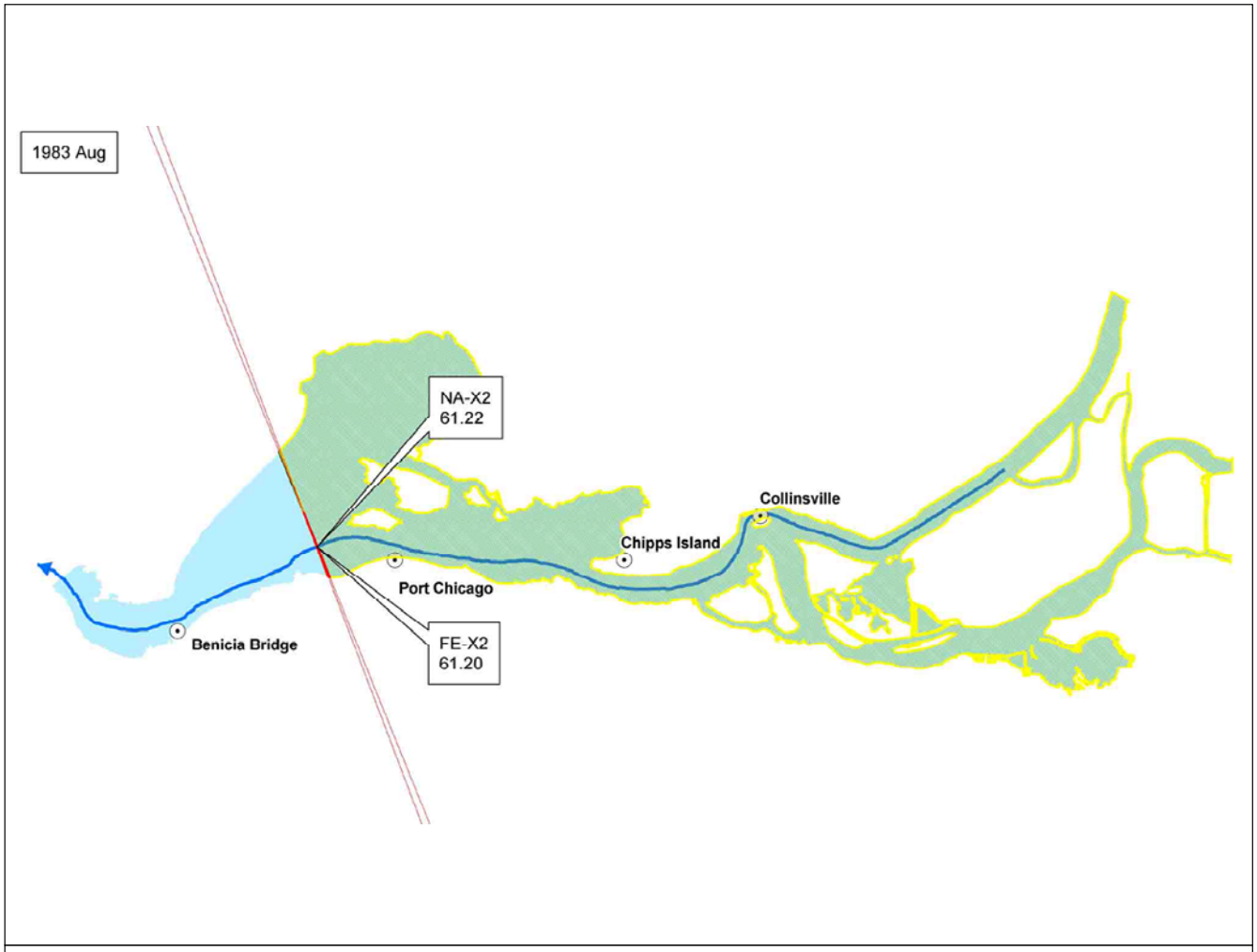

1983 Feb
NA-X2
52.00
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
52.07

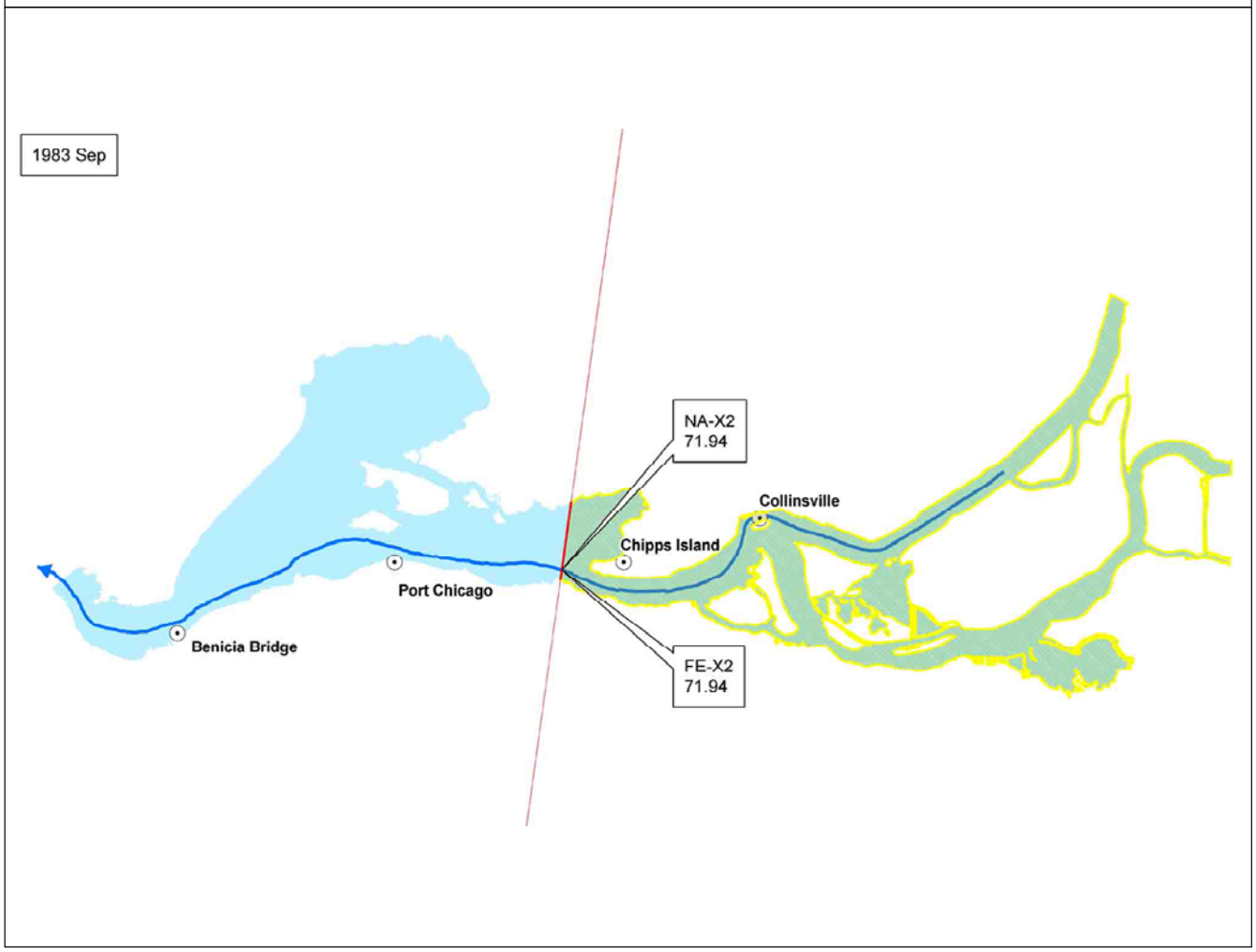

1983 Feb
NA-X2
52.00
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
52.07

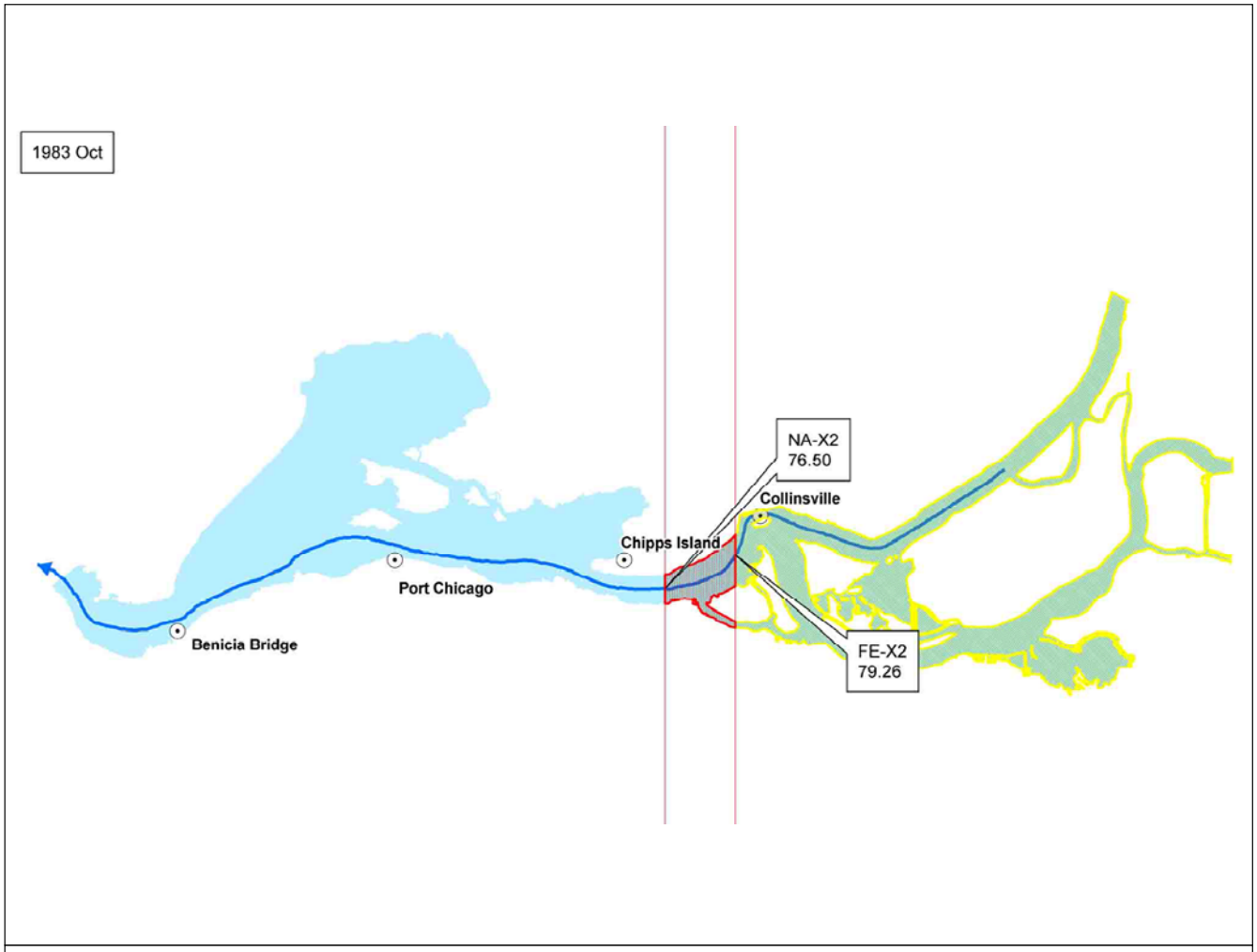

1983 Feb
NA-X2
52.00
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
52.07

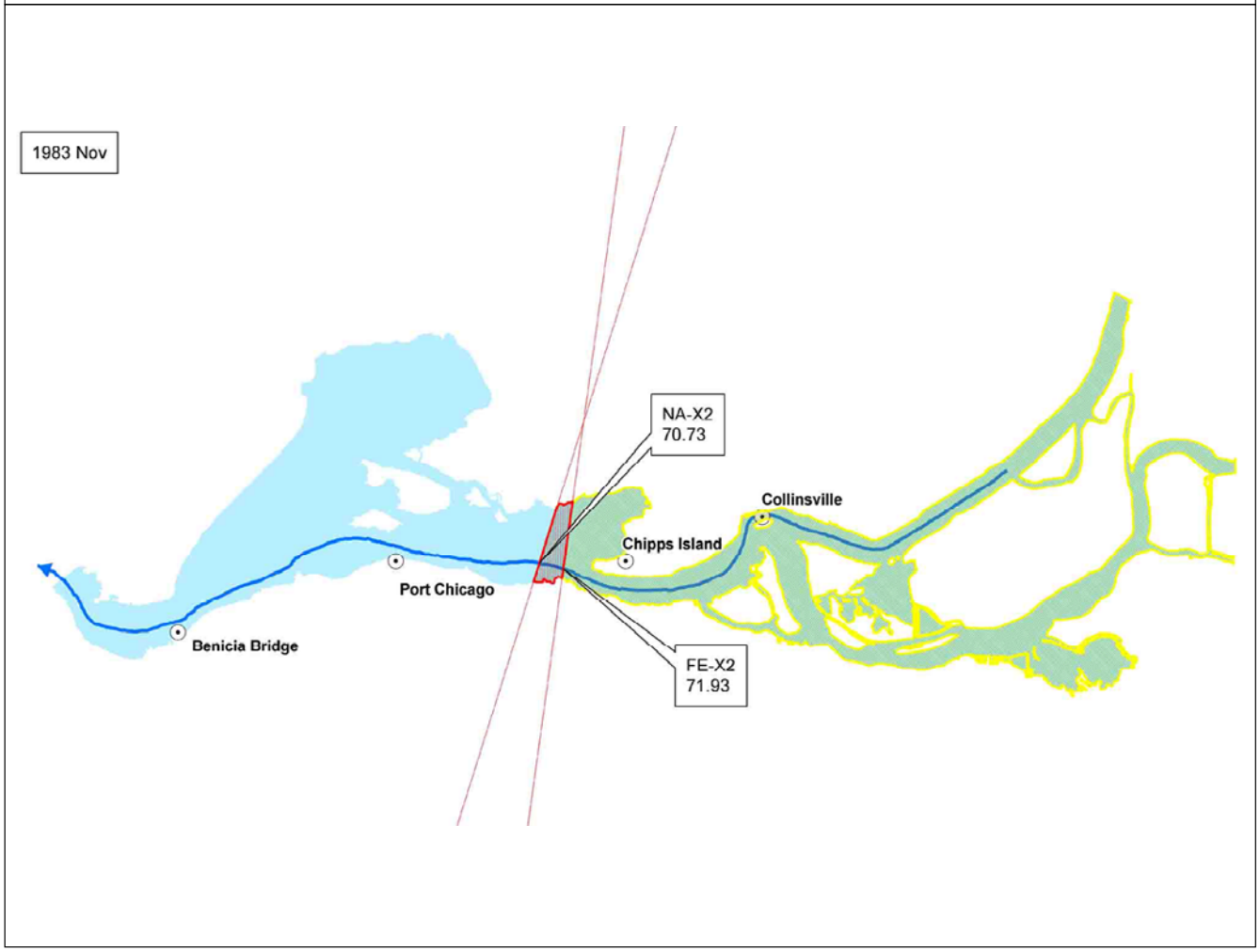

1983 Feb
NA-X2
52.00
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
52.07

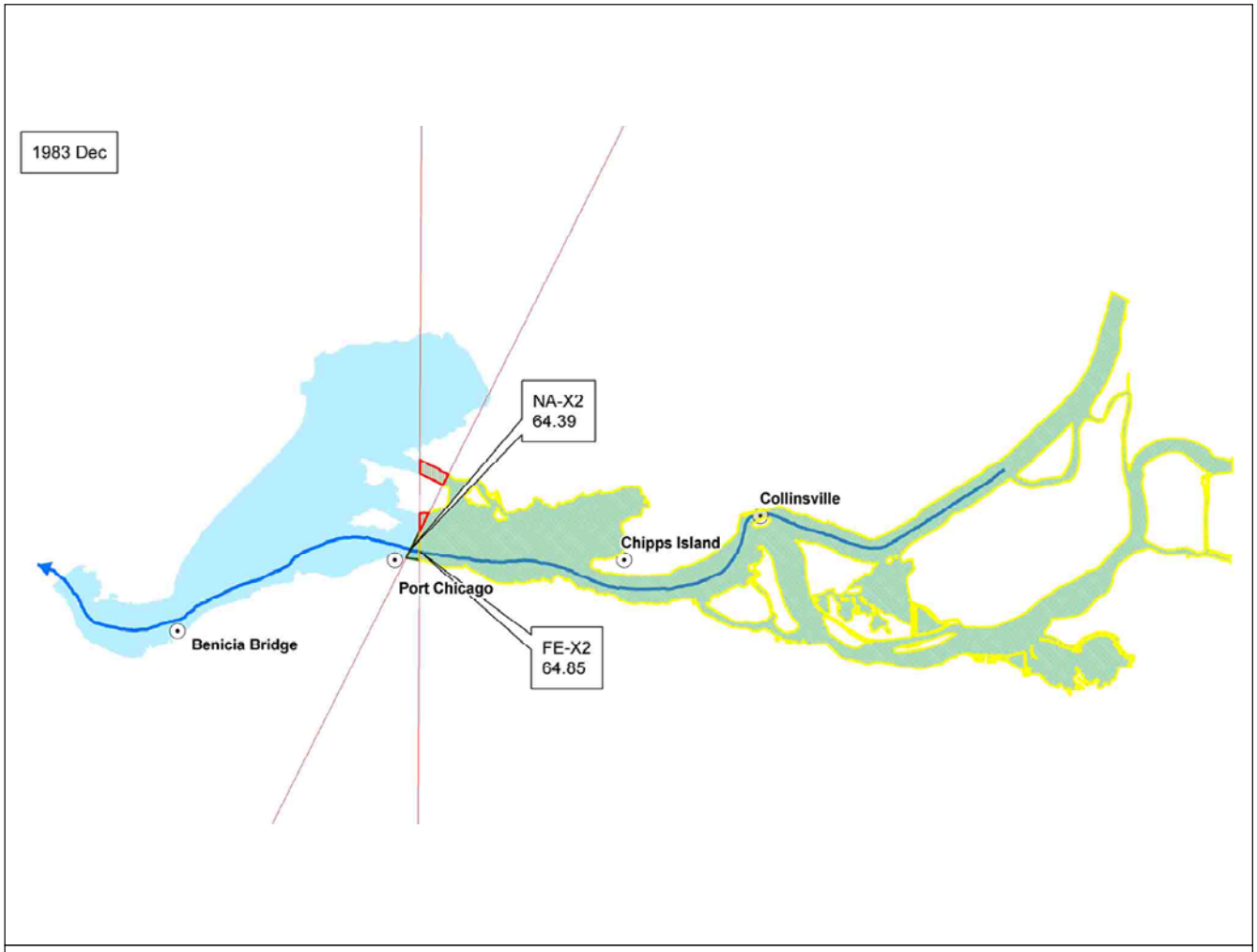

1983 Jul
NA-X2
52.42
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
52.37

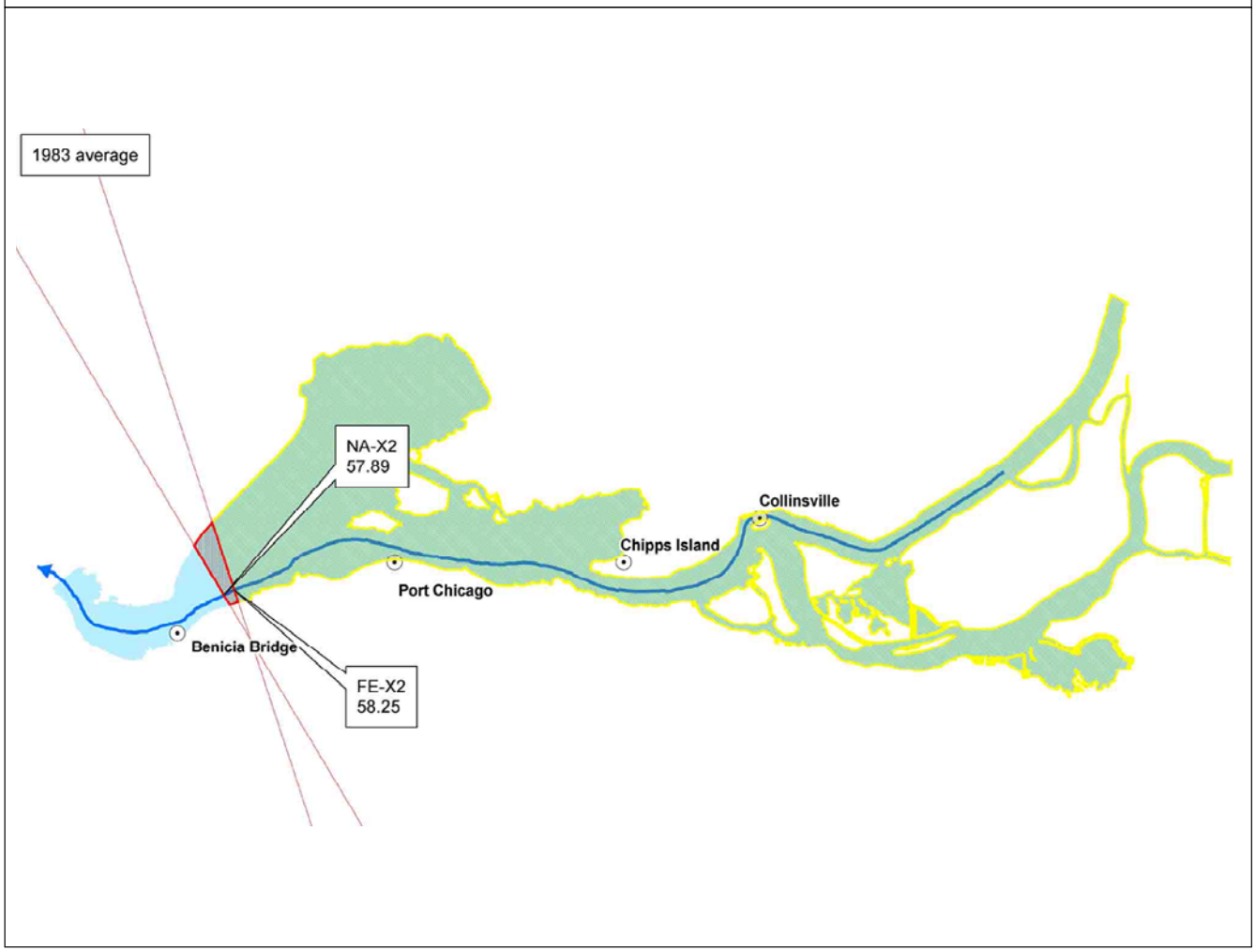

1983 Aug
NA-X2
61.22
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
61.20

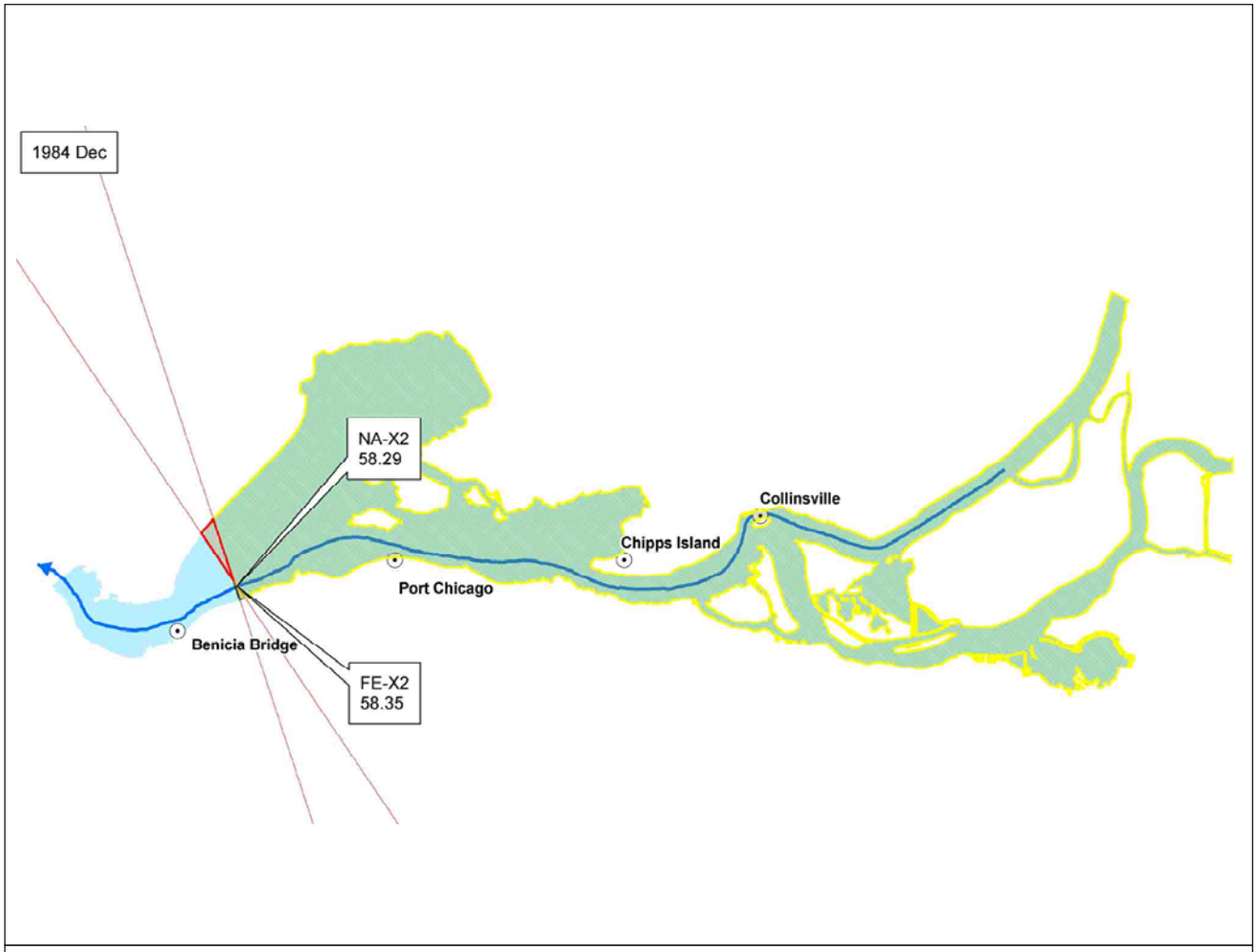

1983 Sep
NA-X2
71.94
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
71.94

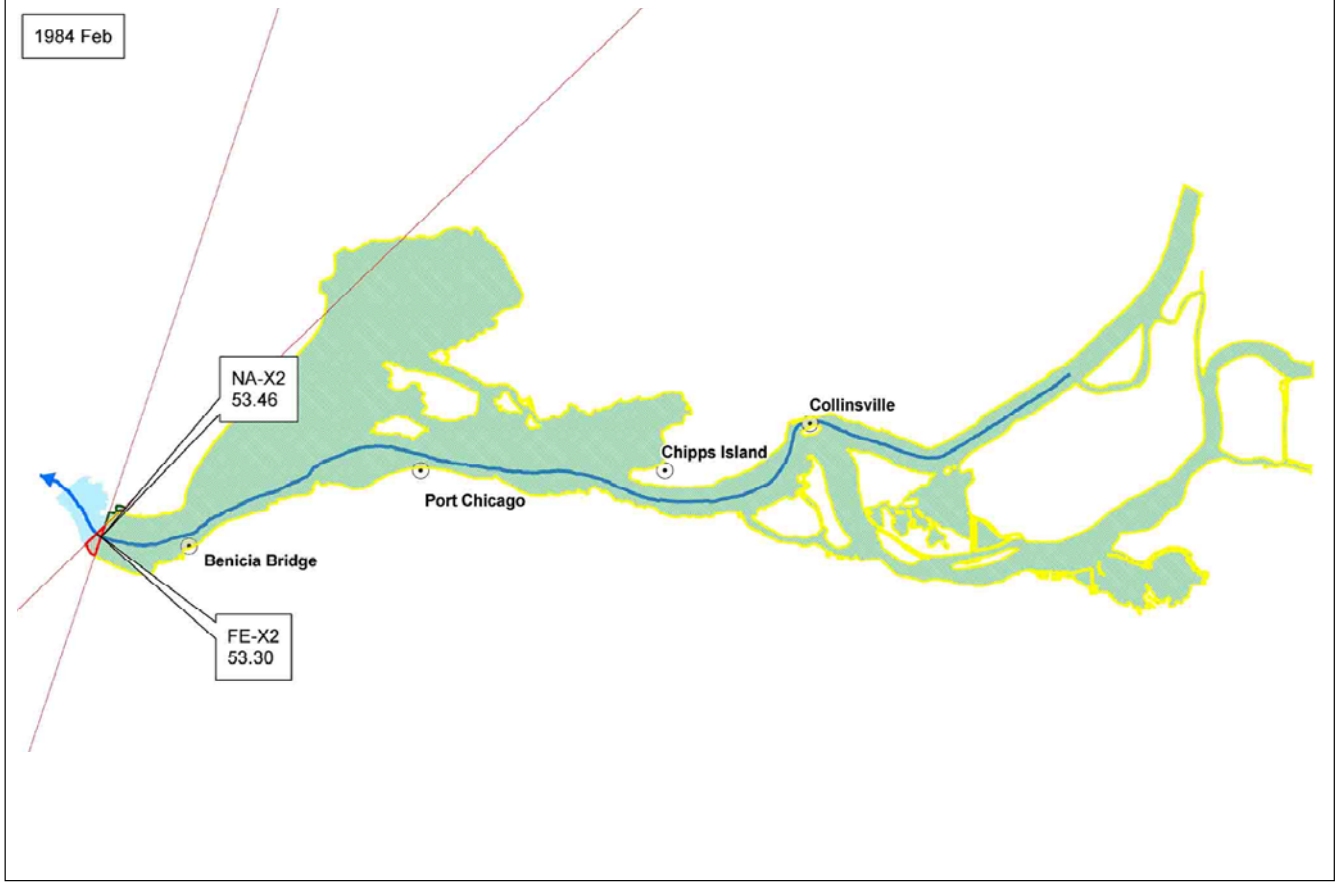

1983 Oct
NA-X2
76.50
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
79.26

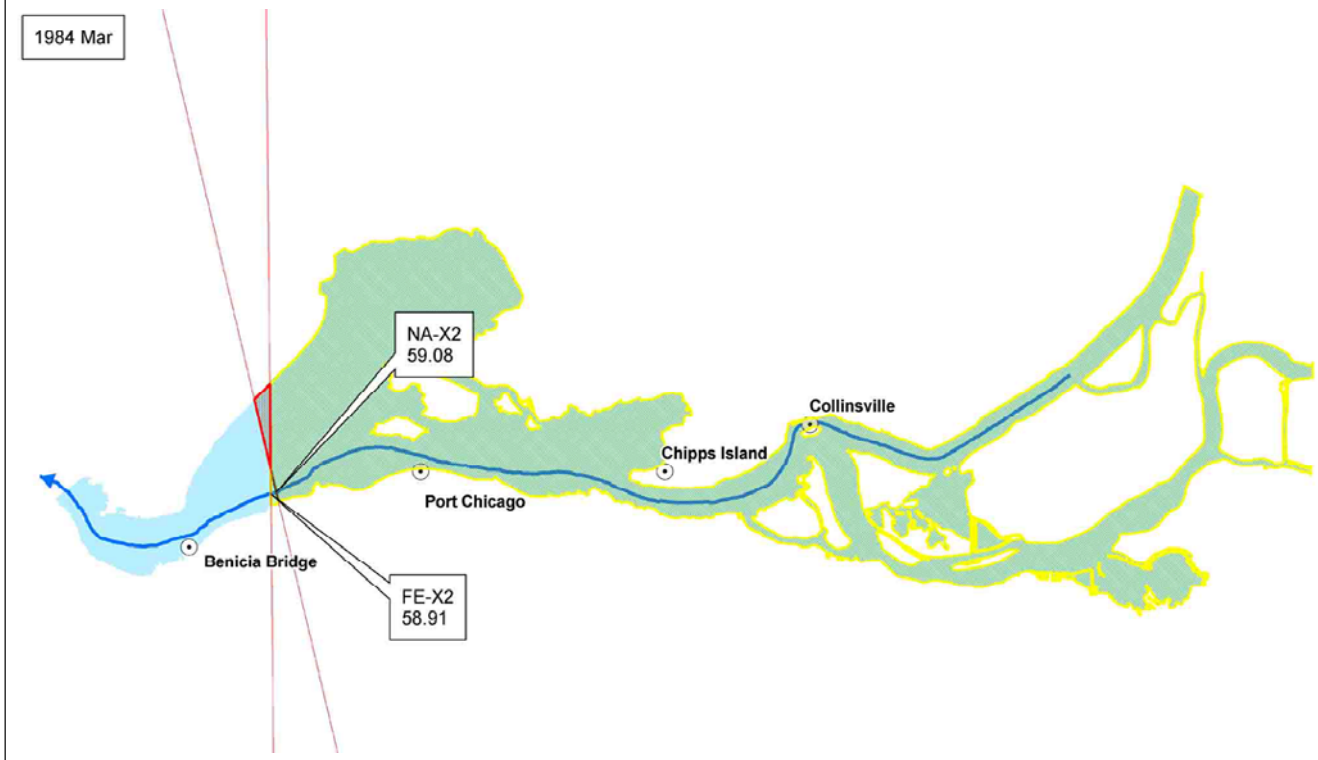

1983 Nov
NA-X2
70.73
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
71.93

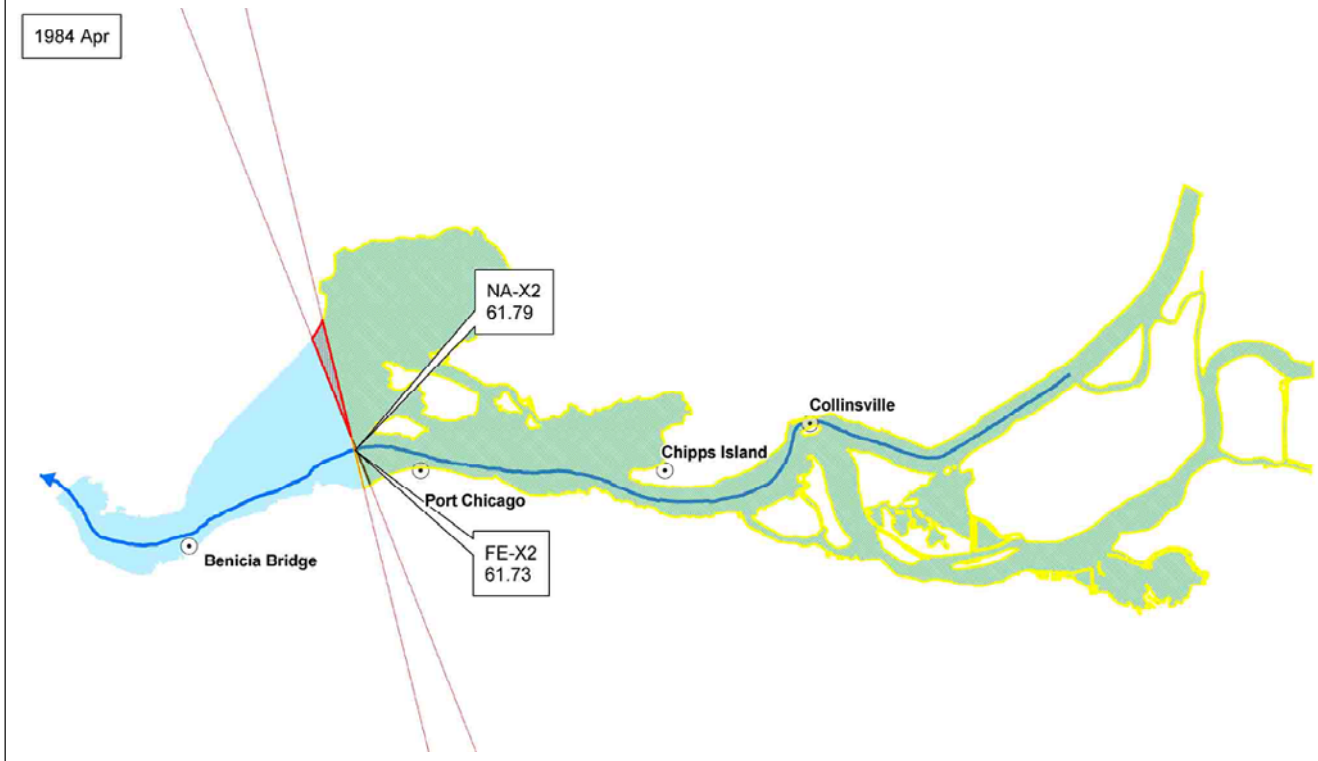

1983 Dec
NA-X2
64.39
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
64.85

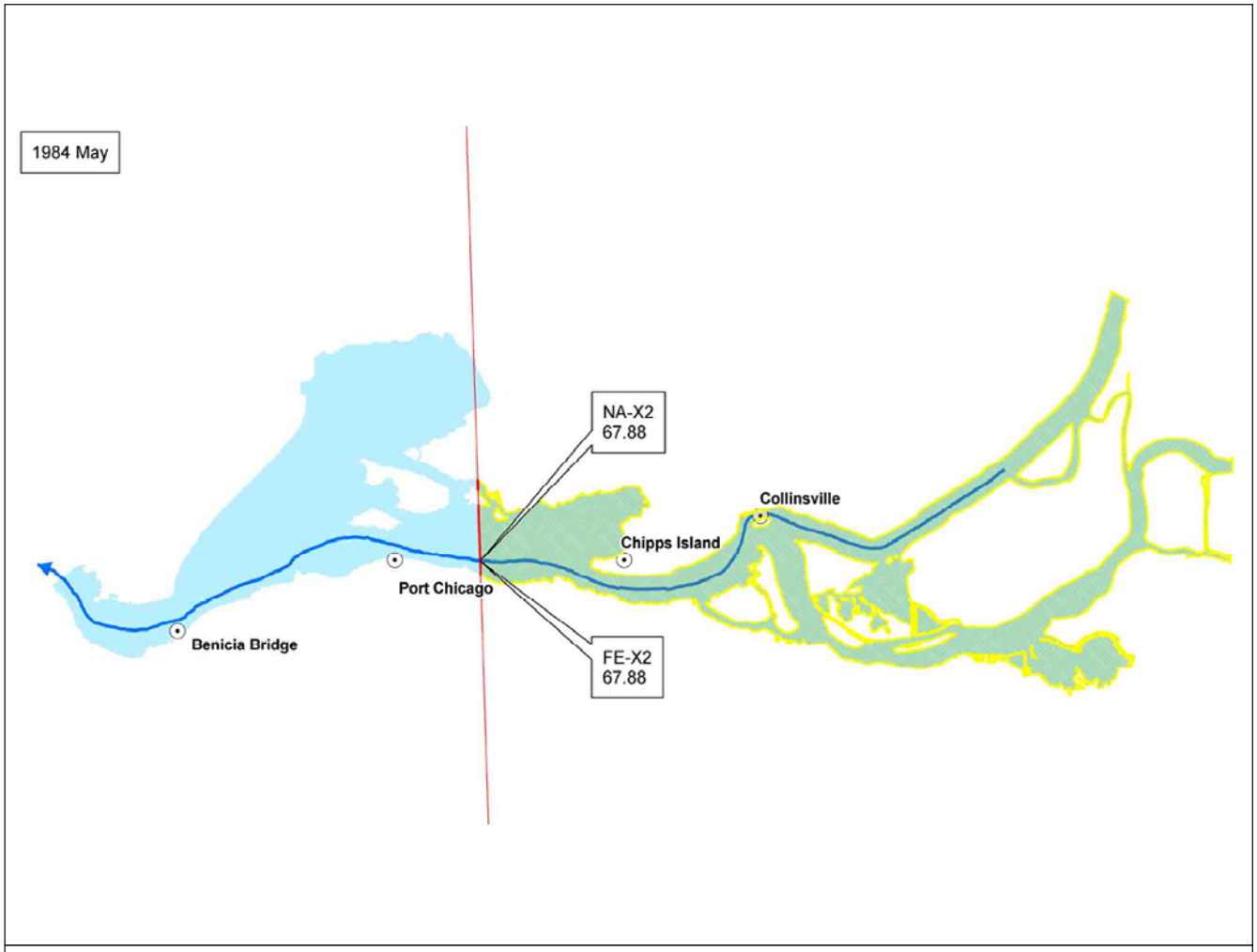

1983 average
NA-X2
57.89
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
58.25


1984 Dec
NA-X2
58.29
FE-X2
58.35
Collinsville
Chipps Island
Port Chicago
Benicia Bridge


1984 Feb
NA-X2
53.46
FE-X2
53.30
Collinsville
Chipps Island
Port Chicago
Benicia Bridge

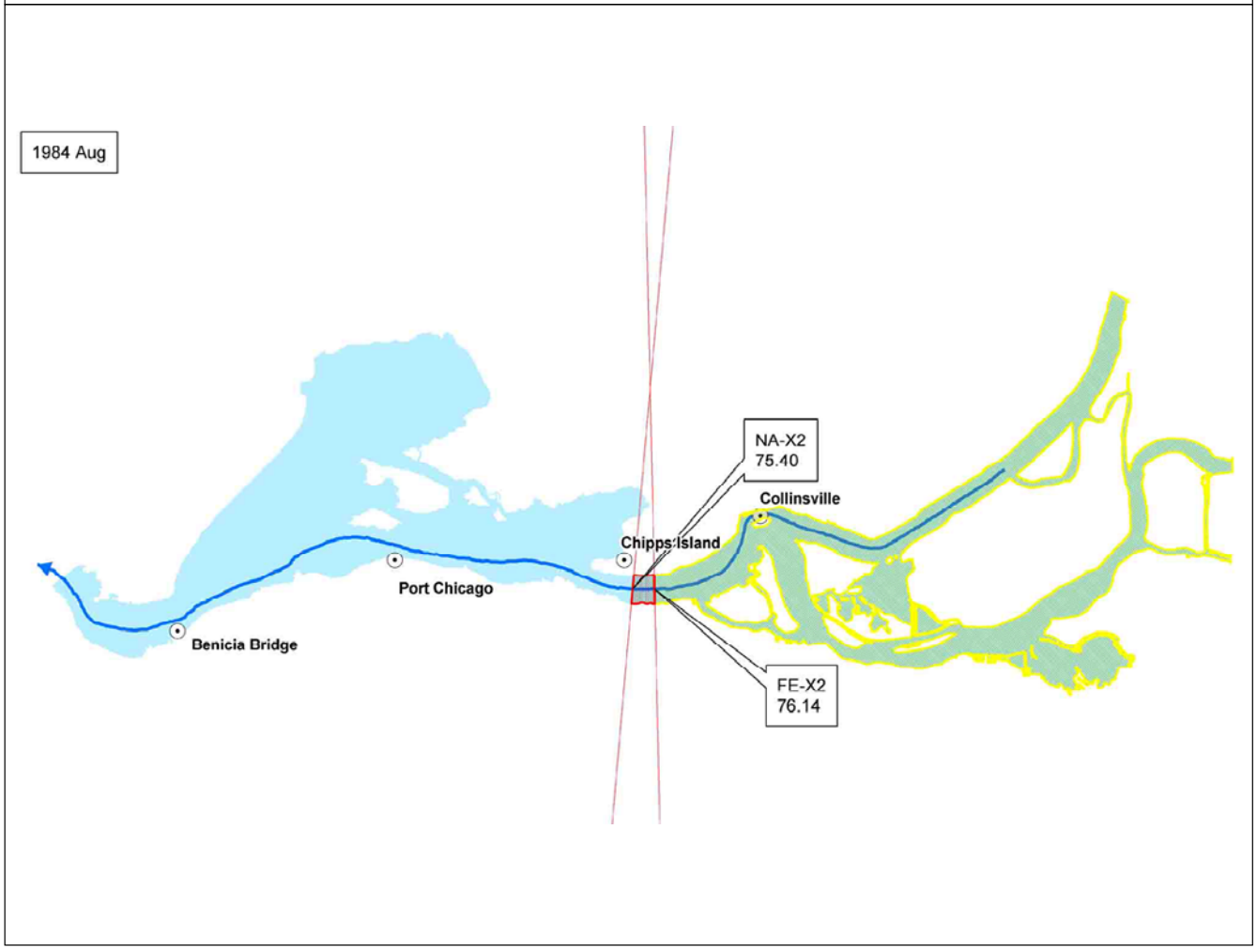

1984 Mar
NA-X2
59.08
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
58.91


1984 Apr
NA-X2
61.79
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
61.73

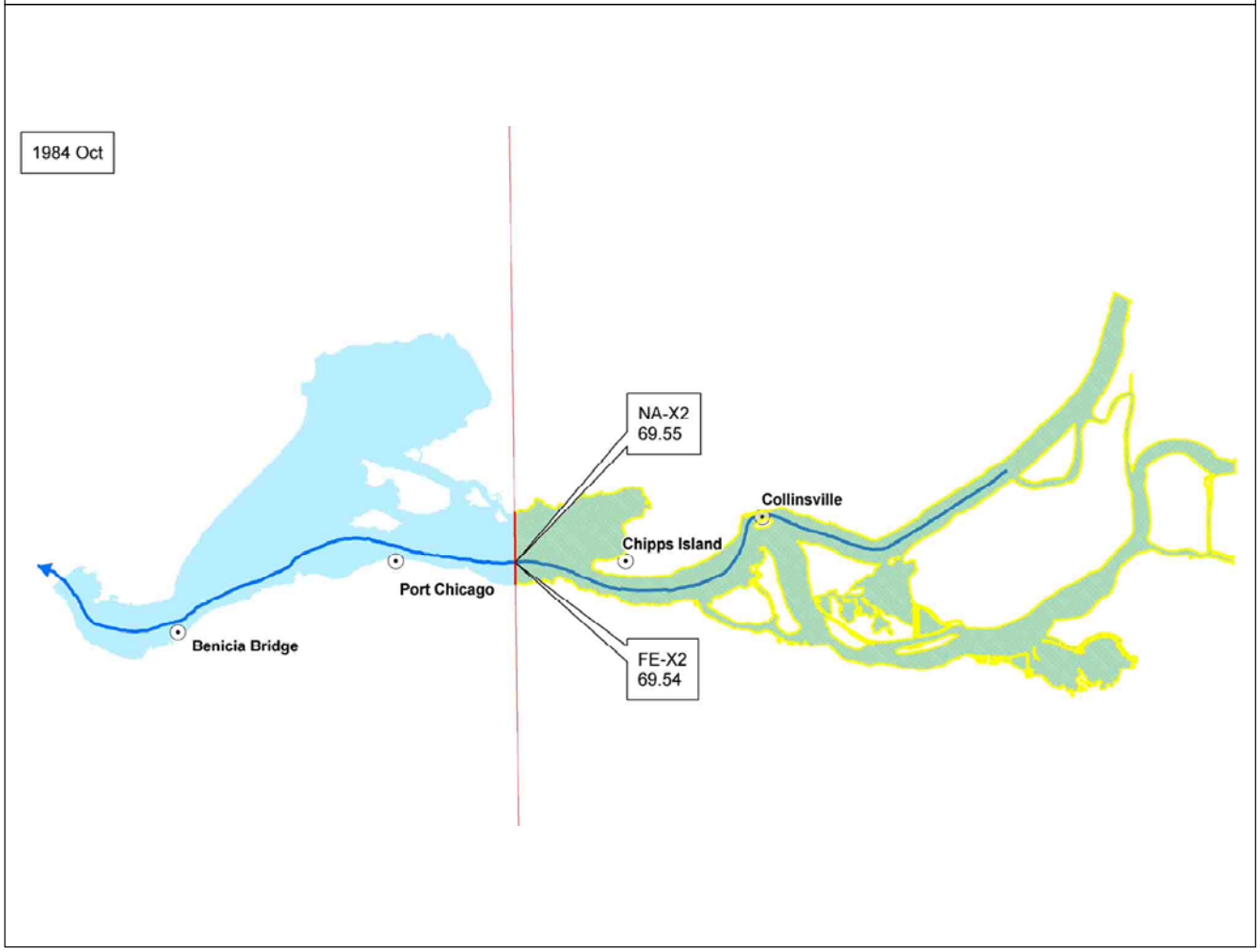

1984 May
NA-X2
67.88
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
67.88


1984 Jun
NA-X2
71.76
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
72.46

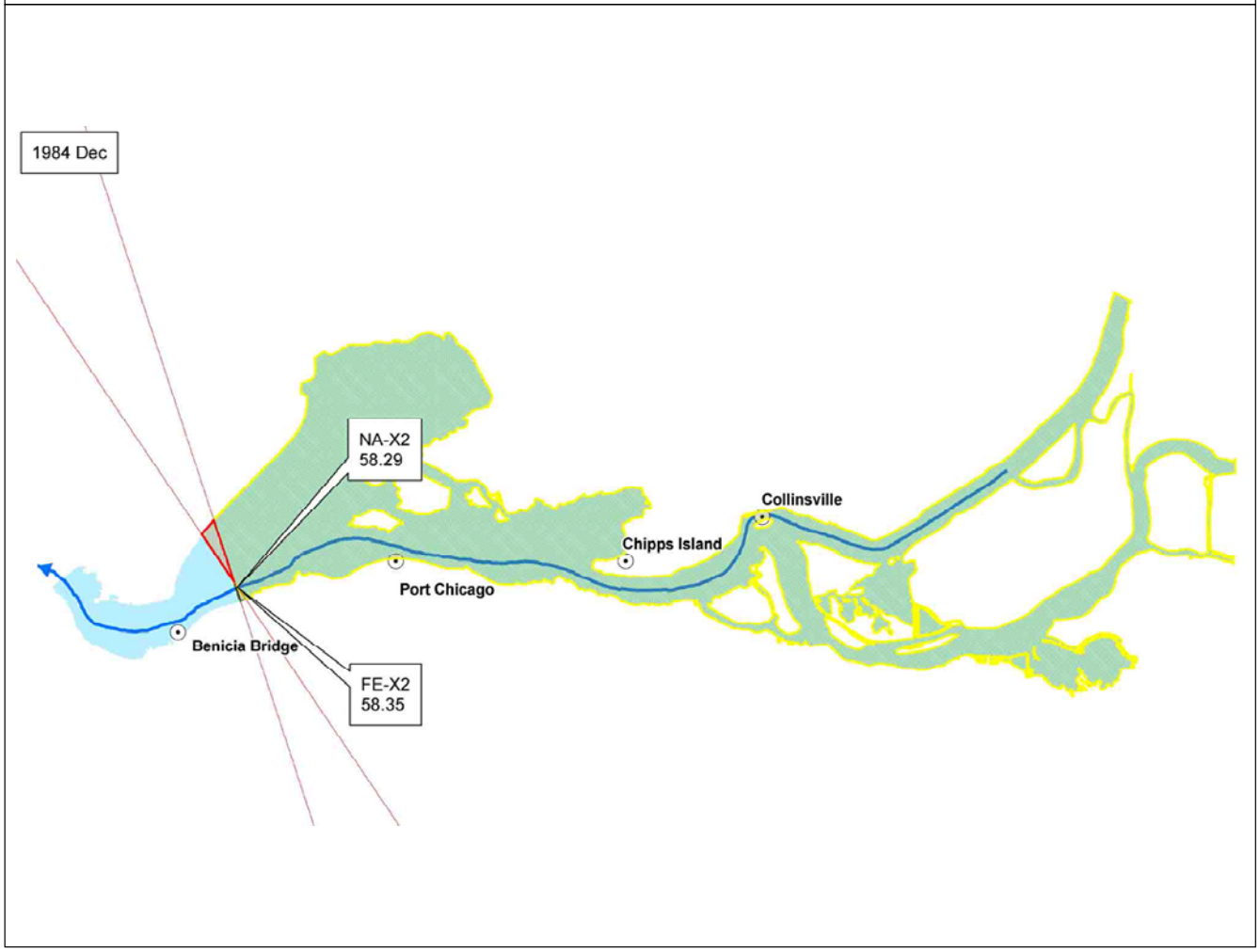

1984 Jul
NA-X2
75.98
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
76.34


1984 Aug
NA-X2
75.40
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
76.14


1984 Sep
NA-X2
83.34
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
83.58


1984 Oct
NA-X2
69.55
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
69.54


1984 Nov
NA-X2
69.01
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
69.35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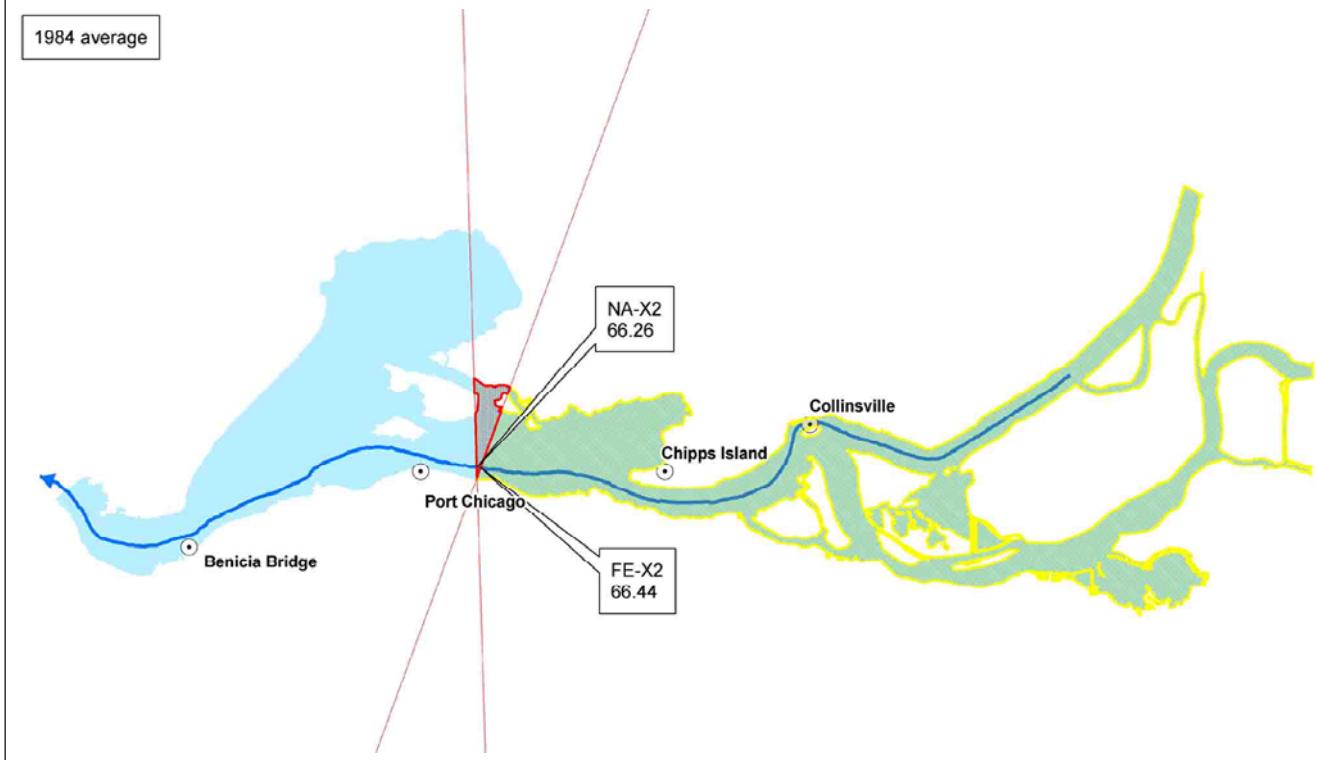
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
58.35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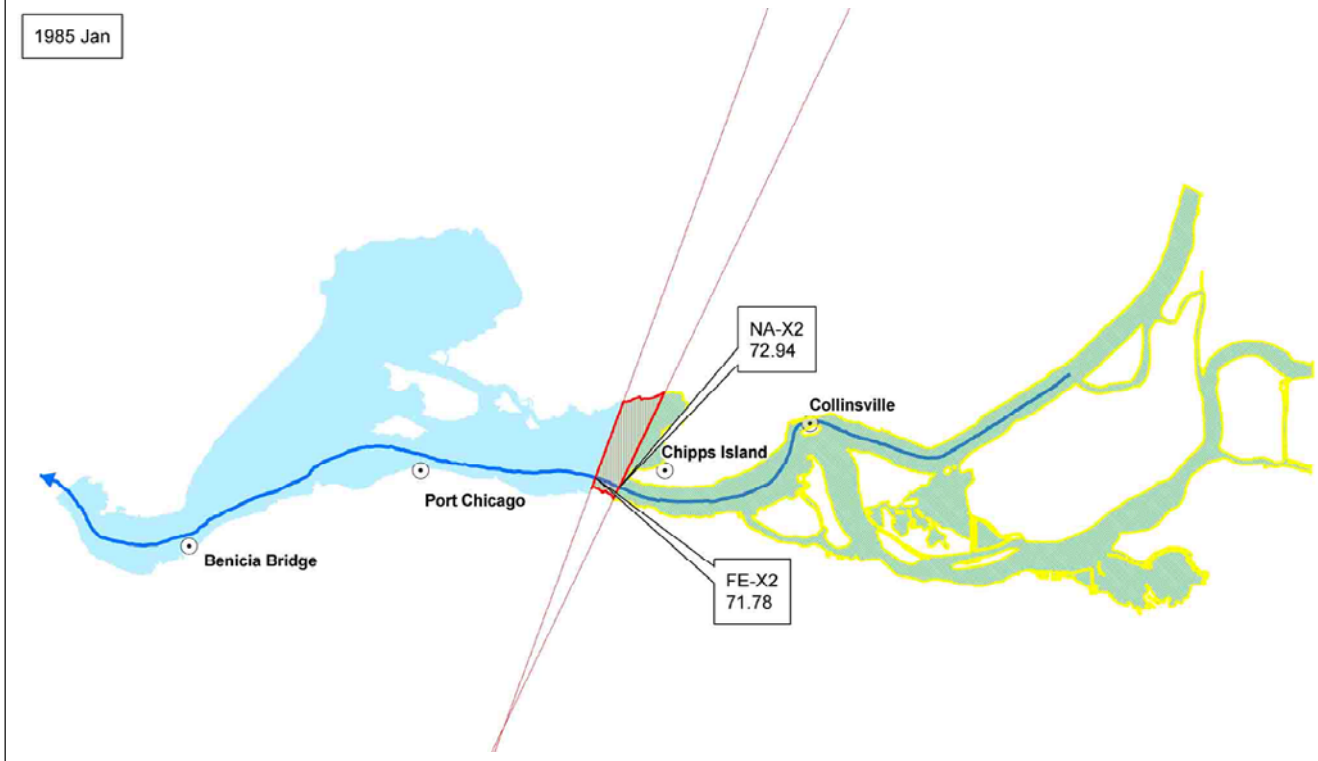
NA-X2
66.26
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
66.44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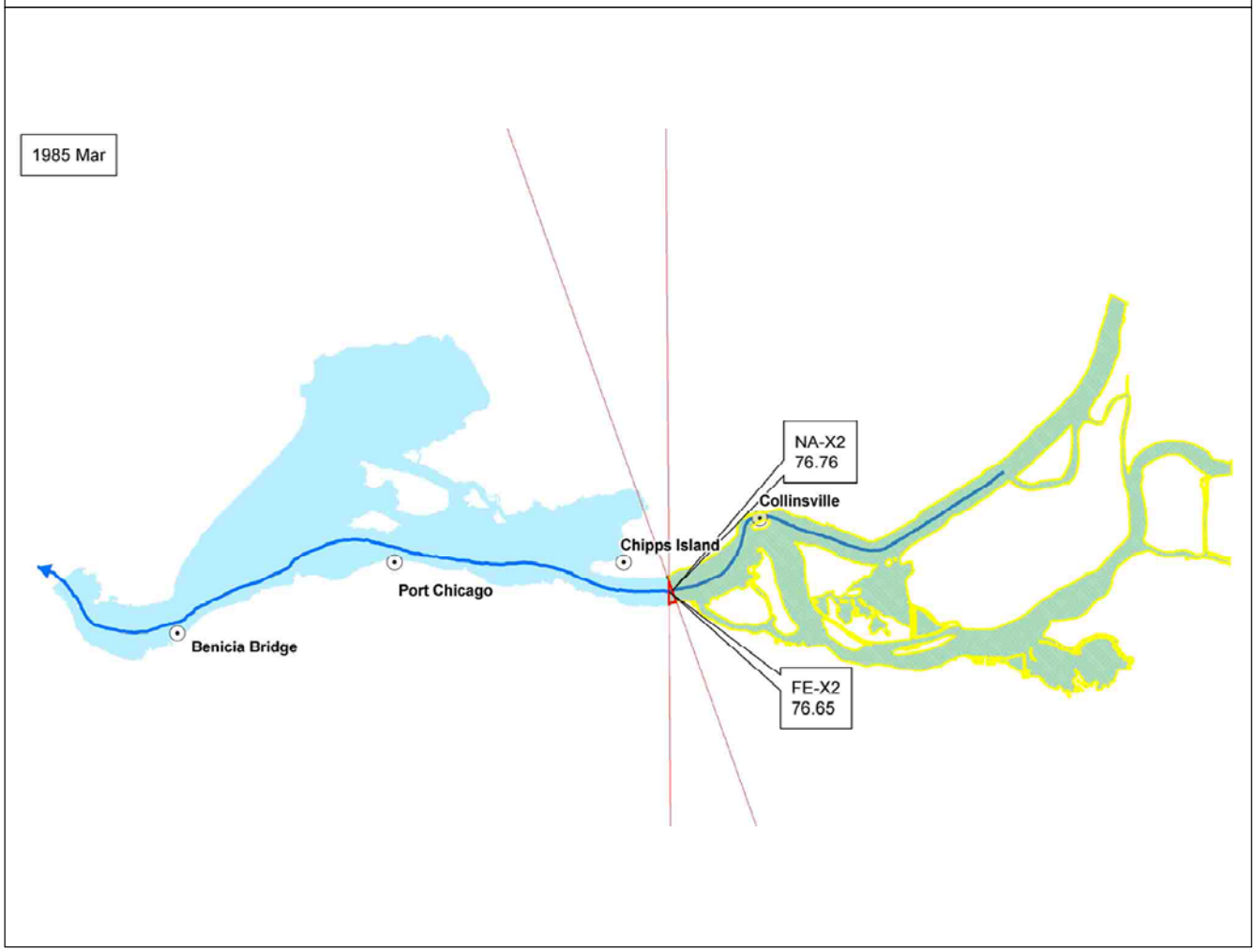
NA-X2
72.94
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
71.78


1985 Feb
NA-X2
79.42
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
79.04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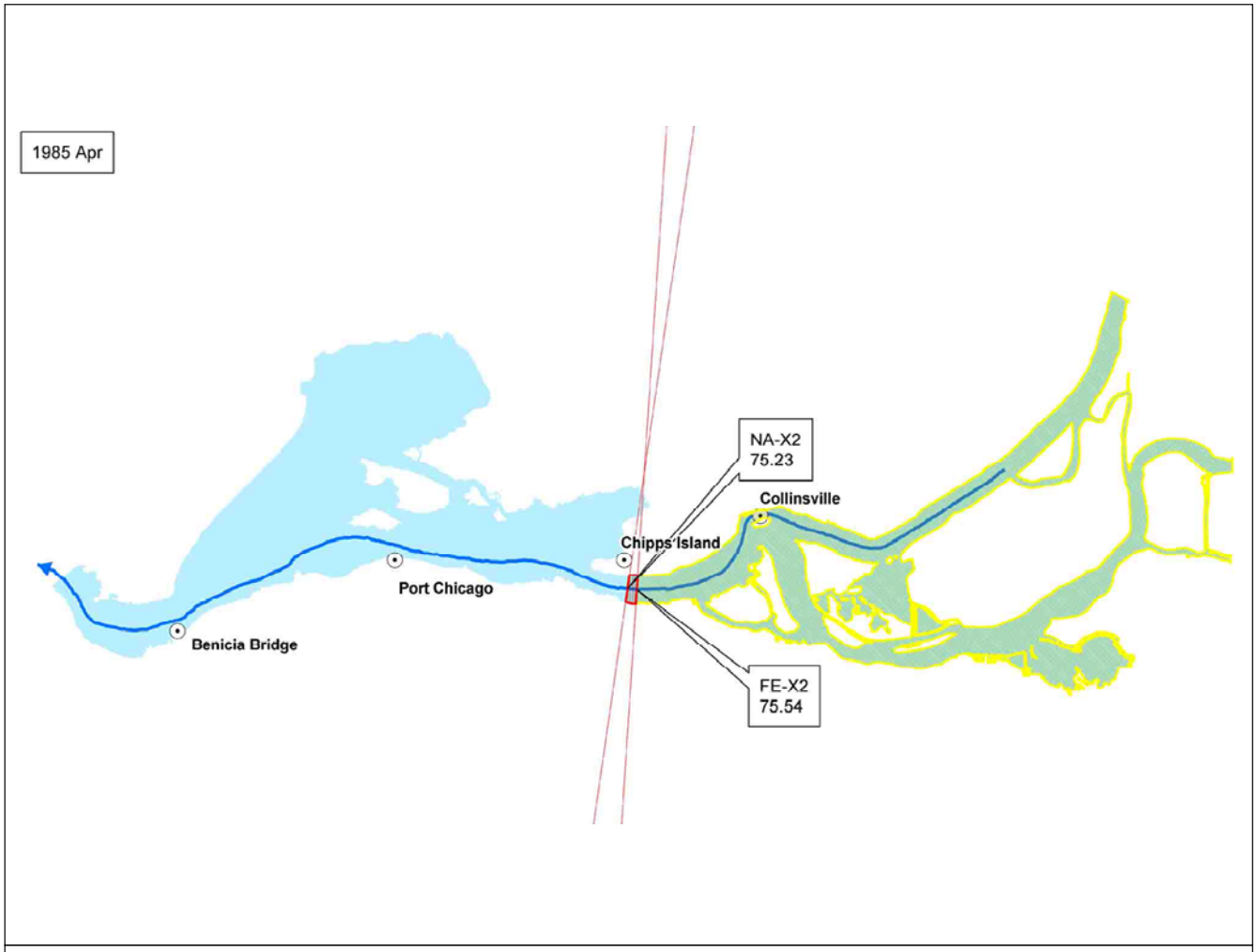
NA-X2
76.76
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
76.65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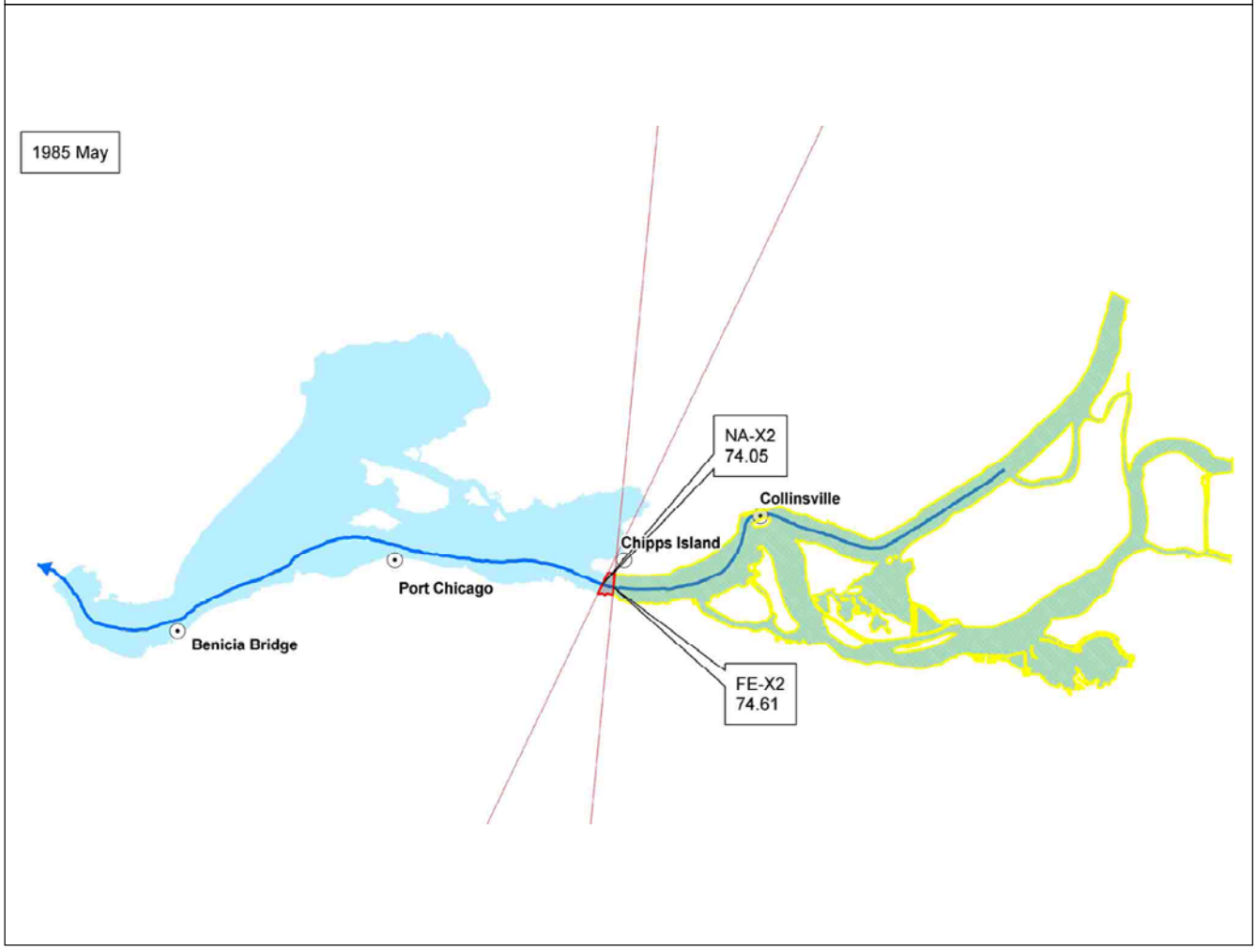
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
75.54


1985 May
NA-X2
74.05
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
74.61


1985 Jun
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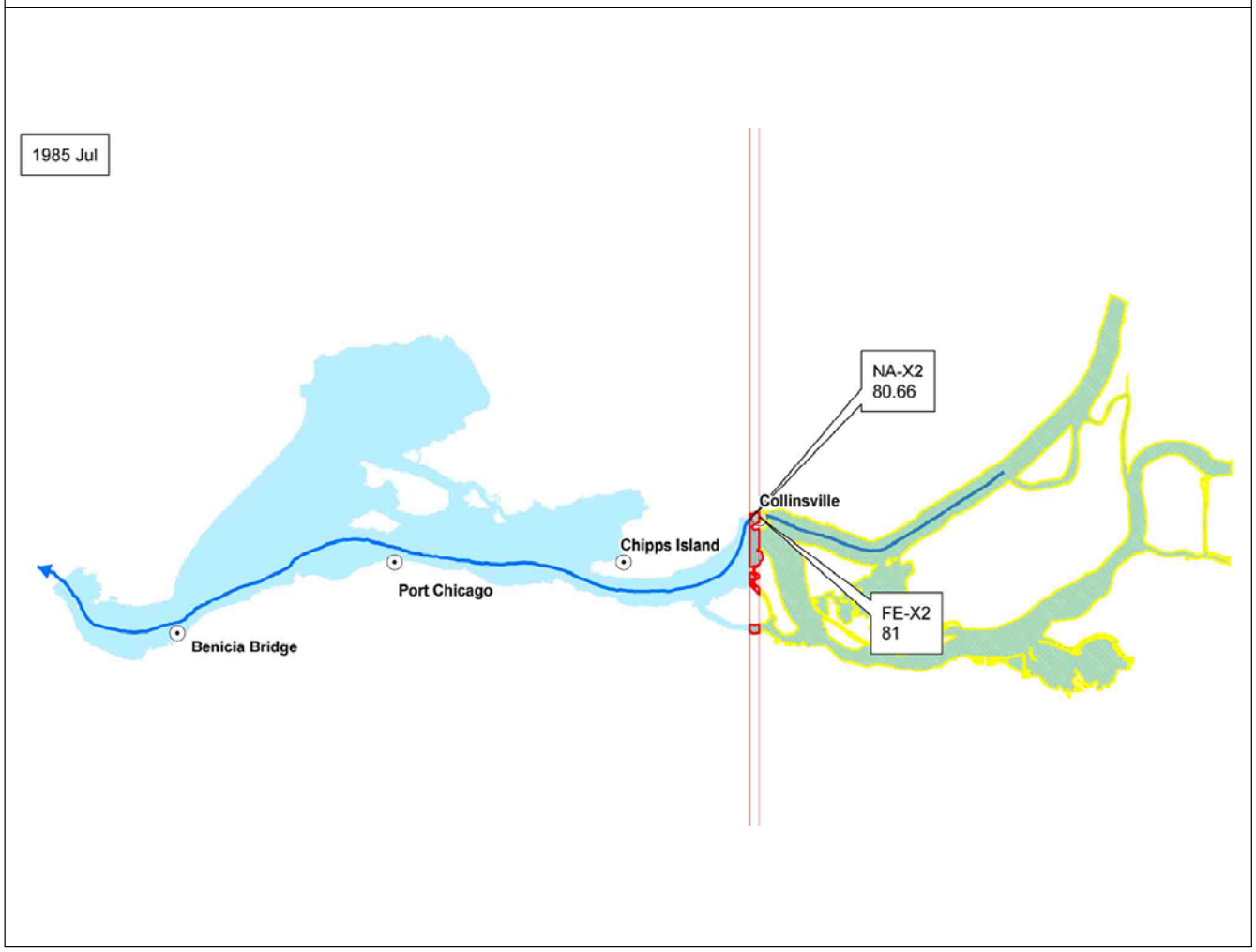
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
76.12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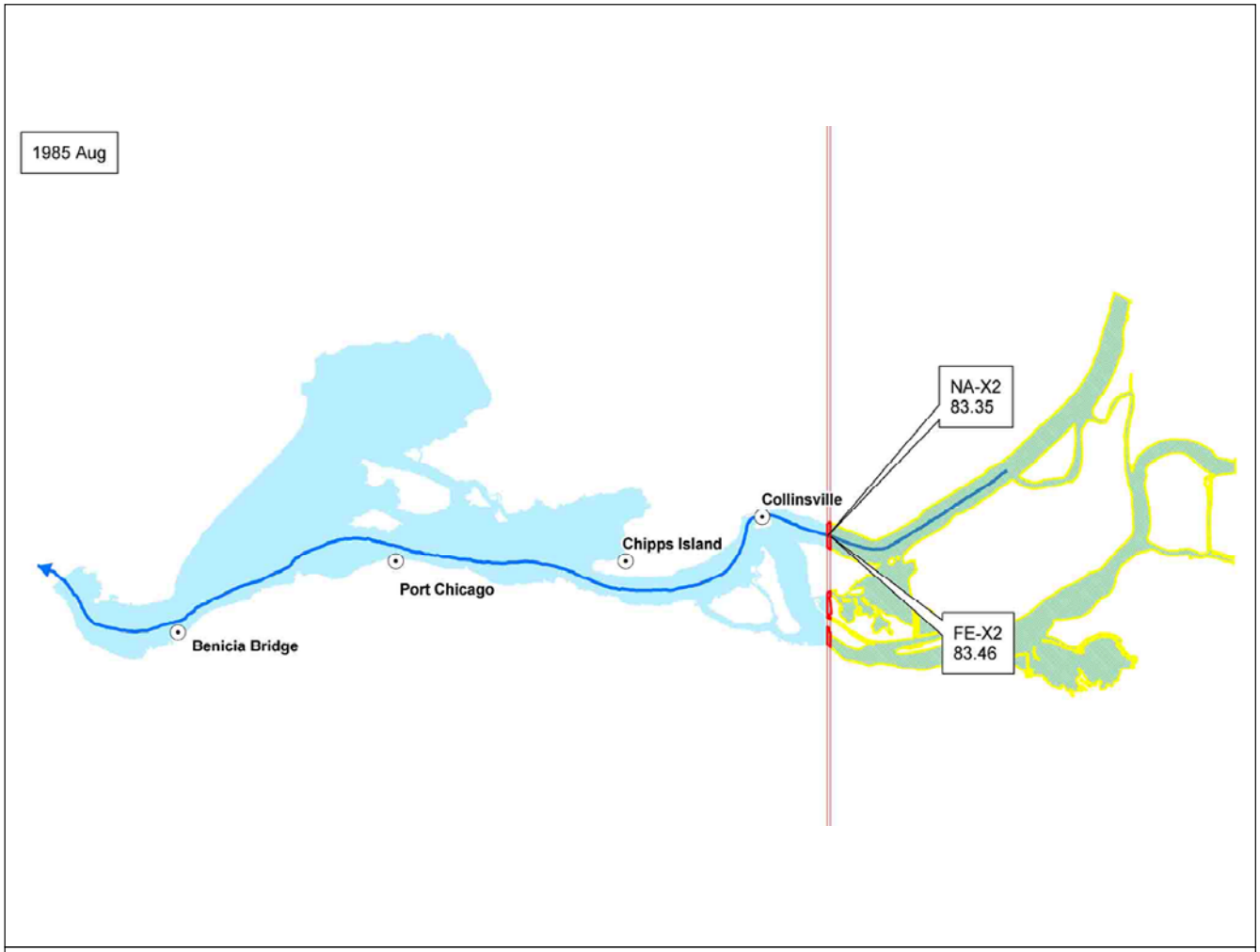
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
81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NA-X2
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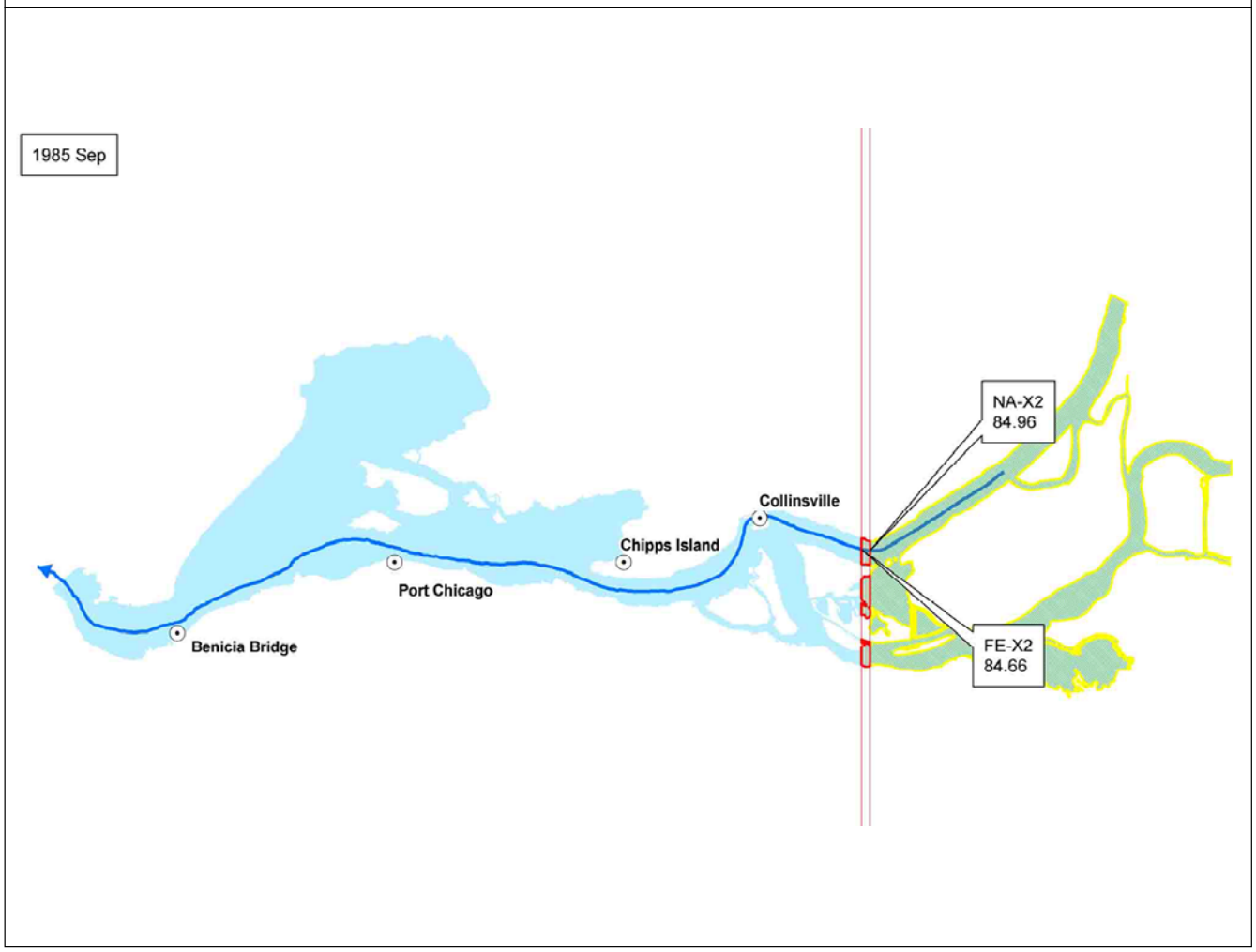
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
83.46


1985 Sep
NA-X2
84.96
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
84.66


1985 Oct
NA-X2
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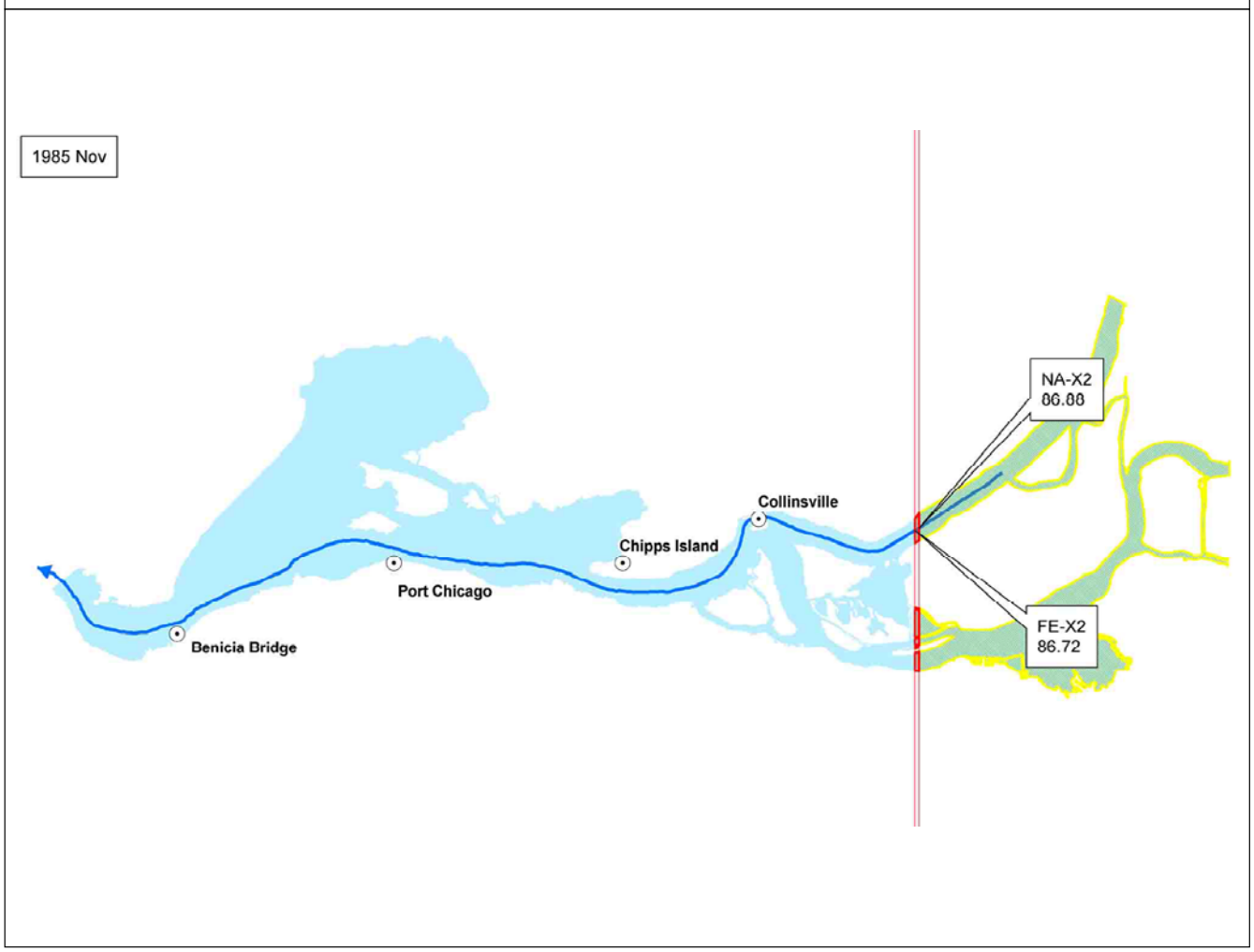
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
86.60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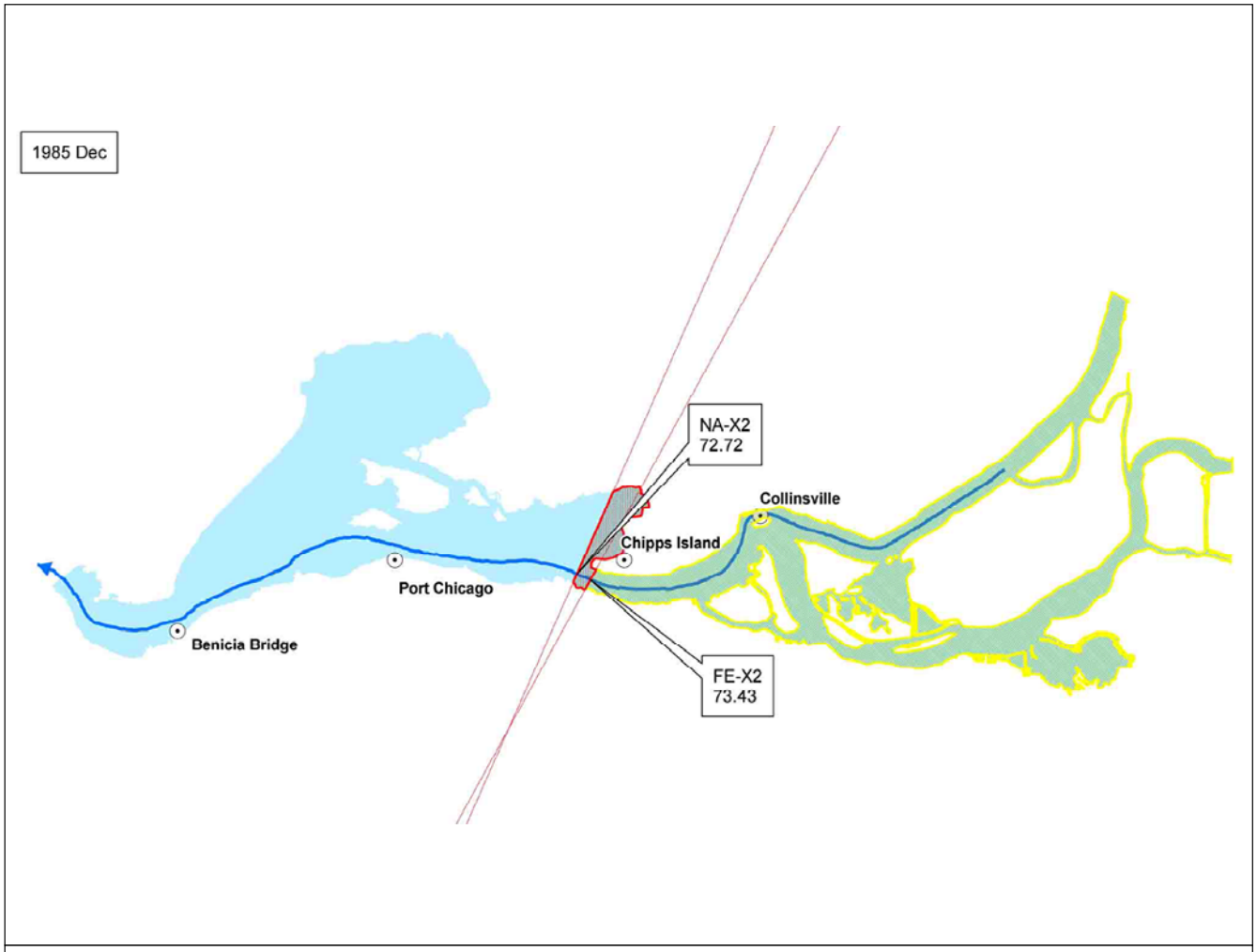
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
86.72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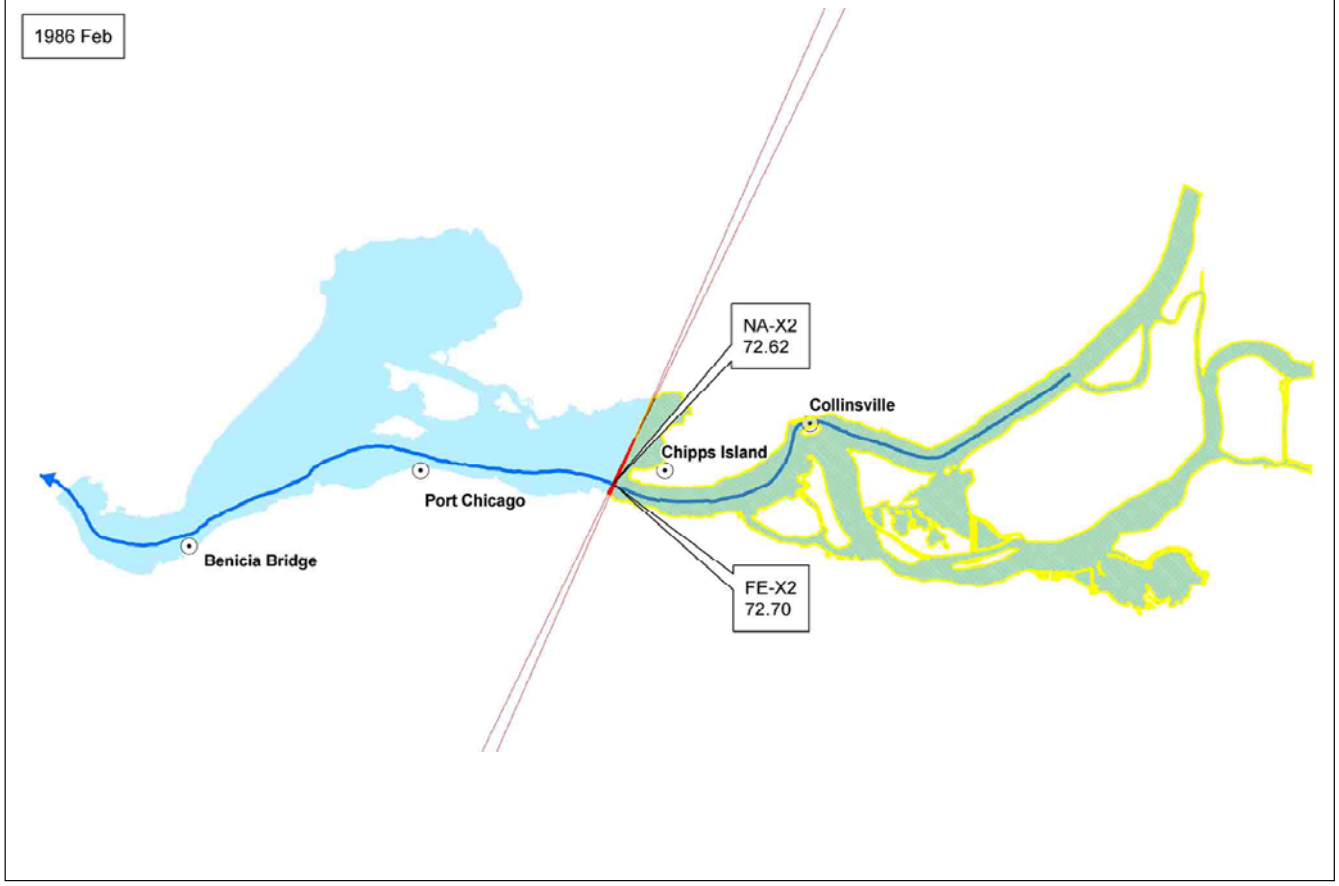
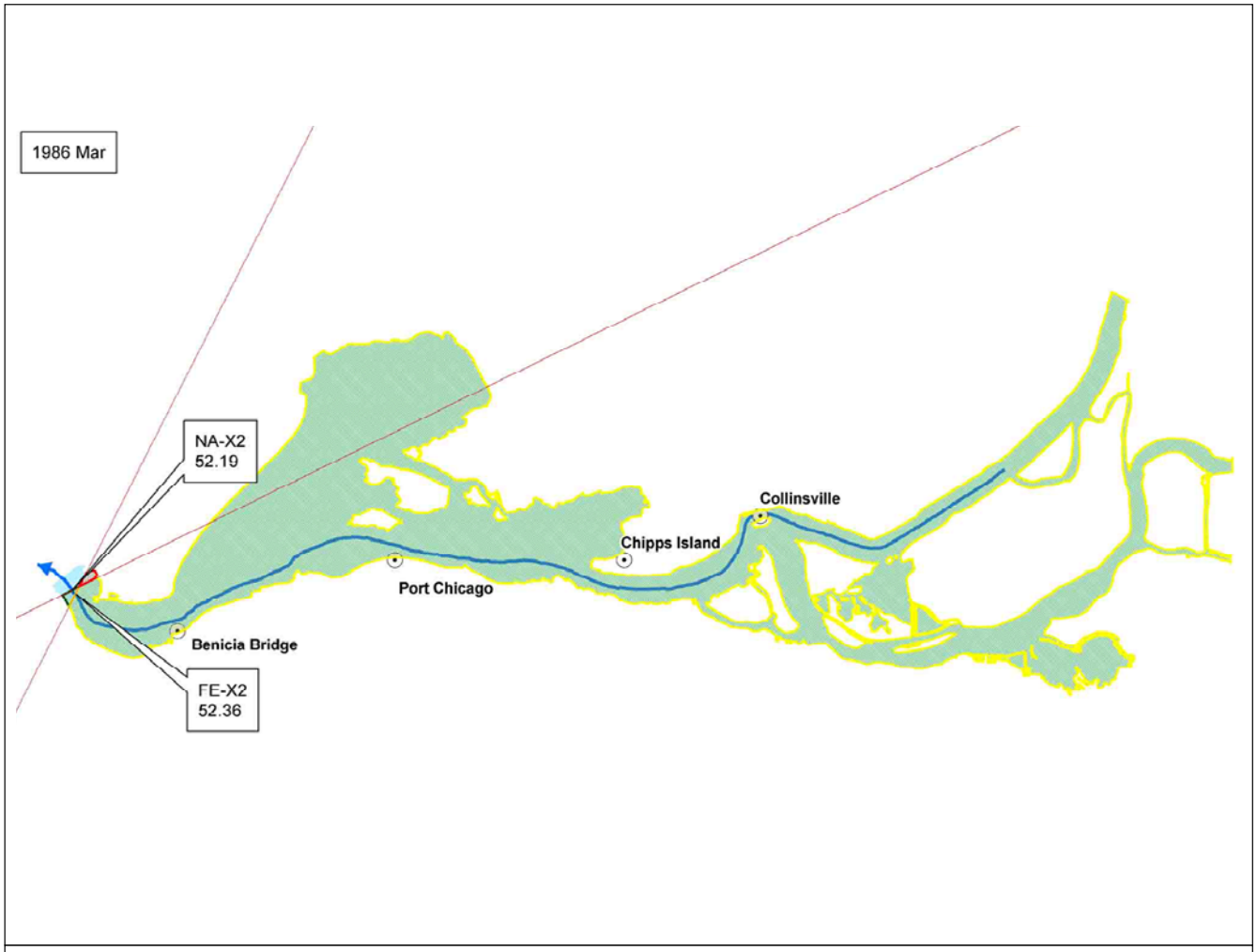
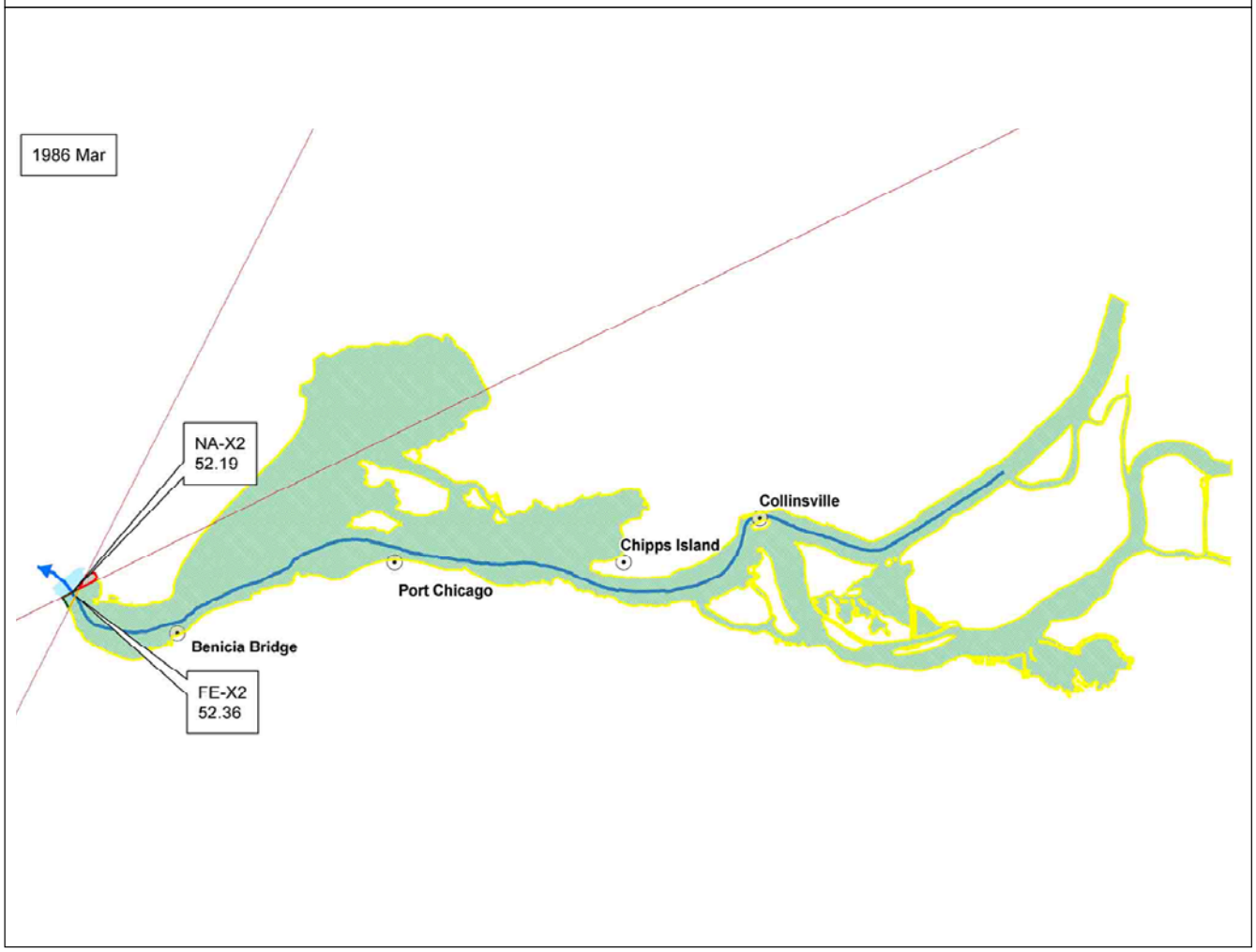
NA-X2
72.72
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
73.43


1985 average
NA-X2
79.11
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
79.13


1986 Jan
NA-X2
77.75
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
77.79


1986 Feb
NA-X2
72.62
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
72.70


1986 Mar
NA-X2
52.19
FE-X2
52.36
Benicia Bridge
Port Chicago
Chipps Island
Collinsville


1986 Mar
NA-X2
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FE-X2
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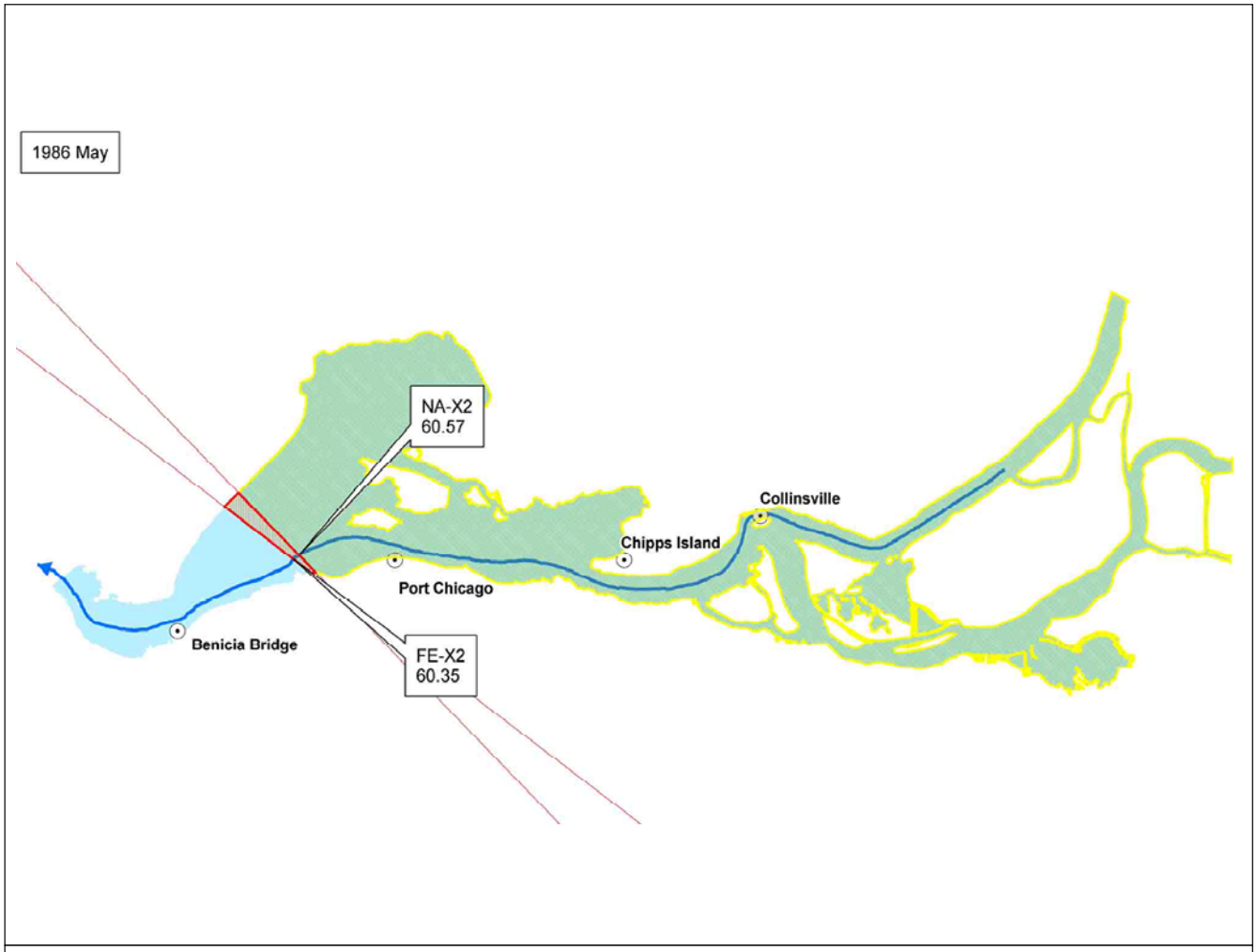
Benicia Bridge
Port Chicago
Chipps Island
Collinsville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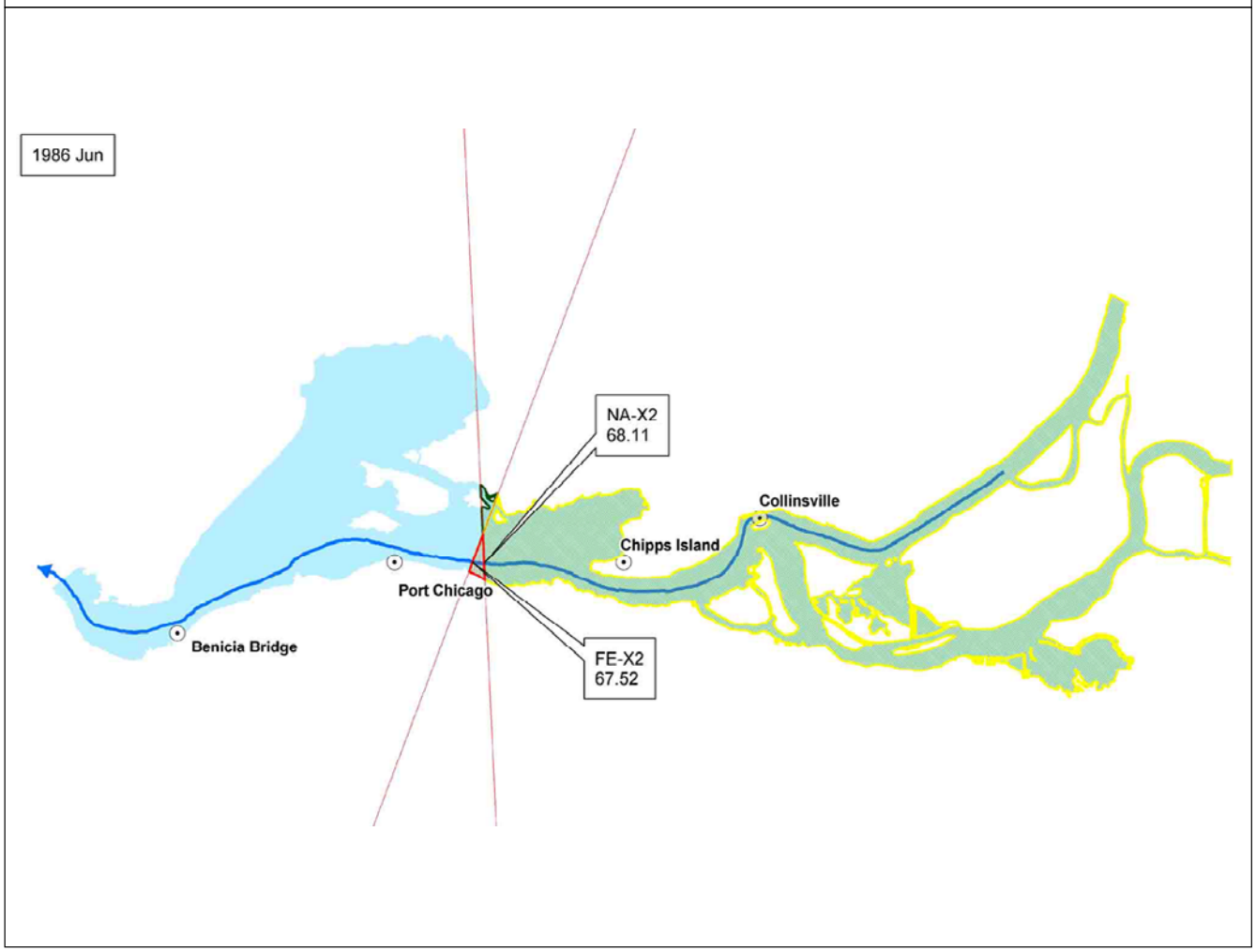
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
60.35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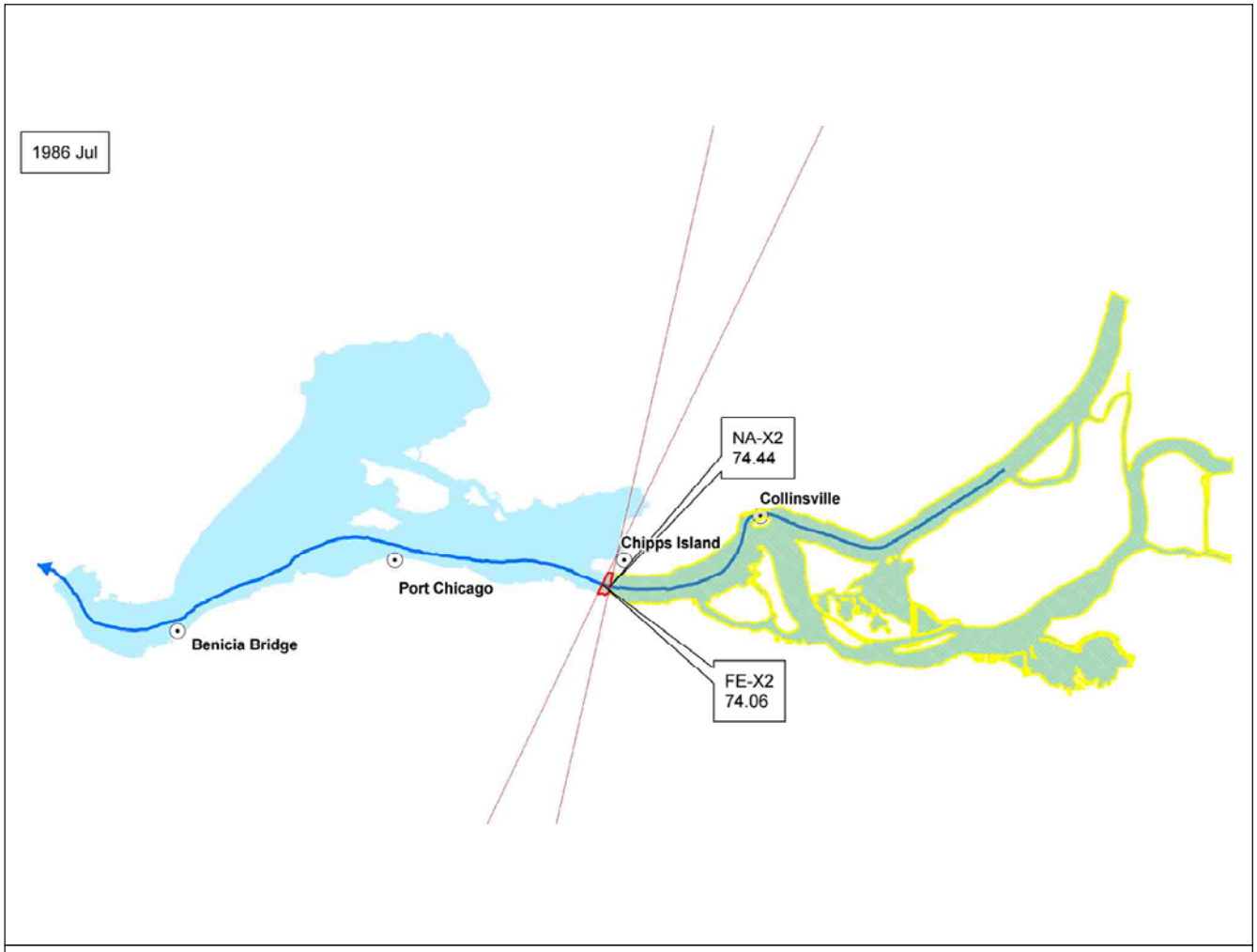
NA-X2
68.11
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
67.52


1986 Jul
NA-X2
74.44
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
74.06


1986 Aug
NA-X2
77.71
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
77.58


1986 Sep
NA-X2
81.20
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
82.89


1986 Oct
NA-X2
85.98
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
85.88


1986 Nov
NA-X2
85.73
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
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1986 Dec
NA-X2
84.52
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
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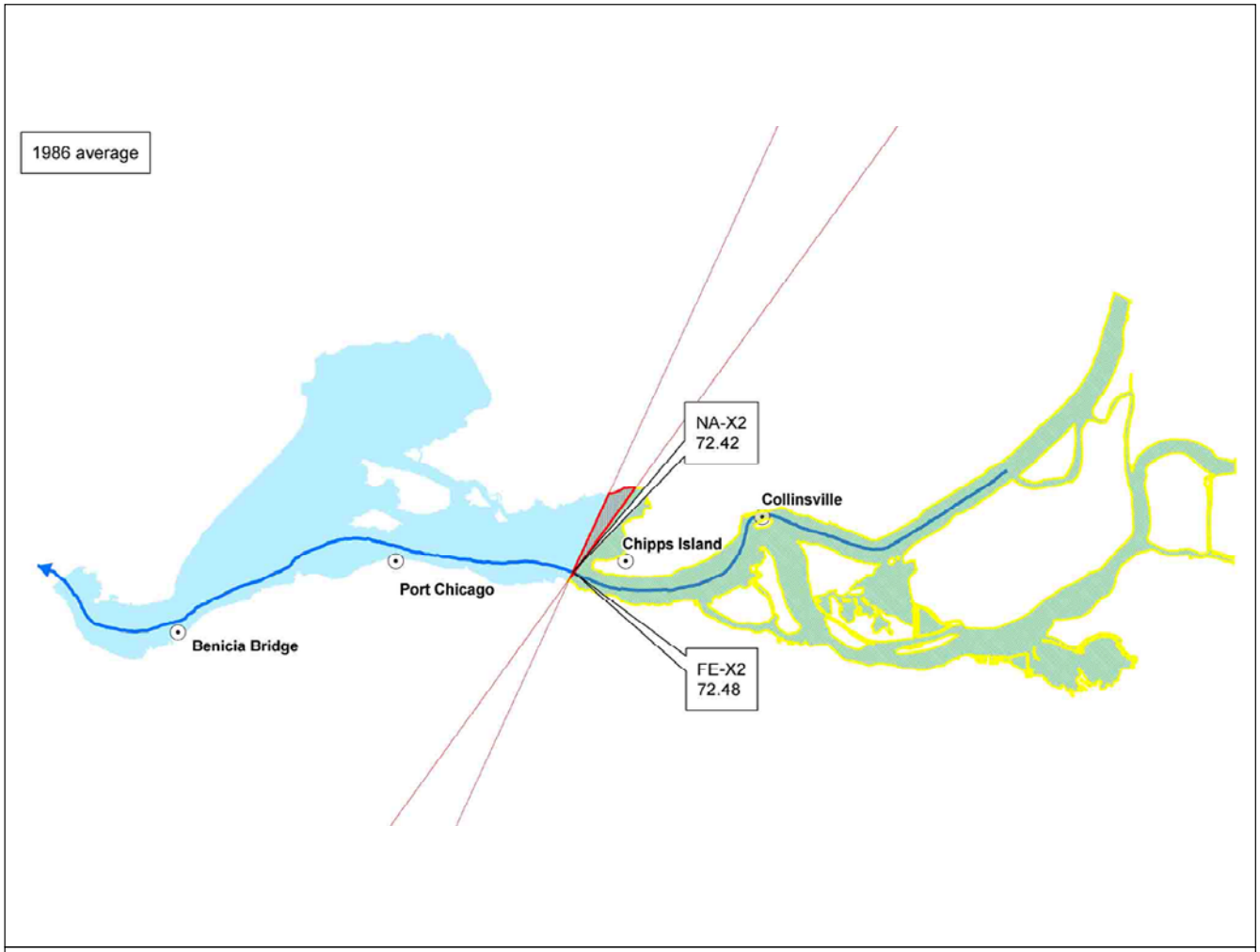
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Chipps Island
Port Chicago
Benicia Bridge
FE-X2
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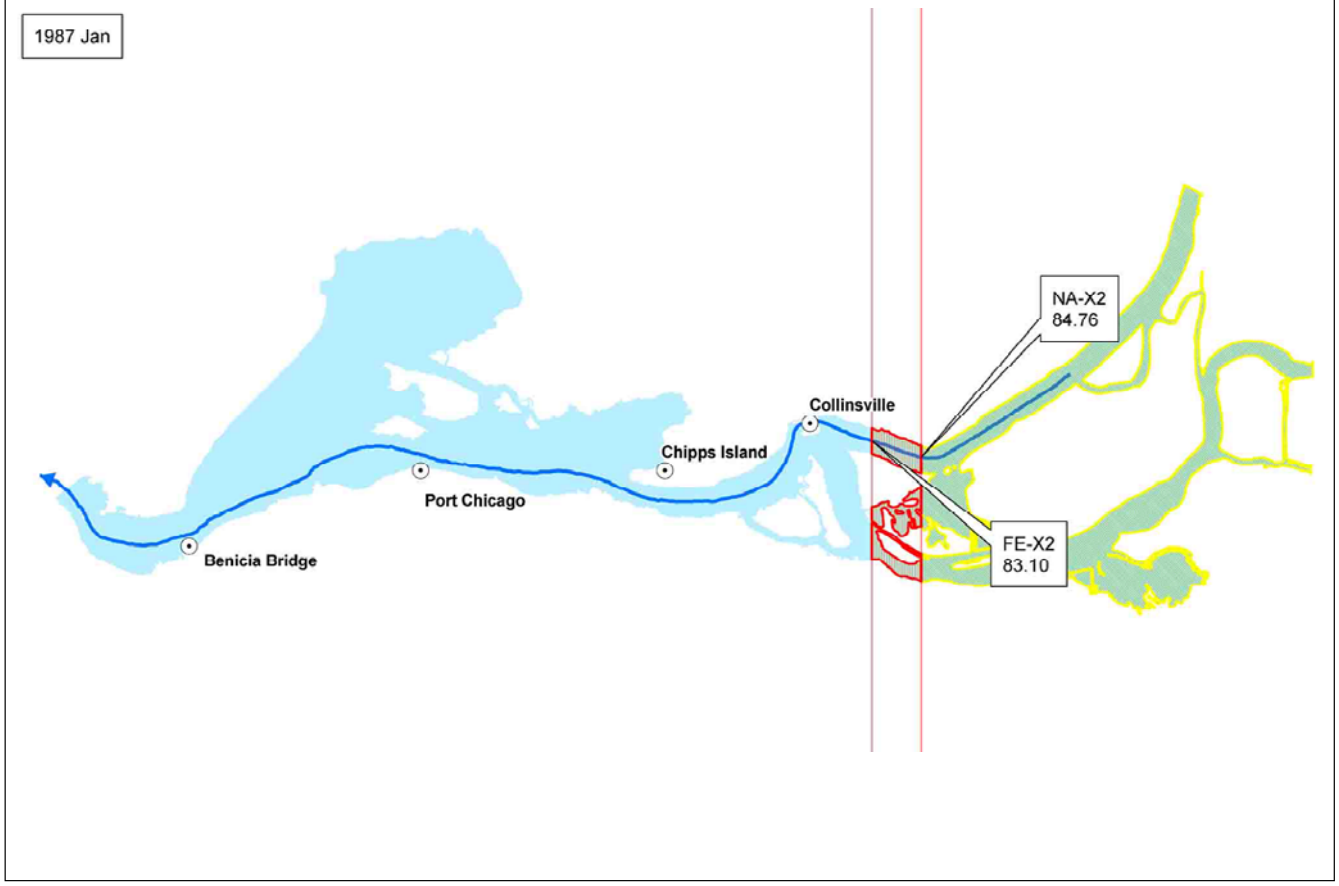
1987 Jan
NA-X2
84.76
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
83.10


1987 Feb
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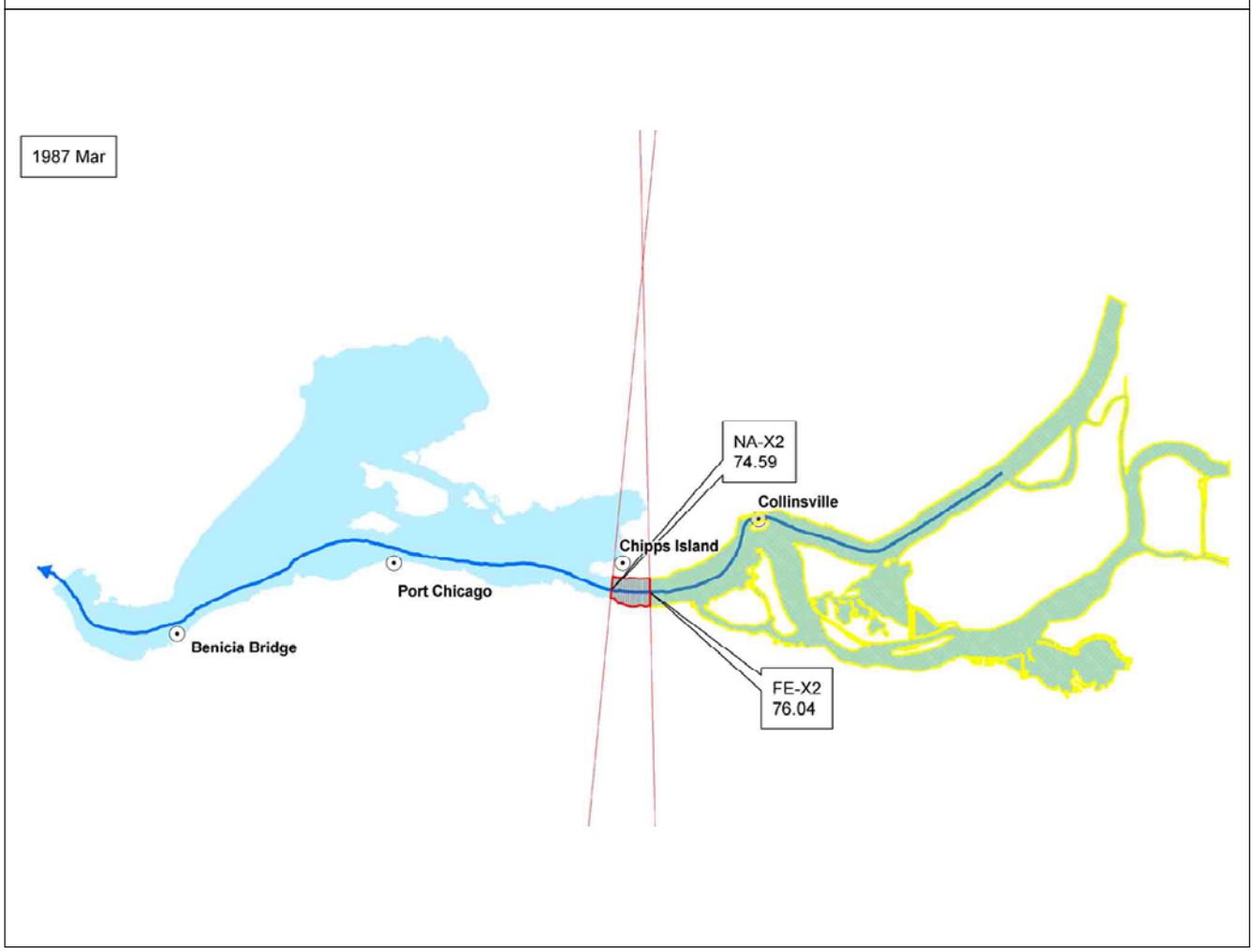
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
83.14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Chipps Island
Port Chicago
Benicia Bridge
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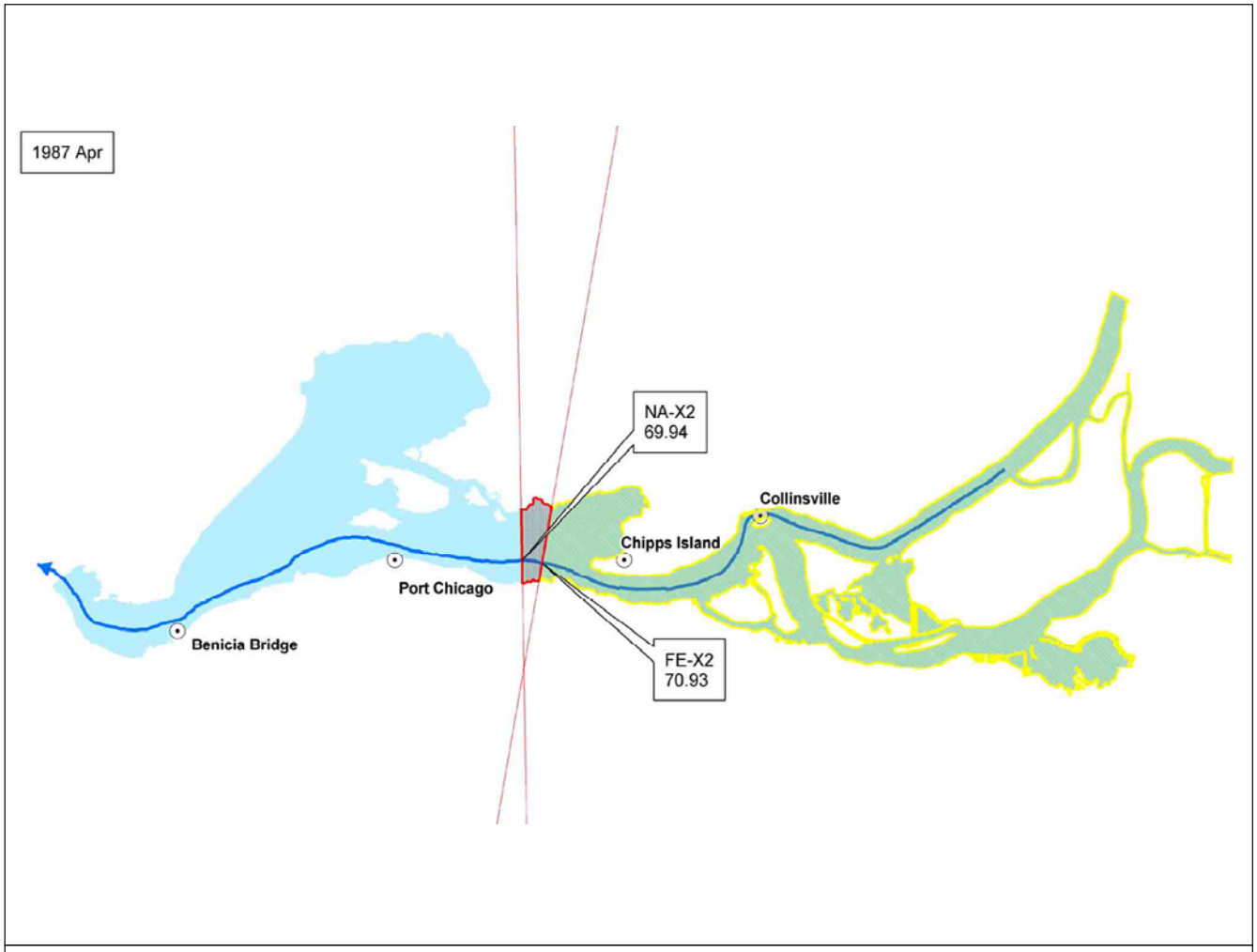
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Collinsville
Chipps Island
Port Chicago
Benicia Bridge
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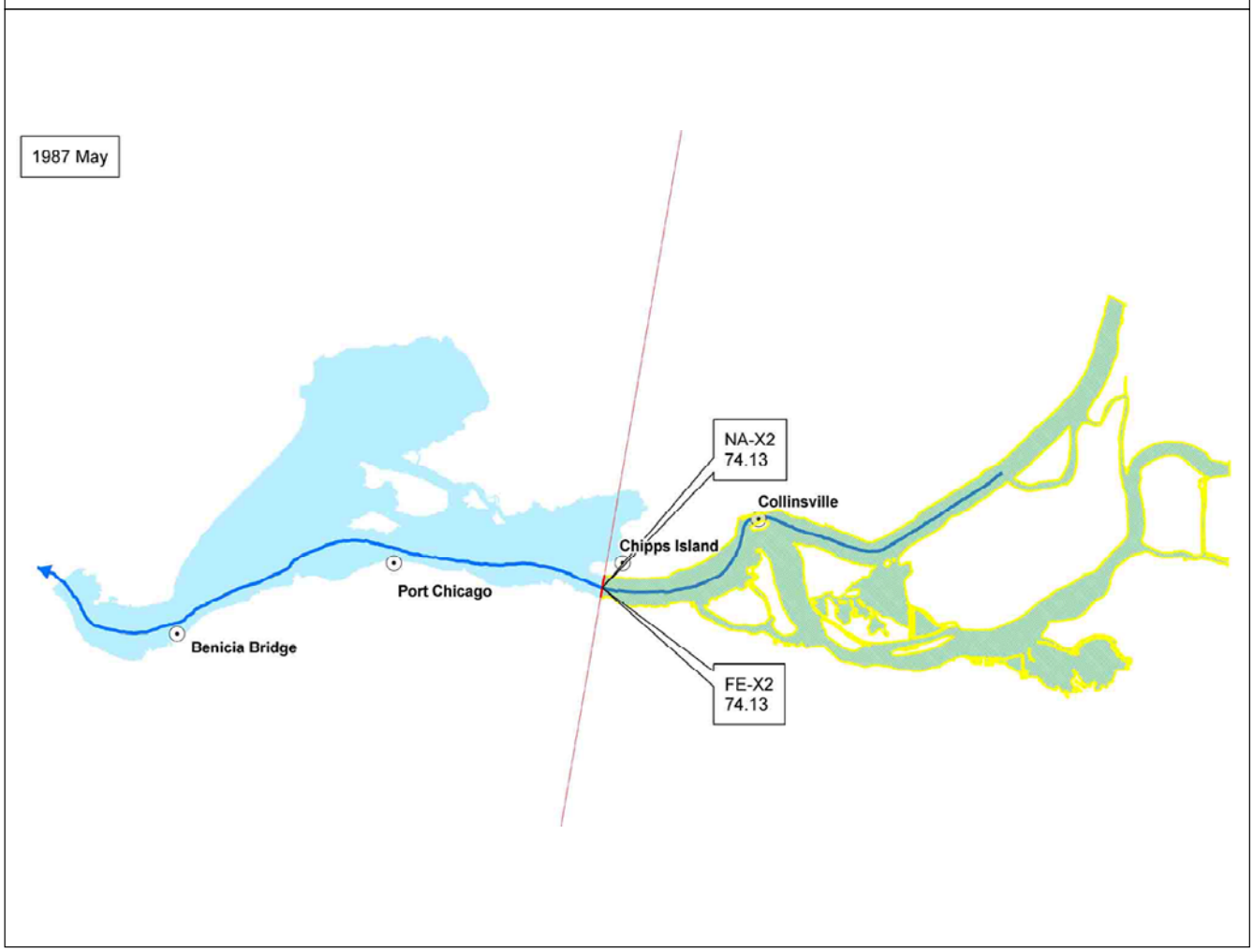
1987 May
NA-X2
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Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
74.13


1987 Jun
NA-X2
77.58
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
78.45


1987 Aug
NA-X2
83.25
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
83.30


1987 Sep
NA-X2
85.77
FE-X2
86.56
Collinsville
Chipps Island
Port Chicago
Benicia Bridge


1987 Oct
NA-X2
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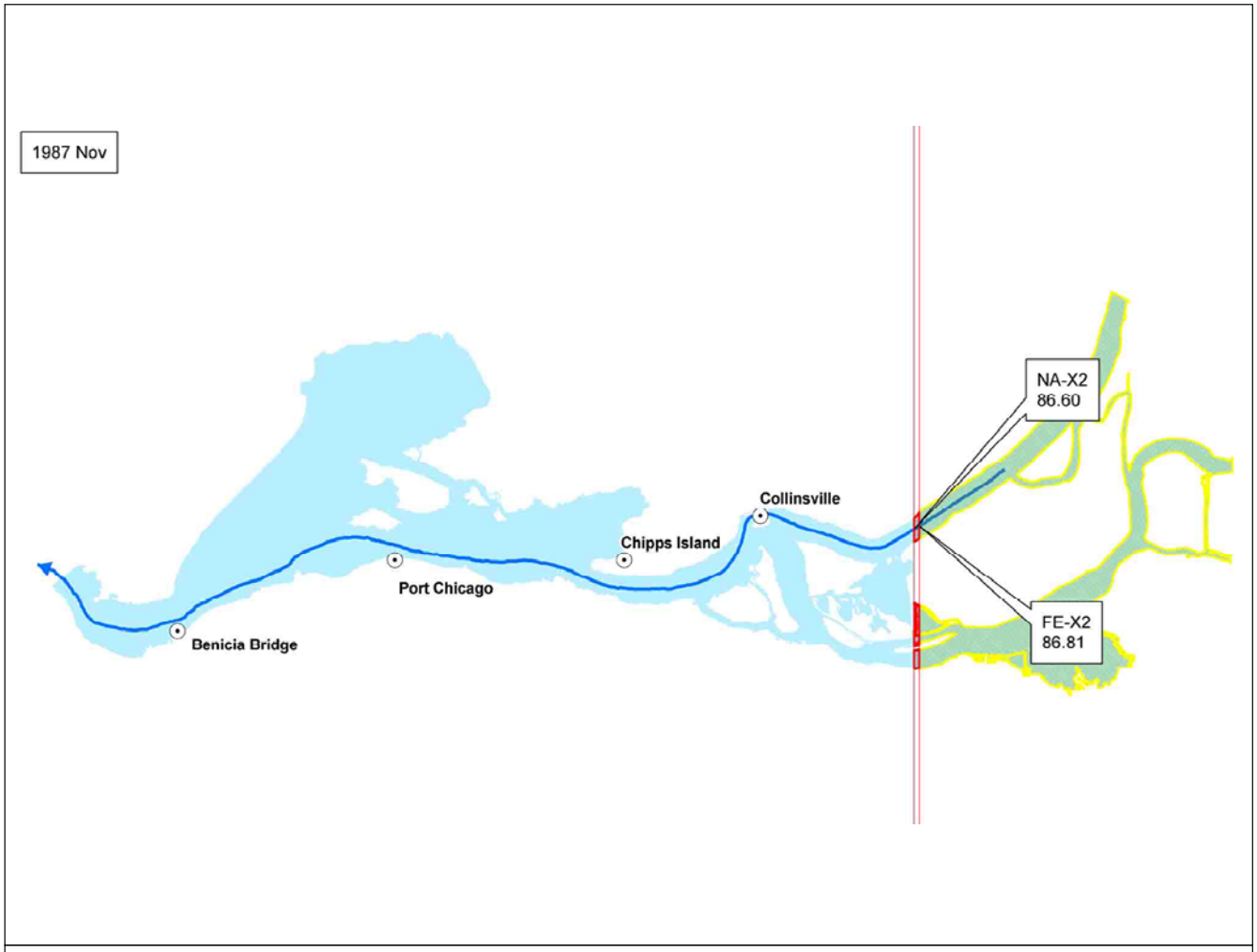
FE-X2
85.98
Collinsville
Chipps Island
Port Chicago
Benicia Bridge


1987 Nov
NA-X2
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Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
86.81


1987 Dec
NA-X2
85.23
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
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1987 average
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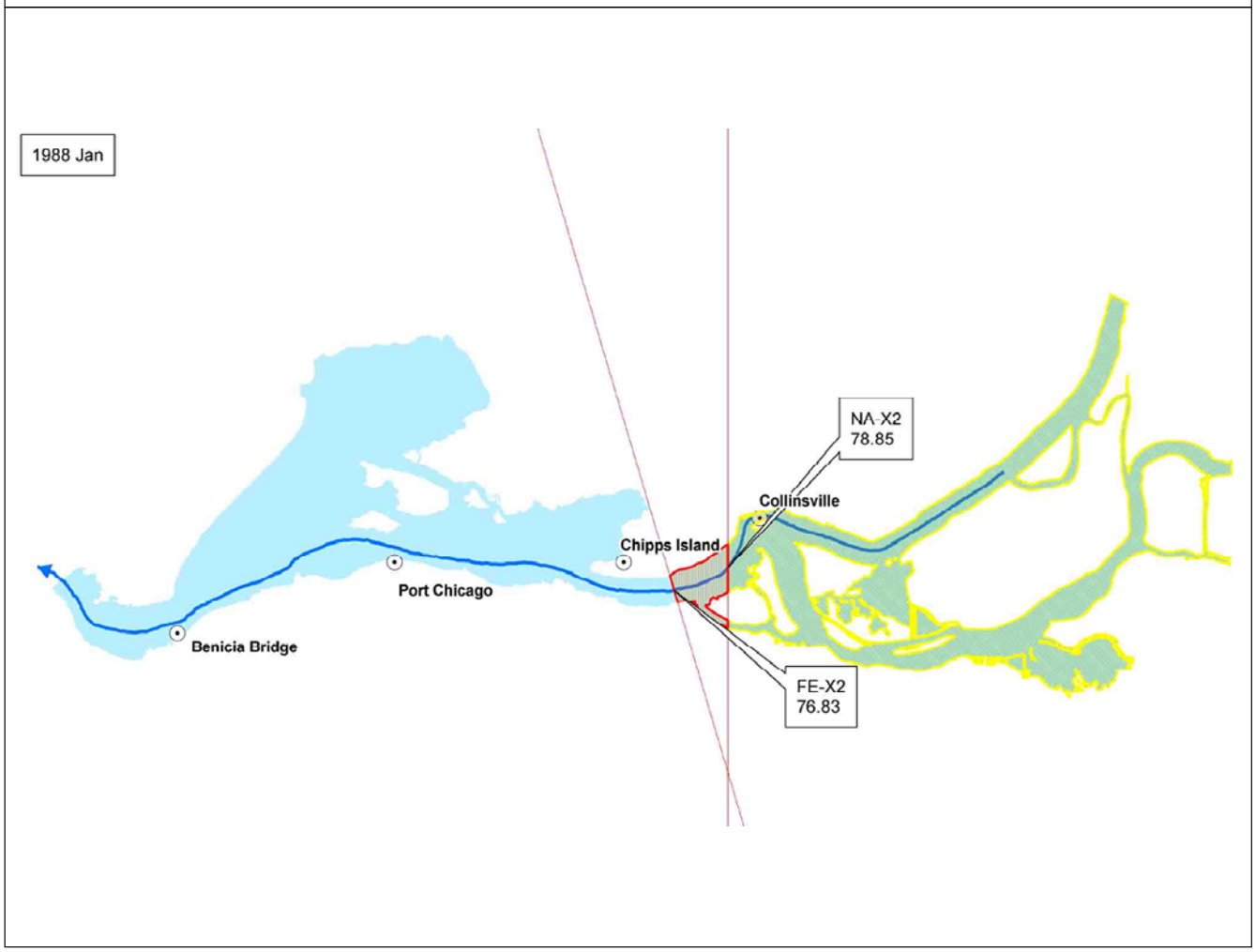
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
81.17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Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
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1988 Feb
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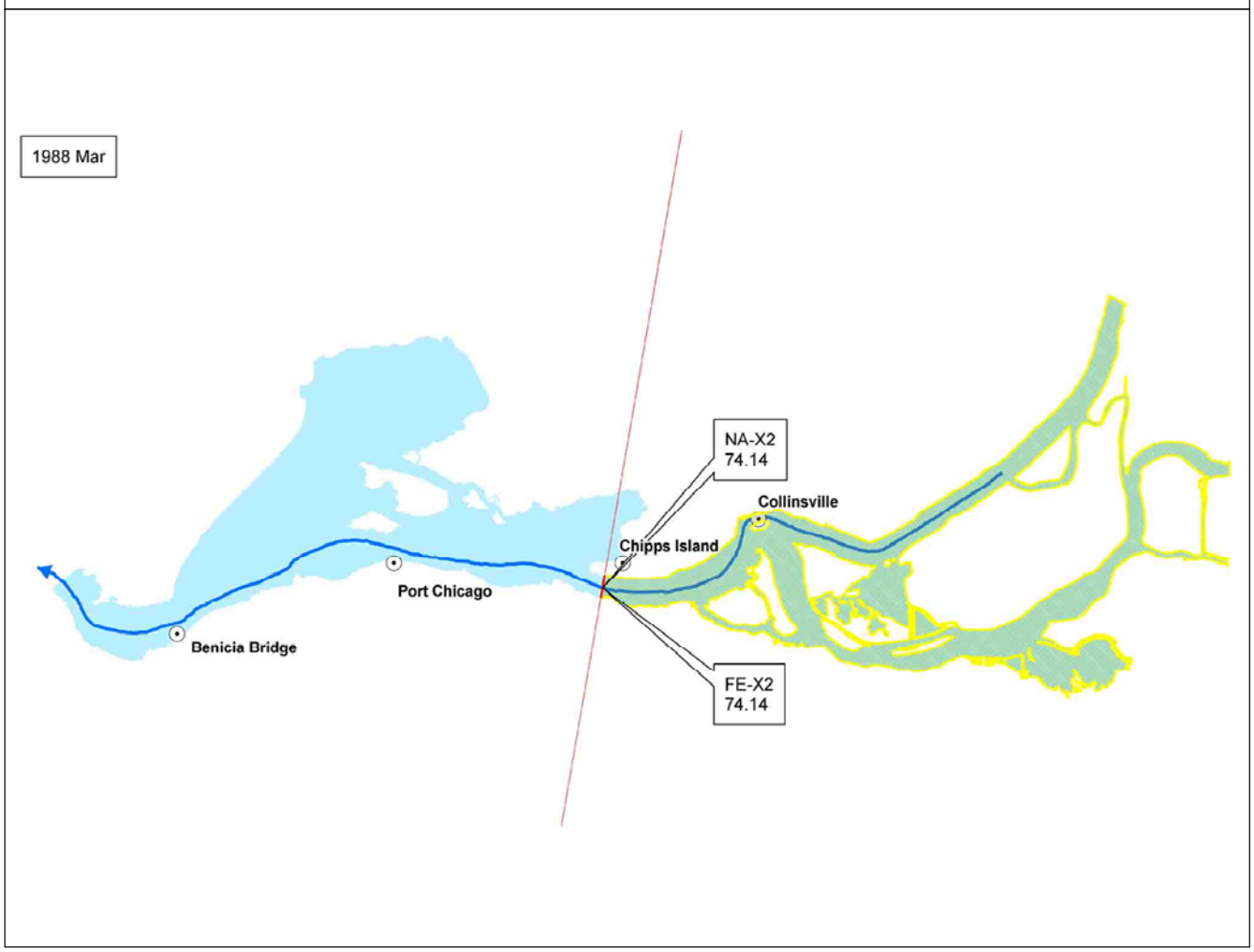
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
70.49


1988 Mar
NA-X2
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Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
74.14


1988 Apr
NA-X2
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Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
77.74


1988 May
NA-X2
79.16
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
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78.94


1988 Jun
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Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
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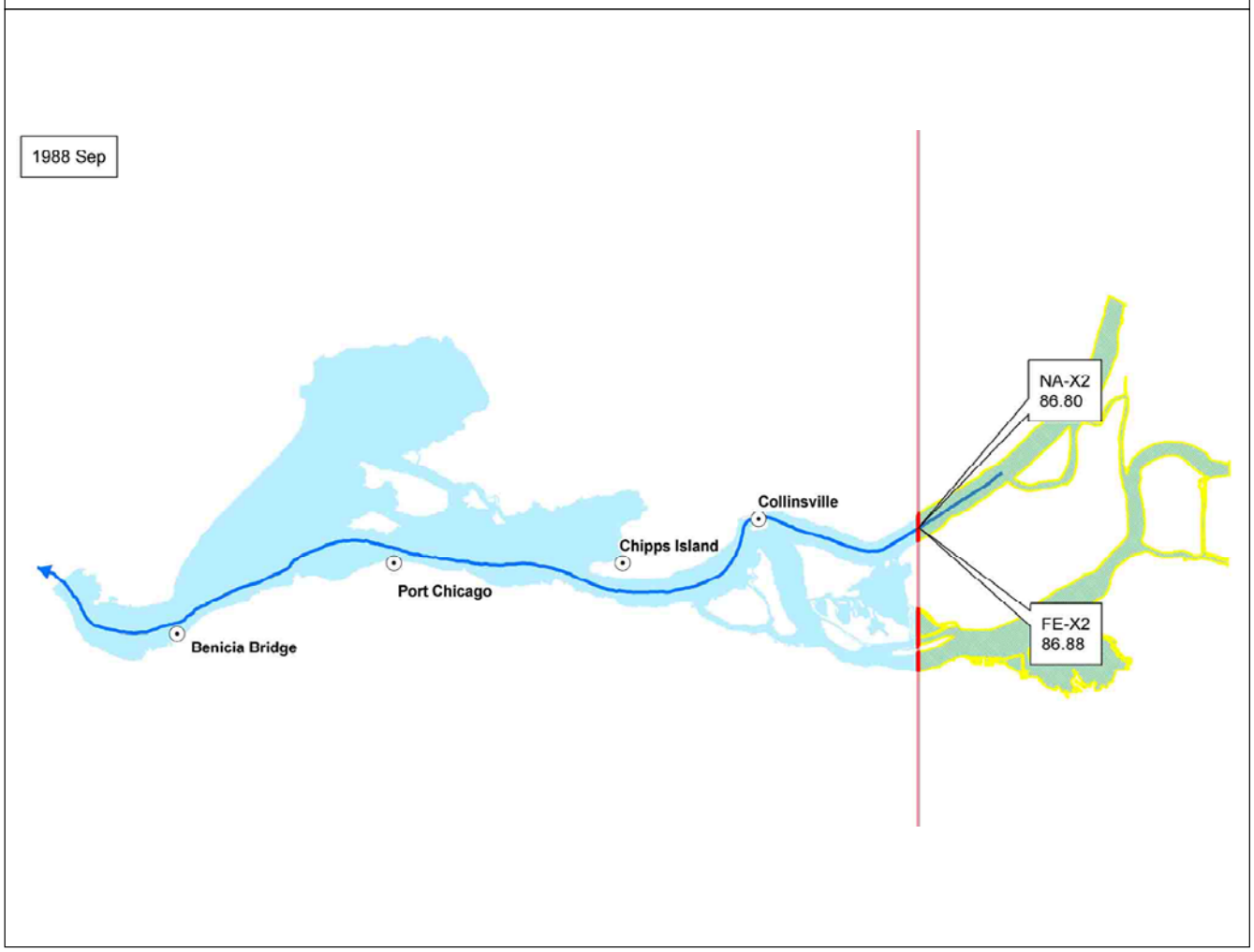
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Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
86.88


1988 Oct
NA-X2
88.94
FE-X2
89.20
Collinsville
Chipps Island
Port Chicago
Benicia Bridge


1988 Nov
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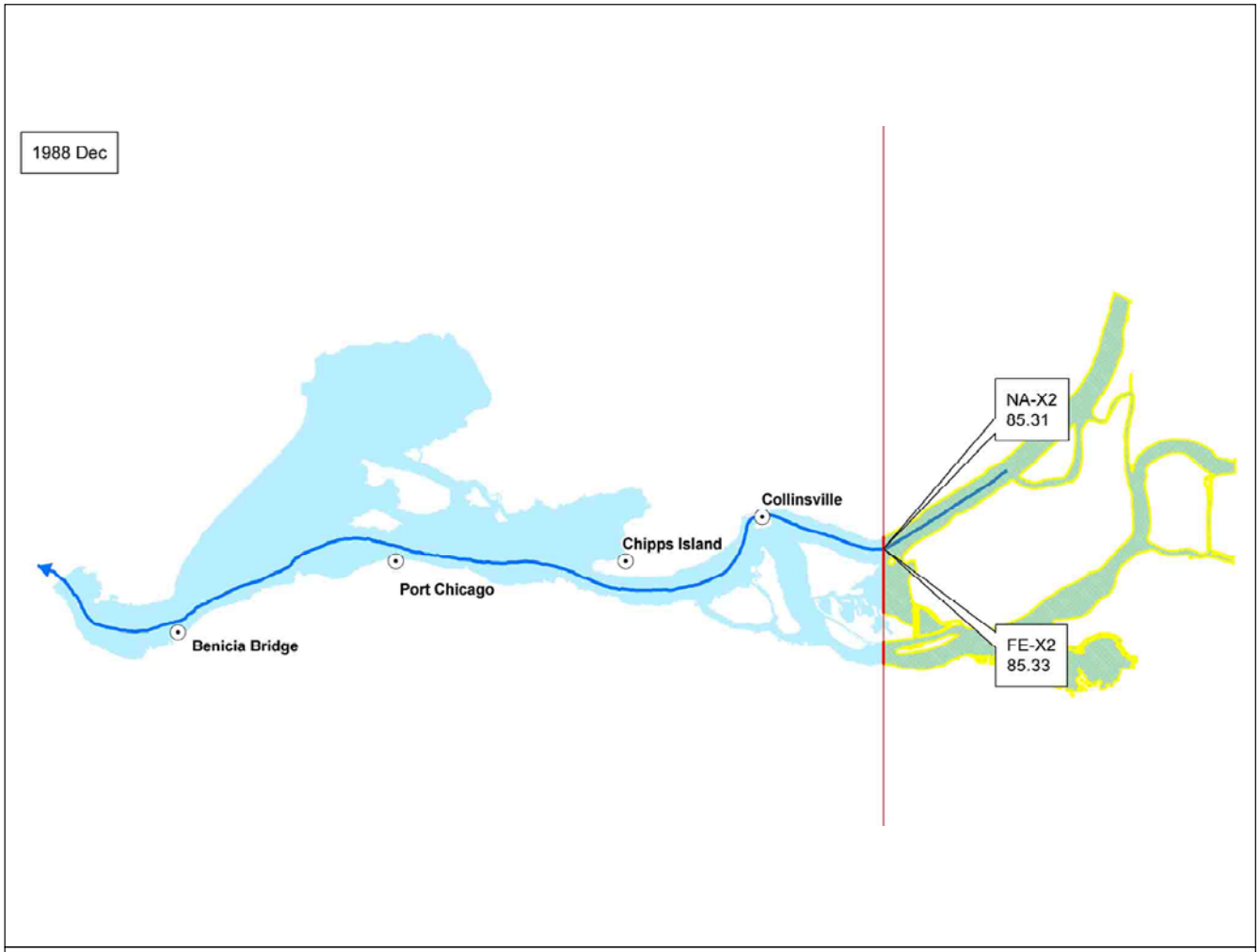
Collinsville
Chipps Island
Port Chicago
Benicia Bridge


1988 Dec
NA-X2
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Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
85.33


1988 average
NA-X2
81.13
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
80.91


1989 Jan
NA-X2
84.10
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
84.08


1989 Feb
NA-X2
81.26
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
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1989 Mar
NA-X2
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Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
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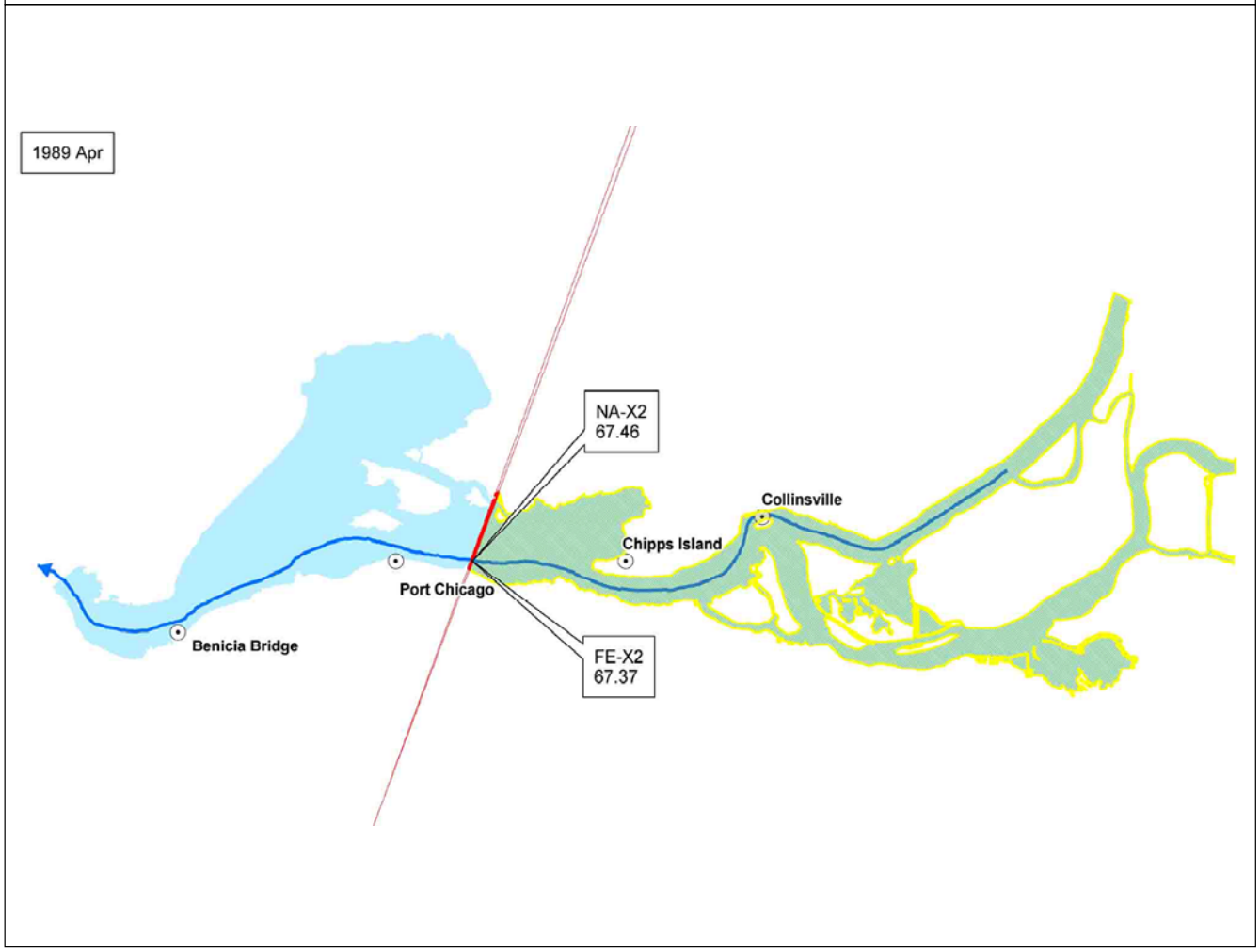
1989 Apr
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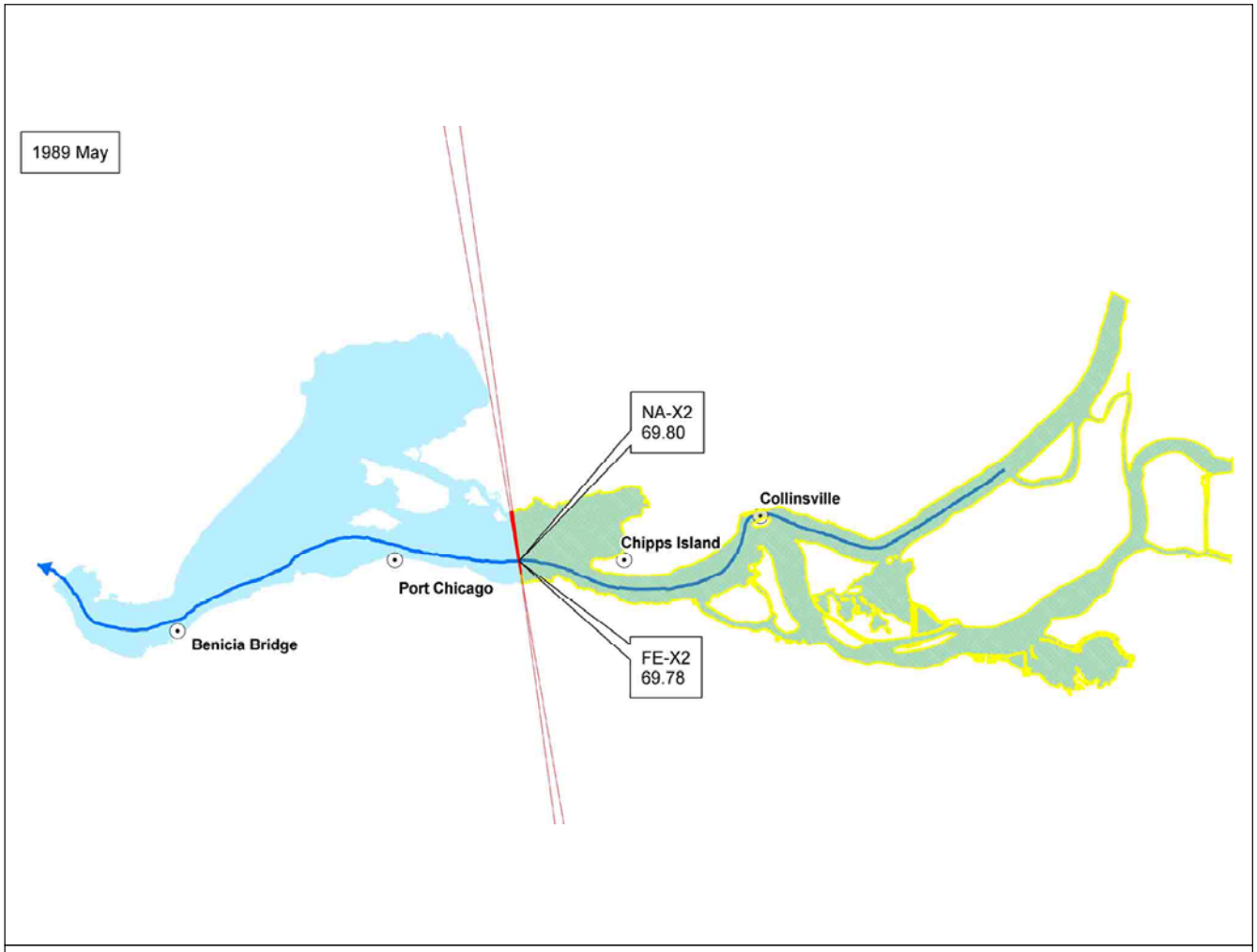
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
67.37


1989 May
NA-X2
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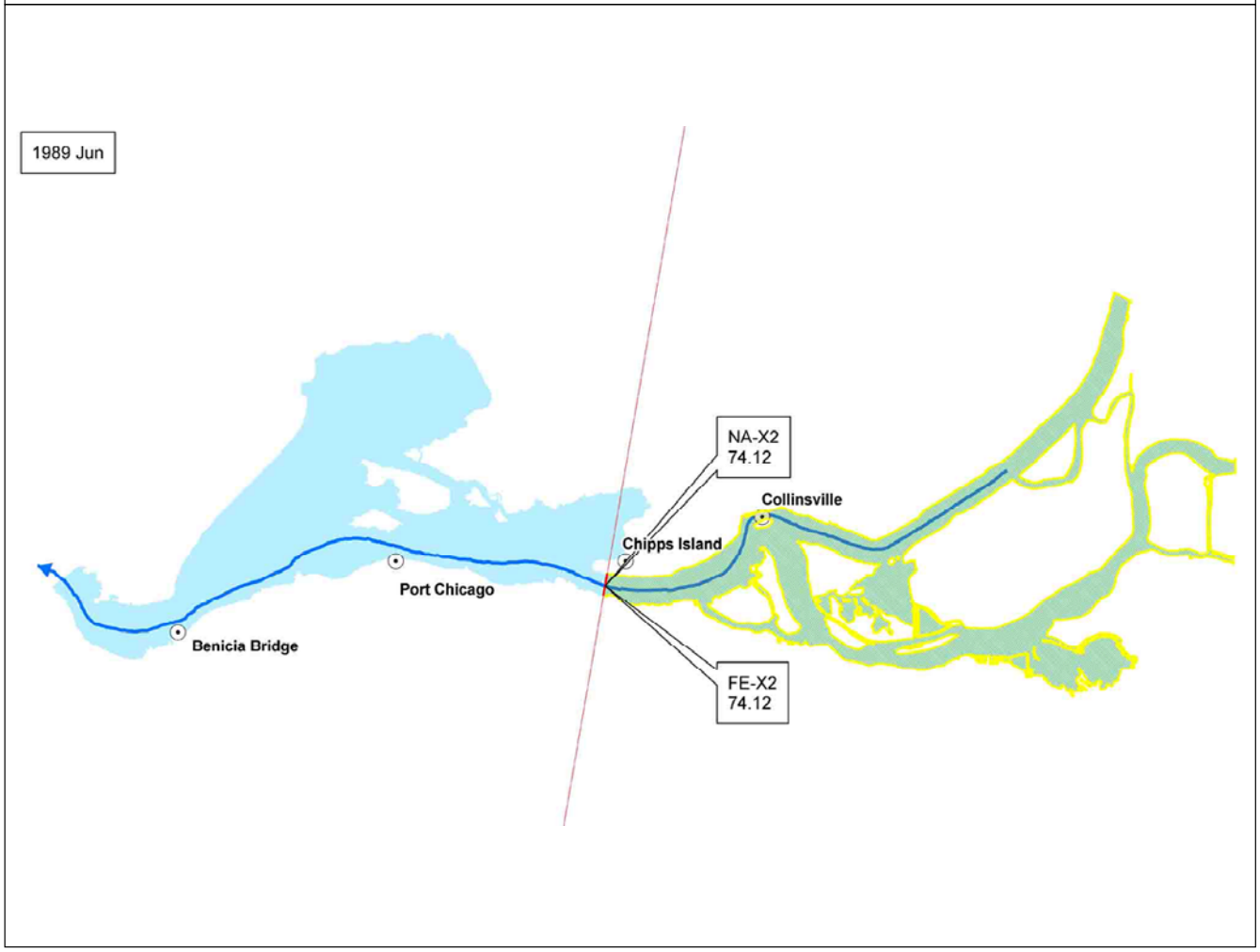
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
69.78


1989 Jun
NA-X2
74.12
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
74.12


1989 Jul
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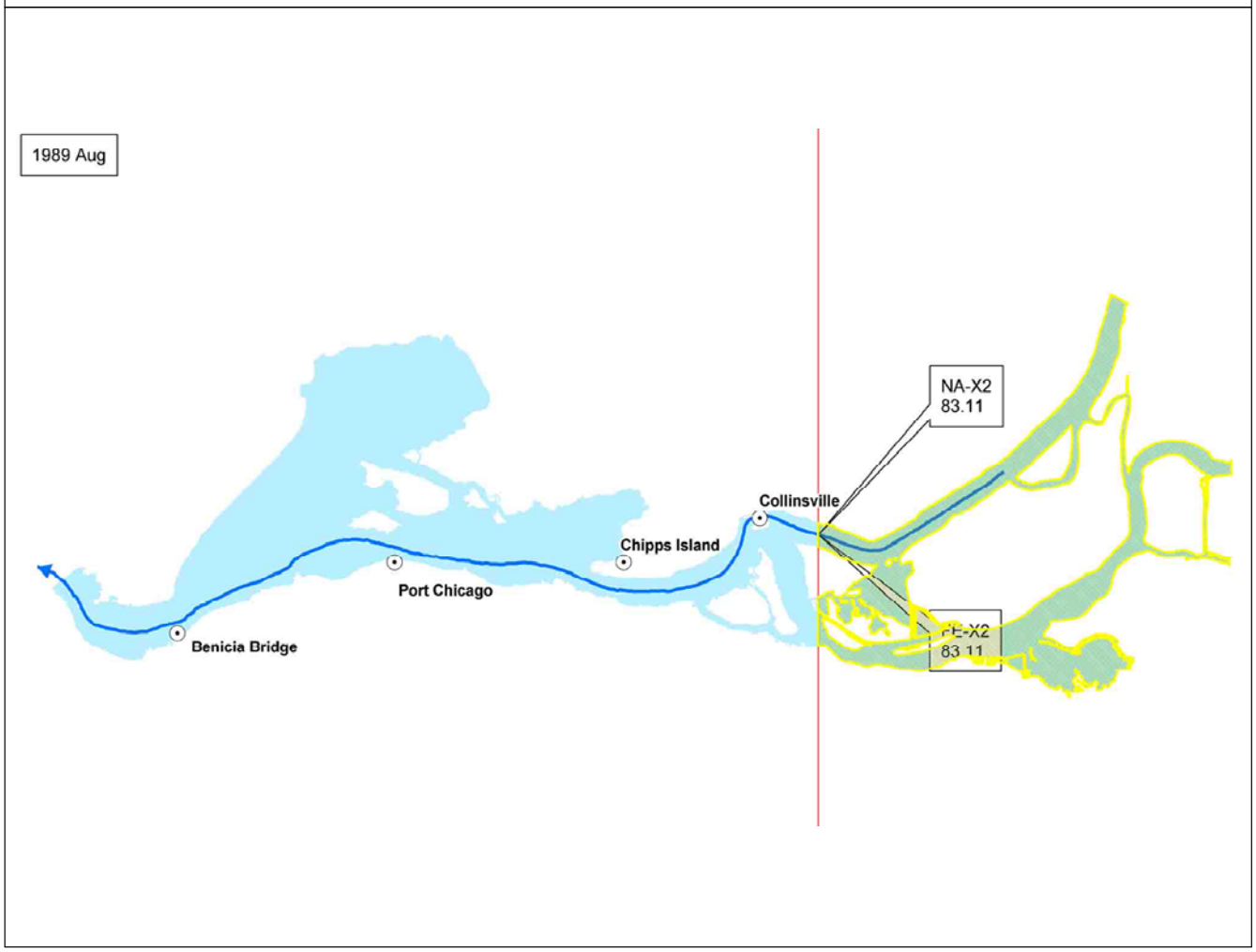
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
79.92


1989 Aug
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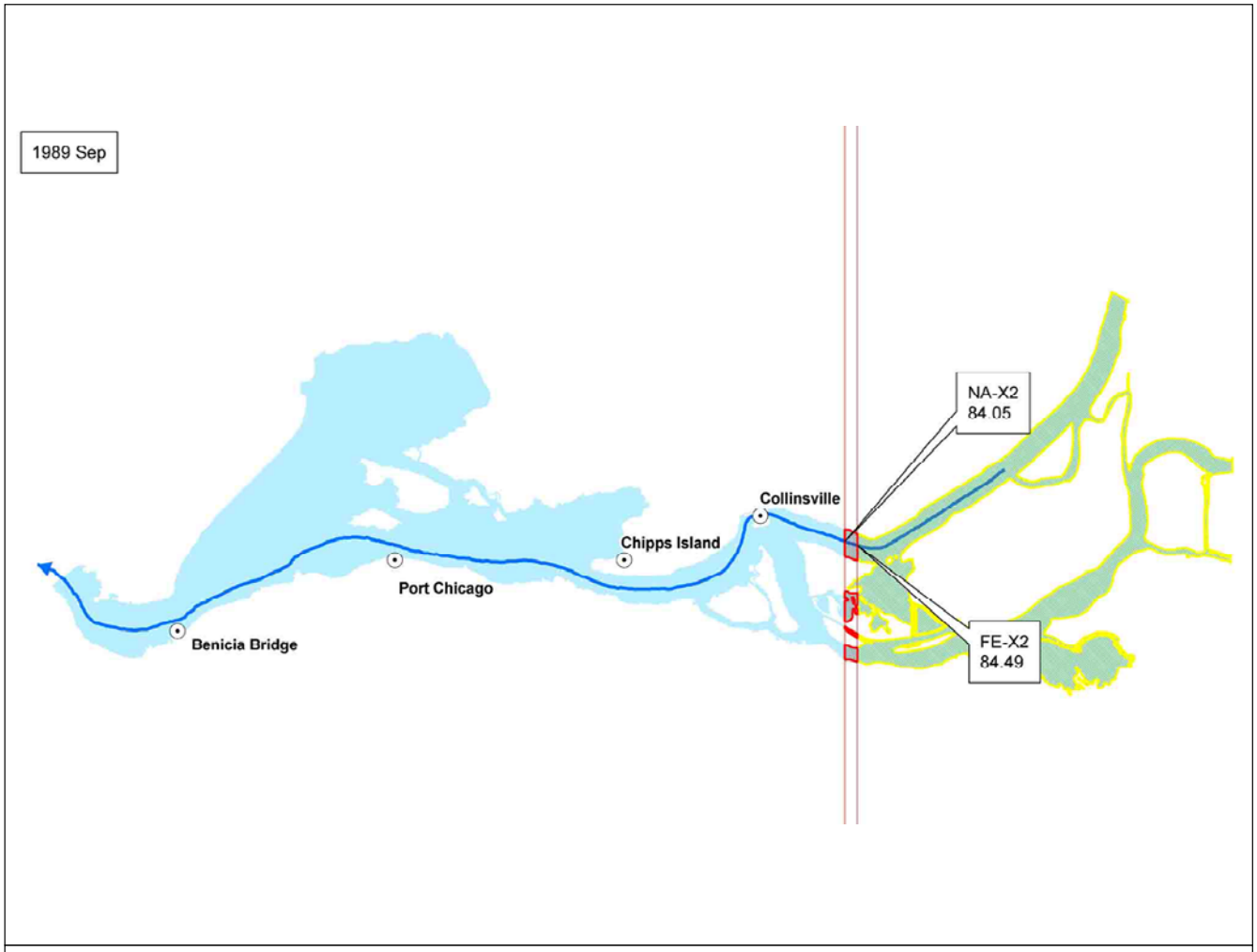
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
83.11


1989 Sep
NA-X2
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Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
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1989 Oct
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Chipps Island
Port Chicago
Benicia Bridge
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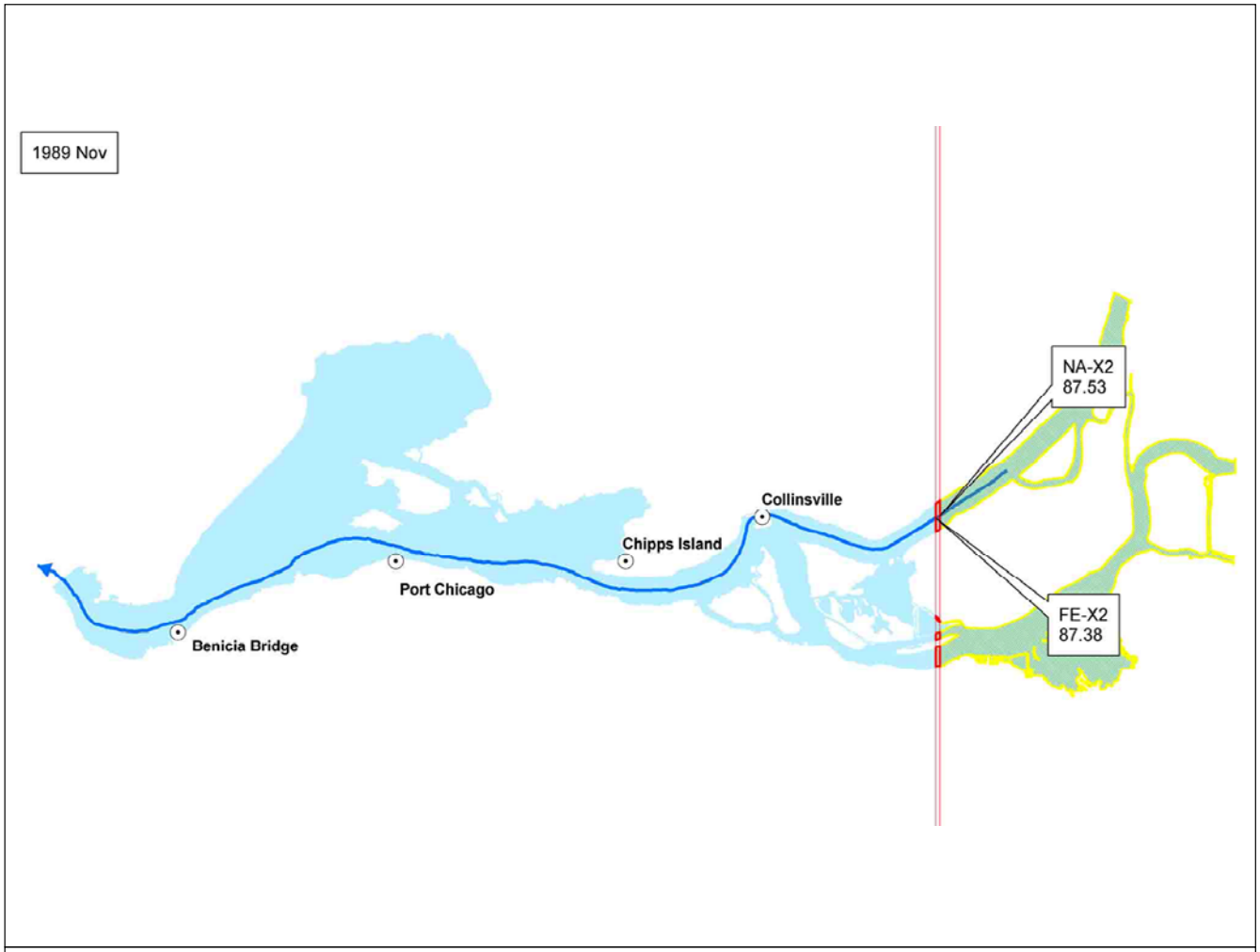
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87.53
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
87.38


1989 Dec
NA-X2
85.24
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
85.20


1989 average
NA-X2
80.50
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
80.52


1990 Jan
NA-X2
84.73
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
84.96


1990 Feb
NA-X2
79.04
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
78.38


1990 Mar
NA-X2
76.50
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
76.29


1990 Apr
NA-X2
77.55
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
77.03


1990 May
NA-X2
77.14
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
76.97


1990 Jun
NA-X2
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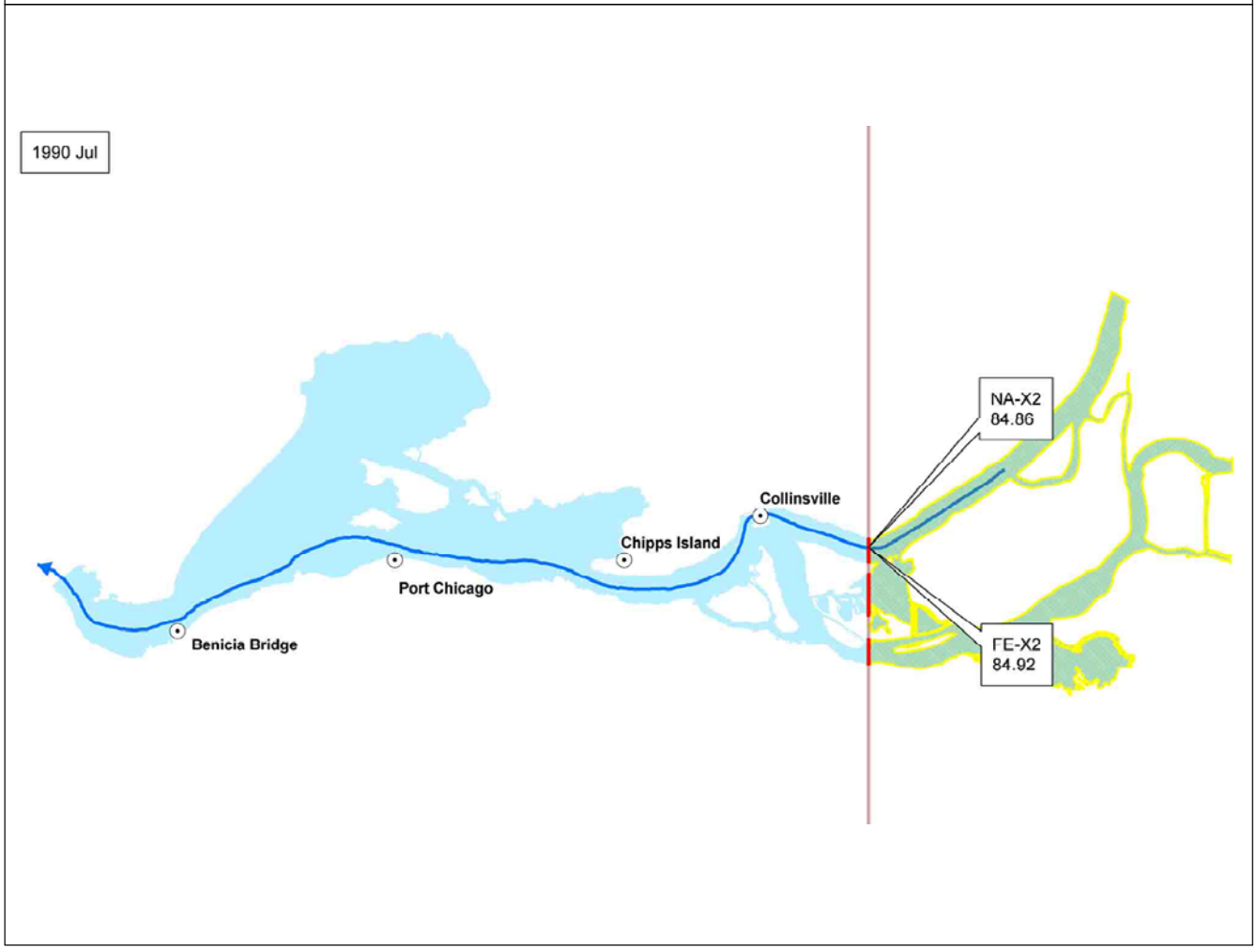
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
80.23


1990 Jul
NA-X2
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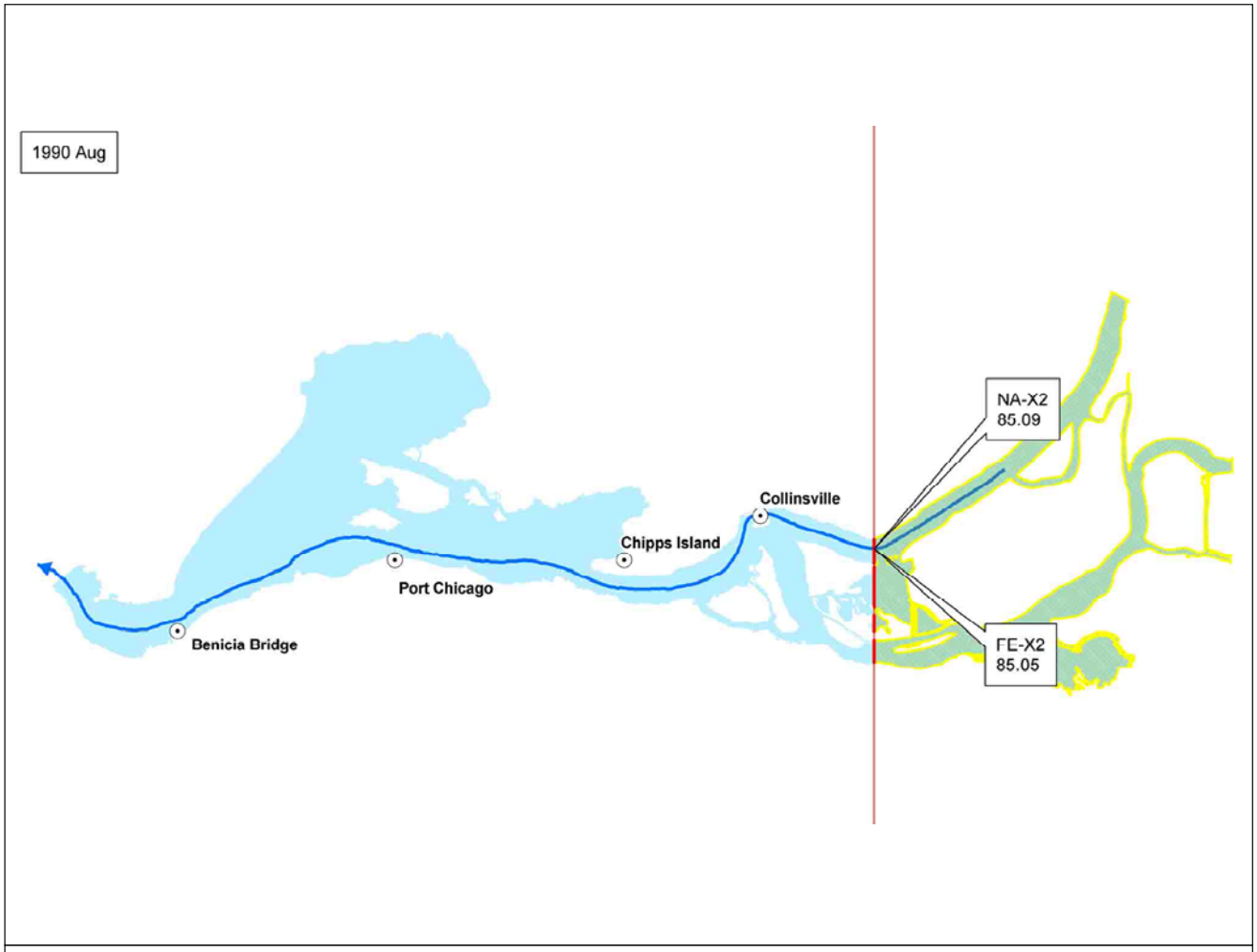
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
84.92


1990 Aug
NA-X2
85.09
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
85.05


1990 Sep
NA-X2
86.07
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
85.97


1990 Oct
NA-X2
86.67
Collinsville
Chipps Island
Port Chicago
Benicia Bridge
FE-X2
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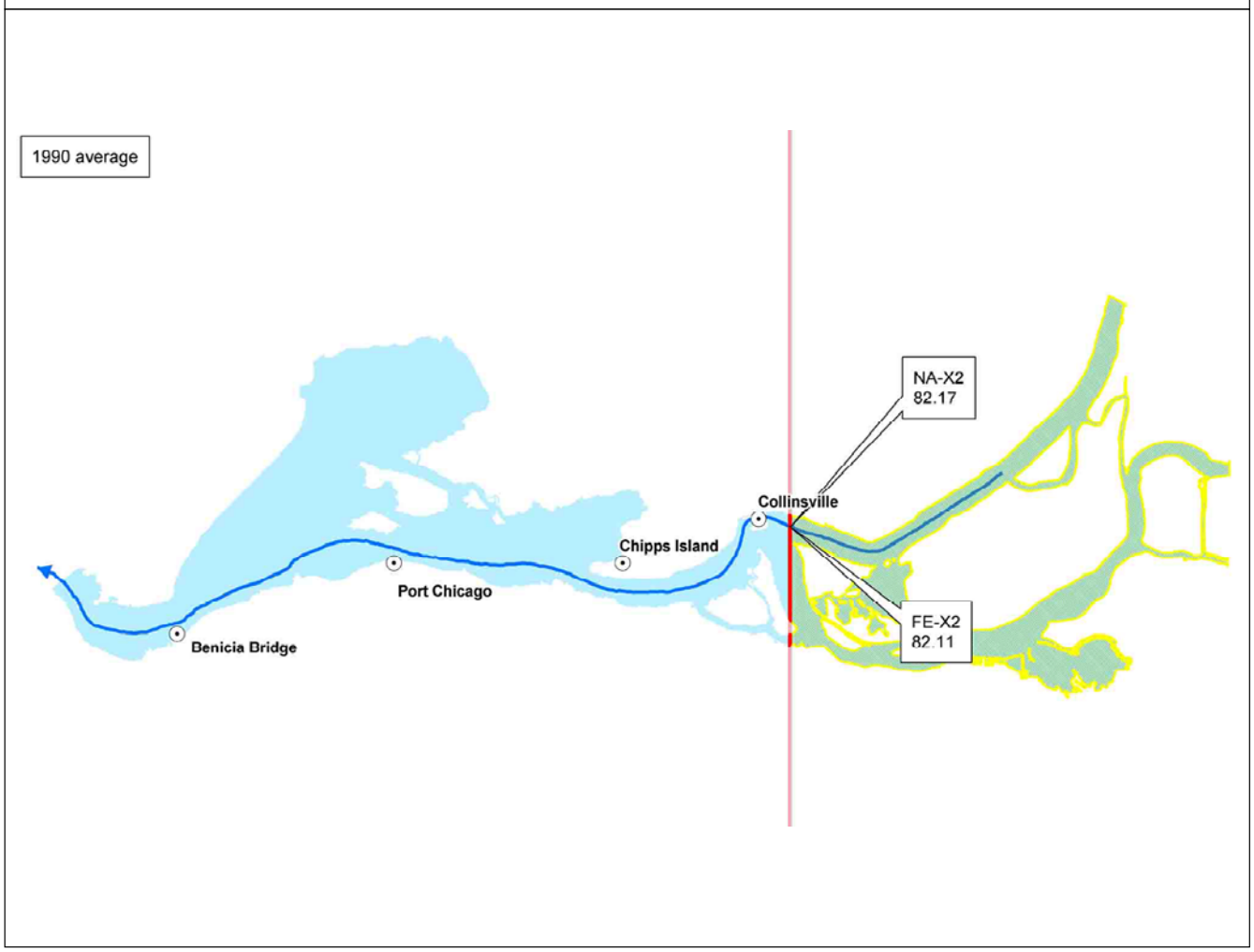
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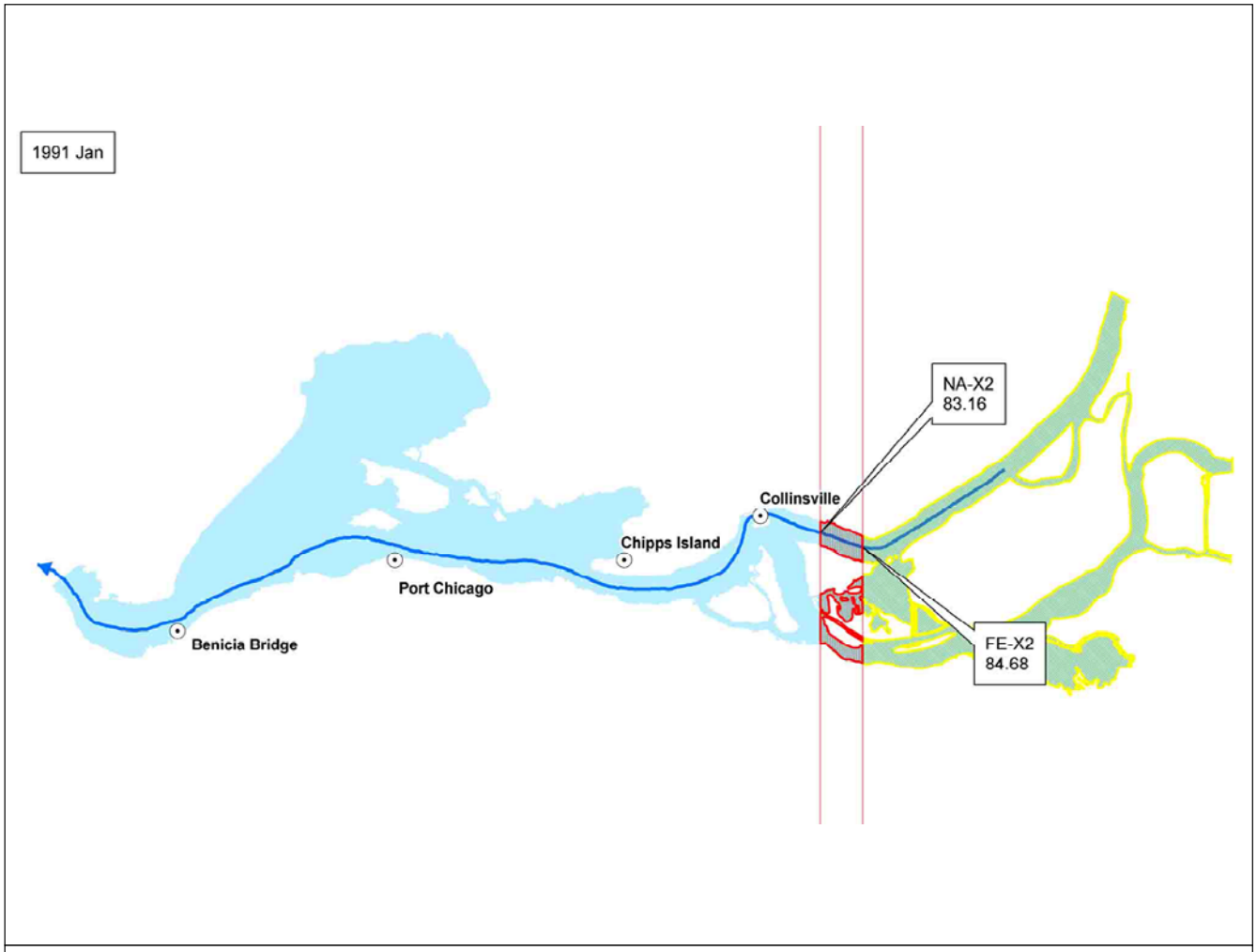
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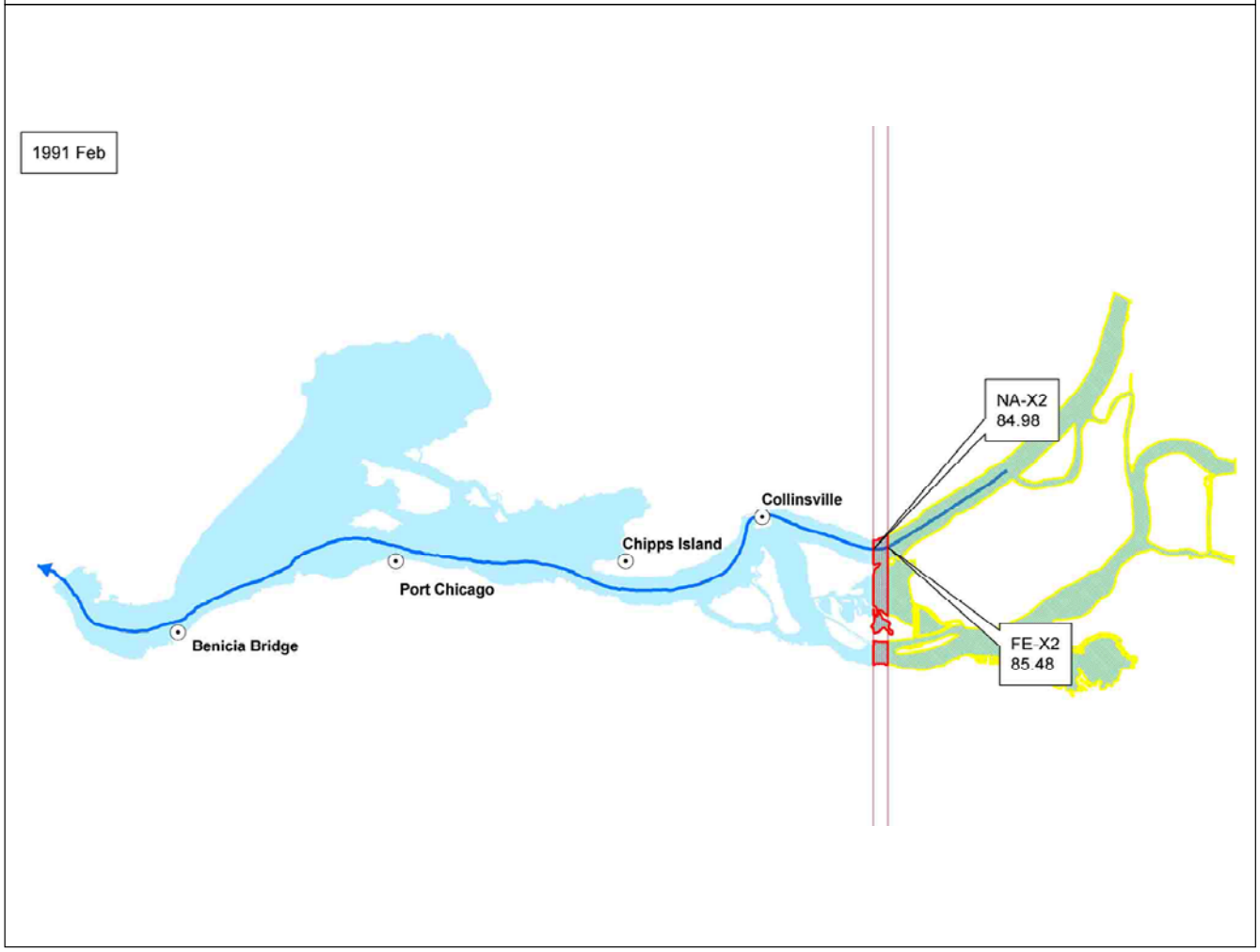
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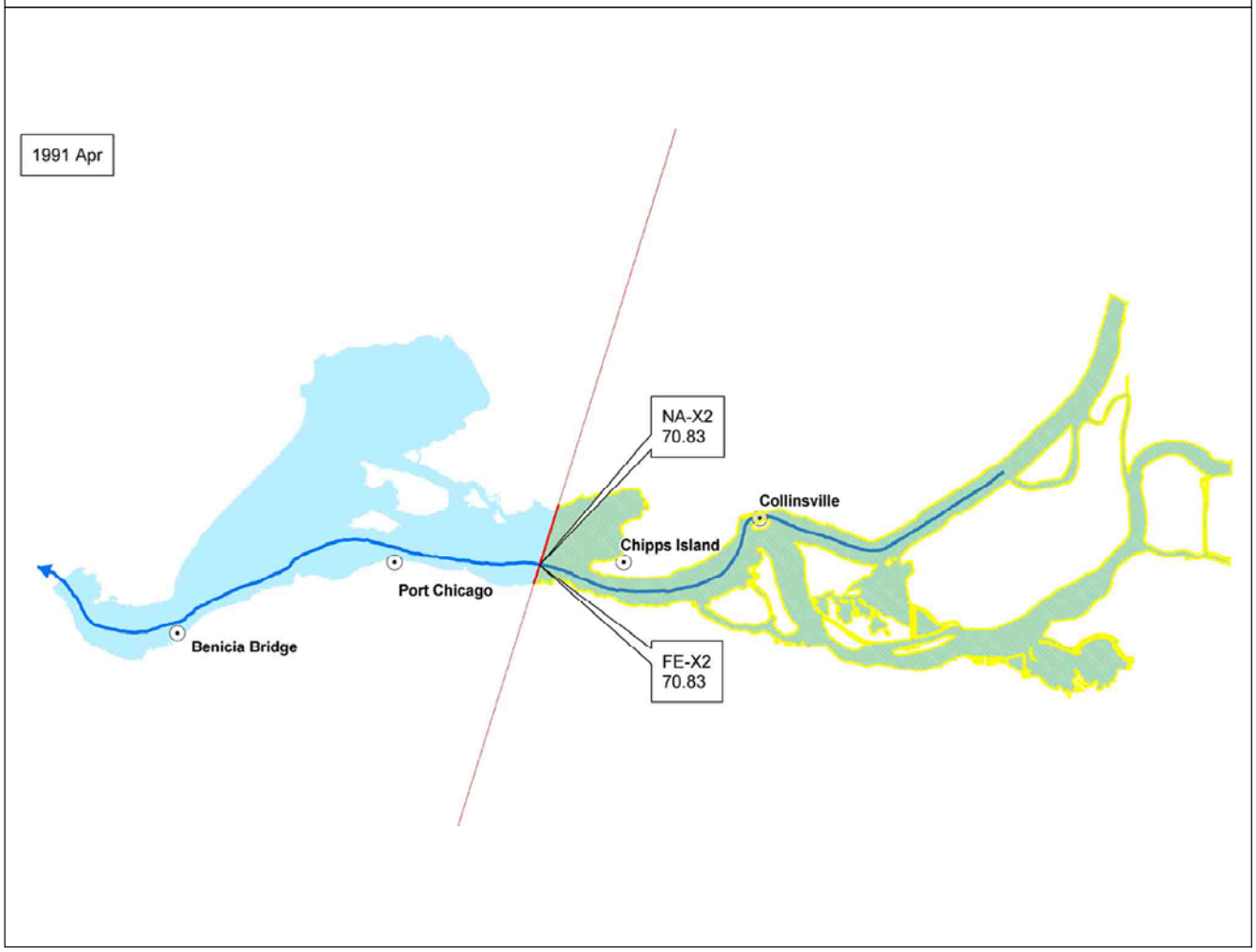
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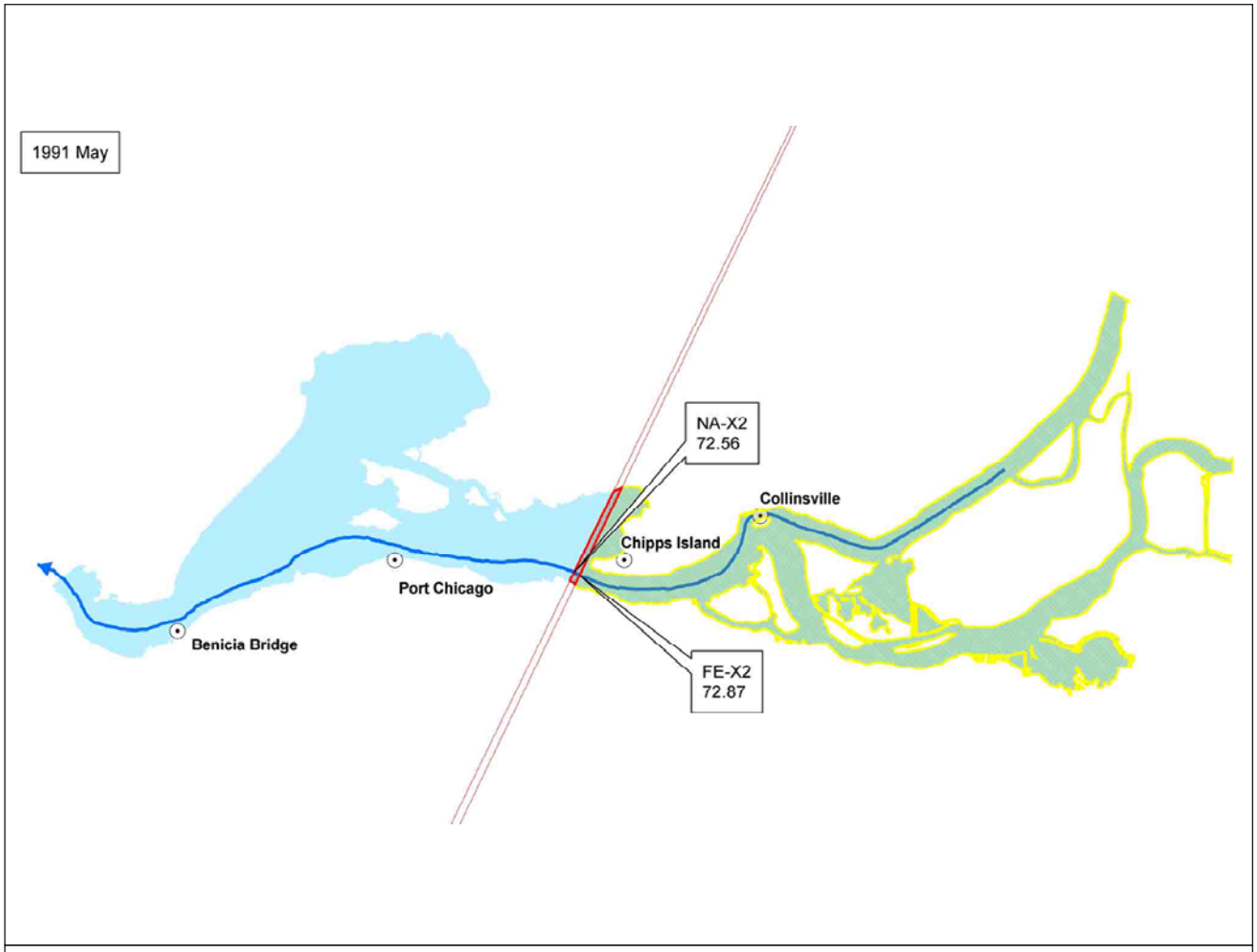
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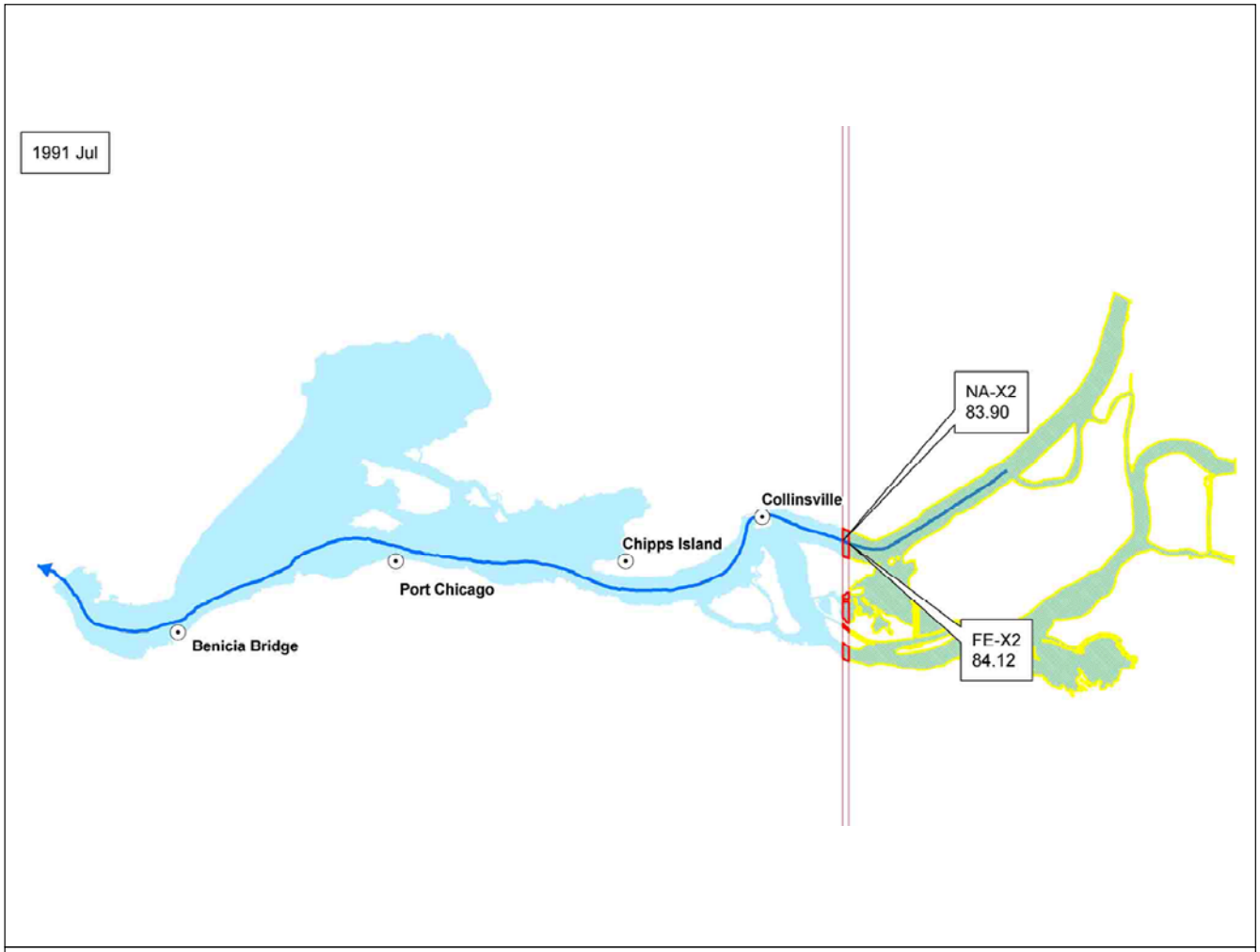
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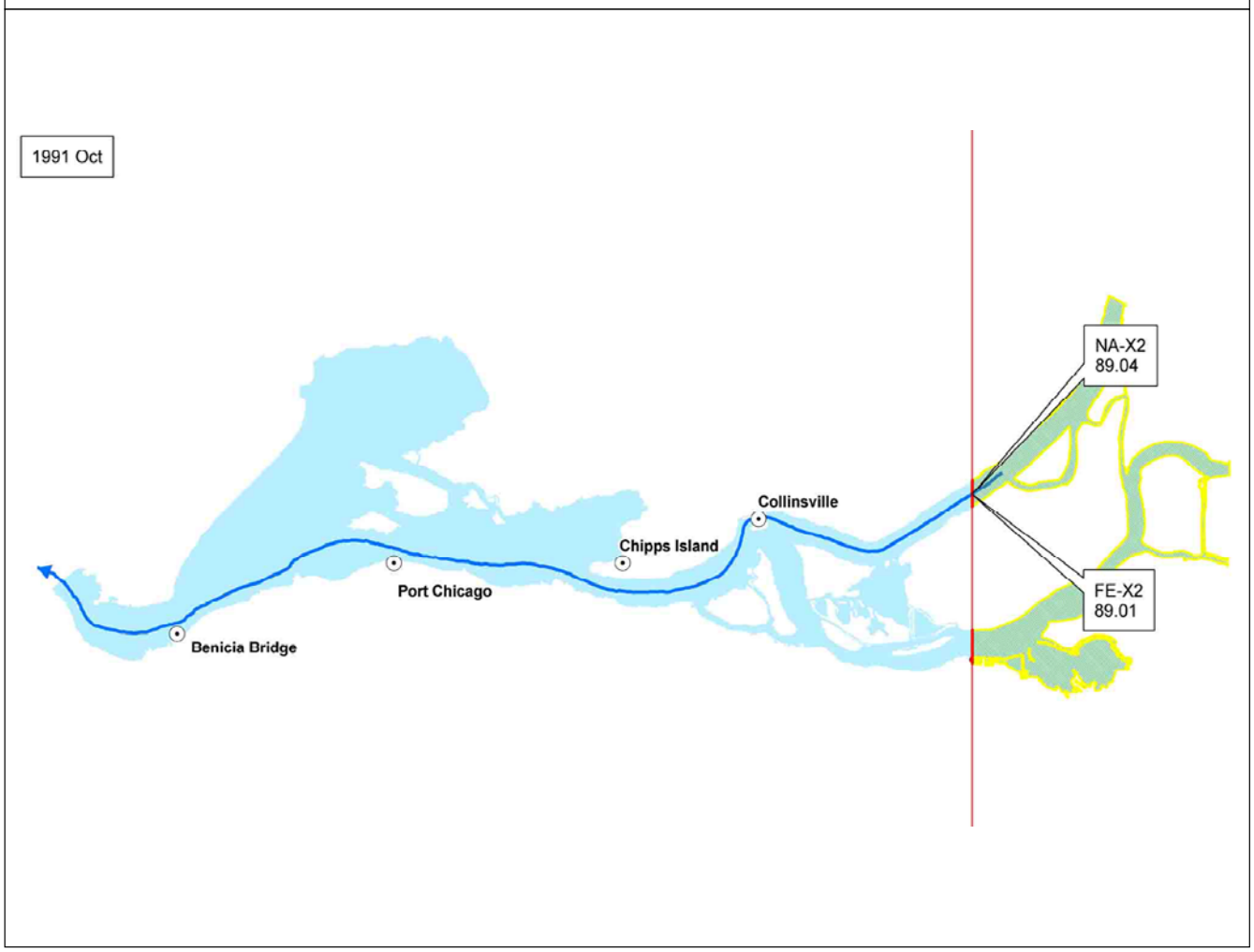
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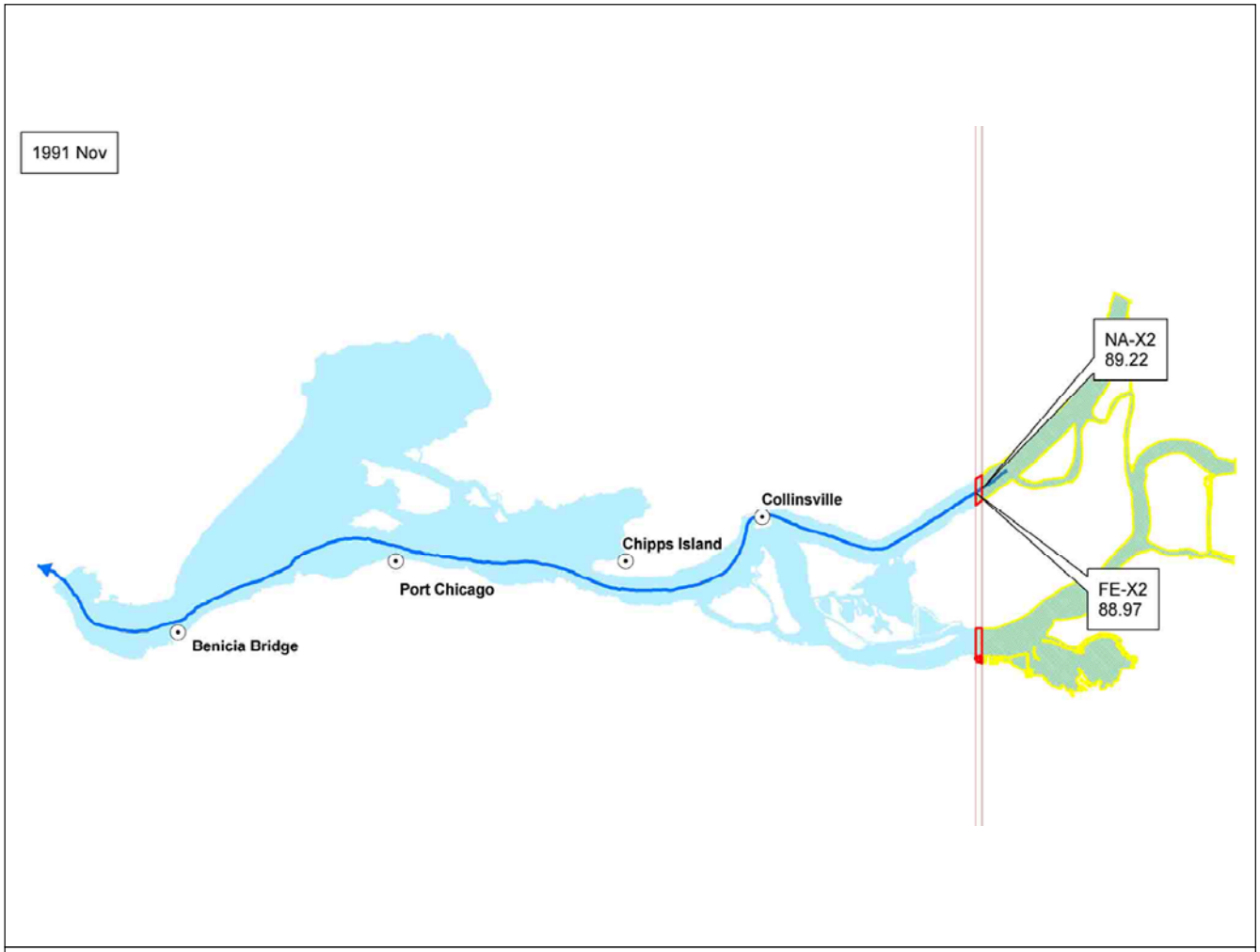
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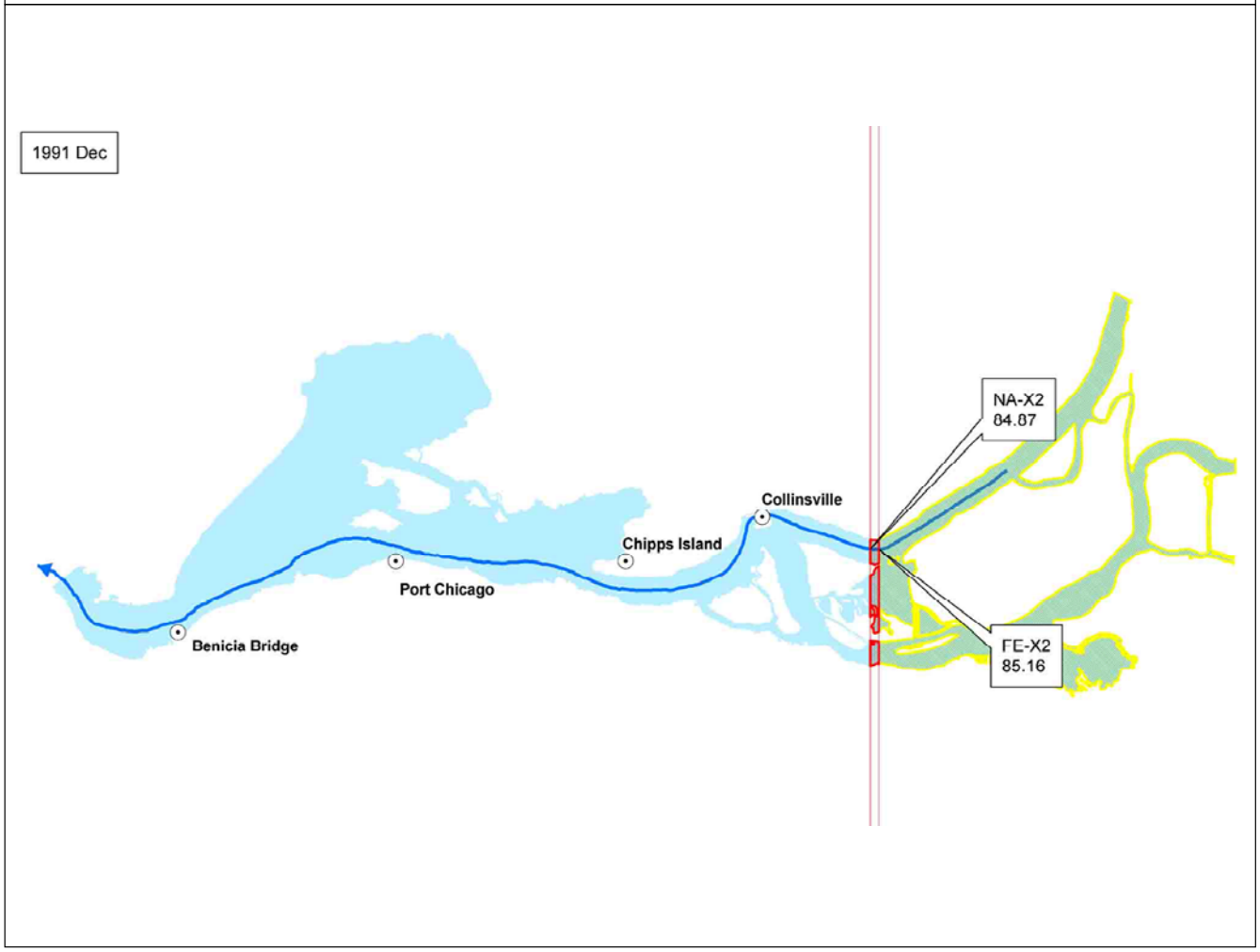
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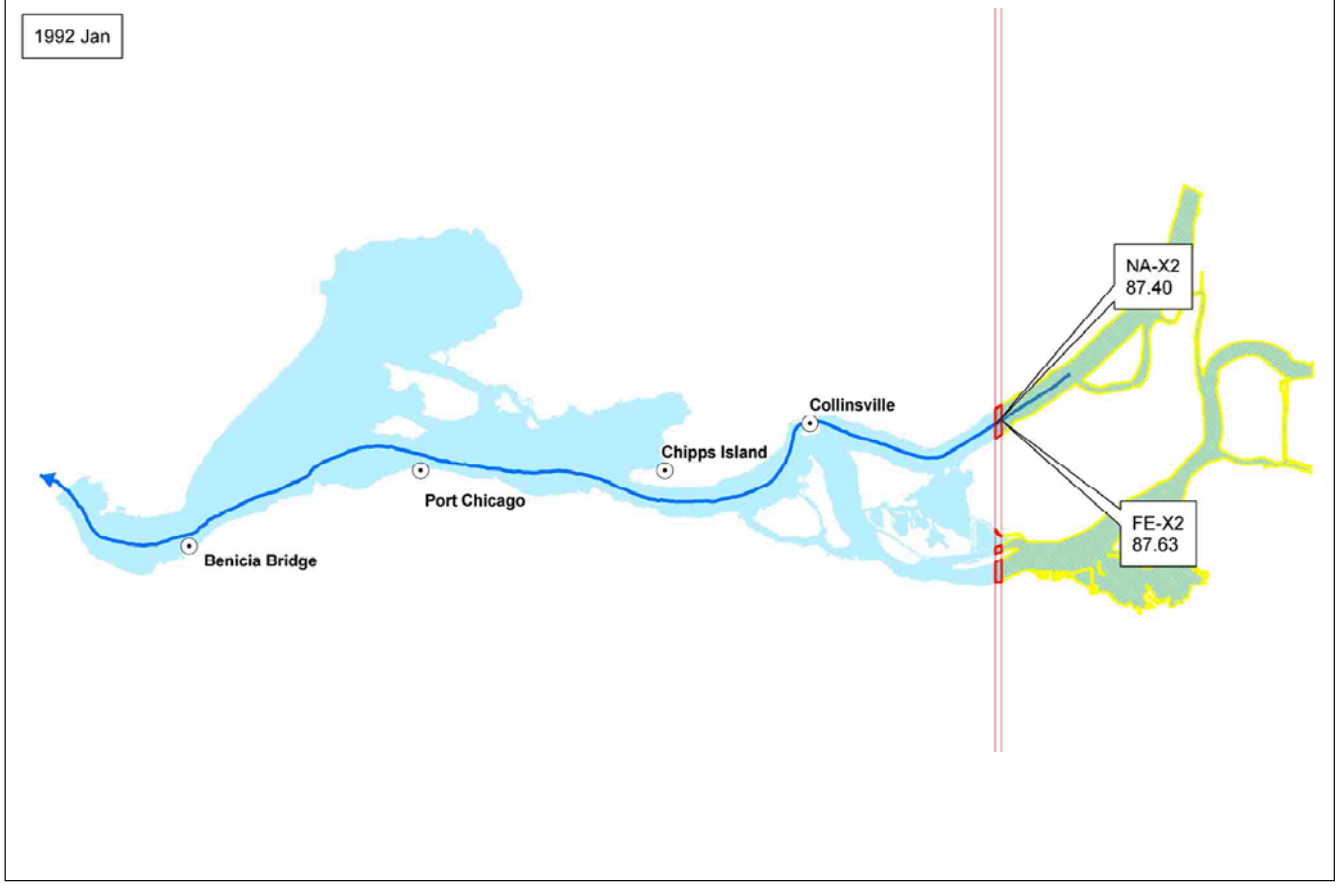
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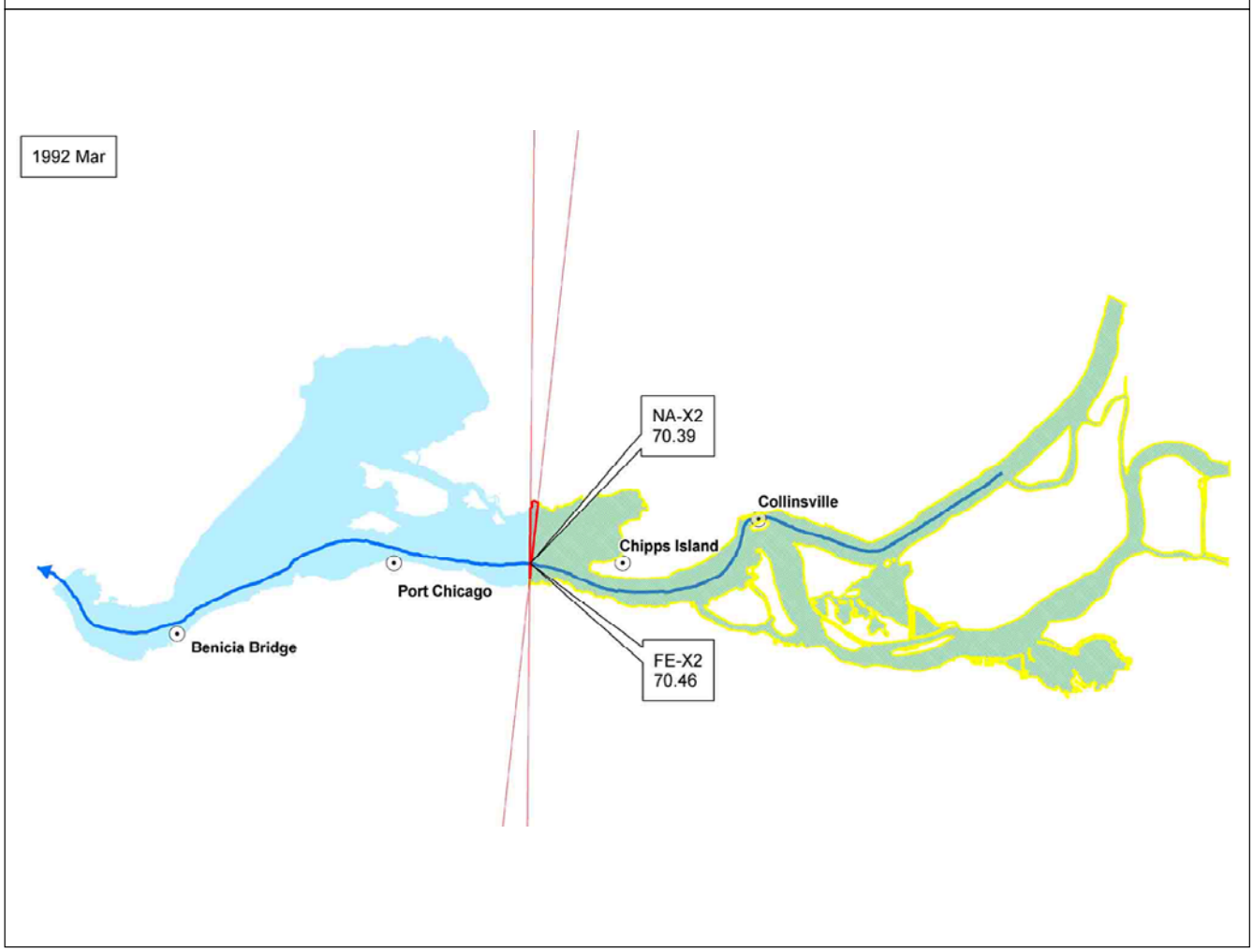
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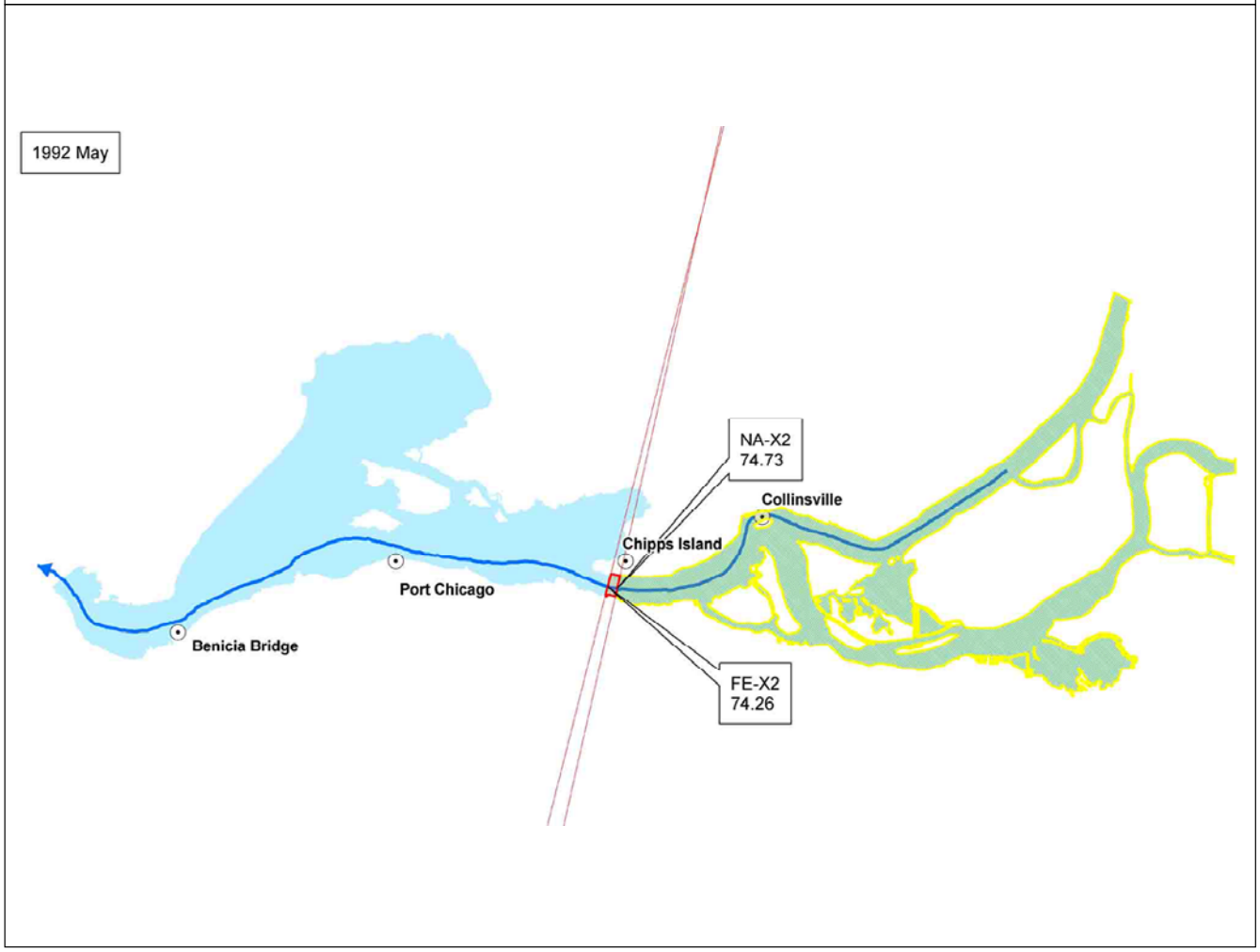
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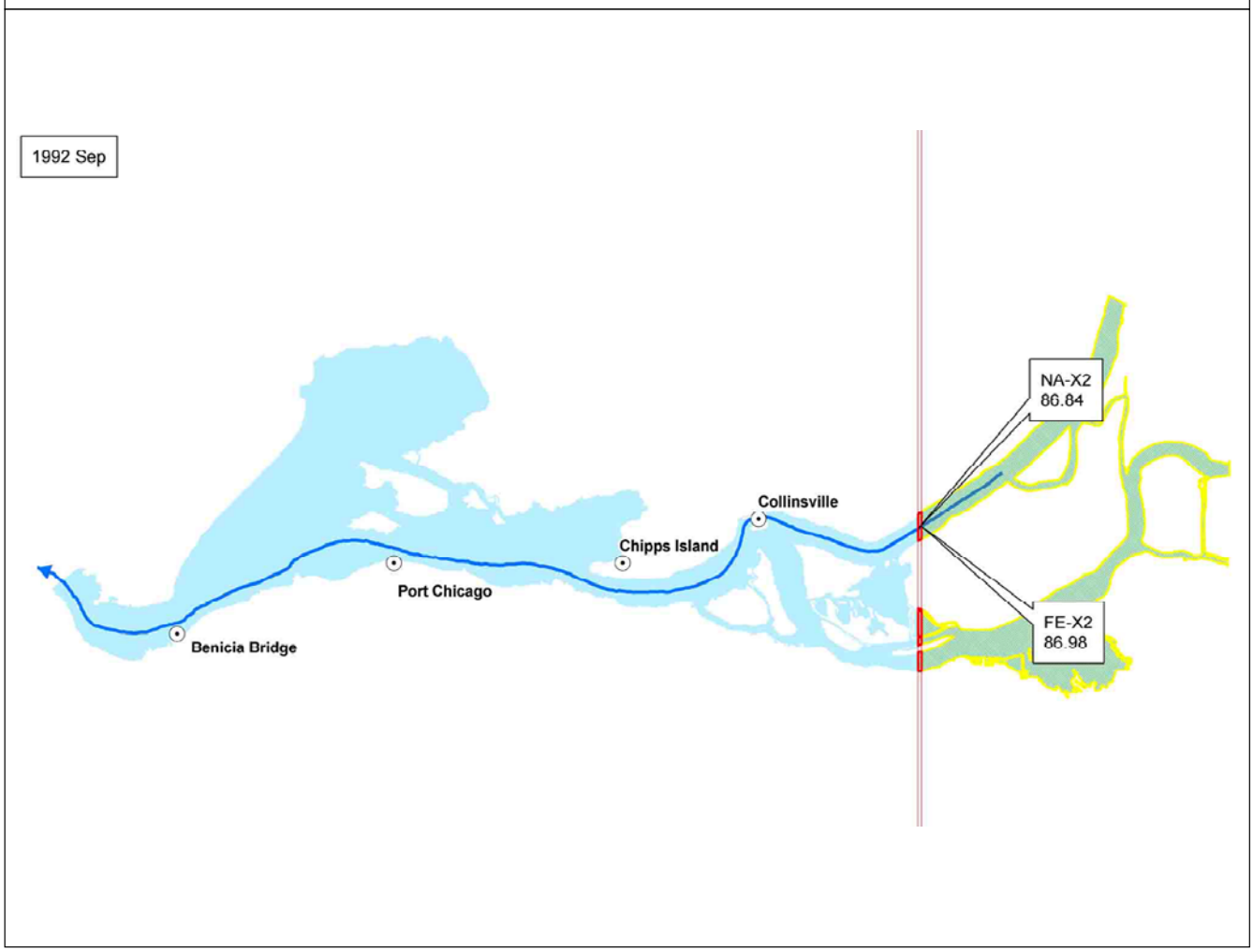
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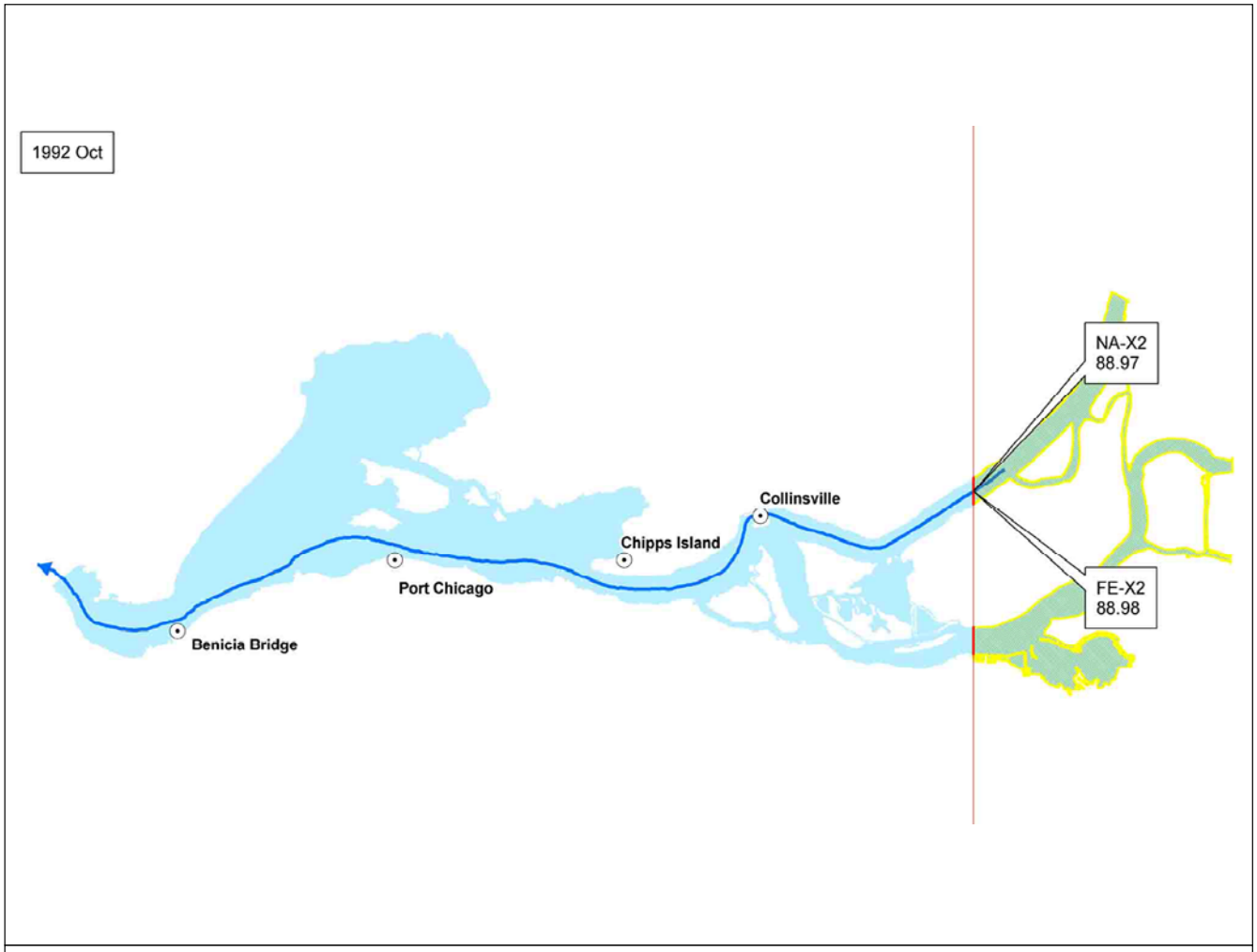
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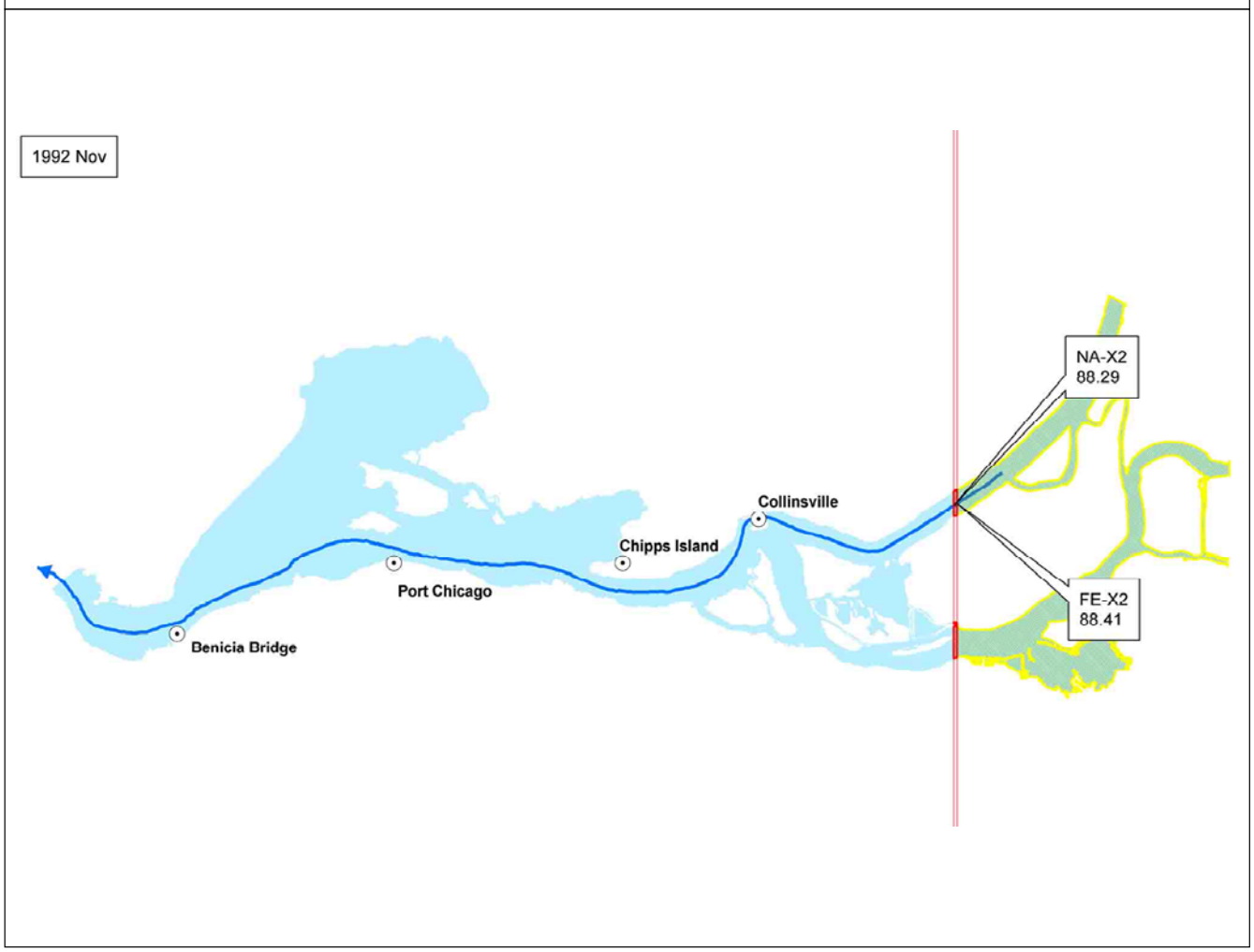
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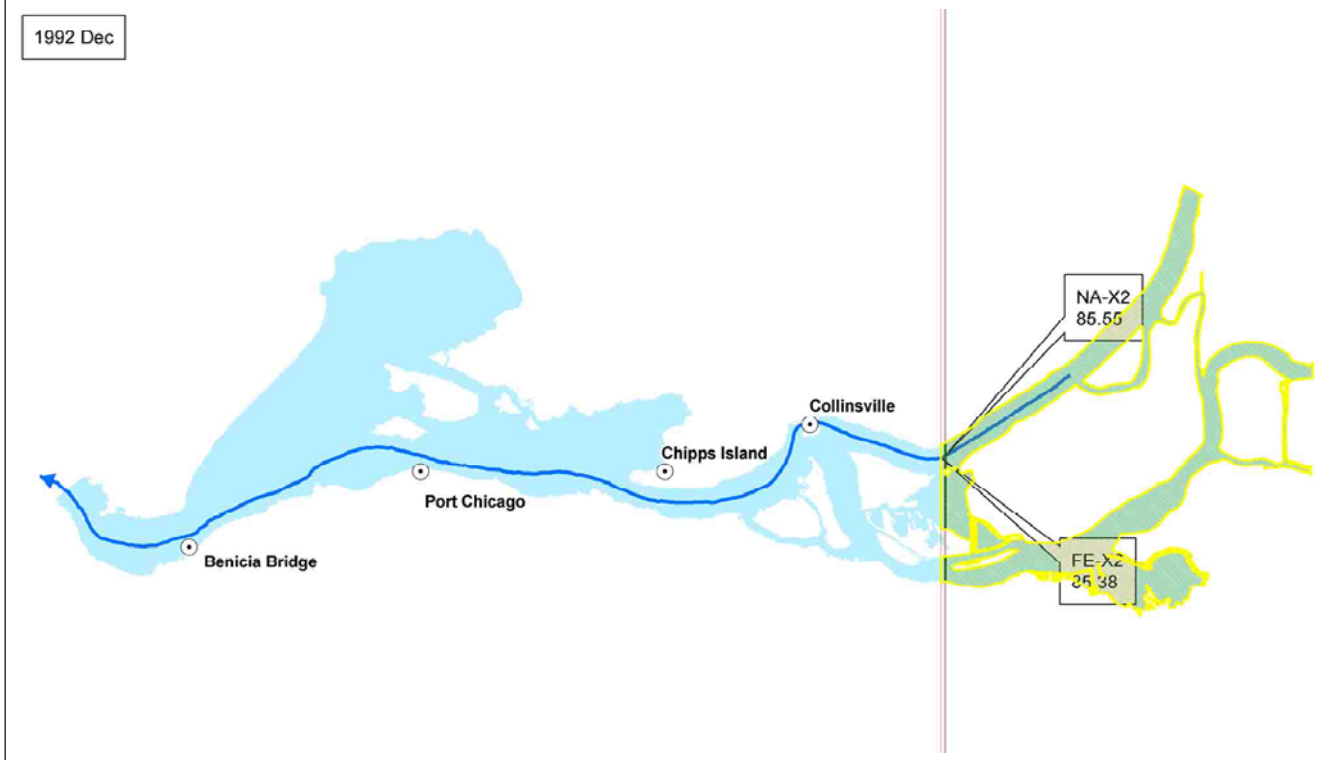
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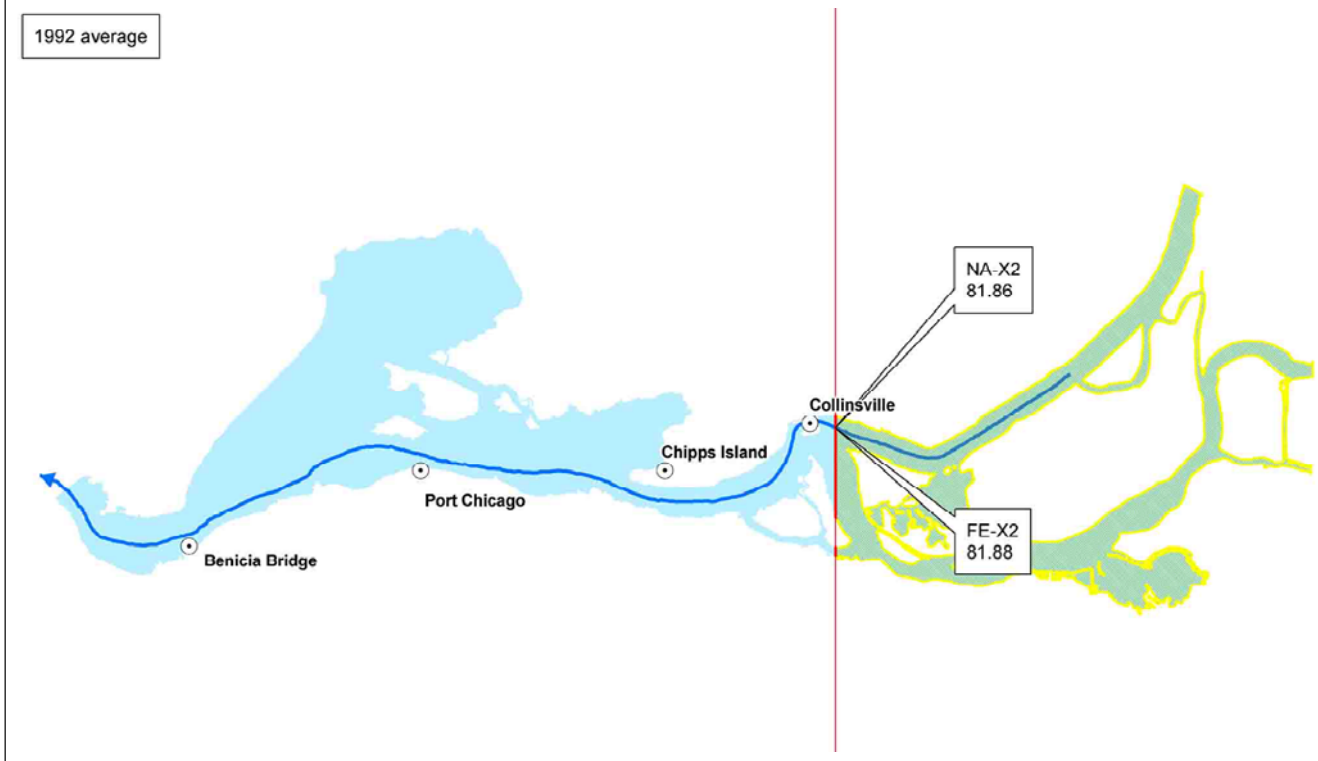
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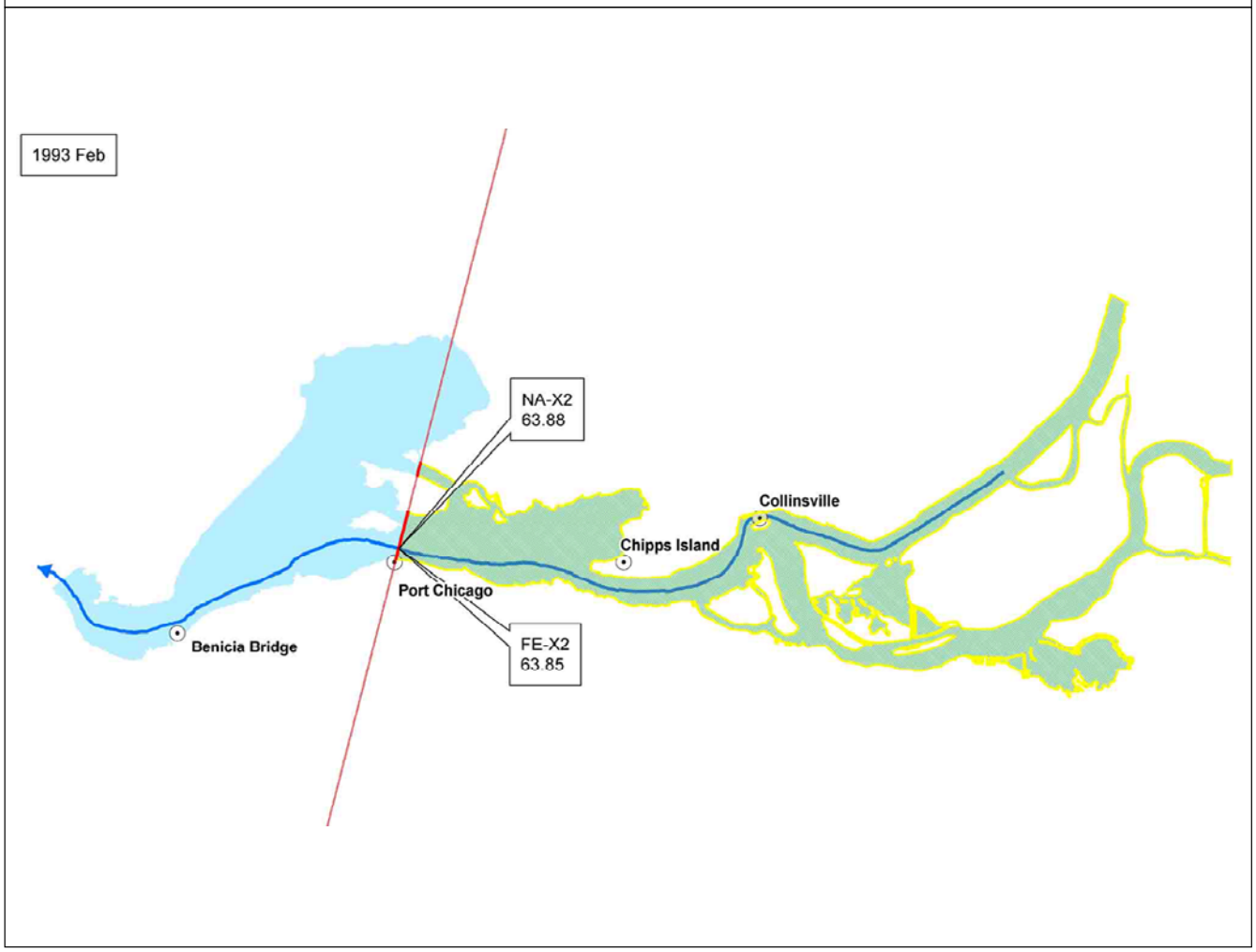
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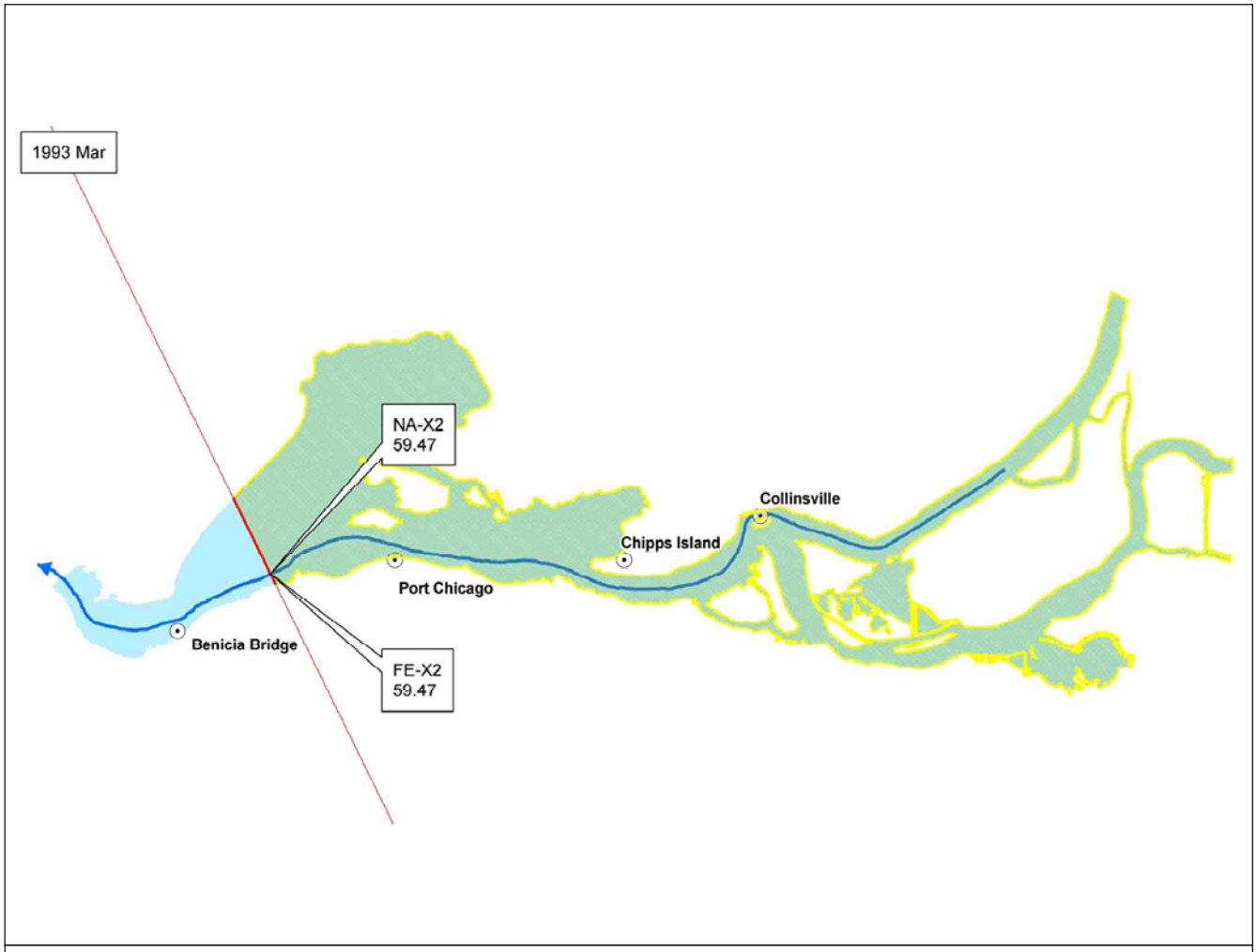
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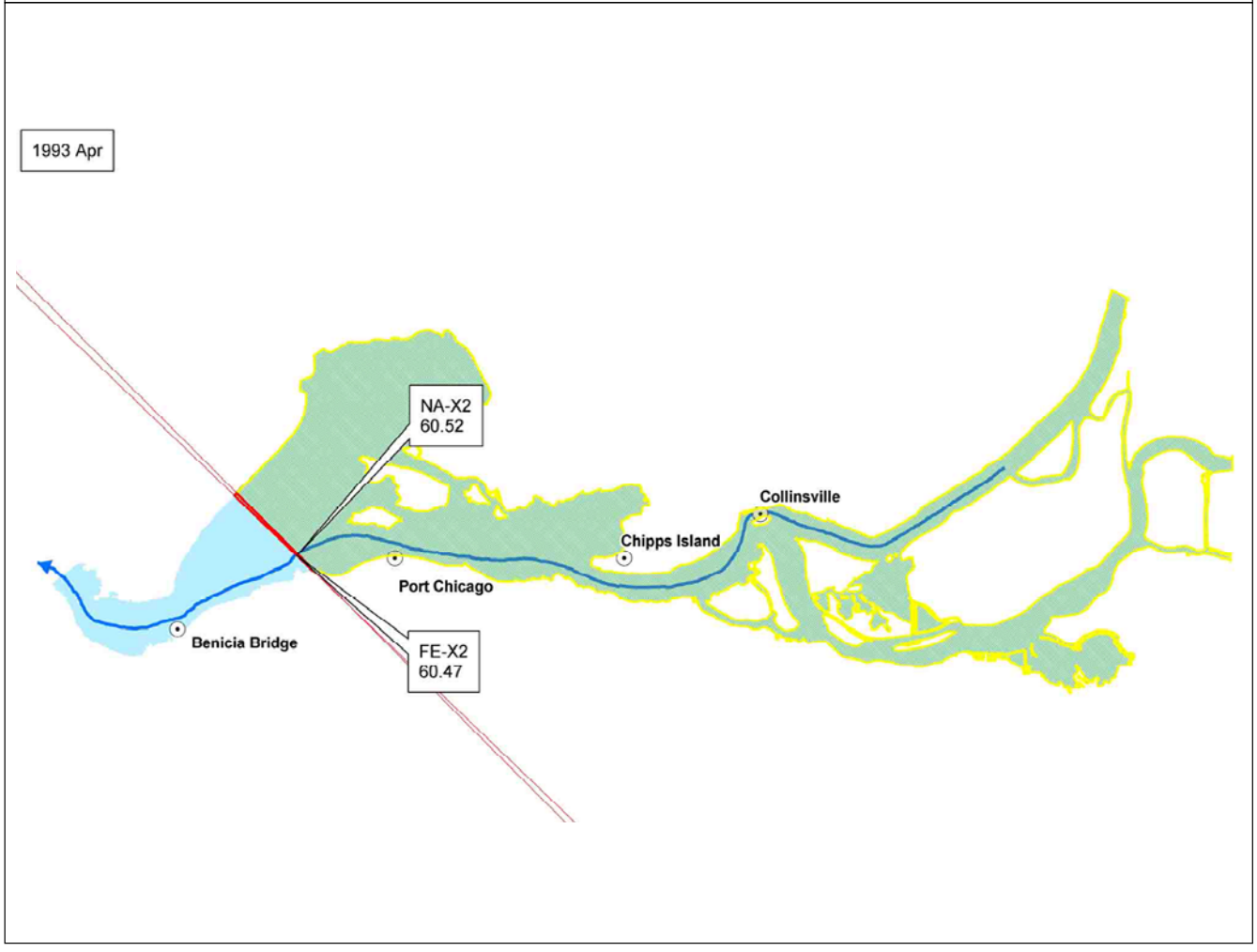
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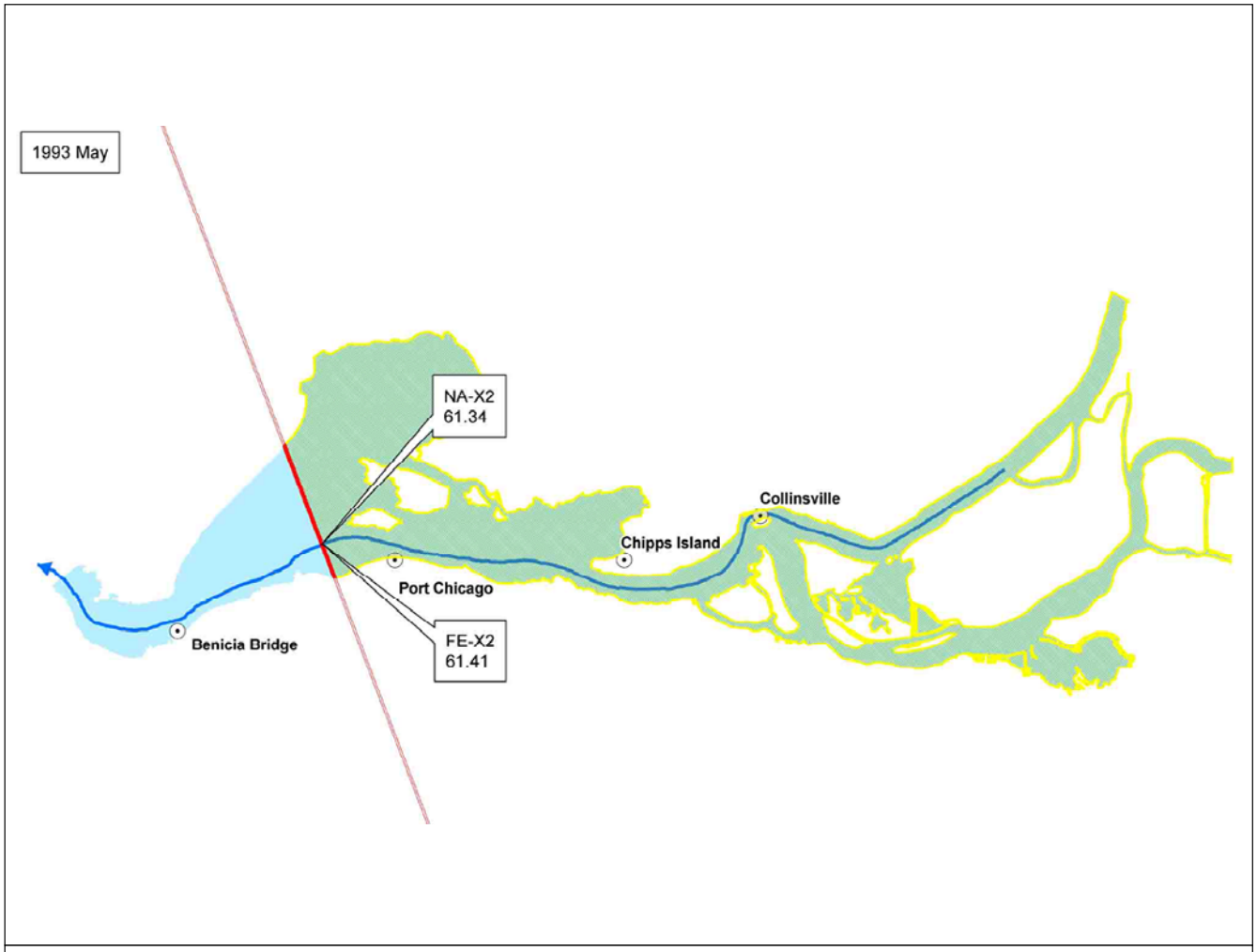
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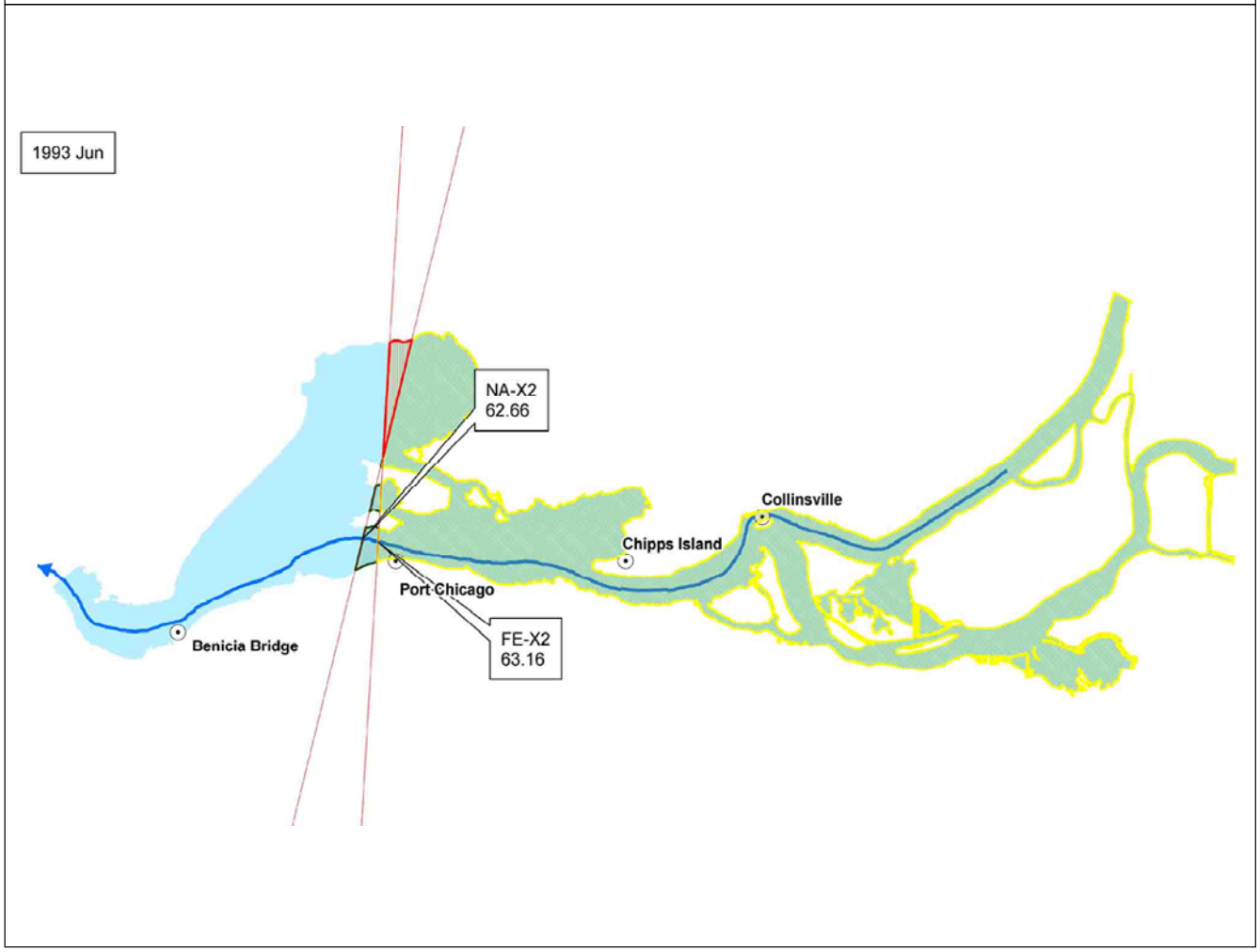
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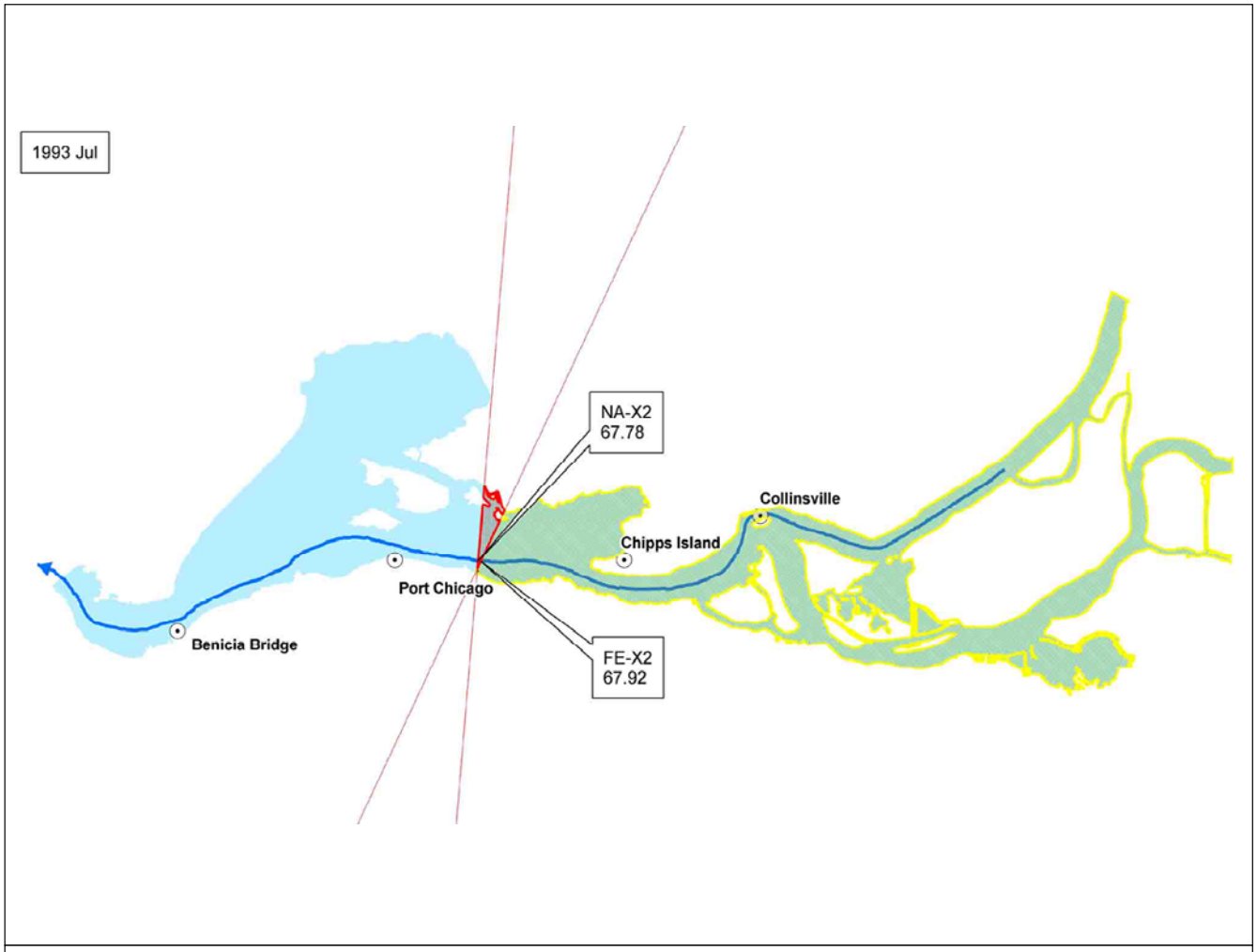
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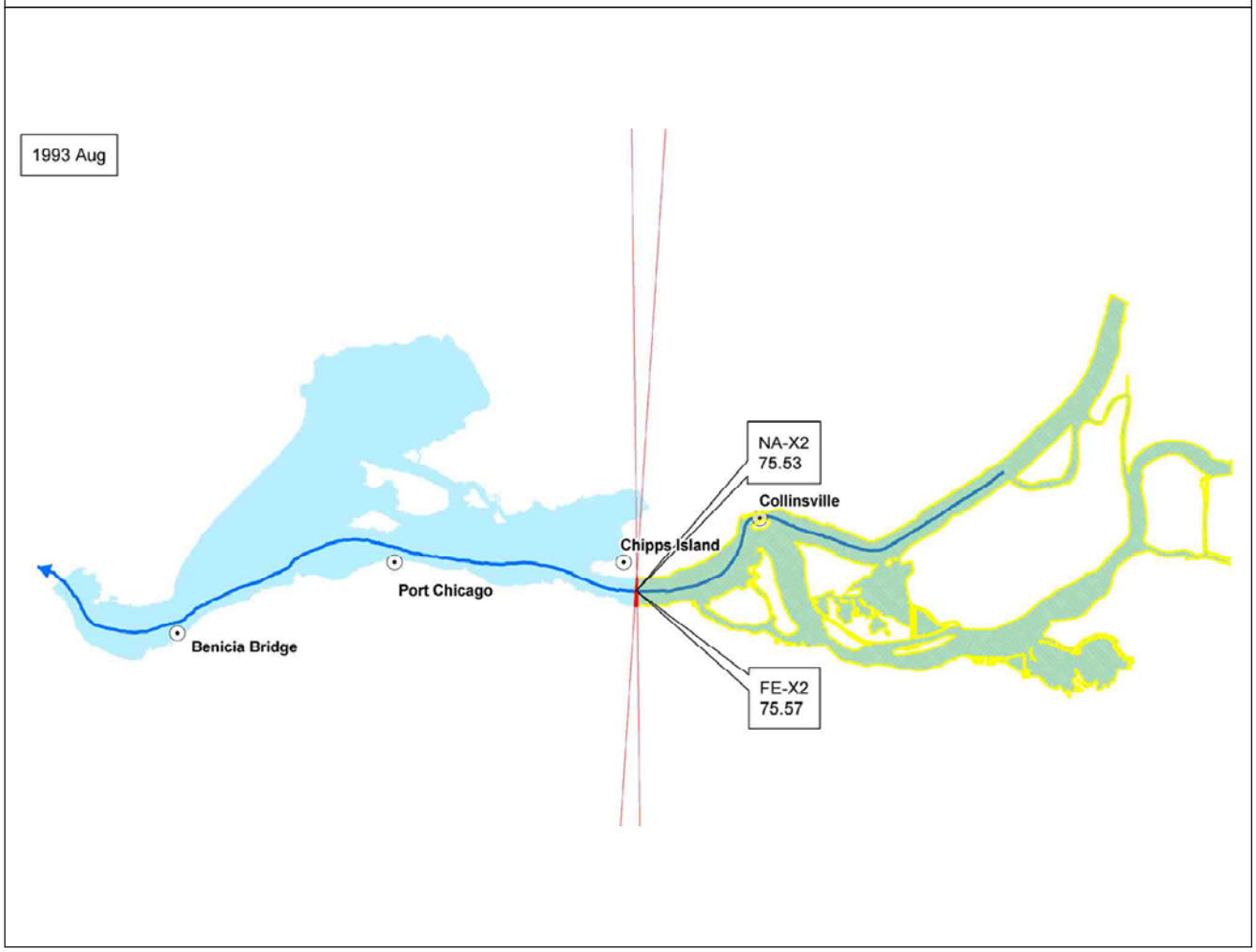
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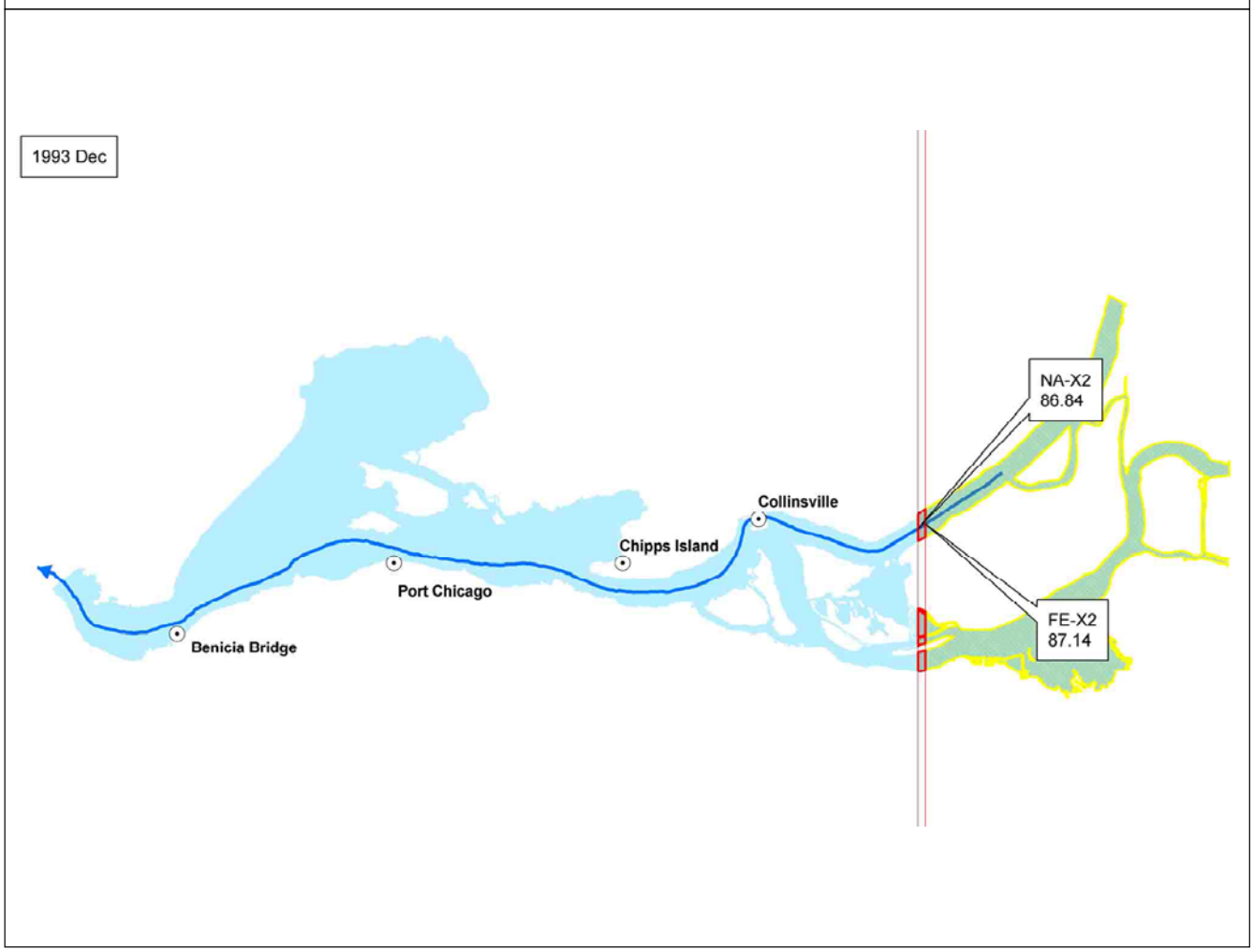
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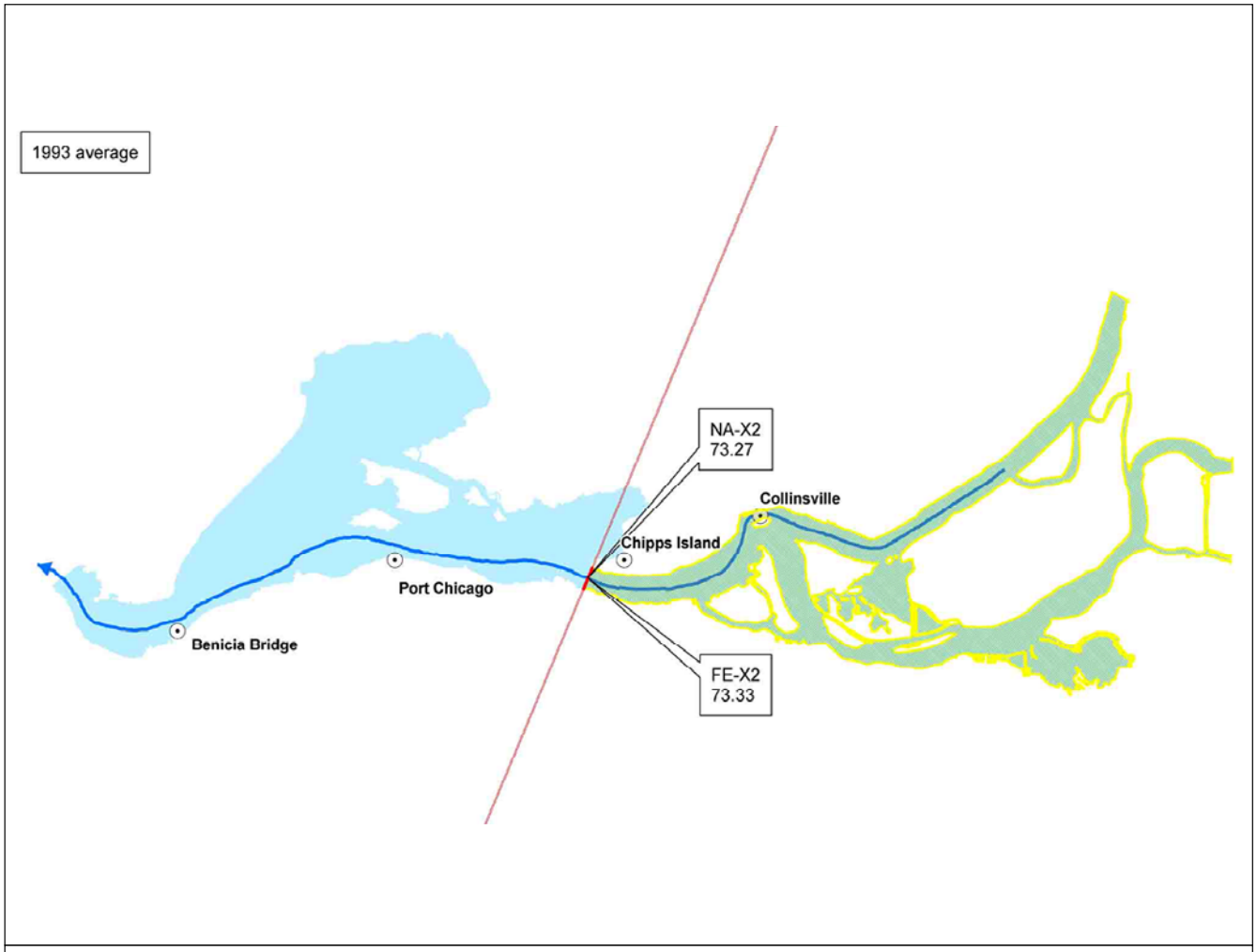
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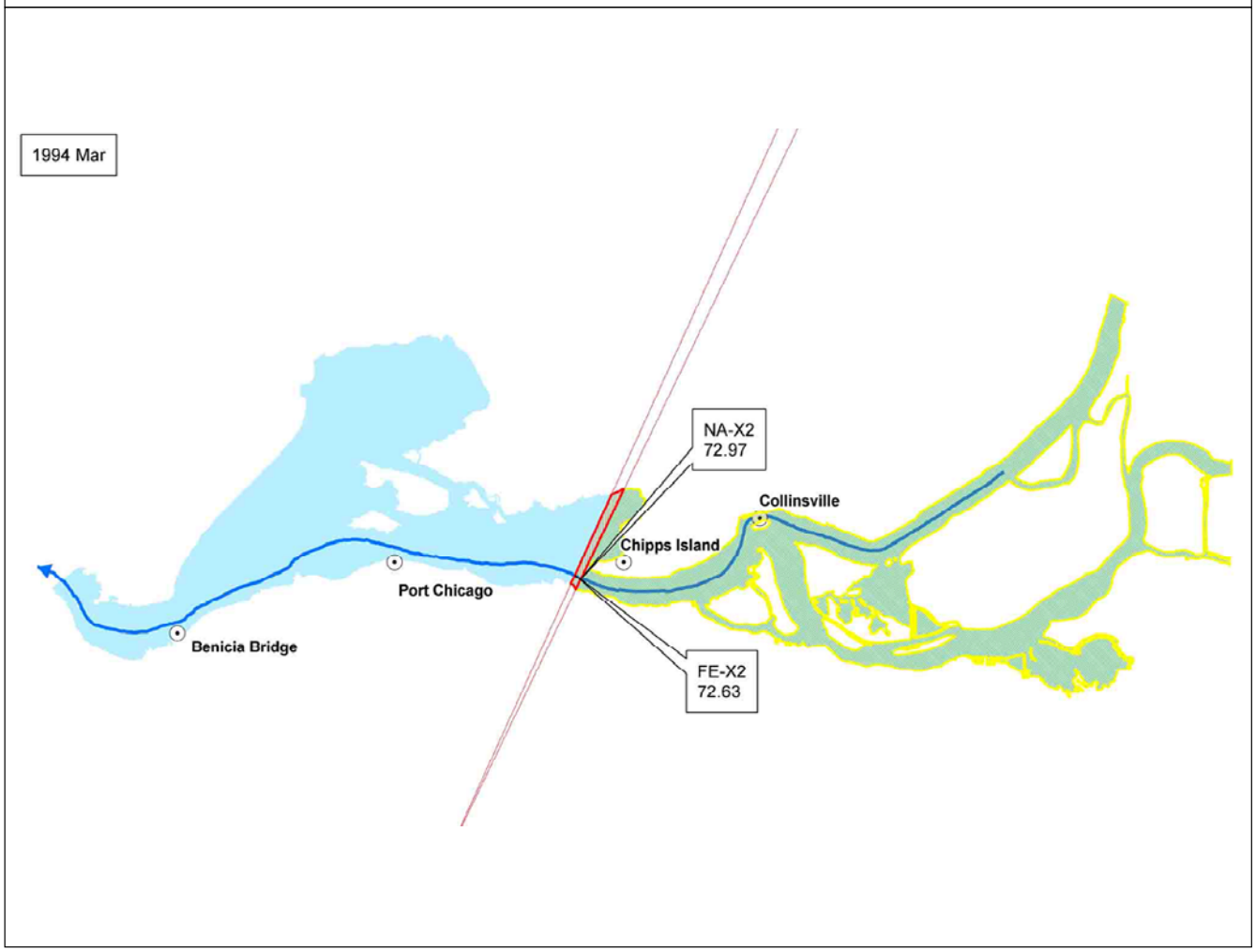
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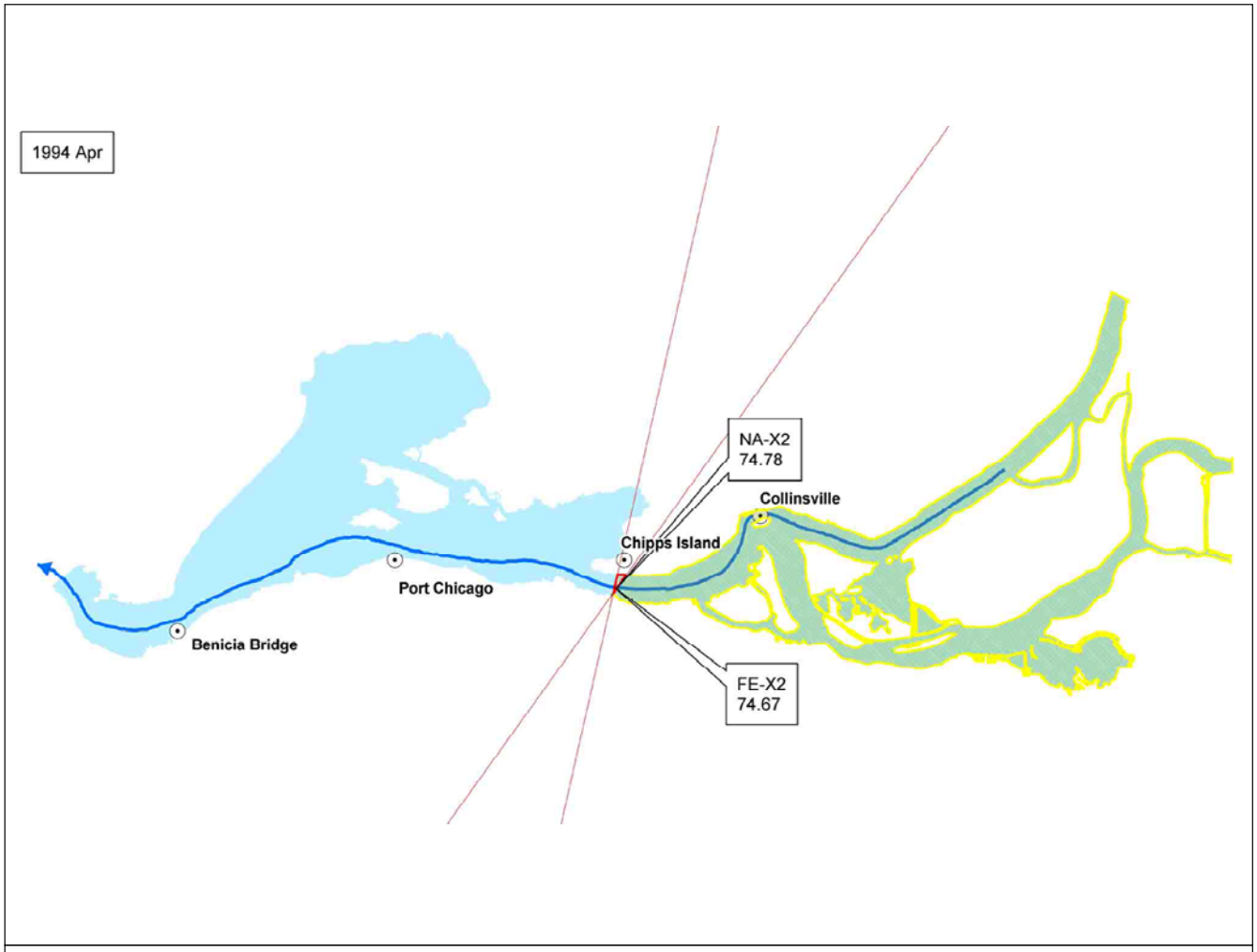
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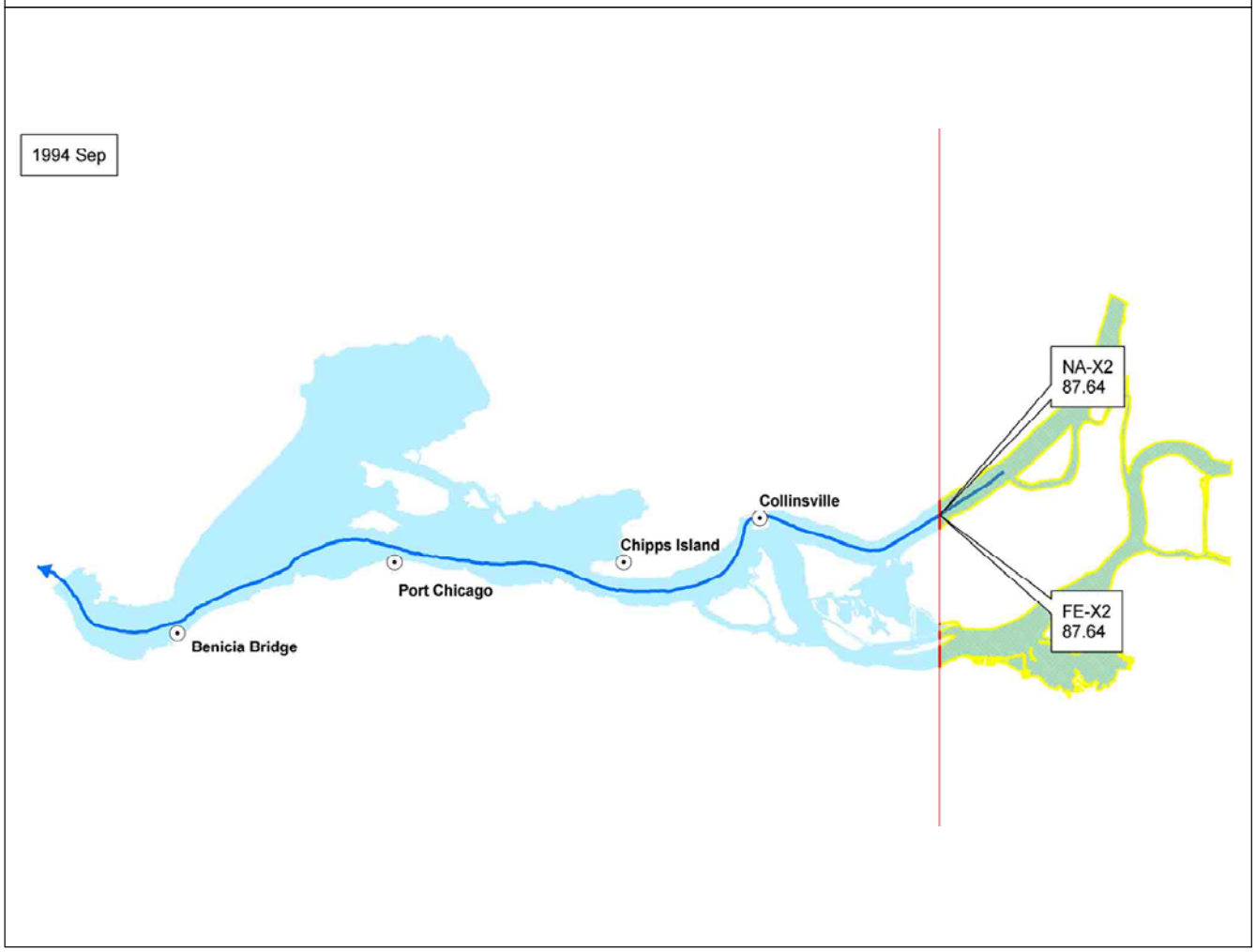
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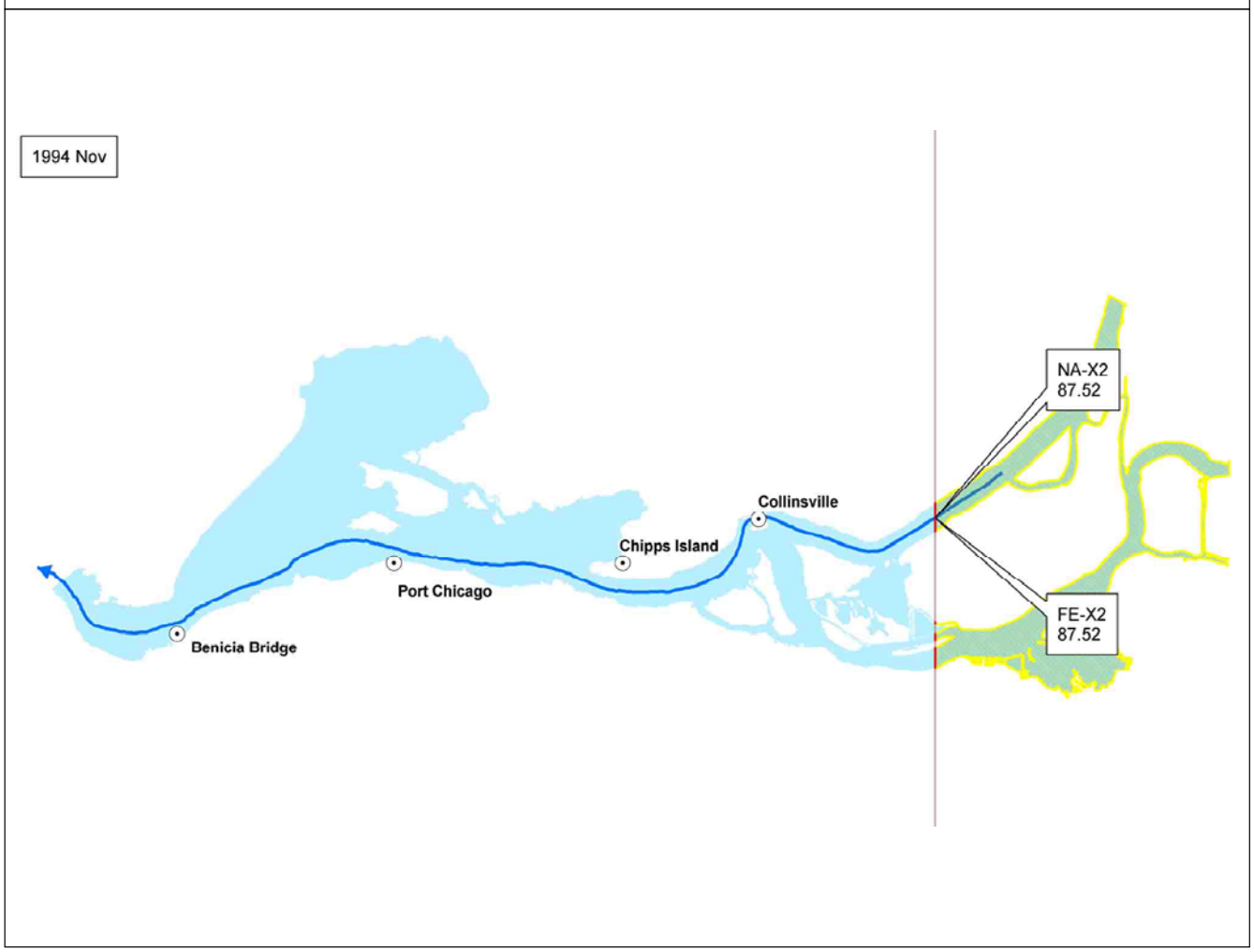
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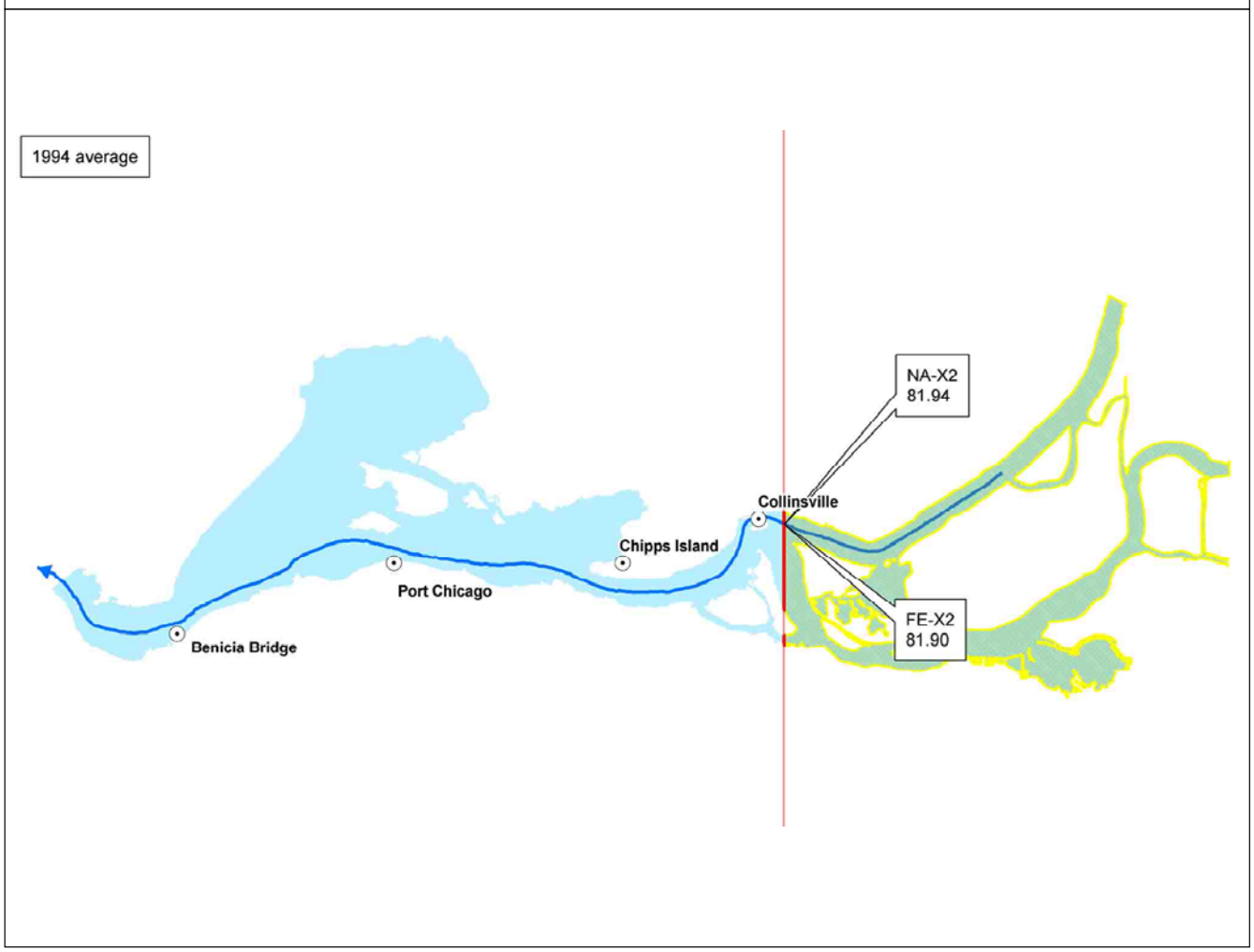
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Power Resources Technical Appendix C

Power Impact Analysis for the Trinity River SEIR/EIS Central Valley Project Phase 2 Report

Revised Draft dated February 5, 2004

Power Impact Analysis for the Trinity River SEIR/EIS Central Valley Project Phase 2 Report

Prepared for:
CH2M HILL and
United States Bureau of Reclamation

Date Prepared:
February 5, 2004

Prepared by:
Henwood Energy Services, Inc.
2379 Gateway Oaks Drive, Suite 100
Sacramento, CA 95833
(916) 569-0985
http://www.henwoodenergy.com

Power Impact Analysis for the Trinity River SEIR/EIS Central Valley Project Phase 2 Report

Prepared for:
CH2M HILL
And
United States Bureau of Reclamation

Date Submitted:
October 16, 2003

Prepared by:



Henwood Energy Services, Inc.
2379 Gateway Oaks Drive, Suite 100
Sacramento, CA 95833
Phone: (916) 569-0985
Fax: (916) 569-0999
http://www.henwoodenergy.com

Contacts:
Richard Lauckhart, Director, WECC Power Market Analysis
Jim Davidson, Project Manager

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1 INTRODUCTION

Henwood Energy Services, Inc. (Henwood) previously provided a Phase 1 report on Power Impact Analysis for the Trinity River SEIR/EIS Central Valley Project. That report was dated October 2, 2002. The Phase 1 Report consisted of two segments. The first segment consisted of a review of the previous power impact analysis and the objections to that prior analysis. The second segment presented a detailed study plan for conducting a Power Impact Analysis for the supplemental environmental impact analysis of the Trinity River Mainstem Fishery Restoration that fully addresses any shortcomings of the previous analysis.

This Phase 2 report presents the results of the revised Power Impact Analysis for the supplemental environmental impact analysis of the Trinity River Mainstem Fishery Restoration that fully addresses any shortcomings of the previous analysis.

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2 BACKGROUND - DECEMBER 2000 ROD, RELATED LITIGATION, AND PLAN FOR SUPPLEMENTAL EIS/EIR

In December 2000, the U.S. Department of the Interior (Department) issued its Record of Decision (ROD) on the Trinity River Mainstem Fishery Restoration. In making its decision, the information and analyses contained in the Final Environmental Impact Statement /Environmental Impact Report (FEIS/EIR) dated October 2000 was reviewed and considered in detail. The ROD recommended increasing the flows in the Trinity River thereby decreasing the diversion of Trinity River water to the Central Valley Project (CVP). This ROD has been challenged in court. In response to the court decision, CH2M HILL is preparing a supplemental environmental impact analysis (SEIS/SEIR) for the Trinity River Mainstem Fishery Restoration.

CH2M HILL's objective is to prepare the SEIS/SEIR for the Trinity River Mainstem Fishery Restoration Program by:

- Incorporating basic elements of the October 2000 SEIS/SEIR so that readers and decision makers can gain full understanding of the Project;
- Analyzing and presenting environmental impacts of the Project in the context of biological opinions issued for CVP operations not considered in the October 2000 SEIS/SEIR;
- Analyzing and presenting environmental impacts of the Project in the context of CVPIA 3406(b)(2) water supplies not considered in the October 2000 SEIS/SEIR;
- Analyzing and presenting potential environmental impacts of the Project in the context of changed conditions in the energy industry; and
- Analyzing potential environmental impacts of new alternatives as identified in the scoping proceedings that will be a part of the SEIS/SEIR.

Henwood was retained by CH2M HILL to provide the Power Impact Analysis for this supplemental environmental impact analysis. As a part of the supplemental power impact analysis, several CH2M HILL staff and subcontractors to CH2M HILL ran models and developed model outputs for use in Henwood's Power Impact Analysis.

The following models were replaced for the SEIS/SEIR effort:

- CALSIM II replaces PROSIM
- CALAG replaces CVPM
- Long-TermGen (LTG) replaces PROSIM Power Module
- MARKETSYM replaces PROSYM

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3 DESCRIPTION OF EFFORT UNDERTAKEN IN PHASE 2

3.1 INFORMATION DEVELOPED BY OTHERS AS INPUT TO THE POWER IMPACT ANALYSIS PERFORMED BY HENWOOD

Certain adjustments were made to the alternatives to be studied for the SEIR/EIS. A brief description of the alternative studies are:

- Existing Conditions (EC) - 340 thousand acre feet of annual flow (TAF) releases down the Trinity River, 2001 Level of Development (i.e. water demands).
- Maximum Flow (MF) - 463-2,146 TAF (zero exports to Sacramento Valley), 2020 Level of Development.
- Preferred Alternative or Flow Evaluation or ROD Flow (PF) – 369-815 TAF, 2020 Level of Development.
- 70 Percent Inflow (70) - 421-1,732 TAF, 2020 Level of Development
- Modified Percent Inflow (MP) – 369-720 TAF, 2020 Level of Development.
- Revised Mechanical (SMUD) – 340-556 TAF, 2020 Level of Development.
- No Action (NA) – 340 TAF, 2020 Level of Development

For each of these 7 alternatives, models were run by others to develop data to be used by Henwood in its Power Impact Analysis. The models run by others were the CALSIM II model (which develops monthly water flows) and LTG (which develops monthly generation from those water flows). The data provided to Henwood for each of the 7 alternatives was:

- Monthly generation under each of 73 different historical years of rainfall for each of the CVP hydroelectric generation facilities consisting of the following power plants (which total approximately 2,000 MW of capacity):
  a. Trinity
  b. J.F. Carr
  c. Spring Creek
  d. Shasta
  e. Keswick
  f. Folsom
  g. Nimbus
  h. San Luis
  i. O'Neill
  j. New Melones
- Monthly CVP electric pumping load under each of 73 different historical years of rainfall. The monthly pumping load was divided between pump load during heavy load hours of that month (these hours consist of 16 hours from 6:00AM to 10:00 PM Monday through Saturday) and pump load during the remaining hours of the month.

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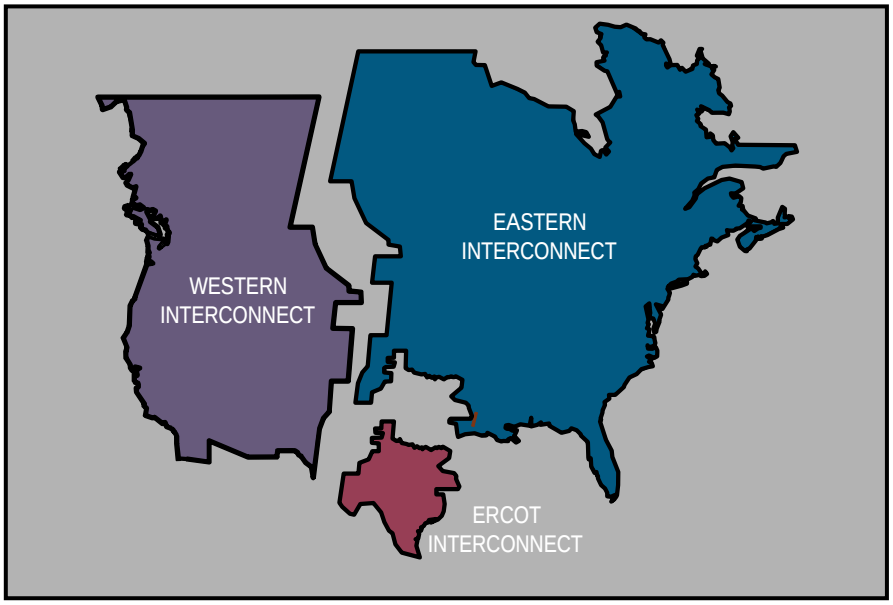
3.2 ANALYSIS PERFORMED BY HENWOOD

Henwood analysis recognizes that the CVP power plants are a part of the Western Interconnection. The Western Interconnection (sometimes called Western Electricity Coordinating Council or "WECC") is one of three major interconnections in North America.

Figure 3-1
Interconnections



The WECC region extends from Canada to Mexico, including the Canadian provinces of Alberta and British Columbia, the northern portion of Baja California, Mexico and all or portions of fourteen U.S. states.

Data needed for analysis

Because of a strong network of transmission lines across WECC, the value of power associated with generators connected to this network, and the reliability of the electric network, are best determined by analysis that reflects all of the generators and loads in WECC. As of 2003, there is approximately 185,000 MW of generation nameplate capacity in WECC, of which 60,000 MW is hydro nameplate capacity. The single hour highest (peak) load in WECC in 2003 was approximately 135,000 MW. The average hourly load over the year 2003 is expected to be approximately 92,000 aMW (805,920 GWH in the year).

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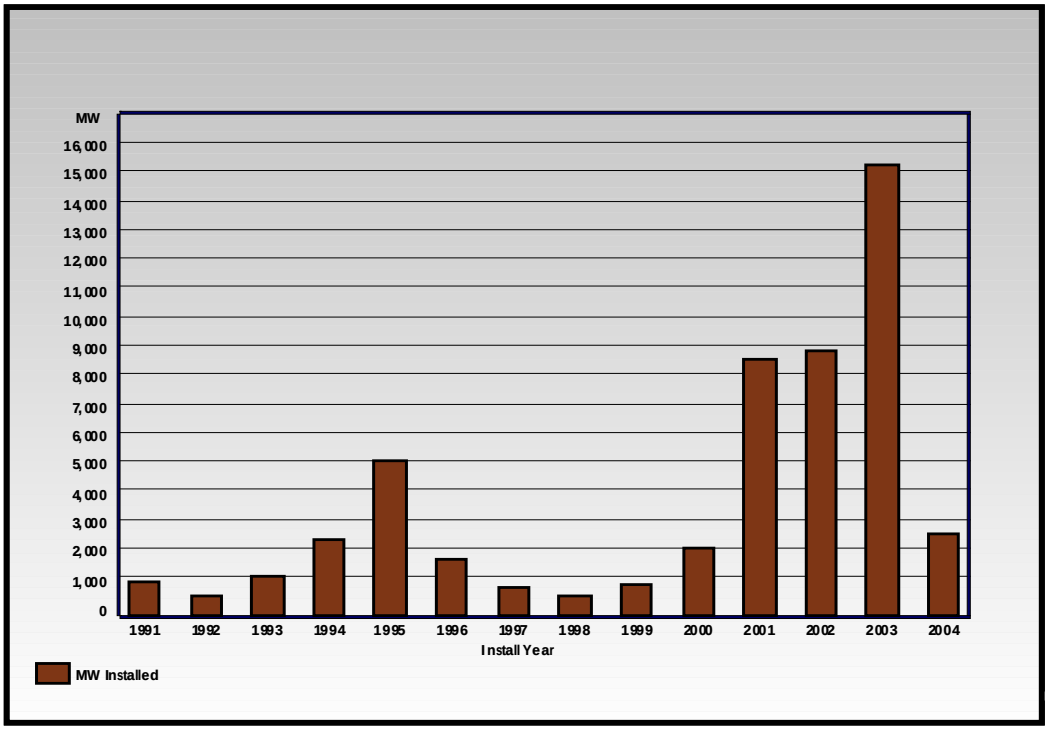
In general it is believed that, with 185,000 MW of generating capacity and 135,000 MW of peak load, there is somewhat of an overbuild of generation in WECC today. This is a much different situation than the one that existed in December of 2000, when the Record of Decision for the Trinity River Mainstream Fishery Restoration was issued. As can be seen from the figure below, a very large amount of new generation has been added in WECC in the years 2001, 2002 and 2003. There was no generation assumed to be added in the year 2005 because of the overbuild that resulted from the large resource additions in WECC in the years 2001-2003.

Figure 3-2
New Generation



Every six months Henwood develops an independent forecast of power prices in WECC. Henwood has used its Spring 2003 price forecast as a starting point to evaluate the power impact of alternatives for Trinity River Mainstem Fishery Restoration. This forecast is a fundamental based forecast that uses Henwood's proprietary MARKETSYM model and updated database to forecast hourly market clearing prices. Over 50 entities have purchased Henwood's Spring 2003 price forecast. These entities include both investor owned and consumer owned utilities, power plant developers, banks, and rating agencies. The forecast is widely accepted as a reasonable forecast.

In developing its forecast of hourly market clearing power prices, Henwood has developed a forecast of hourly loads across the many sub-areas of WECC. A database of

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generation available for operation in these areas is also developed along with the operating restrictions, heat rates, fuel cost, etc. that need to be reflected in an analysis regarding operation of the plants. It is also necessary to represent some of the key transmission path constraints that may limit the ability to move power from one sub-area of WECC to another from hour to hour.

Choosing a year for analysis

In choosing a year to evaluate the power impact of alternatives for Trinity River Mainstem Fishery Restoration, Henwood believes that 2005 would be a reasonable year for performing the analysis. The generation overbuild situation is forecast to be reduced by that time as loads are forecast to grow and little new generation is assumed to be added after 2003. Beyond 2005 it is more difficult to predict just when and how much new generation will be built.

Choosing a topology for analysis

Having chosen the year 2005 as a reasonably representative year for performing Power Impact analysis, Henwood starts with the extensive database developed for the year 2005 from its Spring 2003 price forecast. Henwood then developed the following transmission topology representation for use in the analysis. As can be seen, WECC is divided into 14 zones. The lines on the topology map reflect the ability of the transmission system to move power between the zones. The numbers on the lines indicate the maximum amount of power, in MW, that such line (path) can move in the indicated direction. With this topology, northern California is represented by the NP-15 zone along with the major links that connect this zone to the balance of the WECC power grid. Peak load occurring at normal temperatures expected on a peak day in the NP-15 zone is approximately 21,000 MW. Generation nameplate capacity located within the NP-15 zone is approximately 23,000 MW. As indicated in the chart below, there is approximately 8,500 MW of transmission capability that could be used to import power from other areas of WECC into northern California.

This 14-zone topology reflects the reality that of the 60,000 MW of hydro nameplate capacity in WECC, approximately 10,000 of this hydro capacity is located in California, primarily northern California. The CVP hydro project nameplate capacity accounts for approximately 2,000 MW of this California hydro.

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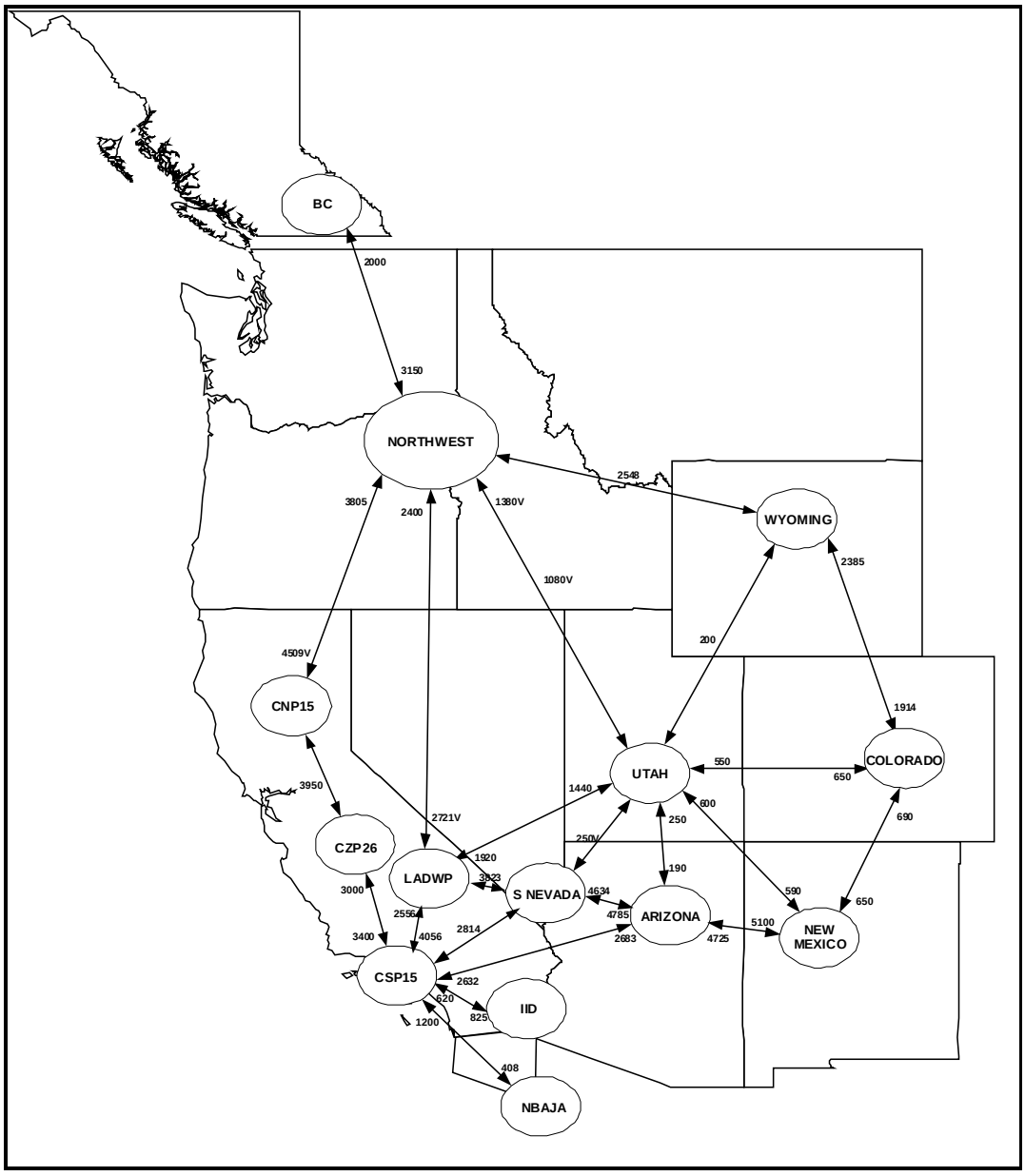
Figure 3-3
Transfer Capabilities Between WECC Subregions (MW)



This 14-zone topology provides a reasonable representation of major transmission constraints in WECC and can be used for market clearing price formation analysis. Henwood analyze uses the MARKETKSYM model to determine hourly dispatch of generation against load across WECC in the year 2005. The analysis is repeated for each of the 7 alternatives. The difference in the analysis between these 7 cases is the different amount of CVP generation associated with each of the 7 alternatives being studied. As discussed below, the model runs were done several times. One stochastic analysis was

run with 73 iterations, and three deterministic analysis were run. Deterministic analysis is done for average hydro conditions, dry hydro conditions in northern California, and wet hydro conditions in northern California.

How the model computes hourly market clearing prices

MARKETKSYM model runs assume that there is no transmission constraint within a zone. In each hour being analyzed, the model first determines the load for the hour in one of the zones, and then determines which generating plants located in that zone must be operated to meet the load. The plants with the lowest bid price[1] are operated first. Once the model determines which resources are needed on the first zone, it then moves on to do the same analysis in each of the remaining zones. Then the model looks to see if a low cost resource is not running in one zone while a higher cost resource is operating in a different zone. If so, the model looks to see if there is transmission capacity to move power between the zones. If the answer is yes, then the model will redispatch these units economically. The model continues to look for these redispatch opportunities until all the zones reflect the same marginal cost or transmission constraints prohibit additional economic redispatch. At this point the model can determine the market clearing price in each zone for that hour. The model then goes on to analyze the next hour in the year.

Modeling can be performed either deterministically or stochastically. In a deterministic analysis, the assumptions used in the modeling are established (generally as "expected" or "central tendency" values) and then a single analysis is performed to show how markets will perform under these fixed assumptions. When doing deterministic analysis, it is also common to run alternative scenarios to see how a change in one or two assumptions might alter how markets will perform. In a stochastic analysis, key parameters are not only given their "expected" or "central tendency" values, but these parameters are also described by statistical parameters that reflect the volatility of the parameter. For example, natural gas prices are entered into the stochastic model as a combination of central tendency prices along with statistical parameters (based on history) of how these prices might vary with abnormal weather conditions. Details of the stochastic analysis are discussed in the following section.

Henwood has performed both deterministic analysis and stochastic analysis to provide the Power Impact Analysis for this supplemental environmental impact analysis. In the deterministic analysis, all inputs driven by weather events were assumed to be normal in

[1] WECC markets are currently bilateral markets. Sellers offer their power at a price they are willing to sell. In general, sellers will need to cover at least their operating cost from a sale or they will simply shut down. Sellers also need to cover additional amounts to cover fixed costs. Competition generally keeps sellers from making excessively high bids. The supply/demand situation in the year 2005 is such that sellers will not be able to charge monopoly prices. Henwood's bid price algorithm reflects competitive limits on bid prices. In the absence of competition, FERC has indicated they will impose some kind of price mitigation regulation.

the Deterministic Average case. Henwood also ran a deterministic dry case. Note, this dry year is only dry in northern California (all northern California hydro including CVP) while the rest of the hydro in WECC is assumed to be normal. Therefore, the market price for power does not increase substantially since only northern California hydro (i.e., less than 20 percent of WECC hydro) is assumed to experience dry conditions. Henwood also ran a deterministic wet case. Note, this wet year is only wet in northern California (all northern California hydro including CVP) while the rest of the hydro in WECC is assumed to be normal. Therefore, the market price for power does not decrease substantially since only northern California hydro (i.e., less than 20 percent of WECC hydro) is assumed to experience wet conditions.[2]

Taking Volatility into account

There are several key inputs needed in the modeling database that are subject to weather induced volatility. For example, the CVP power plants will generate different amounts of power depending on how much rainfall occurs in any year. The data provided to Henwood showing CVP power generation amounts under each of the 7 alternatives was varied depending on rainfall conditions. Henwood was provided 73 different annual generation levels for each CVP power plant for each of the 7 alternatives. The 73 different levels reflect historical rainfall levels over a 73 year history.

In addition to volatility in CVP power generation levels caused by weather, other key inputs impacted by weather are:

- Hydro generation levels in other parts of WECC
- Loads across WECC
- Natural gas prices which fuel natural gas priced generation

(Note: Loads and natural gas prices are also strongly impacted by economic conditions, but we have not attempted to capture economic condition cycles in this analysis.)

[2] In order to select the wet and dry year, Henwood reviewed its data on historical levels of hydro generation for the Northern California area (less USBR) and picked a reasonable range. For northern California it was 73% of average for Dry and 126% for Wet. These values represented the 6th and 94th percentiles. Henwood then looked at the corresponding USBR generation for that same iteration. For the Dry year, the generation was about 68% of average. In checking the USBR generation level, this translated roughly to the water year for 1935. Henwood also consulted with a hydro experts at CH2M HILL. That expert mentioned several years could be used for the dry year, including 1935. For the wet year, we chose 1958 which, for the USBR, was about the 2nd wettest generation year on record. The main objective was to reflect dry, but not extreme conditions in northern California and the calculation of associated market clearing prices for valuation purposes. For the wet year, the selection was not as precise, nor as critical, since the market clearing prices will tend not to decrease as dramatically between the 95 and 99 percentiles.

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In December of 2000 when the Record of Decision for the Trinity River Mainstream Fishery Restoration was issued, WECC was in the midst of a severe drought, especially with regard to hydro generation affected by Pacific Northwest rainfall conditions. It was determined that the Power Impact analysis should reflect the possibility that such conditions could recur.

The Power Impact analysis performed here includes a stochastic analysis. In other words, each of the alternatives analyzed in the year 2005 were run 73 times. Each of the 73 iterations reflected approximately the CVP generation levels for that alternative in one of the 73 hydro years of history. At the same time, Monte-Carlo draws were included to reflect random draws to hourly loads in the 14 zones of WECC. Standard deviation, mean reversion and correlation factors were developed through a process of performing statistical analysis of historical data in varying sub-periods of the year and making test runs to see if resulting distributions of the variables were reasonable. Historical correlation between these zonal load variations were reflected in the analysis. Monte-Carlo draws for Pacific Northwest hydro were also reflected in the 73 iterations based on historic volatility in these generation amounts. Correlation between CVP hydro and Pacific Northwest hydro was reflected in the analysis based on historical correlations of these levels.[3] Monte-Carlo draws of natural gas prices were reflected in the analysis based on historical natural gas price volatility. Finally, Monte-Carlo draws were made on generation unit forced outage based on historical levels of generation forced outage. A total of 73 draws were used in the stochastic analysis.

Determining hourly amounts of CVP generation

Henwood was provided monthly amounts of power generation at each of the CVP projects for each of the alternatives. Determining the expected hourly shape of power generation from monthly data is a complicated undertaking given the complexities of fundamental constraints such as re-regulating downstream reservoirs and subjective human behavior. Henwood has approached the task of determining the hourly shape of power differently in the deterministic analysis than in the stochastic analysis.

In the Deterministic analysis, since there are fewer water conditions being evaluated, it is possible for Henwood to pre-process the hydro generation to develop hourly generation patterns That preprocessing activity is described in a separate work paper.[4]

In the Stochastic analysis of 73 different water conditions and 7 different alternatives, it is not practicable to perform such an elaborate pre-processing analysis for each hydro

[3] Henwood assumes that weather induced changes to CVP power generation are 100% correlated to other Northern California hydro generation levels. Hydro generation amounts in WECC outside of Northern California and the Pacific Northwest are small in comparison to Northern California and Pacific Northwest hydro generation levels. Henwood has included these hydro generation amounts at their average value in all cases.

[4] See June 27, 2003 report entitled “methodology and modeling issues” prepared by Henwood.

condition and alternative. However, reasonable approximations for the hourly shape under these many hydro conditions and alternatives can be determined using computer algorithms available in the MarketSym software. In this stochastic analysis, for each of the projects, Henwood assumed there was a minimum amount of generation that would need to operate in every hour and a maximum capacity that could be operated in any hour. Given a certain quantity of monthly generation, Henwood's analysis first assigned the necessary quantity to meet the minimum generation amount in each hour. The remaining generation was shaped to reflect the hourly shape of loads in the California ISO control area. The maximum generation in any hour could not exceed the maximum capacity of that generator.

Calculating the value of CVP power

The analysis then calculates a value of CVP power under each alternative. For the deterministic analysis there is a base case, a high CVP hydro case and a low CVP hydro case. Value of the CVP power is calculated as CVP power generation levels (net of pumping load requirements) times the market clearing price of power in the Northern California zone.[5] For the Stochastic analysis, the values reported here are the average values calculated for each of the 73 iterations discussed above. In all cases, the value of CVP power has been calculated by adding the Ancillary Services value as discussed in the next section.

Ancillary Services

Power projects such as those owned by CVP have value not only from their ability to produce power, but also from their ability to provide ancillary services. Ancillary services are products needed in order for the power grid to be operated reliably. It is common to talk about five key ancillary services. These five ancillary services are:[6]

- Spinning Reserve - The portion of unloaded synchronized generation capacity that is immediately responsive to system frequency and that is capable of being loaded in ten minutes, and that is capable of running for at least two hours.

[5] In making this calculation, Henwood took the project generation on heavy load hours for each month and valued it at the average of all heavy load market clearing prices for that month. Similarly, Henwood took the project generation on light load hours for each month and valued it at the average of all light load hour market clearing prices for that month. This approach was taken for two reasons. First, much of the power bought and sold in WECC is packaged as "standard products", with a standard product being a flat heavy load hour delivery for a day and a flat light load hour delivery for a day. Henwood is also aware that the hourly load shaping algorithm used here may overstate the amount of power that can be shaped due to issues regarding re-regulating reservoirs that exist on the CVP system. It is not practicable to capture all these limitations in this kind of analysis. The somewhat overly optimistic hourly shaping algorithm is offset by the somewhat pessimistic average pricing approach to reflect a reasonable estimation of the value of project generation.

[6] The definitions below are taken from the California ISO Tariff filed with the Federal Energy Regulatory Commission. Capitalized terms mean that the terms have specific definitions in such Tariff.

- Non-Spinning Reserve - The portion of off-line generating capacity that is capable of being synchronized and ramping to a specified load in ten minutes (or load that is capable of being interrupted in ten minutes) and that is capable of running (or being interrupted) for at least two hours.
- Regulation Up and Regulation Down – The service provided either by Generating Units certified by the ISO as equipped and capable of responding to the ISO's direct digital control signals, or by System Resources that have been certified by the ISO as capable of delivering such service to the ISO Control Area in an upward or downward direction to match, on a real time basis, Demand and resource, consistent with established NERC and WECC operating criteria. Regulation covers both the increase or decrease in output of generation. Regulation Up and Regulation Down are distinct capacity products, with separately stated requirements and Market Clearing Prices in each settlement period.
- Replacement Reserve – Generating capacity that is dedicated to the ISO, capable of starting up if not already operating, being synchronized to the grid, and ramping to a specific load point within a 60 minute period, the output of which can be continuously maintained for a two hour period.

Regulation Up and Regulation Down receive the highest prices of these five ancillary services. However, Henwood assumes that CVP will not allow its generators to be automatically controlled by the ISO's direct digital control signals. Therefore, CVP projects would not be able to realize these prices.

Spinning Reserve is the next highest value of the ancillary services. Henwood assumes that CVP projects could be offered as spinning reserve units to the ISO to the full extent of their capability less the then current operating level. In general, the alternative that results in less hydro generation would result in more sales of spinning reserve.[7] Given the assumption of all unused capacity being sold as spinning reserve, there is nothing else left to sell to the remaining lower value ancillary services markets.

Air Emissions

Henwood modeling can be used to measure SO_2, NO_X and CO_2 emissions by power plant for every hour. CVP project generation does not create air emissions. The existence of more or less generation from CVP projects will results in less or more generation from other fossil fuel generation in WECC. Henwood has calculated the expected levels of total WECC wide SO_2, NO_X and CO_2 emissions for the year 2005 under each of the seven alternatives studied.

[7] The exception is the Maximum Flow alternative which provides no water to the J.F. Carr and Spring Creek projects. With no water, these projects can provide no ancillary services.

Reliability

As a measure of the effect on reliability of power supply in WECC of the 7 alternatives, Henwood has calculated the expected level of load that would not be served under the stochastic analysis in WECC. In other words, generation is expected to be adequate to meet load in all hours of 2005 under "normal" conditions. Normal conditions do not reflect higher than normal loads caused by hotter than normal temperatures. Normal conditions do not reflect drought hydro conditions. Normal conditions do not reflect forced outages of several generating plants at the same time.

Henwood's Monte-Carlo driven stochastic analysis will result in some situations where load is higher than normal and resource availability is lower than normal. Therefore, it is possible that certain areas of WECC may have difficulty meeting load in all hours of the year. Henwood tracked unserved energy associated with each hour of each iteration for each of the alternatives studied. A comparison of expected levels of unserved energy provided an indication of reliability impacts associated with each alternative.

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4 RESULTS

The CVP power values shown in this report are a way to establish a value and determine the change in that value under different operating regimes. The value calculated here is based on the value of power in wholesale power markets in each hour of the year, multiplied by the quantity of power produced by the combined CVP projects under different operating regimes. The differences in value between the operating regimes are relative for comparative purposes. Only these differences are of concern and even these differences do not necessarily reflect in real financial impact to any single or the entire group of Preference Power Customers. The differences merely represent the potential financial impact to the entire group of Preference Power Customers if and only if they had to replace all of the lost power from the NP15 spot market for power.

The values reported are broken out in thee categories. The first category is simply the CVP generation times the spot market value for that generation. The second category shows how much of the CVP generation is needed for pumping load and the value taken up by the pumping load based on the same spot market price. The third category shows the value of unused CVP capacity on any hour in ancillary services markets. The summary table in Section 5 of this report shows CVP Power Value as determined from the gross value of CVP generation less value taken by pumping load plus ancillary service value. Section 5 of the report also separately displays ancillary service value which has been added to the CVP Power Value.

Detailed model outputs:

For purposes of displaying results of this power impact analysis, the following information has been extracted from the modeling:

- Spot market electricity prices in Northern California for each of the three deterministic analysis (normal hydro, dryer than normal, and wetter than normal). Expected (average) spot market prices in Northern California for the stochastic analysis along with the "+2 standard deviation" and "–2 standard deviation" price.[8]
- Monthly generation for the combined CVP project hydro generation, net of CVP pumping load.
- Breakdown of annual net generation as between that net generation occurring during "on-peak" hours and that generation occurring during "off-peak" hours.

[8] The range between the "+2 Standard Deviation" and "-2 Standard Deviation" means that 95% of the expected observations will fall between these two numbers. For example, in the NA alternative, while the expected Market Clearing Price for the NP15 zone in Northern California is 35.09 $/MWh, we know that there is volatility in this price. Analysis indicates that there is a 95% chance that actual Market Clearing Prices for the NP15 zone of Northern California will fall between 27.99 $/MWh and 43.52 $/MWh.

- Average of the annual "on peak" generation and average of the annual "off peak" generation.
- Monthly gross generation for the combined CVP project hydro generation and associated monthly CVP pumping load.
- Monthly "value" of the combined CVP project generation as described in the section above entitled "Calculating the value of CVP power."
- Expected level of unserved energy in Northern California.
- Expected level of unserved energy in WECC.
- Anticipated Value of Ancillary Services that can be provided by the combined CVP Projects.
- Total.

The reported data is displayed as the actual model outputs for the "No Action" alternative and changes in that value for the six other alternatives. The reported detail data is included in the Appendices as follows:

Appendix A. Reports the "expected" value of CVP Power [under each alternative studied] after performing the Monte-Carlo based analysis (e.g. when randomly selecting possible hydro conditions, loads, natural gas prices, etc.).

Appendix B. Reports the value of CVP Power[under each alternative studied] under a single "most probable" set of assumptions about hydro conditions, loads, natural gas prices, etc.

Appendix C. Reports the value of CVP Power [under each alternative studied] under a single "most probable" set of assumptions about hydro conditions, loads, natural gas prices, etc. except that it is assumed that there is a drought in Northern California.[9]

[9] From historical data, we know that there is some correlation between droughts in Northern California and other hydro regions in Western North America. We know that while there is correlation, the correlation is not high. For purposes of this deterministic analysis in this report, we assumed other parts of WECC were normal while Northern California was dry. In the stochastic analysis, the actual correlation parameters from historical data was reflected.

Appendix D. Reports the value of CVP Power [under each alternative studied] under a single "most probable" set of assumptions about hydro conditions, loads, natural gas prices, etc. except that it is assumed that there is a extremely wet condition in Northern California.[10]

[10] From historical data, we know that there is some correlation between droughts in Northern California and other hydro regions in Western North America. We know that while there is correlation, the correlation is not high. For purposes of this deterministic analysis in this report, we assumed other parts of WECC were normal while Northern California was extremely wet. In the stochastic analysis, the actual correlation parameters from historical data was reflected.

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5 OBSERVATIONS AND CONCLUSIONS

The table below provides a summary of CVP power value under each of the alternatives. In this table, the power value includes the value of ancillary services of the CVP projects.

Table 5-1
Summary of CVP Power Value

		Alternative						
Year 2005		NA	EC	MF	PF	MP	SMUD	70
Stochastic	MCP - NP15+2STD ($/MWh)	43.53	43.51	43.76	43.56	43.56	43.53	43.63
Stochastic	MCP - NP15 ave ($/MWh)	35.09	35.09	35.24	35.14	35.12	35.12	35.19
Stochastic	MCP - NP15-2STD ($/MWh)	27.99	27.99	28.14	28.03	28.02	28.00	28.10
CVP Power Value	Stochastic Average	$ 153,099,230	$ 150,439,374	$ 108,020,353	$ 145,945,406	$ 146,342,218	$ 149,748,414	$ 133,706,978
	Change from NA	$ -	$ (2,659,855)	$ (45,078,877)	$ (7,153,824)	$ (6,757,011)	$ (3,350,816)	$ (19,392,252)
Deterministic-Wet	MCP - NP15 ($/MWh)	34.84	34.89	35.13	34.93	34.91	34.89	34.99
CVP Power Value	Deterministic Wet	$ 241,055,512	$ 237,013,149	$ 177,656,114	$ 219,533,890	$ 227,348,369	$ 230,830,214	$ 202,954,006
	Change from NA	$ -	$ (4,042,363)	$ (63,399,398)	$ (21,521,622)	$ (13,707,143)	$ (10,225,298)	$ (38,101,506)
Deterministic-Ave	MCP - NP15 ($/MWh)	36.13	36.15	36.26	36.16	36.17	36.16	36.20
CVP Power Value	Deterministic Ave	$ 166,313,646	$ 162,124,027	$ 120,304,472	$ 159,040,607	$ 162,268,750	$ 163,715,496	$ 147,005,119
	Change from NA	$ -	$ (4,189,619)	$ (46,009,173)	$ (7,273,038)	$ (4,044,895)	$ (2,598,150)	$ (19,308,527)
Deterministic-Dry	MCP - NP15 ($/MWh)	37.75	37.74	37.78	37.75	37.76	37.76	37.78
CVP Power Value	Deterministic Dry	$ 96,033,714	$ 89,609,447	$ 67,510,150	$ 88,316,320	$ 91,538,001	$ 91,920,839	$ 69,499,422
	Change from NA	$ -	$ (6,424,267)	$ (28,523,564)	$ (7,717,393)	$ (4,495,713)	$ (4,112,875)	$ (26,534,292)

The table below provides probability ranges on the Value of CVP Power based on the stochastic evaluation.

Table 5-2
Probability Ranges

Year 2005	Alternative						
CVP Generation, MWh	NA	EC	MF	PF	MP	SMUD	70
10th Percentile	3,726,445	3,761,179	2,835,497	3,522,568	3,601,840	3,644,602	3,193,620
30th Percentile	4,219,252	4,259,321	3,300,156	3,963,826	4,059,446	4,121,223	3,633,235
Average	4,657,546	4,697,679	3,632,718	4,378,731	4,487,804	4,549,167	4,025,067
50th Percentile	4,674,544	4,711,697	3,607,223	4,403,352	4,512,146	4,569,477	4,038,204
70th Percentile	5,059,544	5,104,960	3,913,389	4,755,309	4,872,621	4,939,847	4,333,814
90th Percentile	5,733,570	5,785,514	4,565,328	5,420,137	5,537,428	5,595,601	5,022,862
Market-Based Revenues, 2002$							
10th Percentile	$126,246,560	$127,152,094	$96,947,355	$118,196,643	$121,494,816	$123,385,825	$107,745,596
30th Percentile	$145,160,564	$146,591,815	$114,464,628	$136,272,944	$139,961,417	$142,111,372	$125,877,090
Average	$163,624,140	$165,016,943	$127,014,058	$153,817,162	$157,671,799	$159,913,002	$141,018,498
50th Percentile	$160,355,579	$161,302,455	$126,413,190	$150,124,816	$154,300,654	$156,334,608	$139,337,675
70th Percentile	$177,731,763	$179,182,632	$137,008,312	$165,828,279	$170,671,681	$173,306,851	$151,281,552
90th Percentile	$206,823,137	$208,275,018	$158,419,983	$194,727,365	$199,167,332	$201,512,696	$178,650,797
Pump Energy Consumed, MWh							
10th Percentile	1,017,260	1,147,023	850,843	999,739	1,066,134	1,007,761	1,013,155
30th Percentile	1,115,676	1,236,805	976,390	1,093,464	1,173,122	1,119,022	1,084,039
Average	1,166,056	1,304,370	1,061,229	1,142,453	1,239,846	1,182,209	1,138,371
50th Percentile	1,182,355	1,305,914	1,090,985	1,148,254	1,263,255	1,183,992	1,147,434
70th Percentile	1,229,524	1,384,133	1,152,327	1,187,973	1,315,018	1,243,715	1,191,040
90th Percentile	1,282,289	1,482,097	1,248,257	1,288,964	1,387,863	1,323,686	1,245,759
Pump Energy Cost, 2002$							
10th Percentile	$31,659,556	$34,362,157	$26,232,792	$31,792,169	$33,122,085	$31,634,683	$31,876,667
30th Percentile	$36,393,770	$40,667,083	$31,547,647	$36,110,748	$38,367,850	$36,950,805	$35,351,246
Average	$40,822,107	$45,000,080	$36,837,737	$39,844,397	$42,668,692	$41,291,947	$39,920,397
50th Percentile	$40,087,040	$43,640,954	$36,528,274	$38,820,802	$41,194,507	$41,864,319	$39,443,512
70th Percentile	$44,309,283	$48,929,443	$41,669,050	$42,609,602	$47,226,005	$45,190,864	$43,266,692
90th Percentile	$51,868,042	$56,261,469	$47,361,508	$50,373,439	$54,350,293	$52,120,076	$48,838,774
Energy Not Served (E.N.S), MWh							
10th Percentile	0	0	0	0	0	0	0
30th Percentile	0	0	0	0	0	0	0
Average	4,599	4,599	4,599	4,599	4,599	4,599	4,599
50th Percentile	0	0	0	0	0	0	0
70th Percentile	0	0	0	0	0	0	0
90th Percentile	0	0	0	0	0	0	0

The table below shows information on the ancillary service value determined for CVP projects under each of the alternatives.[11]

Table 5-3
Ancillary Service Value

Year 2005 A/S Value	Alternative						
	NA	EC	MF	PF	MP	SMUD	70
Wet Hydro	$21,613,785	$21,215,890	$21,340,142	$24,121,890	$23,294,042	$23,761,957	$25,490,629
Average Hydro	$30,297,197	$30,422,512	$17,844,032	$31,972,641	$31,339,111	$31,127,359	$32,608,878
Dry Hydro	$23,850,686	$19,710,695	$12,517,417	$18,315,055	$21,347,972	$21,294,470	$13,212,420

No incidences of inability to serve load showed up in any of the 21 deterministic cases run. In the stochastic analysis, there was no inability to serve load in northern California in any of the iterations. The only inability to serve load was found in the Northwest under draws that resulted in extremely low hydro generation in the Northwest. Of the 73 stochastic iterations run there was one iteration in January with "energy not served" (ENS) in the Northwest and two iterations in February with ENS in the Northwest. The number of hours of ENS occurring did not change as a result of the different alternatives being considered for Trinity diversions. Because there was only one iteration with ENS, the ENS does not show in any of the confidence bands, but does show in the "Average" of all iterations run.

As can be seen from the write-up above and the reported results, the alternatives analyzed here do not make a significant impact on power supply in the WECC as a whole or in northern California. This conclusion is based on the small impact on prices and zero impacts on reliability of power supply in the WECC as a whole or in northern California caused by the alternatives analyzed.

That the alternatives do not make a significant impact on WECC as a whole should not be surprising given the fact there is over 185,000 MW nameplate of generation in WECC and the CVP hydro projects have a total nameplate capacity of 2,000 MW. Comparing the 185,000 MW of WECC capacity to 135,000 MW of WECC peak load, it is clear that excess generation exists in WECC and that some small loss of CVP power would therefore not have a large impact on the WECC in total.

That the alternatives do not make a significant impact on northern California prices and reliability should not be surprising given the fact that (a) northern California peak hour load is more than covered with northern California located generation and (b) northern California is interconnected to the rest of WECC through approximately 8,500 MW of

[11] This value was calculated for the deterministic normal condition case and was assumed not to change in the other cases. While this assumption is not technically correct, our interest is in the change in value between alternatives. It is expected that while the actual level of ancillary service value will change under different environments, the change in ancillary service value between alternatives will not be significantly different than the change in value in the deterministic normal case.

transmission capability, and therefore fairly large imports of power into northern California could be accomplished if the need arises.

Notwithstanding the small impact on WECC and northern California power supply, the customers of CVP power will have different cost impacts depending on the chosen alternative. Power cost increases for these CVP customers on an expected basis will range from $3 million per year to $46 million per year if the decision is to move away from the No Action alternative. The lowest power cost alternative is the SMUD alternative. The highest power cost alternative is the MF alternative.

Under the dry year deterministic case, the value of CVP power is decreased substantially in all alternatives due to the fact that there is generally less hydro generation in all the alternatives. Note, this dry year is only dry in northern California (all northern California hydro including CVP) while the rest of the hydro in WECC is assumed to be normal. Therefore, the market price for power does not increase substantially since only northern California hydro (i.e., less than 20 percent of WECC hydro) is assumed to experience dry conditions.

Under the wet year deterministic case, the value of CVP power is increased substantially in all alternatives due to the fact that there is generally more hydro generation in all the alternatives.. Note, this wet year is only wet in northern California (all northern California hydro including CVP) while the rest of the hydro in WECC is assumed to be normal. Therefore, the market pride for power does not decrease substantially since only northern California hydro (i.e., less than 20 percent of WECC hydro) is assumed to experience wet conditions.

Alternatives being considered regarding Trinity River diversions will generally reduce generation from hydroelectric generators and substitute generation from thermal power plants. As a result, there will be an increase in air emissions. In the modeling done here, generation across WECC is re-dispatched, on an economic basis, to make up for the reduction in CVP hydro generation under each alternative. From hour to hour, the replacement generation may come from different areas of WECC. The table below reports the change in WECC-wide air emissions under each alternative.

Table 5-4
Air Emissions

Year 2005			Alternative						
Stochastic Average			NA	EC	MF	PF	MP	SMUD	70
WECC wide Emissions									
	SO2	(000tons)	408.9	408.9	409.0	409.0	409.0	408.9	409.0
	NOx	(000tons)	497.3	497.3	497.6	497.4	497.4	497.4	497.5
	CO2	(000tons)	341,120.3	341,098.7	341,727.4	341,280.8	341,219.8	341,184.7	341,485.9
Increase in CO2 vs NA		(000tons)	-	(21.6)	607.1	160.5	99.5	64.4	365.6

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Since generation on the margin is generally state of the art natural gas fired generation, there is not a large increase in SO_2 emissions or NO_X emissions. While CO_2 emissions are more measurable on the basis of thousand of tons per year, the percentage changes in these emissions is quite small, less than 0.2 percent in all cases.

Economic Impact on Non-CVP Customers

The analytic work done for this report shows that modifications to Trinity River operations of the CVP can change market clearing prices in Northern California by up to 0 to 9 cents per Mwh in the PF alternative and 0 to 5 cents per Mwh in the SMUD case. Under average conditions, prices change by 3 to 5 cents per Mwh in the PF alternative and 3 cents per Mwh in the SMUD alternative. These changes represent a maximum change of 0.3 percent (PF alternative, wet year, deterministic analysis) and an average change of 0.1 percent (both PF and SMUD alternatives, both stochastic and deterministic analyses).

Changes of under 10 cents per Mwh in the price of electricity are well below the standard of significance used in the original Trinity River EIS, 50 cents per Mwh. They are also small compared to the price variation due to hydrological variation in Northern California alone, which is almost $3 per Mwh (difference between deterministic wet and dry analyses). They are even smaller compared to the more than $15/Mwh variation due to the combined effects of hydrology, gas price, and load variations (difference between stochastic analyses).

If the small price impacts calculated by Henwood for Northern California (and the even smaller impacts for other regions) are multiplied times the total regional loads, the result would be an apparent grid-wide impact of $20 million in the PF alternative, and millions of dollars in every case (as compared to the No Action alternative). This might seem like a significant number despite the fact that the rate impact is only a few pennies per Mwh. However, the great majority of electricity in the Western grid is not sold at prices which vary with market conditions. Most generation is either sold at prices based on its cost (e.g., virtually all hydrogeneration and coal and nuclear generation) or is sold at prices pre-determined under long-term contracts (e.g., contracts entered into by the California Department of Water Resources in early 2001 to provide stability to California electricity markets).

The net impact on non-CVP customers of the market price changes quantified by Henwood will thus be a very small fraction of the potential impact.

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APPENDIX A "EXPECTED" VALUE OF CVP POWER

Note: All changes are relative to the NA case. For percentage change, the calculation is: (Case value-NA value)/NA value.
For others, the calculation is Case value - NA value. Thus, if a percentage change is positive, it means the Case value is greater than the NA value, and vice versa.

Results of Case:	NA Stoch	EC Stoch	MF Stoch	PF Stoch	MP Stoch	SMUD Stoch	70 Stoch
1 MCPs	**$/MWh**	% CHG.	% CHG.	% CHG.	% CHG.	% CHG.	% CHG.
+2 SD	43.53	-0.1%	0.5%	0.1%	0.1%	0.0%	0.2%
Mean	35.09	0.0%	0.4%	0.1%	0.1%	0.1%	0.3%
-2 SD	27.99	0.0%	0.5%	0.1%	0.1%	0.0%	0.4%
2 Expected monthly net energy:							
	MWh	% CHG.	% CHG.	% CHG.	% CHG.	% CHG.	% CHG.
Jan	142,609	-16.1%	-4.5%	17.8%	-17.4%	-4.3%	-18.3%
Feb	206,674	-3.3%	5.9%	-5.2%	-5.1%	-2.0%	2.1%
Mar	181,222	-9.2%	-1.0%	-2.2%	-10.4%	-2.4%	7.0%
Apr	288,740	-22.2%	-3.1%	-0.5%	-24.5%	0.3%	5.3%
May	471,487	-1.4%	-13.8%	-4.4%	-4.4%	-2.0%	-10.7%
Jun	463,883	0.7%	-24.0%	-10.1%	-3.5%	-5.5%	-15.8%
Jul	554,085	1.1%	-37.7%	-7.0%	-1.2%	-1.3%	-19.4%
Aug	392,956	0.5%	-51.3%	-6.6%	-1.9%	-1.8%	-19.2%
Sep	303,585	3.1%	-43.0%	-14.2%	-8.8%	-2.4%	-34.9%
Oct	225,999	1.4%	-38.9%	-17.3%	-13.3%	-15.8%	-41.0%
Nov	98,160	-2.0%	-57.4%	-36.4%	-19.8%	-10.9%	-31.6%
Dec	162,089	-1.7%	-32.8%	-8.9%	5.5%	-4.8%	-46.4%
	3,491,490	-2.8%	-26.3%	-7.3%	-7.0%	-3.6%	-17.3%
3 Expected Annual net ene	**MWh**	% CHG.	% CHG.	% CHG.	% CHG.	% CHG.	% CHG.
On-Pk	2,722,291	0.9%	-22.7%	-6.7%	-3.4%	-3.3%	-15.5%
Off-Pk	769,199	-16.0%	-39.2%	-9.5%	-19.6%	-4.6%	-23.9%
Total	3,491,490	-2.8%	-26.3%	-7.3%	-7.0%	-3.6%	-17.3%

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4 Expected aMW of July and August Capacity based on USBR Generation

	aMW	% CHG.	% CHG.	% CHG.	% CHG.	% CHG.	% CHG.
On-Pk	601	0.0%	-30.0%	-4.9%	-2.5%	-1.5%	-15.3%
Off-Pk	240	-0.2%	-34.4%	-9.6%	-5.4%	-3.3%	-21.5%

5 USBR Expected Monthly and Annual Loads and Resources, MWh

	Generation	Load	HG., MW	CHG., MWh	CHG., MWh	CHG., MWh	CHG., MWh	CHG., MWh	CHG., MWh	CHG., MWh	CHG., MWh	CHG., MWh	CHG., MWh	CHG., MWh
Jan	260,007	117,398	3,161	26,080	-23,649	-17,252	-7,595	-33,006	-4,935	19,903	-6,680	-532	-13,237	12,797
Feb	289,404	82,729	1,536	8,319	-3,219	-15,386	-7,734	3,077	-5,822	4,676	-5,111	-955	1,210	-3,154
Mar	305,146	123,925	1,382	18,091	-12,882	-11,025	-7,248	-3,329	-5,031	13,743	-5,613	-1,262	-12,632	-25,236
Apr	344,021	55,281	6,009	70,077	-2,463	6,616	-1,005	405	-1,610	69,055	-3,552	-4,346	9,149	-6,139
May	504,005	32,517	2,777	9,563	-60,213	4,776	-16,257	4,369	-10,928	9,913	-5,815	3,839	-44,825	5,473
Jun	553,318	89,434	6,906	3,671	-98,539	12,792	-28,286	18,627	-17,144	-878	-16,608	9,041	-65,030	8,045
Jul	697,260	143,174	4,403	-1,771	-191,184	17,815	-38,639	69	-21,711	-14,817	-14,879	-7,865	-112,654	-5,285
Aug	554,938	161,982	-4,791	-6,603	-199,732	1,990	-39,586	-13,732	-19,975	-12,439	-10,192	-3,091	-100,904	-25,455
Sep	410,099	106,514	7,645	-1,719	-188,253	-57,742	-53,561	-10,385	-28,340	-1,691	-9,411	-2,169	-130,496	-24,522
Oct	283,365	57,366	5,328	2,181	-121,392	-33,517	-40,993	-1,943	-28,374	1,684	-17,120	18,488	-78,836	13,854
Nov	199,241	101,081	2,890	4,820	-63,336	-7,023	-23,241	12,488	-16,922	2,560	-8,096	2,595	-45,480	-14,452
Dec	256,743	94,655	2,886	5,606	-59,967	-6,871	-14,670	-243	-8,950	-17,919	-5,303	2,411	-38,744	36,391
Annual	4,657,546	1,166,056	40,133	138,315	-1,024,828	-104,826	-278,815	-23,602	-169,742	73,791	-108,378	16,153	-632,479	-27,685

6 USBR Net Value (based on Net Energy), $

	2003 USD	CHG, 2003 USD	CHG, 2003 USD	CHG, 2003 USD	CHG, 2003 USD	CHG, 2003 USD	CHG, 2003 USD
Jan	$5,562,001	-$749,648	-$226,633	$890,565	-$847,350	-$233,068	-$1,024,649
Feb	$6,899,260	-$182,634	$417,018	-$342,469	-$315,441	-$144,548	$130,028
Mar	$6,062,268	-$543,120	-$77,548	-$135,514	-$609,075	-$146,390	$414,949
Apr	$8,828,167	-$1,819,059	-$315,696	-$21,645	-$2,030,507	$57,752	$479,692
May	$14,424,587	-$181,582	-$1,918,174	-$607,091	-$618,232	-$279,535	-$1,491,585
Jun	$15,192,841	$98,237	-$3,516,773	-$1,443,279	-$525,378	-$789,358	-$2,289,950
Jul	$20,509,625	$201,781	-$7,341,958	-$1,370,413	-$250,026	-$236,201	-$3,857,282
Aug	$14,980,450	$58,831	-$7,517,197	-$961,156	-$275,670	-$248,381	-$2,775,407
Sep	$12,322,829	$348,943	-$5,033,749	-$1,672,152	-$991,385	-$278,223	-$4,190,738
Oct	$7,896,463	$107,477	-$2,957,070	-$1,307,584	-$1,028,491	-$1,198,208	-$3,138,980
Nov	$3,746,575	-$52,625	-$2,071,484	-$1,296,423	-$702,382	-$387,282	-$1,107,978
Dec	$6,376,967	-$71,771	-$2,066,448	-$562,109	$395,011	-$297,536	-$2,852,034
Annual	**$122,802,033**	**-$2,785,171**	**-$32,625,713**	**-$8,829,268**	**-$7,798,926**	**-$4,180,978**	**-$21,703,932**

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7	Reliability as Measured by E.N.S. in CNP15	**MWh**	**CHG., MWh**	**CHG., MWh**	**CHG., MWh**	**CHG., MWh**	**CHG., MWh**	**CHG., MWh**
	Annual	0	0	0	0	0	0	0
8	Reliability as Measured by E.N.S. in WECC							
	Annual	4,599	0	0	0	0	0	0
9	Revenues, $							
		2003 USD	**CHG, 2003 USD**	**CHG, 2003 USD**	**CHG, 2003 USD**	**CHG, 2003 USD**	**CHG, 2003 USD**	**CHG, 2003 USD**
	Jan	$6,320,215	-$181,706	-$3,666,272	$67,402	$53,844	$99,894	-$1,596,576
	Feb	$1,424,522	-$73,977	-$927,658	$20,539	$12,910	$11,626	$44,022
	Mar	$1,958,821	-$64,979	-$1,124,792	$32,817	$21,453	$26,862	$175,432
	Apr	$3,313,549	-$543,478	-$1,299,576	$18,238	$108,921	$60,751	$206,404
	May	$3,433,259	-$277,162	-$1,006,384	$506,817	$284,511	$237,181	$613,390
	Jun	$2,679,879	$162,005	-$742,553	$442,264	$230,369	$236,850	$792,944
	Jul	$1,745,989	$892,850	-$91,508	$89,725	$30,533	$16,272	$481,984
	Aug	$1,603,633	$702,939	-$74,320	$69,169	$26,668	$6,556	$338,236
	Sep	$926,856	$309,693	$13,052	$102,575	$35,774	$2,856	$438,243
	Oct	$1,569,793	$65,799	-$492,135	$192,336	$119,537	$72,606	$392,783
	Nov	$1,479,126	-$264,260	-$812,219	$88,617	$71,461	$40,781	$205,592
	Dec	$3,841,554	-$602,408	-$2,228,801	$44,945	$45,934	$17,927	$219,226
	Annual	**$30,297,197**	**$125,316**	**-$12,453,164**	**$1,675,444**	**$1,041,915**	**$830,162**	**$2,311,681**
10	(based on Net Energy							
		2003 USD	**CHG, 2003 USD**	**CHG, 2003 USD**	**CHG, 2003 USD**	**CHG, 2003 USD**	**CHG, 2003 USD**	**CHG, 2003 USD**
	Jan	$11,882,217	-$931,354	-$3,892,905	$957,967	-$793,506	-$133,173	-$2,621,226
	Feb	$8,323,782	-$256,611	-$510,640	-$321,931	-$302,532	-$132,923	$174,050
	Mar	$8,021,089	-$608,099	-$1,202,340	-$102,697	-$587,621	-$119,528	$590,381
	Apr	$12,141,716	-$2,362,537	-$1,615,272	-$3,407	-$1,921,586	$118,502	$686,096
	May	$17,857,846	-$458,745	-$2,924,558	-$100,274	-$333,722	-$42,353	-$878,195
	Jun	$17,872,720	$260,241	-$4,259,326	-$1,001,014	-$295,009	-$552,508	-$1,497,006
	Jul	$22,255,614	$1,094,630	-$7,433,466	-$1,280,687	-$219,493	-$219,930	-$3,375,298
	Aug	$16,584,083	$761,770	-$7,591,517	-$891,986	-$249,001	-$241,824	-$2,437,170
	Sep	$13,249,685	$658,636	-$5,020,697	-$1,569,577	-$955,612	-$275,366	-$3,752,495
	Oct	$9,466,256	$173,276	-$3,449,205	-$1,115,248	-$908,954	-$1,125,602	-$2,746,197
	Nov	$5,225,701	-$316,885	-$2,883,703	-$1,207,806	-$630,921	-$346,501	-$902,385
	Dec	$10,218,521	-$674,179	-$4,295,249	-$517,164	$440,945	-$279,609	-$2,632,807
	Annual	**$153,099,230**	**-$2,659,855**	**-$45,078,877**	**-$7,153,824**	**-$6,757,011**	**-$3,350,816**	**-$19,392,252**

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APPENDIX B VALUE OF CVP POWER UNDER "MOST PROBABLE" CONDITIONS

Note: All changes are relative to the NA case. For percentage change, the calculation is: (Case value-NA value)/NA value. For others, the calculation is Case value - NA value. Thus, if a percentage change is positive, it means the Case value is greater than the NA value, and vice versa.

Results of Case:	NA AvgR	EC	MF	PF	MP	SMUD	70
1 MCPs	**$/MWh**	% CHG.	% CHG.	% CHG.	% CHG.	% CHG.	% CHG.
Mean	36.13	0.0%	0.3%	0.1%	0.1%	0.1%	0.2%
2 Expected monthly net energy:							
	MWh	% CHG.	% CHG.	% CHG.	% CHG.	% CHG.	% CHG.
Jan	168,049	-4.5%	-12.1%	-3.4%	-2.0%	-3.4%	-12.1%
Feb	203,045	-8.0%	4.3%	-4.1%	-2.0%	-1.5%	1.7%
Mar	219,020	-2.7%	1.0%	-2.9%	-1.3%	-2.5%	-2.8%
Apr	305,857	-0.6%	2.2%	-0.5%	-0.5%	-2.0%	3.9%
May	459,960	-1.1%	-10.5%	-1.2%	-1.5%	-1.2%	-8.7%
Jun	473,495	-2.1%	-18.0%	-5.2%	-3.2%	-3.6%	-12.9%
Jul	544,344	-2.1%	-29.8%	-5.5%	-2.8%	-1.6%	-17.9%
Aug	414,643	-2.7%	-42.8%	-8.8%	-4.0%	-2.1%	-22.6%
Sep	308,216	-0.8%	-57.7%	-16.8%	-9.3%	-2.9%	-40.7%
Oct	193,883	-0.3%	-60.1%	-19.5%	-13.0%	-8.6%	-36.7%
Nov	109,089	-11.6%	-50.9%	-19.3%	-13.1%	-6.8%	-36.3%
Dec	147,220	-7.1%	-32.8%	-7.4%	-4.6%	-2.7%	-22.8%
	3,546,820	-2.7%	-24.6%	-6.8%	-4.0%	-2.7%	-16.2%
3 Expected Annual r	**MWh**	% CHG.	% CHG.	% CHG.	% CHG.	% CHG.	% CHG.
On-Pk	3,431,355	-6.7%	-19.6%	-4.6%	-2.8%	-2.0%	-12.0%
Off-Pk	115,466	117.7%	-173.0%	-70.5%	-39.5%	-26.2%	-138.6%
Total	3,546,820	-2.7%	-24.6%	-6.8%	-4.0%	-2.7%	-16.2%

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Expected aMW of July and August Capacity based on

4 USBR Generation	aMW	% CHG.	% CHG.	% CHG.	% CHG.	% CHG.	% CHG.
On-Pk	674	-1.3%	-23.6%	-2.8%	-1.5%	-1.0%	-9.9%
Off-Pk	165	-0.5%	-63.7%	-21.0%	-11.4%	-6.2%	-47.1%

USBR Expected Monthly and Annual Loads and Resources, MWh

5

	Generation	Load	CHG., MWh	CHG., MWh	CHG., MWh	CHG., MWh	CHG., MWh	CHG., MWh	CHG., MWh	CHG., MWh	CHG., MWh	CHG., MWh	CHG., MWh	CHG., MWh
Jan	291,061	123,012	-2,455	5,188	-23,342	-3,006	-8,115	-2,448	-5,040	-1,625	-6,942	-1,187	-17,739	2,632
Feb	313,620	110,575	-14,158	2,165	-1,413	-10,189	-7,941	286	-5,911	-1,781	-5,236	-2,176	1,245	-2,109
Mar	322,289	103,269	-4,779	1,037	-11,884	-14,162	-7,237	-985	-5,104	-2,349	-6,137	-729	-13,168	-6,959
Apr	358,713	52,856	-1,957	-229	2,042	-4,727	-993	482	-1,415	220	-6,288	-163	10,794	-1,277
May	513,016	53,056	-5,885	-854	-56,826	-8,396	-7,846	-2,166	-7,991	-1,155	-6,331	-938	-42,478	-2,310
Jun	563,970	90,476	-6,787	3,012	-98,124	-12,728	-28,317	-3,643	-16,850	-1,842	-18,276	-1,310	-64,737	-3,801
Jul	693,652	149,308	-3,876	7,444	-193,068	-30,999	-39,189	-9,251	-22,194	-6,948	-13,802	-5,163	-112,658	-15,023
Aug	554,911	140,269	-9,845	1,522	-200,127	-22,708	-40,639	-4,284	-21,048	-4,489	-10,878	-2,052	-102,163	-8,532
Sep	416,940	108,724	-1,479	1,009	-188,464	-10,764	-53,600	-1,804	-29,473	-733	-9,490	-546	-131,176	-5,757
Oct	288,485	94,601	-538	46	-123,969	-7,409	-41,130	-3,296	-28,003	-2,829	-17,134	-404	-79,915	-8,831
Nov	214,714	105,625	-12,466	236	-65,014	-9,525	-23,121	-2,035	-16,748	-2,459	-8,003	-628	-47,300	-7,656
Dec	271,033	123,813	-13,733	-3,288	-62,876	-14,516	-15,793	-4,886	-9,670	-2,965	-5,631	-1,698	-41,422	-7,805
Annual	4,802,403	1,255,582	-77,958	17,289	-1,023,063	-149,130	-273,920	-34,030	-169,446	-28,955	-114,149	-16,994	-640,717	-67,428

USBR Net Value (based on Net Energy), $

6

	2003 USD	CHG, 2003 USD	CHG, 2003 USD	CHG, 2003 USD	CHG, 2003 USD	CHG, 2003 USD	CHG, 2003 USD
Jan	$7,271,553	-$405,272	-$836,559	-$218,381	-$125,386	-$226,751	-$842,164
Feb	$7,285,776	-$638,148	$272,977	-$311,855	-$171,585	-$134,144	$124,772
Mar	$8,011,377	-$288,723	$26,154	-$228,312	-$108,099	-$182,822	-$277,780
Apr	$10,002,427	-$104,342	$137,534	-$49,722	-$49,619	-$192,578	$340,351
May	$15,644,974	-$238,387	-$1,561,403	-$197,302	-$157,808	-$125,737	-$1,272,598
Jun	$15,868,478	-$359,336	-$2,766,826	-$850,237	-$486,426	-$547,622	-$1,982,546
Jul	$22,264,122	-$447,338	-$6,050,370	-$954,265	-$496,646	-$261,772	-$3,465,706
Aug	$17,836,131	-$448,479	-$7,084,467	-$1,366,360	-$606,435	-$333,297	-$3,597,288
Sep	$13,063,146	-$153,158	-$7,152,618	-$2,052,524	-$1,093,051	-$348,083	-$4,986,309
Oct	$7,631,739	-$72,859	-$4,262,145	-$1,378,771	-$903,380	-$594,854	-$2,598,713
Nov	$4,805,273	-$600,242	-$2,305,390	-$880,505	-$601,786	-$313,886	-$1,666,429
Dec	$6,331,453	-$558,649	-$1,972,898	-$460,248	-$286,589	-$166,766	-$1,395,798
Annual	**$136,016,449**	**-$4,314,934**	**-$33,556,009**	**-$8,948,482**	**-$5,086,810**	**-$3,428,312**	**-$21,620,208**

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9 USBR Net A/S

	2003 USD	CHG, 2003 USD	CHG, 2003 USD	CHG, 2003 USD	CHG, 2003 USD	CHG, 2003 USD	CHG, 2003 USD
Jan	$6,320,215	-181706.0267	-3666271.88	67402.41825	53843.53552	99894.42916	-1596576.474
Feb	$1,424,522	-73976.84529	-927657.5106	20538.53158	12909.56634	11625.53261	44021.91544
Mar	$1,958,821	-64978.67811	-1124791.673	32817.09226	21453.41285	26862.05323	175432.4646
Apr	$3,313,549	-543477.9541	-1299576.35	18237.88453	108920.8507	60750.71003	206403.992
May	$3,433,259	-277162.3629	-1006383.661	506816.7672	284510.5643	237181.2926	613389.8175
Jun	$2,679,879	162004.505	-742552.611	442264.4856	230369.0669	236849.6947	792943.8969
Jul	$1,745,989	892849.6243	-91507.78618	89725.04674	30533.31649	16271.7164	481984.4673
Aug	$1,603,633	702939.2635	-74319.84152	69169.44736	26668.48492	6556.497018	338236.3061
Sep	$926,856	309692.8214	13052.1982	102574.8665	35773.79627	2856.366153	438243.1862
Oct	$1,569,793	65798.7004	-492134.9632	192335.6787	119537.3546	72606.08901	392783.1701
Nov	$1,479,126	-264259.5389	-812219.3179	88616.74823	71460.63742	40780.68343	205592.1995
Dec	$3,841,554	-602407.9552	-2228801.017	44945.01027	45934.05782	17927.34089	219226.0419
Annual	**$30,297,197**	**125,315.55**	**(12,453,164.41)**	**1,675,443.98**	**1,041,914.64**	**830,162.41**	**2,311,680.98**

10 USBR Net Value

	2003 USD	CHG, 2003 USD	CHG, 2003 USD	CHG, 2003 USD	CHG, 2003 USD	CHG, 2003 USD	CHG, 2003 USD
Jan	$13,591,768	-$586,978	-$4,502,830	-$150,978	-$71,543	-$126,857	-$2,438,741
Feb	$8,710,297	-$712,125	-$654,680	-$291,317	-$158,675	-$122,519	$168,794
Mar	$9,970,199	-$353,702	-$1,098,638	-$195,495	-$86,645	-$155,960	-$102,347
Apr	$13,315,976	-$647,820	-$1,162,042	-$31,484	$59,302	-$131,828	$546,755
May	$19,078,234	-$515,550	-$2,567,787	$309,515	$126,703	$111,445	-$659,208
Jun	$18,548,357	-$197,331	-$3,509,378	-$407,973	-$256,057	-$310,772	-$1,189,602
Jul	$24,010,111	$445,511	-$6,141,877	-$864,540	-$466,113	-$245,500	-$2,983,722
Aug	$19,439,764	$254,460	-$7,158,787	-$1,297,190	-$579,766	-$326,741	-$3,259,051
Sep	$13,990,002	$156,535	-$7,139,566	-$1,949,949	-$1,057,278	-$345,227	-$4,548,066
Oct	$9,201,531	-$7,060	-$4,754,280	-$1,186,436	-$783,843	-$522,248	-$2,205,930
Nov	$6,284,399	-$864,501	-$3,117,609	-$791,888	-$530,325	-$273,105	-$1,460,837
Dec	$10,173,007	-$1,161,057	-$4,201,699	-$415,303	-$240,655	-$148,839	-$1,176,572
Annual	**$166,313,646**	**-$4,189,619**	**-$46,009,173**	**-$7,273,038**	**-$4,044,895**	**-$2,598,150**	**-$19,308,527**

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APPENDIX C VALUE OF CVP POWER UNDER "DROUGHT" CONDITIONS

Note: All changes are relative to the NA case. For percentage change, the calculation is: (Case value-NA value)/NA value.
For others, the calculation is Case value - NA value. Thus, if a percentage change is positive, it means the Case value is greater than the NA value, and vice versa.

Results of Case:	NA Dry	EC	MF	PF	MP	SMUD	70
1 MCPs	**$/MWh**	% CHG.	% CHG.	% CHG.	% CHG.	% CHG.	% CHG.
Mean	37.75	0.0%	0.1%	0.0%	0.0%	0.0%	0.1%
2 Expected monthly net energy:	**MWh**	% CHG.	% CHG.	% CHG.	% CHG.	% CHG.	% CHG.
Jan	-108,734	1.7%	19.2%	-61.8%	-64.0%	2.4%	21.5%
Feb	23,042	2.1%	-16.2%	-55.8%	-63.2%	-30.6%	-11.0%
Mar	-50,744	3.0%	3.2%	-1.9%	-13.9%	3.9%	-78.5%
Apr	184,093	-10.2%	-2.6%	9.0%	20.0%	12.1%	20.5%
May	315,900	-3.6%	2.2%	6.0%	-3.8%	-0.2%	-1.9%
Jun	342,162	-2.9%	-18.5%	-13.4%	-16.3%	-14.3%	-16.9%
Jul	522,454	-5.0%	-27.6%	-12.2%	-12.1%	0.2%	-30.0%
Aug	289,651	-1.0%	-32.0%	-0.5%	-2.0%	-1.4%	-33.9%
Sep	156,274	-2.8%	-39.5%	-27.6%	-0.9%	-0.7%	-40.4%
Oct	75,813	8.3%	-42.8%	41.0%	7.6%	23.7%	-54.0%
Nov	-26,681	-14.4%	-18.2%	49.9%	73.1%	38.4%	-34.5%
Dec	-27,613	-47.3%	66.0%	37.3%	21.5%	24.9%	105.0%
	1,695,616	-3.1%	-25.5%	-3.3%	-3.5%	-2.5%	-23.1%
3 Expected Annual net ener	**MWh**	% CHG.	% CHG.	% CHG.	% CHG.	% CHG.	% CHG.
On-Pk	2,243,573	-3.8%	-14.1%	-2.2%	-2.2%	-1.5%	-13.9%
Off-Pk	-547,957	-6.0%	21.2%	1.3%	1.6%	1.6%	14.6%
Total	1,695,616	-3.1%	-25.5%	-3.3%	-3.5%	-2.5%	-23.1%

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Expected aMW of July and August Capacity based on USBR

4 Generation	aMW	% CHG.	% CHG.	% CHG.	% CHG.	% CHG.	% CHG.
On-Pk	598	-3.3%	-17.8%	-2.8%	-3.2%	0.1%	-18.9%
Off-Pk	102	-0.5%	-53.5%	-26.7%	-27.4%	-0.8%	-58.1%

USBR Expected Monthly and Annual Loads and Resources, MWh

5

	Generation	Load	CHG., MWh	CHG., MWh	CHG., MWh	CHG., MWh	CHG., MWh	CHG., MWh	CHG., MWh	CHG., MWh	CHG., MWh	CHG., MWh	CHG., MWh	CHG., MWh
Jan	82,938	191,672	-5,693	-3,869	-19,533	1,357	-10,415	-77,579	-6,990	-76,569	-971	1,614	-19,504	3,910
Feb	84,857	61,815	1,882	1,390	-5,008	-1,273	-4,779	8,087	-6,209	8,354	-5,969	1,074	-4,662	-2,132
Mar	101,134	151,878	-857	667	-1,638	-10	-142	-1,107	-881	-7,913	-649	1,317	2,716	-37,101
Apr	254,611	70,519	-3,225	15,476	16,269	21,050	7,105	-9,391	12,659	-24,226	3,081	-19,104	9,911	-27,908
May	348,745	32,845	-2,295	9,093	5,770	-1,098	20,404	1,390	-10,695	1,218	349	878	-7,163	-1,027
Jun	426,576	84,414	-1,755	8,063	-54,534	8,612	-44,937	1,003	-56,173	-427	-48,231	531	-60,517	-2,640
Jul	601,668	79,214	-25,619	254	-146,763	-2,432	-63,188	485	-65,176	-1,930	1,246	431	-160,066	-3,333
Aug	439,800	150,149	-4,364	-1,325	-92,935	-278	-1,783	-359	-4,787	1,009	-1,974	1,987	-95,967	2,174
Sep	270,431	114,157	-9,091	-4,766	-61,828	-169	-43,365	-276	-1,039	359	108	1,124	-63,076	26
Oct	105,673	29,861	15,614	9,304	-44,108	-11,659	27,167	-3,922	2,626	-3,129	16,190	-1,777	-46,176	-5,260
Nov	80,747	107,428	-3,981	-7,823	-14,214	-19,076	-9,693	3,621	-10,691	8,812	-6,477	3,771	-14,963	-24,163
Dec	77,337	104,950	920	-12,129	-15,891	2,337	-6,116	4,175	-2,222	3,722	-3,158	3,719	-16,097	12,887
Annual	2,874,518	1,178,902	-38,464	14,335	-434,413	-2,639	-129,742	-73,873	-149,578	-90,722	-46,454	-4,435	-475,565	-84,567

USBR Net Value (based on Net Energy), $

6

	2003 USD	CHG, 2003 USD	CHG, 2003 USD	CHG, 2003 USD	CHG, 2003 USD	CHG, 2003 USD	CHG, 2003 USD
Jan	-$3,568,393	-$94,687	-$888,984	$2,599,370	$2,728,759	-$93,460	-$980,608
Feb	$1,272,383	$22,391	-$152,056	-$487,142	-$550,453	-$278,994	-$106,285
Mar	-$1,328,879	-$64,593	-$63,864	$34,607	$249,954	-$70,441	$1,420,394
Apr	$6,537,390	-$647,328	-$158,842	$542,407	$1,220,641	$737,612	$1,248,878
May	$11,678,529	-$504,603	$194,954	$620,202	-$423,931	-$42,326	-$235,905
Jun	$12,624,758	-$396,556	-$2,160,563	-$1,573,398	-$1,881,031	-$1,657,004	-$1,985,883
Jul	$21,899,095	-$1,018,295	-$5,569,552	-$2,275,054	-$2,254,800	$53,442	-$6,040,463
Aug	$13,373,712	-$193,854	-$3,935,126	-$56,519	-$232,282	-$162,326	-$4,154,396
Sep	$7,216,591	-$205,061	-$2,579,126	-$1,808,946	-$54,490	-$38,380	-$2,634,631
Oct	$3,412,548	$214,542	-$1,269,596	$1,188,768	$214,610	$681,371	-$1,588,071
Nov	-$527,613	$120,441	$127,097	-$550,075	-$784,541	-$416,543	$293,350
Dec	-$407,093	$483,328	-$734,637	-$415,981	-$225,433	-$269,610	-$1,132,406
Annual	**$72,183,028**	**-$2,284,276**	**-$17,190,295**	**-$2,181,762**	**-$1,992,999**	**-$1,556,660**	**-$15,896,026**

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9 USBR Net A/S

	2003 USD	CHG, 2003 USD	CHG, 2003 USD	CHG, 2003 USD	CHG, 2003 USD	CHG, 2003 USD	CHG, 2003 USD
Jan	4665069.035	-1058828.173	-3462682.021	-3433457.478	121311.2804	-28540.93888	-3768755.754
Feb	1489841.354	-271648.7201	-436555.788	-407244.1885	-408668.1229	-413202.4612	-560427.804
Mar	909610.9589	-338988.9516	-4456.568026	6924.415215	7839.895777	4031.664889	-120799.621
Apr	1602938.072	10029.56831	65846.42461	-9546.493925	-5486.775149	7280.736869	555089.9559
May	2545065.008	-387750.7039	-1270742.706	-10699.83836	-1237122.029	-1237541.621	-1091884.26
Jun	2854014.934	-423887.742	-1349420.056	-366752.1667	-376736.5968	-369855.1079	-1392551.982
Jul	1519497.155	-186159.9281	-605756.5418	272748.4368	270367.0042	3140.326437	-446665.6399
Aug	1561868.885	-242797.4386	-737638.6032	3924.120696	-848.0594662	-971.9864331	-599299.2888
Sep	1103964.525	-241826.1032	-583993.9459	347656.3945	-7286.168544	-8306.376869	-608625.0991
Oct	1681523.589	-224499.003	-1047590.809	-167217.5164	-38152.89982	-116577.0632	-800657.6253
Nov	1414844.12	-245400.2186	-872779.3534	-804253.9664	-813724.9594	-394532.9242	-785724.9771
Dec	2502448.078	-528233.4408	-1027498.515	-967712.759	-14206.74645	-1139.724938	-1017963.951
Annual	**$23,850,686**	**-$4,139,991**	**-$11,333,268**	**-$5,535,631**	**-$2,502,714**	**-$2,556,215**	**-$10,638,266**

10 USBR Net Value

	2003 USD	CHG, 2003 USD	CHG, 2003 USD	CHG, 2003 USD	CHG, 2003 USD	CHG, 2003 USD	CHG, 2003 USD
Jan	$1,096,676	-$1,153,515	-$4,351,667	-$834,087	$2,850,070	-$122,001	-$4,749,363
Feb	$2,762,224	-$249,258	-$588,611	-$894,386	-$959,122	-$692,196	-$666,712
Mar	-$419,268	-$403,582	-$68,320	$41,532	$257,794	-$66,409	$1,299,595
Apr	$8,140,328	-$637,299	-$92,995	$532,860	$1,215,154	$744,893	$1,803,968
May	$14,223,594	-$892,354	-$1,075,789	$609,502	-$1,661,053	-$1,279,867	-$1,327,789
Jun	$15,478,773	-$820,444	-$3,509,983	-$1,940,151	-$2,257,768	-$2,026,859	-$3,378,435
Jul	$23,418,593	-$1,204,455	-$6,175,308	-$2,002,306	-$1,984,433	$56,582	-$6,487,129
Aug	$14,935,581	-$436,651	-$4,672,765	-$52,595	-$233,130	-$163,298	-$4,753,696
Sep	$8,320,555	-$446,887	-$3,163,120	-$1,461,289	-$61,776	-$46,686	-$3,243,257
Oct	$5,094,072	-$9,957	-$2,317,187	$1,021,550	$176,457	$564,794	-$2,388,728
Nov	$887,231	-$124,960	-$745,682	-$1,354,329	-$1,598,266	-$811,076	-$492,375
Dec	$2,095,355	-$44,906	-$1,762,136	-$1,383,694	-$239,639	-$270,750	-$2,150,370
Annual	**$96,033,714**	**-$6,424,267**	**-$28,523,564**	**-$7,717,393**	**-$4,495,713**	**-$4,112,875**	**-$26,534,292**

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APPENDIX D VALUE OF CVP POWER UNDER "WET" CONDITIONS

Note: All changes are relative to the NA case. For percentage change, the calculation is: (Case value-NA value)/NA value.
For others, the calculation is Case value - NA value. Thus, if a percentage change is positive, it means the Case value is greater than the NA value, and vice versa.

Results of Case:	NA Wet	EC	MF	PF	MP	SMUD	70
1 MCPs	**$/MWh**	% CHG.	% CHG.	% CHG.	% CHG.	% CHG.	% CHG.
Mean	34.84	0.1%	0.8%	0.2%	0.2%	0.1%	0.4%
2 Expected monthly net energy:							
	MWh	% CHG.	% CHG.	% CHG.	% CHG.	% CHG.	% CHG.
Jan	463,001	0.1%	-7.7%	-2.7%	-2.8%	-2.7%	-17.5%
Feb	646,226	-8.6%	-7.0%	1.2%	2.1%	0.6%	4.3%
Mar	558,306	5.8%	12.3%	0.0%	0.0%	0.0%	11.7%
Apr	487,219	-11.2%	15.4%	-4.4%	-4.6%	-4.4%	3.6%
May	748,478	-4.0%	-30.9%	-9.6%	-3.9%	-3.8%	-27.8%
Jun	693,143	1.7%	-37.1%	-30.0%	-2.0%	-18.2%	-32.0%
Jul	614,898	1.7%	-47.1%	-5.4%	0.0%	0.1%	-14.4%
Aug	474,607	1.1%	-44.8%	-0.3%	0.4%	0.3%	-4.0%
Sep	495,466	-3.9%	-53.1%	-0.5%	0.1%	0.1%	-0.4%
Oct	428,853	-1.0%	-85.3%	-71.7%	-74.4%	-49.6%	-86.6%
Nov	198,432	-2.5%	-61.7%	-44.7%	-32.6%	0.2%	-79.6%
Dec	345,263	-1.5%	-38.5%	-0.7%	-2.7%	0.2%	-60.4%
	6,153,890	-1.8%	-29.5%	-12.0%	-7.4%	-6.4%	-20.3%
3 Expected Annual net energy	**MWh**	% CHG.	% CHG.	% CHG.	% CHG.	% CHG.	% CHG.
On-Pk	4,809,589	-2.2%	-22.7%	-7.7%	-5.4%	-3.6%	-14.3%
Off-Pk	1,344,301	-0.5%	-53.6%	-27.7%	-14.5%	-16.4%	-41.4%
Total	6,153,890	-1.8%	-29.5%	-12.0%	-7.4%	-6.4%	-20.3%

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4 Expected aMW of July and August Capacity based on USBR Generation

	aMW	% CHG.	% CHG.	% CHG.	% CHG.	% CHG.	% CHG.
On-Pk	740	1.0%	-22.9%	-0.4%	-0.2%	0.0%	-2.9%
Off-Pk	241	1.1%	-59.4%	-7.7%	-0.3%	0.0%	-19.4%

5 USBR Expected Monthly and Annual Loads and Resources, MWh

	Generation	Load	CHG., MWh	CHG., MWh	CHG., MWh	CHG., MWh	CHG., MWh	CHG., MWh	CHG., MWh	CHG., MWh	CHG., MWh	CHG., MWh	CHG., MWh	CHG., MWh
Jan	565,607	102,606	-2,250	-2,601	-110,955	-75,265	-13,807	-1,193	-13,995	-1,226	-13,812	-1,127	-83,534	-2,404
Feb	798,866	152,639	-82,524	-26,718	-137,802	-92,340	-175	-7,664	-179	-13,930	-178	-3,831	-206	-28,021
Mar	722,984	164,679	11,630	-20,755	-31,183	-99,979	0	-162	237	277	-1	-244	42,968	-22,608
Apr	573,329	86,110	-33,108	21,230	50,169	-24,761	1	21,405	-6	22,199	-6	21,224	40,298	22,820
May	793,021	44,544	-17,533	12,753	-215,713	15,202	-58,096	13,945	-15,955	13,472	-14,436	14,077	-195,081	12,859
Jun	807,734	114,591	11,167	-590	-255,560	1,847	-208,692	-709	-15,420	-1,595	-126,817	-440	-224,547	-2,805
Jul	823,543	208,646	8,247	-2,308	-256,449	33,411	-29,281	3,744	-3,056	-3,034	-507	-1,427	-77,952	10,438
Aug	636,657	162,049	6,310	983	-208,863	3,598	-2,351	-1,122	-743	-2,678	603	-737	-23,502	-4,442
Sep	615,996	120,530	-19,159	-30	-262,957	306	-2,596	-105	98	-290	532	-61	-2,599	-579
Oct	537,379	108,526	-5,839	-1,600	-359,834	5,904	-308,489	-1,146	-320,257	-1,236	-214,131	-1,221	-372,261	-1,060
Nov	327,272	128,840	-3,455	1,526	-117,264	5,095	-85,377	3,303	-65,513	-895	-399	-821	-180,011	-22,147
Dec	446,008	100,745	-5,083	-74	-149,812	-16,780	-3,715	-1,389	-10,846	-1,429	-445	-1,284	-175,854	32,559
Annual	7,648,396	1,494,506	-131,596	-18,183	-2,056,223	-243,763	-712,577	28,905	-445,634	9,635	-369,598	24,108	-1,252,282	-5,390

6 USBR Net Value (based on Net Energy), $

	2003 USD	CHG, 2003 USD	CHG, 2003 USD	CHG, 2003 USD	CHG, 2003 USD	CHG, 2003 USD	CHG, 2003 USD
Jan	$17,391,400	$40,016	-$1,309,535	-$396,727	-$403,272	-$399,223	-$2,949,299
Feb	$22,139,149	-$1,875,508	-$1,522,028	$280,886	$493,972	$150,368	$972,111
Mar	$18,786,005	$1,082,019	$2,270,450	$12,611	$9,281	$8,335	$2,142,109
Apr	$15,412,303	-$1,648,179	$2,299,074	-$642,215	-$665,017	-$637,304	$657,140
May	$24,019,405	-$895,857	-$6,753,092	-$2,104,064	-$909,644	-$882,673	-$6,127,600
Jun	$21,834,806	$359,637	-$7,597,498	-$6,100,824	-$355,891	-$3,720,997	-$6,516,349
Jul	$23,879,330	$527,493	-$10,156,872	-$1,042,913	-$14,115	$30,796	-$2,939,160
Aug	$19,714,427	$144,353	-$8,246,186	-$45,395	$76,748	$49,351	-$731,990
Sep	$19,905,726	-$756,996	-$10,147,143	-$88,530	$11,441	$27,967	-$68,495
Oct	$15,061,443	-$131,471	-$12,378,539	-$10,363,660	-$10,767,551	-$7,050,158	-$12,604,508
Nov	$8,264,367	-$285,361	-$4,780,503	-$3,457,413	-$2,507,780	$24,459	-$6,289,346
Dec	$13,033,365	-$204,613	-$4,803,881	-$81,482	-$355,573	$25,610	-$7,522,962
Annual	**$219,441,727**	**-$3,644,468**	**-$63,125,755**	**-$24,029,727**	**-$15,387,400**	**-$12,373,470**	**-$41,978,350**

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9 USBR Net A/S

	2003 USD	CHG, 2003 USD	CHG, 2003 USD	CHG, 2003 USD	CHG, 2003 USD	CHG, 2003 USD	CHG, 2003 USD
Jan	5666122.133	-44755.07508	-487474.1632	111292.0749	111488.6086	110572.8586	-544086.5344
Feb	669815.1244	180361.1051	2689.15689	1125.709426	1647.584282	546.2942183	3154.112177
Mar	1262512.45	-45194.01133	28694.07158	79.65553921	-172.8621299	-118.1404616	2686.386214
Apr	1891469.965	128115.0262	1936.031202	-3876.246848	-4300.200523	-4118.21709	-4222.541163
May	1183778.605	11889.08992	1016231.829	973071.7665	-3585.906687	-3684.193542	2307431.859
Jun	1293673.056	-31143.5593	-27121.82647	-25955.45349	795882.3628	1268415.745	-25700.38917
Jul	1112516.05	-240503.6962	-36923.27492	628324.7701	998.6394933	4638.116205	651186.0322
Aug	1865243.181	-227924.8071	-673170.3803	-850.9077481	507.9989293	347.6140869	19984.02965
Sep	958166.0654	50964.81949	-311935.8223	7233.011849	-116.7272973	-1007.270904	7338.767395
Oct	1112112.799	-200387.6128	478094.2524	483946.1567	483707.464	797621.3942	482022.6475
Nov	1305715.386	2072.882834	-39637.60888	350725.5613	246520.9113	-7724.573369	-30341.77984
Dec	3292660.448	18610.30644	-225025.695	-17011.20843	47678.98021	-17318.10652	1007391.133
Annual	**$21,613,785**	**-$397,896**	**-$273,643**	**$2,508,105**	**$1,680,257**	**$2,148,172**	**$3,876,844**

10 USBR Net Value

	2003 USD	CHG, 2003 USD	CHG, 2003 USD	CHG, 2003 USD	CHG, 2003 USD	CHG, 2003 USD	CHG, 2003 USD
Jan	$23,057,522	-$4,739	-$1,797,009	-$285,435	-$291,783	-$288,650	-$3,493,386
Feb	$22,808,965	-$1,695,147	-$1,519,339	$282,012	$495,619	$150,914	$975,265
Mar	$20,048,517	$1,036,825	$2,299,144	$12,691	$9,109	$8,217	$2,144,795
Apr	$17,303,773	-$1,520,064	$2,301,010	-$646,091	-$669,317	-$641,423	$652,917
May	$25,203,183	-$883,967	-$5,736,860	-$1,130,993	-$913,230	-$886,357	-$3,820,168
Jun	$23,128,479	$328,493	-$7,624,620	-$6,126,780	$439,992	-$2,452,582	-$6,542,050
Jul	$24,991,846	$286,989	-$10,193,796	-$414,589	-$13,116	$35,434	-$2,287,974
Aug	$21,579,670	-$83,572	-$8,919,357	-$46,246	$77,256	$49,699	-$712,006
Sep	$20,863,892	-$706,031	-$10,459,079	-$81,297	$11,325	$26,960	-$61,156
Oct	$16,173,556	-$331,859	-$11,900,445	-$9,879,714	-$10,283,844	-$6,252,536	-$12,122,485
Nov	$9,570,083	-$283,288	-$4,820,141	-$3,106,688	-$2,261,259	$16,734	-$6,319,688
Dec	$16,326,026	-$186,003	-$5,028,907	-$98,493	-$307,894	$8,292	-$6,515,571
Annual	**$241,055,512**	**-$4,042,363**	**-$63,399,398**	**-$21,521,622**	**-$13,707,143**	**-$10,225,298**	**-$38,101,506**

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Department of Energy March 9, 2004 Letter

Department of Energy
Western Area Power Administration
Sierra Nevada Customer Service Region
114 Parkshore Drive
Folsom, California 95630-4710

MAR - 9 2004

Mr. Kirk Rodgers
Regional Director
Bureau of Reclamation
Mid-Pacific Region
2800 Cottage Way
Sacramento, CA 95825-1898

Dear Mr. Rodgers:

Thank you for the opportunity to provide the Western Area Power Administration's (Western) views on the analytical methods employed and conclusions reached by the Henwood Energy Services, Inc. (Henwood) in their report, "Power Impact Analysis for the Trinity River Supplemental Environmental Impact Report (SEIR)/Environmental Impact Statement (EIS), Central Valley Project, Phase 2 Report, (revised draft October 20, 2003)".

Western provided comments, informally, to Mr. Kim Nguyen of your staff and Mr. Mike Urkov of CH2M-Hill in December 2003. Our initial comments focused on our concern that the scope of the power impact analysis appeared to concentrate primarily on regional cost impacts to the Western Electricity Coordinating Council region under the EIS/EIR alternatives, and did not appear to evaluate the power-related impacts of alternative water operations at the Trinity Dam and Reservoir upon individual authorized beneficiaries. While the aggregated regional impact analysis may quantify the overall regional cost, from an economic impact basis, Western believes that an analysis identifying how these costs will become the responsibility of a more limited group, primarily the Preference Power customers of the Central Valley Project (CVP) is desirable.

We were pleased to see our concerns were addressed when CH2M-Hill developed additional analytical data describing the potential range of impacts CVP Preference Power customers may incur from alternative water operations at the Trinity Dam and Reservoir. I understand that the revised analysis now includes an assessment of financial impacts to two representative CVP customers, with one example summarizing the impacts to an average customer for which 14 percent of its load is served by CVP power, while the other portrays the impacts to a high-allocation customer, for which 85 percent of its load is served using CVP power. I appreciate the commitment to provide further explanation of the methods used to quantify the change in costs per unit of electricity for these representative customers for each alternative in the Trinity SEIS.

Western agrees the "bookends" regional analytical approach undertaken by Henwood and CH2M-Hill in this study provides a range of possible impacts, and accordingly, we believe the revised analysis addresses the requirements established by the Federal District Court in its legal opinion.

Again, thank you for the opportunity to provide comments on this document.

Sincerely,

Thomas R. Boyko
Power Marketing Manager

U.S. Geological Survey Report
Technical Appendix D

Technical review of portions of the Department of Interior's Trinity River Restoration Plan concerning sediment transport and the management of spawning gravels

By E.D. Andrews, K. M. Nolan, and S.M. Wiele

Introduction

Populations of salmon, both adults and their progeny, in the Trinity River of northern California have declined substantially since the completion of the Central Valley Project's Trinity River Division (TRD) in the early 1960s. The streamflow storage and diversion by the TRD has reduced annual runoff of the Trinity River by as much as 90 percent. Numerous investigations and studies have been conducted in the past 20 years as part of an attempt to recover salmon populations. These studies have considered, among other topics, the relation between streamflows, fluvial sediment transport, and river channel features that provide salmon habitat, including gravel substrate suitable for spawning and relatively low velocity areas utilized by young fish. Based on these studies, several alternative flow regimes have been proposed. These alternatives were evaluated in accordance with NEPA, and an Environmental Impact Statement (EIS) was prepared and reviewed. On December 19, 2000, the Secretary of the Interior issued a Record of Decision (ROD). The preferred alternative consists of (1) five annual flow release regimes from Lewiston Dam depending on the expected basin runoff: critically dry, dry, normal, wet, and extremely wet, (2) the introduction (augmentation) of gravel-sized sediment suitable for salmon spawning below Lewiston Dam, and (3) an adaptive management program to evaluate and change, when necessary, the flow regimes and gravel augmentation.

The Sacramento Municipal Utility District (SMUD) and other parties subsequently challenged the ROD. During August 2002, SMUD met with representatives of the Bureau of Reclamation (BOR) to express their views concerning the effect of the ROD flow regimes and the feasibility of the gravel augmentation, and to propose an alternative flow regime. The substance of the SMUD presentation is a digital document containing 96 figures, photographs**,** and text panels. In late September 2002, the BOR asked the U.S. Geological Survey (USGS) to conduct a partial technical review of SMUD's Trinity River Restoration proposal and consider three specific issues, namely:

1. Evaluate hydrologic and geomorphic components of the ROD plan relative to streambed scour and the configuration of gravel and cobbles in reaches 1,2, and 3. Assess SMUD's assertion of potential gravel mobility problems that may result from ROD flows. Further determine if the alleged mobility of the gravels due to the ROD flows would eliminate the most significant spawning areas in the Trinity River.
2. Assess SMUD's assertion regarding substantial gravel replacement by mechanical means (gravel management plan) as being impractical.
3. Determine if the modified flow rates proposed by SMUD would avoid the assertions made in 1 and 2.

We reported our findings orally to Mr. Kirk Rogers, Mid-Pacific Regional Director, BOR, on October 15, 2002. This report is a record of our findings presented to Mr. Rogers.

Background Information:

Our review relied upon part or all of several reports:

1. The Trinity River Mainstem Fishery Restoration Final EIS/EIR, October 2000,
2. The Record of Decision, December 2000,
3. The SMUD Trinity River Restoration proposal, August 30, 2002,
4. McBain, S., and W. Trush. 1997. *Trinity River Channel Maintenance Flow Study Final Report*. Prepared for the Hoopa Valley Tribe, Trinity River Task Force, and
5. Parker, G. 1979. Hydraulic geometry of active gravel rivers. Journal of the Hydraulic Division, American Society of Civil Engineers, 105(HY9), N85-1201,
6. U.S. Fish and Wildlife Service and the Hoopa Valley Tribe. 1999. Trinity River Flow Evaluation Final Report,
7. Wilcock, P.R., G.M. Kondolf, A.F. Barta, W.V.G. Matthews, and C.C. Shea. 1995. Spawning gravel flushing during trial reservoir releases on the Trinity River. Field observations and recommendations for sediment maintenance flushing flows. Prepared for the U.S. Fish and Wildlife Service, Sacramento, CA., Cooperative Agreements 12-16-0001-91514 and 14-16-0001-91515,

8. Wilcock, P.R., G. M. Kondolf, W. V. G. Matthews, and A. F. Barta. 1996A. Specification of sediment maintenance flows for a large gravel-bed river. Water Resources Research **32**:2911-2921, and
9. Wilcock, P. R., et. al. 1996B. Observations of flow and sediment entrainment on a large gravel-bed river. Water Resources Research **32**:2897-2909.

On October 12, 2002, we met with Drs. Mike Harvey and Robert Mussetter, consultants to SMUD. They presented the SMUD proposal and answered our questions concerning their methods and results. The proposal assertions we were asked to evaluate are summarized in 13 figures from the SMUD presentation. Copies of these figures are attached and we will use them to describe our findings. We will identify each figure by their number within the SMUD presentation.

Streamflow to Maintain Spawning Habitat

Reaches 1 to 3, as shown in figure 5, contain the most important salmon spawning beds on the mainstem of the Trinity River and are the reaches of particular interest identified in the BOR review request. The formation and maintenance of a loose, permeable gravel bed necessary for salmon spawning requires occasional movement and reworking of gravel and the mobilization of relatively fine sediment. Relatively fine sediment deposited in the gravel interstices reduces the exchange and flow of oxygenated river water through the gravel and smothers salmon eggs. Gravel is transported downstream when spawning gravel is reworked and fine sediment is mobilized. In an unregulated, unobstructed river, there is a ready supply of gravel to replace the particles transported downstream. Dams trap the upstream supply of gravel, however, and gravel-bed channels downstream from dams will tend to erode if dam releases are sufficiently high to mobilize the gravel and there is no artificial gravel supplement.

Maintaining suitable spawning gravel downstream of a dam requires a complex balancing of transport and supply of gravel. For some distance below a dam, tributary contributions of gravel may be insufficient to support downstream gravel transport at a rate that will maintain the permeability of the spawning bed. Without a sufficient supply of gravel particles of the sizes suitable for spawning, approximately 15 to 45 mm, spawning beds will, over time, become too

coarse. In many instances, suitable spawning beds can be maintained downstream of a dam only by adding gravel to the river.

Each of the three questions posed by the BOR relates to whether the ROD flow regime and the accompanying gravel augmentation plan achieves a proper balance between reworking of the spawning gravels and supply. SMUD's presentation suggests that the ROD flow regimes will cause so much gravel transport, especially of those sizes suitable for spawning, that it will be impractical to add enough gravel to balance the transport. Implicit in this assertion is the possibility that gravel transport by the ROD flow regimes and associated imbalance will be so large that the spawning gravels could be severely eroded before the imbalance becomes apparent and appropriate action could be taken. SMUD's conclusions regarding excessive gravel transport were derived from their model results. In the sections below, we present our review of the SMUD analysis.

SMUD hydraulic model

The basis for much of the SMUD analysis is a one-dimensional step-backwater hydraulic model. Input to the model consists of channel cross-sections referenced to a common vertical datum at specified longitudinal distances, channel roughness, and discharge. The model computes water surface elevation, water surface width, cross-sectional area, and mean flow velocity that would occur at specified discharges at each cross-section along the channel. The quantity of bed-material transported by the river at specified discharges can be calculated at each cross section using hydraulic predictions from the model at that cross section, a specified riverbed sediment particle-size at that cross section, and an appropriate bedload function. These techniques are useful and widely applied, although they are not without significant uncertainties and pitfalls.

The SMUD hydraulic model analysis covered approximately 40 miles of the Trinity River from Lewiston Dam to the confluence of the North Fork Trinity Fork. This 40-mile reach, which is shown in SMUD figure 5, has been subdivided into 12 shorter reaches defined by channel morphology and major tributaries.

Although a flow model provides the best tool for predicting flow properties in the absence of direct measurement, confidence in the SMUD model results is limited by the scarcity of information with which to calibrate or test the model. The accuracy of predictions produced by any hydraulic model depends on the accuracy with which the physical characteristics of the river are represented in the model. Measured water surface elevations at some known discharges permit the modeler to calibrate the flow resistance input to the model so that the calculated water-surface elevations agree with the measured values. The calibrated model can then be used to compute the water surface elevation over a range of discharge. Experience has shown that extensive model calibrations through a river reach and over a wide range of discharge reduces the uncertainty of model results. The SMUD hydraulic model appears to have been calibrated at only one cross-section (see SMUD figure 7). Among the approximately 540 cross-sections used for the SMUD model, the same flow resistance was applied at all except 15 cross-sections for all discharges from 100 to 14,000 ft^3/s. With such limited calibration, the model results are, at best, a rough approximation. Flow resistance varies along a river as a result of differences in channel width, depth, alignment, size of bed-material etc. As noted above, the SMUD analysis divided the 40-miles into 12 subreaches based, in part, on differences in channel morphology. These differences are summarized in several SMUD figures. Given these significant differences in channel morphology of the Trinity River, we believe it is unjustified to assume a constant flow resistance throughout the 40-mile reach. Flow resistance, also, varies with discharge as flow through a river cross-section becomes wider, deeper, and faster. The SMUD presentation does not provide evidence that their hydraulic model was adequately calibrated and accurately represents flow characteristics in the 40-mile reach.

SMUD's Anaylsis of Sediment Transport

Based on the available information concerning flow and sediment transport in the Trinity River, we believe that the ROD flow regimes and the associated gravel augmentation plan are an appropriate approach to restore and maintain gravel beds suitable for salmonid spawning. Assertions made in the SMUD presentation regarding the possibility of excessive gravel

transport by the largest ROD flows and the infeasibility of supplying enough gravel to balance losses is not substantiated. Results presented in some figures are inconsistent or conflict with material found in other figures. SMUD's calculated rate of sediment transport in reaches 1 and 3 at a discharge of about 6,000 ft^3/s do not agree with actual measurements made in these reaches. Finally, daily streamflows within the range of magnitude, which SMUD asserts will cause damage to spawning habitat, have actually occurred on 46 days since 1997 and no degradation of the gravel spawning beds has been observed. The basis for our conclusions is described below.

Reach-averaged critical discharge

SMUD's calculations of reach-averaged critical discharge (figure 36) are inconsistent with SMUD's assertions that ROD flows will cause excessive gravel transport. Figure 36 shows the calculated critical discharge, which is the discharge at which bed particles begin to move, for the 12 reaches identified in figure 5. The median bed particle size in each reach is shown on the right-hand ordinate. The median diameter of bed particles in reaches 1 to 3 is about 54mm. The indicated critical discharge for gravel motion in reach 1 is 6,000 ft^3/s. Actual particle movement at the critical discharge is extremely small and would be insufficient to rework spawning gravels and mobilize the relatively fine sediment. Consequently, streamflows somewhat larger than the critical discharge must be sustained for a few days to accomplish the desired reworking of a spawning gravel bed. Therefore, according to figure 36, releases from Lewiston Dam must occasionally exceed 6,000 ft^3/s by an appreciable margin to maintain the suitability of spawning gravels in reach 1, but streamflow releases proposed by SMUD are capped at 6,000 ft^3/s (see SMUD figures 15-19).

Our assessment that releases from Lewiston Dam must occasionally exceed 6,000 ft^3/s by an appreciable margin is based upon the fact that dimensionless grain shear stress, which is the ratio of the fluid forces acting on riverbed particles to the fluid forces required to move the bed particle, and thus, is the single hydraulic characteristic of a stream most indicative of the bed-material transport rate, does not vary linearly with discharge. Rather, shear stress varies with about the 0.4 power of discharge. This relation means, for example, that a discharge 3 times greater than the critical discharge will result in a dimensionless grain shear stress that is only 55 percent greater than critical dimensionless grain shear stress.

Critical discharge indicated for reaches 2 to 3 is approximately 4,000 ft^3/s. In these reaches, dam releases of 6,000 ft^3/s would probably be sufficient to rework spawning gravels. Within reach 4 and 5, the critical discharge is estimated to again be about 6,000 ft^3/s, and dam releases of only 6,000 ft^3/s would be insufficient in these reaches unless tributrary inflows to the mainstem were substantial. SMUD's analysis shown in figure 36 indicates, to us, that the ROD flow regimes which provides streamflows greater than 6,000 ft^3/s for a few days during wet and extremely wet years are reasonable.

Critical shear stress at individual cross sections

Longitudinal profiles of the river bed (the thalweg) and water surface elevations computed by SMUD's hydraulic model at individual cross sections at 6,000 ft^3/s and 10,000 ft^3/s through reach 1 are shown in the lower panel of figure 40. Longitudinal profiles of the dimensionless grain shear stress at 6,000 ft^3/s and 10,000 ft^3/s are shown in the upper panel. A value less than 1.0 indicates that fluid forces at that discharge are insufficient to move bed particles. A value greater than 1.0 indicates that fluid forces at that discharge are sufficient to move bed particles. The horizontal dashed line in the upper panel has a value of 1.0 and identifies channel cross-sections with gravel motion and no gravel motion.

Beginning at the Old Dam near Station 205,000, there appears to be 36 locations where the dimensionless grain shear stress has been computed. We chose to start this analysis below the Old Dam site because bedrock outcrops and remnants of the Old Dam appear to distort the local flow characteristics significantly. This effect is artificial and unrepresentative of the rest of reach 1 downstream.

The model results displayed in the upper panel of figure 40 are physically unreasonable. The computed dimensionless grain shear at six cross sections downstream of the Old Dam site is 3 or greater. Four of these cross-sections are located within riffles, which are relatively steep, high velocity portions of the channel. Within several hundred to perhaps a thousand feet, up and/or downstream of these cross-sections with very large dimensionless grain shear stresses, there are cross-sections where the dimensionless grain shear stress is nearly 1.0 or less.

Relatively small longitudinal variations in bed-material transport, especially during the rising or falling limb of a flood hydrograph, are common and can cause short-term net accumulations or depletions of sediment in a given cross-section. Imbalances that exist during one portion of a flood hydrograph are subsequently reversed, so that when the flood has passed, there is no appreciable accumulation or depletion of bed-material. Very large differences in the bed-material transport, however, can only exist in reality for a very short time without causing major changes in channel shape and slope.

River channels adjust over a period of time so that the sediment supplied to the channel is transported by the available discharge. If more sediment is delivered to a cross section than is transported away from the cross section, the bed must aggrade. Conversely, if less sediment is delivered to the cross section than is transported away, the cross section must scour. Thus, a river with the longitudinal grain shear stress profile shown in figure 40 would rapidly adjust; the cross sections with high grain shear stress that are downstream of cross sections with low grain shear stress would erode and cross sections with low grain shear stress that are downstream from cross sections with high grain shear stress would aggrade. Consequently, significant erosion and, thus, enlargement of the channel would reduce local flow velocity, depth, and/or slope, all of which would tend to reduce the local bed-material transport rate. Because such rapid adjustments have not occurred during flows comparable to the modeled flows, we concluded that the dimensionless grain shear stresses greater than about 2.0 shown in figure 40 for both 6,000 ft^3/s and 10,000 ft^3/s are physically unrealistic.

The justification for our conclusion is, perhaps, best demonstrated at the downstream end of reach 1 between station 185,000 and about 188,000. Rush Creek joins the Trinity River at this point. Since the regulation and diversion of Trinity River flows, large volumes of coarse sediment carried by Rush Creek have accumulated as a debris fan that obstructs the Trinity River. The hydraulic effect of this obstruction is shown by a relatively flat upstream water surface slope and a relatively steep water surface slope downstream from the crest of the debris fan (see figure 40). A photograph of the large Rush Creek debris fan is shown in figure 42 in the SMUD presentation . The dimensionless grain shear stress immediately downstream from the debris fan crest is about 3.5 (see figure 40). The bedload transport rate associated with such a shear stress can be estimated using the Parker-Einstein equation (Parker 1979) and a median bed

particle size of 54mm as shown in figure 36. At a discharge of 6,000 ft^3/s, the estimated bedload transport rate would be somewhat more than 25,000 ton per day. With no supply of gravel from upstream, this material would be eroded from the Rush Creek debris fan. A discharge of 6,000 ft^3/s has been recorded on 46 days at the USGS gage, Trinity River near Lewiston, since 1997. During these 46 days, more than 1.1 million tons of sediment would have eroded from the Rush Creek debris fan if the dimensionless grain shear stress shown in figure 40 were correct. Eroding such a quantity of material from the Rush Creek fan would have excavated a new channel approximately 200' wide, 10 feet below the present surface of the debris fan, and over 2 miles long. In short, the Rush Creek debris fan would have been completely removed. In fact, the 46 days of 6,000 ft^3/s have caused little, if any, erosion of the Rush Creek debris fan. SMUD figure 42, is a photograph of the Rush Creek debris fan showing mid-channel gravel bars with established mature vegetation. These gravel bars have existed for years and were not substantially eroded by the extended period of streamflows greater that 6,000 ft^3/s since 1997. SMUD figure 30, proposes that tributary debris fans in reaches 1 to 3, including the Rush Creek debris fan, be removed mechanically; an implicit acknowledgement that streamflows of 6,000 ft^3/s are insufficient to erode these debris fans. For these reasons, we believe that the sharp, local maximums of dimensionless grain shear stress shown in figure 40 are not a correct presentation of hydraulic condition in the Trinity River.

The physically unreasonable result, described above, is largely, if not wholly, a consequence of SMUD's use of the same particle size in the grain shear stress calculation for both the high velocity riffles and for the lower velocity pools. In reality, high velocity zones tend to have larger bed particle sizes than occur in the pools. Grain shear stress is inversely proportional to the particle size. The use of actual bed particle sizes in the computation of grain shear stress would result in a more realistic distribution of grain shear stresses.

Daily and annual rates of sediment transport by reach

SMUD extended their analysis, described above, and estimated the volume of sediment transport within each of the 12 reaches for each of the five flow regimes, critical dry to extremely wet, identified in the ROD and SMUD proposals. Annual sediment fluxes for the 12 reaches during a wet year are shown in figure 56. Annual sediment fluxes for the 12 reaches during an

extremely wet year are shown in figure 50. Because Lewiston Dam releases essentially clear water, the reach 1 sediment flux must be composed principally of bed-material. There would be little or no washload entrained from above or within reach 1.

The volumes of sediment shown in SMUD figures 50 and 56 for both the ROD and SMUD flows are extremely large for a river of the size and slope of the Trinity. Based on the following analysis we conclude that the volumes of sediment shown in figures 50 and 56 are incorrect, and moreover, inconsistent with SMUD's other results discussed above.

In figure 36 the critical discharge for reach 1 was shown to be 6,000 ft^3/s. Because the releases would only equal, but not exceed the critical discharge, the quantity of sediment transported by the SMUD proposed flows should be quite small. As shown in figure 56, however, the estimated volume of sediment transported through reach 1 by the SMUD proposed flows during a wet winter is approximately 600,000$(yds)^3$, almost a million tons. The volume of sediment transported through reach 1 reported in figure 56 is inconsistent with the results shown in figure 36

The daily bedload transport rates needed to move the annual volumes of sediment shown in figure 50 and 56 are also inconsistent with bedload transport rates actually measured over a range of streamflows up to 6,000 ft^3/s at two locations within reaches 1-3. Bedload transport rates have been samples in the vicinity of the USGS gage, Trinity River at Lewiston, near the upstream end of reach 1, see figure 8.7, p. 173, of the Trinity River Maintenance Flow Study Final Report dated November 1997, and at Poker Bar near the end of reach 3, (Wilcock et. al., 1996A and 1996B). Figure 8.7 showing measured transport rates for sediment larger than 8mm together with a fitted relation is included in the back of our report. Both investigations sampled the rate of bedload transport at a discharge slightly less than 6,000 ft^3/s and obtained very similar results, approximately 400 tons/day at the Lewiston gage and 330 tons/day at Poker Bar. Furthermore, Wilcock et. al. (1996A) demonstrate that the sampled bedload transport rates at Poker Bar over a range of discharges are in agreement with the Parker Bedload Function; the most widely applied equation to compute gravel transport rates. Although the ROD and SMUD

wet year hydrographs different somewhat, daily bedload transport rates in reaches 1-3 at a discharge of 6,000ft^3/s would need to be approximately 50 times greater than the measured values in order to move the annual volumes of sediment shown in figure 56.

An estimate of the quantity of sediment larger than 8mm potentially transported by the 5 hydrographs of daily mean flow releases specified in the ROD was calculated using the fitted relation (dashed curve) shown in figure 8.7. Annual bedload fluxes calculated from the measured transport rates are compared with the SMUD estimated in Table 1.

Table 1. Estimated Annual Bedload Sediment Transport in Trinity River Reach 1 in Tons/Year.

	Bedload Sampling	SMUD Model Calculations[1]
Extremely Wet	97,700	1,460,000
Wet	22,800	1,280,000
Normal	3510	Not given
Dry	212	Not given
Critically Dry	0	Not given

[1] A cubic yard of sediment was estimated to weigh 1.35 tons.

The analysis described above shows that the annual load of sediment estimated by SMUD is much larger than one would obtain using actual bedload transport rates measured in the Trinity River reach 1. The measurement of bedload transport involves significant uncertainties and only 3 measurements were used to define the relation in figure 8.7. The fitted relation, however, has the shape of a typical bedload curve and the measurements were made at discharges within the range of interest[1]. Given the available information at this time, we feel that measured bedload transport rates provide a better estimate of the quantity of bedload transported by the 5 annual hydrographs specified in the ROD. Annual bedload transport calculated by the SMUD model for the annual hydrographs are unreasonably large and inconsistent with other results reported by SMUD.

[1] A bedload transport rate of approximately 10 tons/day of material larger than 8mm was measured in the vicinity of the USGS gage at Lewiston when the river discharge was 4,000 ft^3/s. Given this measurement, we believe that the critical discharge in reach 1 is approximately 4,000 ft^3/s, similar to the critical discharge in reach 2 and 3. In either case, the bedload transport rate in the Trinity River, reach 1, is much smaller than indicated by figures 50 and 56.

Suitability of gravel augmentation

The volumes of sediment needed to augment lost spawning gravels as stated under the flow evaluation alternative in the EIS, (Table 2.9) compare favorably with the volumes of bedload predicted using bedload sampling data (Table 1). Data in Table 2, below, compare those data. Note that bedload sampling data are presented in Table 1 in terms of tons/year, and are presented in Table 2 in terms of yd^3/year.

Table 2. Estimated annual bedload transport in Trinity River Reach 1, in yd^3/yr.

	Bedload Sampling	EIS, Table 2.9
Extremely Wet	72,400	49,100
Wet	16,200	14,200
Normal	2600	2000
Dry	157	200
Critically Dry	0	0

We feel the values in Table 2 compare favorably with one another because not all sediment transported as bedload would need to be replaced artificially. Some sediment will come into the reach from tributaries and local bank erosion. Also, bedload transport will include material that is larger than that needed to develop spawning habitat. This larger material would not need to be replaced. In summary, we believe that the analysis of gravel replacement in the EIS is supported by the available bedload transport information.

Finally, the SMUD presentation argues that the EIS estimates of gravel transport during an extremely wet season would require annual augmentation rates that are not feasible. While it is true that it may be difficult to replace all gravel transported during an extremely wet year, the entire volume of gravel would not need to be replaced immediately. Extremely wet conditions are estimated in the EIS to occur about once in eight years. The gravel budget would not necessarily need to be balanced on an annual basis. A consistent rate of annual augmentation would probably be adequate to maintain the gravel-bed habitat.

Summary

We do not believe that the SMUD proposal demonstrates serious flaws in the hydrologic and geomorphic components of the ROD. This assessment is based upon review of historic streamflow records, theoretical computations of bedload transport, and available bedload data. If detrimental changes do occur in these reaches, those changes should occur over a period of time that will allow appropriate action to be taken during the adaptive management phase of the restoration plan.

We do not believe that SMUD's proposed alternative hydrographs will achieve the objectives of the Trinity River Restoration plan. Some of the bedload computations contained in SMUD's presentation appear to be flawed and local flow characteristics determined from SMUD's hydraulic model were applied incorrectly with reach-averaged bed-material sizes. Consequently, SMUD's analysis of bedload transport in Trinity River reaches 1 to 3 are unreasonably large.

Finally, the amount of gravel augmentation planned under the "Flow Evaluation" alternative of the EIS seems to be in line with the volume of sediment that would be transported out of Reach 1 under the five water-year classes.

Figures Follow

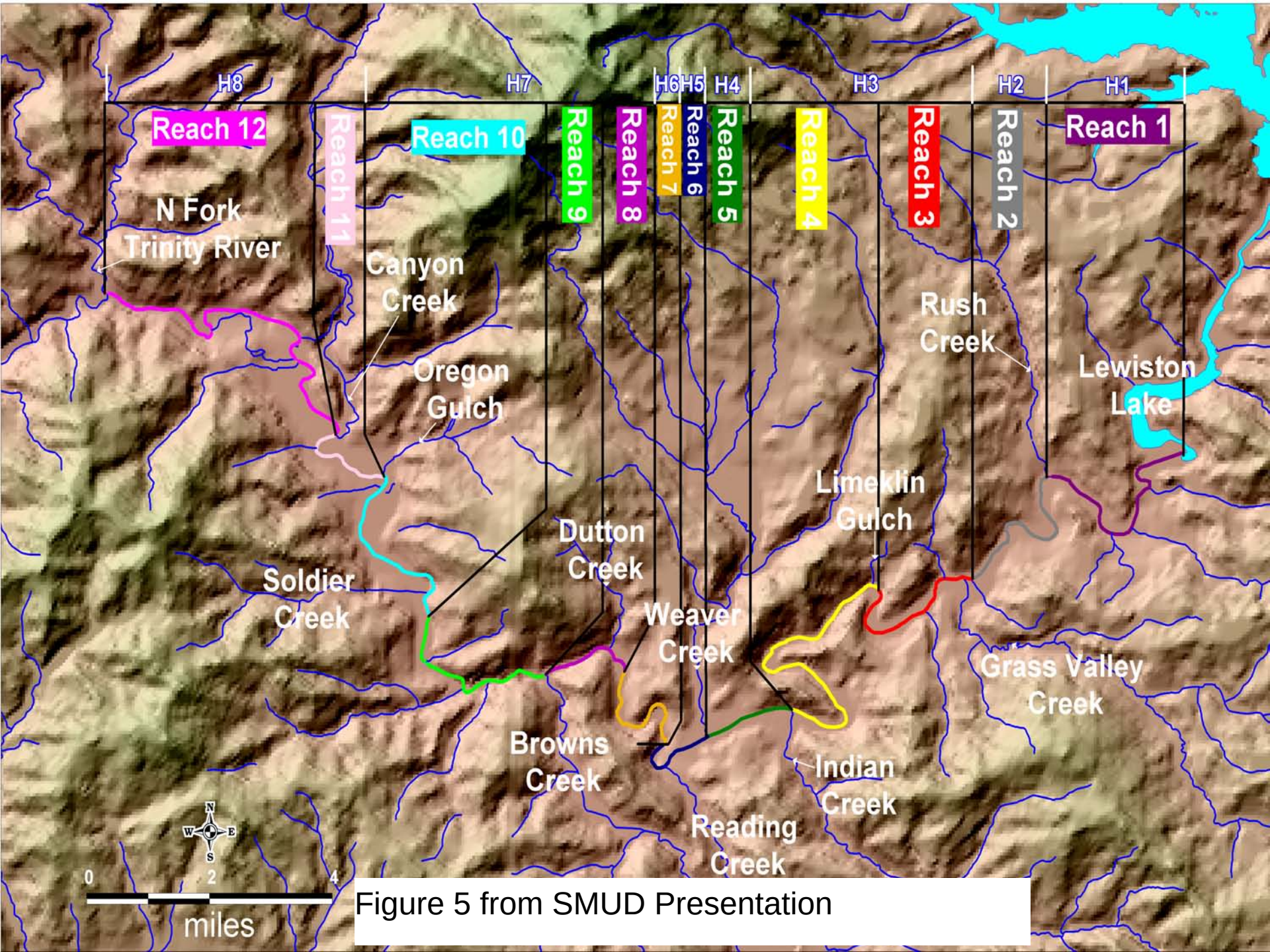

Figure 5 from SMUD Presentation

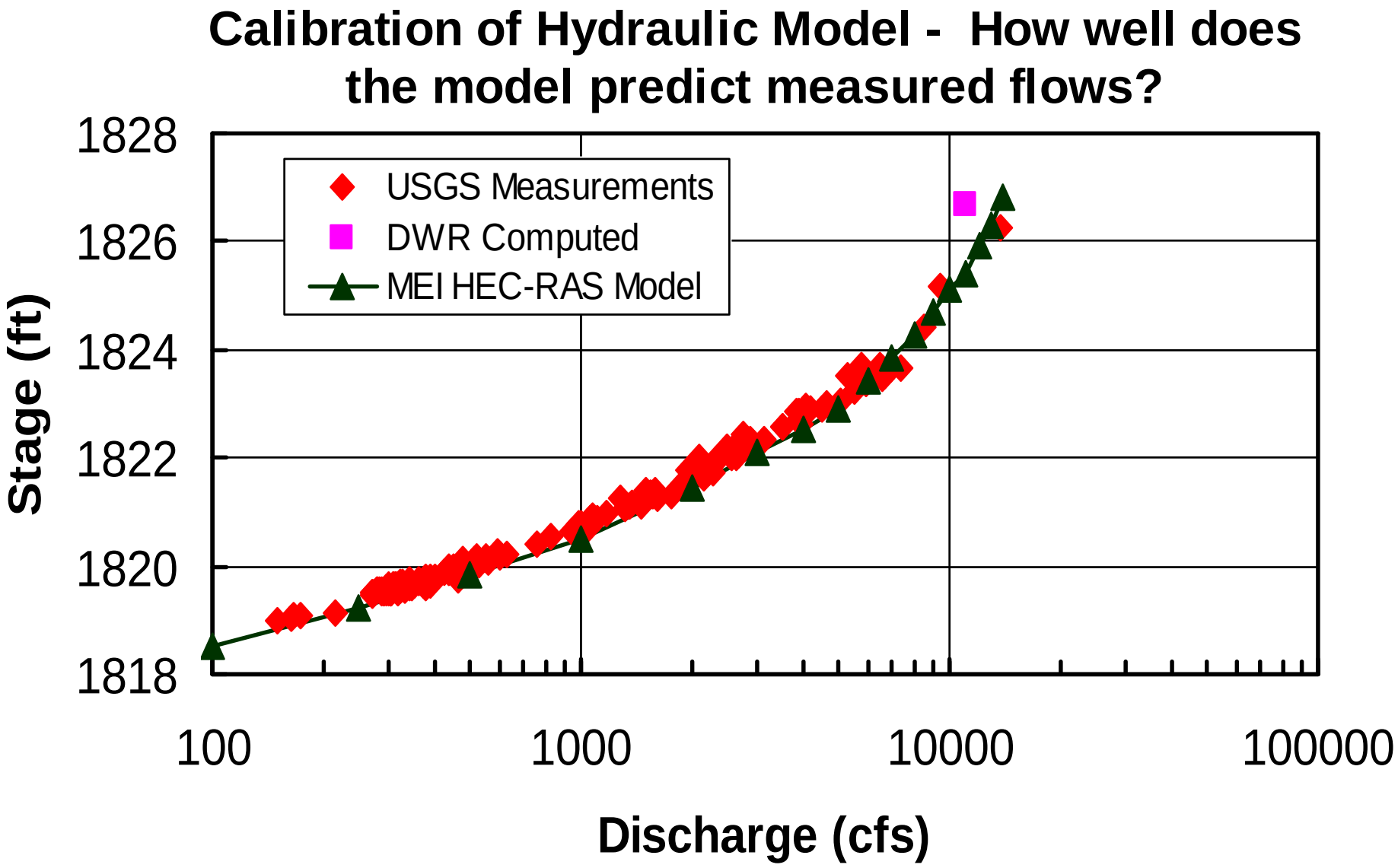

Figure 7 from SMUD Presentation

Proposed Flow Releases for a "Critically Dry" Water Year at Lewiston

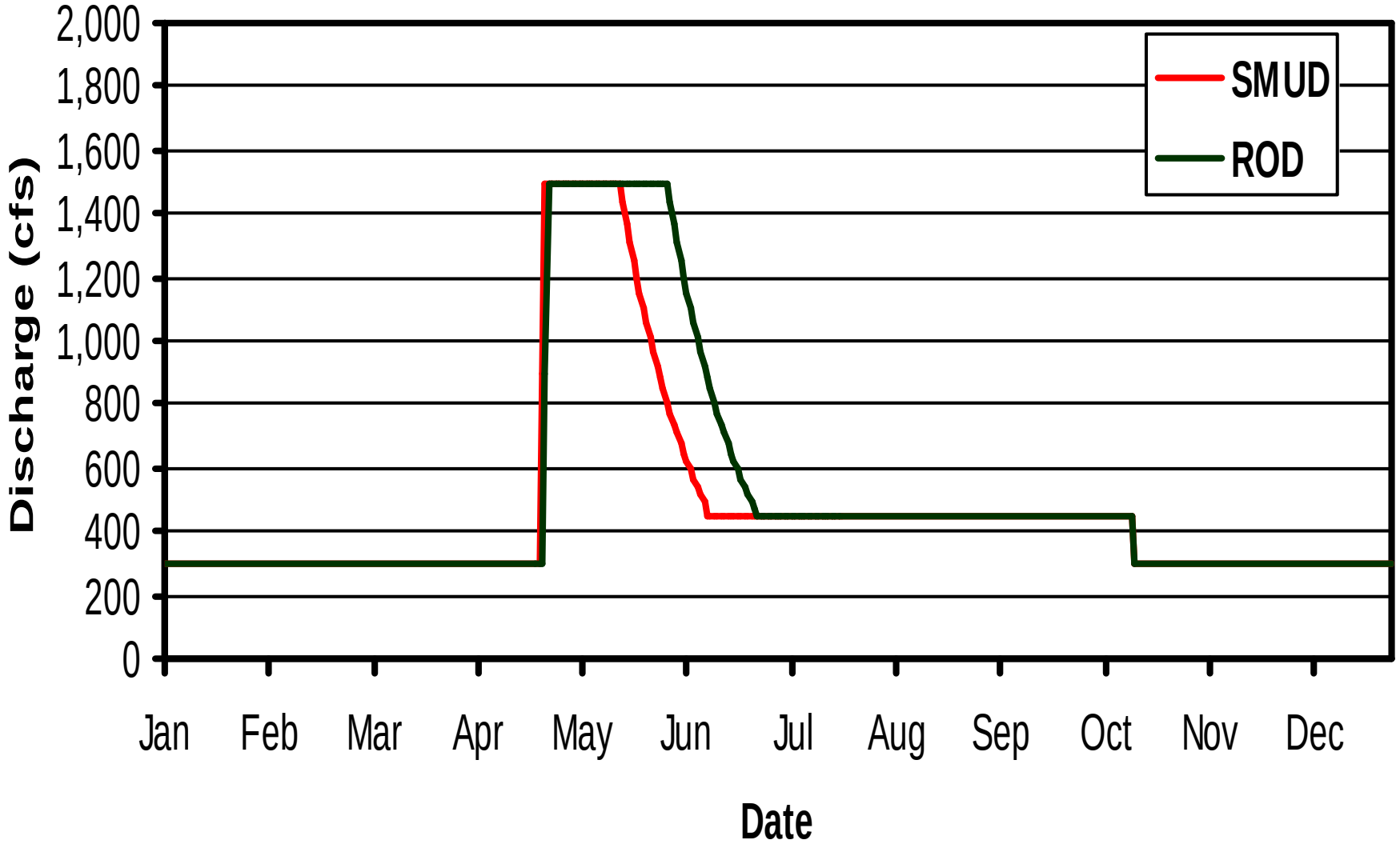

Figure 15 from SMUD Presentation

Proposed Flow Releases for a "Dry" Water Year at Lewiston

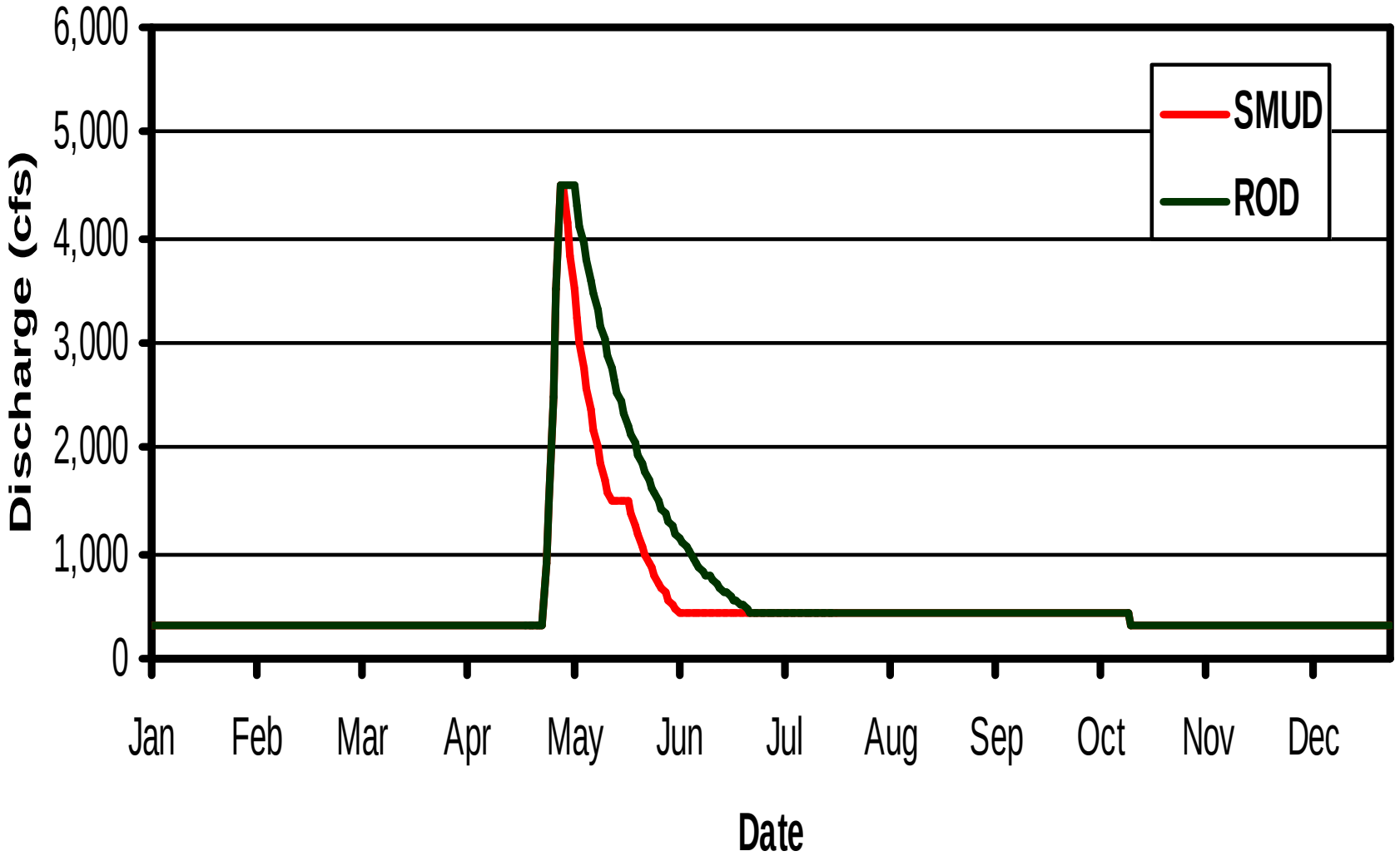

Figure 16 from SMUD Presentation

Proposed Flow Releases for a "Normal" Water Year at Lewiston

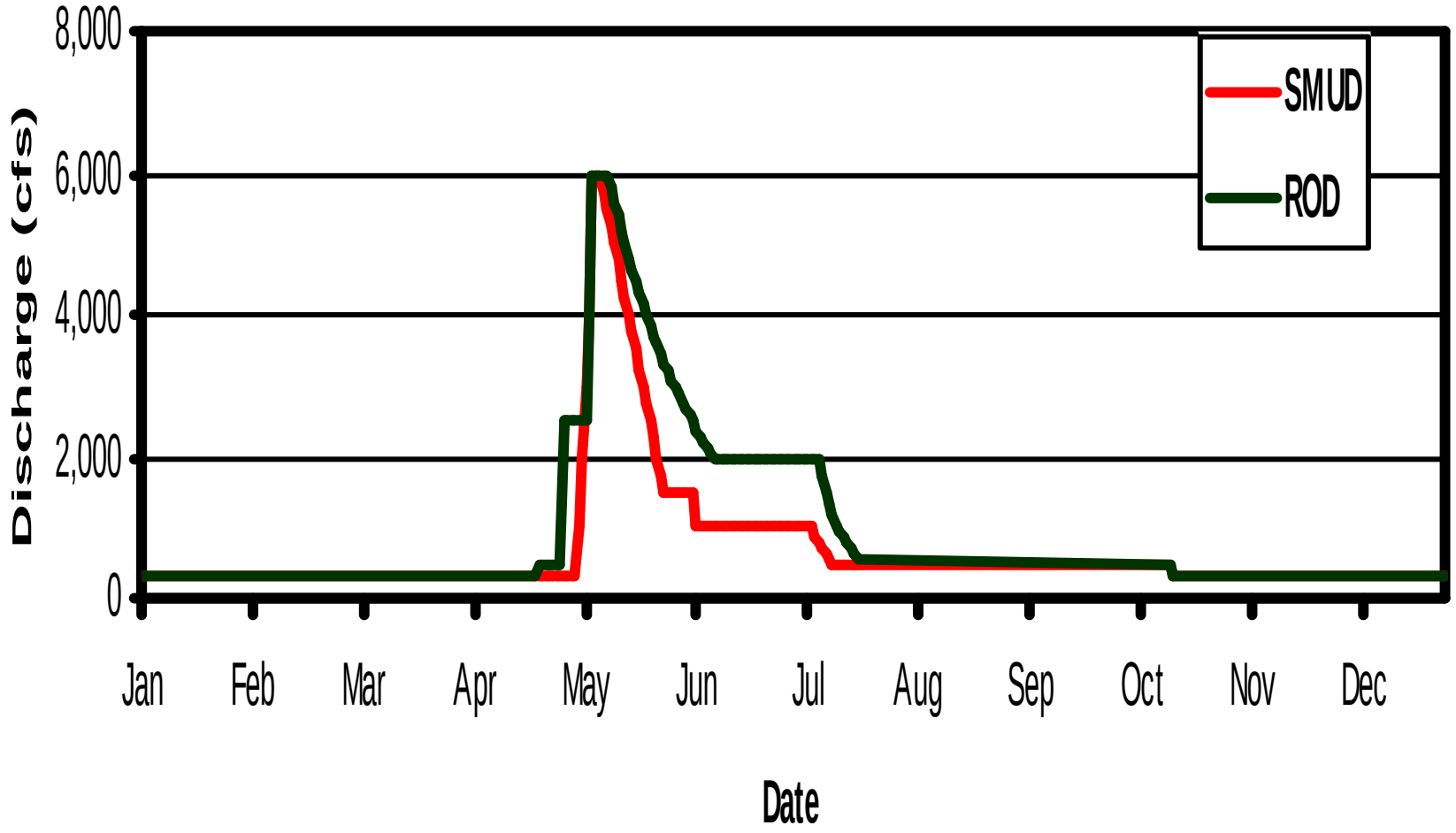

Figure 17 from SMUD Presentation

Proposed Flow Releases for a "Wet" Water Year at Lewiston

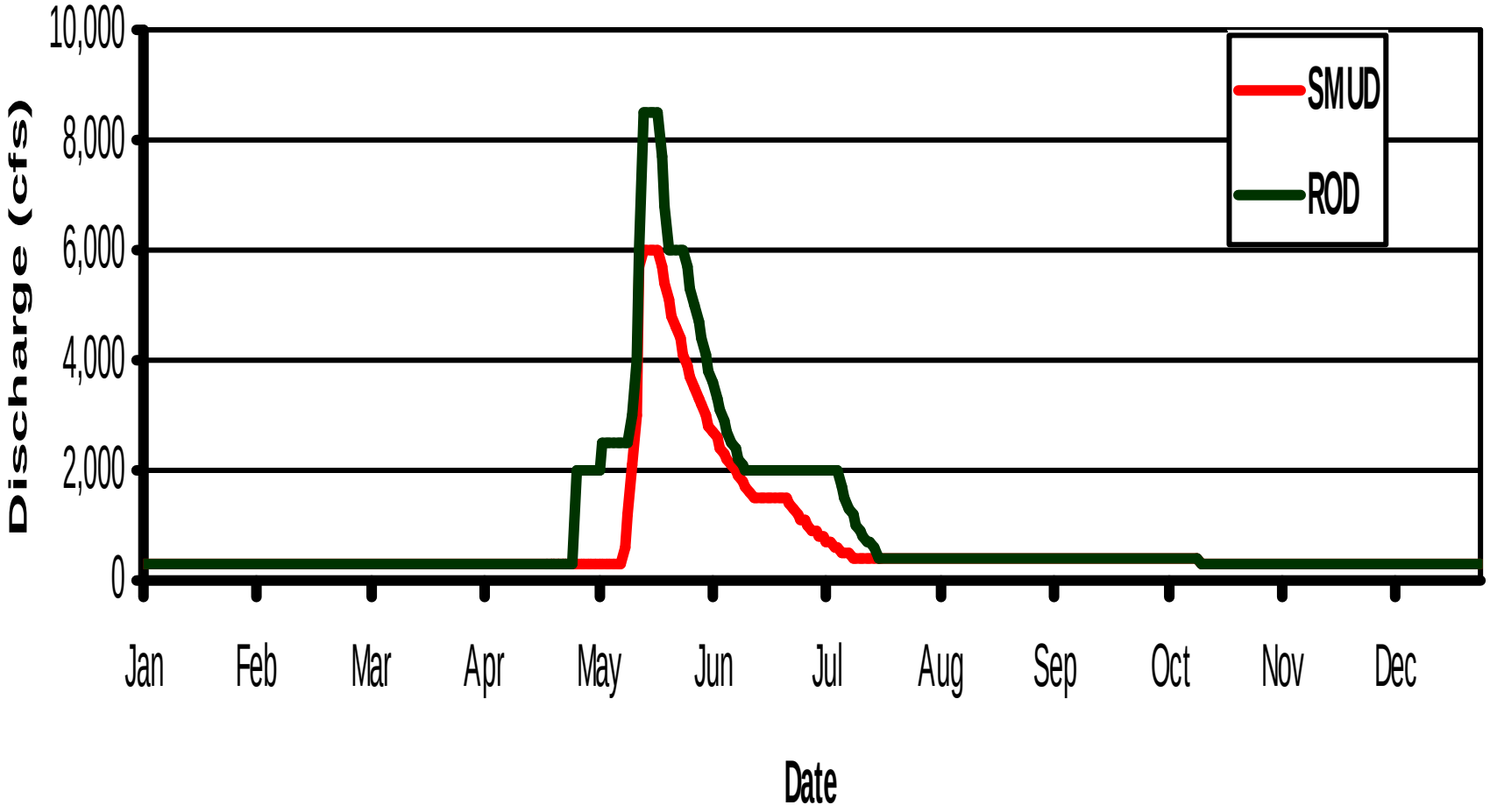

Figure 18 from SMUD Presentation

Proposed Flow Releases for an "Extremely Wet" Water Year at Lewiston

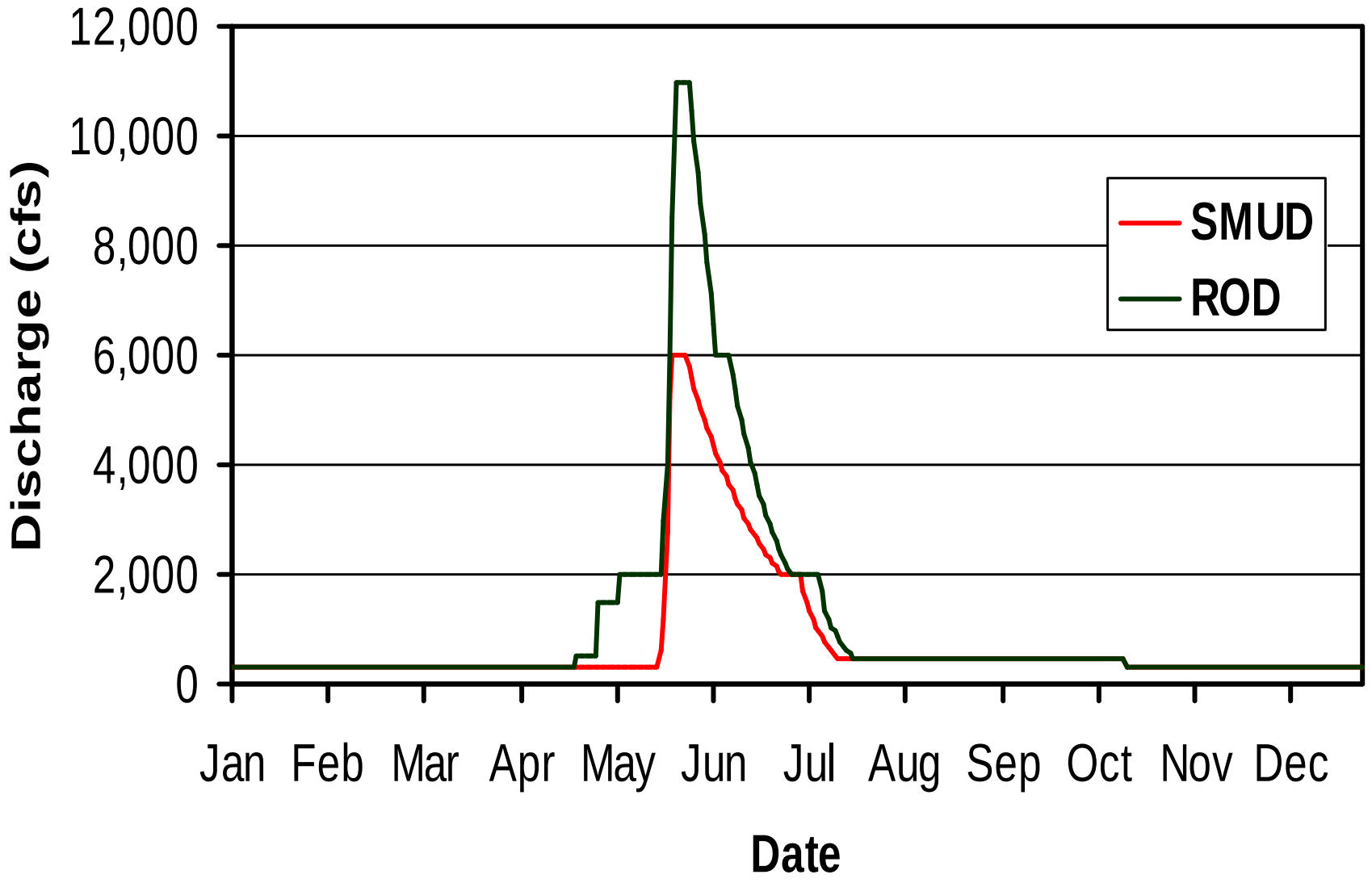

Figure 19 from SMUD Presentation

REACHES 1-3 (ALLUVIAL WITH BEDROCK CONSTRAINTS)

- Existing Condition

  - limited lateral movement
  - low gravel supply
  - high degradation potential
  - high sand supply from Grass Valley Creek and other tributaries

Preferred Upstream Habitat

  - Good spawning, lower temperatures, adult preference

- Alternative Analysis
  - Reach vulnerable to scour of limited gravels by ROD flows
  - Problems with ROD proposed gravel augmentation – source, volume, transport

SMUD Proposes
- Reduced flows
- Mechanical removal of tributary mouth bars – screen and return gravels without sand
- Pool dredging to remove sand
- Additional tributary sediment retention structures

Figure 30 from SMUD Presentation

Reach Averaged Critical Discharge

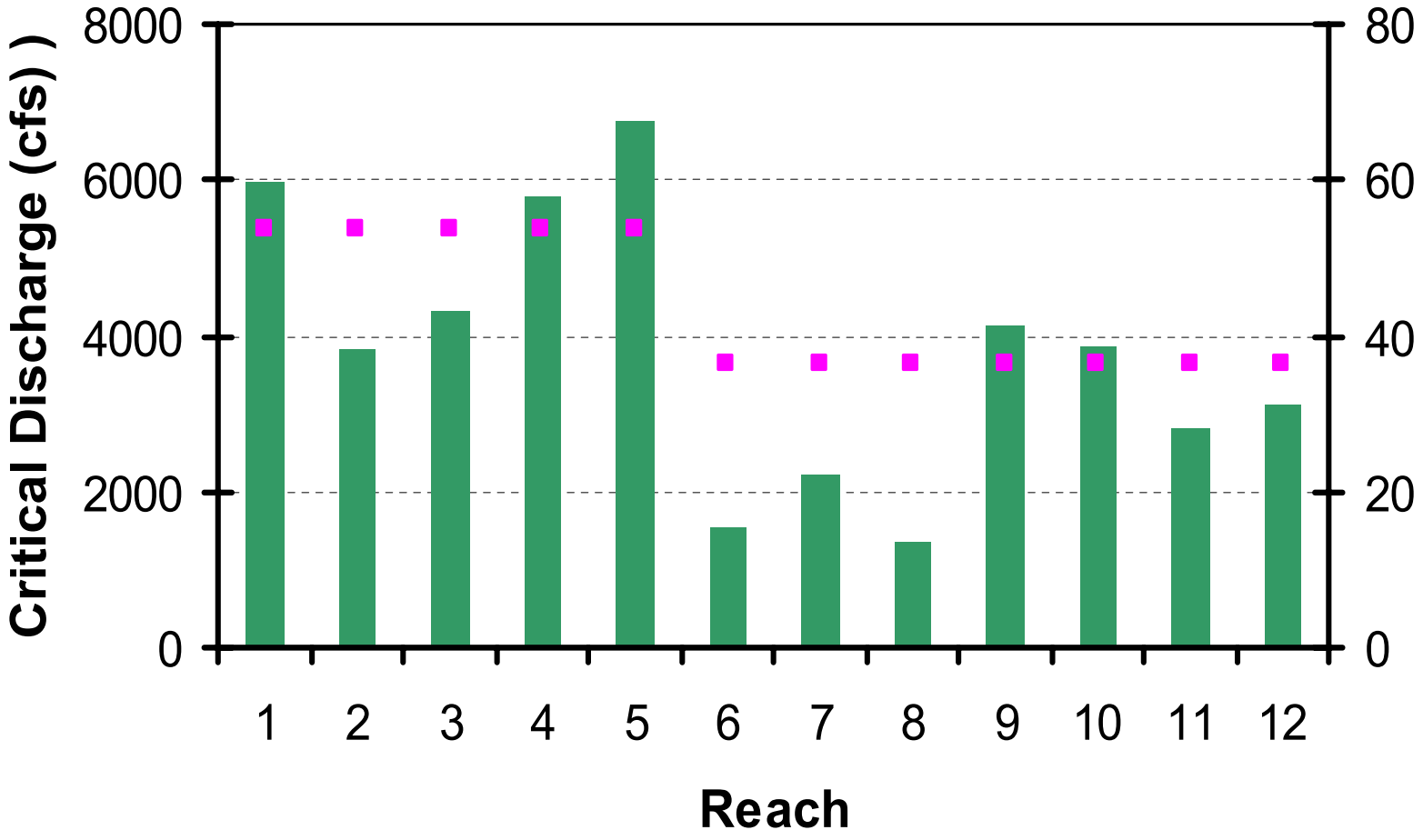

Figure 36 from SMUD Presentation

Reach 1 Critical Shear Stress

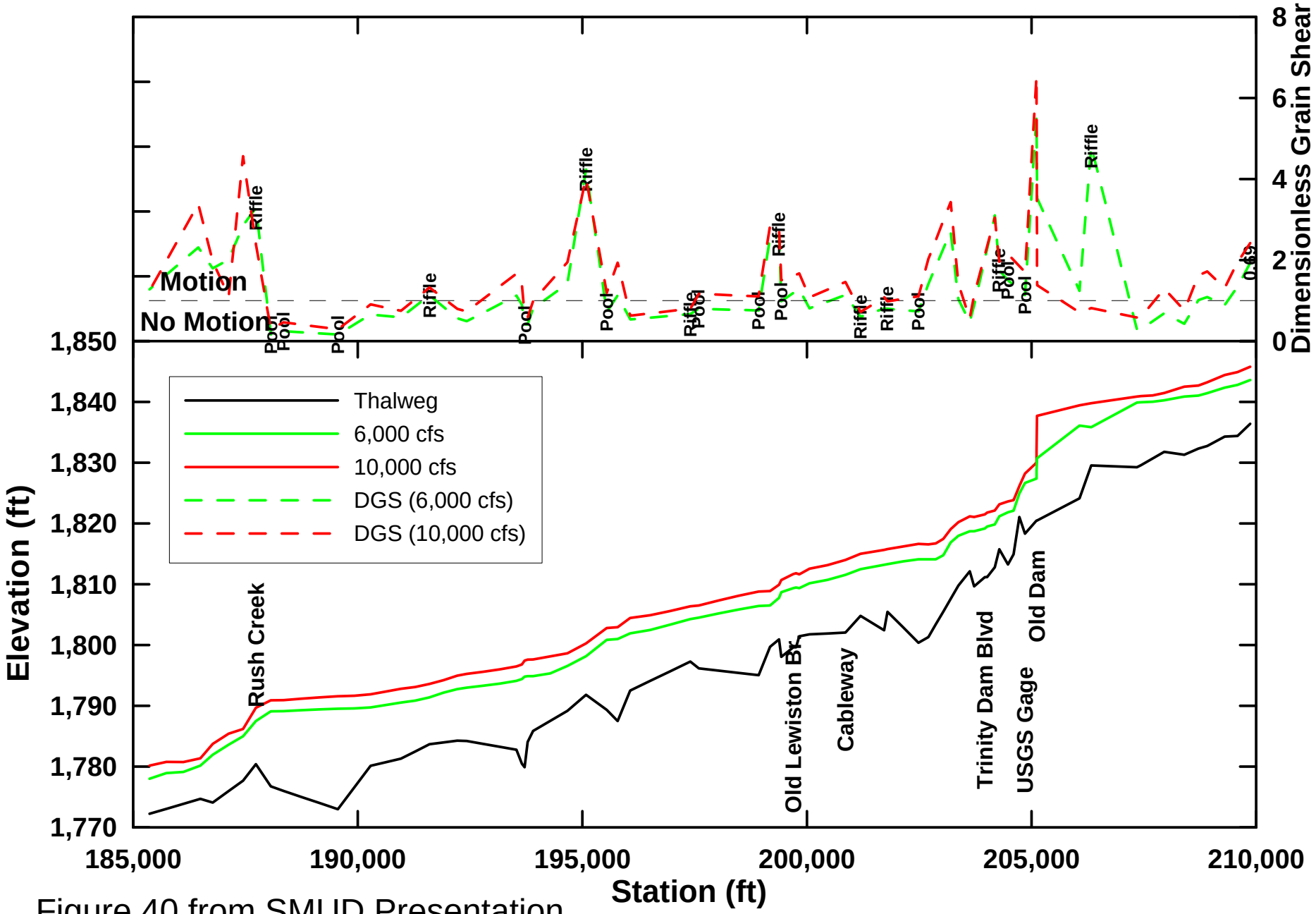

Figure 40 from SMUD Presentation

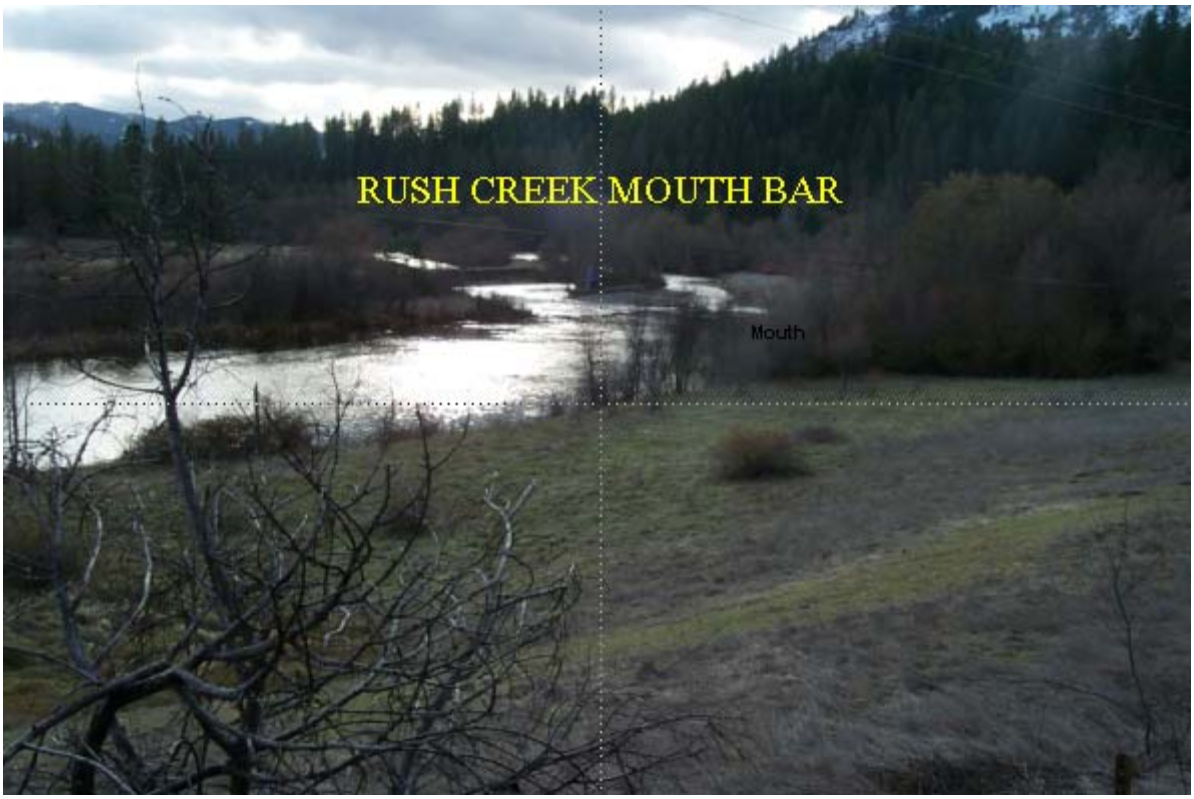

Figure 42 from SMUD Presentation

Sediment Transport Capacity

Extremely Wet Water Year

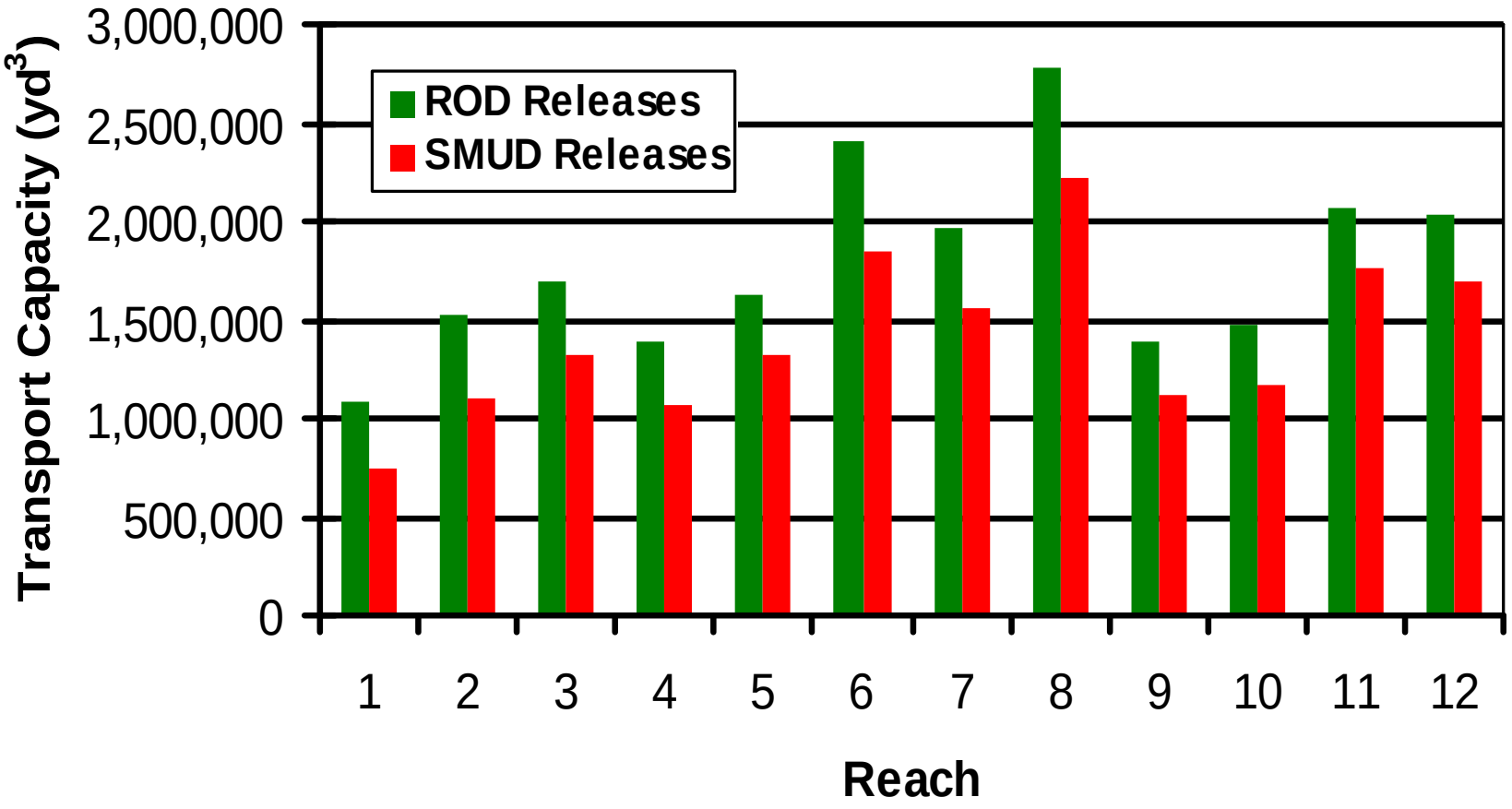

Figure 50 from SMUD Presentation

Sediment Transport Capacity

Wet Water Year

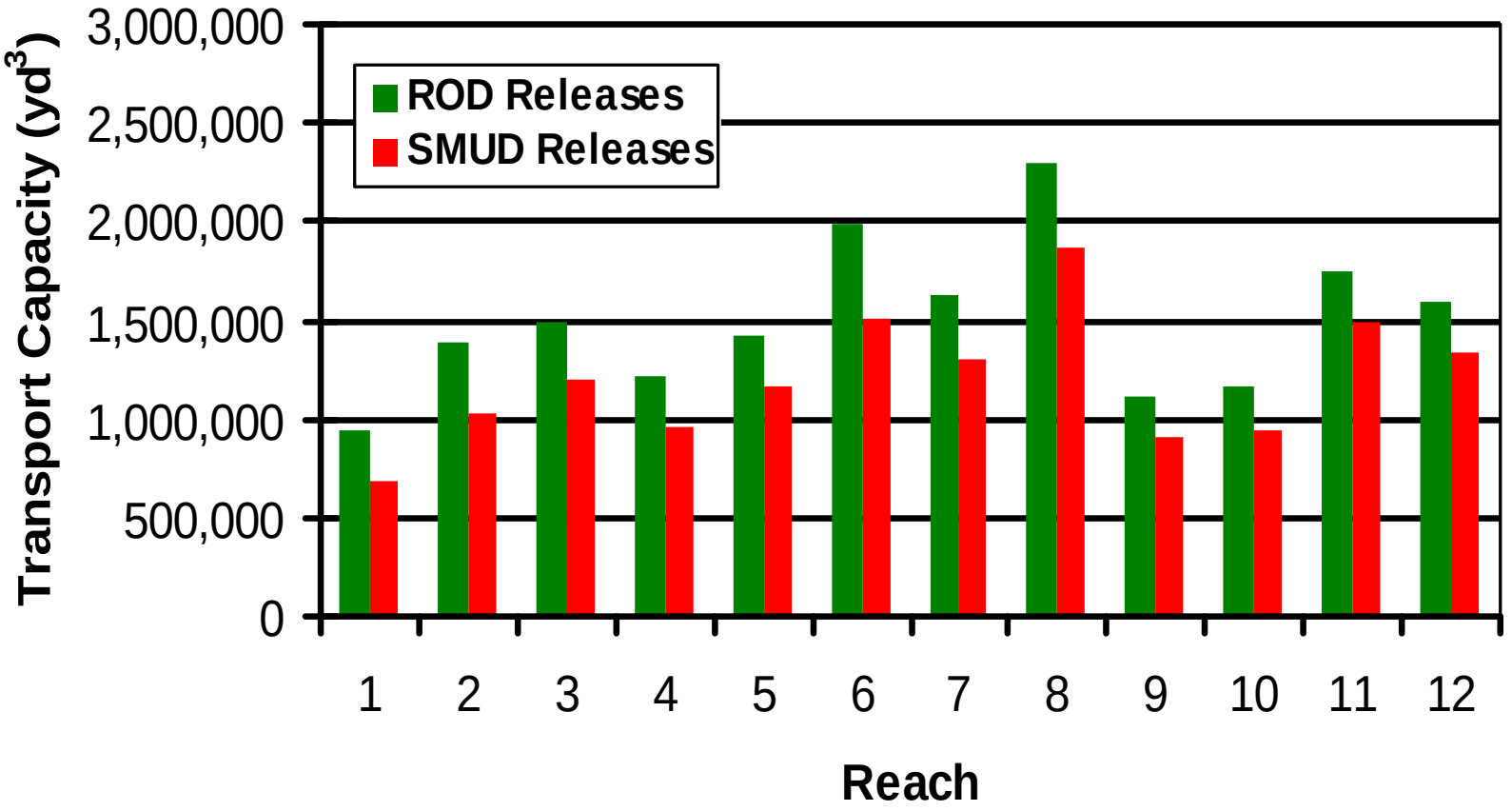

Figure 56 from SMUD Presentation

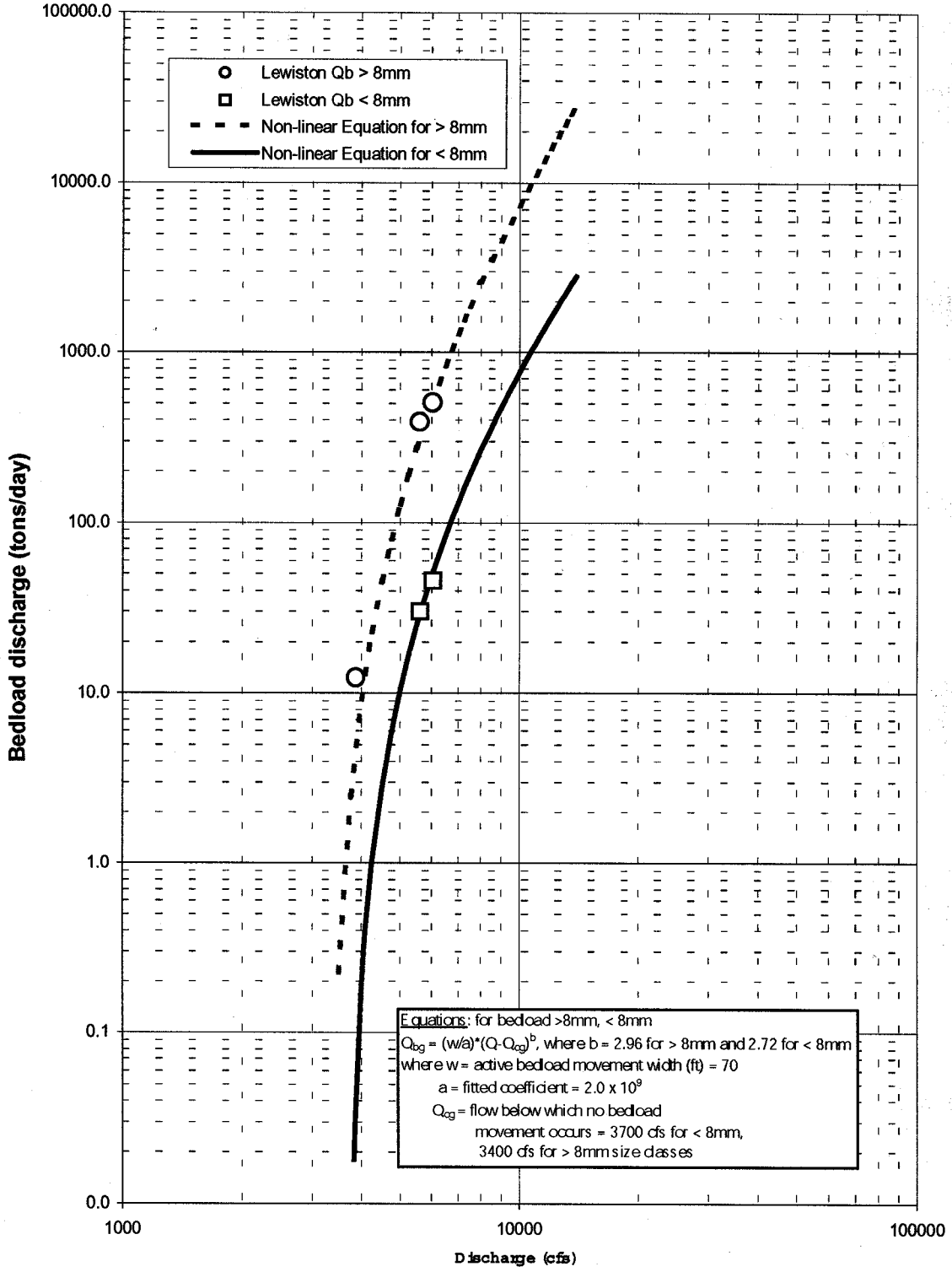

Figure 8.7 Trinity River at Lewiston mainstem bedload transport for > 8mm and < 8mm size classes.

Figure 8.7 from McBain and Trush, 1997

Watershed and Tributary Component of the Flow Evaluation Alternative for the Trinity River Mainstem Fishery Restoration Supplemental EIS/EIR Technical Appendix E

WATERSHED AND TRIBUTARY COMPONENT OF THE FLOW EVALUATION ALTERNATIVE FOR THE TRINITY RIVER MAINSTEM FISHERY RESTORATION SUPPLEMENTAL EIS/EIR (SEIS/EIR)

Summary:
The purpose of the Watershed and Tributary Component is to integrate non-flow measures, such as watershed and tributary restoration, into the Supplemental Environmental Impact Statement/Report for Trinity River Mainstem Fishery Restoration (SEIS/EIR). This component aims to minimize impacts on all other Central Valley Project (CVP) interests, while achieving the statutory goals of Trinity River fishery and basin restoration. The activities described herein are intended to function as a component of the Flow Evaluation alternative addressing the restoration of the Trinity River's fisheries resources.

According to U.S. Environmental Protection Agency's (USEPA) Trinity River Total Maximum Daily Load (TMDL) documentation, a complex restoration program has been implemented on the Trinity River since the late 1970's. *See* "Trinity River Total Maximum Daily Load for Sediment" (USEPA 2001). There is little doubt that the Trinity River Restoration Program and other related efforts have had a beneficial effect on habitat in the river through a combination of watershed restoration, fish passage improvement, sediment detention, riparian improvements, water conservation, land acquisition, increased flows from Lewiston Dam, and mainstem habitat enhancement through pool dredging, side channel construction, and feather edge construction.

Watershed and tributary restoration activities within the basin continue to be implemented by the Trinity River Restoration Program partnering agencies and will continue under each alternative identified in the SEIS/EIR. The majority of projects documented to date include upslope restoration and instream habitat improvement projects within the Upper Middle Trinity and South Fork Trinity Watersheds. The current rate of project implementation is limited due to lack of funding, available staffing and infrastructure, landowner cooperation and other issues. In order to maximize potential benefit from watershed and tributary restoration projects in the Trinity Basin, priority watersheds and restoration types must be identified and re-focused. This component includes the following recommendations:

- Upslope Watershed Restoration Projects are a high priority restoration type. The Upper Middle Reach of the Trinity Watershed (Lewiston Dam to Brown's Creek) is the highest priority in terms of sediment source reduction.
- Emphasis on sediment control should be transferred to the Indian Creek watershed, as it is capable of producing over three times the sediment that the mainstem can transport. Upslope restoration should also be focused in the Browns Creek, Rush Creek, and Weaver Creek watersheds and more generally, on tributaries throughout the Upper Middle Watershed area such as Reading Creek, Hoadley Gulch and Deadwood Creek.

- Prioritization of roads sediment reduction, rehabilitation, and decommissioning projects should be deferred to the implementing agencies that have conducted a systematic road sediment source inventory and/or analysis.
- In the South Fork Trinity River, the Natural Resource Conservation Service (NRCS), the Trinity County Resource Conservation District (TCRCD), and US Forest Service should continue to work towards the 30% reduction of sediment input as recommended in the US EPA's South Fork Trinity River TMDL. Adherence to the Watershed Component of the Trinity ROD should assist in the delegation and prioritization of watersheds and projects to these entities and their current work plans as well as the TMDL implementation plans.
- Fish Passage Improvement Projects are a high priority restoration type throughout the Trinity River Basin, including the South Fork and other tributaries. Fish Passage improvement projects can provide measurable benefits in the restoration of salmon and steelhead populations in the tributaries of the Trinity River Basin. The Implementation Plan for the Trinity River ROD calls for a four fold increase in habitat in the mainstem Trinity River. Current efforts should are focused on those projects which will provide easily accessible habitat from the upper middle mainstem Trinity River (e.g., Soldier Creek, Oregon Gulch, Deadwood Creek).
- Due to limiting factors such as inadequate funding, landowner cooperation, limited staffing, permitting, and low cost-efficiency, the current rate of restoration project implementation for many of the water conservation, land acquisition, instream improvement, and riparian improvement project types cannot be significantly accelerated under existing conditions.
- Projects should be coordinated on a basin-wide scale through the Trinity River Watershed Coordination Effort by TCRCD.
- Upslope sediment reduction and increased instream flows appear to complement each other, but one cannot be traded for the other. The ROD flows are intended to achieve several attributes of a healthy alluvial river system that sediment allocations through the TMDL cannot achieve alone.

Background and Status:
The Final Environmental Impact Study/Report (FEIS/EIR) for The Trinity River Mainstem Fishery Restoration was released in October 2000 by the U.S. Bureau of Reclamation (USBR), U.S. Fish and Wildlife Service (USFWS), and the Hoopa Valley Tribe (HVT), as lead agencies under NEPA, and Trinity County (TC), as the lead agency under the California Environmental Quality Act (CEQA). Former Interior Secretary Bruce Babbitt and former Hoopa Valley Tribal Chairman Duane Sherman signed the Record of Decision (ROD) for that document on December 19, 2000. These two documents were the result of nearly 20 years of studies of the Trinity River and its fisheries.

The ROD mandated that the agencies of the Department of Interior (Department) implement the Preferred Alternative and the "reasonable and prudent" measures described in the Biological Opinions (BOs) by the National Marine Fisheries Service (now NOAA Fisheries) and the USFWS. The Preferred Alternative identified in the ROD incorporates the recommendations developed in the Trinity River Flow Evaluation

Report and evaluated under the Flow Evaluation Alternative, as well as additional watershed protection efforts identified in the Mechanical Restoration Alternative of the EIS/EIR.

Immediately following the Interior Secretary's ROD, the Westlands Water District and the San Luis and Delta-Mendota Water Authority filed suit against the federal government in the Eastern Federal District Court in Fresno, on the grounds that the FEIS/EIR did not fully analyze an adequate range of project alternatives, effects on endangered species or potential impacts to water and power users in the Central Valley. Shortly thereafter, the Sacramento Municipal Utilities District and the Northern California Power Agency intervened in the case in support of the plaintiffs.

In several rulings issued between March 2001 (preliminary injunction) and March 2003 (final judgment), Federal District Court Judge Oliver Wanger concluded that the EIS was inadequate in several areas, notably in its stated purpose, the range of alternatives considered, analysis of power supply in light of the California energy crisis of late 2000 and early 2001, and failure to prepare a supplemental EIS to disclose the impacts of reasonable and prudent measures recommended by NMFS and USFWS in their respective BOs, which had been issued after completion of the draft EIS. In December 2002, the court issued an injunction against the implementation of higher flow releases, ruling that a Supplemental EIS be completed in order to address the deficiencies identified with the original EIS. He ordered that the NMFS and USFWS Biological Opinion Reasonable and Prudent Measures be described and evaluated in that draft SEIS. He limited fishery flow releases to 369,000 AF in critically dry years and 453,000 AF in dry, normal, wet and extremely wet years. All non-flow related activities under the ROD were directed to proceed, including mechanical rehabilitation, floodplain infrastructure improvement, gravel placement, watershed restoration, the establishment of the Trinity Management Council and an Adaptive Environmental Management Program.

The activities described herein are directly linked to the district court's conclusion that the EIS process should have considered an alternative that integrates flow with non-flow measures (such as watershed and tributary restoration) and seeks to minimize impacts on all other Central Valley Project (CVP) interests, while achieving the statutory goals of basinwide Trinity River fishery restoration. The court concluded that the lead agencies and the EIS management team intentionally narrowed the scope of the alternatives to "ecological" and "flow-driven" objectives. It stated that the lead agencies avoided addressing, and foreclosed public participation regarding, any alternative that sought to utilize non-flow measures to meet the Congressionally-mandated Fishery Restoration Goals of the Trinity River Restoration Act of 1984 (Public Law 98-541). The court concluded that the document did not adequately consider whether an integrated management alternative would minimize the overall effect on CVP water and power users and listed species in the Central Valley and the Delta.

Per the district court's order, the activities described herein are intended to function as a component of a larger alternative addressing the restoration of the Trinity River mainstem. The component is also directly linked to the fishery restoration goals of the

Trinity River Basin Fish and Wildlife Management Act of 1984 (P.L. 98-541), which authorized the Secretary of the Interior to formulate and implement a management program to restore the fish and wildlife populations in the Trinity River Basin to levels that existed prior to the construction of the Trinity River Division of the Central Valley Project. To that end, the Secretary was then authorized to take appropriate actions to ensure the preservation and propagation of such fish and wildlife.

Purpose:
The development of a Watershed and Tributary Restoration component will better integrate watershed restoration and "non-flow measures" into the overall approach to the restoration of the Trinity River as mandated in the district court's December 9, 2002, Memorandum Decision and Order. Per that order, implementation of a watershed and tributary component will also help to further meet the Congressionally mandated fishery restoration goals of P.L. 98-541 as follows:

1. Improve the capability of the Trinity River Hatchery to mitigate for salmon and steelhead fishery losses that have occurred above Lewiston Dam;

2. Restore natural (fish spawning in river/stream gravels) salmon and steelhead production in the mainstem and tributaries below Lewiston Dam to pre-dam levels;

3. Contribute to fish harvest management;

4. Compensate for deer and other wildlife losses from flooding of habitat and reduced stream flows as a result of trans-basin water diversions to the Central Valley Project; and

5. Develop and implement land management activities to stabilize watersheds and reduce sediment yield to streams.

Data collection and analysis were conducted in order to establish the current status of watershed and tributary restoration within the basin, to help identify further information needs and priorities, to estimate the costs of increased watershed restoration efforts, and to determine how further watershed and tributary restoration may fit into the current framework of restoration in coordination with higher flow releases from Lewiston Dam.

The Watershed and Tributary Restoration Component may be incorporated into the analysis of one or more of the seven alternatives in the SEISEIR.

Geographic Scope
The Watershed and Tributary Restoration Component includes the Trinity River watershed and tributaries downstream of Lewiston and Trinity Dams, including all Trinity River tributaries such as North Fork, South Fork, New River, etc. It also includes the watershed boundary of the lower Klamath River below its confluence with the Trinity River to the Pacific Ocean for watershed restoration/fine sediment reduction efforts only (See Section 2(a)(1)(A), P.L. 98-541). Watershed restoration efforts to reduce fine

sediment input into the lower Klamath River can improve habitat conditions for migrating Trinity River fish. However, improvement of fish habitat in Lower Klamath River tributaries such as Blue Creek would not improve the production of Trinity River fish, would therefore be inconsistent with the Trinity River fishery restoration goals of P.L. 98-541, and is therefore not considered in this analysis.

Methodology

In order to determine the role of watershed and tributary restoration in the basin, the Tributary/Watershed Alternative Analysis Team categorized restoration projects within the basin into 6 different "restoration types." A restoration type is a conservation treatment or series of conservation treatments aimed at enhancing the natural function of a specific geographic location. In the Trinity River Basin, "restoration types" were categorized into Upslope Watershed Restoration, Instream Habitat Improvement, Riparian Habitat Improvement, Fish Passage Improvement, Water Conservation: Improving Water Supply (Quantity/Quality), and Land Conservation. Restoration project types were then linked to the restoration objectives of the Trinity River Restoration Program, the December 2000 Trinity River Record of Decision, and P.L. 98-541.

The team compiled a database of restoration projects implemented between 1984 (the year the Trinity River Basin Fish and Wildlife Act was signed) and 2000. Project information was obtained from the Bureau of Land Management (BLM), Bureau of Reclamation (BOR), California Conservation Corps, California (CCC), California Department of Fish and Game (CDF&G), Trinity County, California Department of Water Resources (DWR), Five Counties Salmonid Conservation Program (5C), Hoopa Valley Tribe (HVT), North Coast Fisheries Restoration, Trinity Fisheries Improvement Association, Trinity County Resource Conservation District (TCRCD), River Consulting, USDA Forest Service, Lower Trinity Ranger District, Shasta Trinity National Forest, Big Bar Ranger District, Hayfork Ranger District, Shasta Trinity Division, Weaverville Ranger District, Yolla Bolly Ranger District, Six Rivers National Forest, Willow Creek Community Services District, and the Yurok Tribe Watershed Restoration Department/Lower Klamath River Partnership.

Information collected includes each project's implementing agency, watershed, location, land ownership, funding source, contractor, start and end dates, status of completion, average cost, restoration type, specific restoration activity, and cost. When available, appropriate project details were also collected, such as cubic yards of sediment saved, number of stream crossings removed, miles of road decommissioned, miles of instream habitat improved, miles of upslope habitat improved, fish species affected, and materials used. The project team also identified projects currently planned in the basin by different agencies.

In order to identify priorities and further analyze completed projects, the Trinity River watershed was subdivided into 5 planning watersheds, consistent with the Trinity River Total Maximum Daily Load (TMDL). The planning watersheds include the Upper Trinity River, Upper Middle Trinity River, Lower Middle Trinity River, the Lower

Trinity River and the South Fork Trinity River. The five planning watersheds follow the California Watershed Assessment Area (CALWAA) divisions.

Watershed and Tributary Restoration:
In 1994, both the South Fork Trinity River and the Mainstem Trinity River were listed under the Clean Water Act (CWA) Section 303(d) as water quality impaired due to sediment. Sediment levels are currently in excess of the Water Quality Standards (WQS) necessary to protect the beneficial uses of the basin – particularly the cold-water fishery.

According to U.S. Environmental Protection Agency's (USEPA) Trinity River TMDL documentation, a complex restoration program has been implemented on the Trinity River since the late 1970's. *See* "Trinity River Total Maximum Daily Load for Sediment" (USEPA 2001). There is little doubt, based on anecdotal descriptions of the river in that time period, that the Trinity River Restoration Program and other related efforts (such as CDF&G's Fishery Restoration Grants Program) have had a beneficial effect on habitat in the river through a combination of watershed restoration, fish passage improvement, sediment detention, riparian improvements, water conservation, land acquisition, increased flows from Lewiston Dam, and mainstem habitat enhancement through pool dredging, side channel construction, and feather edge construction.

A total of 476 projects were compiled into the database under the six restoration types of upslope restoration, instream habitat improvement, riparian improvement, fish passage improvement, water conservation, and land conservation. The majority of projects documented to date are upslope restoration and instream habitat improvement projects. Most work was completed in the Upper Middle Trinity and South Fork Trinity Watersheds as follows:

Restoration Type	Projects Documented
Upslope Restoration	164
Instream Habitat Improvement	179
Riparian Improvement	49
Fish Passage Improvement	69
Water Conservation	5
Land Conservation	1
Unknown	9

RESTORATION TYPES

Upslope Watershed Restoration
It has been recognized that upslope sediment management and land treatment are integral components in meeting the stated mandate of the 19 December, 2000 Record of Decision (ROD), the goals and objectives of the Trinity River Restoration Program (TRRP), P.L. 98-541 and the Trinity River TMDL for controlling fine sediment. According to the FEIS/EIR, this type of work is identified as critical in restoring salmon and steelhead habitat as part of the ROD on the President's Forest Plan (Final Supplemental EIS on

Management of Habitat for Late-Successional and Old-Growth Forest Related Species Within the Range of the Northern Spotted Owl: U.S. Department of Agriculture and U.S. Department of the Interior, 1994).

Significantly reduced streamflows, combined with accelerated erosion in various sub-watersheds primarily related to land use changes, have resulted in sediment accumulation in the mainstem and South Fork channels. These accumulations have filled pools, covered spawning riffles and over-wintering areas, and impacted rearing areas, thereby greatly reducing salmonid habitat.

The effect of upslope sediment reduction projects and the need for additional releases from Lewiston and Trinity reservoirs into the Trinity River is described on page 65 of the "Trinity River TMDL for Sediment" (U.S. E.P.A, 2001) as follows:

> "*In order for the TMDL to be fully effective in protecting beneficial uses and attaining water quality standards, the ROD flows and restoration program must be implemented.* ***The ROD flows are intended to achieve several attributes of a healthy alluvial river system that sediment allocations through the TMDL cannot achieve alone.*** *For example, the ROD flows include inter- and intraannual flow variations that mimic the natural snowmelt period. These peak flows are critical to support several river functions including the mobilization of channelbed particles, scour pools, create point bars and connect the mainstem to the floodplain. Such conditions are necessary to support habitat elements for spawning, rearing and migration of salmonids. The TMDL sediment allocations will be more effective in supporting beneficial uses if implemented in consort with the ROD flows.* ***Similarly, the ROD flows will be more effective in achieving the river health goals when the TMDL load allocations are implemented****."* (Emphasis added)

No other data or information exists to contradict the above statement from USEPA's Trinity River TMDL. Thus, it cannot be determined if upslope sediment reduction projects will result in decreased demands for instream flow releases from Trinity River Division reservoirs. To the contrary, it appears that upslope sediment reduction and increased instream flows appear to complement each other, and one cannot be traded for the other. It was that rationale which resulted in the inclusion of the Watershed Component of the Mechanical Restoration Alternative in the Preferred Alternative for the December 2000 Trinity ROD approved by the Interior Secretary and the Hoopa Valley Tribe.

Findings and Prioritizations:

The Upper Middle Reach of the Trinity Watershed (Lewiston Dam to Brown's Creek) was identified as the highest priority in terms of sediment source reduction in the Trinity River TMDL (U.S. E.P.A. 2001). The condition of aquatic habitat in the Upper Middle Reach was identified as being of particular importance for two reasons: (1) biologically, it is utilized more extensively for anadromous fish spawning and rearing than are other basins reaches, and (2) the tributaries and mainstem of this basin have been subjected to a high level of habitat modification, due to the Central Valley Project (CVP) Trinity River Diversion, land management in the watersheds and tributaries, and natural slope

processes. The "Water Quality Control Plan for the North Coast Region" (North Coast Regional Water Quality Control Board) has long identified "flow depletion" from CVP Trinity River diversions as a source of sedimentation in the mainstem Trinity River.

Instream impairment factors relating to sediment reduction and upslope restoration activities within the upper half of the Middle Reach are:

1. Limited Sediment Mobilization Below Lewiston Dam: The mainstem channel bed, since the completion of the CVP Trinity River Diversion, has not been adequately mobilized, increasing sediment accumulation at the deltas of tributaries and resulting in loss-of-habitat characteristics associated with alternate bar sequence. The gravels delivered by the mainstem tributaries below the dam have also not been effectively mobilized or dispersed due to inadequate flood flows and fossilized riparian berms.

2. Reduced Main Stem Pool Depth: After access to the upper basin was eliminated due to dam construction, spring chinook, which formerly migrated upstream of Lewiston Dam, had to "summer-over" in any available deep pools below the dams until spawning began in fall. Fine sediment has reduced the mainstem pool depths, affecting the amount of deep pool habitat important for adult salmonids holding over in the summer. Since many of these pools were historically occupied by summer-run steelhead, chinook were forced to compete for pool habitat below the dam.

3. Excessive Levels of Fine Sediment: The reduction of dam controlled scouring flows in the mainstem has contributed to fine sediment infiltration into spawning gravels. This impact is greatest just below the confluence of Grass Valley Creek. Deposition of sediment on exposed cobble bars and lack of flushing flows has created "fossilized" berms or sediment accumulation around riparian vegetation. This contributes to loss of open, shallow, low-velocity gravel bar habitats for rearing salmonid fry.

The Trinity River TMDL identified Grass Valley and Indian Creeks as the primary producers of fine sediment between Lewiston Dam and the North Fork confluence. Due to the level of disturbance within each watershed, both tributaries provide significant fine sediment loads even in critically dry years. In Water Year 2000, combined loads from these two tributaries were over three times larger than the combined loads of all other tributaries from Lewiston Dam to Brown's Creek (Matthews 2000). Weaver, Rush, Reading, Deadwood and Hoadley Creeks also were also identified as impaired, based on an analysis of stream and watershed condition indicators (Matthews 2000, and De la Fuente et al. 2000). Because of their water quality and channel conditions, Weaver and Rush Creeks were rated as functioning at risk and as having a high watershed hazard condition. The same assessment determined that Brown's Creek was in a moderate condition. In other words, physical and biological conditions in these creeks suggest that aquatic and riparian systems are at risk of being unable to support aquatic & riparian dependent species and retain beneficial uses of water.

Numerous studies have described and evaluated sediment sources in and delivery from the Grass Valley Creek (GVC) watershed (Matthews 2000). The Trinity River TMDL Sediment Source Analysis (SSA) states that since the 1984 passage of P.L. 98-541, the TRRP has addressed this problem through a series of approaches and restoration efforts. In 1990, the Buckhorn Debris Dam was built in order to trap sediments from about 25% of the watershed and in 1994, sediment control ponds, known as the "Hamilton Ponds", were constructed near the confluence of Grass Valley Creek and the Trinity River. Changes in land management were accomplished through the purchase and transfer of 17,000 acres in the watershed from Champion International Corporation to the Bureau of Land Management (BLM) in 1993. Throughout the 1990's, the Trinity County Resource Conservation District (TCRCD) and the Natural Resource Conservation Service (NRCS) implemented a major watershed restoration effort in the Grass Valley Creek Watershed primarily on BLM lands. Between 1992 and 1996, this program treated 10,838 acres, including 858 sites inventoried by NRCS (1992); decommissioned 45 miles of old roads, landings, and skid trails; improved 19 miles of permanent roads; installed sediment basins; and revegetated extensive areas using 1.2 million trees, shrubs, and plugs (TCRCD). More recently, additional sediment control structures have been constructed at almost every draw draining a cut slope along Highway 299 (Matthews 2000).

According to the Trinity River TMDL Sediment Source Analysis, monitoring by the TCRCD since 1995 has shown a decreasing sediment yield at the Hamilton Ponds, which is attributed to the implementation of extensive watershed restoration efforts. Over time, a reduction in the intensity of timber management activities has also reduced GVC fine sediment yields (Matthews 2000).

With the most deleterious portion (sand sized particles) trapped in Hamilton Ponds and extensive upslope restoration efforts coordinated by the TCRCD, Grass Valley does not present the enormous problem that it once did (Matthews 2000). The Trinity TMDL states that emphasis on sediment control should be transferred to the Indian Creek watershed, as it is capable of producing over three times the sediment that the mainstem can transport. With this type of loading, the deposits in the mainstem will continue to grow downstream at a significant rate, as has been observed by local residents. This has contributed to, and will continue to contribute to, downstream habitat degradation (Matthews 2000). Upslope restoration also should also be focused in the Browns Creek, Rush Creek, and Weaver Creek watersheds and more generally, on tributaries throughout the Upper Middle Watershed area such as Reading Creek, Hoadley Gulch and Deadwood Creek. Through funding provided to Trinity County, efforts are ongoing to reduce fine sediment production associated with county roads in the Deadwood Creek and Hoadley Gulch drainages.

The lower middle reach assessment area generally consists of relatively steep gradient (i.e., high sediment transport) stream reaches and rugged terrain, much of which lies within the Trinity Wilderness area. Land management disturbance is minimized in much of the area due to its Wilderness designation. However, according to De la Fuente et al. (2000), Canyon Creek is at risk with regard to several aquatic habitat indicators including water quality, stream vegetation, channel stability, and aquatic integrity. The presently

unstable channel conditions in Canyon Creek largely result from intensive historic mining activity and other land use activities for several miles along the lower mainstem that are easily accessible via a primary road (pers. comm. Loren Everest). Conversely, other tributaries in the lower-middle area are relatively difficult to access and have not experienced the same level of disturbance.

For much of the South Fork Basin, unstable and highly erodible terrain as well as land management activities have resulted in high sediment yields from landslides. The greatest source of sediment loading is mass wasting not associated with management sources. Lands west of the South Fork mainstem draining primarily off of the Franciscan Formation soils of South Fork Mountain are particularly susceptible both to natural mass wasting and to accelerated mass wasting from management activities. The rates of sediment loading generated from these areas are significantly greater than that from other locations (South Fork Trinity River (SFTR) TMDL, U.S. E.P.A. 1998).

Based on the analyses conducted for the SFTR TMDL, it is estimated that about two-thirds of sediment loading in the basin is associated with natural sources and about one-third has been associated with various land management activities. Roads generate about twice the levels of sediment loading as timber harvest units, and are the most significant component of management-related sediment production.

The SFTR TMDL states that significant sediment loading reductions appear to be necessary to address the instream problems associated with sediment. Particularly with management activity, load reductions should be more aggressive in the western portion of the South Fork basin, where road/stream interactions are more problematic and terrain is more susceptible to landsliding. Removal of potential road diversions and stream crossing failures, and reductions of road-related sediment throughout the basin, where erosion problems are most significant, will facilitate the continued in-channel improvements.

BLM's Trinity River Watershed Analysis contains an average annual sediment yield estimate at Hoopa of 1,283 yd^3 per square mile (BLM 1995). Extrapolating this figure to the entire basin (exclusive of the areas upstream of Lewiston Dam and federally designated roadless/wilderness areas), the 2,223-square-mile area in question would produce approximately 2.85 million yd^3 of sediment per year. Full-scale implementation of the watershed protection program identified in the Draft EIS/EIR would result in an approximate reduction of 240,000-480,000 yd3/year, which is approximately 9-17 percent of the average annual sediment produced in the Trinity River Basin. Currently, the Department of Fish and Game recognizes $15 per cubic yard of sediment saved as a reasonable cost in implementing upslope sediment reduction projects. The 1999 Draft Trinity EIS/EIR estimated a cost of $5-10 per cubic yard of sediment saved. However, as projects increase in complexity and associated costs such as permitting are taken into account, costs could typically realistically range from $15 - $30 or more per cubic yard. At this range, implementation of the watershed component of the original EIS/EIR alone would amount to anywhere from $3.6 – $7.2 million (240,000-480,000 yd3/year at $15/yd3) to $7.2 - $14.4 million (240,000-480,000 yd3/year at $30/yd3

Accelerated road decommissioning, road maintenance, and road rehabilitation have primarily been focused on public lands within Trinity National Forest (South Fork Management Unit and Upper Middle Trinity River/Weaverville Ranger District Trinity River Management Unit). This area also includes a small portion of the Six Rivers National Forest-Willow Creek Lower Trinity Ranger District in the lower South Fork and lower mainstem watersheds, as well as the private lands and county roads within the entire Trinity River watershed. The Trinity County RCD has inventoried over 940 miles of Forest Service Roads in the South Fork Basin since 1996. Since that time, the District has completed 72 road upgrade projects, 11 road-decommissioning projects, and 11 road hydro closures in the sub-basin. Trinity County, under the Five Counties Salmonid Conservation Program (5C), has completed a sediment source inventory throughout the Trinity River watershed on County Roads, including the SFTR. Sediment reduction projects on County roads were then prioritized according to treatment immediacy, erosion potential and potential sediment yield as well as by several other management and biological factors. 5C has implemented 4 roads sediment reduction projects and three more are slated for construction in 2004.

Many road rehabilitation and maintenance activities were completed in the Weaverville Ranger District approximately 8-12 years ago (Everest pers. comm.) A Watershed Assessment for the Weaverville watershed (Rush Creek, Little Brown's Creek, Weaver Creek) is in the initial stages and the work identified under that assessment is expected to begin within the next 3-4 years. Road rehabilitation work is also planned for the Oregon Fire Area and is expected to also take place within the next five years. 5C will continue to implement projects at the rate of 2-3 per year on County Roads. Other projects are ongoing by the U.S. Forest Service, TCRCD, the Yurok Tribe and others.

Projects on private roads, which make up the remainder of the watershed, can be done through NRCS and TCRCD, and other limited grant sources; however, because landowner cooperation is a limiting factor, projects on private roads are rarely implemented. For instance, grant funding through CDFG's Fishery Restoration Grant Program requires private landowners to allow CDFG staff unlimited access to the project site for 10 years, which many private landowners, both large and small, are reluctant to allow.

Prioritization of roads sediment reduction, rehabilitation, and decommissioning projects should be deferred to the implementing agencies that have conducted a systematic road sediment source inventory and/or analysis. Consistent with the Trinity River TMDL, further prioritization should be placed on those projects within the Upper Middle Trinity River Watershed. These projects should be implemented and coordinated on a basin-wide scale through the TCRCD currently serving as the Trinity River Watershed Coordinator.

The Action Plan for Restoration of the South Fork Trinity River Watershed and its Fisheries was prepared by Pacific Watershed and Associates in 1994 for the South Fork Trinity River Coordinated Resources Management Plan (SFTR CRMP), with funding by

the TRRP. The SFTR CRMP is a stakeholders' group consisting primarily of representatives of landowners, land managers, conservation groups, local, state, and federal agencies, and other interested members of the public. The U.S. Forest Service (USFS) South Fork Management Unit (SFMU) and the TCRCD have been effectively targeting sediment reduction and upslope restoration projects in the South Fork Watershed under the Action Plan. The USFS SFMU has completed 63 upslope restoration projects in the SFMU and as detailed above; the TCRCD has also completed an impressive program of work in the watershed. NRCS has targeted restoration activities on private lands in the South Fork through its Environmental Quality Incentives Program (EQIP) program. These entities should continue to work towards the 30% reduction of sediment input as recommended in the US EPA's SFTR TMDL. Adherence to the Watershed Component of the Trinity ROD should assist in the delegation and prioritization of watersheds and projects to these entities and their current work plans as well as the TMDL implementation plans.

The current rate of project implementation in the South Fork and other watersheds downstream of the North Fork confluence is limited due to available staffing and infrastructure. There is a reluctance of the Trinity River Restoration Program to fund projects in the SFTR Watershed due to a recent interpretation by the Bureau of Reclamation of a 1998 Interior Solicitor's Opinion on use of TRRP funds. Reclamation's position is that projects in most tributaries and watersheds, particularly those downstream of the North Fork confluence (including, but not limited to, the South Fork), do not have a "causal link" to the Trinity River Division of the CVP, and are therefore ineligible for funding through Reclamation. Trinity County disagrees with Reclamation's interpretation of the Solicitor's Opinion and believes there is a causal linkage to restoration activities in the South Fork and other watersheds and tributaries of the Trinity River, even if they might not be as high of a priority as other similar projects upstream of the North Fork closer to Lewiston Dam (Stokely, 2003).

Nonetheless, the TCRCD was recently awarded a contract through the Trinity River Basin Fish and Wildlife Restoration Grant Program, funded through the Bureau of Reclamation and administered by Trinity County. Under this agreement, TCRCD will provide local expertise to coordinate watershed restoration efforts in the tributaries of the Trinity River Watershed under the framework and direction of the Trinity River ROD. This project includes providing a liaison between the US Forest Service and the Trinity River Restoration Program in the development of a Rush Creek Watershed Analysis, assistance in development of a Trinity River Watershed Restoration Strategic Plan, providing education and outreach to landowners and stakeholders in the watershed about restoration needs and methods in the tributaries, coordinating with public and private landowners in providing technical advice and developing and prioritizing watershed restoration needs, and the ability to track and secure significant matching grant funding to implement these restoration projects, which will improve fishery habitat in the Trinity River downstream of Lewiston Dam.

As discussed in Section 2.1 of the Trinity River Mainstem Fishery Restoration Draft EIS/EIR (1999), the SFTR CRMP, GVC watershed restoration, enforcement of Trinity County's Decomposed Granite Grading Ordinance, and related sediment reduction efforts are ongoing and part of the No Action Alternative. As discussed in Section 4.1 (Cumulative Effects) of the Draft EIS/EIR (1999), the Five Counties Salmonid Conservation Program (5C), the USEPA's Trinity River and SFTR TMDL's, the Lower Klamath River Partnership and changes to California Forest Practice Rules are ongoing related projects to reduce fine sediment inputs to the Trinity River mainstem and its tributaries.

Upslope restoration is a high priority restoration type. Upslope restoration project limiting factors include available funding, staffing and infrastructure. Projects on private lands are limited by access, funding and landowner cooperation. Projects should be coordinated on a basin-wide scale through the Trinity River Watershed Coordination Effort by TCRCD.

Fish Passage Improvement

Fish Passage Improvement restoration types include the removal of structures impeding the migration of anadromous and resident fish species. This restoration type also includes the construction of fish passage structures such as fish ladders and baffles. Restoration is aimed at improving the movement of fish migration to suitable spawning and rearing habitat within the Trinity River and its tributaries. Natural and constructed structures that may impede fish passage include culverts, dams, step-pool systems, large woody debris, and/or waterfalls (Oregon watershed Enhancement Board, 1999; U.S Army Corp of Engineers, 2003).

Permanent barriers to fish movement in the Trinity Basin have resulted in habitat fragmentation and a vast reduction of available habitat for spawning and rearing. Other effects of barriers may include increased levels of sedimentation and predation, alteration of stream flows, degradation of stream channels, depletion of riparian areas, modification of water temperature regimes, and loss of habitat diversity and complexity. Barriers can also impair sediment transport, thereby diminishing the replenishment of beneficial sediment (spawning gravel). The cumulative effects of large numbers of these structures within the watershed pose significant risk to the recovery and long-term viability of salmon and steelhead populations and limit the ability to reach the restoration goals of the P.L. 989-541.

Fish Passage Improvement Projects have mainly been focused in the South Fork Trinity and Upper Middle Trinity River Watersheds. According to the Database of Trinity River restoration activities, 69 fish passage improvements have already been implemented. Many barriers within the basin have been identified, and are cited in the California Coastal Conservancy's recently published report, "Inventory of Barriers to Fish Passage in California's Coastal Watershed". The Five Counties Salmonid Conservation Program (5C) has completed a County road inventory, identifying and prioritizing 58 barriers in Trinity County (46 in the Trinity River watershed). 5C has implemented two of these projects within the watershed, with three more slated for construction in 2004. The 5C Program has restored over 100 miles of salmonid habitat within the entire 5C program

area (includes areas outside of the Trinity River basin). The USFS Hayfork Ranger District currently has four projects planned for implementation in the South Fork Basin, and the USFS Weaverville has identified priority projects within its district. In addition, the Trinity County RCD and NRCS continue to work with cooperative landowners to remove barriers to fish passage on private lands**.**

The greatest limiting factors to implementation of these projects are often the extensive, sometimes controversial and lengthy permitting processes, lack of available funding and adequate staffing, landowner cooperation, and high costs associated with full implementation. Costs are in the range of $250,000 per project or more on public roads.

Fish Passage improvement projects can provide measurable benefits in the restoration of salmon and steelhead populations in the tributaries of the Trinity River Basin. The Implementation Plan for the Trinity River ROD calls for a four fold increase in habitat in the mainstem Trinity River. The implementation of fish passage improvement projects on mainstem tributaries can be important in meeting this goal. For example, Trinity County's 3 planned projects for 2004 are all located relatively close to their respective confluences with the mainstem Trinity River. These projects alone will restore access to almost 13 miles of salmonid habitat in tributaries of the Trinity River. However, the combined cost of these projects amounts to approximately $650,000. These projects should be coordinated through an inter-agency effort on a basin-wide scale. **In the context of the Watershed and Tributary Restoration Component of the SEIS/EIR, fish passage improvement projects have a high priority.**

Instream Habitat Improvement

Instream habitat restoration types include activities such as mechanical alterations and coarse sediment augmentations. Restoration is aimed at improving fish habitat. Mechanical restoration includes the removal/improvement/installment of weirs (log, boulder, and/or cement), large woody debris, root wads, boulders, step-pool systems, channel excavation (i.e., dredging) and other alterations that enhance diversity of instream refugia (Oregon watershed Enhancement Board, 1999; U.S Army Corp of Engineers, 2003). Sediment augmentation introduces coarse sediment into the stream channel to create diverse habitats for spawning (Oregon watershed Enhancement Board, 1999). These restoration activities are categorized as Instream Habitat Improvement restoration types based on a common goal of increasing in-channel fish habitat.

Instream restoration projects have primarily been implemented in the South Fork Trinity River and Upper Middle Trinity River Watersheds. Instream habitat improvement projects are often necessary in lower gradient stream systems, many of which have been simplified due to the cumulative effects of historic mining and different land use activities such as logging. Large woody debris and boulder placement can be beneficial at these locations. However, the poor habitat conditions typically warranting instream habitat improvement projects are often a result of excessive sediment input and/or upslope watershed disturbance. In recent years it has often been recognized that upslope restoration projects tend to be more beneficial than instream projects. Instream projects often fail to control the source of the problem in terms of upslope sediment input.

Further, many of the tributaries within the Trinity River Basin are higher gradient streams in which instream habitat improvement projects are inappropriate and ineffective. Due to their failure to treat causative factors, these projects are often short-term and temporary. **These projects will be analyzed as medium priority in the context of the Watershed and Tributary Restoration Component of the SEIS/EIR.**

Riparian Habitat Improvement

Riparian habitat restoration types include streambank stabilization, managing livestock by fencing off portions of the riparian habitat and/or creating a buffer zone between farmland and stream systems (Oregon Watershed Enhancement Board, 1999). Streambank stabilization, which is aimed at improving riparian habitat and water quality, can include using riprap, boulders, cement, vegetation, bio-enhancement, and/or regrading bank slope (U.S Army Corp of Engineers, 2003). Eradication of exotic species, such as scotch broom, can also be a beneficial riparian habitat improvement project. These restoration activities are categorized as Riparian Habitat Improvement based on the common goal of enhancing riparian habitat and water quality.

Stream buffer zone and riparian fencing projects have mainly been implemented by private landowners throughout the South Fork watershed with assistance from TCRCD and NRCS. Further riparian habitat improvement projects of this type are limited by landowner cooperation and available funding. Federal riparian lands are specifically managed for objectives identified under the Northwest Forest Plan, including Riparian Reserve Allocations. Stream bank stabilization projects are not a common need on a basin wide scale; however, they can be very beneficial in discrete locations. Unstable stream banks are often a result of excessive upstream sediment loads or poor adjacent land uses practices (e.g., cattle grazing or roads on steep/unstable streambanks**). As a result of these factors, riparian habitat improvement activities will carry a medium priority for SEIS/EIR analysis purposes.**

Water Conservation: Improving Water Supply (Quantity/Quality)

Water right acquisition and water conservation activities are examples of water supply "restoration types" that can improve water quality. Restoration is aimed at improving water quantity and quality. Water acquisition includes buying instream water rights or senior water rights from private property owners (Oregon Watershed Enhancement Board, 1999). Water conservation includes efficient changes in irrigation methods and domestic water use (ditch lining, pipe replacement, drip system, and/or removal of water diversions) (U.S Army Corp of Engineers, 2003). Acquisition and water conservation activities are categorized under Water Conservation: Improving Water Supply (Quantity/Quality) because of the common goal of improving water quantity and quality.

Through water conservation, water quantity and quality in tributaries can be improved and managed to help provide the elements necessary to support and restore fisheries throughout the basin. During periods of warm weather, salmonids are often found at or in refugia areas created by cold-water flows from various tributaries into larger streams such as the mainstem Trinity River or lower Klamath River. However, it is not expected

that improved cold-water flows from tributaries would be able to decrease mainstem water temperatures significantly, except at their immediate confluence with the mainstem.

Most water conservation projects have been implemented by private landowners within the South Fork Trinity River Watershed through the Trinity County RCD and the NRCS. In several of the smaller watersheds, increased instream flows through water right acquisition and water conservation have helped to provide suitable water temperatures, volumes and velocities for fish habitats. In some cases, these projects have also eliminated fish passage barriers by elimination of instream diversion structures. However, most of the feasible, beneficial projects of this type have been completed. Further implementation is limited by landowner cooperation and funding. Because of concerns with water rights, these projects are not easy for some of the local major landowners/diverters to accept. In terms of augmenting water releases from Lewiston Dam, it is not expected that water conservation will have a significant effect because water diversions are considered small in relation to mainstem flows (0.5-15 cfs, compared to 300-11,000 cfs). **In context of the analysis of a Watershed and Tributary Component of the SEIS/EIR, water conservation projects play a small role and are a medium priority**.

Land Conservation

Land conservation "restoration types" include the acquisition of the fee title or conservation easements of private property.

Public ownership and legal access to lands surrounding tributaries allows for management activities consistent with watershed and tributary restoration riparian reserve allocations and Wild and Scenic River Corridor Criteria. Land Conservation restoration types allow implementing agencies to have the ability to better control sediment sources from lands located in tributaries or to increase protection of private lands through incentives. Floodplain-prone lands along the Trinity River mainstem may also be appropriate for acquisition and/or conservation easements to limit further development in the floodplain.

Land acquisition can provide opportunities for restoration. For example, in the late 1980s and early 1990s, the Trinity River Task Force had become convinced that commercial timber harvesting on highly erosive decomposed granite soils, such as those in Grass Valley Creek, was incompatible with the goals of the restoration program. As a result, some 17,000 acres overlying this erosive formation in the GVC watershed was purchased in 1993 from Champion International. The Bureau of Land Management is now managing the land for purposes other than timber harvest. Since the land purchase, NRCS and the Trinity County Resource Conservation District (TCRCD) have implemented a major watershed restoration effort. The change in land use alone resulted in a significant reduction in discharge of decomposed granite into GVC and the Trinity River.

Approximately 1.58 million acres of the Trinity River watershed (83% of area) are already under Tribal, local, state or federal ownership/management. The Six Rivers and Shasta-Trinity National Forests, and the Bureau of Land Management account for the vast majority of public land management. Almost half of the public lands, 700,000 acres (37% of the watershed area), are within federally designated Wilderness areas or inventoried roadless areas. Additional public lands are within the Wild and Scenic River corridor and/or designated Late Seral Reserves with limited road management or development activities. It is not anticipated that significant land or easement acquisitions would be incorporated into an overall restoration plan for the Trinity River, as remaining private lands are not expected to significantly come into public ownership. **As a result of these factors, land conservation programs will carry a low priority for SEIS/EIR analysis purposes.**

Conclusions

Due to limiting factors such as inadequate funding, limited landowner cooperation, limited staffing, permitting, and low cost-efficiency, the current rate of restoration project implementation for many of the water conservation, land acquisition, instream improvement, and riparian improvement project types cannot be significantly accelerated under existing conditions. However, with increased funding and coordination, as well as additional prioritization, upslope restoration and fish passage improvement projects within the watersheds could be accelerated, particularly on public lands. Agencies should continue to focus on these restoration types. Projects should be prioritized and coordinated on a basin-wide scale regardless of the implementation agency.

As stated in the Trinity River TMDL, upslope restoration and sediment reduction projects should be focused in the Upper Middle Trinity River Watershed and specifically in the Indian Creek sub-basin. Rush Creek, Weaver Creek, and Brown's Creek are also high priority areas in terms of sediment reduction. In the South Fork Basin, load reductions should be more aggressively targeted, particularly with management activity, in the western portion of the South Fork basin, where road/stream interactions are more problematic and terrain is more susceptible to landsliding. Sediment source inventory data should continue to be used in the prioritization of projects.

Fish passage improvement projects are generally prioritized according to habitat quality and quantity, the extent of the barrier, and species diversity. Further prioritization results from factors including cost-effectiveness, permitting complexity, landowner cooperation, and coordination with other capital improvement projects. Although the costs of such projects can sometimes seem prohibitive, cost-effectiveness is generally very high in terms of habitat restored. Project prioritization should defer to implementing agencies but should be coordinated through the Trinity River Watershed coordination effort by TCRCD using TRRP funding.

Fish passage and upslope watershed restoration efforts throughout the Trinity River basin downstream of Lewiston Dam could potentially receive increased funding if interpretation of the 1998 Interior Solicitor's Opinion became less restrictive in terms of spending federal appropriations to the Bureau of Reclamation, including TRRP funds and the Central Valley Project Improvement Act Restoration Fund.

List of Ongoing and Planned Watershed and Tributary Projects:

Trinity County/5C-

Soldier Creek Fish Passage
Roundy Road Fish Passage (Little Browns Creek)
Deadwood Creek Fish Passage
Deadwood Creek sediment reduction
Hoadley Gulch (Lewiston Turnpike Rd) sediment reduction
Big Creek sediment reduction

Trinity County RCD-

-Watershed Coordination (includes small demonstration project for fine sediment, as yet undetermined)
-Watershed Coordination upstream of Trinity Dam (funded by SWRCB) –outside of geographic scope
-Upper Trinity River Basin Road Inventory (USFWS Jobs in the Woods)- outside of geographic scope
-GVC Watershed Restoration- (BLM Jobs in the Woods)
Hamilton Ponds Dredging
-319(H) Sediment Reduction in SFTR ($450,000 over 3 years), mostly implementation, some effectiveness monitoring
-RAC ($55,000) as match for 319H
-Lower Little Creek/SFTR Road Decommissioning (USFS $80,000)
-Road Inventory of all BLM in Trinity River Mainstem Watershed
-Packer's Creek Erosion Control

Natural Resource Conservation District (EQIP)- (disclosure of project location prohibited by federal law (Sec 2004 of the Farm Security and Rural Investment Act of 2002))

One water conservation
Two riparian enhancement
4 Road/sediment reduction

U.S. Forest Service

Tule Creek Fish Passage (3 sites)
Soldier Creek Fish Passage (upstream of Trinity Co. site)
Packers Creek Fish Passage

Sediment Reduction-Road Maintenance/Decommissioning:

Road	Watershed	Area	Rx
28N50 from 30 road Int. to D Spur	Upper So Fork	Wilcox	Maint
28N52	Upper So Fork	Wilcox	Maint
Non System 1	Upper So Fork	Wilcox	Decom
29N62C	East Fork/Smoky		Decom
29N74	East Fork/Smoky		Decom
28N50D	Upper So Fork	Wilcox	Decom
2N37	Butter Creek		Decom
2N37A	Butter Creek		Decom
2N34	Butter Creek		Decom
2N10K	Butter Creek		Decom
32N30A	Lower Hayfork	Lower Little	Decom
32N30B	Lower Hayfork	Lower Little	Decom
4N08A	Lower Hayfork	Lower Little	Decom
28N83	Upper So Fork		Decom

Yurok Tribe/Lower Klamath River Partnership-

-McGarvey Creek Watershed Restoration (road decommissioning)

-Pularvasar Cr. Watershed Restoration (road decommissioning)

-Roach Creek Watershed Assessment

Supplemental 2003 Fall Fishery Flows
Technical Appendix F

Supplemental 2003 Fall Fishery Flows

In a March 5, 2003 court hearing, Judge Oliver Wanger directed the Department of the Interior to determine what actions would be necessary to "assure against the risk of fish losses that occurred late in the season last year." Judge Wanger subsequently issued a ruling on April 4, 2003 allowing Reclamation to use an additional 50,000 af from the Trinity River Division of the Central Valley Project "at its reasonable discretion" to prevent a recurrence of the September 2002 fish die-off.

In fall of 2003 an Action Plan was developed that recommended increased Trinity River flows to reduce the likelihood, and potentially reduce the severity, of a fish die-off occurring during the fall run Chinook salmon migration. The Action Plan provided flows known to be adequate for unimpaired salmon migration through the lower Klamath River. It was expected that increasing flows would reduce or eliminate adverse in-river conditions that contributed to the adult fish die-off of 2002.

An initial presentation of increased late-summer Trinity River dam release options and request for written comments was given at the TMC meeting on June 26, 2003. Written comments were received through July 18, 2003. A technical workgroup of state, federal, and tribal biologists was convened on July 23 and 24, 2003, to consider comments received and evaluate alternatives. That group developed a revised alternative, the Action Plan Flows option, that addresses these concerns. Additional updates were provided to a broadly representative group of stakeholders on July 29, 2003, at a TAMWG meeting in Weaverville, California, and a TMC conference call on

July 30, 2003. A letter of support for the proposed action was forwarded directly to the Secretary of the Interior from the TMC and TAMWG in a letter dated August 8, 2003.

The need for implementing the Action Plan was both biological and legal in nature. In 2002, low flow conditions in the lower Klamath River, warm water temperatures, and an above average fall run Chinook salmon escapement combined to create conditions favorable to an epizootic outbreak resulting in a fish die-off. Biological consequences of a die-off in two consecutive years would substantially impact present efforts to restore the native Trinity River anadromous fish community and fishery. Reductions in the Trinity River fish population would also affect Tribal fishery harvest opportunities, ocean harvest levels, recreational fishing, as well as public perception and recovery mandates. Last year's loss of 3 year-old and a potential loss of 4 year-old fish from the 1999 brood year affect the population structure, and may impede recovery goals authorized by the Trinity River Division Central Valley Project Act of 1955 (P.L. 84-386), the Trinity River Basin Fish and Wildlife Act of 1984 (P.L. 98-541), and the Central Valley Project Improvement Act of 1992 (P.L. 102-575), for naturally produced fall run Chinook salmon.

Projected flow conditions and a large fall run Chinook salmon escapement on the lower Klamath River in 2003 were similar to conditions that existed during the die-off in 2002. The two triggers established for initiating the preventive flow release (low flow and a large return of fall run Chinook salmon) were met as of August 20, 2003. Therefore, Reclamation implemented the release schedule proposed in the Action Plan as a preventative means to reduce the likelihood of another fish die-off in 2003.

Methods

The Action Plan used a conservative risk management approach to avert another fish die-off in 2003. The Action Plan had two flow components. The first component was a preventative flow release, using 33,000 acre-ft (af) of water. The preventative flow was intended to reduce the likelihood of a large scale fish die-off by ensuring adequate conditions for adult upstream migration though the lower Klamath River. The second component was an emergency response flow release, using an additional 17,000 af of water. This flow would be implemented to decrease the severity of a fish die-off if real-time monitoring indicated a rapid spread of the incidence and severity of the disease Ich.

Implementing components of the Action Plan were dependant on separate triggers for initiating preventive and emergency response flow releases. Triggers for initiating the preventive flow release were: (1) a fall run Chinook salmon population size estimate of greater than 110,000 for the Klamath Basin, and (2) a flow of less than 3,000 cfs in the lower Klamath River. Triggers for initiating the emergency response flow release would have been an estimated doubling in less than 7 days of either the incidence (proportion of fish infected) or severity (number of parasites per gill) of Ich. Evaluation of emergency action triggers were based on real-time monitoring of disease incidence conducted by the U.S. Fish & Wildlife Service, Fish Health Center, the Yurok Tribe, the Karuk Tribe and California Department of Fish & Game.

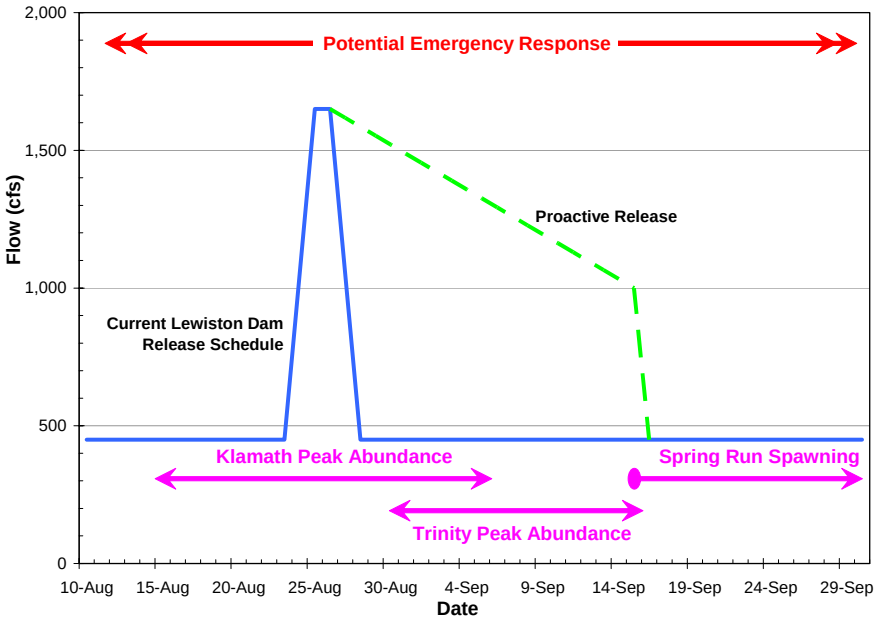

Figure 1. Daily Flow Schedule for Preventative Component of Action Plan.

Existing monitoring programs managed by the U.S. Fish & Wildlife Service, California Department of Fish & Game, the Hoopa Valley Tribe, the Yurok Tribe and the Karuk Tribe assessed the physical and biological effects associated with the Action Plan. Monitoring activities included weir counts, carcass and redd surveys, water temperature, water quality, angler and tribal harvest rates and adult salmon radio tracking, as well as disease incidence and severity from the real-time monitoring used as the trigger for the emergency action component of the Action Plan. Refugia dives and float surveys upstream of the Trinity River confluence were also conducted to evaluate the possibility of unintended effects on Klamath mainstem migrating adults.

Results

Results reported in this memo are preliminary and have not been peer reviewed for consistency with other findings and are subject to revision.

Figures 2, and 3 summarize results of key monitoring to assess effectiveness of the Action Plan release schedule. Additional information on run timing and migration patterns from weir operation, angler and tribal harvest and radio tracking studies is currently being prepared and will be reported in subsequent revisions of this memo.

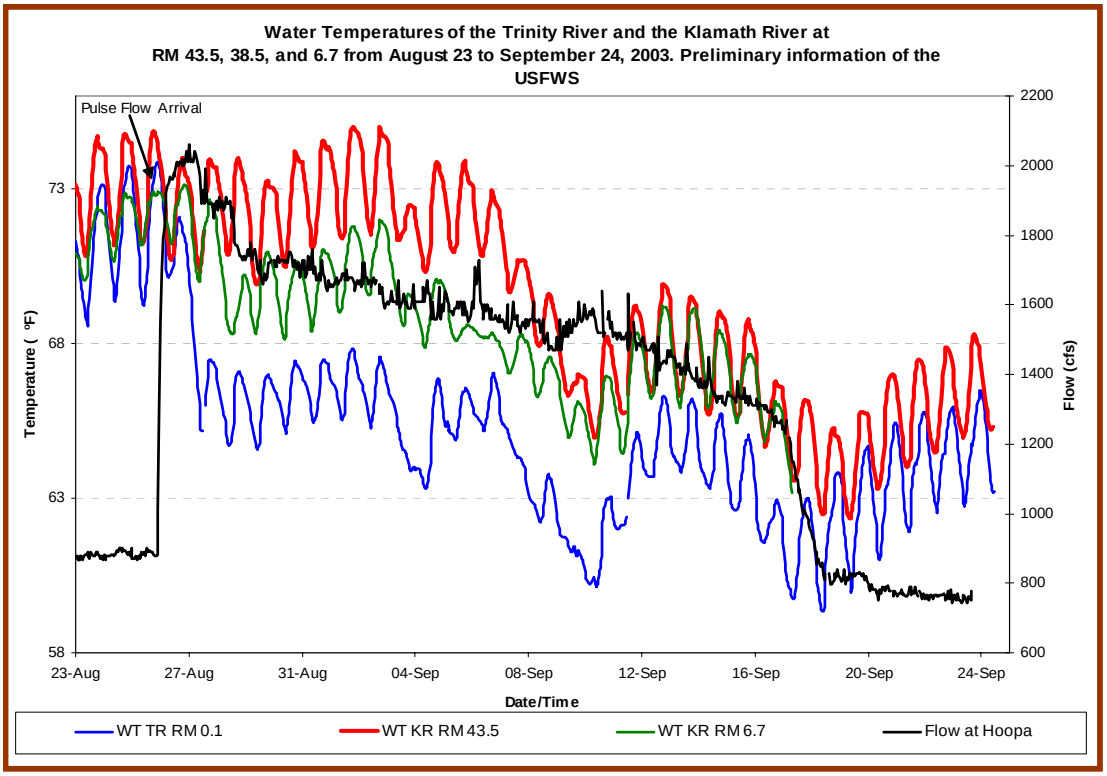

Figure 2. Trinity River flows reduce lower Klamath River water temperatures during the preventative action release schedule. River flow at Hoopa (black) during the fall of 2003, water temperature for the lower Trinity River near Hoopa (blue), Klamath River above Weitchpec (red) and lower Klamath River below the Trinity River confluence (green). Water temperatures above 71.6F inhibit adult Klamath Basin Chinook salmon migration. Preliminary data from Paul Zedonis, Fish & Wildlife Service, Arcata Field Office.

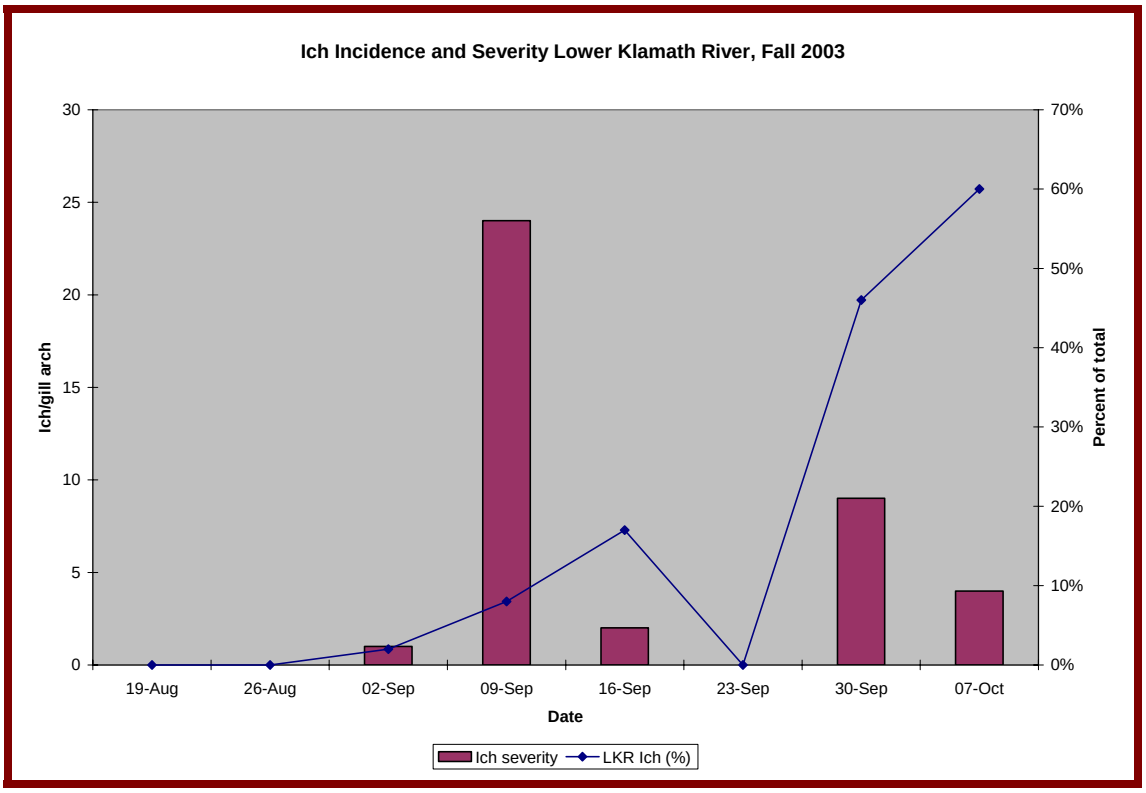

Figure 3. Incidence and severity of Ich (*Ichthyophthirius multifiliis*) on fall run Chinook salmon in the lower Klamath River during the fall of 2003. Disease incidence is reported as proportion of sampled fish with parasites (blue line). Severity is reported as the number of parasites per gill arch (red bars). Standard deviations not reported. Low value for incidence on 23 September is due to low sample size (n=10). Severity values greater than 30 parasites /gill arch is considered to a lower threshold for notable physiological stress. Preliminary data from Scott Foott, Fish & Wildlife Service, Fish Health Center, Red Bluff, Ca.

In addition, two preliminary conclusions from radio tracking studies to understand use of thermal refugia by adult Chinook salmon are relevant to the Trinity River fall flows (Josh Strange, University of Washington pers. com.).

- temperatures above 22C (71.6F) inhibit adult Chinook salmon migration and
- Fish die-off prevention flows from Trinity Dam substantially lowered temperatures in the lower Trinity and Klamath Rivers. During these higher flows thermal refugia use and migration delays were minimal among tagged Chinook salmon.

Conclusions

Monitoring results indicate that implementing the 2003 Trinity River Fall Flows Action Plan was successful in reducing the risk of a major die-off event. No observations of significant adult mortality were noted and the preventative flow schedule maintained water temperatures and flow magnitudes known to provide adequate fish migration in the lower Klamath River, specifically water temperatures were kept below 22C and flows near Klamath, Ca. (Terwar gage) greater than 3000 cfs.

Fall run Chinook salmon migration was unimpeded. Radio tracking of tagged fish demonstrated that migration delays were minimal. Congregations of large numbers of fish at known thermal refugia areas and below critical riffles and rapids were not noted by divers. Observations of fish above the confluence of the Trinity River did not note any negative migration, or health effects to Klamath mainstem Chinook salmon due to these artificially increased flows.

Emergency response flows were not called for although monitoring revealed disease incidence increased throughout the sample period and a doubling did occur. Incidence of Ich did not exceed 20% (10% was assumed to be an acceptable background value) until late September by this time the majority of the fish had migrated out of the lower Klamath and monitoring indicated that disease severity was kept at a low level and therefore did not pose a threat to the physiological health of infected fish.

Spring run Chinook salmon spawning was not affected in the upper Trinity River by the preventative flow schedule. Weekly redd counts in the Trinity River immediately below Lewiston Dam indicate that minimal spawning occurred before September 15, 2003. Lewiston Dam releases returned to the normal (450 cfs) on September 16, 2003. Those redds noted were not threatened by de-watering following flow reductions. Anecdotal reports indicate that fish condition was excellent throughout the run (Loren Everest, Forest Service, Trinity River Management Unit pers. com.).

Operations Criteria and Plan
Biological Assessment
Technical Appendix G

Long-term Central Valley Project and State Water Project Operations Criteria and Plan Biological Assessment for Terrestrial Species

Long-term Central Valley Project and State Water Project Operations Criteria and Plan Biological Assessment for Terrestrial Species

Prepared for

Bureau of Reclamation

February 2004

CH2MHILL
2485 Natomas Park Drive, Suite 600
Sacramento, California

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Introduction

The Bureau of Reclamation (Reclamation) and the California Department of Water Resources (DWR) propose to operate the Central Valley Project (CVP) and State Water Project (SWP) to divert, store, and convey CVP and SWP water consistent with applicable law. The CVP and the SWP are two major inter-basin water storage and delivery systems that divert water from the southern portion of the Sacramento-San Joaquin Delta (Delta). Both projects include major reservoirs north of the Delta and transport water via natural watercourses and canal systems to areas south and west of the Delta. The CVP also includes facilities and operations on the Stanislaus and San Joaquin Rivers.

Reclamation has prepared a Biological Assessment (Long-term Central Valley Project Operations Criteria and Plan [CVP-OCAP] Biological Assessment) addressing the effects of operating the CVP and SWP on listed fish species (Winter-run chinook salmon, Spring-run chinook salmon, Central Valley steelhead, delta smelt, and coho salmon). This component of the Biological Assessment (BA) evaluates the potential effects of continued operations of the CVP and SWP on plant and wildlife species that are listed or proposed for listing under the federal Endangered Species Act (ESA).

Description of the Action Considered

Reclamation's proposed action is to continue to operate the CVP and SWP in the future as described in the CVP-OCAP. The CVP-OCAP provides a comprehensive description of the proposed action. A summary of the proposed action is provided in Chapter 1 of the Long-term CVP-OCAP Biological Assessment that addresses effects to listed fish species.

Other Actions Not Included in the Proposed Action

The proposed action is limited to Reclamation's and DWR's operation of CVP and SWP facilities for the purpose of diverting, storing, and conveying project water. The proposed action does not include diversion of water through non-CVP or non-SWP facilities nor use of diverted water. Further, the proposed action does not include maintenance activities associated with CVP and SWP facilities. Reclamation has an operations and maintenance manual for its facilities that meets the requirements of the ESA.

Action Area

The action area consists of CVP/SWP waterways and adjacent habitats that are dependent on or influenced by the hydrologic or water quality conditions of the CVP/SWP waterways. Figure 1-1 of the Long-term Central Valley Project OCAP Biological Assessment shows the CVP and SWP facilities.

Threatened and Endangered Species Considered

On June 13, 2003, the United States Fish and Wildlife Service (Service) provided Reclamation with a list of special-status species that may occur in the area affected by implementation of the CVP-OCAP. This list was reviewed to identify species that would not be affected by implementation of CVP-OCAP and those that could be affected. Species identified as potentially affected by implementation of CVP-OCAP were retained for evaluation in this BA.

Reclamation's and DWR's action is to implement CVP-OCAP which consists of operating CVP and SWP facilities primarily to:

- Deliver water to diversion points
- Provide flood control
- Release water to meet instream flow and water quality requirements.

The proposed action does not include the actual diversion of water (i.e., direct effects of diversion) or use of diverted water. Potential effects of the proposed action, therefore, consist of

- Changes in flows in streams downstream of CVP and SWP facilities
- Changes in water surface elevations in CVP and SWP reservoirs
- Changes in water quality of CVP and SWP waterways.

Because the potential effects of the proposed action are limited to hydrologic and water quality changes, species potentially affected by the action are limited to species that are aquatic or require the resources of supported by CVP/SWP waterways. The list of species provided by the Service was reviewed to identify species potentially affected by hydrologic or water quality conditions in CVP/SWP waterways. Species for which the proposed action was determined to have no effect are listed in Table 1 along with a brief indication of why the species was considered not to be affected. Species identified as potentially affected by implementation of CVP-OCAP are listed in Table 2. These species are further addressed in this BA.

TABLE 1
Species determined not to be affected by implementation of long-term CVP-OCAP

Common Name	Scientific Name	Reason for No Effect
MAMMALS		
Buena Vista Lake shrew	*Sorex ornatus relictus*	Does not inhabit action area
Fresno kangaroo rat	*Dipodomys nitratoides exilis*	Associated with grassland and scrub habitat
San Joaquin kit fox	*Vulpes macrotis mutica*	Associated with grassland and scrub habitat
Sierra Nevada bighorn sheep	*Orvis canadensis californiana*	Associated with scrub habitat
Tipton kangaroo rat	*Dipodomys mitratoides nitratoides*	Associated with grassland and scrub habitat

TABLE 1
Species determined not to be affected by implementation of long-term CVP-OCAP

Common Name	Scientific Name	Reason for No Effect
Giant kangaroo rat	*Dipodomys ingens*	Associated with grassland and scrub habitat
BIRDS		
California brown pelican	*Pelecanus occidentails californicus*	Does not inhabit action area; associated coastal areas
California condor	*Gymnogyps californianus*	Does not inhabit action area; associated with upland
California least tern	*Sterna antillarum browni*	Does not inhabit action area; associated with coastal areas
Least Bell's vireo	*Vireo bellii pusillus*	Does inhabit action area
Marbled murrelet	*Brachyramphus marmoratus*	Associated with conifer forest habitat and marine habitat
Mountain plover	*Charadius montanus*	Associated with upland habitat
Northern spotted owl	*Strix occidentalis caurina*	Associated with conifer forest habitat
Southwestern willow flycatcher	*Empidonx traillii extimus*	Does not inhabit action area
Western snowy plover	*Charadrius alexandrinus nivosus*	Does not inhabit action area; associated with coastal areas
REPTILES		
Alameda whipsnake	*Masticophis lateralis euryxanthus*	Associated with chaparral and scrub habitats
San Francisco garter snake	*Thamnophis sirtalis tetrataenia*	Does not occur in association with CVP/SWP waterways
Blunt-nosed leopard lizard	*Gambelia sila*	Associated with desert habitat
Desert tortoise	*Gopherus agassizii*	Associated with desert habitat
AMPHIBIANS		
California tiger salamander	*Ambystoma californiense*	Associated with vernal pools and surrounding upland habitat
INVERTEBRATES		
Conservancy fairy shrimp	*Branchinecta conservatio*	Associated with vernal pools
Kern primrose sphinx moth	*Euproserpinus euterpe*	Does not occur in action area; associated with upland plant species
Lange's metalmark butterfly	*Apodemia mormo langei*	Associated with dunes
Shasta crayfish	*Pacifastacus fortis*	Occurs in waterways upstream of CVP/SWP facilities

TABLE 1
Species determined not to be affected by implementation of long-term CVP-OCAP

Common Name	Scientific Name	Reason for No Effect
Bay checkerspot butterfly	*Euphydryas editha bayensis*	Associated with grassland habitat
Callippe silverspot butterfly	*Speyeria callippe callippe*	Associated with grassland habitat
Delta green ground beetle	*Elaphrus viridis*	Associated with grassland-playa habitat
Longhorn fairy shrimp	*Branchinecta longiantenna*	Associated with vernal pools
Vernal pool fairy shrimp	*Branchinecta lynchi*	Associated with vernal pools
Vernal pool tadpole shrimp	*Lepidurus packardi*	Associated with vernal pools
PLANTS		
Antioch Dunes evening-primrose	*Oenothera deltoides ssp. howellii*	Associated with dunes
Bakersfield cactus	*Opuntia treleasei*	Associated with scrub habitat
Butte County meadowfoam	*Limnanthese floccosa ssp. californica*	Associated with vernal pools and ephemeral streams
California jewelflower	*Caulanthus californicus*	Associated with scrub habitats
California sea blite	*Suaeda californica*	Does not occur in action area
Colusa grass	*Neostapfia colusana*	Associated with vernal pools
Contra Costa goldfields	*Lasthenia conjugens*	Associated with vernal pools
Contra Costa wallflower	*Erysimum capitatum ssp. angustatum*	Associated with dunes
Coyote ceanothus	*Ceanothus ferrisae*	Associated with chapparal habitat
Greene's tuctoria	*Tuctoria greenei*	Associated with vernal pools
Hairy Orcutt grass	*Orcuttia piliosa*	Associated with vernal pools
Hatweg's golden sunburst	*Pseudobahia bahiifolia*	Associated with grassland and oak woodland habitat
Hoover's eriastrum	*Eriastrum hooveri*	Associated with upland habitat
Hoover's spurge	*Chamaesyce hooveri*	Associated with vernal pools
Keck's checker-mallow	*Sidalcea keckii*	Associated with grassland habitat
Kern mallow	*Eremalche kernensis*	Associated with saltbush scrub habitat
Large-flowered fiddleneck	*Amsinckia grandiflora*	Associated with upland areas
Layne's butterweed	*Senecio layneae*	Associated with gabbro and serpentine soils
Mariposa pussy-paws	*Calyptridium pulchellum*	Associated with grassland and woodland habitats
McDonald's rock-cress	*Arabis macdonaldiana*	Associated with upland habitat

TABLE 1
Species determined not to be affected by implementation of long-term CVP-OCAP

Common Name	Scientific Name	Reason for No Effect
Metcalf Canyon jewelflower	*Streptanthus albidus ssp. albidus*	Associated with upland habitat
Pallid manzanita	*Arctostaphylos pallida*	Associated with chapparal habitat
Palmate-bracted bird's-beak	*Cordylanthus palmatus*	Associated with seasonally inundated alkali sink habitats but in action area only found in managed wetlands not dependent on river hydrology
Presidio clarkia	*Clarkia franciscana*	Associated with grassland habitat
Robust spineflower	*Chorizanthe robusta var. sobusta*	Associated with upland habitat
Sacramento orcutt grass	*Orcuttia viscida*	Associated with vernal pools
San Benito evening-primrose	*Camissonia benitensis*	Associated with serpentine terraces; does not occur in action area
San Joaquin Valley Orcutt grass	*Orcuttia inaequalis*	Associated with vernal pools
San Joaquin adobe sunburst	*Pseudobahia peirsonii*	Associated with upland habitat
San Joaquin woolly-threads	*Monolopia congdonii*	Associated with grassland and scrub habitats
Santa Clara Valley dudleya	*Dudleya setchellii*	Associated with upland habitat
Santa Cruz tarplant	*Holocarpha macradenia*	Associated with grassland habitat
Showy Indian clover	*Trifolium amoenum*	Associated with grassland habitat
Slender Orcutt grass	*Orcuttia tenuis*	Associated with vernal pools
Solano grass	*Tuctoria mucronata*	Associated with vernal pools
Springville clarkia	*Clarkia springvillensis*	Associated with oak woodland habitat
Succulent owl's-clover	*Castilleja campestris ssp. succulenta*	Associated with vernal pools
Tiburon paintbrush	*Castilleja ssp. neglecta*	Associated with upland habitat

TABLE 2
Listed species potentially affected by implementation of CVP-OCAP

Common Name	Scientific Name	Status	Critical Habitat
MAMMALS			
Riparian brush rabbit	*Sylvilagus bachmani riparius*	E	No
Riparian woodrat	*Neotoma fuscipes riparia*	E	No
Salt marsh harvest mouse	*Reithrodontomys raviventris*	E	No
BIRDS			
Bald eagle	*Haliaeetus leucocephalus*	T	No
California clapper rail	*Rallus longirostris obsoletus*	E	No
REPTILES			
Giant garter snake	*Thamnophis gigas*	T	No
AMPHIBIANS			
California red-legged frog	*Rana aurora draytonii*	T	No
INVERTEBRATES			
Valley elderberry longhorn beetle	*Desmocercus californicus dimporphus*	T	Yes
PLANTS			
Soft bird's beak	*Cordylanthus mollis ssp. mollis*	E	No
Suisun thistle	*Cirsium hydrophilum var. hydrophilum*	E	No

Study Period

This BA evaluates the future effects of continued operation of the CVP and SWP in accordance with CVP-OCAP. The study period encompasses the current (circa 2001) level of development through a projected future level of development expected in approximately 2020.

Consultations to Date

Reclamation consulted with the Service on the effects of implementing the long-term operations criteria and plan for the CVP and SWP on listed species in 1993 (Service 1993). The resulting Biological Opinion (Service 1993), concluded that implementation of CVP-OCAP would not jeopardize the continued existence of the bald eagle, salt marsh harvest mouse or California clapper rail. No critical habitat had been designated for these species at

the time of the consultation and therefore the proposed action was not found to have an adverse effect on critical habitat.

Species Accounts

The following describes the life history and habitat requirements of the species evaluated in this BA. These species accounts were largely derived from species accounts prepared by the Service or California Department of Fish and Game (CDFG) and available at http://sacramento.fws.gov, http://ventura.fws.gov, http://arnica.csustan.edu/esrpp/eslist.htm and http://www.dfg.ca.gov/hcpb/species/t_e_spp/tespp.shtml.

Bald Eagle

Bald eagles occur as year-round and winter residents in California. They are almost always associated with large waterbodies. In California, nesting territories usually are found in mixed conifer and ponderosa pine forests and are always associated with a lake, river, or other large body of water. Nests are typically a platform structure constructed in dominant or co-dominant trees within 1 mile of water with unobstructed views of the water body. Snags and dead-topped trees provide perch and roost sites for the nesting birds. Individuals usually nest in the same territories each year and often reuse the same nest. Breeding occurs from January through July, with peak activity from March to June. Bald eagles are monogamous, and both the male and female tend the nests. A clutch size of two eggs is typical.

Bald eagles winter along rivers, lakes, or reservoirs with abundant prey and adjacent snags or mature trees for perch sites. Mature trees or snags with an open branching structure that are isolated from human disturbance are used for roosting during winter. Bald eagles often roost communally during the winter. The most important component of bald eagle wintering habitat is an adequate food source. Bald eagles predominantly forage on fish but also will prey on waterfowl.

Hundreds of migratory bald eagles from nesting areas in northwestern states and provinces spend the winter in California, arriving during fall and early winter. These wintering birds may remain until February or March, or even into April. In late winter, some adult bald eagles in California have already started nesting, while other eagles have not yet returned to their more nesting territories north or northeast. Some of the adults that winter here have been tracked to their nesting territories in north-central Canada 2,000 miles away.

California Clapper Rail

The California clapper rail is a year-round resident, that is endemic to tidally influenced salt and brackish marshes in California. Areas used by California clapper rails are dominated by pickleweed (*Salicornia virginica*), cordgrass (*Spartina foliosa*) and salt grass in the lower tidal zone and taller pickleweed, gum plant (*Grindelia cuneifolia*), and wrack (the area where debris is deposited) in the upper tidal zone. They also can occupy habitats with other vegetative components, including bulrush (*Scirpus americanus* and *S. maritimus*), cattails (*Typha spp*.), and Baltic rush (*Juncus balticus*). Shrubby areas adjacent to or within the marsh

may be important for predator avoidance during high tides. Nesting also occurs in this habitat.

Clapper rails are most active in early morning and late evening, when they forage in marsh vegetation in and along creeks and mudflat edges. They are highly opportunistic feeders; principal prey includes eating crabs, mussels, spiders, clams, snails, aquatic insects, isopods, pickleweed and Pacific cordgrass vegetation, seeds, and small fish. They often roost at high tide during the day.

The breeding season begins by February. Nesting starts in mid-March and extends into August. The end of the breeding season is typically defined as the end of August, which corresponds with the time when eggs laid during re-nesting attempts have hatched and young are mobile. Clutch sizes range from 5 to 14 eggs. Both parents share in incubation and rearing. Nests are placed to avoid flooding by tides, yet in dense enough cover to be hidden from predators, generally on raised ground near tidal sloughs in low marsh habitats. The young are semiprecocial, incapable of moving from the nest for at least 1 hour after hatching and are brooded by the adults for several days. The young follow the adults during foraging and are able to forage independently on small prey soon after hatching.

Salt Marsh Harvest Mouse

The salt marsh harvest mouse is endemic to the salt and brackish marshes of the San Francisco Bay area and adjacent tidally influenced areas. Salt marsh harvest mice are critically dependent on dense cover and their preferred habitat is pickleweed. However, harvest mice can use a broader source of food and cover, including salt grass (*Distichlis spicata*) and other vegetation typically found in the salt and brackish marshes of the region. Harvest mice are seldom found in cordgrass or alkali bulrush. In marshes with an upper zone of peripheral halophytes (salt-tolerant plants), mice use this vegetation to escape the higher tides, and may even spend a considerable portion of their lives there. Mice also move into the adjoining grasslands during the highest winter tides. During the spring and summer months, some individuals will move from pickleweed marsh to bordering grasslands.

Breeding occurs from March through November. The salt marsh harvest mouse does little nest building, and nest structures are generally composed of a loose arrangement of grass. One or two litters may be produced annually with three to four young per litter.

Riparian Brush Rabbit

The riparian brush rabbit is a small cottontail that is secretive by nature. Riparian brush rabbits prefer dense, brushy areas of valley riparian forests, marked by extensive thickets of wild rose (*Rosa* spp.), blackberries (*Rubus* spp.), and willows (*Salix* spp.). For the most part, riparian brush rabbits remain hidden under protective shrub cover. They seldom venture more than a few feet from cover. A typical response to danger is to retreat back into cover rather than to be pursued in open areas.

Riparian brush rabbits feed at the edges of shrub cover rather than in large openings. Their diet consists of herbaceous vegetation, such as grasses, sedges, clover, forbs, and buds, bark,

and leaves of woody plants. They consume herbaceous plants found along trails, fire breaks, or at the edge of brushy areas, and they eat the leaves, bark, and buds of many types of woody shrubs and vines within and at the edges of thickets.

The approximate breeding season of riparian brush rabbits occurs from January to May. Although males are capable of breeding all year long, females are only receptive during this period. In favorable years, females may produce 3 or 4 litters. The young are born in a shallow burrow or cavity lined with grasses and fur and covered by a plug of dried vegetation. Although these rabbits have a high reproductive rate five out of six rabbits typically do not survive to the next breeding season.

Riparian Woodrat

Riparian woodrats are most numerous where shrub cover is dense and least abundant in open areas. In riparian areas, highest densities of woodrats and their houses are often encountered in willow thickets with an oak overstory. They are common where there are deciduous valley oaks, but few live oaks. Mostly active at night, the woodrat's diet is diverse and principally herbivorous, with leaves, fruits, terminal shoots of twigs, flowers, nuts, and fungi. They are most numerous where shrub cover is dense and least abundant in open areas.

Woodrats are well known for their large terrestrial stick houses some of which can last for 20 or more years after being abandoned. At Caswell Memorial State Park, riparian woodrats make houses of sticks and other litter. Houses typically are placed on the ground against or straddling a log or exposed roots of a standing tree and are often located in dense brush. Nests also are placed in the crotches and cavities of trees and in hollow logs. Sometimes arboreal nests are constructed but this behavior seems to be more common in habitat with evergreen trees such as live oak. With their general dependence on terrestrial stick houses, riparian woodrats can be vulnerable to flooding.

Woodrats live in loosely-cooperative societies and have a matrilineal (mother-offspring associations; through the maternal line) social structure. Unlike males, adjacent females are usually closely related and, unlike females, males disperse away from their birth den and are highly territorial and aggressive, especially during the breeding season. Consequently, populations are typically female-biased and, because of pronounced polygyny (mating pattern in which a male mates with more than one female in a single breeding season), the effective population size (i.e., successful breeders) is generally much smaller than the actual population size. This breeding system in combination with the small size of the only known extant population suggests that the riparian woodrat could be at an increased risk of extinction because of inbreeding depression.

California Red-legged Frog

The California red-legged frog is the largest native frog in the western United States. It is endemic to California and Baja California, Mexico. This species use a variety of habitat aquatic, riparian, and upland habitats including ephemeral ponds, intermittent streams, seasonal wetlands, springs, seeps, permanent ponds, perennial creeks, man-made aquatic features, marshes, dune ponds, lagoons, riparian corridors, blackberry thickets, annual

grasslands, and oak savannas. The common factor in all habitats used by red-legged frogs is an association with a permanent water source.

Breeding sites have been documented in a wide variety of aquatic habitats. Larvae, juveniles and adults have been observed inhabiting streams, creeks, ponds, marshes, sag ponds, deep pools and backwaters within streams and creeks, dune ponds, lagoons, estuaries, and artificial impoundments such as stock ponds. Breeding has been documented in these habitat types irrespective of vegetative cover. Frogs often breed in artificial ponds with little or no emergent vegetation. The importance of riparian vegetation for this species is not well understood. It is thought that the riparian plant community may provide good foraging habitat and may facilitate dispersal in addition to providing pools and backwater aquatic areas for breeding.

Red-legged frogs disperse upstream and downstream of their breeding habitat to forage and seek shelter. Sheltering habitat for red-legged frogs potentially includes all aquatic, riparian, and upland areas within the range of the species and any landscape features that provide cover, such as existing animal burrows, boulders or rocks, organic debris such as downed trees and logs, and industrial debris. Agricultural features such as drains, watering troughs, spring boxes, abandoned sheds, or hay ricks may also be used.

California red-legged frogs breed from November through March with earlier breeding records occurring in southern localities. Individuals occurring in coastal drainages are active year-round, whereas those found in interior sites are normally less active during the cold season. Females attach egg masses to emergent vegetation such as tule stalks, grasses, or willow roots just below the water surface. Larvae hatch 6 to 14 days following fertilization and spend most of their time concealed in submergent vegetation or detritus. Most larvae metamorphose into juvenile frogs 4 to 7 months after hatching, generally between July and September.

The diet of California red-legged frogs is highly variable. Larvae probably eat algae. Invertebrates are the most common food items of adult frogs. Vertebrates, such as Pacific tree frogs (*Hyla regilla*) and California mice (*Peromyscus californicus*), are frequently eaten by larger frogs. Feeding activity likely occurs along the shoreline and on the surface of the water.

Giant Garter Snake

The giant garter snake is one of the largest garter snakes of the genus *Thamnophis*, with a total length up to 4.5 feet or greater. This highly aquatic snake is endemic to the freshwater emergent wetlands of the Central Valley. The larger rivers of Central Valley probably provided suitable habitat for giant garter snakes at one time. However, with the removal of oxbows and backwater areas as a result of channelization for flood control, the larger rivers no longer support suitable habitat for giant garter snakes.

The giant garter snake occurs in a combination of permanent and seasonal freshwater habitats and conducts most of its activities within the immediate vicinity of water. The habitat components most important to giant garter snake survival are: (1) water, including permanent water that persists through the summer months; (2) emergent aquatic vegetation and vegetated banks for cover; and (3) an abundant food supply. The giant garter snake

specializes in aquatic prey, including small fish and frogs, carp, mosquitofish, bullfrogs and treefrogs. Much of the historic wetlands of the Central Valley inhabited by giant garter snakes have been lost. However, the giant garter snake has been found to inhabit rice and waterways associated with agricultural production, such as irrigation and drainage canals.

Irrigation ditches and drains appear to provide valuable giant garter snake habitat as long as they have: (1) enough water during the active summer season to supply food and cover (minimum April - July; optimum March - October); (2) grassy banks for basking; (3) emergent vegetation for cover during the active season (March - October); and (4) nearby high ground or uplands that provide cover and refuge from flood waters during the dormant season (October - March). Giant garter snakes move around to find suitable habitat as conditions in the rice fields, marshes, and canals and ditches change, especially during the dry summer months. Thus, connectivity between canals and ditches in different areas and between these systems and other habitat types is extremely important for genetic interchange and ability to find summer habitat.

Giant garter snakes require suitable areas for basking near to water. Basking occurs on banks of canals and levees, on broken down tules in the water, in branches of willows or saltbush over water, on the ground at water's edge in concealing vegetation, and on dead snags. Basking sites need to be open to sunlight (not beneath heavy riparian vegetation) but ideally should have sufficient cover to escape from predators and allow for thermoregulation. Preferred basking sites are located adjacent to escape cover, including water or vegetation.

Giant garter snakes are active during the spring and summer (starting in March or April) but inactive in the winter. By the end of October, snakes begin entering their winter retreats which can include small mammal burrows on the sides of levees, ditches and drains, railroad embankments, and other upland habitats, as well as man-made structures, such as piles of large rocks or rip rap. Giant garter snakes have been found overwintering up to 200 yards from the shoreline of summer habitat. Burrows, vegetation, and other shelter from predators enhance the suitability of overwintering sites.

Valley Elderberry Longhorn Beetle

The valley elderberry longhorn beetle (VELB) is endemic to the Central Valley of California. The VELB is entirely dependent on elderberry (*Sambucus* species) shrubs for reproduction and survival. Females lay their eggs on the bark. After hatching larvae burrow into the stems where they grow and develop for up to two years. At the end of the larval stage, the larvae exit the elderberry stem, enter the pupal stage and transform into adults. Adults are active from March to June, feeding and mating during this time.

This beetle is nearly always found on or close to its host plant. It appears that in order to serve as habitat, the elderberry shrub must have stems that are 1.0 inch or greater in diameter at ground level. Use of the plants by the animal is rarely apparent. Frequently, the only exterior evidence of the beetle is an exit hole created in the shrub by the larva just before the pupal stage. Field work along the Cosumnes River and in the Folsom Lake area suggests that larval galleries can be found in elderberry stems with no evidence of exit

holes. The larvae either succumb before constructing an exit hole or are not far enough along in the developmental process to construct an exit hole.

Critical Habitat for VELB was designated in 1980 (45 FR 52803) and consists of two zones:

- Sacramento Zone. An area in the city of Sacramento enclosed on the north by the Route 160 Freeway, on the west and southwest by the Western Pacific railroad tracks, and on the east by Commerce Circle and its extension southward to the railroad tracks.
- American River Parkway Zone. An area of the American River Parkway on the south bank of the American River, bounded on the north by latitude 38 37'30" N, and on the South and east by Ambassador Drive and its extension north to latitude 38 37'30" N, Goethe Park, and that portion of the American River Parkway northeast of Goethe Park, west of the Jedediah Smith Memorial Bicycle Trail, and north to a line extended eastward from Palm Drive.

Suisun Thistle

Suisun thistle is a perennial herb in the aster family (Asteraceae). It has slender, erect stems that are 3.0 to 4.5 feet tall and well branched above. Pale lavender-rose flower heads, 1 inch long, grow singly or in loose groups. Flowers appear between July and September. Suisun thistle grows in the upper reaches of tidal marshes of the San Francisco Bay/Estuary, where it is associated with narrowleaf cattail (*Typha angustifolia*), three-square or American bulrush (*Scirpus americanus*), Baltic rush (*Juncus balticus*) and saltgrass.

Soft Bird's-beak

Soft bird's-beak is an annual herb of the snapdragon family (Scrophulariaceae). It grows 10 to 16 inches tall, branching sparingly from the middle and above. A floral bract (modified leaf) with two to three pairs of lobes occurs immediately below each inconspicuous white or yellowish-white flower. Flowers appear between July and September. Like other members of *Cordylanthus* and related genera, soft bird's-beak is partially parasitic on the roots of other plants. Soft bird's-beak is found predominantly in the upper reaches of salt grass/pickleweed marshes of the San Francisco Bay/Estuary at or near the limits of tidal action. It is associated with pickleweed or Virginia glasswort (*Salicornia virginica*), saltgrass, fleshy or marsh jaumea (*Jaumea carnosa*), alkali seaheath (*Frankenia salina*) and seaside arrowgrass (*Triglochin maritima*).

Environmental Baseline and Status of the Species in the Action Area

The following describes the population status and distribution of each species throughout its range and in the action area. Information in this section was largely derived from information compiled by the Service and CDFG and available at http://sacramento.fws.gov, http://ventura.fws.gov, http://arnica.csustan.edu/esrpp/eslist.htm, and http://www.dfg.ca.gov/hcpb/species/t_e_spp/tespp.shtml.

Bald Eagle

The bald eagle ranges over much of the northern portion of the American continent. During the 19th century, bald eagle populations declined in California and elsewhere from shooting, pesticides, and human encroachment leading to loss of habitat. Exposure to organochlorine pesticides after World War II led to decreased reproduction. Legal protection, the banning of DDT, and habitat management has resulted in an increasing breeding population in California and elsewhere in the United States. The following population status information for the bald eagle was obtained from http://www.dfg.ca.gov/hcpb/species/t_e_spp/tespp.shtml and associated links.

The breeding population of bald eagles in the lower 48 states has shown steady improvements since its federal listing. In 1963, the number of breeding pairs was reported as 417. In 1999, the number of nesting pairs in the lower 48 states was estimated at just over 6,000. The wintering population is considered to be stable or increasing.

Historically, bald eagles were widespread and abundant in California, but no historical information exists on population size. By the late 1960s and early 1970s, when the bald eagle was listed as an endangered species, fewer than 30 nesting pairs remained in California and were only in the northern third of the State. With protection under the ESA and the banning of DDT, the population of bald eagles began to increase in California as it did in other parts of its range. In 1999, there were 188 known territories of which 151 were occupied.

This population increase has been accompanied by an increase in the distribution of nesting eagles in the California. In 1977, bald eagles nested in only eight counties in the northern portion of the state. In recent years, bald eagles have been found nesting in 28 of the State's 58 counties. Most of the territories are still in the northern portion of the state. Productivity of the State's population has been good each year, averaging slightly more than 1.0 fledglings per nesting pair during the 1990s. In the action area, nesting territories occur at Shasta Reservoir, Claire Engle Reservoir, Whiskeytown Reservoir, Oroville Reservoir and at a few locations along the upper Sacramento River near the Shasta-Tehama county line. There are about 20 territories at Shasta Reservoir, 3 at Oroville Reservoir, 3 along the upper Sacramento River, 2 at Whiskeytown Reservoir and about 7 at Clair Engle Reservoir.

The annual, nationwide Midwinter Bald Eagle Survey indicates that the State's winter population exceeds 1,000 birds in some winters and appears to be at stable, although exact numbers vary from year to year. Typically, about half of the State's wintering bald eagles are found in the Klamath Basin along the California-Oregon border. This area supports the largest winter concentration of bald eagles in the lower 48 states. In addition, bald eagles winter at lakes, reservoirs, and along major river systems throughout most of central and northern California and in a few southern California localities. Small numbers of bald eagles are regularly observed during winter at Folsom and Oroville Reservoirs. Bald eagles occasionally are observed along the upper Sacramento River during winter.

California Clapper Rail

The California clapper rail is endemic to California and was historically found in tidally influenced salt and brackish marshes in coastal central and northern California. Once found from Humboldt Bay, Humboldt County to Morrow Bay, San Luis Obispo County, California clapper rails are now restricted almost entirely to the marshes of the San Francisco estuary, where the only known breeding populations occur. Use of brackish marshes by clapper rails is largely restricted to major sloughs and rivers of San Pablo Bay and Suisun Marsh, and along Coyote Creek in south San Francisco Bay.

Suitable habitat for California clapper rails has been reduced by approximately 84 percent from historic levels in the San Francisco Bay area due to habitat conversions for urban and agricultural uses, and is a primary factor in the species' decline. Additional factors that have contributed to the decline in clapper rail populations include overharvesting, environmental contamination, and erosion or subsidence of habitat. Throughout the Bay, the remaining clapper rail population is at risk from mammal and bird predators. Several native and nonnative predator species are known to prey on the clapper rail or its eggs. Mercury accumulation in eggs is perhaps the most significant contaminant problem affecting clapper rails in San Francisco Bay.

A preliminary indication from the 1997-98 winter high tide counts in the eastern shore of the south San Francisco Bay is that the south bay population may have increased. Based on winter counts from 1996-97, the south bay population was estimated at 500 to 600 birds. The north bay population is believed to be similar in size (http://www.dfg.ca.gov/hcpb/species/t_e_spp/tespp.shtml).

Salt Marsh Harvest Mouse

The historic range of the salt marsh harvest mouse included tidal marshes within the San Francisco and San Pablo Bay areas, east to the Collinsville-Antioch area. The northern subspecies (*R. r. halicoetes*) inhabited marshes fringing San Francisco, San Pablo and Suisun bays north from Gallinas Creek. The southern subspecies was found along both sides of San Francisco Bay in the central and south regions. At present, the distribution of the northern subspecies is along Suisun and San Pablo Bays north of Point Pinole in contra Costa County and Point Pedro in Marin County. The southern subspecies is currently found in marshes in Corte Madera, Richmond, and South San Francisco Bay, mostly south of the San Mateo Bridge.

Salt marsh harvest mouse populations have presumably declined with the loss of habitat. Only a small portion of the tidal marsh that bordered San Francisco Bay in the mid-1800s remains. The suitability of many marshes for salt marsh harvest mice is further limited, and in some cases precluded, by their small size, fragmentation, and lack other habitat features. Because salt marsh harvest mice live in a tidally influenced environment, oil from spills also poses a threat. Spilled oil can have a direct effect on these mice through ingestion or soiling of fur or indirect effects by modifying the salt-marsh environment in which they live. The effect of heavy metals in soils and plants on salt marsh harvest mice is unknown. Although information is available on the presence of harvest mice in various parts of its range, little data is available regarding harvest mice population size and spatial and temporal dynamics.

Riparian Brush Rabbit

Historically, riparian brush rabbit are known to have occurred in riparian forests along the San Joaquin River and Stanislaus Rivers in Stanislaus and San Joaquin counties. They probably also occupied streamside communities along the other tributaries of the San Joaquin River on the Valley floor. One population estimate is that about 110,000 individuals occurred in this historic range.

The dramatic decline of the riparian brush rabbit began in the 1940s with the building of dams, constructed for irrigation and flood control, on the major rivers of the Central Valley. Protection from flooding resulted in conversion of floodplains to croplands and the consequent reduction and fragmentation of remaining riparian communities. The most serious problem, however has been the lack of suitable habitat above the level of regular floods where the animals can find food and cover for protection from weather and predators.

Today, the largest remaining fragment of habitat and only extant population are found along the Stanislaus River in Caswell Memorial State Park in San Joaquin County, California. No other sightings of riparian brush rabbits outside the Park have been reported in over 40 years. The last population estimate was 213 to 312 individuals at Caswell MSP in January 1993. Anecdotal information suggested that the population declined when more than 80 percent of the Park flooded in January 1997.

Aside from the periodic threats from flooding, wildfire poses a major threat due to long-term fire suppression in the Park and the consequent increase in fuel from dead leaves, woody debris, and decadent, flammable shrubs. Other factors that could affect this population are diseases common to rabbits in California, such as tularemia, plague, myxomatosis, silverwater, encephalitis, listeriosis, Q-fever, and brucellosis. Competition with desert cottontail potentially is another threat.

Riparian Woodrat

The riparian woodrat is the only subspecies of woodrat found on the floor of the Central Valley. The type locality for the riparian woodrat is Kincaid's Ranch, about 2 miles northeast of Vernalis in Stanislaus County, California. Historically, it could have ranged as far as southern Merced County or northern Fresno County

The range of the riparian woodrat is far more restricted today than it was historically. The only population that has been verified is the single, known extant population restricted to about 250 acres of riparian forest on the Stanislaus River in Caswell Memorial State Park. In 1993, the estimated size of this population was 437 individuals.

The amount and extent of riparian habitat in the San Joaquin Valley has declined substantially and the loss and fragmentation of habitat are the principal reasons for the decline of the riparian woodrat. Much of this loss was the result of the construction of large dams and canals which diverted water for the irrigation of crops and permanently altered the hydrology of valley streams. More was lost through cultivation of the river bottoms. Historically, cattle also probably impacted riparian woodrat populations since the thick undergrowth, which is particularly important to woodrats, is sensitive to trampling and browsing and grazing by livestock.

California Red-legged Frog

The historic range of the California red-legged frog extended along the coast from the vicinity of Point Reyes National Seashore, Marin County, California, and inland from the vicinity of Redding, Shasta County, California, southward to northwestern Baja California, Mexico. The species no longer occurs in approximately 75 percent of its former range. California red-legged frogs have been documented in 46 counties in California, but now remain in only 238 streams or drainages in 31 counties. They are still locally abundant along coastal California between the San Francisco Bay area and Ventura County. Within the remaining distribution of the species, only isolated populations have been documented in the Sierra Nevada, northern Coast, and northern Transverse ranges. The species is believed to be extirpated from the southern Transverse and Peninsular ranges, but is still present in Baja California, Mexico. California red-legged frogs population numbers are not precisely known, although the Service believes that many California red-legged frog populations are declining throughout the range of the subspecies.

In the action area, red-legged frogs have been extirpated from the floor of Central Valley and largely extirpated from the Sierra Nevada foothills. In the Sierra Foothills, Jack and Indian Creeks in Butte County and North Fork Weber Creek in El Dorado County still support red-legged frogs (Service 2000a). These creeks are upstream from CVP and SWP facilities. The species is nearly extirpated in the North Coast Range/West Sacramento Valley with the only potentially remaining population in the vicinity of Clear Lake. The North Coast/North San Francisco Bay area supports significant numbers of red-legged frogs in small coastal drainages, ponds, and man-made stock ponds in portions of Marin, Sonoma, Solano and Napa counties. The southern and eastern San Francisco Bay similarly appears to support relatively large numbers of red-legged frogs although the species appears to have been nearly extirpated from lowland portions of Contra Costa and Alameda counties.

Habitat loss and alteration, combined with over exploitation and introduction of exotic predators, were significant factors in the red-legged frog's decline in the early to mid-1900s. The California red-legged frog is threatened within its remaining range by a wide variety of human activities, many of which operate concurrently and cumulatively with each other and with natural disturbances (e.g., droughts and floods). Current factors associated with declining populations of the red-legged frog include degradation and loss of habitat

through urbanization, mining, improper management of grazing, recreation, invasion of nonnative plants, impoundments, water diversions, degraded water quality, and introduced predators. Organophosphorus pesticides from agricultural areas on the San Joaquin Valley floor appear to be transported to the Sierra Nevada on prevailing summer winds, and also could be affecting populations of amphibians that breed in mountain ponds and streams. These factors have resulted in the isolation and fragmentation of habitats within many watersheds. The fragmentation of existing habitat, and the continued colonization of existing habitat by nonnative species, may represent the most significant current threats to California red-legged frogs.

Giant Garter Snake

The following description of the current status and distribution of the giant garter snake was derived from the Service's (2002) Biological Opinion on Interim Water Contract Renewals, March 2, 2002 – February 29, 2004.

The giant garter snake is endemic to the Central Valley and historically, inhabited the estimated 4.1 million acres of flood basins, freshwater marshes, and small tributary streams along the length of the Central Valley. Surveys over the last two decades have located the giant garter snake as far north as the Butte Basin in the Sacramento Valley. Currently, the Service recognizes 13 separate populations of giant garter snakes, with each population representing a cluster of discrete locality records. The 13 extant population clusters largely coincide with historical riverine flood basins and tributary streams throughout the Central Valley: (1) Butte Basin, (2) Colusa Basin, (3) Sutter Basin, (4) American Basin, (5) Yolo Basin–Willow Slough, (6) Yolo Basin–Liberty Farms, (7) Sacramento Basin, (8) Badger Creek--Willow Creek, (9) Caldoni Marsh, (10) East Stockton--Diverting Canal and Duck Creek, (11) North and South Grasslands, (12) Mendota, and (13) Burrel/Lanare. These populations span the Central Valley from just southwest of Fresno (i.e., Burrel-Lanare) north to Chico (i.e., Hamilton Slough). The 11 counties where the giant garter snake is still presumed to occur are: Butte, Colusa, Glenn, Fresno, Merced, Sacramento, San Joaquin, Solano, Stanislaus, Sutter and Yolo. All 13 population clusters are isolated from each other with no protected dispersal corridors. Opportunities for recolonization of small populations which may become extirpated are unlikely given the isolation from larger populations and lack of dispersal corridors between them.

The current distribution and abundance of the giant garter snake are much reduced from former times. Agricultural and flood control activities have extirpated the giant garter snake from the southern one third of its range in former wetlands associated with the historic Buena Vista, Tulare, and Kern lake beds. These lake beds once supported vast expanses of giant garter snake habitat, consisting of cattail and bulrush dominated marshes. Extensive bulrush and cattail floodplain habitat also typified much of the Sacramento Valley historically. Prior to reclamation activities beginning in the mid to late 1800's, about 60 percent of the Sacramento Valley was subject to seasonal overflow flooding in broad, shallow flood basins that provided expansive areas of giant garter snake habitat. All natural habitats have been lost and an unquantifiable small percentage of semi-natural wetlands remain extant. Only a small percentage of these wetlands currently provide habitat suitable for the giant garter snake. Although some giant garter snake populations have persisted in

artificial wetlands associated with agricultural and flood control activities, many of these altered wetlands are now threatened with urban development. Cities within the current range of the giant garter snake that are rapidly expanding include: (1) Chico, (2) Yuba City/Marysville, (3) Sacramento, (4) Galt, (5) Stockton, (6) Gustine, and (7) Los Banos.

San Joaquin Valley sub-populations of giant garter snakes have suffered severe declines and possible extirpations over the last two decades. Prior to 1980, several areas within the San Joaquin Valley supported populations of giant garter snakes. Until recently, there were no post-1980 sightings from Stockton, San Joaquin County, southward, despite several survey efforts. Surveys during 1995 and 1999 revealed as small number of snakes principally in the North Grasslands, in Los Banos Creek, Volta Wildlife Management Area, and Mendota Wildlife area. Snake abundance in the San Joaquin Valley seemed extremely low in comparison to study areas in the Sacramento Valley. The recent survey data indicate that giant garter snakes are still extant in two localities within the San Joaquin, but in extremely low to undetectable numbers.

Selenium contamination and impaired water quality could be a contributing factor in the decline of giant garter snake populations, particularly for the North and South Grasslands subpopulation (i.e., Kesterson NWR area). The bioaccumulative food chain threat of selenium contamination on fish, frogs, and fish-eating birds has been well documented. Though there is little data specifically addressing toxicity of selenium (Se), mercury (Hg), or metals to reptiles, it is expected that reptiles would have toxicity thresholds similar to those of fish and birds.

Valley Elderberry Longhorn Beetle

The VELB is endemic to the Central Valley of California. It has been found as far north as the Shasta-Tehama County line and south to southern San Joaquin valley. Its east-west range extends into the foothills of the Sierra Nevada and the Coast Range up to an elevation of about 3,000 feet. The beetle appears to be patchily distributed, being locally common in some areas while absent in other areas of apparently suitable habitat.

Elderberry shrubs are a common component of riparian habitats in the Central Valley and occur throughout the action area in association with CVP/SWP waterways. Exit holes which are indicative of occupancy by VELB have been observed at many locations along project waterways, including the American River and Sacramento Rivers. The overall population status and trend however, is uncertain.

Extensive destruction of California's Central Valley riparian forests has occurred during the last 150 years due to agricultural and urban development. According to some estimates, riparian forest in the Central Valley declined by as much as 89 percent during that time period. The VELB is believed to have declined due to human activities that have resulted in widespread alteration and fragmentation of riparian habitats, and to a lesser extent, upland habitats, which support the beetle.

Among the threats to habitat for the VELB are:

- loss and alteration of habitat by agricultural conversion
- inappropriate grazing practices

- levee construction, stream and river channelization, removal of riparian vegetation and rip-rapping of shoreline
- nonnative animals such as the Argentine ant, which may eat the early phases of the beetle
- recreational, industrial and urban development.

Insecticide and herbicide use in agricultural areas and along road right-of-ways also could limit the beetle's occurrence in some areas.

Suisun Thistle

The Suisun thistle is restricted to Suisun Marsh in Solano County. In Suisun Bay, most of the estimated 71,100 acres of tidal marshes that existed in 1850 were converted to agricultural land and then to diked seasonal wetlands used for waterfowl management. Only 9,340 acres within Suisun Marsh remain as tidal marsh. Most of the remaining tidal marshes are backed by steep levees, allowing for little or no transitional wetland habitat required by Suisun thistle. In 1975, the plant was reported as possibly extinct because it had not been collected for about 15 years. Extensive surveys, however, relocated the thistle. Collectively, the current occurrences of Suisun thistle total a few thousand plants. Two populations are on California Department of Fish and Game lands and a third occurrence is on Solano County Farmland and Open Space Foundation lands.

Indirect effects from urban development, mosquito abatement activities, competition and potential hybridization with nonnative plants, water pollution, upstream withdrawals of fresh water and projects that alter natural tidal regime threaten Suisun thistle. Its highly restricted distribution increases its susceptibility to random catastrophic events such as disease or pest outbreak, severe drought, oil spills or other natural or human caused disasters.

Soft Bird's-beak

Soft bird's-beak is restricted to tidal marshes of the San Francisco Bay area. There are 19 confirmed locations of soft-bird's beak. Five sites have been extirpated by habitat loss or modification. Five other sites surveyed in 1993 no longer supported the plant, although potential habitat still existed. The remaining nine sites are presumed to be extant. These occupied sites are widely scattered throughout coastal salt or brackish tidal marshes fringing San Pablo and Suisun Bays, in Contra Costa, Napa, and Solano counties. Of the extant population sites, one (McAvoy) has only 23 plants and three sites (Point Pinole, Rush Ranch and Joice Island Bridge) have very limited habitat, covering less than 1 acre each. The population at Fagan Slough covers approximately 3 acres and the two largest populations at Hill Slough and at Concord Naval Weapons Station, each cover about 10 acres.

Habitat conversion, water pollution, increases in salinity of tidal marshes due to upstream withdrawals of fresh water, habitat fragmentation, indirect effects of urbanization, competition with nonnative vegetation, insect predation, projects that alter natural tidal

regime, mosquito abatement activities (including off-road vehicle use), erosion, and naturally occurring events variously threaten the remaining occurrences of soft bird's-beak.

Effects of the Proposed Action

Bald Eagle

In the action area, bald eagles nest at Shasta, Clair Engle, Whiskeytown, and Oroville reservoirs as well as at several locations along the upper Sacramento River. At Shasta Reservoir, Reclamation reported a long-term positive correlation between bald eagle productivity (number of young produced per occupied nest) and the average water surface elevation during April through June in the 1992 BA for CVP-OCAP (Reclamation 1992). To support the evaluation for this BA, the relationship between nesting productivity of eagles at Shasta Reservoir and lake levels was re-evaluated with inclusion of the most recent data for eagles at Shasta Reservoir. Statistically significant relationships were found between several measures of bald eagle reproduction (number of young fledged, number of successful nests, and number of active nests) and average water surface elevation during April through June. The best fit relationship was between the number of active nests and average water surface elevation ($p = 0.0007$, $r^2 = 0.375$, $n = 27$) and was the following

$$\text{\# active nests} = 0.05*(\text{water surface elevation in feet msl}) - 40.766$$

This linear relationship was used to estimate potential effects to bald eagles from changes in the water surface elevation at Shasta Reservoir from implementation of CVP-OCAP between the current and future level of development.

With implementation of the proposed action, the average water surface elevation at Shasta Reservoir during April through June would decline slightly at the future level of development (Figure 1). Based on the relationship between the number of active nests and water surface elevation, the proposed action could result in a very slight decline in the number of active nests (Figure 2). On average, the relationship between the number of active nests and water surface elevation predicts a reduction of 0.1 active nests with a maximum reduction in one year of 0.7 nests. This small potential change would not substantially adversely affect bald eagles.

The relationship between lake levels and bald eagle nesting attempts or productivity have not been investigated at the other CVP and SWP reservoirs where bald eagles nest. For this analysis, bald eagle productivity is assumed to be correlated with average surface elevation during April through June at these other reservoirs as is the case at Shasta Reservoir. At the future level of development the average, surface elevations at Clair Engle, Whiskeytown and Oroville reservoirs would show only small changes from the current level of development (Figures 3, 4, 5). These small changes would not be expected to adversely affect the number or reproductive success of bald eagles nesting at these reservoirs.

California Clapper Rail

California clapper rails are endemic to salt and brackish marshes of San Francisco Bay. The amount of freshwater inflow to the Bay can influence the extent and characteristics of salt and brackish marshes as well as affect the concentrations and residency times of various contaminants discharged to the Bay (Service 1993). In particular, if freshwater inflows to the Bay are reduced, the extent of salt and brackish marshes could be reduced and/or clapper rails could be exposed to higher concentrations of contaminants such as silver, copper, mercury, and selenium. These contaminants can have toxicological effects in birds (Service 2000b).

Predicted Delta inflow, Delta outflow and the location of the 2 parts per thousand isohaline (X2) in the San Francisco Bay/Estuary were used to assess effects of implementation of CVP-OCAP at the future level of development relative to current level of development. Figures 6 and 7 show the predicted exceedance probabilities of total Delta outflow and total Delta inflow, respectively for the current and future level of development. Figures 8 through 12 show the predicted average monthly start position of X2 for the current and future level of development in several water year types. These figures show only very small differences in Delta inflow, Delta outflow and X2 between the current and future level of development indicating that implementation of the proposed action would not substantially change hydrologic conditions in the Delta and Bay. Because hydrologic conditions in the Delta would be substantially similar under the future level of development, the extent of salt and brackish marsh would not be affected and the risk of exposure of clapper rails to harmful levels of contaminants would not change.

Salt Marsh Harvest Mouse

The salt marsh harvest mouse is endemic to the salt and brackish marshes of the San Francisco Bay area and adjacent tidally influenced areas. The extent and characteristics of salt and brackish marshes in the San Francisco Bay area are influenced by the amount of freshwater inflow. Freshwater inflow also can influence the concentration and residency time of various contaminants discharged to the Bay. The degree of exposure to contaminants and risk of toxicological effects to salt marsh harvest mice has not been determined.

Delta inflow, Delta outflow and the location of X2 were used to assess potential effects of the proposed action on salt marsh harvest mouse. As described for the California clapper rail, the future level of development is predicted to have only very small effects on these parameters. Thus, no substantial changes in the extent or characteristics of habitat for salt marsh harvest mouse or in potential exposure to contaminants are expected under the proposed action.

Riparian Brush Rabbit

Currently, the only known population of riparian brush rabbits is at Caswell Memorial State Park on Stanislaus River. Flooding is considered the greatest current threat to this population because of the limited amount of habitat that occurs above the regular high

water level. The proposed action could affect brush rabbits through changes in flows in the Stanislaus River that increase the frequency that the park is flooded or through long term hydrologic changes that could influence the extent and structure of riparian vegetation.

Flows in the Stanislaus River at the mouth were used to evaluate the potential effects of the proposed action on riparian brush rabbits. The proposed action would result in very small differences in Stanislaus River flows between the current level of development and the future level of development (Figure 13). These very small differences would not be expected to affect the extent or characteristics of riparian habitat at Caswell Memorial State Park. Peak flows would not differ between the current and future levels of development and therefore, the proposed action would not change the risk of the brush rabbit population at Caswell Memorial State Park to flooding.

Riparian Woodrat

The only known population of riparian woodrats is at Caswell Memorial State Park on the Stanislaus River. This species inhabits riparian areas of dense shrub cover. Although they may be more capable of escaping flood waters than riparian brush because or their ability to climb shrubs and trees, riparian woodrats also can be adversely affected by long-term flooding similar to riparian brush rabbits. Woodrats live in terrestrial stick houses. With the limited availability of suitable habitat above the regular high water level at Caswell Memorial State Park, riparian woodrats could be adversely affected by prolonged flooding.

As explained for the riparian brush rabbit, the proposed action would result in very small differences in Stanislaus River flows at the mouth between the current level of development and the future level of development (Figure 13). These very small differences would not be expected to affect the extent or characteristics of riparian habitat at Caswell Memorial State Park or alter the frequency or extent of flooding at the park.

California Red-legged Frog

The California red-legged frog can inhabit a wide range of terrestrial and aquatic habitats, but is always found in association with water. Historically, red-legged frogs occurred throughout the Central Valley, the Sierra Nevada foothills, and Coast Range. Currently, it has been extirpated from the valley floor and is nearly extirpated from the Sierra Nevada foothills. The only remaining occurrences of red-legged frogs in the Sierra Nevada foothill are in Jack, Indian and North Fork Weber creeks. These location are upstream of CVP/SWP facilities and therefore would not be affected by CVP/SWP operations.

Giant Garter Snake

Giant garter snakes inhabit freshwater wetlands, rice fields, and agricultural canals and ditches. The rivers of the project area generally do not provide suitable habitat for giant garter snakes because of the presence of shaded conditions created by woody riparian vegetation, absence of emergent vegetation and occurrence of predatory fish. As a result, the small changes in flows in CVP/SWP waterways under the proposed action are not likely to adversely affect giant garter snakes.

Valley Elderberry Longhorn Beetle

The valley elderberry longhorn beetle is dependent on elderberry shrubs. In the Central Valley, elderberry shrubs are a common component of riparian habitats. The proposed action has the potential to influence valley elderberry longhorn beetle through hydrologic changes that influence the distribution and persistence of elderberry shrubs.

Changes in flows on the American, Feather, Stanislaus, Sacramento, and San Joaquin Rivers were used to evaluate potential effects to valley elderberry longhorn beetle. The hydrologic modeling predicts that flows in these CVP/SWP waterways would not change substantially between the current level of development and future level of development. The following summarizes the changes predicted on each river.

- Predicted average Sacramento River flows as represented by Keswick release would decline slightly in nearly every month (Figure 14)
- Average Feather River flows as represented by Thermolito Afterbay release would increase slightly in summer months (June through August) and decrease slightly in other months. (Figure 15)
- Average American River flows as represented by Nimbus release are predicted to decline slightly in every month (Figure 16)
- Average Stanislaus River flows as represented by Tulloch release are predicted to be nearly identical under current and future levels of development (Figure 17)
- Average San Joaquin River flows at Vernalis are predicted to be nearly identical under current and future levels of development (Figure 18)

Although elderberry shrubs are often found in riparian areas in the Central Valley, they are considered have a high tolerance to drought and to have low moisture requirements relative to other plants in the region (USDA NRCS 2002). Considering these moisture requirements and tolerances, the small changes in flows in CVP/SWP waterways as a result of the proposed project would not be expected to adversely affect elderberry shrubs and correspondingly valley elderberry longhorn beetles. Similarly, no adverse effects to designated critical habitat would occur.

Suisun Thistle

The Suisun thistle grows in the upper reaches of tidal marshes and is currently restricted to Suisun Marsh. As a tidal marsh associated plant, this species is sensitive to changes in hydrology (i.e., changes in the timing and duration of inundation) and salinity. Figures 6 and 7 show minimal differences in Delta outflow and Delta inflow between the current and future level of development. These small differences would not be expected to materially affect the hydrology of Suisun Marsh. X2 provides an index to assess effects of the proposed action on salinity levels in Suisun Marsh. As shown in Figures 8 through 12, only very small differences in the location of X2 between the current and future level of development are predicted. These small differences would not be expected to adversely affect Suisun thistle.

Soft Bird's-beak

Soft bird's beak is plants found in the upper reaches of salt grass/pickleweed marshes. The proposed action could affect this species through hydrologic or salinity changes that influence the extent or characteristics of tidal marshes in the San Francisco Bay/Estuary. Delta outflow and Delta inflow would not change materially under the proposed action between the current and future level of development (Figures 6 and 7). Likewise, salinity levels as represented by X2 would change only slightly under the current and future level of development (Figures 8 through 12). These small differences in flow and salinity would not be expected to adversely affect soft bird's beak.

Cumulative Effects

Cumulative effects are those effects of future State, local, or private actions on endangered and threatened species or critical habitat that are reasonably certain to occur in the action area. Future Federal actions that are unrelated to the proposed action are not considered in this section because they will be subject to separate consultations pursuant to section 7 of the ESA.

Numerous activities continue to affect the amount, distribution and quality of habitat for listed and proposed threatened and endangered species in the Central Valley and San Francisco Bay/Estuary. Habitat loss and degradation affecting both animals and plants continues as a result of urbanization, oil and gas development, road and utility right-of-way management, flood control projects, overgrazing by livestock, and continuing agricultural expansion. Listed and proposed animal species also are affected by poisoning, shooting, increased predation associated with human development, and reduction of food sources. All of these nonfederal activities are expected to continue to adversely affect listed and proposed species in the Central Valley and San Francisco Bay/Estuary.

Bald Eagle

Bald eagles continue to be cumulatively affected by water management, recreational activities, fisheries management and pesticides and other contaminants. These factors can influence reproductive success, population size and distribution. DDT was a primary contributor to the decline in bald eagles in the United States. Although this pesticide is no longer in use in the United States, because of its long-term persistence in the environment, eagles can still be exposed to this chemical. Eagles also can accumulate heavy metals and other pollutants which can similarly influence reproductive success.

In California, most eagles nest at reservoirs managed for multiple purposes and that attract substantial recreational activities. Human activity near nests can disturb nesting pairs and potentially influence reproductive success. Impacts from recreation could increase as the human population increases in California.

California Clapper Rail and Salt Marsh Harvest Mouse

The California clapper rail and salt marsh harvest mouse are dependent on tidal marshes of the San Francisco Bay/Estuary. Suitable habitat for these species has been reduced by about 84 percent from historic levels in the San Francisco Bay area as a result of habitat conversions for urban and agricultural uses, and is a primary factor in the species' decline. A number of factors influence the remaining tidal marshes and limit their habitat value.

Much of the East Bay shoreline from San Leandro to Calaveras Point is rapidly eroding. Many marshes around South San Francisco Bay are undergoing vegetational changes because of land subsidence caused by groundwater pumping. In addition, an estimated 600 acres of former salt marsh along Coyote Creek, Alviso Slough, and Guadalupe Slough are

currently dominated by fresh- and brackish-water vegetation due to continuing freshwater discharge from South Bay wastewater facilities and are of lower quality for California clapper rails and salt marsh harvest mice. However, in San Pablo and Suisun Bays in general, average salinities have increased as a result of upstream diversions which as contributed to reduced habitat quality for these species. Intertidal a marsh habitats also can be degraded or destroyed by a variety of development and maintenance activities conducted by private organizations, state agencies, or local governments. Predation by a variety of native and non-native predators also is a concern for both species.

Riparian Brush Rabbit and Riparian Woodrat

A substantial reduction in California's Central Valley riparian forests has occurred during the last 150 years. Riparian forest in the Central Valley possibly declined by as much as 89 percent during that time period. Factors contributing to the loss of riparian forest include: (1) conversion to agriculture and urban development; (2) levee construction and maintenance; (3) bank erosion; (4) grazing by livestock; (5) use of riprap for bank protection; (6) groundwater extraction; (7) flow regulation; (8) continuing development of land along the riparian corridor, and (9) competition and invasion by exotic plant species such as Chinese tree-of-heaven (*Ailanthus altissima*) and black locust (*Robinia pseudoacacia*). Riparian brush rabbits and riparian woodrat populations probably declined as riparian habitats declined.

Limited habitat and periodic flooding continue to threaten the persistence of these species. Riparian brush rabbits also are susceptible to diseases common to rabbits in California and competition with desert cottontail could pose a threat to this species. Both species are at risk to inbreeding and stochastic events given their extremely limited distribution and small population size.

California Red-legged Frog

Habitat loss and alteration, combined with over exploitation and introduction of exotic predators, were significant factors in the red-legged frog's decline in the early to mid-1900s. The California red-legged frog continues to be threatened in its remaining range by a wide variety of human activities, many of which operate concurrently and cumulatively with each other and with natural disturbances (e.g., droughts and floods). Current factors associated with declining populations of the red-legged frog include degradation and loss of habitat through urbanization, mining, improper management of grazing, recreation, invasion of nonnative plants, impoundments, water diversions, degraded water quality, and introduced predators. Organophosphorus pesticides from agricultural areas of the San Joaquin Valley floor appear to be transported to the Sierra Nevada on prevailing summer winds, and also could be affecting populations of amphibians that breed in mountain ponds and streams. Cumulatively, these factors have resulted in the isolation and fragmentation of red-legged frog populations. The fragmentation of existing habitat and populations, and the continued colonization of existing habitat by nonnative species, are significant current threats to California red-legged frogs.

Giant Garter Snake

Historically, vast marshes in the Central Valley provided extensive habitat for giant garter snakes. Urban and agricultural development as well as associated flood control and water supply projects have resulted in the loss of the historic marshes. Activities that continue to cumulatively affect giant garter snakes throughout their range include: (1) conversion of agricultural areas to urban land uses; (2) fluctuations in aquatic habitat from water management, (3) dredging and clearing of vegetation from irrigation canals, (4) discing, mowing, ornamental cultivation and routine grounds maintenance of upland habitat; (5) vehicular traffic on access roads adjacent aquatic habitat, (6) use of burrow fumigants on levess and other potential upland refugia; (7) contaminated run off from agriculture and urbanization ; and (8) predation by feral animals and pets. These factors continue to influence the size, distribution and persistence of giant garter snakes in the Central Valley.

Valley Elderberry Longhorn Beetle

Valley elderberry longhorn beetle are believed to have declined with the general decline in riparian habitat and other native habitats in the Central Valley. Removal of elderberry shrubs continue to affect the valley elderberry longhorn beetle throughout its range. Elderberry shrubs can be lost as a result of urban development, construction and maintenance of flood control measures (e.g., levee construction and maintenance), and construction and maintenance activities associated with water supply and drainage. In addition to direct removal, competition from invasive exotic plants, grazing and herbicide use can negatively affect elderberries. Pesticide use and Argentine fire ants can directly impact valley elderberry longhorn beetles.

Suisun Thistle and Soft Bird's-beak

Suisun thistle and soft bird's-beak are associated with tidal marshes of the San Francisco Bay/Estuary. Suitable conditions for these species have decline substantially as a result of habitat conversions for urban and agricultural uses. Upstream diversions have altered the hydrologic regime of the San Francisco Bay/Estuary and have contributed to reduced suitability of conditions for these two plants. At a local level, a variety of development and maintenance activities conducted by private organizations or state or local governments can directly remove plants or alter the hydrologic or water quality conditions that create suitable conditions.

Non-native plants contribute to adverse cumulative effects to Suisun thistle and soft bird's beak by competing for light, space and nutrients. The lack of natural populations controls for non-natives can allow these species to outcompete native species and form a monoculture of an introduced species. Species such as the yellow star thistle (*Centaurea solstitialis*), barb goatgrass (*Aegilops triuncialis*) and medusahead (*Taeniatherum caputmedusae*) have out-competed native species in some areas.

Both species also can be impacted by vandalism or horticultural collecting. While both species are susceptible to a variety of catastrophic events,. the Suisun thistle's highly

restricted distribution increases its risk of extinction from events such as disease or pest outbreak, severe drought, oil spills or other natural or human caused disasters.

Conclusions and Determinations

Bald Eagle

Under the future level of development, the proposed action would result in slightly lower water surface elevations at Shasta, Clair Engle, Whiskeytown and Oroville Reservoirs. These small changes may affect, but are not likely to adversely affect bald eagles.

California Clapper Rail

The proposed action would result in only very small changes in Delta inflow, Delta outflow and X2. Thus, no substantial changes in the extent of salt and brackish marsh or in the risk of toxicological effects from exposure to contaminants are expected. Based on the very small changes predicted between the current and future level of development, the proposed action may affect, but is not likely to adversely affect California clapper rail.

Salt Marsh Harvest Mouse

The proposed action would result in only very small changes in Delta inflow, Delta outflow and X2. Thus, no substantial changes in the extent of salt and brackish marsh or in the risk of toxicological effects from exposure to contaminants are expected. Based on the very small changes predicted between the current and future level of development, the proposed action may affect, but is not likely to adversely affect salt marsh harvest mouse.

Riparian Brush Rabbit

Very small changes in flow levels in the Stanislaus River are predicted between the current and future level of development. No change in the maximum flow level is predicted. These small changes would not be expected to change the amount of characteristics of riparian habitat or change the flooding frequency of Caswell Memorial State Park. Thus, the proposed action would have no effect on the riparian brush rabbit.

Riparian Woodrat

Changes in flow levels in the Stanislaus River between the current and future level of development are predicted to be very small and no change in the maximum flow is projected. The small changes would not be expected to change the amount of characteristics of riparian habitat or change the flooding frequency of Caswell Memorial State Park. Therefore, the proposed action would have no effect on the riparian woodrat.

California Red-legged Frog

California red-legged frogs no longer inhabit waterways downstream of CVP/SWP facilities where operations of these facilities could affect this species or its habitat. Therefore, the proposed action would have no effect on the California red-legged frog.

Giant Garter Snake

The proposed action would result in only small changes in flows in CVP/SWP waterways. Because the rivers affected by CVP/SWP operations generally do not provide suitable habitat conditions for giant garter snakes, the small changes in flows may affect, but are not likely to adversely affect giant garter snakes.

Valley Elderberry Longhorn Beetle

The proposed action would result in small reductions in flows in several CVP/SWP waterways. These small changes are not likely to affect the distribution or persistence of elderberry shrubs and accordingly, the proposed action may affect, but is not likely to adversely affect valley elderberry longhorn beetle.

Suisun Thistle

The proposed action would result in only very small changes in Delta inflow, Delta outflow and X2. Thus, no substantial changes the hydrology or salinity regime of Suisun Marsh are expected. Based on the very small changes predicted between the current and future level of development, the proposed action may affect, but is not likely to adversely affect Suisun thistle.

Soft Bird's-beak

The proposed action would result in only very small changes in Delta inflow, Delta outflow and X2. Thus, no substantial changes the hydrology or salinity regime of tidal marshes of the San Francisco Bay Estuary are expected. Based on the very small changes predicted between the current and future level of development, the proposed action may affect, but is not likely to adversely affect soft bird's beak.

Figures

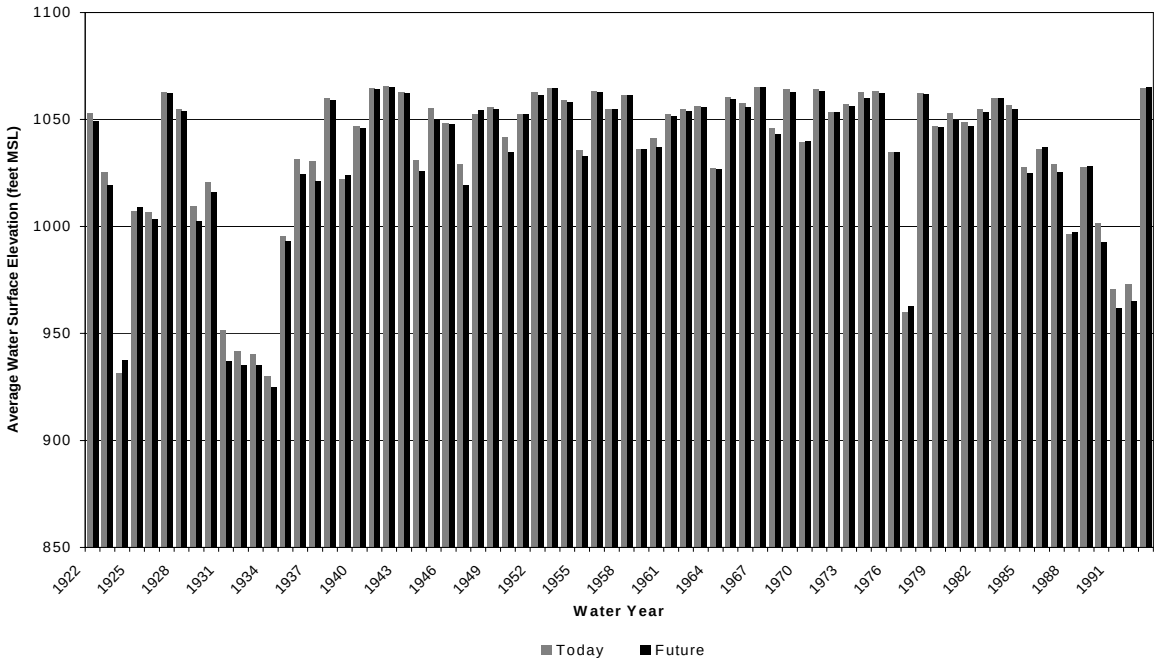


Figure 1 Average Water Surface Elevation during April through June at Shasta Reservoir Under Current and Future Level of Development

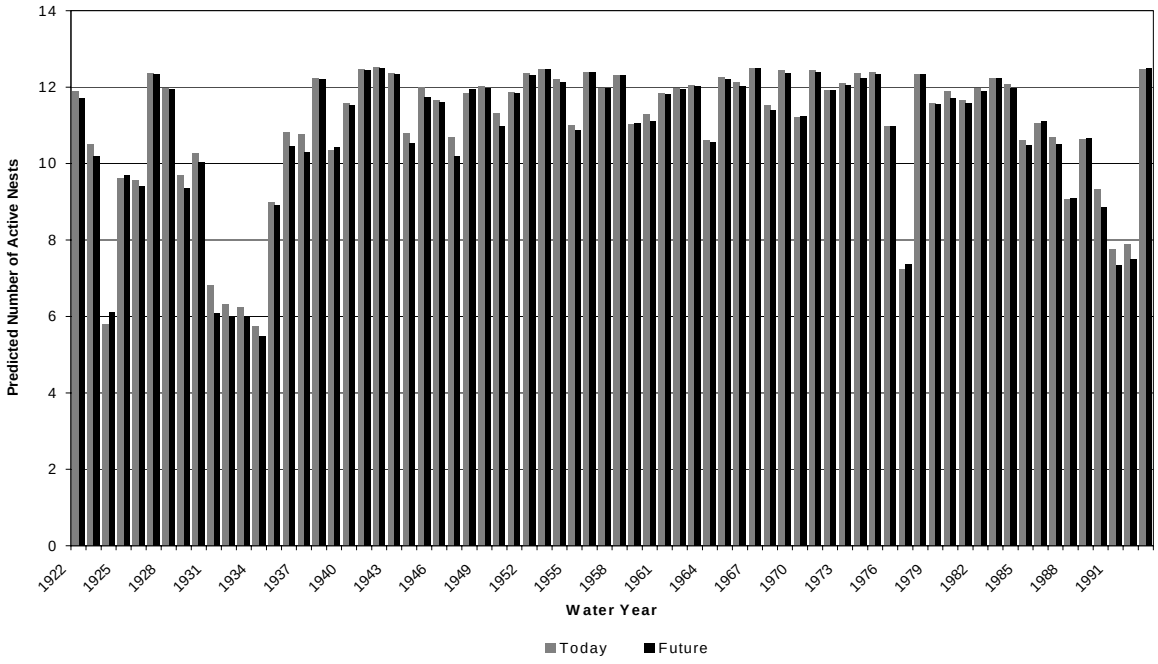


Figure 2 Predicted number of Active Bald Eagle Nests at Shasta Reservoir Under Current and Future Level of Development

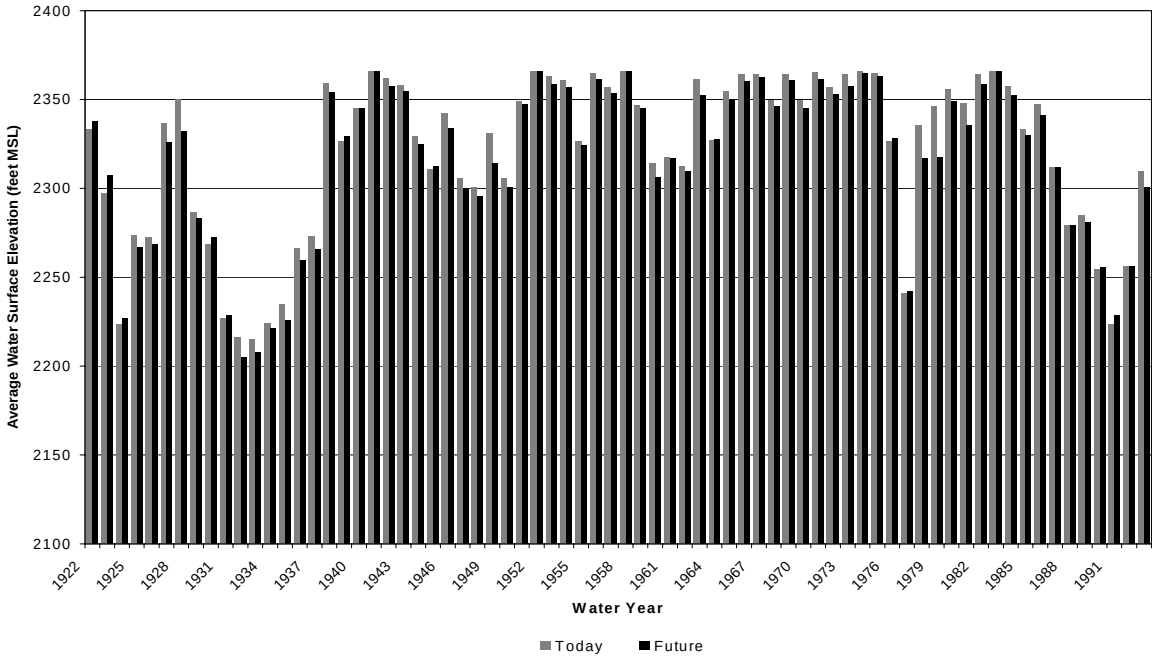


Figure 3 Average Water Surface Elevation during April through June at Clair Engle Reservoir Under Current and Future Level of Development

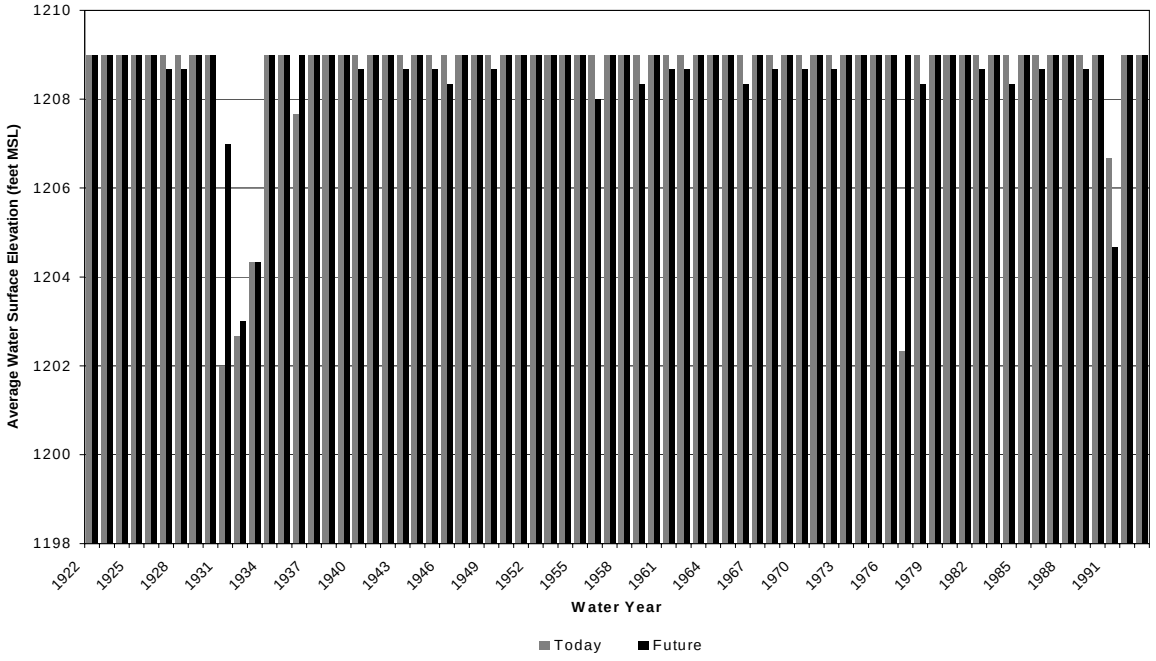


Figure 4 Average Water Surface Elevation during April through June at Whiskeytown Reservoir Under Current and Future Level of Development

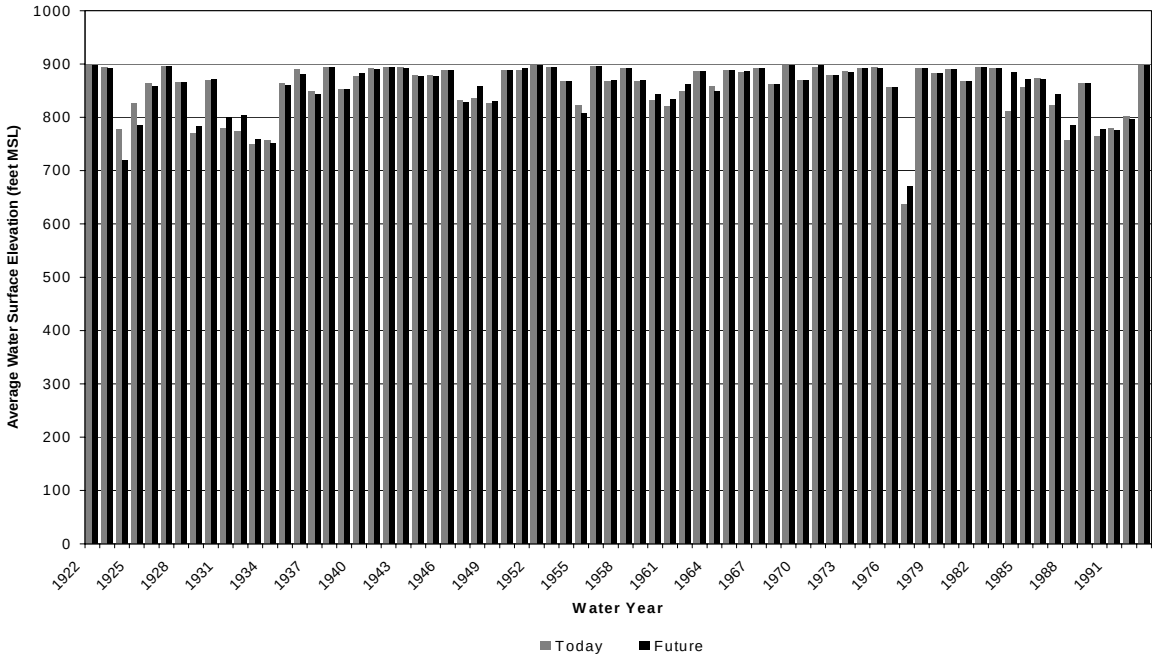


Figure 5 Average Water Surface Elevation during April through June at Oroville Reservoir Under Current and Future Level of Development

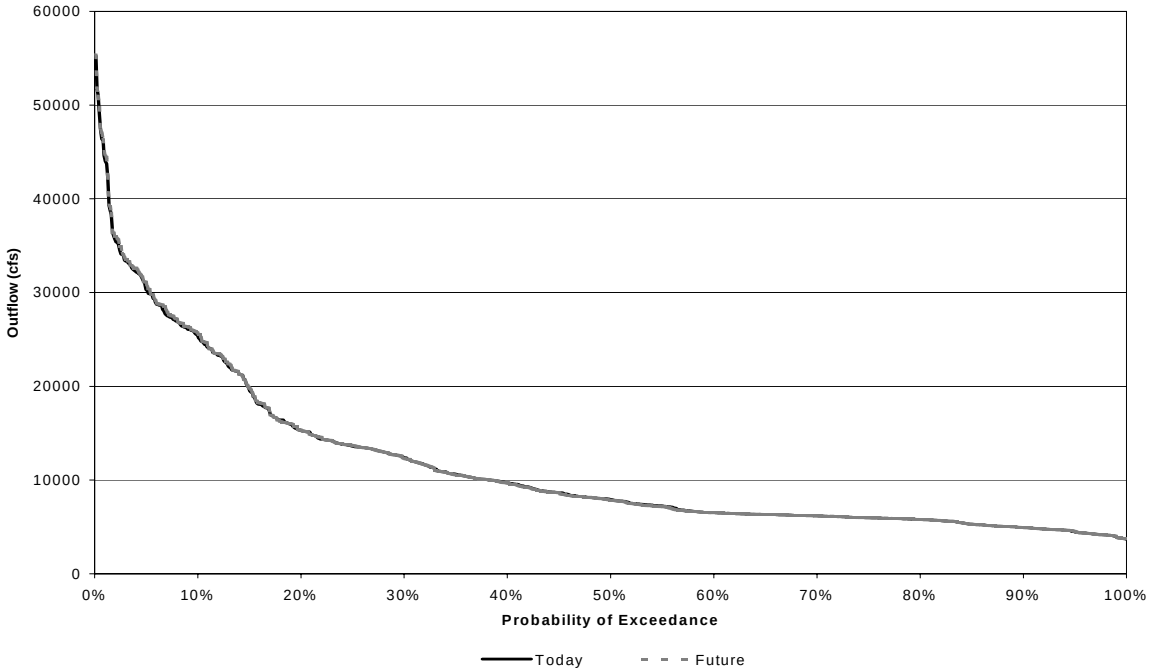


Figure 6 Total Annual Delta Outflow Exceedance under Current and Future Level of Development

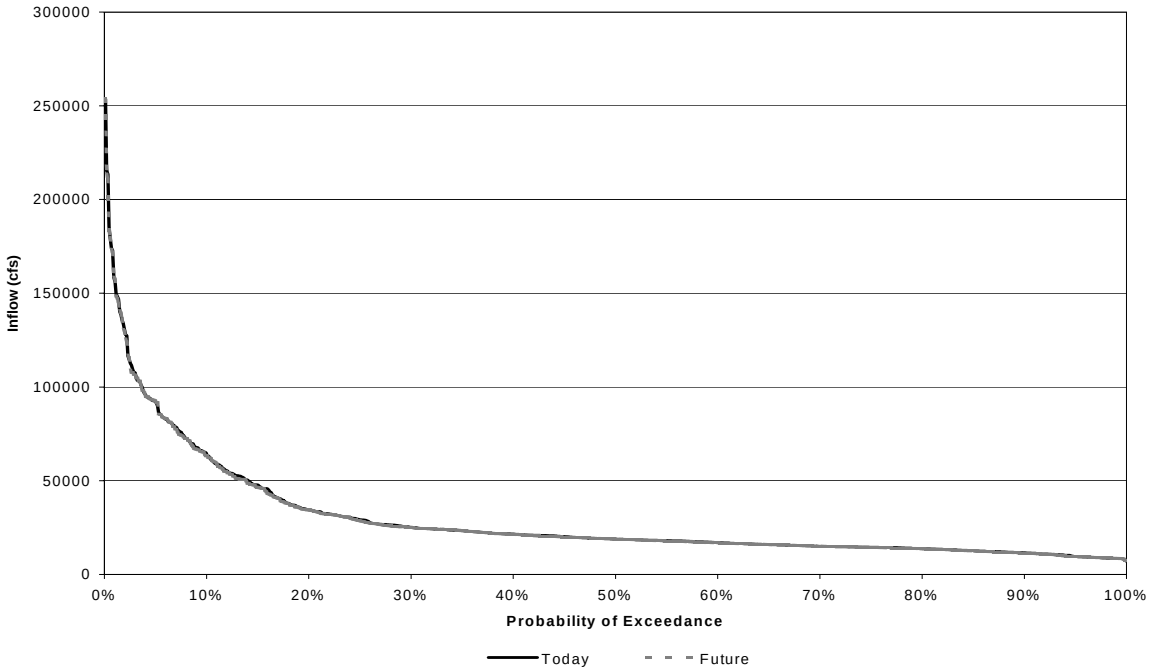


Figure 7 Total Annual Delta Inflow Exceedance under Current and Future Level of Development

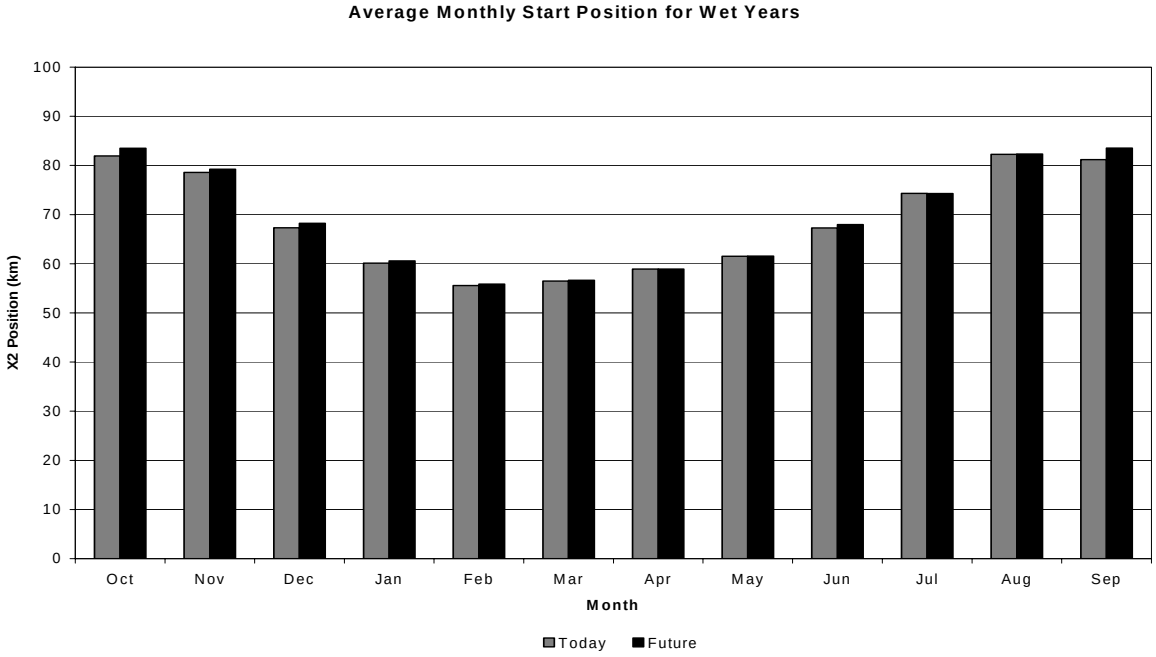


Figure 8 Wet Year Average Monthly X2 Start Position under Current and Future Level of Development

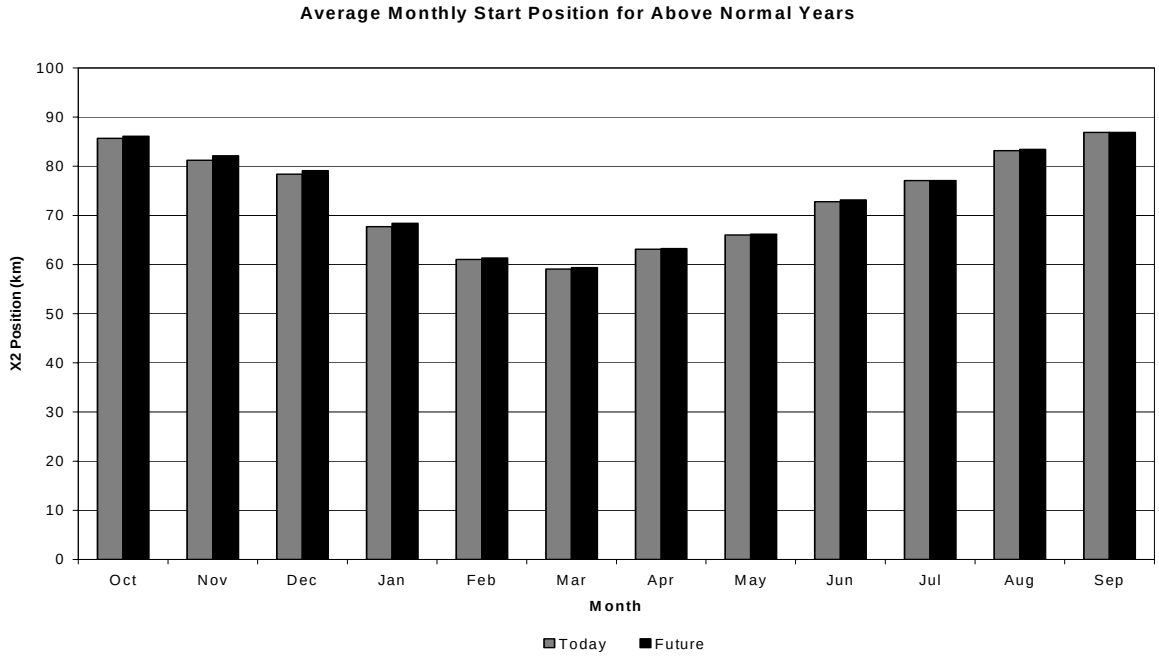


Figure 9 Above Normal Year Average Monthly X2 Start Position under Current and Future Level of Development

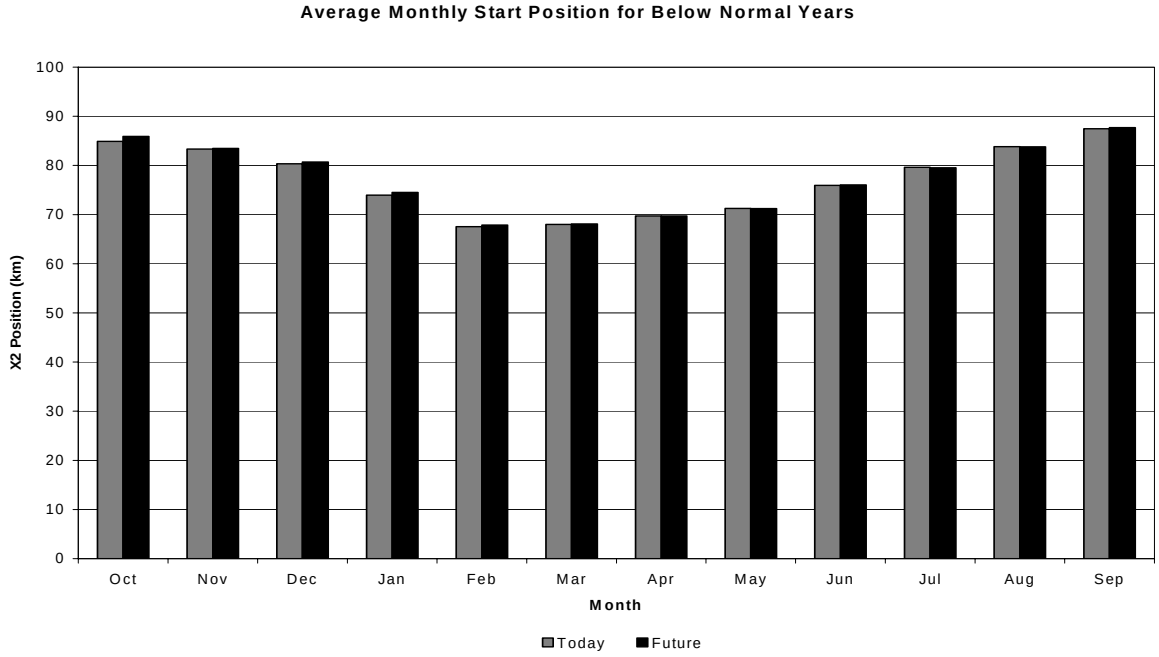


Figure 10 Below Normal Year Average Monthly X2 Start Position under Current and Future Level of Development

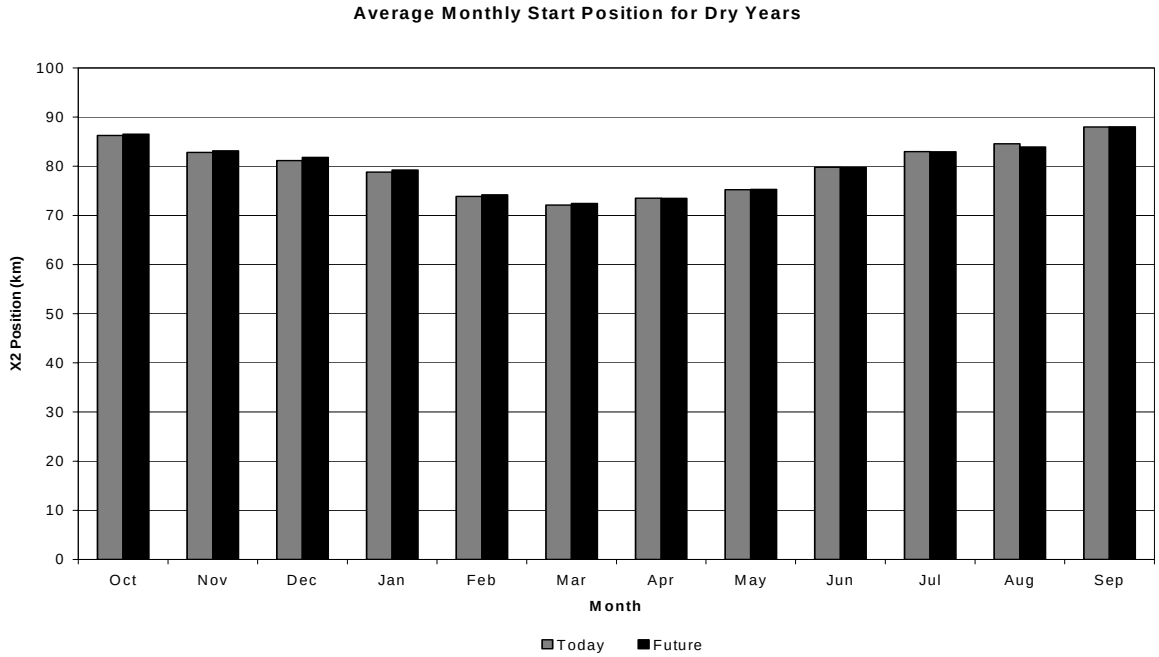


Figure 11 Dry Year Average Monthly X2 Start Position under Current and Future Level of Development

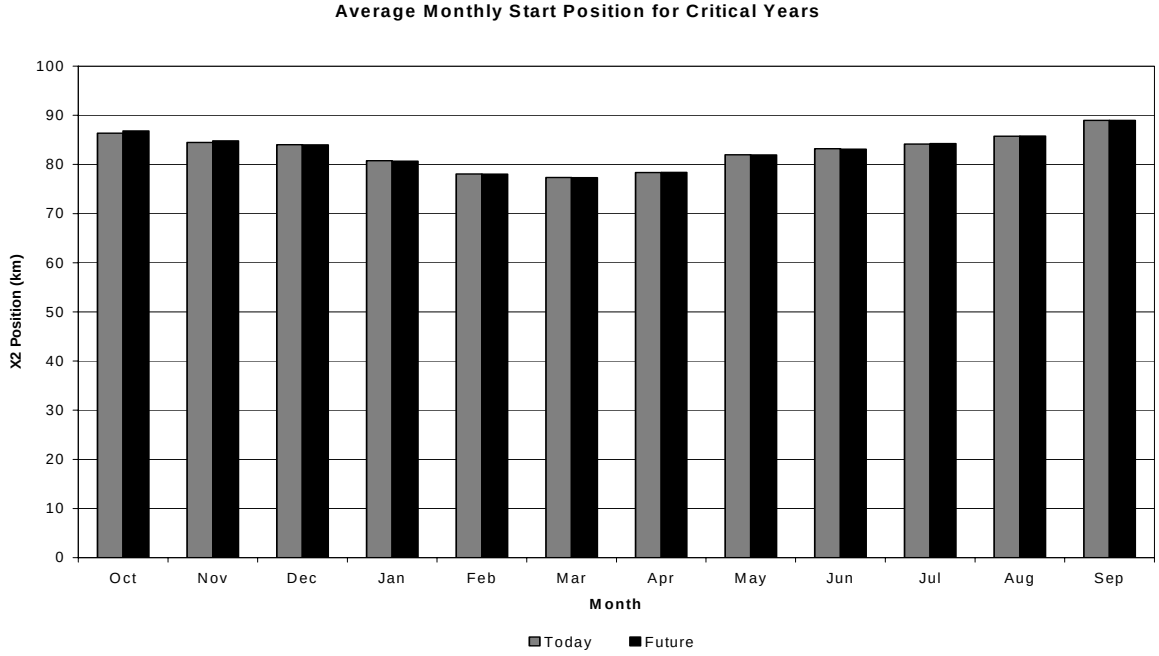


Figure 12 Critical Year Average Monthly X2 Start Position under Current and Future Level of Development

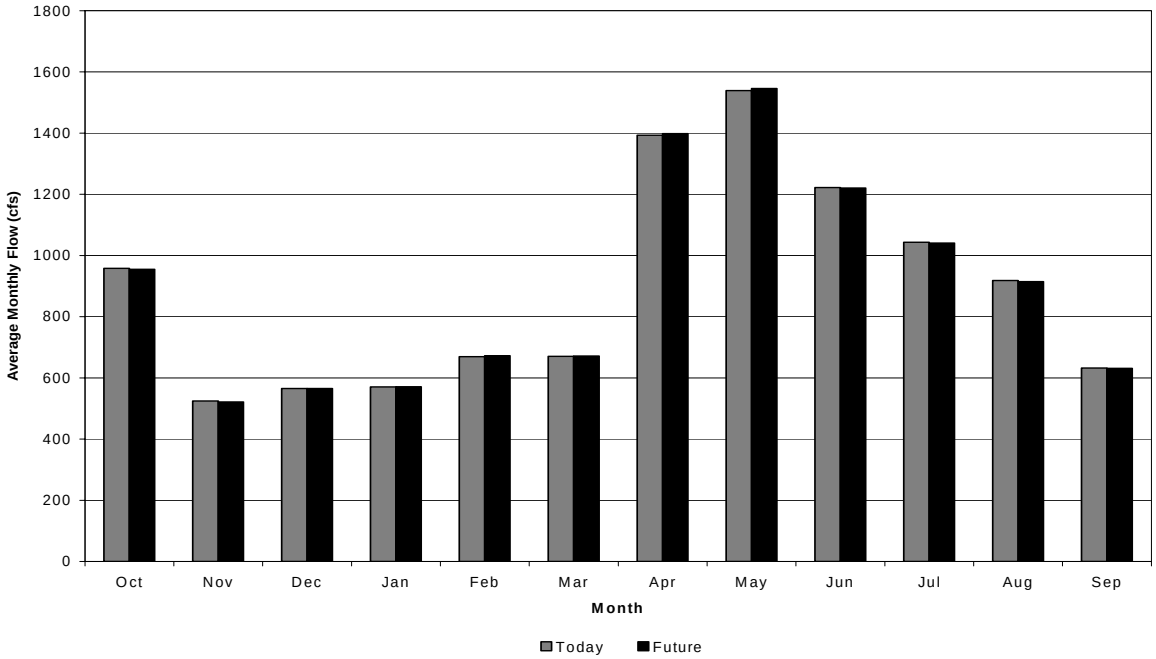


Figure 13 Average Monthly Stanislaus River Flows at the Mouth under Current and Future Level of Development

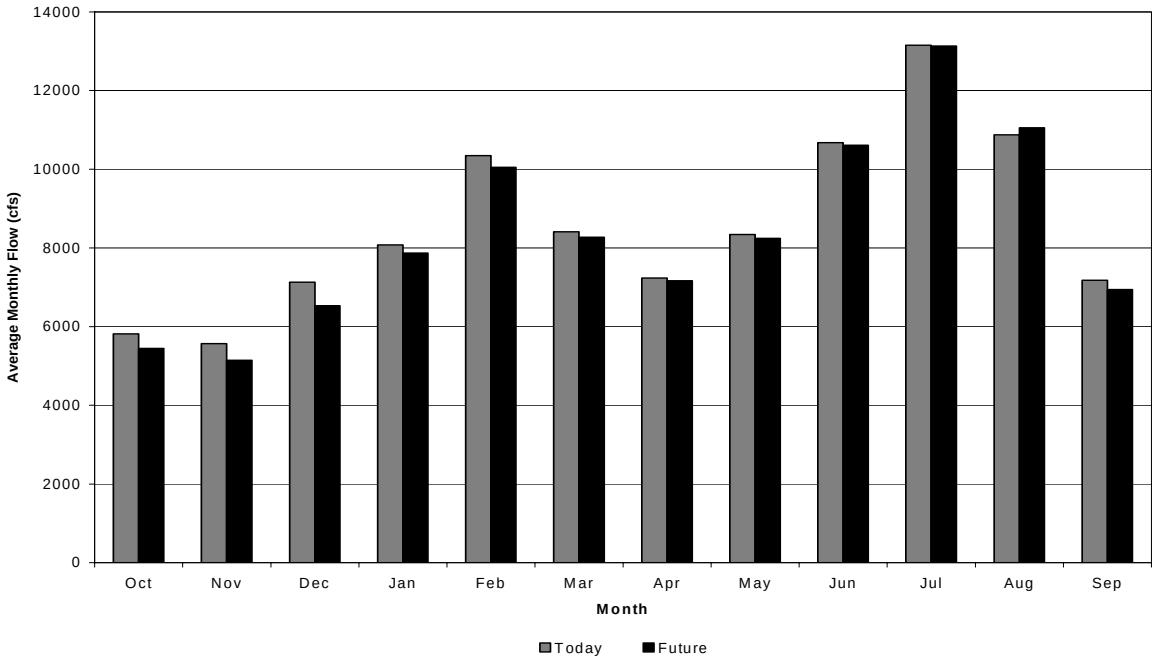


Figure 14 Average Monthly Keswick Release under Current and Future Level of Development

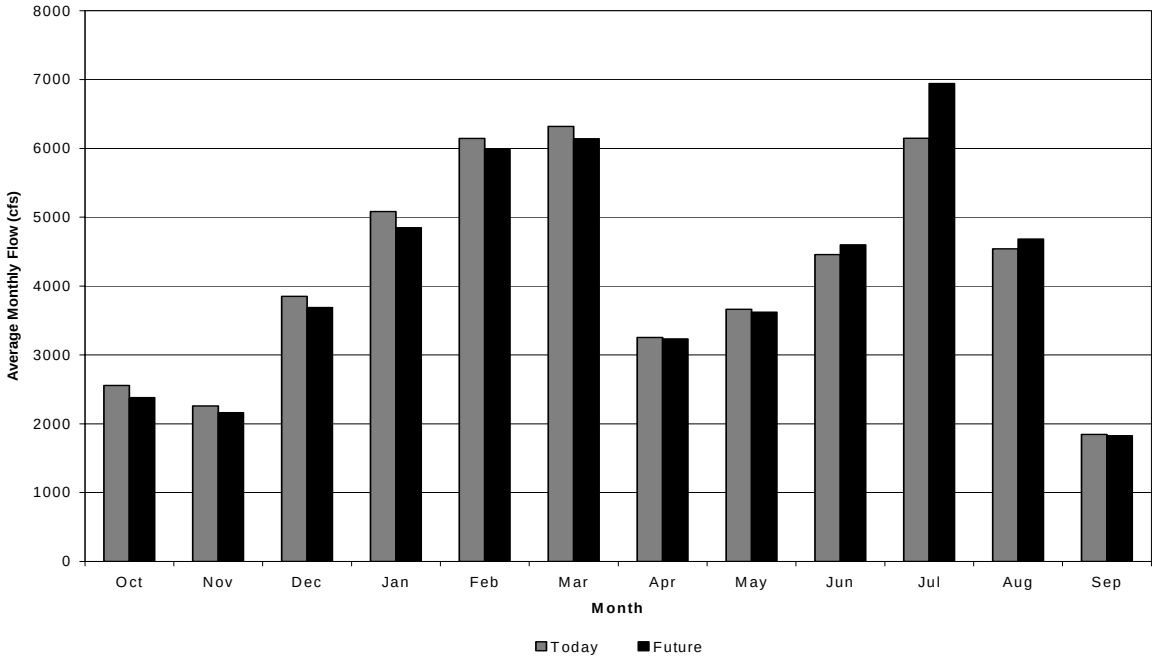


Figure 15 Average Monthly Thermalito Release under Current and Future Level of Development

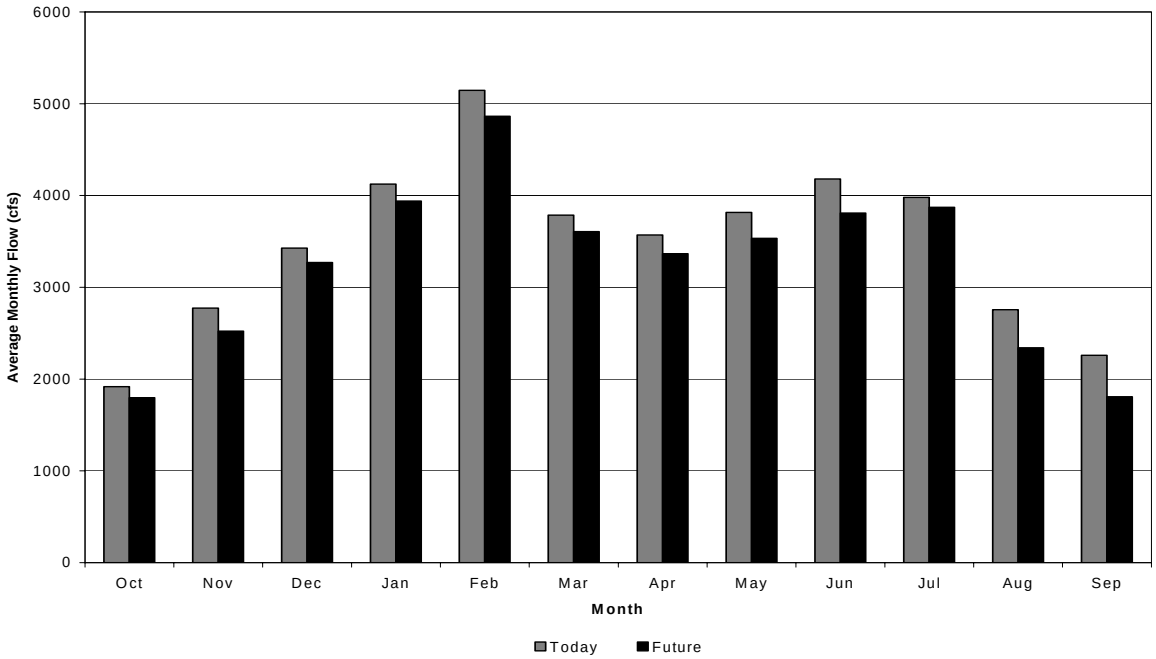
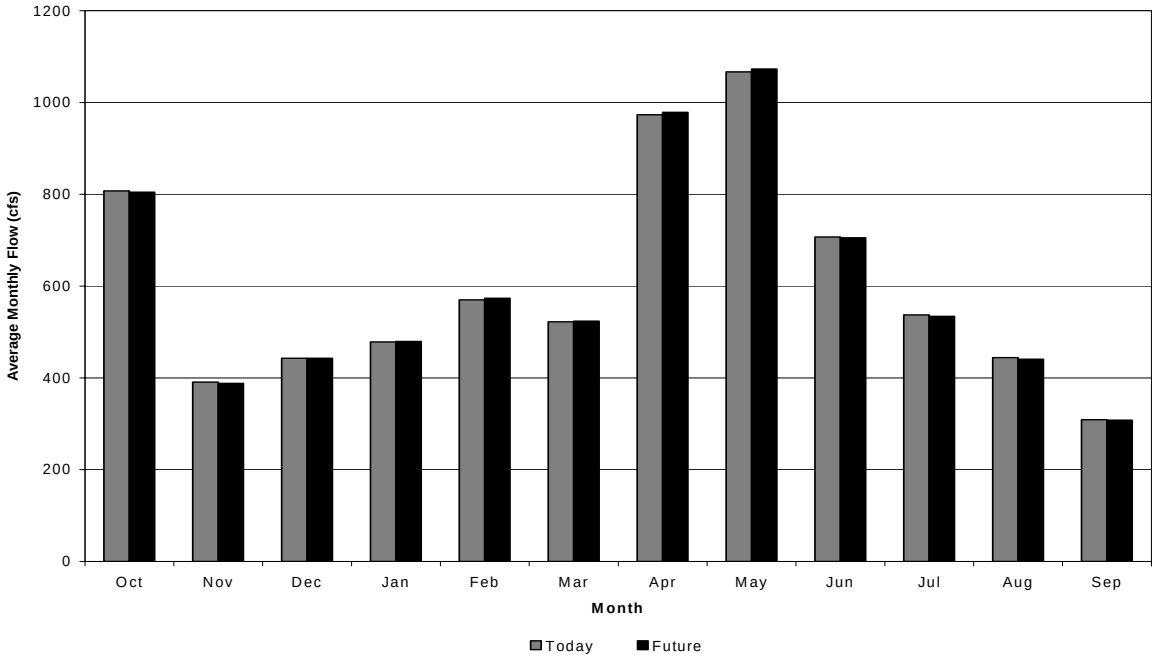


Figure 16 Average Monthly Nimbus Release under Current and Future Level of Development



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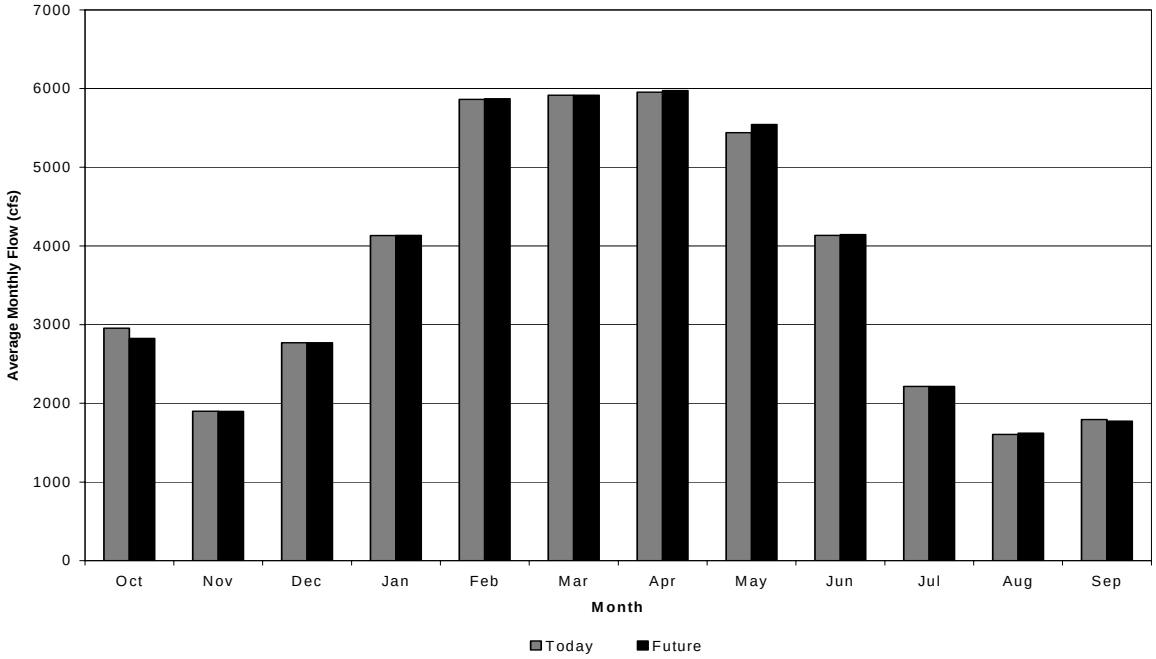

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Long-term Central Valley Project and State Water Project Operations Criteria and Plan Biological Assessment

Long-Term

Central Valley Project and State Water Project

Operations Criteria and Plan

Biological Assessment

U.S. Department of the Interior

Bureau of Reclamation

Mid-Pacific Region

Sacramento, California

March 22, 2004

Mission Statement

The mission of the Bureau of Reclamation is to manage, develop, and protect water and related resources in an environmentally and economically sound manner in the interest of the American public.

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List of Abbreviations/Acronyms

ACID	**Anderson-Cottonwood Irrigation District**
af	**acre-feet**
AFA	**acre-feet per year**
AFRP	**Anadromous Fish Restoration Program**
ALPI	**aleutian low pressure index**
ANN	**artificial neutral network**
ASIP	**Action Specific Implementation Plan**
BA	**biological assessment**
BO	**biological opinion**
BY	**brood year**
B2IT	**CVPIA Section 3406(b)(2) Implementation Team**
CA	**California Aquaduct**
Cal EPA	**California Environmental Protection Agency**
CALSIM	**California Simulation computer model**
CAMP	**Comprehensive Assessment and Monitoring Program**
CCC	**Contra Costa Canal**
CCF	**Clifton Court Forebay**
CCWD	**Contra Costa Water District**
CEQA	**California Environmental Quality Act**
CESA	**California Endangered Species Act**
CFC	**California Fish Commission**
cfs	**cubic feet per second**
CHO	**constant head orifice**
COA	**Coordinated Operation Agreement**
Corps	**U.S. Army Corps of Engineers**
cpm	**catch per minute**
cpue	**catch per unit effort**
CRR	**cohort replacement rate**
CVOO	**Central Valley Operations Office**
CVP	**Central Valley Project**
CVPA	**Central Valley Project Act**
CVPIA	**Central Valley Project Improvement Act**

CWA	**Clean Water Act**
CWT	**coded wire tag**
D-1485	**SWRCB Decision 1485**
DAT	**Data Assessment Team**
DBEEP	**Delta-Bay Enhanced Enforcement Program**
DCC	**Delta Cross Channel**
Delta	**Sacramento-San Joaquin Delta**
DFG	**California Department of Fish and Game**
DMC	**Delta-Mendota Canal**
DO	**Dissolved Oxygen**
DSM2	**Delta Simulation Model 2**
DWR	**California Department of Water Resources**
EBMUD	**East Bay Municipal Utility District**
EC	**Electroconductivity**
EFH	**Essential Fish Habitat**
E/I	**export to inflow ratio**
EID	**El Dorado Irrigation District**
EIR	**Environmental Impact Report**
EIS	**Environmental Impact Statement**
EPA	**U.S. Environmental Protection Agency**
ERP	Ecosystem Restoration Program
ESA	**Federal Endangered Species Act**
ESU	**Evolutionarily Significant Unit**
EWA	**Environmental Water Account**
EWAT	**EWA Team**
FERC	**Federal Energy Regulatory Commission**
FL	**fork length**
FMWT	**Fall Midwater Trawl Survey**
FPA	**Federal Power Act**
FRH	**Feather River Hatchery**
FRWA	**Freeport Regional Water Authority**
FRWP	**Freeport Regional Water Project**
FSD	**Folsom South Canal**
FWS	**U.S. Fish and Wildlife Service**
GCID	**Glenn-Colusa Irrigation District**
GLM	**Generalized Linear Models**
GS	**Georgiana Slough**

HORB	**Head of Old River Barrier**
IEP	**Interagency Ecological Program**
IFIM	**in stream flow incremental methodology**
Interior	**U.S. Department of the Interior**
IPO	**Interim Plan of Operations**
JPE	**Juvenile Production Estimate**
JPOD	**joint point of diversion**
LFC	**low flow channel**
LOD	**Level of Development**
LP	**linear programming**
MAF	**million acre-feet**
Magnuson-Stevens Act	**Magnuson-Stevens Fishery Conservation and Management Act**
Management Agencies	**FWS, NOAA Fisheries, and DFG for the EWA**
M&I	**municipal and industrial (e.g., M&I water supplies)**
mg/L	**milligrams per liter**
MGD	**millions of gallons per day**
MIDS	**Morrow Island Distribution System**
MILP	**mixed integer linear programming**
MLR	**multiple linear regression**
MOA	**Memorandum of Agreement**
MOU	**Memorandum of Understanding**
mS/cm	**microSiemens per centimeter**
MSL	**mean sea level**
NBA	**North Bay Aqueduct**
NCCPA	**Natural Community Conservation Planning Act**
NEPA	**National Environmental Policy Act**
NMFS	**National Marine Fisheries Service – Now NOAA Fisheries (NMFS is still used in references)**
NMIPO	**New Melones Interim Plan of Operation**
NOAA Fisheries	**National Marine Fisheries Service**
NOD	**North of Delta**
NRC	**National Research Council**
OCAP	**Operations Criteria and Plan**
OFF	**Operations and Fisheries Forum**
OID	**Oakdale Irrigation District**
ONCC	**Oregon/Northern California Coast**
Ops Group	**CALFED Operations Coordination Group**

PCBs	**polychlorinated biphenyls**
PCWA	**Placer County Water Agency**
PEIS	**Programmatic Environmental Impact Statement**
PFMC	**Pacific Fishery Management Council**
PG&E	**Pacific Gas and Electric**
PHABSIM	**physical habitat simulation**
Project	**CVP and SWP (as in CVP and SWP water rights)**
Project Agencies	**Reclamation and DWR for the EWA**
PIP	**(See Chapter 3/Page 1)**
ppm	**parts per million**
ppt	**parts per trillion**
PSL	**pre-screen loss**
QWEST	**(See Chapter 5/Page 39)**
RBDD	**Red Bluff Diversion Dam**
Reclamation	**U.S. Bureau of Reclamation**
ROD	**Record of Decision**
RPA	**reasonable and prudent alternative**
RRDS	**Roaring River Distribution System**
RST	**rotary screw trap**
RWQCB	**Regional Water Quality Control Board**
SA	**Settlement Agreement**
SAFCA	**Sacramento Area Flood Control Agency**
SCE	**Southern California Edison**
SCWA	**Sacramento County Water Agency**
SDFF	**South Delta Fish Facility Forum**
SDIP	**South Delta Improvement Project**
SDTB	**South Delta Temporary Barriers**
SJRA	**San Joaquin River Agreement**
SJRWR	**San Joaquin River Water Rights**
SMPA	**Suisun Marsh Preservation Agreement**
SMSCG	**Suisun Marsh Salinity Control Gates**
SMUD	**Sacramento Municipal Utility District**
SOD	**Safety of Dams (same as South of Delta)**
SOD	**South of Delta (same as Safety of Dams)**
SPDP	**Salmon Protection Decision Process**
SRBS	**Stanislaus River Basin Stakeholders**
SRI	**Sacramento River Index**

SRPP	**Spring-run Chinook salmon Protection Plan**
SRTTF	**Sacramento River Temperature Task Force**
SSJID	**South San Joaquin Irrigation District**
SWP	**State Water Project**
SWRCB	**State Water Resources Control Board**
TAF	**thousand acre-feet**
TCCA	**Tehama-Colusa Canal Authority**
TCD	**Temperature Control Device**
TDS	**total dissolved solids**
T&E	**Threatened and Endangered**
TFCF	**Tracy Fish Collection Facility**
TFFIP	**Tracy Fish Facility Improvement Program**
TL	**(See Chapter 7/Page 6)**
TNS	**Townet Survey**
TU	**temperature unit**
USGS	**U.S. Geological Survey**
VAMP	**Vernalis Adaptive Management Program**
Western	**Western Area Power Administration**
Westlands	**Westlands Water District**
WOMT	**Water Operations Management Team**
WQCP	**Water Quality Control Plan**
WRESL	**Water Resources Engineering Simulation Language**
WTP	**Water Treatment Plant**
WUA	**weighted usable spawning area**
WY	**water year**
YOY	**young-of-the-year**
1995 Bay-Delta Plan	**San Francisco Bay/Sacramento-San Joaquin Delta Estuary**

Introduction

This biological assessment (BA) describes the proposed long-term operation of the Central Valley Project by the Bureau of Reclamation and the State Water Project by the California Department of Water Resources (collectively "Project Agencies"). Reclamation, on behalf of itself and the California Department of Water Resources, is submitting this biological assessment pursuant to Section 7(a)(2) of the Endangered Species Act to both the U.S. Fish and Wildlife Service and the National Marine Fisheries Service (collectively "Services") to ensure that the proposed action is not likely to jeopardize the continued existence of listed species.

Purpose of the Biological Assessment

The purpose of a BA is to evaluate the potential effects of the proposed action on listed and proposed species and designated and proposed critical habitat and determine whether any such species or habitats are likely to be adversely affected by the proposed action. Further, the BA is used to determine whether formal consultation or a conference are necessary.

The Project Agencies' objective is to work with the Services toward developing a long-term operations plan that meets the Project Agencies' legal commitments with respect to the Central Valley Project and State Water Project in a manner that is consistent with the requirements of the Endangered Species Act. Reclamation and California Department of Water Resources prepared this biological assessment to describe and analyze the affects of the proposed long-term operations plan for the Central Valley Project and State Water Project on listed species.

Chapter 1 Summary of Legal and Statutory Authorities, Water Rights, and other Obligations Relevant to the Action

Introduction

The Bureau of Reclamation (Reclamation) and the California Department of Water Resources (DWR), propose to operate the Central Valley Project (CVP) and State Water Project (SWP) to divert, store and convey CVP and SWP (Project) water consistent with applicable law. These operations are summarized in this biological assessment (BA) and described in more detail in Chapter 2.

The CVP and the SWP are two major inter-basin water storage and delivery systems that divert water from the southern portion of the Sacramento-San Joaquin Delta (Delta). Both projects include major reservoirs north of the Delta, and transport water via natural watercourses and canal systems to areas south and west of the Delta. The CVP also includes facilities and operations on the Stanislaus and San Joaquin Rivers. The major facilities on these rivers are New Melones and Friant Dams respectively.

The projects are permitted by the California State Water Resources Control Board (SWRCB) to store water during wet periods, divert water that is surplus to the Delta, and re-divert Project water that has been stored in upstream reservoirs. Both projects operate pursuant to water rights issued by the SWRCB to appropriate unappropriated water by diverting to storage or by directly diverting to use and rediverting releases from storage later in the year. Unappropriated water is generally available during the winter and spring each year. As such, the SWRCB requires the projects to be jointly and separately responsible for meeting specific water quality, quantity, and operational criteria within the Delta. It is through SWRCB provisions that operations of the projects are closely coordinated.

The proposed action in this consultation includes activities undertaken by DWR in operating the SWP. As such DWR needs to consult with the California Department of Fish and Game (DFG), as may be appropriate, to address applicable requirements of the State Endangered Species Act. The final version of this BA will describe the mechanisms/methods whereby this consultation will be accomplished.

Legal and Statutory Authorities

Legal and statutory authorities and obligations, water rights, and other obligations guide the Project agencies' proposed action. This section of the BA elaborates on those authorities, responsibilities, and obligations.

CVP

The CVP is the largest Federal Reclamation project and was originally authorized by the Rivers and Harbors Act of 1935. The CVP was reauthorized by the Rivers and Harbors Act of 1937 for

the purposes of "improving navigation, regulating the flow of the San Joaquin River and the Sacramento River, controlling floods, providing for storage and for the delivery of the stored waters thereof, for construction under the provisions of the Federal reclamation laws of such distribution systems as the Secretary of the Interior deems necessary in connection with lands for which said stored waters are to be delivered, for the reclamation of arid and semiarid lands and lands of Indian reservations, and other beneficial uses, and for the generation and sale of electric energy as a means of financially aiding and assisting such undertakings and in order to permit the full utilization of the works constructed." This Act provided that the dams and reservoirs of the CVP "shall be used, first, for river regulation, improvement of navigation and flood control; second, for irrigation and domestic uses; and, third, for power."

The CVP was reauthorized in 1992 through the Central Valley Project Improvement Act (CVPIA). CVPIA modified the 1937 Act and added mitigation, protection, and restoration of fish and wildlife as a project purpose. Further, CVPIA specified that the dams and reservoirs of the CVP should now be used "first, for river regulation, improvement of navigation, and flood control; second, for irrigation and domestic uses and fish and wildlife mitigation, protection and restoration purposes; and, third, for power and fish and wildlife enhancement."

CVPIA Section 3406(b)(1)(B) articulates Congressional intent for (b)(2) water to be used in conjunction with modification of the CVP operations and water acquisitions under Section 3406(b)(3), along with other restoration activities, to meet the fishery restoration goals of the CVPIA. The mandates in Section 3406 (b)(1) are implemented through the Anadromous Fish Restoration Program (AFRP). The AFRP objectives, as they relate to operations, are explained below. The U.S. Department of the Interior's (Interior) Decision on Implementation of Section 3406 (b)(2) of the CVPIA dated May 9, 2003, provides for the dedication and management of 800,000 af of CVP yield annually by implementing upstream and Delta actions.

Additionally, there have been several other statutes that have authorized the construction, operation and maintenance of various divisions of the CVP. In these authorizations, Congress has consistently included language directing the Secretary of the Interior to operate the CVP as a single, integrated project.

SWP

DWR was established in 1956 as the successor to the Department of Public Works for authority over water resources and dams within California. DWR also succeeded to the Department of Finance's powers with respect to State application for the appropriation of water (Stats. 1956, First Ex. Sess., Ch. 52; see also Wat. Code Sec.123) and has permits for appropriation from the SWRCB for use by the SWP. DWR's authority to construct State water facilities or projects is derived from the Central Valley Project Act (CVPA) (Wat. Code Sec. 11100 et seq.); the Burns-Porter Act (California Water Resources Development Bond Act) (Wat. Code Sec.12930-12944); the State Contract Act (Pub. Contract Code Sec. 10100 et seq.); the Davis-Dolwig Act (Wat. Code Sec. 11900-11925); and special acts of the State Legislature. Although the Federal government built certain facilities described in the CVPA, the Act authorizes DWR to build facilities described in the Act and to issue bonds. (Warne v. Harkness (1963) 60 Cal.2d 579.) The CVPA describes specific facilities that have been built by DWR, including the Feather River Project and California Aqueduct (Wat. Code Sec. 11260), Silverwood Lake (Wat. Code Sec. 11261), and the North Bay Aqueduct (Wat. Code Sec. 11270). The Act allows DWR to

administratively add other units (Wat. Code Sec. 11290) and develop power facilities (Wat. Code Sec. 11295).

The Burns-Porter Act, approved by the voters in November 1960, (Wat. Code Sec. 12930-12944) authorizes issuance of bonds for construction of the SWP. The principal facilities of the SWP are Oroville and San Luis Dams, Delta facilities, the California Aqueduct, and the North and South Bay Aqueducts. The Burns-Porter Act incorporates the provisions of the CVPA.

DWR is required to plan for recreational and fish and wildlife uses of water in connection with State-constructed water projects and can acquire land for such uses (Wat. Code Sec. 233, 345, 346, 12582). The Davis-Dolwig Act (Wat. Code Sec. 11900-11925) establishes the policy that preservation (mitigation) of fish and wildlife is part of State costs to be paid by water supply contractors and recreation and enhancement of fish and wildlife are to be provided by appropriations from the General Fund.

Water Rights

CVP

Federal law provides that Reclamation obtain water rights for its projects and administer its projects pursuant to State law relating the control, appropriation, use or distribution of water used in irrigation, unless the State law is inconsistent with express or clearly implied Congressional directives,. 43 U.S.C. §383; California v. United States, 438 U.S. 645, 678 (1978); appeal on remand, 694 F.2d 117 (1982). Reclamation must operate the CVP in a manner that does not impair senior or prior water rights.

Reclamation was issued water rights to appropriate water by the SWRCB for the CVP. Many of the rights for the CVP were issued pursuant to SWRCB Decision 990, adopted in February 1961. Several other decisions and SWRCB actions cover the remaining rights for the CVP. These rights contain terms and conditions that must be complied with in the operation of the CVP. Over time, SWRCB has issued further decisions that modify the terms and conditions of CVP water rights. In August 1978, SWRCB adopted the Water Quality Control Plan (WQCP) for the Delta and Suisun Marsh, which established revised water quality objectives for flow and salinity in the Delta and Suisun Marsh. In D-1485, also adopted in August 1978, SWRCB required Reclamation and DWR to operate the CVP and SWP to meet all the 1978 WQCP objectives, except some of the salinity objectives in the southern Delta. In addition, the SWRCB, November 1983, Decision 1594 and February 1984 Order WR 84-2 defining Standard Permit Term 91 to protect CVP and SWP stored water from diversion by others. Permit terms and requirements, as they relate to operations, are discussed in the OCAP. In 1991, the SWRCB adopted a WQCP which superseded parts of the 1978 plan, but SWRCB did not revise the water rights of DWR and Reclamation to reflect the objectives in the 1991 plan.

On May 22, 1995, SWRCB adopted a WQCP for the San Francisco Bay/Sacramento-San Joaquin Delta (Bay-Delta) Estuary (1995 Bay-Delta Plan). The 1995 Bay-Delta Plan superseded both the 1978 and 1991 plans. On December 29, 1999, the SWRCB adopted (and then revised on March 15, 2000) Decision 1641, amending certain terms and conditions of the water rights of the SWP and CVP. D-1641 substituted certain objectives adopted in the 1995 Bay-Delta Plan for

water quality objectives required to be met as terms and conditions of the water rights of the SWP and CVP. Permit terms and requirements, as they relate to operations, are discussed below.

SWP

Under California law, diversions of appropriated water since 1914 require a permit from the SWRCB. DWR has SWRCB permits and licenses to appropriate water for the SWP. These permits have terms that must be followed by the DWR as the permit holder. The SWRCB has issued several decisions and orders that have modified DWR's permits, many of which are the same decisions and orders that affect Reclamation CVP operations, as described in CVP water rights above.

Water Contracts

CVP

As the divisions of the CVP became operational, Reclamation entered into long-term contracts with water districts, irrigation districts, and others for delivery of CVP water. There are approximately 250 contracts that provide for varying amounts of water. Most of these contracts were for a term of 40 years and are in the process of being renegotiated. As appropriate, Reclamation has executed interim water service contracts. Reclamation has an obligation to deliver water to the CVP contractors in accordance with contracts between Reclamation and the contractors.

Executing long-term contracts will be the subject of a separate Section 7 consultation and therefore is not included as part of the current proposed action.

SWP

In the 1960s, DWR entered into long-term water supply contracts with 32 water districts or agencies to provide water from the SWP. Over the years, a few of these water agencies have been restructured and today DWR has long-term water supply contracts with 29 agencies and districts. These 29 contractors supply water to urban and agricultural water users in Northern California, the San Francisco Bay Area, the San Joaquin Valley, and Southern California. Of the contracted water supply, approximately two-thirds go to municipal and industrial (M&I) users and one-third goes to agricultural users. Through these contracts, the SWP provides a supplemental water supply to approximately two-thirds of California's population. The contracts are in effect for the longest of the following periods: the project repayment period which extends to the year 2035; 75 years from the date of the contract; or the period ending with the latest maturity date of any bond issued to finance project construction costs.

Power contracts

CVP

In 1967, the Secretary of the Interior entered into Contract 2948A with Pacific Gas and Electric (PG&E).). The contract integrates the CVP generation resources with the PG&E generation

system and in return PG&E provides, among other things, CVP load firming, CVP load following, and transmission/distribution of CVP energy to CVP loads. The contract is administered on behalf of the United States by the Western Area Power Administration (Western). Reclamation and Western are currently planning for changes in power marketing and management anticipating the expiration of the contract on December 31, 2004.

A second contract with PG&E (Contract 2207A) provides for transmission wheeling of CVP generation to the San Luis pumping plants. This contract expires in 2016.

SWP

DWR has authority to include as part of SWP facilities the construction of such plants and works for generation of electric power and distribution and to enter into contracts for the sale, use and distribution of the power as DWR may determine to be necessary (Wat. Code Sec. 11295 and 11625). The SWP power plants generate about half of the energy it needs to move water within the State. Because the SWP consumes more power than it generates, it meets its remaining power needs by purchasing energy or making energy exchanges with other utilities.

Federal Power Act

SWP

DWR operates Oroville's facilities as a multipurpose water supply, flood management, power generation, recreation, fish and wildlife enhancement, and salinity control project. The Federal Power Act (FPA) requires that DWR have a license from the Federal Energy Regulatory Commission (FERC) to operate Oroville facilities. DWR operates Oroville facilities under a license issued by the Federal Power Commission, precursor to FERC, on February 11, 1957, for a term of 50 years. The operation license will expire on January 31, 2007. Under FPA and FERC, DWR must file an application for a new license (relicense) on or before January 31, 2005. DWR will be the lead agency for the preparation of an Environmental Impact Report (EIR) for California public agency approvals relating to environmental impacts associated with the proposed relicensing of Oroville's facilities power generation components.

On September 20, 2002, DWR issued a Final National Environmental Policy Act (NEPA) Scoping Document and California Environmental Quality Act (CEQA) Notice of Preparation for the relicensing effort. In order to identify issues, plan studies, and consider potential protection, mitigation, and enhancement measures, DWR, State and Federal agencies, Indian Tribes, local government officials, and interested members of the public are actively participating in the relicensing process as the Collaborative Team. On March 25, 2003, DWR released NEPA Scoping Document 2/Amended CEQA Notice of Preparation which describes in greater detail the alternatives DWR intends to analyze as part of the environmental review process. The Collaborative Team adopted a process protocol that sets forth the structure and procedures for the relicensing procedures.

Tribal Water Rights and Trust Resources

The Yurok and Hoopa Valley Tribes have fishing rights to take anadromous fish within their reservations.; Memorandum from the Solicitor to the Secretary, Fishing Rights of the Yurok and Hoopa Valley Tribes, M-36979 (October 4, 1993). These rights were secured to the Yurok and

Hoopa Valley Tribes through a series of nineteenth century executive orders. Their fishing rights "include the right to harvest quantities of fish on their reservations sufficient to support a moderate standard of living." Id. at 3.

The executive orders setting aside what are now the Yurok and Hoopa Valley Reservations also reserved rights to an in stream flow of water sufficient to protect the Tribes' rights to take fish within their reservations. See Colville Confederated Tribes v.Walton, 647 F.2d 42, 48 (9th Cir.), cert. Denied, 454 U.S. 1092 (1981). Although the Tribes' water rights are presently unquantified, there are rights vested at the latest in 1891 and perhaps as early as 1855. See, e.g., United States v. Adair, 723 F.2d 1394 (9th Cir. 1983).

Other Agreements

Coordinated Operations Agreement (COA)

The CVP and SWP use the Sacramento River and the Delta as common conveyance facilities. Reservoir releases and Delta exports must be coordinated to ensure that the projects operate to agreed upon procedures.

The coordinated operation agreement (COA) between the United States of America and the DWR to operate the CVP and the SWP was signed in November 1986. Under the COA, Reclamation and DWR agree to operate the CVP and SWP in a manner to meet Sacramento Valley and Delta needs while maintaining their respective annual water supplies as identified in the agreement. Coordination between the two projects is facilitated by implementing an accounting procedure based on the sharing principles outlined in the COA. Although the principles were intended to cover a broad range of conditions, changes introduced by past National Marine Fisheries Service (NOAA Fisheries) and U.S. Fish and Wildlife Service (FWS) biological opinions (BO) by the SWRCB D-1641, and by CVPIA were not specifically addressed by the COA. However, these variances have been addressed by Reclamation and DWR through mutual agreement. When water must be withdrawn from storage to meet Sacramento Valley and Delta requirements, 75 percent of the responsibility is borne by the CVP and 25 percent by the SWP. The COA also provides that when unstored water is available for export, 55 percent of the sum of stored water and the unstored export water is allocated to the CVP and 45 percent is allocated to the SWP. Some of the operational constraints introduced in past NOAA Fisheries and FWS biological opinions, by the SWRCB D-1641, and by CVPIA were not addressed by the COA; however, these variances have been addressed by Reclamation and DWR through mutual informal agreement.

CALFED

In the August 28, 2000, CALFED Record of Decision (ROD), Reclamation and other State and Federal agencies committed to implementing a long-term plan to restore the Bay-Delta. This plan consists of many activities including storage, conveyance, ecosystem restoration, levee integrity, watersheds, water supply reliability, water use efficiency, water quality, water transfers, and science.

Coordinated Water Operations

The Implementation Memorandum of Understanding (MOU), also signed on August 28, 2000, memorialized the operations decision-making process that had evolved through the CALFED Operations Coordination Group (Ops Group) process including an Operations Decision Making Process (Attachment D of the ROD). This process consists of staff, stakeholder, and policy level forums for addressing operational issues.

One of these forums, the Water Operations Management Team (WOMT), consists of managers of Reclamation, FWS, NOAA Fisheries, DFG, DWR and the U.S. Environmental Protection Agency (EPA). WOMT provides a weekly frequent opportunity for managers to discuss CVP/SWP operations and related fishery issues.

The Ops Group was established by the 1994 Framework Agreement. The Ops Group consisting of (DWR, DFG, SWRCB, Reclamation, FWS, NOAA Fisheries, and EPA) coordinate the operations of the Projects with fisheries protection and implementation of the CVPIA. Shortly after its formation, the Ops Group provided a forum for stakeholders to provide input into the operations decision process. The Ops Group also established three teams to facilitate the decision-making process, data exchange, and information dissemination. The CVPIA Section 3406(b)(2) Implementation Team (B2IT) assists the U.S. Department of the Interior (Interior) with implementation of CVPIA Section 3406(b)(2). The Data Assessment Team (DAT) is an agency-driven activity that includes participation by stakeholders to review biological data and provide input to Reclamation and DWR on actions to protect fish. The Operations and Fisheries Forum (OFF) is a stakeholder-driven forum to aid information dissemination and facilitate discussion regarding operation of the CVP and SWP and has been meeting since 1995.

The Ops Group developed and implements the Chinook Salmon Protection Decision Process. The process includes monitoring of environmental conditions and salmon movement, data assessment procedures, specific indicators that spring-run Chinook are entering the Delta from upstream or being entrained at the SWP or CVP export facilities, and operational responses to minimize the effects of SWP and CVP facilities on emigrating spring-run salmon. The Ops Group decision-making process is also used for protection of other Chinook salmon runs.

Environmental Water Account

The Environmental Water Account (EWA) is a cooperative management program described in the CALFED ROD. The purpose of EWA is to provide protection to the fish of the Bay-Delta estuary through environmentally beneficial changes in SWP/CVP operations at no uncompensated water cost to the Project's water users. The EWA is intended to provide sufficient water (beyond what is available through existing regulatory actions related to project operations), combined with the Ecosystem Restoration Program (ERP) and the regulatory baseline, to address the CALFED's fishery protection and restoration/recovery needs for the first four years of Stage 1. Before the EWA expires (September 30, 2004) the management agencies and Project agencies will assess the success of EWA operations and analyze the potential impacts from new facilities and expanded conveyance capacity. The agencies will then determine the appropriate size and composition of an EWA, as well as the EWA's sharing in the benefits from new facilities, in the fifth and future years. (CALFED ROD, Attachment 2, EWA Operating Principles Agreement)

The use of EWA assets has been included in the operations studies to reflect current operational flexibility to reduce incidental take of listed species and, as noted above, to provide for restoration and recovery of such species. Inclusion of the EWA in this description of present and also future actions for CVP and SWP operations does not represent a decision on the future implementation of EWA. Following an analysis of a future EWA or surrogate and a decision on long-term implementation of EWA, Reclamation and DWR will determine whether a new assessment of impacts to listed species under OCAP is warranted.

The modeling and biological assessments can only represent in a gross sense the annual and day-to-day use of the EWA in coordination with similar (b)(2) actions. Currently Reclamation and DWR must use forecasts of annual operations in concert with evaluations of annual (b)(2) and EWA assets to request Federal Endangered Species Act (ESA) commitments from the FWS, NOAA Fisheries, and DFG. This commitment is accomplished through the WOMT and Ops Group process to provide for daily management of operations and fishery. Based on this process, changes to the EWA resulting in unanalyzed impacts to listed species will result in re-initiation of OCAP consultation.

Trinity

In December 2000, Interior signed the ROD on the Trinity River Main stem Fishery Restoration Environmental Impact Statement (EIS) and EIR. The ROD was the culmination of years of studies on the Trinity River. The ROD adopted the preferred alternative, a suite of actions which included a variable annual flow regime, mechanical channel rehabilitation, sediment management, watershed restoration, and adaptive management.

The EIS/EIR was challenged in Federal District Court and litigation is ongoing. The District Court has limited the flows available to the Trinity River until preparation of a supplemental environmental document is completed. As a result of ongoing litigation, the flows described in the ROD may not be implemented at this time; however, Reclamation is including the ROD flows as part of this proposed action on which Reclamation is consulting.

San Joaquin River Agreement

The San Joaquin River Agreement (SJRA) includes a 12-year experimental program providing for increased flows and decreased Delta exports in the lower San Joaquin River during a 31-day pulse flow period during April-May. It also provides for the collection of experimental data during that time to further the understanding of the effects of flows, exports, and the Head of Old River Barrier on salmon survival. This experimental program is commonly referred to as the Vernalis Adaptive Management Program (VAMP). The SJRA also provides water for flows at other times on the Stanislaus, Merced, and lower San Joaquin Rivers. The SJRA established a management and technical committee to oversee, plan, and coordinate implementation of activities required under the agreement. Reclamation, DWR, FWS, DFG and NOAA Fisheries are signatories to the SJRA, other signatories include San Joaquin River water rights (SJRWR) holders, CVP and SWP water users, and other stakeholders. The signatory SJRWR holders formed the San Joaquin River Group Authority to coordinate implementation of their responsibilities under the SJRA. Up to 110,000 acre-feet (af) may be provided for VAMP during April-May and an additional 27,500 af is provided at other times. In certain “double-step” years,

up to an additional 47,000 af may need to be acquired to fully meet VAMP flow objectives. This water would be provided under supplemental agreements separate from the SJRA.

Sacramento Valley Water Management Program

In February 2003, Reclamation, FWS, DWR, DFG, State and Federal water-supply contractors, the Northern California Water Association and approximately 40 water districts and water users within the Sacramento River watershed signed a Settlement Agreement (SA) to resolve water right issues with respect to obligations to meet Delta water quality objectives. The SA establishes a collaborative process among the parties to promote better management of California's water resources and avoid prolonged litigation over water rights issues. The SA process calls for implementing multiple, short-term, ten-year, water management projects that will provide a source of new water to meet local water supply needs and to make water available during dry years to the SWP and CVP to assist in meeting SWRCB 1995 WQCP flow related objectives. The parties intend, through development of multiple groundwater projects and storage release projects, that the upstream water users will develop capacity to annually produce up to 185,000 af of water that would otherwise not be available in the Sacramento River. The parties are preparing environmental documents and obtaining funding to implement the short-term projects and expect that in the spring of 2005 the program will begin. The program will be phased in over three years with up to 50,000 af the first year, 100,000 af the second year, and 185,000 af the following years with the potential that these maximum amounts of water could be transferred south of the Delta if pumping capacity is available.

Water Transfers

Water transfers relevant to this BA occur when a water user north of the Delta undertakes actions to make water available for transfer generally south of the Delta. Transfers requiring export from the Delta, such as North of Delta (NOD) transfers for dry-year transfer programs, EWA, etc., are done at times when pumping capacity at the Federal and State pumping plants is available to move the water. Reclamation and DWR will work to facilitate transfers and will complete them in accordance with all existing regulations and requirements.

ESA

Federal agencies have an obligation to ensure that any discretionary action it authorizes, funds, or carries out is not likely to jeopardize the continued existence of any endangered or threatened species or destroy or adversely modify its critical habitat unless that activity is exempt pursuant to the Federal ESA 16 U.S.C. §1536 (a)(2); 50 CFR §402.03. Under Section 7(a)(2), a discretionary agency action jeopardizes the continued existence of a species if it "reasonably would be expected, directly or indirectly, to reduce appreciably the survival and recovery of a listed species in the wild by reducing the reproduction, numbers, or distribution of the species" 50 CFR §402.02.

Through this consultation, Reclamation will comply with its obligations under the Federal ESA, namely, to: 1) avoid any discretionary action that is likely to jeopardize continued existence of listed species or adversely affect designated critical habitat; 2) take listed species only as permitted by the relevant Service; 3) and use Reclamation's authorities to conserve listed

species. Reclamation also is proposing actions to benefit the species under its existing authorities and consistent with its 7(a)(1) obligation to conserve and protect listed species. Section 7(a)(1) alone does not give Reclamation additional authority to undertake any particular action, regardless of its potential benefit for endangered species.

The Proposed Action

The CVP is composed of some 20 reservoirs with a combined storage capacity of over 11 million af, 11 powerplants, and over 500 miles of major canals and aqueducts (see figure 2-1). These various facilities are generally operated as an integrated project, although they are authorized and categorized in divisions. Authorized project purposes include flood control; navigation; provision of water for irrigation and domestic uses; fish and wildlife protection, restoration, and enhancement; and power generation. However, not all facilities are operated to meet each of these purposes. For example, flood control is not an authorized purpose of the CVP's Trinity River Division. The primary CVP purpose was to provide water for irrigation throughout California's Central Valley. The CVPIA has amended CVP authorizations to include fish and wildlife mitigation, protection, and restoration as purposes equal in priority to irrigation and domestic uses, and fish and wildlife enhancement as a purpose equal in priority to power generation.

The SWP stores and distributes water for agricultural, and municipal, and industrial uses in the northern Central Valley, the San Francisco Bay area, the San Joaquin Valley, the Central Coast, and Southern California. Other project functions include flood control, water quality maintenance, power generation, recreation, and fish and wildlife enhancement.

The proposed action is to continue to operate the CVP and SWP. In addition to current day operations several future actions are to be included in this consultation. These actions are: increased flows in the Trinity system, increased pumping at Banks Pumping Plant (referred to as 8500 Banks), permanent barriers operated in the South Delta, an intertie between the California Aqueduct and the Delta-Mendota Canal, a long-term Environmental Water Account (EWA), Freeport Regional Water Project (FRWP), and various operational changes that are identified in this project description.

Although the actions listed in the previous paragraph are not being implemented at present, they are part of the future proposed action on which Reclamation is consulting. As such proposed activities only address the operations of the action; that is, the activities do not include construction of any facilities to implement the actions. All site-specific/localized activities of the actions such as construction/screening and any other site-specific effects will be addressed in a separate section 7 consultation.

Table 1–1 summarizes the proposed operational actions of the CVP covered by this consultation.

Table 1–1 Proposed CVP operational actions for consultation.

Action	Requirement for Action
I.Trinity River Division	-SWRCB Permit Order 124

Action	Requirement for Action
Trinity Lake operations	-Safety Of Dams Criteria
Lewiston Dam releases and Trinity River flows	-SWRCB permits for diversions from Trinity -2000 Trinity ROD -Westlands Water District (Westlands) et al., v. Interior (Trinity litigation)
Whiskeytown Dam releases to Clear Creek	-SWRCB permits for diversions from Trinity, Clear Creek (permits specify minimum downstream releases) -1960 Memorandum of Agreement (MOA) with DFG (establishes minimum flows released to Clear Creek) -1963 release schedule -Consistent with Anadromous Fish Restoration Program (AFRP) objectives (Appendix A to the October 5, 1999 Decision on (b)(2) implementation) and (b)(2) availability -Stability Criteria -Thresholds of Trinity Storage
Townsend requirement	2000 Agreement with FWS (b)(2)
Spring Creek Debris Dam operations	1980 MOA with DFG, SWRCB
Diversions to Sacramento River	-SWRCB WR 90-5 (temperature control objectives), SWRCB WR 91-1
Temperature Objectives	-SWRCB WR 90-5, SWRCB WR 91-1
II. Shasta Division	-SWRCB WR 90-5
Shasta Dam operations	- Regulating Criteria-Flood Control Act 1944 - CVPIA- TCD Operations

Action	Requirement for Action
Keswick Dam releases to Sacramento River Minimum flows of 3,250 cubic feet per second (cfs) October through March	-1960 MOA with DFG: established flow objectives, minimum releases in dry, critical years -1981 agreement with DFG: established normal year minimum releases September-February -SWRCB WR 90-5: established year round minimum flows -AFRP (Appendix A to the October 5, 1999 Decision on (b)(2) implementation) and (b)(2) availability -Navigation flow requirement to Wilkins Slough -CVPIA: ramping criteria consistent with 3406(b)(2) and 3406(b)(9)
III. Sacramento River Division	-SWRCB WR 90-5
Red Bluff Diversion Dam operations • Gates raised from September 15 to May 14 with flexibility to temporarily lower gates in excess of pumping capacity • Future installation of additional pump	-1986 Agreement with NOAA Fisheries et al., gates raised in winter months for fish passage
Tehama Colusa Canal operations	-Temporary diversion from Black Butte Reservoir (SWRCB permit)
Sacramento River temperature objectives	-SWRCB WR 90-5:temperature objectives added to permits, modified 1960 MOUwith DFG regarding minimum flows -SWRCB WR 91-1 (temperature objectives)
Sacramento-Trinity Water Quality Monitoring Network	-SWRCB WR 90-5, 91-1
Sacramento River Temperature Task Group	-SWRCB WR 90-5, 91-1
ACID Diversion Dam ops	Reclamation contract (water service and diversion)

Action	Requirement for Action
IV. American River Division	
Folsom Dam and Power Plant Operations	-U.S. Army Corps of Engineers (Corps) Flood Control Manual, Flood Control Diagram (regulating criteria) -1996 Agreement with Sacramento Area Flood Control Agency (SAFCA) (modified flood control criteria) - AFRP (Appendix A to the October 5, 1999 Decision on (b)(2) implementation) and (b)(2) availability -Draft DFG criteria pursuant to CVPIA 3406(b)(9) (addressing flow fluctuations) - CVP local municipal diversions
Nimbus Dam operations and Lower American River flows • Includes year round temperature control	- AFRP and (b)(2) availability: minimum flows October-September, stability objectives -Draft DFG criteria pursuant to CVPIA 3406(b)(9) (addressing flow fluctuations)
Folsom South Canal operations	-Contractual commitments
Freeport Regional Water Project	-Contract with EBMUD -Sacramento County contract and water rights
V. Eastside Division	

Action	Requirement for Action
New Melones Dam and Reservoir operations and Lower Stanislaus River flows below Goodwin Dam	-Corps Flood Control Manual, Flood Control Diagram (New Melones and Tulloch) -Oakdale Irrigation District (OID), South San Joaquin Irrigation District (SSJID) contract (Tri-dams agreement for afterbay storage) -New Melones Interim Plan of Operation (NMIPO) (includes AFRP flows with (b)(2) water) -1988 OID, SSJID Agreement and Stipulation (release of annual inflows for diversion) -SWRCB D-1422 (release of 98,000 af for fish and wildlife purposes, dissolved oxygen (DO) standards at Ripon) -1987 DFG Agreement (increased flows over SWRCB D-1422) -1995 WQCP (minimum DO concentration) -1999 SJRA flows and water supplies -CVP Water Service contracts
Support of San Joaquin River requirements and objectives at Vernalis	-SWRCB D-1641 (Vernalis flow requirements February-June, Vernalis water quality objectives, SJRA implementation) -CALFED ROD Regulatory Baseline (2:1 flow/export ratio met with (b)(2), EWA)
VI. Delta Division	-SWRCB D-1641
Tracy Pumping plant • Pumping curtailments supported with (b)(2) or EWA assets	-Salmon Tree Decision -CVPIA - CALFED ROD and EWA Operating Prinicples
Delta Cross Channel (DCC) Operation	-SWRCB D-1641(Delta Cross Channel closure: February-May, 14 days between May 21-June 15, 45 days between November-January) -Salmon Decision Tree

Action	Requirement for Action
Contra Costa Canal (CCC) Operations	-CVPIA (Fish Screen Program) -1993 Winter–run Chinook Salmon BO for Los Vaqueros -1993 Delta Smelt BO for Los Vaqueros (requires Old River diversions January-August to extent possible, diversion reduced during dry conditions, reservoir refilling criteria, reservoir releases in spring)
Export/Inflow (EI) ratio	-SWRCB D-1641
X2	-SWRCB D-1641
31 Day export limit (April 15-May 15)	-SJRA- VAMP -SWRCB D-1641
Delta Outflow	-SWRCB D-1641 (minimum outflow July-January: 3000-8000cfs, habitat protection outflow February-June: 7,100-29,200cfs, February Salinity Starting Condition Determination)
Water Quality	-SWRCB D-1641 (M&I standards, agricultural standards for Western/Interior Delta and southern Delta, fish and wildlife standards for San Joaquin River and Suisun Marsh)
JPOD	-SWRCB D-1641
Intertie	-CALFED ROD
VII. Friant Division	
Millerton Lake and Friant Dam operations, Friant-Kern Canal operations, and Madera Canal operations	Corps Flood Control Diagram, Mammoth Pool Operating Contract (with Southern California Edison (SCE), Water Deliveries (Class I, Class II, and Section 215 supply), SJRWR (flow at Gravelly Ford), Miller and Lux Water Rights exchange
VIII. West San Joaquin Division	
San Luis Reservoir, Gianelli Pumping and Generating Plant, San Luis Canal, O'Neill forebay operations, and Dos Amigos Pumping Plant	-1961 DWR/Reclamation Agreement (as amended) - CVP Water Service Contracts and Deliveries

Action	Requirement for Action
IX.San Felipe Division	
Pacheco Pumping Plant, Santa Clara Pipeline, Hollister Conduit and Coyote Pumping Plant	- CVP Water Service Contracts and Deliveries for Santa Clara Valley Water District and San Benito County
X. Other	
Actions using (b)(1), (b)(2)	-CVPIA -AFRP -2003 Final Decision on (b)(2) Implementation.
EWA	-CALFED ROD and Programmatic BOs -EWA Operating Principles -CVPIA

Chapter 2 Project Description for the Central Valley Project and State Water Project

Introduction

Reclamation and DWR propose to operate the Central Valley Project (CVP) and State Water Project (SWP) (collectively the Projects) to divert, store, and convey Project water consistent with applicable law. These operations are summarized in this Biological Assessment (BA) and are described in further detail in the CVP Operations Criteria and Plan (CVP-OCAP).

The Proposed Action

The proposed action is to continue to operate the CVP and SWP in a coordinated manner. In addition to current day operations, several future actions are to be included in this consultation. These actions are: (1) increased flows in the Trinity River, (2) increased pumping at Banks Pumping Plant (referred to as 8500 Banks), (3) permanent barriers operated in the South Delta, (4) an intertie between the California Aqueduct (CA) and the Delta-Mendota Canal (DMC), (5) a long-term Environmental Water Account (EWA), (6) Freeport Regional Water Project (FRWP), and (7) various operational changes that are identified in this project description. Some of these items will be part of early consultation including increased Banks Pumping to 8500 cfs, permanent barriers and the long-term EWA. These proposed actions will come online at various times in the future. Thus, the proposed action is continued operation of the CVP/SWP withou these actions, and operations as they come online.

The actions listed in the preceding paragraph are not being implemented at present; however, they are part of the future proposed action on which Reclamation is consulting. Only the operations associated with the proposed activities are addressed in this consultation; i.e., the activities do not include construction of any facilities to implement the actions. All site-specific/localized activities of the actions such as construction/screening and any other site-specific effects will be addressed in separate action specific section 7 consultations.

Table 2–1 summarizes the differences between current operational actions and future operational actions to be covered by this consultation.

Table 2–1 Proposed future changes in operational actions for consultation.

Area of Project	Today 2004	Future 2030
Trinity & Whiskeytown	368,600-452,600 af	368,600- 815,000 af
Shasta/Sacramento River	RBDD eight months gates out	Same
Oroville and Feather River	Same	Same
Folsom and American River	Current Demands	Build out of demands and Freeport Regional Water Project
New Melones and Stanislaus River	Interim Plan of Operations Guidance	Same
Friant	Same	Same
Sacramento-San Joaquin Delta	2001 Demands	2020 Demands
Suisun March	Same	Same
WQCP	D-1641	Same
COA	1986 Guidance	Integrated Operations
CVPIA	May 9, 2003 Decision	Same
CALFED	EWA	Same
Banks	6680 cfs & Temp Barriers	8500 Banks and Permanent barriers
Tracy	Max of 4600 cfs in summer	Intertie

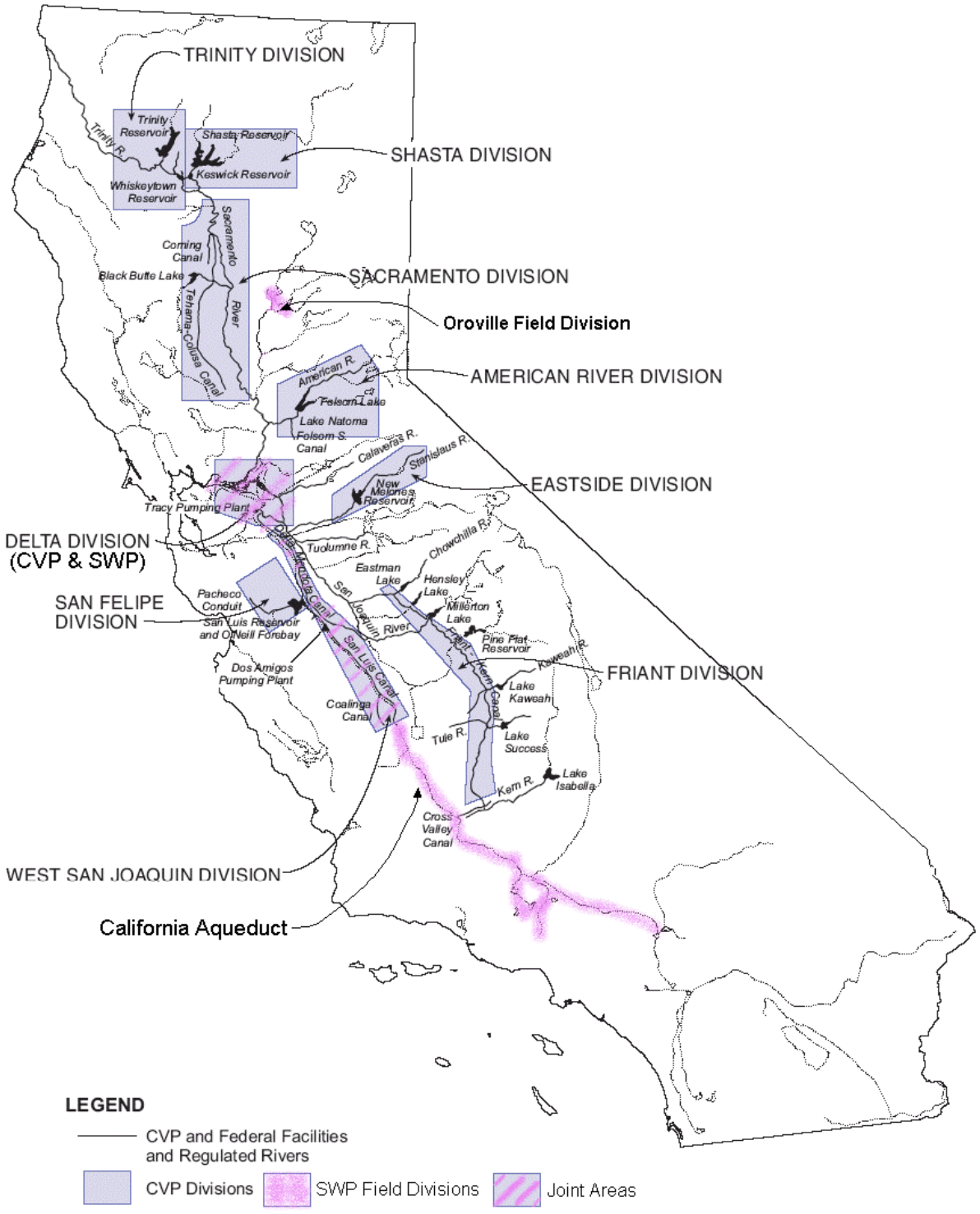

Figure 2–1 CVP and SWP Service Areas (adapted from the draft Trinity SEIR/S)

Coordinated Operation of the CVP and SWP

The CVP and SWP utilize a common water supply in the Central Valley of California. The DWR and Reclamation (collectively referred to as Project Agencies) have built water conservation and water delivery facilities in the Central Valley in order to deliver water supplies to affected water rights holders as well as project contractors. The Project Agencies' water rights are conditioned by the SWRCB to protect the beneficial uses of water

within each respective project and jointly for the protection of beneficial uses in the Sacramento Valley and the Sacramento-San Joaquin Delta Estuary. The Project Agencies operate the CVP and SWP to meet these requirements through the Coordinated Operations Agreement (COA).

The COA defines the project facilities and their water supplies, sets forth procedures for coordination of operations, identifies formulas for sharing joint responsibilities for meeting Delta standards and other legal uses of water, identifies how unstored flow will be shared, sets up a framework for exchange of water and services between the Projects, and provides for periodic review every five years.

The CVP and the SWP use the Sacramento River and the Delta as common conveyance facilities. Reservoir releases and Delta exports must be coordinated to ensure each project achieves its share of benefit from shared water supplies and bears its share of joint obligations to protect beneficial uses.

Implementing the COA

Obligations for In-basin Uses

In-basin uses are defined in the COA as legal uses of water in the Sacramento Basin, including the water required under the SWRCB Decision 1485 (D-1485) Delta standards (D-1485 ordered the CVP and SWP to guarantee certain conditions for water quality protection for agricultural, municipal and industrial [M&I], and fish and wildlife use). Each project is obligated to ensure water is available for these uses, but the degree of obligation is dependent on several factors and changes throughout the year.

Balanced water conditions are defined in the COA as periods when it is agreed that releases from upstream reservoirs plus unregulated flows approximately equals the water supply needed to meet Sacramento Valley in-basin uses plus exports. Excess water conditions are periods when it is agreed that releases from upstream reservoirs plus unregulated flow exceed Sacramento Valley in-basin uses plus exports. Reclamation’s Central Valley Operations Office (CVOO) and DWR’s SWP Operations Control Office jointly decide when balanced or excess water conditions exist.

During excess water conditions, sufficient water is available to meet all beneficial needs, and the CVP and SWP are not required to supplement the supply with water from reservoir storage. Under Article 6(g), Reclamation and DWR have the responsibility (during excess water conditions) to store and export as much water as possible, within physical and contractual limits. In these cases, accountability is not required. However, during balanced water conditions, the Projects share the responsibility in meeting in-basin uses. Balanced water conditions are further defined according to whether water from upstream storage is required to meet Sacramento Valley in-basin use or unstored water is available for export.

When water must be withdrawn from reservoir storage to meet in-basin uses, 75 percent of the responsibility is borne by the CVP and 25 percent is borne by the SWP[1]. When unstored water is available for export (i.e., Delta exports exceed storage withdrawals while balanced water conditions exist), the sum of CVP stored water, SWP stored water, and the unstored water for export is allocated 55/45 to the CVP and SWP, respectively.

Accounting and Coordination of Operations

Reclamation and DWR coordinate on a daily basis to determine target Delta outflow for water quality, reservoir release levels necessary to meet in-basin demands, schedules for joint use of the San Luis Unit facilities, and for the use of each other's facilities for pumping and wheeling.

During balanced water conditions, daily accounts are maintained of the CVP and SWP obligations. This accounting allows for flexibility in operations and avoids the necessity of daily changes in reservoir releases that originate several days travel time from the Delta. It also means adjustments can be made "after the fact" rather than by prediction for the variables of reservoir inflow, storage withdrawals, and in-basin uses.

The accounting language of the COA provides the mechanism for determining the responsibility of each project; however, real time operations dictate actions. For example, conditions in the Delta can change rapidly. Weather conditions combined with tidal action can quickly affect Delta salinity conditions, and therefore, the Delta outflow objective. If, in this circumstance, it is decided the reasonable course of action is to increase upstream reservoir releases, then the response will likely be to increase Folsom releases first. Lake Oroville water releases require about three days to reach the Delta, while water released from Lake Shasta requires five days to travel from Keswick to the Delta. As water from the other reservoirs arrives in the Delta, Folsom releases could be adjusted downward. Any imbalance in meeting each project’s obligation would be captured by the COA accounting.

Reservoir release changes are one means of adjusting to changing in-basin conditions. s in Delta outflow can be also be immediately achieved by increasing or decreasing project exports. As with changes in reservoir releases, imbalances in meeting project obligations are counted in the COA accounting.

During periods of balanced water conditions, when real-time operations dictate project actions, an accounting procedure tracks the water obligations of the CVP and SWP. The Projects maintain a daily and accumulated accounting. The account represents the imbalance resulting from actual coordinated operations compared to the COA-defined sharing of obligations and supply. The project that is “owed” water (i.e., the project that provided more or exported less than its COA-defined share) may request the other project adjust its operations to reduce or eliminate the accumulated account within a reasonable time.

The duration of balanced water conditions varies from year to year. Some very wet years have had no periods of balanced conditions, while very dry years may have had long continuous periods of balanced conditions, and still other years may have had several periods of balanced conditions interspersed with excess water conditions. Account balances continue from one

[1] These percentages were derived from negotiations between Reclamation and DWR

balanced water condition through the excess water condition and into the next balanced water condition. When the project that is owed water enters into flood control operations, at Shasta or Oroville, the accounting is zeroed out for that respective project.

Changes in Operations Coordination Environment since 1986

Implementation of the COA has evolved continually since 1986 as changes have occurred to CVP and SWP facilities, to project operations criteria, and to the overall physical and regulatory environment in which the operations coordination takes place. Since 1986, new facilities have been incorporated into the operations that were not part of the original COA. New water quality and flow standards (D-1641) have been imposed by the SWRCB; the Central Valley Project Impovement Act (CVPIA) has changed how the CVP is operated; and finally, the Federal Endangered Species Act (ESA) responsibilities have effected both the CVP and SWP operations. The following is a list of significant changes that have occurred since 1986. Included after each item is an explanation of how it relates to the COA and its general effect on the accomplishments of the CVP or SWP.

Sacramento River Temperature Control Operations

Temperature operations have constrained the pattern of storage and withdrawal of storage at Shasta, Trinity, and Whiskeytown, for the purpose of improving temperature control. They have also constrained rates of flow, and changes in rates of flow below Keswick Dam in keeping with temperature requirements. Such constraints have reduced the CVP's capability to respond efficiently to changes in Delta export or outflow requirements. Periodically, temperature requirements have caused timing of the CVP releases to be mismatched with Delta export capability, resulting in loss of water supply. On occasion, and in accordance with Articles 6(h) and 6(i) of the COA, the SWP has been able to export water released by the CVP for temperature control in the Sacramento River.

Bay-Delta Accord, and Subsequent SWRCB Implementation of D-1641

The December 1994 Accord committed the CVP and SWP to a set of Delta habitat protective objectives that were eventually incorporated into the 1995 Water Quality Control Plan (WQCP), and later, along with Vernalis Adaptive Management Program (VAMP), were implemented by D-1641. The actions taken by the CVP and SWP in implementing D-1641 significantly reduced the export water supply of both Projects. Article 11 of the COA describes the options available to the United States for responding to the establishment of new Delta standards.

The first option is to amend the COA to provide for continued implementation to accomplish the purposes of the 1986 Agreement. Although the CVP and SWP continue to be operated in coordination to meet D-1641, neither an amendment of the COA nor an evaluation of the new Delta standards (for consistency with Congressional directives) has been undertaken. Significant new elements in the D-1641 standards include: (1) the X2 standards, (2) export to inflow (E/I) ratios, (3) Real-time Delta Cross Channel (DCC) operation, (4) San Joaquin flow standards, and (5) recognition of the CALFED Operations (CALFED Ops) process for flexibility in applying or relaxing certain standards.

Freeport Regional Water Project

The FRWP will be a new facility that will divert up to a maximum of about 300 cubic feet per second (cfs) from the Sacramento River near Freeport for Sacramento County and East Bay Municipal Utility District (EBMUD). EBMUD will divert water pursuant to its amended contract with Reclamation. The County will divert using its water rights and its CVP contract supply. This facility was not in the 1986 COA, and the diversions will result in some reduction in Delta export supply for both the CVP and SWP contractors. Pursuant to an agreement between Reclamation, DWR, and the CVP and SWP contractors in 2003, diversions to EBMUD will be treated as an export in the COA accounting and diversions to Sacramento County will be treated as an in-basin use.

North Bay Aqueduct

North Bay Aqueduct is a SWP feature that can convey up to about 175 cfs diverted from the SWP's Barker Slough Pumping Plant. North Bay Aqueduct Diversions are conveyed to Napa and Solano Counties. Pursuant to an agreement between Reclamation, DWR, and the CVP and SWP contractors in 2003, a portion of the SWP diversions will be treated as an export in COA accounting.

Loss of 195,000 af of D-1485 Condition 3 Replacement Pumping

The 1986 COA affirmed the SWP's commitment to provide replacement capacity to the CVP to make up for May and June pumping reductions imposed by SWRCB D-1485 in 1978. In the evolution of COA operations since 1986, D-1485 was superseded and SWP growth and other pumping constraints reduced available surplus capacity. The CVP has not received replacement pumping since 1993. Since then there have been (and in the current operations environment there will continue to be) many years in which the CVP will be limited by insufficient Delta export capacity to convey its water supply. The loss of the up to 195,000 af of replacement pumping has diminished the accomplishments anticipated by the CVP under the 1986 COA.

Periodic Review of the COA

The language of the COA incorporates a provision for the periodic review of the Agreement. Article 14a of the COA specifies the parties to review operations every five years.

The Agreement proceeds to state that the parties shall:

- Compare the relative success each party has had in meeting its objectives.
- Review operation studies supporting the COA.
- Assess the influence of the factors and procedures of Article 6 in meeting each party's future objectives.

Article 14a further states, "The parties shall agree upon revisions, if any, of the factors and procedures in Article 6, Exhibits B and D, and the Operation Study used to develop Exhibit B."

Beginning in 1995, and continuing under SWRCB D-1641, the Projects have been operating to meet the revised Delta standards. The changes that have occurred to the CVP and SWP since 1986 suggest a COA review would be appropriate. The August 2000 CALFED Record of Decision (ROD) included as an "Implementation Commitment" that DWR and Reclamation

intend to modify the 1986 COA in order to reflect the many changes in regulatory standards, operating conditions, and new project features such as EWA, that have evolved. Should that process indicate a change in the coordinated operation of the CVP and SWP, a review will be completed to determine the need to re-initiate consultation under Section 7 of the ESA.

SWRCB D-1641

The California State Water Resources Control Board imposes a myriad of constraints upon the operations of the Central Valley Project and State Water Project in the Delta. With Water Rights Decision 1641, the SWRCB implements the objectives set forth in the SWRCB 1995 Bay-Delta Water Quality Control Plan and imposes flow and water quality objectives upon the Projects to assure protection of beneficial uses in the Delta. The SWRCB also grants conditional changes to points of diversion for each project with D-1641.

The various flow objectives and export restraints are designed to protect fisheries. These objectives include specific outflow requirements throughout the year, specific export restraints in the spring, and export limits based on a percentage of estuary inflow throughout the year. The water quality objectives are designed to protect agricultural, municipal and industrial, and fishery uses and vary throughout the year and by the wetness of the year.

Figure 2–2 and Figure 2–3 summarize the flow and quality objectives in the Delta and Suisun Marsh for the Projects from D1641. These objectives will remain in place until such time that the SWRCB revisits them per petition or as a consequence to revisions to the SWRCB Water Quality Plan for the Bay-Delta (which is to be revisited periodically.)

On December 29, 1999, SWRCB adopted and then revised (on March 15, 2000) Decision 1641, amending certain terms and conditions of the water rights of the SWP and CVP. Decision-1641 substituted certain objectives adopted in the 1995 Bay-Delta Plan for water quality objectives that had to be met under the water rights of the SWP and CVP. In effect, D-1641 obligates the SWP and CVP to comply with the objectives in the 1995 Bay-Delta Plan. The requirements in D-1641 address the standards for fish and wildlife protection, M&I water quality, agricultural water quality, and Suisun Marsh salinity. SWRCB D-1641 also authorizes SWP and CVP to jointly use each other's points of diversion in the southern Delta, with conditional limitations and required response coordination plans. SWRCB D-1641 modified the Vernalis salinity standard under SWRCB Decision 1422 to the corresponding Vernalis salinity objective in the 1995 Bay-Delta Plan. The criteria imposed upon the CVP and SWP are summarized in Figure 2–2 (Summary Bay-Delta Standards) , Figure 2–3 (Footnotes for Summary Bay-Delta Standards), and Figure 2–4 (CVP/SWP Map).

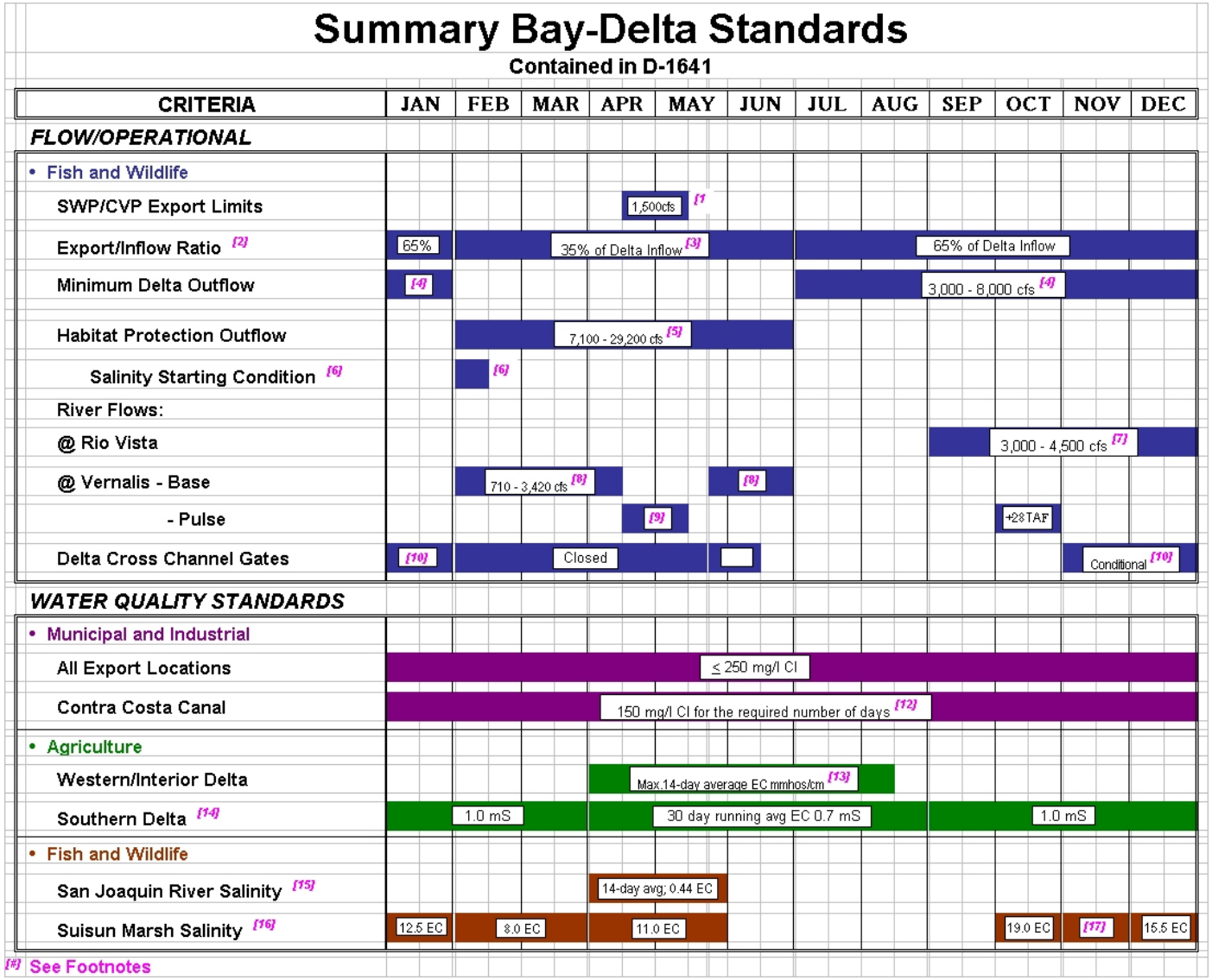

Figure 2–2 Summary Bay Delta Standards (See Footnotes in Figure 2–3)

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Footnotes

[1] Maximum 3-day running average of combined export rate (cfs) which includes Tracy Pumping Plant and Clifton Court Forebay Inflow less Byron-Bethany pumping.

Year Type	All
Apr15 - May15*	The greater of 1,500 or 100% of 3-day avg. Vernalis flow

* This time period may need to be adjusted to coincide with fish migration. Maximum export rate may be varied by CalFed Op's group.

[2] The maximum percentage of average Delta inflow (use 3-day average for balanced conditions with storage withdrawal, otherwise use 14-day average) diverted at Clifton Court Forebay (excluding Byron-Bethany pumping) and Tracy Pumping Plant using a 3-day average. (These percentages may be adjusted upward or downward depending on biological conditions, providing there is no net water cost.)

[3] The maximum percent Delta inflow diverted for Feb may vary depending on the January 8RI.

Jan 8RI	Feb exp. limit
≤ 1.0 MAF	45%
between 1.0 & 1.5 MAF	35%-45%
> 1.5 MAF	35%

[4] Minimum monthly average Delta outflow (cfs). If monthly standard ≤ 5,000 cfs, then the 7-day average must be within 1,000 cfs of standard; if monthly standard > 5,000 cfs, then the 7-day average must be ≥ 80% of standard.

Year Type	All	W	AN	BN	D	C
Jan	4,500*					
Jul		8,000	8,000	6,500	5,000	4,000
Aug		4,000	4,000	4,000	3,500	3,000
Sep	3,000					
Oct		4,000	4,000	4,000	4,000	3,000
Nov-Dec		4,500	4,500	4,500	4,500	3,500

* Increase to 6,000 if the Dec 8RI is greater than 800 TAF

[5] Minimum 3-day running average of daily Delta outflow of 7,100 cfs OR: either the daily average or 14-day running average EC at Collinsville is less than 2.64 mmhos/cm (This standard for March may be relaxed if the Feb 8RI is less than 500 TAF. The standard does not apply in May and June if the May estimate of the SRI IS < 8.1 MAF at the 90% exceedence level in which case a minimum 14-day running average flow of 4,000 cfs is required.) For additional Delta outflow objectives, see **TABLE A**.

[6] February starting salinity: If Jan 8RI > 900 TAF, then the daily or 14-day running average EC @ Collinsville must be ≤ 2.64 mmhos/cm for at least one day between Feb 1-14. If Jan 8RI is between 650 TAF and 900 TAF, then the CalFed Op's group will determine if this requirement must be met.

[7] Rio Vista minimum monthly average flow rate in cfs (the 7-day running average shall not be less than 1,000 below the monthly objective).

Year Type	All	W	AN	BN	D	C
Sep	3,000					
Oct		4,000	4,000	4,000	4,000	3,000
Nov-Dec		4,500	4,500	4,500	4,500	3,500

[8] BASE Vernalis minimum monthly average flow rate in cfs (the 7-day running average shall not be less than 20% below the objective). Take the higher objective if X2 is required to be west of Chipps Island.

Year Type	All	W	AN	BN	D	C
Feb-Apr14 and May16-Jun		2,130 or 3,420	2,130 or 3,420	1,420 or 2,280	1,420 or 2,280	710 or 1,140

[9] PULSE Vernalis minimum monthly average flow rate in cfs. Take the higher objective if X2 is required to be west of Chipps Island.

Year Type	All	W	AN	BN	D	C
Apr15 - May15		7,330 or 8,620	5,730 or 7,020	4,620 or 5,480	4,020 or 4,880	3,110 or 3,540
Oct	1,000*					

* Up to an additional 28 TAF pulse/attraction flow to bring flows up to a monthly average of 2,000 cfs except for a critical year following a critical year. Time period based on real-time monitoring and determined by CalFed Op's group.

[10] For the Nov-Jan period, Delta Cross Channel gates may be closed for up to a total of 45 days.

[11] For the May 21-June 15 period, close Delta Cross Channel gates for a total of 14 days per CALFED Op's group. During the period the Delta cross channel gates may close 4 consecutive days each week, excluding weekends.

[12] Minimum # of days that the mean daily chlorides ≤ 150 mg/l must be provided in intervals of not less than 2 weeks duration. Standard applies at Contra Costa Canal Intake or Antioch Water Works Intake.

Year Type	W	AN	BN	D	C
# Days	240	190	175	165	155

(Footnotes continued on next page)

[13] The maximum14-day running average of mean daily EC (mmhos/cm) depends on water year type.

	WESTERN DELTA				INTERIOR DELTA			
	Sac River @ Emmaton		SJR @ Jersey Point		Mokelumne R @ Terminous		SJR @ San Andreas	
Year Type	0.45 EC from April 1 to date shown	EC value from date shown to Aug15 *	0.45 EC from April 1 to date shown	EC value from date shown to Aug15 *	0.45 EC from April 1 to date shown	EC value from date shown to Aug15 *	0.45 EC from April 1 to date shown	EC value fro date shown Aug15 *
W	Aug 15		Aug 15		Aug 15		Aug 15	
AN	Jul 1	0.63	Aug 15		Aug 15		Aug 15	
BN	Jun 20	1.14	Jun 20	0.74	Aug 15		Aug 15	
D	Jun 15	1.67	Jun 15	1.35	Aug 15		Jun 25	0.58
C		2.78		2.20		0.54		0.87

* When no date is shown, EC limit continues from April 1.

[14] As per D-1641, for San Joaquin River at Vernalis: however, the April through August maximum 30- day running average EC for San Joaquin River at Brandt Bridge,Old River near Middle River, and Old River at Tracy Road Bridge shall be 1.0 EC until April 1, 2005 when the value will be 0.7 EC.

[15] Compliance will be determined between Jersey Point & Prisoners Point.
Does not apply in critical years or in May when the May 90% forecast of SRI ≤ 8.1 MAF.

[16] During deficiency period, the maximum monthly average mhtEC at Western Suisun Marsh stations as per SMPA is:

Month	mhtEC
Oct	19.0
Nov	16.5
Dec-Mar	15.6
Apr	14.0
May	12.5

[17] In November, maximum monthly average mhtEC = 16.5 for Western Marsh stations and maximum monthly average mhtEC = 15.5 for Eastern Marsh stations in all periods types.

TABLE A

Number of Days When Max. Daily Average Electrical Conductivity of 2.64 mmhos/cm Must Be Maintained. (This can also be met with a maximum 14-day running average EC of 2.64 mmhos/cm, or 3-day running average Delta outflows of 11,400 cfs and 29,200 cfs, respectively.) Port Chicago Standard is triggered only when the 14-day average EC for the last day of the previous month is 2.64 mmhos/cm or less. PMI is previous month's 8RI. If salinity/flow objectives are met for a greater number of days than required for any month, the excess days shall be applied towards the following month's requirement. The number of day's for values of the PMI between those specified below shall be determined by linear interpolation.

PMI	Chipps Island (Chipps Island Station D10)				
(TAF)	FEB	MAR	APR	MAY	JUN
≤ 500	0	0	0	0	0
750	0	0	0	0	0
1000	28*	12	2	0	0
1250	28	31	6	0	0
1500	28	31	13	0	0
1750	28	31	20	0	0
2000	28	31	25	1	0
2250	28	31	27	3	0
2500	28	31	29	11	1
2750	28	31	29	20	2
3000	28	31	30	27	4
3250	28	31	30	29	8
3500	28	31	30	30	13
3750	28	31	30	31	18
4000	28	31	30	31	23
4250	28	31	30	31	25
4500	28	31	30	31	27
4750	28	31	30	31	28
5000	28	31	30	31	29
5250	28	31	30	31	29
≥ 5500	28	31	30	31	30

*When 800 TAF < PMI < 1000 TAF, the number of days is determined by linear interpolation between 0 and 28 days.

PMI	Port Chicago (continuous recorder at Port Chicago)				
(TAF)	FEB	MAR	APR	MAY	JUN
0	0	0	0	0	0
250	1	0	0	0	0
500	4	1	0	0	0
750	8	2	0	0	0
1000	12	4	0	0	0
1250	15	6	1	0	0
1500	18	9	1	0	0
1750	20	12	2	0	0
2000	21	15	4	0	0
2250	22	17	5	1	0
2500	23	19	8	1	0
2750	24	21	10	2	0
3000	25	23	12	4	0
3250	25	24	14	6	0
3500	25	25	16	9	0
3750	26	26	18	12	0
4000	26	27	20	15	0
4250	26	27	21	18	1
4500	26	28	23	21	2
4750	27	28	24	23	3
5000	27	28	25	25	4
5250	27	29	25	26	6
5500	27	29	26	28	9
5750	27	29	27	28	13
6000	27	29	27	29	16
6250	27	30	27	29	19
6500	27	30	28	30	22
6750	27	30	28	30	24
7000	27	30	28	30	26
7250	27	30	28	30	27
7500	27	30	29	30	28
7750	27	30	29	31	28
8000	27	30	29	31	29
8250	28	30	29	31	29
8500	28	30	29	31	29
8750	28	30	29	31	30
9000	28	30	29	31	30
9250	28	30	29	31	30
9500	28	31	29	31	30
9750	28	31	29	31	30
10000	28	31	30	31	30
> 10000	28	31	30	31	30

Figure 2–3 Footnotes for Summary Bay Delta Standards

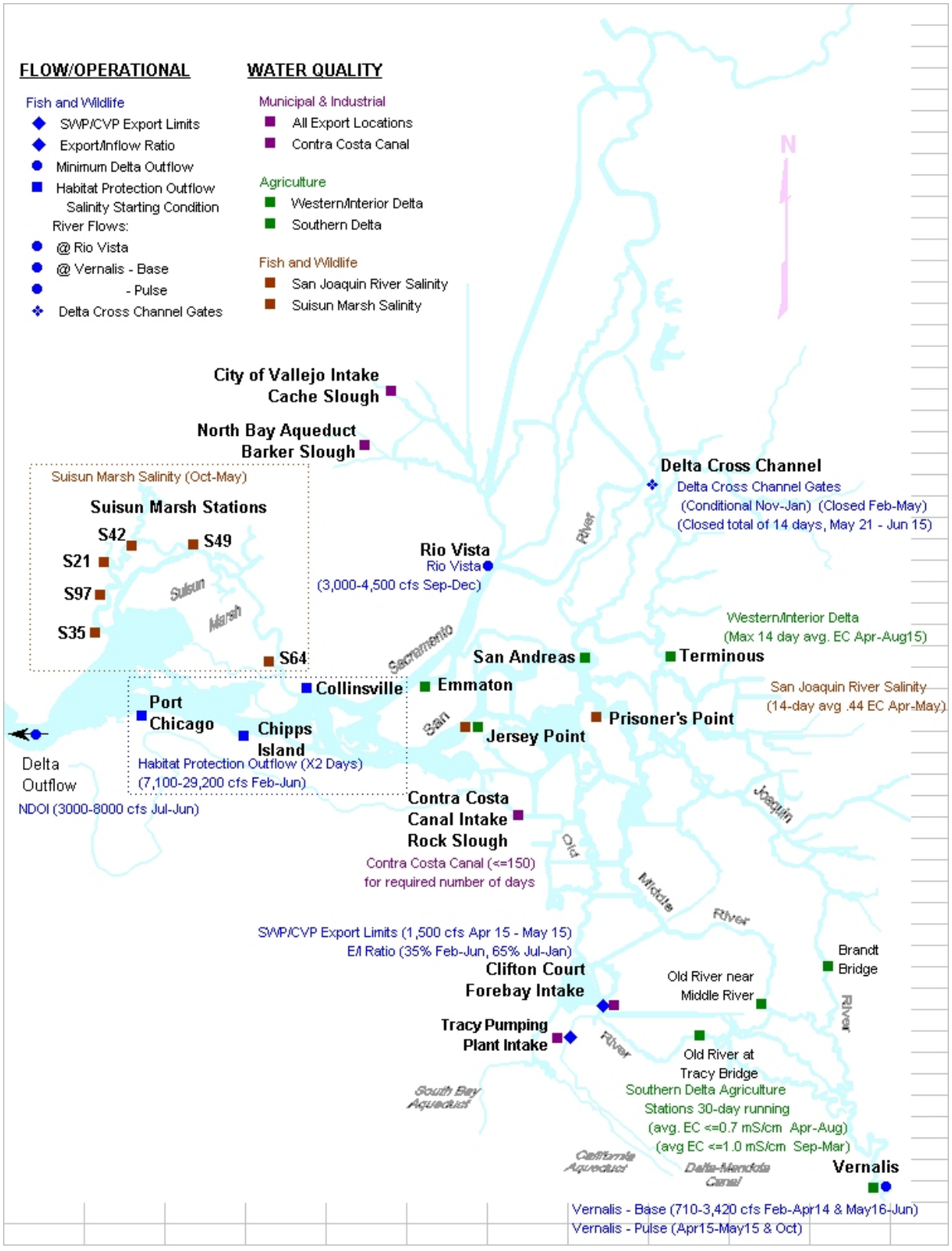

FLOW/OPERATIONAL
Fish and Wildlife
SWP/CVP Export Limits
Export/Inflow Ratio
Minimum Delta Outflow
Habitat Protection Outflow
Salinity Starting Condition
River Flows:
@ Rio Vista
@ Vernalis - Base
- Pulse
Delta Cross Channel Gates
WATER QUALITY
Municipal & Industrial
All Export Locations
Contra Costa Canal
Agriculture
Western/Interior Delta
Southern Delta
Fish and Wildlife
San Joaquin River Salinity
Suisun Marsh Salinity
N
City of Vallejo Intake
Cache Slough
North Bay Aqueduct
Barker Slough
Suisun Marsh Salinity (Oct-May)
Suisun Marsh Stations
S42
S49
S21
S97
S35
S64
Suisun
Marsh
Rio Vista
Rio Vista
(3,000-4,500 cfs Sep-Dec)
Delta Cross Channel
Delta Cross Channel Gates
(Conditional Nov-Jan) (Closed Feb-May)
(Closed total of 14 days, May 21 - Jun 15)
Western/Interior Delta
(Max 14 day avg. EC Apr-Aug15)
San Andreas
Terminous
San Joaquin River Salinity
(14-day avg .44 EC Apr-May)
Collinsville
Emmaton
Port
Chicago
Chipps
Island
Jersey Point
Prisoner's Point
Habitat Protection Outflow (X2 Days)
(7,100-29,200 cfs Feb-Jun)
Delta
Outflow
NDOI (3000-8000 cfs Jul-Jun)
Contra Costa
Canal Intake
Rock Slough
Contra Costa Canal (<=150)
for required number of days
SWP/CVP Export Limits (1,500 cfs Apr 15 - May 15)
E/I Ratio (35% Feb-Jun, 65% Jul-Jan)
Clifton Court
Forebay Intake
Tracy Pumping
Plant Intake
Old River near
Middle River
Brandt
Bridge
Old River at
Tracy Bridge
Southern Delta Agriculture
Stations 30-day running
(avg. EC <=0.7 mS/cm Apr-Aug)
(avg EC <=1.0 mS/cm Sep-Mar)
Vernalis
Vernalis - Base (710-3,420 cfs Feb-Apr14 & May16-Jun)
Vernalis - Pulse (Apr15-May15 & Oct)
Sacramento
River
San
Joaquin
Old
Middle
River
South Bay
Aqueduct
California
Aqueduct
Delta-Mendota
Canal

Figure 2–4 CVP/SWP Delta Map

Joint Point of Diversion

SWRCB D-1641 granted Reclamation and DWR the ability to utilize/exchange each Project's diversion capacity capabilities to enhance the beneficial uses of both Projects. The SWRCB conditioned the use of joint point of diversion (JPOD) capabilities based on a staged implementation and conditional requirements for each stage of implementation. The stages of JPOD in SWRCB D-1641 are:

- Stage 1 – for water service to Cross Valley Canal contractors and Musco Olive, and to recover export reductions taken to benefit fish.
- Stage 2 – for any purpose authorized under the current project water right permits.
- Stage 3 – for any purpose authorized up to the physical capacity of the diversion facilities.

Each stage of JPOD has regulatory terms and conditions which must be satisfied in order to implement JPOD.

All stages require a response plan to ensure water levels in the southern Delta will not be lowered to the injury of water users in the southern Delta (Water Level Response Plan). All stages require a response plan to ensure the water quality in the southern and central Delta will not be significantly degraded through operations of the JPOD to the injury of water users in the southern and central Delta.

All JPOD diversion under excess conditions in the Delta is junior to Contra Costa Water District (CCWD) water right permits for the Los Vaqueros Project, and must have an X2 location west of certain compliance locations consistent with the 1993 Los Vaqueros Biological Opinion (BO) for delta smelt.

Stage 2 has an additional requirement to complete an operations plan that will protect fish and wildlife and other legal users of water. This is commonly known as the Fisheries Response Plan.

Stage 3 has an additional requirement to protect water levels in the southern Delta under the operational conditions of the permanent South Delta Barrier program, along with an updated companion Fisheries Response Plan.

Reclamation and DWR intend to apply all response plan criteria consistently for JPOD uses as well as water transfer uses.

In general, JPOD capabilities will be used to accomplish four basic CVP-SWP objectives:

- When wintertime excess pumping capacity becomes available during Delta excess conditions and total CVP-SWP San Luis storage is not projected to fill before the spring pulse flow period, the project with the deficit in San Luis storage may elect to utilize JPOD capabilities. Concurrently, under the CALFED ROD, JPOD may be utilized to create additional water supplies for the EWA or reduce debt for previous EWA actions.
- When summertime pumping capacity is available at Banks Pumping Plant and CVP reservoir conditions can support additional releases, the CVP may elect to utilize JPOD capabilities to enhance annual CVP south of Delta water supplies.

- When summertime pumping capacity is available at Banks or Tracy Pumping Plant to facilitate water transfers, JPOD may be utilized to further facilitate the water transfer.
- During certain coordinated CVP-SWP operation scenarios for fishery entrainment management, JPOD may be utilized to maximize CVP-SWP exports at the facility with the least fishery entrainment impact while minimizing export at the facility with the most fishery entrainment impact.

Adaptive Management

Reclamation and DWR work closely with the U.S. Fish and Wildlife Service (FWS), the National Marine Fisheries Service (NOAA Fisheries), and the California Department of Fish and Game (DFG) to coordinate the operation of the CVP and SWP with fishery needs. This coordination is facilitated through several forums discussed below.

CALFED Ops Group

The CALFED Ops Group consists of the Project Agencies, the Management Agencies, SWRCB staff, and the Federal Environmental Protection Agency (EPA). The CALFED Ops Group generally meets eleven times a year in a public setting to discuss the operation of the CVP and SWP, as wells as implementation of the CVPIA and coordination with engendered species protection. The CALFED Ops Group held its first public meeting in January 1995, and during the next six years the group developed and refined its process. The CALFED Ops Group has been recognized within the SWRCB D-1641, and elsewhere, as a forum for consultation on decisions to exercise certain flexibility that has been incorporated into the Delta standards for protection of beneficial uses (e.g. E/I ratios, and some DCC Closures). Several teams were established through the Ops Group process. These teams are described below:

Operations and Fishery Forum: The Operations and Fishery Forum (OFF) was established as a stakeholder-driven process to disseminate information regarding recommendations and decisions about the operations of the CVP and SWP. OFF members are considered the contact person for their respective agency or interest group when information regarding take of listed species, or other factors and urgent issues need to be addressed by the CALFED Ops Group. Alternatively, the OFF may be directed by the CALFED Ops Group to develop recommendations on operational responses for issues of concern raised by member agencies.

Data Assessment Team (DAT): The DAT consists of technical staff members from the Project and Management agencies, as well as stakeholders. The DAT meets frequently[2] during the fall, winter, and spring to review and interpret data relating to fish movement, location, and behavior. Based upon its assessment and input concerning the CVP and SWP operations from the Project Agencies, the DAT makes recommendations regarding potential changes in operations to protect fish. These recommendations are a key element to the implementation of the EWA (discussed later).

[2] The DAT holds weekly conference calls and may have additional discussions during other times as needed.

B2 Interagency Team (B2IT): The B2IT was established in 1999 and consists of technical staff members from the Project and Management agencies. The B2IT meets weekly to discuss implementation of section 3406 b(2) of the CVPIA, which defines the dedication of CVP water supply for environmental purposes. It communicates with EWAT and WOMT to ensure coordination with the other operational programs or resource related aspects of project operations.

Environmental Water Account Team (EWAT): The EWAT consists of members from the Project and Management agencies. The EWAT is responsible for implementation and reporting of actions to acquire water for the EWA. It also coordinates with the B2IT to develop strategies that maximize benefits derived from implementation of actions under CVPIA and the EWA.

Fisheries Technical Teams

Several fisheries specific teams have been established to provide guidance on resource management issues. These teams include:

The Sacramento River Temperature Task Group (SRTTG): The SRTTG is a multi-agency group formed pursuant to SWRCB Water Rights Orders 90-5 and 91-1, to assist with improving and stabilizing Chinook population in the Sacramento River. Annually, Reclamation develops temperature operation plans for the Shasta and Trinity divisions of the CVP. These plans consider impacts on winter-run and other races of Chinook salmon, and associated project operations. The SRTTG meets initially in the spring to discuss biological and operational information, objectives, and alternative operations plans for temperature control. Once the SRTTG has recommended an operation plan for temperature control, Reclamation then submits a report to the SWRCB, generally on or before June 1 each year.

After implementation of the operation plan, the SRTTG may perform additional studies and holds meetings as needed to develop revisions based on updated biological data, reservoir temperature profiles and operations data. Updated plans may be needed for summer operations protecting winter-run, or in fall for fall-run spawning season. If there are any changes in the plan, Reclamation submits a supplemental report.

The Salmon Decision Tree: The Chinook Salmon Protection Decision Process is used by the fishery agencies and project operators to facilitate the often complex coordination issues surrounding DCC gate operations and the purposes of fishery protection closures, Delta water quality, and/or export reductions. Inputs such as fish lifestage and size development, current hydrologic events, fish indicators (such as the Knight's Landing Catch Index and Sacramento Catch Index), and salvage at the export facilities, as well as current and projected Delta water quality conditions, are used to determine potential DCC closures and/or export reductions. The coordination process has worked well during the recent fall and winter DCC operations and is expected to be used in the present or modified form in the future.

Delta Smelt Working Group (DSWG): The DSWG was established in 1995 to resolve biological and technical issues regarding delta smelt and to develop recommendations for consideration by the FWS. It is generally activated when Reclamation and DWR seek

consultation with FWS on delta smelt or when unusual salvage of delta smelt occurs. It can also be activated, and has been activated, to assist with the development of strategies to improve habitat conditions for delta smelt.

Delta smelt decision tree: The working group will employ a delta smelt decision tree (DSDT) to assist in formulating recommendations that will be forwarded to the water operations management team. The working group will not decide what actions will be taken, but will merely advise the WOMT. The working group will not supplant the DAT, but will provide an additional source of advice to the WOMT. The group may propose operations modifications that the group believes will protect delta smelt, either by reducing take at the export facilities or by preserving smelt habitat. The DSDT will be adapted by the working group as new knowledge becomes available. A more detailed description of the technical basis for the adoption of the DSDT, the way in which it will be used, and a copy of the current DSDT, is contained in the appendix.

American River Operations Work Group (AROG): In 1996 Reclamation established an operational working group for the lower American River, known as AROG. Although open to anyone, the AROG meetings generally include representatives from several agencies and organizations with on-going concerns regarding management of the lower American River. The group includes Reclamation, FWS, NOAA Fisheries, DFG, Sacramento Area Flood Control Agency (SAFCA), Water Forum, City of Sacramento (City), County of Sacramento, Western Area Power Administration (Western), and Save the American River Association (SARA).

The AROG convenes monthly, or more frequently, with the purpose of providing fishery updates and reports for Reclamation to better manage Folsom Reservoir for fish resources in the lower American River.

San Joaquin River Technical Committee (SJRTC): The SJRTC meets for the purposes of planning and implementing the VAMP each year and oversees two subgroups: the Biology subgroup, and the Hydrology subgroup. These two groups are charged with certain responsibilities, and must also coordinate their activities within the San Joaquin River Agreement (SJRA) Technical Committee.

DCC Project Work Team: The DCC Project Work Team is a multi-agency group under CALFED. Its purpose is to determine and evaluate the affects of DCC gate operations on Delta hydrodynamics, water quality, and fish migration. The work team coordinates with the DAT and OFF groups to conduct gate experiments and members may be used as a resource to estimate impacts from real time gate operations.

Water Operations Management Team

To facilitate timely decision-support and decision making at the appropriate level, a management-level team was established. The Water Operations Management Team (WOMT) first met in 1999, and consists of management level participants from the Project and

Management agencies. The WOMT meets frequently[3] in order to provide oversight and decision making that must routinely occur within the CALFED Ops Group process. The WOMT relies heavily upon the DAT and B2IT for recommendations on fishery actions. It also utilizes the CALFED Ops Group to communicate with stakeholders about its decisions. Although the goal of WOMT is to achieve consensus on decisions, the agencies retain their authorized roles and responsibilities.

Process for Using Adaptive Management

Decisions regarding CVP and SWP operations must consider many factors that include public safety, water supply reliability, cost, as well as regulatory and environmental requirements. To facilitate such decisions, the Project and Management Agencies have developed and refined a process to collect data, disseminate information, develop recommendations, and make decisions.

1. **A workgroup makes a recommendation for a change in CVP and SWP operations.** Generally, operational adjustments to protect fish are initiated as the result of concern expressed over the interpretation of data that have been collected or as a part of an overarching strategic plan to improve habitat conditions. Examples of conditions that could signal concern include observance of large numbers of juvenile Chinook entering the Delta, high salvage of delta smelt at the export facilities, or unfavorable distribution of delta smelt throughout the Delta. Examples of strategic plans include maintaining higher releases for in stream needs or closing the Delta Cross-channel gates to keep emigrating juvenile Chinook from entering the central Delta.
2. **The Project Agencies consider the recommendation and seek consensus with the Management Agencies.** Decisions regarding changes to the CVP and SWP operations must be made quickly to be effective. To accomplish this, recommendations are vetted with the management-level staff of the Project and Management Agencies. This provides for appropriate consideration of the many factors that must be taken into consideration.
3. **The recommendations and decisions are disseminated.** Numerous stakeholders have a keen interest in CVP and SWP operations. In fact, workgroups established through the Ops Group process (DAT and OFF are two prime examples) have significant stakeholder involvement. In addition, decisions regarding the projects can have significant policy-related implications that must be presented to the State and Federal administrations. To facilitate adequate feedback to stakeholders, Reclamation and DWR disseminate recommendations and the resulting decisions to agencies and stakeholders through the OFF and DAT.
4. **Annual reporting is performed to summarize when decision trees are used and results are updated.**

   Example: The DAT determines adult delta smelt are migrating upstream to spawn in sufficient numbers to warrant a change in pumping levels. After careful consideration of

[3] As with the DAT, WOMT holds weekly meetings during the critical fish periods. In addition, it will hold impromptu meetings or conference calls to consider recommendations for changes in the operations of the CVP and SWP.

the water supply costs to the EWA and CVPIA b(2) water assets, DAT recommends a five-day reduction in exports.

The WOMT meets and considers the recommendation of the DAT, and after careful consideration of the recommendation, WOMT agrees that EWA and CVPIA b(2) assets may be used to implement the export reduction. Reclamation and DWR then implement the export reduction as prescribed.

In addition, South Delta barrier operations will be further studied and refined by WOMT/DAT representatives, including Reclamation, DWR, DFG, NOAA Fisheries, delta stakeholders and representatives of the delta smelt working group. Representatives from these groups will meet to determine how best to operate south delta barriers in order to balance fish needs with water levels and water quality needs. Forecast modeling as well as monitoring of real-time barrier operations will be used to modify operations as needed.

Central Valley Project

Project Management Objectives

The CVP is the Mid-Pacific Region's largest project. Facilities are operated and maintained by local Reclamation area offices, with operations overseen by the CVOO at the Joint Operations Center in Sacramento, California. The CVOO is responsible for recommending CVP operating policy, developing annual operating plans, coordinating CVP operations with the SWP and other entities, establishing CVP-wide standards and procedures, and making day-to-day operating decisions. Figure 1-4 shows the relationship between the CVOO and Reclamation area offices in the Mid-Pacific Region.

Central Valley Project Improvement Act

On October 30, 1992, Public Law 102-575, (Reclamation Projects Authorization and Adjustment Act of 1992) was passed. Included in the law was Title 34, the CVPIA. The CVPIA amended previous authorizations of the CVP to include fish and wildlife protection, restoration, and mitigation as project purposes having equal priority with irrigation and domestic water supply uses, and fish and wildlife enhancement having an equal priority with power generation. Among the changes mandated by the CVPIA are:

- Dedicating 800,000 af to fish and wildlife annually
- Authorizing water transfers outside the CVP service area
- Restoring anadromous fish populations by 2002
- Creating a restoration fund financed by water and power users
- Providing for the Shasta Temperature Control Device
- Implementing fish passage measures at Red Bluff Diversion Dam
- Calling for planning to increase the CVP yield
- Mandating firm water supplies for Central Valley wildlife refuges
- Improving the Tracy Fish Collection Facility (TFCF)

- Meeting Federal trust responsibility to protect fishery resources(Trinity River)

The CVPIA is being implemented on a broad front. The Final Programmatic Environmental Impact Statement (PEIS) for the CVPIA analyzes projected conditions in 2022, 30 years from the CVPIA's adoption in 1992. The Final PEIS was released in October 1999 and the CVPIA ROD was signed on January 9, 2001. The BOs were issued on November 21, 2000.

Operations of the CVP reflect provisions of the CVPIA, particularly sections 3406(b)(1), (b)(2), and (b)(3). On May 9, 2003, the Department of the Interior issued its Decision on Implementation of Section 3406 (b)(2) of the Central Valley Project Improvement Act. The B2IT provides the basis for implementing upstream and Delta actions with CVP delivery capability.

Water Service Contracts and Deliveries

Water Needs Assessment

Water needs assessments have been performed for each CVP water contractor eligible to participate in the CVP long-term contract renewal process. Water needs assessments confirm a contractor's past beneficial use and determine future CVP water supplies needed to meet the contractor's anticipated future demands. The assessments are based on a common methodology used to determine the amount of CVP water needed to balance a contractor's water demands with available surface and groundwater supplies.

As of December 2003, most of the contractor assessments have been finalized. However, a couple of assessments remain under analysis and require either additional information from the contractor or do not fit into the assumptions incorporated into the methodology used for the rest of the CVP. The contractors are located primarily in the American River and San Felipe Divisions of the CVP. It is anticipated that all the assessments will be concluded by March 1, 2004. Because of the remaining assessments, the total supply required to meet the all the demands for the CVP cannot be determined at this time.

For modeling purposes, assumptions for future conditions have been made, even though the water assessments continue. The 2020 level of development's demands include higher amounts than the 2001 level of development's demands on the American River.

Future American River Operations - Water Service Contracts and Deliveries

Surface water deliveries from the American River are made by various water rights entities and CVP contractors. Total annual demands are estimated to increase from 217,185 af in 2001 to 475,250 af in 2020, including the FRWP. Reclamation is negotiating the renewal of 13 long-term water service contracts, four Warren Act contracts, and has a role in six infrastructure or Folsom Reservoir operations actions influencing the management of American River Division facilities and water use.

CVP M&I Water Shortage Policy

The CVP has 253 water service contracts (including Sacramento River Settlement Contracts). These water service contracts have had varying water shortage provisions (e.g., in some contracts, M&I and agricultural uses have shared shortages equally; in most of the larger M&I

contracts, agricultural water has been shorted 25 percent of its contract entitlement before M&I water was shorted, and then both shared shortages equally). Since 1991, Reclamation has been attempting to develop an M&I Water shortage policy applicable to as many CVP M&I contractors as appropriate.

For a contractor to receive the M&I minimum shortage allocation by means of the proposed policy, its water service contract must reference the proposed policy. For various reasons, Reclamation expects the proposed policy will not be referenced in contracts for the (1) Friant Division, (2) New Melones interim supply, (3) Hidden and Buchanan Units, (4) Cross Valley contractors, (5) Sugar Pine Units (subjects of title transfer legislation), (6) San Joaquin settlement contractors, and (7) Sacramento River settlement contractors. Any separate shortage- related contractual provisions will prevail.

The proposed policy provides a minimum shortage allocation for M&I water supplies of 75 percent of a contractor's historical use (i.e., the last three years of water deliveries unconstrained by the availability of CVP water). Historical use can be adjusted for growth, extraordinary water conservation measures, and use of non-CVP water as those terms are defined in the proposed policy. Before the M&I water allocation is reduced, the irrigation water allocation would be reduced below 75 percent of contract entitlement.

The proposed policy also provides that when the allocation of irrigation water is reduced below 25 percent of contract entitlement, Reclamation will reassess the availability of CVP water and CVP water demand; however, due to limited water supplies during these times, M&I water allocation may be reduced below 75 percent of adjusted historical use. Shortages for South of Delta and North of Delta irrigation allocations and M&I allocations are the same.

The proposed policy provides that Reclamation will deliver CVP water to all M&I contractors at not less than a public health and safety level if CVP water is available, if an emergency situation exists, (taking into consideration water supplies available to the M&I contractors from other sources), and in recognition that the M&I allocation may, nevertheless, fall to 50 percent when the irrigation allocation drops below 25 percent due to limited CVP supplies.

It should be noted the minimum shortage allocation of 75 percent, as proposed in the September 11, 2001, draft (which was made available for public review and comment) would apply only to that portion of CVP water identified as of September 30, 1994, as shown on Schedule A-12 of the 1996 M&I Water Rates book, and for those contract quantities specified in section 206 of Public Law 101-514. However, under the proposed policy a contractor may request an M&I minimum shortage allocation for post-1994 identified water that is transferred or assigned, converted, provided significant impacts upon irrigation supplies, or upon irrigation and M&I supplies, respectively, are mitigated.

Due to the development of policy alternatives generated by Reclamation after consideration of public comment, that portion of CVP water to which the minimum shortage allocation would apply could change prior to policy finalization. Prior to such finalization, Reclamation will meet the requirements of the National Environmental Policy Act (NEPA) and the Federal ESA.

Ag 100% to 75% then M&I is at 100%

Ag 70%	M&I is 95%
Ag 65%	M&I 90%
Ag 60%	M&I 85%
Ag 55%	M&I 80%
Ag 50% to 25%	M&I 75%

Dry and critical years has a modeling assumption

Ag 20%	M&I 70%
Ag 15%	M&I 65%
Ag 10%	M&I 60%
Ag 5%	M&I 55%
Ag 0	M&I 50%

Trinity River Division Operations

The Trinity River Division, completed in 1964, includes facilities to store and regulate water in the Trinity River, as well as facilities to divert water to the Sacramento River Basin. Trinity Dam is located on the Trinity River and regulates the flow from a drainage area of approximately 720 square miles. The dam was completed in 1962, forming Trinity Lake, which has a maximum storage capacity of approximately 2.4 million af.

The mean annual inflow to Trinity Lake from the Trinity River is about 1.2 million af per year. Historically, an average of about two-thirds of the annual inflow has been diverted to the Sacramento River Basin (1991-2003). Trinity Lake stores water for release to the Trinity River and for diversion to the Sacramento River via Lewiston Reservoir, Carr Tunnel, Whiskeytown Reservoir, and Spring Creek Tunnel where it commingles in Keswick Reservoir with Sacramento River water released from both the Shasta Dam and Spring Creek Debris Dam.

Safety of Dams at Trinity Reservoir

Periodically, increased water releases are made from Trinity Dam consistent with Reclamation safety of dams (SOD) criteria intended to prevent overtopping of Trinity Dam. Although flood control is not an authorized purpose of the Trinity River Division, flood control benefits are provided through normal operations.

Trinity Dam has limited release capacity below the spillway crest elevation. Studies completed by the Army Corps of Engineers (Corps) in 1974 and Reclamation in 1975 showed the spillway and outlet works at Trinity Dam are not sufficient to safely pass the anticipated design flood inflow. Therefore, Reclamation implemented SOD criteria stipulating flood season release and storage criteria at Trinity Dam to reduce the potential for overtopping during large flood events. The SOD criteria attempt to prevent storage from exceeding 2.1 million af from November

through March. The SOD criteria begin to prescribe reservoir releases when storage in Trinity Dam is forecast to exceed 2.0 million af during November through March.

The SOD release criteria specifies that Carr Powerplant capacity should be used as a first preference destination for SOD releases made at Trinity Dam. Trinity River releases are made as a second preference destination. During significant Northern California high water flood events, the Sacramento River water stages are also at concern levels. Under such high water conditions, the water that would otherwise move through Carr Powerplant is routed to the Trinity River. Total river release is limited to 6,000 cfs below Lewiston Dam (under SOD criteria) due to local high water concerns and local bridge flow capacities; until local inflows to Lewiston Lake and Trinity Dam spillway flows exceed 6,000 cfs; and also the Carr Powerplant discharge.

Fish and Wildlife Requirements on Trinity River

Based on the December 19, 2000, Trinity River Main stem ROD, 369,000 to 815,000 af is allocated annually for Trinity River flows. Due to ongoing litigation on the ROSD, the Federal District Court for the Eastern District of California issued a December 10, 2002, Order that directed the CVP to release 368,600 af during critical Trinity River inflow years and 452,000 af during all other conditions. This amount is scheduled in coordination with the FWS to best meet habitat, temperature, and sediment transport objectives in the Trinity Basin.

Temperature objectives for the Trinity River are set forth in SWRCB WR 90-5. These vary by reach and by season. Between Lewiston Dam and Douglas City Bridge, the daily average temperature should not exceed 60° F from July 1 to September 14 and 56° F from September 15 to October 1. From October 1 to December 31, the daily average temperature should not exceed 56° F between Lewiston Dam and the confluence of the North Fork Trinity River. Reclamation consults with FWS in establishing a schedule of rel1eases from Lewiston Dam that can best achieve these objectives.

Operationally, the water year type is forecasted on April 1, based on a 90 percent forecast. Annual runoff upstream of Lewiston Dam is based on actual unimpaired runoff between October 1 and March 31, and the April 1 runoff is from a 90 percent forecast. In the modeling, actual historic Trinity inflows were used rather than a forecast on April 1. There is a temperature curtain in Lewiston Reservoir.

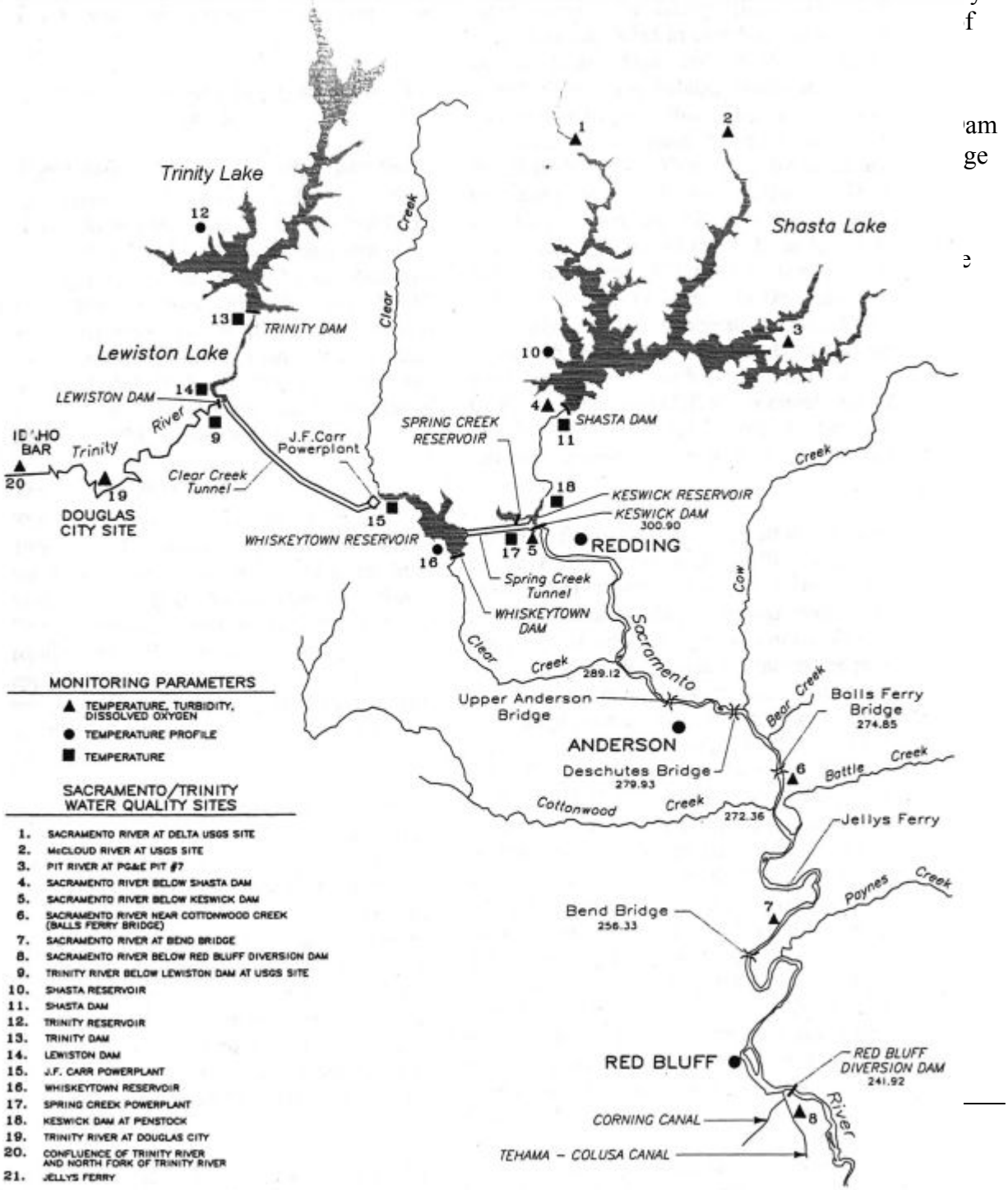
Transbasin Exports

Export of Trinity water to the Sacramento Basin provides water supply and hydroelectric power generation for the CVP and assists in water temperature control in the Trinity River and upper Sacramento River. The amounts and timing of the Trinity exports are determined by subtracting Trinity River scheduled flow and targeted carryover storage from the forecasted Trinity water supply.

The seasonal timing of Trinity exports is a result of determing how to make best use of a limited volume of Trinity export (in concert with releases from Shasta) to help conserve cold water pools and meet temperature objectives on the upper Sacramento and Trinity rivers, as well as power production economics. A key consideration in the export timing determination is the thermal degradation which occurs in Whiskeytown Lake due to the long residence time of trans-basin exports in the lake.

In order to minimize the thermal degradation effects, transbasin export patterns are typically scheduled by an operator to provide an approximate 120,000 af volume to occur in late spring to create a thermal connection to the Spring Creek Powerhouse before larger trans-basin volumes are scheduled to occur during the hot summer months. Typically, to avoid warming and function most efficiently for temperature control, the water flowing from the Trinity Basin through Whiskeytown must be sustained at fairly high rates. When the total volume of Trinity water available for export is limited, that may, in turn, compress the time period for which effective temperature control releases can be made from Whiskeytown Lake.

To increase CVP water supply, export volumes from Trinity are made in coordination with the operation of other CVP water supply reservoirs generally based on reservoir refill potential and CVP Delta export water demand. Other important considerations affecting the timing of Trinity



Whiskeytown Reservoir Operations

Since 1964, a portion of the flow from the Trinity River Basin has been exported to the Sacramento River Basin through the CVP facilities. Water is diverted from the Trinity River at Lewiston Dam via the Clear Creek Tunnel and passes through the Judge Francis Carr Powerhouse as it is discharged into Whiskeytown Lake on Clear Creek. From Whiskeytown Lake, water is released through the Spring Creek Power Conduit to the Spring Creek Powerplant and into Keswick Reservoir. All of the water diverted from the Trinity River, plus a portion of Clear Creek flows, is diverted through the Spring Creek Power Conduit into Keswick Reservoir.

Spring Creek also flows into the Sacramento River and enters at Keswick Reservoir. Flows on Spring Creek are partially regulated by the Spring Creek Debris Dam. Historically (1964-1992), an average annual quantity of 1,269,000 af of water has been diverted from Whiskeytown Lake to Keswick Reservoir. This annual quantity is approximately 17 percent of the flow measured in the Sacramento River at Keswick.

Whiskeytown is normally operated to (1) regulate inflows for power generation and recreation; (2) support upper Sacramento River temperature objectives; and (3) provide for releases to Clear Creek consistent with the CVPIA Anadromous Fish Restoration Program (AFRP) objectives. Although it stores up to 241,000 af, this storage is not normally used as a source of water supply. There is a temperature curtain in Whiskeytown Reservoir.

Spillway flows below Whiskeytown Lake

Whiskeytown Lake is drawn down approximately 35,000 af per year of storage space during November through April to regulate flows for power generation. Heavy rainfall events occasionally result in spillway discharges to Clear Creek, as shown in Table 2–2 below.

Table 2–2 Days of Spilling below Whiskeytown and 40-30-30 Index from Water Year 1978 to 2002

Water Year	Days of Spilling	40-30-30 Index
1978	5	AN
1979	0	BN
1980	0	AN
1981	0	D
1982	63	W
1983	81	W
1984	0	W
1985	0	D
1986	17	W
1987	0	D
1988	0	C

Water Year	Days of Spilling	40-30-30 Index
1989	0	D
1990	8	C
1991	0	C
1992	0	C
1993	10	AN
1994	0	C
1995	14	W
1996	0	W
1997	5	W
1998	8	W
1999	0	W
2000	0	AN
2001	0	D
2002	0	D

Operations at Whiskeytown Lake during flood conditions are complicated by its operational relationship with the Trinity River, Sacramento River, and Clear Creek. On occasion, imports of Trinity River water to Whiskeytown Reservoir may be suspended to avoid aggravating high flow conditions in the Sacramento Basin.

Fish and Wildlife Requirements on Clear Creek

Water rights permits issued by the SWRCB for diversions from Trinity River and Clear Creek specify minimum downstream releases from Lewiston and Whiskeytown Dams, respectively. Two agreements govern releases from Whiskeytown Lake:

- A 1960 Memorandum of Agreement (MOA) with the DFG established minimum flows to be released to Clear Creek at Whiskeytown Dam.
- A 1963 release schedule from Whiskeytown Dam was developed and implemented, but never finalized. Although the release schedule was never formalized, Reclamation has operated according to the proposed schedule since May 1963.

Table 2–3 Minimum flows at Whiskeytown Dam from 1960 MOA with the DFG

Period	*Minimum flow (cfs)*
January 1 - February 28(29)	50
March 1 - May 31	30

Period	*Minimum flow (cfs)*
June 1 - September 30	0
October 1 - October 15	10
October 16 - October 31	30
November 1 - December 31	100
1963 FWS Proposed Normal year flow (cfs)	
January 1 - October 31	50
November 1 - December 31	100
1963 FWS Proposed Critical year flow (cfs)	
January 1 - October 31	30
November 1 - December 31	70

Spring Creek Debris Dam Operations

The Spring Creek Debris Dam (SCDD) is a feature of the Trinity Division of the CVP. It was constructed to regulate runoff containing debris and acid mine drainage from Spring Creek, a tributary to the Sacramento River that enters Keswick Reservoir. The SCDD can store approximately 5,800 af of water. Operation of SCDD and Shasta Dam has allowed some control of the toxic wastes with dilution criteria. In January 1980, Reclamation, the DFG, and the SWRCB executed a Memorandum of Understanding (MOU) to implement actions that protect the Sacramento River system from heavy metal pollution from Spring Creek and adjacent watersheds.

The MOU identifies agency actions and responsibilities, and establishes release criteria based on allowable concentrations of total copper and zinc in the Sacramento River below Keswick Dam.

The MOU states that Reclamation agrees to operate to dilute releases from SCDD (according to these criteria and schedules provided) and that such operation will not cause flood control parameters on the Sacramento River to be exceeded and will not unreasonably interfere with other project requirements as determined by Reclamation. The MOU also specifies a minimum schedule for monitoring copper and zinc concentrations at SCDDand in the Sacramento River below Keswick Dam. Reclamation has primary responsibility for the monitoring; however, the DFG and the RWQCB also collect and analyze samples on an as-needed basis. Due to more extensive monitoring, improved sampling and analyses techniques, and continuing cleanup efforts in the Spring Creek drainage basin, Reclamation now operates SCDD targeting the more stringent Central Valley Region Water Quality Control Plan (Basin Plan) criteria in addition to the MOU goals. Instead of the total copper and total zinc criteria contained in the MOU, Reclamation operates SCDD releases and Keswick dilution flows to not exceed the Basin Plan standards of 0.0056 mg/l dissolved copper and 0.016 mg/l dissolved zinc. Release rates are

estimated from a mass balance calculation of the copper and zinc in the debris dam release and in the river.

In order to minimize the build-up of metal concentrations in the Spring Creek arm of Keswick Reservoir, releases from the debris dam are coordinated with releases from the Spring Creek Powerplant to keep the Spring Creek arm of Keswick Reservoir in circulation with the main water body of Keswick Lake.

The operation of Spring Creek Debris Dam is complicated during major heavy rainfall events. Spring Creek Debris Dam reservoir can fill to uncontrolled spill elevations in a relatively short time period, anywhere from days to weeks. Uncontrolled spills at Spring Creek Debris Dam can occur during flood control events in the upper Sacramento River and also during non-flood control rainfall events. During flood control events, Keswick releases may be reduced to meet flood control objectives at Bend Bridge when storage and inflow at Spring Creek Reservoir are high.

Because SC DD releases are maintained as a dilution ratio of Keswick releases to maintain the required dilution of copper and zinc, uncontrolled spills can and have occurred from Spring Creek Debris Dam. In this operational situation, high metal concentration loads during heavy rainfall are usually limited to areas immediately downstream of Keswick Dam because of the high runoff entering the Sacramento River adding dilution flow. In the operational situation when Keswick releases are increased for flood control purposes, Spring Creek Debris Dam releases are also increased in an effort to reduce spill potential.

In the operational situation when heavy rainfall events will fill Spring Creek Debris Dam and Shasta Reservoir will not reach flood control conditions, increased releases from CVP storage may be required to maintain desired dilution ratios for metal concentrations. Reclamation has voluntarily released additional water from CVP storage to maintain release ratios for toxic metals below Keswick Dam. Reclamation has typically attempted to meet the Basin Plan standards but these releases have no established criteria and are dealt with on a case-by-case basis. Since water released for dilution of toxic spills is likely to be in excess of other CVP requirements, such releases increase the risk of a loss of water for other beneficial purposes.

Shasta Division and Sacramento River Division

The CVP's Shasta Division includes facilities that conserve water in the Sacramento River for (1) flood control, (2) navigation maintenance, (3) agricultural water supplies, (4) M&I water supplies (5) hydroelectric power generation, (6) conservation of fish in the Sacramento River, and (7) protection of the Sacramento-San Joaquin Delta from intrusion of saline ocean water. The Shasta Division includes Shasta Dam, Lake, and Powerplant; Keswick Dam, Reservoir, and Powerplant, and the Shasta Temperature Control Device.

The Sacramento River Division was authorized after completion of the Shasta Division. It includes facilities for the diversion and conveyance of water to CVP contractors on the west side of the Sacramento River. The division includes the Sacramento Canals Unit, which was authorized in 1950 and consists of the Red Bluff Diversion Dam (RBDD), the Corning Pumping Plant, and the Corning and Tehama-Colusa Canals.

The unit was authorized to supply irrigation water to over 200,000 acres of land in the Sacramento Valley, principally in Tehama, Glenn, Colusa, and Yolo counties. Black Butte Dam, which is operated by the Corps, also provides supplemental water to the Tehama-Colusa Canals as it crosses Stony Creek. The operations of the Shasta and Sacramento River divisions are presented together because of their operational inter-relationships.

Shasta Dam is located on the Sacramento River just below the confluence of the Sacramento, McCloud, and Pit Rivers. The dam regulates the flow from a drainage area of approximately 6,649 square miles. Shasta Dam was completed in 1945, forming Shasta Lake, which has a maximum storage capacity of 4,552,000 af. Water in Shasta Lake is released through or around the Shasta Powerplant to the Sacramento River where it is re-regulated downstream by Keswick Dam. A small amount of water is diverted directly from Shasta Lake for M&I uses by local communities.

Keswick Reservoir was formed by the completion of Keswick Dam in 1950. It has a capacity of approximately 23,800 af and serves as an afterbay for releases from Shasta Dam and for discharges from the Spring Creek Powerplant. All releases from Keswick Reservoir are made to the Sacramento River at Keswick Dam. The dam has a fish trapping facility that operates in conjunction with the Coleman National Fish Hatchery on Battle Creek. During the construction of Shasta Dam, the Toyon Pipeline was constructed to supply water from the Sacramento River to the camp used to house the workers at Toyon. The pipeline remains in use today, supplying M&I water to small communities in the area.

Flood Control

Flood control objectives for Shasta Lake require that releases be restricted to quantities that will not cause downstream flows or stages to exceed specified levels. These include a flow of 79,000 cfs at the tailwater of Keswick Dam, and a stage of 39.2 feet in the Sacramento River at Bend Bridge gauging station, which corresponds to a flow of approximately 100,000 cfs. Flood control operations are based on regulating criteria developed by the Corps pursuant to the provisions of the Flood Control Act of 1944. Maximum flood space reservation is 1.3 million af, with variable storage space requirements based on an inflow parameter.

Flood control operation at Shasta Lake requires the forecasting of runoff conditions into Shasta Lake, as well as runoff conditions of unregulated creek systems downstream from Keswick Dam, as far in advance as possible. A critical element of upper Sacramento River flood operations is the local runoff entering the Sacramento River between Keswick Dam and Bend Bridge.

The unregulated creeks (major creek systems are Cottonwood Creek, Cow Creek, and Battle Creek) in this reach of the Sacramento River can be very sensitive to a large rainfall event and produce large rates of runoff into the Sacramento River in short time periods. During large rainfall and flooding events, the local runoff between Keswick Dam and Bend Bridge can exceed 100,000 cfs.

The travel time required for release changes at Keswick Dam to affect Bend Bridge flows is approximately eight to ten hours. If the total flow at Bend Bridge is projected to exceed 100,000 cfs, the release from Keswick Dam is decreased to maintain Bend Bridge flow below 100,000 cfs. As the flow at Bend Bridge is projected to recede, the Keswick Dam release is increased to

evacuate water stored in the flood control space at Shasta Lake. Changes to Keswick Dam releases are scheduled to minimize rapid fluctuations in the flow at Bend Bridge.

The flood control criteria for Keswick releases specify releases should not be increased more than 15,000 cfs or decreased more than 4,000 cfs in any two-hour period. The restriction on the rate of decrease is intended to prevent sloughing of saturated downstream channel embankments caused by rapid reductions in river stage. In rare instances, the rate of decrease may have to be accelerated to avoid exceeding critical flood stages downstream.

Fish and Wildlife Requirements in the Sacramento River

Reclamation operates the Shasta, Sacramento River, and Trinity River divisions of the CVP to meet (to the extent possible) the provisions of SWRCB Order 90-05 and the winter-run Chinook salmon BO. An April 5, 1960, MOA between Reclamation and the DFG originally established flow objectives in the Sacramento River for the protection and preservation of fish and wildlife resources. The agreement provided for minimum releases into the natural channel of the Sacramento River at Keswick Dam for normal and critically dry years. Since October 1981, Keswick Dam has operated based on a minimum release of 3,250 cfs for normal years from September 1 through the end of February, in accordance with an agreement between Reclamation and DFG. This release schedule was included in Order 90-05, which maintains a minimum release of 3,250 cfs at Keswick Dam and RBDD from September through the end of February in all water years, except critically dry years.

Table 2–4 Current minimum flow requirements and objectives (cfs) on the Sacramento River below Keswick Dam

Water year type	*MOA*	*WR 90-5*	*MOA and WR 90-5*	*1993 NOAA Fisheries winter-run BO*
Period	*Normal*	*Normal*	*Critically dry*	*All*
January 1 - February 28(29)	2600	3250	2000	3250
March 1 - March 31	2300	2300	2300	3250
April 1 - April 30	2300	2300	2300	---[a]
May 1 - August 31	2300	2300	2300	---[a]
September 1 - September 30	3900	3250	2800	---[a]
October 1 - November 30	3900	3250	2800	3250
December 1 - December 31	2600	3250	2000	3250

[a] No regulation.

The 1960 MOA between Reclamation and the DFG provides that releases from Keswick Dam (from September 1 through December 31) are made with minimum water level fluctuation or change to protect salmon, and if when doing so, is compatible with other operations requirements. Releases from Shasta and Keswick Dams are gradually reduced in September and early October during the transition from meeting Delta export and water quality demands to operating the system for flood control and fishery concerns from October through December.

The reasonable and prudent alternative (RPA) contained in the 1993 NOAA Fisheries BO required a minimum flow of 3,250 cfs from October 1 through March 31. Also, as part of the RPA, ramping constraints for Keswick release reductions from July 1 through March 31 are required as follows:

- Releases must be reduced between sunset and sunrise.
- When Keswick releases are 6,000 cfs or greater, decreases may not exceed 15 percent per night. Decreases also may not exceed 2.5 percent in one hour.
- For Keswick releases between 4,000 and 5,999 cfs, decreases may not exceed 200 cfs per night. Decreases also may not exceed 100 cfs per hour.
- For Keswick releases between 3,250 and 3,999 cfs, decreases may not exceed 100 cfs per night.
- Variances to these release requirements are allowed under flood control operations.

Reclamation usually attempts to reduce releases from Keswick Dam to the minimum fishery requirement by October 15 each year and to minimize changes in Keswick releases between October 15 and December 31. Releases may be increased during this period to meet unexpected downstream needs such as higher outflows in the Delta to meet water quality requirements, or to meet flood control requirements. Releases from Keswick Dam may be reduced when downstream tributary inflows increase to a level that will meet flow needs. To minimize release fluctuations, the base flow is selected with the intent of maintaining the desired target storage levels in Shasta Lake from October through December.

A recent change in agricultural water diversion practices has affected Keswick Dam release rates in the fall. This program is generally known as the Rice Straw Decomposition and Waterfowl Habitat Program. Historically, the preferred method of clearing fields of rice stubble was to systematically burn it. Today, rice field burning is being phased out due to air quality concerns and goals and is being replaced by a program of rice field flooding that decomposes rice stubble and provides additional waterfowl habitat. The result has been an increase in water demand to flood rice fields in October and November, which has increased the need for higher Keswick releases in all but the wettest of fall months.

The recent change in agricultural practice has not been incorporated into the systematic modeling of agricultural practices and hydrology effects, and therefore, the OCAP CALSIM basis used here does not incorporate this effect. The increased water demand for fall rice field flooding and decomposition on the Sacramento River can produce a conflict during this timeframe with the goal of fall fishery flow stability management.

Minimum Flow for Navigation – Wilkins Slough

Historical commerce on the Sacramento River resulted in the requirement to maintain minimum flows of 5,000 cfs at Chico Landing to support navigation. Currently, there is no commercial traffic between Sacramento and Chico Landing, and the Corps has not dredged this reach to preserve channel depths since 1972. However, long-time water users diverting from the river have set their pump intakes just below this level. Therefore, the CVP is operated to meet the navigation flow requirement of 5,000 cfs to Wilkins Slough, (gauging station on the Sacramento River), under all but the most critical water supply conditions, to facilitate pumping.

At flows below 5,000 cfs at Wilkins Slough, diverters have reported increased pump cavitation as well as greater pumping head requirements. Diverters are able to operate for extended periods at flows as low as 4,000 cfs at Wilkins Slough, but pumping operations become severely affected and some pumps become inoperable at flows lower than this. Flows may drop as low as 3,500 cfs for short periods while changes are made in Keswick releases to reach target levels at Wilkins Slough, but using the 3,500 cfs rate as a target level for an extended period would have major impacts on diverters.

No criteria have been established specifying when the navigation minimum flow should be relaxed. However, the basis for Reclamation's decision to operate at less than 5,000 cfs is the increased importance of conserving water in storage when water supplies are not sufficient to meet full contractual deliveries and other operational requirements.

Water Temperature Operations in the Upper Sacramento River

Water temperature in the upper Sacramento River has been recognized as a key factor of the habitat needs for Chinook salmon stocks inhabiting the river. Water temperature on the Sacramento River system is influenced by several factors, including the relative water temperatures and ratios of releases from Shasta Dam and from the Spring Creek Powerplant. The temperature of water released from Shasta Dam and the Spring Creek Powerplant is a function of the reservoir temperature profiles at the discharge points at Shasta and Whiskeytown, the depths from which releases are made, the seasonal management of the deep cold water reserves, ambient seasonal air temperatures and other climatic conditions, tributary accretions and water temperatures, and residence time in Keswick, Whiskeytown and Lewiston Reservoirs, and in the Sacramento River.

SWRCB Water Rights Order 90-05 and Water Rights Order 91-01

In 1990 and 1991, the SWRCB issued Water Rights Orders 90-05 and 91-01 modifying Reclamation's water rights for the Sacramento River. The orders included a narrative water temperature objective for the Sacramento River and stated Reclamation shall operate Keswick and Shasta Dams and the Spring Creek Powerplant to meet a daily average water temperature of 56° F at RBDD in the Sacramento River during periods when higher temperature would be harmful to fisheries.

Under the orders, the water temperature compliance point may be modified when the objective cannot be met at RBDD. In addition, Order 90-05 modified the minimum flow requirements initially established in the 1960 MOA for the Sacramento River below Keswick Dam. The water right orders also recommended the construction of a Shasta Temperature Control Device (TCD) to improve the management of the limited cold water resources.

Pursuant to SWRCB Orders 90-05 and 91-01, Reclamation configured and implemented the Sacramento-Trinity Water Quality Monitoring Network to monitor temperature and other parameters at key locations in the Sacramento and Trinity Rivers. The SWRCB orders also required Reclamation to establish the Sacramento River Temperature Task Group to formulate, monitor, and coordinate temperature control plans for the upper Sacramento and Trinity Rivers. This group consists of representatives from Reclamation, SWRCB, NOAA Fisheries, FWS, DFG, Western, DWR, and the Hoopa Valley Indian Tribe.

Each year, with finite cold water resources and competing demands usually an issue, the Temperature Task Group has been effective in devising operation plans with the flexibility to provide the best protection consistent with the CVP's temperature control capabilities and considering the annual needs and seasonal spawning distribution monitoring information for winter-run and fall-run Chinook salmon. In every year since the SWRCB issued the orders, those plans have included modifying the RBDD compliance point to make best use of the cold water resources based on the location of spawning Chinook salmon.

Shasta Temperature Control Device

Construction of the TCD at Shasta Dam was completed in 1997. This device is designed for greater flexibility in managing the cold water reserves in Shasta Lake while enabling hydroelectric power generation to occur and to improve salmon habitat conditions in the upper

Sacramento River. The TCD is also designed to enable selective release of water from varying lake levels through the power plant in order to manage and maintain adequate water temperatures in the Sacramento River downstream of Keswick Dam.

Prior to construction of the Shasta TCD, Reclamation released water from Shasta Dam's low-level river outlets to alleviate high water temperatures during critical periods of the spawning and incubation life stages of the winter-run Chinook stock. Releases through the low-level outlets bypass the power plant and result in a loss of hydroelectric generation at the Shasta Powerplant. The release of water through the low-level river outlets was a major facet of Reclamation's efforts to control upper Sacramento River temperatures from 1987 through 1996.

The seasonal operation of the TCD is generally as follows: during mid-winter and early spring the highest elevation gates possible are utilized to draw from the upper portions of the lake to conserve deeper colder resources (see Table 2–5). During late spring and summer, the operators begin the seasonal progression of opening deeper gates as Shasta Lake elevation decreases and cold water resources are utilized. In late summer and fall, the TCD side gates are opened to utilize the remaining cold water resource below the Shasta Powerplant elevation in Shasta Lake.

Table 2–5 Shasta Temperature Control Device Gates with Elevation and Storage

TCD Gates	Shasta Elevation with 35 feet of submergence	Shasta Storage
Upper Gates	1035	~3.65 MAF
Middle Gates	985	~2.50 MAF
Pressure Relief Gates	850	~0.67 MAF
Side Gates		

The seasonal progression of the Shasta TCD operation is designed to maximize the conservation of cold water resources deep in Shasta Lake, until the time the resource is of greatest management value to fishery management purposes. Recent operational experience with the Shasta TCD has demonstrated significant operational flexibility improvement for cold water conservation and upper Sacramento River water temperature and fishery habitat management purposes. Recent operational experience has also demonstrated the Shasta TCD has significant leaks that are inherent to TCD design and operational uncertainties that cumulatively impair the seasonal performance of the Shasta TCD to a greater degree than was anticipated in previous analysis and modeling used to describe long-term Shasta TCD benefits.

ESA related Upper Sacramento River temperature objectives.

In February 1993, NOAA Fisheries issued the long-term BO for the Operation of the Federal CVP and the SWP for the Sacramento River winter-run Chinook salmon. The BO includes a RPA addressing CVP operations criteria for temperature control objectives. The Shasta-Trinity Division section of the 1993 RPA includes the following operational elements relating to temperature control objectives. This section of the RPA was not modified in the 1995 amendment to the BO.

Under the current RPA, Reclamation must make its February 15 forecast of deliverable water based on an estimate of precipitation and runoff at least as conservatively as 90 percent probability of exceedance. Subsequent updates of water delivery commitments must be based on at least as conservatively as 90 percent probability of exceedance forecast.

The use of the conservatively based forecasting approach reduces the risk of over committing potential annual cold water reserves by limiting the Central Valley water supply estimates to a one in ten chance of remaining annual hydrologic conditions being drier than the estimate. This forecasting strategy places an allocation emphasis on reserving sufficient cold water resources during the winter-run Chinook salmon incubation and spawning seasons. The BO also requires a technical demonstration that the water temperature compliance point for winter–run needs can be met using the 90 percent hydrology.

Under the current RPA, Reclamation must maintain a minimum end-of-water-year (September 30) carryover storage in Shasta Reservoir of 1.9 million af. The 1.9 million af Shasta Reservoir carryover target is intended to increase the probability of sufficient cold water resources to maintain suitable water temperature conditions for the following water year winter–run incubation and spawning season needs.

The carryover target does not ensure that adequate cold water reserves (and therefore, winter–run incubation and spawning habitat water temperature) are available during the year the 1.9 million af carryover is required. The BO recognized that it may not be possible to maintain the minimum carryover of 1.9 million af in the driest ten percent of hydrologic circumstances. If Reclamation forecasts end-of-water-year storage levels in Shasta will drop below 1.9 million af, re-initiation of consultation is required prior to the first water allocation announcement for that year.

The current RPA sets water temperature compliance location(s) from April 15 through October 31 for winter–run needs based on a systematic set of Shasta carryover and annual hydrologic conditions.

The BO segregates annual Shasta Reservoir carryover and hydrologic conditions in order to assess the potential cold water resources available from Trinity Reservoir and Shasta Reservoir and to determine a strategy for water temperature compliance location. Generally, the BO sets the compliance location at Bend Bridge on the Sacramento River in conditions of high carryover storage or above normal hydrologic conditions.

For lower carryover storage conditions and dry or critical hydrologic conditions, the BO sets the compliance location at a further upstream location of Jelly's Ferry on the Sacramento River. For low carryover storage and critical or very critical hydrologic conditions (generally associated with extended drought conditions) the BO requires re-initiation of consultation to determine the temperature compliance location.

In almost every year since 1993, Reclamation has reconsulted with NOAA Fisheries to modify the compliance point or allow short-term fluctuation above the 56° F objective because of insufficient cold water resources, extreme ambient air temperature events, or high downstream tributary flows of warm water. The reconsultation actions have been coordinated through the SRTTG to the extent possible. Decisions by Reclamation to reconsult and the resulting decisions by NOAA Fisheries have reflected the best available information on cold water resources and locations of Chinook salmon spawning activity.

Reclamation's Proposed Upper Sacramento River temperature objectives

Since the issuance of the temperature objectives contained in the February 1993 NOAA Fisheries BO, the long-term cold water management operation of the Trinity-Shasta reservoir system has been changed and influenced by several significant water management actions that have occurred during the intervening period. The water management actions include:

- Implementation of CVPIA Section 3406 (b)(2)
- Implementation of SWRCB Delta D-1641
- Continuing implementation of the Trinity River ROD as currently ordered by the District Court
- Installation and actual performance characteristics of the Shasta TCD

Each of these water management actions has changed the availability and the management of cold water resources to the Upper Sacramento River. Future actions addressed in the Proposed Action will affect temperature control as demands on the yield of Shasta Reservoir increase.

Concurrently, the spawning distribution of salmon in the upper Sacramento River has changed. Improved fish passage management actions at RBDD and the Anderson-Cottonwood Irrigation District (ACID) Diversion Dam have allowed winter-run salmon to utilize spawning habitat closer to Keswick Dam. Recent review of the spawning distribution for winter-run salmon has shown conclusively the vast majority spawn above the Ball's Ferry location, with only minor spawning below the Ball's Ferry location.

Reclamation will continue a policy of developing annual operations plans and water allocations based on a conservative 90 percent exceedance forecast. Reclamation is not assuming a minimum end-of-water-year (September 30) carryover storage in Shasta Reservoir.

In continuing compliance with Water Rights Orders 90-05 and 91-01 requirements, Reclamation will implement operations to provide year round temperature protection in the upper Sacramento River, consistent with intent of Order 90-05 that protection be provided to the extent controllable. Among factors that affect the extent to which river temperatures will be controllable will include Shasta TCD performance, the availability of cold water, the balancing of habitat needs for different species in spring, summer, and fall, and the constraints on operations created by the combined effect of the projects and demands assumed to be in place in the future.

Based on cumulative affects of changes to cold water resources and spawning distribution changes, Reclamation has analyzed the capability to manage water temperatures in the upper Sacramento River under future conditions. Reclamation used the water temperature model with an updated calibration of the Shasta TCD and the salmon mortality model with the recent spawning distribution to compare results of targeting different compliance points. One set of results represented operating to target compliance points identified in the 1993 BO. Another set of results represented operating to target compliance at Ball's Ferry, which is further upstream. The analysis under future conditions supports moving the target compliance point upstream to avoid exhausting the available cold water resources too early in the salmon spawning and rearing season.

Under all but the most adverse drought and low Shasta Reservoir storage conditions, CVP facilities should be operated to provide water temperature control at Ball's Ferry or at locations further downstream (as far as Bend Bridge) based on annual plans developed in coordination with the SRTTG. Reclamation and the SRTTG will take into account projections of cold water resources, numbers of expected spawning salmon, and spawning distribution (as monitoring information becomes available) to make the decisions on allocation of the cold water resources.

Locating the target temperature compliance at Ball's Ferry (1) reduces the need to compensate the warming effects of Cottonwood Creek and Battle Creek during the spring runoff months with deeper cold water releases and (2) improves the reliability of cold water resources through the fall months. Reclamation proposes this change in Sacramento River temperature control objectives to be consistent with the capability of the CVP to manage cold water resources and to use the process of annual planning in coordination with the Sacramento River Temperature Task Group to arrive at the best use of that capability.

Anderson-Cottonwood Irrigation District Diversion Dam

Since 1916, water has been diverted into the ACID Canal for irrigation along the west side of the Sacramento River between Redding and Cottonwood. The United States and ACID signed a contract (Number 14-06-200-3346A) providing for the project water service and agreement on diversion of water. ACID diverts to its main canal (on the right bank of the river) from a diversion dam located in Redding about five miles downstream from Keswick Dam. The diversion dam consists of boards supported by a pinned steel superstructure anchored to a concrete foundation across the Sacramento River. The boards are manually set from a walkway supported by the steel superstructure. The number of boards set in the dam varies depending upon flow in the river and desired head in the canal.

Because the diversion dam is a flashboard dam installed for seasonal use only, close coordination is required between Reclamation and ACID for regulation of river flows to allow safe installation and removal of the flashboards. The contract between ACID and the United States allows for ACID to notify Reclamation as far in advance as possible each time it intends to install or remove boards from its diversion dam. Reclamation similarly notifies ACID each time it intends to change releases at Keswick Dam. In addition, during the irrigation season, ACID notifies Reclamation of the maximum flow the diversion dam can safely accommodate (with the current setting of boards). Reclamation notifies ACID (at least 24 hours in advance) of any change in releases at Keswick Dam that exceed such maximum flow designated by ACID.

The irrigation season for ACID runs from April through October. Therefore, around April 1 of each year, ACID erects the diversion dam. This consists of raising the steel superstructure, installing the walkway, and then setting the boards. Around November 1 of each year, the reverse process occurs. The dates of installation and removal can vary depending on hydrologic conditions. Removal and installation of the dam cannot be done safely at flows greater than 6,000 cfs. ACID usually requests Reclamation to limit the Keswick release to a 5,000 cfs maximum for five days to accomplish the installation and removal of the dam. As indicated previously, there may be times during the irrigation season when the setting of the boards must be changed due to changes in releases at Keswick Dam. When boards must be removed due to an increase at Keswick, the release may initially have to be decreased to allow work to be done

safely. If an emergency exists, Reclamation personnel from the Northern California Area Office can be dispatched to assist ACID in removing the boards.

Keswick release rate decreases required for the ACID operations are limited to 15 percent in a 24-hour period and 2.5 percent in any one hour. Therefore, advance notification is important when scheduling decreases to allow for the installation or removal of the ACID dam.

Red Bluff Diversion Dam Operations

The RBDD, located on the Sacramento River approximately two miles southeast of Red Bluff, is a gated structure with fish ladders at each abutment. When the gates are lowered, the impounded water rises about 13 feet, creating Lake Red Bluff and allowing gravity diversions through a set of drum screens into the a stilling basin servicing the Tehama-Colusa and Corning Canals.

The Tehama-Colusa Canal is a lined canal extending 111 miles south from the RBDD and provides irrigation service on the west side of the Sacramento Valley in Tehama, Glenn, Colusa, and northern Yolo counties. The RBDD diverts water to the Corning and Tehama-Colusa Canals. Construction of the Tehama-Colusa Canal began in 1964 and was completed in 1965. Gates were first closed in 1967 with the startup of the State pumps in the Delta.

The Corning Pumping Plant lifts water approximately 56 feet from the screened portion of the settling basin into the unlined, 21 mile-long Corning Canal. The Corning Canal was completed in 1959 to serve water to the CVP contractors in Tehama County that could not be served by gravity from the Tehama-Colusa Canal. Both Canals are operated by the Tehama-Colusa Canal Authority (TCCA). The gates are currently lowered on May 15 to impound water for diversion and raised on September 15 to allow river flow-through.

Since 1986, the RBDD gates have been raised during winter months to allow passage of winter-run Chinook salmon. Since the 1993 NOAA Fisheries BO for winter-run Chinook salmon, the gates have been raised from September 15 through May 14 each year. This eight-month gates-up operation has eliminated passage impedance of upstream migration for all species which need to migrate above the RBDD to spawn, with the exception of 70 percent of the spring-run Chinook and an estimated 35 percent of the green sturgeon migrants (TCCA and Reclamation, 2002).

Reclamation proposes the continued operation of the RBDD using the eight-month gate-open procedures of the past ten years. However, Reclamation proposes to change the status of the research pumping plant from research to production status, along with adding a fourth pump if funding becomes available and the cost-benefit ratios prove favorable. Should a fourth pump be added, Reclamation would install another centrifugal pump. Reclamation also proposes the continued use of rediversions of CVP water stored in Black Butte Reservoir to supplement the water pumped at RBDD during the gates-out period. This water is rediverted with the aid of temporary gravel berms through an unscreened, constant head orifice (CHO) into the Tehema-Colusa Canal.

This arrangement has successfully met the water demand for the past ten years, but the supply has consistently been quite tight. To date, Reclamation has not had to use the provision of the RPA of the winter-run BO allowing up to one closure per year of the gates for up to ten days. While mandatory use of this temporary gates closure provision has been minimized so far, it was used in 1997, a year with an exceptionally dry spring. Its use in another year was avoided only at

the last minute by an exceptionally heavy, late storm. Reclamation will implement with NOAA Fisheries a decision-making protocol to ensure such gate closure decisions can be achieved on short notice.

American River Division

The American River originates in the mountains of the Sierra Nevada range, drains a watershed of approximately 1,895 square miles, and enters the Sacramento River at river mile 60 in the City. The American River contributes approximately 15 percent of the total flow in the Sacramento River. The American River watershed ranges in elevation from 23 feet to over 10,000 feet, and receives approximately 40 percent of its flow from snowmelt. Development on the American River began in the earliest days of the California Gold Rush, when numerous small diversion dams, flumes, and canals were constructed. Currently, 19 major reservoirs in the drainage area have a combined storage capacity of about 1.8 million af.

Folsom Lake, the largest reservoir in the watershed, was formed with the completion of Folsom Dam in 1956 and has a capacity of 977,000 af. Folsom Dam, located approximately 30 miles upstream from the confluence with the Sacramento River, is operated by Reclamation as a major component of the CVP. Water released from Folsom Lake is used to generate hydroelectric power, meet downstream water rights obligations, contribute to Delta inflow requirements, and provide water supplies to CVP contractors.

Releases from Folsom Dam are re-regulated approximately seven miles downstream by Nimbus Dam. This facility is also operated by Reclamation as part of the CVP and began operation in 1955. Nimbus Dam creates Lake Natoma, which serves as a forebay for diversions to the Folsom South Canal. This CVP facility began operation in 1973 and serves water to agricultural and M&I users in Sacramento County. The first two reaches of the canal, extending to just south of Highway 104, were completed in 1973. Construction of the remainder of the canal has been suspended pending reconsideration of alternatives. Releases from Nimbus Dam to the American River pass through the Nimbus Powerplant, or,at flows in excess of 5,000 cfs, the spillway gates.

Although Folsom Lake is the main storage and flood control reservoir on the American River, numerous other small reservoirs in the upper basin provide hydroelectric generation and water supply. None of the upstream reservoirs has any specific flood control responsibilities. The total upstream reservoir storage above Folsom Lake is approximately 820,000 af. Ninety percent of this upstream storage is contained by five reservoirs: French Meadows (136,000 af); Hell Hole (208,000 af); Loon Lake (76,000 af); Union Valley (271,000 af); and Ice House (46,000 af).

French Meadows and Hell Hole reservoirs, located on the Middle Fork of the American River, are owned and operated by the Placer County Water Agency (PCWA). The PCWA provides wholesale water to agricultural and urban areas within Placer County. For urban areas, the PCWA operates water treatment plants and sells wholesale treated water to municipalities that provide retail delivery to their customers. The cities of Rocklin and Lincoln receive water from the PCWA. Loon Lake (also on the Middle Fork), and Union Valley and Ice House reservoirs on the South Fork, are all operated by the Sacramento Municipal Utilities District (SMUD) for hydropower purposes.

American River Operations

The Corps constructed major portions of the American River Division under the authorization of Congress. The American River Basin Development Act of 1949 subsequently authorized its integration into the CVP. The American River Division includes facilities that provide conservation of water on the American River for flood control, fish and wildlife protection, recreation, protection of the Delta from intrusion of saline ocean water, irrigation and M&I water supplies, and hydroelectric power generation. Initially authorized features of the American River Division included Folsom Dam, Lake, and Powerplant; Nimbus Dam and Powerplant, and Lake Natoma.

Flood control requirements and regulating criteria are specified by the Corps and described in the Folsom Dam and Lake, American River, California Water Control Manual (Corps 1987). Flood control objectives for Folsom require the dam and lake are operated to:

- Protect the City and other areas within the lower American River floodplain against reasonable probable rain floods.
- Control flows in the American River downstream from Folsom Dam to existing channel capacities, insofar as practicable, and to reduce flooding along the lower Sacramento River and in the Delta in conjunction with other CVP projects.
- Provide the maximum amount of water conservation storage without impairing the flood control functions of the reservoir.
- Provide the maximum amount of power practicable and be consistent with required flood control operations and the conservation functions of the reservoir.

From June 1 through September 30, no flood control storage restrictions exist. From October 1 through November 16 and from April 20 through May 31, reserving storage space for flood control is a function of the date only, with full flood reservation space required from November 17 through February 7. Beginning February 8 and continuing through April 20, flood reservation space is a function of both date and current hydrologic conditions in the basin.

If the inflow into Folsom Reservoir causes the storage to encroach into the space reserved for flood control, releases from Nimbus Dam are increased. Flood control regulations prescribe the following releases when water is stored within the flood control reservation space:

- Maximum inflow (after the storage entered into the flood control reservation space) of as much as 115,000 cfs, but not less than 20,000 cfs, when inflows are increasing.
- Releases will not be increased more than 15,000 cfs or decreased more than 10,000 cfs during and two-hour period.
- Flood control requirements override other operational considerations in the fall and winter period. Consequently, changes in river releases of short duration may occur.

In February 1986, the American River Basin experienced a significant flood event. Folsom Dam and Reservoir moderated the flood event and performed the flood control objectives, but with serious operational strains and concerns in the lower American River and the overall protection of the communities in the floodplain areas. A similar flood event occurred in January 1997. Since then, significant review and enhancement of lower American River flooding issues has

occurred and continues to occur. A major element of those efforts has been the SAFCA-sponsored flood control plan diagram for Folsom Reservoir.

Since 1996, Reclamation has operated according to modified flood control criteria, which reserve 400 to 670 thousand af of flood control space in Folsom and in a combination of three upstream reservoirs. This flood control plan, which provides additional protection for the Lower American River, is implemented through an agreement between Reclamation and the SAFCA. The terms of the agreement allow some of the empty reservoir space in Hell Hole, Union Valley, and French Meadows to be treated as if it were available in Folsom.

The SAFCA release criteria are generally equivalent to the Corps plan, except the SAFCA diagram may prescribe flood releases earlier than the Corps plan. The SAFCA diagram also relies on Folsom Dam outlet capacity to make the earlier flood releases. The outlet capacity at Folsom Dam is currently limited to 32,000 cfs based on lake elevation. However, in general the SAFCA plan diagram provides greater flood protection than the existing the Corps plan for communities in the American River floodplain.

Required flood control space under the SAFCA diagram will begin to decrease on March 1. Between March 1 and April 20, the rate of filling is a function of the date and available upstream space. As of April 21, the required flood reservation is about 225,000 af. From April 21 to June 1, the required flood reservation is a function of the date only, with Folsom storage permitted to fill completely on June 1.

Fish and Wildlife Requirements in the Lower American River

The minimum allowable flows in the lower American River are defined by SWRCB Decision 893 (D-893) which states that, in the interest of fish conservation, releases should not ordinarily fall below 250 cfs between January 1 and September 15 or below 500 cfs at other times. D-893 minimum flows are rarely the controlling objective of CVP operations at Nimbus Dam. Nimbus Dam releases are nearly always controlled during significant portions of a water year by either flood control requirements or are coordinated with other CVP and SWP releases to meet downstream Sacramento-San Joaquin Delta WQCP requirements and CVP water supply objectives.

Power regulation and management needs occasionally control Nimbus Dam releases. Nimbus Dam releases are expected to exceed the D-893 minimum flows in all but the driest of conditions. It should be noted that discussions are underway among Reclamation, members of the Water Forum, and Management Agencies concerning modification of Reclamation's water rights permits to effect an increase to minimum flows in the lower American River. Until such an action is presented to and adopted by the SWRCB, minimum flows will be limited by D-893. Releases of additional water are made pursuant to Section 3406 (b)(2) of the CVPIA.

Water temperature control operations in the lower American River are affected by many factors and operational tradeoffs. These include available cold water resources, Nimbus release schedules, annual hydrology, Folsom power penstock shutter management flexibility, Folsom Dam Urban Water Supply TCD management, and Nimbus Hatchery considerations. Shutter and TCD management provide the majority of operational flexibility used to control downstream temperatures.

During the late 1960's, Reclamation designed a modification to the trashrack structures to provide selective withdrawal capability at Folsom Dam. Folsom Powerplant is located at the foot of Folsom Dam on the right abutment. Three 15-foot diameter steel penstocks for delivering water to the turbines are embedded in the concrete section of the dam. The centerline of each penstock intake is at elevation 307.0 feet and the minimum power pool elevation is 328.5 feet. A reinforced concrete trashrack structure with steel trashracks protects each penstock intake.

The steel trashracks, located in five bays around each intake, extend the full height of the trashrack structure (between 281 and 428 feet). Steel guides were attached to the upstream side of the trashrack panels between elevation 281 and 401 feet. Forty-five 13-foot steel shutter panels (nine per bay) and operated by the gantry crane, were installed in these guides to select the level of withdrawal from the reservoir. The shutter panels are attached to one another in a configuration starting with the top shutter in groups of 3-2-4.

Selective withdrawal capability on the Folsom Dam Urban Water Supply Pipeline became operational in 2003. The centerline to the 84-inch diameter Urban Water Supply intake is at elevation 317 feet. An enclosure structure extending from just below the water supply intake to an elevation of 442 feet was attached to the upstream face of Folsom Dam. A telescoping control gate allows for selective withdrawal of water anywhere between 331 and 401 feet elevation under normal operations.

The current objectives for water temperatures in the lower American River address the needs for steelhead incubation and rearing during the late spring and summer, and for fall–run Chinook spawning and incubation starting in late October or early November.

The steelhead temperature objectives in the lower American River, as provided by NOAA Fisheries, state:

> "Reclamation shall, to the extent possible, control water temperatures in the lower river between Nimbus Dam and the Watt Avenue Bridge (RM 9.4) from June 1 through November 30, to a daily average temperature of less than or equal to 65°F to protect rearing juvenile steelhead from thermal stress and from warm water predator species. The use of the cold water pool in Folsom Reservoir should be reserved for August through October releases."

Prior to the ESA listing of steelhead and the subsequent BOs on operations, the cold water resources in Folsom Reservoir were used to lower downstream temperatures in the fall when fall-run Chinook salmon entered the lower river and began to spawn. The flexibility once available is now gone because of the need to use the cold water to maintain suitable summer steelhead rearing conditions. The operational objective in the fall spawning season is to provide 60°F or less in the lower river, as soon as available cold water supplies can be used.

A major challenge is determining the starting date at which time the objective is met. Establishing the start date requires a balancing between forecasted release rates, the volume of available cold water, and the estimated date at which time Folsom Reservoir turns over and becomes isothermic. Reclamation will start providing suitable spawning temperatures as early as possible (after November 1) to avoid temperature related pre-spawning mortality of adults and reduced egg viability. Reclamation will be balanced against the possibility of running out of cold

water and increasing downstream temperatures after spawning is initiated and creating temperature related effects to eggs already in the gravel.

The cold water resources available in any given year at Folsom Lake needed to meet the stated water temperature goals are often insufficient. Only in wetter hydrologic conditions is the volume of cold water resources available sufficient to meet all the water temperature objectives. Therefore, significant operations tradeoffs and flexibilities are considered part of an annual planning process for coordinating an operation strategy that realistically manages the limited cold water resources available.

The management process begins in the spring as Folsom Reservoir fills. All penstock shutters are put in the down position to isolate the colder water in the reservoir below an elevation of 401 feet. The reservoir water surface elevation must be at least 25 feet higher than the sill of the upper shutter (426 feet) to avoid cavitation of the power turbines. The earliest this can occur is in the month of March, due to the need to maintain flood control space in the reservoir during the winter. The pattern of spring run-off is then a significant factor in determining the availability of cold water for later use. Folsom inflow temperatures begin to increase and the lake starts to stratify as early as April. By the time the reservoir is filled or reaches peak storage (sometime in the May through June period), the reservoir is highly stratified with surface waters too warm to meet downstream temperature objectives. There are, however, times during the filling process when use of the spillway gates can be used to conserve cold water.

In the spring of 2003, high inflows and encroachment into the allowable storage space for flood control required releases that exceeded the available capacity of the power plant. Under these conditions, standard operations of Folsom calls for the use of the river outlets that would draw upon the cold water pool. Instead, Reclamation reviewed the release requirements, SOD issues, reservoir temperature conditions, and the benefits to the cold water pool and determined that it could use the spillway gates to make the incremental releases above powerplant capacity, thereby conserving cold water for later use. The ability to take similar actions, (as needed in the future), will be evaluated on a case-by-case basis.

A temperature control management strategy must be developed that balances conservation of cold water for later use in the fall, with the more immediate needs of steelhead during the summer. The planning and forecasting process for the use of the cold water pool begins in the spring as Folsom Reservoir fills. Actual Folsom Reservoir cold water resource availability becomes significantly more defined through the assessment of reservoir water temperature profiles and more definite projections of inflows and storage. Technical modeling analysis of the projected lower American River water temperature management can begin. The significant variables and key assumptions in the analysis include:

Starting reservoir temperature conditions;Forecasted inflow and outflow quantities;

Assumed meteorological conditions;

Assumed inflow temperatures; and,

Assumed Urban Water Supply TCD operations.

A series of shutter management scenarios are then incorporated into the model to gain a better understanding of the potential for meeting both summer steelhead and fall salmon temperature needs. Most annual strategies contain significant tradeoffs and risks for water temperature

management for steelhead and fall–run salmon goals and needs due to the frequently limited cold water resource. The planning process continues throughout the summer. New temperature forecasts and operational strategies are updated as more information on actual operations and ambient conditions is gained. This process is shared with the AROG.

Meeting both the summer steelhead and fall salmon temperature objectives without negatively impacting other CVP project purposes requires the final shutter pull be reserved for use in the fall to provide suitable fall-run Chinook salmon spawning temperatures. In most years, the volume of cold water is not sufficient to support strict compliance with the summer temperature target at the downstream end of the compliance reach (Watt Avenue Bridge) and reserve the final shutter pull for salmon or, in some cases, continue to meet steelhead objectives later in the summer. A strategy that is used under these conditions is to allow the annual compliance location water temperatures to warm towards the upper end of the annual water temperature design value before making a shutter pull. This management flexibility is essential to the annual management strategy to extend the effectiveness of cold water management through the summer and fall months.

The Urban Water Supply TCD has provided additional flexibility to conserve cold water for later use. Initial studies are being conducted evaluating the impact of warmer water deliveries to the water treatment plants receiving the water. As water supply temperatures increase into the upper-60°F range, treatment costs, the potential for taste and odor and disinfection byproducts, and customer complaints increase. It is expected that the TCD will be operated during the summer months and deliver water that is slightly warmer than that which could be used to meet downstream temperatures (60°F to 62°F), but not so warm as to cause significant treatment issues.

Water temperatures feeding the Nimbus Fish Hatchery were historically too high for hatchery operations during some dry or critical years. Temperatures in the Nimbus Hatchery are generally in the desirable range of 42° F to 55° F, except for the months of June, July, August, and September. When temperatures get above 60° F during these months, the hatchery must begin to treat the fish with chemicals to prevent disease. When temperatures reach the 60° F to 70° F range, treatment becomes difficult and conditions become increasingly dangerous for the fish. When temperatures climb into the 60° F to 70° F range, hatchery personnel may confer with Reclamation to determine a compromise operation of the temperature shutter at Folsom Dam for the release of cooler water.

The goal is to maintain the health of the hatchery fish while minimizing the loss of the cold water pool for fish spawning in the river during fall. This is done on a case-by-case basis and is different in various months and year types. Temperatures above 70° F in the hatchery usually mean the fish need to be moved to another hatchery. The real time implementation needs for the CVPIA AFRP objective flow management and SWRCB D-1641 Delta standards from the limited water resources of the lower American River has made cold water resource management at Folsom Lake a significant compromise coordination effort. Reclamation consults with the FWS, NOAA Fisheries, and the DFG utilizing the B2IT process (see CVPIA section) when making the difficult compromise decisions. In addition, Reclamation communicates and coordinates with the AROG on real time decision issues.

The Nimbus Fish Hatchery and the American River Trout Hatchery were constructed to mitigate the loss of riverine habitat caused by the construction of Nimbus and Folsom Dam. The hatcheries are located approximately one-quater mile downstream from Nimbus Dam on the south side of the American River To meet the mitigation requirement, annual production goals are approximately 4.2 million salmon smolts and 430,000 steelhead yearlings.

A fish diversion weir at the hatcheries blocks Chinook salmon from continuing upstream and guides them to the hatchery fish ladder entrance. The fish diversion weir consists of eight piers on 30-foot spacing, including two riverbank abutments. Fish rack support frames and walkways are installed each fall via an overhead cable system. A pipe rack is then put in place to support the pipe pickets (¾-inch steel rods spaced on 2½-inch centers). The pipe rack rests on a submerged steel I-beam support frame that extends between the piers and forms the upper support structure for a rock filled crib foundation. The rock foundation has deteriorated with age and is subject to annual scour which can leave holes in the foundation that allow fish to pass if left unattended.

Fish rack supports and pickets are installed around September 15 of each year and correspond with the beginning of the fall-run Chinook salmon spawning season. A release equal to or less than 1,500 cfs from Nimbus Dams is required for safety and to provide full access to the fish rack supports. It takes six people approximately three days to install the fish rack supports and pickets. In years after high winter flows have caused active scour of the rock foundation, a short period (less than eight hours) of lower flow (approximately 500 cfs) is needed to remove debris from the I-beam support frames, seat the pipe racks, and fill holes in the rock foundation. Compete installation can take up to seven days, but is generally completed in less time. The fish rack supports and pickets are usually removed at the end of fall-run Chinook salmon spawning season (mid-January) when flows are less than 2,000 cfs. If Nimbus Dam releases are expected to exceed 5,000 cfs during the operational period, the pipe pickets are removed until flows decrease.

East Side Division

New Melones Operations

The Stanislaus River originates in the western slopes of the Sierra Nevada Mountain Range and drains a watershed of approximately 900 square miles. The average unimpaired runoff in the basin is approximately 1.2 million af per year; the median historical unimpaired runoff is 1.1 million af per year. Snowmelt contributes the largest portion of the flows in the Stanislaus River, with the highest runoff occurring in the months of April, May, and June. Agricultural water supply development in the Stanislaus River watershed began in the 1850's and has significantly altered the basin's hydrologic conditions.

Currently, the flow in the lower Stanislaus River is primarily controlled by New Melones Reservoir, which has a storage capacity of about 2.4 million af. The reservoir was completed by the Corps in 1978 and approved for filling in 1983. New Melones Reservoir is located approximately 60 miles upstream from the confluence of the Stanislaus River and the San Joaquin River and is operated by Reclamation. Congressional authorization for New Melones integrates New Melones Reservoir as a financial component of the CVP, but it is authorized to

provide water supply benefits within the defined Stanislaus Basin per a 1980 ROD before additional water supplies can be used out of the defined Stanislaus Basin.

New Melones Reservoir is operated primarily for purposes of water supply, flood control, power generation, fishery enhancement, and water quality improvement in the lower San Joaquin River. The reservoir and river also provide recreation benefits. Flood control operations are conducted in conformance with the Corps' operational guidelines.

Another major water storage project in the Stanislaus River watershed is the Tri-Dam Project, a hydroelectric generation project that consists of Donnells and Beardsley Dams, located upstream of New Melones Reservoir on the middle fork Stanislaus River, and Tulloch Dam and Powerplant, located approximately six miles downstream of New Melones Dam on the main stem Stanislaus River.

Releases from Donnells and Beardsley Dams affect inflows to New Melones Reservoir. Under contractual agreements between Reclamation, the Oakdale Irrigation District (OID), and South San Joaquin Irrigation District (SSJID), Tulloch Reservoir provides afterbay storage to re-regulate power releases from New Melones Powerplant. The main water diversion point on the Stanislaus River is Goodwin Dam, located approximately 1.9 miles downstream of Tulloch Dam.

Goodwin Dam,constructed by OID and SSJID in 1912, creates a re-regulating reservoir for releases from Tulloch Powerplant and provides for diversions to canals north and south of the Stanislaus River for delivery to OID and SSJID. Water impounded behind Goodwin Dam may be pumped into the Goodwin Tunnel for deliveries to the Central San Joaquin Water Conservation District and the Stockton East Water District.

Twenty ungaged tributaries contribute flow to the lower portion of the Stanislaus River, below Goodwin Dam. These streams provide intermittent flows, occurring primarily during the months of November through April. Agricultural return flows, as well as operational spills from irrigation canals receiving water from both the Stanislaus and Tuolumne Rivers, enter the lower portion of the Stanislaus River. In addition, a portion of the flow in the lower reach of the Stanislaus River originates from groundwater accretions.

Flood Control

The New Melones Reservoir flood control operation is coordinated with the operation of Tulloch Reservoir. The flood control objective is to maintain flood flows at the Orange Blossom Bridge at less than 8,000 cfs. When possible, however, releases from Tulloch Dam are maintained at levels that would not result in downstream flows in excess of 1,250 cfs to 1,500 cfs because of seepage problems in agricultural lands adjoining the river associated with flows above this level. Up to 450,000 af of the 2.4 million af storage volume in New Melones Reservoir is dedicated for flood control and 10,000 af of Tulloch Reservoir storage is set aside for flood control. Based upon the flood control diagrams prepared by the Corps, part or all of the dedicated flood control storage may be used for conservation storage, depending on the time of year and the current flood hazard.

Requirements for New Melones Operations

The operating criteria for New Melones Reservoir are affected by (1) water rights, (2) in stream fish and wildlife flow requirements (including Interior's CVPIA 3406 (b)(2) fishery management objectives), (3) SWRCB D-1641 Vernalis flow requirements, (4) dissolved oxygen (DO) requirements, (5) SWRCB D-1641 Vernalis water quality requirements, (6) CVP contracts, and (7) flood control considerations. Water released from New Melones Dam and Powerplant is re-regulated at Tulloch Reservoir and is either diverted at Goodwin Dam or released from Goodwin Dam to the lower Stanislaus River.

Flows in the lower Stanislaus River serve multiple purposes concurrently. The purposes include water supply for riparian water rights, fishery management objectives, and DO requirements per SWRCB D-1422. In addition, water from the Stanislaus River enters the San Joaquin River where it contributes to flow and helps improve water quality conditions at Vernalis. D-1422, issued in 1973, provided the primary operational criteria for New Melones Reservoir and permitted Reclamation to appropriate water from the Stanislaus River for irrigation and M&I uses. D-1422 requires the operation of New Melones Reservoir include releases for existing water rights, fish and wildlife enhancement, and the maintenance of water quality conditions on the Stanislaus and San Joaquin Rivers.

Water Rights Obligations

When Reclamation began operations of New Melones Reservoir in 1980, the obligations for releases (to meet downstream water rights) were defined in a 1972 Agreement and Stipulation among Reclamation, OID, and SSJID. The 1972 Agreement and Stipulation required Reclamation release annual inflows to New Melones Reservoir of up to 654,000 af per year for diversion at Goodwin Dam by OID and SSJID, in recognition of their prior water rights. Actual historical diversions prior to 1972 varied considerably, depending upon hydrologic conditions. In addition to releases for diversion by OID and SSJID, water is released from New Melones Reservoir to satisfy riparian water rights totaling approximately 48,000 af annually downstream of Goodwin Dam.

In 1988, following a year of low inflow to New Melones Reservoir, the Agreement and Stipulation among Reclamation, OID, and SSJID was superseded by an agreement that provided for conservation storage by OID and SSJID. The new agreement required Reclamation to release New Melones Reservoir inflows of up to 600,000 af each year for diversion at Goodwin Dam by OID and SSJID.

In years when annual inflows to New Melones Reservoir are less than 600,000 af, Reclamation provides all inflows plus one-third the difference between the inflow for that year and 600,000 af per year. The 1988 Agreement and Stipulation created a conservation account in which the difference between the entitled quantity and the actual quantity diverted by OID and SSJID in a year may be stored in New Melones Reservoir for use in subsequent years. This conservation account has a maximum storage limit of 200,000 af, and withdrawals are constrained by criteria in the agreement.

In stream Flow Requirements

Under D-1422, Reclamation is required to release 98,000 af of water per year, with a reduction to 69,000 af in critical years, from New Melones Reservoir to the Stanislaus River on a distribution pattern to be specified each year by DFG for fish and wildlife purposes. In 1987, an agreement between Reclamation and DFG provided for increased releases from New Melones to enhance fishery resources for an interim period, during which habitat requirements were to be better defined and a study of Chinook salmon fisheries on the Stanislaus River would be completed.

During the study period, releases for in stream flows would range from 98,300 to 302,100 af per year. The exact quantity to be released each year was to be determined based on a formulation involving storage, projected inflows, projected water supply, water quality demands, projected CVP contractor demands, and target carryover storage. Because of dry hydrologic conditions during the 1987 to 1992 drought period, the ability to provide increased releases was limited. FWS published the results of a 1993 study which recommended a minimum in stream flow on the Stanislaus River of 155,700 af per year for spawning and rearing (Aceituno 1993).

Bay-Delta Vernalis Flow Requirements

SWRCB D-1641 sets flow requirements on the San Joaquin River at Vernalis from February to June. These flows are commonly known as San Joaquin River base flows.

Table 2–6 San Joaquin Base Flows-Vernalis

Water Year Class	February-June Flow (cfs)*
Critical	710-1140
Dry	1420-2280
Below Normal	1420-2280
Above Normal	2130-3420
Wet	2130-3420

*the higher flow required when X2 is required to be west of Chipps Island

Reclamation committed to provide these flows during the interim period of the Bay-Delta Accord. Since D-1641 has been in place, the San Joaquin base flow requirements have at times, been an additional demand on the New Melones water supply beyond that anticipated in the Interim Plan of Operation (IPO). The IPO describes the commitment Reclamation made regarding the operation of New Melones Reservoir.

Dissolved Oxygen Requirements

SWRCB D-1422 requires that water be released from New Melones Reservoir to maintain DO standards in the Stanislaus River. The 1995 revision to the WQCP established a minimum DO concentration of 7milligrams per liter (mg/l), as measured on the Stanislaus River near Ripon.

Vernalis Water Quality Requirement

SWRCB D-1422 also specifies that New Melones Reservoir must operate to maintain average monthly level total dissolved solids (TDS), commonly measured as a conversion from electrical conductivity, in the San Joaquin River at Vernalis as it enters the Delta. SWRCB D-1422 specifies an average monthly concentration of 500 parts per million (ppm) TDS for all months. Historically, releases have been made from New Melones Reservoir for this standard, but due to shortfalls in water supply, Reclamation has not always been successful in meeting this objective.

In the past, when sufficient supplies were not available to meet the water quality standards for the entire year, the emphasis for use of the available water was during the irrigation season, generally from April through September. SWRCB D-1641 modified the water quality objectives at Vernalis to include the irrigation and non-irrigation season objectives contained in the 1995 Bay-Delta WQCP. The revised standard is an average monthly electric conductivity 0.7 mS/cm (approximately 455 ppm TDS) during the months of April through August, and 1.0 mS/cm (approximately 650 ppm TDS) during the months of September through March.

CVP Contracts

Reclamation entered into water service contracts for the delivery of water from New Melones Reservoir, based on a 1980 hydrologic evaluation of the long-term availability of water in the Stanislaus River Basin. Based on this study, Reclamation entered into a long-term water service contract for up to 49,000 af per year of water annually (based on a firm water supply), and two long-term water service contracts totaling 106,000 af per year (based on an interim water supply). Because diversion facilities were not yet fully operational and water supplies were not available during the 1987 to 1992 drought, water was not made available from the Stanislaus River for delivery to CVP contractors prior to 1992.

New Melones Interim Plan of Operations (IPO)

Proposed CVP operations on the Stanislaus River are derived from the New Melones IPO. The IPO was developed as a joint effort between Reclamation and FWS, in conjunction with the Stanislaus River Basin Stakeholders (SRBS). The process of developing the plan began in 1995 with a goal to develop a long-term management plan with clear operating criteria, given a fundamental recognition by all parties that New Melones Reservoir water supplies are over-committed on a long-term basis, and consequently, unable to meet all the potential beneficial uses designated as purposes.

In 1996, the focus shifted to the development of an interim operations plan for 1997 and 1998. At an SRBS meeting on January 29, 1997, a final interim plan of operation was agreed to in concept. The IPO was transmitted to the SRBS on May 1, 1997. Although meant to be a short-term plan, it continues to be the guiding operations criteria in effect for the annual planning to meet beneficial uses from New Melones storage.

In summary, the IPO defines categories of water supply based on storage and projected inflow. It then allocates annual water release for in stream fishery enhancement (1987 DFG Agreement and CVPIA Section 3406(b)(2) management), SWRCB D-1641 San Joaquin River water quality requirements (Water Quality), SWRCB D-1641 Vernalis flow requirements (Bay-Delta), and use by CVP contractors.

Table 2–7 Inflow characterization for the New Melones IPO

Annual water supply category	*March-September forecasted inflow plus end of February storage (thousand af)*
Low	0 - 1400
Medium-low	1400 - 2000
Medium	2000 - 2500
Medium-high	2500 - 3000
High	3000 - 6000

Table 2–8 New Melones IPO flow objectives (in thousand af)

Storage plus inflow		*Fishery*		*Vernalis water quality*		*Bay-Delta*		*CVP contractors*	
From	*To*	*From*	*To*	*From*	*To*	*From*	*To*	*From*	*To*
1400	2000	98	125	70	80	0	0	0	0
2000	2500	125	345	80	175	0	0	0	59
2500	3000	345	467	175	250	75	75	90	90
3000	6000	467	467	250	250	75	75	90	90

From inspection of the above IPO allocation structure, two key New Melones-Stanislaus River water policies are inferred:

1) When the water supply condition is determined to be in the "Low" IPO designation, no CVP operations guidance is given. It is assumed Reclamation would meet with the SRBS group to coordinate a practical strategy to guide New Melones Reservoir annual operations under the very limited water supply conditions.
2) The IPO only supports meeting the SWRCB D-1641 Vernalis Base flow standards from Stanislaus River water resources when the water supply condition are determined to be in the "High" or "Medium-High" IPO designation, and then are limited to 75,000 af of reservoir release.

The IPO supports only limited reservoir release volumes towards meeting the Vernalis salinity standards. The limited reservoir release volumes dedicated in the IPO may not fully meet the annual SWRCB standard requirement for the Vernalis salinity standard in the "Medium Low" and "Medium" years. If the Vernalis salinity standard cannot be met using the IPO designated Goodwin release pattern, then additional volume is dedicated to meeting the salinity standard. The permit obligations must be met before an allocation can be made to CVPIA Section 3406

(b)(2) uses or CVP contracts. This is a consequence of Vernalis salinity standards existing prior to passage of CVPIA.

In water years 2002 and 2003, Reclamation deviated from the IPO to provide additional releases for Vernalis salinity and Vernalis base flow standards. Several consecutive years of dry hydrology in the San Joaquin River Basin have demonstrated the limited ability of New Melones to fully satisfy the demands placed on its yield. Despite the need to consider annual deviations, the IPO remains the initial guidance for New Melones Reservoir operations.

CVPIA Section 3406 (b)(2) releases from New Melones Reservoir consist of the portion of the fishery flow management volume utilized that is greater than the 1987 DFG Agreement and the volume used in meeting the Vernalis Base flows.

San Joaquin River Agreement/Vernalis Adaptive Management Plan

Adopted by the SWRCB in D-1641, the SJRA includes a 12-year experimental program providing for flows and exports in the lower San Joaquin River during a 31-day pulse flow period during April and May. It also provides for the collection of experimental data during that time to further the understanding of the effects of flows, exports, and the barrier at the head of Old River on salmon survival. This experimental program is commonly referred to as the VAMP.

Within the SJRA, the IPO has been assumed as the baseline operation for New Melones Reservoir, which forms part of the existing flow condition. The existing flow condition is used to compute the supplemental flows which will be provided on the San Joaquin River to meet the target flows for the 31-day pulse during April and May. These supplemental flows will be provided from other sources in the San Joaquin River Basin under the control of the parties to the SJRA.

The parties to the SJRA include several agencies that contribute flow to the San Joaquin, divert from or store water on the tributaries to the San Joaquin, or have an element of control over the flows in the lower San Joaquin River. These include Reclamation; OID; SSJID; Modesto ID; Turlock ID; Merced ID; and the San Joaquin River Exchange Contractors. The VAMP is based on coordination among these participating agencies in carrying out their operations to meet a steady target flow objective at Vernalis.

The target flow at Vernalis for the spring pulse flow period is determined each year according to the specifications contained in the SJRA. The target flow is determined prior to the spring pulse flows as an increase above the existing flows, and so “adapts” to the prevailing hydrologic conditions. Possible target flows specified in the agreement are (1) 2000 cfs, (2) 3200 cfs, (3) 4450 cfs, (4) 5700 cfs, and (5) 7000 cfs.

The Hydrology Group develops forecasts of flow at Vernalis, determines the appropriate target flow, devises an operations plan including flow schedules for each contributing agency, coordinates implementation of the VAMP flows, monitors conditions that may affect the objective of meeting the target flow, updates and adjusts the planned flow contributions as needed, and accounts for the flow contributions. The Hydrology Group includes designees with technical expertise from each agency that contributes water to the VAMP. During VAMP the Hydrology group communicates via regular conference calls, shares current information and

forecasts via e-mail and an internet website. The Hydrology group has two lead coordinators, one from Reclamation's CVO and one designated by the SJRG.

CVP-SWP operations forecasts include Vernalis flows that meet the appropriate pulse flow targets for the predicted hydrologic conditions. The flows in the San Joaquin River upstream of the Stanislaus River are forecasted for the assumed hydrologic conditions. The upstream of the Stanislaus River flows are then adjusted so when combined with the forecasted Stanislaus River flow based on the IPO, the combined flow would provide the appropriate Vernalis flows consistent with the pulse flow target identified in the SJRA. An analysis of how the flows are produced upstream of the Stanislaus River is included in the SJRA Environmental Impract Statement(EIS)/Environmental Impact Report (EIR). For purposes of CVP-SWP operations forecasts, the flows are simply assumed to exist at the confluence of the Stanislaus and San Joaquin Rivers, and the assessment of CVP-SWP operations in the Delta effects begins downstream of that point.

The VAMP program has two distinct components, a flow objective and an export restriction. The flow objectives were designed to provide similar protection to those defined in the WQCP. fishery releases on the Stanislaus above that called for in the 1987 DFG Agreement are typically considered WQCP (b)(2) releases. The export reduction involves a combined State and Federal pumping limitation on the Delta pumps. The combined export targets for the 31 days of VAMP are specified in the SJRA: 1500 cfs (when target flows are 2000, 3200, 4450, or 7000 cfs), and 2250 cfs (when target flow is 5700 cfs, or 3000 cfs [alternate export target when flow target is 7000 cfs]). Typically, the Federal pumping reduction is considered a WQCP (b)(2) expense and the State reduction is covered by EWA actions. In 2003, however, EWA also provided coverage for a portion of the Federal pumping reduction.

Water Temperatures

Water temperatures in the lower Stanislaus River are affected by many factors and operational tradeoffs. These include available cold water resources in New Melones reservoir, Goodwin release rates for fishery flow management and water quality objectives, as well as residence time in Tulloch Reservoir, as affected by local irrigation demand.

The current stated goal for water temperatures in the lower Stanislaus River is 65° F at Orange Blossom Bridge for steelhead incubation and rearing during the late spring and summer. This goal is often unachieved. Fall pulse attraction flows for salmon managed by FWS resources helps to transport cold water resources from New Melones Reservoir into Tulloch Reservoir before the spawning season begins.

Friant Division

This division operates separately from the rest of the CVP and is not integrated into the CVP OCAP, but its operation is part of the CVP for purposes of the project description. Friant Dam is located on the San Joaquin River, 25 miles northeast of Fresno where the San Joaquin River exits the Sierra foothills and enters the valley. The drainage basin is 1,676 square miles with an average annual runoff of 1,774,000 af. Completed in 1942, the dam is a concrete gravity structure, 319 feet high, with a crest length of 3,488 feet. Although the dam was completed in 1942, it wasn't placed into full operation until 1951.

The dam provides flood control on the San Joaquin River, provides downstream releases to meet senior water rights requirements above Mendota Pool, and provides conservation storage as well as diversion into Madera and Friant-Kern Canals. Water is delivered to a million acres of agricultural land in Fresno, Kern, Madera, and Tulare Counties in the San Joaquin Valley via the Friant-Kern Canal south into Tulare Lake Basin and via the Madera Canal northerly to Madera and Chowchilla IDs. A minimum of five cfs is required to pass the last water right holding located about 40 miles downstream near Gravelly Ford.

Flood control storage space in Millerton Lake is based on a complex formula, which considers upstream storage in the Southern California Edison reservoirs. The reservoir, Millerton Lake, first stored water on February 21, 1944. It has a total capacity of 520,528 af, a surface area of 4,900 acres, and is approximately 15 miles long. The lake's 45 miles of shoreline varies from gentle slopes near the dam to steep canyon walls farther inland. The reservoir provides boating, fishing, picnicking, and swimming.

San Felipe Division

Construction of the San Felipe Division of the CVP was authorized in 1967 (Figure 2–6). The San Felipe Division provides a supplemental water supply (for irrigation, M&I uses) in the Santa Clara Valley in Santa Clara County, and the north portion of San Benito County. It prevents further mining of the groundwater in Santa Clara County and replaces boron-contaminated water in San Benito County.

The San Felipe Division was designed to supply about 216,000 af annually by the year 2020. Water is delivered to the service areas not only by direct diversion from the distribution systems, but also through the expansion of the large groundwater recharge operation now being carried out by local interests. The majority of the water supply, about 150,000 af, is used for M&I purposes.

The facilities required to serve Santa Clara and San Benito Counties include 54 miles of tunnels and conduits, two large pumping plants, and one reservoir. About 50 percent of the water conveyed to Santa Clara County is percolated to the underground for agricultural and M&I uses, and the balance is treated for direct M&I delivery. Nearly all of the water provided to San Benito County is delivered via surface facilities. A distribution system was constructed in San Benito County to provide supplemental water to about 19,700 arable acres.

Water is conveyed from the Delta of the San Joaquin and Sacramento Rivers through the DMC. It is then pumped into the San Luis Reservoir and diverted through the 1.8 miles of Pacheco Tunnel Reach 1 to the Pacheco Pumping Plant. Twelve 2,000-horse-power pumps lift a maximum of 480 cfs a distance varying from 85 feet to 300 feet to the 5.3 mile-long Reach 2 of Pacheco Tunnel. The water then flows through the tunnel and without additional pumping, through 29 miles of concrete, high-pressure pipeline, varying in diameter from 10 feet to 8 feet and a mile-long Santa Clara Tunnel. The pipeline terminates at the Coyote Pumping Plant, which is capable of pumping water to Coyote Creek or the Calero Reservoir.

Santa Clara Valley Water District operates the Pacheco Tunnel, Pacheco Pumping Plant, Santa Clara Tunnel and Coyote Pumping Plant.

The Hollister Conduit branches off the Pacheco Conduit eight miles from the outlet of the Pacheco Tunnel. This 19.1 mile-long high-pressure pipeline, with a maximum capacity of 83 cfs, terminates at the San Justo Reservoir.

The 9,906 af capacity San Justo Reservoir is located about three miles southwest of the City of Hollister. The San Justo Dam is an earthfill structure 141 feet high with a crest length of 722 feet. This project includes a dike structure 66 feet high with a crest length of 918 feet. This reservoir regulates San Benito County's import water supplies, allows pressure deliveries to some of the agricultural lands in the service area, and provides storage for peaking of agricultural water.

The San Benito County Water District operates San Justo Reservoir and the Hollister Conduit.

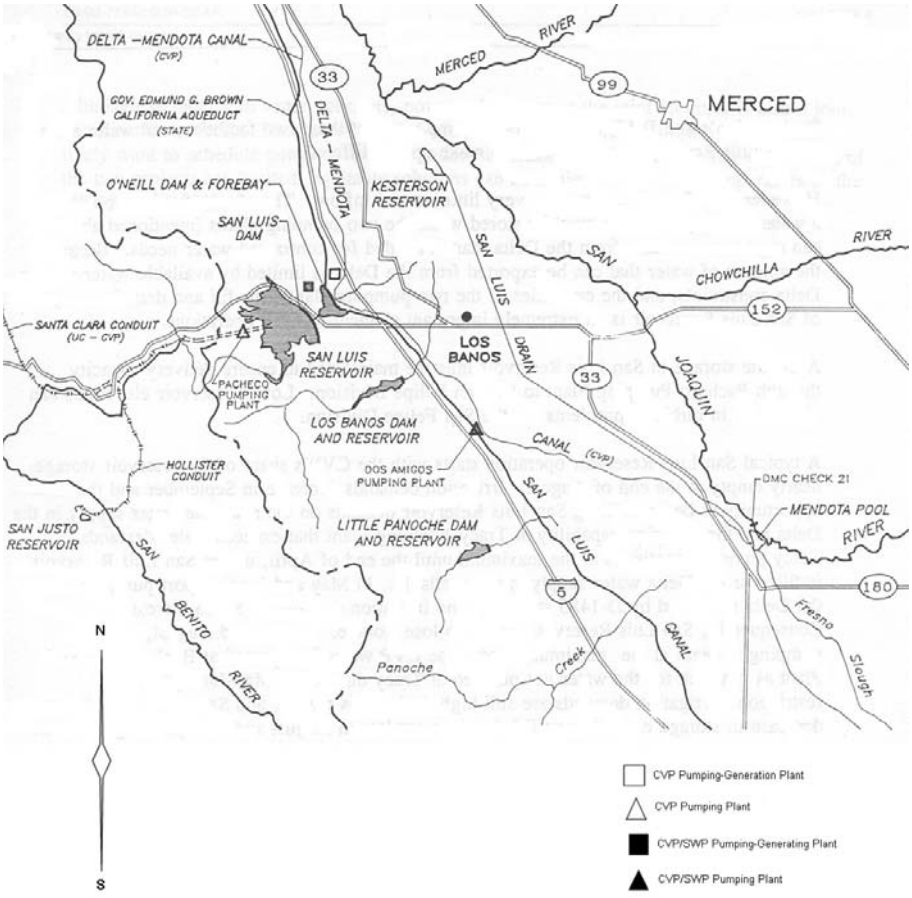


Figure 2–6 West San Joaquin Division and San Felipe Division

State Water Project

The DWR holds contracts with 29 public agencies throughout Central and Southern California for water supplies from the SWP. Water stored in the Oroville facilities, along with surplus water from the Sacramento-San Joaquin Delta are captured in the Delta and conveyed through several facilities to SWP contractors. The operation of these facilities is the subject of this project

description. The facilities include the primary conservation storage complex on the Feather River, export facilities located in the North and South Delta, tidally operated gates in the Suisun Marsh, and operable barriers in the South Delta.[4]

Feather River

SWP Oroville Facilities

Oroville Dam and its appurtenances comprise a multi-purpose project encompassing water conservation, power generation, flood control, recreation, and fish and wildlife enhancement. Oroville Lake stores winter and spring runoff that is released into the Feather River, as necessary, for project purposes. Pumped storage capability permits maximization of the power value produced by these releases.

The Oroville facilities are shown in Figure 2–7. Two small embankments, Bidwell Canyon and Parish Camp Saddle Dams, complement Oroville Dam in containing Lake Oroville. The lake has a surface area of 15,858 acres, a storage capacity of 3,538,000 af, and is fed by the North, Middle, and South forks of the Feather River. Average annual unimpaired runoff into the lake is about 4.5 million af.

A maximum of 17,000 cfs can be released through the Edward Hyatt Powerplant, located underground near the left abutment of Oroville Dam. Three of the six units are conventional generators driven by vertical-shaft, Francis-type turbines. The other three are motor-generators coupled to Francis-type, reversible pump turbines. The latter units allow pumped storage operations. The intake structure has an overflow type shutter system that determines the level from which water is drawn.

Approximately four miles downstream of Oroville Dam and Edward Hyatt Powerplant is the Thermalito Diversion Dam. Thermalito Diversion Dam consists of a 625-foot long, concrete gravity section with a regulated ogee spillway that releases water to the low flow channel of the Feather River. On the right abutment is the Thermalito Power Canal regulating headwork structure.

The purpose of the diversion dam is to divert water into the two-mile long Thermalito Power Canal that conveys water in either direction and creates a tailwater pool (called Thermalito Diversion Pool) for Edward Hyatt Powerplant. The Thermalito Diversion Pool acts as a forebay when Hyatt is pumping water back into Lake Oroville. On the left abutment is the Thermalito Diversion Dam Powerplant, with a capacity of 600 cfs that releases water to the low flow section of the Feather River.

Thermalito Power Canal hydraulically links the Thermalito Diversion Pool to the Thermalito Forebay (11,768 af), which is the off-stream regulating reservoir for Thermalito Powerplant. Thermalito Powerplant is a generating-pumping plant operated in tandem with the Edward Hyatt Powerplant. Water released to generate power in excess of local and downstream requirements is conserved in storage and, at times, pumped back through both powerplants into Lake Oroville during off-peak hours. Energy price and availability are the two main factors that determine if a

[4] Permanent operable barriers are planned for future construction and operation. Only the operation of these facilities is included in this project description. Construction effects will be addressed through a separate consultation process.

pumpback operation is economical. A pumpback operation most commonly occurs when energy prices are high during the weekday on-peak hours and low during the weekday off-peak hours or on the weekend. The Oroville Thermalito Complex has a capacity of approximately 17,000 cfs through the powerplants, which can be returned to the Feather River via the Afterbay's river outlet.

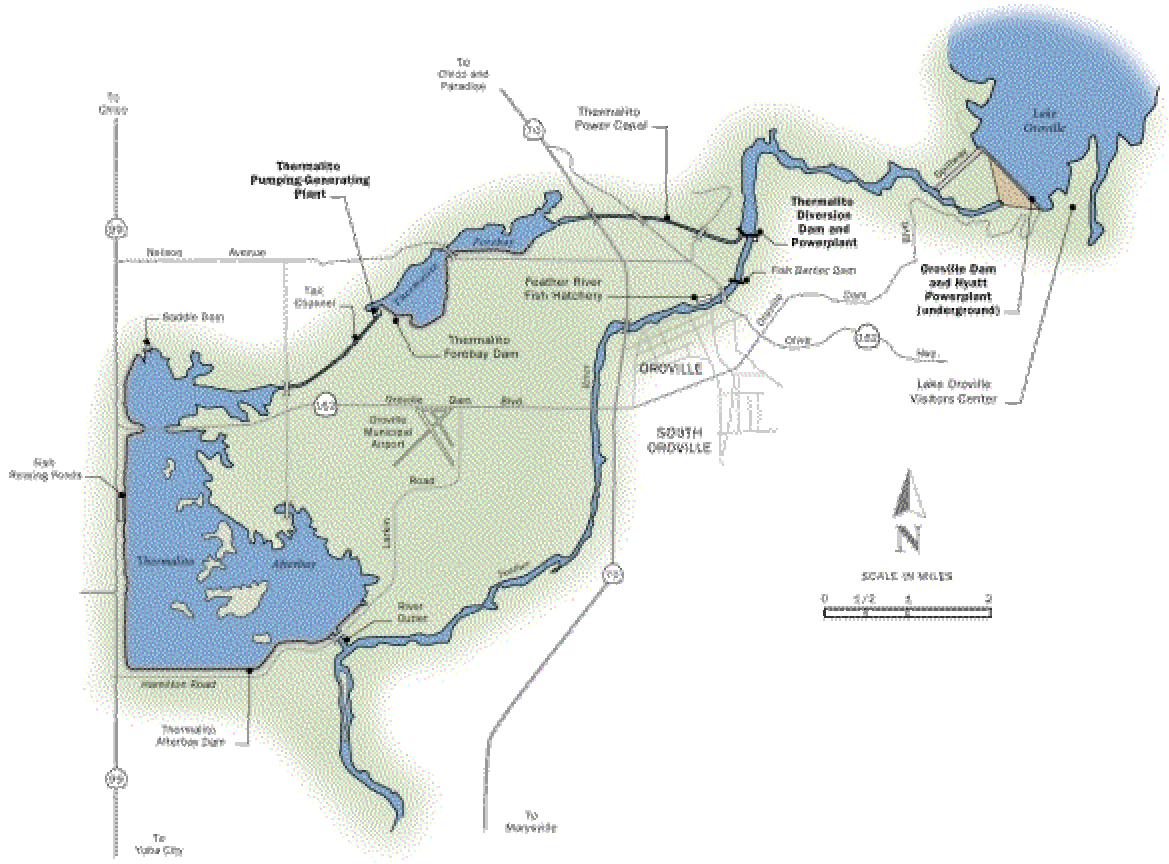


Figure 2–7 Oroville Facilities on the Feather River

Local agricultural districts divert water directly from the Afterbay. These diversion points are in leiu of the traditional river diversion exercised by the local districts whose water rights are senior to the SWP. The total capacity of Afterbay diversions during peak demands is 4,050 cfs.

The DFG operates the Feather River Fish Hatchery for the production of Chinook salmon and steelhead. The hatchery is located downstream of the Thermalito Diversion Dam. Water is provided to the hatchery via a pipeline from the diversion dam. The Feather River Fish Barrier Dam is downstream of the Thermalito Diversion Dam and immediately upstream of the Feather River Fish Hatchery. The flow over the dam maintains fish habitat in the low flow channel of the Feather River between the dam and the Afterbay outlet. The Fish Barrier Dam prevents further

upstream migration by adult salmon and steelhead and helps direct them to the fish ladder entrance located on the right (west) embankment.

Temperature Control

The August 1983 agreement between DWR and DFG, "Concerning the Operation of the Oroville Division of the State Water Project for Management of Fish & Wildlife" sets criteria for flow and temperature for the low flow section of the Feather River, the fish hatchery, and the reach of the Feather River below the river outlet to the confluence with the Sacramento River.

In addition to fish and wildlife obligations, a May 1969 agreement between DWR and the Joint Water Districts recognizes the rights of the Districts to water (at temperatures reasonably related to achieving agricultural production) that would have been available if Oroville Dam had not been constructed. The 1985 agreement among DWR, Western Canal Water District and PG&E contains similar language.

Flood Control

Flood control operations at Oroville Dam are conducted in coordination with DWR's Flood Operations Center and in accordance with the requirements set forth by the Corps. The Federal Government shared the expense of Oroville Dam, which provides up to 750,000 af of flood control space. The spillway is located on the right abutment of the dam and has two separate elements: a controlled gated outlet and an emergency uncontrolled spillway. The gated control structure releases water to a concrete-lined chute that extends to the river. The uncontrolled emergency spill flows over natural terrain.

Table 2–9 Water Year/Days in Flood Control/40-30-30 Index

Water Year	Days in Flood Control	40-30-30 Index
1981	0	D
1982	35	W
1983	51	W
1984	16	W
1985	0	D
1986	25	W
1987	0	D
1988	0	C
1989	0	D
1990	0	C
1991	0	C
1992	0	C
1993	8	AN
1994	0	C
1995	35	W
1996	22	W

1997	57	W
1998	0	W
1999	58	W
2000	0	AN
2001	0	D
2002	0	D

DWR Feather River Fish Studies

DWR initiated fish studies in the lower Feather River in 1991. The present program consists of several elements to monitor salmonid spawning, rearing, and emigration and to document presence and relative abundance of non-salmonid fishes. The focus and methods used for these studies were altered in 2003 as a result of consultations with NOAA Fisheries, DFG, and others to gather information needed to relicense the Oroville facilities with the Federal Energy Regulatory Commission (FERC).

SWP/CVP Delta Facilities

CVP Facilities

The CVP's Delta Division includes the DCC, the CCWD diversion facilities, the Tracy Pumping Plant, the TFCF), and the DMC. The DCC is a controlled diversion channel between the Sacramento River and Snodgrass Slough. The CCWD diversion facilities utilize CVP water resources to serve district customers directly and to operate CCWD's Los Vaqueros Project. The Tracy Pumping Plant diverts water from the Delta to the head of the DMC.

Delta Cross Channel operations

The DCC is a gated diversion channel in the Sacramento River near Walnut Grove and Snodgrass Slough. Flows into the DCC from the Sacramento River are controlled by two 60-foot by 30-foot radial gates. When the gates are open, water flows from the Sacramento River through the cross channel to channels of the lower Mokelumne and San Joaquin Rivers toward the interior Delta. The DCC operation improves water quality in the interior Delta by improving circulation patterns of good quality water from the Sacramento River towards Delta diversion facilities.

Reclamation operates the DCC in the open position to (1) improve the transfer of water from the Sacramento River to the export facilities at the Banks and Tracy Pumping Plants, (2) improve water quality in the southern Delta, and (3) reduce salt water intrusion rates in the western Delta. During the late fall, winter, and spring, the gates are often periodically closed to protect out-migrating salmonids from entering the interior Delta. In addition, whenever flows in the Sacramento River at Sacramento reach 20,000 to 25,000 cfs (on a sustained basis) the gates are closed to reduce potential scouring and flooding that might occur in the channels on the downstream side of the gates.

Flow rates through the gates are determined by Sacramento River stage and are not affected by export rates in the south Delta. The DCC also serves as a link between the Mokelumne River and

the Sacramento River for small craft, and is used extensively by recreational boaters and fishermen whenever it is open. Because alternative routes around the DCC are quite long, Reclamation tries to provide adequate notice of DCC closures so boaters may plan for the longer excursion.

SWRCB D-1641 DCC standards provide for closure of the DCC gates for fisheries protection at certain times of the year. From November through January, the DCC may be closed for up to 45 days for fishery protection purposes. From February 1 through May 20, the gates are closed for fishery protection purposes. The gates may also be closed for 14 days for fishery protection purposes during the period May 21 through June 15. Reclamation determines the timing and duration of the closures after consultation with FWS, DFG, and NOAA Fisheries. Consultation with the CALFED Ops Group will also satisfy the consultation requirement.

The CALFED Ops Group typically relies on monitoring for fish presence and movement in the Sacramento River and Delta, the salvage of salmon at the Tracy and Skinner facilities, and hydrologic cues for the timing of DCC closures, subject also to current water quality conditions in the interior and western Delta. From mid-June to November, Reclamation usually keeps the gates open on a continuous basis. The DCC is also usually opened for the busy recreational Memorial Day weekend, if this is possible from a fishery, water quality, and flow standpoint.

The Spring-run Chinook Salmon Protection Plan (SRPP) included "Indicators of Sensitive Periods for Salmon" such as hydrologic changes, detection of spring-run salmon or spring-run salmon surrogates at monitoring sites or the salvage facilities, and turbidity increases at monitoring sites to trigger the SRPP process. In November 2000, the SRPP was replaced by a CALFED Ops Group plan designed to provide broader protections for juvenile salmon emigrating through the Delta from October through January.

The Chinook Salmon Protection Decision Process (also known as the Salmon Decision Tree) is used by the fishery agencies and project operators to facilitate the often complex coordination issues surrounding DCC gate operations and the purposes of fishery protection closures, Delta water quality, and/or export reductions. Inputs such as fish lifestage and size development, current hydrologic events, fish indicators (such as the Knight's Landing Catch Index and Sacramento Catch Index), and salvage at the export facilities, as well as current and projected Delta water quality conditions, are used to determine potential DCC closures and/or export reductions. The coordination process has worked well during the recent fall and winter DCC operations and is expected to be used in the present or modified form in the future.

Tracy Pumping Plant

The CVP and SWP use the Sacramento River and Delta channels to transport water to export pumping plants in the south Delta. The CVP's Tracy Pumping Plant, about five miles north of Tracy, consists of six available pumps. The Tracy Pumping Plant is located at the end of an earth-lined intake channel about 2.5 miles long. At the head of the intake channel, louver screens (that are part of the TFCF) intercept fish, which are then collected and transported by tanker truck to release sites away from the pumps. Tracy Pumping Plant diversion capacity is approximately 4,600 cfs during the peak of the irrigation season and approximately 4,200 cfs during the winter non-irrigation season before the Intertie, described on page 2-81. The capacity limitations at the Tracy Pumping Plant are the result of a DMC freeboard constriction near

O'Neill Forebay, O'Neill Pumping Plant capacity, and the current water demand in the upper sections of the DMC.

Tracy Fish Collection Facility

The TFCF uses behavioral barriers consisting of primary and secondary louvers to guide targeted fish into holding tanks before transport by truck to release sites within the Delta. Hauling trucks used to transport salvaged fish to release sites contain an eight parts per thousand salt solution to reduce stress. The CVP uses two release sites, one on the Sacramento River near Horseshoe Bend and the other on the San Joaquin River immediately upstream of the Antioch Bridge. During a recent facility inspection, TFCF personnel noticed significant decay of the transition boxes and conduits between the primary and secondary louvers. The temporary rehabilitation of these transition boxes and conduits was performed during the fall and winter of 2002.

When compatible with export operations, and technically feasible, the louvers are operated with the objective of achieving water approach velocities: for stripped bass of approximately one foot per second (ft/s) from May 15 through October 31, and for salmon of approximately three ft/s from November 1 through May 14. Channel velocity criteria are a function of bypass ratios through the facility.

Fish passing through the facility are sampled at intervals of no less than ten minutes every two hours. Fish observed during sampling intervals are identified to species, measured to fork length, examined for marks or tags, and placed in the collection facilities for transport by tanker truck to the release sites away from the pumps.

Contra Costa Water District Diversions Facilities

CCWD diverts CVP water from the Delta for irrigation and M&I uses. Prior to 1997, CCWD's primary diversion facility in the Delta originated at Rock Slough, about four miles southeast of Oakley. At Rock Slough, the water is lifted 127 feet by a series of four pumping plants into the Contra Costa Canal (CCC), a 47.7-mile canal that terminates in Martinez Reservoir. Two short canals, Clayton and Ygnacio, are integrated into the distribution system. The Clayton Canal is no longer in service

Rock Slough diversion capacity of 350 cfs gradually decreases to 22 cfs at the terminus. Historically, actual Rock Slough pumping rates have ranged from about 50 to 250 cfs with seasonal variation. Rock Slough Pumping Plant is an unscreened facility. The fish-screening of the Rock Slough Pumping Plant is directed under the CVPIA and is included in the CCWD's BO for the Los Vaqueros Project. Reclamation, in collaboration with CCWD, is responsible for constructing the fish screen. Reclamation asked for an extension until December 2008 to allow completion of current CALFED project studies that might affect frequency of usage of the Rock Slough intake and therefore, the screen design.

As part of the Los Vaqueros Project, CCWD also diverts from the Delta on Old River near Highway 4 at a fish-screened diversion facility with a capacity of 250 cfs. The Los Vaqueros Project was constructed to improve the delivered water quality and emergency storage reliability to CCWD's customers. The Old River facility allows CCWD to directly divert up to 250 cfs of CVP water to a blending facility with the existing CCC, in addition to the Rock Slough direct

diversions. The Old River facility can also divert up to 200 cfs of CVP and Los Vaqueros water rights water for storage in the 100,000 af Los Vaqueros Reservoir.

The water rights for the Los Vaqueros Project were approved by SWRCB Decision 1629. A NOAA Fisheries BO for the Los Vaqueros winter-run Chinook salmon was provided on March 18, 1993. A FWS BO for Los Vaqueros covering delta smelt was provided on September 9, 1993 and clarified by letter on September 24, 1993. The FWS BO requires CCWD to preferentially divert CVP water from the fish-screened Old River intake from January through August each year.

The FWS BO also requires CCWD to operate all three of its intakes (including CCWD's Mallard Slough intake) and Los Vaqueros Reservoir as an integrated system to minimize impacts to endangered species. The 1993 BO calls for monitoring at all three intakes to determine diversion of water at Rock Slough, Old River, and Mallard Slough to minimize take of delta smelt during the spawning and rearing period.

Due to the water quality objectives of the Los Vaqueros Project, CCWD's total diversions from the Delta are reduced during the late summer and fall when Delta water quality and flows are the poorest of the annual cycle. The CCWD fills the Los Vaqueros Reservoir only when Delta water quality conditions are good, which generally occurs from January to July.

Additionally, under the Los Vaqueros BOs, CCWD is required to cease all diversions from the Delta for thirty days in the spring if stored water is available in Los Vaqueros Reservoir above emergency storage levels and to use releases from the reservoir to meet CCWD demands. To provide additional fisheries protection, CCWD is not allowed to divert water to Los Vaqueros storage for an additional forty-five day period in the winter or spring months.

The CCWD's third diversion facility in the Delta is located at the southern end of a 3,000 foot long channel running due south of Suisun Bay, near Mallard Slough (across from Chipps Island). The old Mallard Slough Pump Station was replaced in 2002 with a new pump station that has a state-of-the-art fish screen. The Mallard Slough Pump Station can pump up to 39.3 cfs,but is only used by CCWD during periods of very high Delta outflows (about 40,000 cfs or greater), when the water quality is good enough in Suisun Bay to meet CCWD's delivered chloride goal of 65 mg/L.

The CCWD has one license and one permit for Diversion and Use of Water issued by the SWRCB, which authorize CCWD to divert up to 26,780 af per year at Mallard Slough. Although the Mallard Slough intake is very small and is only used under extremely high Delta outflow conditions, it is an integral part of CCWD's operations. In 2003, CCWD used Mallard Slough (in conjunction with storage in Reclamation's Contra Loma Reservoir) to optimize its ability to fill Los Vaqueros Reservoir while the Rock Slough intake was out of service for replacement of a section of the CCC. All three Delta intake facilities are being considered in this project description chapter.

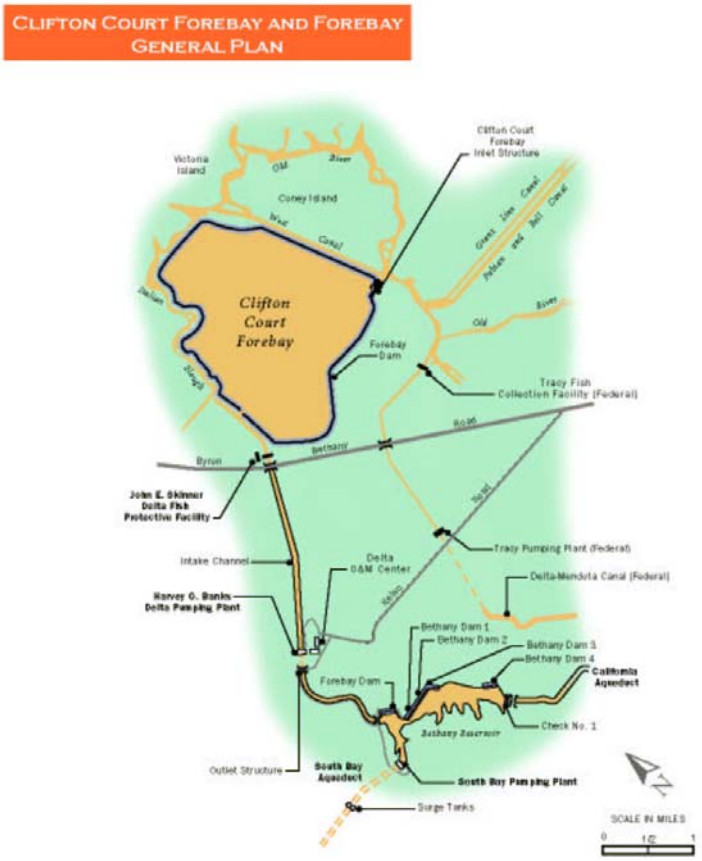
CVP-SWP Delta Export Facilities Operations Coordination

The Delta serves as a natural system of channels to transport river flows and reservoir storage to the CVP and SWP facilities in the south Delta, which export water to the Projects' service areas. Reclamation and DWR closely coordinate the operations of the Tracy and Banks Pumping Plants

with operations of the joint CVP and SWP San Luis Reservoir near Los Banos (Figure 2–8). The Tracy Pumping Plant is usually operated at a constant and uninterrupted rate. When water supply supports it, the Tracy Pumping Plant is usually operated to the capacity limits of the DMC, except when restrictions are imposed by regulatory or fishery requirements. Currently, maximum daily diversions into the Clifton Court Forebay (CCF) are governed by agreement with the Corps. This agreement allows for daily diversion rates of about 13,250 af on a three-day average and 13,870 af on a daily average[5].

Between mid-December and mid-March, an additional amount of water may be diverted equal to one-third of the San Joaquin River (as measured at Vernalis) when the river flow is 1,000 cfs or greater. The CCF is operated to minimize effects to water levels during the low-low tide of the day. Banks Pumping Plant has eleven fixed speed pumps of varying size, which are run to the extent possible during off-peak power periods to convey water into the CA.

The DWR proposes to operate the CCF at a higher rate than is currently used. Referred to as "8500 Banks," the higher rate would result in greater utilization of the full pumping capability of the Banks Pumping Plant. Details regarding the increased diversion rates are covered under the section titled "8500 cfs Operational Criteria.".



[5]Up to an additional 500 cfs of diversion may be allowed from July through September as part of the Environmental Water Account operations. See the section titled "The CALFED Environmental Water Account" for further details.

Figure 2–8 Clifton Court Forebay, Tracy and Banks Pumping Plants

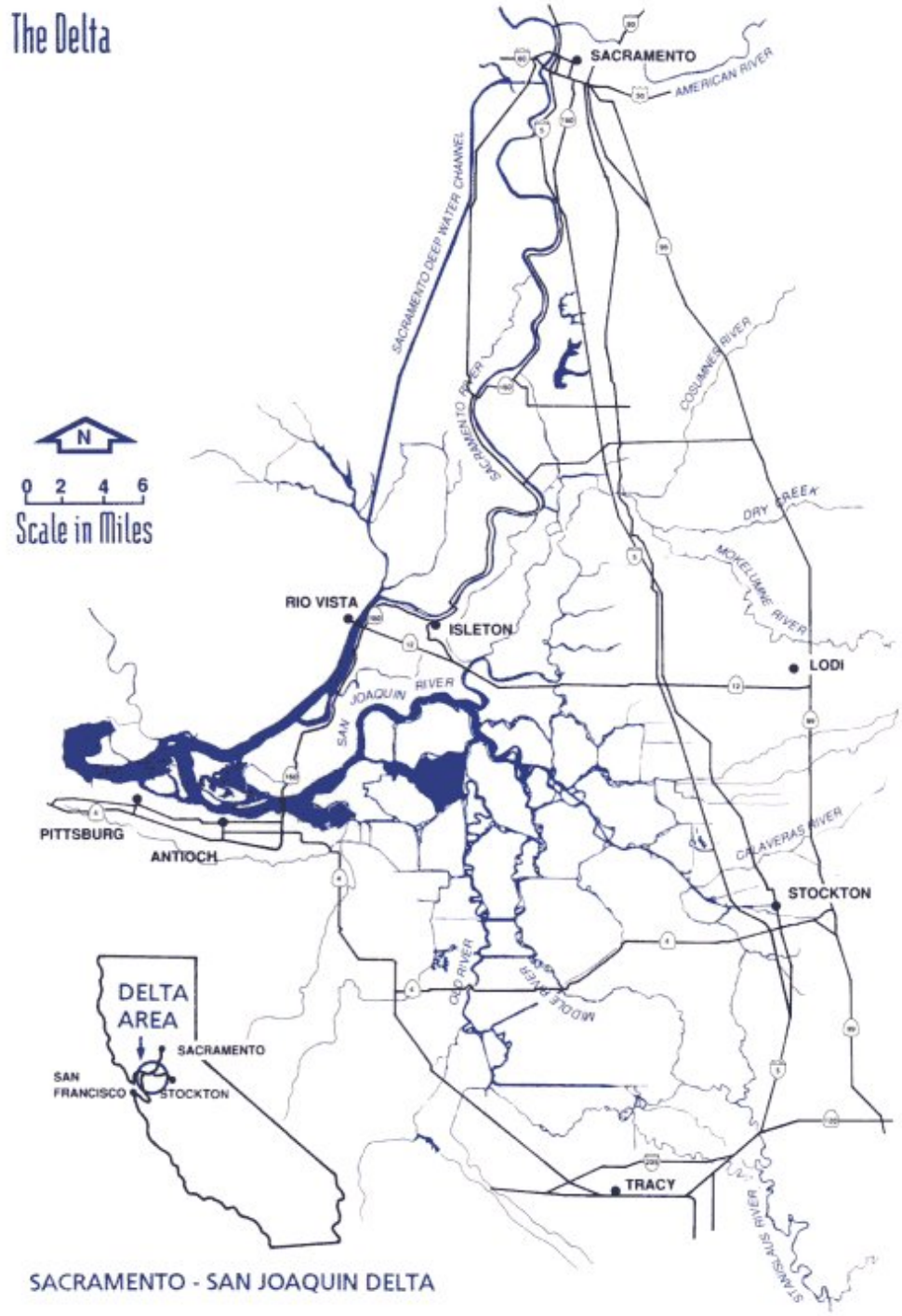


Figure 2–9 Sacramento-San Joaquin Delta

Sacramento-San Joaquin Delta- SWP Facilities

SWP facilities in the southern Delta include CCF, John E. Skinner Fish Facility, and the Harvey O. Banks Pumping Plant. CCF is a 31,000 af reservoir located in the southwestern edge of the Delta, about ten miles northwest of Tracy. CCF provides storage for off-peak pumping, moderates the effect of the pumps on the fluctuation of flow and stage in adjacent Delta channels, and collects sediment before it enters the CA. Diversions from Old River into CCF are regulated by five radial gates.

The John E. Skinner Delta Fish Protective Facility is located west of the CCF, two miles upstream of the Harvey O. Banks Delta Pumping Plant. The Skinner Fish Facility screens fish away from the pumps that lift water into the CA. Large fish and debris are directed away from the facility by a 388-foot long trash boom. Smaller fish are diverted from the intake channel into bypasses by a series of metal louvers, while the main flow of water continues through the louvers and towards the pumps. These fish pass through a secondary system of screens and pipes into seven holding tanks, where they are later counted and recorded. The salvaged fish are then returned to the Delta in oxygenated tank trucks.

The Harvey O. Banks Delta Pumping Plant is in the south Delta, about eight miles northwest of Tracy and marks the beginning of the CA. By means of eleven pumps, including two rated at 375 cfs capacity, five at 1,130 cfs capacity, and four at 1,067 cfs capacity, the plant provides the initial lift of water 244 feet into the CA. The nominal capacity of the Banks Pumping Plant is 10,300 cfs.

Other SWP operated facilities in and near the Delta include the North Bay Aqueduct (NBA), the Suisun Marsh Salinity Control Gates (SMSCG), Roaring River Distribution System, and up to four temporary barriers in the south Delta. Each of these facilities is discussed further in later sections.

Clifton Court Forebay

CCF is a regulated reservoir at the head of the CA in the south Delta. Inflows to the CCF are controlled by radial gates, which are generally operated during the tidal cycle to reduce approach velocities, prevent scour in adjacent channels, and minimize impacts to water level in the south Delta. Generally, the concern is potential effects to the lower of the two low tides in during the day; thus, the gates are operated in a manner to reduce the impact to this low tide condition.

When a large head differential exists between the outside and the inside of the gates, theoretical inflow can be as high as 15,000 cfs for a short time. However, existing operating procedures identify a maximum design rate of 12,000 cfs, which prevents water velocities from exceeding three ft/s to control erosion and prevent damage to the facility. Figure 2–10 shows an example of when the gates could be opened and still minimize impacts to the lowest tide of the day.

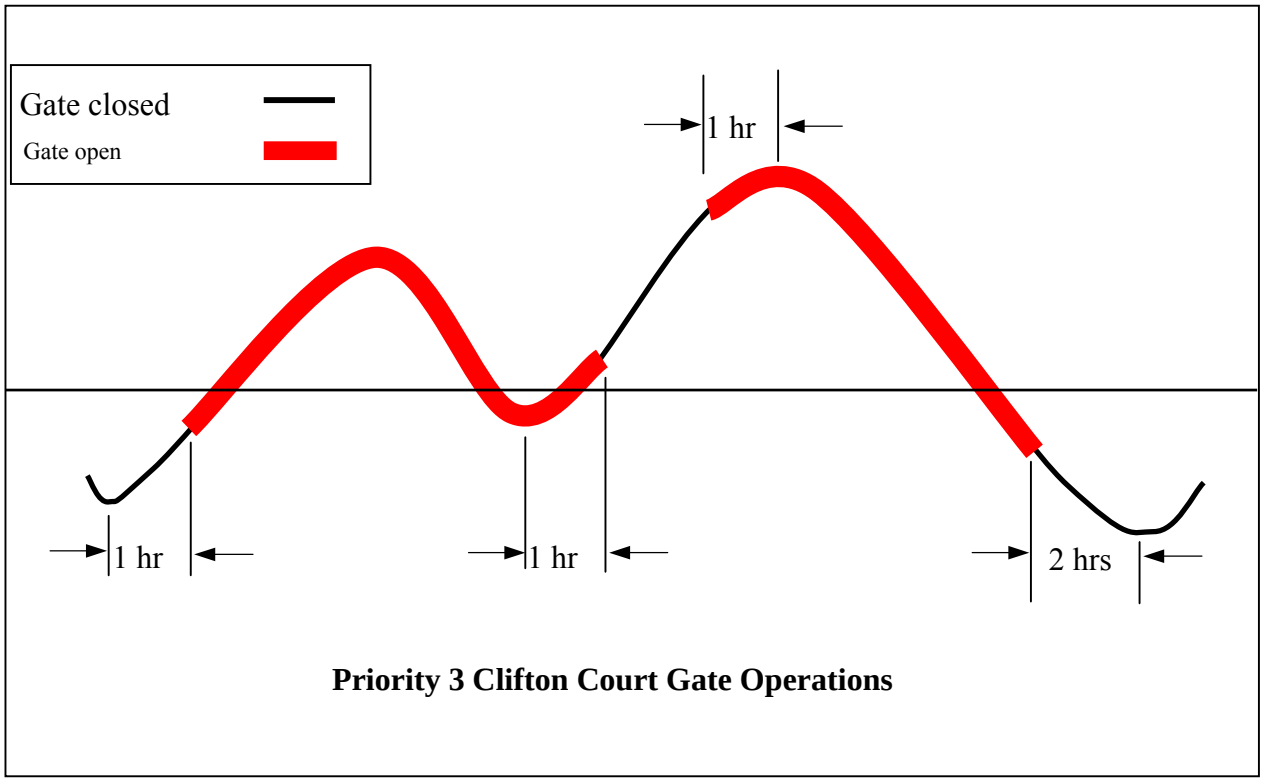


Figure 2–10 Clifton Court Gate Operations

North Bay Aqueduct Intake at Barker Slough

The Barker Slough Pumping Plant diverts water from Barker Slough into the NBA for delivery in Napa and Solano Counties. Maximum pumping capacity is 175 cfs (pipeline capacity). During the past few years, daily pumping rates have ranged between 0 and 140 cfs.

The NBA intake is located approximately ten miles from the main stem Sacramento River at the end of Barker Slough. Each of the ten NBA pump bays is individually screened with a positive barrier fish screen consisting of a series of flat, stainless steel, wedge-wire panels with a slot width of 3/32 inch. This configuration is designed to exclude fish 25 mm or larger from being entrained. The bays tied to the two smaller units have an approach velocity of about 0.2 ft/s. The larger units were designed for a 0.5 ft/s approach velocity, but actual approach velocity is about 0.44 ft/s. The screens are routinely cleaned to prevent excessive head loss, thereby minimizing increased localized approach velocities.

South Delta Temporary Barriers

The South Delta Temporary Barriers (SDTB) are not a project element for purposes of this biological assessment or the resulting consultation. A description of the SDTB is included only to provide information on a related project. A separate biological assessment has been prepared for the Temporary Barriers Project (DWR 1999a).

The existing SDTB Project consists of installation and removal of temporary rock barriers at the following locations:

- Middle River near Victoria Canal, about 0.5 miles south of the confluence of Middle River, Trapper Slough, and North Canal.
- Old River near Tracy, about 0.5 miles east of the DMC intake.
- Grant Line Canal near Tracy Boulevard Bridge, about 400 feet east of Tracy Boulevard Bridge.
- The head of Old River at the confluence of Old River and San Joaquin River.

The barriers on Middle River, Old River near Tracy, and Grant Line Canal are tidal control facilities designed to improve water levels and circulation for agricultural diversions and are in place during the growing season. Installation and operation of the barriers at Middle River and Old River near Tracy can begin May 15, or as early as April 15 if the spring head of Old River barrier is in place. From May 16 to May 31 (if the head of Old River barrier is removed) the tide gates are tied open at both Middle River and Old River near the Tracy barriers. After May 31, the Middle River, the Old River near Tracy, and the Grant Line Canal barriers are permitted to be operational until September 30.

During the spring, the barrier at the head of Old River is designed to reduce the number of out-migrating salmon smolts entering Old River. During the fall, the head of Old River barrier is designed to improve flow and DO conditions in the San Joaquin River for the immigration of adult fall-run Chinook salmon. Operations of the head of Old River barrier are typically between April 15 to May 15 for the spring barrier, and between early September to late November for the fall barrier. Installation and operation of the barrier also depend on San Joaquin flow conditions. DWR was permitted to install and operate these barriers between 1992 and 2000. In 2001, DWR obtained approvals to extend the Temporary Barriers Project for an additional 7 years.

West San Joaquin Division

San Luis Operations

As part of the West San Joaquin Division, the San Luis Unit was authorized in 1960 to be built and operated jointly with the State of California. The San Luis Unit consists of the following: (1) B. F. Sisk San Luis Dam and San Luis Reservoir (joint Federal-State facilities); (2) O'Neill Dam and Forebay (joint Federal-State facilities); (3) O'Neill Pumping-Generating Plant (Federal facility); (4) William R. Gianelli Pumping-Generating Plant (joint Federal-State facilities); (5) San Luis Canal (joint Federal-State facilities); (6) Dos Amigos Pumping Plant (joint Federal-State facilities); (7) Coalinga Canal (Federal facility); (8) Pleasant Valley Pumping Plant

(Federal facility); and (9) the Los Banos and Little Panoche Detention Dams and Reservoirs (joint Federal-State facilities).

The management of the San Luis Unit depends on the operation of the northern features of the CVP, while simultaneously influencing the operation of the northern CVP system. This relationship results from the need to deliver about half of the CVP's annual water supply through the DMC and the San Luis Unit, while essentially all of the water supply must originate from the northern Central Valley.

To accomplish the objective of providing water to CVP contractors in the San Joaquin Valley, three conditions must be considered: (1) water demands and anticipated water schedules for CVP water service contractors and exchange contractors must be determined; (2) a plan to fill and draw down San Luis Reservoir must be made; and (3) coordinating Delta pumping and utilizing San Luis Reservoir must be established. Only after these three conditions are made can the CVP operators incorporate the DMC and San Luis operations into plans for operating the northern CVP system.

Water Demands--DMC and San Luis Unit

Water demands for the DMC and San Luis Unit are primarily composed of three separate types: CVP water service contractors, exchange contractors, and wildlife refuge contracts. A significantly different relationship exists between Reclamation and these three groups. Exchange contractors "exchanged" their senior rights to water in the San Joaquin River for a CVP water supply from the Delta. Reclamation thus guaranteed the exchange contractors a firm water supply of 840,000 af per annum, with a maximum reduction under defined hydrologic conditions of 25 percent.

Conversely, water service contractors did not have water rights to "exchange." Agricultural water service contractors also receive their supply from the Delta, but their supplies are subject to the availability of CVP water supplies that can be developed and reductions in contractual supply can exceed 25 percent. Wildlife refuge contracts provide water supplies to specific managed lands for wildlife purposes and the CVP contract water supply can be reduced under critically dry conditions by up to 25 percent.

Combining the contractual supply of these three types of contractors with the pattern of requests for water is necessary to achieve the best operation of the CVP. In most years, because of reductions in CVP water supplies due to insufficient Delta pumping capability, sufficient supplies are not available to meet all water demands. In some dry or drought years, water deliveries are limited because of insufficient northern CVP reservoir storage to meet all in stream fishery objectives, including water temperatures, and to utilize the delivery capacity of Tracy Pumping Plant. The scheduling of water demands, together with the scheduling of the releases of supplies from the northern CVP to meet those demands, is a CVP operational objective intertwined with the Trinity, Sacramento, and American River operations.

San Luis Reservoir Operations

Two means of moving water from its source in the Delta are available for the DMC and the San Luis Unit (Figure 2–11). The first is Reclamation's Tracy Pumping Plant, which pumps water into the DMC. The second is the State's Banks Pumping Plant, which pumps water into the State

Aqueduct. During the spring and summer, water demands and schedules are greater than Reclamation's and DWR's capability to pump water at these two facilities, and water stored in the San Luis Reservoir must be used to make up the difference.



Figure 2–11 San Luis Complex

The San Luis Reservoir has very little natural inflow, therefore, if it is to be used for a water supply, the water must be stored during the fall and winter months when the two pumping plants can export more water from the Delta than is needed for scheduled water demands. Because the amount of water that can be exported from the Delta is limited by available water supply, Delta constraints, and the capacities of the two pumping plants, the fill and drawdown cycle of San Luis Reservoir is an extremely important element of CVP operations.

Adequate storage in San Luis Reservoir must be maintained to ensure delivery capacity through Pacheco Pumping Plant to the San Felipe Division. Lower reservoir elevations can also result in turbidity and water quality treatment problems for the San Felipe Division users.

A typical San Luis Reservoir annual operation cycle starts with the CVP's share of the reservoir storage nearly empty at the end of August. Irrigation demands decrease in September and the

opportunity to begin refilling San Luis Reservoir depends on the available water supply in the northern CVP reservoirs and the pumping capability at Tracy Pumping Plant that exceeds water demands. Tracy Pumping Plant operations generally continue at the maximum diversion rates until early spring, unless San Luis Reservoir is filled or the Delta water supply is not available. As outlined in the Department of the Interior Decision on Implementation of Section 3406 (b)(2) of the CVPIA, Tracy Pumping Plant diversion rates may be reduced during the fill cycle of the San Luis Reservoir for fishery management.

In April and May, export pumping from the Delta is limited by SWRCB D-1641 San Joaquin River pulse period standards as well as B2/EWA fishery management during the spring months. During this same time, CVP-SWP irrigation demands are increasing. Consequently, by April and May the San Luis Reservoir has begun the annual drawdown cycle. In some exceptionally wet conditions, when excess flood water supplies from the San Joaquin River or Tulare Lake Basin occur in the spring, the San Luis Reservoir may not begin its drawdown cycle until late in the spring.

In July and August, the Tracy Pumping Plant diversion is at the maximum capability and some CVP water may be exported using excess Banks Pumping Plant capacity as part of a Joint Point of Diversion operation. Irrigation demands are greatest during this period and San Luis continues to decrease in storage capability until it reaches a lowpoint late in August and the cycle begins anew.

San Luis Unit Operation--State and Federal Coordination

The CVP operation of the San Luis Unit requires coordination with the SWP since some of its facilities are entirely owned by the State and others are joint State and Federal facilities. Similar to the CVP, the SWP also has water demands and schedules it must meet with limited water supplies and facilities. Coordinating the operations of the two projects avoids inefficient situations (for example, one entity pumping water at the San Luis Reservoir while the other is releasing water).

Total San Luis Unit annual water supply is contingent on coordination with the SWP needs and capabilities. When the SWP excess capacity is used to support CVP JPOD water for the CVP, it may be of little consequence to SWP operations, but extremely critical to CVP operations. The availability of excess SWP capacity by the CVP is contingent on the ability of the SWP to meet its SWP contractors' water supply commitments. Additionally, close coordination by CVP and SWP is required to ensure that water pumped into O'Neill Forebaydoes not exceed the CVP's capability to pump into San Luis Reservoir or into the San Luis Canal at the Dos Amigos Pumping Plant.

Although secondary to water concerns, power scheduling at the joint facilities is also a mutual coordination concern. Because of time-of-use power cost differentials, both entities will likely want to schedule pumping and generation simultaneously. When facility capabilities of the two projects are limited, equitable solutions can be achieved between the operators of the SWP and the CVP.

With the existing facility configuration, the operation of the San Luis Reservoir could impact the water quality and reliability of water deliveries to the San Felipe Division, if San Luis Reservoir is drawn down too low. This operation could have potential impacts to resources in Santa Clara

and San Benito Counties. Implementation of a solution to the San Luis low point problem would allow full utilization of the storage capacity in San Luis Reservoir without impacting the San Felipe Division water supply. Any changes to the operation of the CVP and SWP, as a result of solving the low point problem, would be consistent with the operating criteria of the specific facility. For example, any change in Delta pumping that would be the result of additional effective storage capacity in San Luis Reservoir, would be consistent with the operating conditions for the Banks and Tracy Pumping Plants.

A solution to the San Luis Reservoir low point problem is also included in the long-term operation of the CVP and SWP, and is also part of this consultation. Solving the low point problem in San Luis Reservoir was identified in the August 28, 2000, CALFED ROD as a complementary action which would avoid water quality problems associated with the low point and increase the effective storage capacity in San Luis Reservoir up to 200,000 af. This action, while not implemented at present, is part of the future proposed action on which Reclamation is consulting. All site-specific and localized actions of implementing a solution to the San Luis Reservoir low point problem, such as construction of any physical facilities in or around San Luis Reservoir and any other site-specific effects, will be addressed in a separate consultation.

Suisun Marsh

Suisun Marsh Salinity Control Gates

The SMSCG are located about two miles northwest of the eastern end of Montezuma Slough, near Collinsville (Figure 2–12). The SMSCG span Montezuma Slough, a width of 465 feet. In addition to permanent barriers adjacent to each levee, the structure consists of the following components (from west to east): (1) a flashboard module which provides a 68-foot wide maintenance channel through the structure during June through September when the flashboards are not installed (the flashboards are only installed between September and May, as needed, and can be removed if emergency work is required. Installation and removal of the flashboards requires a large, barge-mounted crane); (2) a radial gate module, 159 feet across, containing three radial gates, each 36 feet wide; and (3) a boat-lock module, 20 feet across, which is operated when the flashboards are in place.

An acoustic velocity meter is located about 300 feet upstream (south) of the gates to measure water velocity in Montezuma Slough. Water level recorders on both sides of the structure allow operators to determine the difference in water level on both sides of the gates. The three radial gates open and close automatically using the water level and velocity data.

Operation of the SMSCG began in October 1988. The facility was implemented as Phase II of the Plan of Protection for the Suisun Marsh. Operating the SMSCG is essential for meeting eastern and central marsh standards in SWRCB D-1641 and the Suisun Marsh Preservation Agreement, and for lowering salinity in the western marsh. Gate operation retards the upstream flow of higher salinity water from Grizzly Bay during flood tides while allowing the normal flow of lower salinity water from the Sacramento River near Collinsville during ebb tides.

During full operation, the gates open and close twice each tidal day. The net flow through the gates during full operation is about 1,800 cfs in the downstream direction when averaged over one tidal day. Typically in summer, when the gates are not operating and the flashboards are

removed, the natural net flow in Montezuma Slough is low and often in the upstream direction from Grizzly Bay toward Collinsville.

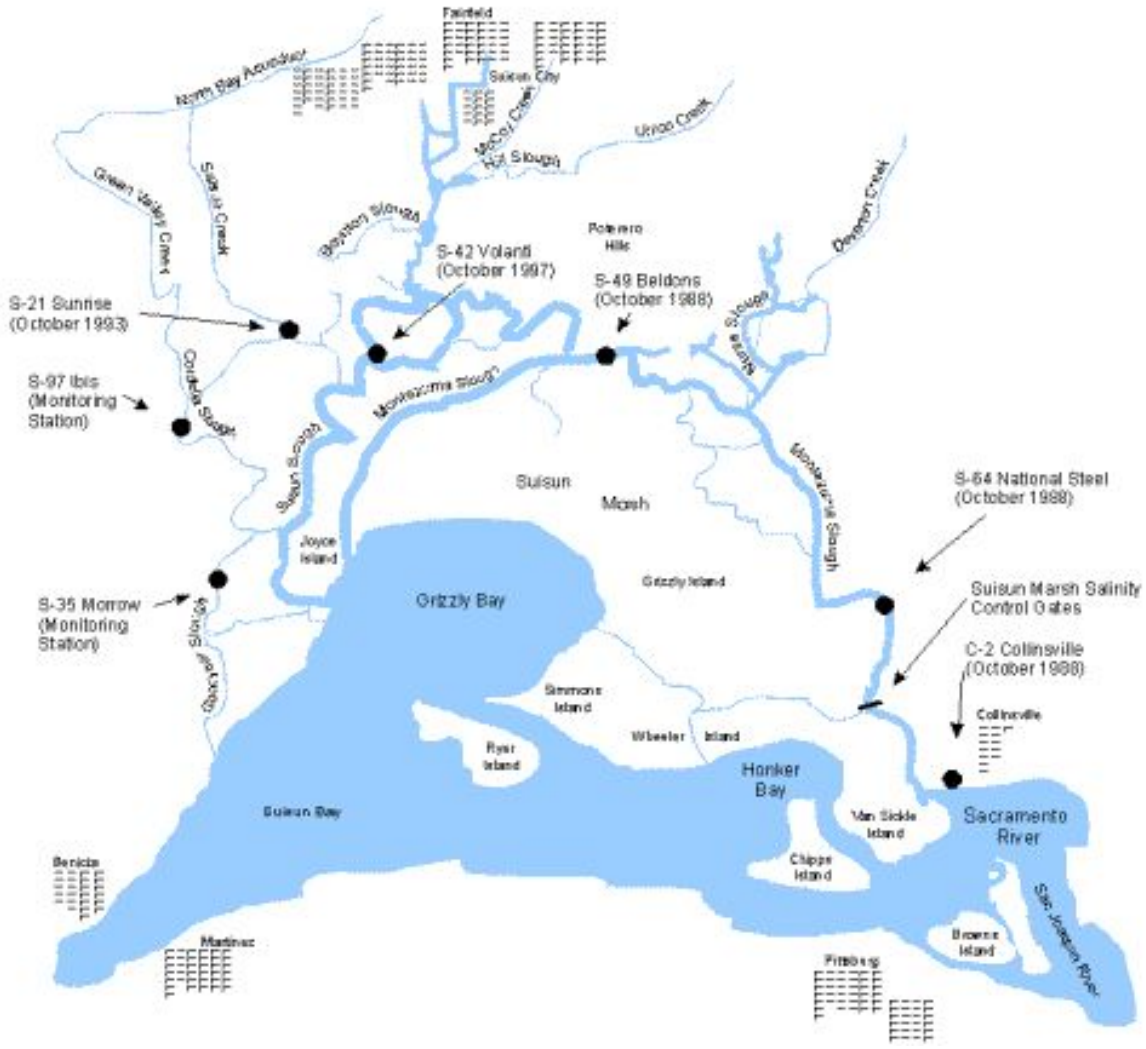


Figure 2–12 Suisun Bay and Suisun Marsh showing the location of the Suisun Marsh Salinity Control Gates and Salinity Control Stations

SMSCG are not in operation June 1 through August 31. When not in operation, the maintenance channel is open, the flashboards are stored in the maintenance yard, the three radial gates are held open, and the boat lock is closed.

The SMSCG are operated (as needed) from September through May 31 to meet SWRCB and Suisun Marsh Preservation Agreement (SMPA) standards in October through May. Operation of the SMSCG will commence in September if high-tide channel water

salinity is above 17 mS/cm at any trigger station (2 mS/cm below the October standard)[6]. Trigger stations are S-35, S-42, S-49, and S-64 (Figure 2–12). Otherwise, the operation will occur October 1 through May 31 if two consecutive high tide salinities are within 2 mS/cm below the current and subsequent months' standards at any trigger station. The flashboards are installed prior to operation.

The operation is suspended (with the radial gates held open) when two consecutive high tide salinities are below 2 mS/cm of the current and subsequent months' standards at all trigger stations. Flashboards are removed when it is determined that salinity conditions at all trigger stations will remain below standards for the remainder of the control season through May 31. SWP operators can exercise discretion with the operations of the SMSCG deviating from the stated triggers as they deem appropriate for the conditions, forecasts, or to accommodate special activities.

SMSCG Fish Passage Study

A three-year study to evaluate whether a modified flashboard system could reduce the delay in adult salmon immigration was initiated in September 1998. For this study, the flashboards were modified, creating two horizontal slots to allow fish passage during gate operation. The first two field seasons were conducted during September and November 1998 and 1999. Salinity was monitored during the evaluation to determine if SWRCB salinity standards could be met with the modified flashboards in place.

Results from the first two years of the modified flashboard system indicated the slots did not provide improved passage for salmon at the SMSCG. The reason(s) for this is still unknown. In addition, the 1999 study showed no statistical difference in passage numbers between the full operation configuration (no slots) and when the flashboards and gates were out of the water. In both 1998 and 1999 there was no statistical difference in time of passage (average hours, indicating delay) between the full operation configurations (no slots) and when the flashboards and gates were out of the water.

Because preliminary results from the modified SMSCG test indicate the slots resulted in less passage than the original flashboards, the SMSCG Steering Group decided to postpone the third year of the test until September 2001 and to reinstall the original flashboards if gate operation was needed during the 2000-2001 control season. The SMSCG Steering Group is evaluating leaving the boat lock open as a means of providing unimpeded passage to adult salmon migrating upstream. Studies were completed during the 2001-2002 and 2002-2003 control seasons and plans are in place for the 2003-2004 control season. The studies included three phases, in varying order, each year:

1. Full Open Operation. The SMSCG flashboards are out, the gates are fixed in the up position, and the boat lock is closed.
2. Full Bore Operation with Boat Lock Open. The SMSCG flashboards are in, the gates are tidally operated, and the boat lock is held open.

[6]Since 1988, the SMSCG have been operated in September during five years (1989, 1990, 1993, 1994, and 1999), either for testing the effectiveness of gate operations, to help reduce channel salinity for initial flooding of managed wetlands during drought conditions, or to test salmon passage.

3. Full Bore Operation with Boat Lock Closed. The SMSCG flashboards are in, the gates are tidally operated, and the boat lock is closed.

Roaring River Distribution System

The Roaring River Distribution System (RRDS) was constructed during 1979 and 1980 as part of the Initial Facilities in the Plan of Protection for the Suisun Marsh. The system was constructed to provide lower salinity water to 5,000 acres of both public and privately managed wetlands on Simmons, Hammond, Van Sickle, Wheeler, and Grizzly Islands. Construction involved enlarging Roaring River Slough and extending its western end. Excavated material was used to widen and strengthen the levees on both sides of the system.

The RRDS includes a 40-acre intake pond (constructed west of the new intake culverts) that supplies water to Roaring River Slough. Motorized slide gates in Montezuma Slough and flap gates in the pond control flows through the culverts into the pond. A manually operated flap gate and flashboard riser are located at the confluence of Roaring River and Montezuma Slough to allow drainage back into Montezuma Slough for controlling water levels in the distribution system and for flood protection. DWR owns and operates this drain gate to ensure the Roaring River levees are not compromised during extremely high tides.

Water is diverted through a bank of eight 60-inch diameter culverts into the Roaring River intake pond on high tides to raise the water surface elevation in RRDS above the adjacent managed wetlands. Managed wetlands north and south of the RRDS receive water, as needed, through publicly and privately owned turnouts on the system.

The intake to the RRDS is screened to prevent entrainment of fish larger than approximately 25 mm. DWR designed and installed the screens using DFG criteria. The screen is a stationary vertical screen constructed of continuous-slot stainless steel wedge wire. All screens have 3/32-inch slot openings. After the listing of delta smelt, RRDS diversion rates have been controlled to maintain an average approach velocity below 0.2 ft/s at the intake fish screen. Initially, the intake culverts were held at about 20 percent capacity to meet the velocity criterion at high tide. Since 1996, the motorized slide gates have been operated remotely to allow hourly adjustment of gate openings to maximize diversion throughout the tide.

Routine maintenance of the system is conducted by DWR and primarily consists of maintaining the levee roads. DWR provides routine screen maintenance. RRDS, like other levees in the marsh, have experienced subsidence since the levees were constructed in 1980. In 1999, DWR restored all 16 miles of levees to design elevation.

Morrow Island Distribution System

The Morrow Island Distribution System (MIDS) was constructed in 1979 and 1980 as part of the Initial Facilities in the Plan of Protection for the Suisun Marsh. The systems was constructed to provide water to privately managed wetlands on Morrow Island and to channel drainage water from the adjacent managed wetlands for discharge into Grizzly Bay rather than Goodyear Slough. The MIDS is used year-round, but most intensively from September through June.

When managed wetlands are filling and circulating, water is tidally diverted from Goodyear Slough just south of Pierce Harbor through three 48-inch culverts. Drainage water from Morrow

Island is discharged into Grizzly Bay by way of the C-Line Outfall (two 36-inch culverts) and into the mouth of Suisun Slough by way of the M-Line Outfall (three 48-inch culverts), rather than back into Goodyear Slough. This helps prevent increases in salinity due to drainage water discharges into Goodyear Slough. The M-Line ditch is approximately 1.6 miles in length and the C-Line ditch is approximately 0.8 miles in length.

The FWS 1997 BO included a requirement for screening the diversion of the MIDS. Reclamation and DWR continue to coordinate with the FWS and NOAA Fisheries in the development of alternatives to screening that may provide greater benefit for listed aquatic species in Suisun Marsh.

Goodyear Slough Outfall

The Goodyear Slough Outfall was constructed in 1979 and 1980 as part of the Initial Facilities. A channel approximately 69-feet wide was dredged from the south end of Goodyear Slough to Suisun Bay (about 2,800 feet). The Outfall consists of four 48-inch culverts with flap gates on the bay side and vertical slide gates on the slough side. The system was designed to increase circulation and reduce salinity in Goodyear Slough by draining water from the southern end of Goodyear Slough into Suisun Bay. The system also provides lower salinity water to the wetland managers who flood their ponds with Goodyear Slough water. No impacts to fish occur in the outfall since fish moving from Goodyear Slough into the outfall would end up in Suisun Bay.

Lower Joice Island Unit

The Lower Joice Island Unit consists of two 36-inch diameter intake culverts on Montezuma Slough near Hunter Cut and two 36-inch diameter culverts on Suisun Slough, also near Hunter Cut. The culverts were installed in 1991. The facilities include combination slide/flap gates on the slough side and flap gates on the landward side. In 1997, DWR contracted with the Suisun Resources Conservation District to construct a conical fish screen on the diversion on Montezuma Slough. The fish screen was completed and has been operating since 1998.

Cygnus Unit

A 36-inch drain gate with flashboard riser was installed in 1991 on a private parcel located west of Suisun Slough and adjacent to and south of Wells Slough. The property owner is responsible for the operation and maintenance of the gate. No impacts to fish are known to occur because of operation of the drain.

Intro of CVPIA Section 3406 (b)(2)

On May 9, 2003, the Department of the Interior issued its Decision on Implementation of Section 3406 (b)(2) of the CVPIA. Dedication of (b)(2) water occurs when Reclamation takes a fishery protection action on behalf of the FWS (and in consultation with NOAA Fisheries and the DFG), pursuant to the primary purpose of Section 3406 (b)(2) or contributes to the AFRP's flow objectives for CVP streams. Dedication of (b)(2) water also assists in meeting WQCP fishery objectives and helps meet the needs of fish listed under the ESA as threatened or endangered since the enactment of the CVPIA.

The May 9, 2003, decision describes the means by which the amount of dedicated (b)(2) water is determined. Planning and accounting for (b)(2) actions are done cooperatively and occur primarily through weekly meetings of the (b)(2) Interagency Team. Actions usually take one of two forms - in stream flow augmentation below CVP reservoirs or CVP Tracy pumping reductions in the Bay-Delta. Chapter 8 of this BA contains a more detailed description of (b)(2) operations, as characterized in the CALSIM modeling for the CVP OCAP, assumptions and results of the modeling are summarized.

CVPIA 3406 (b)(2) operations on Clear Creek

Dedication of (b)(2) water on Clear Creek provides actual in stream flows below Whiskeytown Dam greater than the fish and wildlife minimum flows specified in the 1963 proposed release schedule (Table 2–3). In stream flow objectives are usually taken from the AFRP's plan, in consideration of spawning and incubation of fall–run Chinook salmon. Augmentation in the summer months is usually in consideration of water temperature objectives for steelhead and in late summer for spring–run Chinook salmon.

In 2000, the McCormick-Saeltzer Dam was removed on Clear Creek thereby removing a significant fishery passage impediment. As part of the overall dam removal effort, a new agreement was reached among Townsend Flat Water Ditch Company, its shareholders, FWS, and Reclamation. Townsend Flat Water Ditch Company had an annual diversion capability of up to 12,500 af of Clear Creek flows at McCormick-Saeltzer Dam. With the dam removed, Reclamation will provide (under the new agreement) Townsend with up to 6,000 af of water annually. If the full 6,000 af is delivered, then 900 af will be dedicated to (b)(2) according to the August 2000 agreement.

CVPIA 3406 (b)(2) operations on the Upper Sacramento River

Dedication of (b)(2) water on the Sacramento River provides actual in stream flows below Keswick Dam greater than the fish and wildlife requirements specified in WR 90-5 and the Winter-run Biological Opinion. In stream flow objectives from October 1 to April 15 (typically April 15 is when water temperature objectives for winter-run Chinook salmon become the determining factor) are usually selected to minimize dewatering of redds and provide suitable habitat for salmonid spawning, incubation, and rearing.

CVPIA 3406 (b)(2) operations on the Lower American River

Dedication of (b)(2) water on the American River provides actual in stream flows below Nimbus Dam greater than the fish and wildlife requirements previously mentioned in the American River Division. In stream flow objectives from October through May generally aim to provide suitable habitat for salmon and steelhead spawning, incubation, and rearing. While considering impacts to temperature operations through the summer into fall, objectives for June to September endeavor to provide suitable flows and water temperatures for juvenile steelhead rearing.

Flow Fluctuation and Stability concerns

Through CVPIA, Reclamation has funded studies by DFG to better define the relationships of Nimbus release rates and rates of change criteria in the lower American River to minimize the negative effects of necessary Nimbus release changes on sensitive fishery objectives. Reclamation is presently using draft criteria developed by DFG. The draft criteria have helped reduce the incidence of anadromous fish stranding relative to past historic operations. The operational downside of the draft criteria is that ramping rates are relatively slow and can potentially have significant effects to water storage at Folsom Reservoir if uncertain future hydrologic conditions do not refill the impact to storage at Folsom Reservoir.

The operational coordination for potentially sensitive Nimbus Dam release changes is conducted through the B2IT process. An ad hoc agency and stakeholders group (known as AROG) was formed in 1996 to assist in reviewing the criteria for flow fluctuations. Since that time, the group has addressed a number of operational issues in periodic meetings and the discussions have served as an aid towards adaptively managing releases, including flow fluctuation and stability, and managing water temperatures in the lower American River to better meet the needs of salmon and steelhead trout.

CVPIA 3406 (b)(2) operations on the Stanislaus River

Dedication of (b)(2) water on the Stanislaus River provides actual in stream flows below Goodwin Dam greater than the fish and wildlife requirements previously mentioned in the East Side Division, and is generally consistent with the IPO for New Melones. In stream fishery management flow volumes on the Stanislaus River, as part of the IPO, are based on the New Melones end-of-February storage plus forecasted March to September inflow as shown in the IPO. The volume determined by the IPO is a combination of fishery flows pursuant to the 1987 DFG Agreement and the FWS AFRP in stream flow goals. The fishery volume is then initially distributed based on modeled fish distributions and patterns used in the IPO.

Actual in stream fishery management flows below Goodwin Dam will be determined in accordance with the Department of the Interior Decision on Implementation of Section 3406 (b)(2) of the CVPIA. Reclamation and FWS have begun developing a long-term operations plan for New Melones . This plan will be coordinated with the Agencies at weekly B2IT meetings, along with the stakeholders and the public before it is finalized.

CVPIA 3406 (b)(2) operations in the Delta

Export curtailments at the CVP Tracy Pumping Plant and increased CVP reservoir releases required to meet SWRCB D-1641, as well as direct export reductions for fishery management using dedicated (b)(2) water at the CVP Tracy Pumping Plant, will be determined in accordance with the Department of the Interior Decision on Implementation of Section 3406 (b)(2) of the CVPIA. Direct Tracy Pumping Plant export curtailments for fishery management protection will be based on recommendations of FWS, after consultation with Reclamation, DWR, NOAA Fisheries and DFG pursuant to the weekly B2IT coordination meetings. See the Adaptive Management section for the other coordination groups, i.e., DAT, OFF, WOMT and EWAT.

Environmental Water Account Operations in the Delta

As specified in the CALFED ROD, the EWA has been implemented to provide sufficient water, and combined with the Ecosystem Restoration Program (ERP), to address CALFED's fish protection and restoration/recovery needs while enhancing the predictability of CVP and SWP operations and improving the confidence in and reliability of water allocation forecasts. In the Delta environment, EWA resources and operational flexibility are used as both a real time fish management tool to improve the passage and survival of at-risk fish species in the Delta environment and for specific seasonal planned fish protection operations at the CVP and SWP Delta pumps.

The EWA agencies include Reclamation, FWS, NOAA Fisheries, DWR, and DFG (Agencies) have established protocols for the expenditure of water resources following the guidance given in the CALFED ROD. EWA resources may be used to temporarily reduce SWP Delta exports at Banks Pumping Plant for fish protection purposes above SWRCB D-1641 requirements and to coordinate with the implementation of Section 3406(b)(2) fish actions pursuant to the CVPIA. EWA resources also may be used to temporarily reduce CVP Tracy Pumping Plant export for fish protection purposes above the resources available through Section 3406(b)(2) of the CVPIA.

The EWA is a cooperative management program, whose purpose is to provide protection to the at-risk native fish of the Bay-Delta estuary through environmentally beneficial changes in CVP/SWP operations at no uncompensated water cost to the projects' water users. It is a tool to increase water supply reliability and to protect and recover at-risk fish species.

The EWA described in the CALFED ROD is a four-year program, which the EWA Agencies have been implementing since 2000. However, the EWA Agencies believe a long-term EWA is critical to meet the CALFED ROD goals of increased water supply reliability to water users, while at the same time assuring the availability of sufficient water to meet fish protection and restoration/recovery needs. Thus, the EWA Agencies envision implementation of a long-term EWA as part of the operation of the CVP and SWP. However, inclusion of the EWA in this description does not constitute a decision on the future implementation of EWA. Future implementation of a long-term EWA is subject to NEPA and the California Environmental Quality Act (CEQA).

The EWA allows these Agencies to take actions to benefit fish. An example action would be curtailing project exports by reducing pumping during times when pumping could be detrimental to at-risk fish species. EWA assets are then used to replace project supplies that would have otherwise been exported, but for the pumping curtailment. Used in this way, the EWA allows the EWA Agencies to take actions to benefit fish without reducing water deliveries to the projects' water users.

The commitment to not reduce project water deliveries resulting from EWA actions to benefit fish is predicated on three tiers of protection, as recognized in the CALFED ROD. These three tiers are described as follows:.

- **Tier 1 (Regulatory Baseline)**. Tier 1 is baseline water and consists of currently existing BOs, water right decisions and orders, CVPIA Section 3406(b)(2) water, and other regulatory actions affecting operations of the CVP and SWP. Also included in Tier 1 are other environmental statutory requirements such as Level 2 refuge water supplies.

Although the OCAP BOs will be part of Tier 1, the long-term EWA described in those BOs will not be considered part of Tier 1. If Tier 1 changes significantly over time (from that which was analyzed in the OCAP BOs), Reclamation and DWR will reinitiate consultation on those BOs.

- **Tier 2 (EWA)**. Tier 2 is the EWA and provides fish protection actions supplemental to the baseline level of protection (Tier 1). Tier 2 consists of EWA assets, which combined with the benefits of CALFED's ERP, will allow water to be provided for fish actions when needed without reducing deliveries to water users. EWA assets will include purchased (fixed) assets, operational (variable) assets, and other water management tools and agreements to provide for specified level of fish protection. Fixed assets are those water supplies which are purchased by the EWA Agencies, and will provide the following quantities south of the Delta: (1) 210, 000 af in critical years, (2) 230,000 af in dry years, and (3) 250,000 af in all other year types.[7] These purchased quantities are approximations and subject to some variability. Operational assets are those water supplies made available through CVP and SWP operational flexibility. Some examples include the flexing of the export-to-inflow ratio standard required to for meeting Delta water quality and flows, and ERP water resulting from upstream releases pumped at the SWP Banks Pumping Plant. Water management tools provide the ability to convey, store, and manage water that has been secured through other means. Examples include dedicated pumping capacity, borrowing, banking, and entering into exchange agreements with water contractors. Chapter 8 of this BA contains a more detailed description of EWA operations, as characterized in the CALSIM modeling for the CVP OCAP.
- **Tier 3 (Additional Assets)**. In the event the EWA Agencies deem Tiers 1 and 2 levels of protection insufficient to protect at-risk fish species in accordance with ESA requirements, Tier 3 would be initiated. Tier 3 sets in motion a process based upon the commitment and ability of the EWA Agencies to make additional water available, should it be needed. This Tier may consist of additional purchased or operational assets, funding to secure additional assets if needed, or project water if funding or assets are unavailable. It is unlikely that protection beyond those described in Tiers 1 and 2 will be needed to meet ESA requirements. However, Tier 3 assets will be used when Tier 2 assets and water management tools are exhausted, and the EWA Agencies determine that jeopardy to an at-risk fish species is likely to occur due to project operations, unless additional measures are taken. In determining the need for Tier 3 protection, the EWA Agencies would consider the views of an independent science panel.

With these three tiers of protection in place that are subject to changes based on NEPA/CEQA review, or new information developed through ESA/CESA/ Natural Community Conservation Planning Act (NCCPA) review or the CALFED Science Program, the EWA Agencies will provide long-term regulatory commitments consistent with the intent set forth in the CALFED ROD. The commitments are intended to protect the CVP and SWP exports at the Tracy and Banks Pumping Plants from reductions in water supplies for fish protection beyond those required in Tier 1.

[7]The year types are defined in Water Right Decision 1641 from the State Water Resources Control Board.

Water Transfers

California Water Law and the CVPIA promote water transfers as important water resource management measures to address water shortages provided certain protections to source areas and users are incorporated into the water transfer. Water transferees generally acquire water from sellers who have surplus reservoir storage water, sellers who can pump groundwater instead of using surface water, or sellers who will idle crops or substitute a crop that uses less water in order to reduce normal consumptive use of surface diversions.

Water transfers (relevant to this document) occur when a water right holder within the Delta or Sacramento-San Joaquin watershed undertakes actions to make water available for transfer by export from the Delta. Transfers requiring export from the Delta are done at times when pumping and conveyance capacity at the CVP or SWP export facilities are available to move the water. Additionally, operations to accomplish these transfers must be carried out in coordination with CVP and SWP operations, such that project purposes and objectives are not diminished or limited in any way.

In particular, parties to the transfer are responsible for providing for any incremental changes in flows required to protect Delta water quality standards. Reclamation and the DWR will work to facilitate transfers and will complete them in accordance with all existing regulations and requirements. This document does not address the upstream operations that may be required to produce water for transfer. Also, this document does not address the impacts of water transfers to terrestrial species. Such effects would require a separate ESA consultation with FWS and NOAA Fisheries.

Purchasers of water for water transfers may include Reclamation, DWR, SWP contractors, CVP contractors, other State and Federal agencies, or other parties. DWR and Reclamation have operated water acquisition programs to provide water for environmental programs and additional supplies to SWP contractors, CVP contractors, and other parties. The DWR programs include the 1991, 1992, and 1994 Drought Water Banks and Dry Year Programs in 2001 and 2002.

Reclamation operated a forbearance program in 2001 by purchasing CVP contractors' water in the Sacramento Valley for CVPIA in stream flows, and to augment water supplies for CVP contractors south of the Delta and wildlife refuges. DWR, Reclamation, FWS, NOAA, and DFG cooperatively administer the EWA. Reclamation administers the CVPIA Water Acquisition Program for Refuge Level 4 supplies and fishery in stream flows. The CALFED ERP will, in the future, acquire water for fishery and ecosystem restoration.

The Sacramento Valley Water Management Agreement is a water rights settlement among Sacramento Valley water rights holders, Reclamation, DWR, and the CVP and SWP export water users which establishes a water management program in the Sacramento Valley. This program will provide new water supplies from Sacramento Valley water rights holders (up to 185,000 af per year) for the benefit of the CVP and SWP.

This program has some of the characteristics of a transfer program in that water will be provided upstream of the Delta and increased exports may result. In the past, CVP and SWP contractors have also independently acquired water in the past and arranged for pumping and conveyance through SWP facilities. State Water Code provisions grant other parties access to unused

conveyance capacity, although SWP contractors have priority access to capacity not being used by the DWR to meet SWP contract amounts.

The CVP and SWP may provide Delta export pumping for transfers using surplus capacity that is available, up to the physical maximums of the pumps, consistent with prevailing operations constraints such as E/I ratio, conveyance or storage capacity, and the protective criteria established that may apply as conditions on such transfers. For example, pumping for transfers may have conditions for protection of Delta water levels, water quality, or fish.

The surplus capacity available for transfers will vary a great deal with hydrologic conditions. In general, as hydrologic conditions get wetter, surplus capacity diminishes because the CVP and SWP are more fully using export pumping capacity for Project supplies. CVP has little surplus capacity, except in the drier hydrologic conditions. SWP has the most surplus capacity in Critical and some Dry years, less or sometimes none in a broad middle range of hydrologic conditions, and some surplus again in some Above Normal and Wet years when demands may be lower because contractors have alternative supplies.

The availability of water for transfer and the demand for transfer water may also vary with hydrologic conditions. Accordingly, since many transfers are negotiated between willing buyers and sellers under prevailing market conditions, price of water also may be a factor determining how much is transferred in any year. This document does not attempt to identify how much of the available and useable surplus export capacity of the CVP and SWP will actually be used for transfers in a *particular* year, but recent history, the expectations for EWA, and the needs of other transfer programs suggest a growing reliance on transfers.

This project description assumes the majority of transfers would occur during July through September and would increase Delta exports from 200,000-600,000 af in most years, once the 8,500 cfs Banks capacity is operational (see Chapter 8 - Modeling Results Section sub-heading Transfers for post-processed results on available capacity at Tracy and Banks). Such future transfers would occur within the Banks 8,500 cfs capacity, and the Tracy 4,600 cfs capacity described in this document, and in no case would transfers require higher rates of pumping than those. The range of 200,000-600,000 af describes the surplus export capacity estimated to be available in July-September (primarily at Banks) in about 80 percent of years when 8,500 cfs Banks is in place (see Figure 8-152).

Under these conditions, transfer capability will often be capacity-limited. In the other 20 percent of years (which are critical and some fry years), both Banks and Tracy have more surplus capacity, so capacity most likely is not limited to transfers. Rather, either supply or demand for transfers may be a limiting factor. In some dry and critical years, water transfers may range as high as 800,000[8]-1,000,000 af depending on the severity of the water supply situation, cross-Delta capacity, and available supplies upstream.

During dry or critical years, low project exports and high demand for water supply could make it possible to transfer larger amounts of water. Low project exports in other months may also make it advantageous to expand the "normal transfer" season. Transfers outside the typical July

[8] DWR's 1991 Drought Water Bank purchased over 800,000 af, and conveyed approximately 470,000 af of purchased water across the Delta.

through September season may be implemented when transferors provide water on a "fish-friendly" pattern. Real-time operations would be implemented as needed to avoid increased incidental take of listed species.

Reclamation and DWR coordinate the implementation of transfers in the B2IT, the EWAT, and WOMT to ensure the required changes in upstream flows and Delta exports are not disruptive to planned fish protection actions. Reclamation and DWR will continue to use these groups for routine coordination of operations with transfers during the July through September season. Reclamation and DWR will also use these groups to help evaluate proposed transfers that would expand the transfer season or involve transfers in amounts significantly greater than the typical range anticipated by this project description, i.e., 200,000-600,000 af per year.

Although supply, demand, and price of water may at times be limiting factors, it would not be unreasonable to assume that in many years, all the available CVP and SWP capacity to facilitate transfers will be used.

Intertie Proposed Action

The proposed action, known as the DMC and CA Intertie (DMC/CA Intertie), consists of construction and operation of a pumping plant and pipeline connections between the DMC and the CA. The DMC/CA Intertie alignment is proposed for DMC milepost 7.2 where the DMC and the CA are about 500 feet apart.

The DMC/CA Intertie would be used in a number of ways to achieve multiple benefits, including meeting current water supply demands, allowing for the maintenance and repair of the CVP Delta export and conveyance facilities, and providing operational flexibility to respond to emergencies. The Intertie would allow flow in both directions, which would provide additional flexibility to both CVP and SWP operations. The Intertie includes a 400 cfs pumping plant at the DMC that would allow up to 400 cfs to be pumped from the DMC to the CA. Up to 950 cfs flow could be conveyed from the CA to the DMC using gravity flow.

The DMC/CA Intertie will be operated by the San Luis and Delta Mendota Water Authority (Authority). A three-way agreement among Reclamation, DWR, and the Authority would identify the responsibilities and procedures for operating the Intertie. The Intertie would be owned by Reclamation. A permanent easement would be obtained by Reclamation where the Intertie alignment crossed State property.

Location

The site of the proposed action is an unincorporated area of Alameda County, west of the City of Tracy. The site is situated in a rural area zoned for general agriculture and is under Federal and State ownership. The DMC/CA Intertie would be located at milepost 7.2 of the DMC, connecting with milepost 9.0 of the CA.

Operations

The Intertie would be used under three different scenarios:

1. Up to 400 cfs would be pumped from the DMC to the CA to help meet water supply demands of CVP contractors. This would allow Tracy Pumping Plant to

pump to its authorized capacity of 4,600 cfs, subject to all applicable export pumping restrictions for water quality and fishery protections.

2. Up to 400 cfs would be pumped from the DMC to the CA to minimize impacts to water deliveries due to required reductions in water levels on the lower DMC (south of the Intertie) or the upper CA (north of the Intertie) for system maintenance or due to an emergency shutdown.
3. Up to 950 cfs would be conveyed from the CA to the DMC using gravity flow to minimize impacts to water deliveries due to required reductions in water levels on the lower CA(south of the Intertie) or the upper DMC (north of the Intertie) for system maintenance or due to an emergency shutdown.

The DMC/CA Intertie provides operational flexibility between the DMC and CA. It would not result in any changes to authorized pumping capacity at Tracy Pumping Plant or Banks Delta Pumping Plant.

Water conveyed at the Intertie to minimize reductions to water deliveries during system maintenance or an emergency shutdown on the DMC or CA could include pumping of CVP water at Banks Pumping Plant or SWP water at Tracy Pumping Plant through use of JPOD. In accordance with COA Articles 10(c) and 10(d), JPOD may be used to replace conveyance opportunities lost because of scheduled maintenance, or unforeseen outages. Use of JPOD for this purpose could occur under Stage 2 operations defined in SWRCB D-1641, or could occur as a result of a Temporary Urgency request to the SWRCB. Use of JPOD does not result in any net increase in allowed exports at CVP and SWP export facilities.

To help meet water supply demands of the CVP contractors, operation of the Intertie would allow the Tracy Pumping Plant to pump to its full capacity of 4,600 cfs, subject to all applicable export pumping restrictions for water quality and fishery protections. When in use, water within the DMC would be transferred to the CA via the Intertie. Water diverted through the Intertie would be conveyed through the CA to San Luis Reservoir.

Freeport Regional Water Project

Reclamation and the Freeport Regional Water Authority (FRWA) are proposing to construct and operate the FRWP, a water supply project to meet regional water supply needs. FRWA, a joint powers agency formed under State law by the Sacramento County Water Agency (SCWA) and (EBMUD, is the State lead agency, and Reclamation is the Federal lead agency. A separate BO will be prepared for all other terrestrial and aquatic species related to the construction of the project.

Reclamation proposes to deliver CVP water pursuant to its respective water supply contracts with SCWA and EBMUD through the FRWP, to areas in central Sacramento County. SCWA is responsible for providing water supplies and facilities to areas in central Sacramento County, including the Laguna, Vineyard, Elk Grove, and Mather Field communities, through a capital funding zone known as Zone 40.

The FRWP has a design capacity of 286 cfs (185 millions of gallons per day [MGD]). Up to 132 cfs (85 MGD) would be diverted under Sacramento County's existing Reclamation water service

contract and other anticipated water entitlements and up to 155 cfs (100 MGD) of water would be diverted under EBMUD's amended Reclamation water service contract. Under the terms of its amendatory contract with Reclamation, EBMUD is able to take delivery of Sacramento River water in any year in which EBMUD's March 1 forecast of its October 1 total system storage is less than 500,000 af. When this condition is met, the amendatory contract entitles EBMUD to take up to 133,000 af annually. However, deliveries to EBMUD are subject to curtailment pursuant to CVP shortage conditions and project capacity (100 MGD), and are further limited to no more than 165,000 af in any three-consecutive-year period that EBMUD's October 1 storage forecast remains below 500,000 af. EBMUD would take delivery of its entitlement at a maximum rate of 100 MGD (112,000 af/ per year). Deliveries would start at the beginning of the CVP contract year (March 1) or any time afterward. Deliveries would cease when EBMUD's CVP allocation for that year is reached, when the 165,000 af limitation is reached, or when EB MUD no longer needs the water (whichever comes first). Average annual deliveries to EBMUD are approximately 23,000 af. Maximum delivery in any one water year is approximately 99,000 af.

The primary project components are (1) an intake facility on the Sacramento River near Freeport, (2) the Zone 40 Surface Water Treatment Plant (WTP) located in central Sacramento County, (3) a terminal facility at the point of delivery to the Folsom South Canal (FSC), (4) a canal pumping plant at the terminus of the FSC, (5) an Aqueduct pumping plant and pretreatment facility near Camanche Reservoir, and (6) a series of pipelines carrying water from the intake facility to the Zone 40 Surface WTP and to the Mokelumne Aqueducts. The existing FSC is part of the water conveyance system. See Chapter 9 for modeling results on annual diversions at Freeport in the American River Section, Modeling Results Section sub-heading.

SCWA provides water to areas in central Sacramento County

The long-term master plan for Zone 40 envisions meeting present and future water needs through a program of conjunctive use of groundwater and surface water; or if surface water is not available, through groundwater until surface water becomes available. SCWA presently has a CVP entitlement of 22,000 af through Reclamation. SCWA has subcontracted 7,000 af of this entitlement to the City of Folsom. CVP water for SCWA is currently delivered through the City of Sacramento's (City) intake and treatment facilities based on SCWA need and available city capacity. SCWA's CVP contract also allows it to divert at the location identified as Freeport on the Sacramento River south of downtown Sacramento. SCWA expects to be able to provide additional anticipated surface water entitlements to serve Zone 40 demands, including an assignment of a portion of Sacramento Municipal Utility District's (SMUD) existing CVP water supply contract, potential appropriative water rights on the American and Sacramento Rivers, and potential transfers of water from areas within the Sacramento Valley. Total long-term average Zone 40 water demand is estimated to be 109,500 af per year. Long-term average surface water use is expected to be 68,500 af per year.

East Bay Municipal Utility District

EBMUD is a multi-purpose regional agency that provides water to more than 1.3 million M&I customers in portions of Contra Costa and Alameda Counties in the region east of San Francisco

Bay (East Bay). EBMUD obtains most of its supply from Pardee Reservoir on the Mokelumne River, with the remainder collected from local runoff in East Bay terminal reservoirs.

On July 26, 2001, EBMUD and Reclamation entered into an amendatory CVP contract that sets forth three potential diversion locations to allow EBMUD to receive its CVP supply. One of these locations is Freeport. EBMUD's CVP supply is 133,000 af in any one year, not to exceed 165,000 af in any consecutive three-year period of drought when EBMUD total system storage is forecast to be less than 500,000 af. Subject to certain limitation, the contract also provides for a delivery location on the lower American River and EBMUD retains the opportunity to take delivery of water at the FSC should other alternatives prove infeasible. Additional environmental review is required prior to diversion under the contract.

Water supply forecasts are used in the preparation of operation projections. The water supply forecast is a March 1 forecast of EBMUD's October 1 total system storage, as revised monthly through May 1, as more reliable information becomes available. The main parameters considered in the operation projection are the water supply forecast of projected runoff, water demand of other users on the river, water demand of EBMUD customers, and flood control requirements. According to the terms of its CVP contract with Reclamation, these forecasts determine when EBMUD would be able to take delivery of CVP water through the new intake facility near Freeport to supplement its water supplies and retain storage in its Mokelumne River and terminal reservoir systems.

Under the terms of its amendatory contract with Reclamation, EBMUD is able to take delivery of Sacramento River water in any year in which EBMUD's March 1 forecast of its October 1 total system storage is less than 500,000 af. When this condition is met, the amendatory contract entitles EBMUD to take up to 133,000 af annually. However, deliveries to EBMUD are subject to curtailment pursuant to CVP shortage conditions and project capacity (100 MGD), and are further limited to no more than 165,000 af in any three-consecutive-year period that EBMUD's October 1 storage forecast remains below 500,000 af.

EBMUD would take delivery of its entitlement at a maximum rate of 100 MGD (112,000 af/ per year). Deliveries would start at the beginning of the CVP contract year (March 1) or any time afterward. Deliveries would cease when EBMUD's CVP allocation for that year is reached, when the 165,000 af limitation is reached, or when EBMUD no longer needs the water (whichever comes first). Average annual deliveries to EBMUD are approximately 23,000 af. In the modeling the maximum delivery in any one water year is approximately 99,000 af. It is possible that they could take their full entitlement if there were not shortages imposed.

The City has joined FRWA as an associate member. The City's main interests lie in the design and construction of FRWA project facilities that may be located in the City or on various City properties on rights-of-way. A City representative sits on the FRWA Board of Directors as a non-voting member.

Water Deliveries Associated With The CCWD Settlement Agreement

Under the Contra Costa Waster District (CCWD) settlement agreement, FRWA and EBMUD agreed to "wheel" 3,200 acre-feet per year (af/y) of water for the CCWD. Wheeling is the transmission of water owned by one entity through the facilities owned by another. In this agreement, CCWD water that is normally diverted from the Delta would be diverted from the

Sacramento River and conveyed to CCWD through FRWP facilities, Reclamation's Folsom South Canal, and EBMUD's Mokelumne Aqueduct facilities, at which point CCWD's Los Vaqueros Pipeline intersects the Mokelumne Aqueduct. Unless there are unavoidable conditions that reduce the capacity of the system and prevent function, water would be wheeled to CCWD annually. CCWD would take delivery of a small portion of its Central Valley Project (CVP) supply at the FRWP intake (unlike the past, in which Rock Slough or Old River intakes in the Delta were used).

In the settlement agreement with the Santa Clara Valley Water District (SCVWD), EBMUD would make 6,500 af of its CVP water allocation available to SCVWD in any drought year in which EBMUD would take delivery of Sacramento River water. If the following year is also a drought year in which EBMUD continues to take delivery of Sacramento River water, SCVWD is obligated to return up to 100% of the 6,500 af of water to EBMUD. At EBMUD's discretion, the water may be returned in the following year. If drought conditions do not persist for a second or third year, SCVWD would keep the water and would compensate EBMUD for its Reclamation costs. Since SCVWD would take delivery of the EBMUD CVP water at the Tracy pumping plant, and EBMUD would take delivery of SCVWD's CVP water at Freeport, no additional facilities would be constructed.

The settlement agreements modify the location of CVP deliveries, while the total quantities delivered remain unchanged. In normal and wet years, Delta inflow would be reduced by 3,200 af. This volume is equal to an average reduction of 4 cubic feet per second (cfs). During normal and wet years, Sacramento River flow nearly always exceeds 14,000 cfs, and the anticipated average change would be less than 0.03%. Delta diversions would be reduced by an identical amount, offsetting the minor change in flow. In the first year of a drought, inflow to the Delta would be increased by a nearly identical amount, and this increase would be offset by an identical increase in Delta pumping, resulting in no substantial change. In the second year of a drought, Delta inflow may be decreased by as much as 13 cfs on the average. This decrease (0.1%) remains minor compared to the typical flows of 10,000 cfs in the Sacramento River and is offset by decreased pumping in the Delta. Potential Delta effects associated with changes in pumping location are discussed in Chapter 10.

Items for Early Consultation

There are some items that are part of the early consultation, Operation of Components of the South Delta, CVP/SWP Integration and the long-term EWA.

Operation of Components of the South Delta Improvement Project

Introduction

DWR and Reclamation have agreed to jointly pursue the development of the South Delta Improvement Project (SDIP) to address regional and local water supply needs, as well as the needs of the aquatic environment. Overall, the SDIP components are intended to meet the project purpose and objectives by balancing the need to increase the current regulatory limit on inflow to the CCF with the need to improve local agricultural diversions and migratory conditions for

Central Valley fall and late fall-run Chinook salmon in the San Joaquin River. Two key operational features of the SDIP are included as part of this project description.[9]

8500 cfs Operational Criteria

From March 16 through December 14 - the maximum allowable daily diversion rate into CCF shall meet the following criteria: (1) the three-day running average diversion rate shall not exceed 9,000 cfs, (2) the seven-day running average diversion rate shall not exceed 8,500 cfs, and (3) the monthly average diversion rate shall not exceed 8,500 cfs.

From December 15 through March 15 - the maximum allowable daily diversion rate into CCF shall meet the following criteria: (1) the seven-day running average shall not exceed 8,500 cfs or 6,680 cfs plus one-third of the seven-day running average flow of the San Joaquin River at Vernalis when the flow exceeds 1,000 cfs (whichever is greater), and (2) the monthly average diversion rate shall not exceed 8,500 cfs.

Permanent Barrier Operations

Head of Old River

Barrier operation (closing the barrier) would begin at the start of the VAMP spring pulse flow period, which typically begins around April 15. Operation is expected to continue for 30 consecutive days following the start of the VAMP.

If, in the opinion of the FWS, NOAA Fisheries, and DFG, the barrier needs to be operated at a different time or for a longer period, it may be operated provided the following criteria are met:

- It is estimated that such operation would not increase take of species in excess of the take authorized by the original proposed operation.
- The San Joaquin River flow at Vernalis is less than 10,000 cfs.
- There is a verified presence of out-migrating salmon or steelhead in the San Joaquin River.
- South Delta Water Agency agricultural diverters are able to divert water of adequate quality and quantity.

During the fall months of October and November, the barrier would be operated to improve flow in the San Joaquin River, thus assisting in avoiding historically present hypoxia conditions in the lower San Joaquin River near Stockton. Barrier operation during this period would be conducted at the joint request of DFG, NOAA Fisheries and FWS.

The Head of Old River Barriers (HORB) may be operated at other times provided that the following criteria are met:

[9] This project description does not include any aspect of the SDIP that is not explicitly identified in the text. Examples of SDIP actions that are not included are construction of permanent barriers and dredging. Both of these activities will be covered by subsequent consultation.

- FWS, NOAA Fisheries, and DFG determine that such operation would not increase take of species in excess of the take authorized by the BO for OCAP.
- The San Joaquin River flow at Vernalis is not above 5,000 cfs.
- FWS, NOAA Fisheries, and DFG determine that any impacts associated with barrier operation during this period will not result in additional impacts to threatened and endangered (T&E) species that are outside the scope of impacts analyzed by the BO for OCAP.

Middle River, Old River near the DMC and Grant Line Canal

From April 15 through November 30, barriers on the Middle River and Old River near the DMC and Grant Line Canal would be operated (closed) on an as needed basis to protect water quality and stage for south Delta agricultural diverters (low water levels in Middle River, Old River and Grant Line Canal would not drop below 0.0 mean sea level (MSL) and the 30-day running average electroconductivity (EC) at San Joaquin River at Brandt Bridge, Old River near Middle River and Old River at Tracy Road Bridge would not exceed 0.7 mmhos/cm).

From December 1 through April 15, barriers on the Middle River and Old River near the DMC and Grant Line Canal would be operated (closed) on an as needed basis to protect water quality and stage for south Delta agricultural diverters (low water levels in Middle River, Old River and Grant Line Canal would not drop below 0.0 MSL and the 30-day running average EC at San Joaquin River at Brandt Bridge, Old River near Middle River and Old River at Tracy Road Bridge would not exceed 1.0 mmhos/cm). However, during this period, the barriers may only be operated with permission from the FWS, NOAA Fisheries, and DFG if the following criteria are met:

- FWS, NOAA Fisheries, and DFG determine that such operation would not increase take of species in excess of the take authorized by the BO for OCAP.
- The San Joaquin River flow at Vernalis is not above 5,000 cfs.
- FWS, NOAA Fisheries, and DFG determine that any impacts associated with barrier operation during this period will not result in additional impacts to T&E species that are outside the scope of impacts analyzed by the BO for OCAP.

DWR is also investigating whether the use of low head pumps at barrier locations can further improve water quality at Brandt Bridge. The amount of pumping and the precise location of the pumps have not been determined, nor has the benefit that might be realized by low head pumps been quantified. If DWR concludes there is a benefit to operating low head pumps, it will incorporate the proposed action into the SDIP Action Specific Implementation Plan (ASIP) process. Such an inclusion will require re-initiation of consultation with the services regarding potential effects on listed species. Thus, low head pumps will not be included in the OCAP project description.

Long-term EWA

There is an assumption in the future studies of an EWA similar to the today level studies (see chapter 8). Purchase assets are the same in the today and future, variable assets may differ under the future proposed actions. Refer to the previous discussion of EWA beginning on page 2-77.

Transfers

The capability to facilitate transfers is expanded by the implementation of the 8,500 cfs Banks capacity. Available surplus capacity for transfers will increase in most years. The early consultation includes the increased use of the SWP Delta export facilities for transfers that will derive from the increase in surplus capacity associated with implementation of the 8,500 cfs Banks. As mentioned in the project description under the heading Water Transfers, in all but the driest 20 percent of water years, surplus capacity during the typical transfer season of July through September is usually a factor limiting the amount of transfers that can be accomplished. With the 8,500 cfs Banks, the range of surplus capacity available for transfers (in the wetter 80 percent of years) increases from approximately 60,000-460,000 acre feet per year, to 200,000-600,000 acre feet per year. Transfers in the drier 20 percent of years are not limited by available capacity, but rather by either supply or demand. In those years, transfers could still range up to 800,000-1,000,000 acre feet per year, either with or without the 8,500 cfs Banks. Refer to the Water Transfers section for additional discussion.

CVP and SWP Operational Integration

For many years, Reclamation and DWR have considered and attempted to increase the level of operational coordination and integration. Such coordination allows one project to utilize the other's resources to improve water supply reliability and reduce cost. As such, Reclamation and DWR plan to integrate the strengths of the CVP and SWP (storage and conveyance, respectively) to maximize water supplies for the benefit of both CVP and SWP contractors that rely on water delivered from the Bay-Delta in a manner that will not impair in-Delta uses, and will be consistent with fishery, water quality, and other flow and operational requirements imposed under the Clean Water Act (CWA) and ESA. The Project Agencies have agreed to pursue the following actions:

- Convey water for Reclamation at the SWP. Upon implementation of the increase to 8,500 cfs at Banks, DWR will divert and pump 100,000 af of Reclamation's Level 2 refuge water before September 1. This commitment will allow Reclamation to commit up to 100,000 af of conveyance capacity at Tracy Pumping Plant, formally reserved for wheeling refuge supplies, for CVP supplies.
- Adjust in-basin obligations. Upon implementation of the increase to 8,500 cfs at Banks, Reclamation will supply up to 75,000 af from its upstream reservoirs to alleviate a portion of the SWP's in-basin obligation.
- Prior to implementation of the increase to 8,500 cfs at Banks, DWR will provide up to 50,000 acre feet of pumping and conveyance of Reclamation's Level 2 refuge water. Likewise, Reclamation will supply up to 37,500 acre feet from its upstream storage to alleviate a portion of the SWP's obligation to meet in-basin uses. It should be noted that the biological effects analyzed in this document are for the full 100,000 acre feet of conveyance

and up to 75,000 acre feet of storage, as may occur when the 8,500 Banks is operational. The biological effects of the 50,000 acre feet of conveyance and up to 37,500 acre feet of storage which may occur at the existing permitted Banks capacity, are not analyzed separately, since it is assumed that those effects are encompassed by the analysis of the larger amounts and capacities that may occur when the 8,500 Banks is operational.

- Upstream Reservoir Coordination. Under certain limited hydrologic and storage conditions, when water supply is relatively abundant in Shasta, yet relatively adverse in Oroville, SWP may rely on Shasta storage to support February allocations based on 90 percent exceedence projections, subject to the following conditions. When the CVP's and the SWP's February 90 percent exceedence forecasts project September 30 SWP storage in Oroville Reservoir to be less than 1.5 million acre feet, and CVP storage in Shasta Reservoir to be greater than approximately 2.4 million acre feet, the SWP may, in order to provide allocations based on a 90 percent exceedence forecast, rely on water stored in Shasta Reservoir.
    - Should the actual hydrology be drier than the February 90 percent exceedence forecast, the SWP may borrow from Shasta storage an amount of water equal to the amount needed to maintain the allocation made under the 90 percent exceedence forecast, not to exceed 200,000 acre feet.
    - Storage borrowing will be requested by April 1. Upon the request to borrow storage, Reclamation and DWR will develop a plan within 15 days to accomplish the potential storage borrowing. The plan will identify the amounts, timing, and any limitation or risk to implementation and will comply with conditions on Shasta Reservoir and Sacramento River operations imposed by applicable biological opinions. Water borrowed by the SWP shall be provided by adjustments in Article 6 accounting of responsibilities in the COA.
- Reclamation and DWR have agreed to share water provided by Sacramento Valley interests to alleviate in-basin requirements. The water will be split 60 percent for the SWP and 40 percent for the CVP. Refer to the previous discussion of Water Transfer beginning on page 2-79.
- Maximize use of San Luis Reservoir storage. DWR, in coordination with Reclamation and their respective contractors, will develop an annual contingency plan to ensure San Luis Reservoir storage remains at adequate levels to avoid water quality problems for CVP contractors diverting directly from the reservoir. This action is expected to continue for five years, at which time Reclamation and DWR will re-evaluate the need for the action. The plan will identify actions and triggers to provide up to 200,000 af of source shifting, allowing Reclamation to utilize the CVP share of San Luis Reservoir more effectively to increase CVP allocations.

  Additionally, a solution to the San Luis Reservoir low point problem is also in the long-term operation of the CVP and SWP, and is also part of this consultation. Solving the low point problem in San Luis Reservoir was identified in the August 28, 2000, CALFED ROD as a complementary action which would avoid water quality problems associated with the low point and increase the effective storage capacity in San Luis Reservoir up to 200,000 af. This action, while not implemented at present, is part of the future proposed action on which Reclamation is consulting. All site-specific and localized actions of implementing a solution

to the San Luis Reservoir low point problem, such as construction of any physical facilities in or around San Luis Reservoir and any other site-specific effects, will be addressed in a separate consultation.

Chapter 3 Basic Biology and Life History and Baseline for Central Valley Steelhead

Species as a Biological Concept and Regulatory Criterion

Scientists categorize organisms in hierarchical categories that reflect the best available information regarding their evolutionary histories. The higher levels of classification such as Phyla, represent lineage divergence that has been occurring for hundreds of millions of years (Kozloff 1990). This divergence obscures the evolutionary relationships among the various Phyla because many of the evolutionary intermediates (also known as "missing links") have died out. However, wide divergence means determination of which organisms constitute a Phylum is relatively unambiguous. In other words, the extinction of the intermediates has resulted in relatively discrete groups, each consisting of similar organisms, rather than a gradation from one set of subtle diagnostic characteristics to another.

In contrast, as the taxonomic resolution gets finer (that is, moves from Phylum down toward species) the evolutionary relationships become more evident, but the increasing number of intermediate character states makes categorization more subjective. Salmonid fishes provide a good example of this. The evolutionary relationships among the salmonids are fairly well understood down to the genus level, perhaps even to the level of the formally recognized species (Stearley and Smith 1993). However, the formally recognized species are notoriously variable (Bernatchez 1995; Smith et al. 1995; Utter et al. 1995). The two salmonids covered by this BA, *Oncorhynchus mykiss* (rainbow trout/steelhead) and *Oncorhynchus tshawytscha* (Chinook salmon), are no exception, and provide an excellent example of the difficulty that arises when trying to place these fish into sub-specific taxonomic groups. Rainbow trout/steelhead and Chinook salmon responded to the plethora of local conditions encountered over their broad historical ranges with genetic, ecological, and behavioral adaptations. This plasticity resulted in a large number of individual stocks, which have been wholly or partially reproductively isolated from each other for varying amounts of time (Healey and Prince 1995; Utter et al. 1995; NOAA Fisheries 1998; Teel et al. 2000). This relatively recent and varied stock divergence means that a continuum of genetic and ecological characteristics exists within the species groups.

The Federal ESA was designed to protect the evolutionary legacy of species, and it allows for protection of "distinct population segments" (NRC 1995). Similarly, the California Endangered Species Act (CESA) allows for "subspecies" to be listed. NOAA Fisheries has chosen the Evolutionarily Significant Unit (ESU), as the distinct population segment of Pacific salmon appropriate for listing under the Federal ESA (Waples 1995). Two criteria are used to determine whether a population constitutes an ESU. First, the population must be "substantially reproductively isolated from other conspecific population units," and second, the population must represent "an important component in the evolutionary legacy of the species" (Waples 1995). Nonetheless, given the scientific uncertainty surrounding species classification and the contemporary scientific understanding of population genetics and population dynamics, the

National Research Council (NRC) (1995) supported the scientific validity of ESA protection for unique subspecific lineages like ESUs.

Busby et al. (1996) and NOAA Fisheries (1998) reviewed genetics study results for West Coast steelhead and Chinook salmon populations, and determined that Sacramento-San Joaquin steelhead populations are sufficiently distinct genetically from other West Coast populations, including those distributed along the northern California coast to comprise ESUs. NOAA Fisheries (1998) also determined that Central Valley fall-run and late fall-run, spring-run, and winter-run Chinook salmon all comprised ESUs. Therefore, each of these is considered a "species" for purposes of the Federal ESA.

Status

Populations of naturally spawned Central Valley steelhead are at lower levels than were found historically (Figure 3–1) and are composed predominantly of hatchery fish. Steelhead require cool water to rear through the summer and much of this habitat is now above dams. The California Fish and Wildlife Plan of 1965 estimated the combined annual run size for Central Valley and San Francisco Bay tributaries to be about 40,000 during the 1950s (DFG 1965, as cited in McEwan and Jackson 1996). The spawning population during the mid-1960s for the Central Valley basin was estimated at nearly 27,000 (DFG 1965, as cited in McEwan and Jackson 1996). These numbers likely consisted of both hatchery and wild steelhead. McEwan and Jackson (1996) estimated the annual run size for the Central Valley basin to be less than 10,000 by the early 1990s. Much of the abundance data since the mid-1960's was obtained at the Red Bluff Diversion Dam fish ladders when gates were closed during much of the steelhead migration. Current abundance estimates are unavailable for naturally spawned fish since gate operations were changed, so the extent to which populations have changed following the 1987–94 drought is unknown. NOAA Fisheries listed naturally spawned Central Valley steelhead as threatened under the Federal ESA in 1998. NOAA Fisheries (2003) status review estimated the Central Valley steelhead population at less than 3,000 adults. This document is primarily limited to a discussion of the status of Central Valley steelhead stocks in habitats influenced by CVP and SWP operations. According to McEwan (2001) the primary stressors affecting Central Valley steelhead are all related to water development and water management, and the greatest stressor is the loss of spawning and rearing habitat due to dam construction.

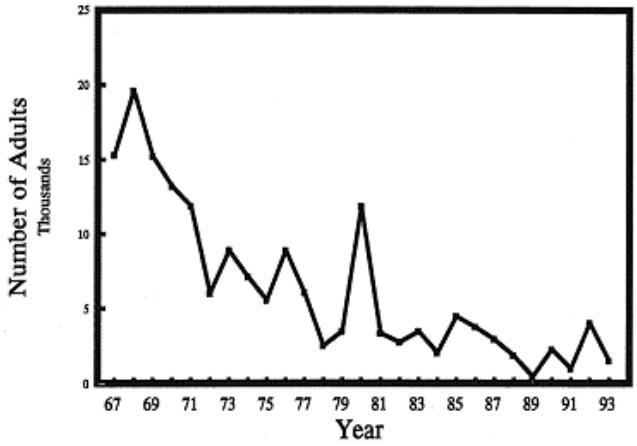
The Central California Coast Steelhead ESU was listed as a threatened species on August 18, 1997. The Central California Coast Steelhead ESU extends from the Russion River on the north to the San Lorezno River on the south and includes Suisun Bay, San Pablo Bay, and San Francisco Bay. Because the project area overlaps this ESU these fish are being addressed in this BA. CVP and SWP operations are not expected to influence conditions significant to steelhead in these areas so effects to Central California Coast Steelhead are not anticipated. The steelhead effects analysis throughout this BA does not identify any effects of the project on steelhead that occur in the Central California Coast ESU so they therefore are not specifically referenced except in the determination of effects.

Taxonomy

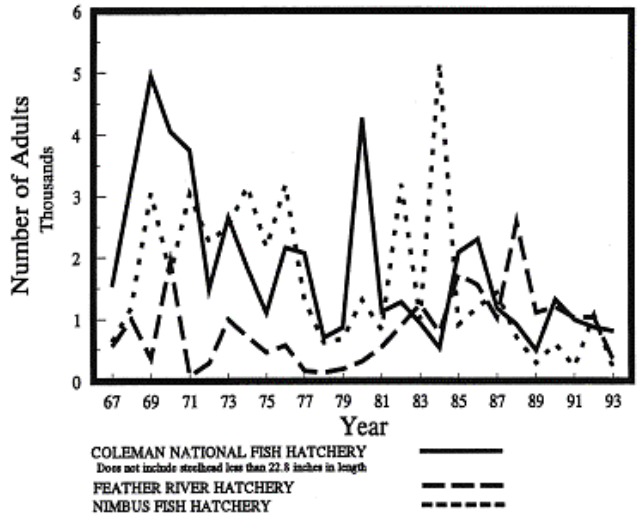
Steelhead is a name used for anadromous rainbow trout (*Oncorhynchus mykiss*), a salmonid

species native to western North America and the Pacific coast of Asia. In North America, steelhead are found in Pacific coast drainages from southern California to Alaska. In Asia, they are found in coastal streams of the Kamchatka Peninsula, with scattered populations on the Siberian mainland (Burgner et al. 1992, as cited in McEwan and Jackson 1996). Known spawning populations are found in coastal streams along much of the California coast, as well as in the Central Valley.

Only two subspecies of North American rainbow trout contain both resident (non-migratory) and anadromous (migratory or sea-run) forms: coastal rainbow trout (*O. m. irideus*), and Columbia River redband trout (*O. m. gairdneri*). Columbia River redband trout occur in tributaries of the upper Columbia River east of the Cascades (McEwan and Jackson 1996). Coastal rainbow trout occupy coastal streams from California to Alaska, including tributaries to the San Francisco Estuary. All California steelhead populations are *O. m. irideus*, including those in the Central Valley.



Adjusted adult steelhead counts at Red Bluff Diversion Dam on the Sacramento River, 1967-1993.



Adult steelhead counts at Coleman, Feather River, and Nimbus fish hatcheries, 1967-1993.

Figure 3–1 Adult steelhead counts at RBD, 1967–93 (top) and adult steelhead counts at Coleman National Fish Hatchery, Feather River Fish Hatchery, and Nimbus Hatchery, 1967-93 (bottom).
Source: McEwan and Jackson 1996.

Rainbow trout/steelhead and other members of the family Salmonidae are characterized as having a streamlined body, emarginate to forked tail, an adipose fin, and an auxiliary process near the pelvic fins. They have nine to 13 branchiostegal rays, no basibranchial teeth, and a large number of pyloric cecae (Moyle 1976). They have 10 to 12 dorsal fin rays and eight to 12 anal

fin rays. The lateral line has 119 to 138 scales. Resident adults have small irregular black spots on their back and on most fins, a pink to red stripe on their side, a black edge on the adipose fin, and distinct radiating rows of black spots on the caudal fin (Page and Burr 1991). The upper jaw barely extends beyond the eye in small juveniles and females, but extends well beyond the eye in large males. Dorsal coloration can be highly variable ranging from steel blue to yellow-green to brown. Ventral coloration ranges from silver to pale yellow-green. Small juveniles have five to 10 widely spaced, short, oval parr marks. Steelhead are distinguished from resident adults by their silver coloration. Yearling steelhead are also silvery and lack parr marks (Moyle and Cech 1988).

Historically, resident rainbow trout and steelhead were considered separate subspecies or different species altogether. However, researchers have found little or no morphologic or genetic differentiation between the two forms inhabiting the same stream system (Behnke 1972; Allendorf 1975; Allendorf and Utter 1979; Busby et al. 1993; Nielson 1994, all as cited in McEwan and Jackson 1996), indicating there is substantial interbreeding. However, differences in mitochondrial DNA have been found by some researchers (Wilson et al. 1985, as cited in McEwan and Jackson 1996). Based on the cumulative genetic evidence, researchers have proposed that steelhead and related resident rainbow trout with the potential to interbreed be considered as one unit for restoration and management purposes (Busby et al. 1993, as cited in McEwan and Jackson 1996; NOAA Fisheries 1996).

NOAA Fisheries (1998) divided West Coast steelhead into 15 ESUs based on distinct genetic characteristics, freshwater ichthyogeography, and other parameters. Most steelhead stocks found in the Central Valley comprise the Central Valley ESU, which recent genetic data indicates is distinct from other coastal steelhead stocks (Busby et al. 1996, NOAA Fisheries 1997b, 1998). DNA analysis of steelhead tissue samples collected from the Coleman National Fish Hatchery, Feather River Hatchery, Deer and Mill Creeks, and the Stanislaus River demonstrated these stocks are genetically similar to each other. Coleman National Fish Hatchery and Feather River Hatchery steelhead stocks are considered part of the Central Valley ESU since broodstock histories and genetic evidence show these two stocks are similar to naturally spawned steelhead in Deer and Mill Creeks.

NOAA Fisheries (1998, 1999) does not consider Nimbus Hatchery and Mokelumne River Fish Installation stocks to be part of the Central Valley ESU. Genetic analysis indicated steelhead from the American River (collected from both the Nimbus Hatchery and the American River) are genetically more similar to Eel River steelhead (Northern California ESU) than other Central Valley steelhead stocks. Eel River steelhead were used to found the Nimbus Hatchery stock. Mokelumne River rainbow trout (hatchery produced and naturally spawned) are genetically most similar to Mount Shasta Hatchery trout, but also show genetic similarity to the northern California ESU (Nielsen 1997, as cited in NOAA Fisheries 1997b). Further analysis is warranted as the Mokelumne River Fish Installation obtains steelhead eggs from the Nimbus Hatchery and this relationship should become evident through future genetic analyses.

Steelhead Biology and Life History

Steelhead, as currently defined, is the anadromous form of rainbow trout (McEwan and Jackson 1996). However, as stated above, steelhead life history can be quite variable with some populations reverting to residency when flow conditions block access to the ocean. The following is an idealized life history for Central Valley stocks. McEwan and Jackson (1996) provided an extensive summary of the biology of coastal and Central Valley stocks and a list of useful references that contain more detailed information.

Adult migration from the ocean to spawning grounds occurs during much of the year, with peak migration occurring in the fall or early winter (Figure 3–2). Migration through the Sacramento River main stem begins in July, peaks at the end of September, and continues through February or March (Bailey 1954; Hallock et al. 1961, both as cited in McEwan and Jackson 1996). Counts made at Red Bluff Diversion Dam (RBDD) from 1969 through 1982 (Hallock 1989, as cited in McEwan and Jackson 1996) and on the Feather River (Painter et al. 1977; DWR unpublished) follow the above pattern, although some fish were counted as late as April and May. Weekly counts at Clough Dam on Mill Creek during a 10-year period from 1953 to1963 showed a similar migration pattern as well. The migration peaked in mid-November and again in February. This second peak is not reflected in counts made in the Sacramento River main stem (Bailey 1954; Hallock et al. 1961, both as cited in McEwan and Jackson 1996) or at RBDD (Hallock 1989, as cited in McEwan and Jackson 1996).

Central Valley steelhead (also known as winter steelhead) mature in the ocean and arrive on the spawning grounds nearly ready to spawn. In contrast, summer steelhead, or stream-maturing steelhead, enter freshwater with immature gonads and typically spend several months in fresh water before spawning. The optimal temperature range during migration is unknown for Central Valley stocks. Based on northern stocks, the optimal temperature range for migrating adult steelhead is 46° F to 52° F (Bovee 1978; Reiser and Bjornn 1979; Bell 1986, all as cited in McEwan and Jackson 1996). The reported minimum depth for successful passage is about 7 inches (Reisner and Bjornn 1979, as cited in McEwan and Jackson 1996). Depth is usually not a factor preventing access to spawning areas in the rivers currently under consultation because migration normally occurs during high outflow months. However, excessive water velocity (>10to 13 ft/s) and obstacles may prevent access to upstream spawning grounds.

Historically, Central Valley steelhead spawned primarily in upper stream reaches and smaller tributaries, although steelhead spawn in most available channel types in unimpounded stream reaches of the Pacific Northwest (Montgomery et al. 1999). Due to water development projects, most spawning is now confined to lower stream reaches below dams. In a few streams, such as Mill and Deer Creeks, steelhead still have access to historical spawning areas. Peak spawning generally occurs from December through April (McEwan and Jackson 1996) (Figure 3–2).

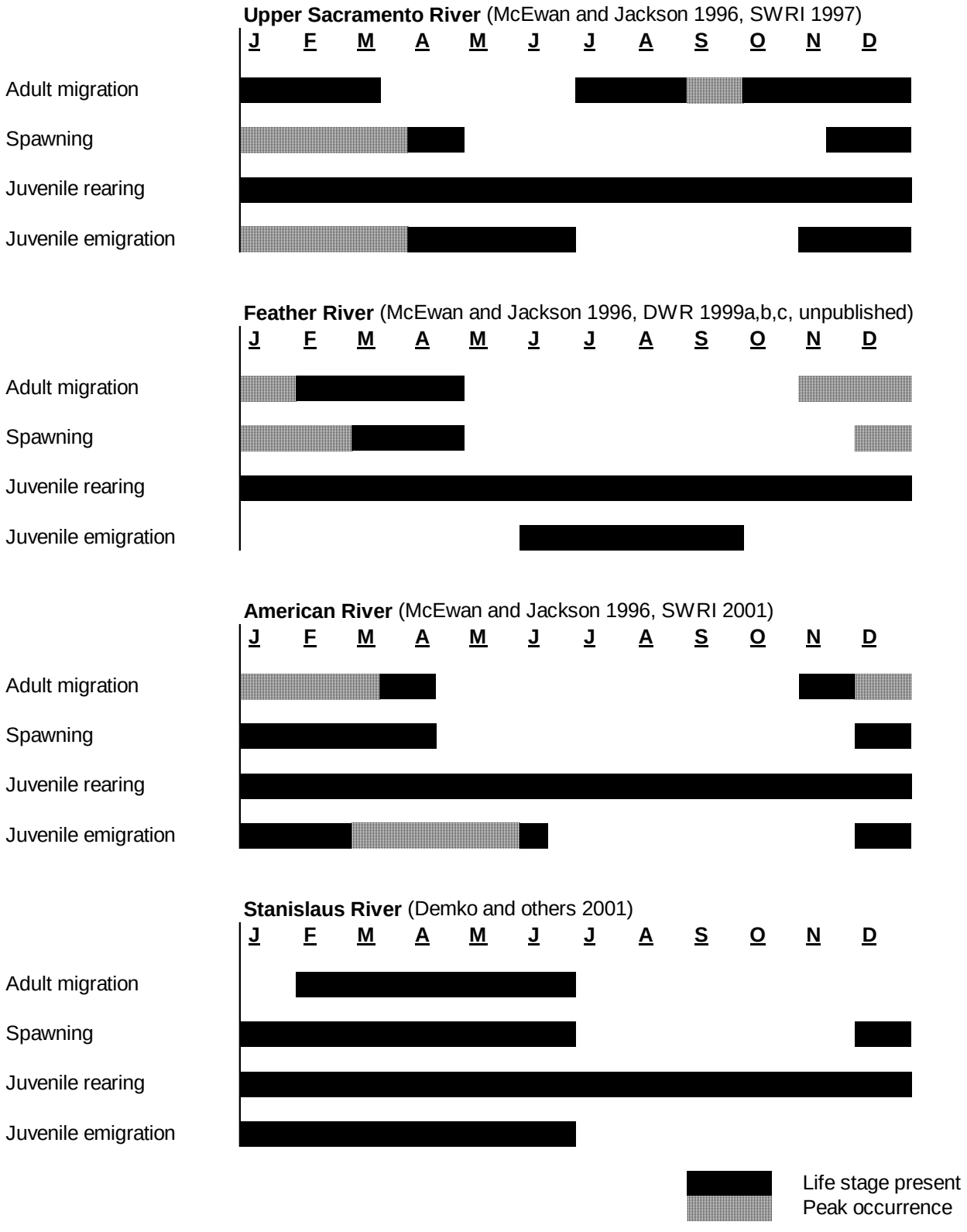


Figure 3–2 Steelhead life cycle for various Central Valley streams.

The female excavates a redd (nest) in the gravel and deposits her eggs, while an attendant male fertilizes them. Fecundity is directly related to body size (Moyle 1976). Spawning females average about 4,000 eggs, but the actual number produced varies among stocks and by the size and age of the fish (Leitritz and Lewis 1976). The eggs are covered with gravel when the female excavates another redd upstream. Spawning occurs mainly in gravel substrates (particle size range of about 0.2–4.0 inches). Sand-gravel and gravel-cobble substrates are also used, but these must be highly permeable and contain less than 5 percent sand and silt to provide sufficient oxygen to the incubating eggs. Adults tend to spawn in shallow areas (6–24 inches deep) with moderate water velocities (about 1 to 3.6 ft/s) (Bovee 1978, as cited in McEwan and Jackson 1996). The optimal temperature range for spawning is 39° F to 52° F in northern steelhead populations (Bovee 1978; Reiser and Bjornn 1979; Bell 1986, all as cited in McEwan and Jackson 1996).

Unlike Chinook salmon, steelhead do not die after spawning (McEwan and Jackson 1996). Some may return to the ocean and repeat the spawning cycle for two or three years. The percentage of adults surviving spawning is generally low for Central Valley steelhead, but varies annually and between stocks.

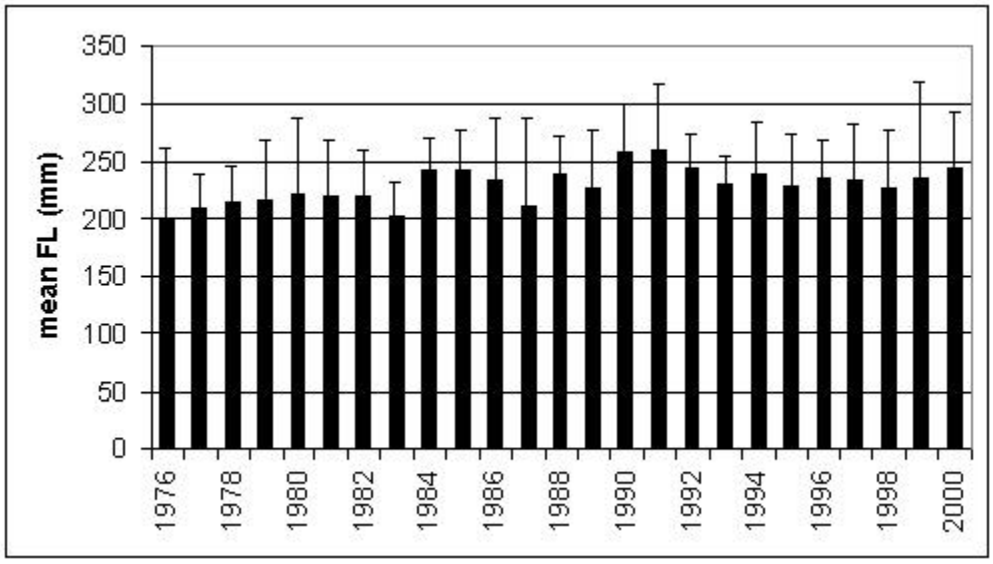


Figure 3–3 Mean FL (mm) plus standard deviation of steelhead collected in the FWS Chipps Island Trawl, 1976-2000.

The time required for egg development is approximately four weeks, but is temperature-dependent (McEwan and Jackson 1996). For northern steelhead populations, optimal egg development occurs at 48° F to 52° F. Egg mortality may begin at temperatures above 56° F in northern populations (Bovee 1978; Reiser and Bjornn 1979; and Bell 1986, all as cited in McEwan and Jackson 1996). After hatching, the yolk-sac fry or alevins remain in the gravel for another four to six weeks (Shapovalov and Taft 1954, as cited in McEwan and Jackson 1996). Upon emergence from the gravel, the fry move to shallow protected areas associated with the stream margin (Royal 1972; Barnhart 1986, both as cited in McEwan and Jackson 1996). Steelhead fry tend to inhabit areas with cobble-rubble substrate, a depth less than 14 inches, and temperature ranging from 45° F to 60° F (Bovee 1978, as cited in McEwan and Jackson 1996).

Older juveniles use riffles and larger juveniles may also use pools and deeper runs (Barnhart 1986, as cited in McEwan and Jackson 1996). However, specific depths and habitats used by juvenile rainbow trout can be affected by predation risk (Brown and Brasher 1995).

Juvenile Central Valley steelhead may migrate to the ocean after spending one to three years in fresh water (McEwan and Jackson 1996). Fork length (FL) data for steelhead emigrating past Chipps Island suggest the Central Valley stocks show little variability in size at emigration (Figure 3–3). Only 0.4 percent of the steelhead collected in the FWS Chipps Island Trawl between 1976 and 1997 were less than 120 mm FL. This should be considered a maximum proportion of young-of-the-year (YOY) emigrants because the gear efficiency of the midwater trawl decreases as fish size increases (McLain 1998), meaning the abundance of large fish relative to smaller fish is underestimated by the gear.

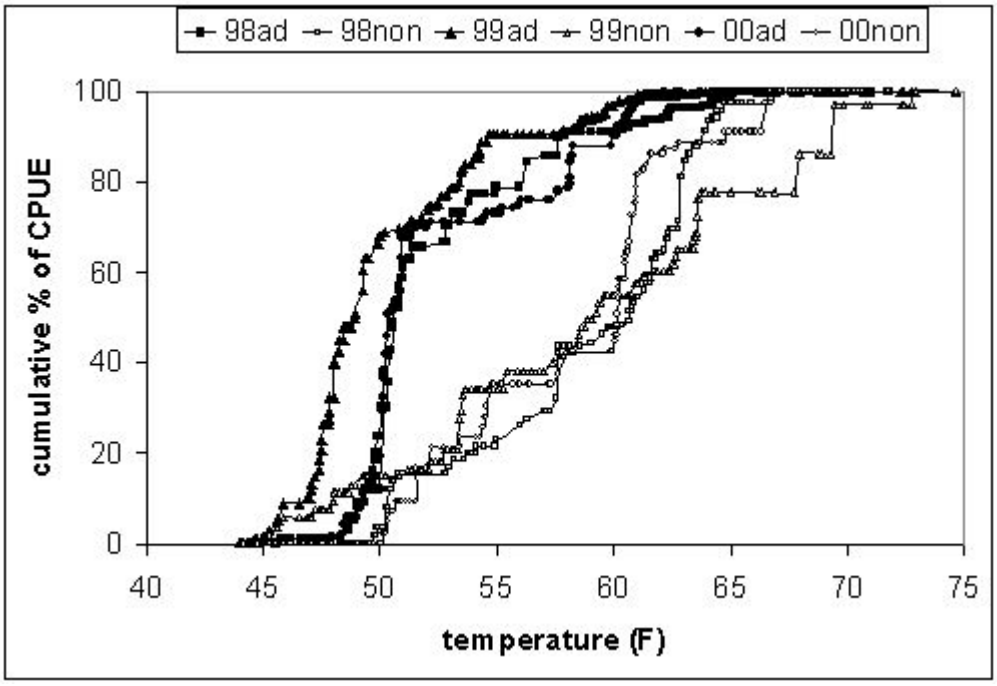


Figure 3–4 Cumulative percentage of steelhead per 10,000 m^3 in the FWS Chipps Island Trawl v. surface water temperature at Chipps Island. Solid symbols represent hatchery fish and open symbols represent wild fish.

During their downstream migration, juveniles undergo smoltification, a physiologic transformation enabling them to tolerate increased salinity. In addition, the juveniles lose their parr marks, become silvery, and produce deciduous scales. Temperatures under 57° F are considered optimal for smolting in northern populations. Data for steelhead smolts emigrating past Chipps Island generally agree with findings for northern populations. Slightly more than 60 percent of the steelhead smolts collected in the FWS Chipps Island trawl between 1998 and 2000 were collected at temperatures > 57 ° F (Figure 3–4). However, this is likely biased by high proportions of hatchery fish that migrate over a shorter period of time than naturally spawned fish.

Steelhead are present at Chipps Island between at least October and July based on catch data from the FWS Chipps Island Trawl (Figure 3–5). It appears that adipose fin-clipped steelhead

have a different emigration pattern than unclipped steelhead. In all three years, adipose fin-clipped steelhead showed distinct peaks in catch per unit effort (CPUE) between January and March corresponding with time of release, whereas unclipped steelhead CPUE were more evenly distributed over a period of six months or more. Presumably, these differences are an artifact of the method and timing of hatchery releases.

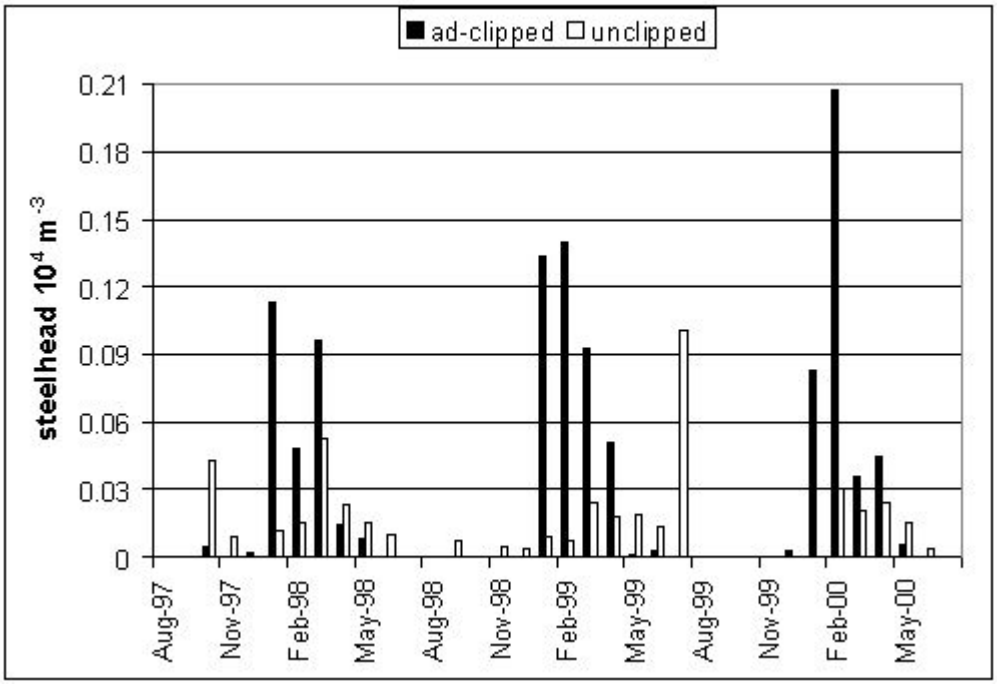


Figure 3–5 CPUE of adipose fin-clipped (black bars) and unclipped (white bars) steelhead from the FWS Chipps Island Trawl, August 1997 through July 2000.

Once in the ocean, steelhead remain there for one to four growing seasons before returning to spawn in their natal streams (Burgner et al. 1992, as cited in McEwan and Jackson 1996). Little data are available on the distribution of Central Valley stocks in the ocean, but at least some California steelhead stocks may move into the north Pacific Ocean, as do the more northerly-distributed stocks.

Historical and Current Distribution and Abundance of Central Valley Steelhead

Steelhead ranged throughout many of the tributaries and headwaters of the Sacramento and San Joaquin Rivers prior to dam construction, water development, and watershed perturbations of the 19th and 20th centuries (McEwan and Jackson 1996). Based on the historical distribution of Chinook salmon, steelhead probably inhabited tributaries above Shasta Dam such as the Little Sacramento, McCloud, Fall, and Pit Rivers, and many tributaries on the west side of the Sacramento Valley, such as Stony and Thomes Creeks (Yoshiyama et al. 1996, 1998).

There is little historical documentation regarding steelhead distribution in the San Joaquin River system, presumably due to the lack of an established steelhead sport fishery in the San Joaquin

basin (Yoshiyama et al. 1996). However, based on historical Chinook salmon distribution in this drainage and on the limited steelhead documentation that does exist, steelhead were present in the San Joaquin River and its tributaries from the Kern River northward. During very wet years, steelhead could access the Kern River through the Tulare Basin.

Steelhead distribution in Central Valley drainages has been greatly reduced (McEwan and Jackson 1996). Steelhead are now primarily restricted to a few remaining free-flowing tributaries and to stream reaches below large dams, although a few steelhead may also spawn in intermittent streams during wet years. Naturally spawning steelhead populations have been found in the upper Sacramento River and tributaries below Keswick Dam, Mill, Deer, and Butte Creeks, and the Feather, Yuba, American, and Mokelumne Rivers (CMARP 1998). However, the records of naturally spawning populations depend on the presence of fish monitoring programs. Recent implementation of monitoring programs has found steelhead in additional streams, such as Auburn Ravine, Dry Creek, and the Stanislaus River. It is possible that naturally spawning populations exist in many other streams but are undetected due to lack of monitoring or research programs. Although impassable dams prevent resident rainbow trout from emigrating, populations with steelhead ancestry may still exist above some dams (Dennis McEwan, personal communication, 1998).

As stated above, the adult Central Valley steelhead population was estimated to number about 27,000 during the early 1960s (DFG 1965, as cited in McEwan and Jackson 1996). Historical counts of steelhead passing RBDD, which included both Coleman Hatchery and naturally spawned fish are shown in Figure 3–1. The counts showed an obvious decline in steelhead returns to the upper Sacramento River between 1967 and 1993. Current escapement data are not available for naturally spawned steelhead in most tributaries, in large part because of the curtailment of gate operations at RBDD and the lack of steelhead population monitoring in most of the Central Valley. A continual decline is not apparent in the time series of returning steelhead trapped at Nimbus (Figure 3–6) and Feather River (Figure 3–7) hatcheries, where data for post-drought years are available. The estimated number of steelhead spawning in the Amercan River in 2002 was 32 percent of the number that entered Nimbus Hatchery (Hannon and Healey, 2002). An estimated 201 - 400 steelhead spawned in the American River in 2002 and 243 - 486 spawned in 2003, based on one to two redds per female. Some escapement monitoring surveys have been initiated in upper Sacramento River tributaries (Beegum, Deer, and Antelope Creeks) using snorkel methods similar to spring-run Chinook escapement surveys.

Although Coleman Hatchery production was included in counts at RBDD, these time series indicate that abundance patterns may differ between wild and hatchery stocks (and also between individual hatchery stocks), confounding interpretation of factors influencing Central Valley steelhead at the population or regional levels. Abundance patterns are conversely related for wild and hatchery fish and may influence each other as shown in Oregon and Washington (NOAA Fisheries, 2003). The following provides an overview of the status of steelhead in Sacramento and San Joaquin tributaries under consultation. More detailed assessments of steelhead status in the Central Valley were provided by McEwan and Jackson (1996) and Busby et al. (1996).

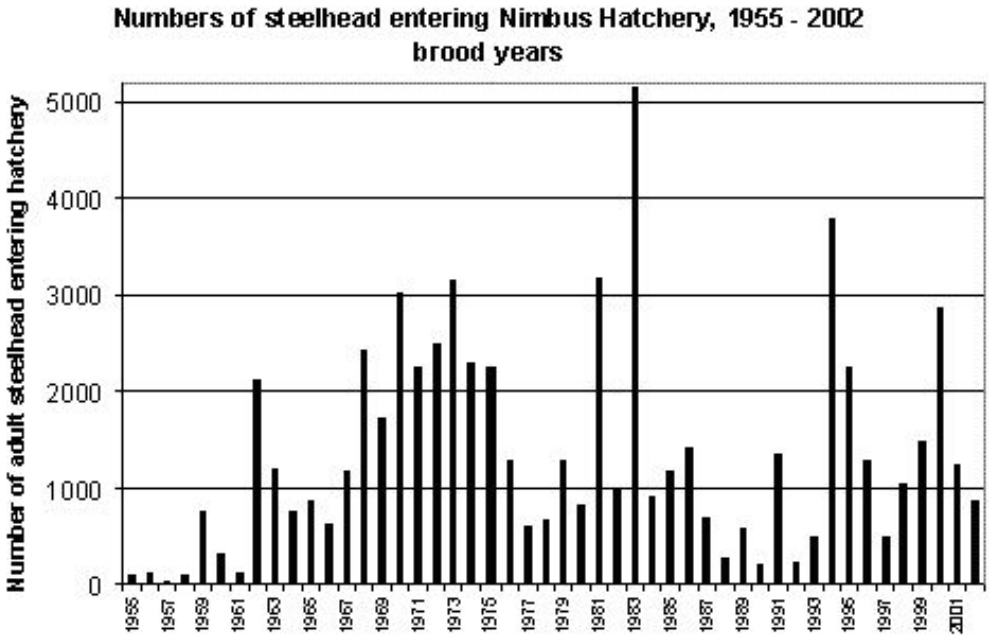


Figure 3–6 Adult steelhead counts at Nimbus Hatchery, brood years 1955-2001. The 2002 brood year means those fish returning to spawn in late 2002 through spring 2003.

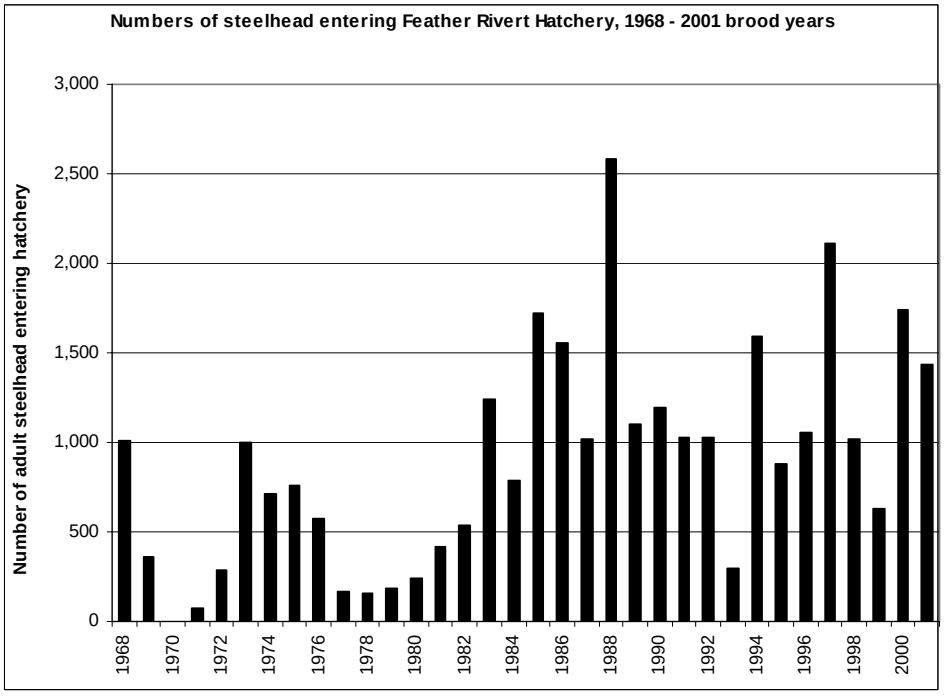


Figure 3–7 Adult steelhead counts at Feather River Hatchery, brood years 1969-2001.

Clear Creek

Historically, steelhead probably ascended Clear Creek past the French Gulch area, but access to the upper basin was blocked by Whiskeytown Dam in 1964 (Yoshiyama et al. 1996). Operation of Whiskeytown Dam can produce suitable cold water habitat downstream to Placer Road Bridge depending on flow releases (DFG 1998). McCormick-Saeltzer Dam, which limited steelhead migrations through ineffective fish ladders, was removed in 2000 allowing steelhead potential access to good habitat up to Whiskeytown Dam. The FWS has conducted snorkel surveys targeting spring-run Chinook (May through September) since 1999. Steelhead/rainbow are enumerated and separated into small, medium, and large (>22 inches) during these surveys; but because the majority of the steelhead run is unsurveyed, no spawner abundance estimates have been attempted (Jess Newton, personal communication, 2001). Redd counts were conducted during the 2001-02 run and found that most spawning occurred upstream, near Whiskeytown Dam. Because of the large resident rainbow population, no steelhead population estimate could be made (Matt Brown, personal communication, June 2002). A remnant "landlocked" population of rainbow trout with steelhead ancestry may exist in Clear Creek above Whiskeytown Dam (Dennis McEwan, personal communication, 1998).

Summertime water temperatures are often critical for steelhead rearing and limit rearing habitat quality in many streams. Figure 3–8 shows that water temperatures in Clear Creek at Igo are maintained below 65° F year-round using releases of cool Whiskeytown reservoir water.

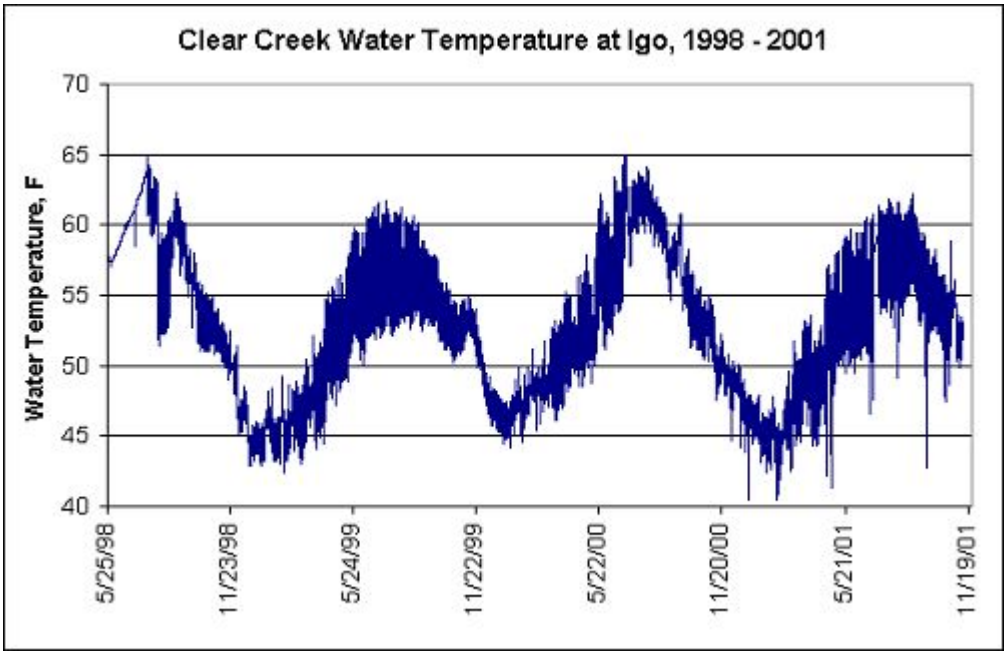


Figure 3–8 Clear Creek water temperature at Igo, 1998-2001 (CDEC).

Feather River

Historically, the Feather River supported a large steelhead population (McEwan and Jackson 1996). Today the run is supported almost entirely by the Feather River Hatchery and is restricted to the region downstream of the fish hatchery dam. The hatchery produces about 400,000

yearling steelhead each year to mitigate for Oroville Dam and losses at the SWP Delta facilities.

Angler surveys by Painter et al. (1977) indicated adult steelhead were present in the Feather River from September through April. However, peak immigration probably occurs from September through January. Most of the fish spawn in the hatchery, although some spawn in the low flow channel. During 2003 redd construction probably began in late December, peaked in late January, and was essentially complete by the end of March. Redd surveys counted 75 steelhead redds and revealed that 48% of all redds were in the upper mile of the river between Table Mountain Bicycle Bridge and lower auditorium riffle in 2003 (Kindopp and Kurth 2003).

Screw trap monitoring indicates steelhead fry are present in the river as early as March (DWR 1999b). Snorkel surveys in 1999, 2000, and 2001 showed young steelhead reared through the summer at suitable locations throughout the low flow channel, primarily along the margins of the channels under riparian cover and in secondary channels with riparian cover (Cavallo et al 2003). The highest densities of YOY steelhead were observed at the upstream end of the low flow channel and in an artificial side channel fed by hatchery discharge. Summer water temperatures below Thermalito Afterbay Outlet are relatively high (>70° F), and snorkel surveys in 1999, 2000, and 2001 found almost no steelhead rearing below the outlet. Most YOY steelhead observed in the surveys were 55 to 75 mm FL by August and September, when many fish moved into higher velocity areas in the channel, away from channel margins. Snorkel surveys conducted in September and October 1999 found many steelhead in the 200 to 400 mm size range. These fish apparently represent early adult returns or resident rainbows. Adipose fin-clipped steelhead were also observed among these fish. By mid-September and October, some YOY steelhead were still present, but most YOY steelhead appear to leave the system before fall of their first year. Rotary screw trapping indicates most steelhead leave before summer (Cavallo et al 2003).

American River

Historically, steelhead occurred throughout the upper reaches of the American River (McEwan and Jackson 1996). From 1850 through 1885, hydraulic mining caused the deposition of large quantities of sediment in the American River basin, silting over spawning gravel and nearly exterminating the salmon runs (Gerstung 1989, as cited in Yoshiyama et al. 1996). A series of impassable dams was constructed between 1895 and 1939. Fish ladders were later constructed around these dams, but many of them had passage problems. Access was restricted to the 27-mile reach below Old Folsom Dam after floodwater destroyed its fish ladder in 1950 (Gerstung 1971, as cited in Yoshiyama et al. 1996). Nimbus and Folsom Dams were completed in 1955 and 1956, respectively. Steelhead are now restricted to a 23-mile stretch below Nimbus Dam, although a remnant population of rainbow trout with steelhead ancestry may exist in the north fork of the American River (Dennis McEwan, personal communication, 1998).

Adult steelhead migrate into the lower American River from November through April, with peak immigration during December through March (SWRI 1997). Juvenile steelhead rear in the lower American River for one or more years and migrate out of the river during January through June (Snider and Titus 2000). Juvenile steelhead were monitored from July to October 2001 to detect the effects of warmer than normal water temperatures on steelhead abundance and distribution. Juvenile steelhead with good condition factors were found as far downstream as Paradise Beach through July and at Watt Avenue through August. Water temperatures during this period in these

areas regularly rose to above 70° F (Figure 3–9). All steelhead recaptures occurred in the same reach of the river as tagging occurred, indicating many fish remained in the same location for extended periods.

The lower American River population is supported almost entirely by Nimbus Hatchery, although natural spawning does occur (Hannon et al 2003). The hatchery produces about 400,000 steelhead yearlings annually to mitigate for Folsom and Nimbus Dam. The hatchery included Eel River steelhead in its founding stock. Genetic analysis indicates Nimbus Hatchery produced steelhead are more closely related to Eel River steelhead than other Central Valley stocks and are therefore not considered part of the Central Valley ESU (Busby et al. 1996; NOAA Fisheries 1997b).

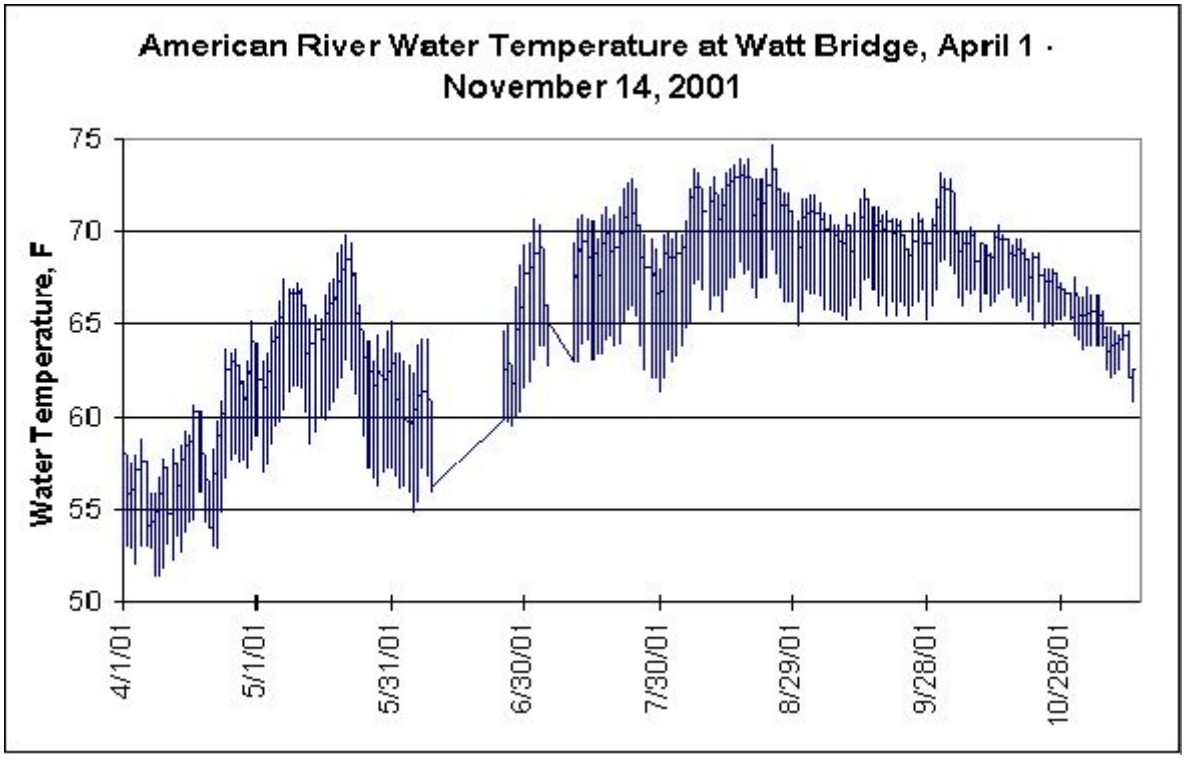


Figure 3–9 American River water temperature at Watt Avenue bridge, April 1 to November 14, 2001.

Currently, all hatchery produced steelhead are adipose clipped to identify them as hatchery fish. Occasionally a few are missed but the majority get clipped. During the 2000-01 steelhead run, the first year that marked fish began to return, 2,877 steelhead adults entered the hatchery through the fish ladder. Of these, 50 steelhead, or 1.7 percent, were not adipose clipped, indicating they came from steelhead that spawned in the river . Informal reports from anglers indicate that the percentage of unclipped (wild) fish in the river is higher than the percentage entering the hatchery. During the 2001-02 steelhead run, 1,435 steelhead entered the hatchery and 69 (4.8 percent) of those were unclipped. During the 2002 – 2003 steelhead run, 27 out of 935 (2.9 percent) of the steelhead that entered the hatchery were unclipped. Hannon and Healey (2002) conducted redd surveys in 2002 to begin an index of in-river spawning steelhead abundance. They counted 159 redds and estimated the number of in-river spawning steelhead to be 400 based on a male to female ratio of 1.52 : 1.0 (determined from fish entering the hatchery)

and one redd per female. Redd density was higher in the upper seven mile reach but redds were present down to the lowest riffle in the river at Paradise Beach. Redd depths were measured in 2001 and 2002 to assess affects from flow changes. The shallowest redds measured had 20 cm (8 inches) of water over them. Table 3–1 shows American River steelhead spawning distribution in 2002 and 2003 delineated into the reaches used in the Chinook salmon mortality model.

Table 3–1 American River steelhead spawning distribution, 2002 and 2003, (Hannon et al 2003).

	American River Steelhead redds					
Reach	**2002 redds**	**2002%**	**2003 redds**	**2003%**	**Total**	**Total %**
Above weir	no surveys		10	5%		
Nimbus to Sunrise bridge	80	51%	75	35%	165	**45%**
Sunrise to Ancil Hoffman	32	21%	52	24%	84	**23%**
Ancil Hoffman to Arden Rapids (use Goethe bike bridge)	3	2%	25	12%	28	**8%**
Arden Rapids (Goethe bridge) to Watt bridge	27	17%	51	24%	78	**21%**
Watt to Fairbairn water intake	1	1%	1	0%	2	**1%**
Fairbairn to H Street bridge	0	0%	0	0%	0	**0%**
H Street bridge to Paradise Beach	13	8%	0	0%	13	**4%**
Paradise Beach to 16th st		0%		0%	0	**0%**
16th st to Sacramento River		0%		0%	0	**0%**
Total	156	100%	214	100%	370	**100%**

Stanislaus River

Historically, steelhead distribution extended into the headwaters of the Stanislaus River (Yoshiyama et al. 1996). Dam construction and water diversion for mining and irrigation purposes began during and after the Gold Rush. Goodwin Dam, constructed in 1913, was probably the first permanent barrier to significantly affect Chinook salmon access to upstream habitat. Goodwin Dam had a fishway, but Chinook could seldom pass it. Steelhead may have been similarly affected. The original Melones Dam, completed in 1926, permanently prevented access to upstream areas for all salmonids. Currently, steelhead can ascend over 58 miles up the Stanislaus River to the base of Goodwin Dam. Although steelhead spawning locations are unknown in the Stanislaus, most is thought to occur upstream of the city of Oakdale where gradients are slightly higher and more riffle habitat is available.

The Fishery Foundation of California (Kennedy and Cannon 2002) has monitored habitat use by juvenile steelhead/rainbow since March 2000 by snorkeling seven sites from Oakdale to Goodwin Dam every other week. Steelhead fry began to show up in late March and April at upstream sites with densities increasing into June and distribution becoming more even between upstream and downstream sites through July. Beginning in August and continuing through the winter months, densities appeared highest at upstream sites (Goodwin to Knights Ferry). Age one+ fish were observed throughout the year with densities generally higher at upstream sites (Goodwin to Knights Ferry). Low densities were observed from late December until April. It is unknown whether fish left the system in December or if, with the cooler winter water temperatures, they were less active and more concealed during the day.

Since 1993, catches of juvenile steelhead/rainbow in rotary screw traps (RSTs) indicate a small portion of the Stanislaus River steelhead/rainbow population displays downstream migratory characteristics at a time that is typical of steelhead migrants elsewhere. The capture of these fish in downstream migrant traps and the advanced smolting characteristics exhibited by many of the fish indicate that some steelhead/rainbow juveniles may migrate to the ocean in spring. However,

it is not known whether the parents of these fish were anadromous or fluvial. Resident populations of steelhead/rainbow in large streams are typically fluvial (they migrate within freshwater) and migratory juveniles look much like smolts. Further work is needed to determine the parental life histories that are producing migratory juveniles. A portable weir has been proposed in the Stanislaus River near the mouth, in part to determine migration characteristics of adult steelhead/rainbow and allow scale samples to be taken to determine the extent of anadromy. Anglers captured adults up to 12 pounds in the Stanislaus in 2001.

Smolts have been captured each year since 1995 in RSTs at Caswell State Park and at Oakdale (Demko et al. 2000). Captures occurred throughout the time the traps were run, generally January through June. Most fish were between 175 and 300 mm at the Caswell site, with only six fish in seven years less than 100 mm. Larger numbers of fry were captured upstream at Oakdale. During 2001, 33 smolts were captured at Caswell and 55 were captured at Oakdale, the highest catch of all years. The higher catch in 2001 was likely due to more fish present and not better trap efficiencies (Doug Demko, personal communication, 2001). Trap efficiencies for Chinook in 2001 ranged from 5 percent to 19 percent at Caswell and from 1 percent to 30 percent at Oakdale and were generally correlated with flow. RSTs are generally not considered efficient at catching fish as large as steelhead smolts.

Genetic analysis of rainbow trout captured below Goodwin Dam show that this population has closest genetic affinities to upper Sacramento River steelhead (NOAA Fisheries 1997b).

The most consistent data available on rainbow/steelhead in the San Joaquin River is collected at the Mossdale trawl site on the lower San Joaquin River (Marston 2003). Figure 3–10 shows that counts were highest in the initial years of the Mossdale trawl survey in 1988–90.

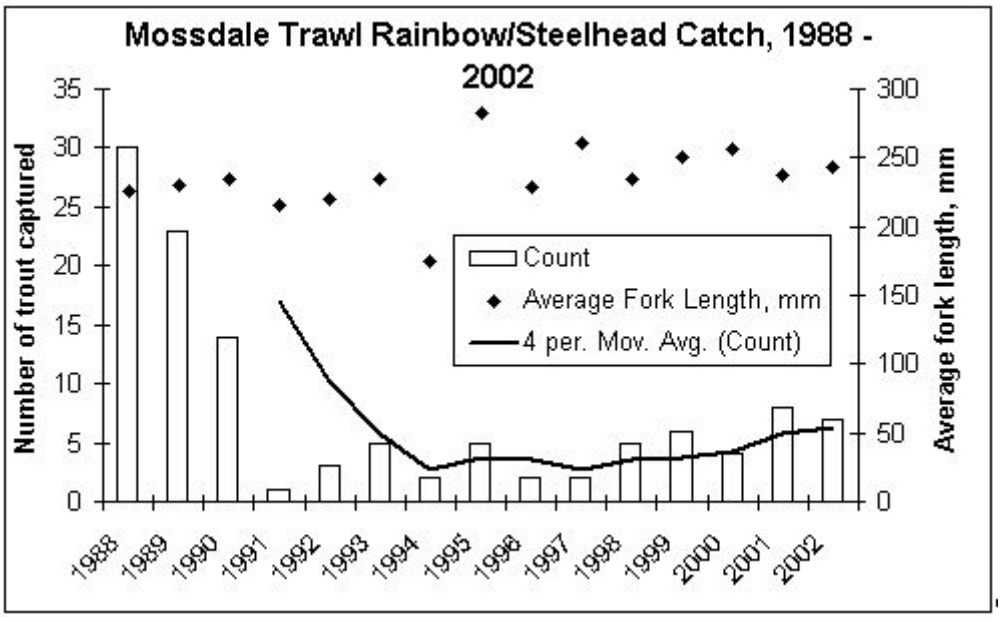


Figure 3–10 Mossdale Trawl rainbow/steelhead catch, 1988-2002 (Marston 2003).

Sacramento-San Joaquin Delta

The Delta serves as an adult and juvenile migration corridor, connecting inland habitat to the ocean. The Delta may also serve as a nursery area for juvenile steelhead (McEwan and Jackson 1996). Estuaries are important nursery grounds for other coastal steelhead populations. However, the historical and current role of the Delta as a steelhead nursery habitat is unknown. Based on fish facility salvage data (Table 3-8) most steelhead move through the delta from November through June with the peak salvage occurring during February, March, and April. The majority of steelhead salvaged range from 175 to 325 mm with the most common size in the 226 to 250 mm range (Figure 3–11). Unlcipped fish tended to have a higher proportion of larger individuals than clipped fish.

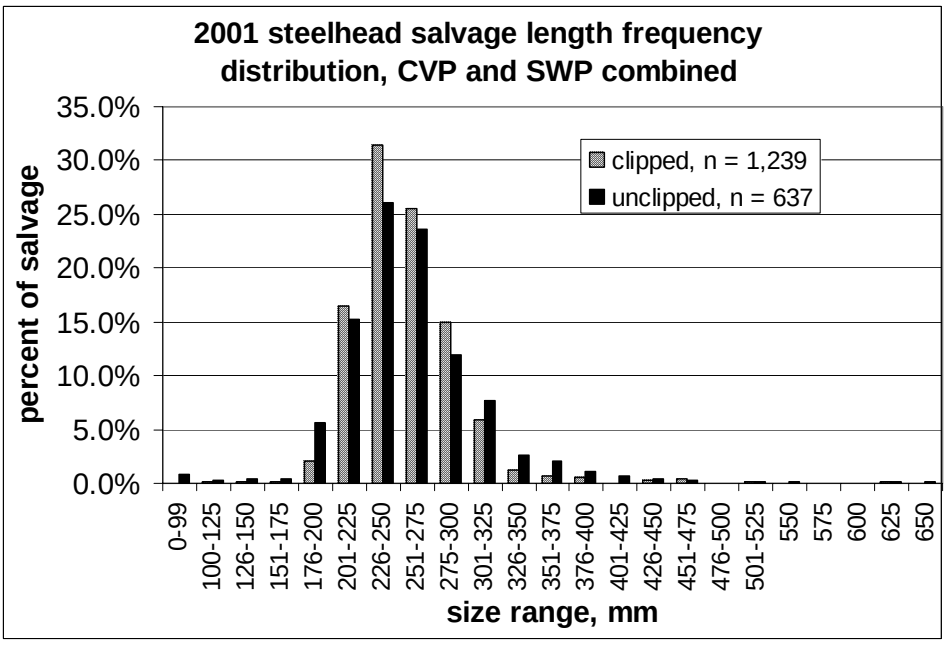


Figure 3–11 Length frequency distribution of clipped and unclipped steelhead salvaged at the CVP and SWP in 2001.

Mokelumne River

Figure 3–12 shows steelhead returns to the Mokelumne River Hatchery from 1965 to 1998. More recent returns, from 1999 through 2003 have been less than 100 steelhead each year. Recently one out of 60 (1.7%) steelhead that returned to the hatchery was unclipped.

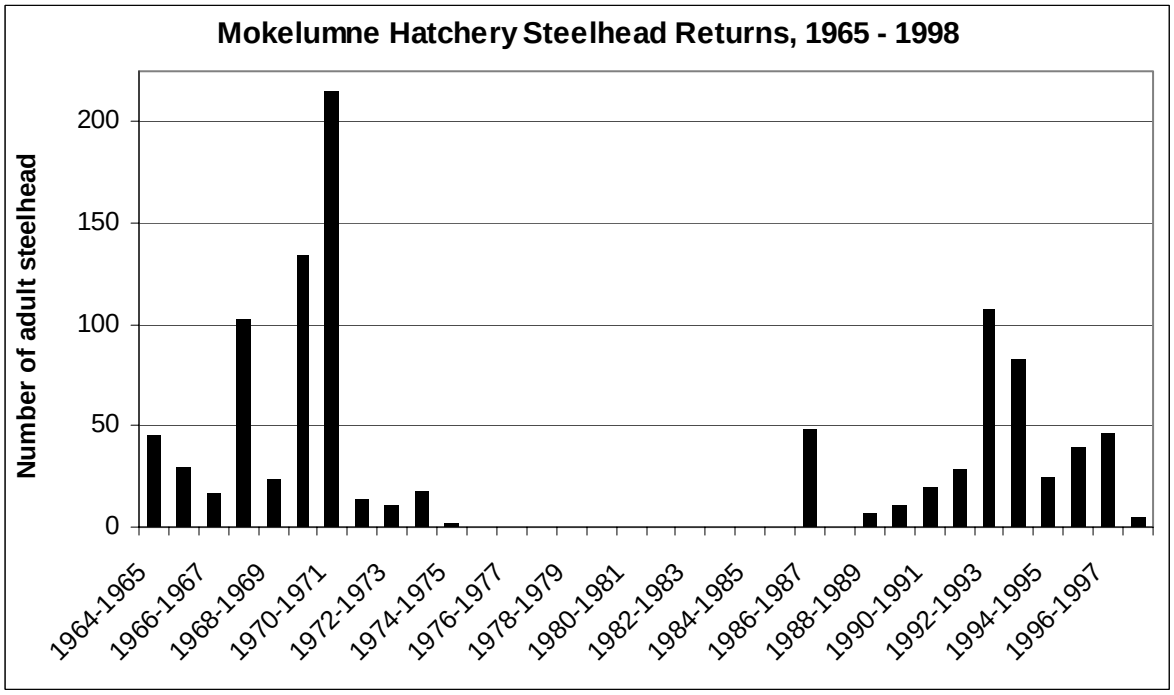


Figure 3–12 Steelhead returns to Mokelumne River Hatchery, 1965 – 1998.

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Chapter 4 Factors That May Influence Steelhead Distribution and Abundance

Water Temperature

Water temperatures that are too low or too high can kill steelhead by impairing metabolic function, or indirectly by increasing the probability of disease, predation, or other secondary mortality factors (Leitritz and Lewis 1976; Reiser and Bjornn 1979, both as cited in McEwan and Jackson 1996). Steelhead temperature tolerances vary among life stages (Bovee 1978; Reiser and Bjornn 1979; Bell 1986, all as cited in McEwan and Jackson 1996) and stocks (Myrick 1998, 2000; Nielson et al. 1994a) (Table 4–1). In this BA, temperature recommendations of McEwan and Jackson (1996) are used for all life stages except fry and juveniles, which have recently been studied using local stocks in a laboratory situation (Myrick 1998, 2000). Except for Myrick (1998, 2000), these temperature criteria are based on Pacific Northwest stocks and may not be completely representative of local strains. Additional studies to help determine the temperature needs of local strains may be conducted during the DWR's relicensing of Oroville Facilities with the FERC.

Myrick (1998, 2000) found the preferred temperatures for Mokelumne River Fish Installation, Feather River Hatchery, and naturally spawned Feather River steelhead placed into thermal gradients were between 62.5° F and 68° F (17° C and 20° C). This is considerably warmer than the rearing temperature recommended by McEwan and Jackson (1996). Feather River snorkel survey observations and temperature data from summer 1999 also appear to corroborate Myrick's (1998, 2000) results. Young of the year steelhead in the American River during August 2001 were observed in snorkel surveys, captured by seining, and PIT tagged in habitats with a daily average temperature of 72° F and a daily maximum over 74° F (DFG and USBR unpublished data).

Table 4–1 Recommended water temperatures (°F) for all life stages of steelhead in Central Valley streams from McEwan and Jackson (1996) and Myrick (1998, 2000).

Life stage	*Temperature recommendation (°F)*
Migrating adult	46–52
Holding adult	?
Spawning	39–52
Egg incubation	48–52
Juvenile rearing	<65
Smoltification	<57

Flow

Adverse effects to steelhead stocks in the Sacramento and San Joaquin Rivers have been mostly attributed to water development (McEwan and Jackson 1996). Specific examples include inadequate in stream flows caused by water diversions, rapid flow fluctuations due to water conveyance needs and flood control operations, inadequate cold water releases from upstream

reservoirs, loss of spawning and rearing habitat due to dams, and juvenile entrainment into unscreened or poorly screened water diversions.

Measures to protect and restore salmon will usually benefit steelhead. However, adequate habitat conditions must be maintained all year for steelhead to benefit. Life history differences between steelhead and Chinook salmon may also lead to different, and potentially conflicting, flow requirements for each species. While the most important flow needs for steelhead are for cold water during the summer and early fall, increased flows for Chinook salmon are typically scheduled for the spring and mid-fall migration periods. In some cases, such as the temperature criteria for winter-run Chinook from Keswick to RBDD, reservoir operations coincide with steelhead requirements. However, this is not a common situation. Differences in the timing of flow needed by different species can create difficult management dilemmas, particularly during an extended drought.

In the upper Sacramento River basin, problems of outflow and temperature are closely related (McEwan and Jackson 1996). Low summer and fall outflows can reduce the quality of steelhead rearing habitat because of associated increases in water temperature.

Sacramento River

FWS (2003) developed spawning flow-habitat relationships for steelhead spawning habitat in the Sacramento River below Keswick Dam using the Physical Habitat Simulation (PHABSIM) component of the in stream flow incremental methodology (IFIM). Relationships were developed by cross section and by stream segments but were not aggregated into river-wide flow-habitat relationships.

Steelhead spawning wetted usable area peaked at 3,250 cfs in the reach upstream of the Anderson-Cottonwood Irrigation District (ACID) Diversion Dam when the dam boards are out and when the boards are in. Between ACID dam and Cow Creek spawning area also peaked at 3,250 cfs. In the lower reach, from Cow Creek to Battle Creek, spawning area peaked at about 13,000 cfs but did not vary significantly in a flow range between about 6,000 and 14,000 cfs.

The minimum Sacramento River flow allowed is 3,250 cfs. This flow level provides adequate physical habitat to meet the needs of all steelhead life stages in the Sacramento River. Flows during the summer greatly exceed this amount to meet temperature requirements for winter-run. The winter-run temperature requirements result in water temperatures suitable for year-round rearing of steelhead in the upper Sacramento River.

Clear Creek

Denton (1986) used the IFIM to estimate optimal Clear Creek flows for salmon and steelhead. The resultant estimate of optimal flows from the IFIM study is shown in Figure 4–4. Summer-rearing habitat resulting from high water temperatures appeared to be the limiting factor for steelhead. Optimal steelhead flows in the upstream (above the former Saeltzer Dam site) reach were 87 cfs for spawning and 112 cfs for juvenile rearing. Optimum flows for steelhead in the reach below Saeltzer Dam were predicted to be 250 cfs in all months except April when they drop to 225 cfs and May 1 through 15 when they are 150 cfs. Denton (1986) recommended that tributary streamflows occurring below Whiskeytown Dam should be included in computing the

additional releases required from Whiskeytown Dam to meet the total recommended fishery flow needs.

Feather River

In 2002, DWR conducted an in stream flow incremental methodology (IFIM) habitat analysis for the lower Feather River (DWR 2004). This analysis drew on the earlier IFIM work of Sommer et al. (2001), but added an additional 24 transects and included additional fish observations. The river segments above (the low flow channel, LFC) and below (the high flow channel, HFC) were modeled separately due to their distinct channel morphology and flow regime. The WUA for steelhead spawning in the LFC had no distinct optimum over the range of flow between 150 and 1,000 cfs. However, in the HFC, a maximum WUA was observed at a flow just under 1,000 cfs. The difference in these results can be attributed to the relative scarcity of suitable steelhead spawning gravels in the LFC segment of the Feather River.

American River

FWS (1997) measured 21 cross sections of the American River in high density Chinook spawning areas. They estimated the flows at which the greatest usable spawning area would be available to steelhead and Chinook based on measurements of water velocity, water depth, and substrate size from steelhead and Chinook redds in the American River. There was low variability in weighted usable spawning area (WUA) throughout the range of flows analyzed (1,000 to 6,000 cfs). Table 4–2 shows the average of the weighted usable spawning area from the 21 cross sections expressed as 1,000 square feet of spawning area per 1,000 feet of stream. WUA for steelhead peaked at a flow of 2,400 cfs. All flows from 1,000 cfs to 4,000 cfs provided at least 84 percent of the maximum WUA.

Table 4–2 Average WUA (expressed as 1,000 square feet of spawning area per 1,000 feet of stream) from 21 cross sections measured in 1995 in high density Chinook spawning areas. Summarized from FWS 1997.

Nimbus Release (cfs)	*Steelhead Average WUA*	*Chinook Average WUA*
1000	31	62
1200	33	71
1400	34	78
1600	35	82
1800	36	84
2000	36	83
2200	36	81
2400	37	78
2600	36	74
2800	36	69
3000	36	65
3200	36	60
3400	35	56
3600	34	52
3800	32	48

Nimbus Release (cfs)	*Steelhead Average WUA*	*Chinook Average WUA*
4000	31	45
4200	29	42
4400	27	38
4600	26	36
4800	24	33
5000	23	31
5200	22	28
5400	21	26
5600	20	25
5800	19	23
6000	19	21

Snider et al. (2001) evaluated effects of flow fluctuations in the American River on steelhead and salmon. They defined flow fluctuations as unnatural rapid changes in stream flow or stage over short periods resulting from operational activities of dams and diversions. They recommended ramping flows in the American River of 100 cfs/hour or less at flows less than 4,000 cfs to reduce stranding of steelhead caused by rapid dewatering of habitat. They further recommended avoiding flow increases to 4,000 cfs or more during critical rearing periods. These are January through July for YOY salmon and steelhead, and October through March for yearling steelhead and non-natal rearing winter-run Chinook salmon, unless the higher flows can be maintained throughout the entire period. For the maintenance of sufficient spawning habitat and to keep water flowing through redds they recommended precluding flow fluctuations that decrease flow below 2,500 cfs during critical spawning periods (December through May).

Ayres Associates (2001) used detailed topography of the river to model sediment mobilization at various flows in the American River. They found that at 115,000 cfs (the highest flow modeled) particles up to 70 mm median diameter would be moved in the high density spawning areas around Sailor Bar and Sunrise Avenue. Preferred spawning gravel size is 50–125 mm (2–5 inches) in diameter.

Snider et al. (2001) produced survival indices for Chinook salmon based on number of redds v. the population estimate of outmigrating juveniles over seven years of monitoring. They found that high flows in January had the largest effect on survival according to the following equation: $\text{Survival} = 11{,}200*(\text{January maximum flow, cfs})^{-0.28}$. The higher the flow in January, the lower the survival index, although the confidence bounds in this relationship are large. January is the period with the greatest number of Chinook eggs in the gravel so supposedly the high flows are reducing survival of incubating eggs by scouring or suffocating the eggs and alevins in redds. Because steelhead spawn in similar habitat and require similar incubation conditions high flows may affect incubating steelhead eggs in a similar manner. Few attempts have been made to estimate steelhead spawning population or juvenile populations so no such relationship can be examined for steelhead.

Monitoring has shown that juvenile steelhead numbers in the river decrease throughout the summer such that the available rearing habitat is not fully seeded with fish. Therefore the rearing

population in the river is not likely limited by density dependent factors. More likely water temperature and potentially predator fish species such as striped bass limit the rearing population of steelhead in the American River. Flows of about 1,500 cfs or greater have sufficient thermal mass to maintain much of the water temperature benefits of cool Folsom releases downstream to Watt Avenue. During years with a low coldwater pool, there may not be enough cold water to last through summer and fall into the peak Chinook spawning period in November.

Stanislaus River

Aceituno (1993) applied the in stream flow incremental methodology to the Stanislaus River between Riverbank and Goodwin Dam (24 river miles) to help to determine in stream flow needs for Chinook salmon and steelhead. Table 4–3 gives the resulting in stream flow recommendations for rainbow and steelhead based on PHABSIM results. Macrohabitat conditions such as water quality, temperature, and the value of outmigration, attraction, and channel maintenance flows were not included in the analysis.

Table 4–3 In stream flows that would provide the maximum weighted usable area of habitat for rainbow trout and steelhead trout in the Stanislaus River between Goodwin Dam and Riverbank, California (Aceituno 1993).

Life stage	*In stream flow (cfs)*	
	for rainbow trout	*for steelhead*
Spawning	100	200
Fry	50	50
Juvenile	150	150
Adult	400	500

Habitat Availability

Large-scale loss of spawning and rearing habitat has been attributed as having the single greatest effect on steelhead distribution and abundance (McEwan and Jackson 1996). Historically, steelhead spawned and reared primarily in mid- to high-elevation streams where water temperatures remained suitable all year. Yoshiyama et al. (1996) estimated that 82 percent of the historical Chinook salmon spawning and rearing habitat has been lost. The percentage of habitat loss for steelhead is presumably greater, because steelhead were more extensively distributed than Chinook salmon. Steelhead could have used numerous smaller tributaries not used by Chinook salmon due to steelhead's upstream migration during periods of higher flow, superior leaping ability, ability to use a wider variety of spawning gravels, and ability to pass through shallower water. The estimated number of historical, pre-impassable dam, and post-impassable dam river miles available to steelhead in the Sacramento, Feather, American, and Stanislaus Rivers and Clear Creek is provided in Table 4–4. The extent of historical habitat is based on Chinook salmon distribution and should be considered minimum estimates for steelhead. Potential migration barriers also occur in many other streams (

Table 4–5).

Table 4–4 Estimated number of historical, pre-dam, and post-dam river miles available to steelhead (includes main stem migratory, spawning, and rearing habitat). Source: Yoshiyama et al. (1996).

	Historical	*Pre-dam*	*Post-dam*	*Lower Dam Completed*
Clear Creek	25	25	16	1963
Sacramento River	493	493	286	1945
Feather River	211	<211	67 (64)	1968
American River	161	27	23 (28)	1955
Stanislaus River	113	113	58 (46)	1912

Table 4–5 Summary of potential salmonid migration barriers on Central Valley streams. Adapted from Yoshiyama et al. (1996).

Stream[a] and passable structures	*Notes*	*First impassable barrier*	Operator
Sacramento River			
Red Bluff Diversion Dam	FB, SC, FL	Keswick Dam	Reclamation
Anderson-Cottonwood Irrigation District Diversion Dam	FB, SC, FL		ACID
Clear Creek			
		Whiskeytown Dam	Reclamation
Battle Creek			
Coleman National Fish Hatchery Weir and various PG&E dams (e.g. Wildcat)	FL[b]	Coleman South Fork Diversion Dam; Eagle Canyon Dam (being laddered as part of restoratorion program)	PG&E
Antelope Creek	DW	mouth	Edwards Ranch; Los Molinos Mutual Water Co.
Mill Creek			
Ward Diversion Dam	SC, SL, FL	Morgan Hot Spring	Los Molinos Mutual Water Co.
Clough Diversion Dam	BR		
Upper Diversion Dam	SC, SL, FL		Los Molinos Mutual Water Co.
Deer Creek			
Stanford-Vina Diversion Dam	SC, FL	Upper Deer Creek Falls	Stanford-Vina Irrigation Co.
Cone-Kimball Diversion Dam	SC, SO		Stanford-Vina Irrigation Co.
Deer Creek Irrigation Co. Diversion	SC, SO		Deer Creek Irrigation Co.

Stream[a] and passable structures	*Notes*	*First impassable barrier*	Operator
Lower and Upper Deer Creek Falls	FL		
Butte Creek			
Parrott-Phelan Diversion Dam	SC, FL	Centerville Head Dam or Quartz Bowl Barrier (barrier most years)	M&T Ranch
Durham-Mutual Diversion Dam	SC, FL		Durham-Mutual Water Co.
Gorill Diversion Dam	SC, FL		Gorrill Ranch
Adams Diversion Dam	SC, FL		Rancho Esquon Investment Co.
Butte Slough Outfall Gates			
Sanborn Slough	FL		USFWS/RD1004
East-West Weir	FL		Butte Slough ID
Weir 2	FL		DWR
Weir 5	FL, SC		Butte Slough ID
Weir 3	FL		Butte Slough ID
Weir 1	FL		USFWS
Stony Creek			
Glenn-Colusa Irrigation District Canal (Formerly a gravel berm was used, but water canal is now piped under river.)	BR	Black Butte Dam	Corps
TCCA rediversion berm (Absent during adult migration)	UN		
Orland North Canal Diversion	FB, UN		
Yuba River			
Daguerre Point Dam	UN, FL	Englebright Dam	Corps and Yuba County Water Agency
Feather River		Feather River Fish Barrier Dam	DFG
American River		Nimbus Dam	Reclamation
Putah Creek		Putah Diversion Dam	Solano County Water Agency
Yolo Bypass[c]		Fremont Weir	DWR
Mokelumne River			
Woodbridge (Lodi Lake) Dam	FL, FB	Camanche Dam	EBMUD
CVP and SWP influenced channels			
Calaveras River[d]			
Bellota Dam	UN with FB	New Hogan Dam	Corps

Stream[a] and passable structures	*Notes*	*First impassable barrier*	Operator
Stanislaus River		Goodwin Dam	Reclamation
Tuolumne River		La Grange Dam	TID
Merced River			
		Crocker-Hoffman Dam	MID
San Joaquin River			
Hill's Ferry Fish Barrier	10/1 - 12/31	Alaskan Weir	DFG
BR = breached; DW = dewatered at some point throughout the year; FB = flashboards removed during winter; FL = fish ladder; SC = screened diversion; SL = sloped dam; SO = salmon can swim over dam; and UN = unscreened diversion.	[a]	[a]	[a]
[a] Only streams with barriers are listed.			
[b] Not currently operational.			
[c] Harrell and Sommer, In press.			
[d] Tetra Tech (2001).			

Habitat Suitability

Fish Passage, Diversion and Entrainment

As described above, upstream passage of steelhead has been most severely affected by large dams blocking access to headwaters of the Sacramento and San Joaquin Rivers on most major tributaries (McEwan and Jackson 1996). The remaining areas below major dams may not have optimal habitat characteristics. For example, lower elevation rivers have substantially different flow, substrate, cover, nutrient availability, and temperature regimes than headwater streams. In addition, small dams and weirs may impede upstream migrating adults, depending on the effectiveness of fish ladders at various flows or whether the boards are removed from the weirs during the migration period. Salmonids are able to pass some of these dams and weirs under certain conditions, but studies have not been conducted to fully evaluate fish passage at all structures at all flows. In particular, there is concern that high flows over small dams and weirs may obscure the attraction flows at the mouths of the ladders, effectively blocking upstream migration (CALFED 1998).

Sacramento River

Until recently, three large-scale, upper Sacramento River diversions (RBDD, ACID, and Glenn-Colusa Irrigation District (GCID)) have been of particular concern as potential passage or entrainment problems for steelhead (McEwan and Jackson 1996). The GCID diversion is now

screened using large flat-plate screens. Operational controls in effect to protect winter-run Chinook (a reduction in diversion rate to reduce approach velocities to 0.33 feet per second (ft/s)) are likely to provide protection to steelhead as well. In addition, construction to double the screen area, increase the number of bypass structures, and provide a new downstream control structure was completed in 2001. A gradient control structure in the main stem of the river at mile 206 was completed in 2001 to provide suitable flow conditions through the side channel for operation of the diversion.

The ACID diversion dam created fish passage problems and requires a substantial reduction in Keswick Reservoir releases to adjust the dam flashboards, which can result in dewatered redds, stranded juveniles and high water temperatures. Reclamation helped modify the flash boards in the 1990s to facilitate adjustment at higher flows, reducing the risk of dewatering redds. New fish ladders and fish screens were installed around the diversion and were operated starting the summer 2001 diversion period.

Salmonid passage problems at RBDD have been well-documented (Vogel and Smith 1986; Hallock 1989; FWS 1987, 1989, 1990b; Vogel et al. 1988, all as cited in DFG 1998). Vogel (1989, as cited in DFG 1998) estimated the entrainment of young salmon from 1982 through 1987 averaged approximately 350,000 fish per year. The fish louver and bypass system originally constructed at RBDD was replaced with rotary drum screens and an improved bypass system, which began operation in April 1990. The drum screen facility was monitored to assess juvenile salmon entrainment into the Tehama-Colusa Canal through 1994 (FWS 1998). No fish were collected in monitoring efforts in 1990 to 1992 or 1994. In 1993, 33 salmon were entrained resulting in an estimated 99.99 percent screening efficiency. The drum screen facility at RBDD is highly efficient at reducing salmonid entrainment when properly operated.

Facilities improvements have been second only to the implementation of "gates-out" operation of RBDD for improving juvenile salmonid survival (FWS 1996). The RBDD gates were raised during the non-irrigation season beginning in 1986-87 to improve fish passage conditions, especially for winter-run Chinook salmon. The initial gates-out period of four months was incrementally increased to eight months by 1994-95. During the current gates-out operation (September 15 through May 14) fish passage conditions are "run of the river" and essentially all adverse effects associated with fish passage are eliminated. Water deliveries at the RBDD are limited during these eight months to diversions through a series of screened, temporary pumps and at the RBDD Research Pumping Plant (FWS 1998). Although the historical counts of juvenile steelhead passing RBDD do not differentiate steelhead from resident rainbow trout, approximately 95 percent of steelhead/rainbow trout juvenile emigrants pass during the gates-out period based on historical emigration patterns at RBDD (DFG 1993, as summarized in FWS 1998).

Immigrating adult steelhead must also negotiate RBDD to gain access to natal streams, including the upper Sacramento River, Clear Creek, and Battle Creek. Approximately 84 percent of adult steelhead immigrants pass RBDD during the gates-out period based on average run timing at RBDD. Therefore, most steelhead have had unimpeded passage past RBDD since 1994-95 (DFG 1993, as summarized in FWS 1998; Tehama-Colusa Canal Authority (TCCA) and Reclamation, 2002). Radio-tagged salmon typically are delayed up to 21 days during the gates in period, but no data specific to steelhead are available (TCCA and Reclamation, 2002).

In addition to the problems created by large-scale diversions, there are an estimated 300 smaller unscreened diversions on the Sacramento River between Keswick Dam and the Delta (McEwan and Jackson 1996) and another 2,000 or so in the Delta itself. Operation of these diversions has the potential to entrain juvenile steelhead. However, no steelhead were observed during several years of sampling agricultural diversions in the Delta (Cook and Buffaloe 1998), and only 1 steelhead was collected during a two-year study of the large Roaring River Diversion in Suisun Marsh before it was screened (Pickard et al. 1982b).

The diversions at the RBDD during the gates-out period are supplemented by rediversions of CVP water stored in Black Butte Reservoir through the Constant Head Orifice (CHO) on the Tehama-Colusa Canal. This rediversion requires the use of a temporary berm that potentially blocks upstream passage and impedes downstream passage of salmonids and creates an entrainment hazard for downstream migrating juveniles. Over 90 percent of the flow is into the CHO at peak diversions during late May, creating a significant hazard for juveniles present upstream of the diversion. Few salmonids are present above the CHO. Recent monitoring data, following installation of the GCID siphon downstream of the CHO caught few salmonids, suggesting this rediversion hazard poses little risk to salmonids. While the data are limited, it appears the salmonids move downstream to the mouth of the creek before rediversions begin, which generally coincides with the rise of temperature above 56° F (Reclamation 1998, 2002, and 2003).

The Sacramento-San Joaquin Delta

The Delta serves as a migration corridor to the upper Sacramento and San Joaquin River basins for adult and juvenile steelhead. It may also serve as a rearing habitat for juveniles that move into the Delta before they enter salt water, but this has not been studied. Presumably, one of the anthropogenic factors that may influence steelhead abundance and distribution in the Delta is CVP and SWP operations. However, little data are available to determine the extent to which CVP and SWP Delta operations affect steelhead population abundance. However, we present what little data are available as an initial assessment of potential effects.

DWR and Reclamation (1999) reported significant linear relationships exist between total monthly export (January through May) and monthly steelhead salvage at both Delta fish facilities. The months included in the analysis were based on months that steelhead consistently appeared in salvage between 1992 and 1998. Scatterplots of 1993 through 2003 CVP and SWP steelhead salvage vs exports are shown in Figure 4–1 and Figure 4–2, respectively. A generalized linear modeling approach confirmed that salvage and total monthly exports are positively correlated, at least at the SWP (Michael Chotkowski, personal communication, 2000).

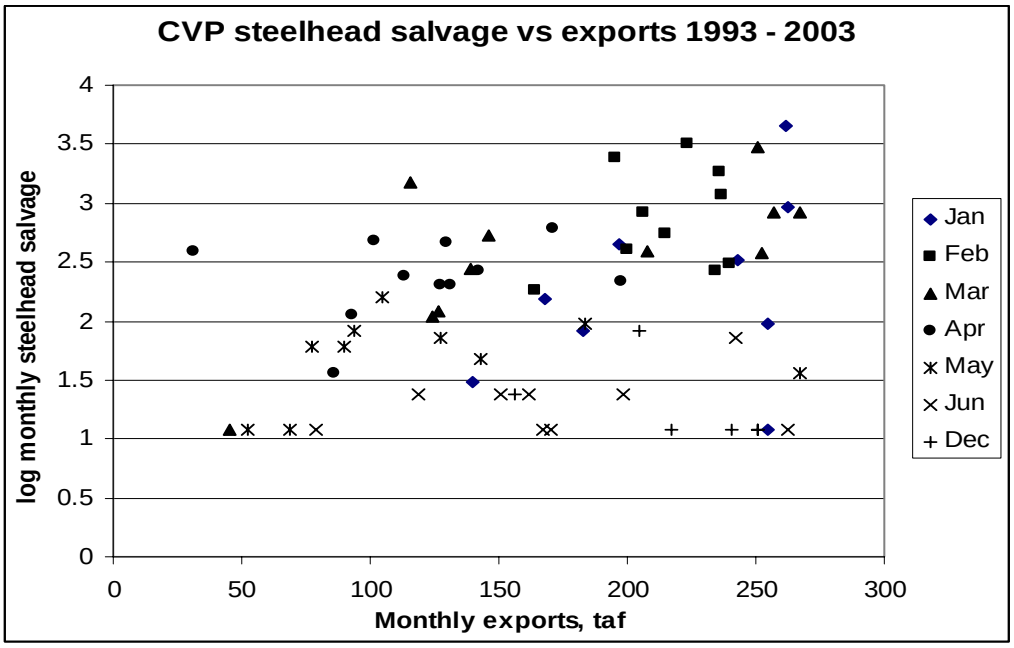

Figure 4–1 Scatterplot of total monthly CVP export in acre feet vs $\log_{10}$ total monthly CVP steelhead salvage, 1993-2003

Future take predictions based on past salvage would be highly speculative so are not attempted . There has been a general decrease in steelhead salvage since 1992 (Table 4–6). This is presumably due to changes in the timing of exports from spring to summer resulting from implementation of the Bay-Delta Accord. Alternatively it is possible that steelhead abundance has continually declined, but this seems less likely since the returns to Nimbus and Feather River Hatcheries since 1992 have not demonstrated such a decline (Figures 2–6 and 2–7). Returns to these hatcheries are not correlated to each other (Spearman $R = -0.32$, $P = 0.09$). The lack of correlation in returns to Nimbus and Feather River Hatcheries does not support the hypothesis that a single factor operating outside the river of origin, such as Delta operations, has a dominant effect on the abundance patterns of all Central Valley steelhead.

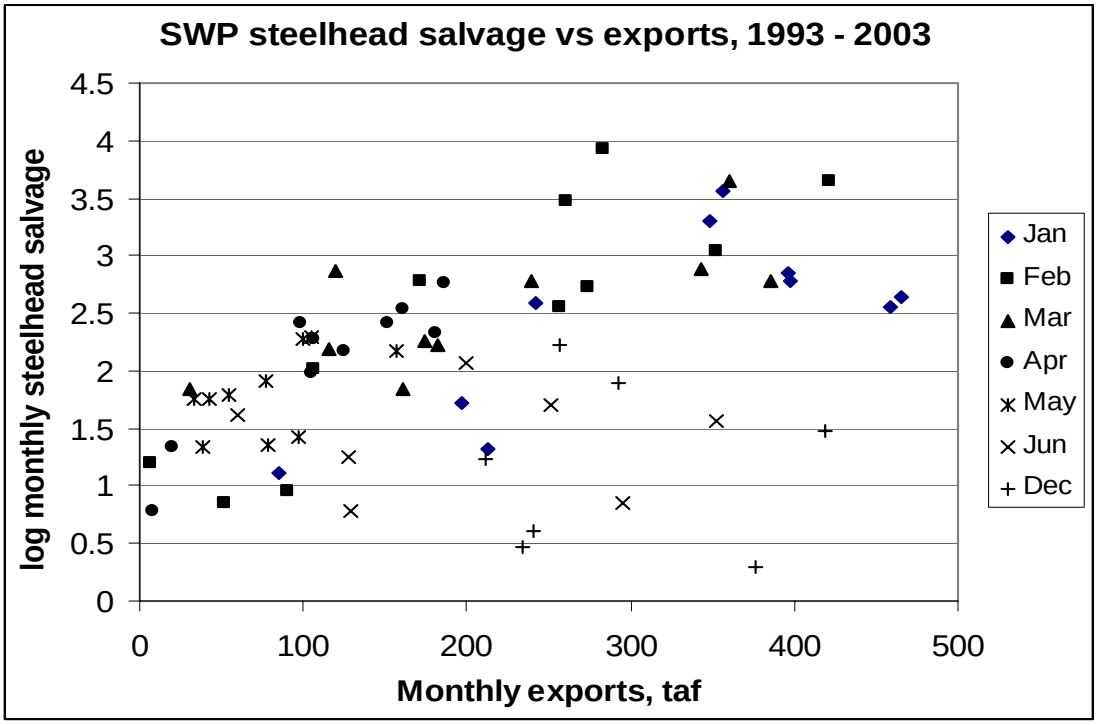

Figure 4–2 Scatterplot of total monthly SWP export in acre feet vs $\log_{10}$ total monthly SWP steelhead salvage, 1993-2003.

In addition to being correlated to amount of water exported, steelhead salvage is positively correlated to December through June CPUE of steelhead in the FWS Chipps Island Trawl (Spearman $R = 0.89$, $P = 0.02$; Figure 4–3), which we consider the best available estimate of juvenile steelhead year class strength. In other words, the Delta facilities take more steelhead when there are more steelhead. This suggests steelhead salvage at the facilities is an indicator of juvenile year class strength. A similar relationship has been found for splittail (Sommer et al. 1997). Both the steelhead and splittail relationships with salvage contrast those reported for delta smelt and longfin smelt, species whose abundance estimates are somewhat inversely correlated to salvage. Like the hatchery data presented above, the Chipps Island data, which includes both hatchery and naturally spawned juveniles, do not indicate steelhead numbers have continually declined since year-round sampling was initiated in 1994.

The currently available data suggest salvage represents small percentages of hatchery and wild steelhead smolts. The estimated percentages of hatchery smolts in combined (SWP and CVP) salvage ranged from 0.01 percent to 0.4 percent of the number released from 1998 through 2000. The estimated percentages of the wild steelhead smolt populations salvaged were higher, but were still less than 1 percent each year and ranged from 0.06 percent to 0.9 percent (Nobriga and Cadrett 2001). Typically for salmonids 1 – 2% of smolts survive to return as adults. At a 2% smolt to adult survival each steelhead smolt lost represents .02 adult or one potential adult for each 50 smolts lost at the pumps. A high percentage of the unclipped steelhead captured at the CVP salvage facility in 2003 had fin erosion indicating they were likely hatchery fish that missed getting clipped. These fish are currently counted as unclipped and assumed to be wild. Lloyd Hess (personal communication 2003) recommended updating the data sheet to include unclipped

steelhead that display physical characteristics of hatchery reared steelhead. Table 4–7 shows total salvage of unclipped steelhead from 1993 through March 2003 and Table 4–8 shows average salvage of steelhead (clipped and unclipped) from 1981 through 2002.

Table 4–6 Combined marked and unmarked steelhead salvage for the 1994 through 2002 emigration seasons (for example, 1994 = October 1993 through July 1994), and percentage of combined salvage occurring between the December through June period depicted in Figure 3-3.

Emigration season	*Combined salvage*	*Percent of salvage from December through June*
1992	18,729	100
1993	18,583	100
1994	1,594	100
1995	2,605	100
1996	5,376	100
1997	1,057	88
1998	926	82
1999	2,544	99.5
2000	9,463	96
2001	12,909	99
2002	3,590	100

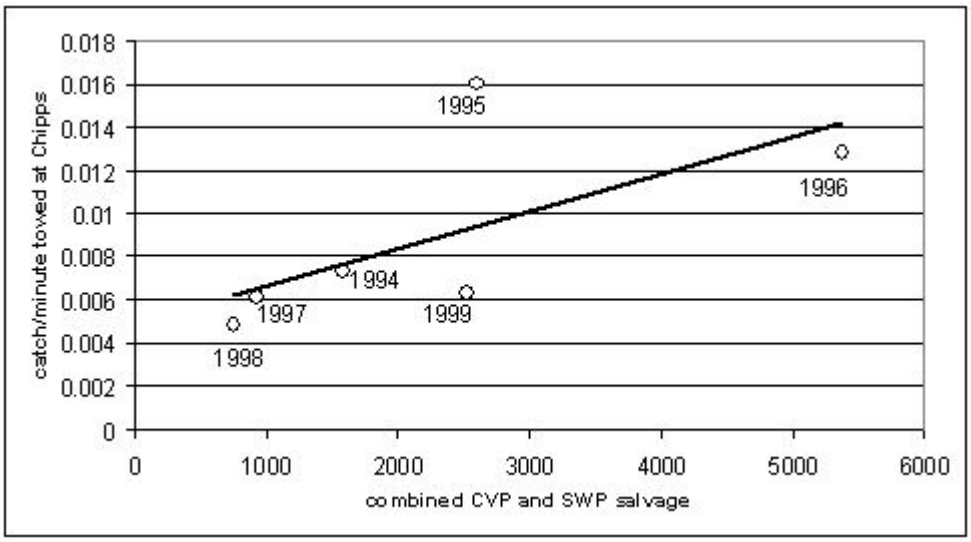

Figure 4–3 Relationship between total combined CVP and SWP steelhead salvage December through June, and December through June steelhead catch per minute trawled at Chipps Island, December 1993 through June 1999.

Table 4–7 Salvage of unclipped steelhead, 1993 - 2003 at the CVP and SWP Delta fish salvage facilities and percent of salvage adipose clipped.

Unclipped Steelhead Salvage				Percent of salvage adipose clipped		
Year	CVP	SWP	Total	CVP	SWP	combined
1993	6,864	9,673	16,537	1	4	3
1994	974	337	1,311	3	7	4
1995	1,176	993	2,169	1	3	2
1996	1,966	3,117	5,083	8	2	4
1997	564	205	769	2	11	5
1998	420	41	461	44	47	45
1999	1,426	942	2,368	5	11	7
2000	1,666	2,257	3,923	44	65	58
2001	1,637	2,834	4,471	64	65	65
2002	959	686	1,645	42	68	56
2003	929	1,245	2,174	87	78	83
Grand Total	18,581	22,329	40,910	38	42	40

Table 4–8 Average monthly total (clipped and unclipped) steelhead salvage at the Delta fish facilities, 1981-2002.

	SWP	CVP	*Total*
January	438	475	913
February	1,465	917	2,382
March	1,687	1,223	2,910
April	1,488	573	2,060
May	302	270	572
June	56	27	84
July	14	75	89
August	4	0	4
September	0	0	0
October	24	0	24
November	149	16	165
December	171	259	430

This BA may be confounded by hatchery fish, which constitute the majority of steelhead in the Central Valley. Since 1998, Central Valley hatcheries have attempted to clip the adipose fins of

all hatchery-produced steelhead, enabling us to estimate the proportion of naturally spawned steelhead smolts emigrating through the Delta. The proportions of adipose fin-clipped steelhead are shown in Table 4–7.

If hatcheries continue to clip the adipose fins of all hatchery-reared steelhead, the FWS Chipps Island Trawl may eventually also be a useful tool for devising an emigration abundance index specifically for naturally-spawned steelhead that can be compared to salvage or other potential influencing factors.

Yolo Bypass

The Yolo Bypass is the primary floodplain of the Sacramento River basin. It is a 59,000 acre leveed basin which conveys flood flows from the Sacramento Valley including the Sacramento River, Feather River, American River, Sutter Bypass and westside streams. The 40-mile long floodplain seasonally floods in winter and spring in about 60 percent of water years, when it is designed to convey up to 500,000 cfs. Under typical flood events, water spills into Yolo Bypass via Fremont Weir when Sacramento basin flows surpass approximately 75,000 cfs. Water initially passes along the eastern edge of the Bypass through the Toe Drain channel, a riparian corridor, before spreading throughout the floodplain. During dry seasons, the Toe Drain channel remains inundated as a result of tidal action. At higher levels of Sacramento Basin flow, the Sacramento Weir is also frequently operated by removal of flashboards. Westside streams such as Cache and Putah Creeks and Knight's Landing Ridge Cut may also be substantial sources of flow. The habitat types include agriculture, riparian, wetlands and permanent ponds.

DWR staff have been conducting fish studies in the Yolo Bypass for the past several years (Harrell and Sommer, In Press). They believe that Fremont Weir, the northernmost part of the Yolo Bypass, is a major impairment to fish passage in the lower Sacramento basin. The key problems are summarized below. Take authorization for the Yolo Bypass studies has already been authorized through a process separate from the OCAP.

Adult Passage During Low Flow Periods

Fyke trap monitoring by DWR since 2000 shows that adult salmon and steelhead migrate up through the Toe Drain in autumn and winter regardless of whether Fremont Weir spills (Harrell and Sommer, In Press). The Toe Drain does not extend all the way to Fremont Weir because there are several locations where the channel is blocked by roads or other higher ground. Even if the channel extended all the way to Fremont Weir, there are no facilities at the weir to pass upstream migrants at lower flows. Therefore, unless there is overflow into the Yolo Bypass, fish cannot pass Fremont Weir and migrate further upstream to reach the Sacramento River. DWR staff has evidence that this is a problem for fall-run, winter-run, and spring-run Chinook salmon and steelhead.

Adult Passage During High Flow Periods

During high flow events water spills from the Sacramento River via Fremont Weir. These flow events attract substantial numbers of upstream migrants through the Yolo Bypass corridor, which can often convey the majority of the Sacramento basin flow (Harrell and Sommer, In Press). At all but the highest flows (for example, 100,000 cfs), it appears that there is an elevation

difference between Yolo Bypass and Sacramento River at the weir. This creates a 1.5-mile long migration barrier for a variety of species, but fish with strong jumping capabilities, such as salmonids, may be able to pass the barrier at higher flows. Although there is a fish ladder (maintained by DFG) at the center of the weir, the ladder is tiny, outdated and exceptionally inefficient. Field and anecdotal evidence suggests that this creates major problems for sturgeon and sometimes salmonids. These species are attracted by high flows into the basin, and then become "concentrated" behind Fremont Weir. They are subject to heavy legal and illegal fishing pressure.

Juvenile Passage

Yolo Bypass has the potential to strand salmonids as floodwaters recede (Sommer et al. 1998). Sixty-two juvenile steelhead were captured during the 1998-99 Yolo Bypass study (58 in 1998; four in 1999) (DWR unpublished data). Twenty-four (38.7 percent) were adipose fin-clipped; 54 (87 percent) of the steelhead were captured in a RST in the Yolo Bypass Toe Drain. The remainder were captured in beach seine hauls in the scour ponds immediately below the Fremont and Sacramento Weirs.

The 1998 Yolo Bypass Toe Drain RST CPUE for steelhead is shown in Figure 4–4. The data indicate steelhead emigrate off the floodplain near the end of drainage cycles. However, small sample size, hatchery releases, and improved gear efficiency during drainage events may confound results. Stranding estimates were not attempted because steelhead were not collected in beach seine hauls outside the scour ponds mentioned above. Although 50-foot beach seines are inefficient at sampling large fish, we do not believe steelhead were stranded in large numbers. Sommer et al. (1998) found most juvenile salmon emigrated off the floodplain as it drained. In later studies, they found that young salmon grew significantly faster in Yolo Bypass than the adjacent Sacramento River, with some evidence of higher survival rates (Sommer et al. 2001). The available evidence suggests steelhead show a similar response to floodplain drainage.

The stomach contents of eight adipose fin-clipped steelhead captured during the 1998 screw trap survey were examined before they were turned over to FWS for coded-wire-tag (CWT) extraction (Table 4–9). The diet data are biased by the artificial feeding opportunities present in the screw trap live box, but they support the hypothesis that steelhead may use the Yolo Bypass as a rearing habitat since they were feeding as they emigrated.

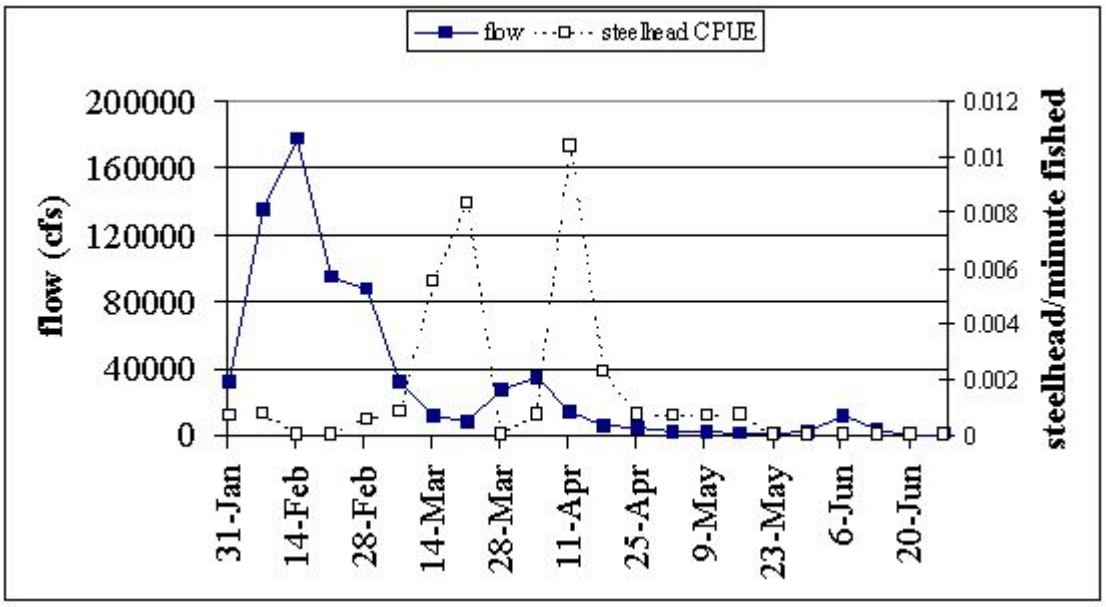

Figure 4–4 Steelhead catch per minute from the Yolo Bypass Toe Drain RST and total Yolo Bypass flow, 1998.

Table 4–9 Stomach contents of adipose fin-clipped steelhead captured in Toe Drain of Yolo Bypass 1998 (DWR unpublished data).

Collection date	*Water temperature (F)*	*Fork length (mm)*	*Stomach contents*
3/1	53	225	8 Chinook salmon (30-50 mm FL); 1 pikeminnow (50 mm FL); 1 unidentified fish; 1 dipteran pupa
3/6	52	217	Empty, but gut distended as if prey recently evacuated
3/6	52	247	4 Chinook salmon (40-50 mm FL); 2 inland silversides (70 mm FL)
3/7	51	234	Empty
3/10	55	234	Empty
3/10	55	206	Larval chironomid remains; Damselfly remains
3/10	55	238	Empty
4/17	61	208	1 damselfly nymph

Suisun Marsh Salinity Control Gates

Work completed by Edwards et al. (1996) and Tillman et al. (1996) found the Suisun Marsh Salinity Control Gages (SMSCG) have the potential to impede all four races of Chinook salmon immigrating through Montezuma Slough. However, population-level effects have not been demonstrated. No work has been completed to specifically test the effects of the SMSCG on immigrating adult steelhead, but it is reasonable to expect similar results. Information pertaining to effects of the SMSCG on Chinook salmon is presented in Chapter 5.

It is possible for SMSCG operations to affect adult steelhead immigration any time the gates are operated from September through May, given the life history of Central Valley steelhead. An evaluation of a method for minimizing gate effects through modification of the flashboards is currently in progress. Results from the first two years of the evaluation indicated that the modified flashboards were not successful in improving salmonid immigration. A third year of evaluation was conducted in 2000 in which DWR and DFG staff cooperatively and thoroughly analyzed all of the SMSCG tagging data collected to date. Following the evaluation, the regular flashboards are reinstalled as long as the gates are needed to control salinity. Based on the results showing that the modification was not successful, another solution was developed for evaluation. The modification implemented for study years 2001-03 is a continuously open boat lock, with full flashboards in when gate is operational. The effort to minimize the adverse effects of the SMSCG on salmonid immigration through Montezuma Slough is ongoing. Since the gates are operated only to meet salinity standards, avoidance measures (in other words, flashboards removed and gates out of water) are already in place during periods when the gates are not needed to control salinity.

Predation and Competition

Restriction of steelhead to main stem habitats below dams may expose eggs and rearing juveniles to higher predation rates than those encountered in historical headwater habitats (McEwan and Jackson 1996). Predatory fish are more abundant and diverse in main stem rivers than headwater streams. Thus predation loss is probably greater in main stem rivers than in the historical spawning areas (CALFED 1998). However, essentially nothing is known about predation on Central Valley steelhead. There are specific locations (e.g., dams, bridges, or diversion structures) where predation has become a significant problem for Chinook salmon (see Chapter 5 for more information). Some of these locations may also pose predation problems for rearing and migrating steelhead. During snorkel observations of juvenile steelhead in the American River, steelhead tended to hold in moderately swift currents in riffles during the summer. In most cases, adult striped bass and pikeminnows were holding within 100 feet downstream from these areas in deeper and slower moving water. When there was structure in faster currents such as bridge pilings or rootwads, adult pikeminnows were congregated in the eddies behind the structures. Steelhead were usually nearby. Anglers report that the most effective bait for stripers in the American River is a rainbow trout imitation.

Large man-made structures like diversion dams increase resting and feeding habitat for predatory fish. As an example, RBDD formerly impeded upstream passage of Sacramento pikeminnow and striped bass, resulting in increased densities of these two predators downstream of the dam. Current estimates of pikeminnow densities around RBDD were substantially lower than they

were when the gates were left in year-round although some aggregations still occur (FWS 1998). Further, pikeminnow densities around RBDD appear to be much lower than the densities found to be a problem in the Columbia River system. Gate removal during March through May, the peak pikeminnow spawning migration period, is considered important in preventing the large aggregations that previously occurred. Approximately 81 percent of adult pikeminnow immigrants should pass during the gates-out period based on average run timing at RBDD (FWS 1998).

Predation rates on fishes are usually size-dependent, with the highest level of predation incurred by smaller size classes. The available data from the FWS Chipps Island Trawl indicate an extremely small percentage of steelhead emigrate as YOY (see above). Therefore, we expect most steelhead predation occurs upstream of the Delta, where the habitat use of small size classes has been shown to be affected by the presence of potential predators (Brown and Brasher 1995) and predation risk appears to be affected by habitat use (DWR unpublished). The small percentages of YOY steelhead emigrating through the Delta would presumably face the same predation pressures as Chinook salmon smolts (Dennis McEwan, personal communication, 1998). However, steelhead were not listed as a prey item for any Delta fish by DFG (1966), even though they were more abundant at that time. The lack of steelhead in the stomachs of Delta piscivores is consistent with the observation that few steelhead emigrate as YOY, and also suggests predation pressure on the relatively large steelhead smolts migrating through the Delta may typically be low. An IEP-funded study (#2000-083 Predator-Prey Dynamics in Shallow Water Habitats of the Sacramento-San Joaquin Delta) is in progress and planned to continue. No steelhead were found in any of the 519 striped bass stomachs and 234 largemouth bass stomachs examined.

The highest ocean mortality for steelhead occurs soon after their initial ocean entry (McEwan and Jackson 1996). Predation is presumed to be the principal cause of mortality, although this has not been studied. The effect may be more substantial during El Nino years when warm water off the California coast increases the metabolic demands of predators and attracts additional piscivorous species like Pacific mackerel.

Competition for spawning space between steelhead, resident rainbow trout, and Chinook salmon can be a source of egg mortality in main stem rivers below dams. Substantial superimposition of salmon redds has been documented in the Feather River at a time of year when some steelhead may be attempting to spawn (Sommer et al. 2001a). Superimposition of salmon redds has also been documented in the upper Sacramento River below Keswick Dam (DFG 1998), and may be a problem for steelhead there as well.

Competition between steelhead and other species for limited food resources in the Pacific Ocean may be a contributing factor to declines in steelhead populations, particularly during years of low productivity (Cooper and Johnson 1992, as cited in McEwan and Jackson 1996). Pacific hake and Pacific salmon may compete with steelhead for food resources. Releases of hatchery salmonids may also increase competition and decrease survival and/or growth of hatchery and wild fish in the ocean. During years of lowered ocean productivity, smolt-to-adult survival rates indicated increased competition and mortality occurred when large numbers of hatchery and wild smolts were present together (McCarl and Rettig 1983; Peterman and Routledge 1983; McGie 1984; Lin and Williams 1988, all as cited in Pearcy 1992). Recent studies are also finding

evidence that the reduced returns of adult salmonids to streams throughout the North Pacific could be seriously limiting the input of marine derived nutrients to spawning and rearing streams (Gresh et al. 2000). The ecological importance of salmonid carcasses and surplus eggs to stream productivity and juvenile steelhead growth has recently been demonstrated experimentally (Bilby et al. 1996, 1998). Bilby et al. (1998) also presented evidence that juvenile steelhead may actively seek out areas of streams with abundant carcasses to prey on unspawned eggs.

Food Abundance in the Delta

Food supply limitation and changes to invertebrate species composition, which influence food availability for young fish in the estuary, have been suggested as factors in the decline of estuarine-dependent species such as delta smelt and striped bass (Bennett and Moyle 1996). However, food limitation for steelhead in the Delta or lower estuary has not been studied. Steelhead smolts tend to migrate through the Delta at the same time that many small Chinook are present. The abundance of the smaller Chinook likely provides a readily available food supply for outmigrating steelhead and may be an important food source during the early stages of ocean rearing.

Contaminants

The introduction of contaminants into steelhead habitat could negatively affect steelhead abundance and distribution directly or indirectly (McEwan and Jackson 1996). However, there is little direct information on individual impacts, and population-level effects are unknown.

Runoff from the Iron Mountain Mine complex into the upper Sacramento River is known to adversely affect aquatic organisms (USRFRHAC 1989). Spring Creek Dam was built to capture pollution-laden runoff from the Iron Mountain Mine complex so lethal effects of the pollutants could be attenuated by controlled releases from the reservoir. Spring Creek Reservoir has insufficient capacity to perform under all hydrologic conditions, and uncontrolled spills resulted in documented fish kills in the 1960s and 1970s. Greater releases from Shasta Reservoir are required to dilute the uncontrolled releases, diminishing storage needed to maintain adequate flows and water temperatures later in the year (McEwan and Jackson 1996).

The role of potential contaminant-related effects on steelhead survival in the Delta also has not been examined, but some common pollutants include effluent from wastewater treatment plants, and chemical discharges such as dioxin from San Francisco Bay petroleum refineries (McEwan and Jackson 1996). In addition, agricultural drainwater, another possible source of contaminants, can contribute up to 30 percent of the total inflow into the Sacramento River during the low flow period of a dry year.

During periods of low flow and high residence time of water through the Stockton deep water ship channel, high oxygen demand from algae concentrations can deplete dissolved oxygen to lethal levels. This can result in a barrier to upstream and downstream migrating steelhead and could kill steelhead present in the area of low dissolved oxygen.

Harvest

There is little information on harvest rates of Central Valley steelhead. Prior to listing in 1998, steelhead were vulnerable to over-harvest because anglers could catch them as juveniles and adults. McEwan and Jackson (1996) did not believe over-harvest had caused the overall steelhead decline, but suggested it could have been a problem in some places. For example, estimates of juvenile harvest, including hatchery produced juveniles from the American River and Battle Creek, were as high as 51 percent and 90 percent, respectively. The proportion of naturally spawned steelhead harvested and the incidence and effects of hooking mortality are unknown. Most of the steelhead sports fishing effort occurs in the American and Feather Rivers. Regulations in place since 1999 prohibit the harvest of naturally produced steelhead greater than 16 inches long.

There is no longer a commercial ocean fishery for steelhead (McEwan and Jackson 1996). However, steelhead may be caught in either unauthorized drift net fisheries, or as bycatch in other authorized fisheries such as salmon troll fisheries. Based on very limited data collected when drift net fishing was legal, the combined mortality estimates for these fisheries were between 5 percent and 30 percent. Steelhead are routinely captured and often retained for personal consumption in salmon seine fisheries in Alaska and British Columbia. McEwan and Jackson (1996) did not think these mortality estimates were high enough to explain the steelhead decline, but they could have been a contributing factor. As mentioned above, the substantial declines in marine-derived nutrients to streams due to overall salmonid declines may also affect growth and survival of juvenile salmonids (Bilby et al. 1996, 1998). Levels of ocean harvest that attempt to maximize production from a minimum of adults may exacerbate stream nutrient deficiencies (Gresh et al. 2000).

Hatcheries

Four Central Valley steelhead hatcheries (Mokelumne River, Feather River, Coleman and Nimbus Hatcheries) collectively produce approximately 1.5 million steelhead yearlings annually when all four hatcheries reach production goals (CMARP 1998). The hatchery steelhead programs originated as mitigation for the habitat lost by construction of dams. Steelhead are released at downstream locations in January and February at about four fish per pound, generally the time period that the peak of outmigration is believed to begin (Table 4–10).

Table 4–10 Production and release data for hatchery steelhead[10].

Hatchery	*River*	*Yearly production goal*	*Number released in 1999*	*Release location*
Coleman	Battle Creek	600,000 smolts	496,525	Battle Creek and Balls Ferry

10 Source: DFG and NOAA Fisheries 2001.

Hatchery	*River*	*Yearly production goal*	*Number released in 1999*	*Release location*
Feather R.	Feather	450,000 yearlings	345,810	Gridley
Nimbus	American	430,000 yearlings	400,060	Sacramento R. below American R.
Mokelumne R.	Mokelumne	100,000 yearlings[11]	102,440	Lower Mokelumne R.

The hatchery runs in the American and Mokelumne Rivers are probably highly introgressed mixtures of many exotic stocks introduced in the early days of the hatcheries (McEwan and Jackson 1996; NOAA Fisheries 1997b, 1998). Beginning in 1962, steelhead eggs were imported into Nimbus Hatchery from the Eel, Mad, upper Sacramento, and Russian Rivers and from the Washougal and Siletz Rivers in Washington and Oregon, respectively (McEwan and Nelson 1991, as cited in McEwan and Jackson 1996). Egg importation has also occurred at other Central Valley hatcheries (McEwan and Jackson 1996).

Stock introductions began at Feather River Hatchery in 1967 when steelhead eggs were imported from Nimbus Hatchery to raise as broodstock. In 1971 the first release of Nimbus-origin fish occurred. From 1975 to 1982, steelhead eggs or juveniles were imported from the American, Mad, and Klamath Rivers and the Washougal River in Washington. The last year that Nimbus-origin fish were released into the Feather River was 1988. Based on preliminary genetic assessments of Central Valley steelhead, NOAA Fisheries (1998) concluded Feather River Hatchery steelhead were part of the Central Valley ESU despite an egg importation history similar to the Nimbus Hatchery stock, which NOAA Fisheries did not consider part of the Central Valley ESU. It is possible the Feather River Hatchery stock maintained substantial genetic affinity to other Central Valley stocks because it was not completely extirpated before the construction of Feather River Hatchery, as the American River stock possibly was (Dennis McEwan, personal communication, 1999).

The concern with hatchery operations is two-fold. First, they may result in unintentional, but maladaptive genetic changes in wild steelhead stocks (McEwan and Jackson 1996). DFG believes its hatcheries take eggs and sperm from enough individuals to avoid loss of genetic diversity through inbreeding depression and genetic drift. However, artificial selection for traits that improve hatchery success (fast growth, tolerance of crowding) are not avoidable and may reduce genetic diversity and population fitness.

The second concern with hatchery operations revolves around the potential for undesirable competitive interactions between hatchery and wild stocks. Intraspecific competition between wild and artificially produced stocks can result in wild fish declines (McMichael et al. 1997, 1999). Although wild fish are presumably more adept at foraging for natural foods than hatchery reared fish, this advantage can be negated by density-dependent effects resulting from large

11 From American or Feather reared at Mokelumne.

numbers of hatchery fish released at a specific locale, as well as the larger size and more aggressive behavior of the hatchery fish.

Hallock et al. (1961, as cited in McEwan and Jackson 1996) reported that the composition of naturally produced steelhead in the population estimates for the 1953-54 through 1958-59 seasons ranged from 82 percent to 97 percent and averaged 88 percent. This probably does not reflect the present composition in the Central Valley due to continued loss of spawning and rearing habitat and increased hatchery production. During the latter 1950s, only Coleman and Nimbus Hatcheries were in operation. Today, four Central Valley steelhead hatcheries (Mokelumne River, Feather River, Coleman, and Nimbus Hatcheries) collectively produce approximately 1.5 million steelhead yearlings annually (CMARP 1998).

Current data are not available to estimate the relative abundance of naturally spawned and hatchery produced steelhead adults in the Central Valley. Since 1998 however, Central Valley hatcheries have attempted to clip the adipose fins of all hatchery-produced steelhead. This provides an opportunity to estimate the proportion of naturally spawned steelhead smolts emigrating through the Delta. Data from the FWS Chipps Island Trawl indicate the proportion of juvenile steelhead that are adipose-clipped is between 60 percent and 80 percent.

Disease and Parasites

Steelhead are presumed to be susceptible to the same diseases as Chinook salmon (Dennis McEwan, personal communication, 1998). Disease problems are often amplified under crowded hatchery conditions and by warm water. See DFG (1998) for a detailed discussion of Central Valley salmonid diseases.

Chapter 5 Basic Biology, Life History, and Baseline for Winter-run and Spring-run Chinook Salmon and Coho salmon

Status

NOAA Fisheries listed winter-run Chinook as threatened under emergency provisions of the ESA on August 4, 1989 (54 FR 32085), and formally listed the species on November 5, 1990 (55 FR 46515). The State of California listed winter-run Chinook as endangered in 1989 under the CESA. On January 4, 1994, NOAA Fisheries reclassified the winter-run Chinook as an endangered species. The Central Valley spring-run Chinook salmon ESU is listed as a threatened species under both the California and the Federal Endangered Species Acts. The State and Federal listing decisions were finalized in February 1999 and September 1999, respectively. The fall/late fall runs of Chinook salmon are proposed for listing but have not been listed. They are included in this consultation to cover Essential Fish Habitat consultation requirements as specified in the Magnuson Stevens Fisheries Conservation and Management Act as amended in 1996.

Taxonomy

Chinook salmon (*Oncorhynchus tshawytscha*) (Walbaum) is one of nine *Oncorhynchus* species distributed around the North Pacific Rim (DFG 1998). The Chinook is most closely related to the Coho salmon (*Oncorhynchus kisutch*)(Walbaum). The Chinook is physically distinguished from other salmon species by its large size (occasionally exceeding 50 lbs.), the presence of small black spots on both lobes of the caudal fin, black pigment along the base of the teeth, and a large number of pyloric cecae (Moyle 1976). The anal fin of Chinook fry and parr is not sickle shaped with the leading edge longer than the base as seen in Coho salmon fry and parr (Pollard et al. 1997). Juvenile characteristics are highly variable however, and in areas where several salmon species co-occur, reliable identification can be dependent on branchiostegal and pyloric cecae counts. The Chinook, like other Pacific salmon, is anadromous. Adults spawn in fresh water and juveniles emigrate to the ocean where they grow to adulthood. Upon their return to freshwater, adults spawn and then die. On the North American coast, spawning populations of Chinook salmon are known to be distributed from Kotzebue Sound, Alaska, to central California (Healey 1991). The southernmost populations of Chinook salmon occur in the SacramentoSan Joaquin system.

Central Valley Chinook Salmon

Chinook salmon stocks exhibit considerable variability in size and age of maturation, and at least some portion of this variation is genetically determined. The relationship between size and length of migration may also reflect the earlier timing of river entry and the cessation of feeding for Chinook salmon stocks that migrate to the upper reaches of river systems. Body size, which is correlated with age, may be an important factor in migration and redd construction success. Roni

and Quinn (1995) reported that under high density conditions on the spawning ground, natural selection may produce stocks with exceptionally large-sized returning adults.

Among Chinook salmon, two distinct types have evolved. One type, described as a "stream-type" Chinook, is found most commonly in headwater streams. Stream-type Chinook salmon have a longer freshwater residency, and perform extensive offshore migrations before returning to their natal streams in the spring or summer months. Stream-type juveniles are much more dependent on freshwater stream ecosystems because of their extended residence in these areas. A stream-type life history may be adapted to areas that are more consistently productive and less susceptible to dramatic changes in water flow allowing juveniles to survive a full year or more in freshwater and obtain a larger size prior to smolting. At the time of saltwater entry, stream-type (yearling) smolts are much larger, averaging 73 to 134 mm depending on the river system, than their ocean-type (subyearling) counterparts and are therefore able to move offshore relatively quickly. Stream-type Chinook salmon are found migrating far from the coast in the central North Pacific (Healey 1991).

The second type is called the "ocean-type" Chinook, which is commonly found in coastal streams in North America. Ocean-type Chinook typically migrate to sea within the first three months of emergence, but a few spend up to a year in freshwater prior to emigration. They also spend their ocean life in coastal waters. Ocean-type Chinook salmon return to their natal streams or rivers as spring-run, winter-run, summer-run, fall-run, and late fall-run, but summer and fall runs predominate. Ocean-type Chinook salmon tend to utilize estuaries and coastal areas more extensively for juvenile rearing. The development of the ocean-type life history strategy may have been a response to the limited carrying capacity of smaller stream systems and unproductive watersheds, or a means of avoiding the impact of seasonal floods. Ocean-type Chinook salmon tend to migrate along the coast. Populations of Chinook salmon south of the Columbia River drainage, including Central Valley stocks, appear to consist predominantly of ocean-type fish, although many Central Valley winter–run and spring–run juveniles do remain in their natal streams for up to a year.

DFG (1998) recognizes four Chinook salmon runs in the Central Valley, which are differentiated by the timing of the adult spawning migration (fall-run, late fall-run, winter-run, and spring-run Chinook salmon). NOAA F (1999) determined the four Central Valley Chinook races comprise only three distinct ESUs, the fall/late fall-run ESU, the spring-run ESU and the winter-run ESU. NOAA Fisheries (1999) determined the Central Valley spring-run Chinook salmon ESU specifically comprises fish occupying the Sacramento River basin, which enter the Sacramento River between March and July and which spawn between late August and early October.

Molecular data, including variability in multiple microsatellites (Banks et al. 2000), major histocompatibility complexes (Kim et al. 1999), and mitochondrial DNA (NOAA Fisheries 1999) have been used to demonstrate genetic distinction between Central Valley Chinook salmon ESUs. This work complements long recognized differences in life history (DFG 1998), but also adds to our understanding of Chinook salmon population genetics in the Central Valley. The historical Chinook phenotypes were differentiated by the timing of spawning migration, degree of sexual maturity when entering fresh water, spawning habitats, and to some degree by the timing of the juvenile emigration (Moyle 1976; DFG 1998). However, recent results by Banks et al. (2000) suggest the spring-run phenotype in the Central Valley is actually shown by two

genetically distinct subpopulations, Butte Creek spring-run and Deer and Mill Creeks spring-run. Spring-run acquired and maintained genetic integrity through spatio-temporal isolation from other Central Valley Chinook salmon runs. Historically, spring-run Chinook was temporally isolated from winter-run, and largely isolated in both time and space from the fall-run. As discussed below, much of this historical spatio-temporal integrity has been broken down, resulting in intermixed life history traits in many remaining habitats. The genetic characteristics of the Feather River spring-run are discussed in a later section.

Spawning

Spawning occurs in gravel beds that are often located at the tails of the holding pools (FWS 1995a, as cited in DFG 1998). Adults have been observed spawning in water 0.8 feet deep and in water velocities of 1.2 to 3.5 feet per second (Puckett and Hinton 1974, as cited in DFG 1998). Montgomery et al. (1999) reported adult Chinook tend to spawn in stream reaches characterized as low gradient pool-riffle or forced pool-riffle reaches. Like steelhead, Chinook dig a redd (nest) and deposit their eggs within the stream sediment where incubation, hatching, and subsequent emergence take place. Optimum substrate for embryos is a gravel/cobble mixture with a mean diameter of 1 to 4 inches and a composition including less than 5 percent fines (particles <0.3 inches in diameter) (Platts et al. 1979; Reiser and Bjornn 1979 both as cited in DFG 1998).

Spring-run Life History and Habitat Requirements Adult Upstream Migration, Holding and Spawning

Adult Sacramento River spring-run Chinook probably begin to leave the ocean for their upstream migration in late January to early February based on time of entry to natal tributaries (DFG 1998). Spring-run Chinook are sexually immature when they enter freshwater. Their gonads mature during the summer holding period. Adult Chinook salmon of any race do not feed in freshwater. Stored body fat reserves are used for maintenance and gonadal development. During their upstream migration, adults require sufficient streamflow to provide olfactory and other orientation cues used to locate their natal streams. Adequate streamflow is also necessary to allow adult passage to holding and spawning habitat. The timing of the spring-run migration is believed to be an adaptation that allowed the fish to use high spring outflow to gain access to upper basin areas (NOAA Fisheries 1998).

The most complete historical record of spring-run migration timing and spawning is contained in reports to the U.S. Fish Commissioners of Baird Hatchery operations on the McCloud River (Stone 1893, 1895, 1896a, 1896b, 1896c, 1898; Williams 1893, 1894; Lambson 1899, 1900, 1901, 1902, 1904, all as cited in DFG 1998). Spring-run migration in the upper Sacramento River and tributaries extended from mid-March through the end of July with a peak in late May and early June. Baird Hatchery intercepted returning adults and spawned them from mid-August through late September (Table 5–1). Peak spawning occurred during the first half of September. The average time between the end of spring-run spawning and the onset of fall-run spawning at Baird Hatchery was 32 days from 1888–1901.

Table 5–1 Dates of spring-run and fall-run Chinook salmon spawning at Baird Hatchery on the McCloud River (DFG 1998).

Year	*Spring-run*	*Fall-run*	*Reference*
1888	8/15-9/24	10/29-12/15	Stone 1893
1889	8/27-9/26	No egg take	Williams 1893
1890	8/15-9/23	11/6-11/25	Williams 1893
1891	8/31-9/19	10/30-11/10	Williams 1894
1892	8/13-9/12	10/20-11/26	Stone 1895
1893	8/22-9/15	10/21-11/28	Stone 1896
1894	8/24-9/30	10/22-11/23	Stone 1896
1895	8/26-9/30	10/18-11/14	Stone 1896
1896	8/2-9/20	No egg take	Stone 1898
1897	8/14-9/20	10/8-12/8	Lambson 1897
1898	8/15-9/17	11/5-12/27	Lambson 1900
1899	8/21-9/27	10/18-11/9	Lambson 1901
1900	8/18-9/22	No egg take	Lambson 1902
1901	8/16-9/25	10/25-11/25	Lambson 1904

Adult Holding

Spring-run may hold in their natal tributaries for up to several months before spawning (DFG 1998). Pools in the holding areas need to be sufficiently deep, cool, and oxygenated to allow over-summer survival. Adults tend to hold in pools in close proximity to quality spawning gravel. DFG (1998) characterized these holding pools as having moderate water velocities (0.5-1.3 feet per second) and cover such as bubble curtains.

Spawning

Spawning occurs in gravel beds that are often located at the tails of the holding pools (FWS 1995a, as cited in DFG 1998). Adult Chinook have been observed spawning in water >0.8 feet deep and in water velocities of 1.2 to 3.5 feet per second (Puckett and Hinton 1974, as cited in DFG 1998). Montgomery et al. (1999) reported adult Chinook tend to spawn in stream reaches characterized as low gradient pool-riffle or forced pool-riffle reaches. Like steelhead, Chinook dig a redd (nest) and deposit their eggs within the stream sediment where incubation, hatching, and subsequent emergence take place. Optimum substrate for embryos is a gravel/cobble mixture with a mean diameter of 1 to 4 inches and a composition including less than 5 percent fines (particles <0.3 inches in diameter) (Platts et al. 1979; Reiser and Bjornn 1979 both as cited in DFG 1998).

Currently, adult Chinook that DFG considers spring-run, spawn from mid- to late August through early October, with peak spawning times varying among locations (Figure 5–1). For instance, in Deer Creek spawning begins first at higher elevations, which are the coolest reaches. Spawning occurs progressively later in the season at lower elevations as temperatures cool (Harvey 1995, 1996, 1997, all as cited in DFG 1998).

Sex and Age Structure

Fisher (1994) reported 87 percent of spring-run adults are three-year-olds based on observations of adult Chinook salmon trapped and examined at RBDD between 1985-1991. Studies of coded wire tagged Feather River Hatchery spring-run recovered in the ocean fishery indicated harvest rates average 18 percent to 22 percent for age-three fish, 57 percent to 85 percent for age-four fish, and 97 percent to 100 percent for age-five fish (DFG 1998). These data are consistent with Fisher's (1994) finding that most of the spawning population is three-year-olds.

Fecundity

DFG (1998) developed a regression model to predict Sacramento River Chinook fecundity from fork length. Using this model they estimated Central Valley spring-run fecundity ranged from 1,350 to 7,193 eggs per female, with a weighted average of 4,161. These values are very similar to the fecundity of spring-run estimated for the Baird Hatchery in the latter 19th century using the number of females spawned and total egg take. Baird Hatchery estimates ranged from 3,278 to 4,896 eggs and averaged 4,159 between 1877 and 1901.

Egg and Larval Incubation

Egg survival rates are dependent on water temperature. Chinook salmon eggs had highest survival in the American River when water temperatures were 53° F to 54° F (Hinze et al. 1959, as cited in Boles et al. 1988). Incubating eggs from the Sacramento River showed reduced viability and increased mortality at temperatures greater than 58° F , and suffered 100 percent mortality at temperatures greater than 65° F (Seymour 1956 as cited in Boles et al. 1988). Velson (1987) (as cited in DFG 1998) found developing Chinook salmon embryos also experienced 100 percent mortality at temperatures less than or equal to 35° F . The time for incubating eggs to reach specific embryonic developmental stages is determined by water temperature. At an incubation temperature of 56° F, eggs would be in the gravel approximately 70 days. Chinook eggs and alevins are in the gravel (spawning to emergence) for 900 to 1,000 accumulated temperature units. One accumulated temperature unit is equal to a temperature of 1° C for one day. Expressed in degrees fahrenheit the range is 1,652 to 1,832 accumulated temperature units.

Juvenile Rearing and Emigration

Juvenile spring-run rear in natal tributaries, the Sacramento River main stem, non-natal tributaries to the Sacramento River, and the Delta (DFG 1998). Emigration timing is highly variable (Figure 5–1). Juvenile spring-run from Mill and Deer Creeks are thought to emigrate as yearlings in greater proportions than spring-run from other tributaries (DFG 1998).

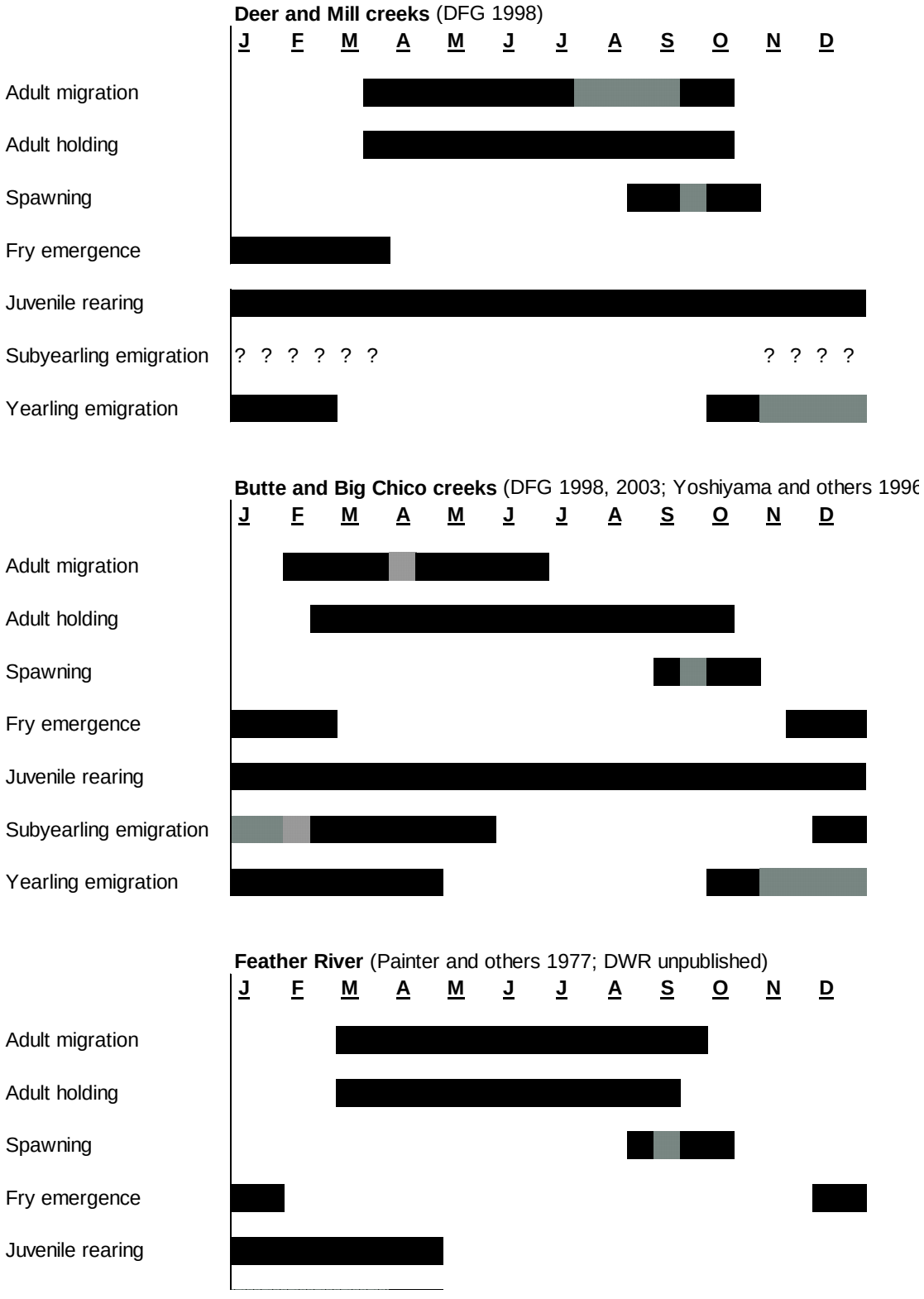

Figure 5–1 Spring-run Chinook salmon life cycle for various Central Valley streams. Cross hatching indicates period of peak occurrence.

This was apparently not the typical historical emigration pattern for the majority of Central Valley spring-run Chinook (NOAA Fisheries 1998). Yearling emigration occurs from October-March and may be triggered in part by precipitation events. In some years however, under certain flow and/or water temperature conditions, greater proportions of juveniles in Mill and Deer Creeks may emigrate as fry or fingerlings soon after emergence. The bulk of Butte and Big Chico Creek production emigrates as fry from natal tributaries in December and January (Brown 1995 as cited in DFG 1998). Some also emigrate as fingerlings from February through May, and as yearlings from October through February. In contrast, no yearling emigration has been detected in the Feather River (DWR 1999c, 1999d).

Juvenile rearing habitat must provide adequate space, cover, and food supply (DFG 1998). Optimal upstream habitat includes abundant in stream and overhead cover (for example, undercut banks, submergent and emergent vegetation, logs, roots, other woody debris, and dense overhead vegetation) to provide refuge from predators, and a sustained, abundant supply of invertebrate and larval fish prey. Further downstream, fry use low velocity areas where substrate irregularities and other habitat features create velocity refuges and they may increasingly rely on turbidity as cover (Gregory and Levings 1998).

Juvenile Chinook, including spring-run also rear in ephemeral habitats including the lower reaches of small intermittent streams (Maslin et al. 1997) and in floodplain areas (Sommer et al. 2001b). Growth rates and mean condition factors were higher for juvenile Chinook rearing in intermittent tributaries than in the heavily channelized Sacramento River (Moore 1997). Similarly, growth rates and bioenergetic status was found to be significantly higher for juvenile Chinook rearing in the intermittent habitat of the Yolo Bypass floodplain than in the adjacent reach of the Sacramento River (Sommer et al. 2001b). These results highlight the importance of off-channel habitats to young Central Valley salmon.

It is not known how similar the rearing patterns of Central Valley spring-run are to the fall-run since the Delta rearing patterns of spring-run Chinook have not been studied. Juvenile emigration is thought to alternate between active movement, resting, and feeding. The amounts of time spent doing each are unknown (DFG 1998), but studies have generally shown feeding is most intense during daylight or crepuscular periods (Sagar and Glova 1988). Juvenile outmigration monitoring results from throughout the Central Valley and elsewhere indicate active emigration is most prevalent at night. Juvenile fall-run salmon may rear for up to several months within the Delta before ocean entry (Kjelson et al. 1982). Rearing within the Delta occurs principally in tidal fresh water habitats. Juveniles typically do not move into brackish water until they have undergone smoltification, after which NOAA Fisheries studies indicate they move quickly to the ocean.

Chironomidae (midges) are typically cited as an important prey for juvenile Chinook upstream of the Delta (Sasaki 1966; Merz and Vanicek 1996; Moore 1997; Sommer et al. 2001b), whereas crustaceans may be more important in the western Delta (Sasaki 1966; Kjelson et al. 1982). Juvenile Chinook diets often vary by habitat type, resulting in differences in caloric intake and growth rate (Rondorf et al. 1990; Moore 1997; Sommer et al. 2001b). However, it remains unclear whether these spatial differences in feeding and growth translate into improved survival (Sommer et al. 2001b).

Before entering the ocean, juvenile Chinook undergo smoltification, a physiologic transformation that prepares them for the transition to salt water (Moyle 1976). The transformation includes lowered swimming stamina and increased buoyancy, which make the fish more likely to be passively transported by currents (Saunders 1965, Folmar and Dickhoff 1980, Smith 1982, all as cited in DFG 1998). It is believed to be optimal for smoltification to be completed as fish near the low salinity zone of an estuary (DFG 1998). Too long a migration delay after the process begins may cause the fish to miss a biological window of optimal physiological condition for the transition (Walters et al. 1978, as cited in DFG 1998). Chinook salmon that complete the juvenile and smolt phases in the 50° F to 64° F range are optimally prepared for saltwater survival (Myrick and Cech 2001). The optimal thermal range during smoltification and seaward migration was estimated to be 50° F to 55° F (Boles et al. 1988), based largely on studies of steelhead and Coho salmon in the Northwest.

Ocean Distribution

CWT recoveries from harvested hatchery released spring–run provide information on ocean distribution and harvest of adult spring–run. Table 5–2 shows that most recoveries of hatchery released spring–run (all from Feather River Hatchery) occur off the California Coast but some do occur along the Oregon Coast. Recent CWT studies conducted on Butte Creek spring-run have shown 12% in the Garibaldi to Coos Bay area, 14% Crescent City to Fort Bragg, 44% Fort Ross to Santa Cruz, and 30% Monterey to Point Sur (DFG 2003).

Table 5–2 Recovery locations of hatchery released spring-run and estimated number recovered, 1978 – 2002 (RMIS database). All are from the Feathery River Hatchery. Location identifiers with less than 8 recoveries (48 of them) are not shown.

Sum of estimated_number	run_year																					
recovery_location_name	1978	1979	1980	1981	1983	1984	1985	1986	1987	1988	1989	1990	1993	1994	1995	1996	1998	1999	2000	2001	2002	Grand Total	percentag
FORT ROSS-PIGEON PT	787	1,981	539	51	12	177	248	400	412	488	404		11	96	236	8	129	568	430			6,976	23.3%
FEATHER RIVER																			414	42	4,412	4,867	16.2%
PIGEON PT.-POINT SUR	159	478	219	14		116	33	375	320	260	186	17		5	216	22		244	970	744	315	4,693	15.7%
FEATHER R HATCHERY																			342	749	420	1,511	5.0%
NEWPORT TROLL 4						6	3	60	58	104	66				60	6		37	63	773	236	1,470	4.9%
PT.REYES-PIGEON PT.																				631	829	1,460	4.9%
C.VIZCAINO-NAVARR.HD	87	424	71	8		9	16	84	15	140	24				6	5		11	23	57	89	1,068	3.6%
FORT ROSS-POINT SUR											139	10		24	45			551	280			1,049	3.5%
COOS BAY TROLL 5						5	18	106	60	118	58	4						107	108	298	108	989	3.3%
POINT SUR-CA/MEX.BOR						4		141	95	60				10	168	3			146	76	41	744	2.5%
PT.ARENA-PT.REYES																				476	239	715	2.4%
SPAN.FLAT-C.VIZCAINO						15	18	81	85	149	44	3			3			14	33	60	55	560	1.9%
BIG LAG.-CENTERV.BEA	8	147	15		3		20	11	53	3	18	3			5			35	29	54	33	438	1.5%
NAVARRO HD-FORT ROSS							5	32	154	44	11			2					2			249	0.8%
COLUSA TO RBDD																				239		239	0.8%
GARIBALDI TROLL 3								14	11	10	5				12			15	19	94	38	218	0.7%
AMERICAN RIVER																			43		126	169	0.6%
SPAN.FLAT-PT.ARENA																				32	135	167	0.6%
CA/OR BOR-FA.KLAM.RC	18	20	4	4		31	17	6	14	8	16								14	5		157	0.5%
WINCHESTER B TROLL 5							4	29	15	33	18							11	12	25	5	153	0.5%
LOW FLOW AREA																				153		153	0.5%
WINCHESTER B SPORT 5					4		3		14	26	2								10	56	29	144	0.5%
BROOKINGS SPORT 6					3	2	22	3	28	27	4	2				2		3	7	18	21	142	0.5%
NAVARRO HD-PIGEON PT										40	66											106	0.4%
PIGEON PT-CA/MEX.BOR															11			2	38		37	88	0.3%
MARINE AREA 2						1	6	9	10	19	2						3	19		9	8	85	0.3%
AMER.R. TO COLUSA																				40	40	80	0.3%
SIUSLAW BAY TROLL 5									12	29	14							10	6			71	0.2%
HIGH FLOW AREA																				66		66	0.2%
SPAN.FLAT-NAVARRO HD										41	11								8			60	0.2%
PORT ORFORD TROLL 5								3	3	1	5							5	2	23	11	53	0.2%
C.VIZCAINO-FORT ROSS										28	10							13				50	0.2%
CA/OR BDR.- HMBT.JET																				27	21	48	0.2%
PT.REYES-PT.SUR																				40	4	44	0.1%
NEWPORT TROLL 5							1		11		1							2	3	12	13	44	0.1%
MARINE AREA 4									4	7	3	3						12	3	7	2	40	0.1%
BROOKINGS TROLL 6								12	9	4				2				6	2	3		38	0.1%
NEWPORT SPORT 4					3		3	3											6	12	7	34	0.1%
COOS BAY TROLL	6	17	11																			34	0.1%
BROOKINGS TROLL		30		2																		32	0.1%
BATTLE CREEK																				17	15	32	0.1%
COOS BAY SPORT 5								4		4									5	4	15	32	0.1%
ASTORIA TROLL 2							2	5		9										10		27	0.1%
MARINE AREA 1	4	3						5		3								3			7	25	0.1%
YUBA RIVER																			2		21	23	0.1%
COOS BAY TROLL 4															7					10	4	22	0.1%
PT.ARENA-PIGEON PT.																					20	20	0.1%
ASTORIA SPORT 2																				15	4	19	0.1%
PT.SN.PEDRO-PIGN.PT.																				6	14	19	0.1%
NEWPORT TROLL		19																				19	0.1%
RBDD TO ACID																				18		18	0.1%
TEHAMA-COLUSA FF		4	8	2		1	2															17	0.1%
NEWPORT TROLL 3								2	1		6									5	3	17	0.1%
WSPT LONG BE											14							3				17	0.1%
1A PLUS 1B										16												16	0.1%
DEPOE BAY SPORT 4								2	2	2								1			10	16	0.1%
FLORENCE SPORT 5									4	9	2											15	0.0%
SWTR 114-000						8				4												13	0.0%
1A (BUOY10 - BRIDGE)																				6	6	12	0.0%
WSPT CREE IS																			12			12	0.0%
OCEAN SPORT AREA 72						4			4	2												10	0.0%
MARINE AREA 3										9								1				10	0.0%
FA.KLA.RC-BIG LAGOON										10												10	0.0%
SWTR 111-000										10												10	0.0%
CLEAR CREEK																				7	3	9	0.0%
PACIFIC CITY TROLL 3									3	6												9	0.0%
SWTR 021-000						9																9	0.0%
HIGH SEAS 1 47N 124W																			9			9	0.0%
MARINE AREA 5 TROLL									7	2												8	0.0%
SWTR 023-234						8																8	0.0%
COLEMAN NFH			1						5	2												8	0.0%
OCEAN SPORT AREA 82							3		2		2											8	0.0%
NWTR 025-000										4								4				7	0.0%

Winter–run Life History and Habitat Requirements

The following information on winter-run Chinook salmon biology is from the proposed winter-run Chinook recovery plan (NOAA Fisheries 1997).

Adult winter–run Chinook salmon return to freshwater during the winter but delay spawning until the spring and summer. Juveniles spend about five to nine months in the river and estuary systems before entering the ocean. This life history pattern differentiates the winter–run Chinook from other Sacramento River Chinook runs and from all other populations within the range of Chinook salmon (Hallock and Fisher 1985, Vogel 1985, DFG 1989).

In addition to their unique life history patterns, the behavior of winter-run Chinook adults as they return to spawn differentiates the population. Adults enter freshwater in an immature reproductive state similar to spring-run Chinook, but winter-run Chinook move upstream much more quickly and then hold in the cool waters below Keswick Dam for an extended period before spawning (Moyle et al. 1989.)

The habitat characteristics in areas where winter-run adults historically spawned suggest unique adaptations by the population. Before construction of Shasta Dam, winter-run Chinook spawned in the headwaters of the McCloud, Pit, and Little Sacramento Rivers and Hat Creek as did spring-run Chinook salmon. Scofield (1900) reported that salmon arriving "earlier" than spring-run (presumable winter–run) ascended Pit River Falls and entered the Fall River while the succeeding spring-run Chinook remained to spawn in the waters below. This implies that winter-run Chinook, unlike the other runs, ascended to the highest portions of theheadwaters, and into streams fed mainly by the flow of constant-temperature springs arising from the lavas around Mount Shasta and Mount Lassen. These headwater areas probably provided winter-run Chinook with the only available cool, stable temperatures for successful incubation over the summer (Slater 1963).

Adult Spawning Migration and Distribution

Sacramento River winter-run Chinook salmon enter San Francisco Bay from November through May or June. Their migration past RBDD at river mile 242 begins in mid-December and continues into early August. The majority of the run passes RBDD between January and May, with the peak in mid-March (Hallock and Fisher 1985). In general, winter-run Chinook spawn in the area from Redding downstream to Tehama. However, the spawning distribution, as determined by aerial redd surveys is somewhat dependent on both the operation of the gates at RBDD, river flow, and probably temperature. At present, winter-run Chinook salmon are found only in the Sacramento River below Keswick Dam.

Timing of spawning and fry emergence

Winter-run Chinook spawn from late-April through mid-August with peak spawning in May and June. Fry emergence occurs from mid-June through mid-October. Once fry emerge, storm events may cause en masse emigration pulses. Martin et al. (2001) evaluated brood years (BYs) 1995-99 and found that emergence began in July during all BYs with peak dispersal occurring in September.

Juvenile Emigration

During 1995-1999 the pre-smolt/smolt emigration (> 45 mm fork length) started in September with 100 percent of production passing RBDD two to three months prior to the next BY. Between 44 and 81 percent of winter-run production used areas below RBDD for nursery habitat and the relative utilization above and below RBDD appeared to be influenced by river discharge during fry emergence (Martinet al.,2001). Emigration past Red Bluff (RM 242) may begin in late July, generally peaks in September, and can continue until mid-March in drier years (Vogel and Marine 1991). They are found above Deer Creek from July through September and spread downstream to Princeton (RM 164) between October and March (Johnsonet al.,1992). The peak emigration of winter-run through the Delta generally occurs from January through April, but the range of emigration may extend from September up to June. Distinct emigration pulses appear to coincide with high precipitation and increased turbidity (Hood 1990).

Scale analysis indicates that winter-run Chinook smolts enter the ocean at an average FL of about 118 mm, while fall-run smolts average about 85 mm FL (DFG unpublished data). This suggests that winter-run juveniles reside in fresh and estuarine waters for five to nine months, exceeding freshwater residence of fall-run Chinook by two to four months.

It is believed that winter-run Chinook salmon, like all Central Valley Chinook, remain localized primarily in California coastal waters. Coded wire tag returns indicate that only 4 percent of winter–run hatchery production recoveries from ocean waters occurred in Oregon (RMIS database).

Historical and Current Distribution and Abundance of Winter-run Chinook Salmon

The following is a summary of original winter–run distribution from Yoshiyama et al. (2001). The winter–run, unique to the Central Valley (Healey 1991), originally existed in the upper Sacramento River system (Little Sacramento, Pit, McCloud and Fall Rivers) and in Battle Creek. There is no evidence that winter runs naturally occurred in any of the other major drainages before the era of watershed development for hydroelectric and irrigation projects. The winter–run typically ascended far up the drainages to the headwaters (CFC 1890). All streams in which winter–run were known to exist were fed by cool, constant springs that provided the flows and low temperatures required for spawning, incubation, and rearing during the summer season (Slater 1963) when most streams typically had low flows and elevated temperatures.

Access to approximately 58 percent of the original winter–run habitat has been blocked by dam construction (Table 5–3). The remaining accessible habitat occurs in the Sacramento River below Keswick Dam and in Battle Creek. Access to all of the original winter-run spawning habitat in the Sacramento River was blocked by Shasta and Keswick Dams. The population now spawns downstream of Keswick Dam. Until recent years, salmon passage was not allowed above the Coleman Hatchery barrier weir. In recent years there have been no winter–run spawning in Battle Creek. All winter–run production occurs in the Sacramento River (DFG 2003).

Table 5–3 Historical upstream limits of winter–run Chinook salmon in the California Central Valley drainage (from Yoshiyama et al. 2001).

Stream	*Upstream distributional limit*	Miles of stream historically available	Miles of stream currently available	Miles lost	Percent lost
Mainsteam Sacramento River	none	299	286	13	4
Pit River	Mouth of Fall River	99	0	99	100
Fall River	Source springs near Dana, about 9 miles above mouth				
McCloud River	Lower McCloud Falls	50	0	50	100
Upper (Little) Sacramento River	Vicinity of Box Canyon Dam (Mt. Shasta City) and Lake Siskiyou (Box Canyon Reservoir)	52	0	52	100
Battle Creek North Fork	Falls 3 miles above Volta Powerhouse	43	43[a]	0	0
Digger Creek	Vicinity of Manton, possibly higher				
South Fork	Falls near highway 36 crossing				
Total		543	329	214	39

[a] Yoshiyama et al. (2001) lists Battle Creek as having unobstructed passage for winter–run but according to Kier Associates (2000) the fish ladders around existing dams are ineffective and need replacement. Length of habitat below/above the lower barriers was not given.

Most of the winter–run production occurs in the Sacramento River. Yearly winter–run escapement is estimated by counts in traps at the top of fish ladders at RBDD (Figure 5–2). These counts show recent escapements are much reduced from escapements in the 1960s and 1970s. In recent years carcass escapement counts have been compared to ladder counts. The population estimates from carcass counts (Peterson estimates) showed higher numbers of winter–run than the ladder counts (Martin et al. 2001).

The Cohort Replacment Rate (CRR) is a parameter used to describe the number of future spawners produced by each spawner and is thus a measure of whether the population is increasing or decreasing. This spawner-to-spawner ratio is defined as the number of naturally produced and naturally spawning adults in one generation divided by the number of naturally spawning adults (regardless of parentage) in the previous generation. As such, the ratio describes the rate at which each subsequent generation, or cohort, replaces the previous one, and can be

described as a natural CRR. When this rate is 1.0, the subsequent cohort exactly replaces the parental cohort and the population is in equilibrium, neither increasing or decreasing. When the rate is less than 1.0, subsequent cohorts fail to fully replace their parents and abundance declines. If the ratio is greater than 1.0, there is a net increase in the number of fish surviving to reproduce naturally in each generation and abundance increases.

Figure 5–3 shows that winter–run CRRs were generally less than one from 1967–90, i.e., the population was declining. CRRs have been greater than one every year since 1990 except 1998, indicating a generally increasing population in recent years. For these calculations, the escapement returns from each BY in subsequent years were divided by the total escapement in each parent BY. For any BY, the subsequent year class produced returned two years later as grilse, and three and four years later as adults. The calculations assumed that 5 percent of the adult returns were four-year olds, and 95 percent of adult returns were three-year olds, an average based on 2001 winter-run scale aging data (Alice Low, personal communication, 2002).

The number of grilse in the population is probably over-estimated in the current RBDD counts. Current RBDD estimates are based on the late portion of the run, passing the dam after May 15 when the dam gates are closed. Historically, when dam counts were made year-round, there was a greater proportion of grilse in the later portion of the run. The proportion of grilse tends to be highly variable from year to year. The carcass count escapement data is believed to provide better abundance estimates, but there is not enough carcass survey data yet to draw any conclusions. Table 5–4 shows a comparison between RBDD fish ladder counts and carcass counts.

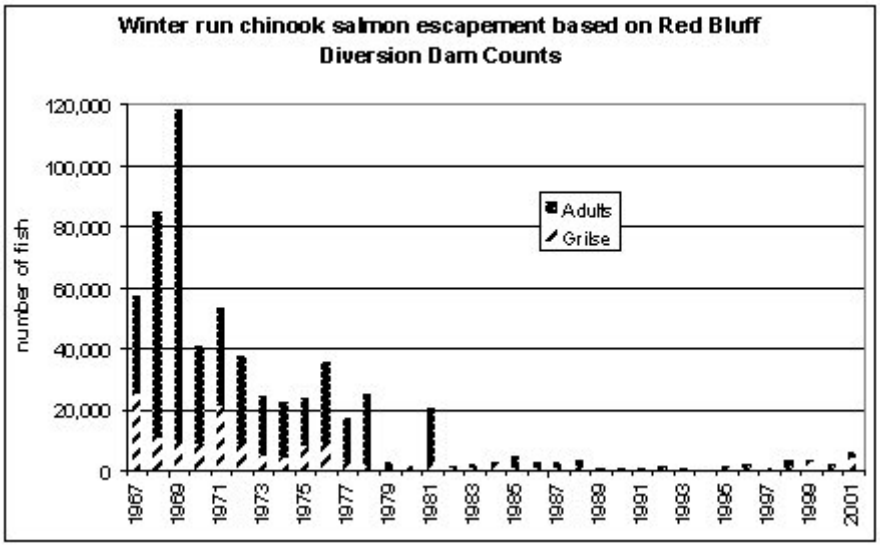

Figure 5–2 Sacramento River winter–run Chinook escapement based on RBDD counts.

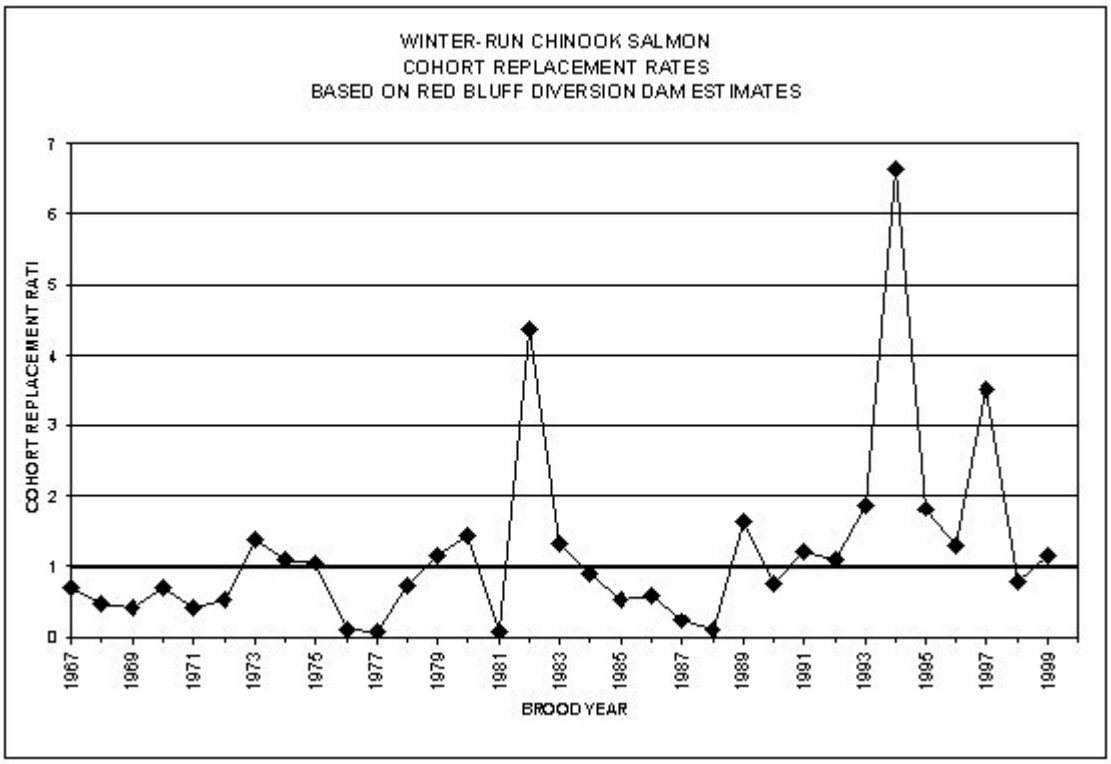

Figure 5–3 Sacramento River winter–run Chinook salmon CRRs based on RBDD escapement estimates.

Rates were calculated by taking the BY escapement and dividing it by the sum of grilse two years later, three-year olds three years later, and four-year olds four years later assuming that 95 percent of adults are three-year olds and 5 percent are four years old, ie the 1999 CRR is based on adult returns in 2000 - 2002 (age distributions based on 2001 scale data).

Table 5–4 Comparison of RBDD winter-run Chinook escapement v. carcass count (Peterson estimate) winter-run escapement.

	Grilse RBDD	Adult RBDD	Total RBDD	Carcass Count
1996	629	708	1,337	820
1997	352	528	880	2,053
1998	924	2,079	3,002	5,501
1999	2,466	822	3,288	2,262
2000	789	563	1,352	6,670
2001	3,827	1,696	5,523	12,797
		Mean	2,564	5,017
		Standard Deviation	1,748	4,416

Aerial redd counts provide information on spatial distribution of spawners and number of redds constructed by winter–run Chinook. The California Department of Fish and Game conducted yearly aerial redd surveys for Chinook spawning in the upper Sacramento River since 1969. The surveys attempted to enumerate winter-run redds beginning in the 1980s. Table 5–5 shows the distribution of redds by reach summarized by time period. RBDD gate operations were changed from1989-93 to the current September 15 through May 15 gates up operation. Redd distribution showed a clear shift to nearly all redds now occurring in locations upstream of RBDD. New fish ladders at the ACID diversion dam began operating in 2001. Almost no winter–run redds were counted upstream of the ACID dam prior to 2001. Surveys counted 484 winter–run redds upstream of the ACID dam in 2001 and 297 redds in 2002. Table 5–5 shows winter–run spawning distribution since 2001. The spawning distribution over this period is used in the temperature model for assessing water temperature effects on spawning and incubating Chinook salmon eggs.

Table 5–5 Sacramento River winter-run Chinook salmon spawning distribution from aerial redd surveys grouped by 1987-92, 1993-2002, and all years combined (data source: Killam 2002).

River Reach	Years 87-92	Yearly average	% distrib.	Years 93-2002	Yearly average	% distrib.	Years 87-2002	Yearly average	% distrib.
Keswick to A.C.I.D. Dam.	17	3	1	836	84	20	853	53	14
A.C.I.D. Dam to Highway 44 Bridge	411	69	23	1211	121	29	1622	101	27
Highway 44 Br. to Airport Rd. Br.	544	91	30	1883	188	45	2427	152	40
Airport Rd. Br. to Balls Ferry Br.	159	27	9	118	12	3	277	17	5
Balls Ferry Br. to Battle Creek.	62	10	3	65	7	2	127	8	2
Battle Creek to Jellys Ferry Br.	88	15	5	15	2	0	103	6	2
Jellys Ferry Br. to Bend Bridge	166	28	9	55	6	1	221	14	4
Bend Bridge to Red Bluff Diversion Dam	23	4	1	0	0	0	23	1	0
Red Bluff Diversion Dam to Tehama Br.	226	38	12	12	1	0	238	15	4
Tehama Br. To Woodson Bridge	124	21	7	0	0	0	124	8	2
Woodson Bridge to Hamilton City Br.	4	1	0	0	0	0	4	0	0
Hamilton City Bridge to Ord Ferry Br.	0	0	0	0	0	0	0	0	0
Ord Ferry Br. To Princeton Ferry.	0	0	0	0	0	0	0	0	0
Total	1824	304	100	4195	420	100	6019	376	100

Table 5–6 Sacramento River winter–run and spring–run redd distribution 2001 through 2003.

	Winter redds	Percent	Spring redds	Percent
Keswick to A.C.I.D. Dam.	1359	47.1%	9	5.8%
A.C.I.D. Dam to Highway 44 Bridge	500	17.3%	26	16.7%
Highway 44 Br. to Airport Rd. Br.	935	32.4%	33	21.2%
Airport Rd. Br. to Balls Ferry Br.	65	2.3%	35	22.4%
Balls Ferry Br. to Battle Creek.	5	0.2%	19	12.2%
Battle Creek to Jellys Ferry Br.	2	0.1%	30	19.2%
Jellys Ferry Br. to Bend Bridge	8	0.3%	3	1.9%
Bend Bridge to Red Bluff Diversion Dam	0	0.0%	0	0.0%
Red Bluff Diversion Dam to Tehama Br.	10	0.3%	1	0.6%
Tehama Br. To Woodson Bridge	0	0.0%	0	0.0%
Woodson Bridge to Hamilton City Br.	0	0.0%	0	0.0%
Hamilton City Bridge to Ord Ferry Br.	0	0.0%	0	0.0%
Ord Ferry Br. To Princeton Ferry.	0	0.0%	0	0.0%
	2884	100.0%	156	100.0%

Historical and Current Distribution and Abundance of Spring-run Chinook Salmon

Spring-run Chinook salmon populations once occupied the headwaters of all major river systems in the Central Valley up to any natural barrier (Yoshiyama et al. 1996, 1998). DFG (1998) reported that historically spring-run abundance was second only to fall-run abundance in the Central Valley, but NOAA Fisheries (1998) indicated spring-run may actually have been the most abundant run in the Central Valley during the 19th Century. The gill-net fishery, established around 1850, operated in the Delta and initially targeted spring- and winter-run Chinook salmon due to their fresher appearance and better meat quality than fall-run, which return to freshwater in a more advanced spawning condition (Stone 1874, as cited in DFG 1998). Early gill-net landings reported in excess of 300,000 spring-run per year (CFC 1882, as cited in DFG 1998). Commercial fishing along with residual effects of mining probably contributed to spring-run declines by the early part of the 20th century (DFG 1998).

Recent estimates indicate roughly 2,000 miles of salmon spawning and rearing habitat were available before dam construction and mining, but 82 percent of that habitat is unavailable or inaccessible today (Yoshiyama et al. 1996). The available habitat may be even less when the quality of remaining habitat is considered. Stream reaches below major dams may be accessible to spring-run, but competition and/or introgression with fall-run may render these reaches marginally useful to the spring-run. Moreover, it is possible that spring-run prefer to spawn in smaller channels similar to their historical upstream habitat, rather than the existing broad, low elevation reaches available below dams. Most of these habitat modifications were in place before more recent declines occurred however, suggesting other factors and/or gradual habitat degredation below dams have also affected spring-run abundance in the Central Valley.

Currently, the bulk of the remaining spring-run Chinook are produced in Deer, Mill and Butte Creeks, the Feather River, and perhaps the main stem Sacramento River. Small numbers of spring-run have intermittently been observed in the recent past in other Sacramento River tributaries as well (DFG 1998). Of the three tributaries producing naturally spawned spring-run

(Mill, Deer, and Butte Creek) Butte Creek has produced an average of 2/3 of the total production over the past 10 years. Some distribution and abundance data are presented below for current spring-run producing streams. Additional details on these and other streams can be found in DFG (1998) and NOAA Fisheries (1998).

Estimation methods for spring–run in the tributaries have varied through the years. Confidence intervals are usually not developed on the escapement estimates making comparison of estimates between years problematic. The recent (last 10 years) preferred method is a snorkel survey in tribs other than Mill Creek. Snorkel surveys are good for identifying population trends. They usually underestimate the actual number of fish present. Recent comparison during 2001 and 2002 on Butte Creek of the snorkel survey with a rigorous Schaefer carcass survey suggest that the snorkel survey is an underestimate by as much as 50% (DFG 2003). The underestimate is probably greater on a stream like Butte Creek with fish in higher densities than in some of the other tributaries.

Clear Creek

Prior to European settlement, Clear Creek supported spring-run, fall-run, and late fall-run Chinook salmon and steelhead. Absent from Clear Creek for 30 years, approximately 30 adult spring-run Chinook salmon re-appeared in the lower reaches of Clear Creek in 1999. Historic accounts of spring-run Chinook in Clear Creek are sparse and population estimates are non-existent. Spring-run were observed in Clear Creek upstream of Saeltzer Dam in 1956 for the first time since 1948. Construction of Whiskeytown Dam in 1963 permanently eliminated access to the upper reaches of the creek to salmon. Previous observations of spring-run indicate they likely held over and spawned in cooler water present in the upper watershed upstream of Whiskeytown Dam. A falls at French Gulch restricted upstream migration to periods of high runoff in the spring.

Attempts to re-establish the spring-run have been made. In 1991, 1992, and 1993, 200,000 juvenile spring-run Chinook salmon from the Feather River Hatchery were planted in Clear Creek. A number of these fish returned to Clear Creek in the fall of 1995 rather than in the spring as expected. They may have remained in the cooler Sacramento River until Clear Creek cooled or they may be offspring of hybrid spawning of spring and fall-run for several generations at Feather River Hatchery. As stated above, 30 potential spring-run were observed in Clear Creek in 1999. During surveys in 2000 nineteen possible spring-run were counted during snorkel surveys. During the decline in numbers of Chinook in September the remains of five Chinook were found, potentially poached (DFG 2001a). During 2001 surveys, nine spring-run were counted from April to July. The monthly survey counts in 2001, however probably included multiple observations of the same fish. The first redd was observed on September 13 in the lowermost reach (DFG 2002).

Results of adult spring–run counts in 2002 are not yet available but at least one fresh adult was observed in Clear Creek below the former Saeltzer dam in mid-May of 2002.

The FWS operates a rotary screw trap at river mile 1.7 on Clear Creek, upstream of the sheet pile dam associated with the ACID canal siphon crossing. Spring-run sized juvenile Chinook salmon are enumerated in the trap based on length criteria developed for the upper Sacramento River. In late 2000, 41 spring Chinook juveniles were collected in the trap. In late 1999, approximately

2,300 spring-run sized juvenile Chinook were collected in the trap after many Chinook had spawned in lower Clear Creek during September. During 2001 the first spring–run sized juvenile was captured in the trap on November 14. The estimated number of potential spring-run captured in the trap in 2001 was 1,083 in November and December (DFG 2002).

Denton (1986) used the IFIM to estimate optimal Clear Creek flows for salmon and steelhead. The resultant estimate of optimal flows from the IFIM study is shown in Figure 5–4. The timing of these flows was based on the fall–run Chinook life cycle, but the recommended steelhead flows would provide the needed flows for spring–run, except potentially in April and May when an extra 25 cfs would bring the flows up to the salmon recommendation. The recommended spawner attraction flow releases shown in October and November could be provided around April and May for spring–run.

Although the optimum flows that were recommended for salmon (fall–run) of 250 cfs may provide a maximum amount of suitable spring–run spawning and rearing habitat, because the number of spring–run in Clear Creek is low the population does not appear to be currently habitat limited as long as temperatures are suitable. The section of Clear Creek from the mouth to the former Saeltzer Dam is fall and late-fall Chinook habitat, while the Clear Creek Road Bridge to Whiskeytown Dam reach is the section of creek more suitable for spring-run Chinook because temperatures are better in that upstream reach in the summer. The IFIM study showed higher flow needs in the downstream habitat than in the upstream habitat. Optimal flows for salmon in the upstream reach where spring–run are located were 62 cfs for spawning and 75 cfs for rearing from the IFIM study (Denton 1986). Optimal steelhead flows in the same upstream reach were 87 cfs for spawning and 112 cfs for juvenile rearing.

Pulse flows have been proposed for Clear Creek to provide an attraction flow to spring-run Chinook in the main stem Sacramento River. A release of 1,200 cfs for one day (plus ramping) was proposed in 2000 but was not implemented due to concerns over attracting winter-run into Clear Creek. Because there has been no significant spring-run in Clear Creek in the recent past, pulse flows may aid re-establishment of spring-run in Clear Creek by attracting some fish that would otherwise remain in the Sacramento River.

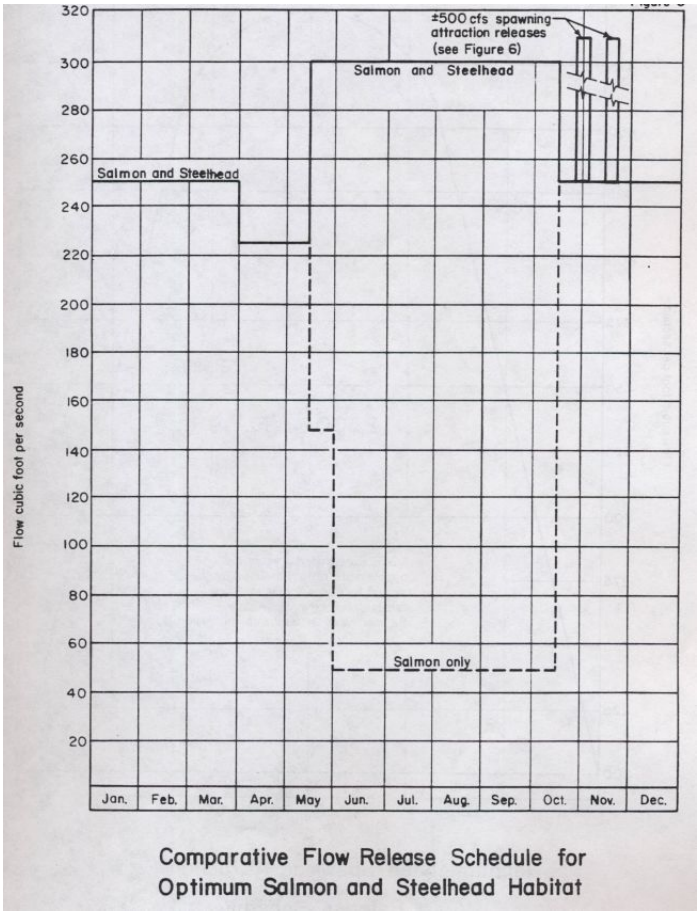

Figure 5–4 Clear Creek flows for optimum salmon and steelhead habitat.

Recent flows in Clear Creek likely resulted from a general flow schedule developed for maintenance of salmon and steelhead. The schedule was intended as an interim flow release schedule for monitoring purposes to be fine tuned as the fishery effects were determined (Denton 1986). Studies are underway by a Clear Creek flow group to fine tune the flow schedule.

Sacramento River Main stem

Some spring-run Chinook may spawn in the Sacramento River between RBDD and Keswick Dam. Sacramento main stem spring-run abundance reported in counts has declined sharply since the mid-1980s (Figure 5–5). The criteria for run classification at RBDD has changed so no conclusions can be reached about spring–run abundance changes in the Sacramento River. The variable abundance estimates may be an artifact of the counting methods used in different years and categorization of fish between runs. The five-year geometric mean abundance reported by NOAA Fisheries (1998) was 435 fish. There is evidence the spring-run that pass RBDD are spring-run/fall-run hybrids (Figure 5–6). Historically, the onset of fall-run spawning occurred well after spring-run had completed spawning. The increasing overlap in spring-run and fall-run spawning periods is evidence that introgression is occurring. Since spring-run and fall-run Chinook now use the same spawning riffles, fall-run spawners may displace the spring-run redds during nest construction. This redd displacement is called superimposition. The criteria used to

distinguish spring from fall-run from 1970 – 1988 probably resulted in many fish being classified as spring-run in August and September that were really fall–run (DFG 2003) so the increasing overlap may be simply an artifact of the variable run classification.

Cohort Replacement Rates used for Mill, Deer, and Butte Creeks

DFG (1998) evaluated spring-run Chinook population trends by examining the strength of BY lineages with a CRR. Due to the varied methods used over the years to estimate population abundance in each tributary, there were few data adequate for such analyses. DFG (1998) considered the more recent data for Mill, Deer, and Butte Creeks to be the most consistent and robust. Individual BY data are lacking altogether on rates of grilse (two-year old) returns, age structure, and sex ratio of returning adults. In estimating CRR, DFG (1998) assumed the following: (1) spawning adults return as three-year-olds (a justification for this was presented above); (2) there is a 1:1 male to female sex ratio; and (3) there is not much variation in these factors between BYs. The CRR for spring–run was estimated by dividing the number of returning adults in a given BY by the number of returning adults three years prior. Values greater than 1.0 suggest the cohort abundance is increasing, while values less than 1.0 indicate cohort abundance is decreasing. A value around 1.0 suggests the cohort has replaced itself. CRR data are provided in the discussions of abundance in Mill, Deer, and Butte Creeks, and also for the Feather River.

Mill Creek

The present range and distribution of spring-run Chinook salmon in Mill Creek is the same as it was historically (DFG 1998). Adults migrate upstream and hold in a 20-mile reach from the Lassen National Park boundary downstream to the confluence of Little Mill Creek. There are no early records of population size for Mill Creek. Spring-run counts were initiated by FWS in 1947 (DFG 1998). Although some of these counts were incomplete, they ranged from 300 to 3,500 fish from 1947 to 1964. The average run size for the 1947-64 period was about 1,900 fish (geometric mean = 1,717).

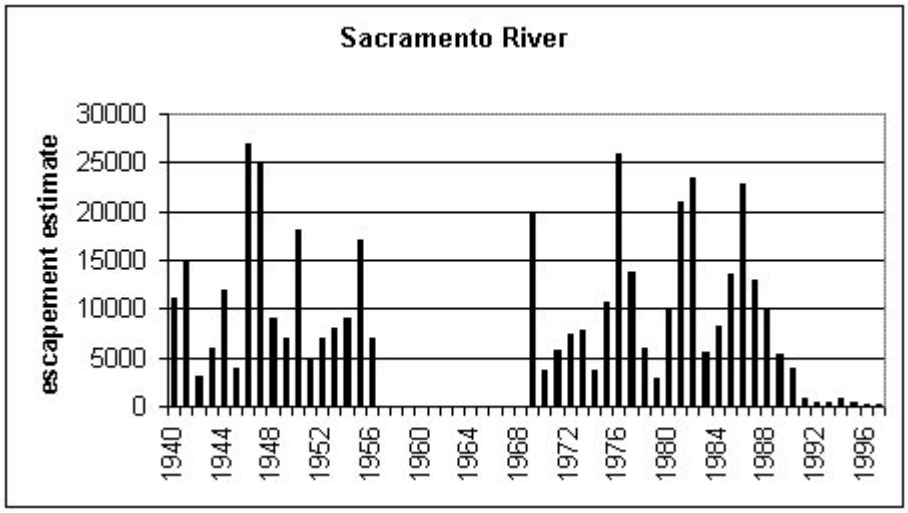

Figure 5–5 Estimated adult spring-run Chinook salmon population abundance in the upper Sacramento River.

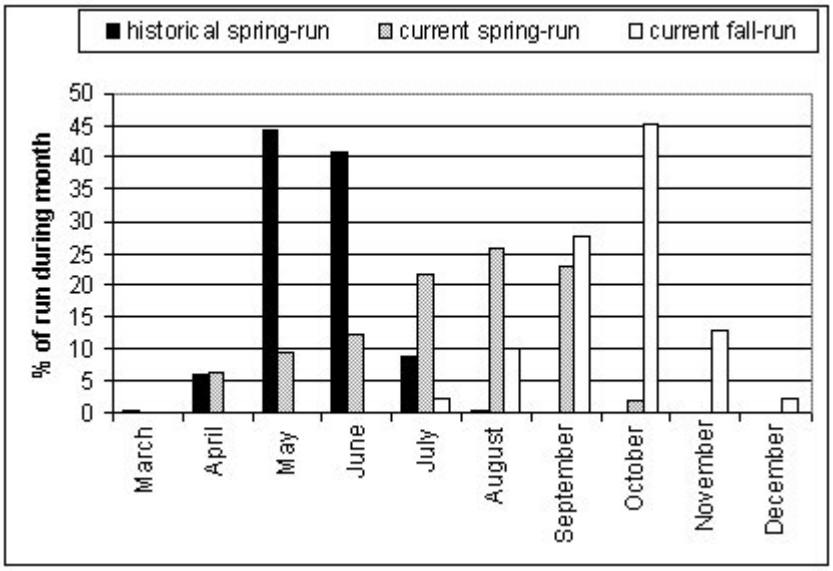

Figure 5–6 Migration timing of spring-run and fall-run Chinook salmon.

Historical distribution of timing is based on composite data from Mill and Deer Creeks, Feather River, and the upper Sacramento River prior to Shasta Dam. Present distributions are for spring-run and fall-run timing past RBDD (1970-1988). Data were taken from DFG 1998.

During the 1990s, the geometric mean spring-run escapement to Mill Creek was 299, an order of magnitude lower than 1947 to 1964 (Figure 5–7). The Mill Creek spring-run population trend during the 1990s was somewhat uncertain. The mean CRR for 1990-99 was 2.2, indicating a population increase (Table 5–7). However, the more conservative geometric mean CRR was only 1.05, suggesting the population was merely replacing itself. This agrees with the 1990-99 three-year running average escapement, which shows no consistent trend of either increase or decrease (Figure 5–8).

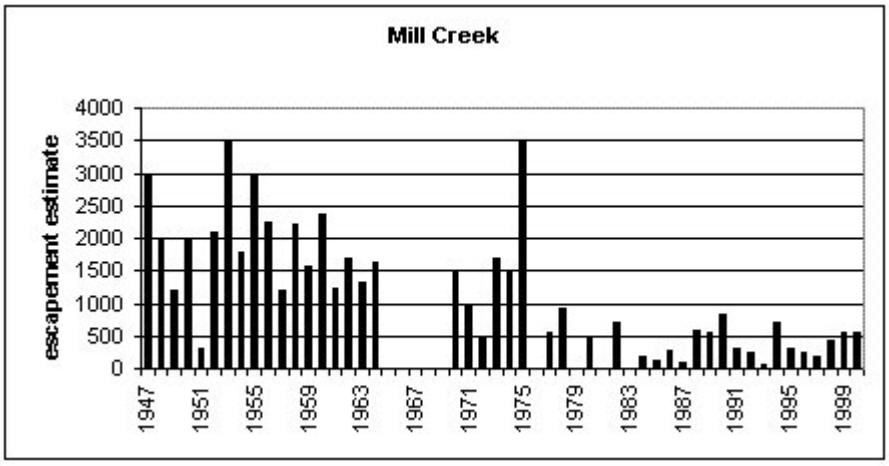

Figure 5–7 Adult spring-run Chinook counts in Mill Creek.

Table 5–7 Mill Creek spring-run Chinook salmon CRR.

Cohort	*BY*	*CRR*
1	1957	1203/1789 = 0.7
2	1958	2212/2967 = 0.7
3	1959	1580/2233 = 0.7
1	1960	2368/1203 = 2.0
2	1961	1245/2212 = 0.6
3	1962	1692/1580 = 1.1
1	1963	1315/2368 = 0.6
2	1964	1628/1245 = 1.3
3	1990	844/89 = 9.5
1	1991	319/572 = 0.6
2	1992	237/563 = 0.4
3	1993	61/844 = 0.1
1	1994	723/319 = 2.3
2	1995	320/237 = 1.4
3	1996	252/61 = 4.1
1	1997	200/723 = 0.3
2	1998	424/320 = 1.3
3	1999	560/252 = 2.2
1	2000	544/200 = 2.7
2	2001	1104/424 = 2.6

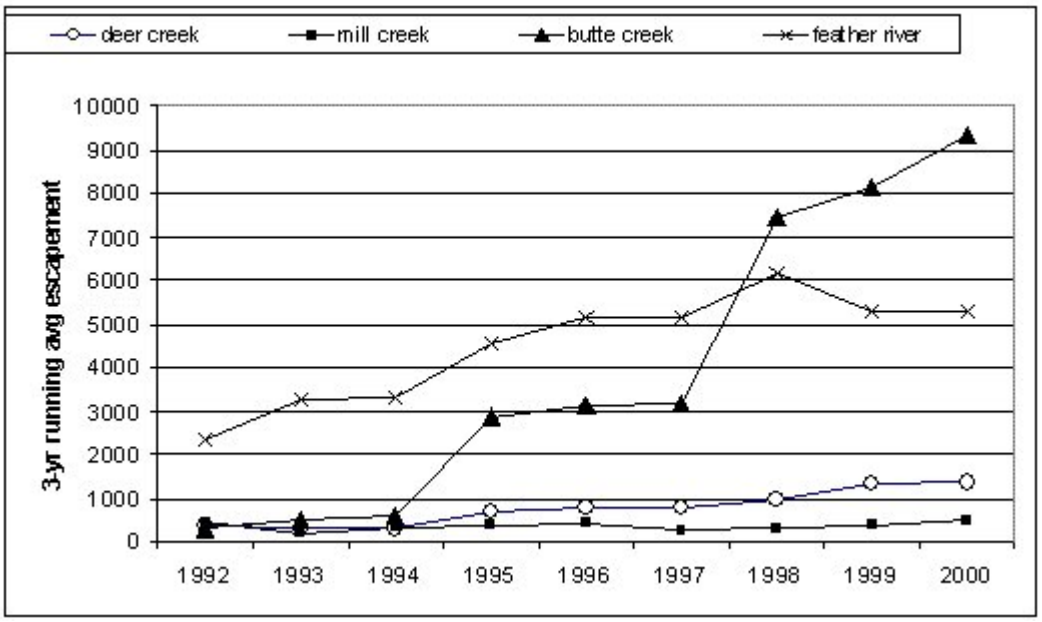

Figure 5–8 Three-year running average abundance of returning adult spring-run Chinook salmon in selected Central Valley streams.

Deer Creek

The present spring-run range in Deer Creek has been extended beyond the historical range (DFG 1998). A fish ladder was constructed around Lower Deer Creek Falls in 1943, opening an additional six miles of holding and spawning habitat. The present habitat is a 22-mile reach extending from Dillon Cove to Upper Deer Creek Falls. Approximately 20 percent of the spawning now occurs in the six-mile extension. A fish ladder constructed around Upper Deer Creek Falls is managed to allow steelhead passage, but not spring-run passage. Spring-run are excluded because the reach lacks large holding pools needed to sustain a large salmon population. There are no early records of spring-run population size for Deer Creek either, but counts were initiated by FWS in 1940 (DFG 1998). As with Mill Creek, some counts were incomplete, but ranged from 268 to 4,271 fish between 1940 and 1964. The average run size for the 1940-64 period was about 2,200 fish (geometric mean = 2,290). Again, as in Mill Creek, recent counts are lower (Figure 5–9), with a geometric mean escapement of 599 for the 1990 through 1999 period.

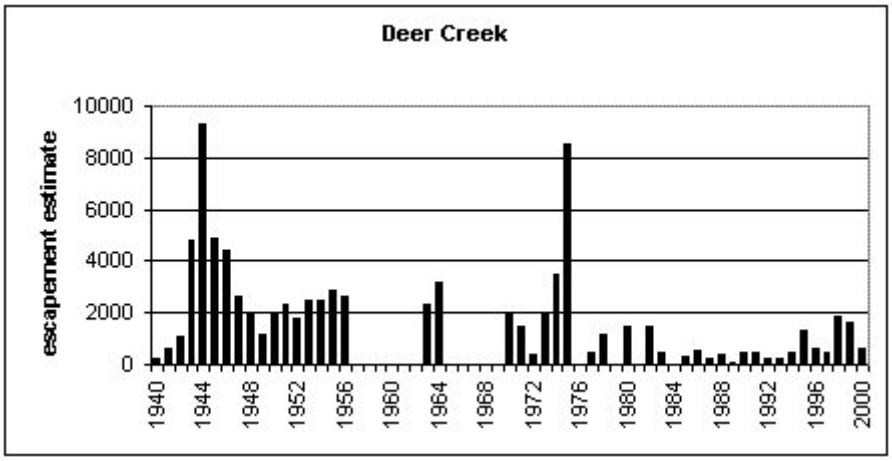

Figure 5–9 Estimated adult spring-run Chinook salmon population abundance in Deer Creek.

The mean Deer Creek CRR has been 2.1 during 1990-99, suggesting that like Mill Creek, the population may be rebounding slightly (Table 5–8). In addition, the geometric mean CRR (1.7), and the 1990-99 three-year running average escapement (Figure 5–8) also suggest a slight population increase during the 1990s.

Table 5–8 Deer Creek spring-run Chinook salmon CRR

Cohort	*BY*	*CRR*
1	1990	458/200 = 2.3
2	1991	448/371 = 1.2
3	1992	209/77 = 2.7
1	1993	259/458 = 0.6
2	1994	485/448 = 1.1

Cohort	BY	CRR
3	1995	1295/209 = 6.2
1	1996	614/259 = 2.4
2	1997	466/485 = 1.0
3	1998	1879/1295 = 1.5
1	1999	1591/614 = 2.6
2	2000	637/466 = 1.4
3	2001	1622/1879 = 0.9

Butte Creek

The present range of spring-run Chinook salmon in Butte Creek does not differ substantially from its historical range and is limited to the reach below the PG&E Centerville Head Dam downstream to the Parrott-Phelan Diversion Dam (DFG 1998). It is likely the historic limit of travel for spring-run salmon and steelhead during most years was a natural barrier (Quartz Bowl Barrier) one mile below the PG&E Centerville Head Dam. Recent DFG surveys have only found fish above the Quartz Bowl barrier during 1998, when flows were atypically high into late-May. Even then, there were only 25 fish noticed out of an estimated total population of 22,000 (DFG 2003). There are numerous additional large impassable natural barriers immediately above the Centerville Head Dam. As with the above mentioned streams, there are no early accounts of the number of spring-run in Butte Creek. During 1954, a counting station was maintained at the Parrott-Phelan Diversion Dam to record adult spring-run salmon passing through the fish ladder (Warner 1954 as cited in DFG 1998). From May 7 to 27, 830 fish were observed. Various census techniques have been employed to evaluate the Butte Creek spring-run population since 1954 (DFG 1998). The population has fluctuated significantly, from a low of 10 in 1979 to a high of 20,259 in 1998. The fluctuation may be explained in part by the variety of survey techniques used, but the population appears to have been nearly extirpated numerous times between the 1960s and the early 1990s (Figure 5–10).

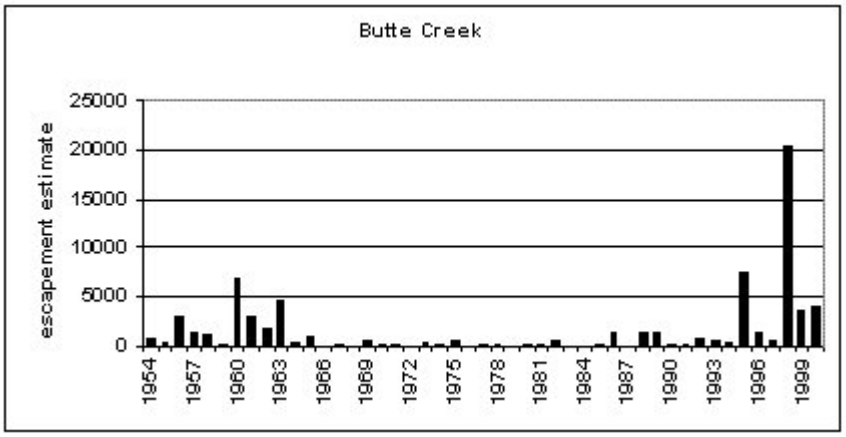

Figure 5–10 Estimated adult spring-run Chinook salmon population abundance in Butte Creek.

The Butte Creek spring-run increased dramatically during the last decade. CRR have been highly variable, but always greater than 1.0 during the last seven years (1993-99), ranging from 1.3 to

10.3, with a mean of 4.3 and a geometric mean of 3.5 (Table 5–9). The three-year running average escapement for 1990-99 suggests a comparatively rapid abundance increase as well (Figure 5–8).

Table 5–9 Butte Creek spring-run Chinook salmon CRR.

Cohort	*BY*	*CRR*
1	1993	650/100 = 6.5
2	1994	474/100 = 4.7
3	1995	7,500/730 = 10.3
1	1996	1,413/650 = 2.2
2	1997	635/474 = 1.3
3	1998	20,259/7,500 = 2.7
1	1999	3,600/1,413 = 2.5
2	2000	4,118/635 = 6.5
3	2001	9,605/20,259 = 0.5

Feather River

Historically, the Feather River spring-run population was similar in magnitude to the size of the present hatchery run (Figure 5–11). Spring-run ascended the very highest streams and headwaters of the Feather River watershed prior to the construction of hydropower dams and diversions (Clark 1929, as cited in DFG 1998). Prior to Oroville Dam (1946-63), available population estimates ranged from 500 to 4,000 fish and averaged 2,200 per year (Painter et al. 1977, Mahoney 1958, 1960, all as cited in DFG 1998; DFG 1998). However, Feather River spring-run had probably been significantly impacted by hydropower facilities in the upper watershed well before the completion of Oroville Dam. For instance, DFG (1998) found substantial overlap in the spawning distributions of fall-run and spring-run Chinook upstream of the Oroville Dam site.

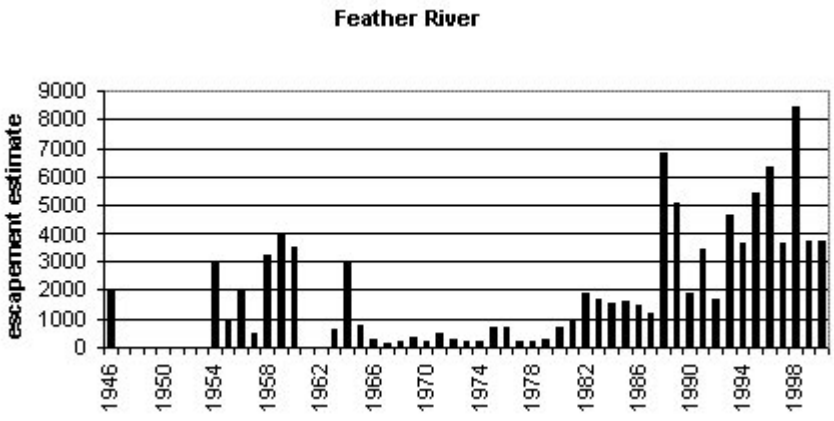

Figure 5–11 Estimated adult spring-run Chinook salmon population abundance in Feather River.

Following construction of Oroville Dam in 1967, the spring-run population dropped to 146 fish, but averaged 312 fish per year between 1968 and 1974 (Menchen 1968; Painter et al. 1977, both as cited in DFG 1998). The highest post-Oroville Dam population estimate was recorded in 1998 (8,430 adults) based on numbers of fish returning to Feather River Hatchery. All post-Oroville spring-run population estimates are based on counts of salmon entering FRH.

Like several of the other spring-run streams, both the mean (1.4) and the geometric mean (1.2) CRR for FRH spring-run suggest the population has been increasing slightly in the recent past (Figure 5–7). The three-year running average escapement suggests the same (Figure 5–8).

Table 5–10 Feather River spring-run Chinook salmon CRR.

Cohort	*BY*	*CRR*
1	1991	3448/6833 = 0.50
2	1992	1670/5078 = 0.33
3	1993	4672/1893 = 2.50
1	1994	3641/3448 = 1.06
2	1995	5414/1670 = 3.24
3	1996	6381/4672 = 1.37
1	1997	3653/3641 = 1.00
2	1998	8430/5414 = 1.56
3	1999	3731/6381 = 0.59
1	2000	3657/3653 = 1.00
2	2001	2468/8430 = 0.29

Since the construction of Oroville Dam however, spring-run salmon have been restricted to the area downstream of the fish barrier dam near Oroville where the intermixing with the fall-run observed by DFG (1959, as cited in DFG 1998) has probably worsened (Figure 5–12 and Figure 5–13). Based on an assessment of FRH operations, the Feather River population was considered a likely hybrid of spring and fall-run populations (Brown and Greene 1993). However, initial genetic studies of spring and fall-run from FRH and Feather River found no distinction between fall and spring-run (Dr. Dennis Hedgecock, presentation at the 1999 Salmon Symposium in Bodega Bay).

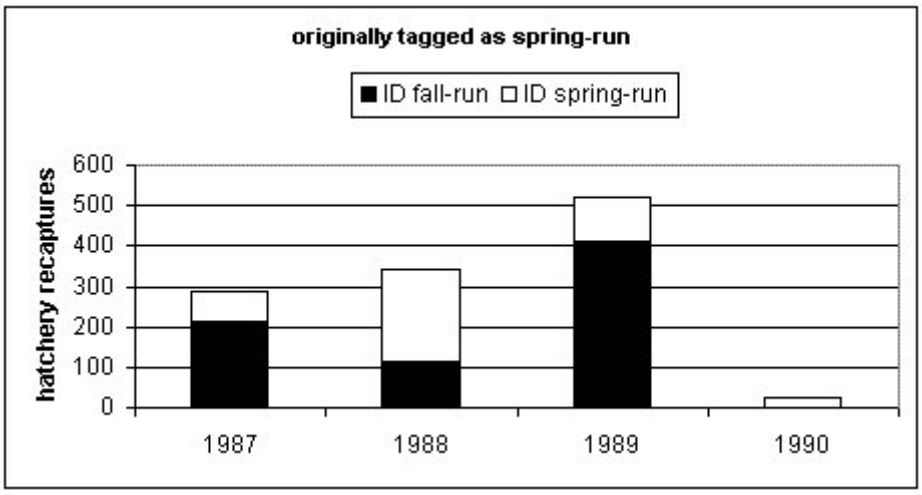

Figure 5–12 The disposition of Chinook salmon spawned, tagged, and released as spring-run from FRH.

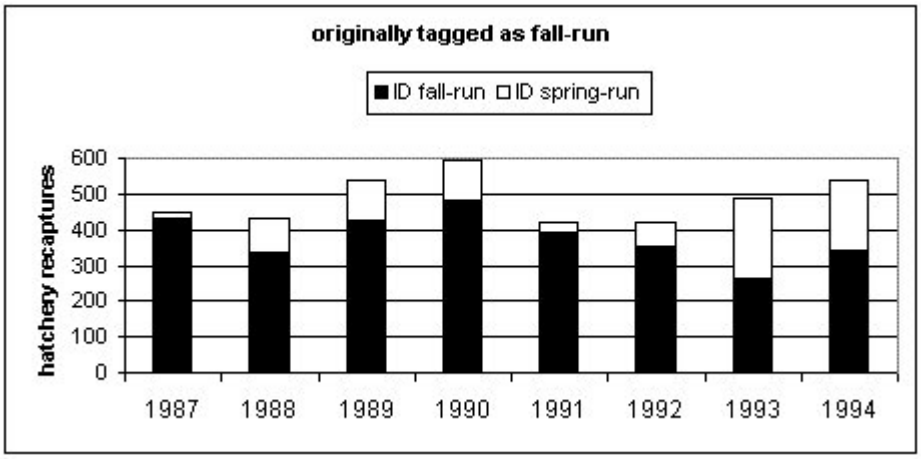

Figure 5–13 The disposition of Chinook salmon spawned, tagged, and released as fall-run from FRH.

Trinity River Coho Salmon

Coho Salmon (*Oncorhynchus kisutch*) in the Trinity River are in the southern Oregon/Northern California Coast coho salmon ESU which was listed as threatened under the Endangered Species Act on June 5, 1997. The southern Oregon/Northern California Coast coho ESU extends from Punta Gorda on the south to Cape Blanco in Oregon.

Life History

Coho salmon exhibit a three year life cycle in the Trinity River and are dependent on freshwater habitat conditions year round due to a full year of freshwater residency. Most coho salmon enter rivers between August and January with some more northerly populations entering as early as June. Coho salmon river entry timing is influenced by a number of factors including genetics, stage of maturity, river discharge, and access past the river mouth. Spawning is concentrated in

riffles or in gravel deposits at the downstream end of pools with suitable water depth, velocity, and substrate size. Spawning in the Trinity River occurs mostly in November and December.

Coho salmon eggs incubate for 35 to over 100 days depending on water temperature and emerge from the gravel two weeks to seven weeks after hatching. Coho eggs hatch after an accumulation of 400 to 500 temperature units measured in degrees celsius and emerge from the gravel after 700 to 800 temperature units. After emergence, fry move into areas out of the main current. As coho grow they spread out from the areas they were spawned.

During the summer, juvenile coho prefer pools and riffles with adequate cover such as large woody debris with smaller branches, undercut banks, and overhanging vegetation and roots. Juvenile coho overwinter in large main stem pools, beaver ponds, backwater areas, and off channel pools with cover such as woody debris and undercut banks. Most juvenile Coho salmon spend a year in freshwater with many northerly populations spending two full years in freshwater. Because juvenile coho remain in their spawning stream for a full year after emerging from the gravel they are exposed the full range of freshwater conditions. Most smolts migrate to the ocean between March and June with most leaving in April and May.

Coho salmon typically spend about 16-18 months in the ocean before returning to their natal streams to spawn as three or four year olds, age 1.2 or 2.2. Southerly populations are mostly three year olds. Some precocious males, called “jacks”, return to spawn after only six months in the ocean.

Trinity River Coho Population Trends

Coho salmon were not likely the dominant species of salmon in the Trinity River before dam construction. Coho were, however, widespread in the Trinity basin ranging as far upstream as Stuarts Fork above Trinity Dam. Wild coho in the Trinity Basin today are not abundant and the majority of the fish returning to the river are of hatchery origin. An estimated 2 percent (200 fish) of the total coho salmon run in the Trinity River were comprised of naturally produced coho from 1991-95 at a point in the river near Willow Creek (FWS 1998). This in part prompted the threatened status listing in 1997. Mark recapture estimates of coho salmon run size conducted since 1977 had a mean run size of 15,959 coho from 1977 through 1999 (DFG 2003). These estimates included a combination of hatchery produced and wild coho.

Chapter 6 Factors That May Influence Abundance and Distribution of Winter-run and Spring-run Chinook Salmon and Coho Salmon

Water Temperature

Water temperatures that are too low or too high can kill Chinook salmon directly by impairing metabolic function or indirectly by increasing the probability of disease, predation, or other secondary mortality factors (Boles et al. 1988). Chinook salmon temperature tolerances vary by life stage, and may also vary among stocks, but the latter is not well studied. The recommendations included in this BA were developed by Boles et al. (1988) based on previous temperature studies of Chinook salmon and other salmonids. An overview of temperature effects on Chinook salmon follows.

Table 6–1 Recommended water temperatures (°F) for all life stages of Chinook salmon in Central Valley streams as presented in Boles et al. (1988).[a]

Life stage	*Temperature recommendation (° F)*
Migrating adult	<65
Holding adult	<60
Spawning	53 to 57.5[b]
Egg incubation	<55
Juvenile rearing	53 to 57.5[c]
Smoltification	54[d]

[a] The lower thermal limit for most life stages was about 38° F.
[b] Can have high survival when spawned at up to 60° F, provided temperatures drop quickly to <55° F.
[c] Temperature range for maximum growth rate based on Brett (1952, as cited in Boles et al. 1988).
[d] No results for Chinook salmon. Estimate based on studies of steelhead and Coho salmon (Boles et al. 1988).

The temperature recommendation for migrating adults was based on Hallock et al. (1970, as cited in Boles et al. 1988) who found Chinook immigration into the San Joaquin River was impeded by temperatures of 70° F, but resumed when the temperature fell to 65° F.

The temperature recommendations for adult holding and spawning, and for egg incubation were based on laboratory studies of Sacramento River Chinook egg survival (Seymour 1956, as cited in Boles et al. 1988). Egg mortality was high at constant temperature of 60° F, but was considerably reduced at temperatures between 55° F and 57.5° F. However, sac-fry mortality

remained very high (greater than 50 percent) at temperatures above 56° F, presumably due to "aberrations in sequential physiological development." Table 6–2 shows the relationship between water temperature and mortality of Chinook eggs and pre-emergent fry compiled from a variety of studies.

Table 6–2 Relationship between water temperature and mortality of Chinook salmon eggs and pre-emergent fry.

Water Temperature (EF)[a]	Egg Mortality[b]	Instantaneous Daily Mortality Rate (%)	Pre-Emergent Fry Mortality[b]	Instantaneous Daily Mortality Rate (%)
41-56	Thermal optimum	0	Thermal optimum	0
57	8% @ 24d	0.35	Thermal optimum	0
58	15% @ 22d	0.74	Thermal optimum	0
59	25% @ 20d	1.40	10% @ 14d	0.75
60	50% @ 12d	5.80	25% @ 14d	2.05
61	80% @ 15d	10.70	50% @ 14d	4.95
62	100% @12d	38.40	75% @ 14d	9.90
63	100% @11d	41.90	100% @ 14d	32.89
64	100% @ 7d	65.80	100% @10d[c]	46.05

[a]This mortality schedule was compiled from a variety of studies each using different levels of precision in temperature measurement the lowest of which was whole degrees Fahrenheit ($\pm$0.5°F). Therefore, the level of precision for temperature inputs to this model is limited to whole degrees Fahrenheit.

[b]These mortality schedules were developed by the FWS and DFG for use in evaluation of Shasta Dam temperature control alternatives in June 1990.[12]

[c]This value was estimated similarly to the preceding values but was not included in the biological assumptions for Shasta outflow temperature control FES (Reclamation, 1991b).

Reclamation installed a temperature control device on Shasta Dam in 1997 to allow cool water releases to be made through the power penstocks, avoiding power bypasses. Release temperatures from Shasta Dam from 1994 to 2001 are shown in Figure 6–1.

Yearly water temperatures downstream at Bend Bridge, a temperature compliance point, are shown in Figure 6–2. Temperature compliance points (Bend Bridge and Jelly's Ferry) vary by water year type and date between April 15 and October 31 for winter–run spawning, incubation, and rearing. The objective is to meet a daily average temperature of 56° F for incubation 60° F

[12]Richardson, T. H., and P. Harrison. 1990. Fish and Wildlife Impacts of Shasta Dam Water Temperature Control Alternatives. Prepared for Reclamation, Sacramento, California. FWS--Fish and Wildlife Enhancement, Sacramento, California.

for rearing. After October 31 natural cooling generally provides suitable water temperatures for all Chinook life cycles.

Rearing juvenile Chinook salmon can tolerate warmer water than earlier life stages. Nimbus Hatchery fall-run were able to feed and grow at temperatures up to at least 66° F (Cech and Myrick 1999), but this is not reflected in the Boles et al. (1988) temperature recommendation for juveniles. The relationship between temperature and growth rate seen in Cech and Myrick's (1999) data parallels that observed in northern salmon that exhibit maximum growth at 66° F when fed satiation rations. Nimbus Chinook had maximum growth rates at 66 F and lower rates at 59 and 52° F (Myrick and Cech 2001). The theoretical upper lethal temperature that Sacramento River Chinook salmon can tolerate has been reported as 78.5° F (Orsi 1971, as cited in Boles et al. 1988). However, this result must be interpreted with several things in mind.

First, the theoretical maximum corresponds to the most temperature tolerant individuals. It is not a generality that can be applied to an entire stock. Second, it is only a 48-hour LT-50. This means it is a temperature that can only be tolerated for a short period of time. It does not indicate a temperature at which a Chinook could feed and grow. Third, indirect mortality factors (for example, disease and predation) would likely lead to increases in total mortality at temperatures well below this theoretical laboratory-derived maximum. For example, Banks et al. (1971, as cited in Boles et al. 1988) found Chinook growth rates were not much higher at 65° F than at 60° F, but the fish had higher susceptibility to disease at 65° F.

The Boles et al. (1988) temperature recommendation for Chinook salmon smoltification is 54° F. This recommendation was based on studies of steelhead and Coho salmon in the Pacific Northwest and is therefore questionably applicable to Chinook stocks at the southern limit of the species' range. This is probably not an important issue for winter-run or spring-run yearlings since they tend to emigrate during the cool November through March period when temperatures are below 55° F in most areas. More recent studies show that Chinook salmon that complete juvenile and smolt phases in the 50° F to 62° F range are optimally prepared for saltwater survival (Myrick and Cech 2001).

Newman (2000) modeled the effect of temperature on coded wire tagged fall-run smolt survival from FWS paired Delta release experiments. Newman's analysis indicated smolt survival would decrease by 40 percent as temperature rose from 58° F to 76° F. We infer from this result that water temperature would be unlikely to affect spring-run smolt survival until it exceeded 58° F. On average, Delta temperatures have exceeded 58° F during April or May (Figure 6–3), when subyearling spring-run are emigrating. However, water project operations cannot efficiently control water temperatures in the Delta.

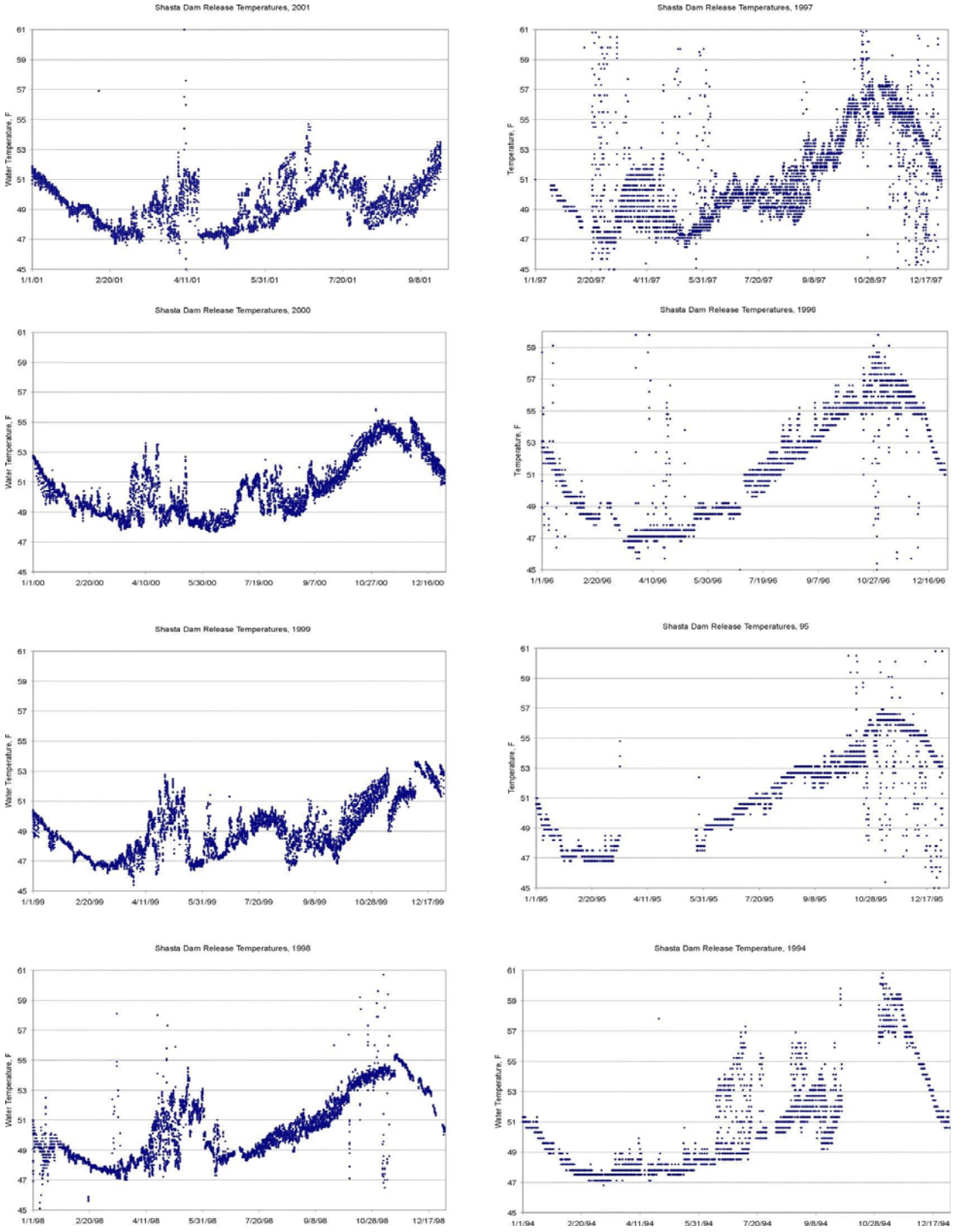

Figure 6–1 Shasta Dam Release Temperatures 1994–2001.

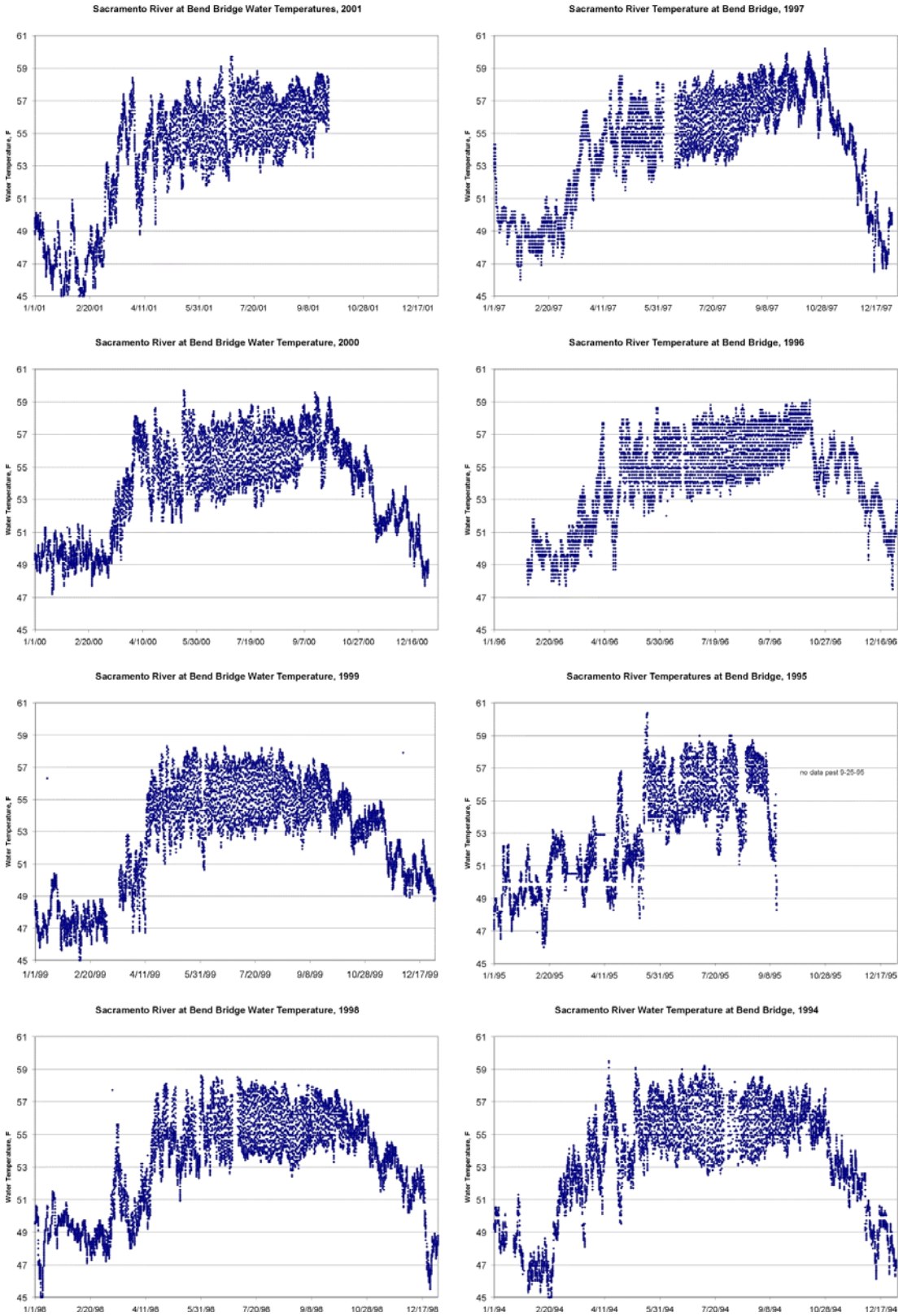

Figure 6–2 Sacramento River at Bend Bridge Water Temperatures 1994–2001.

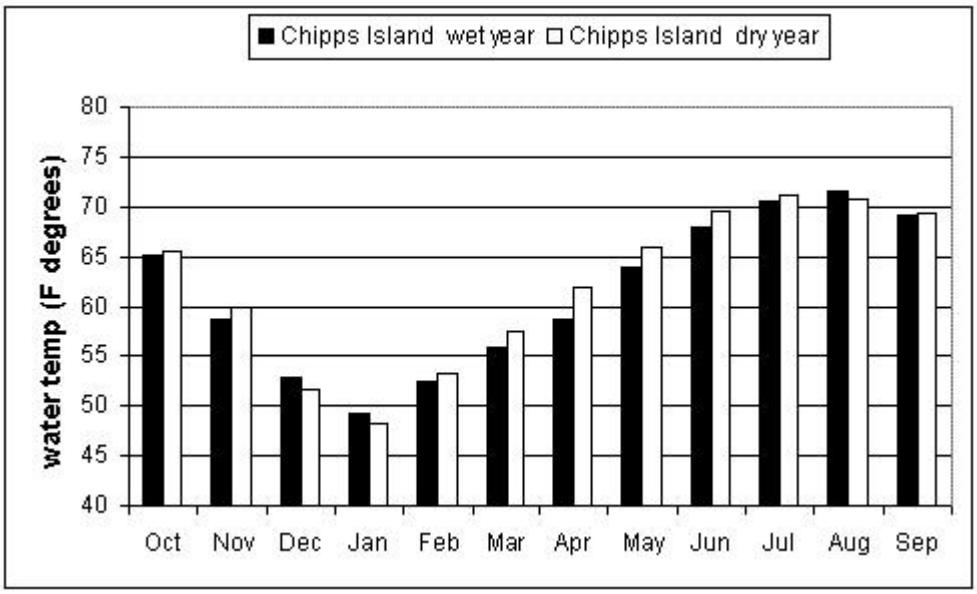

Figure 6–3 Monthly mean water temperatures for the Sacramento River at Chipps Island for water years 1975–1995.

Flow and Spawning

In stream flow recommendations have been developed for Chinook salmon for most major Central Valley streams. Many of the recommendations are intended to optimize habitat area for salmon spawning and egg incubation. High flows can affect redds by scouring the gravel away down to the depth of the eggs and washing the eggs out or by piling more gravel and fines on top of redds so that alevins are unable to emerge or are suffocated. Lowering flows to below the depth of the egg pockets following spawning can kill incubating eggs and alevins.

In stream flow studies

Sacramento River

U.S. Fish and Wildlife Service (2003) developed spawning flow-habitat relationships for winter, fall, and late fall Chinook salmon and steelhead spawning habitat in the Sacramento River below Keswick Dam using the Physical Habitat Simulation (PHABSIM) component of the in stream flow incremental methodology (IFIM). Relationships were developed by cross section and by stream segments but were not aggregated into river-wide flow-habitat relationships.

Winter–run Chinook salmon spawning usable area peaked at around 10,000 cfs in the upstream reach above ACID Dam when the dam boards are in; with the boards out the peak was around 4,000 – 5,000 cfs. In the next reach downstream (ACID Dam to Cow Creek) habitat peaked at 8,000 – 9,000 cfs. In the lower reach (Cow Creek to Battle Creek) spawning habitat peaked at around 4,000 cfs but had low variability in wetted usable spawning habitat area in the flow range analyzed (3,250 – 30,000 cfs). The highest density redd counts for winter-run occur in the upper

and middle reach, although since the ACID fish ladder was built there has been a substantial increase in spawning upstream of the dam (Killam 2002). ACID puts the boards in during early April and they stay in until fall, so the flows dictated by water use would be compatible with maximization of habitat area during that time.

Fall-run and late-fall–run had different wetted usable spawning area values but the flow v. habitat relationship was about the same for the two runs. Upstream of the ACID Dam, spawning habitat peaked at 3,250 cfs with the dam boards out and at about 6,000 cfs with the boards in. Between ACID and Cow Creek spawning habitat peaked at around 4,000 cfs. Between Cow Creek and Battle Creek habitat peaked at about 3,500 cfs. The highest density redd counts for fall and late fall-run occur in the middle reach.

Feather River

Chinook salmon spawning distribution in the Feather River has been studied in detail by Sommer et al. (2001a), although the data are not specific for spring–run. Approximately three-quarters of spawning occurs in the low flow channel, where the heaviest activity is concentrated in the upper three miles. By contrast, spawning activity below Thermalito Afterbay Outlet is fairly evenly distributed. The proportion of salmon spawning in the low flow channel has increased significantly since the completion of the Oroville Complex and FRH. The significant shift in the distribution of salmon spawning in the Feather River to the upper reach of the low flow channel is perhaps one of the major factors affecting any in-channel production of spring-run as a result of superimposition mortality. Since they spawn later in the fall, fall-run fish may destroy a significant proportion of the redds of earlier spawning spring–run.

The major factors that had a statistically significant effect on spawning location were flow distribution and escapement (Sommer et al. 2001a). Significantly more salmon spawned in the low flow channel when a higher proportion of flow originated from that reach. Attraction flows are known to change the spawning distribution of salmon in other rivers. Higher escapement levels were also weakly associated with increased spawning below Thermalito Afterbay Outlet. Since salmon are territorial, increasing densities of salmon would be expected to force more fish to spawn downstream. As will be discussed in further detail in the “Hatchery” section of this chapter, Feather River Fish Hatchery operations may also affect salmon spawning location.

In 2002, DWR conducted an in stream flow incremental methodology (IFIM) habitat analysis for the lower Feather River (DWR 2004). This analysis drew on the earlier IFIM work of Sommer et al. (2001), but added an additional 24 transects, and included additional fish observations. The river segments above (the low flow channel, LFC) and below (the high flow channel, HFC) were modeled separately due to their distinct channel morphology and flow regime. The WUA for Chinook salmon spawning in the LFC increased from 150 cfs to a peak at 800 cfs. Beyond the peak, the WUA index falls sharply again. Although the WUA curve peaks at 800 cfs, the current base flow in the LFC (600 cfs) represents 90 percent of the highest habitat index value. In the HFC, the WUA rises from the lowest modeled flow (500 cfs) and peaks near 1,700 cfs, above which it again declines out to 7000 cfs.

Redd Scouring

High flows, such as those released from dams to draw down storage for flood control during heavy runoff periods, have the potential to scour salmon and steelhead redds and injure eggs or sac-fry in the gravel. These same flows are important for maintaining rearing habitat and high quality spawning gravel. River specific geomorphic studies evaluated the bedload mobilization flow for the affected rivers. The future probability of occurrence of flow releases exceeding the bedload mobilization flow is based on the historic hydrograph since the respective dam was constructed. This is because scouring flows are generally a result of flood control operations during high runoff periods, which will not likely change in the near future.

Sacramento River

Buer (1980) conducted bedload movement experiments by burying a 50 gallon drum in a riffle below Redding. Gravel up to 3 inches in diameter began to accumulate in the barrel at about 25,000 cfs, indicating initiation of surface transport. Painted rocks moved 200 to 300 feet down the riffle at 25,000 cfs. Flows of 40,000 to 50,000 cfs would likely be required to move enough bedload to scour redds (Koll Buer, pers. comm 2003.). The coarse riffles (small boulders and large cobbles), are probably armored from release of sediment-free flows from Shasta Dam. These armored riffles appear not to change and thus probably remain immobile even at flows exceeding 100,000 cfs (Calfed 2000). A bed mobility model was applied to four of the Army Corps of Engineers Comprehensive Study cross sections as another bed mobility estimate to compare to the empirical bed mobility observations. The bed mobility model suggests bed mobility thresholds between 15,000 cfs and 25,000 cfs between River Mile 169 and 187 although the model is not considered appropriate for the Sacramento River (Calfed 2000).

Probability of occurrence for a release exceeding 25,000 cfs at Keswick Dam are approximately 50 percent each year and flows in the 40–50,000 cfs range occur in about 30–40 percent of years (Figure 6–4). Therefore in about 30-40 percent of years some redds could potentially be scoured when flows over 50,000 cfs occur when eggs are in the gravel. This would most likely occur during fall and late fall–run incubation. The significance to the population is difficult to determine, but based on the amount of scouring that occurs in unregulated rivers with large salmon runs compared to regulated rivers such as those in the Central Valley long term negative population effects from redd scouring is probably not very significant. On the Sacramento River, the two-year return interval flood has been reduced from 119,000 cfs to 79,000 cfs since construction of Shasta Dam (as measured at Red Bluff, Figure 6–7).

Clear Creek

Sampling was conducted in Clear Creek at the USGS Clear Creek near Igo gauge during high flows in January and February 1998 to estimate a flow threshold that initiated coarse sediment transport (McBain & Trush and Matthews 1999). Sampling bedload movement during a 2,600 cfs flow showed that mainly sand was being transported. During a 3,200 cfs flow medium gravels were being transported. Particles slightly greater than 32 mm were being transported by the 3,200 cfs (D_{84} = 7.5 mm) flow while no particles larger than 11 mm were sampled during the 2,600 cfs flow (D_{84} = 1.8 mm). Their initial estimate for a coarse sediment transport initiation threshold is in the 3,000 to 4,000 cfs range. Marked rock experiments at Reading Bar, the first

alluvial reach out of the Clear Creek canyon, suggest that large gravels and cobbles (D_{84}) are not significantly mobilized by a 2,900 cfs flow.

The majority of post Whiskeytown Dam floods are produced from tributaries downstream of Whiskeytown Dam, but floods larger than about 3,000 cfs are caused by uncontrolled spillway releases from Whiskeytown Dam, as happened in WY 1983 (19,200 cfs, the largest post-regulation flood), 1997 (15,900 cfs), and 1998 (12,900 cfs) floods. These flows are the result of heavy runoff from the upper Clear Creek watershed and not affected by Reclamation water release operations. Reclamation does not make releases in Clear Creek that exceed the bedload mobilization point unless recommended by fishery agencies for the benefit of fish. A probability of exceedance plot for Whiskeytown Dam is in Figure 6–6. Instantaneous flows of 3,000 cfs occur on average about once every two years and flows of 4,000 cfs occur about once every three years (Figure 6–5). One day average flows of 3,000 cfs occur about once every five years.

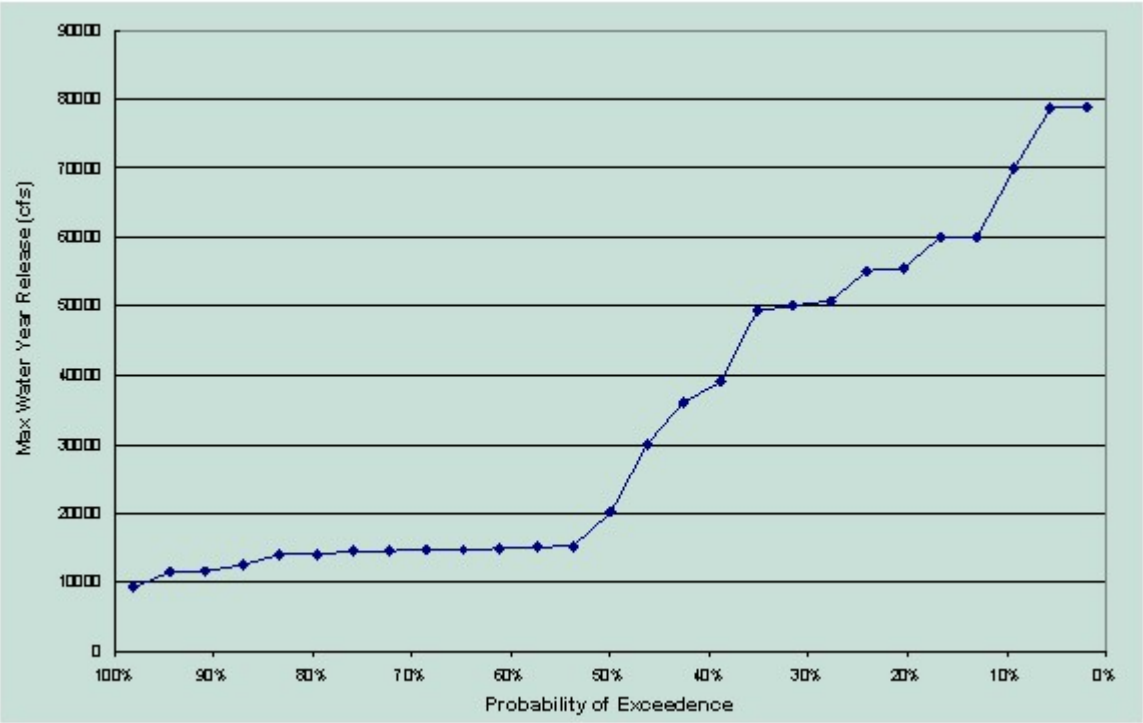

Figure 6–4 Yearly probability of exceedance for releases from Keswick Dam on the Sacramento River.

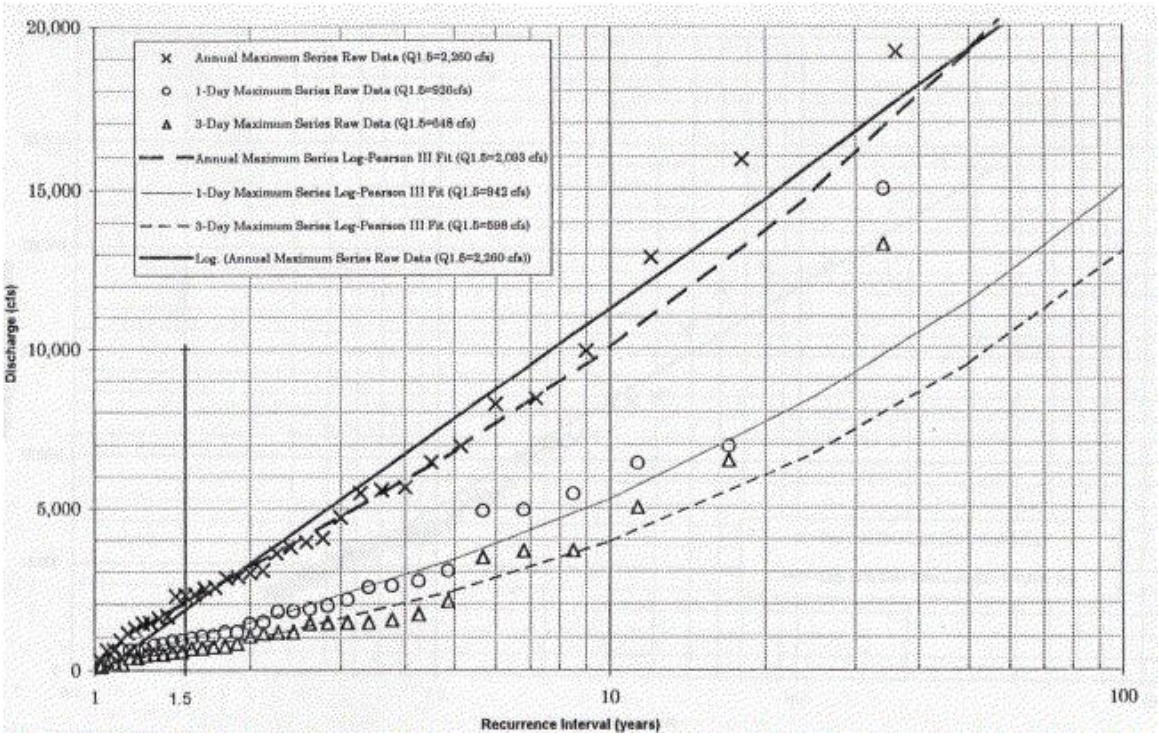

Figure 6–5 Clear Creek near Igo (Station 11-372000) flood frequency analysis of annual maximum, one-day average, and three-day average flood series for post-dam (1964–97) data.

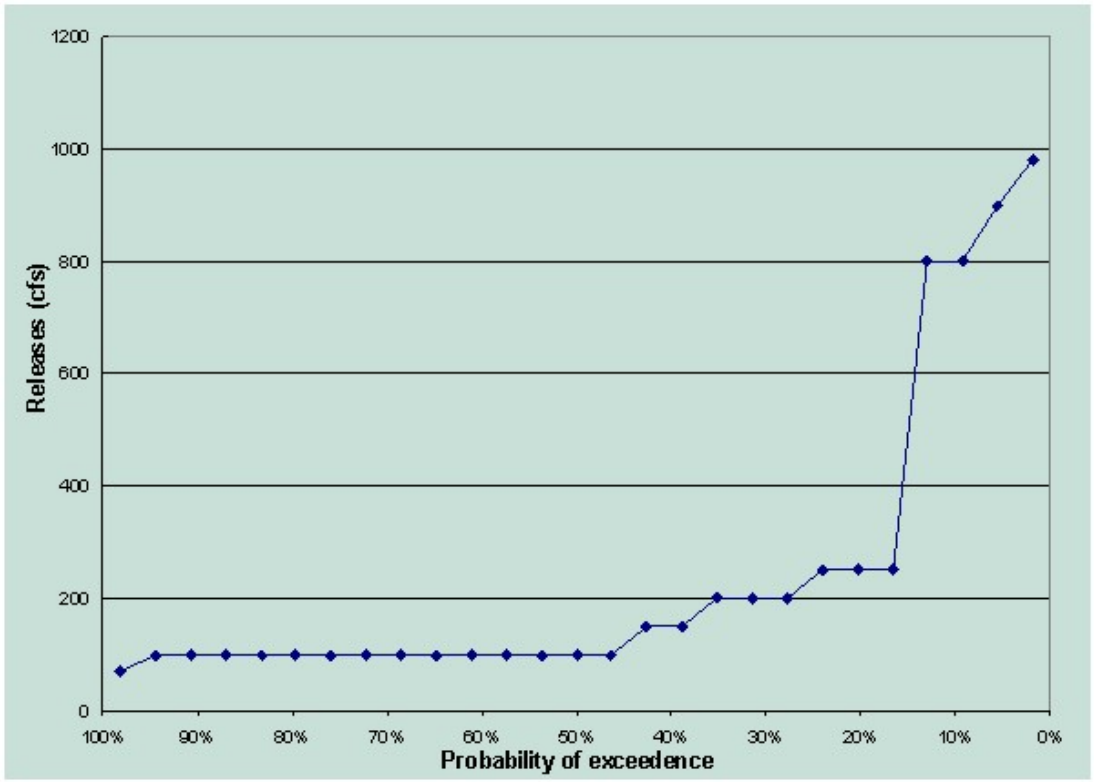

Figure 6–6 Yearly probability of exceedance for releases from Whiskeytown Dam on Clear Creek.

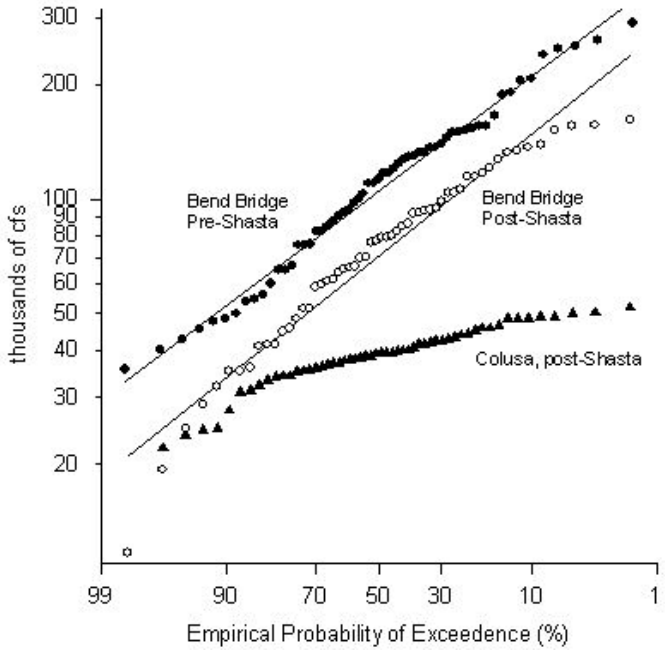

Figure 6–7 Empirical flood frequency plots for the Sacramento River at Red Bluff (Bend Bridge gauge) for pre- and post-Shasta periods, and downstream at Colusa for the post-Shasta period.

The reduced peak flows at Colusa reflect diversions into the Butte Basin between the two gauges. Data from U.S. Geological Survey internet site (www.usgs.gov), Red Bluff (Bend Bridge) and Colusa gauges. Chart from Calfed (2000).

American River

Ayres Associates (2001) used a two-dimensional model of the lower American River constructed from two foot topography to determine at what flows spawning beds would be mobilized. Their modeling results indicated that the spawning bed materials are moving for flows of 50,000 cfs or greater. There appeared to be minimal movement for flows as low as 30,000 cfs, although some movement may occur for flows between 30,000 and 50,000 cfs. Shear stress conditions tend to be highest upstream of Goethe Park, where the majority of salmon and steelhead spawning occurs.

Flood frequency analysis for the American River at Fair Oaks Gauge shows that on average flows will exceed 30,000 cfs about once every four years and exceed 50,000 cfs about once every five years (Figure 6–8). Fair Oaks gauge flows result almost entirely from Folsom and Nimbus releases.

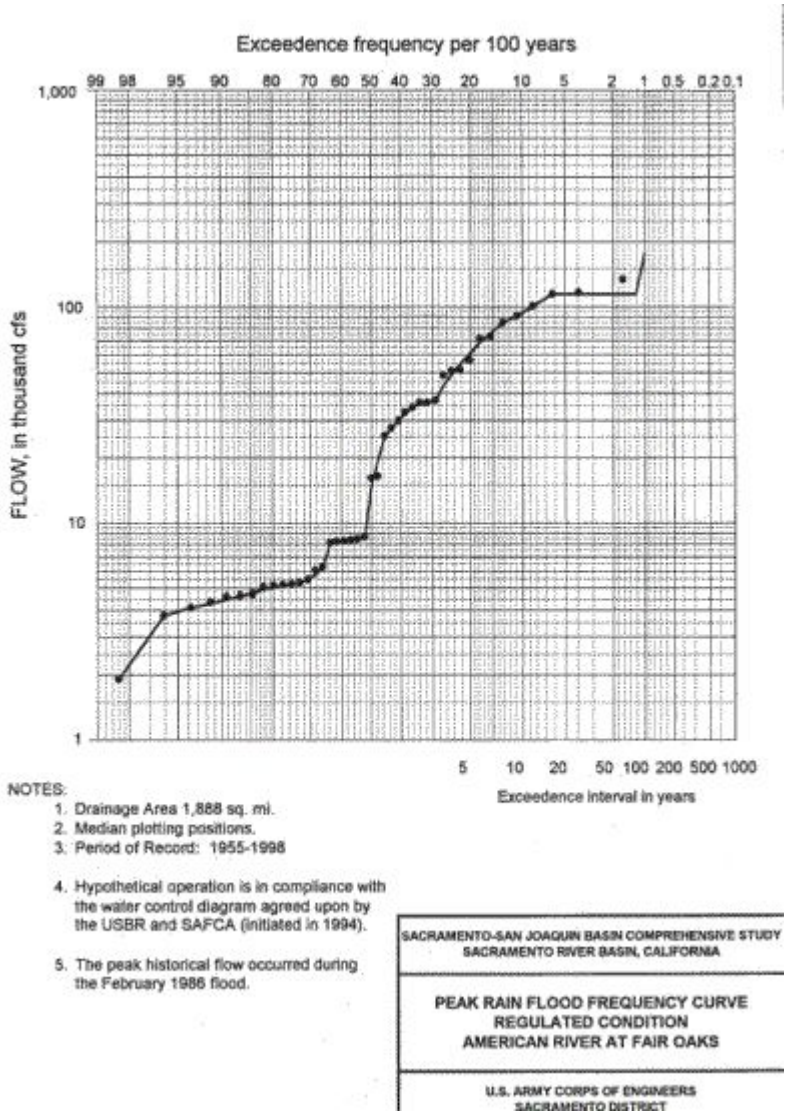

Figure 6–8 Flood frequency analysis for the American River at Fair Oaks Gauge (U.S. Army Corps of Engineers 1999).

Stanislaus River

Kondolf et al. (2001) estimated bedload mobilization flows in the Stanislaus River to be around 5,000 to 8,000 cfs to mobilize the D_{50} of the channel bed material. Flows necessary to mobilize the bed increased downstream from a minimal 280 cfs near Goodwin Dam to about 5,800 cfs at Oakdale Recreation Area.

Before construction of New Melones Dam, a bed mobilizing flow of 5,000 to 8,000 cfs was equivalent to a 1.5 to 1.8 year return interval flow. On the post dam curve, 5000 cfs is approximately a five-year return interval flow, and 8,000 cfs exceeds all flows within the 21 year study period, 1979–99 (max flow = 7,350 cfs on 1/3/97). The probability of occurrence for a daily average flow exceeding 5,330 cfs (the pre-dam bankfull discharge) is 0.01, or one year in a hundred. Figure 6–9 shows the yearly exceedance probability for Goodwin Dam releases.

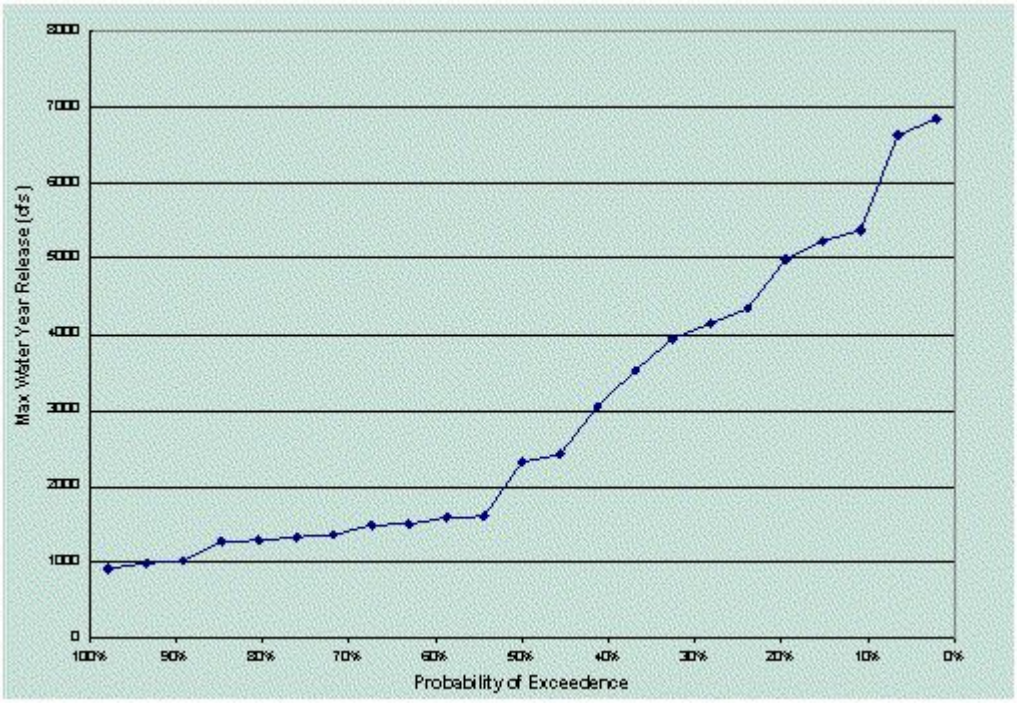

Figure 6–9 Exceedance probability for yearly Goodwin Dam releases.

Flow Fluctuations/Stranding

Flow fluctuations have the potential to dewater salmon and/or steelhead redds or isolate and strand juvenile salmonids below project reservoirs (NOAA fisheries question #3). Depending on the frequency and timing of flow fluctuations within and between years salmon and steelhead populations can be affected.

Clear Creek

Table 6–3 shows the stage discharge relationship in Clear Creek at Igo. If we use the 5 inch redd depth as the threshold for redd dewatering then a flow drop of 100 cfs in the 100 to 300 cfs range could start to dewater the shallowest redds. A flow drop of 150 cfs in the 300 to 800 cfs range could start to dewater redds and a flow drop of 300 cfs between 800 and 1,800 cfs could start to dewater redds. Flows over 500 cfs in Clear Creek are the result of uncontrolled runoff or pulse flows prescribed through collaboration with fishery agencies for the benefit of fish and habitat.

Table 6–3 Stage discharge relationship for the Clear Creek at Igo USGS gauge, Station 11-372000.

STAGE, INCHES	*DISCHARGE, CFS*
33.12	101
38.52	200
42.72	301
46.2	400

STAGE, INCHES	DISCHARGE, CFS
49.32	501
52.2	602
54.72	702
57	803
59.16	903
61.08	1000

Sacramento River

Based on the Sacramento River at Bend Bridge gauge, drops in flow of approximately 800 cfs in the low end of the flow range up to about 20,000 cfs have the potential to start to dry up the shallowest redds 5 inches deep (Table 6–4). Areas of the river away from stream gauges where there is not as much confinement and more spawning activity probably experience less change in stage for a given flow change but the data was not available to evaluate other locations.

Table 6–4 Stage discharge relationship in the Sacramento River at Bend Bridge, gauge 11377100.

STAGE, INCHES	DISCHARGE, CFS
8	4190
10	4500
12	5020
15	5490
18	5990
21	6490
24	6990
27	7490
31	7990
34	8500
38	9000
41	9510
45	10000
48	10500
52	11000
55	11500
59	12000
62	12500
65	13000

STAGE, INCHES	*DISCHARGE, CFS*
68	13500
71	14000
74	14500
78	15000
81	15500
84	16000
87	16500
90	17000
92	17500
95	18000
98	18500
101	19000
103	19500
106	20000
110	21000
114	22000
118	23000
122	24000
126	25000
129	26000
133	27000
137	28000
140	29000
144	30000

American River

Snider et al. (2001) evaluated flow fluctuations relative to stranding in the American River and made the following recommended for operations of the Folsom project.

Ramping rates should not exceed 100 cfs per hour when flows are < 4,000 cfs;

Flow increases to 4,000 cfs or more should be avoided during critical periods (January through July for young of the year salmon and steelhead and October through March for yearling steelhead and non-natal rearing winter-run Chinook salmon) unless they can be maintained throughout the entire period; and

Flow fluctuations that decrease flow below 2,500 cfs during critical spawning periods should be precluded: October – December for Chinook salmon and December – May for steelhead. They define flow fluctuations as unnatural rapid changes in stream flow or stage over short periods resulting from operational activities of dams and diversions.

The shallowest salmon redds observed prior to any flow changes were under 5 inches of water referenced to the original bed surface (Hannon, field observations 2002) and the shallowest steelhead redds observed were over 7 inches deep (Hannon and Healey 2002). Steelhead could likely spawn in water as shallow as Chinook so this analysis is based on water depth reductions of 5 inches that could drop the water level to even with the top of the shallowest redds. Evenson (2001) measured Chinook egg pocket depth in the Trinity River. The shallowest egg depth found was 2.2 inches under the gravel referenced to the original bed surface and the mean depth to the top of the egg pocket was 9 inches. Ninety-three percent of the top of egg pockets were buried at least 5 inches under the gravel. Five inch deep eggs would not become dewatered until water drops at least 10 inches but fry emergence could be prevented if no water is over the surface of the redd. Based on cross sections measured in 1998 by the FWS, flow changes of 100 cfs generally change the water depth by about 1 inch in a flow range of 1,000 to 3,000 cfs and by about 0.5 inch in a flow range from about 3,000 to 11,000 cfs. Therefore, when flows are 3,000 cfs or lower flow drops of 500 cfs or more can begin to dewater redds. When flow is over 4,000 cfs flow drops of 1,000 cfs or more can begin to dewater redds.

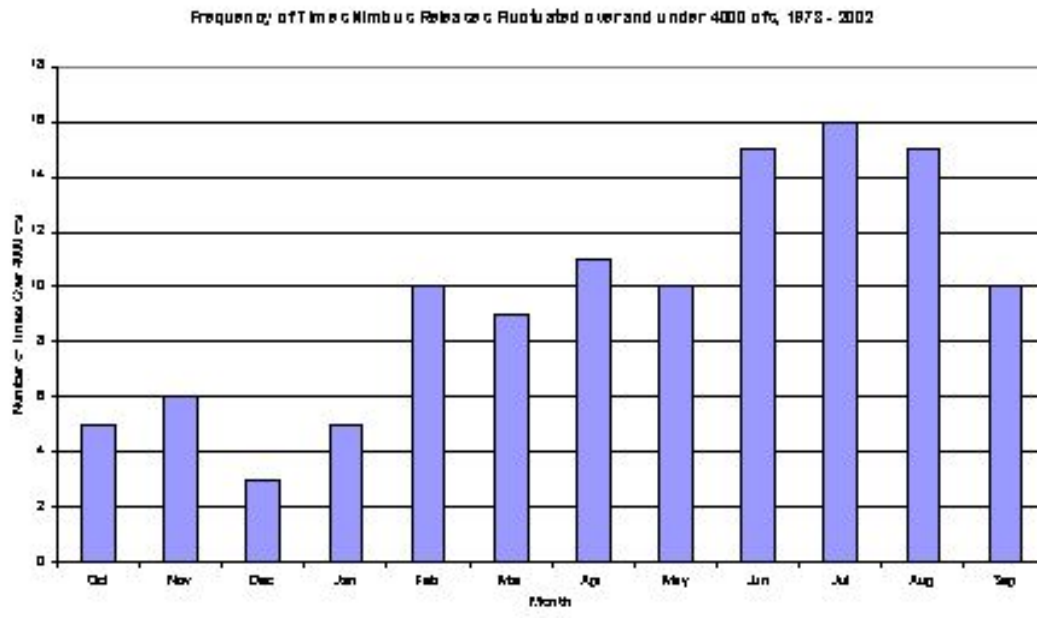

Figure 6–10 Frequency of times Nimbus releases fluctuated over and under 4000 cfs, 1972–2002.

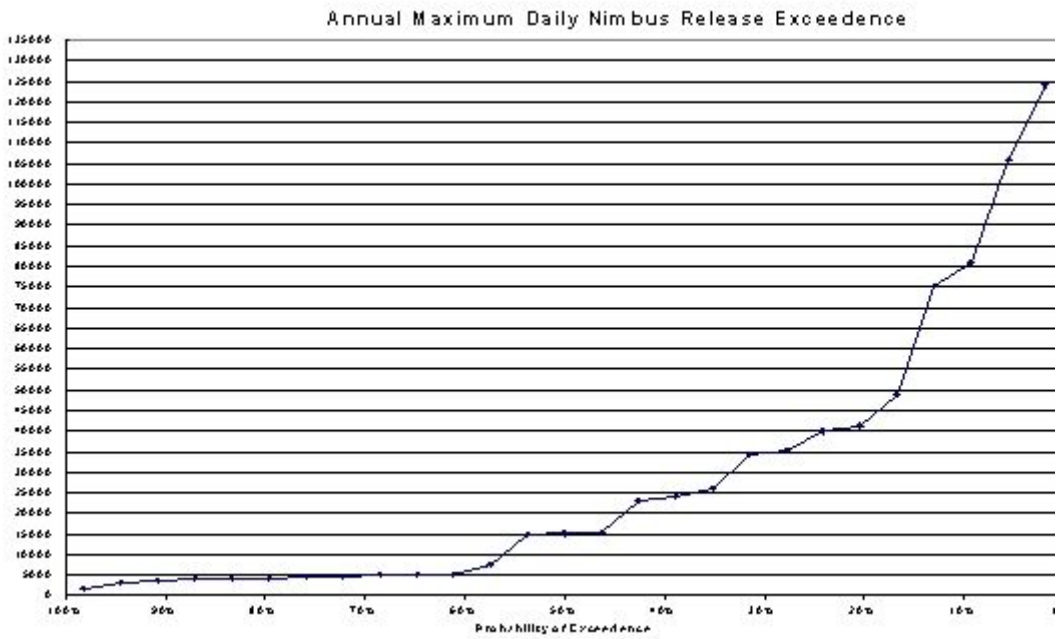

Figure 6–11 Annual Maximum Daily Nimbus Release Exceedance.

Stanislaus River

Based on the Stanislaus River at Ripon gauge, drops in flow of approximately 50 cfs in the flow range of 100 to 300 cfs have the potential to start to dry up the shallowest redds 5 inches deep (Table 6–5). Although the Ripon gauge is downstream of spawning areas, the channel morphology at the gauging station is similar to that through much of the spawning area so the stage discharge relationship should be similar. Drops in flow of 100 cfs in the flow range of about 300 to 1,000 cfs will cause a 5 inch drop in water surface elevation. Drops in flow of about 175 cfs in the flow range of 1,000 to 2000 cfs will cause about a 5 inch drop in water level.

Table 6–5 Stage discharge relationship in the Stanislaus River at Ripon, gauge 11303000.

Stage, inches - 440	*Discharge, cfs*
3	100
5	125
8	150
10	174
13	200
17	251
21	300
24	350
27	400

Stage, inches - 440	*Discharge, cfs*
32	501
37	601
43	700
49	800
54	900
58	1000
67	1200
76	1400
84	1600
92	1800
100	2000
120	2500
139	3000
175	4000
199	5000
215	6000

Flow and Its Importance to Sub-adult Chinook Salmon

Streamflow is important to sub-adult Chinook salmon (Healey 1991). Larger salmon populations tend to occur in larger river systems, suggesting a direct effect of discharge on the amount of suitable habitat area. River flows directly affect through-gravel percolation rates, which are very important to egg survival, and may help disperse swim-up fry to suitable rearing habitats.

Streamflows indirectly affect other environmental conditions, which in turn affect Chinook survival. For instance, flow rates can affect in stream temperatures for a short distance downstream of reservoirs before ambient air temperatures take over. In natural stream systems, flow is correlated with turbidity. Turbidity may be important in juvenile life stages. Juvenile salmon losses to predators may be reduced by at least 45 percent in turbid water stream reaches relative to clear water reaches (Gregory and Levings 1998). Turbid water may also stimulate faster migration rates, which reduces the time young fish are exposed to freshwater mortality risks. The relative survival benefits of longer versus shorter freshwater residence time in juvenile Chinook has not been determined for Central Valley stocks. Pink salmon, the most abundant of the salmon species, emigrate to the ocean immediately upon emergence from the gravel and presumably derive survival benefits from this trait, although pink salmon are generally less abundant in watersheds requiring freshwater migrations over longer distances. High outflows and sediment loads can increase egg mortality through scouring and suffocation (Healey 1991).

In the upper Sacramento Basin, problems of flow and temperature are closely associated during the summer and fall. Low flows make spring-run habitat in tributaries like Clear Creek, Cottonwood Creek, and Antelope Creek marginally usable, or even unusable. Problems with low flow and high temperature may also occur in current spring-run habitat like Butte and Big Chico Creeks. The likelihood that survival will be reduced in low flow years could be greater in unregulated tributaries than in regulated tributaries where stored water can sustain releases longer through dry periods.

Fish Passage

As with steelhead and other salmon races, migration barriers are a problem for winter-run and spring-run Chinook (Table 3-5). Winter-run and Spring-run have been cut off from much of their historical upper basin spawning habitat for decades by large dams. In addition, migration may be slowed or prevented in smaller tributary streams by numerous smaller agricultural diversion facilities.

ACID Diversion Dam

The ACID diversion dam created fish passage problems and can require a substantial reduction in Keswick Reservoir releases to adjust the dam flashboards, which results in dewatered redds, stranded juveniles and higher water temperatures. However, Reclamation assisted in the redesign and renovation of the flashboards and related facilities in the 1990's to reduce the risks of dewatering redds. Fish ladders and fish screens were installed around the diversion and were operated starting with the summer 2001 diversion period. During the spawning runs in 2001 and 2002 there was a substantial increase in spawning upstream of the diversion dam, attributable to the access provided by the fish ladders (Table 4-6 winter–run redd chart).

Red Bluff Diversion Dam

Problems in salmonid passage at RBDD provide a well-documented example of an agricultural facility impairing salmon migration (Vogel and Smith 1984; Hallock 1989; FWS 1987, 1989, 1990a; Vogel et al. 1988, all as cited in DFG 1998). The implementation of gates-out operations and construction of the rotary drum screen facility have substantially improved fish passage conditions at RBDD (see discussion of RBDD in Chapter 3). All spring-run juvenile emigrants pass RBDD during the gates-out period based on historical average run timing at RBDD. However, about 30 percent of adult spring–run immigrants that attempt to pass Red Bluff encounter gates-out conditions based on run timing when gates were lowered year roung (FWS 1998, as cited in DFG 1998). The current gates down operation potentially delays 15 percent of the adult winter–run and 35 percent of the juveniles going downstream in July, August, and September encounter the lowered gates (NOAA Fisheries 2003). Based on winter–run population increases that have occurred since the current gate operations were initiated, the population seems capable of increasing under current operations.

Aerial redd surveys conducted for winter–run and spring–run spawning since 1987 by DFG show that since the gates out period was moved to September 15 – May 15 in 1993, few winter–run have spawned below RBDD (Table 6–6). During 1994 and 1995 higher percentages of spring–run spawned below RBDD than in other years. The majority of spring–run production in

recent years has continued to occur in Sacramento River tributaries downstream of RBDD (Mill Creek, Deer Creek, Big Chico Creek, Butte Creek, and Feather River) despite the partial elimination of migration delays. Not counting Feather River spring–run which are primarily considered to be of hatchery origin, 92 percent of spring–run since 1992 occurred in the tributaries downstream of RBDD. The proportion of spring–run using these tributaries was not affected by migratory delays at RBDD. The 8 percent of spring–run in the Sacramento River and tributaries upstream of RBDD were potentially affected by migratory delays at RBDD.

Table 6–6 Percent of winter run and spring–run redds counted below Red Bluff Diversion Dam, 1987 – 2003. data from Killam (2002).

Year	*Winter–run % Spawning Below RBDD*	*Spring–run % Spawning Below RBDD*	*Months RBDD Gates Raised*
1987	5	no survey	December - March
1988	25	3	December - mid-February
1989	2	0	December - mid-April; gates in 11 days in February
1990	7	0	December - March
1991	0	0	December - April
1992	4	0	December - April
1993	2	0	September 15 - May 15
1994	0	15	September 15 - May 15
1995	1	9	September 15 - May 15
1996	0	0	September 15 - May 15
1997	0	1	September 15 - May 15
1998	3	0	September 15 - May 15
1999	0	no survey	September 15 - May 15
2000	0	0	September 15 - May 15
2001	0.4	3	September 15 - May 15
2002	0.2	0	September 15 - May 15
2003	0.3	0.6	September 15 - May 15

New redds constructed in the Sacramento River during the typical spring-run spawning period (late August and September) since redd surveys began have shown low numbers of new redds relative to new redds counted during winter–run spawning timing and fall–run spawning timing. Peaks in redd count numbers are evident during winter–run spawning and fall–run spawning but not during spring–run spawning. The number of new redds has diminished through July and then increased at the end of September before the large increase that occurs after October 1 when they

become classified as fall-run. This suggests that the number of spring-run spawning in the Sacramento River is low (average of 26 redds counted) relative to the average spring-run escapement estimate between 1990 and 2001 in the main stem Sacramento River of 908. The additional fish have not been accounted for in the tributaries upstream of RBDD. The additional fish appear to spawn in October and get counted as fall-run redds.

Additional analysis of effects of RBDD on salmon and steelhead was analyzed in an EIS (CH2M Hill 2002). Reclamation intends to maintain the same May 15 – September 15 gates in period as has been used since the 1993 winter–run biological opinion as stated in chapter 2.

Suisun Marsh Salinity Control Gates

The Suisun Marsh Salinity Control Gates (SMSCG) have the potential to affect immigration of all four Chinook races as adults move upstream through Montezuma Slough. Edwards et al. (1996) and Tillman et al. (1996) indicated operation of the SMSCG delays and/or blocks the upstream migration of adult salmon. The studies were unable to provide an accurate estimate of the magnitude of the delay or blockage due to variable results, but a potential minimum delay of about 12 hours per tidal day is possible when the gates are closed. The biological significance of this potential increase in migration time to spring-run populations is unknown since DFG staff estimates it takes a salmon 30 days to reach its spawning area from the bays (DFG 1998). Further, Montezuma Slough is only one path through the estuary, and its relative importance to the overall immigration of adult spring-run has not been studied.

Limited information is available regarding the behavior of adult Chinook in estuaries. Information from the literature indicates that tidal phase, natal origin, water temperature, dissolved oxygen, and changes in flow can all affect upstream immigration. Stein (2003) tracked 480 adult salmon, tagged with ultrasonic transmitters, through the Delta as part of multi-agency Delta Cross Channel studies. Salmon movements were inconsistent between individuals. Many salmon crossed back and forth between different channels for weeks while some moved upstream quickly. Transit times in the Delta ranged from3–48 days.

Generally, adult spring-run may be present in Suisun Marsh from February through June, with peak occurrence in May. The SMSCG are operated only to meet salinity standards. Therefore, avoidance measures (flashboards and gates out of water) are already in place to minimize effects during months when specific conductance is below standards by more than two mS/cm. Measures to improve passage for adult spring-run would be most effective if implemented when adult spring-run are moving upstream in late March through May of dry and critical water years, and mid-April through May in above and below normal water years.

DWR (1997) discussed several specific measures to mitigate gate operation effects on immigrating salmon. The measures examined included: (1) structural modifications to the flashboard section of the control gate facility in the form of openings or passages in individual flashboards; (2) lowering the height of the flashboard structure; and (3) altering the timing of gate closure on flood tides.

The Suisun Marsh Salinity Control Gates Steering Group reviewed the results from the examination of mitigation alternatives and requested an evaluation of the potential effects of structural modifications to the flashboards. Under this evaluation, the flashboard structure was modified by removing one of the four, six-foot tall flashboards and creating two, three-foot

horizontal slots at two depths to potentially provide continuous unimpeded passage for adult salmon. To test the effectiveness of this modification, a three-year evaluation was initiated in the fall of 1998 by DFG and DWR to sonic tag adult fall-run Chinook and monitor their movement through the gate structure during threephases of operation: (1) when the gates are open; (2) during full-bore gate operation; and (3) during full-bore gate operation with the modified flashboard structure installed. The evaluation was repeated in two consecutive control seasons with the fish tagging and tracking occurring from approximately September 15 through October 31 of both years. The fish-tagging period was limited to the time when fall-run Chinook were present in Suisun Marsh. The Suisun Marsh Salinity Control Gates Steering Group decided based on preliminary results from the modified SMSCG tests that the slots resulted in less adult passage than the original flashboards. The steering group decided to postpone the third year of the test until September 2001 and to reinstall the original flashboards when gate operation was needed during the 2000–2001 control season. DWR and Reclamation focused on data analysis from August 2000 through February 2001, and conducted the third year of the study during the 2001–02 control season. Based on the these results, another approach to improve passage is being investigated. This modification includes opening the boat lock and using full flashboards when gates are operational. This study will take place over threeyears, from 2001–03. See "Suisun Marsh Salinity Control Gates" in Chapter 10 for more information.

Delta Emigration

The following discussion emphasizes spring-run yearling emigrants, which have been of particular management concern in recent years. This primarily addresses emigration from Mill and Deer Creeks (DFG 1998), which have a higher proportion of spring-run emigrating as yearlings than either Butte Creek (Brown 1995) or the Feather River (DWR 1999a,1999b,1999c). Sub-yearling spring-run emigrate during winter and spring when protections for delta smelt and winter-run Chinook salmon are in place. There is significant uncertainty regarding timing of emigration of yearling spring-run Chinook. Because a relatively small number of yearlings are emigrating, they are difficult to detect in the monitoring programs. Yearlings are relatively large, strong swimmers, so they may also more easily avoid the monitoring gear (McLain 1998). Other juvenile Chinook in the main stem Sacramento River are in the same size range used to define yearling spring-run Chinook, confounding data interpretation.

Marked releases of Coleman Hatchery yearling late fall-run (hereafter Coleman late fall-run Chinook) juveniles have been used as surrogates to estimate the timing of yearling spring-run emigration and take at the Delta export facilities for the Spring-run Protection Plan and the 1992 OCAP. Since 1994, FWS has released approximately 17 percent of the Coleman Hatchery late-fall production in each of November, December, and January to evaluate hatchery operations. The fish were adipose fin-clipped and coded wire tagged before release allowing identification of the members of individual release groups when they are recaptured downstream. The regulatory agencies considered Coleman late-fall Chinook appropriate surrogates for yearling spring-run because they were reared to a similar size as spring-run yearlings and were released in the upper Sacramento River. Because they were large, they were expected to emigrate quickly. They were reared in Sacramento River water, and were therefore expected to quickly habituate to the river conditions. Some patterns have recently been revealed through the Butte Creek coded wire tag

program on naturally spawned spring–run. In particular the potential effects of the Sutter Bypass (lower Butte Creek). Residence time for these fish seems to be 60 – 120 days and dependent on water levels in the bypass resulting from Sacramento River flows (DFG 2003).

Coleman late-fall Chinook released in November were captured at Red Bluff and the Glenn-Colusa Irrigation District facility within two or three days of release. However, they were not captured downstream in the lower Sacramento River or the Delta, until about three days after the first significant, precipitation-induced flow event in November or December (Figure 6–12 through Figure 6–20). This suggests Chinook yearlings may use these flow events as migration cues. Based on captures in the FWS Chipps Island midwater trawl and salvage at the CVP's and SWP's Delta export facilities, some individuals may continue to emigrate for up to five months.

The Coleman late-fall Chinook released in December (Figure 6–12 through Figure 6–20) were released after the first significant, precipitation-induced flow event in the fall. However, they were not captured in the Delta until after a second significant precipitation event occurred unless there was significant Sacramento River flow associated with the earlier precipitation-induced events. Since precipitation events occurred sooner after the December releases than the November releases, these fish may have remained in the upper Sacramento River for a relatively short time (several days up to a week), then taken several more days to reach the Delta following a precipitation-induced flow event. Some emigration continued for up to four months.

The emigration of Coleman late-fall Chinook released in January (Figure 6–12 through Figure 6–20) was not as closely related to precipitation-induced flow events as the November or December releases; perhaps because significant precipitation and high flows had generally occurred prior to their release. The relationship between emigration and flow associated with precipitation events is variable, although the 1994 dry water year (Figure 6–12) is an example of January releases emigrating on precipitation-induced flow events throughout the winter and spring. Again, some emigration continued for up to four months.

Since Coleman late-fall and spring-run yearlings are similar in size and rear in the upper Sacramento River, their emigration patterns should be similar. Therefore, Sacramento River flow associated with precipitation events, along with related tributary flow events, probably provides the major cue for yearling spring-run emigration.

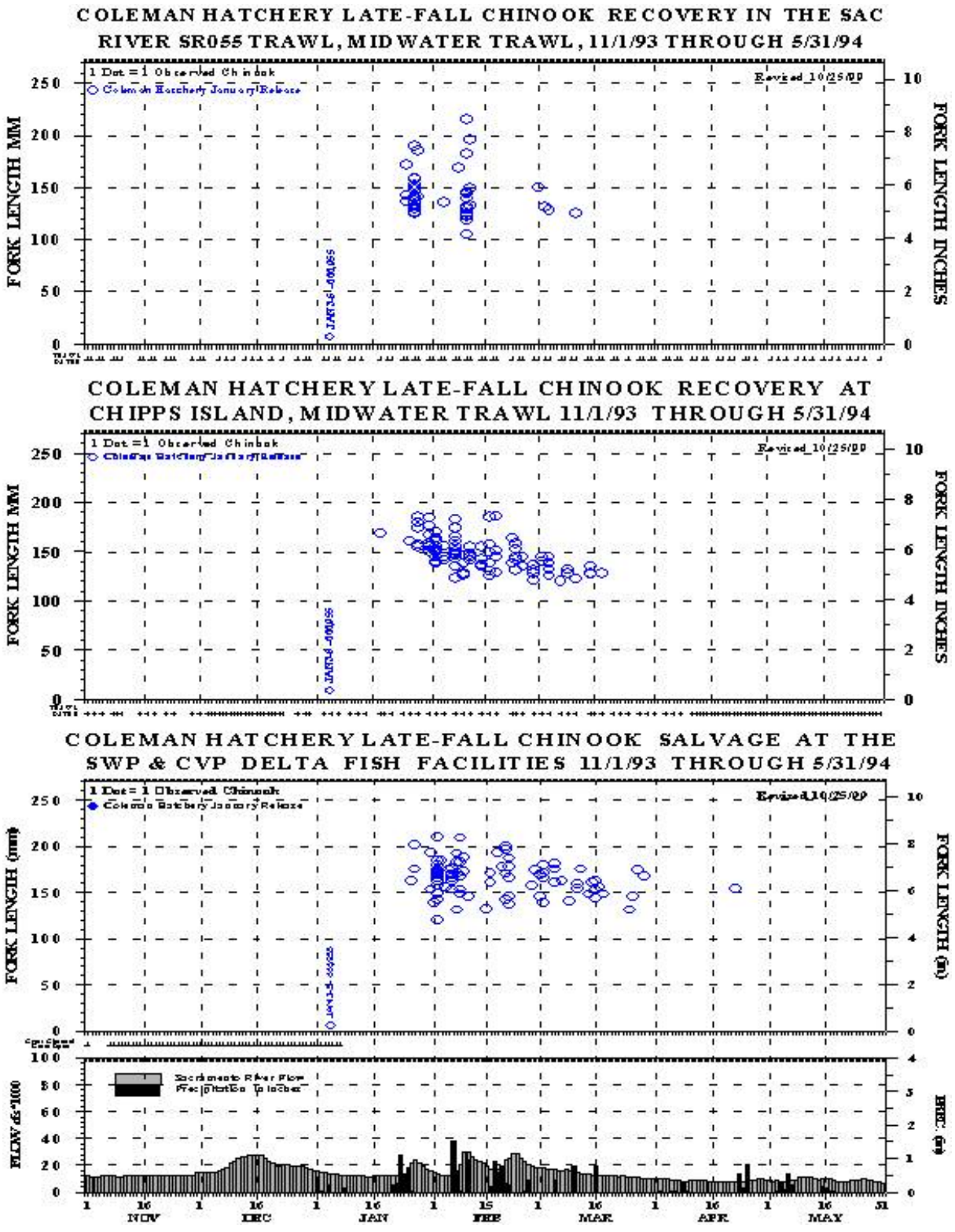

Figure 6–12 Timing of recoveries of coded-wire-tagged Coleman National Fish Hatchery late fall-run Chinook salmon smolts, Sacramento River flow at Freeport, and precipitation at Red Bluff Airport, winter 1993–1994.

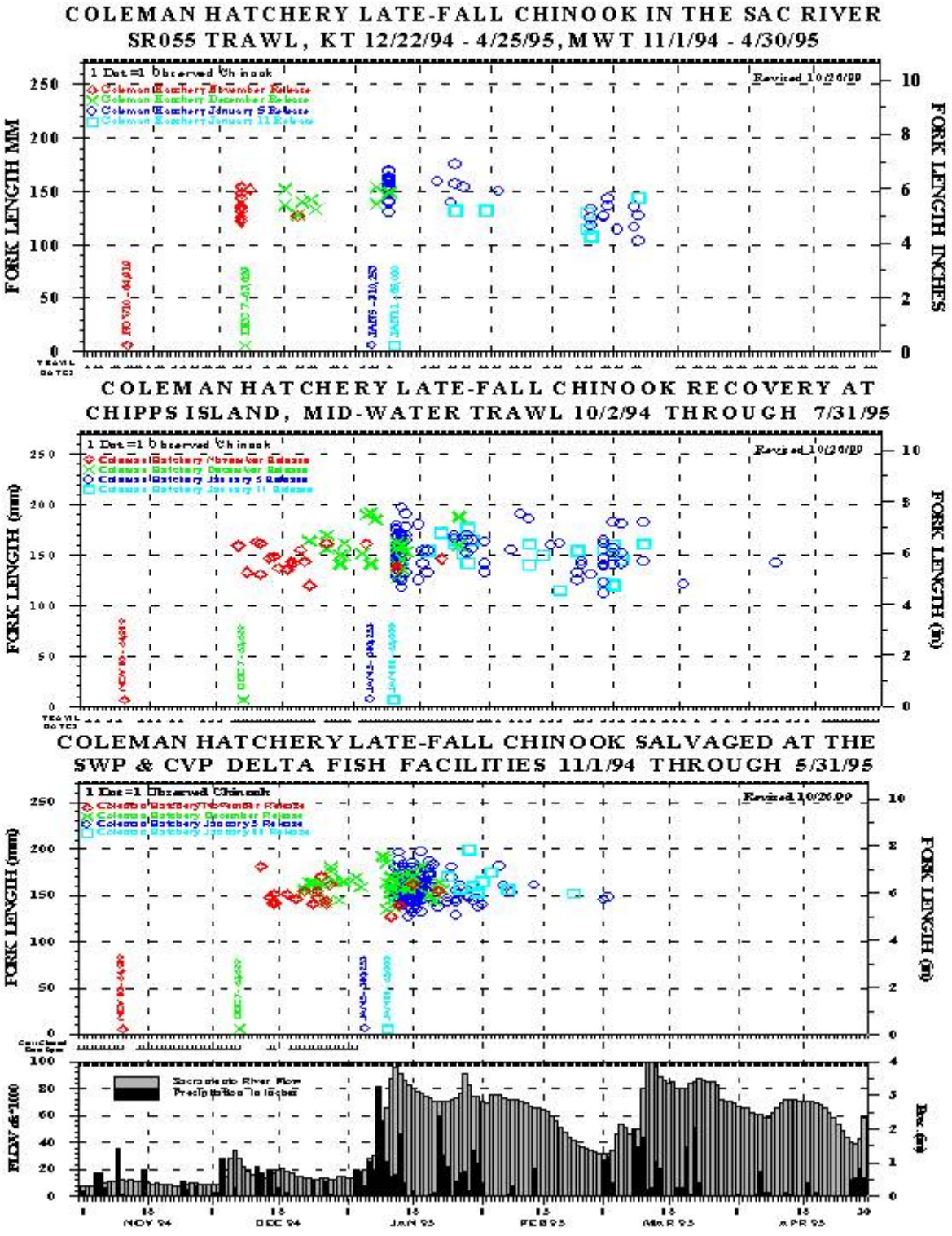

Figure 6–13 Timing of recoveries of coded-wire-tagged Coleman National Fish Hatchery late fall-run Chinook salmon smolts, Sacramento River flow at Freeport, and precipitation at Red Bluff Airport, winter 1994–1995.

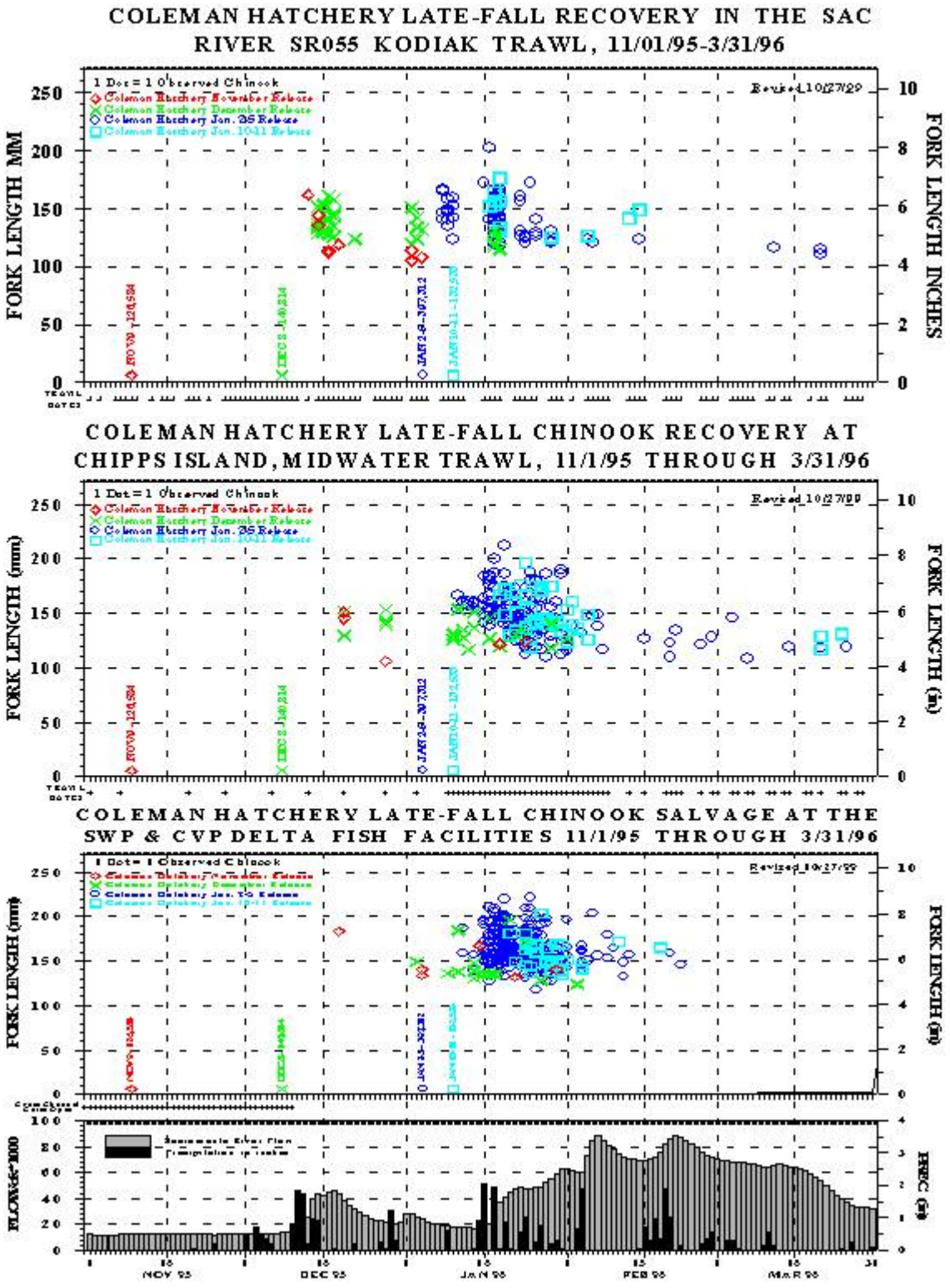

Figure 6–14 Timing of recoveries of coded-wire-tagged Coleman National Fish Hatchery late fall-run Chinook salmon smolts, Sacramento River flow at Freeport, and precipitation at Red Bluff Airport, winter 1995–1996.

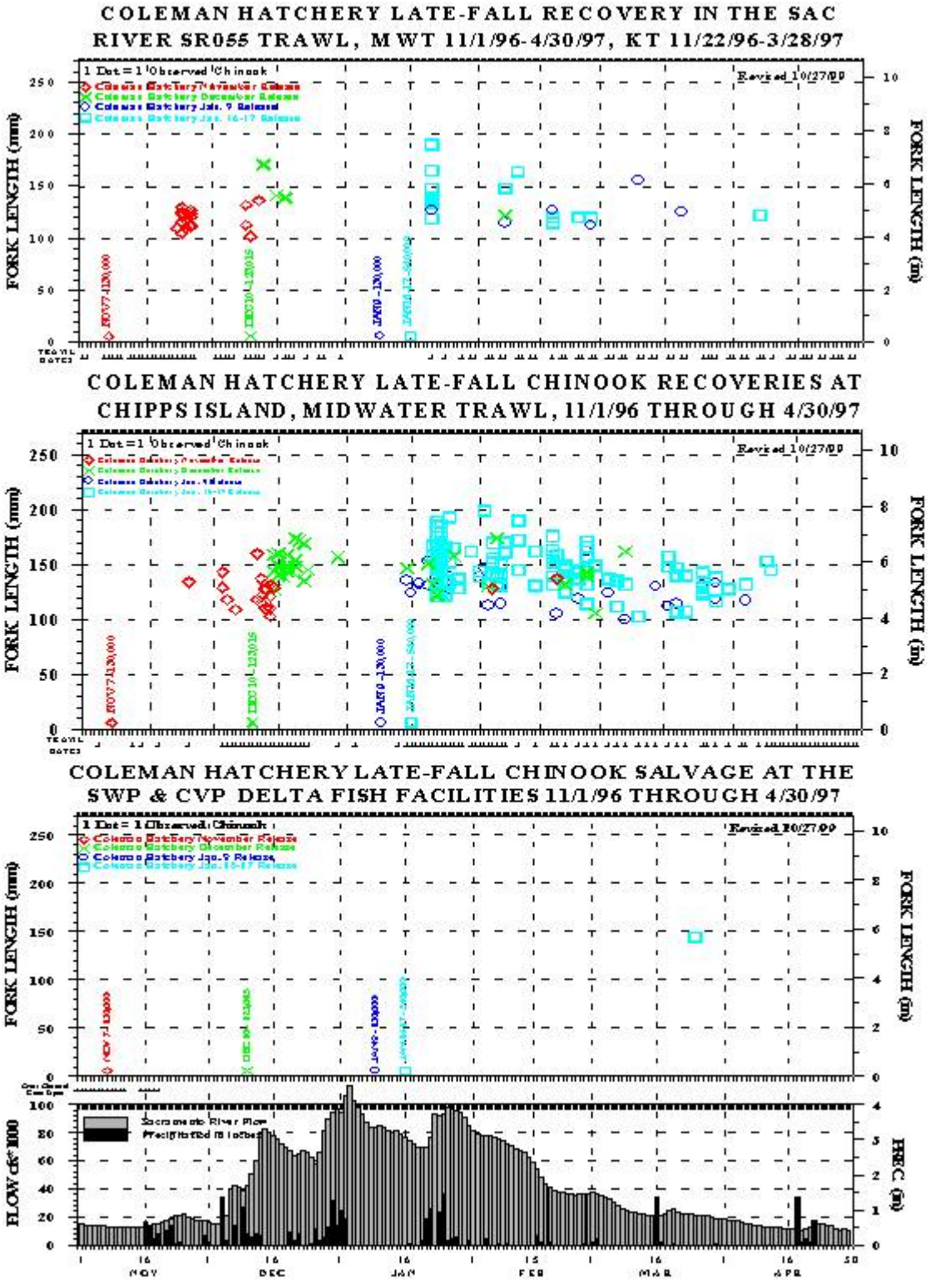

Figure 6–15 Timing of recoveries of coded-wire-tagged Coleman National Fish Hatchery late fall-run Chinook salmon smolts, Sacramento River flow at Freeport, and precipitation at Red Bluff Airport, winter 1996–1997.

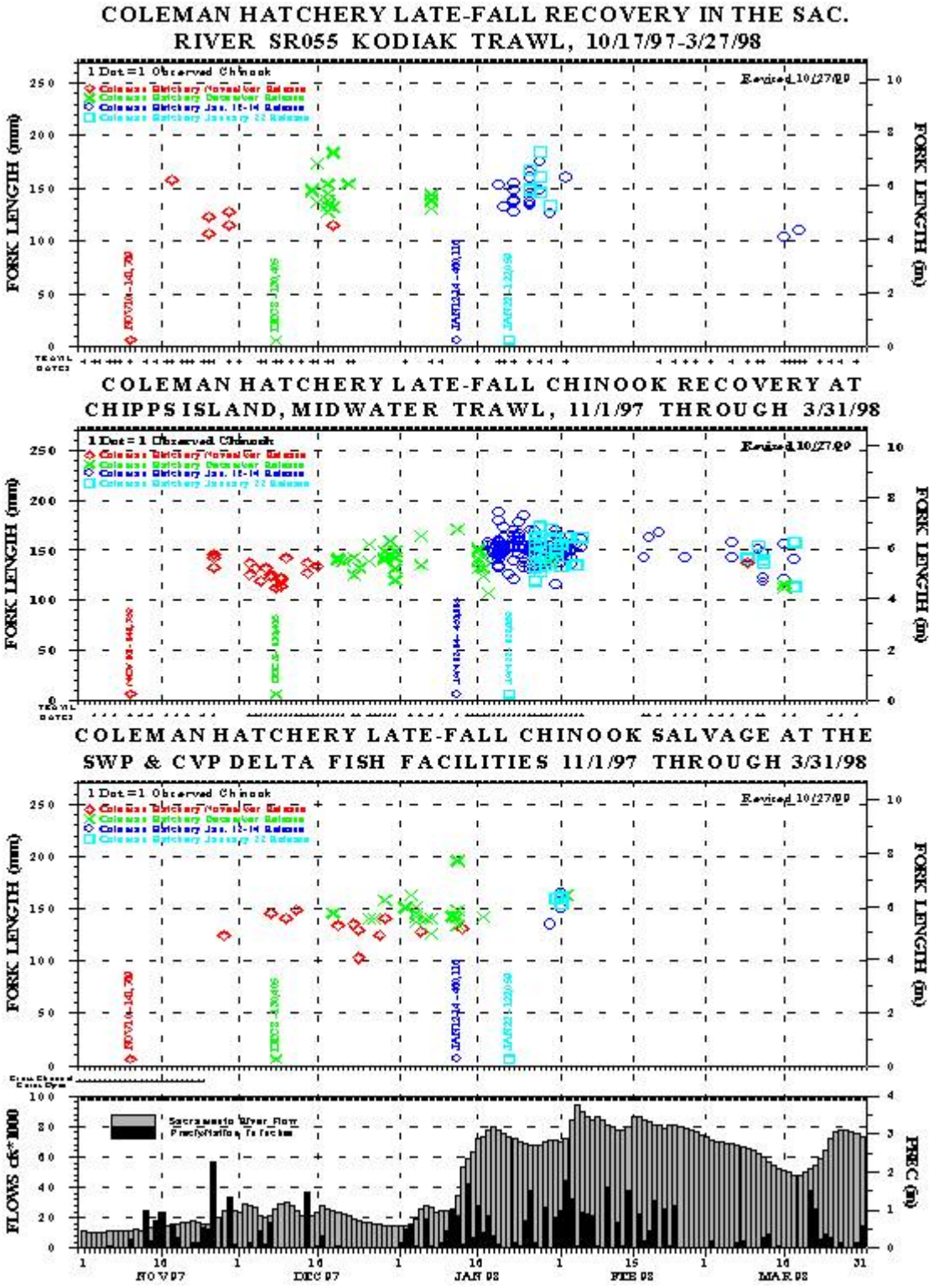

Figure 6–16 Timing of recoveries of coded-wire-tagged Coleman National Fish Hatchery late fall-run Chinook salmon smolts, Sacramento River flow at Freeport, and precipitation at Red Bluff Airport, winter 1997–1998.

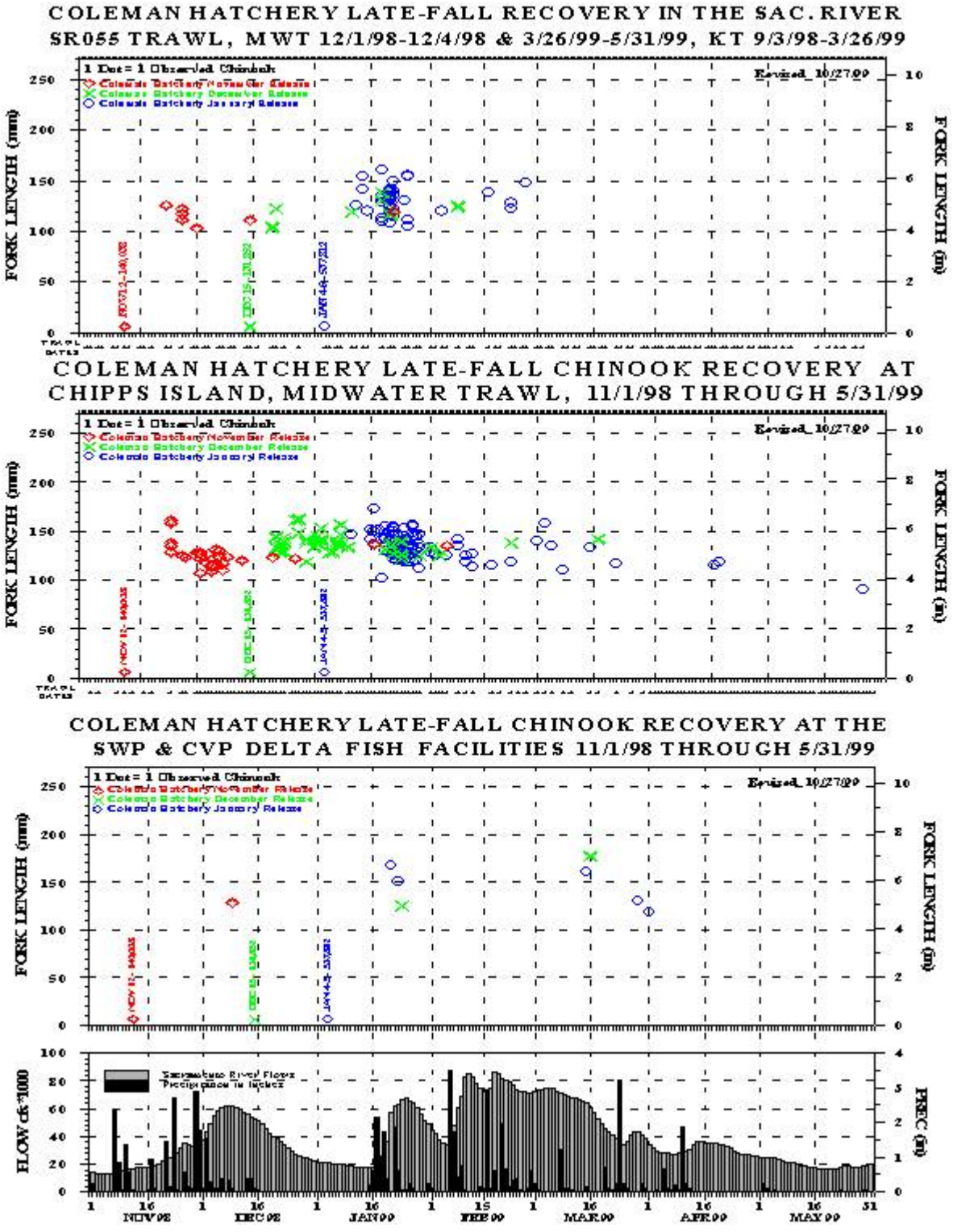

Figure 6–17 Timing of recoveries of coded-wire-tagged Coleman National Fish Hatchery late fall-run Chinook salmon smolts, Sacramento River flow at Freeport, and precipitation at Red Bluff Airport, winter 1998–1999.

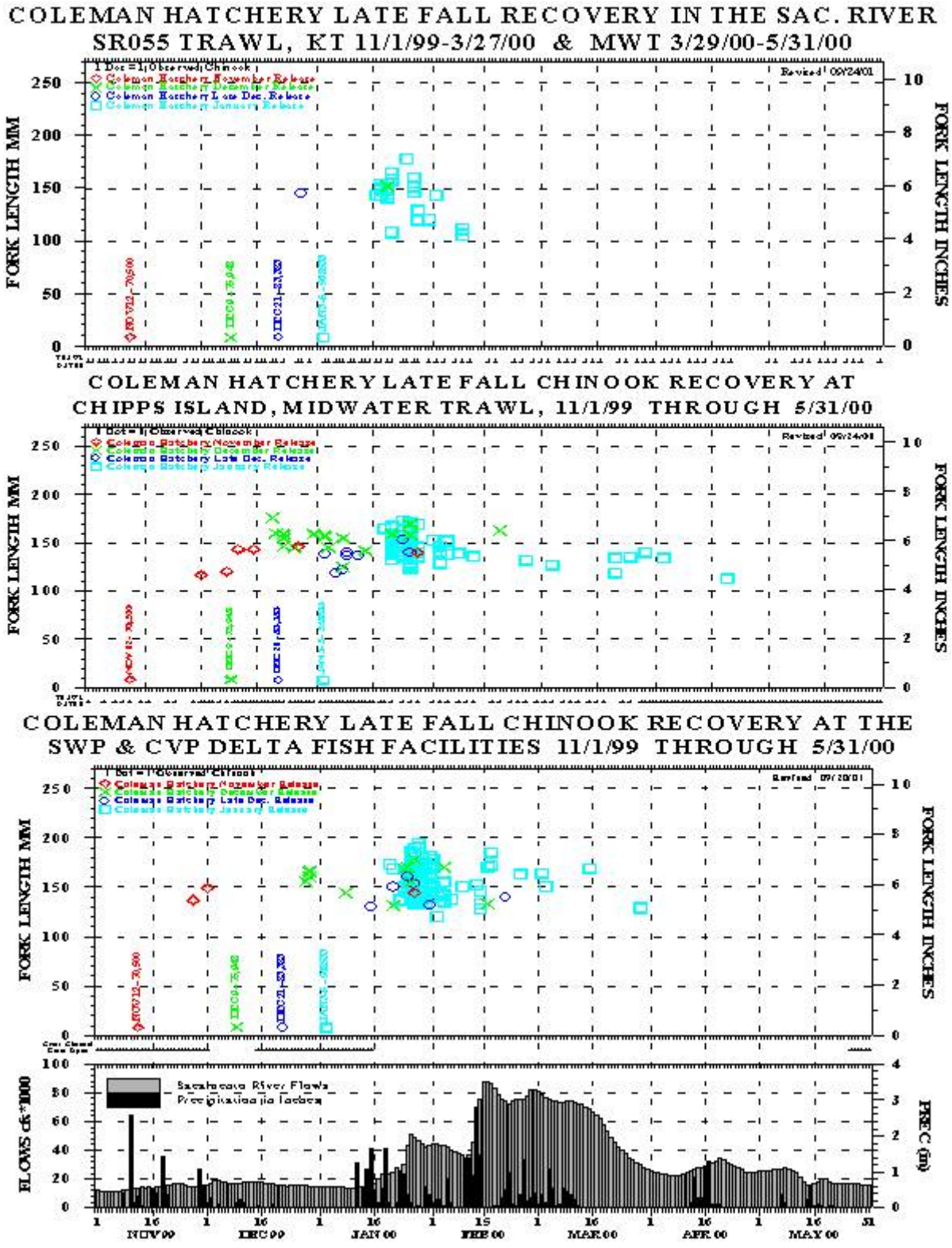

Figure 6–18 Timing of recoveries of coded-wire-tagged Coleman National Fish Hatchery late fall-run Chinook salmon smolts, Sacramento River flow at Freeport, and precipitation at Red Bluff Airport, winter 1999–2000.

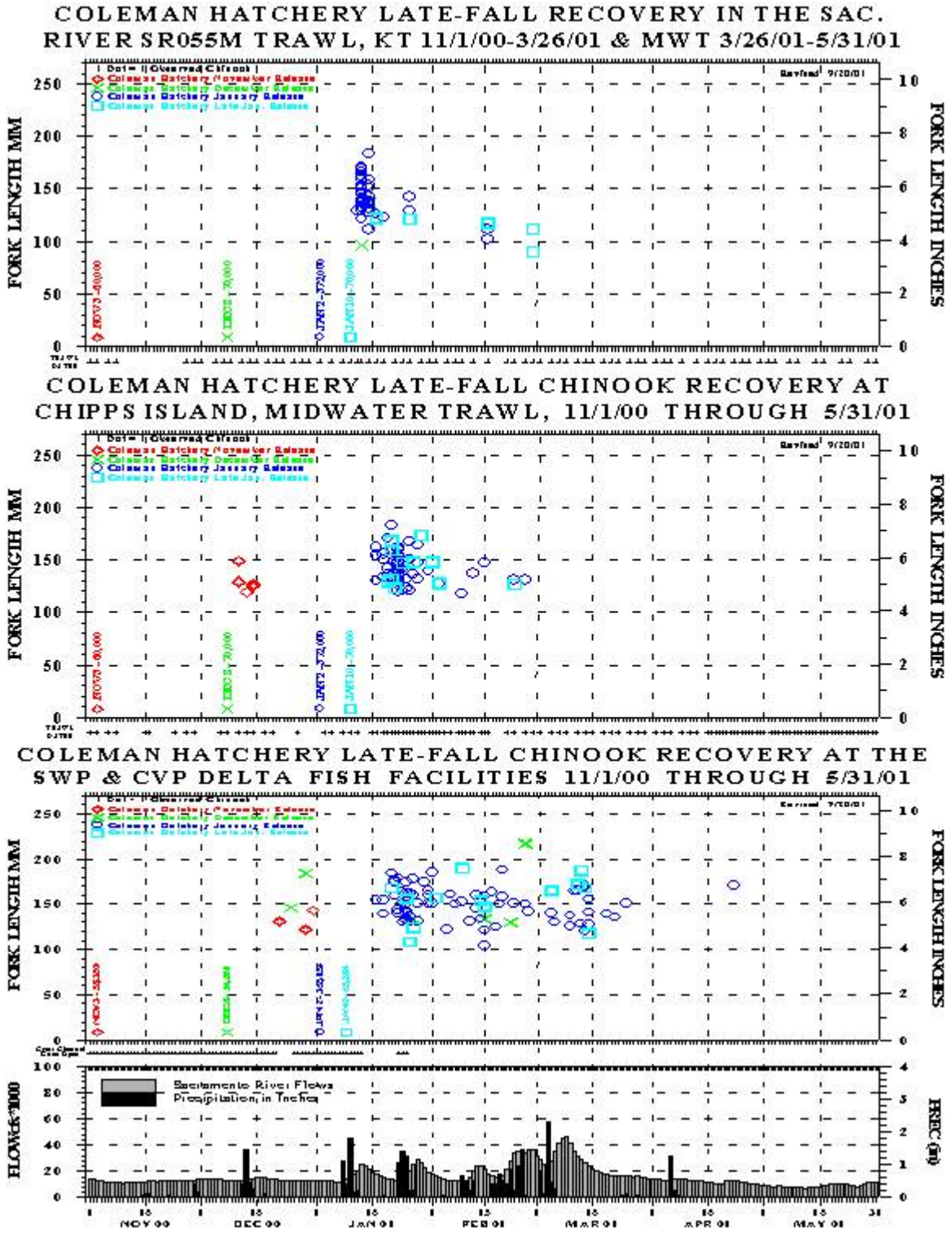

Figure 6–19 Timing of recoveries of coded-wire-tagged Coleman National Fish Hatchery late fall-run Chinook salmon smolts, Sacramento River flow at Freeport, and precipitation at Red Bluff Airport, winter 2000–2001.

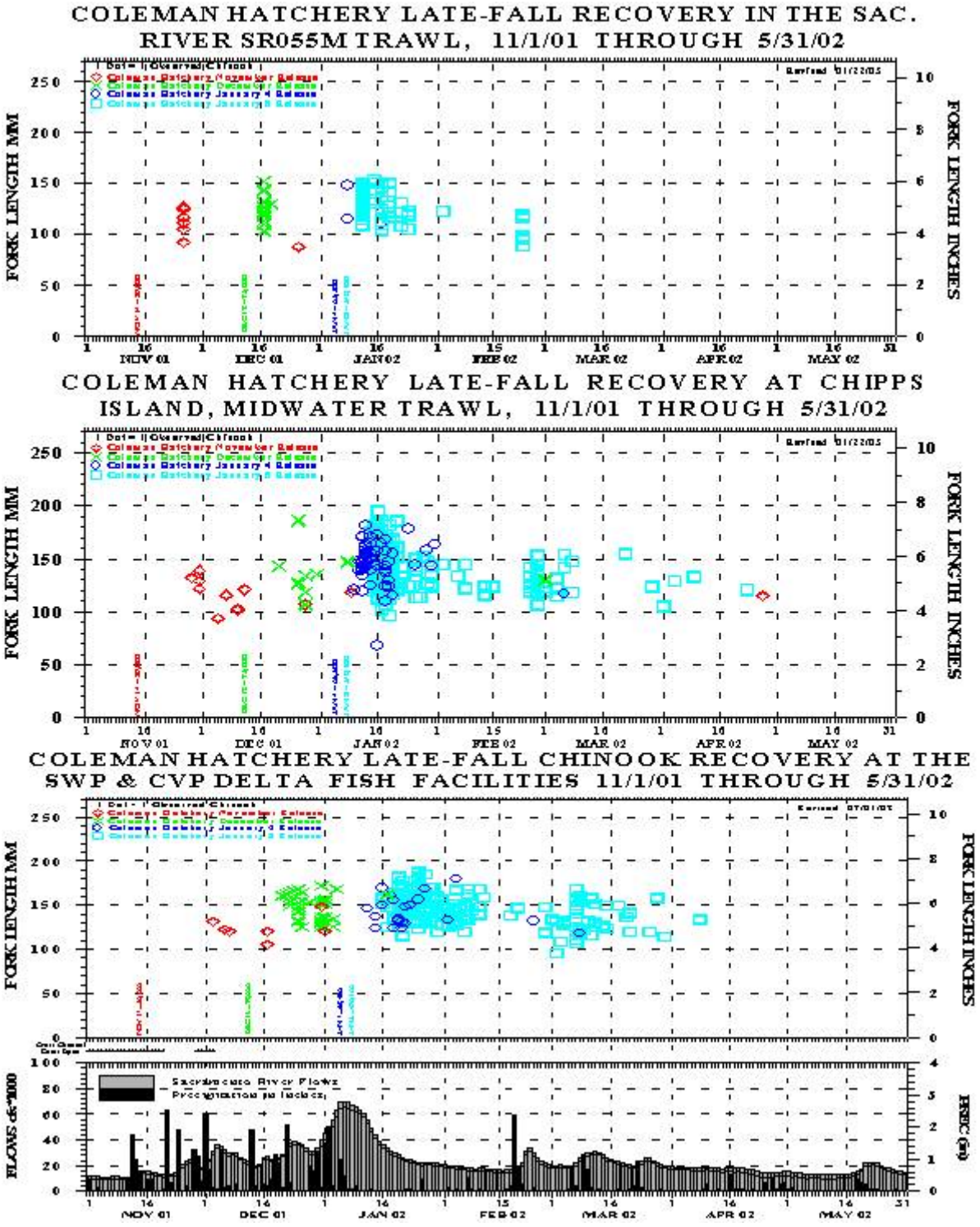

Figure 6–20 Timing of recoveries of coded-wire-tagged Coleman National Fish Hatchery late fall-run Chinook salmon smolts, Sacramento River flow at Freeport, and precipitation at Red Bluff Airport, winter 2001–2002.

Pooling data for all late fall-run yearling releases since November 1993 , the average travel time from Coleman Hatchery to Sacramento has been 19 days, with a standard deviation of 12 days. The average travel time from the hatchery to Chipps Island has been 26 days (standard deviation = 11 days) and the average travel time from the hatchery to the Delta fish facilities has been 33 days (standard deviation = 18 days). The median travel times to Sacramento and the facilities are significantly different; other combinations are not (ANOVA $F = 4.33$; $p = 0.02$, + post hoc multiple comparison tests). Sacramento River flow for 30 days following release from the hatchery explains some of the variability in median travel time to Chipps Island (Figure 6–21)

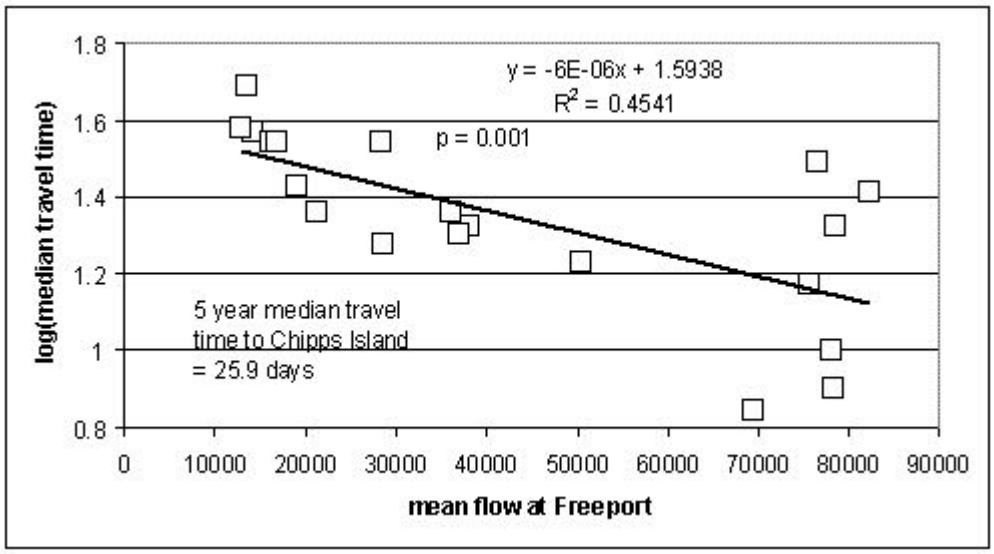

Figure 6–21 Relationship between mean flow (cfs) in the Sacramento River and the log10 time to recapture in the FWS Chipps Island Trawl for Coleman Hatchery late fall-run Chinook salmon smolts. The explanatory variable is mean flow at Freeport for 30 days beginning with the day of release from Coleman Hatchery. The response variable is an average of median days to recapture for November through January releases during winter 1993–94 through 1998–99.

Winter-run migrate through the Delta primarily from December to April. NOAA Fisheries develops an estimate of winter–run juvenile production each year based on the estimated escapement and applying a set of standard survival estimates including pre-spawning mortality, fecundity, egg-to-fry survival, and survival to the Delta (Table 6–7).

Table 6–7 Example of how the winter-run Chinook juvenile production estimate, yellow light and red light levels are calculated using 2001-02 adult escapement data.

2001-2002 Winter-run Chinook Juvenile Production Estimate (JPE)	
Total Spawner escapement (Carcass Survey)	7,572
Number of females (64.4% Total)	4,876
Less 1% pre-spawn mortality	4,828
Eggs (4,700 eggs/female)	22,689,740
Less 0.5% due to high temp	113,449

Viable eggs	22,576,291
Survival egg to smolt (14.75%)	3,330,003
Survival smolts to Delta (56%)	1,864,802
Livingston Stone Hatchery release	252,684
Yellow light(1%natural + 0.5 hatchery)	19,911
Red Light (2% natural + 1% Hatchery)	39,823

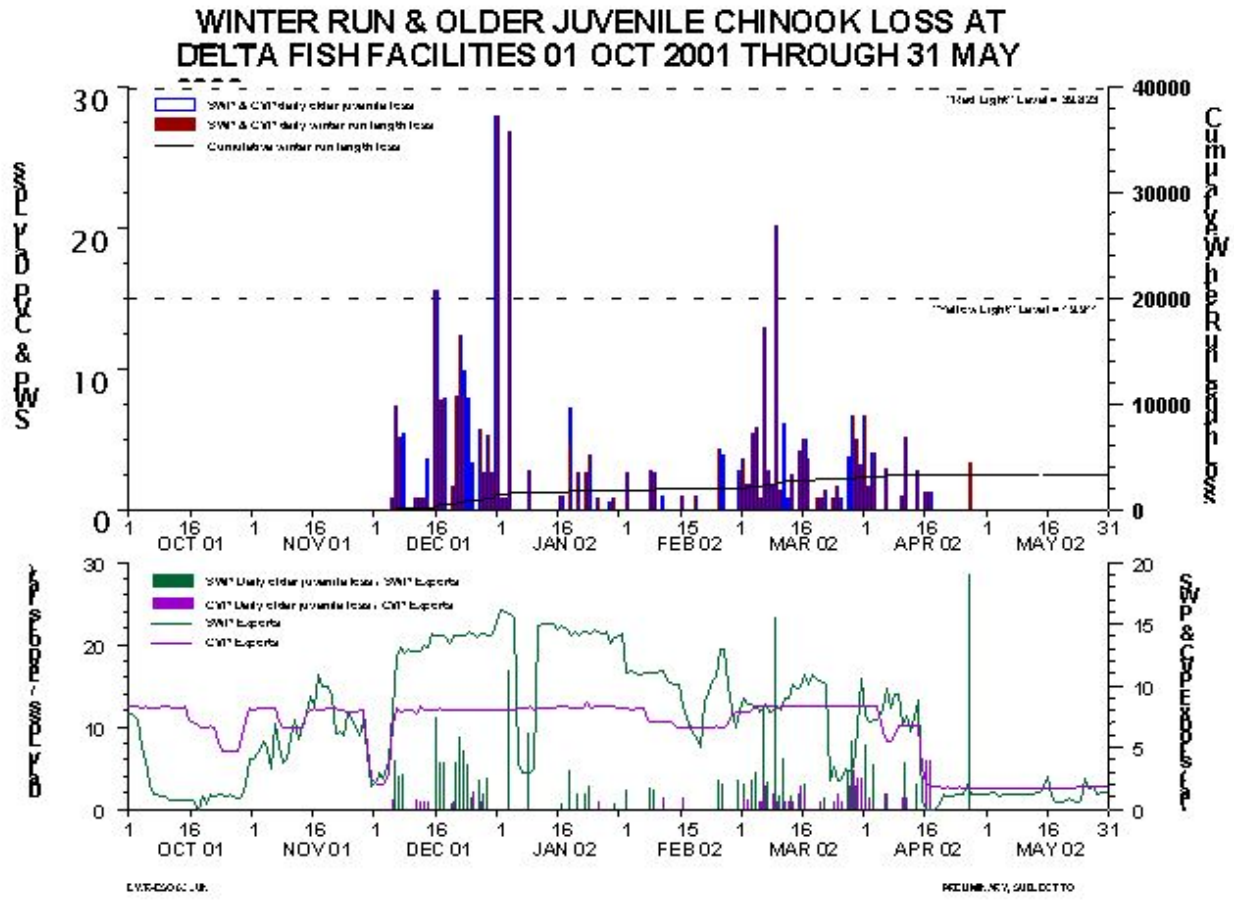

Figure 6–22 Winter–run and older juvenile chinook loss at delta fish facilities, October 2001 – May 2002.

Changes in the Delta Ecosystem and Potential Effects on Winter-run, Spring-run and Fall/Late Fall-run Chinook Salmon

Changes in estuarine hydrodynamics have adversely affected a variety of organisms at all trophic levels, from phytoplankton and zooplankton to the young life stages of many fish species (Jassby

et al. 1995; Arthur et al. 1996; Bennett and Moyle 1996). Ecological processes in the Delta have also been affected by interactions among native and introduced species (Bennett and Moyle 1996; Kimmerer and Orsi 1996), the various effects of water management on Delta water quality and quantity (Arthur et al. 1996), and land use practices within the watershed (Simenstad et al. 1999). Cumulatively, these changes may have diminished the suitability of the Delta as juvenile salmon rearing habitat and may have reduced the survival of young salmon migrating through the Delta to the Pacific Ocean. Population level effects of changes in the delta are complex and have not been quantified.

As juvenile salmon from the Sacramento basin migrate through the Delta towards the Pacific Ocean, they encounter numerous junctions in the river and Delta channels. two such junctions are located near Walnut Grove at the DCC (a man-made channel with an operable gate at the entrance) and Georgiana Slough (a natural channel). Both channels carry water from the Sacramento River into the central Delta. The relatively high quality Sacramento River water flows into the central Delta, mixes with water from the east-side tributaries (Mokelumne, Cosumnes and Calaveras Rivers) and the San Joaquin River. This mixture which much of the time is predominantly Sacramento River water is pumped out of the Delta by the SWP and CVP or flows westward through the estuary. The SWP water consists of a higher proportion of Sacramento River water and the CVP consists of more San Joaquin River water (Lloyd Hess personal communication).

Significant amounts of flow and many juvenile salmon from the Sacramento River enter the DCC (when the gates are open) and Georgiana Slough. Mortality of juvenile salmon entering the central Delta is higher than for those continuing downstream in the Sacramento River. This difference in mortality could be due to a combination of factors: the longer route through the central Delta to the western Delta, higher water temperatures, higher predation, more agricultural diversions, and a more complex channel configuration making it more difficult for salmon to find their way to the western Delta and the ocean.

Water is drawn from the central Delta through lower Old River to the export pumps when combined CVP/SWP pumping exceeds the flow of San Joaquin River water down the upper reach of Old River and Middle Rivers. This situation likely increases the risk of juvenile salmon migrating to the south Delta and perhaps being entrained at the SWP and CVP facilities. This condition can be changed either by reducing exports or increasing Delta inflows. Decreasing exports to eliminate net upstream flows (or, if net flows are downstream, cause an increase in positive downstream flows) may reduce the chances of migrating juvenile salmonids moving up lower Old River towards the CVP/SWP diversions. Tidal flows, which are substantially greater than net flows, play a much more important role in salmon migrations than net reverse flow, which can only be calculated and not measured.

Juvenile salmon, steelhead and other species of fish in the south Delta are directly entrained into the SWP and CVP export water diversion facilities (Table 6–8, Figure 6–9, Table 6–10, Figure 6–23, Figure 6–24). Many juvenile salmon die from predation in Clifton Court Forebay before they reach the SWP fish screens to be salvaged (80 percent mortality currently used in loss calculations). Loss at the SWP is thought to vary inversely with the pumping rate because when water is drawn through Clifton Court Forebay faster salmon are not exposed to predation for as long (Buell 2003). At the CVP pumping facilities the survival rate through the facility for

Chinook is about 67 percent. Salmon from the San Joaquin Basin, and those migrating from the Sacramento River or east Delta tributaries through the central Delta are more directly exposed to altered channel flows due to exports and to entrainment because their main migration route to the ocean puts them in proximity to these diversions. Some juvenile salmon migrating down the main stem Sacramento River past Georgiana Slough may travel through Three-mile Slough or around Sherman Island and end up in the southern Delta. There is considerable lack of understanding about how or why salmon and steelhead from the north Delta end up at the diversions in the south Delta, particularly regarding the influence role of the export pumping. Nevertheless it is clear that once juvenile salmon are in the vicinity of the pumps, they are more likely to be drawn into the diversion facilities with the water being diverted. We assume that by reducing the pumping rate, entrainment of fish, and therefore loss or "take" of these fish is reduced. If reservoir releases are not reduced simultaneously, then the net flow patterns in Delta channels are changed, to the benefit of emigrating salmonids and other fish.

Table 6–8 Total Chinook salmon salvage (all sizes combined) by year at the SWP and CVP salvage facilities.

YEAR	SWP	CVP	Total
1981	101,605	74,864	176,469
1982	278,419	220,161	498,580
1983	68,942	212,375	281,317
1984	145,041	202,331	347,372
1985	140,713	137,086	277,799
1986	435,233	752,039	1,187,272
1987	177,880	92,721	270,601
1988	151,908	54,385	206,293
1989	106,259	42,937	149,196
1990	35,296	6,107	41,403
1991	39,170	31,226	70,396
1992	22,193	41,685	63,878
1993	8,647	20,502	29,149
1994	3,478	12,211	15,689
1995	19,164	64,398	83,562
1996	14,728	39,918	54,646
1997	11,853	53,833	65,686
1998	3,956	167,770	171,726
1999	50,811	132,886	183,697
2000	45,613	78,214	123,827
2001	28,327	29,479	57,806
2002	6,348	15,573	21,921
Total	1,895,584	2,482,701	4,378,285

Table 6–9 Average Chinook salmon salvage (all sizes and marks combined) by facility 1981 – 1992.

MONTH	SWP	CVP
Jan	2,889	1,564
Feb	5,989	47,227
Mar	7,679	8,241
Apr	40,552	33,983
May	56,327	55,146
Jun	21,863	15,929
Jul	496	2,105
Aug	232	233
Sep	33	
Oct	1,474	4,814
Nov	2,181	4,133
Dec	9,682	3,365

Table 6–10 Average Chinook salmon salvage (all sizes and marks combined) by facility, 1993 – 2002.

MONTH	SWP	CVP
Jan	1,224	5,933
Feb	1,214	10,978
Mar	1,483	5,199
Apr	7,728	16,485
May	6,082	16,076
Jun	2,001	5,992
Jul	62	220
Aug	34	18
Sep	147	114
Oct	49	56
Nov	39	159
Dec	393	552

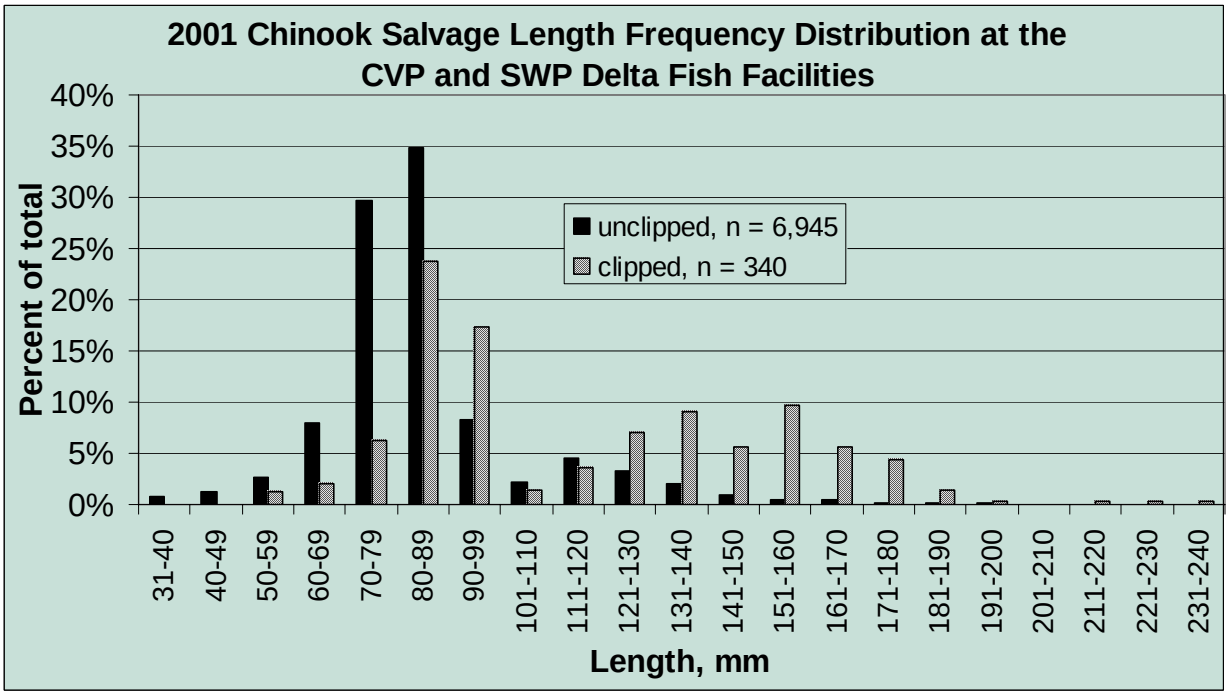

Figure 6–23 Length frequency distribution of Chinook salvaged at the delta fish facilities in 2001.

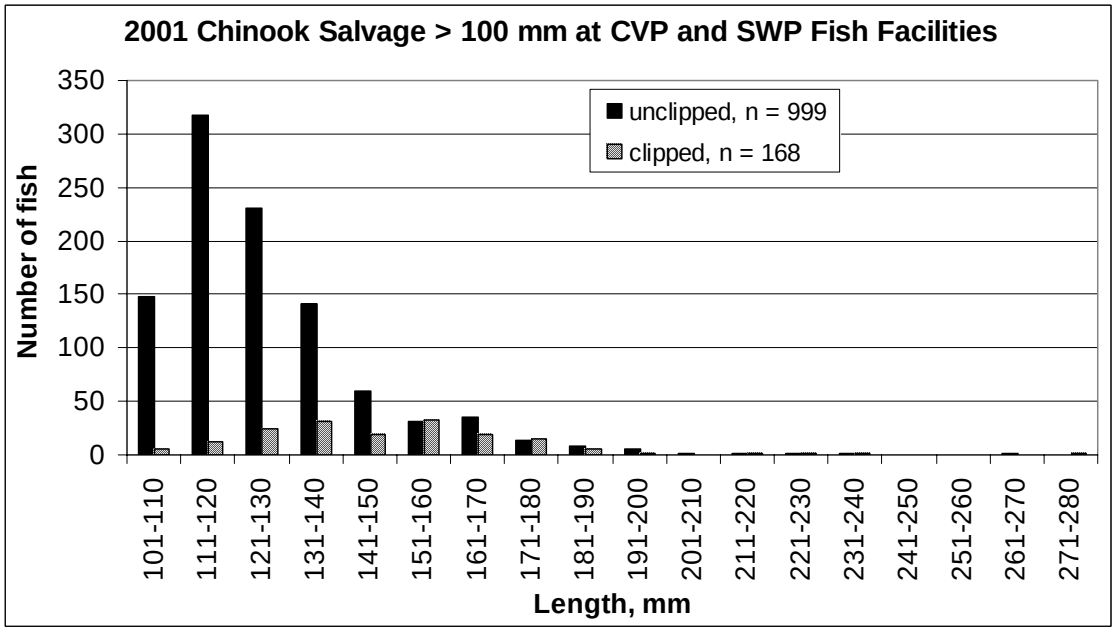

Figure 6–24 Length frequency distribution for Chinook salvaged greater than 100 mm in 2001.

Direct and Indirect Effects of the SWP and CVP Facilities

Delta water project effects on rearing and migrating juvenile Chinook salmon are both direct (based on observations of salvaged fish at the fish salvage facilities) and indirect (mortality in the Delta that is related to export operations). The entrainment rate (direct loss) of juvenile salmon at the facilities is an incomplete measure of water project impact to juvenile salmon, because it doesn't include indirect mortality in the Delta.

FWS CWT studies have been used to assess survival rates of juvenile Chinook migrating through the Delta relative to those remaining in the Sacramento River (Kjelson et al. 1982, Brandes and McLain 2001). Results of these studies suggest survival rates are higher for fish that remain in the Sacramento River, although they do not provide quantitative information regarding what proportion of emigrants remain in the main river, compared to fish that enter the central Delta through the DCC and Georgiana Slough.. Many potential influencing factors have been suggested as indirect effects to salmon survival that may occur when salmon move into the central and/or south Delta from the Sacramento River. Most of these have not been explicitly studied, but the available information is discussed below.

Length of Migration Route and Residence Time in the Delta

The length of time Chinook juvenile salmon spend in the lower rivers and the Delta varies depending on the time of year the salmon emigrate, outflow, and the developmental stage of the fish (Kjelson et al. 1982). Residence times tend to be shorter during periods of high flow relative to periods of low flow, and tend to be longer for fry than for smolts. A proportion of the Chinook salmon production enters the Delta as fry or fingerlings rather than as smolts (DFG 1998). Extending Delta residence time for any juvenile salmon likely increases their susceptibility to the cumulative effects of mortality factors within the Delta but also decreases susceptibility to mortality once they enter the ocean because they are larger.

Much attention has been given to the lower river migration route of salmon produced in the Sacramento watershed (Kjelson et al. 1982; Stevens and Miller 1983; Brandes and McLain 2001). At issue is the migration route via Georgiana Slough (about 37 miles to Chipps Island) compared to that in the Sacramento River from Ryde (27 miles to Chipps Island). Tests completed by FWS found survival is higher for late fall-run Chinook smolts released in the Sacramento River at Ryde vs. Georgiana Slough even though the Georgiana Slough route is only 1.4 times longer. Fish emigrating through Georgiana Slough probably have increased residence time in the Delta due to both the longer travel distance and the generally lower flows in the slough. These factors potentially increase the duration of a migrating salmon's exposure to migration hazards. Delta Cross Channel closures are one of the actions being taken to reduce the likelihood that juvenile Chinook salmon will use an internal Delta route.

The following is an analysis of the relationships between the through-Delta survival of Coleman Hatchery late fall-run Chinook smolts, Delta export losses of these fish in the fall and winter, and Delta hydrologic variables.

FWS has conducted these experiments using late fall-run smolts since 1993. The purpose of the experiments is to determine what factors in the Delta affect yearling Chinook survival. One factor hypothesized to affect survival is emigration route. Based on previous results for fall-run

salmon (Brandes and McLain 2001) FWS hypothesized yearlings emigrating through the interior Delta survive at a lower level than juveniles emigrating through the main stem Sacramento River (Brandes and McLain 2001). The juveniles can enter the interior Delta through Georgiana Slough (GS) or the Delta Cross Channel (DCC) when it is open. Since FWS does not have measurements of gear efficiency for its Chipps Island trawl, and gear efficiency is assumed to vary from experiment to experiment, the survival estimates are considered indices of relative survival, not absolute numbers of survivors. To overcome this limitation, FWS uses the ratio of the survival indices of paired releases in the interior Delta and the main stem Sacramento River at Ryde. Evaluating the relative interior Delta survival cancels out differences in gear efficiency.

Models generated using the data from coded wire tagged fish support the conclusion that closure of the DCC gates will improve survival for smolts originating from the Sacramento Basin and emigrating through the Delta. The greatest mortality for smolts between Sacramento and Chipps Island was in the central Delta, and survival could be improved if the gates were closed (Kjelson et al. 1989).

In a generalized linear model that estimates the effects of various parameters on salmon smolt survival through the Delta, Newman and Rice (1997) found that mortality was higher for smolts released in the interior Delta relative to those released on the main stem Sacramento River. They also found lower survival for releases on the Sacramento River associated with the Delta Cross Channel gate being open. Using paired release data, Newman (2000) found that the cross-channel gate being open had a negative effect on the survival of smolts migrating through the Delta and was confirmed using Baysian and GLM modeling (Newman and Remington 2000).

The analyses to date appear to support the conclusion that closing the DCC gates will improve the survival of smolts originating from the Sacramento basin and migrating through the Delta. Even with the DCC gates closed, Sacramento River water still flows into Georgiana Slough and some Sacramento salmon travel that route to the interior of the Delta.

Radio tracking studies of large juvenile salmon in the Delta (Vogel 2003) showed that localized currents created by the DCC operations and flood and ebb tide cycles greatly affected how radio-tagged fish moved into or past the DCC and Georgianna Slough. Fish migration rates were generally slower than the ambient water velocities. Fish were documented moving downstream past the DCC during outgoing tides and then moving back upstream and into the DCC with the incoming tide. When the DCC gates were closed fish movement into Georgianna Slough was unexpectedly high, probably due to fish positions in the water column in combination with physical and hydrodynamic conditions at the flow split. Radio tagged smolts moved large distances (miles) back and forth with the incoming and outgoing tides. Flow conditions at channel splits were a principal factor affecting the routes used by migrating salmon. Hydroacoustic tracking and trawling (Horn 2003 and Herbold 2003) showed that fish in the vicinity of the DCC were most actively moving at night and that they tend to go with the highest velocity flows. Water flow down through the DCC is much greater during the incoming tidal cycles than on the outgoing tides. These results suggest that during periods of high juvenile salmonid abundance in the vicinity of the DCC, closing the gates during the incoming tidal flows at night could reduce juvenile salmon movement into the central Delta through the DCC but may also increase movement into Georgianna Slough.

The survival indices and estimated losses at the Delta fish facilities for all GS and Ryde releases since 1993 are illustrated in Figure 6–25. A unique symbol is used to highlight each paired experiment. In every paired experiment, the survival index of the Ryde release was higher than the GS release. Additionally, the estimated loss of the GS release was higher than the Ryde release in every paired experiment. Evaluating the GS and Ryde data separately, the GS releases all have low survival over a wide range of losses, and the Ryde releases all have low losses over a wide range of survival indices. Survival indices and losses for each of the GS and Ryde releases are not well related.

Delta hydrology is another factor hypothesized to affect Chinook survival, although hydrology should not be viewed independently from effects due to migration route. The relative interior Delta survival of Coleman late-fall juveniles was plotted against Delta exports, Sacramento River flow, QWEST, and export to inflow ratio. The explanatory (hydrologic) variables are average conditions for 17 days from the day of release. This value was selected by FWS based on previously collected data on the average travel time from the release sites to Chipps Island. The combined CVP and SWP losses from each of the GS and Ryde releases are also plotted against the same four hydrologic variables. A simple linear regression was done for each.

Regression and correlation analyses of these data (1993–98) indicate that the survival of smolts released into Georgiana Slough is increased as exports are reduced, relative to the survival of salmon released simultaneously at Ryde (Figure 6–26). These findings are the basis for reducing exports to further protect juvenile salmon migrating through the Delta. There was also a trend of increased loss of GS releases with increased exports, but it was not significant either (Figure 6–27).

Relationships between relative survival (Figure 6–28) or late-fall salvage at the Delta export facilities (Figure 6–29) and Sacramento River flow were not statistically significant. QWEST was also a poor predictor of both relative survival (Figure 6–30) and losses to the export facilities (Figure 6–31).

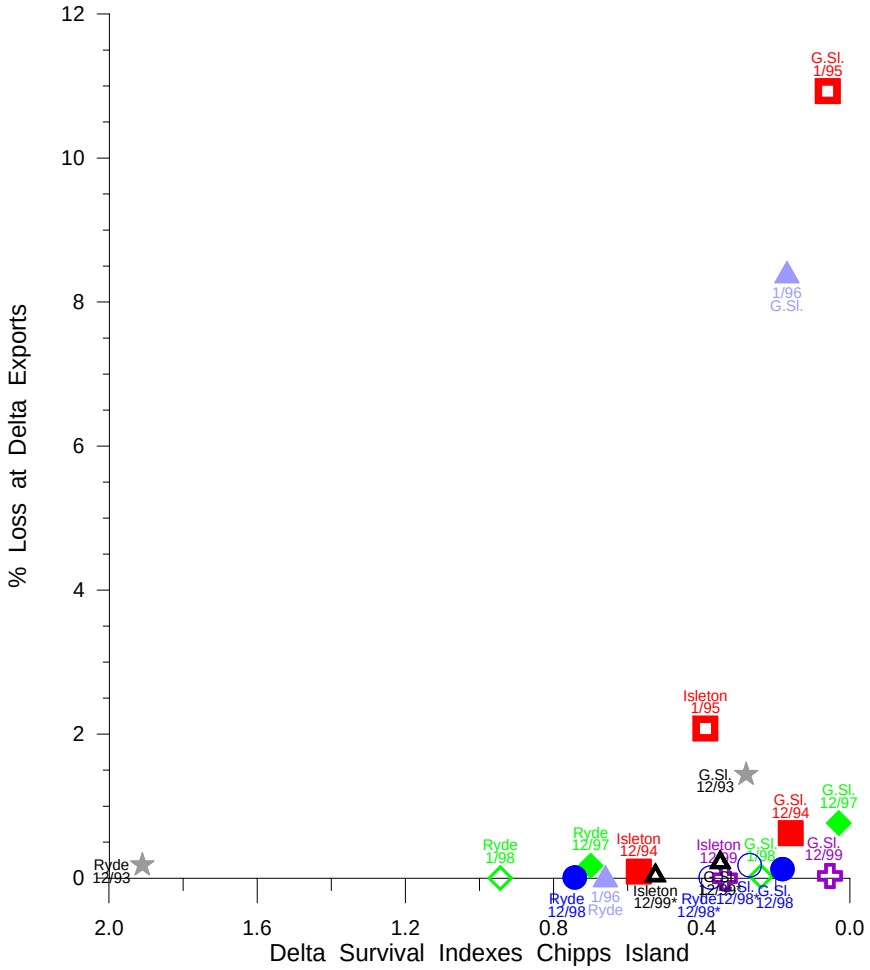

Figure 6–25 Scatterplot of Delta survival indices for Coleman Hatchery late fall-run Chinook salmon from paired release experiments in the Sacramento River and Georgiana Slough v. percentage of the release group salvaged at the CVP and SWP Delta facilities.

There was little trend of decreased relative survival with increased export to inflow ratio (Figure 6–32). The relationship between the export to inflow ratio and the percentage of late fall-run yearlings salvaged was highly insignificant (Figure 6–33), providing no evidence that entrainment is the primary mechanism for reduced relative survival. Newman and Rice (1997), and more recent work by Newman, suggests that reducing export pumping will increase the survival for smolts migrating through the lower Sacramento River in the Delta. Newman and Rice's updated 1997 extended quasi-likelihood model (Ken Newman, personal communication) provides some evidence that increasing the percent of Delta inflow diverted (export to inflow (E/I) ratio) reduces the survival of groups of salmon migrating down the Sacramento River, but the effect was slight and not statistically significant. In Newman's extended quasi-likelihood model using paired data, there was a significant export effect on survival (approximate *P* value of 0.02 for a one-sided test) (Newman 2000).

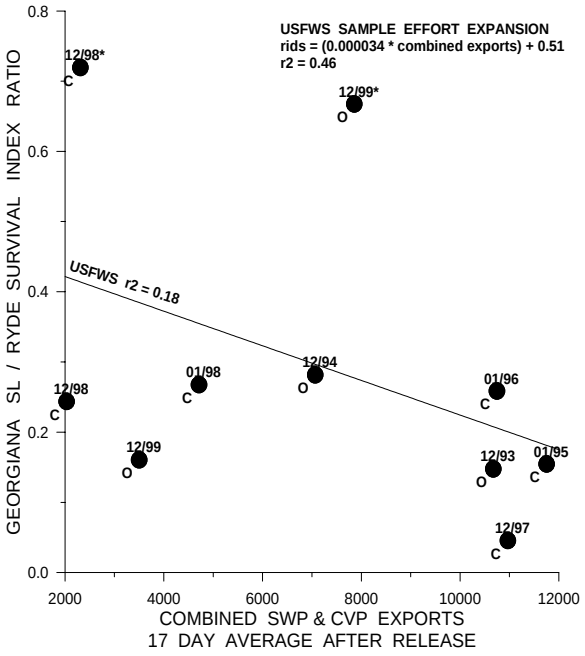

Figure 6–26 Relationship between Delta exports and the Georgiana Slough to Ryde survival index ratio. The export variable is combined average CVP and SWP exports for 17 days after release.

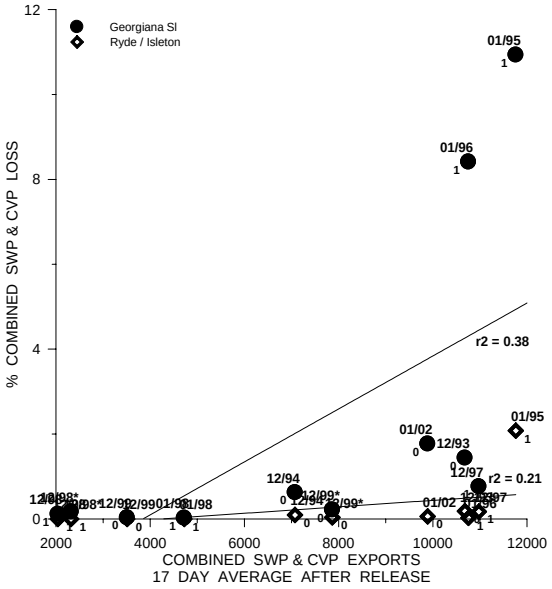

Figure 6–27 Relationship between Delta exports and percentage of late fall-run CWT Chinook salmon Delta release groups salvaged at the CVP and SWP Delta facilities. The export variable is combined average CVP and SWP exports for 17 days after release.

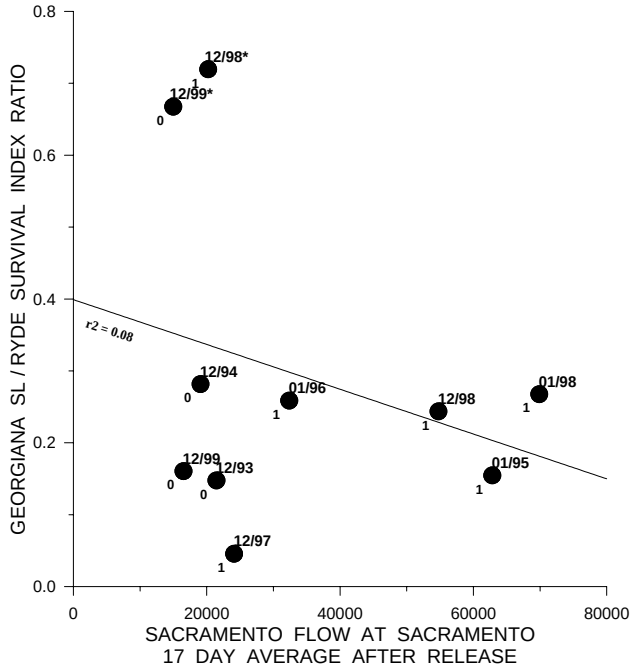

Figure 6–28 Relationship between Sacramento River flow and the Georgiana Slough to Ryde survival index ratio. The flow variable is average Sacramento River flow at Sacramento for 17 days after release.

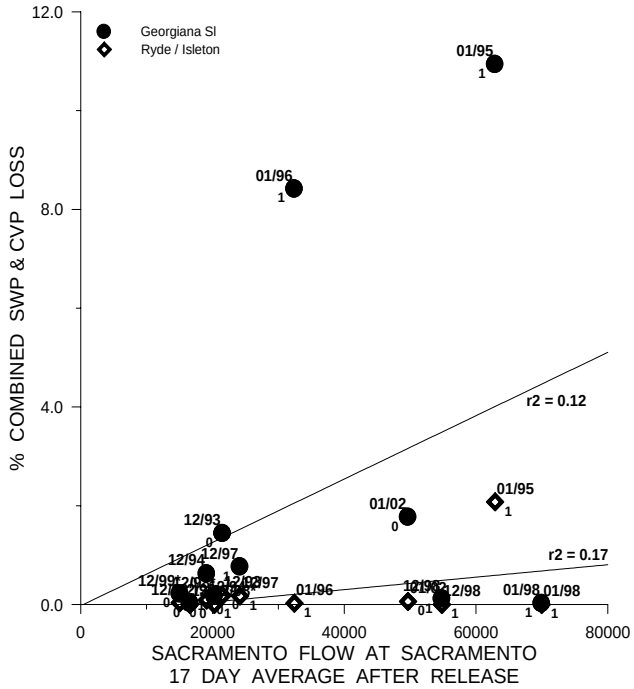

Figure 6–29 Relationship between Sacramento River flow and the percentage of late fall-run CWT Chinook salmon Delta release groups salvaged at the CVP and SWP Delta facilities. The flow variable is average Sacramento River flow at Sacramento for 17 days after release. Georgiana Slough and Ryde releases are plotted separately.

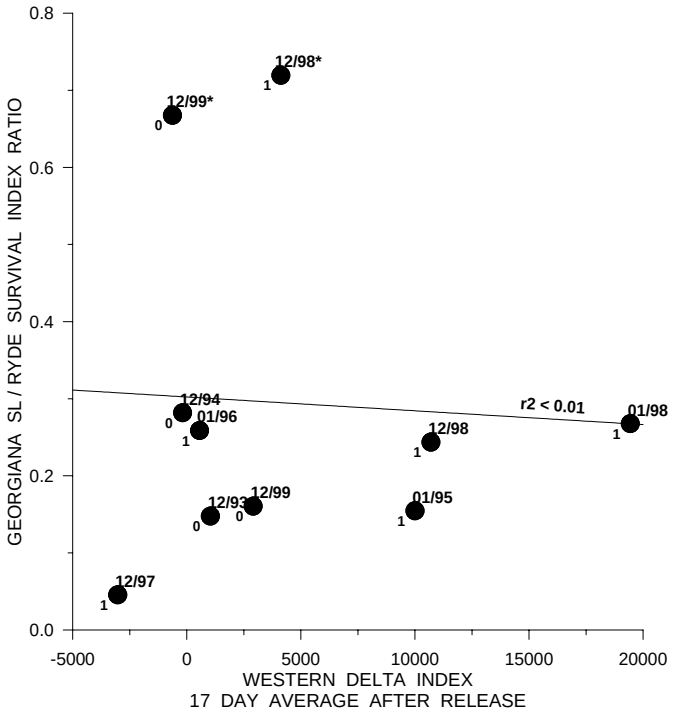

Figure 6–30 Relationship between QWEST flow and the Georgiana Slough to Ryde survival index ratio. The flow variable is average QWEST flow for 17 days after release.

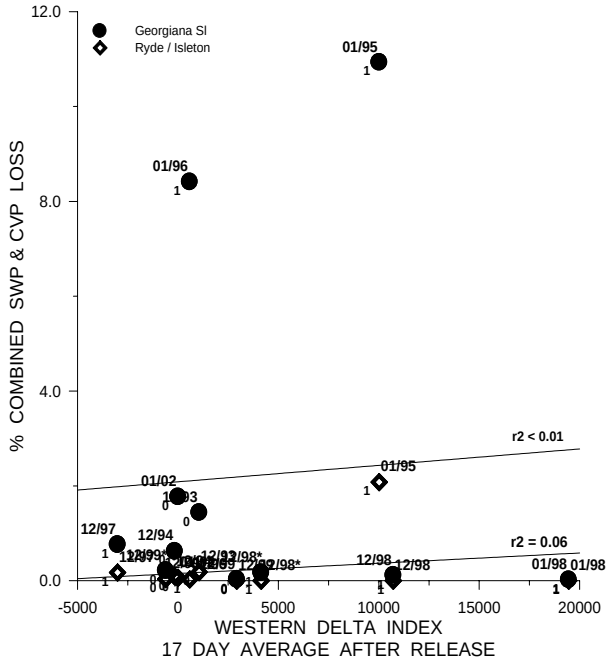

Figure 6–31 Relationship between QWEST flow and the percentage of late fall-run CWT Chinook salmon Delta release groups salvaged at the CVP and SWP Delta facilities. The flow variable is average QWEST flow for 17 days after release.

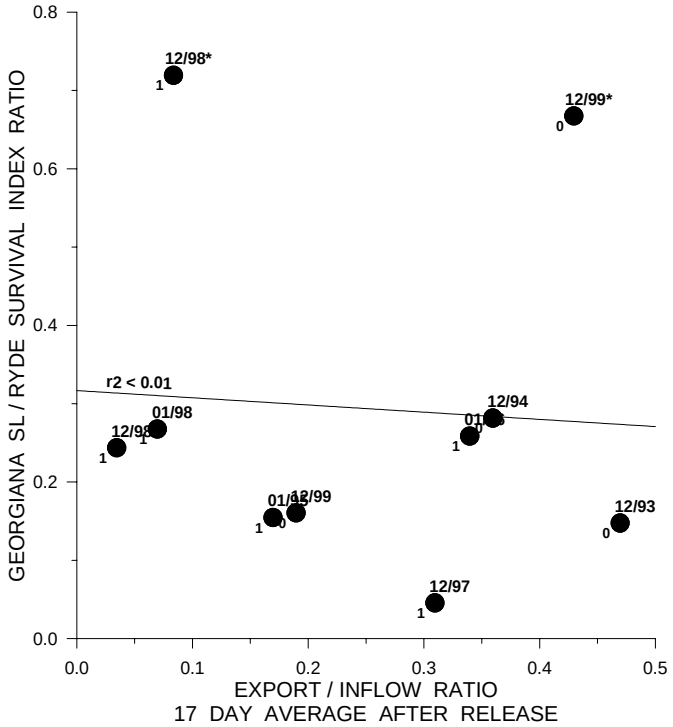

Figure 6–32 Relationship between Export/Inflow ratio and the Georgiana Slough to Ryde survival index ratio. The flow variable is average Export/Inflow ratio for 17 days after release.

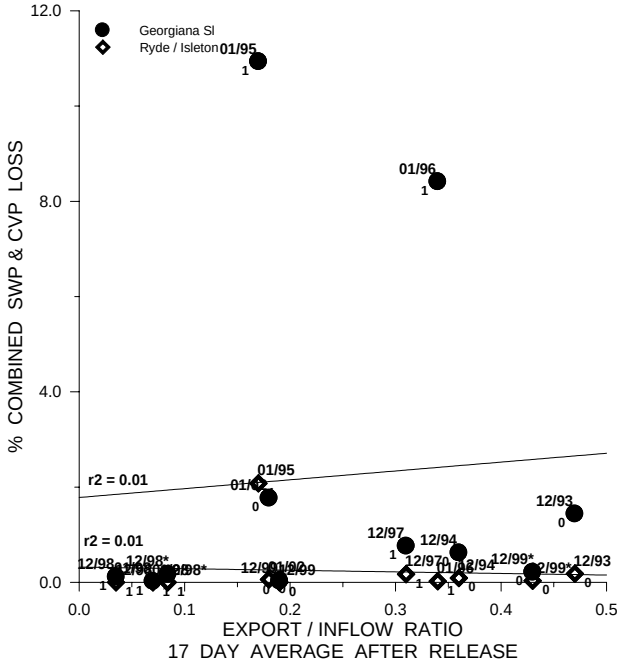

Figure 6–33 Relationship between Export/Inflow ratio and the percentage of late fall-run CWT Chinook salmon Delta release groups salvaged at the CVP and SWP Delta facilities. The flow variable is average Export/Inflow ratio for 17 days after release.

In summary, we did not find significant linear relationships between the GS-Ryde survival ratios for the Coleman late fall-run releases, or the losses of these fish at the Delta export facilities, and commonly used Delta hydrologic variables. Although not statistically significant, relative interior Delta survival was high and losses of both GS and Ryde release groups were low during one of the two low export experiments. At high exports, relative interior Delta survival was generally lower, with relatively high losses of GS release groups on two occasions. The data are not sufficient to provide the information necessary to quantify the benefit of export reductions to the Chinook population, due to the lack of information on the proportion of yearling emigrants using the DCC or Georgiana Slough routes. The data indicate it would take substantial reductions in exports to effect a modest decrease in losses or an increase in survival for Chinook emigrating through the central Delta.

FWS Delta experiments were not designed to test the effects of Delta operations on fish released by hatchery personnel upstream of the Delta. However, releases of Coleman Hatchery late-fall-run yearlings in the upper Sacramento River have occurred coincident with the Delta experiments. These were not paired releases, but they were made within a week of the Delta experiments. A comparison of the direct losses of fish released in the upper Sacramento River, and in the Delta is illustrated in Figure 6–34. The losses of the upper Sacramento releases are all very small (< two percent) even though the releases encompass a wide range of hydrologic conditions. In addition, the loss estimates for fish released upstream of the Delta are very similar to those calculated for the Ryde releases and most of the GS releases.

The survival indices of the upper Sacramento River releases may be helpful in the evaluation of effects on the population. This evaluation should be repeated when FWS completes the calculations of the upper Sacramento River releases' survival indices.

Altered Flow Patterns in Delta Channels

Flow in the Delta from results from a combination of river-derived flow and tidal movement. The relative magnitudes of river and tidal flow depend on location and river flow, with greater tidal dominance toward the west and at lower river inflows. The presence of channel barriers at specific locations has a major influence in flow dynamics. Tidal flows, because of the complex geometry of the Delta, can produce net flows independent of river flow and cause extensive mixing. During high flow periods, water flows into the Delta from Valley streams. During low flow periods, flow in the San Joaquin River is lower than export flows in the southern Delta, so water is released from reservoirs to provide for export and to meet salinity and flow standards in the Delta.

Particle tracking models, using data from direct measurement of river or channel velocities and volume transport at various Delta locations, have given us our most recent view of net flow in Delta channels. The general trend of model results seems to be that a patch of particles released in the Delta will move generally in the direction of river flow but the patch spreads extensively due to tidal dispersion. The export pumps and Delta island agricultural diversions impose a risk that the particle will be lost to the system. This risk increases with greater diversion flow, initial proximity of the particle to the diversion, and duration of the model run. The absolute magnitude of project exports was the best predictor of entrainment at the export pumps while the computed reverse flow in the western San Joaquin River (QWest) had, at most, a minor effect.

Tidal flow measurements allow calculation of tidally averaged net flows. Results indicate that tidal effects are important in net transport, and that net flow to the pumping plants is not greatly affected by the direction of net flow in the western (lower) San Joaquin River

In respect to fish movement, relatively passive life stages as delta smelt larvae should move largely under the influence of river flow with an increasing behavioral component of motion as the fish develop. Larger, strong-swimming salmon smolts are more capable of moving independently but may still be affected to some degree by river flow.

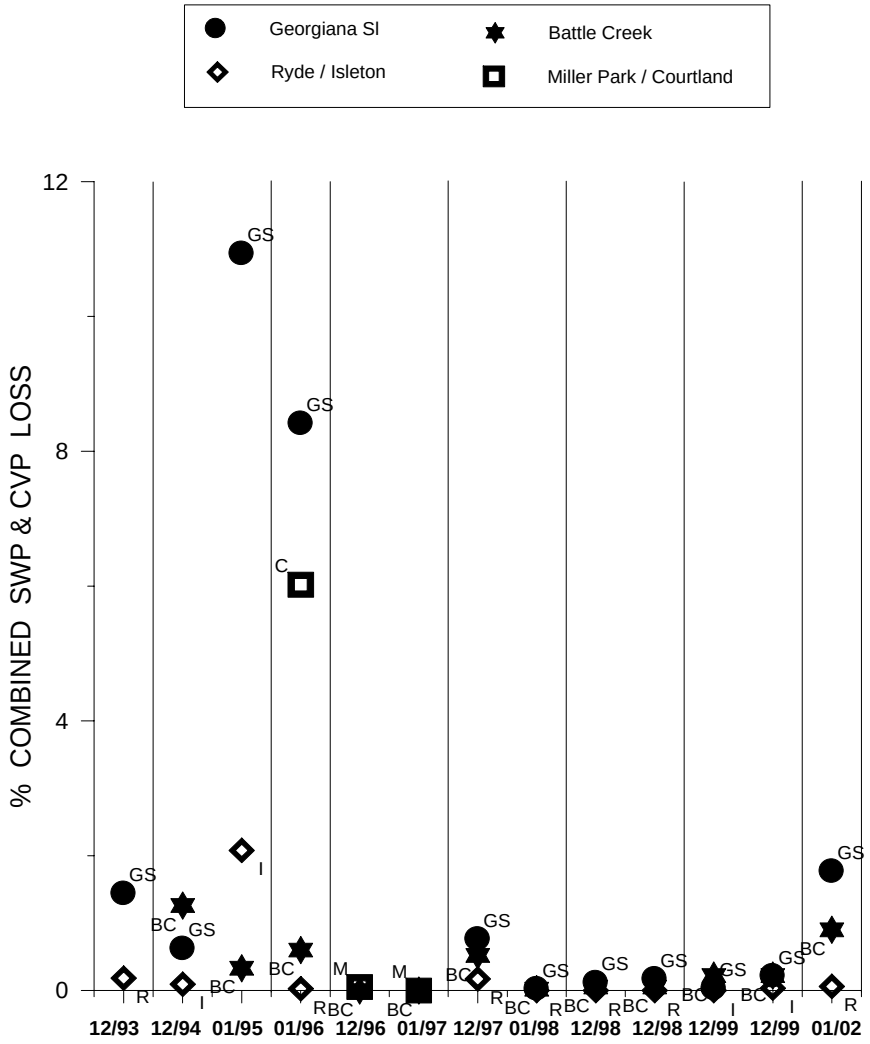

Figure 6–34 The percentage of late fall-run CWT Chinook salmon Sacramento River and Delta release groups salvaged at the CVP and SWP Delta facilities grouped by release date.

Altered Salinity in the Delta

Increasing salinity westward through the estuary may provide one of many guidance cues to emigrating juvenile salmon (DFG 1998). Salinity levels in the central and south Delta are sometimes increased above ambient conditions by agricultural return waters from the south Delta and San Joaquin River. Salmon emigrating from the Sacramento River may move into the interior and south Delta in response to the elevated salinity levels. However, it is not known whether salmon migrating through this region are confused by elevations in salinity caused by agricultural return water, which has a different chemical composition than ocean water, particularly given the magnitude of difference between tidal and net flows in the Delta (Oltmann 1998).

Contaminants

The role of potential contaminant-related effects on salmon survival in the Delta is unknown (DFG 1998). Elevated selenium levels in the estuary may affect salmon growth and survival. The EPA is pursuing reductions in selenium loadings from Bay Area oil refineries, and the San Francisco Regional Water Quality Control Board has recommended an additional 30 percent reduction in selenium levels to adequately protect the Bay's beneficial uses. Non-point sources (including urban and agricultural runoff) contribute to elevated levels of polychlorinated biphenyls (PCBs) and chlorinated pesticides, which have been found in the stomach contents of juvenile salmon from the Bay, the Delta, and from hatcheries (NOAA fisheries 1997, as cited in DFG 1998). Collier (2002) Found that juvenile Chinook in Puget Sound estuaries were contaminated with sediment associated contaminants such as PCBs. They found a reduced immune response affecting fitness in these fish. These contaminants may also affect lower level food web organisms eaten by juvenile salmon, or bioaccumulate in higher trophic level organisms like the salmon themselves. The CALFED Bay-Delta Program has funded studies to assess contaminant effects on emigrating salmon and their potential prey organisms over the next several years.

During periods of low flow and high residence time of water through the Stockton deep water ship channel, high oxygen demand from algae concentrations can deplete dissolved oxygen to lethal levels. This can result in a barrier to upstream and downstream migrating salmon and steelhead and could kill fish present in the area of low dissolved oxygen.

Food Supply Limitations

Food limitation and changes in the Delta's invertebrate species composition have been suggested as factors contributing to abundance declines and/or lack of recovery of estuarine-dependent species such as delta smelt and striped bass (Bennett and Moyle 1996; Kimmerer et al. 2000). There is no direct evidence of food limitation for salmon in the Delta or lower estuary (DFG 1998). However, there is evidence that some habitats (like non-natal tributaries and Yolo Bypass) may provide relatively better feeding and rearing opportunities for juvenile Chinook than the channelized Sacramento River (Moore 1997; Sommer et al. 2001b). Improved feeding conditions contribute to faster growth rates for fish using these habitats. Faster growth may yield at least a slight survival advantage, but the current evidence is insufficient to demonstrate this effect with statistical significance (Sommer et al. 2001b).

Predation and Competition

Predation is an important ecosystem process that helps to structure and maintain fish communities. Predation effects are very difficult to discern in nature because they are typically nonlinear and density-dependent (Bax 1999). Even without human intervention, natural predation rates are affected by spatio-temporal overlap of predators and prey, activity and metabolic needs of predators and prey at different temperatures, efficiency of different types of predators at capturing different prey, and the relative availability of appropriate prey types. Every Central Valley and Pacific Ocean predator's diet includes prey items other than salmon. Anthropogenic changes to ecosystems can alter these predator-prey dynamics, resulting in artificially elevated predation rates (Pickard et al. 1982a; Gingras 1997). Perhaps the most significant example of altered predation rates on Chinook salmon is human predation through harvest, which is discussed in the next section. Excepting direct human harvest, there are three factors that could affect predation dynamics on juvenile salmon. These are changes in the species composition and diversity of potential salmon predators through exotic species introductions, changes in the abundance of potential salmon predators (both of these may or may not be coupled to habitat alteration), and the placement of large structures in the migratory pathways of the salmon.

Changes in the species composition of predators can cause fish declines. Many potential salmon predators have been introduced to Central Valley waterways, particularly during the latter part of the 1800s and the early part of the 1900s (Dill and Cordone 1997). These included piscivorous fishes like striped bass, largemouth bass, crappies, and white catfish. Channel catfish is another common Delta-resident piscivore that seems to have become established considerably later, during the 1940s. All of these fish were establishing Central Valley populations during a time spring-run Chinook were declining for a variety of reasons. This makes it difficult to determine whether one or more of these predatory fishes significantly affected juvenile salmon survival rates.

There have been substantial changes in the abundance of several potential Chinook salmon predators over the past 20 to 30 years. These changes could have altered the predation pressure on salmon, but the data needed to determine this have not been collected. A few examples of changes in potential predator abundance are discussed below.

The striped bass is the largest piscivorous fish in the Bay-Delta. Its abundance has declined considerably since at least the early 1970s (Kimmerer et al. 2000). Both striped bass and spring-run and winter-run Chinook were much more abundant during the 1960s (DFG 1998) when comprehensive diet studies of striped bass in the Delta were last reported on. During fall and winter 1963–64, when spring-run yearlings and juvenile winter-run would have been migrating through the Delta, Chinook salmon only accounted for 0 percent, 1 percent, and 0 percent of the stomach content volume of juvenile, subadult, and adult striped bass respectively (Stevens 1961). During spring and summer 1964, Chinook salmon accounted for up to 25 percent of the stomach content volume of subadult striped bass in the lower San Joaquin River, although most values were less than 10 percent. Presumably most of these spring and summer prey were fall-run since they dominate the juvenile salmon catch during that time of year. These results do not suggest striped bass had a major predation impact on spring-run Chinook during the year studied, though year is not adequate to draw firm conclusions. Despite lower population levels, striped bass are

suspected of having significant predation effects on Chinook salmon near diversion structures (see below).

Although striped bass abundance has decreased considerably, the abundance of other potential Chinook salmon predators may have increased. Nobriga and Chotkowski (2000) reported that the abundance of virtually all centrarchid fishes in the Delta, including juvenile salmon predators like largemouth bass and crappies, had increased since the latter 1970s, probably as a result of the proliferation of Brazilian water weed, *Egeria densa*. The increase in largemouth bass abundance is further corroborated by DFG fishing tournament data (Lee 2000). Predation by centrarchids such as largemouth bass and bluegill on salmon is probably minor because centrarchids are active at higher temperatures than those prefered by salmon so the two species are not likely present in the same areas at the same time.

Surveys at the Farallon Islands also indicate populations of pinnipeds (seals and sea lions) have increased substantially since the early 1970s (Sydeman and Allen 1999). High concentrations of seals and sea lions at the relatively narrow Golden Gate could impact the abundance of returning adult salmon. However, the extent to which marine mammals target the salmon populations over other prey types has not been studied thoroughly.

Predatory fish are known to aggregate around structures placed in the water, where they maximize their foraging efficiency by using shadows, turbulence, and boundary edges. Examples include dams, bridges, diversions, piers, and wharfs (Stevens 1961, Vogel et al. 1988, Garcia 1989, Decoto 1978, all as cited in DFG 1998).

In the past, salmon losses to Sacramento pikeminnow predation at RBDD were sometimes high, particularly after large releases of juvenile Chinook from Coleman Hatchery. Currently, predation mortality on spring-run at RBDD is probably not elevated above the background in-river predation rate (DFG 1998). All spring-run juvenile emigrants should pass RBDD during the gates-out period based on average run timing at RBDD (FWS 1998, as cited in DFG 1998). During the gates-out operation (September 15 through May 14) fish passage conditions are run-of-the-river and most of the adverse effects associated with the diversion dam have been eliminated. Gates-out operations are also important in preventing the large aggregations of Sacramento pikeminnow and striped bass that once occurred at RBDD.

The GCID diversion near Hamilton City is another one of the largest irrigation diversions on the Sacramento River (DFG 1998). Predation at this diversion is likely most intense in the spring when Sacramento pikeminnow and striped bass are migrating upstream, juvenile Chinook are migrating downstream, and irrigation demands are high. Predation may be significant in the oxbow and bypass system (DFG 1998), but this was not substantiated during two years of study in the GCID oxbow (Cramer et al. 1992). The GCID facility is an atypical oxbow with cooler temperatures and higher flows than most relatively high flows through the oxbow.

Predation in Clifton Court Forebay (CCF) has also been identified as a potentially substantial problem for juvenile Chinook. Between October 1976 and November 1993, DFG conducted 10 mark and recapture experiments in CCF to estimate pre-screen loss (which includes predation) of fishes entrained to the forebay (Gingras 1997). Eght of these experiments involved hatchery-reared juvenile Chinook salmon. Pre-screen loss (PSL) rates for juvenile fall-run Chinook ranged from 63 percent to 99 percent, and for late-fall-run smolts they ranged from 78 percent to 99

percent. PSL of juvenile Chinook was inversely proportional to export rate, and striped bass predation was implicated as the primary cause of the losses. Although a variety of potential sampling biases confound the PSL estimates, the results suggest salmon losses are indeed high at the times of year when the studies were conducted

Predation studies have also been conducted at the release sites for fish salvaged from the SWP and CVP Delta pumping facilities (Orsi 1967, Pickard et al. 1982, as cited in DFG 1998). Orsi (1967) studied predation at the old surface release sites, which are no longer in use. Pickard et al. (1982a) studied predation at the currently used subsurface release pipes. Striped bass and Sacramento pikeminnow were the primary predators at these sites. They were more abundant and had more fish remains in their guts at release sites than at nearby control sites. However, Pickard et al. (1982a) did not report the prey species composition found in the predator stomachs. The current release sites release fish in deeper where tidal currents distribute fish over seven miles. Therefore there is not the predation associated with the old release sites. Night releases may be most beneficial and lowering stress in fish and potentially reducing predation.

DFG conducted predator sampling at the Suisun Marsh Salinity Control Gates (SMSCG) from 1987 through 1993 and concluded the striped bass population increased substantially in the vicinity of this structure (DWR 1997). However, the sampling during 1987 through 1992 did not include a control site to measure background predation potential. During the 1993 study, a control site was added two miles upstream. Results from the 1993 study showed no significant differences in catch of predatory fishes between the control site and sampling sites at the SMSCG.

An analysis of the Suisun Marsh Monitoring database indicated few juvenile Chinook salmon (of any race) occur in Suisun Marsh (only 257 were captured by beach seine and otter trawl between 1979 and 1997). This suggests that even if striped bass have increased in abundance at SMSCG, they may not pose a predation problem for the winter-run or spring-run population as a whole. This hypothesis is supported by diet data from striped bass and Sacramento pikeminnow collected near the SMSCG. Only three Chinook salmon were found during seven years of diet studies (Heidi Rooks, personal communication, 1999). Dominant striped bass prey were fishes associated with substrate, such as 3-spine stickleback, prickly sculpin, and gobies (DWR 1997). Dominant pikeminnow prey types were gobies and smaller pikeminnows. Adult Chinook are too large to be consumed by any predatory fishes that inhabit the Delta, so delays resulting from operation of the gates would not result in predation losses.

Ocean Conditions and Harvest

The loss of inland salmonid habitat in the Central Valley to human development has resulted in substantial ecological effects to salmonids (Fisher 1994; Yoshiyama et al. 1998). Ocean sport and commercial fisheries take large numbers (> than 50 percent) of adult fish. Central Valley salmon populations are managed to maintain a fairly consistent level of spawner escapement (Figure 6–36). The ocean fishery is largely supported by hatchery-reared fall-run Chinook salmon. A large hatchery system is operated to allow these levels of harvest. Harvest may be the single most important source of salmon mortality, but all the hatchery fish probably would not be reared and released if there were no ocean harvest. During 1994 an estimated 109 coded wire tagged winter–run were harvested in the ocean troll fishery off the California coast while

escapement in the Sacramento River was estimated at only 144 fish (table 5-11). Major changes in ocean harvest regulations were made in 1995, due to ESA concerns for winter-run Chinook. Harvest levels on Central Valley stocks have been lower since 1995. Strong year-classes like 1988 and 1995 were so heavily fished such that their reproductive potential was never realized. The 2000 Central Valley fall-run Chinook spawning escapement of 478,000 was the highest recorded since 1953 when an escapement of 478,000 also occurred. The high escapement in 2000 was probably due to above average precipitation during freshwater residency and good ocean conditions combined. The high escapement in 2000 was exceeded in 2001 when an estimated escapement of 599,158 occurred and again 2002 with an escapement of 850,000. The reason for the high escapement in 2001 was probably because most of the Chinook were concentrated north of the open commercial fishing area and thus were missed in the commercial fisheries and escaped. The commercial harvest in 2001 of 179,600 Chinook was the second lowest harvest since 1966. The Central Valley Index of abundance (commercial landings + escapement) in 2001 was 806,000 Chinook, which was actually lower than the forecasted production based on prior year two year old returns. The Central Valley harvest index in 2001 of 27 percent (percent of production harvested) was the lowest ever recorded. The next lowest harvest index was 51 percent in 1985 (PFMC 2002). This illustrates the substantial effect of ocean harvest on Chinook escapement. Restrictions on ocean harvest to protect southern Oregon and northern California coho salmon and Central Valley winter–run and spring–run played a role in the recent high escapements and contributed to the recent increases in winter–run and spring–run escapement to the Central Valley.

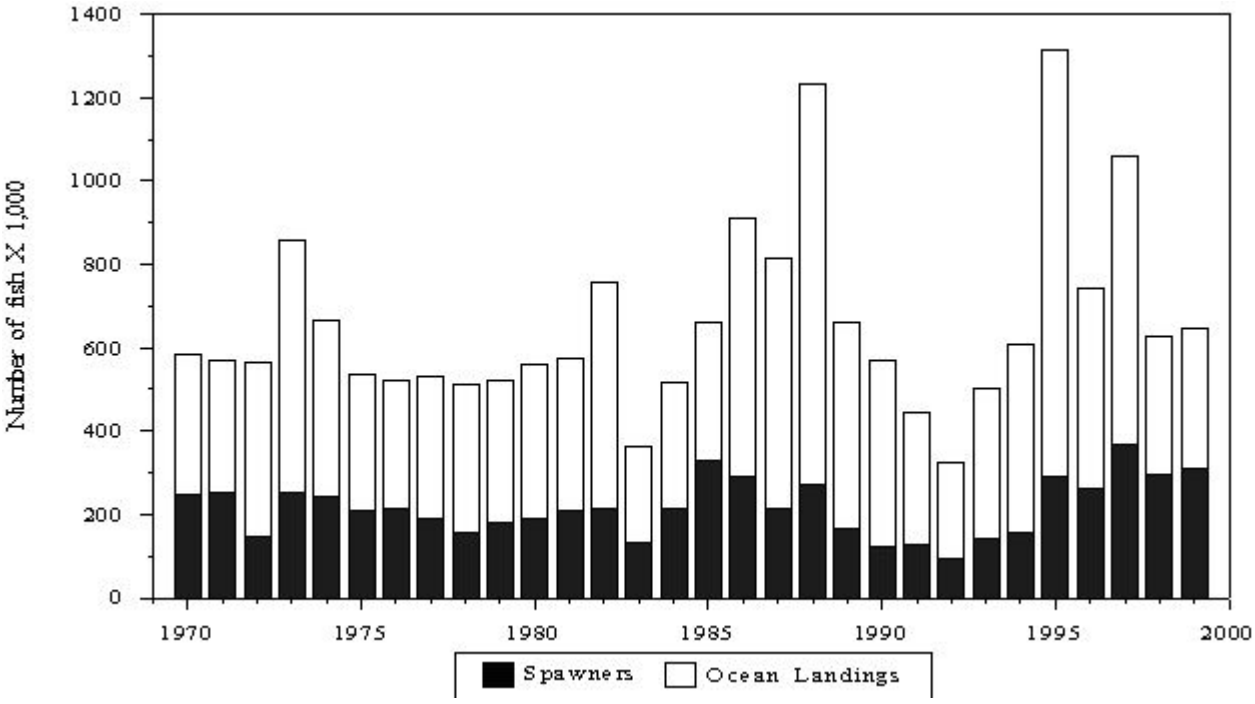

Figure 6–35 Central Valley Chinook salmon (all races) abundance index, 1970–99. 2000 = 1.74 million production with 55% harvested, 2001 = .849 million production with 27% harvested, 2002 = 1.285 million production with 34% harvested.

The percentage of Central Valley salmon harvested in ocean fisheries has averaged 66 percent since 1970 (Figure 6–22), and has approached 80 percent several times during the last 12 years. The average number of Central Valley Chinook landed in ocean fisheries between 1970 and 1999 was 442,000 fish per year (all races combined). Survival rates of young salmon are very low, meaning a large number must enter the ocean to support an average annual fishery of 442,000 fish. Beamish and Neville (1999) reported that smolt to adult survival rates for Fraser River (British Columbia) Chinook ranged from about 0.2 percent to about 6.8 percent, with an average during good ocean conditions of 4.8 percent. If the average Chinook smolt to adult survival is 4.2 percent and the pumps take 2 percent of winter–run this take would equate to 67 adults out of a winter–run escapement of 7,000, a 0.96 percent reduction in number of adults.

Assuming Central Valley smolt to adult survival rates also average 4.8 percent, 9.2 million Central Valley smolts would have to enter the ocean every year to support the average ocean fishery. Production of fall-run Chinook at Central Valley hatcheries exceeds 9.2 million smolts, and may more than support the entire ocean fishery. This number is actually higher than the total number of young salmon salvaged at both the SWP and CVP facilities (about 7 million or 230,000 per year) during the 30-year period 1970 through 1999. Salvage does not account for indirect losses attributable to project operations, which may be substantial and are estimated to be five times the direct losses. Nonetheless, this suggests that on average, indirect losses from Delta operations would have to be more than 30 times higher than the number salvaged to equal the adult-equivalent mortality contributed by the ocean fisheries, assuming 4.8 percent smolt to adult survival. Considering the projects are exporting a high portion of the total freshwater outflow, this suggests that salmon are finding their way out of the system and not being diverted at the facilities in direct proportion to the diversion rate. Both the ocean harvest and Delta salvage are managed to protect the ESA-listed races.

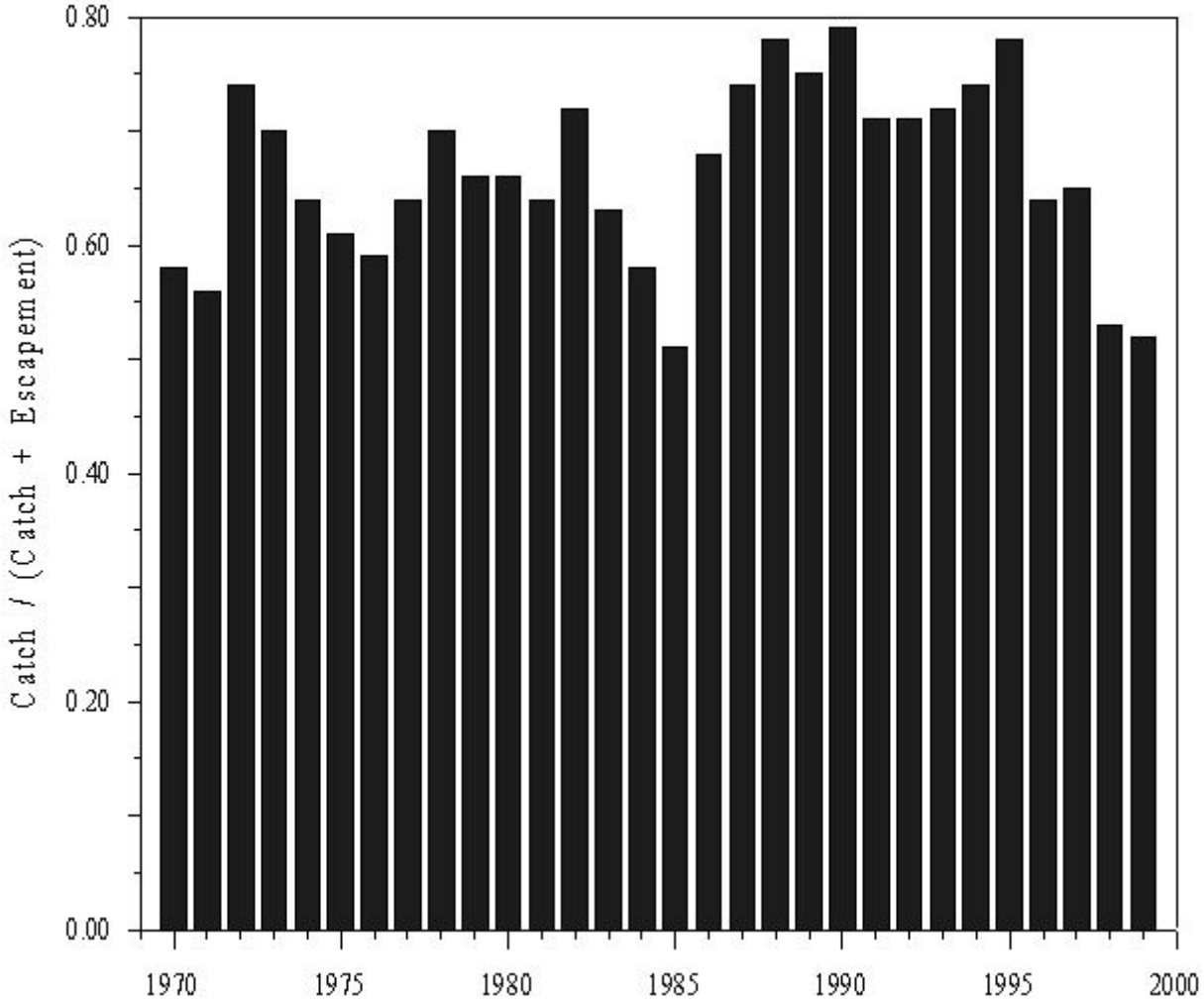

Figure 6–36 Central Valley Chinook salmon Ocean Harvest Index, 1970–99.

Recent advances in the scientific understanding of interdecadal changes in oceanographic conditions on marine fisheries were outlined in Chapter 3. The abundance of pink, chum, and sockeye salmon appears to fluctuate out of phase with Chinook stocks to the south (Beamish and Bouillon 1993, as cited in Bakun 1999; Beamish and Neville 1999). Beamish and Neville (1999) found Chinook smolt survival rates to adulthood in the Strait of Georgia (Fraser River stocks) declined from 4.8 percent prior to abrupt changes in local oceanographic conditions during the latter 1970s, to 0.7 percent after the oceanographic changes. As a consequence, adult Chinook returns to the Fraser River system decreased to about 25 percent of 1970s levels even though approximately twice as many smolts were entering the Strait during the 1980s. The specific reasons for decreased smolt survival rates were unclear, but the authors suggested that decreased coastal precipitation and resultant decreased river discharge, increased temperatures in the strait and an increased tendency for spring plankton blooms to precede the peak smolt immigration into the strait were likely contributing factors. In addition, aggregations of opportunistic predators like spiny dogfish, may have contributed to lower hatchery smolt survival rates due to the increasing density of young fish added into the Strait of Georgia by hatcheries.

No dramatic change in Central Valley salmon abundance occurred during the latter 1970s (Figure 6–35), like the one observed in Fraser River stocks. In fact, Central Valley salmon abundance was remarkably consistent during the 1970s. However, the variation in abundance of Central Valley Chinook increased dramatically beginning in 1983. Since 1983, Central Valley salmon abundance has flip-flopped by a factor of three during two periods of five years or less.

All Central Valley Chinook salmon stocks have overlapping ocean distributions (DFG 1998). This may provide the opportunity for occasional overharvest of a rare stock like winter or spring–run, relative to the abundant target stock, fall–run. This situation has occurred occasionally in the past. The brood year 1976 Feather River Hatchery spring-run was fished at levels about five to 13 times higher than the background rate on coded wire tagged fall-run Chinook by both the recreational and commercial fisheries for several years (Figure 6–37) This may also have happened to a lesser degree with the brood year 1983 spring-run from FRH. For whatever reason, these year classes remained particularly susceptible to the ocean fisheries for the duration of their ocean phase. Current ocean and freshwater fishing regulations are designed to avoid open fishing in areas where winter–run and spring–run are concentrated. Estimated harvest of winter–run coded wire tagged release groups are shown in Table 6–11.

Table 6–11 Winter–run Chinook estimated harvest of coded wire tagged release groups (expanded from tag recoveries) by harvest location (data from RMIS database).

Winter run recoveries (estimated) from RMIS database, 4/15/2003

Sum of estimated_number	run_year											
recovery_location_name	1980	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	Grand Total
AMER.R. TO COLUSA									8	17		25
BATTLE CREEK												
BIG LAG.-CENTERV.BEA									4			4
BROOKINGS SPORT 6									3			3
C.VIZCAINO-NAVARR.HD	6									8		14
CARQUINEZ TO AMER. R									14			14
COLEMAN NFH												
COLUSA TO RBDD										67		67
COOS BAY SPORT 5											2	2
COOS BAY TROLL 5									4		4	8
FORT ROSS-PIGEON PT	24	5	55	8	4	18		8	25			147
GSPTS YEO PT								3				3
NEWPORT SPORT 4										2		2
NEWPORT TROLL 4										3		3
NTR 02W-118							6					6
NWTR 026-000											7	7
PIGEON PT.-POINT SUR	7	7	34	5	5	19			86	22	34	218
PIGEON PT-CA/MEX.BOR									8			8
POINT SUR-CA/MEX.BOR			20	9	5	10			3	14	8	68
PT.ARENA-PT.REYES										7	15	22
PT.REYES-PIGEON PT.										18	27	45
PT.SN.PEDRO-PIGN.PT.										4	8	12
SACRA.R, ABO FEATHER												
Grand Total	37	13	109	22	13	47	6	11	154	162	105	679
Escapement	1,142	349	144	1,159	1,001	836	2,930	3,288	1,352	7,572	7,337	27,110
# CWT fish released 2 years prior	9,988	10,866	27,383	17,034	41,412	48,154	4,553	20,846	147,393	30,433	162,198	530,653
Estimated % of cwt released fish recovered	0.37%	0.12%	0.40%	0.13%	0.03%	0.10%	0.13%	0.05%	0.10%	0.53%	0.06%	0.13%

In addition to occasional effects to particular year-classes, ocean fishing may affect the age structure of Central Valley spring-run Chinook. A DFG (1998) analysis using CWT spring-run from the Feather River Hatchery estimated harvest rates were 18 percent to 22 percent for age-three fish, 57 percent to 85 percent for age-four fish, and 97 percent to 100 percent for age-five fish. Since length tends to be correlated with age, and fecundity is correlated with length (DFG 1998), the effect of ocean fishing on the age structure of the population may have subtle effects on population fecundity.

Recent papers have re-emphasized the ecological importance of salmon carcasses to stream productivity (Bilby et al. 1996, 1998; Gresh et al. 2000). As mentioned in the preceding chapter on steelhead, the substantial declines in mass transport of marine-derived nutrients to streams due to overall salmonid declines may also affect growth and survival of juvenile salmonids (Bilby et al. 1996, 1998). Levels of ocean harvest that attempt to maximize production from a minimum of adults may exacerbate nutrient deficiencies (Gresh et al. 2000). The relatively high ocean harvest indices for Central Valley salmon suggest this idea should be studied locally.

In addition to ocean harvest, legal and illegal inland fishing for spring-run salmon undoubtedly occurs at fish ladders and other areas where adult fish are concentrated, such as pools below dams or other obstructions (DFG 1998). Mill, Deer, and Butte Creeks, as well as other tributaries with spring-run populations, are particularly vulnerable to poaching during the summer holding months because of the long period in which adults occupy relatively confined areas. The significance of illegal freshwater fishing to the spring-run salmon adult population, however, is unknown. The increased law enforcement programs have reduced poaching the last few years.

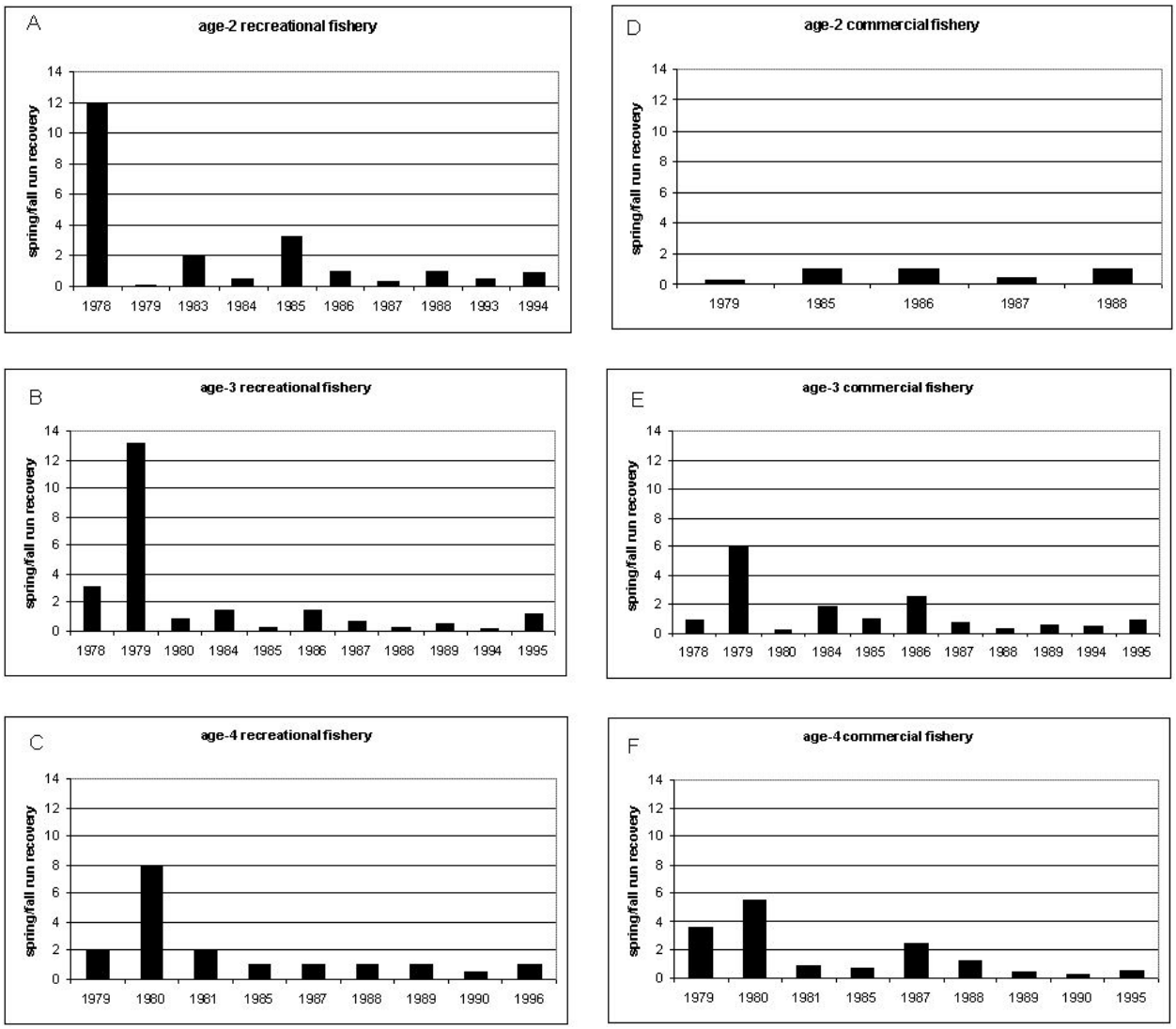

Figure 6–37 Coded-wire-tag (CWT) recovery rate of Feather River Hatchery spring-run Chinook salmon relative to the CWT recovery rate of Central Valley fall-run Chinook salmon. Data were taken from DFG (1998), and are presented individually for recreational and commercial fisheries for age-two, age-three, and age-four fish. Values greater than one indicates fishing pressure above the level sustained by the fall-run.

Hatchery Influence

Central Valley Chinook salmon runs are heavily supplemented by hatcheries to mitigate for the loss of habitat when dams were built. Table 6–12 lists salmon hatcheries operating in the Central Valley and their yearly production goals. When all hatcheries reach their production goals, over 34 million Chinook smolts are released into the system. This large number of smolts in the common ocean environment may result in competition with wild fish in times of limited food resources.

Table 6–12 Production data for hatchery produced Chinook salmon.[13]

Hatchery	*River*	*Chinook runs*	*Yearly production goal*
Coleman NFH	Battle Creek	Fall, late-fall, winter	13,200,000 smolts
Livingston Stone	Sacramento	winter	
Feather River	Feather	Fall, spring	~14,000,000 smolts
Nimbus	American	Fall	4,000,000 smolts
Mokelumne River	Mokelumne	Fall	2,500,000 post smolt
Merced River	Merced	Fall	960,000 smolts
Total			34,660,000

The percentage of the Central Valley fall-run Chinook return taken at hatcheries for spawning has shown a gradual increase since 1952 (Figure 6–38). Hatcheries have likely helped to maintain Chinook populations at a level allowing a harvestable surplus. However, hatcheries may have reduced genetic fitness in some populations, especially the more depressed runs, by increasing hybridization between different runs. Fish have been transferred between watersheds resulting in unknown genetic effects. Livingston Stone Hatchery produces winter-run Chinook and has assisted in the recent population increases for winter–run.

A majority of hatchery releases are trucked to downstream release locations and in all except Coleman and Livingston Stone hatcheries are trucked to San Pablo Bay. The downstream releases increase survival of the hatchery stocks but also increase the proportion of hatchery relative to wild survival and increase straying. Recent cwt data shows that a good portion of the Chinook in spring-run streams like Clear Creek and Mill Creek are of hatchery origin (NOAA Fisheries 2003). A recent review of hatchery practices (DFG and NOAA fisheries 2001) recommended reducing the practice of using downstream releases and instead releasing fish in the river of origin. This practice would reduce the survival of hatchery fish, but could also reduce the in-river survival of wild fish when the carrying capacity of the habitat is surpassed resulting in intraspecific competition. Currently the proportion of hatchery vs wild fish contributing to fisheries and to the escapement is unknown. Visually marking all hatchery production would allow harvest to take only hatchery fish thus allowing wild salmon populations to increase. Otolith marking would allow a better estimate of the proportion of adults consisting of hatchery produced fish to be made at a reduced cost from fin clipping or CWTs.

13Source: DFG and NOAA fisheries 2001.

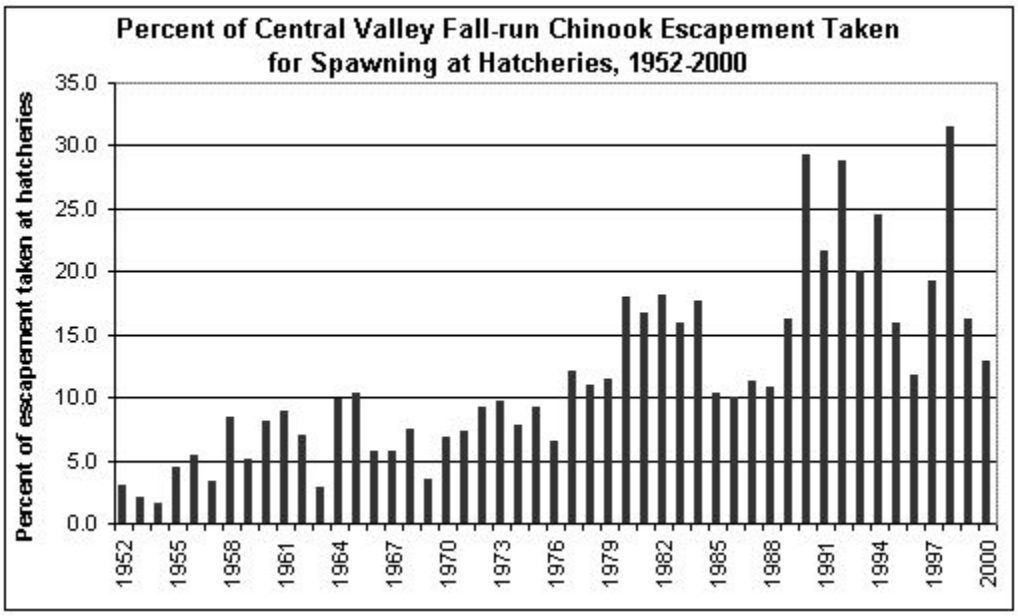

Figure 6–38 Percent of Central Valley fall-run Chinook escapement taken for spawning 1952–2000.

Feather River Hatchery-Genetics, Competition for Spawning, and Rearing Habitat

Historically, the adult spring-run salmon immigration into the upper rivers and tributaries extended from mid-March through the end of July with the peak in late May and early June (DFG 1998). Spawning started in mid-August, peaked in early September, and ceased in late September. The peaks of spawning between spring- and fall-run salmon were almost two months apart, and more than 30 days separated the end of spring-run spawning and the onset of fall-run spawning at Baird Hatchery at the end of the 1800s.

Although hydraulic mining and dams initially fostered intermixing of Chinook races in the Sacramento River system, hatchery practices have contributed as well (DFG 1998; NOAA fisheries 1998). The Feather River Hatchery (FRH) was built by DWR at the request of DFG to mitigate for the loss of habitat upstream of Oroville Dam. The hatchery was dedicated on October 1, 1967 and is operated by DFG. During the five-year period prior to the opening of the hatchery (1962 through 1966) all adult salmon were trapped and transported above the site of Oroville Dam. During 1968 and 1969 spring-run salmon were allowed to enter the hatchery as soon as they arrived. The result was greater than 50 percent mortality, because warm water temperatures resulted in an inability to hold adults during the summer months until they were ready for spawning. As a result, since 1970 hatchery policy has been to exclude spring-run salmon entry until the onset of spawning, (August through October, generally early September to October 1). This practice has resulted in the inability of the hatchery operators to clearly identify spring-run based on their adult upstream migration timing, thereby increasing the likelihood of genetic introgression of spring-run and fall-run Chinook stocks.

Coded wire tag analysis provided verification of the inter-mixing of fall and spring runs. Twenty-two percent of juveniles tagged as fall-run subsequently spawned as spring–run, and 295 juveniles tagged as spring-run were subsequently spawned as fall-run (Brown and Greene 1994). Preliminary genetic characterization results from the IEP Central Valley Salmonid Genetics Project provided additional evidence of inter-mixing. University of California geneticists presented preliminary work on Feather River spring-run genetic characterization at the 1999 Salmon Symposium in Bodega Bay. They had access to samples from Feather River hatchery "spring–run," late summer season in-river carcass surveys and a limited number of samples from spring season in-river angler surveys. They found no genetic difference between the Feather River fall and spring runs. The two groups were genetically similar, and homogenous. They were most similar to Central Valley fall-runs, and were not genetically similar to spring-run from Mill, Deer or Butte Creeks.

In 1994, the FRH fish ladder was kept open between May 16 and June 6 to assess the current numbers of Chinook that exhibited spring-run adult migration timing. Prior to June 6, only one fish had entered the hatchery. On June 6, 31 fish entered the hatchery and the ladder was closed (DFG 1998). The implication is that few fish exhibiting the "typical" spring-run salmon adult migration timing ascended the Feather River during 1994. Alternatively, many spring-run adults may have been holding, or not moving, during the period the gates were open. When the ladder was reopened on September 6, 1994, 3,641 "spring-run" Chinook entered the hatchery.

FRH spring-run have been documented as straying throughout the Central Valley for many years and have intermixed with wild-spawned spring-run and fall-run Chinook in the upper Sacramento River, although the extent of hybridization has not been determined (DFG 1998). In 1982, early returning CWT Chinook were observed at RBDD and subsequently identified as FRH fall-run from the 1980 brood year. Now it is commonplace at RBDD to intercept fish tagged as fall-run during the spring-run migration period (mid-March through the end of July) (Figure 4–4). This intermixed life history pattern was evident when FRH fish were used in an attempt to re-establish spring-run in Clear Creek. More than 523,000 FRH spring-run fry were planted at the base of Whiskeytown Dam during the three-year period 1991–93 (DFG 1998). Some of the fish were coded wire tagged. Since 1993, snorkeling surveys have been performed during the adult spring-run holding period to determine if the plants were successful. Three unmarked salmon were observed during the spring-run adult holding period in 1993 and two in 1995. However, 23 CWT adults returned between 1993 and 1995 during the adult fall-run spawning migration.

DFG (1998) questioned the viability and genetic integrity of the Butte Creek spring-run because of the potential for intermixing with Feather River salmon. Butte Creek has several different sources of introduced water, including West Branch Feather River water, main stem Feather River water, and Sacramento River water. As a consequence, it is possible that some spring-run salmon in Butte Creek could be strays from the Feather River. Despite the mixing of Feather River water into Butte Creek, DFG (1998) suggested the relative numbers of adult spring-run entering Butte Creek and FRH, for the period 1964 to 1991 did not show a strong relationship, suggesting they are generally independent. In support of this information, Banks, et al, (2000) published genetic characterization research results and determined spring-run from Deer and Mill Creeks are more closely related to Central Valley fall-run populations than Butte Creek spring-run. This result would not be expected if Butte Creek spring-run were hybridized with

FRH spring-run because FRH spring-run are known to be hybridized with FRH fall-run. More recently, Hedgecock, et al, (2002) re-exmained Feather River fall hatchery, spring hatchery and spring wild. Field biologists have found a spring-run phenotype in the Feather River. Hedgecock found that spring hatchery and spring wild form a genetically distinct population that is different from the fall–run, although the Feather River spring–run population is still more closly related to fall–run than to either Mill or Deer Creeks spring–run populations. In conclusion, Hedgecock found two distinct populations in the Feather River, one of which exhibits a spring–run phenotype. The Feather River spring–run population is not closely related to Mill and Deer Creeks spring–run and may be, therefore a spring–run in the Sacramento Valley may be poly-phyletic.

The Banks et al. (2000) genetic results are surprising however, because the escapement estimates for Butte Creek and Feather River spring-run are strongly correlated over more recent years (1987 through 1998), (Spearman $R = 0.83\text{-}0.86$, $p < 0.001$). (The variability in the R-value is due to separate tests of FRH spring-run escapement v. the smallest and largest available Butte Creek escapement estimates.) In contrast, the spring-run escapement estimates for Deer and Mill Creeks, which Banks et al. (2000) found were not genetically different from each other, are not significantly correlated for the 1987 through 1998 period (Spearman $r = 0.27$, $p = 0.40$).

FRH spring-run fry and juveniles were released into Butte Creek in 1983, 1984, and 1985, Brood Years 1982, 1983, and 1984 respectively. Only BY 1983 releases affected resultant year-classes, showing large increases in BY 1986 and BY 1989. There was a significant reduction in adult returns for BY 1992, but BY 1995 was the largest observed (7,500 adults) since 1960, and BY 1998 was higher still (20,259 adults). Since 1995 there have been over 500,000 Butte Creek spring–run tagged and released. While the inland recoveries have been limited, all of the tags recovered within the spring–run population have been from spring–run tagged and released in Butte Creek. One tagged fish was recovered in the Feather River, but no Feather River or other origin fish have been found among the Butte Creek spring–run (DFG 2003).

During the 1977 drought, adult spring-run were trucked from RBDD to Mill, Deer, and Butte Creeks (DFG 1998). No appreciable effect was seen in the subsequent year class (1980) on Butte or Mill Creeks. However there was an apparent single year (1980) increase in the Deer Creek population.

The Yuba River was planted with surplus FRH spring-run in 1980 (15,925), 1983 (106,600), and 1985 (96,800) (DFG 1998). Influence of these three introductions on subsequent adult spring-run returns cannot be determined since escapement surveys were not conducted. In 1984, Antelope Creek was planted with 302,733 FRH spring-run juveniles. In 1985, the creek was planted with another 205,000 juveniles. There is no persistent spring-run population in Antelope Creek, so the effect of hatchery supplementation in this drainage is irrelevant.

The effects of introgression and planting are poorly understood. In the case of the Feather River, Sommer et al. (2001a) found evidence that hatchery operations have had major population effects. As noted previously in this chapter, the authors examined factors responsible for a long-term shift in the spawning distribution toward the low flow channel of the Feather River. While they found statistical evidence that flow and escapement may affect the distribution of spawning salmon, they concluded that hatchery operations probably account for much of the change. One hypothesis was introgression with spring-run causes the fall-run population to spawn as far

upstream as possible, similar to the historical spring-run life history pattern. Another possibility was that a shift in the stocking location of young salmon to the estuary resulted in higher survival rates and an increased proportion of hatchery fish in the population. Hatchery fish would tend to spawn closer to the hatchery in the low flow channel. In support of the latter hypothesis, there has been a significant increase in the number of fish entering FRH since 1968 (Ted Sommer, DWR unpublished data). The effects of these changes for spring-run are unclear. However, a shift in spawning distribution to the heavily-used low flow channel is expected to result in exceptional spawning superimposition and egg mortality for any spring-run that may be present.

Disease and Parasites

Spring-run Chinook are susceptible to numerous diseases during different phases of their life cycle. Disease problems are often amplified under crowded hatchery conditions and by warm water. See DFG (1998) for a detailed discussion of Central Valley salmonid diseases.

In stream Habitat

Dam operations generally store water runoff during winter and spring to be released for in stream flows, water delivery, and water quality during late spring, summer and fall. Historical high flows in regulated rivers have been dampened for flood control and water storage. Moderate flows have been extended throughout much of the year to provide appropriate in stream flows for fish, water quality in the Delta and water for pumping in the Delta. The long term effect of the lack of high flows is the simplification of in stream habitat. High channel forming flows maintain high quality spawning habitat and riparian floodplain conditions. High flows mobilize spawning sized gravels from streambanks and incorporate them into the active channel. Low flows that typically occurred in late summer and fall do not occur because of the dampening effect of dam operations. High flows are not as high as occurred under natural conditions but the duration of high flows is longer because flood control operations spread them out over time. The longer duration of moderately high flows may be sufficient enough to wash quality spawning gravel out of riffles and deposit it in deeper water where it is unavailable for spawning but not high enough to mobilize new gravel supplies from the gravel bars, banks, and floodplain. The presence of dams has eliminated upstream sources of bedload and woody debris, increasing the importance of streamside sources. Depending on reservoir operations and whether this increases or decreases the number of bankfull days in the respective river, the availability of spawning gravel downstream could be increased or decreased.

Levees and bank protection projects have been constructed along the lower reaches of many Central Valley rivers, limiting the potential for rivers to meander. Many streambanks near developed areas have been riprapped to cut down on natural channel adjustments and streambank erosion. Natural streambanks generally provide higher quality habitat to salmonids than riprapped banks. In addition, when banks are riprapped riparian vegetation is eliminated in the riprapped portion, eliminating overhanging vegetation and future woody debris sources.

Large woody debris provides valuable habitat to salmonids. Woody debris has been removed from some rivers because it is perceived as a hazard to swimmers and boaters and impedes navigation. The habitat loss cumulatively from lack of woody debris recruitment, woody debris removal, and riprapping could be a significant factor in the current state of Central Valley

salmon populations. The likelihood that this would reduce the survival of the current Chinook or steelhead populations is unknown.

Factors that May Influence Abundance and Distribution of Coho Salmon

A number of interrelated factors affect coho abundance and distribution. These include water temperature, water flow, habitat suitability, habitat availability, hatcheries, predation, competition, disease, ocean conditions and harvest. Current CVP operations affect primarily water temperature, water flow, and habitat suitability. Water temperature suitability criteria for Coho salmon are shown in Table 6–13.

Table 6–13 Water Temperature suitability criteria for Coho salmon life stages from DFG 2002a.

Life Stage	Suitable Range, degrees F	Reference or Citation
Migrating adult	44.6 – 59	Reiser and Bjornn 1979
Spawning adult	39.2 – 48.2	Bjornn and Reiser 1991
Rearing juvenile	48 – 59.9 = optimum 63.7 – 64.9 = optimum (2 studies gave optimums) 35 = lower lethal 78.8 - 83.8 = upper lethal	Bjornn and Reiser 1991; Flosi et al 1998; Ambrose et al 1996; Ambrose and Hines 1997, 1998; Hines and Ambrose ND; Welsh et al. 2001
Eggs and fry	39.2 - 55.4 = optimum 32 – 62.6	Davidson and Hutchinson 1938; Bjornn and Reiser 1991; PFMC 1999

Juvenile coho salmon spend a full year in freshwater before migrating to the ocean. Their habitat preferences change through the year and are highly influenced by water temperature. During the warmer summer months when coho are most actively feeding and growing they spend more time closer to main channel habitats. Coho tend to use slower water than steelhead or Chinook salmon. Coho juveniles are more oriented to submerged objects such as woody debris while Chinook and steelhead tend to select habitats in the summer based largely on water movement and velocities, although the species are often intermixed in the same habitat. Juvenile coho tend to use the same habitats as pikeminnows, a possible reason that coho are not present in Central Valley watersheds. Juvenile coho would be highly vulnerable to predation from larger pikeminnows during warm water periods. When the water cools in the fall, juvenile coho move further into backwater areas or into off-channel areas and beaver ponds if available. There is often no water velocity in the areas inhabited by coho during the winter. These same off-channel habitats are often dry or unsuitable during summer because temperatures get too high.

Lewiston Dam blocks access to 109 miles of upstream habitat (USDI 2000). Trinity River Hatchery produces coho salmon with a production goal of 500,000 yearlings to mitigate for the upstream habitat loss. Habitat in the Trinity River has changed since flow regulation with the encroachment of riparian vegetation restricting channel movement and limiting fry rearing habitat (Trush et al 2000). According to the Trinity River Restoration Plan higher peak flows are

needed to restore attributes of a more alluvial river such as alternate bar features and more off channel habitats. These are projected in the restoration plan to provide better rearing habitat for coho salmon than the dense riparian vegetation currently present.

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Chapter 7 Basic Biology and Life History of Delta Smelt and Factors that May Influence Delta Smelt Distribution and Abundance

Delta Smelt Biology and Population Dynamics

General Biology

The delta smelt is a small (adults typically < 100 mm in length) pelagic fish found in tidal fresh and brackish water habitats of the upper San Francisco Estuary (Moyle et al. 1992). It typically has an annual life cycle though a small percentage (< 10 percent) of the population can live to and possibly reproduce at age-two (Brown and Kimmerer 2001). On average, ripe females produce about 1,900 eggs, but fecundity can range from about 1,200 to about 2,600 eggs per female (Moyle et al. 1992). Moyle et al. (1992) considered delta smelt fecundity to be "relatively low", but based on Figure 2a in Winemiller and Rose (1992) delta smelt fecundity is actually fairly high for a fish its size. Delta smelt move into tidal freshwater habitats to spawn in late winter through spring. Most spawning occurs in the Delta, but some also occurs in Suisun Marsh and the Napa River (DFG unpublished). An optimal spawning temperature "window" of about 15º C -18º C (59º F - 64.4º F) has recently been reported (Bridges unpublished; Bennett unpublished). After hatching, larvae are dispersed throughout low salinity habitats, generally moving into Suisun Bay, Montezuma Slough, and the lower Sacramento River below Rio Vista as they mature (Grimaldo et al. 1998; Sweetnam 1999). Delta smelt are zooplanktivorous throughout their lives, feeding mainly on a few species of copepods with which they co-occur (Moyle et al. 1992; Lott 1998; Nobriga 2002). In the larger picture of fish life history strategies, delta smelt best fit the "opportunistic strategy" of Winemiller and Rose (1992). Opportunistic fishes are characterized as placing "a premium on early maturation, frequent reproduction over an extended spawning season, rapid larval growth, and rapid population turnover rates", and "maintain dense populations in marginal habitats (e.g. ecotones, constantly changing habitats)…(Winemiller and Rose 1992)."

Distribution, Population Dynamics, and Baseline Conditions

Distribution

Delta smelt spend most of their lives rearing in low salinity habitats of the northern estuary (Moyle et al. 1992; Sweetnam and Stevens 1993). Delta smelt can temporarily tolerate salinities as high as 19 ppt (Swanson et al. 2000) and have been collected in the field at salinities as high as 18 ppt (Baxter et al. 1999). However, most delta smelt are collected at much lower salinities-typically in the range of about 0.2 – 5.0 ppt (Sweetnam and Stevens 1993). The geographical position of these low salinity habitats varies principally as a function of freshwater flow into the estuary. Therefore, the delta smelt population's center of mass has on average been located in the western Delta during years of low freshwater flow and in Suisun Bay during years of high

freshwater flow. This relationship between flow and distribution is particularly strong during the larval period (Figure 7–1), but persists throughout the first year of life (Sweetnam and Stevens 1993).

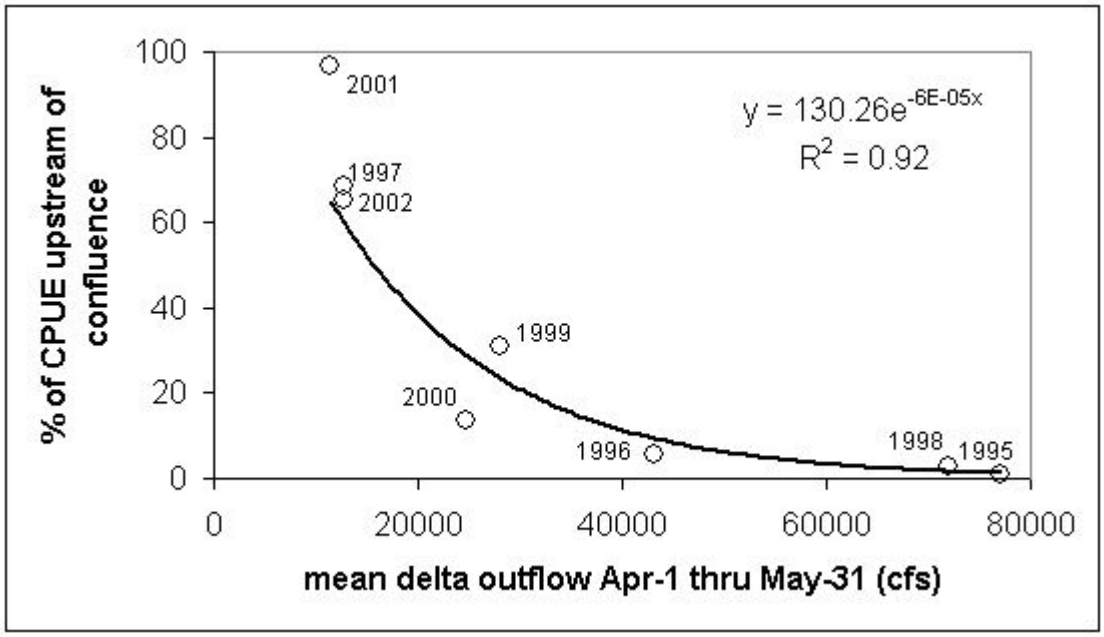

Figure 7–1 (x-axis is DAYFLOW; y-axis is first 20-mm Survey following VAMP).

Currently, the approximate spatial position of low salinity habitat in the estuary is indexed by X2, defined as the distance in km from the Golden Gate to the location of 2 ppt salinity near the bottom of the water column (Jassby et al. 1995). The longitudinal position of X2 during spring and/or early summer, which varies as a function of freshwater flow into the estuary, has been correlated with abundance or survival indices of numerous estuarine taxa (Jassby et al. 1995) including delta smelt (Kimmerer 2002). Both late larval (Bennett et al. 2002) and juvenile (Aasen 1999) delta smelt actively maintain positions in low salinity habitats by using swimming behaviors timed to tidal and diel cues.

Population Abundance Trends

The DFG Fall Midwater Trawl Survey (FMWT) provides the best long-term index of relative abundance of maturing adult delta smelt (Moyle et al. 1992; Sweetnam 1999). It has been conducted each September-December since 1967 (except 1974 and 1979). The DFG Summer Townet Survey (TNS), which has been conducted since 1959 (except 1966-68), provides an index of juvenile delta smelt abundance during June-July. These surveys cannot provide statistically defensible population abundance estimates. However, they are generally believed to provide a respectable basis for indexing long-term trends.

The TNS indices have ranged from a low of 0.9 in 1985 to a high of 62.5 in 1978 (Figure 7–2). The MWT indices have ranged from a low of 102 in 1994 to 1,653 in 1970 (Figure 7–3). Although peak high and low values have varied in time, the TNS and FMWT indices show similar time series of delta smelt relative abundance (Sweetnam 1999; Figure 7–2 and Figure 7–3).

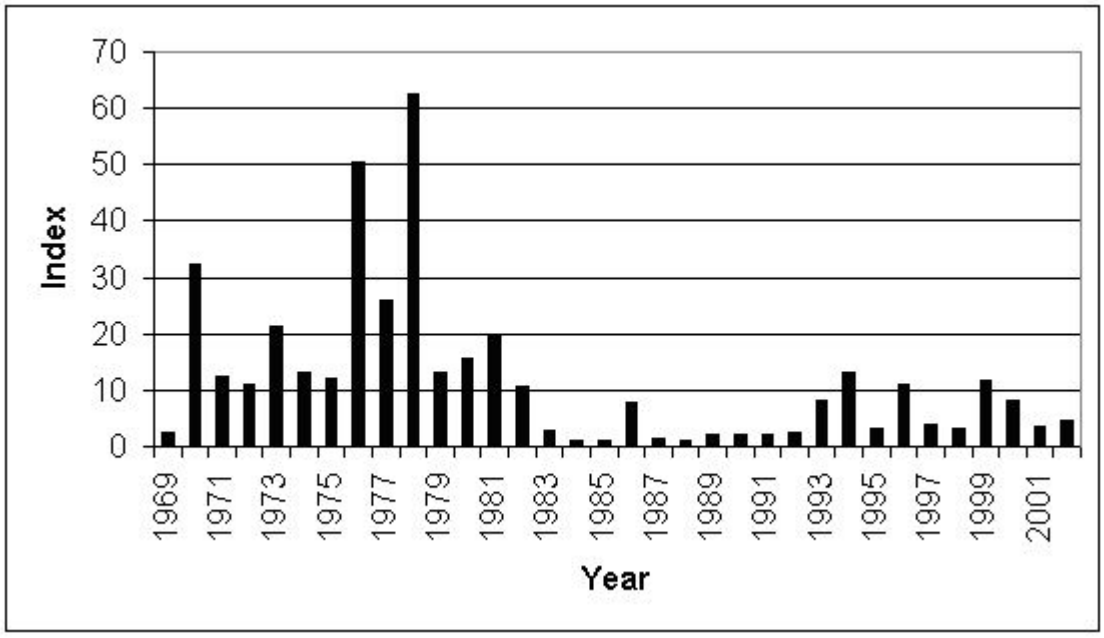

Figure 7–2 TNS indices 1969-2002.

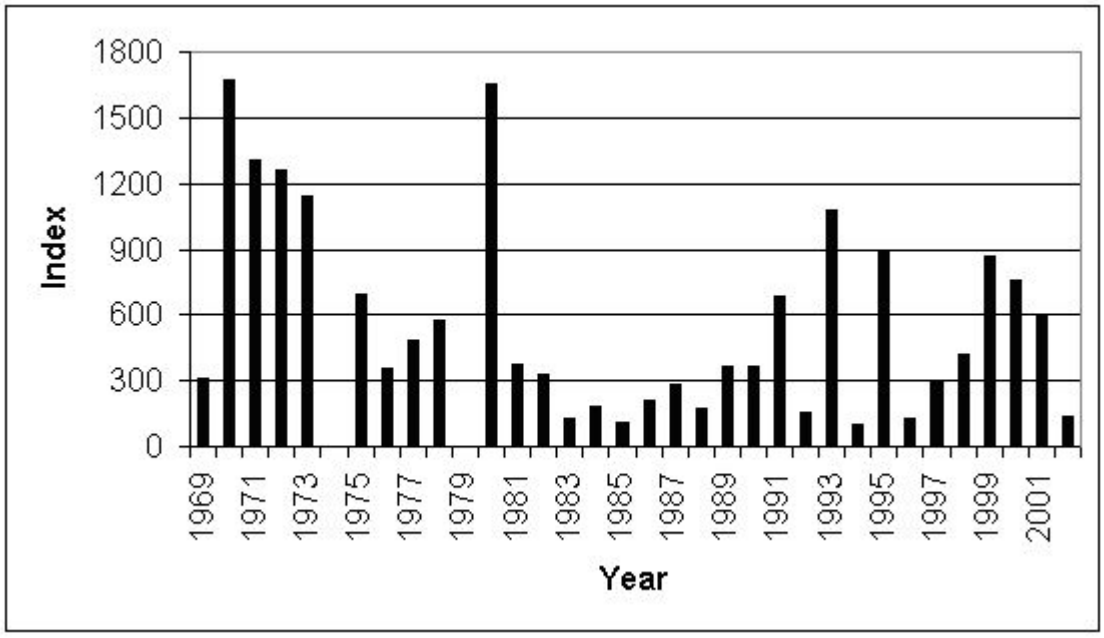

Figure 7–3 FMWT indices 1969-2002.

From 1969-81, mean delta smelt TNS and FMWT indices were 22.5 and 894 respectively. Both indices suggest the delta smelt population declined abruptly in the early 1980s (Moyle et al. 1992). From 1982-1992, mean delta smelt TNS and FMWT indices dropped to 3.2 and 272

respectively. The population has rebounded somewhat since the early 1990s (Sweetnam 1999); mean TNS and FMWT indices were 7.1 and 529 during 1993-2002.

Factors That May Influence the Abundance and Distribution of Delta Smelt

Numerous factors are hypothesized to influence the population dynamics of delta smelt (Bennett and Moyle 1996). Some of these factors (e.g., climatic influences on the physical environment) are thought to exert strong, consistent influences, while others are thought to exert more subtle influences (e.g., factors affecting growth rates), or to be important only under certain conditions (e.g., entrainment losses). Currently, most mechanistic hypotheses are based on inferences from statistical correlations of abundance and/or survival with environmental variables (see Sweetnam and Stevens 1993; Brown and Kimmerer 2001). Many of these correlative analyses are described further in appropriate sections below.

Climatic Effects on Environmental Conditions in the Estuary

Currently, X2 (which is controlled by both climate and water operations) is a strong predictor of the TNS index but curiously, the slope of the X2-TNS relationship switched sign about the time of the delta smelt decline in the early 1980s (Kimmerer 2002). During 1959-81, TNS indices were highest in years of low freshwater flow. In contrast, during 1982-2000, TNS indices were usually among the lowest recorded during years of low freshwater flow. Throughout 1959-2000, TNS indices have been comparable during years of high freshwater flow. The reason(s) for this change in the relationship of young delta smelt abundance to low spring flow conditions beginning in the early 1980s is unknown.

Currently, the number of days during spring that water temperature remained between 15º C and 20º C (59º F to 68º F), with a density-dependence term to correct for the saturating TNS-FMWT relationship (described below), is the best statistical model to explain the FMWT indices ($r^2 \approx 0.70$; $p < 0.05$; Bennett unpublished presentation at the 2003 CALFED Science Conference). The spring temperature "window" is thought to influence delta smelt abundance by influencing reproductive success - a longer period of optimal water temperatures during spring increases the number of cohorts produced. More cohorts translate into a higher probability for a strong year class. Water temperatures in the Delta and estuary are primarily affected by air temperatures and cannot be controlled by operations because water storage facilities are too far away from the Delta. Therefore, Delta water operations cannot manage water temperatures to enhance conditions for delta smelt spawning or rearing in a manner analogous to strategies used for salmonid fishes in Delta tributaries.

The number of days X2 is in Suisun Bay during spring also is weakly positively correlated with the FMWT indices (Brown and Kimmerer 2001). Hypotheses regarding potential mechanisms underlying X2-abundance relationships have been described previously (Moyle et al. 1992; Jassby et al. 1995; Bennett and Moyle 1996; Kimmerer 2002). However, it is probable that X2 position covaries with the number of days spawning temperatures remain optimal during spring, so both of these correlations may reflect the same phenomenon.

Stock-Recruitment Effects

Stock-recruitment analyses attempt to elucidate the influence of population size at a starting point on population size at another point in the future. Moyle et al. (1992) and Sweetnam and Stevens (1993) both reported that number of delta smelt spawners (indexed by the FMWT) was a poor predictor of subsequent recruits (indexed by the following year's TNS). Both linear and nonlinear Beverton-Holt models suggested that only about a quarter of the variance in delta smelt TNS abundance could be explained by the abundance of the adult spawners. This means that most of the variation in delta smelt abundance is due to environmental factors.

At present, there is an ongoing scientific debate concerning interpretation of within-year stock-recruit dynamics of delta smelt. Both the TNS and FMWT indices suggest similar long-term abundance trends for delta smelt collected in the summer and fall respectively (Figure 7–2 and Figure 7–3). However, when all of the available data are considered together, a nonlinear Beverton-Holt model describes the relationship between the TNS and FMWT data better than a linear model (Bennett unpublished; reproduced in Figure 7–4).

The standard fisheries interpretation of such a relationship is that it indicates a carrying capacity for the population - in this case during late summer of the first year of life. Phrased another way, this relationship suggests that as the number of juveniles produced increases, so does population mortality. Evidence for this density-dependent mortality was presented in Brown and Kimmerer's (2001) Figure 19. In fisheries science, density-dependence is the mechanism allowing stocks to be sustainably fished. A correlation of abundance and mortality means there is "surplus production" that can be harvested without negatively affecting a population's viability.

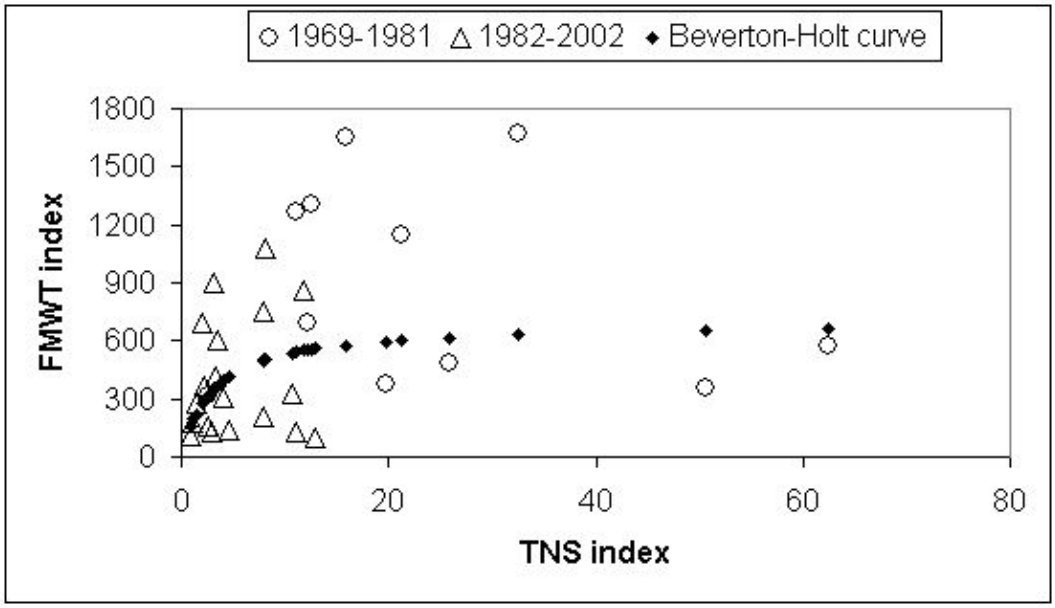

Figure 7–4 (Beverton-Holt curve was fitted to all data even though time periods are shown separately).

The evidence for density-dependent mortality in the delta smelt population has not been universally accepted by delta smelt biologists (Brown and Kimmerer 2001). One reason for this skepticism is that it may not be appropriate to pool all years of data. In Figure 7–4, the data

points from the pre-decline period (1969-1981) almost all occur outside of the range of the post-decline (1982-2002) data points. Therefore, an alternative explanation of the TNS-MWT relationship is possible - the non-linearity may reflect two different relationships from two time periods with different delta smelt carrying capacities. This latter relationship suggests that summer abundance is not and has never been a statistically significant predictor of fall abundance. As stated above, which (if either) of these interpretations is correct remains a subject of debate.

One possible problem with analyses using the TNS index is that it is not considered as robust an abundance index as the FMWT (Miller 2000). However, the TNS indices are correlated with two unpublished versions of a larval abundance index derived from the DFG 20-mm Delta Smelt Survey, which has been conducted each spring-summer since 1995 (Figure 7–5).

This provides support for the density-dependent mortality hypothesis because it suggests the Townet Survey reflects the large differences in YOY delta smelt abundance that underlie the density-dependent mortality hypothesis.

Scientific debate also continues regarding the meaning of statistically significant autocorrelation in the TNS and FMWT time series. Autocorrelation means that index values within the time series are dependent in part on values that preceded them. Both sets of indices show significant autocorrelation at lag two years, meaning that successive index values are correlated with index values from two years prior. Bennett (unpublished) hypothesized the lag two-year autocorrelation was evidence for a reproductive contribution of age-two spawners, but this interpretation has not thus far been backed by strong empirical evidence. The contribution of age-two spawners to delta smelt population dynamics is currently under investigation (Brown and Kimmerer 2002).

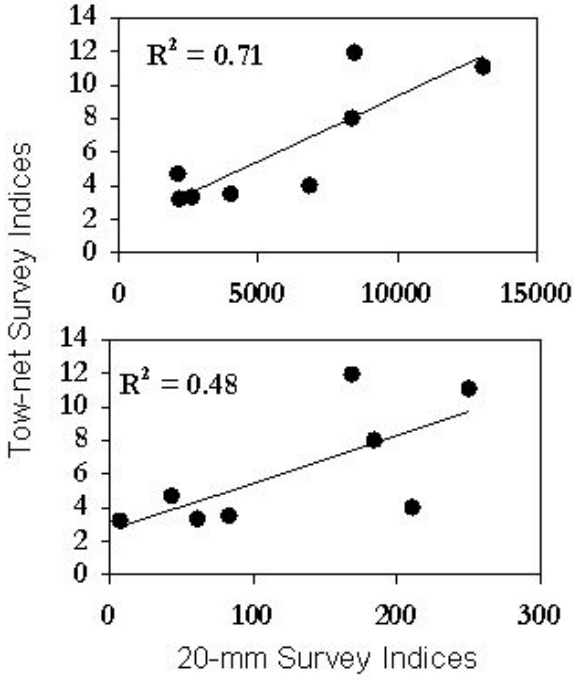

Figure 7–5 Relationships between 20-mm Survey indices and TNS indices, 1995-2002.

Reclamation and DWR (1994) were concerned about autocorrelation resulting in spurious conclusions about environmental influences on delta smelt population dynamics. Statistically speaking, autocorrelation in a time series or in the residuals from a correlative analysis of the time series and an explanatory variable can complicate interpretation because a variable may happen to covary with, but not actually influence the underlying process resulting in the autocorrelation. Recent statistical analyses have mitigated for this by using residuals from various stock-recruit relationships (Brown and Kimmerer 2001) and by testing regression residuals for significant autocorrelation.

SWP and CVP Water Export Operations

The CVP and SWP water export operations include upstream reservoirs, the DCC, the SMSCG, the North Bay Aqueduct facilities (NBA), the Contra Costa Canal facilities (CCC), CCF, the Banks Pumping Plant/Skinner Fish Facilities (hereafter SWP), the South Delta Temporary Barriers (SDTB) and the Tracy Pumping Plant/Fish Collection Facilities (hereafter CVP). The description and operation of these facilities was covered in the "Project Description" section of this Biological Assessment and will not be repeated here.

Water export operations occur primarily at SWP and CVP, with far smaller amounts of water diverted at NBA and CCC. As described in the "Project Description", the NBA diversions have fish screens designed to FWS criteria for delta smelt protection. In addition, a larval delta smelt monitoring program occurs each spring in the sloughs near NBA. This monitoring program is used to trigger NBA export reductions when delta smelt larvae are nearby. Because the FWS deems these NBA measures to be protective of delta smelt, the NBA will not be considered further.

Direct Effects – fish entrainment into CVP and SWP facilities

The CVP and SWP export operations are most likely to impact adult delta smelt during their upstream spawning migration between December and April. A significant negative correlation between November-February delta smelt salvage and the residuals from a FMWT index at year one vs. FMWT index at year two stock-recruit relationship is evidence for an influence of adult entrainment on delta smelt population dynamics (Brown and Kimmerer 2001). Delta smelt spawn over a wide area (much of the delta and some areas downstream). In some years a fairly large proportion of the population seems to spawn in or be rapidly transported to the central and southern delta. Presumably, entrainment vulnerability is higher during those years. Unfortunately, it is not currently known what cues decisions about where to spawn.

The CVP and SWP water operations are not thought to have any impact on delta smelt eggs because they remain attached to substrates. Upon hatching, larvae are vulnerable to entrainment at all points of diversion, but are not counted in SWP or CVP fish salvage operations. Juvenile delta smelt also are vulnerable to entrainment and are counted in salvage operations once they reach 20-25 mm in length. Most juvenile salvage occurs from April-July with a peak in May-June (Nobriga et al. 2001).

Water operations impacts to the delta smelt population are greatest in dry years when a high proportion of YOY rear in the delta (Moyle et al. 1992; Reclamation and DWR 1994; Sommer et

al. 1997; Figure 7–6). In recent years however, salvage also has been highest in moderately wet conditions (Nobriga et al. 2000; 2001; springs of 1996, 1999, and 2000) even though a large fraction of the population was downstream of the Sacramento-San Joaquin River confluence. Nobriga et al. (2000; 2001) attributed recent high wet year salvage to a change in operations for the VAMP that began in 1996. The VAMP provides a San Joaquin River pulse flow from mid-April to mid-May each year that probably improves rearing conditions for delta smelt larvae and also slows the entrainment of fish rearing in the delta. The high salvage events may have resulted from smelt that historically would have been entrained as larvae and therefore not counted at the fish salvage facilities growing to a salvageable size before being entrained. However, a more recent analysis summarized in Figure 7–6 provides an alternative explanation. Delta smelt salvage in 1996, 1999, and 2000 was not outside of the expected historical range when three factors are taken into account, (1) delta smelt distribution as indexed by X2 position, (2) delta smelt abundance as indexed by the TNS, and (3) the amount of water exported. Therefore, it is uncertain that operations changes for VAMP have influenced delta smelt salvage dynamics as strongly as suggested by Nobriga et al. (2000). Nonetheless, it is likely that actual entrainment has decreased since the initiation of the VAMP because of the improved transport flows it provides. In addition, "assets" from CALFED's Environmental Water Account (EWA) are often used during this time of year to further reduce delta smelt entrainment. Although the population level benefits of these actions are unknown, they appear to have been successful at keeping delta smelt salvage under the limits set by FWS (1993) (Brown and Kimmerer 2002).

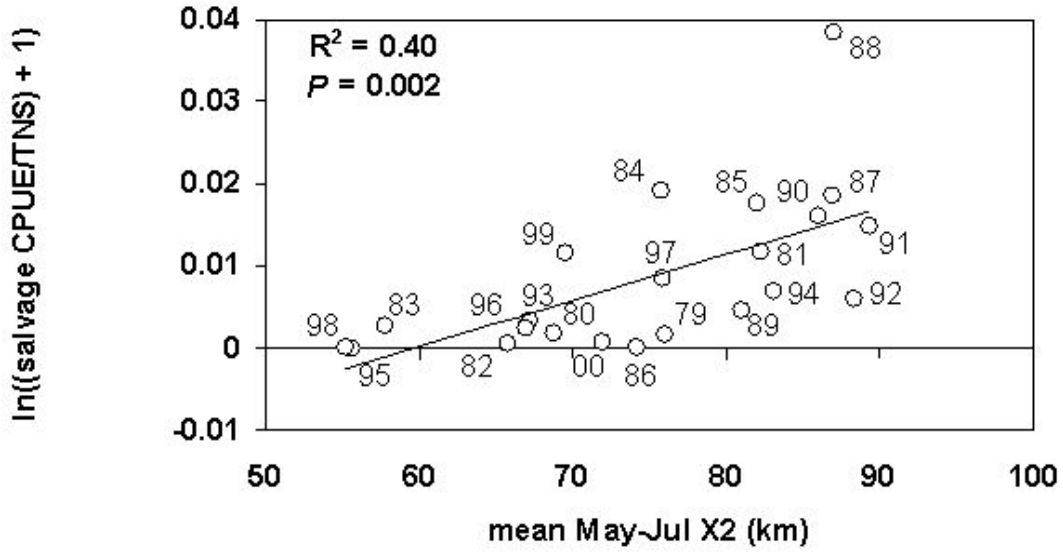

Figure 7–6 Water operations impacts to the delta smelt population.

Another possible effect on delta smelt entrainment is the SDTB. The SDTB are put in place during spring and removed again each fall (see the "Project Description" section of this Biological Assessment for more detail). Computer simulations have shown that placement of the barriers changes south delta hydrodynamics, increasing central delta flows toward the export facilities (DWR 2000). When delta smelt occur in areas influenced by the barriers, entrainment losses could increase.

Several significant correlations between delta smelt abundance and survival indices and both export and salvage variables have been recently reported (Brown and Kimmerer 2001). It should be noted that Bennett (Table 1 in Brown and Kimmerer 2001) performed 48 separate correlation analyses that included either delta smelt salvage or SWP/CVP south delta exports as explanatory variables. Of the 48 tests, only six produced a statistically significant result. Further, among the significant correlations, at least two of them are unlikely to have biological meaning because there was a mismatch between when the take was implied by the explanatory variable and when delta smelt abundance or survival was measured. For instance, a significant ($p = 0.04$) negative correlation was reported between July-October exports and the TNS abundance index. The TNS index is always set for delta smelt during late June or July, so it is unclear how exports that occurred mostly after the index was set could have affected the index values. There also was a highly significant ($p = 0.004$) negative correlation between the residuals from a MWT-TNS stock-recruit relationship and July-October exports. Briefly, this analysis suggests that exports during the summer and early fall negatively influence springtime survival. It is not readily clear how this could be possible. It is very likely that with so many correlations in the matrix, some spurious ones were generated. It should be noted that although many separate analyses were performed, two significant correlations invoking March-June export and salvage may provide evidence of negative influences of springtime water operations on delta smelt. Combined CVP/SWP exports during March-June explained a significant amount of the variation ($p = 0.046$) in the MWT-TNS stock-recruit residuals described above. In addition, March-June delta smelt salvage was significantly ($p = 0.03$) positively correlated with an index of egg-adult mortality.

At present, no demonstrable statistical relationships between delta smelt losses to water export operations and delta smelt abundance have been published in a peer-reviewed forum. It should also be noted that scientists are currently attempting to increase the sophistication of operations-related explanatory variables to test hypotheses about water diversion impacts on the delta smelt population. These new variables will combine particle tracking model results with surveys of delta smelt distribution to estimate the proportion of the population vulnerable given its distribution in the estuary and the prevailing hydrodynamic conditions in the delta. The simplest compound variable proposed is the export to inflow ratio (E/I). The Interagency Ecological Program (IEP) for the San Francisco Estuary has currently funded a particle tracking model study to examine the appropriateness of the E/I and alternatives to it for characterizing entrainment vulnerability. Unfortunately, preliminary results from this work will not be available until 2004.

Indirect Effects

By directly influencing delta smelt distribution, freshwater flow ultimately controls the sources and temporal persistence of mortality factors the population is exposed to (Bennett and Moyle 1996). Because the amount of freshwater entering the estuary is often controlled by CVP and SWP water operations, water operations may play indirect roles in delta smelt mortality through influences on population distribution. Examples of indirect effects include increased exposure of the delta smelt population to predators (Turner and Kelley 1966) or agricultural diversions (Nobriga et al. in press). However, the significance of indirect effects of CVP and SWP operations on delta smelt population dynamics is unknown.

Changes to the Food Web of the Upper Estuary

The unintentional introduction of the clam *Potamocorbula amurensis* in 1986 resulted in dramatic declines in, and upstream shifts in the abundance maxima of, phytoplankton (Alpine and Cloern 1992; Lehman 2000; Jassby et al. 2002) and zooplankton (Kimmerer et al. 1994; Kimmerer and Orsi 1996; Orsi and Mecum 1996). The *P. amurensis* introduction exacerbated long-term declines in lower food web productivity already occurring before its introduction. This has been considered potentially detrimental to delta smelt because it may represent a decrease in food availability. In addition to the declines, numerous introductions of exotic zooplankton also have occurred. It is not known whether changes in zooplankton species composition, particularly spring-summer copepods have had any positive or negative influence on delta smelt population dynamics.

Food limitation can impact the survival of larval fish directly through starvation (Hunter 1981) or indirectly by reducing growth rate (Betsill and Van den Avyle 1997), which results in higher predation mortality (Letcher et al. 1996). Food limitation primarily affects post-larval fishes via the latter mechanism (Houde 1987). Larval delta smelt feeding success varies interannually in part due to variation in copepod abundance (Nobriga 2002). This variation is most pronounced near the time of first-feeding. This means that interannual variation in starvation mortality is likely because these small larvae have limited reserves on which to survive. Despite the well-documented declines in zooplankton abundance following the *P. amurensis* invasion (Kimmerer and Orsi 1996), catastrophic changes in larval delta smelt survival attributable to *P. amurensis* impacts on the food web have not been supported by data analysis. Kimmerer (2002) examined changes in species relationships to X2 and found that delta smelt TNS abundance relative to X2 changed well before *P. amurensis* invaded and did not change again after the invasion. Therefore, it does not appear that larval delta smelt starvation mortality has changed since *P. amurensis* invaded.

It is possible that FMWT indices have remained lower than 1970s levels after the return of wet weather in the mid to late 1990s because food web alterations reduced the system carrying capacity for delta smelt. Current research is focusing on subtle influences of feeding success on survival or mortality (Brown and Kimmerer 2002). Sweetnam (1999) reported that the mean size of delta smelt collected in the FMWT had decreased significantly since the early 1990s. More recently, Bennett (unpublished) has documented individual variation in liver glycogen levels among delta smelt, suggesting some juvenile and adult individuals are food limited at times. To date no connection has been made between feeding success or growth and survival.

Changes in Predation Pressure

Predator-prey dynamics in the San Francisco Estuary are poorly understood, but are currently receiving considerable research attention by the IEP and CALFED. Studies during the early 1960s found delta smelt were an occasional prey fish for striped bass, black crappie and white catfish (Turner and Kelley 1966). This, coupled with the substantial decline in striped bass abundance has been taken as evidence that delta smelt are not very vulnerable to predation (Sweetnam and Stevens 1993). In recent years, it has become clear that the prey choices of piscivorous fishes switch as the relative abundances of species in the prey field change (Buckel et al. 1999). Even in the 1960s, delta smelt was rare relative to the dominant prey fishes of striped bass (age-zero striped bass and threadfin shad) (Turner and Kelley 1966). Therefore,

there should have been no expectation that delta smelt would be commonly found in stomach contents samples. Because delta smelt are still rare relative to currently common prey fishes, the same holds true today (Nobriga et al. 2003). Because of the limitations of using stomach samples, IEP researchers are attempting to model potential impacts of striped bass on delta smelt using bioenergetics and individual-based approaches.

Bennett and Moyle (1996) proposed that inland silverside may be impacting delta smelt through predation (on delta smelt eggs and/or larvae) and competition (for copepod prey). This hypothesis is supported by recent statistical analyses showing negative correlations between inland silverside abundance and delta smelt TNS indices, and two indices of egg and/or larval survival (Brown and Kimmerer 2001). The hypothesis also is consistent with the recent analysis by Kimmerer (2002) showing a change in the sign of the delta smelt X2-TNS relationship (described above) because inland silversides began to increase in abundance about the same time the relationship changed sign (Brown and Kimmerer 2001). It should be noted however that since the early 1980s, there also have been increases in other potential larval fish predators such as coded wire tagged Chinook salmon smolts released in the Delta for survival experiments (Brandes and McLain 2001) and centrarchid fishes (Nobriga and Chotkowski 2000). In addition, striped bass appear to have switched to piscivorous feeding habits at smaller sizes than they historically did following severe declines in the abundance of mysid shrimp (Feyrer et al. in press). We suspect that CWT salmon and centrarchid abundance, as well as the striped bass diet switch have covaried with the increase in inland silverside abundance and the declines in phytoplankton and zooplankton abundance mentioned above. We caution that all assertions regarding predatory impacts on delta smelt, including inland silverside, are speculation.

Contaminants

Agricultural sources are untreated and unmeasured but probably vary widely in concentration and composition in time and space (Kuivila and Foe 1995). There have been strong shifts in recent years toward newer types of contaminants and various regulatory efforts to reduce contaminant impacts have often generated shifts from one type of compound to another. Contaminant concentrations are often sufficient to kill invertebrates and larval cyprinids in bioassay tests. Chronic effects are largely uninvestigated for any fish in the estuary Delta smelt may suffer from contaminant effects directly in either acute or chronic forms and may also be affected by contaminant effects on populations of their prey (Kuivila and Moon 2002). However, examination of the 1999 and 2000 cohorts using COMET assays of blood cell DNA did not find a high proportion of delta smelt collected in the TNS and FMWT surveys with broken DNA. This suggests that at least in the very recent past, contaminants were not a major stressor for the delta smelt population (Brown and Kimmerer 2002).

Agricultural Water Diversion Operations

There are 2,209 agricultural diversions in the Delta and an additional 366 diversions in Suisun Marsh used for enhancement of waterfowl habitat (Herren and Kawasaki 2001). The vast majority of these diversions do not have fish screens to protect fish from entrainment. It has been recognized for many years that delta smelt are entrained in these diversions (Hallock and Van Woert 1959; Pickard et al. 1982). In the early 1980s delta smelt were the most abundant fish entrained in the Roaring River diversion in Suisun Marsh (Pickard et al. 1982), so it is possible the waterfowl diversions are detrimental. However, delta smelt may not be especially vulnerable

to Delta agricultural diversions for several reasons. First, adult delta smelt move into the Delta to spawn during winter-early spring when agricultural diversion operations are at a minimum. Second, larval delta smelt occur transiently in most of the Delta. Third, Nobriga et al. (2002; in press) examined delta smelt entrainment at an agricultural diversion in Horseshoe Bend during July 2000 and 2001, when much of the YOY population was rearing within one tidal excursion of the diversion. Delta smelt entrainment was low compared to density estimates from the DFG 20 mm Delta Smelt Survey. Low entrainment was attributed to (1) offshore distribution of delta smelt, and (2) the extremely small hydrodynamic influence of the diversion relative to the channel it was in. Because Delta agricultural diversions are typically close to shore and probably take small amounts of water relative to what is in the channels they draw water from, delta smelt vulnerability may be low despite their modest swimming ability and their poor performance near simulated fish screens in laboratory settings (Swanson et al. 1998; 2002). It should be noted however that DWR screened five agricultural diversions around Sherman Island, an area consistently used by delta smelt of all life stages.

Pacific Gas & Electric Company

PG&E operates two power generation facilities within the range of delta smelt: Contra Costa Power Plant and Pittsburg Power Plant. Contra Costa Power Plant is about six miles east of the confluence of the Sacramento and San Joaquin rivers. Pittsburg Power Plant is on the south shore of Suisun Bay, in the town of Pittsburg. Each power plant has seven generating units that rely on diverted water for condenser cooling. Cooling water is diverted at a rate as high as about 1,500 cfs for the Contra Costa plant and 1,600 cfs for the Pittsburg plant, forming a thermal plume as it is discharged back into the estuary. Pumping rates are often significantly lower under normal operation. Potential impacts of the power plants fall into two categories - direct and indirect. Previous data on direct and indirect impacts of the power plants were summarized by Reclamation and DWR (1994). However, robust data analyses of population level effects of power plant operation on delta smelt and other fishes have not been performed. Briefly, the direct impact of the power plants comes from the removal of fish during diversion operations. Indirect effects stem from water temperature increases when the cooling water is returned to the estuary. Intakes at all units at both power plants employ a screening system to remove debris, but the screens allow entrainment of fish smaller than about 38 mm and impingement of larger fish.

Since the 1978–79 studies were completed, PG&E has implemented a resource management program to reduce striped bass loss. During the period of peak striped bass entrainment (May to mid-July), power generation units are operated preferentially, using fish monitoring data. This program has reduced entrainment losses of larval and juvenile striped bass by more than 75 percent (PG&E 1992a). Given its timing, this management program also may be beneficial to delta smelt. PG&E also is reportedly considering use of better fish exclusion devices, known as a gunderbooms, at their facilities which are expected to reduce entrainment to nearly zero.

Genetic Introgression with Wakasagi

Hybridization and genetic introgression are not currently thought to represent a threat to the persistence of delta smelt. Hybridization between delta smelt and wakasagi has been shown to be very low due to a more distant taxonomic relationship than was previously thought (Trenham et al. 1998).

Chapter 8 Hydrologic and Temperature Modeling with 3406 (b)(2) and EWA Analyses

The effects of proposed CVP and SWP operations on steelhead , coho salmon, delta smelt winter-run and spring-run Chinook salmon were evaluated using results from a series of monthly simulation models. The changes in operations relative to current assumptions that are expected to impact the CVP and SWP are Lewiston releases on the Trinity River (368,600-452,600 af to 368,600-815,000 af annually), the Freeport project, Level of Development, CVP/SWP Integration Agreement (100,000 af dedicated CVP Refuge Level 2 Pumping at Banks and 75,000 af of CVP releases for SWP COA requirements), the Intertie, and the South Delta Improvement Project (increase Banks pumping capacity from 6680 cfs to 8500 cfs). CALSIM II for the OCAP BA studies has the most current assumptions of the (b)(2) policy, May 2003. Studies 3 & 5 have the most current assumptions for the EWA program as agreed to October 2003.

Assumptions and methodologies for CALSIM II and the temperature conditions are described in the sections below. CALSIM II results were used in a series of temperature models that provide estimates of mean monthly temperatures at a variety of locations along CVP and SWP influenced rivers. Modeled temperatures were then compared to thermal criteria for specific life stages in the months when they would be present in the given river as the primary means of assessing potential effects of proposed CVP and SWP operations.

Hydrologic Modeling Methods

The DWR/Reclamtion Joint CALSIM II planning model was used to simulate the CVP and SWP water operations on a monthly time step from water year 1922 to 1994. CALSIM II utilizes optimization techniques to route water through a network. A linear programming (LP)/mixed integer linear programming (MILP) solver determines an optimal set of decisions for each time period given a set of weights and system constraints (DWR 2002). The physical description of the system is expressed through a user-interface with tables outlining the system characteristics. The priority weights and basic constraints are also entered in the system tables. The programming language used, Water Resources Engineering Simulation Language (WRESL), serves as an interface between the user and the LP/MILP solver, time-series database, and relational database. Specialized operating criteria are expressed in WRESL (DWR 2000).

The hydrology in CALSIM II was developed jointly by DWR and Reclamation. Water diversion requirements (demands), stream accretions and depletions, rim basin inflows, irrigation efficiency, return flows, non-recoverable losses, and groundwater operation are components that make up the hydrology used in CALSIM II. Sacramento Valley and tributary rim basin hydrologies are developed using a process designed to adjust the historical sequence of monthly stream flows to represent a sequence of flows at a future level of development. Adjustments to historic water supplies are determined by imposing future level land use on historical meteorological and hydrologic conditions. San Joaquin River basin hydrology is developed using fixed annual demands and regression analysis to develop accretions and depletions. The resulting hydrology represents the water supply available from Central Valley streams to the CVP and SWP at a future level of development (DWR 2002).

CALSIM II uses DWR's Artificial Neural Network (ANN) model to simulate the flow-salinity relationships for the Delta. The ANN model correlates DSM2 model-generated salinity at key locations in the Delta with Delta inflows, Delta exports, and Delta Cross Channel operations. The ANN flow-salinity model estimates electrical conductivity at the following four locations for the purpose of modeling Delta water quality standards: Old River at Rock Slough, San Joaquin River at Jersey Point, Sacramento River at Emmaton, and Sacramento River at Collinsville. In its estimates, the ANN model considers antecedent conditions up to 148 days, and considers a "carriage-water" type of effect associated with Delta exports (DWR 2002).

CALSIM II uses logic for determining deliveries to north-of-Delta, and south-of-Delta CVP and SWP contractors. The delivery logic uses runoff forecast information, which incorporates uncertainty and standardized rule curves (i.e. Water Supply Index versus Demand Index Curve). The rule curves relate forecast water supplies to deliverable "demand", and then use deliverable "demand" to assign subsequent delivery levels to estimate the water available for delivery and carryover storage. Updates of delivery levels occur monthly from January 1 through May 1 for the SWP and March 1 through May 1 for the CVP as water supply parameters (i.e. runoff forecasts) become more certain. The south-of Delta SWP delivery is determined based upon water supply parameters and operational constraints. The CVP system wide delivery and south-of-Delta delivery are determined similarly upon water supply parameters and operational constraints with specific consideration for export constraints (DWR 2002).

CVPIA 3406 (b)(2) and Environmental Water Account Modeling

CALSIM II dynamically models CVPIA 3406(b)(2) and the Environmental Water Account (EWA). CVPIA 3406(b)(2) accounting procedures in CALSIM II are based on system conditions under operations associated with SWRCB D-1485 and D-1641 regulatory requirements (DWR 2002). Similarly, the operating guidelines for selection of actions and allocation of assets under the EWA are based on system conditions under operations associated with a Regulatory Baseline as defined by the CALFED ROD, which includes SWRCB D-1641 and CVPIA 3406 (b)(2) among other elements. Given the task of simulating dynamic EWA operations, and the reality of interdependent operational baselines embedded in EWA's Regulatory Baseline, a modeling analysis has been developed to dynamically integrate five operational baselines for each water year of the hydrologic sequence. These five steps constitute a position analysis with five cases linked to different regulatory regimes: D1485, D1641, B2, JPOD, and EWA. The results from the final case of the position analysis (EWA) is accepted as the end-of-year system state, and serve as the initial conditions for each of the five cases in the following year's position analysis. The general modeling procedure is outlined below, and shown on Figure 8-1:

1. Run the D1641 simulation for Oct-Sep of the current water year.
2. Run the D1485 simulation for Oct-Sep of the current water year and compute annual water costs for implementing D1641 operations relative to D1485 operations (i.e. Water Quality Control Plan costs).
3. Run the B2 simulation for Oct-Sep of the current water year, dynamically accounting for the (b)(2) account balance with knowledge of annual Water Quality Control Plan costs, and implementing fish protection actions according to preferences defined for OCAP.

4. Run the JPOD simulation for Oct-Sep of the current water year, repeating B2 actions from Step 3, assessment of Joint Point of Diversion (JPOD) capacity, and simulated CVP usage of 50% of JPOD capacity.
5. Run the EWA simulation for Oct-Sep of the current water year, repeating B2 actions from Step 3, repeating CVP usage of 50% of JPOD capacity from Step 4, taking EWA actions, comparing Step 4 and 5 results to assess EWA debt, and managing EWA debt through acquisition and application of assets (e.g., SWP transfer or 50% of B2 gains to EWA, EWA usage of 50% of JPOD capacity, fixed purchases north and south of Delta).
6. Accept the state of the system from end-of-September in Step 5 as the initial condition for the following year's position analysis cases (i.e. D1641, D1485, B2, JPOD, and EWA).

Repeat steps 1-6 for all years of the period of record.

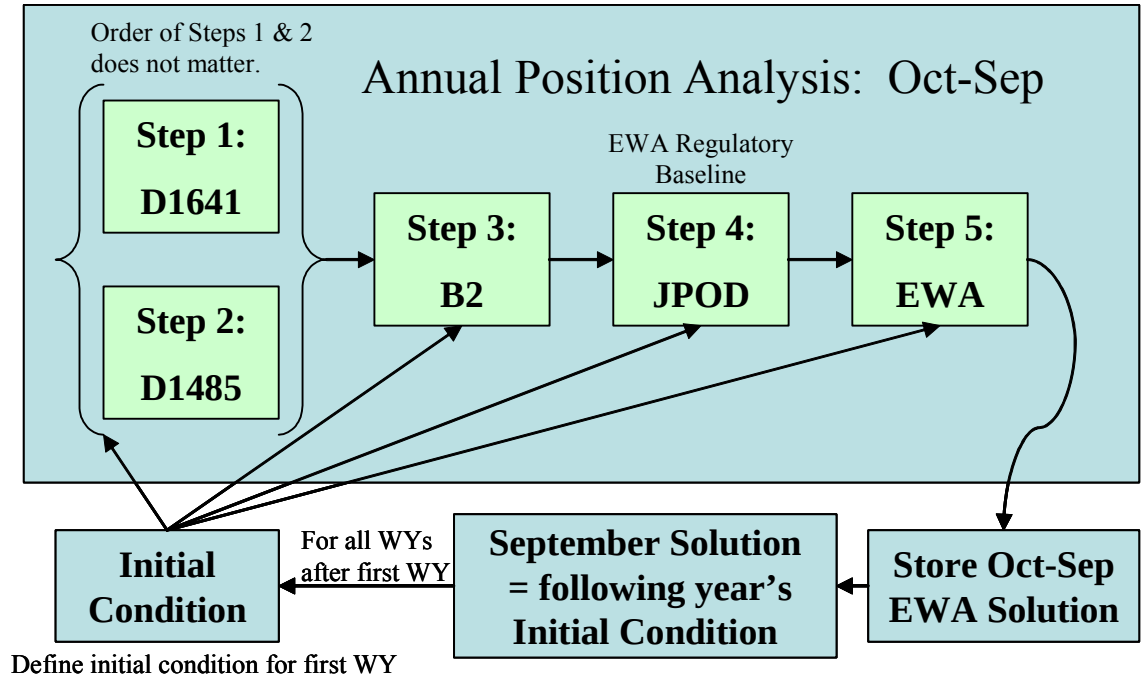

Figure 8-1. CALSIM II procedure to simulate EWA operations. (Note: Step 4 is named "JPOD" in the OCAP Today Studies and "SDIP" in the OCAP Future Studies.)

CVPIA (b)(2)

According to the 1992 Central Valley Project Improvement Act (CVPIA) the Central Valley Project must "dedicate and manage annually 800,000 acre-feet of Central Valley Project yield for the primary purpose of implementing the fish, wildlife, and habitat restoration purposes and measures authorized by this title; to assist the State of California in its efforts to protect the waters of the San Francisco Bay/Sacramento-San Joaquin Delta Estuary; and to help to meet such obligations as may be legally imposed upon the Central Valley Project under State or Federal law following the date of enactment of this title, including but not limited to additional

obligations under the Federal Endangered Species Act." This dedicated and managed water or (b)(2) water, as it is called, is water FWS in consultation with Reclamation and other agencies (See the Chapter 2 describtion of B2IT in Adaptive Management) has at its disposal to use to meet the CVP's Water Quality Control Plan (WQCP) obligations and meet any reqirements imposed after 1992. CVPIA 3406 (b)(2) water may be used to augment river flows and also to curtail pumping in the Delta to supplement the WQCP requirements.

To simulate the 3406 (b)(2) accounting the model uses metrics calculated in the (b)(2) simulation. The metrics measure the flow increases and export decreases from D1485 to D1641 WQCP Costs, and from D1485 to (b)(2), total (b)(2) costs. The following assumptions were used to model the May 2003 3406 (b)(2) Dept. of the Interior decision.

- Allocation of (b)(2) water is 800,000 af/YR, 700,000 af/YR in 40-30-30 Dry Years, and 600,000 af/YR in 40-30-30 Critical years
- Upstream flow metrics are calculated at Clear Creek, Keswick, Nimbus and Goodwin Reservoirs where (b)(2) water can be used to increase flow for fishery purposes. The assumptions used in CALSIM II for taking an upstream action at one of the previously mentioned reservoirs are:
    - Oct-Jan
        - Clear Creek Releases: Action is on if Trinity Beginning of Month Storage > 600,000 af.
        - Keswick Releases: Action is on if Shasta Beginning-of-Month Storage > 1,900,000 af.
        - Nimbus Releases: Action is on if Folsom Beginning-of-Month Storage > 300,000 af.
        - For all releases if the 200,000 af target is projected to be violated the model will try to reduce the magnitude of the actions in December and/or January.
    - Feb-Sep
        - Clear Creek Releases: Action is on if Trinity Beginning of Month Storage > 600,000 af.
        - Keswick Releases: Action is on if Shasta Beginning-of-Month Storage > 1,900,000 af and if remaining b2 account > projected coming WQCP costs.
        - Nimbus Releases: Action is on if Folsom Beginning-of-Month Storage > 300,000 af and if remaining b2 account > projected coming WQCP costs.
- The export metric is the change in total CVP pumping (Tracy + CVP Banks) from the base case (D1485). Assumptions used in CALSIM II for taking a delta action are:
    - Winter Actions (December thorugh February) and Pre-VAMP (April Shoulder) actions are off

- VAMP Actions: Always taken and done at a 2:1 ratio if non-VAMP Vernalis flows are greater than 8600 cfs
- May Shoulder: Action turned on if the remaining (b)(2) is greater than or equal to the discounted remaining WQCP cost + anticipated Clear Creek cost (25,000 af). DISCOUNT = If the annual WQCP cost > 500,000 af, the difference is subtracted from the remaining WQCP cost.
- June Ramping: Action turned on if the remaining (b)(2) is greater than or equal to the discounted remaining WQCP cost + anticipated Clear Creek cost (20,000 af).
- Both May Shoulder and June Ramping are further restricted to stay within the remaining (b)(2)account – remaining WQCP costs.

Environmental Water Account

Three Management Agencies (i.e. FWS, NOAA Fisheries and DFG) and two Project Agencies (i.e. Reclamation and DWR) share responsibility in the implementation and management of the Environmental Water Account (EWA). The Management Agencies manage the EWA assets and exercise the biological judgment to recommend operation changes in the CVP and SWP that are beneficial to the Bay-Delta system. Together, the Management and Project Agencies form an EWA Team, or EWAT.

The objective of simulating EWA for OCAP modeling is to represent the functionality of the program in three ways: as it was designed in the CALFED ROD, as it's been implemented by EWAT during WY2001-2003, and as it's foreseen to be implemented in coming years by CALFED Operations. The EWA representation in CALSIM II simulates is not a prescription for operations; it is only a representation of the following EWA operating functions:

- implementing actions at projects' export facilities
- assessing debt caused by these actions, including year-to-year carryover debt
- acquiring assets for managing debt
- storing assets in San Luis, and transferring (or losing) stored assets to the projects due to projects' operations to fill San Luis during winter months
- spending assets to compensate SOD debt
- tracking and mitigating the effects of NOD debt and NOD backed-up water
- spilling carryover debt at SWP San Luis
- wheeling assets from NOD to SOD for storage or usage
- accounting system re-operation effects due to EWA operations

For the OCAP modeling, action definitions reflect monthly to seasonal aggregate actions implemented by EWAT from WY2001-2003 and in the foreseeable future. Assets in OCAP modeling reflect a subset of actions that CALSIM II can simulate. Several types of assets were not simulated in CALSIM II and consequently the simulated actions have been modulated to be

in balance with their absence. Accounting for these additional assets is discussed in the EWA OCAP Modeling Chapter.

The following actions are simulated in the OCAP modeling for EWA fishery purposes:

- Winter-period Export Reduction (December – February):

  Definition: "Asset spending goal" where a constraint is imposed on total Delta exports that equals 50,000 af less per month relative to the amount of export under the Regulatory Baseline. This is modeled as a monthly action and conceptually represents EWAT implementation of multiple several-day actions during the month.

  Trigger: All years for December and January; also in February if the hydrologic year-type is assessed to be Above Normal and Wet according to the Sac 40-30-30 Index.

- VAMP-period Export Reduction (April 15 – May 15):

  Definition: Reduce exports to a target-restriction level during the VAMP-period, regardless of the export level under the Regulatory Baseline; target depends on San Joaquin River flow conditions.

  Trigger: All years. Taking action during the VAMP period has been a EWAT high priority in 2001-2003, and is therefore modeled as a high priority.

- Pre-VAMP "Shoulder-period" Export Reduction (April 1 – April 15):

  Definition: Extend the target-restriction level applied for VAMP-period into the April 1 – April 15 period.

  Trigger: Never. It was not simulated to occur based on actions implemented by EWAT from WY2001-2003 and in the foreseeable future.

- Post-VAMP "Shoulder-period" Export Reduction (May 16 – May 31):

  Definition: Extend the target-restriction level applied for VAMP-period into the May 16 – May 31 period.

  Trigger: In any May if collateral exceeds debt at the start of May.

- June Export Reduction:

  Definition: Steadily relieve the constraint on exports from the target-restriction level of the Post-VAMP period to the June Export-to-Inflow constraint level. Complete this steady relief on constraint during a 7-day period.

  Trigger: If the Post-VAMP "Shoulder-period" Export Reduction was implemented and if collateral exceeds debt at the start of June.

The following assets are included in the OCAP modeling:

- Allowance for Carryover Debt (Replacing "One-Time Acquisition of Stored-Water Equivalent" defined in the CALFED ROD)
- Water Purchases, North and South of Delta
- 50% Gain of SWP Pumping of (b)(2)/ERP Upstream Releases
- 50% Dedication of SWP Excess Pumping Capacity (i.e. JPOD)
- Jul-Sep Dedicated Export Capacity at Banks

The role of these fixed and operational assets in mitigating the effects of EWA actions is dependent upon operational conditions and is ascertained dynamically during the simulation. On the issue of the one-time acquisition of stored-water equivalent, the CALFED ROD specified the acquisition of initial and annual assets dedicated to the EWA, and EWA was to be guaranteed 200,000 acre-feet of stored water south of Delta. This SOD groundwater bank was excluded in the CALSIM II studies for OCAP given its absence in actual EWAT operations from WY2001-2003. Since development of this asset has been delayeed, EWAT developed a replacement asset (i.e. allowance for carryover debt and subsequent debt spilling) and operational procedures for managing this asset. OCAP modeling reflects EWAT guidelines for carrying over and spilling debt in the case of debt situated at SWP San Luis.

Several potential assets are excluded from the OCAP modeling with CALSIM II, and are addressed in CALSIM II post-processing through the EWA OCAP Modeling Chapter:

- Export/Inflow Ratio Flexibility
- Source-Shifting Agreements
- Exchanges

The impacts of actions on system operations is assessed in the OCAP modeling as EWA debt. Debt is defined as a reduction in project deliveries and/or storage relative to the EWA Regulatory Baseline (i.e. results from Step 4). CALSIM II tracks three general types of EWA debt:

- Deliveries to contractors south of Delta (SOD)
- Storage levels SOD
- Storage levels north of Delta (NOD)

Occurrence of SOD deliveries debt and subsequent failure to immediately payback this debt is an indicator that the simulated EWA program's assets are not in balance with the assumed actions. Occurrence of storage debt does not require immediate debt management.

Carried-over SOD storage debt is simulated to be managed through either: (1) direct dedication of assets, or (2) debt spilling. Dedication of assets involves transferring the accumulated purchases and variable assets from EWA San Luis into the projects' shares of San Luis to repay impacts caused by this year's actions and/or carried-over impacts from last year. The second tool, debt spilling, involves elimination of carried-over SOD debt at SWP San Luis given that several conditions were met at the end of the previous month (as described by EWAT).

- there was remaining capacity at Banks,
- there was surplus water in the Delta that could have been exported,
- the summation of end-of-month debt and stored water at SWP San Luis exceeded the summation of storage capacity and the "Article 21 deficit" (Figure 8-2); an Article 21 deficit represents demand minus what was delivered.
- there was carried-over debt left to be spilled at SWP San Luis.

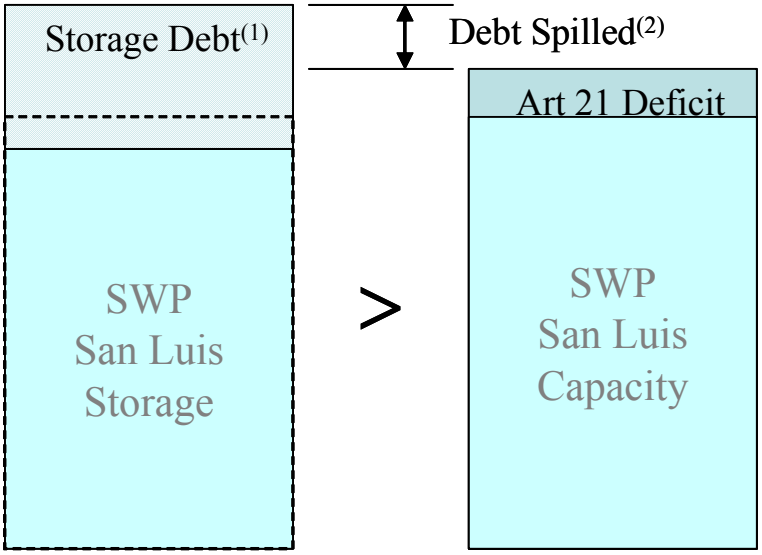

Figure 8-2 Conditions for spilling carried-over debt at SWP San Luis in CALSIM II. Notes

1. Since the Regulatory Baseline cannot exceed SWP San Luis Capacity (i.e. the dashed line in Stack A), then the debt above this capacity line must be carried-over debt. Therefore, this spill tool will only be applicable to erasing carried-over debt and will not affect "new" debt conditions due to this year's actions.
2. Spill amount is limited by the availability of excess capacity at Banks and surplus water in the Delta

CALSIM II Modeling Studies

The two Benchmark Studies (2001 and 2020 LOD) have been developed by staff from both DWR and Reclamation for the purpose of creating a CALSIM II study that is to be used as a basis in comparing project alternatives. From the Benchmark Studies five studies have been developed to evaluate the impacts of changes in operations for the Trinity River, Freeport Project, Intertie, Level of Development, CVP/SWP Project Integrations and SDIP. Table 8-1 shows the five studies developed for OCAP and how the previously mentioned changes in operations are incorporated into them.

Table 8-1. Summary of Assumptions in the OCAP CALSIM II runs

	Trinity Min Flows	CVPIA 3406 (b)(2)	Level of Development	EWA	SDIP	CVP/SWP Integration	Freeport	Intertie
Study 1 D1641 with b(2) (1997)	340,000 af/yr	May '03	2001					
Study 2 Today b(2)	368,600-452,600 af/yr	Same as above	Same as above					
Study 3 Today EWA	Same as above	Same as above	Same as above	X				
Study 4 Future SDIP	368,600-815,000 af/yr	Same as above	2020		X	X	X	X
Study 5 Future EWA	Same as above	Same as above	Same as above	X	X	X	X	X

Study 1 is used evaluate how the operations and regulations have been impacted since the Delta Smelt Biological Opinion with (b)(2) operations acting as a surrogate for the 2:1 VAMP restrictions. Studies 2 and 4 are to evaluate the Tier 1 environmental regulatory effects that are mandated by law. Studies 3 and 5 were run to evaluate the EWA costs as the modeling can best simulate the current actions taken by the EWA program. The current EWA program may be regarded as representative of foreseeable future EWA operations. However, it is noted that the EWA has not been finalized with a long-term plan of operations.

Table 8-2 shows the detailed assumptions of the five studies. The table illustrates specific operational changes regarding regulatory and operational rules. It also details assumptions within the major changes to operations in Table 8-1. Table 8-3 and Table 8-4 show the changes in demand from the Today to the Future studies for American River system for diversion dynamically modeled in CALSIM II.

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Table 8-2 Assumptions for the Base and Future Studies

	Study 1	Study 2	Study 3	Study 4	Study 5
	D1641 w/ CVPIA 3406 (b)(2) (1997)	**Today CVPIA 3406 (b)(2)**	**Today CVPIA 3406 (b)(2) with EWA**	**Future 3406 (b)(2) and SDIP**	**Future 3406 (b)(2) and SDIP with EWA**
Period of Simulation	73 years (1922-1994)	Same	Same	Same	Same
HYDROLOGY					
Level of Development (Land Use)	2001 Level, DWR Bulletin 160-98[14]	Same as Study 1	Same as Study 1	2020 Level, DWR Bulletin 160-98	Same as Study 4
Demands					
North of Delta (exc American R)					
CVP	Land Use based, limited by Full Contract	Same	Same	Same	Same
SWP (FRSA)	Land Use based, limited by Full Contract	Same	Same	Same	Same
Non-Project	Land Use based	Same	Same	Same	Same
CVP Refuges	Firm Level 2	Same	Same	Same	Same
American River Basin					

[14] 2000 Level of Development defined by linearly interpolated values from the 1995 Level of Development and 2020 Level of Development from DWR Bulletin 160-98

	Study 1	Study 2	Study 3	Study 4	Study 5
Water rights	2001[15]	Same as Study 1	Same as Study 1	2020, as projected by Water Forum Analysis[16]	Same as Study 4
CVP	2001[17]	Same as Study 1	Same as Study 1	2020, as projected by Water Forum Analysis [18]	Same as Study 4
San Joaquin River Basin					
Friant Unit	Regression of historical	Same	Same	Same	Same
Lower Basin	Fixed annual demands	Same	Same	Same	Same
Stanslaus River Basin	New Melones Interim Operations Plan	Same	Same	Same	Same
South of Delta					
CVP	Full Contract	Same	Same	Same	Same
CCWD	124,000 af/YR[19]	Same as Study 1	Same as Study 1	158,000 af/YR[20]	Same as Study 4

[15] Presented in attached

Table 8-3 2001 American River Demand Assumptions (Note that cuts are not made predicated on Inflow to Folsom for the 2001 **Demands)**

[16] Presented in attached Table 8-4 2020 American River Demand Assumptions

[17] Same as footnote 2

[18] Same as footnote 3 but modified with PCWA 35 TAF CVP contract supply diverted at the new American River PCWA Pump Station

[19] Delta diversions include operations of Los Vaqueros Reservoir and represents average annual diversion

	Study 1	Study 2	Study 3	Study 4	Study 5
SWP (w/ North Bay Aqueduct)	3.0-4.1 MAF/YR	Same as Study 1	Same as Study 1	3.3-4.1 MAF/YR	Same as Study 4
SWP Article 21 Demand	MWDSC up to 50,000 af/month, Dec-Mar, others up to 84,000 af/month	Same	Same	Same	Same
FACILITIES					
Freeport Regional Water Project	None	Same as Study 1	Same as Study 1	Included[21]	Same as Study 4
Banks Pumping Capacity	6680 cfs	Same as Study 1	Same as Study 1	8500 cfs	Same as Study 4
Tracy Pumping Capacity	4200 cfs + deliveries upstream of DMC constriction	Same as Study 1	Same as Study 1	4600 cfs w/ intertie	Same as Study 4
REGULATORY STANDARDS					
Trinity River					
Minimum Flow below Lewiston Dam	340,000 af/YR	368,600-452,600 af/YR	Same as Study 2	Trinity EIS Preferred Alternative (368,600-815,000 af/YR)	Same as Study 4
Trinity Reservoir End-of-September Minimum Storage	Trinity export-to-inflowS Preferred Alternative (600,000 af as able)	Same	Same	Same	Same

[20] Same as footnote 6

[21] Includes modified EBMUD operations of the Mokelumne River

	Study 1	Study 2	Study 3	Study 4	Study 5
Clear Creek					
Minimum Flow below Whiskeytown Dam	Downstream water rights, 1963 USBR Proposal to USFWS and NPS, and USFWS use of CVPIA 3406(b)(2) water	Same	Same	Same	Same
Upper Sacramento River					
Shasta Lake End-of-September Minimum Storage	SWRCB WR 1993 Winter-run Biological Opinion (1.9 Million af)	Same	Same	Same	Same
Minimum Flow below Keswick Dam	Flows for SWRCB WR 90-5 and 1993 Winter-run Biological Opinion temperature control, and USFWS use of CVPIA 3406(b)(2) water	Same	Same	Same	Same
Feather River					
Minimum Flow below Thermalito Diversion Dam	1983 DWR, DFG Agreement (600 CFS)	Same	Same	Same	Same
Minimum Flow below Thermalito Afterbay outlet	1983 DWR, DFG Agreement (1000 – 1700 CFS)	Same	Same	Same	Same
American River					
Minimum Flow below Nimbus Dam	SWRCB D-893 (see accompanying Operations Criteria), and USFWS use of	Same	Same	Same	Same

	Study 1	Study 2	Study 3	Study 4	Study 5
	CVPIA 3406(b)(2) water				
Minimum Flow at H Street Bridge	SWRCB D-893	Same	Same	Same	Same
Lower Sacramento River					
Minimum Flow near Rio Vista	SWRCB D-1641	Same	Same	Same	Same
Mokelumne River					
Minimum Flow below Camanche Dam	FERC 2916-029, 1996 (Joint Settlement Agreement) (100 – 325 CFS)	Same	Same	Same	Same
Minimum Flow below Woodbridge Diversion Dam	FERC 2916-029, 1996 (Joint Settlement Agreement) (25 – 300 CFS)	Same	Same	Same	Same
Stanislaus River					
Minimum Flow below Goodwin Dam	1987 USBR, DFG agreement , and USFWS use of CVPIA 3406(b)(2) water	Same	Same	Same	Same
Minimum Dissolved Oxygen	SWRCB D-1422	Same	Same	Same	Same
Merced River					
Minimum Flow below Crocker-Huffman Diversion Dam	Davis-Grunsky (180 – 220 CFS, Nov – Mar), and	Same	Same	Same	Same

	Study 1	Study 2	Study 3	Study 4	Study 5
	Cowell Agreement				
Minimum Flow at Shaffer Bridge	FERC 2179 (25 – 100 CFS)	Same	Same	Same	Same
Tuolumne River					
Minimum Flow at Lagrange Bridge	FERC 2299-024, 1995 (Settlement Agreement) (94,000 – 301,000 af/YR)	Same	Same	Same	Same
San Joaquin River					
Maximum Salinity near Vernalis	SWRCB D-1641	Same	Same	Same	Same
Minimum Flow near Vernalis	SWRCB D-1641, and Vernalis Adaptive Management Program per San Joaquin River Agreement	Same	Same	Same	Same
Sacrameto River-San Joaquin River Delta					
Delta Outflow Index (Flow and Salinity)	SWRCB D-1641	Same	Same	Same	Same
Delta Cross Channel Gate Operation	SWRCB D-1641	Same	Same	Same	Same
Delta Exports	SWRCB D-1641, USFWS use of CVPIA 3406(b)(2) water	Same as Study 1	Same as Study 1 with CALFED Fisheries Agencies use of EWA assets	Same as Study 1	Same as Study 3

	Study 1	Study 2	Study 3	Study 4	Study 5
OPERATIONS CRITERIA					
Subsystem					
Upper Sacramento River					
Flow Objective for Navigation (Wilkins Slough)	3,250 – 5,000 CFS based on Lake Shasta storage condition	Same	Same	Same	Same
American River					
Folsom Dam Flood Control	SAFCA, Interim-Reoperation of Folsom Dam, Variable 400/670 (without outlet modifications)	Same	Same	Same	Same
Flow below Nimbus Dam	Operations criteria corresponding to SWRCB D-893 required minimum flow	Same	Same	Same	Same
Sacramento Water Forum Mitigation Water	None	Same as Study 1	Same as Study 1	Sacramento Water Forum (up to 47,000 af/YR in dry years)[22]	Same as Study 4
Feather River					
Flow at Mouth	Maintain the DFG/DWR flow target above Verona or 2800 cfs for Apr – Sep dependent on Oroville inflow and FRSA allocation	Same	Same	Same	Same

[22] This is implemented only in the PCWA Middle Fork Project releases used in defining the CALSIM II inflows to Folsom Lake

	Study 1	Study 2	Study 3	Study 4	Study 5
Stanislaus River					
Flow below Goodwin Dam	1997 New Melones Interim Operations Plan	Same	Same	Same	Same
San Joaquin River					
Flow near Vernalis	San Joaquin River Agreement in support of the Vernalis Adaptive Management Program	Same	Same	Same	Same
System-wide					
CVP Water Allocation					
CVP Settlement and Exchange	100% (75% in Shasta Critical years)	Same	Same	Same	Same
CVP Refuges	100% (75% in Shasta Critical years)	Same	Same	Same	Same
CVP Agriculture	100% - 0% based on supply	Same	Same	Same	Same
CVP Municipal & Industrial	100% - 50% based on supply	Same	Same	Same	Same
SWP Water Allocation					
North of Delta (FRSA)	Contract specific	Same	Same	Same	Same
South of Delta	Based on supply; Monterey Agreement	Same	Same	Same	Same
CVP/SWP Coordinated Operations					
Sharing of Responsibility for In-Basin-Use	1986 Coordinated Operations Agreement	Same	Same	Same	Same

	Study 1	Study 2	Study 3	Study 4	Study 5
Sharing of Surplus Flows	1986 Coordinated Operations Agreement	Same	Same	Same	Same
Sharing of Restricted Export Capacity	Equal sharing of export capacity under SWRCB D-1641; use of CVPIA 3406(b)(2) only restricts CVP exports; EWA use restricts CVP and/or SWP exports as directed by CALFED Fisheries Agencies	Same	Same	Same	Same
Transfers					
Dry Year Program	None	Same	Same	Same	Same
Phase 8	None	Same	Same	Same	Same
MWDSC/CVP Settlement Contractors	None	Same	Same	Same	Same
CVP/SWP Integration					
Dedicated Conveyance at Banks	None	Same as Study 1	Same as Study 1	SWP to convey 100,000 af of Level 2 refuge water each year at Banks PP.	Same as Study 4
NOD Accounting Adjustments	None	Same as Study 1	Same as Study 1	CVP to provide the SWP a max of 75,000 af of water to meet in-basin requirements through adjustments in COA accounting.	Same as Study 4
CVPIA 3406(b)(2)	Dept of Interior 2003 Decision	Same	Same	Same	Same
Allocation	800,000 af/YR, 700,000 af/YR in 40-30-30 Dry Years, and 600,000 af/YR in 40-30-30 Critical years	Same	Same	Same	Same
Actions	1995 WQCP, Fish flow objectives (Oct-Jan), VAMP	Same	Same	Same	Same

	Study 1	Study 2	Study 3	Study 4	Study 5
	(Apr 15- May 16) CVP export restriction, 3000 CFS CVP export limit in May and June (D1485 Striped Bass continuation), Post (May 16-31) VAMP CVP export restriction, Ramping of CVP export (Jun), Upstream Releases (Feb-Sep)				
Accounting Adjustments	Per May 2003 Interior Decision, no limit on responsibility for D1641 requirements no Reset with the Storage metric and no Offset with the Release and Export metrics,	Same	Same	Same	Same
CALFED Environmental Water Account	None	None	Modeled	None	Same as Study 3
Actions			Dec-Feb reduce total exports by 50,000 af/month relative to total exports without EWA; VAMP (Apr 15- May 16) export restriction on SWP; Post (May 16-31) VAMP export restriction on SWP and potentially on CVP if B2 Post-VAMP action is not taken; Ramping of exports (Jun)		Same as Study 3
Assets			Fixed Water Purchases 250,000 af/yr, 230,000 af/yr in 40-30-30 dry years, 210,000 af/yr in 40-30-30 critical years. The purchases range from 0 af in Wet Years to approximately 153,000 af in Critical Years NOD, and 57,000 af in Critical Years to 250,000 af in Wet Years SOD. Variable assets		Same as Study 3

	Study 1	Study 2	Study 3	Study 4	Study 5
Debt restrictions			include the following: used of 50% JPOD export capacity, acquisition of 50% of any CVPIA 3406(b)(2) releases pumped by SWP, flexing of Delta Export/Inflow Ratio (post-processed from CALSIM II results), dedicated 500 CFS pumping capacity at Banks in Jul – Sep Delivery debt paid back in full upon assessment; Storage debt paid back over time based on asset/action priorities; SOD and NOD debt carryover is allowed; SOD debt carryover is explicitly managed or spilled; NOD debt carryover must be spilled; SOD and NOD asset carryover is allowed.		Same as Study 3

Table 8-3 2001 American River Demand Assumptions (Note that cuts are not made predicated on Inflow to Folsom for the 2001 Demands)

	ALLOCATION TYPE (MAXIMUM)					
Location / Purveyor	**CVP AG**	**CVP MI**	**CVP Settlement / Exchange**	**Water Rights / Non-CVP / No Cuts**	**CVP Refuge**	**Total**
Auburn Dam Site (D300)						
Placer County Water Agency	0	0	0	8,500	0	8,500
Total	**0**	**0**	**0**	**8,500**	**0**	**8,500**
Folsom Reservoir (D8)						
Sacramento Suburban	0	0	0	0	0	0
City of Folsom (includes P.L. 101-514)	0	0	0	20,000	0	20,000
Folsom Prison	0	0	0	2,000	0	2,000
San Juan Water District (Placer County)	0	0	0	10,000	0	10,000
San Juan Water District (Sac County) (includes P.L. 101-514)	0	11,200	0	33,000	0	44,200
El Dorado Irrigation District	0	7,550	0	0	0	7,550
El Dorado Irrigation District (P.L. 101-514)	0	0	0	0	0	0
City of Roseville	0	32,000	0	0	0	32,000
Placer County Water Agency	0	0	0	0	0	0
Total	**0**	**50,750**	**0**	**65,000**	**0**	**115,750**
Folsom South Canal (D9)						
So. Cal WC/ Arden Cordova WC	0	0	0	3,500	0	3,500
California Parks and Recreation	0	100	0	0	0	100
SMUD (export)	0	0	0	15,000	0	15,000

South Sacramento County Agriculture (export, SMUD transfer)	0	0	0	0	0	0
Canal Losses	0	0	0	1,000	0	1,000
Total	**0**	**100**	**0**	**19,500**	**0**	**19,600**
Nimbus to Mouth (D302)						
City of Sacramento	0	0	0	63,335	0	63,335
Arcade Water District	0	0	0	2,000	0	2,000
Carmichael Water District	0	0	0	8,000	0	8,000
Total	**0**	**0**	**0**	**73,335**	**0**	**73,335**
Sacramento River (D162)						
Placer County Water Agency	0	0	0	0	0	0
Total	**0**	**0**	**0**	**0**	**0**	**0**
Sacramento River (D167/D168)						
City of Sacramento	0	0	0	38,665	0	38,665
Sacramento County Water Agency (SMUD transfer)	0	0	0	0	0	0
Sacramento County Water Agency (P.L. 101-514)	0	0	0	0	0	0
EBMUD (export)	0	0	0	0	0	0
Total	**0**	**0**	**0**	**38,665**	**0**	**38,665**
Total	**0**	**50,850**	**0**	**166,335**	**0**	**217,185**

Table 8-4 2020 American River Demand Assumptions

	ALLOCATION TYPE (MAXIMUM)									
Location / Purveyor	**CVP AG**	**CVP MI**	**CVP Settlement / Exchange**	**Water Rights / Non-CVP / No Cuts**	**CVP Refuge**	**Total**	FUI (Mar - Sep +60 TAF)			**Notes**
							>	>	<	
							1600	950	400	
Auburn Dam Site (D300)										
Placer County Water Agency	0	35,000	0	35,500	0	70,500	70,500	70,500	70,500	1/2/3/12
Total	**0**	**35,000**	**0**	**35,500**	**0**	**70,500**	**70,500**	**70,500**	**70,500**	
Folsom Reservoir (D8)										
Sacramento Suburban	0	0	0	29,000	0	29,000	29,000	0	0	4/5/11
City of Folsom (includes P.L. 101-514)	0	7,000	0	27,000	0	34,000	34,000	34,000	20,000	1/2/3
Folsom Prison	0	0	0	5,000	0	5,000	5,000	5,000	5,000	
San Juan Water District (Placer County)	0	0	0	25,000	0	25,000	25,000	25,000	10,000	1/2/3/11
San Juan Water District (Sac County) (includes P.L. 101-514)	0	24,200	0	33,000	0	57,200	57,200	57,200	44,200	1/2/3
El Dorado Irrigation District	0	7,550	0	17,000	0	24,550	24,550	24,550	22,550	1/2/3
El Dorado Irrigation District (P.L. 101-514)	0	7,500	0	0	0	7,500	7,500	7,500	0	1/2/3
City of Roseville	0	32,000	0	30,000	0	62,000	54,900	54,900	39,800	1/2/3/11/ 12
Placer County Water Agency	0	0	0	0	0	0	0	0	0	11
Total	**0**	**78,250**	**0**	**166,000**	**0**	**244,250**	**237,150**	**208,150**	**141,550**	
Folsom South Canal (D9)										
So. Cal WC/ Arden Cordova WC	0	0	0	5,000	0	5,000	5,000	5,000	5,000	
California Parks and Recreation	0	5,000	0	0	0	5,000	5,000	5,000	5,000	

SMUD (export)	0	15,000	0	15,000	0	30,000	30,000	30,000	15,000	1/2/3
South Sacramento County Agriculture (export, SMUD transfer)	0	0	0	0	0	0	0	0	0	1/2/3
Canal Losses	0	0	0	1,000	0	1,000	1,000	1,000	1,000	
Total	**0**	**20,000**	**0**	**21,000**	**0**	**41,000**	**41,000**	**41,000**	**26,000**	
Nimbus to Mouth (D302)										
City of Sacramento	0	0	0	96,300	0	96,300	96,300	96,300	50,000	6/7/8
Arcade Water District	0	0	0	11,200	0	11,200	11,200	11,200	3,500	13
Carmichael Water District	0	0	0	12,000	0	12,000	12,000	12,000	12,000	
Total	**0**	**0**	**0**	**119,500**	**0**	**119,500**	**119,500**	**119,500**	**65,500**	
Sacramento River (D162)										
Placer County Water Agency	0	0	0	0	0	0	0	0	0	
Total	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	
Sacramento River (D167/D168)										
City of Sacramento	0	0	0	34,300	0	34,300	34,300	34,300	80,600	8
Sacramento County Water Agency (SMUD transfer)	0	30,000	0	0	0	30,000				10
Sacramento County Water Agency (P.L. 101-514)	0	15,000	0	0	0	15,000				10
EBMUD (export)	0	133,000	0	0	0	133,000				
Total	**0**	**178,000**	**0**	**34,300**	**0**	**212,300**	**34,300**	**34,300**	**80,600**	
Total	**0**	**133,250**	**0**	**342,000**	**0**	**475,250**	**468,150**	**439,150**	**303,550**	

Notes

1/ Wet/average years for this diverter are defined as those years when the projected March through November unimpaired inflow to Folsom Reservoir is greater than 950,000 af.

2/ Drier years for this diverter are defined as those years when the projected March through November unimpaired inflow to Folsom Reservoir is less than 950,000 af but greater than 400,000 af.

3/ Driest years for this diverter are defined as those years when the projected March through November unimpaired inflow to Folsom Reservoir is less than 400,000 af.

4/ Wet/average years for this diverter are defined as those years when the projected March through November unimpaired inflow to Folsom Reservoir is greater than 1,600,000 af.

5/ Drier years for this diverter are defined as those years when the projected March through November unimpaired inflow to Folsom Reservoir is less than 1,600,000 af.

6/ Wet/average years as it applies to the City of Sacramento are time periods when the flows bypassing the E. A. Fairbairn Water Treatment Plant diversion exceed the "Hodge flows."

7/ Drier years are time periods when the flows bypassing the City's E.A. Fairbairn Water Treatment Plant diversion do not exceed the "Hodge flows."

8/ For modeling purposes, it is assumed that the City of Sacramento's total annual diversions from the American and Sacramento River in year 2030 would be 130,600 af.

10/ The total demand for Sacramento County Water Agency would be up to 78,000 af. The 45,000 af represents firm entitlements; the additional 33,000 af of demand is expected to be met by intermittent surplus supply. The intermittent supply is subject to Reclamation reduction (50%) in dry years.

11/ Water Rights Water provided by releases from PCWA's Middle Fork Project; inputs into upper American River model must be consistent with these assumptions.

12/ Demand requires "Replacement Water" as indicated below

13/ Arcade WD demand modeled as step function: one demand when FUI > 400, another demand when FUI < 400.

Temperature and Mortality Modeling Methods

The objective of the temperature models is to assist in the fisheries impact evaluations of alternative CVP/SWP operation scenarios required for the CVP-OCAP analysis. The Reclamation temperature model was used to estimate temperatures in the Trinity, Sacramento, Feather, American, and Stanislaus River systems. The joint DWR/Reclamation simulation model CALSIM II provided monthly CVP/SWP project operations input to the temperature model for a 72-year hydrologic period (1922-93). Because of the CALSIM Model's complex structure of CALSIM II, flow arcs were combined at appropriate nodes to insure compatibility with the temperature model. The Reclamation salmon mortality model computed salmon spawning losses in the five rivers based on the temperature model estimates. The temperatures and salmon losses for each alternative were compared to a base study.

Model Description

The Reclamation temperature models for the Sacramento, Feather, and American Rivers are documented in a 1990 Reclamation report (1). The Trinity River temperature model is documented in a 1979 Reclamation report (7). The Stanislaus River temperature model is documented in a 1993 Reclamation report (3). The models are also described in Appendix IX of the 1997 Reclamation Draft CVPIA-PEIS (2). The reservoir temperature models simulate monthly mean vertical temperature profiles and release temperatures for Trinity, Whiskeytown, Shasta, Oroville, Folsom, New Melones and Tulloch Reservoirs based on hydrologic and climatic input data. The temperature control devices (TCD) at Shasta, Oroville, and Folsom Dams can selectively withdraw water from different reservoir levels to provide downstream temperature control. The TCD's are generally operated to conserve cold water for the summer and fall months when river temperatures become critical for fisheries. The models simulate the TCD operations by making upper level releases in the winter and spring, mid-level releases in the late spring and summer, and low level releases in the late summer and fall.

Temperature changes in the downstream regulating reservoirs: Lewiston, Keswick, Thermalito, Natomas, and Goodwin are computed from equilibrium temperature decay equations in the reservoir models, which are similar to the river model equations. The river temperature models output temperatures at 3 locations on the Trinity River from Lewiston Dam to the North Fork, 12 locations on the Sacramento River from Keswick Dam to Freeport, 12 locations on the Feather River from Oroville Dam to the mouth, 9 locations on the American River from Nimbus Dam to the mouth, and 8 locations on the Stanislaus River from Goodwin Dam to the mouth. The river temperature calculations are based on regulating reservoir release temperatures, river flows, and climatic data. Monthly mean historical air temperatures for the 72-year period and other long-term average climatic data for Trinity, Shasta, Whiskeytown, Redding, Red Bluff, Colusa, Oroville, Marysville, Folsom, Sacramento, New Melones, and Stockton were obtained from National Weather Service records and are used to represent climatic conditions for the five river systems.

The Reclamation salmon mortality model is documented in a 1994 CVPIA-PEIS report (6) and a 1993 Reclamation report (3). The model's generalized salmon loss calculation procedure is documented in Appendix A of the 1991 Reclamation Shasta TCD EIS (4). The model uses DFG and FWS data on Chinook salmon spawning distribution and timing in the five rivers (4)(5)(6).

Temperature-exposure mortality criteria for 3 life stages (pre-spawned eggs, fertilized eggs, and pre-emergent fry) are used along with the spawning distribution data and output from the river temperature models to compute salmon spawning losses in percent. Temperature units (TU), defined as the difference between river temperatures and 32° F, are calculated daily by the mortality model and used to track life-stage development. Eggs are assumed to hatch upon exposure to 750 TUs following fertilization. Fry are assumed to emerge from the gravel after exposure to 750 TUs following egg hatching into the pre-emergent fry stage. The temperature mortality rates for fertilized eggs, the most sensitive life stage, range from 8% in 24 days at 57° F to 100% in 7 days at 64° F or above (6). Most salmon spawning generally occurs above the North Fork on the Trinity River, above Red Bluff on the Sacramento River for all four salmon runs, above Honcut Creek on the Feather River, above Watt Avenue on the American River, and above Riverbank on the Stanislaus River. Fall-run salmon spawning usually occurs from mid-October thru December, peaking about mid-November. Winter-run salmon usually spawn on the Sacramento River during May-July, and spring-run salmon during August-October.

CALSIM II, Temperature, and Salmon Mortality Model Limitations

The main limitation of CALSIM II and the temperature models used in the study is the time-step. Mean monthly flows and temperatures do not define daily variations that could occur in the rivers due to dynamic flow and climatic conditions. However, monthly results are still useful for general comparison of alternatives. The temperature models are also unable to accurately simulate certain aspects of the actual operations strategies used when attempting to meet temperature objectives, especially on the upper Sacramento River. To account for the short-term variability and the operational flexibility of the system to respond to changing conditions, cooler water than that indicated by the model is released in order to avoid exceeding the required downstream temperature target. There is also uncertainty regarding performance characteristics of the Shasta TCD. Due to the hydraulic characteristics of the TCD, including leakage, overflow, and performance of the side intakes, the model releases are cooler than can be achieved in real-time operations; therefore, a more conservative approach is taken in real-time operations that is not fully represented by the models.

The salmon model is limited to temperature effects on early life stages of Chinook salmon. It does not evaluate potential direct or indirect temperature impacts on later life stages, such as emergent fry, smolts, juvenile out-migrants, or adults. Also, it does not consider other factors that may affect salmon mortality, such as in-stream flows, gravel sedimentation, diversion structures, predation, ocean harvest, etc. Since the salmon mortality model operates on a daily time-step, a procedure is required to utilize the monthly temperature model output. The salmon model computes daily temperatures based on linear interpolation between the monthly temperatures, which are assumed to occur on the 15th day of the month.

CALSIM II cannot completely capture the policy-oriented operation and coordination the 800,000 af of dedicated CVPIA 3406 (B)(2) water and the CALFED EWA. Because the model is set up to run each step of the 3406(B)(2) on an annual basis and because the WQCP and ESA actions are set on a priority basis that can trigger actions using 3406(b)(2) water or EWA assets, the model will exceed the dedicated amount of 3406(b)(2) water that is available. Moreover, the

3406(b)(2) and EWA operations in CALSIM II are just one set of plausible actions aggregated to a monthly representation and modulated by year type. However, they do not fully account for the potential weighing of assets versus cost or the dynamic influence of biological factors on the timing of actions. The monthly time-step of CALSIM II also requires day-weighted monthly averaging to simulate minimum instream flow levels, VAMP actions, export reductions, and X2-based operations that occur within a month. This averaging can either under- or over-estimate the amount of water needed for these actions.

Since CALSIM II uses fixed rules and guidelines results from extended drought periods might not reflect how the SWP and CVP would operate through these times. The allocation process in the modeling is weighted heavily on storage conditions and inflow to the reservoirs that are fed into the curves mentioned previously in the Hydrologic Modeling Methods section beginning on page 8-1 and does not project inflow from contributing streams when making an allocation. This curve based approach does cause some variation in results between studies that would be closer with a more robust approach to the allocation process.

CALSIM Modeling Results

A summary of long-term averages and critical drought-period averages (i.e. Water Years 1928 to 1934) can be found in Table 8-5 for flows, storages, delta output, and deliveries. The rest of this section will be broken up into either subsystems of the CVP and SWP or grouped into results for 3406 CVPIA (b)(2) accounting and EWA.

For more results including month-by-year tables, exceedance charts, monthly averages by water year type and monthly percentiles for selected CALSIM II outputs refer to the CALSIM II Modeling Appendix. The appendix contains a directory of spreadsheets that compare all five studies simulated and directories that contain spreadsheets that directly compare two studies (includes month by year difference tables). The Temperature Modeling appendix includes temperature results from both the Bend Bridge and Balls Ferry compliance points. The appendix also includes mortality results for the Balls Ferry compliance runs, source code, and the raw output files for the CALSIM II studies. Raw output files and documentation for the tempertare and mortality models are also provided.

Post-processing of the CALSIM II simulation of EWA operations was completed by the DWR Transfers Office. This post-processing involved further annual operations simulation, which is described in the OCAP EWA Modeling appendix. The results in this appendix are based on post-processing the Future EWA model (Study 5) and show increased use of assets as mentioned in the Environmental Water Account section

The results in this chapter are generally shown in exceedance charts for a particular month or set of months, average and percentile monthly data, and on a sort by water year type for a particular month. The probability of exceedance charts show values on the y-axis with the percent of time (probability of exceedance) that the value was exceeded. An expample, the end of September exceedance charts show the probability that the revervoir was able to carryover storage into the next water year for each of the five studies. The exceedance charts are also a good measure of trend between the studies either higher or lower on average. Averages by water year type are sorted in this chapter on the 40-30-30 Sacramento Valley Index and show how average changes from Wet to Critical years. The 60-20-20 San Joaquin Valley Index was used for sorting

temperature and CALSIM II output from the Stanislaus and San Joaquin Rivers. The percentile graphs show monthly values for the 50th, 5th, and 95th percentiles for a given output variable and were used to indicate how flows are being effected by flood and minimum flow requirements.

Table 8-5 Long term Averages and 28-34 Averages from each of the five studies

	Study 1: D1641 with (b)(2) (1997)		Study 2: Today (b)(2)		Study 3: Today EWA		Study 4: Future SDIP		Study 5: Future EWA	
	Average	28-34	Average	28-34	Average	28-34	Average	28-34	Average	28-34
End of Sep Storages (TAF)										
Trinity	1418	790	1341	722	1335	694	1286	657	1289	641
Whiskeytown	234	227	234	219	233	219	232	211	232	211
Shasta	2705	1595	2663	1476	2659	1471	2532	1372	2529	1341
Oroville	2085	1502	2091	1558	2079	1454	2050	1576	2044	1507
Folsom	545	454	543	448	535	415	504	378	500	361
New Melones	1390	910	1390	911	1389	911	1390	910	1391	910
CVP San Luis	213	296	215	302	231	303	238	320	245	314
SWP San Luis	401	318	395	280	355	301	375	305	302	313
Total San Luis	614	614	609	581	674	716	614	625	634	802
River Flows (cfs)										
Trinity Release	611	473	729	590	726	590	927	648	928	651
Clear Creek Tunnel	1054	682	940	565	944	565	749	494	748	490
Spring Creek Tunnel	1235	696	1123	582	1127	587	933	519	931	513
Clear Creek Release	166	104	164	101	163	97	163	96	163	97
Keswick Release	8673	5876	8563	5776	8567	5788	8375	5754	8373	5754
Nimbus Release	3477	2401	3478	2402	3477	2393	3228	2181	3227	2184
Mouth of American	3347	2260	3347	2261	3347	2252	3032	1991	3031	1994
Red Bluff Diversion Dam	11251	7457	11147	7372	11150	7382	10981	7399	10977	7401
Wilkin's Slough	9176	6142	9090	6056	9098	6067	8930	6048	8925	6047
Feather Low Flow Channel	709	600	709	600	600	600	705	600	600	600

Flow Below Thermolito	4177	2505	4177	2503	4177	2510	4176	2528	4175	2519
Feather Flow Below Yuba Mouth	6287	3678	6287	3675	6285	3684	6278	3698	6276	3689
Feather Mouth	7500	4169	7500	4166	7499	4174	7503	4192	7500	4184
Sac at Freeport	22476	13951	22376	13870	22390	13867	22193	13893	22200	13879
Tulloch Release	604	307	604	307	604	306	604	308	604	308
Stanislaus Mouth	892	550	892	550	892	550	892	551	892	551
SJR Flow w/o Stanislaus	2866	1567	2865	1566	2866	1566	2866	1569	2867	1569
Flow at Vernalis	3723	2081	3722	2079	3723	2079	3723	2083	3723	2083
Mokelumne	2079	187	2073	181	2060	193	2040	211	2025	219
Yolo Bypass	878	436	878	436	878	436	881	445	881	445
Delta Parameters										
SWP Banks (cfs)	4448	3244	4443	3265	4180	2985	4671	3429	4404	3083
CVP Banks (cfs)	109	59	108	53	180	80	157	45	202	44
Tracy (cfs)	3396	2560	3364	2484	3207	2344	3335	2409	3198	2330
Total Banks (cfs)	4557	3303	4551	3318	4499	3262	4828	3474	4748	3344
Cross Valley Pumping (cfs)	109	59	108	53	109	53	107	45	107	44
Sac Flow at Freeport (cfs)	22362	13951	22264	13870	22277	13867	22089	13893	22095	13879
Flow at Rio Vista (cfs)	18392	9233	18307	9165	18291	9156	18121	9222	18095	9196
Excess Outflow (cfs)	12001	2705	11929	2686	12110	2783	11406	2650	11565	2727
Required Outflow (cfs)	7716	6510	7722	6501	7750	6609	7773	6514	7822	6641
X2 Position (km)	75.8	80.6	75.9	80.7	75.8	80.4	76.2	80.7	76.1	80.4
Yolo Bypass (cfs)	2053	187	2047	181	2034	193	2014	211	2000	219
Mokelumne Flow (cfs)	869	436	869	436	869	436	872	445	872	445
SJR + Calaveras Flow (cfs)	3888	2178	3887	2176	3888	2176	3888	2181	3888	2181
Modeled Required DO (cfs)	7488	6280	7524	6281	7501	6263	7545	6274	7526	6258

Flow at Georgiana Slough (cfs)	3803	2684	3790	2674	3792	2673	3767	2677	3768	2675
DXC Flow (cfs)	1740	1701	1734	1693	1749	1712	1731	1684	1748	1708
Flow below DXC (cfs)	16818	9566	16739	9504	16736	9482	16591	9532	16580	9496
North Bay Aqueduct (cfs)	54	37	54	38	54	37	73	54	74	52
CCWD (cfs)	171	168	171	168	171	168	218	208	218	208
Total Inflow (cfs)	29171	16752	29067	16664	29068	16672	28863	16730	28855	16724
Total Outflow (cfs)	19717	9215	19651	9188	19860	9392	19179	9164	19387	9368
Allocations (%)	**Average**	**29-34***	**Average**	**29-34***	**Average**	**29-34***	**Average**	**29-34***	**Average**	**29-34***
CVP										
North of Delta										
Agriculture	73%	15%	71%	12%	71%	11%	67%	11%	67%	10%
M&I	89%	64%	88%	61%	88%	60%	87%	60%	87%	59%
South of Delta										
Agriculture	61%	15%	60%	12%	61%	11%	61%	11%	61%	10%
M&I	87%	64%	86%	61%	87%	60%	86%	60%	86%	59%
SWP										
Agriculture	80%	39%	80%	40%	80%	37%	80%	42%	80%	40%
M&I (non-MWD)	84%	44%	84%	45%	84%	42%	82%	44%	83%	42%
Metropolitan Water Dist.	81%	39%	81%	41%	81%	38%	80%	43%	81%	41%
Deliveries (TAF)	**Average**	**29-34***	**Average**	**29-34***	**Average**	**29-34***	**Average**	**29-34***	**Average**	**29-34***
CVP										
North of Delta										
Agriculture	246	55	240	43	240	40	237	39	238	37
Settlement Contracts	1831	1747	1832	1747	1832	1747	1876	1749	1876	1751
M&I	30	28	30	27	30	27	38	41	38	41

Refuge	105	90	105	90	105	90	105	89	105	90
Total	2123	1919	2208	1907	2207	1905	2183	1918	2189	1919
South of Delta										
Agriculture	1102	279	1079	217	1110	206	638	195	659	185
Exchange	847	736	847	736	847	736	864	736	864	736
M&I	123	92	122	87	124	86	108	86	107	85
Refuge	280	240	280	240	280	240	288	240	288	240
Total**	2536	1530	2512	1464	2545	1451	2088	1440	2111	1429
SWP										
Metropolitan Water Dist.	1319	759	1320	782	1317	730	1522	832	1532	792
Agriculture	885	434	885	447	708	338	877	475	708	373
M&I (non-MWD)	777	372	777	383	777	358	778	414	785	394
Article 21	175	141	170	131	168	168	152	122	138	145
Water Rights	185	185	185	185	185	185	185	185	185	185
Total***	3045	1630	3047	1676	2867	1490	3242	1786	3090	1623

* Represents 1929 - 1934 Delivery Years, Mar - Feb for CVP and Jan - Dec for SWP

** Total includes canal losses due to evaporation

*** Total is MWD + Ag + M&I (non-MWD) + canal losses

CVPIA 3406 (b)(2)

For the purposes of analyzing water use for the CVPIA Section 3046 (b)(2) actions the Today (b)(2) and Future SDIP studies (i.e. Study 2 and Study 4) will be used in this section.

From Table 8-6 and Table 8-7 the average annual cost of (b)(2) water used increases from 735 TAF annually to 743 TAF annually on an long-term average basis with most of the increases occurring during the Oct – Jan period see Figure 8-5. The probability of exceeding 200 TAF target during the Oct-Jan period increases from 26 percent to 35 percent from the Today (b)(2) to the Future SDIP studies. Exceeding the 200 TAF target is generally due to the model taking high costs actions at Nimbus and Keswick before the accounting algorthims can reduce costs for this period. Another reason for high costs during this period is from Delta salinity requirements during dry and critical years in the WQCP accounting.

Annual (b)(2) modeled costs exceed their allocated amount 54% in the Today (b)(2) run and 51% in the Future SDIP run, Figure 8-3 and Figure 8-4. The annnual costs exceeding the allocated amount of (b)(2) water available is generally due to years where there are a combination of high release costs due to X2 Roe Island requirements, high VAMP costs for the Apr 15 to May 15 export curtailments (triggered in every year of simulation), and not anticipating payback pumping costs in the late summer. CALSIM II also does not use any forecasting algorthim for overall (b)(2) costs. This also results in over and under utilization of the allocated amount of (b)(2) water. Years when the (b)(2) costs are less than the allocated amount are generally in wet years, because flood releases are, generally, nearly identical between the D1485 baseline and (b)(2) annual simulations, and VAMP export cutailments are up to the 2:1 ratio when non-VAMP flows are greater than 8600 cfs.

Table 8-8 shows the average required costs for a (b)(2) export action and what the (b)(2) operation was actually able to support given the water available in the account and anticipated WQCP costs for both the Today (b)(2) and Future SDIP studies. The ability for (b)(2) water to support various actions decreases in the Future SDIP due to increased release costs. The Above and Below Normal years are more costly than dry or critical years due to full VAMP restrictions and the ability to pump more water in the D1485 baseline.

Table 8-9 displays the percentage of times that the simulated actions were triggered given the assumptions for taking an action. Reduction in the percentage of times that the releases were reduced are due to reduction in upstream storages in the Future SDIP study. Reduction in percentage of times that the May Shoulder and June Ramping are triggered are due to increased release metric costs in the Future SDIP study.

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Table 8-6 Average Monthly WQCP and Total (b)(2) Costs by Month, Total Oct – Jan Costs, and Total Annual Costs for Study 3 Today (b)(2)

Today b2	Oct	Nov	Dec	Jan	Oct-Jan Subtotal	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Annual
WQCP Release Cost	15	16	7	3	40	24	22	30	13	48	10	21	32	241
WQCP Export Cost	1	5	8	3	17	5	23	45	12	2	28	89	4	225
WQCP Total Cost	15	20	15	6	57	29	45	75	26	50	38	110	36	466
(b)(2) Release Cost	24	42	41	32	139	36	52	56	39	37	12	21	27	419
(b)(2) Export Cost	1	2	4	3	10	5	28	77	57	11	31	92	5	316
(b)(2) Total Cost	25	44	45	34	149	41	79	133	97	47	43	114	32	735

Table 8-7 Average Monthly WQCP and Total (b)(2) Costs by Month, Total Oct – Jan Costs, and Total Annual Costs for Study 4 Future SDIP

Future SDIP	Oct	Nov	Dec	Jan	Oct-Jan Subtotal	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Annual
WQCP Release Cost	17	13	4	3	37	22	21	32	11	48	16	16	28	232
WQCP Export Cost	0	8	11	6	25	5	24	33	15	5	22	91	7	227
WQCP Total Cost	17	21	15	9	62	28	45	65	26	52	37	108	35	459
(b)(2) Release Cost	33	44	45	28	150	36	46	59	40	36	16	18	27	427
(b)(2) Export Cost	2	5	7	7	21	9	34	60	57	12	24	92	8	316
(b)(2) Total Cost	34	49	52	35	170	44	80	119	97	48	40	110	35	743

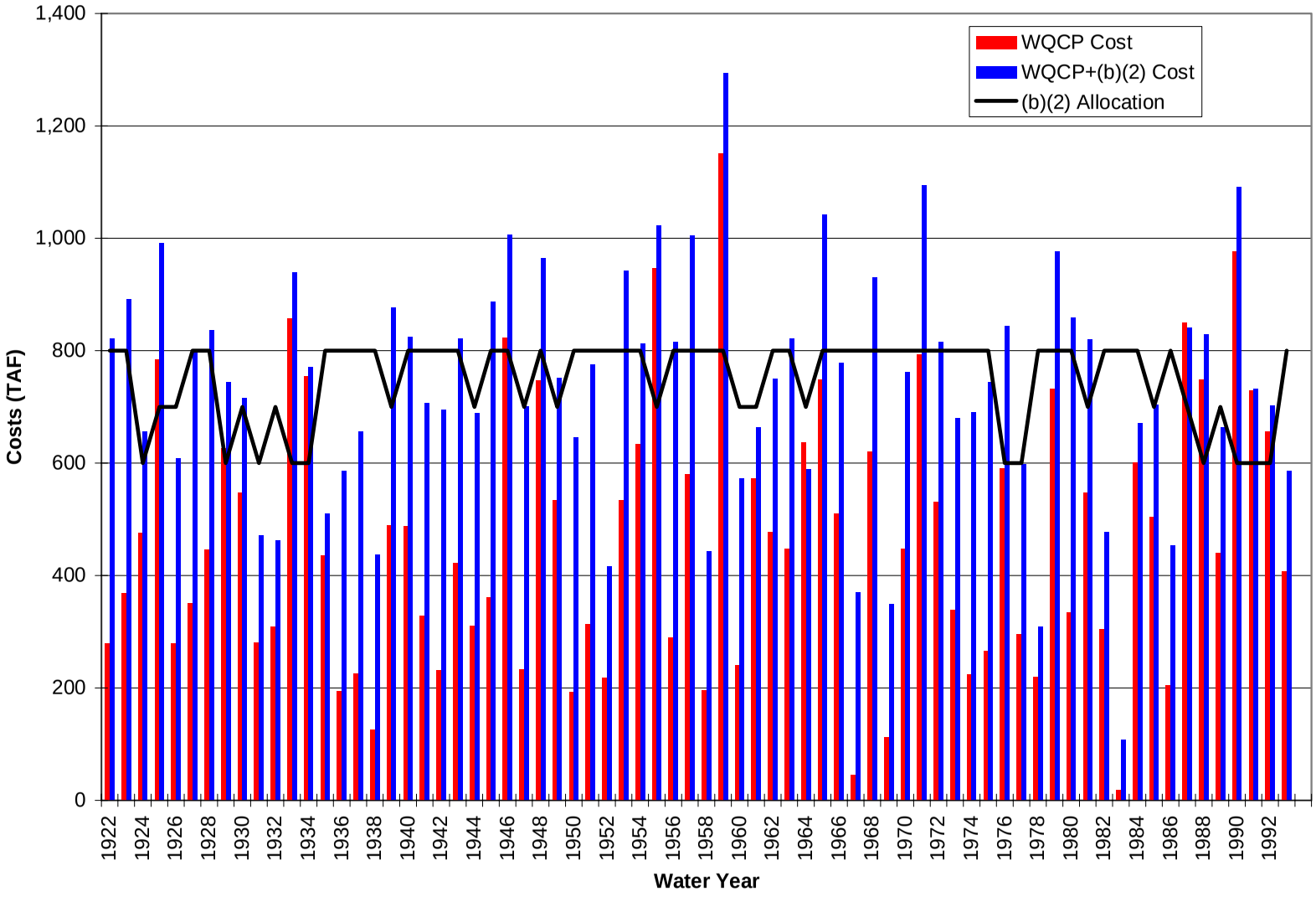

Figure 8-3 Today (b)(2) Total Annual WQCP and Total (b)(2) costs

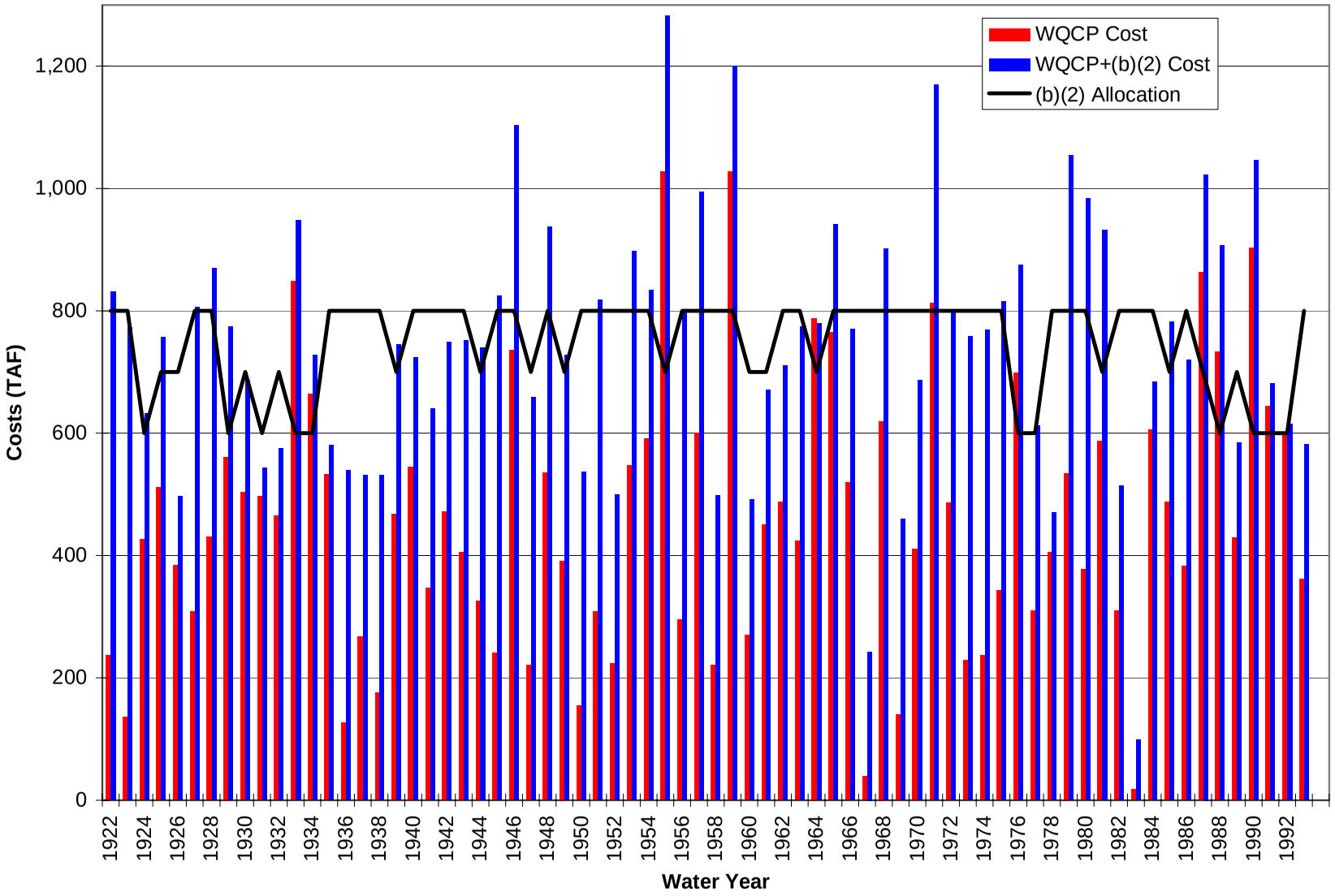

Figure 8-4 Future SDIP Total Annual WQCP and Total (b)(2) costs

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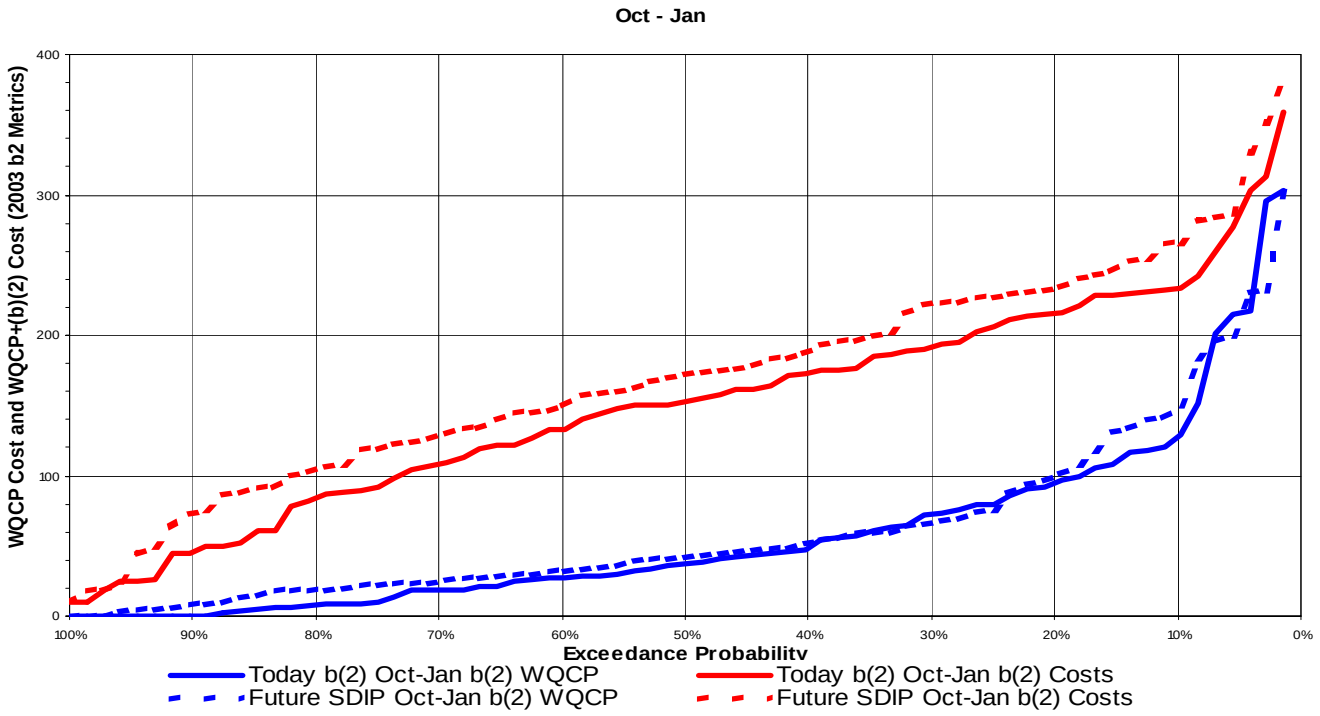

Figure 8-5 Oct – Jan WQCP and Total (b)(2) Costs probability of exceedance

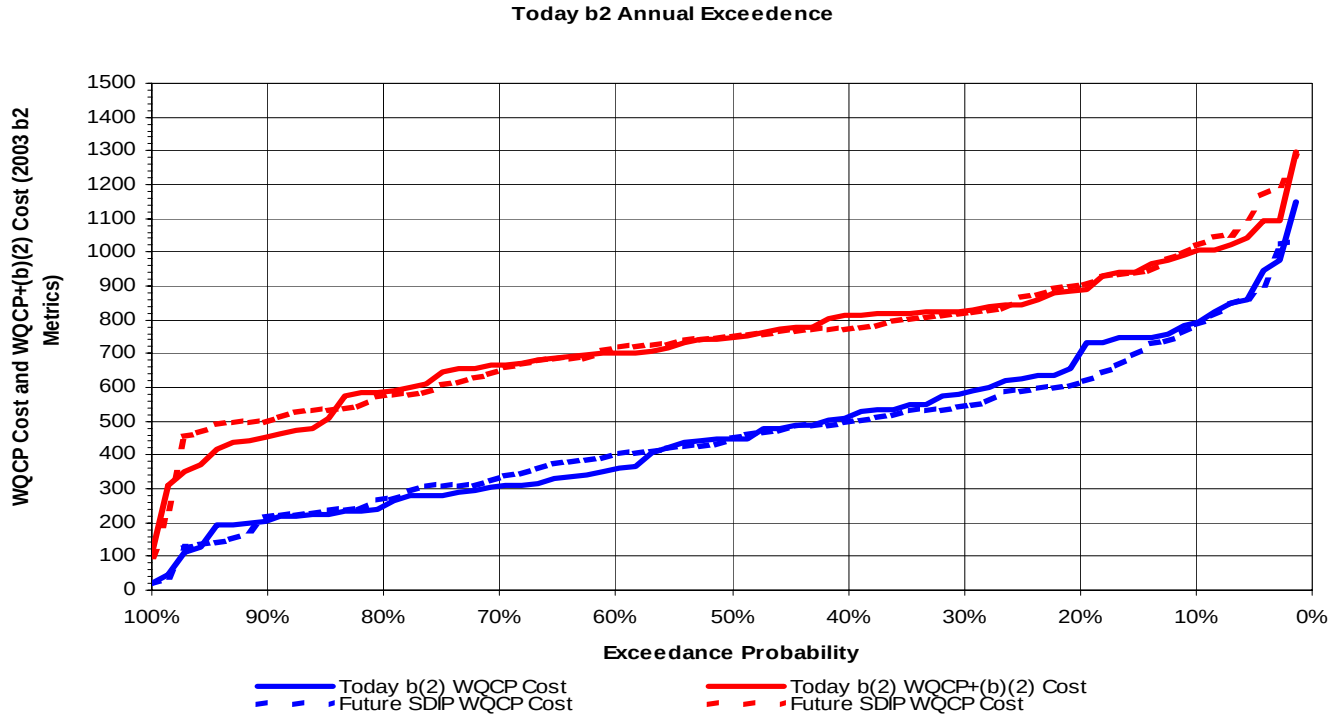

Figure 8-6 Annual WQCP and Total (b)(2) Costs probability of exceedance

Table 8-8 Total (b)(2) water required for export actions versus amount of (b)(2) water used

	Total (b)(2) Water Required			Actually (b)(2) Water Used		
Today (b)(2)	Apr-May Vamp	May Shoulder	June Ramping	Apr-May Vamp	May Shoulder	June Ramping
Average	108	41	18	108	19	7
W	95	35	15	95	22	7
AN	138	53	23	138	27	10
BN	141	57	26	141	25	8
D	110	40	21	110	18	6
C	57	24	2	57	3	2
Future SDIP	Apr-May Vamp	May Shoulder	June Ramping	Apr-May Vamp	May Shoulder	June Ramping
Average	96	19	8	96	14	5
W	85	27	8	85	18	5
AN	128	10	4	128	10	4
BN	129	29	8	129	24	8
D	94	11	11	94	9	5
C	52	8	10	52	1	1

Table 8-9 Percent of possible occurrences action was triggered

Actions	Today (b)(2)	Future SDIP
Keswick Releases	66%	64%
Whiskeytown Releases	94%	93%
Nimbus Releases	69%	67%
Dec-Jan Export Cuts	n/a	n/a
VAMP Export Cuts	100%	100%
Late May Export Cuts	79%	76%
Jun Export Cuts	60%	50%
Early Apr Export Cuts	n/a	n/a
Feb-Mar Export Cuts	n/a	n/a

Environmental Water Account

This section summarizes results from the two OCAP studies that included EWA operations: Study 3 (i.e. Today EWA) and Study 5 (i.e. Future EWA). Operations are summarized for the following categories:

- Annual costs of EWA actions (i.e. expenditures) measured as export reductions
- Delivery debt status and payback (i.e. adherence to the No Harm Principle)
- Carryover debt conditions from year to year
- Annual accrual of EWA assets to mitigate impacts of EWA actions (i.e. water purchases, B2 gains, use of JPOD capacity, wheeling of backed-up water)
- Spilling of carryover debt situated at SWP San Luis
- Annual costs specific to each EWA action measured as export reductions

The annual EWA expenditures for the simulation are shown on Figure 8-7, first as the summation of expenditures associated with Winter and Spring EWA actions, and second as the expenditures only associated with the Spring VAMP action (i.e. EWA Action 3). For the combination of Winter and Spring EWA actions, both Today EWA and Future EWA studies had similar extremes in annual expenditures (i.e. cost ranges of approximately 100,000 to 600,000 af). However, in between these extremes, costs for Future EWA operations tended to be slightly higher. For VAMP costs only, low-cost years tended to be similar between Today EWA and Future EWA, but higher cost years tended to result in greater spending with Future EWA.

Another way of viewing annual EWA Expenditures is to consider their year-type dependent averages. Sacramento 40-30-30 index was used to classify and sort years. Average annual expenditures by year-type are listed in Table 8-10. Comparing Today EWA and Future EWA results, the year-type dependent averages for Critical and Dry years are very similar. However, the averages for Below Normal, Above Normal, and Wet years tend to be higher under Future EWA conditions as opposed to Today EWA conditions. In these years, when supplies are greater relative to Critical and Dry years, the expanded capacity of 8500 Banks is more utilized and it appears that, on average, the cost of simulated EWA actions increases. Another contributing factor to increased cost of EWA actions in Future EWA relative to Today EWA is that SWP has higher South-of-Delta (SOD) deliveries, based on a long-term annual average, in Future EWA relative to Today EWA (Table 8-5).

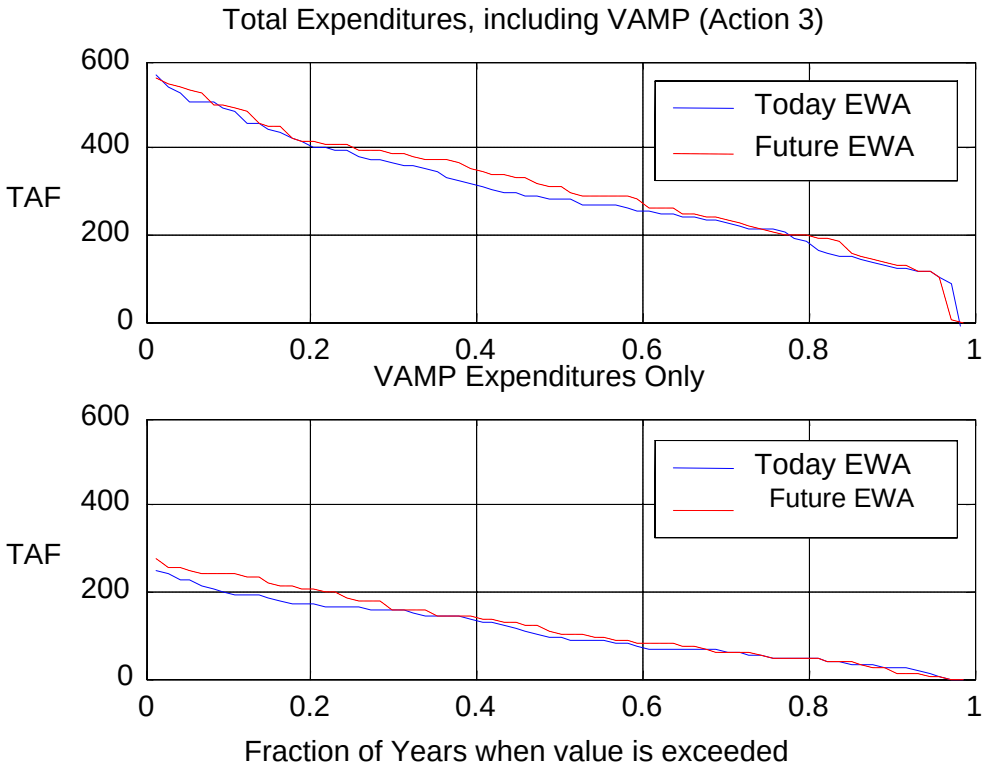

Figure 8-7 – Annual EWA Expenditures simulated by CALSIM II, measured in terms of export reductions from exports under the EWA Regulatory Baseline (i.e. Step 4 of Figure 8-1**) relative to exports with EWA operations (i.e. Step 5 of** Figure 8-1**).**

Table 8-10 – Annual EWA Expenditures simulated by CALSIM II, averaged by Hydrologic Year-Type, defined according to the Sacramento River 40-30-30 Index.

Hydrologic Year-Type	Today EWA (TAF)	Future EWA (TAF)
Critical	135	139
Dry	235	237
Below Normal	331	352
Above Normal	360	407
Wet	373	385

The measure of deliveries debt payback is the key indicator on whether the simulated EWA operations adhere to the No Harm to Deliveries principle set forth in the CALFED ROD. In CALSIM II modeling, SOD delivery debt is assessed in the month after which it occurs. Upon assessment, that debt is to be repaid in full through dedication of EWA asset available SOD (either as a SOD purchase planned for that month, a wheeled NOD asset planned for that month, or an EWA San Luis storage withdrawl that month). Instances when SOD delivery debt could not be repaid in full can be noted through post-simulation analysis of CALSIM II results. Occurrence of delivery debt not being immediately repaid only occurred for CVP debt in 1943 of the Future EWA study **(**Table 8-11**)**.

Levels of unpaid debt are very minor and within CALSIM II margins or error. Moreover, these amounts of unpaid delivery debt could presumably be managed by EWA assets not represented in CALSIM II (i.e. source-shifting, exchanges). The fact that instances of unpaid delivery debt occurred in the Future EWA run suggests that simulated EWA actions and assets are somewhat near balanced.

Table 8-11 – Instances of not adhering to the EWA "No Harm Principle" (i.e. not repaying delivery debt in full upon assessment), simulated by CALSIM II.

Delivery Debt Account	Today EWA	Future EWA
CVP South-of-Delta	None	3 instances: Jan 1943 (-2,000 af), Feb 1943 (-2,000 af), Mar 1943 (-2,000 af)
SWP South-of-Delta	None	None

A key feature of simulated and real EWA operations that enables increased flexibility of mitigating the impacts of EWA actions is the allowance for carryover debt. In CALSIM II modeling, due to the model structure depicted on Figure 8-1, the annual interruption of the simulated EWA operational baseline necessitates special measures for accounting for carryover debt relative to debt caused by this year's actions (i.e. "new debt" in CALSIM II semantics). The result of these measures are separate debt accounts for carryover and new debt. Unpaid new debt ultimately gets rolled over into the carryover debt account, which can represent one or more years of unpaid debt.

The roll-over of new debt into the carryover debt account occurs in November of Step 5 (Figure 8-7). Results on carryover debt conditions at CVP/SWP San Luis are shown on Figure 8-8 for 73 Octobers and Novembers of Step 5. These carryover debt conditions are at a maximum in November after which they are managed to a minimum in October through dedication of physical EWA assets available SOD or spilling of carryover debt at SWP San Luis. Focusing on the October results, simulated operations under Today EWA and Future EWA suggest similar findings: both suggest that at least 50,000 af of carryover debt will persist for more than one year in 20% of the 73 simulation years, and at least 100,000 af will persist for more than one year in 10% of the 73 years. Extreme amounts of carryover debt persisting for more than one year are higher in Future EWA than with Today EWA.

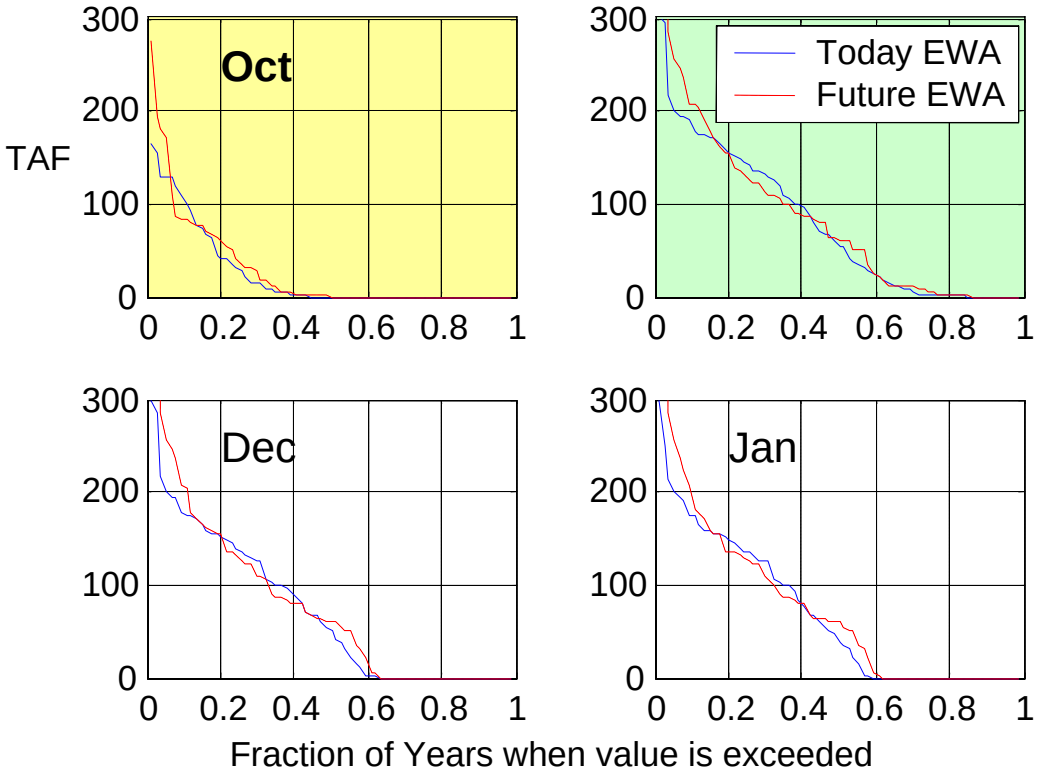

Figure 8-8– Combined carryover debt at CVP and SWP San Luis, simulated in CALSIM II, at the end (Oct) and start (Nov) of the carryover debt assessment year.

The comparative ranges of acquired EWA assets under Today EWA and Future EWA are summarized on Figure 8-9. Focusing first on water purchases only, results are comparable for Today EWA and Future EWA. However there are some years when total purchases under Future EWA are greater than those under Today EWA. It seems that the presence of 8500 Banks in Future EWA somewhat mitigates the limitations of Delta constraints on summer wheeling that sometimes occurred in Today EWA operations. Even though EWA has dedicated 500cfs conveyance capacity at Banks during July-September, this capacity is still vulnerable to interruption due to export reductions caused by other Delta constraints (e.g., Minimum Required Delta Outflow, Export-Inflow limit, Delta salinity objectives).

Focusing on total acquired EWA assets (i.e. water purchases, B2 gains, use of JPOD capacity, wheeling backed-up water), the results for Today EWA and Future EWA are virtually identical except in extreme low-asset years when asset availability is slightly better with Future EWA. On the subject of backed-up water, occurrence can only be induced by Spring EWA actions, but wheeling of the asset from NOD storage to SOD use can occur any time o the year. Results indicate that conveyance of backed-up water occurs in 60% of years. Annual conveyed volumes were less in the Today EWA study relative to the Future EWA study (~10,000 af). Generally, backed-up water conveyance exceeds 30,000, 50,000, and 100,000 af in 40%, 20%, and 10% of the years, respectively.

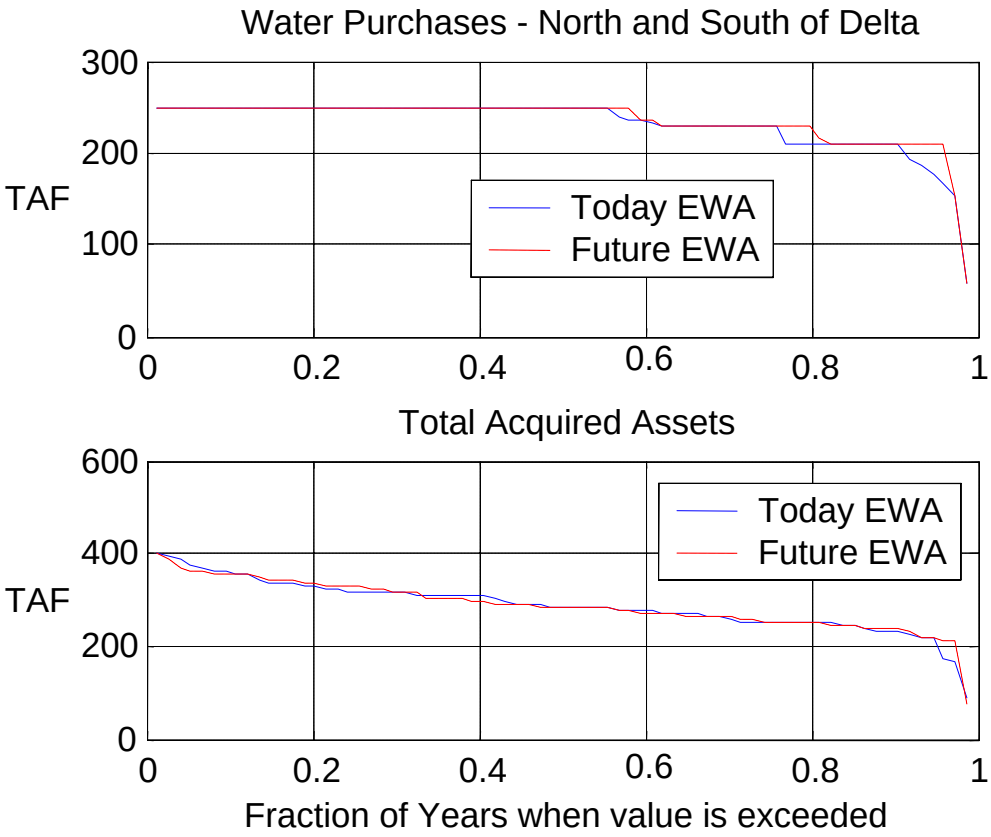

Figure 8-9 – Annual EWA assets simulated in CALSIM II. "Total Acquired Assets" includes Water Purchases and operational assets (i.e. EWA acquisition of 50% of SWP gains from B2 releases, EWA conveyance of Delta Surplus flows using 50% of JPOD capacity or summer dedicated capacity, EWA conveyance of backed-up water caused by Spring EWA actions on exports).

A unique tool for managing carryover debt situated at SWP San Luis is debt spilling, described earlier. In CALSIM II, carryover debt conditions need to be present and severe enough in order to trigger the use of this tool, based on the spill-conditions that were outlined earlier. Also note that there is a symmatics difference between what's called "spill" in CALSIM II and what's called "spill" by EWAT. CALSIM II only designates erasing of carryover debt at SWP San Luis, or reservoir filling in NOD reservoirs as "spilling" debt; it doesn't designate "pumping-to-erase" new debt at San Luis as "spill", even though this is a term sometimes used by EWAT. That distinction noted, the occurrence of carryover debt spilling at SWP San Luis is depicted on Figure 8-10. The frequency of this carryover debt spilling in the Today EWA results is 25 of 73 years with a maximum annual spill of 171,000 af; the frequency in the Future EWA results is 23 of 73 years with a maximum annual spill of 226,000 af.

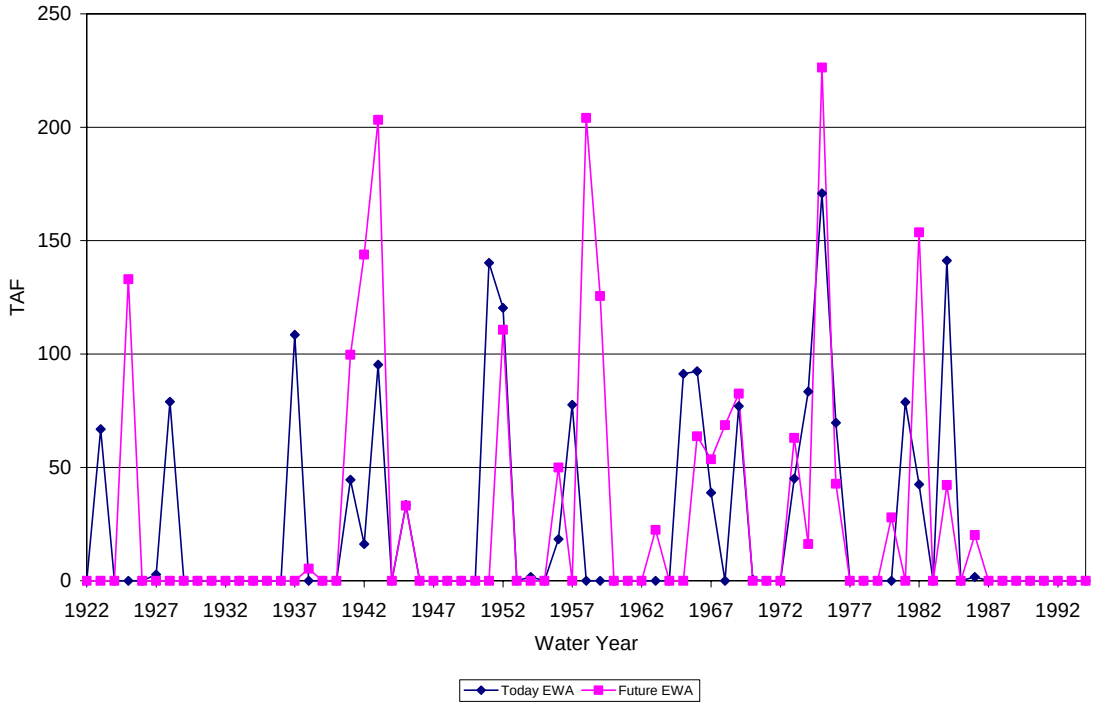

Figure 8-10 – Annual carryover-debt spilling at SWP San Luis, simulated in CALSIM II.

Action-specific expenditures for Winter Export Reductions are expected to be 50,000 af for each month in which their implemented, according to modeling assumptions. Generally this is the case, based on simulated export reductions measured between Step 4 and Step 5 in both the Today EWA and Future EWA studies (Figure 8-11). The action is always taken in December and Januarys, and it is also taken in February if the Sacramento River 40-30-30 Index defines the year to be Above Normal or Wet. Simulation results show that export reductions are always as expected for January and February and nearly always as expected for December (approximately 95% of the years).

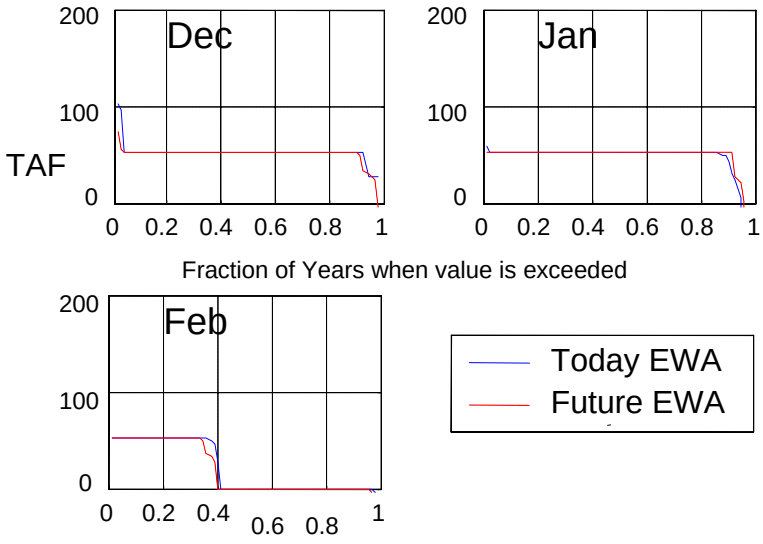

Figure 8-11– Simulated export reductions associated with taking EWA Action 2 (i.e. Winter Export Reductions).

Expectations for Spring actions' expenditures are more difficult to make prior to simulation compared to expenditures for Winter Actions. This is because Spring actions (i.e. EWA Actions 3, 5, and 6) are not linked to spending goals, and are instead linked to target export restriction levels related to VAMP. Results show that action-specific export costs for Spring actions are slightly higher in the Future EWA study relative to the Today EWA study (Figure 8-12 through Figure 8-14). Moreover, the frequency implementing June export reductions (i.e. EWA Action 6, Figure 8-14) is slightly less in Future EWA relative to Today EWA. It appears that in Future EWA, more debt is developed leading up to June in some years, relative to operations under Today EWA, causing the June action to not be triggered since it is conditional on debt conditions. The fact that more debt can develop by June under Future EWA relative to Today EWA seems to be linked to operation of 8500 Banks and the higher average-annual deliveries being made to SWP SOD water users in Future EWA compared to Today EWA (**Table 8-7**).

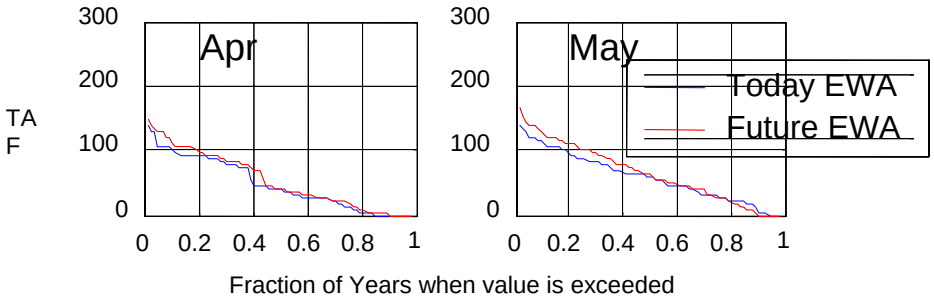

Figure 8-12 – Simulated export reductions associated with taking EWA Action 3 (i.e. VAMP related restrictions).

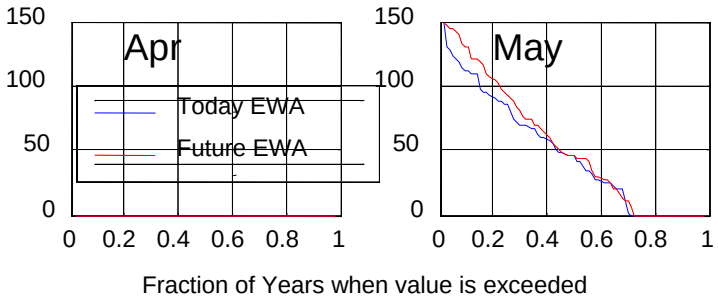

Figure 8-13 – **Simulated export reductions associated with taking EWA Action 5 (i.e. extension of VAMP related restrictions into May 16 – May 31 (i.e. the May Shoulder)).**

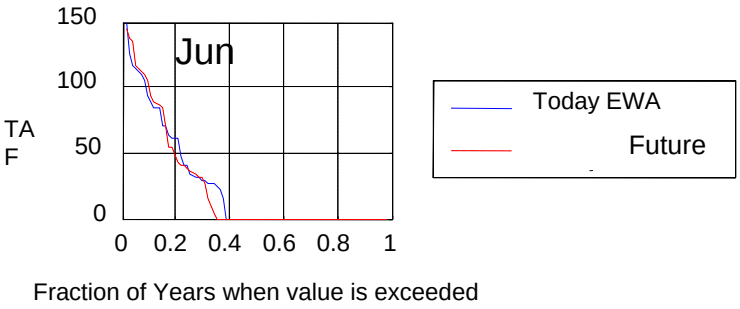

Figure 8-14 – Simulated export reductions associated with taking EWA Action 6 (i.e. representation of June "ramping" from May Shoulder restriction to June Export-to-Inflow restriction).

Post-Processed EWA Results

The results in this section are from the EWA spredsheet model developed by the DWR Transfers Section. The model accounts for assets that CALSIM II does not represent (i.e. E/I Relaxation, Exchanges, Source-Shifting; see Figure 8-15 for assets modeled). Like CALSIM II, the model can be used to describe annual EWA operations. However, the model provides much more assumptions on asset source, availability and includes a financial cost module for analyzing asset acquisition strategies. It is structured to accept output from CALSIM II runs and other computations to allow testing and analysis of how the EWA would fare if the 73-year hydrologic record were to be repeated. The DWR Transfers Section uses this model to test the ability of various tools and management options to meet annual targets for fish actions. Like CALSIM II, this model assumes that actions are implemented as Delta pumping curtailments. However, this model employs much simpler assumptions on action costs, assuming that they vary only with year-type. The annual average action costs by water year type can bee seen in Table 8-12.

Figure 8-16 shows the timeseries of annual debt status for the 73 year analysis. Simulated EWA operations lead to accumulating assets during the long-term drought periods and accumulating debt during wet periods. Maximum debt accumulation happens in 1970 and is a little over 400 TAF. Figure 8-17shows annual pumping expenditures. Figure 8-18 show the annual costs in dollars for the EWA program. For more detailed results and assumption about the model see the EWA Model for OCAP appendix.

Table 8-12. Annual EWA Expenditures Targets by Water Year Type

40-30-30 Index	Annual Cost
Wet	430
Above Normal	490
Below Normal	400
Dry	300
Critical	250

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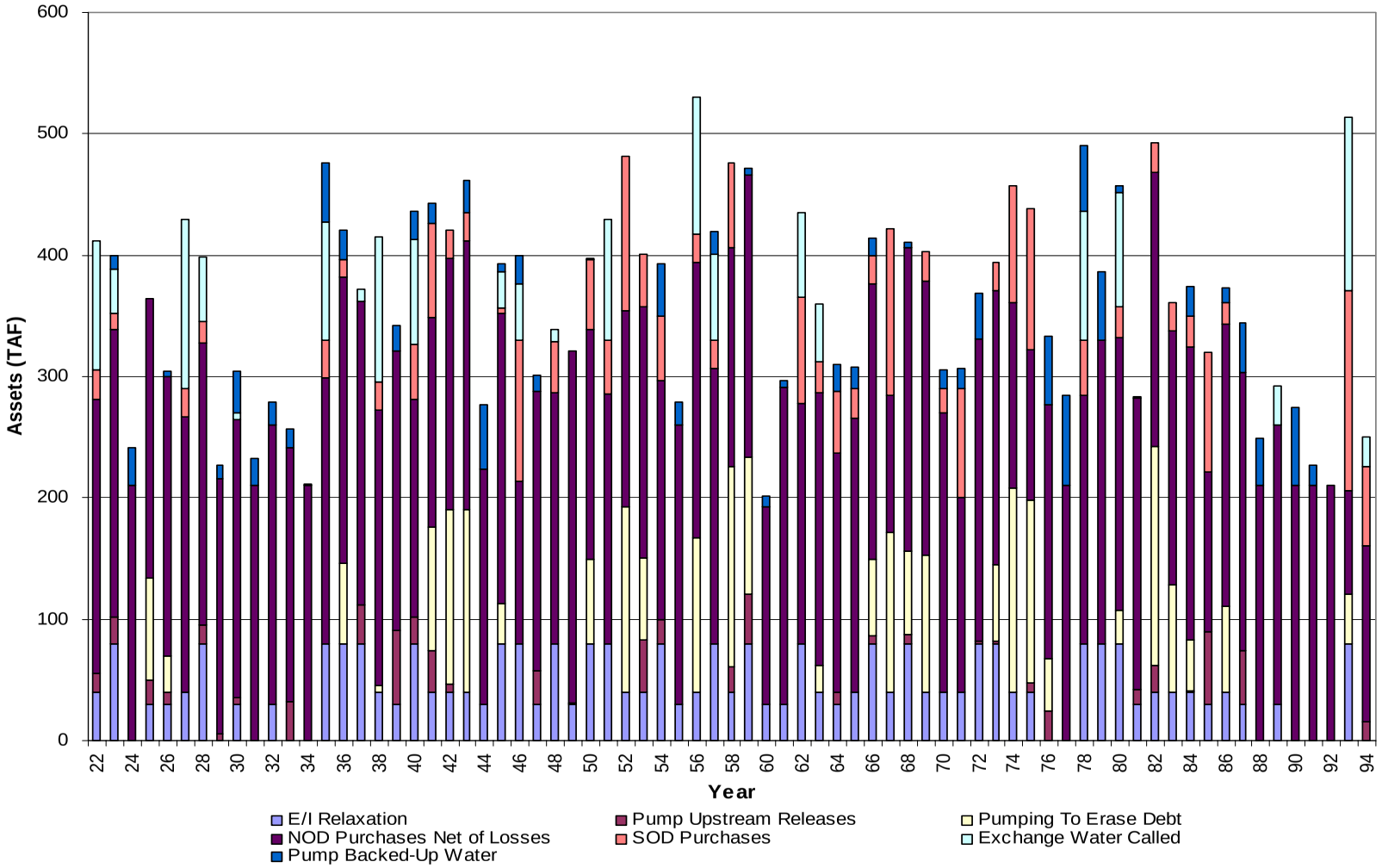

Figure 8-15 EWA Assets by Water Year

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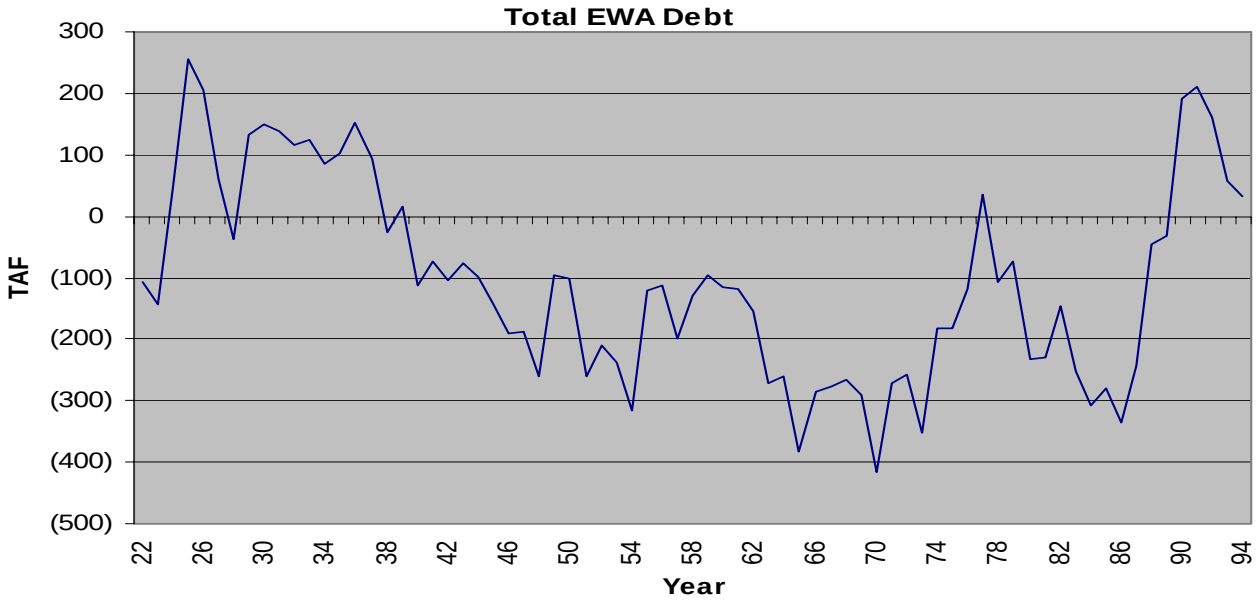

Figure 8-16 Total EWA Debt Balance by Water Year

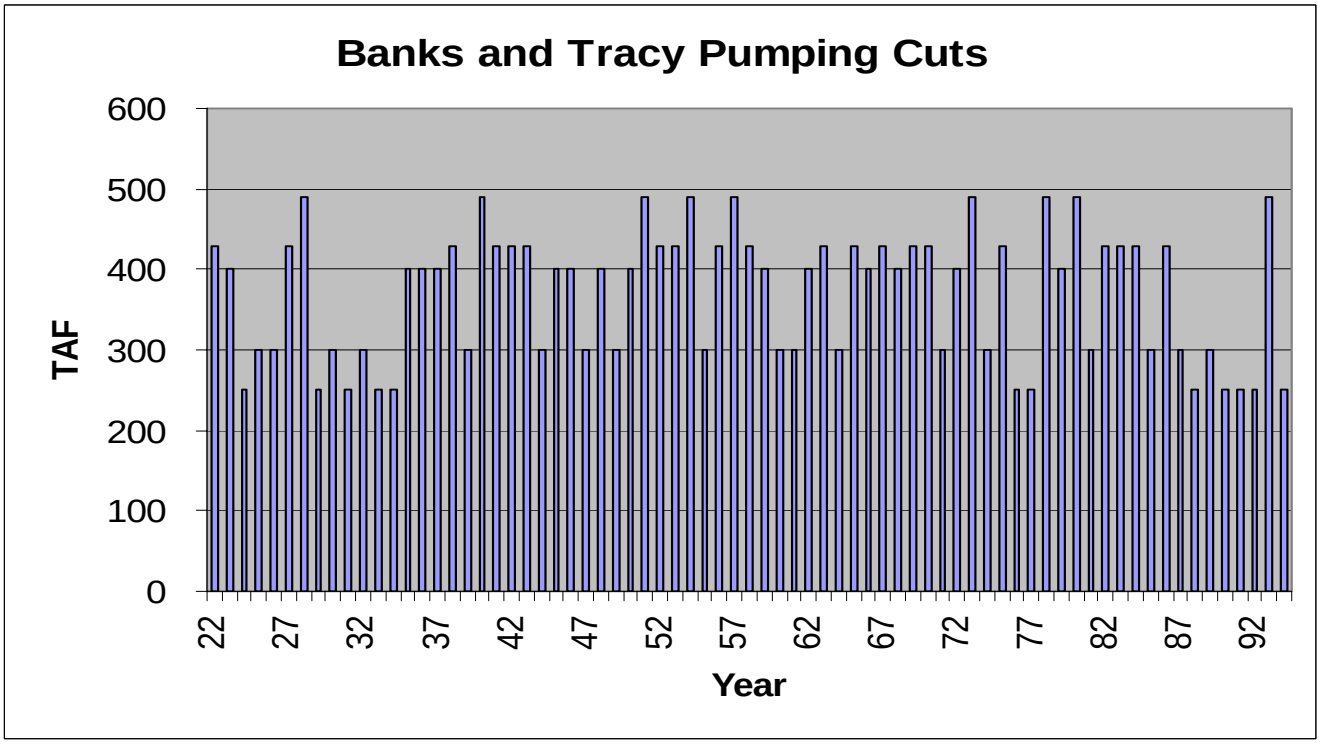

Figure 8-17 Banks and Tracy Cuts

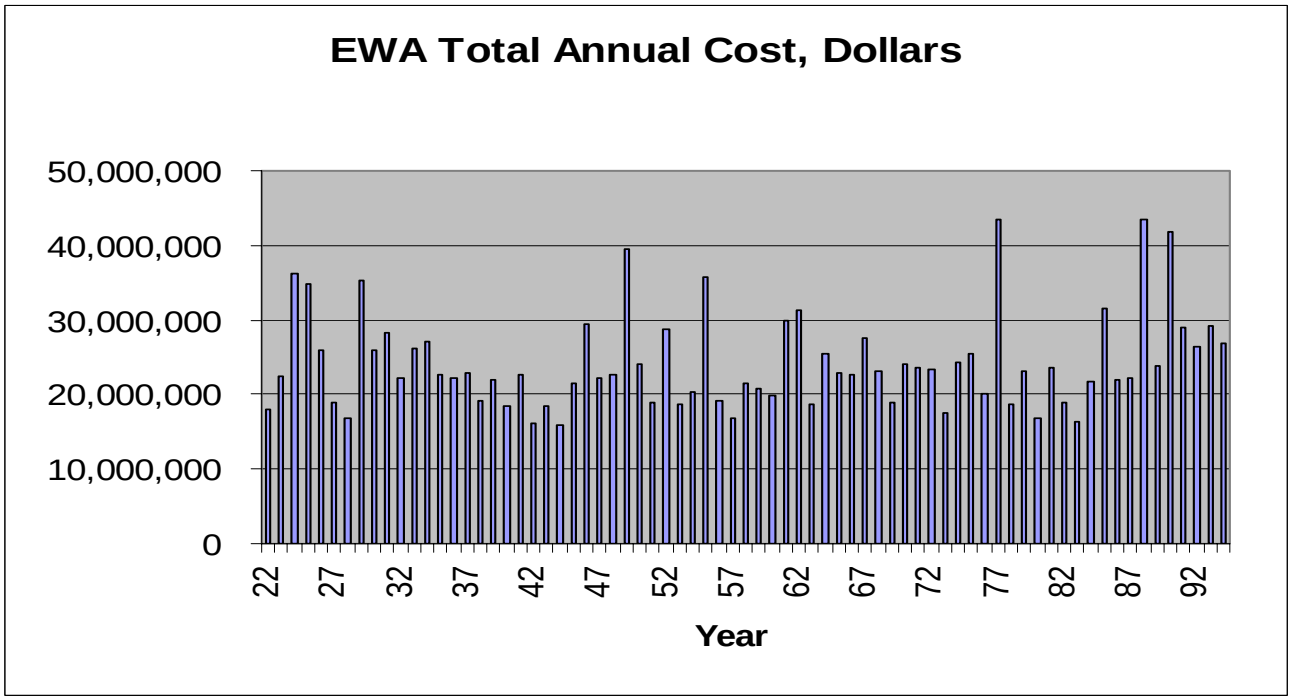

Figure 8-18 Total annual cost of EWA by water year

Conclusions

The main reduction in Shasta Storage is due to the decrease in imports from the Trinity through Spring and Clear Creek Tunnels which is caused from increased flow targets for the Trinity River. Trinity Reservoir storage decreases are due to increased flows targets to the Trinity River.

Decreases in Folsom Lake storage levels are due to increased demands associated with changes in the Level of Development along the American River. Level of Development would include buildout of the water rights and water service contracts. The operation of the American River, specifically operations for the modified D-893 minimum instream flows and the demands for the Future simulations, reflect operations specific to OCAP modeling and may be different than the agreement between Reclamation and the Water Forum. The 47 TAF of mitigation water that is released in this version of Water Forum modeling may not occur in the Future and is showing greater water in the Delta for Exports than may happen in actual operations.

Impact differences between the five studies on the Feather River system are minimal and shift releases to either earlier or later in the year. The change in timing of releases has more to do with the EWA reduction than with increases in demands south of the delta. Oroville does have reduced carryover storage in the Wet through Below Normal years due to a more aggressive allocation curve and increased demands south of the Delta but is less aggressive in the drier years due to reduced carryover storage.

The Stanislaus River shows no major impacts between the five studies because Interim Operations Plan elements are implemented in each of the studies. Assumptions associated with

the Future condition studies do not seem to affect operational conditions as simulated under Today conditions.

The increase in export capacity with the intertie at Tracy and the ability to pump up to 8500 cfs at Banks allows for more excess outflow from the delta to be pumped. The upstream reservoirs show marginal extra releases for exports as a result of the increased capacity at the pumps.

October to January costs of operations for CVPIA Section 3406 (b)(2) increase in the future and limit the ability of (b)(2) to cover export restrictions. The over- and under-spending of allocated (b)(2) water shows the following:

- The inability of CALSIM II to completely capture the adaptive management process that occurs on at least a weekly basis in the B2IT Meetings.
- Over-spending demonstrates a need for CALSIM II to have improved forecasting of annual (b)(2) costs.
- Under-spending shows that the current implementation needs a forecasting tool to allow for additional actions to be taken in Wet to Below Normal water years.
- This representation shows just one set of actions that can be taken under CVPIA, and are not the actual operations. The CALSIM II representation of (b)(2) is meant to be used as a planning tool for grossly evaluating (b)(2) costs under various operating scenarios.

The simulated operations of EWA actions and assets in both the Today EWA and Future EWA studies seem to be somewhat in balance. It is noted that simulated EWA operations are based on assumptions that do not perfectly map to the considerations affecting real EWAT operations:

- CALSIM II must simulate EWA operations on a monthly time step with relatively inflexible rules that must apply for a wide variety of simulation years (according to hydrology and operational conditions); EWAT makes operational decisions on a day-to-day basis through a flexible, adaptive management procedure.
- CALSIM II employs an annual position analysis paradigm to track multiple operational baselines (Figure 8-7**)**, which necessitates split accounting for new and carryover debt; EWAT's procedures for tracking multiple operational baselines doesn't get interrupted annually like that of CALSIM II, and therefore they can describe debt without the split accounting.
- CALSIM II represents action possibilities (especially during Winter and June) as a monthly representation of many different action possibilities; EWAT retains the flexibility of selecting among many combinations of multi-day actions during Winter and/or June.
- To reiterate, the CALSIM II representation of EWA operations is a simplified representation that reflects an adaptive management program and does not limit the operational flexibility held by EWAT. The CALSIM II representation is meant to capture a reasonable representation of EWAT's current and foreseeable operations.

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Chapter 9 Project Impacts for CVP and SWP Controlled Streams

CVP and SWP project operations affect flow and water temperature in river reaches downstream of project reservoirs. The following effects discussion refers to the monthly reservoir release exceedance charts and monthly water temperature exceedance charts found in CALSIM Modeling Appendix and Temperature Modeling Appendix respectively. Recommended temperature ranges and flows for the species are compared to the exceedance charts. Variation in temperatures and flows within months and days are not available from modeling results but will be similar to what occurs currently. The modeling displays more of a net change by month and shows the general direction of change useful for comparing the five scenarios. Monthly exceedance charts are shown for the following locations among others and compare the five modeling runs outlined in chapter 8:

Trinity River Coho Salmon

Modeling

Table 9-1 shows the average annual differences between the five studies for total annual flow and End of September Trinity Storage. Reductions in imports through Clear Creek Tunnel are directly proportional increases in Trinity River minimum required in stream flows. Figure 9-1 shows the Chronology of Trinity Storage from Oct 1921 – Sep 1993. Figure 9-2 shows the end of September exceedance chart for Trinity.

Table 9-2 shows that the increased flows in Study 4 and Study 5 mainly impact the Above Normal and Below Normal years and not the Wetter hydrologic years or the Dry and Critical years when compared to Study 2 and Study 3. Study 1 with the minimum flow requirement at 340,000 af/year the carryover storage remains steadily higher than the other four studies. Other figures presented in this section are the percentile of Trinity Releases Figure 9-3, and the monthly averages for Lewiston Releases by Long-term average and by 40-30-30 Index water year type can be seen in Figure 9-4 to Figure 9-9. Figure 9-10 shows the monthly percentile from imports from the Trinity through Clear Creek Tunnel. The graphs of averages and percentiles show how the flow increases in the Trinity and adheres to the minimum flow standard on average. The monthly percentiles for imports from Clear Creek tunnel are reduced as the minimum flow requirement increases from Study 1 to Study 2 and 3 to Study 4 and 5.

Table 9-1. Long-term Average Annual Impacts to the Trinity River System

Differences (TAF)	Study 2 - Study 1	Study 3 - Study 1	Study 5 - Study 1	Study 4 - Study 2	Study 5 - Study 3
Average Trinity EOS	-76	-83	-128	-56	-46
Average Annual Lewiston Release	86	83	230	143	146
Average Annual Clear Creek Tunnel Flow	-82	-80	-222	-138	-142

Table 9-2. 1928 - 1934 Average Annual Impacts to the Trinity River System

Differences (TAF)	Study 2 - Study 1	Study 3 - Study 1	Study 5 - Study 1	Study 4 - Study 2	Study 5 - Study 3
Average Trinity EOS	-49	-69	-108	-48	-38
Average Annual Lewiston Release	85	85	128	42	44
Average Annual Clear Creek Tunnel Flow	-85	-85	-139	-51	-55

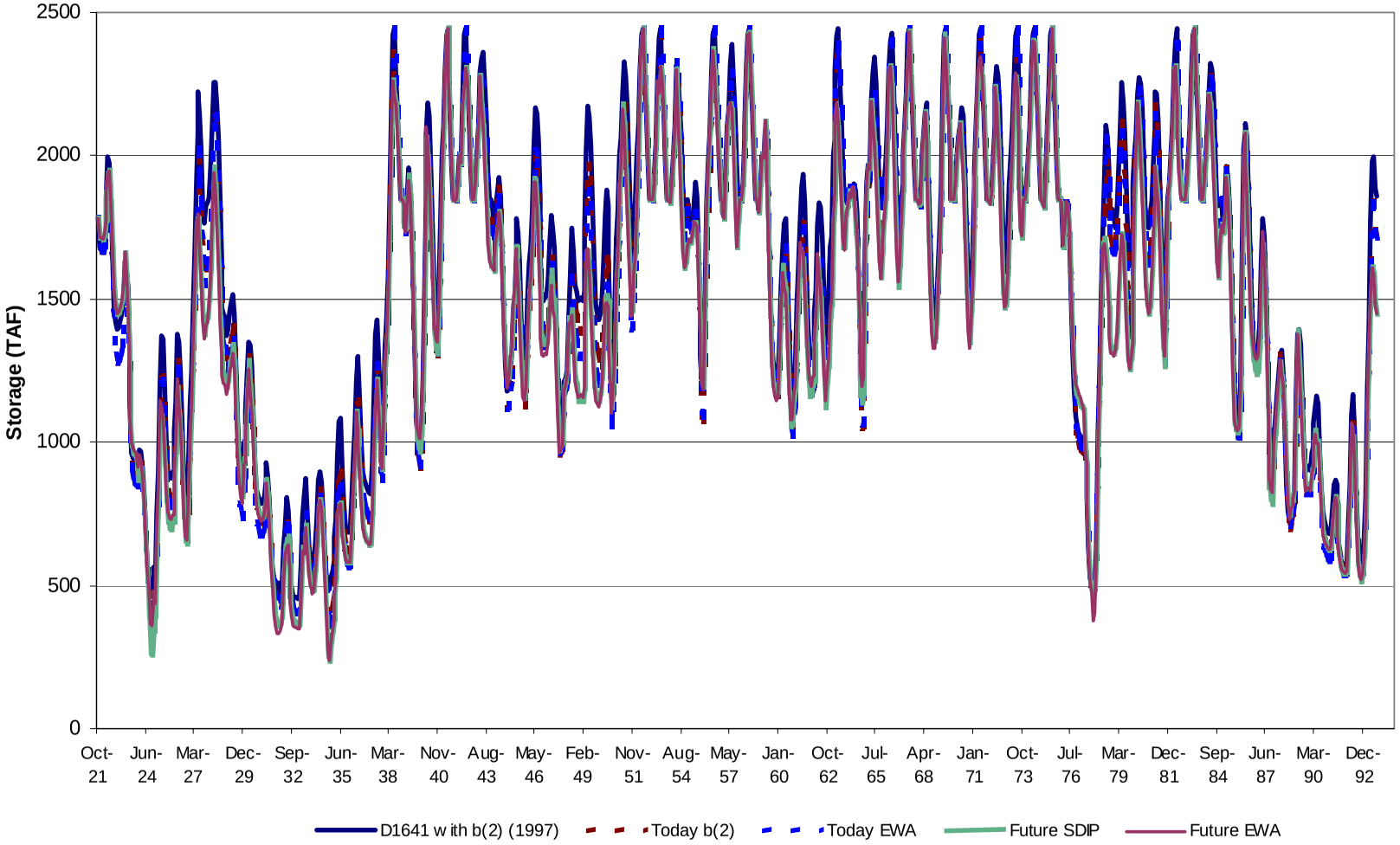

Figure 9-1 Chronology of Trinity Storage Water Year 1922 - 1993

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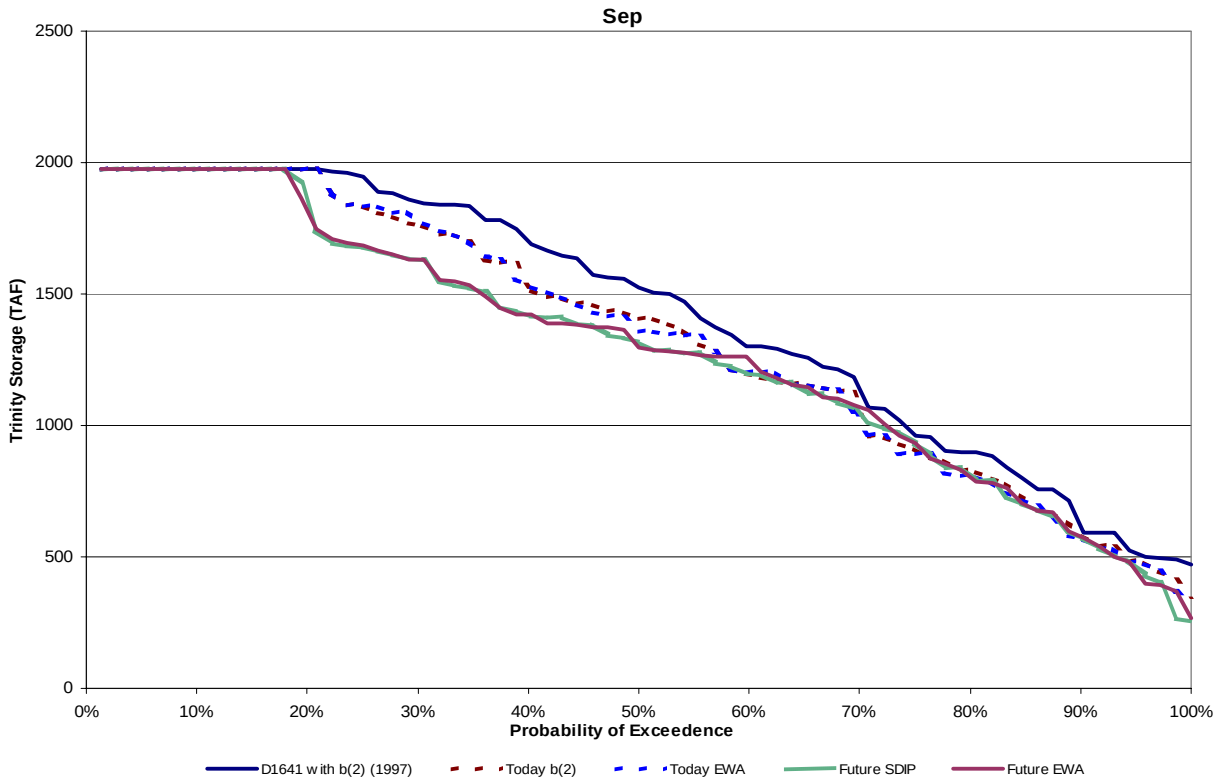

Figure 9-2 Trinity Reservoir End of September Exceedance

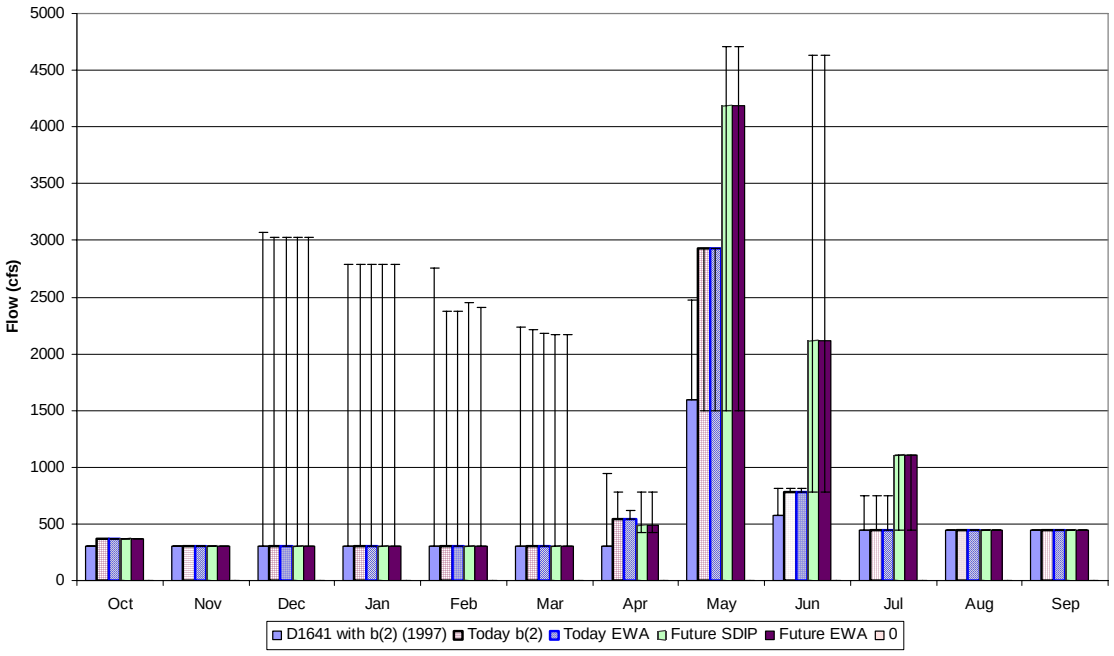

Figure 9-3 Lewiston 50th Percentile Monthly Releases with the 5th and 95th as the bars

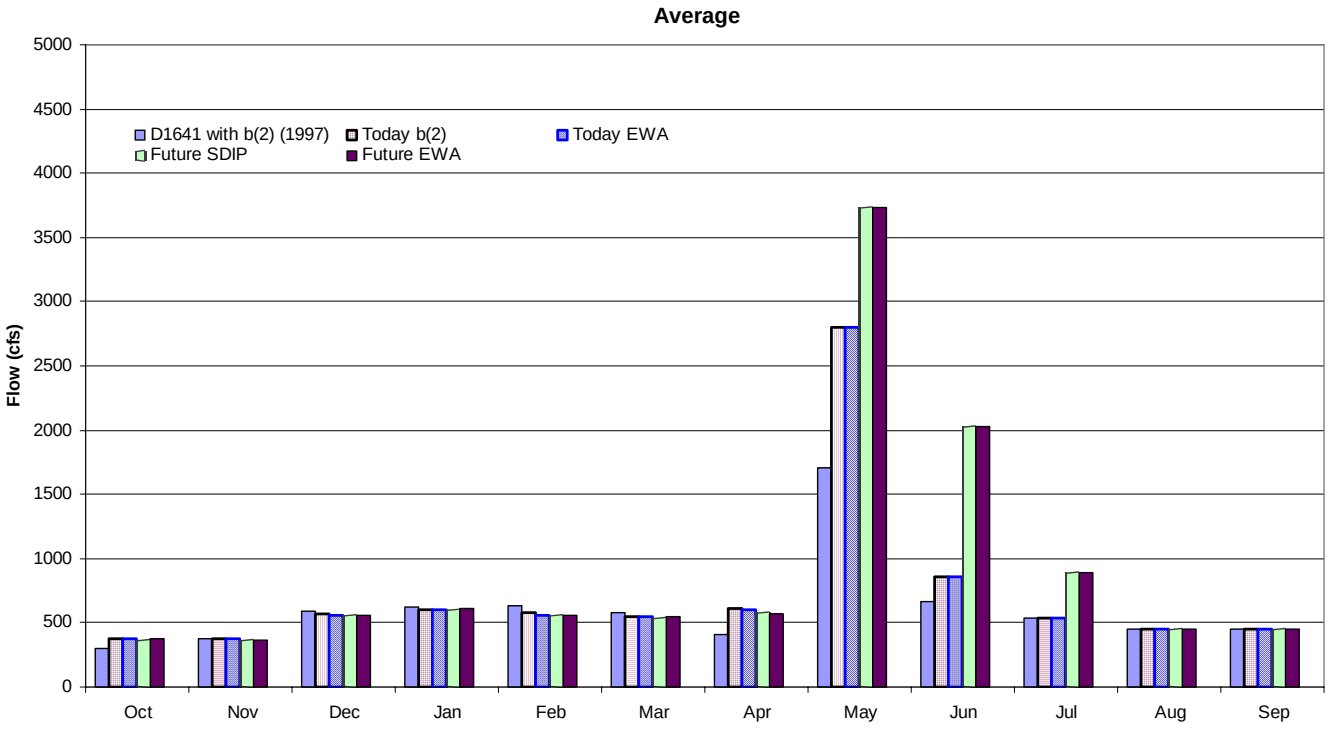

Figure 9-4 Average Monthly Releases to the Trinity from Lewiston

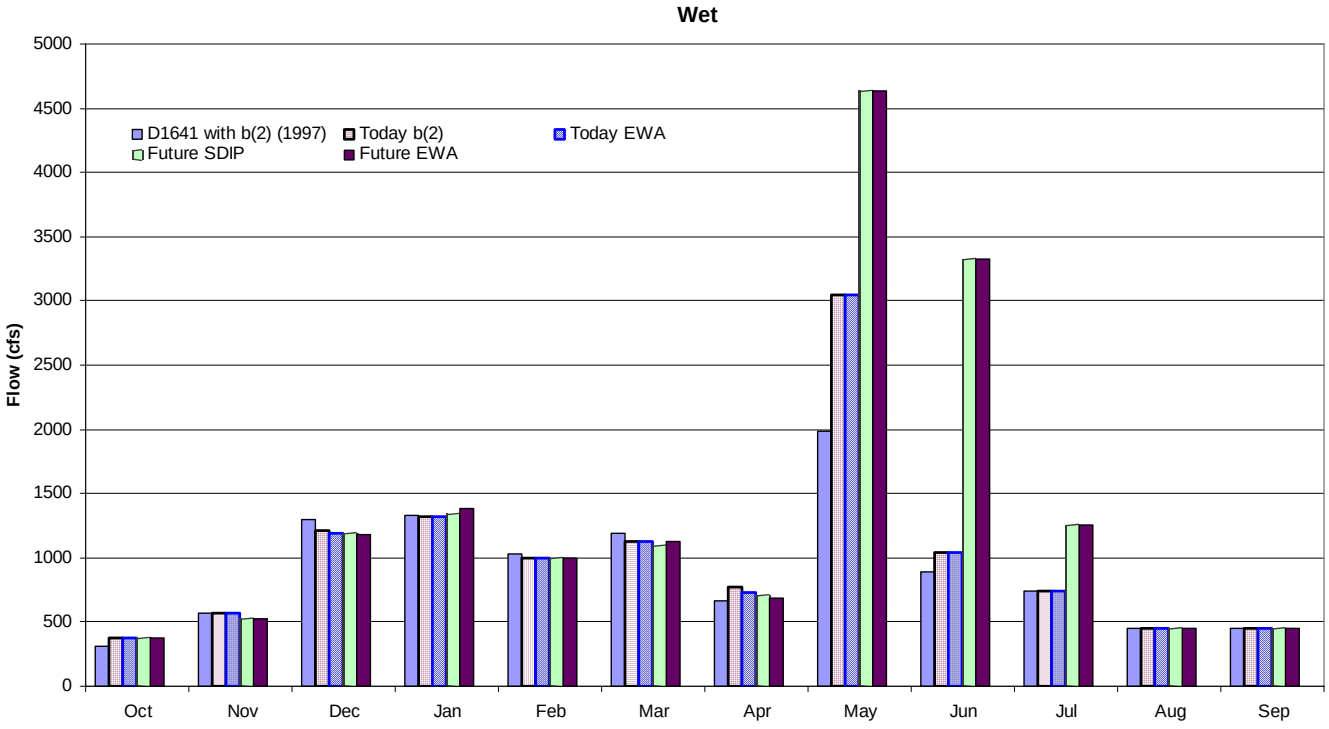

Figure 9-5 Average wet year (40-30-30 Classification) monthly releases to the Trinity

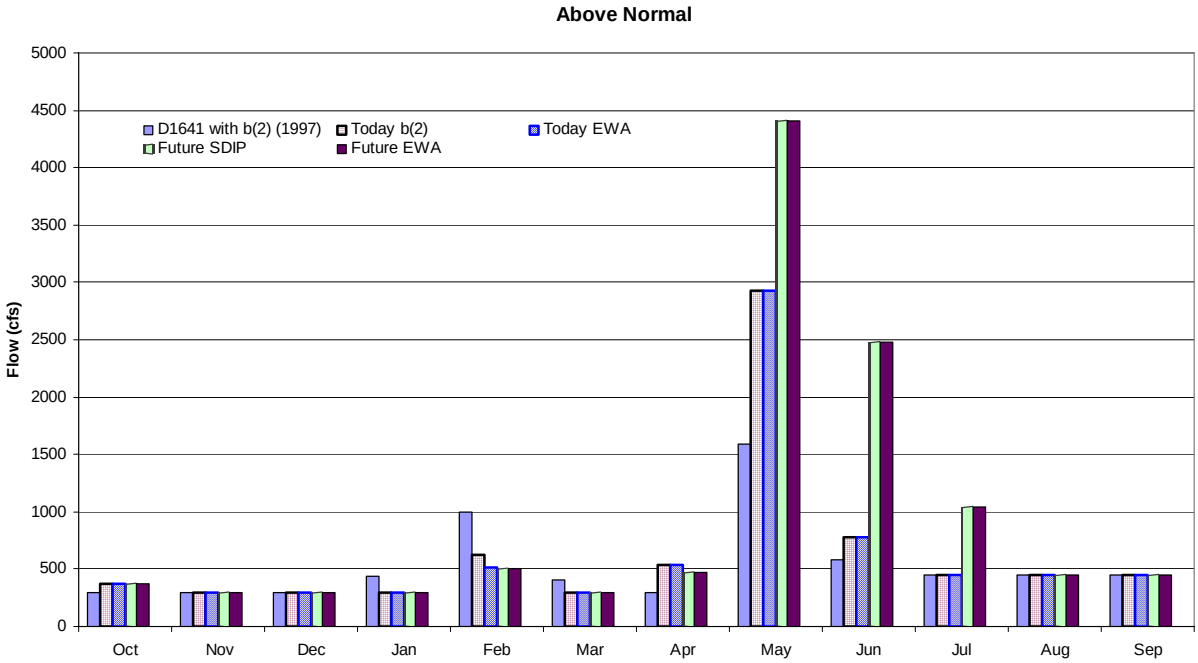

Figure 9-6 Average above normal year (40-30-30 Classification) monthly releases to the Trinity

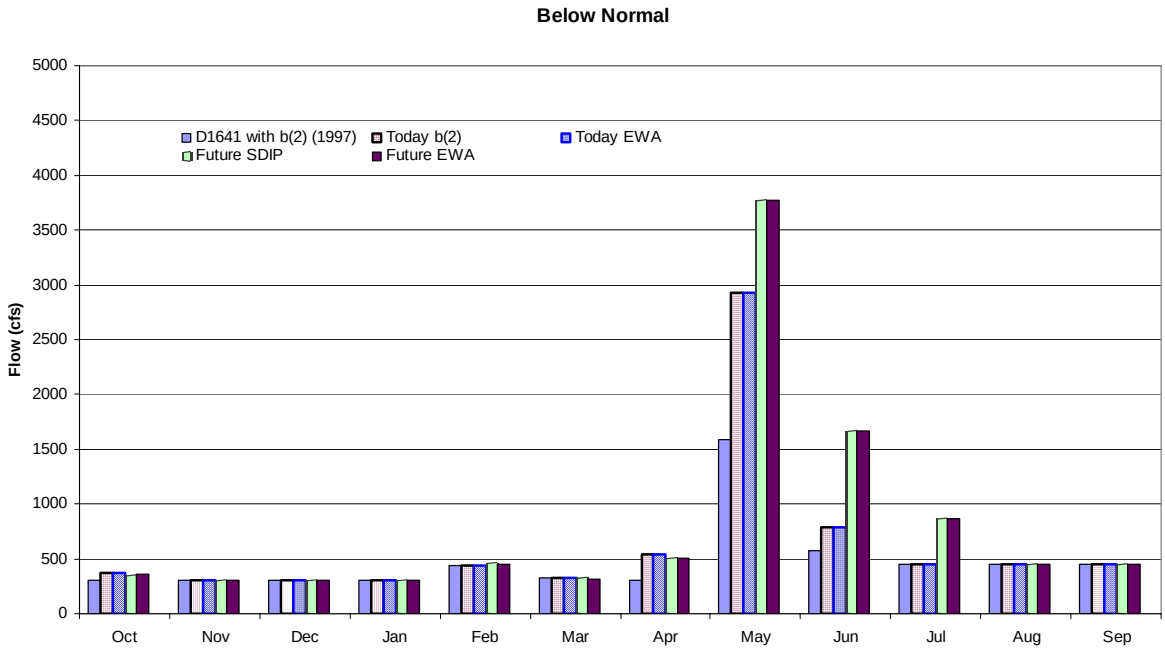

Figure 9-7 Average below normal year (40-30-30 Classification) monthly releases to the Trinity

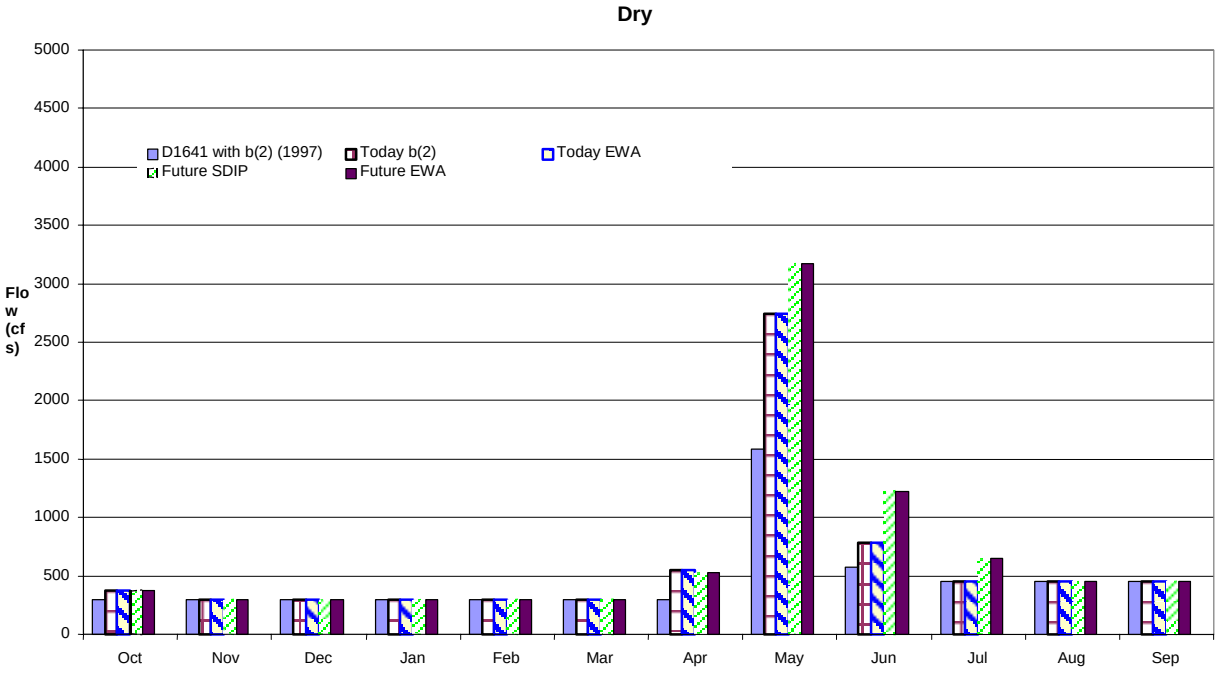

Figure 9-8 Average dry year (40-30-30 Classification) monthly releases to the Trinity

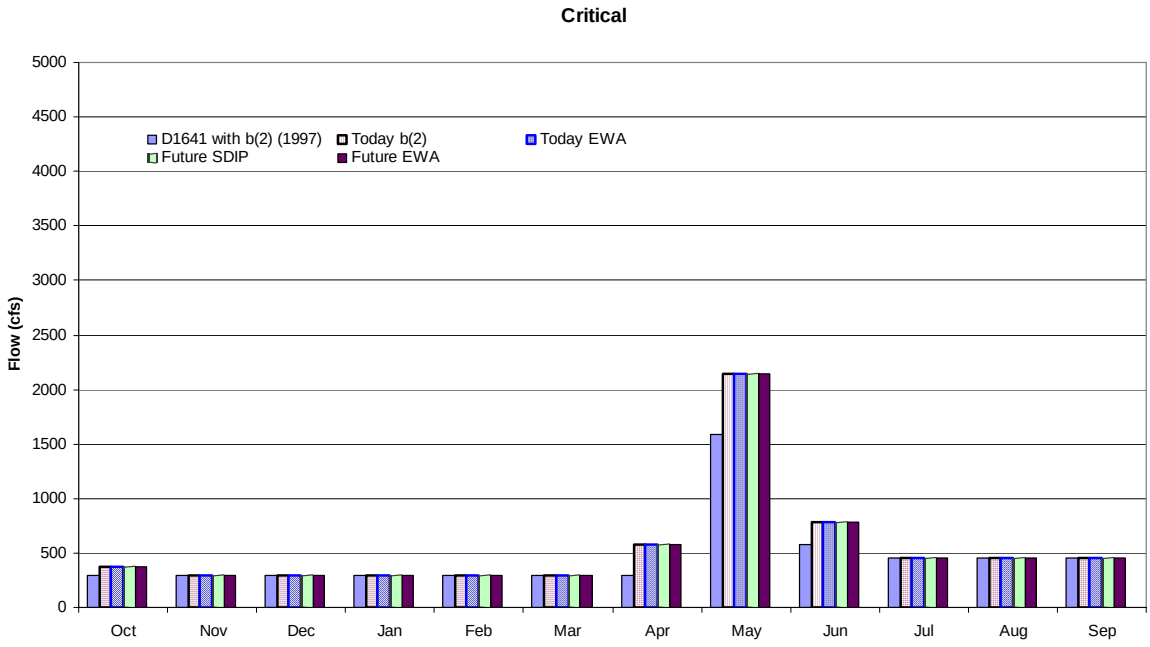

Figure 9-9 Average critical year (40-30-30 Classification) monthly releases to the Trinity

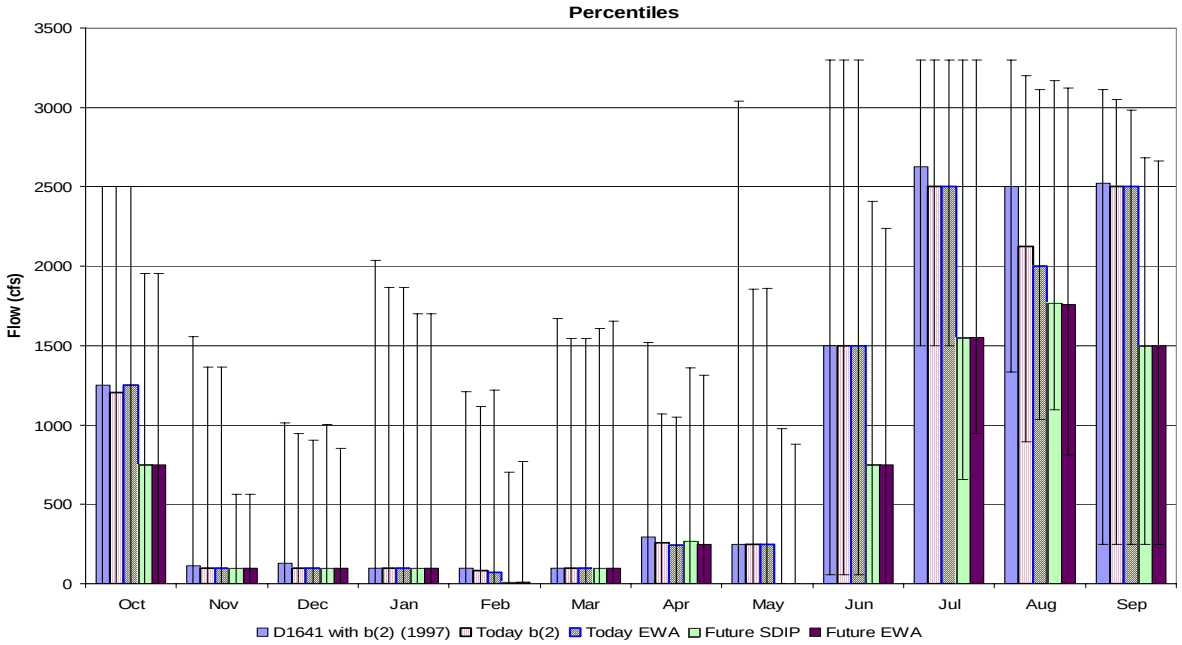

Figure 9-10 Clear Creek Tunnel 50th Percentile Monthly Releases with the 5th and 95th as the bars

Effects to Coho salmon in Trinity River

Adult Migration, Spawning, and Incubation

Flows in the Trinity River would be on more of a prescriptive schedule than in the Central Valley Rivers (Table 9–3).

Table 9–3 Trinity River releases (monthly average) at Lewiston Dam under current and future operations. Numbers in parentheses are frequency of occurrence. Ramping is figured into monthly averages. The hydrologic modeling period is less than 100 years so not all months add up to 100 percent due to rounding.

	Current, cfs	Future, cfs	Note
January	300	300	>300 (10%)
February	300	300	>300 (11%)
March	300	300	>300 (8%)
April	540 (83%)	427 (7%), 460 (27%), 493 (20%), 540 (26%)	>600 (17%)
May	1,498 (11%), 2,924 (89%)	1,498 (11%), 2,924 (26%), 4,189 (20%), 4,570 (11%), 4,709 (27%)	

	Current, cfs	Future, cfs	Note
June	783	783 (40%), 2,120 (18%), 2,526 (26%), 4,626 (12%)	
July	450	450 (60%), 1,102 (40%)	
August	450	450	
September	450	450	
October	373	373	
November	300	300	
December	300	300	>300 (10%)

Adult coho typically enter the Klamath River and the mouth of the Trinity starting in September with peak upstream migration occurring in October and November. Flows during this time would be a minimum of 300 cfs in all year types and would not change between the current operations and future operations scenarios. Flows are increased from 300 cfs to 373 cfs in October since 1997. This flow would provide adequate in stream conditions for the upstream migration of coho salmon. Water temperatures early in the upstream migratory period, in September, would often be above preferred ranges near the mouth of the Trinity, but dam operations cannot efficiently control water temperature at the mouth, 110 miles below Lewiston Dam. Releases would always be 450 cfs in September. Temperatures were modeled down to Douglas City. This is the reach where Trinity operations have the greatest temperature effect. Temperatures in September would be below 60° F at Douglas City in September of about 90 percent of years and suitable for holding adult coho. During a few dry years temperatures could exceed 60° F in September, potentially delaying upstream migration and leaving adults in warmer Lower Klamath and Trinity River reaches. Temperatures under future operations are increased by about 1° F in September, with or without EWA. Between October and May mean monthly temperatures at Douglas City would always be maintained at or below 60° F. During November when spawning initiates, average monthly temperatures would be almost always below 50° F at Douglas City. Flows during spawning and incubation would be maintained at 300 cfs, which has been shown to provide suitable conditions for spawning and incubation of coho salmon. Most coho spawning in the main stem occurs between Lewiston Dam and Douglas City with the greatest concentration in the first few miles below the dam.

Fry, Juveniles, and Smolts

The Trinity River supports young coho salmon in the main stem year round. Most rearing occurs upstream of Douglas City. A critical period for juvenile coho rearing in the Trinity may be June through September of dry years when water temperatures are at the high end of what is considered optimal for coho rearing. Under current operations water temperatures would be above a monthly average of 60° F about 20 percent of years in June, 60 percent of years in July, and 25 percent of years in August. Conditions under the future operational scenarios would be improved during this period. Temperatures in June would rise above 60° F about 5 percent of the time and in July they would be above 60° F in 30 percent of years. August temperatures would

be relatively unchanged. The temperature benefits under future operations are the result of higher releases provided in April through July. Temperatures are reduced by about 2° F on average under future operations in May, June, and July, with and without EWA.

The spring high flows under the future condition are provided to mimic the natural hydrograph during the snowmelt period. These flows should increase survival of out-migrating coho smolts. The higher flows are intended to return more natural geomorphic processes to the Trinity River (USDI 2000). These higher flows should benefit coho salmon through the long-term habitat values provided. The higher flows are designed to discourage riparian vegetation establishment down to the edge of the lower flow channel margins and to scour the bed to maintain spawning and rearing habitat (USDI 2000). Off channel habitats out of the main river flow are important for sustaining juvenile coho salmon through the winter months when water is cooler and may potentially be created by the higher flows. Flows under current operations should be adequate to sustain the in-river spawning coho salmon population at the current level. Flows in the future condition are intended to increase salmon and steelheads populations.

The net effect of future CVP operations on Coho salmon in the Trinity River should be a benefit to the population through the habitat values provided. The effect of current operations should be no change attributable to water operations.

Trinity River Chinook Salmon EFH

The increased flows in the spring for the restoration program would aid out-migrating Chinook so smolt survival should increase. The habitat benefits provided through more natural geomorphic processes should benefit Chinook salmon.

Temperatures in the Trinity during the fall Chinook spawning period will be slightly increased in the future because more water would be released early in the season. The result will be slightly higher egg mortality, mostly in critically dry years (Figure 9–11).

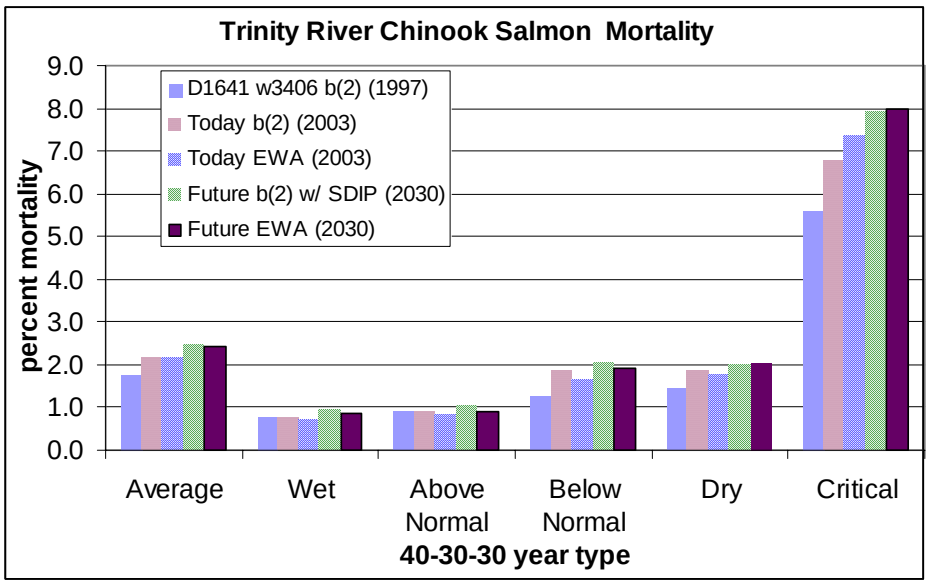

Figure 9–11 Percent mortality of Chinook salmon from egg to fry in the Trinity River based on water temperature by water year type.

Clear Creek

Modeling

Whiskeytown Reservoir tries to maintain 235,000 af End of September storage. Figure 9-12 shows that the End of September Storage for Whiskeytown dropped from 235,000 af to 180,000 af from once in Study 1 (1932) to three times in Study 2 and Study 3 (1924, 1932 and 1934) and increases to 4 times in Study 4 and Study 5 (1924, 1931, 1932 and 1934). The drawdown of storage are also illustrated in the Storage spreadsheet for the 5 study comparison in the CALSIM II Modeling Appendix. The increased frequency of drawdowns during the 1928 – 1934 drought are due to trying to maintain the same minimum flows down Clear Creek while importing as much from Clear Creek Tunnel and and causing increased dedication of inflow for releases, see Table 9-4 and Table 9-5.

Table 9-4. Long-term Average Annual Differences in Flows for Clear Creek Tunnel, Clear Creek Release and Spring Creek Tunnel

Differences (TAF)	Study 2 - Study 1	Study 3 - Study 1	Study 5 - Study 1	Study 4 - Study 2	Study 5 - Study 3
Annual Clear Creek Tunnel	-82	-80	-222	-138	-142
Annual Clear Creek Release	-2	-3	-2	-1	0
Annual Spring Creek Tunnel	-81	-78	-220	-138	-142

Table 9-5. Average Annual Differences in Flows for Clear Creek Tunnel, Clear Creek Release and Spring Creek Tunnel for the 1928 to 1934 drought period

Differences (TAF)	Study 2 - Study 1	Study 3 - Study 1	Study 5 - Study 1	Study 4 - Study 2	Study 5 - Study 3
Annual Clear Creek Tunnel	-85	-85	-139	-51	-55
Annual Clear Creek Release	-2	-5	-5	-4	0
Annual Spring Creek Tunnel	-83	-79	-132	-46	-53

Figure 9-13 shows that Clear Creek is mainly being driven by the 3406 (b)(2) releases with the 50th and 95th percentiles for each month in all 5 studies being identical. Figure 9-14 to Figure 9-19 illustrate the monthly averages by long-term average and by 40-30-30 Water Year Classification.

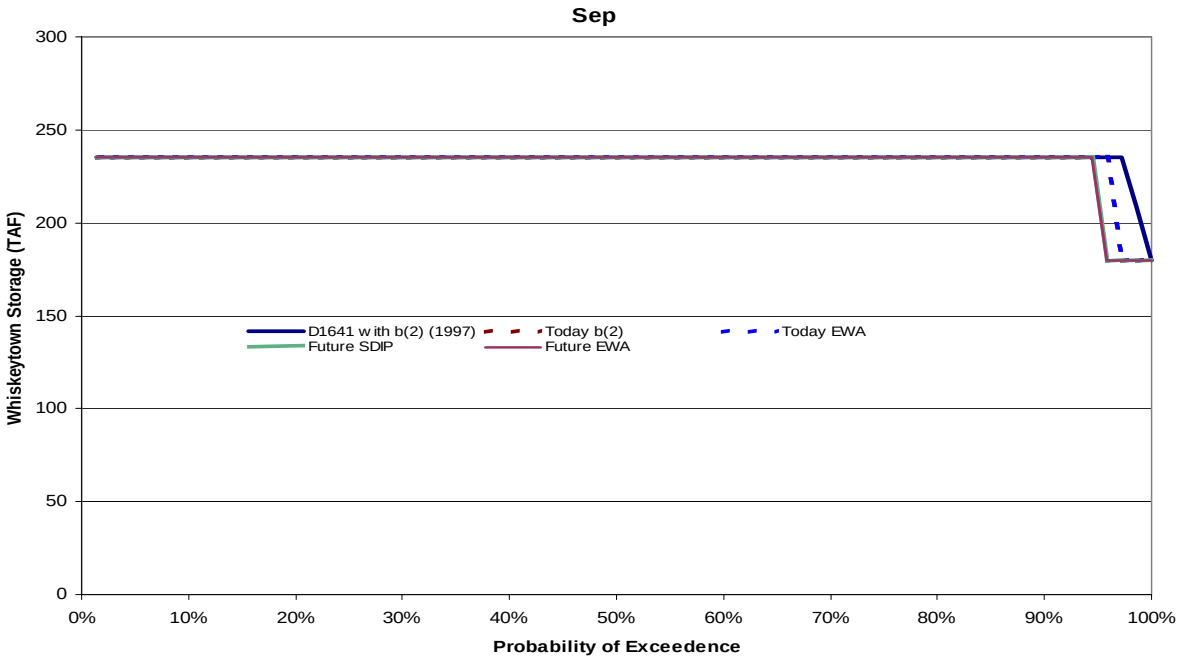

Figure 9-12. Whiskeytown Reservoir End of September Exceedance



Figure 9-13 Clear Creek Releases 50th Percentile Monthly Releases with the 5th and 95th as the bars

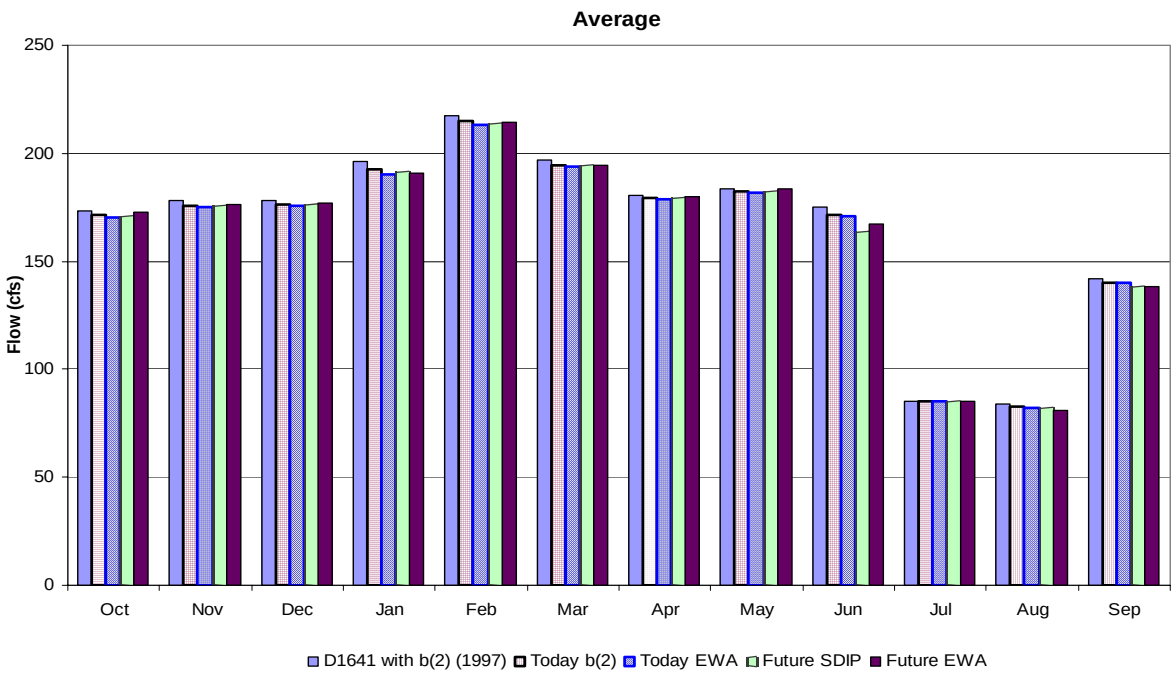

Figure 9-14 Long-term Average Monthly Releases to Clear Creek

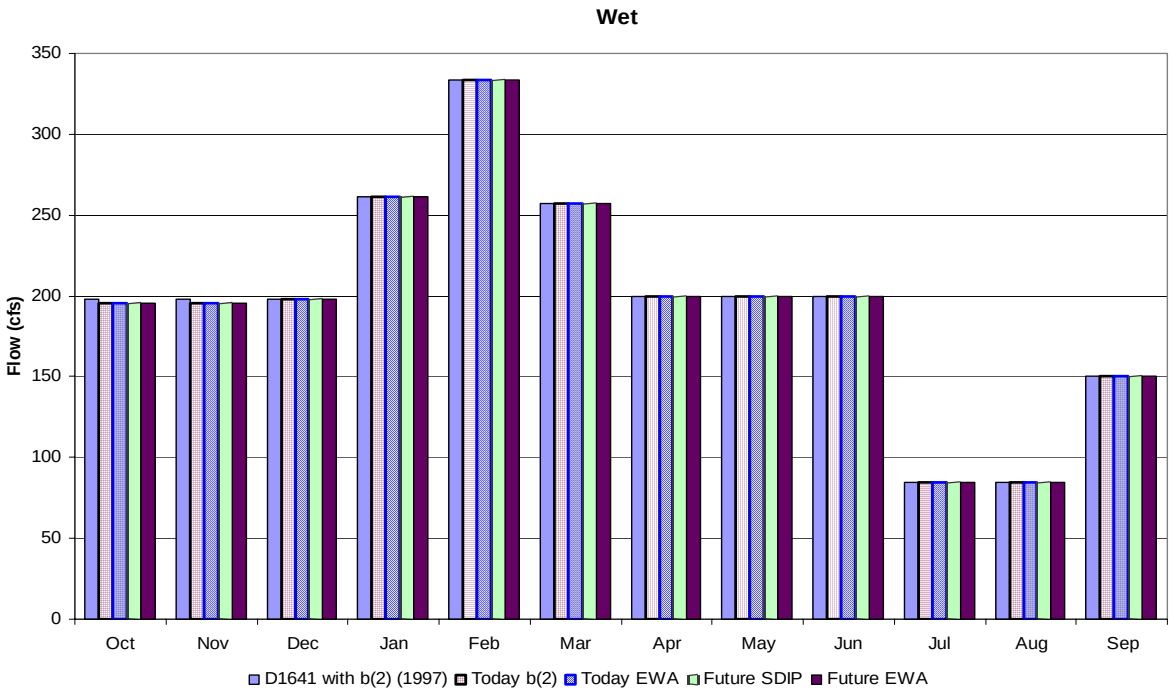

Figure 9-15 Average wet year (40-30-30 Classification) monthly releases to Clear Creek

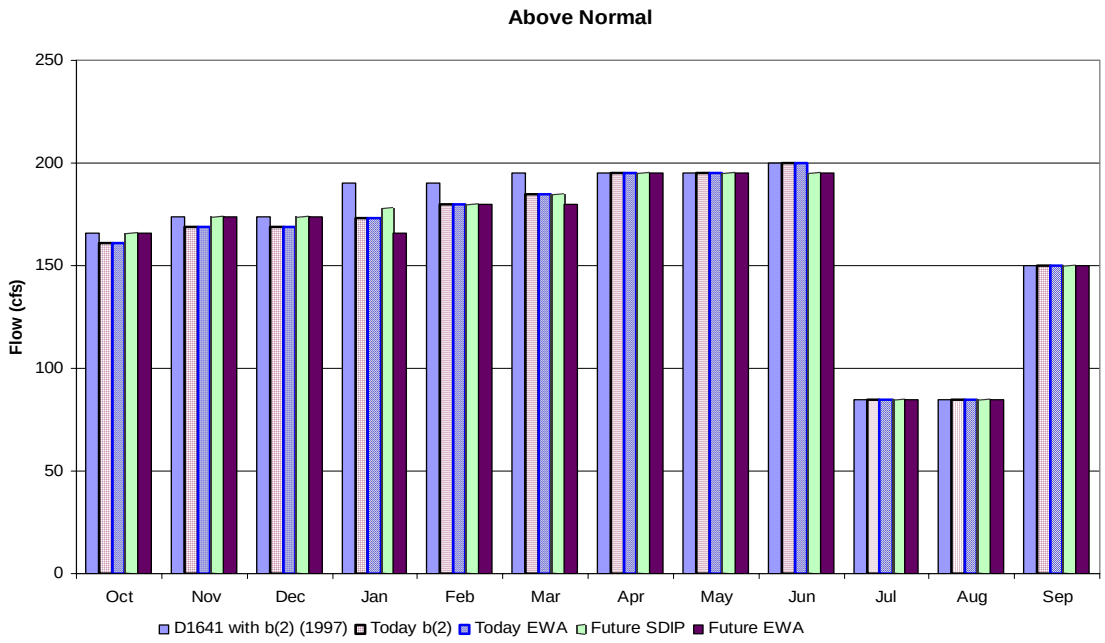

Figure 9-16 Average above normal year (40-30-30 Classification) monthly releases to Clear Creek

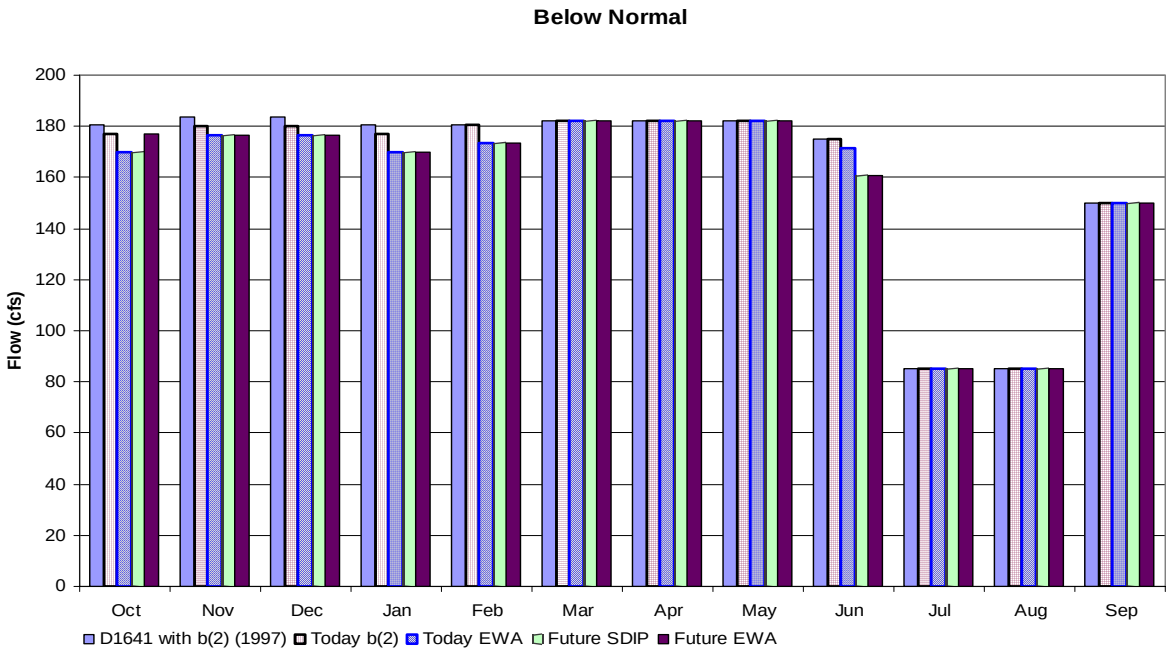

Figure 9-17 Average below normal year (40-30-30 Classification) monthly releases to Clear Creek

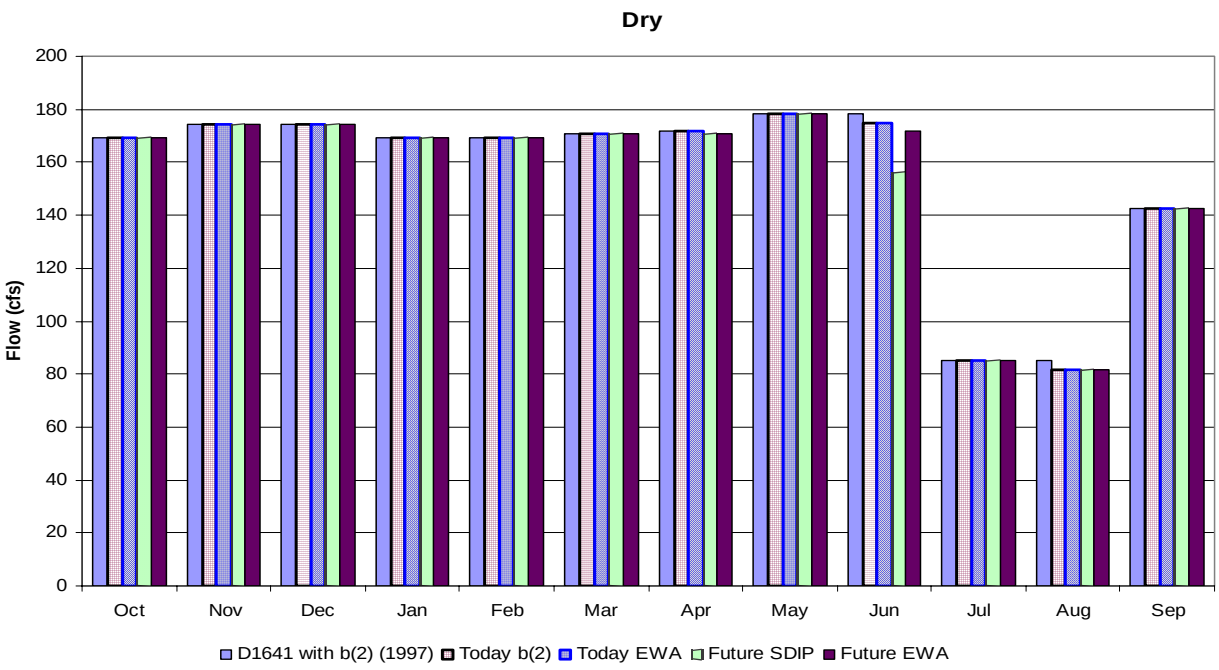

Figure 9-18 Average dry year (40-30-30 Classification) monthly releases to Clear Creek

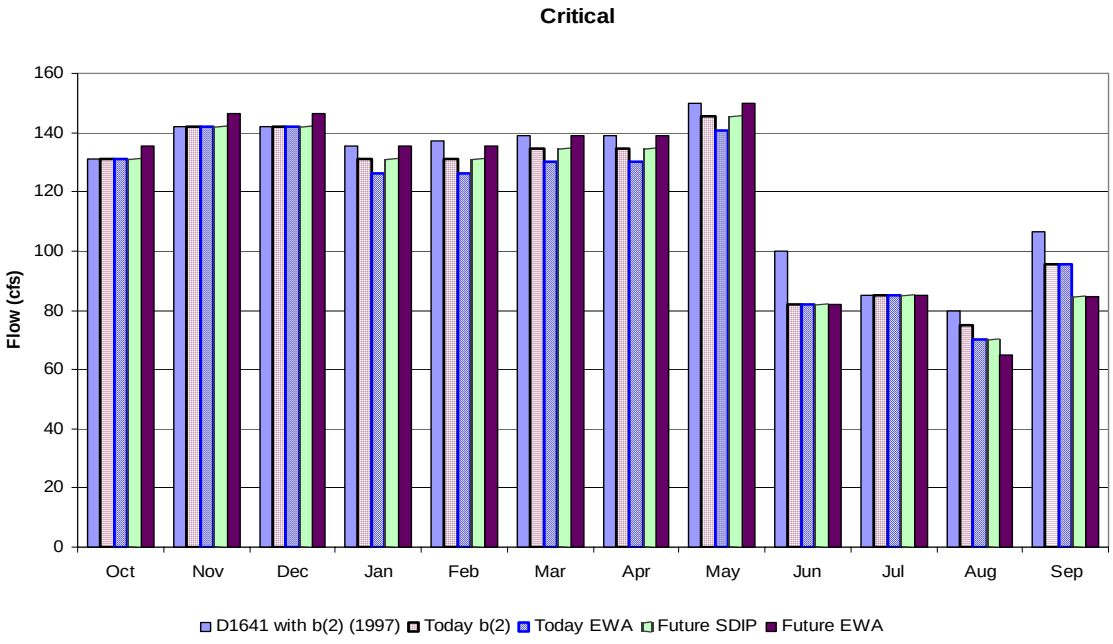

Figure 9-19 Average critical year (40-30-30 Classification) monthly releases to Clear Creek

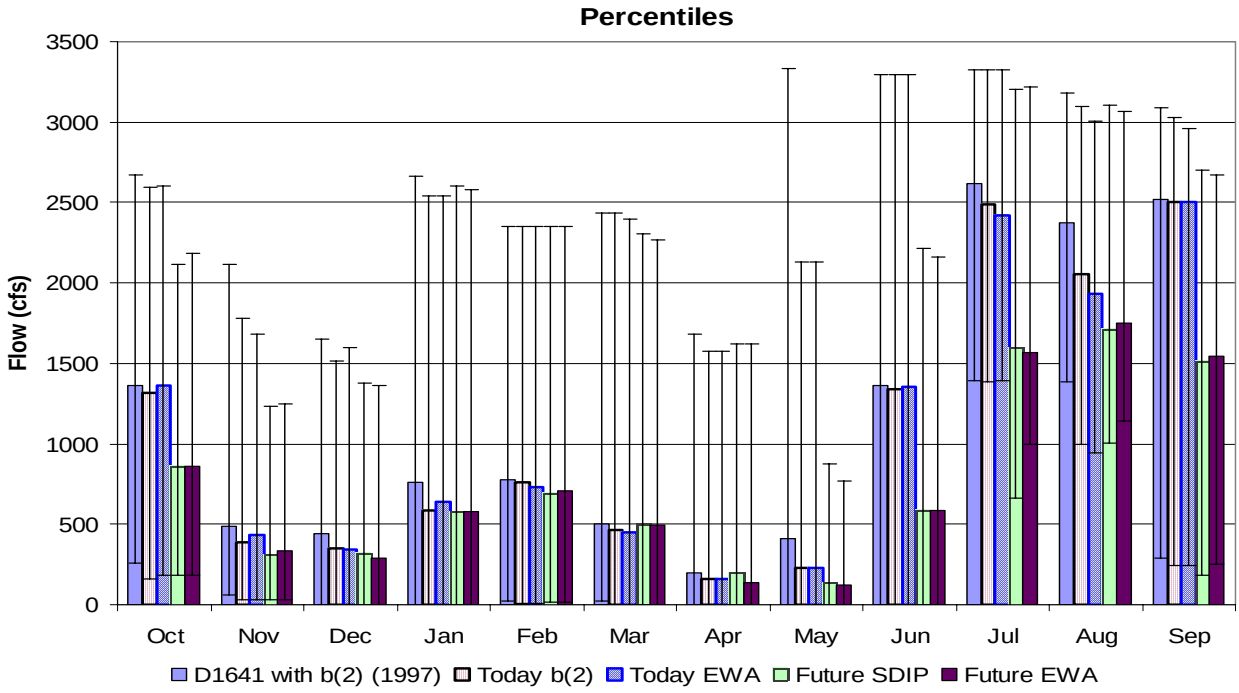

Figure 9-20 Spring Creek Tunnel 50th Percentile Monthly Releases with the 5th and 95th as the bars

Adult Migration, Spawning, and Incubation

The removal of the McCormick-Saeltzer Diversion Dam in 2000 at river mile 6.5 gave salmon and steelheads easier access to the base of Whiskeytown Dam 18 miles upstream from the Sacramento River. A natural bedrock chute just below the old Saeltzer dam site may be a low flow partial barrier to Chinook. Most steelheads adults are expected to migrate upstream in Clear Creek during December through March to spawn with spawning potentially stretching into April. Water temperatures during this period are projected to be within the preferred range for steelheads spawning and incubation between Whiskeytown Dam and Igo. Flow releases from Whiskeytown Dam into Clear Creek during upstream migration are expected to be 200 cfs in about 70 percent of the years during steelheads upstream migration in all scenarios. During the drier years releases are expected to be lower, as low as 30 cfs in the driest years in all scenarios. Optimal spawning flows were estimated to be 87 cfs upstream of the old Saeltzer dam site and 250 cfs below the old dam site (Denton 1986). Nearly all steelheads/rainbow spawning documented in redd surveys occurs close to Whiskeytown Dam (Jess Newton, personal communication, April 2003). During most years flows should be suitable for spawning in upstream areas but during dry years flows for attraction, holding, and upstream migration could be less than optimal. Tributary inflows downstream of Whiskeytown Dam provide some variation in the lower river hydrograph for increased attraction and migratory flows during rainfall events.

Spring–run Chinook salmon enter Clear Creek from April through September and spawn during August and September. Flow releases would be 200 cfs over 70 percent of the time in April, May, and June. Flows in July would always be 85 cfs and in August almost always 85 cfs except during the driest years when they could drop to 30 cfs. September flows would be 150 cfs except during the driest 10 percent of years when they would be 30 cfs. These flows should provide adequate habitat for Chinook salmon upstream of the former Saeltzer Dam site. During the driest years the 30 cfs flows would not accommodate a large number of spawners so depending on run size more competition for spawning sites may occur. Spring–run may benefit from a spawning attraction release during the late spring period to assist in upstream migration and passage through the bedrock chute area. This may be provided by CVPIA section (b)(2) water. Flows during dry years could be as low as 30 cfs. These flows would likely be too low for spring–run to migrate upstream. Chinook would not likely make it past the bedrock chute area at this flow. The area of Clear Creek upstream of the Clear Creek road bridge to Whiskeytown Dam is considered to be spring–run habitat (Jim DeStaso, personal communication). Denton (1986) estimated optimal flows for salmon in this reach would be 62 cfs for spawning and 75 cfs for rearing based on the IFIM study, provided suitable incubation and rearing temperatures were provided. Spring–run begin spawning in Clear Creek in September. The flows of 30 cfs in dry years would be below the optimum flow for Chinook spawning. Unless the spring–run population increases above present levels, spawning habitat availability should not be limiting, as long as the fish are able to migrate to the habitat at the lower flow levels. Water temperatures at Igo sometimes exceed optimal spawning and incubation temperatures of <56° F. Most spring–run would likely spawn upstream closer to Whiskeytown Dam where optimal spawning and incubation temperatures can be provided year round. NOAA Fisheries (2003) states that the Denton (1986) flow recommendations are not applicable and that there are no applicable studies completed that can be used to describe the effect of operations on rearing, emigration, and spawning. Therefore use of the Denton (1986) recommendations may be somewhat subjective but in the absence of other on-the-ground recommendations we used Denton (1986).

High flow events during the incubation period have the potential to scour redds and injure pre-emergent fry. High flow events in excess of 1,000 cfs often occur during heavy rain in the winter and spring (Figure 11–7). High flow events of approximately 3,000 cfs or greater, which occur infrequently, are needed to wash the artificially deposited gravel downstream (Table 9–9). Whiskeytown Reservoir releases remain constant during all but the heaviest runoff periods when the reservoir overflows through the glory hole outlet. High flow events in Clear Creek are now smaller than those that occurred prior to flow regulation in the system. Clear Creek fishery studies found that spawning gravel in Clear Creek could be improved by adding spawning gravel below Whiskeytown Dam and allowing high flows to deposit it in downstream spawning areas. High flow events of approximately 3,000 cfs or greater, which occur infrequently, are needed to wash the artificially deposited gravel downstream(Table 9–9).

Steelheads fry are expected to emerge from redds from approximately mid-February through May. Release temperatures from Whiskeytown Dam are modeled to remain at optimal levels throughout this period. Most fry will likely remain in upstream areas near where they were spawned, at least through the early rearing period until early summer. Spring–run Chinook fry emerge from redds between December and February, depending on water temperature where they are spawned. Water temperatures during this period are optimal for survival of fry.

Fall–run Chinook salmon are expected to enter the river starting in August and continuing through October, with spawning occurring in November and December. Higher than preferred temperatures during August of some years could potentially delay entry of adults into the river because Sacramento River temperatures will be a few degrees cooler. Temperatures during the spawning period should be suitable for incubation of fall–run Chinook salmon.

Fry, Juveniles, and Smolts

The freshwater life stages of steelheads and Chinook salmon could occupy Clear Creek throughout the year. Mean monthly temperatures of Whiskeytown Reservoir releases are modeled to be in the preferred range for growth and development of steelheads (45° F to 60° F) and of Chinook salmon (50° F to 60° F) throughout the year under all hydrologic conditions. Whiskeytown releases would be about 1° F cooler under both future scenarios in July through September and up to 1° F warmer in October and November. Other months would be essentially unchanged. Average monthly temperatures downstream below Igo will rise above 60° F in August in about 5 percent of years in the future vs. 4 percent of years under current operations. The average monthly temperatures are always within the range that the species have been shown to survive and grow well with adequate food supplies (Myrick and Cech 2001). Based on observations of juvenile salmonids and their prey in streams further north, food availability does not appear to be a limiting factor to salmon or steelheads in the upstream rearing areas of any of the affected Central Valley streams.

Optimal rearing and emigration flows have not been estimated for Clear Creek. We expect that the modeled flows will be suitable for the rearing, smoltification, and emigration of steelheads and Chinook salmon during most years. During the driest years flows during summer and fall could be limiting for steelheads rearing and for spring–run Chinook that hold over in Clear Creek through the summer. During dry years, a source of somewhat higher flows for out migration could be provided by brief tributary inflows during rainfall events, but these would be dependent on the weather.

There would be little difference in flows between current and future operations under all scenarios. No change in effect on fish is anticipated. Water temperature below Igo would be about 1° F cooler in August and September and 1° F warmer in October and November under future operations. The result should be slightly improved conditions for spring–run and steelheads during late summer. The warmer October and November temperatures would primarily affect fall–run spawning and spring–run incubation but are within the preferred temperature ranges of the species.

Stranding of fry and juvenile steelheads and Chinook salmon could occur following high flow events if river stages drop rapidly and isolate fish in stream margins that are not connected to the main channel. Whiskeytown Reservoir releases typically remain constant under the majority of flood events. If uncontrolled spills do occur, they are made through the “glory hole” at Whiskeytown Reservoir. The reservoir attenuates flood flows by spreading stage changes over the entire surface area and the glory hole naturally dampens the change in rate of flow along with the changes in reservoir water surface elevation. Rapid decreases in river stage following high flow events are typically the result of unimpaired flows from local and tributary inflows

downstream from Whiskeytown Reservoir. Flow changes under proposed operations are less than those that occurred prior to flow regulation.

Sacramento River

Modeling

The largest impact to Shasta reservoir operations is reduction of Trinity Imports from Spring Creek Tunnel in the summer months (Table 9-6). The reduction in imports is more damaging to storage and cold water pool during the long-term droughts as the reservoir is not allowed to fill and the pool diminishes each consecutive year (see for averages during the 1928 – 1934; see Figure 9-21 and Figure 9-22 for traces of the 1928 - 1934 and 1986 - 1992 droughts, respectively).

Table 9-6. Long-term Average Annual and End of September Storage Differences for Shasta Storage, Spring Creek Tunnel Flow, and Keswick Release

Differences (TAF)	Study 2 - Study 1	Study 3 - Study 1	Study 5 - Study 1	Study 4 - Study 2	Study 5 - Study 3
Annual Spring Creek Import	-81	-78	-220	-138	-142
Shasta EOS	-43	-46	-177	-131	-130
Annual Keswick Release	-79	-77	-217	-136	-141

Table 9-7. Average Annual and End of September Storage Differences for Shasta Storage, Spring Creek Tunnel Flow, and Keswick Release for the 1928 to 1934 drought period

Differences (TAF)	Study 2 - Study 1	Study 3 - Study 1	Study 5 - Study 1	Study 4 - Study 2	Study 5 - Study 3
Annual Spring Creek Import	-83	-79	-132	-46	-53
Shasta EOS	-119	-124	-254	-104	-129
Annual Keswick Release	-72	-64	-88	-16	-24

Figure 9-24 shows the End of September exceedance for Shasta storage, the 1.9 Million af requirement in the Winter Run B.O (1993) is more frequently violated as the imports from the Trinity are reduced from Study 1 to Studies 2 and 3 and from Studies 2 and 3 to Studies 4 and 5. Figure 9-25 shows the monthly percentiles flows for releases from Keswick Reservoir. Figure 9-26 to Figure 9-31 show the monthly average flows by long-term average and by 40-30-30 Index water year classification. The percentile and average charts indicate that as the imports from Trinity decrease the monthly flow also decrease. The simulated decreases in monthly flow releases are affected by the interpolation of required flow release versus storage and actual operations might include the same monthly flow and would lead to a further decrease in Shasta storage.

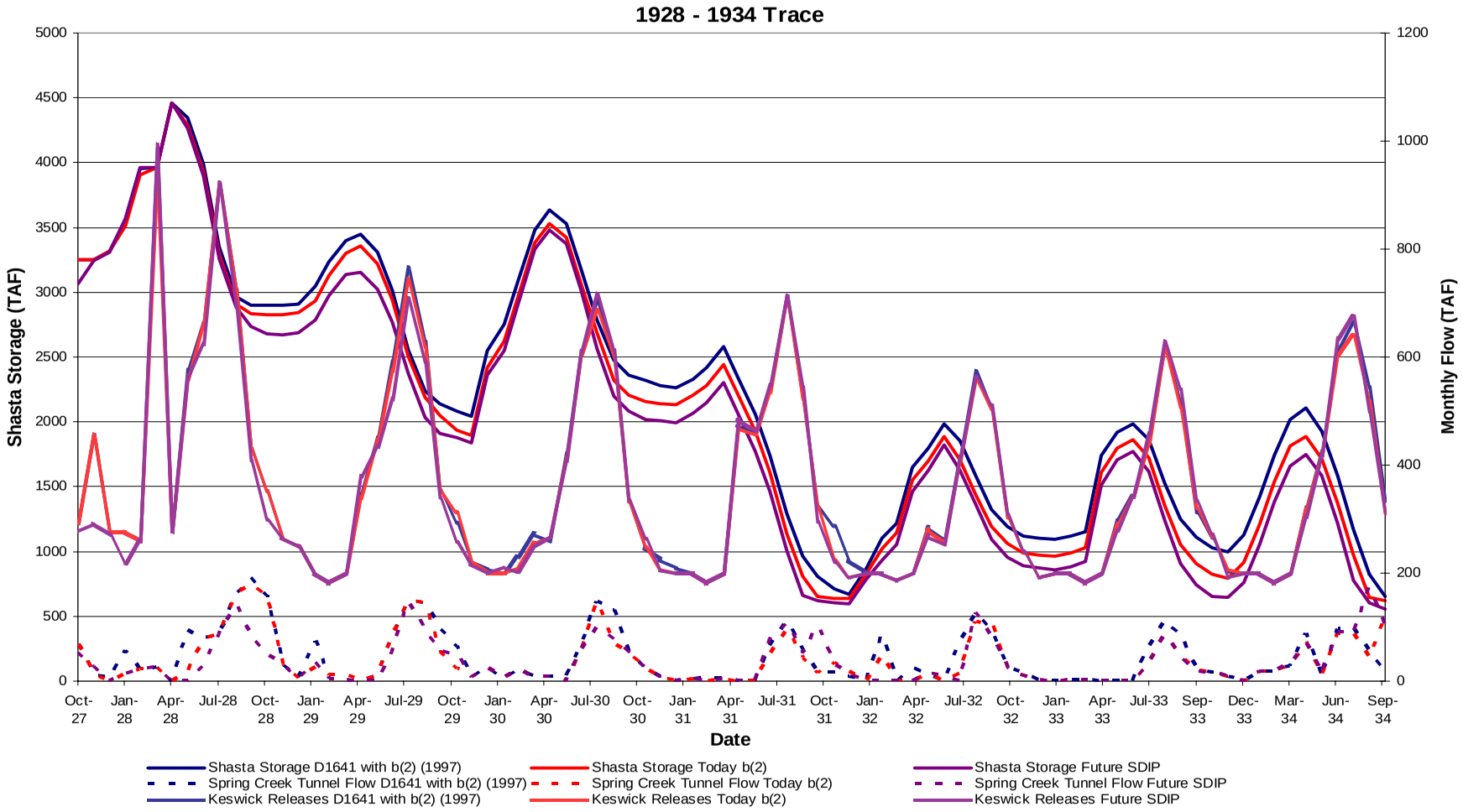

Figure 9-21. Oct-1927 to Sep-1934 Trace of Shasta Storage, Spring Creek Tunnel Flow, and Keswick Release for Studies 1, 2 and 4

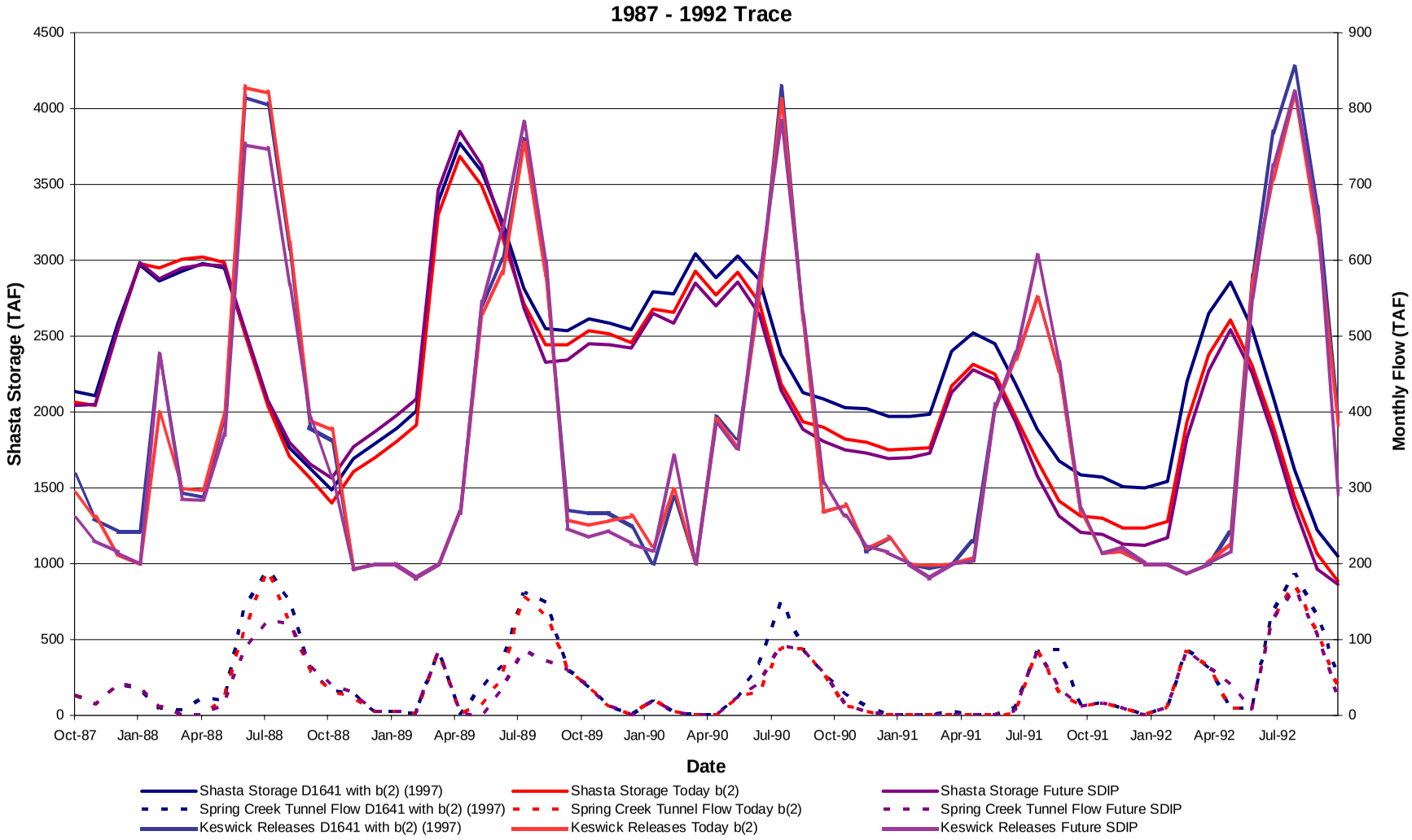

Figure 9-22. Oct-1987 to Sep-1992 Trace of Shasta Storage, Spring Creek Tunnel Flow, and Keswick Release for Studies 1, 2 and 4

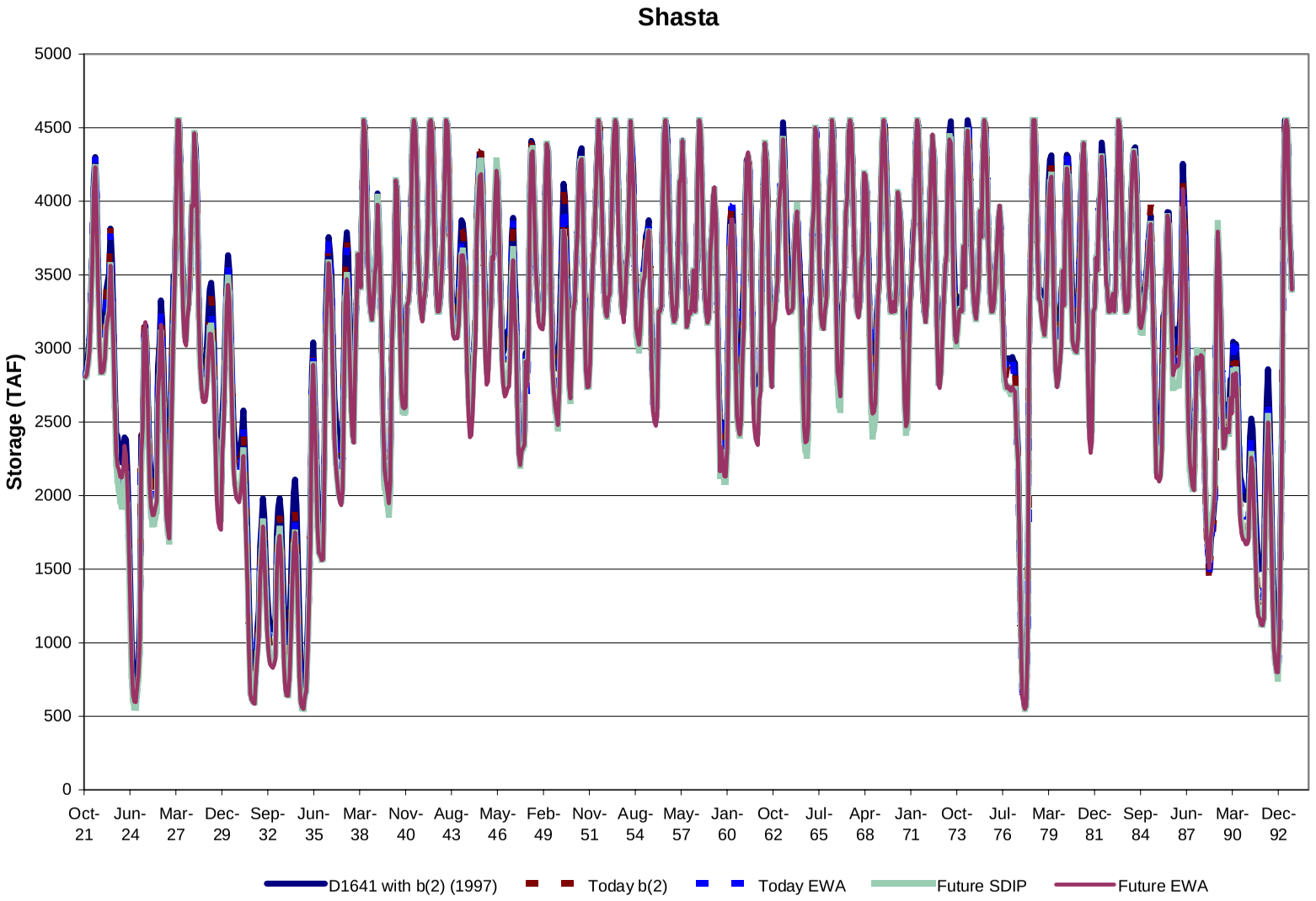

Figure 9-23. Chronology of Shasta Storage Water Year 1922 - 1993

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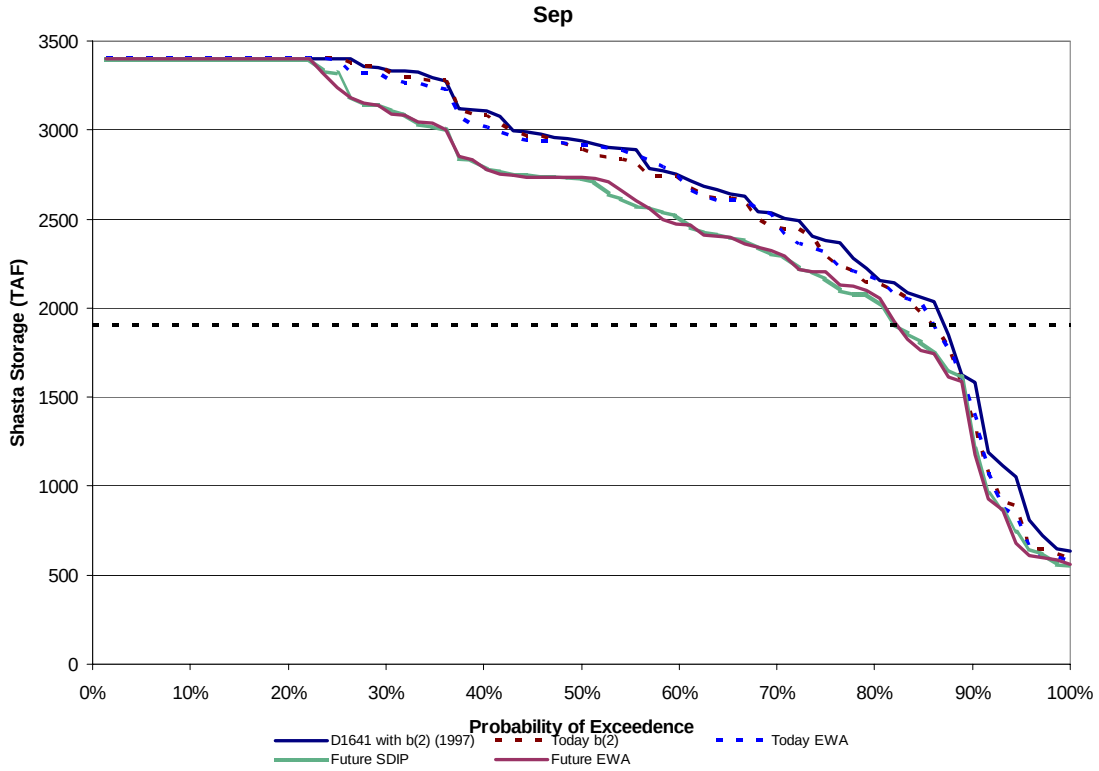


Figure 9-24 Shasta Reservoir End of September Exceedance

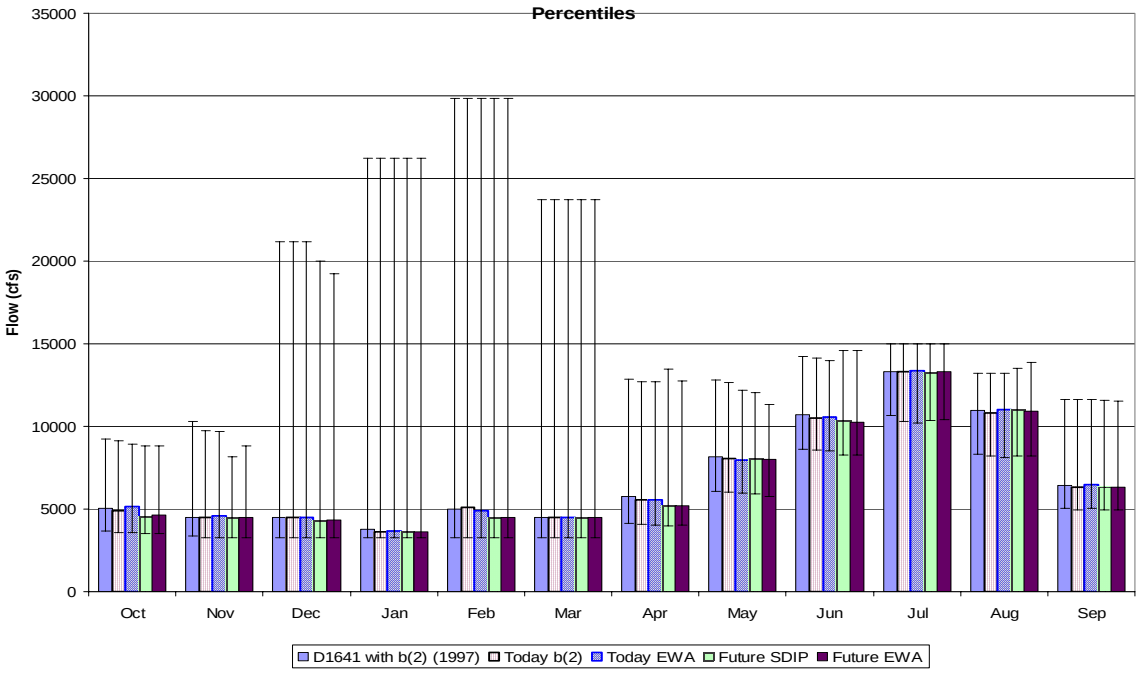


Figure 9-25 Keswick 50th Percentile Monthly Releases with the 5th and 95th as the bars

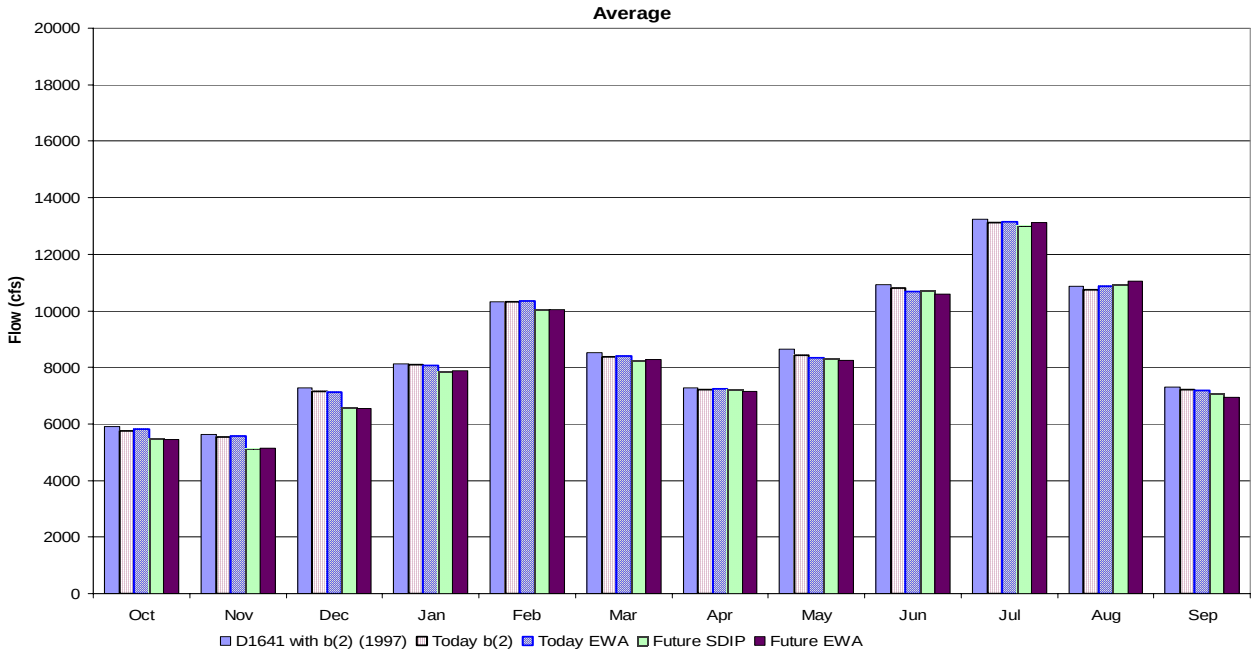


Figure 9-26 Average Monthly Releases from Keswick

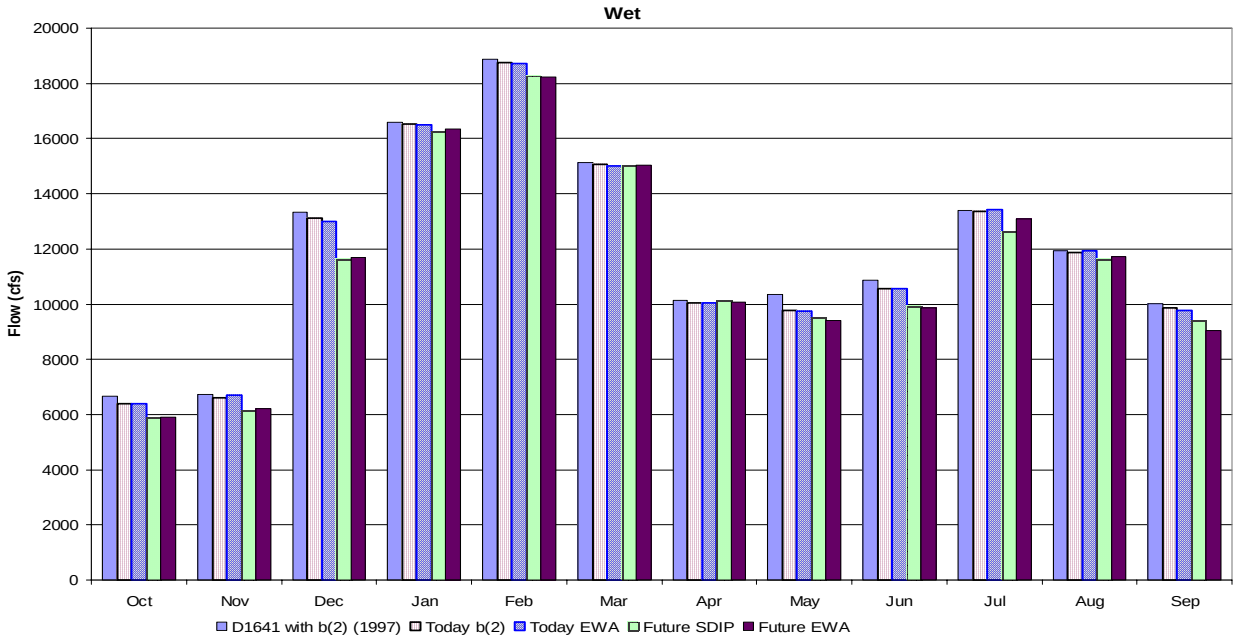


Figure 9-27 Average wet year (40-30-30 Classification) monthly releases from Keswick

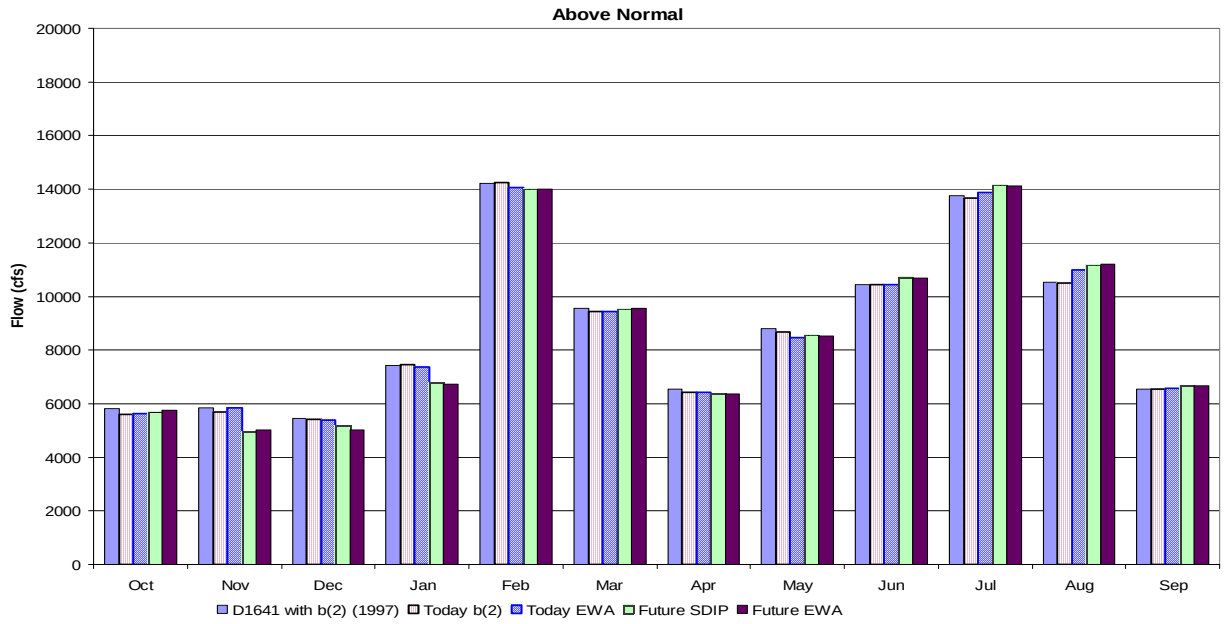


Figure 9-28 Average above normal year (40-30-30 Classification) monthly releases from Keswick

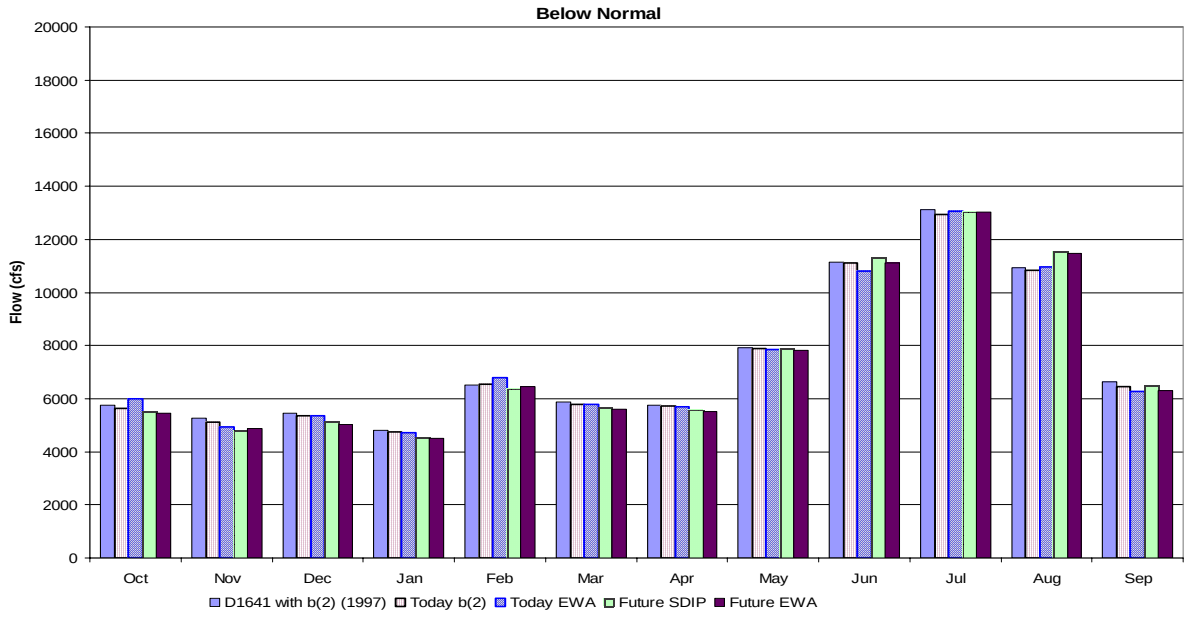


Figure 9-29 Average below normal year (40-30-30 Classification) monthly releases from Keswick

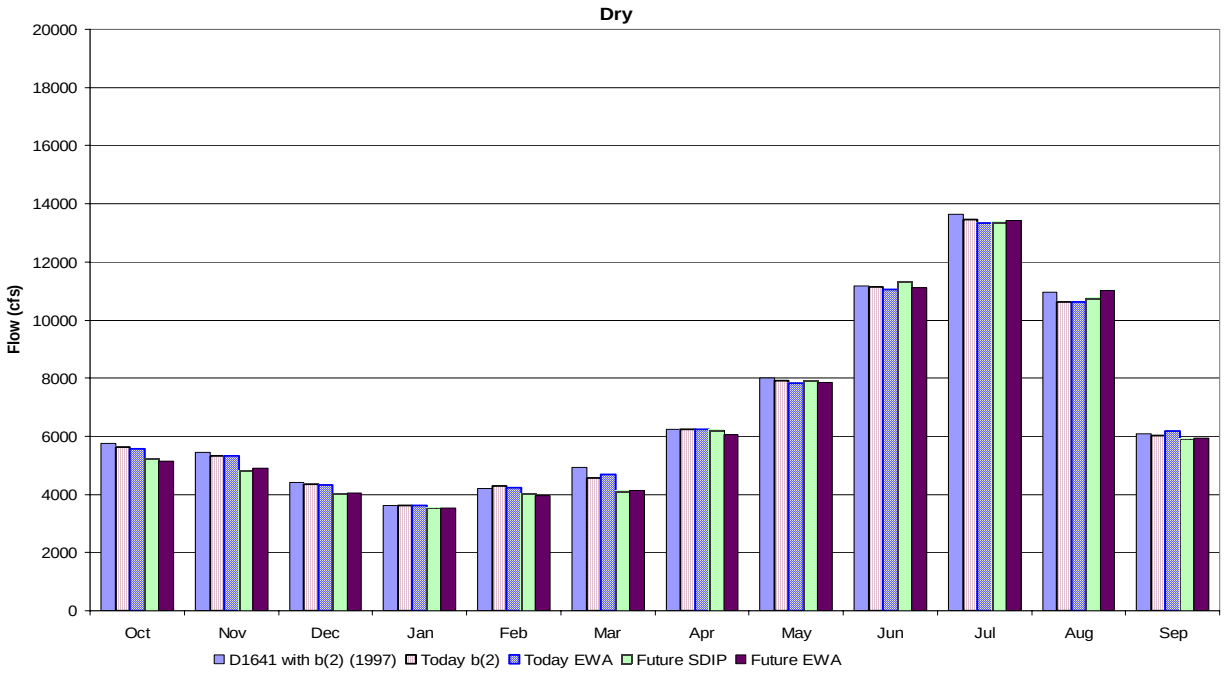


Figure 9-30 Average dry year (40-30-30 Classification) monthly releases from Keswick

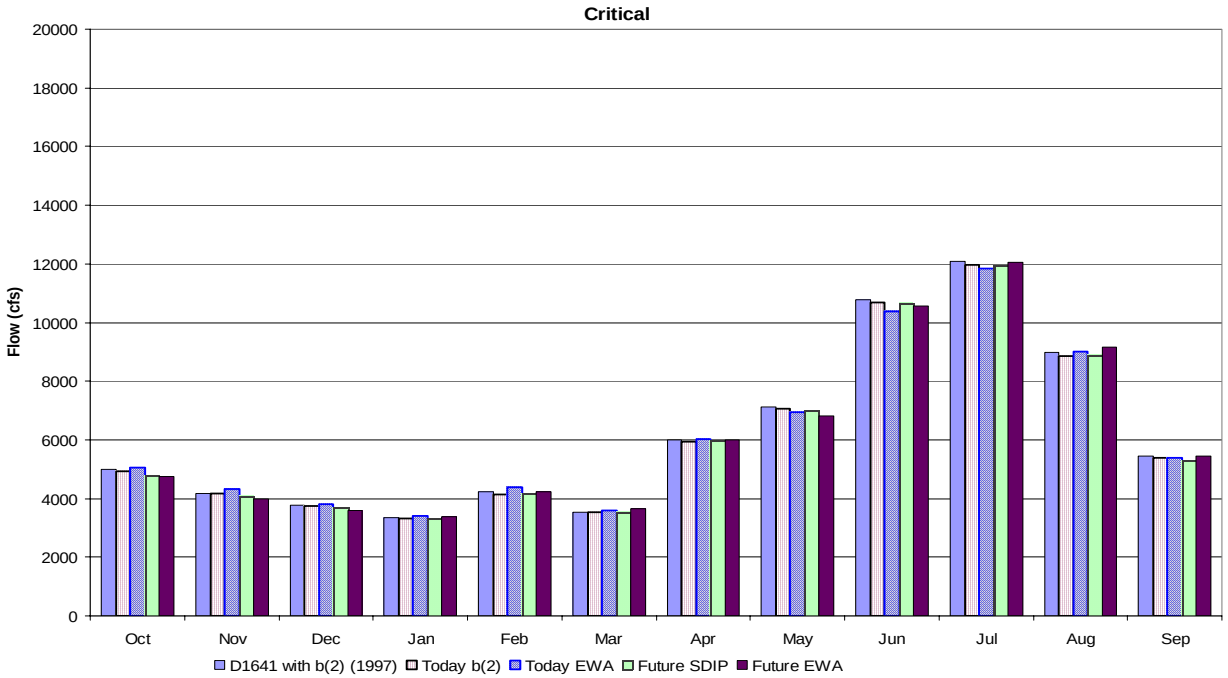


Figure 9-31 Average critical year (40-30-30 Classification) monthly releases from Keswick

Adult Migration, Spawning, and Incubation

Adult steelheads are expected to migrate upstream past Red Bluff primarily from August through December and spawn in the Sacramento River from December through April with peak activity occurring from January through March (McEwan 2001). During the upstream migration time period flows are high during August as water deliveries are being made. Flows get gradually lower as water deliveries tail off and weather cools so less water is needed for temperature control. Flows are expected to affect upstream migrating steelheads only to the extent that they affect water temperatures. The minimum Keswick release is 3,250 cfs. Steelheads spawning wetted usable area peaks at 3,250 cfs in the upper river reaches and peaks at about 13,000 cfs in the lower reach, forty miles further downstream, but with a low variability in availability (FWS 2003). Therefore we surmise that the 3,250 cfs flow level provides adequate physical habitat to meet the needs of all steelheads life stages in the Sacramento River. Flows during the summer greatly exceed this amount to meet temperature requirements for winter–run. The winter–run temperature objectives during the summer and run of the river temperatures the rest of the year result in water temperatures suitable for year-round rearing of steelheads in the upper Sacramento River.

Winter–run–run Chinook migrate upstream during January through June. Spring–run migrate from March into October, although the run is nearly complete by the end of June. Fall–run and late fall–run are migrating through the rest of the year so that Chinook salmon are migrating upstream in the Sacramento River during all months of the year (Figure 12-5). Winter–run spawning peaks in May through July and spring–run spawning peaks in August and September. Redd counts in recent years showed no spawning peak in the Sacramento River during the expected spring–run spawning period until October when the redds were considered fall–run redds (DFG aerial redd count survey data). Keswick average monthly releases between January and October range from a low of 3,250 cfs during dry years in all scenarios in January – April and October to a high of 53,000 during flood control releases in the wettest years in January and February. The largest difference in flow between the current and future operations will be slightly lower releases in July, September, and October in the future. Flows during July exceed what is needed for salmon and steelheads from a physical habitat standpoint so the reduction should not negatively affect fish as long as temperatures are suitable in July. Flows at the low end of the range of projected flows (3,250 cfs) provide enough spawning area for approximately 14,000 winter–run Chinook (FWS 2003), which is roughly double the recent escapement levels. If escapement increases significantly to near recovery goals, the flow versus habitat relationships should be reassessed at the higher escapement levels. The lower flows in September and October would lower the amount of spring–run spawning habitat. Spring–run spawning habitat was not estimated but is not limiting the population because few Chinook spawn in the main stem Sacramento River during the spring–run spawning period, i.e. there is plenty of space with suitable spawning habitat for the ones that are there. During very wet years monthly flows as high as 53,000 cfs could occur during upstream migration for winter–run. During winter–run spawning, flood control peak flows above 50,000 cfs could occur and when combined with tributary inflow could potentially affect redd survival (Table 9–9). Attempts are made to spread flood control releases out whenever possible. When the high peaks occur egg to fry survival could decrease for a brood year due to redd scouring or entombment. Long-term habitat benefits from high flood control flows should include gravel recruitment from streamside sources enhancing spawning gravel, LWD recruitment, and establishment of new cottonwood seedlings. The population effects should be maintained or better egg to smolt survival rates in the future.

Most of the winter–run spawning (98 percent) in recent years with better access to upstream habitat has occurred upstream of Balls Ferry. Water temperatures during winter–run spawning can be maintained below 56° F down to Balls Ferry in about 90 percent of years in May through August and 70 percent of years in September. Temperatures in the future modeling scenarios would be slightly increased 1 – 2° F in the driest 10 percent of years with the greatest increase in September. Temperatures at Bend Bridge in about 65-80 percent of years in May through September would exceed 56° F. They would exceed 56° F about 25 percent of years in April and 40 percent of years in October. The highest water temperatures of the year would occur in August through October during dry years as the cold-water pool is depleted. During the years when 56° F cannot be maintained the cold-water pool storage in Shasta Reservoir would not be sufficient to maintain cool temperatures throughout the summer and decisions would have to be made as to how to allocate the available cool water throughout the warm weather period. Increased flows for the Trinity River restoration program in the future decrease the ability to maintain cool temperatures in the Sacramento. Effects of water temperature on egg incubation are evaluated using the water temperature mortality model. Figure 9–32 shows the average percent mortality of Chinook salmon eggs and pre-emergent fry in the Sacramento River based on water temperature while eggs are in the gravel. The model projects that water temperature related mortality would be slightly higher for all runs in the future than under current operations. The greatest change in mortality would occur in dry and critical year types and is greatest for spring–run. During dry years only about 5 percent of winter–run eggs are projected to suffer mortality but in critically dry years 45 percent would suffer mortality (Figure 9–33). The hydrological period contains eleven critically dry years, which is 15 percent of the years used in modeling. During dry years about a 20 percent of spring–run eggs could suffer mortality with 80 percent of them affected in critical years. A relatively small percentage of the total Central Valley spring–run population spawns in the main stem Sacramento River. Therefore an overall spring–run population effect from reduced egg survival in the Sacramento River is not likely, assuming spring–run in the main stem are not genetically distinct from those in the tributaries.

Table 9–8 shows that Reclamation has reconsulted on winter-run and recommended moving the temperature compliance point nearly every year since the NOAA Fisheries B.O. was issued in 1993.

Table 9–8 Winter-Run B.O. Temperature Violations and Reinitiation Letters

				Reclamation letters		
Water Year	Water Year Starting Shasta Storage (TAF)	End of April Shasta Storage (TAF)	40-30-30 Index	Date	Action	Compliance
1993	1683	4263	AN			
1994	3102	3534	C			
1995	2102	4165	W	7/13/1995	Conserve cold water	Jelly's Ferry
1996	3136	4308	W	5/17/1996	Exceed 56 ^{o}F 4/26	Bend Bridge

				Reclamation letters		
				7/12/1996	Exceed 56 °F 5/27	
				7/18/1996	Conserve cold water	Jelly's Ferry
				8/28/1996	Conserve cold water	Ball's Ferry
				9/23/1996	Transition to stable min flow for fall-run salmon by Oct 15	Clear Creek
1997*	3089	3937	W	7/30/1997	Exceed 56 °F at Bend 4 days	
				8/8/1997	Conserve cold water	Jelly's Ferry
1998	2308	4061	W	6/25/1998	Exceed 56 °F at Bend 4 days	
				9/18/1998	Temp exceed 56 since Sep 12	Jelly's Ferry
1999	3441	4256	W	8/19/1999	Exceed 56 °F at Bend 4 days	
2000	3327	4153	AN	6/2/2000	Exceed 56 °F at Bend 3 days	
				7/14/2000	Conserve cold water	Jelly's Ferry
				8/29/2000	Conserve cold water	Ball's Ferry
				10/16/2000	Exceed 56 °F at Balls 3 days	
2001	2985	4020	D	7/17/2001	Exceed 56.5 °F at Jelly's 2 days	
				1/10/2002	Exceed 56 °F at Jelly's 8/28/2001 to 9/1/2001 and 9/152001 to 9/30/2001	
2002	2200	4297	D	6/5/2002	Exceed 56 °F at Jelly's 5/18/2003	

				Reclamation letters		
2003	2558	4537	AN	6/18/2003	Exceed 56 ^{o}F at Bend 5/14/2003	
				8/28/2003	Conserve cold water	Ball's Ferry
* 1997 was the first year that the TCD was used						

The spawning distribution used in the temperature model for winter–run and spring–run was updated following 2003 redd surveys based on 2001 through 2003 spawning data to reflect the shift in distribution since the ACID fish ladder was installed. Fall and late-fall distribution was not updated because the diversion dam has always been removed during their spawning migrations. Table 9–10 shows the Chinook spawning distribution used in the model.

A second temperature modeling run was conducted targeting 56° F at Bend Bridge (16 miles downstream of Balls Ferry) and Jellys Ferry (1993 winter run BO). This run met 56° F at Balls Ferry most of the time in May and June, about 90 percent of the time in July and August, 45 percent (current) and 30 percent (future) of the time in September, 50 percent (current) and 30 percent (future) in October, and 90 percent of the time in November. Downstream at Bend Bridge 56° F was met about 80 percent of the time in May, 75 percent of the time in June, 65 percent in July, 25 percent of the time in August, 15-20 percent of the time in September, and 20 – 35 percent of the time in October. Temperature at Bend would exceed 65° F about 10 percent of years in August and September. Temperatures at Red Bluff would exceed 65° F about 12 percent of years in August and September. The main difference in the temperature runs is that the cold-water pool runs low sooner in the summer with the Bend Bridge target. More cold-water is used to dilute warmer tributary flows from Battle Creek and Cottonwood Creek early in the temperature control season with the Bend Bridge/Jellys Ferry target. Changes in mortality during the incubation period are shown in Figure 9–32, Figure 9–33, and Figure 9–34. Mortality is higher using the Bend/Jellys temperature target than with the Balls Ferry target on average for all runs in all year types because the cold water is used more efficiently to extend the cold water supply out through the summer. Use of the Shasta temperature control device can be adjusted year to year by the Sacramento Temperature Group based on known storage conditions. Sacramento River at Shasta Dam release temperatures and at Bend Bridge temperatures for 1994 through 2001 are in Figures 6-1 and 6-2 and show the effect of past temperature control operations.

Stranding of some salmon and steelheads redds could occur and is analyzed in chapter 6 for each project river by comparing stage discharge relationships to typical spawning water depths and egg pocket depth. Some fall–run redds have been dewatered in the Sacramento River when flows are lowered after the rice decomposition program is completed and Shasta releases decreased in the fall (NOAA Fisheries 2003). The extent of redds dewatering and population level effects for Chinook has not been evaluated.

Table 9–9 Estimated bed mobility flows for affected Central Valley Rivers.

River and reference	Bed load movement initiated, cfs	Bed mobility flow that may scour some redds, cfs
Sacramento River (Buer 1980 and pers. comm. 2003)	25,000	40,000 – 50,000
Clear Creek (McBain&Trush and Matthews 1999)	2,600 (up to 11 mm particles)	3,000 – 4,000 coarse sediment transport (32 mm)
Feather River		
American River (Ayres Associates 2001)	30,000 – 50,000	50,000
Stanislaus River (Kondolff et al 2001)	280 cfs for gravel placed in river near Goodwin Dam	5,000 – 8,000 to move D_{50}
Trinity River (USDI 2000)	6,000 cfs to move D_{84}	11,000 cfs to scour point bars

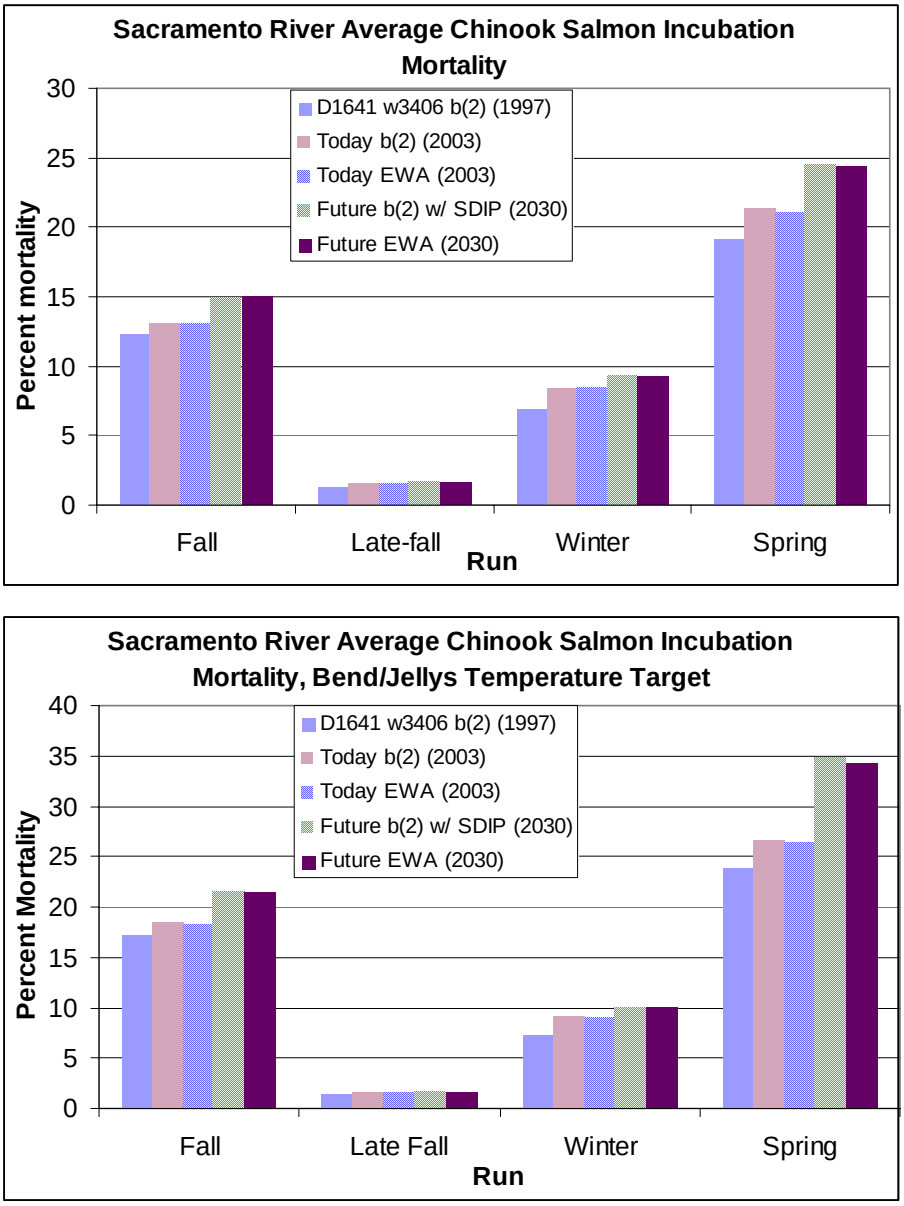
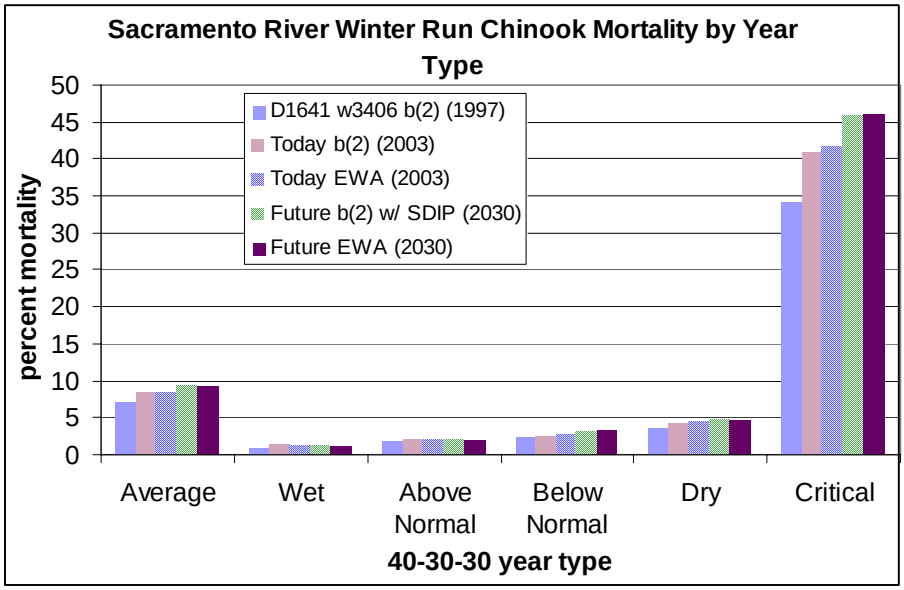


Figure 9–32 Average Chinook salmon mortality in the Sacramento River during the incubation period based on water temperature. Top chart is Balls Ferry temperature target; bottom chart is Bend Bridge/Jelly's Ferry temperature target.



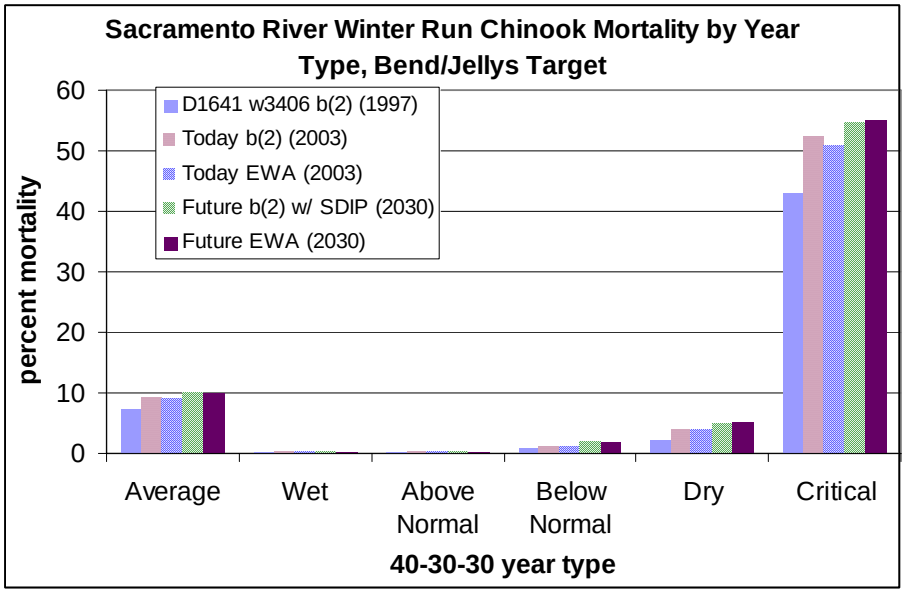
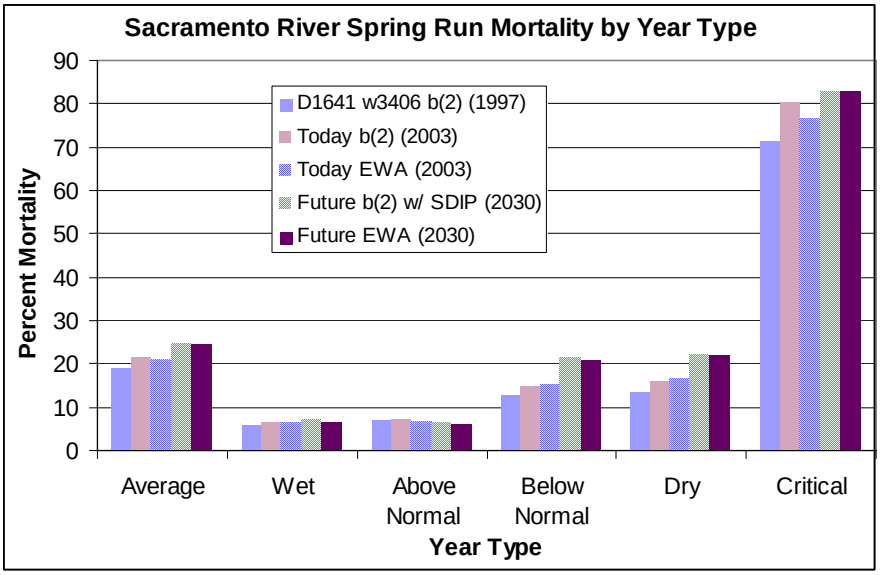


Figure 9–33 Sacramento River winter run Chinook salmon mortality due to water temperature during incubation, by year type. Top chart is Balls Ferry temperature target; bottom chart is Bend Bridge/Jelly's Ferry temperature target.



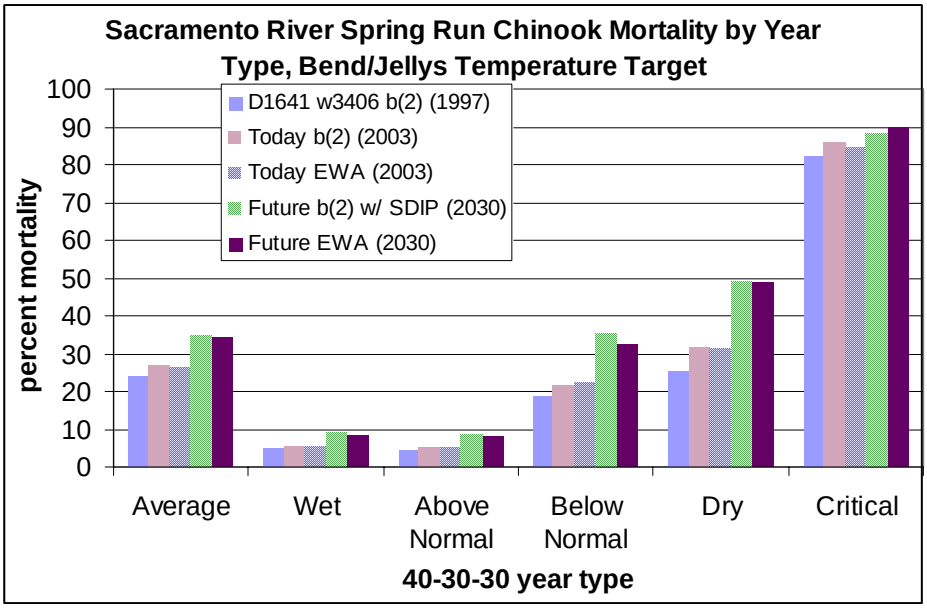


Figure 9–34 Sacramento River spring run Chinook salmon mortality due to water temperature during incubation, by year type. Top chart is Balls Ferry temperature target; bottom chart is Bend Bridge/Jelly's Ferry temperature target.

Table 9–10 Spawning distribution by reach used in the Chinook salmon temperature related egg to fry mortality models.

Sacramento River

Salmon Reach	No.	River Reach	Spawning Distribution (%) (Old winter and spring distribution in parentheses)				
			Fall	Late-Fall	Winter	Spring	Distance
UPPER	1	Keswick Dam – ACID Dam	4.26	25.5	47.1 (2.7)	5.8 (0)	3 miles
	2	ACID Dam – Hwy 44	10.54	21.7	17.3 (54.7)	16.7 (45.6)	2.5 miles
	3	Hwy 44 – Upper Anderson Bridge	13.98	21.1	32.4 (29.2)	21.2 (28.8)	13.5 miles
	4	Upper Anderson Bridge – Balls Ferry	13.05	13.9	2.3 (7.9)	22.4 (7.2)	8 miles
	5	Balls Ferry – Jelly's Ferry	12.88	4.4	0.3 (1.5)	31.4 (8.0)	9 miles
	6	Jelly's Ferry – Bend Bridge	6.96	1.7	0.3 (2.1)	1.9 (3.2)	9 miles
	7	Bend Bridge – Red Bluff Div Dam	1.88	1.1	0.0	0.0	15 miles
	Total – Upper Salmon Reach		**63.55**	**89.4**	**99.7 (98.1)**	**99.4 (92.8)**	**60 miles**
MIDDLE	8	Red Bluff Div Dam – Tehama Bridge	22.29	5.6	0.3 (1.6)	0.6 (6.4)	13.7 miles
	9	Tehama Bridge – Woodson Bridge	6.35	2.2	0 (0.3)	0 (0.8)	11 miles

	10	Woodson Bridge – Hamilton City	5.59	1.1	0.0	0.0	19 miles
	Total – Middle Salmon Reach		**34.23**	**8.9**	**0.3 (1.9)**	**0.6 (7.2)**	**43.7 miles**
LOWER	11	Hamilton City – Ord Ferry	1.54	1.1	0.0	0.0	15 miles
	12	Ord Ferry – Princeton	0.68	0.6	0.0	0.0	20 miles
	Total – Lower Salmon Reach		**2.22**	**1.7**	**0.0**	**0.0**	**35 miles**

Feather River

Spawning Reach	No.	River Reach	Spawning Distribution (%)
UPPER	1	Fish Dam – RM 65.0	20
	2	RM 65.0 – RM 62.0	20
	3	RM 62.0 – Upstream of After bay	20
	Total – Upper Salmon Reach		**60**
LOWER	4	Downstream of After bay – RM 55.0	10
	5	RM 55.0 – Gridley	10
	6	Gridley – RM 47.0	10
	7	RM 47.0 – Honcut Creek	10
	8	Honcut Creek – Yuba River	0
	9	Yuba River – Mouth	0
	Total – Lower Salmon Reach		**40**

American River

No.	River Reach	Spawning Distribution (%)
1	Nimbus Dam – Sunrise Blvd	31
2	Sunrise Blvd – A. Hoffman/Cordova	59
3	Ancil Hoffman/Cordova – Arden	5

4	Arden – Watt Ave	3
5	Watt Ave – Filtration Plant	1
6	Filtration Plant – H St	0
7	H St – Paradise	1
8	Paradise – 16th St	0
9	16th St – Mouth	0

Fry, Juveniles, and Smolts

The freshwater life stages of steelheads and Chinook salmon occupy the upper Sacramento River throughout the year. The minimum flow of 3,250 cfs should provide adequate rearing area and water velocities for emigration. Juveniles will benefit from tributary inflows during rainfall events when emigrating downstream from the upper river. Monitoring data along the river and in the delta shows that juveniles emigrate in greatest numbers during freshets that occur during rainfall events. Mean monthly temperatures below Keswick Reservoir and downstream at Bend Bridge are forecast to be in the preferred range for growth and development of steelheads (45° F to 60° F) and Chinook salmon (50° F to 60°F) throughout all of most years. Temperatures in about 10 percent of years could rise above 60° F at Keswick during August through October and rise as high as 67° F in August. Temperatures could exceed 60 in August – October in about 20 percent of years at Bend Bridge. Temperatures in the future are increased by about one degree in August through October. This would lower the amount of suitable rearing area for winter–run Chinook during the first couple months of juvenile rearing but Chinook would still be able to utilize most of the habitat down to at least Bend Bridge in most years until water cools in the fall and the temperature becomes suitable for rearing further down the river. This amount of habitat should be suitable to sustain the present winter–run population through the early rearing stage. Some Chinook fry begin emigration immediately upon emergence while others remain near the spawning area until they begin emigration at a larger size. Martin (et al 2001) concluded that larger proportions of winter Chinook fry rear above RBDD at lower discharge volumes during their emergent period. Temperatures would be marginal at RBDD for juvenile Chinook rearing in about 10 percent of years in August through October. Temperatures at Red Bluff in the future will be increased in September and October.

Steelheads have been found to survive and grow in other Central Valley streams (American and Feather Rivers) at temperatures in this range. Ramping criteria for Keswick Reservoir that are in place July through March minimize stranding effects to steelheads and Chinook salmon when release changes are made and flood control is not an issue. Reclamation uses these same criteria between April and June under normal operating conditions. Greater magnitude fluctuations in flow occur when pulses are produced from rainfall than occur due to reservoir operations.

Flows in the lower Sacramento River are important for rearing and emigrating salmon and steelheads. The species often out-migrate during periods of increased flow. Freeport flows are displayed. These include the sum of flows from the Sacramento, Feather, and American and other tributaries. The monthly modeling does not show the flow peaks used by outmigrating salmonids. The peaks would likely be similar in the future because they result largely from uncontrolled runoff from the tributaries added to the relatively constant reservoir releases. The monthly average Freeport flows show a slight decrease at times in the future but the decreases shown by modeling would not likely be detectable by fish. Because salmon and steelheads move largely in response to the peaks in flow, the lower average

flows in the lower Sacramento River at Freeport may or may not significantly affect salmon or steelheads. Flow changes will still occur in response to precipitation and changing Delta water needs and provide needed cues for upstream and downstream migrating salmon and steelheads.

Red Bluff Diversion Dam

Reclamation plans to continue the current May 15-September 15 gates lowered period at RBDD. The gates will be in a closed position during the tail end of the winter–run upstream migration and during much of the upstream migration season for spring–runspring–run. Approximately 15 percent of winter–run and 70 percent of spring–run that attempt to migrate upstream past RBDD may encounter the closed gates (TCCA and Reclamation 2002). This is based on run timing at the fish ladders (ie. after the delay in migration has occurred) when the gates were lowered year round so a delay is built into the run timing estimate. Most of the spring–run that do pass RBDD pass before May 15 and over 90 percent of the spring–run population spawns in tributaries downstream of RBDD. These downstream tributary runs never encounter the gates. When the gates are closed, upstream migrating Chinook salmon have to use the fish ladders to get past RBDD. Vogel et al (1988) found the average time of delay for fish passing through RBDD was three to13 days depending on the run (spring–run was the highest) and individual delays of up to 50 days occur. Recent radio tagging data indicate an average delay of 21 days (TCCA and Reclamation 2002). Although studies have shown that fish do not immediately pass the fish ladders, the extent that delayed passage affects ultimate spawning success is unknown. Average monthly water temperatures at Red Bluff would be maintained at suitable levels for upstream migrating and holding Chinook through July of all years. Fish delayed by RBDD should not suffer high mortality due to high temperatures unless warmer than average air temperatures warm the water significantly above the monthly average temperatures predicted by the model. Average monthly water temperatures during August and September could be greater than 65° F in 10 percent of years and as high as 69° F in years with low cold water pool storage in Shasta. During these years delays at RBDD would be more likely to result in mortality or cause sufficient delay to prevent migration into tributaries. This would effect primarily fall–run fish. The proportion of the spring–run and winter–run populations that encounter closed gates is small so effects of delays at RBDD during these dry years would probably not be as great as the population effect of higher than optimal spawning and incubation temperatures.

The spring–run population upstream of RBDD has failed to recover from what appears to have been a down cycle that should have ended shortly after the by-passes at Shasta Dam for temperature control began (1987) and shortly before the full eight months gates out operation began (1995). During this same period, spring–run downstream of the RBDD have increased about 20 fold, suggesting that some upstream event other than the RBDD operations have caused the decline in the spring–run population (TCCA and Reclamation 2002). This may be an artifact of a change in sampling protocols, but remains an unknown. It is also possible that some spring destined for the upper Sacramento River get delayed at RBDD so head back downstream and enter tributaries to span.

Early migrating steelheads encounter the lowered gates at RBDD. Approximately 84 percent of adult steelheads immigrants pass RBDD during the gates-out period based on average run timing at RBDD. Although the historical counts of juvenile steelheads passing RBDD do not differentiate steelheads from resident rainbow trout, approximately 95 percent of steelheads/rainbow trout juvenile emigrants pass during the gates-out period based on historical emigration patterns at RBDD (DFG 1993, as summarized in FWS 1998). Effects of RBDD operation on steelheads run timing would be unchanged

from the current condition. About 16% of steelheads would still be delayed. Steelheads this early in the run are not ready to spawn and steelheads are repeat spawners so the slight delay of a small portion of the steelheads run is not a big effect on steelheads.

Fry, juveniles, and smolts that pass RBDD when the gates are lowered are more susceptible to predation below the gates because pike minnows and striped bass congregate there. The predation situation at RBDD has improved since gate operations were changed so that not as many predator species now stop at RBDD during their upstream migrations (CH2M Hill 2002). The predation situation as it is now would likely continue through future operations.

Fall–run Chinook salmon migrate into the upper Sacramento between August and October with the peak migration occurring during October. RBDD gates are raised during the majority of the fall–run migration but some do get delayed prior to September 15 when the gates get raised. Fall–run Chinook salmon spawn heavily in the main stem of the Sacramento River, primarily upstream of Red Bluff, although a few do spawn just downstream of the RBDD. The highest density spawning area occurs from the city of Anderson upstream to the first riffle downstream of Keswick Dam.

Feather River

Modeling

Figure 9-36 shows the end-of month Oroville Reservoir storages for all five studies. Generally the storages for all five cases are very similar over the 72 years simulated. Oroville storage results in Study 3 are occasionally lower than results from the other simulations a few times. These lower values may be attributed to the EWA actions in the third study. The increased Banks export capacity in Studies 4 and 5 increases the States ability to draw down Oroville Reservoir, however the plot seems to indicate that this is counterbalanced by the SWP's enhanced ability to export additional unstored water during excess conditions.

Figure 9-36 shows that the Oroville storage is reduced in Studies 4 and 5 when the end of September Oroville Reservoir storage is greater than 2.5 MAF. The model seems to be taking advantage of the increased Banks export capacity to move additional water from Oroville in the wetter cases, resulting in lower carryover storage. Figure 9-37 shows that the 8,500 cfs Banks implementation seems to shift releases from winter months to the summer months. Figure 9-38 through Figure 9-43 indicate that this trend is consistent over all five water year types. As water availability decreases with water year type lower Oroville Reservoir releases are required during the July - September period.

Table 9-11 compares some of the annual average impacts to Feather River flows between the studies. While the earlier figures show that the various scenarios do affect the monthly distribution of Feather River releases, the average annual impacts appear to be insignificant. Long term average annual Feather River impacts flows are almost identical for the five studies. The 1928-1934 averages do show some very slight differences between the studies but overall the average annual impacts are minimal.

Table 9-11 Long-Term Average Annual Impacts to the Feather River

Differences (cfs)	Study 2 - Study 1	Study 3- Study 1	Study 5- Study 1	Study 4- Study 2	Study 5- Study 3
Long Term Average Feather River Flow below Thermalito	0	0	-2	-1	-2
1928-1934 Average Feather River Flow below Thermalito	-3	5	14	26	9

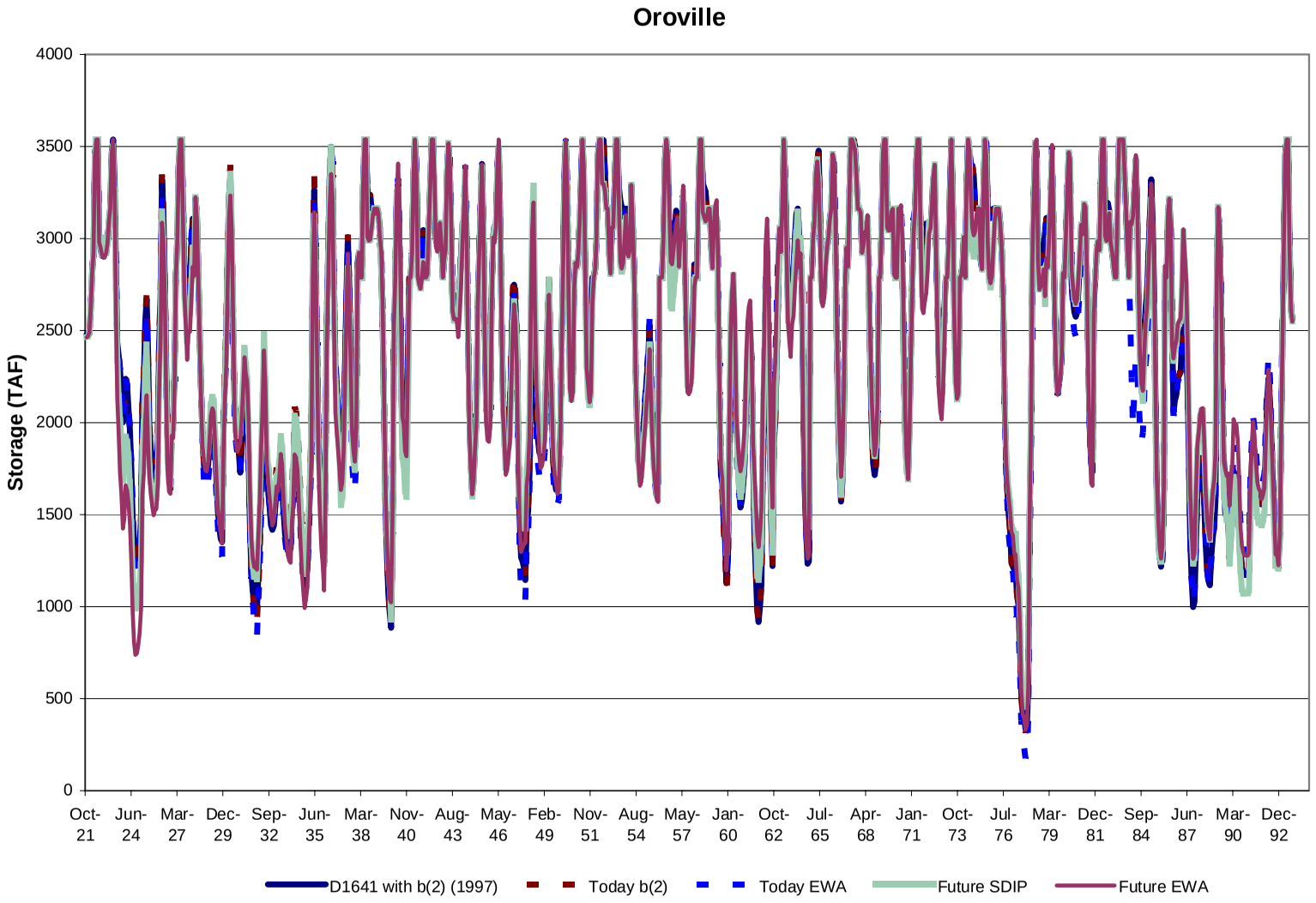


Figure 9-35 Chronology of Oroville Storage Water Year 1922 - 1993

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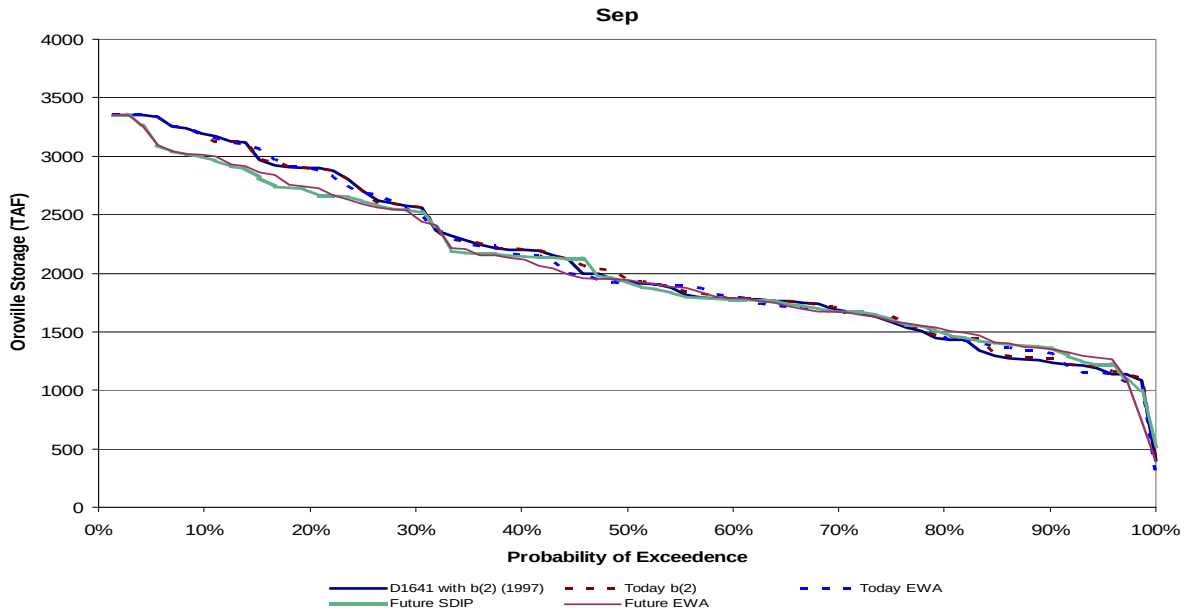

Figure 9-36 Oroville Reservoir End of September Exceedance

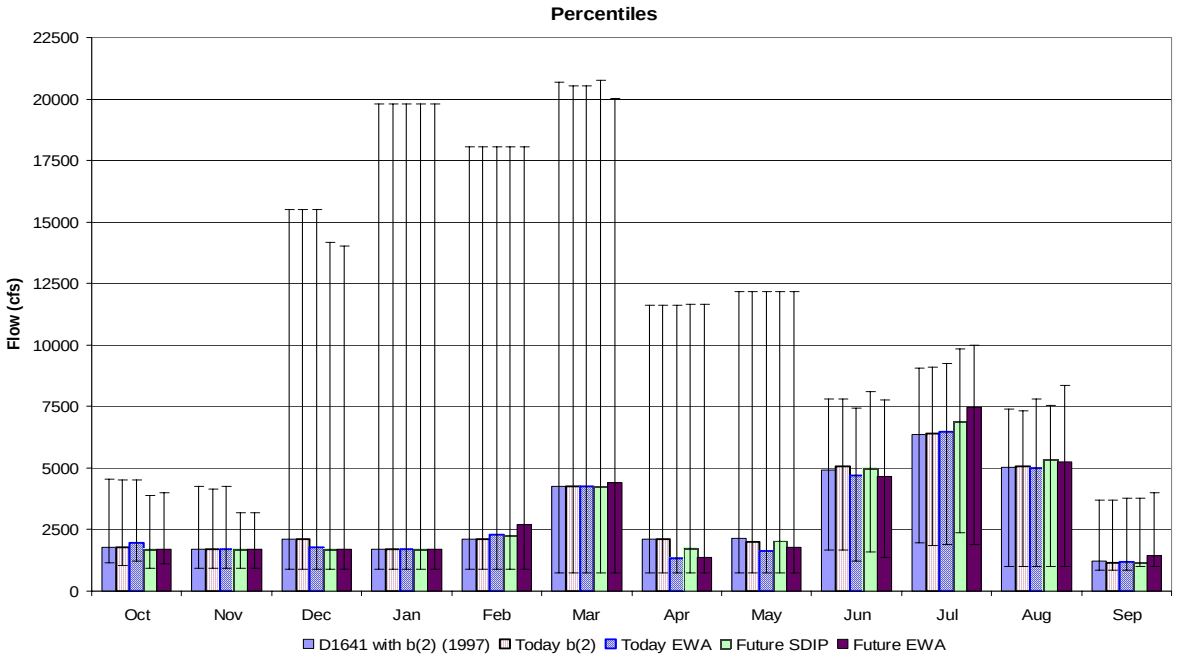

Figure 9-37 Flow Below Thermoltio 50th Percentile Monthly Releases with the 5th and 95th as the bars

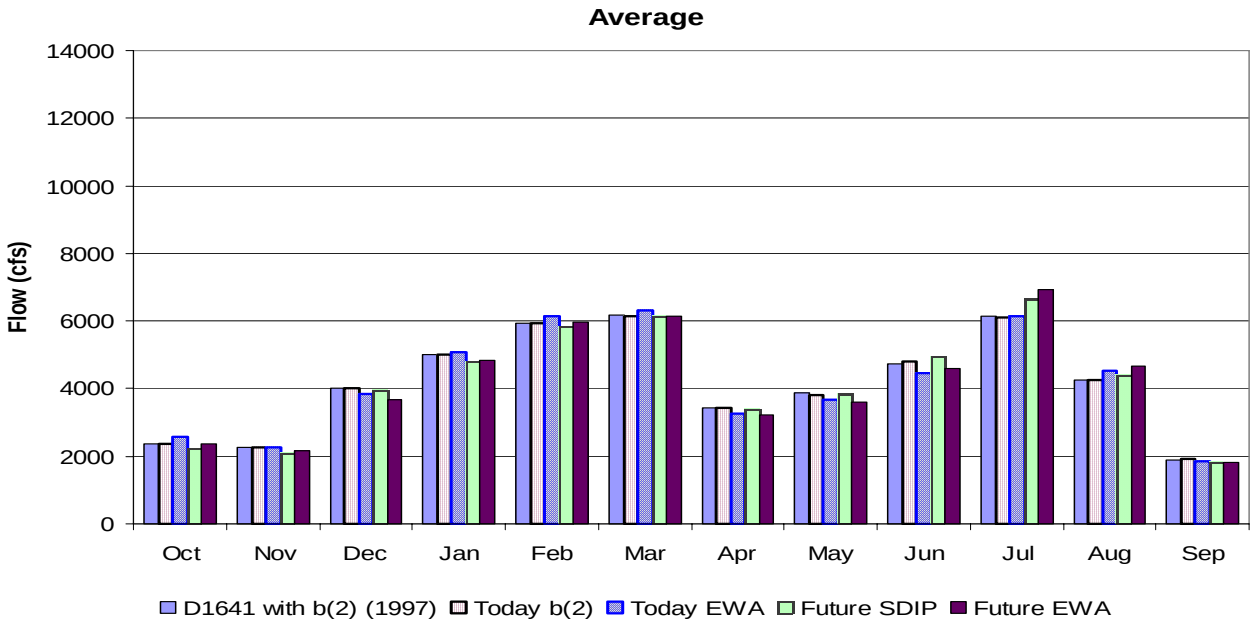

Figure 9-38 Average Monthly Flow Below Thermolito

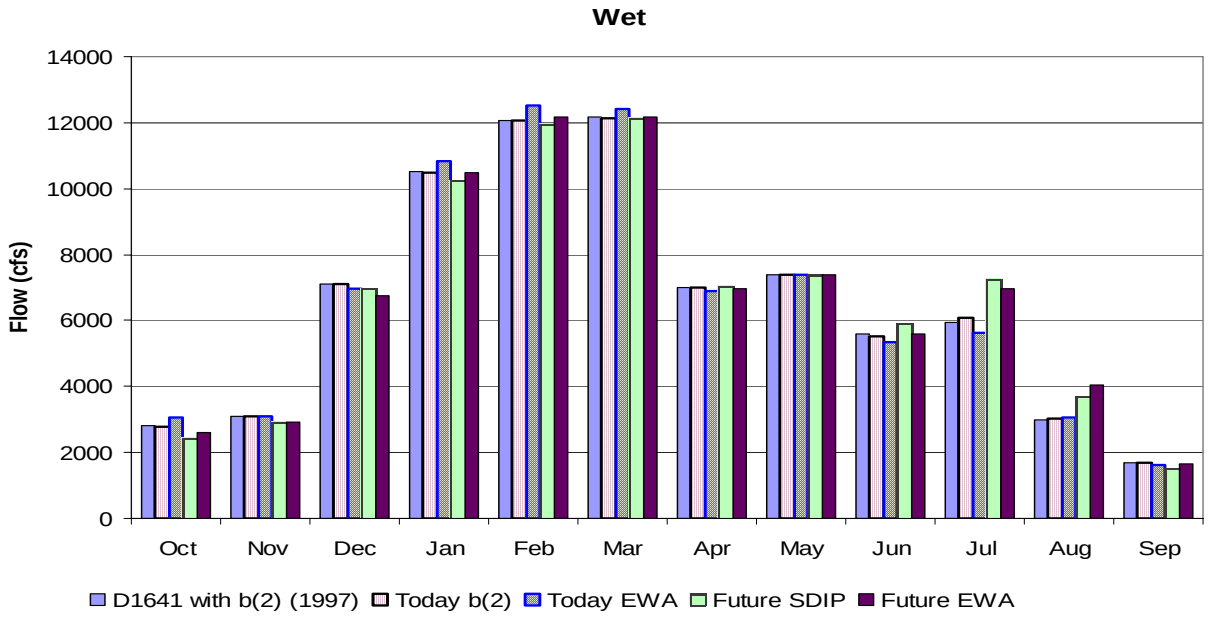

Figure 9-39 Average wet year (40-30-30 Classification) monthly Flow Below Thermolito

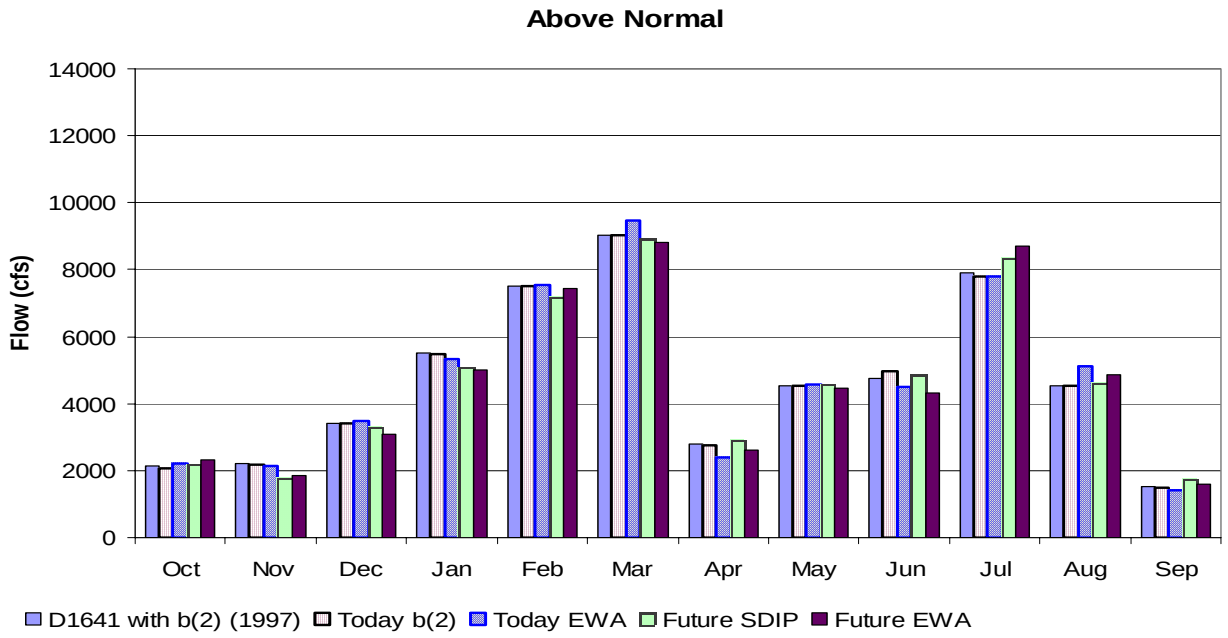

Figure 9-40 Average above normal year (40-30-30 Classification) monthly Flow Below Thermolito

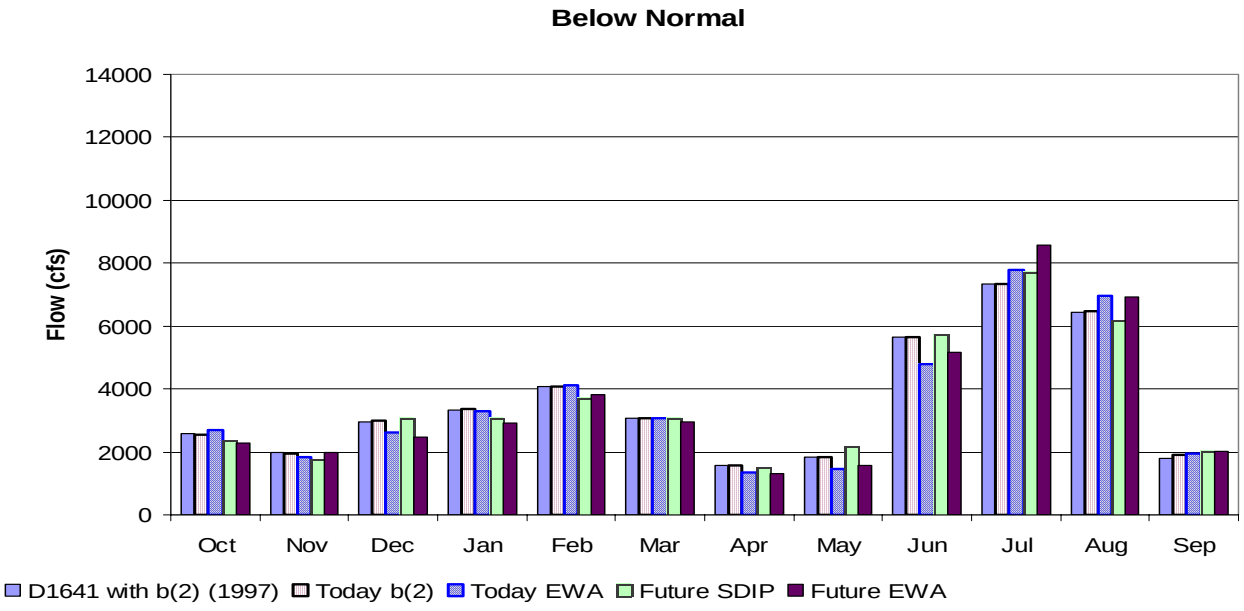

Figure 9-41 Average below normal year (40-30-30 Classification) monthly Flow Below Thermolito

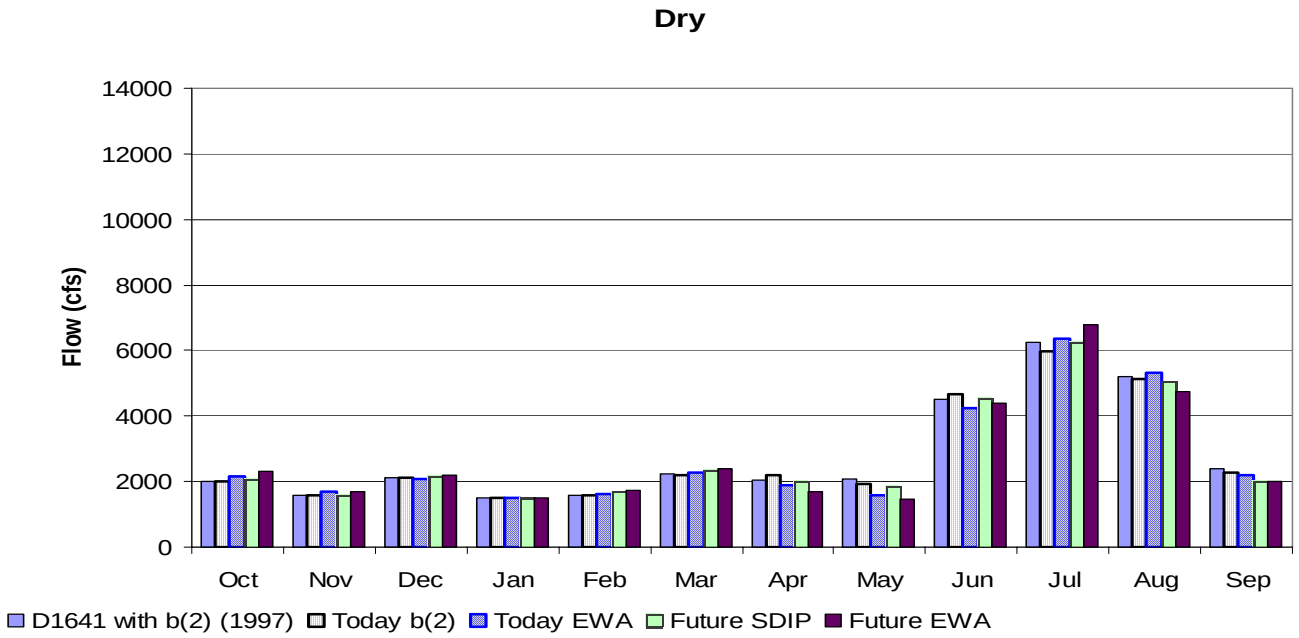

Figure 9-42 Average dry year (40-30-30 Classification) monthly Flow Below Thermolito

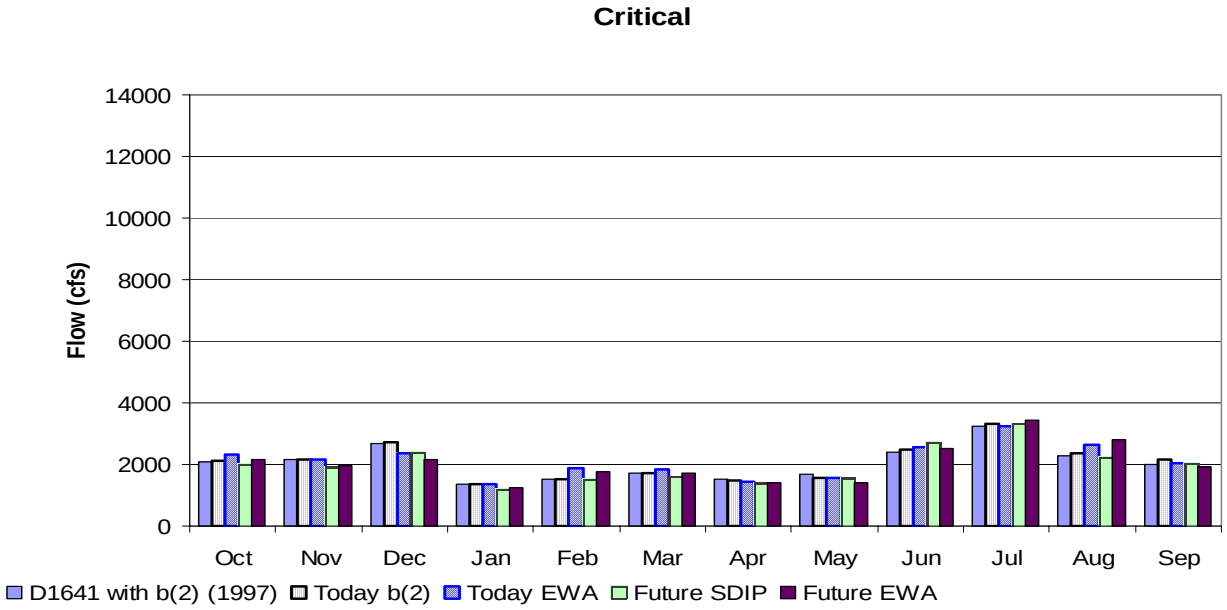

Figure 9-43 Average critical year (40-30-30 Classification) monthly Flow Below Thermolito

The approach to analyze the effects of proposed operations on steelheadss and spring–run Chinook salmon in the Feather River was similar to the approach used for CVP streams. Mean monthly flows and temperatures were simulated for a range of exceedance level hydrologies and compared to recommended temperature ranges for different life history stages of steelheads and spring–run Chinook salmon. For Chinook salmon only, the previously described temperature and mortality models were used to simulate egg mortality during the egg incubation period for fall–run and spring–run. As noted previously, a limitation of this approach is that the flow and temperature simulations were performed using a monthly operations model, which cannot predict diurnal temperature fluctuations that may be out of the recommended range for the two fish species.

Historical Feather River flow and temperature data were presented in DWR and Reclamation (1999). Projected Feather River flows downstream of Thermalito After bay for a range of exceedance levels are shown in CALSIM Modeling Appendix (UpstreamFlows.xls). Temperature results for a range of exceedance levels are presented in Temperature Modeling Appendix (Feather Temperature.xls).

Steelheads

Flow in the LFC is projected to remain constant at 600 cfs during the period addressed in this biological assessment except during occasional flood control releases that occur less than 10 percent of the time between December and May. This flow is less than pre-dam levels during all months of the year as a result of water diversions through the Thermalito Facilities (DWR and Reclamation 1999). The significance of these flow conditions for steelheads spawning and rearing is uncertain. The LFC is the primary reach for steelheads spawning and rearing. Although there is relatively little natural steelheads production in the river, most steelheads spawning and rearing appears to occur in the LFC in habitats associated with well-vegetated side channels (Kindopp and Kurth 2003, Cavallo et al 2003). Since these habitats are relatively uncommon they could limit natural steelheads production. Feather River RST data suggests that salmonids initiate emigration regardless of flow regime (i.e. they aren't waiting for a high flow pulse). The LFC is the primary reach for all salmonid spawning and rearing, so the direct effect of constant flow regime is, if anything, positive. Water temperatures in the LFC could also affect the quality of habitat for steelheads. However, studies have revealed that steelheads rear successfully at the downstream extent of the LFC where summer temperatures reach or occasionally exceed 65° F (Figure 9–44). A recent laboratory study also found that Feather River steelheads have a relatively high thermal preference (Myrick 2000). This study also found that in-channel produced steelheads displayed a higher thermal tolerance than steelheads from the Feather River hatchery.

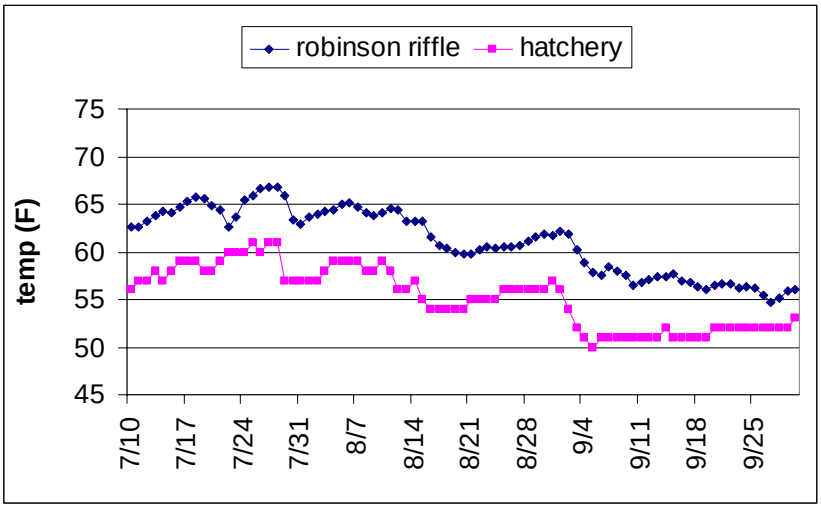

Figure 9–44 Summer temperature differences in the Feather River LFC between the fish hatchery dam and Robinson Riffle based on data collected by continuous temperature loggers during summer 1998.

Predicted water temperatures will not be harmful to steelheads Temperature Modeling Appendix (Feather Temperature.xls). Temperatures are at or below the 52° F recommended upper limit for most of the November through April adult migration and spawning periods. This should provide suitable habitat conditions for spawning, egg incubation and fry emergence during the winter and early spring. Overall, these analyses suggest that water temperatures should be satisfactory for steelheads even at the 50 percent exceedance.

Daily water temperatures in the LFC can also be affected by pump-back operations through the Thermalito complex. This practice typically occurs in summer or fall during "off-peak" periods. The effects of pump back operations are most noticeable in extreme drought periods such as 1990 through 1992, when the reservoir storage dropped below 1.2 million acre-feet. Low reservoir elevation causes the cold water level to drop below the power plant intake shutters, which provide control over the temperature of dam releases. Operational simulations indicate that reservoir elevations are unlikely to drop below 1.2 million acre-feet, even at the 90/75 percent exceedance hydrology. As a result, if pump back operations are conducted, they are not expected to adversely affect steelheads in the LFC.

Water conditions below the Thermalito After bay are not as favorable for steelheads. The projected exceedance flows for the Feather River below Thermalito After bay are shown in Temperature Modeling Appendix (Feather Temperature.xls). Like other post-dam years, predicted temperatures are less than 52° F during the winter, but rise above the recommended level during March, when egg incubation and emergence may still be occurring. Water temperatures near the mouth of the river are projected to exceed 65° F by May. By June, the entire river below the outlet is projected to be >65° F. As a result, and like most years, conditions below the outlet are expected to be marginal for steelheads rearing except during fall and winter. Although young-of-the-year steelheadss are occasionally observed in this area, we have not found evidence of substantial steelheads spawning or rearing below the Thermalito outlet (Kindopp and Kurth 2003, Cavallo et al 2003). As indicated above, most young steelheads rear in the LFC, which has several miles of habitat with appropriate water temperatures. The river channel below Thermalito offers essentially none of the habitat types upon which steelheads

appear to rely in the LFC. Experiments and fish observations also suggest that predation risk is higher below Thermalito outlet (DWR unpublished). Increased predation risk is likely a function of water temperature, where warm water exotic species are more prevalent, and in general, predators have greater metabolic requirements. Thus, excessively warm summer temperatures and the absence of preferred steelheads habitat; appear to limit steelheads below the Thermalito outlet. However, the relative importance of these two factors is unknown. For example, it is unclear whether a reduction in summer water temperatures below Thermalito would be enough to induce or allow successful steelheads rearing and spawning.

Spring–run Chinook Salmon

Predicted flow conditions were discussed previously for steelheads. It is unclear whether there is substantial in-channel spawning of spring–run Chinook salmon, so the following analysis is highly speculative. However, the analysis makes the conservative assumption that there is some in-channel spring–run Chinook salmon spawning. The fact that spring–run hold during summer in the upper reaches of the LFC suggests any such spawning would most likely be restricted to that reach. LFC spawners are unlikely to be limited by the amount of "space" created by the predicted flow level because they would be the first to arrive at the spawning riffles. However, superimposition on spring–run redds by fall–run spawners, which spawn later, could be a major source of egg mortality. Studies by Sommer and others (2001a) indicate superimposition rates may be determined by the percentage of the population that spawns in the LFC, which is in turn influenced by flow distribution, escapement level and perhaps hatchery operations. Flow distribution is defined as the percentage of total October and November river flow that passes through the LFC. In the case of both the Base and Future operations, the LFC releases would be fixed at 600 cfs. We predict that superimposition rates would be higher at the higher exceedance levels (e.g. >75 percent) because the LFC would comprise a greater percentage of total flow.

The Base and Future temperatures at the Fish Barrier Dam should be generally suitable for all life history stages Temperature Modeling Appendix (Feather Temperature.xls). Most spring–run adults typically hold in the upper three miles of the LFC (Dick Painter, personal communication, 1998), where temperatures remain closer to the recommended thresholds Temperature Modeling Appendix (Feather Temperature.xls). Temperatures in most of the LFC are expected to be within the recommended range for spring–run spawning beginning about September, but temperatures will be marginal for spring–run spawning in the downstream portion of the LFC until October, when fall–run Chinook salmon begin spawning. Temperatures throughout the LFC should be suitable for rearing and emigration during January through April for the Base and Future cases.

Base and Future temperatures below Thermalito After bay Outlet will be marginal for adult spring–run, but suitable for fry. Predicted Base and Future temperatures downstream of the outlet could begin affecting adult immigration about May. Summer holding temperatures below Thermalito will be marginal. Temperatures are projected to be too high for spawning until November Temperature Modeling Appendix (Feather Temperature.xls). Therefore it is unlikely that adult spring–run will use the river downstream of the outlet, except perhaps as a migration corridor. As stated above, the entire river from the Fish Barrier Dam to the mouth should be suitable for rearing and emigrating fry until at least April, by which time most fry have historically emigrated from the river (DWR 1999a, 1999b, 1999c).

Egg survival model results are summarized in Figure 9–45. Egg mortality during the fall incubation period was less that 2.5 percent for all but critically dry year types when mortality was about 4 percent. Mortality values for current and future operations are very similar.

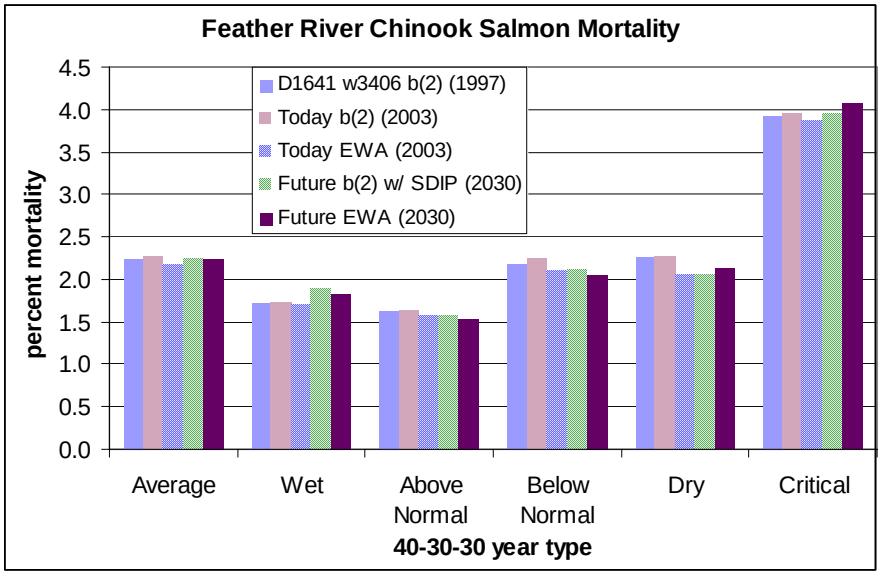

Figure 9–45 Percent mortality from egg to fry due to water temperature for Chinook in the Feather River by water year type.

Fall–run Chinook Salmon

Predicted base and future flow and temperature conditions were discussed previously for steelheads and spring–run salmon. Fall–run Chinook salmon compose the largest population of the anadromous salmonids in the Feather River. Fall–run Chinook salmon begin arriving in September and spawn in-channel from October through December. Unlike spring–run salmon, there is a distinct and substantial amount of in-channel spawning and rearing among fall–run salmon in the Feather River. Generally, the arrival, spawning, and rearing timing of fall–run minimizes their exposure to unfavorable water temperatures and flows. Fall–run spawning activity begins in the LFC and then gradually intensifies downstream. Typically the peak of spawning occurs about one month earlier in the LFC than in the river below Thermalito Outlet (DWR unpublished). Approximately two-thirds of total fall–run spawning occurs in the LFC, while roughly one-third occurs below Thermalito Outlet (Cavallo 2001). Due to the success of the FRH, large numbers of fall–run salmon spawn in the Feather River. This large, hatchery supported salmon population often outstrips the habitat available for spawning, which results in competition for spawning area in the lower Feather River. This competition, and resulting superimposition of fall–run redds, is most intense in the LFC where flows are predicted to remain at 600 cfs, and where the highest density of spawning occurs.

The base and future temperatures should generally be suitable for all life history stages of fall–run Chinook salmon. As with spring–run, any fall–run salmon arriving early in the river (before September) may hold in the upper three miles of the LFC where temperatures remain closer to the recommended thresholds. Temperatures in most of the LFC are expected to be within the

recommended range for fall–run spawning beginning about September. Temperatures below the Thermalito outlet, while marginal in September, are predicted adequate by October when the bulk of fall–run spawning generally begins.

The majority of Feather River fall–run Chinook salmon emigrate from the system by the end of March (Figure 12–13). Temperatures throughout the lower river should be suitable for rearing and emigration during this period.

As described for spring–run, the egg survival model results are provided in Figure 9-x. Again, egg mortality during the fall incubation period was less that 2.5 percent for all but critically dry year types when mortality was about 4 percent. Mortality values for current and future operations are very similar.

Feather River Fish Studies

Fish monitoring and studies in the Feather River will continue take of steelheads and spring–run salmon. DWR is likely to modify and perhaps expand on such activities to gather information needed by the NOAA Fisheries and California Department of Fish and Game during the relicensing of the Oroville Facilities with the Federal Energy Regulatory Commission.

Steelheads and spring–run salmon take could occur during RST sampling, fyke net sampling, beach seine sampling, or snorkeling. Low numbers of steelheads are typically collected in the RSTs between February and July (2002), although the RST is not considered an effective gear for monitoring steelheads emigration. Fyke net sampling is supplemental to RSTs, and began in the 1999-2000 season.

RSTs have been in use since 1996. Fyke nets are supplemental to RSTs, and began in the 1999-2000 season. Combined RST and fyke net catch for the 2001-02 season was as follows:

- 194 spring–run sized young-of-year salmon, four juveniles, and seven mortalities
- 306 wild, YOY steelheads trout, 44 juveniles, and four mortalities

DWR discontinued its regular seining program after 2001. Collective findings of the seining program are summarized in DWR 2002a. We anticipate that seining will only be used as required by stranding surveys. NOAA Fisheries requested the juvenile fish stranding survey in the 2000-01 season. Stranded fish will be assessed and removed from isolated pools and released into the river. This will occasionally require transporting fish over short distances. Catch in the 2001 stranding survey was as follows:

- 147 spring–run sized young-of-year salmon, including five mortalities
- 2 wild, juvenile steelheads trout, zero mortalities

Snorkel surveys conducted during spring and summer will not result in the lethal take of any steelheads or spring–run size salmon. Snorkel survey observations include repeated observations of some individuals. As an example of typical numbers of fish observed, 1999 data was as follows:

- steelheads, 5,856 YOY, 739 juveniles of unknown age;
- spring–run sized salmon, 3,034 juveniles of unknown age.

The total annual potential steelheads take for the Feather River fish monitoring program, is estimated to be 7,855 (6,835 YOY, 980 juveniles (age unknown), and 40 adults). Total annual lethal take is estimated to be 2 percent or 157 steelheads. These estimates are based on the largest seasonal catch to date and the relative proportions of the different life stages in the catch combined with the estimate of take for the sampling elements. The lethal take estimate is based on the average incidental take over four seasons of sampling (1.4 percent) and rounded up to the next whole number.

The total annual potential spring–run take is estimated to be 6,500 (6,355 YOY, 146 juveniles (age unknown), and seven adults). Total annual lethal take is estimated to be 2 percent or 130 spring–run salmon. These estimates are based on the largest seasonal catch to date and the relative proportions of the different life stages in the catch combined with the estimate of take for the sampling elements. The lethal take estimate is based on the average of incidental take over four seasons of sampling (1.8 percent) and rounded up to the next whole number.

Steelheads and spring–run sized salmon mortalities incidental to the sampling efforts will be retained for diet, scale, and otolith analyses.

Measures to Reduce Handling Stress

Several measures will be incorporated as standard operating procedures to reduce the exposure to physiological stress and minimize harm associated with the capture and handling of steelheads and spring–run salmon. These measures are intended to maximize the survival after release.

1. Captured steelheads and spring–run salmon shall be handled with extreme care and kept in cool, aerated local water to the maximum extent possible during sampling and processing procedures. Artificial slime products or anesthetics may be used to reduce physiological or osmotic stress. Steelheads and spring–run salmon handled out-of-water for the purpose of recording biological information or taking scale samples will be anesthetized when necessary to prevent mortality. Anesthetized fish will be allowed to recover (in untreated river water) before being released.
2. With sampling gear that captures a mixture of species, steelheads and spring–run salmon will be removed and processed first and returned to the river as soon as practicably possible.

Sampling by traps will be suspended by raising the trapping cone or removing the live box on the fyke net during periods of high debris load.

American River

Modeling

The greatest impact to the American River is the increases in demands from the 2001 to the 2020 Level of Development (LOD) see (see Chapter 8, Tables 8-3 and 8-4.) The actual deliveries, based on long-term average, increase from a total of 251,000 af in the 2001 LOD (total Water Rights and M&I) to 561,000 af in the 2020 LOD. Based on the 1928 to 1934 average, deliveries increase from 242,000 af to 530,000 af in the Future see Table 9-12. From Figure 9-47 the ability to fill Folsom Reservoir in May is reduced from 50 percent of the time to 40 percent of the time between the Today and Future runs. Carryover September storage in Folsom Reservoir is reduced by 30,000 to 45,000 af on a long-

term average basis from the Today to the Future, (Chapter 8, Table 8-5.) It also trends lower in the Future runs relative to the Today runs see Figure 9-48.

The future studies 4 and 5 do take water forum cuts on the demands see (see Chapter 8, Tables 8-3 and 8-4) and provide 47,000 af of mitigation water. Since the Water Forum contracts are not final and the EIR/EIS has not been completed the representation of the American River in the OCAP CALSIM II modeling may be different than what the actual Future operation could be. The 47,000 af of mitigation water in the dry years could also show a transfer ability in the Delta that might actually be part of the future operations.

Sacramento County Water Agency (SCWA) takes water in all years at Freeport with an annual average of 59 TAF, see Figure 9-56. From Figure 9-56 SCWA diversions decrease as the 40-30-30 Index gets drier due to allocation reductions in the dry and critical years to an annual average of 48 and 41 TAF respectively. East Bay Municipal Utility District (EBMUD) in the dry and critical years take an annual average of 36 and 63 TAF/yr when the EBMUD system storage of most likely to be less than 500,000 af.

Figure 9-57 shows results from Study 4 on annual (Mar – Feb) Freeport diversions for SCWA and EBMUD for Study 4. EBMUD can only take 133,000 af in any one year in which EBMUD's total system storage forecast remains below 500,000 af, not to exceed 165,000 af in any consecutive 3-year drought period. EBMUD takes an annnual max of 94,000 af five times in the 72 years that are analyzed (1939, 1959, 1962, 1968, and 1987). The 165,000 af limit is reached in two consecutive years 3 times (1929-1930, 1959-1960, and 1987-1988) and in three consecutive years 4 times (1962-1964, 1976-1978, 1977-1979 and 1990-1992).

Figure 9-49 shows the monthly percentile values for Nimbus releases. Figure 9-50 to Figure 9-55 show the average monthly Nimbus Releases by long-term average and 40-30-30 Water Year Classification. The average monthly flows for all water year types generally decrease because of implementing minimum flow requirments or from decreased flood releases due to lower storage values.

Table 9-12. American River Deliveries for each of the five studies

	D1641 with (b)(2) (1997)		Today (b)(2)		Today EWA		Future SDIP		Future EWA	
	Average	Dry	Average	Dry	Average	Dry	Average	Dry	Average	Dry
American River Water Rights Deliveries										
PCWA at Auburn Dam Site	8.5	8.5	8.5	8.5	8.5	8.5	65.5	57.8	65.5	57.7
NRWD	0.0	0.0	0.0	0.0	0.0	0.0	16.5	8.3	16.5	8.3
City of Folsom	20.0	20.0	20.0	20.0	20.0	20.0	26.7	26.6	26.7	26.6
Folsom Prison	2.0	2.0	2.0	2.0	2.0	2.0	5.0	5.0	5.0	5.0
SJWD (Placer County)	10.0	10.0	10.0	10.0	10.0	10.0	23.7	22.5	23.7	22.5
SJWD (Sac County)	33.0	33.0	33.0	33.0	33.0	33.0	33.0	33.0	33.0	33.0
El Dorado ID & WA	0.0	0.0	0.0	0.0	0.0	0.0	17.0	17.0	17.0	17.0
City of Roseville	0.0	0.0	0.0	0.0	0.0	0.0	30.0	30.0	30.0	30.0
So. Cal WC/ Arden Cordova WC	3.5	3.5	3.5	3.5	3.5	3.5	5.0	5.0	5.0	5.0
California Parks and Rec	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SMUD MI	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0
Folsom South Canal Losses	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
City of Sac/ Arcade Water District/ Carmichael WD	73.2	73.0	73.2	73.0	73.2	73.0	110.8	104.7	110.9	104.7
City of Sac	38.8	39.0	38.8	39.0	38.8	39.0	42.8	49.1	42.7	49.1
SCWA "other" water at Freeport	0.0	0.0	0.0	0.0	0.0	0.0	14.8	15.2	14.8	15.2
SCWA appropriated excess water at Freeport	0.0	0.0	0.0	0.0	0.1	0.2	13.5	5.4	14.0	6.1
Total	205.0	205.0	205.0	205.0	205.1	205.2	420.3	395.6	420.7	396.2
American River CVP Deliveries										
City of Folsom	0.0	0.0	0.0	0.0	0.0	0.0	5.5	3.3	5.5	3.3
SJWD (Sac County)	10.0	7.7	9.9	7.4	9.9	7.4	20.9	15.4	20.9	15.4
El Dorado ID & WA	4.9	4.6	4.9	4.6	4.9	4.5	12.9	9.6	12.9	9.5
City of Roseville	25.1	21.3	24.9	20.5	24.9	20.3	22.8	19.1	22.8	19.1
California Parks and Rec	0.1	0.1	0.1	0.1	0.1	0.1	4.3	3.2	4.3	3.2
SMUD MI	0.0	0.0	0.0	0.0	0.0	0.0	12.4	8.8	12.4	8.8
South Sac County Ag	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
PCWA at Sac River	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SCWA CVP diversion at Sac Water Treatment Plant	6.4	5.0	6.3	4.8	6.3	4.7	8.6	6.4	8.6	6.3
EBMUD Freeport diversion	0.0	0.0	0.0	0.0	0.0	0.0	23.2	45.8	23.2	45.8
SCWA CVP diversion at Freeport	0.0	0.0	0.0	0.0	0.0	0.0	30.2	22.3	30.2	22.2
Total	46.4	38.7	46.1	37.3	46.1	36.9	140.9	134.0	140.9	133.6

Note

1) "Average" is the average value of 73 year simulation period (1922-1993).

2) "Dry" is the average value of 1928-1934 dry period.

3) All units are in TAF

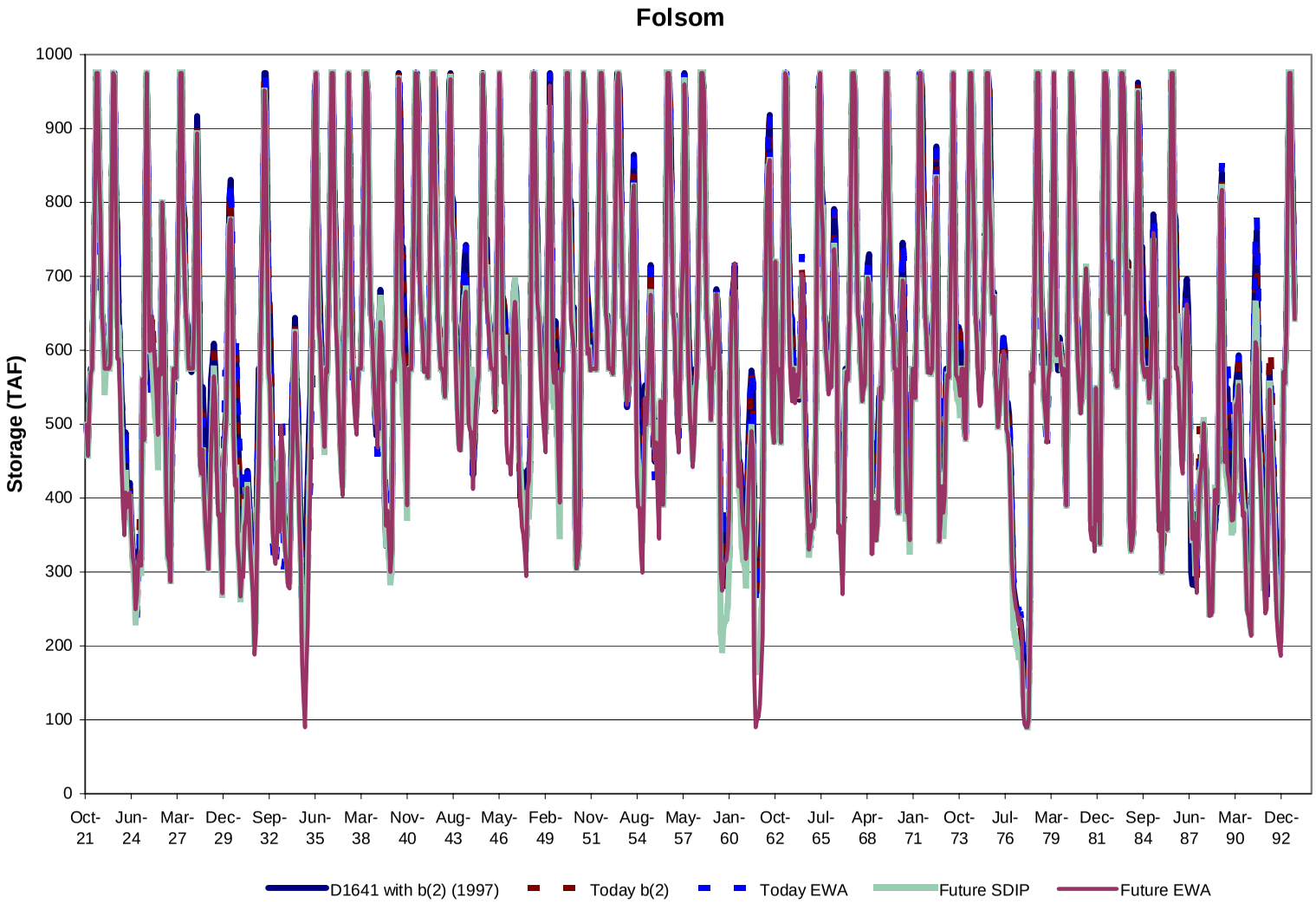

Figure 9-46. Chronology of Folsom Storage Water Year 1922 - 1993

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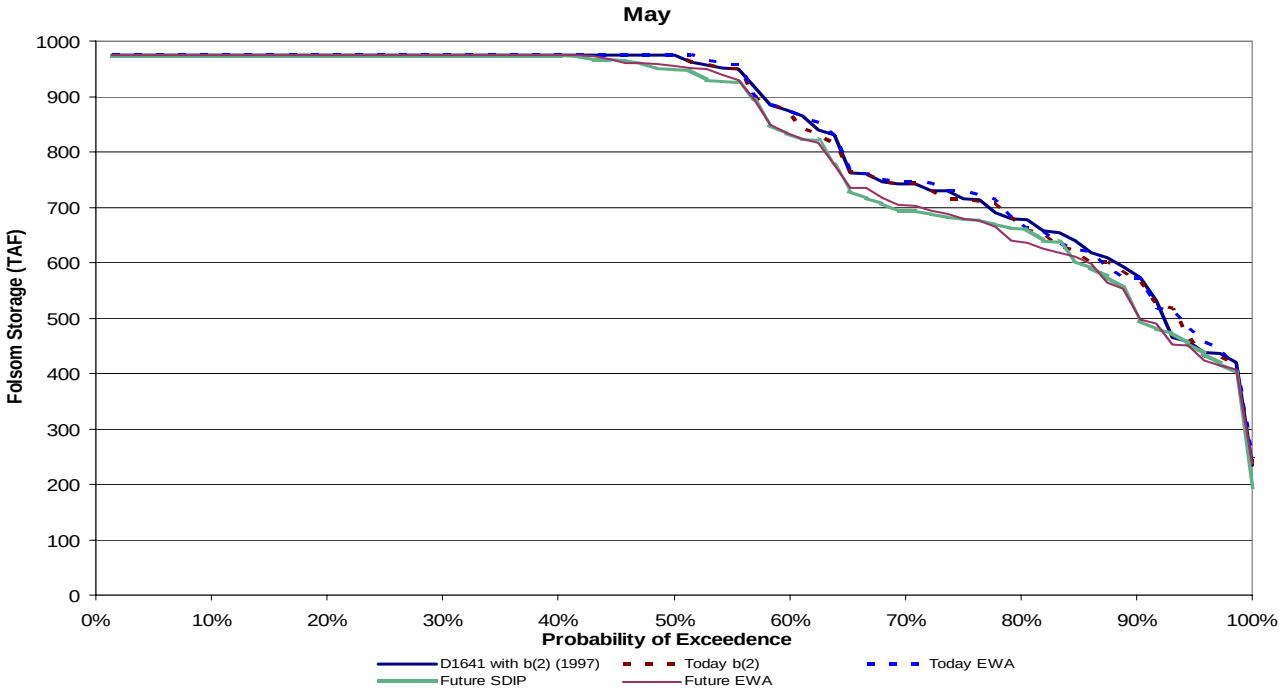


Figure 9-47 Folsom Reservoir End of May Exceedance

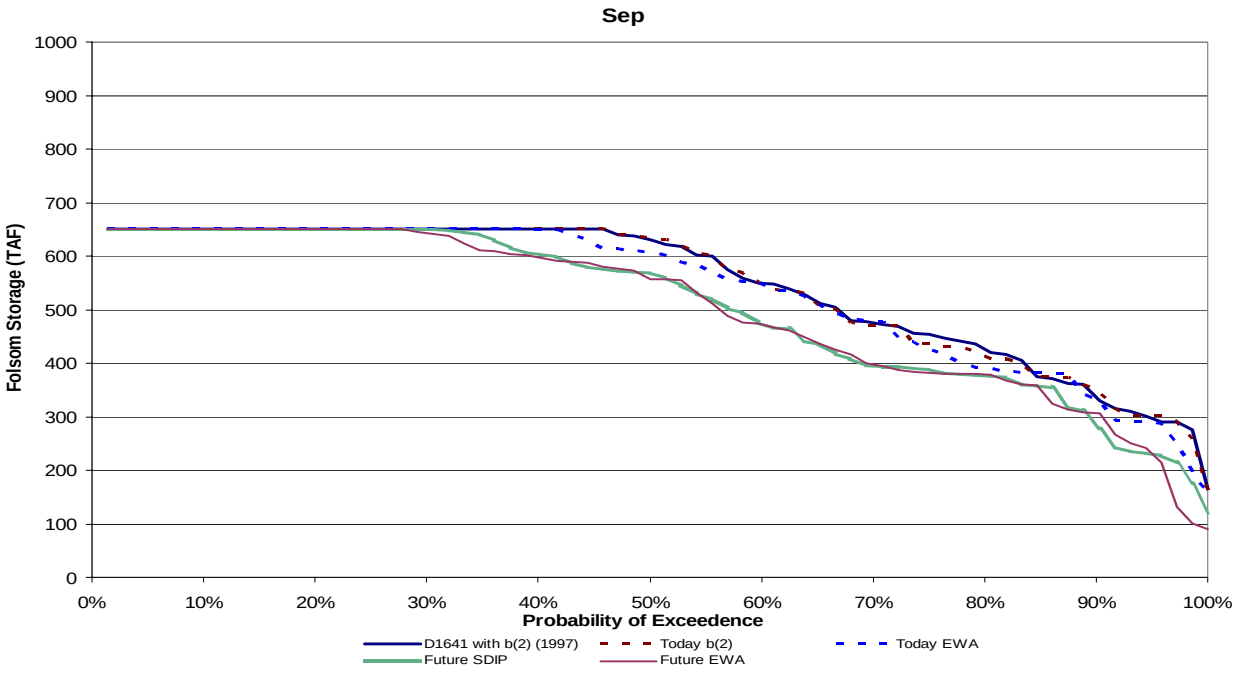


Figure 9-48 Folsom Reservoir End of September Exceedance

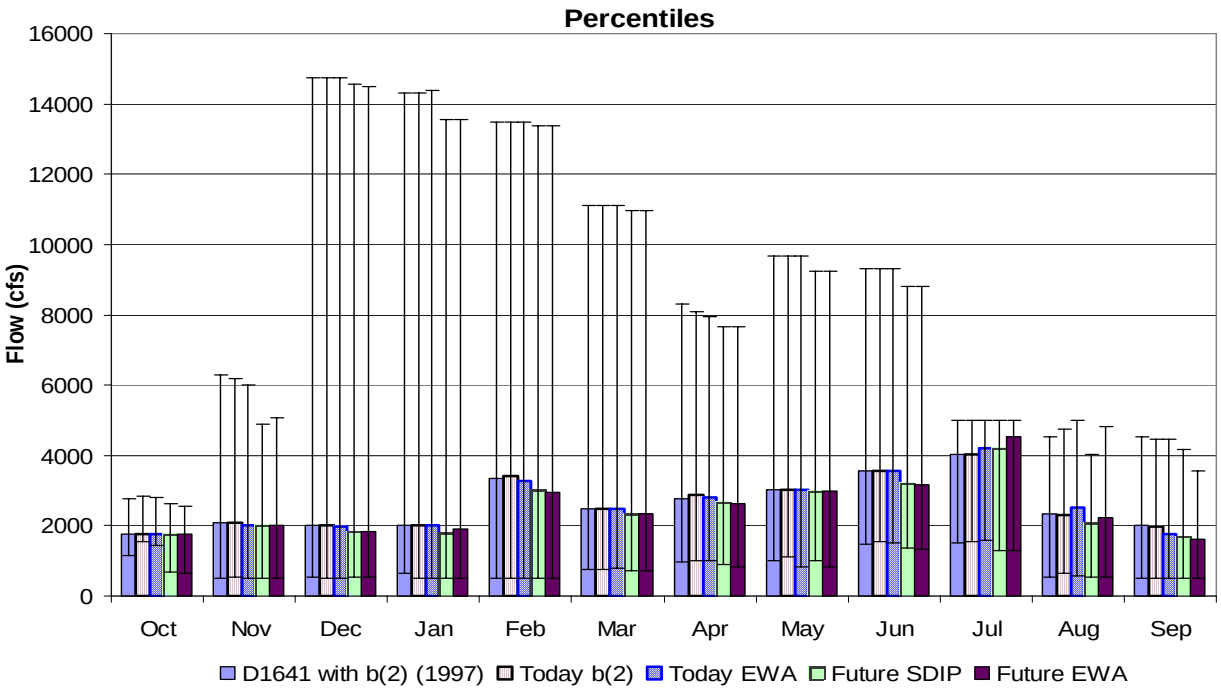


Figure 9-49 Nimbus Release 50th Percentile Monthly Releases with the 5th and 95th as the bars

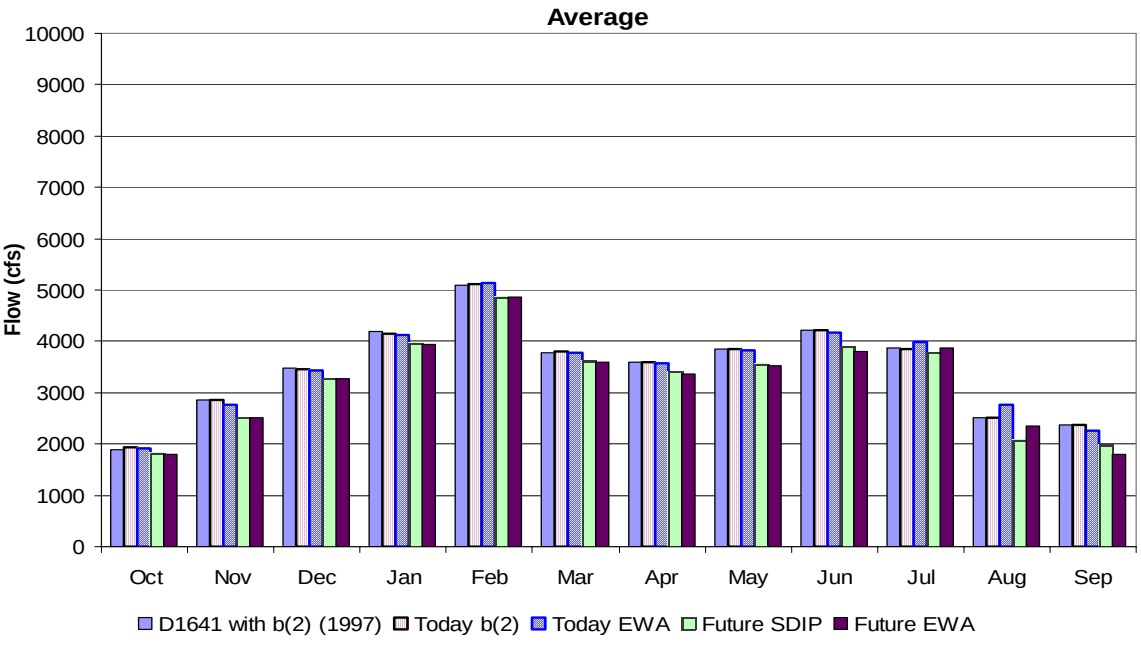


Figure 9-50 Average Monthly Nimbus Release

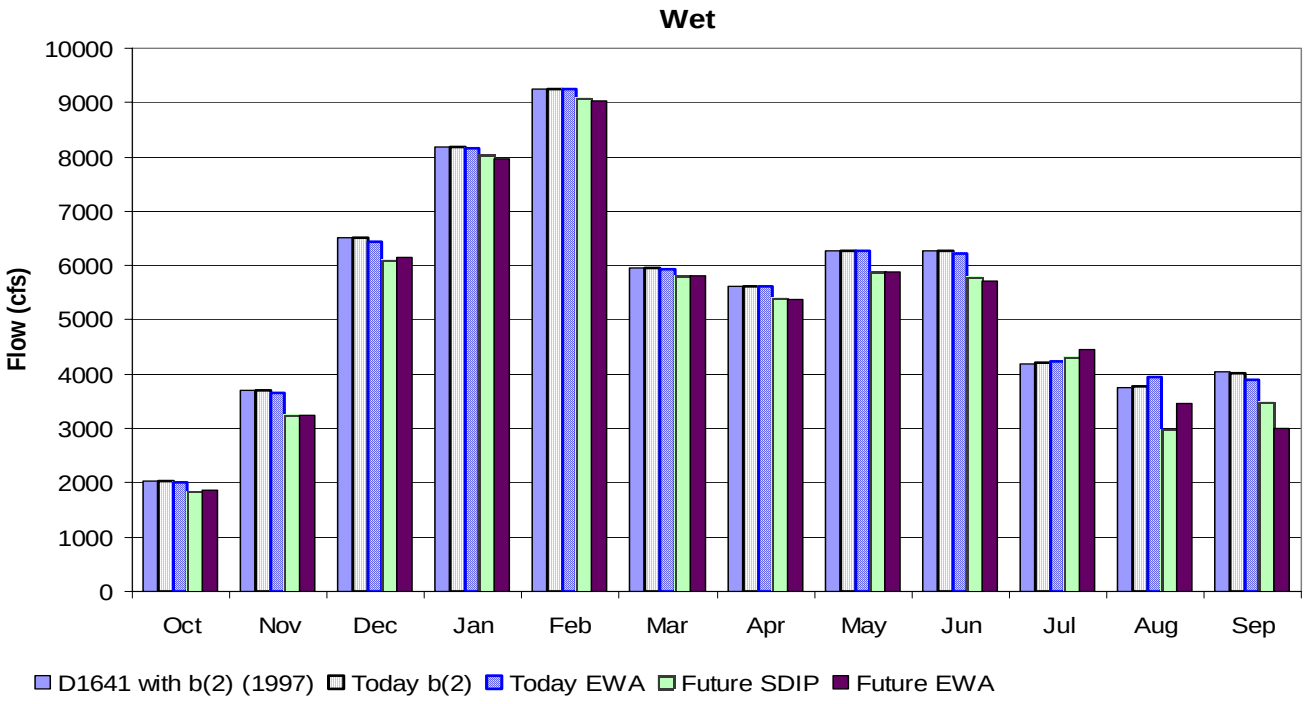


Figure 9-51 Average wet year (40-30-30 Classification) monthly Nimbus Release

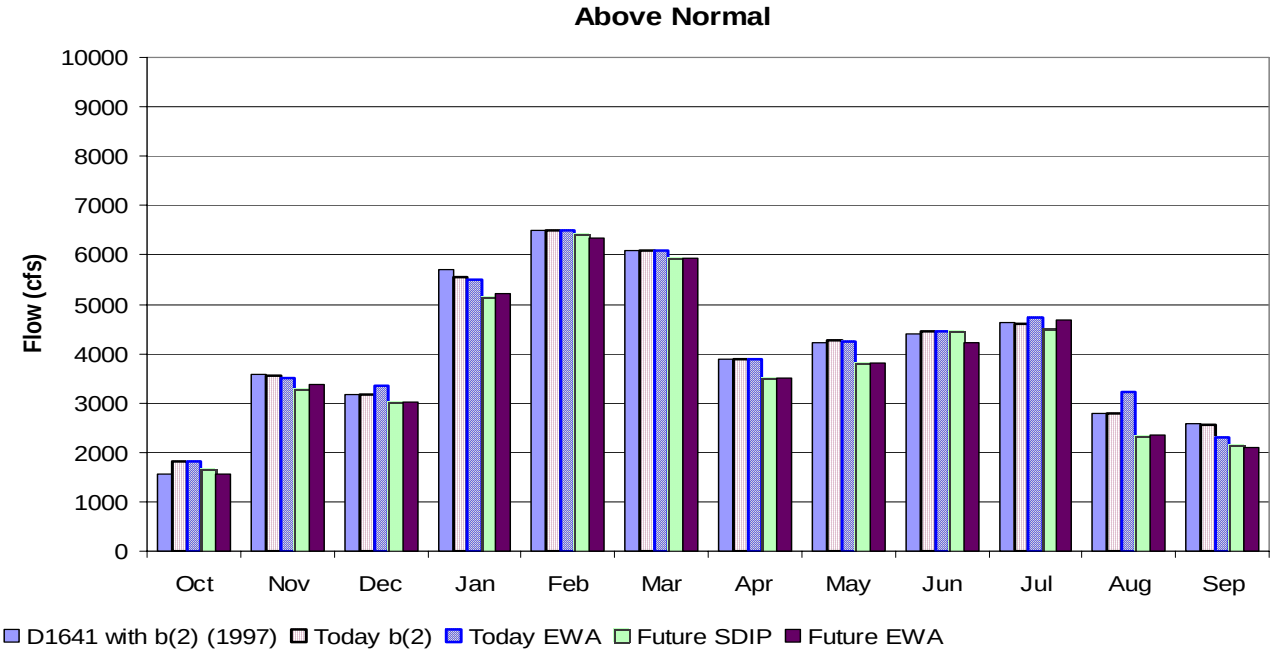


Figure 9-52 Average above normal year (40-30-30 Classification) monthly Nimbus Release

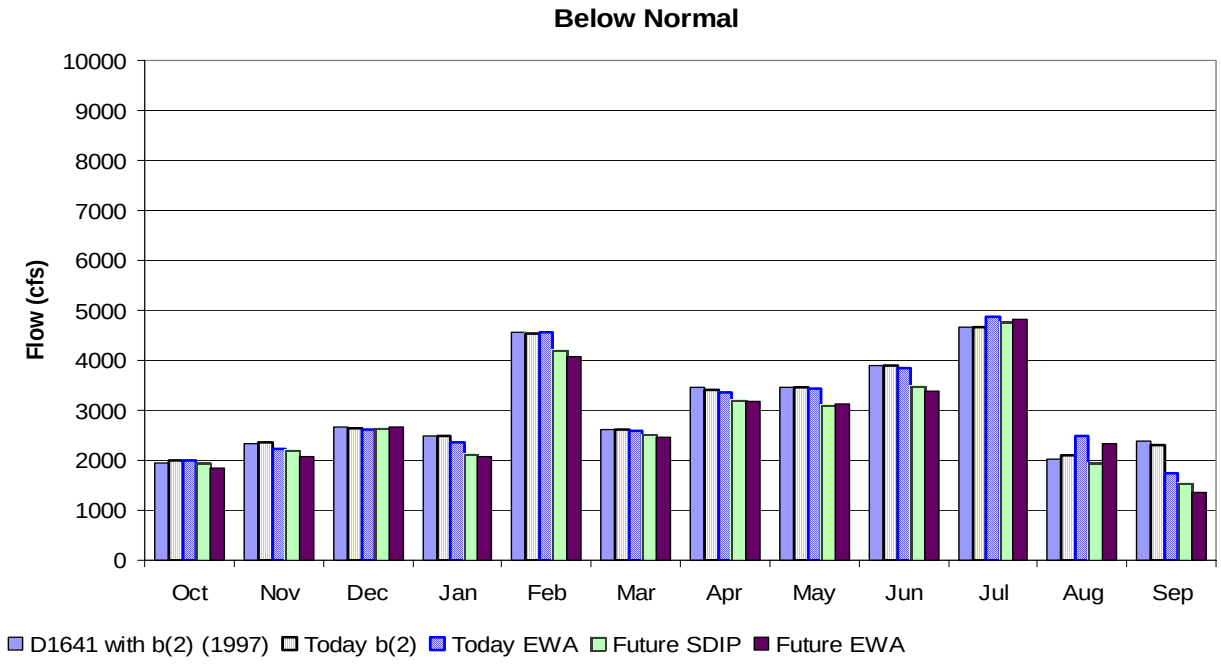


Figure 9-53 Average below normal year (40-30-30 Classification) monthly Nimbus Release

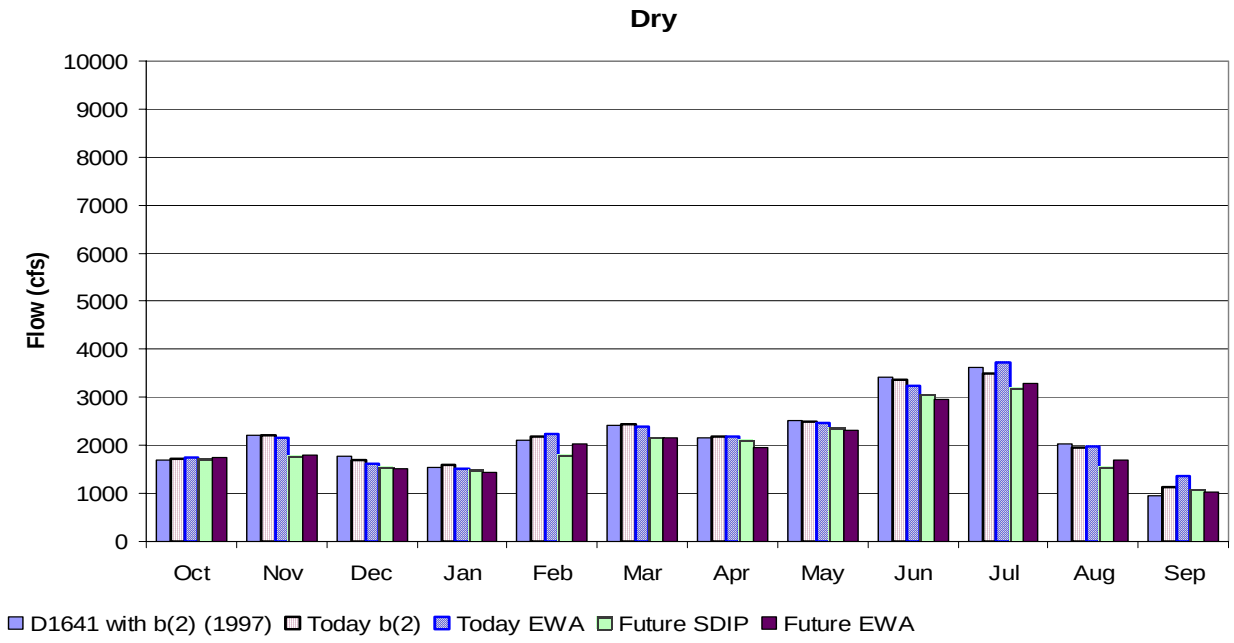


Figure 9-54 Average dry year (40-30-30 Classification) monthly Nimbus Release

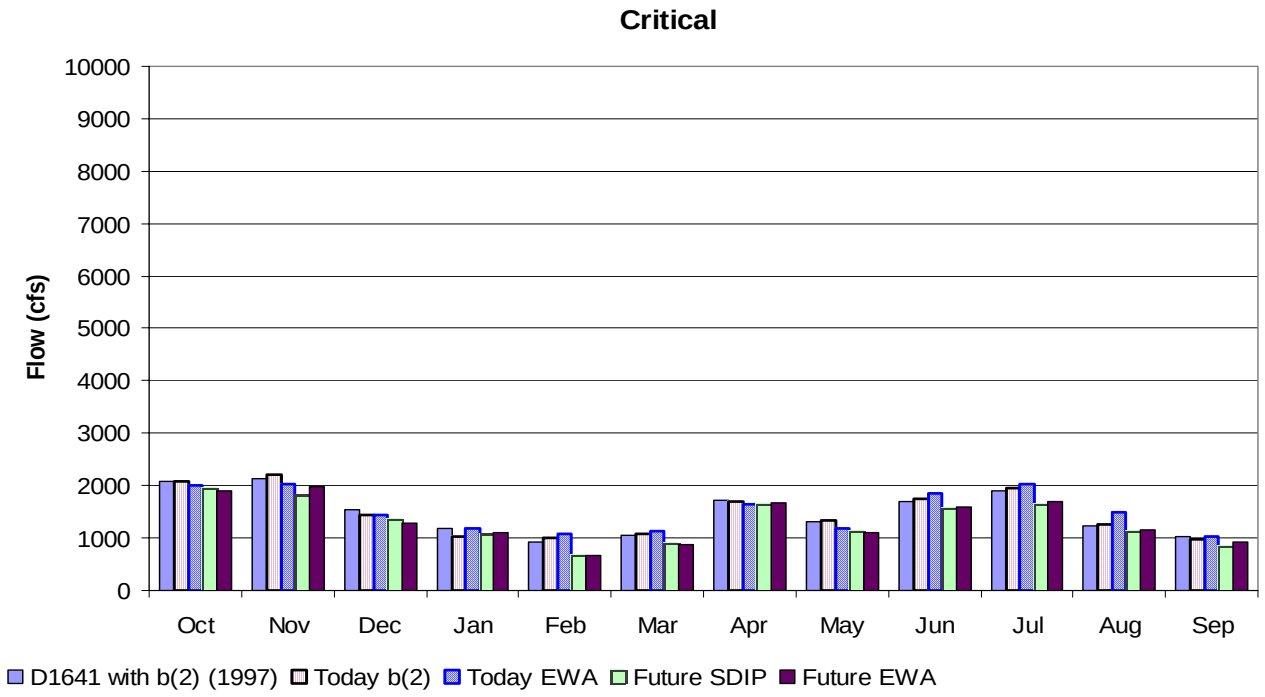
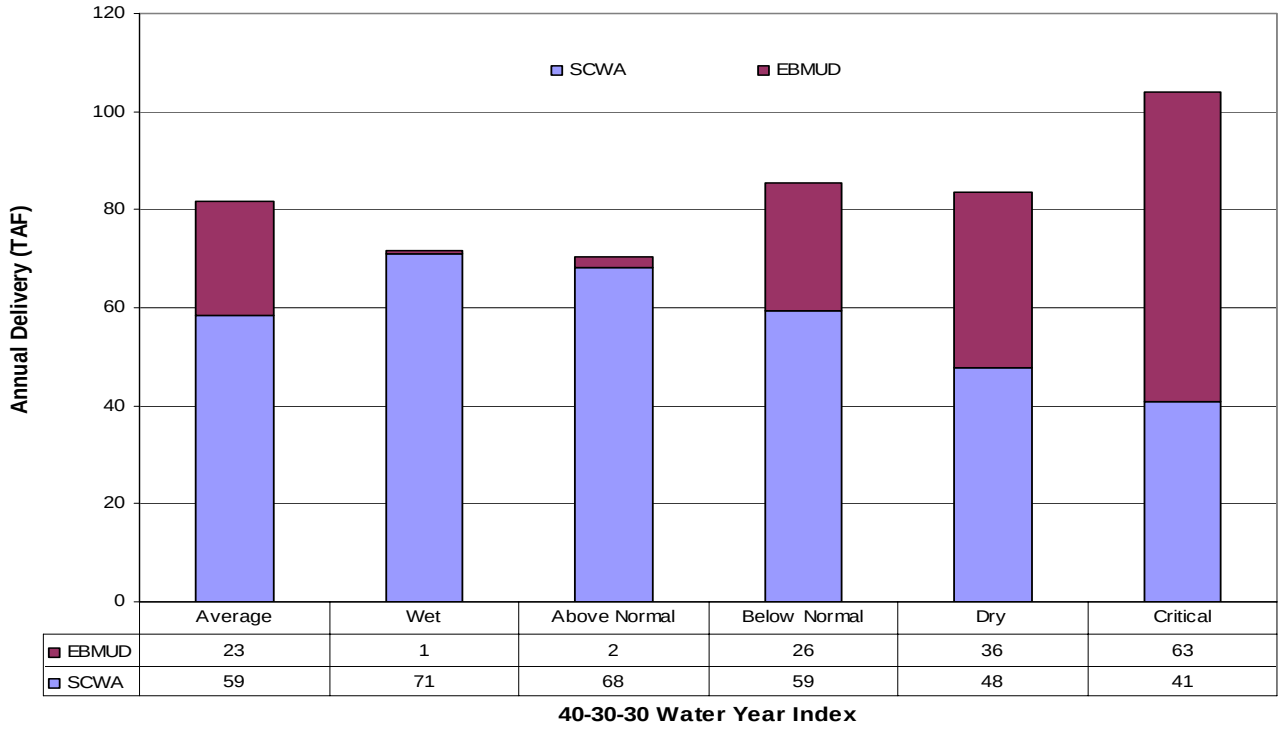


Figure 9-55 Average critical year (40-30-30 Classification) monthly Nimbus Release



	Average	Wet	Above Normal	Below Normal	Dry	Critical
EBMUD	23	1	2	26	36	63
SCWA	59	71	68	59	48	41

Figure 9-56 Average Annual Freeport Diversion for SCWA and EBMUD from Study 4

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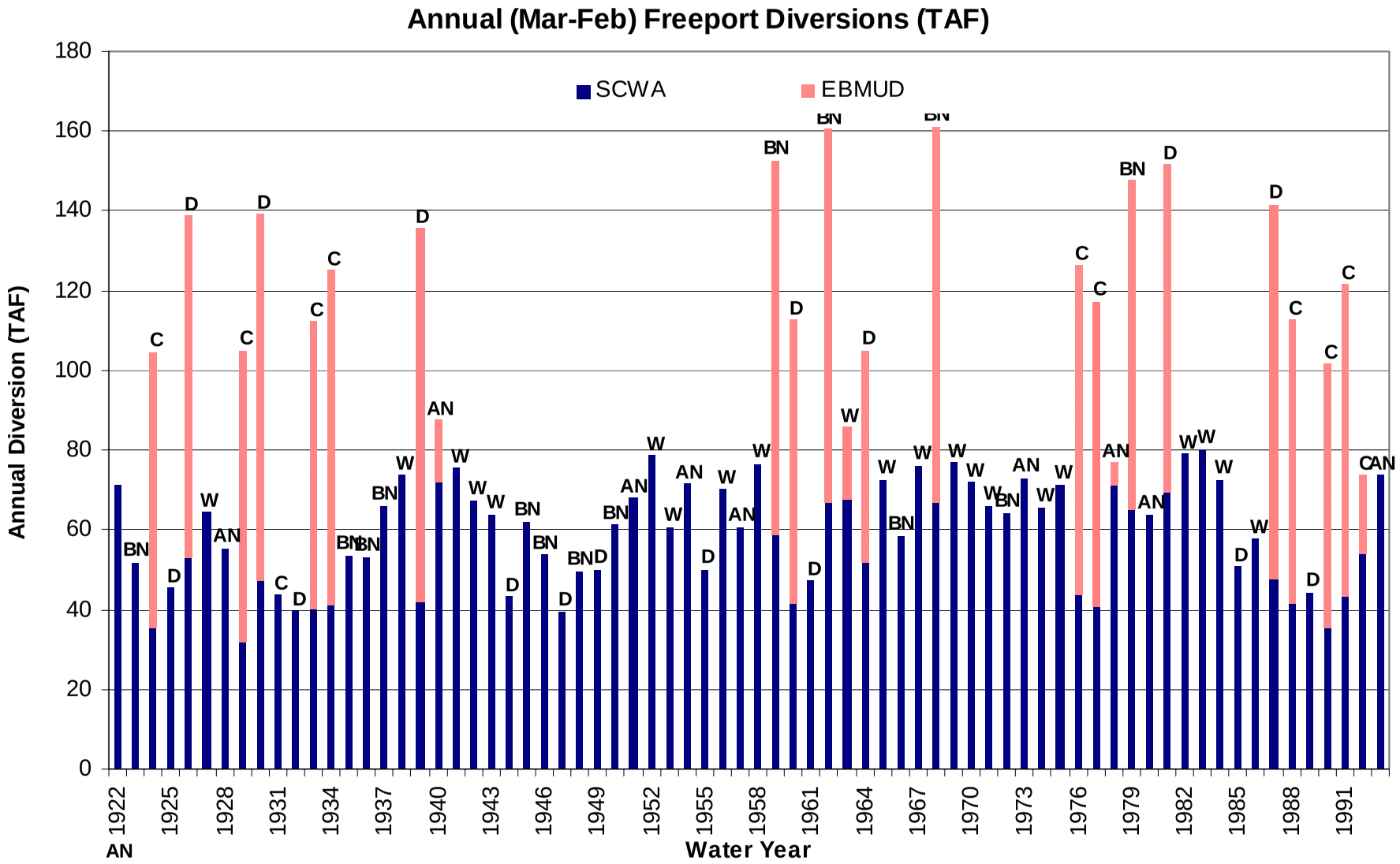

Figure 9-57. Shows the Mar – Feb annual diversions at Freeport for SCWA and EBMUD with 40-30-30 water year classifications

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Adult Migration, Spawning, and Incubation

The American River supports a steelheads run but no spring–run or winter–run Chinook. Adult steelheads migration in the American River typically occurs from November through April and peaks in December through March (McEwan and Jackson 1996; SWRI 1997). Predicted flows could drop as low as 500 cfs in up to 10 percent of years and be as high as 33,000 cfs as a monthly average. Flows in the future will be lower in these months with or without EWA. Steelheads spawning habitat area peaks at 2,400 cfs (Table 4–2) but shows very little variability in spawning habitat area between 1,000 and 4,000 cfs. Flows during the spawning period would be below 2,400 cfs in about 30 to 60 percent of years, depending on the month. Average monthly flows could range up over 30,000 cfs in the wettest years with instantaneous flows likely over 100,000 cfs for flood control. The flows over about 50,000 cfs could scour some redds (Ayres Associates 2001), but will provide needed reconfiguration of the channel for long-term maintenance of good spawning and rearing habitat. At the 90 percent exceedance level flows could average as low as 500 cfs. Spawning habitat area was not predicted for flows below 1,000 cfs but spawning habitat would certainly be less and important side channel spawning habitat would be nearly absent. The steelheads population in the American River does not appear to be ultimately limited by spawning habitat availability, but by factors following fry emergence such as summer water temperatures and predation. The number of juvenile steelheads in the river drops quickly at the beginning of the summer, possibly due to predation. Predators likely take more steelheads when the water is warmer. Flow conditions are expected to provide suitable depths and velocities for upstream passage of adults to spawning areas within the lower American River. No migration barriers exist below Nimbus Dam, except when the hatchery picket weir is in operation.

Steelheadss prefer 46° F to 52° F water for upstream migration. Temperatures of 52° F or lower are best for steelheads egg incubation. Average temperatures at Watt Avenue are generally within this range much of the time between December and March. During dry years temperatures in November, March, April, and May would be higher than preferred and could be as high as 71° F in May of warm dry years. Over 90 percent of the steelheads spawning activity is thought to occur during late December through March when temperatures are generally within an acceptable range for spawning (Hannon et al. 2003). Steelheads eggs are in the gravel from December until mid-May. Temperatures from March through May could be above the preferred range for egg incubation at Watt Avenue in about 50 percent of years during March, and in all years in April and May. Fish surveys identify newly emerged steelheads in the American through May indicating that eggs do survive at temperatures above the preferred range. Temperatures are relatively unchanged between all modeling runs during the steelheads spawning and incubation period.

Fall–run Chinook migration typically begins in August and peaks in October, although a few Chinook sometimes show up as early as May. Spawning generally initiates in late October or early November depending on water temperature and continues through December with a few later fish still spawning in January. Chinook-spawning habitat peaks at 1,800 cfs based on PHABSIM studies (Table 4–2). Snider et al (2002) calculated that a flow of 2,625 cfs would best support a spawning population of 70,000 Chinook and that 3,000 cfs provides 340 acres of spawning habitat and 1,000 cfs provides 275 acres of spawning habitat. The extent to which the naturally spawning Chinook population is limited by spawning habitat availability in the American River has not been determined, nor can it be determined without knowing the proportion of adult returns that is hatchery produced each year. Flows

of 1,000 cfs or below would occur during October and November in about 20-25 percent of the years. Flows would generally increase after November and through the spring. A flow of 1,200 cfs in 1991 supported a spawning population of 18,145 adult Chinook with an 8 percent superimposition rate (Snider et al 2002). Most spawning occurs in the upper three miles of the river. Under reduced flow conditions in this area fish tend to spawn in overlapping areas rather than extending spawning distribution downstream, resulting in superimposition. Flows in the future would be lower than under present conditions throughout much of the year due to increased diversions upstream of Folsom. Flows in the river could potentially be as low as 300 cfs in May under the driest condition in the future in both scenarios. Most Chinook have left the river by May.

A temperature below 60° F is considered suitable for Chinook spawning and egg incubation in the American River with the preferred temperature being less than 56° F. The primary Chinook spawning area is from Goethe Park upstream to Nimbus Dam, but some spawning occurs downstream as far as mile 5 at Paradise Beach. Monthly average temperatures meet 60° F at Watt Avenue in October in all but 25 percent of the years and in November in all but about five percent of years. Meeting temperature objectives for steelheads during the summer and for Chinook in the fall involves trade-offs between whether to use more cool water during the summer for steelheads rearing or saving some amount of cool water until fall to increase Chinook spawning success. Temperatures during upstream migration are increased in the future scenarios in September and October.

Reclamation manages the cold water pool in Folsom reservoir with regular input from the American River Operations Group. Temperature shutters on each of the power penstocks are raised throughout the summer and fall when needed to provide cool water in the lower American River for steelheads and Chinook. The shutters allow releases to be made from four different levels of the reservoir, depending on the desired water temperature in the lower river.

Flood flows that are not reflected in the operations forecasts have the potential to scour steelheads redds resulting in the injury and mortality of steelheads eggs and sac-fry. Most flood control operations are not expected to result in flow conditions that are likely to create scour (>50,000 cfs). Flow reductions following flood control releases have the potential to dewater redds constructed during the higher flow period. Higher flood control releases over a one or two-day period rather than lower releases over an extended period would preclude steelheads spawning in areas that will be later dewatered. The American River Operations Group can consider such releases. Planning for the normal operations of Folsom Reservoir during this period considers the potential for high flood control releases during spawning and incubation period. Non-flood control operations are typically designed to avoid large changes in flow that may create stranding problems. Because Folsom Reservoir is the closest water source to the Delta, releases from Folsom can be needed to maintain delta water quality requirements when delta water quality deterioration occurs. Once requirements are met or increased flows from other reservoirs make it to the delta Folsom releases can be cut back to conserve storage, sometimes affecting fish or redds in the river. CVPIA section (b)(2) water may be used during this period to support higher flows or avoid reductions that otherwise would be made. Dewatered steelheads redds likely lowered the number of steelheads fry produced in 2003. The limiting period to in-river steelheads production seems to occur after fry emergence.

Fry, Juveniles, and Smolts

The freshwater life stages of steelheads occupy the American River throughout the year. Most literature has indicated that rearing fry and juvenile steelheads prefer water temperatures between 45°

F and 60° F (Reiser and Bjorn 1979; Bovee 1978; Bell 1986). However, Myrick (1998) found the preferred temperatures for Mokelumne River Hatchery steelheads placed into thermal gradients were between 62.6° F and 68° F. NOAA Fisheries generally uses a daily average temperature of 65° F at Watt Avenue as a temperature objective for steelheads rearing in the American River and then adjusts the temperature objective and point depending on Folsom cold-water pool each year. Temperatures could exceed a monthly average of 65° F at times between May and October with the highest temperatures of up to 75° F in occurring in July and August of years with a low cold-water pool storage in Folsom. Temperatures are modeled to be almost always higher than 65° F at Nimbus Dam in July through September. Temperatures would exceed 70° F during July in 20 percent of years and in August in 50 percent of years at Watt Avenue. These high summer temperatures are likely what limits the naturally spawned steelheads population in the American River. Monitoring during 2001 and 2002 indicated that steelheads did not appear to be finding water cooler than that found in the thalweg and they persisted below Watt Avenue in water with a daily average temperature of 72° F and a daily maximum over 74° F. Water temperature in the future runs is predicted to be approximately 1° F warmer from July to October and about 0.5° F warmer in June and November. Temperatures are about the same with and without EWA. Temperatures the rest of the year will be relatively unchanged. The increased temperatures will put additional temperature stress on rearing steelheads during summer and adult Chinook holding and spawning. Due to the high temperatures the steelheads run in the American River will likely remain primarily supported by the hatchery.

Juvenile salmon emigration studies using rotary screw traps in the lower American River at Watt Avenue generally capture steelheads fry from March through June while steelheads yearlings and smolts emigrate from late December till May, with most captured in January (Snider and Titus 2000). Specific flow needs for emigration in the American River have not been determined. Steelheads emigrate at a relatively large size so are good swimmers and presumably do not need large pulses to emigrate effectively from the American River as long as temperatures are suitable through the lower river and in the Sacramento River. Modeled flows are expected to provide suitable depth and velocity conditions for emigration during most years. Flows could drop below 1,000 cfs between December and May in about 5 to 15 percent of years depending on month. Low flows would occur slightly more often in the future than under current operations. Reductions could be as great as 700 cfs in February with EWA and would result in significantly less rearing habitat available in dry years. This would probably affect juvenile salmon more than juvenile steelheads due to the high salmonid densities. The habitat is generally not fully seeded with steelheads fry. December through March forecast mean monthly temperatures are expected to be generally within the optimum smoltification and emigration range (44° F to 52° F) during most years but temperatures may exceed 52° F in February in about 10 percent of years and in about 50 percent of years in March. No change in temperatures between current and future operations during December through March is expected to occur.

Rearing steelheads fry and juveniles can be exposed to stranding and isolation from main channel flows when high flows are required for flood control or Delta outflow requirements and then subsequently reduced after the requirement subsides. After high flow events when rearing steelheads fry and juveniles issues are a concern, Reclamation coordinates flow reduction rates utilizing the B2IT and American River Operation Group adaptive management processes to minimize the stranding and isolation concerns versus current hydrologic conditions and future hydrologic projections to Folsom cold-water management. Reclamation attempts to avoid flow fluctuations during non-flood control events that raise flows above 4,000 cfs and then drop them back below 4,000 cfs as recommended by

Snider et al (2002). Flow fluctuations are sometimes difficult to avoid with competing standards to meet in the Delta and upstream so some stranding will continue to occur.

Chinook fry generally emerge from the gravel starting in late December, peaking in February and continuing up through March (Snider and others 1997, Snider and others 1998, Snider and Titus 2000). More than 99 percent of the Chinook fry emigrate from the river as pre-smolts. Peak emigration occurs around late February. Nearly all Chinook leave the river before the end of June. Preferred temperature for juvenile Chinook is 53° F to 57.5° F (Boles and others 1988). Water temperature generally exceeds this range starting in April of over 50 percent of years. The majority of Chinook (>90 percent) leave the river prior to April. Although most Chinook leave before April, those that stay in the river longer grow larger before emigration so survival through the Delta is likely better than for smaller fish. As mentioned above the temperature control shutters have the capability to provide water within the preferred range for Chinook rearing. The timing of cool water releases through the year involves trade-offs between providing cool water for the Chinook life cycle or providing cool water so that juvenile steelheads can survive in the river through the warm summer months.

The Chinook egg mortality model results for the American River indicate that Chinook egg to fry water temperature related mortality will increase during all except critically dry year types in the future (Figure 9–58). The increase in mortality is greatest in the wettest year types. The effect of decreased egg to fry survival on the returning adult population is impossible to determine because there is currently no marking program to determine what proportion of the returning adults consists of naturally spawned fish versus hatchery fish.

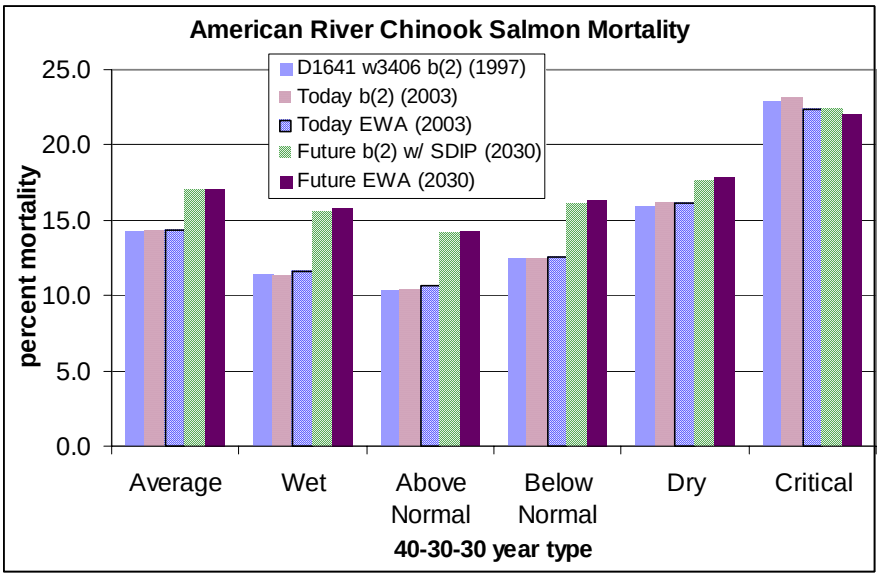

Figure 9–58 Percent mortality of Chinook salmon from egg to fry in the American River based on water temperature by water year type.

Mokelumne River

Mokelumne River information is included in this assessment because the new diversions from the Sacramento River at Freeport will be affected by the change in EBMUD operations in the Mokelumne River.

Adult steelheads begin to immigrate up the Mokelumne River in August with peak upstream migration in December through February. Spawning occurs December through March with the peak in January and February (EBMUD data). Flow releases from Camanche Dam are not controlled by Reclamation so release data was not available. Delta inflow data from Mokelumne is available but is not representative of releases at Camanche Dam. Diversions downstream of Camanche Dam remove much of the water so that delta inflow is generally less than what is released from Camanche Dam. Delta inflow from the Mokelumne is less than 50 cfs in about 70 percent of years in November, 40 percent of years in December, 30 percent of years in January, 25 percent of years in February, 20 percent of years in March 8 percent of years in April and May. At times there would be no inflow to the Delta during November through March when adult steelheads are migrating upstream. Low Delta inflow could result in steelheads returning to the Mokelumne not being able to find the river in years of low inflow and Mokelumne Hatchery fish showing up in other rivers. This may be why steelheads returns (hatchery and wild) have been below 100 fish greater than 380 mm since 1999 (EBMUD data). For the steelheads that make it into the upper river, based on past release data reservoir releases are generally greater than 200 cfs and provide adequate flow for spawning and incubation. Delta inflow is projected to be generally slightly higher in the future. EBMUD indicated that releases to the river will be improved in the future with the extra water from the Freeport Diversion. Twenty percent (up to 20,000 acre-feet) of the amount of water diverted at Freeport will be made available for Camanche Reservoir releases to the Mokelumne. EBMUD provides an extensive fisheries monitoring and restoration program in the Mokelumne River to better understand the life cycle and assist in recovery of steelheads.

Steelheads fry were found to emigrate from the Mokelumne River in the spring, primarily April through June and sub-yearling smolts emigrate April through June. Fewer juveniles stay in the river the rest of the year to emigrate as yearlings. Mokelumne flows are intended to maintain suitable rearing habitat through the year but specific flow information is not available. Delta inflows would exceed 50 cfs during March in 75 percent of years, during April 92 percent of years, and during May and June in most years.

Stanislaus River

Modeling

Between the five studies there is no change in operations on the Stanislaus and no significant effects of the previously mentioned changes in assumptions. Figure 9-59 shows the chronology of New Melones and Figure 9-60 shows the End of September exceedance plot. Both figures show that there are no significant differences in storage between the five studies. Figure 9-61 shows the percentile values for the releases out of Goodwin Reservoir and Figure 9-62 to Figure 9-67 show the monthly averages by 60-20-20 water year types. The Goodwin release graphs also show no significant effect to operations between the five studies.

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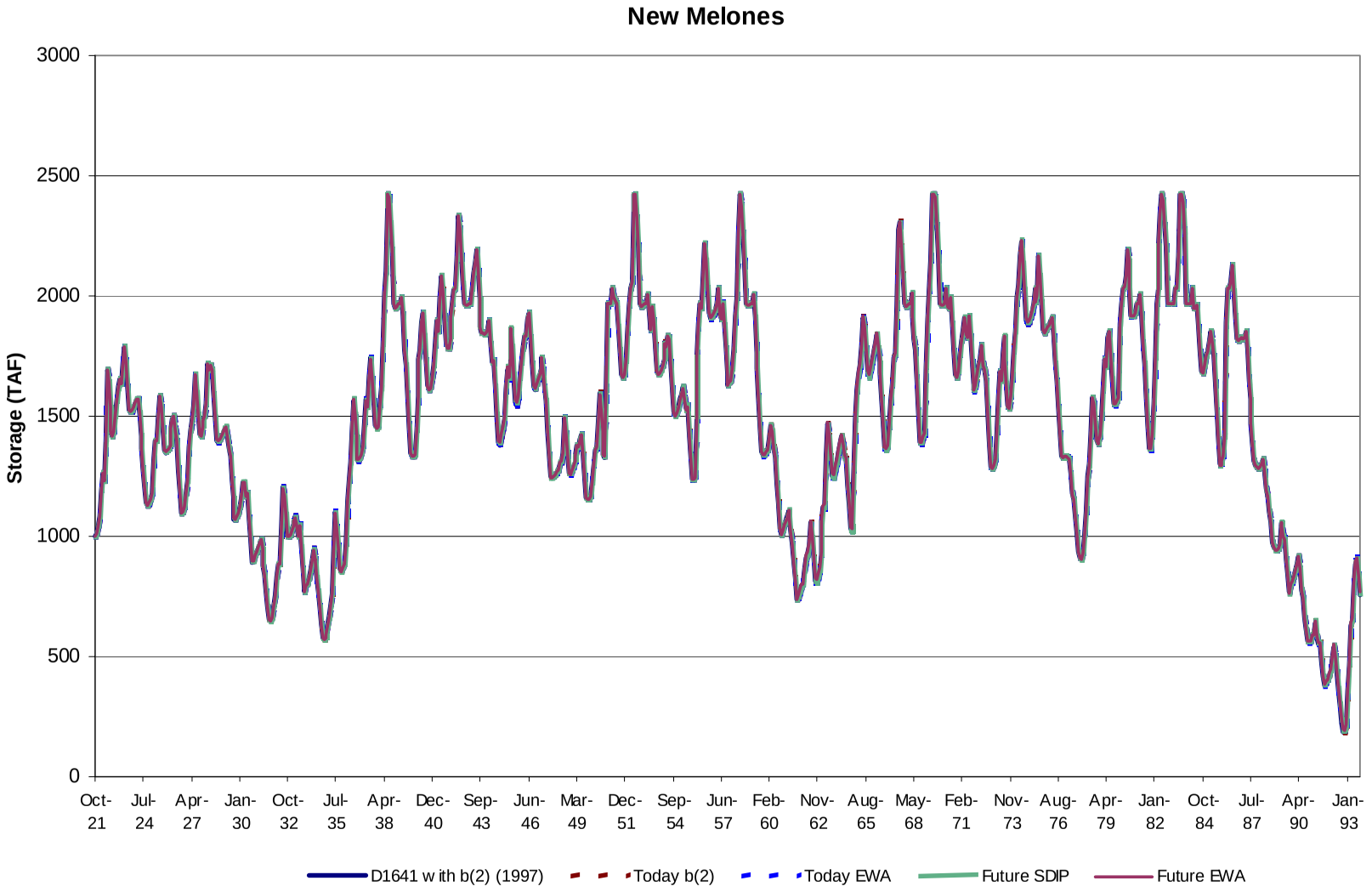

Figure 9-59 Chronology of New Melones Storage Water Year 1922 - 1993

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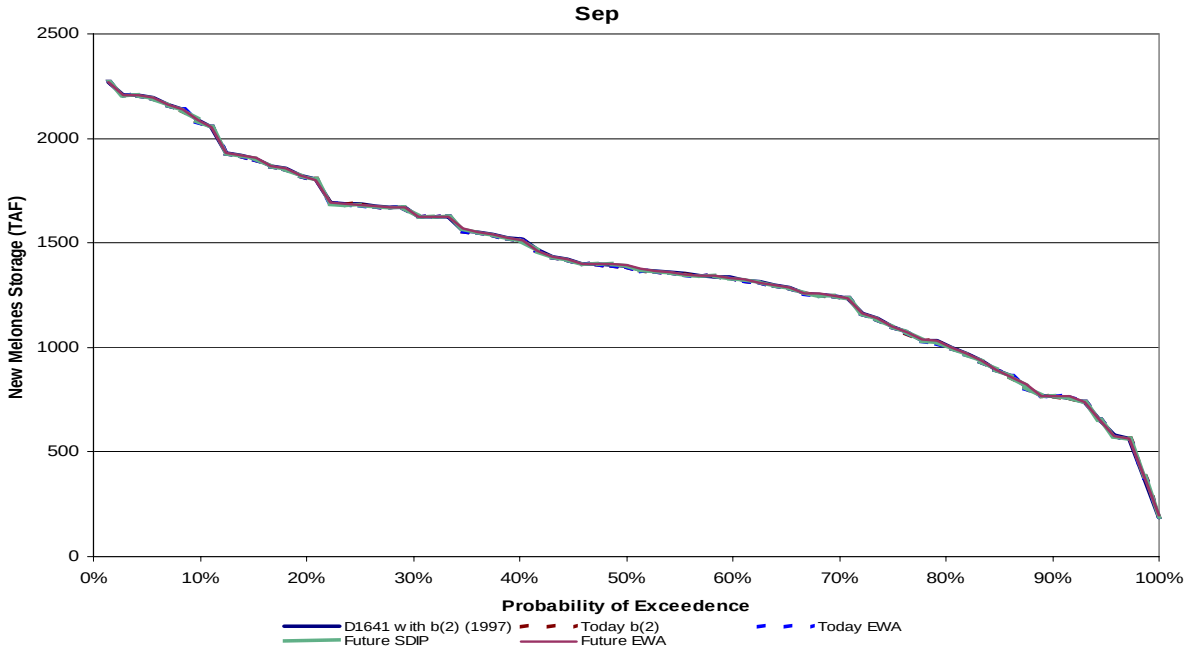

Figure 9-60 New Melones Reservoir End of September Exceedance

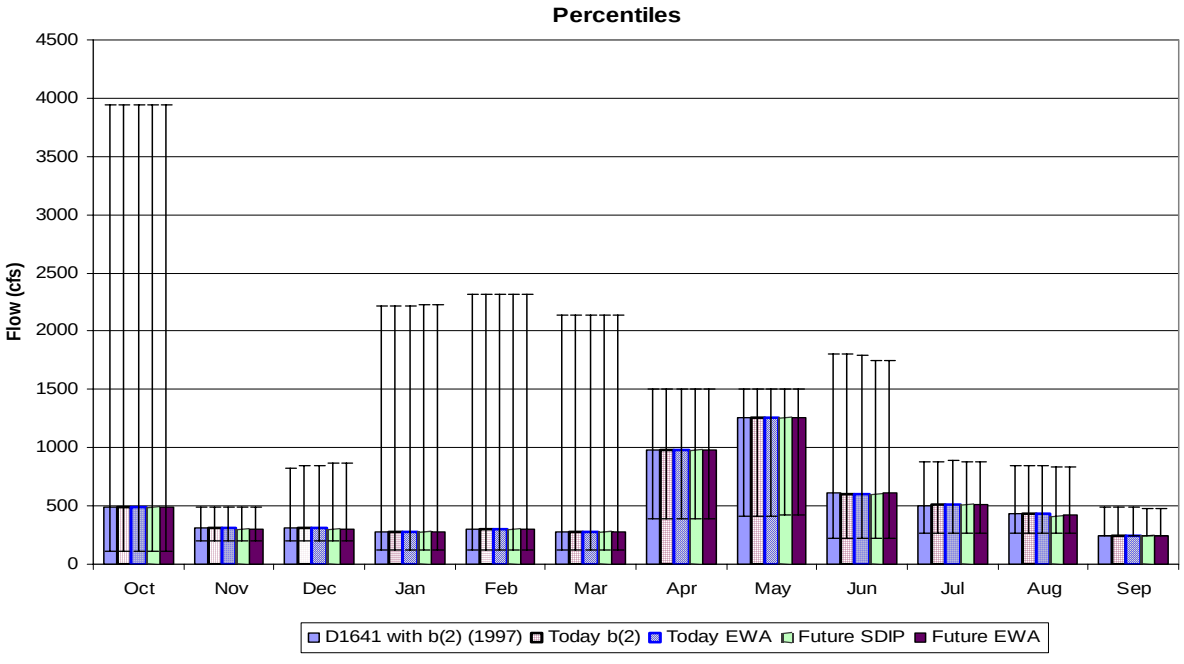

Figure 9-61 Goodwin Releases 50th Percentile Monthly Releases with the 5th and 95th as the bars

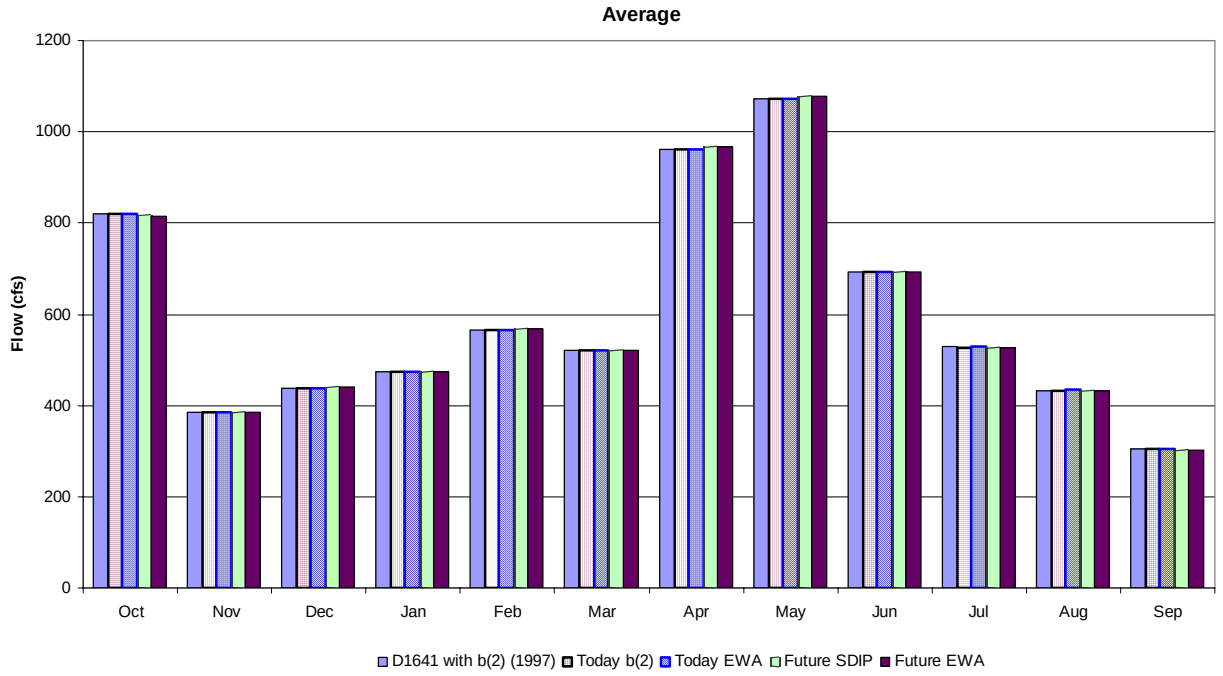

Figure 9-62 Average Monthly Goodwin Releases

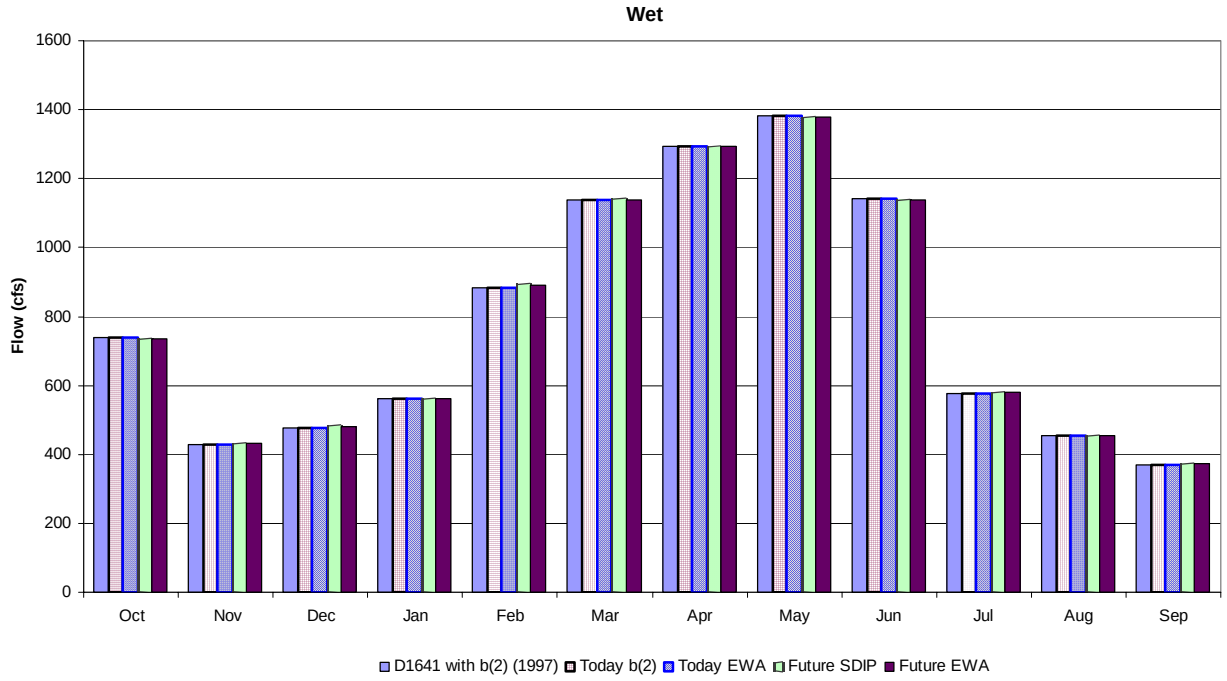

Figure 9-63 Average wet year (40-30-30 Classification) monthly Goodwin Releases

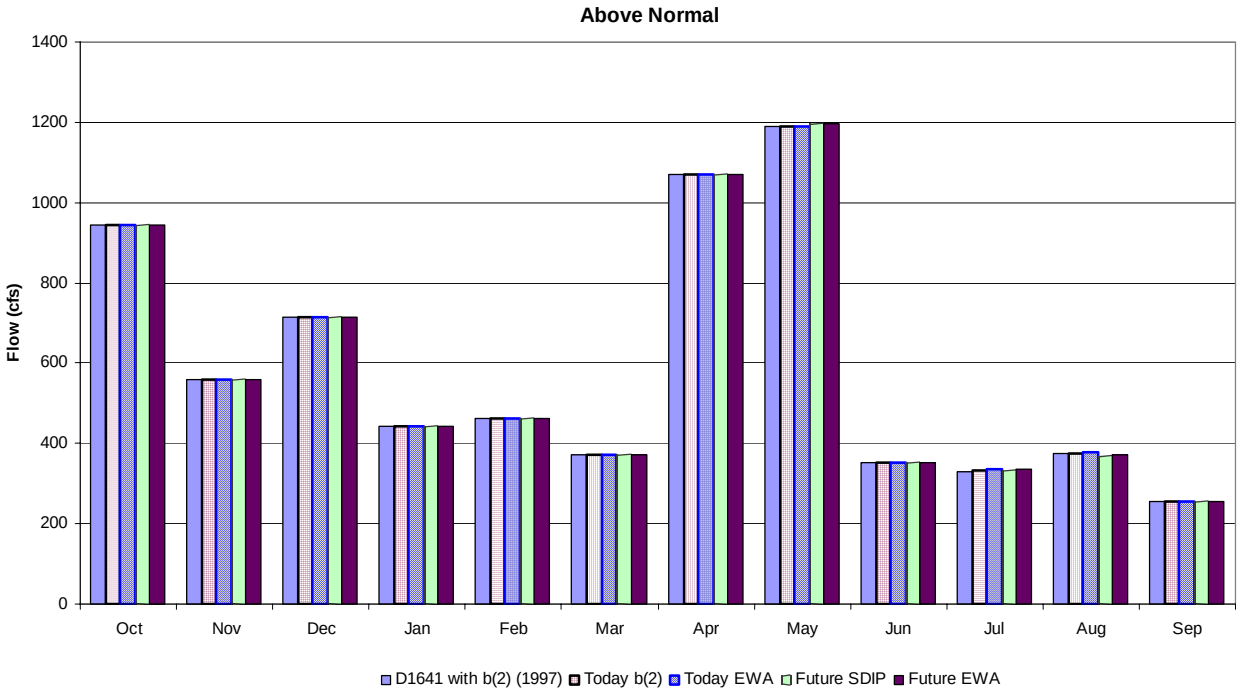

Figure 9-64 Average above normal year (40-30-30 Classification) monthly Goodwin Releases

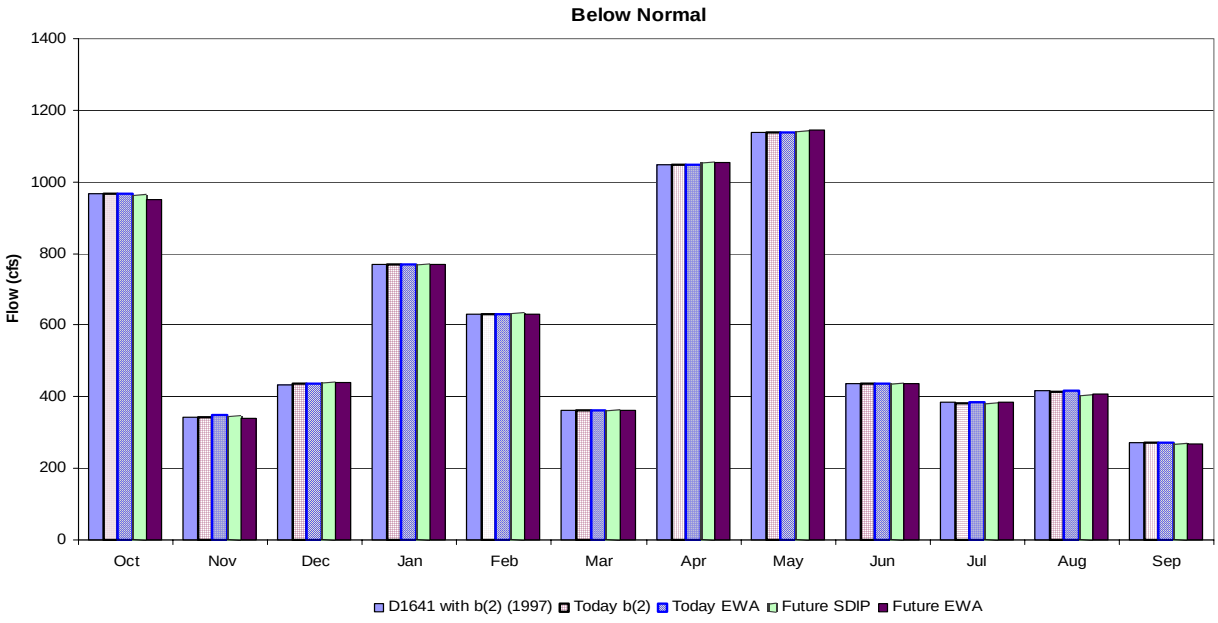

Figure 9-65 Average below normal year (40-30-30 Classification) monthly Goodwin Releases

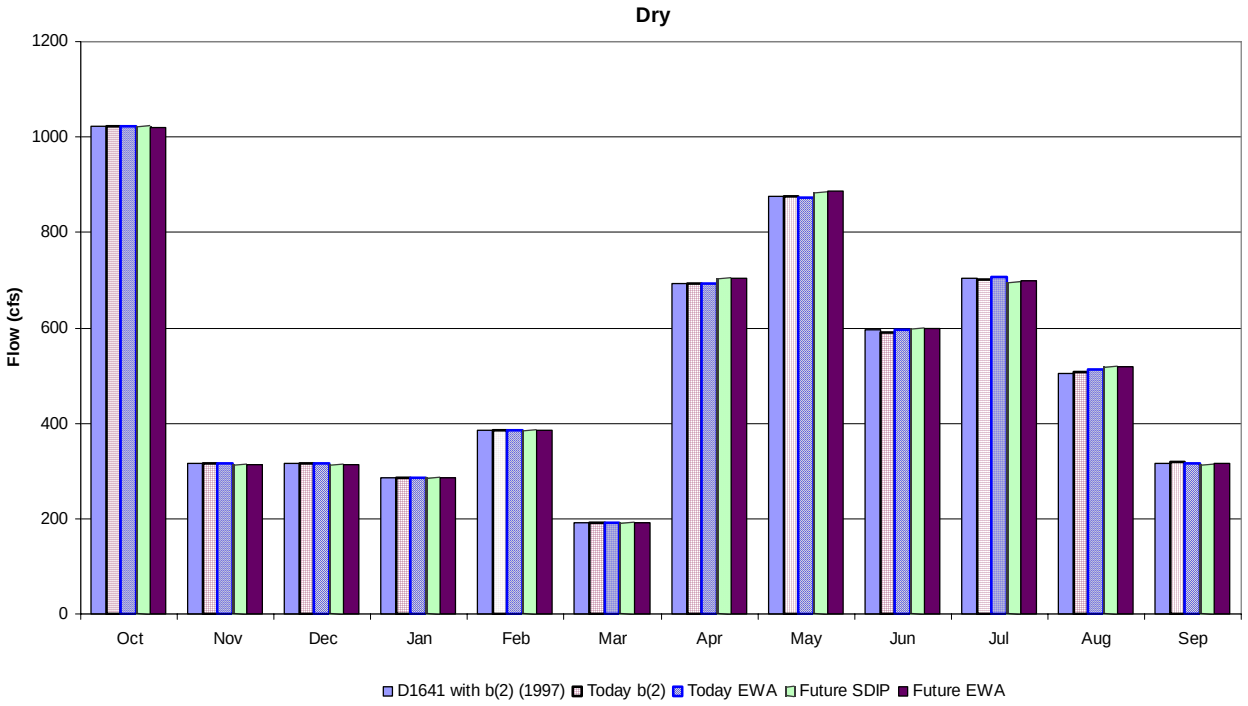

Figure 9-66 Average dry year (40-30-30 Classification) monthly Goodwin Releases

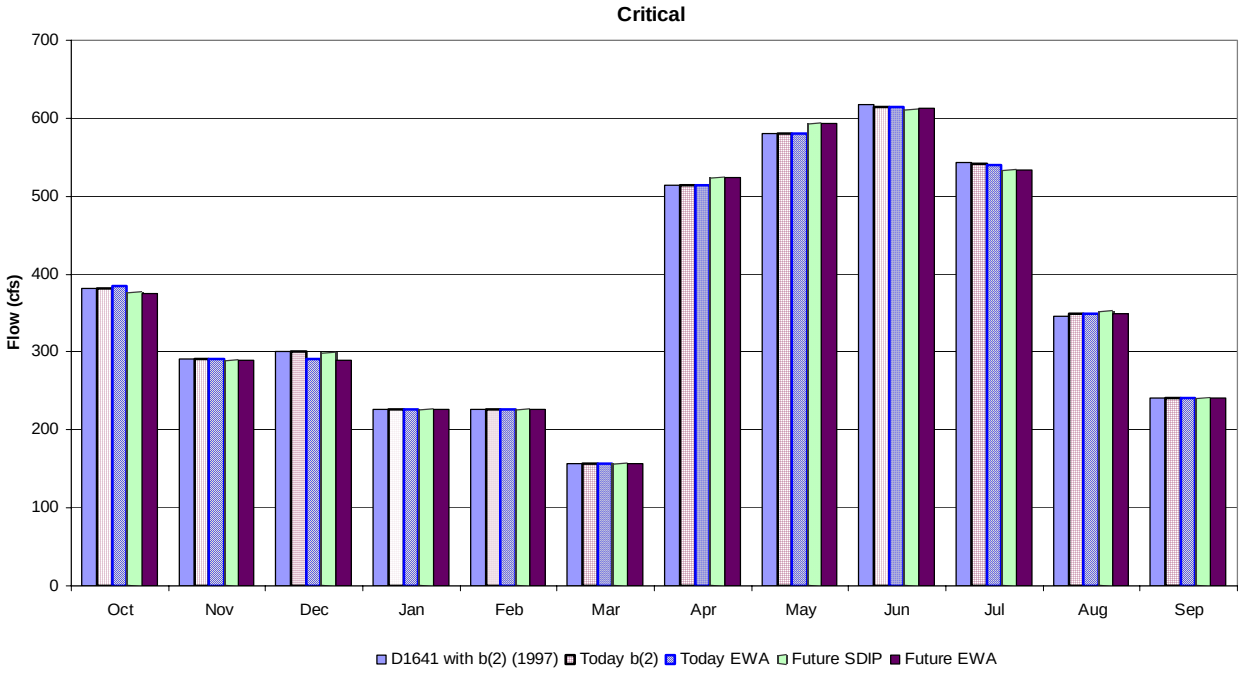

Figure 9-67 Average critical year (40-30-30 Classification) monthly Goodwin Releases

Adult Migration, Spawning, and Incubation

Steelheads life history patterns in the Stanislaus River and the rest of the San Joaquin River system are only partially understood, but studies are underway to determine steelheads populations, extent of anadromy, and run timing. Resident rainbow trout are abundant in the first 10 miles downstream from Goodwin Dam. Anglers report catches of adults that appear to them to be steelheads based on large size and coloration. Rotary screw traps at Oakdale and Caswell catch downstream migrating steelheads with smolting characteristics each year. Because the full life cycle of steelheads is not known for the Stanislaus, some life history patterns from Sacramento River steelheads are used in this assessment. The Stanislaus River receives the highest year-round flows and has the coolest water of the three major San Joaquin tributaries. A high population of resident trout in the Stanislaus indicates conditions are favorable year round for the resident form of the species.

A weir was installed near Riverbank during part of the 2002-2003 run. Permitting issues prevented weir operations during the anticipated primary upstream migration period. No steelheadss were captured at the weir during the 2002-2003 run. Take authorization for steelheads monitoring using the weir and rotary screw traps will be needed for continuation of the monitoring program.

There is essentially no difference in Goodwin releases between the five modeling scenarios. Stanislaus operations will be the same in the future as they are now. Steelheadss in Sacramento River tributaries migrate upstream to spawn primarily between December and March. Spawning occurs during this period and may extend through April. Based on trout fry observations in Stanislaus snorkel surveys, spawning timing appears to be about the same in the Stanislaus. Goodwin Dam releases during this period would be mostly from 200 to 500 cfs in December and 125 to 400 cfs in January through March. Flows in April and May would be between 400 and 1,500 cfs. Steelheads spawning flows were estimated to be maximized at 200 cfs and in stream habitat for adult migration and rearing was estimated to be maximized at 500 cfs (Table 4–3). Spawning or holding habitat for adult steelheads is not likely limiting in the Stanislaus because the anadromous component of the population does not appear to be large. Monthly mean flows as high as 5,000 cfs and as low as 125 cfs could occur throughout the range of precipitation regimes. Flows above about 5,000 cfs could affect egg survival in redds or scour some redds. Spawning occurs on a number of gravel addition sites. Bed mobility flows are likely lower at these sites until the initial high flows distribute the gravel in a more natural manner. The flows as low as 125 cfs in 90 percent exceedance years and dryer would still provide some spawning habitat for steelheadss. The recommended spawning flows for rainbow trout were 100 cfs (Table 4–3). Low flows for upstream migration and attraction during dry years may result in fewer steelheadss reaching the spawning areas. During years when flows are low in the Stanislaus they would likely be low in other rivers so that Stanislaus flows should still be a similar proportion of total San Joaquin River flow and Delta outflow.

During low flows from the San Joaquin River dissolved oxygen sometimes reaches lethal levels in the Stockton deep-water ship channel. The low DO can cause a barrier to upstream migrating steelheads and Chinook so that they are delayed or migrate up the Sacramento River or other tributary instead. Flows from the Stanislaus help to address the low DO problem by meeting the Vernalis flow standard when possible, although there is not always enough water available from New Melones to meet the flow standard at all times.

Chinook begin to enter the Stanislaus River in August and the peak in upstream migration occurs in October. Adult Chinook have occasionally been documented in the river as early as May but these fish are believed to be strays from Feather River. Most spawning occurs in November and December. The lowest flows modeled would occur in October and could be as low as 110 cfs. Chinook should still be able to migrate upstream at this flow provided temperatures are suitable and enough water is coming out of the mouth of the river for attraction. Other rivers would likely be proportionately lower in the same years so the proportion of Stanislaus River water in the San Joaquin and Delta should be similar. Flows during November and December would be as low as 200 cfs in about 25 percent of the years. Aceituno (1993) estimated that 200 cfs would provide the maximum amount of spawning habitat for Chinook and 150 cfs would be best for incubation and fry rearing. Between January and March flows could drop down to 125 cfs. This should provide sufficient flow to keep most redds that were constructed at 200 cfs underwater. The configuration of the Stanislaus River channel is such that dewatering of spawning areas is an uncommon occurrence. Most of the channel perimeter remains wetted at low flows.

No change in Stanislaus River temperatures is projected to occur between any of the model runs. Temperatures at Orange Blossom Bridge would be 52° F or below most of the time from December to February. In March and April temperatures would exceed 52° F in about 45 percent of years and in May in 80 percent of years. Because these temperatures are unchanged from past operations and the Stanislaus River supports a large trout population year round with these temperatures, these temperatures appear to provide sufficient cold water for the current trout population. Figure 9–68 shows Chinook temperature model results. There is no difference in mortality between the modeled scenarios.

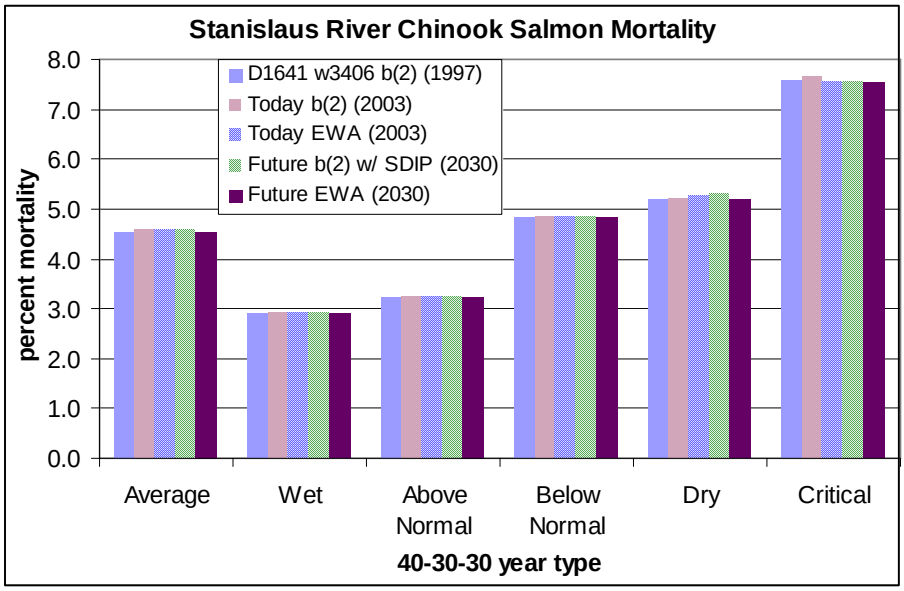

Figure 9–68 Temperature related mortality of fall–run Chinook salmon eggs in the Stanislaus River.

Fry, Juveniles, and Smolts

Most literature has indicated that rearing fry and juvenile steelheads prefer water temperatures between 45° F and 60° F (Reiser and Bjorn 1979; Bovee 1978; Bell 1986). However, Myrick (1998) found the preferred temperatures for Mokelumne River Hatchery steelheads placed into thermal gradients were between 62.6° F and 68° F.

Snorkel surveys (Kennedy and Cannon 2002) identified trout fry starting in April in 2000 and 2001 with the first fry observed in upstream areas each year. During 2003 a few trout fry were identified as early as January but most did not appear until April as in 2000 and 2001. Rotary screw trap fishing at Oakdale and Caswell has captured rainbow trout/steelheads that appear to exhibit smolting characteristics (Demko and others 2000). These apparent smolts are typically captured from January to mid-April and are 175 to 300 mm fork length. Because steelheads smolts are generally large (>200 mm) and strong swimmers, predicted Goodwin Dam releases are expected to provide adequate depth and velocity conditions for emigration at all times. Spring storms that generally occur during this period provide pulse flows from tributaries below Goodwin Dam that will stimulate and assist in out migration. The lowest flows predicted between January and April would be 125 cfs. Flows would pick up in mid-April for the VAMP period and provide an out migration pulse for any steelheads smolts still in the river that late.

Smolts are thought to migrate through the lower reaches rather quickly so should be able to withstand the few days of warmer temperatures when migrating to the estuary or ocean. The current temperature compliance point is 65° F at Orange Blossom Bridge. Temperatures would be below 65° F through July. In August and September temperatures could exceed 65° F at Orange Blossom in about 1 percent of years. Year round temperatures for steelheads in the upper river above Orange Blossom Bridge are suitable for steelheads rearing. Once steelheads reach the ocean, the ocean temperature in February through May outside San Francisco averages about 52° F (San Francisco buoy data).

Chinook fry rearing and out migration occurs from January through June with peak out migration generally occurring around February (Demko and others 2000). Flows during this period would be a minimum of 125 cfs and would be this low in about 20 percent of years. Aceituno (1993) found that a release of 200 cfs would maximize juvenile Chinook rearing habitat. The lower flows in the 125 cfs range could lower fry survival to out migration if sufficient peak flows do not occur from tributaries to stimulate out migration. When pulse flows do not occur during the fry life-stage the fry may remain in the river rather than outmigrating as fry (Demko and others 2000). This situation could result in increased mortality from in-river predation. No one knows whether it is more advantageous to have a large number of fry out-migrate early in the year or a small number of larger smolts leave later in the spring. Higher flows are provided during April and May as part of the VAMP. These flows will assist in out migration of smolts and late emerging fry from the Stanislaus. These high flows may be too late in the year for many of the Chinook fry in the Stanislaus (data provided by SP Cramer 2001). Studies are underway in the Stanislaus to determine the best springtime flow regimes to maximize survival of outmigrating Chinook.

San Joaquin River

Adult Migration, Spawning, and Incubation

The modeling shows essentially no difference in flows in the San Joaquin River between the modeled scenarios. Steelheads life history patterns in the San Joaquin River system are only partially understood, but studies are underway to determine steelheads populations, extent of anadromy, and run timing. Steelheads/rainbow populations exist in the San Joaquin tributaries and a few smolt-sized fish get captured by trawling in the lower river near Mossdale (Figure 3-10). Adult steelheads are assumed to migrate up the San Joaquin River in late fall and winter, after temperatures and dissolved oxygen conditions become suitable for migrations to occur. Spawning, although not well documented, likely occurs in the tributaries primarily from January through March. No steelheads spawning or incubation occurs in the main stem San Joaquin River.

Supplemental water released down the Stanislaus River per D-1641 in October will generally provide conditions (attraction flow, lower temperature, and higher dissolved oxygen) in the lower San Joaquin River and through the Stockton Deep-water Ship Channel suitable for upstream migrating steelheads. During November and through the rest of the upstream migratory period ambient cooling generally provides suitable conditions for migrations up through the San Joaquin. Prior to the October pulse, conditions in the lower San Joaquin and Stockton Deepwater Ship Channel are sometimes unsuitable for migrating steelheads (Lee 2003). Early returning fish could be delayed or stray to the Sacramento River tributaries when San Joaquin River conditions are unsuitable. Based on initial results from the Stanislaus River weir (no steelheads identified during September through November 2003) early returning steelheads are not expected to make up a high proportion of the run. During pre-dam days temperatures were likely higher and flows in the lower San Joaquin were likely lower than what occurs currently (although dissolved oxygen was probably not as much of an issue then) so there were not likely historically steelheads returning to the San Joaquin during late summer and fall before ambient cooling occurred.

Fry, Juveniles, and Smolts

Habitat conditions in the San Joaquin River do not appear well suited to young steelheads rearing. Fry and juvenile steelheads rearing for long periods in the San Joaquin River is not likely a common occurrence. The river likely serves primarily as a migratory corridor for smolts heading to saltwater. Out migration from the San Joaquin tributaries to saltwater probably occurs from November through May. The lowest flows during this period would be 1,030 cfs in January of 1 percent of years. The 50th percentile flows range from about 1,800 cfs in December to 5,000 cfs in April. The larger size of steelheads smolts makes them stronger swimmers than juvenile salmon so they should be better able to out-migrate during the low water velocity years when flows are lower. Conditions during the summer and fall are not conducive to successful out migration because water is warmer and dissolved oxygen sags occur.

Drought Period Operations

Operational flexibility of the CVP to meet seasonal flow and temperature needs of salmonids is severely limited in dry and critically dry years, see the Adaptive Management section in Chapter

2. During drought periods, CVP operations are driven by minimum fish flow releases, temperature requirements, water right deliveries (at reduced levels), and Delta water quality requirements. Under these dry conditions, there is no operational flexibility in the CVP/SWP system as it is over-committed, and storage must be drawn down to meet legally mandated requirements and non-discretionary actions. As Shasta storage drops and the cold water pool reserve is depleted, Sacramento River in stream temperatures increase to a level deleterious to cold water fish species such as winter and spring run Chinook salmon and steelheads. Further, recent court rulings on the use of Trinity River water have resulted in reduced availability of cold water inputs into the Sacramento River system from the Trinity River

The following actions serve to guide Reclamation's operations of the CVP during periods of drought, and are intended to provide either direct or ancillary benefits to listed fish species and help minimize adverse effects associated with elevated in stream temperatures. These actions are non-discretionary and driven by existing regulation or mandated environmental commitments.

Sacramento River watershed:

- Minimum flow releases of 3,250 cfs on the Sacramento River below Keswick Dam from October 1 through March 31 during all water year types (per the 1993 NOAA Fisheries winter-run Chinook salmon biological opinion). Additional RPA's define ramping constraints for Keswick releases.
- Maintain a minimum end-of-water-year (September 30) carryover storage in Shasta Reservoir of 1.9 million acre-feet (per the 1993 NOAA Fisheries winter-run Chinook salmon biological opinion). In the driest years when this amount of water is not available to retain in storage, Reclamation is required to re-consult with NOAA Fisheries in order to determine the most appropriate actions for continued protection of salmonids during critical months of their life cycle.
- D-1641 of the SWRCB Water Quality Control Plan of 1994, which requires minimum water quality standards, is maintained in the Delta. During dry years, much of Shasta's releases may go toward meeting this purpose, as Folsom Reservoir holds only 1 MAF and New Melones is already severely over appropriated.
- Implementation of the CVP water shortage policy: (1) M&I allocations are decreased to a maximum of 50 percent for basic health and safety; (2) irrigation allocations are decreased 25 percent or a maximum of 100 percent; and (3) water rights settlement and exchange contractors and wildlife refuges are reduced a maximum of 25 percent .
- Maintain a minimum navigation flow requirement of 5,000 cfs at Wilkins Slough on the Sacramento River under all but the most critical water supply conditions in order to keep agricultural diversion pumps in the water. While no criteria have been established for critically dry years, Reclamation can relax the standard to a minimum flow target of 3,500 cfs for short durations in order to conserve water storage in Shasta Reservoir and manage for multiple project and environmental objectives.
- Establishment of the Sacramento River Temperature Task Group (consisting of Reclamation, NOAA Fisheries, FWS, DFG, Western, DWR, and the Hoopa Indian Tribe) to formulate, monitor, and coordinate temperature control plans for the upper Sacramento and

Trinity rivers in order to best manage cold water resources based on the location of spawning Chinook salmon.

In dry and critically dry water years, operation of the Shasta Temperature Control Device has limited effectiveness because Shasta storage is reduced so significantly there ceases to be a cold water pool to draw from. Additionally, environmental water under both section 3406 b (3) of CVPIA and Calfed's Environmental Water Account (EWA) is not available for acquisition.

San Joaquin River Watershed:

- D-1422 issued by the SWRCB requires a minimum release of 69,000 acre-feet from New Melones Reservoir on the Stanislaus River during critically dry years. This was superceded by a 1987 Agreement between Reclamation and DFG providing a minimum of 98,300 acre-feet per year from New Melones Reservoir. D-1422 also requires water releases from New Melones Reservoir on the Stanislaus River to meet established minimum dissolved oxygen concentrations on the Stanislaus River, and total dissolved solids in the San Joaquin River at Vernalis.
- Implementation of the CVP water shortage policy: (1) M&I allocations are decreased to a maximum of 50 percent; (2) irrigation allocations are decreased 25 percent or a maximum of 100 percent; and (3) water rights settlement and exchange contractors and wildlife refuges are reduced a maximum of 25 percent . Be careful here as the Friant Division has its own CVP water allocation that is independent of the overall CVP.
- Bay-Delta Vernalis Flow Requirements. SWRCB D-1641 sets flow requirements on the San Joaquin River at Vernalis from February to June. These flows are commonly known as San Joaquin River base flows. During critically dry and dry water years the flows range from 710 to 1140, and 1420 to 2280, respectively.
- Vernalis Adaptive Management Plan (VAMP) providing 31-day pulse flows during April and May of each year. Target flow at Vernalis for the spring pulse flow period is determined each year and adapts to prevailing hydrologic conditions. The minimum target flow in the agreement is 2000 cfs. The VAMP program also includes Delta pumping limitations during the pulse flow period. A maximum pumping limitation of 1500 cfs is enacted in drought years when pulse flows are a minimum of 2000 cfs.

The current goal for temperature management on the lower Stanislaus River is 65° F at Orange Blossom Bridge for steelheads incubation and rearing during the late spring and summer. This goal is often unachieved due to an insufficient cold-water pool in New Melones Reservoir resulting from competing environmental and project demands for New Melones water.

Chapter 10 CVP and SWP Delta Effects on Steelhead, Chinook Salmon, and Delta Smelt

This section addresses the effects associated with Delta pumping on steelhead, spring and winter run Chinook salmon, and delta smelt. Fish monitoring programs for CVP and SWP facilities are described, and salvage and loss estimates provided by species and life stage. Effects associated with water transfers and cumulative effects are also described, and an overall effects determination made for each species. Instream temperature effects on salmonids resulting from CVP and SWP operations were discussed in Chapter 9, and addressed separately in the effects determination for that section.

Steelhead and Chinook Salmon

CVP and SWP South Delta Pumping Facilities

Steelhead salvage is seasonally significant with a positive correlation to exports at both the CVP and SWP facilities in the south Delta, (Figures 4-1 and 4-2). As discussed in Chapter 4, the steelhead salvage-export relationships are confounded by (1) breakdown in the relationships during months fringing the salvage "season;" (2) a decline in steelhead salvage since 1992; and (3) a positive correlation between salvage and abundance. Steelhead salvage records are shown in tables 4–7 and 4–8.

There is a weak relationship between the Delta survival of juvenile Chinook released into the interior Delta in Georgiana Slough relative to the Sacramento mainstem and exports (as presented in Figure 6–26). In Newman's extended quasi-likelihood model using paired data, there was a significant export effect on survival (approximate *P* value of 0.02 for a one-sided test) (Newman 2000).

It is unclear what proportion of naturally migrating Sacramento River salmon uses a central Delta emigration route, or how that proportion changes with environmental conditions. Modeling conducted by Newman and Rice in 2002 show a weak relationship between juvenile Chinook Delta survival and exports (the export to inflow ratio in this case). In both cases, it would take a very large change in exports to affect a small change in Delta survival, and it is not statistically significant. At the request of the resource agencies, we have estimated future loss and salvage for winter run and spring run Chinook salmon and steelhead using the assumption that changes salvage and loss are directly proportional to changes in export.

Data from the FWS Chipps Island Trawl suggest steelhead emigration occurs between October and June (Figure 3–5). However, steelhead salvage at the Delta fish facilities has typically occurred between January and June, with consistently low salvage after April (Figure 10–1 and Figure 10–2). October through June encompasses the emigration periods of all Chinook runs. The highest salvage occurs in February through June but salvage of winter–run and spring–run can be significant in December and January.

Both steelhead and Chinook are expected to receive protection from actions such as reduced Delta exports during periods of high fish salvage, export-to-inflow ratios, and DCC gate closures

during spring. These actions are believed to reduce take of emigrating salmonids. Older juvenile Chinook will receive additional protection from the Salmon Protection Decision Process outlined in Chapter 2 of this biological assessment.

The modeled monthly CVP and SWP Delta export exceedance plots are shown in CALSIM Modeling Appendix (Delta-ExportsDeliveries.xls) for Chapter 10. The export levels are within the range defined by the 1995-2001 post-Bay-Delta Accord period for essentially all of the October through June period when juvenile salmon and steelhead are present in the Delta. Exports are also at or below the existing export-to-inflow ratio standards during all months (Figure 10-34 and Figure 10-39).

Direct Losses to Entrainment by CVP and SWP Export Facilities

Exports would increase in the future with the implementation of the South Delta Improvement Program. Exports would generally be greater without EWA than with EWA during months when listed species are not present near the export facilities (July – October) as exported water is stored to be used to decrease exports when needed to lower entrainment of listed species. Exports would generally be less in the future with EWA during months when listed species are near the export facilities (December through May). Increased take of salmon and steelhead is more likely in the future without an EWA program than with an EWA program because EWA allows more flexibility to modify pumping rates when listed species are being taken at the pumps.

Table 10–1 shows potential loss and salvage changes for winter-run, spring-run and steelhead comparing operations today to future operations (model 2 vs 4, model 3 vs 5, and model 1 vs 5) if we assumed that salvage is directly proportional to the amount of water exported (i.e. doubling the amount of water exported doubles the number of fish salvaged). Average loss and salvage numbers used in the calculations is shown in Table 10–2. Loss for steelhead was calculated from salvage by multiplying the monthly salvage totals by 0.579 for Tracy and by 4.34 at Banks.

Typically close to 1.5 million steelhead are released each year from the Central Valley hatcheries at a relatively large size, ready to smolt, and begin to show up in the salvage facilities quickly following release. If at least 50% of these smolts make it to the Delta then 750,000 hatchery steelhead would be in the Delta. During 2003, a year of high hatchery steelhead salvage, the salvage facilities captured 10,189 clipped and 1,752 unclipped steelhead. The clipped (hatchery) salvage equates to 1.4% of 750,000. If unclipped fish were salvaged at a similar rate (1.4%) with 1,752 salvaged then about 130,000 wild (unclipped) steelhead smolts passed through the Delta.

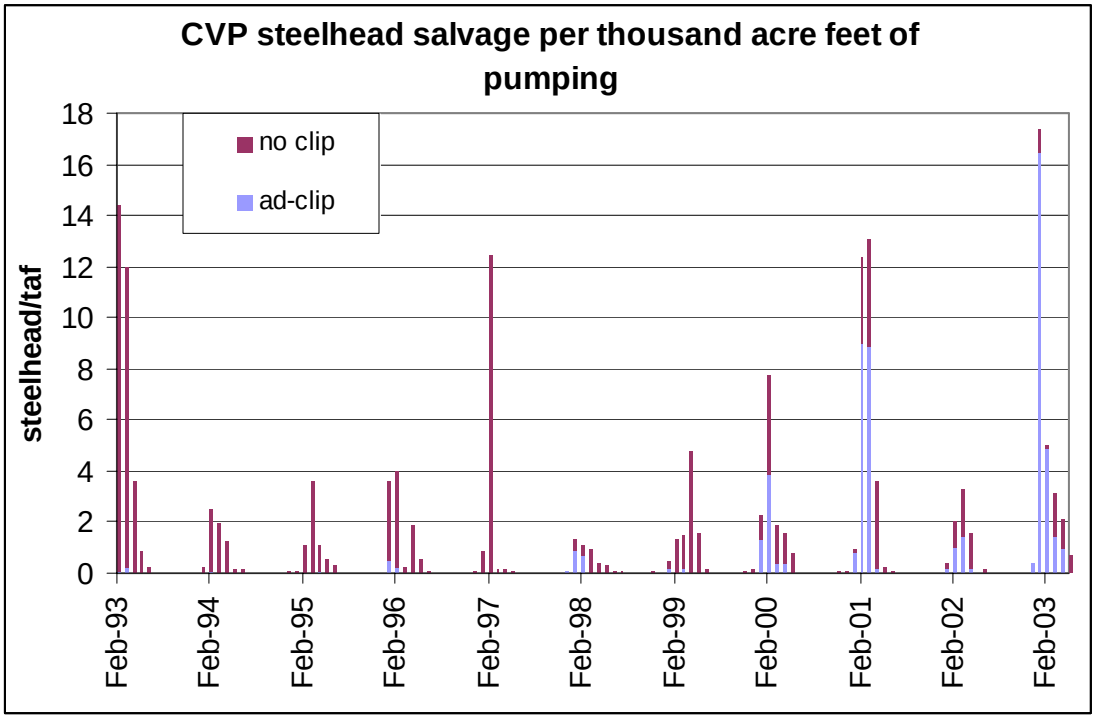

Figure 10–1 CVP steelhead salvage density, 1993-2003.

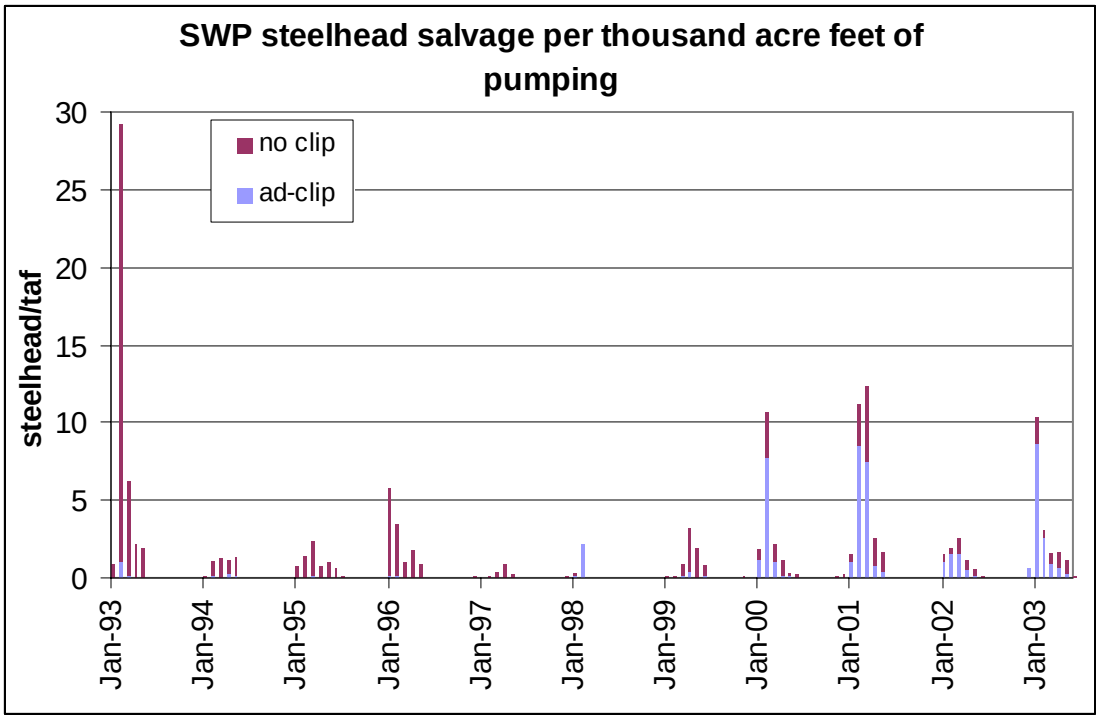

Figure 10–2 SWP steelhead salvage density, 1993-2003.

Table 10–1 Average change in winter run, spring run, and steelhead loss (first 10 charts) and salvage (last 10 charts) by water year type and export facility assuming a direct relationship between monthly exports and monthly salvage. Steelhead salvage calculations are based on unclipped fish 1998 – 2003, salmon salvage data was broken into runs based on fish lengths measured in 1993 – 2003 and calculated separately for wet years (1993, 1995-2000 ,2003) and dry years (1994, 2001, 2002).

Banks

Critical	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Overall
2 v 4 change in loss												
Winter-run number	0	0	40	79	149	249	0	1	0	0	0	518
Winter-run percent			2.4%	3.6%	4.6%	3.8%	0.0%	6.2%				3.7%
Spring-run number	0	0	0	0	0	113	4	181	0	0	0	299
Spring-run percent				3.6%	4.6%	3.8%	0.0%	6.2%	1.8%			1.5%
Steelhead number	0	-1	2	33	86	84	0	16	2	0	0	222
Steelhead percent	3.8%	-1.4%	2.4%	3.6%	4.6%	3.8%	0.0%	6.2%	1.8%	-1.0%	-1.4%	3.4%
3 v 5 change in loss												
Winter-run number	0	0	-32	49	31	175	0	-1	0	0	0	222
Winter-run percent			-2.0%	2.2%	1.0%	2.7%	-0.1%	-4.9%				1.6%
Spring-run number	0	0	0	0	0	79	-14	-143	0	0	0	-78
Spring-run percent				2.2%	1.0%	2.7%	-0.1%	-4.9%	-5.4%			-0.4%
Steelhead number	0	-1	-1	21	18	59	-1	-13	-6	0	0	77
Steelhead percent	3.5%	-0.8%	-2.0%	2.2%	1.0%	2.7%	-0.1%	-4.9%	-5.4%	-0.2%	2.6%	1.2%
1 v 5 change in loss												
Winter-run number	0	0	-30	-95	178	90	-8	-3	0	0	0	133
Winter-run percent			-1.8%	-4.3%	5.5%	1.4%	-2.5%	-26.7%				1.0%
Spring-run number	0	0	0	0	0	41	-362	-782	0	0	0	-1,104
Spring-run percent				-4.3%	5.5%	1.4%	-2.5%	-26.7%	1.5%			-5.5%
Steelhead number	0	0	-1	-40	102	30	-24	-70	2	3	1	3
Steelhead percent	6.7%	-0.5%	-1.8%	-4.3%	5.5%	1.4%	-2.5%	-26.7%	1.5%	15.4%	23.4%	0.0%

Tracy

Critical	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Overall
2 v 4 change in loss												
Winter-run number	0	0	64	76	29	153	8	-1	0	0	0	329
Winter-run percent			3.9%	3.4%	0.9%	2.3%	2.5%	-9.1%				2.4%
Spring-run number	0	0	0	0	0	69	359	-267	0	0	0	161
Spring-run percent				3.4%	0.9%	2.3%	2.5%	-9.1%	-7.8%			0.8%
Steelhead number	0	-2	3	32	17	51	24	-24	-8	-1	0	91
Steelhead percent	-0.9%	-3.4%	3.9%	3.4%	0.9%	2.3%	2.5%	-9.1%	-7.8%	-3.4%	-4.6%	1.4%
3 v 5 change in loss												
Winter-run number	0	0	-12	65	40	85	13	0	0	0	0	190
Winter-run percent			-0.7%	3.0%	1.2%	1.3%	4.2%	-3.6%				1.4%
Spring-run number	0	0	0	0	0	38	605	-107	0	0	0	536
Spring-run percent				3.0%	1.2%	1.3%	4.2%	-3.6%	-4.3%			2.7%
Steelhead number	0	-2	0	28	23	28	40	-10	-5	0	0	103
Steelhead percent	-2.9%	-2.7%	-0.7%	3.0%	1.2%	1.3%	4.2%	-3.6%	-4.3%	0.4%	-3.8%	1.6%
1 v 5 change in loss												
Winter-run number	0	0	-42	-35	-10	69	8	-3	0	0	0	-12
Winter-run percent			-2.6%	-1.6%	-0.3%	1.1%	2.7%	-26.2%				-0.1%
Spring-run number	0	0	0	0	0	31	389	-770	-1	0	0	-350
Spring-run percent				-1.6%	-0.3%	1.1%	2.7%	-26.2%	-8.4%			-1.7%
Steelhead number	0	-3	-2	-15	-6	23	26	-69	-9	0	0	-54
Steelhead percent	-3.0%	-4.0%	-2.6%	-1.6%	-0.3%	1.1%	2.7%	-26.2%	-8.4%	-1.5%	-6.0%	-0.8%

Banks

Dry	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Overall
2 v 4 change in loss												
Winter-run number	0	0	72	135	121	237	3	0	0	0	0	568
Winter-run percent			4.4%	6.1%	3.7%	3.6%	1.1%	3.0%				4.1%
Spring-run number	0	0	0	0	0	107	153	88	0	0	0	348
Spring-run percent				6.1%	3.7%	3.6%	1.1%	3.0%	-6.8%			1.7%
Steelhead number	0	1	3	57	70	79	10	8	-7	0	0	221
Steelhead percent	1.8%	1.6%	4.4%	6.1%	3.7%	3.6%	1.1%	3.0%	-6.8%	2.0%	3.0%	3.4%
3 v 5 change in loss												
Winter-run number	0	0	125	160	125	280	4	-1	0	0	0	693
Winter-run percent			7.5%	7.2%	3.9%	4.3%	1.3%	-5.3%				5.0%
Spring-run number	0	0	0	1	0	127	180	-155	0	0	0	153
Spring-run percent				7.2%	3.9%	4.3%	1.3%	-5.3%	2.3%			0.8%
Steelhead number	0	2	5	68	72	94	12	-14	2	1	0	242
Steelhead percent	1.0%	3.2%	7.5%	7.2%	3.9%	4.3%	1.3%	-5.3%	2.3%	6.6%	-4.0%	3.7%
1 v 5 change in loss												
Winter-run number	0	0	87	18	134	289	-34	-7	0	0	0	487
Winter-run percent			5.2%	0.8%	4.2%	4.4%	-11.1%	-67.9%				3.5%
Spring-run number	0	0	0	0	0	131	-1,586	-1,992	0	0	0	-3,447
Spring-run percent				0.8%	4.2%	4.4%	-11.1%	-67.9%	-4.0%			-17.0%
Steelhead number	0	0	3	8	77	97	-106	-178	-4	5	0	-98
Steelhead percent	3.9%	0.7%	5.2%	0.8%	4.2%	4.4%	-11.1%	-67.9%	-4.0%	23.6%	1.7%	-1.5%

Tracy

Dry	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Overall
2 v 4 change in loss												
Winter-run number	0	0	36	15	-37	-58	8	0	0	0	0	-36
Winter-run percent			2.1%	0.7%	-1.2%	-0.9%	2.6%	-2.9%				-0.3%
Spring-run number	0	0	0	0	0	-26	372	-84	0	0	0	261
Spring-run percent				0.7%	-1.2%	-0.9%	2.6%	-2.9%	-5.8%			1.3%
Steelhead number	0	-1	1	6	-21	-19	25	-8	-6	-1	0	-24
Steelhead percent	0.9%	-1.5%	2.1%	0.7%	-1.2%	-0.9%	2.6%	-2.9%	-5.8%	-6.2%	-8.5%	-0.4%
3 v 5 change in loss												
Winter-run number	0	0	23	61	122	70	-6	0	0	0	0	271
Winter-run percent			1.4%	2.8%	3.8%	1.1%	-2.0%	-0.5%				1.9%
Spring-run number	0	0	0	0	0	32	-282	-14	-1	0	0	-264
Spring-run percent				2.8%	3.8%	1.1%	-2.0%	-0.5%	-8.6%			-1.3%
Steelhead number	0	0	1	26	70	24	-19	-1	-9	-1	0	90
Steelhead percent	0.7%	-0.4%	1.4%	2.8%	3.8%	1.1%	-2.0%	-0.5%	-8.6%	-5.2%	-9.5%	1.4%
1 v 5 change in loss												
Winter-run number	0	0	-50	-132	103	-288	-3	-4	0	0	0	-373
Winter-run percent			-3.0%	-6.0%	3.2%	-4.4%	-1.0%	-32.6%				-2.7%
Spring-run number	0	0	0	0	0	-130	-141	-958	-1	0	0	-1,230
Spring-run percent				-6.0%	3.2%	-4.4%	-1.0%	-32.6%	-12.3%			-6.1%
Steelhead number	0	-2	-2	-56	59	-97	-9	-86	-13	-2	0	-207
Steelhead percent	0.5%	-2.9%	-3.0%	-6.0%	3.2%	-4.4%	-1.0%	-32.6%	-12.3%	-9.4%	-16.8%	-3.2%

Banks

Below Norma	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Overall
2 v 4 change in loss												
Winter-run number	0	0	134	164	125	552	8	3	0	0	0	986
Winter-run percent			8.1%	7.4%	3.9%	8.4%	2.6%	25.0%				7.1%
Spring-run number	0	0	0	1	0	250	371	735	0	0	0	1,357
Spring-run percent				7.4%	3.9%	8.4%	2.6%	25.0%	-0.8%			6.7%
Steelhead number	0	2	5	70	72	185	25	66	-1	1	0	425
Steelhead percent	-0.2%	3.2%	8.1%	7.4%	3.9%	8.4%	2.6%	25.0%	-0.8%	5.8%	3.1%	6.6%
3 v 5 change in loss												
Winter-run number	0	0	134	108	6	350	5	-2	0	0	0	601
Winter-run percent			8.1%	4.9%	0.2%	5.4%	1.5%	-14.9%				4.3%
Spring-run number	0	0	0	0	0	159	210	-436	1	0	0	-67
Spring-run percent				4.9%	0.2%	5.4%	1.5%	-14.9%	9.7%			-0.3%
Steelhead number	0	2	5	46	4	117	14	-39	10	2	0	161
Steelhead percent	-2.2%	3.1%	8.1%	4.9%	0.2%	5.4%	1.5%	-14.9%	9.7%	7.8%	2.4%	2.5%
1 v 5 change in loss												
Winter-run number	0	0	63	40	163	411	-102	-11	0	0	0	564
Winter-run percent			3.8%	1.8%	5.0%	6.3%	-33.1%	-99.5%				4.0%
Spring-run number	0	0	0	0	0	186	-4,748	-2,921	-1	0	0	-7,484
Spring-run percent				1.8%	5.0%	6.3%	-33.1%	-99.5%	-11.4%			-37.0%
Steelhead number	0	1	2	17	94	138	-317	-261	-12	4	0	-333
Steelhead percent	2.0%	1.9%	3.8%	1.8%	5.0%	6.3%	-33.1%	-99.5%	-11.4%	22.0%	14.3%	-5.2%

Tracy

Below Norma	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Overall
2 v 4 change in loss												
Winter-run number	0	0	10	65	-66	-332	-5	-1	0	0	0	-328
Winter-run percent			0.6%	3.0%	-2.0%	-5.1%	-1.5%	-5.2%				-2.3%
Spring-run number	0	0	0	0	0	-150	-210	-154	0	0	0	-514
Spring-run percent				3.0%	-2.0%	-5.1%	-1.5%	-5.2%	0.1%			-2.5%
Steelhead number	0	1	0	28	-38	-111	-14	-14	0	0	0	-148
Steelhead percent	0.5%	1.4%	0.6%	3.0%	-2.0%	-5.1%	-1.5%	-5.2%	0.1%	-2.4%	-1.8%	-2.3%
3 v 5 change in loss												
Winter-run number	0	0	14	37	97	-199	-3	-1	0	0	0	-56
Winter-run percent			0.8%	1.7%	3.0%	-3.0%	-1.1%	-11.6%				-0.4%
Spring-run number	0	0	0	0	0	-90	-161	-342	0	0	0	-593
Spring-run percent				1.7%	3.0%	-3.0%	-1.1%	-11.6%	0.3%			-2.9%
Steelhead number	0	1	1	16	56	-67	-11	-31	0	0	0	-35
Steelhead percent	0.0%	1.3%	0.8%	1.7%	3.0%	-3.0%	-1.1%	-11.6%	0.3%	-2.5%	-1.1%	-0.5%
1 v 5 change in loss												
Winter-run number	0	0	-62	-58	76	-589	-13	-4	0	0	0	-650
Winter-run percent			-3.8%	-2.6%	2.4%	-9.0%	-4.1%	-36.9%				-4.7%
Spring-run number	0	0	0	0	0	-267	-593	-1,084	0	0	0	-1,944
Spring-run percent				-2.6%	2.4%	-9.0%	-4.1%	-36.9%	0.3%			-9.6%
Steelhead number	0	0	-2	-24	44	-197	-40	-97	0	-1	0	-318
Steelhead percent	-0.1%	-0.2%	-3.8%	-2.6%	2.4%	-9.0%	-4.1%	-36.9%	0.3%	-4.7%	-2.6%	-4.9%

Banks

Above Norma	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Overall
2 v 4 change in loss												
Winter-run number	0	0	-16	-73	75	217	35	0	0	0	0	238
Winter-run percent			-2.9%	-1.1%	4.7%	19.9%	10.5%	4.1%	2.2%			2.3%
Spring-run number	0	0	0	0	3	1,109	3,703	512	47	0	0	5,375
Spring-run percent	6.4%			-1.1%	4.7%	19.9%	10.5%	4.1%	2.2%			9.7%
Steelhead number	0	2	-2	-10	79	353	106	15	3	1	0	547
Steelhead percent	5.8%	3.3%	-2.4%	-1.1%	4.3%	16.1%	11.0%	5.7%	2.6%	5.9%	1.0%	8.5%
3 v 5 change in loss												
Winter-run number	0	0	20	162	5	185	24	0	0	0	0	396
Winter-run percent			3.6%	2.4%	0.3%	16.9%	7.3%	-4.1%	3.5%			3.8%
Spring-run number	0	0	0	0	0	946	2,579	-508	74	0	0	3,093
Spring-run percent	7.8%			2.4%	0.3%	16.9%	7.3%	-4.1%	3.5%			5.6%
Steelhead number	0	5	2	23	5	301	73	-15	4	2	0	400
Steelhead percent	7.1%	7.0%	3.0%	2.5%	0.3%	13.7%	7.7%	-5.6%	4.1%	8.3%	-7.3%	6.2%
1 v 5 change in loss												
Winter-run number	0	0	7	-241	-31	277	-74	-4	0	0	0	-66
Winter-run percent			1.2%	-3.5%	-1.9%	25.4%	-22.4%	-56.2%	-0.4%			-0.6%
Spring-run number	0	0	0	0	-1	1,417	-7,886	-7,016	-9	0	0	-13,495
Spring-run percent	8.5%			-3.5%	-1.9%	25.4%	-22.4%	-56.2%	-0.4%			-24.3%
Steelhead number	0	3	1	-34	-33	451	-225	-204	-1	3	0	-38
Steelhead percent	7.7%	4.5%	1.0%	-3.6%	-1.7%	20.6%	-23.5%	-77.9%	-0.5%	16.1%	6.3%	-0.6%

Tracy

Above Normal	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Overall
2 v 4 change in loss												
Winter-run number	0	0	2	-1	22	-33	0	0	0	0	0	-9
Winter-run percent			0.3%	0.0%	1.4%	-3.0%	0.1%	6.8%	2.9%			-0.1%
Spring-run number	0	0	0	0	2	-317	62	570	20	0	0	336
Spring-run percent	0.4%			0.0%	2.5%	-5.7%	0.2%	4.6%	0.9%			0.6%
Steelhead number	0	2	0	0	70	-123	3	28	2	0	0	-17
Steelhead percent	1.9%	3.2%	0.7%	0.0%	3.8%	-5.6%	0.3%	10.6%	2.2%	-0.7%	-1.4%	-0.3%
3 v 5 change in loss												
Winter-run number	0	0	1	78	14	-11	0	0	0	0	0	82
Winter-run percent			0.2%	1.1%	0.9%	-1.0%	0.1%	0.3%	1.0%			0.8%
Spring-run number	0	0	0	0	1	-109	51	27	7	0	0	-23
Spring-run percent	-0.3%			3.3%	1.6%	-2.0%	0.1%	0.2%	0.3%			0.0%
Steelhead number	0	1	0	35	45	-42	3	1	1	0	0	44
Steelhead percent	-1.4%	1.7%	0.5%	3.8%	2.4%	-1.9%	0.3%	0.5%	0.8%	-0.5%	-3.0%	0.7%
1 v 5 change in loss												
Winter-run number	0	0	-9	-74	-33	-8	0	-1	0	0	0	-125
Winter-run percent			-1.6%	-1.1%	-2.1%	-0.8%	0.0%	-8.2%	1.8%			-1.2%
Spring-run number	0	0	0	0	-2	-79	-5	-689	12	0	0	-763
Spring-run percent	0.0%			-3.1%	-3.7%	-1.4%	0.0%	-5.5%	0.6%			-1.4%
Steelhead number	0	1	-3	-33	-107	-31	0	-34	1	0	0	-205
Steelhead percent	0.0%	2.3%	-3.9%	-3.6%	-5.7%	-1.4%	0.0%	-12.8%	1.4%	-0.5%	-3.3%	-3.2%

Banks

Wet	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Overall
2 v 4 change in loss												
Winter-run number	0	0	90	435	72	187	52	1	0	0	0	838
Winter-run percent			16.3%	6.3%	4.5%	17.1%	15.9%	11.7%	4.3%			8.0%
Spring-run number	0	0	0	0	3	956	5,598	1,458	92	0	0	8,108
Spring-run percent	7.6%			6.3%	4.5%	17.1%	15.9%	11.7%	4.3%			14.6%
Steelhead number	0	4	9	61	77	304	159	42	5	1	0	663
Steelhead percent	6.9%	5.4%	13.5%	6.6%	4.1%	13.9%	16.7%	16.2%	5.1%	4.8%	-3.8%	10.2%
3 v 5 change in loss												
Winter-run number	0	0	111	463	48	105	31	0	0	0	0	759
Winter-run percent			20.0%	6.7%	3.0%	9.6%	9.6%	5.1%	11.1%			7.2%
Spring-run number	0	0	0	0	2	534	3,371	639	238	0	0	4,785
Spring-run percent	8.2%			6.7%	3.0%	9.6%	9.6%	5.1%	11.1%			8.6%
Steelhead number	0	1	11	65	51	170	96	19	14	1	0	428
Steelhead percent	7.5%	1.2%	16.6%	7.0%	2.7%	7.8%	10.0%	7.1%	13.2%	7.2%	0.8%	6.6%
1 v 5 change in loss												
Winter-run number	0	0	77	284	25	349	-47	-4	0	0	0	684
Winter-run percent			14.0%	4.1%	1.6%	31.9%	-14.2%	-60.3%	4.4%			6.5%
Spring-run number	1	0	0	0	1	1,783	-5,000	-7,540	94	0	0	-10,661
Spring-run percent	13.8%			4.1%	1.6%	31.9%	-14.2%	-60.3%	4.4%			-19.2%
Steelhead number	1	2	8	40	26	567	-142	-219	6	1	0	289
Steelhead percent	12.6%	3.7%	11.6%	4.3%	1.4%	25.9%	-14.9%	-83.7%	5.2%	4.9%	4.9%	4.5%

Tracy

Wet	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Overall
2 v 4 change in loss												
Winter-run number	0	0	8	18	-6	-17	-8	0	0	0	0	-3
Winter-run percent			1.5%	0.3%	-0.3%	-1.5%	-2.4%	-0.2%	-0.3%			0.0%
Spring-run number	0	0	0	0	0	-160	-1,006	-17	-2	0	0	-1,186
Spring-run percent	0.4%			0.8%	-0.6%	-2.9%	-2.9%	-0.1%	-0.1%			-2.1%
Steelhead number	0	1	2	8	-18	-62	-52	-1	0	0	0	-121
Steelhead percent	1.7%	1.9%	3.7%	0.9%	-1.0%	-2.8%	-5.4%	-0.3%	-0.2%	0.6%	0.4%	-1.9%
3 v 5 change in loss												
Winter-run number	0	0	1	7	12	9	0	0	0	0	0	29
Winter-run percent			0.2%	0.1%	0.7%	0.8%	0.0%	-0.3%	0.7%			0.3%
Spring-run number	0	0	0	0	1	86	-11	-21	5	0	0	60
Spring-run percent	0.0%			0.3%	1.3%	1.5%	0.0%	-0.2%	0.2%			0.1%
Steelhead number	0	2	0	3	38	34	-1	-1	1	0	0	75
Steelhead percent	-0.2%	3.1%	0.4%	0.3%	2.0%	1.5%	-0.1%	-0.4%	0.5%	-0.3%	0.4%	1.2%
1 v 5 change in loss												
Winter-run number	0	0	-12	-153	-38	17	-4	0	0	0	0	-190
Winter-run percent			-2.3%	-2.2%	-2.4%	1.6%	-1.1%	-4.8%	0.1%			-1.8%
Spring-run number	0	0	0	0	-3	165	-465	-403	1	0	0	-706
Spring-run percent	0.1%			-6.5%	-4.3%	2.9%	-1.3%	-3.2%	0.0%			-1.3%
Steelhead number	0	0	-4	-69	-123	64	-24	-20	0	0	0	-175
Steelhead percent	0.3%	0.7%	-5.5%	-7.4%	-6.6%	2.9%	-2.5%	-7.5%	0.1%	0.1%	0.4%	-2.7%

Banks

Critical	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Overall
2 v 4 change in salvage												
Winter-run number	0	0	13	28	86	83	0	0	0	0	0	210
Winter-run percent			2.4%	3.6%	4.6%	3.8%	0.0%	6.2%				3.8%
Spring-run number	0	0	0	0	0	51	3	54	0	0	0	109
Spring-run percent				3.6%	4.6%	3.8%	0.0%	6.2%	1.8%			1.0%
Steelhead number	0	0	0	11	34	31	0	7	1	0	0	85
Steelhead percent	3.8%	-1.4%	2.4%	3.6%	4.6%	3.8%	0.0%	6.2%	1.8%	-1.0%	-1.4%	3.4%
3 v 5 change in salvage												
Winter-run number	0	0	-10	17	18	59	0	0	0	0	0	83
Winter-run percent			-2.0%	2.2%	1.0%	2.7%	-0.1%	-4.9%				1.5%
Spring-run number	0	0	0	0	0	36	-9	-43	0	0	0	-16
Spring-run percent				2.2%	1.0%	2.7%	-0.1%	-4.9%	-5.4%			-0.1%
Steelhead number	0	0	0	7	7	22	0	-5	-2	0	0	28
Steelhead percent	3.5%	-0.8%	-2.0%	2.2%	1.0%	2.7%	-0.1%	-4.9%	-5.4%	-0.2%	2.6%	1.1%
1 v 5 change in salvage												
Winter-run number	0	0	-10	-34	102	30	-6	-1	0	0	0	83
Winter-run percent			-1.8%	-4.3%	5.5%	1.4%	-2.5%	-26.7%				1.5%
Spring-run number	0	0	0	-1	0	19	-224	-235	0	0	0	-440
Spring-run percent				-4.3%	5.5%	1.4%	-2.5%	-26.7%	1.5%			-4.0%
Steelhead number	0	0	0	-13	41	11	-11	-29	1	1	0	0
Steelhead percent	6.7%	-0.5%	-1.8%	-4.3%	5.5%	1.4%	-2.5%	-26.7%	1.5%	15.4%	23.4%	0.0%

Tracy

Critical	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Overall
2 v 4 change in salvage												
Winter-run number	0	0	21	27	17	51	6	0	0	0	0	121
Winter-run percent			3.9%	3.4%	0.9%	2.3%	2.5%	-9.1%				2.2%
Spring-run number	0	0	0	0	0	32	222	-80	-1	0	0	173
Spring-run percent				3.4%	0.9%	2.3%	2.5%	-9.1%	-7.8%			1.6%
Steelhead number	0	-1	1	11	7	19	11	-10	-3	0	0	35
Steelhead percent	-0.9%	-3.4%	3.9%	3.4%	0.9%	2.3%	2.5%	-9.1%	-7.8%	-3.4%	-4.6%	1.4%
3 v 5 change in salvage												
Winter-run number	0	0	-4	23	23	28	10	0	0	0	0	80
Winter-run percent			-0.7%	3.0%	1.2%	1.3%	4.2%	-3.6%				1.4%
Spring-run number	0	0	0	0	0	17	374	-32	0	0	0	359
Spring-run percent				3.0%	1.2%	1.3%	4.2%	-3.6%	-4.3%			3.2%
Steelhead number	0	-1	0	9	9	11	18	-4	-2	0	0	41
Steelhead percent	-2.9%	-2.7%	-0.7%	3.0%	1.2%	1.3%	4.2%	-3.6%	-4.3%	0.4%	-3.8%	1.6%
1 v 5 change in salvage												
Winter-run number	0	0	-14	-12	-6	23	6	-1	0	0	0	-3
Winter-run percent			-2.6%	-1.6%	-0.3%	1.1%	2.7%	-26.2%				0.0%
Spring-run number	0	0	0	0	0	14	240	-231	-1	0	0	23
Spring-run percent				-1.6%	-0.3%	1.1%	2.7%	-26.2%	-8.4%			0.2%
Steelhead number	0	-1	-1	-5	-2	9	12	-29	-3	0	0	-20
Steelhead percent	-3.0%	-4.0%	-2.6%	-1.6%	-0.3%	1.1%	2.7%	-26.2%	-8.4%	-1.5%	-6.0%	-0.8%

Banks

Dry	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Overall
2 v 4 change in salvage												
Winter-run number	0	0	23	48	70	79	3	0	0	0	0	222
Winter-run percent			4.4%	6.1%	3.7%	3.6%	1.1%	3.0%				4.0%
Spring-run number	0	0	0	1	0	49	94	26	-1	0	0	170
Spring-run percent				6.1%	3.7%	3.6%	1.1%	3.0%	-6.8%			1.5%
Steelhead number	0	0	1	19	28	30	5	3	-2	0	0	84
Steelhead percent	1.8%	1.6%	4.4%	6.1%	3.7%	3.6%	1.1%	3.0%	-6.8%	2.0%	3.0%	3.3%
3 v 5 change in salvage												
Winter-run number	0	0	40	57	72	93	3	0	0	0	0	265
Winter-run percent			7.5%	7.2%	3.9%	4.3%	1.3%	-5.3%				4.7%
Spring-run number	0	0	0	1	0	58	111	-47	0	0	0	124
Spring-run percent				7.2%	3.9%	4.3%	1.3%	-5.3%	2.3%			1.1%
Steelhead number	0	1	2	23	29	35	5	-6	1	1	0	90
Steelhead percent	1.0%	3.2%	7.5%	7.2%	3.9%	4.3%	1.3%	-5.3%	2.3%	6.6%	-4.0%	3.6%
1 v 5 change in salvage												
Winter-run number	0	0	28	7	77	96	-26	-1	0	0	0	180
Winter-run percent			5.2%	0.8%	4.2%	4.4%	-11.1%	-67.9%				3.2%
Spring-run number	0	0	0	0	0	60	-980	-598	0	0	0	-1,518
Spring-run percent				0.8%	4.2%	4.4%	-11.1%	-67.9%	-4.0%			-13.7%
Steelhead number	0	0	1	3	31	36	-47	-74	-1	2	0	-50
Steelhead percent	3.9%	0.7%	5.2%	0.8%	4.2%	4.4%	-11.1%	-67.9%	-4.0%	23.6%	1.7%	-2.0%

Tracy

Critical	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Overall
2 v 4 change in salvage												
Winter-run number	0	0	11	5	-21	-19	6	0	0	0	0	-18
Winter-run percent			2.1%	0.7%	-1.2%	-0.9%	2.6%	-2.9%				-0.3%
Spring-run number	0	0	0	0	0	-12	230	-25	0	0	0	192
Spring-run percent				0.7%	-1.2%	-0.9%	2.6%	-2.9%	-5.8%			1.7%
Steelhead number	0	0	0	2	-9	-7	11	-3	-2	0	0	-8
Steelhead percent	0.9%	-1.5%	2.1%	0.7%	-1.2%	-0.9%	2.6%	-2.9%	-5.8%	-6.2%	-8.5%	-0.3%
3 v 5 change in salvage												
Winter-run number	0	0	7	22	70	24	-5	0	0	0	0	118
Winter-run percent			1.4%	2.8%	3.8%	1.1%	-2.0%	-0.5%				2.1%
Spring-run number	0	0	0	0	0	15	-174	-4	-1	0	0	-164
Spring-run percent				2.8%	3.8%	1.1%	-2.0%	-0.5%	-8.6%			-1.5%
Steelhead number	0	0	0	9	28	9	-8	-1	-3	0	0	33
Steelhead percent	0.7%	-0.4%	1.4%	2.8%	3.8%	1.1%	-2.0%	-0.5%	-8.6%	-5.2%	-9.5%	1.3%
1 v 5 change in salvage												
Winter-run number	0	0	-16	-47	59	-96	-2	-1	0	0	0	-103
Winter-run percent			-3.0%	-6.0%	3.2%	-4.4%	-1.0%	-32.6%				-1.8%
Spring-run number	0	0	0	-1	0	-59	-87	-287	-1	0	0	-435
Spring-run percent				-6.0%	3.2%	-4.4%	-1.0%	-32.6%	-12.3%			-3.9%
Steelhead number	0	-1	-1	-19	24	-36	-4	-36	-4	-1	0	-78
Steelhead percent	0.5%	-2.9%	-3.0%	-6.0%	3.2%	-4.4%	-1.0%	-32.6%	-12.3%	-9.4%	-16.8%	-3.1%

Banks

Below Norma	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Overall
2 v 4 change in salvage												
Winter-run number	0	0	43	58	72	184	6	1	0	0	0	364
Winter-run percent			8.1%	7.4%	3.9%	8.4%	2.6%	25.0%				6.5%
Spring-run number	0	0	0	1	0	114	229	221	0	0	0	565
Spring-run percent				7.4%	3.9%	8.4%	2.6%	25.0%	-0.8%			5.1%
Steelhead number	0	1	2	23	29	70	11	27	0	0	0	163
Steelhead percent	-0.2%	3.2%	8.1%	7.4%	3.9%	8.4%	2.6%	25.0%	-0.8%	5.8%	3.1%	6.5%
3 v 5 change in salvage												
Winter-run number	0	0	43	38	4	117	3	0	0	0	0	205
Winter-run percent			8.1%	4.9%	0.2%	5.4%	1.5%	-14.9%				3.7%
Spring-run number	0	0	0	1	0	72	130	-131	1	0	0	73
Spring-run percent				4.9%	0.2%	5.4%	1.5%	-14.9%	9.7%			0.7%
Steelhead number	0	1	2	15	1	44	6	-16	3	1	0	57
Steelhead percent	-2.2%	3.1%	8.1%	4.9%	0.2%	5.4%	1.5%	-14.9%	9.7%	7.8%	2.4%	2.3%
1 v 5 change in salvage												
Winter-run number	0	0	20	14	94	137	-78	-2	0	0	0	185
Winter-run percent			3.8%	1.8%	5.0%	6.3%	-33.1%	-99.5%				3.3%
Spring-run number	0	0	0	0	0	85	-2,934	-877	-1	0	0	-3,727
Spring-run percent				1.8%	5.0%	6.3%	-33.1%	-99.5%	-11.4%			-33.5%
Steelhead number	0	0	1	6	37	52	-142	-109	-4	2	0	-157
Steelhead percent	2.0%	1.9%	3.8%	1.8%	5.0%	6.3%	-33.1%	-99.5%	-11.4%	22.0%	14.3%	-6.3%

Tracy

Below Norma	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Overall
2 v 4 change in salvage												
Winter-run number	0	0	3	23	-38	-111	-3	0	0	0	0	-126
Winter-run percent			0.6%	3.0%	-2.0%	-5.1%	-1.5%	-5.2%				-2.3%
Spring-run number	0	0	0	0	0	-68	-130	-46	0	0	0	-244
Spring-run percent				3.0%	-2.0%	-5.1%	-1.5%	-5.2%	0.1%			-2.2%
Steelhead number	0	0	0	9	-15	-42	-6	-6	0	0	0	-59
Steelhead percent	0.5%	1.4%	0.6%	3.0%	-2.0%	-5.1%	-1.5%	-5.2%	0.1%	-2.4%	-1.8%	-2.4%
3 v 5 change in salvage												
Winter-run number	0	0	4	13	56	-66	-3	0	0	0	0	4
Winter-run percent			0.8%	1.7%	3.0%	-3.0%	-1.1%	-11.6%				0.1%
Spring-run number	0	0	0	0	0	-41	-100	-103	0	0	0	-243
Spring-run percent				1.7%	3.0%	-3.0%	-1.1%	-11.6%	0.3%			-2.2%
Steelhead number	0	0	0	5	22	-25	-5	-13	0	0	0	-15
Steelhead percent	0.0%	1.3%	0.8%	1.7%	3.0%	-3.0%	-1.1%	-11.6%	0.3%	-2.5%	-1.1%	-0.6%
1 v 5 change in salvage												
Winter-run number	0	0	-20	-20	44	-197	-10	-1	0	0	0	-204
Winter-run percent			-3.8%	-2.6%	2.4%	-9.0%	-4.1%	-36.9%				-3.6%
Spring-run number	0	0	0	0	0	-122	-366	-325	0	0	0	-813
Spring-run percent				-2.6%	2.4%	-9.0%	-4.1%	-36.9%	0.3%			-7.3%
Steelhead number	0	0	-1	-8	18	-74	-18	-40	0	0	0	-124
Steelhead percent	-0.1%	-0.2%	-3.8%	-2.6%	2.4%	-9.0%	-4.1%	-36.9%	0.3%	-4.7%	-2.6%	-5.0%

Banks

Above Normal	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Overall
2 v 4 change in salvage												
Winter-run number	0	0	-5	-23	25	95	16	0	0	0	0	107
Winter-run percent			-2.9%	-1.1%	4.7%	19.9%	10.5%	4.1%	2.2%			3.1%
Spring-run number	0	0	0	0	2	909	2,041	305	23	0	0	3,280
Spring-run percent	6.4%			-1.1%	4.7%	19.9%	10.5%	4.1%	2.2%			10.1%
Steelhead number	0	1	0	-4	33	149	57	10	2	1	0	248
Steelhead percent	5.5%	3.2%	-1.9%	-1.2%	4.5%	18.0%	13.3%	8.7%	4.9%	7.6%	1.2%	9.9%
3 v 5 change in salvage												
Winter-run number	0	0	7	50	2	81	11	0	0	0	0	150
Winter-run percent			3.6%	2.4%	0.3%	16.9%	7.3%	-4.1%	3.5%			4.3%
Spring-run number	0	0	0	0	0	775	1,422	-302	37	0	0	1,932
Spring-run percent	7.8%			2.4%	0.3%	16.9%	7.3%	-4.1%	3.5%			5.9%
Steelhead number	0	2	0	8	2	127	40	-9	3	1	0	173
Steelhead percent	6.7%	6.9%	2.4%	2.6%	0.3%	15.4%	9.3%	-8.6%	7.7%	10.6%	-9.0%	6.9%
1 v 5 change in salvage												
Winter-run number	0	0	2	-75	-10	121	-34	-4	0	0	0	1
Winter-run percent			1.2%	-3.5%	-1.9%	25.4%	-22.4%	-56.2%	-0.4%			0.0%
Spring-run number	0	0	0	0	-1	1,161	-4,347	-4,174	-5	0	0	-7,366
Spring-run percent	8.5%			-3.5%	-1.9%	25.4%	-22.4%	-56.2%	-0.4%			-22.6%
Steelhead number	0	1	0	-12	-14	190	-121	-131	0	2	0	-85
Steelhead percent	7.3%	4.4%	0.8%	-3.8%	-1.8%	23.1%	-28.3%	-119.1%	-1.0%	20.6%	7.7%	-3.4%

Tracy

Above Normal	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Overall
2 v 4 change in salvage												
Winter-run number	0	0	2	-1	22	-33	0	0	0	0	0	-9
Winter-run percent			0.9%	0.0%	4.1%	-6.9%	0.3%	7.7%	1.9%			-0.3%
Spring-run number	0	0	0	0	2	-317	62	570	20	0	0	336
Spring-run percent	2.0%			0.0%	4.1%	-6.9%	0.3%	7.7%	1.9%			1.0%
Steelhead number	0	1	0	0	30	-52	2	18	1	0	0	-1
Steelhead percent	1.7%	3.2%	0.6%	0.0%	4.0%	-6.3%	0.4%	16.3%	4.2%	-0.9%	-1.7%	0.0%
3 v 5 change in salvage												
Winter-run number	0	0	1	78	14	-11	0	0	0	0	0	82
Winter-run percent			0.7%	3.7%	2.6%	-2.4%	0.3%	0.4%	0.7%			2.4%
Spring-run number	0	0	0	0	1	-109	51	27	7	0	0	-23
Spring-run percent	-1.6%			3.7%	2.6%	-2.4%	0.3%	0.4%	0.7%			-0.1%
Steelhead number	0	0	0	13	19	-18	1	1	1	0	0	17
Steelhead percent	-1.3%	1.7%	0.4%	4.0%	2.5%	-2.2%	0.3%	0.8%	1.5%	-0.7%	-3.7%	0.7%
1 v 5 change in salvage												
Winter-run number	0	0	-9	-74	-33	-8	0	-1	0	0	0	-125
Winter-run percent			-4.7%	-3.4%	-6.3%	-1.7%	0.0%	-9.3%	1.2%			-3.6%
Spring-run number	0	0	0	0	-2	-79	-5	-689	12	0	0	-763
Spring-run percent	0.0%			-3.4%	-6.3%	-1.7%	0.0%	-9.3%	1.2%			-2.3%
Steelhead number	0	0	-1	-12	-45	-13	0	-22	1	0	0	-91
Steelhead percent	0.0%	2.2%	-3.0%	-3.8%	-6.0%	-1.6%	0.0%	-19.7%	2.6%	-0.6%	-4.0%	-3.6%

Banks

Wet	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Overall
2 v 4 change in salvage												
Winter-run number	0	0	31	135	24	82	24	1	0	0	0	296
Winter-run percent			16.3%	6.3%	4.5%	17.1%	15.9%	11.7%	4.3%			8.5%
Spring-run number	0	0	0	0	2	784	3,086	868	45	0	0	4,785
Spring-run percent	7.6%			6.3%	4.5%	17.1%	15.9%	11.7%	4.3%			14.7%
Steelhead number	0	1	2	22	32	128	86	27	3	0	0	303
Steelhead percent	6.5%	5.4%	10.6%	6.9%	4.3%	15.6%	20.1%	24.8%	9.5%	6.1%	-4.6%	12.1%
3 v 5 change in salvage												
Winter-run number	0	0	37	144	16	46	14	0	0	0	0	258
Winter-run percent			20.0%	6.7%	3.0%	9.6%	9.6%	5.1%	11.1%			7.4%
Spring-run number	0	0	0	0	1	438	1,858	380	117	0	0	2,795
Spring-run percent	8.2%			6.7%	3.0%	9.6%	9.6%	5.1%	11.1%			8.6%
Steelhead number	0	0	3	23	21	72	52	12	9	1	0	192
Steelhead percent	7.1%	1.1%	13.0%	7.4%	2.9%	8.7%	12.1%	10.8%	24.6%	9.2%	1.0%	7.7%
1 v 5 change in salvage												
Winter-run number	0	0	26	88	8	152	-21	-4	0	0	0	249
Winter-run percent			14.0%	4.1%	1.6%	31.9%	-14.2%	-60.3%	4.4%			7.2%
Spring-run number	0	0	0	0	1	1,461	-2,756	-4,486	46	0	0	-5,734
Spring-run percent	13.8%			4.1%	1.6%	31.9%	-14.2%	-60.3%	4.4%			-17.6%
Steelhead number	0	1	2	14	11	239	-77	-140	3	0	0	54
Steelhead percent	11.9%	3.7%	9.1%	4.5%	1.5%	29.0%	-18.0%	-128.0%	9.7%	6.2%	6.0%	2.1%

Tracy

Wet	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Overall
2 v 4 change in salvage												
Winter-run number	0	0	8	18	-6	-17	-8	0	0	0	0	-3
Winter-run percent			4.5%	0.9%	-1.0%	-3.5%	-5.2%	-0.2%	-0.2%			-0.1%
Spring-run number	0	0	0	0	0	-160	-1,006	-17	-2	0	0	-1,186
Spring-run percent	1.9%			0.9%	-1.0%	-3.5%	-5.2%	-0.2%	-0.2%			-3.6%
Steelhead number	0	0	1	3	-7	-26	-28	-1	0	0	0	-59
Steelhead percent	1.6%	1.8%	2.9%	0.9%	-1.0%	-3.2%	-6.6%	-0.5%	-0.4%	0.7%	0.5%	-2.3%
3 v 5 change in salvage												
Winter-run number	0	0	1	7	12	9	0	0	0	0	0	29
Winter-run percent			0.5%	0.3%	2.2%	1.9%	-0.1%	-0.3%	0.4%			0.8%
Spring-run number	0	0	0	0	1	86	-11	-21	5	0	0	60
Spring-run percent	-0.2%			0.3%	2.2%	1.9%	-0.1%	-0.3%	0.4%			0.2%
Steelhead number	0	1	0	1	16	14	0	-1	0	0	0	31
Steelhead percent	-0.2%	3.0%	0.3%	0.4%	2.1%	1.7%	-0.1%	-0.6%	1.0%	-0.4%	0.5%	1.2%
1 v 5 change in salvage												
Winter-run number	0	0	-12	-153	-38	17	-4	0	0	0	0	-190
Winter-run percent			-6.7%	-7.1%	-7.3%	3.6%	-2.4%	-5.4%	0.1%			-5.5%
Spring-run number	0	0	0	0	-3	165	-465	-403	1	0	0	-706
Spring-run percent	0.3%			-7.1%	-7.3%	3.6%	-2.4%	-5.4%	0.1%			-2.2%
Steelhead number	0	0	-1	-25	-52	27	-13	-13	0	0	0	-76
Steelhead percent	0.3%	0.7%	-4.3%	-7.8%	-6.9%	3.3%	-3.0%	-11.5%	0.2%	0.2%	0.5%	-3.0%

Table 10–2 Average monthly loss (top chart) and salvage (bottom chart) for winter-run, spring-run, and steelhead used in loss and salvage change calculations. Dry years = 1994, 2001, 2002, Wet years = 1993, 1995-2000 ,2003, steelhead loss based on unclipped fish 1998 – 2003. Winter run and spring run were categorized into runs by length measurements.

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Dry Year Loss												
Winter Run	0	0	1,660	2,207	3,232	6,538	307	11	0			
Spring Run	0	0	0	7	3	2,960	14,329	2,936	6			0
Steelhead	4	65	65	935	1,860	2,191	957	262	106	20	3	0
Wet Year Loss												
Winter Run	0	0	554	6,877	1,604	1,093	329	7	1			
Spring Run	5	0	0	6	65	5,583	35,274	12,495	2,137			3
Steelhead	4	65	65	935	1,860	2,191	957	262	106	20	3	0

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Dry year salvage												
Winter Run			531	782	1,860	2,181	236	2	0			
Spring Run	0			12	4	1,349	8,855	881	8			0
Steelhead unclipped	1	22	20	314	744	824	428	110	35	8	1	0
Wet year salvage												
Winter Run			187	2,137	529	476	151	7	2			
Spring Run	1			5	39	4,576	19,445	7,434	1,053			1
Steelhead unclipped	1	22	20	314	744	824	428	110	35	8	1	0

The unexpanded steelhead salvage for which lengths were measured from 1993 – 2003 contains about 3.5% adults (Figure 10–3). Fish greater than 350 mm were considered adults. Most of the adult salvage occurs in March through May, a time when adults would more likely be moving back downstream than upstream, so the salvaged adults may be mostly post-spawn adults heading back to the ocean. Future adult salvage was not estimated separately but is assumed that it will remain around 3.5% of the total number of steelhead salvaged. Figure 10–4 shows all steelhead fork lengths measured at the salvage facilities from 1993 – 2003.

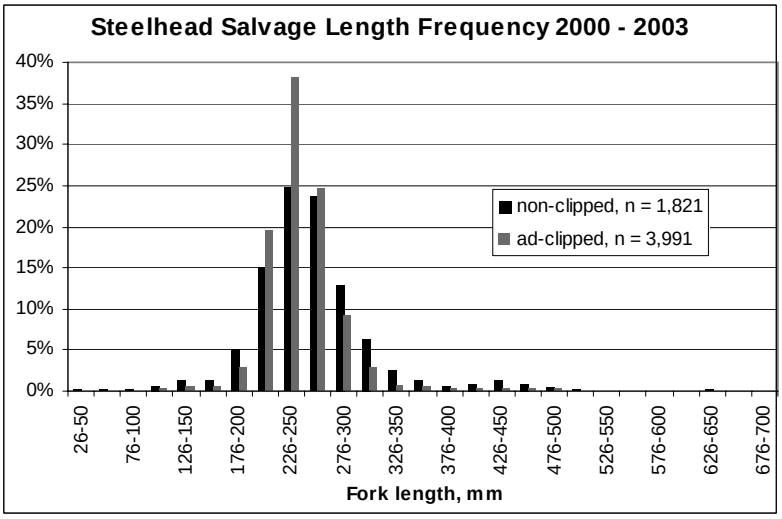

Figure 10–3 Length frequency distribution of steelhead salvaged at the CVP and SWP 2000 – 2003.

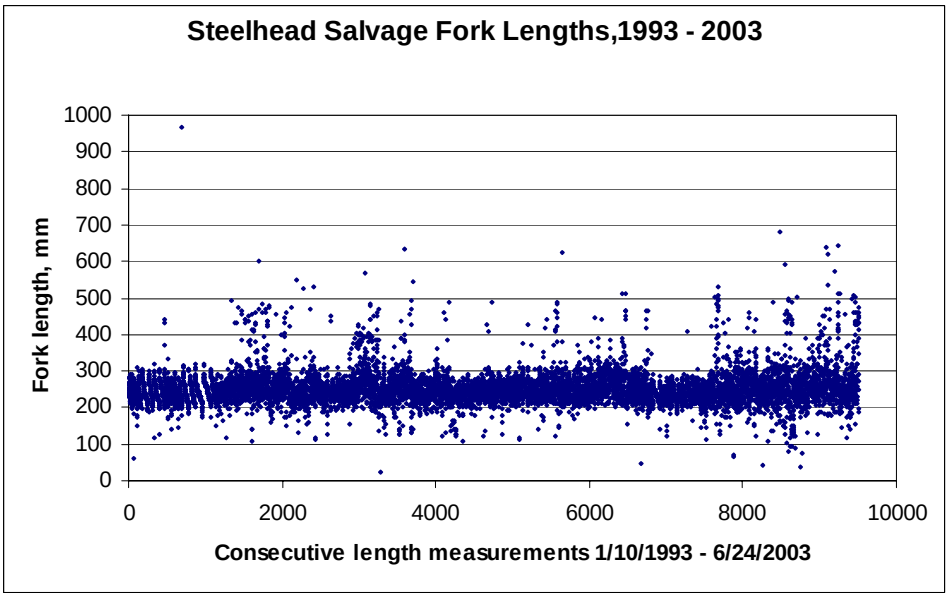

Figure 10–4 Steelhead salvage fork lengths measured since 1993 and listed consecutively as measured.

North Bay Aqueduct

The maximum pumping capacity of the NBA facility is 175 cfs, but its mean is typically lower. The NBA facility has positive barrier fish screens built to DFG specifications to exclude juvenile salmon. The screens have approach velocities ranging between 0.2 and 0.4 feet per second. DFG has determined this is sufficient to prevent entrainment of juvenile salmonids. The facility is

located at the end of Barker Slough, more than 10 miles from the mainstem Sacramento River. There is no information on salmonids migrating up Barker Slough.

Sommer et al. (2001b) reported the 1998 and 1999 Chipps Island survival indices were comparable to or higher for CWT Chinook released into Yolo Bypass than for fish released simultaneously in the Sacramento River. Similarly, Brandes and McLain (2001) found survival indices were higher for CWT Chinook that passed through the Steamboat-Sutter slough complex than for fish that traveled down the mainstem Sacramento River. Both Yolo Bypass and Steamboat Slough empty into Cache Slough placing fish closer to the NBA pumping plant than they would have been had they remained in the main river channel. This suggests the NBA facility does not significantly adversely impact juvenile salmonids traveling in the river or Cache Slough. The higher survival of Steamboat-Sutter smolts does not affect the conclusions of the Newman and Rice analyses.

Delta Cross Channel

Juvenile salmon survival is higher when the fish remain in the Sacramento River, than when they migrate through the central Delta (Kjelson et al. 1982, Brandes and McLain 2001; Newman 2002). This has not been studied for steelhead, but they are likely affected in a similar manner, although to a lesser extent because steelhead emigrants are larger than Chinook. SWRCB D-1641 provides for closure of the DCC gates from February 1 through May 20. During November through January, the gates may be closed for up to 45 days for the protection of fish. The gates may also be closed for 14 days during the period May 21 through June 15. Reclamation shall determine the timing and duration of the closures after consultation with FWS, DFG, and NOAA Fisheries. Consultation with the CALFED Operations Group will also satisfy the consultation requirement. The CALFED Ops Group has developed and implemented the Salmon Protection Decision Process. The Salmon Protection Decision Process depends on identifying the time when young salmon are likely entering the Delta and taking actions to avoid or minimize the effects of DCC and other Project operations on their survival in the Delta. The decision process identifies “Indicators of sensitive periods for salmon” such as hydrologic changes, detection of spring–run or spring–run surrogates at monitoring sites or the salvage facilities, and turbidity increases at monitoring sites. These actions should provide protection to both steelhead and Chinook salmon for much of their peak emigration period. Figure 10–5 and Figure 10–6 show the percent of the Sacramento River flow passing through the DCC and through Georgiana Slough during critically dry years. Figure 10–7 shows the percent continuing on down the main Sacramento River channel. During the other water year types a lower percentage of flow passes through the DCC with the lowest percentage occurring in wet years. The percentage passing through the DCC increases in the future in June and August. The increased flow through the DCC occurs when few juvenile salmon or steelhead are present in the Delta. The cross channel gate closure in February through May and low percentage passing through the channel in December and January avoids the majority of salmon and steelhead emigrating from the Sacramento system.

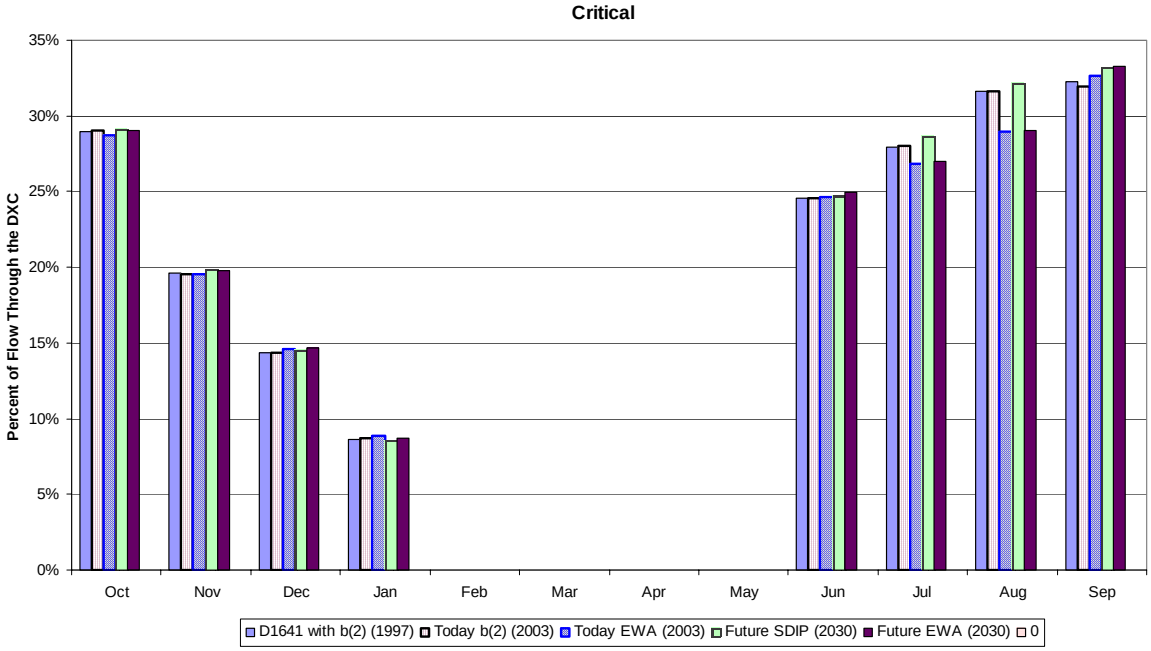

Figure 10–5 Percent of Sacramento River flow passing through the DCC during critically dry years under the five scenarios.

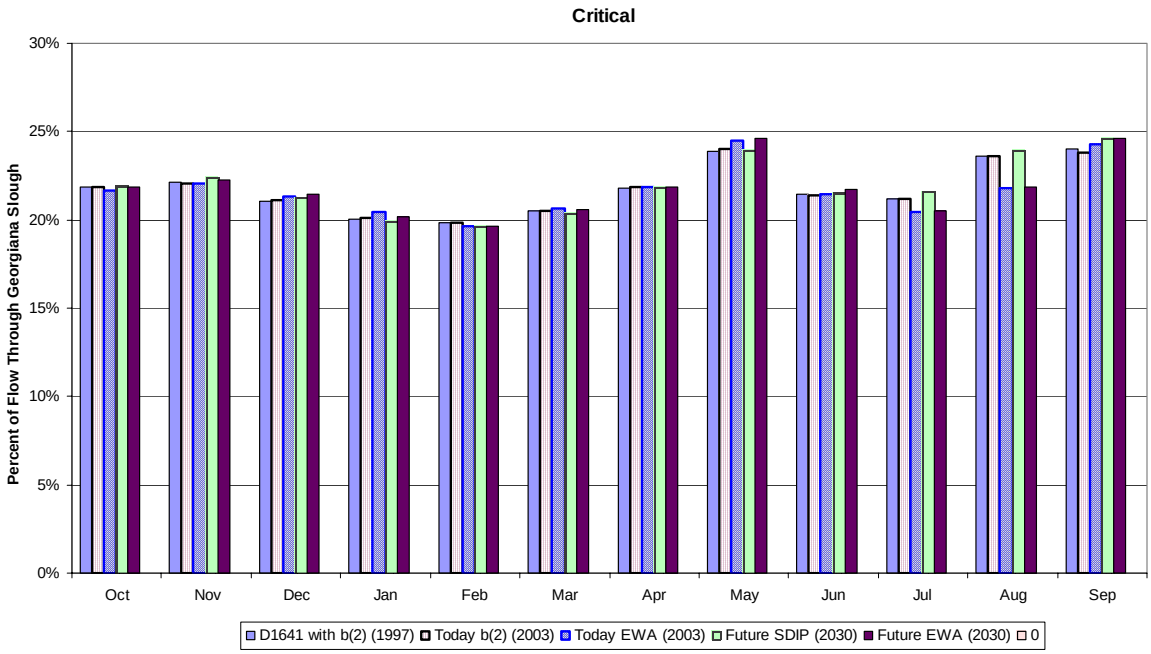

Figure 10–6 Percent of Sacramento River flow passing through Georgiana Slough during critically dry years under the five scenarios.

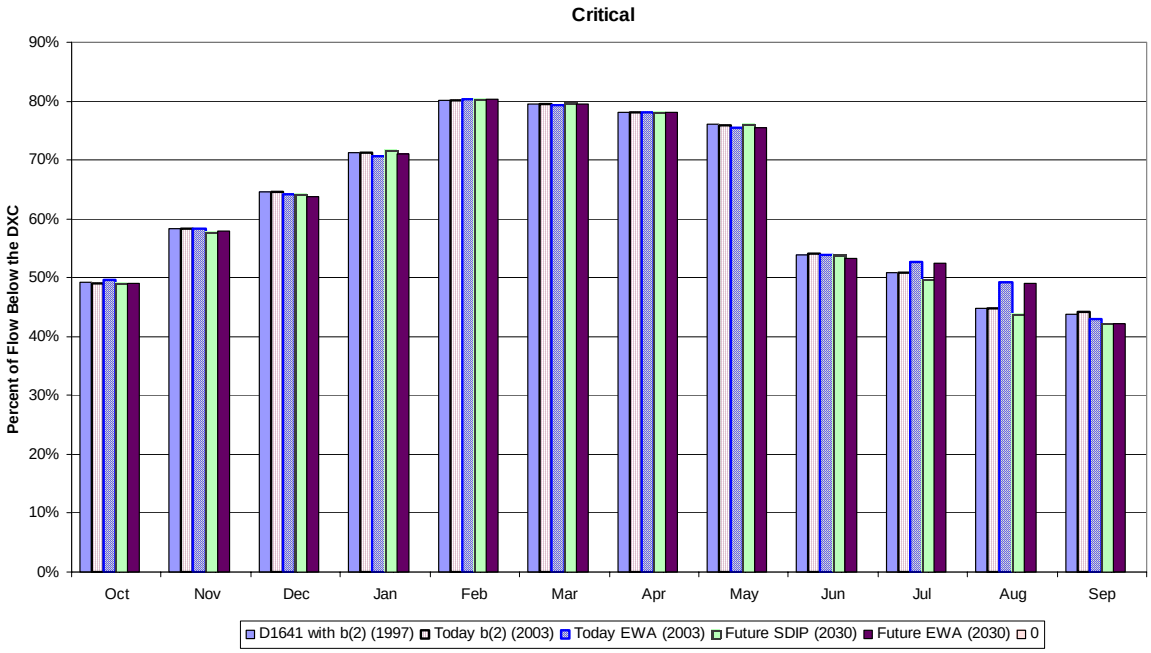

Figure 10–7 Percent of Sacramento River flow continuing down the main Sacramento River channel past the DCC and Georgiana Slough during critically dry years under the five scenarios.

Rock Slough Old River Intake

The Rock Slough diversion diverts water from Old River into the Contra Costa Canal. The historical diversion pattern varied between 50 to 250 cfs (Jerry Morinaka 1998, 2003 pers. comm., Table 10–4), with the higher pumping rates typical of the late spring through late fall period. The diversion is presently unscreened and construction of a fish screen is not currently planned. The extrapolated numbers of steelhead entrained by the facility between 1994 and 1996 were low, ranging from 52 to 96 per year (Morinaka 1998). Additional losses (8 percent to 30 percent) were recorded from the remains of fish killed during passage through the intake. Further losses could have occurred through predation due to the facility's location at the end of a dead-end slough, but this was not assessed for steelhead.

The following is a summary of fisheries monitoring conducted at Rock Slough since 1994. Numbers of listed fish species captured during monitoring is shown in Table 10–3.

Fish Monitoring Program at Pumping Plant #1

1994 to beginning of 1997

- Sample with a sieve-net in the Contra Costa Canal
- Sampled approximately 90–100 percent of the flow of water
- Sampled for an 8-hour period each sampling effort
- Year round monitoring program:

February through May = every other day
June and July = every 4th day
August and September = once a week
October through January = every 4th day

- Rock Slough was the primary source to meet the water demands in the Contra Costa Canal throughout this monitoring program

Fish Monitoring Program at the Headworks Location (Rock Slough Intake)

1998 to present

- Sampled with a sieve-net at the headworks structure of the Contra Costa Canal intake channel (4 miles upstream of Pumping Plant #1)
- Sampled approximately 10 – 15 percent of the flow of water
- Sampled for periods of 3 to 5 hours
- Year round monitoring program (once a week throughout the year)
- Rock Slough intake was used less after 1998 when Los Vaqueros Reservoir and the Old River Pumping Plant were operating

Table 10–3 Numbers of listed fish species captured at Pumping Plant # 1 of the Contra Costa Canal and the headworks at the Rock Slough Intake during fisheries monitoring, 1994-2002.

	1994	1995	1996	1997	1998	1999	2000	2001	2002
Chinook Salmon (All Races)	101	95	40	0	1	0	3	0	0
Winter–run Sized Chinook Salmon	2	6	4	0	1	0	0	0	0
Spring–run Sized Chinook Salmon	29	54	25	0	0	0	0	0	0
Steelhead	10	14	12	0	0	0	0	0	0
Delta Smelt	2	0	2	0	0	0	0	0	0

Table 10–4 Average monthly diversion rate at the Rock Slough intake, 1998-2002.

Contract	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Year	cfs	cfs	cfs	cfs	cfs	cfs	cfs	cfs	cfs	cfs	cfs	cfs
1998	35	28	38	69	102	115	132	159	171	139	107	88
1999	40	38	28	64	8	147	218	140	18	3	2	21
2000	8	15	28	73	20	149	100	149	155	54	35	13
2001	40	37	31	68	48	166	29	32	9	10	13	13
2002	6	6	38	60	31	165	146	22	18	10	11	17

The extrapolated numbers of juvenile Chinook salmon (all races) entrained by the facility between 1994 and 1996 ranged from 262 to 642 per year (Morinaka 1998). Additional losses due

to predation and fish being killed passing through the intake were estimated using juvenile marked hatchery fall–run Chinook salmon in 28 release groups. Survival estimates (estimated from recaptures in a sieve net 60 feet downstream of Pumping Plant #1) ranged from 0 percent to 51 percent and averaged about 18 percent. The large variation in survival rates may have resulted from releases done at different times of day and with different numbers of fish (see Morinaka 1998 for details). If we assume that only about 20 percent of salmon passing through the pumping plant survive, then the estimated numbers of juvenile salmon (all races) entrained between 1994 and 1996 would be about 1,695, 3,210 and 1,310 respectively.

Because most diversions occur during the summer months when salmon and steelhead are not present in the vicinity of the diversion and very few listed fish species (one winter–run and one splittail) have been captured during monitoring since 1997, the Rock Slough diversion is not believed to be a significant source of mortality for any of the listed species. Take of salmon and steelhead will likely continue to occur at levels similar to the past, which were estimated to be up to 3,200 juvenile Chinook (all races) per year assuming 20% survival from the diversion to the sampling site. No listed runs have been captured in sampling since 1996 so take of listed runs is expected to be very low, probably fewer than 50 spring–run, 50 winter–run and 15 steelhead.

Suisun Marsh Salinity Control Gates

The SMSCG could be operated as needed to meet State salinity standards in the marsh September through May, overlapping with an expected January through May peak emigration of steelhead through the Delta. However, young steelhead are rare in Suisun Marsh and are therefore unlikely to be substantially affected by gate operations. Examination of the UC Davis Suisun Marsh Monitoring databases revealed six steelhead were captured from 1979 through 1997. Only two of the six were sub-adult sized fish. The very low number of steelhead in the samples is partly due to poor capture efficiencies of the beach seines and otter trawl used in the UC Davis survey. However, 1,505 splittail greater than 200 mm, were collected by UC Davis sampling during the same period. Both adult splittail and yearling steelhead are excellent swimmers and are inefficiently sampled by the gear types used in this program. The much higher incidence of adult splittail in the samples suggests steelhead are relatively rare in the marsh. Furthermore, the marsh sampling collected more adult steelhead (4) than yearlings (2). The adults are larger and faster and therefore sampled less efficiently, providing additional evidence that yearling steelhead seldom occur in Suisun Marsh. The very infrequent occurrence of steelhead in the marsh suggests predation associated with migration delays is unlikely to significantly affect the steelhead population. As support for this hypothesis, steelhead were not listed as a prey item of striped bass or Sacramento pikeminnow captured near this facility between 1987 and 1993 (DWR 1997).

The Suisun Marsh Salinity Control Gates could potentially be operated September through May, overlapping with an expected November through May spring–run emigration. However, juvenile Chinook salmon of all races are rare in Suisun Marsh and are therefore unlikely to be substantially affected by gate operations. Examination of the UC Davis Suisun Marsh Monitoring databases showed only 257 juvenile Chinook salmon were captured from 1979 through 1997.

The infrequent occurrence of young Chinook in the marsh suggests that predation associated with migration delays is unlikely to significantly affect the spring–run or winter–run population. As support for this hypothesis, only three Chinook salmon were found in the stomachs of striped bass and pikeminnow captured near this facility between 1987 and 1993 (Heidi Rooks, pers. comm.).

Although young Chinook salmon will probably not be significantly affected by gate operations, it is possible upstream passage of adults could be influenced. Adult winter–run and spring–run may pass through the marsh channels from December through May when their migration could potentially be delayed. The SMSCG Steering Group decided based on preliminary results from the modified SMSCG tests that the slots resulted in less adult passage than the original flashboards. The modification made for the 2001-02 control season was to leave the boat lock at the SMSCG open at all times. This modification is currently being tested. It is hoped that this continuous opening at the structure will facilitate increased adult salmon passage. See "Suisun Marsh Salinity Control Gates" in Chapter 5 for more information.

Delta Smelt

This analysis is based on two CALSIM II case comparisons: model case #1 v model case #4 and model case #1 v model case #5 (see detailed explanation of model scenarios in Chapter 8). We have focused on these comparisons in order to characterize the future conditions with and without EWA against the baseline condition. The CALSIM II model scenarios represent the only available data simulating the movement of water through the delta under the various future scenarios considered in this document. The model results provide a (crude) basis to make these model case comparisons. The analysis is crude, because the monthly timestep of the CALSIM II model forces us to draw inferences from only a few data representing the critical seasons of each year.

In each model case comparison, we have considered (1) changes in expected direct entrainment loss at the CVP and SWP export facilities, (2) changes in X2, and (3) changes in the Export-Inflow ratio (E/I). Potential changes in entrainment are important indices of the effects of facility operations because entrainment directly reduces the pool of delta smelt available to replenish the population. Changes in X2 may not in themselves increase mortality, but may modify the proportion of the delta smelt population at risk of becoming entrained into the export facilities. The export-inflow ratio can index the extent to which export operations influence the pattern of flow through the delta, and may be useful where comparisons can be made at constant inflow. The index does not, however, tell us which areas of the delta are influenced by the pumps, nor is it reliable when comparisons cannot be made at constant inflow.

Direct losses to entrainment by CVP and SWP export facilities.

Some delta smelt are entrained by the south delta export facilities and lost to the estuarine population. Because the species is migratory, entrainment is seasonal. Adult delta smelt may be present in the south delta and vulnerable to entrainment from December through April; larvae and juveniles are likely to be present and vulnerable during late March through early July.

Entrainment is actually estimated by extrapolating salvage from periodic salvage measurements, which are assumed to index entrainment, and then applying assumptions. To make prediction of

the difference in salvage between model scenarios possible, we assumed that salvage density (fishes per volume) is independent of the pumping rate. Because salvage density is not independent of delta outflow and varies seasonally, we estimated salvage density for wet and dry water year types from historical data representing the period 1993–2002. There were too few years of most water-year types to reasonably estimate salvage density for each type, so data from wet (Wet and Above Normal) and dry (Below Normal, Dry, and Critically Dry) types were pooled. The difference in salvage between two model cases was then computed simply by estimating the difference in pumping rate from the CALSIM II model output and multiplying by the corresponding salvage density estimate. We separately estimated changes in salvage for each (a) salvage facility and (b) Sacramento River water-year type. The monthly differences were computed as $(X_y–X_1)/X_1$ where the subscript y is either 4 or 5 (corresponding to those model cases), and X_1 represents the base case (#1).

We have focused on typical differences between the model cases, and have used the median rather than the mean to represent them. The median ordinarily divides a body of scalar data into two groups of equal size. The distributions of differences in the pumping data were skewed in some cases, with one tail of the distribution much longer than the other. This usually arose in cases where some of the base-case values X_1 were much smaller than other X_1 values within the case for reasons having to do with the CALSIM II model assumptions. Because X_1 appears in the denominator of the difference calculation, small values tend to telescope the distribution of differences. Use of the median avoids the mean's tendency to track the longer tail of the distribution, thus overstating the typical difference between the data being compared.

Results:

Salvage of adult delta smelt

All comparisons of model cases #4 and #5 are with model case #1. Unspent adult delta smelt of considerably more value to the population than juveniles, so salvage of individuals likely to fall into this class is important. In general, the results suggest modest increases in salvage in typical years at the CVP facility in model case #4, while there is either no change or a trivial decrease when EWA actions are included in case #5 (Table 10–5 – Table 10–14). At the SWP facility, there is a more consistent increase in model case #4, usually of 10% or less; the inclusion of EWA actions apparently has substantial effect in some cases, with the net result that there is little overall change in adult salvage in case #5 with respect to case #1. In typical wet years, there is a substantial 18% increase in adult December salvage at Banks in case #4 that is reduced to 13.7% under case #5. There are similar typical increases in both future cases in March. In critically dry years model case #5 produces a net decrease in adult entrainment at Banks. It is unclear what effect these changes might have on the smelt population in typical years. The increases in December and March in typical wet years under both case #4 and case #5 may be of concern in some years, depending on the abundance and distribution of adult delta smelt during those months.

Table 10–5 CVP salvage in Wet years

Month	Median model case 1 pumping (c.f.s.)	Median change in case 4	Median change in case 5	Density of delta smelt at Tracy[1]	Predicted median difference in salvage[2]	
					4 – 1	5 – 1
Adults						
December	4222	+8.9%	–0.7%	0.010	+3.8	–0.3
January	4226	+8.8%	–0.8%	0.095	+35.3	–3.2
February	4243	+8.3%	–2.2%	0.151	+53.2	–14.1
March	4273	–2.9%	+7.0%	0.159	–19.7	+47.6
Largely Juveniles						
April	2747	0	0	0.206	0	0
May	2274	0	0	7.430	0	0
June	3000	0	0	2.017	0	0
July	4588	+0.3%	0	0.036	+0.5	0
Net: December – March					+73	+29
Net: April – July					+1	0

[1]Average delta smelt salvage density (fishes c.f.s.$^{-1}$ month^{-1}) estimated from pooled Above Normal and Wet years 1995-2000.

[2]Predicted median difference has unit: fishes month.$^{-1}$. See text for explanation of calculation.

Table 10–6 CVP salvage in Above Normal years

Month	Median model case 1 pumping (c.f.s.)	Median change in case 4	Median change in case 5	Density of delta smelt at Tracy[1]	Predicted median difference in salvage[2]	
					4 – 1	5 – 1
Adults						
December	4221	+8.9%	–0.7%	0.010	+3.8	–0.3
January	4225	+8.9%	–0.8%	0.095	+35.7	–3.2
February	4242	+8.4%	–2.2%	0.151	+53.8	–14.1
March	4262	–14.3%	+0.3%	0.159	–96.9	+2.0
Largely Juveniles						
April	2742	0	0	0.206	0	0
May	1911	0	0	7.430	0	0
June	2920	0	0	2.017	0	0
July	4580	+0.1%	+0.2%	0.036	+0.2	+0.3
Net: December – March					–4	–16
Net: April – July					0	0

[1]Average delta smelt salvage density (fishes c.f.s.$^{-1}$ month^{-1}) estimated from pooled Above Normal and Wet years 1995-2000.

[2]Predicted median difference has unit: fishes month.$^{-1}$. See text for explanation of calculation.

Table 10–7 CVP salvage in Below Normal years

Month	Median model case 1 pumping (c.f.s.)	Median change in case 4	Median change in case 5	Density of delta smelt at Tracy[1]	Predicted median difference in salvage[2] 4 – 1	5 – 1
Adults						
December	4221	+7.3%	–3.5%	0.067	+20.6	–9.9
January	4225	+8.9%	–0.7%	0.180	+67.7	–5.3
February	4241	+8.1%	+8.2%	0.235	+80.7	+81.7
March	4235	–3.8%	–4.8%	0.201	–32.3	–40.9
Largely Juveniles						
April	2321	0	–1.1%	0.259	0	–6.6
May	1911	0	–34.0%	11.93	0	–7751
June	3000	0	0	1.584	0	0
July	4554	+0.3%	+0.2%	0.005	+0.1	+0.1
Net: December – March					+137	+26
Net: April – July					0	–7758

[1]Average delta smelt salvage density (fishes c.f.s.$^{-1}$ month^{-1}) estimated from pooled Dry and Critically Dry years 1994 and 2001-2.

[2]Predicted median difference has unit: fishes month.$^{-1}$. See text for explanation of calculation.

Table 10–8 CVP salvage in Dry years

Month	Median model case 1 pumping (c.f.s.)	Median change in case 4	Median change in case 5	Density of delta smelt at Tracy[1]	Predicted median difference in salvage[2] 4 – 1	5 – 1
Adults						
December	4220	+8.9%	–0.7%	0.067	+25.2	–2.0
January	4225	+8.8%	–0.8%	0.180	+66.9	–6.1
February	4235	+8.4%	+8.4%	0.235	+83.6	+83.6
March	4208	+1.4%	–0.8%	0.201	+11.8	–6.8
Largely Juveniles						
April	1808	+0.7%	+0.9%	0.259	+3.3	+4.2
May	1720	0	–38.1%	11.93	0	–7818
June	2874	0	–8.9%	1.584	0	–405
July	4421	–0.3%	–5.7%	0.005	–0.1	–1.3
Net: December – March					+188	+69
Net: April – July					+3	–8220

[1]Average delta smelt salvage density (fishes c.f.s.$^{-1}$ month^{-1}) estimated from pooled Dry and Critically Dry years 1994 and 2001-2.

[2]Predicted median difference has unit: fishes month.$^{-1}$. See text for explanation of calculation.

Table 10–9 CVP salvage in Critically Dry years

Month	Median model case 1 pumping (c.f.s.)	Median change in case 4	Median change in case 5	Density of delta smelt at Tracy[1]	Predicted median difference in salvage[2] 4 – 1	5 – 1
Adults						
December	2897	+4.8%	–19.1%	0.067	+9.3	–37.1
January	4218	+8.9%	–9.7%	0.180	+67.6	–73.6
February	3979	+1.9%	–0.1%	0.235	+17.8	–9.4
March	1247	+2.9%	0	0.201	+7.3	0
Largely Juveniles						
April	800	0	0	0.259	0	0
May	1189	0	–32.6%	11.93	0	–4624
June	953	–1.1%	0	1.584	–16.6	0
July	800	–1.5%	0	0.005	–0.1	0
Net: December – March					+102	–120
Net: April – July					–17	–4624

[1]Average delta smelt salvage density (fishes c.f.s.$^{-1}$ month^{-1}) estimated from pooled Dry and Critically Dry years 1994 and 2001-2.

[2]Predicted median difference has unit: fishes month.$^{-1}$. See text for explanation of calculation.

Table 10–10 SWP salvage in Wet years

Month	Median model case 1 pumping (c.f.s.)	Median change in case 4	Median change in case 5	Density of delta smelt at Banks[1]	Predicted median difference in salvage[2] 4 – 1	5 – 1
Adults						
December	7033	+18.0%	+13.7%	0.015	+19.0	+14.5
January	7408	+9.5%	+8.4%	0.214	+150.6	+133.2
February	5848	+2.4%	+4.1%	0.242	+34.0	+58.0
March	5653	+17.2%	+24.8%	0.069	+67.1	+96.7
Largely Juveniles						
April	4830	+8.7%	–19.2%	0.058	+24.4	–53.8
May	4660	+5.8%	–48.4%	12.52	+3384	–28238
June	5925	–0.1%	+7.0%	10.90	–64.6	+4521
July	6680	+12.7%	+17.4%	0.611	+518.3	+710
Net: December – March					+271	+302
Net: April – July					+3862	–23061

[1]Average delta smelt salvage density (fishes c.f.s.$^{-1}$ month^{-1}) estimated from pooled Above Normal and Wet years 1993 and 1995-2000.

[2]Predicted median difference has unit: fishes month.$^{-1}$. See text for explanation of calculation.

Table 10–11 SWP salvage in Above Normal years

Month	Median model case 1 pumping (c.f.s.)	Median change in case 4	Median change in case 5	Density of delta smelt at Banks[1]	Predicted median difference in salvage[2] 4 – 1	5 – 1
Adults						
December	6484	+9.3%	+4.8%	0.015	+9.0	+4.7
January	7548	0	–4.8%	0.214	0	–77.5
February	7451	+2.1%	–3.1%	0.242	+37.9	–55.9
March	5784	+14.3%	+26.6%	0.069	+57.1	+106.2
Largely Juveniles						
April	4508	+7.4%	–23.5%	0.058	+19.3	–61.4
May	3596	+2.3%	–58.3%	12.52	+1036	–26248
June	3942	+3.5%	+0.6%	10.90	+1504	+257.8
July	6157	+7.7%	+27.0%	0.611	+289.7	+1016
Net: December – March					+104	–23
Net: April – July					+2848	–25036

[1]Average delta smelt salvage density (fishes c.f.s.$^{-1}$ month^{-1}) estimated from pooled Above Normal and Wet years 1993 and 1995-2000.

[2]Predicted median difference has unit: fishes month.$^{-1}$. See text for explanation of calculation.

Table 10–12 SWP salvage in Below Normal years

Month	Median modelcase 1 pumping (c.f.s.)	Median change in case 4	Median change in case 5	Density of delta smelt at Banks[1]	Predicted median difference in salvage[2] 4 – 1	5 – 1
Adults						
December	5938	+11.2%	+6.0%	0.050	+33.3	+17.8
January	7172	+7.5%	–0.4%	0.209	+112.4	–6.0
February	5850	+2.1%	+5.7%	0.134	+16.5	+44.7
March	5713	+12.4%	+8.9%	0.178	+126.1	+90.5
Largely Juveniles						
April	3548	+1.0%	–25.2%	0.369	+13.1	–329.9
May	3235	+3.9%	–50.0%	29.97	+3781	–48477
June	3977	–0.2%	–2.6%	6.706	–53.3	–693.4
July	5320	+4.0%	+23.1%	0.446	+94.9	+548
Net: December – March					+288	+147
Net: April – July					+3836	–48952

[1]Average delta smelt salvage density (fishes c.f.s.$^{-1}$ month^{-1}) estimated from pooled Dry and Critically Dry years 1994 and 2001-2.

[2]Predicted median difference has unit: fishes month.$^{-1}$. See text for explanation of calculation.

Table 10–13 SWP salvage in Dry years

Month	Median model case 1 pumping (c.f.s.)	Median change in case 4	Median change in case 5	Density of delta smelt at Banks[1]	Predicted median difference in salvage[2] 4 – 1	5 – 1
Adults						
December	5358	+9.5%	+9.5%	0.050	+25.5	+25.5
January	5717	+10.0%	–8.6%	0.209	+119.5	–102.8
February	5303	+7.2%	+9.5%	0.134	+51.2	+67.5
March	4413	–0.1%	–0.1%	0.178	–0.8	–0.8
Largely Juveniles						
April	2168	+0.1%	–18.1%	0.369	+0.8	–144.8
May	2099	–1.8%	–58.1%	29.97	–1132	–36549
June	2952	–0.8%	–6.7%	6.706	–158.4	–1326
July	5217	+0.1%	+29.2%	0.446	+2.3	+679.4
Net: December – March					+195	–11
Net: April – July					–1288	–37341

[1]Average delta smelt salvage density (fishes c.f.s.$^{-1}$ month^{-1}) estimated from pooled Dry and Critically Dry years 1994 and 2001-2.

[2]Predicted median difference has unit: fishes month.$^{-1}$. See text for explanation of calculation.

Table 10–14 SWP salvage in Critically Dry years

Month	Median model case 1 pumping (c.f.s.)	Median change in case 4	Median change in case 5	Density of delta smelt at Banks[1]	Predicted median difference in salvage[2] 4 – 1	5 – 1
Adults						
December	4267	+6.0%	–5.9%	0.050	+12.8	–12.6
January	4891	+6.2%	–13.2%	0.209	+63.4	–134.9
February	3198	+13.4%	+14.4%	0.134	+57.4	+61.7
March	2030	+14.2%	+0.3%	0.178	+51.3	+1.1
Largely Juveniles						
April	1197	0	0	0.369	0	0
May	1189	0	–32.7%	29.97	0	–11652
June	300	0	0	6.706	0	0
July	553	–1.1%	+53.5%	0.446	–2.7	+132.0
Net: December – March					+185	–85
Net: April – July					–3	–11521

[1]Average delta smelt salvage density (fishes c.f.s.$^{-1}$ month^{-1}) estimated from pooled Dry and Critically Dry years 1994 and 2001-2.

[2]Predicted median difference has unit: fishes month.$^{-1}$. See text for explanation of calculation.

Salvage of Juvenile Delta Smelt

All comparisons of model cases #4 and #5 are with model case #1. There are only small changes in juvenile salvage at the CVP facility under both case #4 and case #5. Changes at Banks under case #4 are also small. There are substantial median reductions in Banks pumping in April and May when EWA actions are added in case #5. These would result in reductions in juvenile smelt salvage during those months that might benefit the species in some years, particularly those in which high entrainment episodes would otherwise occur during that period (particularly in May).

It should be noted that although it is used for the purpose, salvage does not particularly reliably index entrainment of delta smelt. Furthermore, delta smelt salvage is highly variable at all time scales, because fish are locally patchily distributed in the delta and may spawn at different times and in different regions in different years. Delta smelt also present no good stock-recruit relationship. Consequently, while this analysis credibly predicts what might happen in typical years, there will – even under the "baseline" model case 1 scenario – certainly be a small percentage of future years in which the confluence of natural and anthropogenic circumstances causes large delta smelt entrainment episodes. Delta smelt spend more time closer to the export facilities under low-flow conditions, making these episodes more likely in dry years; however, they might occur in any water-year type. Because an analysis of the likelihood of these events would require modeling delta smelt movement using detailed historical distributional data that are unavailable, we cannot determine whether the frequency of large entrainment events would be different from model case #1 under model cases #4 or #5. Better modeling and improved monitoring may provide a means to attack this question in the future.

There may have been a population-level export effect – i.e., depression of the delta smelt population in the fall following a spring with especially high entrainment -- in a few years during 1980–2002. If these effects are real, they will probably occur again when similar circumstances arise. New analytical approachs that employ estimates of the boundary of the zone of entrainment to predict the proportion of the delta smelt population that is subject to entrainment are under development. If these efforts succeed, they could provide a respectable basis for evaluating the population-level effects of export operations and proposed changes to operations.

Changes in Habitat Availability for Delta Smelt Based on X2 Movement

Average X2 during March–July of each year differed very little between model case #1 and either #4 or #5. However, a review of the monthly data revealed that there were isolated differences that were larger than most others during the March–July months. We are concerned about upstream movements of X2 during the spring and early summer primarily because smelt tend to aggregate in a region defined by low salinity, and movement of that region upstream moves those aggregations closer to the export pumps. Because there is no basis for identifying a particular value as the critical one that separates a dangerous X2 difference from an innocuous one, we arbitrarily selected one kilometer as the criterion for review.

The difference between X2 in CALSIM II model cases #4 and #5 and case #1 were plotted against X2 in case #1 for each of the months March through July (Figure 10–8 – Figure 10–12). In each figure, five panels representing each of the Sacramento River water-year types are presented. Positive differences represent movement of X2 upstream. In each figure, difference

values larger than one kilometer in Below Normal, Dry, and Critically Dry years have been labeled with the years they represent.

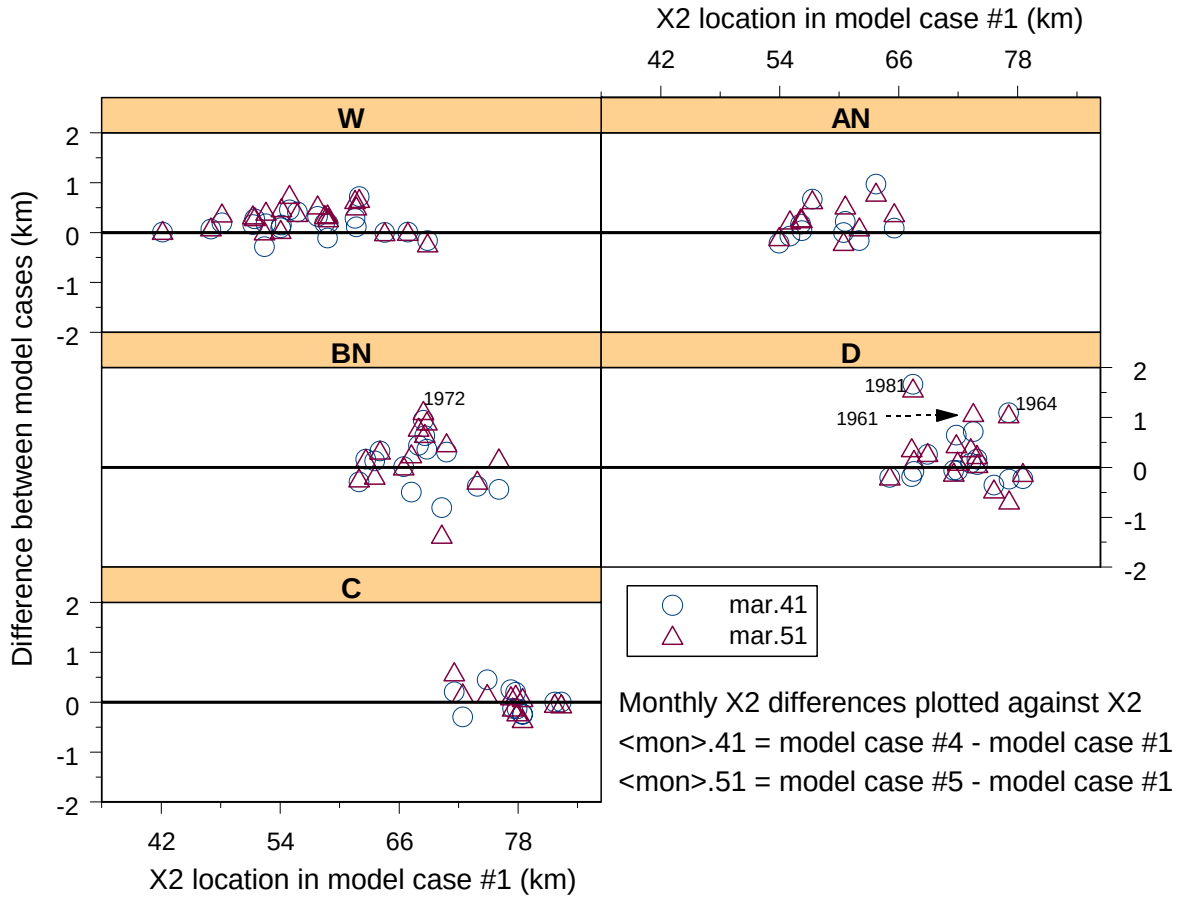

Figure 10–8 Differences in X2 under model cases #4 and #5 in March. Water year types: W=Wet, AN=Above Normal, BN=Below Normal, D=Dry, C=Critically Dry

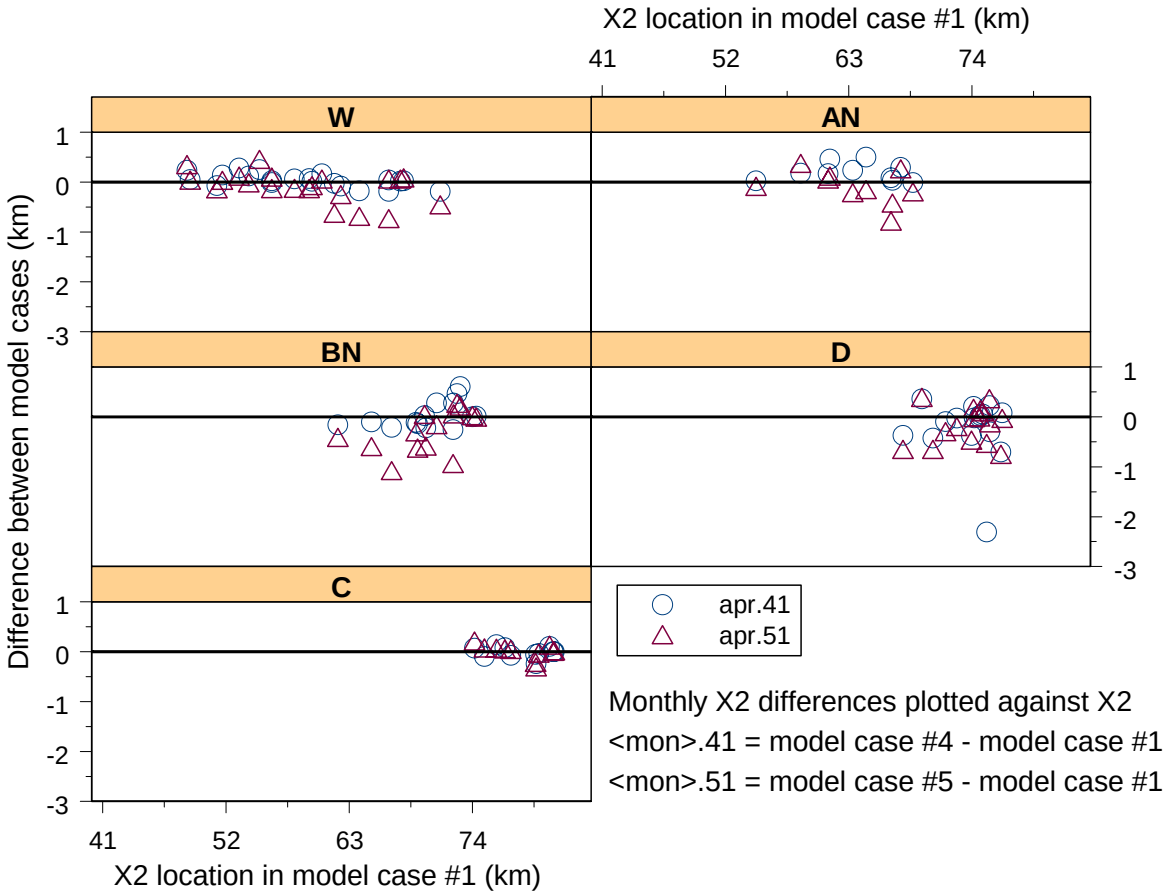

Figure 10–9 Differences in X2 under model cases #4 and #5 in April. Water year types: W=Wet, AN=Above Normal, BN=Below Normal, D=Dry, C=Critically Dry

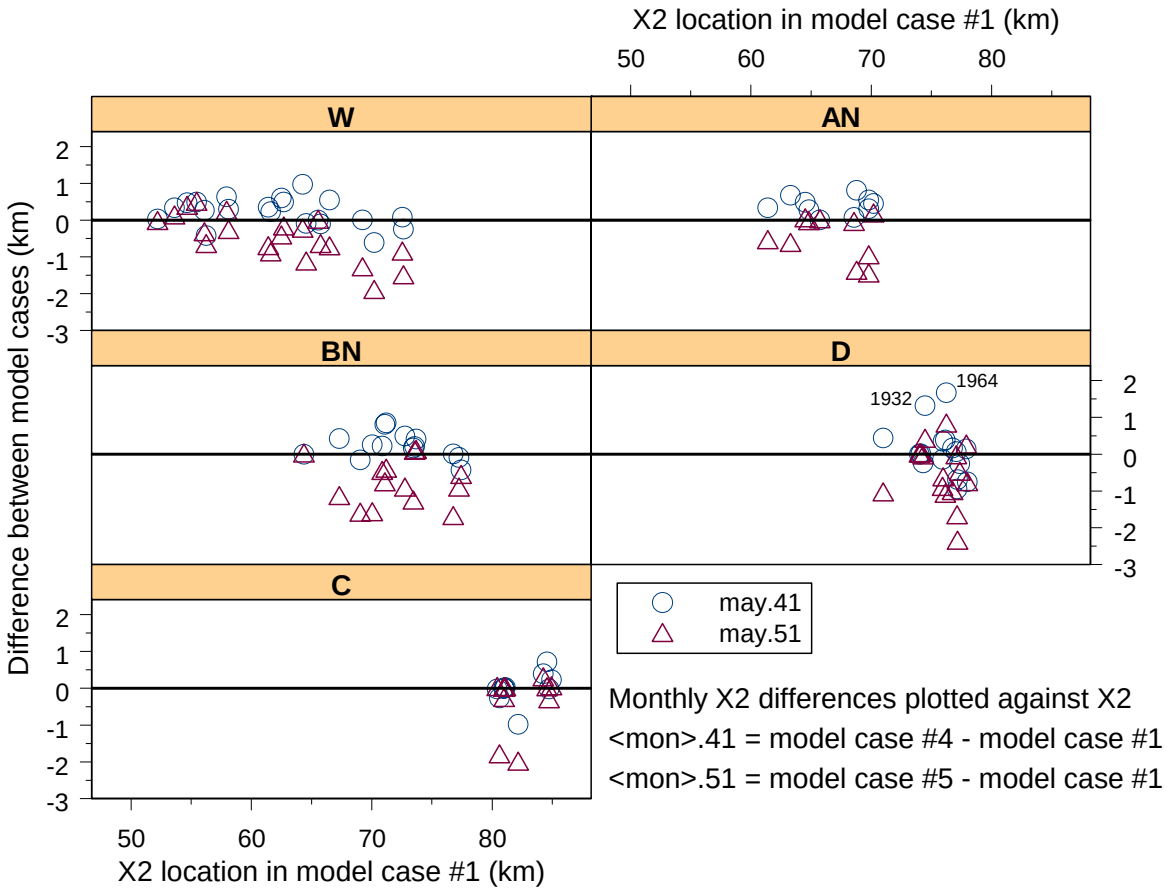

Figure 10–10 Differences in X2 under model cases #4 and #5 in May. Water year types: W=Wet, AN=Above Normal, BN=Below Normal, D=Dry, C=Critically Dry

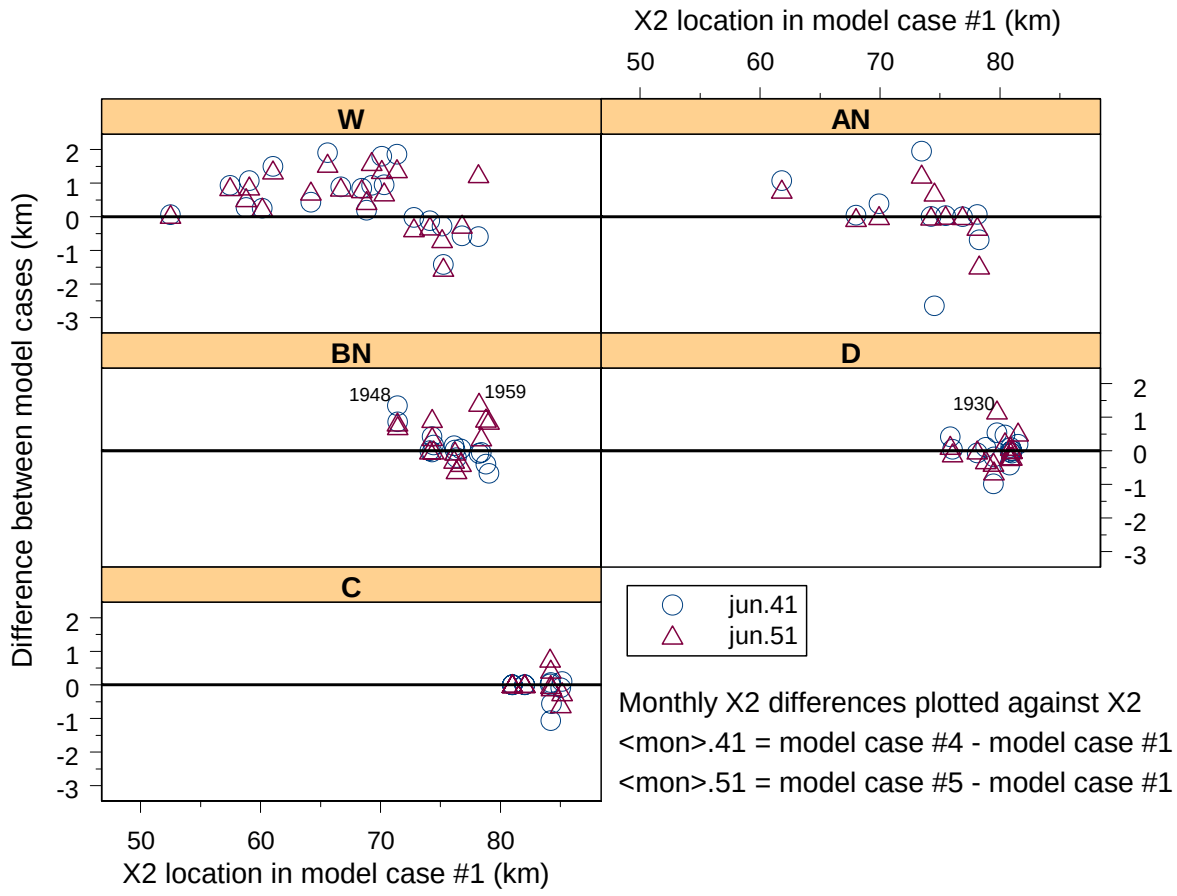

Figure 10–11 Differences in X2 under model cases #4 and #5 in June. Water year types: W=Wet, AN=Above Normal, BN=Below Normal, D=Dry, C=Critically Dry

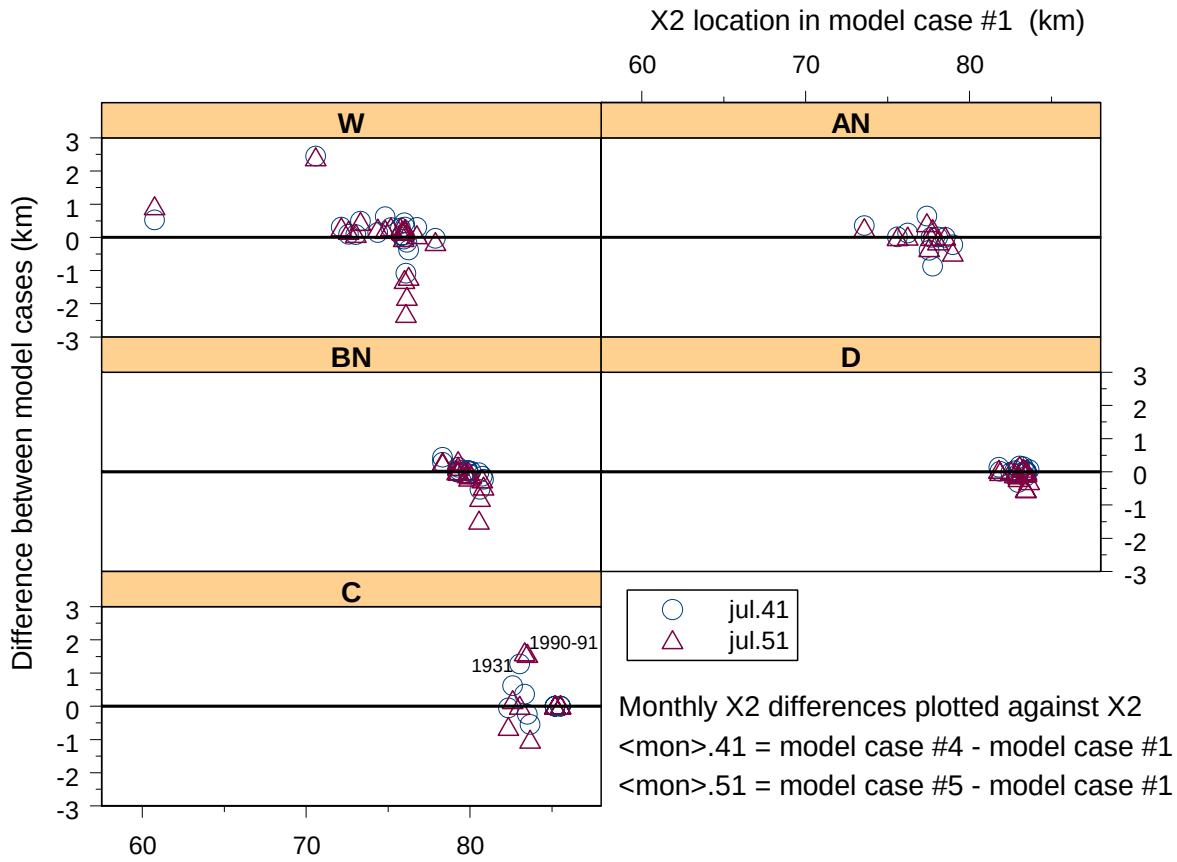

Figure 10–12 Differences in X2 under model cases #4 and #5 in July. Water year types: W=Wet, AN=Above Normal, BN=Below Normal, D=Dry, C=Critically Dry

Results:

March

There was one difference of at least one kilometer in a Below Normal year (1972) and three occurrences in Dry years (1961, 1964, 1981). In all four cases the base X2 value was similar (70–78 km). In 1961 and 1972, model case #4 yielded a lower X2 value than case #5 (0.71 vs. 1.08 in 1961 and 0.95 vs. 1.11 in 1972); in the other cases the model #4 and #5 values were similar. None of these larger differences was followed by an April X2 difference larger than 0.34 km; indeed, two of the April differences were negative and one was zero.

April

There were no differences larger than one kilometer in April.

May

There were two differences of at least one kilometer in model case #4 during May in Dry years. In both cases (1932 and 1964), the differences were greatly reduced (1.3 km vs. 0.4 km in 1932

and 1.67 vs. 0.8 km in 1964) by the addition of EWA actions in model case #5. In both cases, there were either negative differences or small upstream differences in adjacent months.

June

In June there were two Below Normal (1948, 1959) years and one Dry (1930) year which met the one-kilometer criterion for review. In 1948, a model case #4 value of 1.34 km was reduced to 0.82 km in case #5. Neither adjacent month in either future model case reached 0.5 km. In 1930 and 1959 the largest values occurred in case #5, with smaller values in case #4 (1.18 km in case #5 vs. 0.53 km in case #4 for 1930; 1.41 km in case #5 vs. –0.1 km in case #4 in 1959). None of these cases had an adjacent month in which the difference exceeded 0.5 km.

July

In July there were three Critically Dry years (1931, 1990, 1991) where the criterion was reached. In 1931 a difference of 1.28 km in case #4 was erased in case #5, while in both 1990 and 1991 negligible values in case #4 were replaced by positive values (1.6 km and 1.56 km, respectively) in case #5. Upstream movements of X2 in July are unlikely to be of significant concern except in unusual circumstances.

Summary

In the drier years, upstream movements of X2 predicted in model cases #4 and #5 reach one kilometer only in isolated months. In some cases upstream movements observed in case #4 are erased or reduced in case #5. In a few cases the upstream movement is larger in case #5. The seasonal average difference between both future cases and the base case is close to zero, and is sometimes negative. We are skeptical that a change as small as one kilometer – about an order of magnitude smaller than the typical tidal excursion at, for example, Chipps Island – in a single month would ordinarily affect the vulnerability of the smelt population near X2, even in critically dry years when X2 is far upstream during the spring. We conclude that X2 differences in the future cases are by themselves unlikely to affect delta smelt in most years. This conclusion is tentative, and might be modified in the future as our understanding of the circumstances that impose delta smelt vulnerability increases.

Export-Inflow ratio

Exceedence plots of the Export-Inflow ratio (E/I) reveal that in both cases #4 and #5 E/I is similar to or lower than case #1 in the months December–July. We do not expect changes to E/I predicted by cases #4 or #5 to create delta smelt protective concerns.

Water Transfers

Water transfers would increase Delta exports from 200,000 – 600,000 af in about 80% of years and potentially up to 1,000,000 af in some Dry and Critical years. Most of the transfers would occur during July through September. Juvenile salmonids are rarely present in the Delta in these months so no increase in salvage due to water transfers during these months is anticipated. Water transfers could be beneficial if they shift the time of year that water is pumped from the Delta from the winter and spring period to the summer, avoiding periods of higher salmonid abundance in the vicinity of the pumps. Some adult salmon and steelhead are immigrating upstream through the Delta during July through September. Increased pumping is not likely to

affect immigrating adults because they are moving in a general upstream direction against the current. For transfers that occur outside of the July through September period all current water quality and pumping restrictions would still be in place to limit effects that could occur.

Post-processing of model data for Transfers

This sections shows results from post-processed available pumping capacity at Banks and Tracy for the Future SDIP (Study 4) the assumptions for the calculations are:

- Capacities are for the Late-Summer period July through September total.
- The pumping capacity calculated is up to the export-to-inflow ratio and is limited by either the total physical or permitted capacity and do not include restrictions due to ANN salinity requirements with consideration of carriage water costs.
- The calculations do assume a reserve of 90 TAF for EWA pumping total for the July to September months at Banks.

Figure 10-15 and Figure 10-16 show the total available export capacity from highest to lowest for Banks and Tracy in the Future SDIP study with the 40-30-30 water year type on the x-axis and the water year labeled on the bars. Figure 10-13 and Figure 10-14 show the available export capacity for the Today b(2) study at Banks and Tracy respectively. The SWP allocation or the CVP south or Delta allocation is the allocation from CALSIM II output from the water year.

From Figure 10-13 and Figure 10-15 the years with the most capacity at Banks are generally the Dry and Critical years with the lowest allocations and reflect years when transfers maybe higher to augment water supply to export contractors. For the Today b(2) study in approximately 80% of the years the available capacity at Banks for transfer ranges from about 60 to 460 TAF in the (if the 90 TAF dedicated for EWA is included). In most years (approximately 80%) the available capacity at Banks for transfer ranges from about 200 to 600 TAF in the Future SDIP study (if the 90 TAF dedicated for EWA is included). Transfers at Tracy (Figure 10-14 and Figure 10-16) are probably most likely to occur in the Critical years when there is available capacity and low allocations.

The transfer results just show the capacity at the export pumps and do not reflect the amount of water available from willing sellers or the ability to move through the Delta.

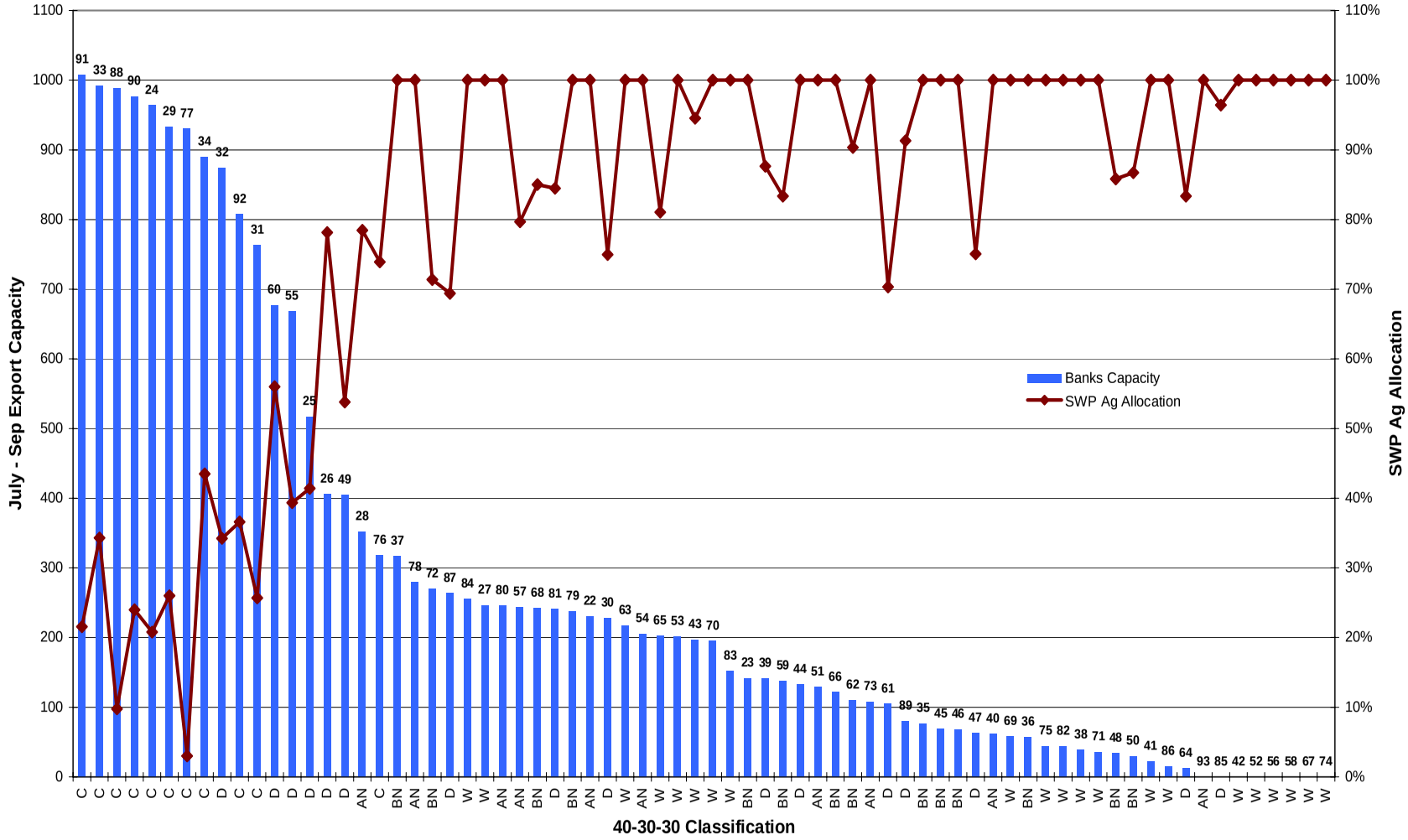

Figure 10-13 Total Banks pumping for July – September capacity in the Today b(2) Study sorted from highest to lowest with the corresponding SWP Allocation

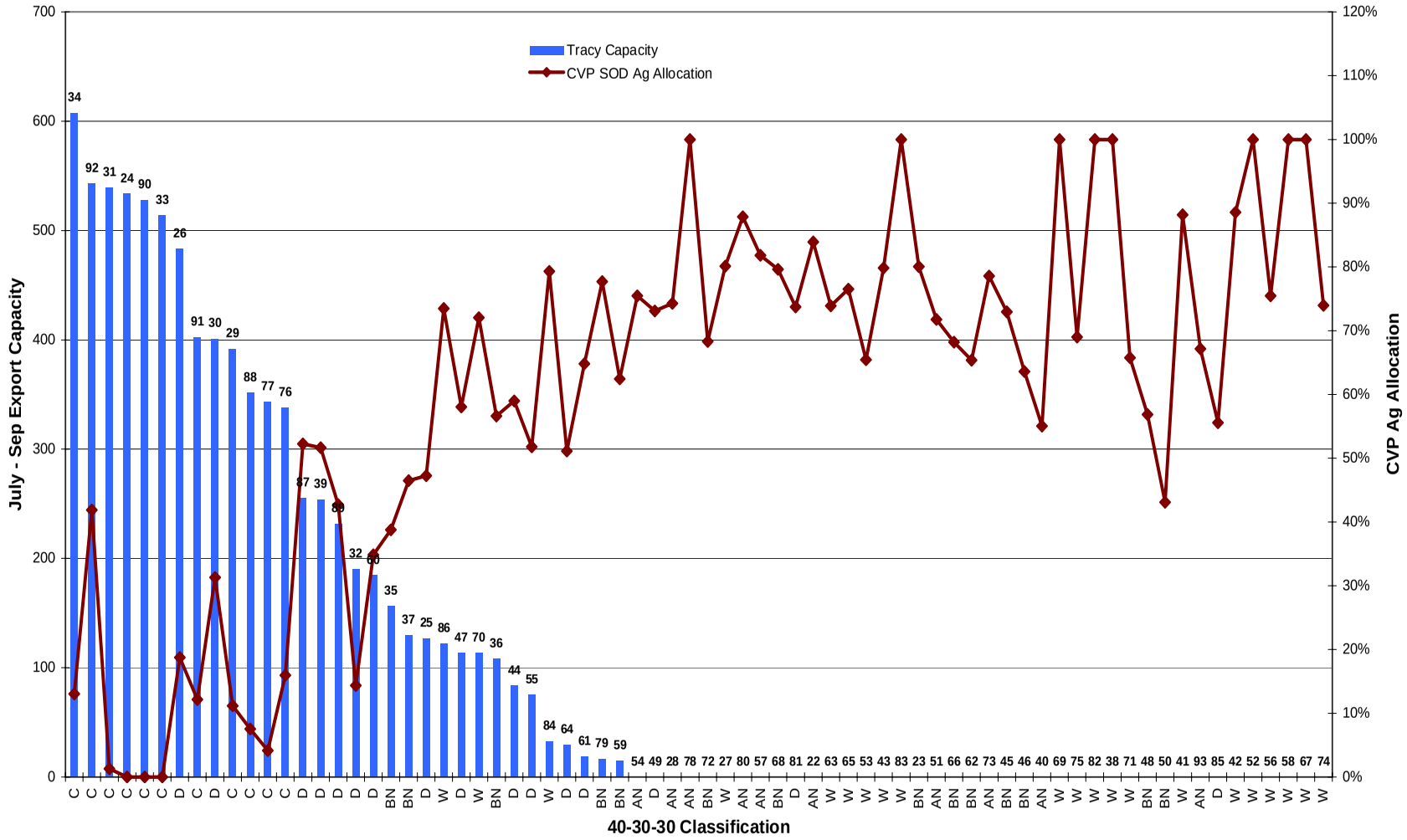

Figure 10-14 Total Tracy pumping for July – September capacity in the Today b(2) Study sorted from highest to lowest with the corresponding CVP south of Delta Ag Allocation

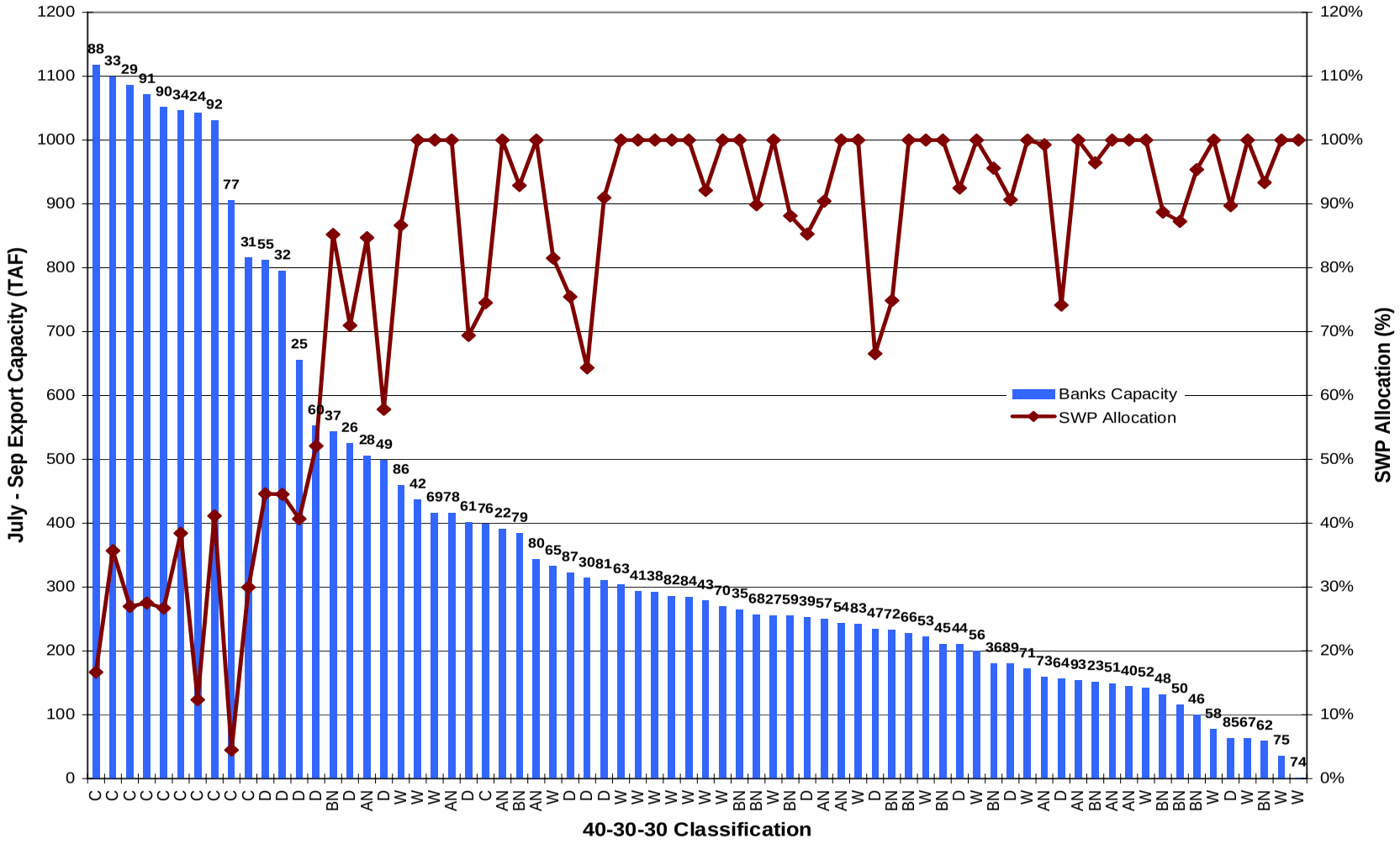

Figure 10-15. Total Banks pumping for July – September capacity in the Future SDIP Study sorted from highest to lowest with the corresponding SWP Allocation

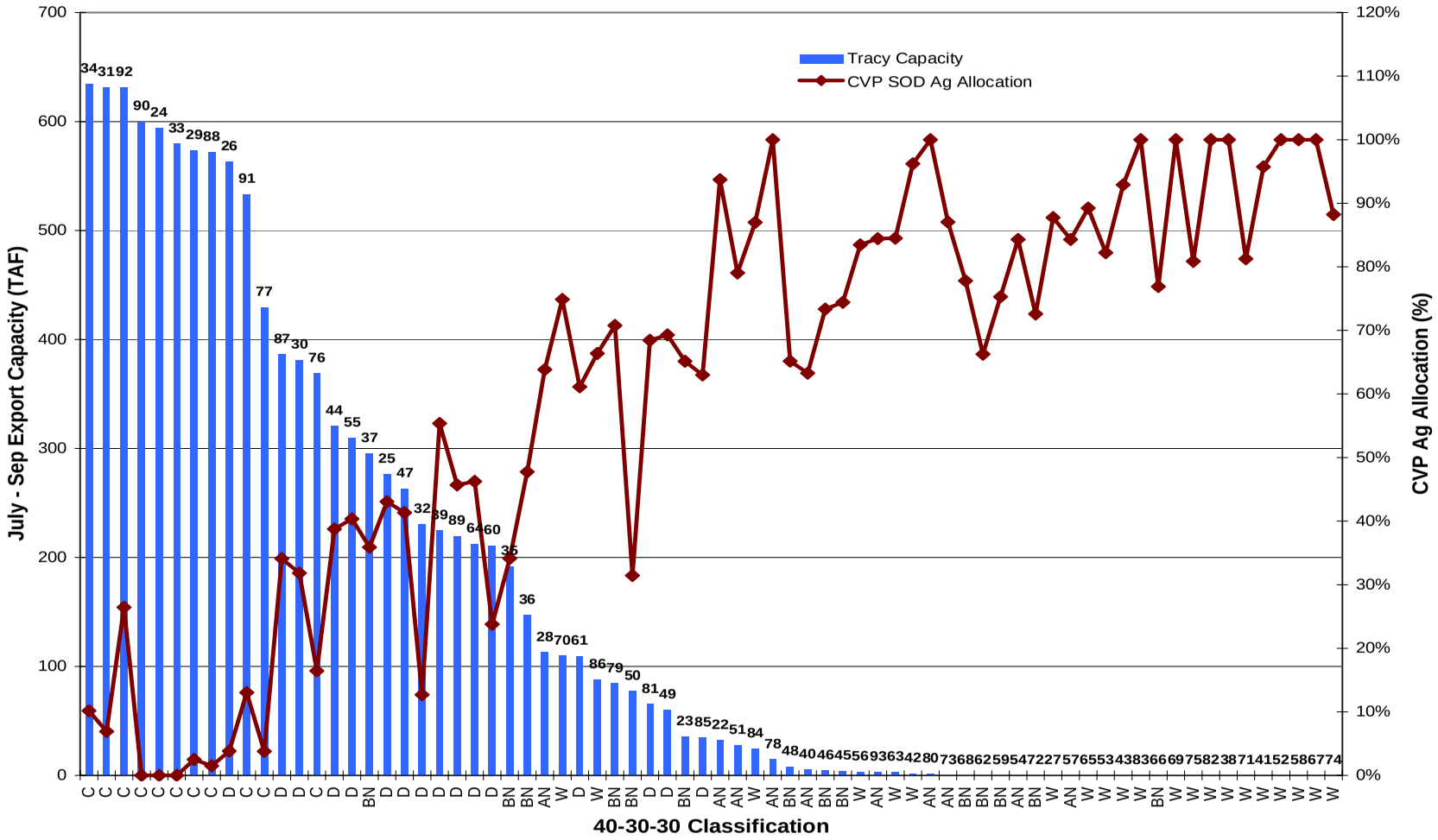

Figure 10-16 Total Tracy pumping for July – September capacity in the Future SDIP Study sorted from highest to lowest with the corresponding CVP south of Delta Ag Allocation

Delta CALSIM Modeling Results

Inflow

Total delta inflow in the model is treated as the sum of Yolo Bypass, Sacramento River, Mokelumne River, Calaveras River, Consumnes River, and the San Joaquin River. Table 10-15 lists average annual inflow into the delta on a long-term average and 1928 to 1934 average bases. The total annual inflow decreases in all comparisons on average between studies with the exception of the long-term drought period when comparing the Today runs to the Future runs. The increases in delta inflow in the dry period are generally for increased pumping at Banks.

Table 10-15 Differences in annual Delta Inflow for Long-term average and the 28-34 Drought

Differences (TAF)	Study 2 - Study 1	Study 3 - Study 1	Study 5 - Study 1	Study 4 - Study 2	Study 5 - Study 3
Total Delta Inflow Long-term Average	-76	-75	-229	-148	-154
Total Delta Inflow 28-34	-64	-58	-20	48	37

Figure 10-17 shows the chronology of total inflow for all 5 of the studies. The highest inflows occur January through April due to flood flows and July when pumping is increased though the late summer with the 50th percentiles being greater than 20,000 cfs Figure 10-18 in the other months the inflow tends to be less than 20,000 cfs. Considering the monthly averages by 40-30-30 water year classification, Figure 10-19 toFigure 10-24, the results show little difference on average with the exception of months when (b)(2) or EWA are taking actions and the inflow decreases in response to the reservoirs release reductions coincident with pumping restrictions. Delta inflow is also being affected by the decrease in Keswick and Nimbus releases due to decreasing storage conditions that either casue the minimum flows to be less of the magnitude of flood flows to decrease when comparing Studies 4 and 5 to Studies 1, 2, and 3.

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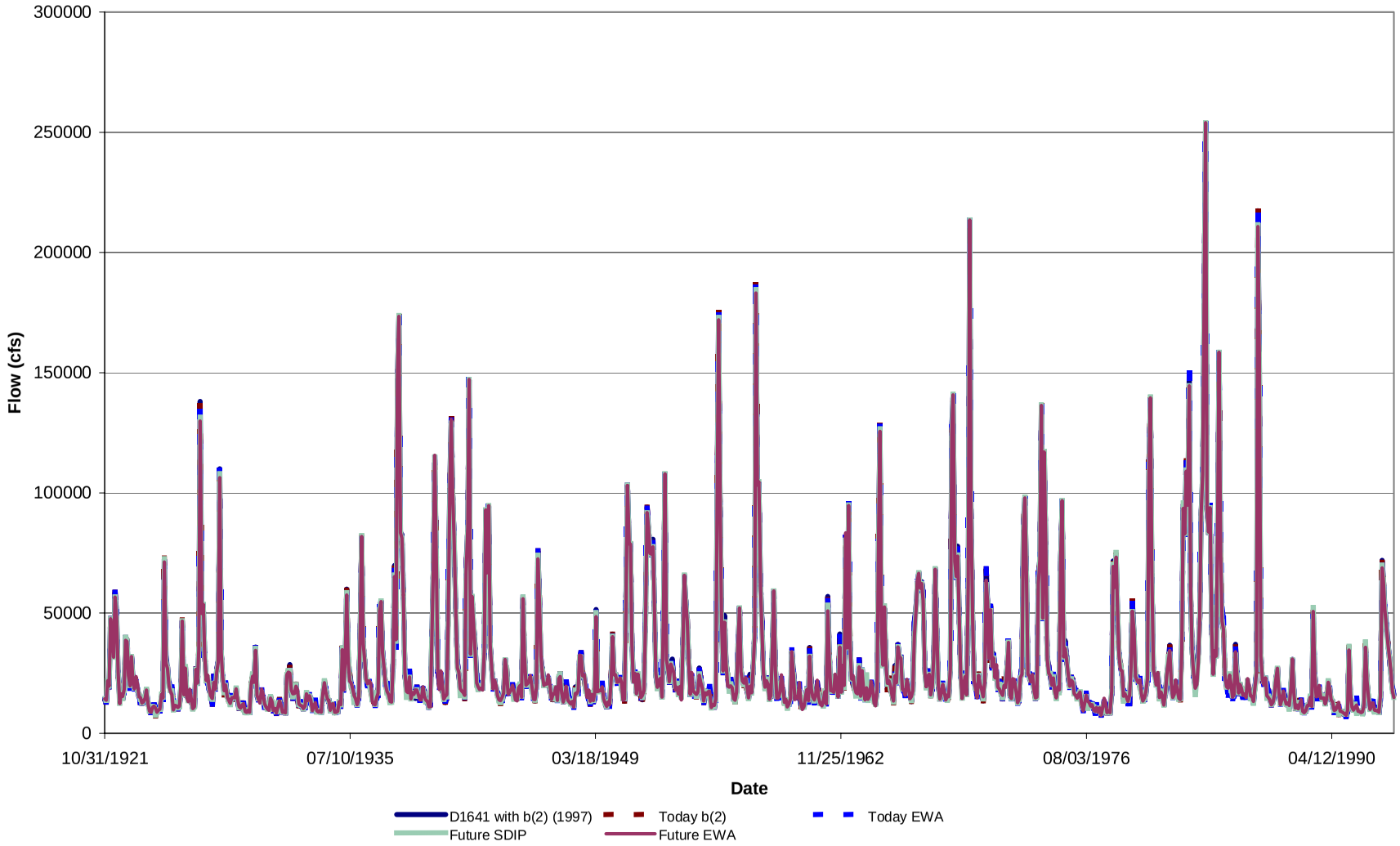

Figure 10-17 Chronology of Total Delta Inflow

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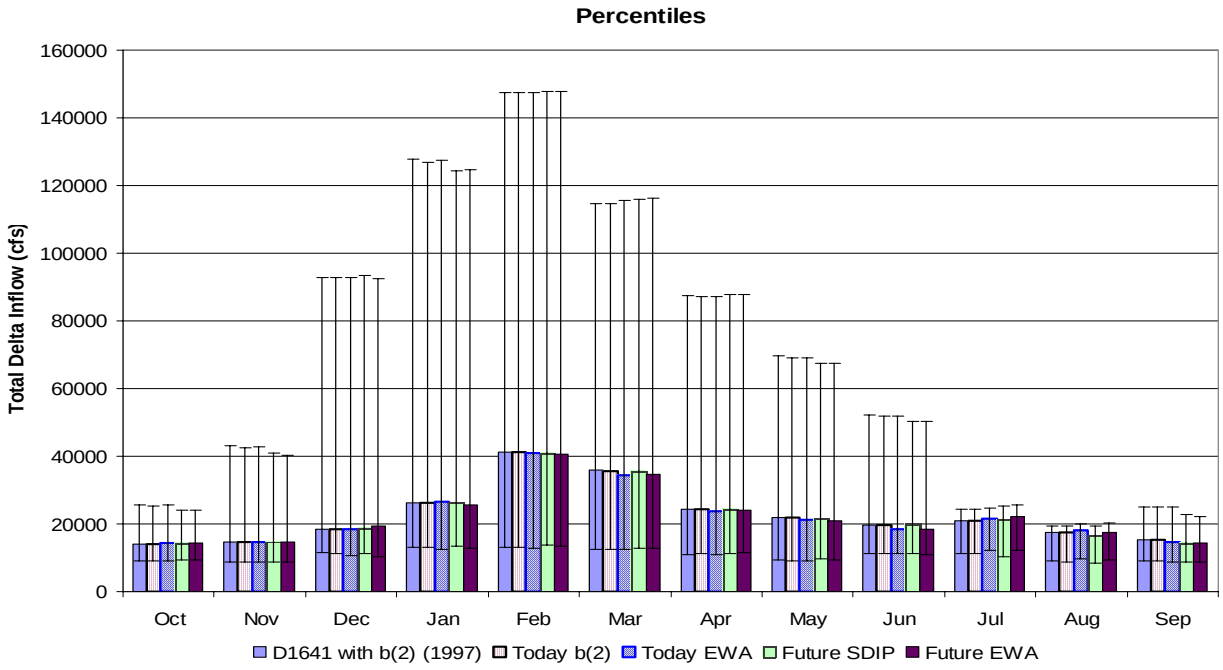

Figure 10-18 Total Delta Inflow 50th Percentile Monthly Releases with the 5th and 95th as the bars

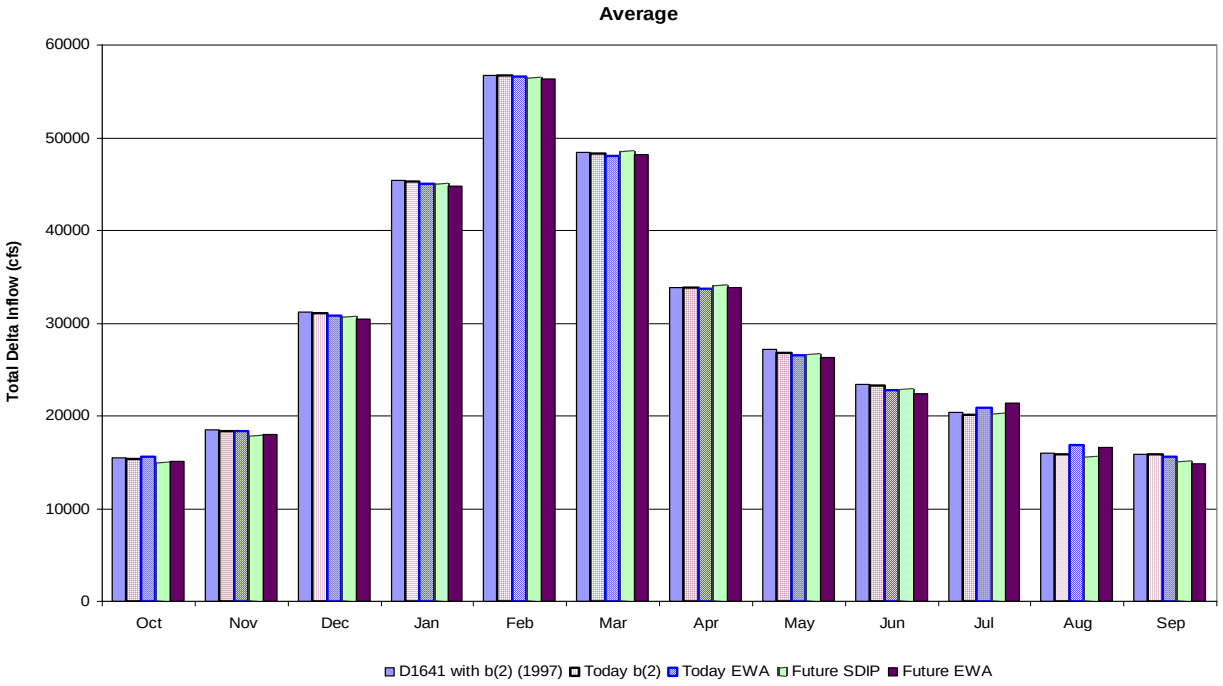

Figure 10-19 Average Monthly Total Delta Inflow

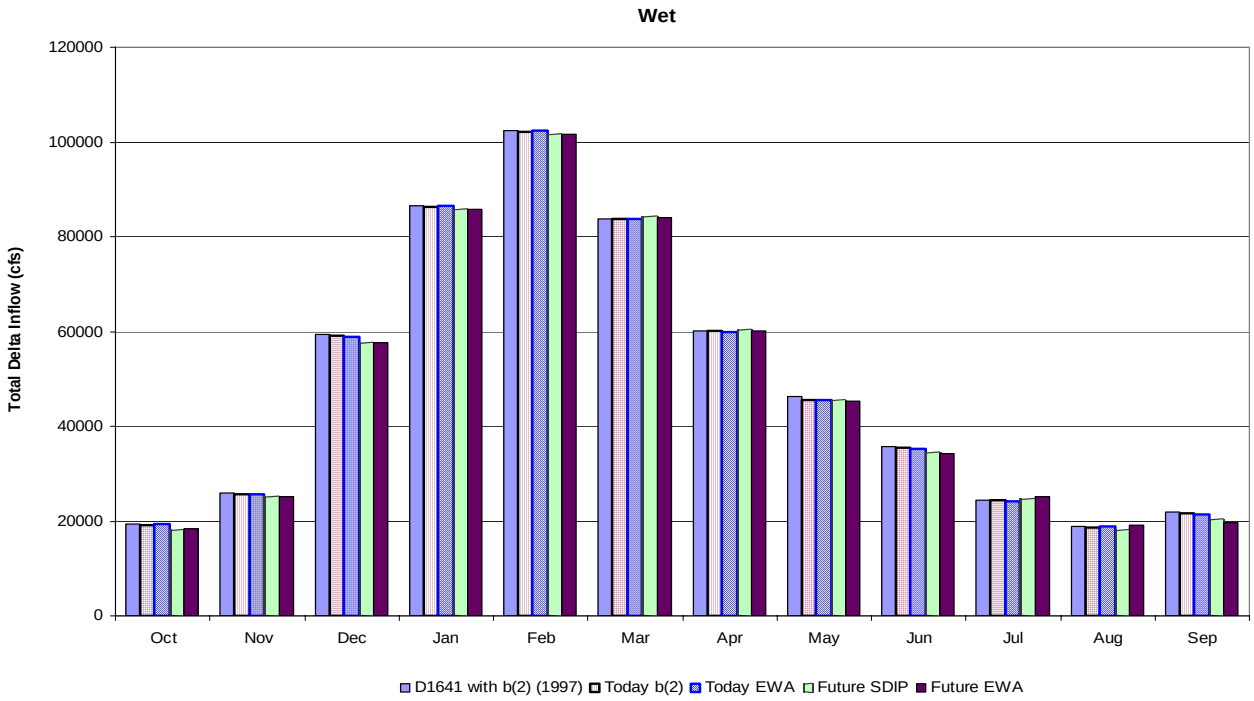

Figure 10-20 Average wet year (40-30-30 Classification) monthly Outflow Delta Inflow

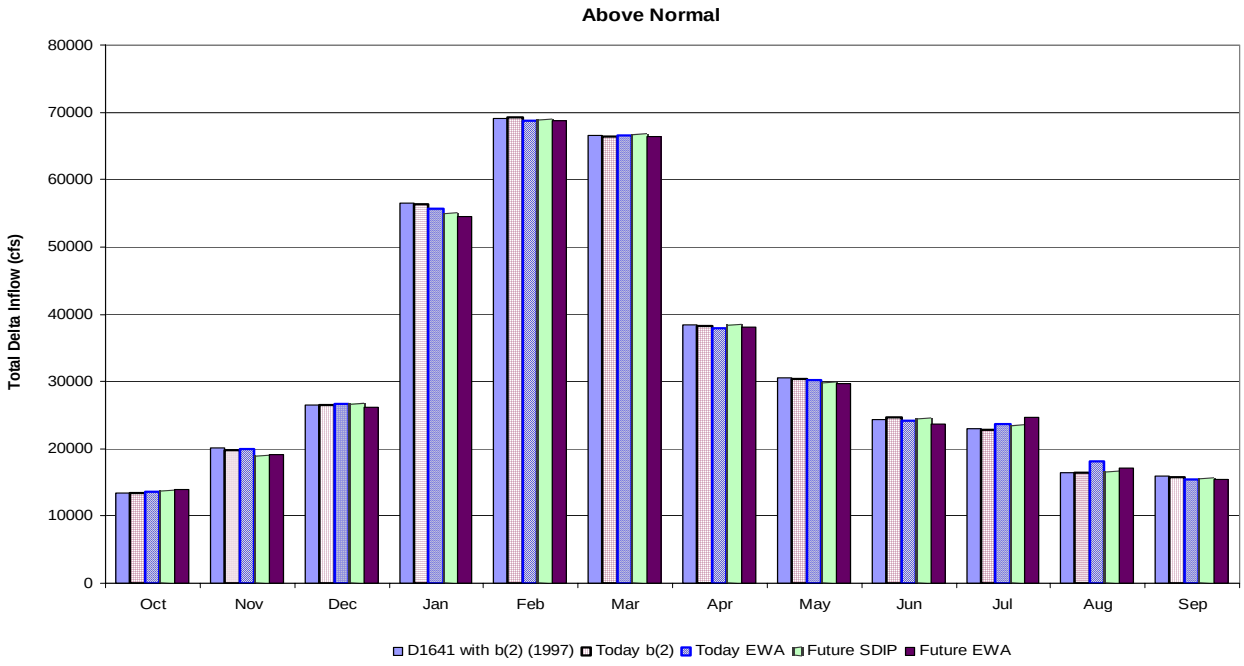

Figure 10-21 Average above normal year (40-30-30 Classification) monthly Outflow Delta Inflow

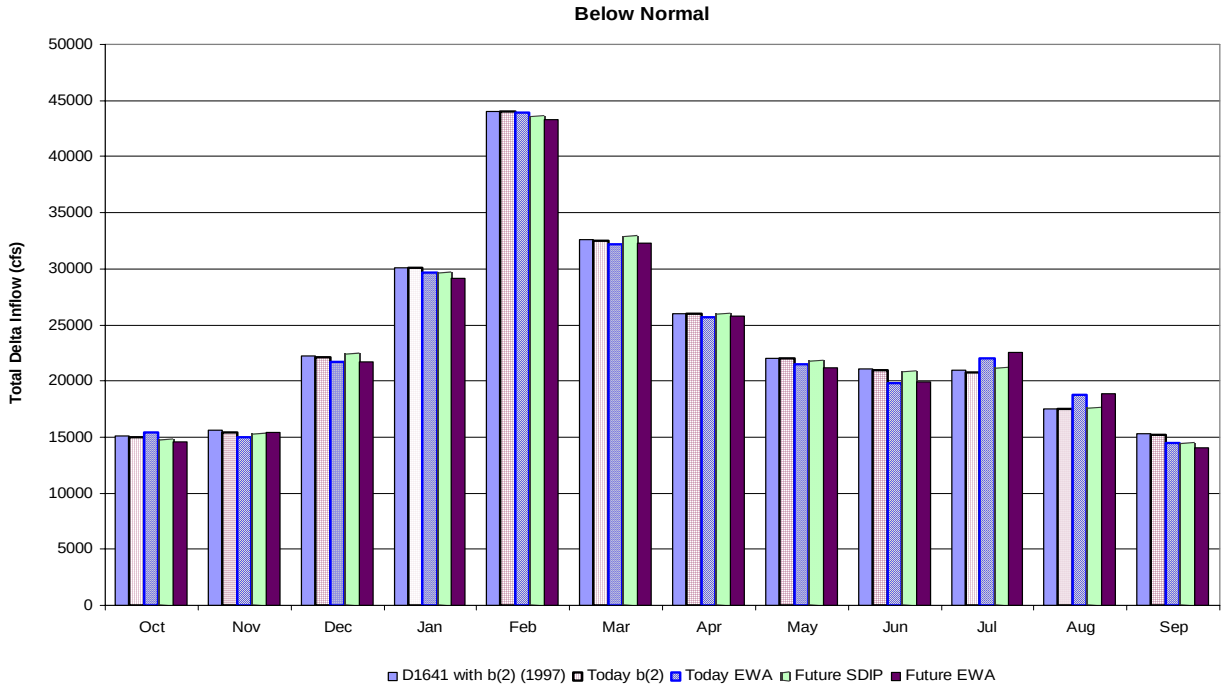

Figure 10-22 Average below normal year (40-30-30 Classification) monthly Outflow Delta Inflow

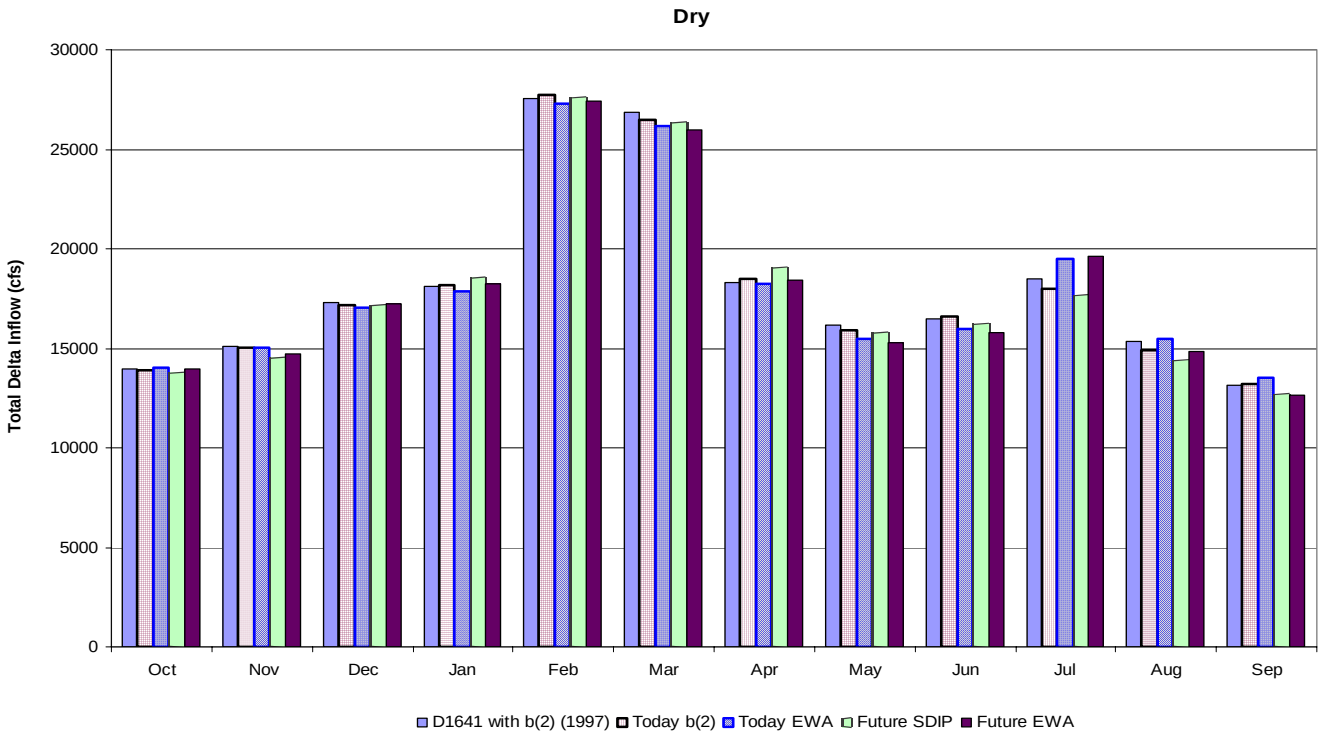

Figure 10-23 Average dry year (40-30-30 Classification) monthly Outflow Delta Inflow

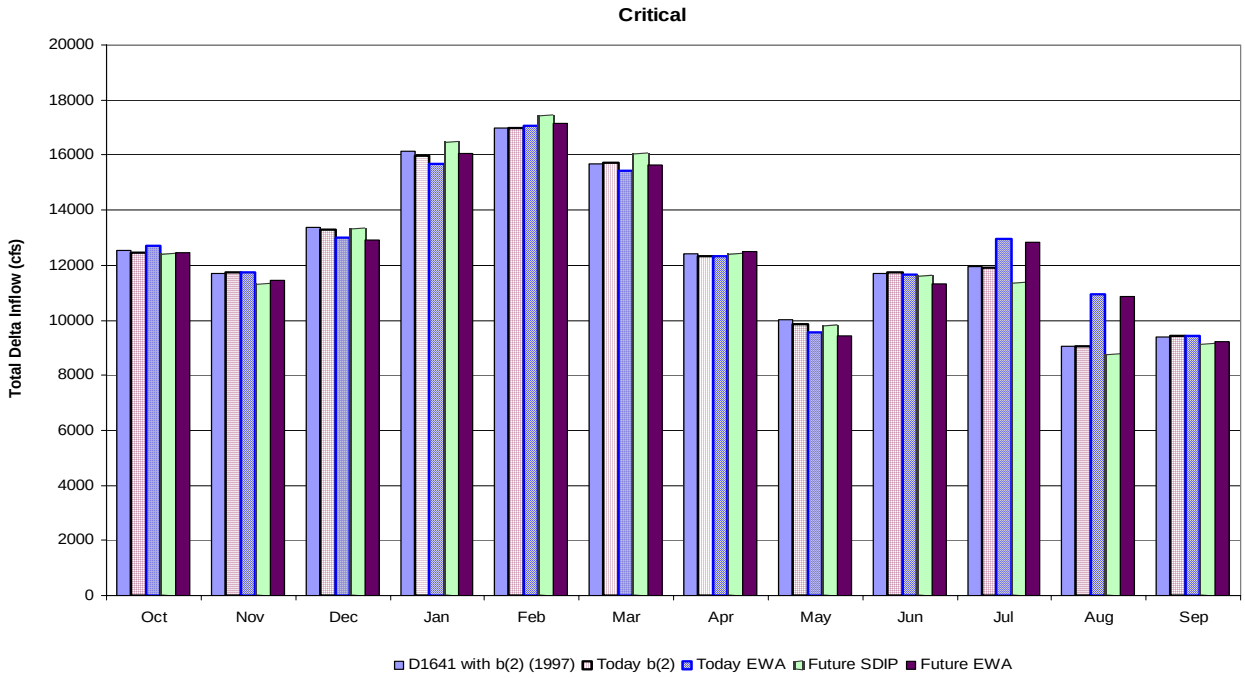

Figure 10-24 Average critical year (40-30-30 Classification) monthly Outflow Delta Inflow

Outflow

The chronology of delta outflow is shown in Figure 10-25 and indicates that peaks in outflow can be seen due to EWA actions. Table 10-16 shows the differences in total and excess outflow for the five studies. On Study-to-Study comparisons (Table 10-16) with the exception of comparing Study 3 to 1, the average annual outflow decreases. Comparing of Study 5 to 1 increases outflow during the long-term drought period which appears to be due to delivery reductions and EWA actions during this period. The delivery reductions do not violate the "No Harm Principal" of EWA since delivery reductions are from lower storages relating to increased Trinity flows and increased demands in the American River system. The excess outflow numbers in this analysis do not reflect the salinity requirements from ANN calculations.

Figure 10-26 displays that the model always meets the required monthly required outflow for all five of the studies. Both average and percentiles outflow values increase in April, and May due to the actions taken under the 3406 (b)(2) and EWA programs, see Figure 10-27 and Figure 10-28 toFigure 10-33. Reductions in Delta outflow can be seen for the Future Studies from increased pumping activities taking more of the excess outflow than in the Today Studies.

Table 10-16 Differences in annual Delta Outflow and Excess Outflow for Long-term average and the 28-34 Drought

Differences (TAF)	Study 2 - Study 1	Study 3 - Study 1	Study 5 - Study 1	Study 4 - Study 2	Study 5 - Study 3
Total Delta Outflow Long-term Average	-48	103	-239	-341	-343
Total Delta Outflow 28-34	-20	128	111	-17	-17
Total Excess Outflow Long-term Average	-52	79	-316	-378	-394
Total Excess Outflow 28-34	-14	56	16	-26	-40

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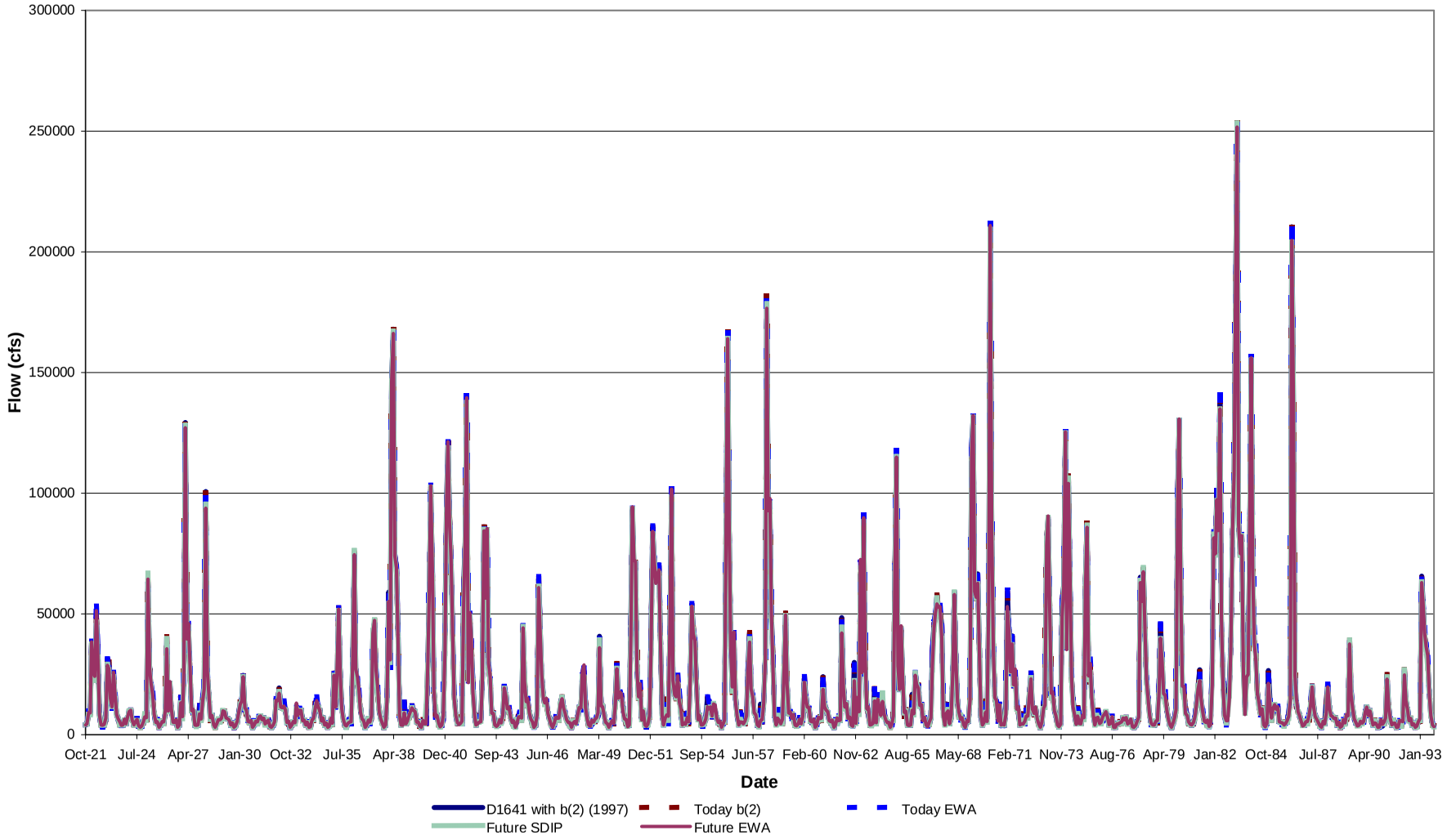

Figure 10-25 Chronology of Total Delta Outflow

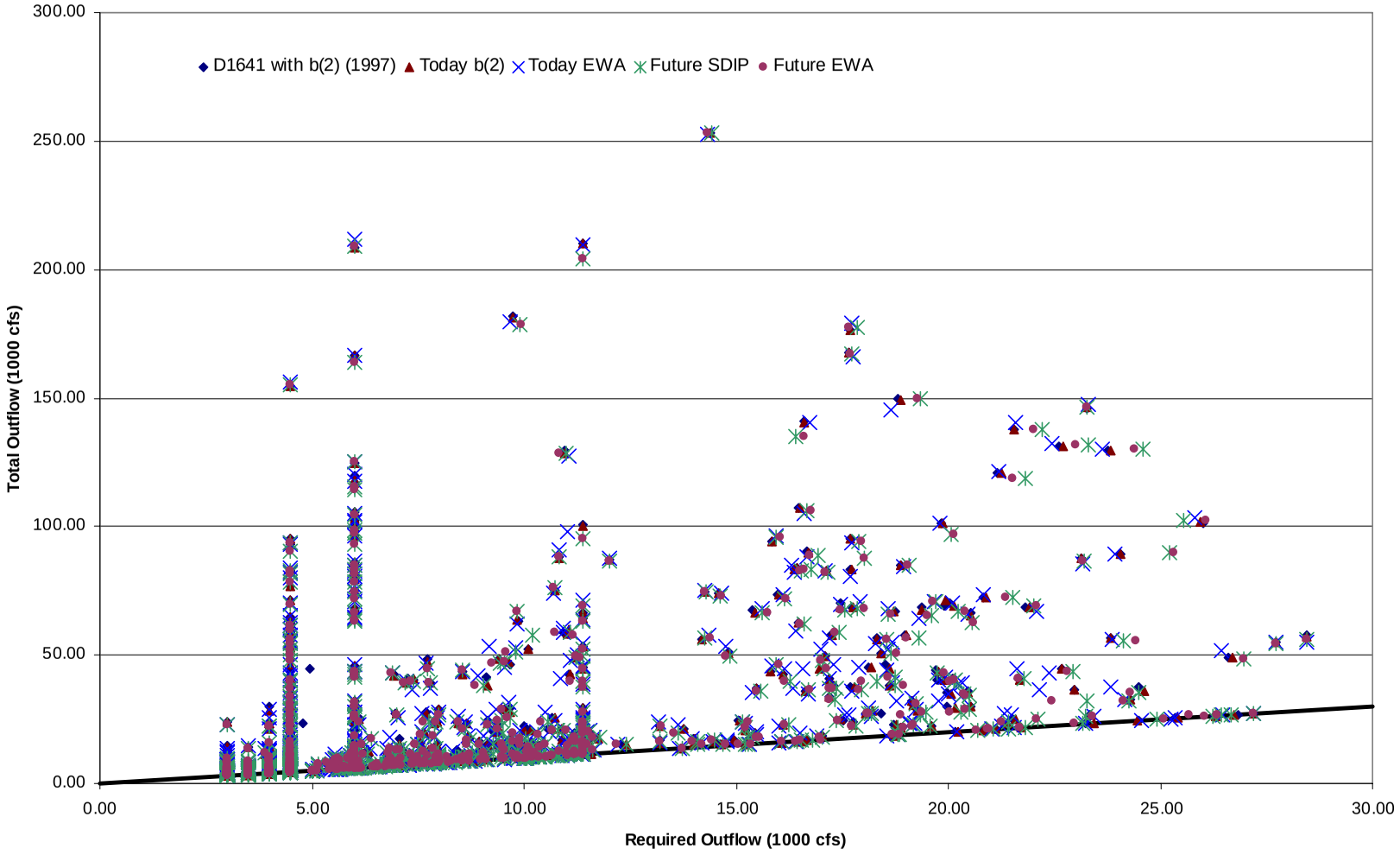

Figure 10-26 Total Delta Outflow versus Required Delta Outflow for the Oct 1921 to Sep 1993 simulation period

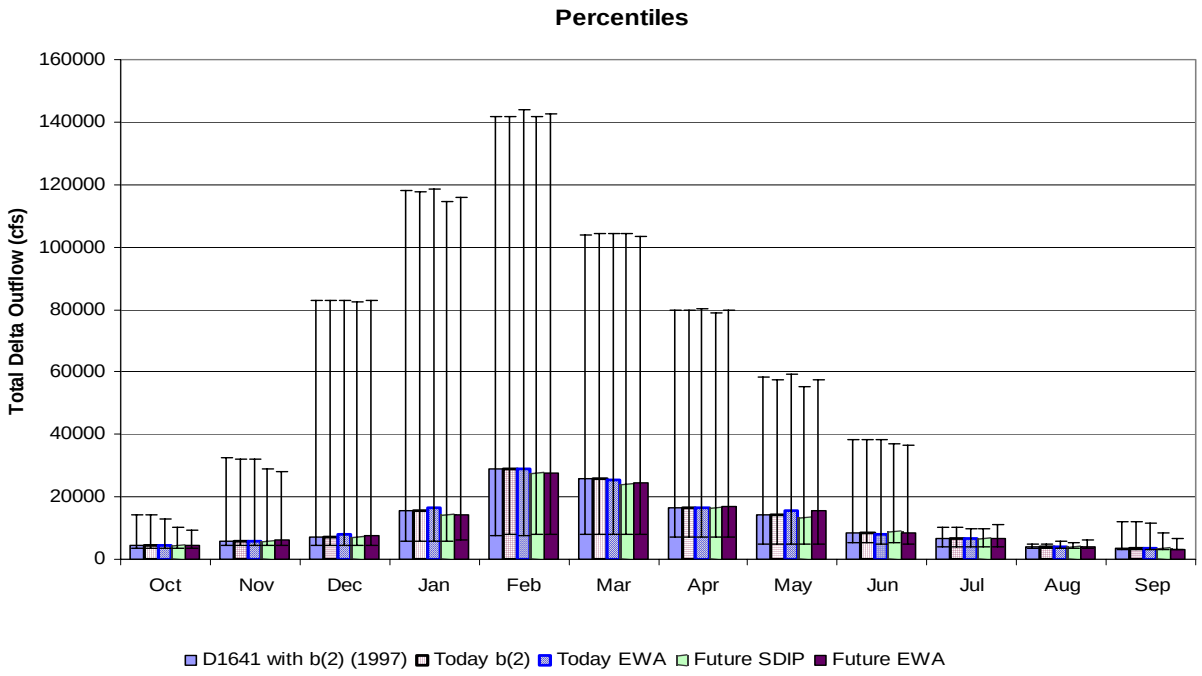

Figure 10-27 Total Delta Outflow 50th Percentile Monthly Releases with the 5th and 95th as the bars

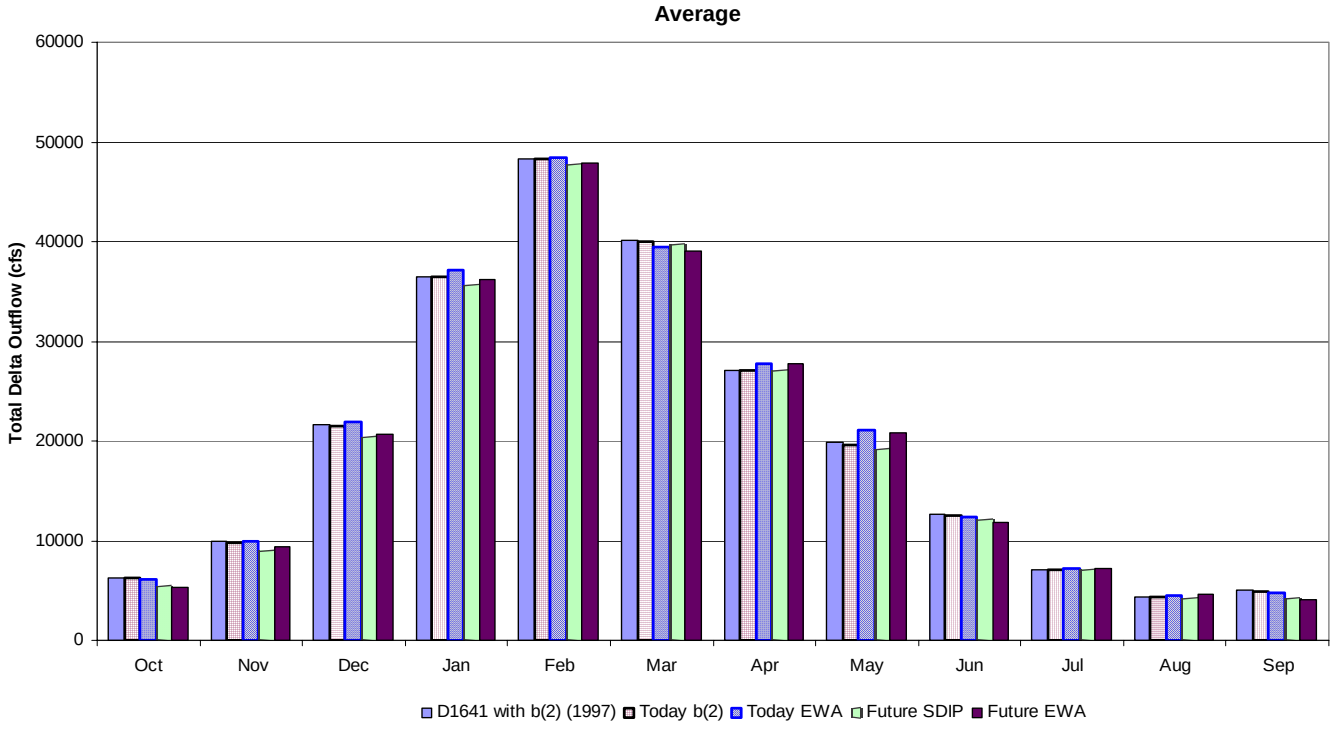

Figure 10-28 Average Monthly Total Delta Outflow

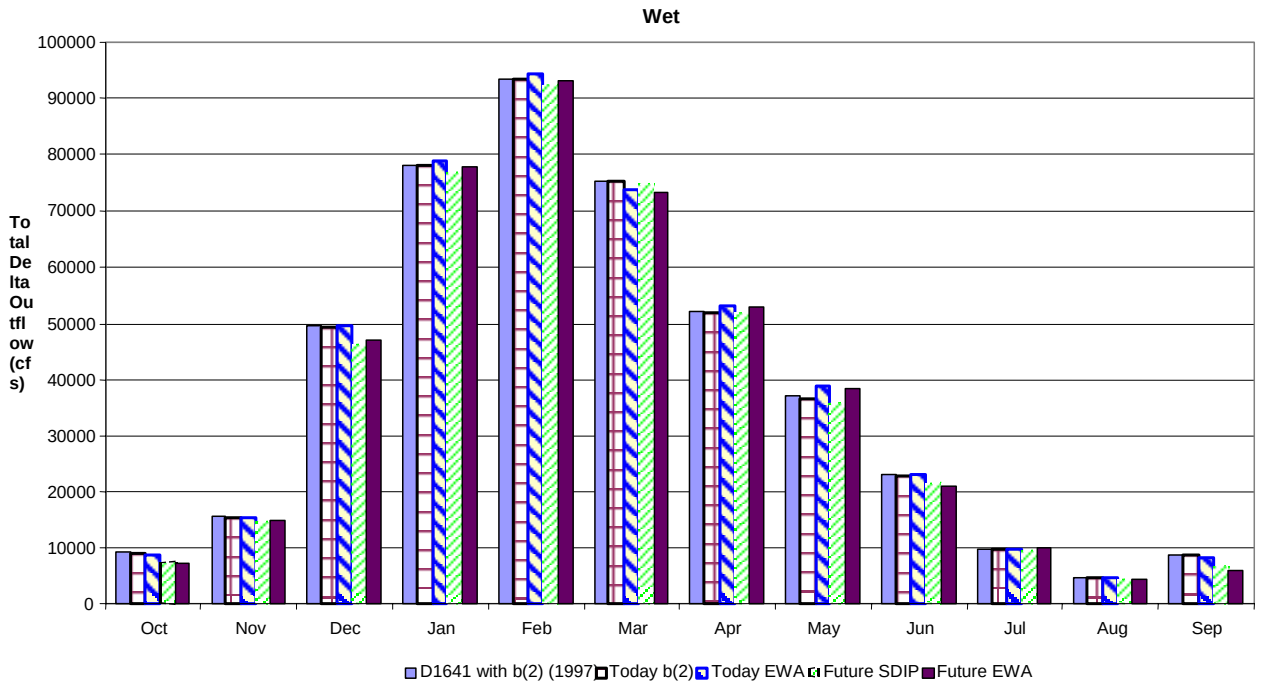

Figure 10-29 Average wet year (40-30-30 Classification) monthly Delta Outflow

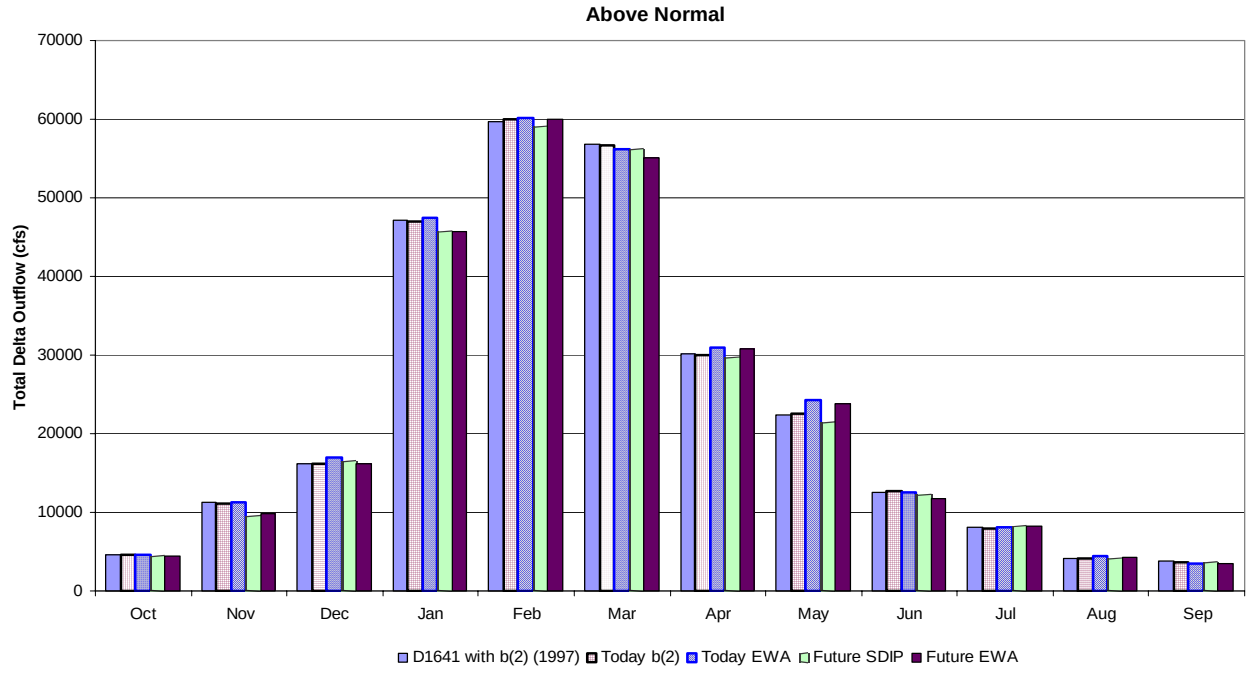

Figure 10-30 Average above normal year (40-30-30 Classification) monthly Delta Outflow

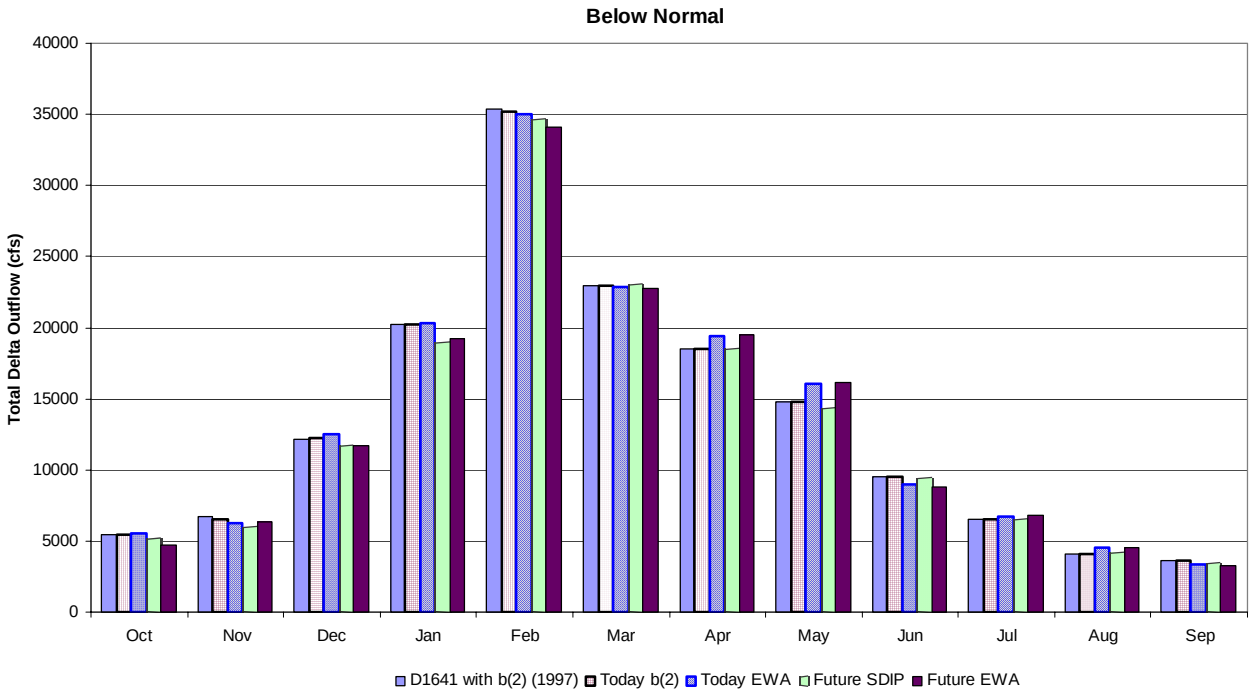

Figure 10-31 Average below normal year (40-30-30 Classification) monthly Delta Outflow

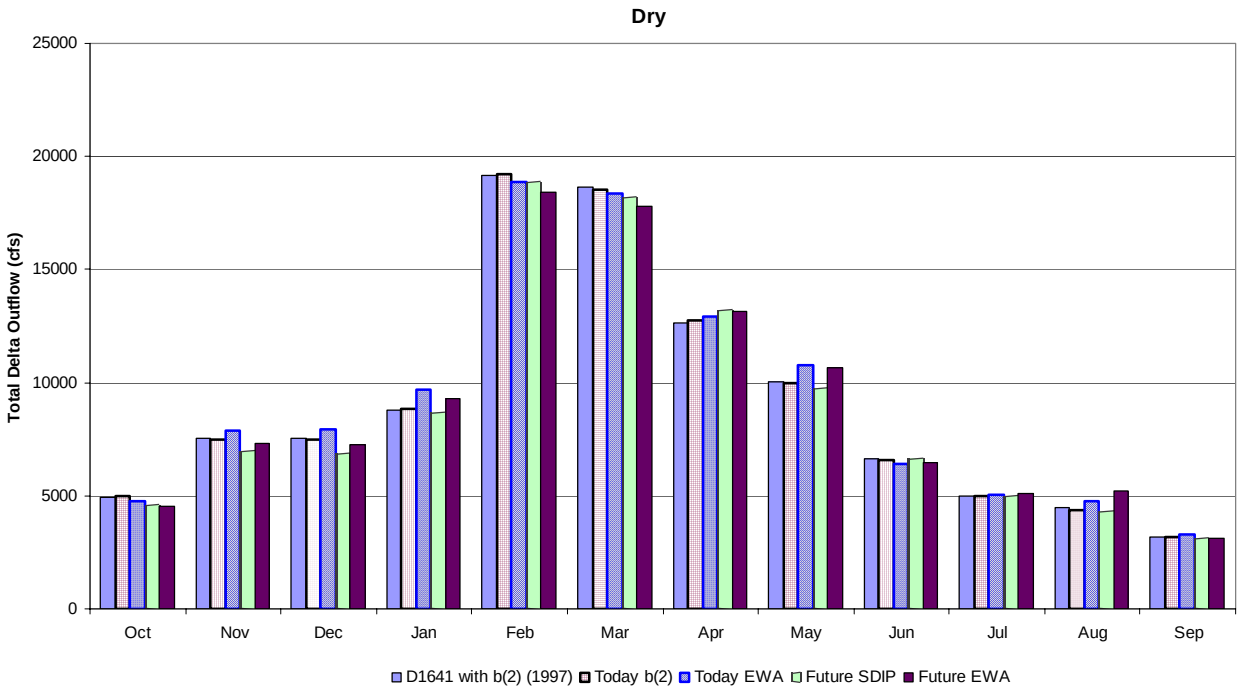

Figure 10-32 Average dry year (40-30-30 Classification) monthly Delta Outflow

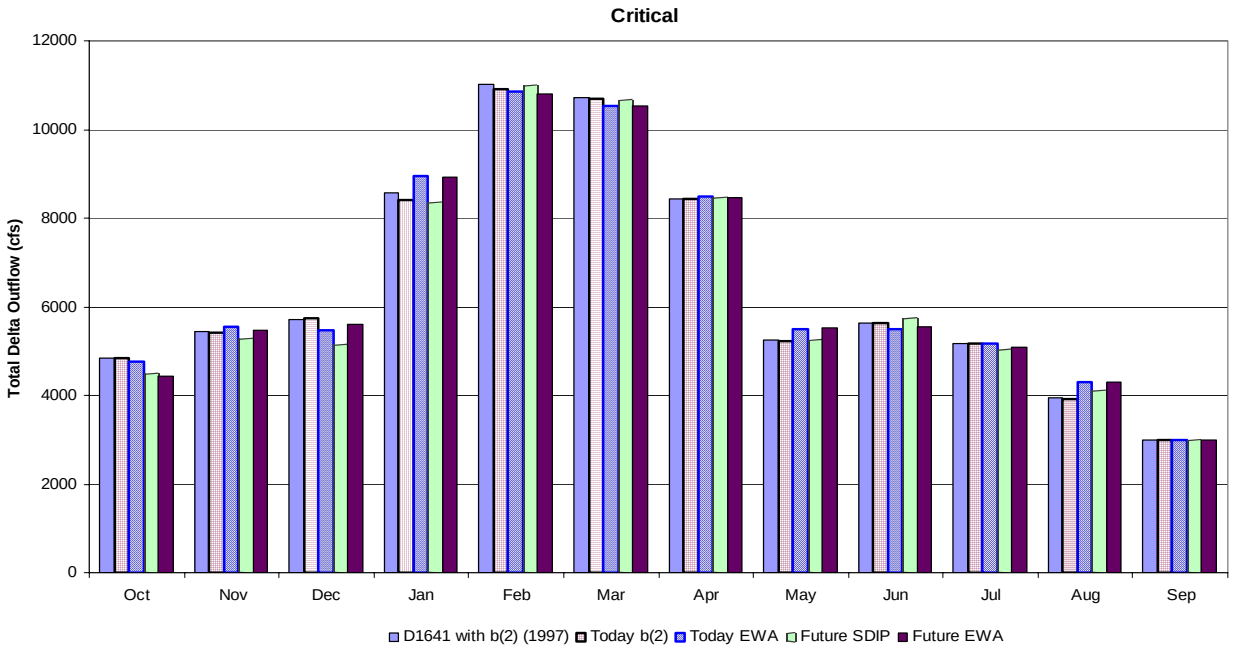

Figure 10-33 Average critical year (40-30-30 Classification) monthly Delta Outflow

Export-to-Inflow Ratio

The same general trend in monthly export-to-inflow ratio is found based on a monthly long-term average basis and averaged monthly by 40-30-30 index has the same general monthly trend (Figure 10-34 toFigure 10-39). From Figure 10-34 to Figure 10-39 during months where EWA actions are taken the export-to-inflow ratio decreases (December, January, February, April, May and June) in Studies 3 and 5 compared 1, 2 and 4. The later summer months show increases in export-to-inflow due to increased pumping with the exception of some dry and critical years in the Future runs due to either reduced storage or worsening salinity requirements from the more aggressive deliveries in Studies 4 and 5.

Figure 10-40 to Figure 10-51 show the monthly export-to-inflow ratios sorted from wettest to driest by 40-30-30 Index. The Studies 3 and 5 show lower export-to-inflow Ratios when EWA actions are taken and then increased export-to-inflow ratios in the late summer and fall periods. Studies 4 and 5 show increased export-to-inflow ratios when compared to Studies 1, 2 and 3. In Figure 10-42 the December 1940 values drops off significantly from the others in Study 4 (Future SDIP) due to the Rock Slough salinity standard.

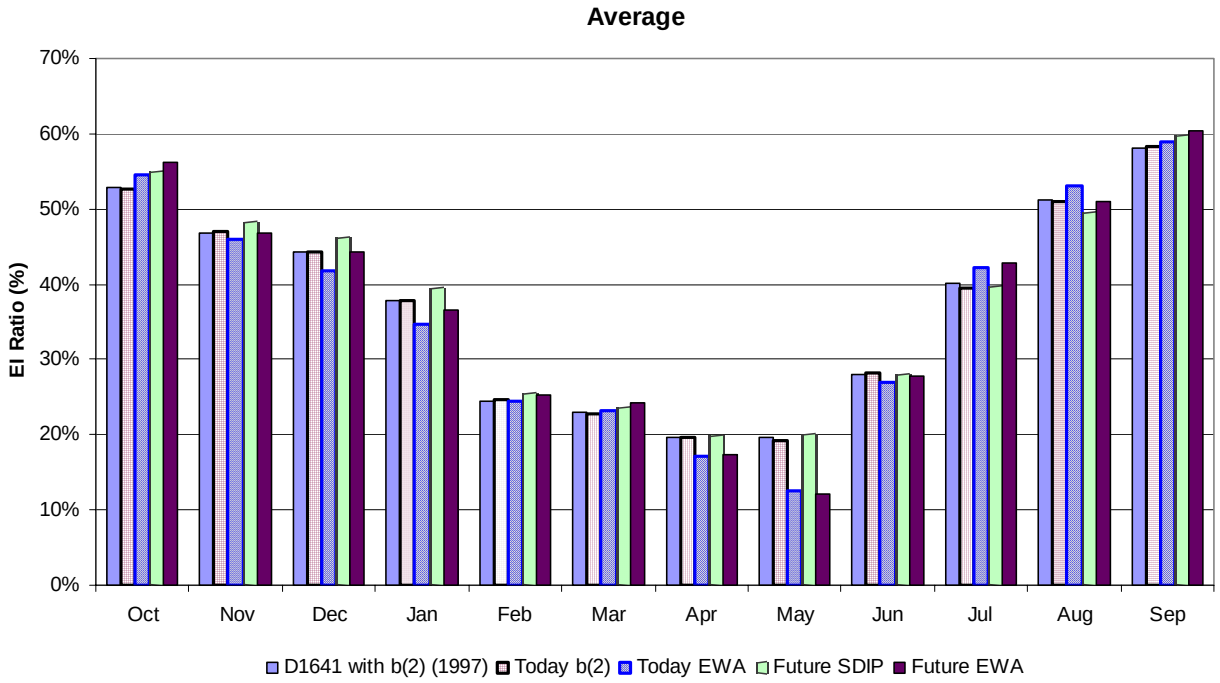

Figure 10-34 Average Monthly export-to-inflow ratio

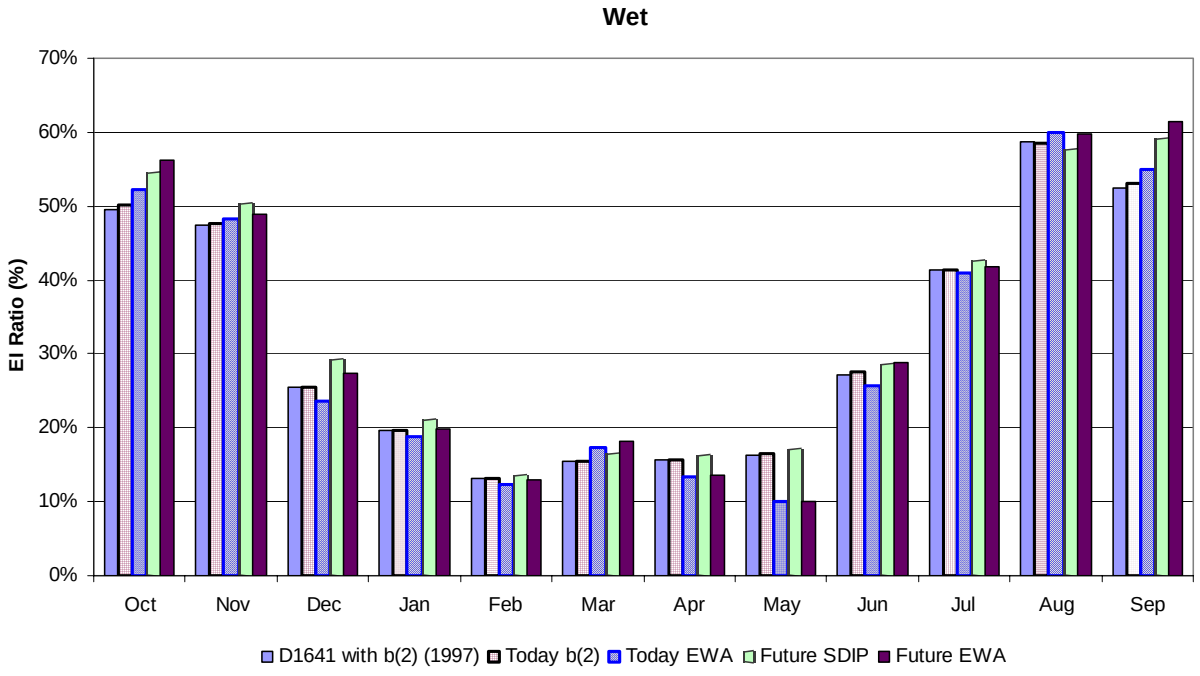

Figure 10-35 Average wet year (40-30-30 Classification) monthly export-to-inflow ratio

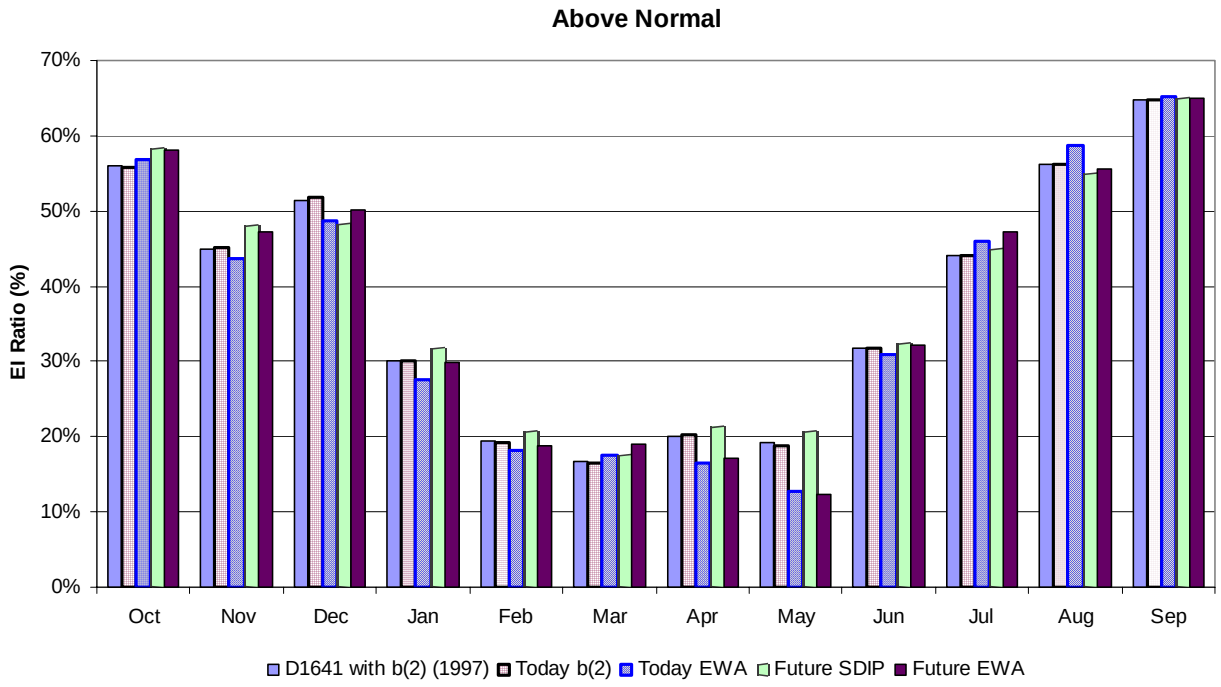

Figure 10-36 Average above normal year (40-30-30 Classification) monthly export-to-inflow ratio

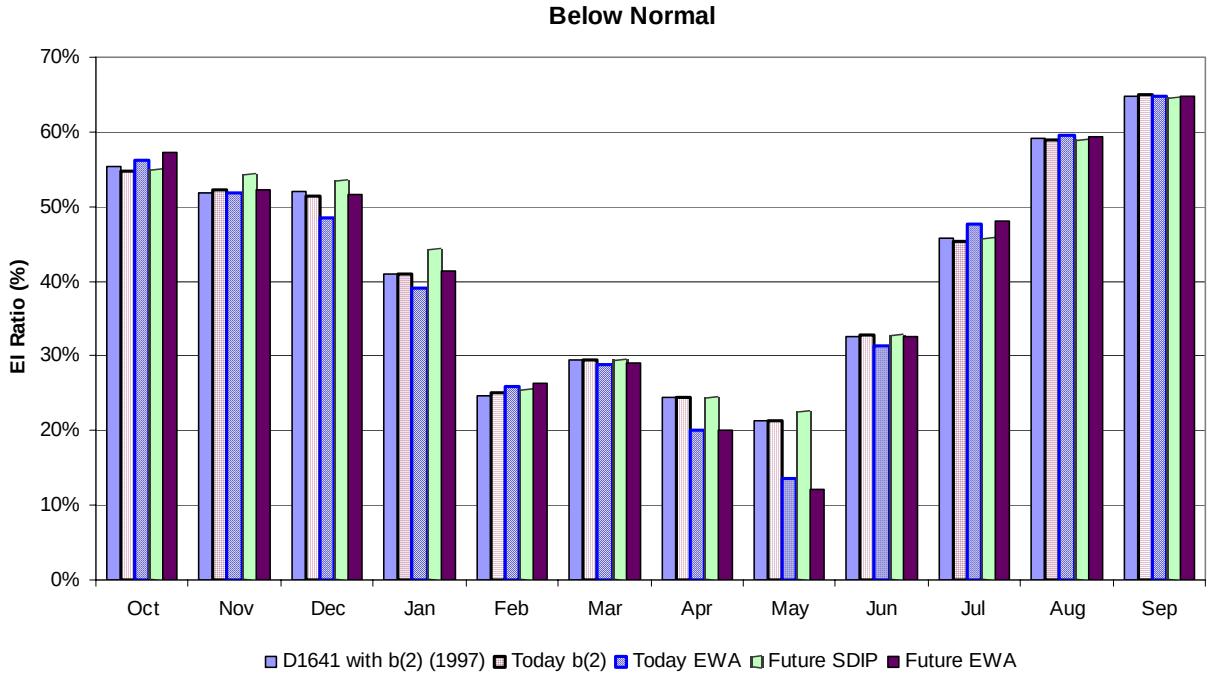

Figure 10-37 Average below normal year (40-30-30 Classification) monthly export-to-inflow ratio

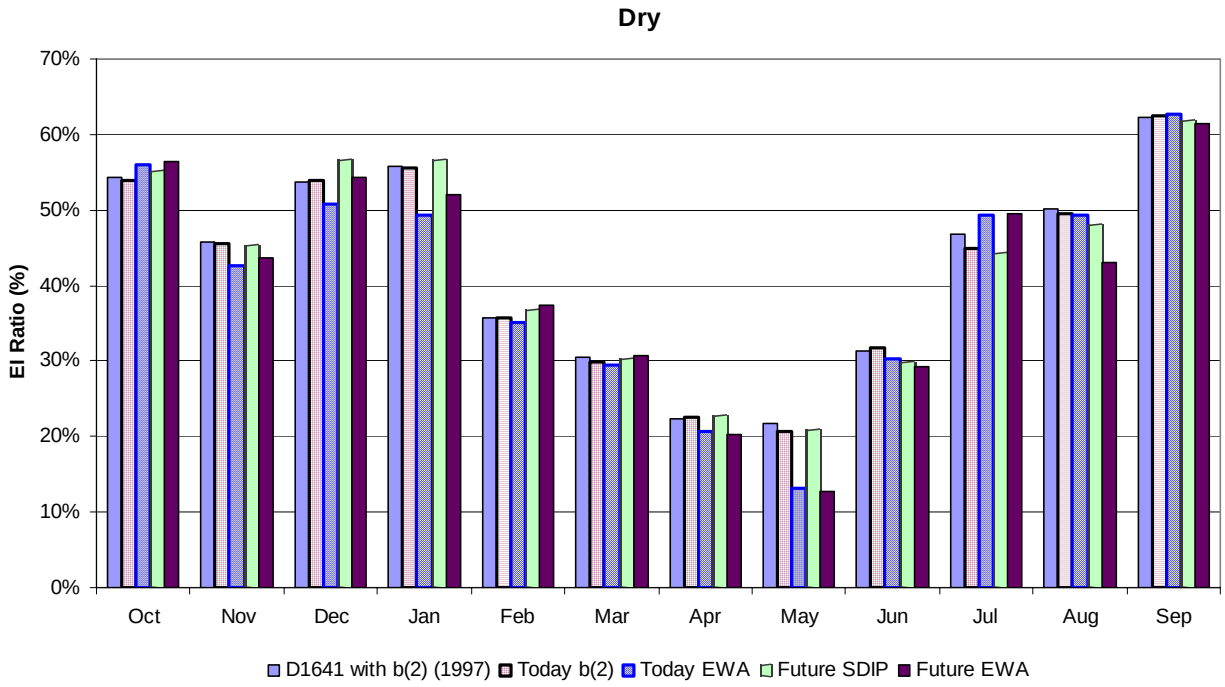

Figure 10-38 Average dry year (40-30-30 Classification) monthly export-to-inflow ratio

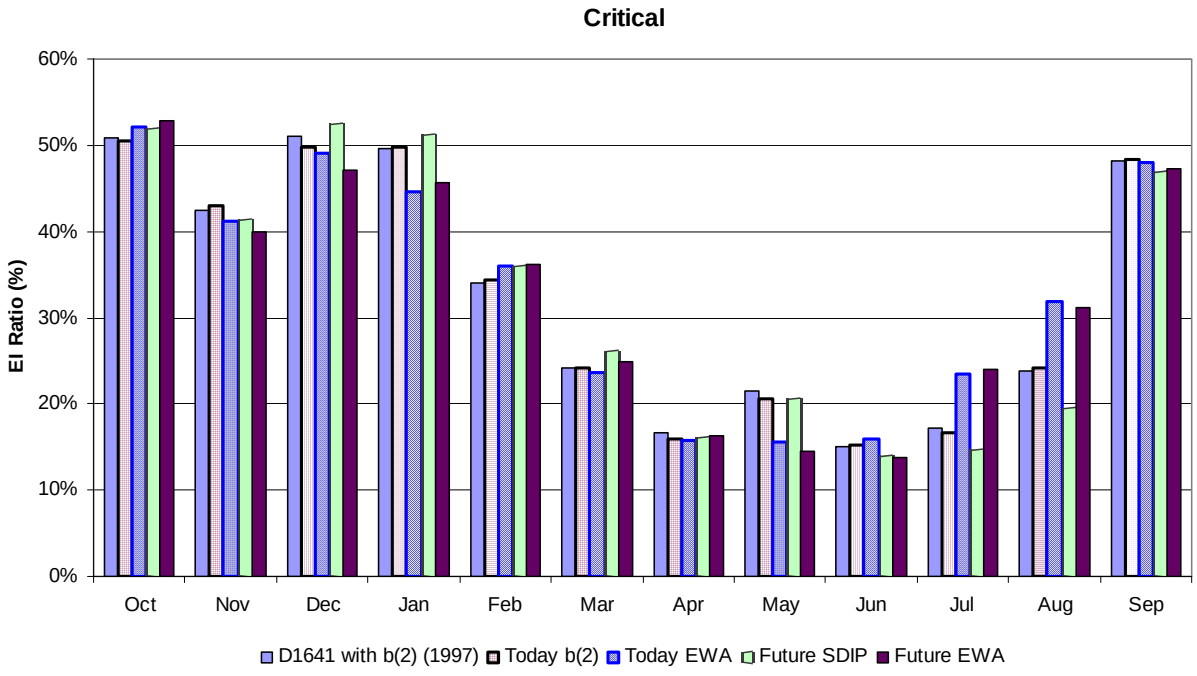

Figure 10-39 Average critical year (40-30-30 Classification) monthly export-to-inflow ratio

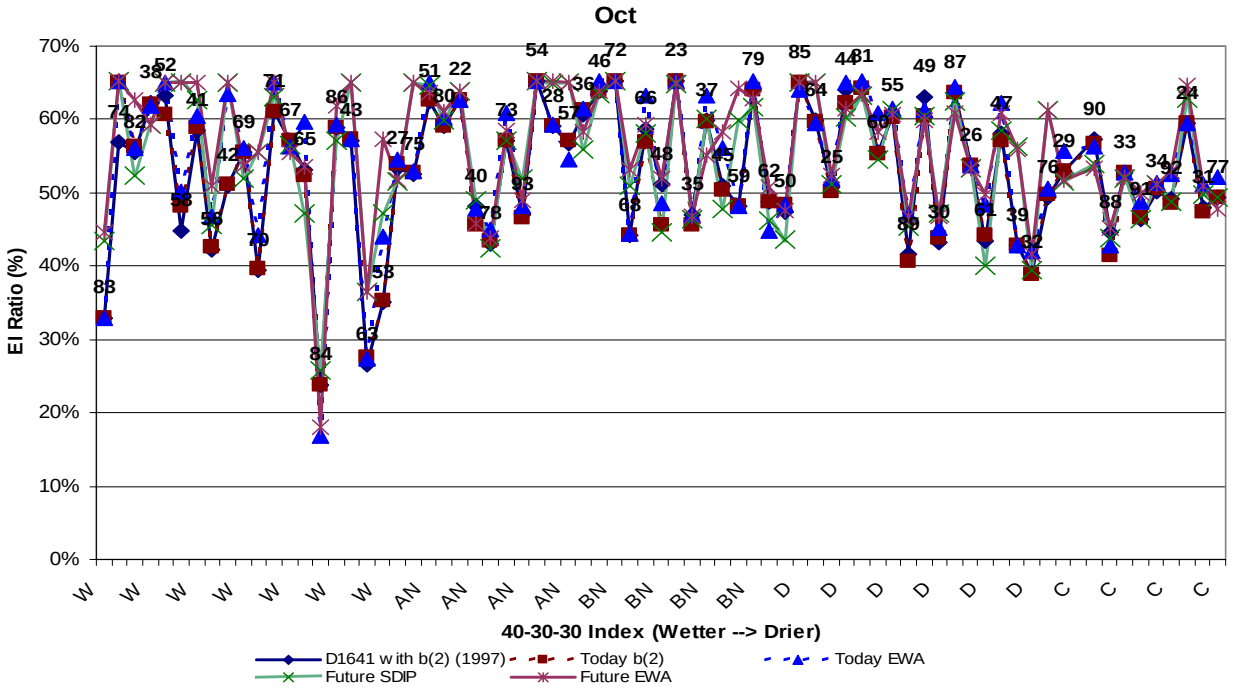

Figure 10-40 October export-to-inflow ratio sorted by 40-30-30 Index

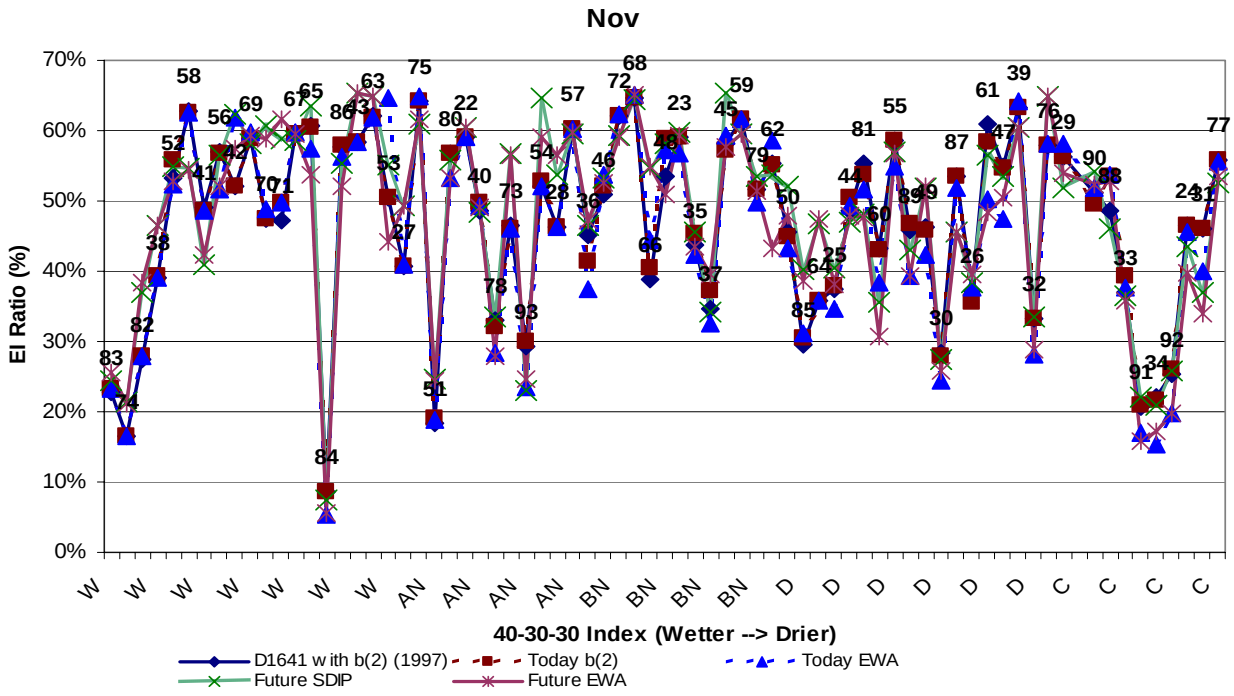

Figure 10-41 November export-to-inflow ratio sorted by 40-30-30 Index

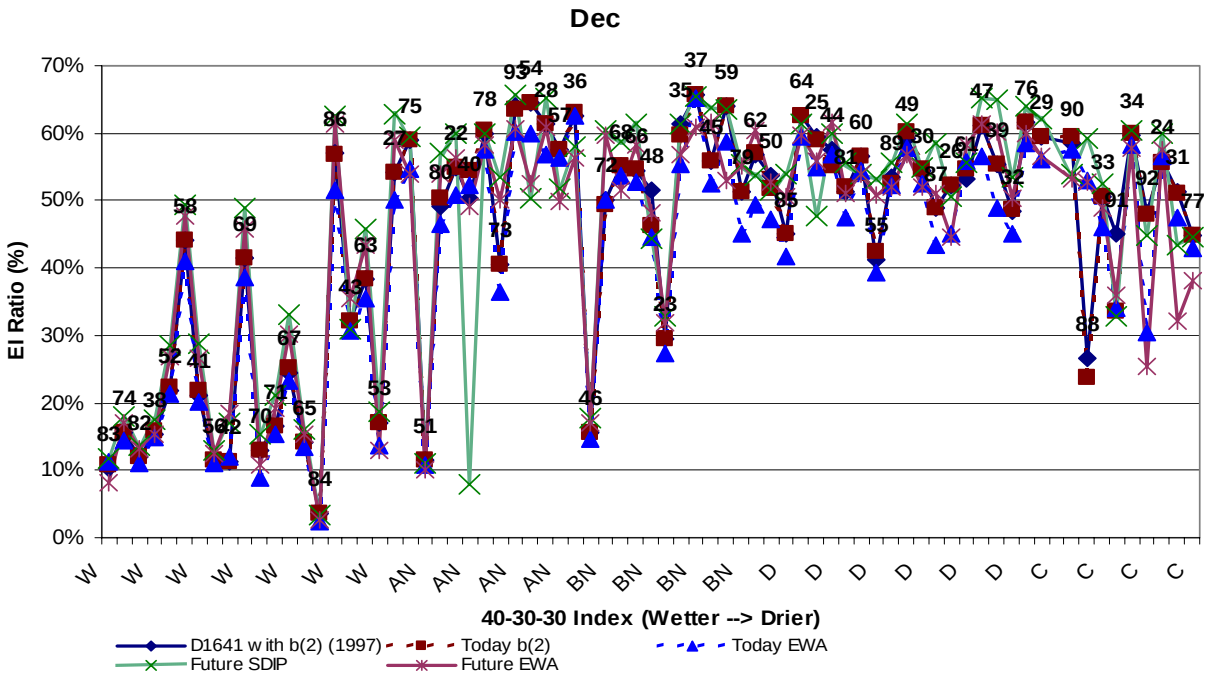

Figure 10-42 December export-to-inflow ratio sorted by 40-30-30 Index

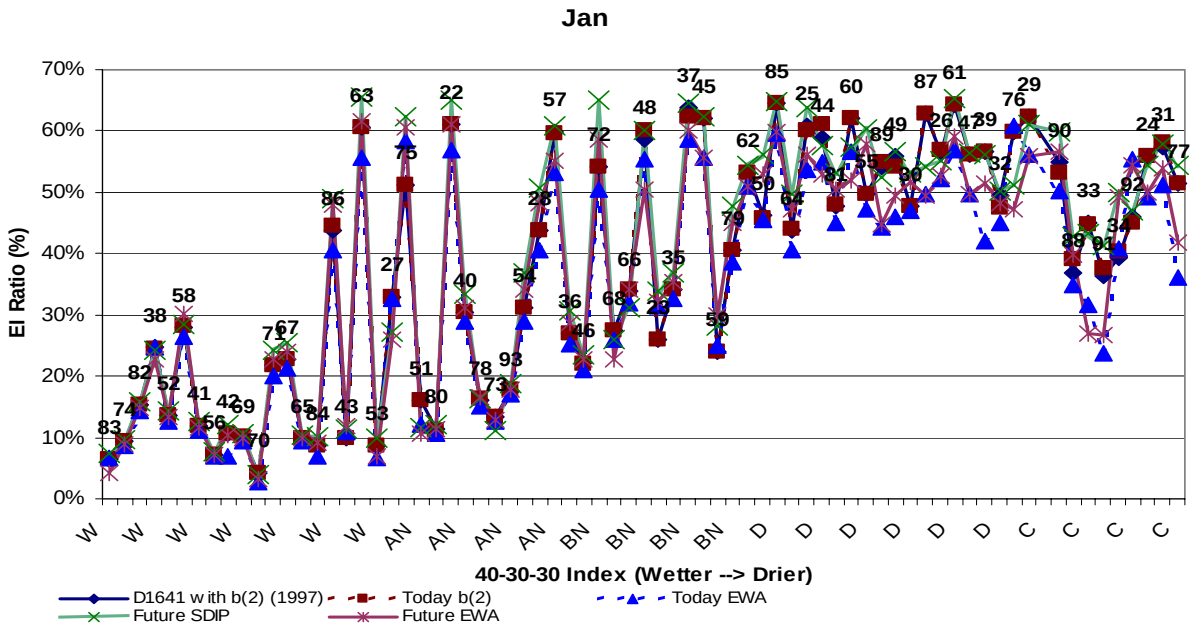

Figure 10-43 January export-to-inflow ratio sorted by 40-30-30 Index

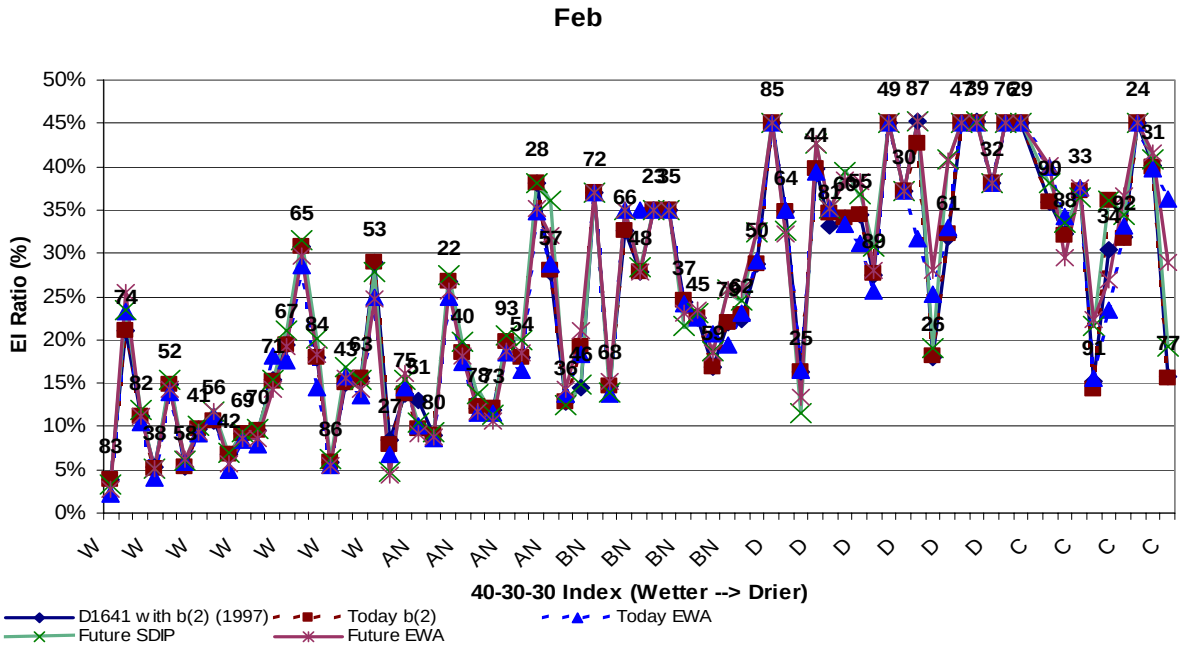

Figure 10-44 February export-to-inflow ratio sorted by 40-30-30 Index

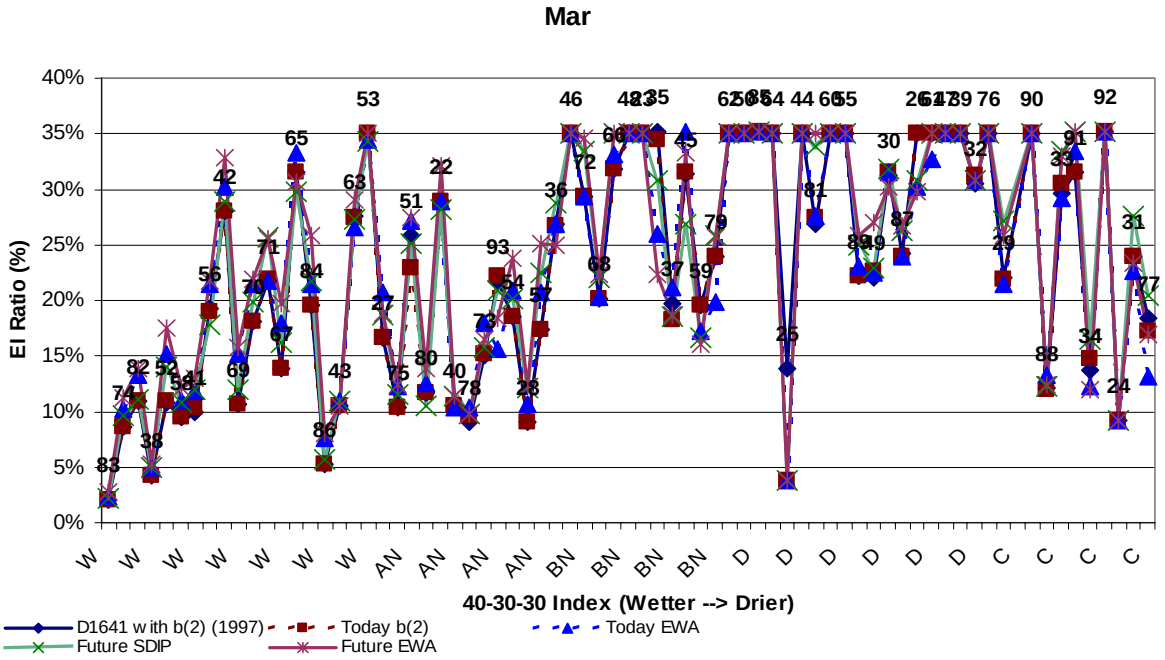

Figure 10-45 March export-to-inflow ratio sorted by 40-30-30 Index

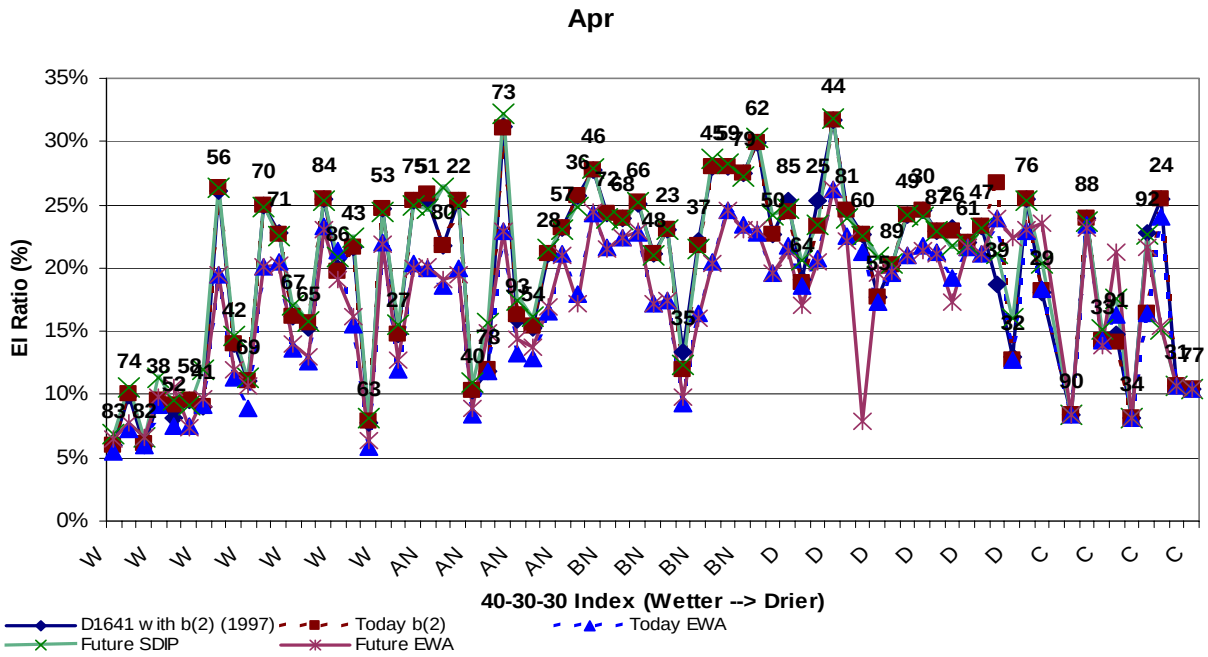

Figure 10-46 April export-to-inflow ratio sorted by 40-30-30 Index

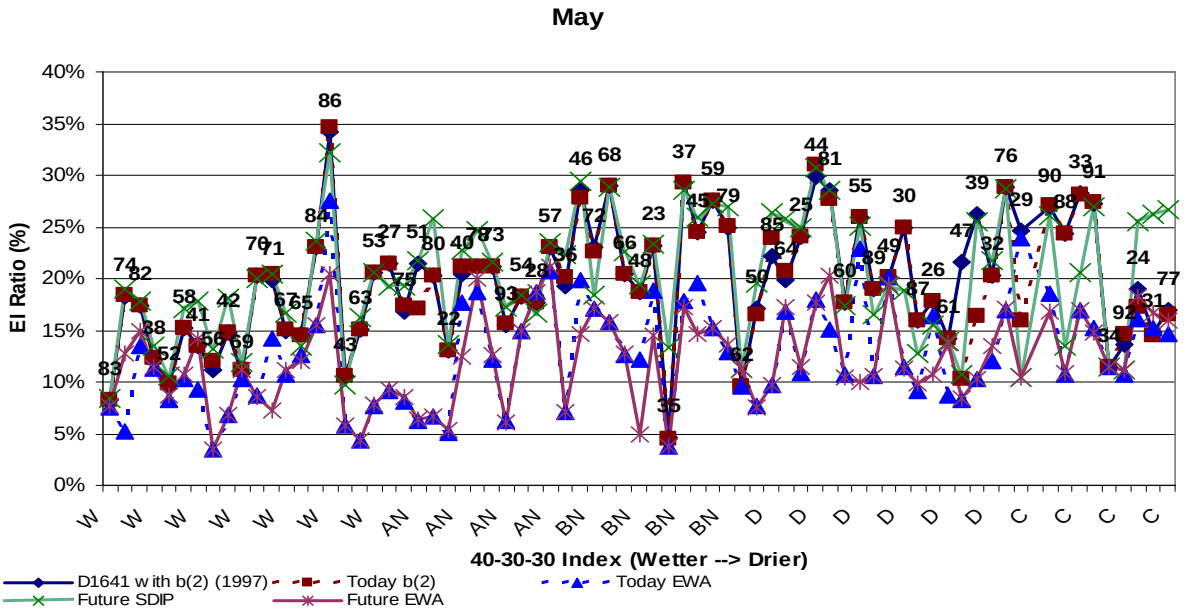

Figure 10-47 May export-to-inflow ratio sorted by 40-30-30 Index

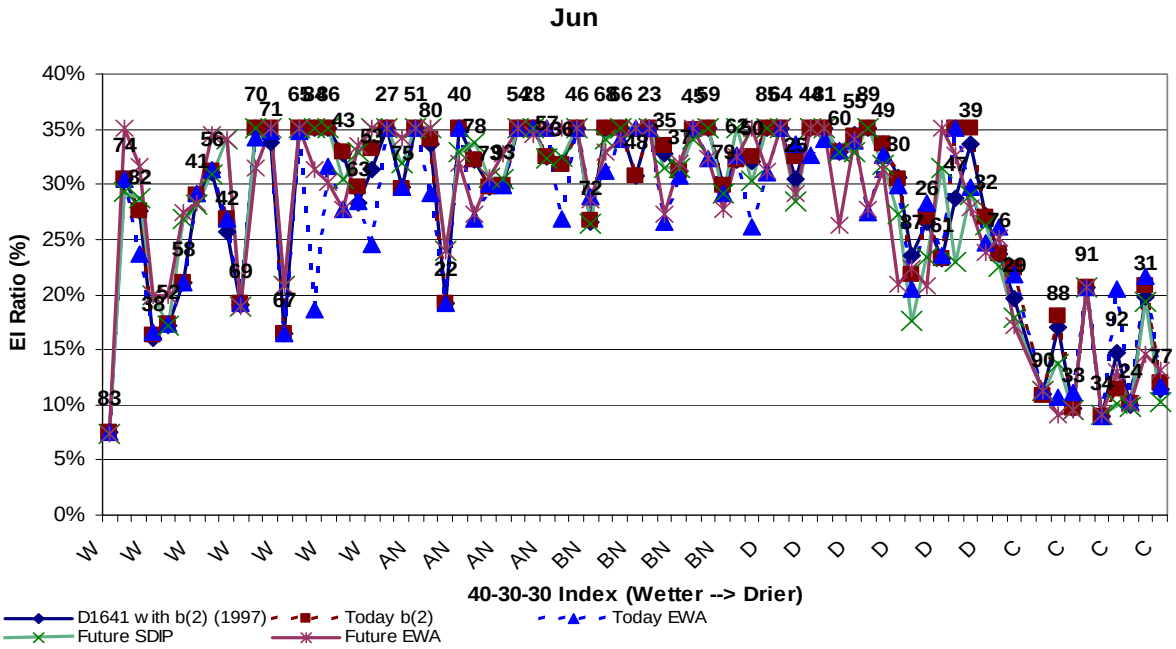

Figure 10-48 June export-to-inflow ratio sorted by 40-30-30 Index

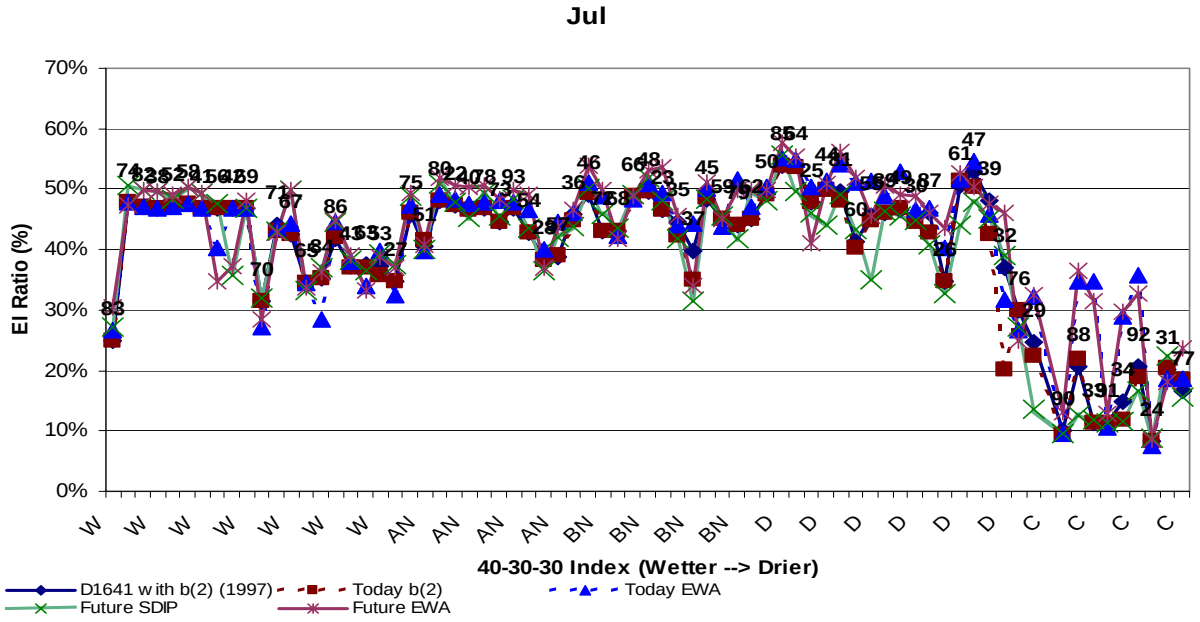

Figure 10-49 July export-to-inflow ratio sorted by 40-30-30 Index

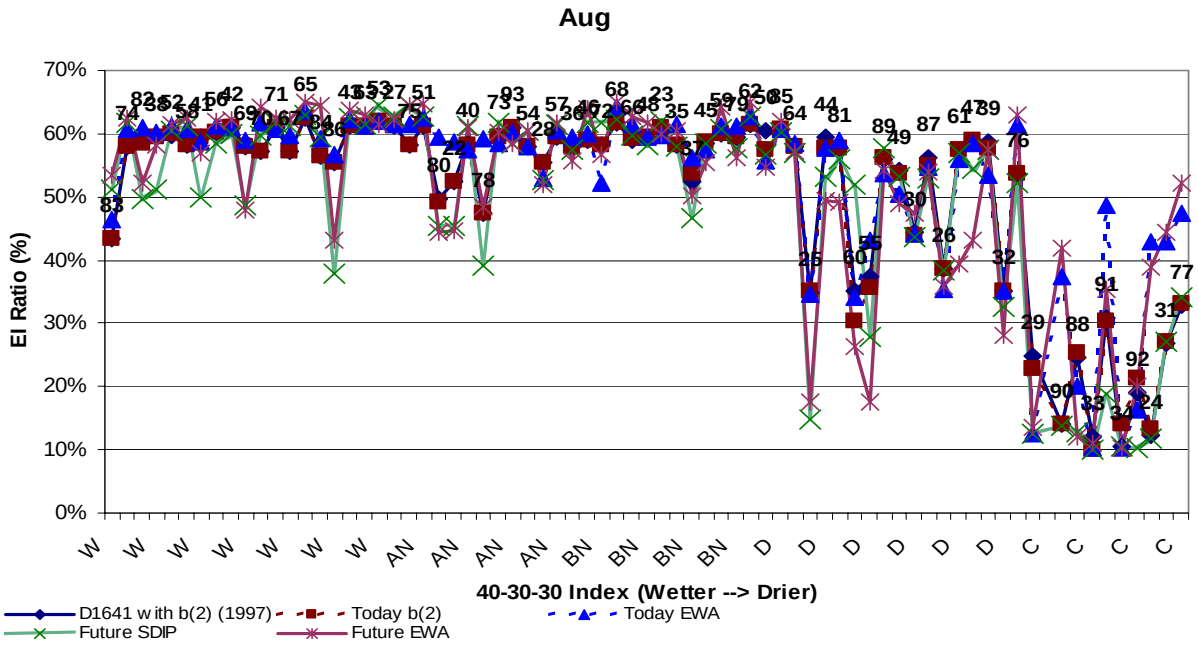

Figure 10-50 August export-to-inflow ratio sorted by 40-30-30 Index

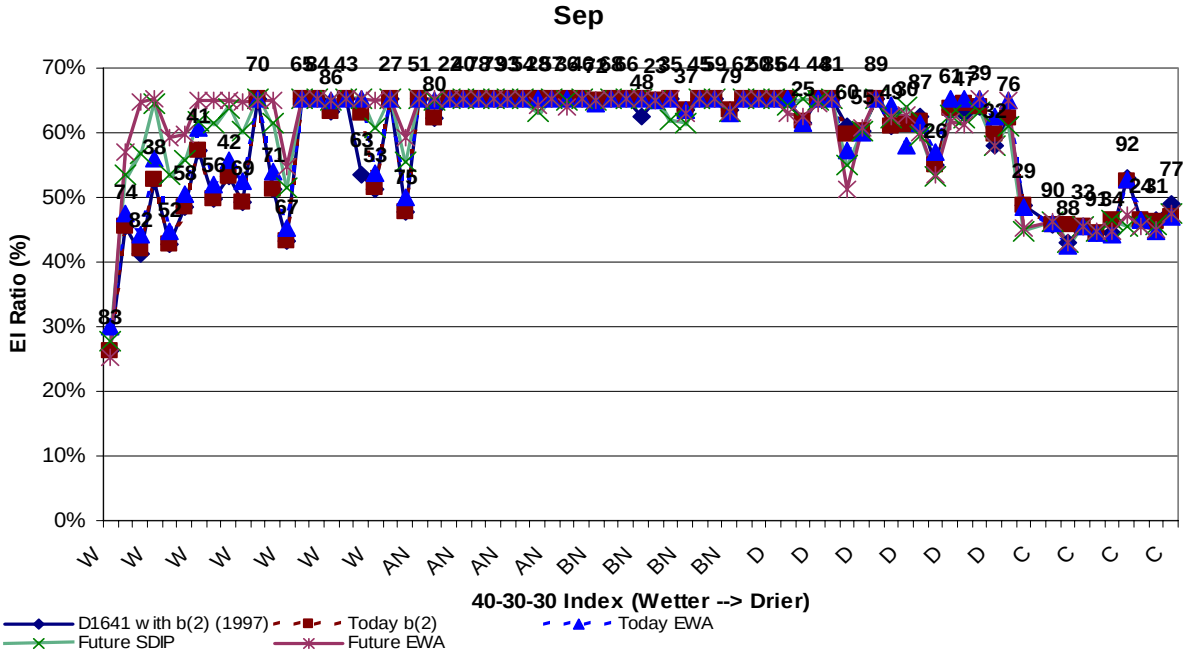

Figure 10-51 September export-to-inflow ratio sorted by 40-30-30 Index

X2 Position

The X2 position in CALSIM II represents where 2 ppt isohaline lies in the Delta calculated from the monthly average NDO (Net Delta Outflow). Since the model represents the end of month X2 position, the day to day effect of CVP/SWP operations are not resolved in this representation.

Figure 10-52 shows the exceedance plot for monthly differences in X2 position between the Studies for all February to June values simulated. Operational changes in Study 2 – Study 1 have minor influence on the X2 position. Operational changes in Study 3 have a greater effect than those in Study 2 due to EWA effects on pumping operations. The largest effect on X2 is in Study 5 compared to Study 1 this comparison shows the cumulative effect on X2 with 0.5 km shifts occurring about equal on either side of the curve. The relative X2 position in the Study 4 – Study 2 and Study 5 – Study 3 cases show relatively the same frequency of shifts in X2 position.

The monthly average X2 position based on long-term and on type dependent averages are shown in Figure 10-53 toFigure 10-58. The six Figures generally indicate the same trend from Feb to June in the X2 position on average as it moves more upstream into the delta. Also in the months Feb, Apr, May, and June the X2 position shifts slightly downstream in Studies 3 and 5 when compared to the other Studies.

Figure 10-59 to Figure 10-63. show the X2 position sorted from wettest to driest 40-30-30 Index and show the variability within a particular group of water years. These results show that X2 moves upstream as the water years get drier. Figure 10-64 to Figure 10-66. show the total number of days annually that the X2 position is downstream of one of the three compliance points (Confluence, Chipps Island and Roe Island). These latter results represent gross approximations because CALSIM II must estimate "the total number of days" values based on monthly simulation results and does not simulate the daily position of X2.

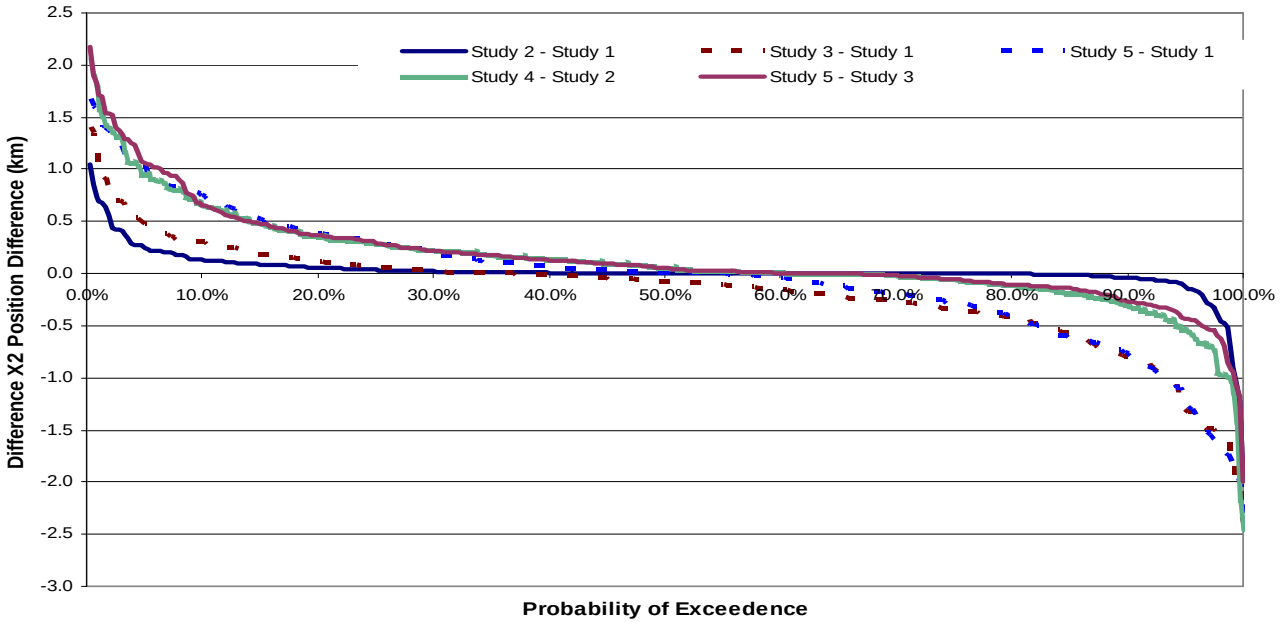

Figure 10-52 Probability of Exceedance for Monthly Shifts in X2 Position for the Feb – June Period

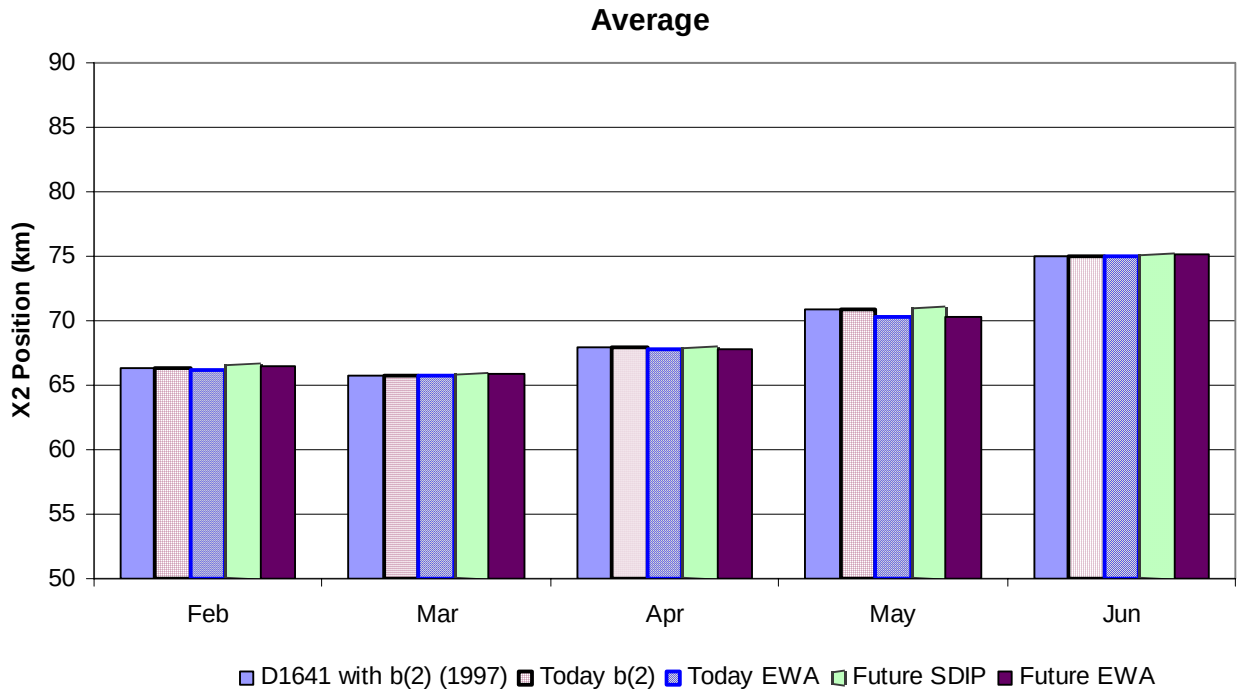

Figure 10-53 Average Monthly X2 Position

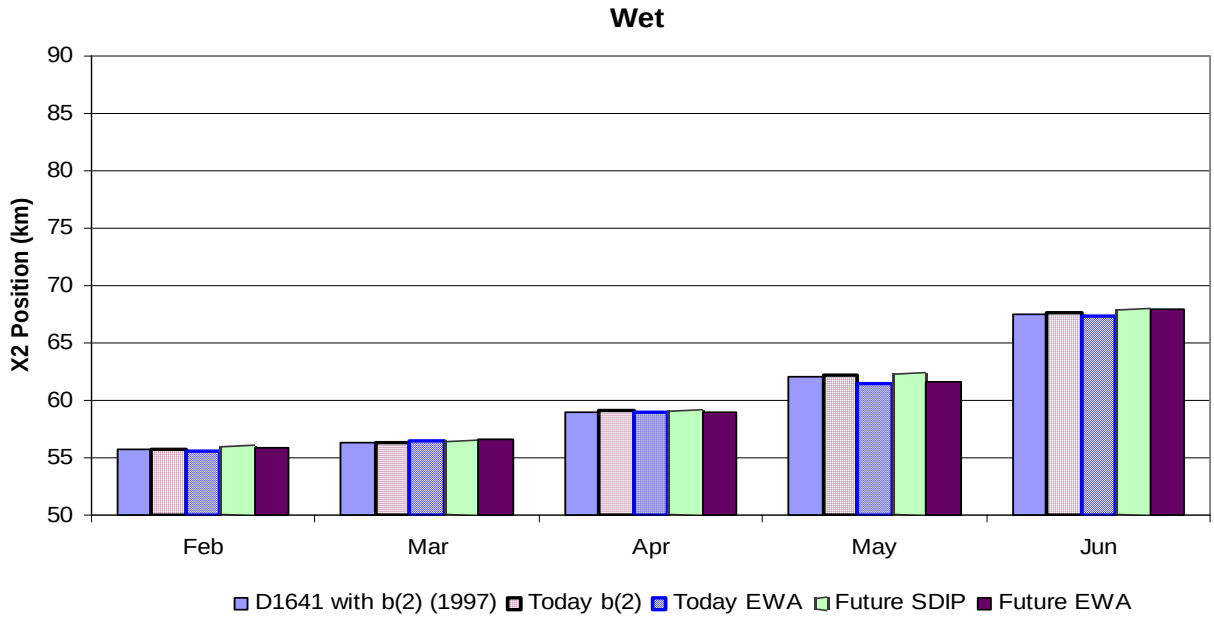

Figure 10-54 Average wet year (40-30-30 Classification) monthly X2 Position

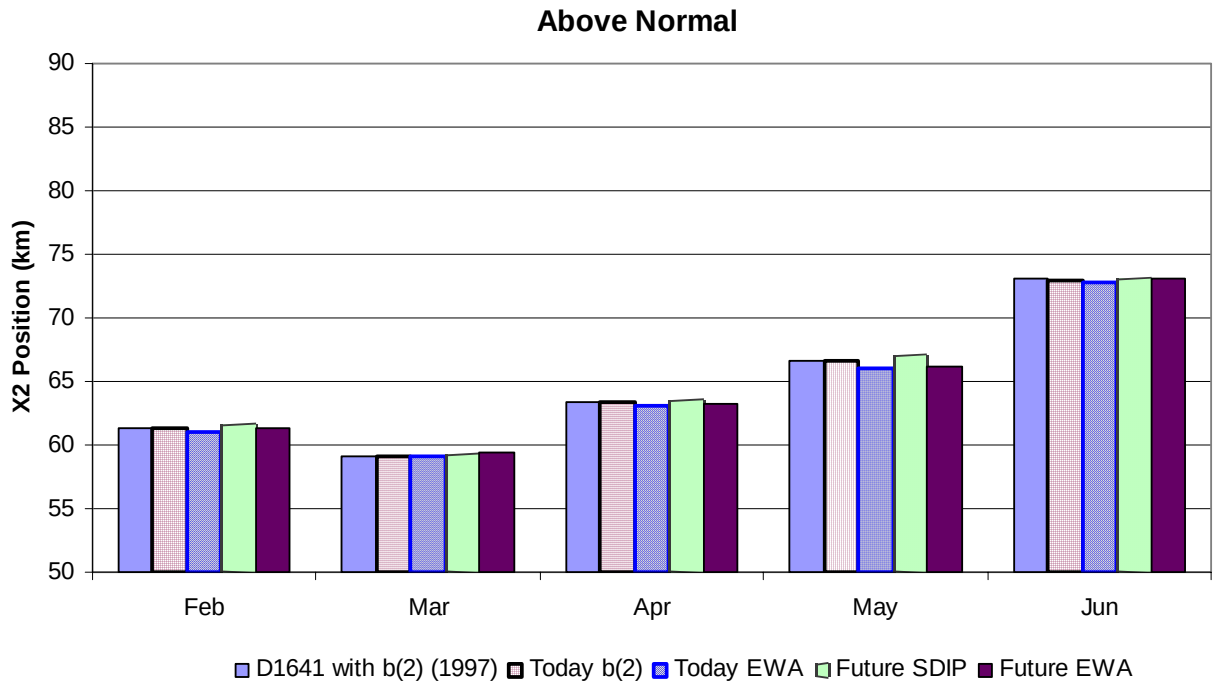

Figure 10-55 Average above normal year (40-30-30 Classification) monthly X2 Position

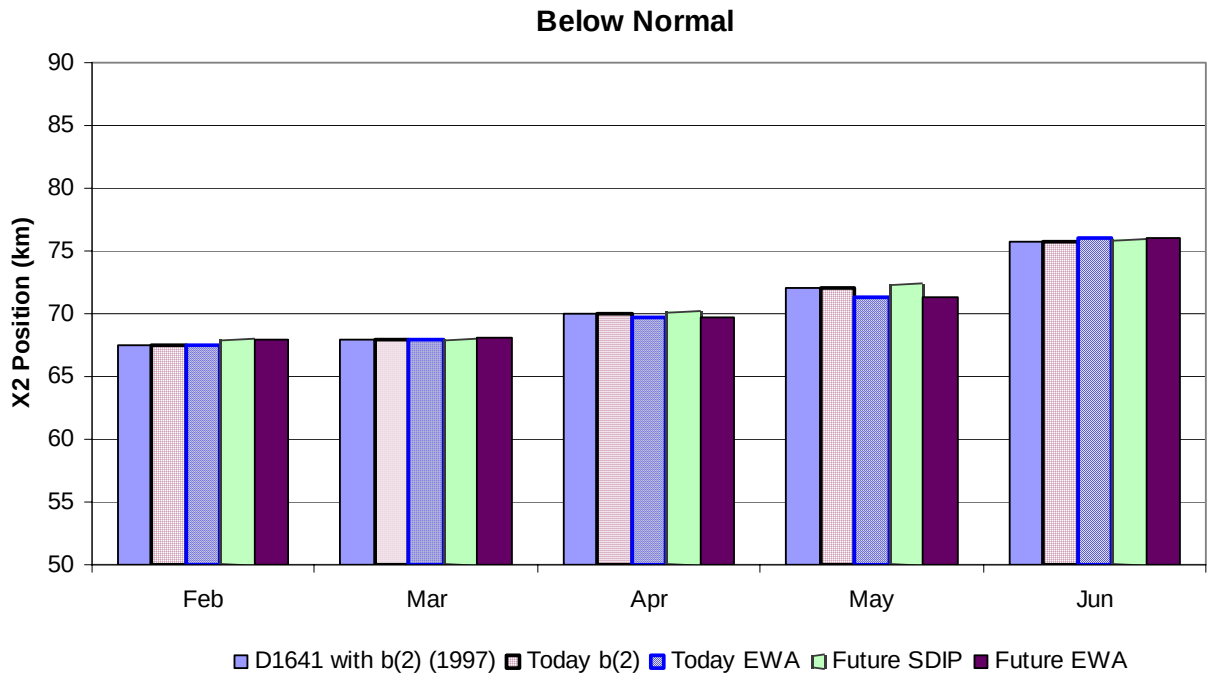

Figure 10-56 Average below normal year (40-30-30 Classification) monthly X2 Position

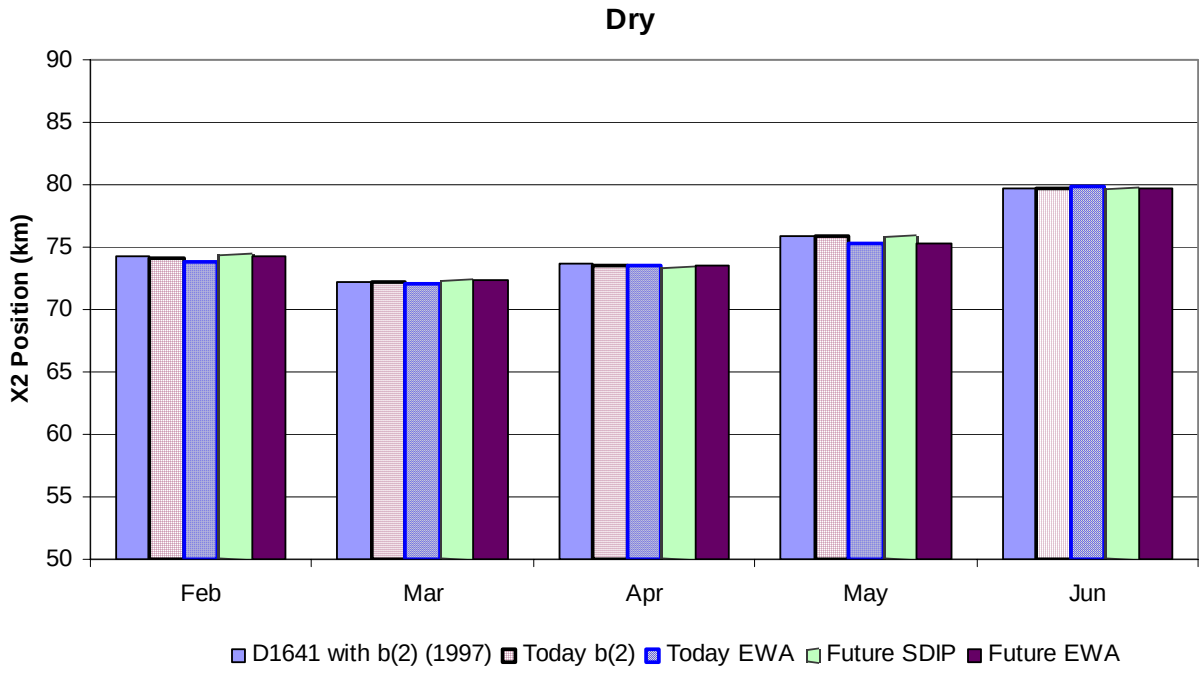

Figure 10-57 Average dry year (40-30-30 Classification) monthly X2 Position

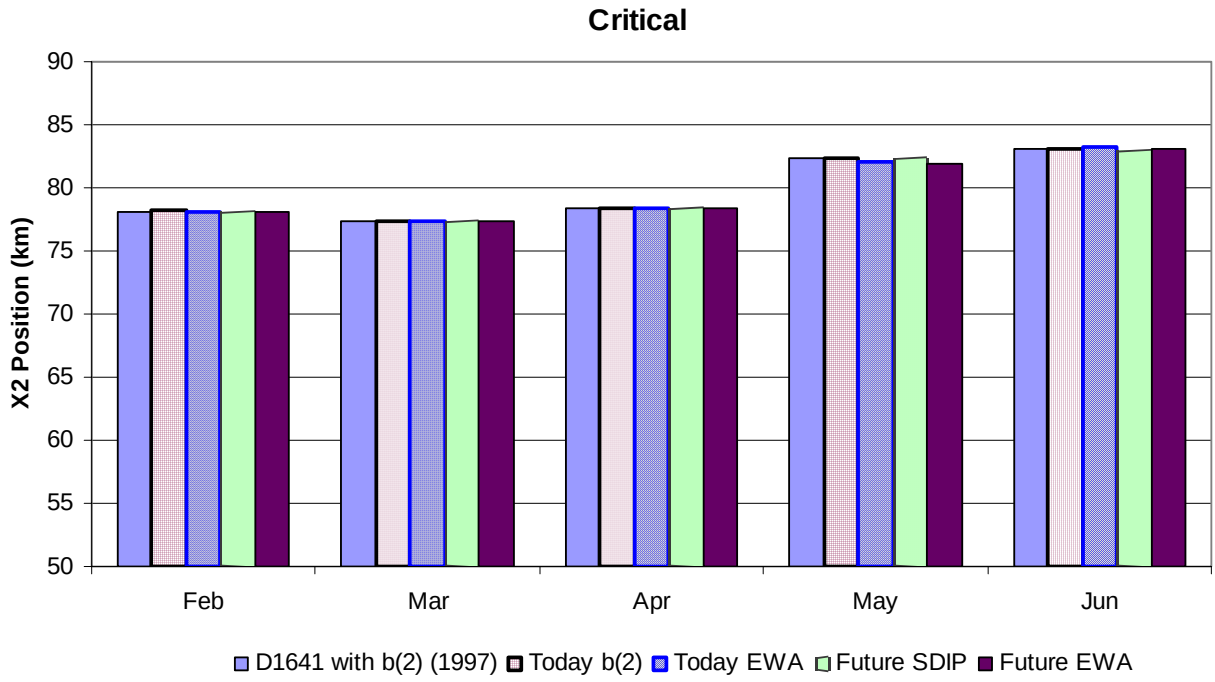

Figure 10-58 Average critical year (40-30-30 Classification) monthly X2 Position

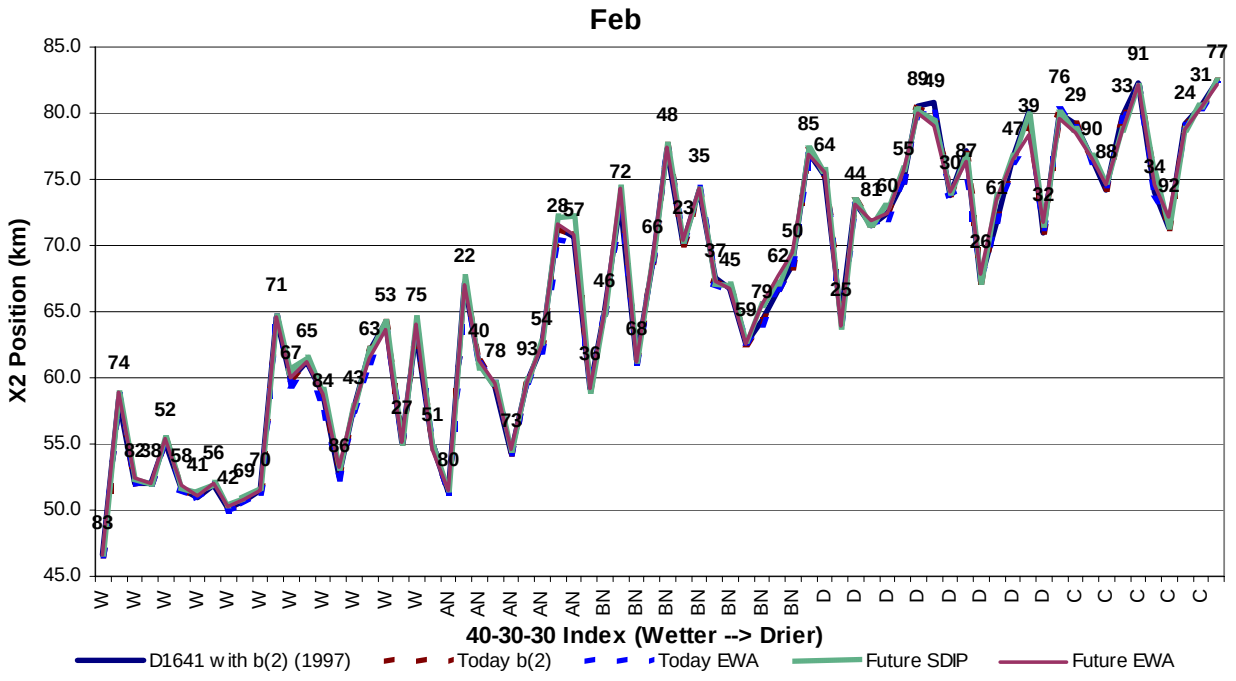

Figure 10-59 February X2 Position sorted by 40-30-30 Index

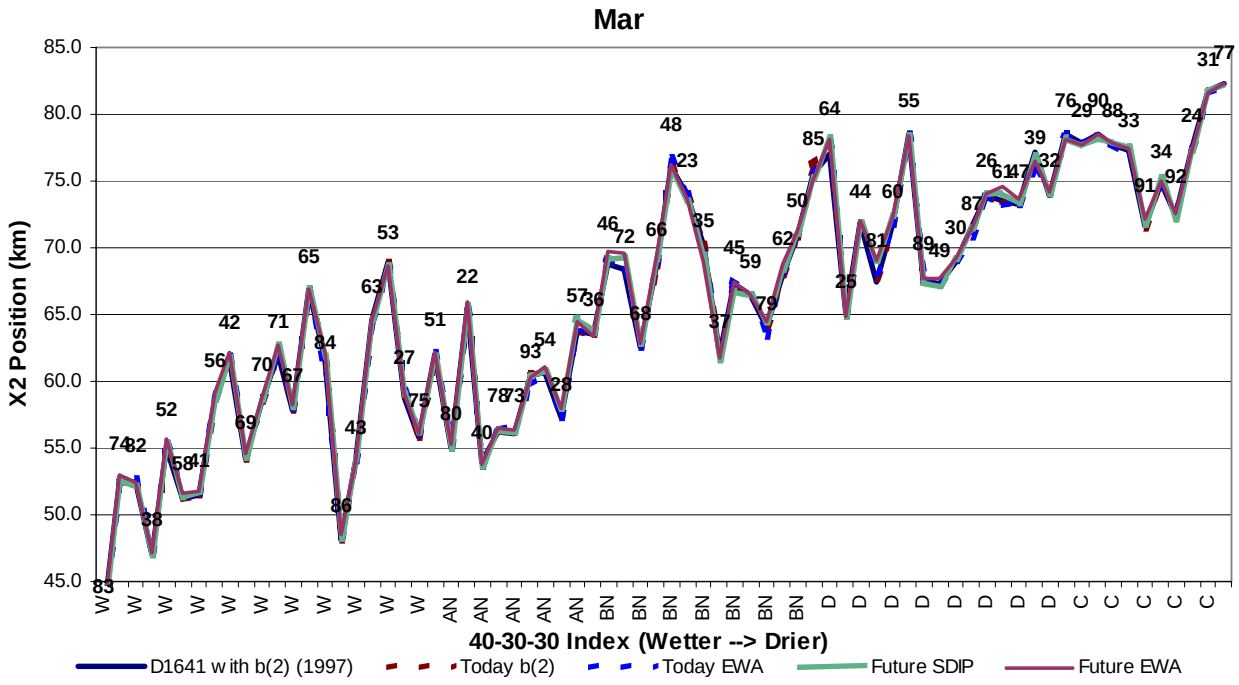

Figure 10-60 March X2 Position sorted by 40-30-30 Index

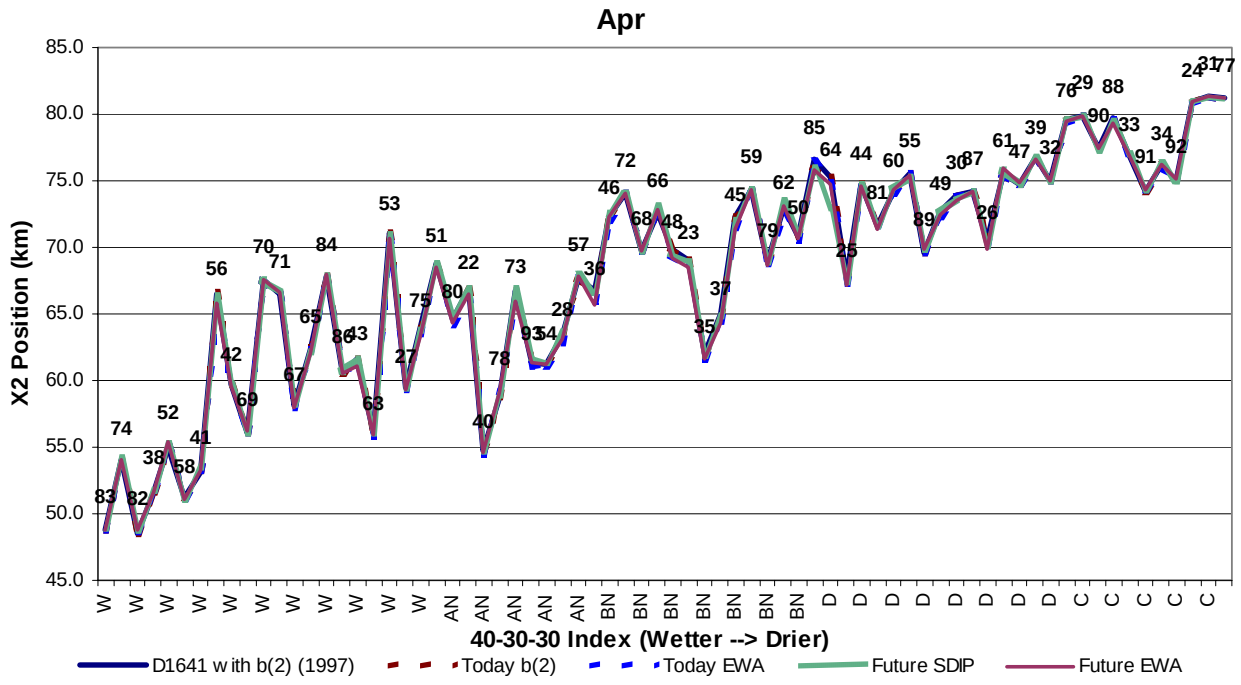

Figure 10-61 April X2 Position sorted by 40-30-30 Index

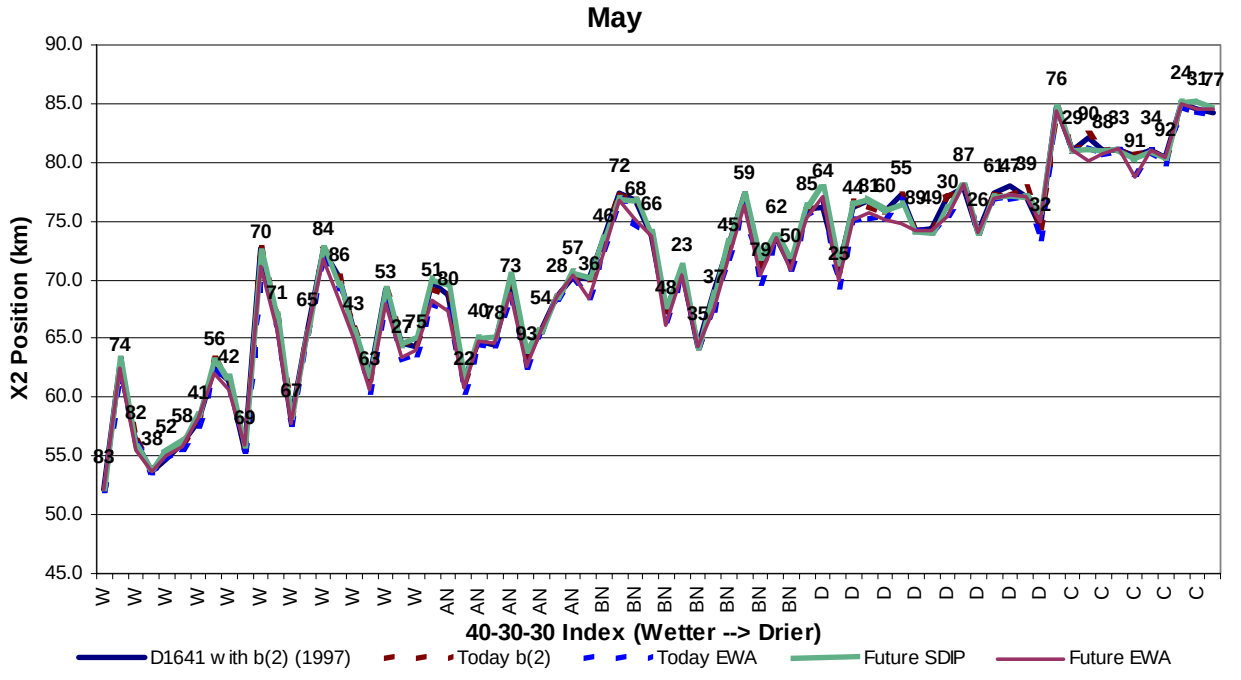

Figure 10-62 May X2 Position sorted by 40-30-30 Index

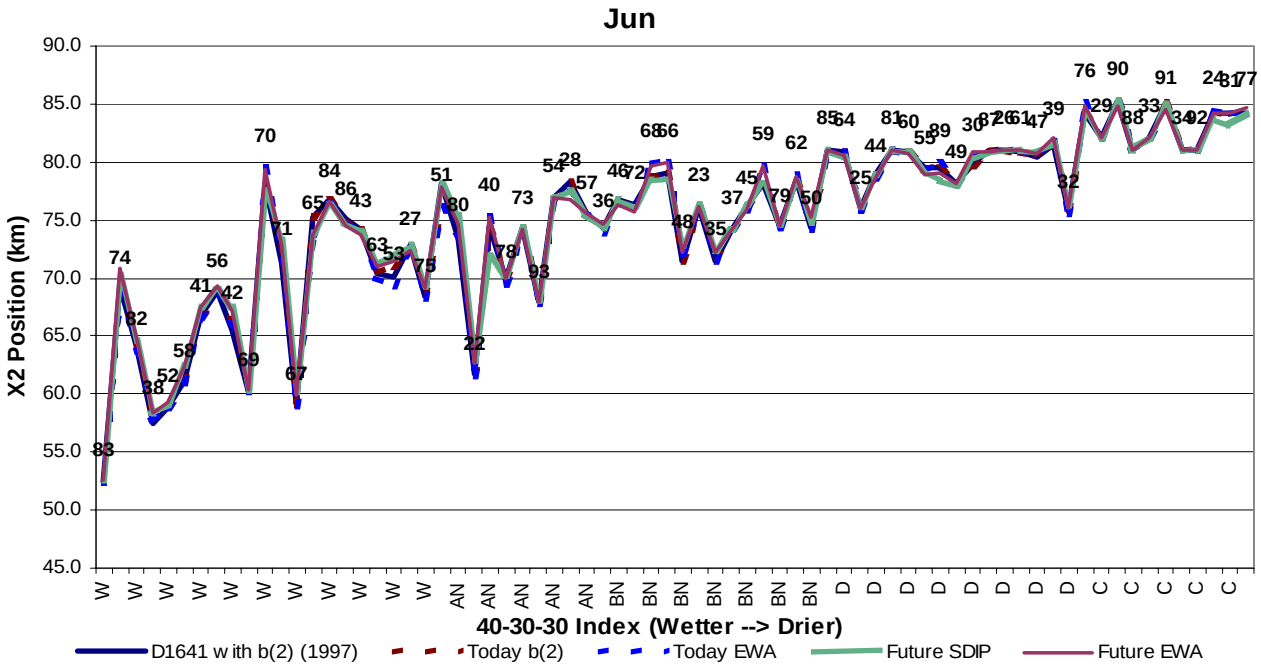

Figure 10-63 June X2 Position sorted by 40-30-30 Index

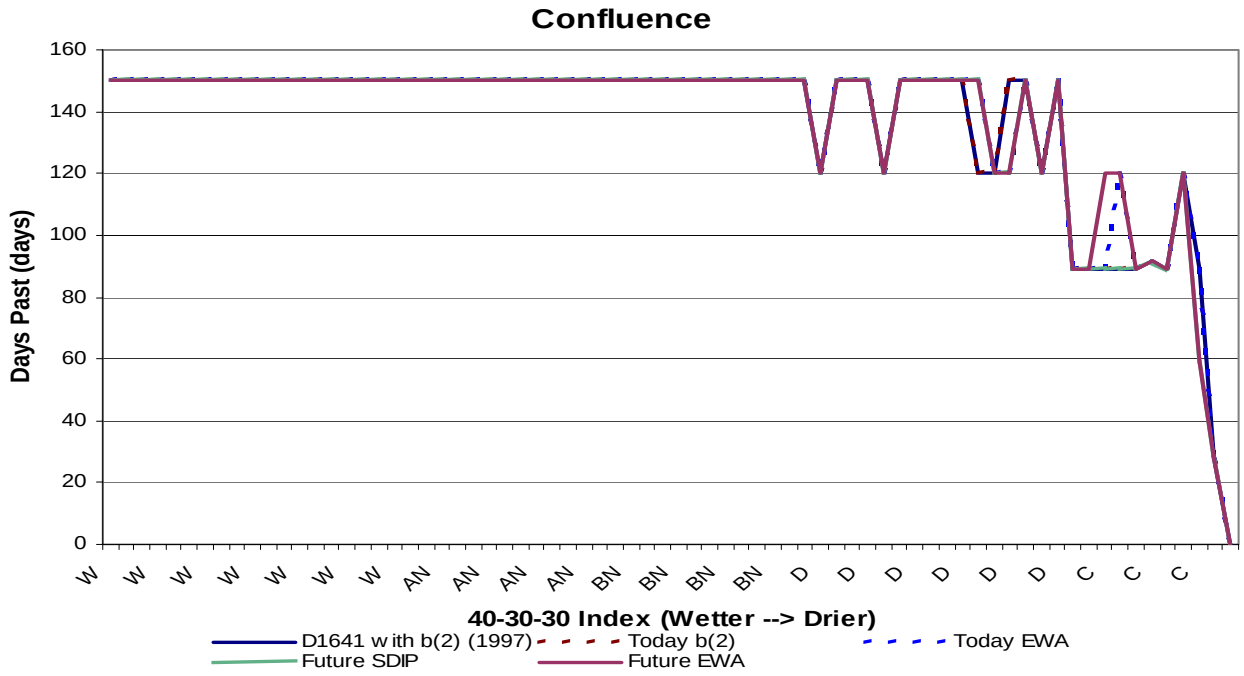

Figure 10-64 Total number of days average monthly X2 position is past the Confluence 40-30-30 Index
(Note: that the total days for a month are assigned if the average X2 position is past the confluence)

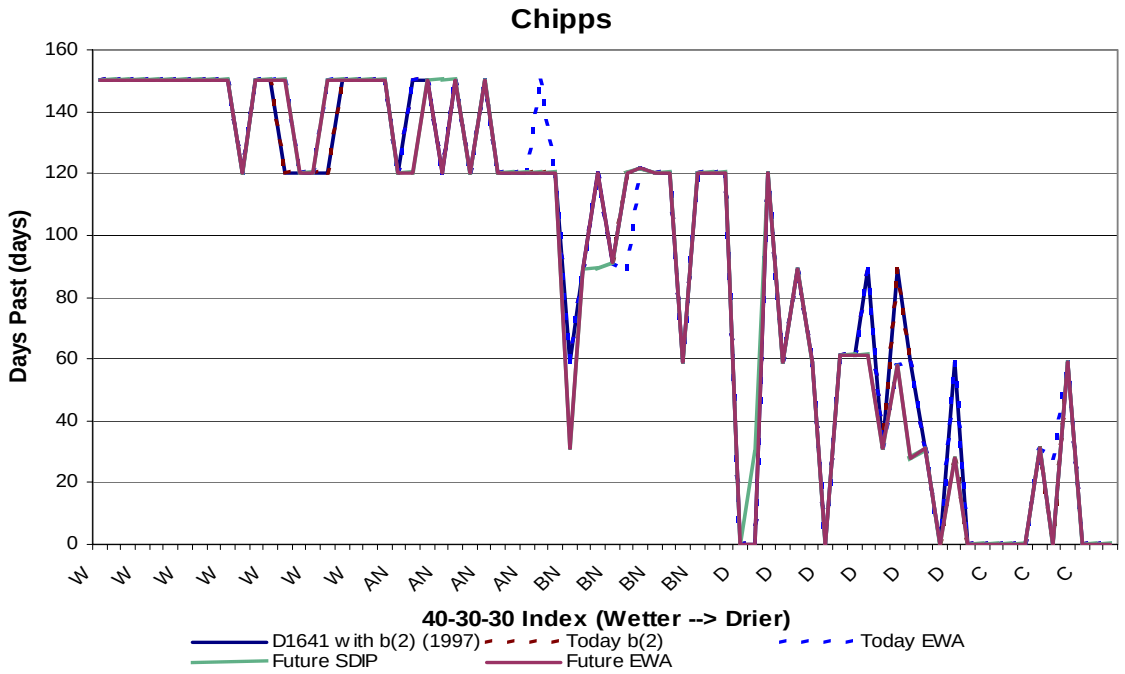

Figure 10-65 Total number of days average monthly X2 position is past the Chipps Island 40-30-30 Index
(Note: that the total days for a month are assigned if the average X2 position is past the Chipps Island)

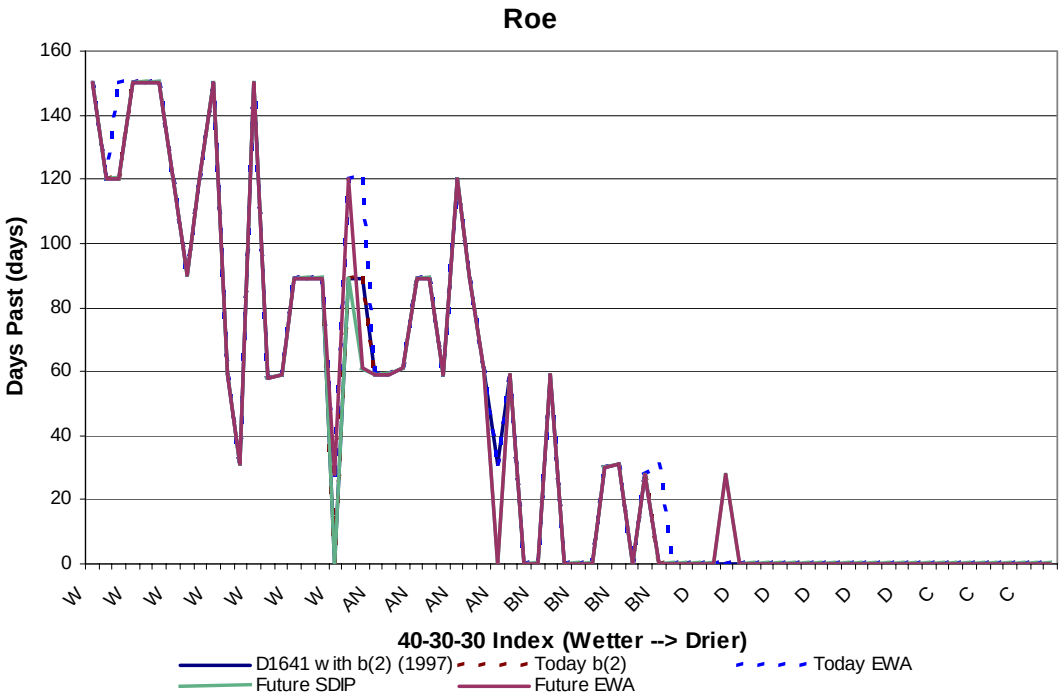

Figure 10-66 Total number of days average monthly X2 position is past the Roe Island 40-30-30 Index
(Note: that the total days for a month are assigned if the average X2 position is past the Roe Island)

Exports

The exports discussed in this section are Tracy pumping, Banks pumping, Federal Banks pumping and diversions for Contra Costa Water District (CCWD) and the North Bay Aqueduct. Figure 10-67 shows the total annual pumping of Tracy and Banks facilities. The study with the most available pumping is the Future SDIP that includes the intertie at Tracy, 8500 cfs at Banks pumping plant and does not include EWA reductions in pumping. Study 3 generally has the least amount of pumping as Tracy and Banks have existing permitted and physical capacities due to the constriction in the Delta Mendota Canal while EWA imposes restrictions on pumping.

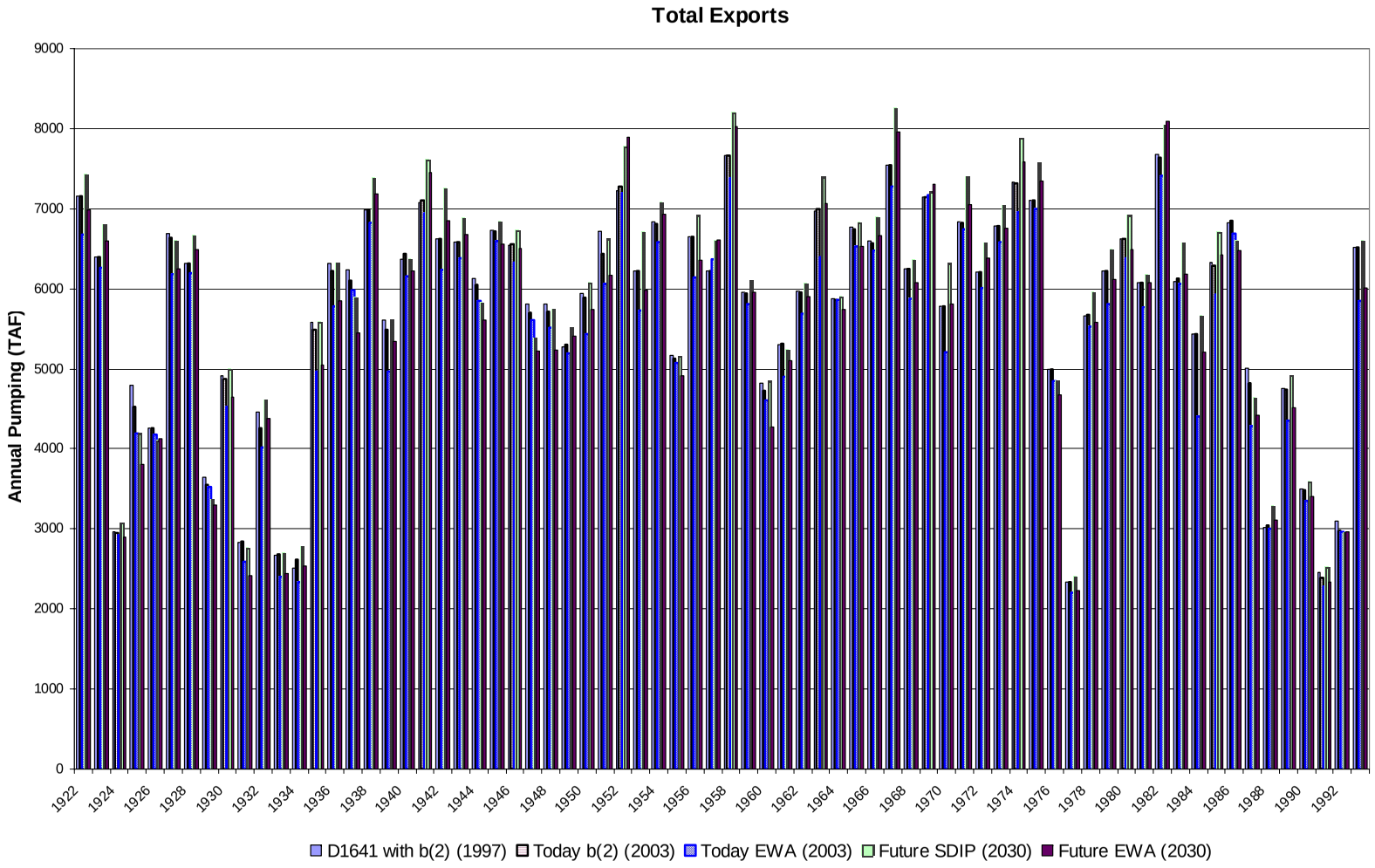

Figure 10-67 Total Annual Tracy + Banks Pumping

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Tracy Pumping

The Tracy pumps in Studies 1, 2 and 3 are limited to 4200 cfs plus the diversions upstream of the constriction in the Delta Mendota Canal. In studies 4 and 5 the intertie allows pumping to increase to the facility design capacity of 4600 cfs. Figure 10-68 shows the percentile values for monthly pumping at Tracy. November through February are the months when Tracy most frequently pumps at 4600 cfs with the 50th percentile at that level for most of the months in Study 4. Wet years tend to be when Tracy can more utilitze the 4600 cfs pumping in Study 4 and Study 5, seeFigure 10-70.

From Figure 10-68 December through February the pumping is decreased during this time frame in Studies 3 and 5 due to the 25 TAF/month pumping restriction from the EWA program. April, May and June see reductions from the other months because of the VAMP restrictions and May has further reductions in the EWA studies due to EWA spending some assets to supplement the May Shoulder pumping redcution. June is limited by the 3000 cfs limit for in all studies which affects the amount of reduction in the 50th percentile. July through September see pumping increase generally for irrigation deliveries. July and August have the 5th percentiles down to the 800 cfs minimum pumping (assumption of pumping rate with one pump on) and to 600 cfs when Shasta gets below 1500 TAF in storage.

Figure 10-69 to Figure 10-74. show similar trends in monthly average exports by year type with pumping being greatest December through February and July through September. The exception is in the Critical year, Figure 10-74, when the pumping stays between 1000 cfs and 1500 cfs through August due to reduced storage and salinity conditions in the Delta.

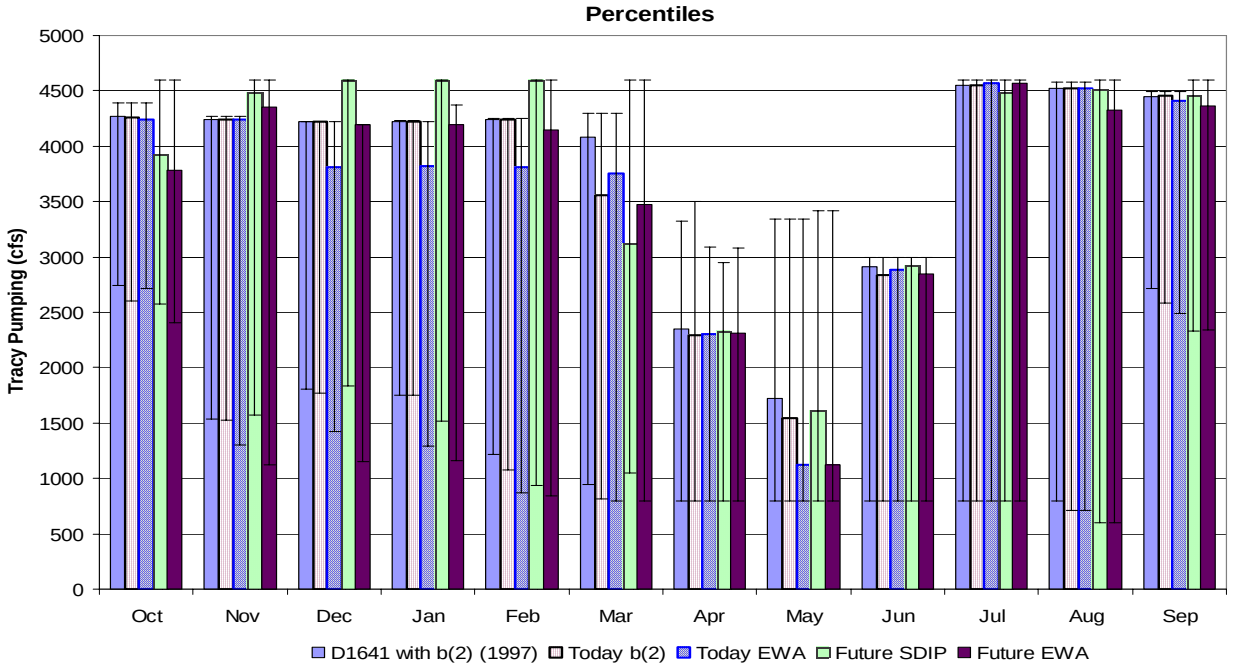


Figure 10-68 Tracy Pumping 50th Percentile Monthly Releases with the 5th and 95th as the bars

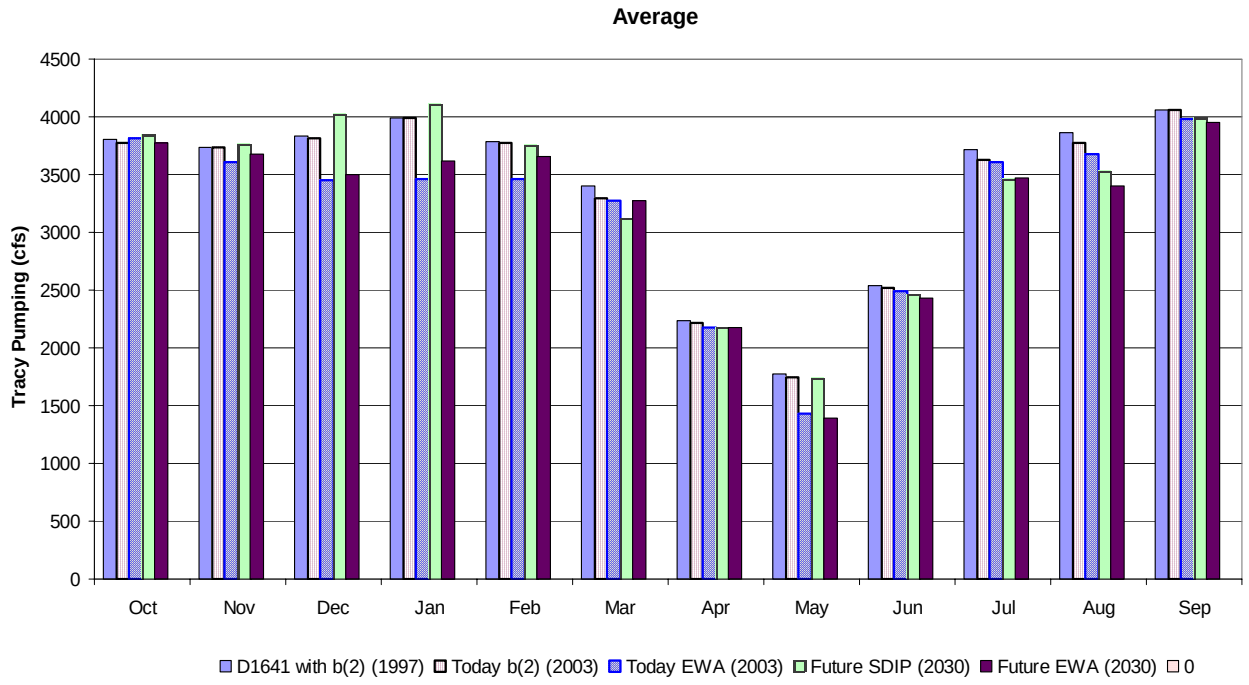


Figure 10-69 Average Monthly Tracy Pumping

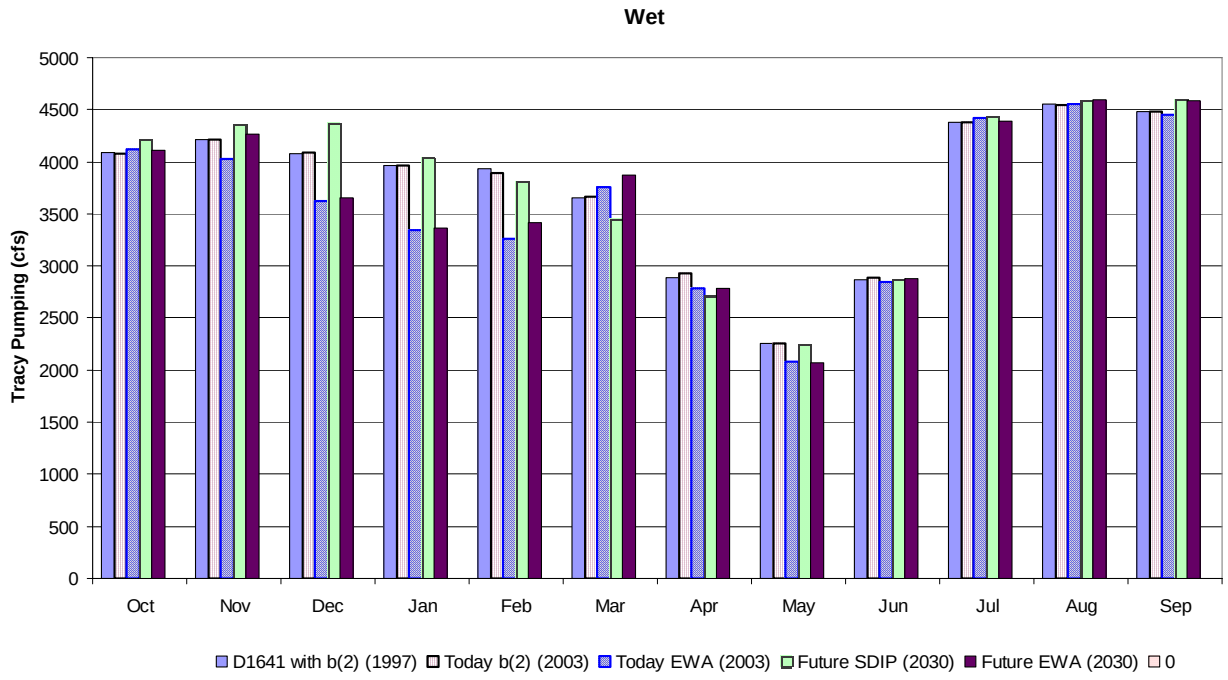


Figure 10-70 Average wet year (40-30-30 Classification) monthly Tracy Pumping

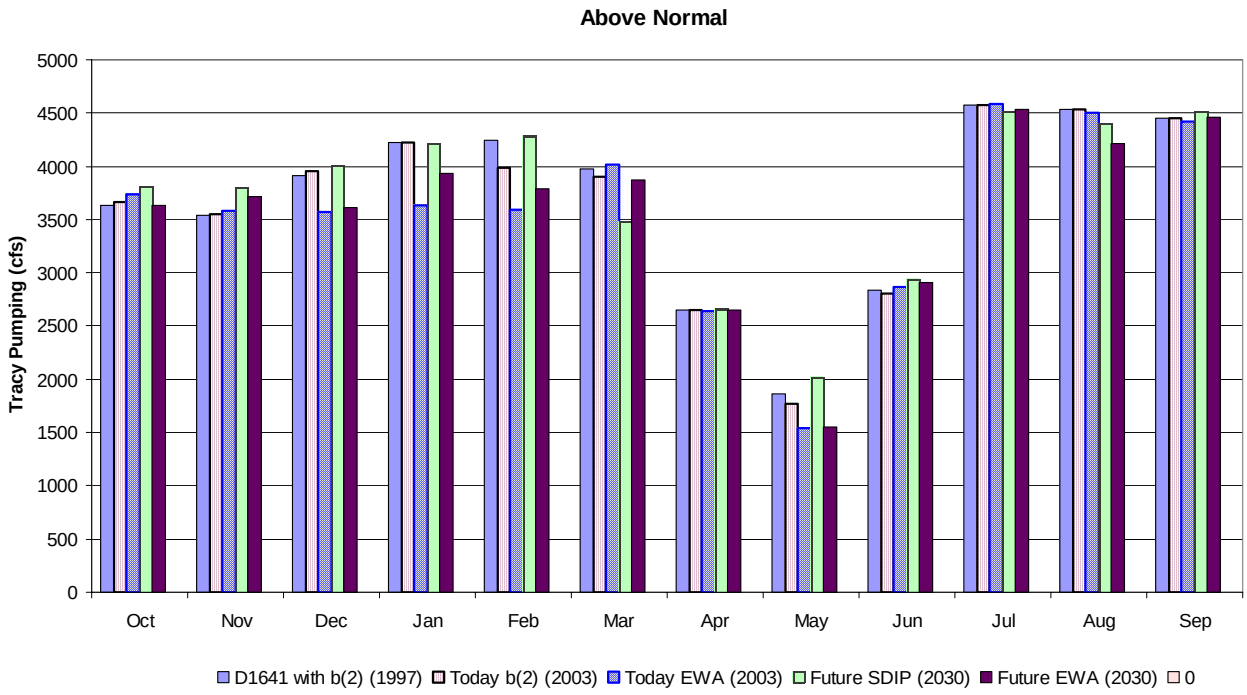


Figure 10-71 Average above normal year (40-30-30 Classification) monthly Tracy Pumping

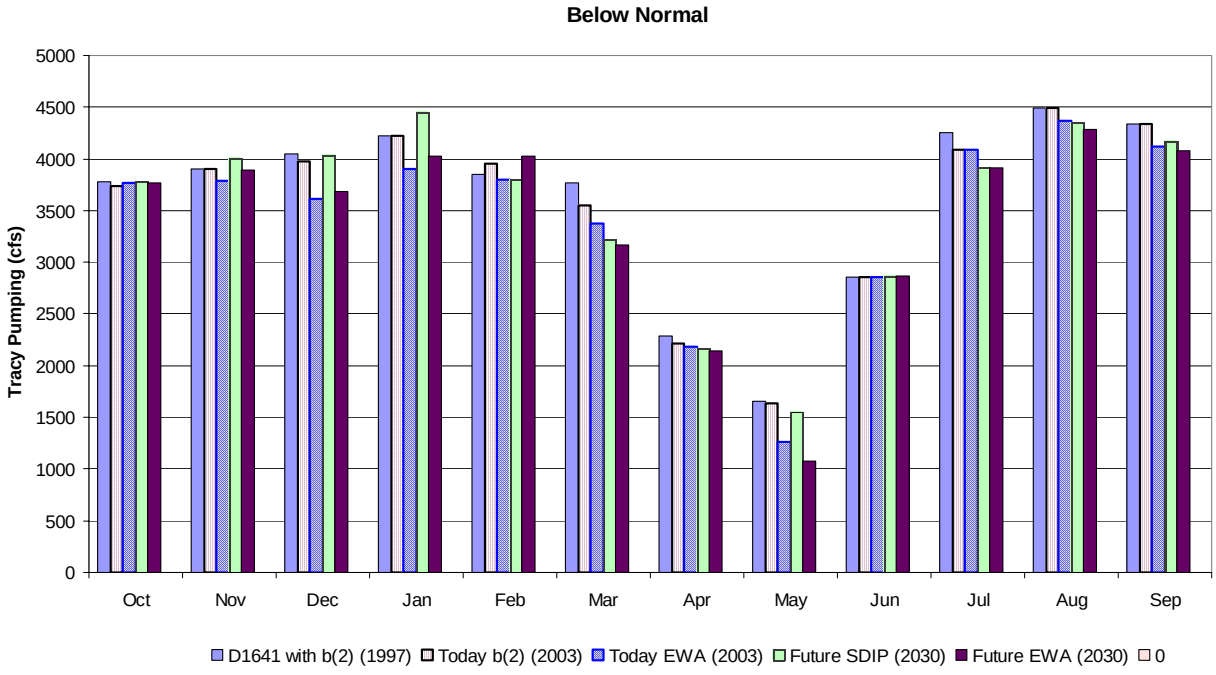


Figure 10-72 Average below normal year (40-30-30 Classification) monthly Tracy Pumping

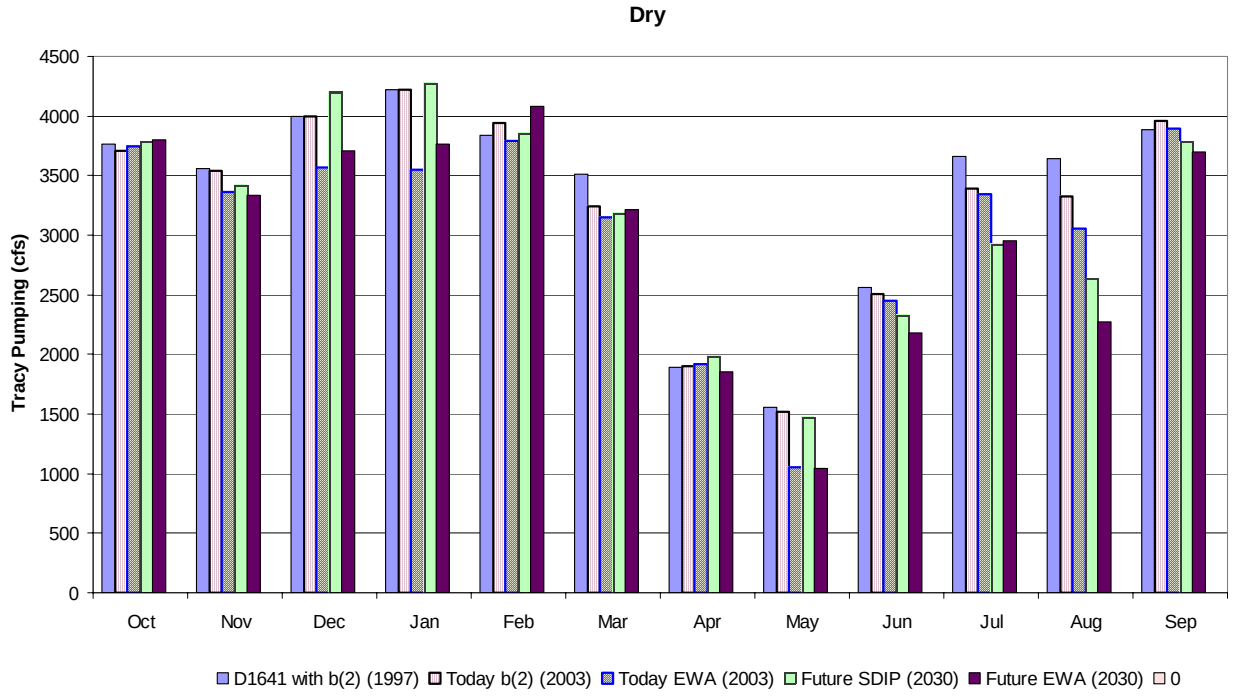


Figure 10-73 Average dry year (40-30-30 Classification) monthly Tracy Pumping

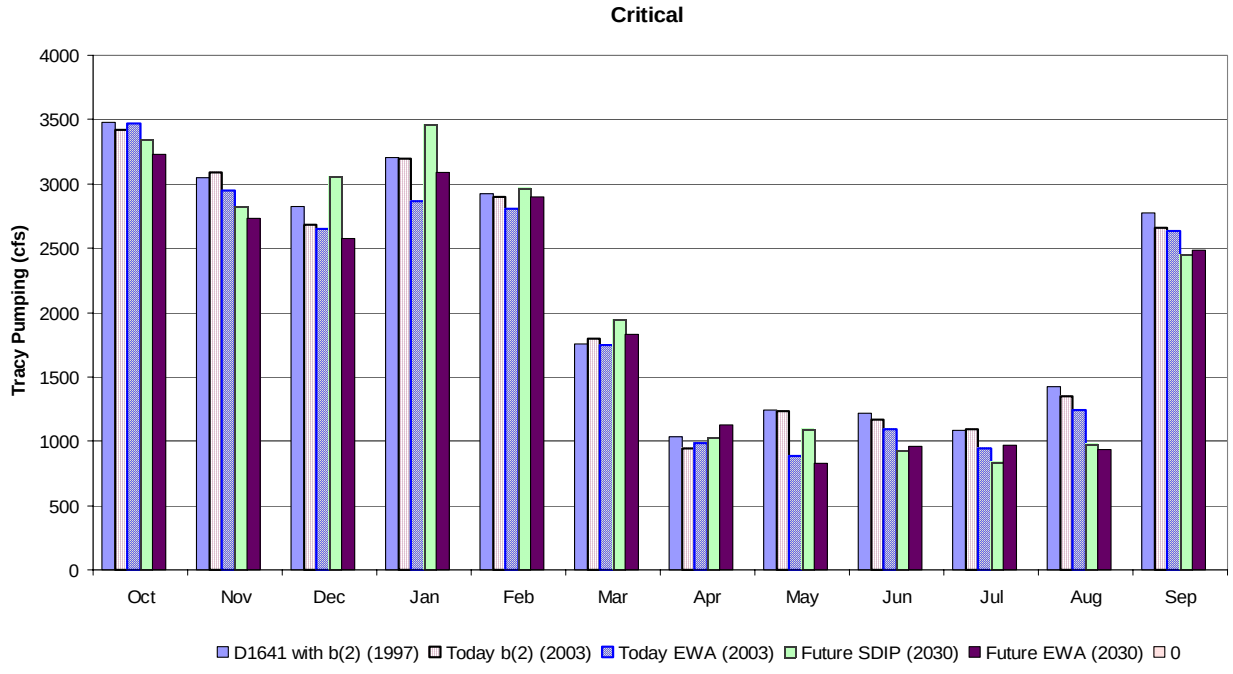


Figure 10-74 Average critical year (40-30-30 Classification) monthly Tracy Pumping

Banks Pumping

Figure 10-75 through Figure 10-81 represent simulated total Banks exports for the five studies. Figure 10-75 shows that export levels in Studies 3, 4 and 5 are greater export levels than Studies 1 and 2 which are the (b)(2) scenarios. The SDIP case shows higher pumping over almost all months even during the April-May period. The Today EWA and Future EWA export levels are higher most months except for April and May. The whisker plot (Figure 10-75) also shows that a 8500 export level is reached at least 5% of the time in the SDIP and the EWA future cases

While EWA and SDIP implementation in Studies 3 and 5 result in higher export levels in all months except for April and May, the percentage of the summer time increases vary as a function of year type (Figure 10-69 toFigure 10-74.).

In the driest years EWA related exports more than double the July, August, and September exports when compared to the (b)(2) cases modeled in Studies 1 and 2.

Most of the time EWA exports are increased primarily during the summertime to make up for reduced exports due to EWA export reductions in April and May. In all scenarios April and May EWA exports are lower than either of the (b)(2) cases.

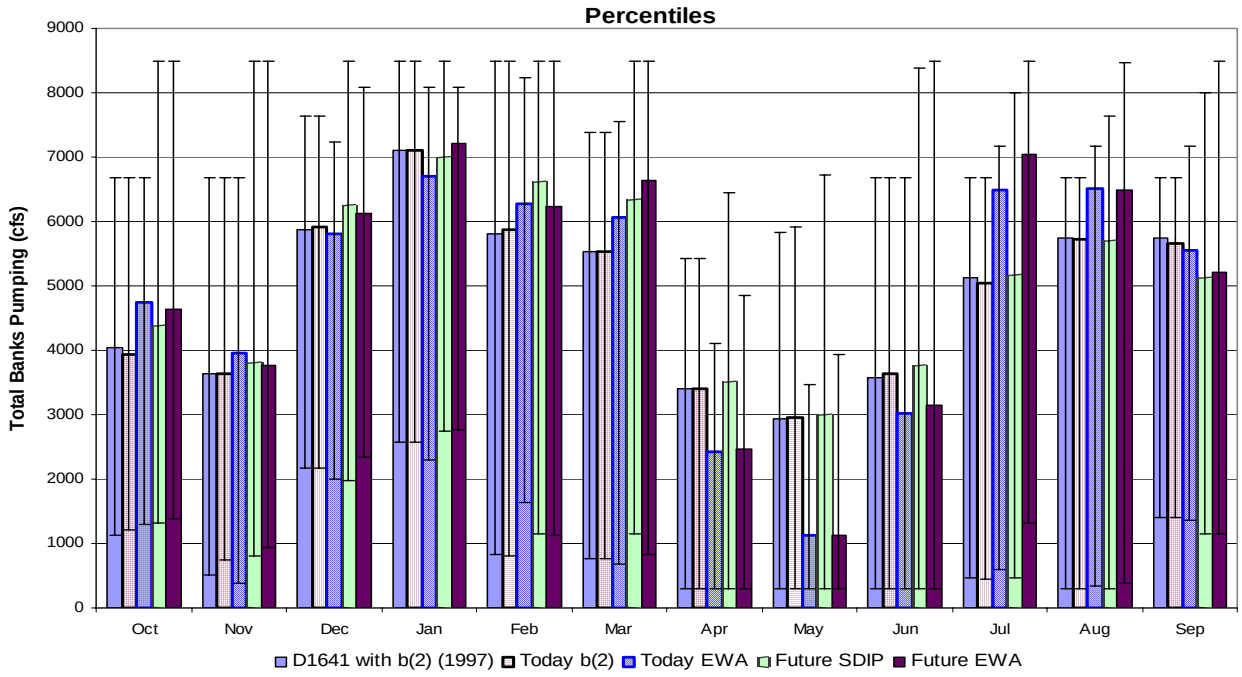


Figure 10-75 Banks Pumping 50th Percentile Monthly Releases with the 5th and 95th as the bars

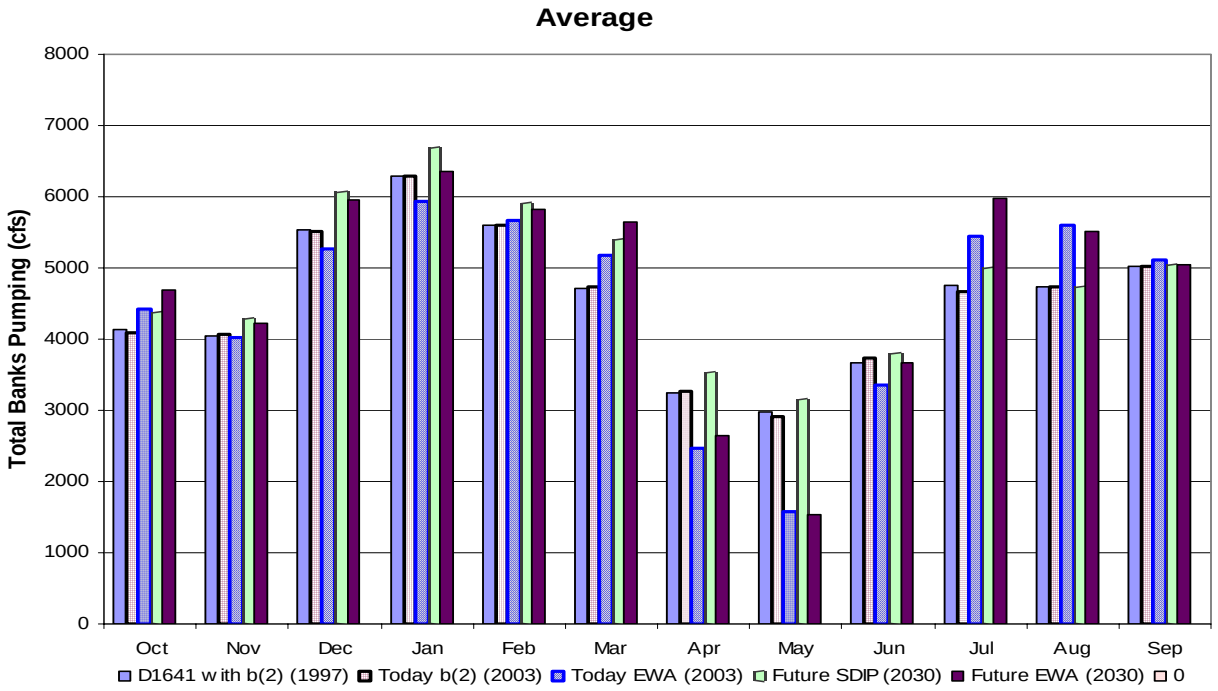


Figure 10-76 Average Monthly Banks Pumping

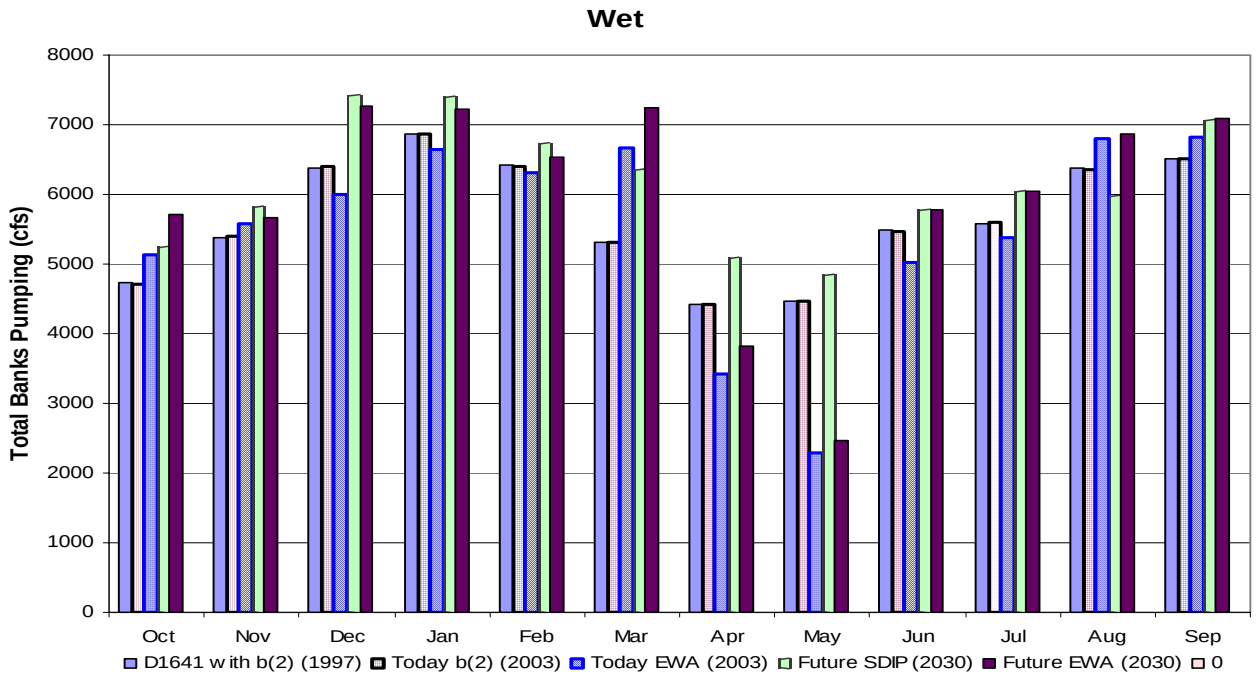


Figure 10-77 Average wet year (40-30-30 Classification) monthly Banks Pumping

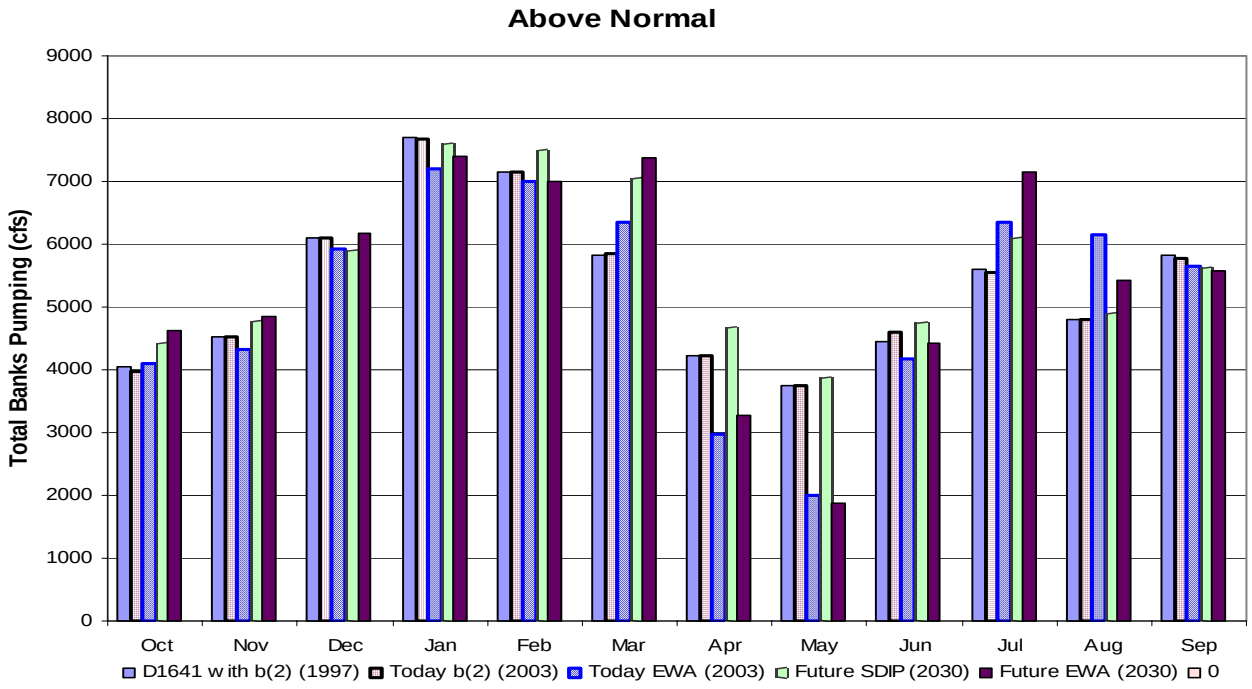


Figure 10-78 Average above normal year (40-30-30 Classification) monthly Banks Pumping

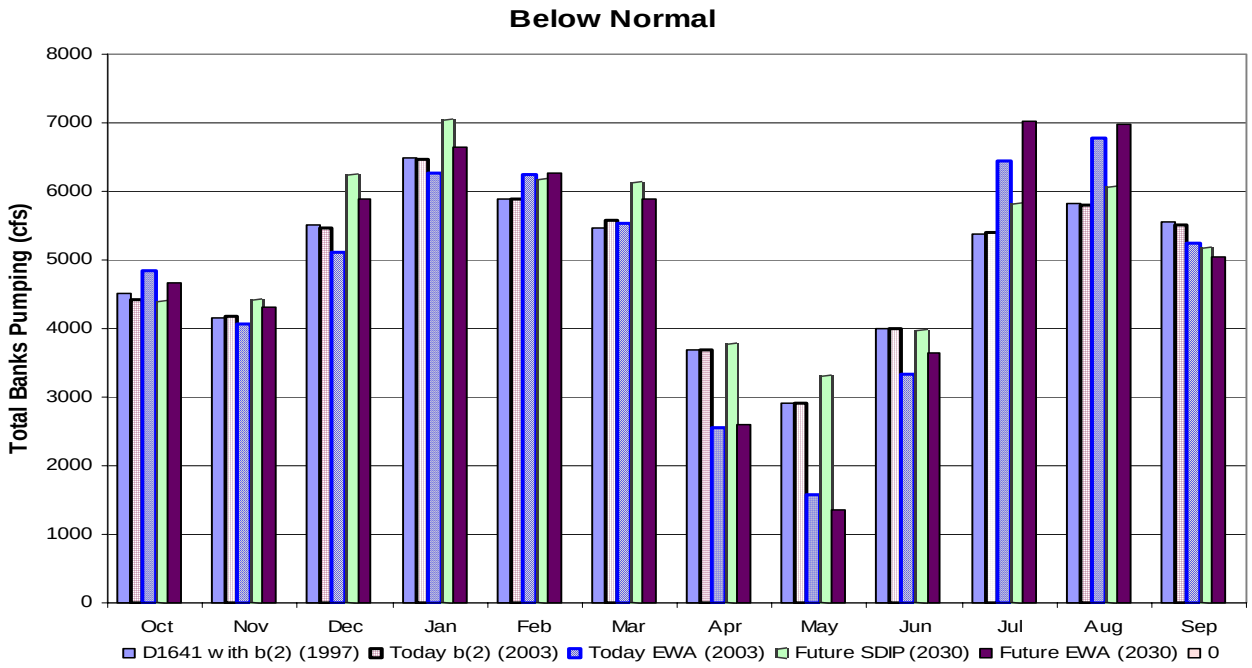


Figure 10-79 Average below normal year (40-30-30 Classification) monthly Banks Pumping

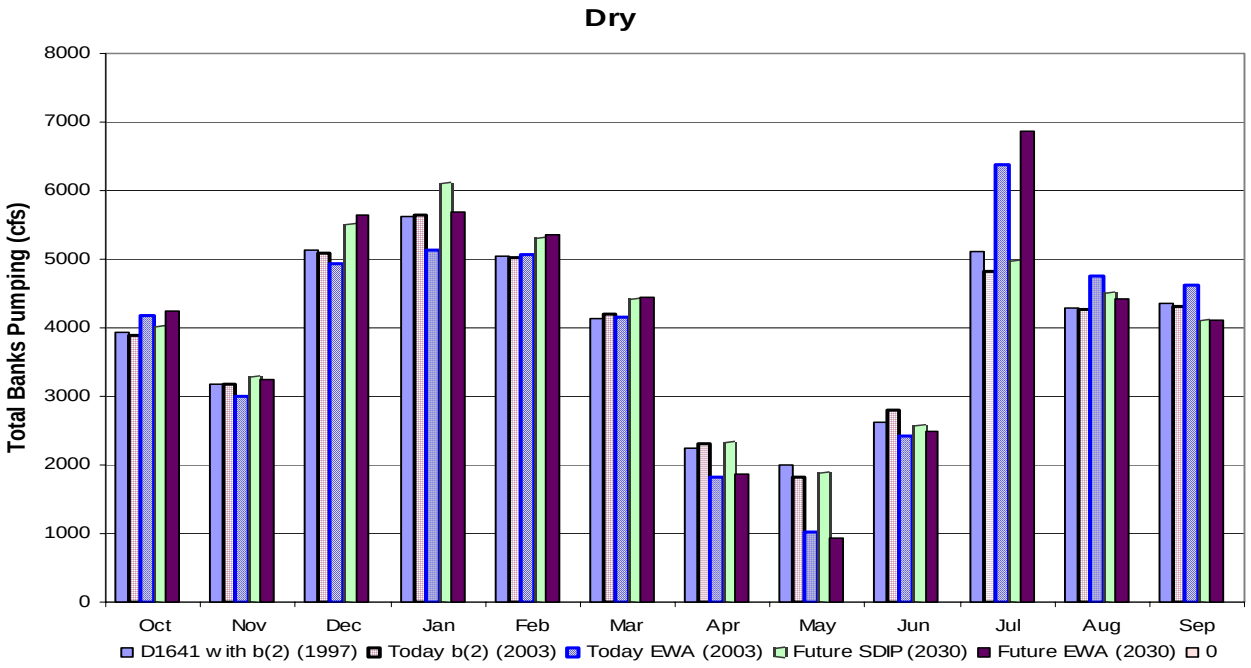


Figure 10-80 Average dry year (40-30-30 Classification) monthly Banks Pumping

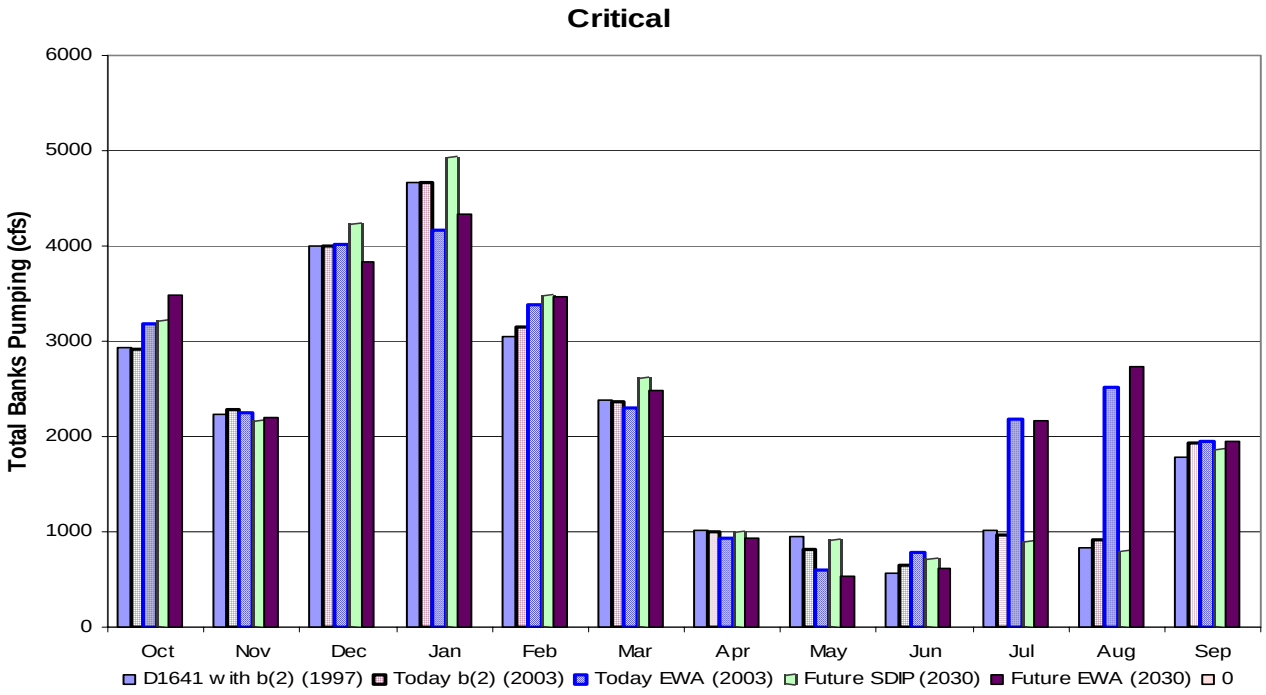
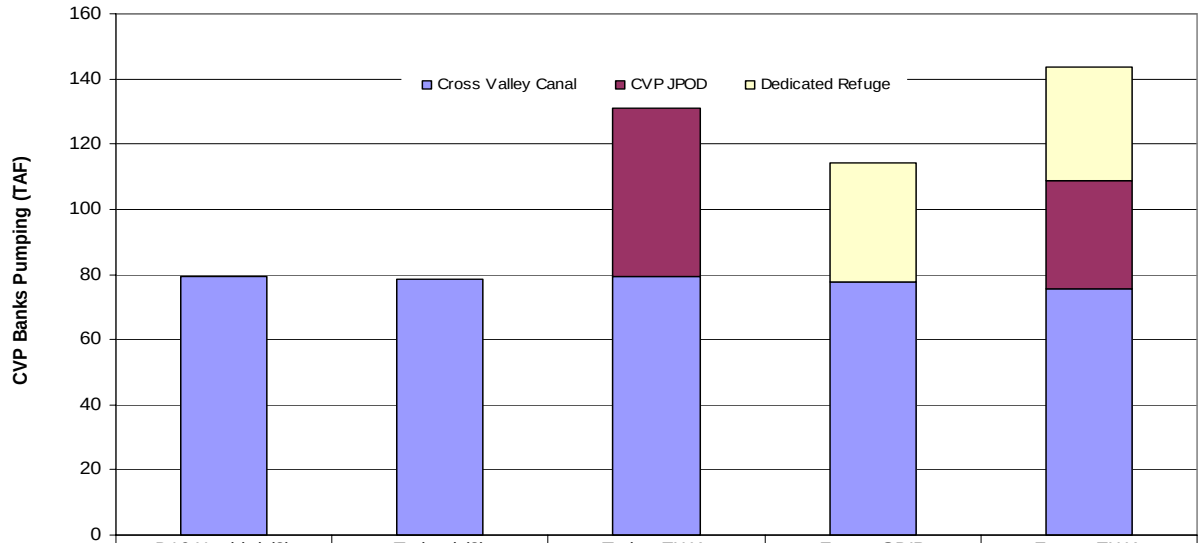


Figure 10-81 Average critical year (40-30-30 Classification) monthly Banks Pumping

Federal Banks Pumping

Federal pumping at Banks generally occurs in the late Summer months, see Figure 10-83. Some Federal pumping occurs during October through March for Cross Valley Contractors. Pumping is generally higher in Studies 4 and 5 due to increased pumping capacity from 6680 cfs to 8500 cfs and the dedicated 100,000 af/Yr. Wet years show the most pumping at Banks with pumping averages decreasing as the years get drier.

Figure 10-82 shows the annual average use of Banks pumping for the CVP by study. The average JPOD pumping in the Today EWA and Future EWA was 52 TAF and 33 TAF respectively. If the Future EWA JPOD includes the dedicated 100,000 af/yr the number is 68 TAF. Pumping for Cross Valley Canal (Tier 1 JPOD pumping) ranges from 75 TAF to 79 TAF between the studies.



	D1641 with b(2)	Today b(2)	Today EWA	Future SDIP	Future EWA
Dedicated Refuge	0	0	0	37	35
CVP JPOD	0	0	52	0	33
Cross Valley Canal	79	78	79	78	75

Figure 10-82 Average use of Banks pumping for the CVP

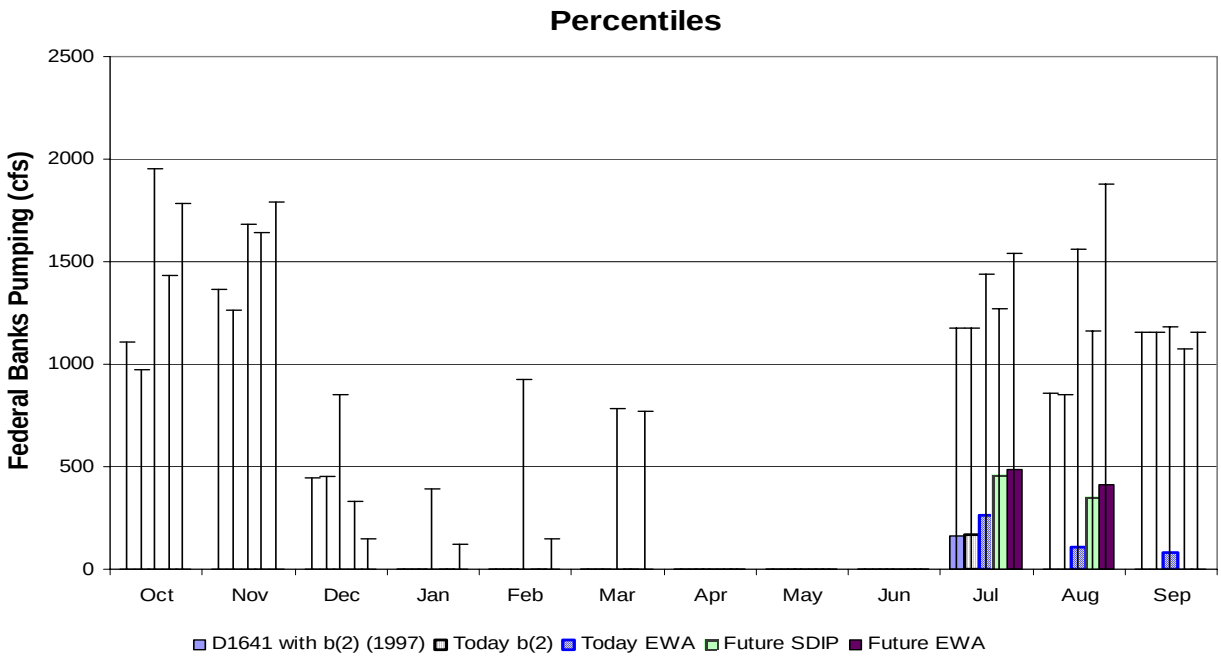


Figure 10-83 Federal Banks Pumping 50th Percentile Monthly Releases with the 5th and 95th as the bars

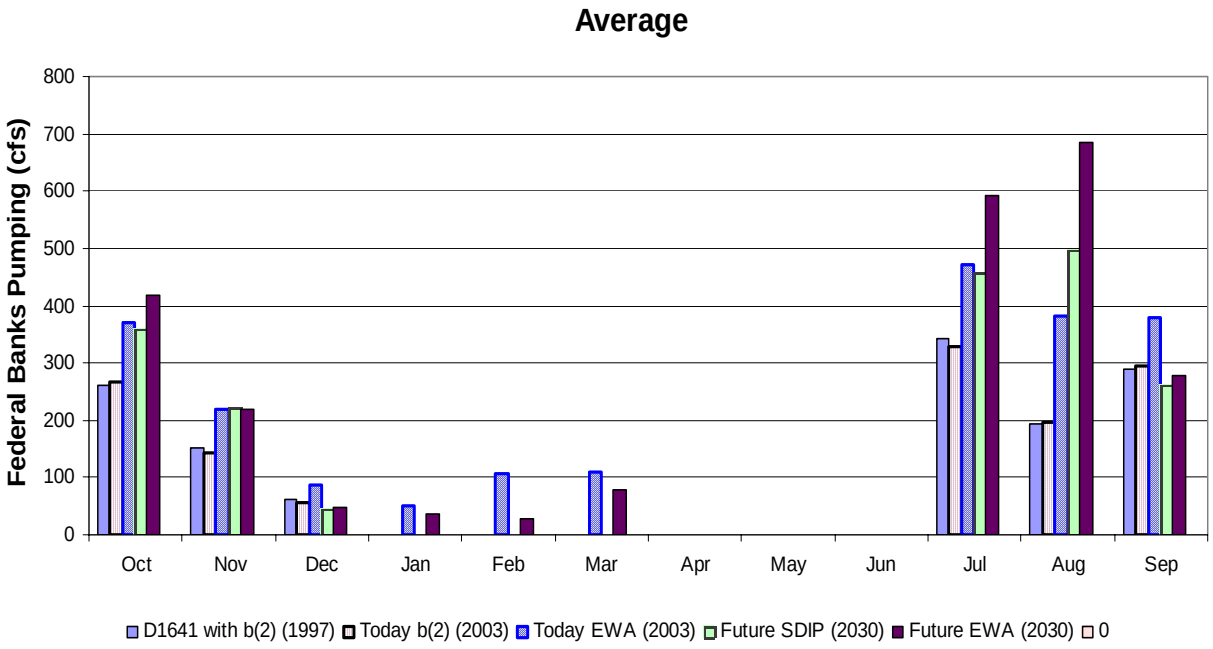


Figure 10-84 Average Monthly Federal Banks Pumping

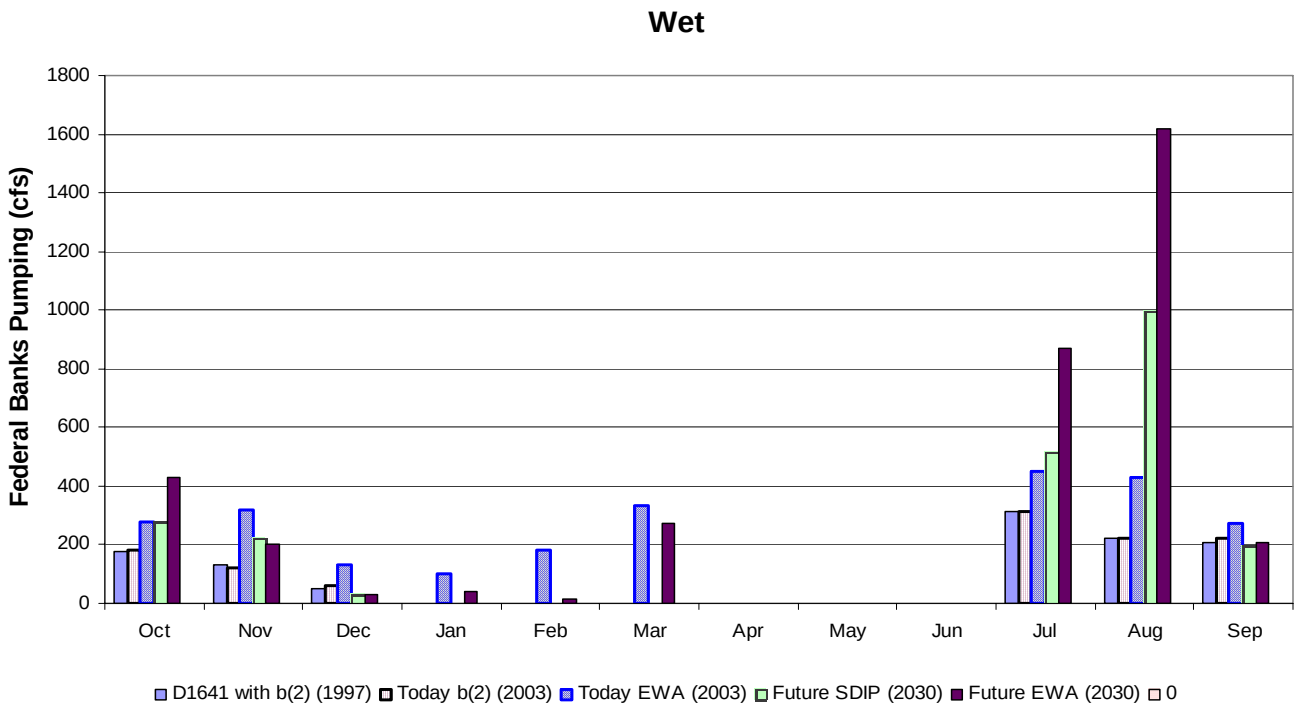


Figure 10-85 Average wet year (40-30-30 Classification) monthly Federal Banks Pumping

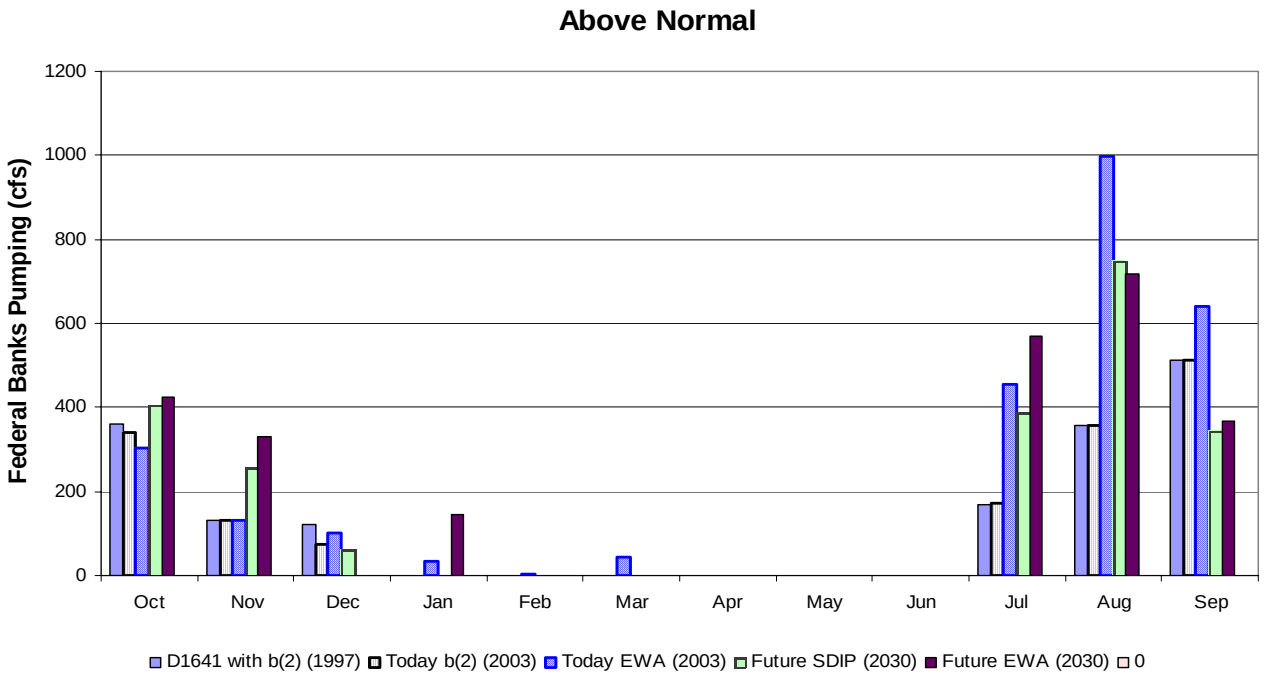


Figure 10-86 Average above normal year (40-30-30 Classification) monthly Federal Banks Pumping

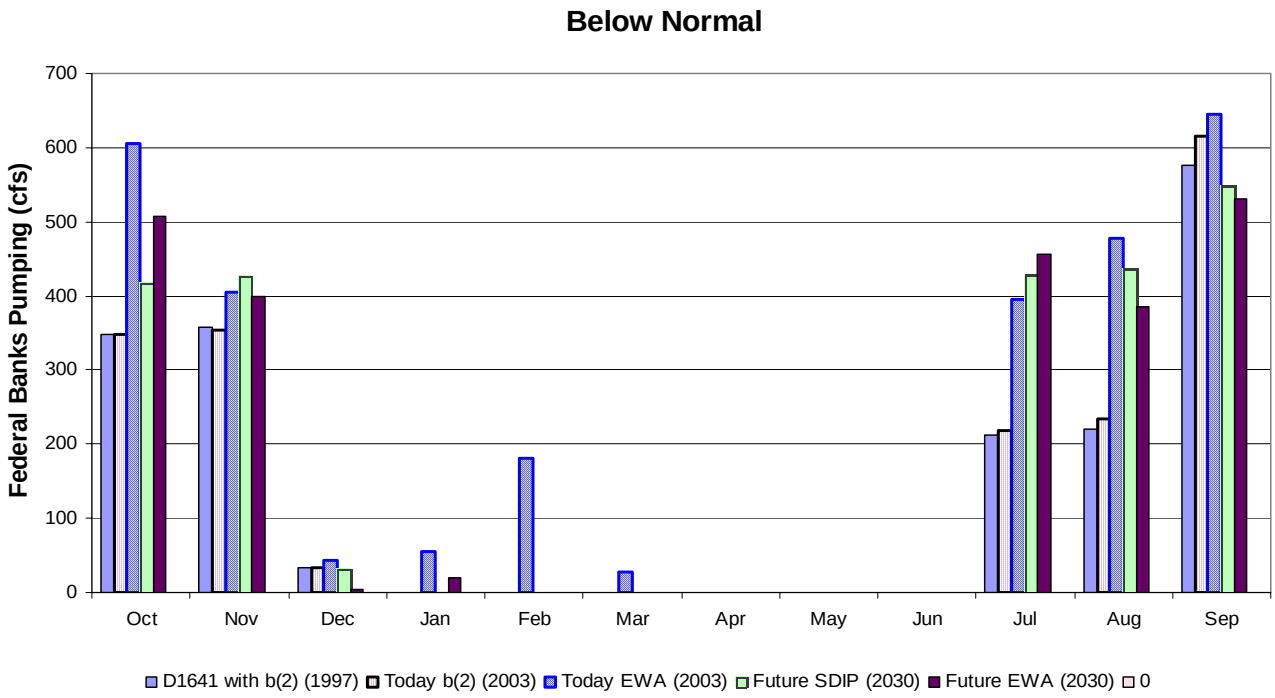


Figure 10-87 Average below normal year (40-30-30 Classification) monthly Federal Banks Pumping

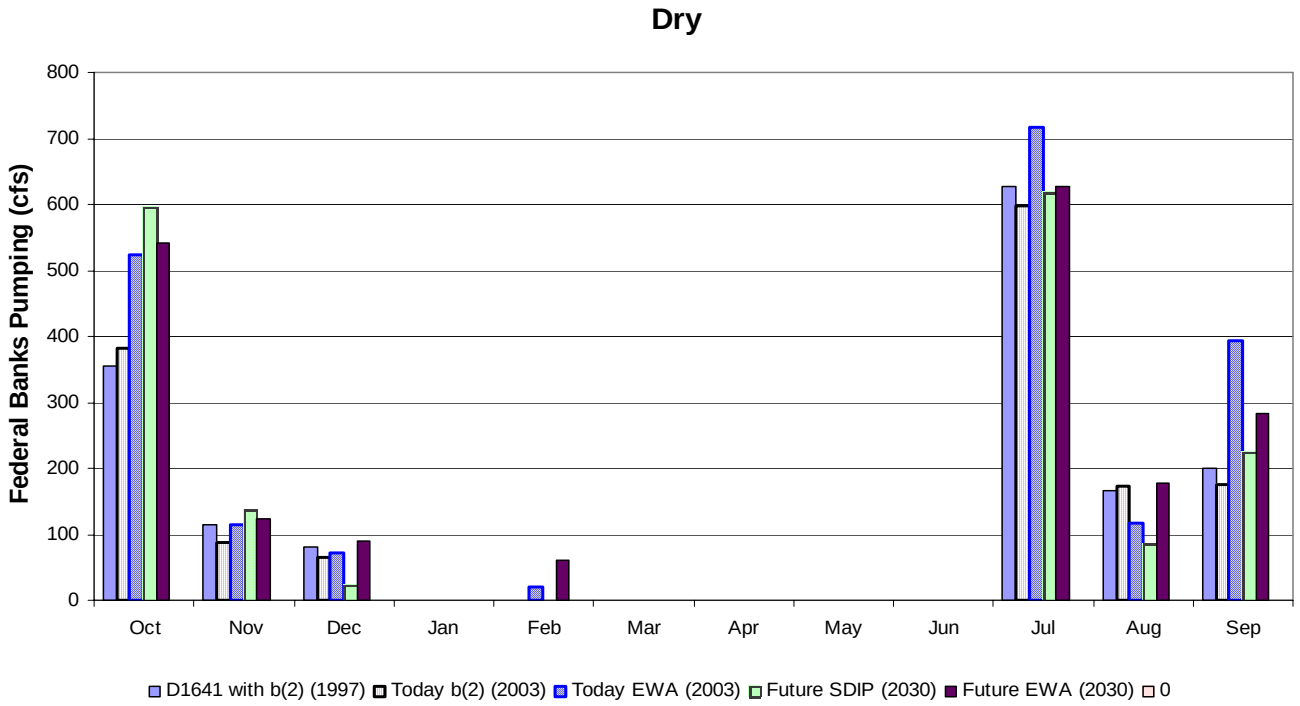


Figure 10-88 Average dry year (40-30-30 Classification) monthly Federal Banks Pumping

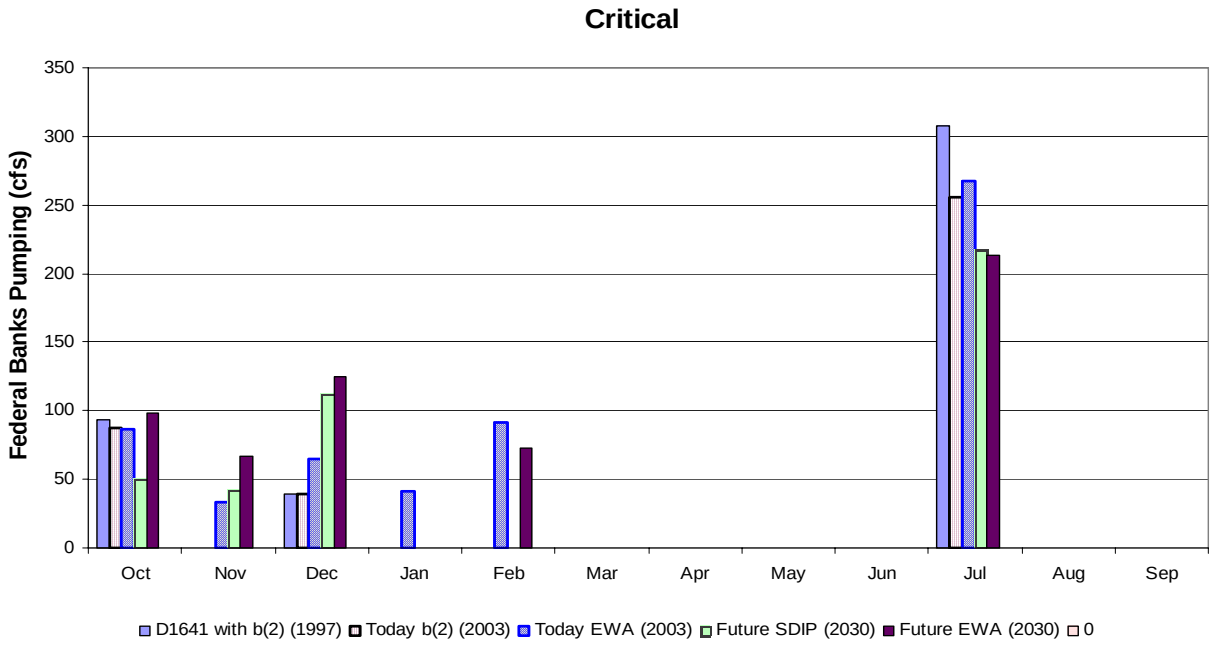


Figure 10-89 Average critical year (40-30-30 Classification) monthly Federal Banks Pumping

Contra Costa Water District and North Bay Aqueduct Diversions

Diversions from Contra Costa Water District and North Bay Aqueduct increased from the 2001 LOD to the 2020 LOD seeTable 10-17. Monthly average diversions at North Bay Aqueduct increased 20 cfs on a long-term average basis for the 72 years of simulation and 15 cfs on average during the 1928 to 1934 drought period. CCWD diversions increased by 47 cfs long-term and 40 cfs during the 1928 to 1934 drought, see Table 8-5 and Figure 10-90 to Figure 10-91. Most of the diversions occur during the late summer months and extend into October for the North Bay Aqueduct. CCWD's pattern peaks in June decreases during the summer and then stays around 200 cfs during the winter period.

Table 10-17 Average Anuual and Long-term Drought Differences in North Bay Aqueduct and CCWD Diversions

Differences (TAF)	Study 2 - Study 1	Study 3 - Study 1	Study 5 - Study 1	Study 4 - Study 2	Study 5 - Study 3
North Bay Aqueduct Long-term Average	0	0	14	14	14
North Bay Aqueduct 28-34 Anuual Average	0	0	11	11	11
CCWD Long-term Average	0	0	34	34	34
CCWD 28-34 Anuual Average	0	0	29	29	29

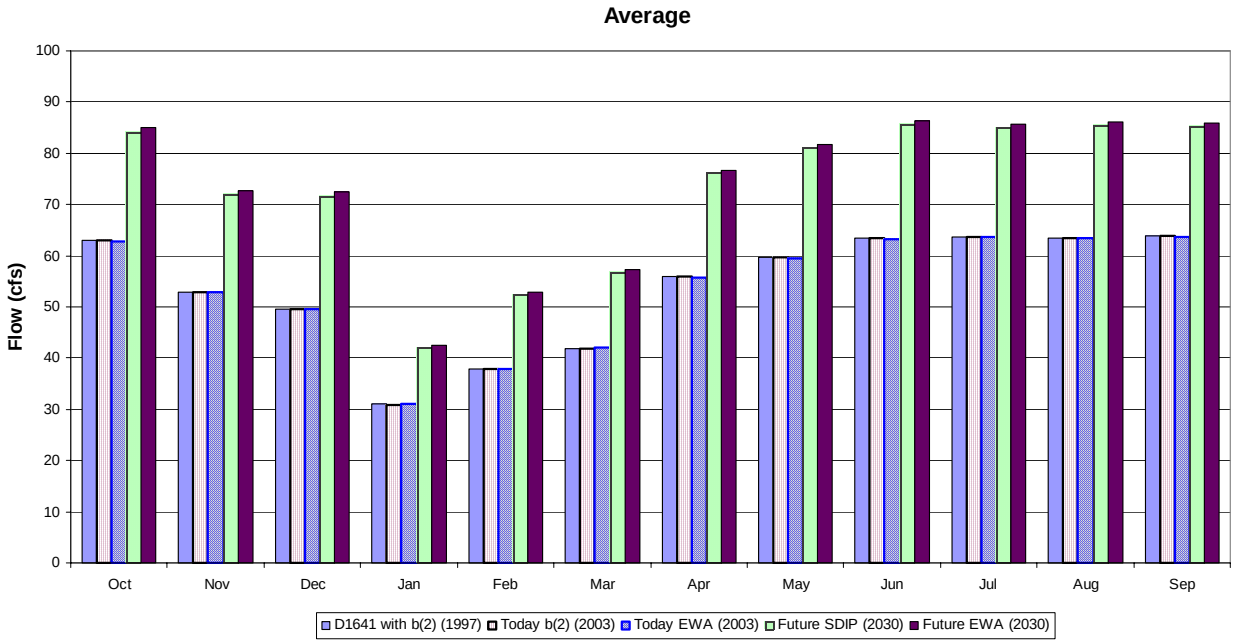


Figure 10-90 Average Monthly North Bay Aqueduct Diversions from the Delta

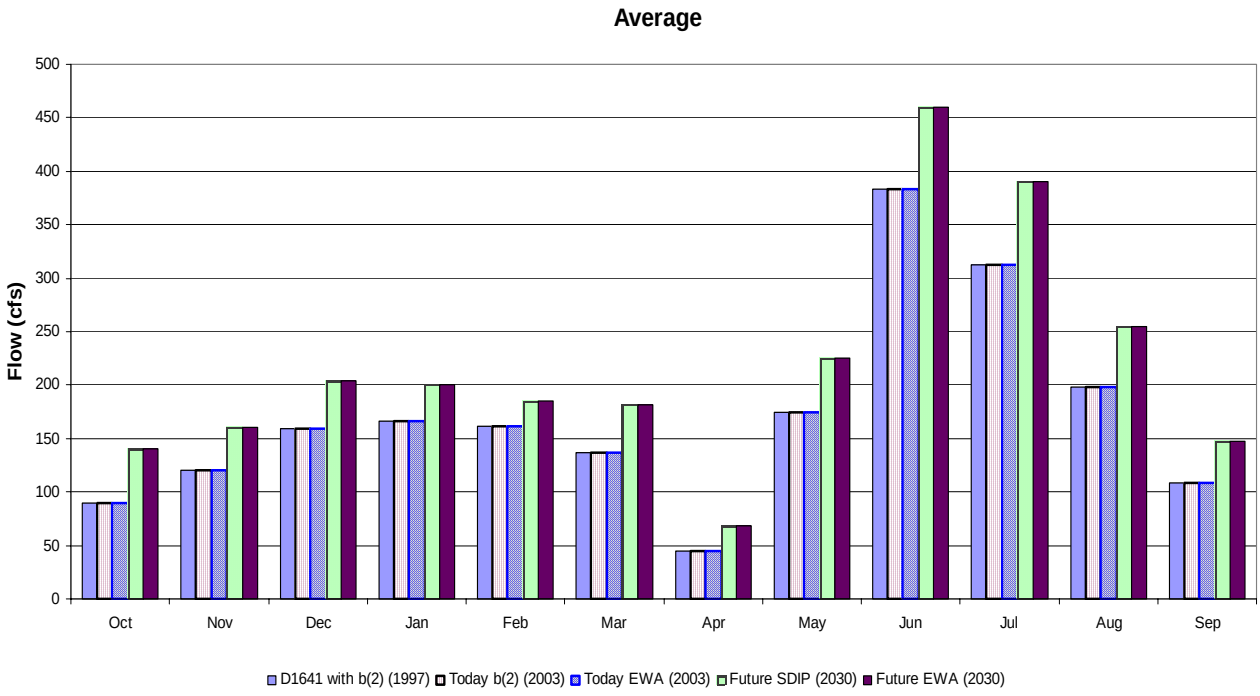


Figure 10-91 Average Monthly Contra Costa Water District Diversions from the Delta

Chapter 11 Summary of Effects Analysis and Effects Determination

Proposed Actions

Trinity Effects

Upsteam effects of Trinity are summarized in Chapter 9. Trinity information begins on page 9-1 to 9-11. Clear Creek information begins on page 9-12 to 9-19 and Sacramento information begins on page 9-20 to 9-41. In the FWS October 12, 2000 B.O. for Trinity there is a RPM about maintaining X2 in the February through June 30 at no more than 0.5 km from the base condition. When we had finished the modeling we looked at the months when X2 was 0.5 km from the base condition. FWS went through the years and we had CH2M Hill do the maps of the delta like they did for the Trinity analyses. An analyses of X2 was also done, see Chapter 10.

American River Effects and Freeport Project

Summarized modeling on page 9-55 to page 9-72. There is a summary of deliveries on the American River in Table 9-12. Figures 9-56 and 9-57 summarized the Freeport project deliveries. Mokelumne summary information is found on page 9-73 .

Intertie Effects

Summarized in Chapter 10 under Tracy Exports, see page 10-37 to page 10-40. Intertie is added in the future model runs to bring Tracy to the full capacity of 4600 cfs.

Delta Effects

Inflow is found on page 10-43 to page 10-50. Outflow is found on page 10-50 to page 10-58. With changes in the upstream system both in the Trinity and American upstream systems there are changes to the delta inflow and outflow. E/I Ratio is found on page 10-58 to page 10-67.

X2 Changes found on page 10-68 to 10-75. As discussed above in the Trinity there was a more extensive look at X2. A comparison between study 1 and both study 4 and study 5 was used. Then differences of 0.5 km or more were made into maps by a GIS person at CH2M Hill. A review of the data reduced the list of concern timeframes.

North Bay Aqueduct see figure 10-90 and Rock Slough, Old River Diversions see figure 10-91. Discussion of the NBA and CCWD diversions is found on page 10-91 to page 10-92.

JPOD also called Federal Banks pumping, see page 10-45 to 10-49. Although we don't show it in the modeling there is also JPOD for the state to pump at Tracy.

Water Transfers Effects

See summary in Chapter 10 at the end.

Early consultation Items

Banks at 8500 cfs is in the future study, summary information on pages 10-83 to 10-86. The CALSIM modeling doesn't include the permanent barriers.

There is an assumption of EWA in the future, this may not be the long-term EWA.

Project Integration is also part of the early consultation. The only items explicitly modeled are the 100,000 acre-feet of CVP pumping at Banks for refuges and up to 75,000 acre-feet of CVP releases made for the SWP delta water quality.

Summary of Effects Analysis

We evaluated potential effects of CVP and SWP operations into the future by examining modeled river flows and temperatures with respect to life history stage, timing of occurrence, and temperature requirements of Central Valley steelhead, Central Valley Chinook salmon, Trinity River coho salmon, and delta smelt . Operations of diversions and facilities affecting migrations were included in the analysis.

Central Valley Steelhead

Upper Sacramento River

Keswick Reservoir releases are expected to provide suitable flows for adult steelhead passage and spawning. The minimum release of 3,250 cfs will sustain the population through dry years. Red Bluff Diversion Dam operations allow most steelhead to pass unimpeded. Operations agreements already in place will help to ameliorate effects due to flood control releases should they occur. Water temperatures provided through operation of the Shasta temperature control device in the upper Sacramento River will be appropriate for all steelhead life history stages present in the upper river year-round. We project that steelhead populations in the upper Sacramento River will be maintained through continued operation of the project. The steelhead life history includes anadromous and resident forms of the species (O. mykiss) allowing populations to persist during periods of poor ocean conditions and periods of low freshwater in streams. The nature of straying allows steelhead to repopulate areas of local disturbance, although no such disturbances requiring straying to repopulate areas are likely to occur due to project operations.

Clear Creek

Whiskeytown Reservoir releases will provide adequate flows for passage and spawning in most years. During some years additional CVPIA (b)(2) water may be needed for better attraction and upstream migration conditions for steelhead. Water temperatures should generally be adequate for all steelhead and Chinook life stages throughout the year in the upper river where Whiskeytown releases have the most effect on water temperature. Whiskeytown project releases will not result in scour of redds. Some minor stranding of juveniles could potentially occur, similar to that which occurs in unregulated rivers. We project that steelhead populations in Clear Creek will be maintained through continued operation of the project. The steelhead life history includes anadromous and resident forms of the species (O. mykiss) allowing populations to persist both during periods of poor ocean conditions and periods of low freshwater in streams.

The nature of straying allows steelhead to repopulate areas of local disturbance, although no such disturbances requiring straying to repopulate areas are likely to occur due to project operations.

Feather River

Flow, habitat, and water temperature conditions should be generally suitable for all steelhead life history stages all year in the low flow channel. The reach below the Thermalito outlet will be less suitable. Water temperatures generally begin exceeding the spawning and emergence recommendations during March. However, this is the latter part of the spawning/emergence season in the Feather River. Summer temperatures will generally exceed 65° F below the Thermalito outlet by June, and will remain too warm for steelhead rearing throughout the summer months. We project that steelhead populations in the Feather River will be maintained through continued operation of the project. The steelhead life history includes anadromous and resident forms of the species (O. mykiss) allowing populations to persist both during periods of poor ocean conditions and periods of low freshwater in streams. The nature of straying allows steelhead to repopulate areas of local disturbance, although no such disturbances requiring straying to repopulate areas are likely to occur due to project operations.

American River

Nimbus Reservoir releases are expected to provide suitable flows for adult steelhead passage and spawning. Operations agreements already in place should ameliorate effects due to flood control releases should they occur. Water temperatures should be generally appropriate for steelhead spawning and emergence from December through March. However, temperatures may be marginal for spawning and emergence during March through May of some years. May through mid-October water temperatures will be marginal for steelhead rearing at times and will be higher in the future. The survival of some juveniles through summer under similar conditions during previous years indicates the conditions are tolerable for some fish. Water temperatures should be appropriate for yearling emigration between December and March. Temperatures will be higher in June through November under the future operations scenarios. The steelhead run in the American will likely continue to be supported primarily by the hatchery with limited successful in-river smolt production in dry water years.

Stanislaus River

No changes in Stanislaus River operations are proposed. Conditions for steelhead in the Stanislaus River should generally be favorable for completion of the life cycle. Goodwin Dam releases will provide suitable flows for adult steelhead passage and spawning. Water temperatures are suitable for adult migration and spawning and juvenile rearing. Water temperatures between Goodwin Dam and Orange Blossom Bridge should be suitable for all steelhead life history stages present most of the year. Temperatures at and below Oakdale may exceed the preferred range for rearing at times during the summer months, but the presence of a large resident trout population in the river indicates suitable in-river conditions. This resident population will be maintained and provide a source of the anadromous form of the species for when San Joaquin migratory conditions are poor at times. The steelhead life history includes anadromous and resident forms of the species (O. mykiss) allowing populations to persist both during periods of poor ocean conditions and periods of low freshwater in streams. The nature of

straying allows steelhead to repopulate areas of local disturbance, although no such disturbances requiring straying to repopulate areas are likely to occur due to project operations.

Mokelumne River

Under current operations, conditions for steelhead in the Mokelumne River will be unchanged. Under future operations the Freeport diversion project will be implemented. Twenty percent (up to 20,000 acre-feet) of the amount of water diverted at Freeport will be made available for Camanche Reservoir releases to the Mokelumne on a schedule determined by CDFG and USFWS. Based on this information conditions for steelhead in the river upstream of Woodbridge Dam should improve in the future. Delta inflow from the Mokelumne will increase slightly in the future so that, although still low, conditions will be slightly improved if the water from Freeport that is released into the Mokelumne River is released at a time and is of adequate quality to benefit steelhead.

Sacramento-San Joaquin Delta

Previous plans in place to protect spring- and winter–run Chinook salmon and delta smelt have helped reduce steelhead salvage, and help to minimize CVP and SWP Delta effects on steelhead. The DAT team will continue to monitor conditions in the Delta so that actions can be taken when higher numbers of steelhead are more vulnerable to being taken at the pumps. Projected operation of other Delta facilities (for example, the North Bay Aquaduct, the Delta Cross Channel, Rock Slough Diversion, and the Suisun Marsh Salinity Control Gates) are not expected to substantially impact steelhead. Steelhead take at these facilities has historically been low relative to the Central Valley Steelhead population as a whole.

Steelhead Summary

CVP and SWP operations result in take of some steelhead. The magnitude and effects on population trends are unknown but the effects on the Central Valley steelhead population should be small relative to the population as a whole. Steelhead population trends in the Central Valley are largely unknown in comparison with Chinook salmon because of the greater difficulty and lower effort occurring to monitor steelhead populations, thus hampering the ability to evaluate effects. Effects of water operations on steelhead populations will be greater during dry years when cold water supplies are not high enough to maintain suitable rearing conditions throughout the habitat generally used by steelhead. Wild steelhead are consistently captured in smolt outmigration monitoring programs and observed in snorkel surveys. This information along with increased efforts to enhance conditions for wild steelhead since they were listed in 1998 suggests that protections and enhancements in freshwater habitats and the Delta are sufficient to maintain populations of Central Valley Steelhead at a level similar to the current population. The steelhead life history includes anadromous and resident forms of the species (O. mykiss) allowing populations to persist both during periods of poor ocean conditions and periods of low freshwater in streams. The nature of straying allows steelhead to repopulate areas of local disturbance, although no such disturbances requiring straying to repopulate areas are likely to occur due to project operations.

Central Valley Winter–run, Spring–run (and Fall/late fall–run for EFH) Chinook Salmon

Upper Sacramento River

Keswick Reservoir releases are expected to provide suitable flows for adult Chinook salmon passage and spawning. The minimum release of 3,250 cfs can sustain the population through dry years if suitable temperatures are maintained in the upper river. Operations agreements already in place will ameliorate effects due to flood control releases when they occur. Water temperatures will be appropriate for most Chinook salmon life history stages year-round during most years in the upper river, but during dry years temperatures during late summer and fall will be above preferred ranges for spawning and rearing so will likely result in lower production than during wet years. Temperatures will increase in the future because less water will be available from the Trinity River. Winter–run spawning has shifted upstream with passage enhancements so that although water temperature will be higher, upper river temperatures will maintain incubation conditions for 98% of winter–run spawning. The few spring–run that spawn in the Sacramento River spawn further downstream than winter–run so effects will be greater on them. During critically dry years most spring–run eggs could suffer mortality due to high water temperature during incubation. A small proportion of the Central Valley spring-run population spawns in the Sacramento River so overall population effects of low spring run production in the mainstem river will be minor. The entire winter-run population spawns in the upper Sacramento River.

Clear Creek

Whiskeytown Reservoir releases should provide adequate flows for passage and spawning most years. During some years additional CVPIA (b)(2) water may be needed for better attraction and upstream migration conditions for spring–run and fall–run. Summer water temperatures are expected to be suitable for adult holding in the upper river. Water temperatures will be suitable for most life history stages above Igo, but spawning and rearing temperatures near the mouth of the creek will be slightly above the preferred range during the summer. A very small proportion of the Central Valley spring-run population enters Clear Creek so overall population level effects of low spring run production in the Clear Creek will be minor.

American River

No listed Chinook runs spawn in the American River. Flows are projected to be adequate for fall–run Chinook spawning in normal water conditions but if dry conditions occur, flows are projected to provide less than optimal spawning habitat for Chinook. Flows in the spring should be adequate for outmigration. Temperature goals for fall–run Chinook spawning and incubation are projected to be met in November of almost every year but meeting the goals will likely involve trade-offs between providing cool water for better steelhead rearing conditions during the summer and providing it for Chinook spawning in the fall. Water temperatures for Chinook rearing are forecast to exceed the preferred range generally starting in April. Most Chinook leave the river by early April. Temperatures will be higher in June through November under future operations due to increased upstream diversions, causing more temperature stress on migrating and holding adults in the fall.

Stanislaus River

No listed Chinook runs spawn in the Stanislaus River. Flows are projected to be adequate for fall–run Chinook spawning in nearly all years. Water temperatures will be warm in the lower part of the river during the early part of the immigration period but should be suitable for spawning and rearing in the upper river during the entire spawning and rearing period. Temperatures should be suitable for outmigration of fry and smolts, but when dry conditions occur, flows can be less than desired for optimal outmigration prior to the VAMP period. No changes in operations are proposed for the Stanislaus River.

Feather River

Flow and water temperature conditions should be generally suitable for all spring–run Chinook salmon life history stages all year in the low flow channel, particularly in the upper low flow channel. However, superimposition on spring–run Chinook salmon redds by fall–run Chinook may continue to be a problem. The reach below the Thermalito outlet will be less suitable. Water temperatures below Thermalito will be too warm for adult holding and spawning, but will be appropriate for juvenile rearing and emigration during winter and early spring.

Sacramento-San Joaquin Delta

Increases in loss due to export changes are less than 10% in all year types except for during wet years at Banks without EWA when spring run sized loss increases by an average of 14.6% and steelhead loss increases by 10.2% (mostly March through May). Loss is generally less with EWA than without EWA. Actions taken in the past to protect winter–run and spring–run Chinook and delta smelt provide protection during the winter and spring, thereby reducing the impact of CVP and SWP Delta operations. Emigrating yearling Chinook salmon will receive protection from actions triggered through the Salmon Protection Decision Process during the emigration period. The DAT team will continue to keep an eye on fish monitoring data throughout the system so that operational adjustments can be made during times of high salvage.

Winter-run and spring-run Chinook Summary

Chinook losses due to CVP and SWP operations may be substantial. However, the cohort replacement rate methodology discussed in Chapter 4 indicates Chinook salmon populations are generally increasing. The CRR data from the Sacramento River, Deer, Mill and Butte creeks suggest existing protections and enhancements in the upper watershed and the Delta are sufficient to maintain populations of Central Valley winter–run, Central Valley spring–run and fall/late fall–run Chinook salmon during the continued operations of the CVP and SWP considered in this consultation. The spring run population utilizes primarily non-project tributaries for spawning and rearing and uses the Sacramento River and Delta as a migratory corridor. Migratory conditions will be adequate to maintain the spring run and winter-run populations.

Southern Oregon/Northern California Coasts Coho Salmon

The southern Oregon/northern California coasts coho salmon occurs in the Trinity River. Under todays operations Reclamation is proposing no changes in Trinity River flows. These flows will provide habitat and temperature conditions similar to the recent past and should not negatively

affect the existing coho population. Under future operations Reclamation would implement higher flows for the Trinity River Restoration Program in the Trinity River during wet years. The net effect of future CVP operations on coho salmon in the Trinity River should be a benefit to the population through the habitat values provided as outlined in the Trinity River Restoration Program.

Delta Smelt

We have considered (1) changes in expected direct entrainment loss at the CVP and SWP export facilities, (2) changes in X2, and (3) changes in the Export-Inflow ratio (E/I).

(1) Potential changes in entrainment are important indices of the effects of facility operations because entrainment directly reduces the pool of delta smelt available to replenish the population. Under the future scenarios considered we expect increases in the entrainment of unspent adults at the SWP and CVP export facilities in some months. Whether these entrainment increases will cause subsequent year classes to be smaller in size is unclear. We conclude that increased entrainment of unspent adult delta smelt at the export pumps may sometimes adversely affect the species. There is a net decrease in entrainment of juvenile delta smelt under the future scenarios considered. We conclude that changes in entrainment of juvenile delta smelt at the export pumps presents no threat to the species.

(2) Changes in X2 may not in themselves increase mortality, but may modify the proportion of the delta smelt population at risk of becoming entrained into the export facilities. Changes in X2 in drier years, when X2 is farther upstream to begin with, are sufficiently small and uncommon that we do not expect them to adversely affect delta smelt in most years. However, in a few years the movements of X2 during critical months may adversely affect the delta smelt population.

(3) The export-inflow ratio can index the extent to which export operations influence the pattern of flow through the delta, and may be useful where comparisons can be made at constant inflow. The index does not, however, tell us which areas of the delta are influenced by the pumps, nor is it reliable when comparisons cannot be made at constant inflow. Differences in E/I between the base model case and both future scenarios are sufficiently small that we do not expect them to adversely affect delta smelt.

Summary of Beneficial Effects

CVPIA (b)(2) and EWA, VAMP. Adaptive Management. See Chapter 13 for more.

Cumulative Effects

Cumulative effects include the effects of future State, tribal, local, or private actions that are reasonably certain to occur in the action area of this biological assessment. Future Federal actions that are unrelated to the proposed action are not included because they require separate ESA consultation.

Non-Federal actions that may affect the action area include State angling regulation changes, commercial fishing management changes, voluntary State or private habitat restoration, State hatchery practices, agricultural practices, water withdrawals/diversions, increased population

growth, mining activities, and urbanization. State angling regulations are generally moving towards greater restrictions on sport fishing to protect listed fish species. Commercial fishing regulations are designed to target the abundant fall–run Chinook and avoid fishing during times and in areas where listed species are more likely to be caught. Habitat restoration projects may have short term negative effects associated with construction but the outcome is generally a benefit to listed species. State hatchery practices may have negative effects on naturally produced salmon and steelhead through genetic introgression, competition, and disease transmission from hatchery introductions. Farming activities may have negative effects on Sacramento and San Joaquin water quality due to runoff laden with agricultural chemicals. Water diversions may result in entrainment into diversions and may result in reduced flows necessary for migration, spawning, rearing, and habitat maintenance. The increased temperatures in the American River in the future are primarily the result of an increase in upstream diversions lowering the coldwater pool in Folsom. Urban development and mining may adversely affect water quality, riparian function, and stream productivity.

Determination of Effects

The following determination of effects for Central Valley Steelhead, Central California Coast Steelhead, winter–run Chinook salmon, spring–run Chinook salmon, coho salmon, and delta smelt considers direct and indirect effects of the proposed action on the listed species together with the effect of other activities that are interrelated or interdependent with the action. These effects are considered along with the environmental baseline and the predicted cumulative effects. The reasoning for the effects determinations is presented in the summary of effects above.

Central Valley Steelhead

Storage and release of water for project purposes will affect river flows and temperatures downstream of project reservoirs and may affect, and is likely to adversely affect Central Valley steelhead.

Diversion of water downstream of reservoirs and in the Delta may affect and is likely to adversely affect Central Valley steelhead at fish screens and pumps.

Effects of project operations on the central Valley steelhead population as a whole are not likely to jeopardize the continued existence of Central Valley steelhead. Wild steelhead reproduce and rear in additional tributaries with no CVP or SWP facilities.

Central California Coast Steelhead

Central California Coast Steelhead may be present in Suisun Bay streams (Suisun Creek and Green Valley Creek) and points to the west. Because this area is at the downstream influence of CVP and SWP operations no effect on steelhead of this ESU is anticipated. Changes in operations in the Delta are not great enough to affect these steelhead that migrate through the lower end of the Delta.

Winter–run Chinook salmon

Storage and release of water for project purposes will affect river flows and temperatures downstream of project reservoirs and may affect, and is likely to adversely affect winter–run Chinook salmon.

Diversion of water downstream of reservoirs and in the Delta may affect, and is likely to adversely affect winter–run Chinook salmon at fish screens and pumps.

Effects of project operations on winter-run Chinook salmon are not likely to jeopardize the continued existence of the species and should be able to provide for additional population increases above existing population levels.

Spring–run Chinook salmon

Storage and release of water for project purposes will affect river flows and temperatures downstream of project reservoirs and may effect, and is likely to adversely affect spring–run Chinook salmon.

Diversion of water downstream of reservoirs and in the Delta may affect, and is likely to adversely affect spring–run Chinook salmon at fish screens and pumps.

Effects of project operations on the spring run Chinook population as a whole are not likely to jeopardize the continued existence of Central Valley steelhead. Most spring run reproduce in tributaries without CVP or SWP facilities.

Coho salmon in Trinity River

Release of water into the Trinity River will affect flows and temperatures downstream of Lewiston Reservoir and may affect and is not likely to adversely affect coho salmon in the Trinity River.

Delta Smelt

We conclude that changes in entrainment of juvenile delta smelt at the export pumps presents no threat to the species. In a few years the movements of X2 during critical months may adversely affect the delta smelt population. Differences in E/I between the base model case and both future scenarios are sufficiently small that we do not expect them to adversely affect delta smelt.

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Chapter 12 Essential Fish Habitat Assessment

Essential Fish Habitat Background

The Magnuson-Stevens Fishery Conservation and Management Act (Magnuson-Stevens Act) mandates Federal action agencies which fund, permit, or carry out activities that may adversely impact the essential fish habitat (EFH) of Federally managed fish species to consult with the NOAA Fisheries regarding the potential adverse effects of their actions on EFH (Section 305 (b)(2). Section 600.920(a)(1) of the EFH final regulations state that consultations are required of Federal action agencies for renewals, reviews, or substantial revisions of actions if the renewal, review, or revision may adversely affect EFH. The EFH regulations require that Federal action agencies obligated to consult on EFH also provide NOAA Fisheries with a written assessment of the effects of their action on EFH (50 CFR Section 600.920). The statute also requires Federal action agencies receiving NOAA Fisheries EFH Conservation Recommendations to provide a detailed written response to NOAA Fisheries within 30 days upon receipt detailing how they intend to avoid, mitigate or offset the impact of the activity on EFH (Section 305(b)(4)(B).

The objective of this EFH assessment is to describe potential adverse effects to designated EFH for Federally-managed fisheries species within the proposed action area. It also describes conservation measures proposed to avoid, minimize, or otherwise offset potential adverse effects to designated EFH resulting from the proposed action.

The northern anchovy and starry flounder are managed as “monitored species” by the Coastal Pelagic Species Fishery Management Plan and the Pacific Coast Groundfish Fishery Management Plan of the Pacific Fishery Management Council (PFMC), respectively, and are subject to Essential Fish Habitat consultation as a result (PFMC 1998a, 1998c).

The fall/late fall-run Chinook salmon is a candidate species and information is found in the salmon Chapters 4 and 5 of this document for EFH.

Identification of Essential Fish Habitat

Essential fish habitat is defined as those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity. For the purpose of interpreting the definition of EFH, “waters” include aquatic areas and their associated physical, chemical, and biological properties that are used by fish, and may include areas historically used by fish where appropriate; “substrate” includes sediment, hard bottom, structures underlying the waters, and associated biological communities; “necessary” means habitat required to support a sustainable fishery and a healthy ecosystem; and “spawning, breeding, feeding, or growth to maturity” covers a species full life cycle.

The Coastal Pelagic Species Fishery Management Plan has designated essential fish habitat for all coastal pelagic species, including the central subpopulation of the northern anchovy (PFMC 1998a). Essential fish habitat is defined to be all marine and estuarine waters along the Pacific coast from Washington to California. The specific limits of this area are defined by temperature-based thermoclines and isotherms, which vary seasonally and annually (PFMC 1998a). The level

of EFH information is 1 (Presence/absence distribution data are available) for this species (PFMC 1998a).

Reclamation's proposed operation is described in Chapter 3 of the BA for the CVP OCAP. The Bay/Delta provides habitat for northern anchovy (*Engraulis mordax*) and starry flounder (*Platichthys stellatus*), which are covered under the EFH provisions of Magnuson-Stevens Act, but are not listed under the ESA. DWR's proposed operation is described in Chapter 4 of the OCAP. Chapter 2 of OCAP has the overall operations of both projects.

Essential Fish Habitat Requirements for Northern Anchovy

The northern anchovy occurs from Suisun Bay to South San Francisco Bay and occasionally in the lower Delta. This species is most abundant downstream of the Carquinez Strait and outside the Bay in the California Current (Herbold et al. 1992, Goals Project 2000).

The east-west geographic boundary of EFH for the northern anchovy is defined to be all marine and estuarine waters from the shoreline along the coasts of California, Oregon, and Washington offshore to the limits of the exclusive economic zone and above the thermocline where sea surface temperatures range between 10° C to 26° C (50 ° F to 78.8 ° F). The southern extent of EFH for the anchovy is the United States-Mexico maritime boundary. The northern boundary of the anchovy's EFH is the position of the 10° C (50 ° F) isotherm which varies both seasonally and annually (PFMC 1998b).

The adults and juveniles of the northern anchovy are pelagic and form tightly packed schools that range from the water surface to 164 fathoms deep (McCrae 1994). This species is found from seawater to mesohaline (moderately brackish water with salinity range of 5 to 18 ppt) and occasionally found in oligohaline (brackish water with low salinity range of 0.5 to 5 ppt) areas. Adults are found in estuaries, near-shore areas, and out to 300 miles offshore, although most are found within 100 miles of shore (Airame 2000). Juveniles are abundant in shallow near-shore areas and estuaries.

The northern anchovy does not migrate extensively but does have inshore-offshore, along-shore, and daily movements (McCrae 1994). Although northern anchovy are found in the San Francisco Bay area throughout the year, they tend to peak there from April to October (Goals Project 2000). The spring influx to the bay areas may result from higher temperatures and increasing plankton production in the bay and coastal upwelling; the autumn exodus may be linked to cooler temperatures in the bay. Larvae and juveniles that were spawned in late summer tend to overwinter in the bay. In the summer and fall months, anchovy larvae follow the salt wedge into warm, productive shallows of Suisun Bay and the lower Delta (Berkeley Elibrary 2002). Schooling juveniles are found in sea- and freshwater in the Sacramento-San Joaquin estuary, especially in July and August. During the summer, adults and juveniles have daily movements from 60 to 100 fathoms deep in the day to surface waters at night (Bergen and Jacobson 2001).

Anchovies feed diurnally either by filter feeding or biting, depending on the size of the food (Berkeley Elibrary 2002). Juvenile and adult northern anchovies are considered secondary and higher consumers, selectively eating larger zooplankton, fish eggs, and fish larvae. First-feeding larvae eat phytoplankton and dinoflagellates, while larger larvae pick up copepods and other zooplankton. Female anchovies need to eat approximately 4 to 5 percent of their wet weight per day for growth and reproduction (Goals Project 2000).

The northern anchovy spawns in batches throughout the year and the timing of spawning varies by area. This species is a broadcast spawner and females can produce up to 30,000 eggs a year in batches of about 6,000. Most spawning takes place in channels or within 60 miles of the coast in the upper mixed layers at night, in water temperatures of 54º F to 59º F. The San Francisco Bay is thought to provide favorable reproductive habitat for the anchovy because abundant food exists for both adults and larvae and coastal upwelling keeps eggs and larvae in productive areas. Spawning in the bay occurs at higher temperatures and lower salinities than spawning in coastal areas (McCrae 1994, Bergen and Jacobson 2001).

Northern anchovy eggs are oval, pelagic, and approximately 1.5 by 0.75 millimeters (mm) in size. Larvae range in size from 2.5 to 25 mm in length and begin schooling at 11 to 12 mm in length. Juveniles range in size from 25 to 140 mm in length. Some fish mature at less than one year of age (71 to 100 mm) and all are nature at two to three years. Maximum age is seven years, but most live for four years. Maximum size is about 230 mm, although most are not over 158 mm in length (McCrae 1994, Bergen and Jacobson 2001).

The northern anchovy is one of the most abundant and productive fishes in the San Francisco Bay area (Berkeley Elibrary 2002). All life stages of the northern anchovy are important prey for virtually every predatory fish, bird, and mammal in the California current, including California halibut, Chinook and Coho salmon, rockfishes, yellowtail, tunas, sharks, squid, harbor seal, northern fur seal, sea lions, common murre, brown pelican, sooty shearwater, and cormorants. The breeding success of California brown pelicans is correlated with anchovy abundance (Bergen and Jacobson 2001). Competitors with the anchovy include sardines and other schooling planktivores, such as jacksmelt and topsmelt. These species are also potential predators on young anchovy life stages (Goals Project 2000).

Essential Fish Habitat Requirements for Starry Flounder

The starry flounder is covered by the West Coast Groundfish Fishery Management Plan (PFMC 1998c). Starry flounder range from the Sea of Japan, north to the Bering Sea and the Arctic coast of Alaska, and southward down the coast of North America to southern California (Haugen and Thomas 2001). Starry flounder can be found in Suisun Bay and the lower portion of the San Joaquin River in the Delta. The distribution of the starry flounder tends to shift with growth. Young juveniles are commonly found in fresh or brackish water of Suisun Bay, Suisun Marsh, and the Delta, older juveniles range from brackish to marine water of Suisun and San Pablo Bays, and adults tend to live in shallow marine waters within and outside the San Francisco Bay before returning to estuaries to spawn (Goals Project 2000).

The starry flounder was a common species in commercial and recreational fisheries of California prior to the 1980s, but has declined dramatically in the 1990s. This flounder is generally not targeted by commercial fishers, except in Puget Sound, but is mostly taken as by-catch by bottom trawl, gill nets, and trammel nets. Recreational catch occurs by angling from piers, boats, and shore in estuarine and rocky areas (PFMC 1998d). Commercial catch trends suggest that populations of this flounder are at extremely low levels, reduced from more than million pounds of annual landings in the 1970s to an average of 62,225 pounds of annual landings in the 1990s (Haugen and Thomas 2001). SWP/CVP fish salvage facilities in the Sacramento-San Joaquin Delta recorded average monthly salvage records for the starry flounder for the period from 1981 to 2002 as 187 fish per month at CVP and 77 at SWP (Foss 2003).

Starry flounder is an important member of the inner continental shelf and shallow sublittoral communities, and is one of the most common flatfish in the San Francisco Bay and Delta (Haugen and Thomas 2001). Older juveniles and adults are found from 120 km up coastal rivers to the outer continental shelf at 375 m, but most adults are found within 150 m. Spawning occurs in estuaries or sheltered inshore bays in water less than 45 m deep (Goals Project 2000). Juveniles prefer sandy and muddy substrates and adults prefer sandy and coarse substrates. Eggs are found in polyhaline (brackish water with moderate salinity range from 18 to 30 ppt) to euhaline (brackish water with high salinity range from 30 to 40 ppt) waters; juveniles are found in mesohaline (brackish water with moderate salinity range from 5 to 18 ppt) to fresh waters; adults and larvae are found in euhaline to fresh waters. All life stages can survive and grow at temperatures below 0º C to 12.5º C (32º F to 54.5º F) (Orcutt 1950).

Starry flounder is not considered to be a migratory species. Adults move inshore in winter or early spring to spawn and offshore and deeper in the summer and fall, but these coastal movements are generally less than 5 km. Some starry flounder have shown movements of greater than 200 km, but this is not considered typical. Adults and juveniles are known to swim great distances up major coastal rivers (greater than 120 km) but this is not a migratory trend. Larvae may be transported great distances by oceanic currents (CDFG 2001).

Starry flounder are oviparous; eggs are fertilized externally. Spawning occurs annually in a short time frame in winter and spring, with the exact timing depending on location. In central California, starry flounder spawn from November to February, peaking in December and January (Orcutt 1950). The number of eggs produced by females depends on fish size; a 56 cm fish can produce 11,000,000 eggs (CDFG 2001). Fertilized eggs are spherical and between 0.89 and 1.01 mm in diameter (Orcutt 1950). Eggs hatch in 2.8 days at 12.5º C (54.5º F), 4.6 days at 10.0ºC (50º F), and 14.7 days at 2.0° C to 5.4º C (35.6º F to 41.7º F). Eggs are pelagic and occur at or near the surface over water 20 to 70 m deep (CDFG 2001).

Eggs and larvae of the starry flounder are epipelagic, while juveniles and adults are demersal. Larvae are approximately 2 mm long at hatching and they start settling to the bottom after two months at approximately 7 mm in length. Metamorphosis to the benthic juvenile form occurs at 10 to 12 mm and sexually immature juveniles range in size from 10 mm to 45 cm, depending on sex (Orcutt 1950). Transforming larvae and juveniles depend on ocean currents to keep them in rearing areas near estuarine areas and the lower reaches of major coastal rivers (Goals Project 2000). Starry flounder tend to rear for up to two years in estuarine areas before moving to shallow coastal marine waters. Adults occur in estuaries or their freshwater sources year-round in Puget Sound. Females begin maturing at 24 cm and three years, but some may not mature until 45 cm and four to six years. Males begin maturing at two years and 22 cm, but some may not reach maturity until four years and 36 cm (Orcutt 1950). Maximum age is reported as 21 years and maximum length is 915 mm.

Starry flounder change their diet as they develop from pelagic to demersal stages (Orcutt 1950). Larvae tend to be planktivorous and eat copepods, amphipods, eggs and nauplii as well as barnacle larvae and diatoms. Juveniles and adults are primary to secondary carnivores on larger benthic invertebrates. Newly metamorphosed juveniles feed on copepods, amphipods, annelid worms, and the siphon tubes of clams. Larger fish with jaws and teeth feed on a wider variety of items, including clams, crabs, polychaete worms, sand dollars, brittle stars, and other more mobile foods (Orcutt 1950). Starry flounder do not feed during spawning or coldwater periods.

Starry flounder larvae and juveniles are eaten by larger fish, and wading and diving seabirds (e.g., herons and cormorants). Adults are eaten by pinnipeds, larger fishes, sharks and marine mammals.

The starry flounder probably competes with other soft-bottom benthic fishes of estuaries and shallow nearshore bays. Individuals with characteristics intermediate between starry flounder and English sole are evidence of possible hybridization between those species (Haugen and Thomas 2001).

The Pacific Coast Groundfish Fishery Management Plan (PFMC 1998c) has designated EFH for 83 species of groundfish, which taken together include all waters from the high water line, and the upriver extent of saltwater intrusion in river mouths along the coast from Washington to California. Composite habitats most important for the starry flounder are estuarine (for all life stages), non-rocky shelf (for juveniles and adults), and neritic habitats (for eggs and larvae), as defined by the fishery management plan (PFMC 1998d). The level of EFH information is 1 (Presence/absence distribution data are available) for all life stages of this species. When Level 1 information is available, EFH for a species' life stage is its general distribution, the geographic area of known habitat associations containing most (e.g., about 95 percent) of the individuals (PFMC 1998d). The National Marine Fisheries Service is proposing to amend the fishery plan to identify and describe essential fish habitat for each managed groundfish species (PFMC 1998c).

Potential Adverse Effects of Proposed Project

Northern Anchovy

Because Northern anchovy is primarily a marine species and CVP and SWP operations have little effect on marine conditions, there are not expected to be any adverse effects from the proposed project on EFH for the northern anchovy.

Starry Flounder

The withdrawal of seawater can create unnatural conditions to the EFH of starry flounder. Various life stages can be affected by water intake operations such as entrapment through water withdrawal and impingement on intake screens. Starry flounder salvage occurs at the CVP and SWP export facilities (Table 12–1). Most salvage occurs in May, June, and July. High approach velocities along with intake structures can create unnatural conditions to the EFH of starry flounder. These structures may withdraw most larval and post-larval organisms, and some proportion of more advanced life stages. Periods of low light (e.g., turbid waters, nocturnal periods) may also entrap adult and subadults. Freshwater withdrawal also reduces the volume and perhaps timing of freshwater reaching estuarine environments, thereby potentially altering circulation patterns, salinity, and the upstream migration of saltwater.

Starry flounder is primarily a marine and estuarine species. CVP and SWP operations do not significantly affect marine conditions, although they can affect estuarine conditions and some take occurs at the pumping plants. The proposed CVP OCAP can affect EFH of the starry flounder in the Delta by changing flow and water quality. Starry flounder is a widespread species not directly targeted by commercial fisheries. Effects to starry flounder habitat are minor

relative to flounder habitat as a whole and no commercial fisheries will be affected by localized effects on the habitat or population.

Table 12–1 Starry flounder salvage at the SWP and CVP export facilities, 1981 – 2002.

Starry Flounder Salvage at the SWP and CVP Delta Fish Salvage Facilities, 1981 - 2002													
				1 = SWP, 2 = CVP									
Sum of SALVAGE			Sum of SA	FACILITY									
MONTH	Total		MONTH	1	2	Grand Total							
1	24		1		24	24							
2	181		2		181	181							
3	33		3	33		33							
4	325		4	294	31	325							
5	1733		5	795	938	1733							
6	7188		6	6174	1014	7188							
7	2242		7	1849	393	2242							
8	295		8	154	141	295							
9	51		9	27	24	51							
10	76		10		76	76							
11	6		11	6		6							
12	12		12		12	12							
Grand Total	12166		Grand Tot	9332	2834	12166							

Sum of SALVAGE	MONTH												
YEAR	1	2	3	4	5	6	7	8	9	10	11	12	Grand Total
1981				169	405			48	19				641
1983						60							60
1984						294							294
1985					154	2429	78						2661
1986				31	46	66	615						758
1987				64				168					232
1988		128			49	2707	829						3713
1989					3								3
1990						267	143						410
1991		53			63	43	119			28			306
1992			25	6	29					36		12	108
1994				1	18	24	24						67
1995						12							12
1996						126	170	15	8				319
1997				45	816	854	42	36		12			1805
1998	24				102	80	30		24				260
1999					12	94	96	4			6		212
2000			8	9	24	72	24	24					161
2001							24						24
2002					12	60	48						120
Grand Total	24	181	33	325	1733	7188	2242	295	51	76	6	12	12166

Essential Fish Habitat Conservation Measures

The Coastal Pelagic Species Fishery Management Plan (PFMC 1998a) requires a permit to commercially harvest coastal pelagic finfish species, such as the northern anchovy, south of Point Arena, California. The fishery management plan includes the northern anchovy as a "monitored species" because of low fishery demand and high stock size and thus does not impose harvest limits based on biomass estimates. There is no limit on live bait catch for this species.

The Pacific Coast Groundfish Fishery Management Plan (PFMC 1998c) outlines measures to reduce negative impacts on essential fish habitat. These measures include fishing gear restrictions, seasonal and area closures, harvest limits, among others. There are currently no harvest limits specific to the starry flounder. Conservation measures include recommending that all intake structures be designed to minimize entrainment or impingement of fish, and mitigation should be provided for the net loss of habitat from placement of the intake structure and delivery pipeline.

Conclusion for Northern Anchovy and Starry Flounder

Upon review of the effects of Reclamation's proposed CVP OCAP, the proposed project will not affect EFH of the northern anchovy and may affect the EFH of starry flounder.

Essential Fish Habitat for Central Valley Fall and Late Fall-run Chinook

Note: The following information is background data on fall and late fall-run Chinook. The effects for these runs are included in chapter 9 and summarized at the end of this chapter..

On September 16, 1999, NOAA Fisheries determined that listing was not warranted for this ESU (NOAA Fisheries 1999). However, the ESU is designated as a candidate for listing due to concerns over specific risk factors. The ESU includes all naturally spawned populations of fall-run Chinook salmon in the Sacramento and San Joaquin River basins and their tributaries, east of Carquinez Strait, California. Major river basins containing spawning and rearing habitat for this ESU comprise approximately 13,760 square miles in California.

Effects on spring run and winter run Chinook salmon, coho salmon, and steelhead habitat are described in the biological assessment.

Population Trends-Central Valley Fall-run Chinook Salmon

Central Valley Chinook salmon constitute the majority of salmon produced in California and at times have accounted for 70 percent or more of the statewide commercial harvest (Yoshiyama et al. 2001). Chinook salmon populations in the Central Valley are monitored in a number of ways. Adult Chinook production is estimated using tributary escapement counts and adding this number to the estimated ocean harvest. Tributary counts come from carcass counts, fish ladder counts, aerial redd surveys, hatchery returns and in-river harvest. The total escapement (in-river plus hatchery) of fall-run Chinook in the Central Valley from 1952-2001 is shown in Figure 12–1.

Figure 12–2 shows Chinook salmon in-river escapement estimates by watershed from 1995-2001. The watershed specific component of the ocean harvest of fall-run Chinook salmon is calculated by multiplying the total ocean harvest by the watershed-specific proportion of the total in-river run size. Tagging programs have not been sufficiently implemented Central Valley wide to provide more exact commercial harvest estimates by watershed. During 1999, ocean harvest accounted for 41 percent (335,700) of the total Central Valley Chinook production of 822,352 (all runs combined). The total production includes both natural in-river and hatchery production estimates.

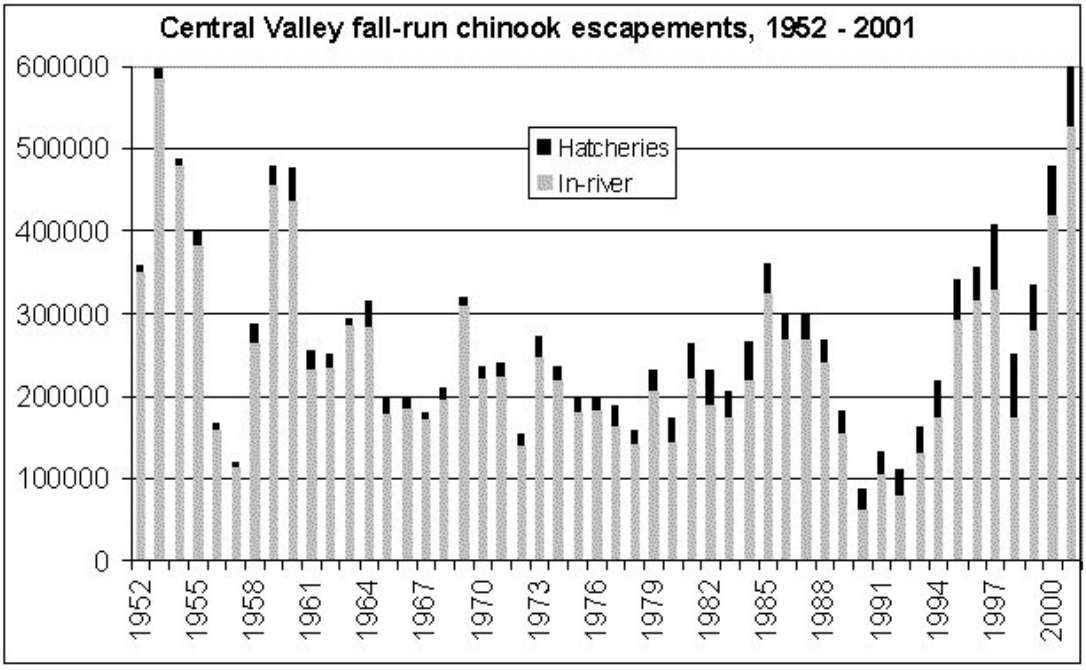

Figure 12–1 Central Valley fall-run Chinook salmon escapements, 1952-2001. Source: DFG data.

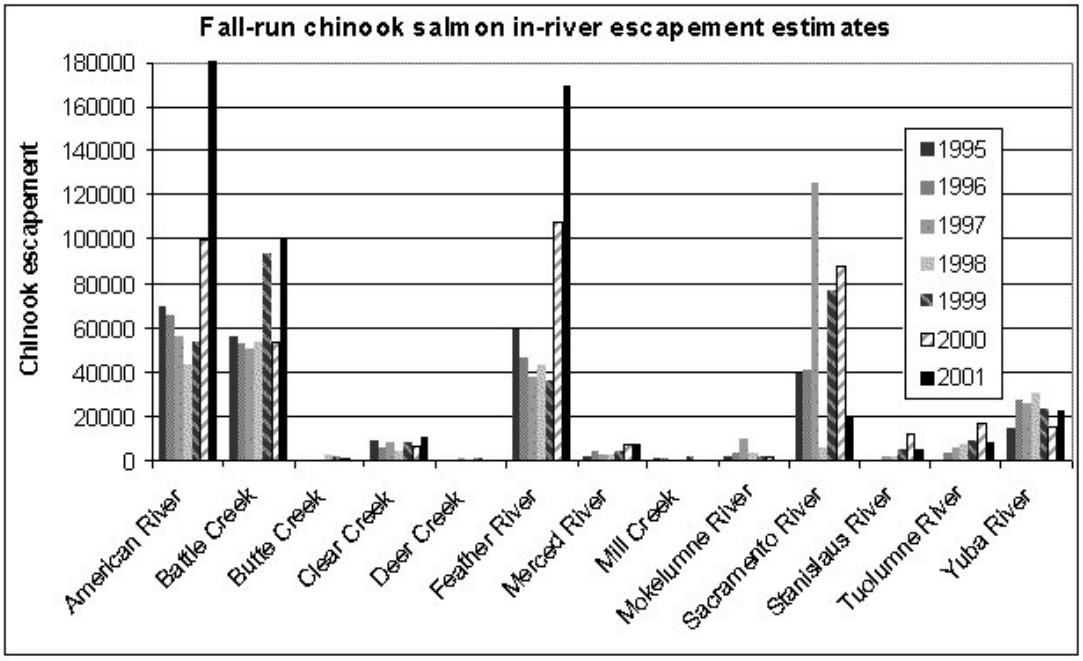

Figure 12–2 Fall-run Chinook salmon in-river escapement estimates in the California Central Valley, 1995-2001. Source: Interior (2001).

The Comprehensive Assessment and Monitoring Program (CAMP) annual report (Interior 2001) summarizes results of monitoring anadromous fisheries production in the Central Valley relative

to the CVPIA doubling goal. The CVPIA set the baseline anadromous fisheries production level as the average attained during 1967-91. Progress toward production targets is assessed using a modification of the Pacific Salmon Commission's (1996) rebuilding assessment methods when a minimum of five years of monitoring data is available. Indicator races or species are classified into three categories: (1) those at or above their production target; (2) those meeting their rebuilding schedule; and (3) those not rebuilding. Results based on past escapement estimates need to be qualified due to the vagaries of the estimation methods used over the years (DFG 2003).

Battle Creek, Clear Creek, and Mokelumne River populations of fall-run Chinook salmon and Butte Creek spring-run salmon are classified as meeting restoration goals. Fall-run salmon from the Yuba watershed are classified as Rebuilding. All other races and watershed-specific runs of Chinook salmon are classified as Not Rebuilding, except for American River fall-run salmon classified as Indeterminate. Table 12–2 shows the 1995-99 mean Chinook salmon production expressed as a percent of the goal, which is the mean of the 1967-91 production.

Many variables affect yearly salmon production including ocean conditions and water supplies, which have recently been at good levels for California salmon runs. The 2000, 2001, and 2002 Chinook salmon runs were outstanding in many Central Valley watersheds.

Table 12–2 Status of CAMP-monitored Central Valley stocks of Chinook salmon races using Pacific Salmon Commission methodology.

Watershed	*Race*	*1995-99 mean Chinook production as percent of goal*	*Watershed status through 1999 Chinook run*
American	Fall-run	77 percent	Indeterminate, declines halted
Battle	Fall-run	235 percent	Above goal
Butte	Spring-run	551 percent	Above goal
Clear	Fall-run	218 percent	Above goal
Deer	Spring-run	44 percent	Not Rebuilding
Feather	Fall-run	63 percent	Not Rebuilding
Merced	Fall-run	49 percent	Not Rebuilding
Mill	Spring-run	22 percent	Not Rebuilding
Mokelumne	Fall-run	169 percent	Above goal
Sacramento	Fall-run	48 percent	Not Rebuilding
	Spring-run	2 percent	Not Rebuilding
	Winter-run	5 percent	Not Rebuilding
Stanislaus	Fall-run	17 percent	Not Rebuilding
Tuolumne	Fall-run	30 percent	Not Rebuilding
Yuba	Fall-run	91 percent	Rebuilding, declines halted
Total (all CAMP streams)	Fall-run	66 percent	Not Rebuilding
	Spring-run	22 percent	Not Rebuilding
	Winter-run	5 percent	Not Rebuilding

Clear Creek

Clear Creek originates on the eastern side of the Trinity Alps and flows south to its confluence with the Sacramento River. The Clear Creek watershed is approximately 35 miles long, ranges from five to 12 miles wide, and covers a total area of approximately 249 square miles, or 159,437 acres. Maximum elevation in the watershed is 6,209 feet at the top of Shasta Bally. Clear Creek channel morphology varies from steep confined bedrock reaches above Clear Creek Road bridge to wide meandering alluvial reaches from the bridge to its confluence with the Sacramento River. Fish passage through ladders on Saeltzer Dam (constructed in 1903), six miles upstream of the Sacramento River confluence, was poor so the dam was removed in 2000. Upstream of Saeltzer Dam at river mile 9.9 and 12 are two series of natural falls which could be barriers to upstream migrants (DFG 1984b).

Fall and late fall-run Chinook salmon use the creek during the fall, winter and spring, when water temperatures are cooler. Therefore, fall and late fall-run Chinook were not as severely impacted by the loss of habitat upstream. In 1995, an unusually large run of 9,298 fall-run Chinook salmon spawned in Clear Creek (Figure 12–3). Increased minimum flow releases are thought to be one factor responsible for the increased number of spawners during that year (Figure 12–4). Late fall-run Chinook spawn in January through April. High seasonal flows and turbid water hinder the ability to conduct escapement surveys during that time of year. Fry and juvenile Chinook rear from January through May. Some late fall-run Chinook juveniles may remain in stream through June, depending on flow and water temperature conditions that occur during the season.

Pulse flows have been proposed for Clear Creek to provide an attraction flow to spring-run Chinook in the mainstem Sacramento River. A release of 1,200 cfs for one day (plus ramping) was proposed in 2000 but was not implemented due to concerns over attracting winter-run into Clear Creek. Because there has been no significant spring-run in Clear Creek in the recent past, pulse flows may aid re-establishment of spring-run in Clear Creek by attracting some fish that would otherwise remain in the Sacramento River.

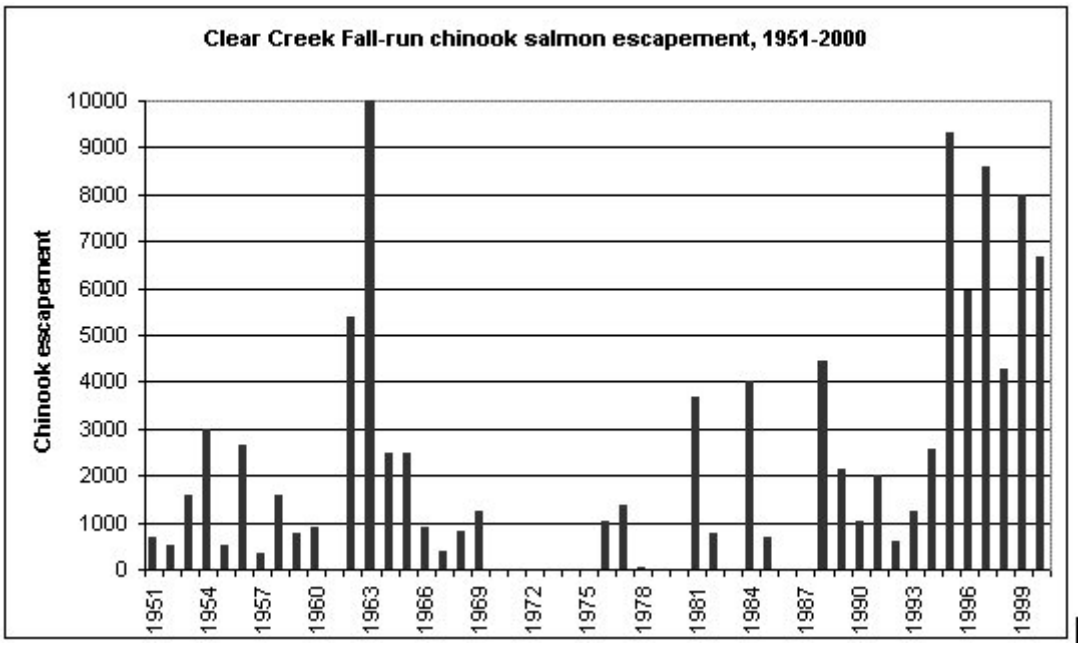

Figure 12–3 Clear Creek fall-run Chinook salmon escapement, 1951-2000. Source: DFG data.

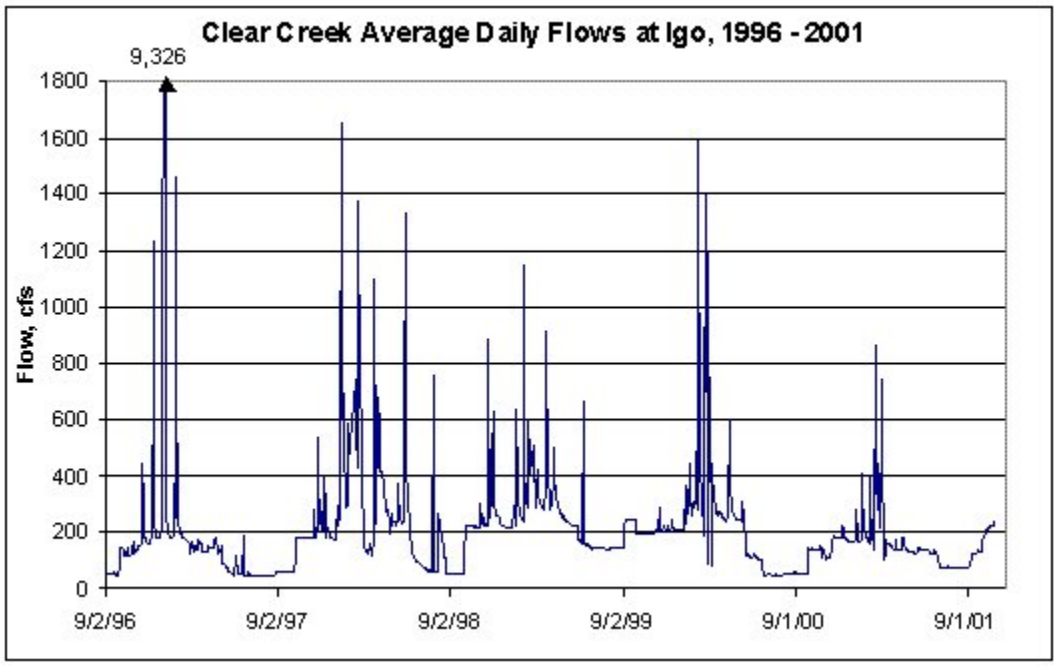

Figure 12–4 Average daily flow in Clear Creek, 1996-2001.

Sacramento River

The Sacramento River drains a watershed area of 21,250 square miles. Keswick Dam at river mile 302 serves as the upstream limit to anadromous habitat. The river is constrained by levees

along much of the lower reaches. Stressors identified in the Sacramento River include high water temperatures, a modified hydrograph, simplified instream habitat, diversion dams, predation, and harvest. Water temperature and flow fluctuation are the main short-term factors affected by operation of the water projects.

Escapement of fall-run in the Sacramento River exceeded 100,000 fish every year except one between 1959 and 1970. Escapement has not exceeded 100,000 since 1970. The primary spawning area used by Chinook salmon is in the area from the city of Red Bluff upstream to Keswick Dam. Spawning densities for each of the four runs are generally highest in this reach. This reach is where operations of the Shasta/Keswick and Trinity Divisions of the CVP have the most significant effects on salmon spawning and rearing habitat in the mainstream Sacramento River. Rapid flow fluctuations can dewater edge and backwater habitat and strand fry and juvenile salmon. Redds can also be dewatered as a result of flow fluctuations. Approximately 15 to 30 percent of the total number of fall and late fall-run Chinook spawn downstream of Red Bluff when water quality is good (Vogel and Marine 1991).

Run timing for all Chinook salmon runs and life stages in the Sacramento River is depicted in Figure 12–5. All life stages are present in the river essentially at all times through the year. Abundance of adult Chinook peaks in the fall during the fall-run spawning migrations and then tapers off as fish considered late fall-run spawn. Winter-run enter the river as the late fall-run fish are spawning, starting in January. The winter-run then spawn with the peak in spawning activity in June. Spring-run enter the river soon after the winter run, starting in March and April. They then hold out until spawning in August and September, during the lowest water flows and highest water temperatures of the year.

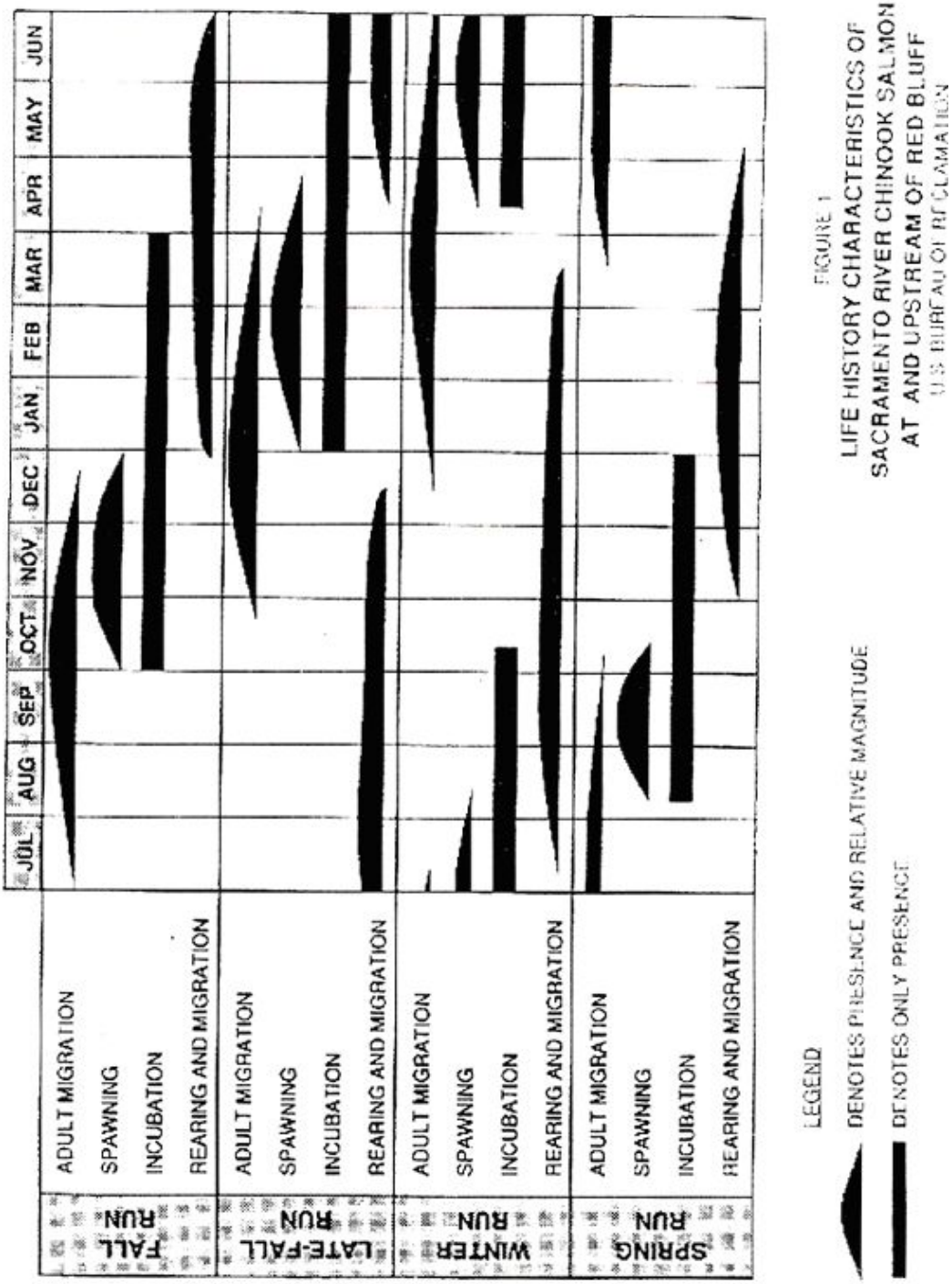

Figure 12–5 Life cycle timing for Sacramento River Chinook salmon. Adapted from Vogel and Marine (1991).

Fall-run are entering the river as spring-run are spawning. Fall-run Chinook salmon escapement is shown in Figure 12–6, the hydrograph since 1993 is in Figure 12–7.

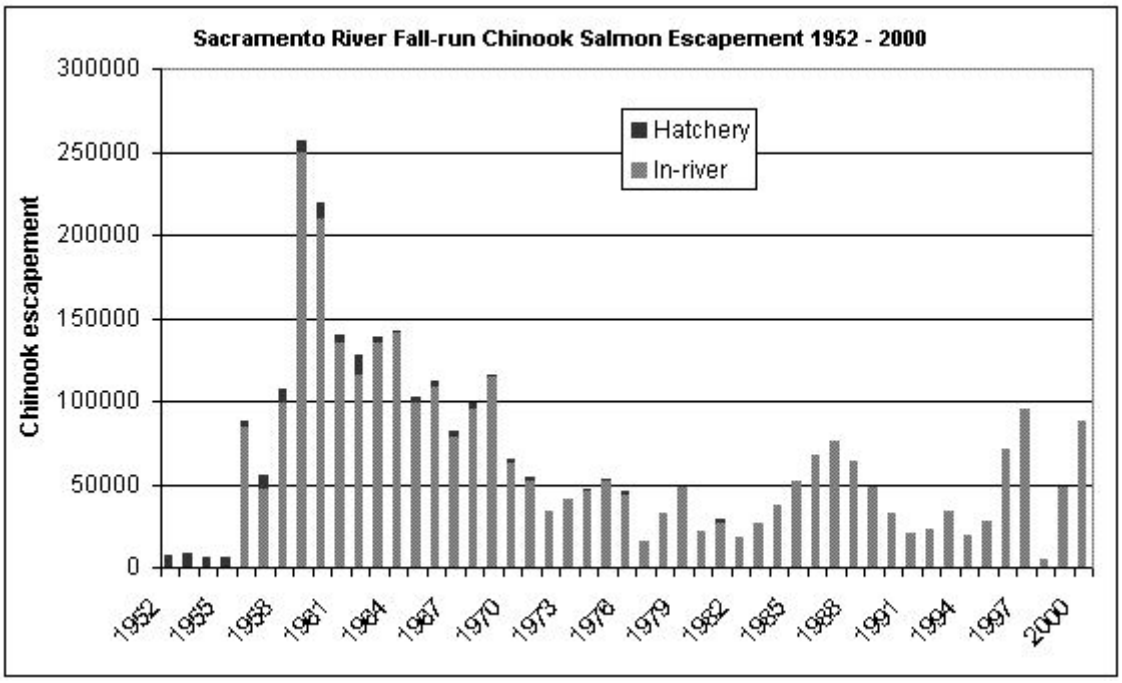

Figure 12–6 Fall-run Chinook salmon escapement in the Sacramento River.

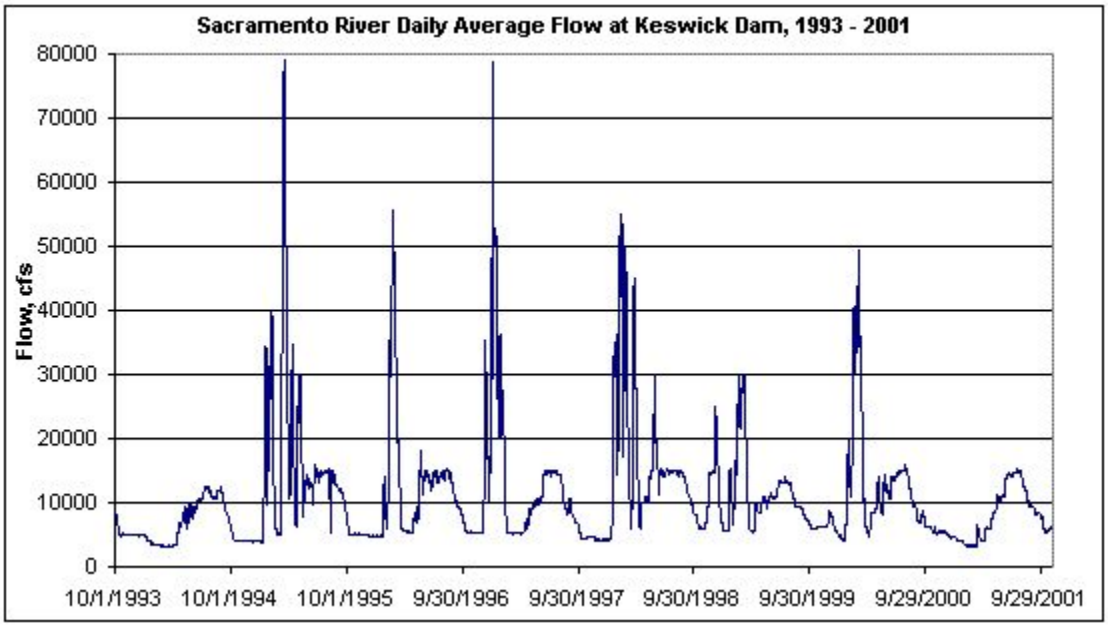

Figure 12–7 Sacramento River daily average flow at Keswick Dam from 1993-2001.

Sacramento River water temperature is controlled primarily by using releases from Shasta Lake through the TCD and also by diversions from Trinity River. The TCD was installed in 1997. Prior to 1997 low level releases were made by opening the lower river outlets, which bypasses

power. The TCD enabled power bypasses to be greatly reduced while maintaining desired water temperatures in downstream fish habitat.

Flows in the Sacramento River generally peak during winter and spring storm events. Sustained moderately high releases (greater than 10,000 cfs) occur during the major irrigation season of June through September. These flows help to meet water temperature criteria for winter-run Chinook spawning and incubation. They also maintain suitable habitat for spring-run and early returning fall-run fish.

American River

The American River drains a roughly triangular watershed covering 1,895 square miles that is widest at the crest of the Sierra Nevada, and narrows almost to the width of the river at its confluence with the Sacramento River at the City of Sacramento. Elevations range from 10,400 feet at the headwaters to about 200 feet at Folsom Dam. Folsom Dam, completed in 1956, provides flood control, hydropower generation and water supply storage. The reservoir is kept partly empty during the winter so that temporary storage is available to regulate the runoff from major storms, preventing flooding in the downstream urban area. Nimbus Dam is seven miles downstream from Folsom Dam. It serves as the limit to upstream migration for anadromous fish. Available anadromous habitat in the American River watershed has been reduced from 161 miles to 23 miles.

Adult Chinook salmon begin to enter the American River in August. Upstream migration peaks in October. Spawning generally commences close to November 1 and peaks in late November. Early spawning success is low if water temperature in early November is above 60° F . American River Chinook salmon escapement has averaged 41,895 since 1952 and ranged from 6,437 to 110,903 (Figure 4–18). Peaks in escapement over 60,000 fish occurred in 1973, 1974, 1981, 1985, 1995, 1996, 1998, and 2000. Low escapements, less than 20,000, fish occurred in 1955, 1956, 1957, 1990, and 1992.

Juvenile Chinook emigration from the American River generally begins in December, peaks in February and March and tails off into June. Nearly all (>99 percent) of the emigrating Chinook salmon from the American River moving past the smolt traps at Watt Avenue are pre-smolts. This suggests that the smolting process is not completed in the lower American River but will continue downstream, likely in the Delta and estuary (Snider and Titus 2000). The 2001 outmigration past Watt Avenue was estimated to be 25 million fish, the largest measured from the American River since rotary screw trapping began (Bill Snider, personal communication, 2001).

The main stressors identified in the American River include an altered flow regime, high water temperatures, hatchery operations and reduced habitat complexity and diversity. The operation of Folsom and Nimbus Dams for water delivery and flood control can affect all of the stressors directly or indirectly.

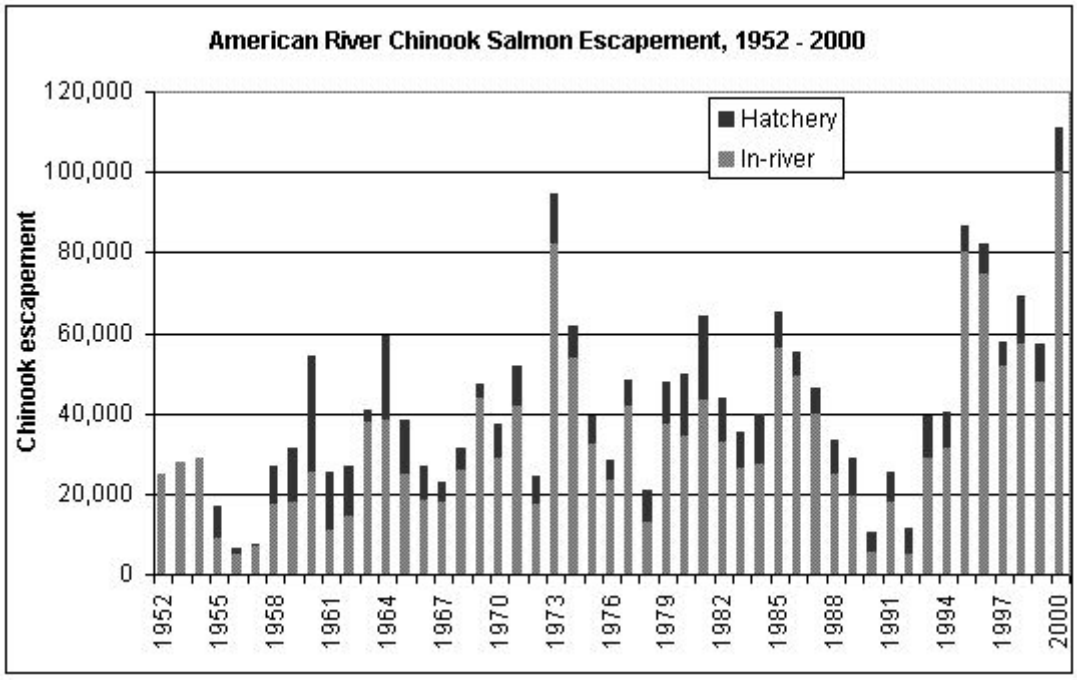

Figure 12–8 American River Chinook salmon escapement estimates, 1952-2000.

Dam operations store water runoff during winter and spring to be released for instream flows, water delivery, and water quality during late spring, summer and fall. Historical high flows in the river have been dampened for flood control and water storage. Moderate flows of around 1,500 to 2,500 cfs have been extended throughout much of the year to provide appropriate instream flows for fish, water quality in the Delta and water for pumping in the Delta. The long-term effect of the lack of high flows is the simplification of instream habitat. High channel forming flows maintain high quality spawning habitat and riparian floodplain conditions. High flows mobilize spawning sized gravels from streambanks and incorporate them into the active channel. Low flows that typically occurred in late summer and fall do not occur because of the dampening effect of the dam operations. High flows are not as high as occurred under natural conditions but the duration of high flows is longer because flood control operations spread them out over time. The longer duration of moderately high flows may be sufficient enough to wash quality spawning gravel out of riffles and deposit it in deeper water where it is unavailable for spawning but not high enough to mobilize new gravel supplies from the extensive gravel bars, banks, and floodplain. Ayres Associates (2001) used detailed topography of the river to model sediment mobilization at various flows in the American River. They found that at 115,000 cfs (the highest flow modeled) particles up to 70 mm median diameter would be moved in the high density spawning areas around Sailor Bar and Sunrise Avenue. Preferred spawning gravel size is 50-125 mm (2-5 inches) in diameter.

Flow fluctuations (below flood release flows) occur as a result of Delta water quality conditions requiring increased releases to maintain water quality for the desired pumping rates. Flow fluctuations can cause stranding of fish and dewatering of redds when the flows are reduced. Based on cross sections measured in 1998 by the FWS, flow changes of 100 cfs generally change the water depth by about 1 inch in a flow range of 1,000 to 3,000 cfs and by about 0.5 inch in a

flow range from about 3,000 to 11,000 cfs. These depth changes vary throughout the river depending on the channel configuration at a location. Decreases in water depth of about 6 inches following spawning can begin to dry up the shallowest redds and will change water velocity over and through the redds.

Snider (2001) is evaluating the effects of flow fluctuations on salmon stranding in the American River. Aerial photos and ground truthing were used to measure areas isolated during flow changes. The greatest area isolated occurs at flows around 11,000 cfs (183 acres) and 8,000 cfs (85 acres). Smaller areas of isolation occur around 4,000 cfs (3.6 acres), 3,000 cfs (14.5 acres), 2,000 cfs (13.3 acres), and 1,000 cfs (12.7 acres). Although off-channel areas are important salmon habitat, when salmonids become isolated in off-channel areas for extended periods mortality occurs.

The period of concern for flow fluctuations causing stranding of redds and juvenile Chinook in the American River extends from the initiation of spawning at about the beginning of November until juveniles have emigrated from the river, generally by the end of June. Figure 4–22 shows American River flows from 1993-2001.

FWS (1997) measured 21 cross sections of the American River in high density Chinook spawning areas. They estimated the flows at which the greatest usable spawning area would be available based on water velocity, water depth, and substrate size. Most cross sections showed the greatest usable spawning area available to be in a flow range between 1,600 and 2,400 cfs. Table 12–3 shows the average of the weighted usable spawning area from the 21 cross sections expressed as 1,000 square feet of spawning area per 1,000 feet of stream. Weighted usable spawning area peaked at a flow of 1,800 cfs.

In order to maximize survival from egg to fry, flows need to be maintained near or above the level at which spawning occurred. Chinook spawning occurs at water depths greater than about 6 inches. Drops in flow greater than about 500 cfs from the preferred spawning flows following spawning need to be carefully considered. A 500 cfs drop will lower water level in most areas by about 5 inches. Some mortality could occur when water flow over redds drops as flow drops but mortality is greatest when redds begin to become dewatered. Because most Chinook do not spend much time rearing in the American River, spawning habitat may be a limiting factor to Chinook production. Most spawning occurs upstream of the Goethe Park side channels, where river channel gradients are generally higher and riffles more frequent.

Folsom Dam storage capacity is small relative to the annual runoff from the watershed. Because of this, the amount of cold water that can be stored during the winter for release during the summer and fall is limited. Chinook typically begin to show up in the American River in August. Spawning usually initiates about November 1 or when water temperature reaches a daily average of 60° F . A temperature of 56° F or below is best for survival of incubating eggs. In dry years, such as 2001, water temperature does not reach 60° F until mid-November. A dense school of Chinook holds below the hatchery diversion weir from October until spawning commences. The hatchery opens the fish ladder when water temperature reaches 60° F , typically late October to mid-November. If spawning is delayed past mid-November, the typical peak in spawning, then significant mortality of eggs or pre-spawning mortality may occur. Fish holding in high densities are particularly vulnerable to the effects of high water temperatures, which when coupled with low streamflow can deplete dissolved oxygen and increase disease.

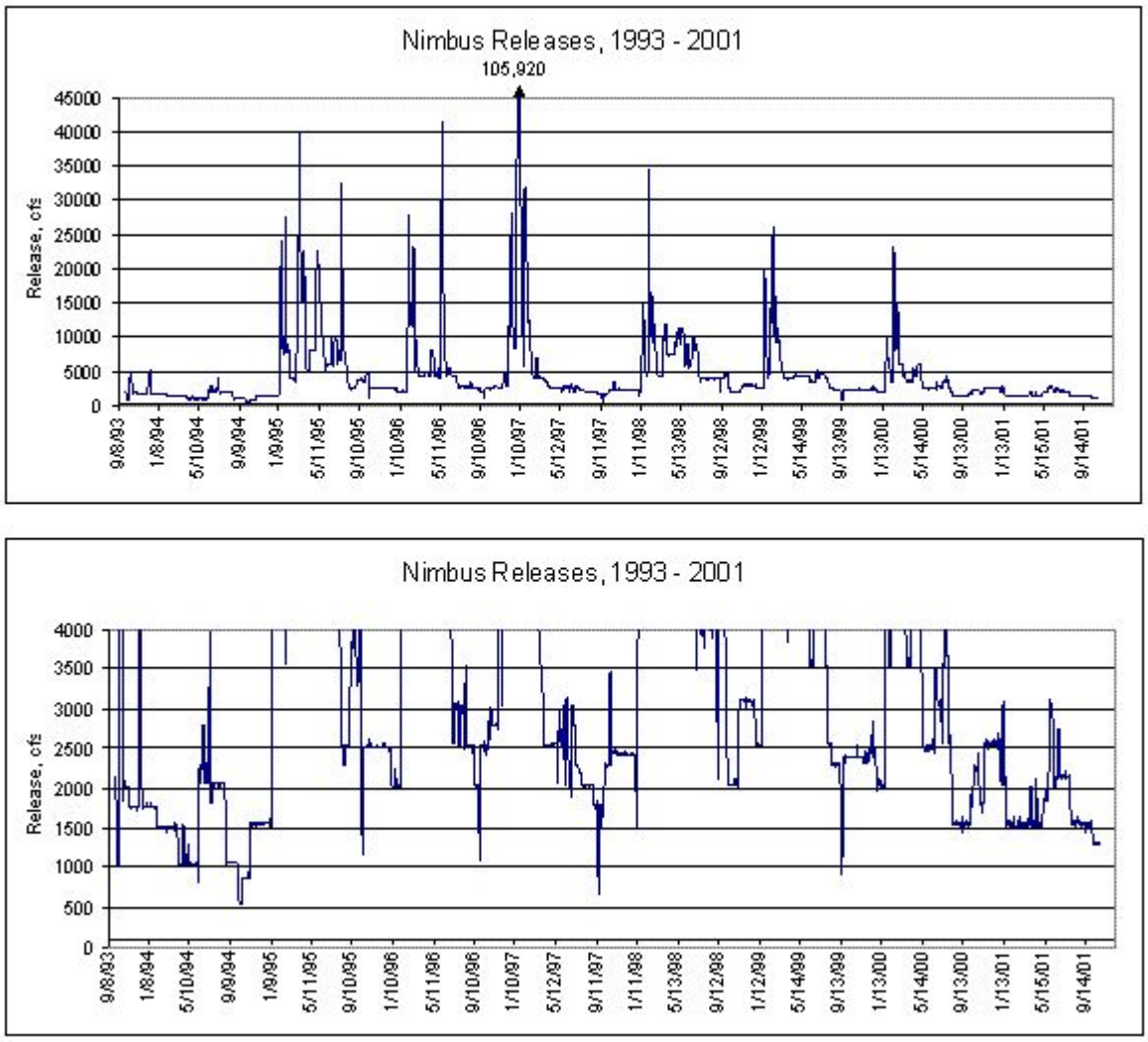

Figure 12–9 American River flows as released from Nimbus Dam, 1993-2001. The top chart shows the entire hydrograph. The bottom chart shows a close-up of the 0 to 4000 cfs range.

Table 12–3 Average weighted usable spawning area in the American River (expressed as 1,000 square feet of spawning area per 1,000 feet of stream) from 21 cross sections measured in 1996. Summarized from FWS 1997.

Flow (cfs)	*Average Weighted Usable Area, 1996*
1000	62
1200	71
1400	78
1600	82
1800	84
2000	83
2200	81
2400	78

Flow (cfs)	*Average Weighted Usable Area, 1996*
2600	74
2800	69
3000	65
3200	60
3400	56
3600	52
3800	48
4000	45
4200	42
4400	38
4600	36
4800	33
5000	31
5200	28
5400	26
5600	25
5800	23
6000	21

American River water temperatures are typically suitable for egg incubation once water temperature cools to 56° F . Before cooling to 56° F , temperature-related mortality of spawned Chinook eggs may occur. Generally temperatures reach 56° F by early December. Cool water temperatures are then sustained through winter egg incubation and juvenile rearing and emigration through the spring.

Efforts are underway by various groups coordinated by the Water Forum to improve American River water temperatures for salmonids. A funding proposal has been submitted for temperature curtains in Lake Natoma. Temperature curtains may lower water temperatures in the river by 3° F during summer and fall. Mechanization and reconfiguration of the temperature shutters on Folsom Dam has also been proposed. The temperature shutter work is expected to improve flexibility in operation of the shutters to spread out cold water availability for a longer period of the year. Construction is underway on Folsom Dam water supply intake to reduce depletions from the coldwater pool. El Dorado Irrigation District is also pursuing a new water intake which would be constructed so that water would not be taken from the cold water pool. Efforts are underway to raise Folsom Dam to provide better flood protection to downstream urban areas. If the dam is raised then the increased storage capacity may alleviate the water temperature concerns in many years.

Reclamation funds operation of Nimbus Salmon and Steelhead Hatchery as mitigation for the habitat blocked by construction of Nimbus and Folsom Dams. An average of 9,370 adults, 22 percent of the average in-river escapement, have been taken at the hatchery each year since 1955. The hatchery production goal is for 4,000,000 fall Chinook salmon smolts each year. The smolts are released into San Pablo Bay to increase survival over in-river releases. A recent review of hatchery practices in California (DFG and NOAA Fisheries 2001) recommended discontinuing

releases downstream of the American River. They recommended instead to consider releasing Chinook smolts at the hatchery during periods when flow releases can be obtained to maximize smolt survival through the Delta. No consistent coded wire tagging program has been in place so the proportion of the returning salmon that are of hatchery origin v. in-river spawned is unknown. A portion of the release group was coded wire tagged in 2001. This should allow estimates of contribution to commercial and sports fisheries to be made. The proportion of hatchery production contributing to in-river spawning should be able to be determined by comparing the proportion of adipose clipped fish in the carcass mark-recapture survey escapement estimate to the proportion of the release group tagged. Coded wire tagging is recommended to continue to determine contribution to commercial and sports fisheries and survival to spawning.

Stanislaus River

The Stanislaus River is the northern most major tributary to the San Joaquin River. Average monthly unimpaired flows at New Melones Dam are approximately 96,000 af. These flows are reduced to approximately 57,000 af at Ripon, near the confluence with the San Joaquin River, due to flow diversion and regulation at Goodwin Dam.

Goodwin Dam is about 15 miles below New Melones. It serves as the limit to upstream migration for anadromous fish. Anadromous habitat has been reduced from 113 miles to 46 miles. There are approximately forty small, unscreened pump diversions (for agricultural purposes) along the river. New Melones Reservoir is operated to store water during the winter and spring and release it during the summer (San Joaquin River Group Authority 1999).

Adult Chinook salmon begin to return to the Stanislaus River in August with the peak in returns occurring in October. Spawning activity peaks in November and continues into January. Adult Chinook have occasionally been observed in the Stanislaus as early as May. Stanislaus River Chinook escapements have averaged 5,556 and ranged from 0 to 35,000 between 1947 and 2000 (Figure 12–10). Peaks in escapement of over 10,000 fish occurred in the late 1940s, early 50s, late 60s and early 70s, and mid 80s.

The downstream migration of Chinook salmon fry and smolts in the Stanislaus River generally begins in December with newly emergent fry and continues into June. A majority emigrate as fry in January through March. A smaller proportion rear for about one to four months in the river before emigrating. While out-migration of smolts does not appear to be triggered by high flows (Demko et al. 2000), peaks in movement of fry are often correlated with high flow events. When high flow events do not occur, a greater proportion of fry establish rearing territories in the river and remain there longer. Figure 12–11 shows recent Chinook outmigration estimates and prior fall spawning escapement estimates. Higher escapements appeared to result in higher juvenile outmigration until 2001 when outmigration was low. This may be due to the lack of freshets during the outmigration period in 2001 resulting in more fish remaining in the river longer, decreasing in-river survival.

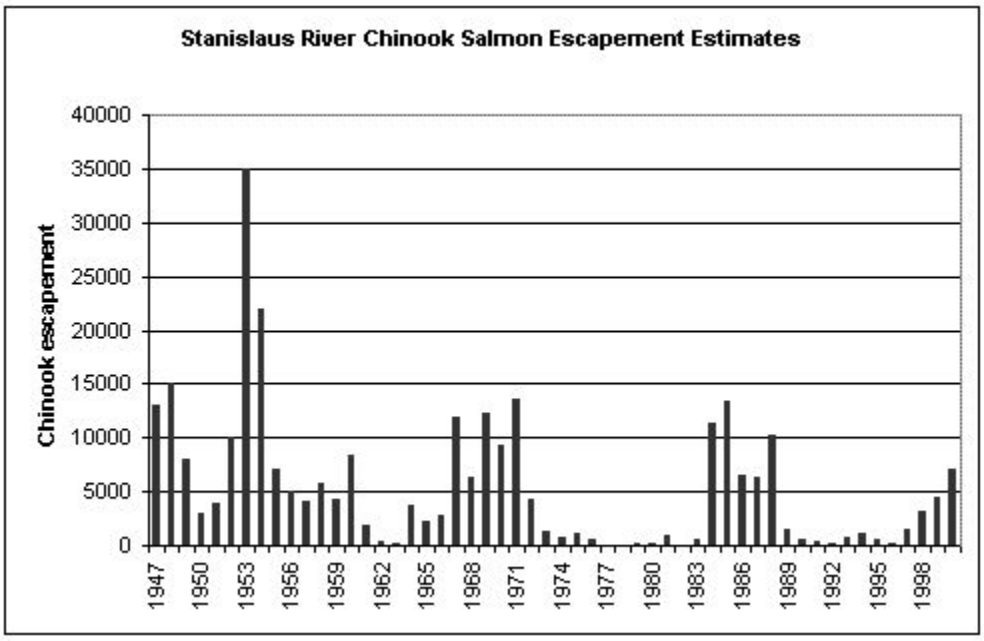

Figure 12–10 Chinook salmon escapement in the Stanislaus River, 1947-2000.

The main Chinook salmon stressors identified in the Stanislaus River include an altered hydrograph lacking significant peak flows, high water temperatures during summer and fall, predation by striped bass and pikeminnows, and a shortage of high quality spawning gravel. Operation of New Melones and Goodwin Dam for water delivery and flood control can affect all of these stressors, directly or indirectly.

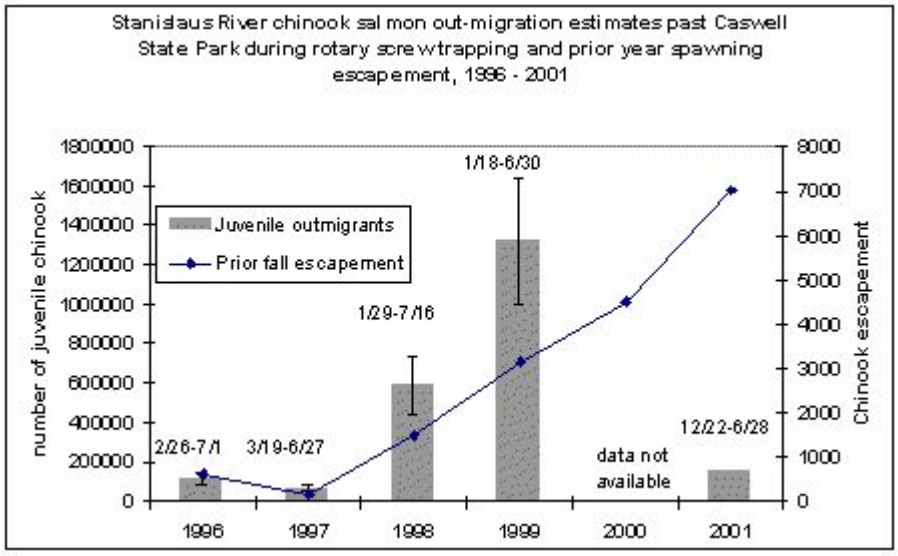

Figure 12–11 Stanislaus River Chinook salmon out-migration estimates past Caswell State Park during rotary screw trapping and prior year spawning escapement, 1996-2001.

Error bars are 95 percent confidence intervals. Dates of trapping are shown above the bars. 1996-97 trapping captured only the latter part of the run. 1996-99 data is from Demko et al. (2000). 2001 estimate calculated from data provided by S.P. Cramer & Associates.

Dam operations store water during winter and spring for releases to irrigators during late spring, summer, and fall. Historical high flows in the river have been dampened for flood control and water storage (Figure 12–12). The 20-year flood flow has been decreased by eight times compared to the historic flow. Moderate flows of around 300-600 cfs have been extended out through much of the year to provide better water quality in the Stanislaus for fish and in the Delta for pumping operations. The long-term effect of the lack of high flows is the simplification of instream habitat. High channel forming flows maintain high quality spawning habitat and riparian floodplain conditions. With reduced flows, riparian vegetation along the banks has become more stable. When high flows do occur they are unable to reshape the channel as occurred historically when high flood flows were more frequent events. High flows mobilize spawning sized gravels from streambanks and incorporate them into the active channel. In the absence of high flows, spawning habitat quality has decreased. In addition, the dams have eliminated recruitment of spawning gravel from upstream sources. Based on an aerial photo analysis 161,400 square feet (30 percent) of spawning gravel was lost between 1961 and 1972 and 150,600 square feet was lost between 1972 and 1994. Spawning gravel additions have occurred regularly in an attempt to maintain good spawning habitat.

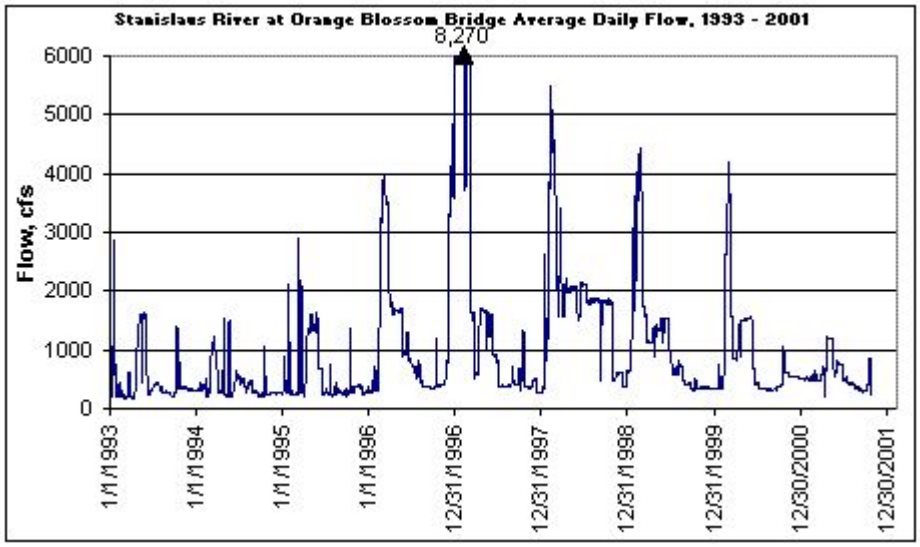

Figure 12–12 Stanislaus River flow at Orange Blossom Bridge, 1993-2001.

Access to upstream habitat, where water temperatures are cooler, has been blocked by the dams. Therefore, cool water temperatures are critical in the available anadromous habitat. The summer time release of water stored in upstream reservoirs provides late summer flows higher than those that occurred historically. These releases have allowed anadromous fisheries populations to persist in the remaining accessible habitat below Goodwin Dam.

Predation by introduced striped bass and native pikeminnows may be a significant stressor to juvenile fish rearing in the river. Cooler water lowers the metabolic rate of predators and likely reduces the effect of predation. Gravel mining along the river has created backwater areas where there is no flow, allowing the water to become warmer. Predators such as striped bass, pikeminnows, and largemouth bass do well in these backwater areas and may use them as refuge habitat from the cooler water areas.

Aceituno (1993) applied the instream flow incremental methodology to the Stanislaus River between Riverbank and Goodwin Dam (24 river miles) to help to determine instream flow needs for Chinook salmon and steelhead. Table 12–4 gives the resulting instream flow recommendations for Chinook salmon.

Studies are underway in the Stanislaus to determine the best spring time flow regimes to maximize survival of juvenile Chinook. The studies utilize survival estimates from marked hatchery fish released at various flows(Table 12–5). These tests took place during the VAMP flows which occur after the peak outmigration period from the Stanislaus River.

Table 12–4 Instream flows (cfs) that would provide the maximum weighted usable area of habitat for Chinook salmon in the Stanislaus River between Goodwin Dam and Riverbank[23].

Life Stage	*Dates*	*Number of days*	*Flow at Goodwin (cfs)*	*Dam release (af)*
Spawning	October 15 - December 31	78	200	46,414
Egg Incubation/Fry Rearing	January 1 - February 15	46	150	13,686
Juvenile Rearing	February 15 - October 15	241	200	95,605
Total		365		155,705

Table 12–5 Stanislaus River summary of past smolt survival tests.

Stanislaus River Summary of Past Smolt Survival Tests														
				Flow at	Avg. Temp			Release	Recoveries	Survival to	Recoveries	Survival to	Recoveries	Riverwide
Year	tag codes	Rel. Start	Rel. End	OBB (cfs)	at Ripon1	Rel. Location	# Released	Length (mm)	at Oakdale	Oak RST	at Caswell	Cas RST	at Mossdale2	Survival
1986		28-Apr	28-Apr	1200	62	Knights Ferry			na	na	na	na		
		28-Apr	28-Apr	1200	62	Naco West			na	na	na	na		0.59
1988	b6-11-05, -06	26-Apr	26-Apr	900	60	Knights Ferry	71,675	75.2	na	na	na	na	278	0.54
	b6-11-03, -04	26-Apr	26-Apr	900	60	Naco West	68,788	79.6	na	na	na	na	828	
1989	b6-14-09,-10	20-Apr	20-Apr	900	64	Knights Ferry	103,863	77.4	na	na	na	na	471	0.37
	b6-01-01, -14-11	19-Apr	19-Apr	900	64	Naco West	74,073	76.5	na	na	na	na	860	
	b6-14-12	3-May	3-May			Naco West	46,169	72.4	na	na	na	na	173	
1999		1-Jun	1-Jun	1300	60	Knights Ferry	25,536		156	0.77	35	0.07		
		1-Jun	1-Jun	1300	60	RM 40	4,975	84.4	na	na	10	0.10		
		2-Jun	2-Jun	1300	60	RM 40	4,403	83.2	na	na	7	0.08		
					60	RM 40 (combined)	9,378	83.8	na	na	17	0.09		
		1-Jun	1-Jun	1300	60	RM 38	4,981	85.3	na	na	8	0.08		
		2-Jun	2-Jun	1300	60	RM 38	5,007	84.8	na	na	8	0.08		
					60	RM 38 (combined)	9,998	85.1	na	na	16	0.08		
2000		18-May	19-May	1500	61	Knights Ferry	77,438		546	0.73	127	0.13		
		20-May	20-May	1500	61	Two Rivers	50,547		na	na	na	na		0.57
1 1986-1989 from CDFG reports. 1999 and 2000 from SPCA Caswell.														
2 1988 & 1989 from Demko's files of Mossdale catch.														

Feather River

The lower Feather River has two runs of Chinook salmon, the fall-run and spring-run. Adult fall-run typically return to the river to spawn during September through December, with a peak from mid-October through early December. Spring-run enter the Feather River from March through June and spawn the following autumn (Painter et al. 1977). Fry from both races of salmon

23Source: Aceituno 1993.

emerge from spawning gravels as early as November (Painter et al. 1977; DWR unpublished data) and generally rear in the river for at least several weeks. Emigration occurs from December to June, with a typical peak between January and March (Figure 12–13). The vast majority of these fish emigrate as fry (DWR unpublished data), suggesting that rearing habitat is limiting or that conditions later in the season are less suitable. Risks for late migrating salmon include higher predation rates and high temperatures. The primary location(s) where these fish rear is unknown, however in wetter years it appears that many young salmon rear for weeks to months in the Yolo Bypass floodplain immediately downstream of the Feather River before migrating to the estuary (Sommer et al. 2001b).

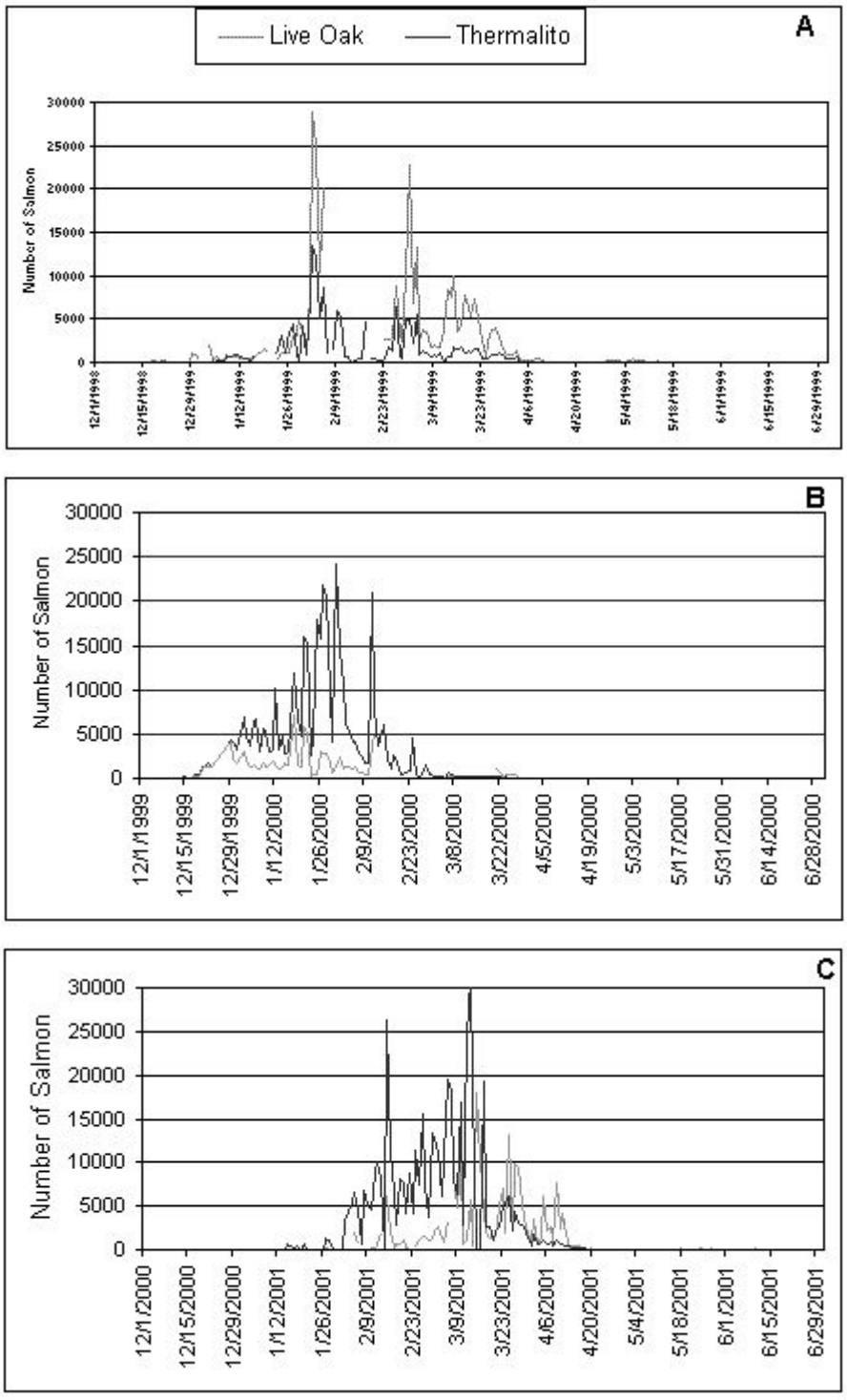

Figure 12–13 Daily catch distribution of fall-run Chinook salmon caught at Live Oak and Thermalito rotary screw traps during 1998, 1999, and 2000 (trapping years a, b, and c, respectively).

Historical distribution and abundance of Chinook salmon in the Feather River is reviewed by Yoshiyama et al. (2001). They note that fall-run historically spawned primarily in the mainstem

river downstream of the present site of Lake Oroville, while spring-run ascended all three upstream branches. Fry (1961) reported fall-run escapement estimates of 10,000 to 86,000 for 1940-59, compared to 1,000 to about 4,000 for spring-run. Recent fall-run population trends continue to show annual variability, but are more stable than before Oroville Dam was completed (Figure 12–14). Pre-dam escapement levels have averaged approximately 41,000 compared to about 46,000 thereafter (see also Reynolds et al. 1993). This increase appears to be a result of hatchery production in the system.

Hatchery History and Operations

Feather River Hatchery was opened in 1967 to compensate for the loss of upstream habitat by the construction of Oroville Dam. The facility is operated by the DFG and typically spawns approximately 10,000 adult salmon each year (Figure 12–14). Until the 1980s, the majority of the young hatchery salmon was released into the Feather River (Figure 12–15). However, the release location was shifted to the Bay-Delta Estuary to improve survival. DFG is now considering shifting the release of at least a portion of the hatchery fish back to the Feather River to reduce the potential for straying into other watersheds.

Hydrology

The Feather River drainage is located within the Central Valley, draining about 3,600 square miles of the western slope of the Sierra Nevada (Sommer et al. 2001a). The reach between Honcut Creek and Oroville Dam is of low gradient. The river has three forks, the North Fork, Middle Fork, and South Fork, which meet at Lake Oroville. Lake Oroville, created by the completion of Oroville Dam in 1967, has a capacity of about 3.5 million acre-feet (MAF) of water and is used for flood control, water supply, power generation, and recreation. The lower Feather River below the reservoir is regulated by Oroville Dam, Thermalito Diversion Dam, and Thermalito Afterbay Outlet. Under normal operations, the majority of the Feather River flow is diverted at Thermalito Diversion Dam into Thermalito Forebay. The remainder of the flow, typically 600 cfs, flows through the historical river channel, the "low flow channel" (LFC). Water released by the forebay is used to generate power before discharge into Thermalito Afterbay. Water is returned to the Feather River through Thermalito Afterbay Outlet, then flows southward through the valley until the confluence with the Sacramento River at Verona. The Feather River is the largest tributary of the Sacramento River.

The primary area of interest for salmon spawning is the low flow channel, which extends from the Fish Barrier Dam (river mile 67) to Thermalito Afterbay Outlet (river mile 59), and a lower reach from Thermalito Afterbay Outlet to Honcut Creek (river mile 44). There is little spawning activity in the Feather River below Honcut Creek.

The hydrology of the river has been considerably altered by the operation of the Oroville complex. The major change is that flow that historically passed through the LFC is now diverted into the Thermalito complex. Mean monthly flows through the LFC are now 5 percent to 38 percent of pre-dam levels (Figure 12–16). Mean total flow is presently lower than historical levels during February through June, but higher during July through January.

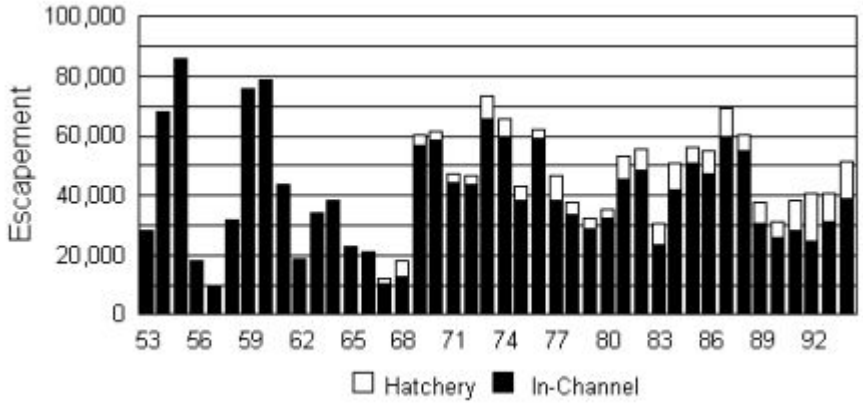

Figure 12–14 Escapement of fall-run Chinook salmon (1953-94) in the FRH and channel.

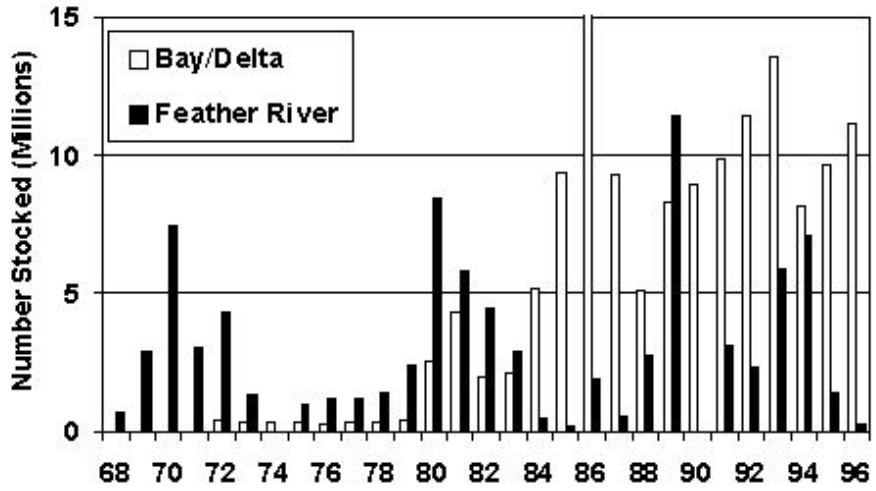

Figure 12–15 Stocking rates of juvenile salmon from the FRH into river and Bay-Delta locations.

Project operations have also changed water temperatures in the river. Compared to historical levels, mean monthly water temperatures in the LFC at Oroville are 2° F to 14° F cooler during May through October and 2° F to 7° F warmer during November through April. Pre-project temperature data are not available for the reach below Thermalito Afterbay Outlet, but releases from the broad, shallow Thermalito Afterbay reservoir probably create warmer conditions than historical levels for at least part of the spring and summer.

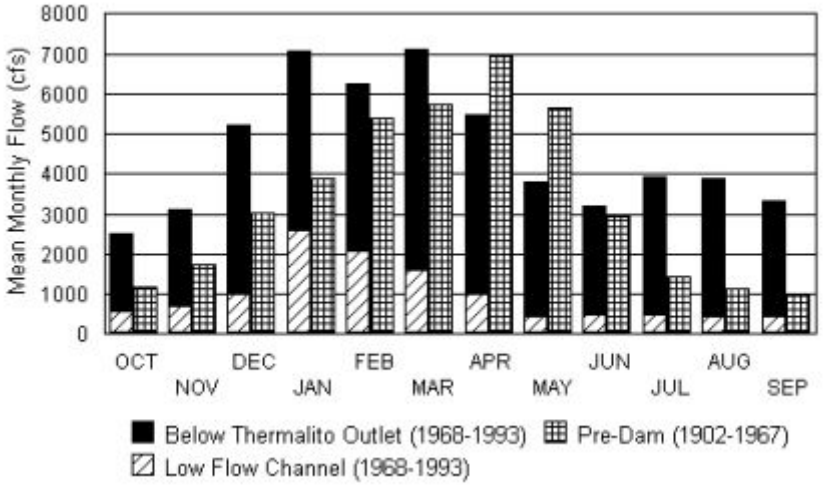

Figure 12–16 Mean monthly flows (cfs) in the Feather River for the pre-Oroville Dam (1902-67) and post-Oroville Dam (1968-93) periods.

Total flow in the post-dam period includes the portion from the low flow channel and the portion diverted through the Thermalito complex.

Spawning Distribution

Since the construction of Oroville Dam and FRH, there has been a marked shift in the spawning distribution of Chinook salmon in the lower Feather River. Salmon have shifted their spawning activity from predominantly in the reach below Thermalito Afterbay Outlet to the LFC (Figure 12–17) (Sommer et al. 2001a).

An average of 75 percent of spawning activity now occurs in the LFC with the greatest portion crowded in the upper three miles of the LFC. While there is evidence that this upper section of the LFC was also intensively used after the construction of the dam and hatchery, the shift in the spawning distribution has undoubtedly increased spawning densities. The high superimposition indices in the LFC suggest that there is not enough spawning habitat for the large numbers of salmon attempt to utilize the area. It must be observed; however, that the very success of the hatchery is responsible for the large population of adult fall-run spawners. Without the production of the FRH it would be impossible for salmon populations to regularly exceed the river's post-dam carry capacity. Therefore, the high density of hatchery produced salmon spawning at the upstream end of the low flow channel may be attributed to hatchery production levels, and potentially, to a tendency among hatchery fish to return to their place of origin.

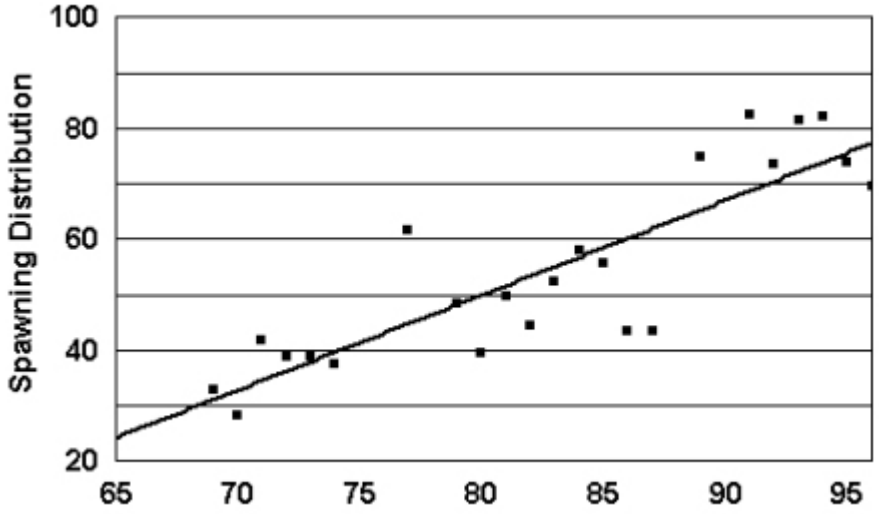

Figure 12–17 The percentage of salmon spawning in the Feather River low flow channel for 1969-96. The increase is significant at the *P* < 0.001 level.

Currently several studies are underway to evaluate salmon and steelhead populations in the Feather River. Since fall 2000, DWR in cooperation with DFG has conducted salmon spawning escapement data on the Feather River. This survey takes place from September through December. The purpose of this survey is to measure the abundance and distribution of spawning effort among fall-run salmon on the Feather River. The escapement surveys also collects information about the size and sex distribution among the population, and on the rates of pre-spawning mortality among female salmon. DWR staff also operate two rotary screw traps on the Feather River. These traps are located upstream of the Thermalito Outlet and near Live Oak. These traps are operated from November throughJune and collect information about the abundance of juvenile salmonids and the factors which may influence their migration timing. During the spring and summer DWR also conducts snorkel surveys on the Feather River. The purpose of these surveys is to document abundance, distribution and habitat use among juvenile salmonids during this period of time when the effects of environmental stressors may be most acute.

Trinity River Chinook Salmon EFH

The increased flows in the spring for the restoration program would aid outmigrating Chinook so smolt survival should increase. The habitat benefits provided through more natural geomorphic processes should benefit Chinook salmon.

Temperatures in the Trinity during the fall Chinook spawning period will be slightly increased in the future because more water would be released early in the season. The result will be slightly higher egg mortality, mostly in critically dry years (Figure 9–11).

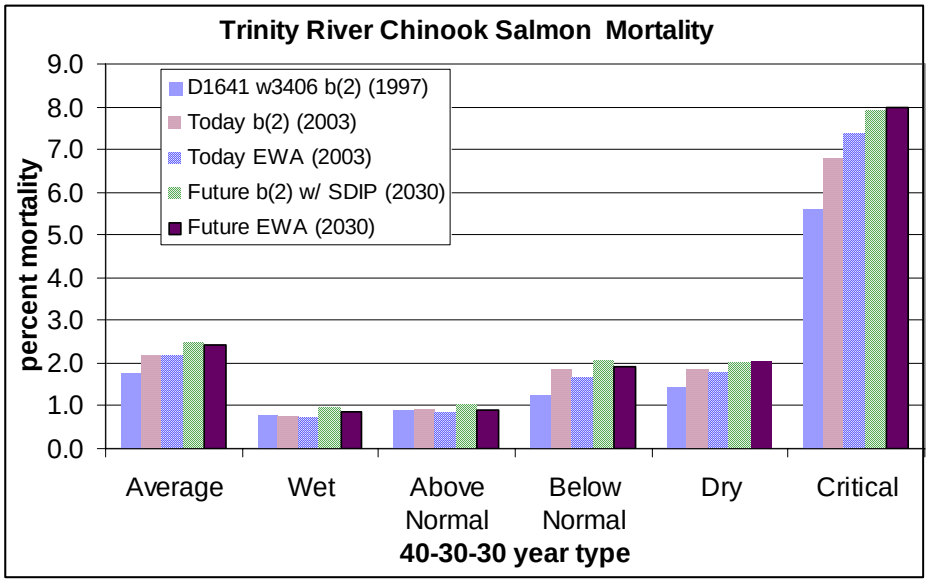

Figure 12–18 Percent mortality of Chinook salmon from egg to fry in the Trinity River based on water temperature by water year type.

Summary of effects on EFH for Fall run and Late Fall Run Chinook Salmon

Mortality model outputs for fall run and late fall run Chinook are included at the end of this section. See Figure 12–19 to Figure 12–23.

Upper Sacramento River

Fall/late fall-run spawning in the upper Sacramento River may be affected in some years when flows are dropped off in the fall as water demands decrease. Redd dewatering is possible in some years. This may be the most significant effect of project operations on fall/late fall-run in the upper Sacramento.

Clear Creek

Temperatures and flows are generally suitable year round in Clear Creek for fall run Chinook. No effects to EFH for fall run in Clear Creek are anticipated.

Feather River

Flow and water temperature conditions should be generally suitable for all fall–run Chinook salmon life history stages all year in the low flow channel, particularly in the upper low flow channel. Superimposition on spring–run Chinook salmon redds by fall–run Chinook may continue to be a problem. The reach below the Thermalito outlet will be less suitable. Water temperatures below Thermalito will be too warm for adult holding and spawning, but will be appropriate for juvenile rearing and emigration during winter and early spring.

American River

Flows are projected to be adequate for fall–run Chinook spawning in normal water conditions but if dry conditions occur, flows are projected to provide less than optimal spawning habitat for Chinook. Flows in the spring should be adequate for outmigration. Temperature goals for fall–run Chinook spawning and incubation are projected to be met in November of almost every year but meeting the goals will likely involve trade-offs between providing cool water for better steelhead rearing conditions during the summer and providing it for Chinook spawning in the fall. Water temperatures for Chinook rearing are forecast to exceed the preferred range generally starting in April. Most Chinook leave the river by early April. Temperatures will be higher in June through November under future operations due to increased upstream diversions, causing more temperature stress on migrating and holding adults in the fall.

Stanislaus River

No listed Chinook runs spawn in the Stanislaus River. Flows are projected to be adequate for fall–run Chinook spawning in nearly all years. Water temperatures will be warm in the lower part of the river during the early part of the immigration period but should be suitable for spawning and rearing in the upper river during the entire spawning and rearing period. Temperatures should be suitable for outmigration of fry and smolts, but when dry conditions occur, flows can be less than desired for optimal outmigration prior to the VAMP period. No changes in operations are proposed for the Stanislaus River.

Delta

Fall and late fall-run Chinook take occurs at the Delta pumping facilities. Protective measures target winter run and spring run Chinook, but the VAMP period is intended to focus on the fall and late-fall run through Delta migration peak.

Conclusion for Fall and late fall-run Chinook

CVP and SWP operations will affect the EFH of fall run and late fall run Chinook. Chinook salmon EFH in the Trinity River should benefit from the Trinity River Restoration Program flows and other habitat improvement measures.

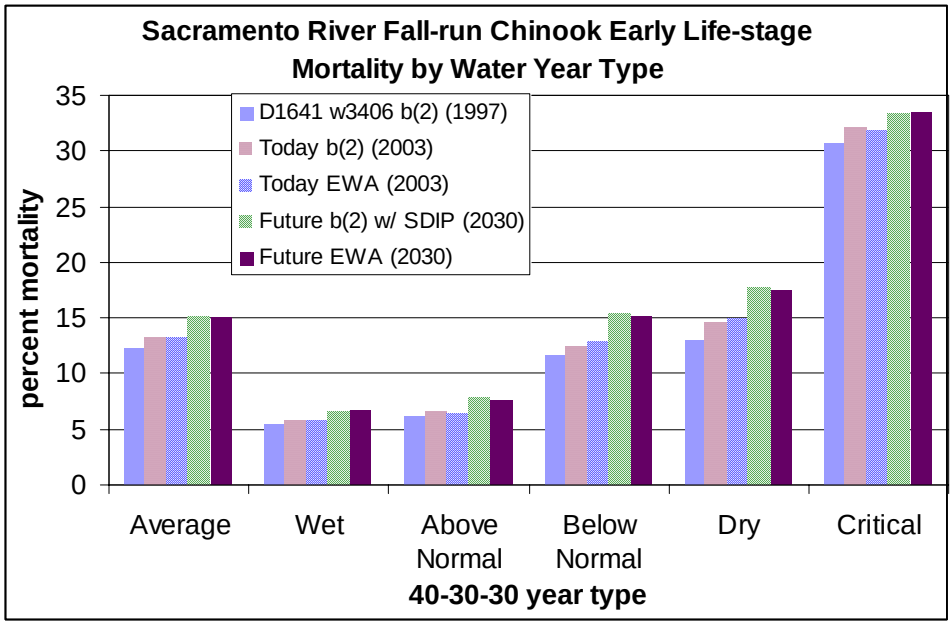

Figure 12–19 Sacramento River Fall-run Chinook Early Life-stage Mortality by Water Year Type

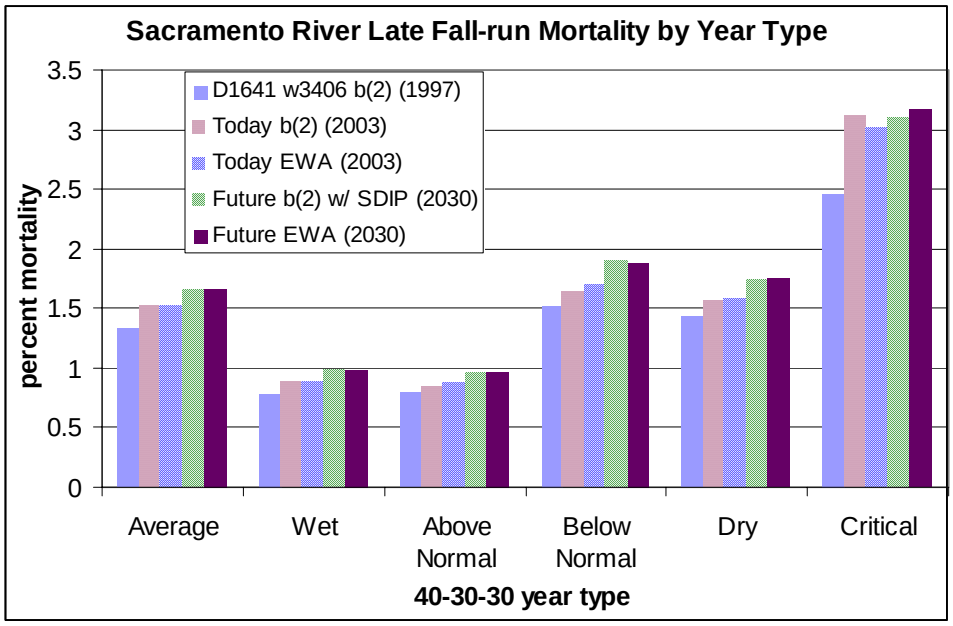

Figure 12–20 Sacramento River Late Fall-run Mortality by Year Type

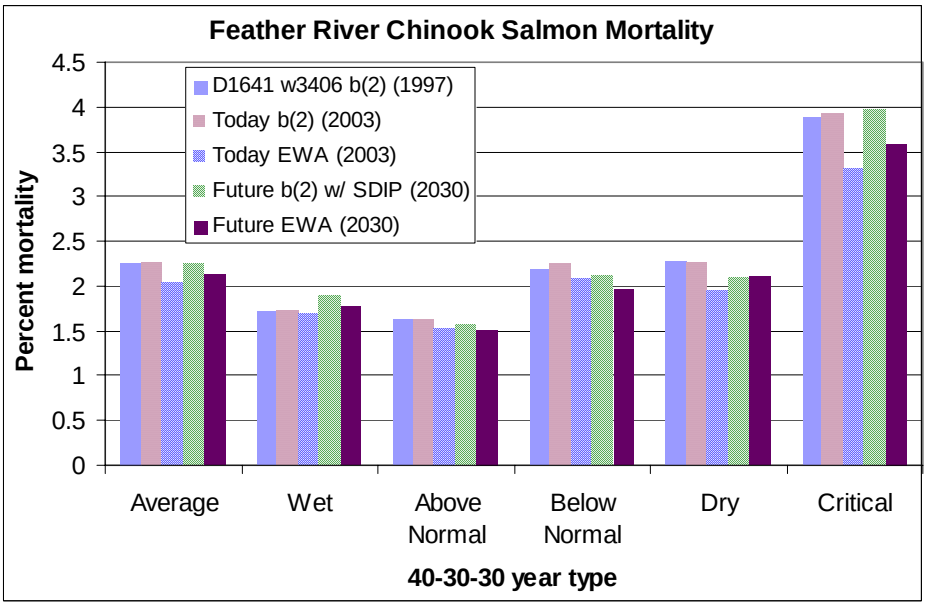

Figure 12–21 Feather River Chinook Salmon Mortality

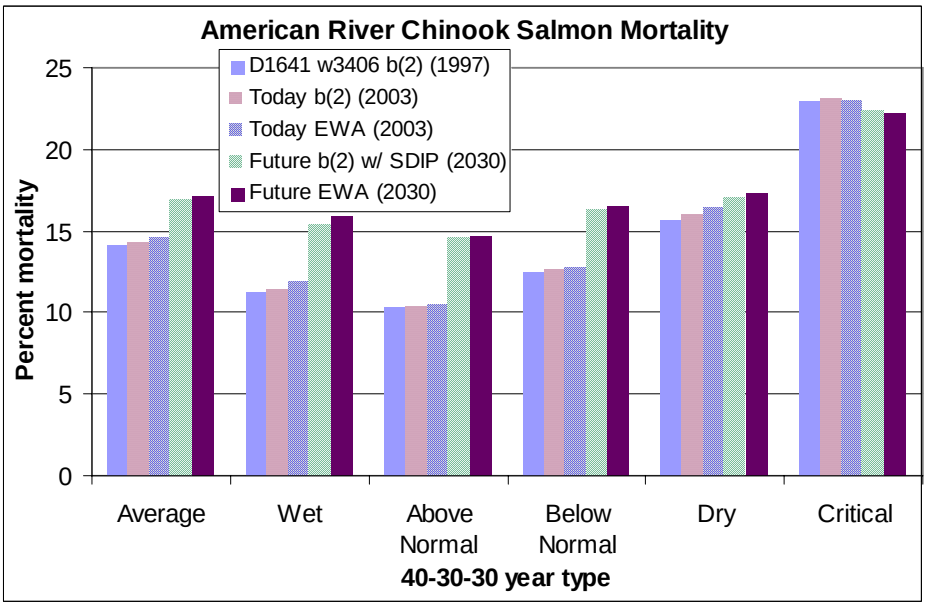

Figure 12–22 American River Chinook Salmon Mortality

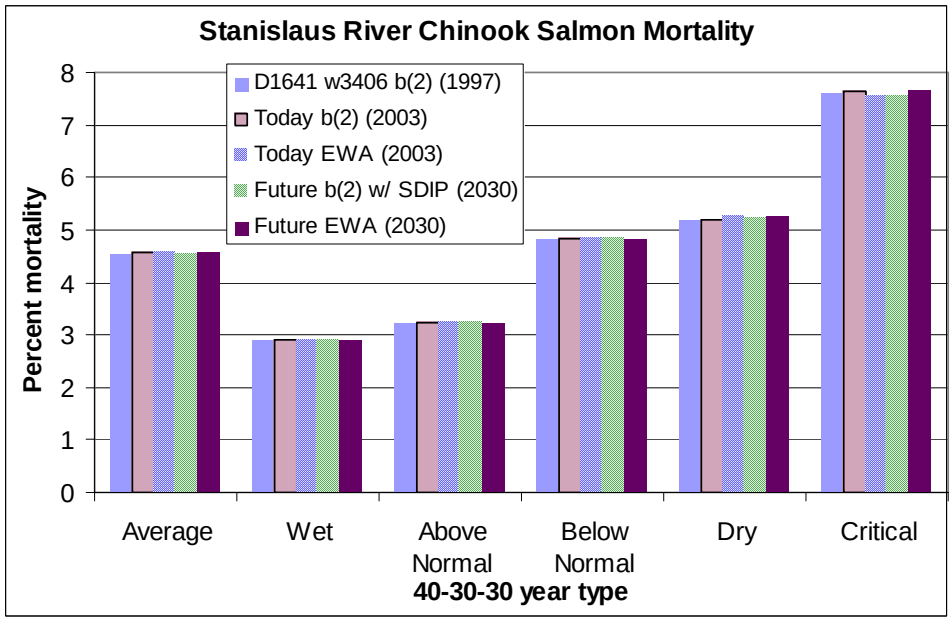

Figure 12–23 Stanislaus River Chinook Salmon Mortality

Chapter 13 Ongoing Actions to Address State Water Project and Central Valley Project Impacts

DWR and Reclamation work with DFG, FWS, and NOAA Fisheries to mitigate losses of salmon, delta smelt, and steelhead that cannot be reasonably avoided. Several agreements and programs are in place that mitigate for direct losses at the SWP and CVP and help improve and restore fishery resources. Chinook salmon, delta smelt, and steelhead are among the species that benefit from the mitigation actions provided under these agreements and programs.

Central Valley Project Improvement Act

On October 30, 1992, the Reclamation Projects Authorization and Adjustment Act of 1992 (Public Law 102–575) was signed into law, including Title XXXIV, the CVPIA. The CVPIA amends the authorization of the CVP to include fish and wildlife protection, restoration, and mitigation as project purposes having equal priority with irrigation and domestic uses, and fish and wildlife enhancement as a purpose equal to power generation. Implementation of CVPIA measures to double anadromous fish populations, improve habitat, and reduce losses of steelhead, spring-run salmon, and other salmon races include habitat restoration, improving fish passage, and diversion screening.

DFG has identified the CVPIA as one of the two major restoration plans addressing habitat restoration projects to benefit Chinook salmon, with great potential to successfully fund and implement restoration actions needed to protect and restore the run (DFG 1998). The other major restoration plan is DFG's action plan for restoring Central Valley streams (DFG 1993).

Since passage of the CVPIA, Reclamation and the FWS, with the assistance of the State of California and the cooperation of many partners, have completed many of the necessary administrative requirements, conducted numerous studies and investigations, implemented hundreds of measures, and have generally made significant progress towards achieving the goals and objectives established by the CVPIA. Positive effects in the Central Valley ecosystem are being observed in many species and habitat types. Clearly, much more needs to be done, and it will be many years before all goals can be achieved.

CVPIA Sections 3406 (b)(1) through (21) authorize and direct actions that will ultimately assist in protecting and restoring salmon and steelhead. These actions include modification of CVP operations, management and acquisition of water for fish and wildlife needs, and mitigation for pumping plant operations. Also included are actions to minimize and resolve fish passage problems, improve fish migration and passage (pulse flows, increased flows, seasonal fish barriers), replenish spawning gravels, restore riparian habitat, and a diversion screening program.

A summary of the actions completed in these past 10 years is provided below in Table 13–1. A more detailed narrative discussion of these efforts and of the progress towards achieving CVPIA goals follows. This discussion contains information from a draft 10-year Report being prepared by Reclamation and FWS.

Table 13–1 SUMMARY OF CVPIA ACCOMPLISHMENTS - 1992-2002.

PROGRAM OR PROJECT	STATUS
Anadromous Fish - Habitat Restoration	
Anadromous Fish Restoration Program	Established AFRP, developed Restoration Plan to guide implementation of efforts; partnered with local watershed groups; acquired over 8,200 acres and enhanced over 1,000 acres of riparian habitat; restored over 5.6 miles of stream channel and placed 62,300 tons of spawning gravels; eliminated predator habitat in San Joaquin River tributaries; and provided for fish protective devices at 7 diversion structures on Butte Creek
Dedicated CVP Yield	Implemented management of 800,000 acre-feet of water dedicated to CVPIA purposes; ongoing
Water Acquisition Program (Anadromous Fish Focus)	Acquired 913,952 acre-feet of water for anadromous fish from 1993-2002
Clear Creek Fishery Restoration	Removed Saeltzer Dam and diversion; increased flows; restored 2.0 miles of stream channel and 68 acres of floodplain; added 54,000 tons of spawning gravel; 152 acres of shaded fuelbreak have been constructed and 12 miles of roadway treated to control erosion.
Gravel Replenishment and Riparian Habitat Protection	Developed long-term plans for CVP streams; placed 111,488 tons of gravel in Sacramento, American and Stanislaus Rivers.
Trinity River Fishery Flow Evaluation Program	Conducted flow evaluation studies; completed EIR/EIS to analyze range of alternatives for restoring and maintaining fish populations downstream from Lewiston Dam; Record of Decision signed December 2000; construction underway on improvements to infrastructure to accommodate increased streamflows
Anadromous Fish - Structural Measures	
Tracy Pumping Plant Mitigation	Improved predator removal; increased biological oversight of pumping; developed better research program, new lab and aquaculture facilities; improved and modified existing facilities
Contra Costa Canal Pumping Plant Mitigation	Established cooperative program for fish screen project for Rock Slough intake of Contra Costa Canal; 90 % designs and environmental evaluation completed. New short-term, low-cost mitigation measures are being developed to allow for an extension of the construction completion date. Final design and construction pending results of CALFED Stage 1 and other studies.
Shasta Temperature Control Device	Completed 2/28/97; since operated to reduce river temperatures without stopping power generation operations [cost $80 million; loss in power generation pre-TCD was $35 million over 7 years]
Red Bluff Dam Fish Passage Program	Completed interim actions and modification of Red Bluff Diversion Dam to meet needs of fish and water users; studies of fish passage alternatives is ongoing.

PROGRAM OR PROJECT	STATUS
Coleman National Fish Hatchery Restoration and Keswick Fish Trap Modification	Installed ozone water treatment system; installed fish trap improvements; improved raceways and barrier weir and ladders; installed interim screens at intakes. Established Livingston Stone National Fish Hatchery.
Anderson-Cottonwood I.D. Fish Passage	Modified dam and operations to improve fish passage; designed new fish ladders and screens.
Glenn-Colusa I.D. Pumping Plant	Constructed fish screen for 3,000 cfs diversion; completed water control structure and access bridge. Completed improvements on side channel.
Anadromous Fish Screen Program	Established program; installed 17 screens and 3 fish ladders at diversions totaling 3,200 cfs capacity; removed 4 dams and 14 diversions. Three screens under construction: others in design.
Other Fish and Wildlife	
Habitat Restoration Program	Established Habitat Restoration Program and San Joaquin River Riparian Habitat Restoration Program; helped acquire 88,364 acres of native habitat and restore 1,111 acres.
Land Retirement Program	Established land retirement program to decrease drainage problems in San Joaquin Valley and enhance wildlife habitat and recovery of endangered species; acquired over 10,000 acres from willing sellers; demonstration project underway with various land treatments applied on over 2200 acres of retired lands to date.
Monitoring	
Comprehensive Assessment and Monitoring Program	Established program to evaluate success of restoration efforts; ongoing
Studies, Investigations and Modeling	
Flow Fluctuation	Coordinated management of CVP facilities; developed standards to minimize fishery impacts from flow fluctuation; studies on American and Stanislaus Rivers are ongoing
Shasta and Trinity Reservoir Carryover Storage Studies	Ongoing studies [related studies funded under 3406(b)(9)]
San Joaquin River Comprehensive Plan	Initiated evaluation to reestablish anadromous fish from Friant Dam to Bay-Delta Estuary; due to public opposition to continued study, Congress dropped funding
Stanislaus River Basin Water Needs	Prepared Stanislaus and Calaveras River water use program and ESA report; additional studies ongoing concurrent with development of Stanislaus River long-term management plans

PROGRAM OR PROJECT	STATUS
Central Valley Wetlands Water Supply Investigations	Report completed that identified private wetlands and water needs, alternative supplies and potential water supplies for supplemental wetlands. Developed GIS database to identify potential water supply sources.
Investigation on Maintaining Temperatures for Anadromous Fish	Completed field investigations on interaction between riparian forests and river water temperatures and on the general effects on water temperature of vegetation, irrigation return flow and sewage effluent discharge; ongoing
Investigations on Tributary Enhancement	Completed report in 1998 on investigations to eliminate fish barriers and improve habitat on all Central Valley tributary streams
Report on Fishery Impacts	Completed report in 1995 describing major impacts of CVP reservoir facilities and operations on anadromous fish
Ecological and Hydrologic Models	Developing models and data to evaluate effects of various operations of water facilities and systems in Sacramento, San Joaquin and Trinity River watersheds (to evaluate potential impacts of various CVP actions; cooperative effort with DWR, USGS, others); ongoing
Project Yield Increase (Water Augmentation Program)	Developed least-cost plan considering supply increase and demand reduction opportunities

Delta Pumping Plant Fish Protection Agreement

On December 30, 1986, the Directors of DWR and DFG signed an agreement to provide for offsetting direct losses of fish caused by the diversion of water at the Banks Pumping Plant. The agreement is commonly referred to as the Four Pumps Agreement because it was adopted as part of the mitigation package for four new pumps at the Banks Pumping Plant. Among its provisions, the Agreement provides for the estimation of annual fish losses and mitigation credits, and for the funding and implementation of mitigation projects. The Agreement gives priority to mitigation measures for habitat restoration and other non-hatchery measures to help protect the genetic diversity of fish stocks and avoid over reliance on hatcheries. In the case of chinook salmon, priority is given to salmon measures in the San Joaquin River system.

The Four Pumps Program has approved about $49 million for projects that benefit salmon and steelhead production in the Sacramento-San Joaquin Basins and Delta since 1986. About $39 million of these approved funds have been expended, with the remaining funds allocated for new or longer-term salmon projects. Projects that have been completed, are on-going, or will be implemented in future years are listed by project type as follows:

1. Screening of unscreened water diversions in Suisun Marsh (8 screens), Butte Creek (2 screens), and San Joaquin tributaries (6 to 10 screens).
2. Enhanced law enforcement efforts to reduce illegal harvest in the Bay-Delta and upstream in the Sacramento-San Joaquin Basins (2 projects).

3. Seasonal barriers to guide salmon away from undesirable spawning habitat or migration pathways (2 projects).
4. Water exchange projects on Mill and Deer Creeks to provide salmonid passage flows for adult spawners and out-migrant young (2 projects).
5. Fish ladders for improved upstream passage on Butte Creek (2 projects).
6. Spawning gravel replacement and maintenance on the Sacramento system (2 projects) and San Joaquin tributaries (7 projects).
7. Other salmonid habitat enhancement projects that combine spawning and rearing habitat improvement, elimination of salmonid predator habitat, and improved channel, floodplain, and riparian areas (6 projects).
8. Salmon and steelhead hatchery production projects (3 projects).
9. Salmon acclimation pens to improve survival of hatchery salmon released In Carquinez Strait (1 project).

Four Pumps projects that benefit spring-run Chinook salmon and steelhead include water exchange projects on Mill and Deer Creeks; enhanced law enforcement efforts from San Francisco Bay upstream into the Sacramento and San Joaquin Rivers and their tributaries; and design and construction of fish screens and ladders on Butte Creek. Predator habitat isolation and removal and spawning habitat enhancement projects on the San Joaquin tributaries benefit fall-run Chinook salmon and steelhead. About a third of approved funding for salmonid projects are specifically targeting spring-run salmon in the upper Sacramento tributaries. Most of these projects also benefit steelhead and fall-run salmon.

The water exchange projects on Mill and Deer Creeks provide for new wells that enable irrigators to switch from stream diversions to groundwater, thus leaving water in the creeks during critical migration periods. Spring-run Chinook salmon are the primary benefactors of this project, with secondary benefits to fall-run Chinook salmon and steelhead. Costs for construction and 15-year operations for both projects are estimated to be $4.6 million. The Mill Creek project has operated since 1990. A pilot project using one of the 10 pumps originally proposed for Deer Creek was tested in summer 2003. Another run of testing is scheduled for summer 2004.

Enhanced law enforcement activities continue to be implemented throughout the fall-run, spring-run, and steelhead range. The Spring-run Salmon Increased Protection Project provides overtime wages for DFG wardens to focus on spring-run salmon protection, reducing illegal take and illegal diversions on upper Sacramento River tributaries and adult holding areas, where they are very vulnerable to poaching. The project covers Mill, Deer, Antelope, Butte, Big Chico, Cottonwood, and Battle Creeks, and has been in effect since 1995. The Delta-Bay Enhanced Enforcement Program (DBEEP) is a larger effort, initiated in 1994, that also provides increased salmonid enforcement from the San Francisco Bay Estuary upstream into the Sacramento and San Joaquin Basins. This program (which has been partially funded by Reclamation) has a team of 10 wardens that focus enforcement efforts to protect salmon, steelhead, and striped bass. The Sacramento River program continues to focus specific enforcement during the spring-run migration and summer holding period. The combined cost of these programs through 2005 is $9.6 million.

Four Pumps has provided about $400,000 in cost-share funds for several projects to improve passage for adult and juvenile spring-run salmon on Butte Creek, with secondary benefits to fall-run and steelhead. These funds played an important role in completing these projects because they were readily available at crucial points of project implementation. Funds were made available to expedite design and engineering on three priority passage problem sites until Tracy Mitigation Funds were in place for these costs, thus preventing unnecessary fish losses if corrective measures had been postponed a season. Four Pumps also helped fund construction of the Parrot-Phelan Fish Ladder and the Durham Mutual Fish Ladder and Screens. The passage projects have improved salmon survival by allowing adult spawners to pass upstream during low water periods, through the quick passage of salmon progeny downstream, and by decreased injury of adults during all water years.

Several other projects funded by Four Pumps also provide benefits to fall-run and spring-run salmon and steelhead. About $2.5 million have been spent on eight fish screens in Suisun Marsh and $1.2 million for the eradication of northern pike. Steelhead will also benefit from the numerous projects completed or planned on the San Joaquin tributaries to remove or isolate salmonid predator habitat and enhance spawning habitat, particularly on the Stanislaus River. About $12 million has been provided for these projects. A quantitative analysis of Four Pumps mitigation for spring-run Chinook salmon follows.

Chinook Salmon Delta Losses

Estimations of both the losses and benefits to salmon for Four Pumps mitigation are based on the best available information and assumptions mutually agreed to by DFG and DWR. For purposes of the agreement, direct losses are defined as losses occurring from the time fish enter Clifton Court Forebay until surviving salvaged fish are returned to Delta channels. Direct losses include those fish that are eaten by predators or otherwise lost in the forebay, those that pass through the Skinner fish screens, and those that die as a result of handling and trucking stresses during the salvage process.

Quantification of overall spring-run losses in the Delta due to SWP operation is difficult. This is due both to our inability to distinguish spring-run from other salmon races in the Delta and our uncertainty about the relative importance of the variety of factors affecting spring-run survival in the Delta. However, there are several sources of information that can be used to determine the general magnitude of these losses.

The first source of information is the DFG annual estimate of salmon losses at the SWP's south Delta pumping facilities, which is provided in accordance to the provisions of the Four Pumps Agreement. DFG's annual salmon loss estimate includes all the losses of salmon occurring from the time the fish enter Clifton Court Forebay to the time salvaged fish are returned to the Delta. During the last five years, the total salmon losses have ranged between about 53,000 and 273,000 smolt equivalents and averaged about 178,000 smolt equivalents.

Only a small percent of the total salmon losses at the SWP's south Delta pumping facilities are spring-run salmon. DFG and DWR believe most of the salmon losses are San Joaquin River fall-run, and have reflected that belief in the Four Pumps Agreement by giving priority to mitigation projects in the San Joaquin Basin. For this analysis we assume that the spring-run losses are 3 percent of the total losses at the south Delta facilities.

Over the years, mark and recapture studies suggest that losses of juvenile spring-run salmon in Delta channels may be several times the losses estimated at the SWP pumping facility. It is not known how much of these Delta channel losses are due to SWP operations. However, for this analysis we assume that the indirect losses in the Delta channels are five times those at the south Delta facilities. Using (1) DFG estimates of direct salmon losses at the SWP pumping facility, (2) the assumption that 3 percent of these are spring-run, and (3) the assumption that indirect losses are five times those of the direct losses, we calculated the spring-run losses due to SWP Delta operations during the last five years. These calculated spring-run losses are shown in Table 13–2.

Table 13–2 Spring-run salmon losses due to SWP's Delta operations (in smolt equivalents).

	1999	*2000*	*2001*	*2002*	*2003*
Pumping losses (3% actual)	8,200	7,200	5,300	1,600	4,200
Channel losses (5X actual)	41,000	36,500	26,500	8,000	21,000
Total losses	49,200	43,800	31,800	9,600	25,200

Chinook Salmon Mitigation

DFG and DWR have approved four projects that have been totally or partly funded through the Four Pumps Agreement, which include quantified benefits to spring-run salmon. These projects and DFG estimates of how many additional spring-run they will produce in the Delta to offset losses at Banks Pumping Plant are presented below (Table 13–3). The DFG estimates reflect the average annual benefits of each project over its life based on recent historical conditions.

Table 13–3 Predicted annual spring-run benefits of approved Four Pumps mitigation projects (in smolt equivalents).

Project	*Credits*
Warden overtime (Revised Estimate for 2003-4)	122,622
Durham Mutual/Parrott-Phelan screen and ladders	5,518
Mill Creek water exchange	35,915
Deer Creek water exchange	76,715
Total predicted credits	240,770

The warden, Durham Mutual/Parrot Phelan and Mill Creek projects have been implemented. DFG expects them to produce an annual average of over 164,000 additional spring-run in the Delta. As described above, a pilot Deer Creek Project is tested in summer 2003 with a second test scheduled for summer 2004

DFG has also agreed that two other Four Pumps salmon projects would offset spring-run losses at the Delta Pumping Plant. DFG has credited DWR with offsetting losses of two million salmon at the Delta Pumping Plant for funding the reduction of the northern pike population in Lake Davis, and with 250,000 salmon per year for funding 10 additional game wardens to reduce poaching in the Delta. One of these wardens was to focus primarily on protecting spring-run in Delta tributaries. DFG did not quantify the spring-run benefits of these two projects, and we have therefore not included them in this analysis.

The Four Pumps Agreement also provides $15 million for the implementation of additional fish improvement projects beyond those needed to replace the annual losses. These include screening of seven diversions in the Suisun Marsh and the cost sharing in the screening of an eighth diversion. The specific spring-run benefits of these screens were also not quantified and have not been included in this analysis.

The actual mitigation benefits of the Four Pumps spring-run projects are expected to vary from year to year, depending on the actual size and distribution of the stock in each tributary, the hydrology and other factors in a particular year. Overall, the three spring-run projects that have been implemented have provided substantially more spring-run mitigation credits during the last several years than expected based on historical conditions. This has been due primarily to a relatively high spring-run escapement in recent years. Following are the actual Four Pumps spring-run mitigation credits that have been produced by each of implemented projects during the last six years (Table 13–4).

Table 13–4 Actual annual spring-run salmon mitigation credits produced by Four Pumps projects in smolt equivalents.

Project	*1999*	*2000*	*2001*	*2002*	*2003*	*2004*
Warden overtime	344,931	94,743	82,341	191,393	197,764	143,017
Durham Mutual/Parrott-Phelan	78,086	17,548	19,642	45,814	41,903	20,978
Mill Creek water exchange	5,890	26,548	24,249	104,699	207,565	179,369
Total credits	428,907	138,839	126,232	341,906	447,232	343,363

The three fishery improvement projects already implemented under the Four Pumps Program appear likely to have produced between 3 and 3.5 times more spring-run salmon between 1999 and 2003 than lost due to the direct and indirect effects of the SWP Delta operations. Over the entire five years, DFG specifically credited these projects producing six times more spring-run salmon than were likely lost due to SWP Delta operations. These figures do not reflect the significant, but unquantified benefits to spring-run salmon that DFG has attributed to the DBEEP or the Suisun Marsh fish screen projects.

Table 13–5 Spring-run salmon losses and mitigation credits in smolt equivalents.

	1999	*2000*	*2001*	*2002*	*2003*	*Total*
Credits	428,907	138,839	126,232	191,393	197,764	1,083,135
Potential losses	49,200	43,800	31,800	9,600	25,200	159,600
Extra mitigation	379,707	95,039	94,432	181,793	172,564	923,535
Percent extra	772%	217%	297%	1,894%	685%	%

The Warden Overtime Program, the Durham Mutual/Parrot Phelan Screen and Ladder Project and the Mill Creek Water Exchange Project continue to provide spring-run credits in 2004, which, based on the last five years experience, are likely to more than replace the number of fish lost in the Delta due to SWP operations. The DBEEP and Suisun Marsh screens would provide additional but unquantified benefits. It therefore appears that the effects of the SWP Delta operations on spring-run salmon are being fully mitigated and are unlikely to jeopardize the survival of the species.

Tracy Fish Collection Facility Direct Loss Mitigation Agreement/Tracy Fish Facility Improvement Program

On March 7, 2000, Reclamation and DFG signed the revised Tracy Agreement to reduce and offset direct losses of Chinook salmon and striped bass associated with the operation of the Tracy Pumping Plant and the Tracy Fish Collection Facility (TFCF). The Tracy Agreement provides for improving operations at TFCF, making necessary structural modifications, and annual funding to DFG for mutually agreed upon programs to offset and replace direct losses. Approximately $2.65 million of mitigation funding was provided for projects to offset losses in Federal fiscal years 1993 through 1997. The Tracy Agreement also provides for an additional $7.67 million in funding during Federal fiscal years 1998 through 2004 to DFG to be used for projects that offset and replace direct losses of fishery resources resulting from the operation of the Tracy Pumping Plant.

The Tracy Fish Facility Improvement Program (TFFIP) is identifying and making physical improvements and operational changes, assessing fishery conditions, and monitoring salvage operations at the TFCF per agreements with DFG in 1992 and Section 3406(b)(4) of the CVPIA. Research and evaluation efforts to date have included predator removals, louver efficiency estimates, holding tank surveys, biology and movements of local native species (splittail), secondary louver netting, water quality monitoring, egg and larvae density studies, improved fish handling, and improved fish identification. Facility improvements have included new fish hauling trucks, new louver cleaner rakes, predator removal screens, improved instrumentation, and surface painting of holding tanks to minimize fish abrasion. All activities accomplished under the TFFIP are documented in Reclamation reports as part of the Tracy report series. To date approximately 20 reports have been completed or currently under preparation. Reclamation's research efforts are coordinated with the other water and regulatory agencies

through the IEP and CALFED. ESA considerations are covered either through language contained in the biological opinions or application of ESA Section 10 permits.

In addition to the research efforts on-site at Tracy and in Reclamation's lab in Denver, Reclamation is proposing construction of a test/demonstration facility to test and demonstrate new technologies to be used in the south Delta for improved fish protection. The facility is currently under review by the CALFED South Delta Fish Facility Forum (SDFF) due primarily to concerns over size and cost. It is anticipated that a final decision on the fate of the facility will be made soon.

Chinook Salmon and Steelhead Benefits

The Tracy Agreement provides for a mechanism to identify, develop, and implement habitat restoration measures for anadromous fish in a manner similar to the Agreement. The program has funded about $2.5 million in projects that provide benefits to spring-run Chinook salmon and steelhead. This funding source is particularly important because it can provide start-up funds for preliminary design and engineering work needed to develop proposals for other funding sources. Most other funding sources do not generally fund these types of activities.

Among the projects funded with spring-run benefits, about $100,000 was provided for the design, environmental documentation, and permitting for the Western Canal Siphon Project on Butte Creek. This project removed four dams to improve salmon passage, and replaced them with a siphon to move irrigation water under Butte Creek. The Tracy Agreement has also funded the preliminary engineering and design of salmon passage improvements at six other sites on important spring-run Chinook salmon tributaries at the cost of $390,000. These sites include Battle Creek (Eagle Canyon Diversion), Clear Creek (McCormick-Saeltzer Dam), Butte Creek (Adams, Gorrill, and Durham Mutual dams), and the Yuba River.

The Tracy Agreement has cost shared in several projects with the Four Pumps Program which provide benefits to spring-run salmon and steelhead as discussed in the Four Pumps Agreement section. Cost-share funding was provided for the DBEEP enhanced law enforcement program for five years for a total of $1 million though 1999. Also, Reclamation has contributed $310,000 toward the construction and maintenance of the Grizzly Island Fish Screen.

Primary Louver Bypass Modification at TFCF

Existing fish bypass transition boxes have deteriorated and will be replaced. Current schedule calls for the replacement to occur in the spring of 2004. The new transition boxes were previously modeled in Reclamation's lab in Denver and will be modeled again for velocity field conditions after installation.

Tracy Mitten Crab Screen Debris Studies

The existing traveling water screen used for removal of Chinese mitten crabs at the TFCF will be further studied for debris removal strategies in the secondary channel while assessing any fish impacts. Other research will be conducted on-site to explore improved debris removal at various points in the system.

TFCF Full Facility Evaluation

Reclamation will be conducting full facility evaluations of the TFCF as it relates to the various species of fish entering the facility, especially those that are listed species, and how well the system can effectively louver fish into the holding tanks for release back into the Delta. Research has already been conducted within the secondary louver system for several different species.

Evaluation of 10 Minute Count Screen for Collecting Small Fish at the TFCF

Reclamation is evaluating the count screens used in the 10 minute sampling operations to determine if improvements can be made in regards to loss of small fish.

Improve Removal Procedures from Fish Holding Tanks

Recently conducted studies indicate that survival of fish in holding tanks could be improved with new fish removal procedures, especially during high debris events. The studies will consider new designs that would have application to both the Tracy and Federal fish facilities. Tank and valve development, fish separation strategies, and consideration of fish pumping will be analyzed.

California Bay-Delta Authority

NOTE: Information in this section is from the 2003 California Bay-Delta Authority Annual Report.

Now in its fourth year of implementation, the Bay-Delta Program is delivering on its promise to break through years of gridlock and litigation by providing a balanced, collaborative approach to the state's most challenging water issues. Fish populations are improving, water supplies are becoming more dependable and several large-scale water quality projects are underway.

The California legislature established the California Bay-Delta Authority as a new governance structure to oversee the Program and the CALFED agencies. Collectively these agencies have allocated nearly $2 billion for local projects to expand groundwater storage, ensure efficient water use, increase water recycling, stabilize levees and restore ecosystems.

Highlights of Accomplishments in Years 1 – 3

CALFED agencies have achieved major progress on **groundwater storage**, with more than $180 million in grants and loans awarded for local projects that will improve groundwater management and increase the water supply yield from groundwater storage and conjunctive use by more than 200,000 acre-feet a year. Groundwater storage projects are increasingly providing multiple benefits, including water quality improvements, environmental enhancement and flood control.

Surface storage feasibility studies are well underway on all five potential projects under investigation. The projects could increase the state's water storage capacity and add flexibility needed to protect at-risk species, meet water quality standards and ensure reliable water supplies for cities and farms. Decisions on which projects, if any, will move ahead are expected in 2005/06.

State and federal agencies continue to make progress on **conveyance** improvements proposed in the South Delta, including an intertie between the State Water Project and Central Valley Project canals and other actions that will improve water quality for water users in and near the Delta. The South Delta Improvements Program includes plans to increase State Water Project pumping in the Delta to 8,500 cfs and install operable barriers at key locations. Actions planned for Veale and Byron tracts will reduce the effects of agricultural drainage on drinking water quality.

On **water transfers**, CALFED agencies have made strides on streamlining the approval process and assisted in the transfer of more than 500,000 acre-feet of water in 2003 (including 277,000 acre-feet for the Environmental Water Account). Meanwhile, work is underway on an environmental impact report on state-sponsored water transfer activities.

Significant investments have been made in **water use efficiency** and recycling projects, particularly in Southern California and the San Joaquin Valley. To date, nearly $46 million in state and federal funds have been invested that will conserve an estimated 46,000 acre-feet of water per year. Another $122 million has been invested in local recycling programs that will produce more than 400,000 acre-feet of recycled water each year.

Launched initially as a four-year experiment, work is underway to renew the **EWA** as a long-term program. So far, state and federal agencies have spent about $219 million on EWA efforts and provided over 900,000 acre-feet of water to protect at-risk species and maintain deliveries to water users.

Bay-Delta agencies to date have invested $34 million in 21 **drinking water quality** projects, including source water protection, monitoring and treatment technology. In addition, a drinking water framework is under development to help factor water quality considerations into the planning process for all Bay-Delta Program areas.

More than 700 miles of **Delta levees** have been preserved and improved. CALFED agencies have awarded $37 million in funding since 2001 to improve Delta levees, and more than 324,000 cubic yards of dredge material has been reused to increase levee stability and enhance habitat in the Delta.

Ecosystem restoration efforts continue to improve habitat and address the needs of key species. To date, $476 million has been invested in over 400 ecosystem projects. 100,000 acres of habitat have been protected or restored. CALFED agencies have funded projects to install 68 new or improved fish screens and launched 23 comprehensive studies to answer important scientific questions linked to implementation of the program.

The **Watersheds** Program awarded 83 grants totaling $25.5 million to 50 community-based organizations for projects addressing watershed health, drinking water quality, non-point sources of pollution and watershed protection. Twenty watershed coordinators are now in place throughout the Bay-Delta system.

Through the **Science** Program, the Authority has brought together many of the nation's most distinguished scientists to work on Bay-Delta issues. An Independent Science Board is up and running to make recommendations on science issues to the Authority. A new Science Consortium is integrating related research topics and scientific resources.

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Long-term Central Valley Project and State Water Project Operations Criteria and Plan Biological Assessment for Terrestrial Species Protected Under the State Endangered Species Act

Long-term Central Valley Project and State Water Project Operations Criteria and Plan Biological Assessment for Terrestrial Species Protected Under the State Endangered Species Act

Prepared by

Department of Water Resources for

U.S. Bureau of Reclamation

March 2004

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Acronyms and Abbreviations

BA	Biological Assessment
Reclamation	U. S. Bureau of Reclamation
DFG	California Department of Fish and Game
CESA	California Endangered Species Act
CVP	Central Valley Project
CVP-OCAP	Long-term Central Valley Project Operations Criteria and Plan
Delta	Sacramento-San Joaquin Delta
DWR	California Department of Water Resources
FESA	Federal Endangered Species Act
USF&WS	U. S. Fish and Wildlife Service
SWP	State Water Project
EWA	Environmental Water Account
SDIP	South Delta Improvement Program

Introduction

The Bureau of Reclamation (Reclamation) and the California Department of Water Resources (DWR) operate the Central Valley Project (CVP) and State Water Project (SWP) to divert, store, and convey CVP and SWP water consistent with applicable law. The CVP and the SWP are two major inter-basin water storage and delivery systems that divert water from the southern portion of the Sacramento-San Joaquin Delta (Delta). Both projects include major reservoirs north of the Delta and transport water via natural watercourses and canal systems to areas south and west of the Delta. The CVP also includes facilities and operations on the Stanislaus and San Joaquin Rivers.

Reclamation has prepared a Biological Assessment (Long-term Central Valley Project Operations Criteria and Plan [CVP-OCAP] Biological Assessment) addressing the effects of operating the CVP and SWP in accord with the CVP-OCAP on listed fish species including:

- Winter-run Chinook salmon
- Spring-run Chinook salmon
- Central Valley steelhead
- Delta smelt
- Coho Salmon

Reclamation has also prepared a Biological Assessment (Long-term Central Valley Project Operations Criteria and Plan [CVP-OCAP] Biological Assessment) addressing the effects of operating the CVP and SWP on wildlife and plant species that are listed or proposed for listing under the federal Endangered Species Act (FESA). These species include:

- bald eagle
- California clapper rail
- salt marsh harvest mouse
- riparian brush rabbit
- riparian woodrat
- California red-legged frog
- giant garter snake
- valley elderberry longhorn beetle
- Suisun thistle
- soft bird's-beak

DWR has prepared this Biological Assessment (Long-term Central Valley Project Operations Criteria and Plan [CVP-OCAP] Biological Assessment) addressing the effects of operating the SWP on wildlife species that are listed or proposed

for listing under the State Endangered Species Act (CESA) and not already addressed by Reclamation's assessment. These species include:

- Bank swallow
- Swainson's hawk
- Western yellow-billed cuckoo

Description of the Action Considered
DWR's proposed action is to operate the SWP in the future, as described in the CVP-OCAP. The CVP-OCAP provides a comprehensive description of the proposed action. A summary of the proposed action is provided in Chapter 1 of the *Long-term CVP-OCAP Biological Assessment* that addresses effects to listed fish species.

Other Actions Not Included in the Proposed Action
The proposed action is limited to DWR's operation of SWP facilities for the purpose of diverting, storing, and conveying project water. The proposed action does not include diversion of water through non-SWP facilities or use of diverted water. Furthermore, the proposed action does not include maintenance activities associated with Oroville facilities. Impacts associated with maintenance activities are being addressed in a separate consultation process.

Action Area
The action area covered under this BA consists of the Oroville Reservoir complex, the Feather River downstream of Oroville, the Sacramento River downstream of the Feather River, the Sacramento-San Joaquin Delta, and adjacent habitats that are dependent on or influenced by the hydrologic or water quality conditions of these waterways.

Threatened and Endangered Species Considered
Per DFG recommendation, this BA will focus on evaluation of current and future SWP operational impacts to three State listed species including bank swallow, Swainson's hawk, and western yellow-billed cuckoo.

The purpose and need of Reclamation's and DWR's actions is to implement CVP-OCAP, which consists of operating CVP and SWP facilities primarily to:

- Deliver water to diversion points
- Provide flood control
- Release water to meet instream flow and water quality requirements.

The proposed action does not include the actual diversion of water (i.e., direct effects of diversion) or use of diverted water. Potential effects of the proposed action, therefore, consist of:

- Changes in flows in waterways downstream of the Oroville Reservoir complex
- Changes in water surface elevations in the Oroville reservoirs
- Changes in water quality of downstream waterways

Because the potential effects of the proposed action are limited to hydrologic and water quality changes, species potentially affected by the action are limited to species that are aquatic or require the resources supported by the affected waterways. All three species recommended by DFG for impact assessment can potentially be affected by hydrologic conditions of these waterways.

Study Period
This BA evaluates the future effects of operation of the SWP in accordance with CVP-OCAP. The study period encompasses the current (circa 2001) level of development through a projected future level of development expected in approximately 2020.

Consultations to Date
DWR has recently initiated consultation with DFG concerning potential current and future impacts to nesting bank swallows related to SWP operations. This potential impact is based on modeling results developed for and presented in this assessment. To date, take of bank swallow due to SWP operations has not been documented.

Species Accounts

Bank Swallow
The State of California listed the bank swallow as a threatened species during March 1989. This species is not listed under the Federal Endangered Species Act. However, bank swallows are protected under the Federal Migratory Bird Treaty Act.

Historically, bank swallows nested in suitable habitat throughout lowland California (Grinnell and Miller 1944). The bank swallow's range in California has decreased significantly with only four known populations south of San Francisco Bay and about 70 percent of the statewide population currently occurs along the Sacramento and Feather rivers (California Department of Fish and Game 1992).

Bank swallows are a migratory species and begin to arrive back in the Sacramento Valley in late March and early April, with the bulk of the birds arriving in late April and early May (Garrison 2001). Juveniles begin to disperse from the nest colonies around mid-June and early July and are absent from the nest colonies by mid-July (Garrison 2001).

Bank swallows occur in riverine habitat and require a sandy or silty vertical bluff or riverbank for nesting (Zeiner and others 1990). Bank erosion is required to create and maintain the eroded banks favored by this migratory, colonial species. The principal threat to bank swallows is bank protection projects (Remsen 1978). Over 133 miles of rip-rap bank protection have been installed along the Sacramento River since 1960 (Jones and Stokes Associates 1987).

Swainson's Hawk

The Swainson's hawk was listed as a threatened species by the State in 1983. This species is not listed under the Federal Endangered Species Act. However, Swainson's hawks are protected under the Federal Migratory Bird Treaty Act.

Current distribution is limited to northeast California (primarily Modoc, Siskiyou and Lassen counties) and the Central Valley. Swainson's hawks arrive in California from wintering areas in South America, Central America, and Mexico between mid-March and early April (Estep 1989). Nesting is initiated by mid-April with most chicks fledge by mid-July. This species begins its southern migration during August and are generally absent from California by mid-September.

Swainson's hawks currently use a variety of agricultural crops for foraging including alfalfa, fallow fields, beet, tomato, irrigated pasture, rice (non-flooded), and cereal grains. Diet consists primarily of small mammals although birds and insects are also frequently consumed. Nesting habitat includes isolated trees, small groupings of trees, and linear groupings of trees associated with roadsides or narrow riparian zones near foraging areas.

Western Yellow-billed Cuckoo

The western yellow-billed cuckoo was listed as a State threatened species in 1971 and reclassified to endangered in 1987. This species is not currently listed under the Federal Endangered Species Act. However, this species is protected under the Federal Migratory Bird Treaty Act.

Cuckoos are a neotropical migratory species wintering in South and Central America. This species arrives in California in late May and June. Nesting generally occurs in late-June or July with most cuckoos initiating fall migration out of the State by mid-September.

Cuckoos are a riparian obligate-forest interior species. Suitable cuckoo nesting habitat is described as deciduous riparian thickets or forests with dense low understory near slow moving waterways (Zeiner et al 1990). Preferred habitat is a mosaic of riparian habitats including willows, cottonwoods, and open water. Nesting cuckoos appear to require a block of suitable habitat at least 20 acres in size and 100 to 200 yards in width while habitat blocks of 80 acres is size and 600 yards in width are considered optimal (Laymon and Halterman 1988).

Foraging cuckoos appear to selectively prey on larger sized prey within riparian habitats including green caterpillars, katydids, tree frogs, and grasshoppers (Laymon 1998).

Environmental Baseline and Status of the Species in the Action Area

2002 and 2003 survey results indicate that bank swallows, Swainson's hawks, and western yellow-billed cuckoos are absent from Oroville facility reservoirs.. This assessment focuses on evaluation of proposed OCAP changes in the magnitude, timing, and duration of project water releases to the Feather River.

Bank Swallow

Current Population-2002 survey results indicate that eight active bank swallow colonies were present on the Feather River between Oroville Dam and Verona totaling 2,274 burrows (Table 1). An additional six inactive colonies were also identified within the same survey area totaling 813 burrows.

Table 1 Bank swallow occurrence on the Feather River below Oroville Dam during 2002 and 2003.

Category	2002	2003
# of colonies	14	18
# of active colonies	8	15
Total # of burrows	3,087	4,179
Total # of active burrows	2,274	3,594

The 2003 survey results documented the presence of 15 bank swallow colonies on the Feather River between Oroville Dam and Verona totaling 3,594 burrows (Figures 1 and 2). Three inactive colonies were identified totaling 585 burrows.

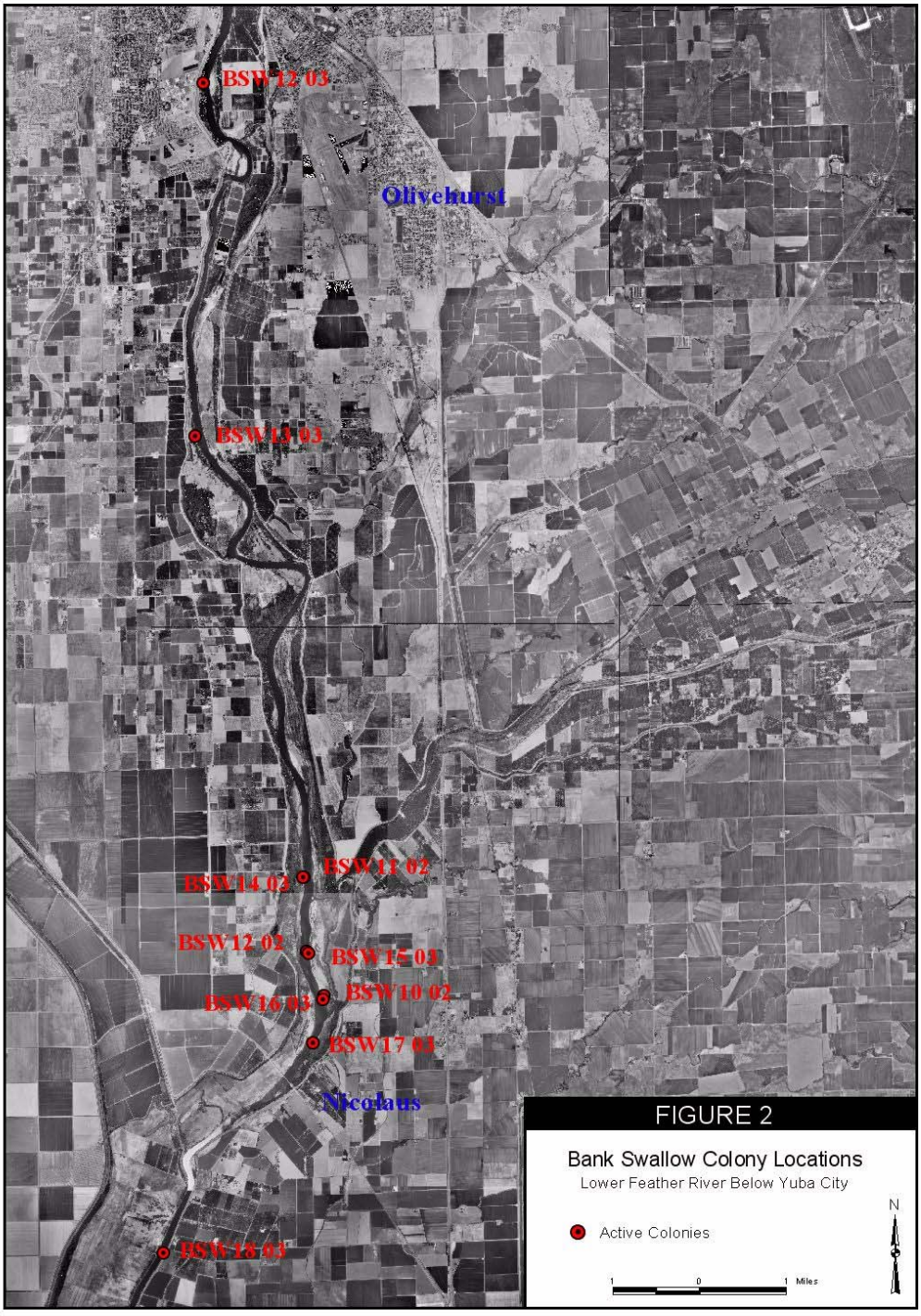
In 2003, inactive colony size ranged from 43 to 375 burrows. Active colony size ranged from 18 burrows to 1,164 burrows. An occupancy rate of 47 percent was applied to the number of burrows in active colonies yielding an adult population estimate of 1,056 pairs in 2002 and 1,689 pairs in 2003.

During 2002, five colonies were identified between Oroville Dam and Yuba City with an estimated population of 890 pairs. An additional 3 colonies were present between Yuba City and Verona with an estimated adult population of 166 pairs. In 2003, 9 colonies were present between Oroville Dam and Yuba City with an estimated adult population of 1,411 pairs. Six additional colonies were present downstream from Yuba City with an estimated adult population of 278 pairs.

Comparison with historic nest survey information indicate that the 2002 and 2003 bank swallow nesting populations on the Feather River is substantially lower than those collected in 1987 which identified seven colonies ranging in size from 140 to 2,000 burrows (Humphrey and Garrison 1987). During the 1988 survey, 18 colonies containing a total of 6,592 burrows were recorded (Laymon and

others 1988). The 1987 and 1988 DFG surveys are the most recent previous complete surveys of the entire Feather River.





Swainson's Hawk

Swainson's hawks were historically common throughout most of lowland California (Grinnell and Miller 1944). By 1979, it was estimated that this migratory species had experienced a 91 percent population decline in California (Bloom 1980). The Statewide population was estimated at 550 pairs in 1989 with approximately 80 percent of the population occurring in the Central Valley (Estep

1989). This species decline is believed to be related to agricultural and urban land conversions which have virtually eliminated native grassland foraging habitat (Estep 1989).

In addition to habitat losses associated with conversion of native grasslands to agriculture, recent trends in agricultural land use have further diminished potential foraging habitat. These changes include conversion of croplands suitable for Swainson's hawk foraging to unsuitable crops including vineyards, orchards, cotton, and rice.

Historical survey data indicate that Swainson's hawks nest within strips of riparian habitat in the Feather River floodplain between Marysville and Verona (DFG 2003). Two recently discovered nests were present between the Thermalito Afterbay outfall and Sunset Pumps during 2003. Complete nesting surveys of the Feather River floodplain have not occurred. However, potentially suitable nesting habitat is present along a substantial portion of the approximately 55 mile reach of the Feather River downstream from the Oroville Wildlife Area. In most areas, a thin strip of potential nest trees are present on levees adjacent to agricultural fields.

Western Yellow-billed Cuckoo
Historic records indicate that this species was common in the Central Valley (Belding 1890). However by the 1940's the species is described as rare (Grinnell and Miller 1944). Today its distribution is limited to several small isolated areas of the State. The two largest remaining populations in the State are near the Kern and Sacramento rivers. The 1977 statewide population was estimated at between 122 and 163 pairs (Gaines and Laymon 1984). A subsequent statewide survey in 1988 estimated that only 31 to 33 pairs remained (Laymon and Halterman 1988). Loss and fragmentation of riparian habitat accounts for most of the population decline (Laymon 1980).

The 1988 statewide survey identified 900 acres of potentially suitable cuckoo nesting habitat along the Feather River. One pair of cuckoos was identified within this potentially suitable habitat.

Both direct and indirect effects of pesticide use have been identified as a potential factor in this species population decline (Laymon 1998). Another potential threat to the species is the establishment and spread of exotic/invasive plant species into riparian habitats including salt cedar, giant reed, and domestic fig.

Effects of Proposed Action

Bank Swallow
The SWP has the potential to impact bank swallow populations on the Feather River below Oroville Dam through flood control and water supply operations.

Flood Control- Bank swallows are dependent upon vertical eroded banks of a proper friable soil composition. High flows and associated bank erosion can result in both positive and negative impacts on this species. Flooding causes bank erosion and soil deposition. Erosion produces the vertical banks, while soil deposition is the source of the friable soils needed for burrow construction. Lack of high flows results in decreased slope of eroded banks and subsequent abandonment by nesting bank swallows. However, bank erosion and flooding can also result in the need for flood control, bank protection, and channelization which reduce the quantity and quality of bank swallow habitat.

Bank erosion does occur at certain locations on the Feather River at flows as low as 10,000 cfs. However, major flows in the 20,000 to 30,000 cfs range are generally required to create and maintain significant amounts of bank swallow nesting habitat. These channel forming events can create extensive amounts of high quality bank swallow habitat for a period of time. Data analyses indicate that flows > 20,000 cfs have occurred post-project on the average at a 2.3 year return intervals (Gridley Gage data). Further, data analyses indicate that flows greater than 20,000 cfs occurred pre-project on the average of 0.09 year return interval (Oroville gage data). Project related flood control activities have substantially altered the reoccurrence interval of flows in the 20,000 cfs range. Further, the reoccurrence interval of major flood flows (>than 50,000 cfs) have also been substantially reduced from a 1.9 year return interval pre-project (Oroville gage data) to a 3.1 year return interval post-project (Gridley gage data). Streamflow is not the only factor controlling bank erosion rates. Bank saturation, length of the period of high flow, bank vegetative cover, channel geometry, soil composition, geologic structure, and bank protection measures can also influence erosion rates. Bank protection measures are currently in place along 11.2 percent of the Feather River channel below the Thermalito Outlet (DWR unpublished data). In general, these bank protection measures prevent bank erosion at flows up to bank full events. Both bank protection measures and project related flood control activities serve to limit/restrict the quantity and quality of bank swallow habitat created and maintained. Further, U.S. Army Corps of Engineers mandated flood releases have occasionally occurred during the bank swallow nesting season resulting in increased river stage and possible inundation of nests and eggs.

Water Supply Operations- The SWP also has the potential to impact bank swallow production through water supply operations. Bank swallows are a migratory species and begin to arrive back in the Sacramento Valley in late March and early April, with the bulk of the birds arriving in late April and early May (Garrison 2001). Juveniles begin to disperse from the nest colonies around mid-June and early July and are absent from the nest colonies by mid-July (Garrison 2001). Excluding uncommon spring emergency flood releases, project operations historically have resulted in relatively low flows (<2500 cfs releases) during April, May and June. However, water supply deliveries frequently result in

much higher releases during July (>9,000 cfs). Historic data indicate that July pre-project flows of 9,000 cfs did not occur. However, pre-project flows in this range occurred about 14 percent of the time during June. The operational pattern of relatively low Feather River flows throughout the majority of the nesting season with greatly increased flows at the end of the nesting season could result in losses of prefledged nestlings.

To evaluate the potential for project-related inundation of pre-fledged nestlings, stage discharge relationships were modeled for each of the 2003 active colony locations. These stage/discharge relationships were compared to the elevation of the lowest burrow in each colony with a 1-foot buffer (Figures 3 through 17). This modeling indicates that current (2003) project operations during early July have the potential to inundate at least a portion of nine of the fifteen active colonies while pre-fledged young are potentially present within the nest burrows. This modeling does not take into account potential losses related to flow induced bank collapse or saturation which could also potentially induce losses of adults and pre-fledged young.

Projected flow increases in July under the OCAP 2020 SDIP scenario of 400 to 800 cfs (depending on water year type) could result in increased potential for take of bank swallows over and above current losses as they would result in a higher percentage of the burrows being flooded prior to fledging. Projected flow increases in July under the OCAP future Environmental Water Account (EWA) scenario would further exacerbate this potential problem with SWP project releases increasing by as much as 1400 cfs over current conditions. These increased July future EWA flows could increase river stage an additional 1.5 feet at some bank swallow colony locations. Further, the OCAP proposes to continue the existing operational pattern of relatively low flows throughout the majority of the bank swallow nesting cycle (allows burrow excavation and nesting on the lower portions of eroding river banks) followed by significant increases in stream flow and water surface elevation at the end of the nesting season.

Figure 3. 2003 stage/discharge relationship at bank swallow colony #1 - RM 54.95

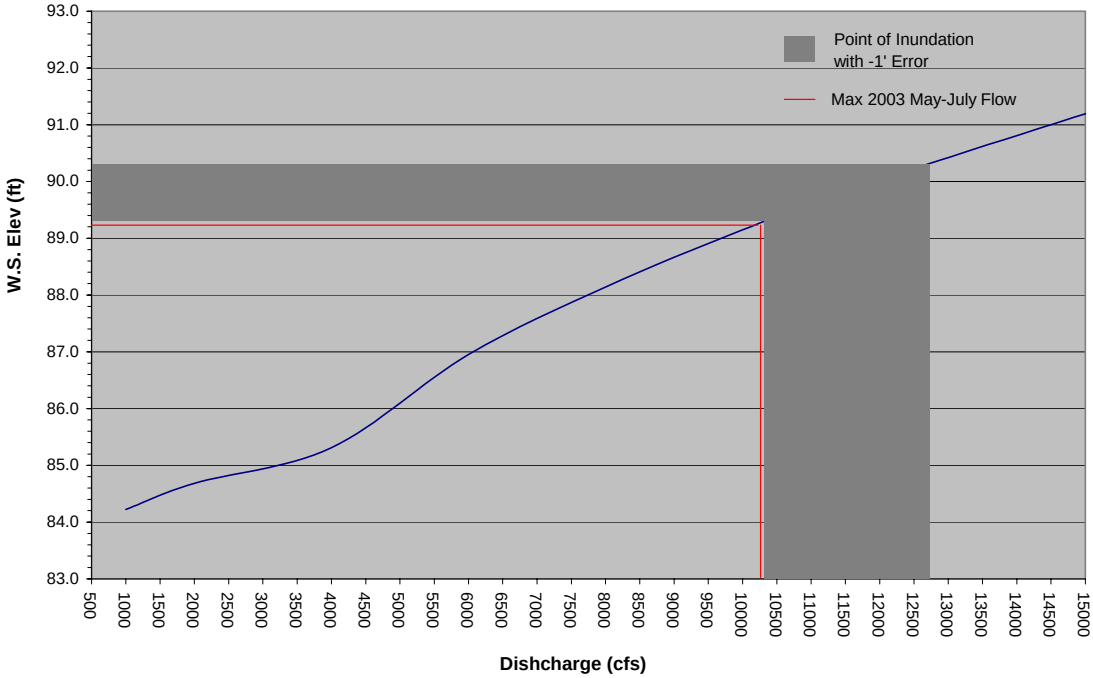


Figure 4. 2003 stage/discharge relationship at bank swallow colony #4- RM 45.05

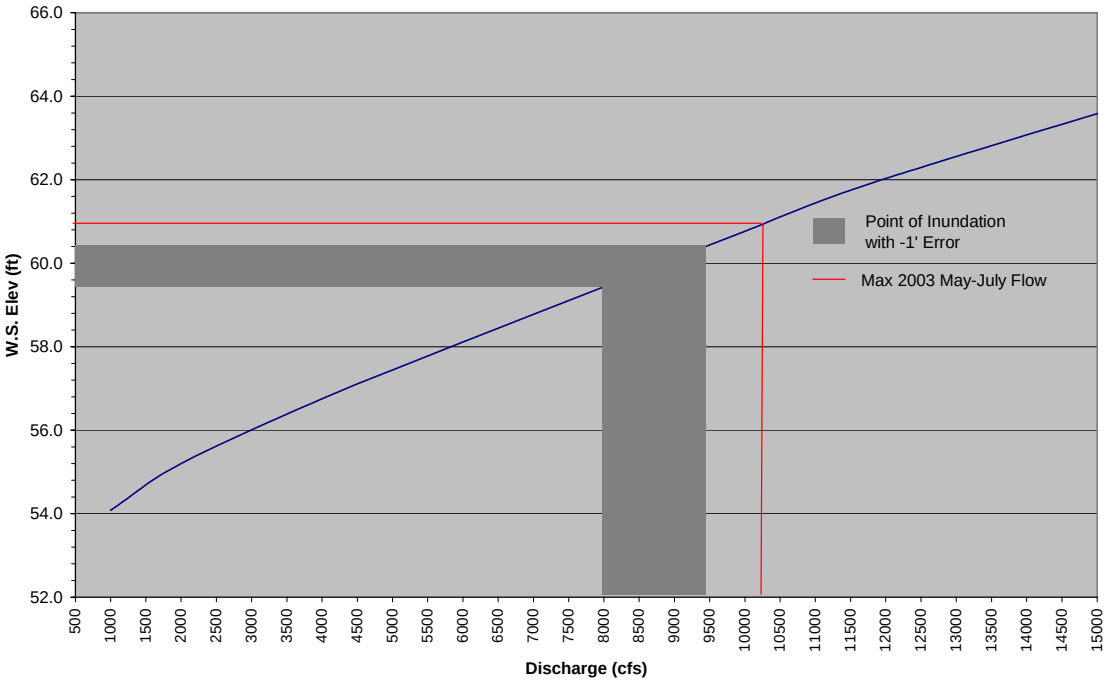


Figure 5. 2003 stage/discharge relationship at bank swallow colony #5 - RM 44.5

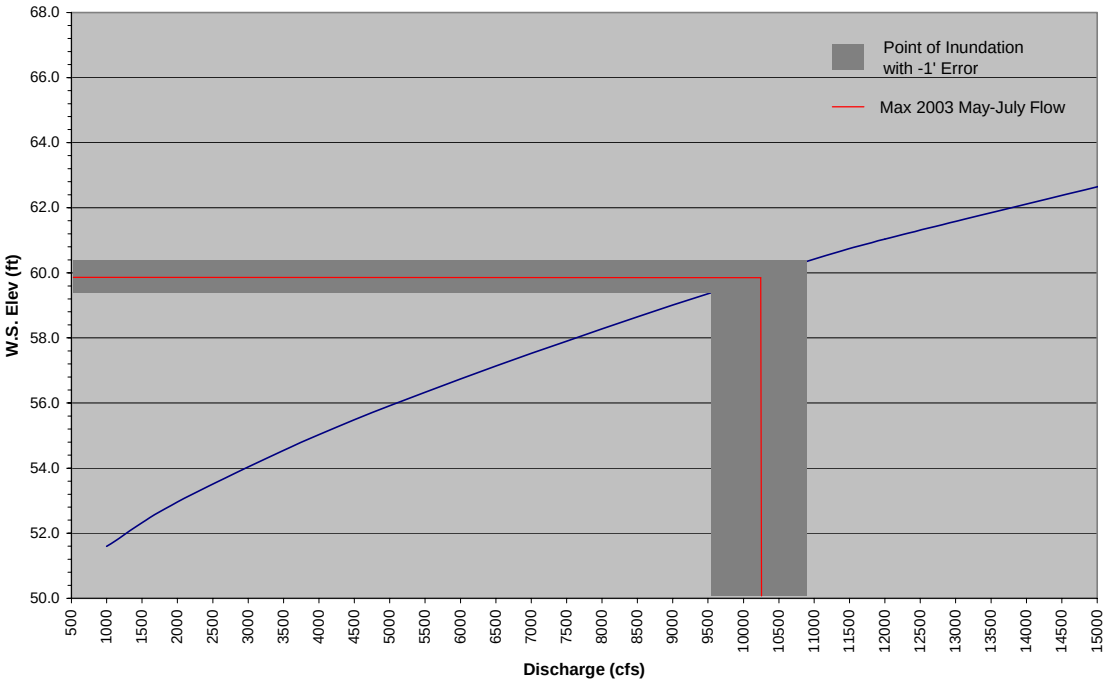


Figure 6. 2003 stage/discharge relationship at bank swallow colony #7 - RM 40.5

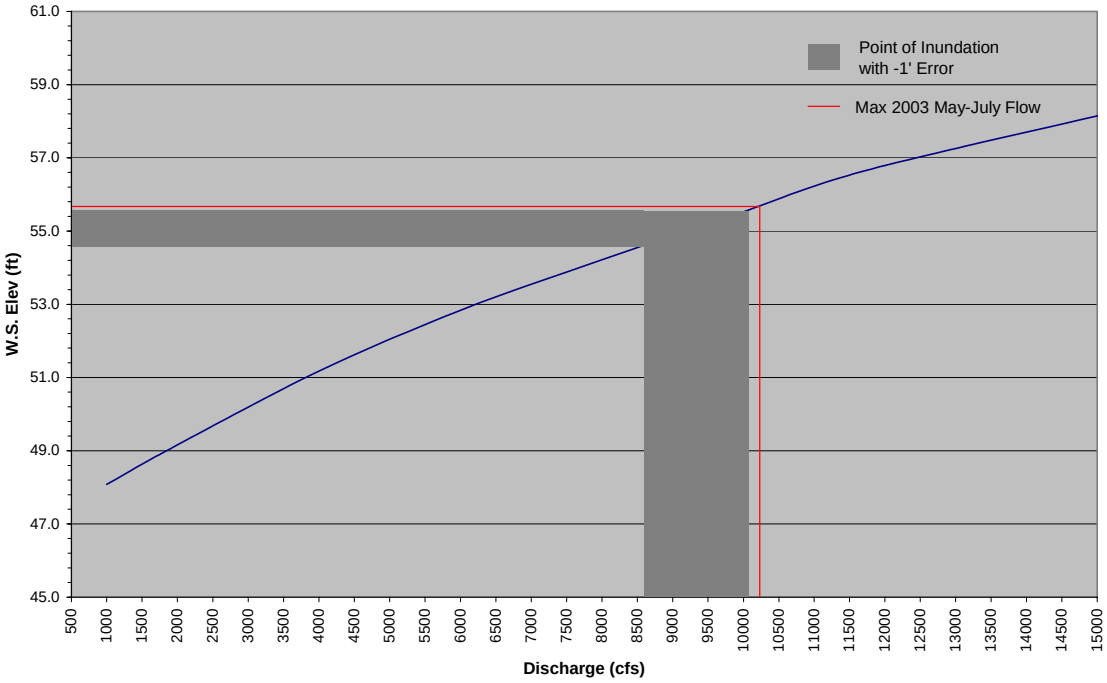


Figure 7. 2003 stage/discharge relationship at bank swallow colony #8- RM 40.4

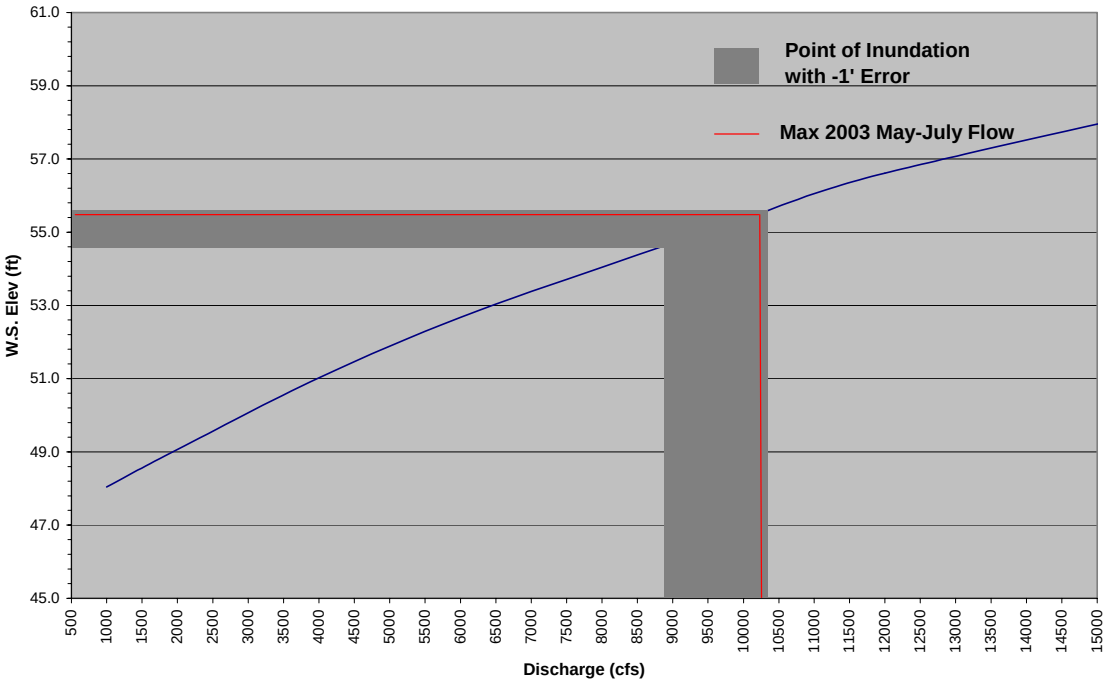


Figure 8. 2003 stage/discharge relationship at Bank Swallow Colony #9 - RM 35.6

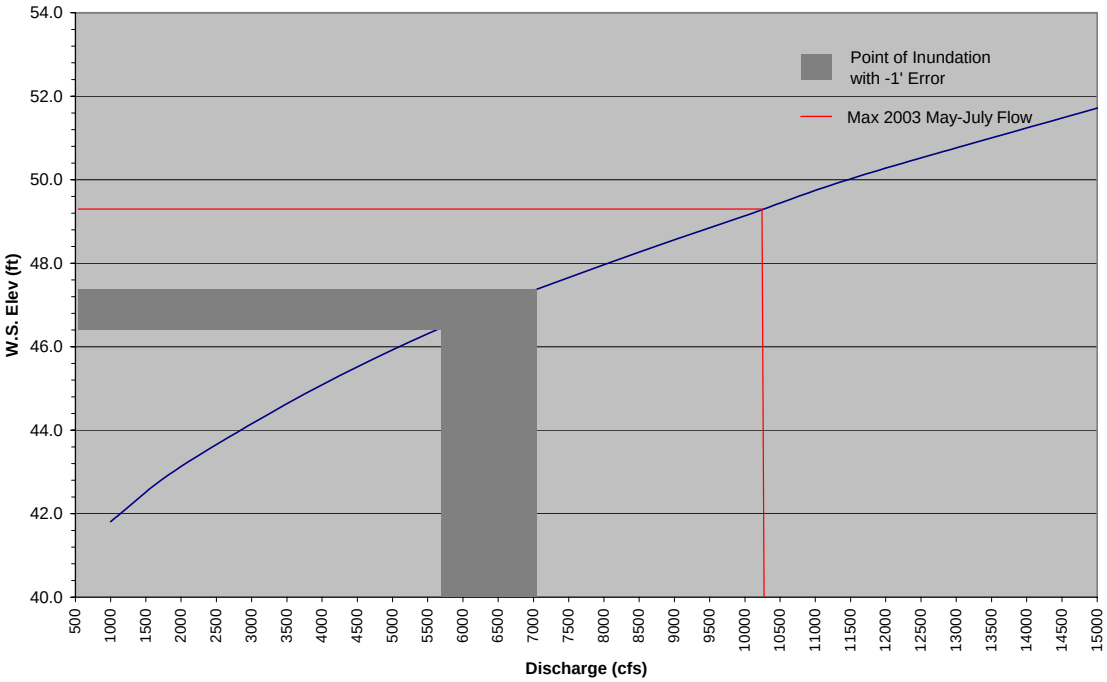


Figure 9. 2003 stage discharge relationship at bank swallow colony #10- RM 34.5

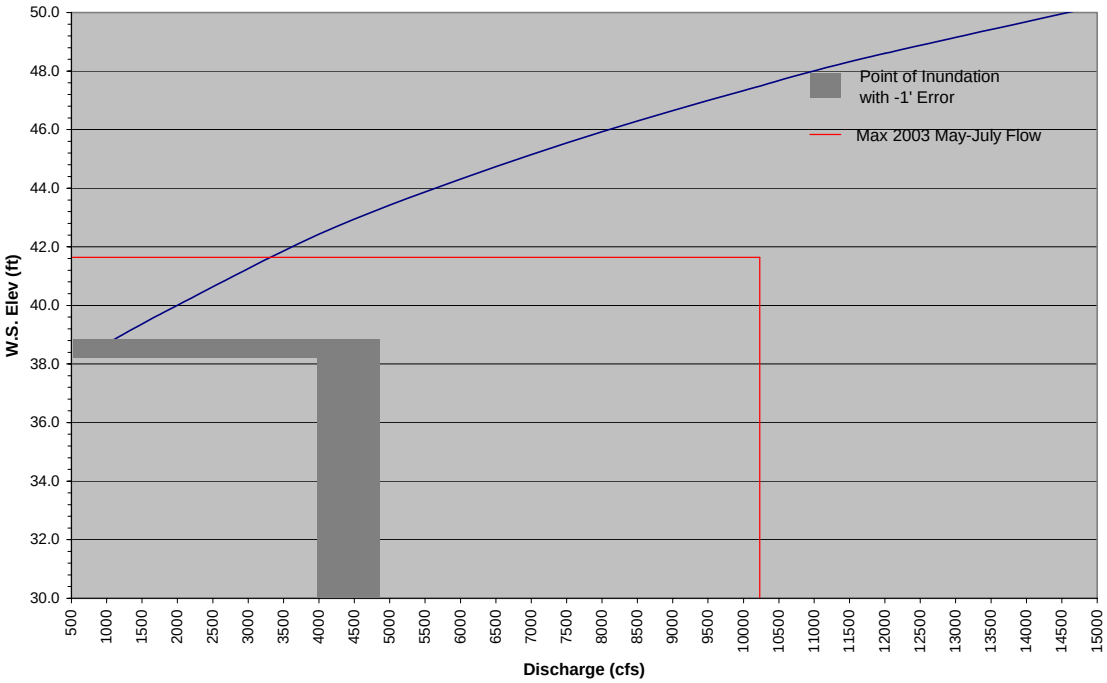


Figure 10. 2003 stage/discharge relationship at bank swallow colony #11 - RM 34.15

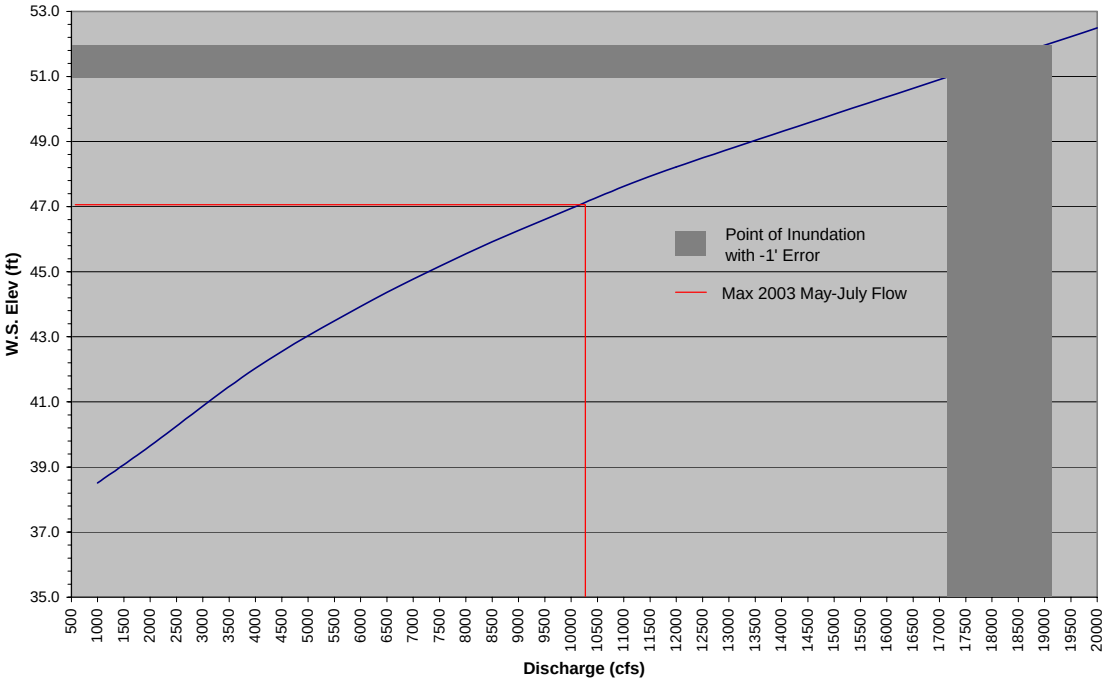


Figure 11. 2003 stage/discharge relationship at bank swallow colony #12 - RM 26.1

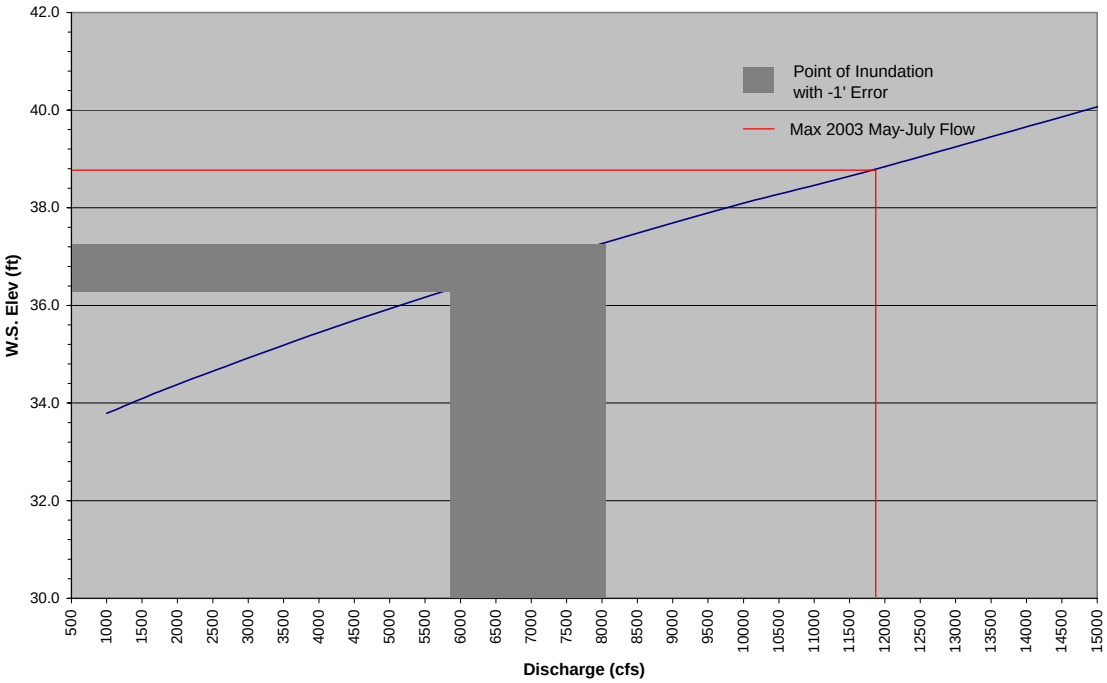


Figure 12. 2003 stage/discharge relationship at bank swallow colony #13 - RM 20.45

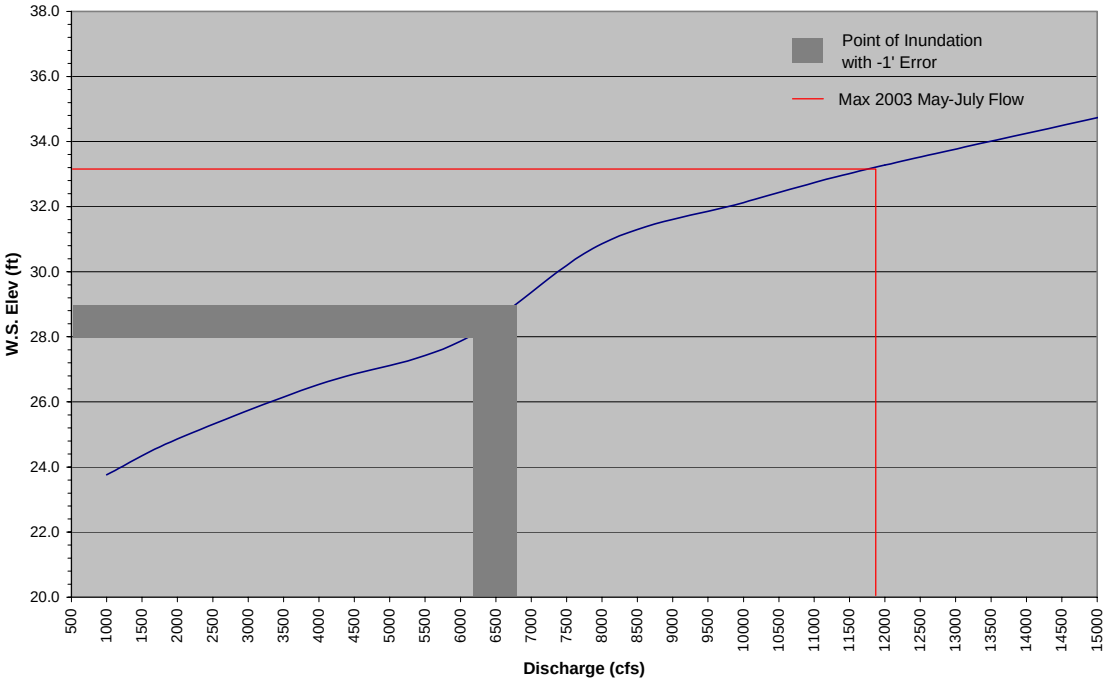


Figure 13. 2003 stage/discharge relationship at bank swallow colony #14 - RM 12.3

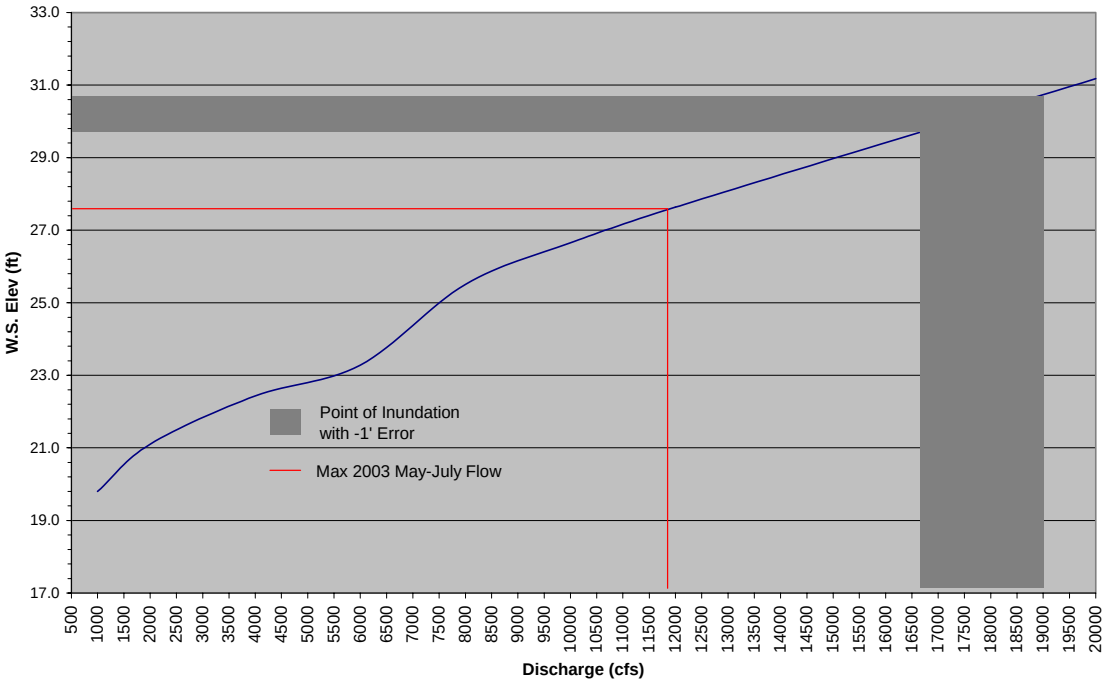


Figure 14. 2003 stage/discharge relationship at bank swallow colony #15 - RM 11.2

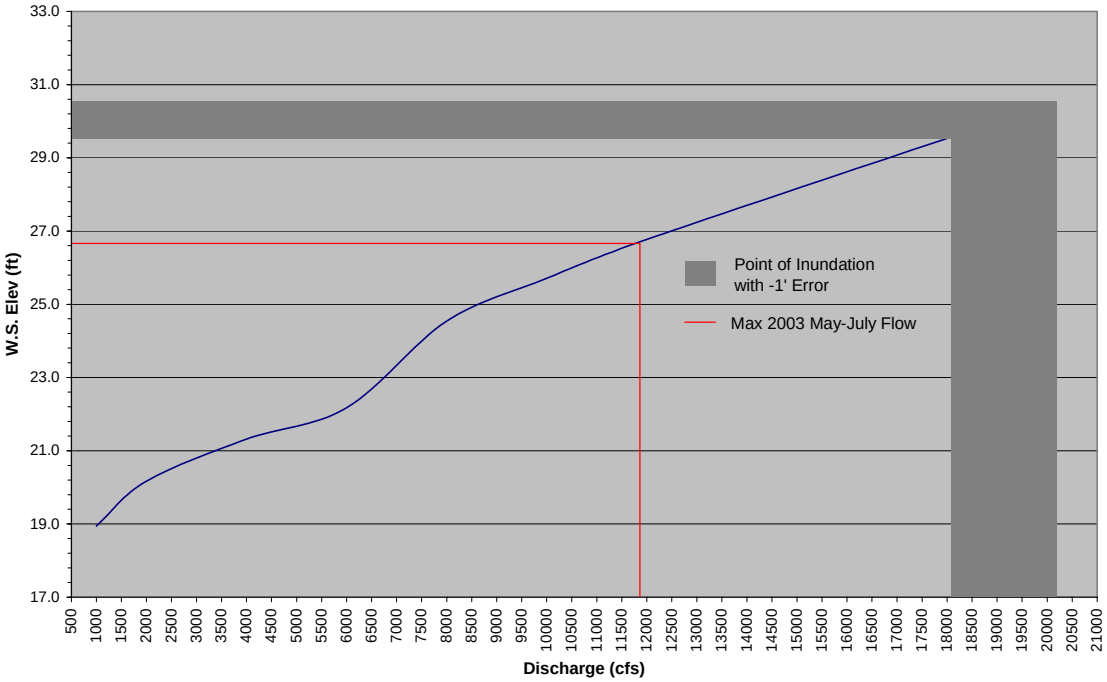


Figure 15. 2003 stage/discharge relationship at bank swallow colony #16 - RM 10.5

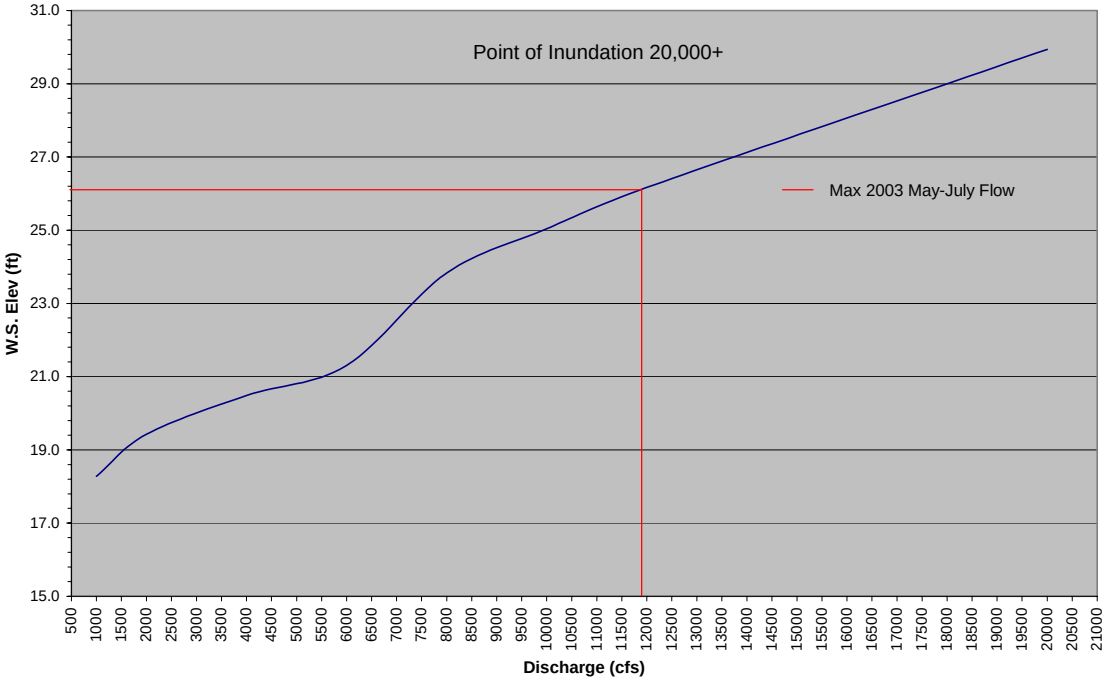


Figure 16. 2003 stage/discharge relationship at bank swallow colony #17 - RM 9.9

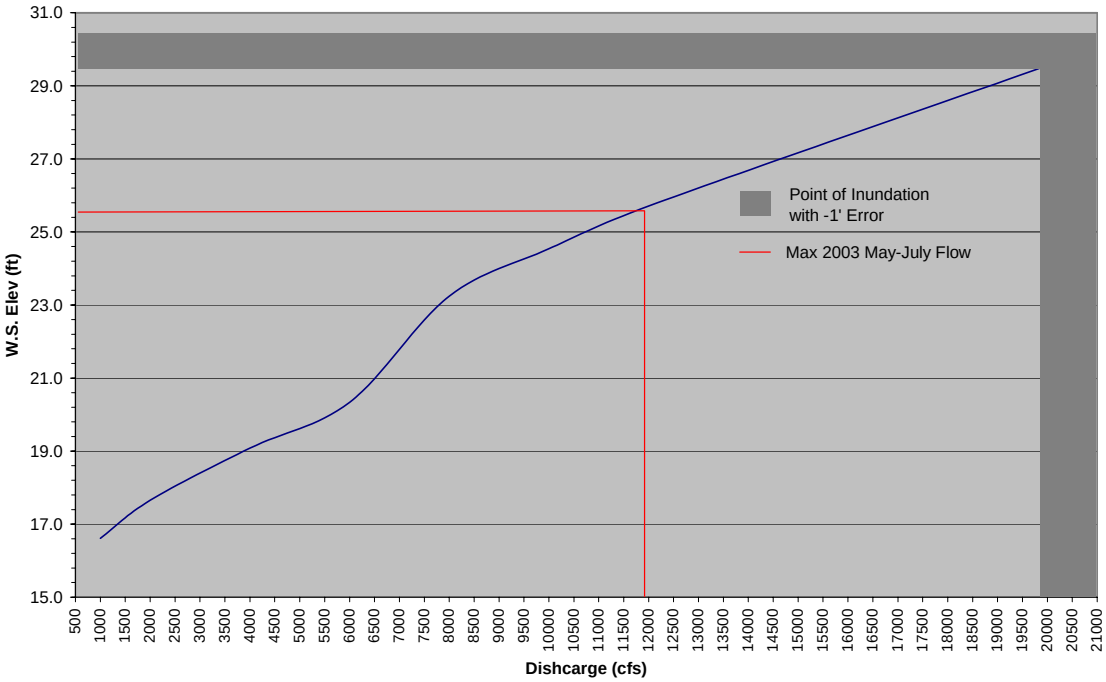
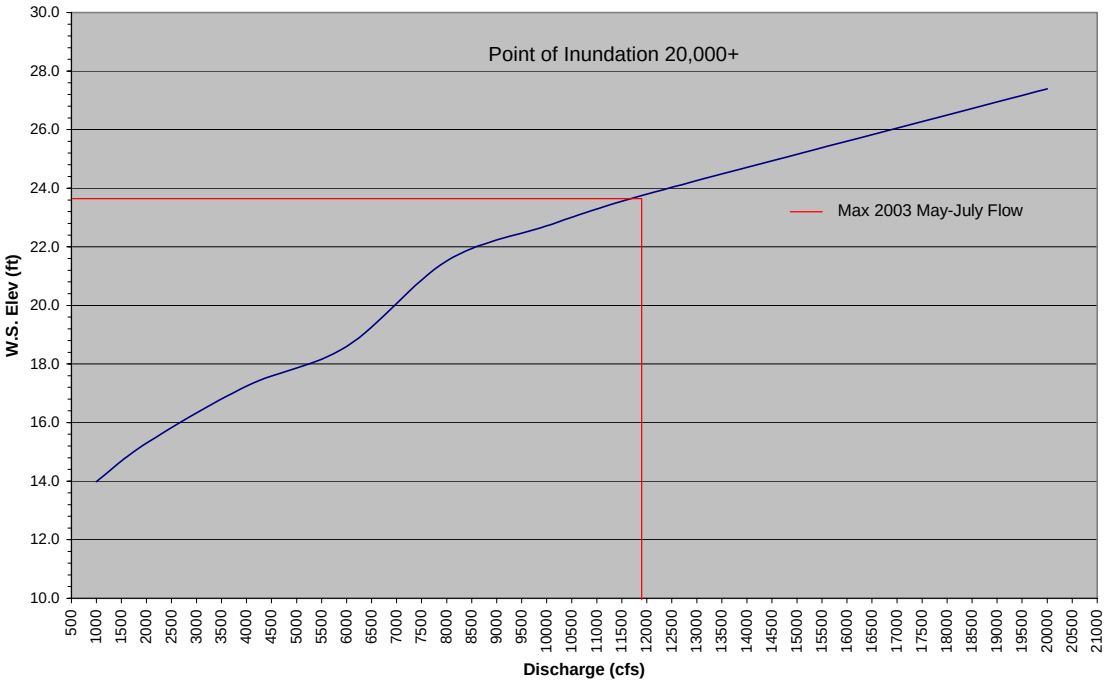


Figure 17. 2003 stage/discharge relationship at bank swallow colony #18 - RM 5.95



Swainson's Hawk

Current and future project operations as described in the OCAP have little or no potential to result in take of Swainson's hawk. Flood releases (both controlled and uncontrolled) have the potential to remove nest trees. However, floods of the magnitude required to remove mature trees have historically occurred outside of the breeding season when the birds are absent from California, thus flood related take is unlikely. Flow regime changes proposed in the OCAP are relatively minor and generally within the historical range of operations.

The current and future project operations described in the OCAP are unlikely to result in benefits to Swainson's hawks or aide in the species recovery.

Western Yellow-billed Cuckoo

Current and future project operations as described in the OCAP have little or no potential to result in take of cuckoos. Flood releases (both controlled and uncontrolled) have the potential to inundate potential nesting habitat. However, flows of the magnitude required to inundate nesting habitat have historically occurred outside of the breeding season when the birds are absent from California, thus flood related take is unlikely. Flow related changes in channel geomorphology and riparian succession have the potential to enhance the quantity and quality of cuckoo habitat by creating the habitat mosaic preferred by cuckoos. However, the flow related changes proposed in the OCAP are unlikely to produce any measurable benefits to cuckoo habitat.

The current and future project operations described in the OCAP are unlikely to result in benefits to western yellow-billed cuckoos or aide in the species recovery.

Cumulative Effects

Cumulative effects are those effects of State, local, and private actions on endangered and threatened species or critical habitat that are reasonably certain to occur in the action area. Future federal actions that are unrelated to the proposed action are not considered in this section because they will be subject to separate consultations pursuant to Section 7 of the federal ESA.

Numerous activities continue to affect the amount, distribution, and quality of habitat for State listed endangered and threatened species within the Feather River watershed. Habitat loss and degradation affecting State listed species continues as a result of urbanization, flood control, bank protection, changes in agricultural practices, spread of non-native plant species, and agricultural expansion.

Bank Swallow
Bank swallows continue to be cumulatively affected by flood control and bank protection measures. Flood control activities continue to affect the quantity and quality of bank swallow nesting habitat created and maintained annually. Private and local government bank protection measures continue to permanently eliminate suitable nesting habitat along the length of the Feather River to protect private and public infrastructure and farmlands. These habitat losses are the greatest long-term threat to bank swallow populations in the Sacramento Valley.

Swainson's Hawk
Swainson's hawks continue to be cumulatively affected by habitat loss or degradation associated with rapid urbanization, agricultural expansion, and changes in agricultural cropping patterns. Pesticide poisoning in wintering areas has been documented to result in significant mortality. Shooting remains a cause of direct mortality.

Ongoing and future project operations in the form of land fallowing associated with water transfers and water banking has the potential to adversely impact Swainson's hawk nesting success and production in localized areas. Swainson's hawks largely rely on agricultural habitats for foraging including: alfalfa, fallow fields, beet, tomato, irrigated pasture, rice (non-flooded), and cereal grains. DWR requires that lands fallowed under the Water Transfer and Water Banking programs be disked and maintained throughout the growing season in an unvegetated condition to minimize evapotranspiration losses. Replacement of suitable Swainson's hawk foraging habitat with barren habitat can affect individual Swainson's hawks foraging success and energetics and ultimately can reduce nestling survival and production. Due to the nature of the Water Transfer

and Water Banking programs the potential impacts to individual Swainson's hawks are difficult to predict or quantify.

Western Yellow-billed Cuckoo
Western yellow-billed cuckoos continue to be cumulatively affected by habitat loss related to urbanization, flood control, pest management, and agricultural conversion. The rate of agricultural conversion may have slowed significantly in the last decade as extensive riparian restoration has occurred within the Sacramento Valley. Pest management activities, primarily mosquito abatement activities, may serve to reduce food resources for cuckoos. Control of West Nile virus may require increased mosquito control activities.

Conclusions and Determinations

Bank Swallow
Under the future level of development, the proposed action would result in higher SWP releases during the nesting season. These increased releases will result in increased Feather River stage during July and potentially increased loss of bank swallow nestlings. These changes are likely to adversely affect bank swallow populations.

Swainson's Hawk
The proposed changes are unlikely to affect Swainson's hawk nesting or foraging habitat and will not result in direct mortality. The proposed action is not likely to affect Swainson's hawks.

Western Yellow-billed Cuckoo
The proposed changes are unlikely to affect western yellow-billed cuckoo nesting or foraging habitat and will not result in direct mortality. The proposed action is not likely to affect western yellow-billed cuckoos.

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