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

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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

°F	degrees Fahrenheit
°C	degrees Celsius
1995 Bay-Delta Plan	San Francisco Bay/Sacramento-San Joaquin Delta Estuary
8500 Banks	Banks Pumping Plant
ACID	Anderson-Cottonwood Irrigation District
af	acre-feet
af/yr	acre-feet per year
AFRP	Anadromous Fish Restoration Program
ALPI	aleutian low pressure index
ANN	Artificial Neural Network
AROG	American River Operations Work Group
ASIP	Action Specific Implementation Plan
Authority	San Luis and Delta Mendota Water Authority
B2IT	CVPIA Section 3406 (b)(2) Implementation Team
BA	biological assessment
BO	biological opinions
BR	breached
BY	brood year
CA	California Aqueduct
Cal EPA	California Environmental Protection Agency
CALFED	CALFED Bay-Delta Program
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
CFR	Code of Federal Regulations
cfs	cubic feet per second
CHO	Constant Head Orifice
City	City of Sacramento
cm	centimeters
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	Bureau of Reclamation’s 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	CVPIA Section 3406 (b)(2) 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
DSDT	delta smelt decision tree
DSWG (Working Group)	Delta Smelt Working Group
DW	dewatered at some point throughout the year
DWR	California Department of Water Resources
E/I	export/inflow

EBMUD	East Bay Municipal Utility District
EC	electroconductivity
EFH	essential fish habitat
EID	El Dorado Irrigation District
EIR	Environmental Impact Report
EIR/EIS	Environmental Impact Report/Environmental Impact Statement
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	Environmental Water Account Team
FB	flashboards removed during winter
FERC	Federal Energy Regulatory Commission
FL	Fork length
FLD	fish ladder
FMWT	Fall Midwater Trawl Survey
FPA	Federal Power Act
FRH	Feather River Hatchery
FRWA	Freeport Regional Water Authority
FRWP	Freeport Regional Water Project
FRWP	Freeport Regional Water Project
ft/s	foot/feet per second
FWS	U.S. Fish and Wildlife Service
GCID	Glenn-Colusa Irrigation District
GIS	geographic information system
GLM	Generalized Linear Models
GS	Georgiana Slough
HFC	high-flow channel
HORB	Head of Old River Barrier

IEP	Interagency Ecological Program
ID	Irrigation District
IFIM	Instream Flow Incremental Methodology
Interior	U.S. Department of the Interior
IPO	Interim Plan of Operation
JPE	Juvenile Production Estimate
JPOD	joint point of diversion
km	kilometer
LFC	low-flow channel
LOD	Level of Development
LP	linear programming
LWD	large woody debris
M&I	municipal and industrial
maf	million acre-feet
Magnuson-Stevens Act	Magnuson-Stevens Fishery Conservation and Management Act
Management Agencies	FWS, NOAA Fisheries, and DFG for EWA
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
mm	millimeters
mmhos/cm	millimhos per centimeter
MOA	Memorandum of Agreement
MOU	Memorandum of Understanding
mS/cm	milliSiemens per centimeter
msl	mean sea level
NBA	North Bay Aquaduct
NCCPA	Natural Community Conservation Planning Act
NCWA	Northern California Water Association
NDO	Net Delta Outflow

NEPA	National Environmental Policy Act
NGVD	National Geodetic Vertical Datum
NMIPO	New Melones Interim Plan of Operation
NOAA Fisheries	National Marine Fisheries Service
NOAA Fisheries	National Oceanic and Atmospheric Administration Fisheries (formerly National Marine Fisheries Service [NMFS])
NOD	North of Delta
NRC	National Research Council
OCAP	Operating Criteria and Procedures
OFF	Operations and Fisheries Forum
OID	Oakdale Irrigation District
ONCC	Oregon/Northern California Coast
Ops Group	CALFED Operations Coordination Group
PCBs	Polychlorinated biphenyls
PCWA	Olacer County Water Agency
PEIS	Programmatic Environmental Impact Statement
PFMC	Pacific Fishery Management Council
PG&E	Pacific Gas and Electric
PHABSIM	Physical Habitat Simulation
PIT	passive integrated transponder
ppm	parts per million
ppt	parts per trillion
Project	CVP and SWP (as in CVP and SWP water rights)
Project Agencies	DWR and Reclamation
PSL	Pre-screen loss
RBDD	Red Bluff Diversion Dam
Reclamation	U.S. Bureau of Reclamation
RMIS	Regional Mark Information System (RMIS)
ROD	Record of Decision
RPA	reasonable and prudent alternative
RRDS	Roaring River Distribution System

RST	rotary screw fish trap
RWQCB	Regional Water Quality Control Board
SA	Settlement Agreement
SAFCA	Sacramento Area Flood Control Agency
SCDD	Spring Creek Debris Dam
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
SJRTC	San Joaquin River Technical Committee
SJRWR	San Joaquin River water rights
SL	sloped dam
SMPA	Suisun Marsh Preservation Agreement
SMSCG	Suisun Marsh Salinity Control Gates
SOD	South of Delta
SOD	Safety of Dams
SRPP	Spring-run Chinook Salmon Protection Plan
SRTTG	Sacramento River Temperature Task Group
SSJID	South San Joaquin Irrigation District
SWP	State Water Project
SWRCB	California State Water Resources Control Board
T&E	threatened and endangered
taf	thousand acre-feet
TCCA	Tehama-Colusa Canal Authority
TCD	temperature control device
TDS,	total dissolved solids
TFCF	Tracy Fish Collection Facility
T&E	Threatened and Endangered
TFFIP	Tracy Fish Facility Improvement Program

TNS	Townet Survey
TU	temperature units
U.S.C.	United States Code
UN	unscreened diversion
USGS	U.S. Geological Survey
VAMP	Vernalis Adaptive Management Plan
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

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.

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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 CVP and SWP 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 redivert 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). The CVPIA modified the 1937 Act and added mitigation, protection, and restoration of fish and wildlife as a project purpose. Further, the 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 acre-feet (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. See 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. See 43 United States Code (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 (D)-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 of the 1978 WQCP objectives, except some of the salinity objectives in the southern Delta. In addition, the SWRCB, November 1983, D-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 Operations Criteria and Plan (OCAP). In 1991, the SWRCB adopted a WQCP that 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) D-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 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. Approximately 250 contracts 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 that 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 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 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. 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.

Tribal Water Rights and Trust Resources

The Yurok and Hoopa Valley Tribes have fishing rights to take anadromous fish within their reservations. See 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 that set 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 in 1891, at the latest, 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 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 that meets Sacramento Valley and Delta needs while maintaining their respective annual water supplies as identified in the COA. 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 BOs, 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 Bay-Delta Program (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 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) coordinates 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 Interior with implementation of CVPIA Section 3406(b)(2). The Data Assessment Team (DAT) is an agency-driven group that includes stakeholder participation 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's 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 CALFED's fishery protection and restoration/recovery needs for the first 4 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 BAs 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 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 reinitiation of OCAP consultation.

Trinity

In December 2000, the Interior signed the ROD on the Trinity River Mainstem 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 that 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 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 (NCWA), 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, 10-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 the program will begin in the spring of 2005. The program will be phased in over 3 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 they authorize, fund, or carry out are 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 Code of Federal Regulations (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 more than 11 million af, 11 powerplants, and more than 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 M&I 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 as follows: 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 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. Therefore, 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
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., vs. 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 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-Temperature Control Device (TCD) Operations
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)

Table 1–1 Proposed CVP operational actions for consultation.

Action	Requirement for Action
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 MOU with 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)
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 East Bay Municipal Utility District (EBMUD) Sacramento County contract and water rights

Table 1–1 Proposed CVP operational actions for consultation.

Action	Requirement for Action
V. Eastside Division	
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 Principles
Delta Cross Channel (DCC) operation	SWRCB D-1641(DCC closure: February-May, 14 days between May 21-June 15, 45 days between November-January) Salmon Decision Tree
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 (Mid-April-Mid-May)	SJRA-VAMP SWRCB D-1641
Delta outflow	SWRCB D-1641 (minimum outflow July-January: 3,000-8,000 cfs, habitat protection outflow February-June: 7,100-29,200 cfs, February Salinity Starting Condition Determination)

Table 1–1 Proposed CVP operational actions for consultation.

Action	Requirement for Action
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)
Joint Point of Diversion (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
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

Bureau of Reclamation (Reclamation) and California Department of Water Resources (DWR) propose to operate the Central Valley Project (CVP) and State Water Project (SWP) (collectively the Project) 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 cubic feet per second (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 without 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	Circa 1997	Today 2004	Future 2030
Trinity & Whiskeytown	340,000 af	368,600-452,600 af	368,600- 815,000 af
Shasta/Sacramento River	Red Bluff Diversion Dam (RBDD) 8 months gates out	Same	Same
Oroville and Feather River	Same	Same	Same
Folsom and American River	Current Demands	Current Demands	Build out of demands and Freeport Regional Water Project
New Melones and Stanislaus River	Interim Plan of Operations Guidance	Same	Same
Friant	Same	Same	Same
Sacramento-San Joaquin Delta	2001 Demands	2001 Demands	2020 Demands
Suisun March	Same	Same	Same
WQCP	D-1641	D-1641	Same
COA	1986 Guidance	1986 Guidance	Integrated Operations
CVPIA	May 9, 2003 Decision	May 9, 2003 Decision	Same
CALFED	None	EWA	Same
Banks	6680 cfs & Temp Barriers	6680 cfs & Temp Barriers	8500 Banks and Permanent barriers
Tracy	Max of 4600 cfs in summer	Max of 4600 cfs in summer	Intertie

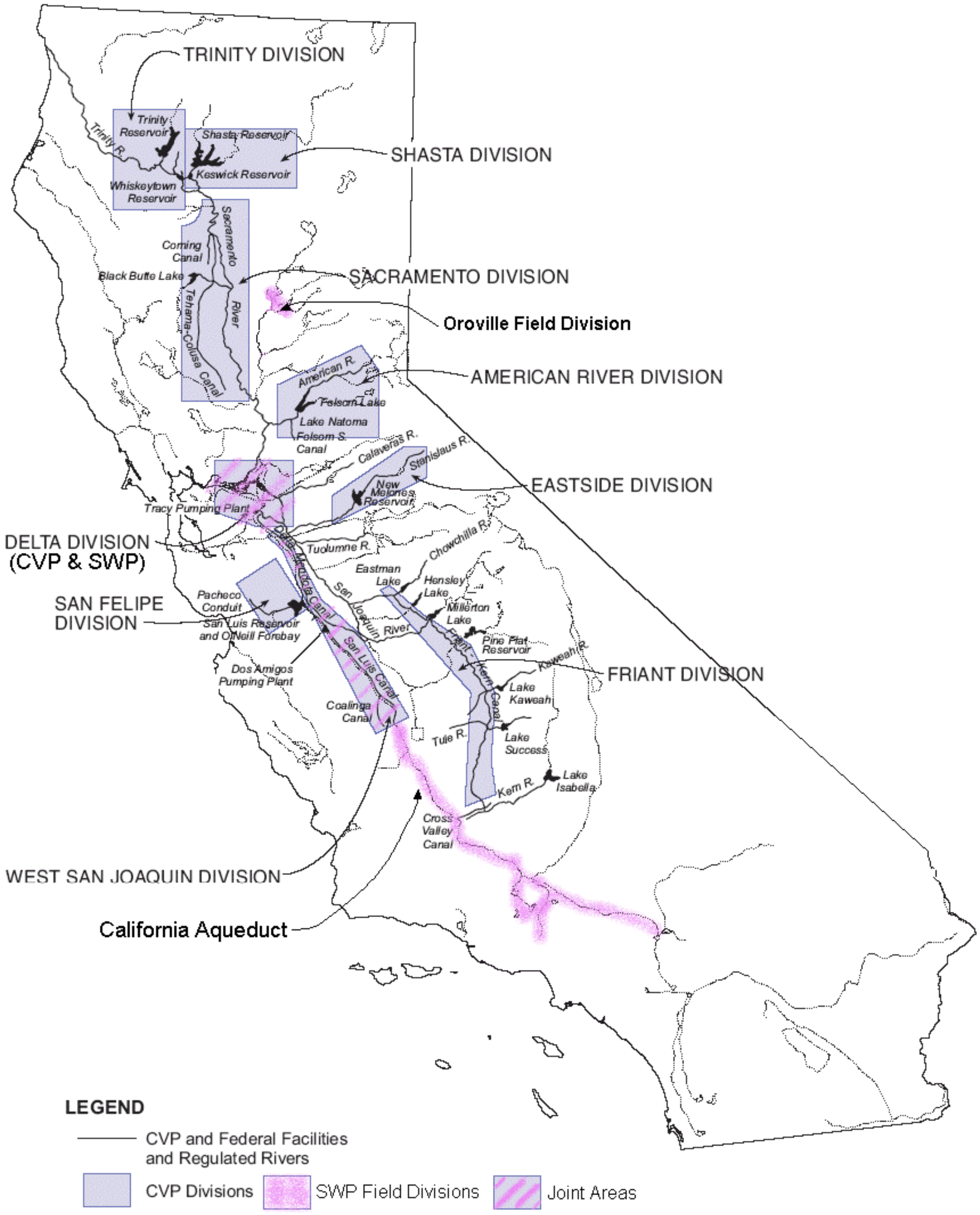

Figure 2–1 CVP and SWP Service Areas

Coordinated Operation of the CVP and SWP

The CVP and SWP use 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 California State Water Resources Control Board (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 5 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 5 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. Changes in Delta outflow can 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

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[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 Projects.

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 Coordination Group (Ops Group) 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 5 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 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.

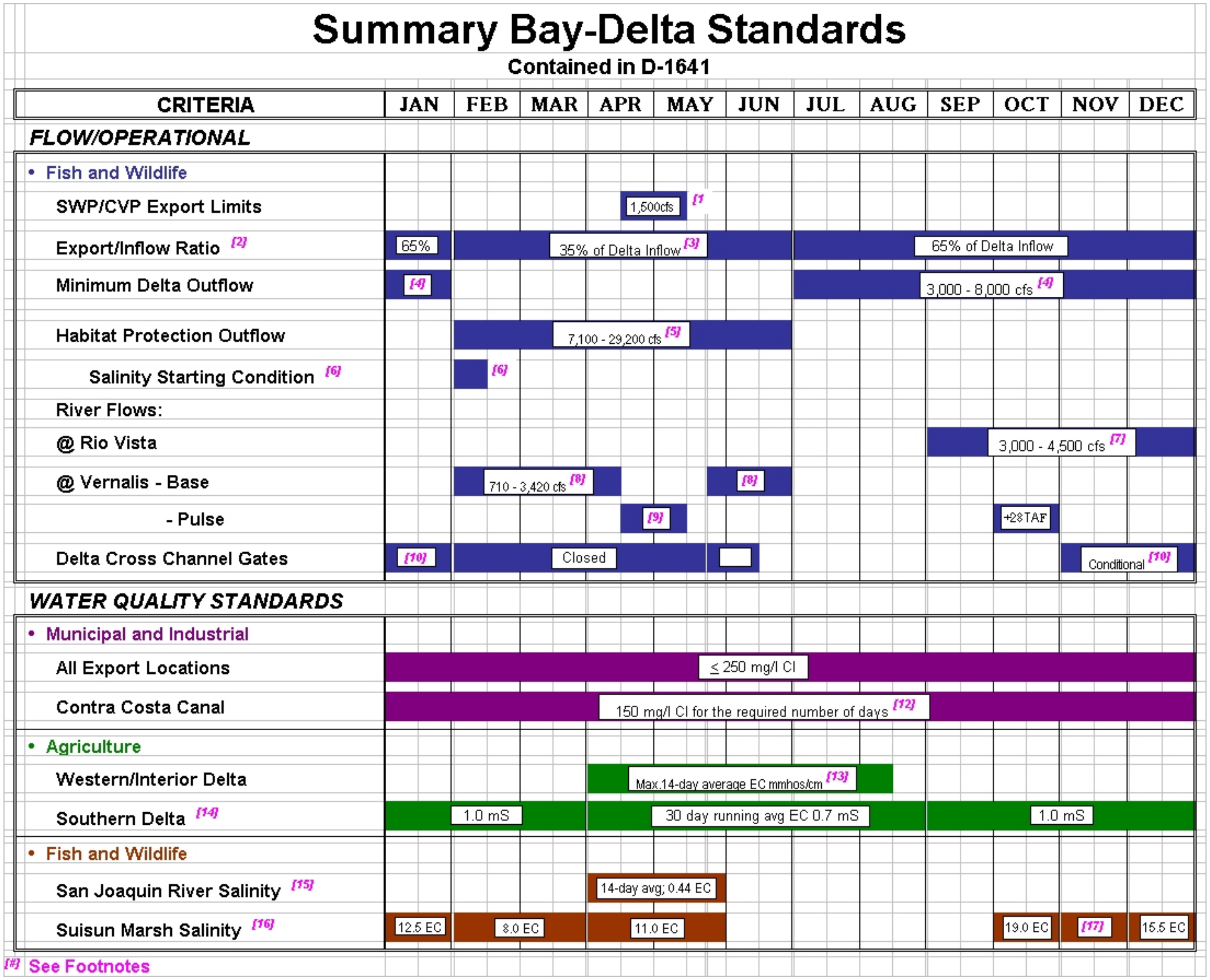
SWRCB D-1641

The SWRCB imposes a myriad of constraints upon the operations of the CVP and SWP 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).



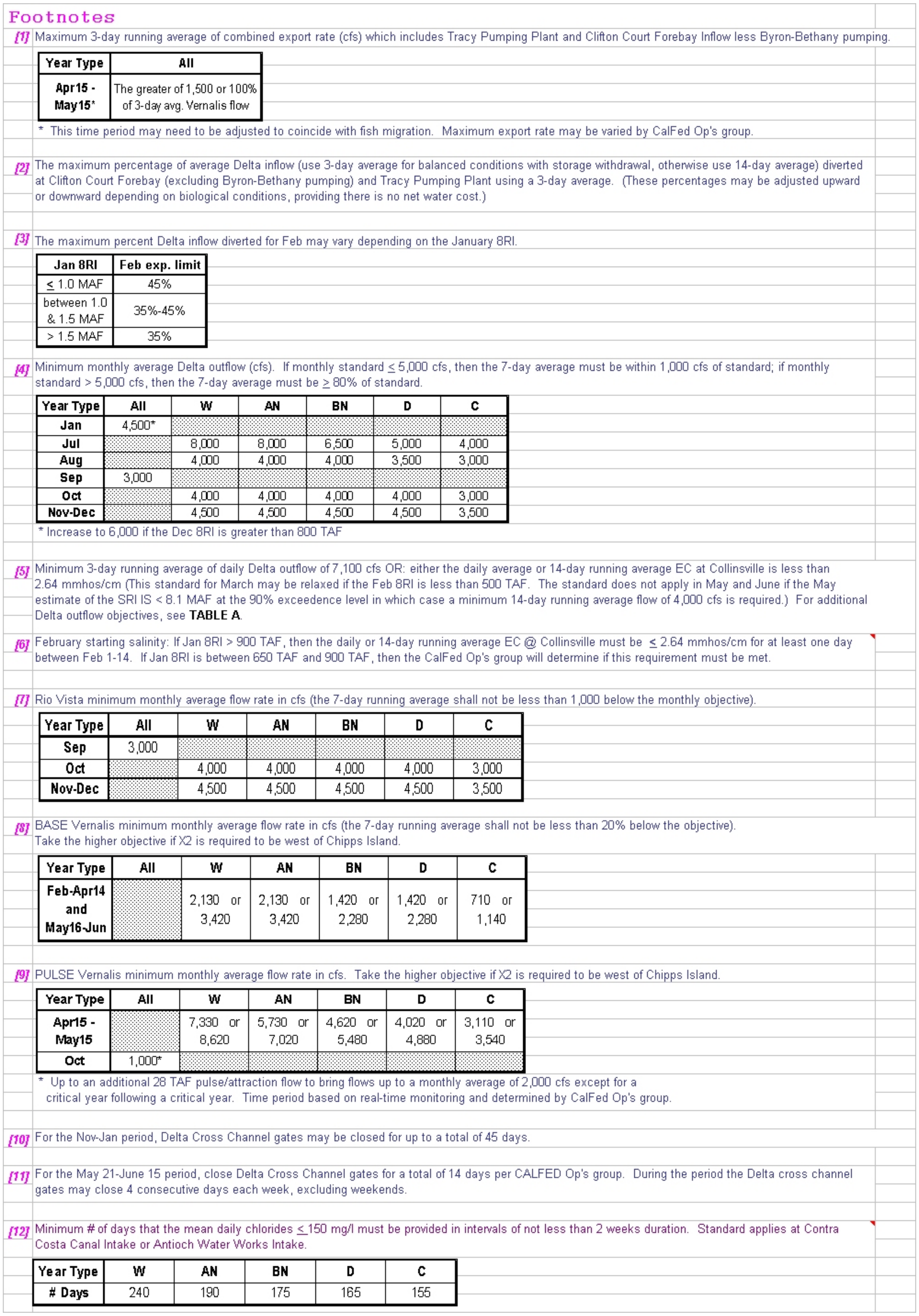
Summary Bay-Delta Standards

Contained in D-1641

CRITERIA	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
FLOW/OPERATIONAL												
• Fish and Wildlife												
SWP/CVP Export Limits				1,500cfs [1	▨							
Export/Inflow Ratio [2]	65%	▨	▨	35% of Delta Inflow [3]	▨	▨	▨	▨	65% of Delta Inflow	▨	▨	▨
Minimum Delta Outflow	[4]						▨	▨	3,000 - 8,000 cfs [4]	▨	▨	▨
Habitat Protection Outflow		▨	▨	7,100 - 29,200 cfs [5]	▨	▨						
Salinity Starting Condition [6]		▨ [6]										
River Flows:												
@ Rio Vista									▨	3,000 - 4,500 cfs [7]	▨	▨
@ Vernalis - Base		▨	710 - 3,420 cfs [8]	▨	▨	[8]						
- Pulse				▨	[9]					+28TAF		
Delta Cross Channel Gates	[10]	▨	Closed	▨	▨	☐					Conditional [10]	▨
WATER QUALITY STANDARDS												
• Municipal and Industrial												
All Export Locations	▨	▨	▨	▨	▨	≤ 250 mg/l Cl	▨	▨	▨	▨	▨	▨
Contra Costa Canal	▨	▨	▨	▨	▨	150 mg/l Cl for the required number of days [12]	▨	▨	▨	▨	▨	▨
• Agriculture												
Western/Interior Delta				▨	Max.14-day average EC mmhos/cm [13]	▨	▨	▨				
Southern Delta [14]	▨	1.0 mS	▨	▨	▨	30 day running avg EC 0.7 mS	▨	▨	▨	1.0 mS	▨	▨
• Fish and Wildlife												
San Joaquin River Salinity [15]				14-day avg; 0.44 EC	▨							
Suisun Marsh Salinity [16]	12.5 EC	8.0 EC	▨	11.0 EC	▨					19.0 EC	[17]	15.5 EC

[#] See Footnotes

Figure 2–2 Summary Bay Delta Standards (See Footnotes in Figure 2–3)



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.

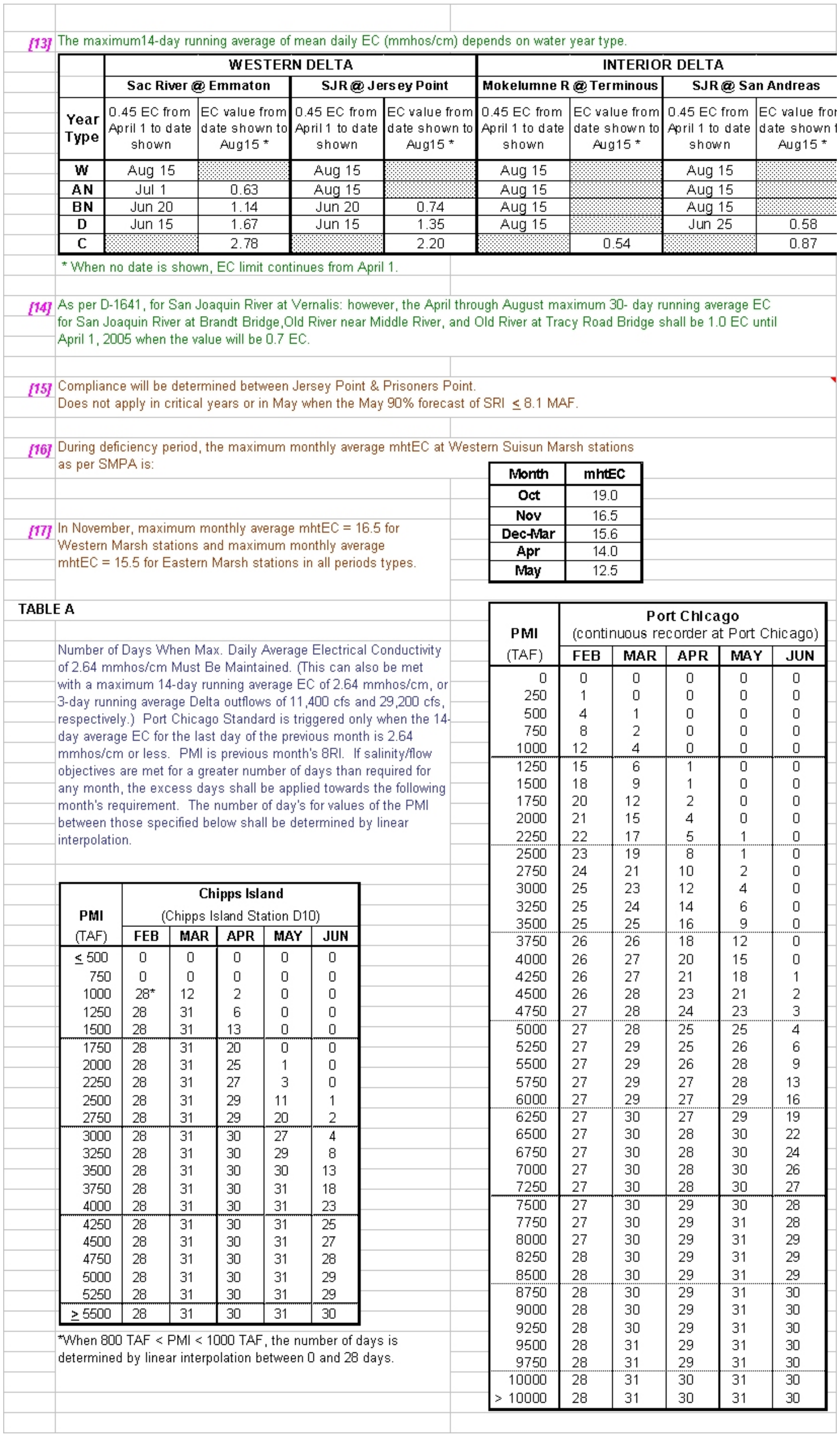
[10] For the Nov-Jan period, Delta Cross Channel gates may be closed for up to a total of 45 days.

[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.

Year Type	WESTERN DELTA Sac River @ Emmaton 0.45 EC from April 1 to date shown	 EC value from date shown to Aug15 *	 SJR @ Jersey Point 0.45 EC from April 1 to date shown	 EC value from date shown to Aug15 *	INTERIOR DELTA Mokelumne R @ Terminous 0.45 EC from April 1 to date shown	 EC value from date shown to Aug15 *	 SJR @ San Andreas 0.45 EC from April 1 to date shown	 EC value fro date shown t 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 (TAF)	Chipps Island (Chipps Island Station D10) 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 (TAF)	Port Chicago (continuous recorder at Port Chicago) 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

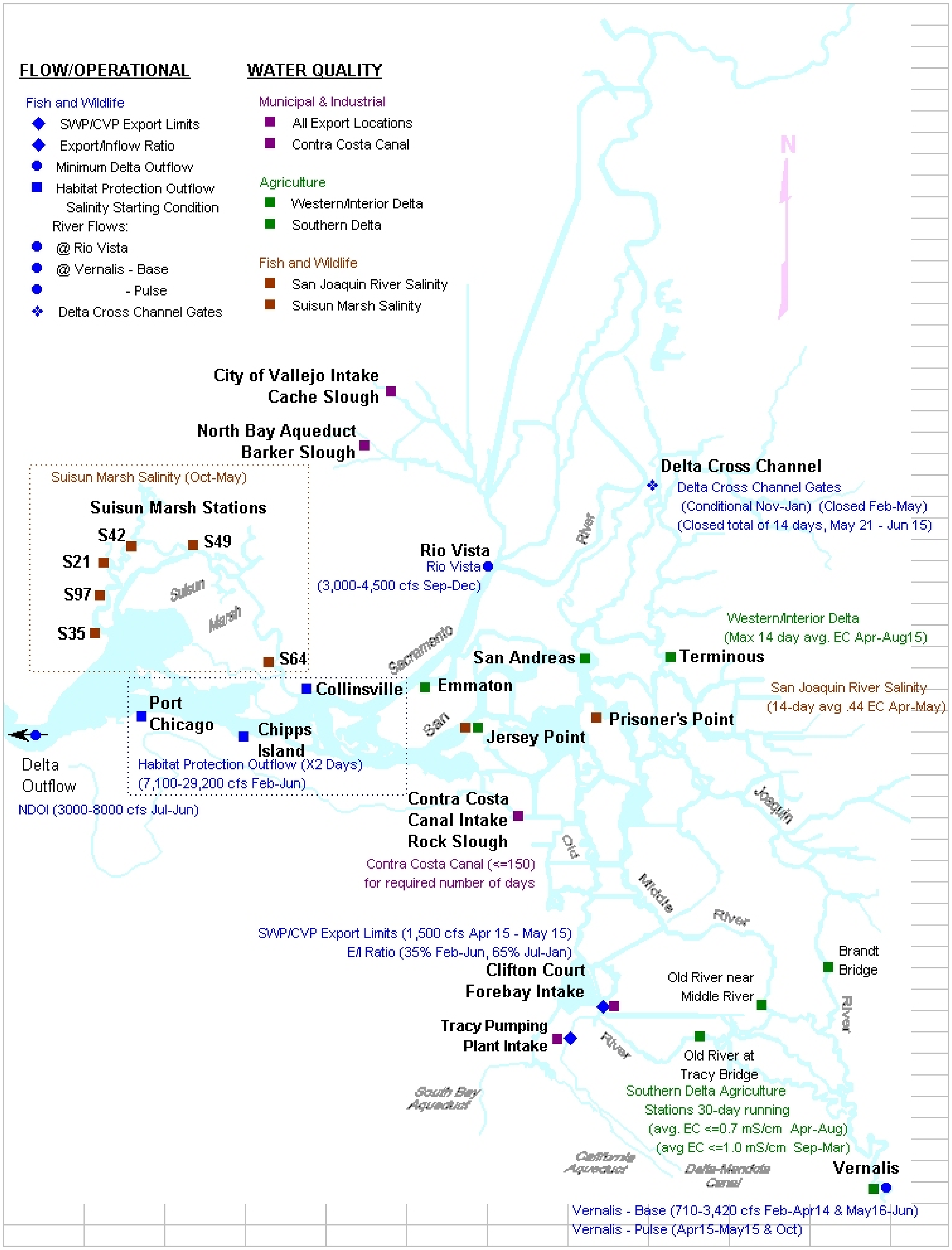


Figure 2–4 CVP/SWP Delta Map

Joint Point of Diversion

SWRCB D-1641 granted Reclamation and DWR the ability to use/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 use JPOD capabilities. Concurrently, under the CALFED ROD, JPOD may be used 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 use 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 used to further facilitate the water transfer.
- During certain coordinated CVP-SWP operation scenarios for fishery entrainment management, JPOD may be used 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 endangered species protection. The CALFED Ops Group held its first public meeting in January 1995, and during the next 6 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).

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[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 the Environmental Water Account Team (EWAT) and Water Operations Management Team (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 multiagency 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 Process: The Salmon 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. See Appendix B.

Delta Smelt Working Group (Working Group): The Working Group 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 unusually high 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.

The Working Group will consist of representatives from the FWS, CDFG, CDWR, USEPA, Reclamation and the California Bay-Delta Authority. FWS will chair the group and a designated lead will be assigned by each agency. At a minimum, representatives must be present from the FWS, DWR and Reclamation at a Working Group meeting for any recommendation to be decided upon and transmitted to the WOMT. The Working Group may meet at the request of any member of the group.

Delta Smelt Risk Assessment Matrix: The Working Group will employ a delta smelt risk assessment matrix (DSRAM) to assist in formulating recommendations. This document will be a product and tool of the Working Group and will be modified by the Working Group with the approval of WOMT as new knowledge becomes available. The current DSRAM has been provided by the Working Group for informational purposes (Appendix A).

Recommendations formulated by the Working Group will be forwarded to the WOMT. 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 by reducing take at the export facilities or by preserving smelt habitat.

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.

The AROG convenes monthly, or more frequently if needed, 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 multiagency 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 WOMT first met in 1999, and consists of management level participants from the Project and Management agencies. The WOMT meets frequently[3] 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 uses 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.

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.

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.

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.

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 the water supply costs to the EWA and CVPIA b(2) water assets, DAT recommends a 5-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

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[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.

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 annually to fish, wildlife, and habitat restoration
- Authorizing water transfers outside the CVP service area
- Implementing an anadromous fish restoration program
- 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 U.S. Department of the Interior (Interior) issued its Decision on Implementation of Section 3406 (b)(2) of the CVPIA. The B2IT provides the basis for implementing upstream and Delta actions with CVP delivery capability.

Water Service Contracts, Allocations 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 summer, 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 on the American and Sacramento Rivers are estimated to increase from about 255,850 af in 2001 to about 687,550 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.

Water Allocation – CVP

In most years, the combination of carryover storage and runoff into CVP reservoirs is sufficient to provide the water to meet CVP contractors' demands. Since 1992, increasing constraints placed on operations by legislative and ESA requirements have removed some of the capability and operations flexibility required to actually deliver the water to CVP contractors. Water allocations south of the Delta have been most affected by changes in operations ensuing from passage of the CVPIA and the biological opinions covering protection of the winter-run Chinook salmon and the Delta smelt.

The water allocation process for CVP begins in the fall when preliminary assessments are made of the next year's water supply possibilities, given current storage conditions combined with a range of hydrologic conditions. These preliminary assessments may be refined as the water year progresses. Beginning February 1, forecasts of water year runoff are prepared using precipitation to date, snow water content accumulation, and runoff to date. All of CVP's Sacramento River water rights contracts and San Joaquin Exchange contracts require that contractors be informed no later than February 15 of any possible deficiency in their supplies. In recent years, February 15th has been the target date for the first announcement of all CVP contractors' forecasted water allocations for the upcoming contract year.

The National Marine Fisheries Service (NOAA Fisheries) Biological Opinion requires Reclamation to use a conservative (at least 90 percent probability of exceedance) forecast as the basis of water allocations. Furthermore, NOAA Fisheries reviews the operations plans devised to support the initial water allocation, and any subsequent updates to them, for sufficiency with respect to the criteria for Sacramento River temperature control.

Forecasts of runoff and operations plans are updated at least monthly between February and May. Water allocations may or may not change as the year unfolds. Because a conservative forecast of runoff is used, it is quite likely that forecasted water supply will increase as the year progresses. While this may result in increased allocations, it also means that knowledge of the final allocation of water may be delayed until April, May, or June. This adds to the uncertainty facing Agricultural contractors who need reliable forecasts of available supply as early as possible to assist in decision-making for farm management.

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 3 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 acre-feet (maf).

The mean annual inflow to Trinity Lake from the Trinity River is about 1.2 maf 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 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 U.S. 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 safety of dams criteria stipulating flood season release and storage criteria at Trinity Dam to reduce the potential for overtopping during large flood events. The safety of dams criteria attempt to prevent storage from exceeding 2.1 maf from November through March. The safety of dams criteria begin to prescribe reservoir releases when storage in Trinity Dam is forecast to exceed 2.0 maf during November through March, see appendix C for the historic times safety of dams releases have been made.

The safety of dams release criteria specifies that Carr Powerplant capacity should be used as a first preference destination for safety of dams 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 safety of dams 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, 368,600 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 USFWS 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 degrees Fahrenheit (°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 USFWS in establishing a schedule of releases from Lewiston Dam that can best achieve these objectives.

For the purpose of determining the Trinity water year type, forecasts using a 50 percent exceedance will be used. Trinity River flow regimes will be planned and adjusted, if necessary, to be consistent with forecasts prepared during the April 1 through May period. There will be no make-up/or increases for flows forgone if the water year type changes up or down from an earlier 50 percent forecast. In the modeling, actual historic Trinity inflows were used rather than a forecast. 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 determining 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 that occurs in Whiskeytown Lake due to the long residence time of transbasin exports in the lake.

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 transbasin 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 exports are based on the utility of power generation and allowances for normal maintenance of the diversion works and generation facilities.

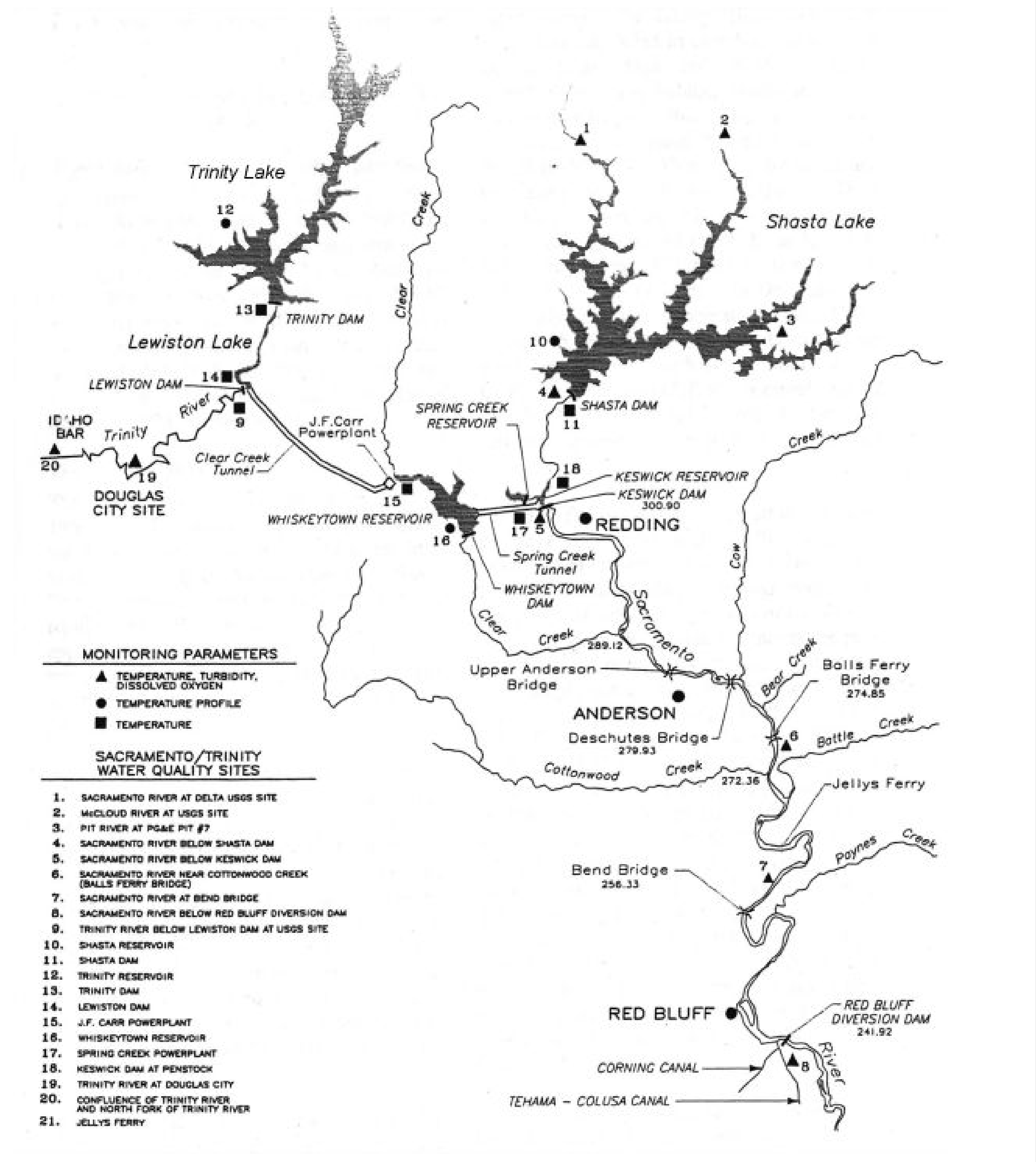

Figure 2–5 Sacramento-Trinity Water Quality Network (with river miles)

Power production, as a result of cross-basin diversion of Trinity River water through Trinity Division powerplants, is approximately three times greater than power production at Shasta Dam for an equivalent amount of water released. Trinity Lake historically reached its greatest storage level at the end of May. With the present pattern of prescribed Trinity releases, maximum storage may occur by the end of April or in early May.

Reclamation maintains at least 600,000 af in Trinity Reservoir, until the 10 to 15 percent of the years when Shasta Reservoir is also drawn down. Reclamation will discuss end of water year carryover on a case-by-case basis in dry and critically dry water year types with FWS and NOAA Fisheries.

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

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
1984	0	W
1985	0	D
1986	17	W
1987	0	D
1988	0	C
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
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 SCDD and 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 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 maf, 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 8 to 10 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 2-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	---*
May 1 - August 31	2300	2300	2300	---*
September 1 - September 30	3900	3250	2800	---*
October 1 - November 30	3900	3250	2800	3250
December 1 - December 31	2600	3250	2000	3250

Note: * 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. Also, operational uncertainties 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 for 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. Construction of RBDD was completed in 1964.

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 1965, enlargement approved in 1967, first operational in 1969 and was completed in 1980.

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 of Sacramento. 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. Reclamation is participating in continuing discussions with the Sacramento Water Forum, FWS, NOAA Fisheries, DFG, and other interested parties regarding integration of a revised flow standard for the lower American River into CVP operations and water rights. Reclamation intends to accomplish such incorporation, including associated revisions to the OCAP Project Description, in coordination with the parties. That revised project description, amending the lower American River flows to make them consistent with the revised flow standard, will be presented to the agencies, together with supporting material and analysis needed for review under ESA Section 7. 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 1960s, 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, safety of dams 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
- 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 using 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-quarter 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 maf per year; the median historical unimpaired runoff is 1.1 maf 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 1850s 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 maf. 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’s 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 6 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 maf 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 at or 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 7 milligrams 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 milliSiemens per centimeter (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:

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.

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, 2003 and 2004, 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 Impact 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 the VAMP shoulder 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 was not 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 5 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.

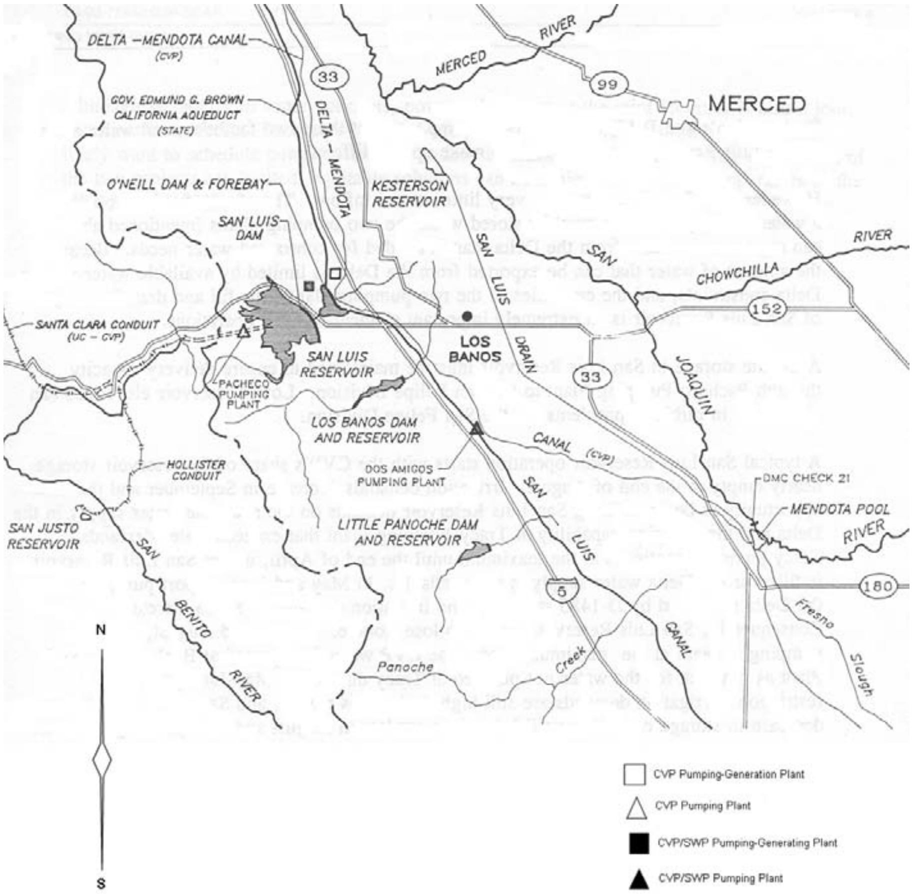

Figure 2–6 West San Joaquin Division and San Felipe Division

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 8 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.

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 multipurpose 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

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[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.

operations. The intake structure has an overflow type shutter system that determines the level from which water is drawn.

Approximately 4 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.

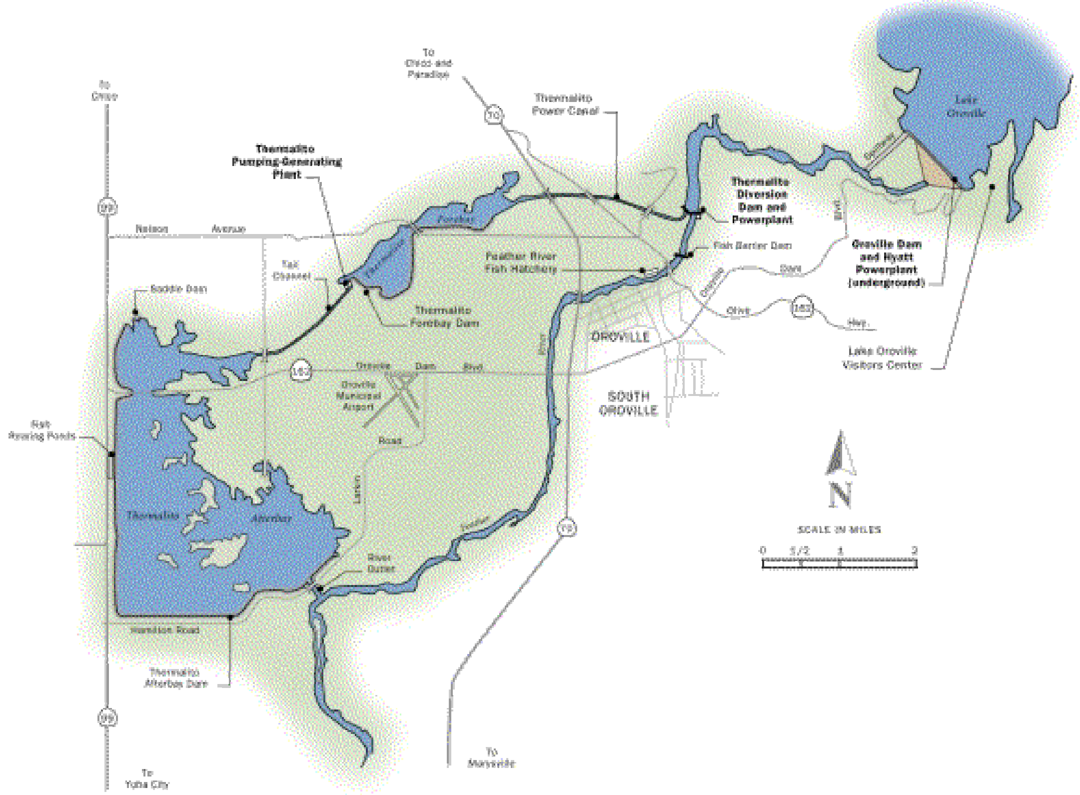


Figure 2–7 Oroville Facilities on the Feather River

The purpose of the diversion dam is to divert water into the 2-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 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.

Local agricultural districts divert water directly from the afterbay. These diversion points are in lieu 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.

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

Table 2–9 Water Year/Days in Flood Control/40-30-30 Index

Water Year	Days in Flood Control	40-30-30 Index
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 nonsalmonid 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 Delta Cross Channel (DCC), the CCWD diversion facilities, the Tracy Pumping Plant, the Tracy Fish Collection Facility, and the Delta Mendota Canal. The DCC is a controlled diversion channel between the Sacramento River and Snodgrass Slough. The CCWD diversion facilities use 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 May 21 through June 15 period. 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 Salmon Decision Process (see Appendix B) 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 Salmon Decision Process . In November 2000, the previously entitled Spring Run Protection Plan 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 Salmon 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.

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 2-83. 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 facility inspection a few years ago, 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. Extensive rehabilitation of the transition boxes and conduits was completed during the San Joaquin pulse period of 2004.

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 1 foot per second (ft/s) from May 15 through October 31, and for salmon of approximately 3 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 10 minutes every 2 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 30 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 45-day period in the winter or spring months.

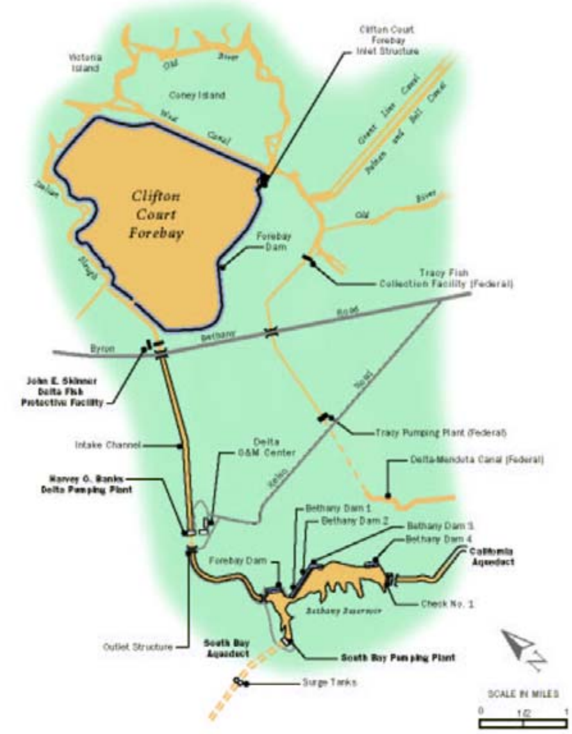
The CCWD's third diversion facility in the Delta is located at the southern end of a 3,000-foot-long channel running due south of Suisun Bay, near Mallard Slough (across from Chipps Island). The old Mallard Slough Pump Station was replaced in 2002 with a new pump station that has a state-of-the-art fish 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 3-day average and 13,870 af on a daily average[5].

CLIFTON COURT FOREBAY AND FOREBAY GENERAL PLAN



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 11 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

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[5] Up to an additional 500 cfs of diversion may be allov
Water Account operations. See the section titled "The CALFED Environmental Water Account" for further details.

increased diversion rates are covered under the section titled “8500 cfs Operational Criteria.”

Figure 2–8 Clifton Court Forebay, Tracy and Banks Pumping Plants

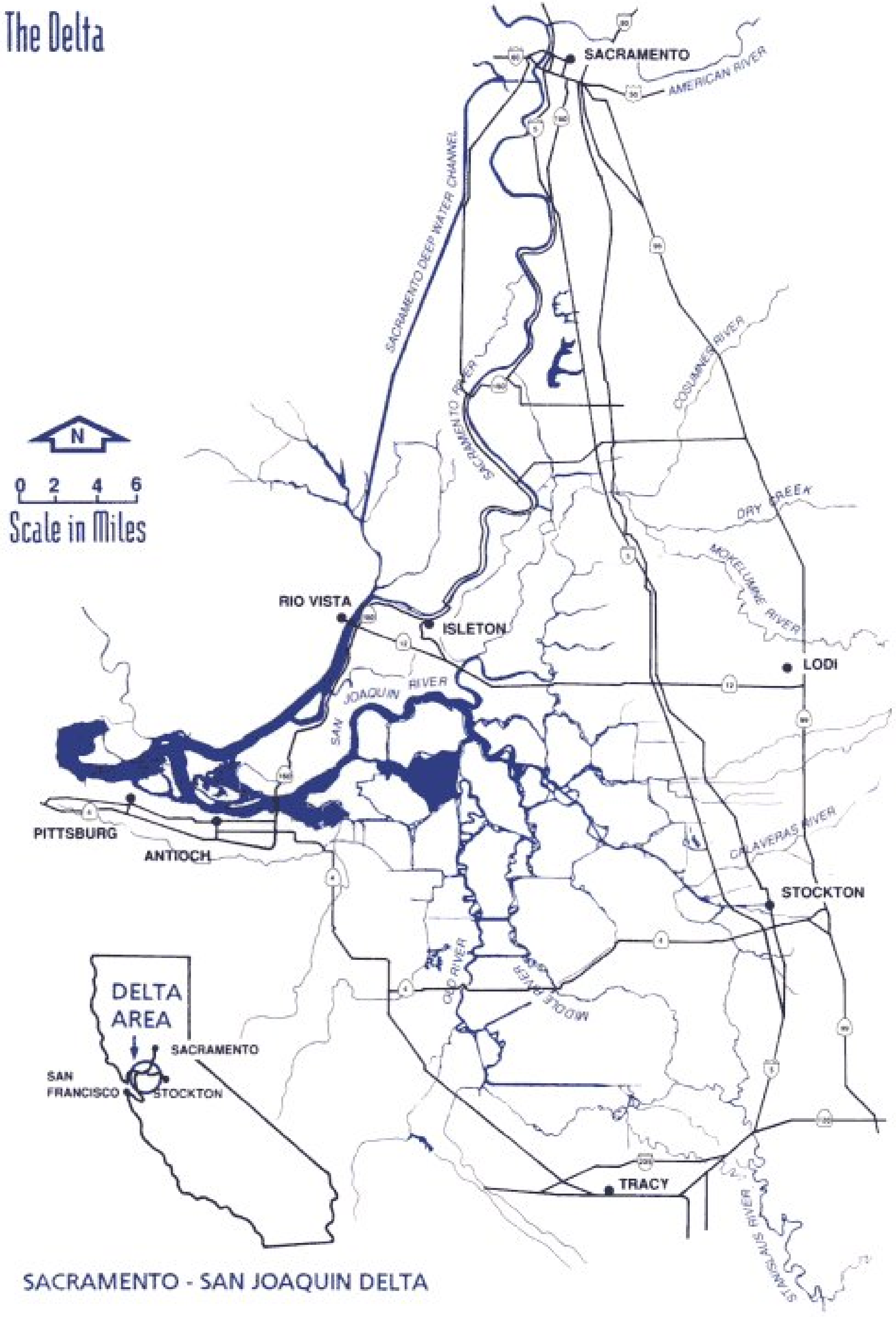

Figure 2–9 Sacramento-San Joaquin Delta

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 10 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, 2 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 8 miles northwest of Tracy and marks the beginning of the CA. By means of 11 pumps, including 2 rated at 375 cfs capacity, 5 at 1,130 cfs capacity, and 4 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 (RRDS), and up to four temporary barriers in the south Delta. Each of these facilities is discussed further in later sections.

Since its conception the State Water Project’s water supply has been highly dependent upon unregulated flow into the Delta. The delivery of water within the SWP in any given year is a function of operational requirements, Project storage conditions, demands (and the pattern of those demands), and the availability of unregulated flow into the Delta. To the extent that unregulated water has been available in the Delta, beyond that necessary to meet scheduled Project purposes and obligations, said water has been made available to any contractor who can make use of it. The original water supply contracts for SWP contractors included various labels for this Project water depending on the intended use–including the prominently used label of “interruptible”.

In 1994, the contracts were amended in what is commonly referred to as the Monterey Amendment. The basic objective of the amendment was to improve the management of SWP supplies–it did not affect the Project operations in the Delta or on the Feather River. Article 21 of the amendment stipulates that any SWP contractor is entitled to water available to the SWP when excess water to the Delta exceeds the Project’s need to fulfill scheduled deliveries, meet operational requirements, or meet storage goals for the current or following years. This includes the water that was before known as “interruptible” as well as some other lesser known labels of water diverted under the same conditions. Article 21 water is and always has been an important source of water for various contractors during the wet winter months and is used to fill groundwater storage and off-stream reservoirs in the SWP service areas. It is also used to pre-irrigate croplands thereby preserving groundwater and local surface water supplies for later use during dry periods.

The assumptions in CALSIM II for the demands that drives Banks Pumping varies by month with some variation across years. The demand for Article 21 water is one component of this total demand. In general, the assumed demand December through March for Article 21 water in CALSIM II is 134 taf per month–the assumed demand December through March Article 21 accounts for 90 percent of the annual total. With this assumed demand, 400 taf or more of Article 21 water is diverted 10 percent of the time.

It is likely that if the demand is assumed higher in these months, more may be diverted. To test this sensitivity DWR staff conducted an auxiliary simulation based on Study 2 with a demand set at 203 taf January through March (in the original Study 2, demand is never fully met in December) and with a demand of 300 taf January through March. With these higher demands 400 taf or more of Article 21 water is delivered 26 percent of the time. One other result worth noting is that based on Study 4 (a future conditions study with the same Article 21 demands as Study 2), there is an 8 percent chance of delivering 400 taf or more Article 21 water between December and March in any given year.

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.

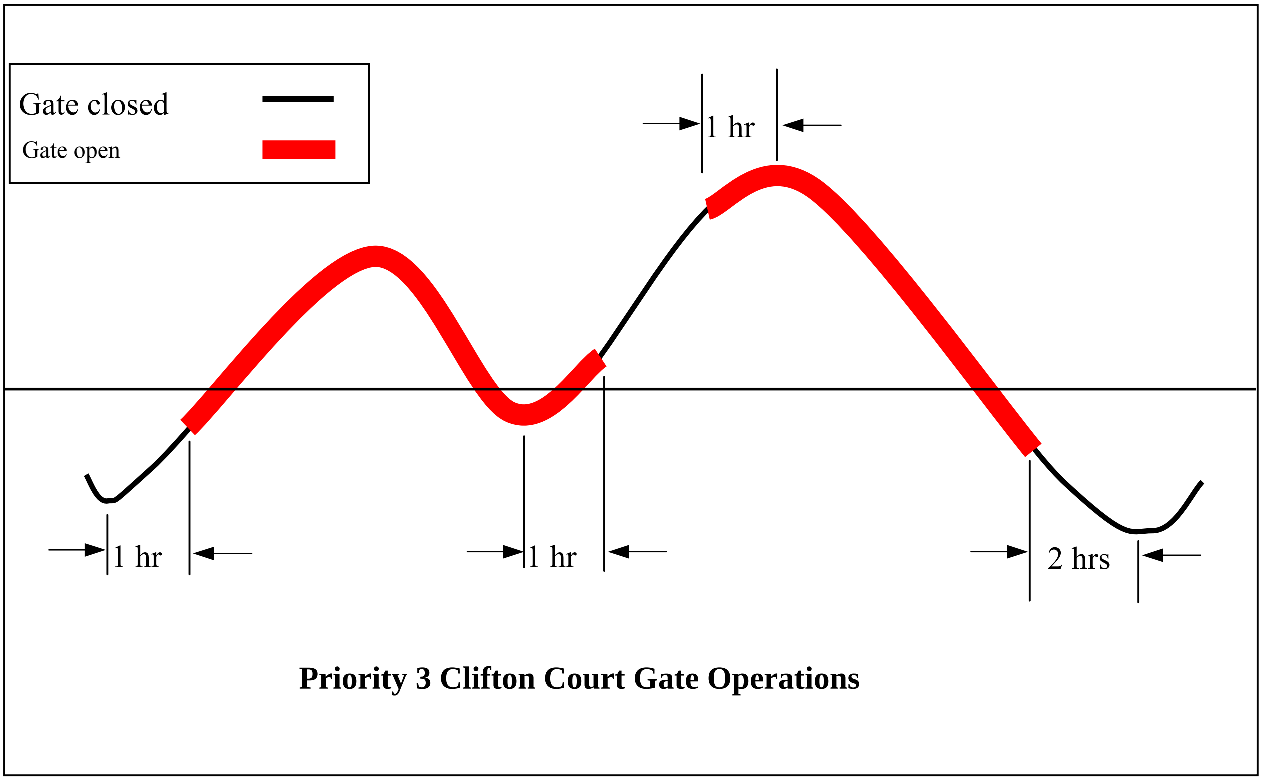

Figure 2–10 Clifton Court Gate Operations

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 10 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 millimeters (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.

Delta smelt monitoring presently required at Barker Slough under the March 6, 1995 OCAP Biological Opinion. Since 1995, monitoring has been required every other day at three sites from mid-February through mid-July, when delta smelt may be present. As part of the Interagency Ecological Program (IEP), DWR has contracted with the Department of Fish and Game to conduct the required monitoring each year since the Biological Opinion was issued.

A recent review by the IEP indicates that the present NBA monitoring program is not very effective for the management of smelt. Data from the past 9 years of monitoring show that catch of delta smelt in Barker Slough has been consistently very low, an average of just five percent of the values for nearby north Delta stations (Cache, Miner and Lindsey sloughs) (10-45). These results are discussed in further detail in Chapter 10.

Based on these findings, the Delta Smelt Working Group (Working Group) has recommended a broader regional survey during the primary period when delta smelt are most vulnerable to water project diversions. An alternative sampling approach would be conducted as a 1-2 year pilot effort in association with the Department of Fish and Game's existing 20-mm survey (http://www.delta.dfg.ca.gov/data/20mm). The survey would cover all existing 20-mm stations, but would have an earlier seasonal start and stop date to focus on the presence of larvae in the Delta. The proposed gear type is a surface boom tow, as opposed to oblique sled tows that have traditionally been used to sample larval fishes in the San Francisco Estuary. Under the proposed work plan, the Working Group will evaluate utility of the study and effectiveness of the gear in each year of the pilot work.

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 using 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 use 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 Interior's 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 low point 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 Forebay does 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.

Suisun Marsh

Suisun Marsh Salinity Control Gates

The SMSCG are located about 2 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.

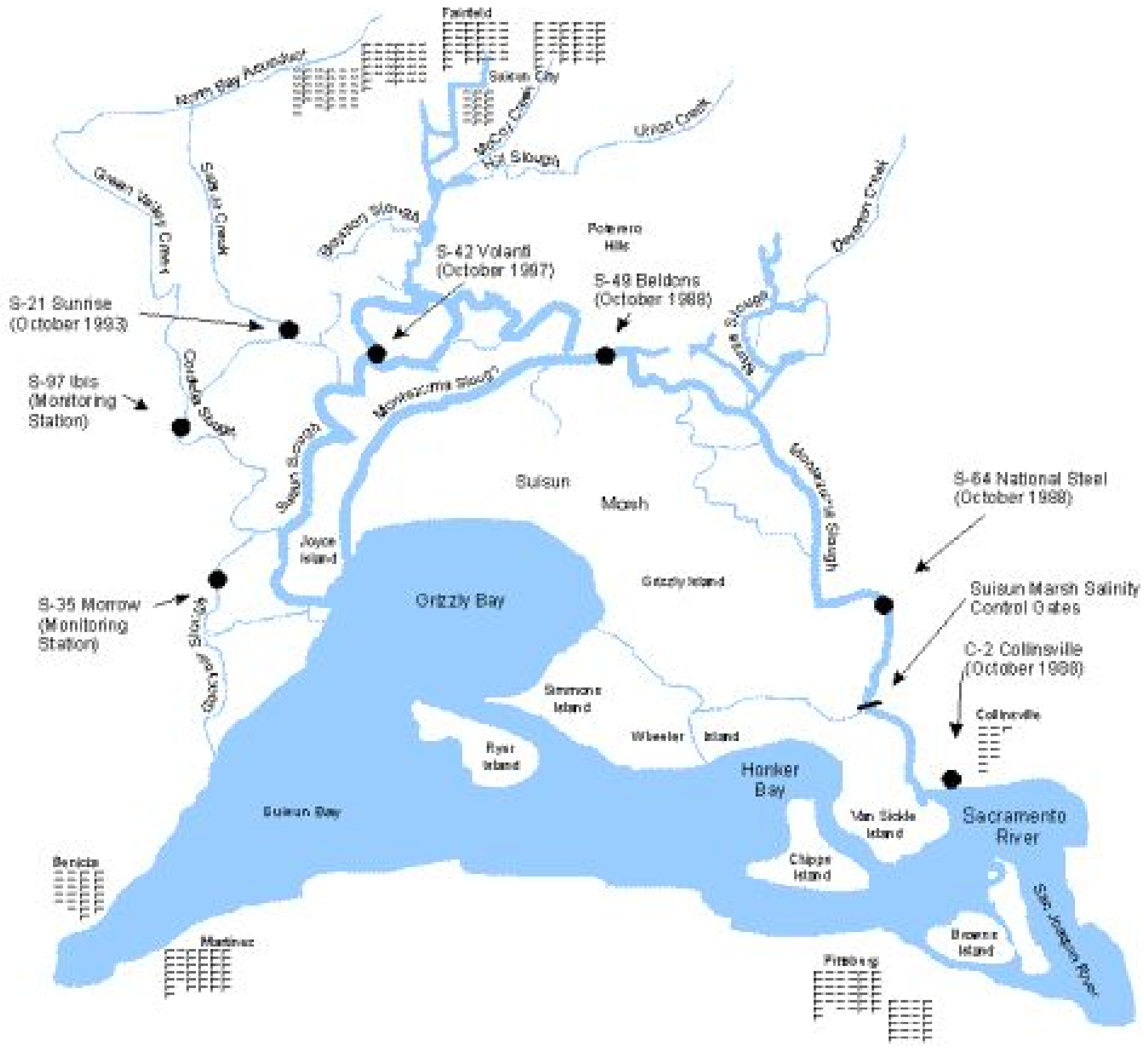

Figure 2–12 Suisun Bay and Suisun Marsh showing the location of the Suisun Marsh Salinity Control Gates and Salinity Control Stations

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

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[6] Since 1988, the SMSCG have been operated in September during 5 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.

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 3-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 2 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:

Full Open Operation. The SMSCG flashboards are out, the gates are fixed in the up position, and the boat lock is closed.

Full Bore Operation with Boat Lock Open. The SMSCG flashboards are in, the gates are tidally operated, and the boat lock is held open.

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 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.

CVPIA Section 3406 (b)(2)

On May 9, 2003, 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 fish, wildlife habitat restoration action based on recommendations 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 and management of (b)(2) water may also assist 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 a process to develop 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 in addition to 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 4-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.

- **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 that are purchased by the EWA Agencies. 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.

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 subheading 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[7]-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 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.

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[7] DWR’s 1991 Drought Water Bank purchased over 800,000 af, and conveyed approximately 470,000 af of purchased water across the Delta.

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:

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.

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.

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 O’Neill Forebay.

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 3-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 subheading.

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 multipurpose 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 3-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 3-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 Water District (CCWD) settlement agreement, FRWA and EBMUD agreed to "wheel" 3,200 af per year 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 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 percent 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 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 percent. 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 percent) 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.[8]

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 3-day running average diversion rate shall not exceed 9,000 cfs, (2) the 7-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 7-day running average shall not exceed 8,500 cfs or 6,680 cfs plus one-third of the 7-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.

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[8] 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.

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 31 consecutive days following the start of the VAMP.

If, in the view 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 threatened or endangered species in excess of the take authorized by the OCAP biological opinion.
- 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:

- FWS and NOAA Fisheries will determine in coordination with DFG that such operation would not increase take of threatened or endangered species in excess of the take authorized by the OCAP biological opinion.
- The San Joaquin River flow at Vernalis is not above 5,000 cfs.
- FWS and NOAA Fisheries will determine in coordination with DFG 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[9] and stage[10] for south Delta agricultural diverters . However, if FWS and NOAA Fisheries in

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[9] Minimum Water Quality goals, 30-day running average electrical conductivity (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, April – August; and 1.0 mmhos/cm, September – March.

[10] Minimum water levels goals in Middle River, Old River and Grant Line Canal would not drop below 0.0 mean sea level (MSL) - Based on the 1929 National Geodetic Vertical Datum (NGVD)

coordination with DFG determine there are fishery concerns with the operating the barriers, the matter will be brought to the WOMT.

From December 1 through April 15 the barriers may only be operated with permission from the FWS, NOAA Fisheries, and DFG if the following criteria are met:

- FWS and NOAA Fisheries, in coordination with DFG, will 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 and NOAA Fisheries, in coordination with DFG, will 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.

The barriers on the Middle River and Old River near the DMC and Grant Line Canal may need to be operated (closed) to protect water quality[1] and stage[2] for south Delta agricultural diverters.

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 FWS and NOAA 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 2-78.

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 af per year, to 200,000-600,000 af 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 af per year, either with or without the 8,500 cfs Banks. Refer to the Water Transfers section for additional discussion.

Reclamation and DWR have agreed to share water provided by Sacramento Valley interests to alleviate in-basin requirements. The Sacramento Valley Water Management Agreement 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 2-80.

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 af 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 exceedance projections, subject to the following conditions. When the CVP's and the SWP's February 90 percent exceedance forecasts project September 30 SWP storage in Oroville Reservoir to be less than 1.5 maf, and CVP storage in Shasta Reservoir to be greater than approximately 2.4 maf, the SWP may, in order to provide allocations based on a 90 percent exceedance forecast, rely on water stored in Shasta Reservoir.

  - Should the actual hydrology be drier than the February 90 percent exceedance 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 exceedance forecast, not to exceed 200,000 af.
  - 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.
- 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. 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 that 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.

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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 biological assessment (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 subspecific 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.

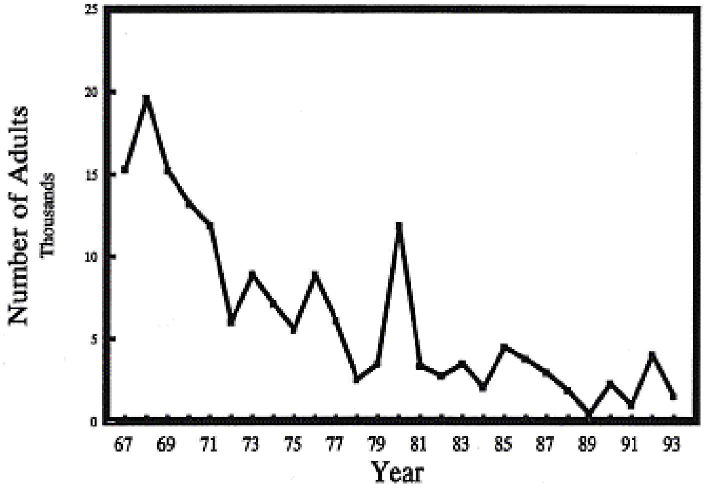
The Federal Endangered Species Act (ESA) was designed to protect the evolutionary legacy of species, and it allows for protection of “distinct population segments” (National Research Council [NRC] 1995). Similarly, the California Endangered Species Act (CESA) allows for “subspecies” to be listed. National Marine Fisheries Service (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 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.

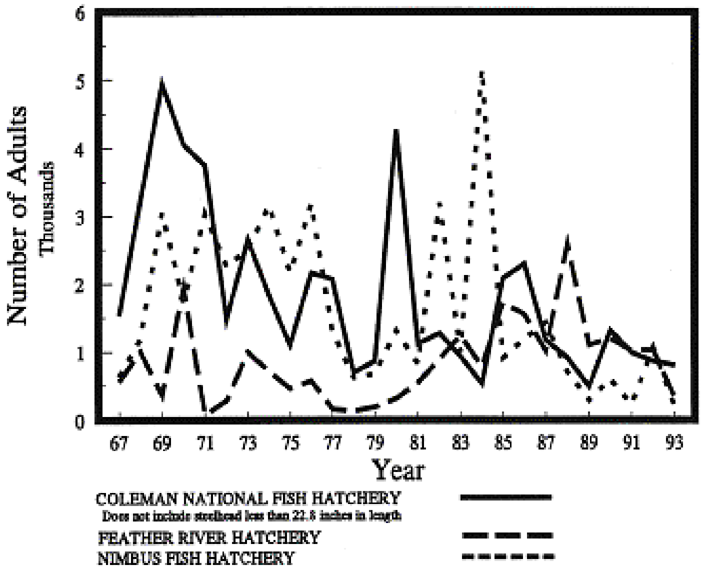
Status

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-1960s was obtained at the Red Bluff Diversion Dam (RBDD) 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 Russian River on the north to the San Lorenzo 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; therefore, they are not specifically referenced except in the determination of effects.



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 RBDD, 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.

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 (nonmigratory) 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.

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 9 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 8 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 5 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 because 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 because 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 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 to 1963 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 freshwater 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 to 52 degrees Fahrenheit (°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

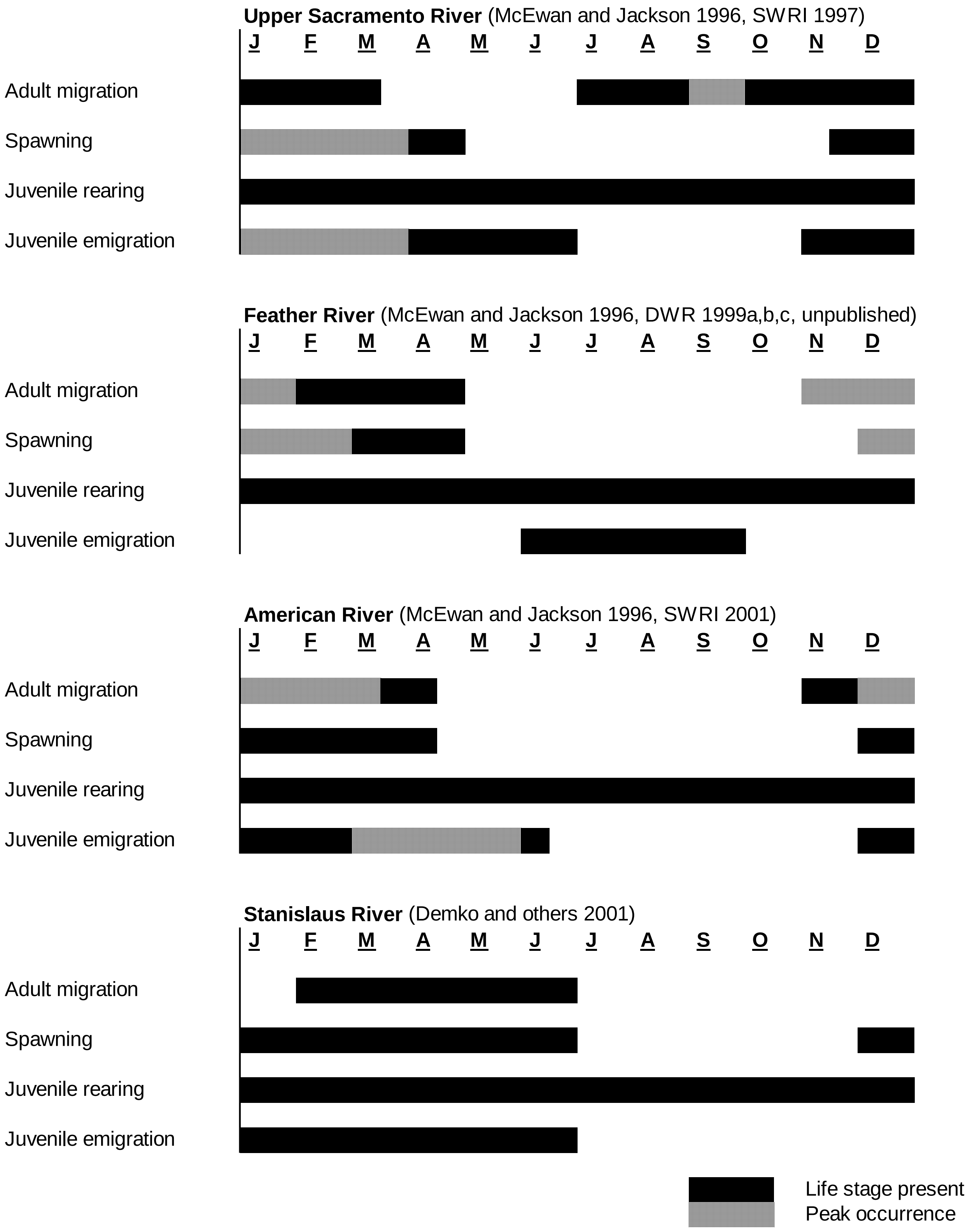


Figure 3–2 Steelhead life cycle for various Central Valley streams.

consultation because migration normally occurs during high outflow months. However, excessive water velocity (>10 to 13 feet per second [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).

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 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 2 or 3 years. The percentage of adults surviving spawning is generally low for Central Valley steelhead, but varies annually and between stocks.

The time required for egg development is approximately 4 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 4 to 6 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 1 to 3 years in freshwater (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 U.S. Fish and Wildlife Service (FWS) Chipps Island Trawl between 1976 and 1997 were less than 120 millimeters (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.

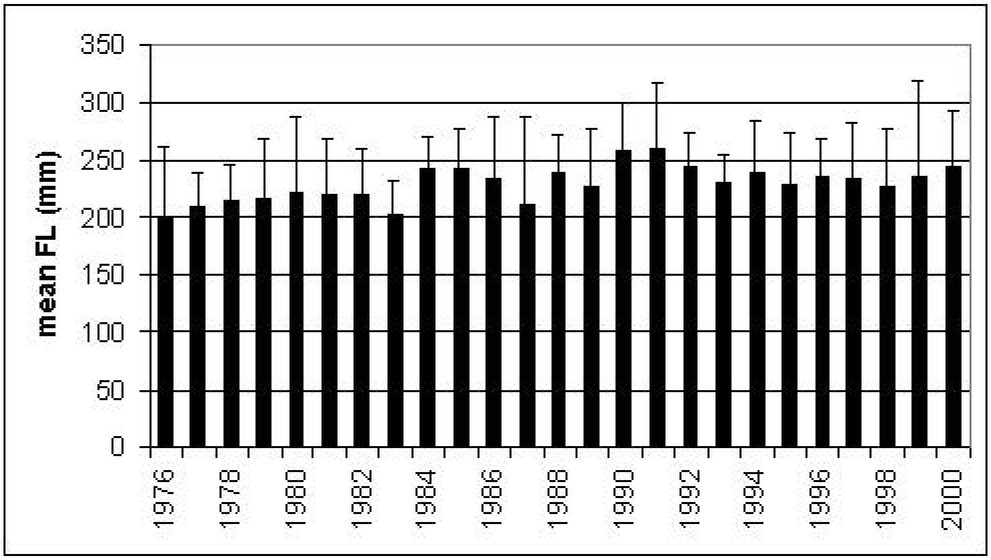


Figure 3–3 Mean FL (mm) plus standard deviation of steelhead collected in the FWS Chipps Island Trawl, 1976-2000.

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, according to 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 3 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 6 months or more. Presumably, these differences are an artifact of the method and timing of hatchery releases.

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.

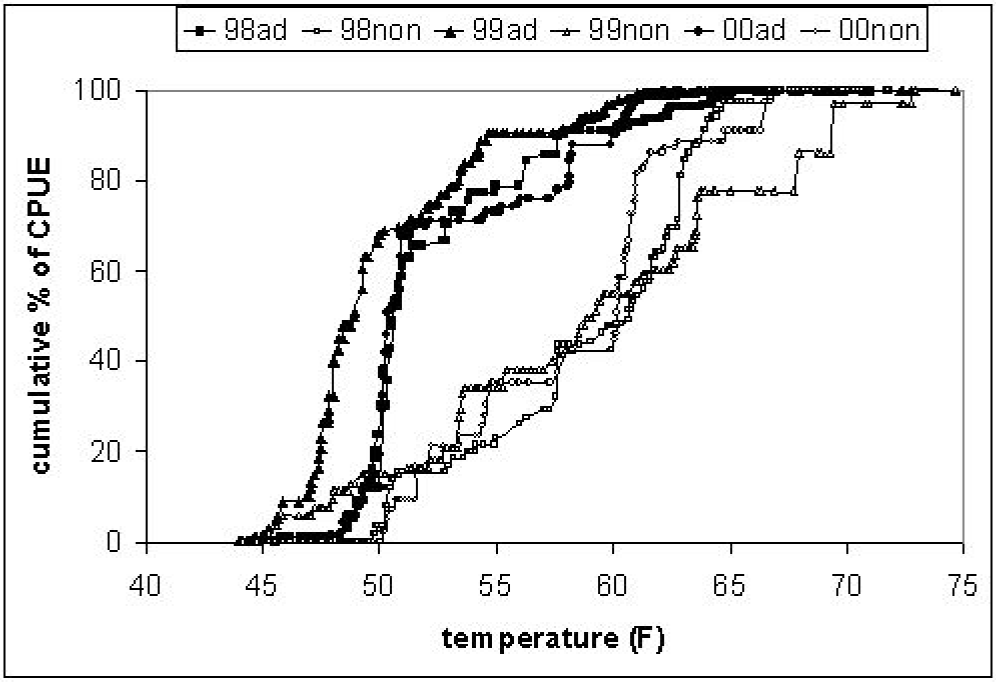


Figure 3–4 Cumulative percentage of steelhead per 10,000 m^3 in the FWS Chipps Island Trawl vs. surface water temperature at Chipps Island. Solid symbols represent hatchery fish and open symbols represent wild fish.

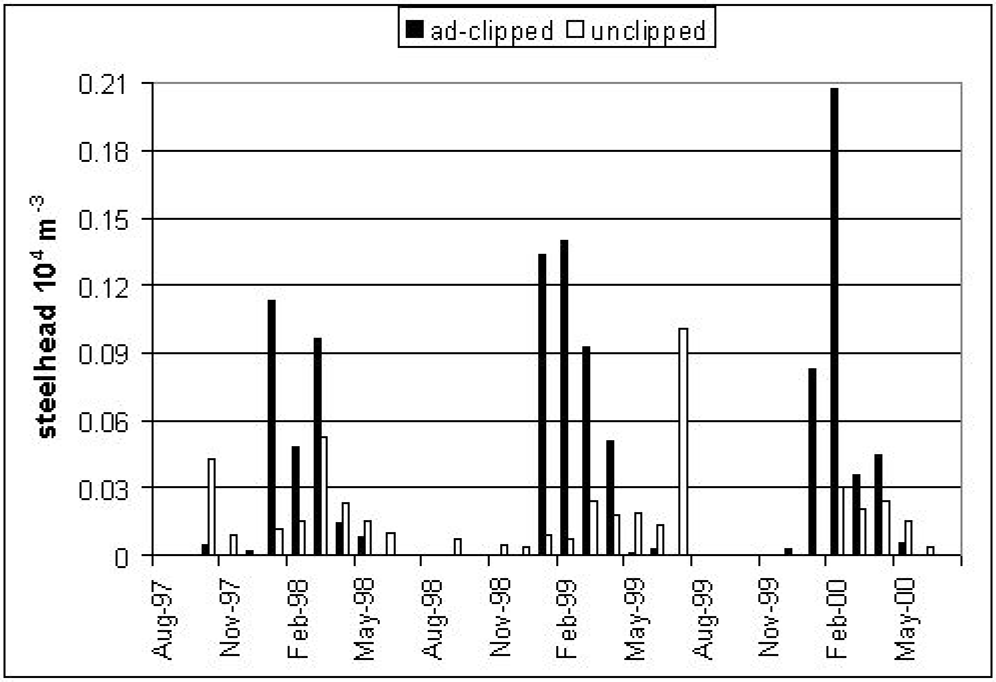


Figure 3–5 CPUE of adipose fin-clipped (black bars) and unclipped (white bars) steelhead from the FWS Chipps Island Trawl, August 1997 through July 2000.

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 American 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.

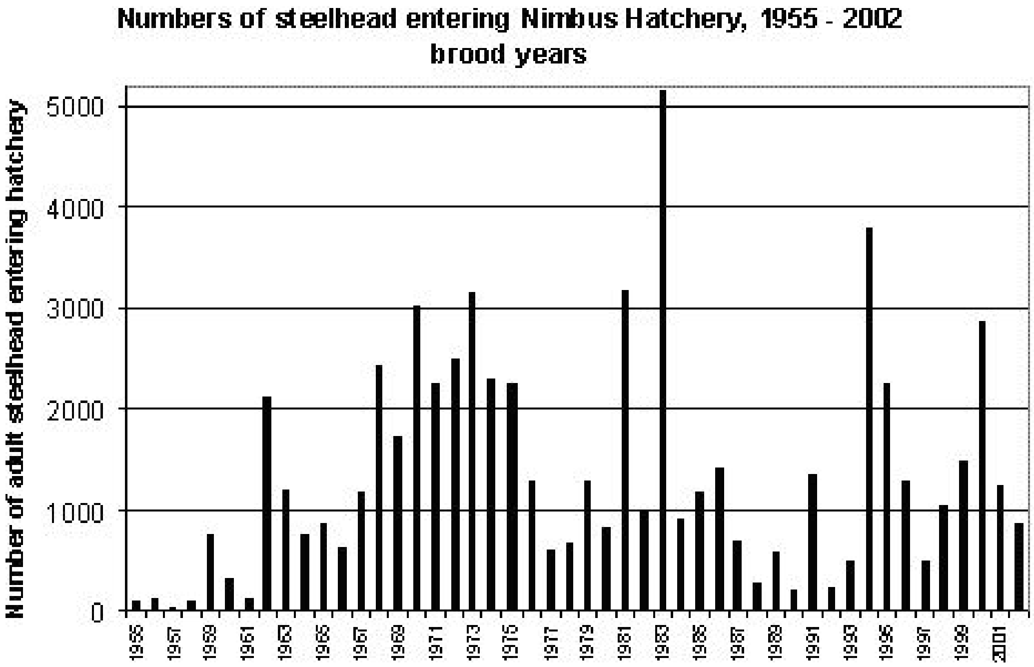


Figure 3–6 Adult steelhead counts at Nimbus Hatchery, brood years 1955-2001. The 2002 brood year means those fish returning to spawn in late 2002 through spring 2003.

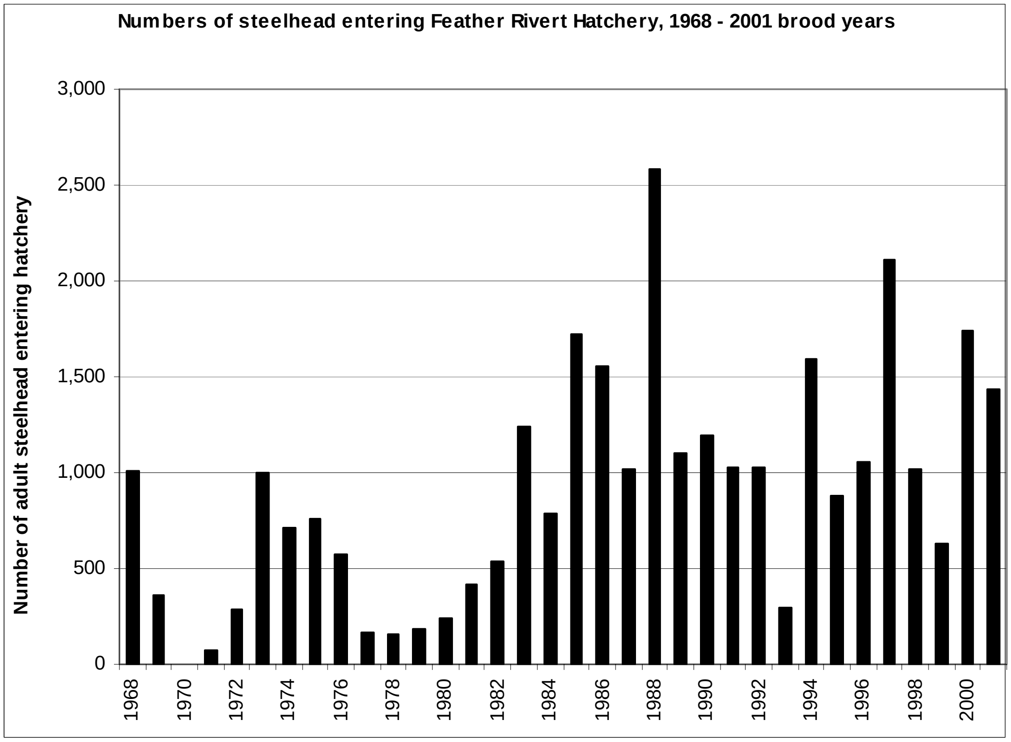


Figure 3–7 Adult steelhead counts at Feather River Hatchery, brood years 1969-2001.

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).

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 coldwater 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.

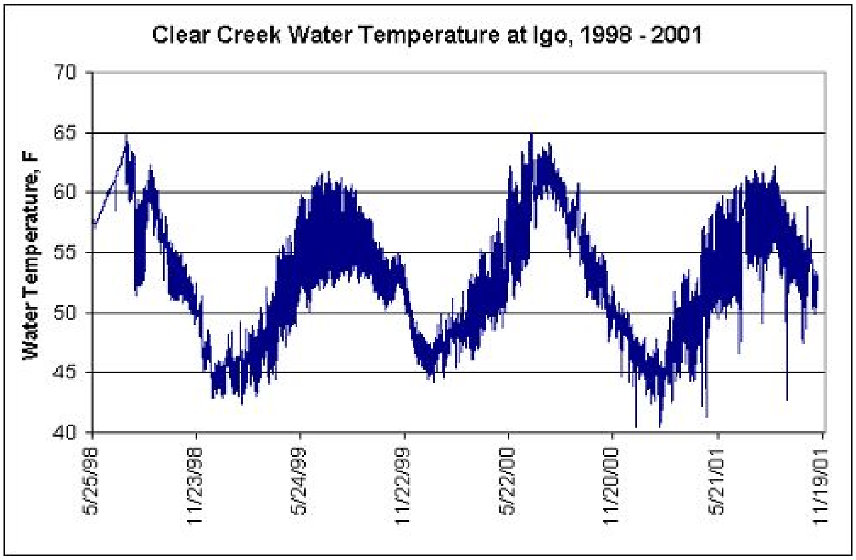


Figure 3–8 Clear Creek water temperature at Igo, 1998-2001 (CDEC).

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 percent 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 (RST) 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.

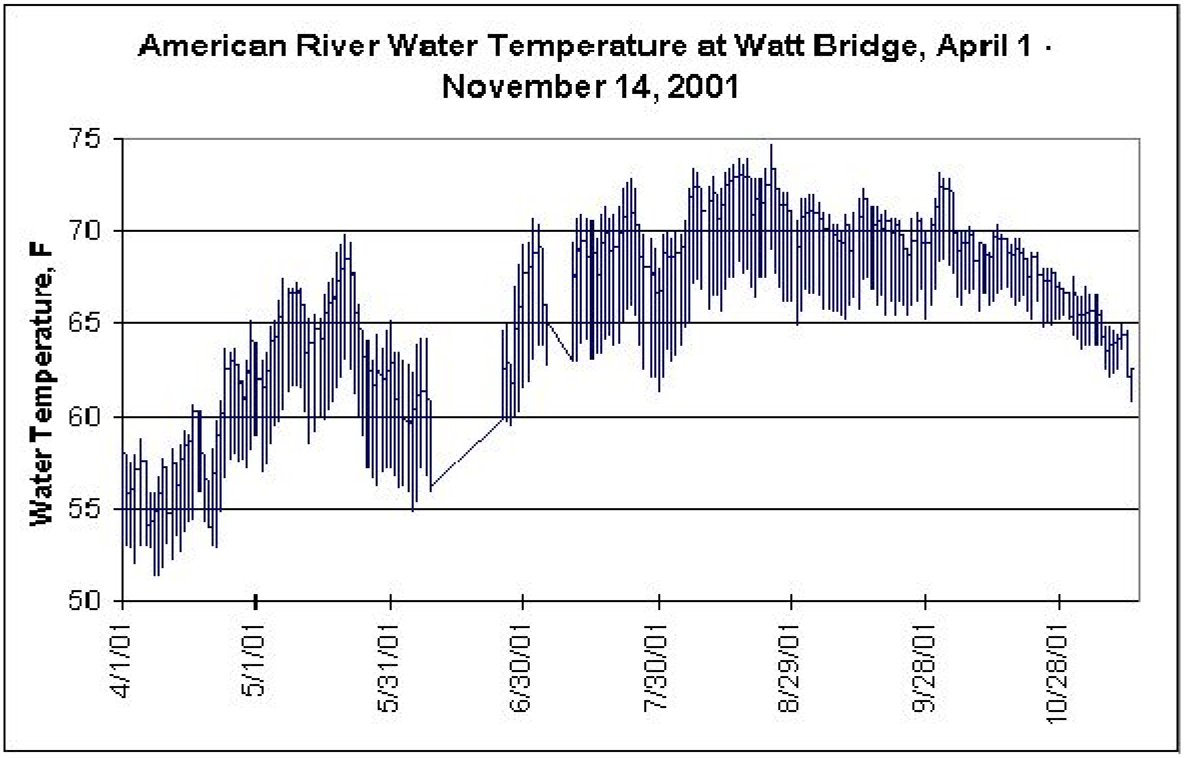


Figure 3–9 American River water temperature at Watt Avenue bridge, April 1 to November 14, 2001.

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).

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 show 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 2002–03 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 7-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 centimeters (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 1-plus 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 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 might 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 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 6 fish in 7 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 to 19 percent at Caswell and from 1 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 shows 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.

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 175–325 mm, with the most common size in the 226–250 mm range (Figure 3–11). Unclipped fish tended to have a higher proportion of larger individuals than clipped fish.

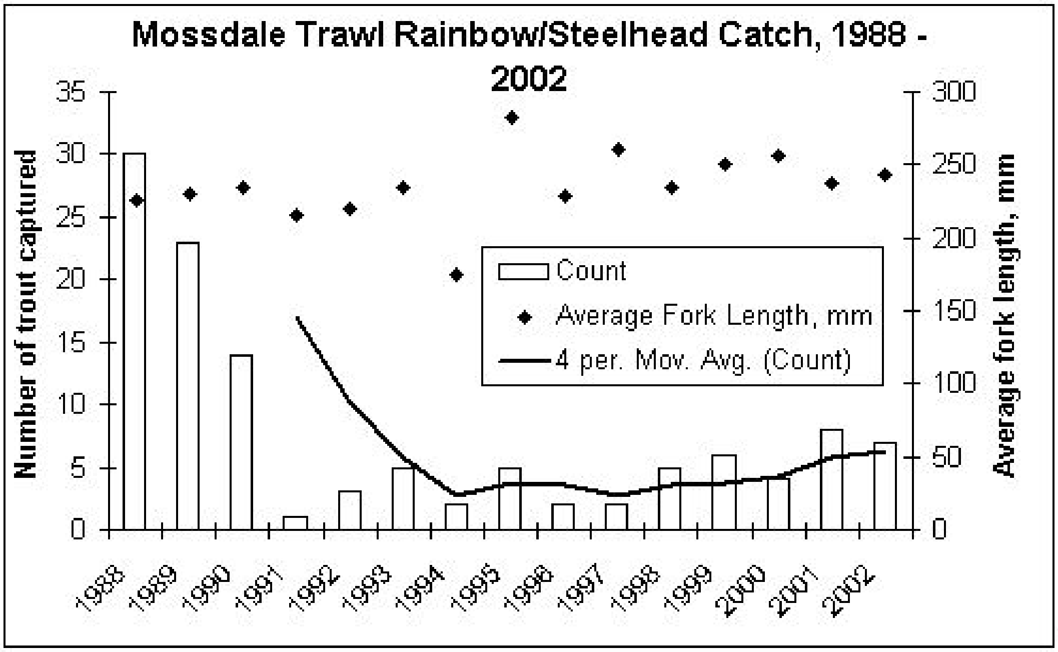


Figure 3–10 Mossdale Trawl rainbow/steelhead catch, 1988-2002 (Marston 2003).

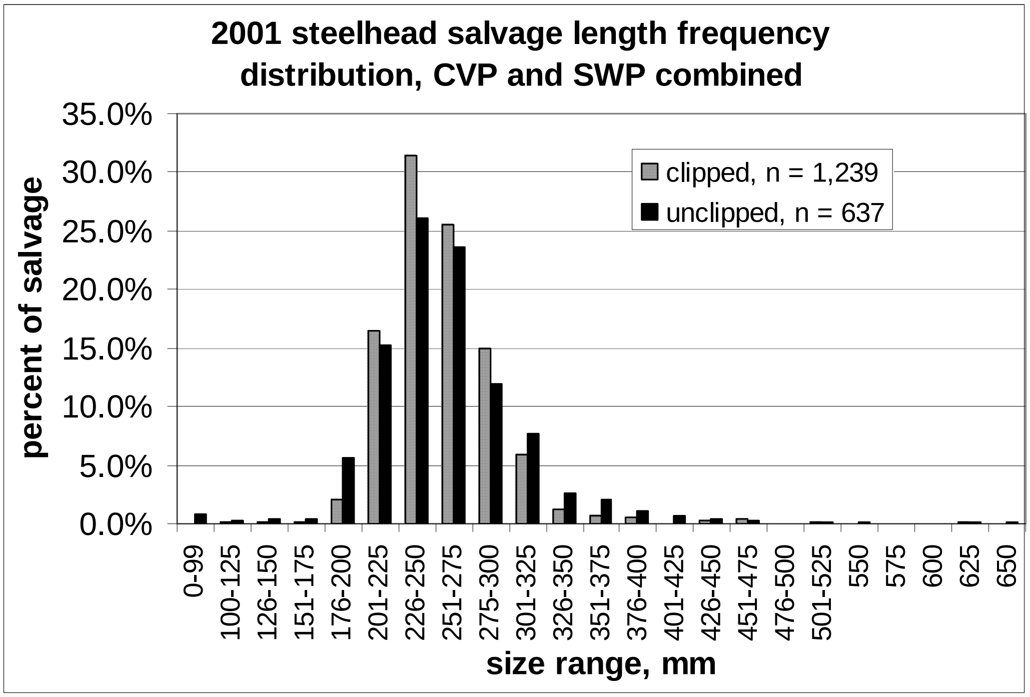


Figure 3–11 Length frequency distribution of clipped and unclipped steelhead salvaged at the CVP and SWP in 2001.

Mokelumne River

Figure 3–12 shows steelhead returns to the Mokelumne River Hatchery from 1965-98. More recent returns, from 1999 through 2003 have been less than 100 steelhead each year. Recently, 1 out of 60 (1.7 percent) steelhead that returned to the hatchery were unclipped.

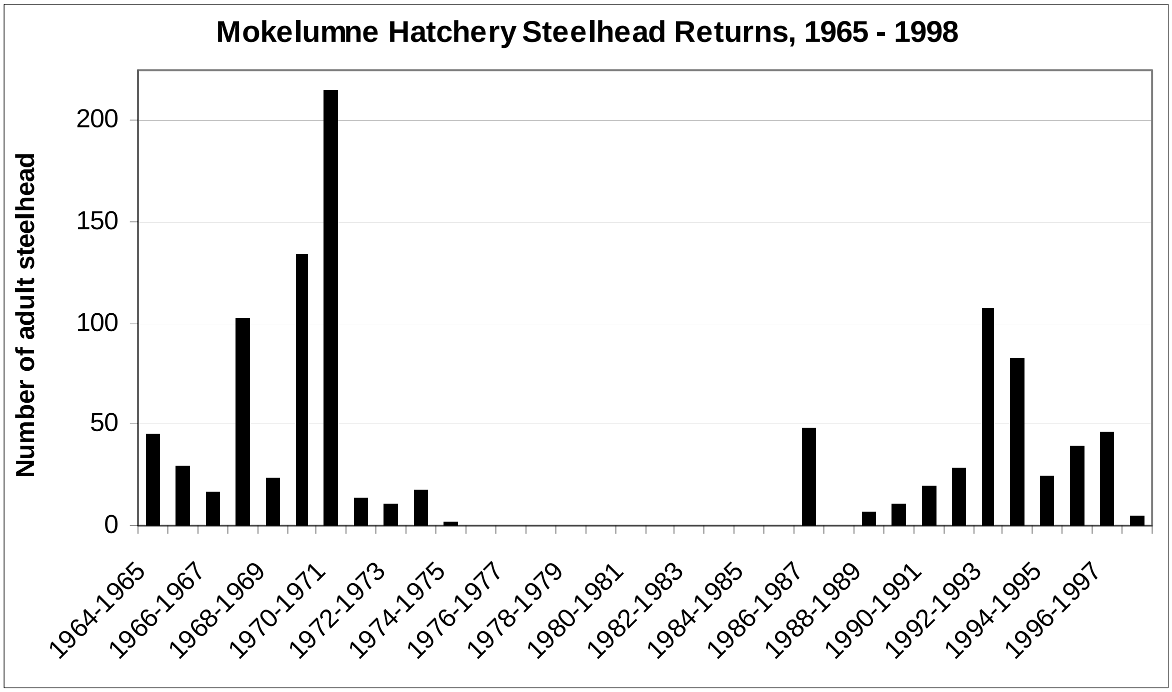


Figure 3–12 Steelhead returns to Mokelumne River Hatchery, 1965 – 1998.

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 biological assessment (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 California Department of Water Resources' (DWR's) relicensing of Oroville Facilities with the Federal Energy Regulatory Commission (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 degrees Fahrenheit (°F) and 68°F (17 and 20 degrees Celsius [°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 passive integrated transponder (PIT) tagged in habitats with a daily average temperature of 72°F and a daily maximum over 74°F (California Department of Fish and Game [DFG] and the U.S. Bureau of Reclamation [Reclamation] 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 coldwater 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. Although 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

The U.S. Fish and Wildlife Service (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 riverwide flow-habitat relationships.

Steelhead spawning wetted usable area peaked at 3,250 cubic feet per second (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 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 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 because of their distinct channel morphology and flow regime. The weighted usable (spawning) area (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 WUA throughout the range of flows analyzed (1,000-6,000 cfs). Table 4–2 shows the average of the WUA from the 21 cross sections expressed as 1,000 square feet of spawning area per 1,000 feet of stream. The WUA for steelhead peaked at a flow of 2,400 cfs. All flows from 1,000-4,000 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
1,000	31	62
1,200	33	71
1,400	34	78
1,600	35	82
1,800	36	84
2,000	36	83
2,200	36	81

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
2,400	37	78
2,600	36	74
2,800	36	69
3,000	36	65
3,200	36	60
3,400	35	56
3,600	34	52
3,800	32	48
4,000	31	45
4,200	29	42
4,400	27	38
4,600	26	36
4,800	24	33
5,000	23	31
5,200	22	28
5,400	21	26
5,600	20	25
5,800	19	23
6,000	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-streamflow 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 young-of-the-year (YOY) salmon and steelhead, and October through March for yearling steelhead and nonnatal 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 millimeters (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 versus the population estimate of outmigrating juveniles over 7 years of monitoring. They found that high flows in January had the largest effect on survival according to the following equation: Survival = 11,200*(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; thus, the high flows are supposedly 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 could 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 IFIM 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)	
	Rainbow Trout	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 the 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, FLD	Keswick Dam	Reclamation
Anderson-Cottonwood Irrigation District Diversion Dam	FB, SC, FLD		ACID
Clear Creek			
		Whiskeytown Dam	Reclamation

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
Battle Creek			
Coleman National Fish Hatchery Weir and various Pacific Gas & Electric (PG&E) dams (e.g. Wildcat)	FLD[b]	Coleman South Fork Diversion Dam; Eagle Canyon Dam (being laddered as part of restoration program)	PG&E
Antelope Creek	DW	Mouth	Edwards Ranch; Los Molinos Mutual Water Co.
Mill Creek			
Ward Diversion Dam	SC, SL, FLD	Morgan Hot Spring	Los Molinos Mutual Water Co.
Clough Diversion Dam	BR		
Upper Diversion Dam	SC, SL, FLD		Los Molinos Mutual Water Co.
Deer Creek			
Stanford-Vina Diversion Dam	SC, FLD	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.
Lower and Upper Deer Creek Falls	FLD		
Butte Creek			
Parrott-Phelan Diversion Dam	SC, FLD	Centerville Head Dam or Quartz Bowl Barrier (barrier most years)	M&T Ranch
Durham-Mutual Diversion Dam	SC, FLD		Durham-Mutual Water Co.
Gorill Diversion Dam	SC, FLD		Gorrill Ranch
Adams Diversion Dam	SC, FLD		Rancho Esquon Investment Co.
Butte Slough Outfall Gates			
Sanborn Slough	FLD		FWS/RD1004
East-West Weir	FLD		Butte Slough Irrigation District
Weir 2	FLD		DWR
Weir 5	FLD, SC		Butte Slough Irrigation District
Weir 3	FLD		Butte Slough Irrigation District
Weir 1	FLD		FWS
Stony Creek			
Glenn-Colusa Irrigation District (GCID) Canal (Formerly a gravel berm was used, but water canal is now piped under river.)	BR	Black Butte Dam	U.S. Army Corps of Engineers (USACE)

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
Tehama Colusa Canal Authority (TCCA) rediversion berm (Absent during adult migration)	UN		
Orland North Canal Diversion	FB, UN		
Yuba River			
Daguerre Point Dam	UN, FLD	Englebright Dam	USACE 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	FLD, FB	Camanche Dam	East Bay Municipal Utility District (EMBUD)
Central Valley Project (CVP)- and State Water Project (SWP)-influenced channels			
Calaveras River[d]			
Bellota Dam	UN with FB	New Hogan Dam	USACE
Stanislaus River		Goodwin Dam	Reclamation
Tuolumne River		La Grange Dam	Tulare Irrigation District
Merced River			
		Crocker-Hoffman Dam	Maxwell Irrigation District
San Joaquin River			
Hill’s Ferry Fish Barrier	10/1 - 12/31	Alaskan Weir	DFG

[a] Only streams with barriers are listed.

[b] Not currently operational.

[c] Harrell and Sommer, In press.

[d] Tetra Tech (2001).

BR = breached
DW = dewatered at some point throughout the year
FB = flashboards removed during winter
FLD = fish ladder
SC = screened diversion
SL = sloped dam
SO = salmon can swim over dam
UN = unscreened diversion

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 (Red Bluff Diversion Dam [RBDD], ACID, and 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 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 flashboards 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 4 months was incrementally increased to 8 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 RBDD are limited during these 8 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; 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 one steelhead was collected during a 2-year study of the large Roaring River Diversion in Suisun Marsh before it was screened (Pickard et al. 1982b).

The diversions at 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. Although 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 saltwater, but this has not been studied. Presumably, one of the anthropogenic factors that might 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, what little data are available are presented here as an initial assessment of potential effects.

DWR and Reclamation (1999) reported that 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 versus 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).

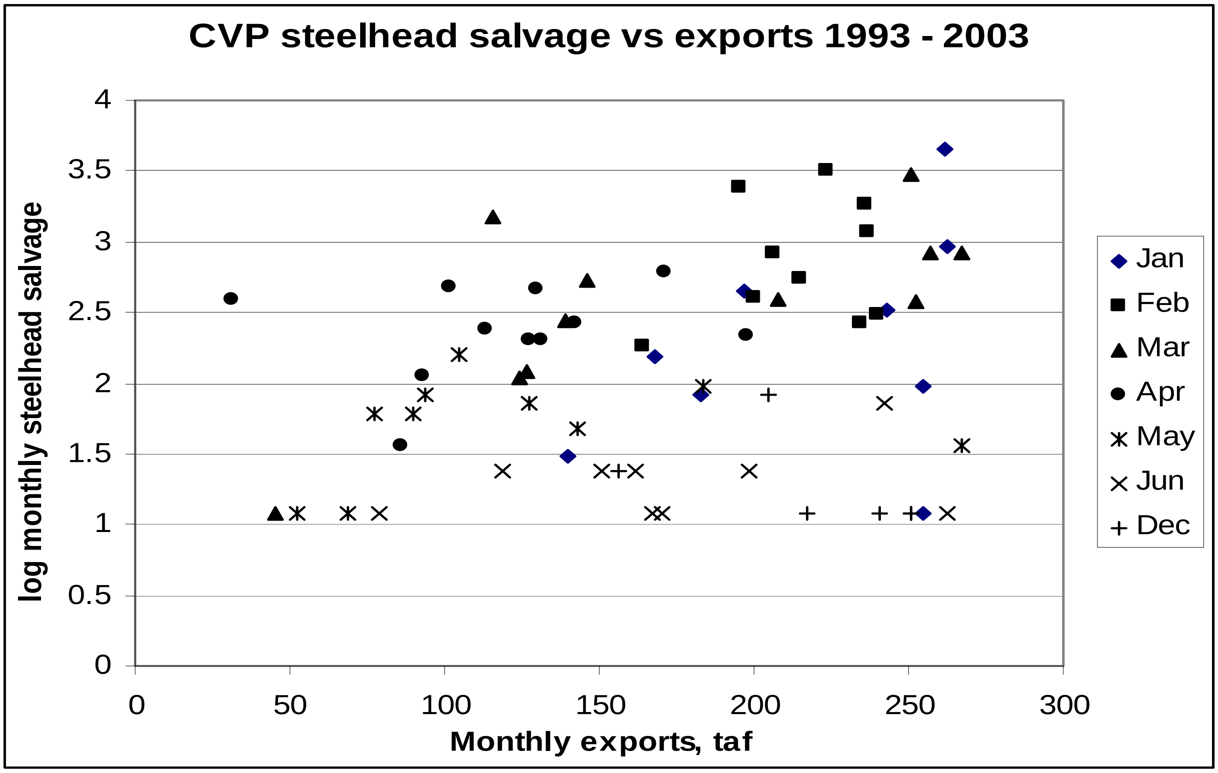


Figure 4–1 Scatterplot of total monthly CVP export in acre feet vs. $\log_{10}$ total monthly CVP steelhead salvage, 1993-2003

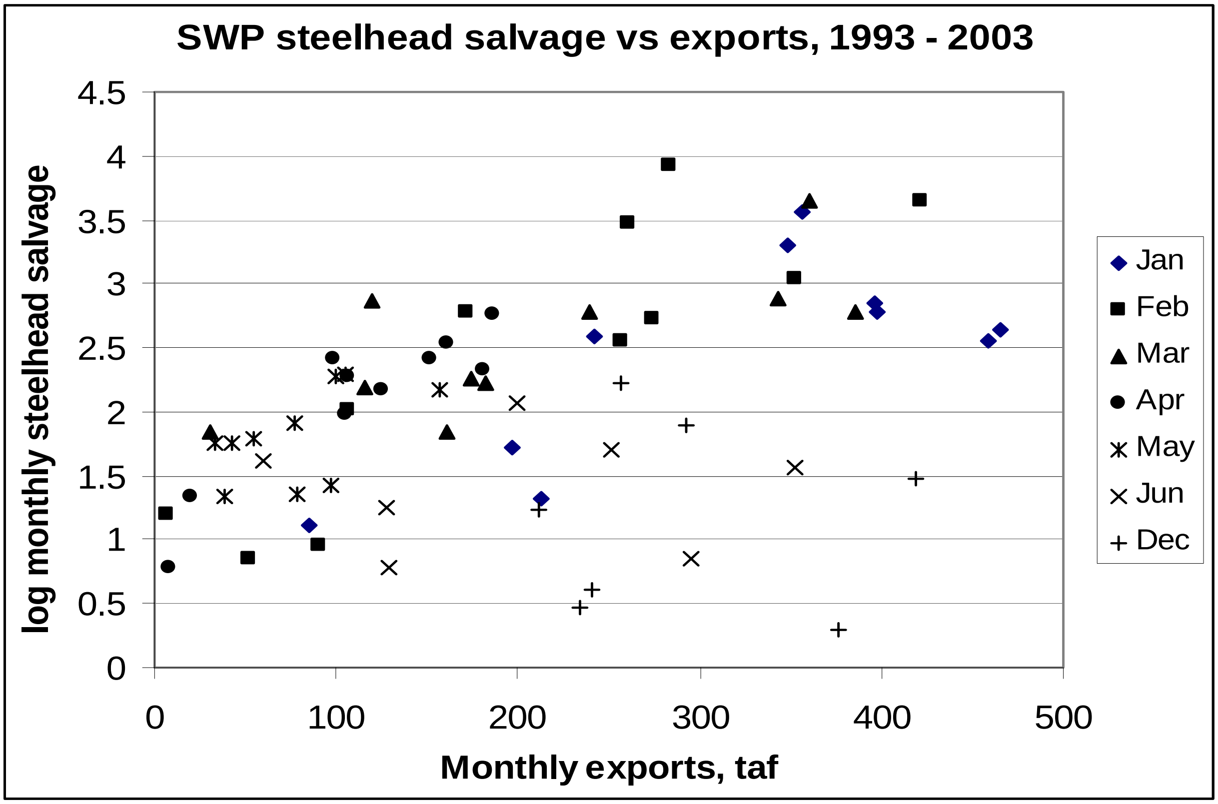


Figure 4–2 Scatterplot of total monthly SWP export in acre-feet vs. $\log_{10}$ total monthly SWP steelhead salvage, 1993-2003.

Future take predictions based on past salvage would be highly speculative, so they are not attempted. There has been a general decrease in steelhead salvage since 1992 (Table 4–6). This is presumably caused by 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 because 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.

In addition to being correlated to amount of water exported, steelhead salvage is positively correlated to December through June catch per unit effort (CPUE) of steelhead in the FWS Chipps Island Trawl (Spearman $R = 0.89$, $P = 0.02$; Figure 4–3), which is considered 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 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). For salmonids, typically 1-2 percent of smolts survive to return as adults. At a 2 percent smolt-to-adult survival, each steelhead smolt lost represents 0.02 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

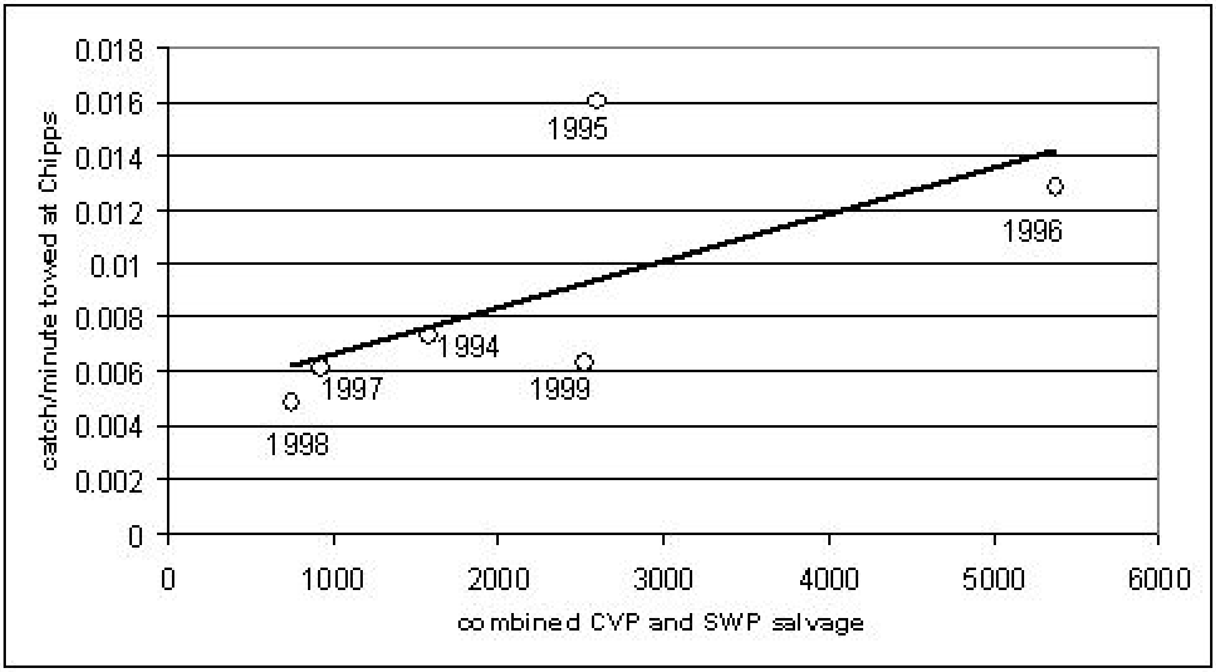


Figure 4–3 Relationship between total combined CVP and SWP steelhead salvage December through June, and December through June steelhead catch per minute trawled at Chipps Island, December 1993 through June 1999.

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 an estimate of 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 that 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 the channel is blocked by roads or other higher ground at several locations. 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 farther 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; 4 in 1999) (DWR unpublished data). Twenty-four (38.7 percent) were adipose fin-clipped; 54 (87 percent) of the steelhead were captured in an 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 rotary screw fish trap (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, it is not believed that 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.

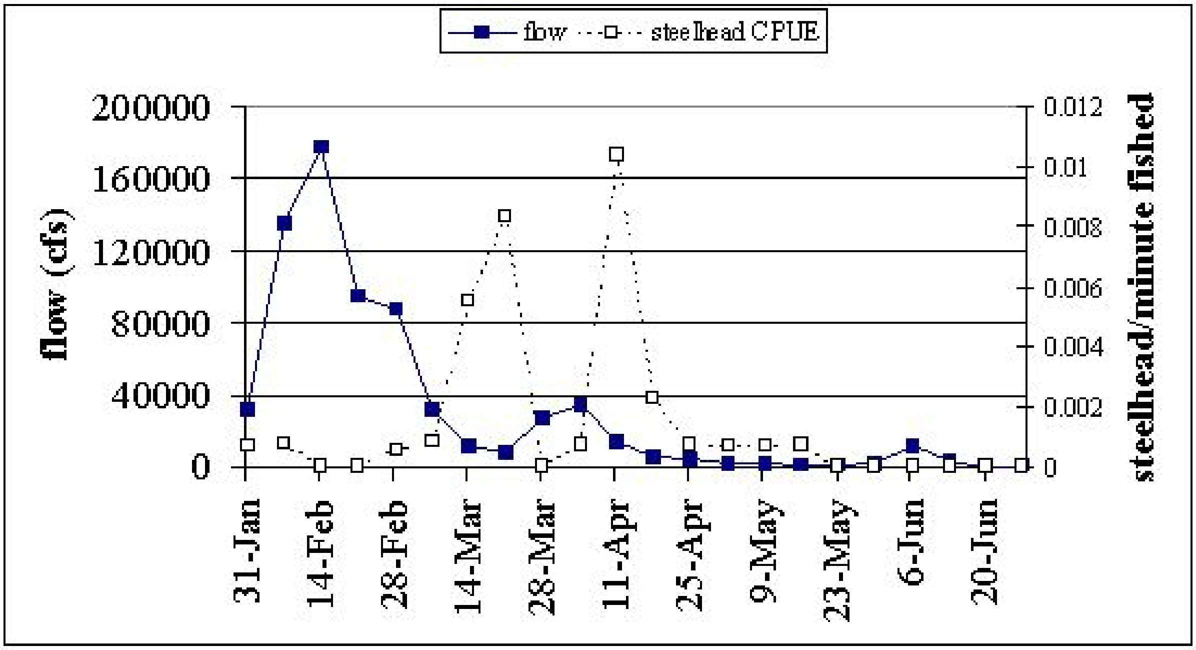


Figure 4–4 Steelhead catch per minute from the Yolo Bypass Toe Drain RST and total Yolo Bypass flow, 1998.

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 because they were feeding as they emigrated.

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 FLD); 1 pikeminnow (50 mm FLD); 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 FLD); 2 inland silversides (70 mm FLD)

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
3/7	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 2 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 re-installed 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 the gate is operational. The effort to minimize the adverse effects of the SMSCG on salmonid immigration through Montezuma Slough is ongoing. Because 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 constructed 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). Furthermore, 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, it is expected that 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 Niño years when warm water off the California coast increases the metabolic demands of predators and attracts additional piscivorous species such as the Pacific mackerel.

Competition for spawning space among 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 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.[a]

Hatchery	River	Yearly production goal	Number released in 1999	Release location
Coleman	Battle Creek	600,000 smolts	496,525	Battle Creek and Balls Ferry
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 [b]	102,440	Lower Mokelumne R.

[a] Source: DFG and National Marine Fisheries Service (NOAA Fisheries) 2001.

[b] From American or Feather reared at Mokelumne.

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 Evolutionarily Significant Unit (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 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 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.

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Chapter 5 Basic Biology, Life History, and Baseline for Winter-run and Spring-run Chinook Salmon and Coho Salmon

Status

National Oceanic and Atmospheric Association (NOAA) Fisheries listed winter-run Chinook as threatened under emergency provisions of the Endangered Species Act (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 California Endangered Species Act (CESA). On January 4, 1994, NOAA Fisheries reclassified the winter-run Chinook as an endangered species. The Central Valley spring-run Chinook salmon Ecologically Significant Unit (ESU) is listed as a threatened species under both the California and the Federal ESAs. The State and Federal listing decisions were finalized in February 1999 and September 1999, respectively. The fall and 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 (California Department of Fish and Game [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 pounds.), 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 Sacramento San Joaquin River systems.

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 (nest) construction success. Roni and Quinn (1995) reported that under high-density conditions on the spawning ground, natural selection may produce stocks with exceptionally large returning adults.

Among Chinook salmon, two distinct types have evolved: stream and ocean. The stream-type, 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 grow larger prior to smolting. At the time of saltwater entry, stream-type (yearling) smolts are much larger, averaging 73 to 134 millimeters (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).

Ocean-type Chinook are commonly found in coastal streams in North America. Ocean-type Chinook typically migrate to sea within the first 3 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 use 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 effects 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.

The 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). NOAA Fisheries (1999) determined the four Central Valley Chinook races comprise only three distinct ESUs: the fall/late-fall-run, the spring-run, and the winter-run. NOAA Fisheries (1999) determined that 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 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 broken down, resulting in intermixed life history traits in many remaining habitats.

Spawning

Spawning occurs in gravel beds that are often located at the tails of holding pools (US Fish and Wildlife Service [FWS] 1995a, as cited in DFG 1998). Adults have been observed spawning in water 0.8 foot 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 less than 0.3 inch 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 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 through 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 near quality spawning gravel. DFG (1998) characterized these holding pools as having moderate water velocities (0.5 to 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 holding pools (FWS 1995a, as cited in DFG 1998). Adult Chinook have been observed spawning in water greater than 0.8 foot 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 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 less than 0.3 inch in diameter) (Platts et al. 1979; Reiser and Bjornn 1979 both as cited in DFG 1998).

Currently, adult Chinook that DFG consider 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 that 87 percent of spring-run adults are 3-year olds based on observations of adult Chinook salmon trapped and examined at Red Bluff Diversion Dam (RBDD) between 1985 and 1991. Studies of coded wire-tagged Feather River Hatchery spring-run recovered in the ocean fishery indicated harvest rates average 18 to 22 percent for 3-year-old fish, 57 percent to 85 percent for 4-year-old fish, and 97 to 100 percent for 5-year-old fish (DFG 1998). These data are consistent with Fisher's (1994) finding that most of the spawning population are 3-year olds.

Fecundity

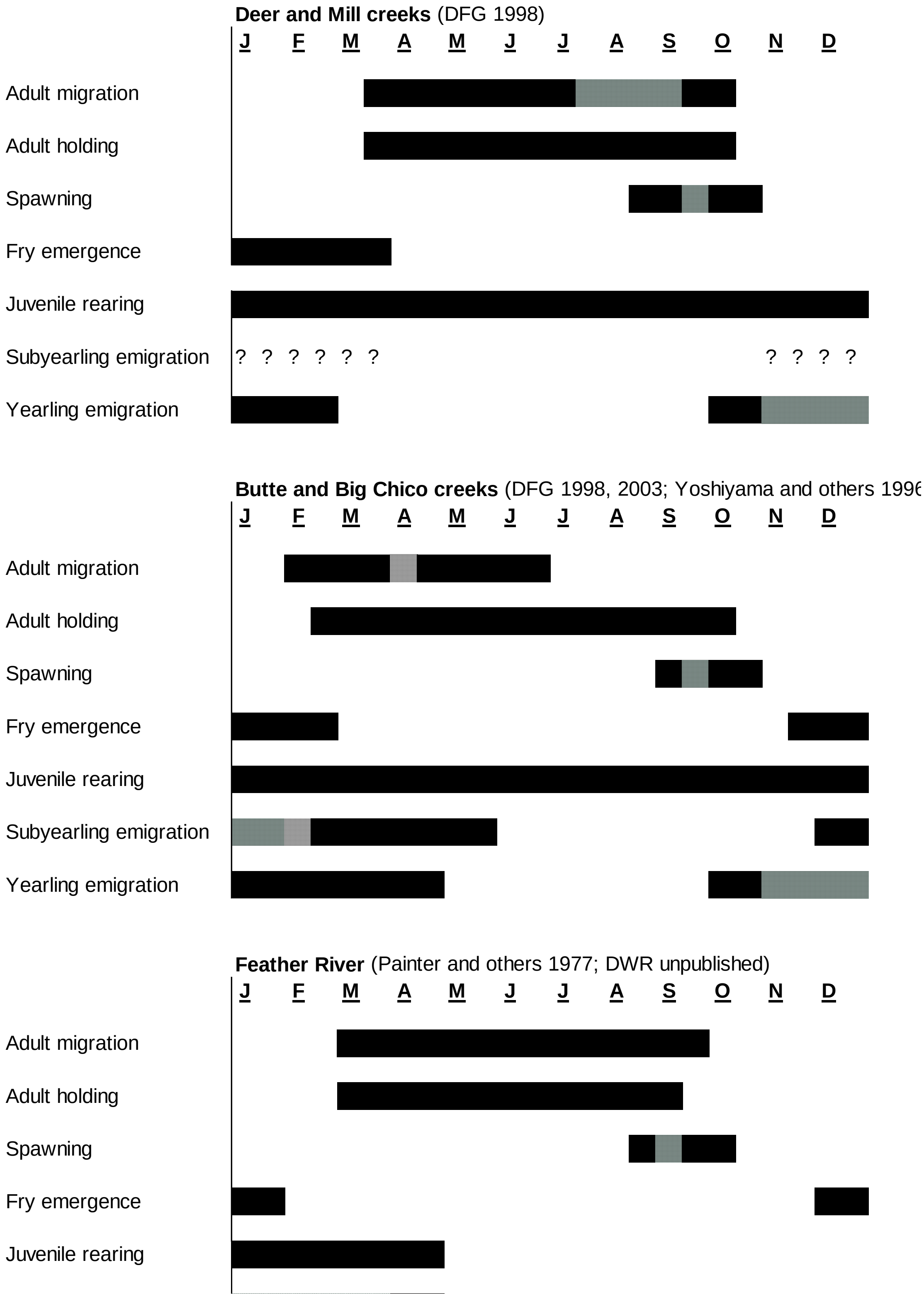
DFG (1998) developed a regression model to predict Sacramento River Chinook fecundity from fork length. Using this model, they estimated Central Valley spring-run fecundity ranged from 1,350 to 7,193 eggs per female, with a weighted average of 4,161. These values are very similar to the fecundity of spring-run estimated for the Baird Hatchery in the latter nineteenth 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 the highest survival in the American River when water temperatures were 53 to 54 degrees Fahrenheit (°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 1 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, nonnatal 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).



Deer and Mill creeks (DFG 1998)

Butte and Big Chico creeks (DFG 1998, 2003; Yoshiyama and others 199

Feather River (Painter and others 1977; DWR unpublished)

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 through 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 were 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 because 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 that 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 freshwater habitats. Juveniles typically do not move into brackish water until they have smolted, 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 smolt, 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 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 to 55°F (Boles et al. 1988), based largely on studies of steelhead and Coho salmon in the Northwest.

Ocean Distribution

Coded-wire tag (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 120 percent in the Garibaldi to Coos Bay area, 14 percent from Crescent City to Fort Bragg, 44 percent from Fort Ross to Santa Cruz, and 30 percent from Monterey to Point Sur (DFG 2003).

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 5 to 9 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 the 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 (presumably 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 indicates that winter-run Chinook, unlike the other runs, ascended to the highest portions of the headwaters, 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).

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%

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 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 through 1999 and found that emergence began in July during all BYs with peak dispersal occurring in September.

Juvenile Emigration

From 1995 through 1999, the pre-smolt/smolt emigration (greater than 45 mm fork length) started in September with 100 percent of production passing RBDD 2 to 3 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 use above and below RBDD appeared to be influenced by river discharge during fry emergence (Martin et 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). Juveniles are found above Deer Creek from July through September and spread downstream to Princeton (RM 164) between October and March (Johnson et 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 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 fork length of about 118 mm, while fall-run smolts average about 85-mm fork lengths (DFG unpublished data). This suggests that winter-run juveniles reside in fresh and estuarine waters for 5 to 9 months, exceeding freshwater residence of fall-run Chinook by 2 to 4 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 (Regional Mark Information System (RMIS) database).

Historical and Current Distribution and Abundance of Winter-run Chinook Salmon

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. Shasta and Keswick Dams blocked access to the original winter-run spawning habitat in the Sacramento River. 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 has 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
Mainstem 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*	0	0
Digger Creek	Vicinity of Manton, possibly higher				
South Fork	Falls near Highway 36 crossing				
Total		543	329	214	39

* 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 significantly 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).

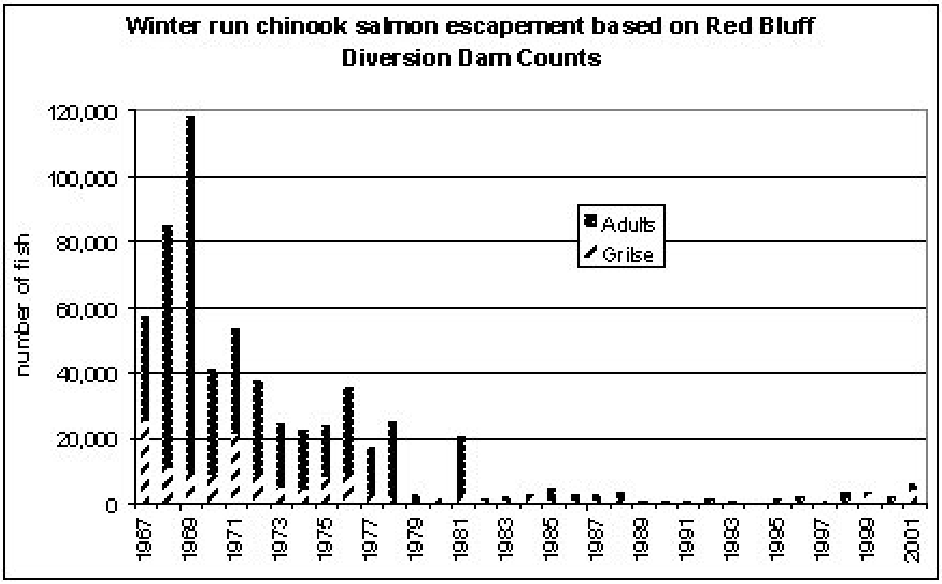


Figure 5–2 Sacramento River winter-run Chinook escapement based on RBDD counts.

The Cohort Replacement 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 nor 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 1 from 1967 to 1990, i.e., the population was declining. CRRs have been greater than 1 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 2 years later as grilse, and 3 and 4 years later as adults. The calculations assumed that 5 percent of the adult returns were 4-year olds, and 95 percent of adult returns were 3-year olds, an average based on 2001 winter-run scale aging data (Alice Low, personal communication, 2002).

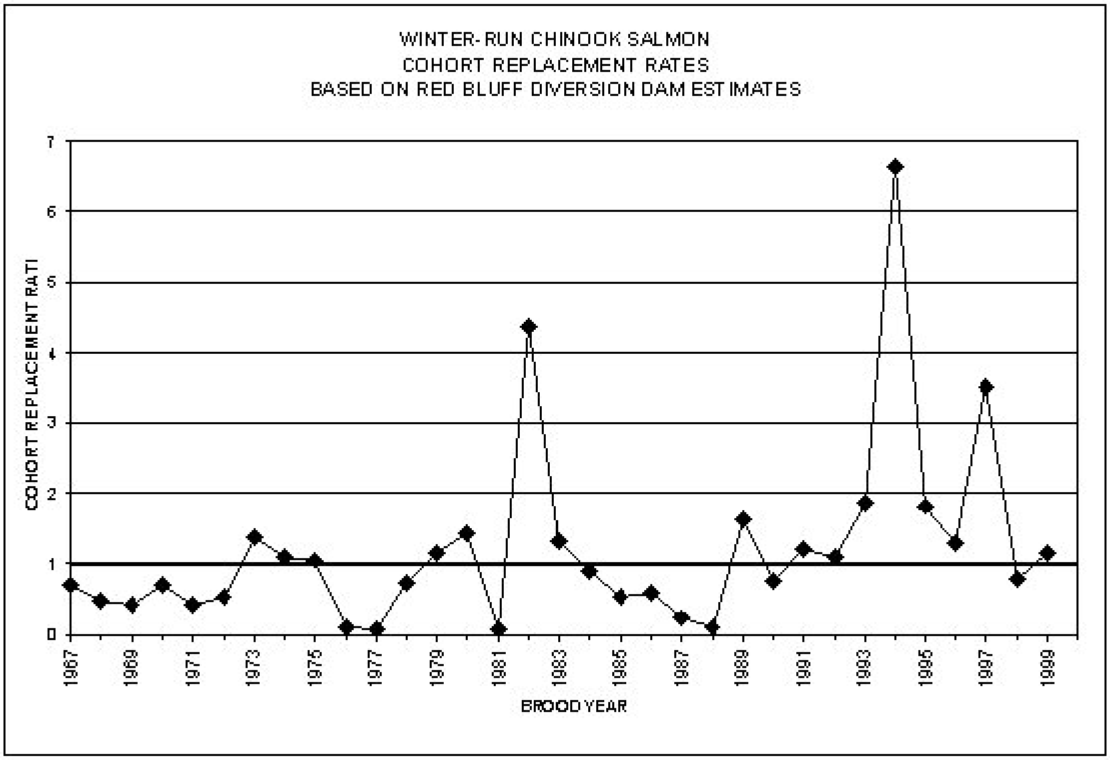


Figure 5–3 Sacramento River winter-run Chinook salmon CRRs based on RBDD escapement estimates.

Rates were calculated by taking the BY escapement and dividing it by the sum of grilse 2 years later, 3-year olds 3 years later, and 4-year olds 4 years later; assuming that 95 percent of adults are 3-year olds and 5 percent are 4 years old, i.e., the 1999 CRR is based on adult returns in 2000 - 2002 (age distributions based on 2001 scale data).

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 are 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.

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

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
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. DFG has 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. RBDD gate operations were changed from 1989 through 1993 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 ACID Dam.	17	3	1	836	84	20	853	53	14
ACID 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 nineteenth 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 twentieth 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 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 two-thirds 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 tributaries other than Mill Creek. Snorkel surveys are good for identifying population trends. They usually underestimate the actual number of fish present. Recent comparisons during 2001 and 2002 on Butte Creek of the snorkel survey with a rigorous Schaefer carcass survey suggest that the snorkel survey underestimates by as much as 50 percent (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 reappeared in the lower reaches of Clear Creek in 1999. Historical accounts of spring-run Chinook in Clear Creek are sparse and population estimates are nonexistent. 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 that they likely held over and spawned in cooler water present in the upper watershed upstream of Whiskeytown Dam. A fall 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, 19 possible spring-run were counted during snorkel surveys. During the decline in numbers of Chinook in September, the remains of 5 Chinook were found, potentially poached (DFG 2001a). During 2001 surveys, 9 spring-run were counted from April to July. However, the monthly survey counts in 2001 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 according to 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 Instream Flow Incremental Methodology (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 cubic feet per second (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 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. 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 than in the 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 1 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 reestablishment of spring-run in Clear Creek by attracting some fish that would otherwise remain in the Sacramento River.

Recent flows in Clear Creek likely resulted from a general flow schedule developed for salmon and steelhead maintenance. 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.

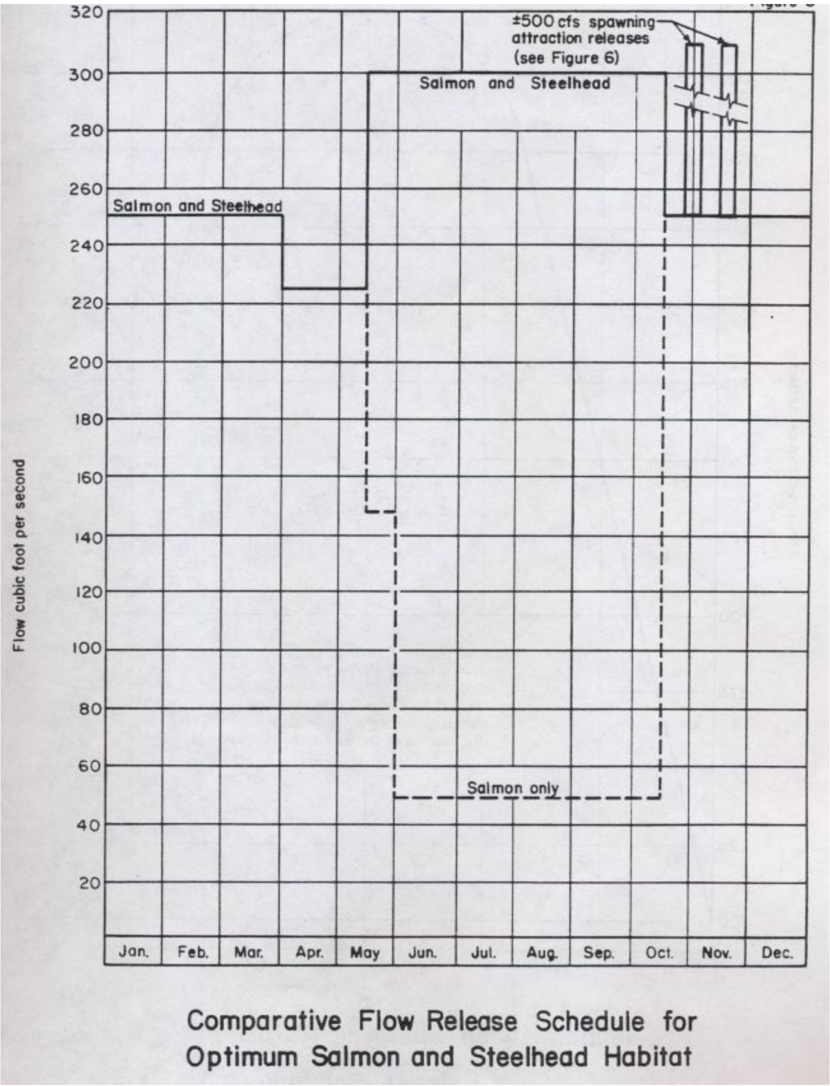


Figure 5–4 Clear Creek flows for optimum salmon and steelhead habitat.

Sacramento River Main Stem

Some spring-run Chinook may spawn in the Sacramento River between RBDD and Keswick Dam. Sacramento River 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 5-year geometric mean abundance reported by NOAA Fisheries (1998) was 435 fish. There is evidence that 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. Because 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-run from fall-run between 1970 and 1988 probably resulted in many fall-run fish being classified as spring-run (DFG 2003), so the increasing overlap may be simply an artifact of the variable run classification.

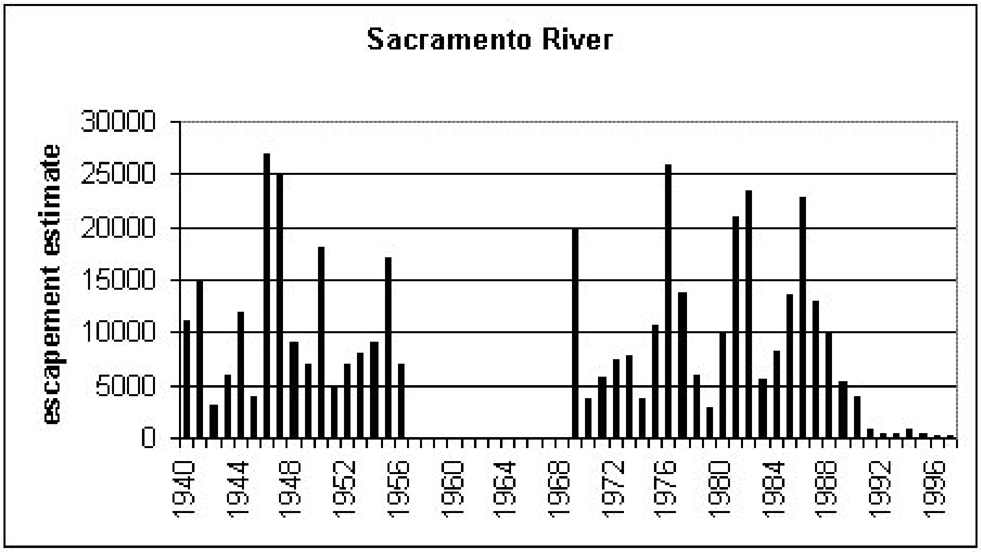


Figure 5–5 Estimated adult spring-run Chinook salmon population abundance in the upper Sacramento River.

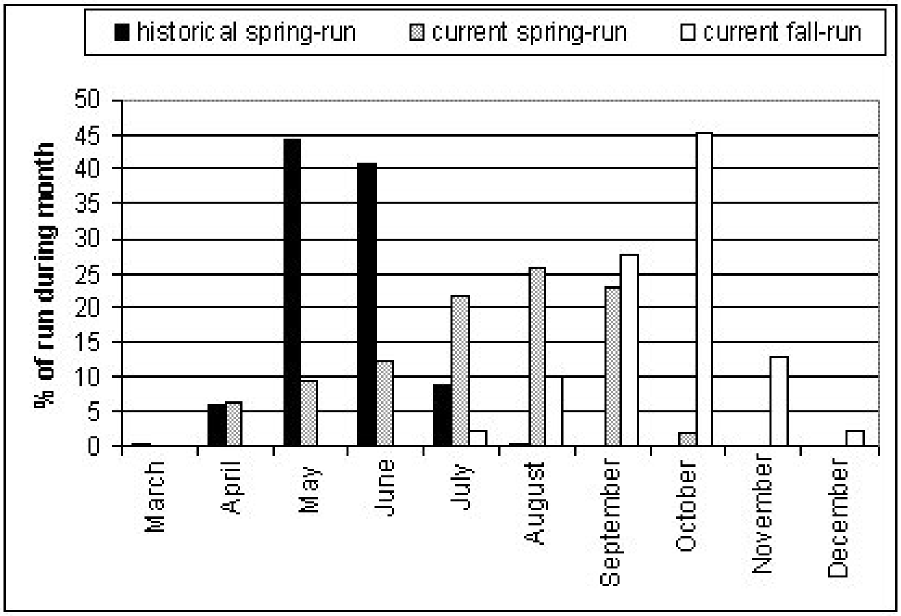


Figure 5–6 Migration timing of spring-run and fall-run Chinook salmon.

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.

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. The varied methods used over the years to estimate population abundance in each tributary left 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 (2-year old) returns, age structure, and sex ratio of returning adults. In estimating CRR, DFG (1998) assumed the following: (1) spawning adults return as 3-year olds; (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 3 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 to 1964 period was about 1,900 fish (geometric mean = 1,717).

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 through 1999 3-year running average escapement, which shows no consistent trend of either increase or decrease (Figure 5–8).

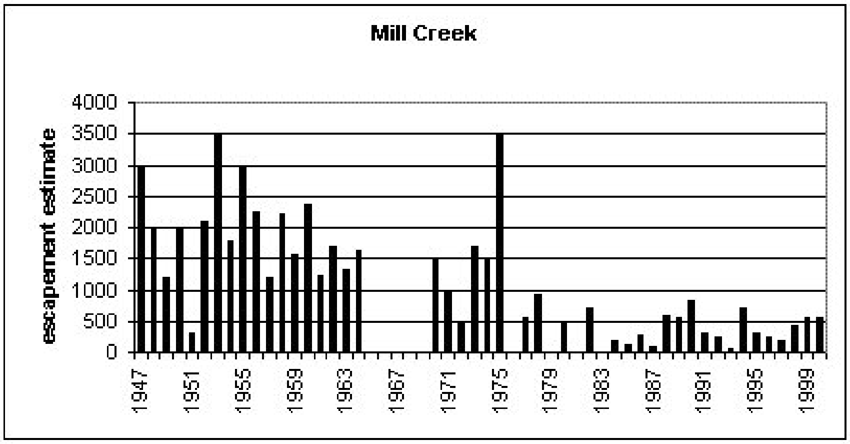


Figure 5–7 Adult spring-run Chinook counts in Mill Creek.

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

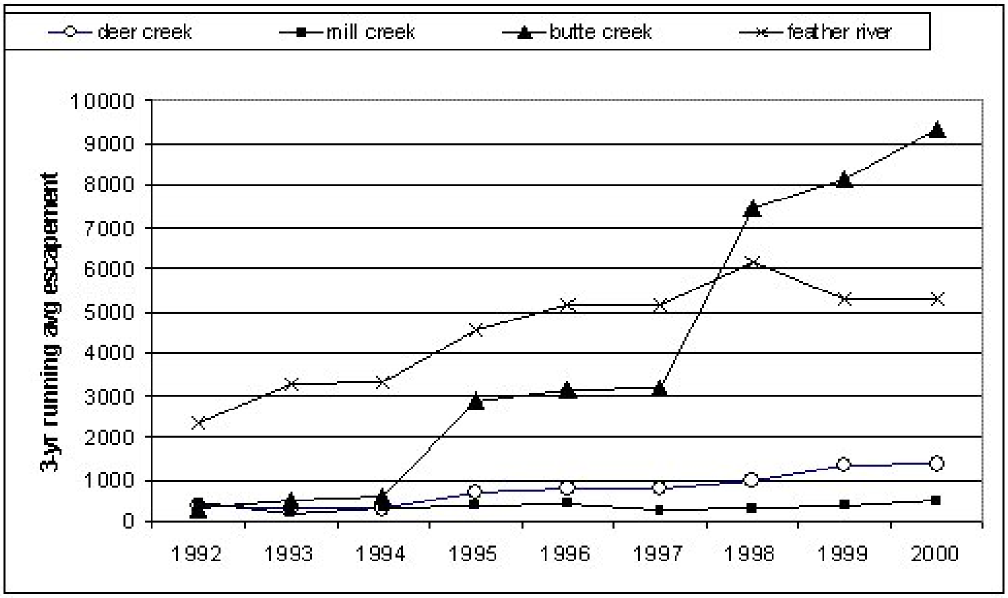


Figure 5–8 Three-year running average abundance of returning adult spring-run Chinook salmon in selected Central Valley streams.

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 6 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 6-mile extension. A fish ladder constructed around Upper Deer Creek Falls allows steelhead passage, but not spring-run passage. Spring-run are excluded because the reach lacks the 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 through 1964 period was about 2,200 fish (geometric mean of 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.

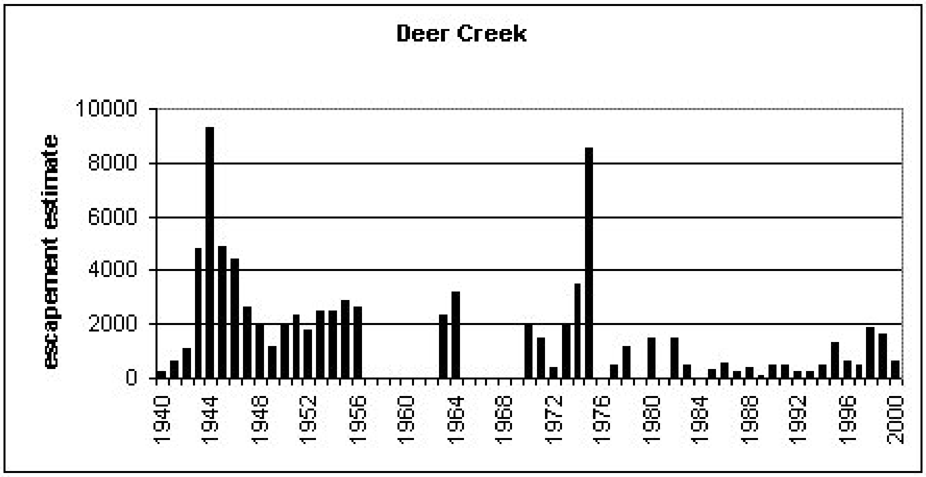


Figure 5–9 Estimated adult spring-run Chinook salmon population abundance in Deer Creek.

The mean Deer Creek CRR was 2.1 during 1990 through 1999, suggesting that, like Mill Creek, the population may be rebounding slightly (Table 5–8). In addition, the geometric mean CRR of 1.7, and the 1990 through 1999 3-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
3	1995	1295/209 = 6.2

Table 5–8 Deer Creek spring-run Chinook salmon CRR

Cohort	BY	CRR
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 historical limit of travel for spring-run salmon and steelhead during most years was a natural barrier (Quartz Bowl Barrier) 1 mile below the PG&E Centerville Head Dam. Recent DFG surveys have only found fish above the Quartz Bowl barrier, 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 through 27, 1954, 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).

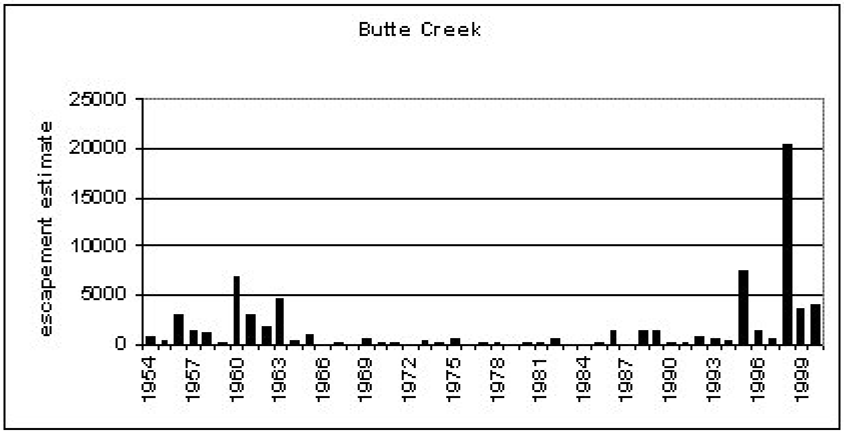


Figure 5–10 Estimated adult spring-run Chinook salmon population abundance in Butte Creek.

The Butte Creek spring-run increased dramatically during the last decade. CRRs have been highly variable, but always greater than 1.0 during the last 7 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 3-year running average escapement for 1990 though 1999 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 affected 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.

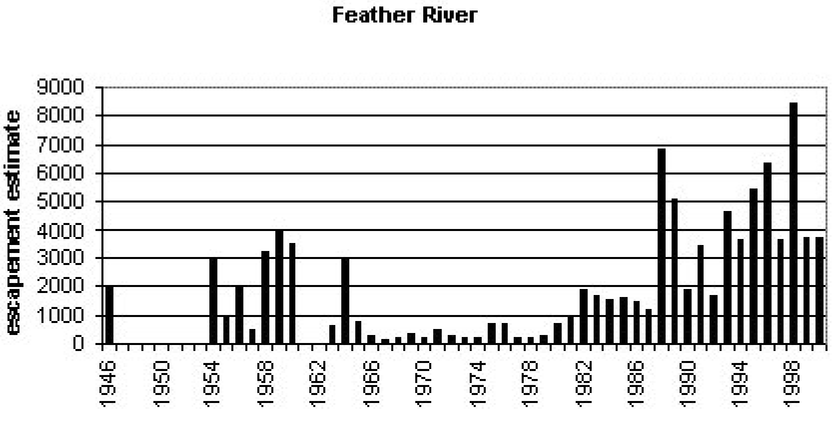


Figure 5–11 Estimated adult spring-run Chinook salmon population abundance in Feather River.

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. The Feather River spring-run Chinook salmon CRR is presented in Table 5-10. 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 (Table 5–10). The 3-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 increased (Figure 5–12 and Figure 5–13). Based on an assessment of Feather River Hatchery (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 spring- and fall-run (Dr. Dennis Hedgecock, presentation at the 1999 Salmon Symposium in Bodega Bay).

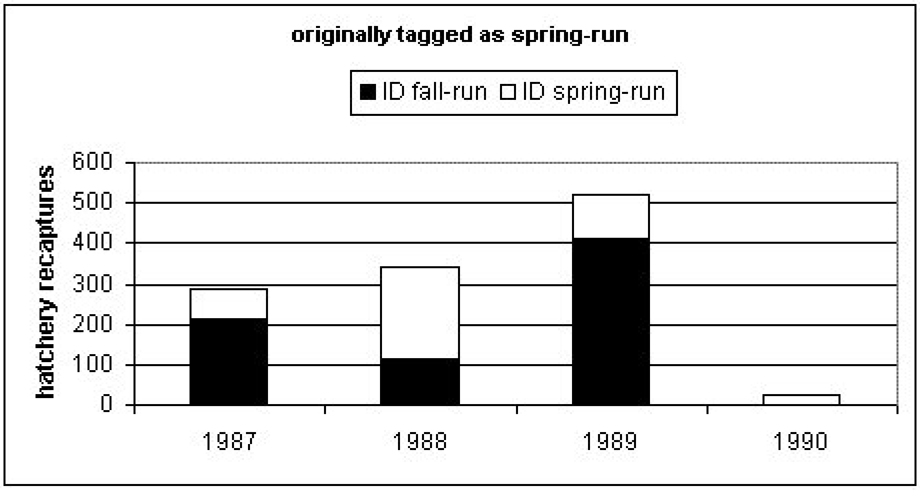


Figure 5–12 The disposition of Chinook salmon spawned, tagged, and released as spring-run from FRH.

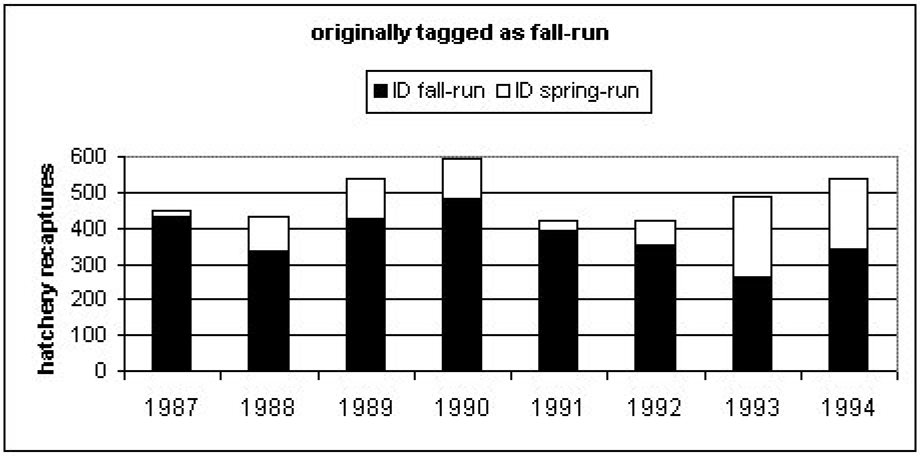


Figure 5–13 The disposition of Chinook salmon spawned, tagged, and released as fall-run from FRH.

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 3-year life cycle in the Trinity River and are dependent on freshwater habitat conditions year round because they spend a full year residing in freshwater. 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 from 35 to more than 100 days depending on water temperature, and emerge from the gravel 2 weeks to 7 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 where 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 2 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 to 18 months in the ocean before returning to their natal streams to spawn as 3- or 4-year olds, age 1.2 or 2.2. Southerly populations are mostly 3-year olds. Some precocious males, called jacks, return to spawn after only 6 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 composed of naturally produced coho from 1991 through 1995 at a point in the river near Willow Creek (FWS 1998). This in part prompted the threatened status listing in 1997. Recapture estimates of coho salmon run size conducted since 1977 had a mean of 15,959 coho from 1977 through 1999 (DFG 2003). These estimates included a combination of hatchery produced and wild coho.

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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 Biological Opinion (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 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 less than 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).

Note: °F = degrees Fahrenheit.

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 (±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.[11]

[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 Jellys 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 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's and Myrick's (1999) data parallels that observed in northern salmon. Northern salmon exhibit maximum growth at 66°F when fed satiation rations. Nimbus Chinook had maximum growth rates at 66°F and lower rates at 59°F and 52°F (Myrick and Cech 2001). The theoretical upper lethal

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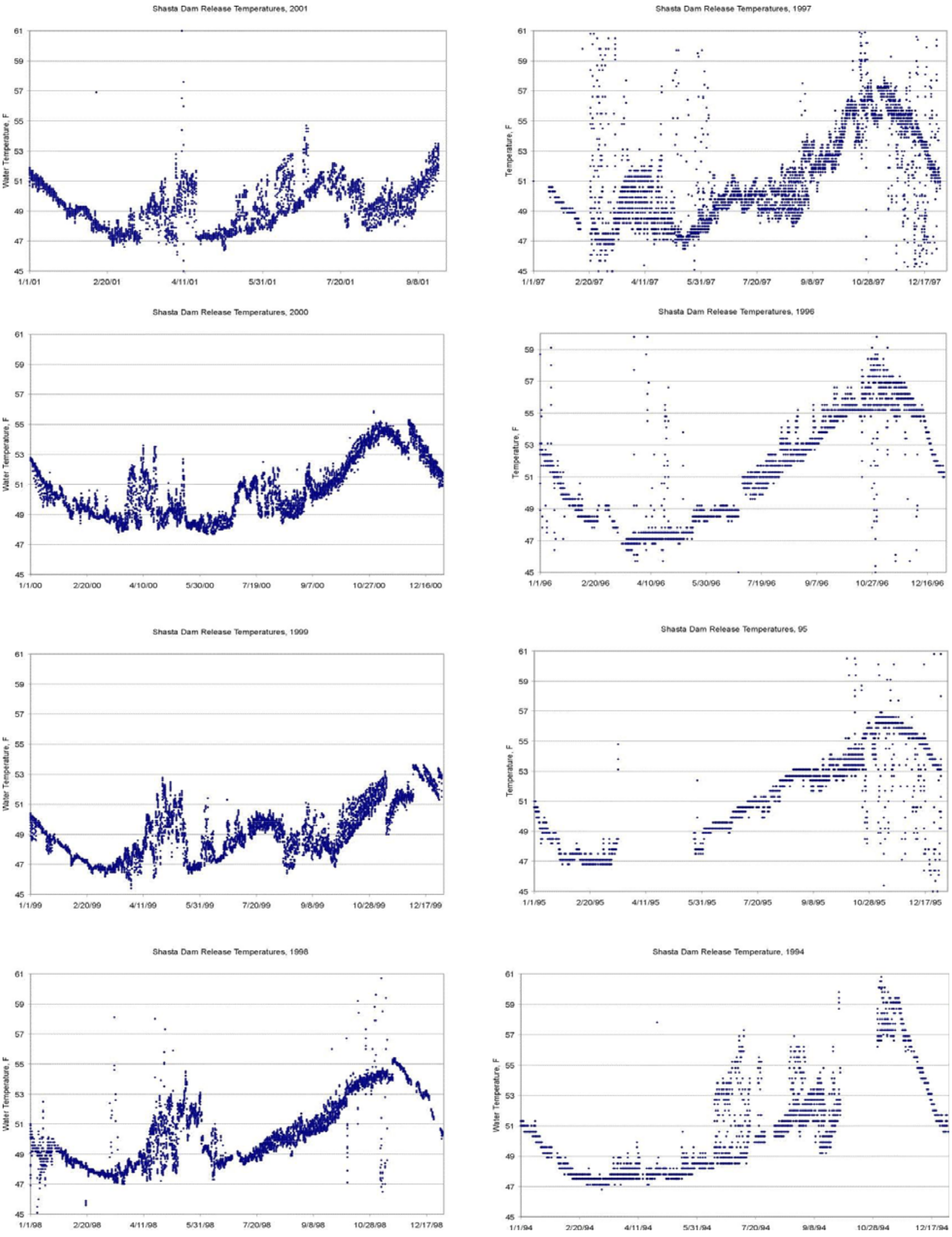
[11] Richardson, T. H., and P. Harrison. 1990. Fish and Wildlife Impacts of Shasta Dam Water Temperature Control Alternatives. Prepared for Reclamation, Sacramento, California. FWS--Fish and Wildlife Enhancement, Sacramento, California.



Shasta Dam Release Temperatures, 2001

Shasta Dam Release Temperatures, 1997

Shasta Dam Release Temperatures, 2000

Shasta Dam Release Temperatures, 1996

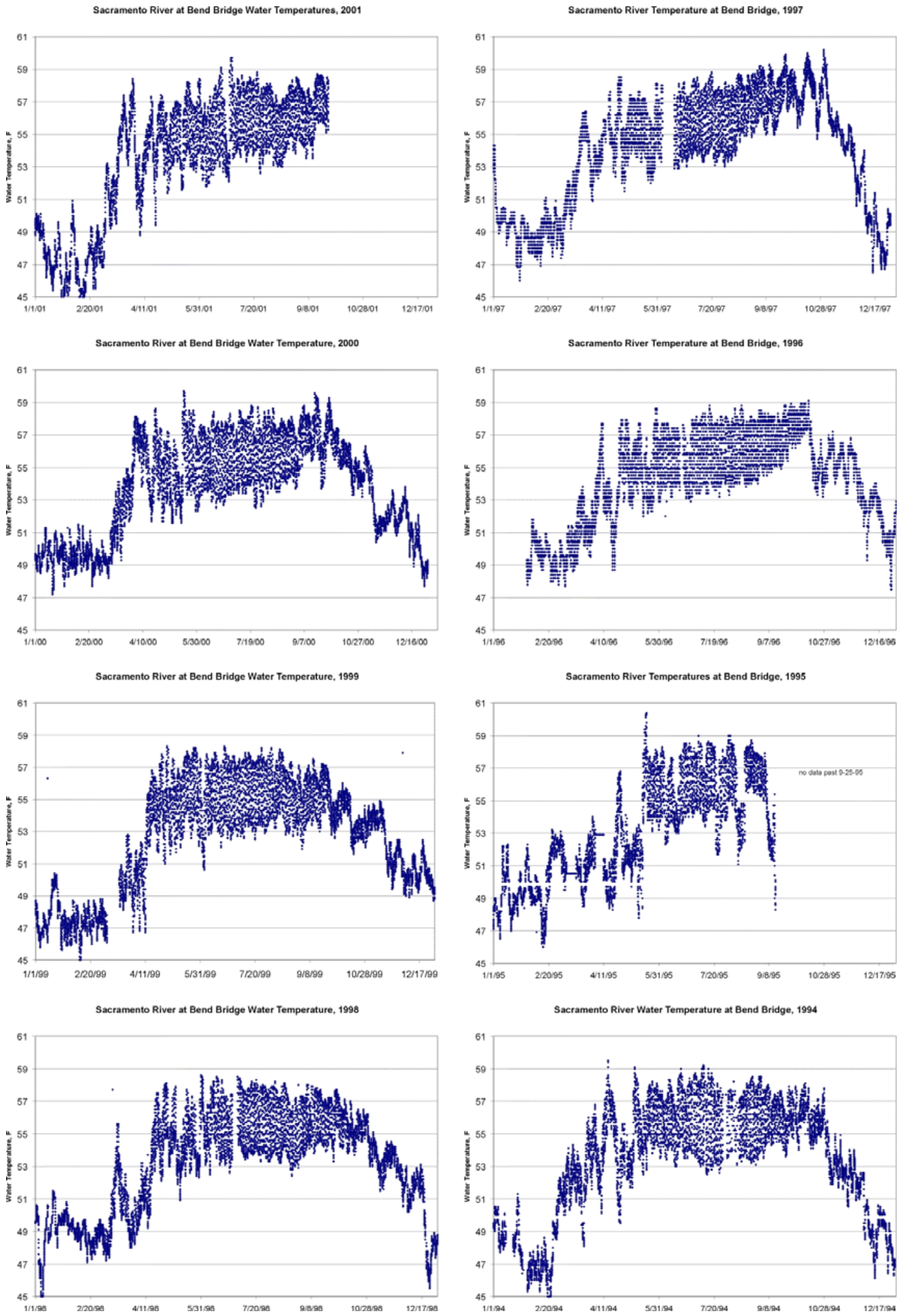
Shasta Dam Release Temperatures, 1999

Shasta Dam Release Temperatures, 95

Shasta Dam Release Temperatures, 1998

Shasta Dam Release Temperature, 1994

Figure 6–1 Shasta Dam Release Temperatures 1994–2001.


Sacramento River at Bend Bridge Water Temperatures, 2001

Sacramento River Temperature at Bend Bridge, 1997

Sacramento River at Bend Bridge Water Temperature, 2000

Sacramento River Temperature at Bend Bridge, 1996

Sacramento River at Bend Bridge Water Temperature, 1999

Sacramento River Temperatures at Bend Bridge, 1995

Sacramento River at Bend Bridge Water Temperature, 1998

Sacramento River Water Temperature at Bend Bridge, 1994

Figure 6–2 Sacramento River at Bend Bridge Water Temperatures 1994–2001.

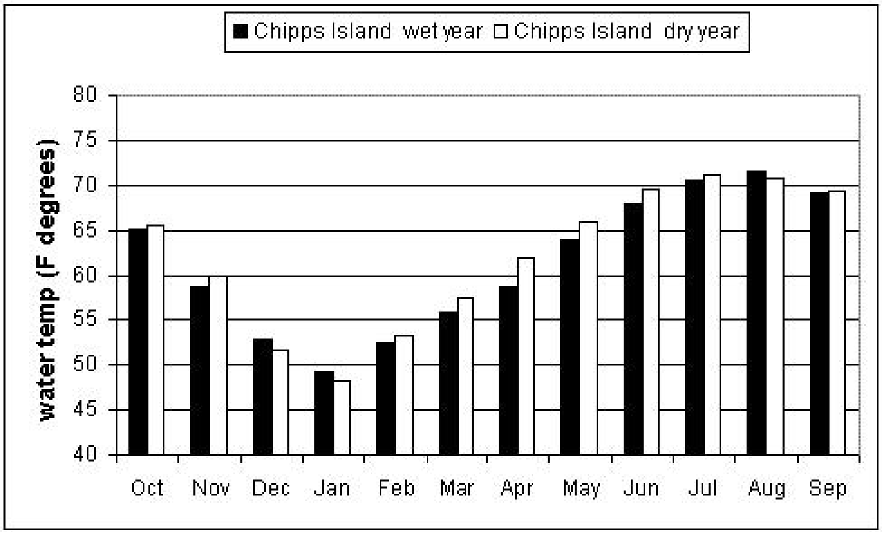
temperature that Sacramento River Chinook salmon can tolerate has been reported as 78.5°F (Orsi 1971, as cited in Boles et al. 1988). However, this result must be interpreted with several things in mind.

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 (lethal time for 50% mortality). This means it is a temperature that can only be tolerated for a short period. 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 because 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 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 U.S. Fish and Wildlife Service (FWS) paired Delta release experiments. Newman's analysis indicated smolt survival would decrease by 40 percent as temperatures rose from 58 to 76°F. This result indicates 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 6–3 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

The FWS (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 usable spawning area peaked at around 10,000 cubic feet per second (cfs) in the upstream reach above the Anderson-Cottonwood Irrigation District (ACID) Dam when the dam boards are in. With the boards out, the peak was around 4,000 to 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 versus 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 Feather River Hatchery (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 7,000 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.

Clear Creek

Sampling was conducted in Clear Creek at the U.S. Geological Survey (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 millimeters (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 are not affected by Reclamation water release operations. Reclamation does not make releases into 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 shown in Figure 6–4. Instantaneous flows of 3,000 cfs occur on average about once every 2 years and flows of 4,000 cfs occur about once every 3 years (Figure 6–5). One-day average flows of 3,000 cfs occur about once every 5 years.

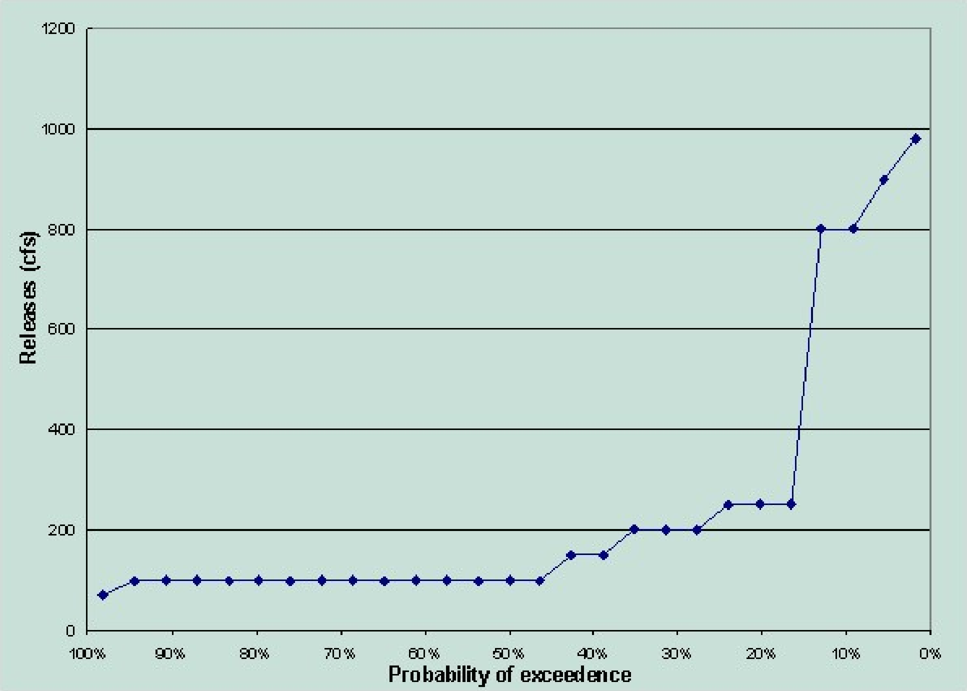


Figure 6–4 Yearly probability of exceedance for releases from Whiskeytown Dam on Clear Creek.

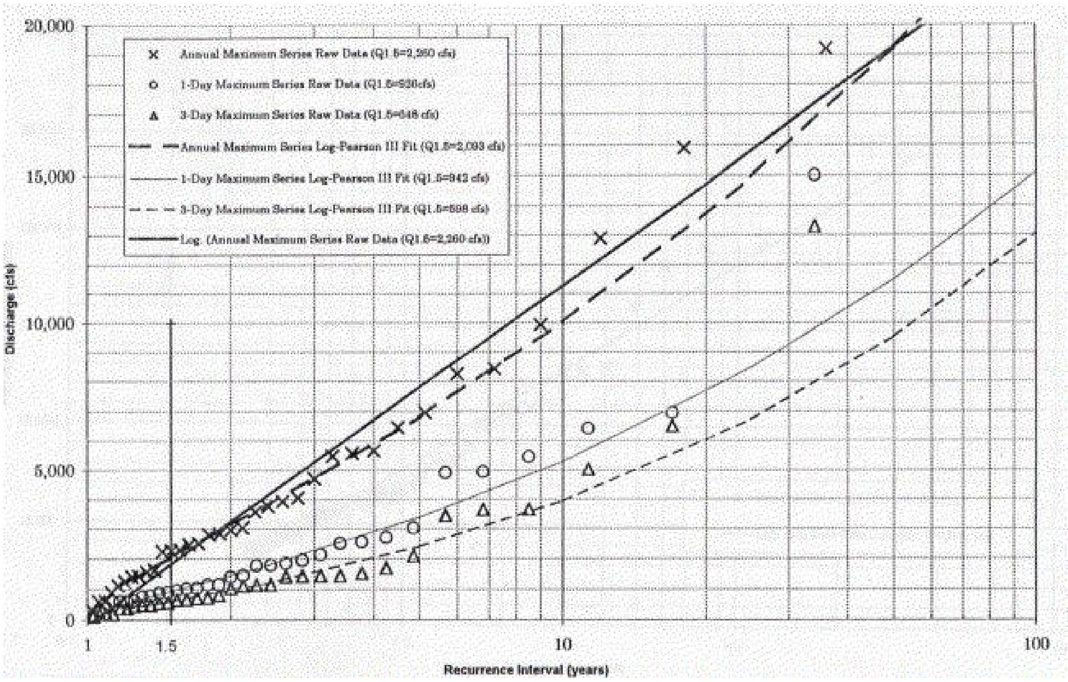


Figure 6–5 Clear Creek near Igo (Station 11-372000) flood frequency analysis of annual maximum, 1-day average, and 3-day average flood series for post-dam (1964–97) data.

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 and 25,000 cfs between River Miles 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 is approximately 50 percent each year and flows in the 40,000 to 50,000 cfs range occur in about 30 to 40 percent of years (Figure 6–6). Therefore, in about 30 to 40 percent of years some redds could potentially be scoured when flows over 50,000 cfs occur while 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 are probably not very significant. On the Sacramento River, the 2-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).

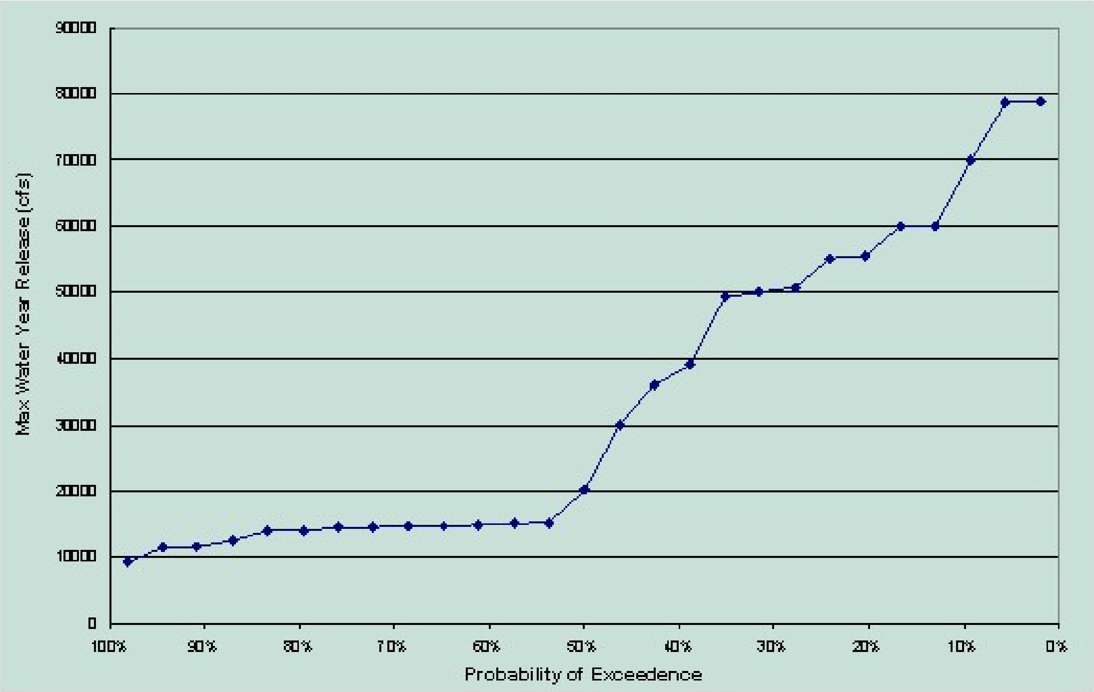


Figure 6–6 Yearly probability of exceedance for releases from Keswick Dam on the Sacramento River.

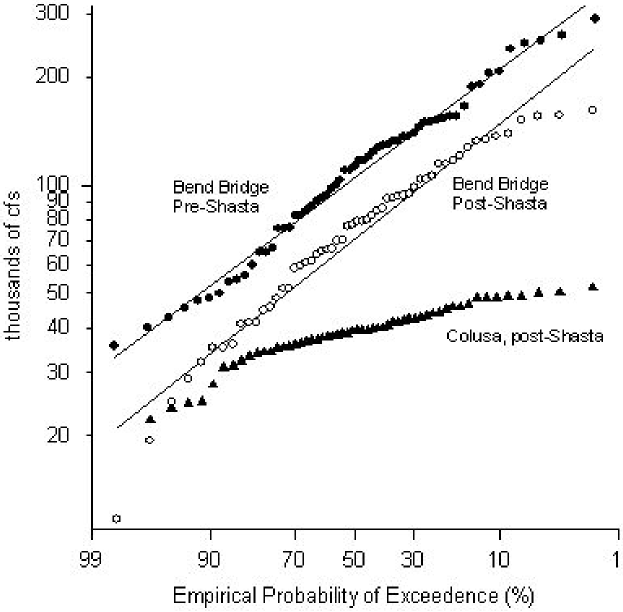


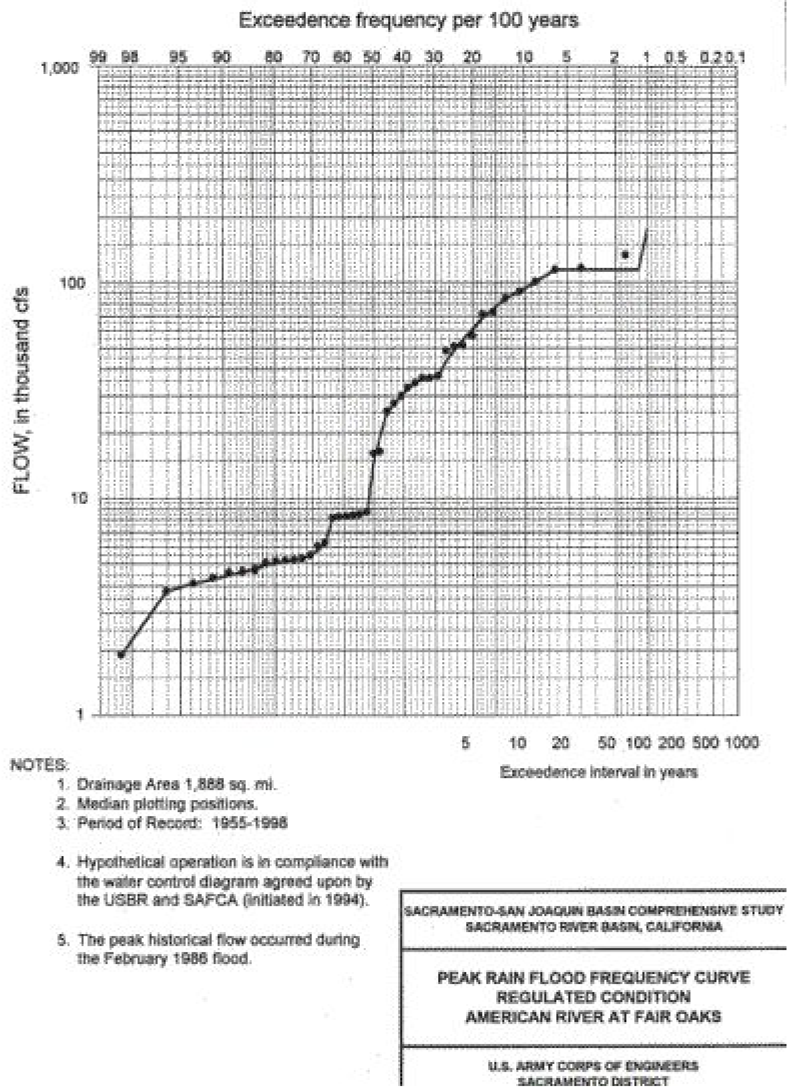
Figure 6–7 Empirical flood frequency plots for the Sacramento River at Red Bluff (Bend Bridge gauge) for pre- and post-Shasta periods, and downstream at Colusa for the post-Shasta period.

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 2-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 4 years and exceed 50,000 cfs about once every 5 years (Figure 6–8). Fair Oaks gauge flows result almost entirely from Folsom and Nimbus releases.



NOTES:

1. Drainage Area 1,888 sq. mi.
2. Median plotting positions.
3. Period of Record: 1955-1998
4. Hypothetical operation is in compliance with the water control diagram agreed upon by the USBR and SAFCA (initiated in 1994).
5. The peak historical flow occurred during the February 1986 flood.

SACRAMENTO-SAN JOAQUIN BASIN COMPREHENSIVE STUDY
SACRAMENTO RIVER BASIN, CALIFORNIA

PEAK RAIN FLOOD FREQUENCY CURVE
REGULATED CONDITION
AMERICAN RIVER AT FAIR OAKS

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

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 5-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 January 3, 1997). The probability of occurrence for a daily average flow exceeding 5,330 cfs (the pre-dam bankfull discharge) is 0.01, or 1 year in 100. Figure 6–9 shows the yearly exceedance probability for Goodwin Dam releases.

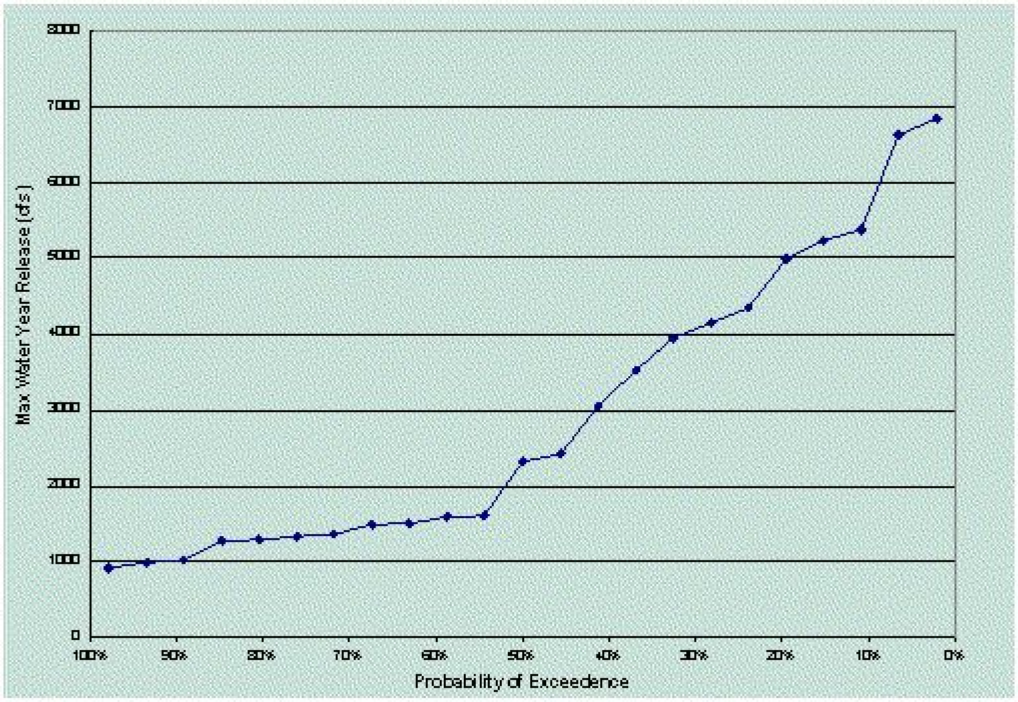


Figure 6–9 Exceedance probability for yearly Goodwin Dam releases.

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. Using the 5-inch redd depth as the threshold for redd dewatering, a 100-cfs flow drop 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
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 drying 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 were 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

Table 6–4 Stage discharge relationship in the Sacramento River at Bend Bridge, gauge 11377100.

Stage, inches	Discharge, cfs
31	7990
34	8500
38	9000
41	9510
45	10000
48	10500
52	11000
55	11500
59	12000
62	12500
65	13000
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

Table 6–4 Stage discharge relationship in the Sacramento River at Bend Bridge, gauge 11377100.

Stage, inches	Discharge, cfs
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 recommendations for operations of the Folsom project.

- Ramping rates should not exceed 100 cfs per hour when flows are less than 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 through December for Chinook salmon and December through 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 shows the number of times by month that flow was raised above 4,000 cfs and then dropped back below 4,000 over a 20 year period. The annually maximum daily Nimbus release exceedance is shown in Figure 6–11.

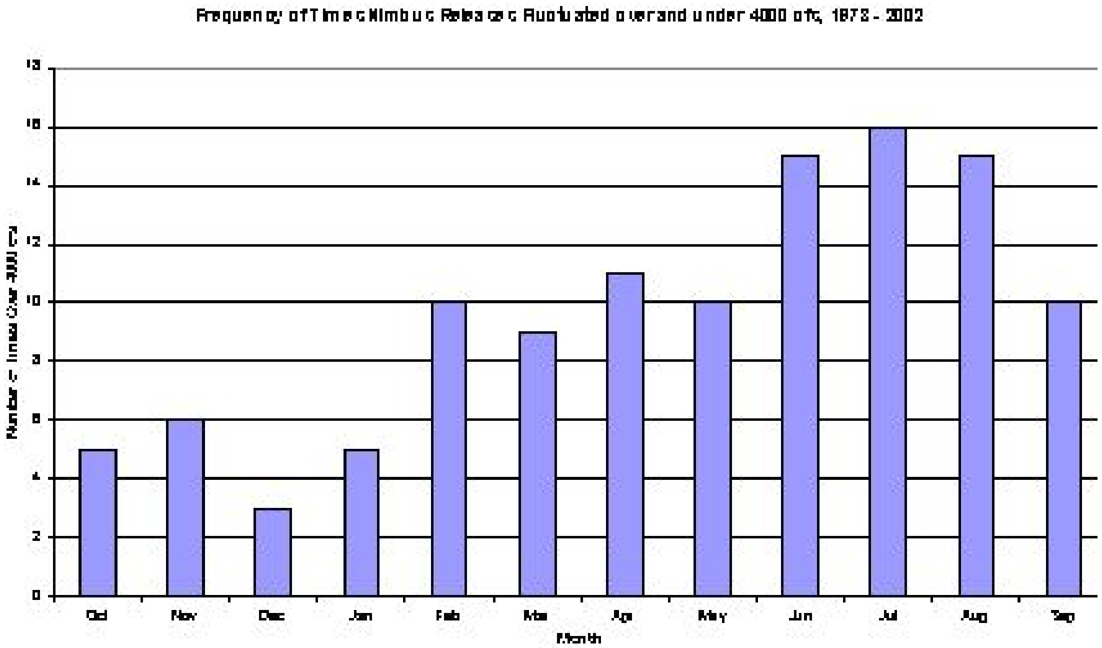


Figure 6–10 Frequency of times Nimbus releases fluctuated over and under 4000 cfs, 1972-2002.

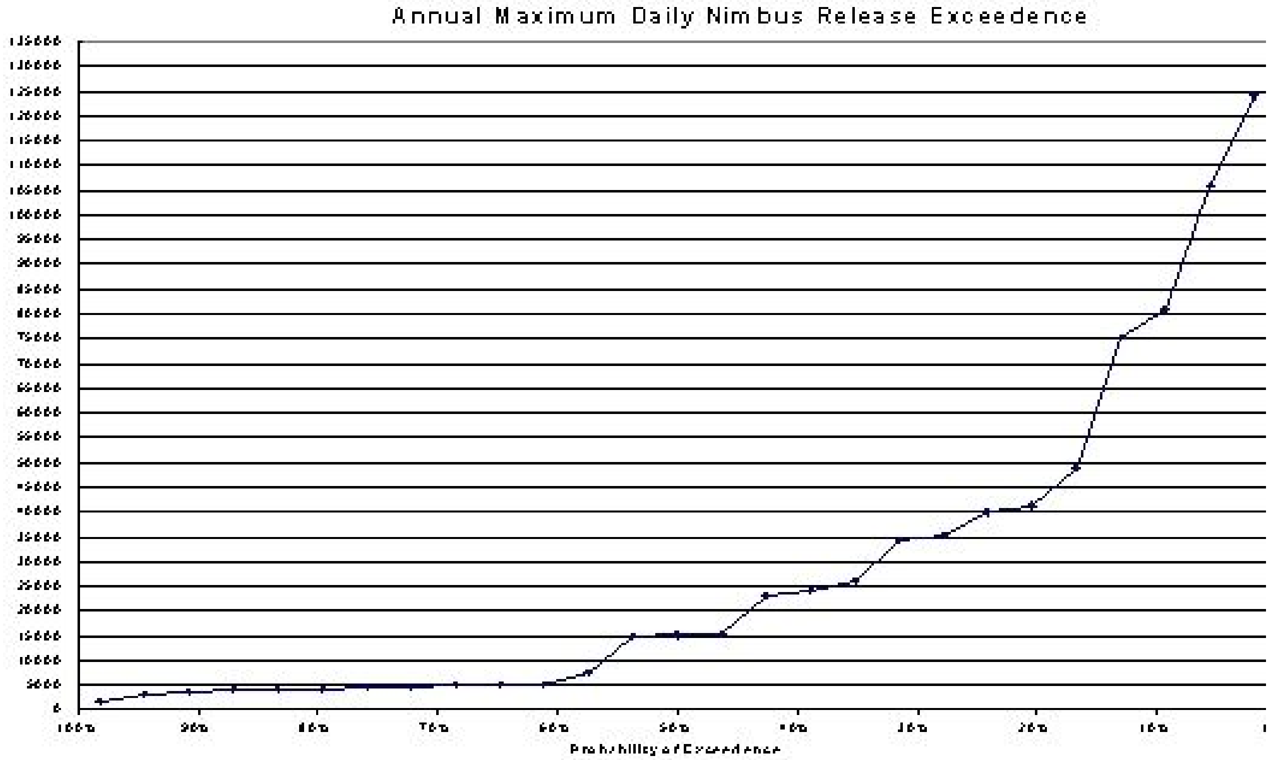


Figure 6–11 Annual Maximum Daily Nimbus Release Exceedance.

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
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 subadult 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 4-5). Winter-run and spring-run have been cutoff 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 that required a substantial reduction in Keswick Reservoir releases to adjust the dam flashboards, which resulted in dewatered redds, stranded juveniles, and higher water temperatures. Reclamation assisted in the redesign and renovation of the flashboards and related facilities in the 1990s to reduce the risks of dewatering redds. Fish ladders and fish screens were installed around the diversion and were operated starting in the summer 2001 diversion period. During the spawning runs in 2001 and 2002, spawning upstream of the diversion dam substantially increased, which was attributable to the access provided by the fish ladders (Table 5-5 winter-run redd chart).

Red Bluff Diversion Dam

Problems in salmonid passage at Red Bluff Diversion Dam (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 4). 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 round (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 to 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

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
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 Environmental Impact Statement (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 because DFG staff estimates that 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 multiagency DCC 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 from 3-48 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 2 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, 6-foot-tall flashboards and creating two, 3-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 three phases 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 2001-2002 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 3 years, from 2001-2003. See “Suisun Marsh Salinity Control Gates” in Chapter 10 for more information.

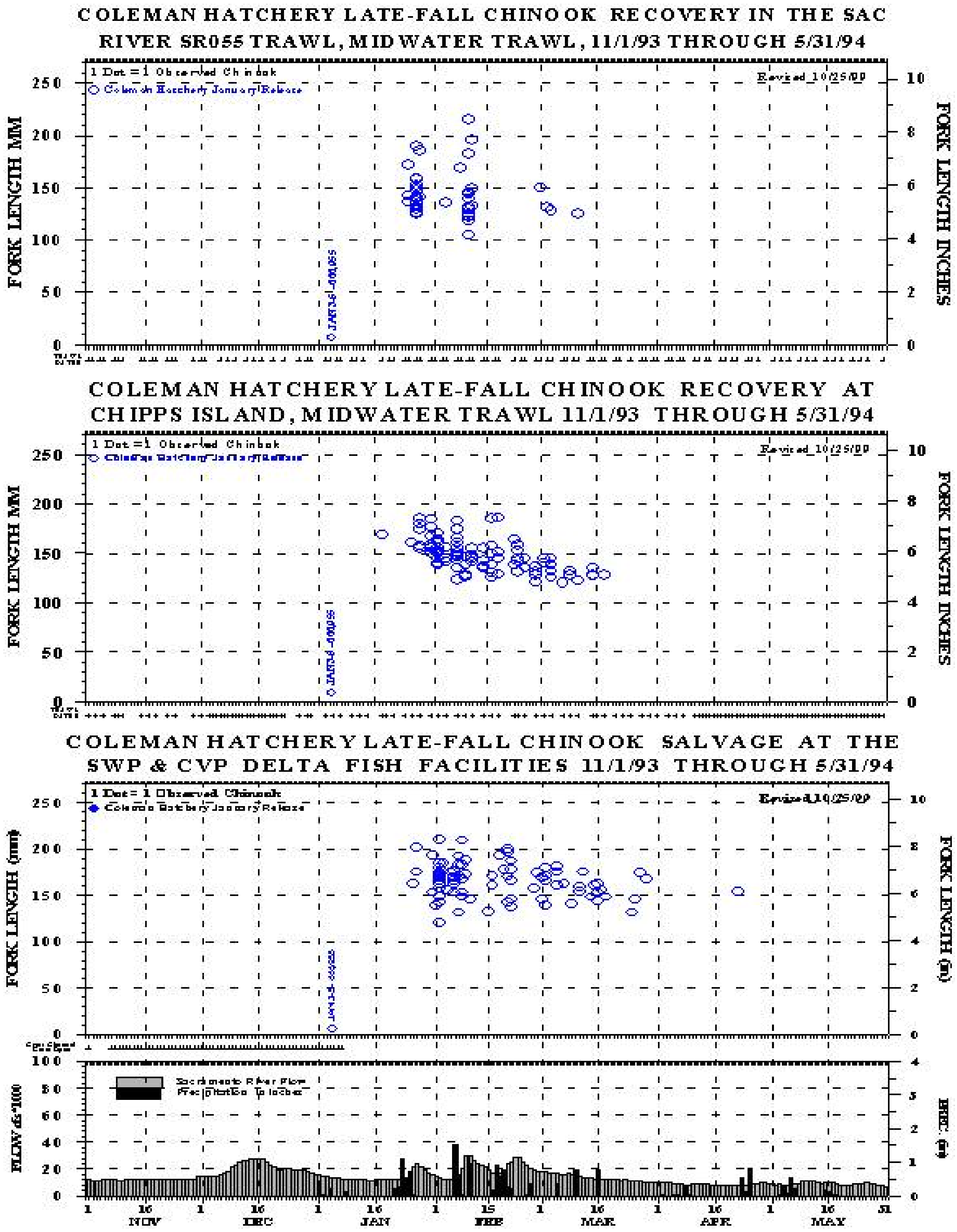
Delta Emigration

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 to 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 (GCID) facility within 2 or 3 days of release. However, they were not captured downstream in the lower Sacramento River or the Delta, until about 3 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 Central Valley Project's (CVP) and State Water Project's (SWP) Delta export facilities, some individuals may continue to emigrate for up to 5 months.

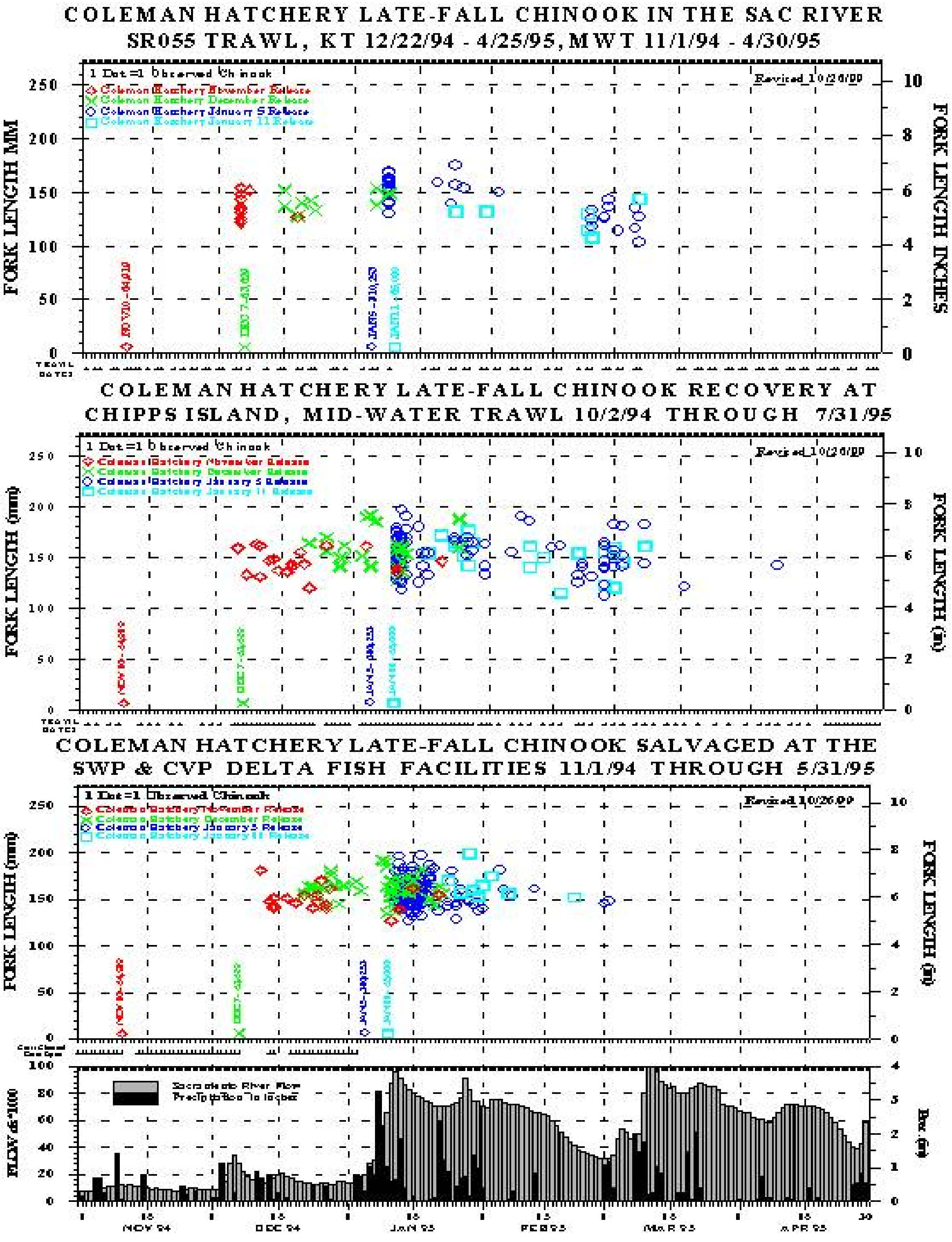
The Coleman late-fall Chinook released in December (Figure 6–12 through Figure 6–20) were released after the first significant, precipitation-induced flow event in the fall. However, they were not captured in the Delta until after a second significant precipitation event occurred unless there was significant 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 4 months.


COLEMAN HATCHERY LATE-FALL CHINOOK RECOVERY IN THE SAC RIVER SR055 TRAWL, MIDWATER TRAWL, 11/1/93 THROUGH 5/31/94

COLEMAN HATCHERY LATE-FALL CHINOOK RECOVERY AT CHIPPS ISLAND, MIDWATER TRAWL 11/1/93 THROUGH 5/31/94

COLEMAN HATCHERY LATE-FALL CHINOOK SALVAGE AT THE SWP & CVP DELTA FISH FACILITIES 11/1/93 THROUGH 5/31/94

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.

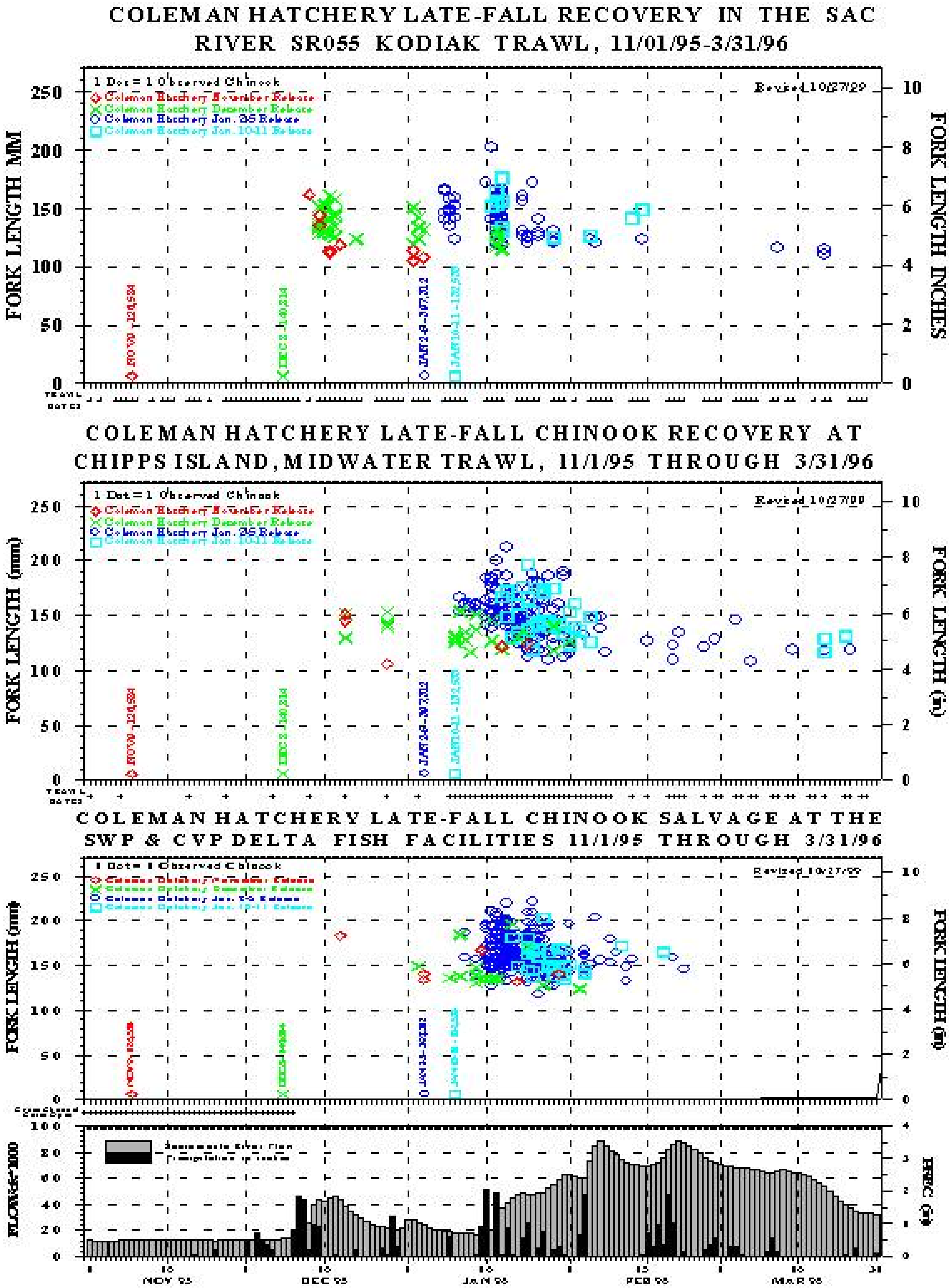


COLEMAN HATCHERY LATE-FALL CHINOOK IN THE SAC RIVER
SR055 TRAWL, KT 12/22/94 - 4/25/95, MWT 11/1/94 - 4/30/95

COLEMAN HATCHERY LATE-FALL CHINOOK RECOVERY AT CHIPPS ISLAND, MID-WATER TRAWL 10/2/94 THROUGH 7/31/95

COLEMAN HATCHERY LATE-FALL CHINOOK SALVAGED AT THE SWP & CVP DELTA FISH FACILITIES 11/1/94 THROUGH 5/31/95

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.

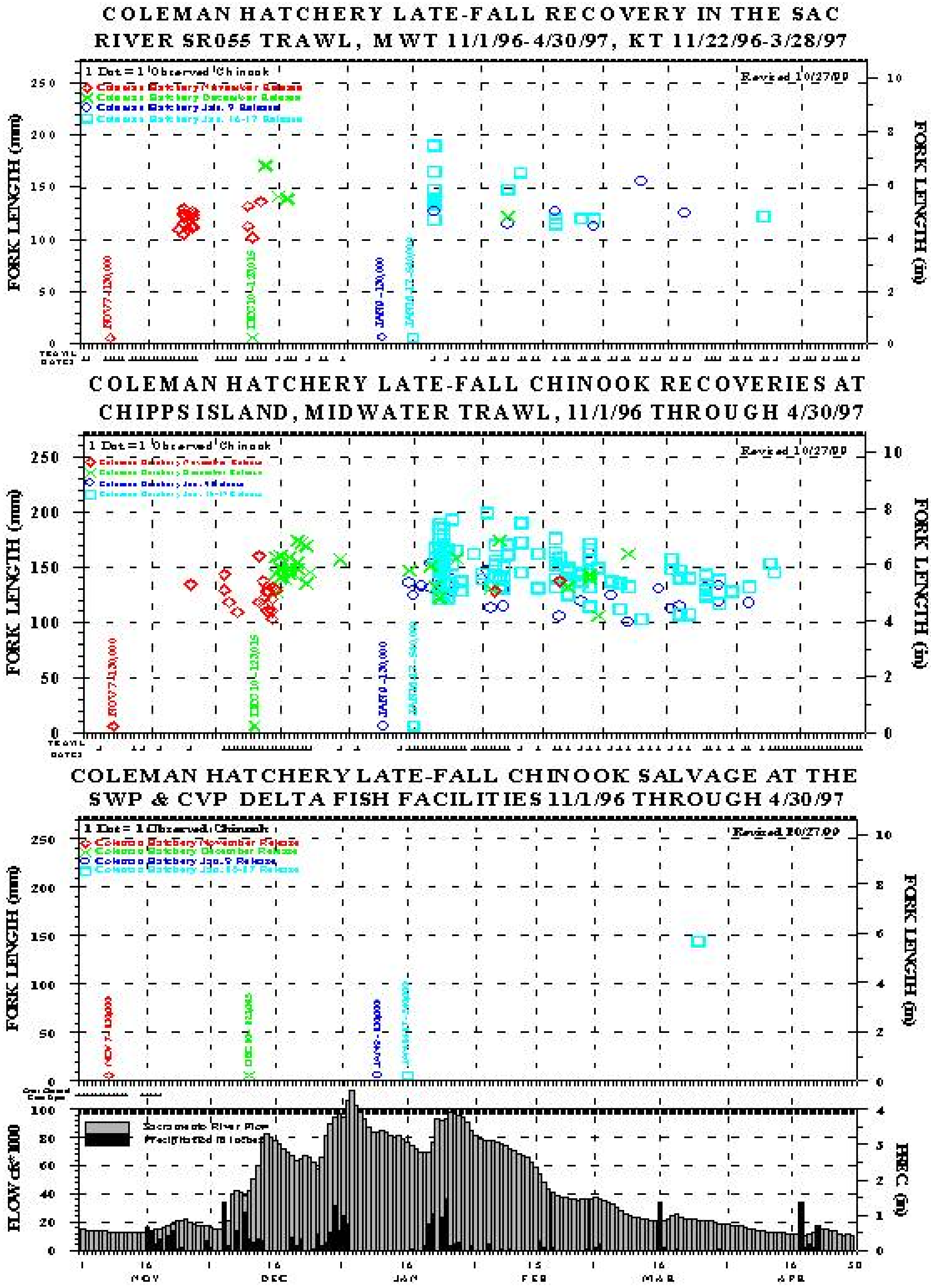


COLEMAN HATCHERY LATE-FALL RECOVERY IN THE SAC RIVER SR055 KODIAK TRAWL, 11/01/95-3/31/96

COLEMAN HATCHERY LATE-FALL CHINOOK RECOVERY AT CHIPPS ISLAND, MIDWATER TRAWL, 11/1/95 THROUGH 3/31/96

COLEMAN HATCHERY LATE-FALL CHINOOK SALVAGE AT THE SWP & CVP DELTA FISH FACILITIES 11/1/95 THROUGH 3/31/96

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.

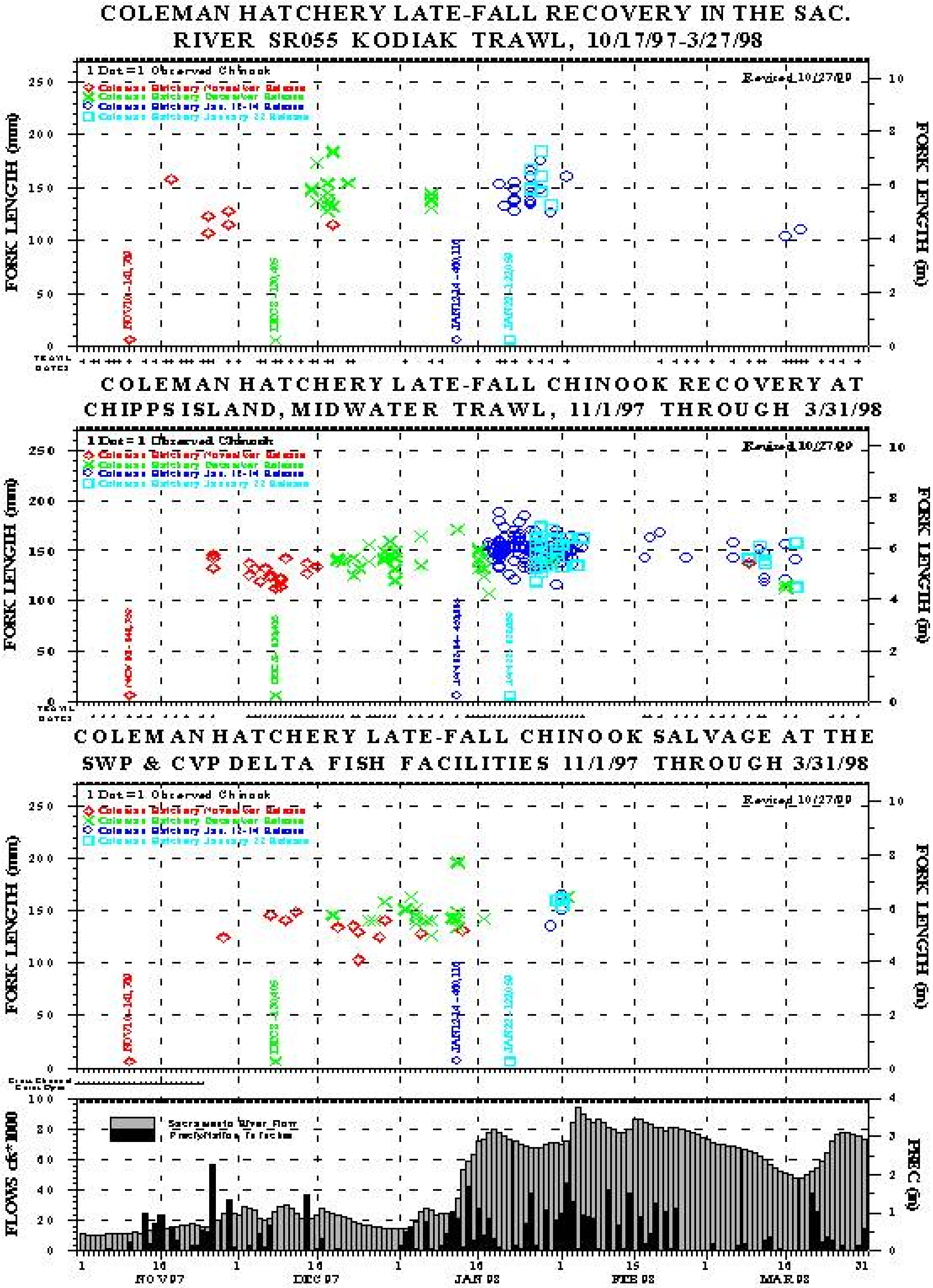


COLEMAN HATCHERY LATE-FALL RECOVERY IN THE SAC RIVER SR055 TRAWL, MWT 11/1/96-4/30/97, KT 11/22/96-3/28/97

COLEMAN HATCHERY LATE-FALL CHINOOK RECOVERIES AT CHIPPS ISLAND, MIDWATER TRAWL, 11/1/96 THROUGH 4/30/97

COLEMAN HATCHERY LATE-FALL CHINOOK SALVAGE AT THE SWP & CVP DELTA FISH FACILITIES 11/1/96 THROUGH 4/30/97

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.

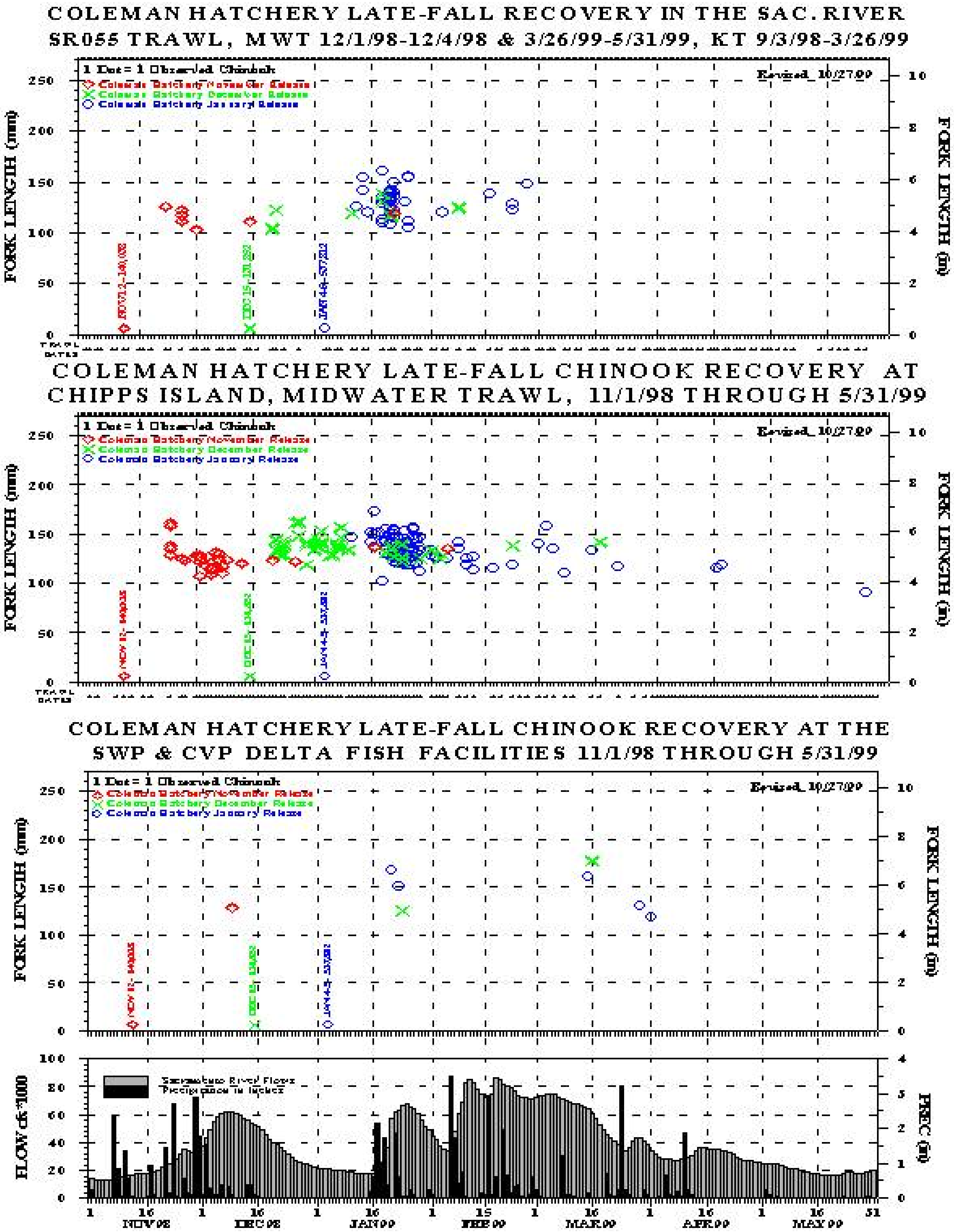


COLEMAN HATCHERY LATE-FALL RECOVERY IN THE SAC. RIVER SR055 KODIAK TRAWL, 10/17/97-3/27/98

COLEMAN HATCHERY LATE-FALL CHINOOK RECOVERY AT CHIPPS ISLAND, MIDWATER TRAWL, 11/1/97 THROUGH 3/31/98

COLEMAN HATCHERY LATE-FALL CHINOOK SALVAGE AT THE SWP & CVP DELTA FISH FACILITIES 11/1/97 THROUGH 3/31/98

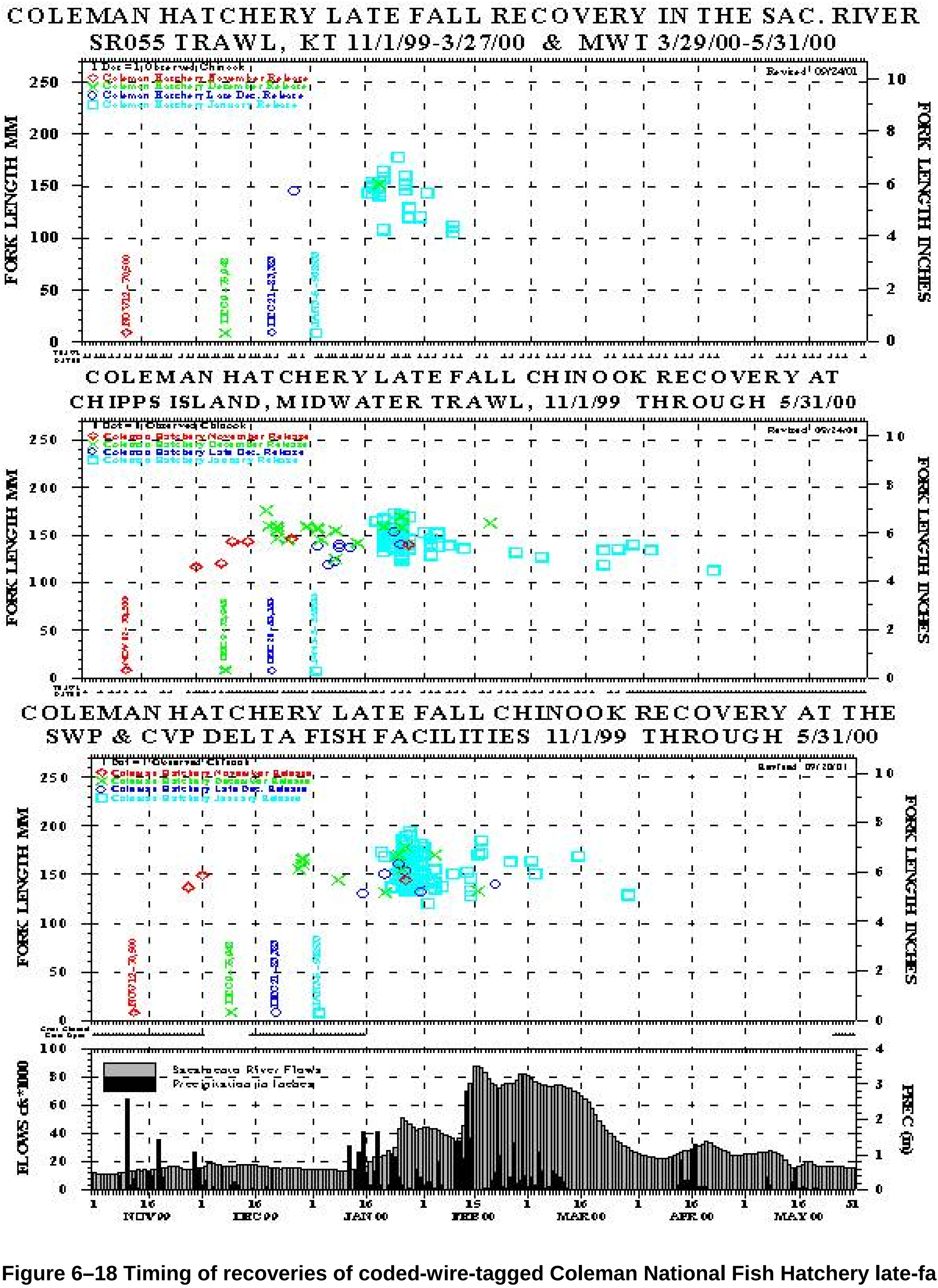
Figure 6–16 Timing of recoveries of coded-wire-tagged Coleman National Fish Hatchery late-fall-run Chinook salmon smolts, Sacramento River flow at Freeport, and precipitation at Red Bluff Airport, winter 1997–1998.


COLEMAN HATCHERY LATE-FALL RECOVERY IN THE SAC. RIVER
SR055 TRAWL, MWT 12/1/98-12/4/98 & 3/26/99-5/31/99, KT 9/3/98-3/26/99

COLEMAN HATCHERY LATE-FALL CHINOOK RECOVERY AT CHIPPS ISLAND, MIDWATER TRAWL, 11/1/98 THROUGH 5/31/99

COLEMAN HATCHERY LATE-FALL CHINOOK RECOVERY AT THE SWP & CVP DELTA FISH FACILITIES 11/1/98 THROUGH 5/31/99

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.



COLEMAN HATCHERY LATE FALL RECOVERY IN THE SAC. RIVER SR055 TRAWL, KT 11/1/99-3/27/00 & MWT 3/29/00-5/31/00

COLEMAN HATCHERY LATE FALL CHINOOK RECOVERY AT CHIPPS ISLAND, MIDWATER TRAWL, 11/1/99 THROUGH 5/31/00

COLEMAN HATCHERY LATE FALL CHINOOK RECOVERY AT THE SWP & CVP DELTA FISH FACILITIES 11/1/99 THROUGH 5/31/00

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.

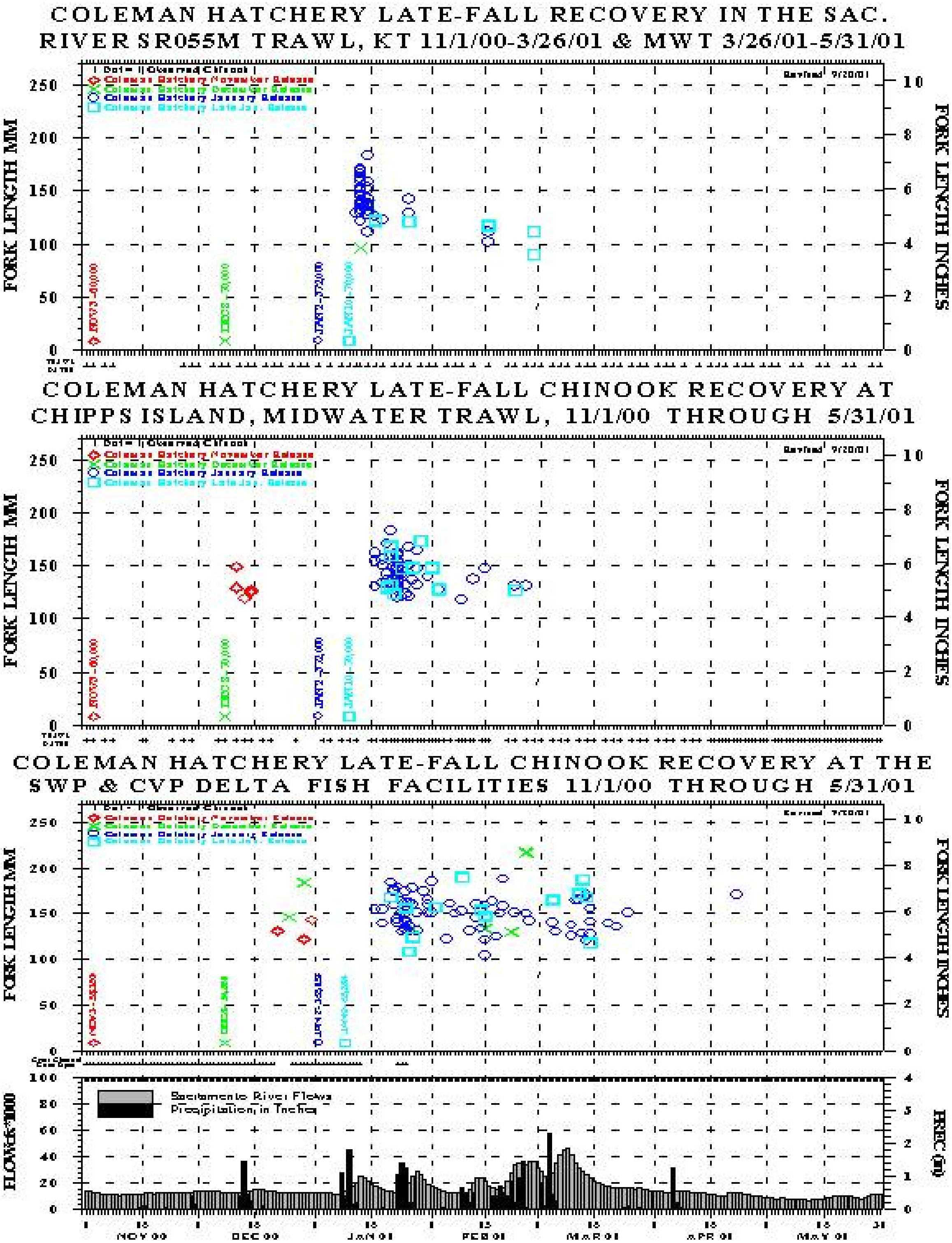


Figure 6–19 Timing of recoveries of coded-wire-tagged Coleman National Fish Hatchery late-fall-run Chinook salmon smolts, Sacramento River flow at Freeport, and precipitation at Red Bluff Airport, winter 2000–2001.

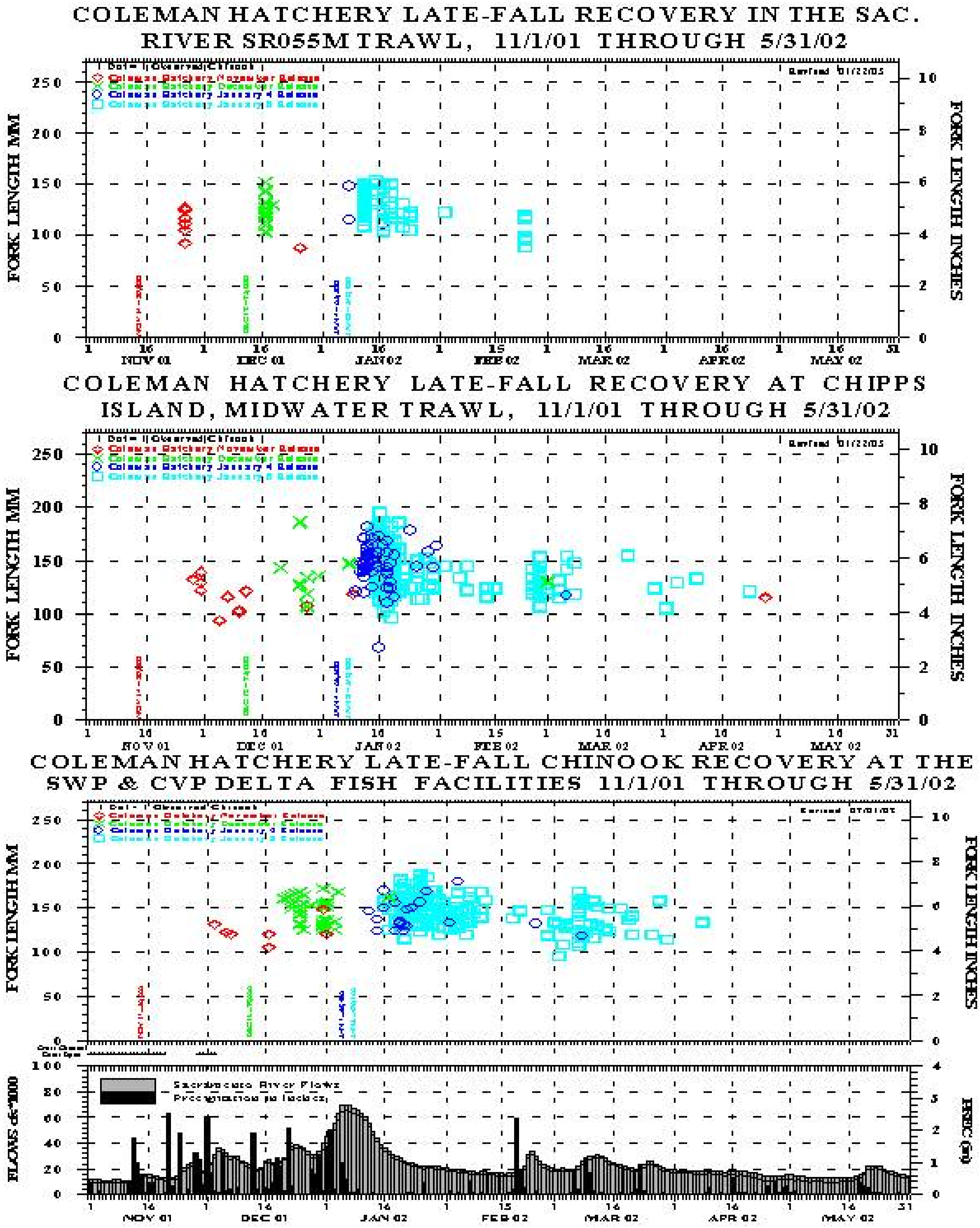


Figure 6–20 Timing of recoveries of coded-wire-tagged Coleman National Fish Hatchery late-fall-run Chinook salmon smolts, Sacramento River flow at Freeport, and precipitation at Red Bluff Airport, winter 2001–2002.

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 4 months.

Because 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.

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)

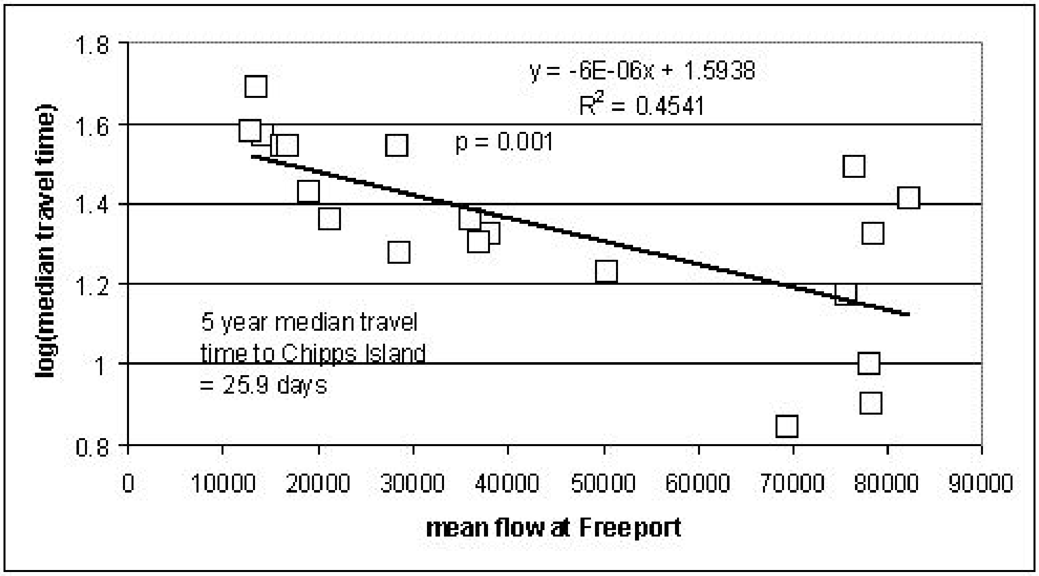


Figure 6–21 Relationship between mean flow (cfs) in the Sacramento River and the log10 time to recapture in the FWS Chipps Island Trawl for Coleman Hatchery late-fall-run Chinook salmon smolts. The explanatory variable is mean flow at Freeport for 30 days beginning with the day of release from Coleman 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 prespawning mortality, fecundity, egg-to-fry survival, and survival to the Delta (Table 6–7). Figure 6–22 shows Winter-run and older juvenile Chinook loss at Delta fish facilities, October 2001-May 2002.

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

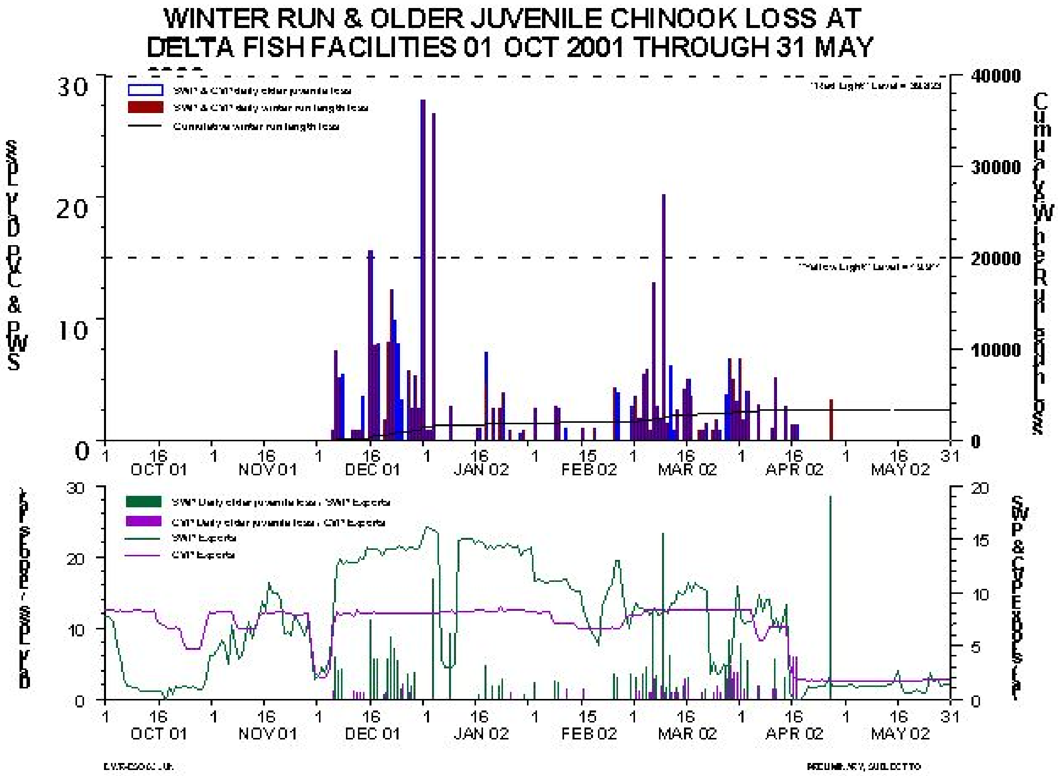


Figure 6–22 Winter-run and older juvenile Chinook loss at Delta fish facilities, October 2001-May 2002.

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 a 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 toward the Pacific Ocean, they encounter numerous junctions in the river and Delta channels. Two such junctions are located near Walnut Grove at the Delta Cross Channel (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 caused by 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, Table 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 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. 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, 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

Table 6–8 Total Chinook salmon salvage (all sizes combined) by year at the SWP and CVP salvage facilities.

Year	SWP	CVP	Total
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

Table 6–10 Average Chinook salmon salvage (all sizes and marks combined) by facility, 1993 - 2002.

Month	SWP	CVP
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

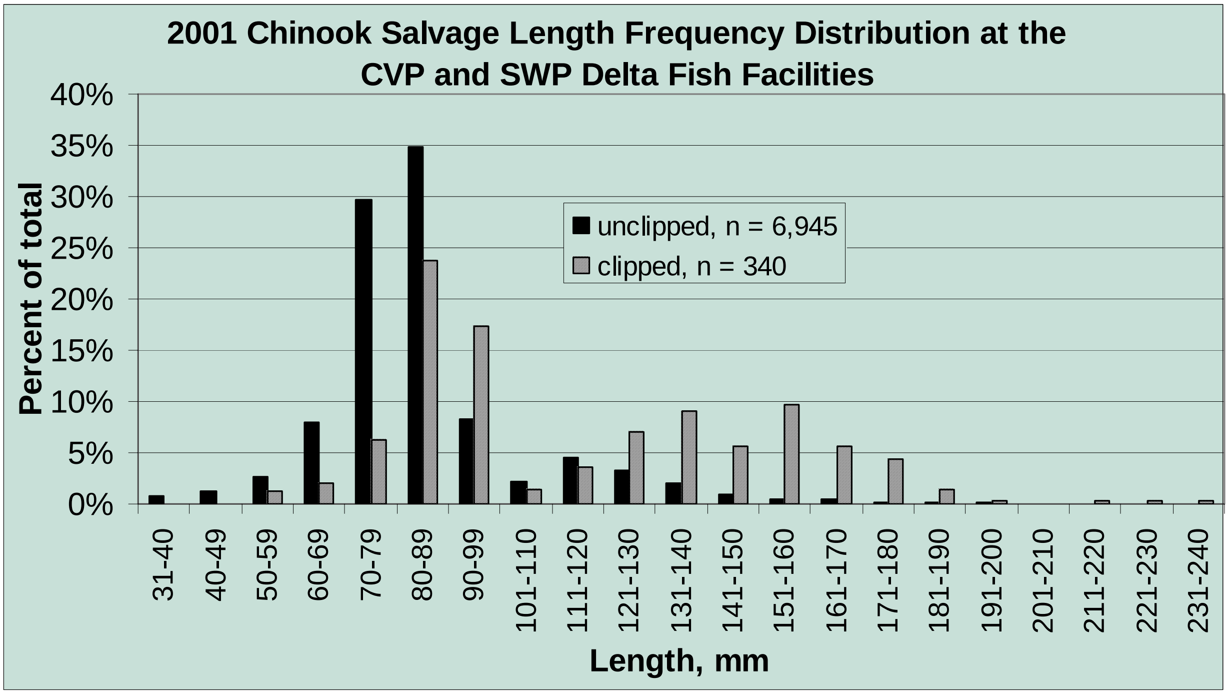


Figure 6–23 Length frequency distribution of Chinook salvaged at the Delta fish facilities in 2001.

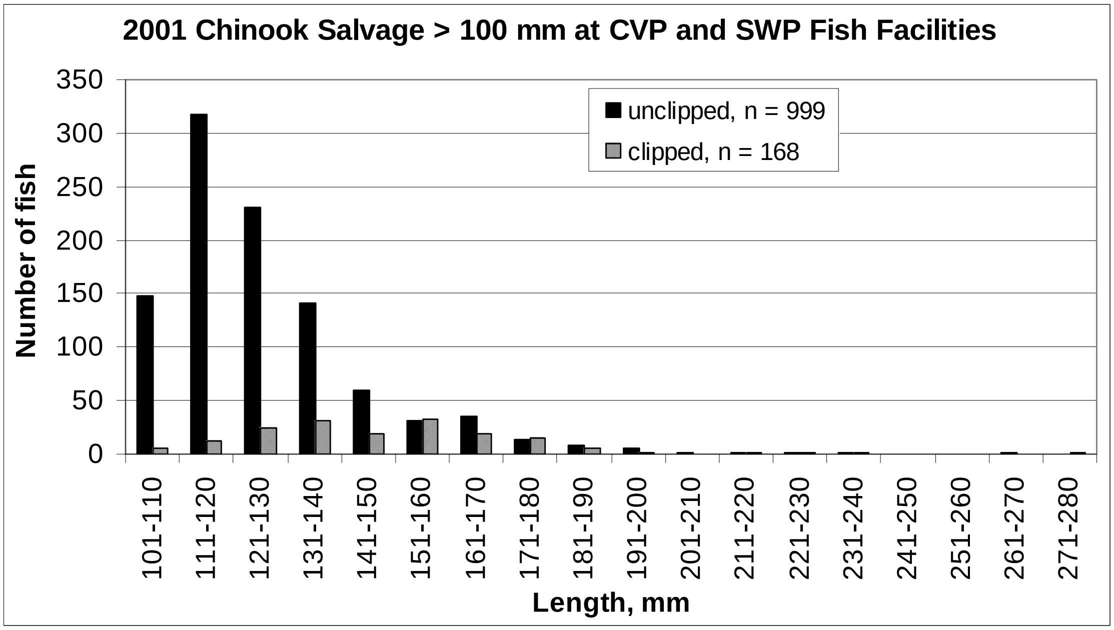


Figure 6–24 Length frequency distribution for Chinook salvaged greater than 100 mm in 2001.

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 does not include indirect mortality in the Delta.

FWS coded-wire-tag (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 outflow, time of year the salmon emigrate, 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 versus 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. DCC 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 or the 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 DCC 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 Georgiana Slough 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 Georgiana Slough release. Additionally, the estimated loss of the Georgiana Slough release was higher than the Ryde release in every paired experiment. Evaluating the Georgiana Slough and Ryde data separately, the Georgiana Slough 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 Georgiana Slough 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 of 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 Georgiana Slough 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 Georgiana Slough 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).

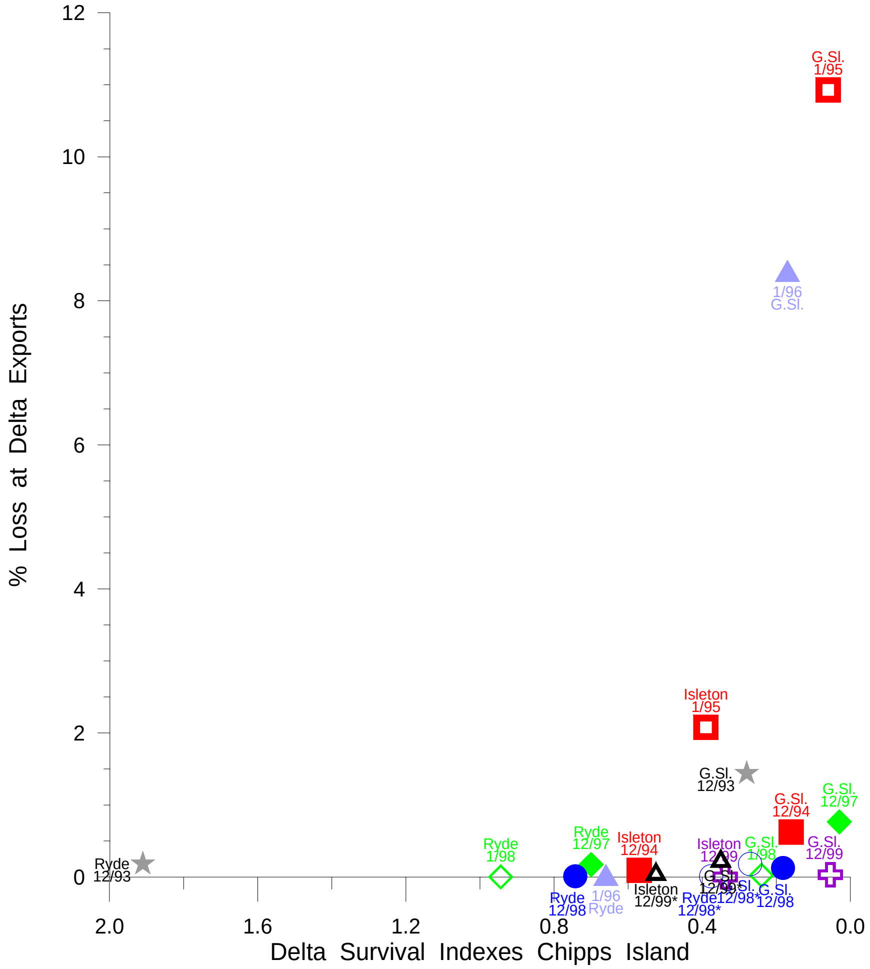


Figure 6–25 Scatterplot of Delta survival indices for Coleman Hatchery late-fall-run Chinook salmon from paired release experiments in the Sacramento River and Georgiana Slough v. percentage of the release group salvaged at the CVP and SWP Delta facilities.

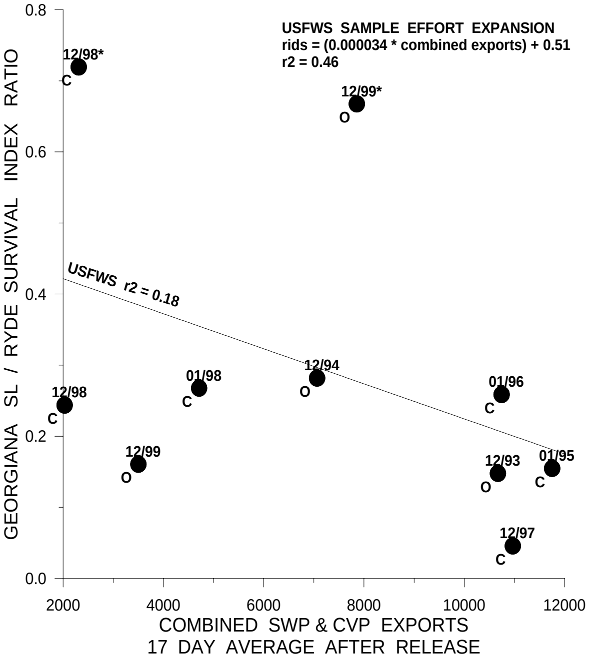


Figure 6–26 Relationship between Delta exports and the Georgiana Slough to Ryde survival index ratio. The export variable is combined average CVP and SWP exports for 17 days after release.

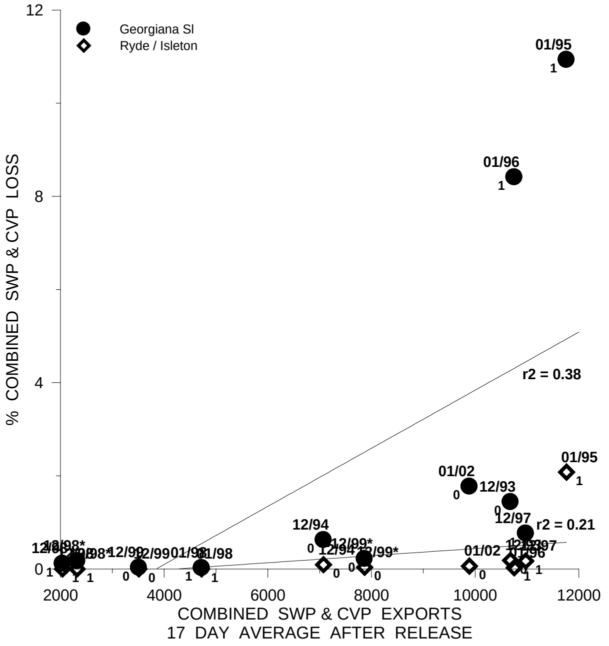


Figure 6–27 Relationship between Delta exports and percentage of late-fall-run CWT Chinook salmon Delta release groups salvaged at the CVP and SWP Delta facilities. The export variable is combined average CVP and SWP exports for 17 days after release.

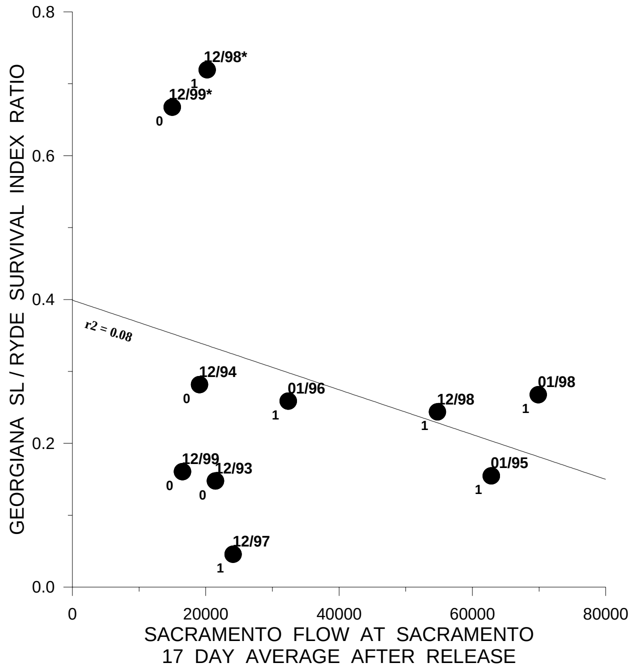


Figure 6–28 Relationship between Sacramento River flow and the Georgiana Slough to Ryde survival index ratio. The flow variable is average Sacramento River flow at Sacramento for 17 days after release.

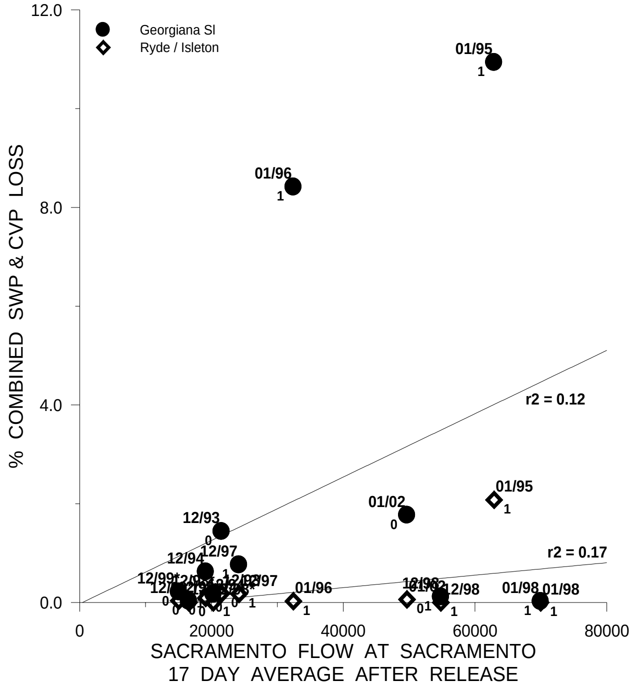


Figure 6–29 Relationship between Sacramento River flow and the percentage of late-fall-run CWT Chinook salmon Delta release groups salvaged at the CVP and SWP Delta facilities. The flow variable is average Sacramento River flow at Sacramento for 17 days after release. Georgiana Slough and Ryde releases are plotted separately.

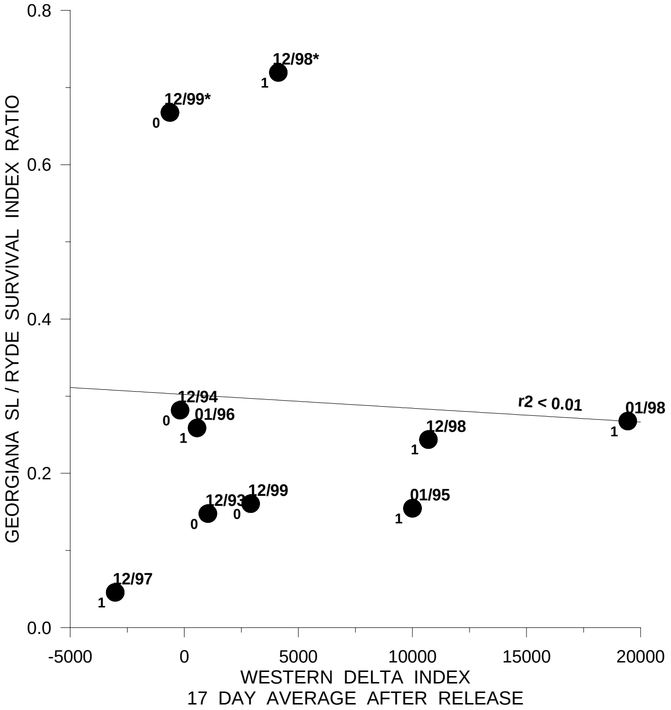


Figure 6–30 Relationship between QWEST flow and the Georgiana Slough to Ryde survival index ratio. The flow variable is average QWEST flow for 17 days after release.

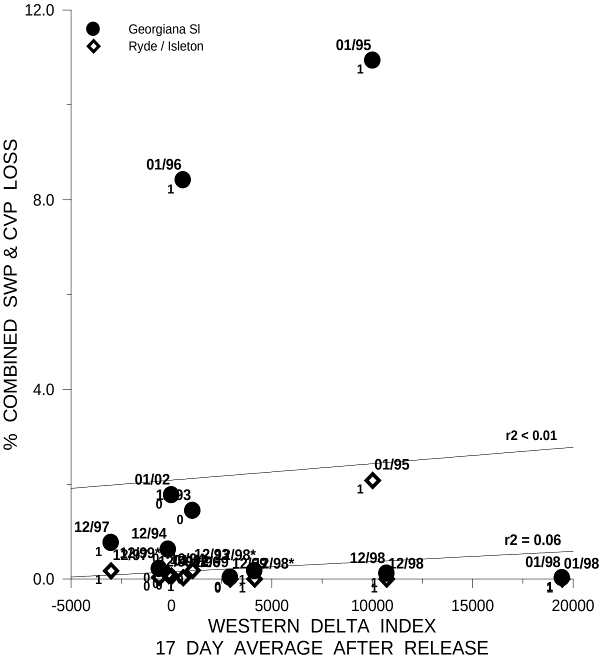


Figure 6–31 Relationship between QWEST flow and the percentage of late-fall-run CWT Chinook salmon Delta release groups salvaged at the CVP and SWP Delta facilities. The flow variable is average QWESTflow for 17 days after release.

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).

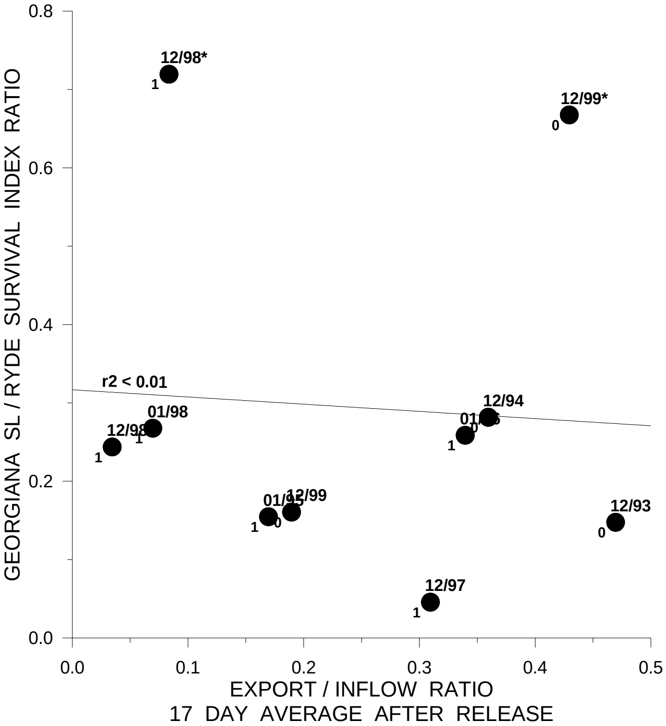


Figure 6–32 Relationship between Export/Inflow ratio and the Georgiana Slough to Ryde survival index ratio. The flow variable is average Export/Inflow ratio for 17 days after release.

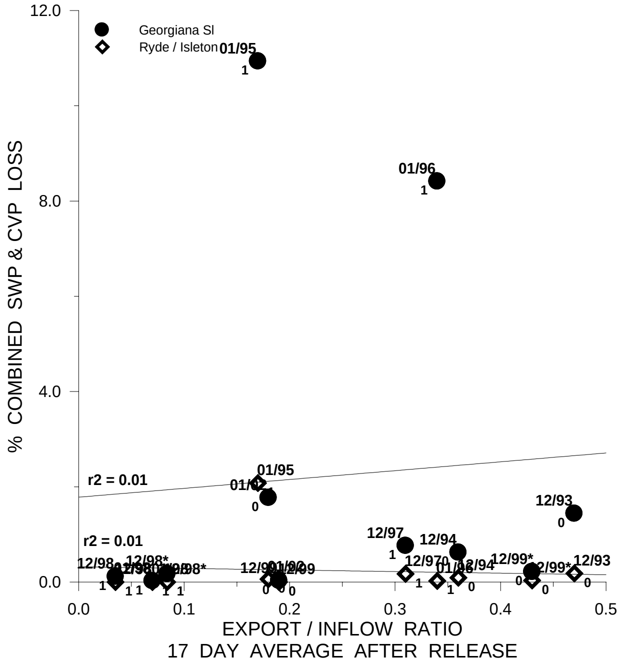


Figure 6–33 Relationship between Export/Inflow ratio and the percentage of late-fall-run CWT Chinook salmon Delta release groups salvaged at the CVP and SWP Delta facilities. The flow variable is average Export/Inflow ratio for 17 days after release.

In summary, no significant linear relationships were found between the Georgiana Slough-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 Georgiana Slough 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 Georgiana Slough 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 (less than 2 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 Georgiana Slough 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.

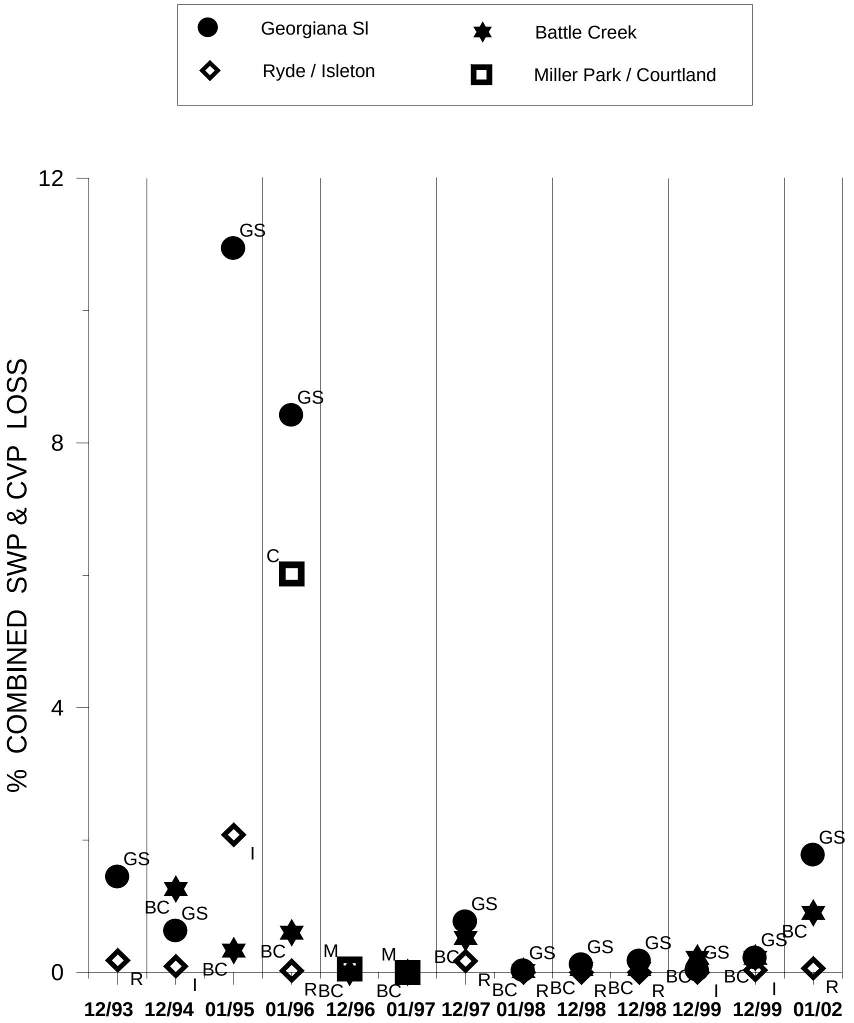


Figure 6–34 The percentage of late-fall-run CWT Chinook salmon Sacramento River and Delta release groups salvaged at the CVP and SWP Delta facilities grouped by release date.

Altered Flow Patterns in Delta Channels

Flow in the Delta 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.

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. Nonpoint 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 nonnatal 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 1963-1964, 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 a 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 preferred 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 wharves (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 2 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 prescreen loss (which includes predation) of fishes entrained to the forebay (Gingras 1997). Eight of these experiments involved hatchery-reared juvenile Chinook salmon. Prescreen 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 water where tidal currents distribute fish over 7 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 2 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 7 years of diet studies (Heidi Rooks, personal communication, 1999). Dominant striped bass prey were fishes associated with substrate, such as three-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 (greater than 50 percent) of adult fish. Central

Valley salmon populations are managed to maintain a fairly consistent level of spawner escapement (Figure 6–35). 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 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 in 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 by 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 2-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.

The percentage of Central Valley salmon harvested in ocean fisheries has averaged 66 percent since 1970 (Figure 6–35), 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.

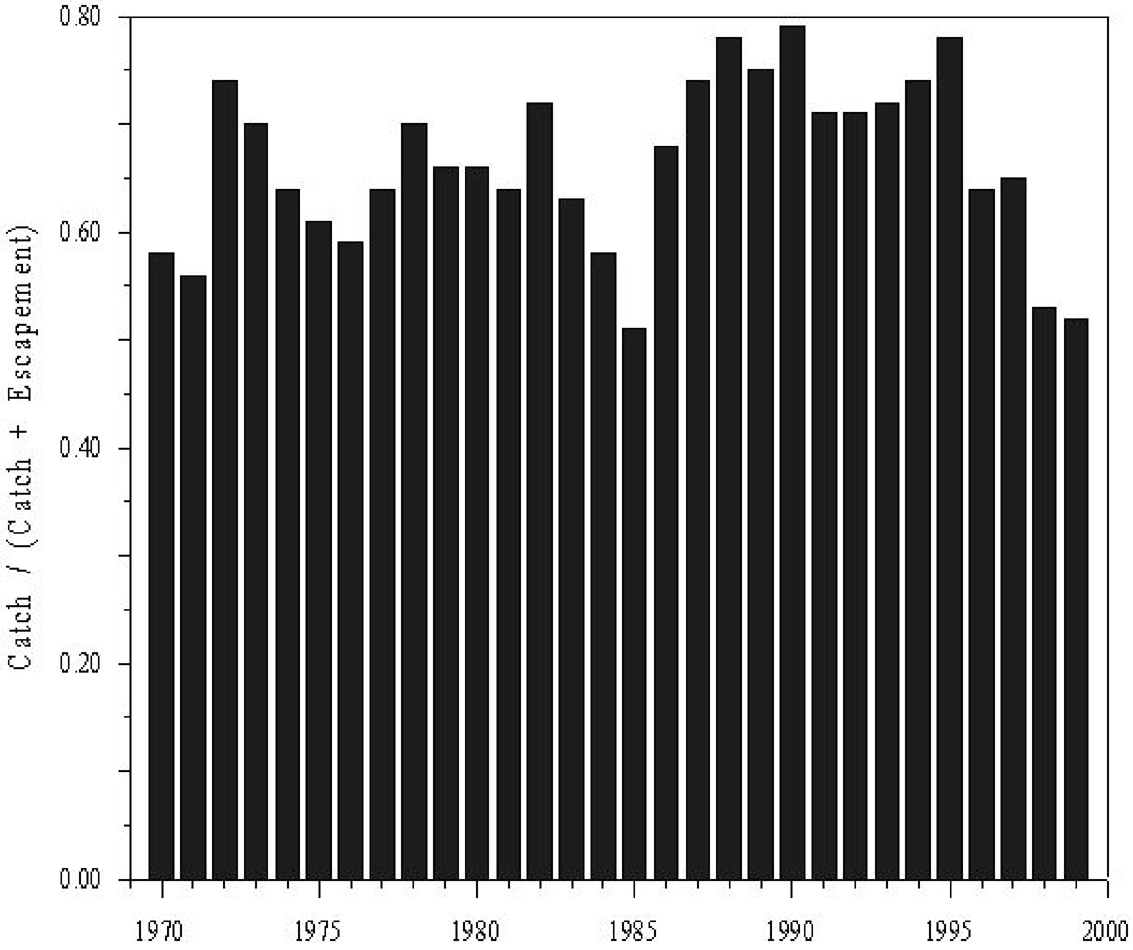


Figure 6–35 Central Valley Chinook salmon Ocean Harvest Index, 1970–99.

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.

Recent advances in the scientific understanding of interdecadal changes in oceanographic conditions on marine fisheries were outlined in Chapter 4. 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 6–36), 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 5 years or less.

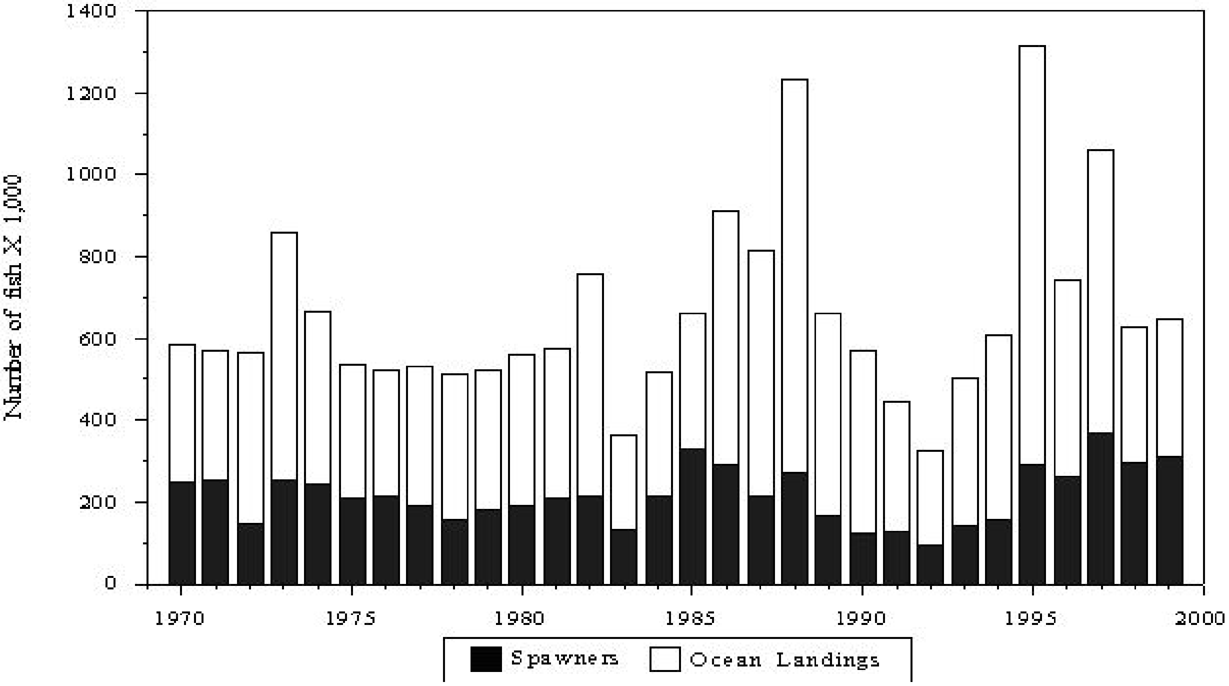


Figure 6–36 Central Valley Chinook salmon (all races) abundance index, 1970–99. 2000 = 1.74 million production with 55% harvested, 2001 = 0.849 million production with 27% harvested, 2002 = 1.285 million production with 34% harvested.

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 code-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-3 fish, 57 percent to 85 percent for age-4 fish, and 97 percent to 100 percent for age-5 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 reemphasized 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.

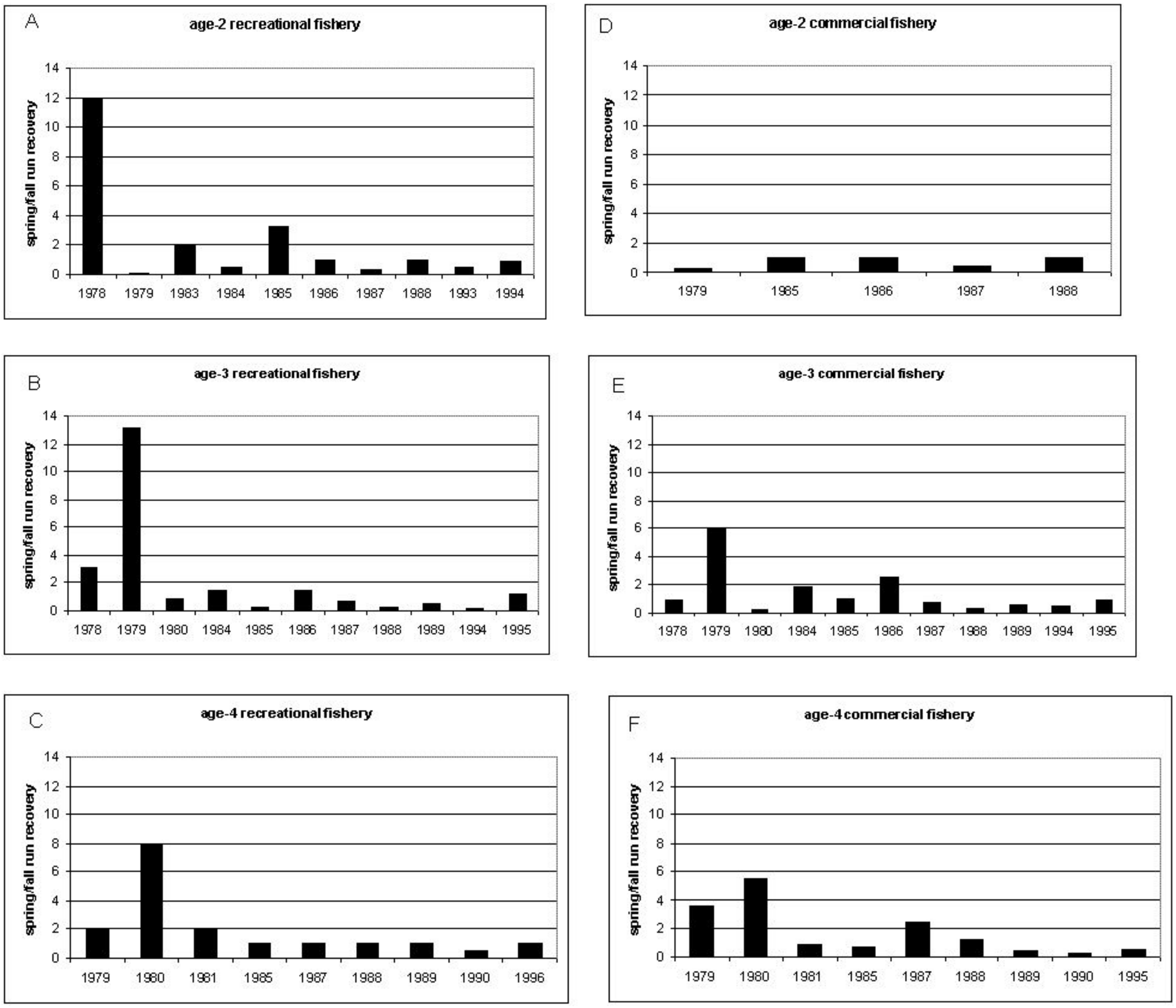


Figure 6–37 Coded-wire tag recovery rate of Feather River Hatchery spring-run Chinook salmon relative to the coded-wire tag recovery rate of Central Valley fall-run Chinook salmon. Data were taken from DFG (1998), and are presented individually for recreational and commercial fisheries for age-2, age-3, and age-4 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. Chinook salmon are also produced in the Trinity River hatchery and released in the Trinity River.

Table 6–12 Production data for Central Valley hatchery produced Chinook salmon.

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
Source: DFG and NOAA fisheries 2001.			

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 versus 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.

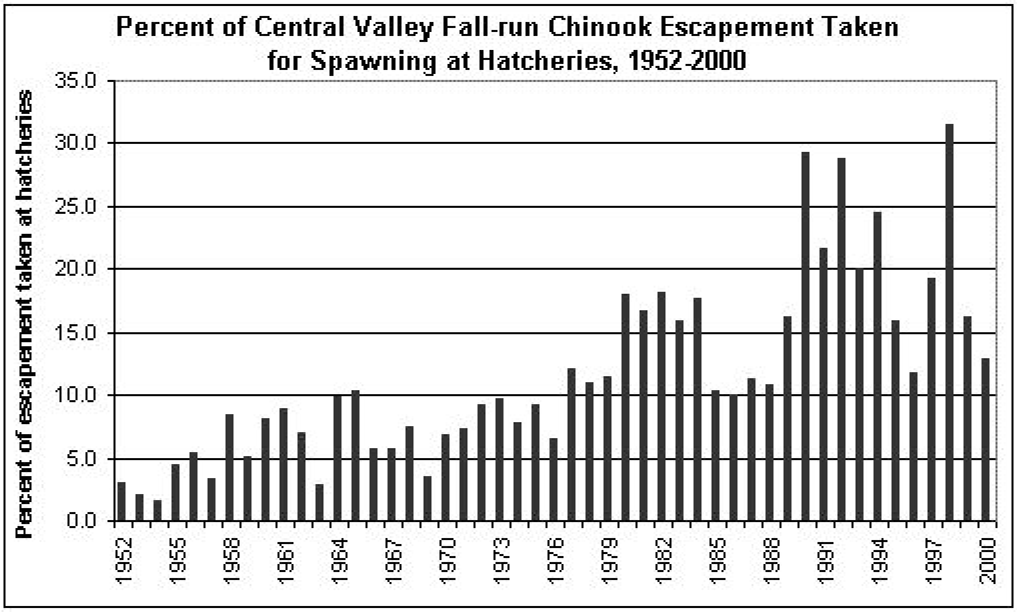


Figure 6–38 Percent of Central Valley fall-run Chinook escapement taken for spawning 1952–2000.

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 2 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 5-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 intermixing 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 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 intermixing. 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 FRH 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 5–6). This intermixed life history pattern was evident when FRH fish were used in an attempt to reestablish spring-run in Clear Creek. More than 523,000 FRH spring-run fry were planted at the base of Whiskeytown Dam during the 3-year period 1991–1993 (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) reexamined 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 closely 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 versus 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 throughout 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 (U.S. Department of the Interior 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 less than 100 millimeters (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, although a small percentage (less than 10 percent) of the population can live to and possibly reproduce at age 2 (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 15 to 18ºC (59 to 64.4ºF) 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 fish 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 parts per thousand (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 to 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).

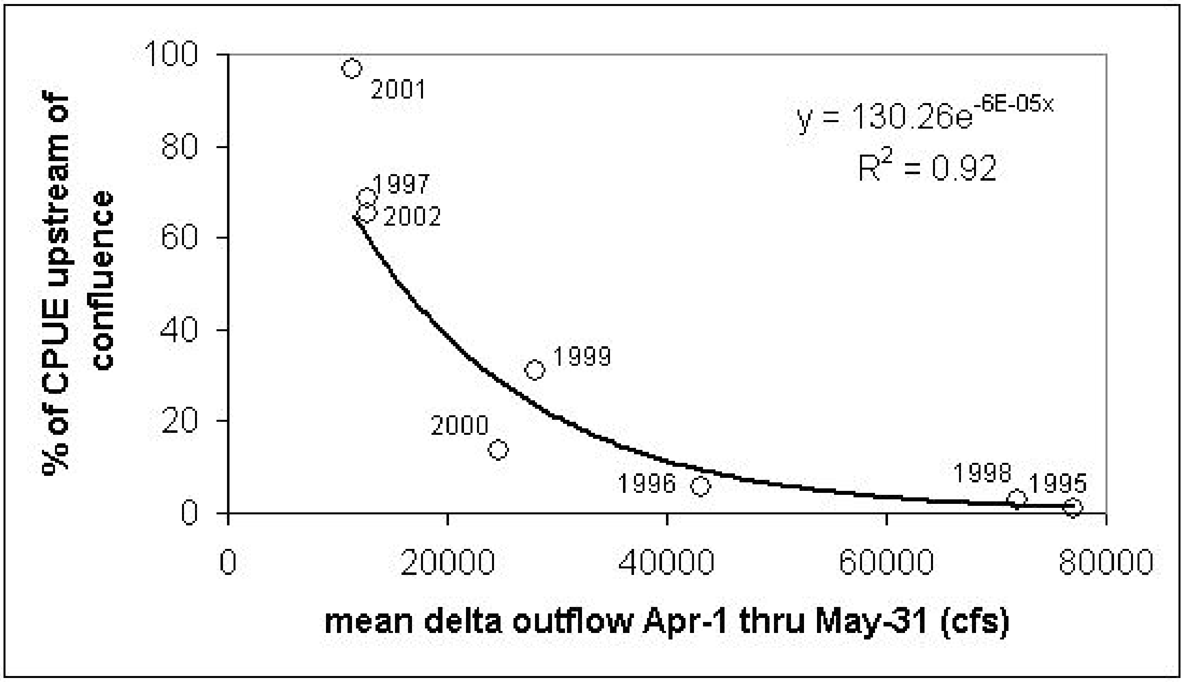

Figure 7–1 (x-axis is DAYFLOW; y-axis is first 20-mm Survey following VAMP).

Currently, the approximate spatial position of low-salinity habitat in the estuary is indexed by X2, defined as the distance in kilometers 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 California Department of Fish and Game (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 through 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 and 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.

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).

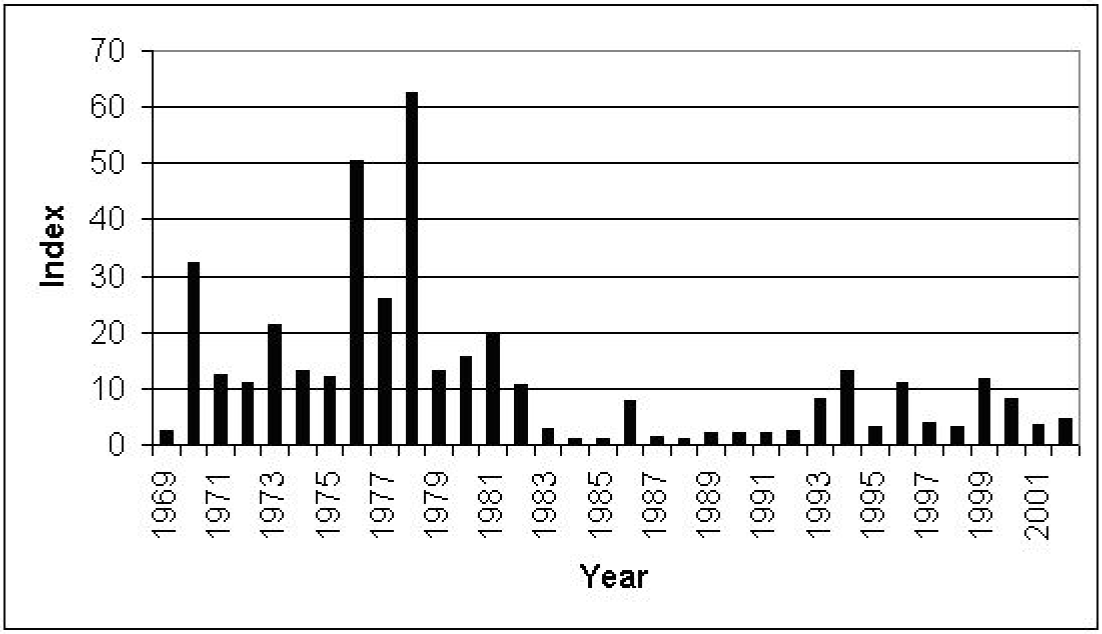

Figure 7–2 TNS indices 1969-2002.

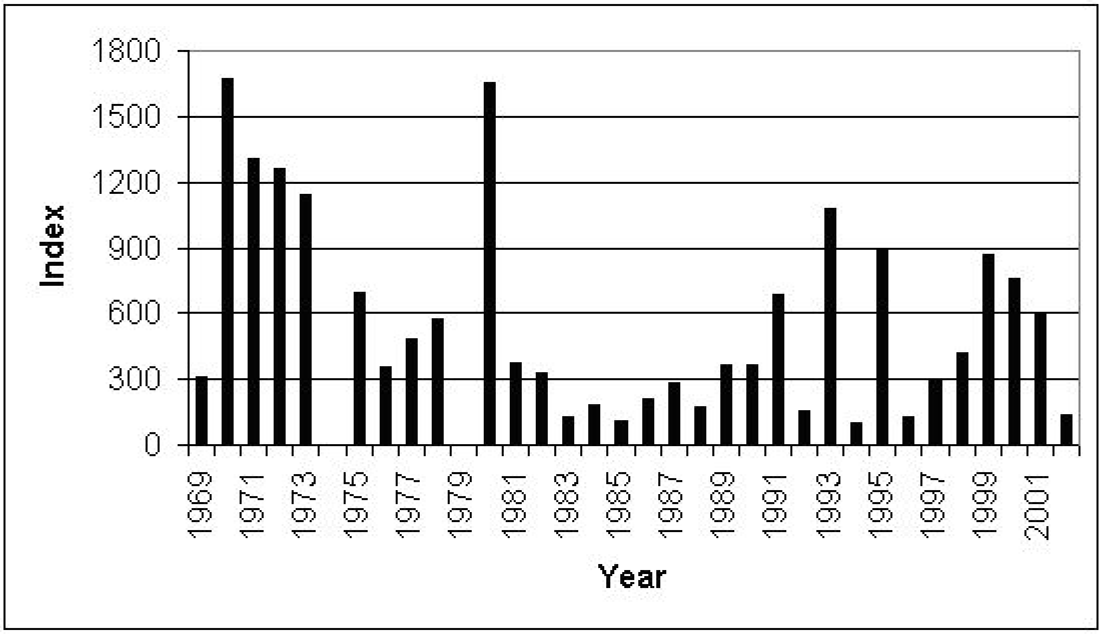

Figure 7–3 FMWT indices 1969-2002.

From 1969 through 1981, 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 through 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 through 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 through 1981, TNS indices were highest in years of low freshwater flow. In contrast, during 1982 through 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 15ºC and 20ºC (59ºF to 68ºF), 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 less than 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 the 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 adult spawners. This means that most of the variation in delta smelt abundance is caused by environmental factors.

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.

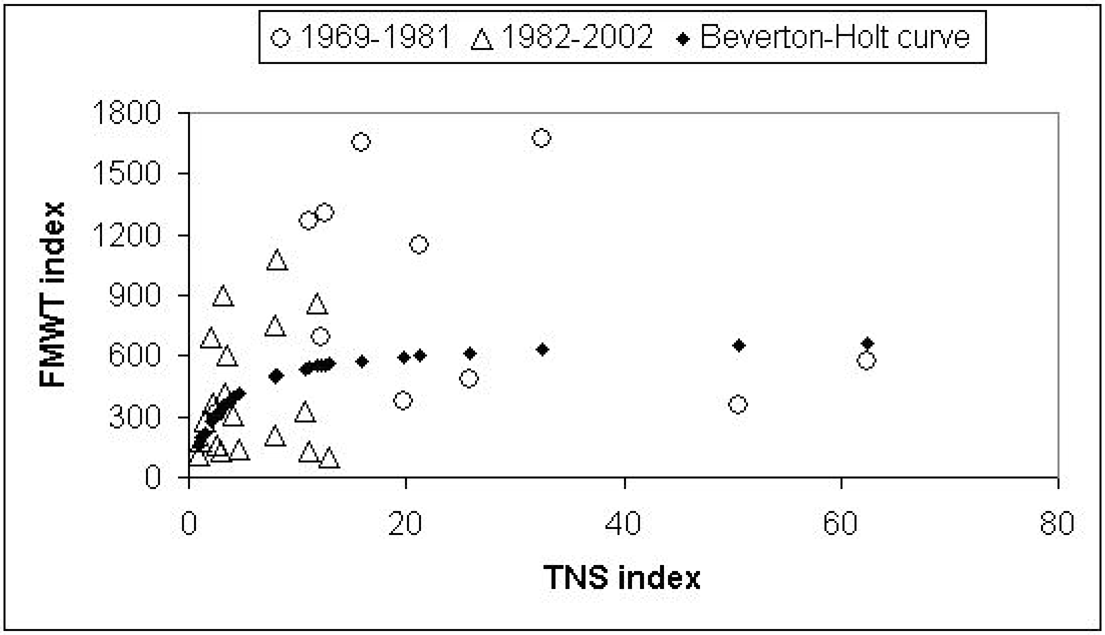

Figure 7–4 (Beverton-Holt curve was fitted to all data even though time periods are shown separately).

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 to 1981) almost all occur outside of the range of the post-decline (1982 to 2002) data points. Therefore, an alternative explanation of the TNS-MWT relationship is possible—the nonlinearity 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 young-of-year (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 2 years, meaning that successive index values are correlated with index values from 2 years prior. Bennett (unpublished) hypothesized the lag 2-year autocorrelation was evidence for a reproductive contribution of age-2 spawners, but this interpretation has not thus far been backed by strong empirical evidence. The contribution of age-2 spawners to delta smelt population dynamics is currently under investigation (Brown and Kimmerer 2002).

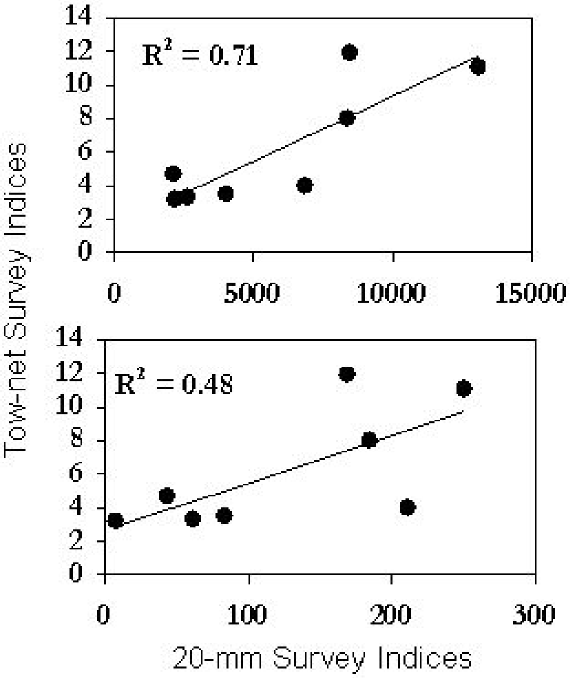

Figure 7–5 Relationships between 20-mm Survey indices and TNS indices, 1995-2002.

Reclamation and DWR (1994) were concerned about autocorrelation resulting in spurious conclusions about environmental influences on delta smelt population dynamics. Statistically speaking, auto-correlation 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 co-vary with, but not actually influence, the underlying process resulting in the auto-correlation. 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 auto-correlation.

SWP and CVP Water Export Operations

The Central Valley Project (CVP) and State Water Project (SWP) water-export operations include upstream reservoirs, the Delta Cross Channel (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 1 versus FMWT index at year 2 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 to 25 mm in length. Most juvenile salvage occurs from April through July with a peak in May or 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).

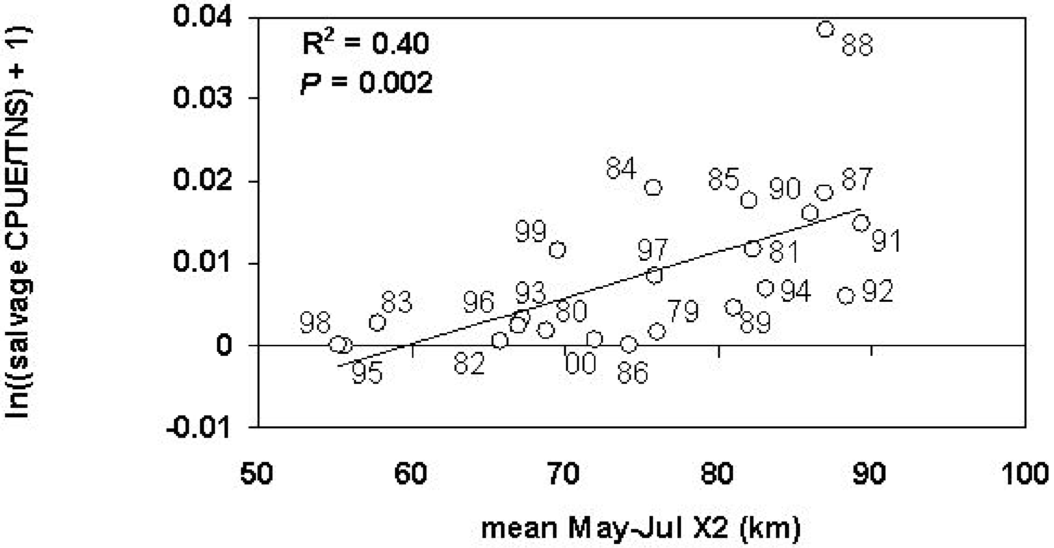

Figure 7–6 Water operations impacts to the delta smelt population.

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). 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 and 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. 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). However, 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). However, DWR screened five agricultural diversions around Sherman Island, an area consistently used by delta smelt of all life stages.

Pacific Gas & Electric Company

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 6 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 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 Assumptions with 3406 (b)(2) and EWA Analyses

The CALSIM II monthly model results were used to analyze effects of proposed Central Valley Project (CVP) and State Water Project (SWP) operations on steelhead, coho salmon, Delta smelt, and winter-run and spring-run Chinook salmon. The major changes in operations relative to current assumptions that are expected to impact the CVP and SWP are:

- Lewiston releases on the Trinity River (340,000 acre-feet [af], ranging between 368,600 to 452,600 af and 368,600 to 815,000 af annually)
- 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 Coordinated Operations Agreement COA requirements)
- The Intertie
- South Delta Improvement Project (increase Banks pumping capacity from 6,680 cfs to 8,500 cfs)

CALSIM II for the OCAP Biological Assessment (BA) studies has the most current assumptions of the (b)(2) policy, May 2003. Studies 3, 5, and 5a have as input the most current assumptions for the Environmental Water Account (EWA) program as agreed to in October 2003. The aforementioned changes in assumptions are further broken into formal and early consultation modeling runs as seen in Table 8-1 (Note: if it is listed under formal consultation, it is modeled under both scenarios).

Table 8-1 Summary of Formal and Early Consultation Assumption Differences

	Early Consultation	Formal Consultation
South Delta Improvement Plan	X	
DMC Intertie		X
CVP/SWP Project Integration	X	
Freeport		X

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.

CALSIM II replaces both the DWRSIM and PROSIM models as the CVP-SWP simulation model developed and used by the California Department of Water Resources (DWR) and the U.S. Bureau of Reclamation (Reclamation), respectively. CALSIM II represents the best available planning model for the CVP-SWP system. As quoted in the April 9, 2004, Draft Response Plan from the CALFED Science Program Peer Review of CALSIM II:

> *"As the official model of those projects, Calsim II is the default system model for any inter-regional or statewide analysis of water in the Central Valley…California needs a large-scale relatively versatile inter-regional operations planning model and Calsim II serves that purpose reasonably well."*

The two Benchmark Studies (2001 and 2020 Level of Development) 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 for comparing project alternatives. Because CALSIM II uses generalized rules to operate the CVP and SWP systems, the results are a gross estimate and may not reflect how actual operations would occur. CALSIM II should only be used as a comparative tool to reflect how changes in facilities and operations may affect the CVP-SWP system.

Hydrologic Modeling Methods

The DWR/Reclamation Joint CALSIM II planning model was used to simulate the CVP and SWP water operations on a monthly time step from water year (WY) 1922 to WY1994. CALSIM II uses 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, nonrecoverable 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 historical 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 (NOD) and South of Delta (SOD) 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 forecasted 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 SOD SWP delivery is determined from water supply parameters and operational constraints. The CVP systemwide delivery and SOD delivery are determined similarly from 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 Central Valley Project Improvement Act (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 State Water Resources Control Board (SWRCB) D-1485 and D-1641 regulatory requirements (DWR 2002). Similarly, the operating guidelines for selecting actions and allocating assets under the EWA are based on system conditions under operations associated with a Regulatory Baseline as defined by the CALFED Record of Decision, 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 was 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, Joint Point of Diversion (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 [WQCP] 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 WQCP 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 JPOD capacity, and simulated CVP usage of 50 percent 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 percent 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 percent of B2 gains to EWA, EWA usage of 50 percent of JPOD capacity, fixed purchases north and south of Delta).
6. Accept the state of the system from the 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.

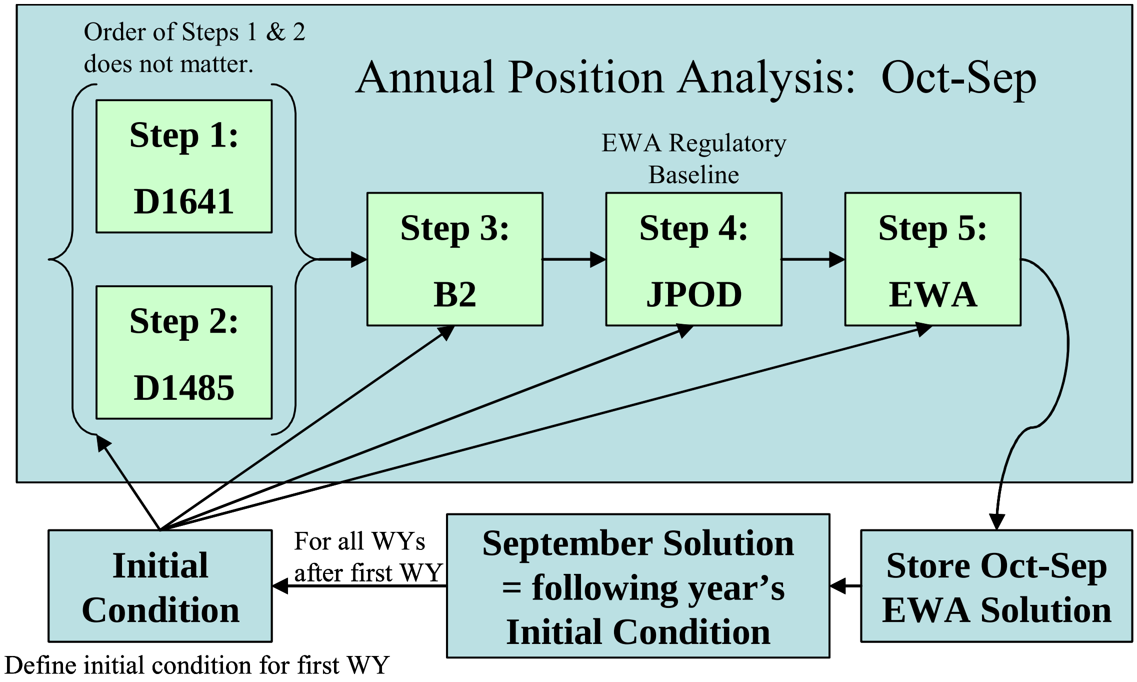

Figure 8–1. CALSIM II Procedure to Simulate EWA Operations (Note: Step 4 is named "JPOD" in the OCAP Today Studies and "SDIP" in the OCAP Future Studies)

CVPIA (b)(2)

According to the 1992 CVPIA, the CVP 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 that the U.S. Fish and Wildlife Service (FWS), in consultation with Reclamation and other agencies (see the Chapter 2 description of

B2IT in Adaptive Management), has at its disposal to use to meet the primary restoration purposes of CVPIA 3406(b)(2), the CVP's WQCP obligations and any legal requirements imposed on the CVP after 1992. CVPIA 3406 (b)(2) water may be managed 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) Department of the Interior decision.

- Allocation of (b)(2) water is 800,000 acre-feet per year (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:
  - October-January
    - ○ 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.
  - February-September
    - ○ 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 (b)(2) account > projected coming WQCP costs.
    - ○ Nimbus Releases: Action is on if Folsom Beginning-of-Month Storage > 300,000 af and if remaining (b)(2) 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 through February) and Pre-Vernalis Adaptive Management Plan (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 8,600 cubic feet per second (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 (FWS, National Oceanic and Atmospheric Administration Fisheries [NOAA Fisheries – formerly called National Marine Fisheries Service or NMFS], and California Department of Fish and Game [DFG]) and two project agencies (Reclamation and DWR) share responsibility for implementing and managing the Environmental Water Account (EWA). The management agencies manage the EWA assets and exercise the biological judgment to recommend operational 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 has been implemented by EWAT during WY2001-2003, and as it is foreseen to be implemented in coming years by CALFED Operations. The EWA representation that 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 as a result of 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 reoperation effects resulting from 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 Sacramento 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 an EWAT high priority in 2001–2003 and is, therefore, modeled as a high priority.

- Pre-VAMP “Shoulder-period” Export Reduction (April –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 percent Gain of SWP Pumping of (b)(2)/ERP Upstream Releases
- 50 percent Dedication of SWP Excess Pumping Capacity (i.e., JPOD)
- July-September Dedicated Export Capacity at Banks

The role of these fixed and operational assets in mitigating the effects of EWA actions depends on 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 thousand acre-feet (taf) of stored water SOD. 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 delayed, 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 (E/I) Ratio Flexibility
- Source-shifting Agreements
- Exchanges

The impacts of actions on system operations are 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 SOD
- Storage levels SOD
- Storage levels NOD

Occurrence of SOD deliveries debt and subsequent failure to immediately pay back 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 assuming 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 sum of end-of-month debt and stored water at SWP San Luis exceeded the sum 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

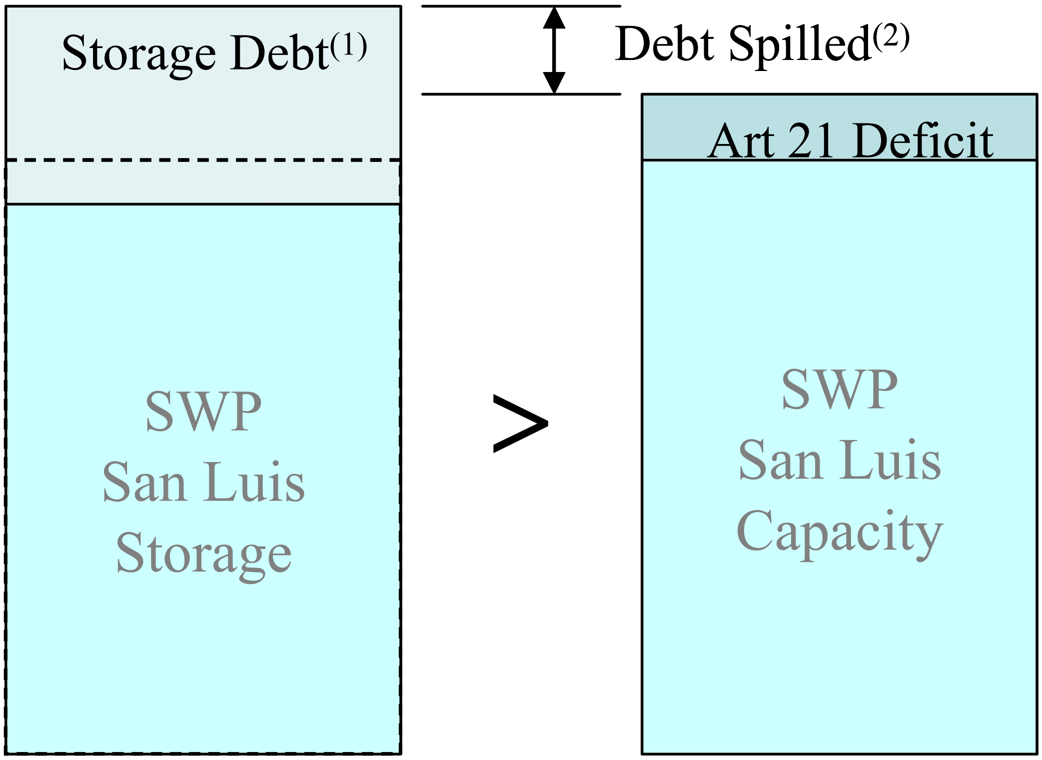

Figure 8–2 Conditions for Spilling Carried-over Debt at SWP San Luis in CALSIM II
Because the Regulatory Baseline cannot exceed SWP San Luis Capacity (i.e., the dashed line in Stack A), then the debt above this capacity line must be carried-over debt. Therefore, this spill tool will only be applicable to erasing carried-over debt and will not affect "new" debt conditions from this year's actions.

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 Level of Development [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 for comparing project alternatives. From the Benchmark Studies, seven studies have been developed to evaluate the impacts of changes in operations for the Trinity River, Freeport Project, Intertie, LOD, CVP/SWP Project Integrations and South Delta Improvements Program (SDIP). Table 8-2 shows the seven studies developed for OCAP and how the previously mentioned changes in operations are incorporated into them.

Table 8-2. 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 2003	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 4a Future b(2)	Same as above	Same as above	Same as above				X	X
Study 5 Future EWA	Same as above	Same as above	Same as above	X	X	X	X	X
Study 5a Future EWA 6680	Same as above	Same as above	Same as above	X			X	X

Study 1 is used to 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, 4, and 4a are to evaluate the CALFED Tier 1 environmental regulatory effects that are mandated by law. Studies 3, 5, and 5a 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. Studies 4a and 5a represent the models that evaluate effects of the formal consultation studies, while 4 and 5 represent the early consultation simulations.

Table 8-3 shows the detailed assumptions of the seven studies. The table illustrates specific operational changes regarding regulatory and operational rules. It also details assumptions within the major changes to operations in Table 8-2. and shows the changes in demand from the Today to the Future studies for American River system for diversions dynamically modeled in CALSIM II.

Table 8-3 Assumptions for the Base and Future Studies

	Study 1	**Study 2**	**Study 3**	**Study 4**	**Study 4a**	**Study 5**	**Study 5a**
	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)**	**Future 3406 (b)(2) and SDIP with EWA**	**Future 3406 (b)(2) with EWA 6680**
Period of Simulation	73 years (1922-1994)	Same	Same	Same	Same	Same	Same
HYDROLOGY							
Level of Development (Land Use)	2001 Level, DWR Bulletin 160-98[a]	Same as Study 1	Same as Study 1	2020 Level, DWR Bulletin 160-98	2020 Level, DWR Bulletin 160-98	Same as Study 4	Same as Study 4
Demands							
North of Delta (exc. American R)							
CVP	Land Use based, Limited by Full Contract	Same	Same	Same	Same	Same	Same
SWP (FRSA)	Land Use based, Limited by Full Contract	Same	Same	Same	Same	Same	Same
Non-Project	Land Use based	Same	Same	Same	Same	Same	Same
CVP Refuges	Firm Level 2	Same	Same	Same	Same	Same	Same
American River Basin							
Water rights	2001[b]	Same as Study 1	Same as Study 1	2020, as projected by Water Forum Analysis[c]	Same as Study 4	Same as Study 4	Same as Study 4
CVP	2001 [b]	Same as Study 1	Same as Study 1	2020, as projected by Water Forum Analysis[d]	Same as Study 4	Same as Study 4	Same as Study 4
San Joaquin River Basin							
Friant Unit	Regression of Historical	Same	Same	Same	Same	Same	Same

Table 8-3 Assumptions for the Base and Future Studies

	Study 1	Study 2	Study 3	Study 4	Study 4a	Study 5	Study 5a
	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)**	**Future 3406 (b)(2) and SDIP with EWA**	**Future 3406 (b)(2) with EWA 6680**
Lower Basin	Fixed Annual Demands	Same	Same	Same	Same	Same	Same
Stanislaus River Basin	New Melones Interim Operations Plan	Same	Same	Same	Same	Same	Same
South of Delta							
CVP	Full Contract	Same	Same	Same	Same	Same	Same
CCWD	124,000 af/yr[e]	Same as Study 1	Same as Study 1	158,000 af/yr[a]	Same as Study 4	Same as Study 4	Same as Study 4
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	Same as Study 4	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	Same	Same
FACILITIES							
Freeport Regional Water Project	None	Same as Study 1	Same as Study 1	Included[f]	Same as Study 4	Same as Study 4	Same as Study 4
Banks Pumping Capacity	6680 cfs	Same as Study 1	Same as Study 1	8500 cfs	Same as Study 1	Same as Study 4	Same as Study 1
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	Same as Study 4	Same as Study 4
OPERATIONS CONSTRAINTS AND CRITERIA							
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	Same as Study 4	Same as Study 4

Table 8-3 Assumptions for the Base and Future Studies

	Study 1	Study 2	Study 3	Study 4	Study 4a	Study 5	Study 5a
	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)**	**Future 3406 (b)(2) and SDIP with EWA**	**Future 3406 (b)(2) with EWA 6680**
Trinity Reservoir End-of-September Minimum Storage	Trinity export-to-inflows Preferred Alternative (600,000 af as able)	Same	Same	Same	Same	Same	Same
Clear Creek							
Minimum Flow below Whiskeytown Dam	Downstream water rights, 1963 USBR Proposal to FWS and NPS, and FWS use of CVPIA 3406(b)(2) water	Same	Same	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	Same	Same
Minimum Flow below Keswick Dam	Flows for SWRCB WR 90-5 and 1993 Winter-run Biological Opinion temperature control, and FWS use of CVPIA 3406(b)(2) water	Same	Same	Same	Same	Same	Same
Feather River							
Minimum Flow below Thermalito Diversion Dam	1983 DWR, DFG Agreement (600 CFS)	Same	Same	Same	Same	Same	Same
Minimum Flow below Thermalito Afterbay outlet	1983 DWR, DFG Agreement (1000 – 1700 CFS)	Same	Same	Same	Same	Same	Same

Table 8-3 Assumptions for the Base and Future Studies

	Study 1	Study 2	Study 3	Study 4	Study 4a	Study 5	Study 5a
	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)**	**Future 3406 (b)(2) and SDIP with EWA**	**Future 3406 (b)(2) with EWA 6680**
American River							
Minimum Flow below Nimbus Dam	SWRCB D-893 (see accompanying Operations Criteria), and FWS use of CVPIA 3406(b)(2) water	Same	Same	Same	Same	Same	Same
Minimum Flow at H Street Bridge	SWRCB D-893	Same	Same	Same	Same	Same	Same
Lower Sacramento River							
Minimum Flow near Rio Vista	SWRCB D-1641	Same	Same	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	Same	Same
Minimum Flow below Woodbridge Diversion Dam	FERC 2916-029, 1996 (Joint Settlement Agreement) (25 – 300 CFS)	Same	Same	Same	Same	Same	Same
Stanislaus River							
Minimum Flow below Goodwin Dam	1987 USBR, DFG agreement, and FWS use of CVPIA 3406(b)(2) water	Same	Same	Same	Same	Same	Same
Minimum Dissolved Oxygen	SWRCB D-1422	Same	Same	Same	Same	Same	Same

Table 8-3 Assumptions for the Base and Future Studies

	Study 1	Study 2	Study 3	Study 4	Study 4a	Study 5	Study 5a
	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)**	**Future 3406 (b)(2) and SDIP with EWA**	**Future 3406 (b)(2) with EWA 6680**
Merced River							
Minimum Flow below Crocker-Huffman Diversion Dam	Davis-Grunsky (180 – 220 CFS, Nov – Mar), and Cowell Agreement	Same	Same	Same	Same	Same	Same
Minimum Flow at Shaffer Bridge	FERC 2179 (25 – 100 CFS)	Same	Same	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	Same	Same
San Joaquin River							
Maximum Salinity near Vernalis	SWRCB D-1641	Same	Same	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	Same	Same
Sacramento River-San Joaquin River Delta							
Delta Outflow Index (Flow and Salinity)	SWRCB D-1641	Same	Same	Same	Same	Same	Same

Table 8-3 Assumptions for the Base and Future Studies

	Study 1	Study 2	Study 3	Study 4	Study 4a	Study 5	Study 5a
	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)**	**Future 3406 (b)(2) and SDIP with EWA**	**Future 3406 (b)(2) with EWA 6680**
Delta Cross Channel Gate Operation	SWRCB D-1641	Same	Same	Same	Same	Same	Same
Delta Exports	SWRCB D-1641, FWS 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 1	Same as Study 3	Same as Study 3
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	Same	Same
American River							
Folsom Dam Flood Control	SAFCA, Interim-Reoperation of Folsom Dam, Variable 400/670 (without outlet modifications)	Same	Same	Same	Same	Same	Same
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	Same	Same

Table 8-3 Assumptions for the Base and Future Studies

	Study 1	Study 2	Study 3	Study 4	Study 4a	Study 5	Study 5a
	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)**	**Future 3406 (b)(2) and SDIP with EWA**	**Future 3406 (b)(2) with EWA 6680**
Stanislaus River							
Flow below Goodwin Dam	1997 New Melones Interim Operations Plan	Same	Same	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	Same	Same
System-wide							
CVP Water Allocation							
CVP Settlement and Exchange	100% (75% in Shasta Critical years)	Same	Same	Same	Same	Same	Same
CVP Refuges	100% (75% in Shasta Critical years)	Same	Same	Same	Same	Same	Same
CVP Agriculture	100% - 0% based on supply	Same	Same	Same	Same	Same	Same
CVP Municipal & Industrial	100% - 50% based on supply	Same	Same	Same	Same	Same	Same
SWP Water Allocation							
North of Delta (FRSA)	Contract specific	Same	Same	Same	Same	Same	Same
South of Delta	Based on supply; Monterey Agreement	Same	Same	Same	Same	Same	Same

Table 8-3 Assumptions for the Base and Future Studies

	Study 1	Study 2	Study 3	Study 4	Study 4a	Study 5	Study 5a
	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)**	**Future 3406 (b)(2) and SDIP with EWA**	**Future 3406 (b)(2) with EWA 6680**
CVP/SWP Coordinated Operations							
Sharing of Responsibility for In-Basin-Use	1986 Coordinated Operations Agreement	Same	Same	Same	Same	Same	Same
Sharing of Surplus Flows	1986 Coordinated Operations Agreement	Same	Same	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	Same	Same
Transfers							
Dry Year Program	None	Same	Same	Same	Same	Same	Same
Phase 8	None	Same	Same	Same	Same	Same	Same
Water Forum Analyses Water transfers /Mitigation Water	None	Same as Study 1	Same as Study 1	Water Forum Analyses (up to 47,000 af/yr in dry years)[g]	Same as Study 4	Same as Study 4	Same as Study 4
MWDSC/CVP Settlement Contractors	None	Same	Same	Same	Same	Same	Same

Table 8-3 Assumptions for the Base and Future Studies

	Study 1	Study 2	Study 3	Study 4	Study 4a	Study 5	Study 5a
	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)**	**Future 3406 (b)(2) and SDIP with EWA**	**Future 3406 (b)(2) with EWA 6680**
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.	None	Same as Study 4	None
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.	None	Same as Study 4	None
CVPIA 3406(b)(2)	Dept of Interior 2003 Decision	Same	Same	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	Same	Same
Actions	1995 WQCP, Fish flow objectives (Oct-Jan), VAMP (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)	Same	Same	Same	Same	Same	Same

Table 8-3 Assumptions for the Base and Future Studies

	Study 1	Study 2	Study 3	Study 4	Study 4a	Study 5	Study 5a
	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)**	**Future 3406 (b)(2) and SDIP with EWA**	**Future 3406 (b)(2) with EWA 6680**
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	Same	Same
CALFED Environmental Water Account	None	None	Modeled	None	None	Same as Study 3	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	Same as Study 3

Table 8-3 Assumptions for the Base and Future Studies

	Study 1	Study 2	Study 3	Study 4	Study 4a	Study 5	Study 5a
	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)	Future 3406 (b)(2) and SDIP with EWA	Future 3406 (b)(2) with EWA 6680
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 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 E/I Ratio (post-processed from CALSIM II results), dedicated 500 CFS pumping capacity at Banks in Jul – Sep			Same as Study 3	Same as Study 3

Table 8-3 Assumptions for the Base and Future Studies

	Study 1	Study 2	Study 3	Study 4	Study 4a	Study 5	Study 5a
	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)**	**Future 3406 (b)(2) and SDIP with EWA**	**Future 3406 (b)(2) with EWA 6680**
Debt restrictions			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	Same as Study 3

[a] 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

[b] Presented in attached Table 8-4 –2001 American River Demands (Note that cuts are not predicated on Inflow for the 2001 Demands)

[c] Presented in attached Table 8-5 –2020 American River Demands.

[d] Presented in attached Table 8-4 –2001 American River Demands, but modified with PCWA 35 TAF CVP contract supply diverted at the new American River PCWA Pump Station

[e] Delta diversions include operations of Los Vaqueros Reservoir and represents average annual diversion

[f] Includes modified EBMUD operations of the Mokelumne River

[g] This is implemented only in the PCWA Middle Fork Project releases used in defining the CALSIM II inflows to Folsom Lake

Table 8-4 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**

Table 8-4 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**
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**
Total from the American River	**0**	**50,850**	**0**	**166,335**	**0**	**217,185**
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 from the Sacramento River	**0**	**0**	**0**	**38,665**	**0**	**38,665**
Total Sacramento + American Demands	**0**	**50,850**	**0**	**205,000**	**0**	**255,850**

Table 8-5 2020 American River Demand Assumptions

Location / Purveyor	ALLOCATION TYPE (MAXIMUM)						FUI (Mar - Sep +60 TAF)			Notes
	CVP AG	CVP MI	CVP Settlement / Exchange	Water Rights / Non-CVP / No Cuts	CVP Refuge	Total	>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	a, c, c, k
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	d, e, k
City of Folsom (includes P.L. 101-514)	0	7,000	0	27,000	0	34,000	34,000	34,000	20,000	a, b, c
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	a, c, c, j
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	a, b, c
El Dorado Irrigation District	0	7,550	0	17,000	0	24,550	24,550	24,550	22,550	a, b, c
El Dorado Irrigation District (P.L. 101-514)	0	7,500	0	0	0	7,500	7,500	7,500	0	a, b, c
City of Roseville	0	32,000	0	30,000	0	62,000	54,900	54,900	39,800	a, b, c, j, k
Placer County Water Agency	0	0	0	0	0	0	0	0	0	j
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	a, b, c

Table 8-5 2020 American River Demand Assumptions

Location / Purveyor	ALLOCATION TYPE (MAXIMUM)						FUI (Mar - Sep +60 TAF)			Notes
	CVP AG	CVP MI	CVP Settlement / Exchange	Water Rights / Non-CVP / No Cuts	CVP Refuge	Total	>1600	>950	<400	
South Sacramento County Agriculture (export, SMUD transfer)	0	0	0	0	0	0	0	0	0	a, b, c
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	f, g, h
Arcade Water District	0	0	0	11,200	0	11,200	11,200	11,200	3,500	l
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**	
Total Demands from the American River	**0**	**133,250**	**0**	**342,000**	**0**	**475,250**	**468,150**	**439,150**	**303,550**	
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	h
Sacramento County Water Agency (SMUD transfer)	0	30,000	0	0	0	30,000				i
Sacramento County Water Agency (P.L. 101-514)	0	15,000	0	0	0	15,000				i
EBMUD (export)	0	133,000	0	0	0	133,000				

Table 8-5 2020 American River Demand Assumptions

	ALLOCATION TYPE (MAXIMUM)						FUI (Mar - Sep +60 TAF)			
Location / Purveyor	**CVP AG**	**CVP MI**	**CVP Settlement / Exchange**	**Water Rights / Non-CVP / No Cuts**	**CVP Refuge**	**Total**	**>1600**	**>950**	**<400**	**Notes**
Total Demands from the Sacramento River	**0**	**178,000**	**0**	**34,300**	**0**	**212,300**	**34,300**	**34,300**	**80,600**	
Total Sacramento + American River Demands	**0**	**311,250**	**0**	**376,300**	**0**	**687,550**	**502,450**	**473,450**	**384,150**	

[a] 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.

[b] 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.

[c] 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.

[d] 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.

[e] 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.

[f] 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."

[g] 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."

[h] 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.

i 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.

[j] Water Rights Water provided by releases from PCWA's Middle Fork Project; inputs into upper American River model must be consistent with these assumptions.

[k] Demand requires "Replacement Water" as indicated below

[l] Arcade WD demand modeled as step function: one demand when FUI > 400, another demand when FUI < 400.

Future Level American River Demands

The modeling representation of future total American River water demand is consistent with the Water Forum analysis and portrayal of future water demands. The modeling also includes the Water Forum representation of the Water Forum program for demand reductions in certain dry and critical hydrologic conditions in the American basin. The modeling also includes the Water Forum representation of the Water Forum program for additional releases from the Middle Fork Project to support the Water Forum program. The Water Forum program is proposing these program elements to be part of a water transfer program by the project proponents that would occur in the future and be coordinated to occur at times beneficial to fishery conditions.

The modeling demand logic used in CALSIM analysis has adopted this Water Forum program representation of total American River demand operation dynamics. Therefore, this analysis may over-represent the total water supply available to meet CVP water resource commitments because of the inclusion of the Water Forum demand program and Middle Fork Project operations inherent in current CALSIM logic. Figures 8-3 and 8-4, respectively, show future-level American basin water demand and replacement water release based on Water Forum demand projections.

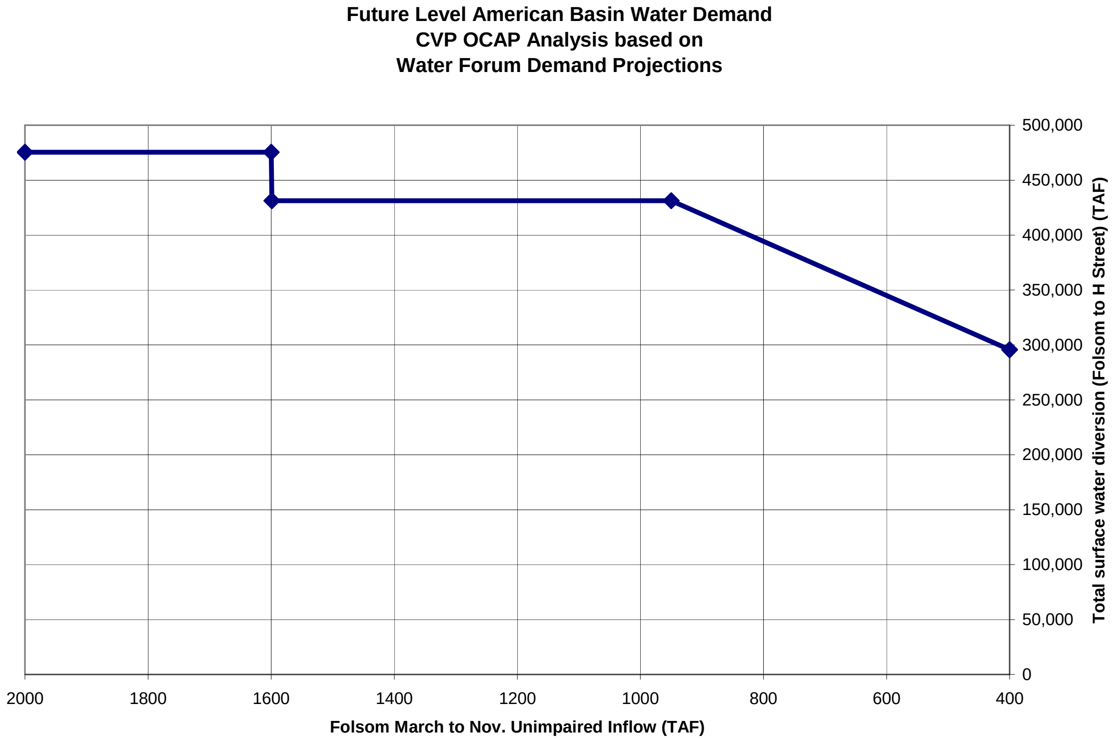

Figure 8–3 Future Level American Basin Water Demand

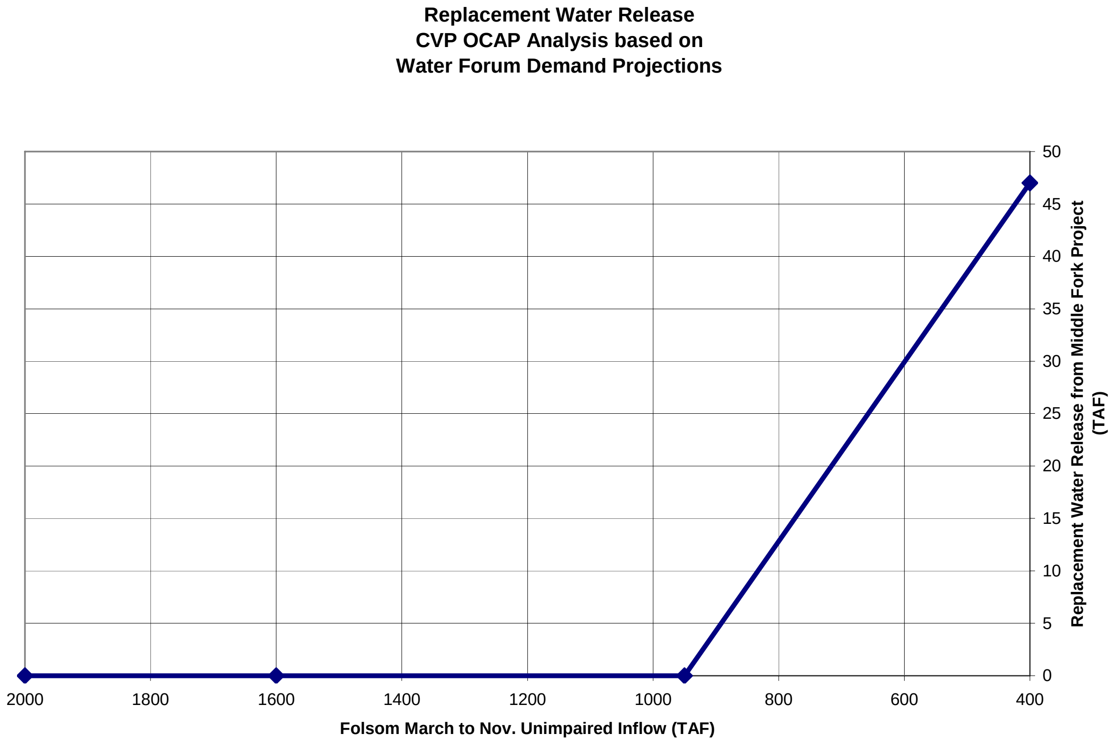

Figure 8–4 Replacement Water Release

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 ensure 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 Programmatic Environmental Impact Statement (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 TCDs 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 Environmental Impact Statement (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 three 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 percents of salmon spawning losses. 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 percent in 24 days at 57°F to 100 percent 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 through December, peaking about mid-November. Winter-run salmon usually spawn in 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 from 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 to avoid exceeding the required downstream temperature target. There is also uncertainty regarding performance characteristics of the Shasta TCD. Because of 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. Because the salmon mortality model operates on a daily time step, a procedure is required to use the monthly temperature model output. The salmon model computes daily temperatures by using 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 Endangered Species Act (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 in-stream 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.

Because 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 8-2 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., WY1928 to WY1934) is shown in Table 8-6 for flows, storages, Delta output, and deliveries. The rest of this section presents results for 3406 CVPIA (b)(2) accounting and EWA. The Formal Consultation effects are in Chapter 9 for the upstream and Chapter 10 for the Delta. Chapter 11 analyzes the differences between the formal and early consultation studies. The results for Early Consultation effects are in Chapters 12 and 13 for the Upstream and Delta results, respectively.

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 Appendices (Appendix F for the Formal Consultation results, and Appendix H for the Early Consultation results). The appendices contain directories of spreadsheets that compare all five studies simulated and directories that contain spreadsheets that directly compare two studies (including month-by-year difference tables). The temperature modeling appendices (Appendix I for Formal Consultation and Appendix J for Early Consultation) include 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 temperature 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 (Appendix H). The results in this appendix derive from post-processing the Future EWA model (Study 5) and show increased use of assets as mentioned in the EWA 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. For example, the end-of-September exceedance charts show the probability that the reservoir was able to carry over 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 the 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 affected by flood and minimum-flow requirements.

Table 8-6 Long-term Averages and 28-34 Averages From Each of the Five Studies

	Study 1: 1997 D1641 w/ b2		**Study 2: Today b(2)**		**Study 3: Today EWA**		**Study 4: Future SDIP**		**Study 4a: Future b(2)**		**Study 5: Future EWA**		**Study 5a: Future EWA 6680**	
	Average	**28-34**	**Average**	**28-34**	**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	1290	647	1289	641	1287	649
Whiskeytown	234	227	234	219	233	219	232	211	232	211	232	211	231	211
Shasta	2705	1595	2663	1476	2659	1471	2532	1372	2549	1361	2529	1341	2546	1353
Oroville	2085	1502	2091	1558	2079	1454	2050	1576	2038	1577	2044	1507	2042	1593
Folsom	545	454	543	448	535	415	504	378	510	378	500	361	510	380
New Melones	1390	910	1390	911	1389	911	1390	910	1391	911	1391	910	1391	910
CVP San Luis	213	296	215	302	231	303	238	320	241	348	245	314	241	315
SWP San Luis	401	318	395	280	355	301	375	305	352	307	302	313	296	297
Total San Luis	614	614	609	581	674	716	614	625	593	655	634	802	593	709
River Flows (cfs)														
Trinity Release	611	473	729	590	726	590	927	648	928	648	928	651	928	648
Clear Creek Tunnel	1054	682	940	565	944	565	749	494	748	496	748	490	748	491
Clear Creek Release	166	104	164	101	163	97	163	96	163	96	163	97	164	100
Keswick Release	8673	5876	8563	5776	8567	5788	8375	5754	8373	5757	8373	5754	8372	5752
Nimbus Release	3477	2401	3478	2402	3477	2393	3228	2181	3228	2181	3227	2184	3227	2179
Mouth of American	3347	2260	3347	2261	3347	2252	3032	1991	3032	1991	3031	1994	3031	1989
Red Bluff Diversion Dam	11251	7457	11147	7372	11150	7382	10981	7399	10978	7402	10977	7401	10974	7398
Wilkins Slough	9176	6142	9090	6056	9098	6067	8930	6048	8915	6051	8925	6047	8914	6046
Feather Low Flow Channel	709	600	709	600	600	600	705	600	704	600	600	600	600	600
Flow Below Thermalito	4177	2505	4177	2503	4177	2510	4176	2528	4176	2520	4175	2519	4175	2503
Feather Flow Below Yuba Mouth	6287	3678	6287	3675	6285	3684	6278	3698	6279	3690	6276	3689	6276	3674
Feather Mouth	7500	4169	7500	4166	7499	4174	7503	4192	7502	4184	7500	4184	7499	4168

Table 8-6 Long-term Averages and 28-34 Averages From Each of the Five Studies

	Study 1: 1997 D1641 w/ b2		Study 2: Today b(2)		Study 3: Today EWA		Study 4: Future SDIP		Study 4a: Future b(2)		Study 5: Future EWA		Study 5a: Future EWA 6680	
	Average	**28-34**	**Average**	**28-34**	**Average**	**28-34**	**Average**	**28-34**	**Average**	**28-34**	**Average**	**28-34**	**Average**	**28-34**
Sac at Freeport	22476	13951	22376	13870	22390	13867	22193	13893	22202	13884	22200	13879	22213	13869
Tulloch Release	604	307	604	307	604	306	604	308	604	307	604	308	604	307
Stanislaus Mouth	892	550	892	550	892	550	892	551	892	551	892	551	892	551
SJR Flow w/o Stanislaus	2866	1567	2865	1566	2866	1566	2866	1569	2865	1569	2867	1569	2866	1570
Flow at Vernalis	3723	2081	3722	2079	3723	2079	3723	2083	3723	2083	3723	2083	3723	2084
Mokelumne	2079	187	2073	181	2060	193	2040	211	2041	220	2025	219	2024	215
Yolo Bypass	878	436	878	436	878	436	881	445	881	445	881	445	881	445
Delta Parameters														
SWP Banks (cfs)	4448	3244	4443	3265	4180	2985	4672	3429	4557	3327	4407	3083	4326	3026
CVP Banks (cfs)	109	59	108	53	180	80	157	45	105	45	202	44	135	50
Tracy (cfs)	3396	2560	3364	2484	3207	2344	3335	2409	3333	2406	3197	2330	3240	2362
Total Banks (cfs)	4557	3303	4551	3318	4499	3262	4828	3474	4662	3373	4751	3344	4549	3238
Cross Valley Pumping (cfs)	109	59	108	53	109	53	107	45	105	45	107	44	105	46
Sac Flow at Freeport (cfs)	22362	13951	22264	13870	22277	13867	22088	13893	22096	13884	22097	13879	22105	13869
Flow at Rio Vista (cfs)	18392	9233	18307	9165	18291	9156	18122	9222	18130	9227	18095	9196	18111	9193
Excess Outflow (cfs)	12002	2705	11929	2686	12110	2783	11406	2650	11610	2789	11561	2727	11771	2843
Required Outflow (cfs)	7716	6510	7721	6501	7750	6609	7773	6514	7745	6481	7825	6641	7783	6587
X2 Position (km)	75.9	80.5	75.9	80.5	75.8	80.2	76.2	80.5	76.1	80.6	76.1	80.2	75.9	80.4
Yolo Bypass (cfs)	2053	187	2047	181	2034	193	2016	211	2016	220	1999	219	1999	215
Mokelumne Flow (cfs)	869	436	869	436	869	436	872	445	872	445	872	445	872	445
SJR + Calaveras Flow (cfs)	3888	2178	3887	2176	3888	2176	3888	2181	3887	2181	3888	2181	3887	2181
Modeled Required	7521	6280	7524	6281	7501	6263	7545	6274	7536	6265	7526	6258	7519	6252

Table 8-6 Long-term Averages and 28-34 Averages From Each of the Five Studies

	Study 1: 1997 D1641 w/ b2		Study 2: Today b(2)		Study 3: Today EWA		Study 4: Future SDIP		Study 4a: Future b(2)		Study 5: Future EWA		Study 5a: Future EWA 6680	
	Average	**28-34**	**Average**	**28-34**	**Average**	**28-34**	**Average**	**28-34**	**Average**	**28-34**	**Average**	**28-34**	**Average**	**28-34**
DO (cfs)														
Flow at Georgiana Slough (cfs)	3803	2684	3790	2674	3792	2673	3767	2677	3768	2676	3768	2675	3769	2674
DXC Flow (cfs)	1740	1701	1734	1693	1749	1712	1731	1684	1731	1682	1748	1708	1741	1699
Flow below DXC (cfs)	16818	9566	16740	9504	16736	9482	16590	9532	16597	9526	16580	9496	16595	9497
North Bay Aqueduct (cfs)	54	37	54	38	54	37	73	54	72	52	74	52	73	51
CCWD (cfs)	171	168	171	168	171	168	218	208	218	208	218	208	218	208
Total Inflow (cfs)	29171	16752	29067	16664	29068	16672	28863	16730	28870	16730	28855	16724	28864	16710
Total Outflow (cfs)	11406	8458	11409	8457	11386	8439	11430	8455	19354	9270	11412	8438	19554	9430
Allocations (%)	**Average**	**29-34[a]**	**Average**	**29-34[a]**	**Average**	**29-34[a]**	**Average**	**29-34[a]**	**Average**	**29-34[a]**	**Average**	**29-34[a]**	**Average**	**29-34[a]**
CVP														
North of Delta														
Agriculture	73%	15%	71%	12%	71%	11%	67%	11%	67%	10%	67%	10%	68%	11%
M&I	89%	64%	88%	61%	88%	60%	87%	60%	87%	59%	87%	59%	87%	60%
South of Delta														
Agriculture	61%	15%	60%	12%	61%	11%	61%	11%	58%	10%	61%	10%	59%	11%
M&I	87%	64%	86%	61%	87%	60%	86%	60%	86%	59%	86%	59%	86%	60%
SWP														
Agriculture	80%	39%	80%	40%	80%	37%	80%	42%	79%	41%	80%	40%	79%	39%
M&I (non-MWD)	84%	44%	84%	45%	84%	42%	82%	44%	82%	43%	83%	42%	82%	41%
Metropolitan Water District	81%	39%	81%	41%	81%	38%	80%	43%	79%	42%	81%	41%	80%	39%
Deliveries (TAF)	**Average**	**29-34[a]**	**Average**	**29-34[a]**	**Average**	**29-34[a]**	**Average**	**29-34[a]**	**Average**	**29-34[a]**	**Average**	**29-34[a]**	**Average**	**29-34[a]**
CVP														
North of Delta														
Agriculture	246	55	240	43	240	40	237	39	238	37	238	37	240	40
Settlement	1831	1747	1832	1747	1832	1747	1876	1749	1876	1749	1876	1751	1875	1749

Table 8-6 Long-term Averages and 28-34 Averages From Each of the Five Studies

	Study 1: 1997 D1641 w/ b2		Study 2: Today b(2)		Study 3: Today EWA		Study 4: Future SDIP		Study 4a: Future b(2)		Study 5: Future EWA		Study 5a: Future EWA 6680	
	Average	**28-34**	**Average**	**28-34**	**Average**	**28-34**	**Average**	**28-34**	**Average**	**28-34**	**Average**	**28-34**	**Average**	**28-34**
Contracts														
M&I	30	28	30	27	30	27	38	41	37	41	38	41	37	41
Refuge	105	90	105	90	105	90	105	89	105	89	105	90	105	89
Total	**2212**	**1919**	**2208**	**1907**	**2207**	**1905**	**2256**	**1918**	**2256**	**1916**	**2257**	**1919**	**2259**	**1919**
South of Delta														
Agriculture	1102	279	1079	217	1110	206	1095	195	1056	187	1108	185	1073	198
Exchange	847	736	847	736	847	736	847	736	847	736	847	736	847	736
M&I	123	92	122	87	124	86	123	86	122	85	123	85	123	86
Refuge	280	240	280	240	280	240	280	240	280	240	280	240	280	240
Total [b]	**2536**	**1530**	**2512**	**1464**	**2545**	**1451**	**2528**	**1440**	**2489**	**1431**	**2541**	**1429**	**2507**	**1443**
SWP														
Metropolitan Water District	1319	759	1320	782	1317	730	1522	832	1507	807	1532	792	1514	768
Agriculture	885	434	885	447	708	338	877	475	868	461	708	373	696	360
M&I (non-MWD)	777	372	777	383	777	358	778	414	771	401	785	394	776	382
Article 21	175	141	170	131	168	168	152	122	100	100	138	145	94	124
Water Rights	185	185	185	185	185	185	185	185	185	185	185	185	185	185
Total [c]	**3045**	**1630**	**3047**	**1676**	**2867**	**1490**	**3242**	**1786**	**3211**	**1733**	**3090**	**1623**	**3051**	**1574**

[a] Represents 1929 - 1934 Delivery Years, Mar - Feb for CVP and Jan - Dec for SWP

[b] Total includes canal losses due to evaporation

[c] 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.

Table 8-7 and Table 8-8 show that the average annual cost of (b)(2) water used increases from 735 taf annually to 743 taf annually on a long-term, average basis, with most of the increases occurring during the October–January period (see Figure 8–7 and Figure 8–8). The probability of exceeding the 200 taf target during the October–January 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 a result of the model taking high-cost actions at Nimbus and Keswick before the accounting algorithms can reduce costs for this period. Another reason for high costs during this period is Delta salinity requirements during Dry and Critical years in the WQCP accounting.

Annual (b)(2)-modeled costs exceed their allocated amount by 54 percent in the Today (b)(2) run and 51 percent in the Future SDIP run (Figure 8–5 and Figure 8–6). The annual costs that exceed the allocated amount of (b)(2) water available generally occur during years when there is a combination of high release costs because of X2 Roe Island requirements, high VAMP costs for the April 15 to May 15 export curtailments (triggered in every year of simulation), and when payback pumping costs in the late summer are not anticipated. CALSIM II also does not use any forecasting algorithm for overall (b)(2) costs. This also results in over- and under-utilization of the allocated amount of (b)(2) water. The years when the (b)(2) costs are less than the allocated amount are generally Wet years, because flood releases are nearly identical between the D1485 baseline and (b)(2) annual simulations, and VAMP export curtailments are up to the 2:1 ratio when non-VAMP flows are greater than 8,600 cfs.

Table 8-9 shows the average required costs for a (b)(2) export action and what the (b)(2) operation was actually able to support with the water available in the account and anticipated WQCP costs for both the Today (b)(2) and Future SDIP studies. The ability of (b)(2) water to support various actions decreases in the Future SDIP because of increased release costs. The Above and Below Normal years are more costly than Dry or Critical years because of full VAMP restrictions and the ability to pump more water in the D1485 baseline.

Table 8-10 displays the percentage of times that the simulated actions were triggered under the assumptions for taking an action. Reduction in the percentage of times that the releases were reduced is a result of reduction in upstream storages in the Future SDIP study. Reduction in percentage of times that the May Shoulder and June Ramping are triggered occurs from increased release metric costs in the Future SDIP study.

Table 8-7 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 8-8 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

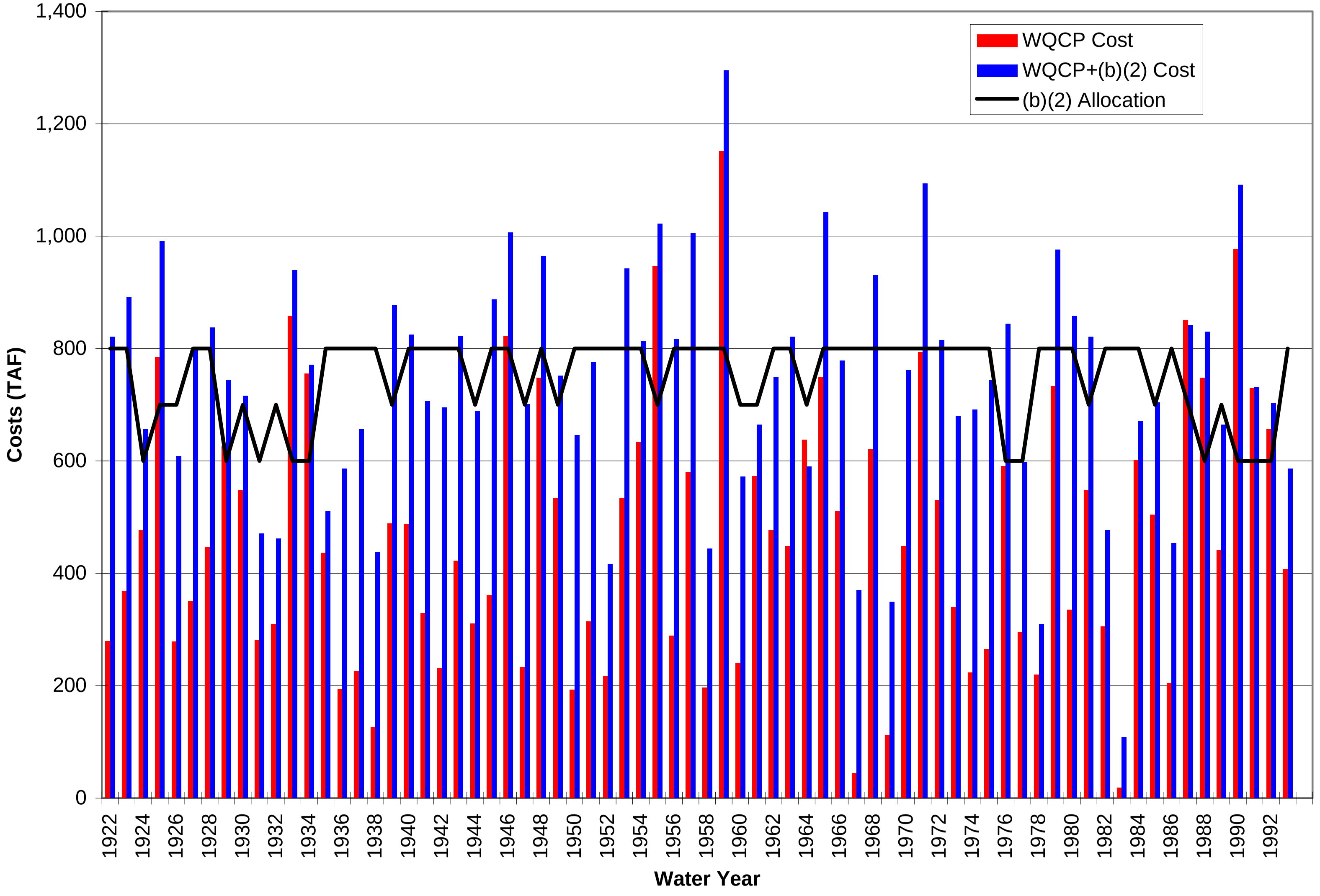

Figure 8–5 Today (b)(2) Total Annual WQCP and Total (b)(2) Costs

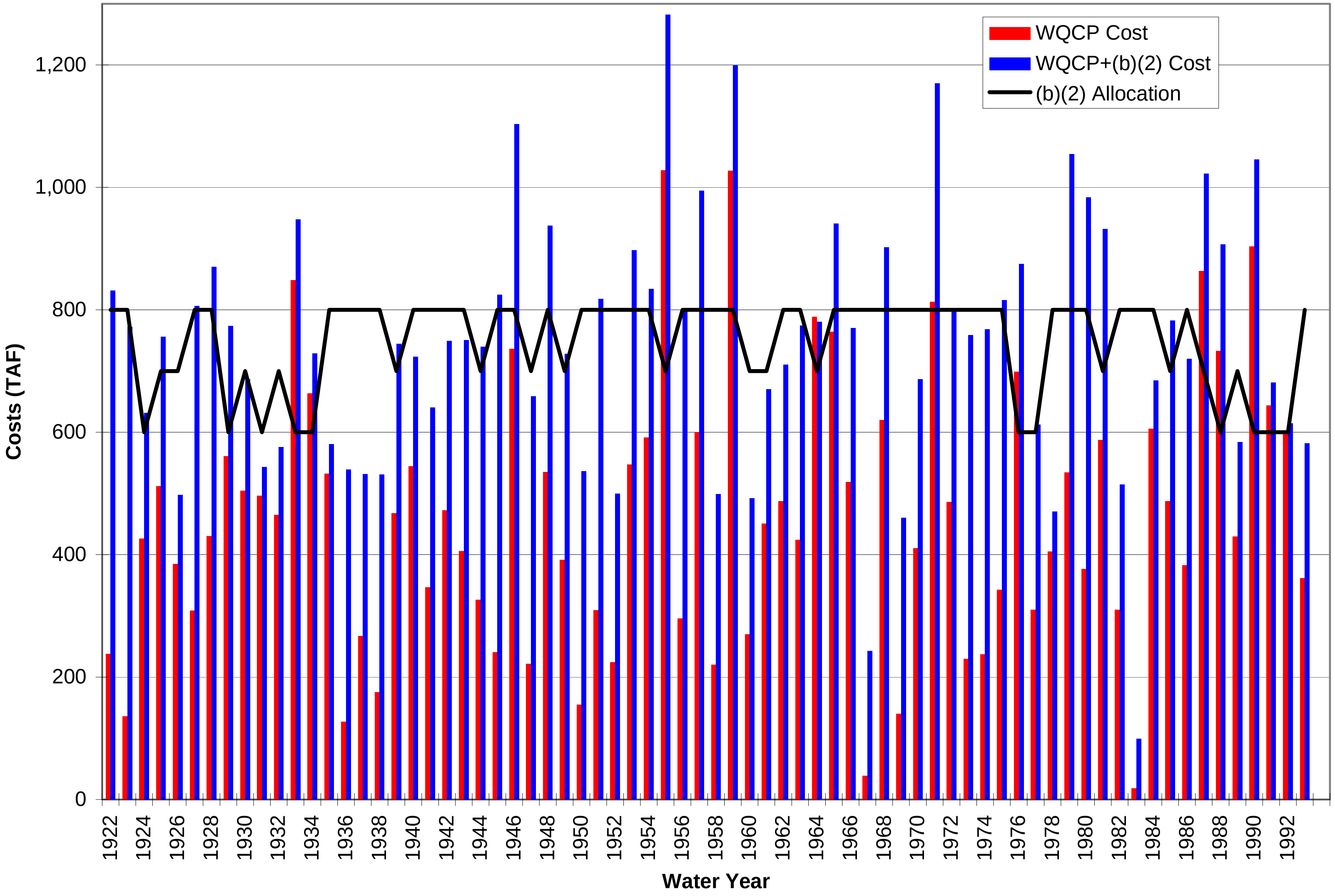

Figure 8–6 Future SDIP Total Annual WQCP and Total (b)(2) Costs

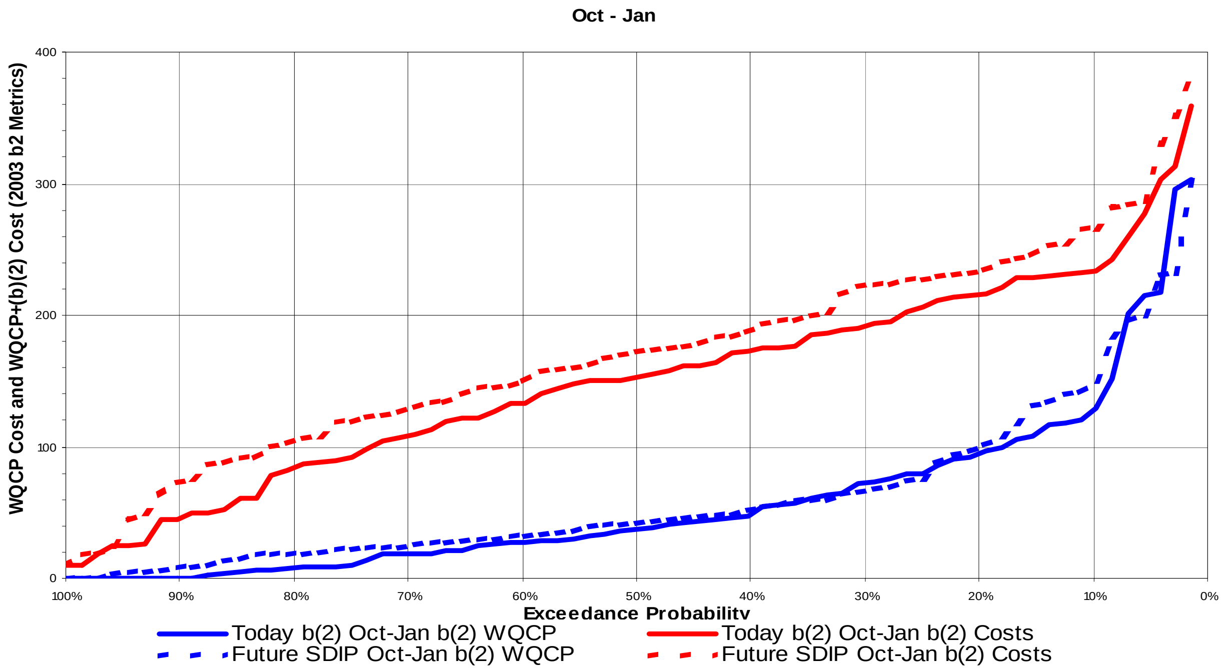

Figure 8–7 Oct – Jan WQCP and Total (b)(2) Costs Probability of Exceedance

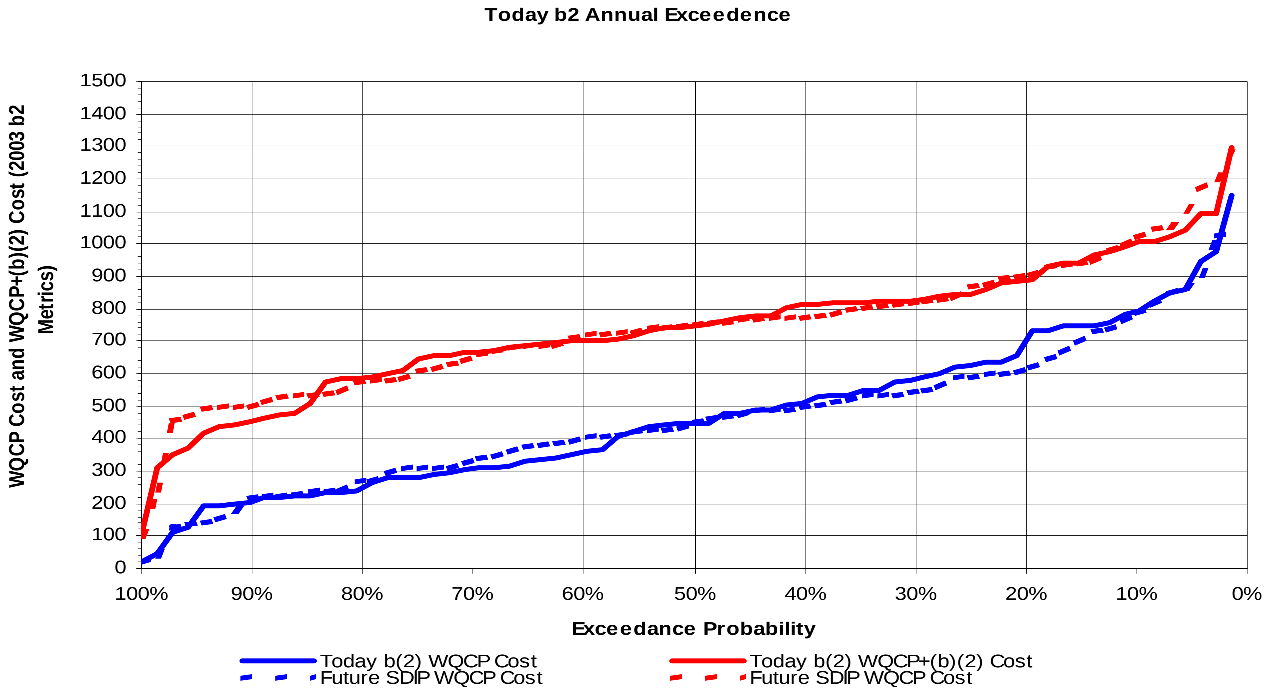

Figure 8–8 Annual WQCP and Total (b)(2) Costs Probability of Exceedance

Table 8-9 Total (b)(2) Water Requested for Export Actions Versus Amount of (b)(2) Water Used

	Total (b)(2) Water Requested			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 8-10 Percent That 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 8–9, first as the sum 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, 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’s 40-30-30 index was used to classify and sort years. Average annual expenditures by year type are listed in Table 8-11. 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 8,500 Banks is used more, 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 SOD deliveries, based on a long-term annual average, in Future EWA relative to Today EWA (Table 8-12).

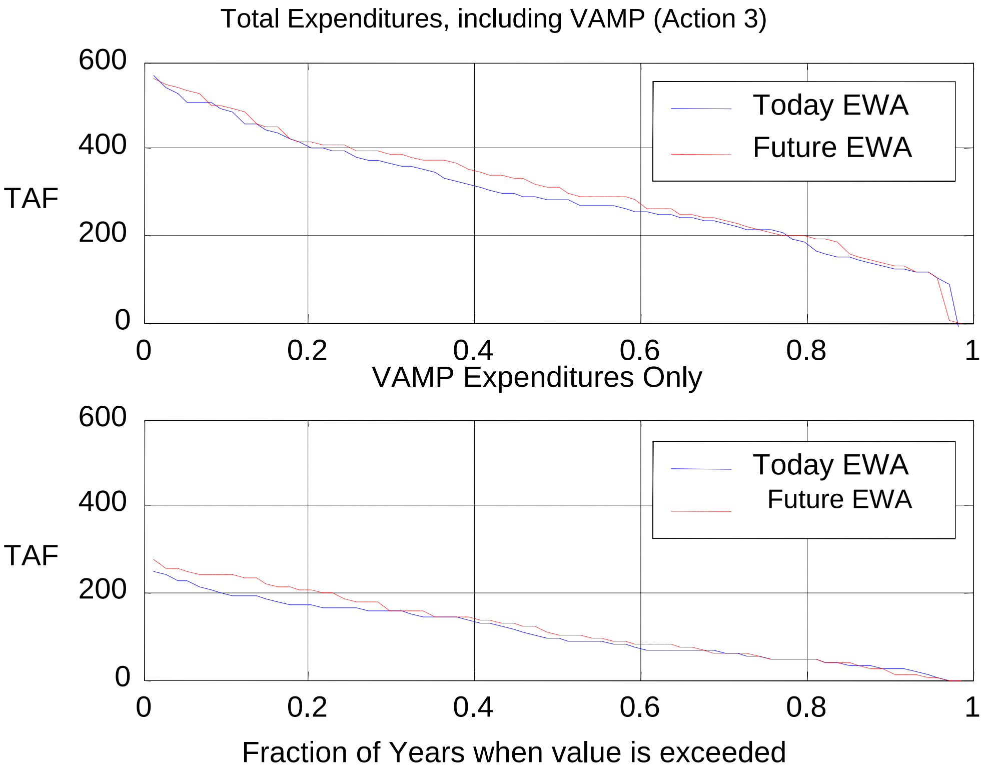

Figure 8–9 – **Annual EWA Expenditures Simulated by CALSIM II, measured in terms of export reductions from exports under the EWA Regulatory Baseline (i.e., Step 4 of Figure 8-1) relative to exports with EWA operations (i.e., Step 5 of Figure 8-1).**

Table 8-11 – **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 of 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 it occurs. Upon assessment, that debt is to be repaid in full through dedication of an 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 withdrawal that month). Instances when SOD delivery debt could not be repaid in full can be noted through post-simulation analysis of CALSIM II results. Instances of delivery debt not being immediately repaid only occurred for CVP debt in 1943 of the Future EWA study (Table 8-12). Levels of unpaid debt are very minor and within CALSIM II margins of 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 nearly balanced.

Table 8-12 – 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 to mitigate the impacts of EWA actions is the allowance for carryover debt. In CALSIM II modeling, because of the model structure depicted on Figure 8–1, the annual interruption of the simulated EWA operational baseline necessitates special measures to account 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 rollover of new debt into the carryover debt account occurs in November of Step 5 (Figure 8–9). Results on carryover debt conditions at CVP/SWP San Luis are shown on Figure 8–10 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: at least 50,000 af of carryover debt will persist for more than 1 year in 20 percent of the 73 simulation years, and at least 100,000 af will persist for more than 1 year in 10 percent of the 73 years. Extreme amounts of carryover debt persisting for more than 1 year are higher in Future EWA than in Today EWA.

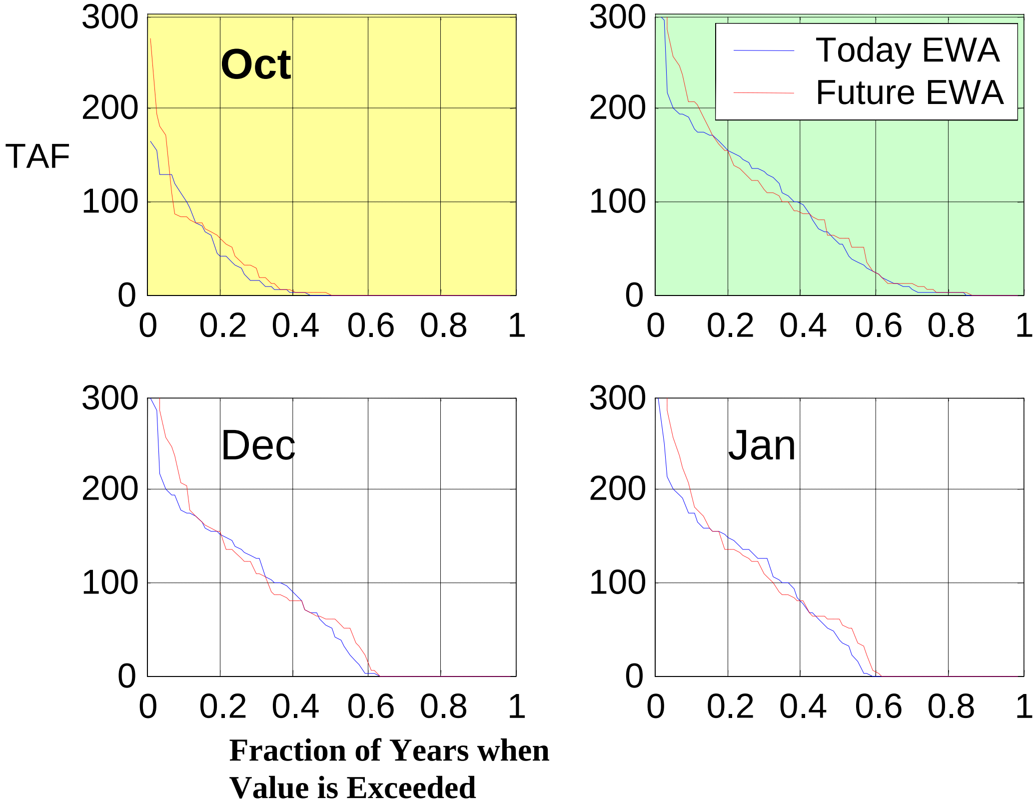

Figure 8–10– Combined Carryover Debt at CVP and SWP San Luis, Simulated in CALSIM II, at the End (Oct) and Start (Nov) of the Carryover Debt Assessment Year

The comparative ranges of acquired EWA assets under Today EWA and Future EWA are summarized on Figure 8–11. 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 8,500 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 a dedicated 500-cfs conveyance capacity at Banks during July-September, this capacity is still vulnerable to interruption by 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. Regarding 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 percent 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 percent, 20 percent, and 10 percent of the years, respectively.

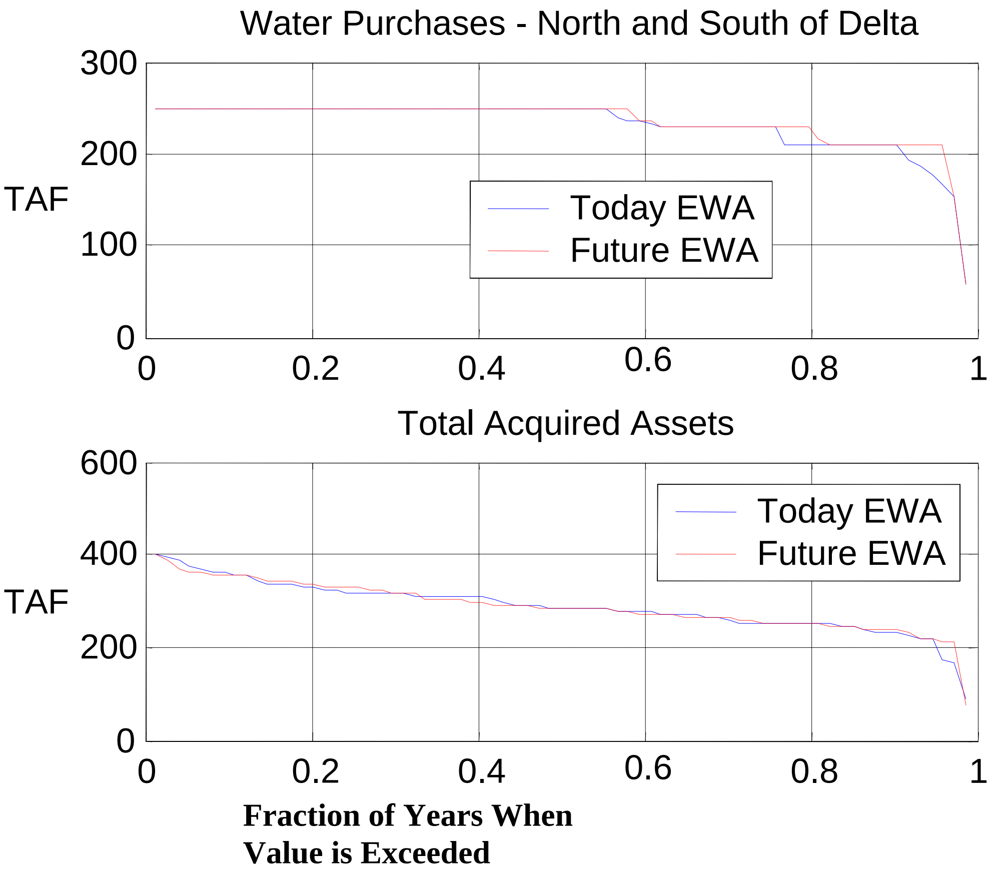

Figure 8–11 – Annual EWA Assets Simulated in CALSIM II. "Total Acquired Assets" includes Water Purchases and operational assets (i.e., EWA acquisition of 50 percent of SWP gains from B2 releases, EWA conveyance of Delta Surplus flows using 50 percent of JPOD capacity or summer dedicated capacity, EWA 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 to trigger the use of this tool under the spill conditions that were outlined earlier. Also note that there is a semantics difference between what is called "spill" in CALSIM II and what is 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 does not 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 8–12. 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.

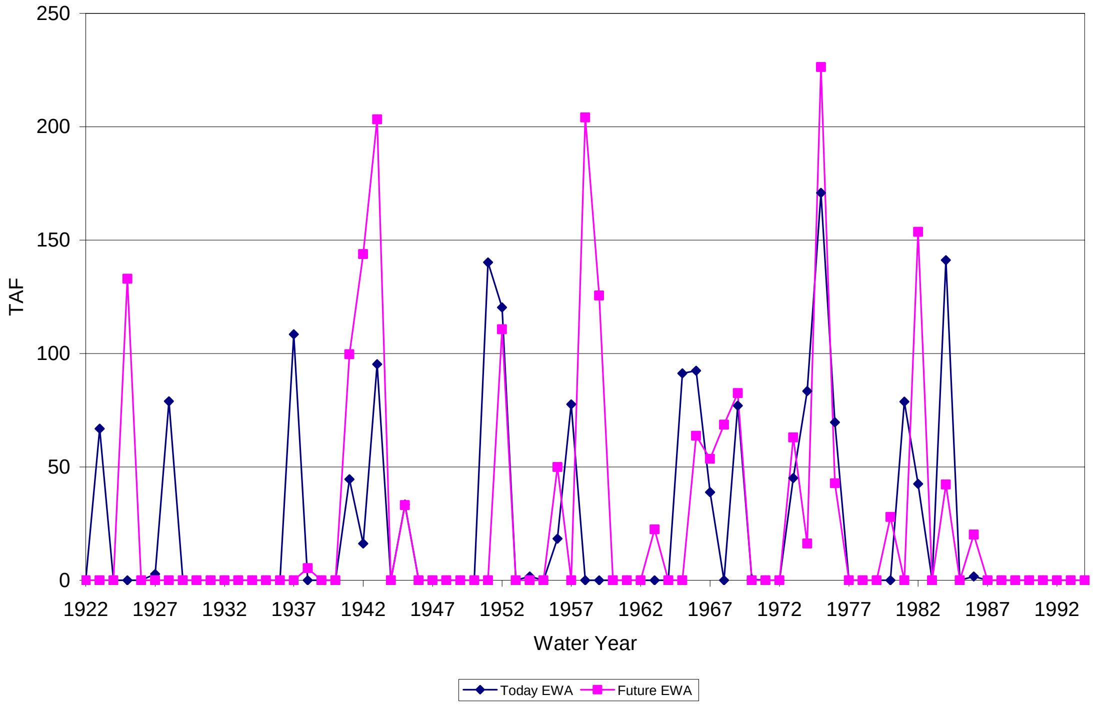

Figure 8–12 – **Annual Carryover-debt Spilling at SWP San Luis, Simulated in CALSIM II.**

Action-specific expenditures for Winter Export Reductions are expected to be 50,000 af for each month in which they are implemented, according to modeling assumptions. Generally, this is the case, as indicated by simulated export reductions measured between Step 4 and Step 5 in both the Today EWA and Future EWA studies (Figure 8–13). The action is always taken in December and January, 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 percent of the years).

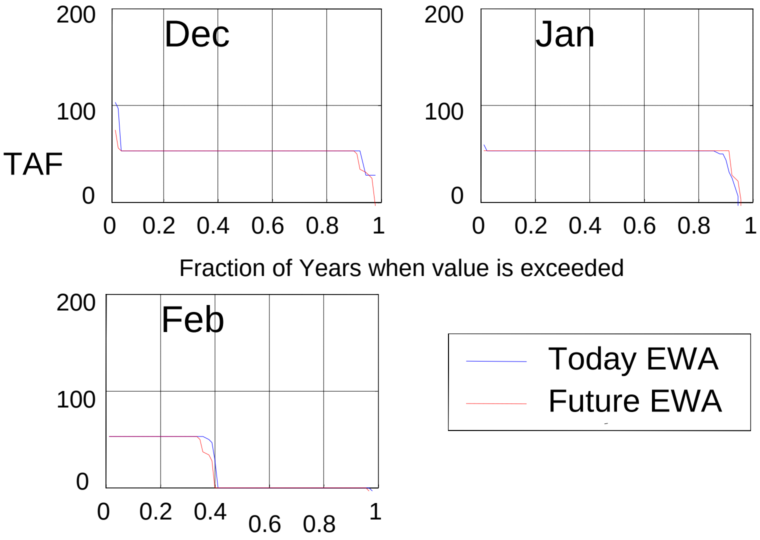

Figure 8–13– Simulated Export Reductions Associated with Taking EWA Action 2 (i.e., Winter Export Reductions).

Expectations for spring actions expenditures are more difficult to predict 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, but 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 compared to the Today EWA study (Figure 8–14 through Figure 8–16). Moreover, the frequency of implementing June export reductions (i.e., EWA Action 6, Figure 8–16) is slightly less in Future EWA than in Today EWA. It appears that in Future EWA, more debt is developed leading up to June in some years compared to operations under Today EWA, causing the June action to not be triggered because it is predicated on debt conditions. The fact that more debt can develop by June under Future EWA than Today EWA seems to be linked to operation of 8,500 Banks and the higher average annual deliveries being made to SWP SOD water users in Future EWA than in Today EWA (Table 8-6).

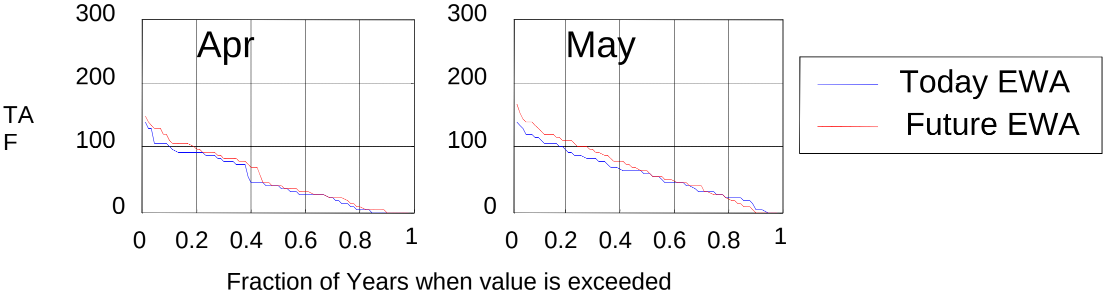

Figure 8–14 – Simulated Export Reductions Associated with Taking EWA Action 3 (i.e., VAMP-related restrictions).

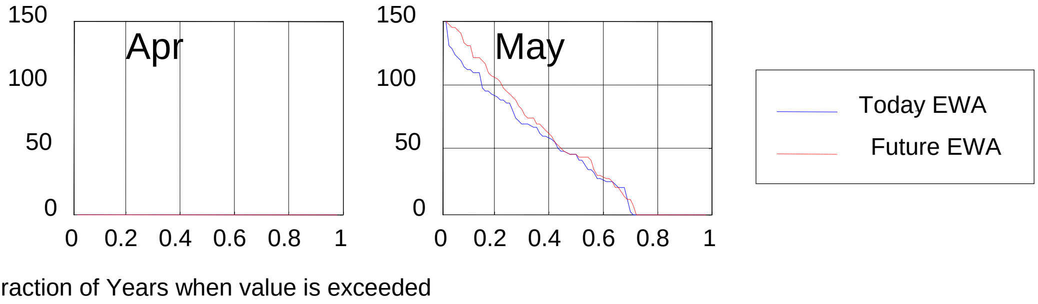

Figure 8–15 – **Simulated Export Reductions Associated with Taking EWA Action 5 (i.e., extension of VAMP-related restrictions into May 16–May 31 (i.e., the May Shoulder)).**

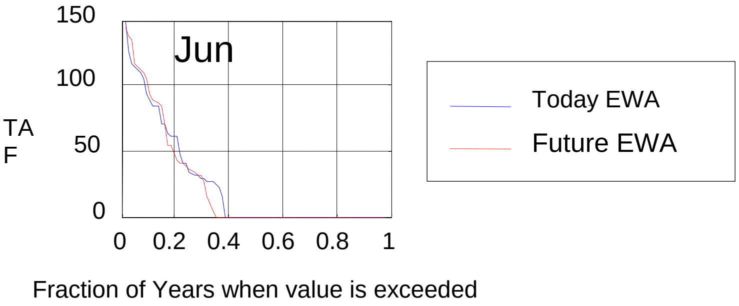

Figure 8–16 – Simulated Export Reductions Associated with Taking EWA Action 6 (i.e., representation of June “ramping” from May Shoulder restriction to June Export-to-Inflow restriction).

Post-processed EWA Results

The results in this section are from the EWA spreadsheet 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 8–17 for assets modeled). Like CALSIM II, the model can be used to describe annual EWA operations. However, the model provides many more assumptions on asset source and 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 are shown in Table 8-13.

Figure 8–18 shows the time series of annual debt status for the 73-year analysis. Simulated EWA operations led 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 8–19 shows annual pumping expenditures. Figure 8–20 show the annual costs in dollars for the EWA program. For more detailed results and assumptions about the model, see the EWA Model for OCAP appendix.

Table 8-13. Annual EWA Expenditures Targets by Water Year Type

40-30-30 Index	Annual Cost
Wet	430,000 af
Above Normal	490,000 af
Below Normal	400,000 af
Dry	300,000 af
Critical	250,000 af

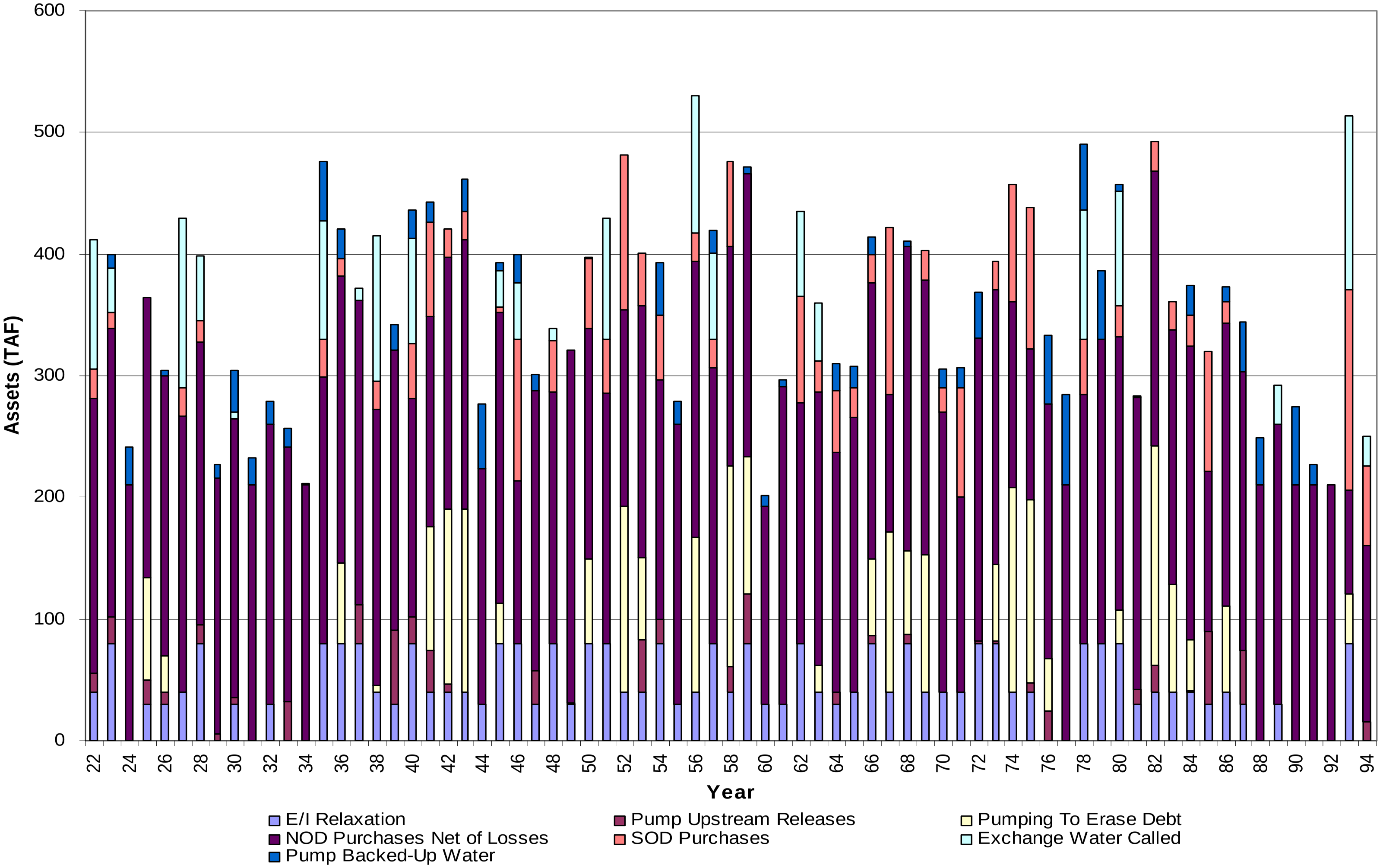

Figure 8–17 EWA Assets by Water Year

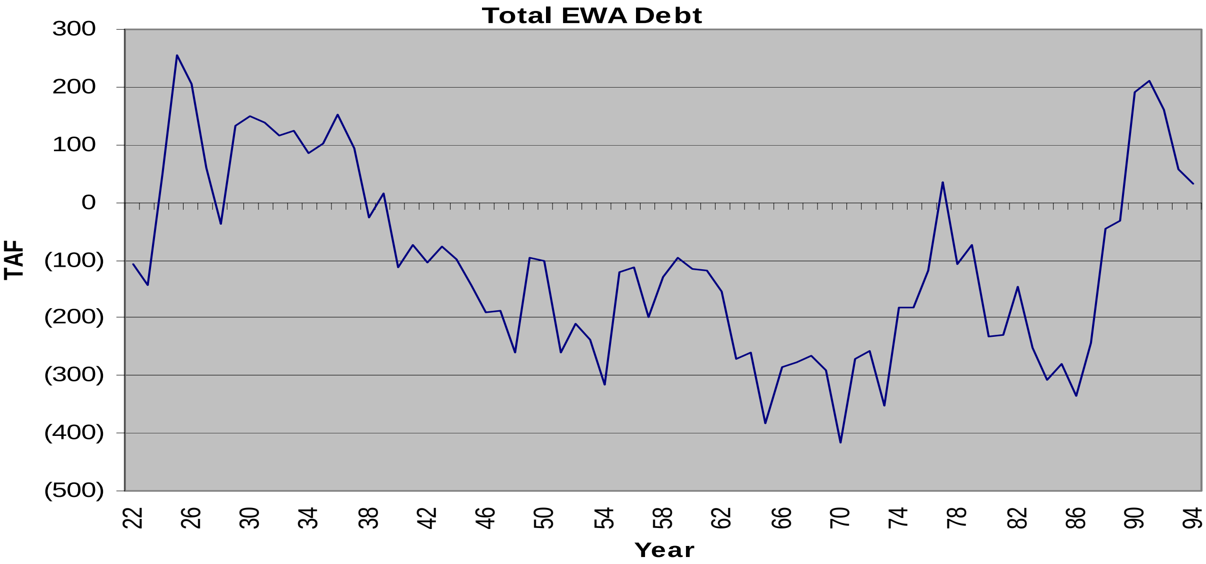

Figure 8–18 Total EWA Debt Balance by Water Year

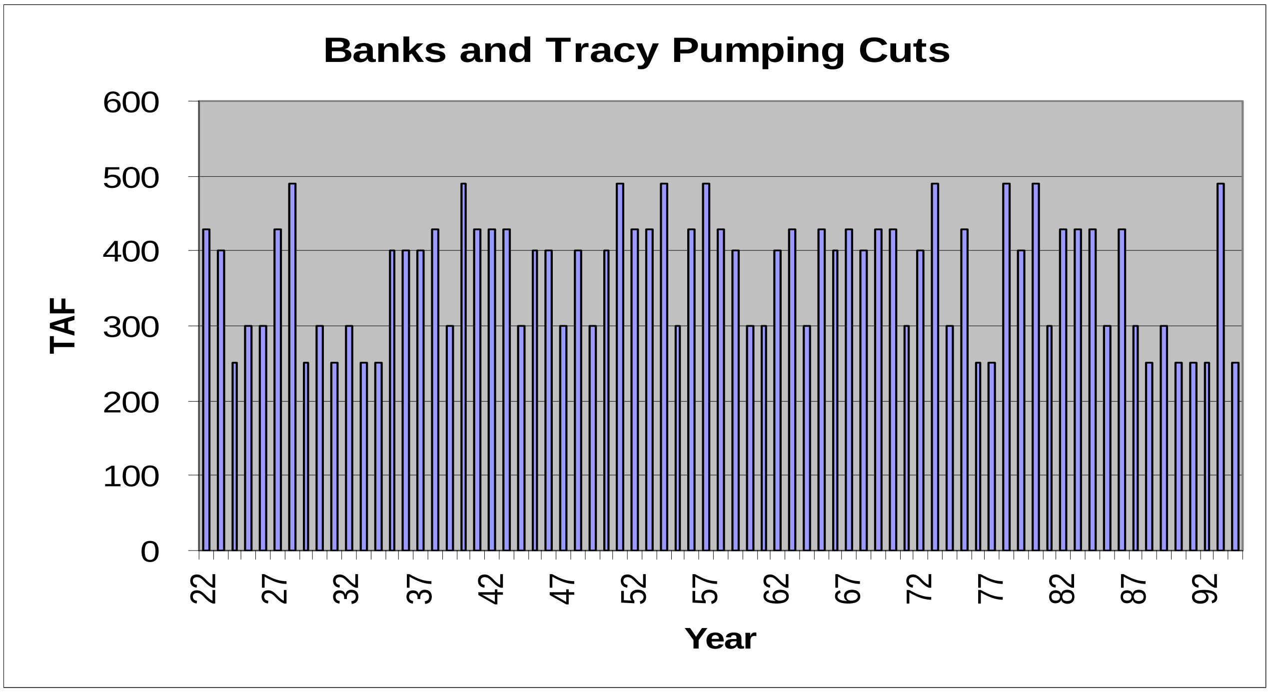

Figure 8–19 Banks and Tracy Cuts

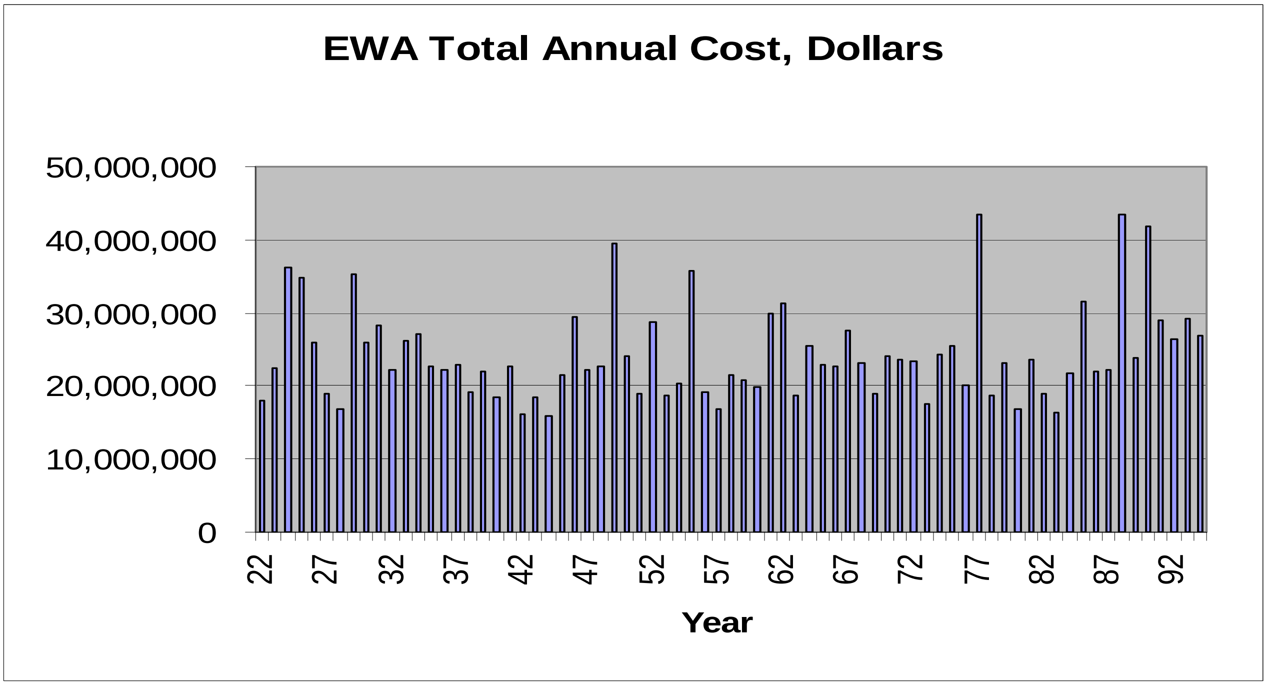

Figure 8–20 Total Annual Cost of EWA by Water Year

Conclusions

The main reduction in Shasta Storage are attributable to the decrease in imports from the Trinity through Spring Creek and Clear Creek Tunnels, which is caused from increased flow targets for the Trinity River. Trinity Reservoir storage decreases result from increased flow targets to the Trinity River.

Decreases in Folsom Lake storage levels are related to increased demands associated with changes in the LOD along the American River. LOD would include buildout of the water rights and water service contracts. The operation of the American River, specifically operations for the in-stream 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.

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 SOD demands. Oroville does have reduced carryover storage in the Wet through Below Normal years because of a more aggressive allocation curve and increased SOD demands but is less aggressive in the drier years because of reduced carryover storage.

The Stanislaus River shows no major impacts among 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 8,500 cfs at Banks allows for more excess outflow to be pumped from the Delta. 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 demonstrates the following:

- The inability of CALSIM II to completely capture the adaptive management process that occurs at least weekly in the B2IT Meetings.
- Over-spending demonstrates a need for CALSIM II to have improved capability to forecast 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 does not represent 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. Simulated EWA operations are based on assumptions that do not perfectly match the considerations affecting real EWAT operations, as shown in the following:

- 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 8–9), which necessitates split accounting for new and carryover debt; EWAT's procedures for tracking multiple operational baselines do not get interrupted annually like those of CALSIM II and, therefore, they can describe debt without the split accounting.
- CALSIM II represents action possibilities (especially during winter and June) as many different monthly 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 – Formal Consultation

This chapter focuses on the Central Valley Project (CVP) and State Water Project (SWP) project operations considered in the formal consultation and how the 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 F and Temperature Modeling Appendix I, 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

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 to increases in Trinity River minimum required in-stream flows. Figure 9–1 shows the chronology of Trinity storage from October 1921 through September 1993. Figure 9–2 shows the end-of-September exceedance chart for Trinity.

Figure 9–2 shows that the increased flows in Study 4a and Study 5a mainly impact the Above Normal and Below Normal years and not the Wet hydrologic years or the Dry and Critical years when compared to Study 2 and Study 3. In Study 1, with the minimum flow requirement at 340,000 acre-feet per year (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 (Figure 9–4 through 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 4a and 5.

Table 9–1. Long-term Average Annual Impacts to the Trinity River System

Differences (in thousand acre-feet [taf])	Study 2 - Study 1	Study 3 - Study 1	Study 5a - Study 1	Study 4a - Study 2	Study 5a - Study 3
Trinity EOS	-76	-83	-130	-52	-48
Annual Lewiston Release	86	83	230	144	146
Annual Clear Creek Tunnel	-82	-80	-222	-139	-142

Table 9–2. 1928 - 1934 Average Annual Impacts to the Trinity River System

Differences (in thousand acre-feet [taf])	Study 2 - Study 1	Study 3 - Study 1	Study 5a - Study 1	Study 4a - Study 2	Study 5a - Study 3
Trinity EOS	-49	-69	-103	-55	-33
Annual Lewiston Release	85	85	127	42	42
Annual Clear Creek Tunnel	-85	-85	-138	-50	-53

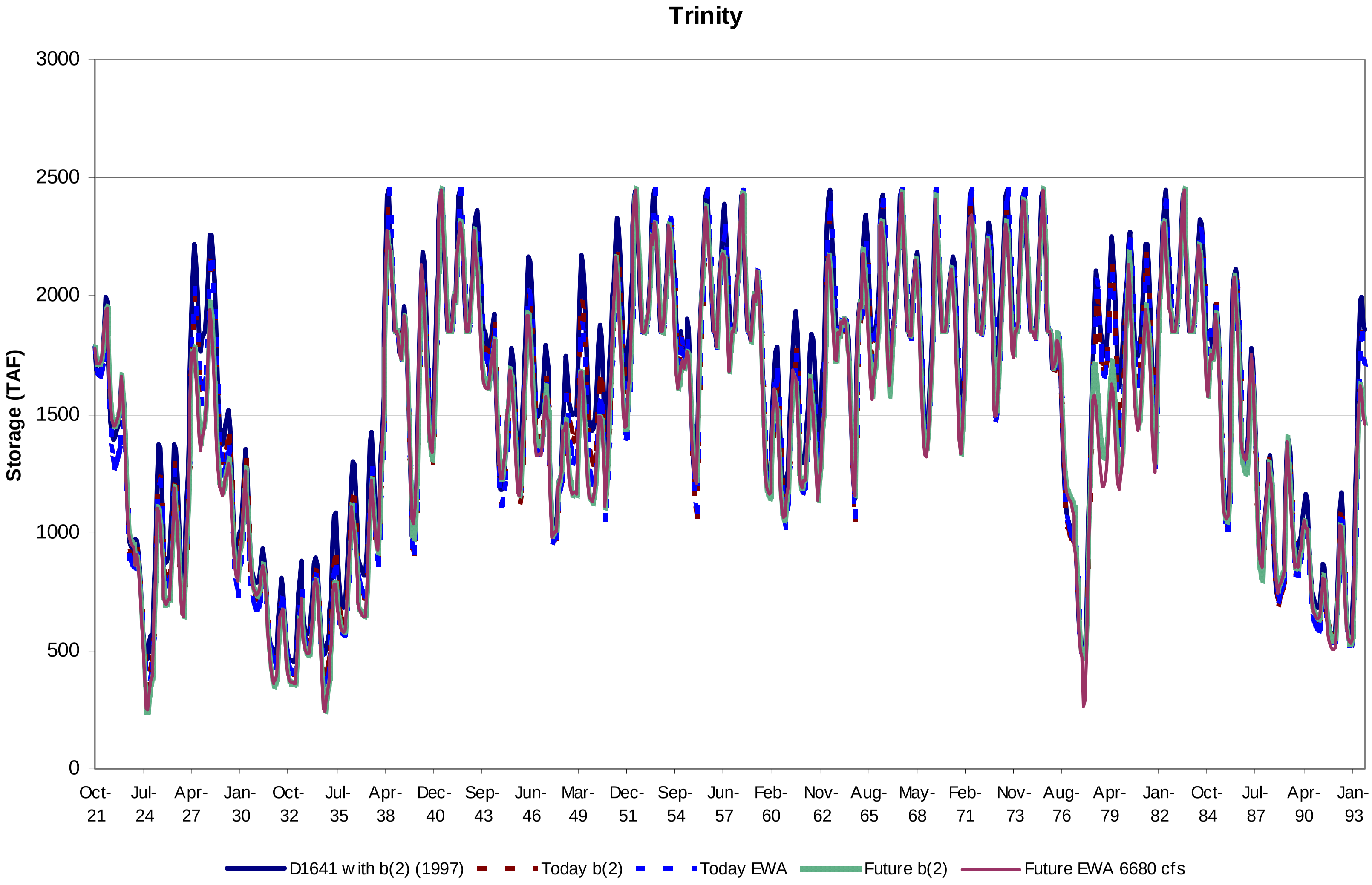


Figure 9–1 Chronology of Trinity Storage Water Year 1922 - 1993

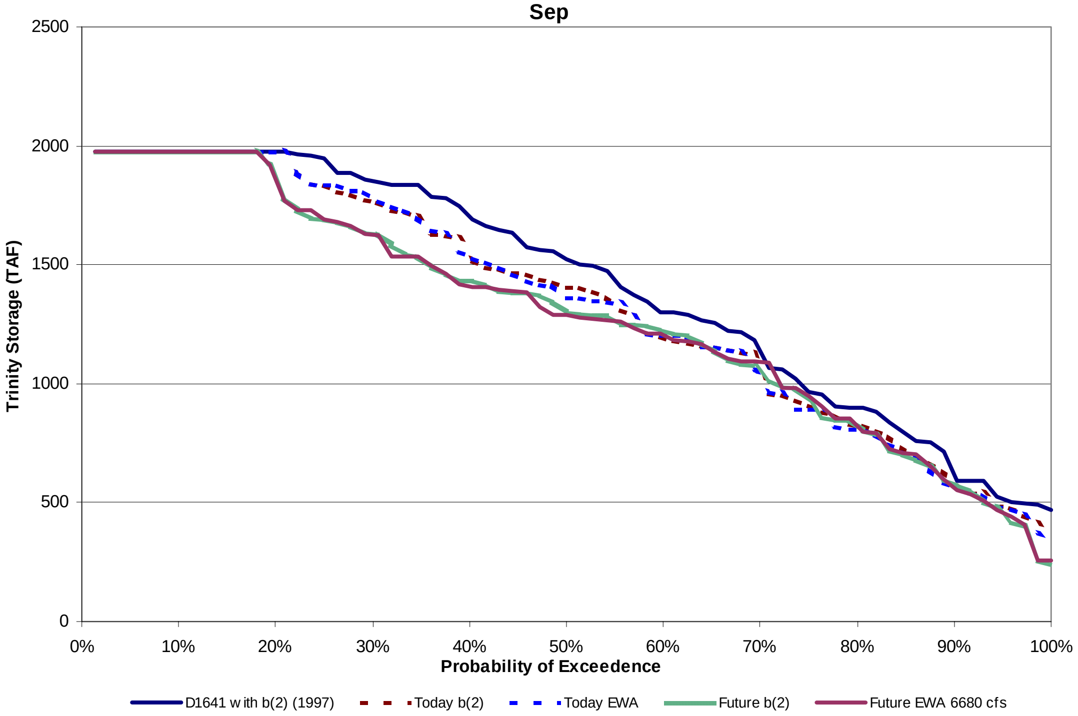


Figure 9–2 Trinity Reservoir End of September Exceedance

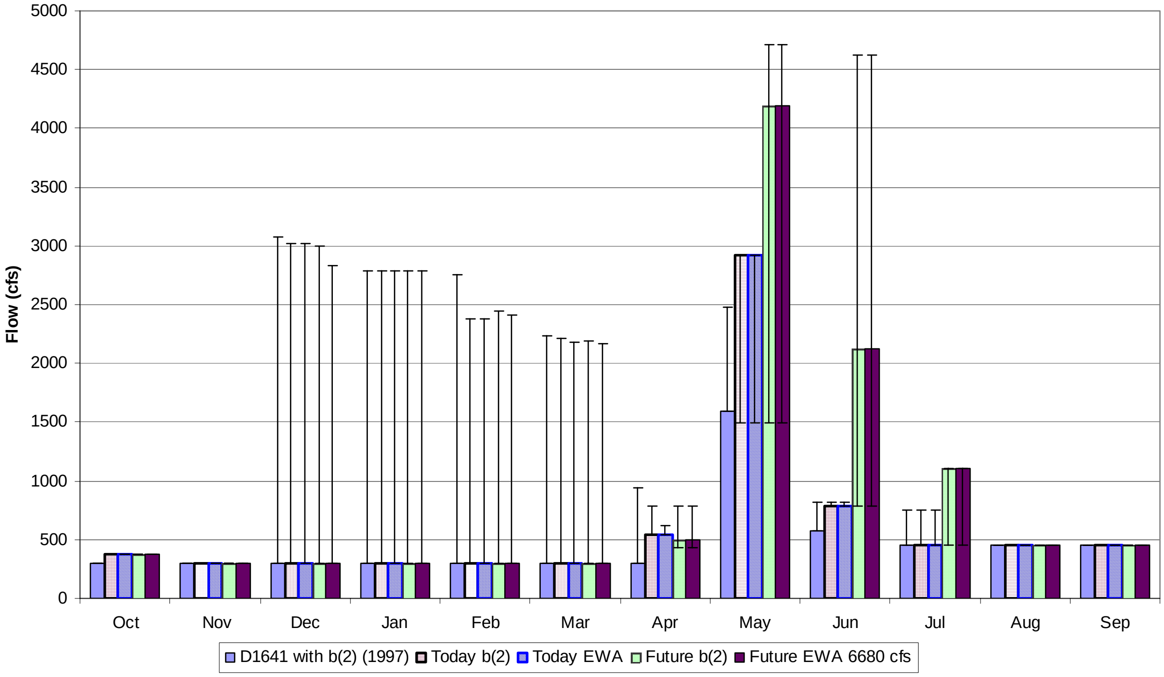


Figure 9–3 Lewiston 50th Percentile Monthly Releases with the 5th and 95th as the Bars

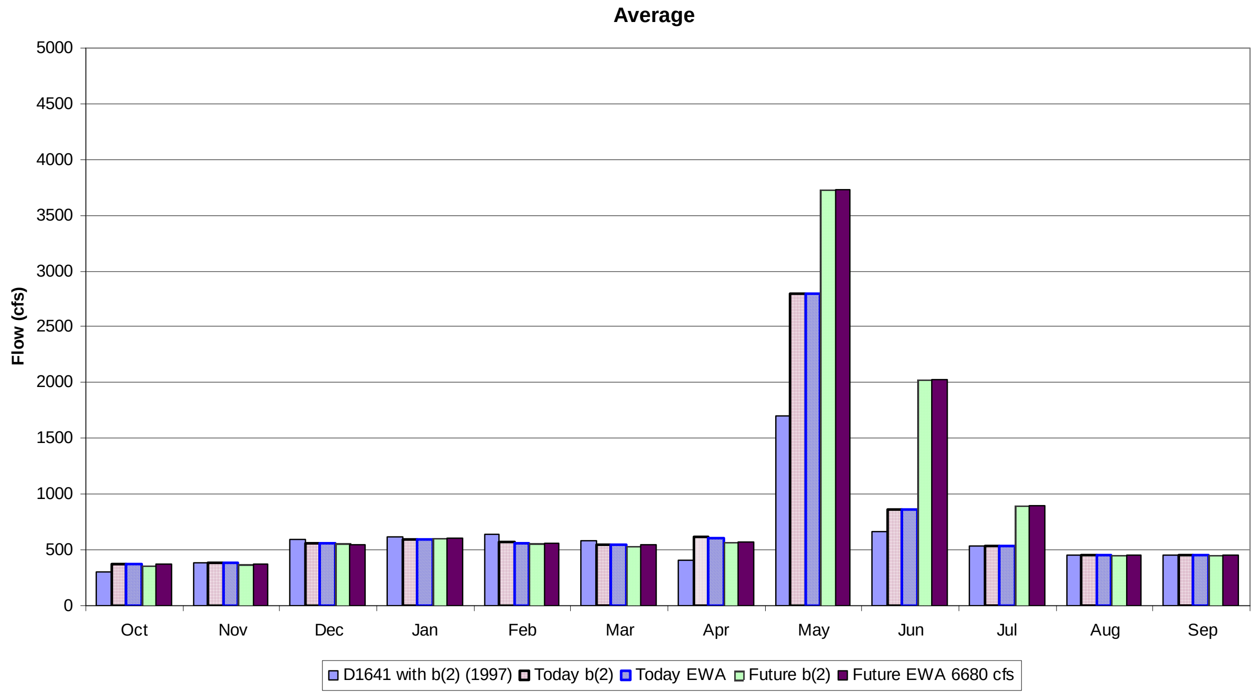


Figure 9–4 Average Monthly Releases to the Trinity from Lewiston

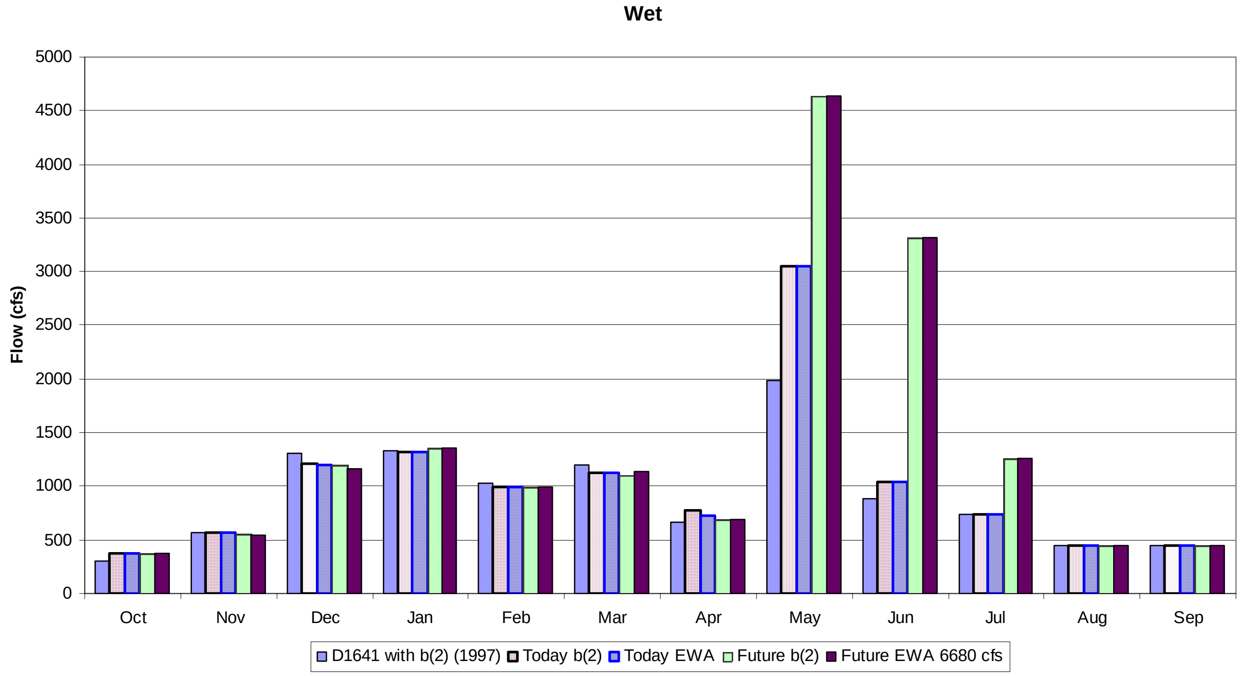


Figure 9–5 Average Wet Year (40-30-30 Classification) Monthly Releases to the Trinity

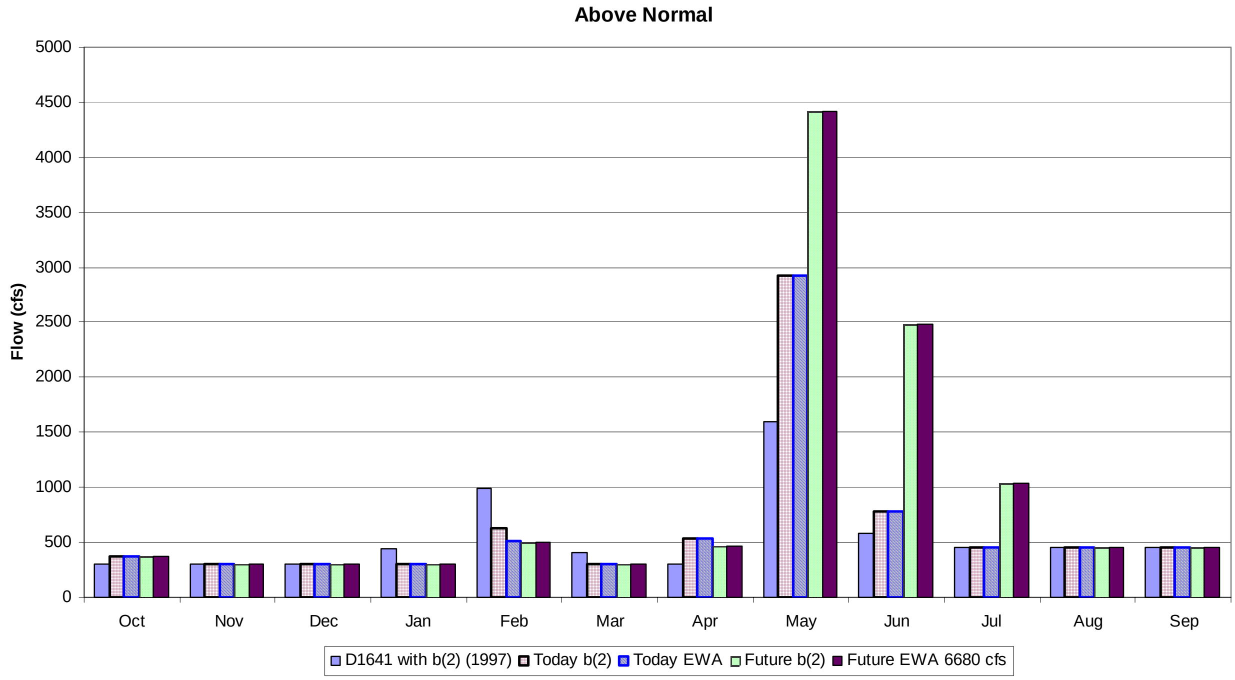


Figure 9–6 Average Above-normal Year (40-30-30 Classification) Monthly Releases to the Trinity

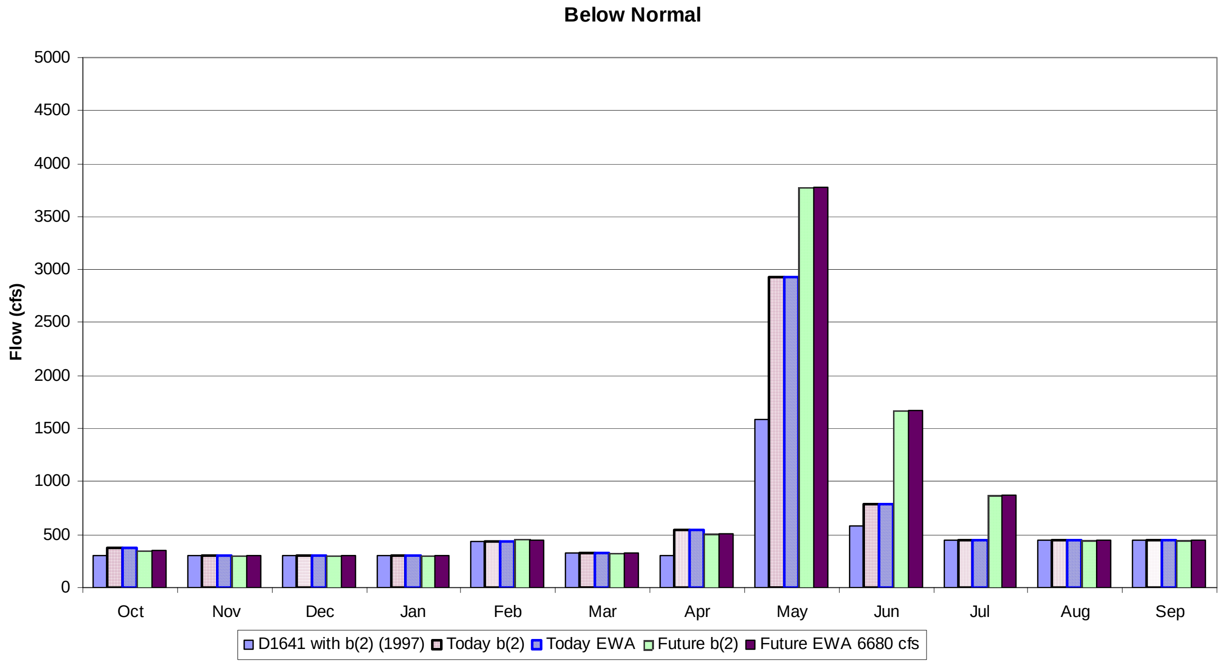


Figure 9–7 Average Below-normal Year (40-30-30 Classification) Monthly Releases to the Trinity

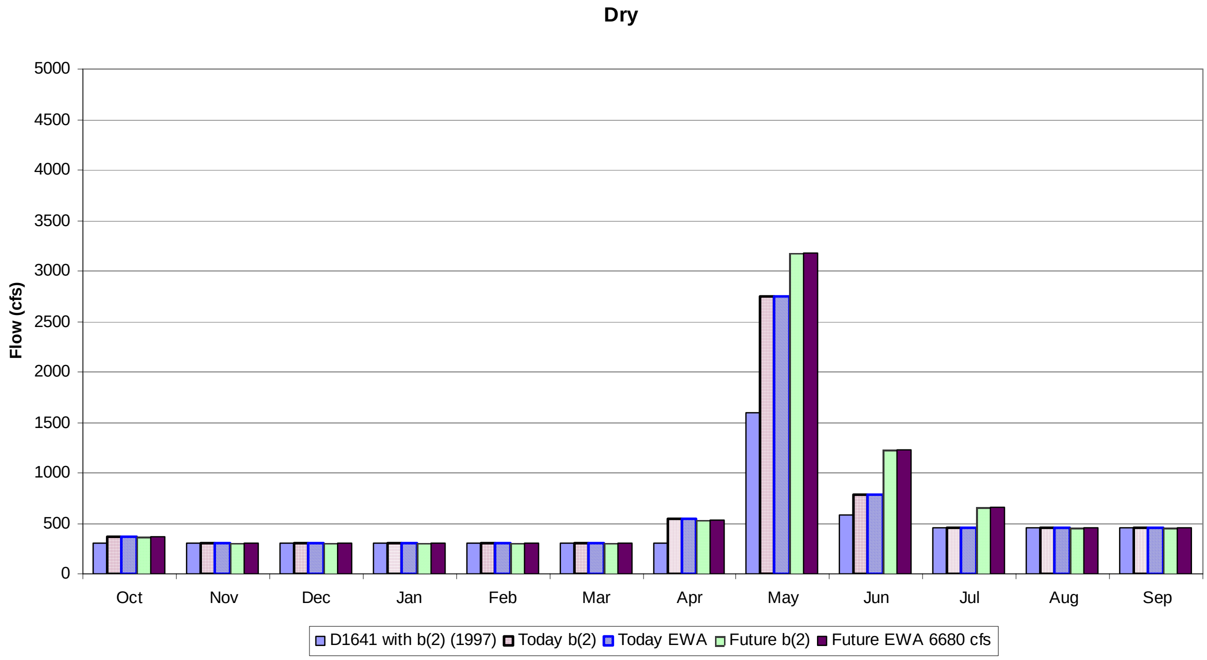


Figure 9–8 Average Dry-year (40-30-30 Classification) Monthly Releases to the Trinity

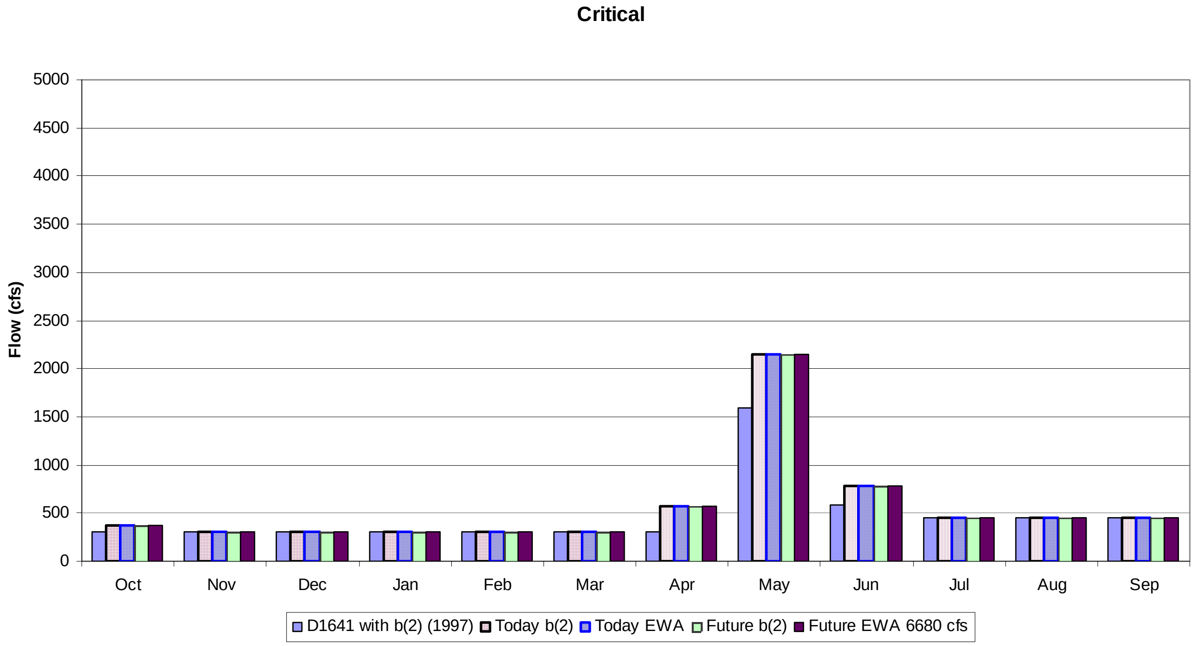


Figure 9–9 Average Critical-year (40-30-30 Classification) Monthly Releases to the Trinity

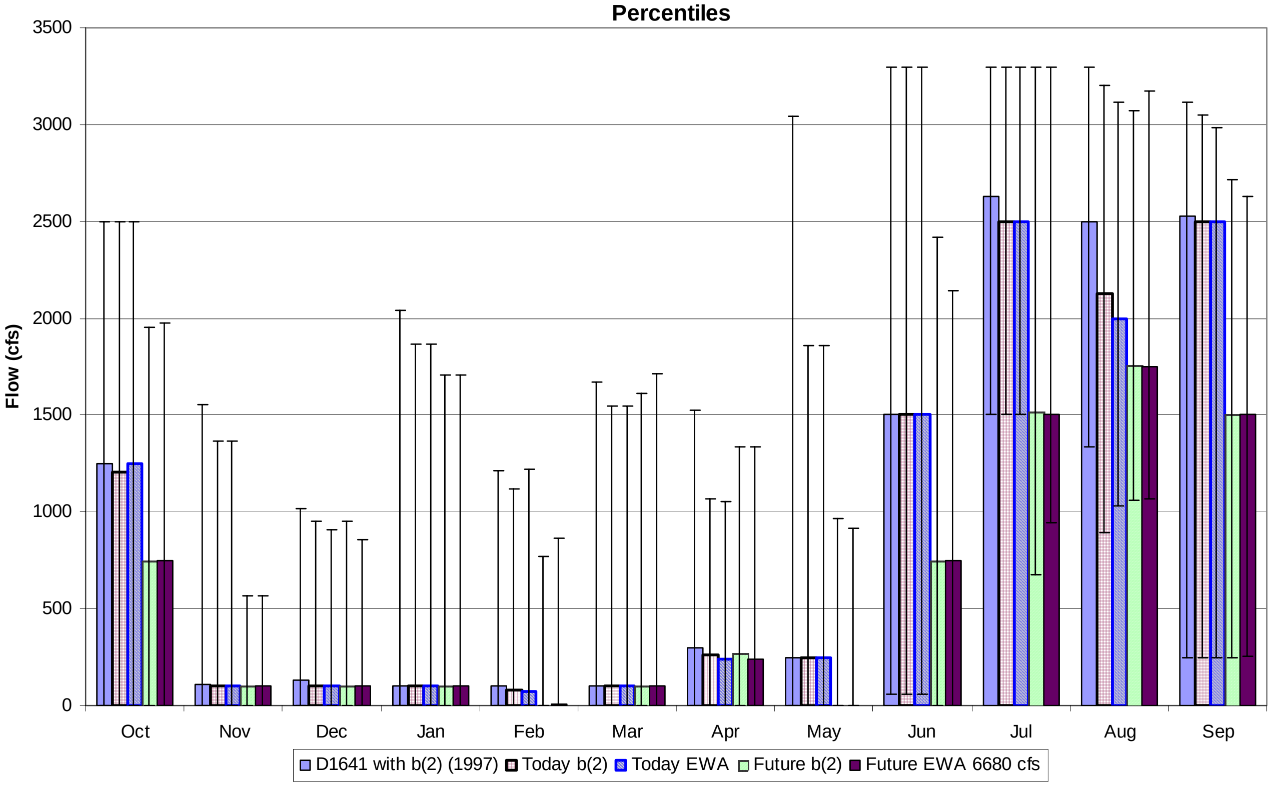


Figure 9–10 Clear Creek Tunnel 50th Percentile Monthly Releases with the 5th and 95th as the Bars

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 because of rounding.

	Study 1, 340,000 af (values in cfs)	**Study 2 & 3, 369-453 taf (values in cfs)**	**Study 4/4a & 5/5a, 369-815 taf (values in cfs)**	**Note**
January	300	300	300	>300 (10%)
February	300	300	300	>300 (11%)

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 because of rounding.

	Study 1, 340,000 af (values in cfs)	Study 2 & 3, 369-453 taf (values in cfs)	Study 4/4a & 5/5a, 369-815 taf (values in cfs)	Note
March	300	300	300	>300 (8%)
April	300	540 (83%)	427 (7%), 460 (27%), 493 (20%), 540 (26%)	>600 (17%)
May	1,591	1,498 (11%), 2,924 (89%)	1,498 (11%), 2,924 (26%), 4,189 (20%), 4,570 (11%), 4,709 (27%)	
June	578	783	783 (40%), 2,120 (18%), 2,526 (26%), 4,626 (12%)	
July	450	450	450 (60%), 1,102 (40%)	
August	450	450	450	
September	450	450	450	
October	300	373	373	
November	300	300	300	
December	300	300	300	>300 (10%)

Adult coho salmon 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 cubic feet per second (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 in September, early in the upstream migratory period, 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 sustaining 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 the Environmental Water Account (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 almost always be 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. Stranding of coho fry can occur when the flows are lowered following the restoration program-prescribed flows (Chamberlain 2003). 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 steelhead populations.

High flows down the Trinity will also occur during safety of dams releases during high runoff events, generally between December and May, to prevent overtopping of the dam. These safety of dams releases occur during about 10 percent of years and are projected to occur slightly less in the future. Depending on timing of these releases, they can help or hurt juvenile coho. Additional rearing habitat is available during the higher releases, but when the releases are subsequently lowered, some stranding can occur where off-channel areas are isolated from the river. The higher releases make it easier for smolts to out-migrate from the river when the timing of the flows coincides with a period when fish are ready to out-migrate. Stranded fish tend to receive a lot of attention because they are visible and easy to count, while benefits of the pulsed higher flows to the fish population are not as easily quantified.

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 Essential Fish Habitat

The increased flows in 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 (see Figure 14-18).

Clear Creek

Modeling

Whiskeytown Reservoir tries to maintain 235 thousand acre-feet (taf) end-of-September storage. Figure 9–11 shows that the end-of-September storage for Whiskeytown dropped from 235 taf to 180 taf from once in Study 1 (1932) to three times in Study 2 and Study 3 (1924, 1932, and 1934), and increases to four times in Study 4a and Study 5a (1924, 1931, 1932, and 1934). The increased frequency of drawdowns during the 1928-1934 drought are from trying to maintain the same minimum flows down Clear Creek while importing as much from Clear Creek Tunnel 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 5a - Study 1	Study 4a - Study 2	Study 5a - Study 3
Annual Clear Creek Tunnel	-82	-80	-222	-139	-142
Annual Clear Creek Release	-2	-3	-2	-1	1
Annual Spring Creek Tunnel	-81	-78	-220	-139	-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 5a - Study 1	Study 4a - Study 2	Study 5a - Study 3
Annual Clear Creek Tunnel	-85	-85	-138	-50	-53
Annual Clear Creek Release	-2	-5	-3	-4	2
Annual Spring Creek Tunnel	-83	-79	-133	-44	-54

Figure 9–12 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 five studies being identical. Figure 9–13 to Figure 9–18 illustrate the monthly averages by long-term average and by 40-30-30 Water Year Classification.

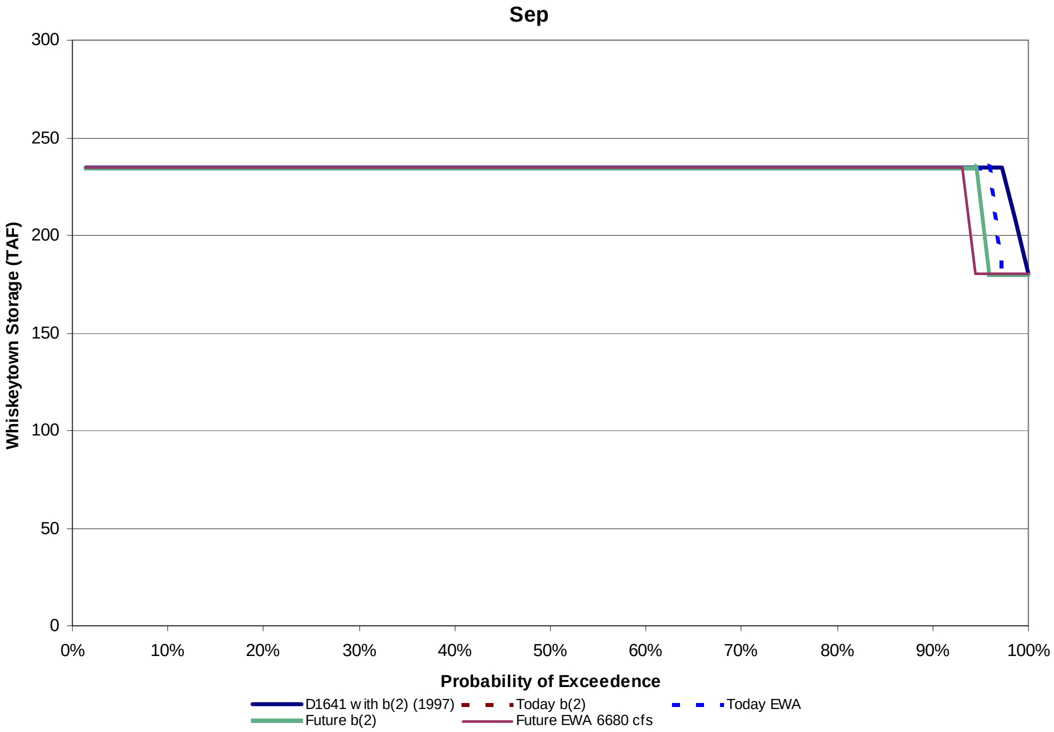


Figure 9–11. Whiskeytown Reservoir End-of-September Exceedance

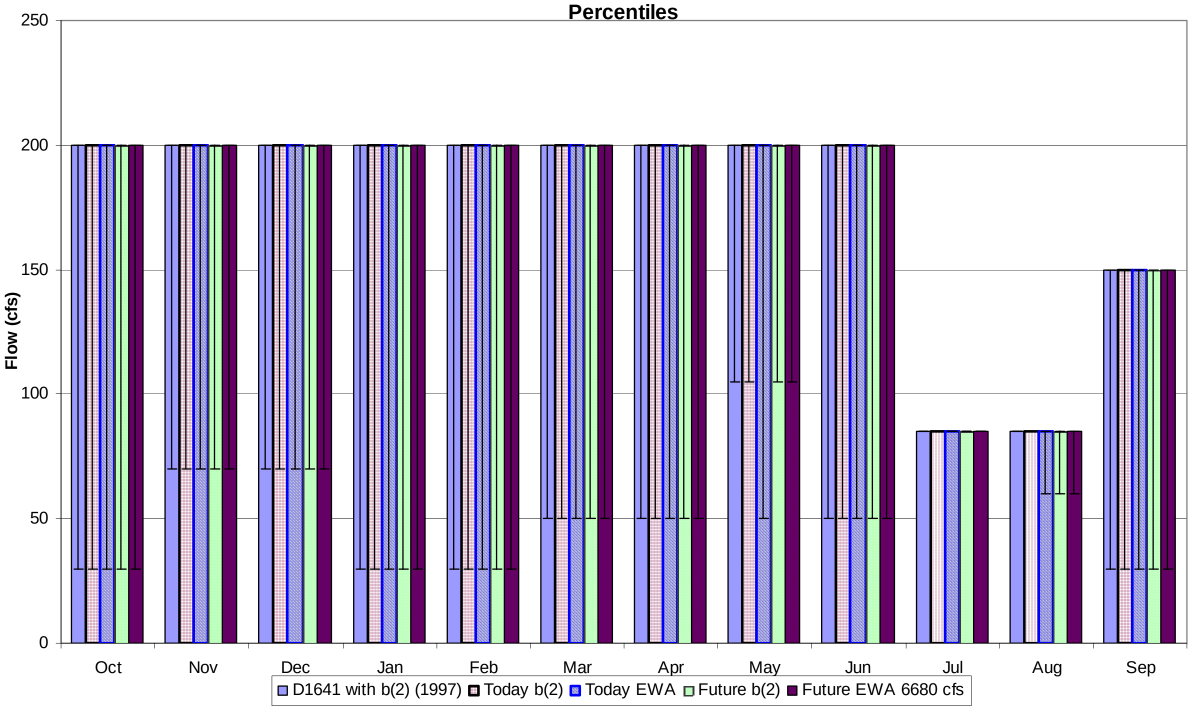


Figure 9–12 Clear Creek Releases 50th Percentile Monthly Releases with the 5th and 95th as the Bars

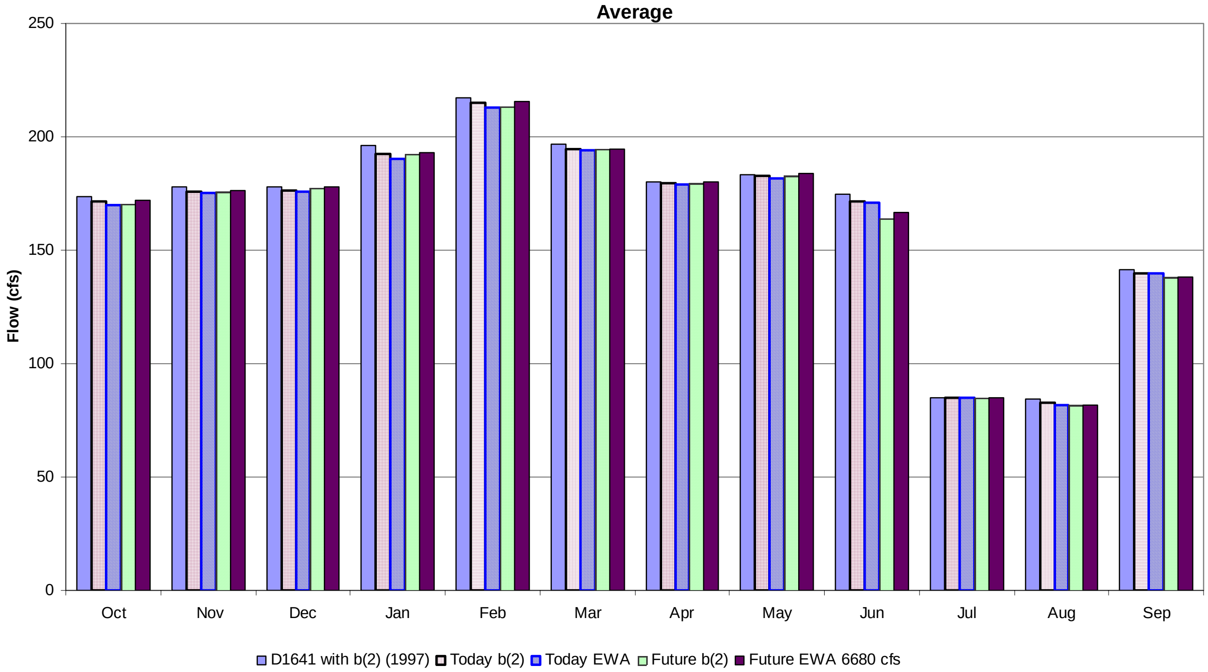


Figure 9–13 Long-term Average Monthly Releases to Clear Creek

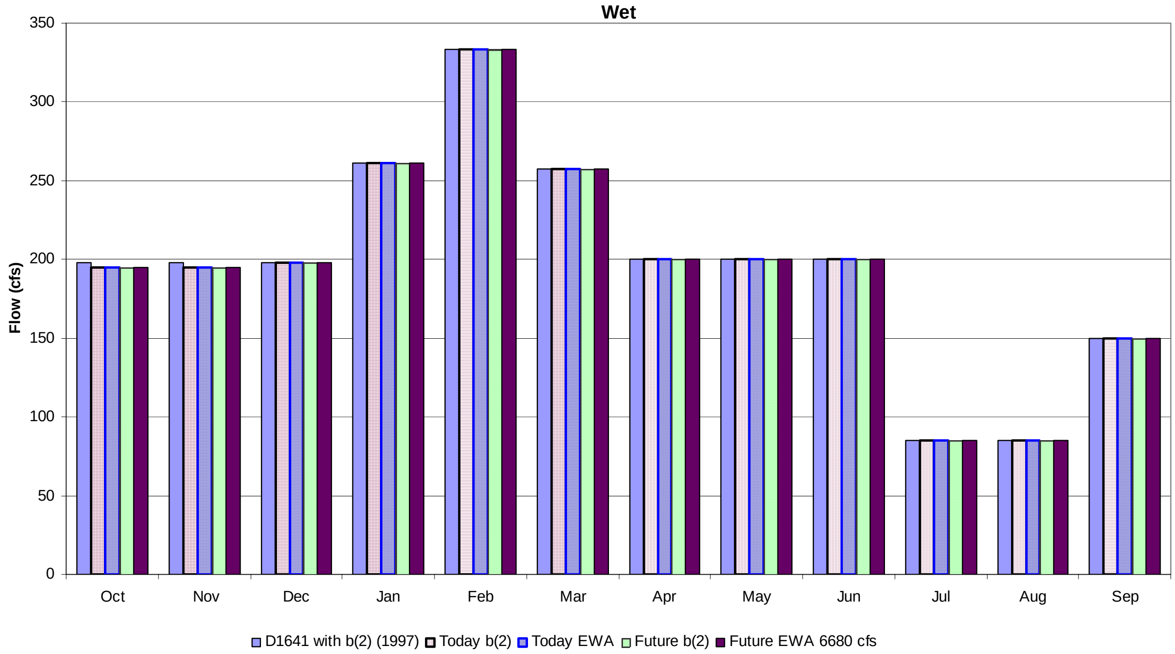


Figure 9–14 Average Wet Year (40-30-30 Classification) Monthly Releases to Clear Creek

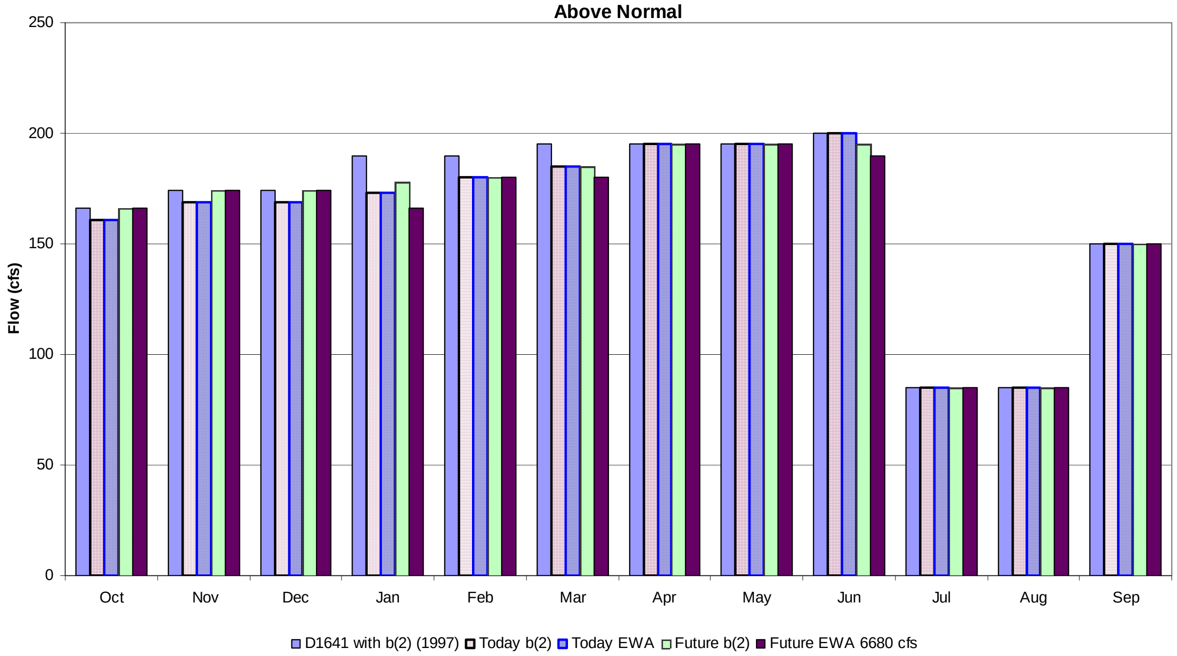


Figure 9–15 Average Above Normal Year (40-30-30 Classification) Monthly Releases to Clear Creek

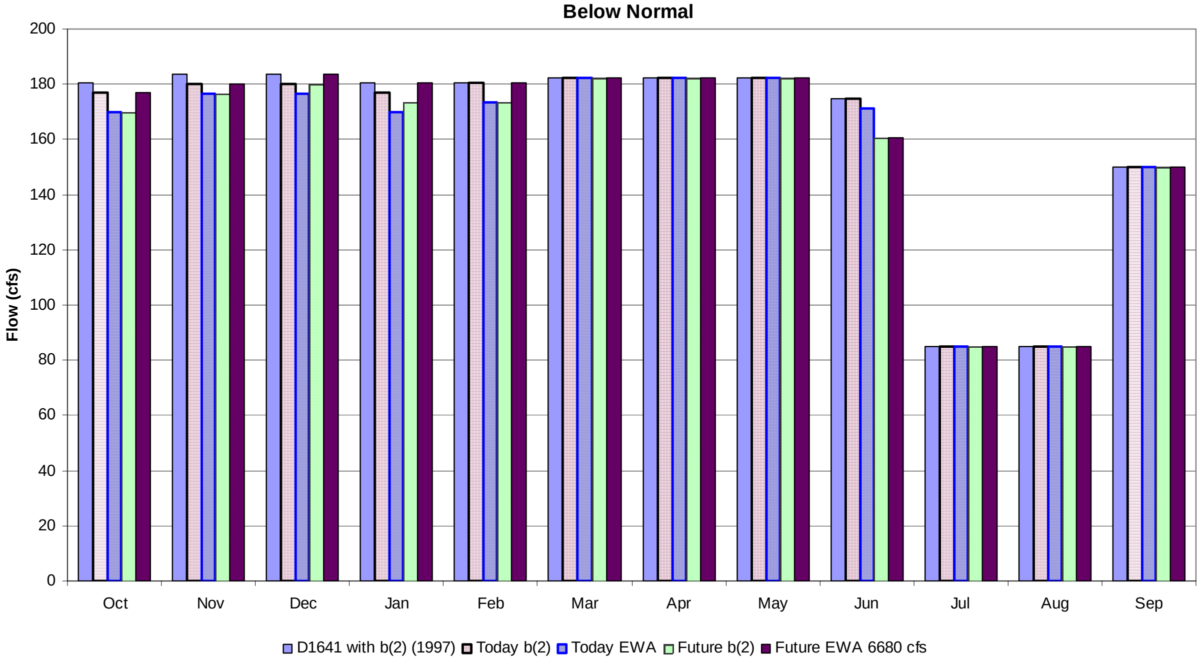


Figure 9–16 Average Below Normal Year (40-30-30 Classification) Monthly Releases to Clear Creek

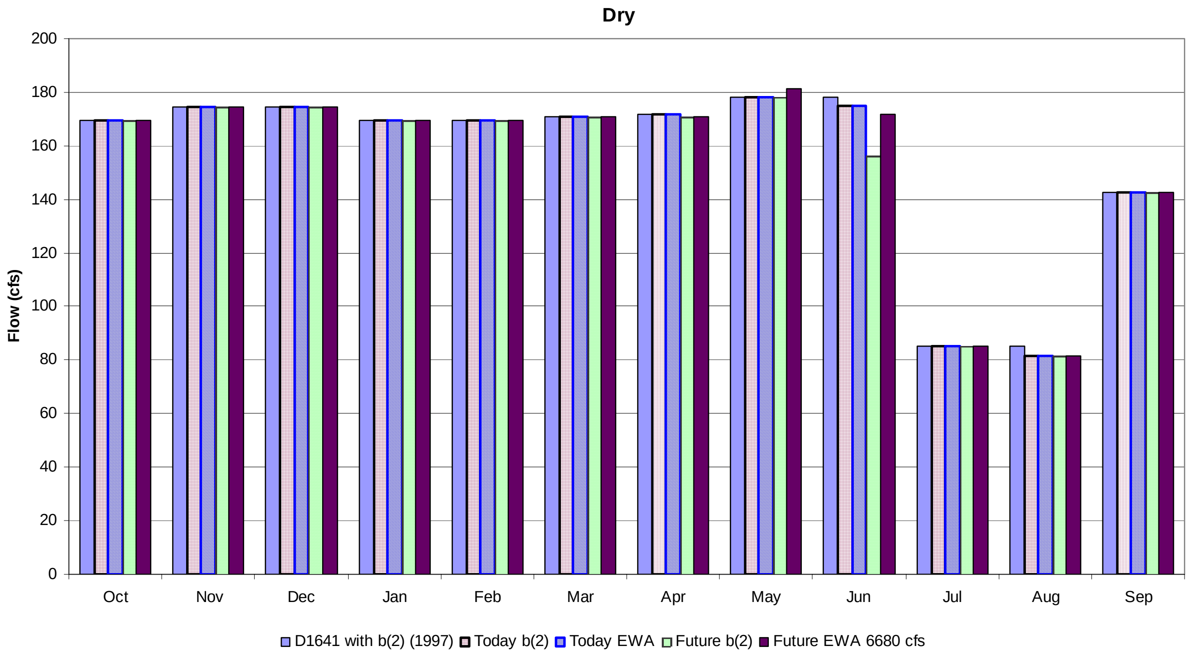


Figure 9–17 Average Dry Year (40-30-30 Classification) Monthly Releases to Clear Creek

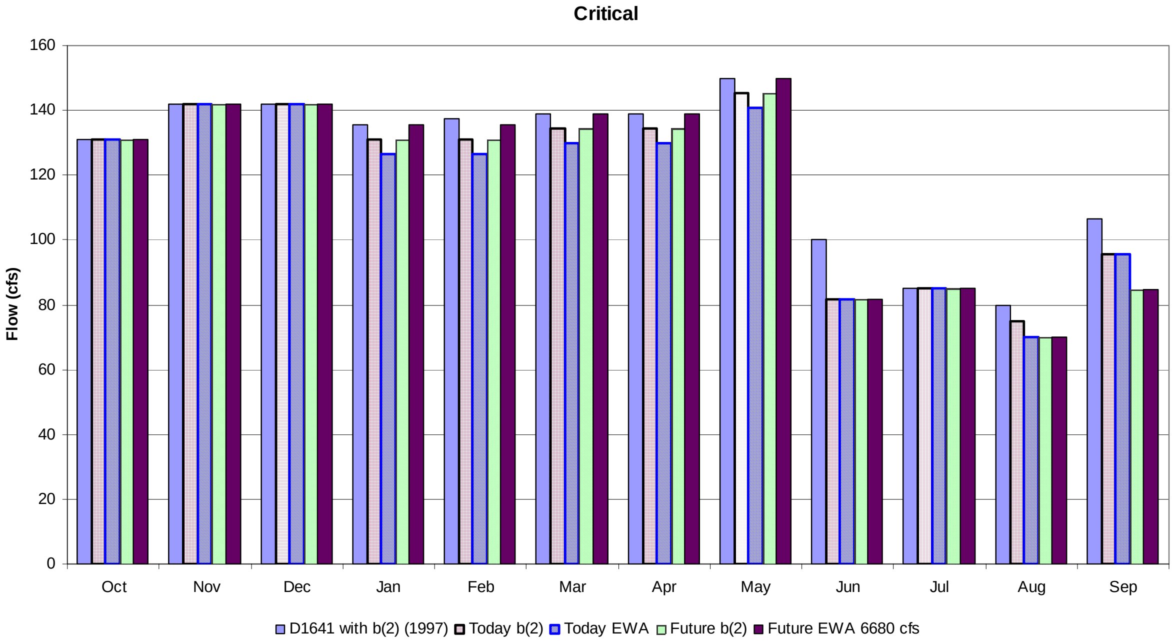


Figure 9–18 Average Critical Year (40-30-30 Classification) Monthly Releases to Clear Creek

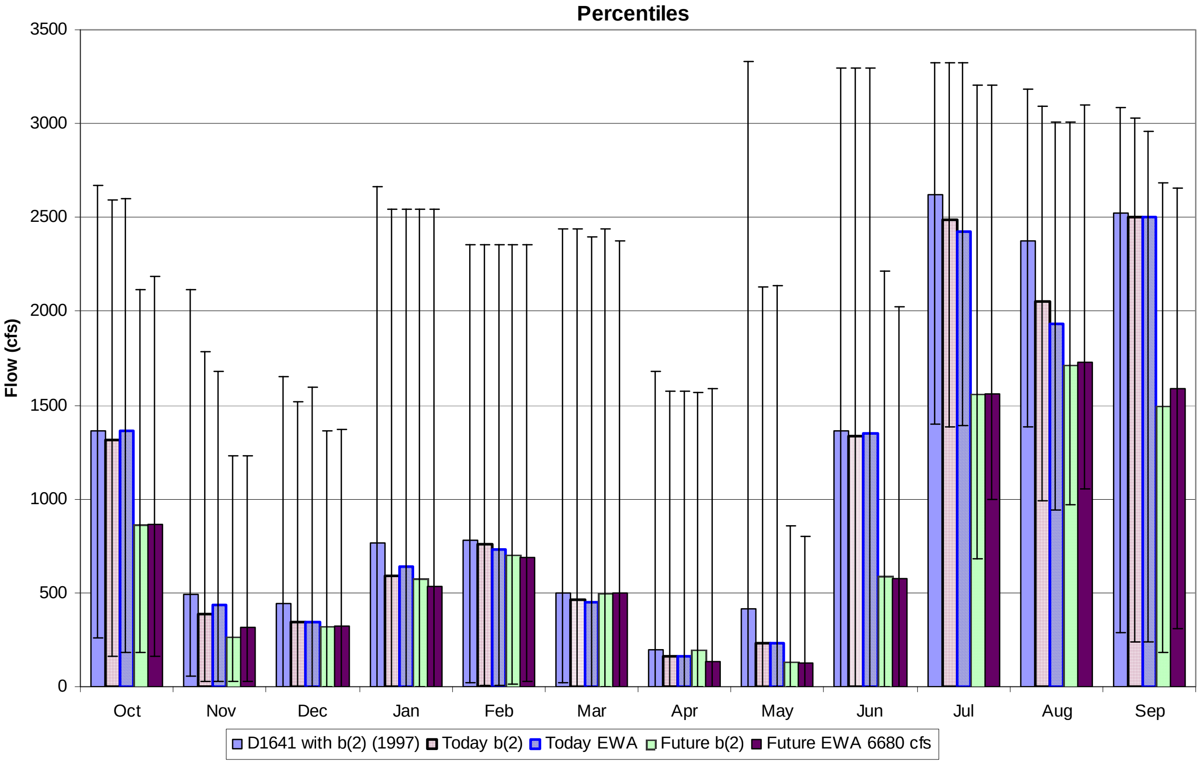


Figure 9–19 Spring Creek Tunnel 50th Percentile Monthly Releases with the 5th and 95th as the Bars

Adult Migration, Spawning, and Incubation

The removal of the McCormick-Saeltzer Diversion Dam in 2000 at river mile 6.5 gave salmon and steelhead 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 steelhead 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 steelhead 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 steelhead 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 steelhead/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 Central Valley Project Improvement Act (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 Chinook to migrate upstream. Chinook would not likely make it past the bedrock chute area at this flow volume. 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 that optimal flows for salmon in this reach would be 62 cfs for spawning and 75 cfs for rearing, based on the Instream Flow Incremental Methodology (IFIM) study, when suitable incubation and rearing temperatures were provided. Spring-run Chinook 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 Chinook would likely spawn upstream closer to Whiskeytown Dam, where optimal spawning and incubation temperatures can be provided year-round. National Oceanic and Atmospheric Administration Fisheries (NOAA Fisheries – formerly called National Marine Fisheries Service [NMFS]) (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, this study relied on Denton (1986).

High-flow events during the incubation period have the potential to scour redds and injure pre-emergent fry. High-flow events that exceed 1,000 cfs often occur during heavy rain in winter and spring (Figure 14-4). 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).

Steelhead 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.

Adult 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 steelhead 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 steelhead (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 versus 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 steelhead 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. It is expected that the modeled flows will be suitable for the rearing, smoltification, and emigration of steelhead and Chinook salmon during most years. During the driest years, flows in summer and fall could be limiting for steelhead 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 depend 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 Chinook and steelhead 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 steelhead 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 Table 9–7 for averages during the 1928 – 1934 drought; see Figure 9–20 and Figure 9–21 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 5a - Study 1	Study 4a - Study 2	Study 5a - Study 3
Annual Spring Creek Import	-81	-78	-220	-139	-142
Shasta EOS	-43	-46	-159	-113	-113
Annual Keswick Release	-79	-77	-218	-137	-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 5a - Study 1	Study 4a - Study 2	Study 5a - Study 3
Annual Spring Creek Import	-83	-79	-133	-44	-54
Shasta EOS	-119	-124	-242	-115	-118
Annual Keswick Release	-72	-64	-90	-14	-26

Figure 9–23 shows the end-of-September exceedance for Shasta storage, the 1.9 million af (maf) requirement in the Winter-run Biological Opinion (BO) (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 4a and 5a. Figure 9–24 shows the monthly percentile flows for releases from Keswick Reservoir. Figure 9–25 to Figure 9–30 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 flows 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.

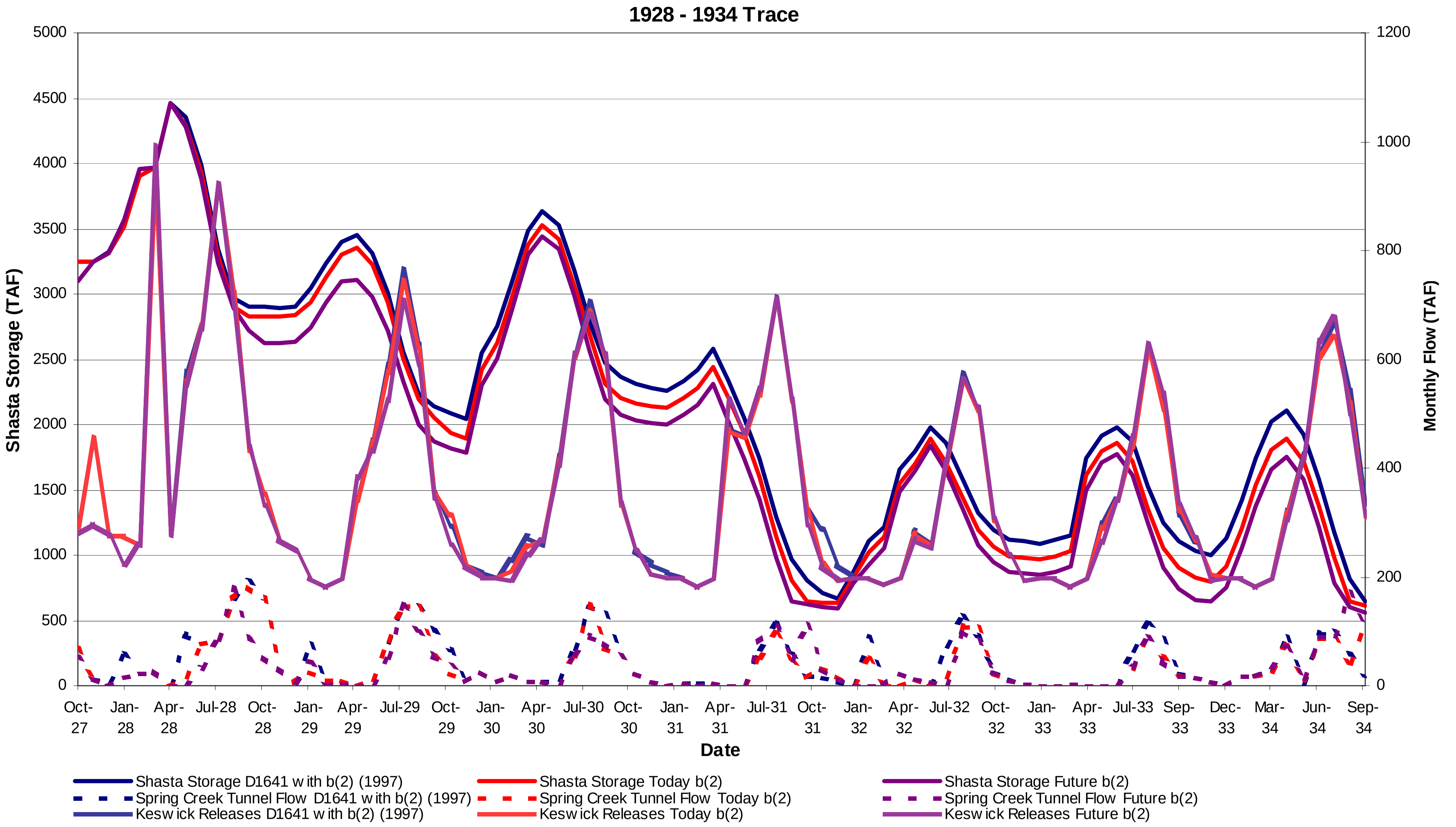


Figure 9–20. October-1927 to September-1934 Trace of Shasta Storage, Spring Creek Tunnel Flow, and Keswick Release for Studies 1, 2 and 4

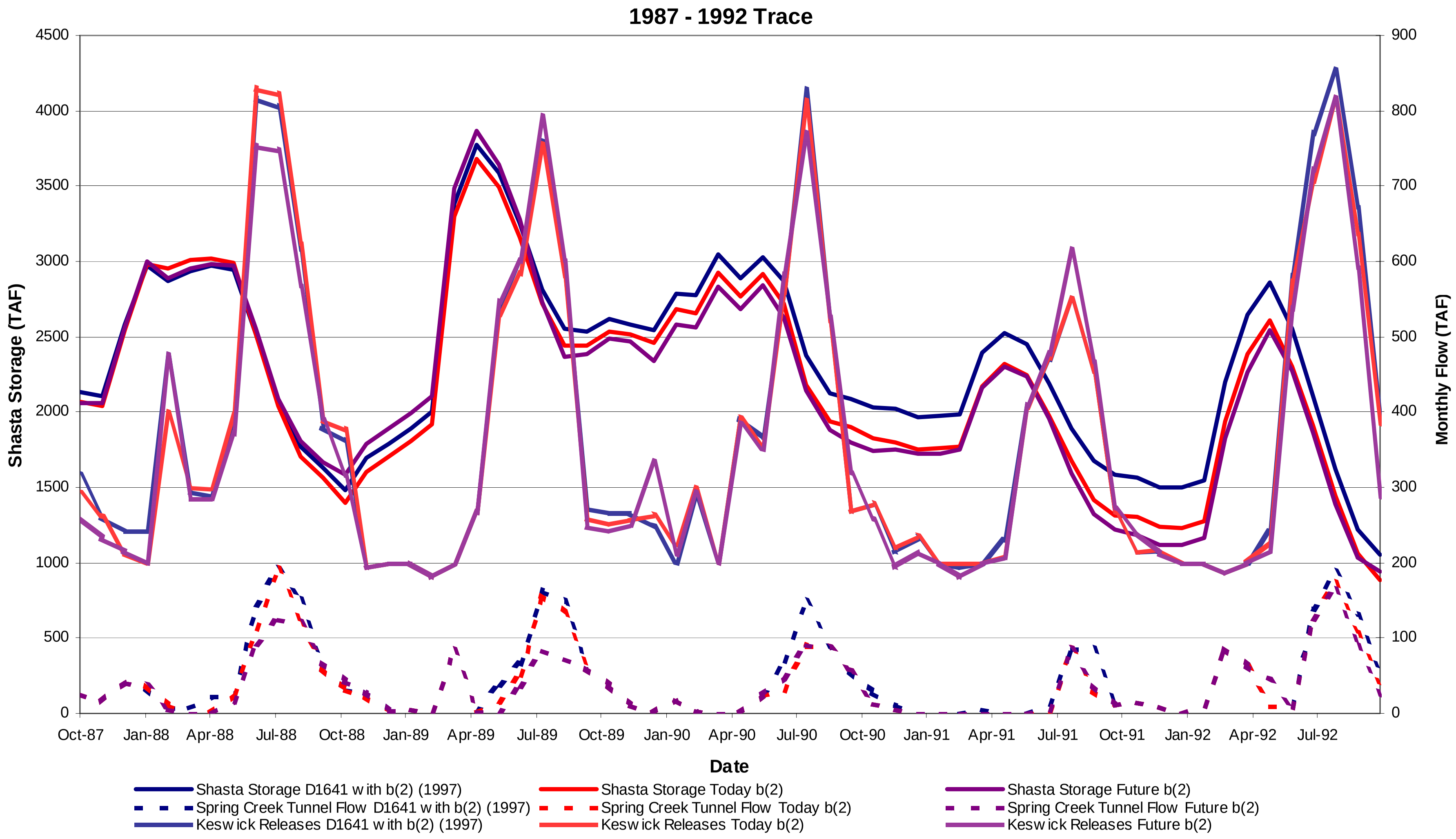


Figure 9–21. October-1987 to September-1992 Trace of Shasta Storage, Spring Creek Tunnel Flow, and Keswick Release for Studies 1, 2 and 4

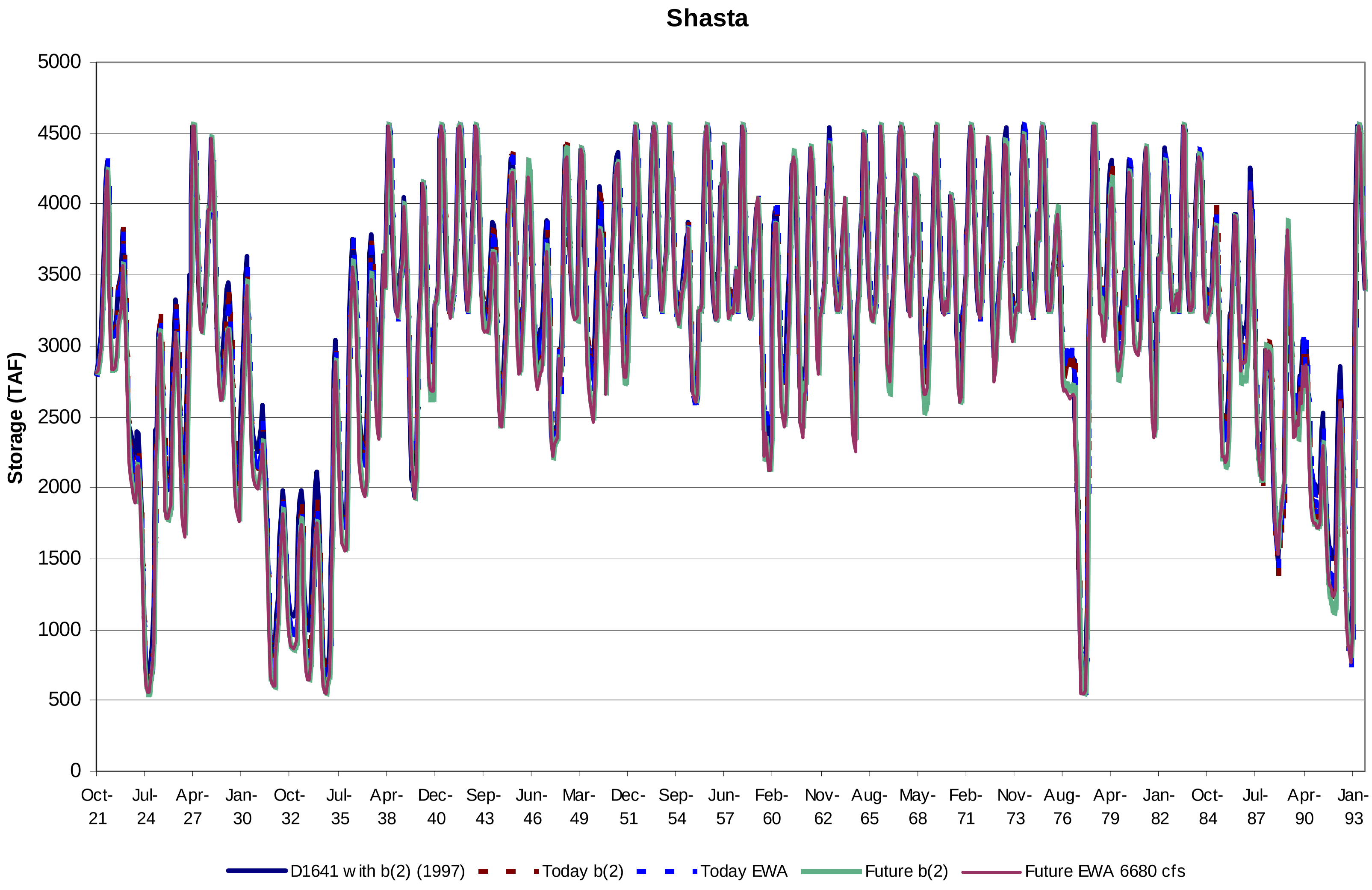


Figure 9–22. Chronology of Shasta Storage, Water Years 1922 - 1993

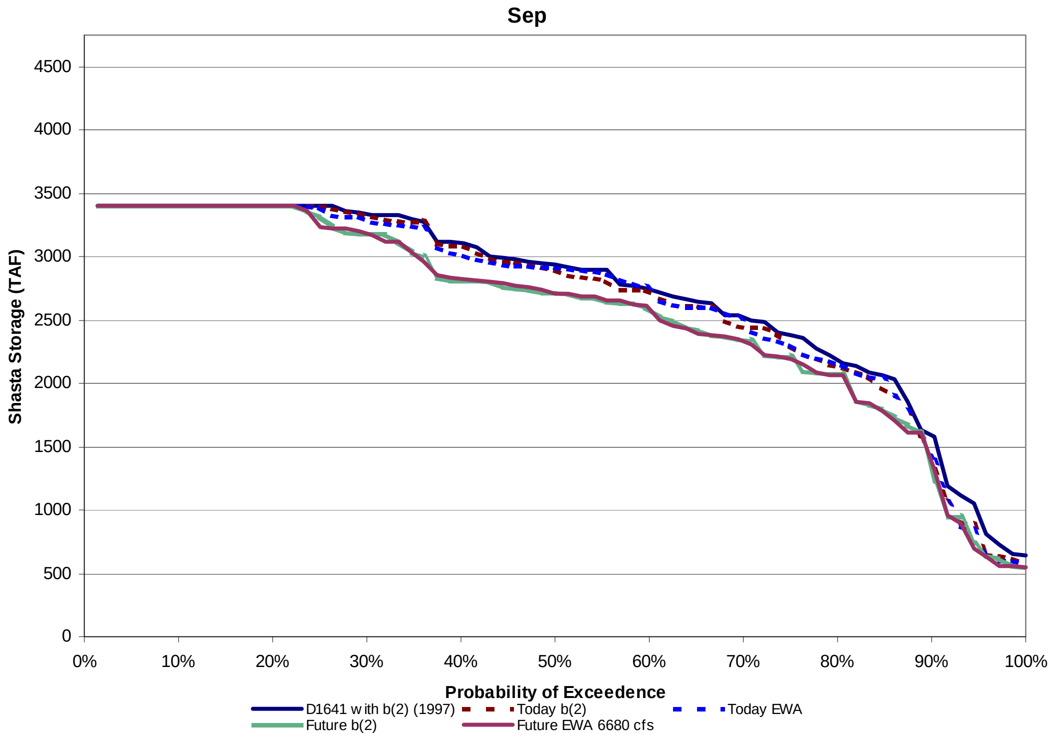


Figure 9–23 Shasta Reservoir End-of-September Exceedance

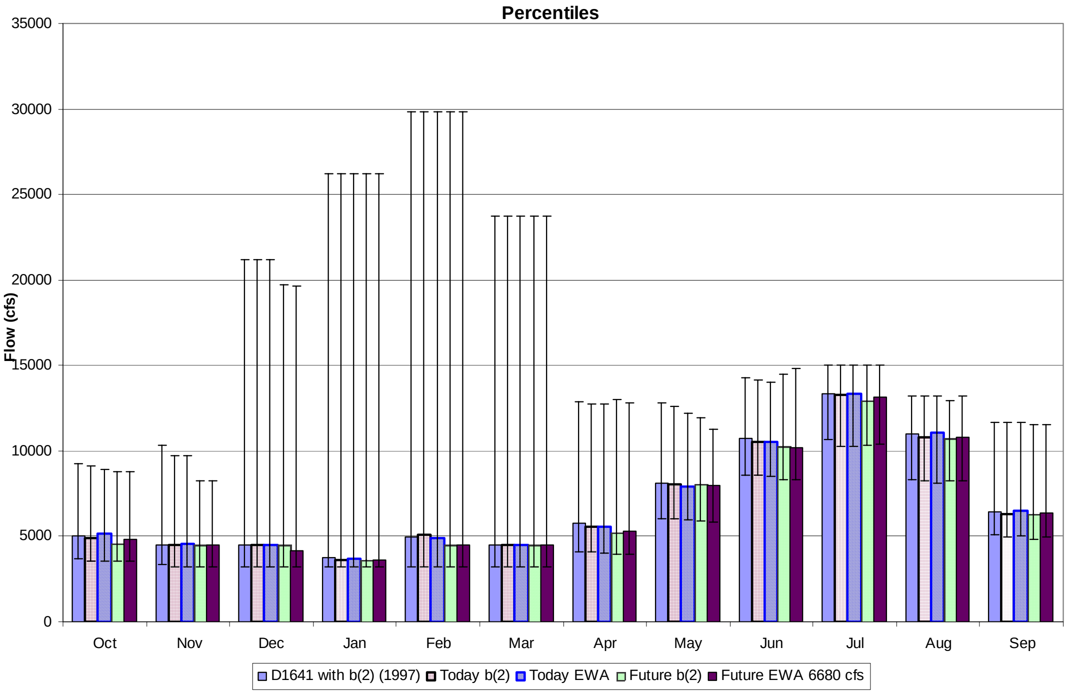


Figure 9–24 Keswick 50th Percentile Monthly Releases with the 5th and 95th as the Bars

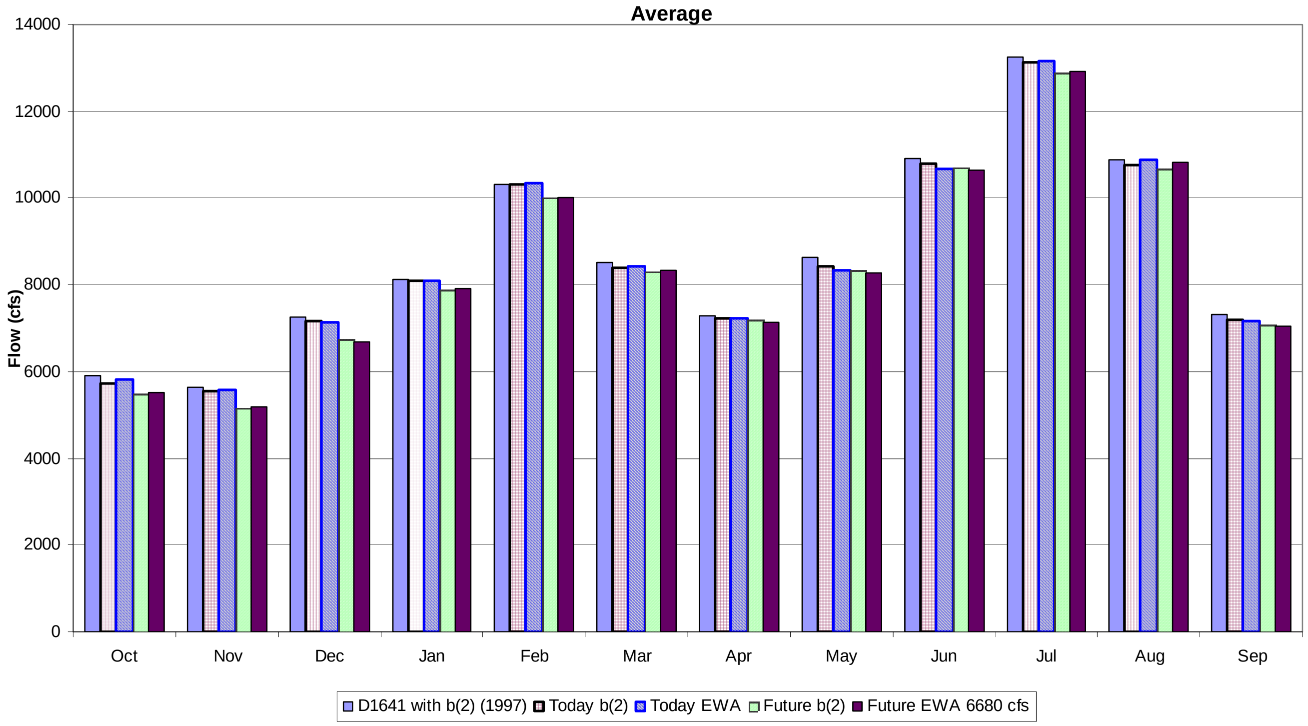


Figure 9–25 Average Monthly Releases from Keswick

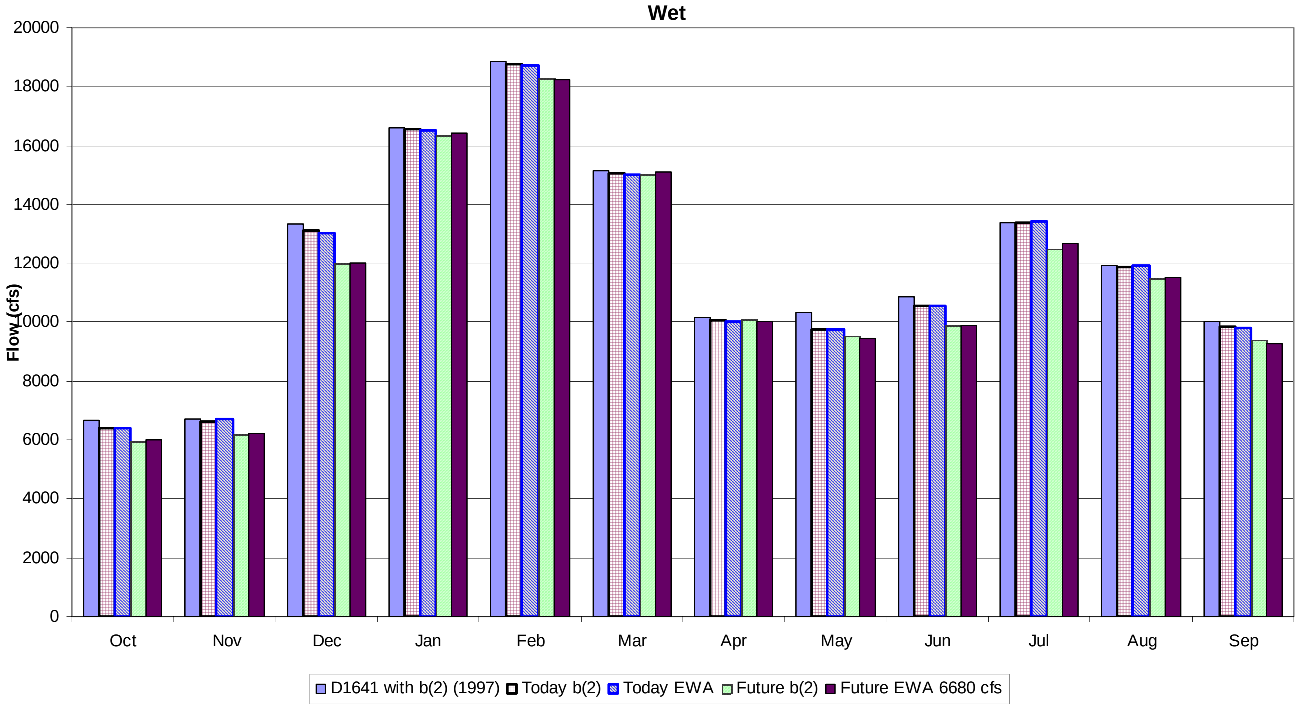


Figure 9–26 Average Wet Year (40-30-30 Classification) Monthly Releases from Keswick

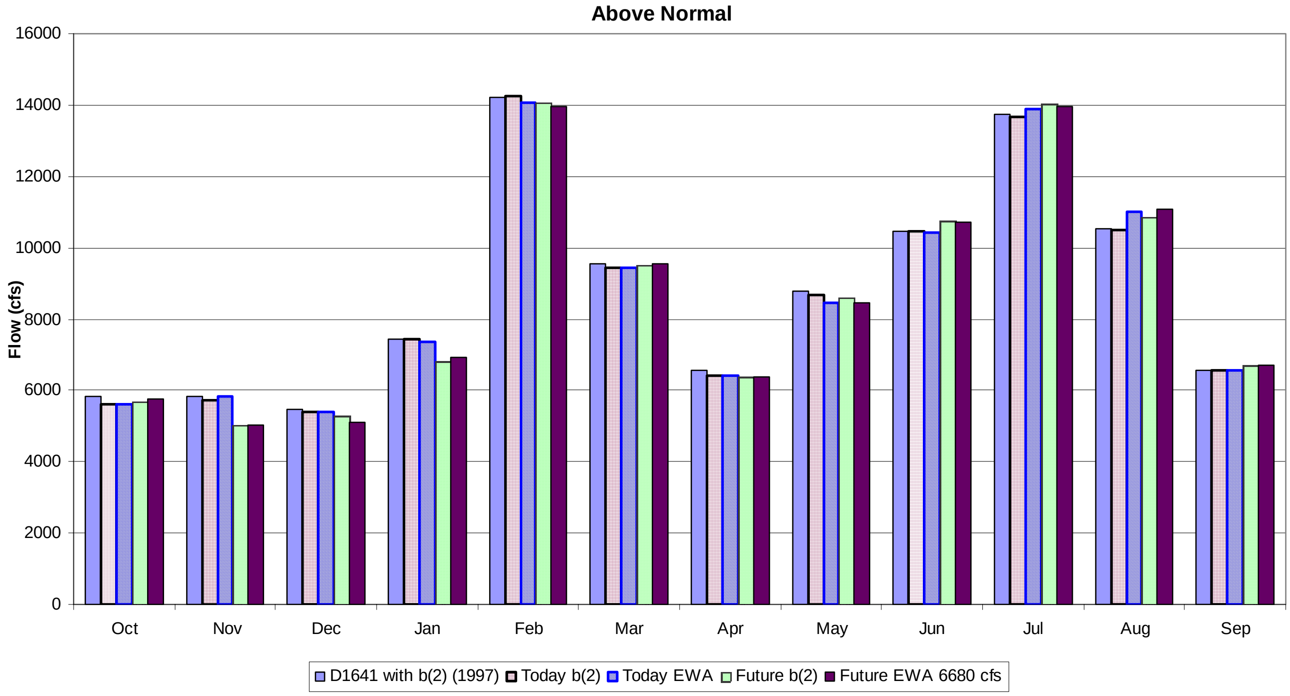


Figure 9–27 Average Above Normal Year (40-30-30 Classification) Monthly Releases from Keswick

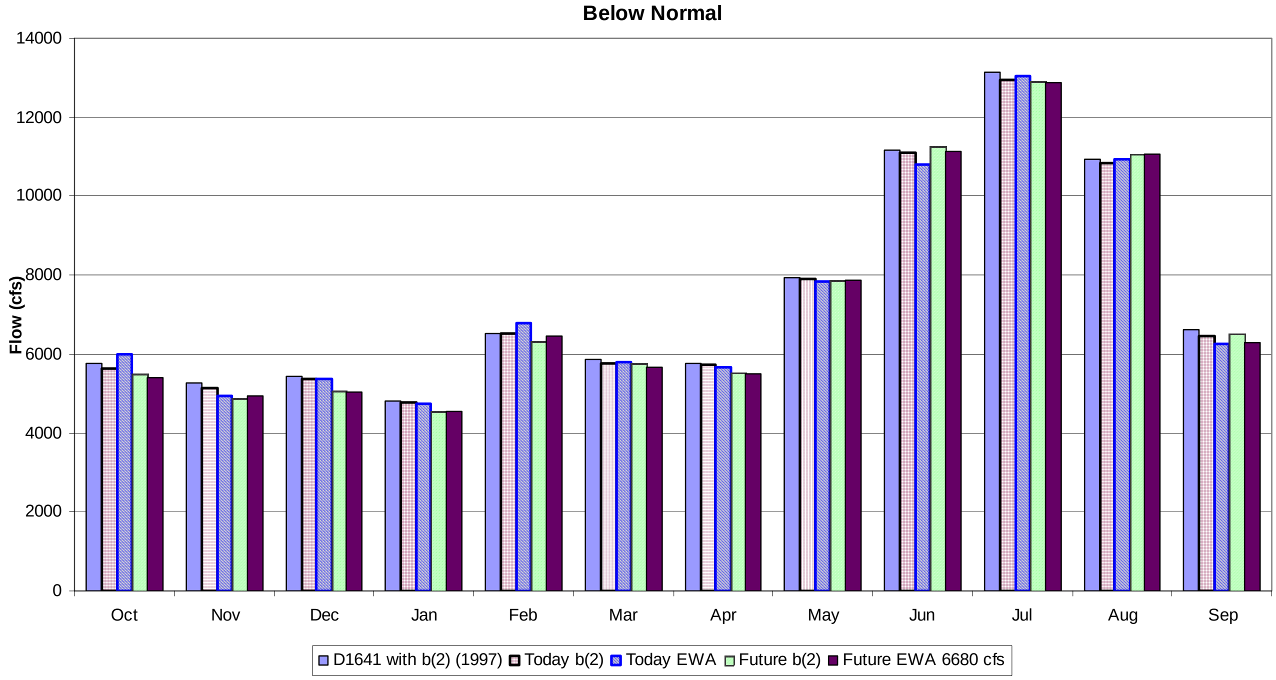


Figure 9–28 Average Below Normal Year (40-30-30 Classification) Monthly Releases from Keswick

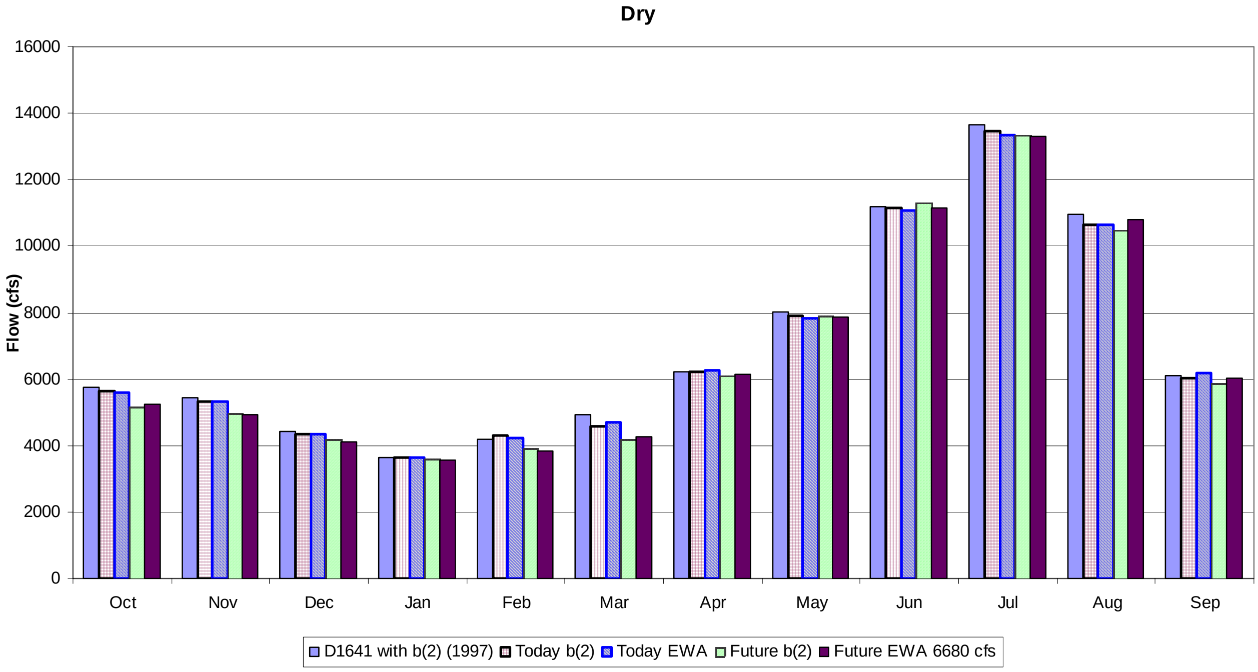


Figure 9–29 Average Dry Year (40-30-30 Classification) Monthly Releases from Keswick

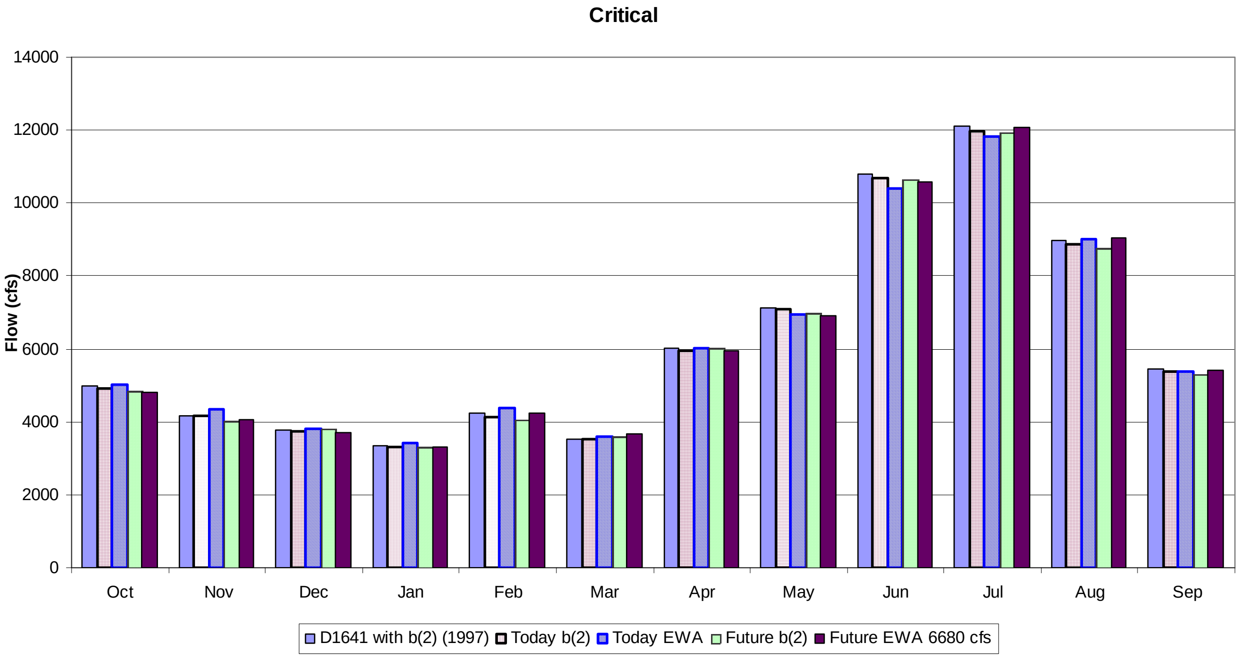


Figure 9–30 Average Critical Year (40-30-30 Classification) Monthly Releases from Keswick

Adult Migration, Spawning, and Incubation

Adult steelhead 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 steelhead only to the extent that they affect water temperatures. The minimum Keswick release is 3,250 cfs. Steelhead 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, 40 miles farther downstream, but with a low variability in availability (U.S. Fish and Wildlife Service [FWS] 2003). Therefore, it is surmised that the 3,250-cfs 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 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 steelhead in the upper Sacramento River.

Winter-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 (California Department of Fish and Game [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 cfs 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 steelhead 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 from redd scouring or entombment. Long-term habitat benefits from high flood control flows should include gravel recruitment from streamside sources enhancing spawning gravel, large woody debris recruitment, and establishment of new cottonwood seedlings. The population effects should be maintained for 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 by 1 to 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 on 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 River. Effects of water temperature on egg incubation are evaluated using the water temperature mortality model. Figure 9–31 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 fish. 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 9–32). The hydrological period contains 11 critically dry years, which is 15 percent of the years used in modeling. During dry years, about 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 the U.S. Bureau of Reclamation (Reclamation) has reconsulted on winter-run and recommended moving the temperature compliance point nearly every year since the NOAA Fisheries BO was issued in 1993.

Table 9–8 Winter-Run B.O. Temperature Violations and Reinitiation Letters

Water Year	Water Year Starting Shasta Storage (taf)	End of April Shasta Storage (taf)	40-30-30 Index	Reclamation letters		
				Date	Action	Compliance
1993	1683	4263	AN			
1994	3102	3534	C			
1995	2102	4165	W	7/13/1995	Conserve cold water	Jellys Ferry

Table 9–8 Winter-Run B.O. Temperature Violations and Reinitiation Letters

Water Year	Water Year Starting Shasta Storage (taf)	End of April Shasta Storage (taf)	40-30-30 Index	Reclamation letters		
				Date	Action	Compliance
1996	3,136	4,308	W	5/17/1996	Exceed 56 °F 4/26	Bend Bridge
				7/12/1996	Exceed 56 °F 5/27	
				7/18/1996	Conserve cold water	Jellys Ferry
				8/28/1996	Conserve cold water	Balls Ferry
				9/23/1996	Transition to stable min flow for fall-run salmon by Oct 15	Clear Creek
1997*	3,089	3,937	W	7/30/1997	Exceed 56 °F at Bend 4 days	
				8/8/1997	Conserve cold water	Jellys Ferry
1998	2,308	4,061	W	6/25/1998	Exceed 56 °F at Bend 4 days	
				9/18/1998	Temp exceed 56 since Sep 12	Jellys Ferry
1999	3,441	4,256	W	8/19/1999	Exceed 56 °F at Bend 4 days	
2000	3,327	4,153	AN	6/2/2000	Exceed 56 °F at Bend 3 days	
				7/14/2000	Conserve cold water	Jellys Ferry
				8/29/2000	Conserve cold water	Balls Ferry
				10/16/2000	Exceed 56 °F at Balls 3 days	
2001	2,985	4,020	D	7/17/2001	Exceed 56.5 °F at Jellys 2 days	
				1/10/2002	Exceed 56 °F at Jellys 8/28/2001 to 9/1/2001 and 9/152001 to 9/30/2001	
2002	2,200	4,297	D	6/5/2002	Exceed 56 °F at Jellys 5/18/2003	
2003	2,558	4,537	AN	6/18/2003	Exceed 56 °F at Bend 5/14/2003	
				8/28/2003	Conserve cold water	Balls Ferry

Note:

* 1997 was the first year that the temperature control device (TCD) was used.

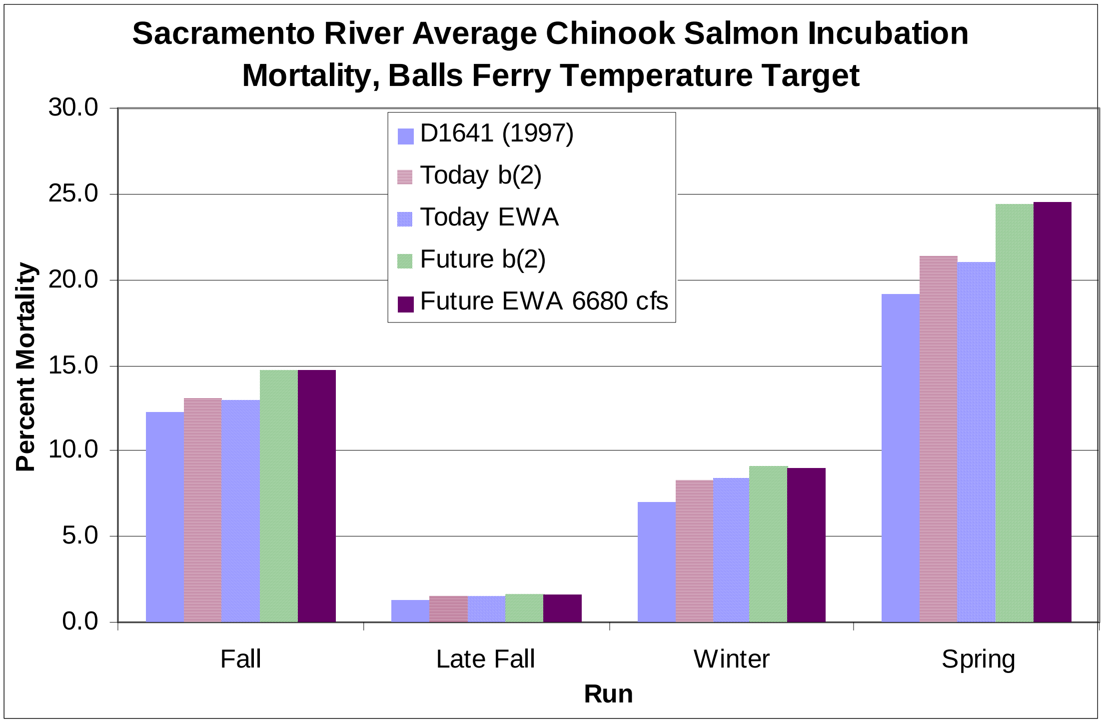
The spawning distribution used in the temperature model for winter-run and spring-run was updated following 2003 redd surveys based on 2001 through 2003 spawning data to reflect the shift in distribution since the Anderson-Cottonwood Irrigation District (ACID) fish ladder was installed. Fall and late-fall distribution was not updated because the ACID diversion dam has always been removed during 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 achieved 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 to 20 percent of the time in September, and 20 to 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 on Figure 9–31, Figure 9–32, and Figure 9–33. 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 (TCD) 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 on Figures 6-1 and 6-2 and show the effect of past temperature control operations.

Stranding of some salmon and steelhead 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 have 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



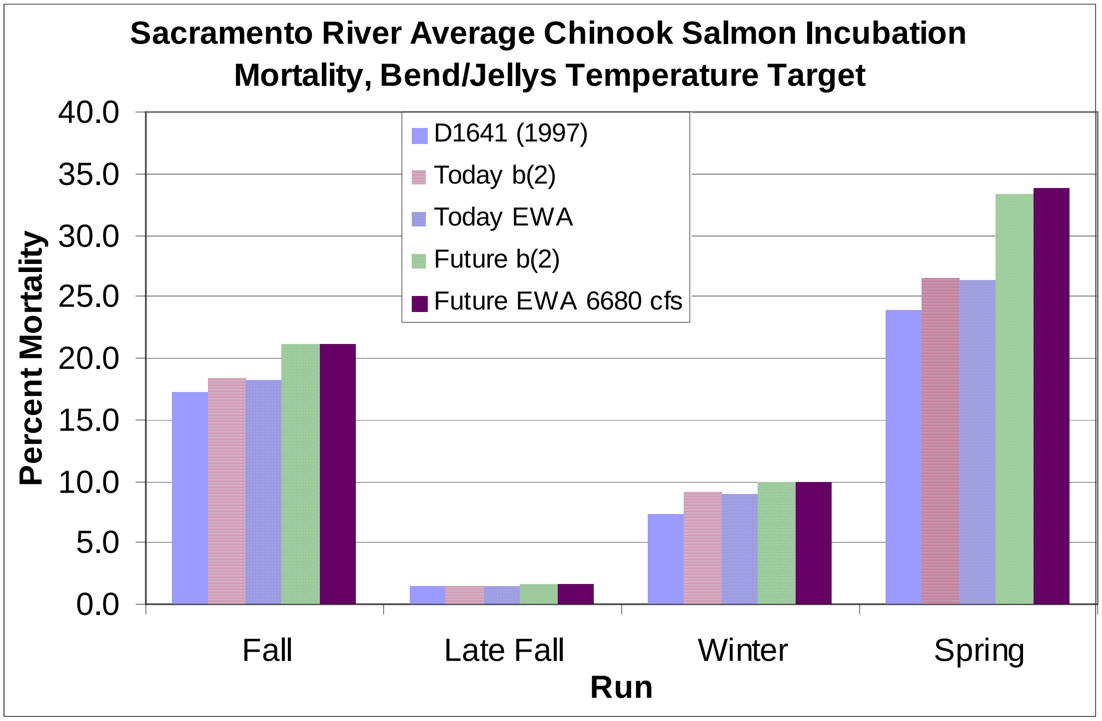
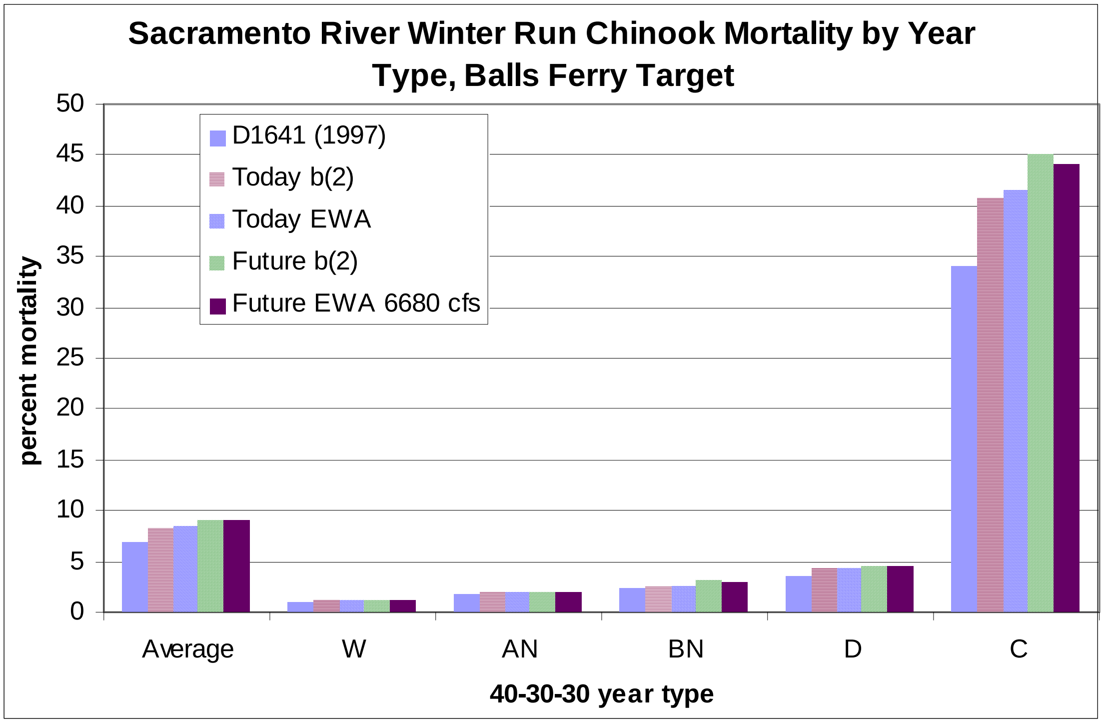


Figure 9–31 Average Chinook Salmon Mortality in the Sacramento River during the Incubation Period Based on Water Temperature (top chart is Balls Ferry temperature target; bottom chart is Bend Bridge/Jellys Ferry temperature target)



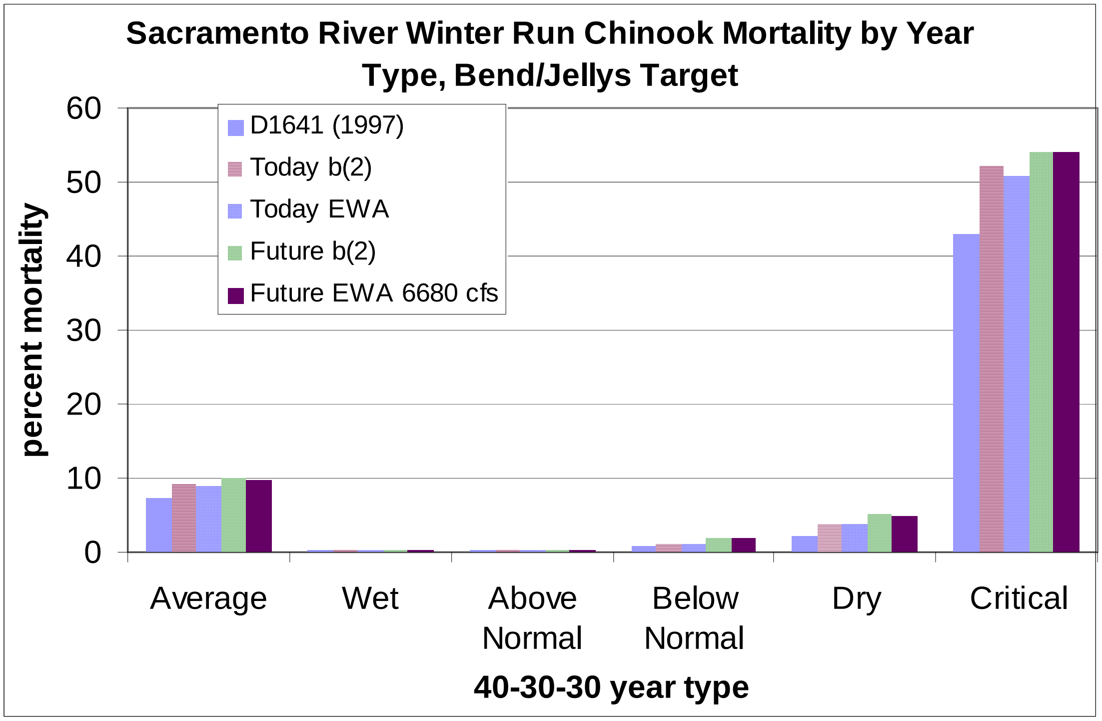
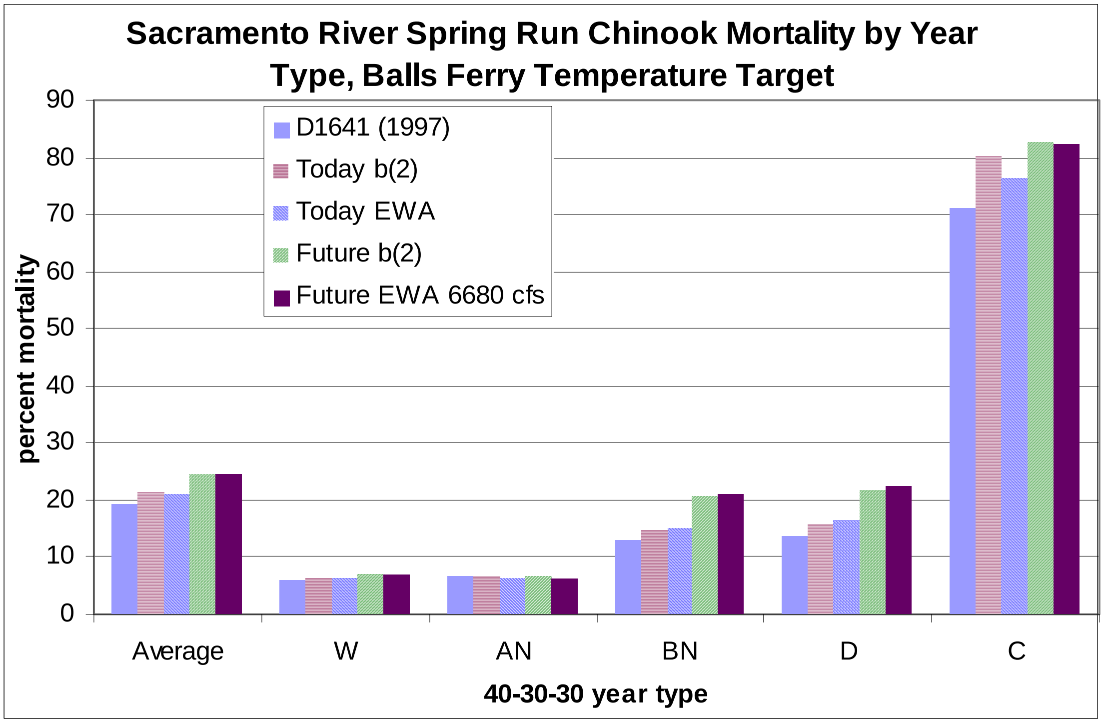


Figure 9–32 Sacramento River Winter-run Chinook Salmon Mortality Because of Water Temperature During Incubation, by Year Type (top chart is Balls Ferry temperature target; bottom chart is Bend Bridge/Jellys Ferry temperature target)



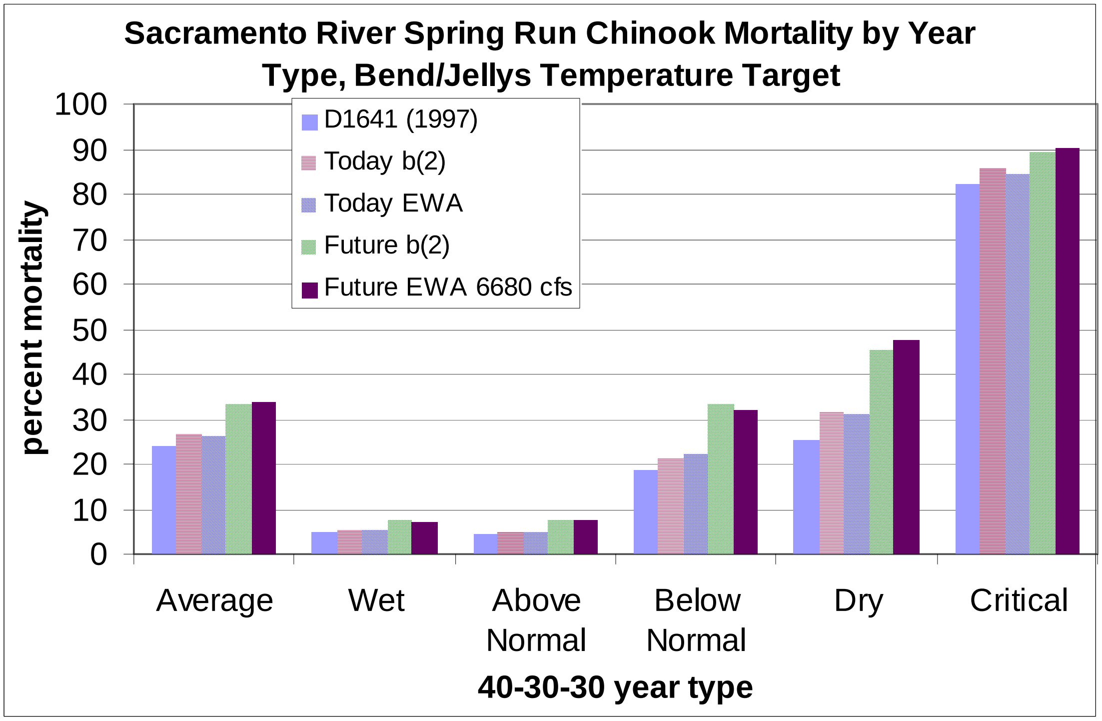


Figure 9–33 Sacramento River Spring-run Chinook salmon Mortality Because of Water Temperature During Incubation, by Year Type (top chart is Balls Ferry temperature target; bottom chart is Bend Bridge/Jellys Ferry temperature target)

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)**				**Distance**
			Fall	**Late-Fall**	**Winter**	**Spring**	
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 – Jellys Ferry	12.88	4.4	0.3 (1.5)	31.4 (8.0)	9 miles
	6	Jellys 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**

Table 9–10 Spawning Distribution by Reach Used in the Chinook Salmon Temperature-related Egg-to-Fry Mortality Models

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 steelhead 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 show 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 forecasted to be in the preferred range for growth and development of steelhead (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°F in August through October in about 20 percent of years at Bend Bridge. Temperatures in the future are increased by about 1 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 farther 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 Red Bluff Diversion Dam (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.

Steelhead 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 steelhead 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 from reservoir operations.

Flows in the lower Sacramento River are important for rearing and emigrating salmon and steelhead. The species often out-migrate during periods of increased flow. Freeport flows are displayed in the model. These include the sum of flows from the Sacramento, Feather, and American Rivers and other tributaries. The monthly modeling does not show the flow peaks used by out-migrating 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 steelhead 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 steelhead. 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 steelhead.

Red Bluff Diversion Dam

Reclamation plans to continue the current May 15 to 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-run fish. Approximately 15 percent of winter-run and 70 percent of spring-run that attempt to migrate upstream past RBDD may encounter the closed gates (Tehama-Colusa Canal Authority [TCCA] and Reclamation 2002). This is based on run timing at the fish ladders (i.e., 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 fish that do pass RBDD pass before May 15, and more than 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 3 to 13 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 from 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 affect 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 a perceived down cycle; this decline in population should have ended shortly after the bypasses for temperature control began at Shasta Dam (1987) and shortly before the full 8-month gates out operation began (1995). During this same period, spring-run populations downstream of the RBDD have experienced an approximate 20-fold increase, suggesting that some upstream event other than the RBDD operations have caused the decline in the upstream spring-run population (TCCA and Reclamation 2002). This decline may be a result of a change in sampling protocols, but the cause remains unknown. It is also possible that some spring-run fish destined for the upper Sacramento River get delayed at RBDD and return downstream to enter tributaries to spawn.

Early migrating steelhead encounter the lowered gates at RBDD. Approximately 84 percent of adult steelhead immigrants pass RBDD during the gates-out period based on average run timing at RBDD. 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 as indicated by historical emigration patterns at RBDD (DFG 1993, as summarized in FWS 1998). Effects of RBDD operation on steelhead run timing would be unchanged from the current condition. About

16 percent of steelhead would still be delayed. Steelhead this early in the run are not ready to spawn, and steelhead are repeat spawners, so the slight delay of a small portion of the steelhead run is not a big effect on steelhead.

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 are 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 9–35 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 4a and 5a increases the State's 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 9–35 shows that the Oroville storage is reduced in Studies 4a and 5a 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 9–36 shows that the monthly percentiles for flows Below Thermalito with the late summer flows being higher in Studies 4a and 5a and then decreasing through the winter months. Figure 9–37 through Figure 9–42 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 to 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 impact flows are almost identical for the five studies. The 1928-1934 averages 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 5a-Study 1	Study 4a-Study 2	Study 5a-Study 3
Long Term Average Feather River Flow below Thermalito	0	0	-1	-1	-1
1928-1934 Average Feather River Flow below Thermalito	-2	4	-1	13	-5

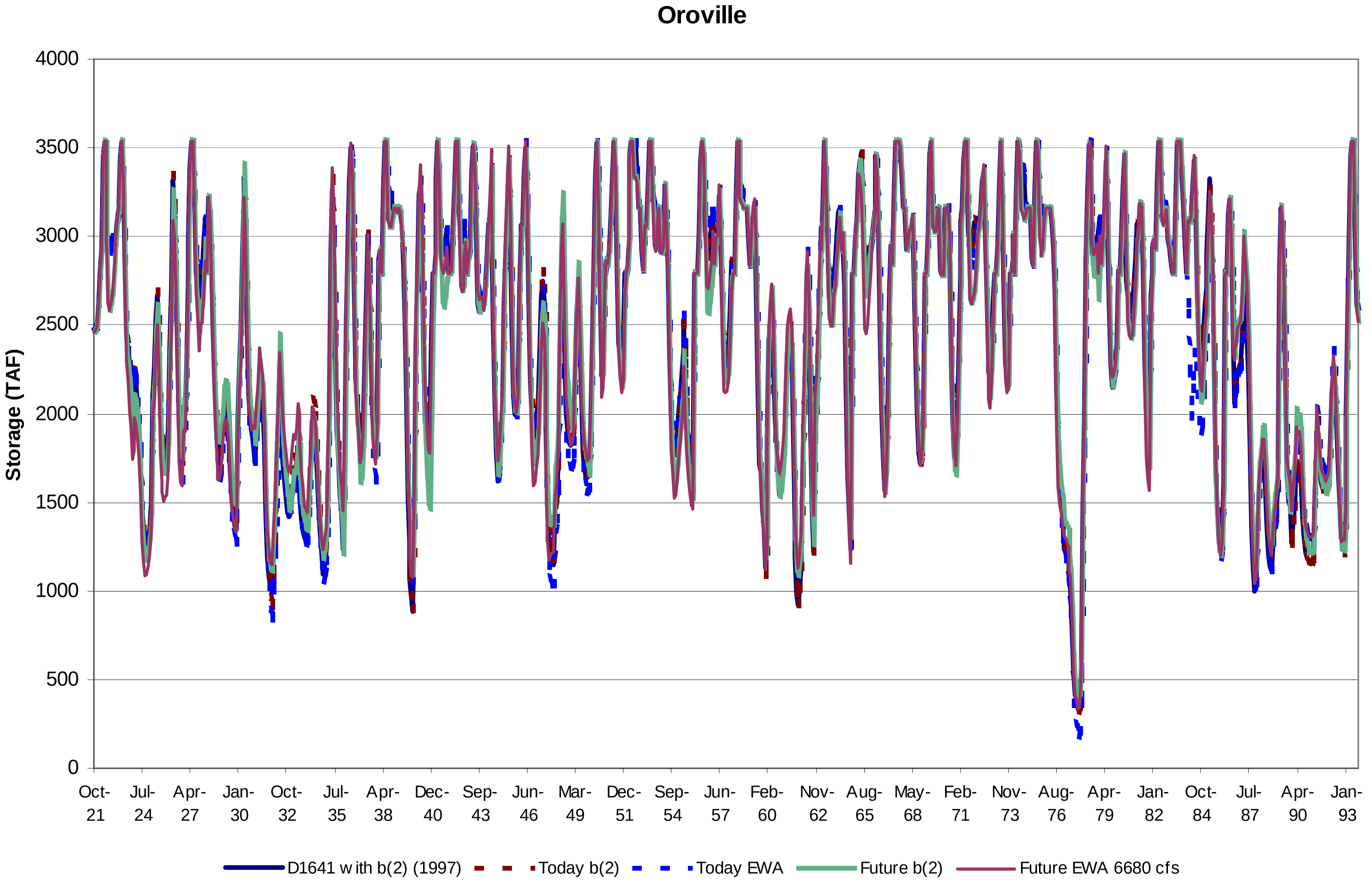


Figure 9–34 Chronology of Oroville Storage, Water Years 1922 – 1993

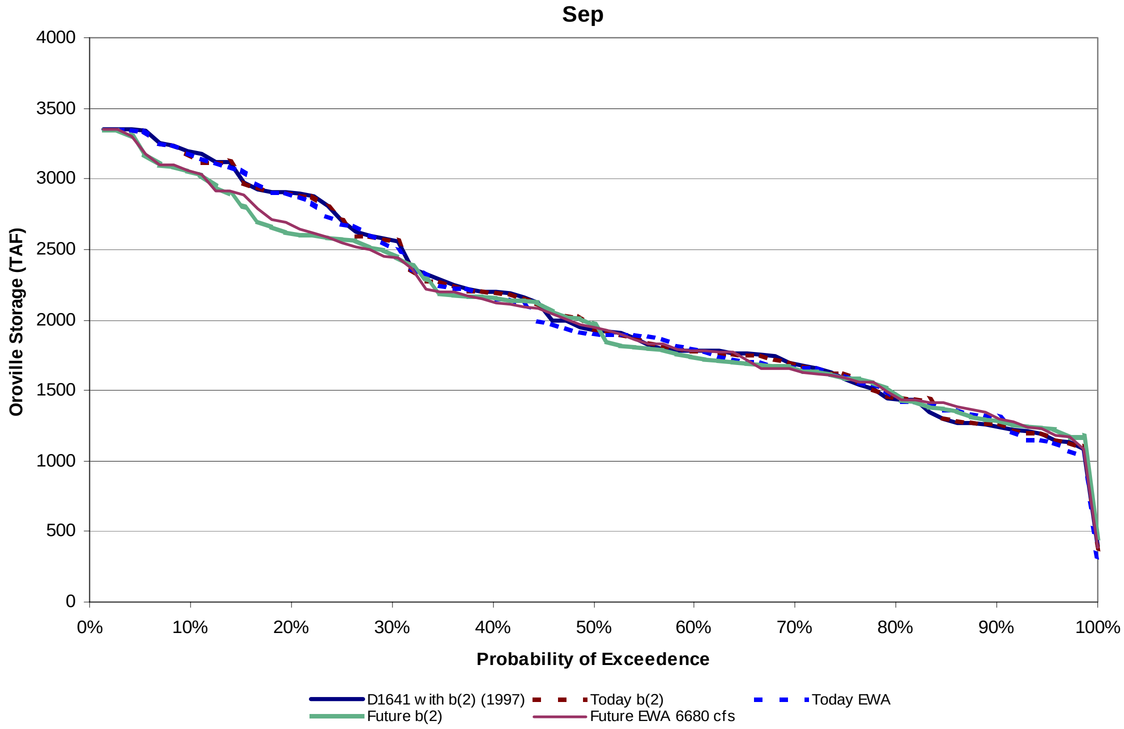


Figure 9–35 Oroville Reservoir End of September Exceedance

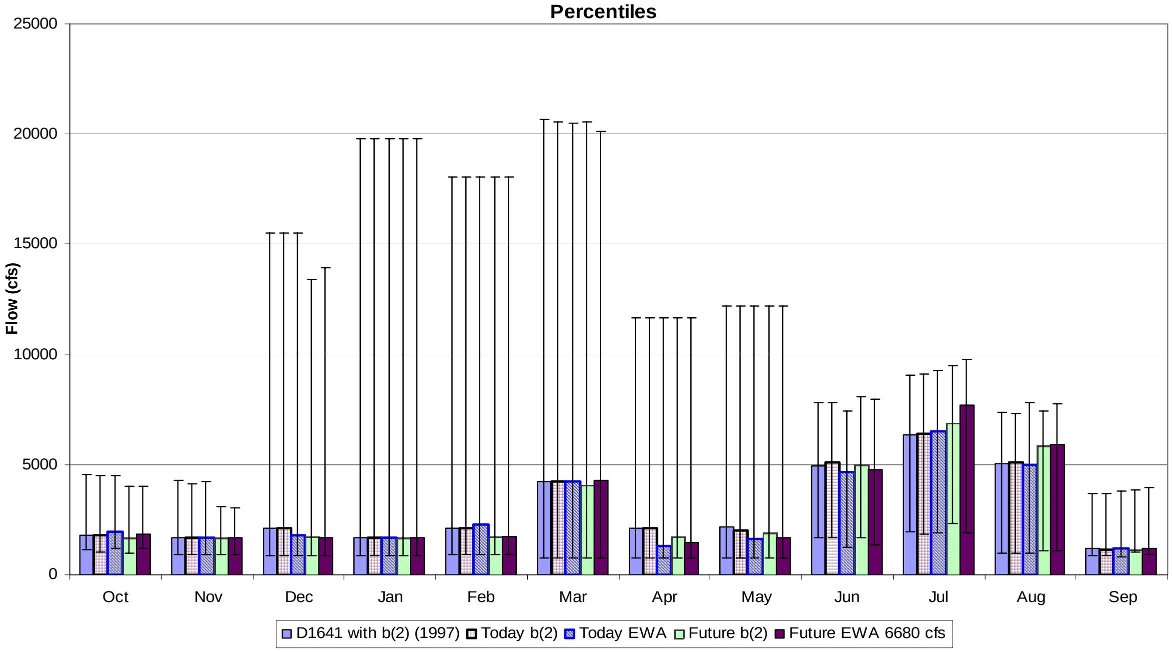


Figure 9–36 Flow Below Thermalito 50th Percentile Monthly Releases with the 5th and 95th as the Bars

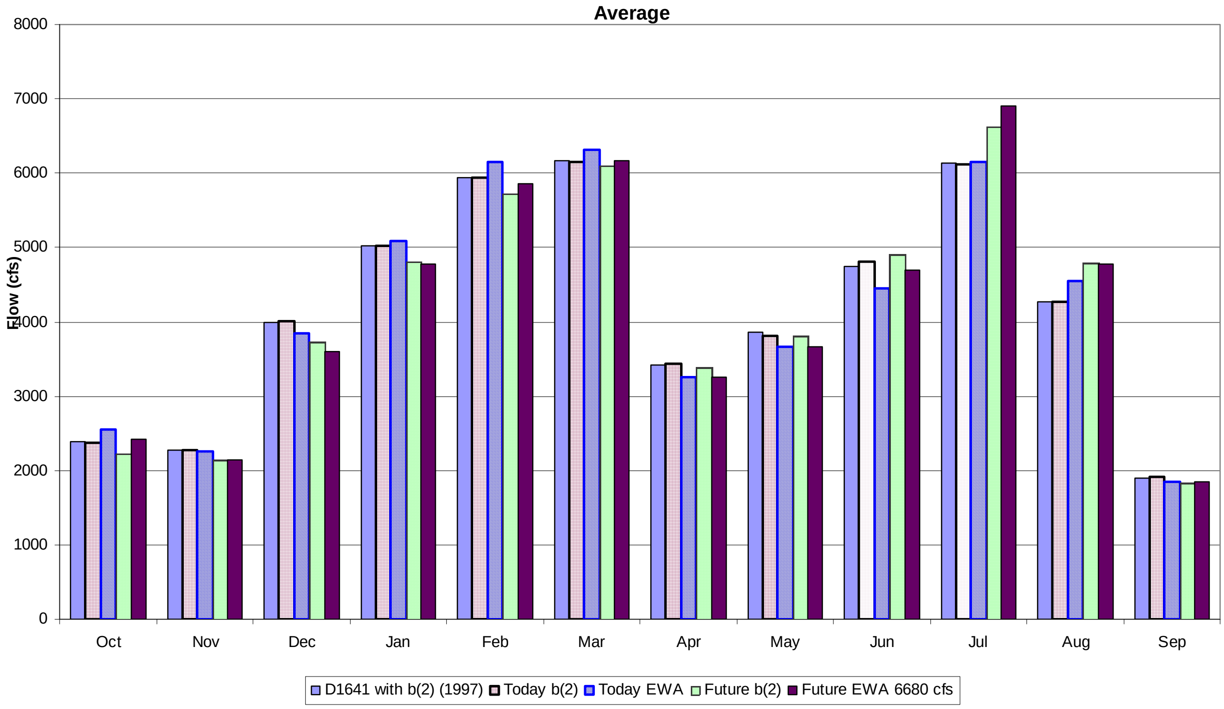


Figure 9–37 Average Monthly Flow Below Thermalito

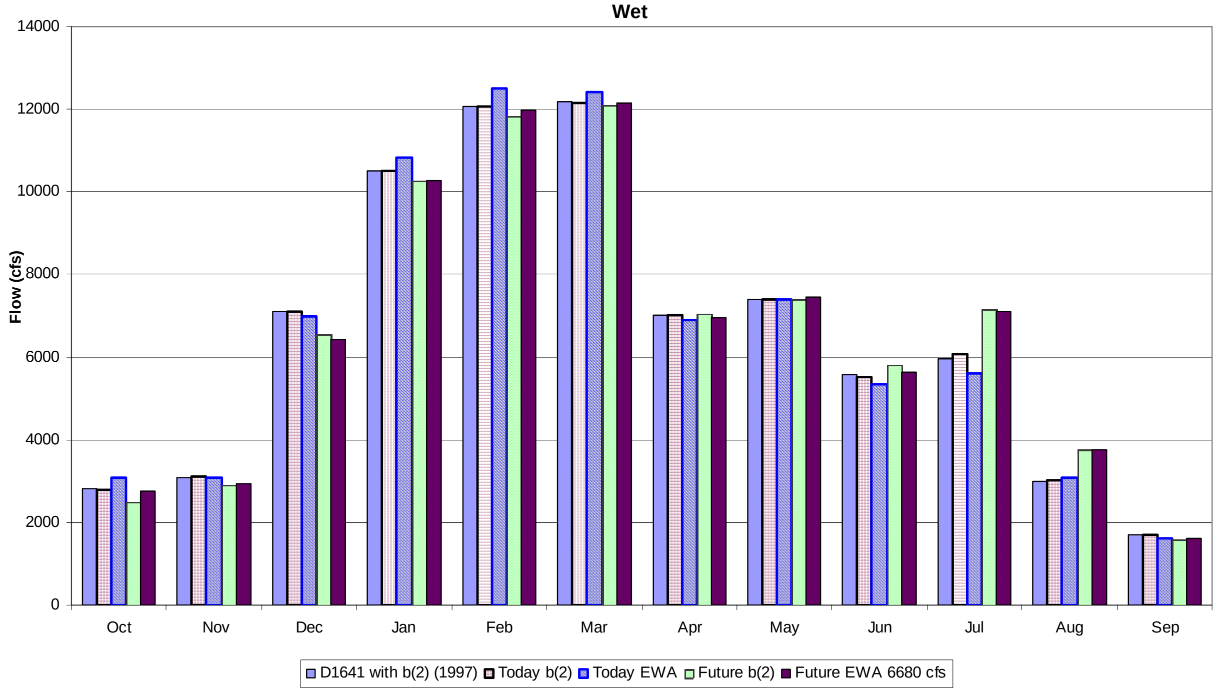


Figure 9–38 Average wet year (40-30-30 Classification) monthly Flow Below Thermalito

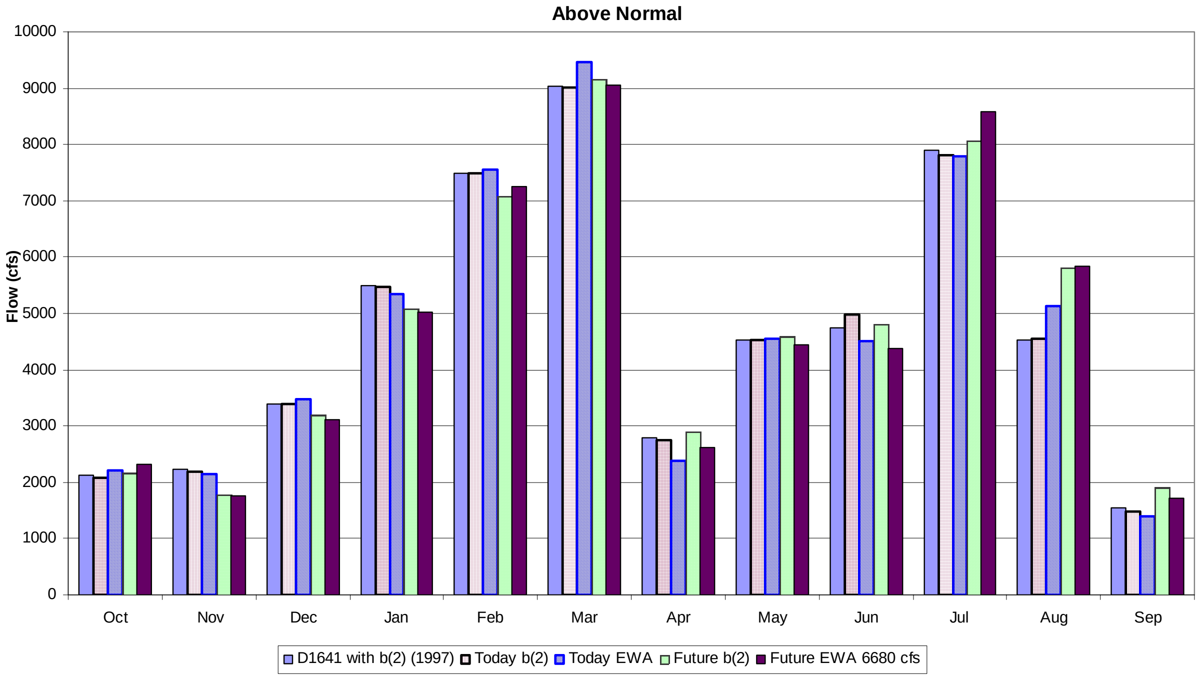


Figure 9–39 Average Above Normal Year (40-30-30 Classification) Monthly Flow Below Thermalito

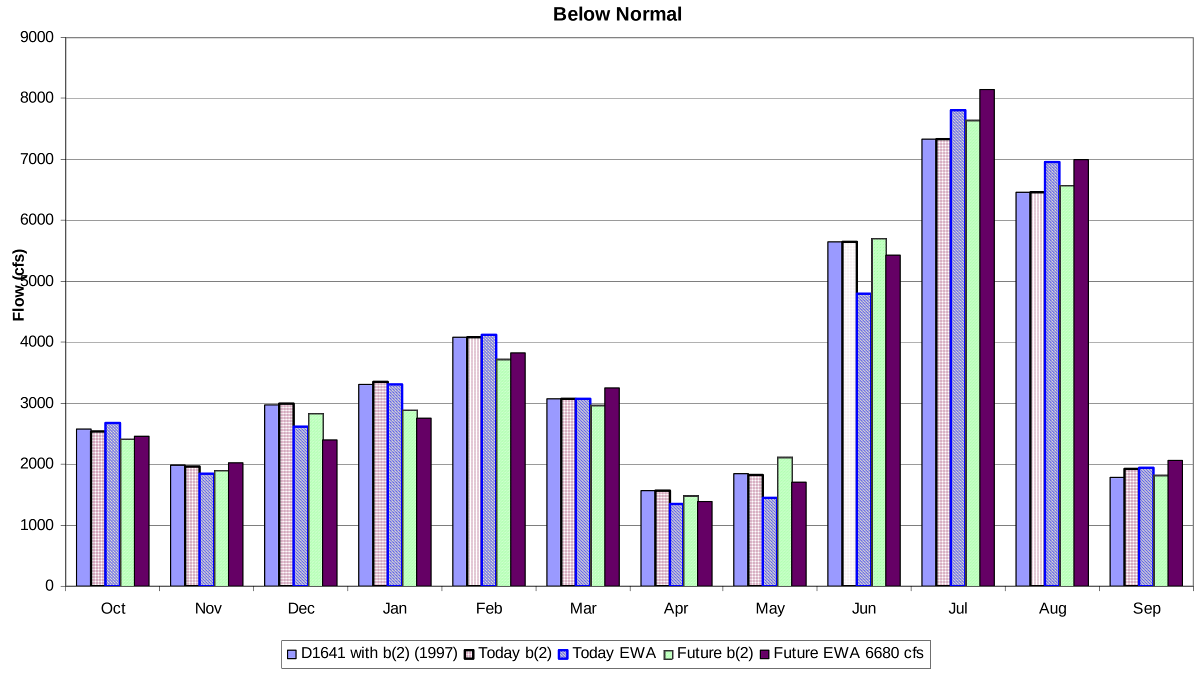


Figure 9–40 Average Below Normal Year (40-30-30 Classification) Monthly Flow Below Thermalito

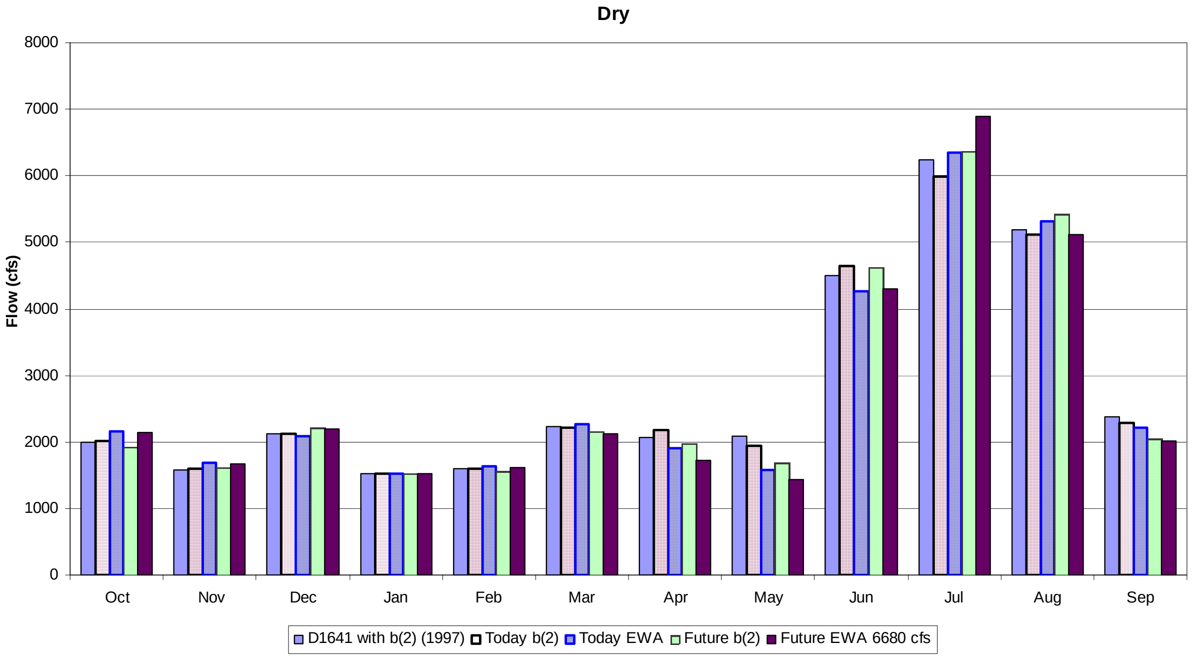


Figure 9–41 Average Dry Year (40-30-30 Classification) Monthly Flow Below Thermalito

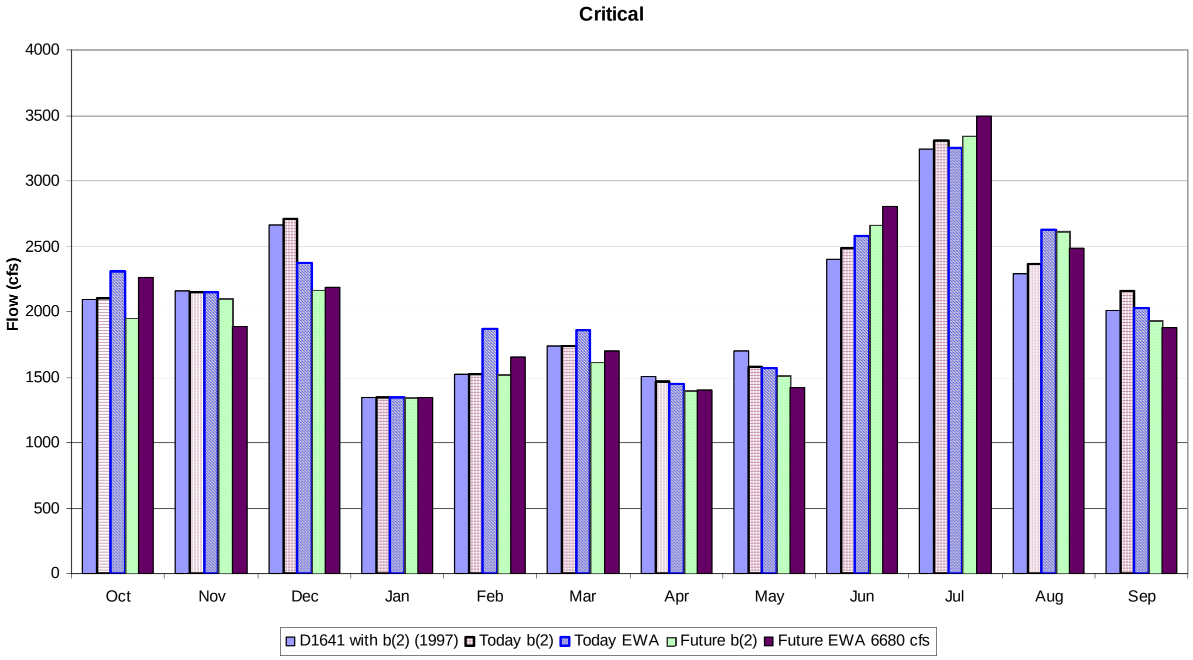


Figure 9–42 Average Critical Year (40-30-30 Classification) Monthly Flow Below Thermalito

The approach to analyze the effects of proposed operations on steelheads 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 steelhead 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 Afterbay for a range of exceedance levels are shown in CALSIM Modeling Appendix F (UpstreamFlows.xls). Temperature results for a range of exceedance levels are presented in Temperature Modeling Appendix I (Feather Temperature.xls).

Steelhead

Flow in the low flow channel (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 steelhead spawning and rearing is uncertain. The LFC is the primary reach for steelhead spawning and rearing. Although there is relatively little natural steelhead production in the river, most steelhead 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). Because these habitats are relatively uncommon, they could limit natural steelhead production. Feather River rotary screw trap (RST) data suggest 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 steelhead. However, studies have revealed that steelhead rear successfully at the downstream extent of the LFC where summer temperatures reach or occasionally exceed 65°F (Figure 9–43). A recent laboratory study also found that Feather River steelhead have a relatively high thermal preference (Myrick 2000). This study also found that in-channel-produced steelhead displayed a higher thermal tolerance than steelhead from the Feather River Hatchery.

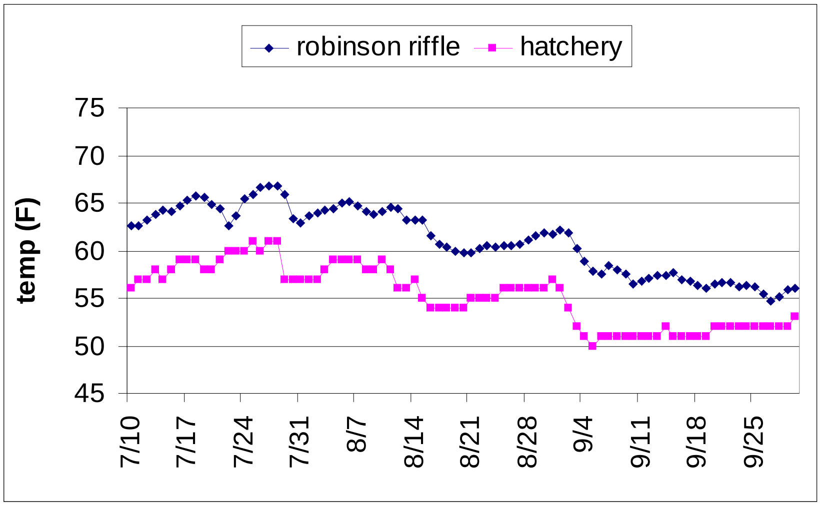


Figure 9–43 Summer Temperature Differences in the Feather River LFC Between the Fish Hatchery Dam and Robinson Riffle Based on Data Collected by Continuous Temperature Loggers During Summer 1998

Predicted water temperatures will not be harmful to steelhead according to Temperature Modeling Appendix I (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 winter and early spring. Overall, these analyses suggest that water temperatures should be satisfactory for steelhead even at the 50 percent exceedance.

Daily water temperatures in the LFC can also be affected by pumpback operations through the Thermalito complex. This practice typically occurs in summer or fall during “off-peak” periods. The effects of pumpback operations are most noticeable in extreme drought periods such as 1990 through 1992, when the reservoir storage dropped below 1.2 maf. 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 maf, even at the 90/75 percent exceedance hydrology. As a result, if pumpback operations are conducted, they are not expected to adversely affect steelhead in the LFC.

Water conditions below the Thermalito Afterbay are not as favorable for steelhead. The projected exceedance flows for the Feather River below Thermalito After bay are shown in Temperature Modeling Appendix I (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 steelhead rearing except during fall and winter. Although young-of-the-year steelheads are occasionally observed in this area, evidence has not been found of substantial steelhead spawning or rearing below the Thermalito outlet (Kindopp and Kurth 2003, Cavallo et al. 2003). As indicated above, most young steelhead 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 steelhead 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 steelhead habitat appear to limit steelhead 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 steelhead rearing and spawning.

Spring–run Chinook Salmon

Predicted flow conditions were discussed previously for steelhead. 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 that 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 that 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 according to the Temperature Modeling Appendix I (Feather Temperature.xls). Most spring-run adults typically hold in the upper 3 miles of the LFC (Dick Painter, personal communication, 1998), where temperatures remain closer to the recommended thresholds (Temperature Modeling Appendix I [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 Afterbay 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 I [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 on Figure 9–44. Egg mortality during the fall incubation period was less than 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.

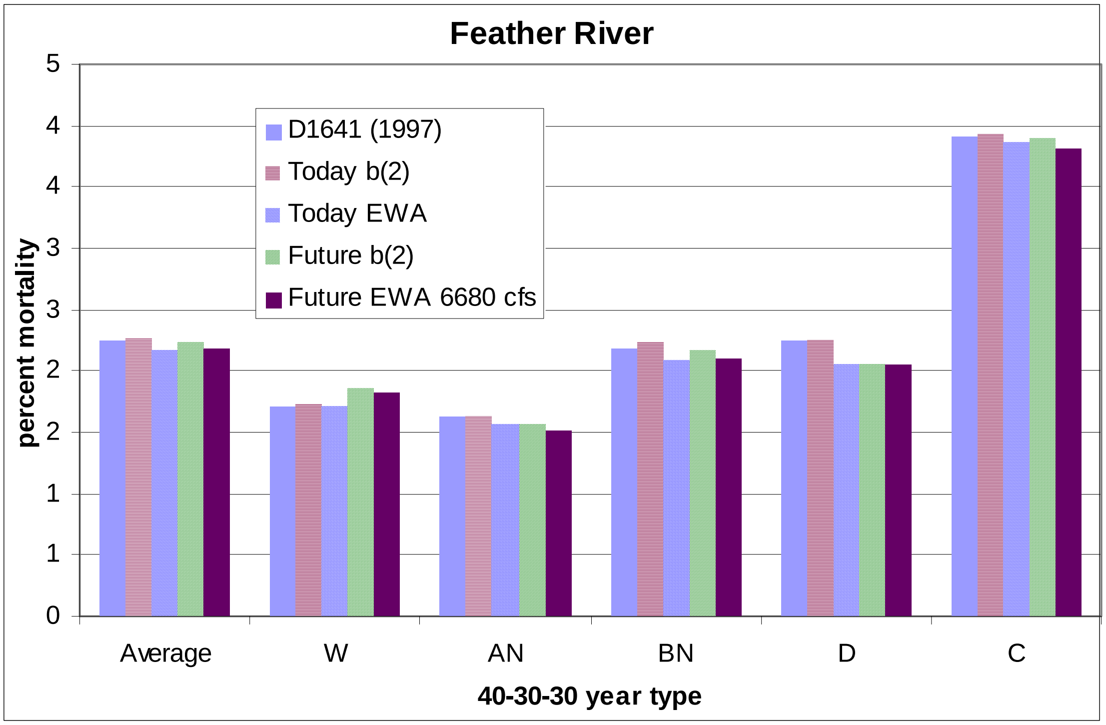


Figure 9–44 Percent Mortality from Egg to Fry Because of Water Temperature for Chinook in the Feather River by Water Year Type

Fall–run Chinook Salmon

Predicted base and future flow and temperature conditions were discussed previously for steelhead 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 1 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). Because of the success of the Feather River Hatchery, 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 3 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 to be 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 on Figure 9-44. Again, egg mortality during the fall incubation period was less than 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 takes of steelhead and spring-run salmon. DWR is likely to modify and perhaps expand on such activities to gather information needed by NOAA Fisheries and DFG during the relicensing of the Oroville Facilities with the Federal Energy Regulatory Commission.

Steelhead and spring-run salmon take could occur during RST sampling, fyke net sampling, beach seine sampling, or snorkeling. Low numbers of steelhead are typically collected in the RSTs between February and July (2002), although the RST is not considered an effective gear for monitoring steelhead 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, young-of-year steelhead 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 steelhead trout, zero mortalities

Snorkel surveys conducted during spring and summer will not result in the lethal take of any steelhead 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 were as follows:

- Steelhead, 5,856 young-of-year, 739 juveniles of unknown age
- Spring-run-sized salmon, 3,034 juveniles of unknown age

The total annual potential steelhead take for the Feather River fish monitoring program is estimated to be 7,855 (6,835 young-of-year, 980 juveniles [age unknown], and 40 adults). Total annual lethal take is estimated to be 2 percent, or 157 steelhead. 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 young-of-year, 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.

Steelhead 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 steelhead and spring-run salmon. These measures are intended to maximize the survival after release.

1. Captured steelhead 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. Steelhead 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, steelhead 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 Chapter 8, Tables 8-3 and 8-4.) The actual deliveries, based on long-term average, increase from a total of 251 taf in the 2001 LOD (total Water Rights and municipal and industrial [M&I]) to 561 taf in the 2020 LOD. Based on the 1928 to 1934 average, deliveries increase from 242 taf to 530 taf in the Future (see Table 9–12). Figure 9–46 shows that 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 to 45 taf 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 9–47).

The future studies 4a and 5a take Water Forum cuts on the demands (see Chapter 8, Tables 8-3 and 8-4) and provide 47 taf of mitigation water. Because the Water Forum contracts are not final and the Environmental Impact Report/Environmental Impact Statement (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 taf 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 9–55). On Figure 9–55, SCWA diversions decrease as the 40-30-30 Index gets drier from 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 takes an annual average of 36 and 63 taf/yr when the EBMUD system storage is most likely to be less than 500 taf.

Figure 9–56 shows results from Study 4a on annual (Mar to Feb) Freeport diversions for SCWA and EBMUD for Study 4a. EBMUD can only take 133 taf in any one year in which EBMUD's total system storage forecast remains below 500 taf, not to exceed 165 taf in any consecutive 3-year drought period. EBMUD takes an annual maximum of 94 taf twice in the 72 years that are analyzed (1959 and 1962). The 165 taf limit is reached in two consecutive years three times (1929-1930, 1959-1960, and 1987-1988) and in three consecutive years five times (1962-1964, 1976-1978, 1977-1979, 1979-1981, and 1990-1992).

Figure 9–48 shows the monthly percentile values for Nimbus releases. Figure 9–49 to Figure 9–54 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 requirements or from decreased flood releases from 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 b(2)		Future EWA 6680 cfs	
	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

Notes:

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

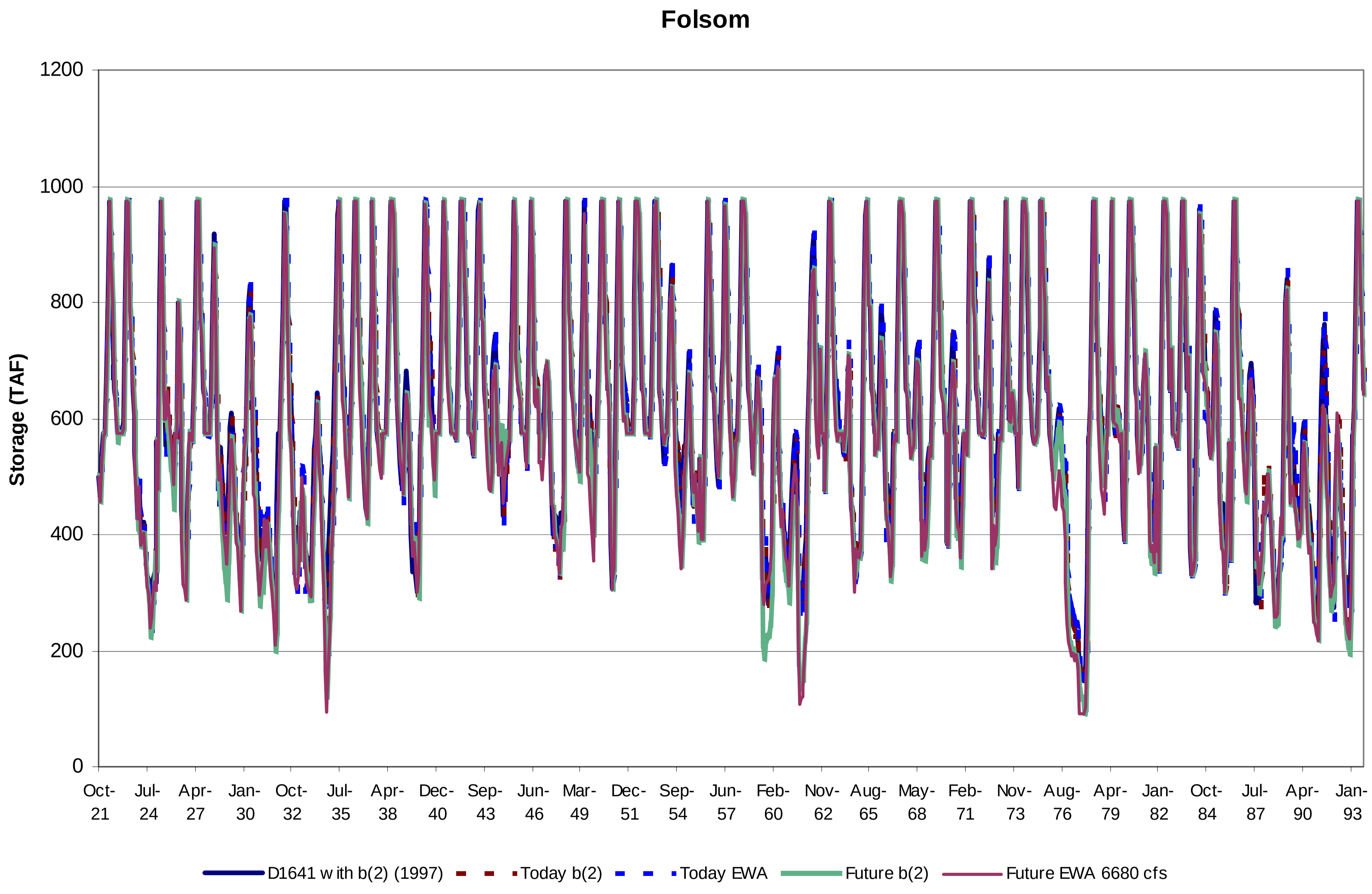


Figure 9–45. Chronology of Folsom Storage Water Years 1922 – 1993

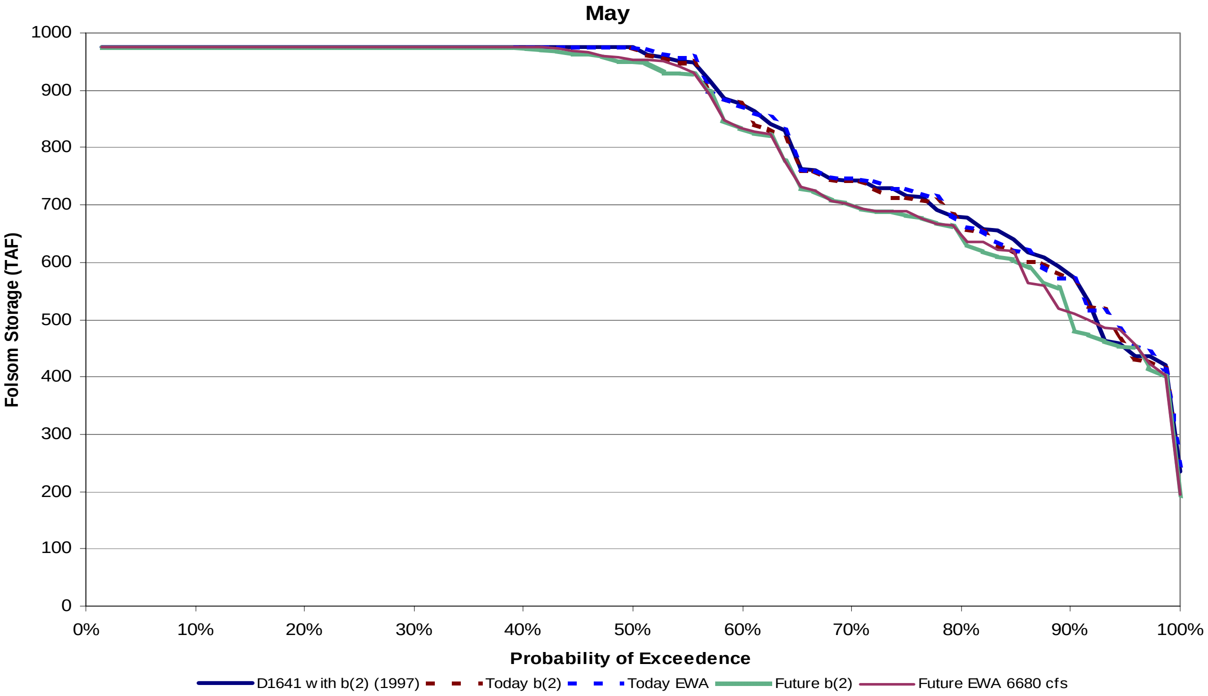


Figure 9–46 Folsom Reservoir End of May Exceedance

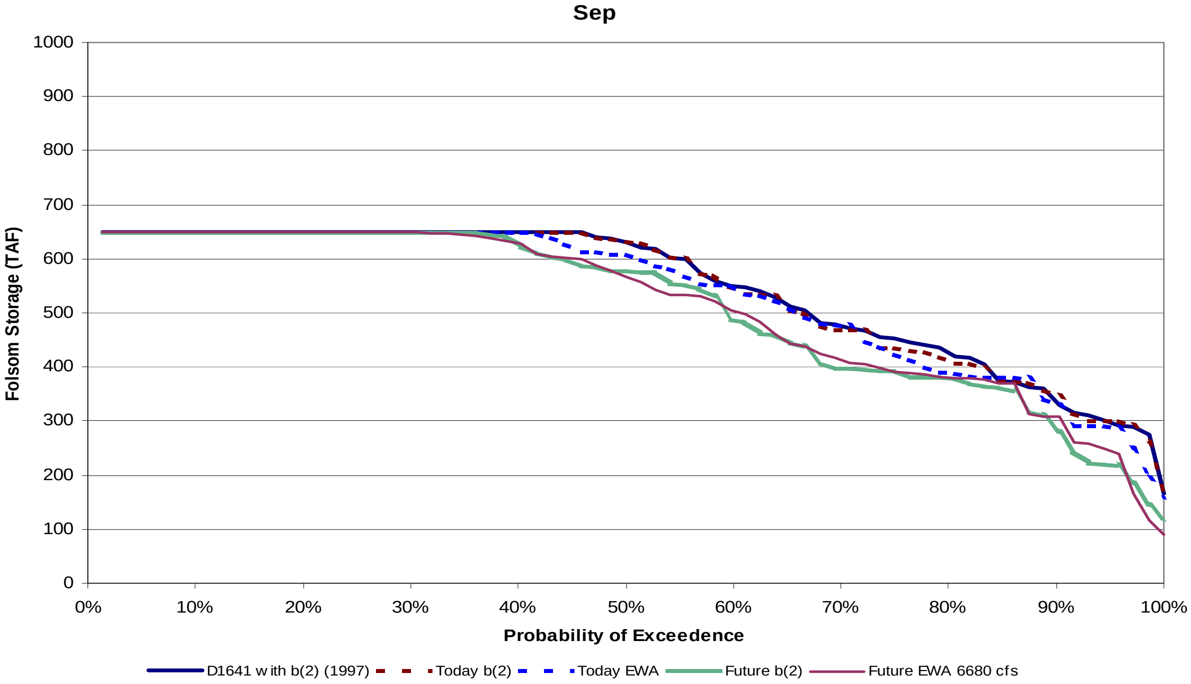


Figure 9–47 Folsom Reservoir End of September Exceedance

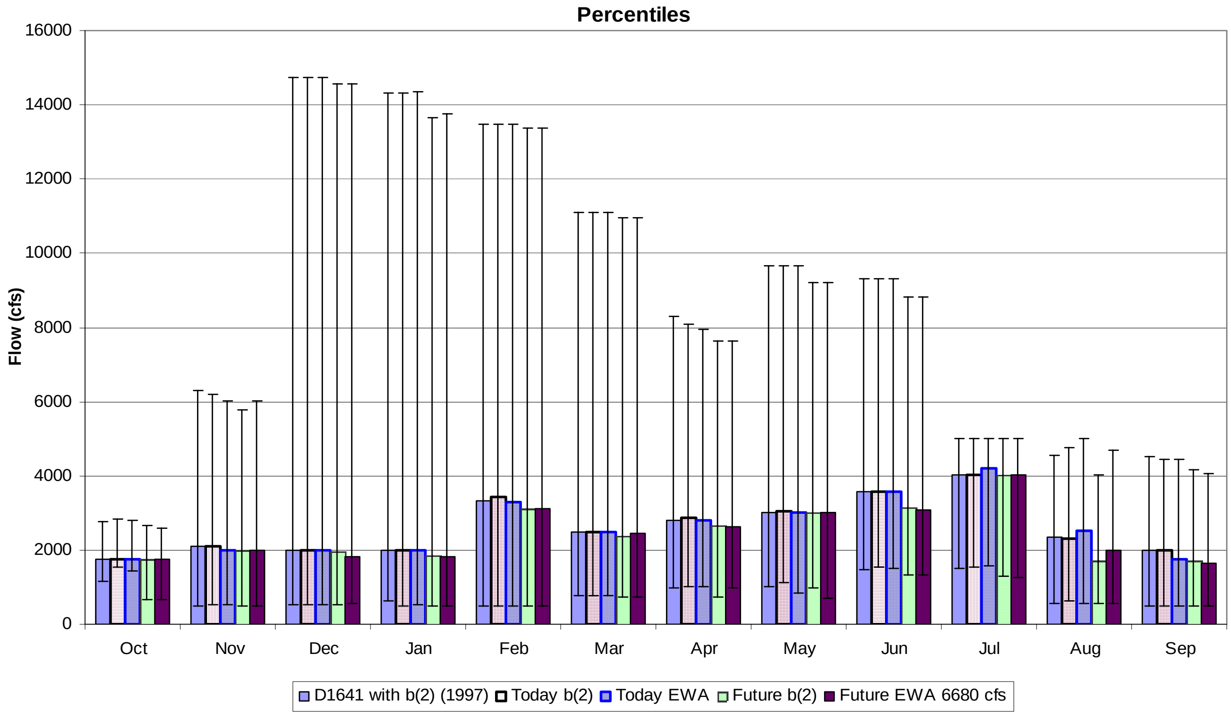


Figure 9–48 Nimbus Release 50th Percentile Monthly Releases with the 5th and 95th as the Bars

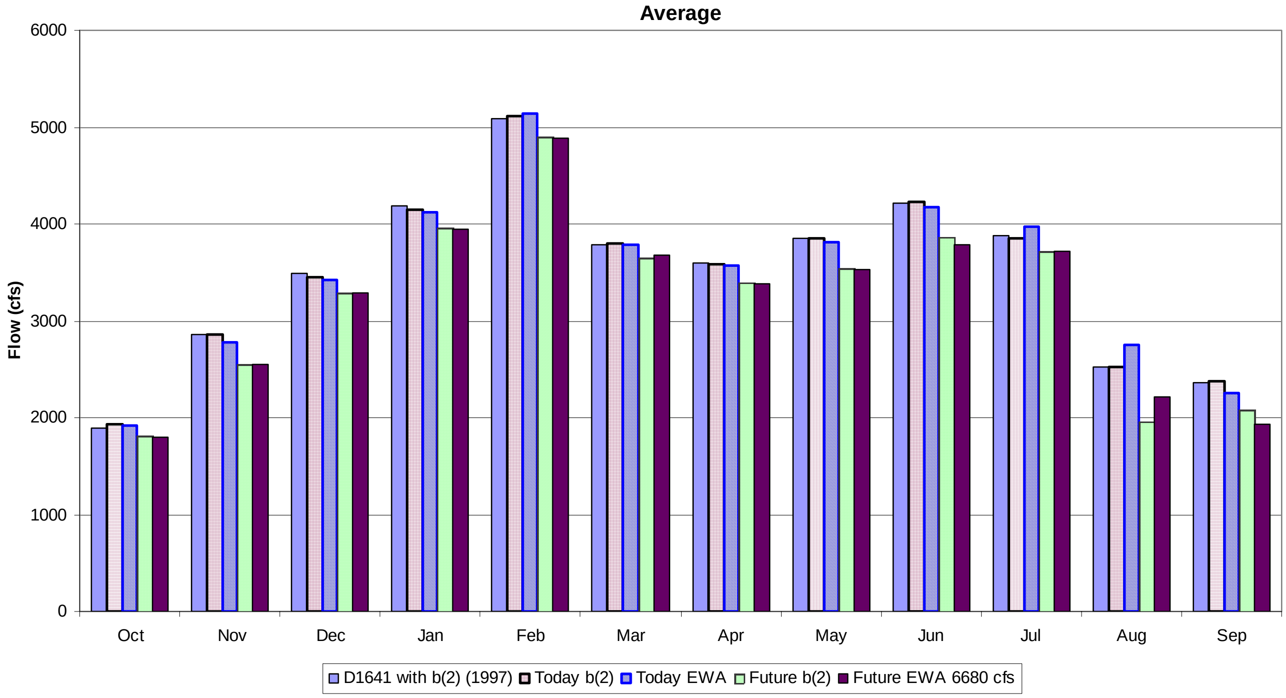


Figure 9–49 Average Monthly Nimbus Release

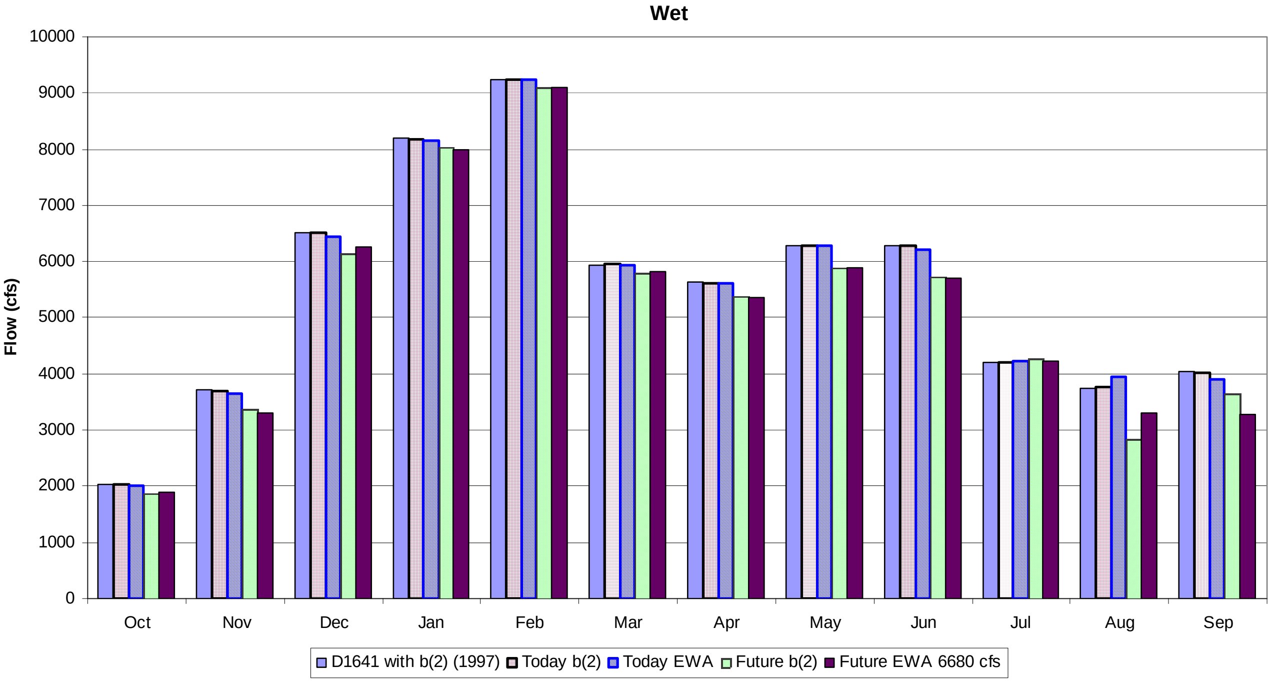


Figure 9–50 Average Wet Year (40-30-30 Classification) Monthly Nimbus Release

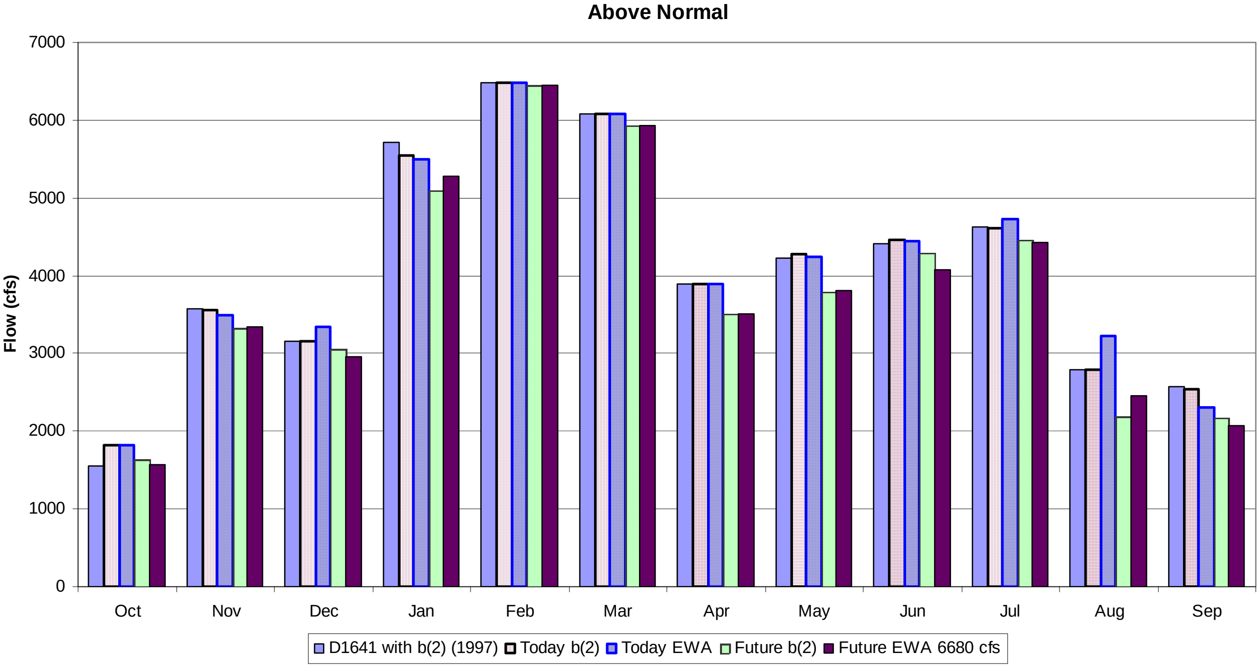


Figure 9–51 Average Above Normal Year (40-30-30 Classification) Monthly Nimbus Release

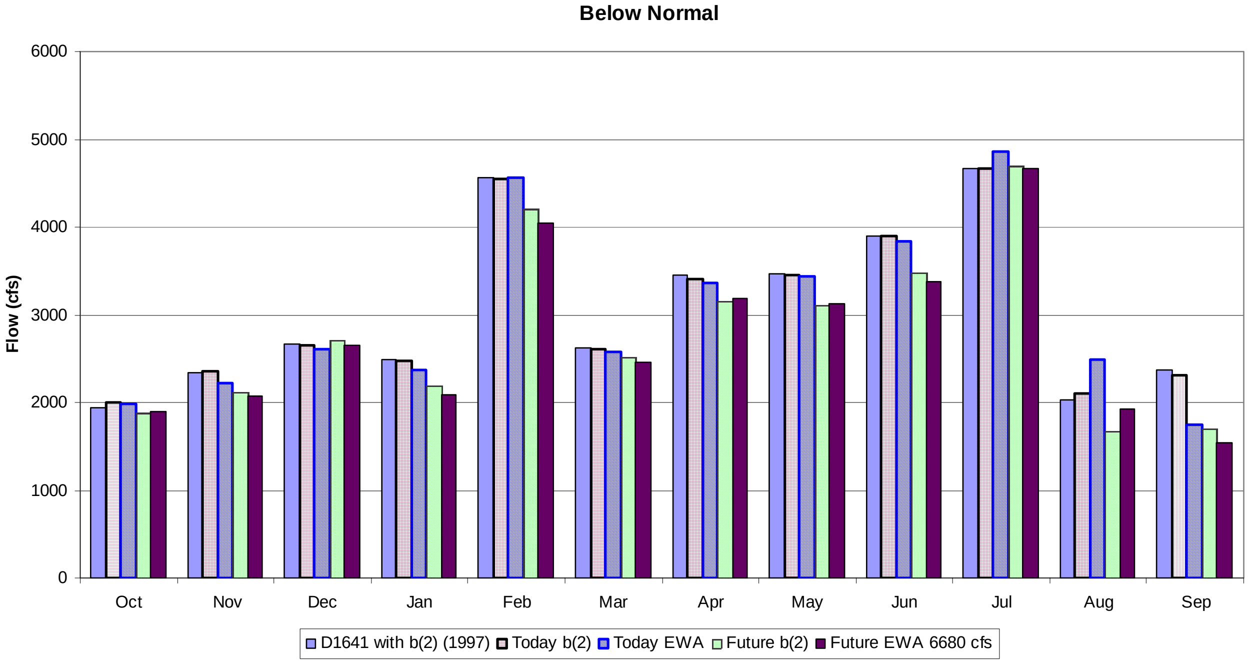


Figure 9–52 Average Below Normal Year (40-30-30 Classification) Monthly Nimbus Release

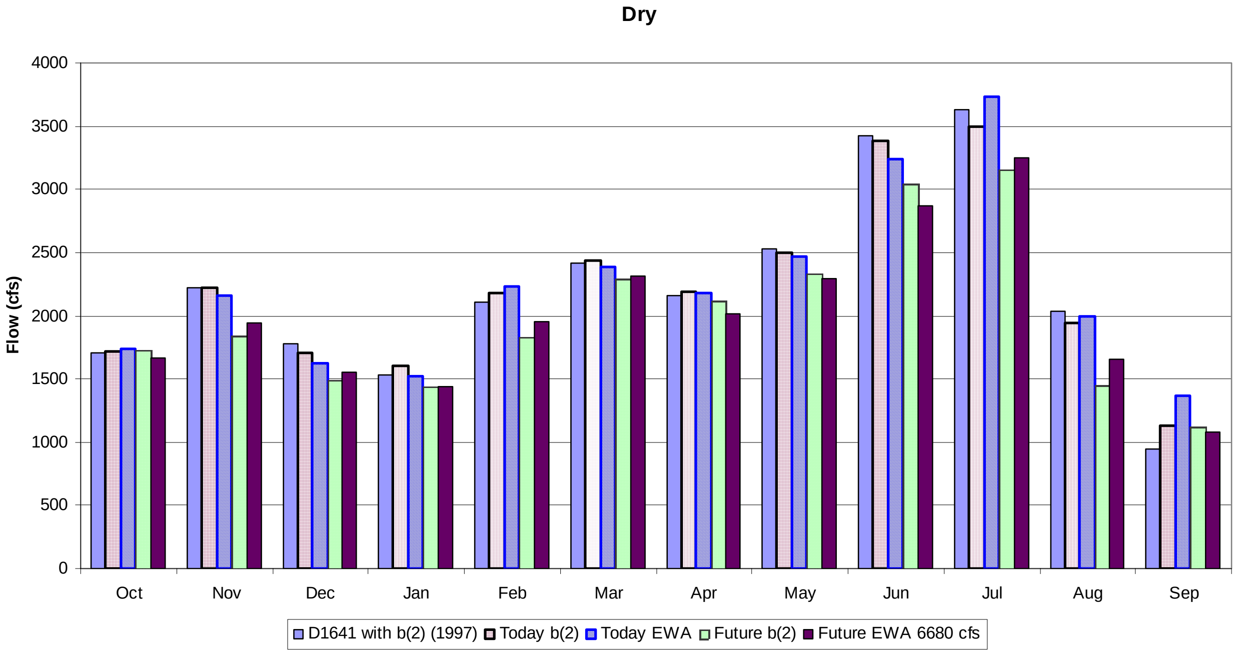


Figure 9–53 Average Dry Year (40-30-30 Classification) Monthly Nimbus Release

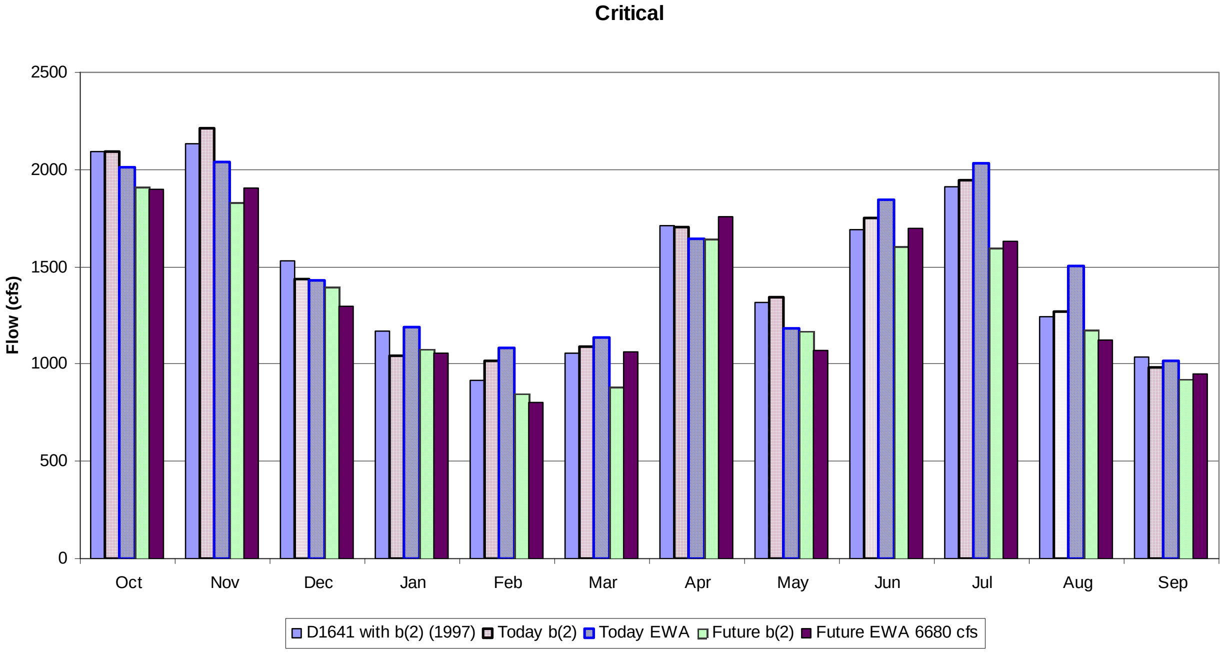
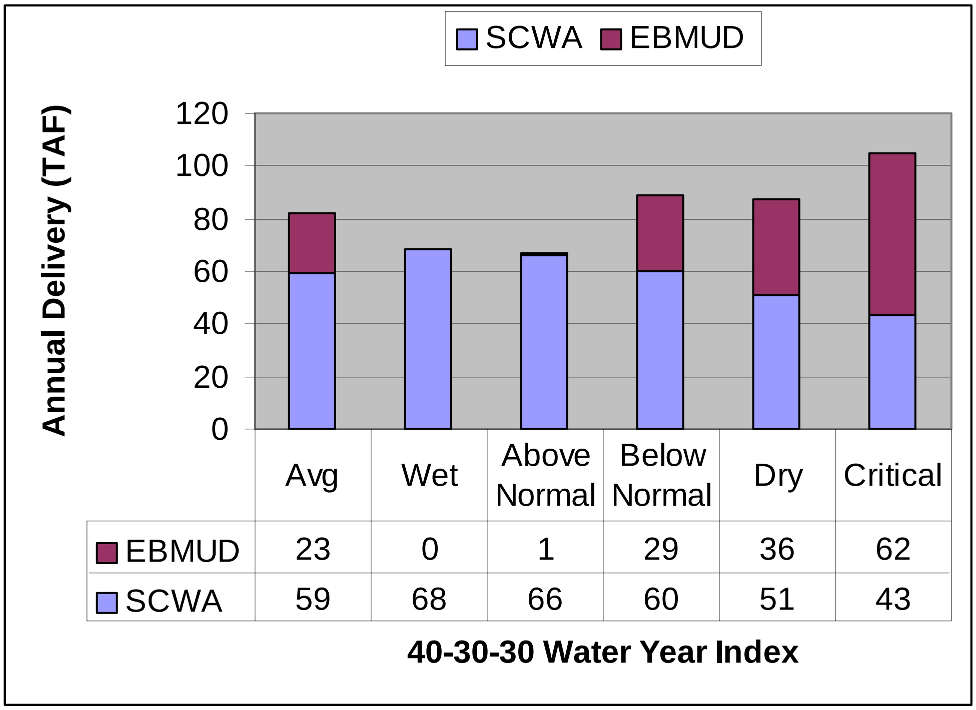


Figure 9–54 Average Critical Year (40-30-30 Classification) Monthly Nimbus Release



	Avg	Wet	Above Normal	Below Normal	Dry	Critical
EBMUD	23	0	1	29	36	62
SCWA	59	68	66	60	51	43

Figure 9–55 Average Annual Freeport Diversion for SCWA and EBMUD from Study 4a

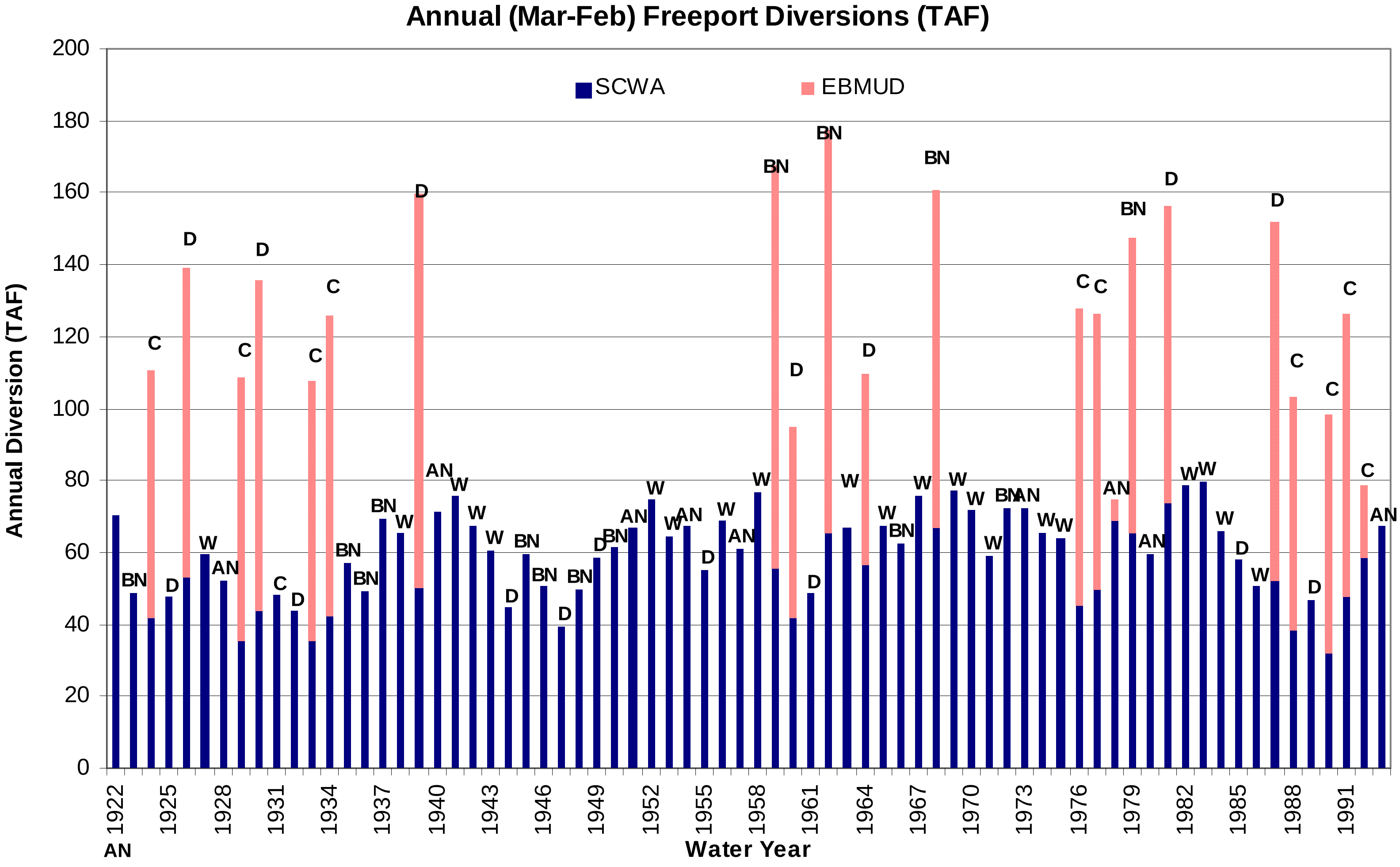


Figure 9–56. March – February Annual Diversions at Freeport for SCWA and EBMUD with 40-30-30 Water Year Classifications

Adult Migration, Spawning, and Incubation

The American River supports a steelhead run but no spring-run or winter-run Chinook. Adult steelhead migration in the American River typically occurs from November through April and peaks in December through March (McEwan and Jackson 1996; Surface Water Resources, Inc. [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. Steelhead 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 above 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 steelhead 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 steelhead in the river drops quickly at the beginning of the summer, possibly from predation. Predators likely take more steelhead 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.

Steelheads prefer 46°F to 52°F water for upstream migration. Temperatures of 52°F or lower are best for steelhead 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. More than 90 percent of the steelhead 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). Steelhead 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 steelhead 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 steelhead 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 according to 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 to 25 percent of the years. Flows would generally increase after November and through 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 3 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 because of 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 the 60°F objective at Watt Avenue in October in all but 25 percent of the years and in November in all but about 5 percent of years. Meeting temperature objectives for steelhead during the summer and for Chinook in the fall involves tradeoffs between whether to use more cool water during the summer for steelhead rearing or saving some 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 summer and fall when needed to provide cool water in the lower American River for steelhead 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 steelhead redds, resulting in the injury and mortality of steelhead 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 1 or 2-day period rather than lower releases over an extended period would preclude steelhead 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 steelhead redds likely lowered the number of steelhead fry produced in 2003. The limiting period to in-river steelhead production seems to occur after fry emergence.

Fry, Juveniles, and Smolts

The freshwater life stages of steelhead occupy the American River throughout the year. Most literature has indicated that rearing fry and juvenile steelhead 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 steelhead 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 steelhead 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 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 steelhead population in the American River. Monitoring during 2001 and 2002 indicated that steelhead 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 steelhead during summer and adult Chinook holding and spawning. Because of the high temperatures, the steelhead run in the American River will likely remain primarily supported by the hatchery.

Juvenile salmon emigration studies using RSTs in the lower American River at Watt Avenue generally capture steelhead fry from March through June, while steelhead yearlings and smolts emigrate from late December until May, with most captured in January (Snider and Titus 2000). Specific flow needs for emigration in the American River have not been determined. Steelhead emigrate at a relatively large size, so they 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 steelhead because of the high salmonid densities. The habitat is generally not fully seeded with steelhead fry. December through March forecasted 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 steelhead 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 steelhead fry and juvenile 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 through March (Snider et al. 1997, Snider et al. 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 et al. 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 tradeoffs between providing cool water for the Chinook life cycle or providing cool water so that juvenile steelhead 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 9–57). 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.

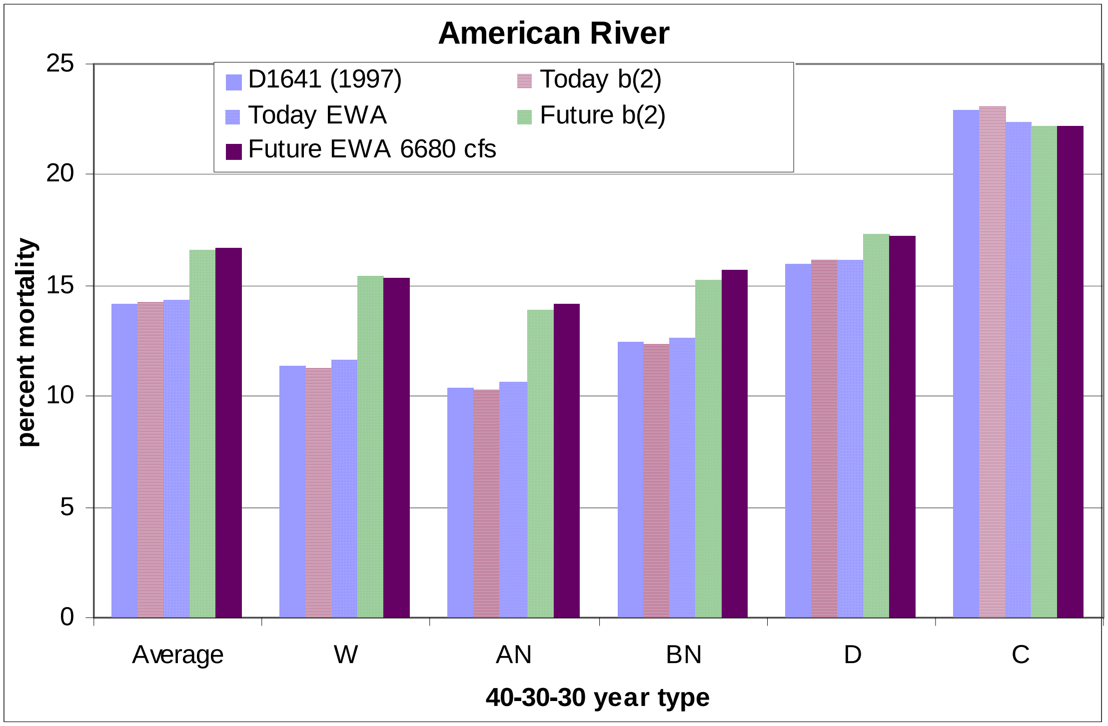


Figure 9–57 Percent Mortality of Chinook Salmon from Egg to Fry in the American River Based on Water Temperature by Water Year Type

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 steelhead 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 were not available. Delta inflow data from Mokelumne are available but are 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, and 8 percent of years in April and May. At times there would be no inflow to the Delta during November through March when adult steelhead are migrating upstream. Low Delta inflow could result in steelhead 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 steelhead returns (hatchery and wild) have been below 100 fish greater than 380 millimeters (mm) long since 1999 (EBMUD data). Past release data that for steelhead that make it into the upper river, 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 taf) 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 steelhead.

Steelhead 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

Among the five studies, there is no change in operations on the Stanislaus and no significant effects of the previously mentioned changes in assumptions. Figure 9–58 shows the chronology of New Melones, and Figure 9–59 shows the end-of-September exceedance plot. Both figures show that there are no significant differences in storage among the five studies. Figure 9–60 shows the percentile values for the releases from Goodwin Reservoir, and Figure 9–61 to Figure 9–66 show the monthly averages by 60-20-20 water-year types. The Goodwin release graphs also show no significant effect to operations among the five studies.

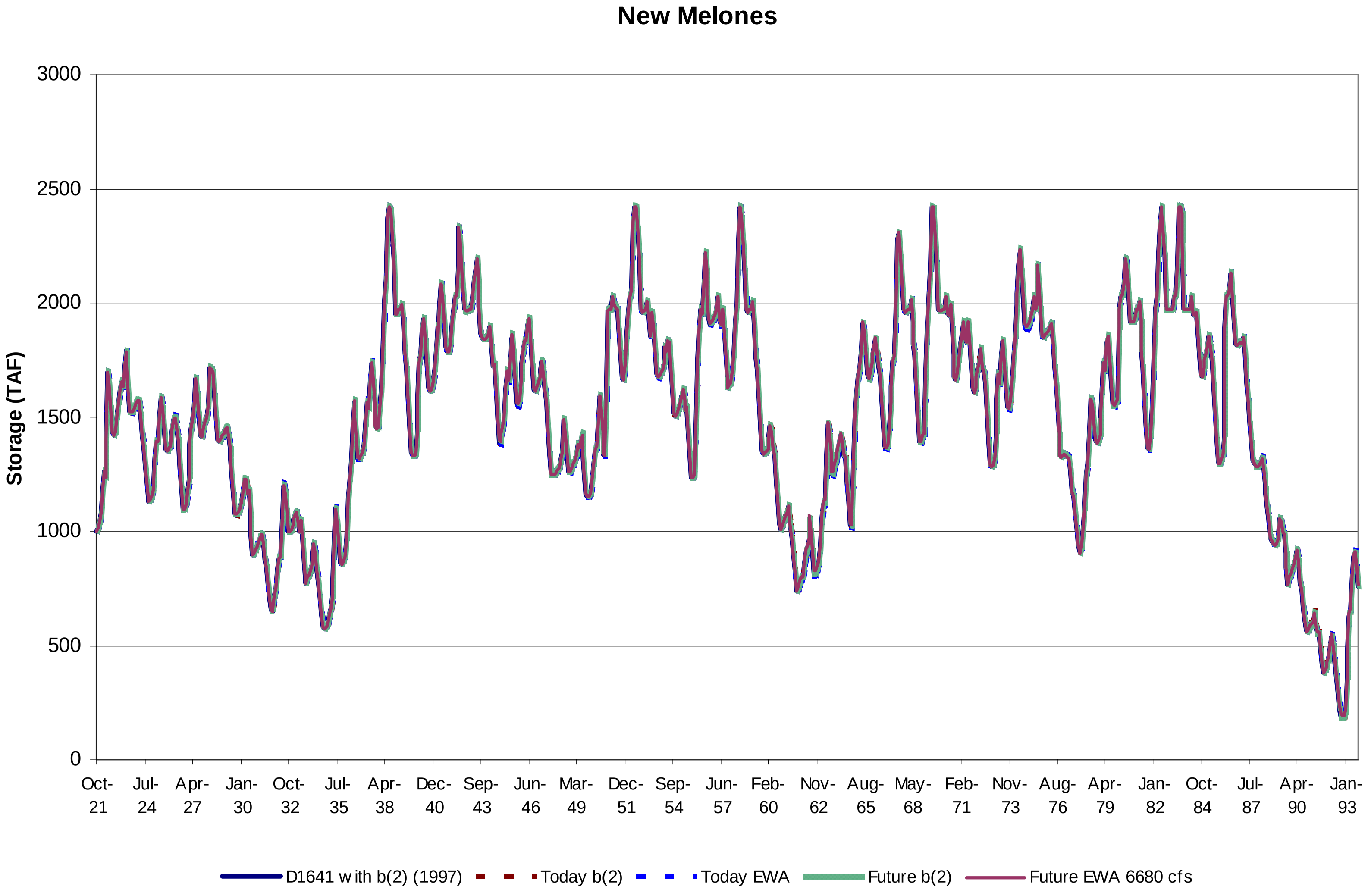


Figure 9–58 Chronology of New Melones Storage Water Years 1922 – 1993

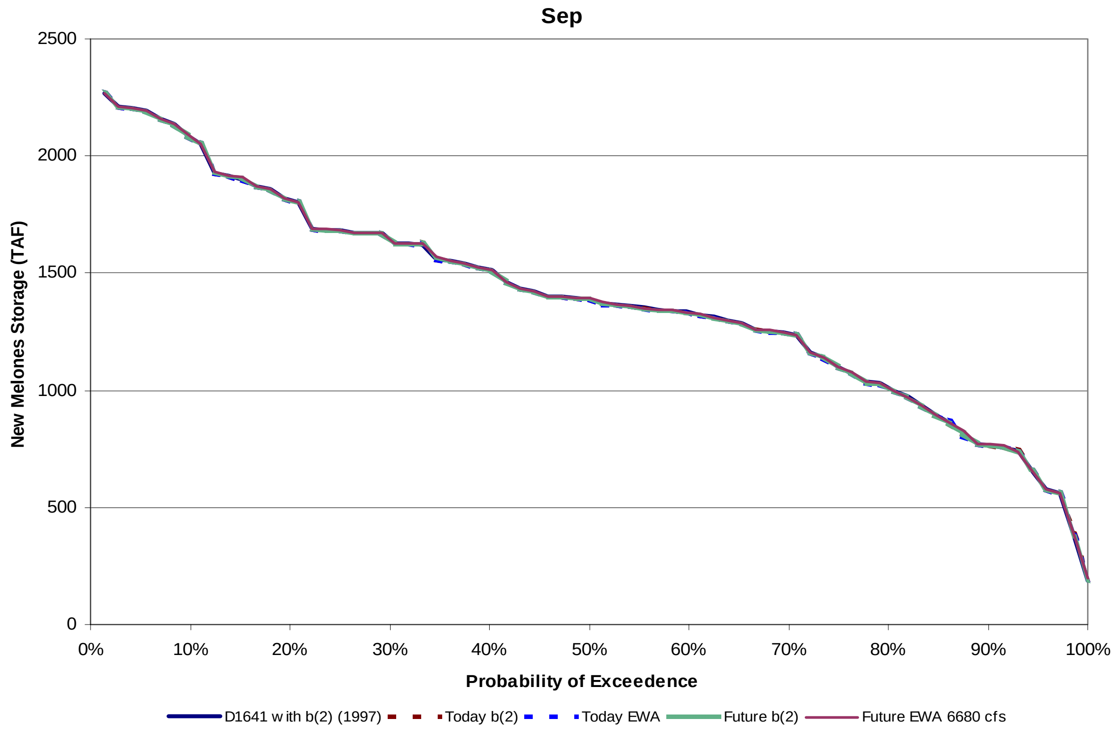


Figure 9–59 New Melones Reservoir End of September Exceedance

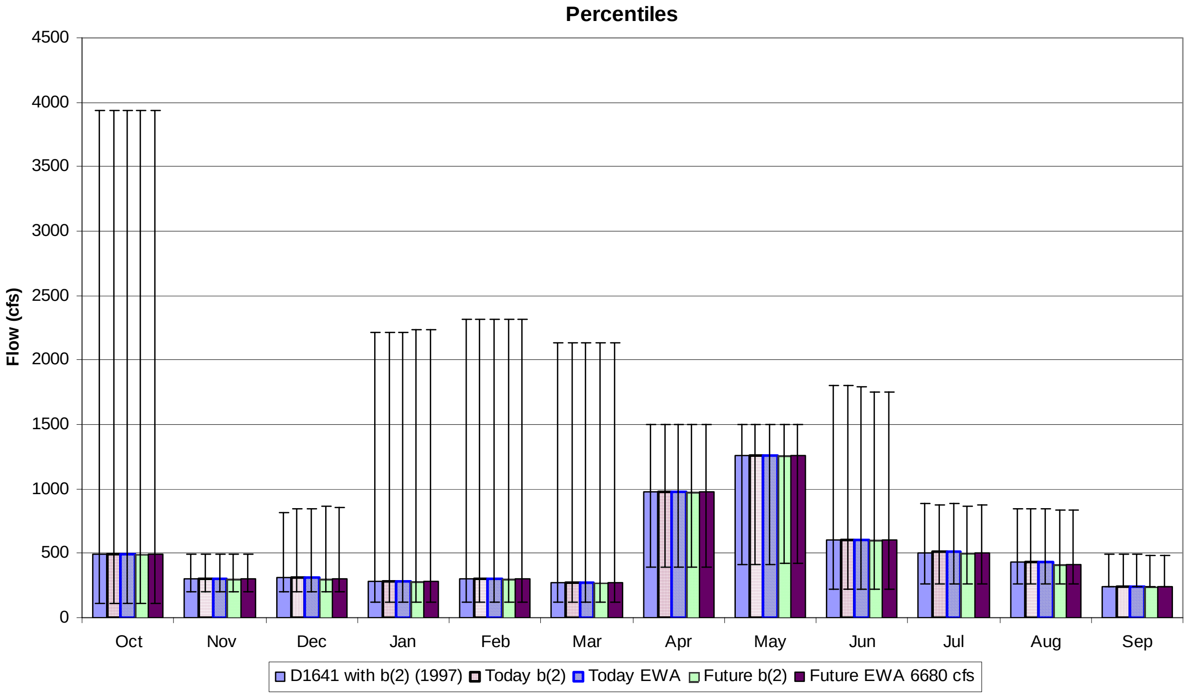


Figure 9–60 Goodwin Releases 50th Percentile Monthly Releases with the 5th and 95th as the Bars

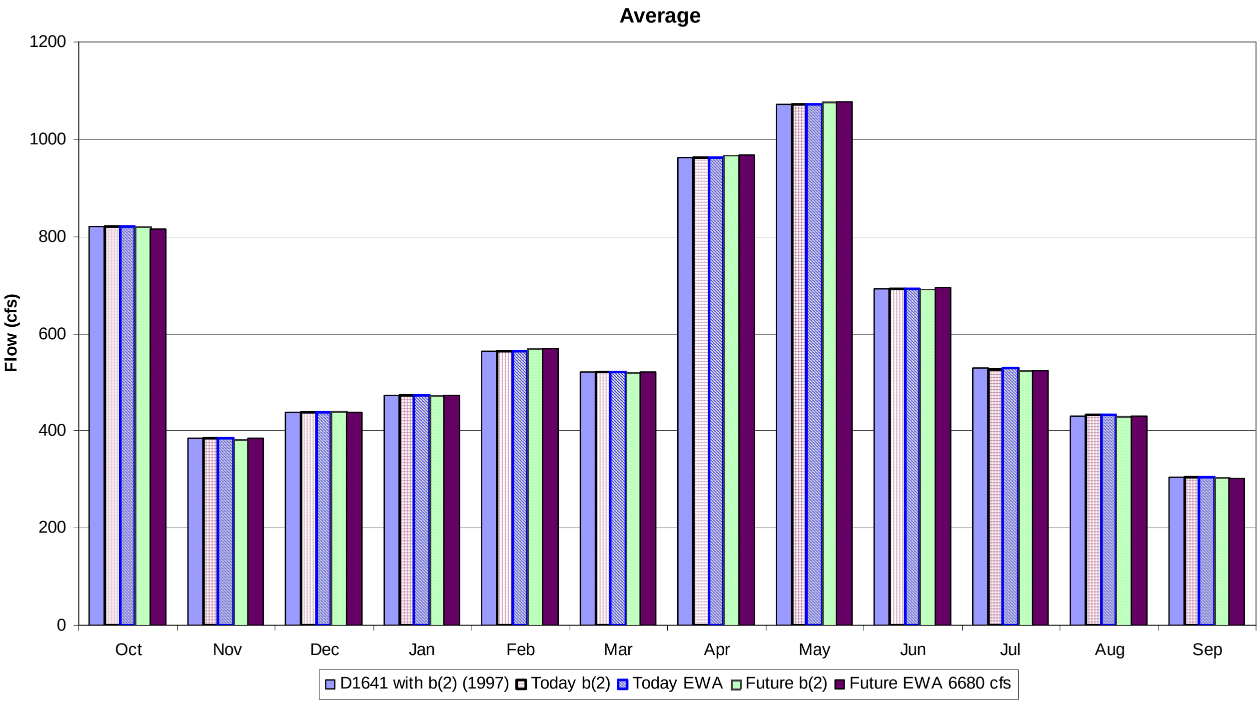


Figure 9–61 Average Monthly Goodwin Releases

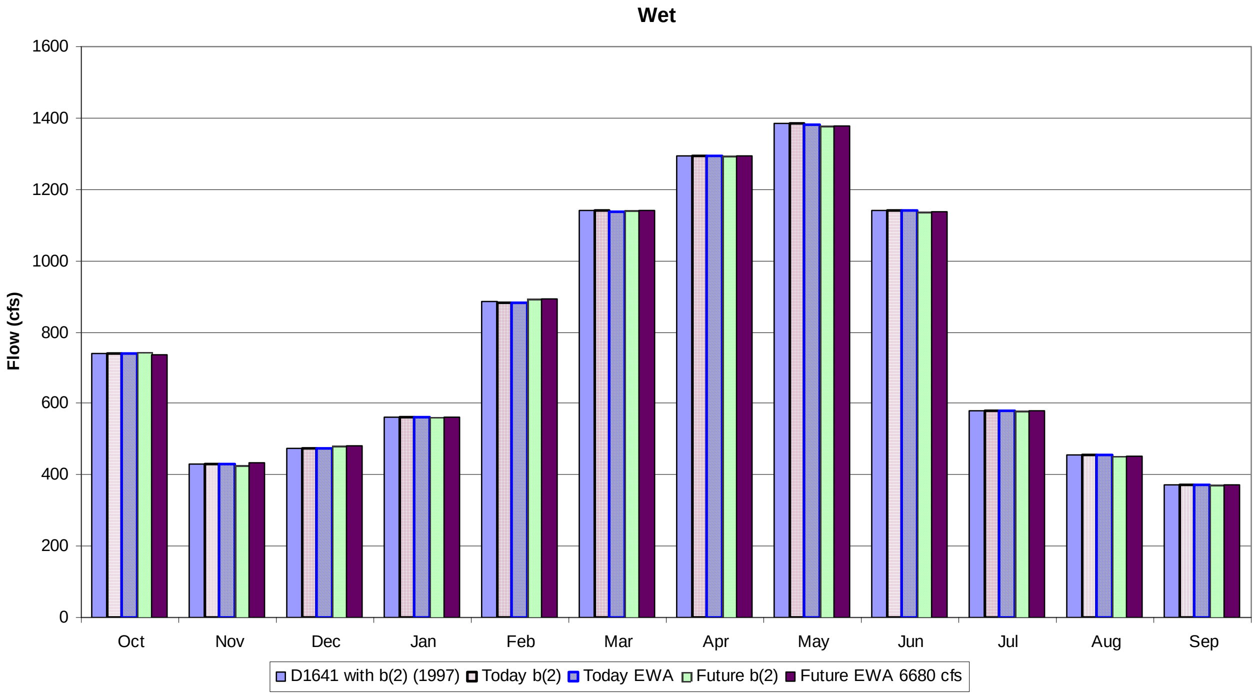


Figure 9–62 Average Wet Year (40-30-30 Classification) Monthly Goodwin Releases

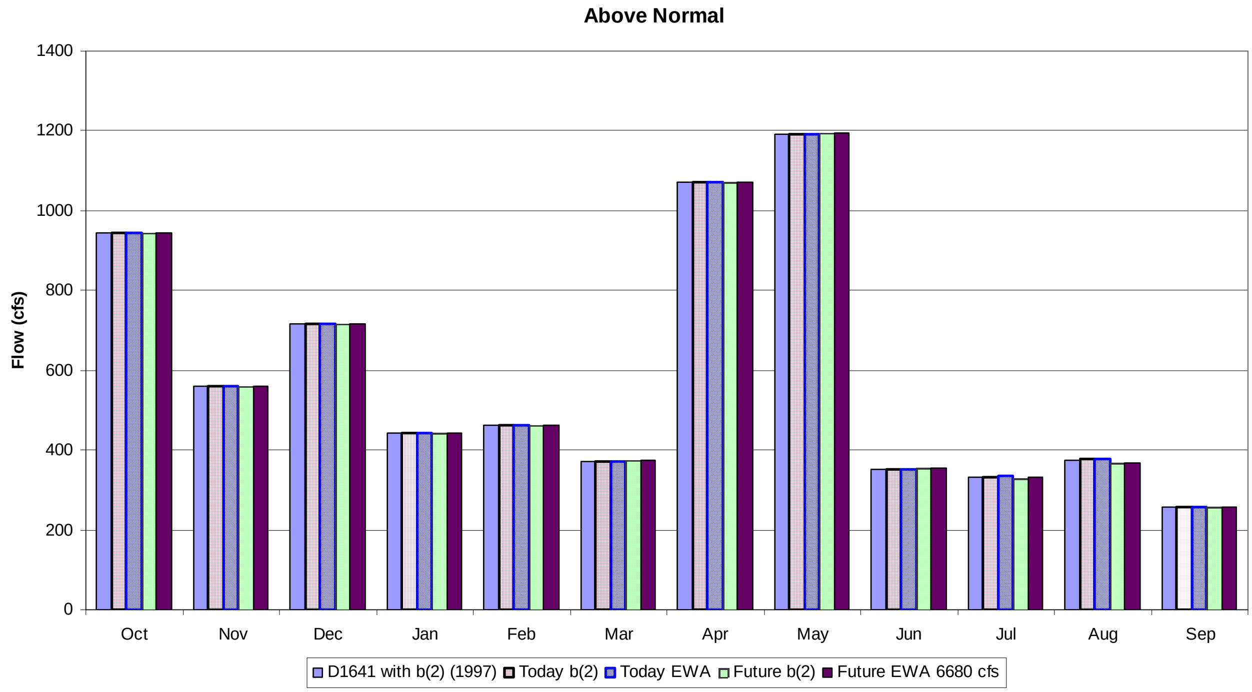


Figure 9–63 Average Above Normal Year (40-30-30 Classification) Monthly Goodwin Releases

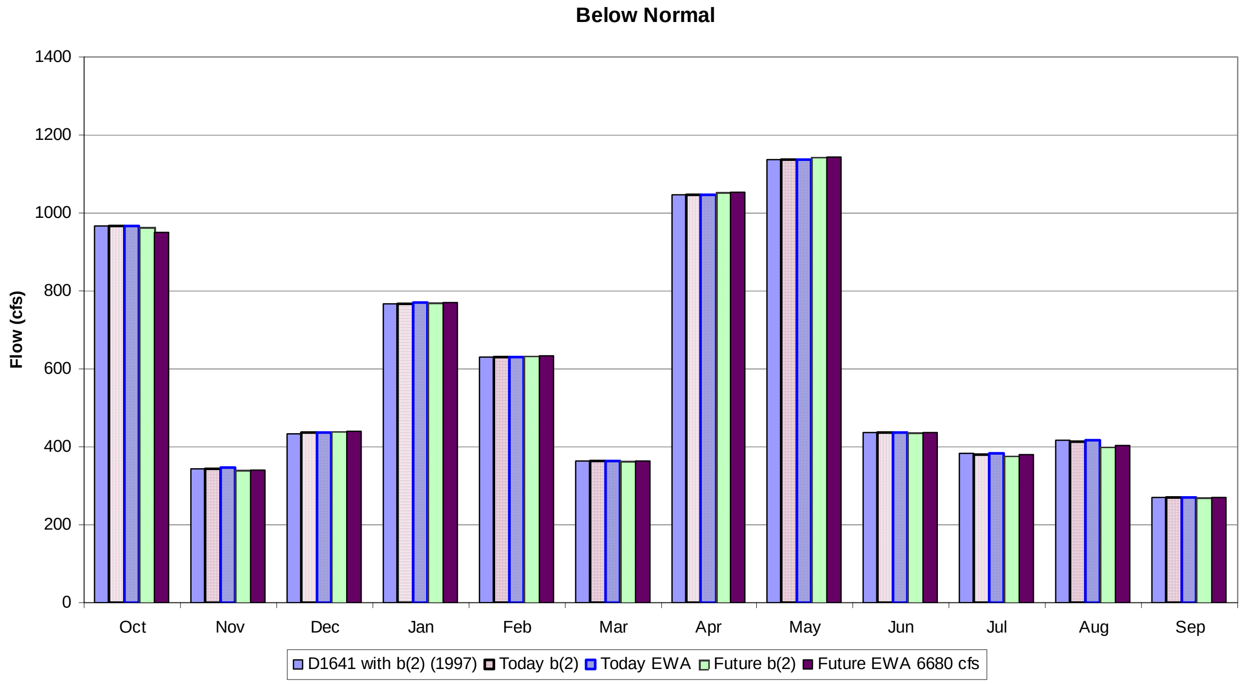


Figure 9–64 Average Below Normal Year (40-30-30 Classification) Monthly Goodwin Releases

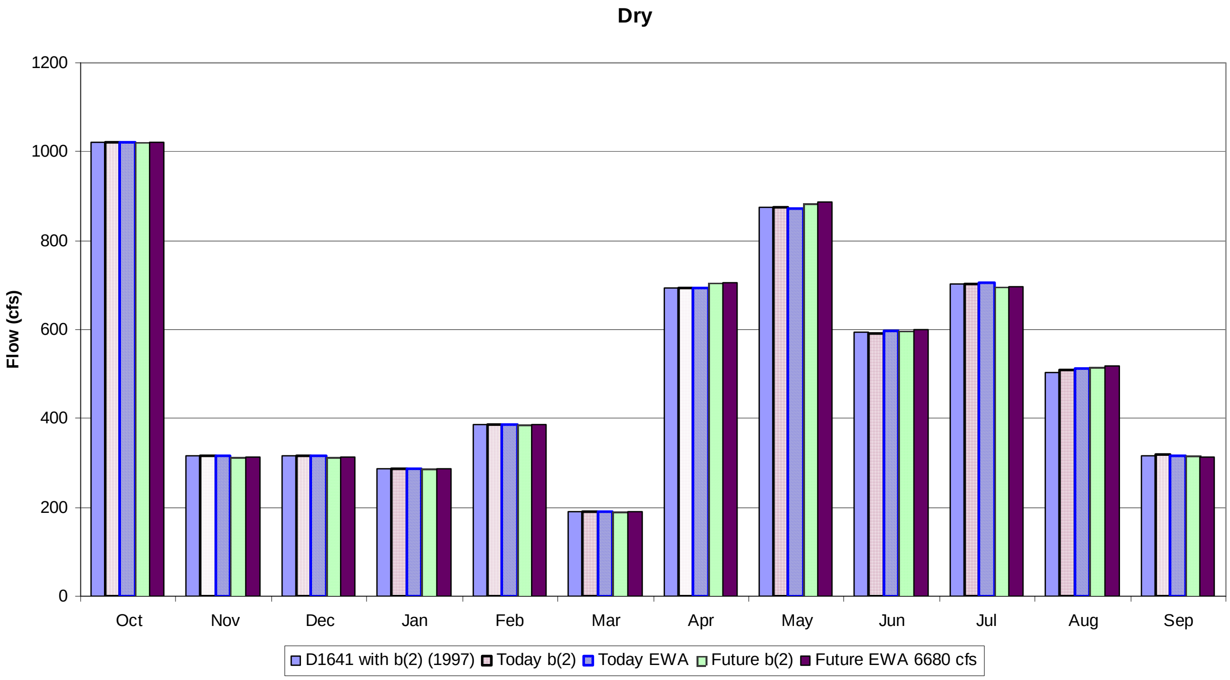


Figure 9–65 Average Dry Year (40-30-30 Classification) Monthly Goodwin Releases

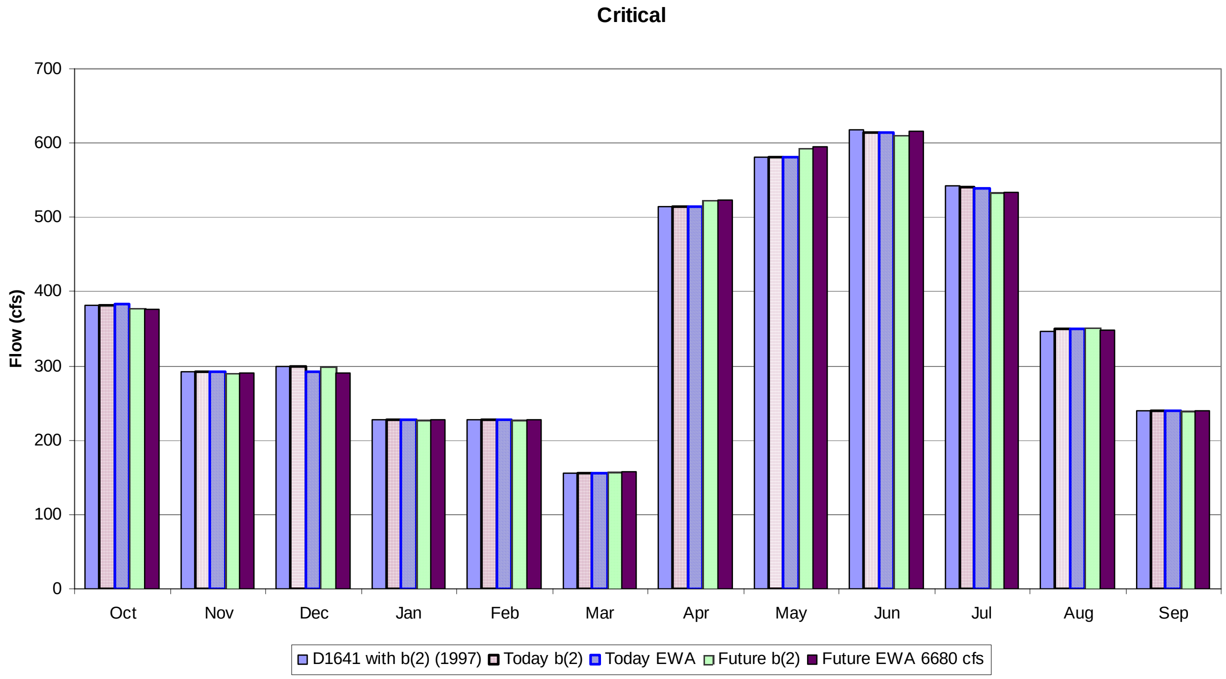


Figure 9–66 Average Critical Year (40-30-30 Classification) Monthly Goodwin Releases

Adult Migration, Spawning, and Incubation

Steelhead 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 steelhead 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 steelhead based on large size and coloration. Rotary screw traps at Oakdale and Caswell catch downstream migrating steelhead with smolting characteristics each year. Because the full life cycle of steelhead is not known for the Stanislaus, some life history patterns from Sacramento River steelhead 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 that 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 steelhead were captured at the weir during the 2002-2003 run. Take authorization for steelhead monitoring using the weir and RSTs will be needed to continue the monitoring program.

There is essentially no difference in Goodwin releases among the five modeling scenarios. Stanislaus operations will be the same in the future as they are now. Steelhead 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. Steelhead spawning flows were estimated to be maximized at 200 cfs, and flows for in-stream habitat for adult migration and rearing were estimated to be maximized at 500 cfs (Table 4–3). Spawning or holding habitat for adult steelhead 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 steelheads. 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 steelhead 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 (DO) sometimes reaches lethal levels in the Stockton deep-water ship channel. The low DO can cause a barrier to upstream-migrating steelhead and Chinook so that they are delayed or migrate up the Sacramento River or other tributaries 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 renders dewatering of spawning areas as 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 during 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 9–67 shows Chinook temperature model results. There is no difference in mortality among the modeled scenarios.

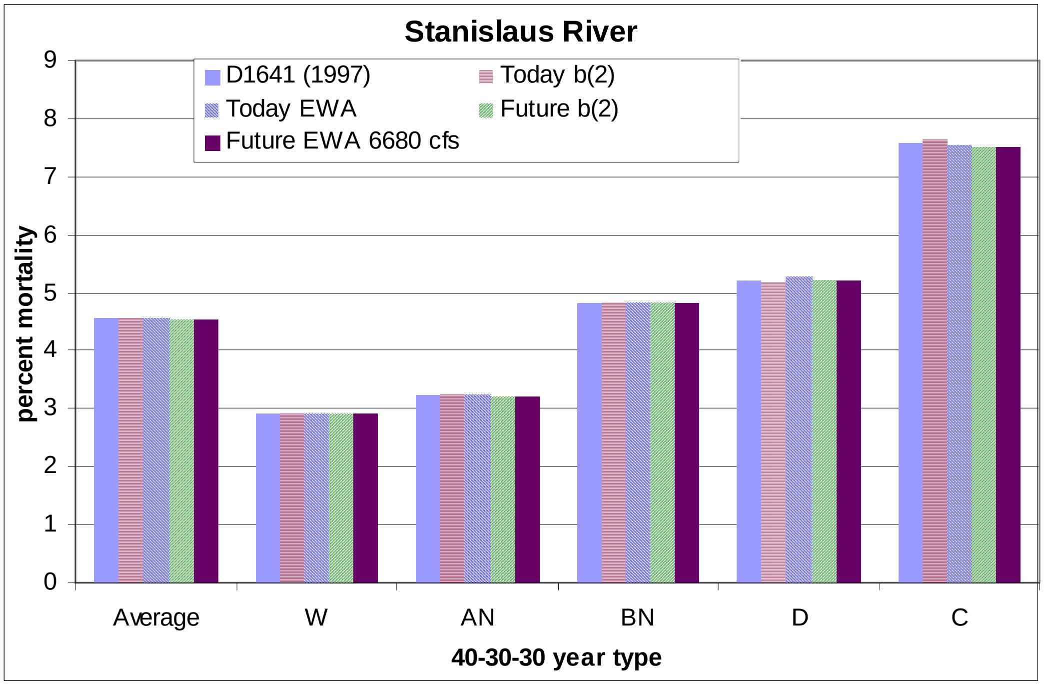


Figure 9–67 Temperature-related Mortality of Fall–run Chinook Salmon Eggs in the Stanislaus River

Fry, Juveniles, and Smolts

Most literature has indicated that rearing fry and juvenile steelhead prefer water temperatures between 45°F and 60°F (Reiser and Bjorn 1979; Bovee 1978; Bell 1986). However, Myrick (1998) found that the preferred temperatures for Mokelumne River Hatchery steelhead 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. RST fishing at Oakdale and Caswell has captured rainbow trout/steelhead that appear to exhibit smolting characteristics (Demko et al. 2000). These apparent smolts are typically captured from January to mid-April and are 175- to 300-mm fork length. Because steelhead 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 Vernalis Adaptive Management Plan (VAMP) period and provide an out-migration pulse for any steelhead smolts still in the river that late.

Smolts are thought to migrate through the lower reaches rather quickly and 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 steelhead in the upper river above Orange Blossom Bridge are suitable for steelhead rearing. Once steelhead 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 occur from January through June, with peak out-migration generally occurring around February (Demko et al. 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 during 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 out-migrating as fry (Demko et al. 2000). This situation could result in increased mortality from in-river predation. It is unknown 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 out-migrating Chinook.

San Joaquin River

Adult Migration, Spawning, and Incubation

The modeling shows essentially no difference in flows in the San Joaquin River among the modeled scenarios. Steelhead life history patterns in the San Joaquin River system are only partially understood, but studies are underway to determine steelhead populations, extent of anadromy, and run timing. Steelhead/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 steelhead are assumed to migrate up the San Joaquin River in late fall and winter, after temperatures and DO conditions become suitable for migrations to occur. Spawning, although not well documented, likely occurs in the tributaries primarily from January through March. No steelhead 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 DO) in the lower San Joaquin River and through the Stockton Deepwater Ship Channel suitable for upstream migrating steelhead. 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 steelhead (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 steelhead identified during September through November 2003), early returning steelhead 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 DO was probably not as much of an issue then), so historically, there were not likely steelhead 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 steelhead rearing. Fry and juvenile steelhead 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 steelhead 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 DO 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 steelhead. 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 BO). Additional Reasonable Prudent Alternatives define ramping constraints for Keswick releases.
- Maintain a minimum end-of-water-year (September 30) carryover storage in Shasta Reservoir of 1.9 maf (per the 1993 NOAA Fisheries winter-run Chinook salmon BO). 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 to determine the most appropriate actions for continued protection of salmonids during critical months of their life cycle.
- D-1641 of the State Water Resources Control Board (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 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 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 Area Power Administration, DWR, and the Hoopa Indian Tribe) to formulate, monitor, and coordinate temperature control plans for the upper Sacramento and Trinity Rivers 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 TCD 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 EWA is not available for acquisition.

San Joaquin River Watershed:

- D-1422, issued by the SWRCB, requires a minimum release of 69 taf 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 98.3 taf/yr from New Melones Reservoir. D-1422 also requires water releases from New Melones Reservoir on the Stanislaus River to meet established minimum DO 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. 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 1,140 cfs, and 1,420 to 2,280 cfs, respectively.
- 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 2,000 cfs. The VAMP program also includes Delta pumping limitations during the pulse flow period. A maximum pumping limitation of 1,500 cfs is enacted in drought years when pulse flows are a minimum of 2,000 cfs.

The current goal for temperature management on 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 because of an insufficient cold-water pool in New Melones Reservoir resulting from competing environmental and project demands for New Melones water.

Estimated Loss from Unscreened Diversions on the Sacramento River

Hansen (2001) studied juvenile Chinook salmon (mean length = 102 mm) entrainment at unscreened diversions during June at the Princeton Pumping Plant (river mile 164.4) and at the Wilkins Slough Diversion (river mile 117.8). He found that the percent of the released hatchery Chinook diverted was 0.05 to 0.07 times the percent of the Sacramento River flow diverted for the two sites, respectively. An average percent of juveniles diverted is assumed to be 0.06 times the percentage of the Sacramento River flow diverted for purposes of calculating entrainment into unscreened diversions. The average juvenile winter-run Chinook passage past Red Bluff Diversion Dam (Martin et al. 2001) for the brood years 1995 through 1999 was used to represent the number and timing of winter-run present in the Sacramento River. All of the 123 unscreened diversions (not counting those in the process of being screened) are downstream of RBDD.

Average Sacramento River flow at Red Bluff from CALSIM Modeling Study 5 was used to represent the river flow past the diversions.

Timing and quantity of diversions were based on the monthly average of historical diversions from Sacramento River contractors with currently unscreened diversions, 1964 through 2003, and are shown in Table 9–13.

Table 9–13 Timing and Quantity of Sacramento Diversions

Sacramento Diversion Timing						
		Project			**Base**	
	Percent	**amount, acre-ft**	**cfs**	**Percent**	**amount, acre-ft**	**cfs**
April	0.0%	20	0	11.9%	40,475	680
May	0.0%	3	0	27.0%	91,460	1,487
June	8.8%	11,264	189	26.9%	91,252	1,534
July	34.7%	44,310	721	18.6%	63,030	1,025
August	44.5%	56,845	924	11.0%	37,348	607
September	11.7%	14,922	251	2.2%	7,450	125
October	0.3%	364	6	2.4%	8,124	132

Average summer water temperatures may be somewhat suitable down to Butte City. They are projected to average about 67°F in June through August. Seventeen diversions are between RBDD and Butte City and probably pose the highest risk to fish based on location and timing of diversions. Juvenile winter-run passage numbers past RBDD are shown in Table 9–14.

Table 9–14 Juvenile winter-run passage numbers past RBDD

Numbers of winter run passing RBDD by month, Martin et al 2001.								
Brood Year	**April**	**May**	**June**	**July**	**Aug**	**Sep**	**Oct**	**Total**
BY 95	236	0	0	751	81,804	1,147,684	299,047	1,529,522
BY 96	1,378	272	0	903	18,836	228,197	24,226	273,812
BY 97	732	0	0	18,584	134,165	925,284	410,781	1,489,546
BY 98	1,754	262	0	184,896	1,540,408	2,128,386	404,275	4,259,981
BY 99	1,092	375	0	8,186	91,836	404,378	163,482	669,349
Average	**1,038**	**182**	**0**	**42,664**	**373,410**	**966,786**	**260,362**	**1,644,442**

The number of fish diverted was calculated for each of the 123 unscreened diversions, and then the fish numbers summed for an overall entrainment estimate. No specific information on the configuration of the diversion points relative to fish habitat was used in the entrainment estimates. Only the amount of water diverted by month was used. Entrainment for the diversions upstream of Butte City is estimated to be 81 winter-run from the project supply and 22 winter-run from the base supply. This is the primary area where pumping occurs when winter-run are likely to be present in the vicinity of the pumps because water temperatures are suitable.

Total winter-run entrainment for all diversions, assuming timing of fish presence is the same in the lower river as at RBDD, is estimated to be 4,216 from project pumping and 2,879 from base supply pumping, for a total of 7,095 winter-run. This is very likely an over-estimate because the lower river is too warm through much of the summer for juvenile salmon rearing (see Figure 9–68). The estimated entrainment includes six older juveniles (April through June), all from base water deliveries. The rest are fry entrained during July through October. One diversion at river mile 32 accounted for 65 percent of the entrainment estimate.

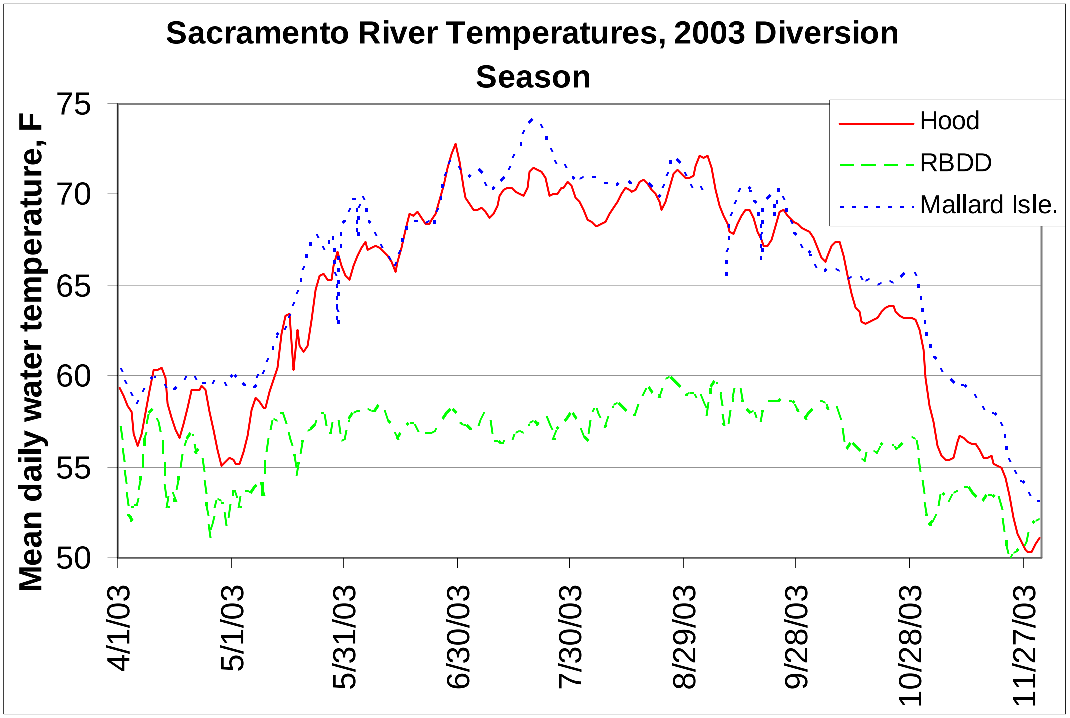


Figure 9–68 Sacramento River Temperatures, 2003 Diversion Season

The total estimated entrainment into unscreened diversions represents 0.37 percent of the estimated winter-run juvenile passage past RBDD. No estimate of entrainment was attempted for other salmon runs or steelhead. Abundance and timing data were not obtained for the other salmon runs. Steelhead habitat use differs from Chinook salmon, so the relationship between water diversions and steelhead entrainment is probably different than that assumed for Chinook. For spring-run, fall-run, and late-fall-run the percentage of fish present that is diverted should be the same as that shown for winter-run in Table 9–15. The proportion of spring-run diverted in the Sacramento River is likely lower than that for winter-run because they emerge from the gravel mostly after the diversion season, although more larger juvenile spring-run may be diverted. Higher numbers of fall- and late-fall-run are likely diverted in April and May, when mostly base water supplies are diverted.

Table 9–15 Percentage of Winter-run Diverted

Sac Flow @ Red Bluff, c	10,497	9,506	10,671	12,504	10,477	6,994	8,124	
Project Water	April	May	June	July	August	September	October	Total
% of flow diverted	0.0%	0.0%	1.8%	5.8%	8.8%	3.6%	0.1%	
% of fish diverted	0.0%	0.0%	0.1%	0.3%	0.5%	0.2%	0.0%	
# of winter run entrained	0	0	0	148	1,977	2,080	11	4,216
Base Water	April	May	June	July	August	September	October	
% of flow diverted	6.5%	15.6%	14.4%	8.2%	5.8%	1.8%	2.1%	
% of fish diverted	0.4%	0.9%	0.9%	0.5%	0.3%	0.1%	0.1%	
# of winter run entrained	4	2	0	210	1,299	1,038	326	2,879
Total (Project + Base)	April	May	June	July	August	September	October	
% of flow diverted	6.5%	15.6%	16.1%	14.0%	14.6%	5.4%	2.2%	
% of fish diverted	0.4%	0.9%	1.0%	0.8%	0.9%	0.3%	0.1%	
# of winter run entrained	4	2	0	357	3,276	3,118	338	7,095

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Chapter 10 CVP and SWP Delta Effects on Steelhead, Chinook Salmon, and Delta Smelt – Formal Consultation

This section addresses the effects associated with Delta pumping (including the intertie and Banks pumping at 6680 cubic feet per second (cfs)) on steelhead, spring and winter-run Chinook salmon, and Delta smelt. Fish monitoring programs for Central Valley Project (CVP) and State Water Project (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 (see 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 Table 4–7 and Table 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 shows 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 in salvage and loss are directly proportional to changes in the amount of water pumped.

Data from the U.S. Fish and Wildlife Service (FWS) Chipps Island Trawl suggest steelhead emigration occurs between October and June (see 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 fish 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 Delta Cross Channel (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 (BA).

The modeled monthly CVP and SWP Delta export exceedance plots are shown in CALSIM Modeling Appendix F(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 (see Figure 10–27 and Figure 10–32).

Direct Losses to Entrainment by CVP and SWP Export Facilities

Exports would slightly increase in the future with the implementation of the Intertie Program. Exports would generally be greater without Environmental Wa ter Account (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 changes for winter-run, spring-run, and steelhead, comparing operations today to future operations (model 2 vs 4a, model 3 vs 5a, and model 1 vs 5a) 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 are 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. Loss for winter-run and spring-run fish was calculated daily by the California Department of Fish and Game (DFG).

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 they begin to show up in the salvage facilities quickly following release (Figure 10-1 and Figure 10-2). If at least 50 percent 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 percent of 750,000. If unclipped fish were salvaged at a similar rate (1.4 percent) with 1,752 salvaged, then about 130,000 wild (unclipped) steelhead smolts passed through the Delta.

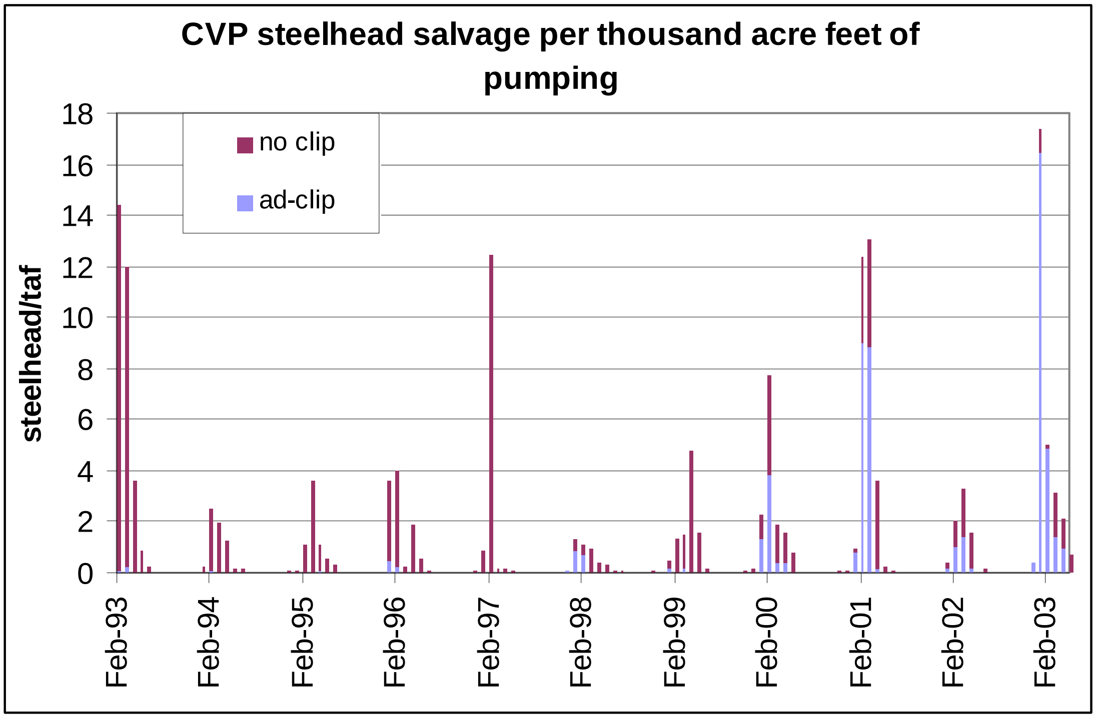


Figure 10–1 CVP steelhead salvage density, 1993-2003.

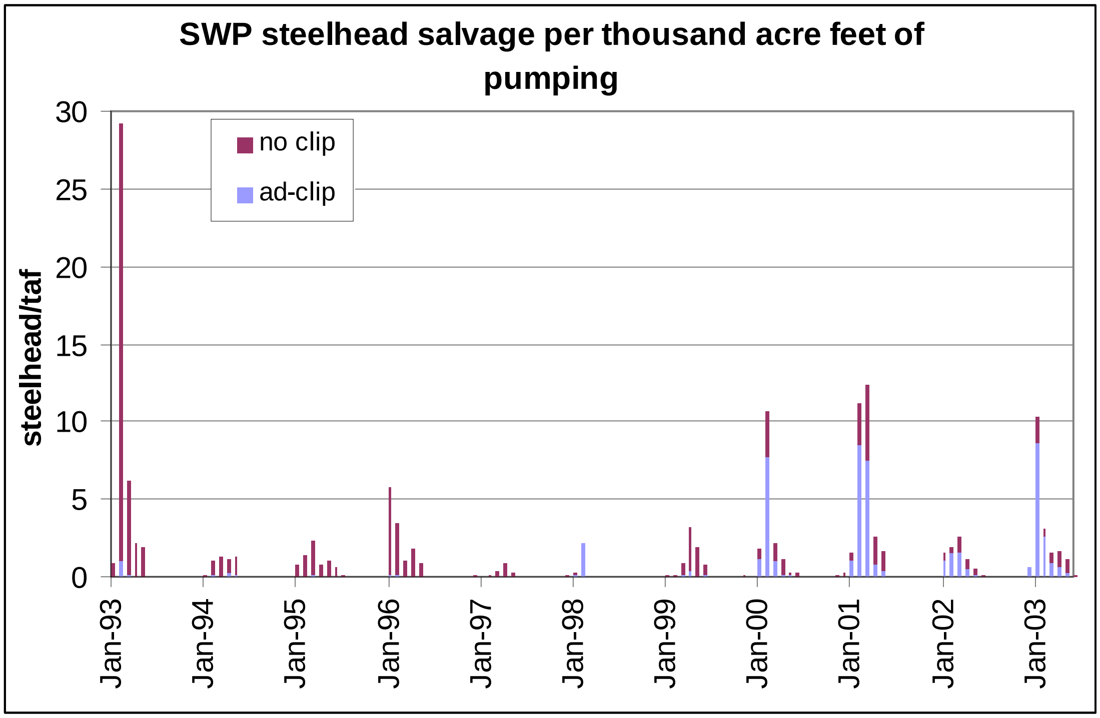


Figure 10–2 SWP steelhead salvage density, 1993-2003.

Table 10–1 Average change in winter-run, spring-run, and steelhead loss 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 were 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 4a change in loss												
Winter-run number	0	0	-5	-27	122	149	0	0	0	0	0	239
% of historic			-0.3%	-1.2%	3.8%	2.3%	0.1%	2.5%				1.7%
Spring-run number	0	0	0	0	0	67	8	73	0	0	0	149
% of historic				-1.2%	3.8%	2.3%	0.1%	2.5%	3.1%			0.7%
Steelhead number	0	2	0	-11	67	45	0	4	2	0	0	108
% of historic	-1.4%	2.4%	-0.4%	-1.2%	3.6%	2.0%	0.0%	1.6%	1.7%	-0.4%	1.7%	1.7%
3 v 5a change in loss												
Winter-run number	0	0	-5	54	-58	140	0	0	0	0	0	131
% of historic			-0.3%	2.5%	-1.8%	2.1%	-0.1%	-1.1%				0.9%
Spring-run number	0	0	0	0	0	63	-19	-31	0	0	0	13
% of historic				2.5%	-1.8%	2.1%	-0.1%	-1.1%	4.6%			0.1%
Steelhead number	0	-1	0	22	-32	42	-1	-2	3	0	0	30
% of historic	1.2%	-1.5%	-0.4%	2.3%	-1.7%	1.9%	-0.1%	-0.7%	2.5%	0.6%	-3.8%	0.5%
1 v 5a change in loss												
Winter-run number	0	0	-2	-89	88	55	-8	-3	0	0	0	42
% of historic			-0.1%	-4.1%	2.7%	0.8%	-2.6%	-22.9%				0.3%
Spring-run number	0	0	0	0	0	25	-367	-671	1	0	0	-1,013
% of historic				-4.1%	2.7%	0.8%	-2.6%	-22.9%	11.5%			-5.0%
Steelhead number	0	-1	0	-36	48	17	-20	-39	7	3	0	-22
% of historic	4.6%	-1.2%	-0.2%	-3.8%	2.6%	0.8%	-2.1%	-14.9%	6.2%	12.8%	13.1%	-0.3%
Tracy												
Critical	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Overall
2 v 4a change in loss												
Winter-run number	0	0	31	76	74	177	12	-1	0	0	0	369
% of historic			1.9%	3.5%	2.3%	2.7%	4.0%	-11.1%				2.6%
Spring-run number	0	0	0	0	0	80	579	-325	0	0	0	335
% of historic				3.5%	2.3%	2.7%	4.0%	-11.1%	-7.4%			1.7%
Steelhead number	0	-3	2	31	40	53	32	-19	-4	0	0	131
% of historic	0.5%	-4.8%	2.4%	3.3%	2.2%	2.4%	3.3%	-7.2%	-4.0%	-2.3%	-3.4%	2.0%
3 v 5a change in loss												
Winter-run number	0	0	-1	60	80	182	14	0	0	0	0	335
% of historic			0.0%	2.7%	2.5%	2.8%	4.6%	-3.2%				2.4%
Spring-run number	0	0	0	0	0	83	665	-95	0	0	0	652
% of historic				2.7%	2.5%	2.8%	4.6%	-3.2%	-2.6%			3.2%
Steelhead number	0	-2	0	24	44	54	37	-6	-2	0	0	150
% of historic	-1.9%	-3.0%	-0.1%	2.6%	2.4%	2.5%	3.8%	-2.1%	-1.4%	0.3%	-3.1%	2.3%
1 v 5a change in loss												
Winter-run number	0	0	-31	-40	30	167	10	-3	0	0	0	133
% of historic			-1.9%	-1.8%	0.9%	2.6%	3.1%	-25.8%				1.0%
Spring-run number	0	0	0	0	0	76	449	-758	0	0	0	-234
% of historic				-1.8%	0.9%	2.6%	3.1%	-25.8%	-6.7%			-1.2%
Steelhead number	0	-3	-2	-16	17	50	25	-44	-4	0	0	22
% of historic	-2.0%	-4.3%	-2.4%	-1.7%	0.9%	2.3%	2.6%	-16.9%	-3.6%	-1.3%	-4.9%	0.3%

Banks											
Dry	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Overall
2 v 4a change in loss												
Winter-run number	0	0	14	36	29	148	8	-1	0	0	0	234
% of historic			0.8%	1.6%	0.9%	2.3%	2.6%	-5.5%				1.7%
Spring-run number	0	0	0	0	0	67	370	-162	0	0	0	275
% of historic				1.6%	0.9%	2.3%	2.6%	-5.5%	-4.5%			1.4%
Steelhead number	0	-1	1	14	16	44	20	-9	-3	1	0	84
% of historic	-1.9%	-1.0%	1.1%	1.5%	0.9%	2.0%	2.1%	-3.6%	-2.4%	2.7%	1.1%	1.3%
3 v 5a change in loss												
Winter-run number	0	0	38	54	0	118	4	0	0	0	0	214
% of historic			2.3%	2.5%	0.0%	1.8%	1.2%	3.2%				1.5%
Spring-run number	0	0	0	0	0	53	167	95	0	0	0	315
% of historic				2.5%	0.0%	1.8%	1.2%	3.2%	-1.6%			1.6%
Steelhead number	0	0	2	22	0	35	9	6	-1	0	0	73
% of historic	-2.1%	0.6%	2.9%	2.3%	0.0%	1.6%	1.0%	2.1%	-0.9%	0.0%	-1.1%	1.1%
1 v 5a change in loss												
Winter-run number	0	0	0	-87	9	126	-34	-7	0	0	0	8
% of historic			0.0%	-3.9%	0.3%	1.9%	-11.2%	-59.3%				0.1%
Spring-run number	0	0	0	0	0	57	-1,599	-1,742	0	0	0	-3,284
% of historic				-3.9%	0.3%	1.9%	-11.2%	-59.3%	-7.9%			-16.2%
Steelhead number	0	-1	0	-35	5	38	-88	-102	-5	3	0	-185
% of historic	1.0%	-1.9%	0.0%	-3.7%	0.3%	1.7%	-9.2%	-38.8%	-4.3%	13.3%	3.5%	-2.9%

Tracy												
Dry	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Overall
2 v 4a change in loss												
Winter-run number	0	0	33	39	-93	-255	6	0	0	0	0	-270
% of historic			2.0%	1.8%	-2.9%	-3.9%	1.9%	0.1%				-1.9%
Spring-run number	0	0	0	0	0	-115	272	3	0	0	0	159
% of historic				1.8%	-2.9%	-3.9%	1.9%	0.1%	-7.4%			0.8%
Steelhead number	0	-1	2	16	-51	-76	15	0	-4	-1	0	-100
% of historic	1.5%	-1.0%	2.5%	1.7%	-2.7%	-3.5%	1.6%	0.1%	-4.0%	-5.3%	-4.8%	-1.6%
3 v 5a change in loss												
Winter-run number	0	0	38	88	105	64	1	0	0	0	0	296
% of historic			2.3%	4.0%	3.2%	1.0%	0.4%	2.1%				2.1%
Spring-run number	0	0	0	0	0	29	56	61	-1	0	0	146
% of historic				4.0%	3.2%	1.0%	0.4%	2.1%	-11.1%			0.7%
Steelhead number	0	0	2	35	57	19	3	4	-6	-1	0	113
% of historic	1.4%	0.0%	2.9%	3.8%	3.1%	0.9%	0.3%	1.4%	-6.0%	-4.3%	-5.2%	1.7%
1 v 5a change in loss												
Winter-run number	0	0	-34	-106	85	-294	4	-3	0	0	0	-348
% of historic			-2.1%	-4.8%	2.6%	-4.5%	1.4%	-30.1%				-2.5%
Spring-run number	0	0	0	0	0	-133	197	-883	-1	0	0	-820
% of historic				-4.8%	2.6%	-4.5%	1.4%	-30.1%	-14.8%			-4.1%
Steelhead number	0	-2	-2	-42	47	-88	11	-52	-8	-2	0	-138
% of historic	1.2%	-2.6%	-2.6%	-4.5%	2.5%	-4.0%	1.1%	-19.7%	-8.0%	-7.6%	-11.2%	-2.1%

Banks												
Below Normal	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Overall
2 v 4a change in loss												
Winter-run number	0	0	80	118	187	312	4	3	0	0	0	704
% of historic			4.8%	5.3%	5.8%	4.8%	1.4%	23.3%				5.0%
Spring-run number	0	0	0	0	0	141	203	684	0	0	0	1,029
% of historic				5.3%	5.8%	4.8%	1.4%	23.3%	-1.2%			5.1%
Steelhead number	0	1	4	47	102	93	11	40	-1	0	0	299
% of historic	-2.3%	1.3%	6.2%	5.1%	5.5%	4.3%	1.2%	15.2%	-0.7%	1.7%	-0.1%	4.6%
3 v 5a change in loss												
Winter-run number	0	0	89	55	-22	301	1	1	0	0	0	425
% of historic			5.4%	2.5%	-0.7%	4.6%	0.4%	11.4%				3.0%
Spring-run number	0	0	0	0	0	136	53	336	1	0	0	527
% of historic				2.5%	-0.7%	4.6%	0.4%	11.4%	16.2%			2.6%
Steelhead number	0	2	4	22	-12	90	3	20	9	0	0	137
% of historic	-3.6%	2.5%	6.9%	2.4%	-0.7%	4.1%	0.3%	7.5%	8.7%	-1.4%	-3.3%	2.1%
1 v 5a change in loss												
Winter-run number	0	0	19	-13	134	362	-105	-8	0	0	0	389
% of historic			1.1%	-0.6%	4.1%	5.5%	-34.2%	-73.2%				2.8%
Spring-run number	0	0	0	0	0	164	-4,905	-2,149	0	0	0	-6,890
% of historic				-0.6%	4.1%	5.5%	-34.2%	-73.2%	-4.9%			-34.0%
Steelhead number	0	1	1	-5	74	108	-271	-125	-3	2	0	-219
% of historic	0.9%	1.3%	1.4%	-0.6%	4.0%	4.9%	-28.4%	-47.8%	-2.6%	9.7%	6.3%	-3.4%
Tracy												
Below Normal	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Overall
2 v 4a change in loss												
Winter-run number	0	0	8	99	-181	-375	-5	0	0	0	0	-453
% of historic			0.5%	4.5%	-5.6%	-5.7%	-1.5%	-3.3%				-3.2%
Spring-run number	0	0	0	0	0	-170	-221	-97	0	0	0	-487
% of historic				4.5%	-5.6%	-5.7%	-1.5%	-3.3%	1.1%			-2.4%
Steelhead number	0	1	0	40	-99	-112	-12	-6	1	0	0	-187
% of historic	0.2%	2.1%	0.6%	4.3%	-5.3%	-5.1%	-1.3%	-2.2%	0.6%	-1.9%	-1.7%	-2.9%
3 v 5a change in loss												
Winter-run number	0	0	13	52	98	-182	-3	0	0	0	0	-21
% of historic			0.8%	2.3%	3.0%	-2.8%	-0.9%	2.1%				-0.2%
Spring-run number	0	0	0	0	0	-83	-130	63	0	0	0	-149
% of historic				2.3%	3.0%	-2.8%	-0.9%	2.1%	-0.4%			-0.7%
Steelhead number	0	0	1	21	54	-55	-7	4	0	0	0	17
% of historic	0.4%	0.7%	1.0%	2.2%	2.9%	-2.5%	-0.7%	1.4%	-0.2%	-2.5%	-1.2%	0.3%
1 v 5a change in loss												
Winter-run number	0	0	-63	-43	77	-573	-12	-3	0	0	0	-616
% of historic			-3.8%	-1.9%	2.4%	-8.8%	-3.9%	-23.1%				-4.4%
Spring-run number	0	0	0	0	0	-259	-562	-679	0	0	0	-1,500
% of historic				-1.9%	2.4%	-8.8%	-3.9%	-23.1%	-0.4%			-7.4%
Steelhead number	0	-1	-3	-17	42	-171	-31	-40	0	-1	0	-221
% of historic	0.3%	-0.8%	-4.8%	-1.8%	2.3%	-7.8%	-3.2%	-15.1%	-0.2%	-4.2%	-2.5%	-3.4%

Banks											
Above Normal	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Overall
2 v 4a change in loss												
Winter-run number	0	0	-52	-234	57	180	23	0	0	0	0	-26
% of historic			-9.4%	-3.4%	3.5%	16.4%	7.1%	2.4%	-1.1%			-0.2%
Spring-run number	0	0	0	0	2	918	2,520	300	-23	0	0	3,717
% of historic	3.7%			-3.4%	3.5%	16.4%	7.1%	2.4%	-1.1%			6.7%
Steelhead number	0	-1	-5	-33	60	292	72	9	-1	0	0	393
% of historic	3.4%	-1.8%	-7.8%	-3.5%	3.2%	13.3%	7.5%	3.3%	-1.3%	0.8%	7.6%	6.1%
3 v 5a change in loss												
Winter-run number	0	0	-20	-123	10	131	10	0	0	0	0	7
% of historic			-3.7%	-1.8%	0.6%	12.0%	3.0%	-4.1%	-1.0%			0.1%
Spring-run number	0	0	0	0	0	671	1,052	-516	-21	0	0	1,186
% of historic	5.7%			-1.8%	0.6%	12.0%	3.0%	-4.1%	-1.0%			2.1%
Steelhead number	0	-1	-2	-17	10	213	30	-15	-1	0	0	218
% of historic	5.2%	-1.0%	-3.0%	-1.9%	0.5%	9.7%	3.1%	-5.7%	-1.2%	0.4%	0.9%	3.4%
1 v 5a change in loss												
Winter-run number	0	0	-34	-526	-26	223	-88	-4	0	0	0	-454
% of historic			-6.1%	-7.7%	-1.6%	20.5%	-26.7%	-56.2%	-4.9%			-4.3%
Spring-run number	0	0	0	0	-1	1,142	-9,414	-7,024	-105	0	0	-15,403
% of historic	6.3%			-7.7%	-1.6%	20.5%	-26.7%	-56.2%	-4.9%			-27.7%
Steelhead number	0	-2	-3	-74	-27	363	-268	-204	-6	2	0	-220
% of historic	5.8%	-3.5%	-5.1%	-7.9%	-1.5%	16.6%	-28.0%	-77.9%	-5.8%	8.2%	14.6%	-3.4%
Tracy												
Above Normal	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Overall
2 v 4a change in loss												
Winter-run number	0	0	1	-8	16	-58	-1	0	0	0	0	-49
% of historic			0.2%	-0.1%	1.0%	-5.3%	-0.3%	6.3%	3.0%			-0.5%
Spring-run number	0	0	0	0	1	-553	-137	535	21	0	0	-133
% of historic	0.4%			-0.3%	1.8%	-9.9%	-0.4%	4.3%	1.0%			-0.2%
Steelhead number	0	2	0	-4	51	-215	-7	26	2	0	0	-143
% of historic	1.6%	3.8%	0.4%	-0.4%	2.8%	-9.8%	-0.7%	10.0%	2.3%	-0.5%	-0.6%	-2.2%
3 v 5a change in loss												
Winter-run number	0	0	4	58	19	-29	-1	0	0	0	0	51
% of historic			0.7%	0.8%	1.2%	-2.6%	-0.3%	0.3%	1.6%			0.5%
Spring-run number	0	0	0	0	1	-276	-145	27	11	0	0	-381
% of historic	0.0%			2.5%	2.2%	-4.9%	-0.4%	0.2%	0.5%			-0.7%
Steelhead number	0	2	1	26	62	-107	-8	1	1	0	0	-20
% of historic	-0.1%	3.0%	1.6%	2.8%	3.3%	-4.9%	-0.8%	0.5%	1.3%	-0.4%	-0.6%	-0.3%
1 v 5a change in loss												
Winter-run number	0	0	-6	-94	-28	-26	-2	-1	0	0	0	-156
% of historic			-1.1%	-1.4%	-1.7%	-2.3%	-0.5%	-8.2%	2.4%			-1.5%
Spring-run number	0	0	0	0	-2	-246	-200	-689	17	0	0	-1,120
% of historic	0.3%			-4.0%	-3.1%	-4.4%	-0.6%	-5.5%	0.8%			-2.0%
Steelhead number	0	2	-2	-43	-89	-95	-10	-34	2	0	0	-269
% of historic	1.3%	3.6%	-2.8%	-4.5%	-4.8%	-4.4%	-1.1%	-12.8%	1.9%	-0.4%	-0.9%	-4.2%

Banks											
Wet	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Overall
2 v 4a change in loss											
Winter-run number	0	0	36	313	115	208	30	0	0	0	0	702
% of historic			6.5%	4.6%	7.2%	19.0%	9.2%	3.7%	-1.8%			6.7%
Spring-run number	0	0	0	0	5	1,064	3,236	467	-38	0	0	4,733
% of historic	2.4%			4.6%	7.2%	19.0%	9.2%	3.7%	-1.8%			8.5%
Steelhead number	0	1	3	44	121	338	92	14	-2	0	0	612
% of historic	2.2%	1.0%	5.4%	4.7%	6.5%	15.4%	9.6%	5.2%	-2.1%	1.4%	-6.3%	9.5%
3 v 5a change in loss											
Winter-run number	0	0	37	309	71	54	14	1	0	0	0	486
% of historic			6.8%	4.5%	4.4%	4.9%	4.4%	10.9%	2.8%			4.6%
Spring-run number	0	0	0	0	3	274	1,539	1,365	60	0	0	3,241
% of historic	1.5%			4.5%	4.4%	4.9%	4.4%	10.9%	2.8%			5.8%
Steelhead number	0	-1	4	44	75	87	44	40	4	1	0	296
% of historic	1.4%	-1.0%	5.6%	4.7%	4.0%	4.0%	4.6%	15.1%	3.3%	2.9%	-6.6%	4.6%
1 v 5a change in loss											
Winter-run number	0	0	4	130	47	298	-64	-4	0	0	0	412
% of historic			0.8%	1.9%	3.0%	27.3%	-19.4%	-54.5%	-3.9%			3.9%
Spring-run number	0	0	0	0	2	1,523	-6,832	-6,814	-84	0	0	-12,204
% of historic	7.1%			1.9%	3.0%	27.3%	-19.4%	-54.5%	-3.9%			-22.0%
Steelhead number	0	1	0	18	50	485	-195	-198	-5	0	0	157
% of historic	6.5%	1.6%	0.6%	2.0%	2.7%	22.1%	-20.3%	-75.6%	-4.7%	0.6%	-2.5%	2.4%
Tracy											
Wet	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Overall
2 v 4a change in loss											
Winter-run number	0	0	8	31	-3	-32	-9	0	0	0	0	-6
% of historic			1.4%	0.4%	-0.2%	-3.0%	-2.7%	-0.7%	-0.4%			-0.1%
Spring-run number	0	0	0	0	0	-311	-1,160	-62	-3	0	0	-1,535
% of historic	0.5%			1.3%	-0.4%	-5.6%	-3.3%	-0.5%	-0.1%			-2.8%
Steelhead number	0	2	2	14	-11	-121	-60	-3	0	0	0	-177
% of historic	2.3%	3.5%	3.5%	1.5%	-0.6%	-5.5%	-6.3%	-1.2%	-0.3%	0.3%	0.5%	-2.7%
3 v 5a change in loss											
Winter-run number	0	0	8	38	7	14	2	0	0	0	0	69
% of historic			1.4%	0.6%	0.4%	1.3%	0.7%	-0.2%	0.6%			0.7%
Spring-run number	0	0	0	0	0	138	299	-21	4	0	0	421
% of historic	0.4%			1.6%	0.7%	2.5%	0.8%	-0.2%	0.2%			0.8%
Steelhead number	0	2	2	17	21	54	15	-1	1	0	0	111
% of historic	1.9%	3.1%	3.4%	1.9%	1.1%	2.4%	1.6%	-0.4%	0.5%	-0.7%	0.4%	1.7%
1 v 5a change in loss											
Winter-run number	0	0	-6	-121	-44	22	-1	0	0	0	0	-150
% of historic			-1.1%	-1.8%	-2.7%	2.1%	-0.4%	-4.8%	0.1%			-1.4%
Spring-run number	0	0	0	0	-3	216	-155	-403	1	0	0	-345
% of historic	0.5%			-5.2%	-4.9%	3.9%	-0.4%	-3.2%	0.0%			-0.6%
Steelhead number	0	0	-2	-55	-140	84	-8	-20	0	0	0	-140
% of historic	2.4%	0.8%	-2.6%	-5.9%	-7.5%	3.8%	-0.8%	-7.5%	0.1%	-0.2%	0.4%	-2.2%

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 percent adults (Figure 10–3). Fish greater than 350 millimeters (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 it is assumed it will remain around 3.5 percent of the total number of steelhead salvaged. Figure 10–4 shows all steelhead fork lengths measured at the salvage facilities from 1993-2003.

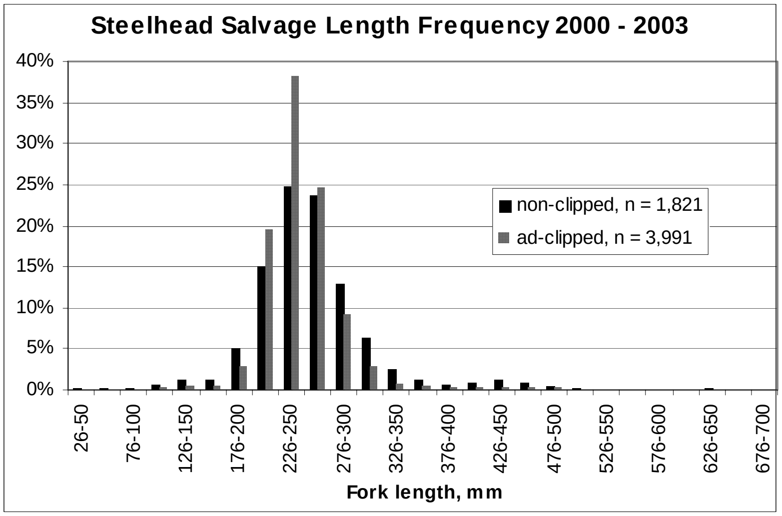


Figure 10–3 Length frequency distribution of steelhead salvaged at the CVP and SWP 2000 – 2003.

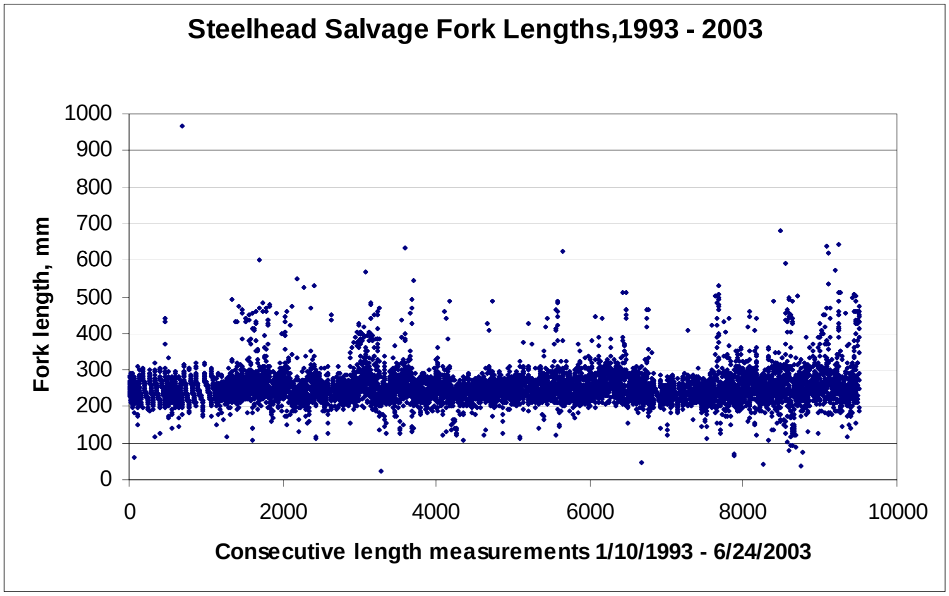


Figure 10–4 Steelhead salvage fork lengths measured since 1993 and listed consecutively as measured.

North Bay Aqueduct

The maximum pumping capacity of the North Bay Aquaduct (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. California State Water Resources Control Board (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 the National Marine Fisheries Service (NOAA Fisheries). Consultation with the CALFED Bay-Delta Program (CALFED) Operations Group will also satisfy the consultation requirement. The CALFED Operations 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 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.

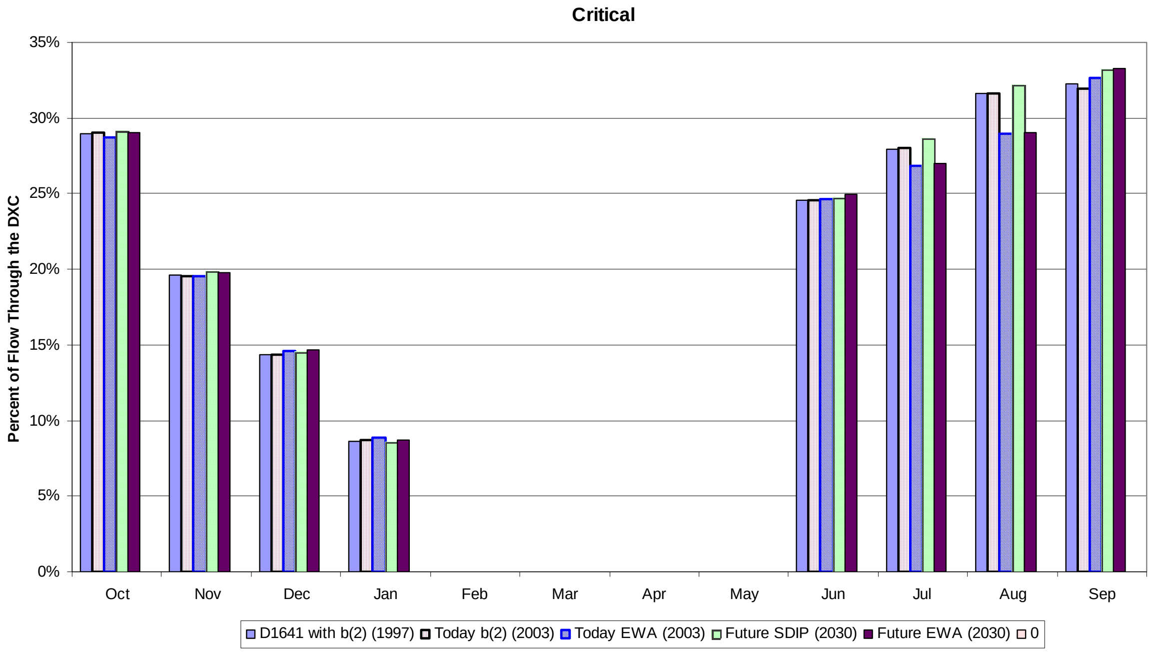


Figure 10–5 Percent of Sacramento River flow passing through the DCC during critically dry years under the five scenarios.

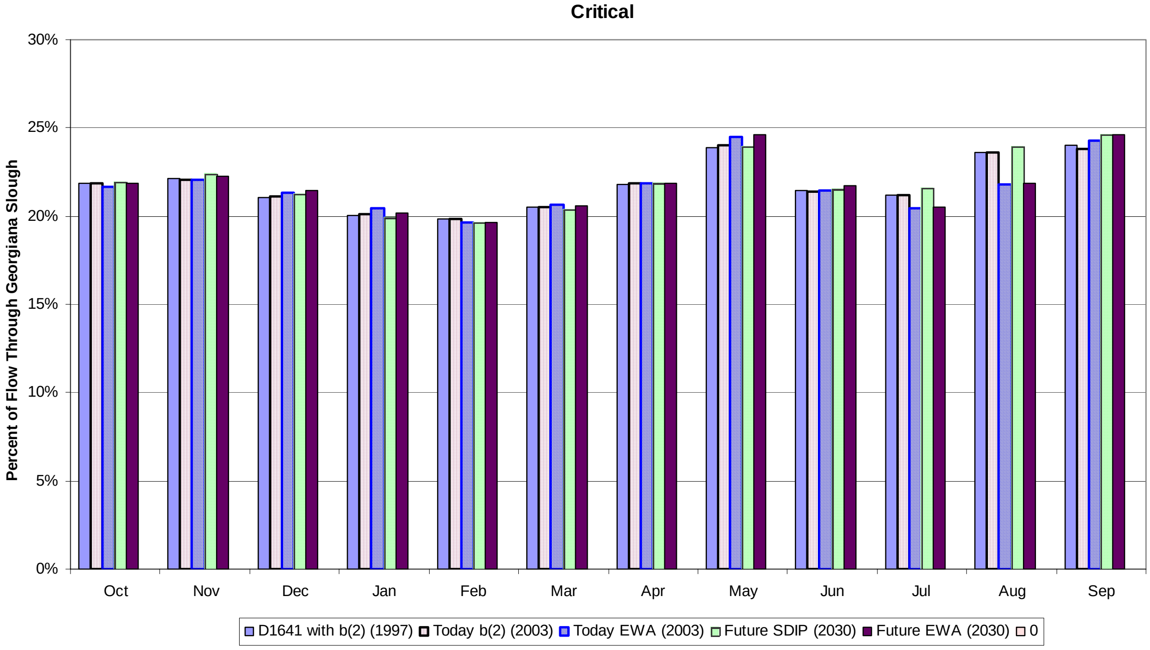


Figure 10–6 Percent of Sacramento River flow passing through Georgiana Slough during critically dry years under the five scenarios.

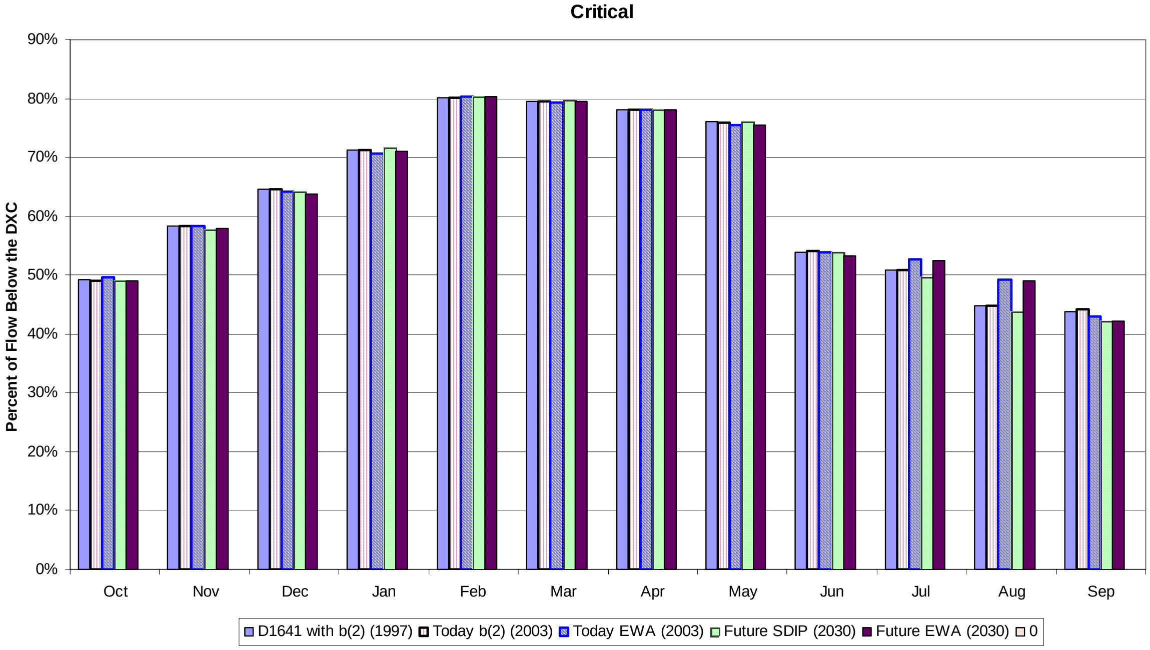


Figure 10–7 Percent of Sacramento River flow continuing down the main Sacramento River channel past the DCC and Georgiana Slough during critically dry years under the five scenarios.

Rock Slough Old River Intake

The Rock Slough diversion diverts water from Old River into the Contra Costa Canal. The historical diversion pattern varies 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 are 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 the 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 those in the past, which were estimated to be up to 3,200 juvenile Chinook (all races) per year assuming 20 percent 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 Suisun Marsh Salinity Control Gates (SMSCG) could be operated as needed to meet State salinity standards in the marsh from 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 SMSCG 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 fish 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 #4a and model case #1 v model case #5a (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 time step 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, (3) changes in the Export-Inflow ratio (E/I), and (4) entrainment by the NBA. 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 E/I 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 (Tables 10-5 through 10-14). 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 4a or 5a (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.

Table 10–5 CVP salvage in Wet years

Month	Median model case 1 pumping (c.f.s.)	Median change in case 4a	Median change in case 5a	Density of delta smelt at Tracy[a]	Predicted median difference in salvage[b]	
					4a – 1	5a – 1
Adults						
December	4222	+8.9%	–0.7%	0.010	+9	–1
January	4226	+8.8%	–0.8%	0.095	+140	–13
February	4243	+8.2%	–2.3%	0.151	+116	–33
March	4273	–9.0%	+7.5%	0.159	–35	+29
Largely Juveniles						
April	2747	0.0%	0.0%	0.206	0	0
May	2274	0.0%	0.0%	7.430	0	0
June	3000	0.0%	0.0%	2.017	0	0
July	4588	0.0%	0.0%	0.036	0	0
Net: December – March					+230	–17
Net: April – July					0	0

[a] Average delta smelt salvage density (fishes c.f.s.$^{-1}$ month^{-1}) estimated from pooled Above Normal and Wet years 1995-2000.

[b] 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 4a	Median change in case 5a	Density of delta smelt at Tracy[a]	Predicted median difference in salvage[b]	
					4a – 1	5a – 1
Adults						
December	4221	+8.9%	–0.7%	0.010	+9	–1
January	4225	+8.9%	–0.8%	0.095	+144	–13
February	4242	+8.4%	–2.0%	0.151	+151	–36
March	4262	–22.9%	–9.9%	0.159	–91	–40
Largely Juveniles						
April	2742	0.0%	0.0%	0.206	0	0
May	1911	0.0%	0.0%	7.430	0	0
June	2920	0.0%	0.0%	2.017	0	0
July	4580	+0.2%	+0.3%	0.036	+8	+11
Net: December – March					+212	–89

Net: April – July					+8	+11

[a] Average delta smelt salvage density (fishes c.f.s.$^{-1}$ month^{-1}) estimated from pooled Above Normal and Wet years 1995-2000.

[b] 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 4a	Median change in case 5a	Density of delta smelt at Tracy[a]	Predicted median difference in salvage[b]	
					4a – 1	**5a – 1**
Adults						
December	4221	+7.3%	–0.9%	0.067	+22	–3
January	4225	+8.9%	–0.8%	0.180	+133	–12
February	4241	–3.8%	+8.1%	0.235	–30	+63
March	4235	–6.7%	–8.2%	0.201	–68	–83
Largely Juveniles						
April	2321	0.0%	–1.2%	0.259	0	–16
May	1911	0.0%	–9.3%	11.93	0	–9017
June	3000	0.0%	0.0%	1.584	0	0
July	4554	+0.4%	0.3%	0.005	+9	+7
Net: December – March					+57	–35
Net: April – July					+9	–9025

[a] Average delta smelt salvage density (fishes c.f.s.$^{-1}$ month^{-1}) estimated from Dry and Critically Dry years 1994 and 2001-2

[b] 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 4a	Median change in case 5a	Density of delta smelt at Tracy[a]	Predicted median difference in salvage[b]	
					4a – 1	5a – 1
Adults						
December	4220	+7.8%	–1.3%	0.067	+21	–3
January	4225	+8.8%	–0.8%	0.180	+105	–10
February	4235	+8.3%	+8.4%	0.235	+59	–60
March	4208	–9.5%	–2.4%	0.201	–75	–19
Largely Juveniles						
April	1808	+0.8%	+0.6%	0.259	+6	+5
May	1720	0.0%	–23.0%	11.93	0	–14469
June	2874	–4.1%	–14.7%	1.584	–812	–2910
July	4421	–7.5%	–3.2%	0.005	–175	–74
Net: December – March					+110	+28
Net: April – July					–980	–17448

[a] Average delta smelt salvage density (fishes c.f.s.$^{-1}$ month^{-1}) estimated from Dry and Critically Dry years 1994 and 2001-2

[b] 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 4a	Median change in case 5a	Density of delta smelt at Tracy[a]	Predicted median difference in salvage[b]	
					4a – 1	5a – 1
Adults						
December	2897	–0.4%	–19.3%	0.067	–1	–41
January	4218	+6.0%	–9.6%	0.180	+61	–98
February	3979	+8.5%	+2.1%	0.235	+36	+9
March	1247	+6.8%	+0.2%	0.201	+25	+1
Largely Juveniles						
April	800	0.0%	0.0%	0.259	0	0
May	1189	0.0%	–32.7%	11.93	0	–11652
June	953	0.0%	0.0%	1.584	0	0
July	800	0.0%	0.0%	0.005	0	0
Net: December – March					+121	–130
Net: April – July					0	–11652

[a] Average delta smelt salvage density (fishes c.f.s.$^{-1}$ month^{-1}) estimated from pooled Dry and Critically Dry years 1994 and 2001-2

[b] 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 4a	Median change in case 5a	Density of delta smelt at Tracy[a]	Predicted median difference in salvage[b]	
					4a – 1	5a – 1
Adults						
December	7033	0.0%	–5.6%	0.015	0	–6
January	7408	0.0%	–4.8%	0.214	0	–76
February	5848	0.1%	+6.1%	0.242	+1	+86
March	5653	+16.4%	+25.0%	0.069	+64	+98
Largely Juveniles						
April	4830	+4.4%	–21.5%	0.058	+12	–60
May	4660	0.0%	–46.6%	12.52	0	–27188
June	5925	–0.2%	–1.7%	10.9	–129	–1098
July	6680	0.0%	0.0%	0.611	0	0
Net: December – March					+65	+102
Net: April – July					–117	–28346

[a] Average delta smelt salvage density (fishes c.f.s.$^{-1}$ month^{-1}) estimated from pooled Above Normal and Wet years 1993 and 1995-2000.

[b] 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 4a	Median change in case 5a	Density of delta smelt at Tracy[a]	Predicted median difference in salvage[b]	
					4a – 1	5a – 1
Adults						
December	6484	0.0%	–5.7%	0.015	0	–6
January	7548	0.0%	–5.4%	0.214	0	–87
February	7451	0.0%	–5.2%	0.242	0	–94
March	5784	+21.9%	+22.9%	0.069	+87	+91
Largely Juveniles						
April	4508	–0.3%	–29.6%	0.058	–1	–77
May	3596	+0.9%	–57.6%	12.52	+405	–25933
June	3942	+0.8%	–0.3%	10.9	+344	–129
July	6157	0.0%	+7.5%	0.611	0	+282
Net: December – March					+87	–95
Net: April – July					+748	–25857

[a] Average delta smelt salvage density (fishes c.f.s.$^{-1}$ month^{-1}) estimated from pooled Above Normal and Wet years 1993 and 1995-2000.

[b] 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 model case 1 pumping (c.f.s.)	Median change in case 4a	Median change in case 5a	Density of delta smelt at Tracy[a]	Predicted median difference in salvage[b]	
					4a – 1	5a – 1
Adults						
December	5938	0.0%	–5.4%	0.050	0	–16
January	7172	0.0%	–5.5%	0.209	0	–82
February	5850	+4.4%	0.0%	0.134	+34	0
March	5713	+7.7%	+6.2%	0.178	+78	63
Largely Juveniles						
April	3548	–0.3%	–27.2%	0.369	–4	–356
May	3235	+3.5%	–32.1%	29.97	+3393	–31122
June	3977	+0.3%	–0.2%	6.706	+80	–53
July	5320	0.0%	+13.4%	0.446	0	+318
Net: December – March					+113	–35
Net: April – July					+3469	–31213

[a] Average delta smelt salvage density (fishes c.f.s.$^{-1}$ month^{-1}) estimated from pooled Dry and Critically Dry years 1994 and 2001-2

[b] 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 4a	Median change in case 5a	Density of delta smelt at Tracy[a]	Predicted median difference in salvage[b]	
					4a – 1	5a – 1
Adults						
December	5358	0.0%	–5.6%	0.050	0	–15
January	5717	0.0%	–7.3%	0.209	0	–87
February	5303	+2.2%	0.0%	0.134	+16	0
March	4413	0.0%	0.0%	0.178	0	0
Largely Juveniles						
April	2168	+0.1%	–18.1%	0.369	+1	–144
May	2099	–3.0%	–51.0%	29.97	–1887	–32083
June	2952	–0.7%	–6.4%	6.706	–139	–1267
July	5217	–0.1%	+21.2%	0.446	–2	+493
Net: December – March					+16	–102
Net: April – July					–2027	–33000

[a] Average delta smelt salvage density (fishes c.f.s.$^{-1}$ month^{-1}) estimated from pooled Dry and Critically Dry years 1994 and 2001-2

[b] 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 4a	Median change in case 5a	Density of delta smelt at Tracy[a]	Predicted median difference in salvage[b]	
					4a – 1	5a – 1
Adults						
December	4267	+8.2%	–5.3%	0.050	+17	–11
January	4891	–0.1%	–10.2%	0.209	–1	–104
February	3198	+13.1%	+12.0%	0.134	+56	+51
March	2030	+10.1%	+0.6%	0.178	+36	+2
Largely Juveniles						
April	1197	0.0%	0.0%	0.369	0	0
May	1189	0.0%	–20.4%	29.97	0	–7269
June	300	0.0%	0.0%	6.706	0	0
July	553	+2.9%	+70.8%	0.446	+7	+175
Net: December – March					+109	–62
Net: April – July					+7	–7095

[a] Average delta smelt salvage density (fishes c.f.s.$^{-1}$ month^{-1}) estimated from pooled Dry and Critically Dry years 1994 and 2001-2

[b] Predicted median difference has unit: fishes month^{-1}. See text for explanation of calculation.

Results:

Salvage of adult delta smelt

All comparisons of model cases #4a and #5a are with model case #1. In general, there were median increases of 6-9% in CVP pumping during December through March in case #4a. We would expect a corresponding increase in adult delta smelt salvage during that period. There is a general decrease in CVP pumping during the same months in case #5a, which we would expect to result in correspondingly lower adult salvage. Median SWP pumping in case #4a was up to 7.7% higher in February and March in Below Normal and Dry years, but was 10-13.1% higher in Critically Dry years. We would expect correspondingly higher salvage in critically dry years, therefore. Although case #5a was similar to the base case in most months, median SWP pumping was up to 25% higher during March.

Salvage of Juvenile Delta Smelt

All comparisons of model cases #4a and #5a are with model case #1. Both CVP and SWP pumping is generally flat or declining under both #4a and #5a, with corresponding reductions in predicted salvage that are similar to those described for cases #4 and #5 above. The only exceptions are SWP pumping in July of Dry and Critically Dry years, with median increases of 21.2 percent and 13.4 percent, respectively. We expect corresponding increases in salvage, but because the population is downstream in July, the direct effect would likely be minimal.

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 the future model cases we have examined. Better modeling and improved monitoring may provide a means to answer 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 approaches 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 basis for evaluating the population-level effects of export operations and proposed changes to operations.

X2 Position

The X2 position in CALSIM II represents where 2 ppt isohaline lies in the Delta calculated from the monthly average Net Delta Outflow (NDO). Because the model represents the end of month

X2 position, the day-to-day effect of CVP/SWP operations is not resolved in the CALSIM II representation.

The monthly average X2 position based on long-term and on water year type dependent averages are shown in Figure 10–8 to Figure 10–13. The six figures generally indicate the same trend from February to June in the X2 position on average as it moves more upstream into the Delta. Also, in the months February, April, May and June the X2 position shifts slightly downstream in Studies 3 and 5a when compared to the other studies.

Figure 10–14 to Figure 10–18 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 10–19 to Figure 10–21 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.

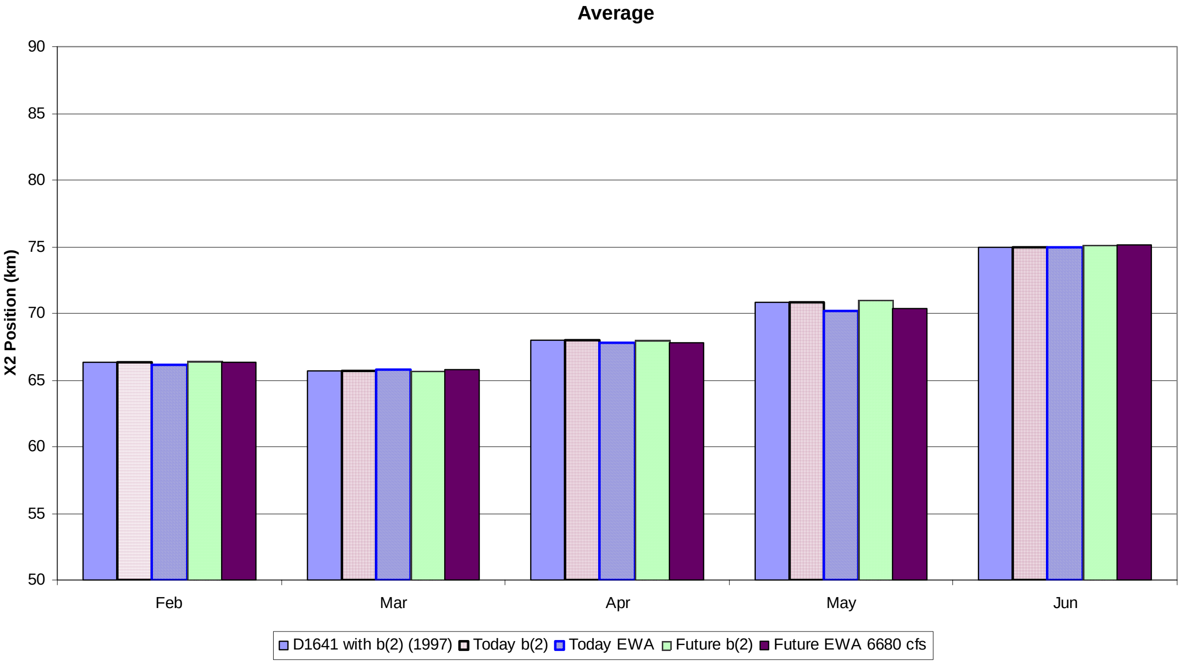


Figure 10–8 Average Monthly X2 Position

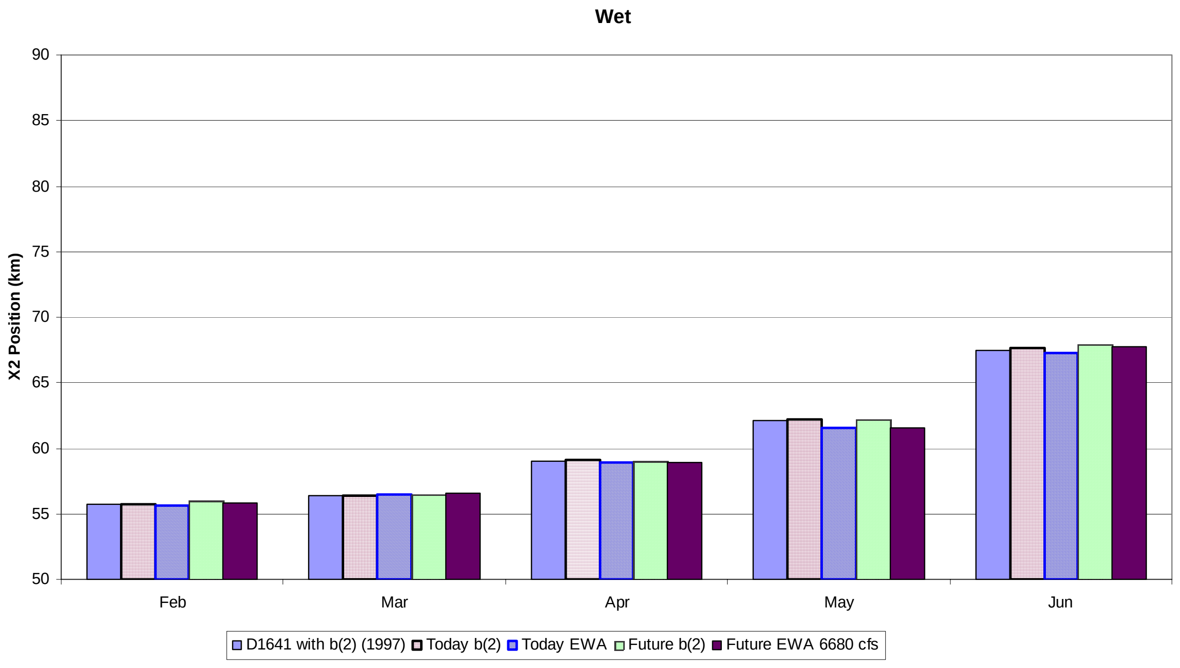


Figure 10–9 Average wet year (40-30-30 Classification) monthly X2 Position

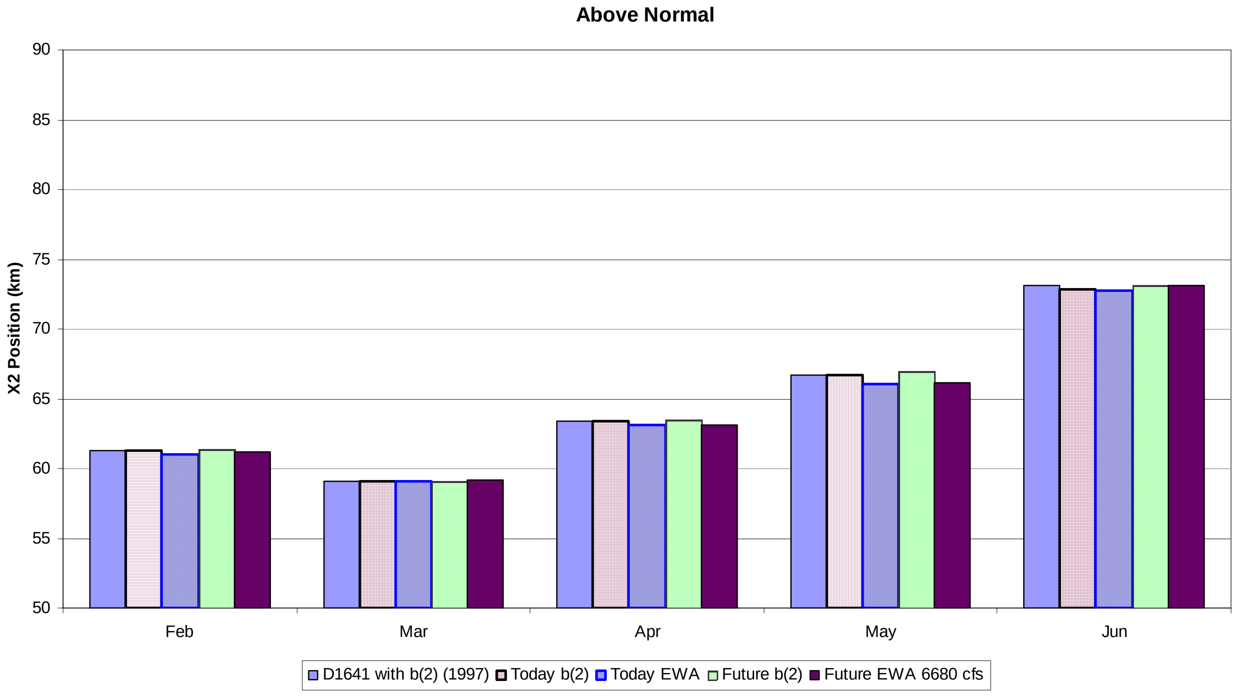


Figure 10–10 Average above-normal year (40-30-30 Classification) monthly X2 Position

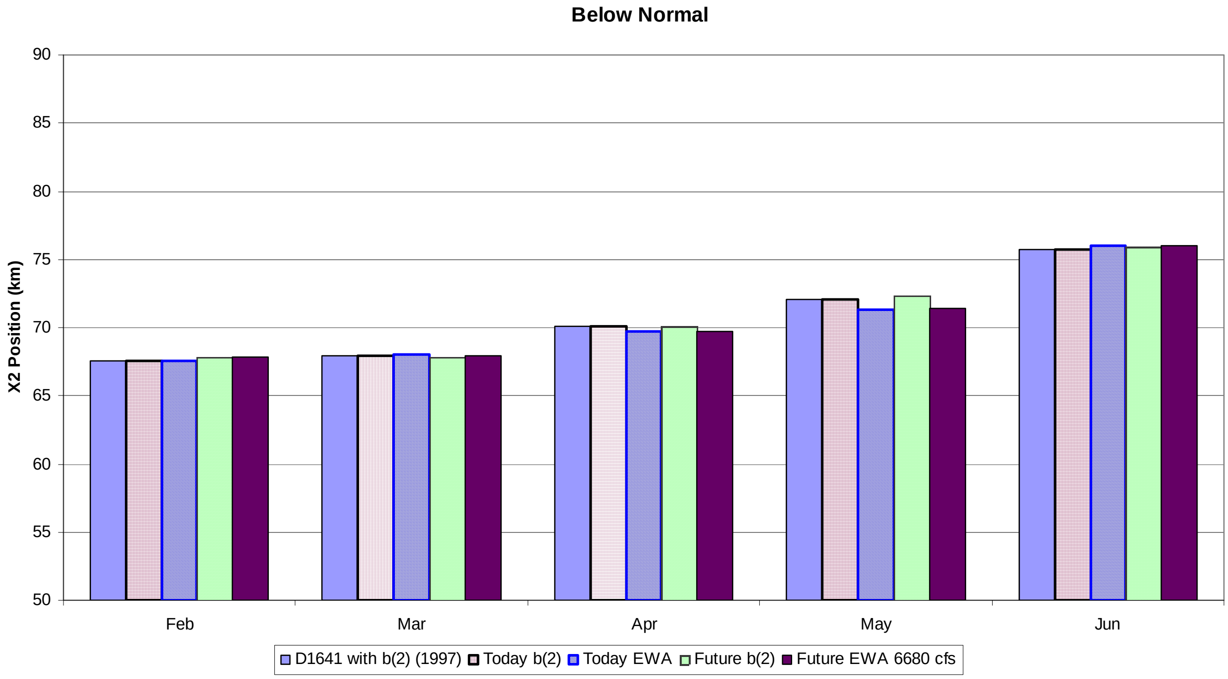


Figure 10–11 Average below-normal year (40-30-30 Classification) monthly X2 Position

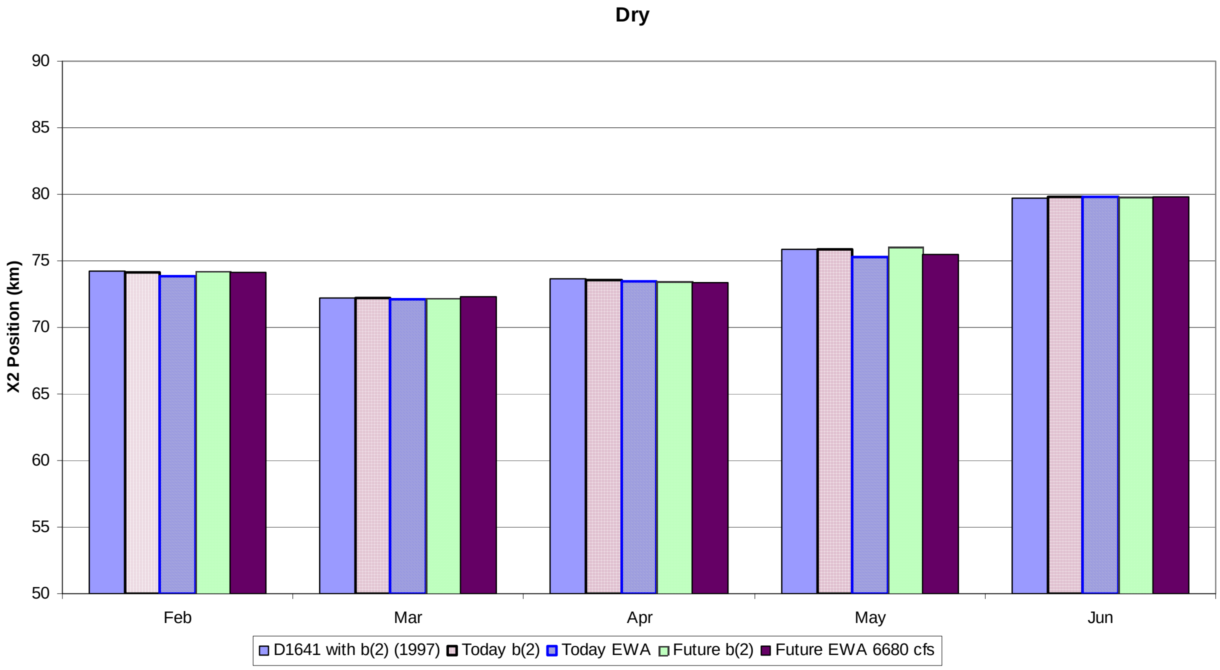


Figure 10–12 Average dry year (40-30-30 Classification) monthly X2 Position

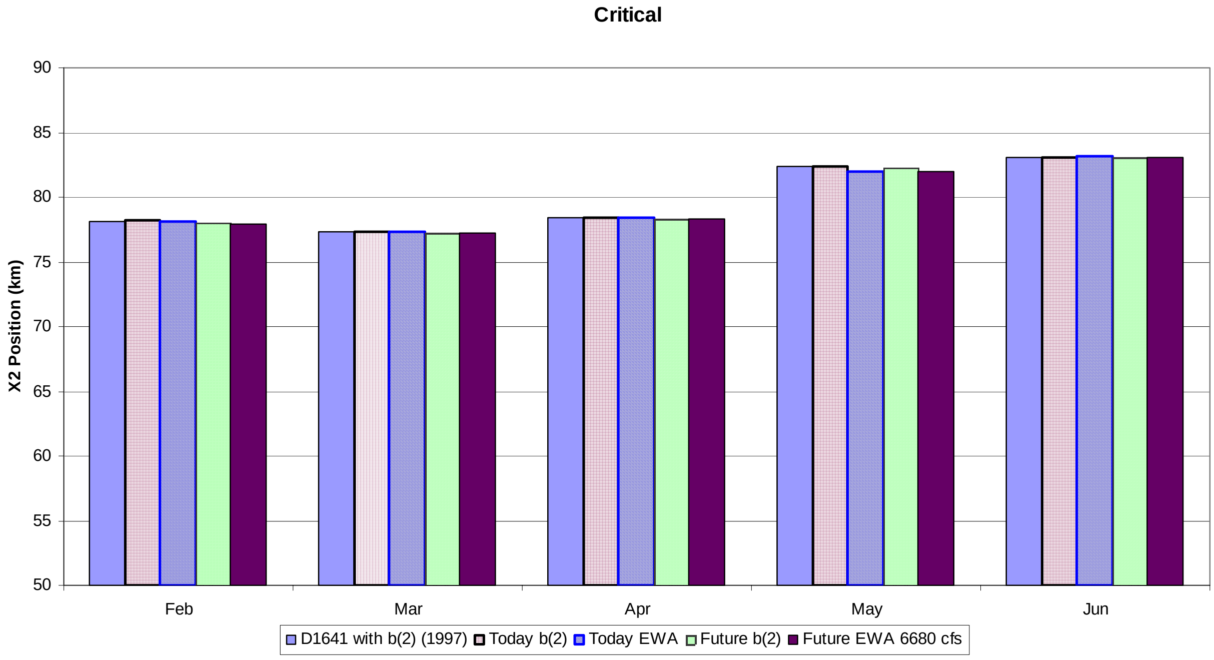


Figure 10–13 Average critical year (40-30-30 Classification) monthly X2 Position

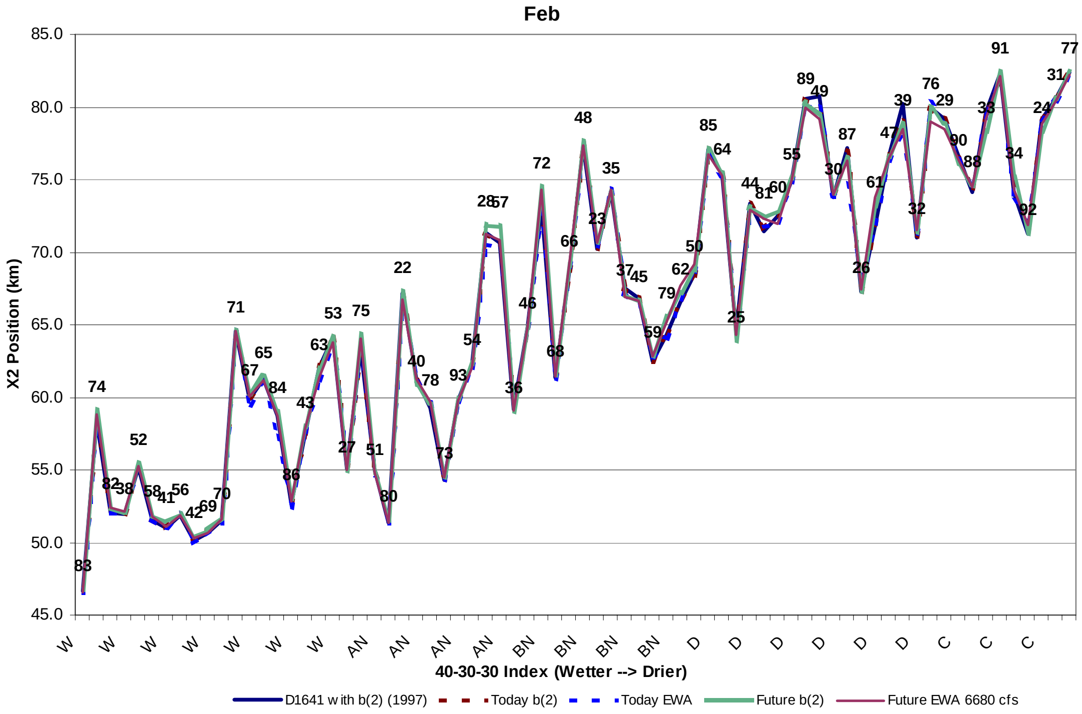


Figure 10–14 February X2 Position sorted by 40-30-30 Index

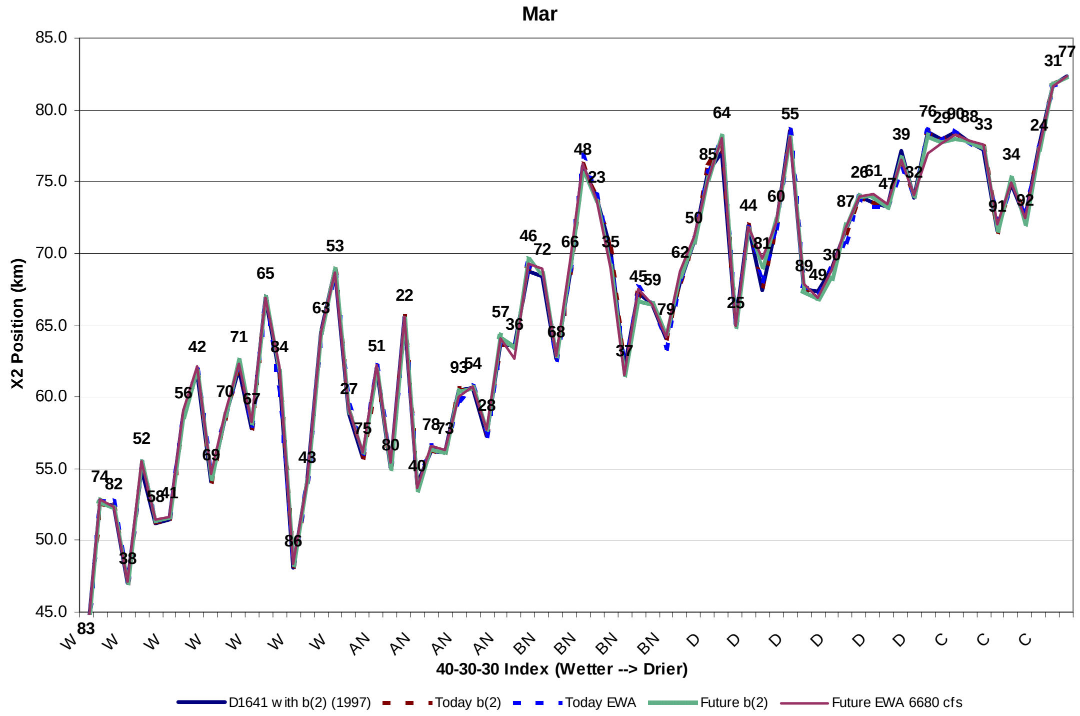


Figure 10–15 March X2 Position sorted by 40-30-30 Index

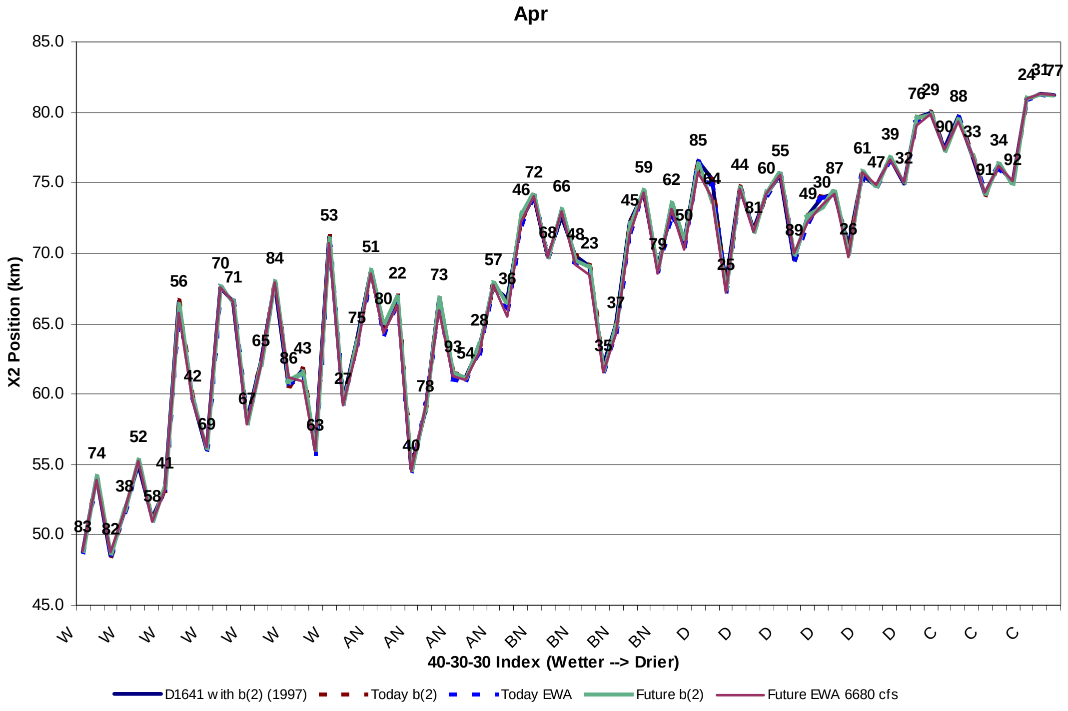


Figure 10–16 April X2 Position sorted by 40-30-30 Index

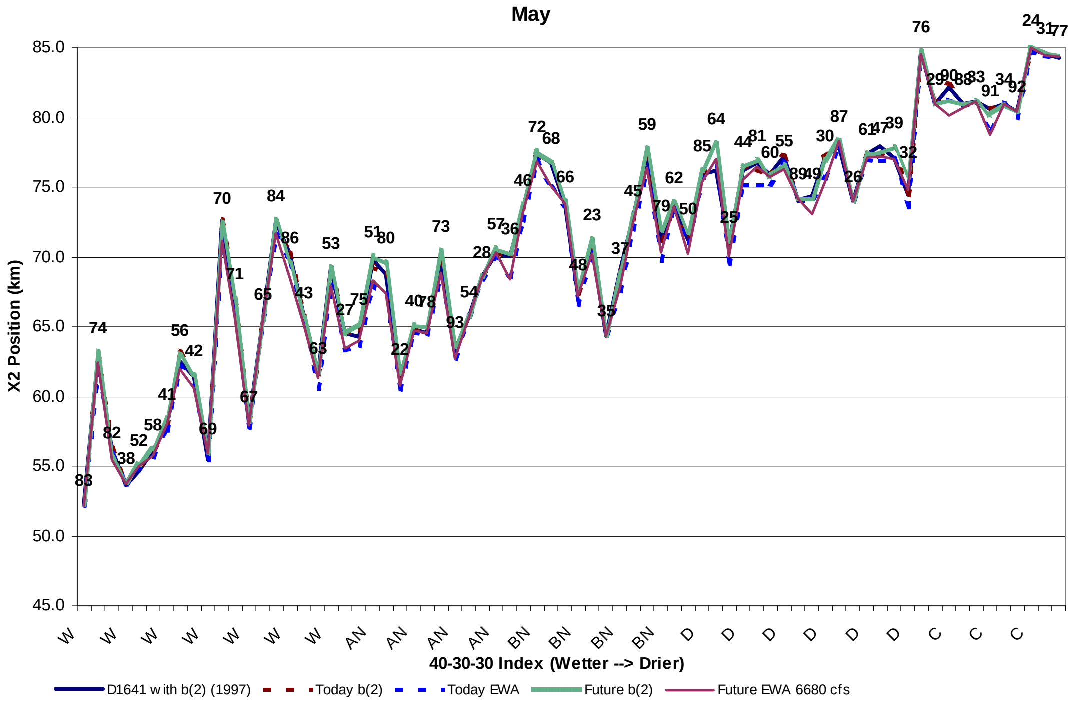


Figure 10–17 May X2 Position sorted by 40-30-30 Index

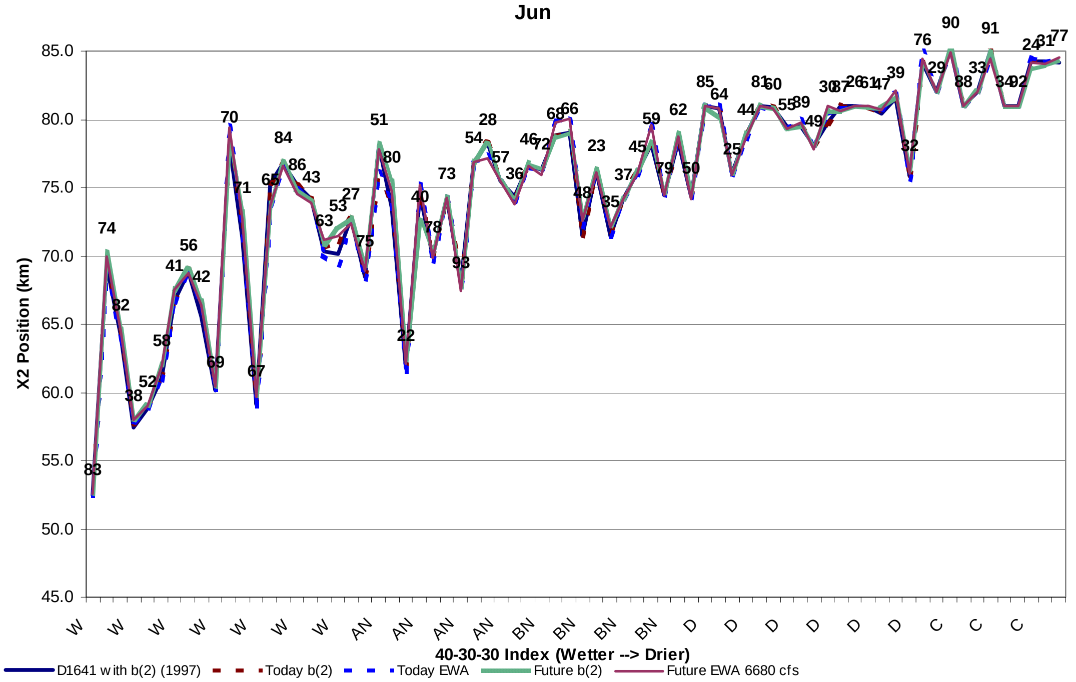


Figure 10–18 June X2 Position sorted by 40-30-30 Index

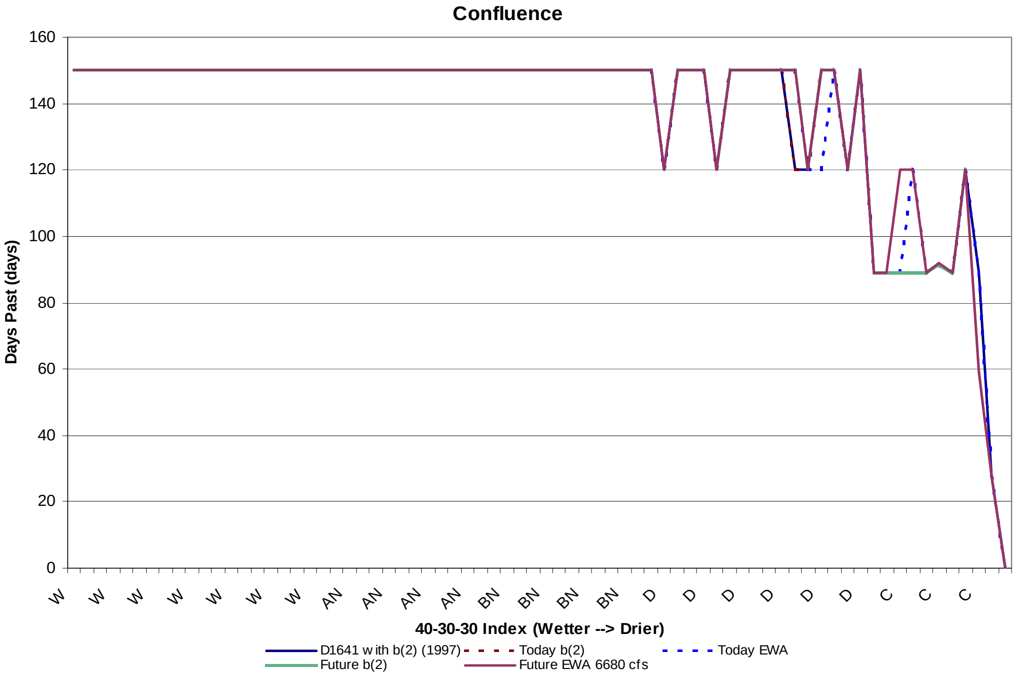


Figure 10–19 Total number of days average monthly X2 position is past the Confluence 40-30-30 Index (Note: the total days for a month are assigned if the average X2 position is past the Confluence)

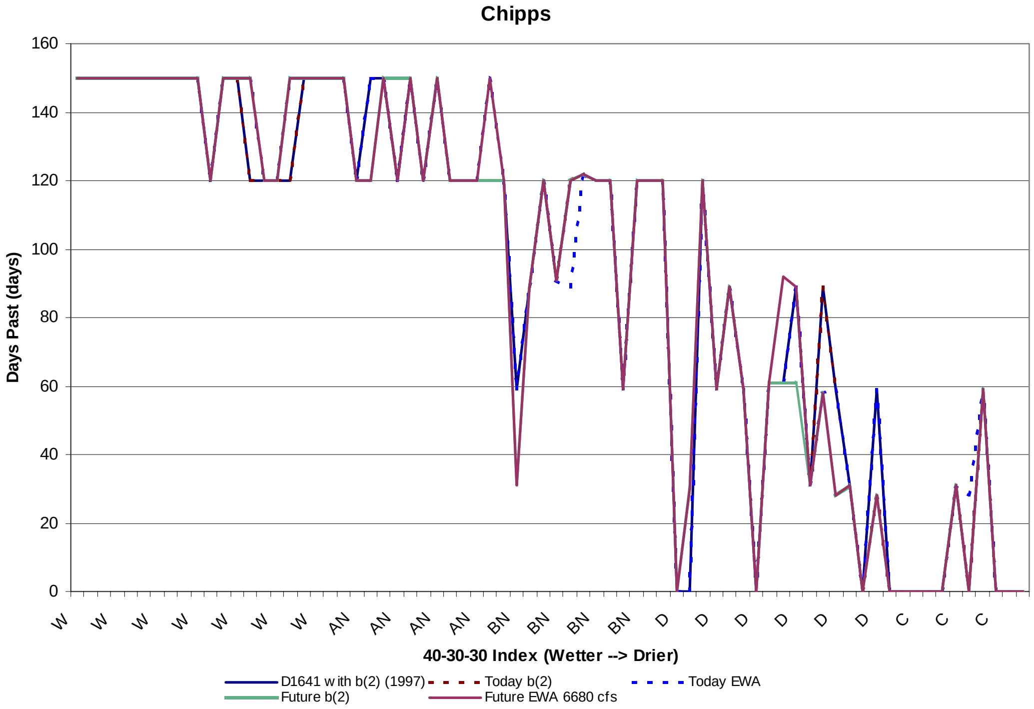


Figure 10–20 Total number of days average monthly X2 position is past the Chipps Island 40-30-30 Index (Note: the total days for a month are assigned if the average X2 position is past the Chipps Island)

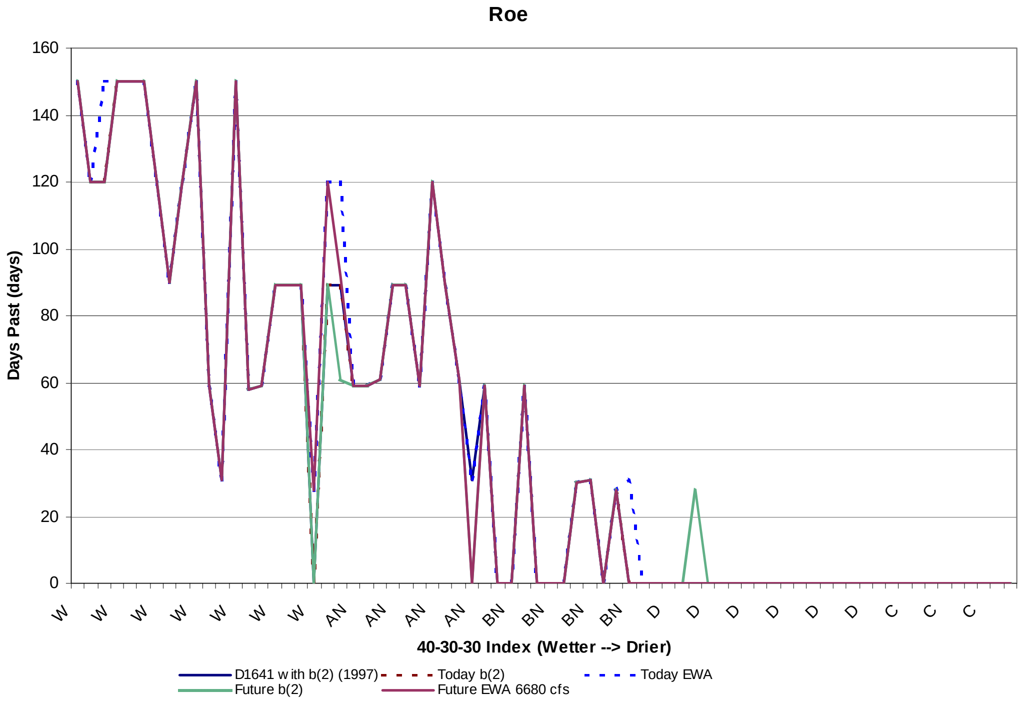


Figure 10–21 Total number of days average monthly X2 position is past the Roe Island 40-30-30 Index **(Note: that the total days for a month are assigned if the average X2 position is past the Roe Island)**

Changes in Habitat Availability for Delta Smelt Based on X2 Movement

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 "critical value" that reliably separates a dangerous X2 difference from an innocuous one, we arbitrarily selected one kilometer as the criterion for review. However, the location of X2 may affect how important an upstream change in X2 could be (Nobriga et al. unpublished analysis). When X2 is downstream of Chipps Island, an upstream movement, even of several kilometers, is unlikely to affect delta smelt if it does not result in X2 moving east of Chipps Island. When it is already upstream of Chipps Island, a shift of a few kilometers farther upstream probably does not increase the risk of entrainment at the facilities. Movement of X2 from downstream to upstream of Chipps Island may be associated with a marginal increased risk of smelt entrainment at the export facilities. Unfortunately, the present evidence for this claim relies on the regression of a ratio of a delta smelt index to salvage at the export facilities against river kilometer index, and does not provide a suitable basis for estimating the marginal risk of X2 shifts to delta smelt. The risk of one-kilometer shifts is probably small. A better reckoning of the risk to delta smelt posed by X2 shifts may be available in the future when improved modeling of the consequences of changes in water operations is available.

To explore the changes in X2 location that might result from future operations, the differences between X2 in CALSIM II model cases #4a and #5a and case #1 were plotted against X2 in case #1 for each of the months March through July (Figure 10–22 to Figure 10–26). 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 (km) in Below Normal, Dry, and Critically Dry years have been labeled with the years they represent. We note where X2 difference between model cases seems to imply a shift from downstream to upstream of Chipps Island in a future scenario, and whether X2 location in the succeeding month seems to indicate a persistent shift upstream.

Results

Average X2 during March–July of each year differed very little between model case #1 and either #4a or #5a. However, a review of the monthly data revealed that there were occasionally differences that were larger than most others during the March–July months (Figure 10-22 to

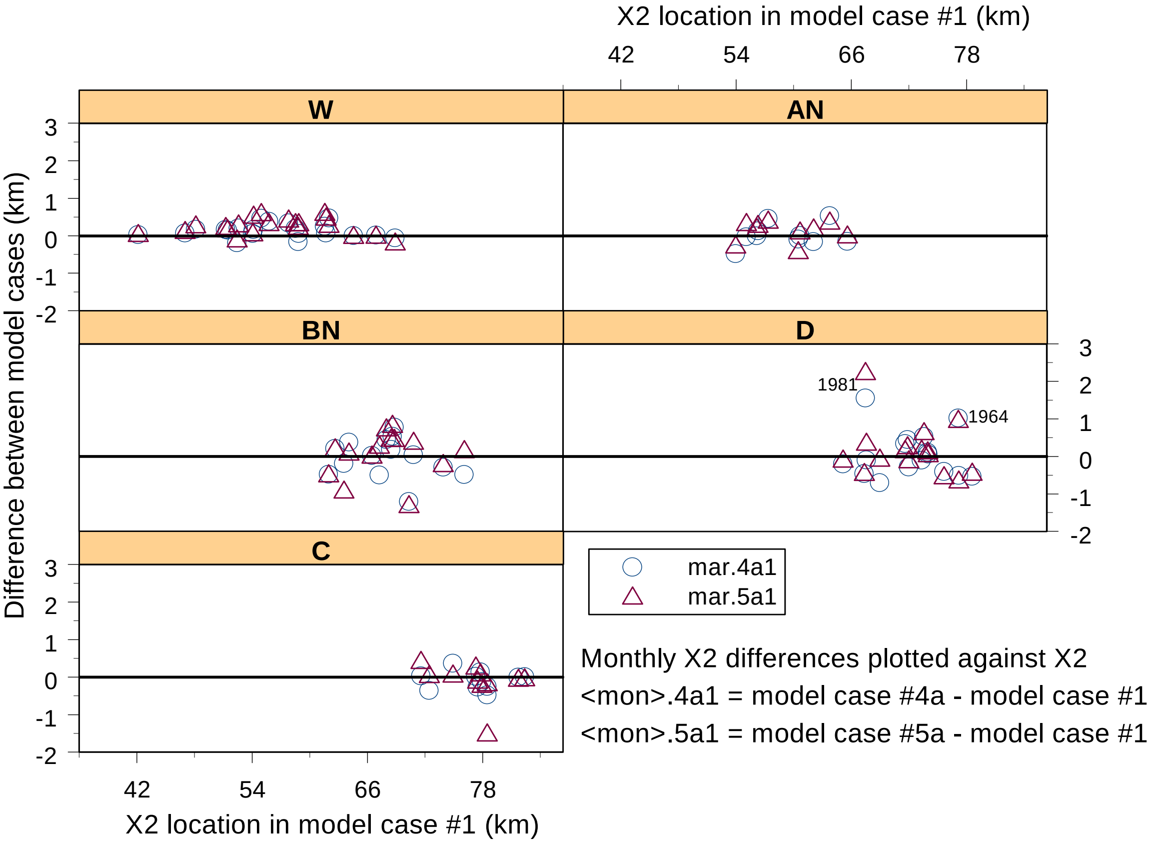
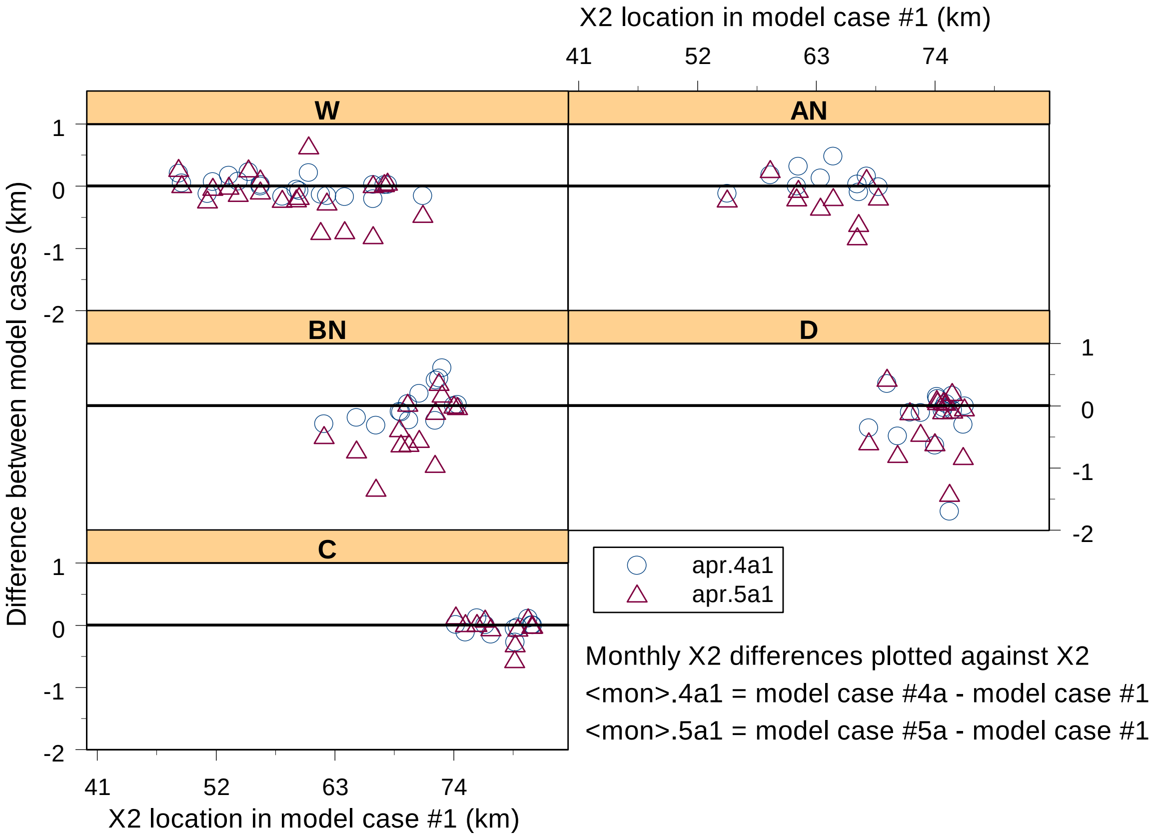


Figure 10–22 Differences in X2 under model cases #4 and #5 in March. Water year types: W=Wet, AN=Above Normal, BN=Below Normal, D=Dry, C=Critically Dry



Monthly X2 differences plotted against X2
<mon>.4a1 = model case #4a - model case #1
<mon>.5a1 = model case #5a - model case #1

Figure 10–23 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

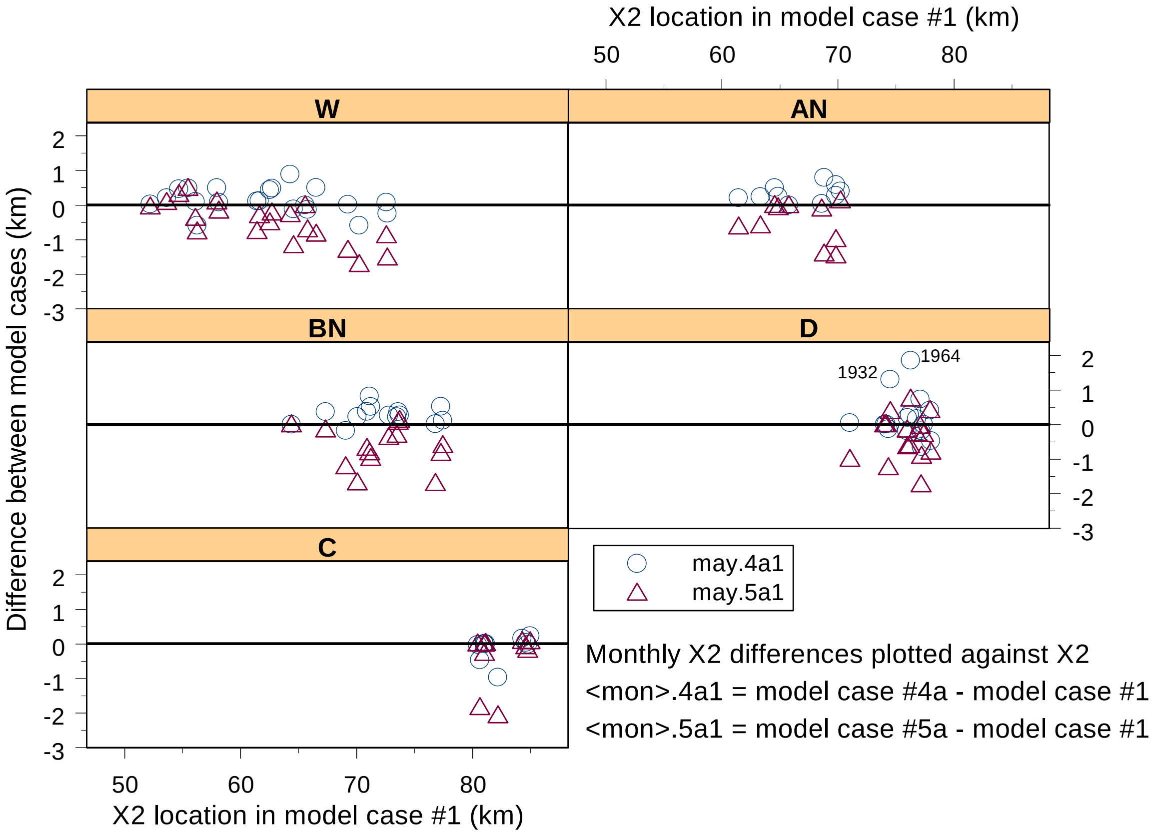


Figure 10–24 Differences in X2 under model cases #4 and #5 in May. Water year types: W=Wet, AN=Above Normal, BN=Below Normal, D=Dry, C=Critically Dry

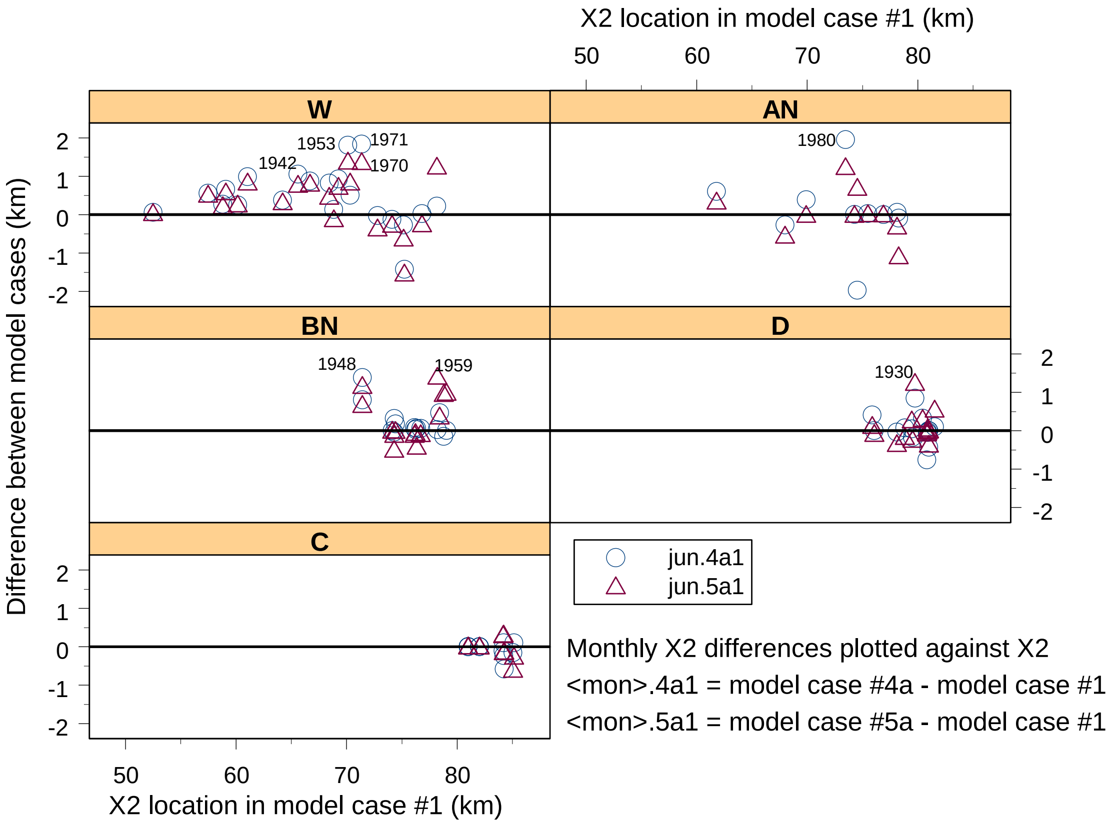


Figure 10–25 Differences in X2 under model cases #4 and #5 in June. Water year types: W=Wet, AN=Above Normal, BN=Below Normal, D=Dry, C=Critically Dry

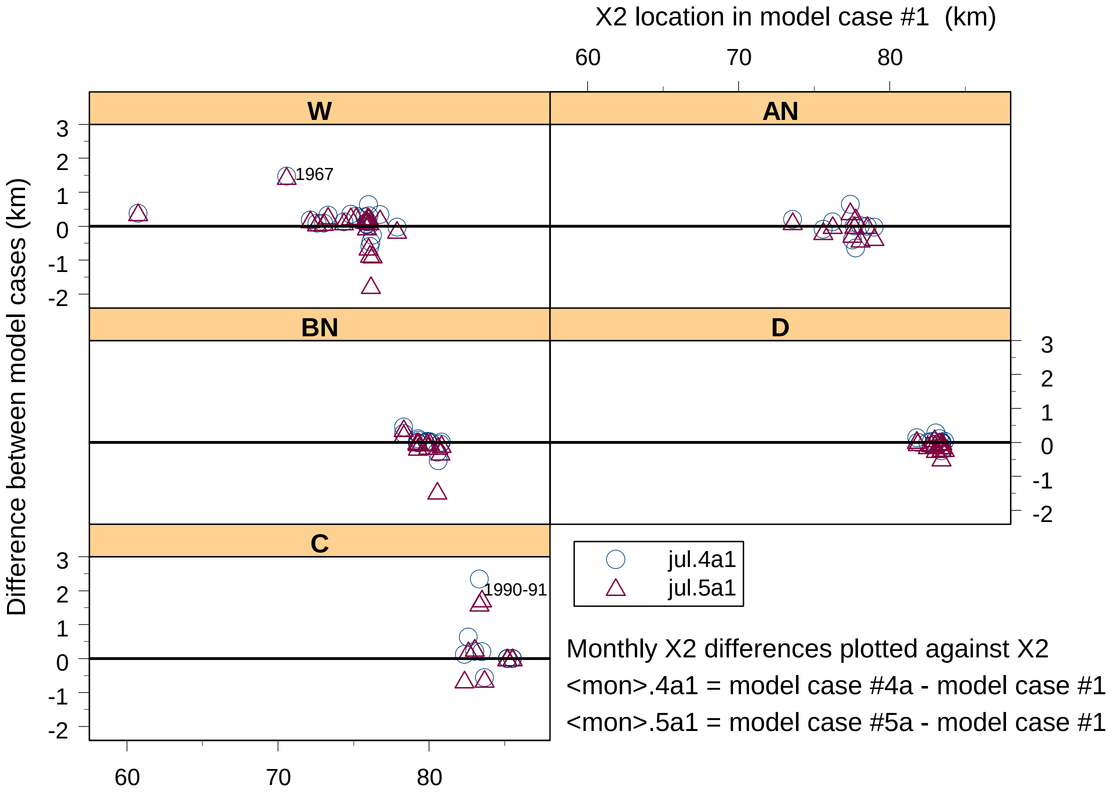


Figure 10–26 Differences in X2 under model cases #4 and #5 in July. Water year types: W=Wet, AN=Above Normal, BN=Below Normal, D=Dry, C=Critically Dry

Results: Cases #4a and #5a yielded results very similar to #4 and #5, with the exception that upstream movement in March 1981 was farther in #4a and #5a than in #4 and #5.

March

Relative to case #1, there were two upstream shifts of X2 of at least one kilometer in Dry years in Scenario #4a (1964:1.0 km; 1981: 1.5 km) and one in #5a (1981: 2.2 km). Neither case involves a movement past Chipps Island. In all three cases the shift in the following month was downstream of the value predicted in case #1. Most differences that occurred in March in this comparison involved a movement of X2 downstream in the future scenario.

April

There were no differences larger than one kilometer in April.

May

The criterion was met twice in Model Case #4a in Dry years (1932: 1.3 km; 1964: 1.8 km). There was no occurrence in case #5a. In case #4a, the 1932 positive May value was followed by a smaller (0.4 km) positive June value; the 1964 positive May value was followed by a negative (-0.8 km) June value. The 1.3 km 1932 shift in case #4a appears to pass Chipps Island.

June

In June there were three differences of at least a kilometer in case #4a in Wet years (1942: 1.1 km; 1953: 1.8 km; 1971: 1.8 km), one in an Above Normal year (1980: 2.0 km), and one in a Below Normal year (1948: 1.4 km). All of these except 1971 was followed by a smaller positive shift in July. In case #5a there were three in Wet years (1953: 1.4 km; 1970: 1.2 km; 1971: 1.4 km), one in an Above Normal year (1980: 1.2 km), two in Below Normal years (1948: 1.2 km; 1959: 1.4 km), and one in a Dry year (1930: 1.2 km). Four of these seven were followed by downstream shifts in July. In none of these cases does X2 appear to move past Chipps Island.

July

In Model Case #4a, the criterion was reached in one Wet year (1967: 1.5 km) and one Critically Dry year (1990, 2.3 km). The Critically Dry year occurrence was followed by a small downstream difference in August; the Wet year occurrence was followed by an even larger (1.8 km) upstream difference in August. In Case #5a, the criterion was reached in 1967 (1.4 km), 1990 (1.6 km), and 1991 (a Critically Dry year, 1.7 km). The two Critically Dry year occurrences were followed by negative differences in August, while the Wet year occurrence was followed by a larger positive difference (1.8 km) in August. None of these cases involved a shift past Chipps Island.

Summary

Upstream movements of X2 predicted in the future model cases reach one kilometer or more only occasionally. In some cases upstream movements observed in case #4a are erased or reduced in case #5a. In a few cases the upstream movement is larger in case #5a. There were a few movements from the west to the east side of Chipps Island, but these were of small magnitude. In general, the largest differences among the Model Cases appear to be attributable to the use of environmental water in Case #5a.

The seasonally averaged differences between future cases and the base case are close to zero, and 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 – during 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. Given that there were few differences much larger than one kilometer in these comparisons, 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 affect delta smelt vulnerability increases.

Export-to-Inflow Ratio

Figure 10–27 to Figure 10–32 show the E/I ratio on a monthly long-term average basis and averaged monthly by 40-30-30 index. From Figure 10–27 to Figure 10–32 during months where EWA actions are taken, the E/I ratio decreases (December, January, February, April, May and June) in Studies #3 and #5a compared to #1, #2, and #4a. The later summer months show increases in E/I 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 #4a and #5a.

Figure 10–33 to Figure 10–44 show the monthly E/I ratios sorted from wettest to driest by 40-30-30 Index. Studies 3 and 5a show lower E/I ratios when EWA actions are taken and then increased E/I ratios in the late summer and fall periods. Studies 4a and 5a show increased E/I ratios when compared to Studies 1, 2 and 3. In Figure 10–35 the December 1940 values drops off significantly from the others in Study 4a (Future b(2)) due to the Rock Slough salinity standard.

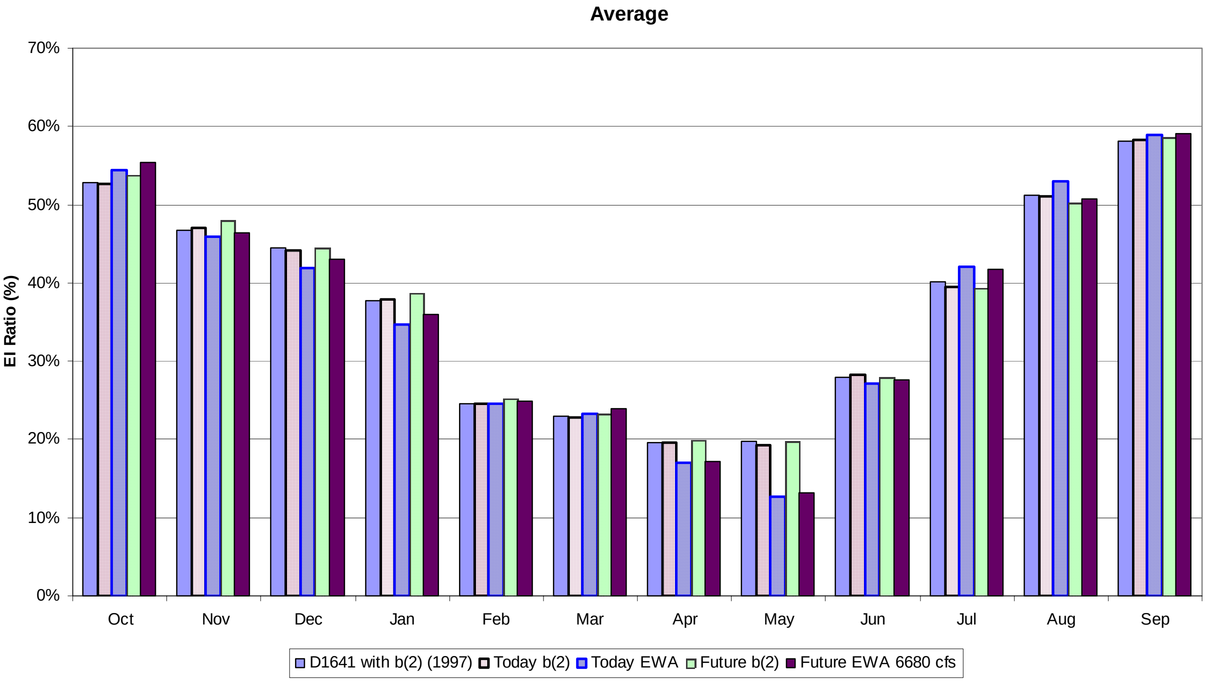


Figure 10–27 Average Monthly export-to-inflow ratio

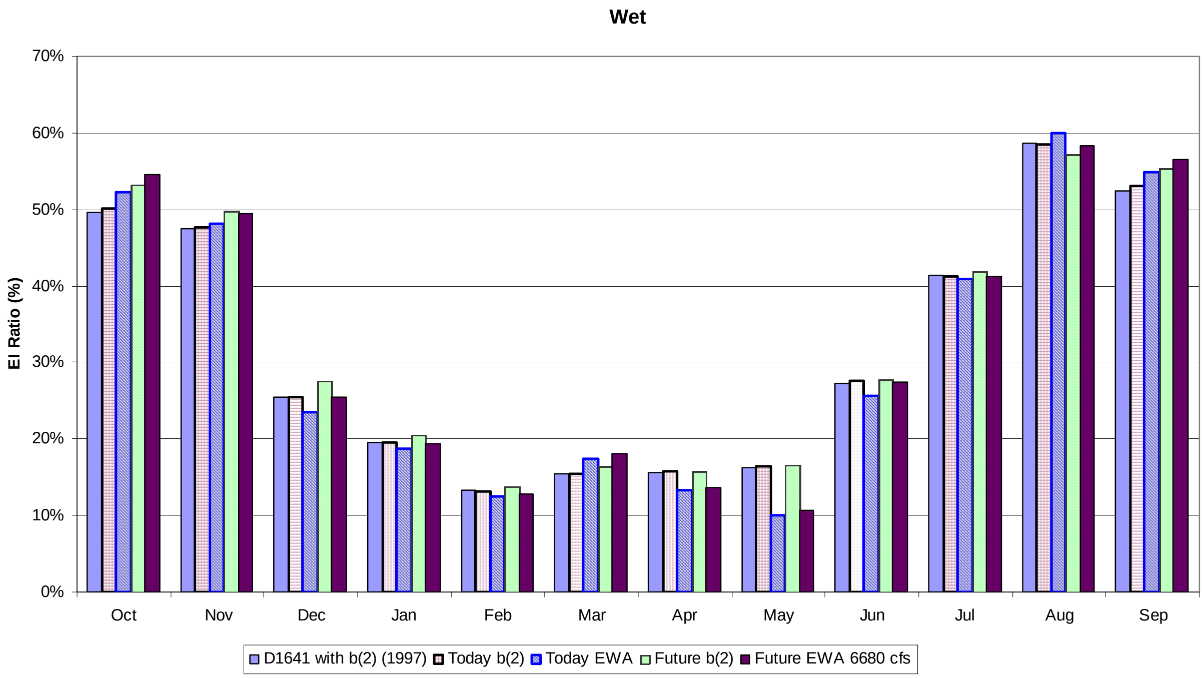


Figure 10–28 Average wet year (40-30-30 Classification) monthly export-to-inflow ratio

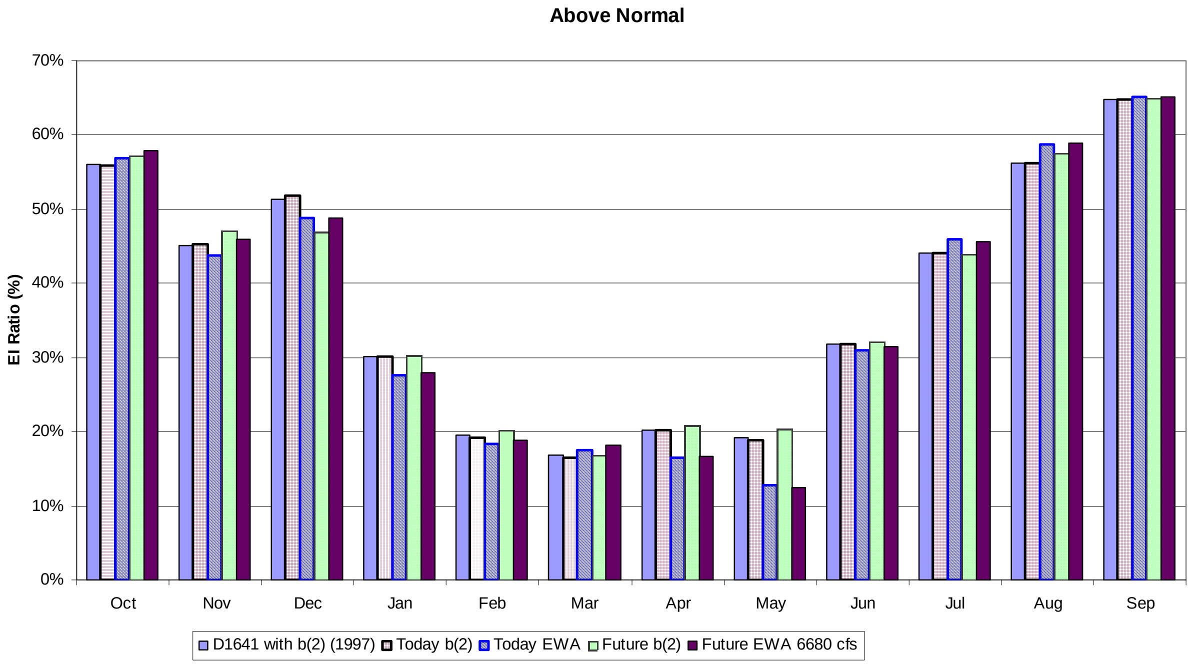


Figure 10–29 Average above normal year (40-30-30 Classification) monthly export-to-inflow ratio

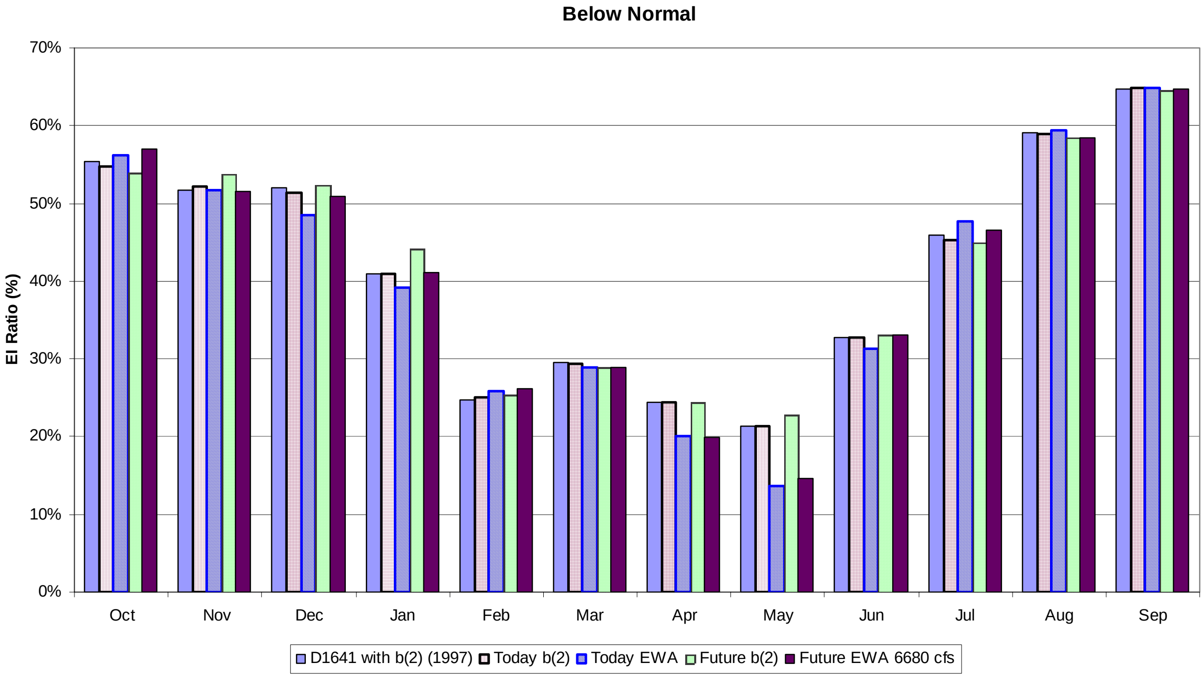


Figure 10–30 Average below normal year (40-30-30 Classification) monthly export-to-inflow ratio

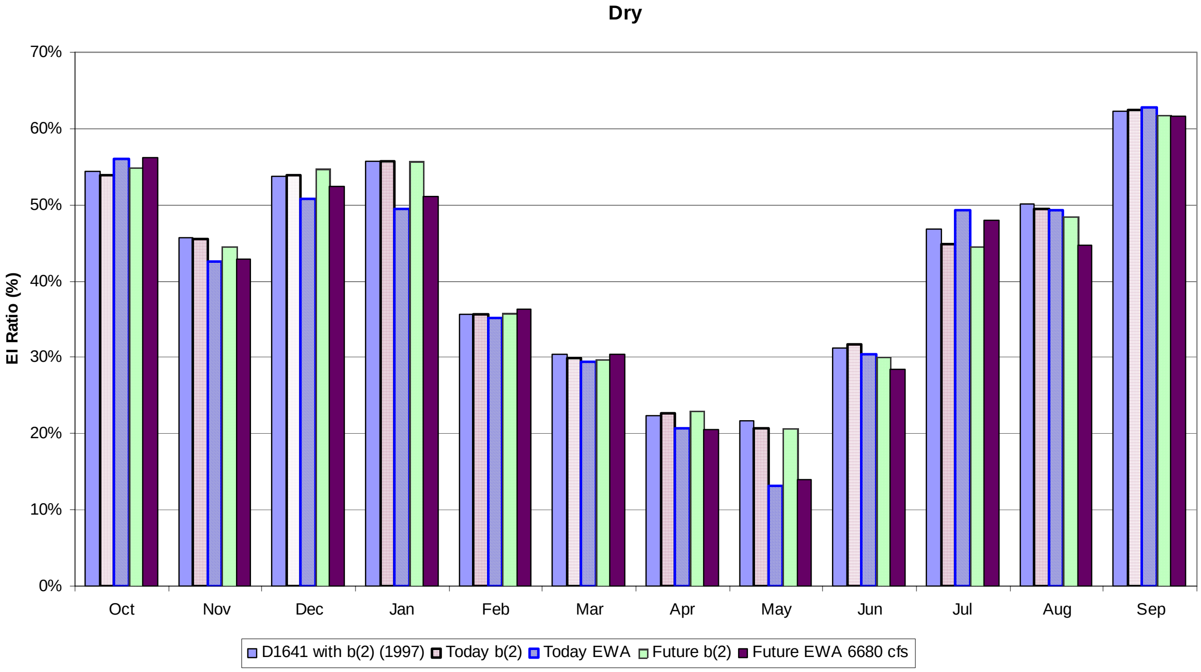


Figure 10–31 Average dry year (40-30-30 Classification) monthly export-to-inflow ratio

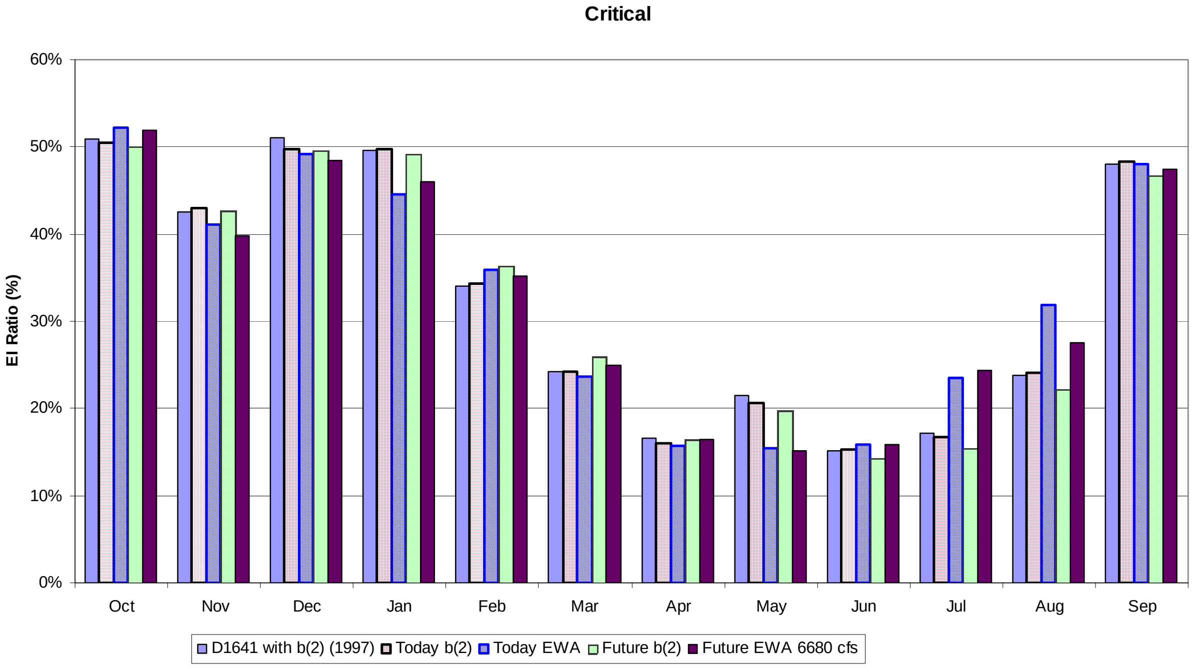


Figure 10–32 Average critical year (40-30-30 Classification) monthly export-to-inflow ratio

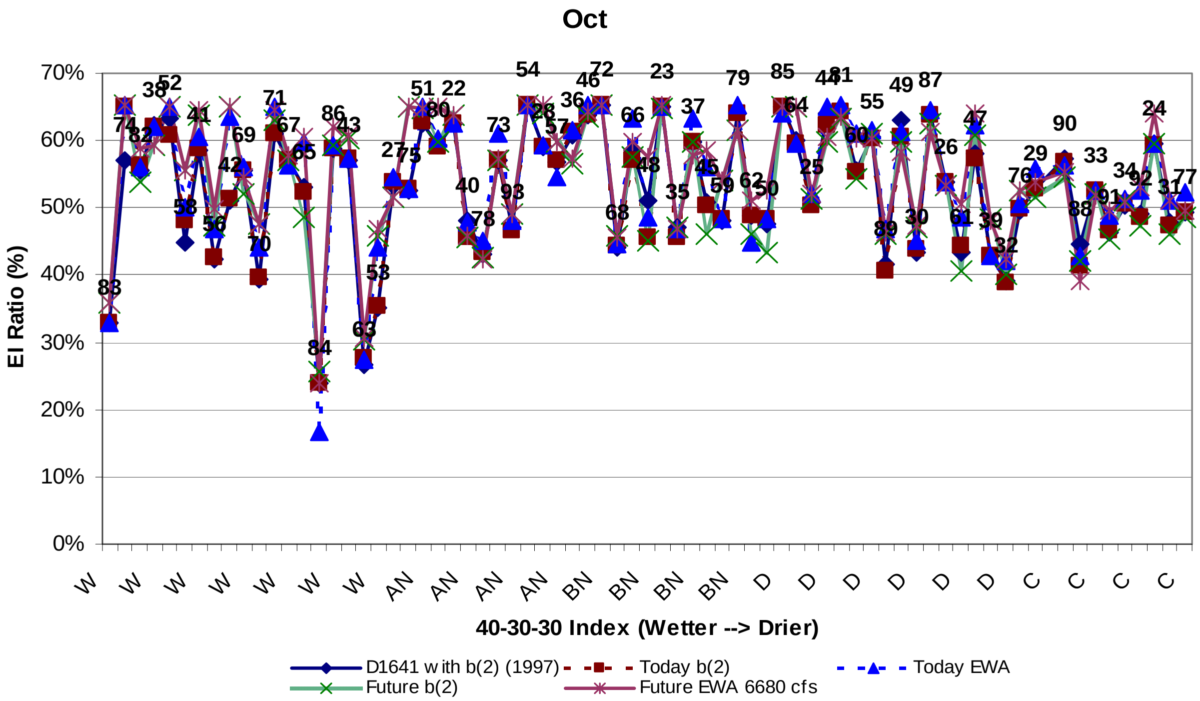


Figure 10–33 October export-to-inflow ratio sorted by 40-30-30 Index

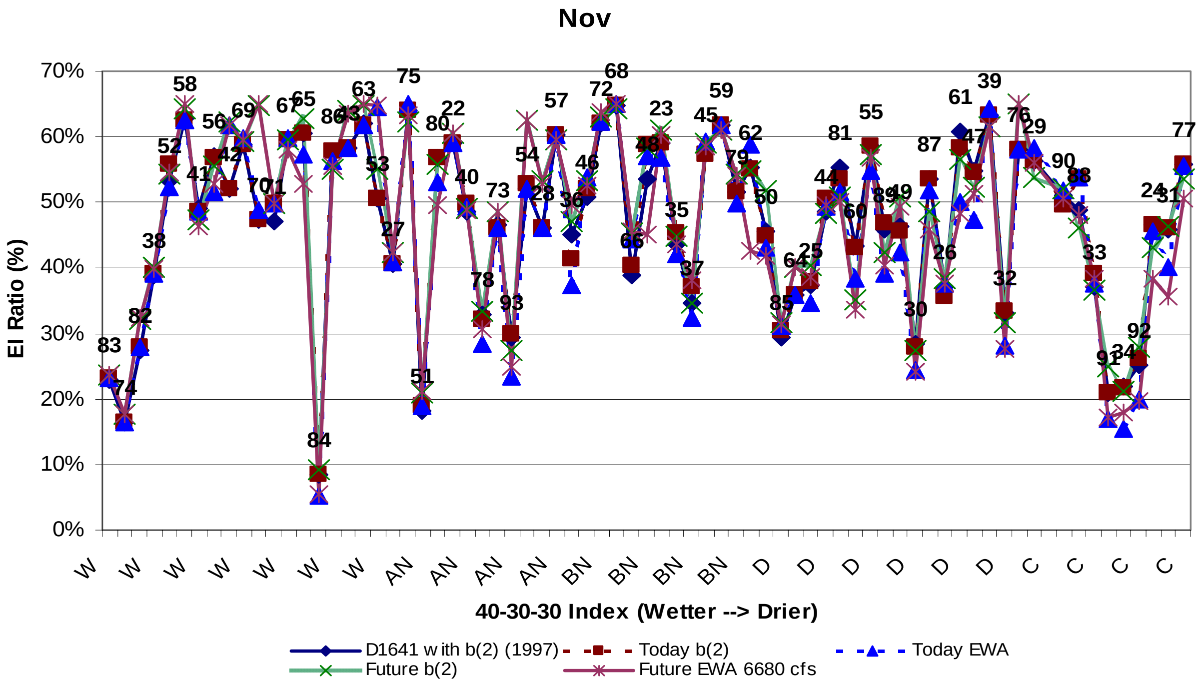


Figure 10–34 November export-to-inflow ratio sorted by 40-30-30 Index

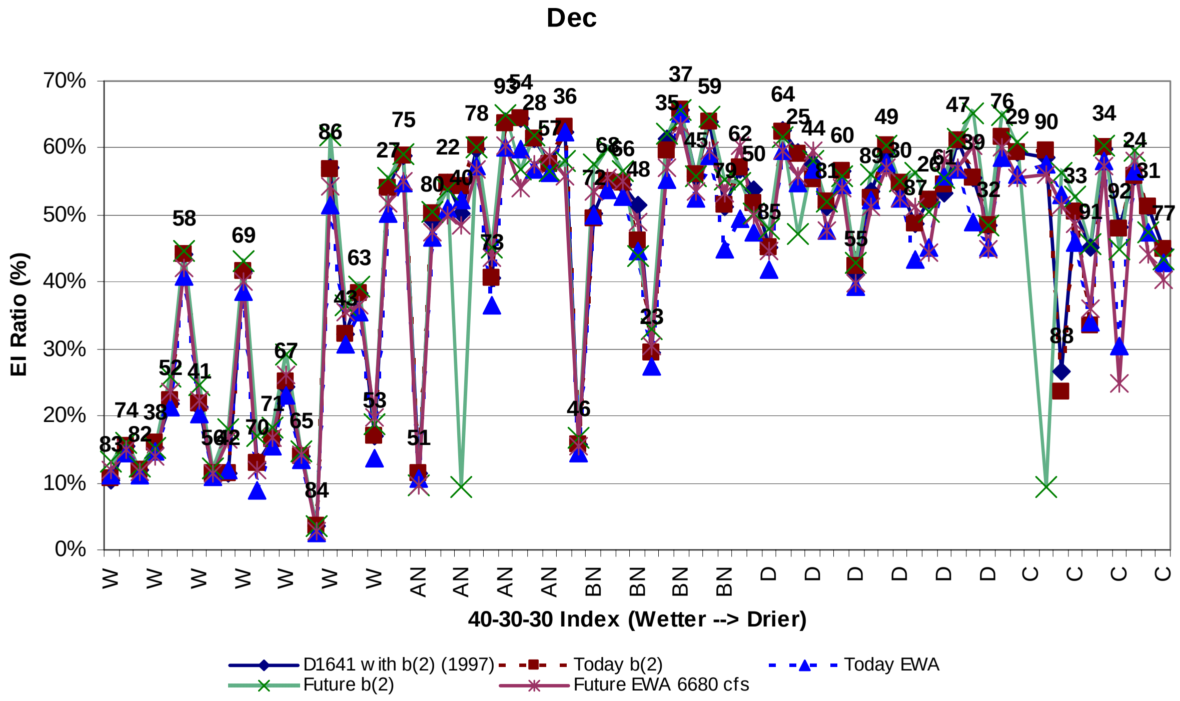


Figure 10–35 December export-to-inflow ratio sorted by 40-30-30 Index

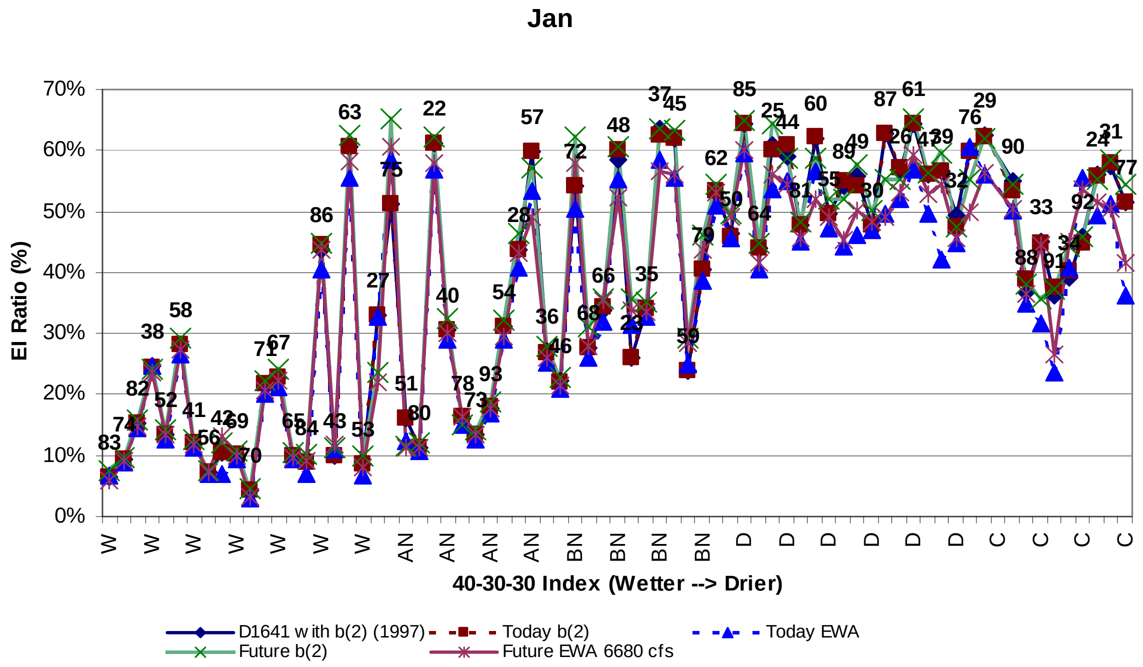


Figure 10–36 January export-to-inflow ratio sorted by 40-30-30 Index

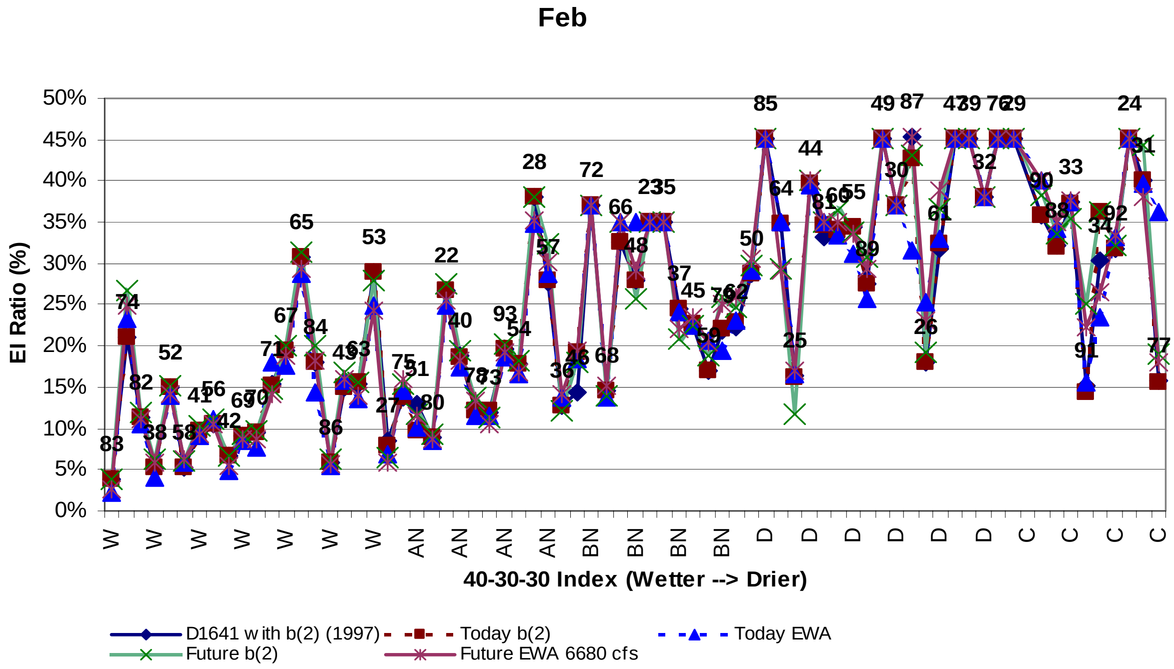


Figure 10–37 February export-to-inflow ratio sorted by 40-30-30 Index

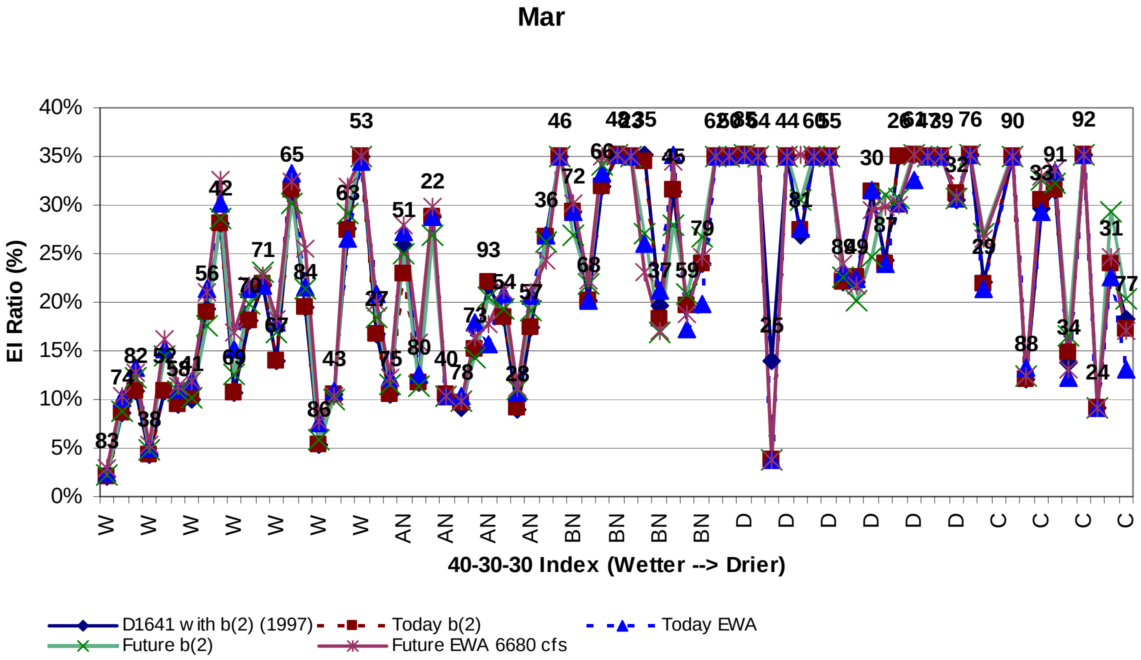


Figure 10–38 March export-to-inflow ratio sorted by 40-30-30 Index

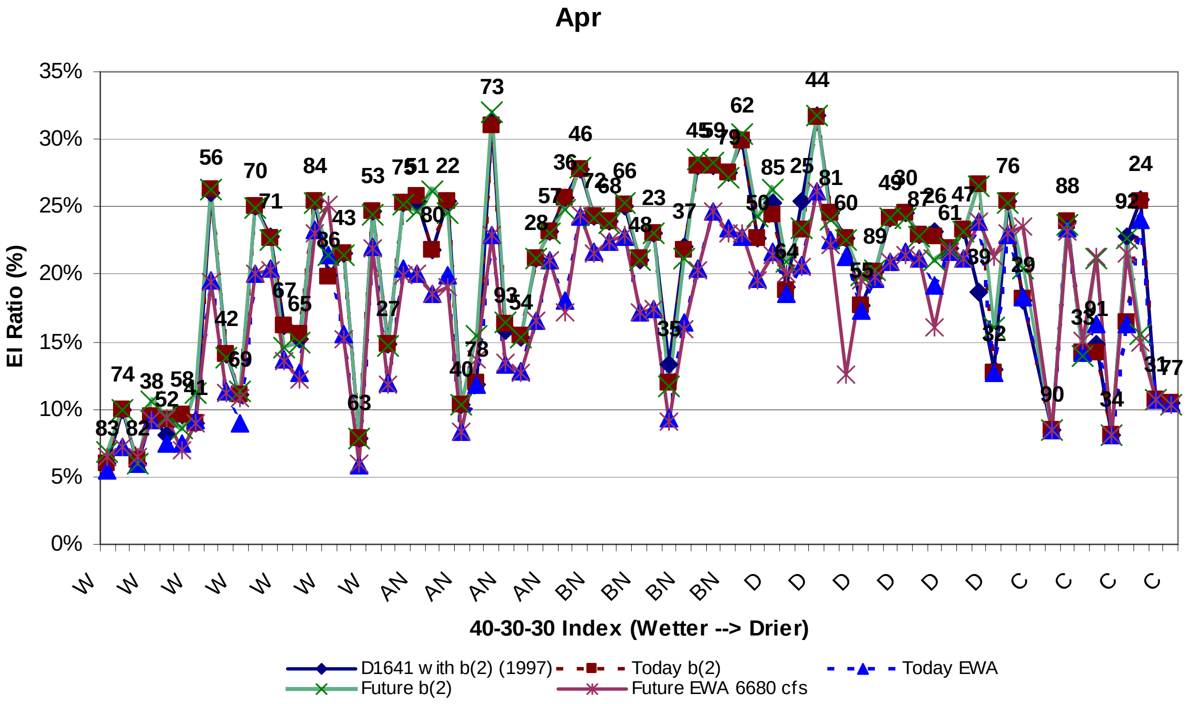


Figure 10–39 April export-to-inflow ratio sorted by 40-30-30 Index

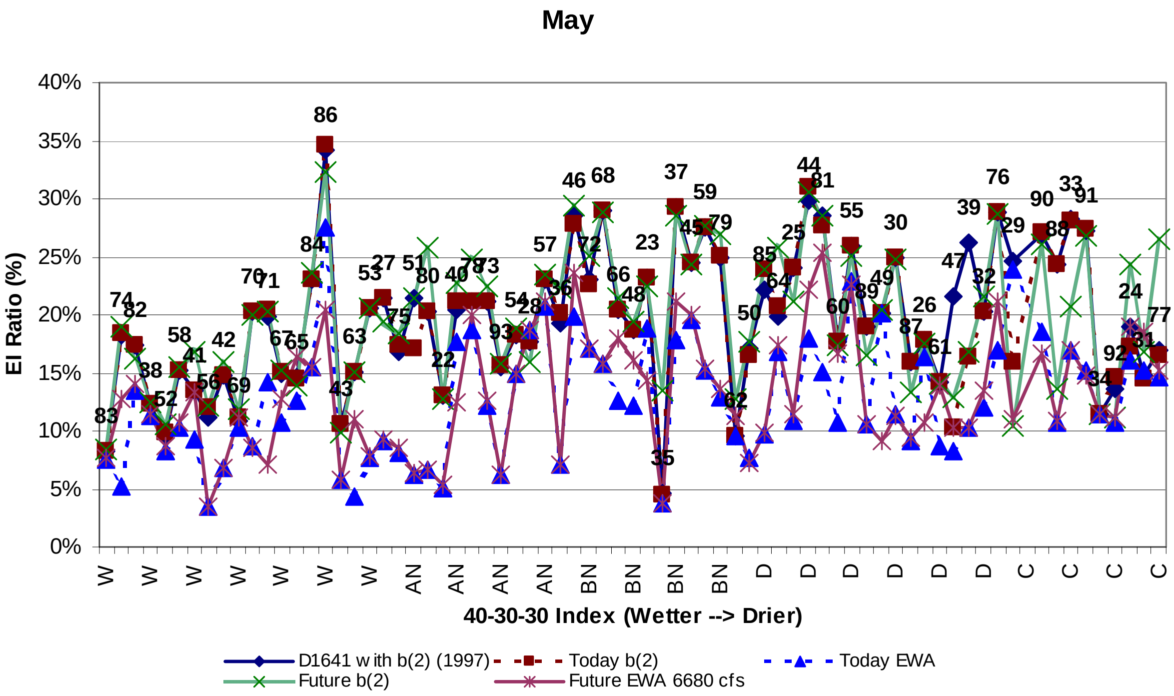


Figure 10–40 May export-to-inflow ratio sorted by 40-30-30 Index

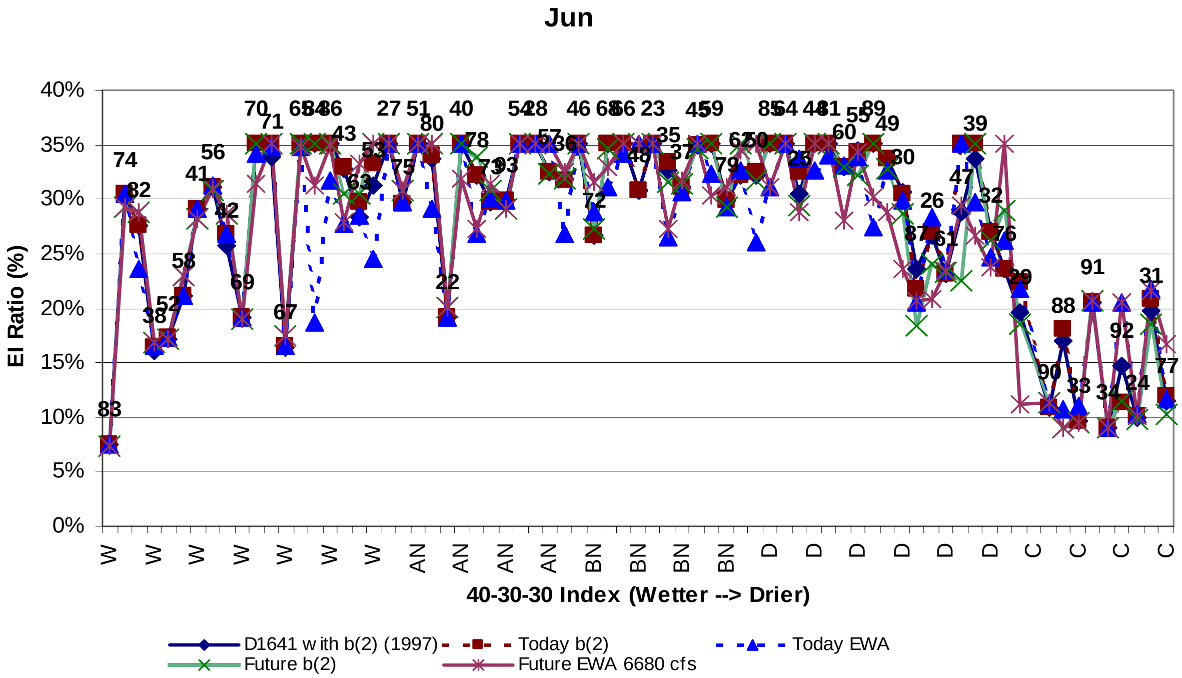


Figure 10–41 June export-to-inflow ratio sorted by 40-30-30 Index

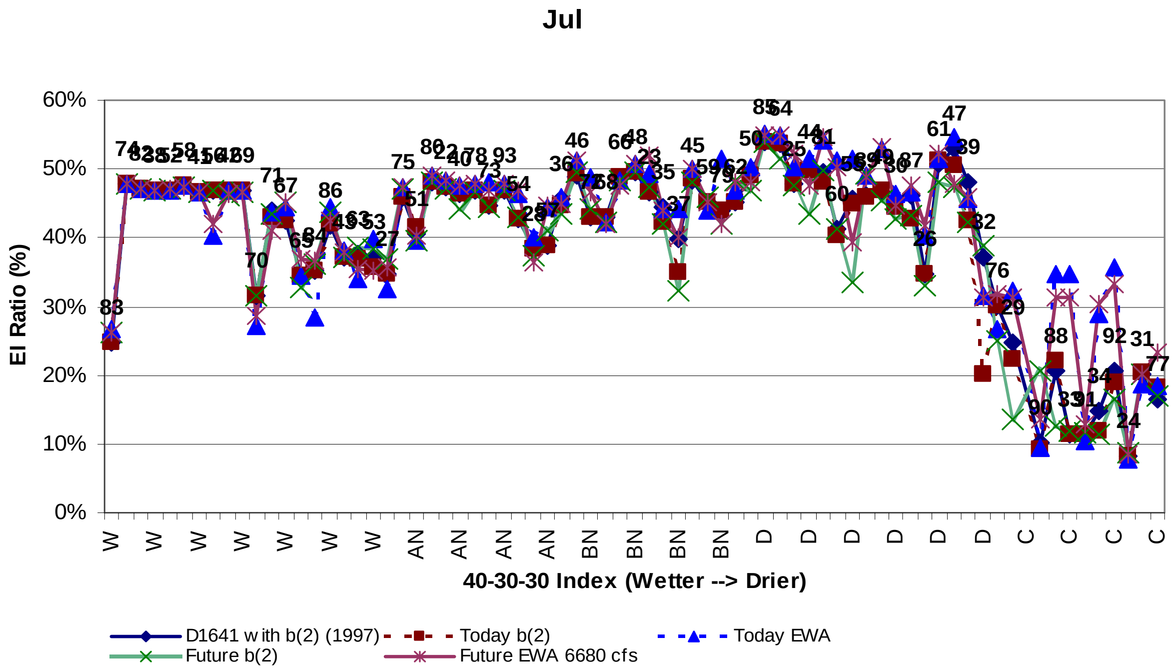


Figure 10–42 July export-to-inflow ratio sorted by 40-30-30 Index

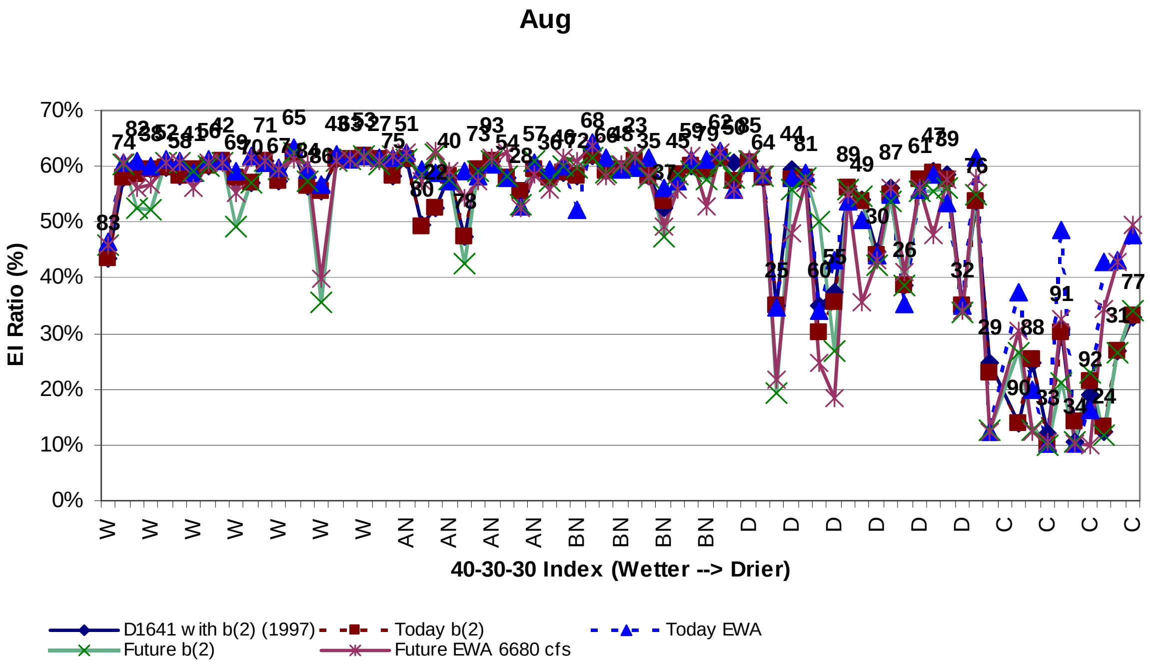


Figure 10–43 August export-to-inflow ratio sorted by 40-30-30 Index

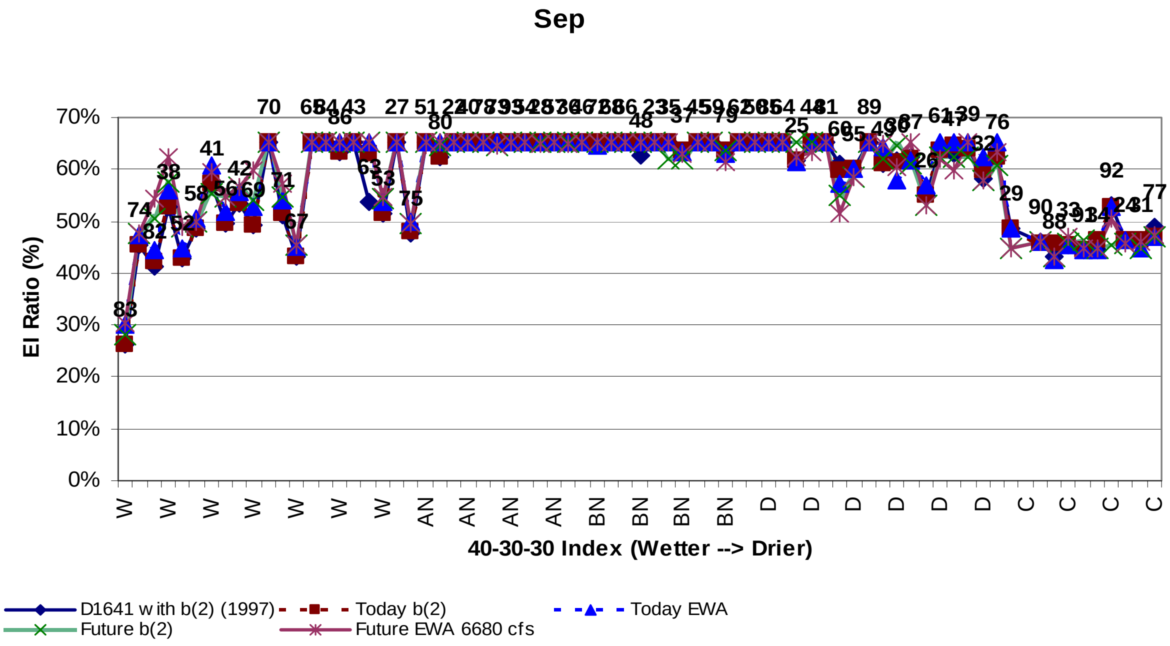


Figure 10–44 September export-to-inflow ratio sorted by 40-30-30 Index

Export-Inflow ratio results

Exceedance plots of the E/I ratio reveal that in both cases #4a and #5,an 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 #4a or #5a to create Delta smelt protective concerns.

North Bay Aqueduct

Analysis of the effects of the NBA is based on monitoring required under the March 6, 1995 Operating Criteria and Plan (OCAP) Biological Opinion (BO). Specifically, the 1995 BO required the California Department of Water Resources (DWR) to monitor larval Delta smelt in Barker Slough, from which the NBA diverts its water. Since then, monitoring has been required every other day at three sites from mid-February through mid-July, when Delta smelt may be present. As part of the Interagency Ecological Program, DWR has contracted with the DFG to conduct the required monitoring each year since the BO was issued.

Data from the past 9 years of monitoring show that catch of Delta smelt in Barker Slough has been consistently very low, an average of just 5 percent of the values for nearby north Delta stations (Cache, Miner, and Lindsey sloughs) (Figure 10–45). In other words, sampling over the past decade indicates that a relatively small portion of the Delta smelt population in this region is typically susceptible to NBA diversions. Moreover, recent research by the Interagency Ecological Program indicates that well-designed positive barrier fish screens (such as those used by NBA) effectively limit smelt entrainment. These results are consistent with Nobriga et. al. (2004), who found that a small diversion with a positive barrier screen resulted in no entrainment of Delta smelt despite the fact that the diversion was located in a channel with a high concentration of smelt. These results suggest that many of the Delta smelt detected near the NBA would not have been very susceptible to entrainment.

In summary, NBA diversions do not appear to have had a substantial effect on Delta smelt. The proposed operations are fairly similar, indicating that the effect of NBA on smelt will continue to be relatively low.

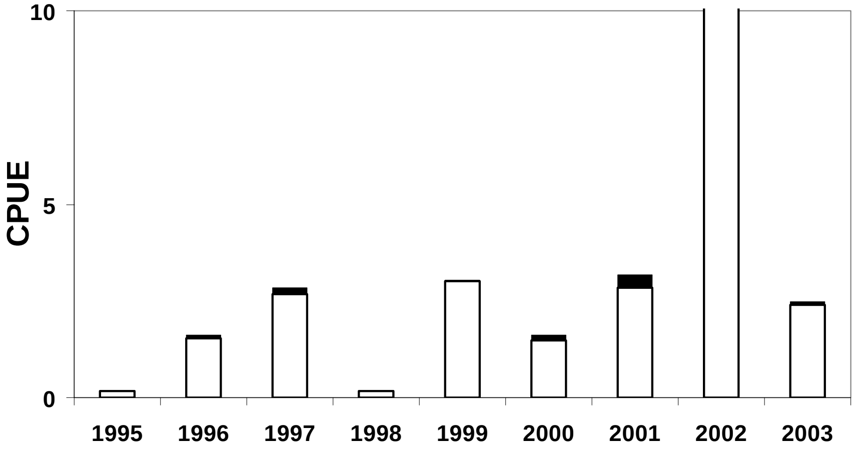


Figure 10–45 Comparison of Delta smelt catch-per-unit-effort (fish/trawl) for NBA monitoring sites in Barker Slough (dark bars) to nearby north Delta sites: Lindsey, Cache, and Miner sloughs (white bars). The NBA values are the mean annual CPUE for stations 720, 721, and 727. The nearby North Delta sites represent the mean annual CPUE for stations 718, 722, 723, 724, and 726

SWP Demand Assumptions

Since its conception, the SWP's water supply has been highly dependent on unregulated flow into the Delta. The delivery of water within the SWP in any given year is a function of operational requirements, Project storage conditions, demands (and the pattern of those demands), and the availability of unregulated flow into the Delta. To the extent that unregulated water has been available in the Delta beyond that necessary to meet scheduled Project purposes and obligations, said water has been made available to any contractor who can make use of it. The original water supply contracts for SWP contractors included various labels for this Project water depending on the intended use—including the prominently used label of "interruptible."

In 1994, the contracts were amended in what is commonly referred to as the Monterey Amendment. The basic objective of the amendment was to improve the management of SWP supplies—it did not affect the Project operations in the Delta or on the Feather River. Article 21 of the amendment stipulates that any SWP contractor is entitled to water available to the SWP when excess water to the Delta exceeds the Project's need to fulfill scheduled deliveries, meet operational requirements, or meet storage goals for the current or following years. This includes the water that was before known as "interruptible," as well as some other lesser-known labels of water diverted under the same conditions. Article 21 water is and has always been an important source of water for various contractors during the wet winter months and is used to fill groundwater storage and off-stream reservoirs in the SWP service areas. It is also used to pre-irrigate croplands, thereby preserving groundwater and local surface water supplies for later use during dry periods.

The assumptions in CALSIM II for the demands that drive Banks Pumping vary by month, with some variation across years. The demand for Article 21 water is one component of this total demand. In general, the assumed demand December through March for Article 21 water in CALSIM II is 134 taf per month—the assumed demand December through March Article 21 accounts for 90 percent of the annual total. With this assumed demand, 400 taf or more of Article 21 water is diverted 10 percent of the time. See Figure 10–46 (based on Study 2).

It is likely that if the demand is assumed higher in these months, more may be diverted. To test this sensitivity, DWR staff conducted an auxiliary simulation based on Study 2 with a demand set at 203 taf January through March (in the original Study 2, demand is never fully met in December) and with a demand of 300 taf January through March. With these higher demands, 400 taf or more of Article 21 water is delivered 26 percent of the time. One other result worth noting is that, based on Study 4 (a future conditions study with the same Article 21 demands as Study 2), there is an 8 percent chance of delivering 400 taf or more of Article 21 water between December and March in any given year.

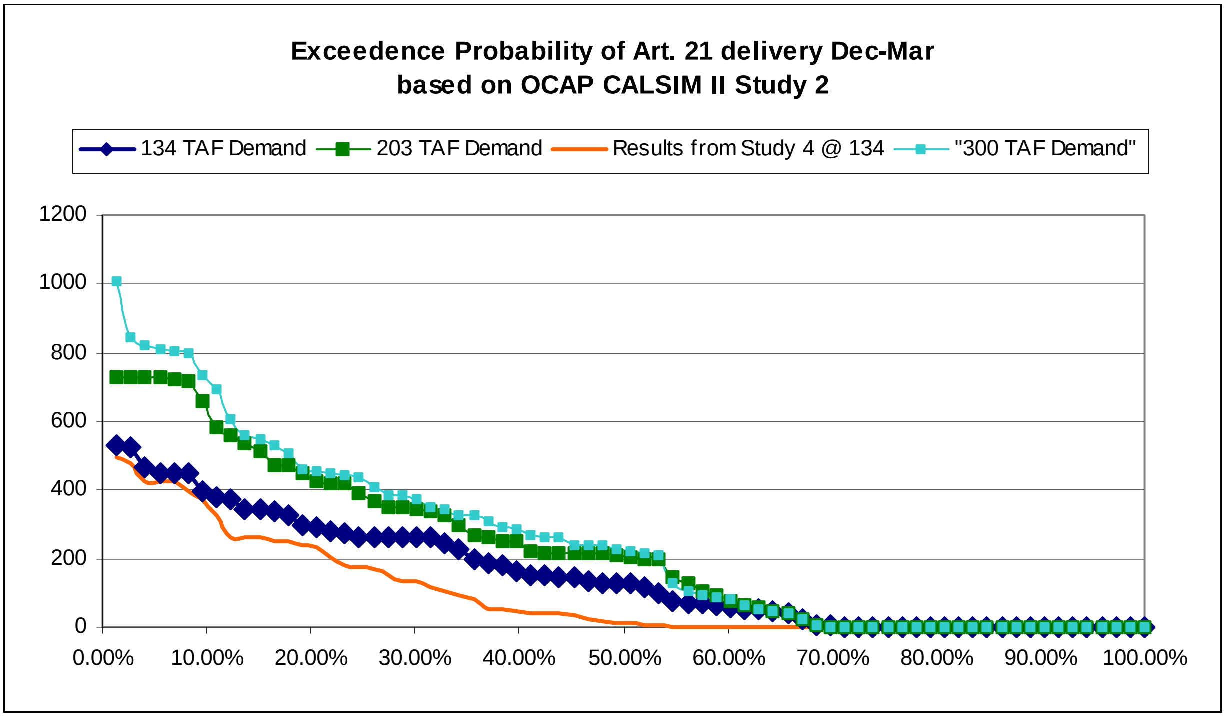


Figure 10–46 Exceedance Probability of Article 21 Delivery Dec-Mar

These differences are appropriately illustrated in the larger context of total SWP diversions from the South Delta in Figure 10–47. For example, there is a 32 percent chance that Banks Pumping will total 1600 taf or more December through March assuming an Article 21 demand of 134 taf/month; the chances increase to 36 percent assuming an Article 21 demand of 203 taf/month and 41 percent assuming an Article 21 demand of 300 taf/month. These differences are best characterized with the probabilistic exceedance plots. Nevertheless, a similar characterization is illustrated in

Figure 10–48, which depicts the total Banks diversions with the different Article 21 demands averaged by water year type. A corollary look at the effects on the position of X2 is presented in Figure 10–49.

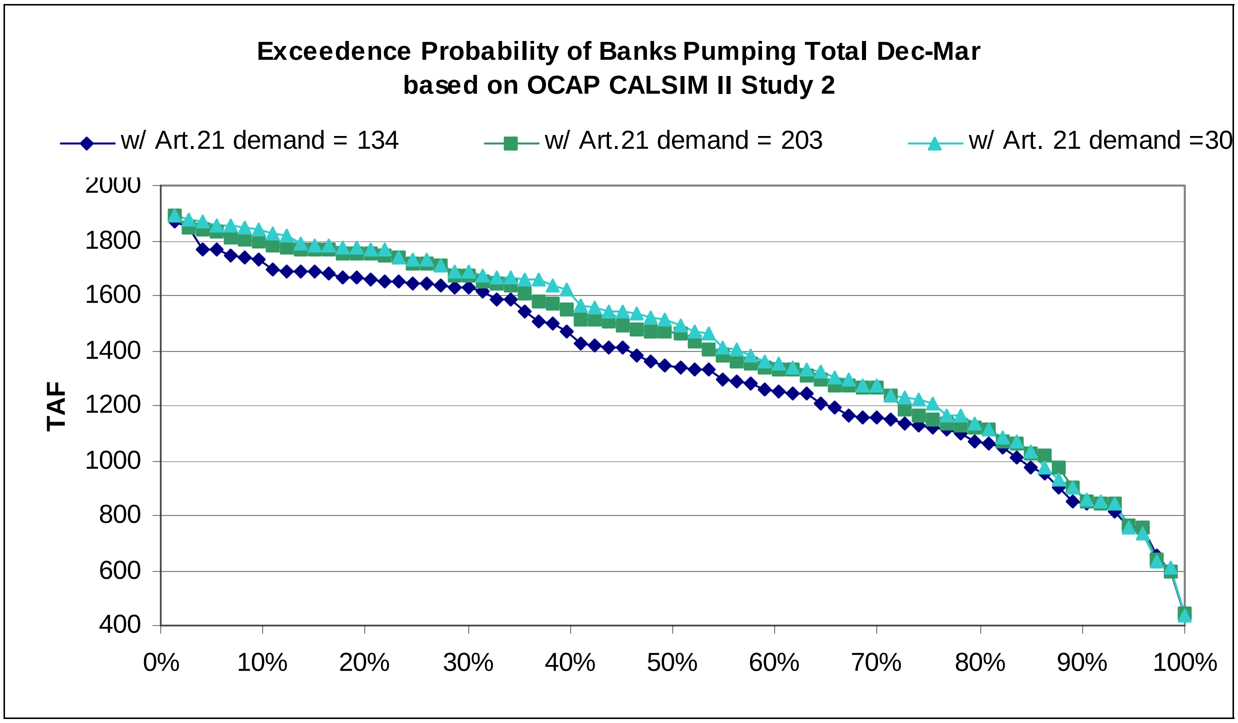


Figure 10–47 Exceedance Probability of Banks Pumping Dec-Mar

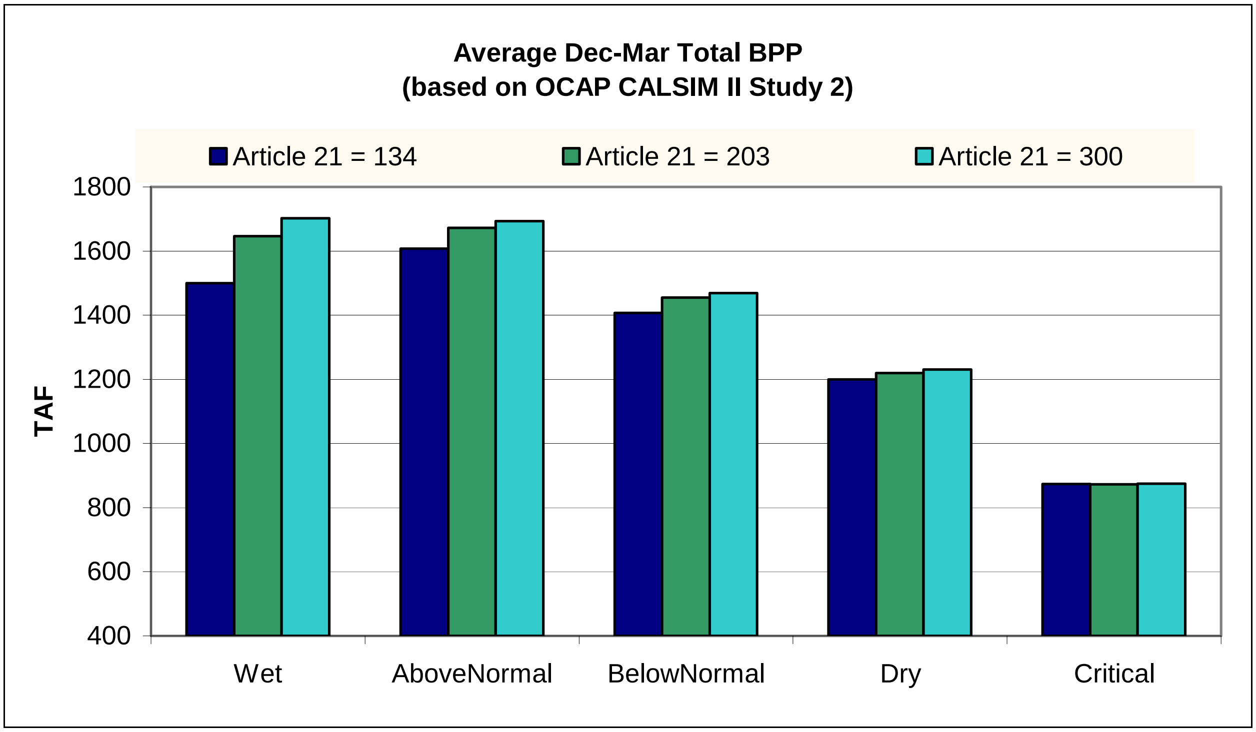


Figure 10–48 Average Banks Pumping Dec-Mar by Water Year Type

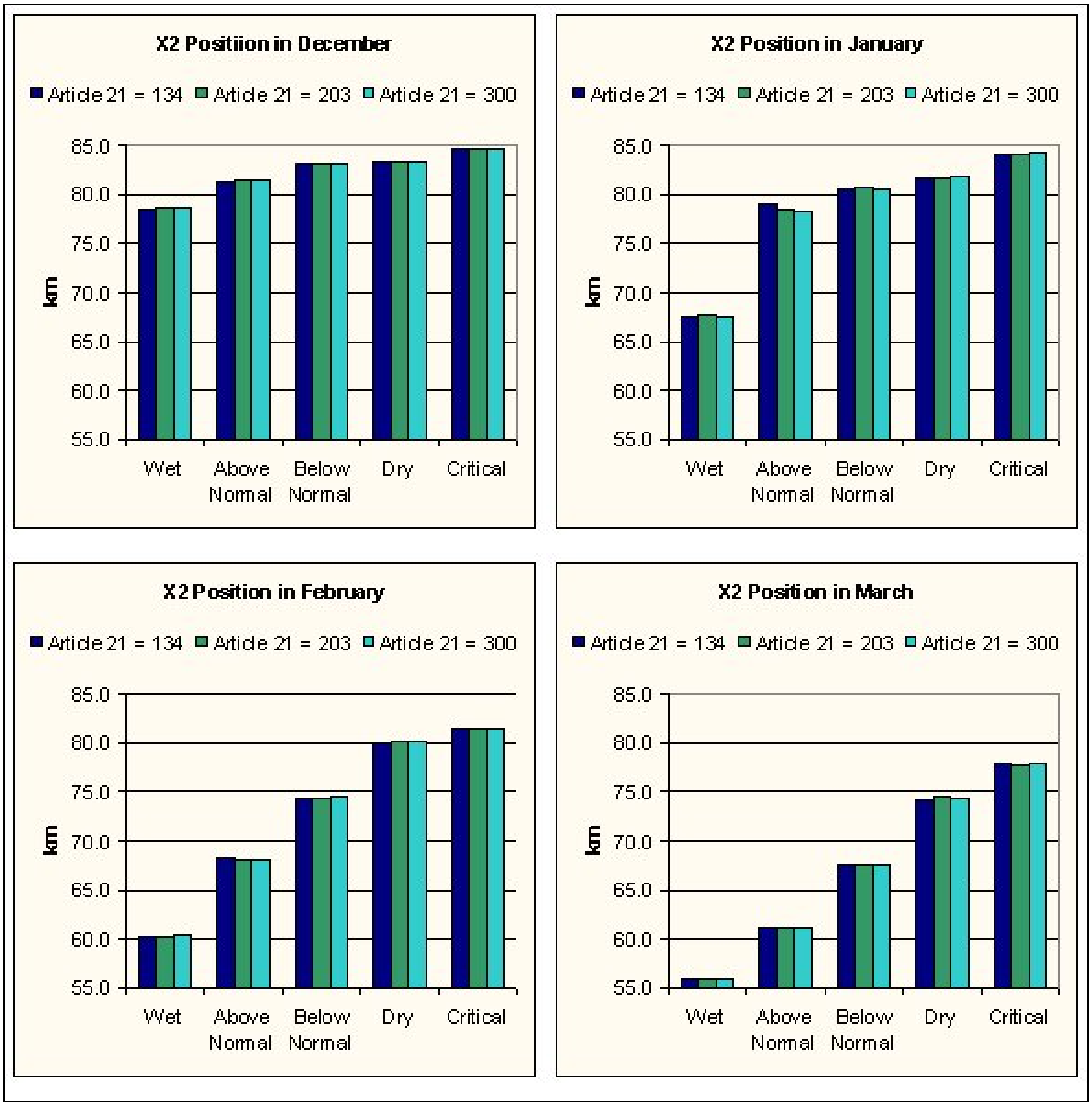


Figure 10–49 Average Position X2 Dec-Mar by Water Year Type

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, Cosumnes 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 5a - Study 1	Study 4a - Study 2	Study 5a - Study 3
Total Delta Inflow Long-term Average	-76	-75	-223	-143	-148
Total Delta Inflow 28-34	-64	-58	-30	48	28

Figure 10–50 shows the chronology of total inflow for all five of the studies. The highest inflows occur January through April due to flood flows, and July when pumping is increased through the late summer with the 50th percentiles being greater than 20,000 cfs (Figure 10–51). 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 10–52 to Figure 10–57), the results show little difference on average, with the exception of months when 3406 (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 cause the minimum flows to be less, and the magnitude of flood flows decreases when comparing Studies 4a and 5a to Studies 1, 2, and 3.

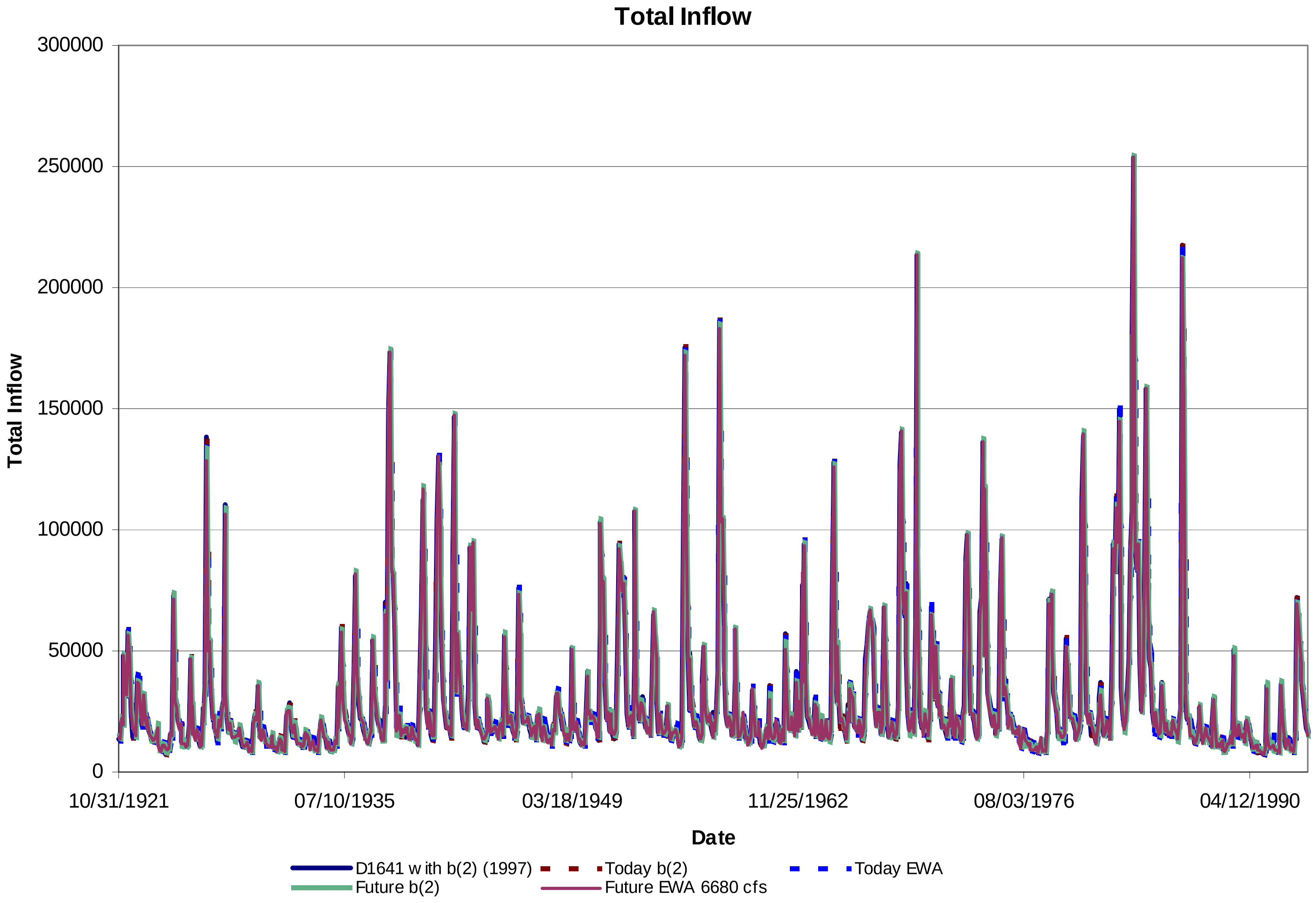


Figure 10–50 Chronology of Total Delta Inflow

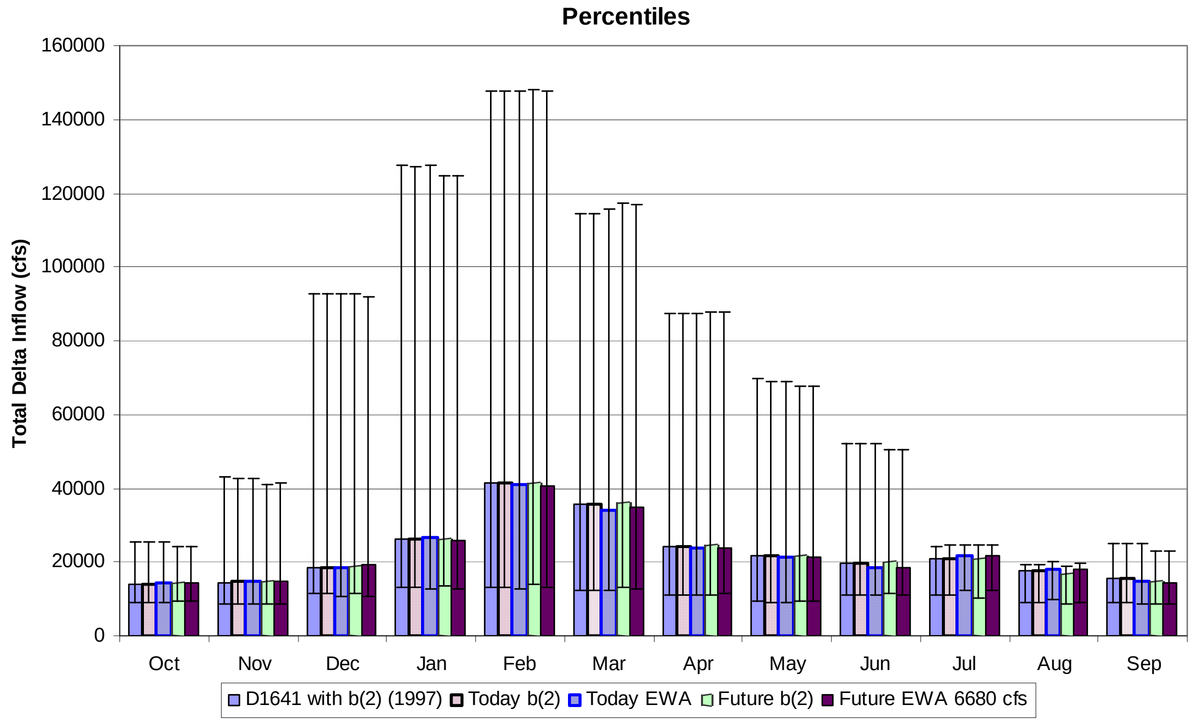


Figure 10–51 Total Delta Inflow 50th Percentile Monthly Releases with the 5th and 95th as the bars

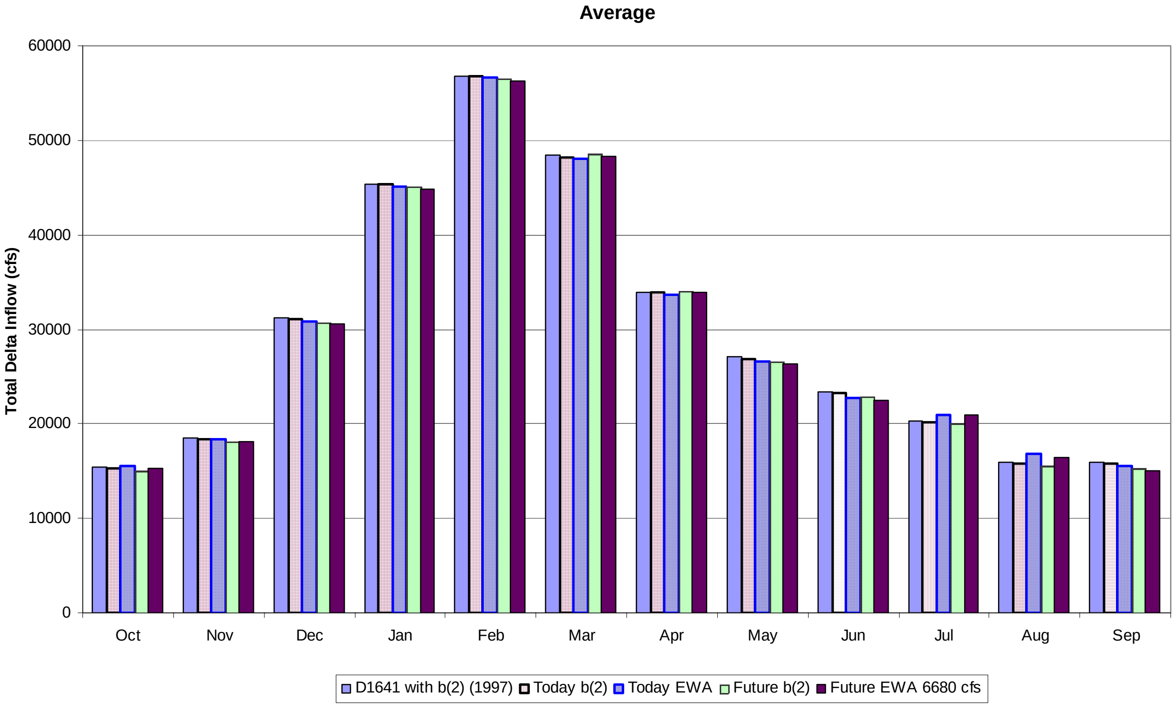


Figure 10–52 Average Monthly Total Delta Inflow

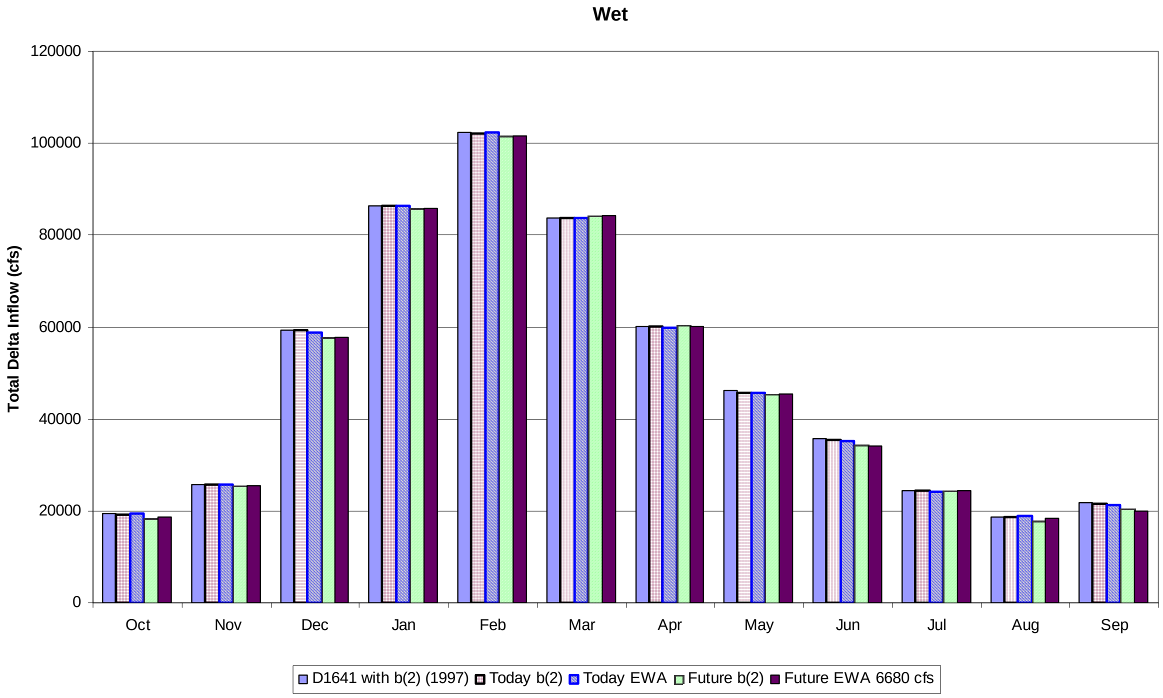


Figure 10–53 Average wet year (40-30-30 Classification) monthly Outflow Delta Inflow

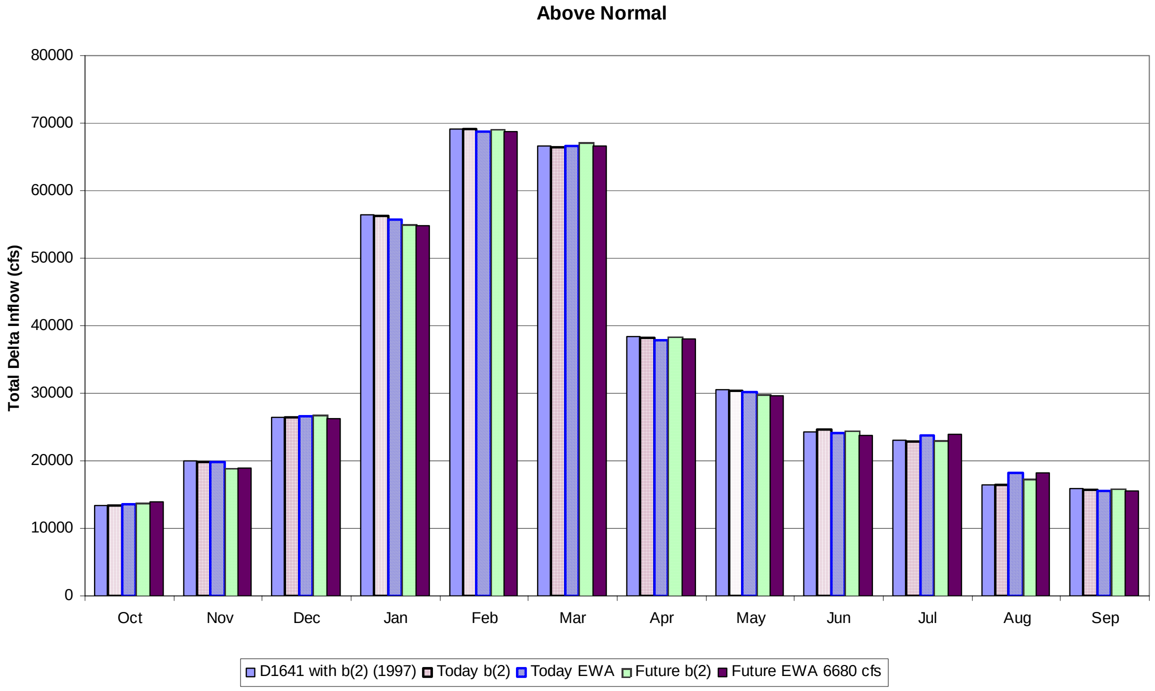


Figure 10–54 Average above normal year (40-30-30 Classification) monthly Outflow Delta Inflow

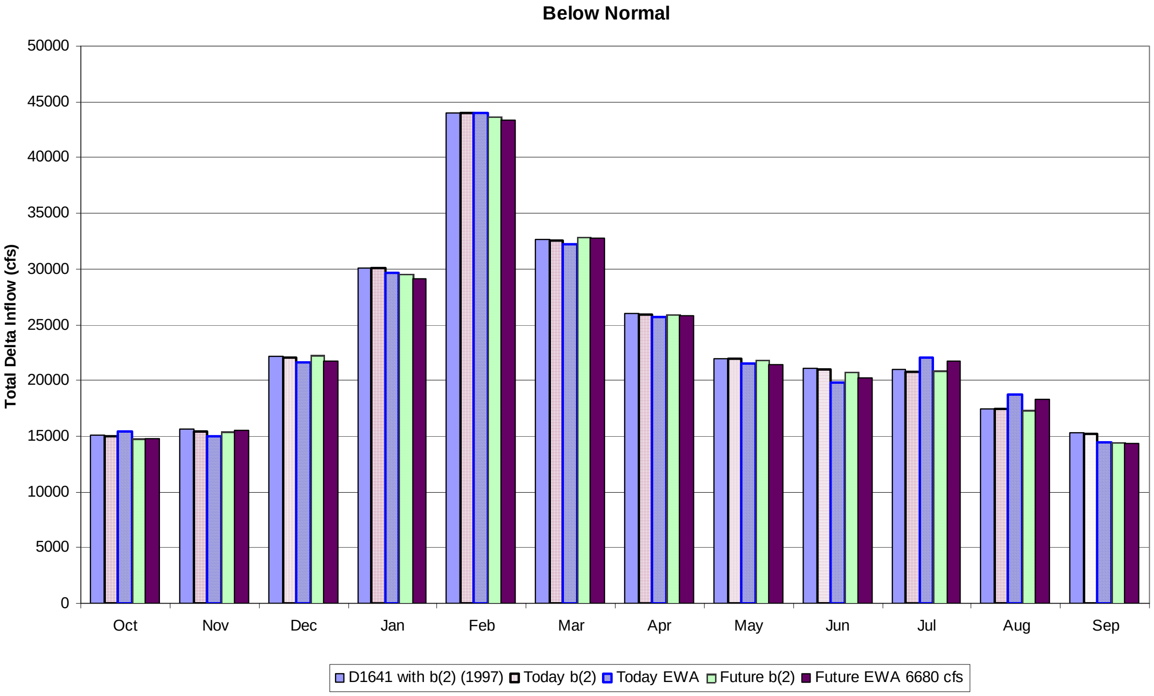


Figure 10–55 Average below normal year (40-30-30 Classification) monthly Outflow Delta Inflow

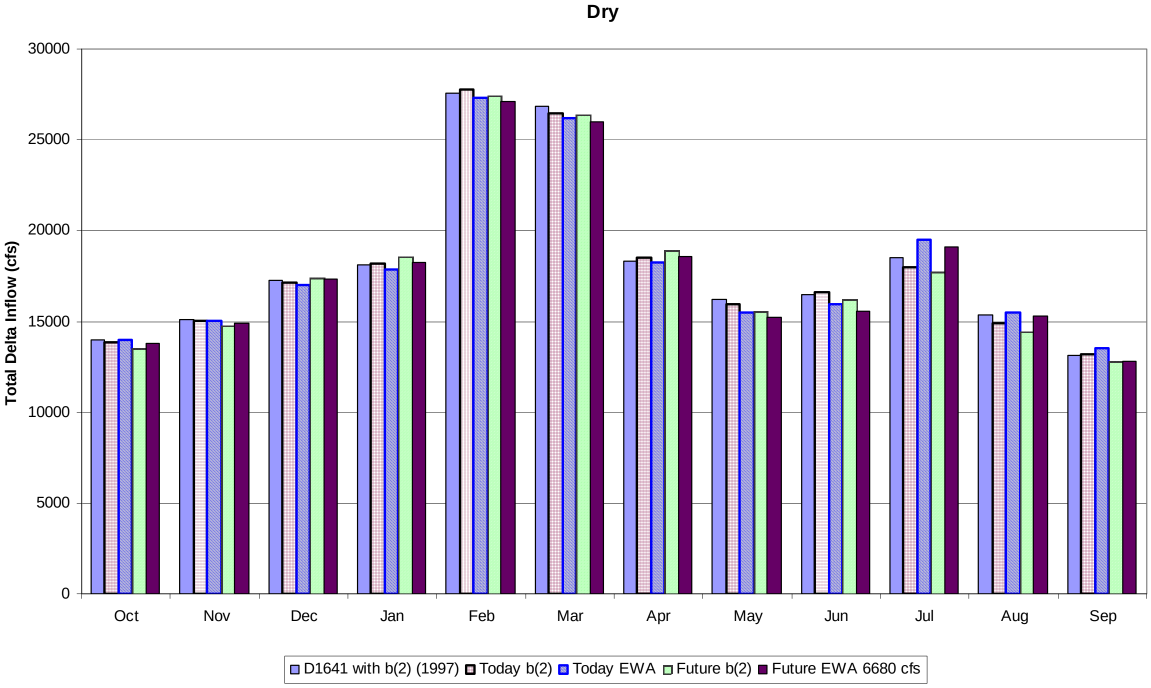


Figure 10–56 Average dry year (40-30-30 Classification) monthly Outflow Delta Inflow

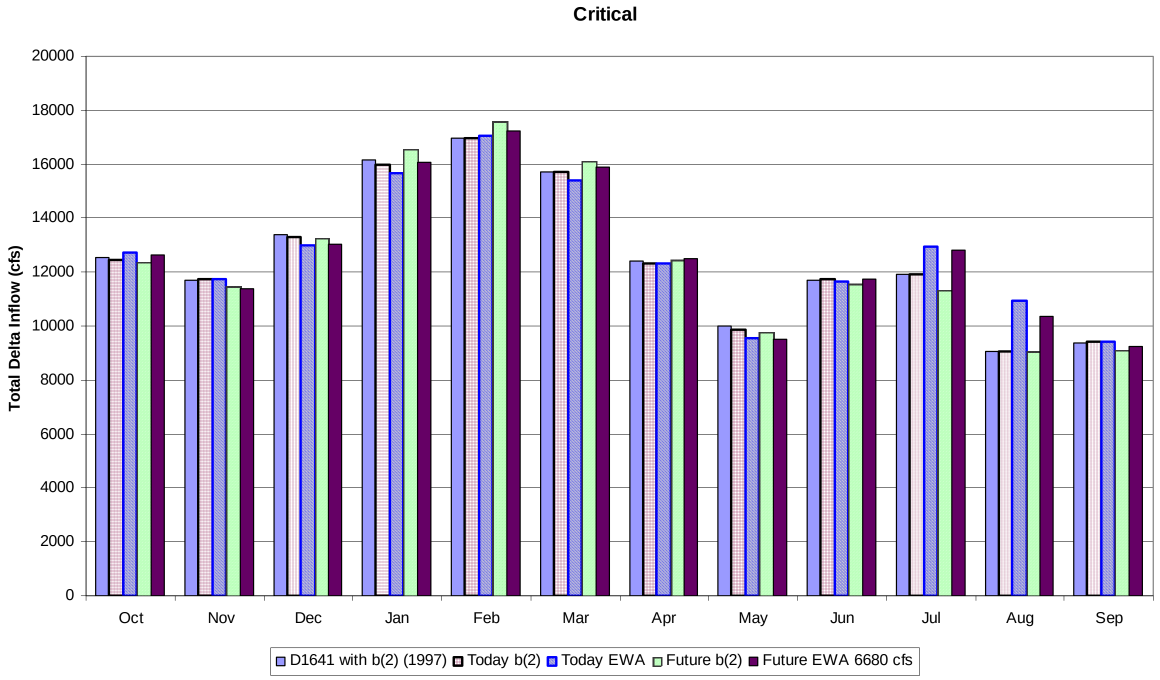


Figure 10–57 Average critical year (40-30-30 Classification) monthly Outflow Delta Inflow

Outflow

The chronology of Delta outflow is shown in Figure 10–58 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 Study 1, the average annual outflow decreases. Comparing Study 5a to 1, there are increases to 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 because delivery reductions are from lower storages relating to increased Trinity flows and demands in the American River system. The excess outflow numbers in this analysis do not reflect the salinity requirements from ANN calculations.

Figure 10–59 displays that the model always meets the required monthly outflow for all five of the studies. Both average and percentile outflow values increase in April and May due to the actions taken under the 3406 (b)(2) and EWA programs (see Figure 10–60 and Figure 10–61 to Figure 10–66. 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 5a - Study 1	Study 4a - Study 2	Study 5a - Study 3
Total Delta Outflow Long-term Average	-76	-75	-223	-143	-148
Total Delta Outflow 28-34	-64	-58	-30	48	28

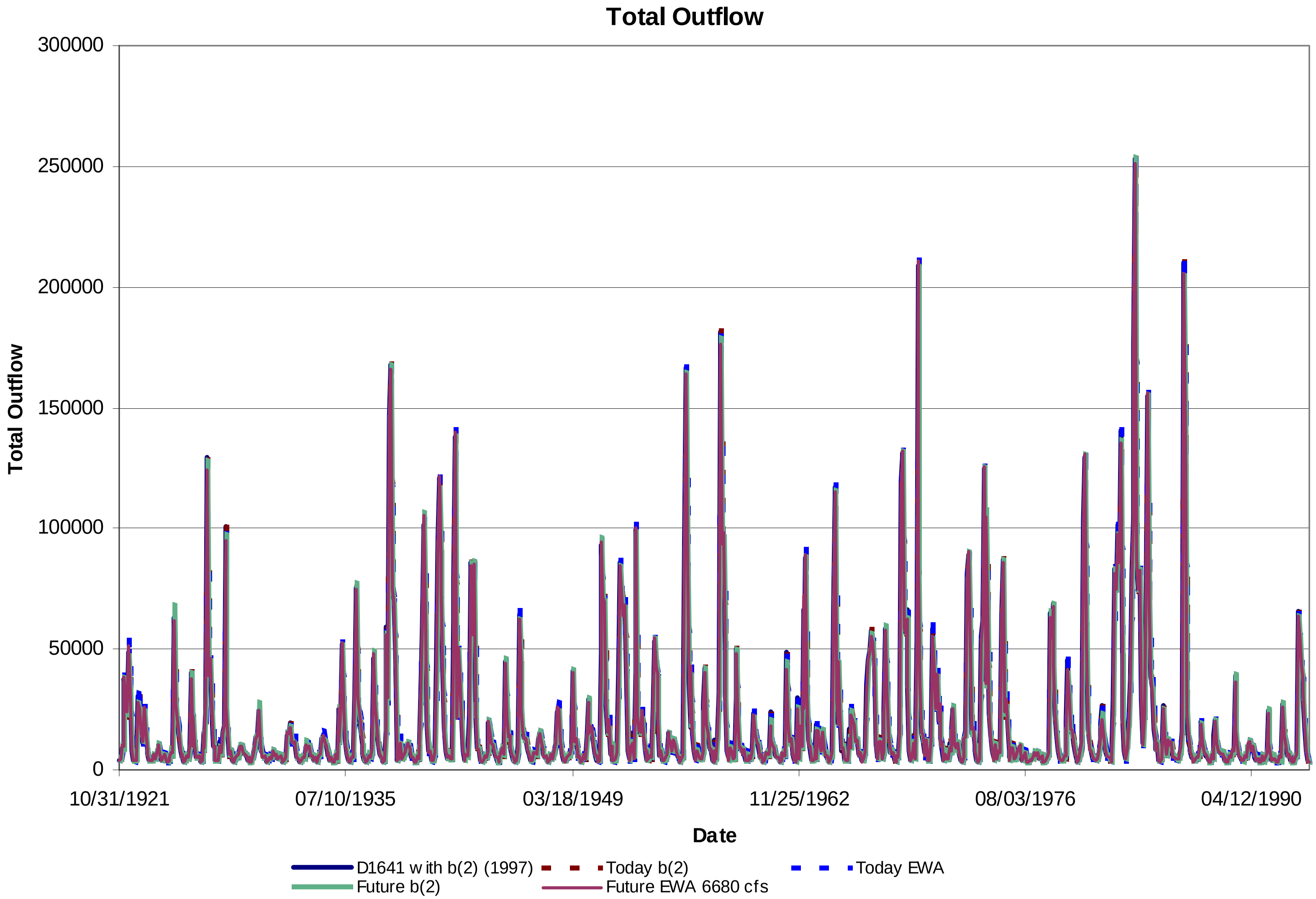


Figure 10–58 Chronology of Total Delta Outflow

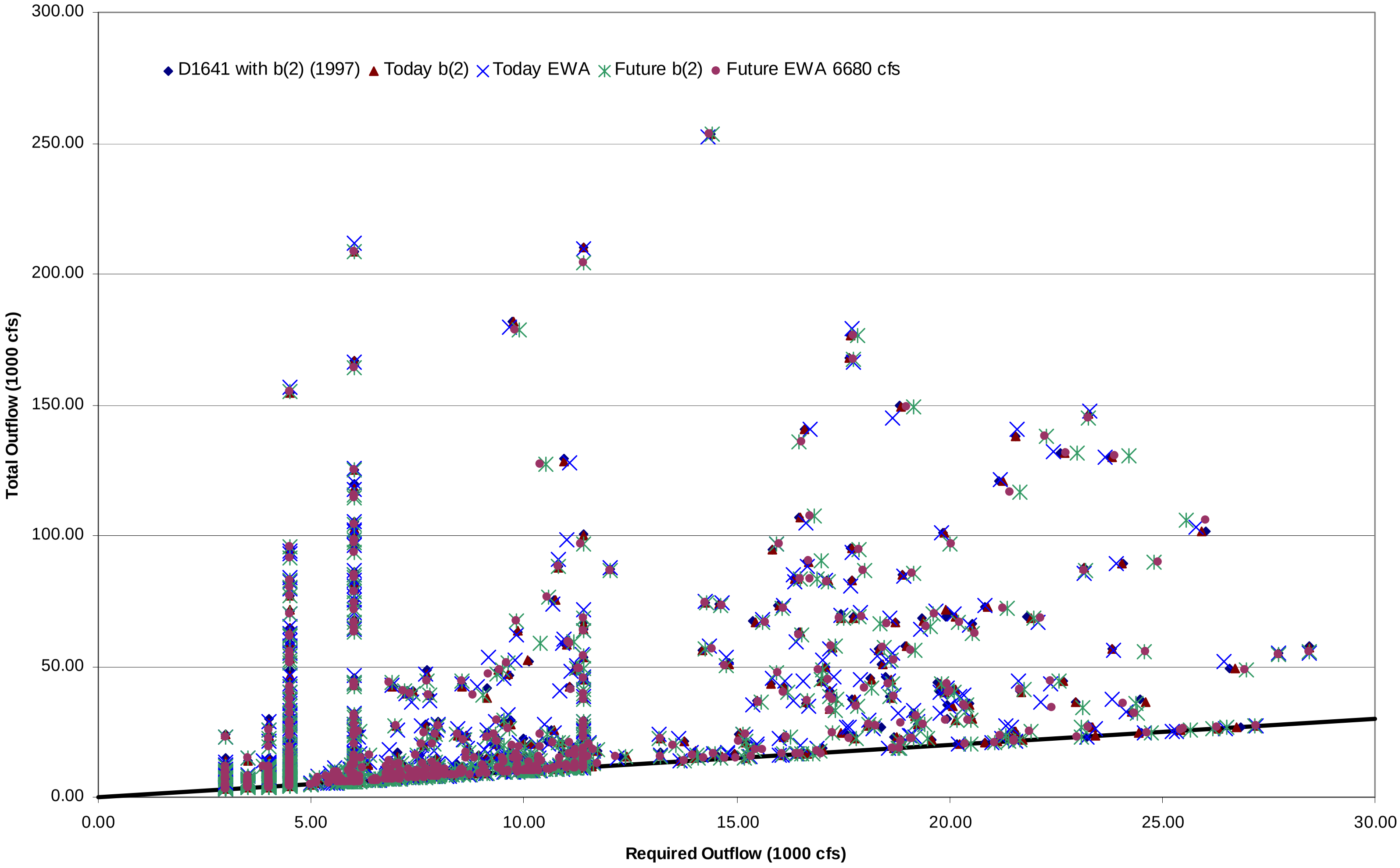


Figure 10–59 Total Delta Outflow versus Required Delta Outflow for the Oct 1921 to Sep 1993 simulation period

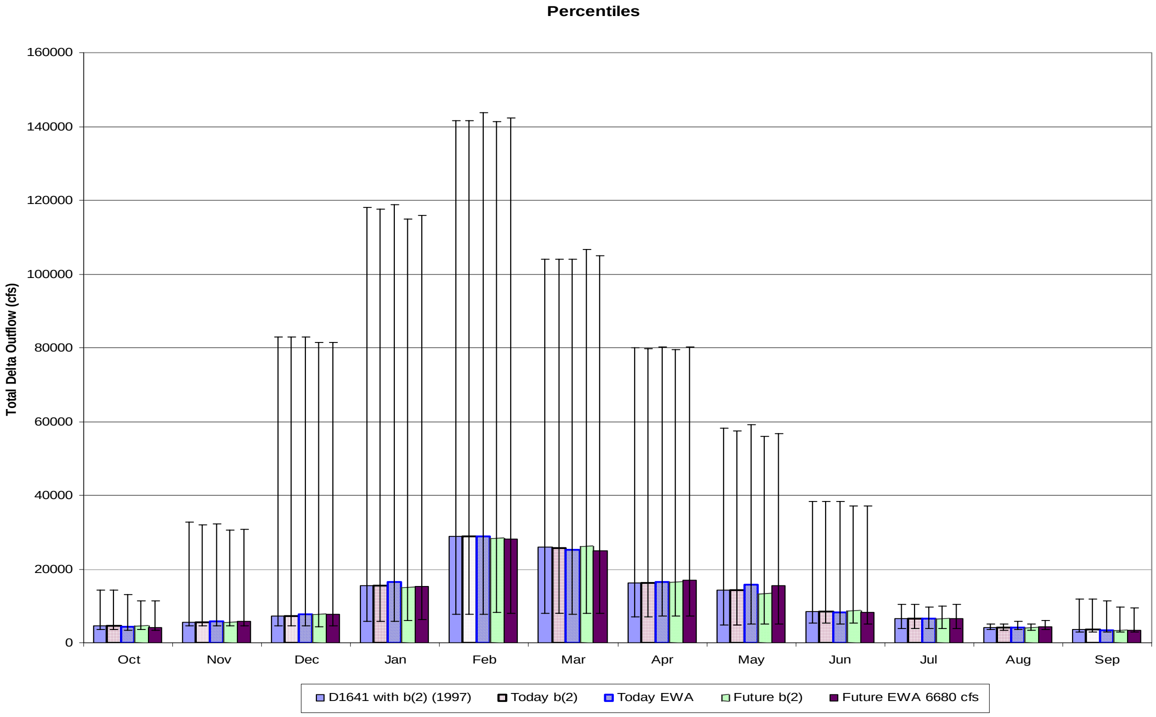


Figure 10–60 Total Delta Outflow 50th Percentile Monthly Releases with the 5th and 95th as the bars

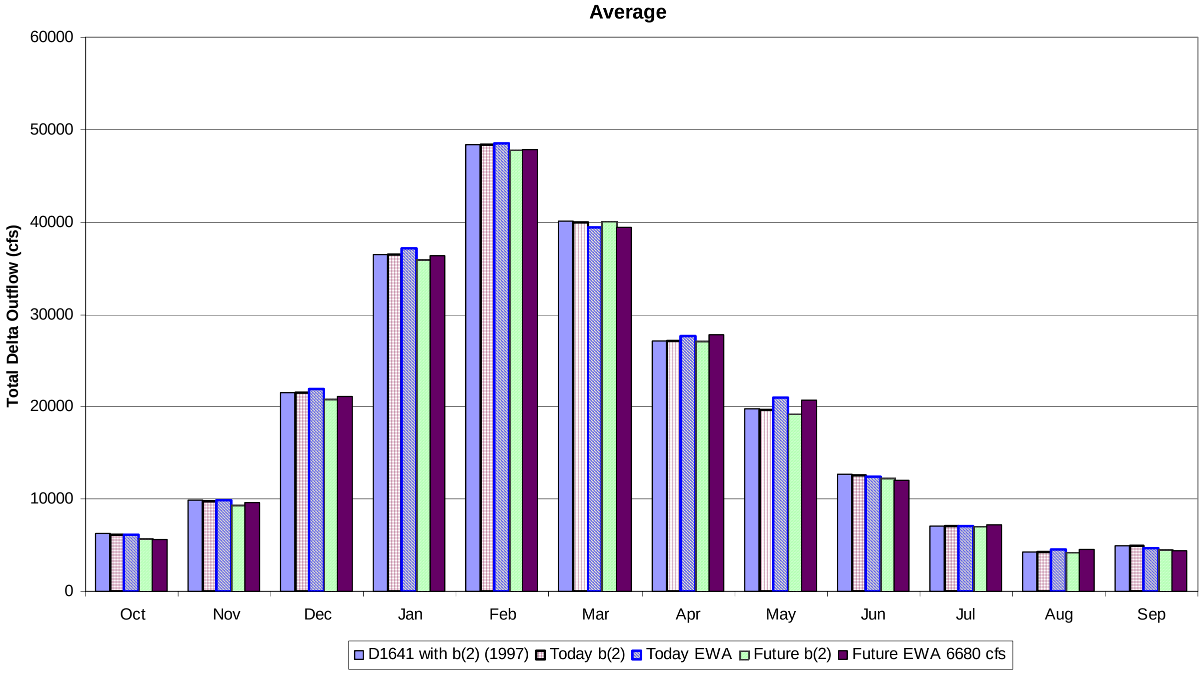


Figure 10–61 Average Monthly Total Delta Outflow

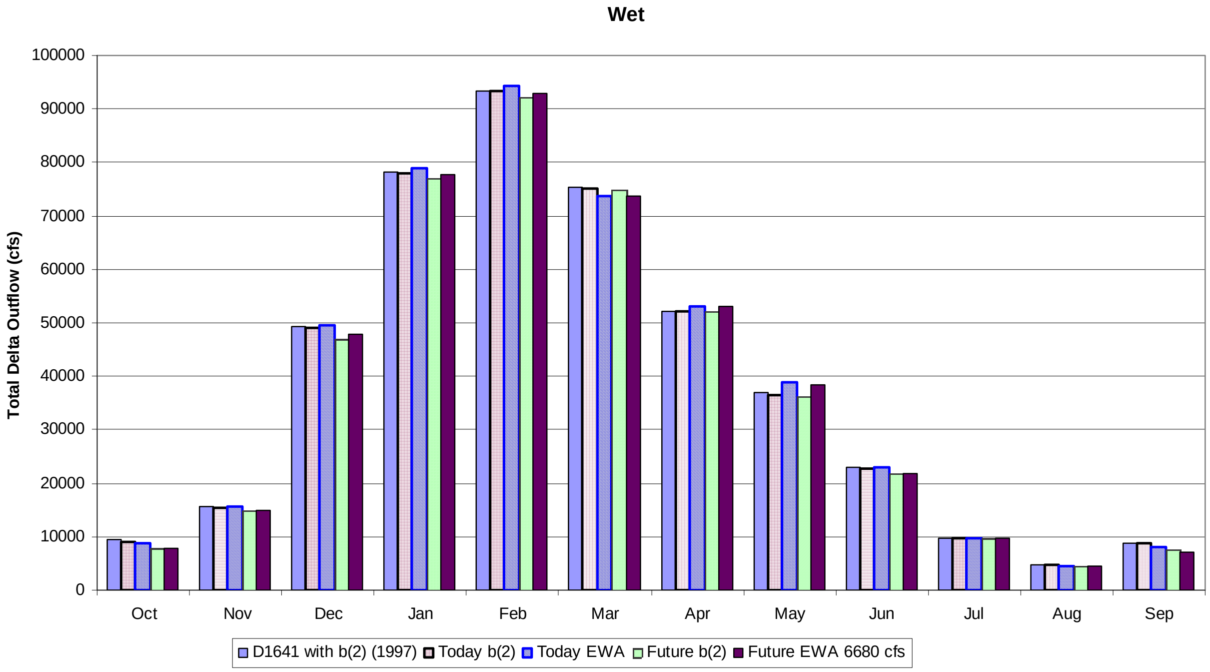


Figure 10–62 Average wet year (40-30-30 Classification) monthly Delta Outflow

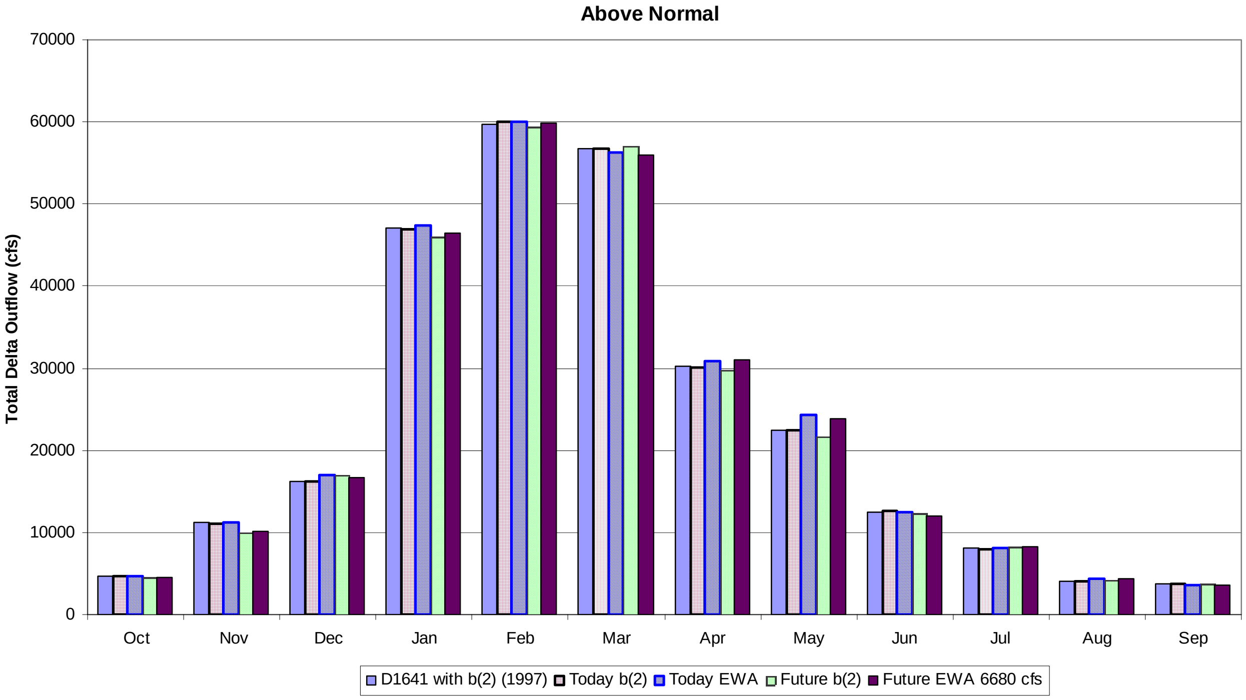


Figure 10–63 Average above normal year (40-30-30 Classification) monthly Delta Outflow

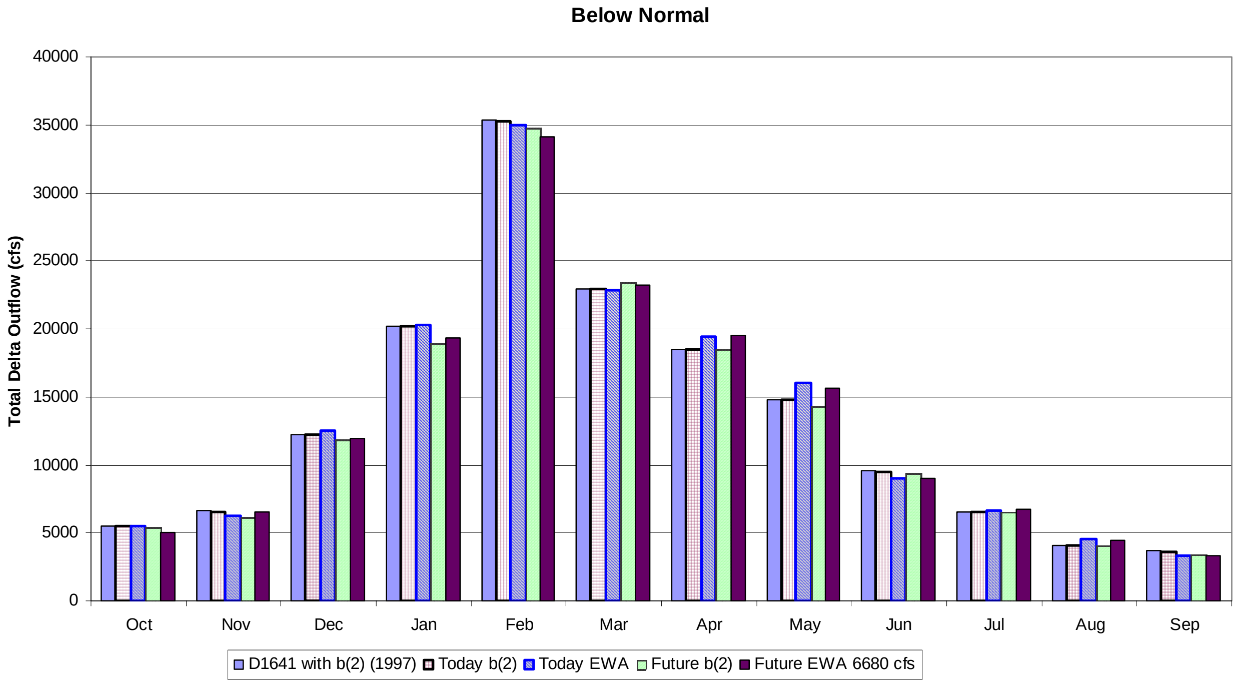


Figure 10–64 Average below normal year (40-30-30 Classification) monthly Delta Outflow

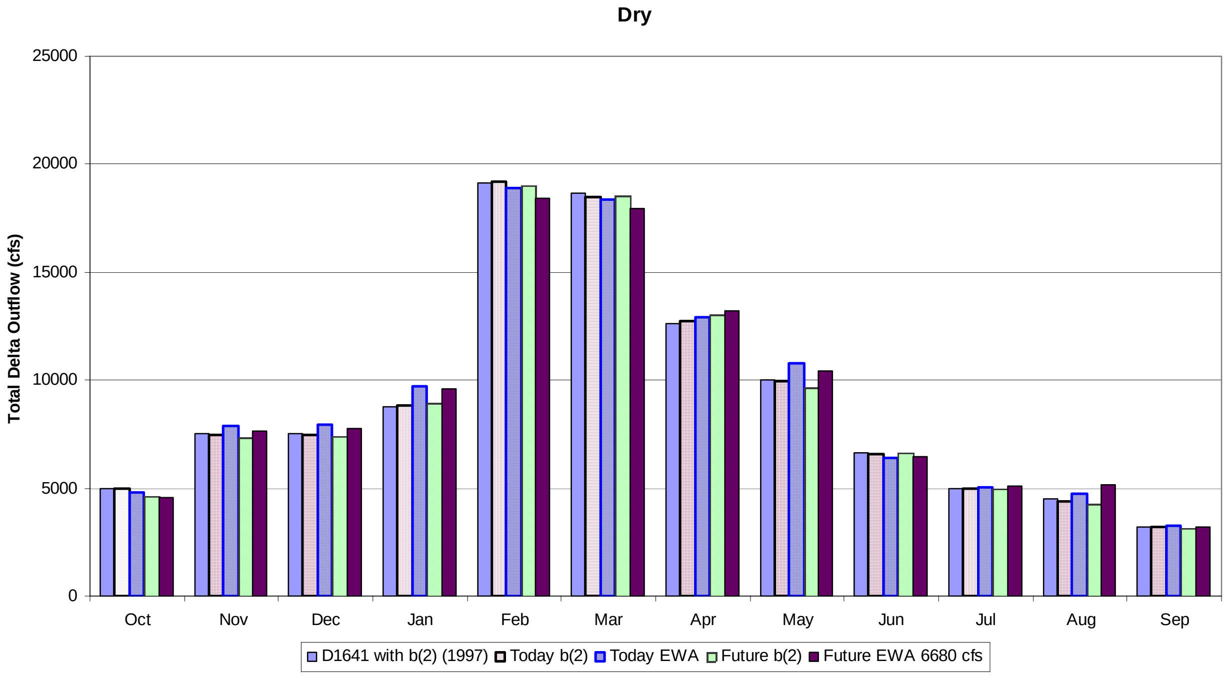


Figure 10–65 Average dry year (40-30-30 Classification) monthly Delta Outflow

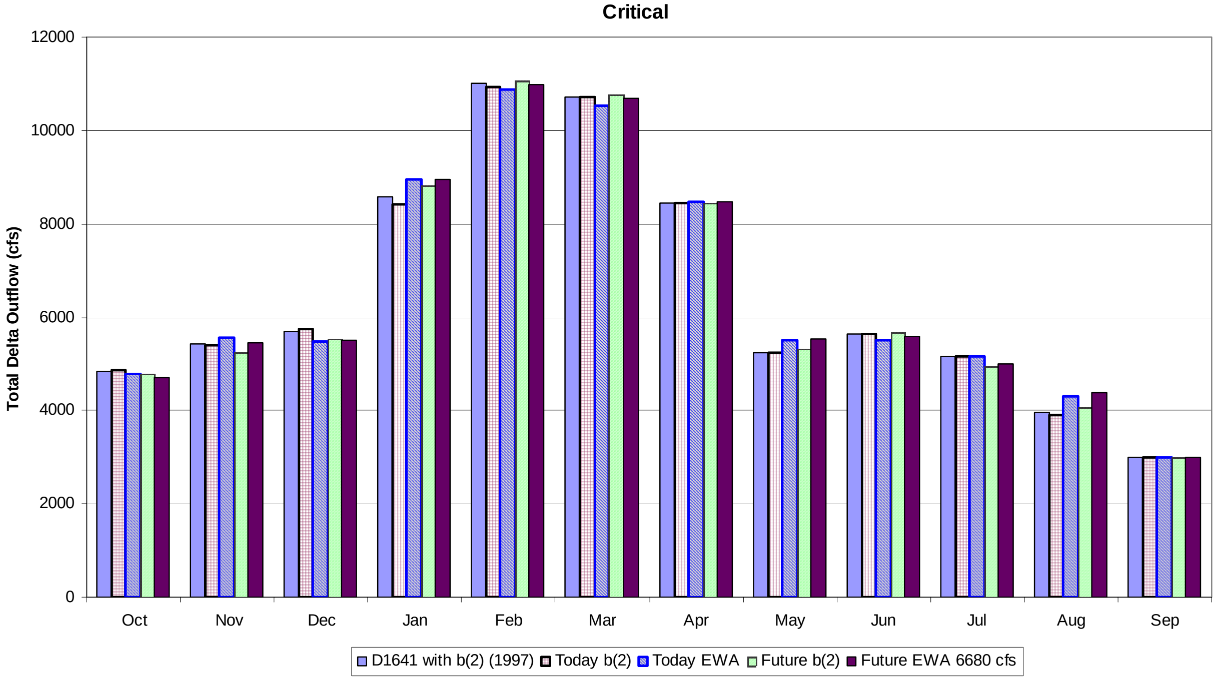


Figure 10–66 Average critical year (40-30-30 Classification) monthly Delta Outflow

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 NBA. Figure 10–67 shows the total annual pumping of Tracy and Banks facilities. Study 3 generally has the least amount of pumping because Tracy and Banks have existing permitted and physical capacities due to the constriction in the Delta Mendota Canal, while EWA imposes restrictions on pumping.

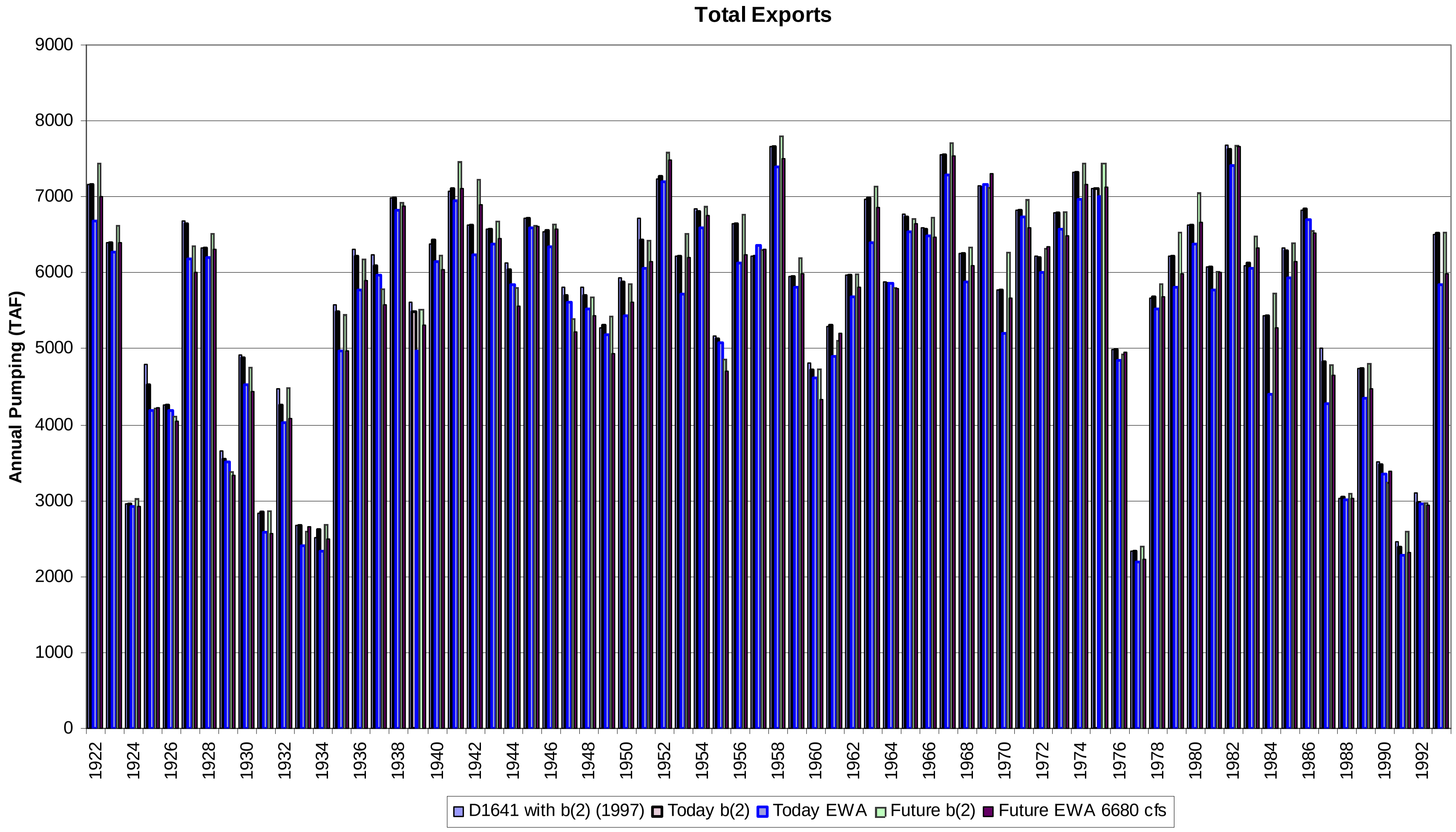


Figure 10–67 Total Annual Tracy + Banks Pumping

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 #4a and #5a 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 4a. Wet years tend to be when Tracy can utilize the 4600 cfs pumping in Study 4a and Study 5a (see Figure 10-69).

From Figure 10–68 December through February the pumping is decreased during this time frame in Studies 3 and 5a 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 Vernalis Adaptive Management Program (VAMP) restrictions and May has further reductions in the EWA studies due to EWA spending some assets to supplement the May Shoulder pumping reduction. July through September see pumping increasing 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 (see 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.

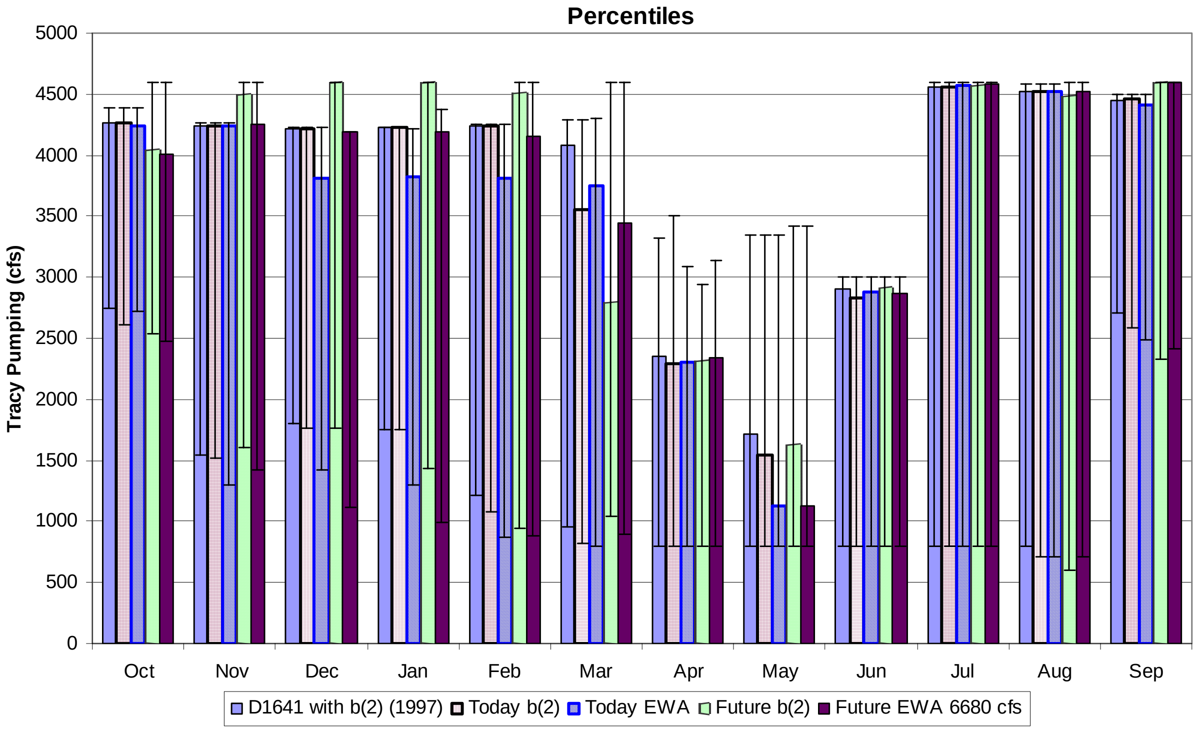


Figure 10–68 Tracy Pumping 50th Percentile Monthly Releases with the 5th and 95th as the bars

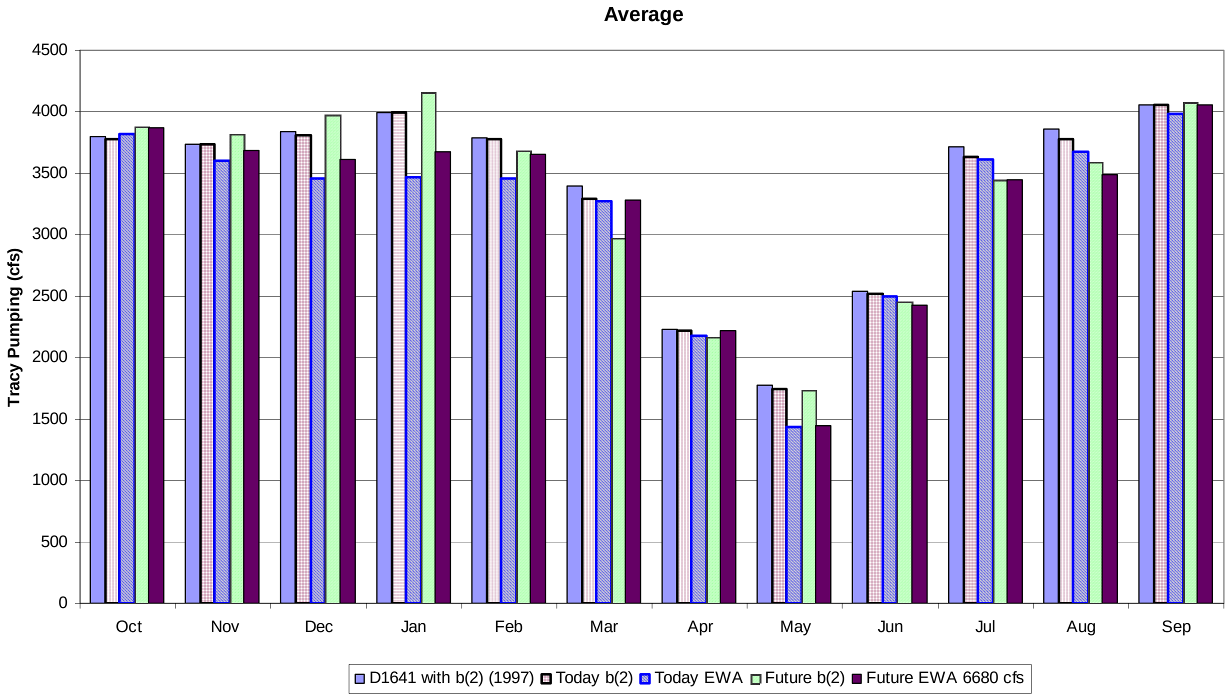


Figure 10–69 Average Monthly Tracy Pumping

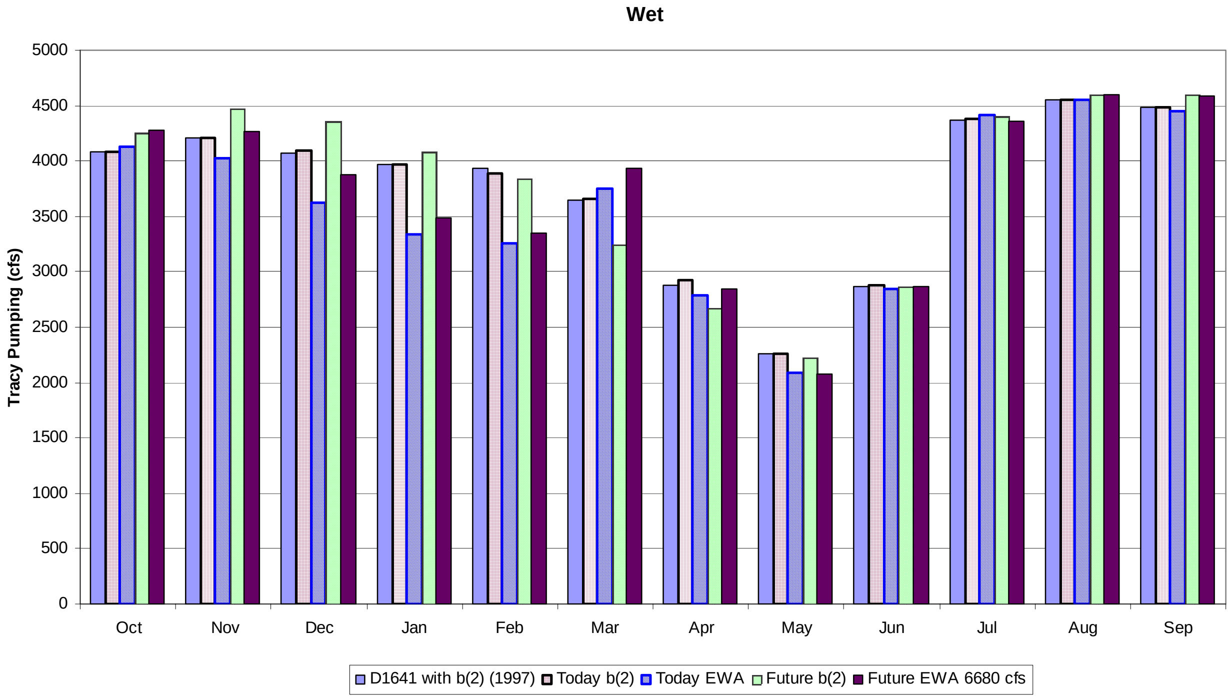


Figure 10–70 Average wet year (40-30-30 Classification) monthly Tracy Pumping

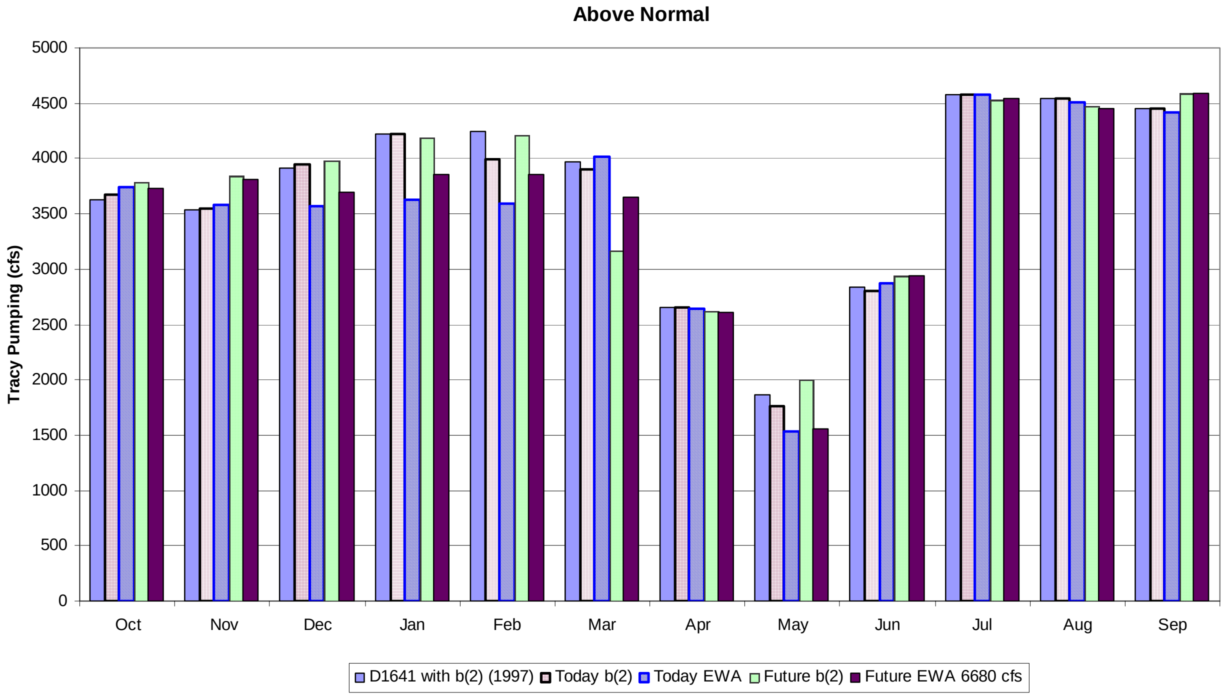


Figure 10–71 Average above normal year (40-30-30 Classification) monthly Tracy Pumping

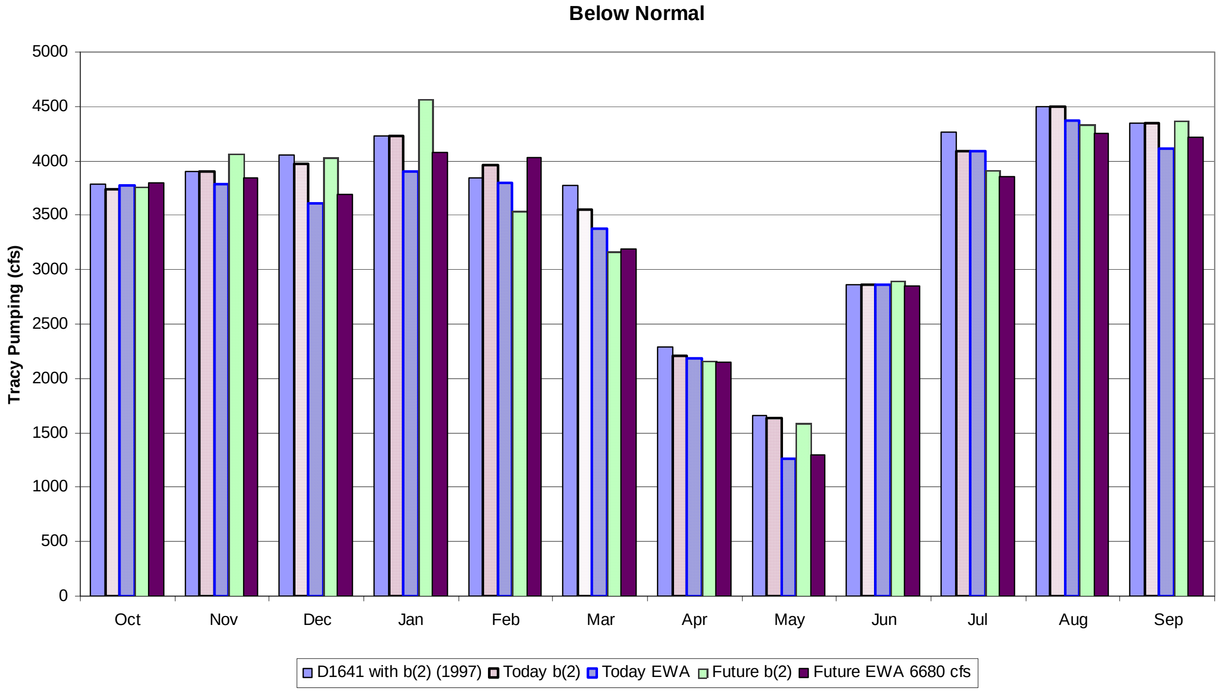


Figure 10–72 Average below normal year (40-30-30 Classification) monthly Tracy Pumping

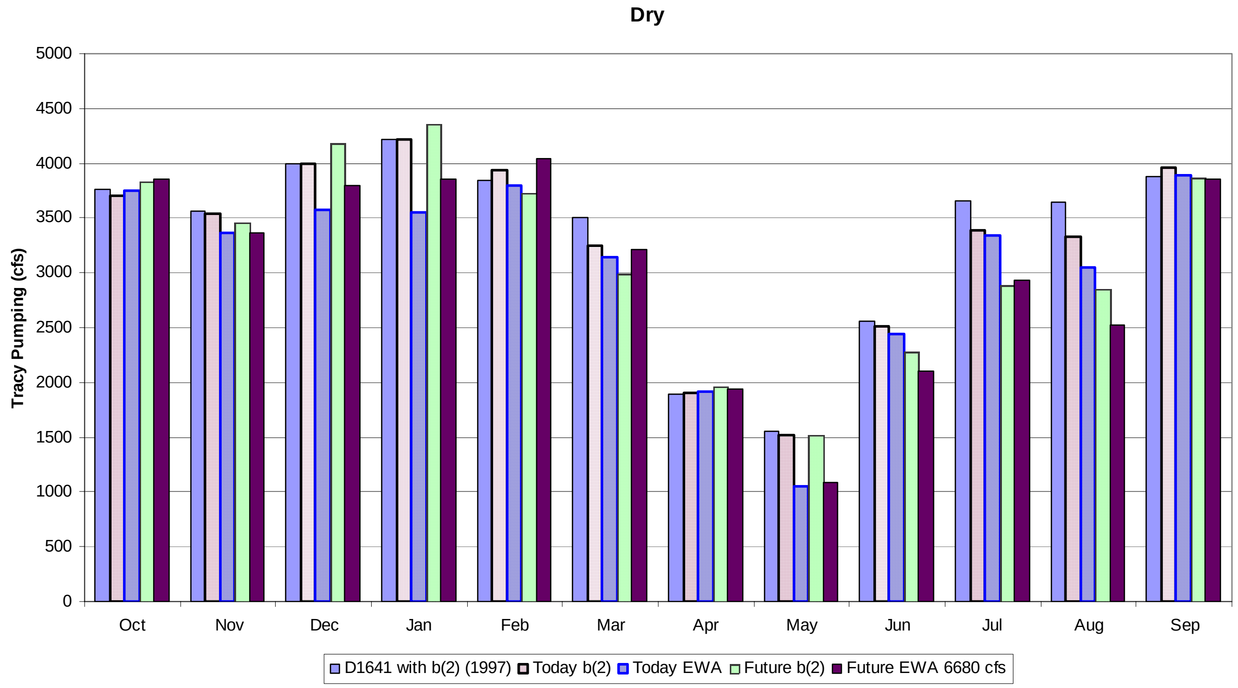


Figure 10–73 Average dry year (40-30-30 Classification) monthly Tracy Pumping

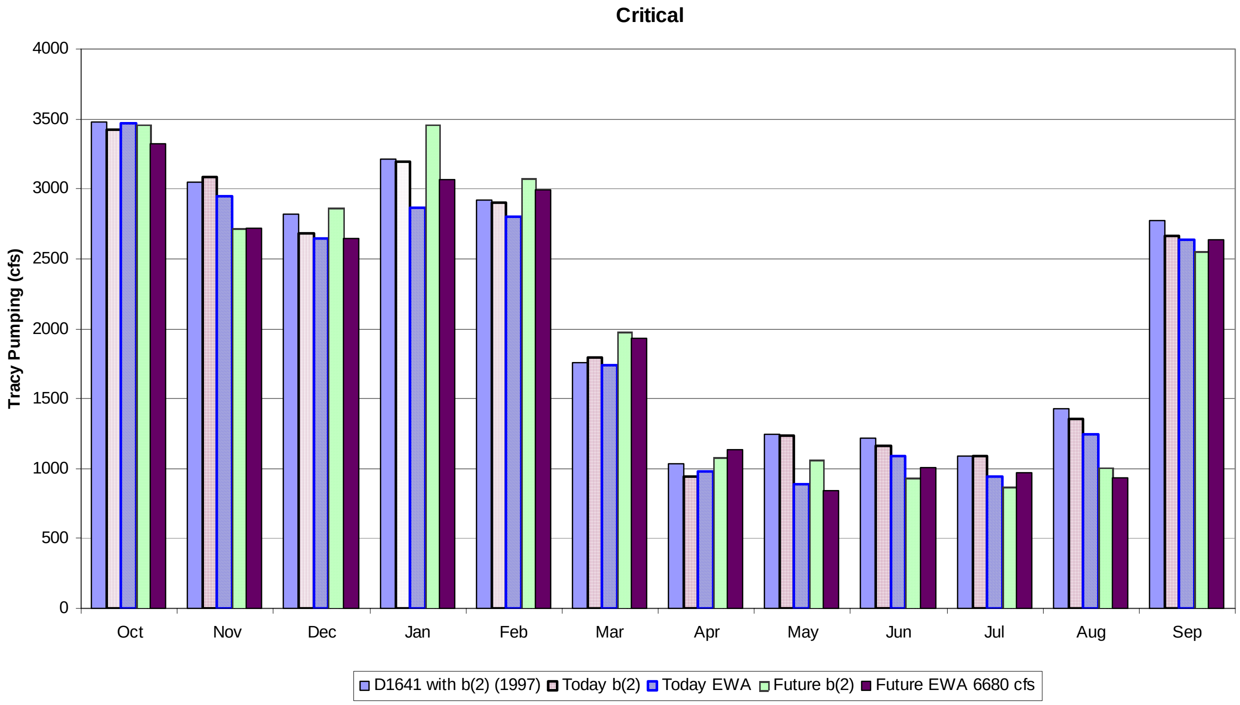


Figure 10–74 Average critical year (40-30-30 Classification) monthly Tracy Pumping

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, 4a, and 5a are greater export levels than Studies 1 and 2, which are the 3406 (b)(2) scenarios. The Future 3406 (b)(2) 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.

While EWA and Future 3406 (b)(2) implementation in Studies 3 and 5a result in higher export levels in all months except for April and May, the percentage of the summertime increases vary as a function of year type (see Figure 10–69 to Figure 10–74.).

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 3406 (b)(2) cases.

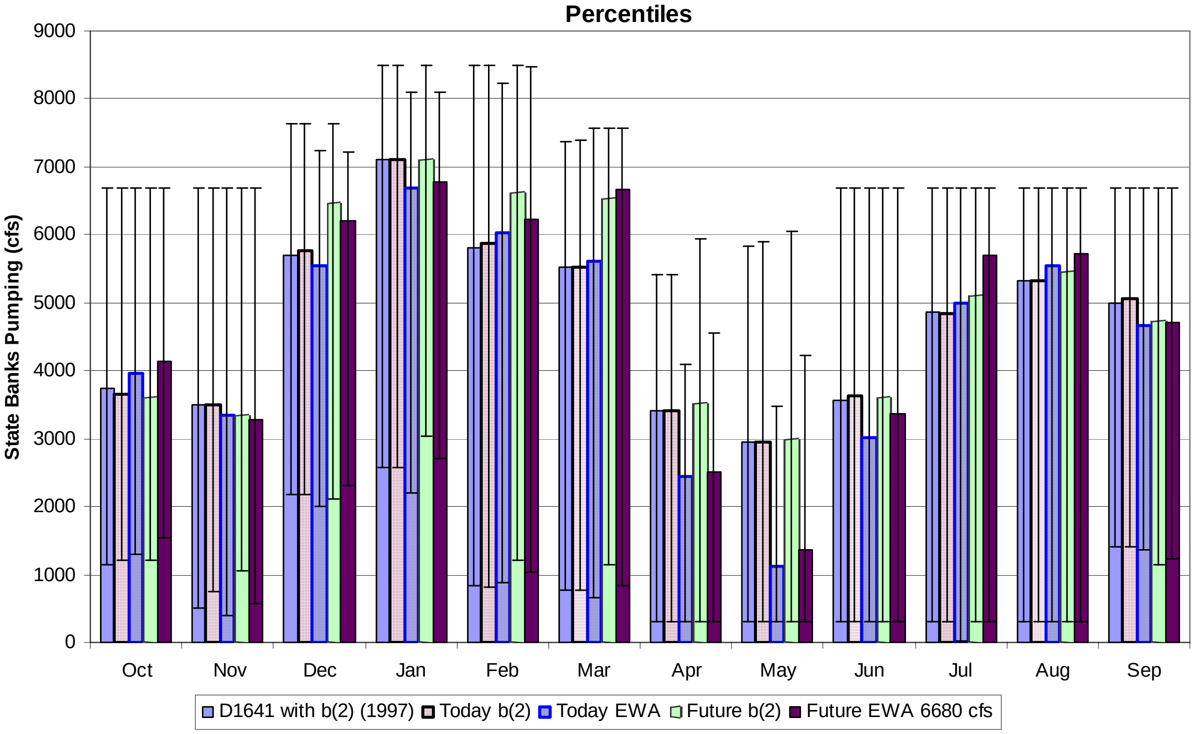


Figure 10–75 Banks Pumping 50th Percentile Monthly Releases with the 5th and 95th as the bars

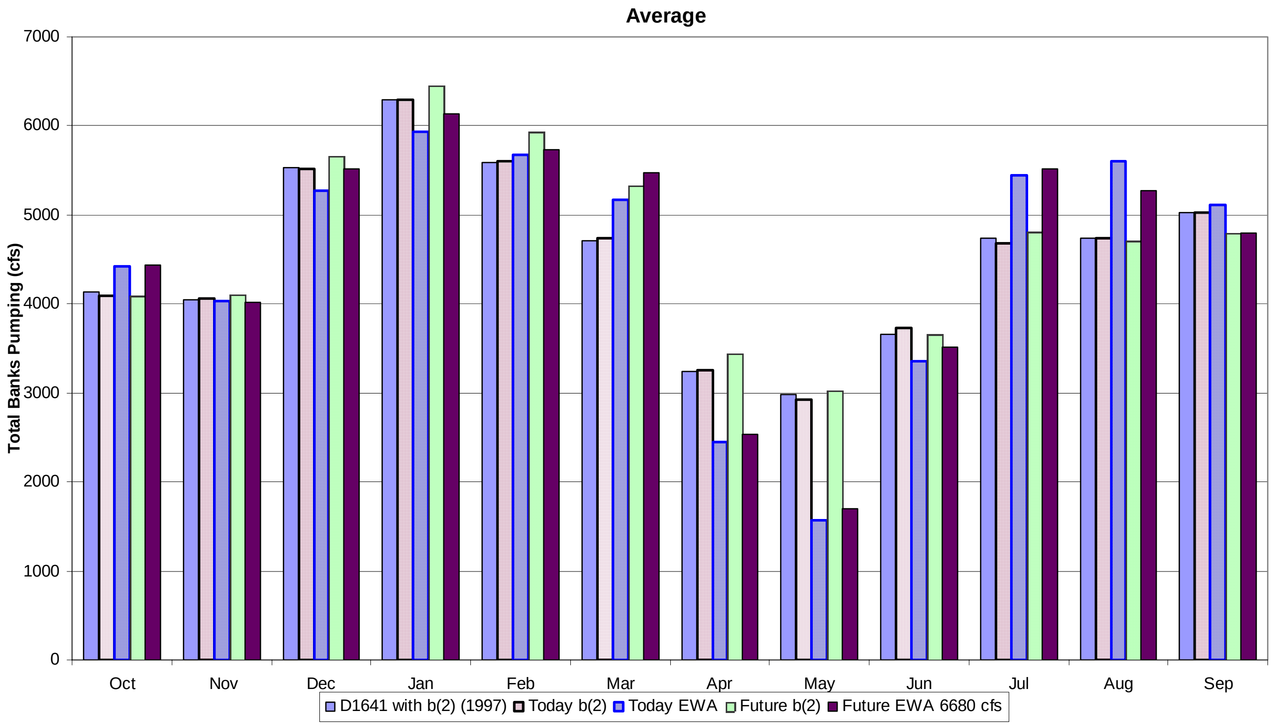


Figure 10–76 Average Monthly Banks Pumping

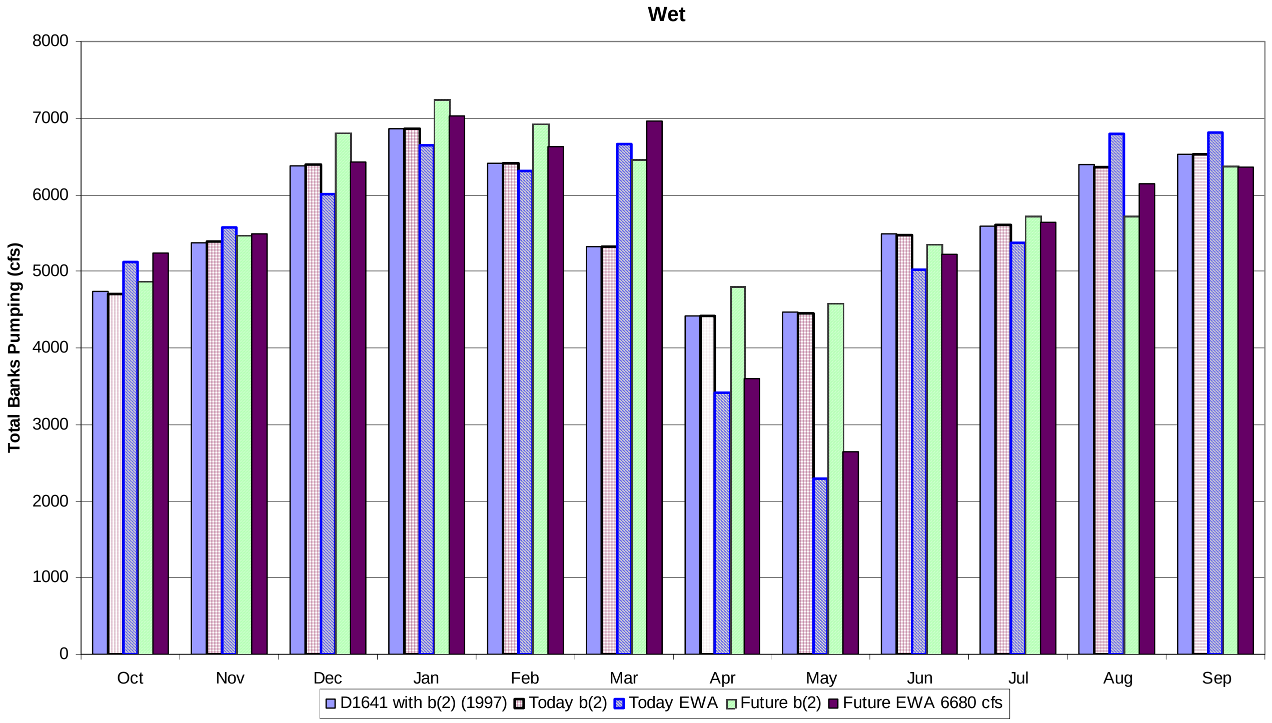


Figure 10–77 Average wet year (40-30-30 Classification) monthly Banks Pumping

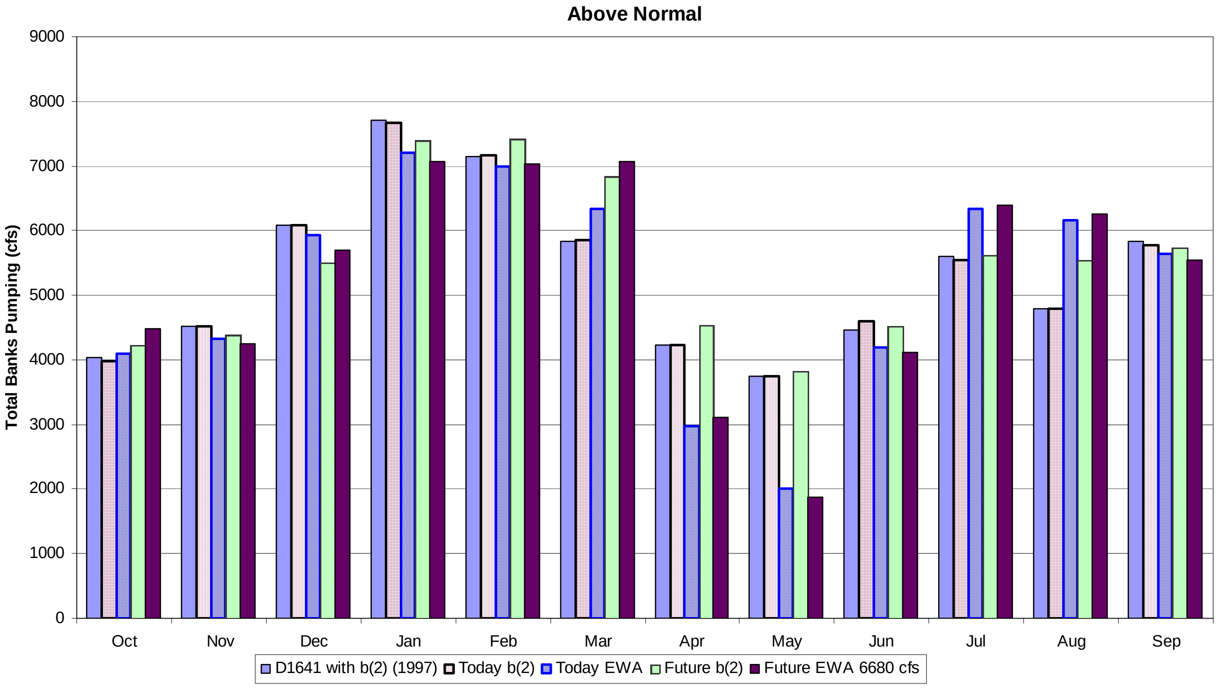


Figure 10–78 Average above normal year (40-30-30 Classification) monthly Banks Pumping

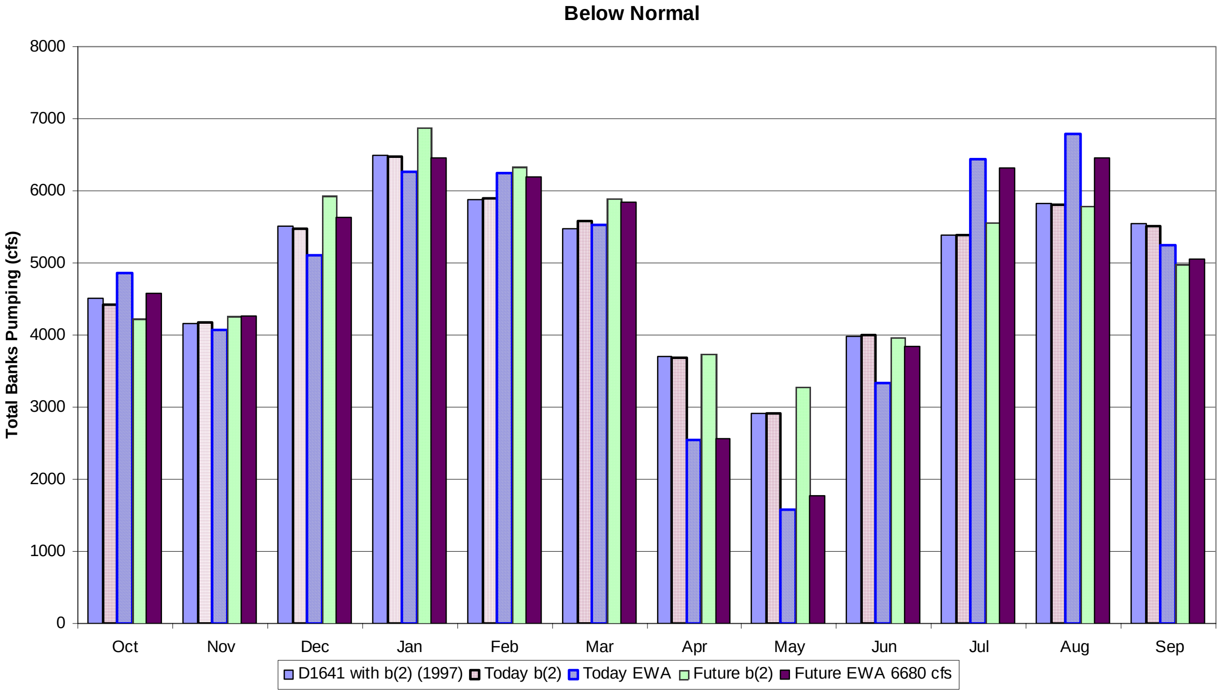


Figure 10–79 Average below normal year (40-30-30 Classification) monthly Banks Pumping

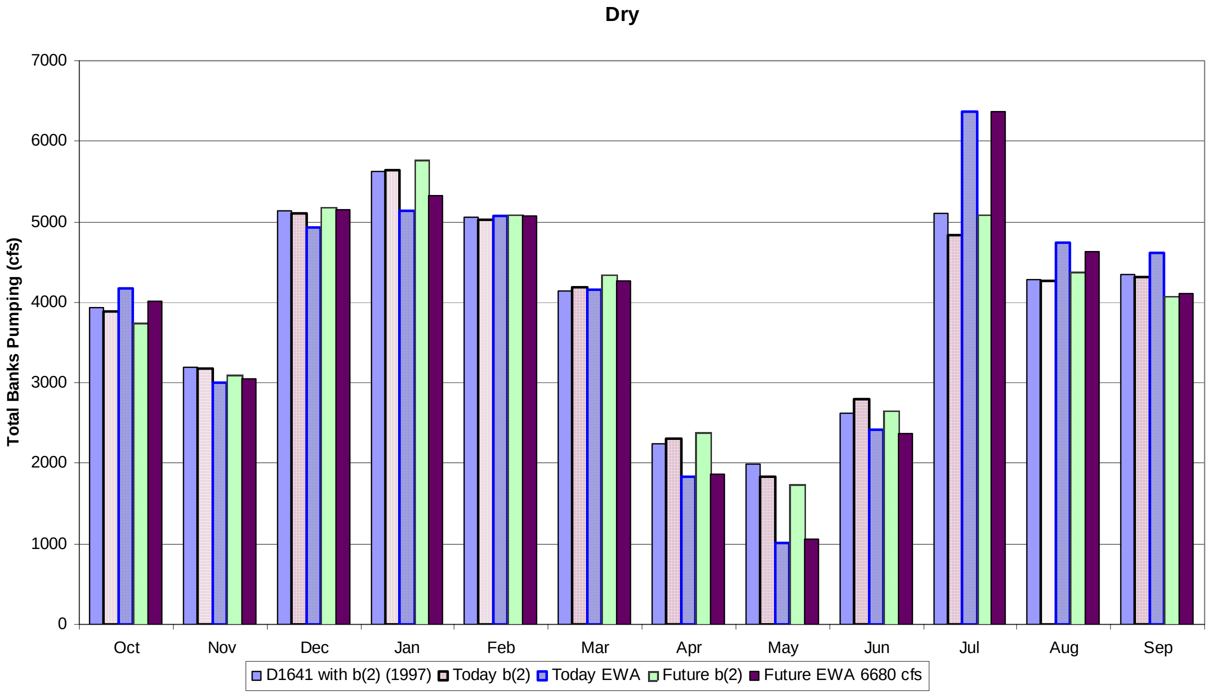


Figure 10–80 Average dry year (40-30-30 Classification) monthly Banks Pumping

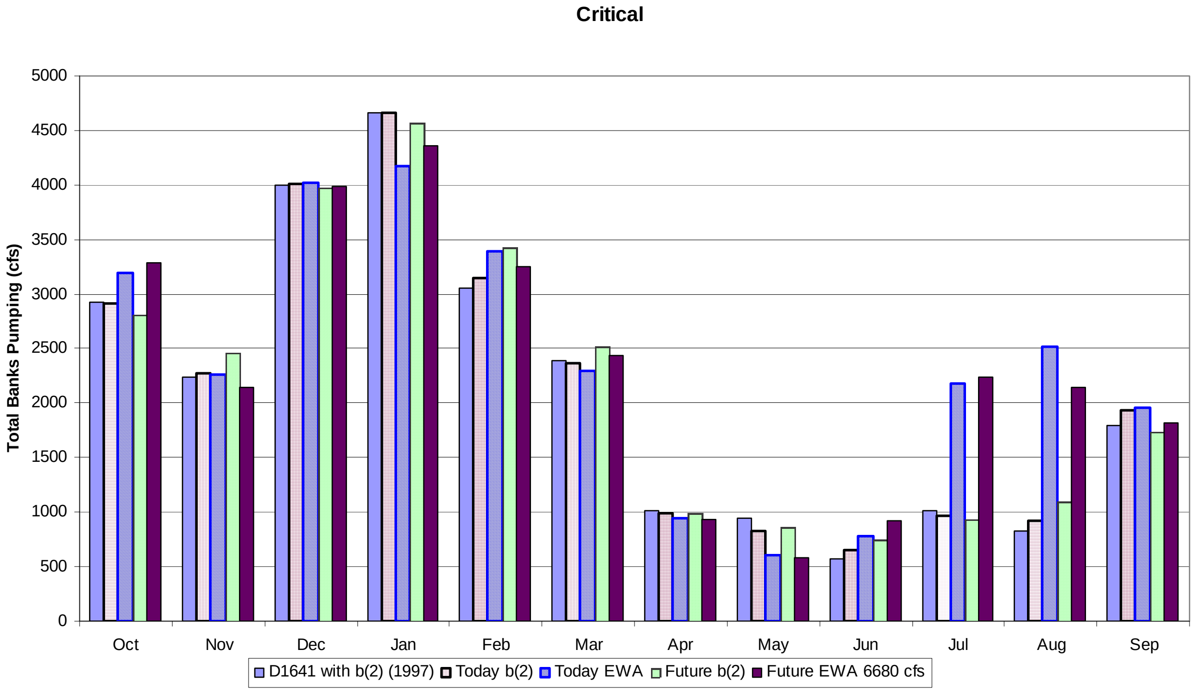
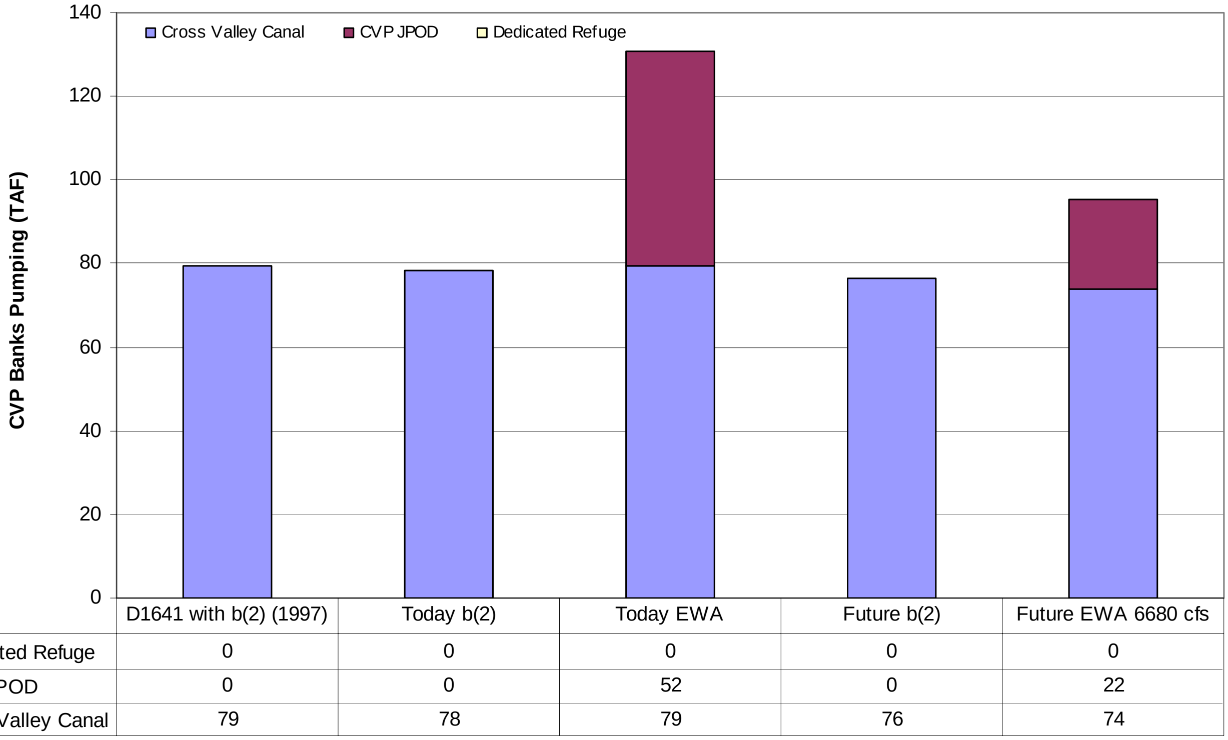


Figure 10–81 Average critical year (40-30-30 Classification) monthly Banks Pumping

Federal Banks Pumping

Figure 10–82 shows the annual average use of Banks pumping for the CVP by study. The average JPOD pumping between the Today EWA to the Future EWA 6680 was reduced due to loss of export capacity from higher State deliveries. The Future studies do not include the dedicated 100,000 acre-feet/year (af/yr) of dedicated refuge level 2 capacity at Banks. Pumping for Cross Valley Canal (Tier 1 JPOD pumping) ranges from 74 taf to 79 taf between the studies.

Federal pumping at Banks generally occurs in the late Summer months (Figure 10-83 through Figure 10-89). Some Federal pumping occurs during October through March for Cross Valley Contractors. Pumping is generally higher in Studies 3 and 5a due to CVP having the capability of pumping half of the joint point of diversion (JPOD) availability above the Cross Valley Contractors pumping. Wet years show the most pumping at Banks, with pumping averages decreasing as the years get drier.



	D1641 with b(2) (1997)	Today b(2)	Today EWA	Future b(2)	Future EWA 6680 cfs
□ Dedicated Refuge	0	0	0	0	0
■ CVP JPOD	0	0	52	0	22
■ Cross Valley Canal	79	78	79	76	74

Figure 10–82 Average use of Banks pumping for the CVP

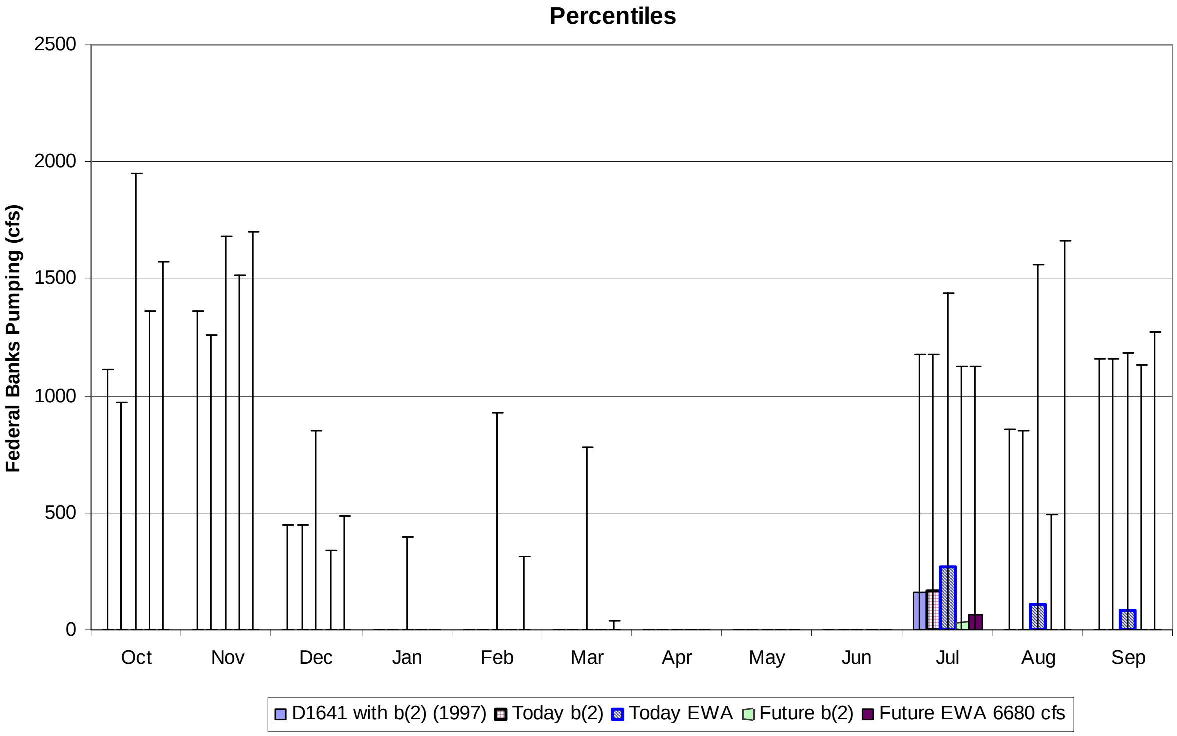


Figure 10–83 Federal Banks Pumping 50th Percentile Monthly Releases with the 5th and 95th as the bars

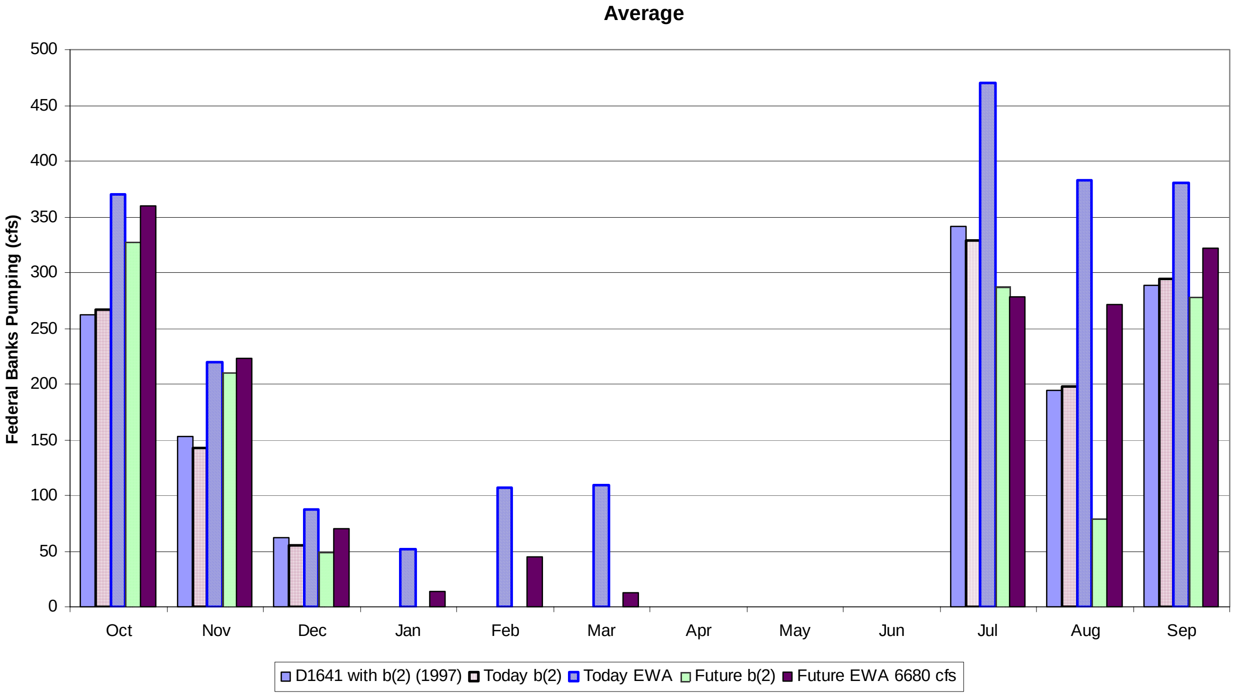


Figure 10–84 Average Monthly Federal Banks Pumping

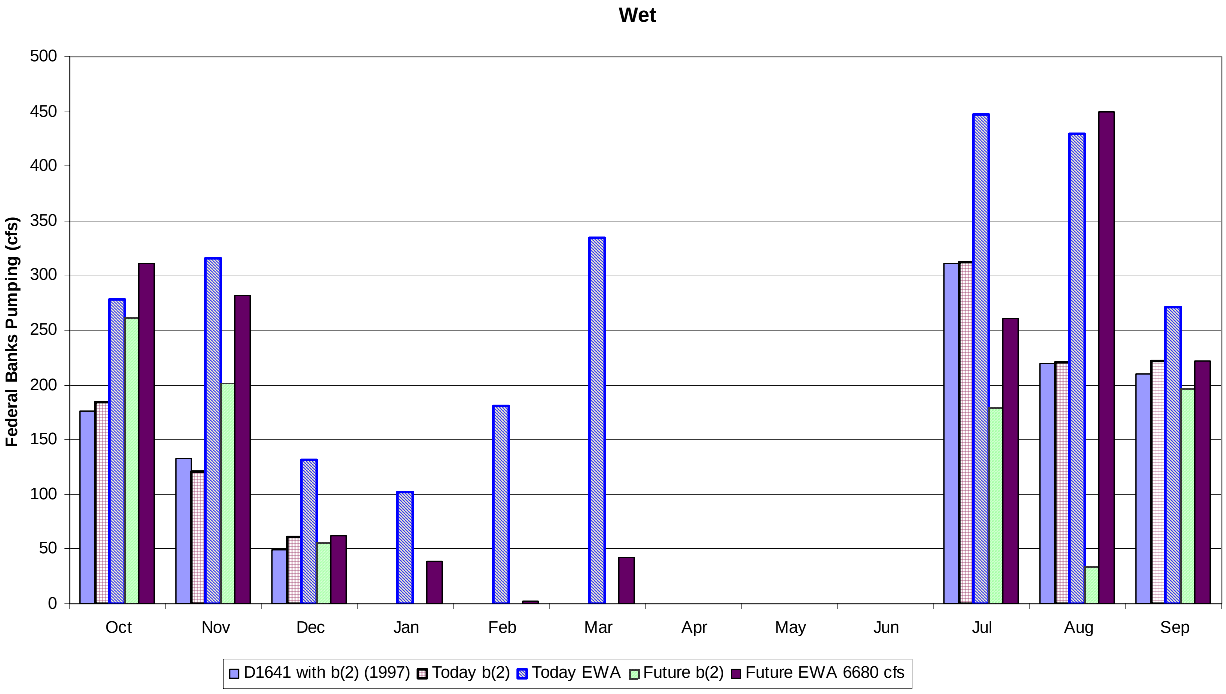


Figure 10–85 Average wet year (40-30-30 Classification) monthly Federal Banks Pumping

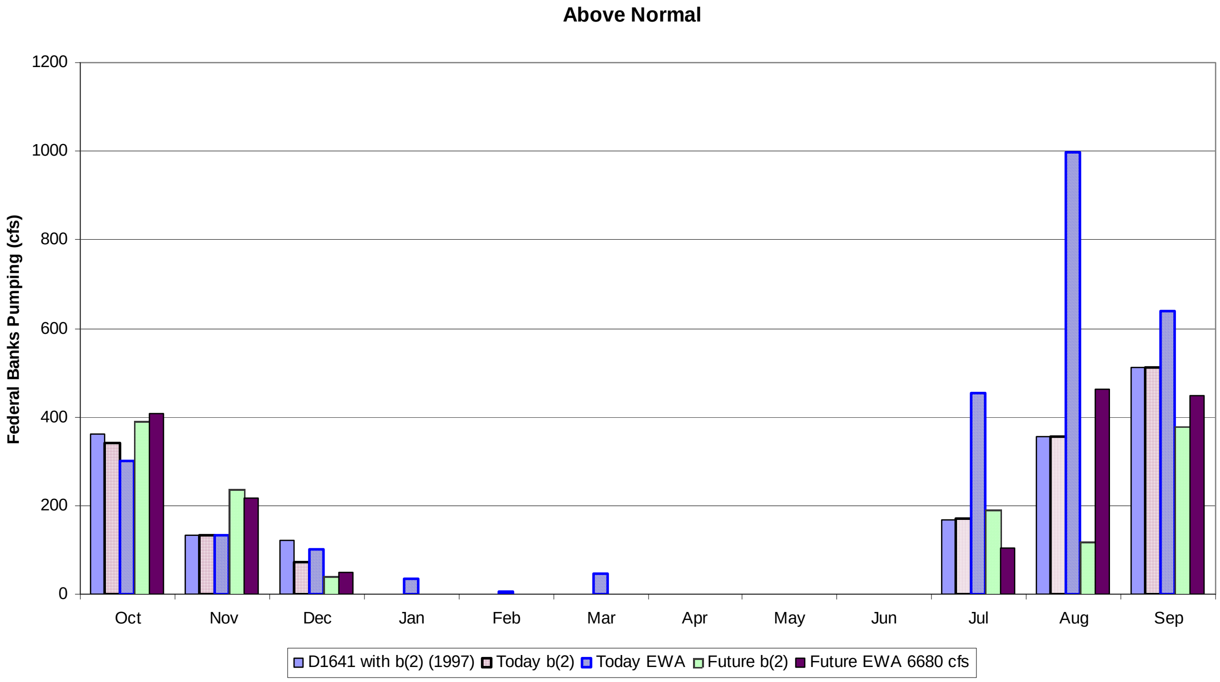


Figure 10–86 Average above normal year (40-30-30 Classification) monthly Federal Banks Pumping

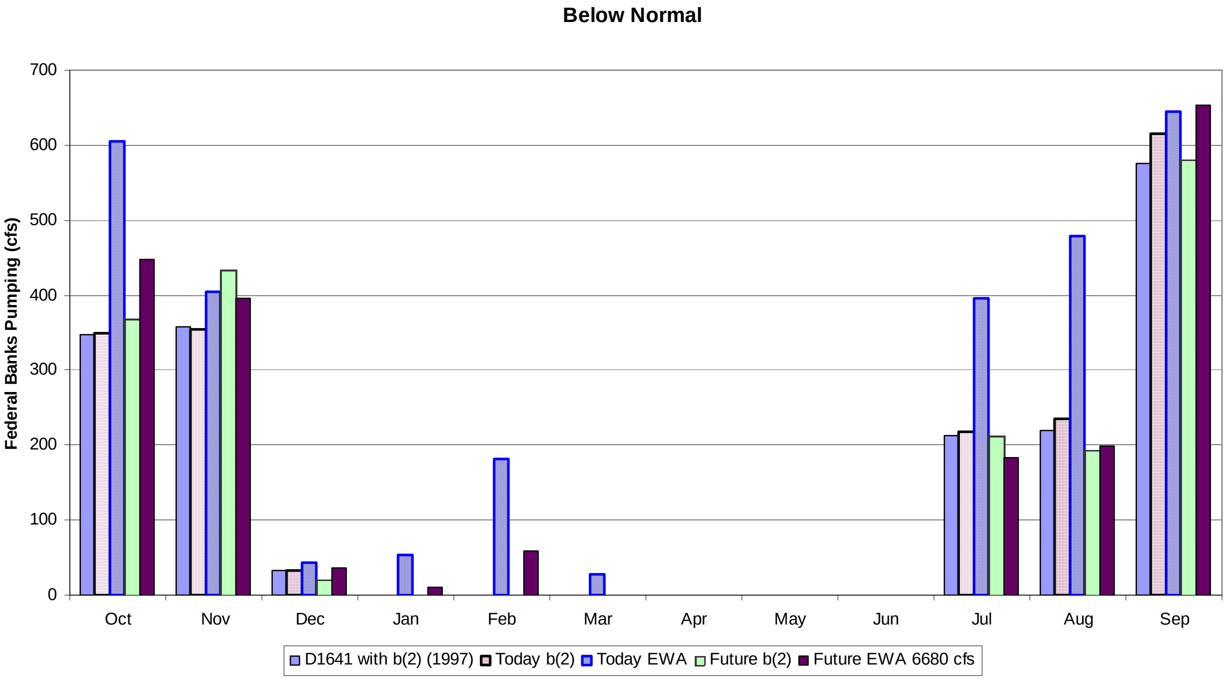


Figure 10–87 Average below normal year (40-30-30 Classification) monthly Federal Banks Pumping

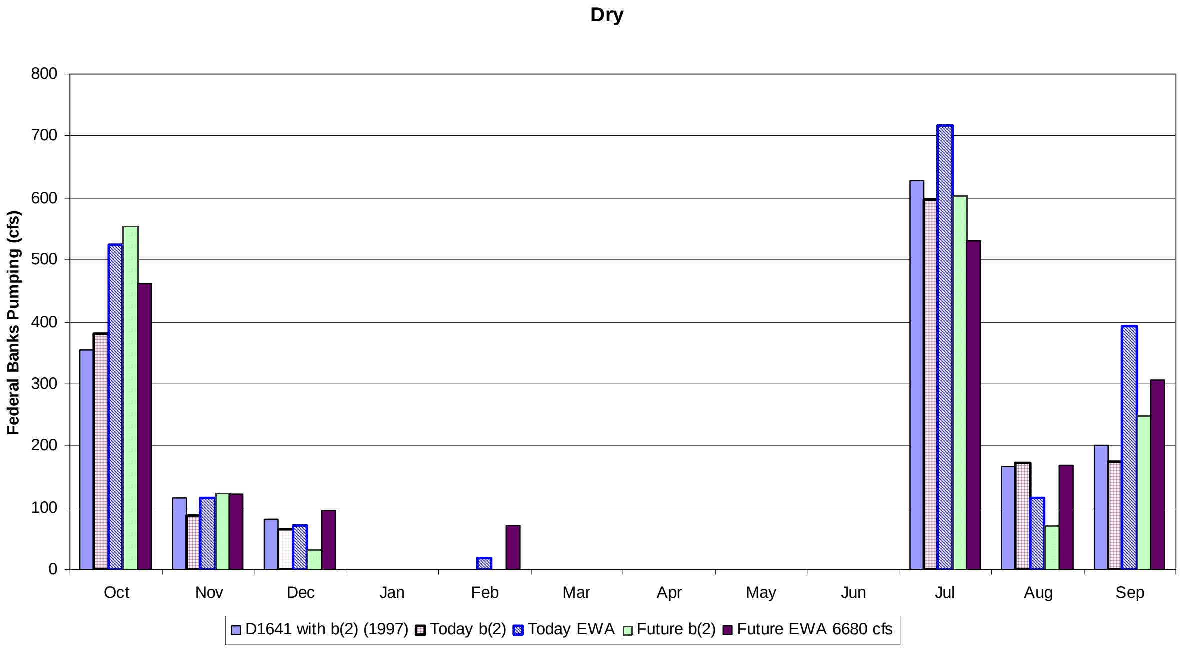


Figure 10–88 Average dry year (40-30-30 Classification) monthly Federal Banks Pumping

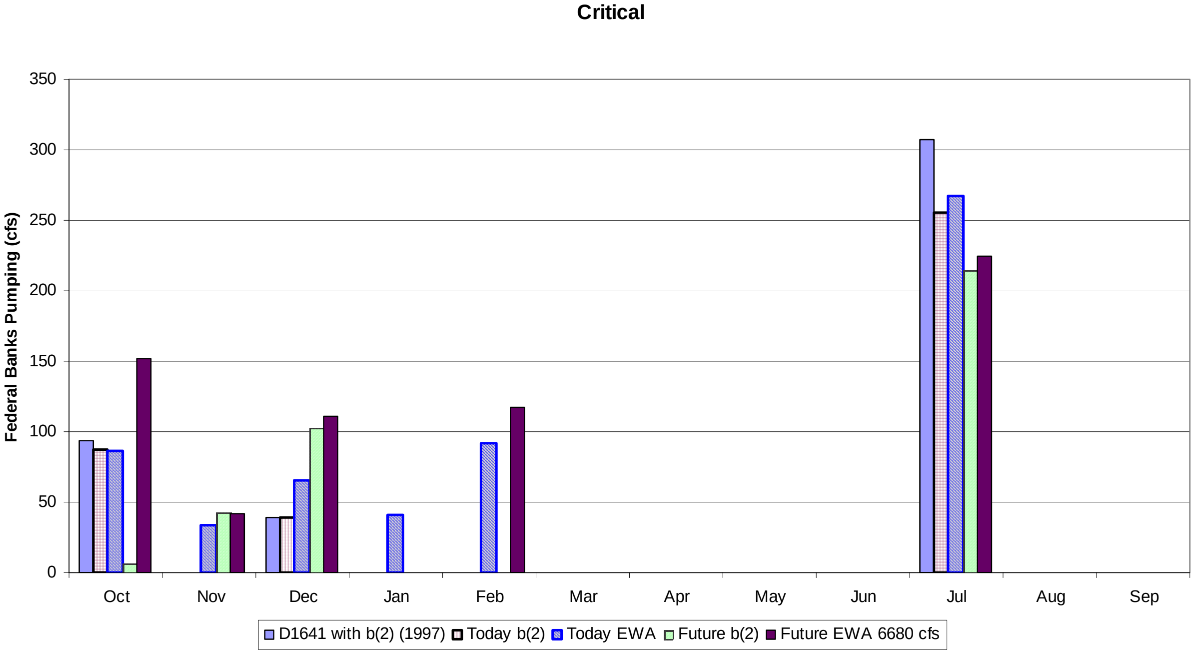


Figure 10–89 Average critical year (40-30-30 Classification) monthly Federal Banks Pumping

Contra Costa Water District and North Bay Aqueduct Diversions

Diversions from CCWD and NBA increased from the 2001 LOD to the 2020 LOD (see Table 10-17. Monthly average diversions at NBA 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 and Figure 10–91. Most of the diversions occur during the late summer months and extend into October for the NBA. CCWD's pattern peaks in June, decreases during the summer, and then stays around 200 cfs during the winter period.

Table 10-17 Average Annual and Long-term Drought Differences in North Bay Aqueduct and CCWD Diversions

Differences (taf)	Study 2 - Study 1	Study 3 - Study 1	Study 5a - Study 1	Study 4a - Study 2	Study 5a - Study 3
North Bay Aqueduct Long-term Average	0	0	14	14	14
North Bay Aqueduct 28-34 Annual Average	0	0	11	11	11
CCWD Long-term Average	0	0	34	34	34
CCWD 28-34 Annual Average	0	0	29	29	29

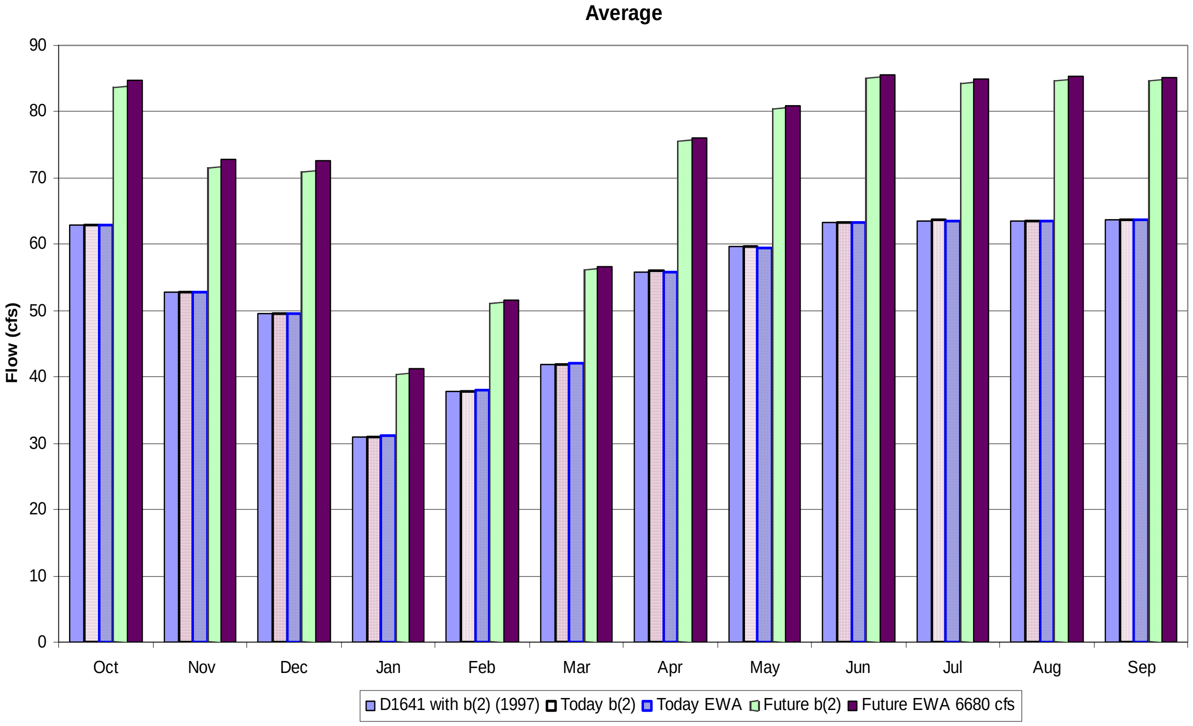


Figure 10–90 Average Monthly North Bay Aqueduct Diversions from the Delta

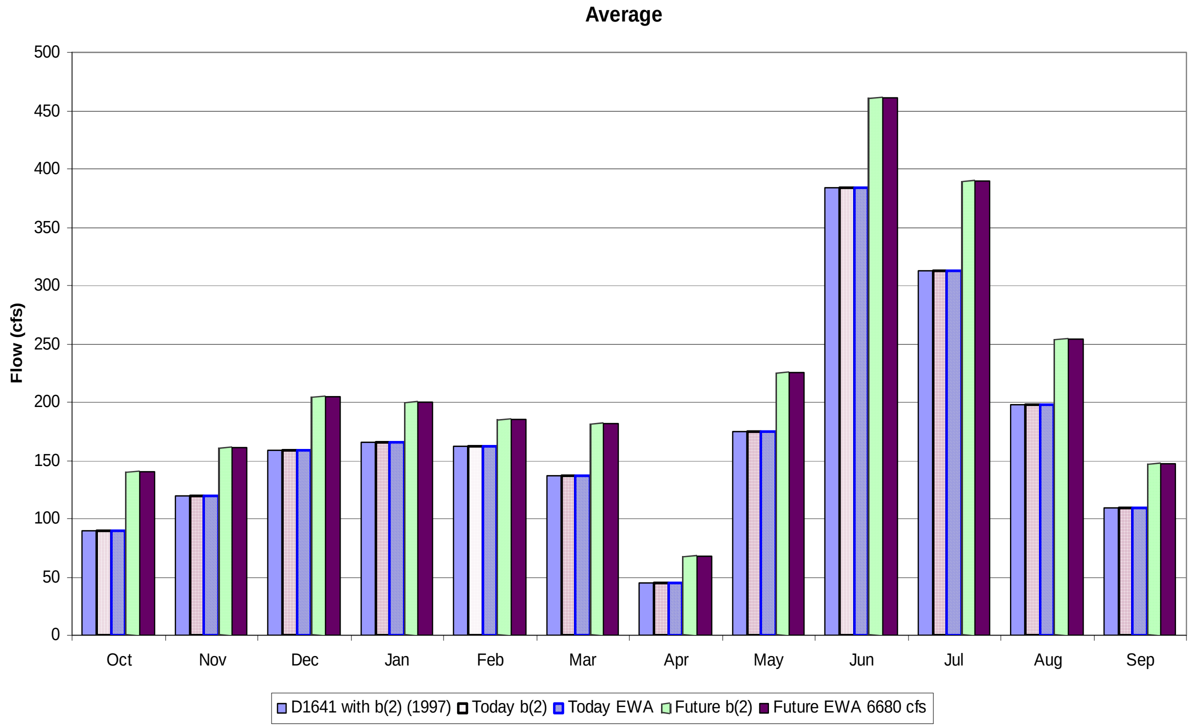


Figure 10–91 Average Monthly Contra Costa Water District Diversions from the Delta

Water Transfers

Water transfers would increase Delta exports from 200,000 – 600,000 acre-feet (af) in about 80 percent 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 section 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 E/I ratio and is limited by either the total physical or permitted capacity, and does 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 10–92 and Figure 10–93 show the available export capacity for the Today b(2) study at Banks and Tracy, with the 40-30-30 water year type on the x-axis and the water year labeled on the bars. Figure 10–94 and Figure 10–95 show the total available export capacity from highest to lowest for Banks and Tracy in the Future SDIP study, respectively. The SWP allocation or the CVP south or Delta allocation is the allocation from CALSIM II output from the water year.

From Figure 10–92 and Figure 10–94 the years with the most capacity at Banks are generally the Dry and Critical years with the lowest allocations, and reflect years when transfers may be higher to augment water supply to export contractors. For the Today b(2) study, in approximately 80 percent of the years the available capacity at Banks for transfer ranges from about 60 to 460 taf (if the 90 taf dedicated for EWA is included). In most years, approximately 80 percent of 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 10–93 and Figure 10–95) 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.

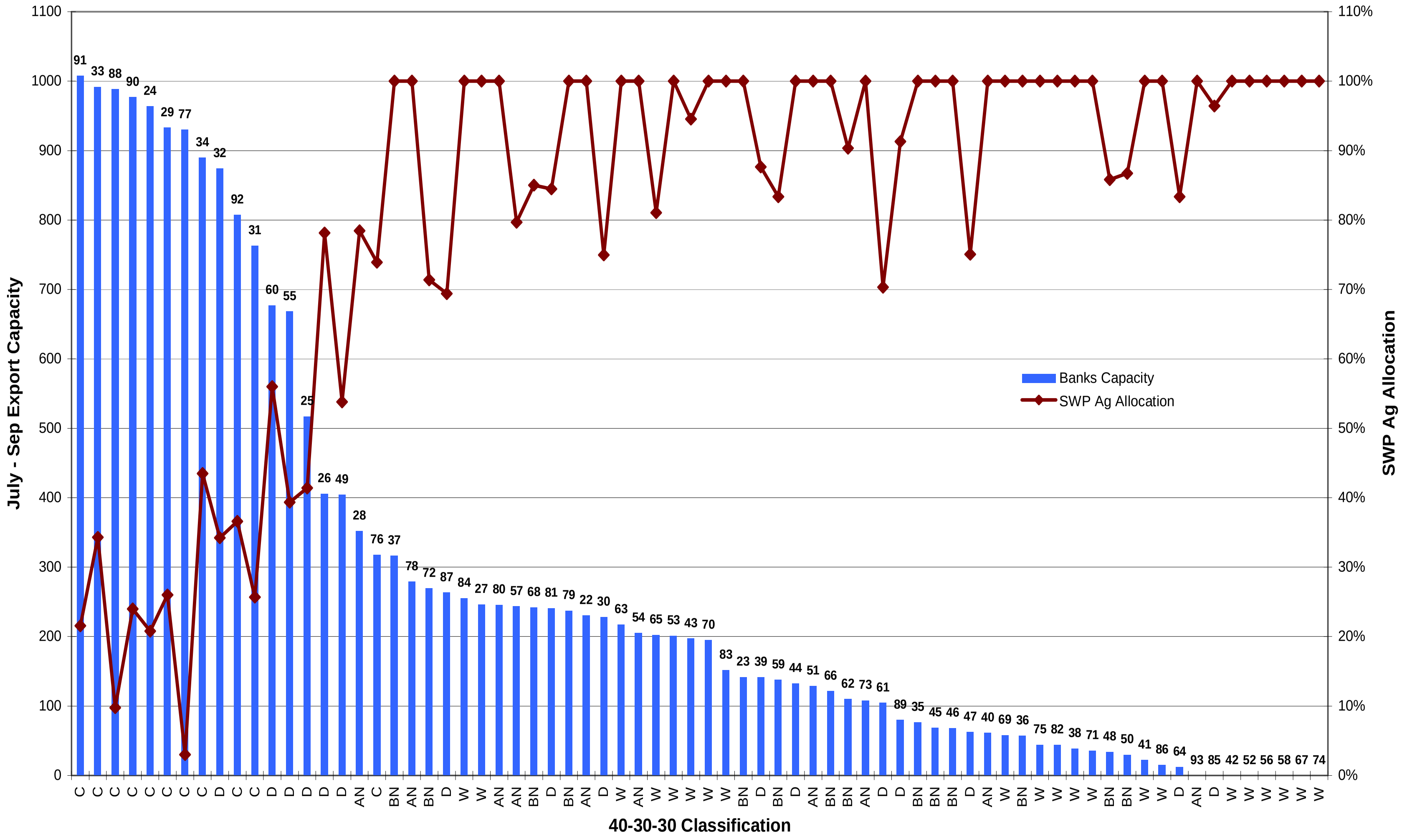


Figure 10–92 Total Banks pumping for July – September capacity in the Today b(2) Study sorted from highest to lowest with the corresponding SWP Allocation

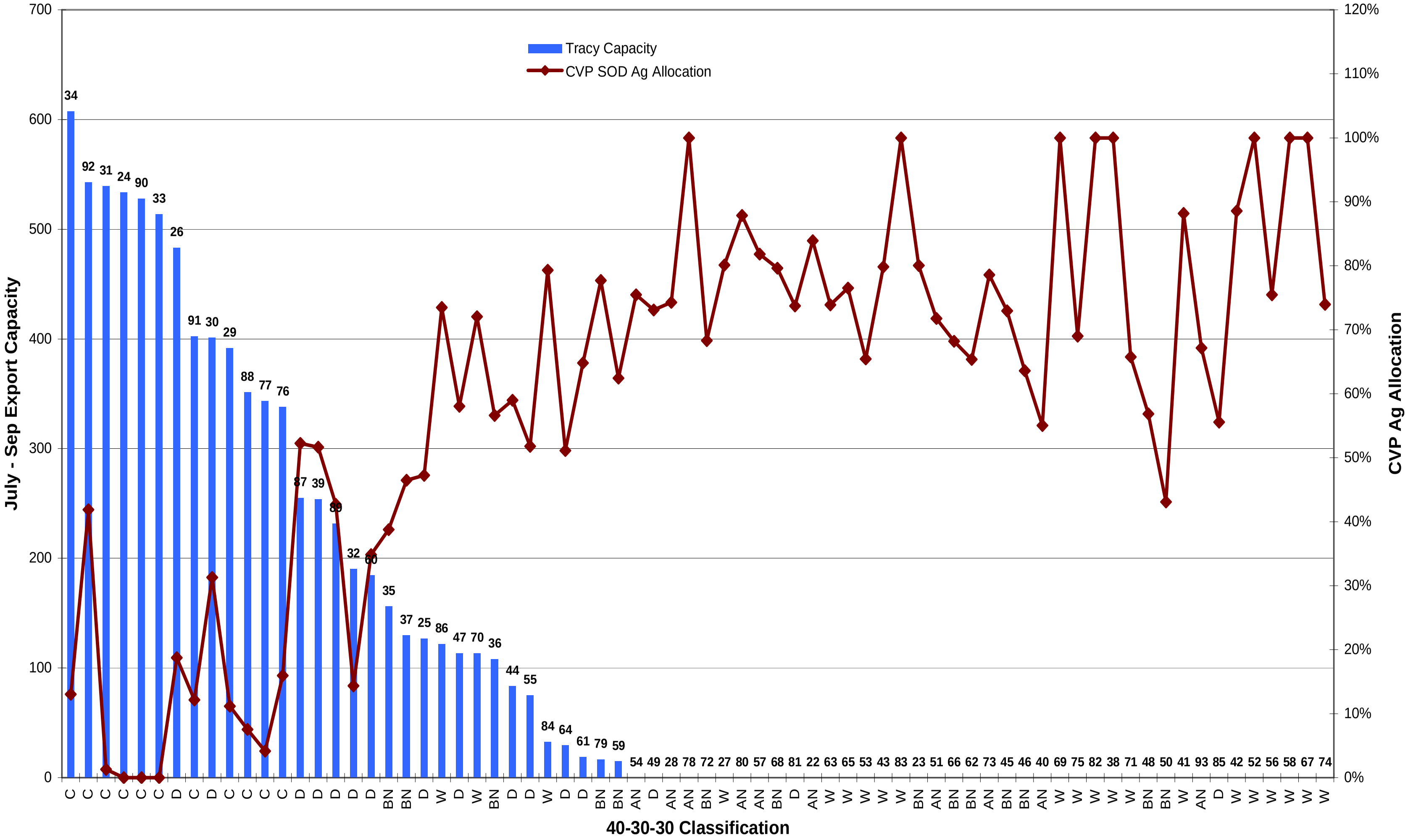


Figure 10–93 Total Tracy pumping for July – September capacity in the Today b(2) Study sorted from highest to lowest with the corresponding CVP south of Delta Ag Allocation

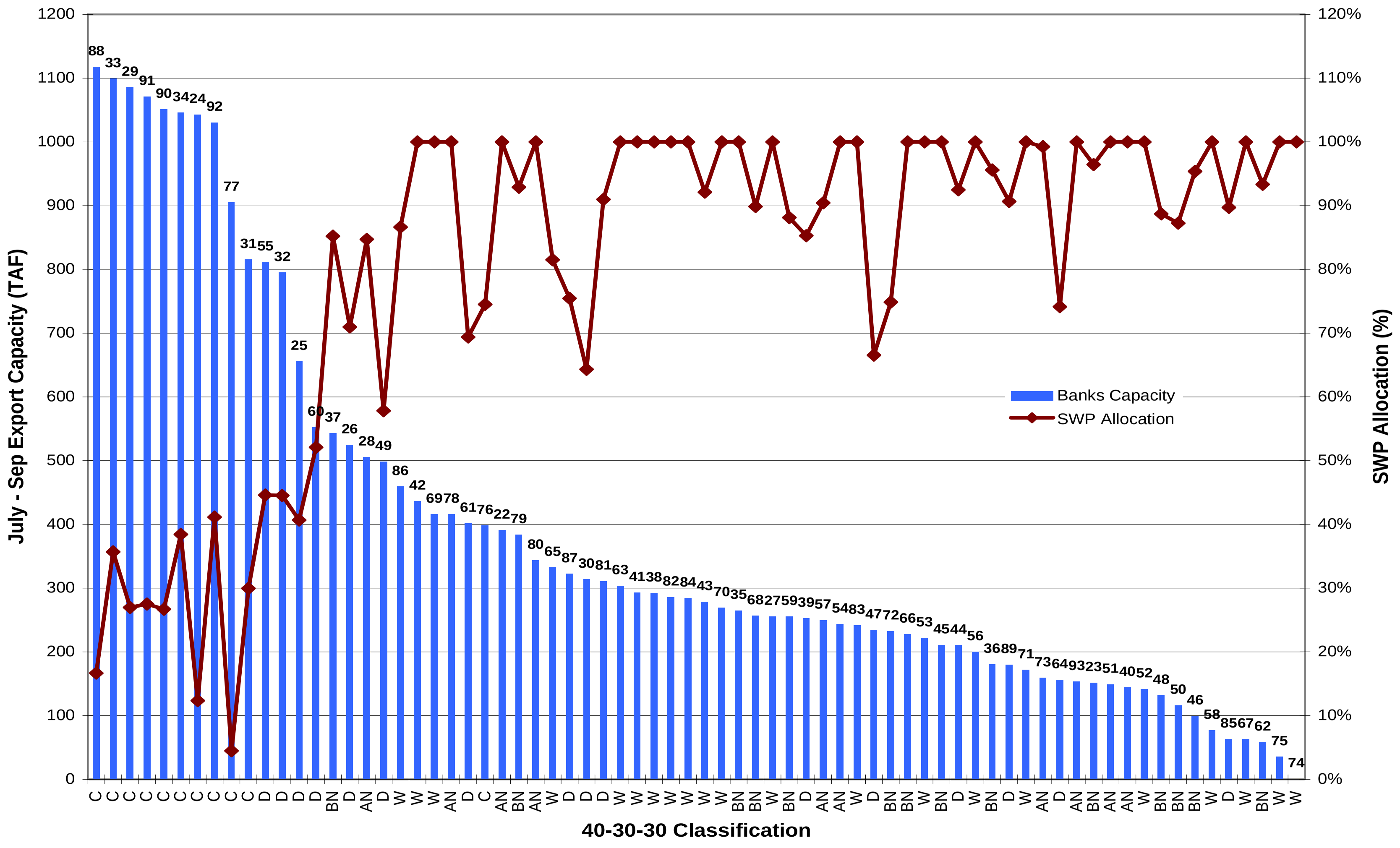


Figure 10–94. Total Banks pumping for July – September capacity in the Future SDIP Study sorted from highest to lowest with the corresponding SWP Allocation

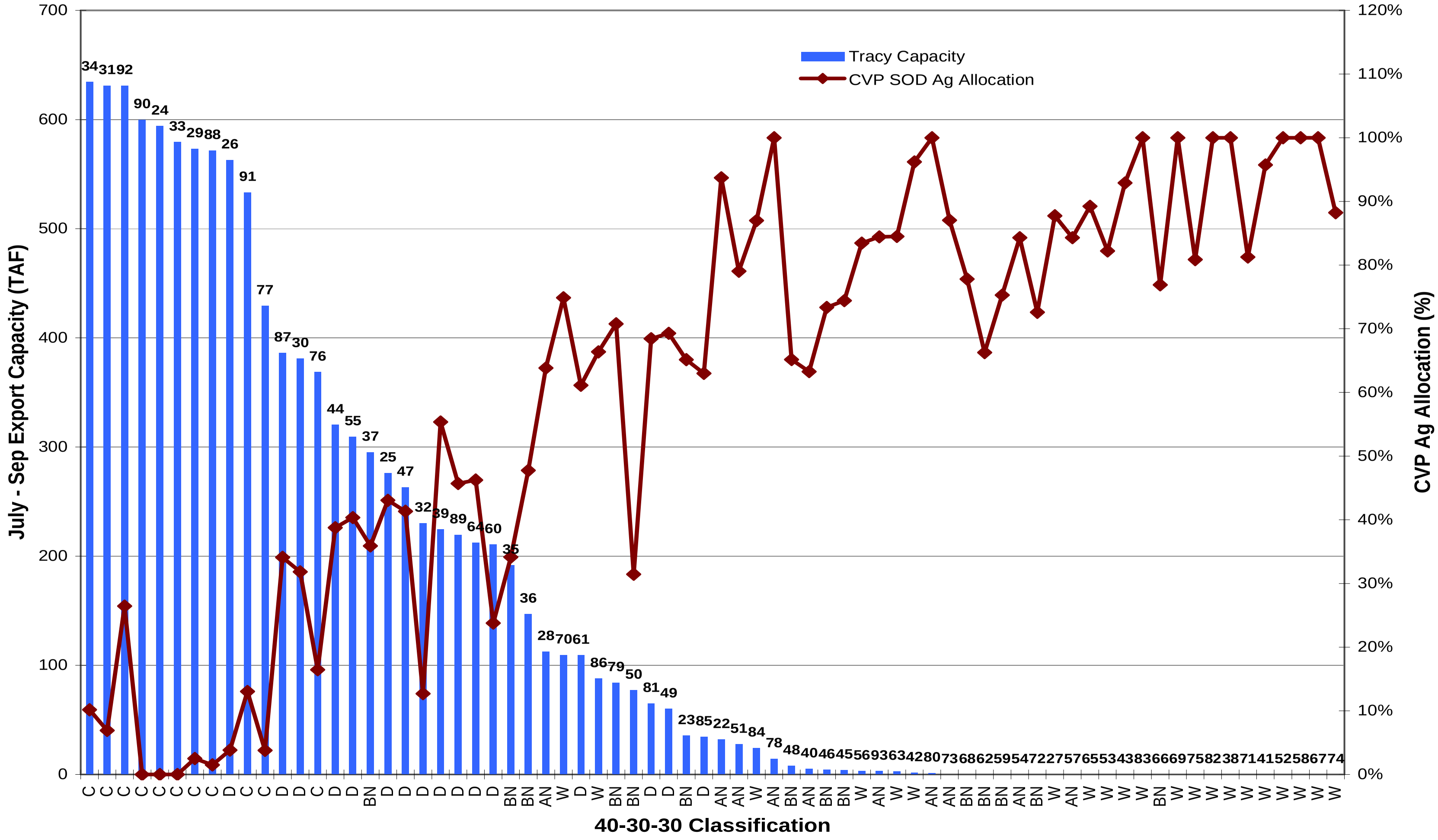


Figure 10–95 Total Tracy pumping for July – September capacity in the Future SDIP Study sorted from highest to lowest with the corresponding CVP south of Delta Ag Allocation

Chapter 11 Effects Analysis of Early versus Formal Consultation

Two additional CALSIM II studies were developed for the Formal Consultation in addition to the Early Consultation Studies 4 and 5. The Formal Consultation studies take Studies 4 and 5 and remove the South Delta Improvement Project (SDIP) and Project Integration components considered as Early Consultation assumptions. The additional Studies 4a and 5a keep the proposed operations for Formal Consultation. The Formal Consultation components include Delta-Mendota Canal (DMC) Intertie, Trinity at 368,600 to 815,000 acre-feet per year (af/yr), and Freeport Project, and Banks is held at 6,680 cubic feet per second (cfs). Table 11-1 shows the main assumptions of the Early and Formal Consultation studies, more detailed assumptions of the CALSIM II studies can be seen in Table 8-2.

Table 11-1 Assumptions of Studies 4, 4a, 5, and 5a

	Trinity Min Flows	CVPIA 3406 (b)(2)	Level of Development	EWA	SDIP	CVP/SWP Integration	Freeport	Intertie
Study 4 Future SDIP	368,600-815,000 af/yr	May 2003 Decision	2020		X	X	X	X
Study 4a Future b(2)	Same as above	Same as above	Same as above				X	X
Study 5 Future EWA 8500 cfs	Same as above	Same as above	Same as above	X	X	X	X	X
Study 5a Future EWA 6680 cfs	Same as above	Same as above	Same as above	X			X	X

CVPIA = Central Valley Project Improvement Act
EWA = Environmental Water Account
CVP = Central Valley Project
SWP = State Water Project

The remainder of this chapter will focus on the differences in operations between Studies 4a to 4 and Studies 5a to 5 for effects to the upstream rivers, Delta, and to EWA. After reviewing the results there was no significant effect between the studies on the Stanislaus River, Trinity River, and to CVPIA 3406 (b)(2) accounting. Additional modeling results can be found in the Formal Consultation Modeling Appendix F for the CALSIM II results, temperature and mortality models. For the Upstream Effects section the comparison of Studies 1, 2, and 3 to 4 and 5 will be done for the Sacramento, Feather and American Rivers and are considered the Early Consultation analysis for these rivers.

Upstream Effects

This section will focus on the effects to the Sacramento River, Feather River, and American Rivers. The results presented are differences in end of May and September storages between 4a to 4 and 5a to 5 and monthly percentile flows. For modeling purposes the 75 thousand af (taf) of CVP storage for use in meeting SWP in-basin requirements was modeled as exclusively coming out of Shasta storage. Neither the origin of the water nor the timing of the water were set as strict rules in the Project Integration Agreement and are just assumptions for modeling the possible system impacts.

Trinity River

Effects to Trinity reservoir, Clear Creek Tunnel, and releases to the river were minimal when comparing Studies 4a and 5a to Studies 4 and 5. The largest impact to the Trinity River is the increased Record of Decision (ROD) flows and the analysis can be seen in Chapter 9 of this document.

Clear Creek

There are no effects to Clear Creek when comparing in Studies 4a to 4 and 5a to 5. For analysis of Clear Creek operations see Chapter 9 in this document.

Sacramento River

The main effect to Shasta in the early consultation Studies 4 and 5 are the releases of CVP storage out of Shasta to assist in meeting in-basin needs of the SWP. CALSIM II begins releasing for the SWP in August and will continue to do so if there is capacity below 15,000 cfs of releases from Keswick or up to the minimum of either 75 taf or the North of Delta (NOD) Agriculture allocation. Releases are highest in the wet years and reduce in magnitude as the year get drier, see Table 11-2.

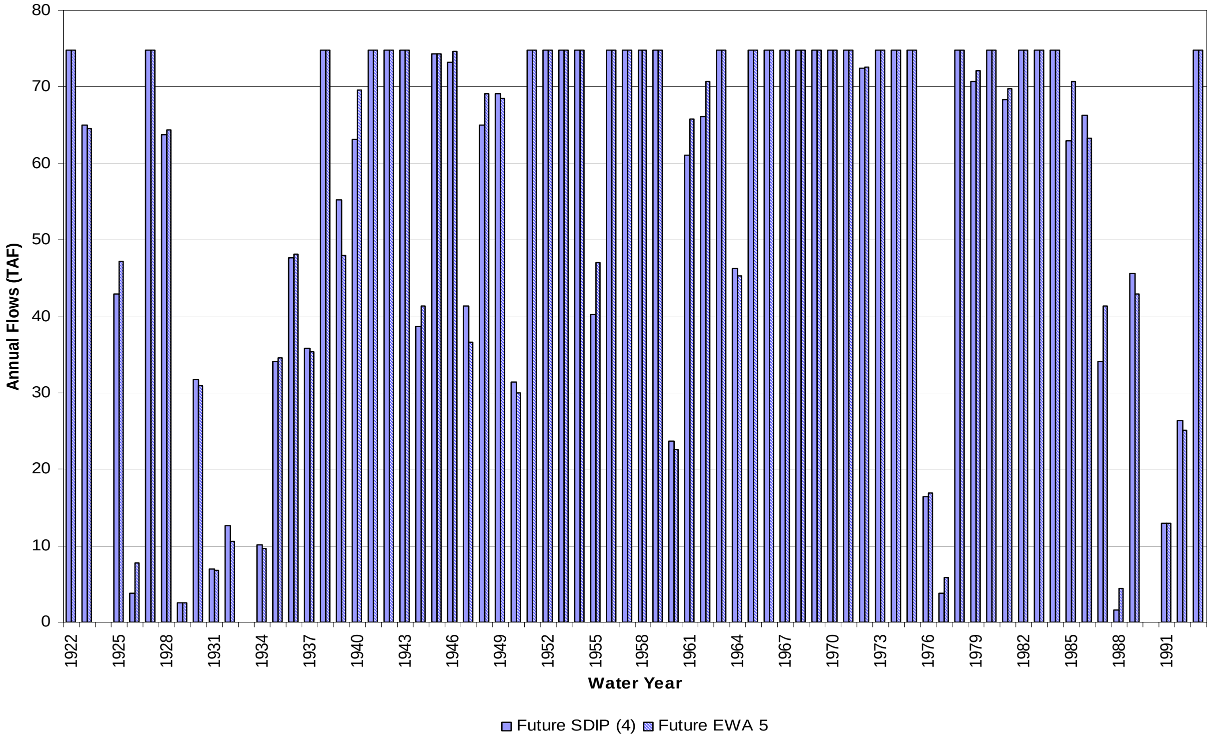


Figure 11-1 Annual CVP Releases for SWP from Shasta from August to November

Table 11-2 Average and 40-30-30 Index Water Year for the months of August and September

40-30-30 Classification	Future SDIP (4)	Future EWA 5
Average	51	52
Wet	74	74
Above Normal	66	67
Below Normal	58	55
Dry	37	40
Critical	7	8

The releases for SWP and extra capacity to do joint point of diversion (JPOD) pumping due the 8,500 cfs pumping and dedicated 100 taf of Refuge Level 2 pumping at Banks increase the late summer average releases. Figure 11-2 shows that the 50th percentile for monthly releases July and August are increases for Studies 4 and 5 and beginning in December the flows for the 50th percentile are generally higher in Studies 4a and 5a. The flows being higher in the winter through spring time occur due to higher storages that increases the minimum flow targets for those months. Table 11-3 shows the same trend as Figure 11-2 for the average monthly flow and the average monthly flow by 40-30-30 Index classification.

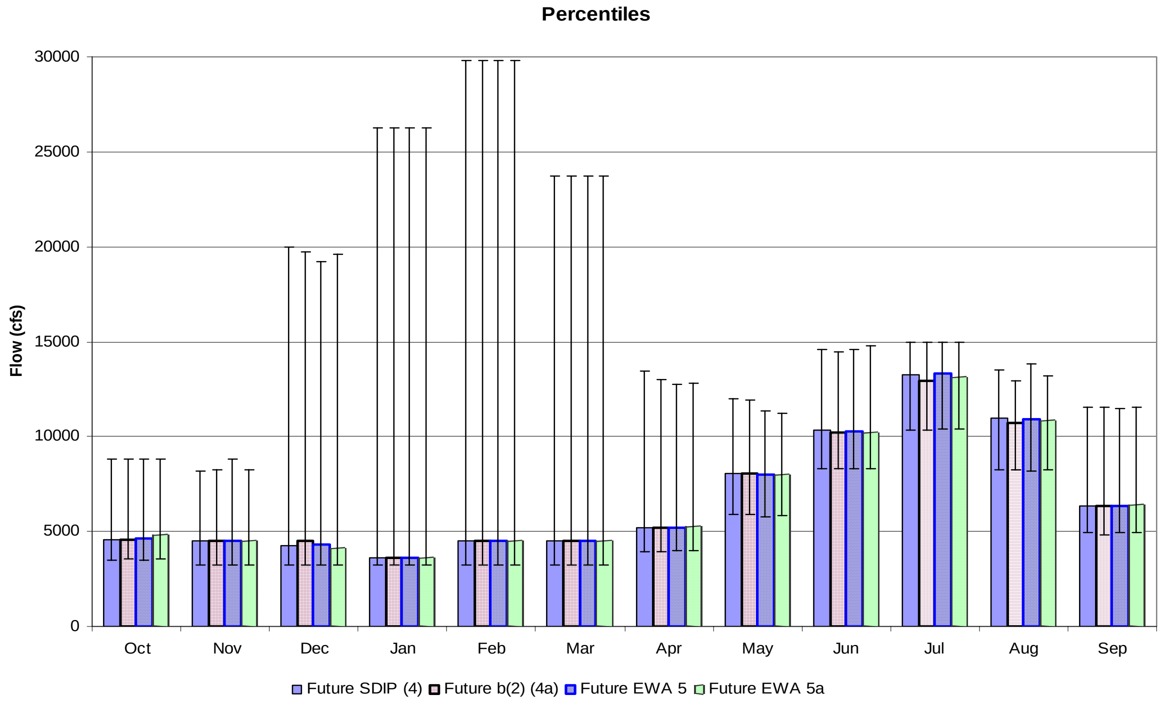


Figure 11-2 Keswick Release monthly percentiles the bars represent the 50th percentile and the whiskers the 5th and 95th percentile

Table 11-3 Average and 40-30-30 Index Water Year types monthly Keswick Releases

Average	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Future SDIP (4)	5467	5111	6567	7855	10031	8247	7216	8321	10726	12984	10930	7049
Future b(2) (4a)	5492	5171	6735	7898	10005	8306	7191	8328	10713	12899	10682	7061
Future EWA 5	5448	5146	6534	7873	10050	8271	7165	8244	10608	13134	11055	6942
Future EWA 5a	5509	5183	6675	7923	10016	8337	7142	8262	10630	12928	10833	7030
Wet	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**
Future SDIP (4)	5882	6156	11629	16242	18255	14993	10150	9511	9910	12643	11631	9411
Future b(2) (4a)	5967	6200	11993	16318	18264	15030	10115	9527	9904	12500	11499	9408
Future EWA 5	5900	6196	11695	16334	18236	15023	10091	9417	9875	13079	11729	9048
Future EWA 5a	6010	6209	12027	16410	18231	15101	10006	9444	9877	12649	11520	9281
Above Normal	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**
Future SDIP (4)	5683	4960	5170	6784	14012	9531	6376	8545	10708	14166	11173	6661
Future b(2) (4a)	5701	5021	5287	6825	14085	9527	6378	8616	10761	14042	10876	6703
Future EWA 5	5741	5020	5012	6716	14008	9545	6373	8515	10678	14130	11188	6668
Future EWA 5a	5760	5019	5101	6911	13971	9532	6374	8444	10733	13945	11094	6704
Below Normal	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**
Future SDIP (4)	5495	4814	5136	4530	6351	5648	5560	7880	11327	13018	11526	6476
Future b(2) (4a)	5499	4878	5070	4556	6335	5767	5537	7879	11276	12906	11068	6526
Future EWA 5	5447	4871	5027	4495	6465	5587	5522	7837	11099	13033	11461	6302
Future EWA 5a	5402	4933	5043	4539	6472	5674	5489	7871	11149	12868	11078	6294
Dry	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**
Future SDIP (4)	5232	4798	4025	3541	4008	4111	6201	7922	11330	13377	10741	5893
Future b(2) (4a)	5173	4955	4197	3602	3903	4188	6121	7896	11288	13356	10478	5884
Future EWA 5	5155	4887	4048	3538	3959	4146	6054	7867	11121	13415	11034	5942
Future EWA 5a	5257	4919	4108	3549	3826	4253	6139	7872	11137	13304	10786	6029
Critical	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**
Future SDIP (4)	4782	4083	3690	3325	4158	3523	5964	6988	10654	11948	8887	5303
Future b(2) (4a)	4851	4029	3823	3298	4073	3581	6011	6976	10659	11951	8751	5296
Future EWA 5	4744	3980	3601	3377	4245	3641	6006	6825	10576	12053	9159	5442
Future EWA 5a	4824	4074	3701	3307	4250	3666	5938	6902	10577	12067	9039	5423

Figure 11-3 and Figure 11-4 show the end of May and September storage differences between 4a to 4 and 5a to 5 respectively. In general the September carryover storage tend to be higher in Studies 4a and 5a. The September storage reductions in Studies 4 and 5 are generally due to the releases from Keswick for SWP in-basin requirements and for the extra pumping capacity for JPOD. In May the storages general are the same between 4a and 4, and 5a and 5, or at the least the differences are reduced due to the aforementioned shift in releases.

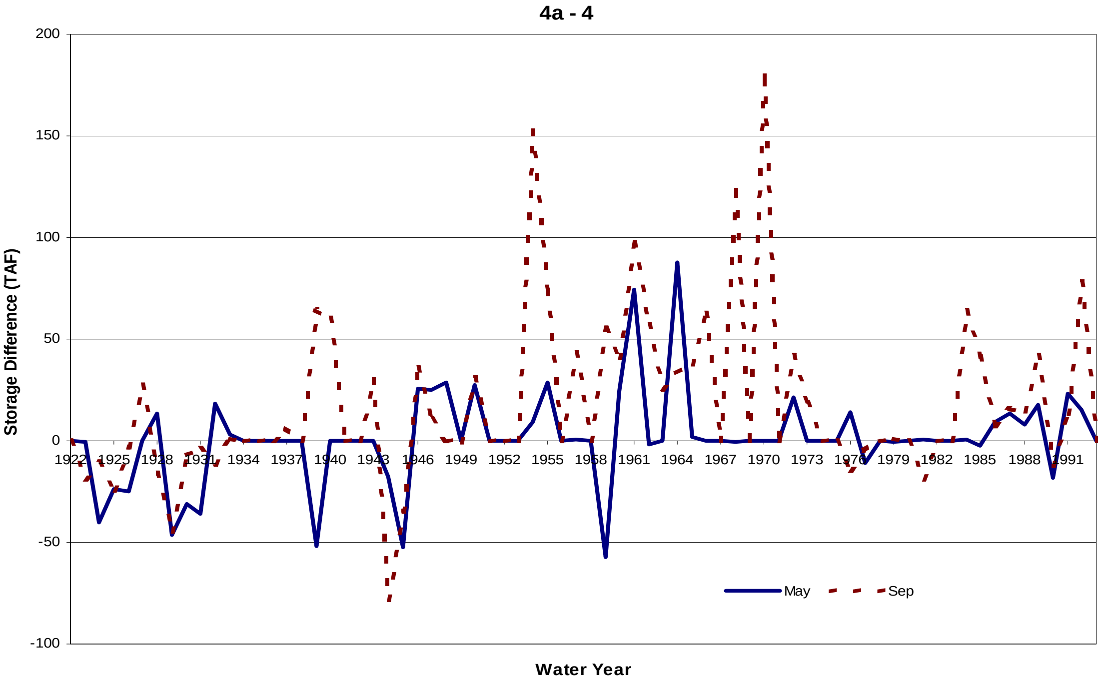


Figure 11-3 Chronology of Shasta End of May and September Storage differences between Studies 4a to 4

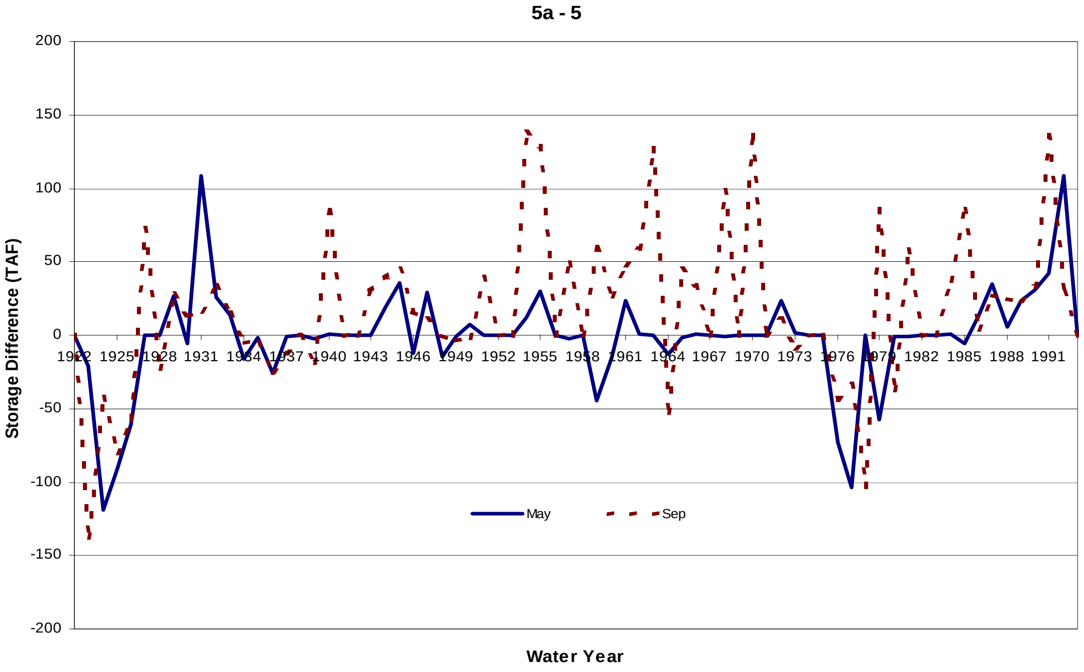


Figure 11-4 Chronology of Shasta End of May and September Storage differences between Studies 5a to 5

Early Consultation

The largest impact to Shasta reservoir operations is reduction of Trinity Imports from Spring Creek Tunnel in the summer months (Table 11-4). 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 Table 11-5 for averages during the 1928 – 1934).

Table 11-4. 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 11-5. 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 11-6 shows the End of September exceedance for Shasta storage, the 1.9 million af (maf) requirement in the Winter Run biological opinion (BO) (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 11-7 shows the monthly percentiles flows for releases from Keswick Reservoir. 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.

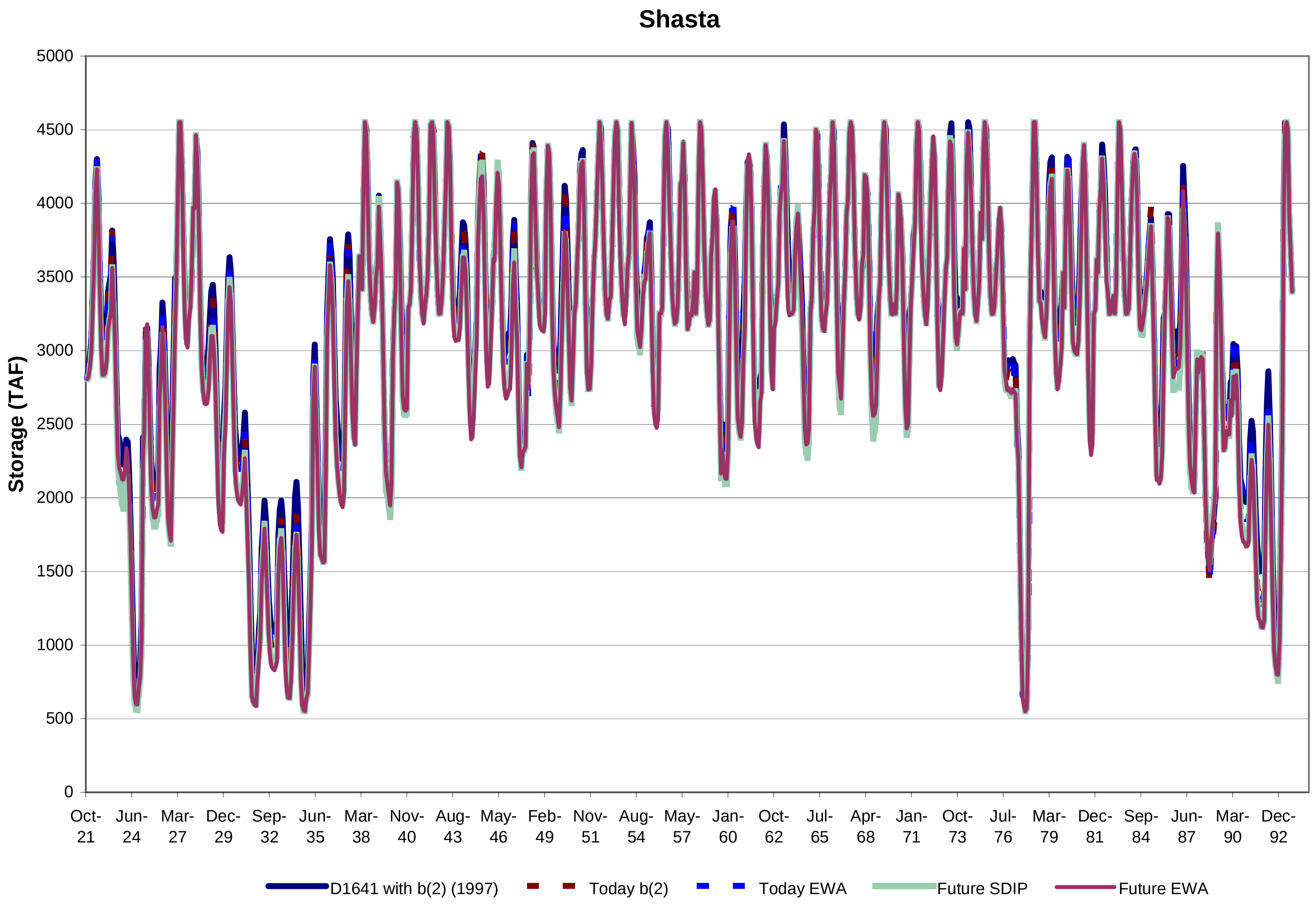


Figure 11-5. Chronology of Shasta Storage Water Year 1922 - 1993

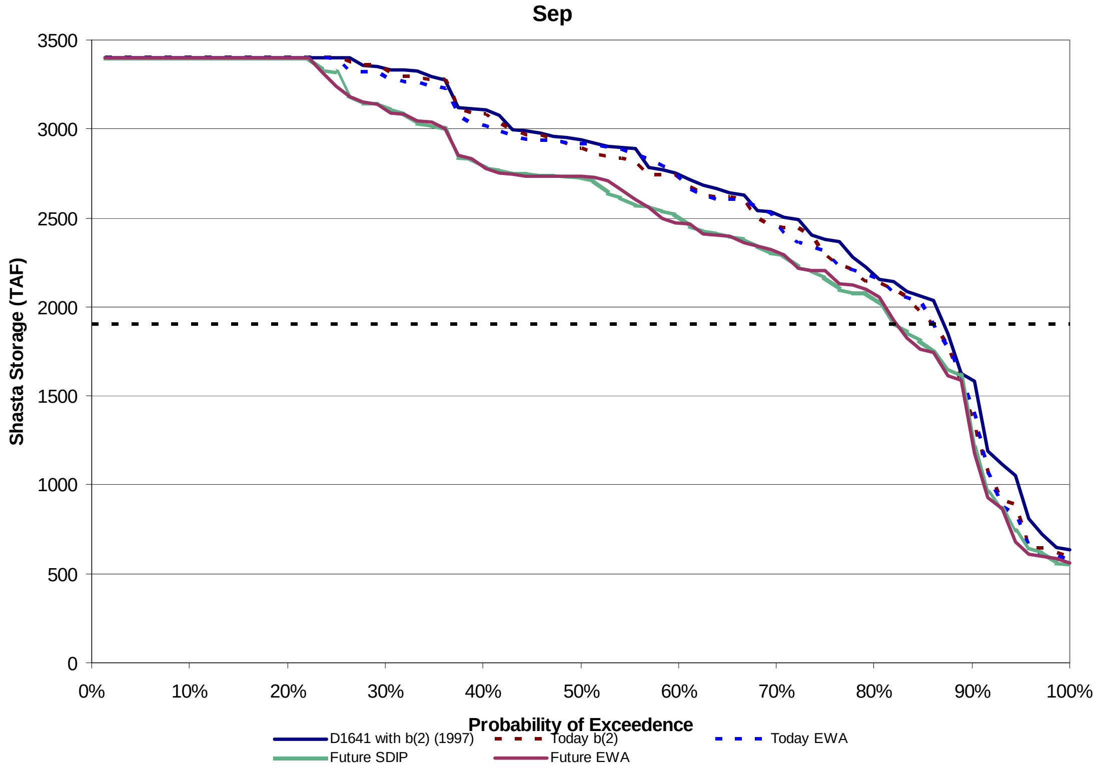


Figure 11-6 Shasta Reservoir End of September Exceedance

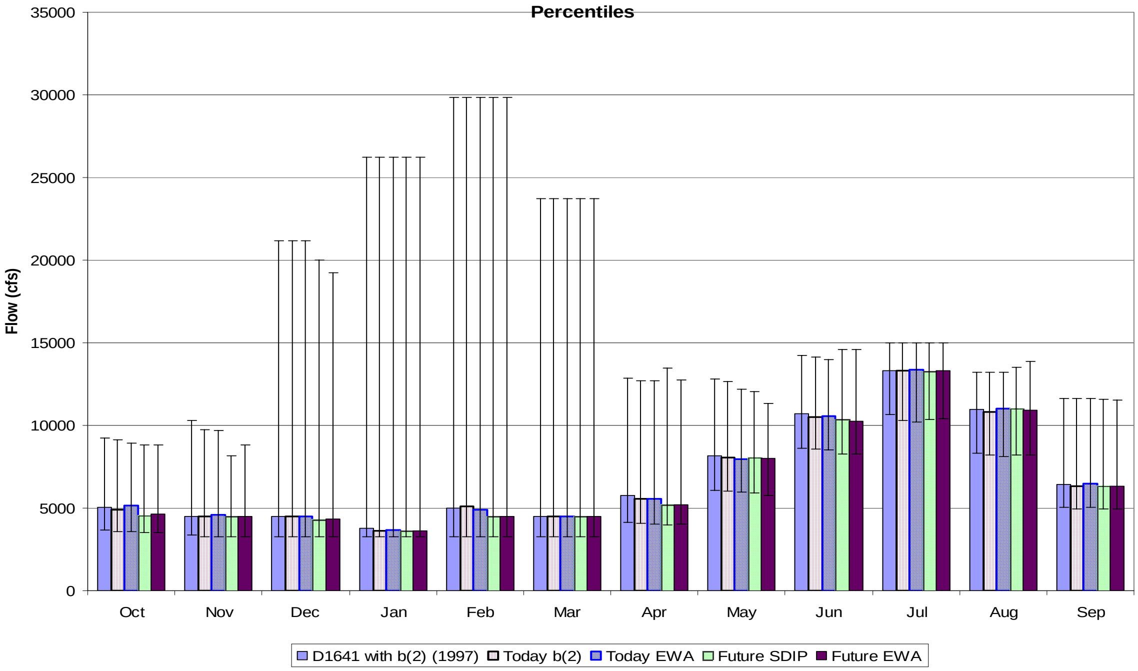


Figure 11-7 Keswick 50th Percentile Monthly Releases with the 5th and 95th as the bars

Feather River

Figure 11-8 shows the differences in end of May and end of September storages in Oroville storage between Studies 4a to 4. Study 4a shows periods of increased carryover storages in the 1920s and during the 1987 to 1993 drought period with marginal effect to carryover storage in the 1928 to 1934 drought period. End of May storage conditions are flat between Studies 4a and 4 with the exception of the 1920s and 1987 to 1993 drought.

Figure 11-9 shows the differences between Study 5a to Study 5 end of May and September storages. Increases in storage in Study 5a when compared to Study 5 are in the 1920s as well as in the 1928 to 1934 drought periods due to a drop in deliveries for the SWP. On average in the above normal and dry years the end of September storages tend to be higher in Studies 4 and 5. While in wet, below normal and critical years Oroville end of September storages are higher.

Figure 11-10 shows the monthly percentiles of the flow below Thermalito. The releases for SWP from Keswick tend to decrease flows in Studies 4 and 5 below Thermalito in August and to a lesser degree in September. Studies 4 and 5 suggest the more aggressive delivery targets in the SDIP studies have little effect on flows October through January and result in increased flows February and March due to. Table 11-7 shows the monthly average flow below Thermalito Afterbay for all years and also segregated by 40-30-30-index water year type. In general, lower flows in August and September coincide with higher flows in February and March in Studies 4 and 5.

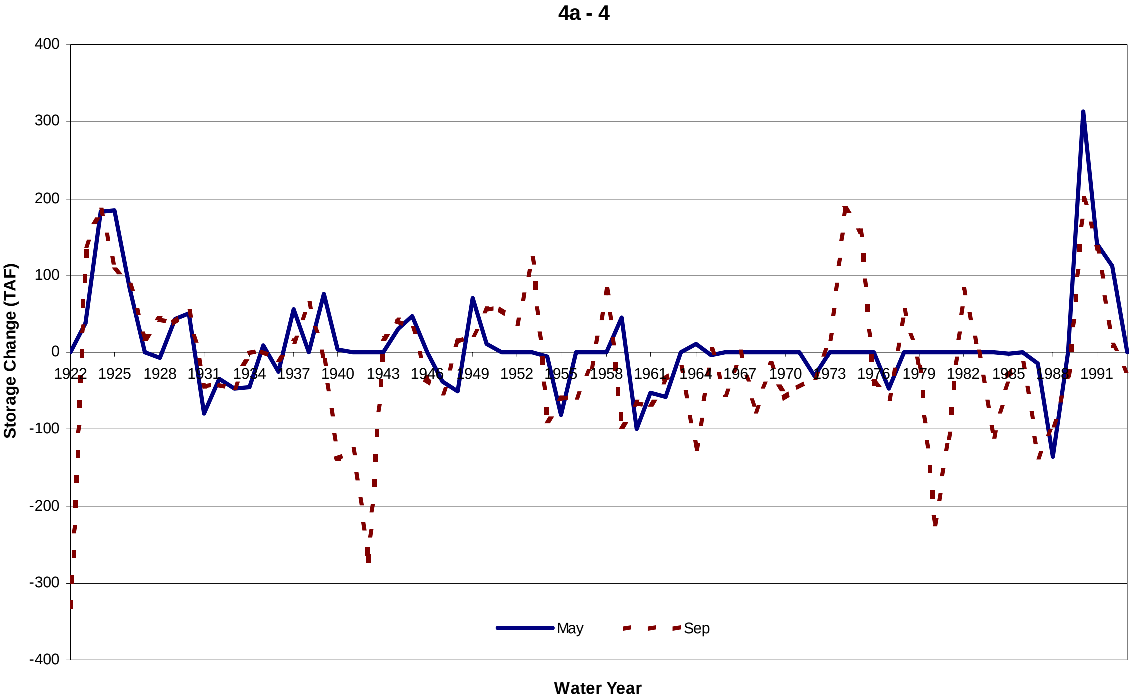


Figure 11-8 Chronology of Oroville End of May and September Storage differences between Studies 4a to 4

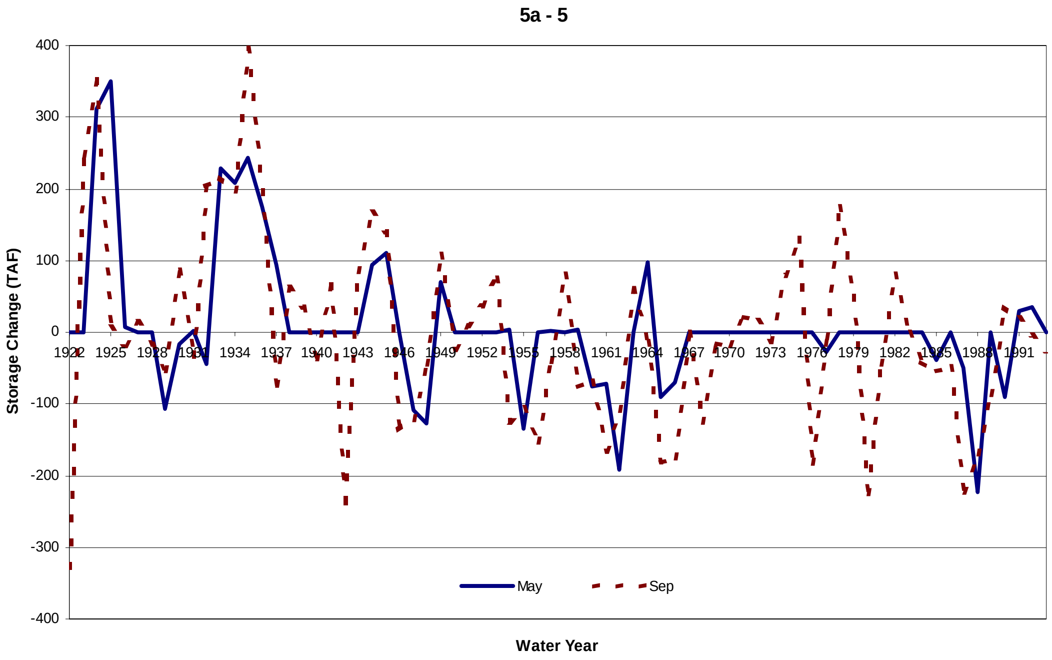


Figure 11-9 Chronology of Oroville End of May and September Storage differences between Studies 5a to 5

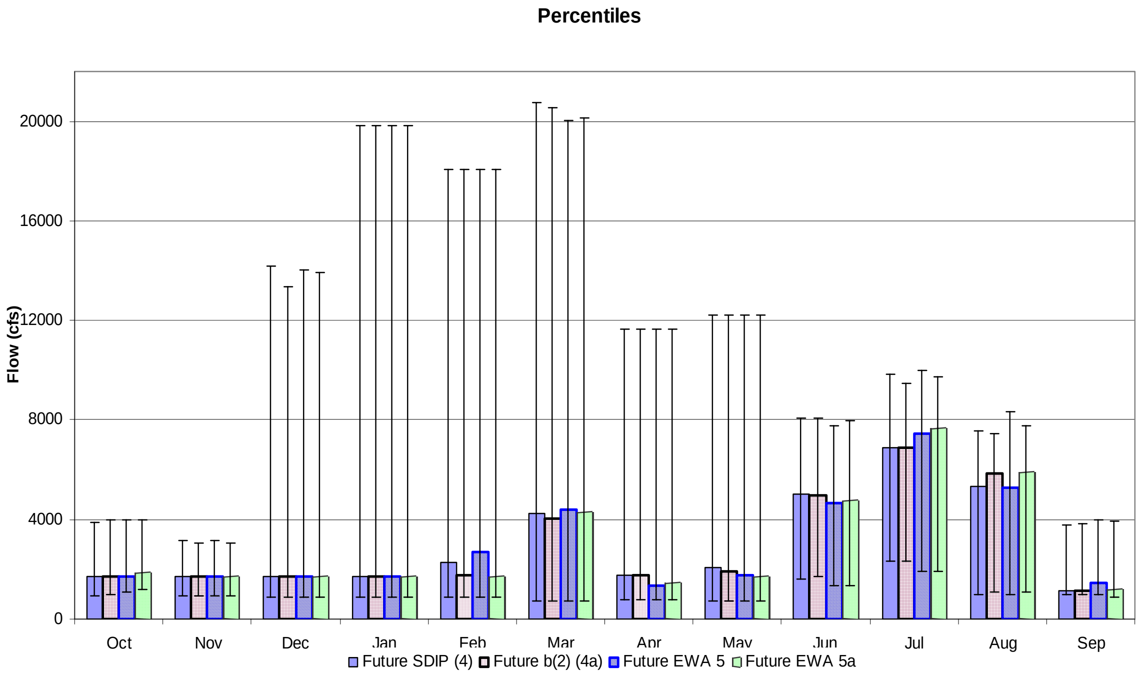


Figure 11-10 Feather River Flow Below Thermalito monthly percentiles the bars represent the 50th percentile and the whiskers the 5th and 95th percentile

Early Consultation

Figure 11-12 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 State's 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 11-12 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 11-13 shows that the 8,500 cfs Banks implementation seems to shift releases from winter months to the summer months. Table 11-6 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 11-6 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

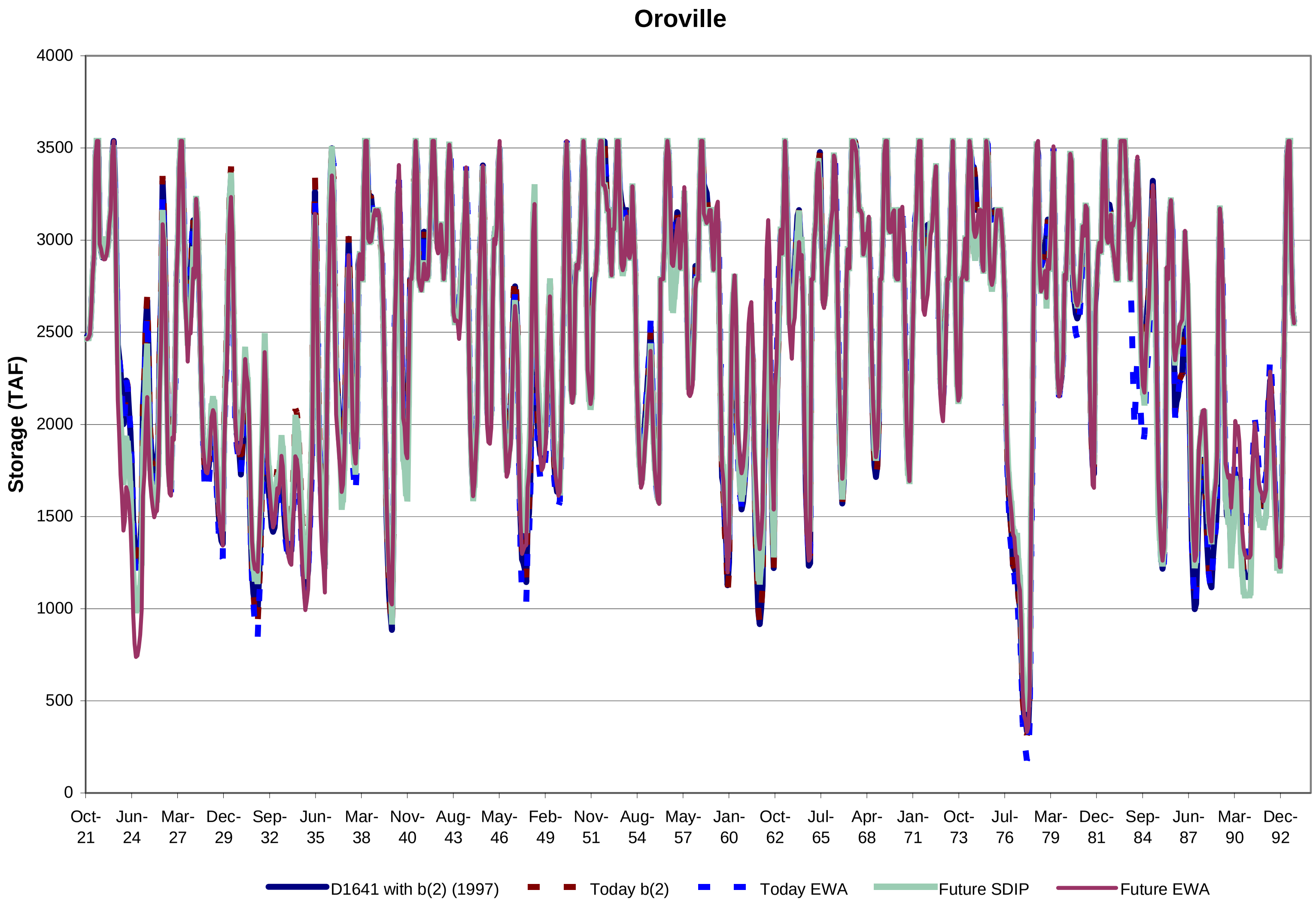


Figure 11-11 Chronology of Oroville Storage Water Year 1922 - 1993

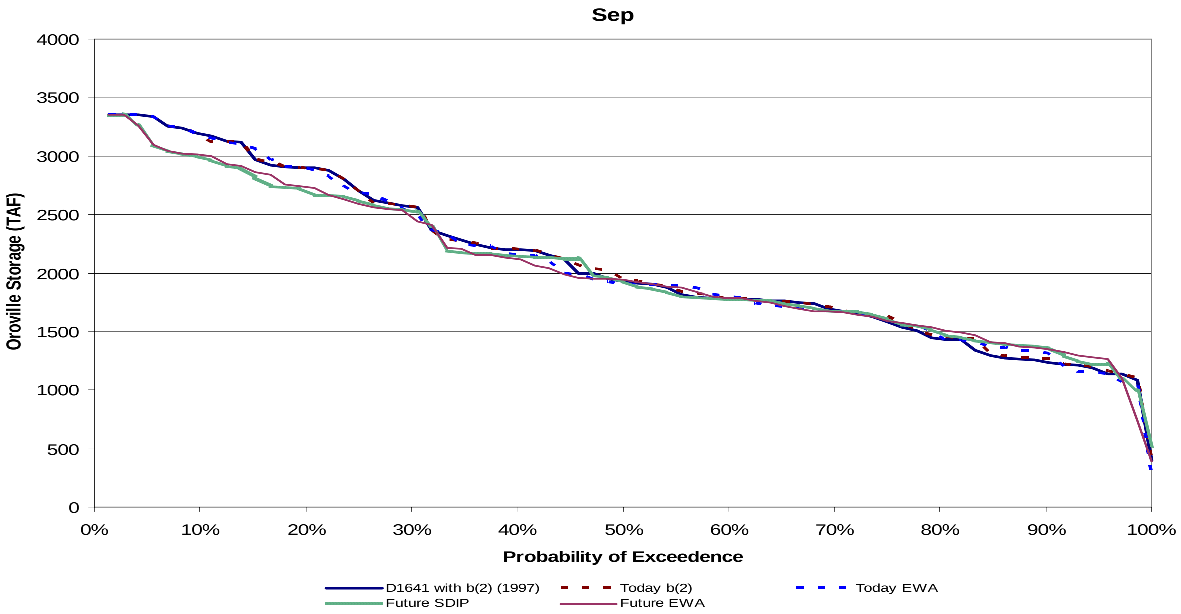


Figure 11-12 Oroville Reservoir End of September Exceedance

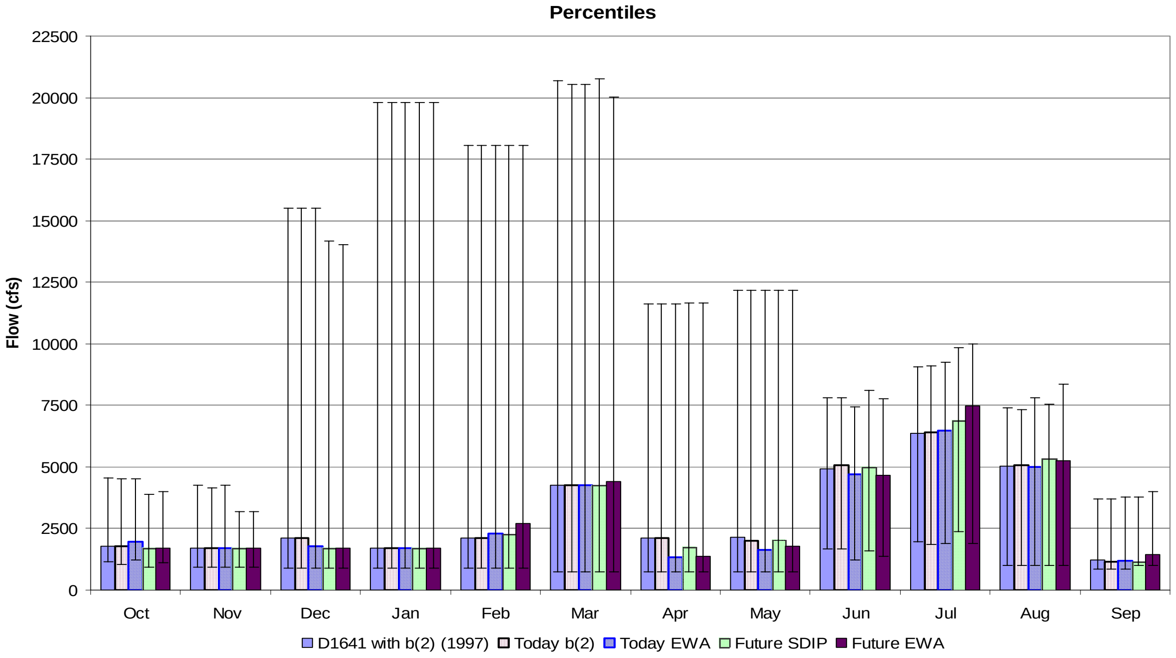


Figure 11-13 Flow Below Thermalito 50th Percentile Monthly Releases with the 5th and 95th as the bar

Table 11-7 Average and 40-30-30 Index Water Year type monthly Flow below Thermalito

Average	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Future SDIP (4)	2240	2084	3930	4810	5817	6147	3403	3854	4935	6667	4386	1835
Future b(2) (4a)	2221	2149	3727	4809	5734	6107	3392	3811	4912	6621	4793	1834
Future EWA 5	2379	2161	3686	4848	5984	6140	3233	3620	4599	6941	4681	1828
Future EWA 5a	2426	2151	3593	4769	5854	6162	3254	3663	4695	6909	4779	1844
Wet	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**
Future SDIP (4)	2428	2909	6966	10233	11967	12148	7033	7386	5897	7253	3700	1527
Future b(2) (4a)	2493	2906	6547	10278	11820	12097	7033	7389	5819	7153	3770	1590
Future EWA 5	2610	2911	6751	10498	12186	12165	6948	7394	5607	6962	4038	1647
Future EWA 5a	2758	2927	6434	10261	11961	12137	6948	7465	5649	7098	3745	1610
Above Normal	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**
Future SDIP (4)	2186	1782	3304	5078	7184	8910	2903	4560	4853	8359	4623	1728
Future b(2) (4a)	2170	1791	3201	5082	7081	9163	2888	4585	4816	8072	5814	1909
Future EWA 5	2325	1859	3077	4989	7422	8829	2618	4459	4305	8703	4859	1590
Future EWA 5a	2321	1751	3106	5012	7262	9046	2613	4453	4377	8584	5830	1710
Below Norma	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**
Future SDIP (4)	2364	1774	3073	3068	3717	3067	1482	2154	5732	7700	6181	2010
Future b(2) (4a)	2411	1911	2834	2893	3727	2970	1484	2116	5719	7654	6589	1820
Future EWA 5	2301	1970	2454	2902	3822	2971	1304	1564	5152	8565	6936	2009
Future EWA 5a	2462	2023	2391	2762	3824	3260	1378	1707	5432	8139	6996	2061
Dry	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**
Future SDIP (4)	2087	1587	2148	1518	1682	2352	2010	1832	4548	6244	5035	2000
Future b(2) (4a)	1917	1619	2211	1518	1557	2167	1971	1694	4621	6362	5421	2048
Future EWA 5	2321	1679	2179	1518	1742	2374	1688	1474	4415	6786	4740	2002
Future EWA 5a	2140	1678	2187	1518	1622	2125	1722	1435	4297	6887	5114	2021
Critical	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**
Future SDIP (4)	1998	1903	2387	1220	1520	1619	1399	1573	2720	3315	2252	2054
Future b(2) (4a)	1951	2103	2165	1347	1520	1619	1399	1514	2661	3350	2617	1939
Future EWA 5	2172	1949	2146	1252	1761	1701	1400	1387	2503	3460	2794	1905
Future EWA 5a	2261	1884	2185	1347	1656	1701	1400	1420	2807	3492	2491	1881

American River

In Figure 11-14 and Figure 11-15 the end of May storages are generally the same between Studies 4a to 4 and 5a to 5. The end of September storages generally show changes in just a single year and not changes over multiple years as was seen in Oroville and Shasta. The changes generally are increased storage in 4a and 5a when compared to 4 and 5. The increases in end of September storage generally occur due to increased flows in months of July and August, see Figure 11-16, for increased JPOD pumping, and for assisting Keswick releases that are being used for SWP COA requirements. The low impact May storages is from slight decreases in Nimbus releases in most months from September to March and the refill potential of Folsom.

Table 11-8 shows the monthly average releases from Nimbus and the monthly average releases by water year type. The table shows the same trend as Figure 11-16 with increases in July and August releases for each of the water year types on average. The only exception is in the critical years when do not always allow for additional increases for expanded JPOD pumping.

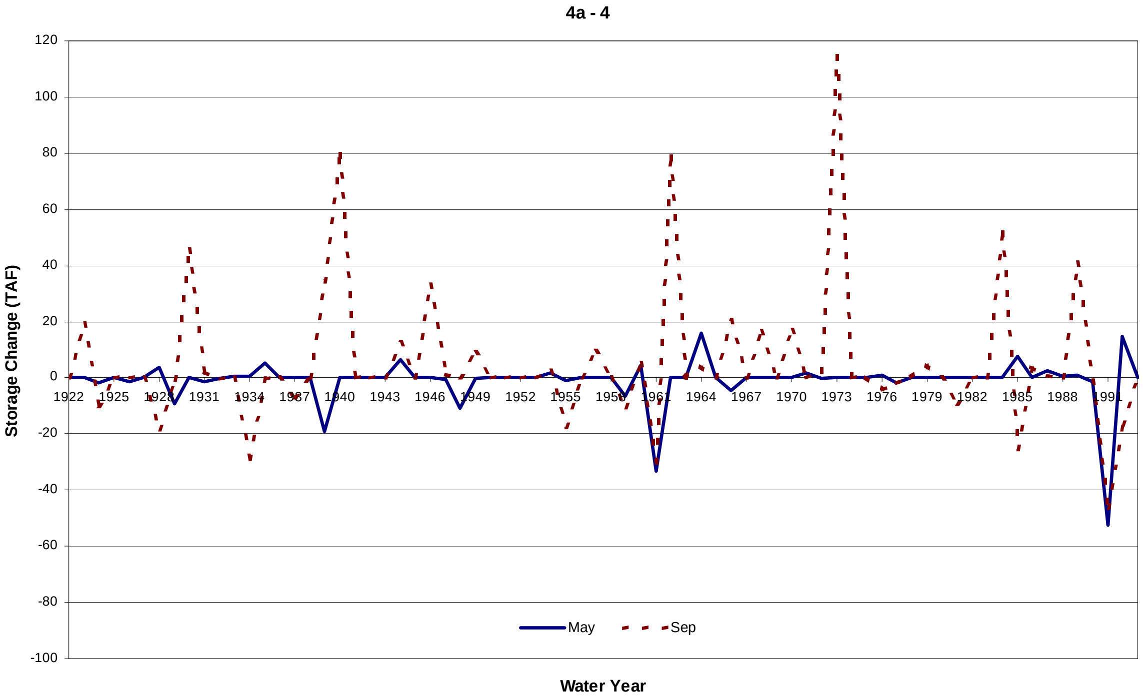


Figure 11-14 Chronology of Folsom End of May and September Storage differences between Studies 4a to 4

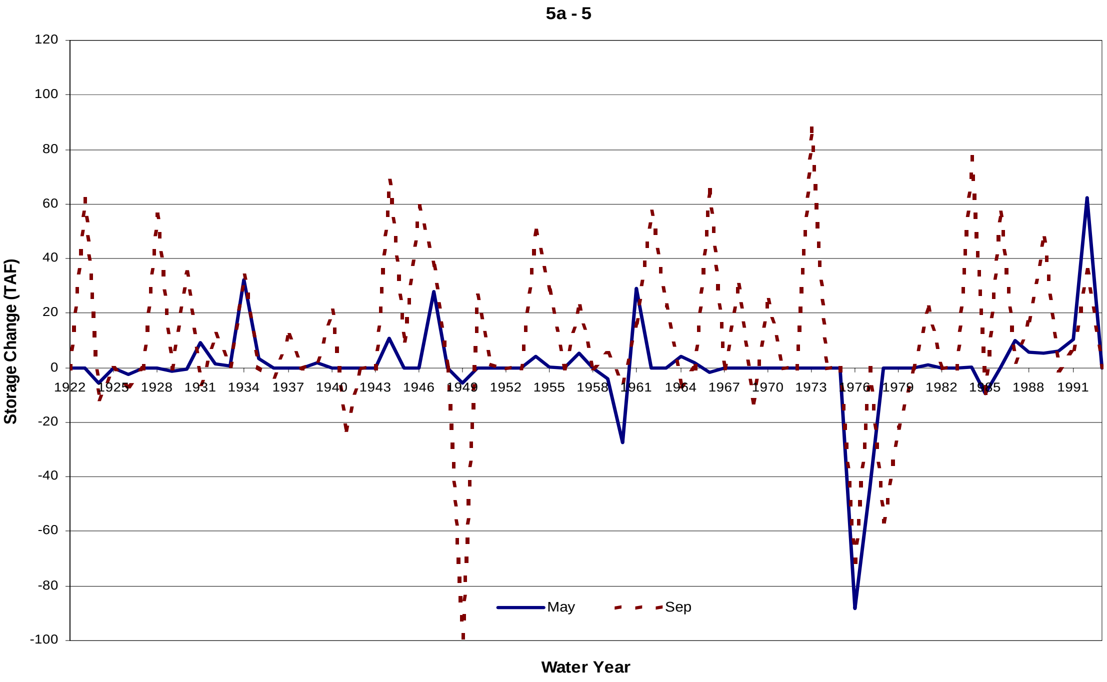


Figure 11-15 Chronology of Folsom End of May and September Storage differences between Studies 5a to 5

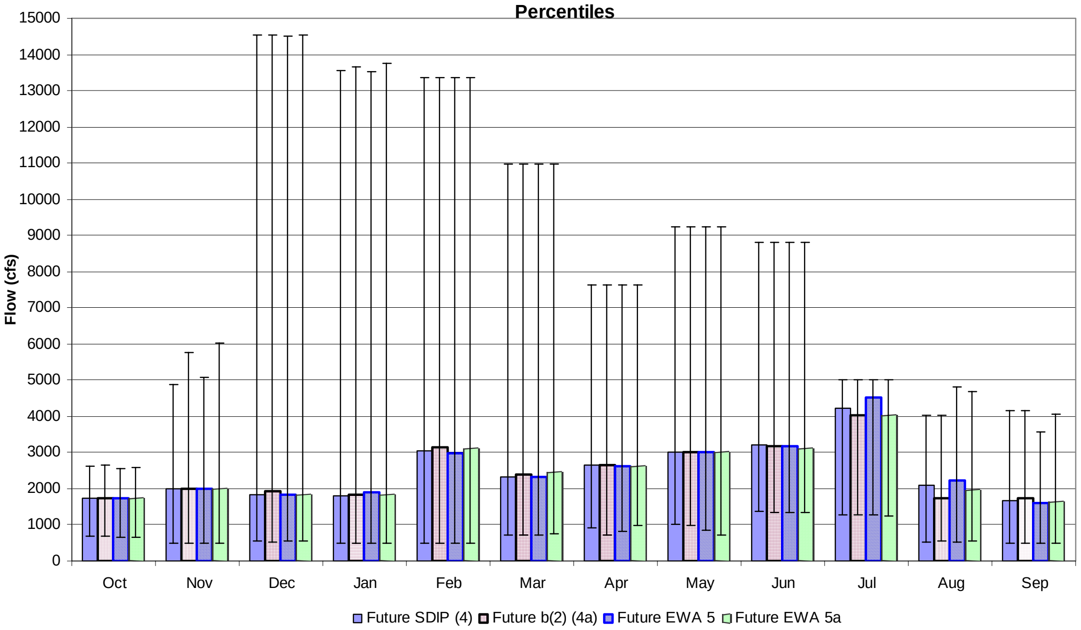


Figure 11-16 Nimbus Release monthly percentiles the bars represent the 50th percentile and the whiskers the 5th and 95th percentile

Table 11-8 Average and 40-30-30 Index Water Year type monthly Nimbus Release

Average	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Future SDIP (4)	1830	2503	3266	3965	4857	3621	3401	3546	3901	3772	2082	1988
Future b(2) (4a)	1813	2545	3288	3961	4900	3650	3393	3546	3869	3722	1963	2084
Future EWA 5	1798	2523	3270	3939	4862	3606	3365	3534	3808	3872	2341	1807
Future EWA 5a	1798	2553	3293	3951	4889	3675	3389	3525	3784	3725	2216	1927
Wet	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**
Future SDIP (4)	1835	3235	6097	8027	9084	5801	5388	5884	5782	4316	2967	3483
Future b(2) (4a)	1864	3375	6143	8028	9089	5806	5383	5884	5738	4265	2852	3640
Future EWA 5	1855	3246	6149	7970	9040	5803	5379	5881	5708	4445	3458	3007
Future EWA 5a	1883	3300	6262	7990	9089	5815	5368	5881	5706	4225	3296	3272
Above Normal	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**
Future SDIP (4)	1672	3281	3029	5148	6410	5926	3506	3798	4448	4511	2328	2150
Future b(2) (4a)	1645	3328	3065	5100	6445	5926	3505	3796	4292	4467	2185	2177
Future EWA 5	1572	3371	3020	5212	6330	5926	3513	3799	4216	4682	2341	2104
Future EWA 5a	1577	3338	2953	5273	6443	5926	3505	3802	4076	4423	2450	2078
Below Normal	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**
Future SDIP (4)	1944	2200	2636	2118	4194	2507	3192	3111	3494	4766	1946	1547
Future b(2) (4a)	1877	2115	2705	2192	4202	2515	3158	3114	3487	4692	1675	1697
Future EWA 5	1845	2083	2674	2086	4071	2449	3182	3133	3373	4813	2327	1356
Future EWA 5a	1899	2079	2648	2095	4041	2463	3182	3129	3374	4670	1931	1537
Dry	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**
Future SDIP (4)	1728	1781	1547	1487	1801	2156	2121	2359	3047	3188	1539	1089
Future b(2) (4a)	1728	1836	1493	1444	1831	2298	2119	2333	3046	3156	1453	1120
Future EWA 5	1757	1793	1528	1431	2033	2166	1947	2304	2964	3282	1692	1041
Future EWA 5a	1667	1942	1550	1436	1956	2316	2020	2298	2870	3245	1656	1080
Critical	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**
Future SDIP (4)	1965	1832	1374	1092	662	912	1641	1135	1572	1645	1133	855
Future b(2) (4a)	1911	1830	1395	1076	848	880	1645	1172	1602	1599	1174	924
Future EWA 5	1895	1990	1291	1094	673	867	1682	1110	1592	1701	1168	935
Future EWA 5a	1899	1903	1294	1059	800	1060	1761	1068	1700	1631	1120	947

Early Consultation

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 11-9. From Figure 11-18 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 11-19.

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 Environmental Impact Report/Environmental Impact Statement (EIR/EIS) has not been completed the representation of the American River in the Operating Criteria and Plan (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. Figure 11-20 shows the monthly percentile values for Nimbus releases.

Table 11-9. 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

	D1641 with (b)(2) (1997)		Today (b)(2)		Today EWA		Future SDIP		Future EWA	
	Average	**Dry**	**Average**	**Dry**	**Average**	**Dry**	**Average**	**Dry**	**Average**	**Dry**
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**

Notes:

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

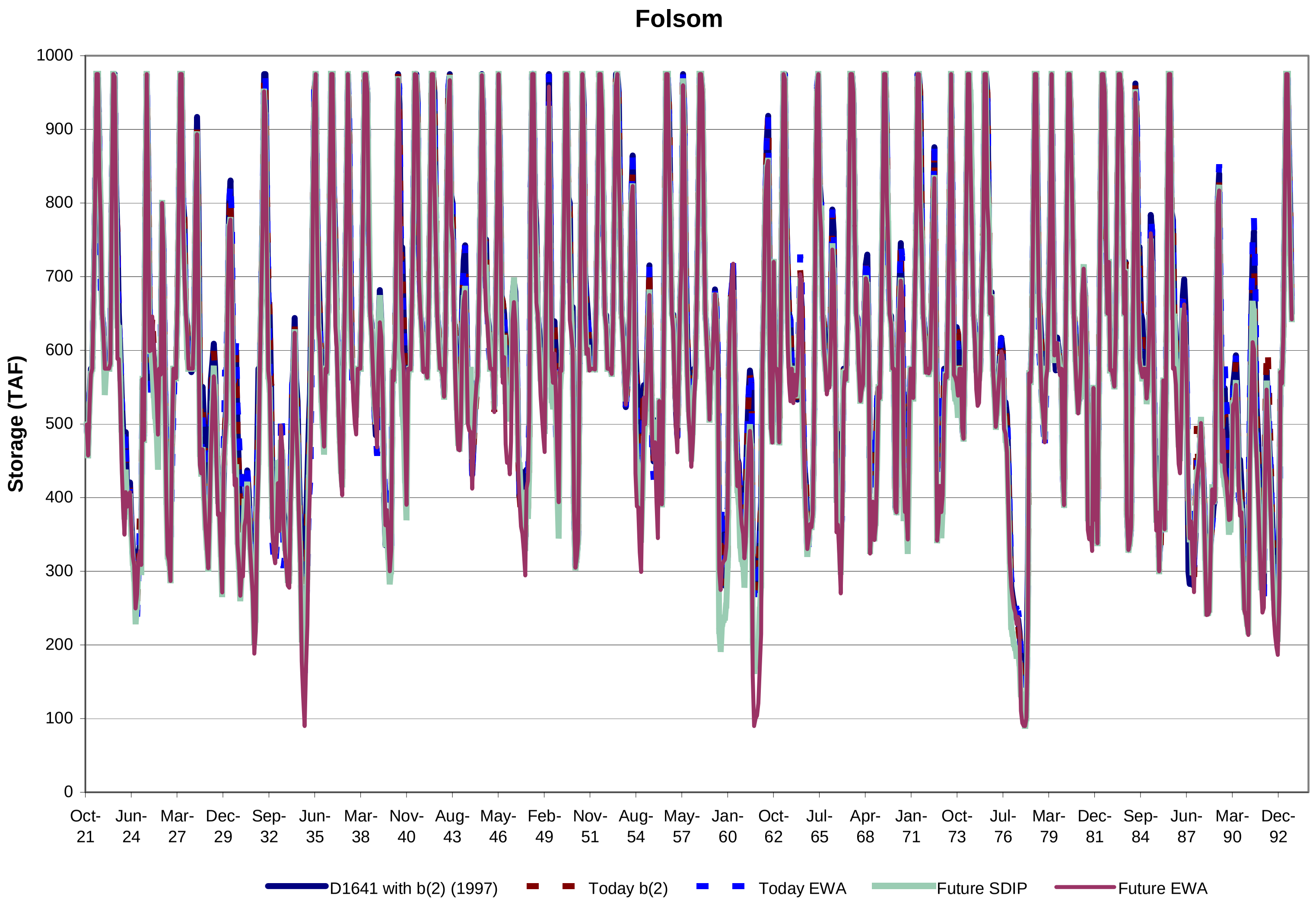


Figure 11-17. Chronology of Folsom Storage Water Year 1922 - 1993

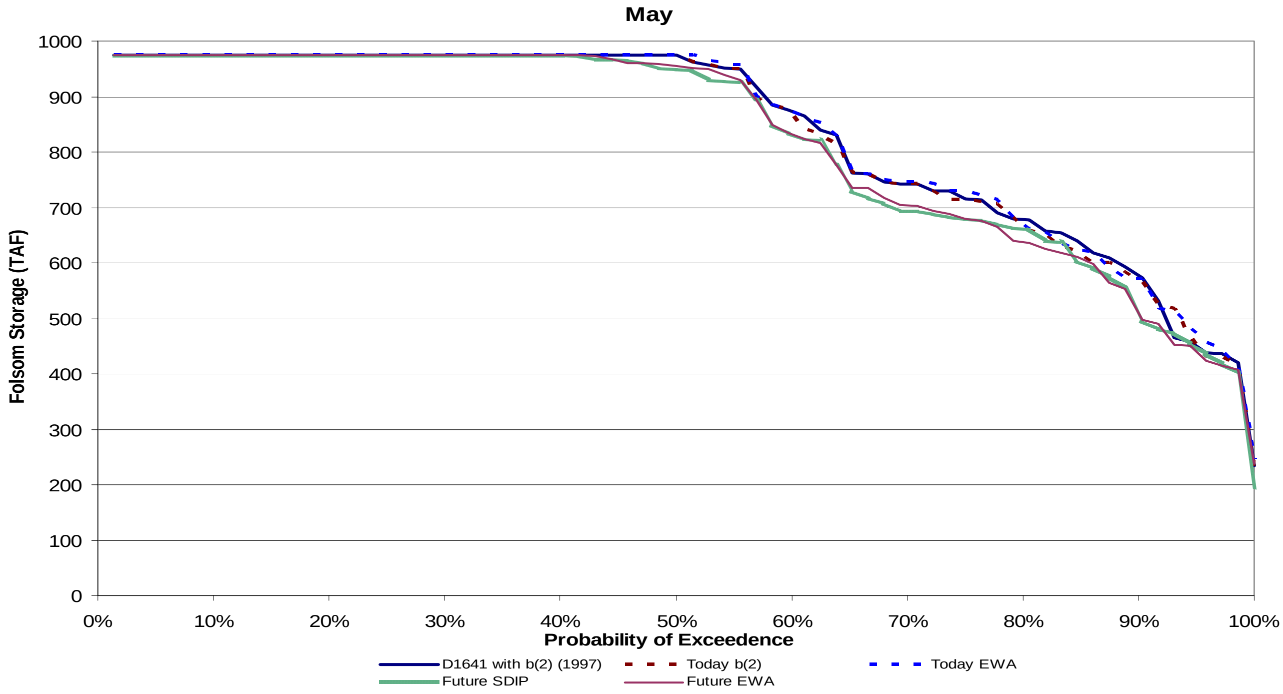


Figure 11-18 Folsom Reservoir End of May Exceedance

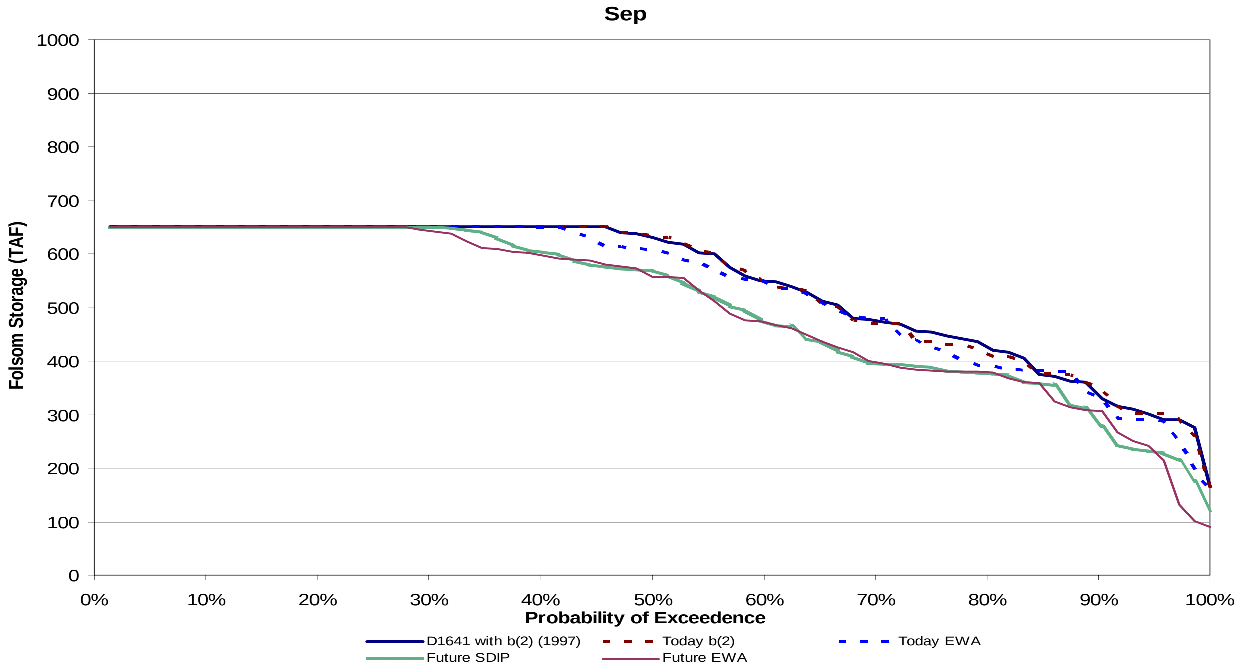


Figure 11-19 Folsom Reservoir End of September Exceedance

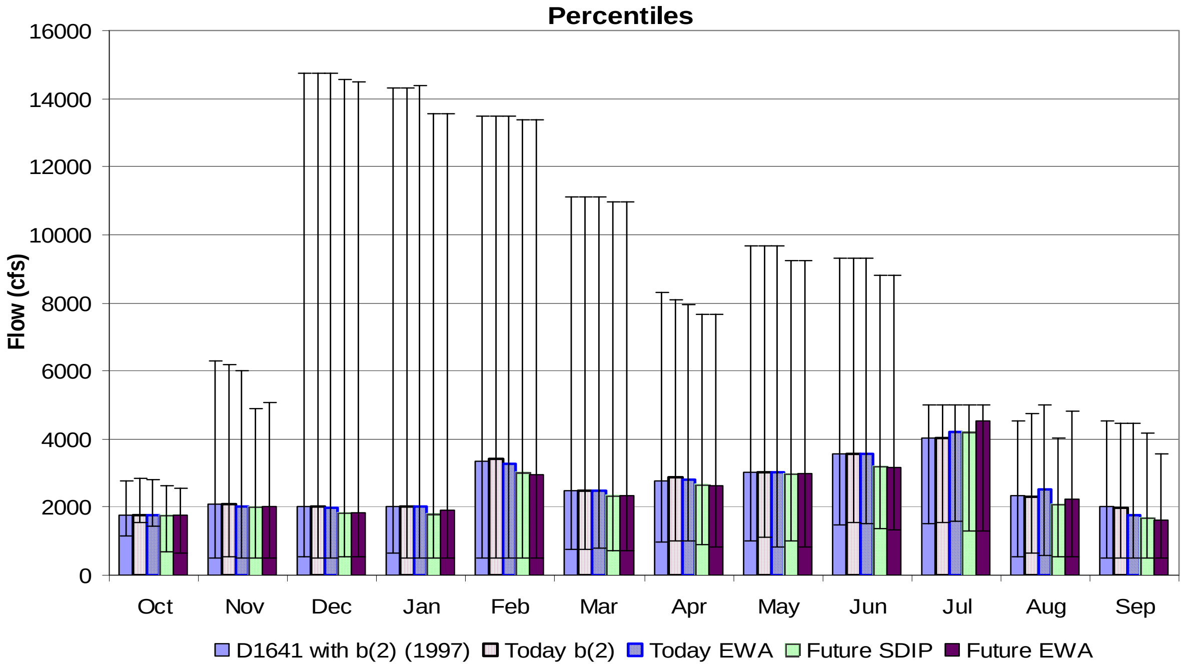


Figure 11-20 Nimbus Release 50th Percentile Monthly Releases with the 5th and 95th as the bars

Stanislaus River

There are no effects to the New Melones Reservoir storage or releases to the river in Studies 4a to 4 and 5a to 5 since the operations are the same in all seven studies. For analysis see Chapter 9 in this document.

Delta Effects

The changes in assumptions between Studies 4 and 4a and between Studies 5 and 5a include the SDIP with Banks pumping plant capacity at 8,500 cfs in 4 and 5 and 6,680 cfs in 4a and 5a. One other change to the assumptions is the dedication of 100 taf of diversion capability at Banks Pumping Plant for Refuge Level 2 water; 30 taf of capacity is assumed to be made available in July and 70 taf in August. This section examines the impacts to Delta Inflow, Delta Outflow, Exports (Tracy, SWP Banks, and CVP Banks), X2 and Export/Import (E/I) Ratio.

Delta Inflow

Figure 11-21 shows the differences in annual Delta Inflows between 4a and 4 and between 5a and 5. Between Studies 4a and 4 there are no significant yearly changes in inflow with the exception of the 1923 inflow. The differences between Study 5a and 5 are of greater magnitude than those between 4a and 4 due to EWA actions. On average the non-SDIP studies (4a and 5a) have about 7 to 8 taf more inflow to the Delta due to the increase in flows from higher carryover storage, see Table 11-10. From Table 11-10 the greatest impacts occur in Above Normal years with less inflow of 60 taf and 57 taf between 4a and 4 and between 5a and 5 respectively; The changes in critical years are 31 taf less flow from 4a to 4 and 32 taf from 5a to 5.

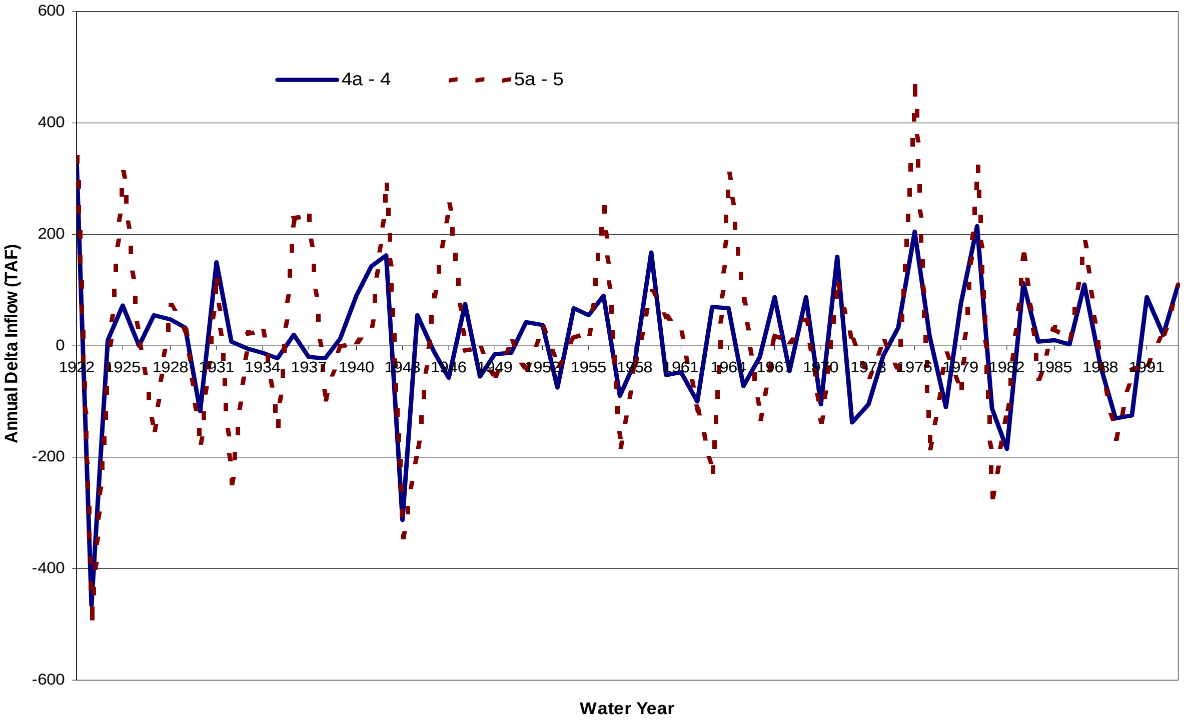


Figure 11-21 Chronology of differences in annual (Oct-Sep) Delta inflow between Studies 4a to 4 and 5a to 5

Table 11-10 Long-term average and 40-30-30 index water year type annual averages

40-30-30 Index	Future SDIP (4)	Future b(2) (4a)	4a - 4	Future EWA 5	Future EWA 5a	5a - 5
Average	20870	20877	7	20867	20875	8
Wet	34484	34495	11	34479	34471	-8
Above Normal	23858	23918	60	23803	23860	57
Below Normal	16808	16759	-49	16721	16718	-2
Dry	12833	12833	-1	12863	12853	-10
Critical	9023	9054	31	9131	9163	32

From Figure 11-22, focusing in on the 50th percentile, the months with the biggest change in flow between the Studies 4 and 5 versus Studies 4a and 5a are the late summer flows with increases in inflow in Studies 4 and 5 due to releases being higher for increased export capacity at Banks.

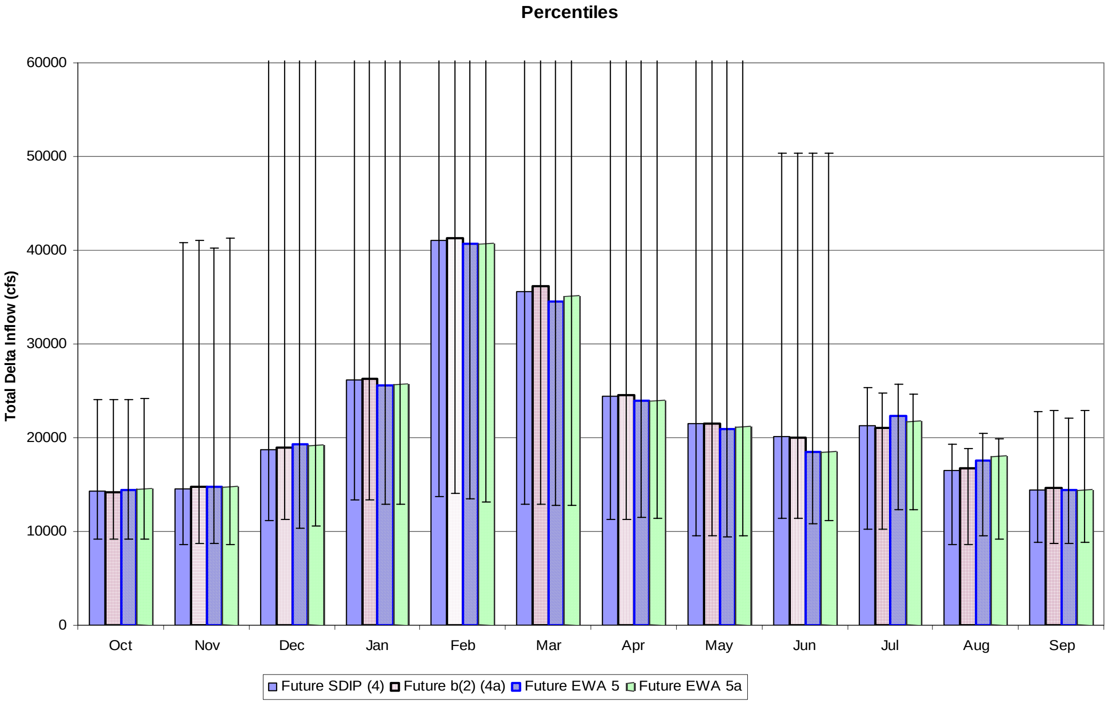


Figure 11-22 Delta inflow monthly percentiles the bars represent the 50th percentile and the whiskers the 5th and 95th percentile

Delta Outflow

From Figure 11-23 the annual Delta outflow trend higher in Studies 4a and 5a versus Studies 4 and 5 due to the increase in pumping and the Delta inflow being, on an annual basis very similar. Table 11-11 shows the long-term average difference in outflow 129 taf higher in 4a versus 4 and 123 taf higher in 5a versus 5. Wet years show the most amount of impact to outflow from Studies 4a to 4 and 5a to 5. The dry and critical differences in 4a to 4 being higher than in 5a to 5 are due to EWA making the pumping in the spring more uniform between Studies 5 and 5a.

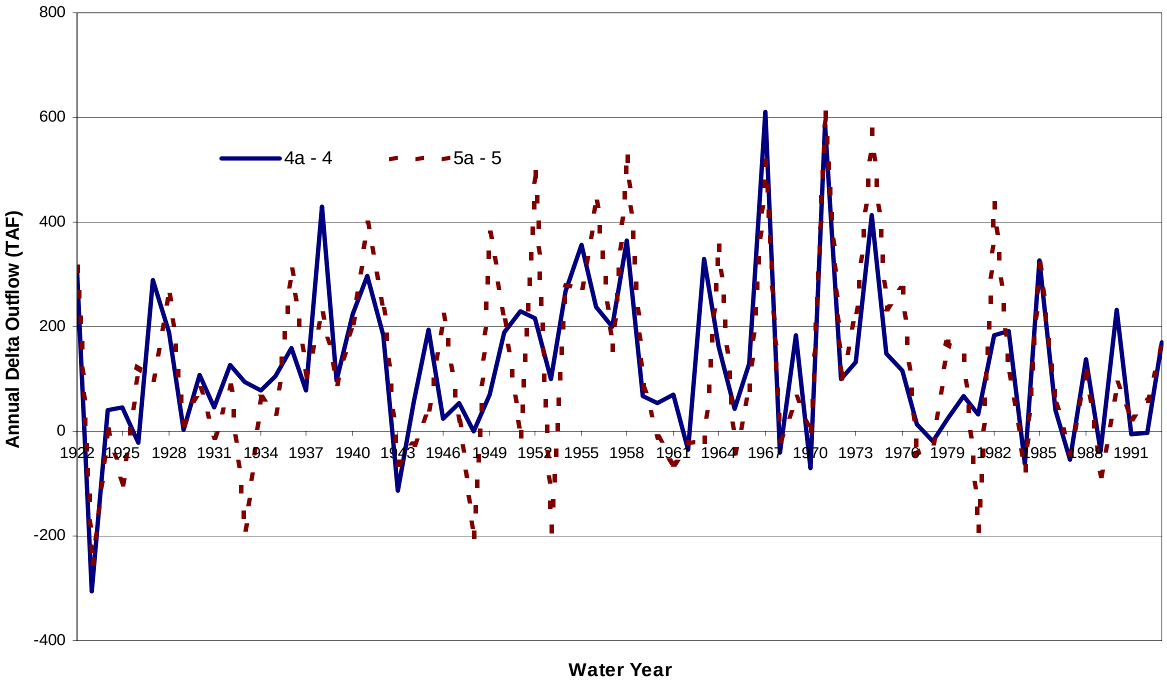


Figure 11-23 Chronology of differences in annual (Oct-Sep) Delta outflow between Studies 4a to 4 and 5a to 5

Table 11-11 Long-term average and 40-30-30 index water year type annual averages for Delta Outflow

40-30-30 Index	Future SDIP (4)	Future b(2) (4a)	4a - 4	Future EWA 5	Future EWA 5a	5a - 5
Average	13864	13993	129	14017	14140	123
Wet	26410	26629	219	26628	26848	220
Above Normal	16168	16345	177	16334	16507	173
Below Normal	9285	9335	50	9417	9479	62
Dry	6342	6433	91	6475	6551	76
Critical	4588	4656	69	4659	4695	36

From Figure 11-24 months with the most frequent reductions in outflow between Studies 4a and 4 and between 5a and 5 are December to March due to more aggressive delivery targets in Studies 4 and 5. The late summer 50th percentiles are virtually identical, because the increased pumping during that time is being offset by more Delta inflow, see Figure 11-22.

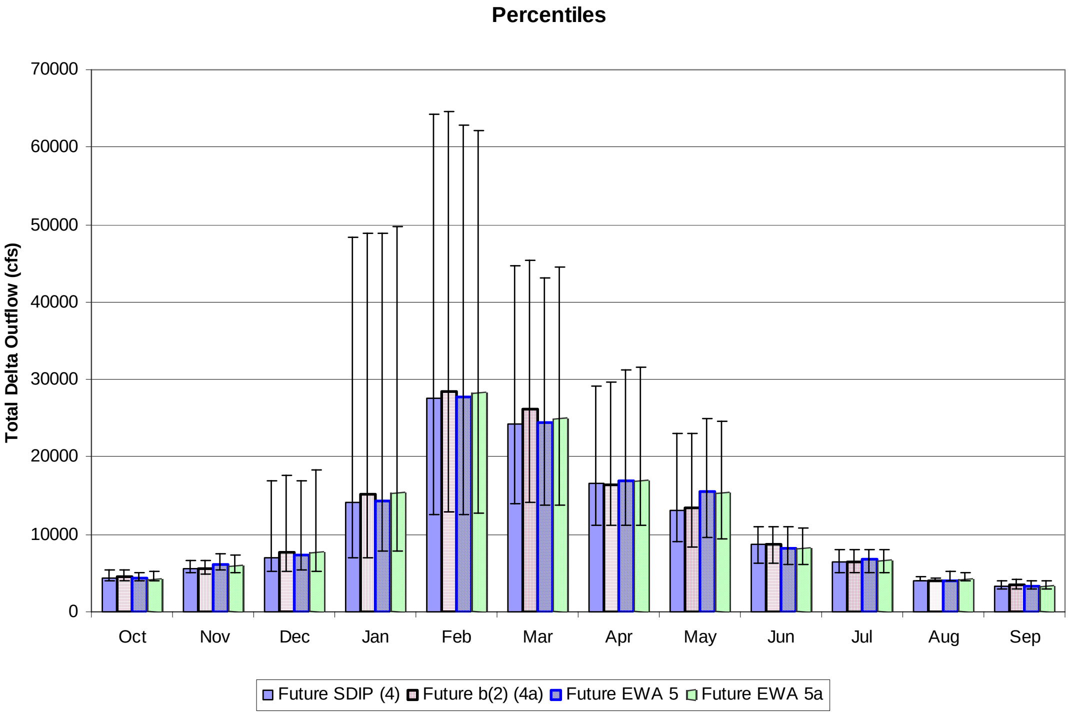


Figure 11-24 Delta outflow monthly percentiles the bars represent the 50th percentile and the whiskers the 5th and 95th percentile

Exports

The exports section will review the impacts to the early versus formal consultation studies for Tracy, SWP Banks, and CVP Banks.

Tracy

On annual basis, Tracy pumping between Study 4a to 4 shows no significant difference, see Figure 11-25. The maximum difference comes in water year 1957 when Study 4 pumps 135 taf more than 4a. Outside of that year, the annual difference never exceeds 100 taf between 4a and 4. From Figure 11-25 the difference in 5a to 5 being more extreme than in 4a to 4 are due to better San Luis storages in the CVP portion in Study 5 due to increased ability to pumping JPOD in the 8,500 cfs EWA scenario.

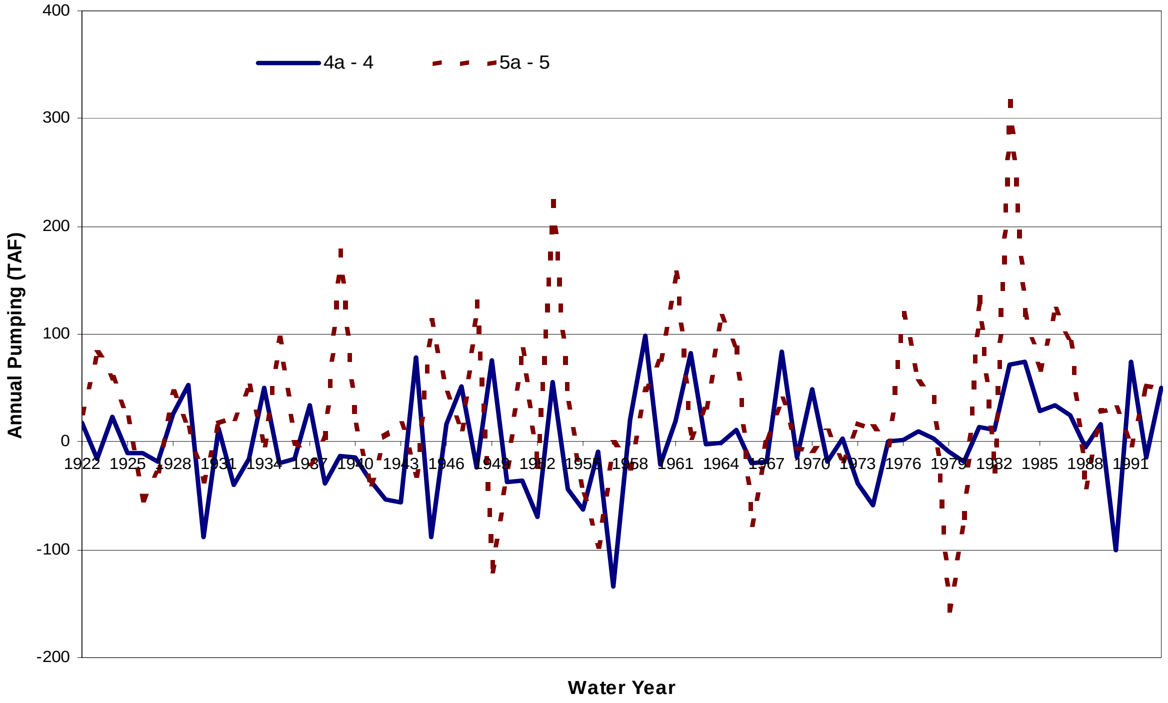


Figure 11-25 Chronology of differences in annual (Oct-Sep) Tracy pumping between Studies 4a to 4 and 5a to 5

Table 11-12 shows the annual average Tracy pumping. Between 4a to 4 on an average basis the differences are minor long-term and by-water-year type. Comparing 5a to 5, the annual pumping in 5a was higher on average with dry years averaging 39 taf more than in 5.

Table 11-12 Long-term Average and 40-30-30 Index water year type annual averages for Tracy Pumping

40-30-30 Index	Future SDIP (4)	Future b(2) (4a)	4a - 4	Future EWA 5	Future EWA 5a	5a - 5
Average	2406	2406	0	2307	2338	30
Wet	2753	2749	-3	2651	2684	34
Above Normal	2688	2669	-19	2582	2606	25
Below Normal	2547	2554	6	2463	2482	19
Dry	2278	2282	4	2159	2197	39
Critical	1497	1505	8	1421	1453	32

The major change in monthly pumping occurs in August to October between 5a and 5 when CVP San Luis has more water in 5 in the late summer than in 5a, see 50th percentiles in Figure 11-26. There is no significant change in monthly pumping between 4 and 4a looking at Figure 11-26.

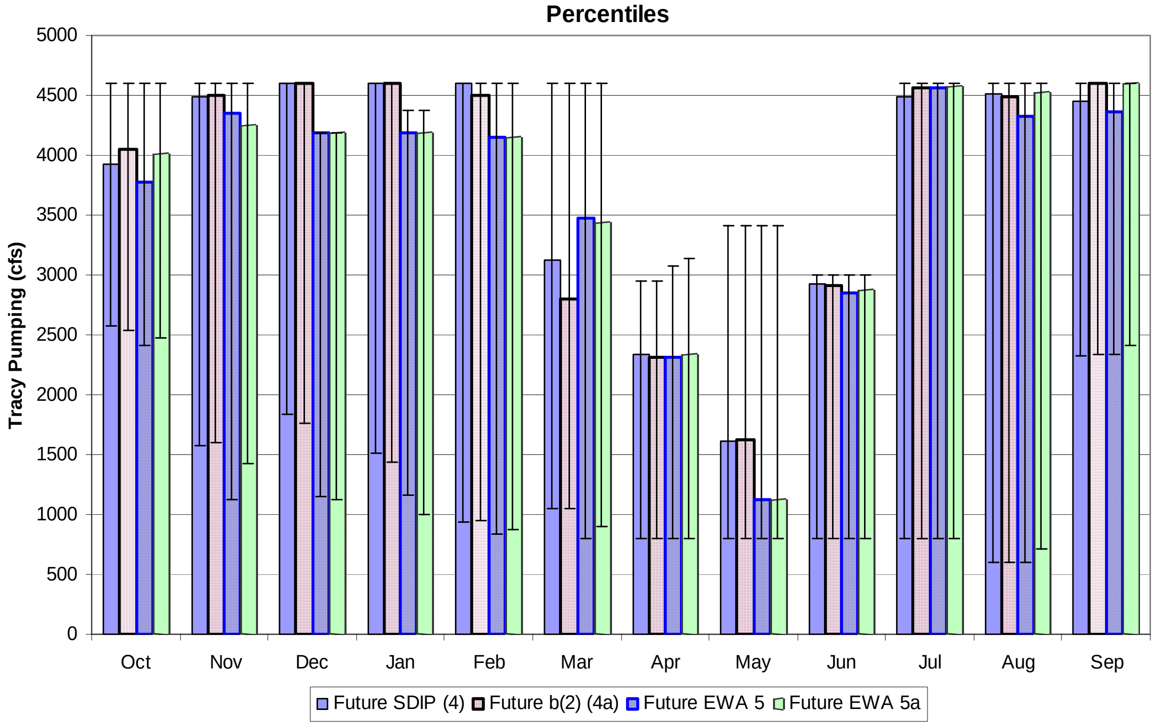


Figure 11-26 Tracy Pumping monthly percentiles the bars represent the 50th percentile and the whiskers the 5th and 95th percentile

State Banks

Figure 11-27 shows more pumping in Studies 4 and 5 than 4a and 5a on an annual basis. Study 4 is the most aggressive and the differences between 4 and 4a are greater on an average basis, 84 taf long term, than the 57 taf between 5 and 5a, see Table 11-13. Dry years show the highest difference in annual pumping between the below normal, dry, and critical year types with 4 and 5 pumping more than 4a and 5a by 92 taf and 86 taf, respectively. During critical years Study 4 pumps 42 taf more than 4a and Study 5 pumps 9 taf less than 5a.

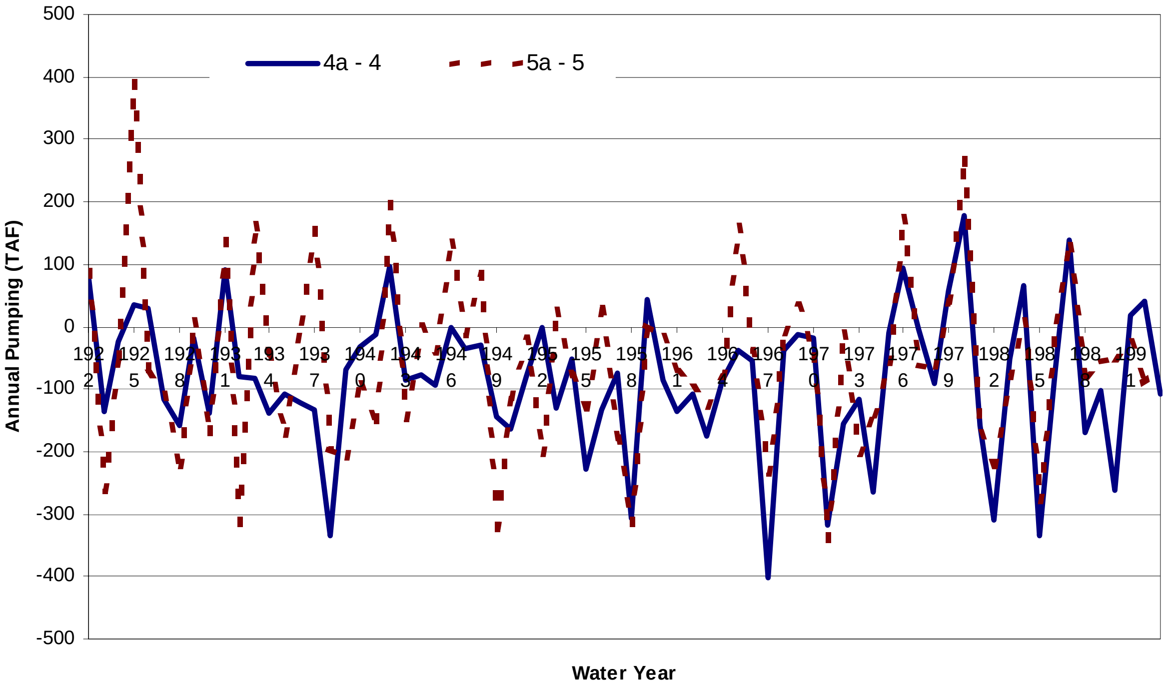


Figure 11-27 Chronology of differences in annual (Oct-Sep) State Banks Pumping between Studies 4a to 4 and 5a to 5

Table 11-13 Long-term average and 40-30-30 index water-year type annual averages for State Banks Pumping

40-30-30 Index	Future SDIP (4)	Future b(2) (4a)	4a - 4	Future EWA 5	Future EWA 5a	5a - 5
Average	3381	3297	-84	3185	3128	-57
Wet	4304	4179	-125	4041	3951	-91
Above Normal	3905	3859	-46	3687	3630	-57
Below Normal	3630	3555	-74	3403	3381	-22
Dry	2856	2764	-92	2726	2640	-86
Critical	1591	1549	-42	1482	1491	9

The major difference in monthly pumping is a result of the increased capacity of 8,500 cfs of studies 4 and 5 versus the 6,680 cfs in Studies 4a and 5a. From Figure 11-28, the 95th percentiles increase in the months of June through November due to the increased capacity. In all 4 studies, from December 15th to March 15th the pumping rates are capped at stated Banks capacity plus one-third of the flow at Vernalis.

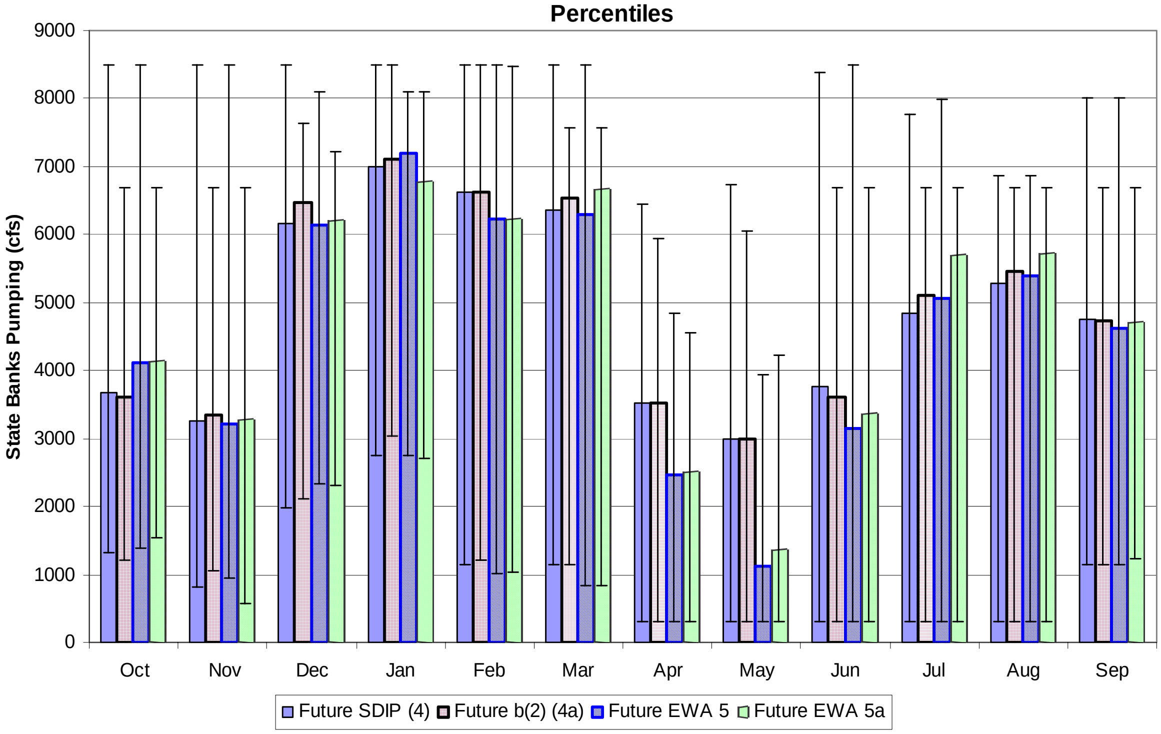


Figure 11-28 State Banks monthly percentiles the bars represent the 50th percentile and the whiskers the 5th and 95th percentile

Federal Banks

Studies 4 and 5 show consistently higher pumping at Federal Banks, use of JPOD, than Studies 4a and 5a respectively. The higher pumping is due to the increase in capacity at Banks in Studies 4 and 5, and the dedicated 100 TAF of pumping at Banks for the CVP. Figure 11-30 shows the average annual pumping at Federal Banks with the different pumping needs broken out. Study 4a has the least pumping since it is pumping only for Cross Valley Contractors while Study 5 has the most pumping with the addition of dedicated capacity and half the excess capacity at Banks being used for wheeling water for the CVP. Studies 4 and 5 show 37 taf and 36 taf annual average pumping of the dedicated 100 taf respectively. Table 11-14 shows the long-term annual average and the water year type annual average Federal pumping at Banks. The largest difference is in the wet years when the increased capacity at Banks allows for more excess flow in the Delta to be picked up.

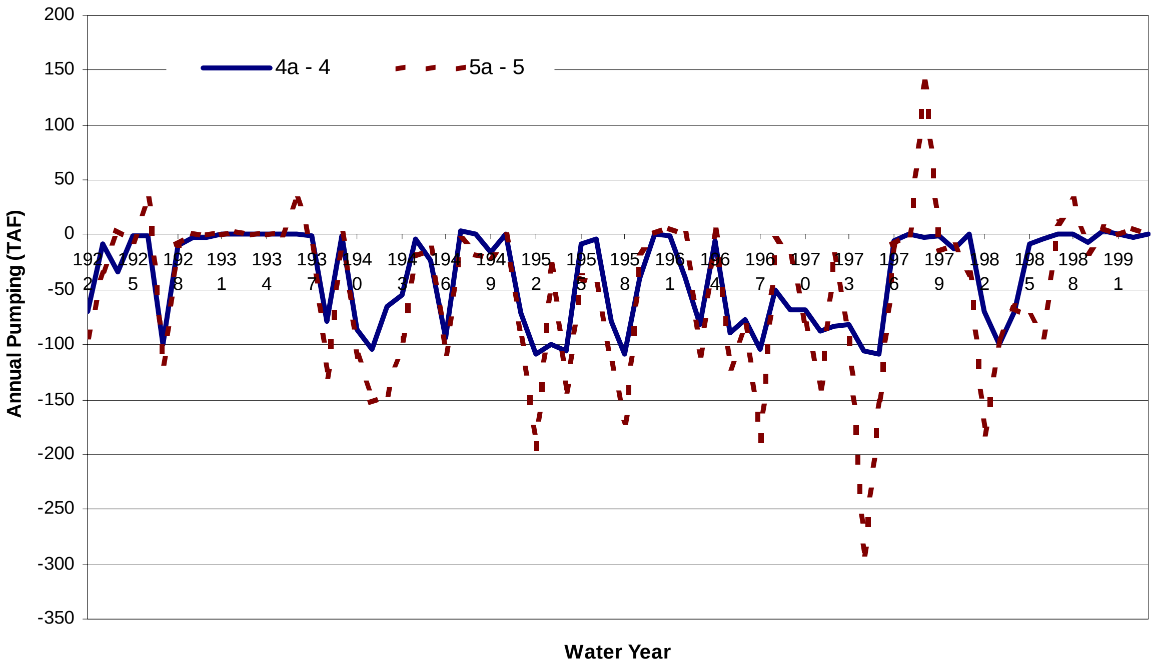
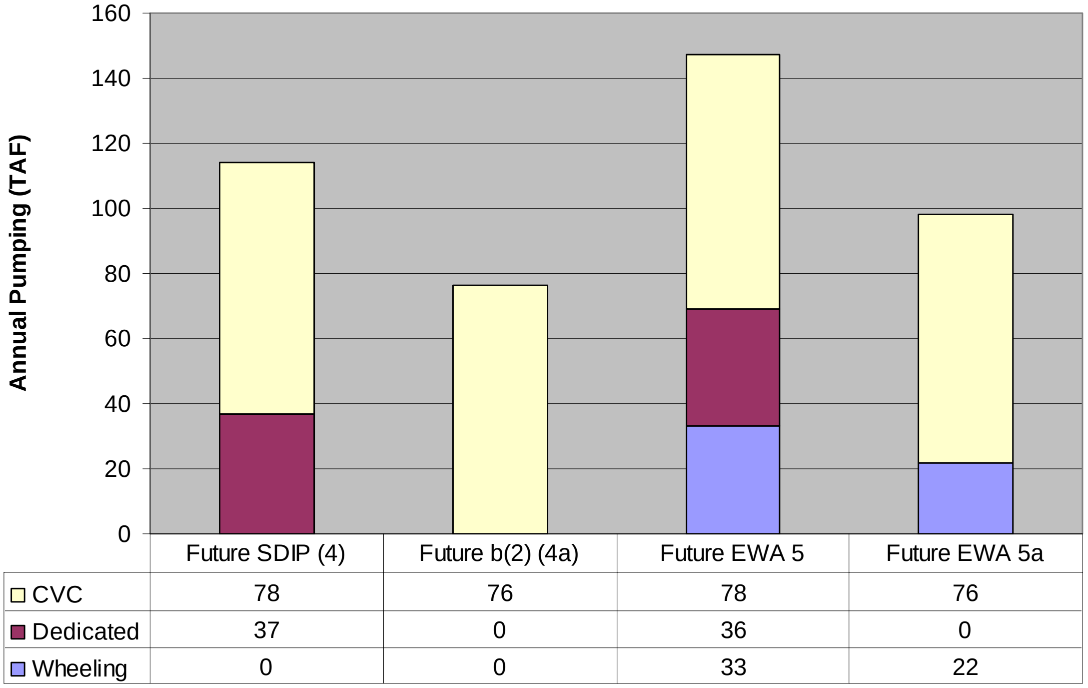


Figure 11-29 Chronology of differences in annual (Oct-Sep) Federal Banks Pumping between Studies 4a to 4 and 5a to 5



	Future SDIP (4)	Future b(2) (4a)	Future EWA 5	Future EWA 5a
□ CVC	78	76	78	76
■ Dedicated	37	0	36	0
■ Wheeling	0	0	33	22

Figure 11-30 Annual average Federal Banks Pumping

Table 11-14 Long-term average and 40-30-30 index water-year type annual averages for Federal Banks Pumping

40-30-30 Index	Future SDIP (4)	Future b(2) (4a)	4a - 4	Future EWA 5	Future EWA 5a	5a - 5
Average	112	75	-37	145	97	-49
Wet	137	56	-80	225	101	-124
Above Normal	134	82	-52	156	102	-53
Below Normal	139	109	-30	139	119	-20
Dry	102	100	-3	116	106	-9
Critical	26	22	-3	35	39	4

From Figure 11-31 the months that are impacted by the increased capacity are July and August where the 50th percentiles are higher in Studies 4 and 5 than in 5a and 5a. Oct and November see spikes in the 95th percentile in Studies 4 and 5.

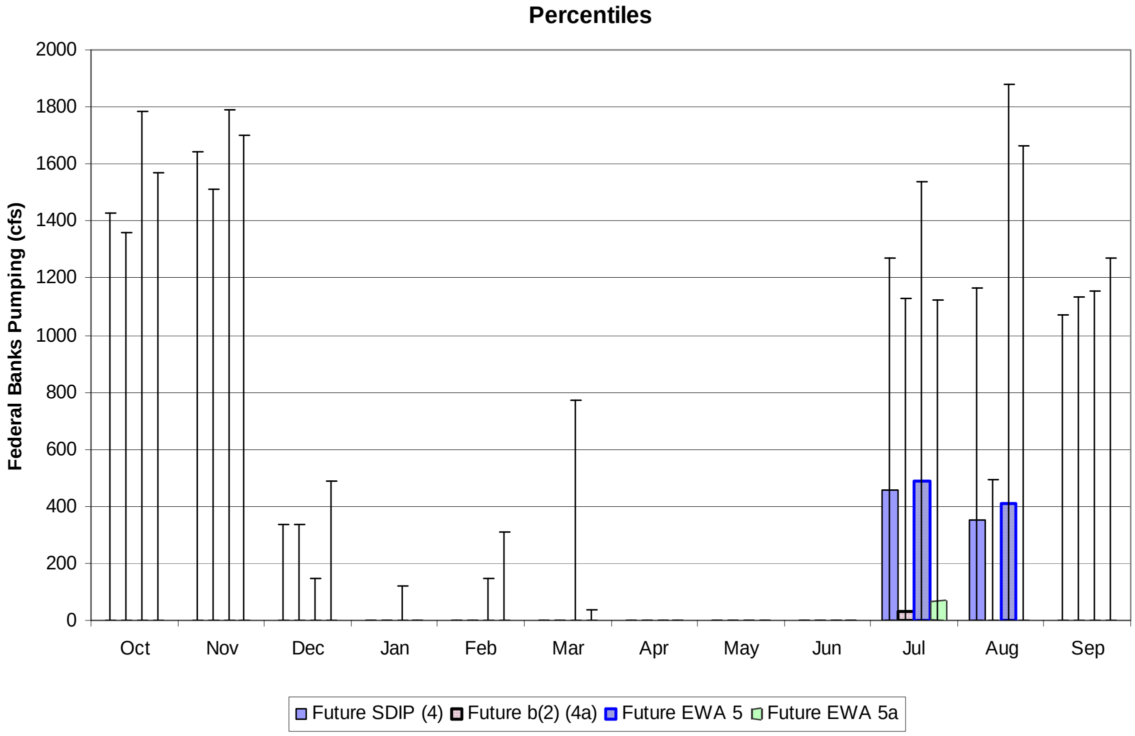


Figure 11-31 Federal Banks monthly percentiles the bars represent the 50th percentile and the whiskers the 5th and 95th percentile

Early versus Formal Losses to Entrainment by CVP and SWP Export Facilities

The following tables show the difference in numbers of fish lost at the Delta export facilities depending on whether or not the SDIP with an 8,500 cfs pumping limit at the SWP is implemented. The numbers displayed are the estimated change in numbers of fish lost when the pumping limit is increased from 6,680 cfs to 8,500 cfs at Banks for the given comparison. For example, for the first item the number displayed is (2 vs. 4 change in loss) – (2 vs. 4a change in loss).

Differences in number of fish when pumping is 8,500 cfs vs. 6,680 cfs (8,500 minus 6,680)											
	Critical Year Type										
Banks	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Overall**
2 vs. 4 change in loss												
Winter-run number	0	0	45	106	27	100	0	0	0	0	0	279
Spring-run number	0	0	0	0	0	45	-4	108	0	0	0	150
Steelhead number	0	-2	2	43	15	30	0	6	-1	0	0	93
3 vs. 5 change in loss												
Winter-run number	0	0	-28	-5	90	35	0	0	0	0	0	91
Spring-run number	0	0	0	0	0	16	5	-111	-1	0	0	-91
Steelhead number	0	0	-1	-2	49	11	0	-6	-6	0	0	45
1 vs. 5 change in loss												
Winter-run number	0	0	-28	-5	90	35	0	0	0	0	0	91
Spring-run number	0	0	0	0	0	16	5	-111	-1	0	0	-91
Steelhead number	0	0	-1	-2	49	11	0	-6	-6	0	0	45

Differences in number of fish when pumping is 8,500 cfs vs. 6,680 cfs (8,500 minus 6,680)												
	Critical Year Type											
Tracy	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Overall**
2 vs. 4 change in loss												
Winter-run number	0	0	33	0	-45	-24	-5	0	0	0	0	-40
Spring-run number	0	0	0	0	0	-11	-220	57	0	0	0	-174
Steelhead number	0	1	2	0	-25	-7	-12	3	0	0	0	-38
3 vs. 5 change in loss												
Winter-run number	0	0	-11	5	-40	-98	-1	0	0	0	0	-145
Spring-run number	0	0	0	0	0	-44	-60	-12	0	0	0	-116
Steelhead number	0	0	-1	2	-22	-29	-3	-1	-1	0	0	-55
1 vs. 5 change in loss												
Winter-run number	0	0	-11	5	-40	-98	-1	0	0	0	0	-145
Spring-run number	0	0	0	0	0	-44	-60	-12	0	0	0	-116
Steelhead number	0	0	-1	2	-22	-29	-3	-1	-1	0	0	-55

Differences in number of fish when pumping is 8,500 cfs vs. 6,680 cfs (8,500 minus 6,680)

	Dry Year Type										
Banks	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Overall**
2 vs. 4 change in loss												
Winter-run number	0	0	58	99	92	89	-5	1	0	0	0	334
Spring-run number	0	0	0	0	0	40	-218	250	0	0	0	72
Steelhead number	0	2	3	40	50	26	-12	15	-1	0	0	122
3 vs. 5 change in loss												
Winter-run number	0	0	87	105	125	163	0	-1	0	0	0	479
Spring-run number	0	0	0	0	0	74	13	-250	0	0	0	-163
Steelhead number	0	2	4	42	69	49	1	-15	2	1	0	155
1 vs. 5 change in loss												
Winter-run number	0	0	87	105	125	163	0	-1	0	0	0	479
Spring-run number	0	0	0	0	0	74	13	-250	0	0	0	-163
Steelhead number	0	2	4	42	69	49	1	-15	2	1	0	155

Differences in number of fish when pumping is 8,500 cfs vs. 6,680 cfs (8,500 minus 6,680)

	Dry Year Type											
Tracy	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Overall**
2 vs. 4 change in loss												
Winter-run number	0	0	2	-24	55	197	2	0	0	0	0	233
Spring-run number	0	0	0	0	0	89	100	-87	0	0	0	102
Steelhead number	0	0	0	-10	30	59	6	-5	1	0	0	81
3 vs. 5 change in loss												
Winter-run number	0	0	-15	-26	17	6	-7	0	0	0	0	-26
Spring-run number	0	0	0	0	0	3	-338	-75	0	0	0	-410
Steelhead number	0	0	-1	-10	9	2	-19	-4	1	0	0	-22
1 v 5 change in loss												
Winter-run number	0	0	-15	-26	17	6	-7	0	0	0	0	-26
Spring-run number	0	0	0	0	0	3	-338	-75	0	0	0	-410
Steelhead number	0	0	-1	-10	9	2	-19	-4	1	0	0	-22

Differences in number of fish when pumping is 8,500 cfs vs. 6,680 cfs (8,500 minus 6,680)												
	Below Normal Year Type											
Banks	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Overall**
2 vs. 4 change in loss												
Winter-run number	0	0	54	46	-62	240	4	0	0	0	0	282
Spring-run number	0	0	0	0	0	109	168	51	0	0	0	328
Steelhead number	0	1	3	19	-34	72	9	3	0	1	0	74
3 vs. 5 change in loss												
Winter-run number	0	0	45	53	29	49	3	-3	0	0	0	176
Spring-run number	0	0	0	0	0	22	157	-772	0	0	0	-593
Steelhead number	0	0	2	21	16	15	9	-45	-4	1	0	16
1 vs. 5 change in loss												
Winter-run number	0	0	45	53	29	49	3	-3	0	0	0	176
Spring-run number	0	0	0	0	0	22	157	-772	0	0	0	-593
Steelhead number	0	0	2	21	16	15	9	-45	-4	1	0	16

Differences in number of fish when pumping is 8,500 cfs vs. 6,680 cfs (8,500 minus 6,680)												
	Below Normal Year Type											
Tracy	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Overall**
2 vs. 4 change in loss												
Winter-run number	0	0	1	-34	115	43	0	0	0	0	0	125
Spring-run number	0	0	0	0	0	20	11	-57	0	0	0	-27
Steelhead number	0	0	0	-14	63	13	1	-3	-1	0	0	58
3 vs. 5 change in loss												
Winter-run number	0	0	0	-15	-1	-16	-1	-2	0	0	0	-34
Spring-run number	0	0	0	0	0	-7	-31	-405	0	0	0	-443
Steelhead number	0	0	0	-6	-1	-5	-2	-24	0	0	0	-36
1 vs. 5 change in loss												
Winter-run number	0	0	0	-15	-1	-16	-1	-2	0	0	0	-34
Spring-run number	0	0	0	0	0	-7	-31	-405	0	0	0	-443
Steelhead number	0	0	0	-6	-1	-5	-2	-24	0	0	0	-36

Differences in number of fish when pumping is 8,500 cfs vs. 6,680 cfs (8,500 minus 6,680)											
	Above Normal Year Type										
Banks	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Overall
2 vs. 4 change in loss												
Winter-run number	0	0	36	161	18	37	11	0	0	0	0	264
Spring-run number	0	0	0	0	1	191	1,183	213	70	0	0	1,658
Steelhead number	0	3	3	23	19	61	34	6	4	1	0	154
3 vs. 5 change in loss												
Winter-run number	0	0	40	285	-5	54	14	0	0	0	0	389
Spring-run number	0	0	0	0	0	275	1,528	8	96	0	0	1,907
Steelhead number	0	5	4	40	-5	87	44	0	6	2	0	182
1 vs. 5 change in loss												
Winter-run number	0	0	40	285	-5	54	14	0	0	0	0	389
Spring-run number	0	0	0	0	0	275	1,528	8	96	0	0	1,907
Steelhead number	0	5	4	40	-5	87	44	0	6	2	0	182

Differences in number of fish when pumping is 8,500 cfs vs. 6,680 cfs (8,500 minus 6,680)											
	Above Normal Year Type										
Tracy	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Overall
2 vs. 4 change in loss												
Winter-run number	0	0	1	8	6	25	2	0	0	0	0	40
Spring-run number	0	0	0	0	0	237	199	34	-1	0	0	470
Steelhead number	0	0	0	3	19	92	10	2	0	0	0	126
3 vs. 5 change in loss												
Winter-run number	0	0	-2	20	-5	17	2	0	0	0	0	31
Spring-run number	0	0	0	0	0	166	196	0	-4	0	0	358
Steelhead number	0	-1	-1	9	-17	65	10	0	-1	0	0	64
1 vs. 5 change in loss												
Winter-run number	0	0	-2	20	-5	17	2	0	0	0	0	31
Spring-run number	0	0	0	0	0	166	196	0	-4	0	0	358
Steelhead number	0	-1	-1	9	-17	65	10	0	-1	0	0	64

Differences in number of fish when pumping is 8,500 cfs vs. 6,680 cfs (8,500 minus 6,680)											
	Wet Year Type										
Banks	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**
2 vs. 4 change in loss											
Winter-run number	0	0	54	122	-42	-21	22	1	0	0	0
Spring-run number	0	0	0	0	-2	-107	2,362	991	131	0	0
Steelhead number	0	3	5	17	-45	-34	67	29	8	1	0
3 vs. 5 change in loss											
Winter-run number	0	0	73	154	-23	51	17	0	0	0	0
Spring-run number	0	0	0	0	-1	260	1,832	-726	178	0	0
Steelhead number	0	1	7	22	-24	83	52	-21	11	1	0
1 vs. 5 change in loss											
Winter-run number	0	0	73	154	-23	51	17	0	0	0	0
Spring-run number	0	0	0	0	-1	260	1,832	-726	178	0	0
Steelhead number	0	1	7	22	-24	83	52	-21	11	1	0

Banks (cont.)	**Overall**
2 vs. 4 change in loss	
Winter-run number	136
Spring-run number	3,375
Steelhead number	51
3 vs. 5 change in loss	
Winter-run number	272
Spring-run number	1,543
Steelhead number	132
1 vs. 5 change in loss	
Winter-run number	272
Spring-run number	1,543
Steelhead number	132

Differences in number of fish when pumping is 8,500 cfs vs. 6,680 cfs (8,500 minus 6,680)												
	Wet Year Type											
Tracy	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Overall**
2 vs. 4 change in loss												
Winter-run number	0	0	0	-12	-2	16	1	0	0	0	0	3
Spring-run number	0	0	0	0	0	151	153	45	1	0	0	349
Steelhead number	0	-1	0	-6	-7	58	8	2	0	0	0	55
3 vs. 5 change in loss												
Winter-run number	0	0	-7	-31	5	-5	-2	0	0	0	0	-41
Spring-run number	0	0	0	0	0	-52	-310	0	0	0	0	-361
Steelhead number	0	0	-2	-14	17	-20	-16	0	0	0	0	-36
1 vs. 5 change in loss												
Winter-run number	0	0	-7	-31	5	-5	-2	0	0	0	0	-41
Spring-run number	0	0	0	0	0	-52	-310	0	0	0	0	-361
Steelhead number	0	0	-2	-14	17	-20	-16	0	0	0	0	-36

X2 Position

Between Studies 4 and 4a the number of times out the of 72 years X2 shifted upstream in Study 4 compared 4a was most frequently in February, see Table 11-15. Figure 11-32 all 5 of the shifts in February occurred in the dry and critical year types. Shifts in X2 upstream of Study 5a in Study 5 occurred in March 4 times two of the shifts occurred in dry and critical years with the other two times occurring in below normal years, see Figure 11-33. June had 6 shifts upstream of greater than 0.5 km comparing 5a to 5 from Figure 11-36 the shifts occurred in the wet and below normal year types. Figure 11-32 to Figure 11-36 show the monthly X2 position sorted by water year type with the differences between 4a to 4 and 5a to 5 shown on the secondary axis. Looking at the figures most of the shifts between the studies tend the occur in February, March and June with little movement in April and may due to the Vernalis Adaptive Management Program (VAMP) reduction making exports more uniform.

Table 11-15 Number of times X2 Position in a Studies 4 and 5 shifted upstream of Studies 4a and 5a

	Feb	Mar	Apr	May	June
4a to 4	5	2	0	1	2
5a to 5	2	4	1	2	6

Figure 11-37 to Figure 11-39 show the number of days that the X2 position is downstream of the Confluence, Chipps, and Roe. Note that all the days for a month are assigned to a data point if the monthly average X2 position is past one of the compliance points and days not reflect the actual number of days that X2 could have been past the compliance point. There are no significant changes between 4a to 4 and 5a to 5 in days past the Confluence, Chipps, and Roe.

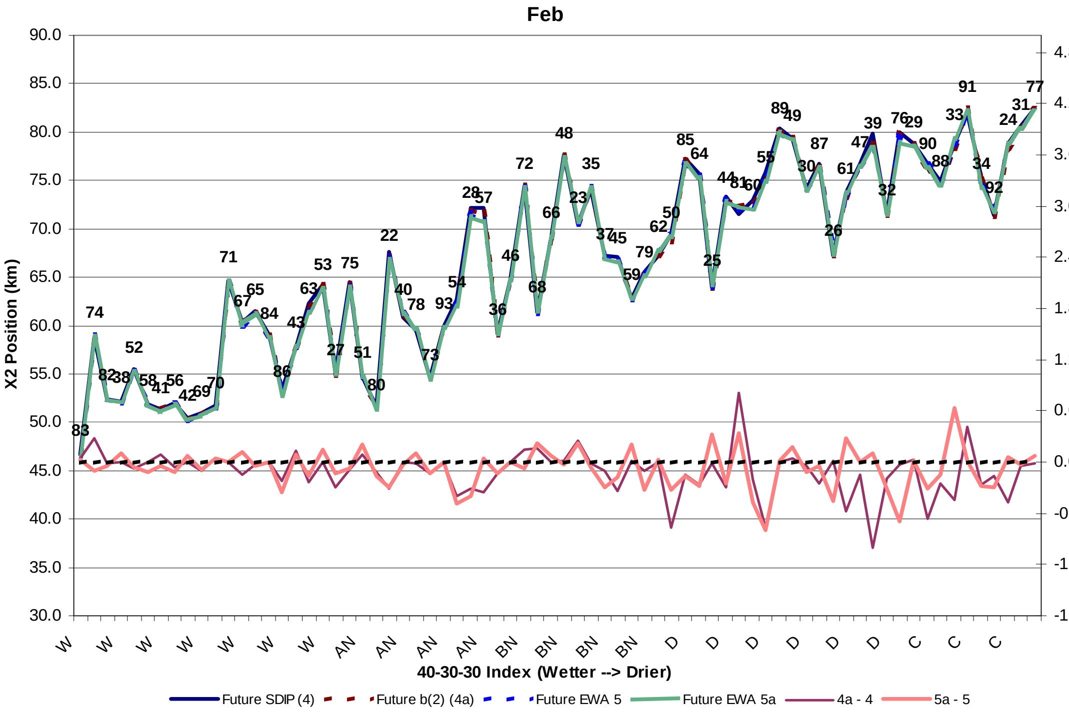


Figure 11-32 X2 positions for February sorted by 40-30-30 index with differences of 4a to 4 and 5a to 5 on the secondary axis

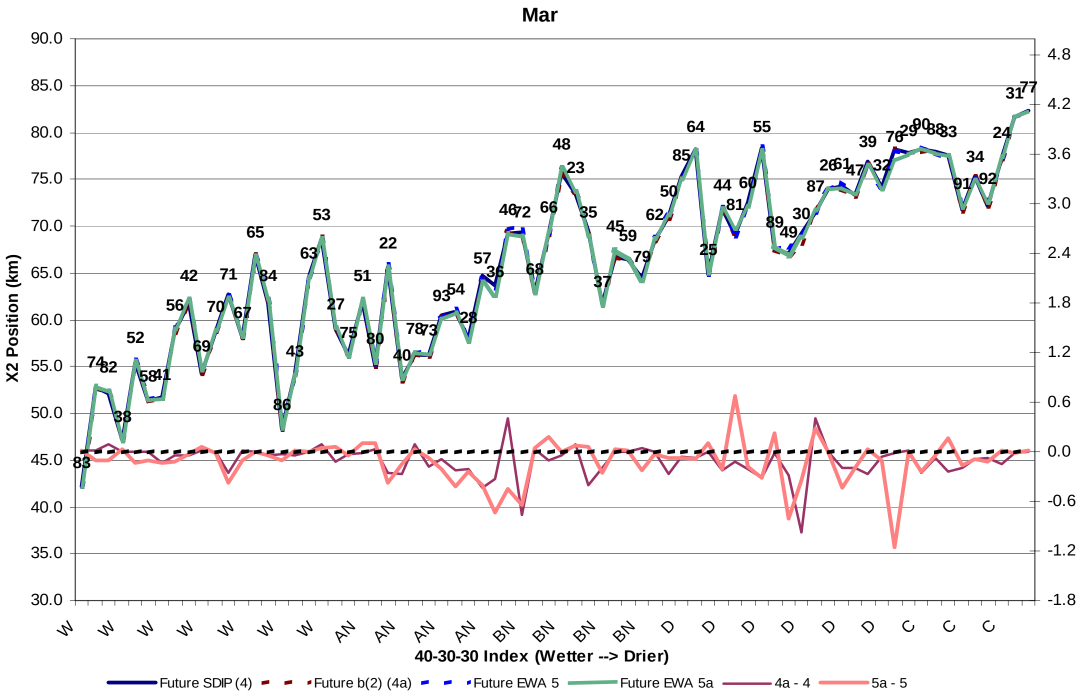


Figure 11-33 X2 positions for March sorted by 40-30-30 index with differences of 4a to 4 and 5a to 5 on the secondary axis

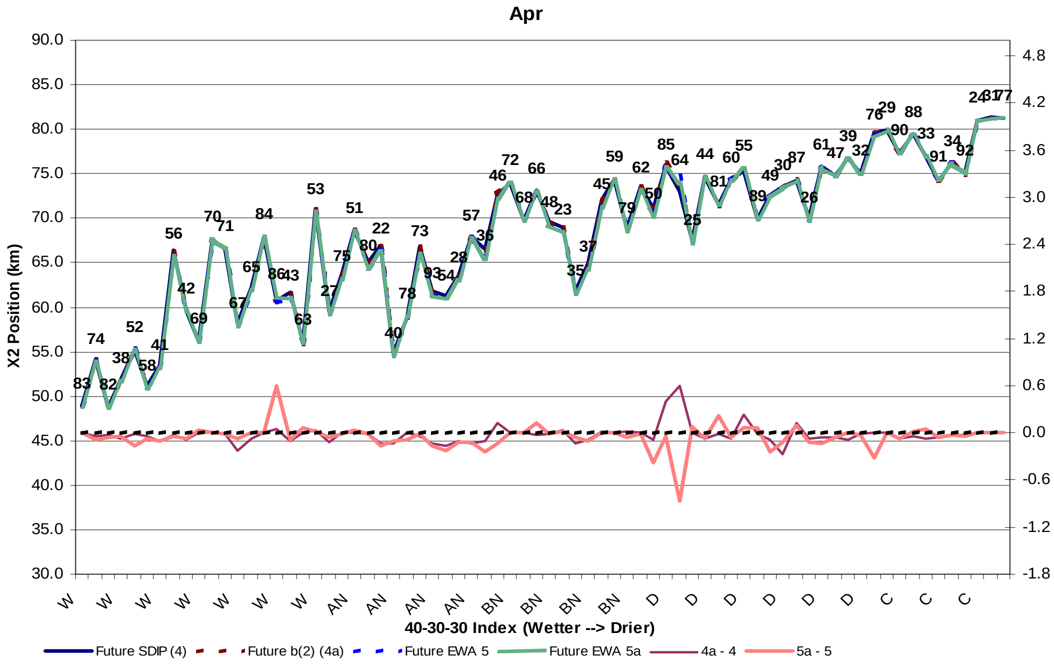


Figure 11-34 X2 positions for April sorted by 40-30-30 index with differences of 4a to 4 and 5a to 5 on the secondary axis

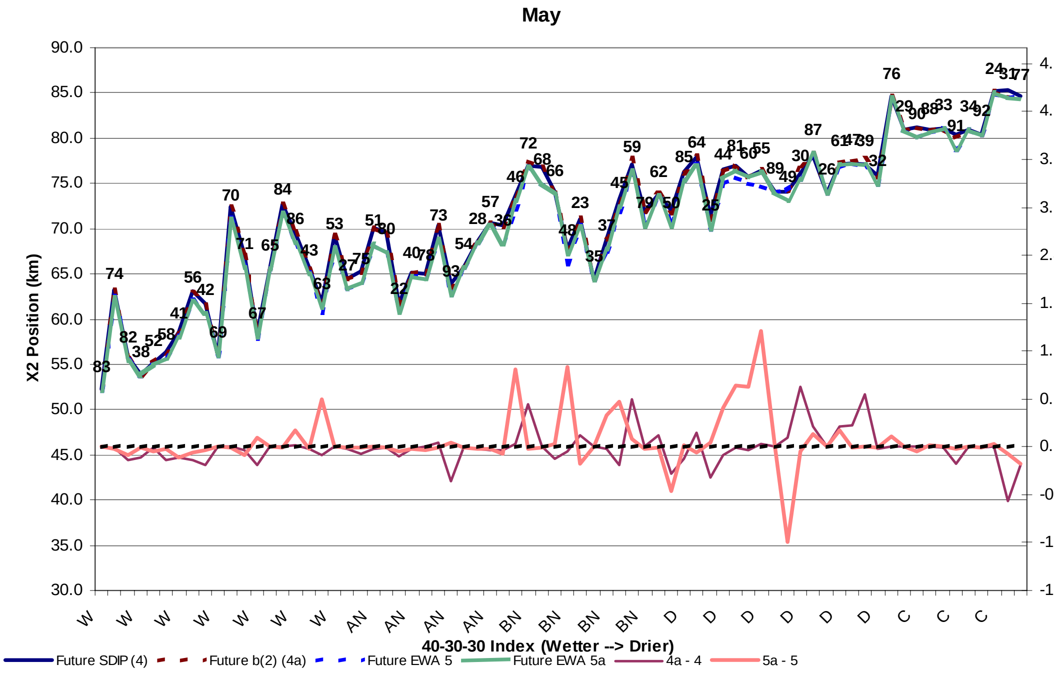


Figure 11-35 X2 positions for May sorted by 40-30-30 index with differences of 4a to 4 and 5a to 5 on the secondary axis

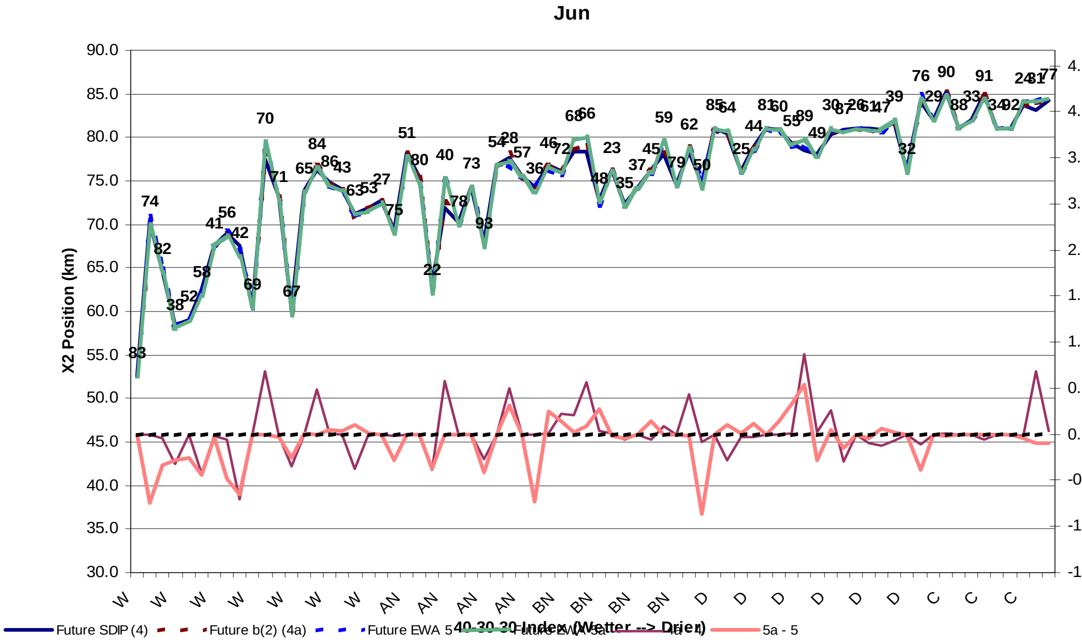


Figure 11-36 X2 positions for June sorted by 40-30-30 index with differences of 4a to 4 and 5a to 5 on the secondary axis

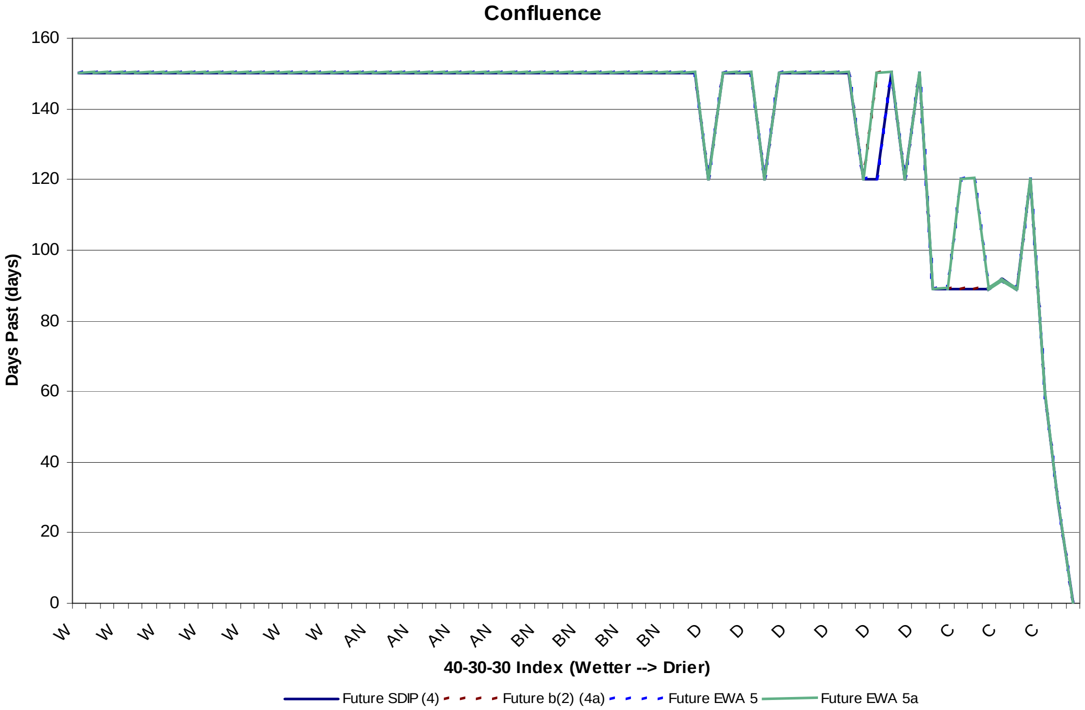


Figure 11-37 Number of days X2 downstream of the confluence (note that the total number of days are assigned if the monthly average X2 position is greater than the confluence)

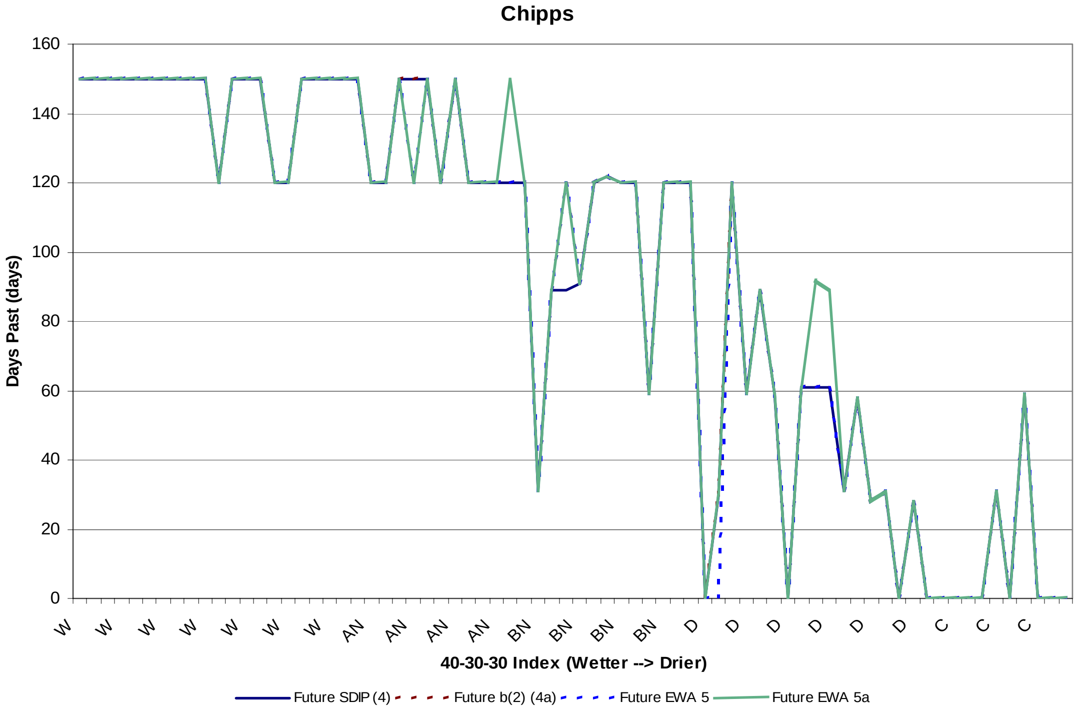


Figure 11-38 Number of days X2 downstream of the chipps (note that the total number of days are assigned if the monthly average X2 position is greater than the confluence)

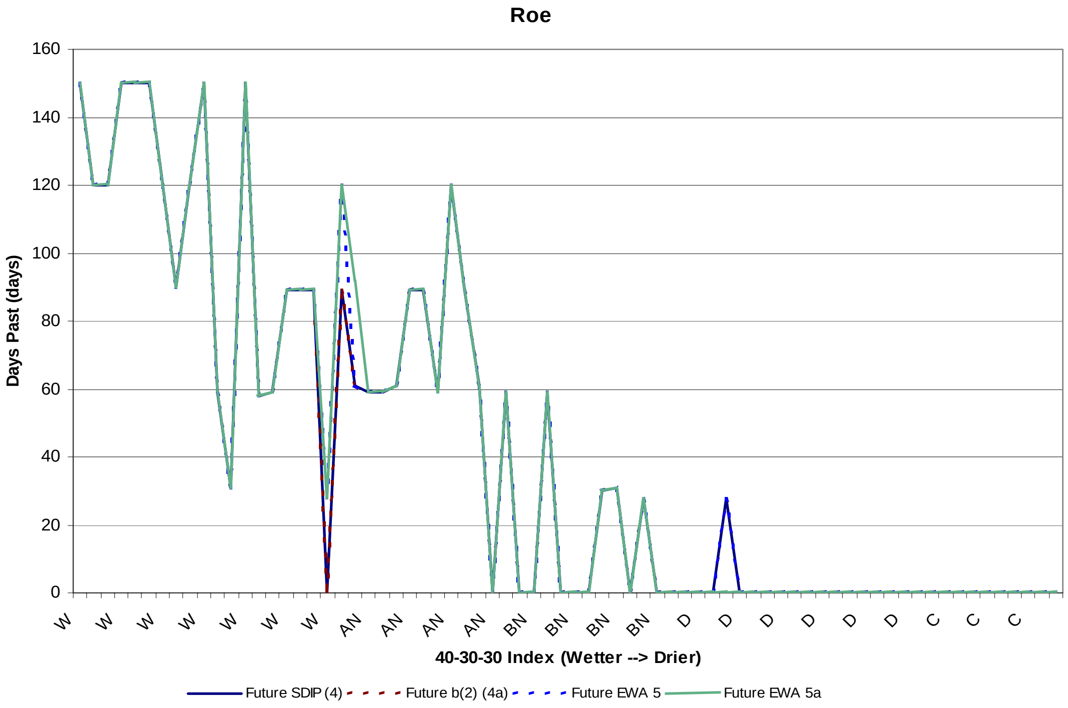


Figure 11-39 Number of days X2 downstream of the roe (note that the total number of days are assigned if the monthly average X2 position is greater than the confluence)

Export-to-Inflow Ratio

Studies 4 and 5 increase the E/I Ratio long-term average October through January, July, and September, see Table 11-16. Increases in the E/I Ratios tend to occur October through February of dry years with the 8,500 cfs pumping capacity at Banks. In critical years, some increases in the winter and early spring E/I Ratios occur in Studies 4 and 5 when compared to Studies 4a and 5a.

Figure 11-40 to Figure 11-51 show the monthly E/I Ratios sorted by the 40-30-30 index. October to January show some increases in E/I Ratio from Studies 4 and 5, see Figure 11-40 to Figure 11-43. September also shows increases in E/I Ratio in studies 4 and 5 in the wet years, Figure 11-51. The months of February to August show no significant increase in E/I Ratio from Studies 4 and 5, see Figure 11-44 to Figure 11-50. This is likely due to either pumping reductions from 3406 b(2) or EWA or from increased flows in the late summer directed to pumping.

Table 11-16 Average and 40-30-30 index water-year-type monthly E/I Ratios

Average	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Future SDIP (4)	54.9%	48.3%	46.3%	39.6%	25.5%	23.7%	19.9%	20.0%	28.1%	39.6%	49.5%	59.8%
Future b(2) (4a)	53.8%	48.0%	44.5%	38.7%	25.3%	23.3%	19.9%	19.7%	27.9%	39.3%	50.2%	58.6%
Future EWA 5	56.2%	46.8%	44.3%	36.6%	25.4%	24.2%	17.2%	12.1%	27.9%	42.8%	51.0%	60.4%
Future EWA 5a	55.4%	46.4%	43.1%	35.9%	24.9%	24.0%	17.2%	13.1%	27.5%	41.8%	50.7%	59.0%
Wet	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**
Future SDIP (4)	54.6%	50.3%	29.3%	21.1%	13.7%	16.4%	16.2%	17.1%	28.7%	42.7%	57.7%	59.2%
Future b(2) (4a)	53.2%	49.8%	27.5%	20.5%	13.9%	16.4%	15.8%	16.6%	27.8%	41.9%	57.2%	55.4%
Future EWA 5	56.3%	48.9%	27.4%	19.9%	12.9%	18.3%	13.6%	10.1%	28.9%	41.9%	59.8%	61.5%
Future EWA 5a	54.5%	49.5%	25.4%	19.3%	12.9%	18.1%	13.6%	10.6%	27.4%	41.3%	58.3%	56.5%
Above Normal	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**
Future SDIP (4)	58.4%	48.0%	48.2%	31.7%	20.6%	17.6%	21.3%	20.6%	32.4%	44.9%	54.9%	65.0%
Future b(2) (4a)	57.1%	47.1%	46.9%	30.2%	20.2%	16.8%	20.9%	20.4%	32.2%	43.9%	57.5%	65.0%
Future EWA 5	58.1%	47.2%	50.2%	29.9%	18.9%	19.1%	17.2%	12.4%	32.1%	47.2%	55.6%	65.0%
Future EWA 5a	57.9%	45.9%	48.7%	28.0%	18.9%	18.2%	16.7%	12.4%	31.5%	45.6%	58.8%	65.1%
Below Normal	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**
Future SDIP (4)	54.9%	54.3%	53.5%	44.3%	25.6%	29.5%	24.4%	22.6%	32.8%	45.7%	58.9%	64.5%
Future b(2) (4a)	54.0%	53.8%	52.4%	44.1%	25.3%	28.9%	24.4%	22.9%	33.0%	45.0%	58.5%	64.6%
Future EWA 5	57.3%	52.3%	51.7%	41.4%	26.4%	29.1%	20.0%	12.1%	32.7%	48.1%	59.4%	64.8%
Future EWA 5a	57.0%	51.6%	50.9%	41.1%	26.2%	28.9%	19.9%	14.6%	33.0%	46.6%	58.5%	64.7%
Dry	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**
Future SDIP (4)	55.3%	45.3%	56.6%	56.7%	36.9%	30.4%	22.7%	20.9%	30.0%	44.3%	48.0%	61.9%
Future b(2) (4a)	54.9%	44.6%	54.6%	55.7%	35.7%	29.7%	23.1%	20.7%	30.0%	44.5%	48.5%	61.9%
Future EWA 5	56.4%	43.6%	54.4%	52.1%	37.4%	30.6%	20.3%	12.8%	29.3%	49.6%	43.0%	61.4%
Future EWA 5a	56.2%	42.9%	52.4%	51.1%	36.4%	30.3%	20.6%	14.0%	28.4%	48.0%	44.7%	61.6%
Critical	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**
Future SDIP (4)	51.9%	41.4%	52.5%	51.2%	36.0%	26.1%	16.1%	20.7%	14.0%	14.6%	19.5%	46.9%
Future b(2) (4a)	50.1%	42.8%	49.6%	49.2%	36.3%	25.9%	16.4%	19.7%	14.3%	15.4%	22.2%	46.8%
Future EWA 5	52.8%	40.0%	47.1%	45.7%	36.2%	24.8%	16.3%	14.6%	13.9%	24.0%	31.2%	47.2%
Future EWA 5a	51.9%	39.8%	48.4%	46.0%	35.1%	25.0%	16.4%	15.2%	15.9%	24.4%	27.5%	47.5%

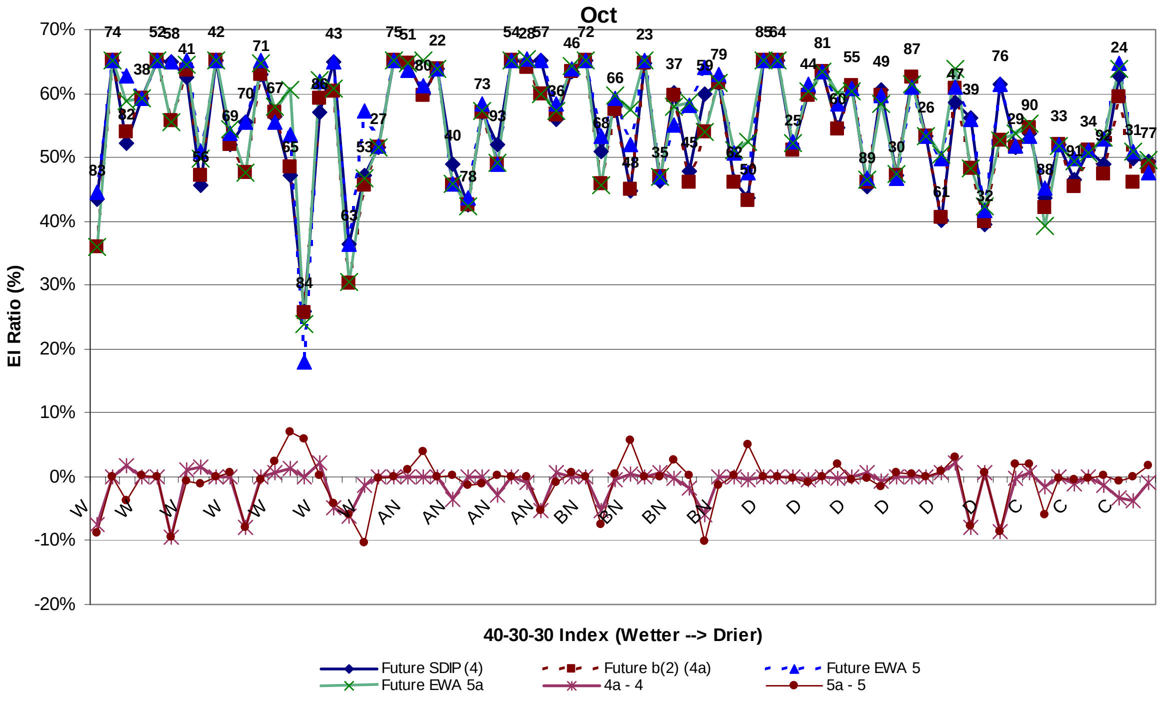


Figure 11-40 October E/I Ratios sorted by 40-30-30 index with differences between 4a and 4 and 5a and 5

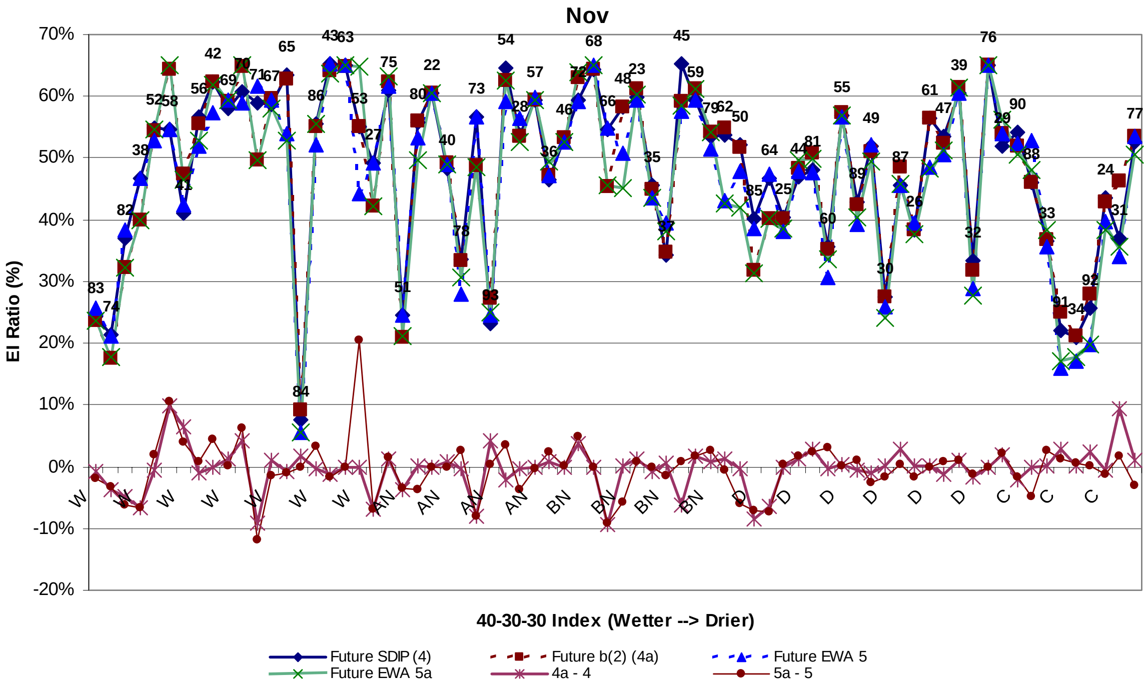


Figure 11-41 November E/I Ratios sorted by 40-30-30 index with differences between 4a and 4 and 5a and 5

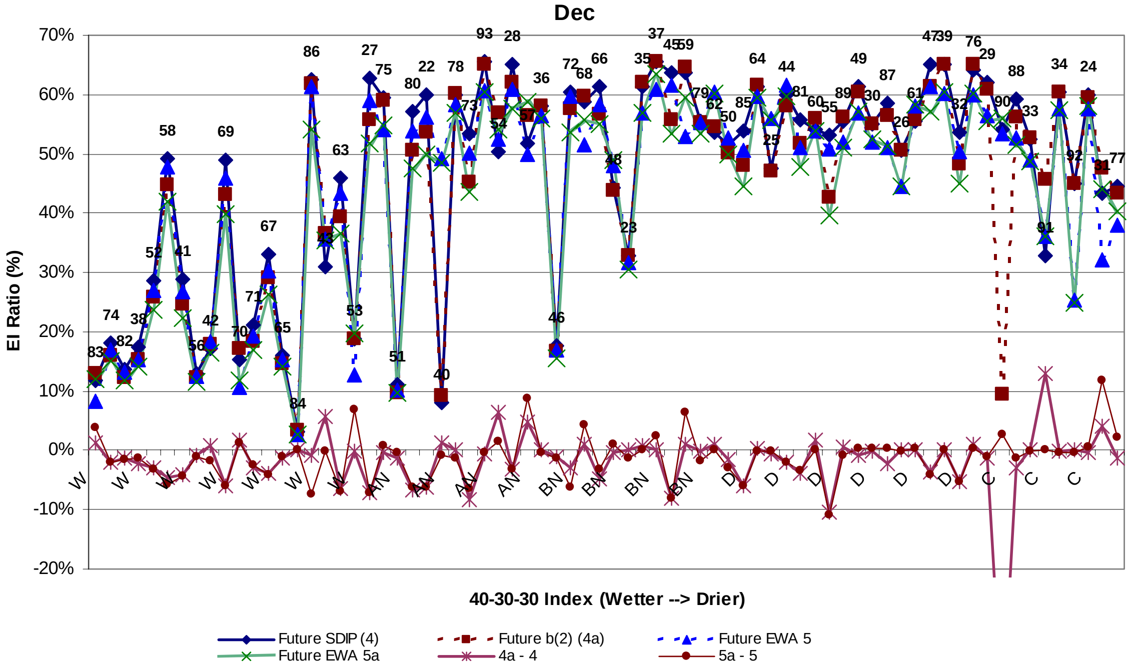


Figure 11-42 December E/I Ratios sorted by 40-30-30 index with differences between 4a and 4 and 5a and 5

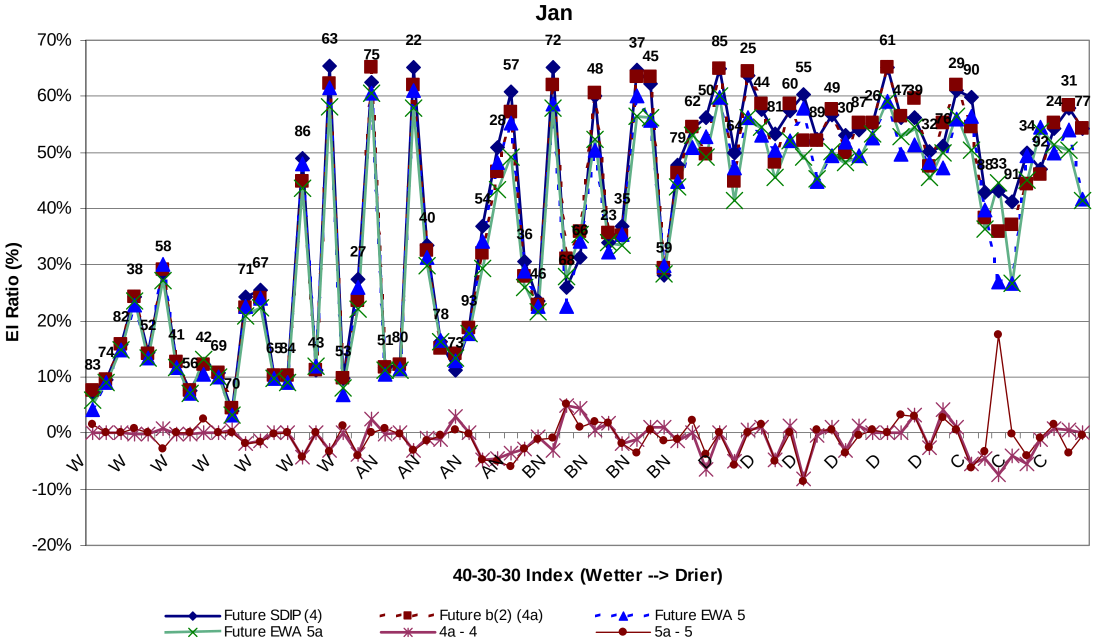


Figure 11-43 January E/I Ratios sorted by 40-30-30 index with differences between 4a and 4 and 5a and 5

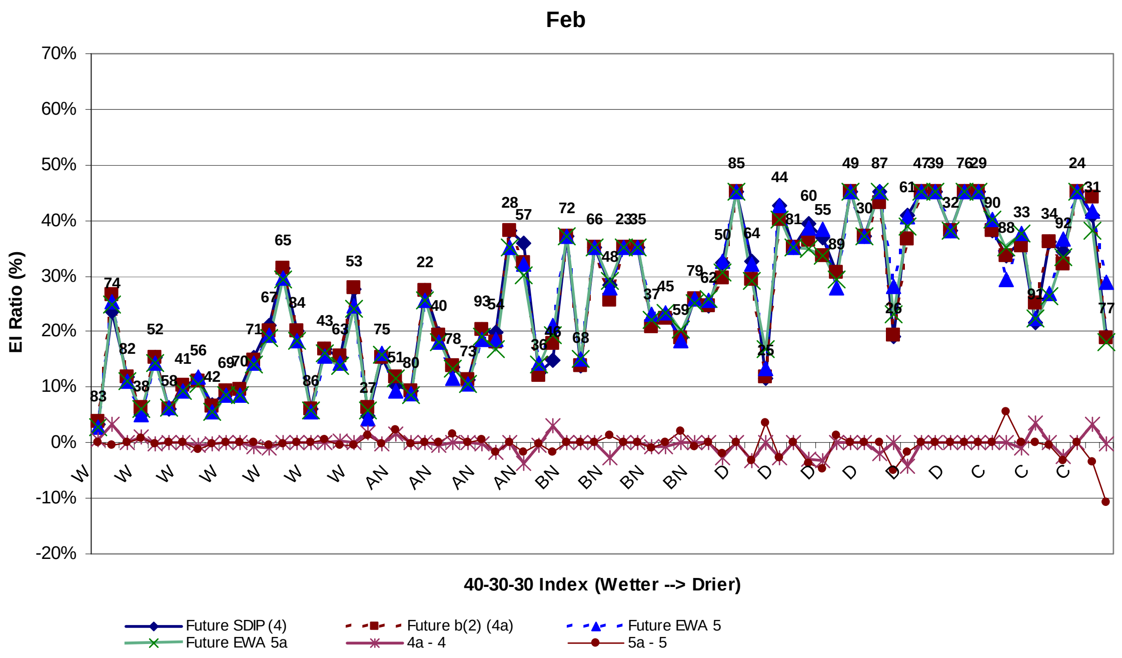


Figure 11-44 February E/I Ratios sorted by 40-30-30 index with differences between 4a and 4 and 5a and 5

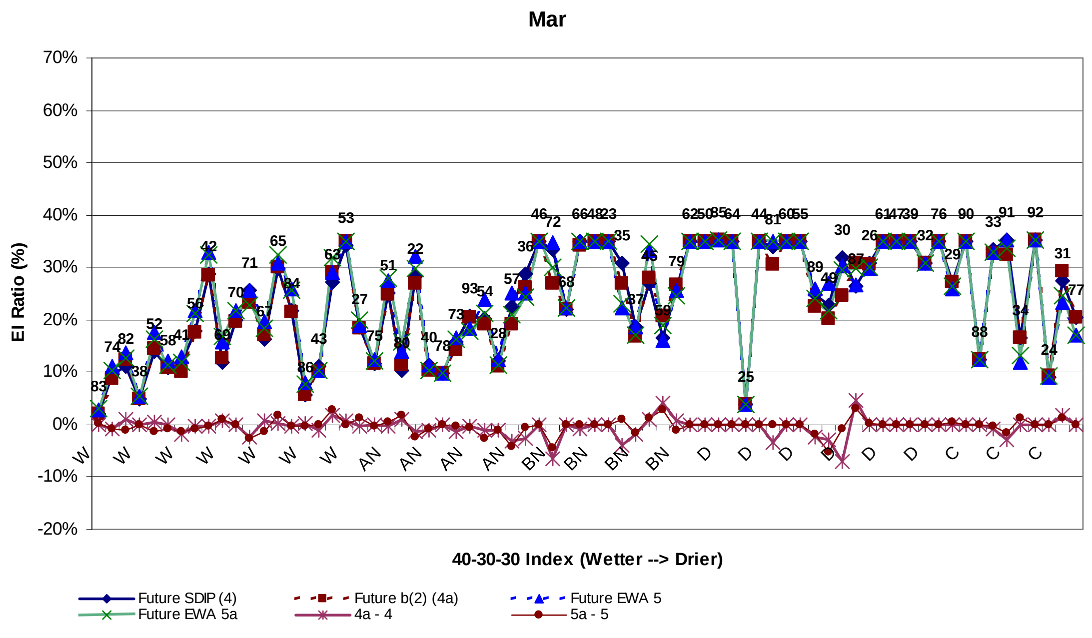


Figure 11-45 March E/I Ratios sorted by 40-30-30 index with differences between 4a and 4 and 5a and 5

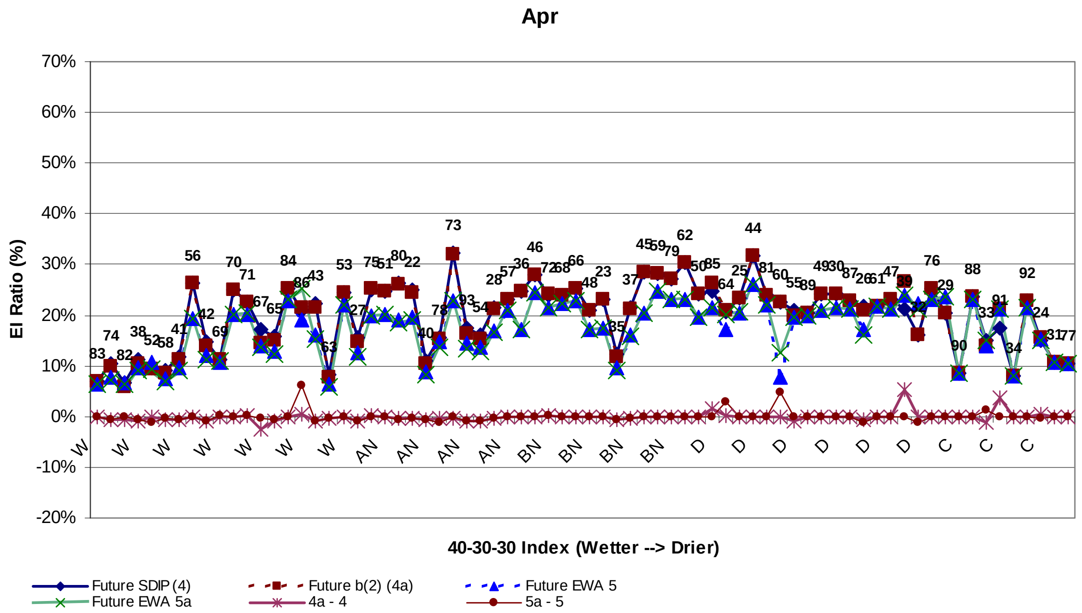


Figure 11-46 April E/I Ratios sorted by 40-30-30 index with differences between 4a and 4 and 5a and 5

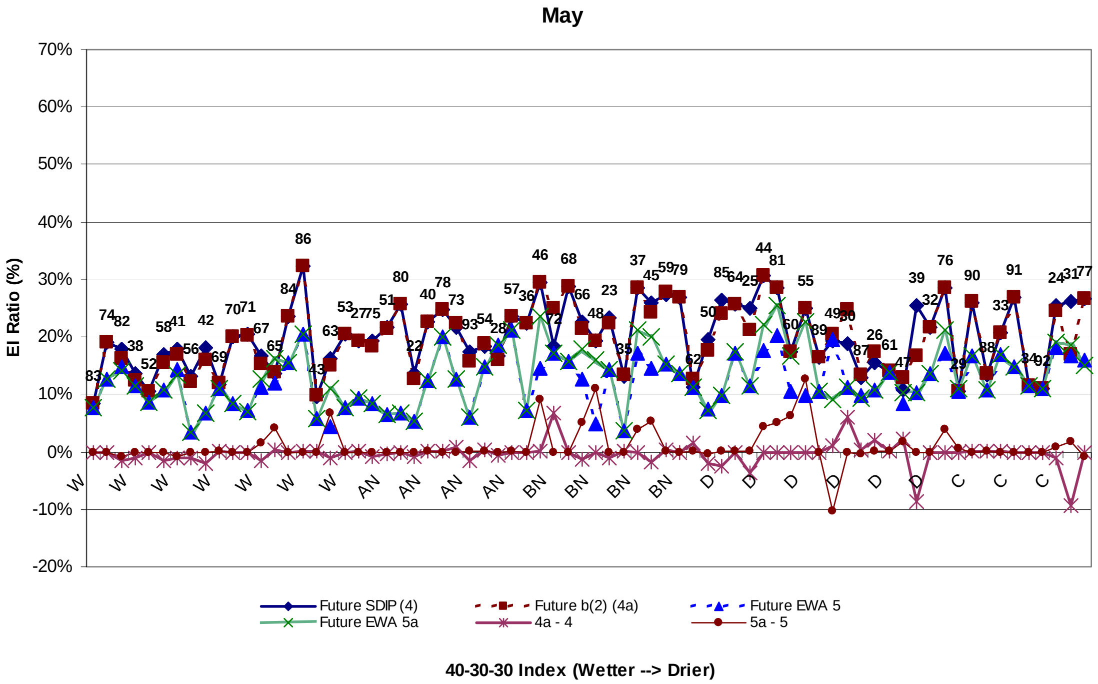


Figure 11-47 May E/I Ratios sorted by 40-30-30 index with differences between 4a and 4 and 5a and 5

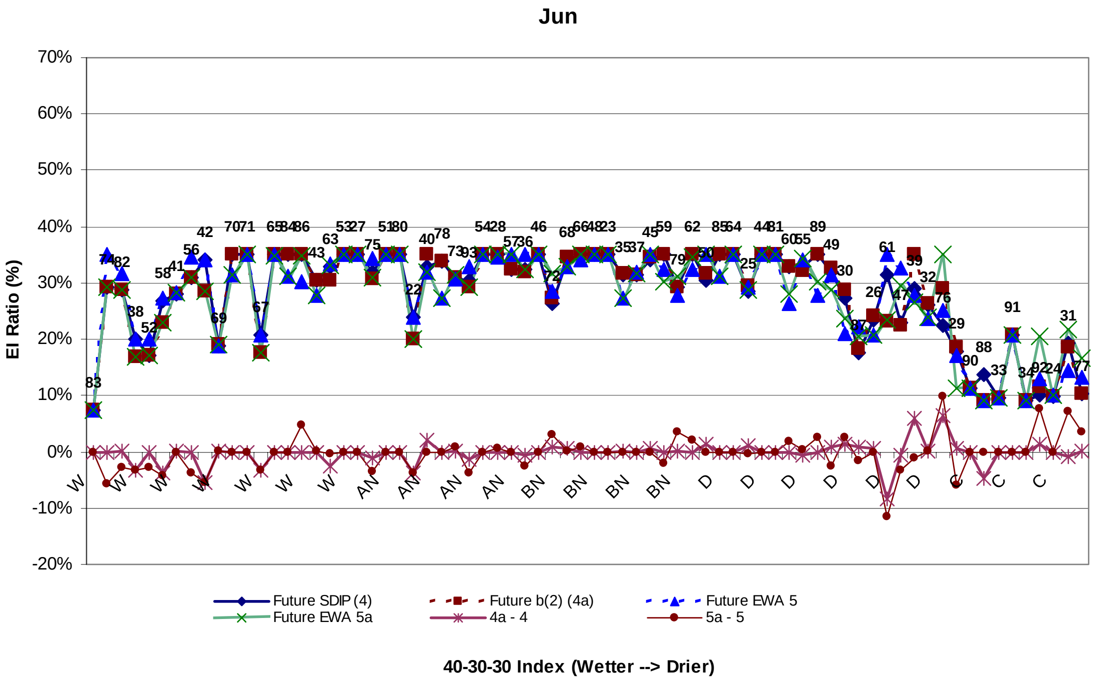


Figure 11-48 June E/I Ratios sorted by 40-30-30 Index with differences between 4a and 4 and 5a and 5

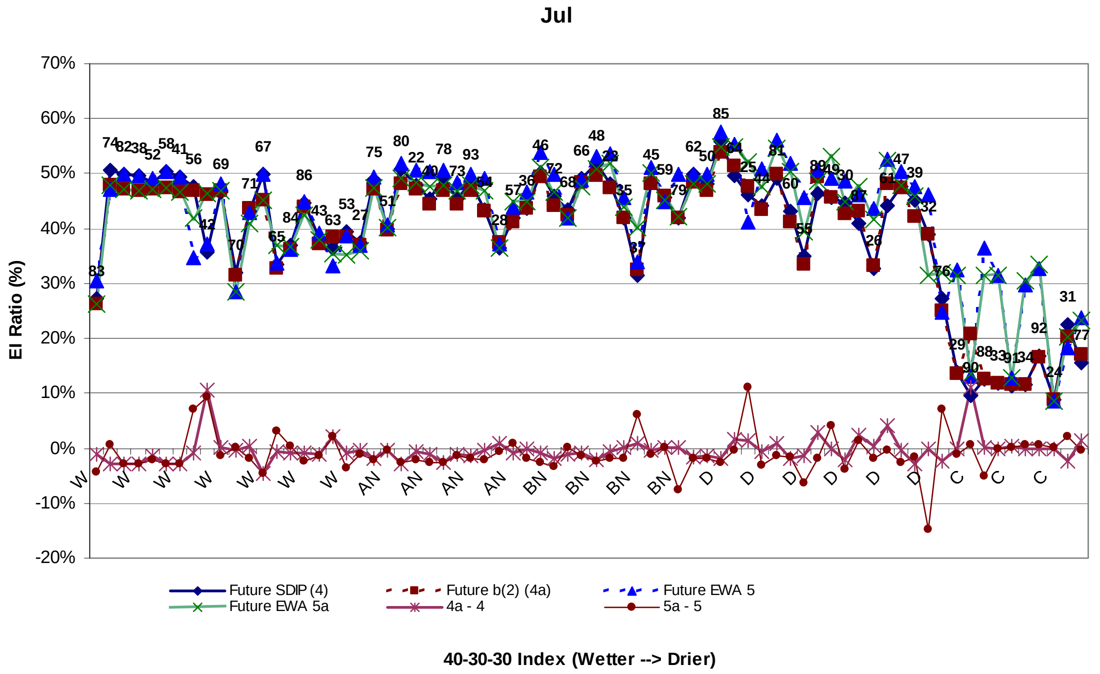


Figure 11-49 July E/I Ratios sorted by 40-30-30 index with differences between 4a and 4 and 5a and 5

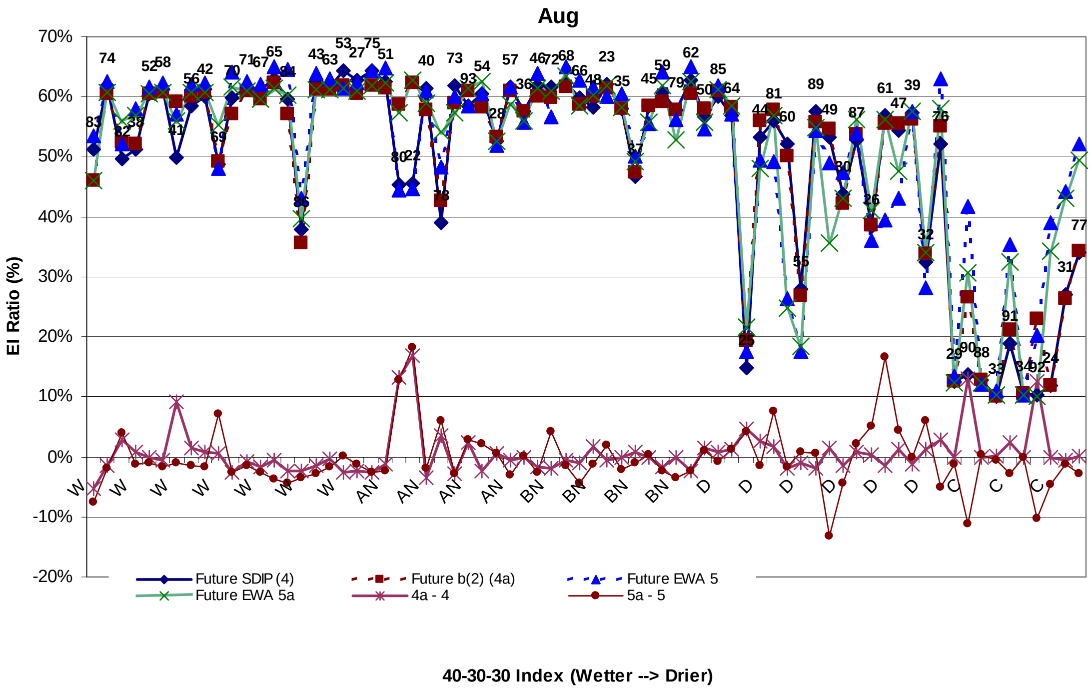


Figure 11-50 August E/I Ratios sorted by 40-30-30 index with differences between 4a and 4 and 5a and 5

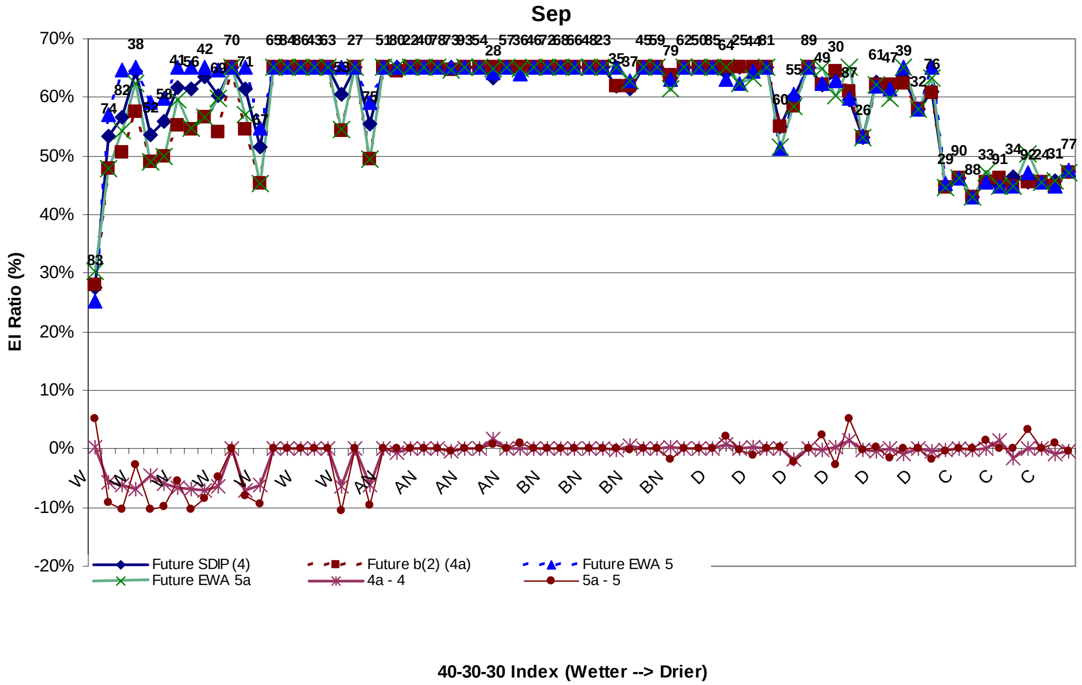


Figure 11-51 September E/I Ratios sorted by 40-30-30 index with differences between 4a and 4 and 5a and 5

Environmental Water Account

This section compares results from Operating Criteria and Plan (OCAP) Study 5 and OCAP Study 5a. Comparison of these studies shows the impact on EWA operations of changing from Banks operating at 8,500 cfs capacity (i.e., OCAP Study 5) to Banks operating at 6,680 cfs capacity (i.e., OCAP Study 5a). Impacts are measured for several aspects of EWA operations: (a) asset acquisition, (b) debt management at San Luis via carryover-debt spilling, (c) violations of "No Harm to Deliveries" principle, (d) typical amounts of carryover debt, and (e) average annual action-expenditures classified by hydrologic year-type.

Asset Acquisition

The most significant asset acquisition impact is the reduced amount of acquired operational assets (i.e,. total acquired water minus water purchases, Figure 11-52). Most of this reduction is associated with lost opportunities to create "backed-up" water in upstream reservoirs, which is coincidental with EWA actions to curtail exports.

Figure 11-53 describes "backed-up" water impacts in terms of the amounts and frequency of wheeled "backed-up" water to South of Delta (SOD) for Studies 5 and 5a. Given 8500 Banks (Study 5), the wheeled amounts exceed 30 taf in 40 percent of the years and peak at about 140 taf. Given 6680 Banks, the wheeled amounts exceed 30 taf in about 5 percent of the years and peak at about 70 taf.

Causes for "backed-up" water reduction seem two-fold. First, the "backed-up" water is more likely to spill before EWA has the opportunity to convey it to SOD for debt management because EWA has less access to capacity at Banks. Additionally, as the projects experience less pumping capacity at Banks, their export patterns change enough to affect the amount of "backed-up" water that can be created in coincidence with an EWA export curtailment action.

Fixed asset acquisition through water purchases remains largely unchanged given 6,680 or 8500 Banks. Some reductions in total purchases occur with 6,680 Banks. This appears to be due to more frequent occurrence of conveyance constraints that limit EWA's ability to wheel NOD purchases amounts relative to NOD purchase targets.

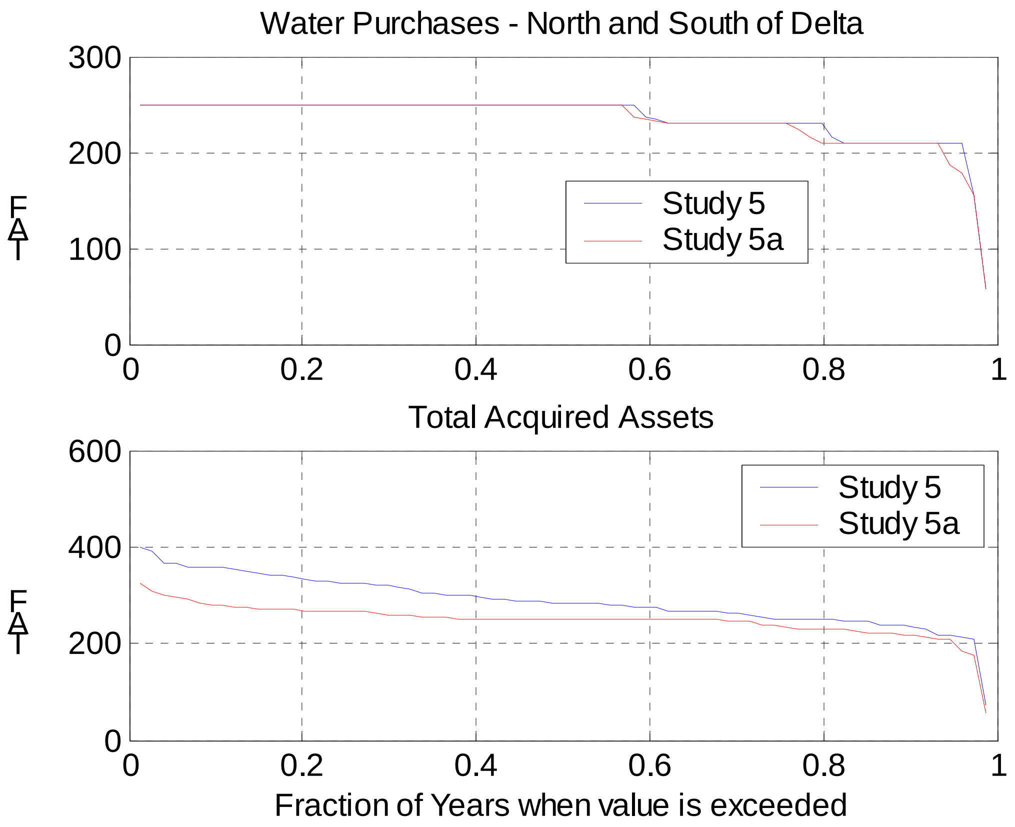


Figure 11-52 Simulated water purchases and total acquired assets (i.e., combination of water purchases, 50 percent of SWP-B2 Gains, wheeling of NOD backed-up water, and Delta surplus exported via EWA pumping capacity at Banks).

Frequency of Spilling Debt at San Luis

One of the debt-management tools represented in CALSIM II is carried-over debt spilling at SWP San Luis. This tool is called upon during the simulation when enough carried-over debt exists and when spill criteria are met. One of those criteria is that there must be remaining pumping capacity at Banks and that the amount of spilled debt must not exceed the volumetric excess capacity at Banks for that month. Reducing Banks capacity from 8,500 cfs to 6,680 cfs is more likely to reduce the frequency of meeting this criterion, and is likely to limit the amount of carried-over debt that can be spilled in any given month when spill criteria are met. These anticipated impacts are reflected in comparison of Study 5 and Study 5a results, but not to a large degree. In Study 5, debt spilling occurred in 23 of 73 simulation years, with maximum annual spill equal to 226 taf. In Study 5a, debt spilling frequency reduced to 22 of 73 simulation years, with maximum annual spill equal to 173 taf.

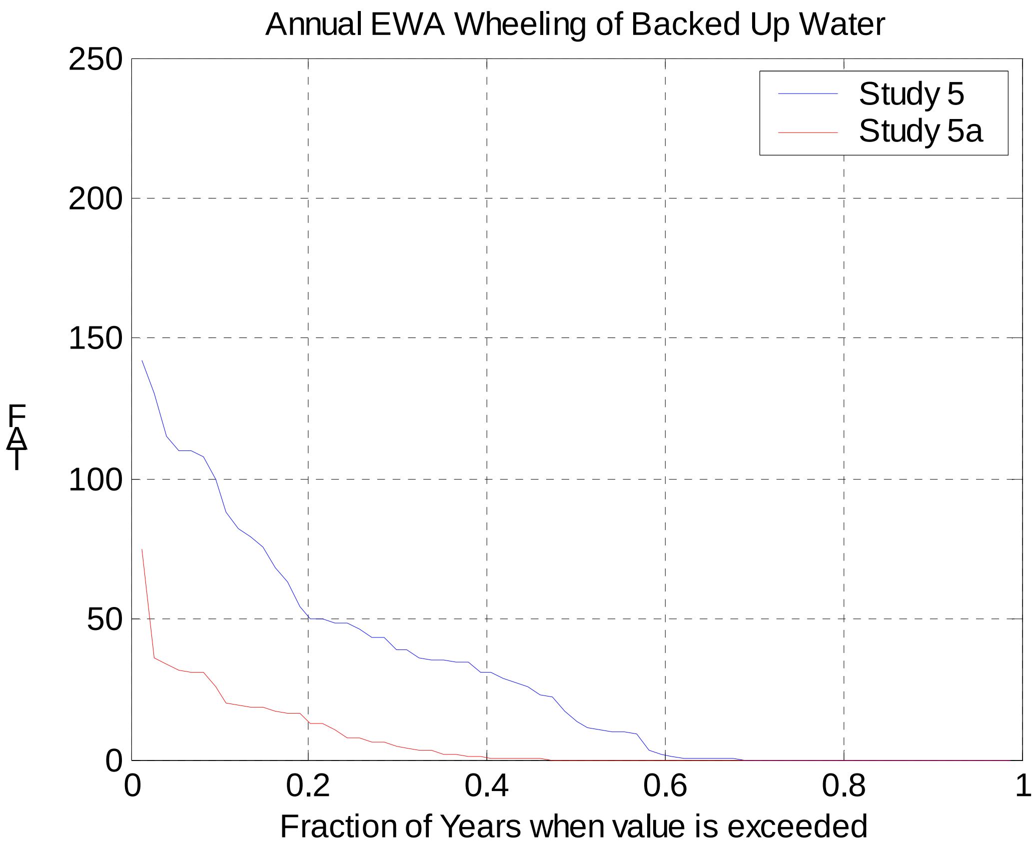


Figure 11-53 Simulated amounts of "backed-up" water that gets wheeled by EWA to manage SOD debt conditions.

Violations to "No Harm to Deliveries" Principle

The CALSIM II simulations indicate violation of the "No Harm to Deliveries" principle when the simulation results show joint occurrence of (a) SOD deliveries debt assessed at the beginning of the month, and (b) lack of repayment-in-full during this month. If there are no violations during simulation, then the simulated assets and debt management tools are considered sufficient to cover the simulated actions. Conversely, the more that violations occur and become severe suggests the degree to which simulated actions are out of balance with the available assets and debt management tools.

Given Banks 8500 (Study 5), the occurrence and magnitudes of unpaid deliveries debt were assessed by project for simulation water-years 1922-1993:

- SWP: 0 occurrences
- CVP: 3 occurrences
  - Jan 1943 (2 taf), Feb 1943 (2 taf), Mar 1943 (2 taf)

Given Banks 6680 (Study 5a), the occurrence and magnitudes of unpaid deliveries debt become more significant:

- SWP: 8 occurrences
  - Jun 1964 (15 taf), Jul 1964 (8 taf), Sep 1971 (42 taf), Oct 1871 (42 taf), July 1985 (98 taf), Aug 1985 (43 taf), Sep 1985 (60 taf), Oct 1985 (60 taf)
- CVP: 5 occurrences
  - Jan 1943 (1 taf), Feb 1943 (1 taf), Mar 1943 (1 taf), Sep 1985 (43 taf), Oct 1985 (43 taf)

These results suggest that the presence of 8500 Banks is necessary to enable the simulated EWA assets and actions from OCAP Study 3 (i.e., Today CVPIA 3406g (b)(2) with EWA) to remain balanced and adequate given the "future" system assumptions of OCAP Study 5.

Carryover Debt Analysis

Reducing Banks capacity from 8500 cfs to 6680 cfs increases the amounts of debt carried-over from year to year at SWP San Luis (Figure 11-54) and, to a lesser degree, at CVP San Luis (results not shown). Carried-over debt accounting in CALSIM II is on a November-October cycle. Unpaid debt from last year's or previous years' actions are assessed each November and set aside into a carried-over debt account, managed separately from the "new debt" associated with this year's actions.

Ideally, carried-over debt accounts would be cleared or greatly reduced by each October. Focusing on beginning-of-October assessment and considering 8500 Banks, SWP San Luis is carrying-over debt related to actions from more than one year ago in 40 percent of the simulation years. The severity of this multiyear carryover exceeds 100 taf in less than 10 percent of the years. Changing consideration to 6680 Banks, the occurrence of multiyear carryover increases to about 65 percent of the simulation years and the severity exceeds 100 taf in about 25 percent of the years. Lost ability to capture and convey operational assets (i.e., "backed-up" water) is a contributing factor to these elevated carry-over debt conditions in San Luis.

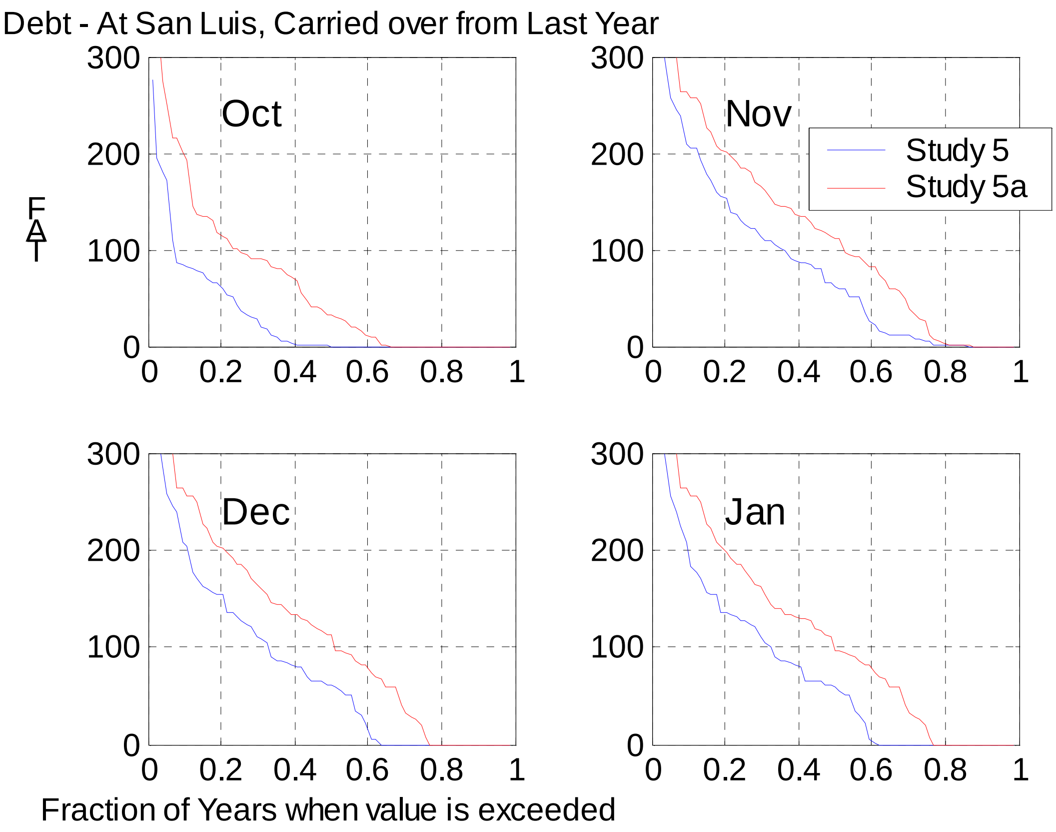


Figure 11-54 Frequency and amounts of carried-over debt conditions at SWP San Luis. These are start-of-month assessments of debt associated with last year's or previous years' actions; this debt does not overlap with debt caused by this year's actions.

Average expenditures by water year type

Reducing Banks pumping capacity from 8,500 cfs to 6,680 cfs reduces the magnitudes of debt conditions created in San Luis and SOD (Table 11-17). This impact somewhat offsets the impacts of losing access to "backed-up" assets and being less able to eliminate carried-over debt in SWP San Luis given 6680 Banks instead of 8500 Banks.

Table 11-17 EWA average annual expenditures measured as export reductions relative to the simulated baseline in association with EWA winter and spring actions.

Sac 40-30-30 Year Type	Study 5 (taf)	Study 5a (taf)
Critical	139	123
Dry	237	241
Below Normal	352	298
Above Normal	407	419
Wet	385	363

Conclusions

The effects to CVP reservoirs NOD are mainly due to shifts in timing of releases as seen in the average end of September storages being less with the end of May storage practically the same between Studies 4a to 4 and 5a to 5. The shifts occur with higher releases in the late summer in Studies 4 and 5 for the SWP in-basin requirements and ability to pump more water through JPOD from 8,500 cfs pumping. Shasta shows a decrease of 18 taf on average in September from the early consultation assumptions and Folsom shows a drop of 5 taf between Study 4a to 4 and 11 taf between 5a to 5. New Melones shows virtually no change in storage. Trinity does not show much of an impact relative to its size.

Oroville tends to show some drops in carryover storage between Studies 4a and 4 with May having generally the same storage. Between studies 5 and 5a the frequency of shifts in carryover storage are larger in magnitude than between 4 and 4a. On average in the above normal and dry years the end of September storages tend to be higher in Studies 4 and 5. While wet, below normal and critical years end of September storages conditions are higher in Studies 4a and 5a.

There is very little effect on Delta inflow with the non-SDIP studies (4a and 5a) having about 7 to 8 taf more inflow to the Delta. The above normal years have the highest impact to Inflow 60 taf and 57 taf less flow in 4a to 4 and 5a to 5 respectively with critical years having 31 taf less flow from 4a to 4 and 32 taf from 5a to 5.

Outflow is affected by the increase in pumping with the long-term average difference in outflow 129 taf higher in 4a versus 4 and 123 taf higher in 5a versus 5. Wet years show the largest impact to outflow from Studies 4a to 4 and 5a to 5.

Tracy pumping between 4a to 4 on an average basis the differences are minor long-term and by-water-year-type. Comparing 5a to 5 the annual pumping in 5a was higher on average with dry years averaging 39 taf more than in 5.

The major difference in monthly pumping is the increase in capacity allowing for higher pumping capacity 8,500 cfs versus 6,680 cfs in studies 4 and 5 versus 4a and 5a. Dry years show the highest difference in annual pumping between the below normal, dry, and critical year types with 4 and 5 pumping more than 4a and 5a by 92 taf and 86 taf respectively. During critical years Study 4 pumps 42 taf more than 4a and 5 pumps 9 taf less than 5a.

Studies 4 and 5 show consistently higher pumping at Federal Banks, or JPOD, than Studies 4a and 5a respectively. The higher pumping is due to the increase in higher capacity at Banks in Studies 4 and 5, and the dedicated 100 taf of pumping at Banks for the CVP.

Shifts in X2 position between the studies tend to occur in February, March, and June with little movement in April and May due to the VAMP reduction, making exports more uniform.

On a monthly average basis Studies 4 and 5 increases the export-to-inflow ratio long-term average in October through January, and in July and September.

EWA conclusions:

- Some reductions in total purchases occur with 6680 Banks. This appears to be due to more frequent occurrence of conveyance constraints that limit EWA’s ability to wheel NOD purchases amounts relative to NOD purchase targets.

- In Study 5, debt spilling occurred in 23 of 73 simulation years, with maximum annual spill equal to 226 TAF. In Study 5a, debt spilling frequency reduced to 22 of 73 simulation years, with maximum annual spill equal to 173 TAF.
- Given Banks 6680 (Study 5a), the occurrence and magnitudes of unpaid deliveries debt become more significant and suggest that the presence of 8500 Banks is necessary to enable the simulated EWA assets and actions from OCAP Study 3 (i.e. Today CVPIA 3406 (b)(2) with EWA) to remain balanced and adequate given the "Future" system assumptions of OCAP Study 5.
- Reducing Banks pumping capacity from 8500 cfs to 6680 cfs reduces the magnitudes of debt conditions created in San Luis and SOD.

Chapter 12 CVP and SWP Delta Effects on Steelhead, Chinook Salmon, and Delta Smelt – Early Consultation

This section addresses the effects associated with Delta pumping on steelhead, spring and winter-run Chinook salmon, and Delta smelt. Fish monitoring programs for Central Valley Project (CVP) and State Water Project (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 Chapters 9 and 11, and are 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 (see 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 Table 4–7 and Table 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 shows a weak relationship between juvenile Chinook salmon Delta survival and exports (the export-to-inflow (E/I) 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 in salvage and loss are directly proportional to changes in the amount of water pumped.

Data from the U.S. Fish and Wildlife Service (FWS) Chipps Island Trawl suggest steelhead emigration occurs between October and June (see Figure 3–5). However, steelhead salvage at the Delta fish facilities has typically occurred between January and June, with consistently low salvage after April (see 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, E/I ratios, and Delta Cross Channel (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 H (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 E/I ratio standards during all months (see Figure 12–24 and Figure 12–29).

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 Environmental Water Account (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 12–1 shows potential loss 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). Table 12–1 also shows, at the bottom of each section, the difference between the loss changes, comparing operations today to future operations with a future upper pumping limit at Banks of 8,500 cfs versus an upper limit in the future of 6,680 cubic feet per second (cfs). Average loss and salvage numbers used in the calculations are shown in Table 12–2. Loss for steelhead was calculated from salvage by multiplying the monthly salvage totals by 0.579 for Tracy and by 4.34 at Banks. Loss for winter-run and spring-run was calculated daily by the California Department of Fish and Game (DFG).

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 they begin to show up in the salvage facilities quickly following release. If at least 50 percent 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 percent of 750,000. If unclipped fish were salvaged at a similar rate (1.4 percent) with 1,752 salvaged, then about 130,000 wild (unclipped) steelhead smolts passed through the Delta.

Table 12–1 Average change in winter-run, spring-run, and steelhead loss 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 were 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
% of historic			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
% of historic				3.6%	4.6%	3.8%	0.0%	6.2%	1.8%			1.5%
Steelhead number	0	-1	2	32	82	75	0	11	1	0	0	201
% of historic	4.0%	-1.4%	3.0%	3.4%	4.4%	3.4%	0.0%	4.0%	1.0%	-0.8%	-1.2%	3.1%
3 v 5 change in loss												
Winter-run number	0	0	-32	49	31	175	0	-1	0	0	0	222
% of historic			-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
% of historic				2.2%	1.0%	2.7%	-0.1%	-4.9%	-5.4%			-0.4%
Steelhead number	0	-1	-2	20	17	52	-1	-8	-3	0	0	75
% of historic	3.7%	-0.8%	-2.5%	2.1%	0.9%	2.4%	-0.1%	-3.2%	-2.9%	-0.1%	2.1%	1.2%
1 v 5 change in loss												
Winter-run number	0	0	-30	-95	178	90	-8	-3	0	0	0	133
% of historic			-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
% of historic				-4.3%	5.5%	1.4%	-2.5%	-26.7%	1.5%			-5.5%
Steelhead number	0	0	-1	-38	97	27	-20	-46	1	2	1	23
% of historic	7.1%	-0.5%	-2.3%	-4.1%	5.2%	1.2%	-2.1%	-17.4%	0.8%	12.1%	19.0%	0.4%

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
% of historic			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
% of historic				3.4%	0.9%	2.3%	2.5%	-9.1%	-7.8%			0.8%
Steelhead number	0	-2	3	31	16	46	20	-16	-4	-1	0	92
% of historic	-1.0%	-3.5%	5.0%	3.3%	0.9%	2.1%	2.1%	-6.0%	-4.2%	-2.6%	-3.8%	1.4%
3 v 5 change in loss												
Winter-run number	0	0	-12	65	40	85	13	0	0	0	0	190
% of historic			-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
% of historic				3.0%	1.2%	1.3%	4.2%	-3.6%	-4.3%			2.7%
Steelhead number	0	-2	-1	26	22	25	33	-6	-2	0	0	95
% of historic	-3.1%	-2.8%	-0.9%	2.8%	1.2%	1.2%	3.5%	-2.4%	-2.3%	0.3%	-3.1%	1.5%
1 v 5 change in loss												
Winter-run number	0	0	-42	-35	-10	69	8	-3	0	0	0	-12
% of historic			-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
% of historic				-1.6%	-0.3%	1.1%	2.7%	-26.2%	-8.4%			-1.7%
Steelhead number	0	-3	-2	-14	-6	21	22	-45	-5	0	0	-32
% of historic	-3.2%	-4.1%	-3.3%	-1.5%	-0.3%	0.9%	2.2%	-17.1%	-4.5%	-1.2%	-4.9%	-0.5%

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
% of historic			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
% of historic				6.1%	3.7%	3.6%	1.1%	3.0%	-6.8%			1.7%
Steelhead number	0	1	4	54	66	71	8	5	-4	0	0	206
% of historic	1.9%	1.6%	5.6%	5.8%	3.6%	3.2%	0.9%	2.0%	-3.6%	1.6%	2.5%	3.2%
3 v 5 change in loss												
Winter-run number	0	0	125	160	125	280	4	-1	0	0	0	693
% of historic			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
% of historic				7.2%	3.9%	4.3%	1.3%	-5.3%	2.3%			0.8%
Steelhead number	0	2	6	64	68	84	10	-9	1	1	0	228
% of historic	1.1%	3.2%	9.6%	6.9%	3.7%	3.8%	1.0%	-3.5%	1.2%	5.2%	-3.2%	3.5%
1 v 5 change in loss												
Winter-run number	0	0	87	18	134	289	-34	-7	0	0	0	487
% of historic			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
% of historic				0.8%	4.2%	4.4%	-11.1%	-67.9%	-4.0%			-17.0%
Steelhead number	0	0	4	7	74	86	-88	-116	-2	4	0	-30
% of historic	4.1%	0.7%	6.7%	0.8%	4.0%	3.9%	-9.2%	-44.4%	-2.2%	18.5%	1.4%	-0.5%

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
% of historic			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
% of historic				0.7%	-1.2%	-0.9%	2.6%	-2.9%	-5.8%			1.3%
Steelhead number	0	-1	2	6	-20	-17	21	-5	-3	-1	0	-19
% of historic	1.0%	-1.5%	2.7%	0.7%	-1.1%	-0.8%	2.1%	-1.9%	-3.1%	-4.9%	-6.9%	-0.3%
3 v 5 change in loss												
Winter-run number	0	0	23	61	122	70	-6	0	0	0	0	271
% of historic			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
% of historic				2.8%	3.8%	1.1%	-2.0%	-0.5%	-8.6%			-1.3%
Steelhead number	0	0	1	25	67	21	-16	-1	-5	-1	0	91
% of historic	0.7%	-0.4%	1.8%	2.6%	3.6%	1.0%	-1.6%	-0.3%	-4.6%	-4.1%	-7.7%	1.4%
1 v 5 change in loss												
Winter-run number	0	0	-50	-132	103	-288	-3	-4	0	0	0	-373
% of historic			-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
% of historic				-6.0%	3.2%	-4.4%	-1.0%	-32.6%	-12.3%			-6.1%
Steelhead number	0	-2	-2	-53	56	-86	-8	-56	-7	-1	0	-160
% of historic	0.5%	-2.9%	-3.8%	-5.7%	3.0%	-3.9%	-0.8%	-21.3%	-6.6%	-7.4%	-13.7%	-2.5%

Banks											
Below Normal	**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
% of historic			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
% of historic				7.4%	3.9%	8.4%	2.6%	25.0%	-0.8%			6.7%
Steelhead number	0	2	7	66	69	165	21	43	0	1	0	373
% of historic	-0.2%	3.2%	10.3%	7.1%	3.7%	7.5%	2.1%	16.4%	-0.4%	4.5%	2.6%	5.8%
3 v 5 change in loss												
Winter-run number	0	0	134	108	6	350	5	-2	0	0	0	601
% of historic			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
% of historic				4.9%	0.2%	5.4%	1.5%	-14.9%	9.7%			-0.3%
Steelhead number	0	2	7	43	3	105	12	-25	6	1	0	153
% of historic	-2.3%	3.1%	10.3%	4.6%	0.2%	4.8%	1.2%	-9.7%	5.2%	6.1%	2.0%	2.4%
1 v 5 change in loss												
Winter-run number	0	0	63	40	163	411	-102	-11	0	0	0	564
% of historic			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
% of historic				1.8%	5.0%	6.3%	-33.1%	-99.5%	-11.4%			-37.0%
Steelhead number	0	1	3	16	89	123	-263	-171	-7	3	0	-203
% of historic	2.1%	1.9%	4.9%	1.7%	4.8%	5.6%	-27.4%	-65.0%	-6.1%	17.2%	11.6%	-3.1%

Tracy											
Below Normal	**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
% of historic			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
% of historic				3.0%	-2.0%	-5.1%	-1.5%	-5.2%	0.1%			-2.5%
Steelhead number	0	1	0	26	-36	-99	-12	-9	0	0	0	-129
% of historic	0.5%	1.4%	0.8%	2.8%	-1.9%	-4.5%	-1.2%	-3.4%	0.1%	-1.9%	-1.5%	-2.0%
3 v 5 change in loss												
Winter-run number	0	0	14	37	97	-199	-3	-1	0	0	0	-56
% of historic			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
% of historic				1.7%	3.0%	-3.0%	-1.1%	-11.6%	0.3%			-2.9%
Steelhead number	0	1	1	15	53	-59	-9	-20	0	0	0	-19
% of historic	0.0%	1.3%	1.1%	1.6%	2.9%	-2.7%	-0.9%	-7.6%	0.2%	-1.9%	-0.9%	-0.3%
1 v 5 change in loss												
Winter-run number	0	0	-62	-58	76	-589	-13	-4	0	0	0	-650
% of historic			-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
% of historic				-2.6%	2.4%	-9.0%	-4.1%	-36.9%	0.3%			-9.6%
Steelhead number	0	0	-3	-23	42	-176	-33	-63	0	-1	0	-257
% of historic	-0.2%	-0.2%	-4.8%	-2.5%	2.2%	-8.0%	-3.4%	-24.1%	0.2%	-3.7%	-2.1%	-4.0%

Banks											
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	-16	-73	75	217	35	0	0	0	0	238
% of historic			-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
% of historic	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
% of historic	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
% of historic			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
% of historic	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
% of historic	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
% of historic			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
% of historic	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
% of historic	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
% of historic			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
% of historic	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
% of historic	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
% of historic			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
% of historic	-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
% of historic	-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
% of historic			-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
% of historic	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
% of historic	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
% of historic			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
% of historic	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
% of historic	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
% of historic			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
% of historic	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
% of historic	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
% of historic			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
% of historic	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
% of historic	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
% of historic			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
% of historic	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
% of historic	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
% of historic			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
% of historic	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
% of historic	-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
% of historic			-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
% of historic	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
% of historic	0.3%	0.7%	-5.5%	-7.4%	-6.6%	2.9%	-2.5%	-7.5%	0.1%	0.1%	0.4%	-2.7%

Table 12–2 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 percent adults (see Figure 10-3). Fish greater than 350 millimeters (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 it is assumed it will remain around 3.5 percent of the total number of steelhead salvaged. Figure 10-4 shows all steelhead fork lengths measured at the salvage facilities from 1993 – 2003.

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. California State Water Resources Control Board (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. The Bureau of Reclamation (Reclamation) shall determine the timing and duration of the closures after consultation with FWS, DFG, and the National Marine Fisheries Service (NOAA Fisheries). Consultation with the CALFED Bay-Delta Program

Operations Coordination Group (CALFED Ops 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 12–1 and Figure 12–2 show the percent of the Sacramento River flow passing through the DCC and through Georgiana Slough during critically dry years. Figure 12–3 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.

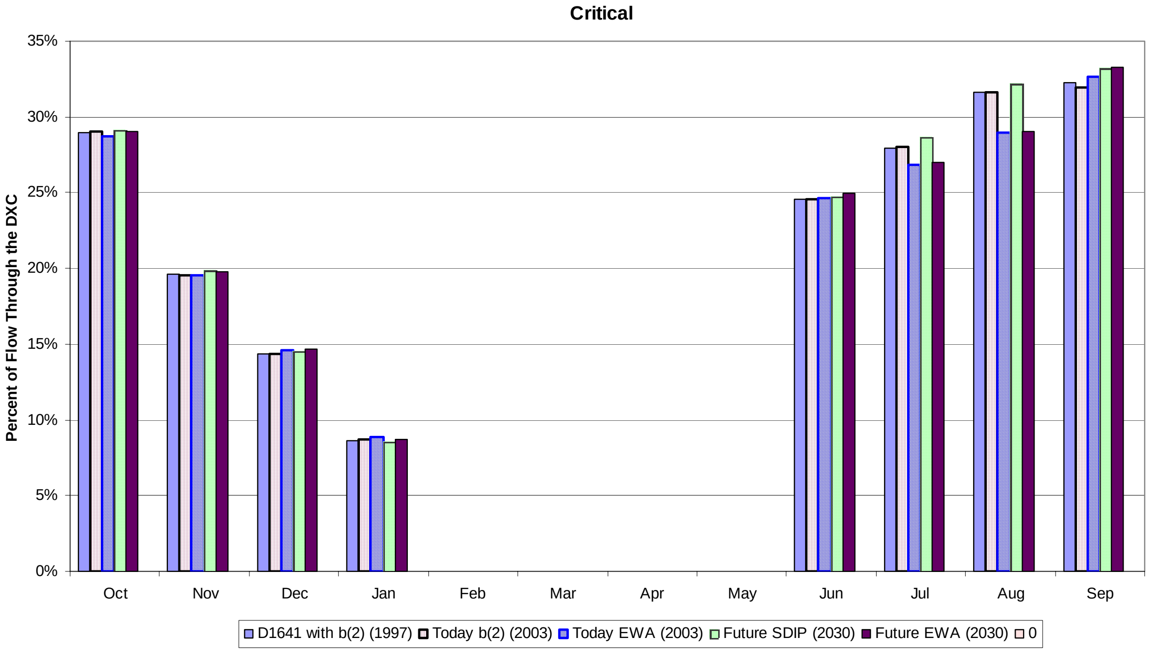


Figure 12–1 Percent of Sacramento River flow passing through the DCC during critically dry years under the five scenarios.

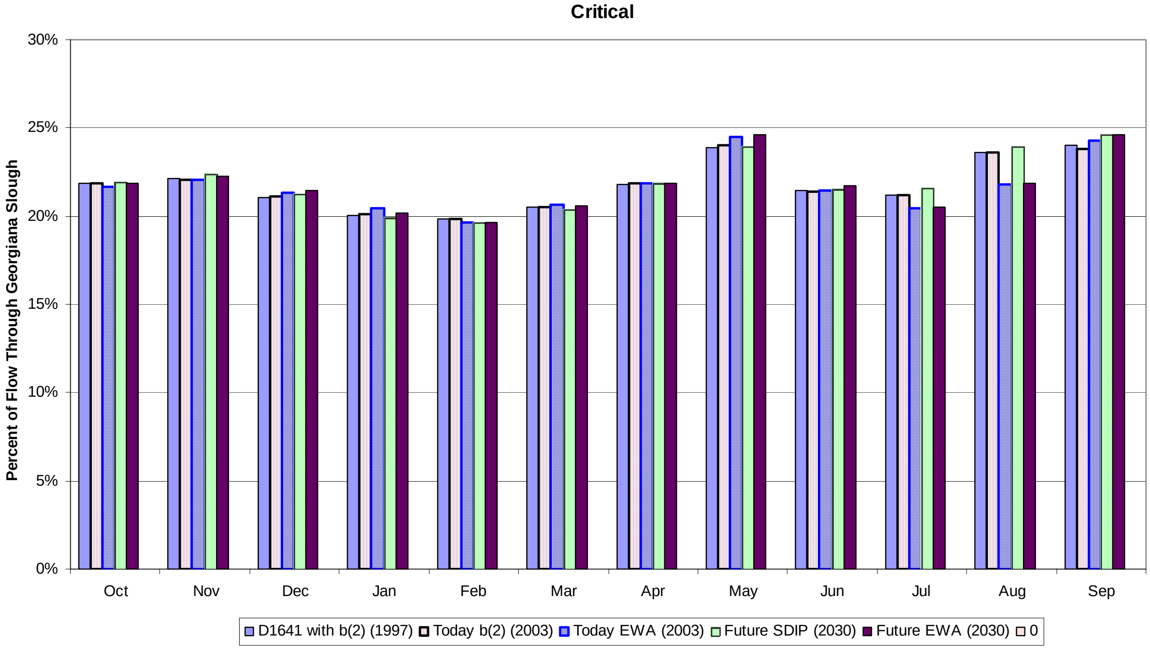


Figure 12–2 Percent of Sacramento River flow passing through Georgiana Slough during critically dry years under the five scenarios.

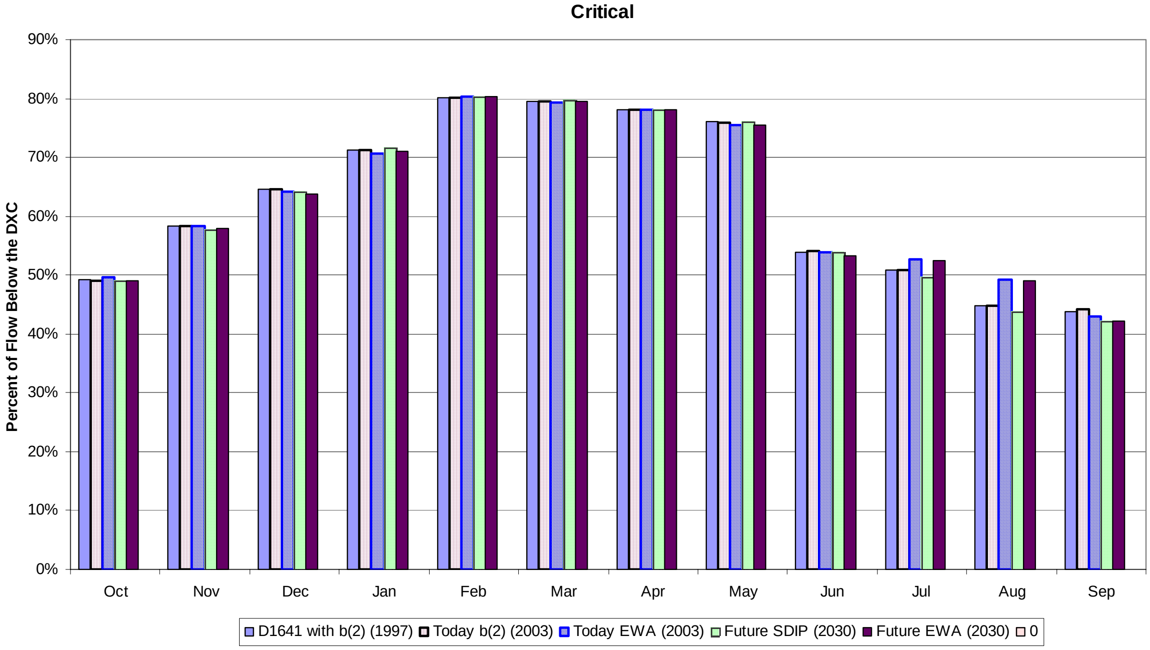


Figure 12–3 Percent of Sacramento River flow continuing down the main Sacramento River channel past the DCC and Georgiana Slough during critically dry years under the five scenarios.

Suisun Marsh Salinity Control Gates

The Suisum Marsh Salinity Control Gates (SMSCG) could be operated as needed to meet State salinity standards in the marsh from 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 University of California (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 SMSCG 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 fish 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 time step 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 E/I ratio. 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 E/I 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. We have separately predicted changes in adult salvage despite the comparatively small numbers of adults salvaged, because unspent adult Delta smelt are of considerably more value to the population than juveniles. However, it must be stressed that we have no evidence at present that adult mortality at the export facilities has driven Delta smelt population dynamics.

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:

Table 12–3 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[a]	Predicted median difference in salvage[b]	
					4 – 1	5 – 1
Adults						
December	4222	+8.9%	–0.7%	0.010	+4	0
January	4226	+8.8%	–0.8%	0.095	+35	–3
February	4243	+8.3%	–2.2%	0.151	+53	–14
March	4273	–2.9%	+7.0%	0.159	–19	+47
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	0
Net: December – March					+73	+30
Net: April – July					0	0

[a] Average delta smelt salvage density (fishes c.f.s.$^{-1}$ month^{-1}) estimated from pooled Above Normal and Wet years 1995-2000.

[b] Predicted median difference has unit: fishes month.$^{-1}$. See text for explanation of calculation.

Table 12–4 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[a]	Predicted median difference in salvage[b]	
					4 – 1	5 – 1
Adults						
December	4221	+8.9%	–0.7%	0.010	+4	0
January	4225	+8.9%	–0.8%	0.095	+36	–3
February	4242	+8.4%	–2.2%	0.151	+54	–14
March	4262	–14.3%	+0.3%	0.159	–73	–45
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	+1
Net: December – March					+20	–62
Net: April – July					0	+1

[a] Average delta smelt salvage density (fishes c.f.s.$^{-1}$ month^{-1}) estimated from pooled Above Normal and Wet years 1995-2000.

[b] Predicted median difference has unit: fishes month.$^{-1}$. See text for explanation of calculation.

Table 12–5 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[a]	Predicted median difference in salvage[b]	
					4 – 1	5 – 1
Adults						
December	4221	+7.3%	–3.5%	0.067	+21	–10
January	4225	+8.9%	–0.7%	0.180	+68	–6
February	4241	+8.1%	+8.2%	0.235	+81	+82
March	4235	–3.8%	–4.8%	0.201	–32	–41
Largely Juveniles						
April	2321	0	–1.1%	0.259	0	–7
May	1911	0	–34.0%	11.93	0	–7761
June	3000	0	0	1.584	0	0
July	4554	+0.3%	+0.2%	0.005	0	0
Net: December – March					+137	+26
Net: April – July					0	–7768

[a] Average delta smelt salvage density (fishes c.f.s.$^{-1}$ month^{-1}) estimated from pooled Dry and Critically Dry years 1994 and 2001-2.

[b] Predicted median difference has unit: fishes month.$^{-1}$. See text for explanation of calculation.

Table 12–6 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[a]	Predicted median difference in salvage[b]	
					4 – 1	5 – 1
Adults						
December	4220	+8.9%	–0.7%	0.067		
January	4225	+8.8%	–0.8%	0.180		
February	4235	+8.4%	+8.4%	0.235		
March	4208	+1.4%	–0.8%	0.201		
Largely Juveniles						
April	1808	+0.7%	+0.9%	0.259		
May	1720	0	–38.1%	11.93		
June	2874	0	–8.9%	1.584		
July	4421	–0.3%	–5.7%	0.005		
Net: December – March						
Net: April – July						

[a] Average delta smelt salvage density (fishes c.f.s.$^{-1}$ month^{-1}) estimated from pooled Dry and Critically Dry years 1994 and 2001-2.

[b] Predicted median difference has unit: fishes month.$^{-1}$. See text for explanation of calculation.

Table 12–7 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[a]	Predicted median difference in salvage[b]	
					4 – 1	5 – 1
Adults						
December	2897	+4.8%	–19.1%	0.067	+9	–37
January	4218	+8.9%	–9.7%	0.180	+67	–73
February	3979	+1.9%	–0.1%	0.235	+18	0
March	1247	+2.9%	0	0.201	+7	0
Largely Juveniles						
April	800	0	0	0.259	0	0
May	1189	0	–32.6%	11.93	0	–4638
June	953	–1.1%	0	1.584	–17	0
July	800	–1.5%	0	0.005	0	0
Net: December – March					+102	–110
Net: April – July					–17	–4638

[a] Average delta smelt salvage density (fishes c.f.s.$^{-1}$ month^{-1}) estimated from pooled Dry and Critically Dry years 1994 and 2001-2.

[b] Predicted median difference has unit: fishes month.$^{-1}$. See text for explanation of calculation.

Table 12–8 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[a]	Predicted median difference in salvage[b]	
					4 – 1	5 – 1
Adults						
December	7033	+18.0%	+13.7%	0.015	+19	+14
January	7408	+9.5%	+8.4%	0.214	+151	+133
February	5848	+2.4%	+4.1%	0.242	+34	+58
March	5653	+17.2%	+24.8%	0.069	+67	+97
Largely Juveniles						
April	4830	+8.7%	–19.2%	0.058	+24	–54
May	4660	+5.8%	–48.4%	12.52	+3366	–28216
June	5925	–0.1%	+7.0%	10.90	–229	+4547
July	6680	+12.7%	+17.4%	0.611	+520	+711
Net: December – March					+270	+302
Net: April – July					+3682	–23011

[a] Average delta smelt salvage density (fishes c.f.s.$^{-1}$ month^{-1}) estimated from pooled Above Normal and Wet years 1993 and 1995-2000.

[b] Predicted median difference has unit: fishes month.$^{-1}$. See text for explanation of calculation.

Table 12–9 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[a]	Predicted median difference in salvage[b]	
					4 – 1	5 – 1
Adults						
December	6484	+9.3%	+4.8%	0.015	+8	+6
January	7548	0	–4.8%	0.214	0	–7
February	7451	+2.1%	–3.1%	0.242	+62	+103
March	5784	+14.3%	+26.6%	0.069	+60	+36
Largely Juveniles						
April	4508	+7.4%	–23.5%	0.058	+22	–66
May	3596	+2.3%	–58.3%	12.52	+1540	–22496
June	3942	+3.5%	+0.6%	10.90	+1268	–1099
July	6157	+7.7%	+27.0%	0.611	+372	+869
Net: December – March					+130	+137
Net: April – July					+3201	–22792

[a] Average delta smelt salvage density (fishes c.f.s.$^{-1}$ month^{-1}) estimated from pooled Above Normal and Wet years 1993 and 1995-2000.

[b] Predicted median difference has unit: fishes month.$^{-1}$. See text for explanation of calculation.

Table 12–10 SWP 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 Banks[a]	Predicted median difference in salvage[b]	
					4 – 1	**5 – 1**
Adults						
December	5938	+11.2%	+6.0%	0.050	+33	+18
January	7172	+7.5%	–0.4%	0.209	+113	–7
February	5850	+2.1%	+5.7%	0.134	+17	+45
March	5713	+12.4%	+8.9%	0.178	+126	+90
Largely Juveniles						
April	3548	+1.0%	–25.2%	0.369	+13	–330
May	3235	+3.9%	–50.0%	29.97	+3792	–48444
June	3977	–0.2%	–2.6%	6.706	–50	–682
July	5320	+4.0%	+23.1%	0.446	+94	+548
Net: December – March					+289	+146
Net: April – July					+3849	–48908

[a] Average delta smelt salvage density (fishes c.f.s.$^{-1}$ month^{-1}) estimated from pooled Dry and Critically Dry years 1994 and 2001-2.

[b] Predicted median difference has unit: fishes month.$^{-1}$. See text for explanation of calculation.

Table 12–11 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[a]	Predicted median difference in salvage[b]	
					4 – 1	**5 – 1**
Adults						
December	5358	+9.5%	+9.5%	0.050	+25	+26
January	5717	+10.0%	–8.6%	0.209	+119	–103
February	5303	+7.2%	+9.5%	0.134	+51	+67
March	4413	–0.1%	–0.1%	0.178	0	0
Largely Juveniles						
April	2168	+0.1%	–18.1%	0.369	+1	–145
May	2099	–1.8%	–58.1%	29.97	–1111	–36577
June	2952	–0.8%	–6.7%	6.706	–155	–1330
July	5217	+0.1%	+29.2%	0.446	+1	+679
Net: December – March					+196	–10
Net: April – July					–1265	–37373

[a] Average delta smelt salvage density (fishes c.f.s.$^{-1}$ month^{-1}) estimated from pooled Dry and Critically Dry years 1994 and 2001-2.

[b] Predicted median difference has unit: fishes month.$^{-1}$. See text for explanation of calculation.

Table 12–12 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[a]	Predicted median difference in salvage[b]	
					4 – 1	5 – 1
Adults						
December	4267	+6.0%	–5.9%	0.050	+13	–12
January	4891	+6.2%	–13.2%	0.209	+63	–135
February	3198	+13.4%	+14.4%	0.134	+58	+62
March	2030	+14.2%	+0.3%	0.178	+51	+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	–3	+132
Net: December – March					+185	–84
Net: April – July					–3	–11521

[a] Average delta smelt salvage density (fishes c.f.s.$^{-1}$ month^{-1}) estimated from pooled Dry and Critically Dry years 1994 and 2001-2.

[b] Predicted median difference has unit: fishes month.$^{-1}$. See text for explanation of calculation.

Salvage of adult delta smelt

In general, there is a 7-10 percent increase in median pumping in typical years at the CVP in model case #4, while there is either no change or a trivial decrease when EWA actions are included in case #5 (Table 12–3 through Table 12–12). There are smaller increases of 1.9 – 8.9 percent at the CVP in Critically Dry years in #4; the corresponding months in #5 feature either reductions in pumping relative to the base case or no change. March is exceptional in #4, with up to a 10.8 percent decrease in pumping (relative to #1) in the wetter months.

At the SWP facility, median pumping winter pumping rate changes in wetter years ranged as high as +18 percent in December in #4 and +24.8 percent in March in #5, though most of the other wetter-year changes are +10 percent or less. In drier years median changes varied between zero and +14.4 percent, with several values above +10 percent.

In all, predicted adult salvage at the CVP differs very little in #4 and #5 from #1, and there are consistent increases of up to a few hundred individuals under both #4 and #5 at the SWP.

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 answer 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 in the future. New analytical approaches that employ estimates of the boundary of the zone of entrainment to predict the proportion of the delta smelt population that is subject to entraiment are under development. If these efforts succeed, they could provide a basis for evaluating the population-level effects of export operations and proposed changes to operations.

X2 Position

The X2 position in CALSIM II represents where 2 ppt isohaline lies in the Delta calculated from the monthly average Net Delta Outflow (NDO). Since the model represents the end of month X2 position, the day-to-day effects of CVP/SWP operations are not resolved in this representation.

Figure 12–4 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 and 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-kilometer (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 shows 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 12–5 to Figure 12–10. These six figures generally indicate the same trend from February to June in the X2 position on average as it moves more upstream into the Delta. Also, in the months February, Apr, May, and June, the X2 position shifts slightly downstream in Studies 3 and 5 when compared to the other studies.

Figure 12–11 to Figure 12–15 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 12–16 to Figure 12–18 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.

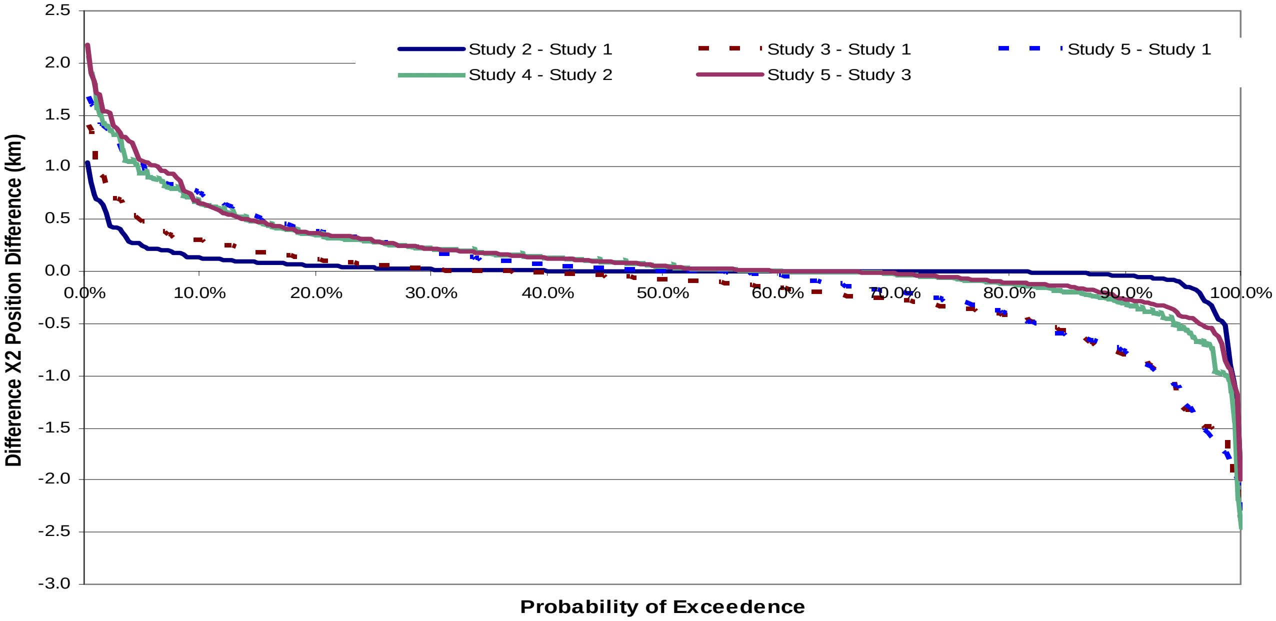


Figure 12–4 Probability of Exceedance for Monthly Shifts in X2 Position for the Feb – June Period

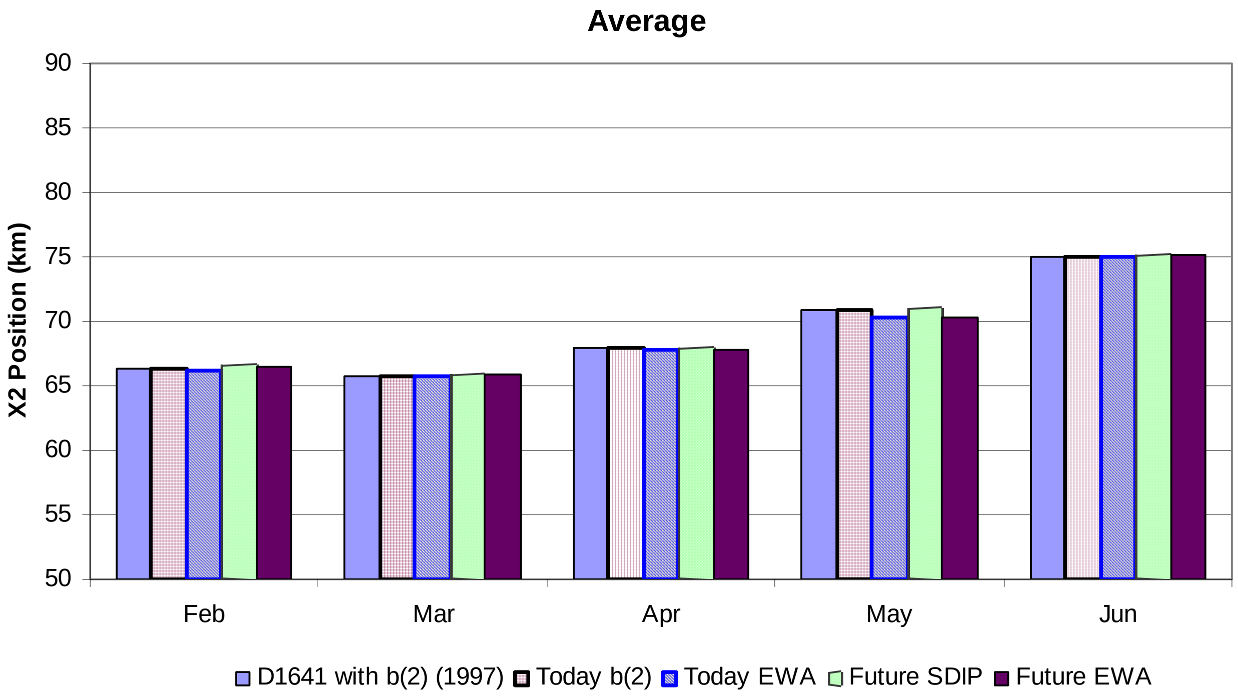


Figure 12–5 Average Monthly X2 Position

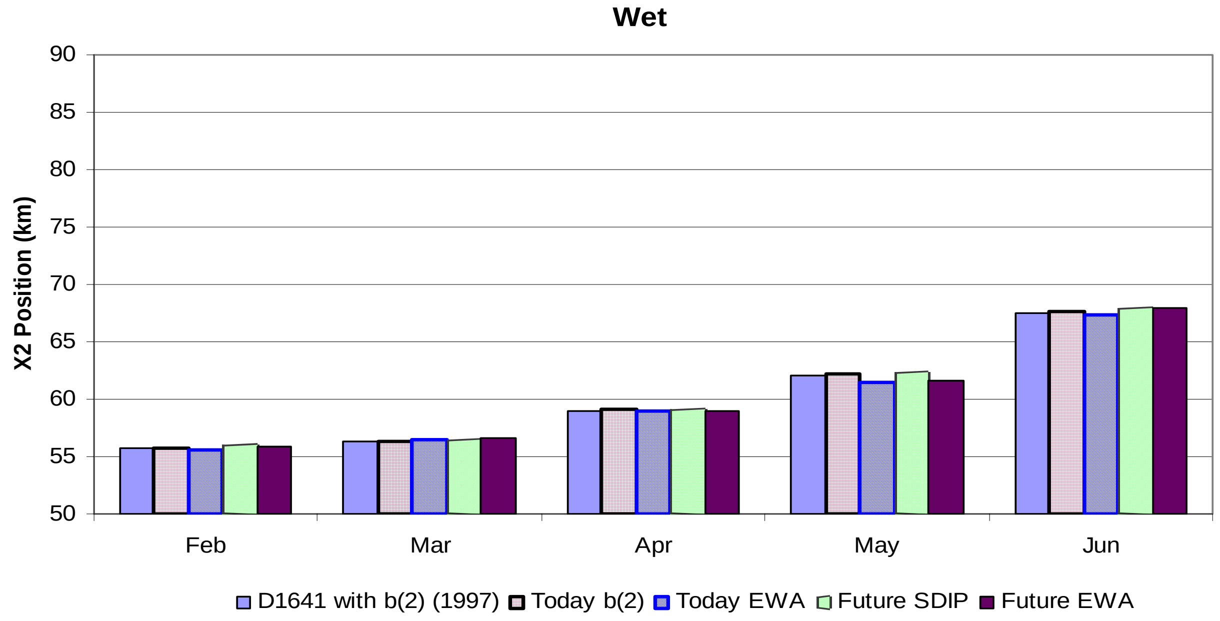


Figure 12–6 Average wet year (40-30-30 Classification) monthly X2 Position

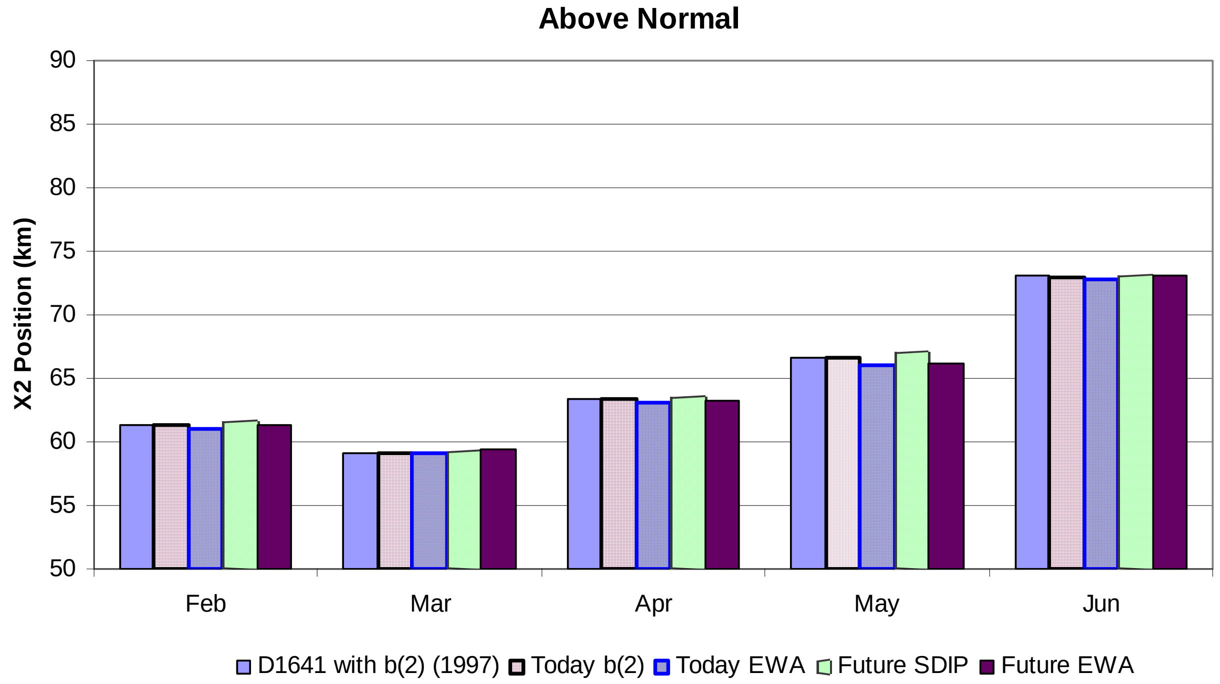


Figure 12–7 Average above normal year (40-30-30 Classification) monthly X2 Position

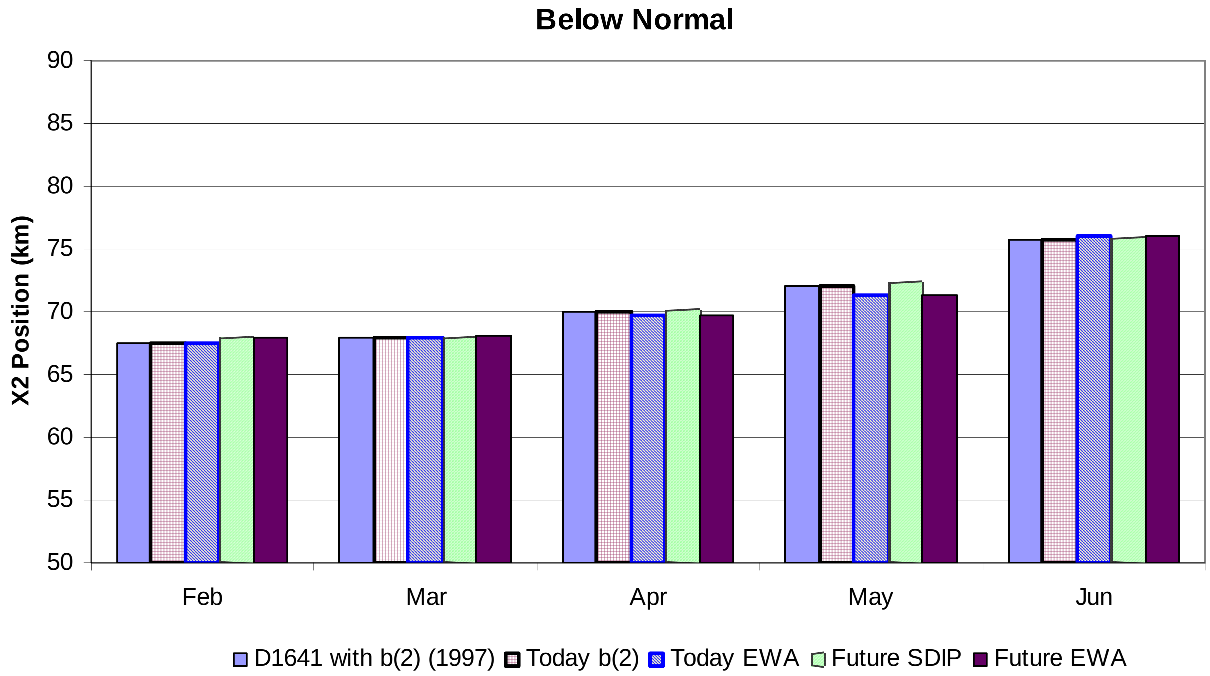


Figure 12–8 Average below normal year (40-30-30 Classification) monthly X2 Position

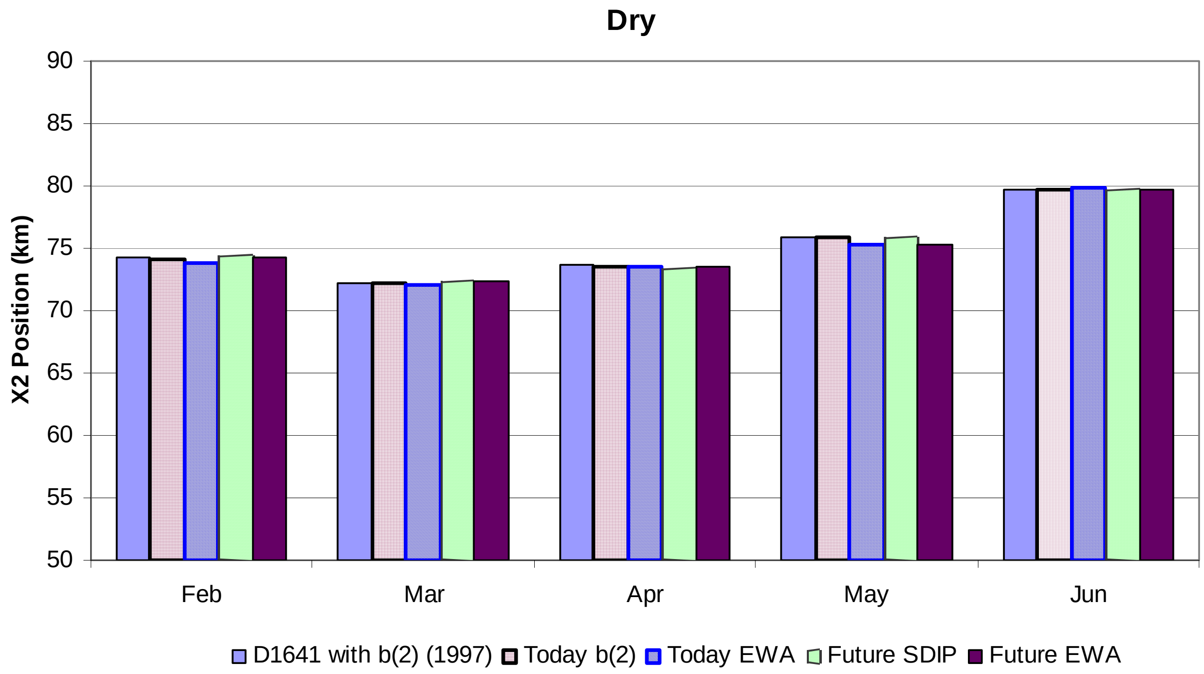


Figure 12–9 Average dry year (40-30-30 Classification) monthly X2 Position

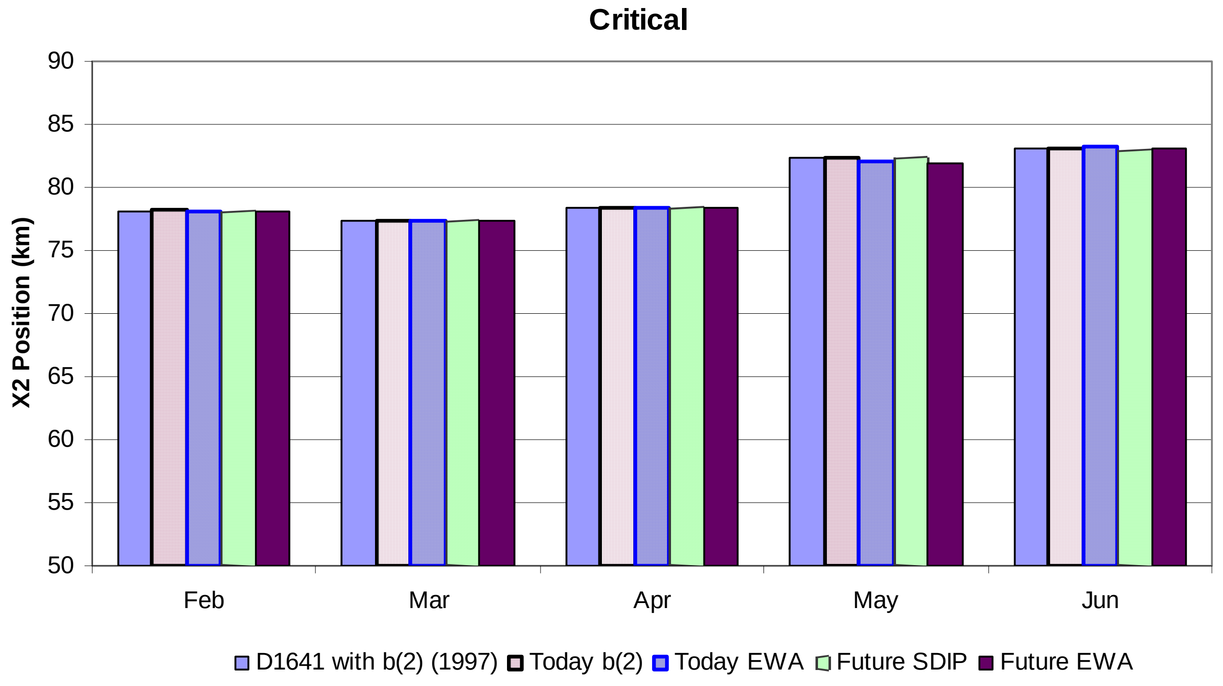


Figure 12–10 Average critical year (40-30-30 Classification) monthly X2 Position

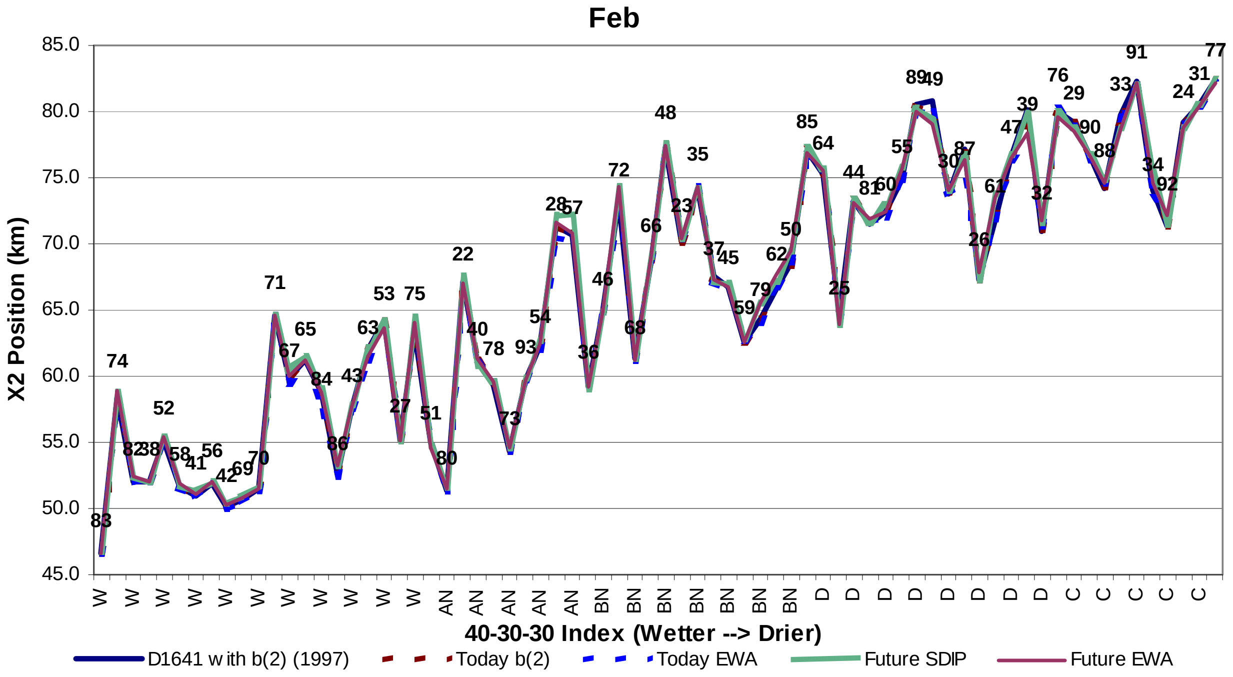


Figure 12–11 February X2 Position sorted by 40-30-30 Index

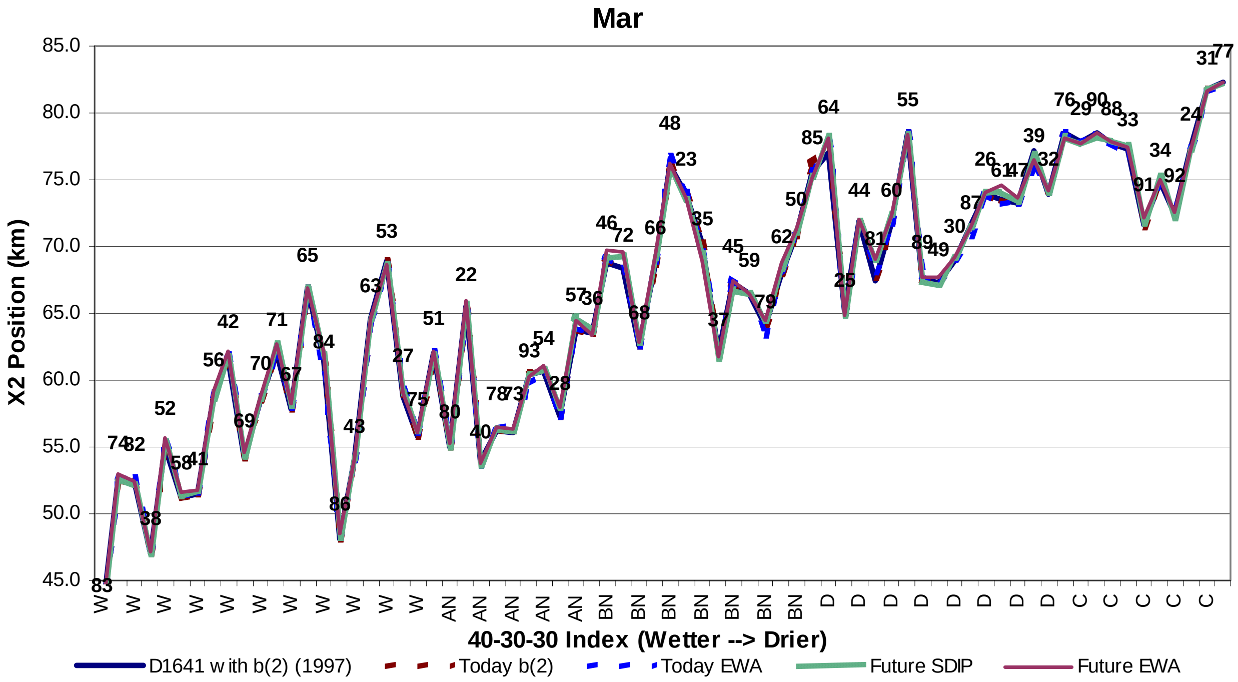


Figure 12–12 March X2 Position sorted by 40-30-30 Index

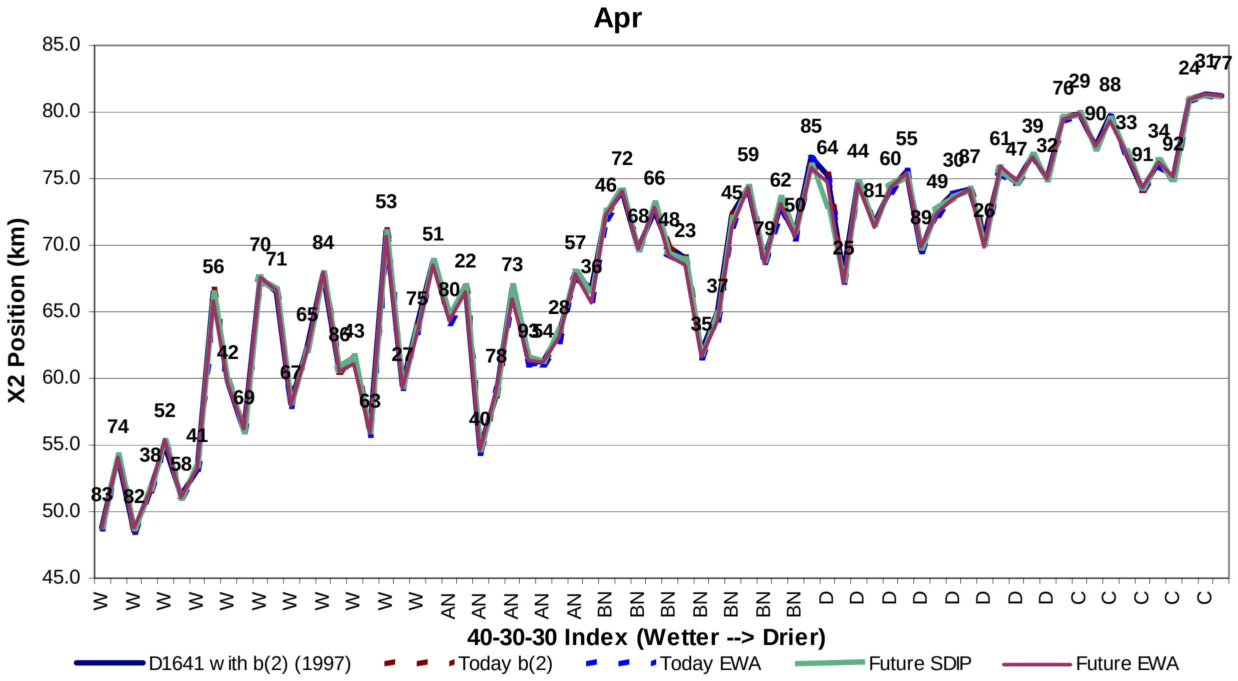


Figure 12–13 April X2 Position sorted by 40-30-30 Index

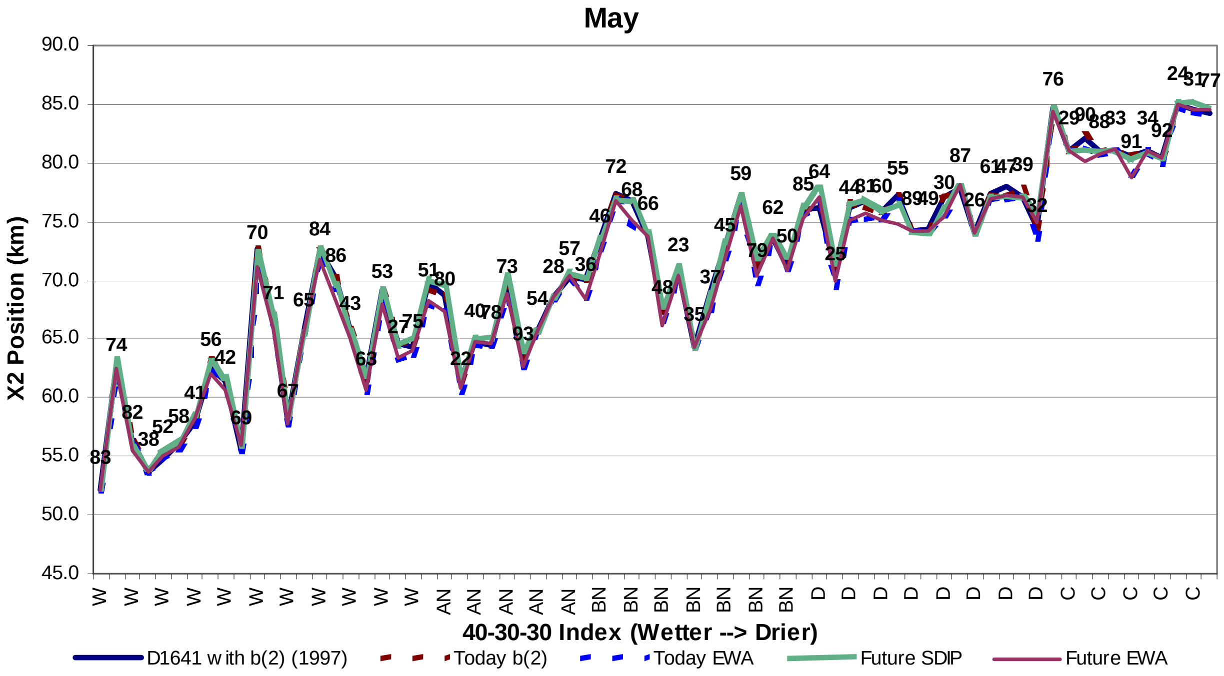


Figure 12–14 May X2 Position sorted by 40-30-30 Index

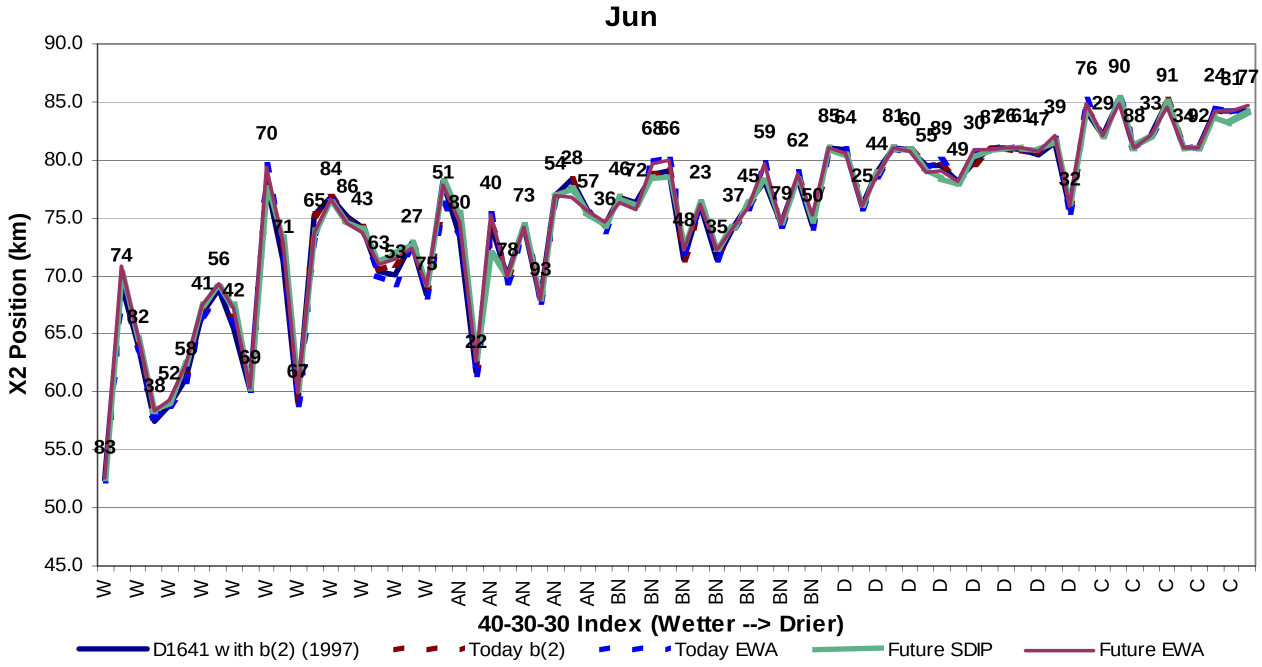


Figure 12–15 June X2 Position sorted by 40-30-30 Index

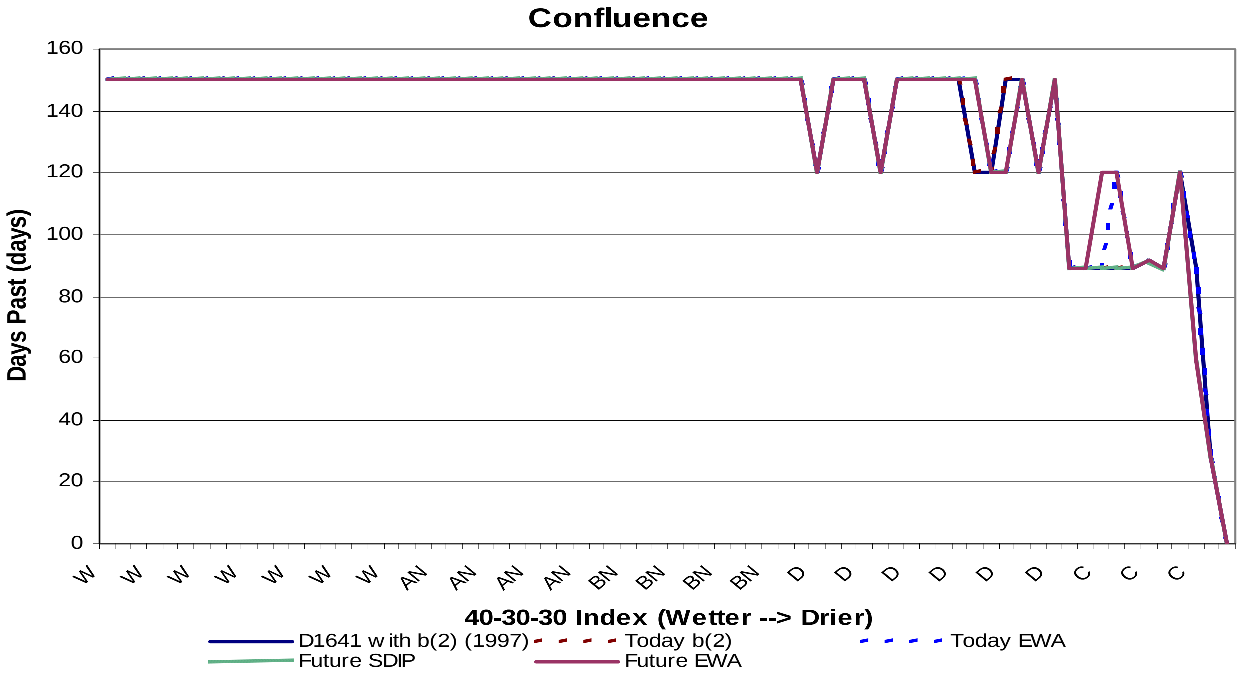


Figure 12–16 Total number of days average monthly X2 position is past the Confluence 40-30-30 Index **(Note: that the total days for a month are assigned if the average X2 position is past the confluence)**

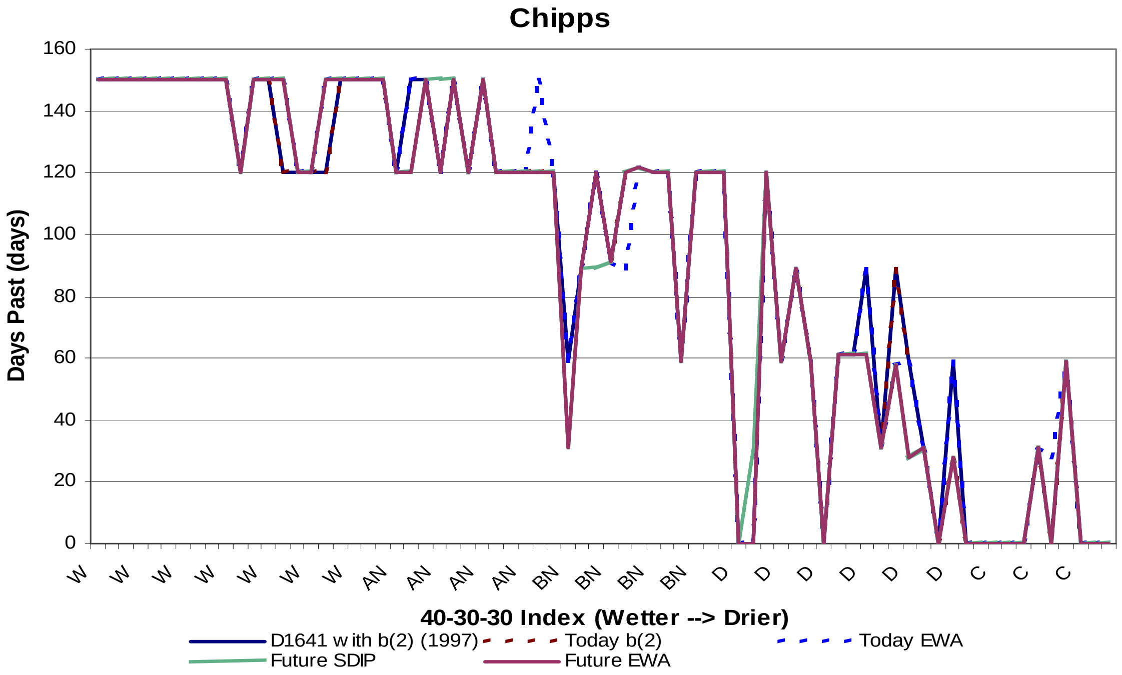


Figure 12–17 Total number of days average monthly X2 position is past the Chipps Island 40-30-30 Index **(Note: that the total days for a month are assigned if the average X2 position is past the Chipps Island)**

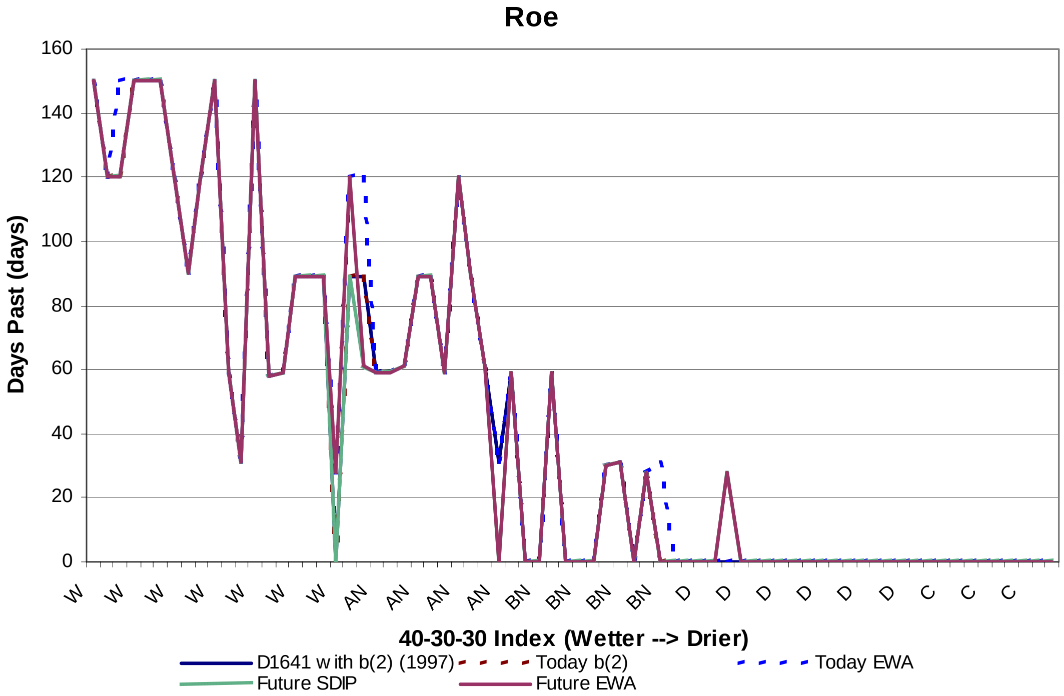


Figure 12–18 Total number of days average monthly X2 position is past the Roe Island 40-30-30 Index **(Note: that the total days for a month are assigned if the average X2 position is past the Roe Island)**

Changes in Habitat Availability for Delta Smelt Based on X2 Movement

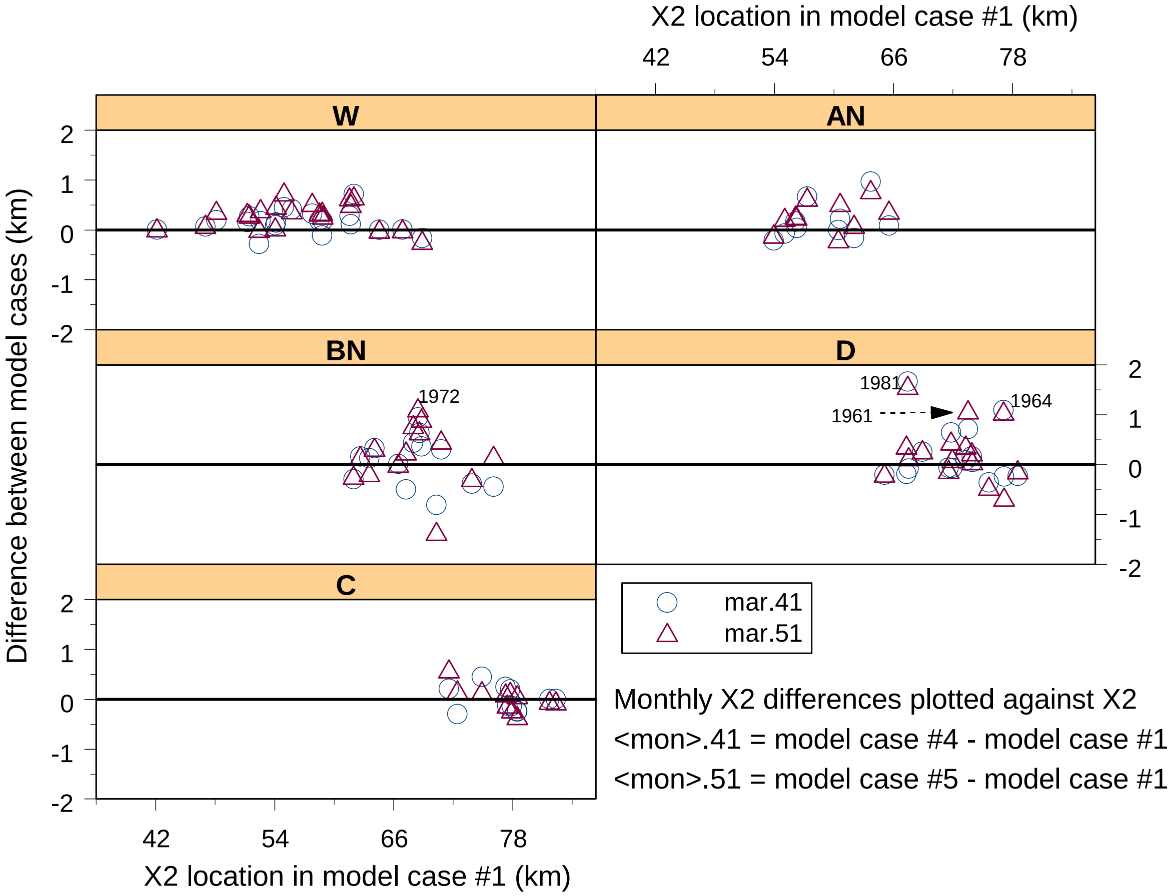
We are concerned about upstream movements of X2 during the spring and early summer primarily because smelt tend to aggregate in a region defined by low salinity, and movement of that region upstream moves those aggregations closer to the export pumps. Because there is no "critical value" that reliably separates a dangerous X2 difference from an innocuous one, we arbitrarily selected one kilometer as the criterion for review. However, the location of X2 may affect how important an upstream change in X2 could be (Nobriga et al. unpublished analysis). When X2 is downstream of Chipps Island, an upstream movement, even of several kilometers, is unlikely to affect delta smelt if it does not result in X2 moving east of Chipps Island. When it is already upstream of Chipps Island, a shift of a few kilometers farther upstream probably does not increase the risk of entrainment at the facilities. Movement of X2 from downstream to upstream of Chipps Island may be associated with a marginal increased risk of smelt entrainment at the export facilities. Unfortunately, the present evidence for this claim relies on the regression of a ratio of a delta smelt index to salvage at the export facilities against river kilometer index, and does not provide a suitable basis for estimating the marginal risk of X2 shifts to delta smelt. The risk of one-kilometer shifts is probably small. A better reckoning of the risk to delta smelt posed by X2 shifts may be available in the future when improved modeling of the consequences of changes in water operations is available.

To explore the changes in X2 location that might result from future operations, 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 12–19 – Figure 12–23).

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. We note where X2 difference between model cases seems to imply a shift from downstream to upstream of Chipps Island in a future scenario, and whether X2 location in the succeeding month seems to indicate a persistent shift upstream.

Results

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 exceeding one kilometer (of upstream shift) during the March–July months (Figure 12–19 – Figure 12–23).



Monthly X2 differences plotted against X2
<mon>.41 = model case #4 - model case #1
<mon>.51 = model case #5 - model case #1

Figure 12–19 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

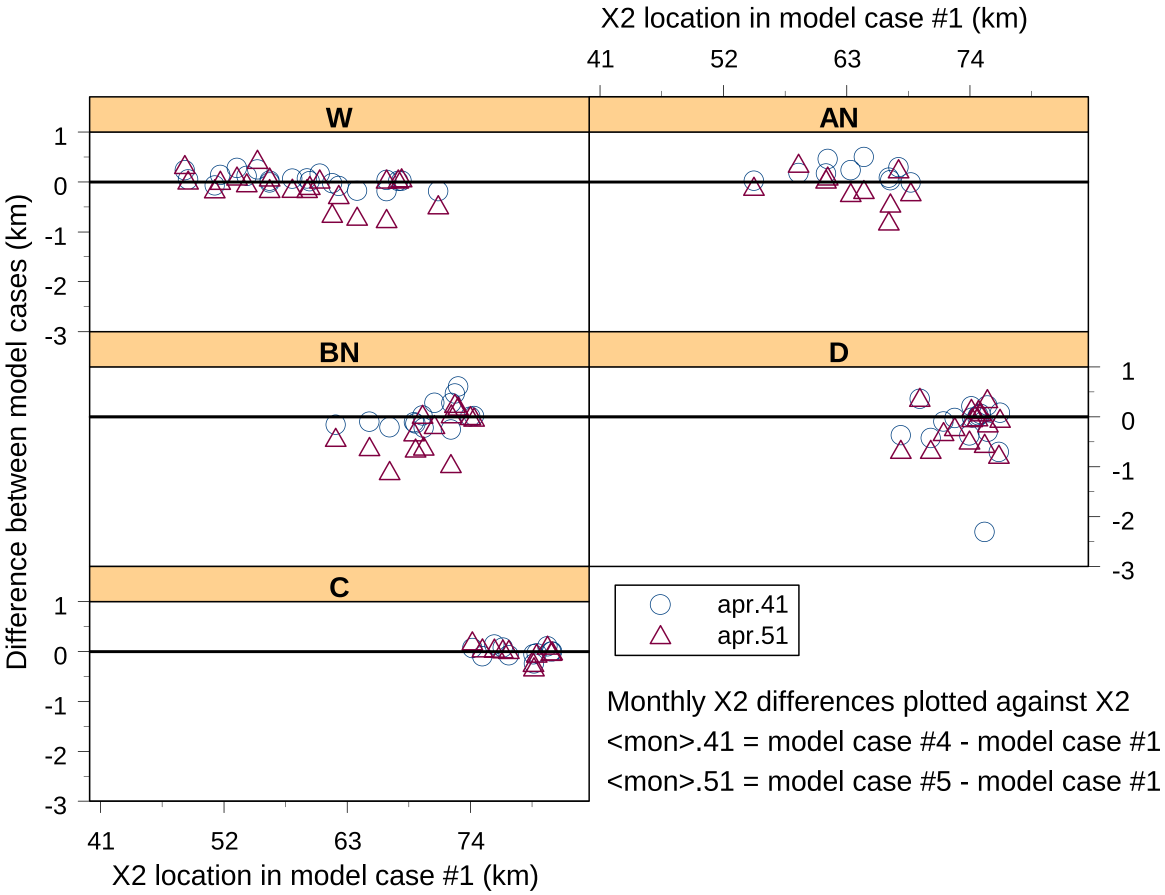


Figure 12–20 Differences in X2 under model cases #4 and #5 in April. Water year types: W=Wet, AN=Above Normal, BN=Below Normal, D=Dry, C=Critically Dry

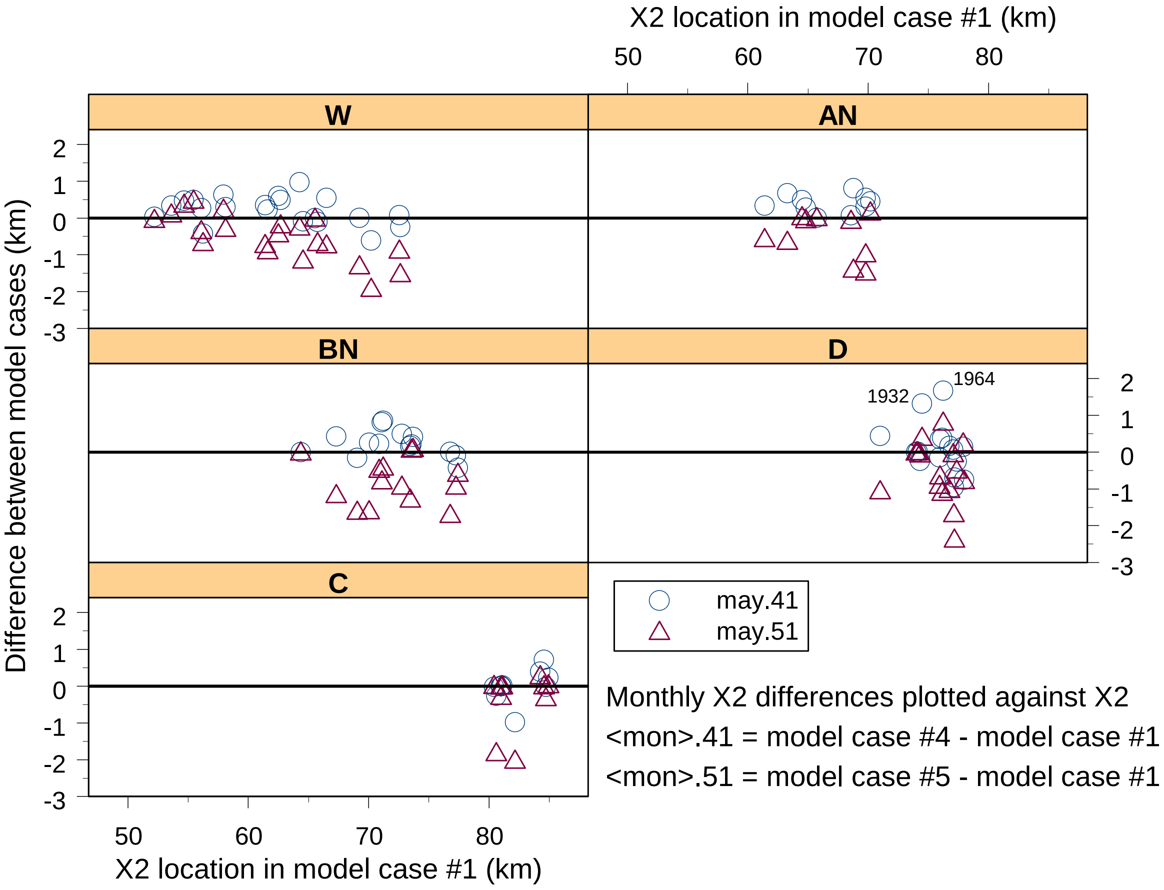


Figure 12–21 Differences in X2 under model cases #4 and #5 in May. Water year types: W=Wet, AN=Above Normal, BN=Below Normal, D=Dry, C=Critically Dry

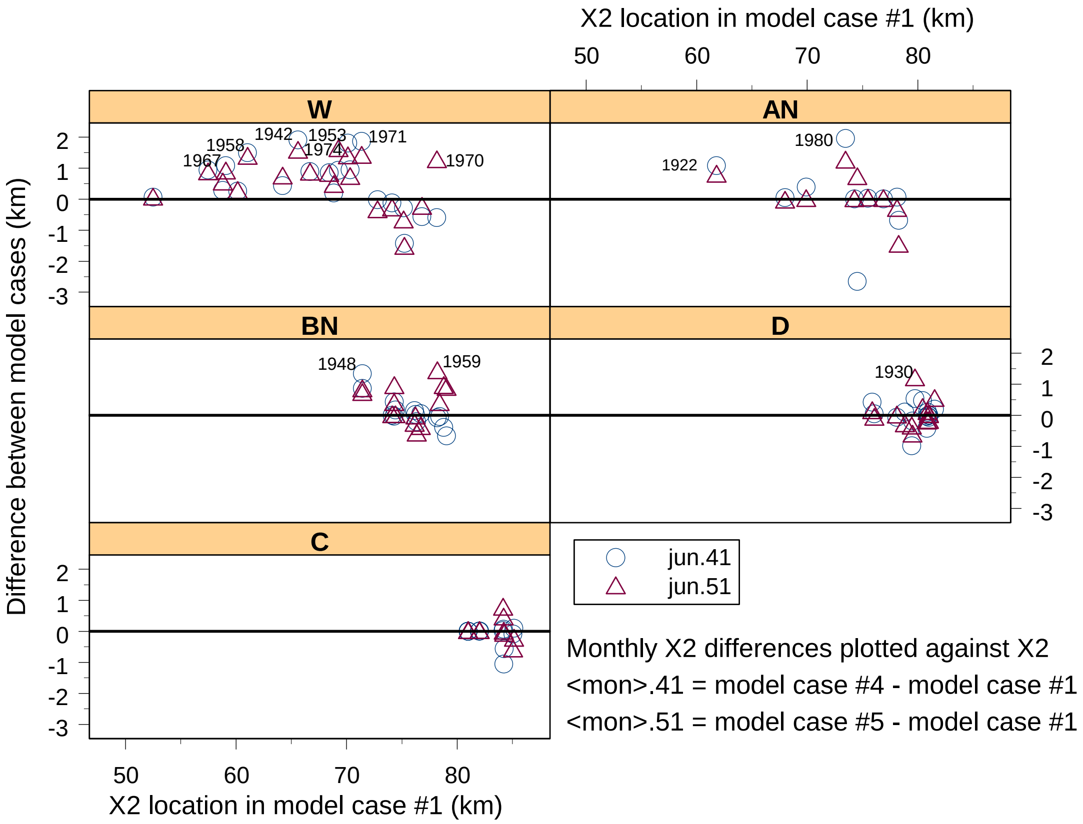
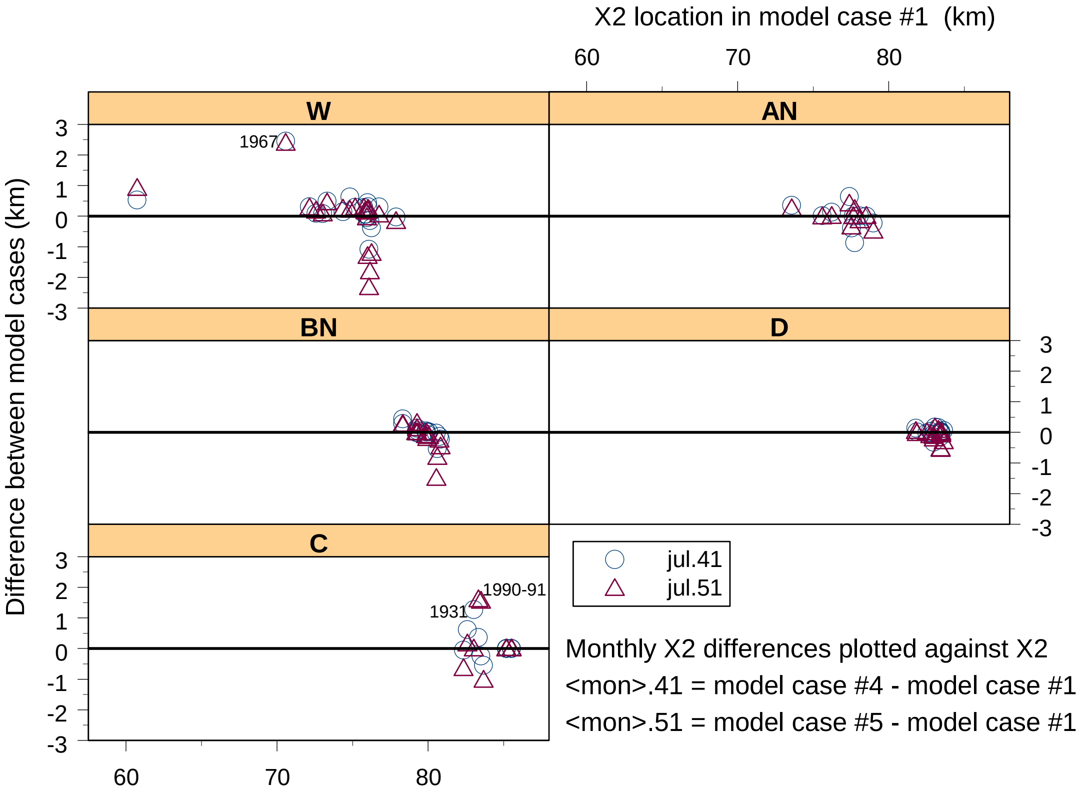


Figure 12–22 Differences in X2 under model cases #4 and #5 in June. Water year types: W=Wet, AN=Above Normal, BN=Below Normal, D=Dry, C=Critically Dry



Monthly X2 differences plotted against X2
<mon>.41 = model case #4 - model case #1
<mon>.51 = model case #5 - model case #1

Figure 12–23 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

In Model Case #4 the difference criterion was reached in two Dry years (1964: 1.1 km; 1981: 1.7 km). In Model Case #5 it was achieved in three Dry years (1961: 1.1 km; 1964: 1.0 km; 1981: 1.6 km), and one Below Normal Year (1972: 1.1 km). None of these larger differences was followed by an April X2 difference larger than 0.34 km; indeed, all but two of the April differences were negative and another was zero. It did not appear that X2 passed Chipps Island in any of these examples.

April

There were no differences larger than one kilometer in April.

May

The criterion was met twice in Model Case #4 during May in Dry years (1932: 1.3 km; 1964: 1.7 km). 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, resulting in

Model Case #5 not reaching the criterion in any month. In the 1932 case there was a positive difference (0.4 km) in the following month, while in the 1964 case there was a negative difference (-0.4 km) in June. In the 1932 case, X2 moved past Chipps Island (from 74.5 km in Model Case #1 to 75.8 km in Model Case #4).

June

In Model Case #4 the criterion was reached five times in Wet years (1942: 1.9 km; 1953: 1.8 km; 1958: 1.5 km; 1967: 1.1 km; 1971: 1.9 km), twice in Above Normal years (1922: 1.1 km; 1980: 2.0 km), and once in a Below Normal year (1948: 1.3 km). In Model Case #5 it was reached six times in Wet years (1942: 1.6 km; 1953: 1.4 km; 1958: 1.4 km; 1970: 1.2 km; 1971: 1.4 km; 1974: 1.6 km), once in an Above Normal year (1980: 1.2 km), once in a Below Normal year (1.4 km), and once in a Dry year (1930: 1.2 km). In all of these instances save 1967 in Model Case #4a the X2 difference in the following month was much smaller or negative. In the exception case, a difference of 1.1 km in June was followed by larger upstream differences of 2.5 km in July and 2.7 km in August. None of these cases appears to involve a movement of X2 past Chipps Island.

July

In Model Case #4 the criterion was reached once in a Wet year (1967: 2.5 km) and once in a Critically Dry year (1931: 1.3 km). In #5 it was reached in 1967 (2.4 km) and twice in Critically Dry years (1990: 1.6 km; 1991: 1.6 km). In all cases except #4 in 1967, there was a downstream shift from Model Case #1 in the following month. None of these cases involved a shift of X2 east past Chipps Island.

Summary

Upstream movements of X2 predicted in the future model cases reach one kilometer or more only occasionally. In some cases upstream movements observed in case #4 were reduced or erased in case #5. In a few cases the upstream movement is larger in cases #5 and #5a. There were a few movements from the west to the east side of Chipps Island, but these were of small magnitude. In general, the largest differences among the Model Cases appear to be attributable to the use of environmental water in Case #5.

The seasonally averaged differences between future cases and the base case are close to zero, and 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 – during 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. Given that there were few differences much larger than one kilometer in these comparisons, 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 affect delta smelt vulnerability increases.

Export-to-Inflow Ratio

The same general trend in monthly E/I 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 12–24 to Figure 12–29). From Figure 12–24 to Figure 12–29, during months where EWA actions are taken the E/I ratio decreases (December, January, February, April, May and June) in Studies 3 and 5 compared to 1, 2, and 4. The later summer months show increases in E/I 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 12–30 to Figure 12–41 show the monthly E/I ratios sorted from wettest to driest by 40-30-30 index. Studies 3 and 5 show lower E/I ratios when EWA actions are taken and then increased E/I ratios in the late summer and fall periods. Studies 4 and 5 show increased E/I ratios when compared to Studies 1, 2, and 3. In Figure 12–32 the December 1940 values drop off significantly from the others in Study 4 (Future SDIP) due to the Rock Slough salinity standard.

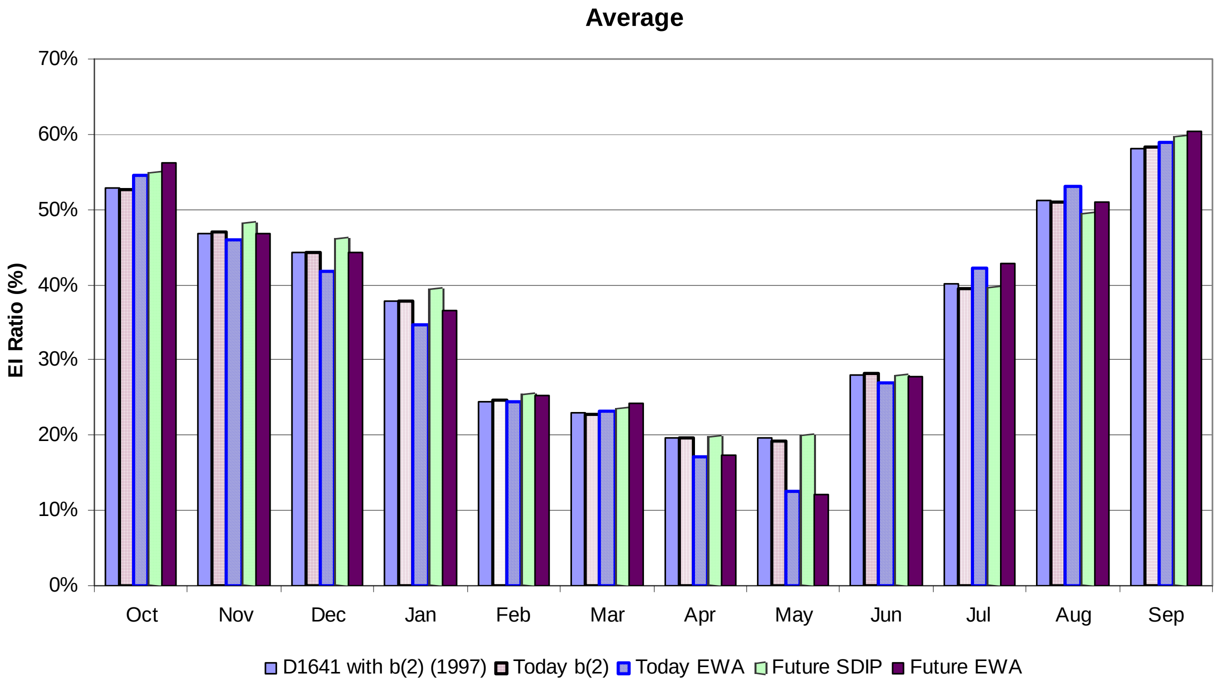


Figure 12–24 Average Monthly export-to-inflow ratio

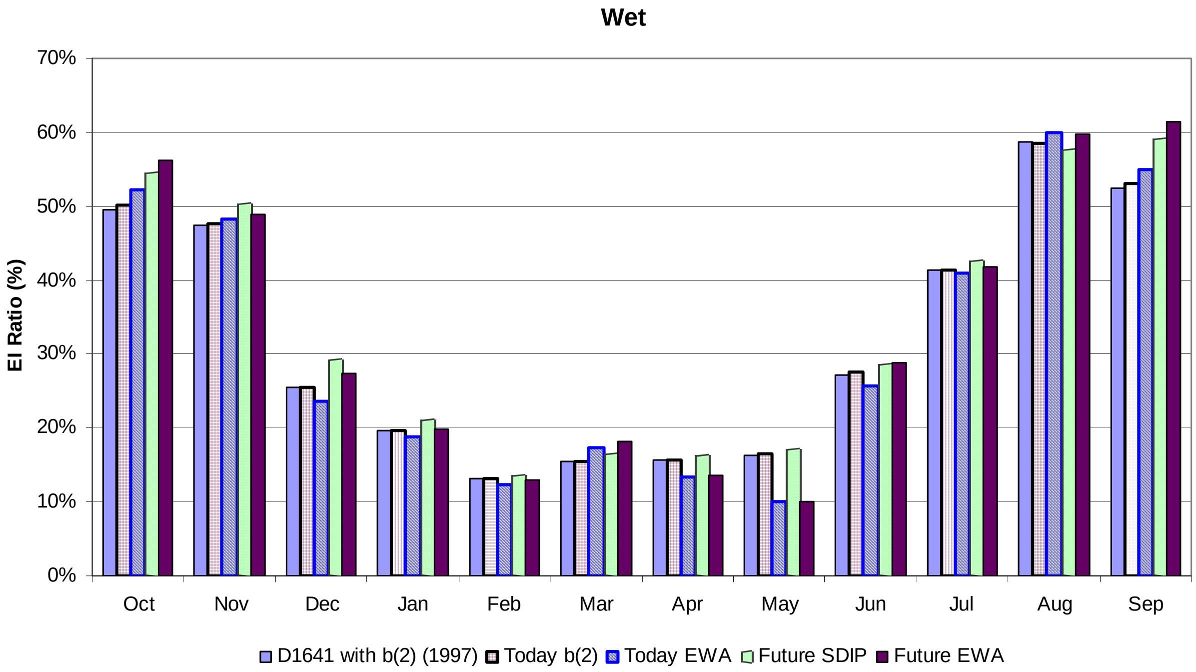


Figure 12–25 Average wet year (40-30-30 Classification) monthly export-to-inflow ratio

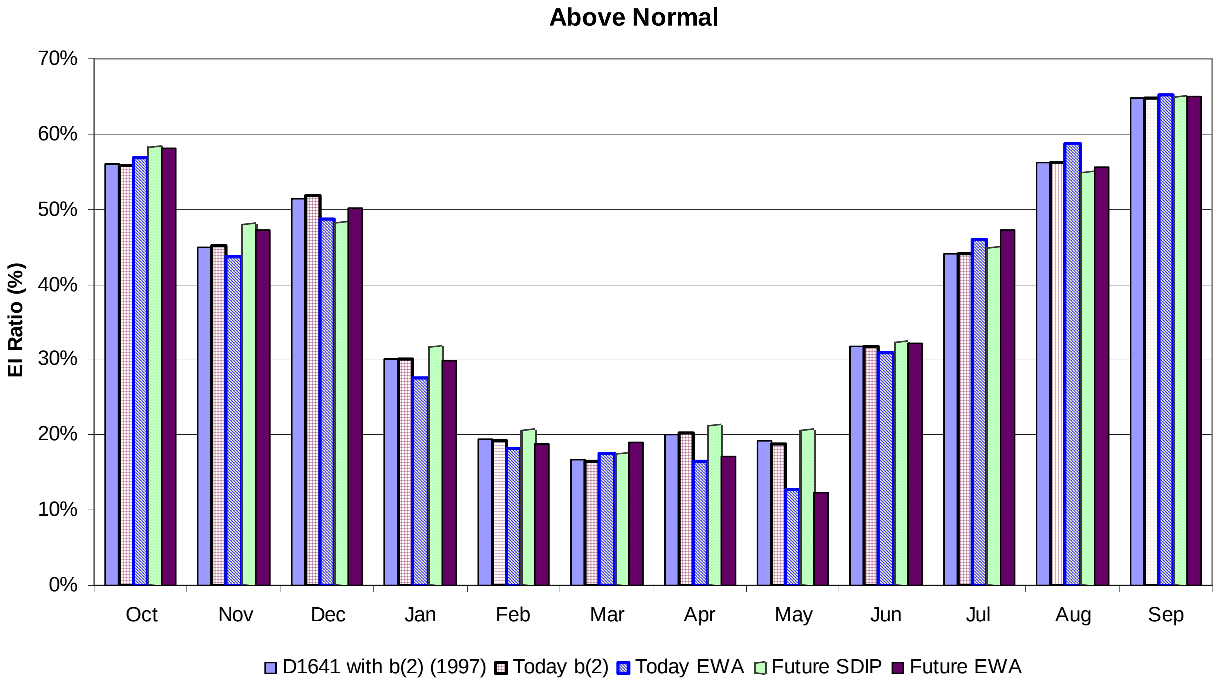


Figure 12–26 Average above normal year (40-30-30 Classification) monthly export-to-inflow ratio

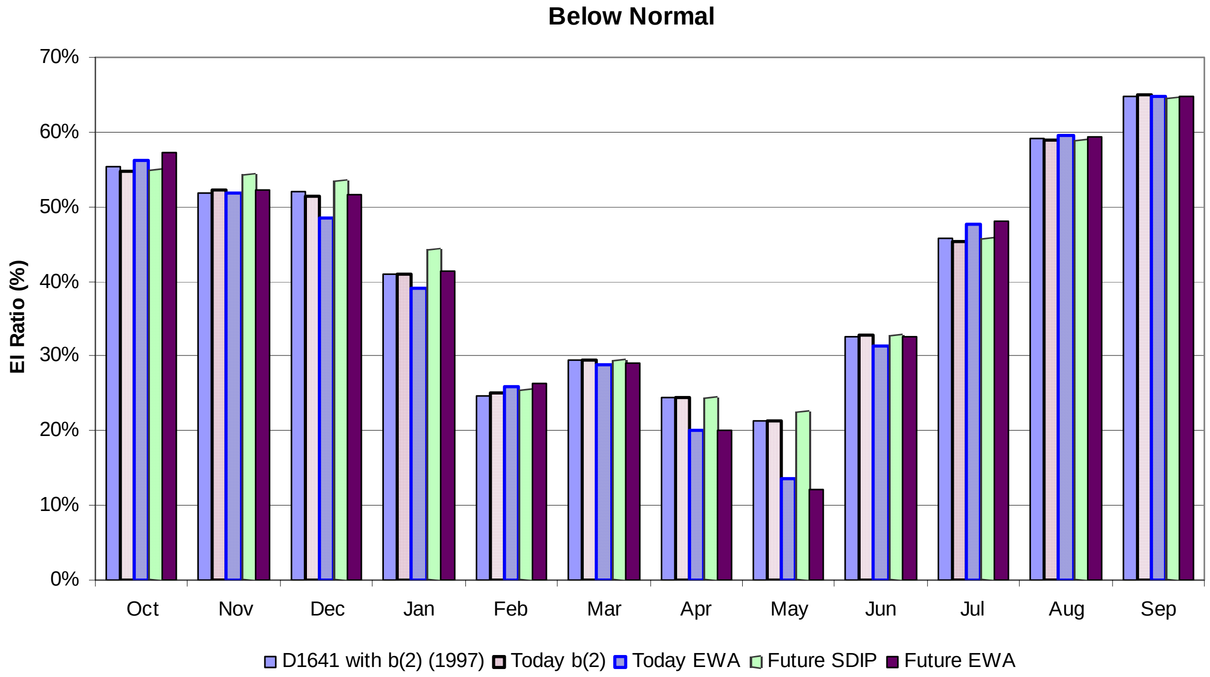


Figure 12–27 Average below normal year (40-30-30 Classification) monthly export-to-inflow ratio

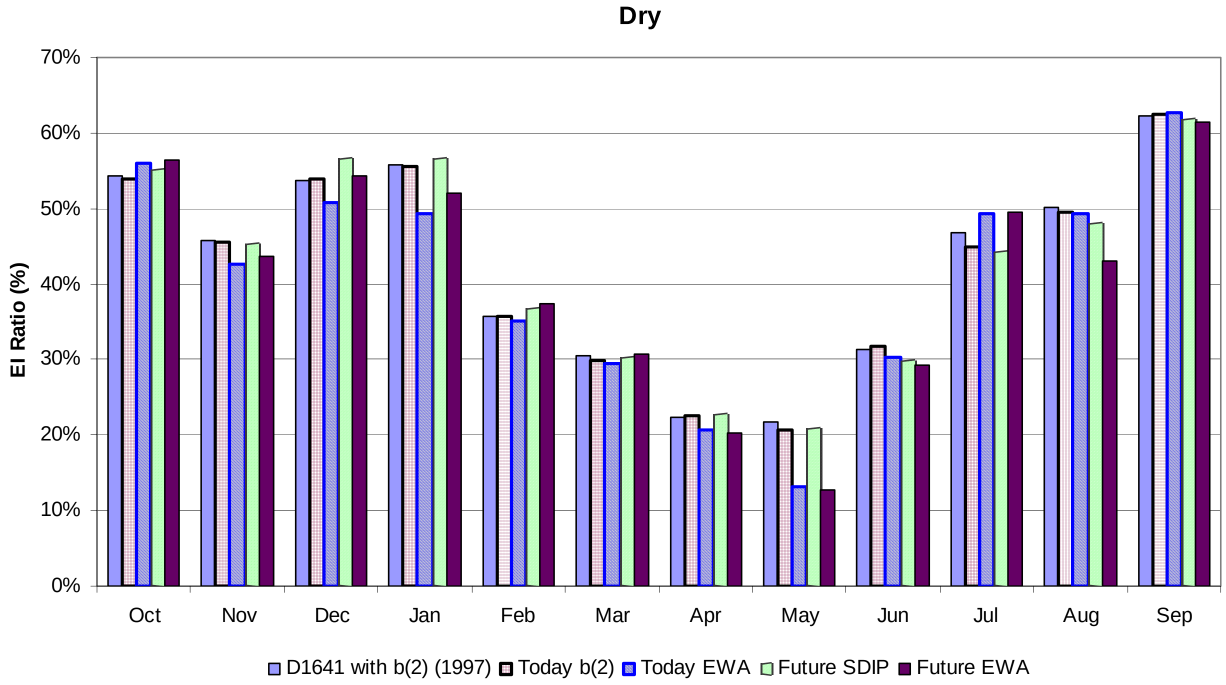


Figure 12–28 Average dry year (40-30-30 Classification) monthly export-to-inflow ratio

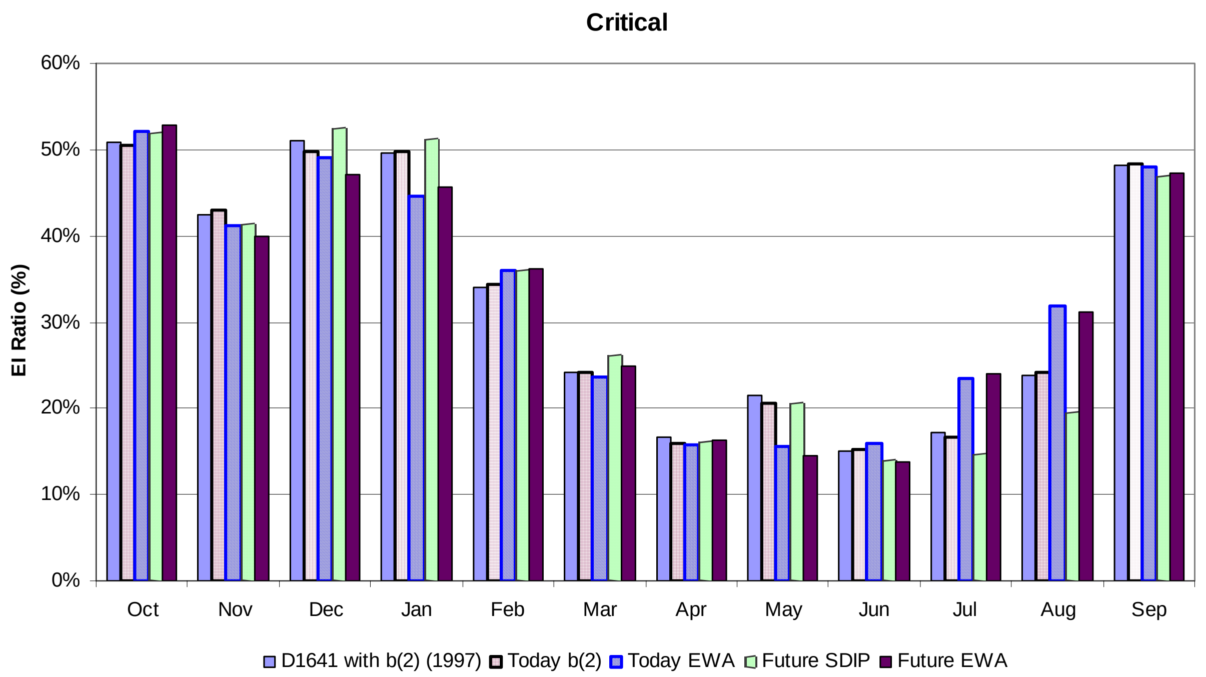


Figure 12–29 Average critical year (40-30-30 Classification) monthly export-to-inflow ratio

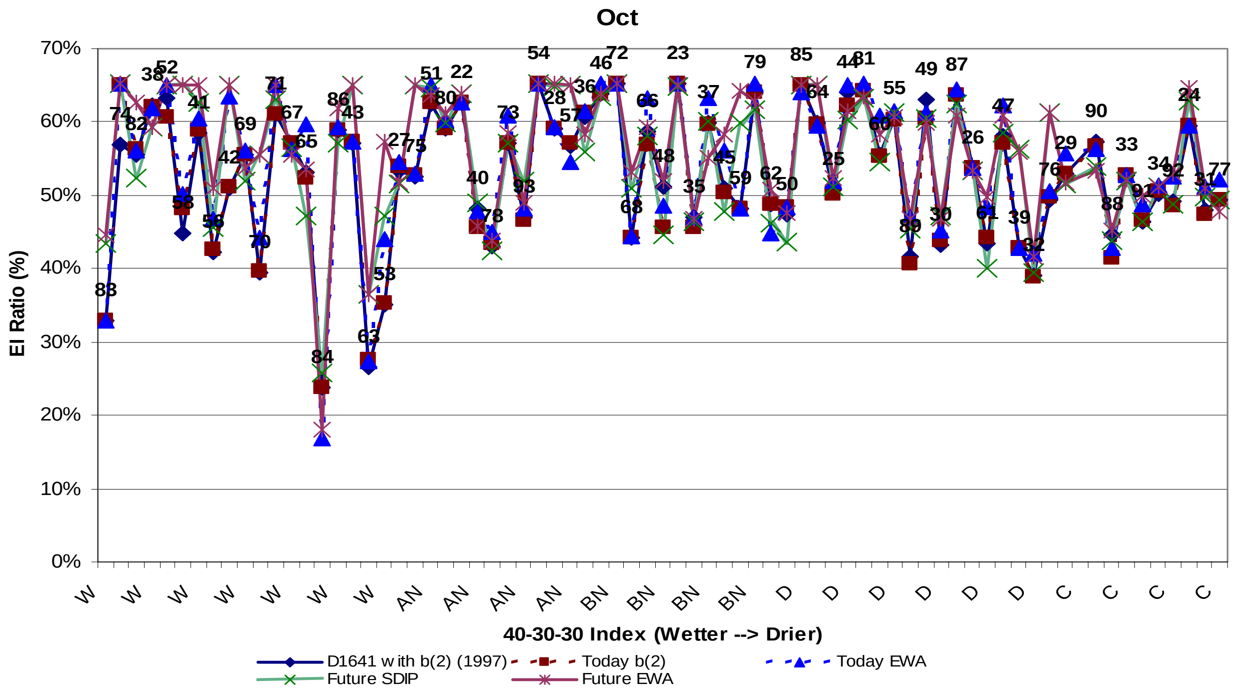


Figure 12–30 October export-to-inflow ratio sorted by 40-30-30 Index

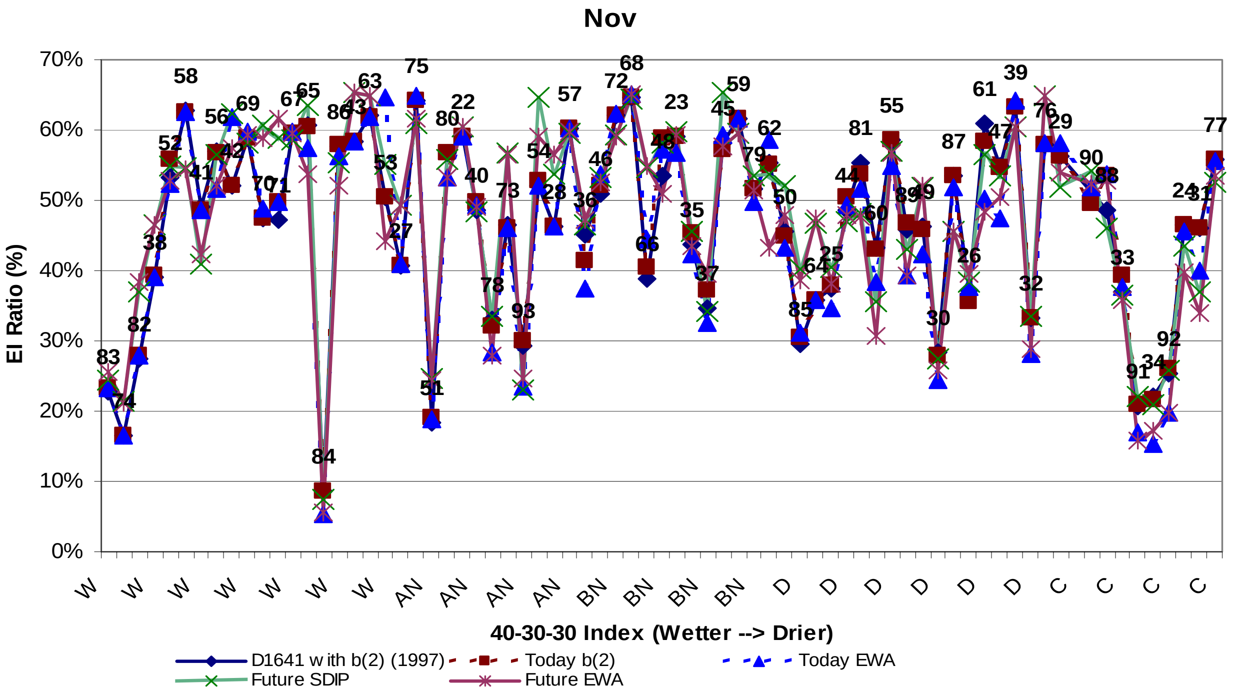


Figure 12–31 November export-to-inflow ratio sorted by 40-30-30 Index

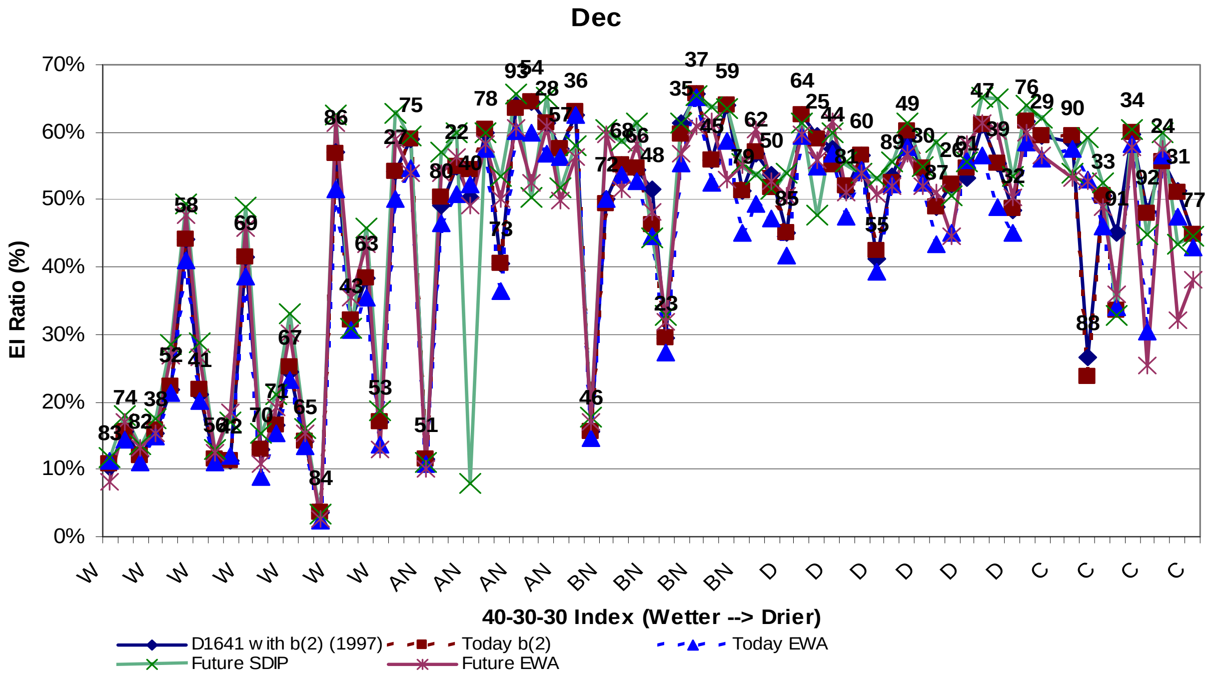


Figure 12–32 December export-to-inflow ratio sorted by 40-30-30 Index

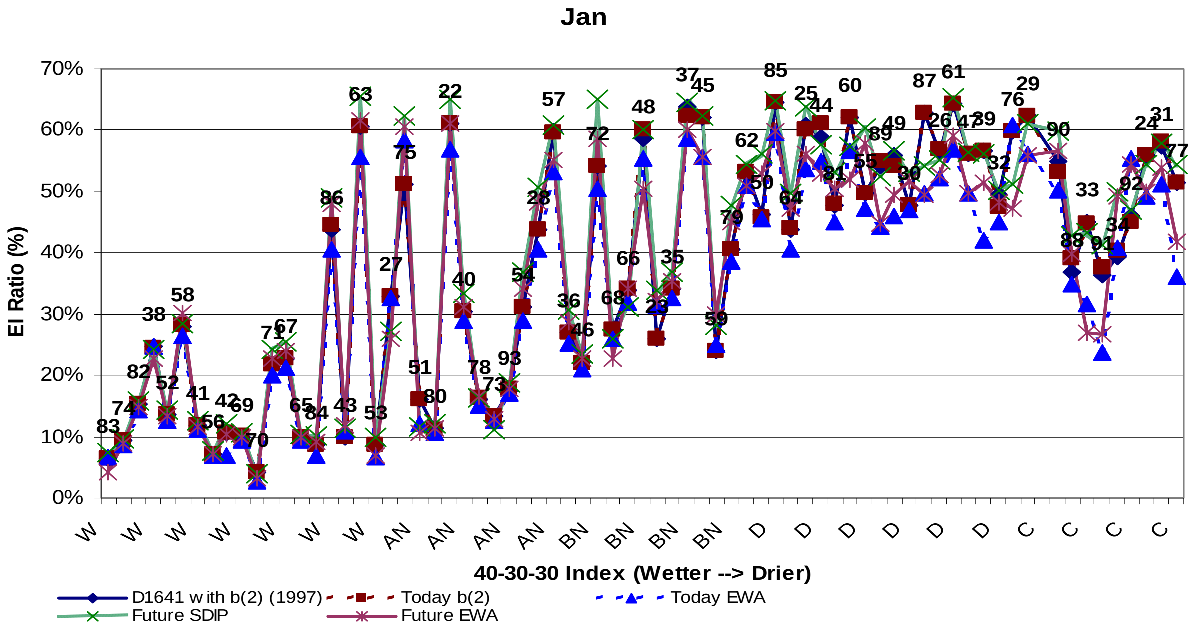


Figure 12–33 January export-to-inflow ratio sorted by 40-30-30 Index

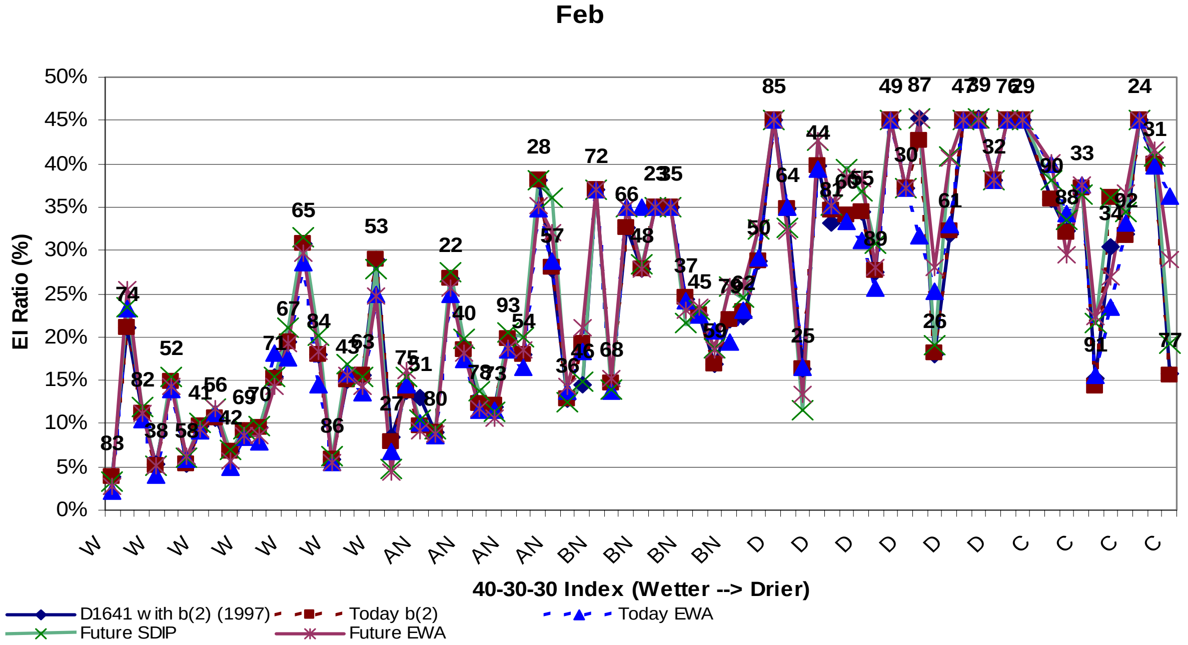


Figure 12–34 February export-to-inflow ratio sorted by 40-30-30 Index

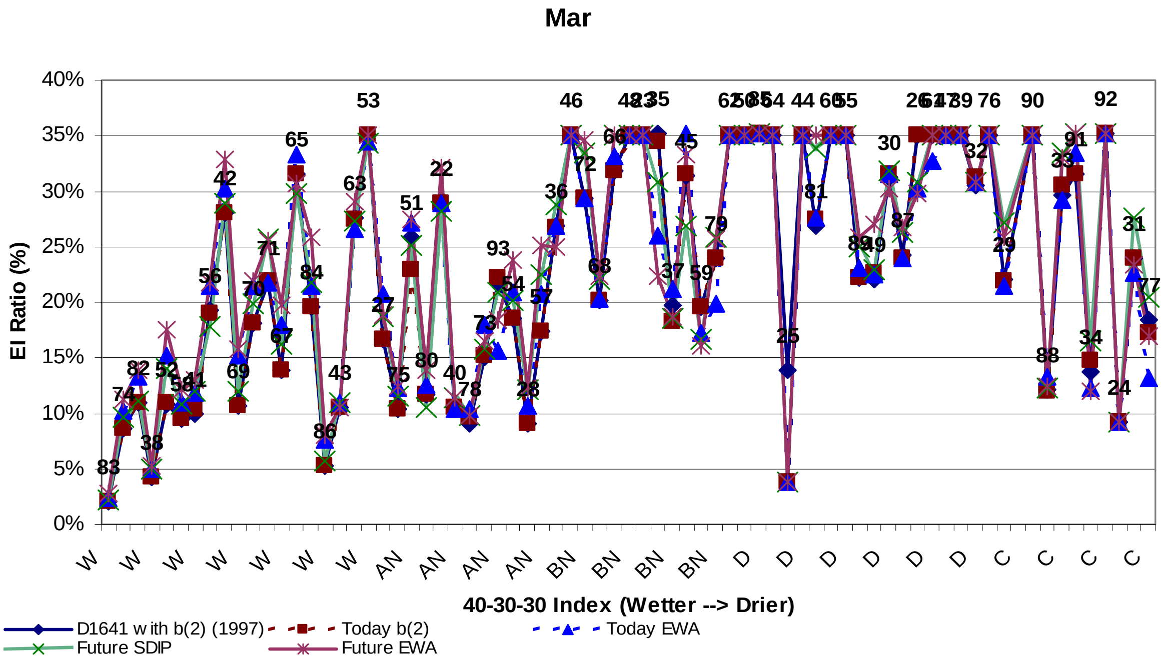


Figure 12–35 March export-to-inflow ratio sorted by 40-30-30 Index

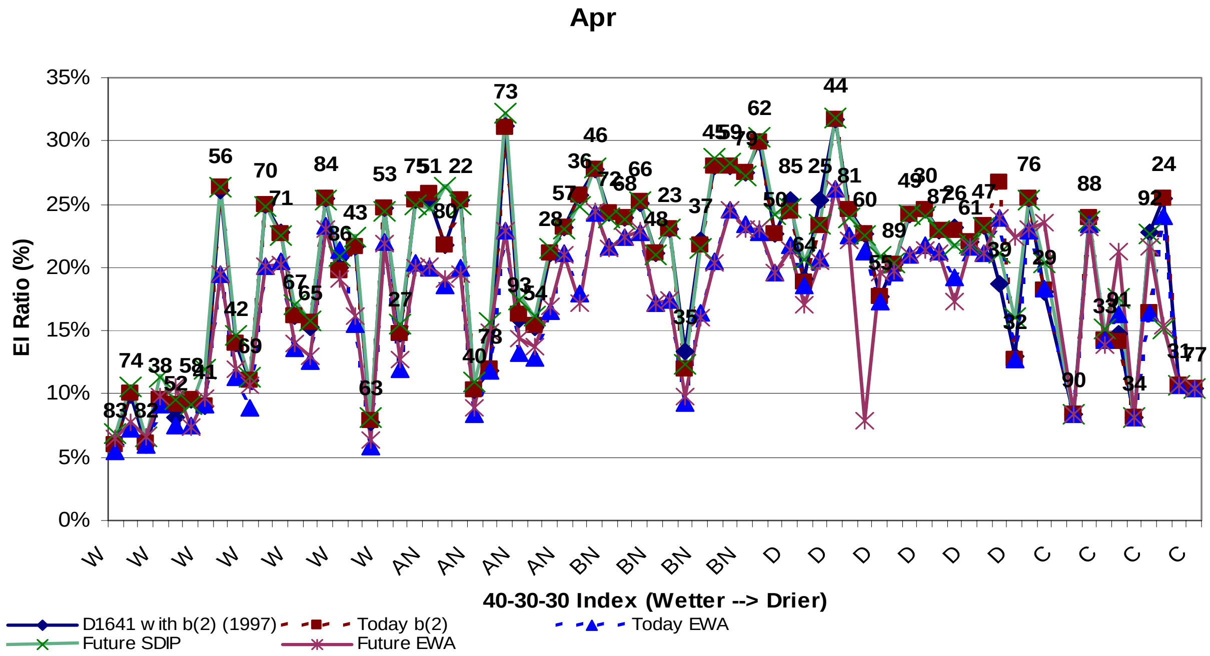


Figure 12–36 April export-to-inflow ratio sorted by 40-30-30 Index

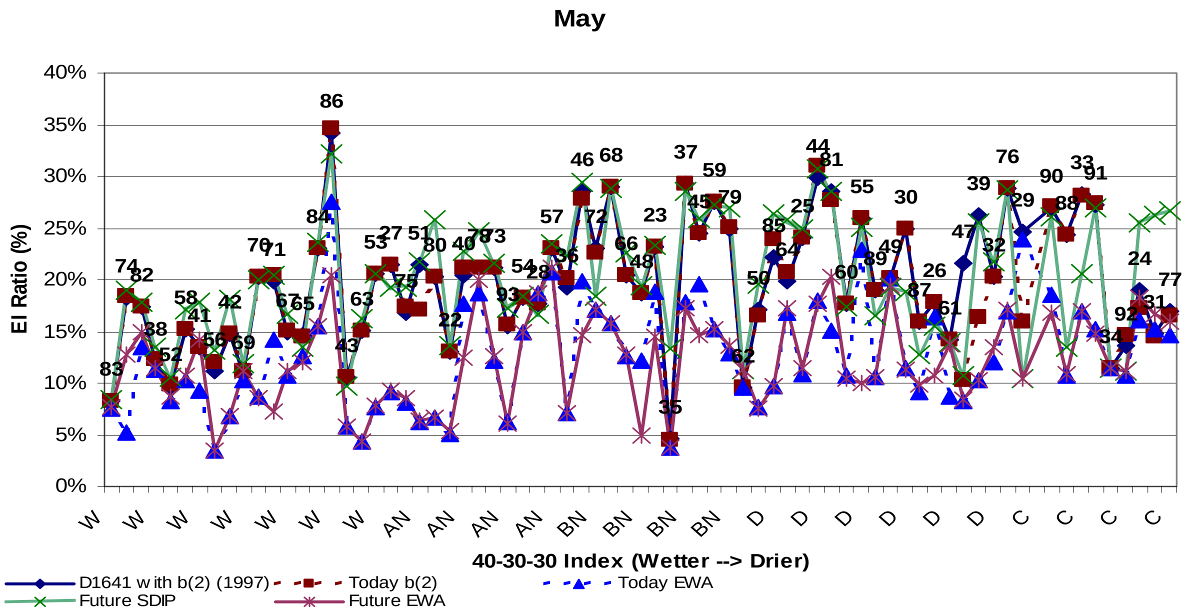


Figure 12–37 May export-to-inflow ratio sorted by 40-30-30 Index

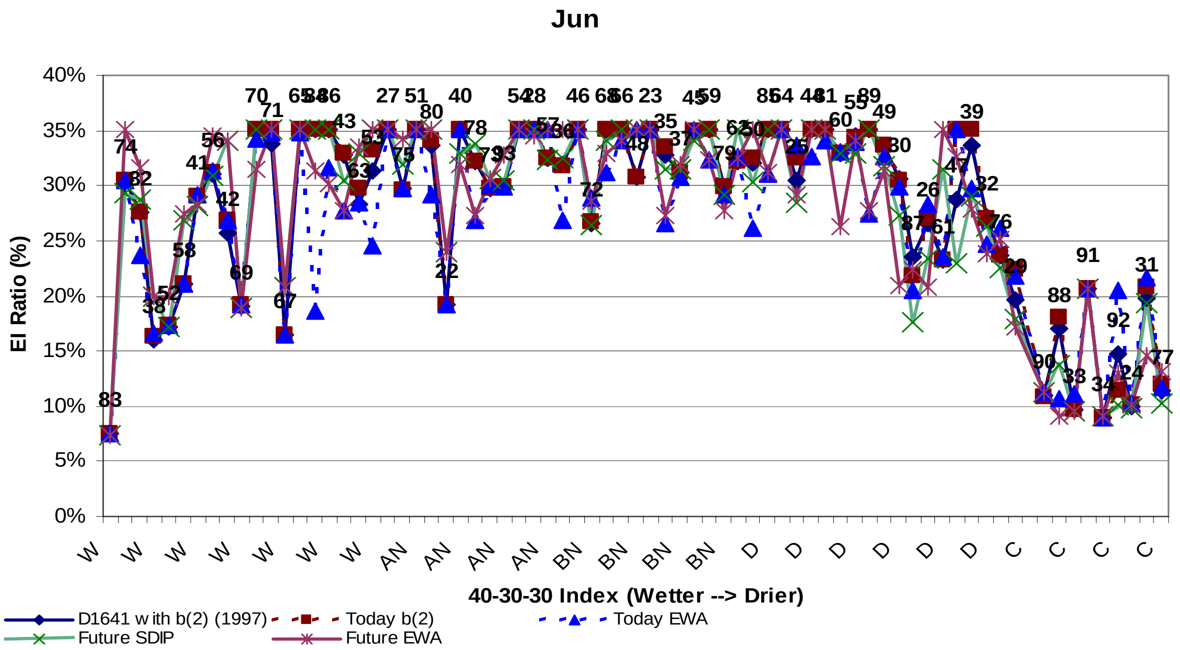


Figure 12–38 June export-to-inflow ratio sorted by 40-30-30 Index

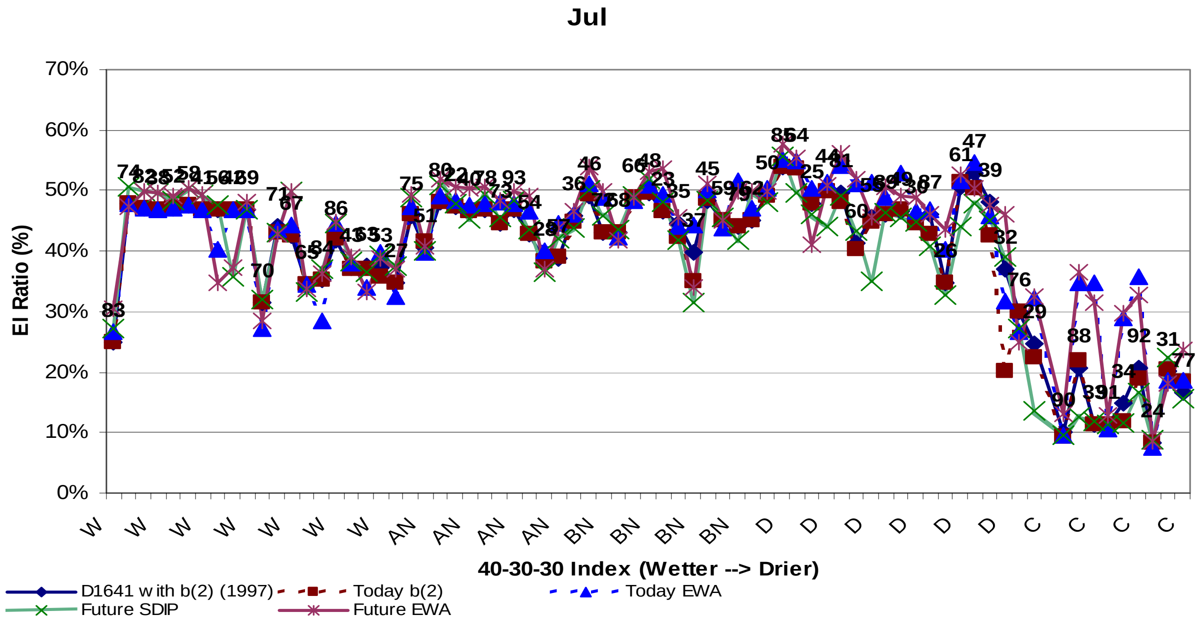


Figure 12–39 July export-to-inflow ratio sorted by 40-30-30 Index

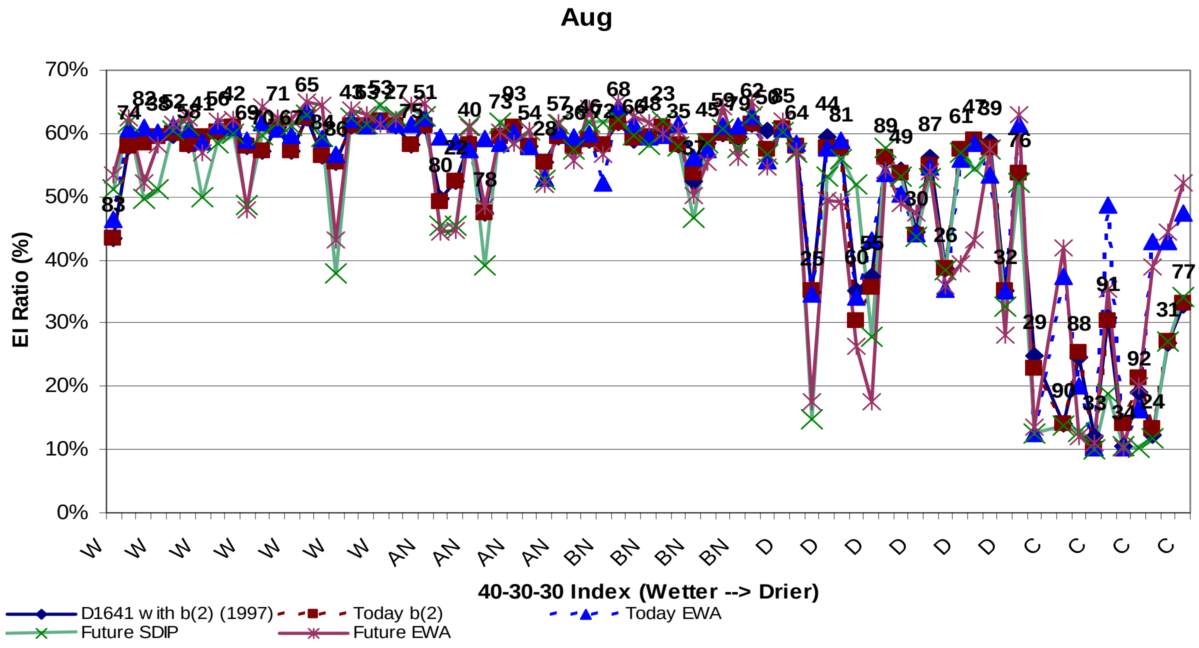


Figure 12–40 August export-to-inflow ratio sorted by 40-30-30 Index

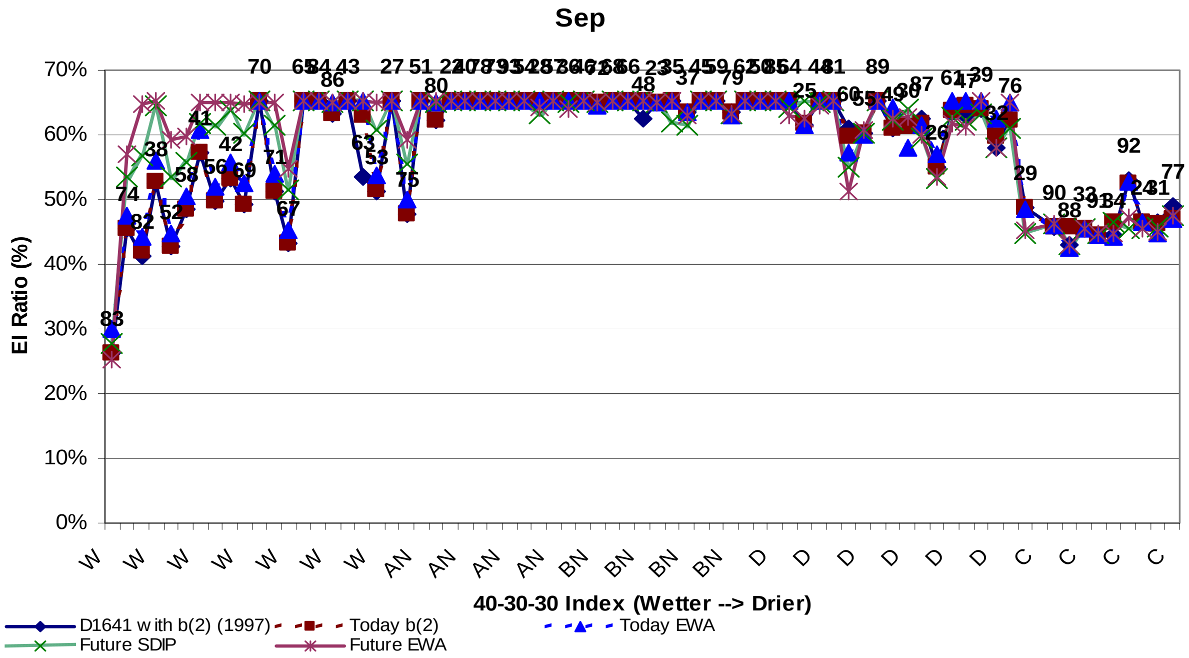


Figure 12–41 September export-to-inflow ratio sorted by 40-30-30 Index

<u>Export-Inflow ratio</u>

Exceedance plots of the E/I ratio 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.

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, Cosumnes River, and the San Joaquin River. Table 12–13 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 12–13 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 12–42 shows the chronology of total inflow for all five of the studies. The highest inflows occur January through April due to flood flows, and July when pumping is increased through the late summer, with the 50th percentiles being greater than 20,000 cfs (Figure 12–43). 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 12–44 to Figure 12–49, the results show little difference on average with the exception of months when 3406 (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 cause the minimum flows to be less than the magnitude of flood flows, and decrease when comparing Studies 4 and 5 to Studies 1, 2, and 3.

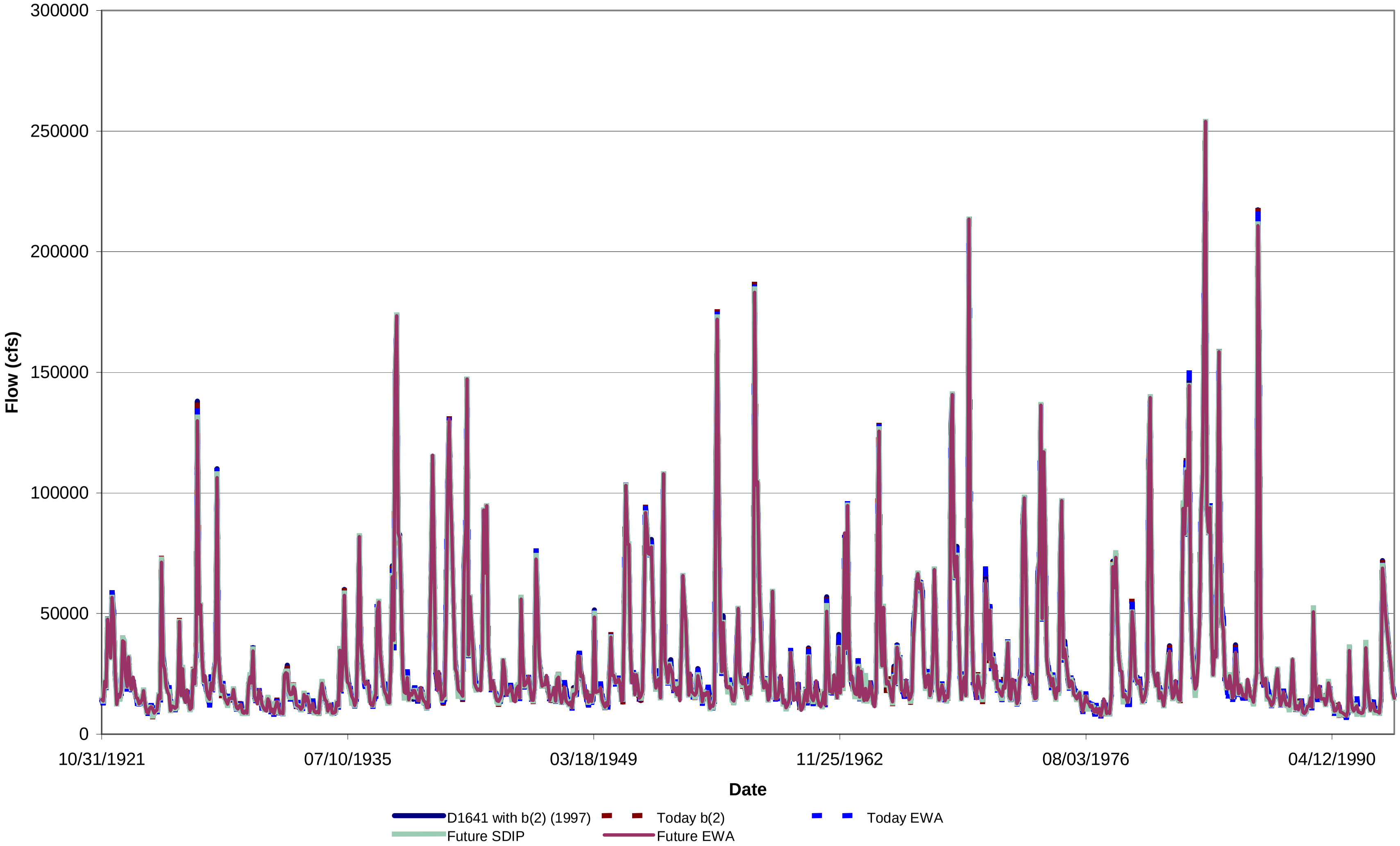


Figure 12–42 Chronology of Total Delta Inflow

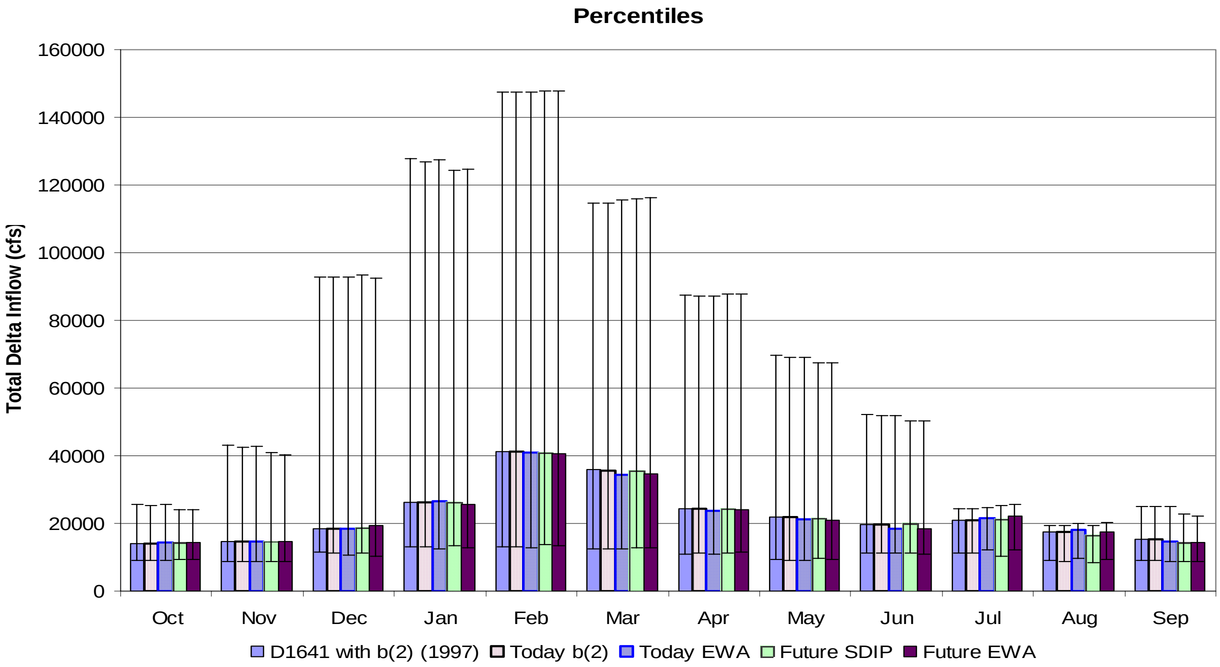


Figure 12–43 Total Delta Inflow 50th Percentile Monthly Releases with the 5th and 95th as the bars

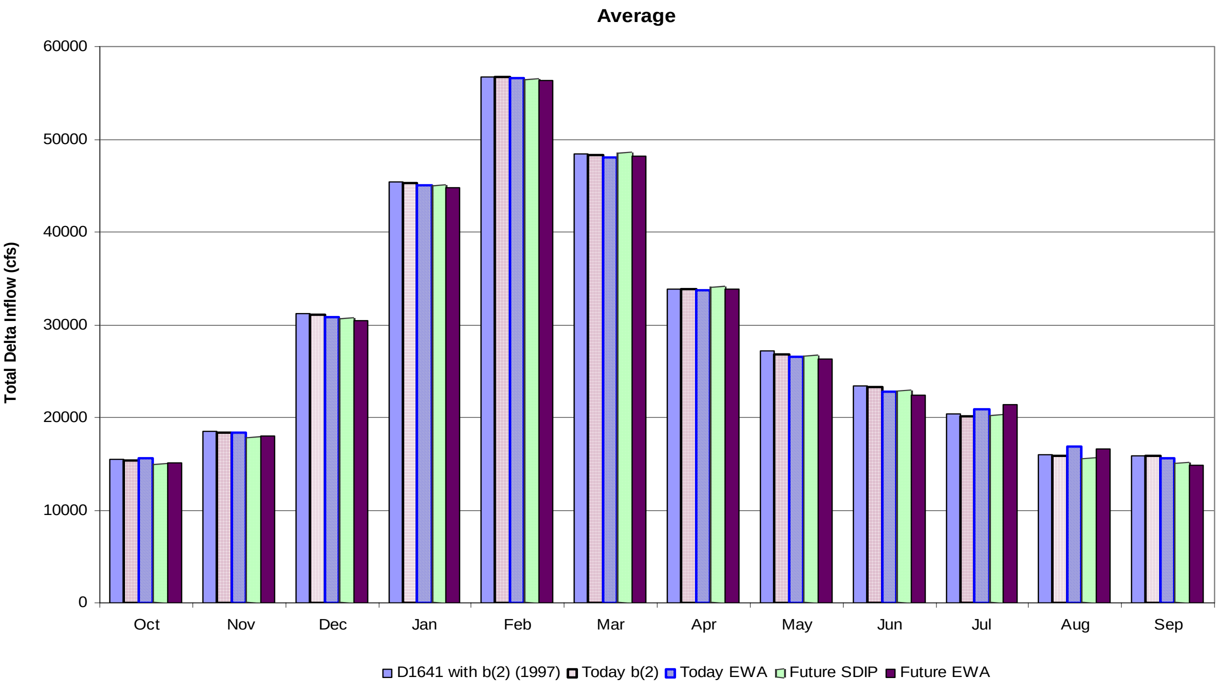


Figure 12–44 Average Monthly Total Delta Inflow

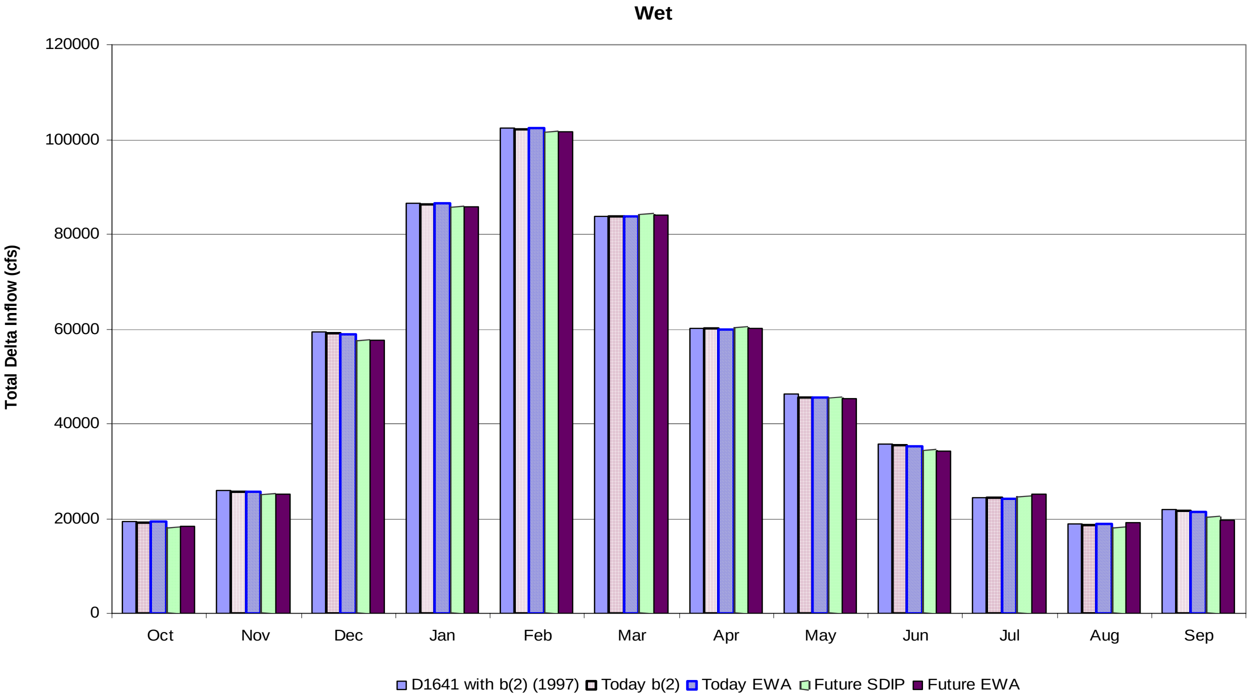


Figure 12–45 Average wet year (40-30-30 Classification) monthly Outflow Delta Inflow

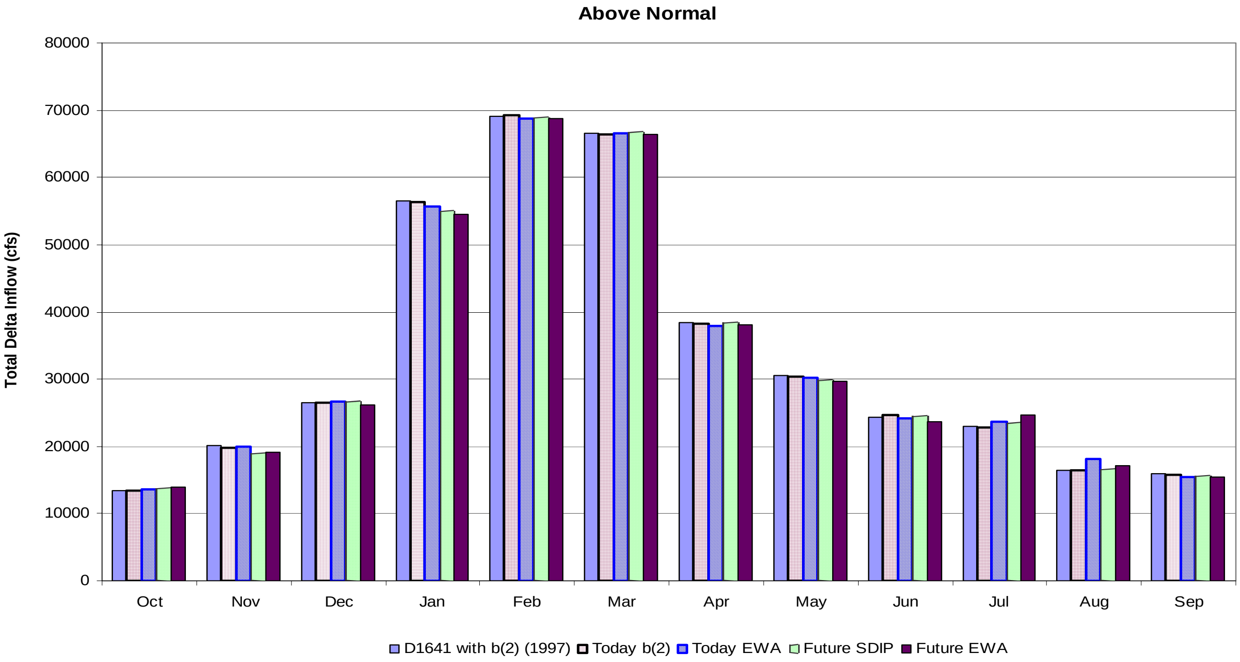


Figure 12–46 Average above normal year (40-30-30 Classification) monthly Outflow Delta Inflow

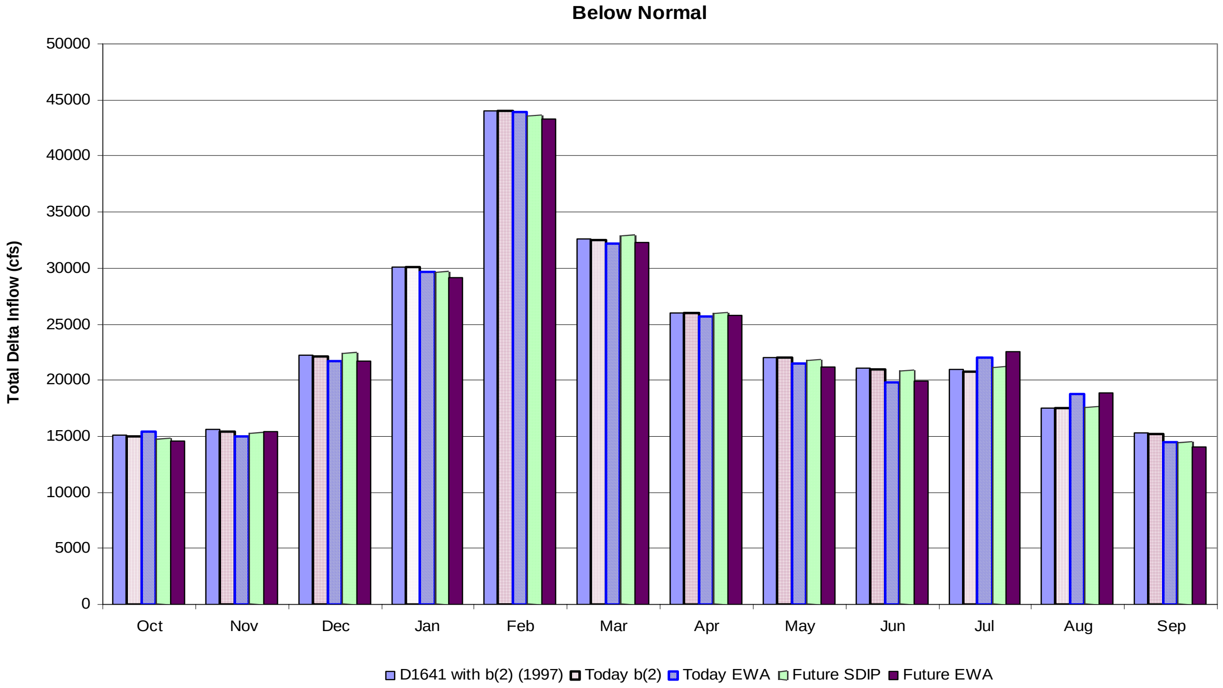


Figure 12–47 Average below normal year (40-30-30 Classification) monthly Outflow Delta Inflow

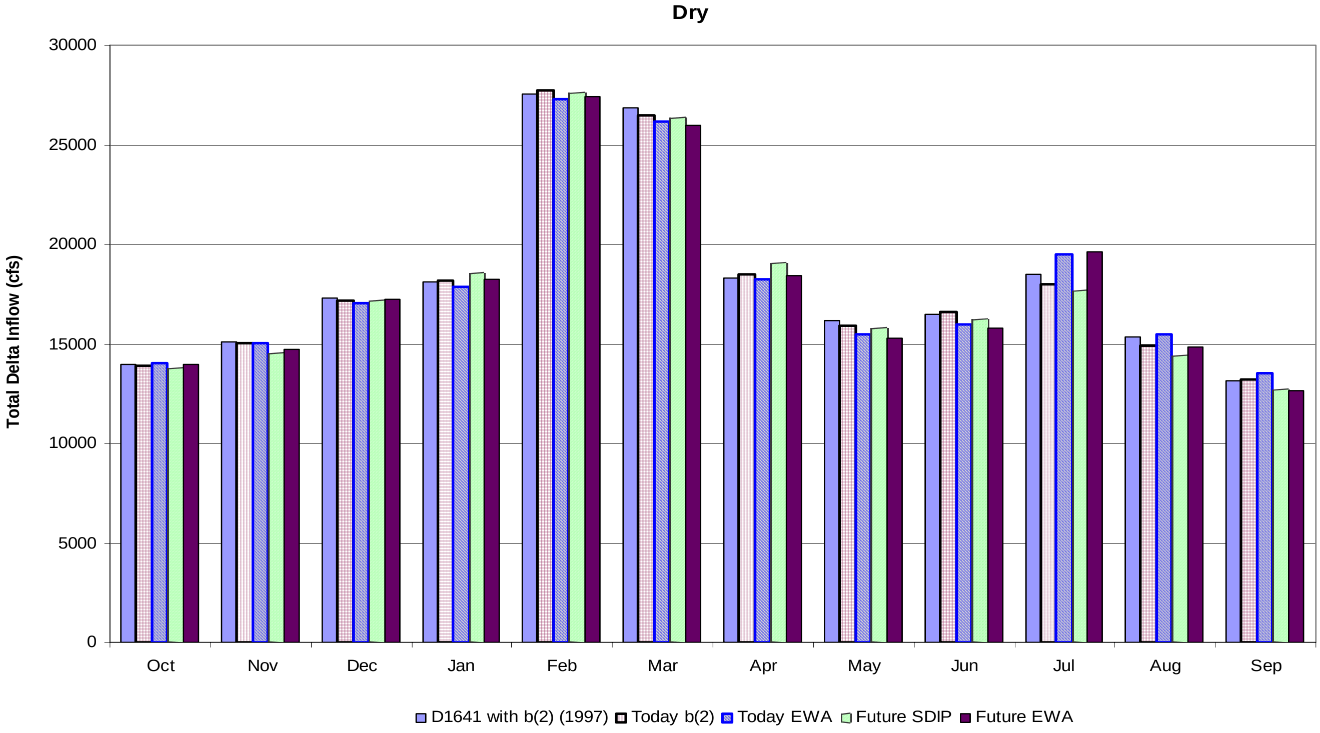


Figure 12–48 Average dry year (40-30-30 Classification) monthly Outflow Delta Inflow

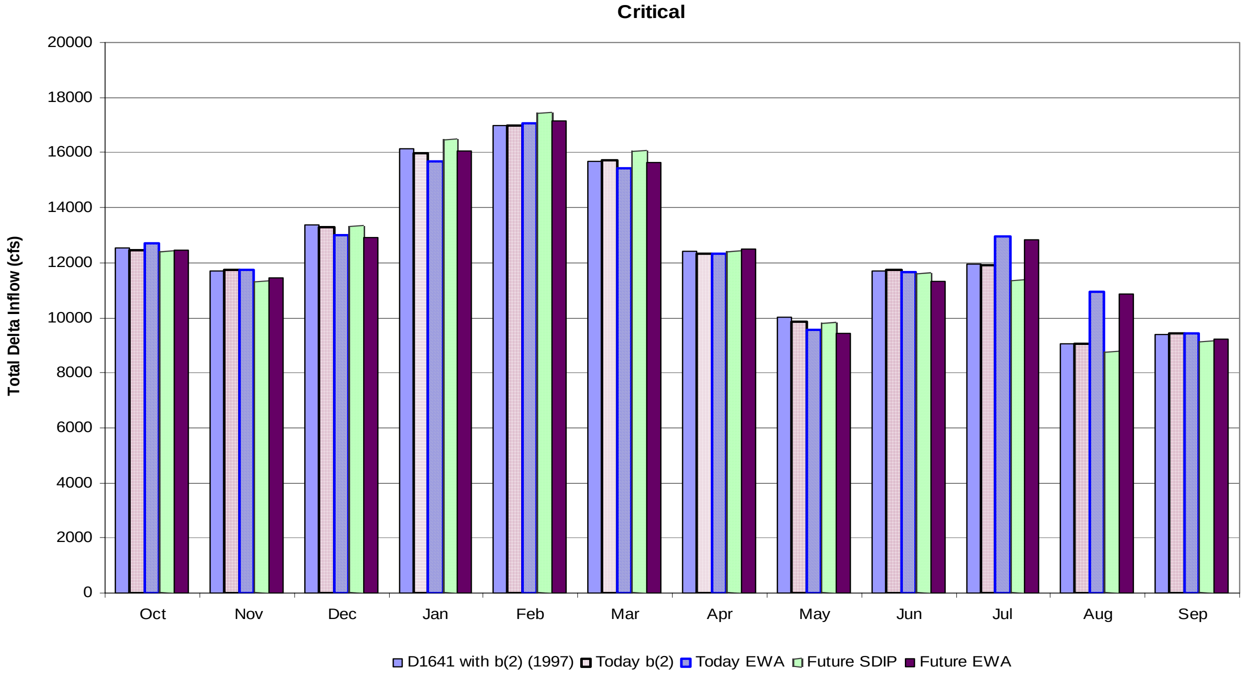


Figure 12–49 Average critical year (40-30-30 Classification) monthly Outflow Delta Inflow

Outflow

The chronology of Delta outflow is shown in Figure 12–50 and indicates that peaks in outflow can be seen due to EWA actions. Table 12–14 shows the differences in total and excess outflow for the five studies. On Study-to-Study comparisons (Table 12–14), with the exception of comparing Study 3 to 1, the average annual outflow decreases. Comparing of Study 5 to 1 shows increases in 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 12–51 shows that the model always meets the required monthly required outflow for all five of the studies. Both average and percentile outflow values increase in April and May due to the actions taken under the 3406 (b)(2) and EWA programs (Figure 12–52 and Figure 12–53 to Figure 12–58). 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 12–14 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

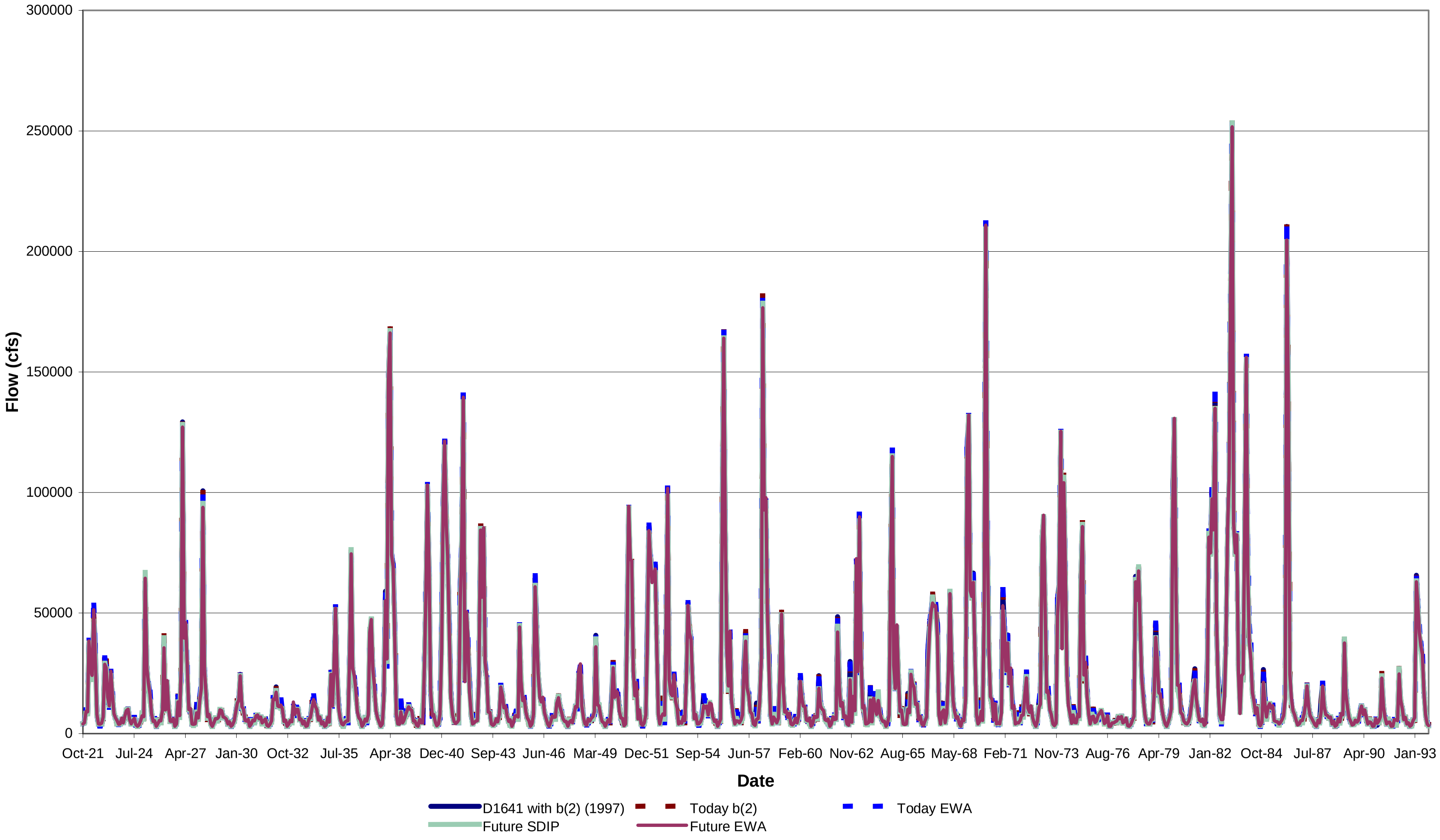


Figure 12–50 Chronology of Total Delta Outflow

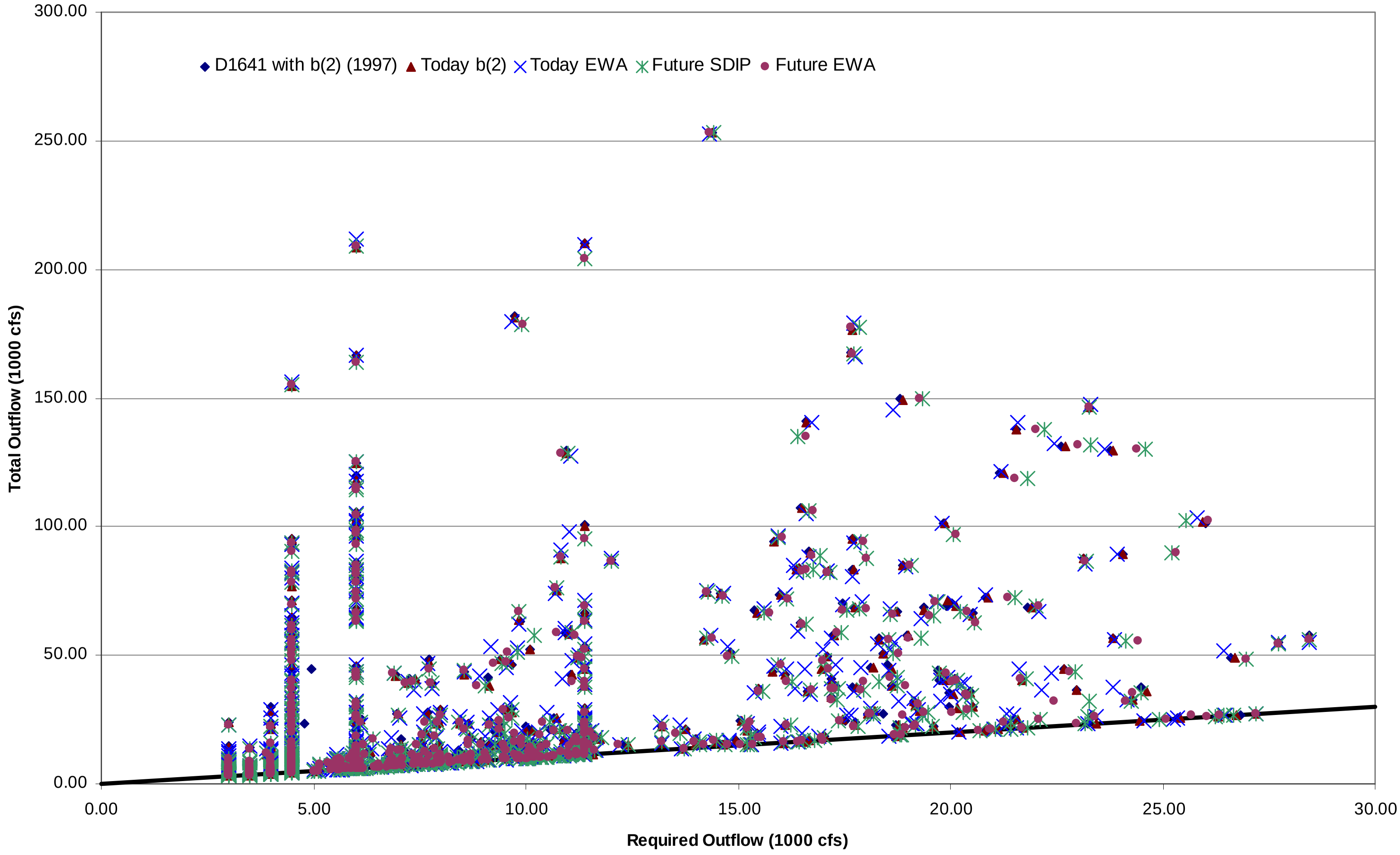


Figure 12–51 Total Delta Outflow versus Required Delta Outflow for the Oct 1921 to Sep 1993 simulation period

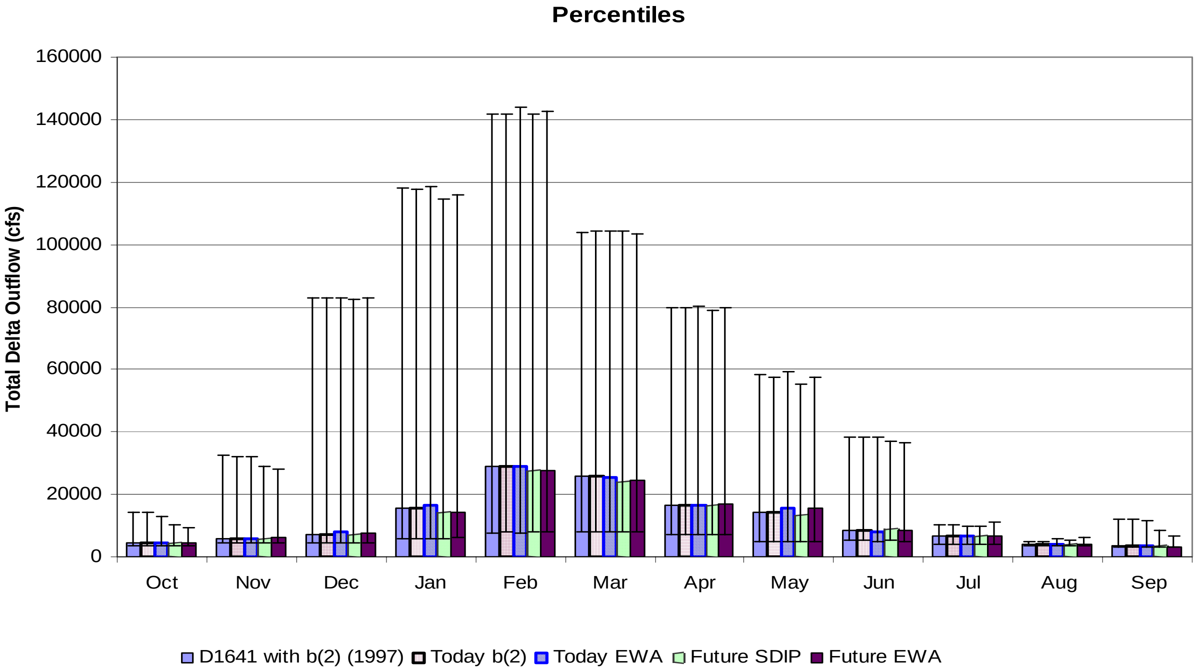


Figure 12–52 Total Delta Outflow 50th Percentile Monthly Releases with the 5th and 95th as the bars

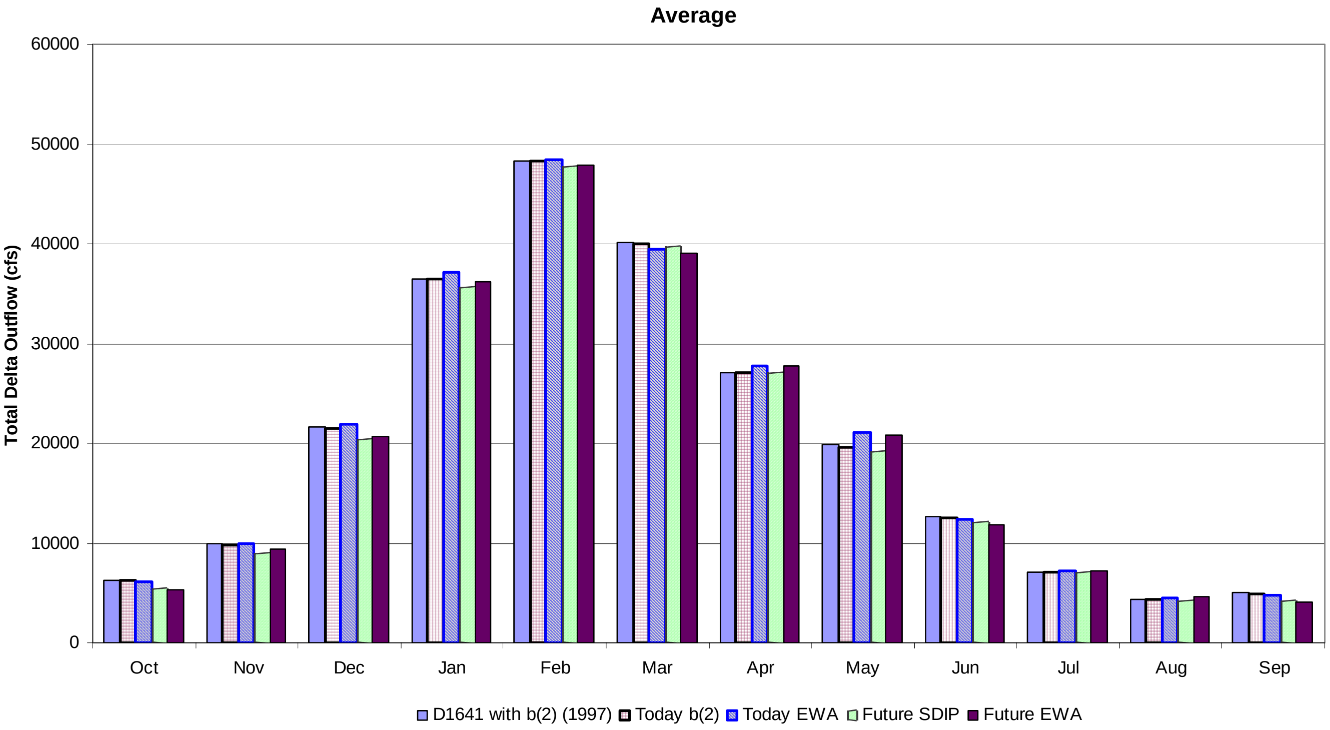


Figure 12–53 Average Monthly Total Delta Outflow

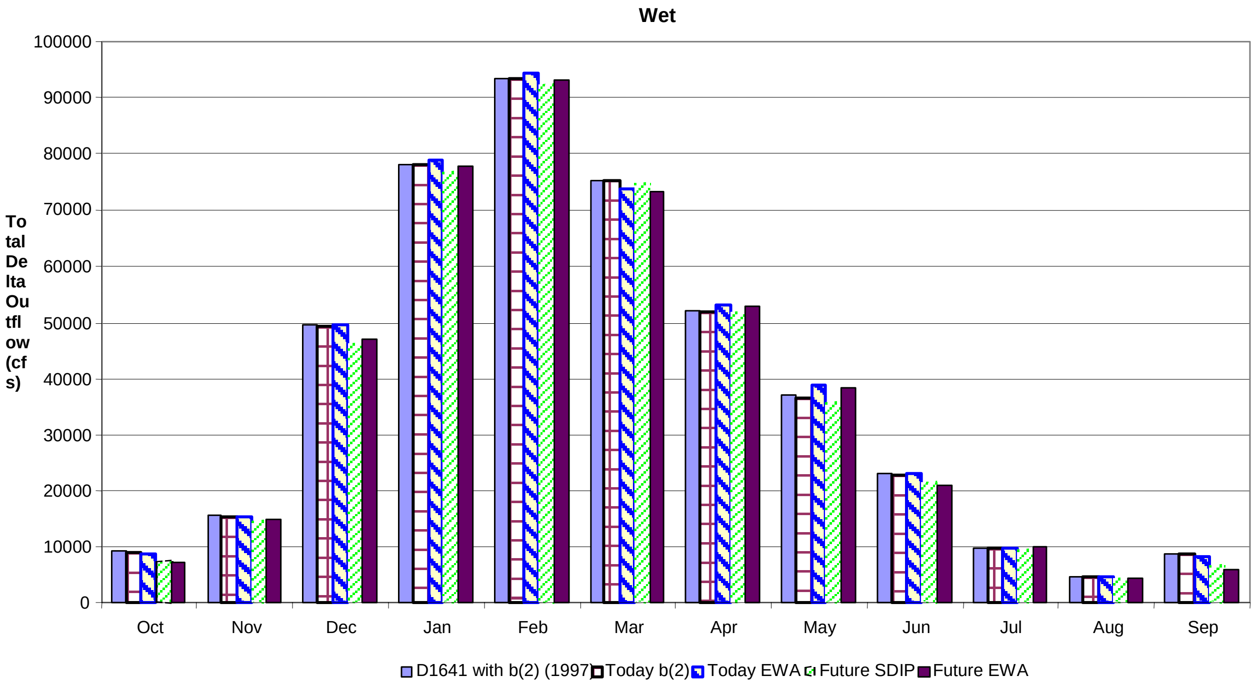


Figure 12–54 Average wet year (40-30-30 Classification) monthly Delta Outflow

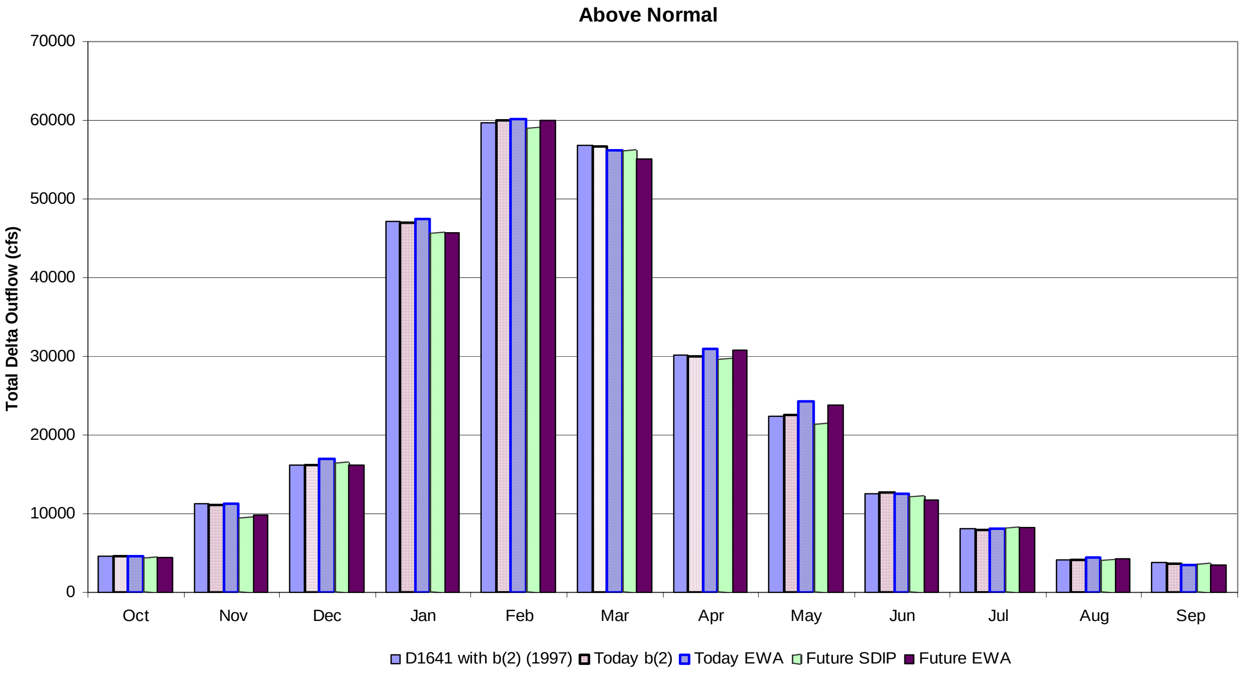


Figure 12–55 Average above normal year (40-30-30 Classification) monthly Delta Outflow

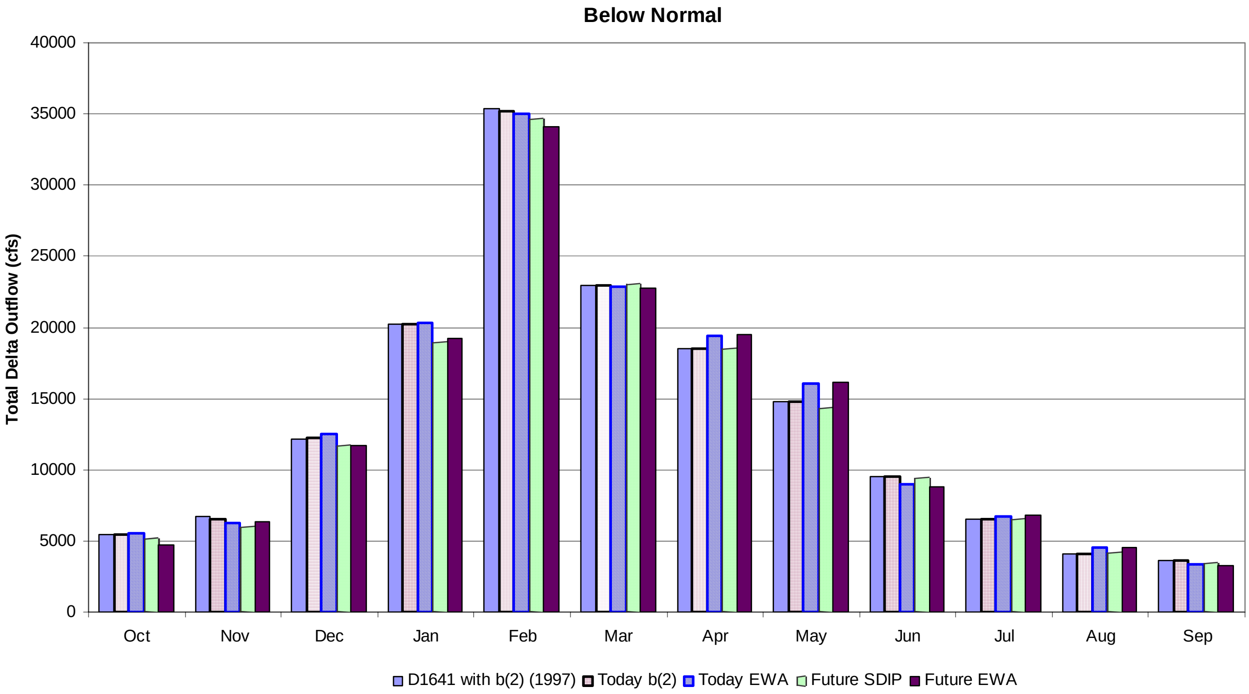


Figure 12–56 Average below normal year (40-30-30 Classification) monthly Delta Outflow

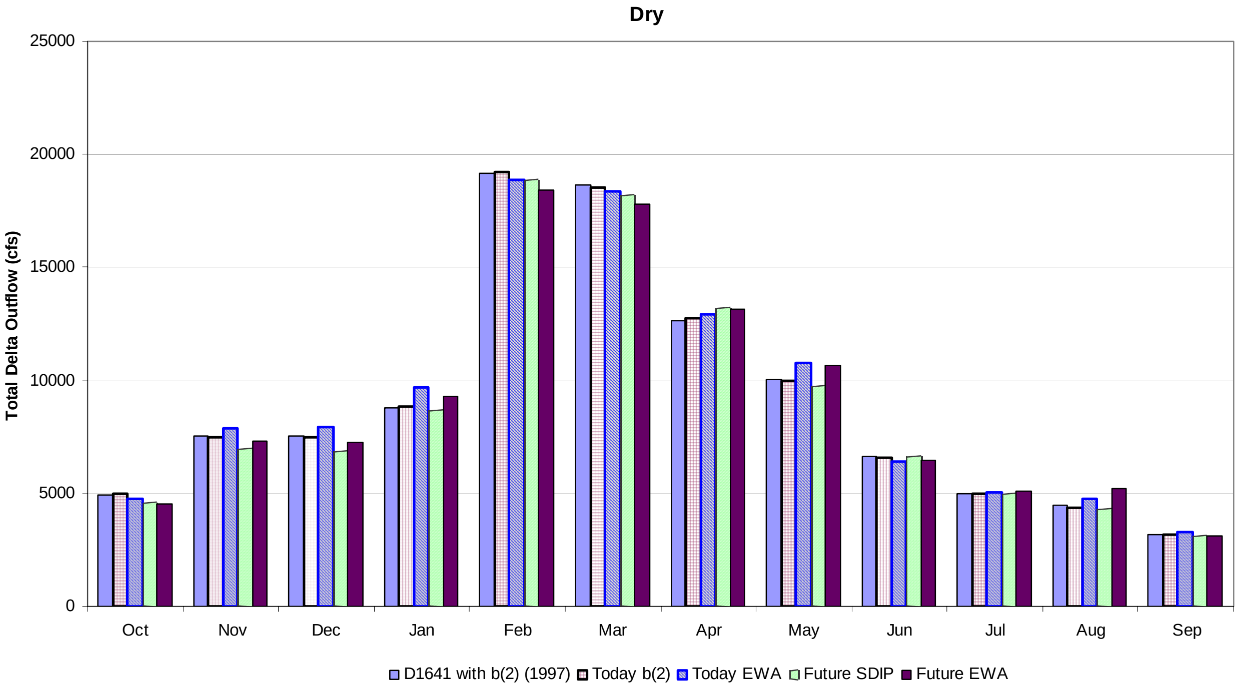


Figure 12–57 Average dry year (40-30-30 Classification) monthly Delta Outflow

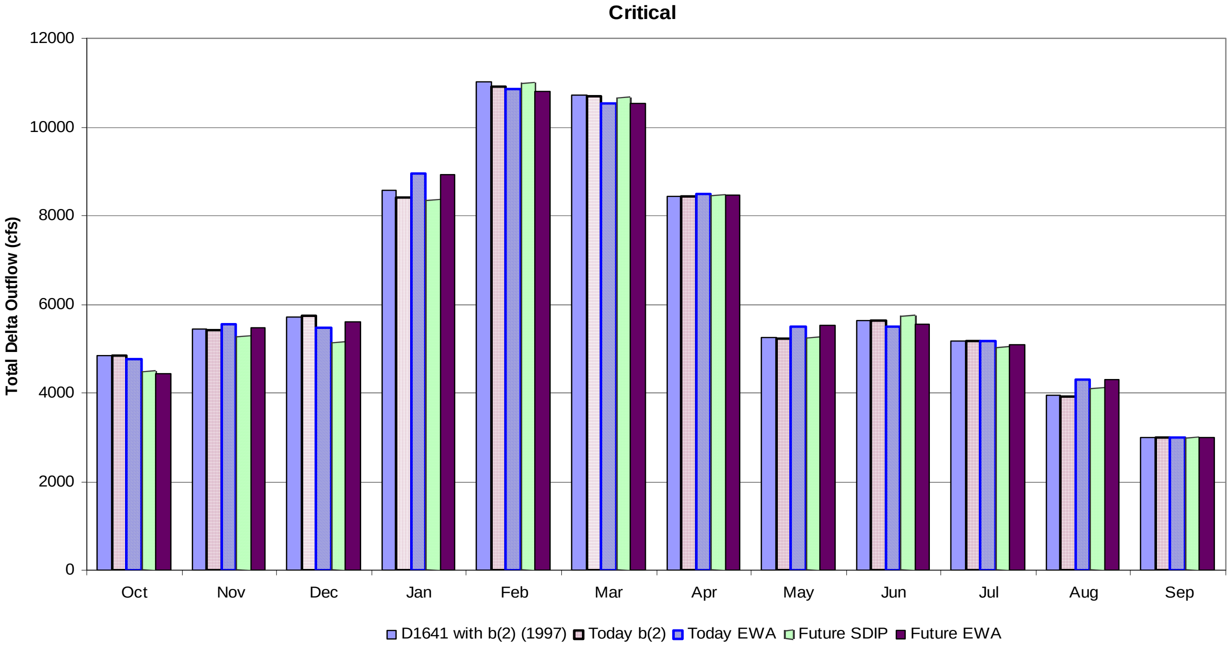


Figure 12–58 Average critical year (40-30-30 Classification) monthly Delta Outflow

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 (NBA). Figure 12–59 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 and 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 (DMC), while EWA imposes restrictions on pumping.

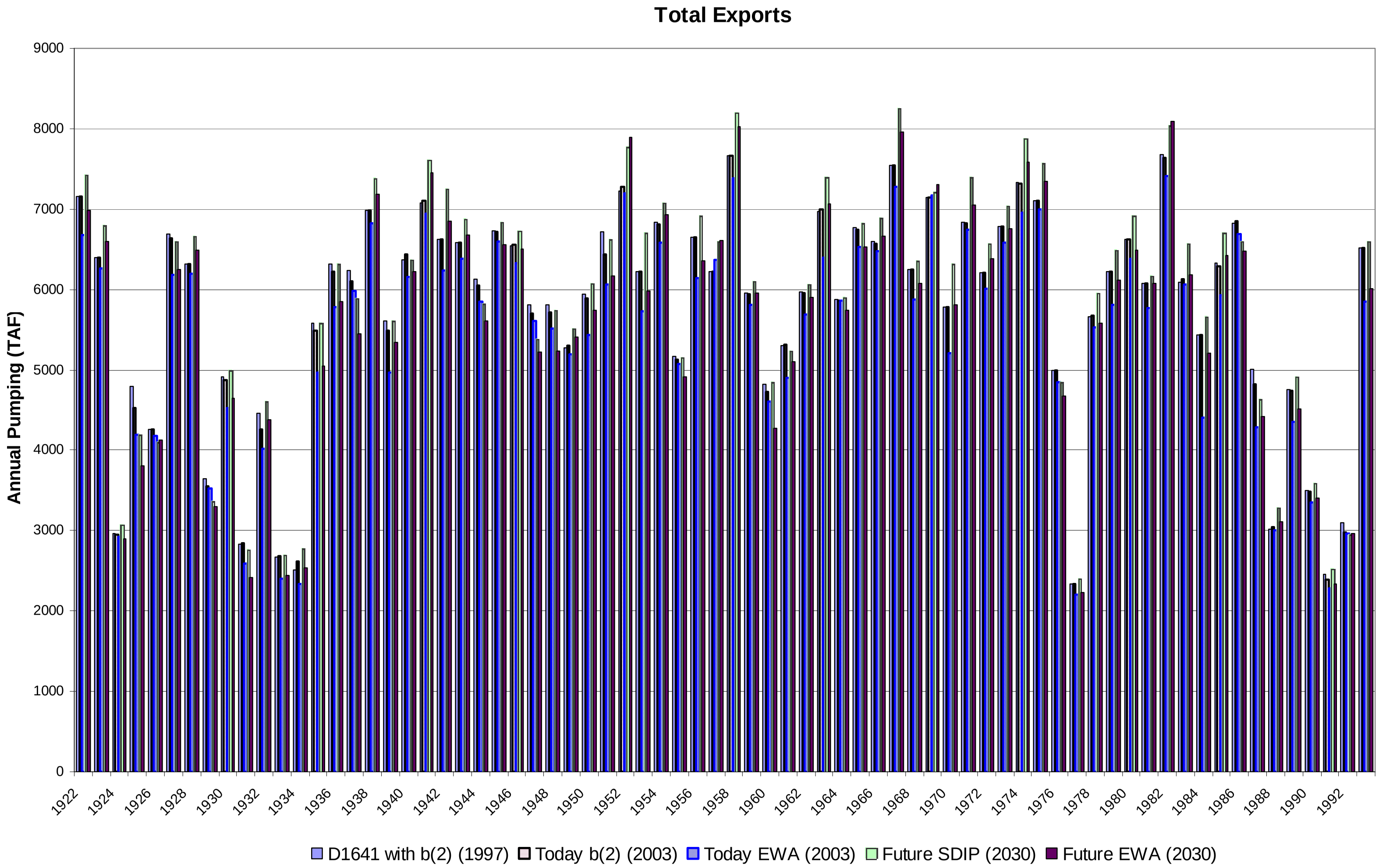


Figure 12–59 Total Annual Tracy + Banks Pumping

Tracy Pumping

The Tracy pumps in Studies 1, 2, and 3 are limited to 4,200 cfs plus the diversions upstream of the constriction in the DMC. In studies 4 and 5, the intertie allows pumping to increase to the facility design capacity of 4,600 cfs. Figure 12–60 shows the percentile values for monthly pumping at Tracy. November through February are the months when Tracy most frequently pumps at 4,600 cfs, with the 50th percentile at that level for most of the months in Study 4. Wet years tend to be when Tracy can utilize the 4,600 cfs pumping in Study 4 and Study 5 (Figure 12-61).

From Figure 12–60 December through February, the pumping is decreased during this timeframe 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 Vernalis Adaptive Management Program (VAMP) restrictions, and May has further reductions in the EWA studies due to EWA spending some assets to supplement the May Shoulder pumping reduction. June is limited by the 3,000 cfs limit 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 12–61 to Figure 12–66 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 12–66) when the pumping stays between 1,000 cfs and 1,500 cfs through August due to reduced storage and salinity conditions in the Delta.

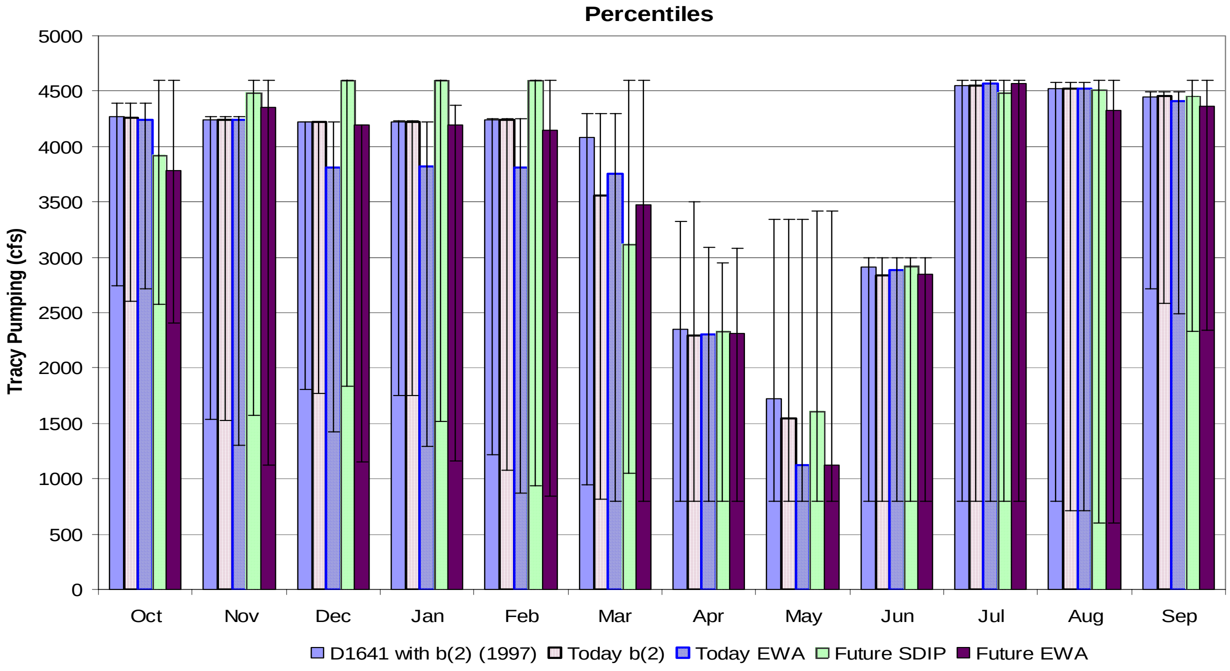


Figure 12–60 Tracy Pumping 50th Percentile Monthly Releases with the 5th and 95th as the bars

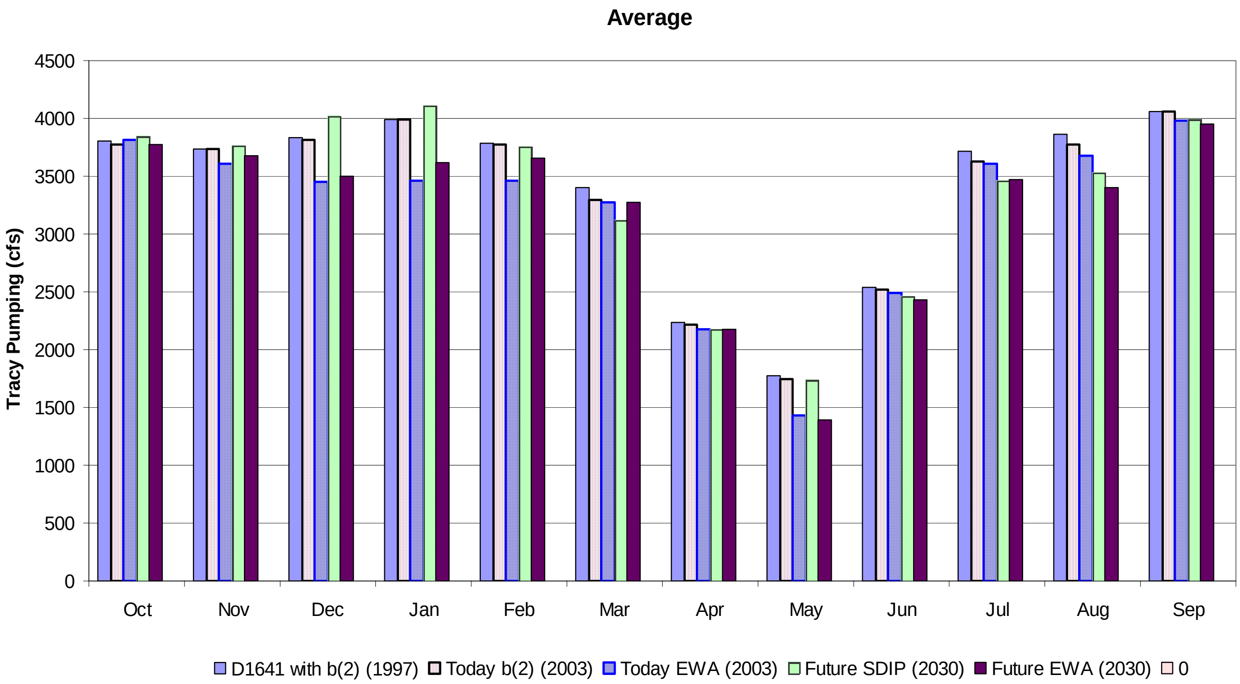


Figure 12–61 Average Monthly Tracy Pumping

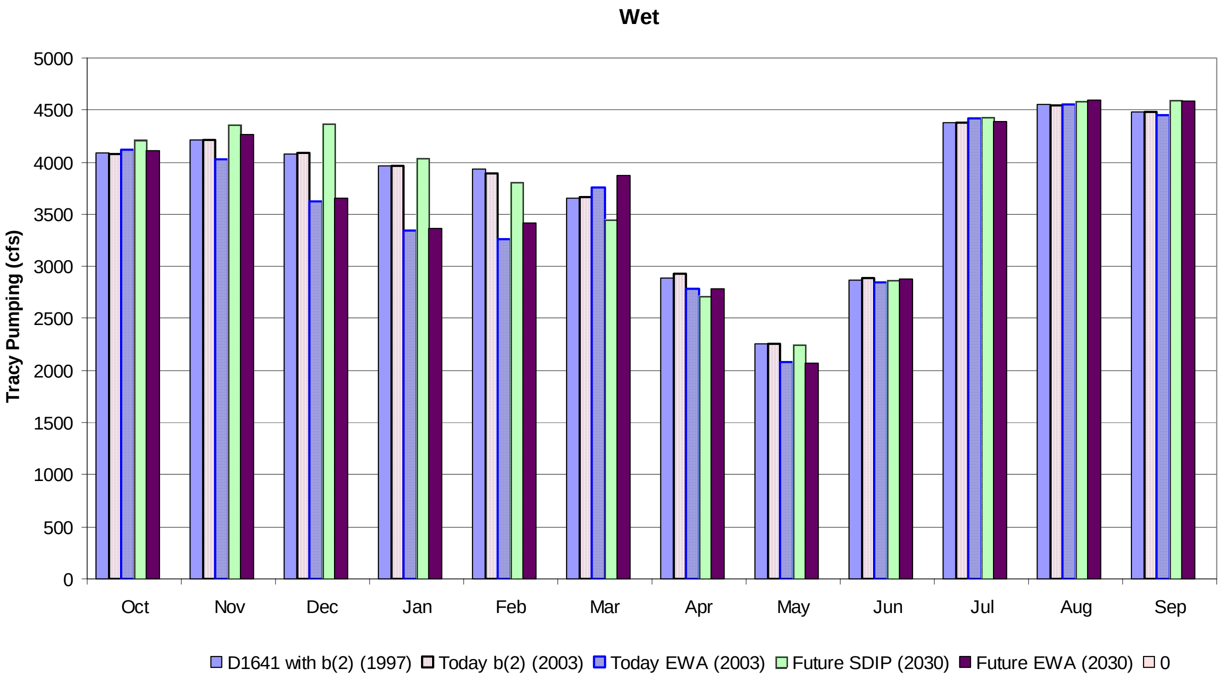


Figure 12–62 Average wet year (40-30-30 Classification) monthly Tracy Pumping

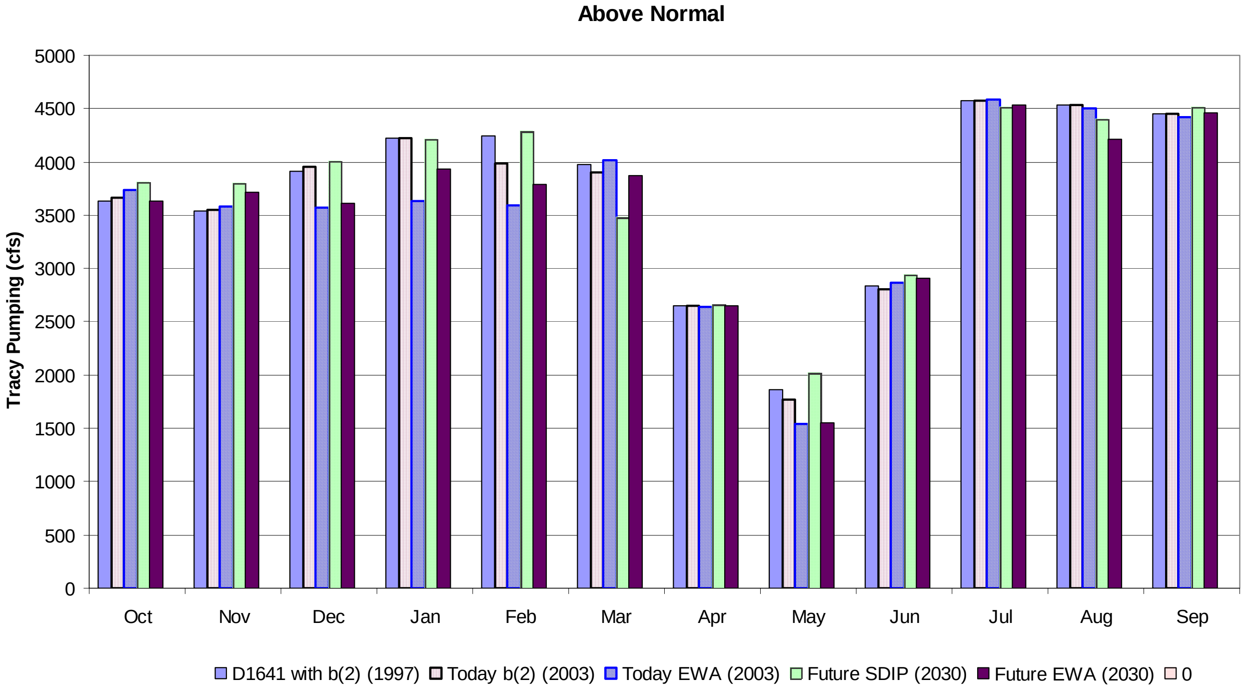


Figure 12–63 Average above normal year (40-30-30 Classification) monthly Tracy Pumping

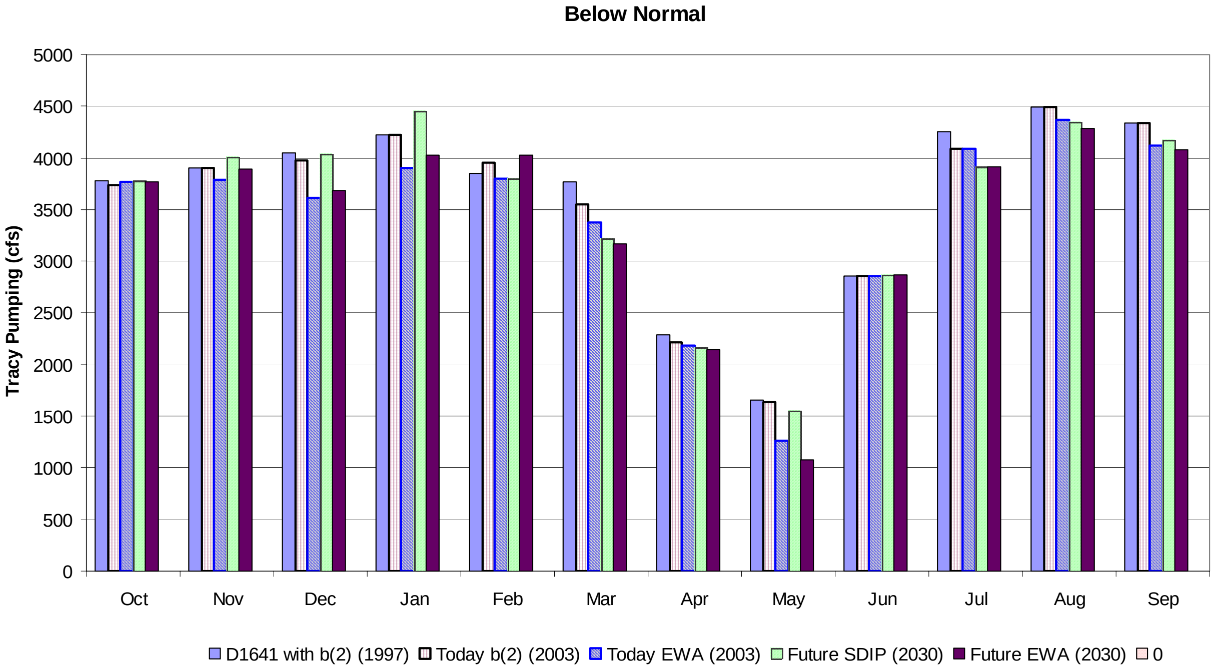


Figure 12–64 Average below normal year (40-30-30 Classification) monthly Tracy Pumping

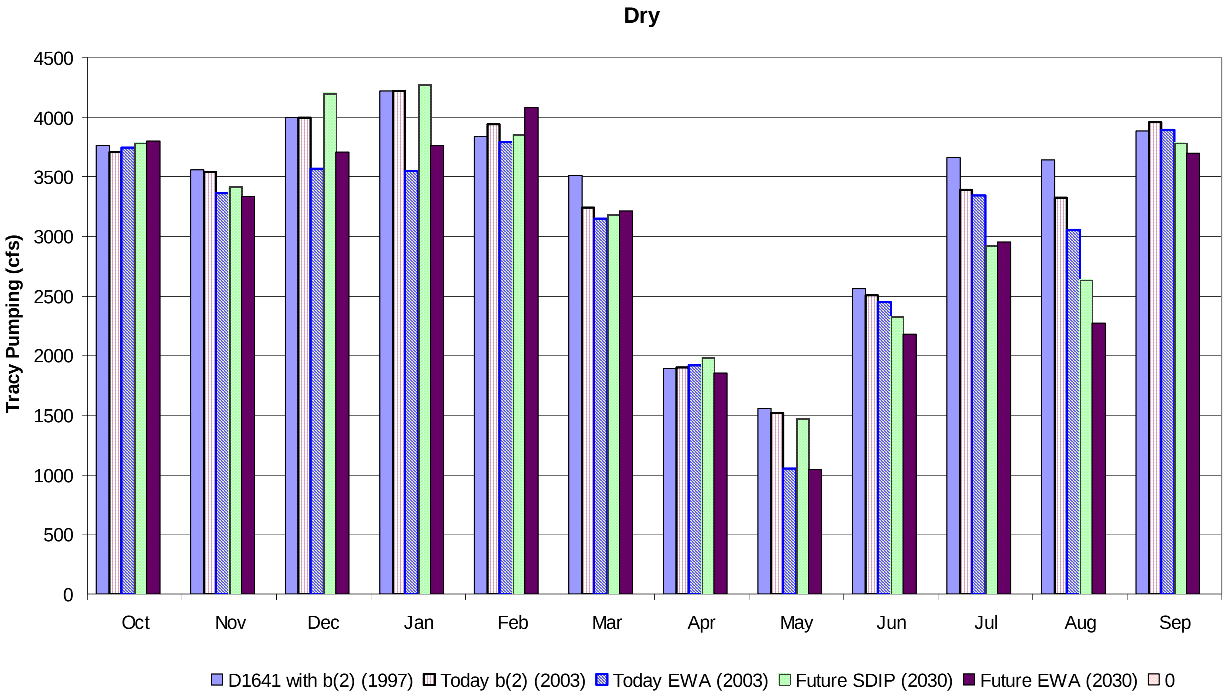


Figure 12–65 Average dry year (40-30-30 Classification) monthly Tracy Pumping

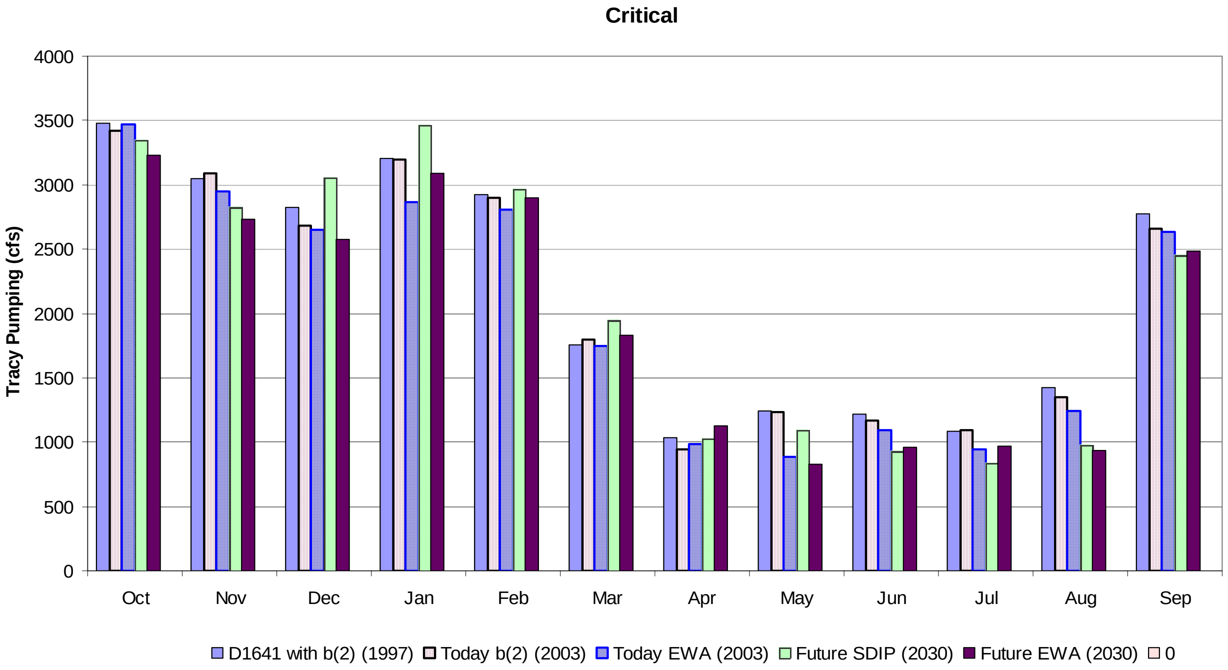


Figure 12–66 Average critical year (40-30-30 Classification) monthly Tracy Pumping

Banks Pumping

Figure 12–67 through Figure 12–73 represent simulated total Banks exports for the five studies. Figure 12–67 shows that export levels in Studies 3, 4, and 5 are greater export levels than Studies 1 and 2, which are the 3406 (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 12–67) also shows that a 8,500 export level is reached at least 5 percent of the time in the SDIP and the EWA Future cases

While EWA and SDIP implementation in Studies 3 and 5 results in higher export levels in all months except for April and May, the percentage of the summertime increases varies as a function of year type (see Figure 12–61 to Figure 12–66).

In the driest years, EWA-related exports more than double the July, August, and September exports when compared to the 3406 (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 3406 (b)(2) cases.

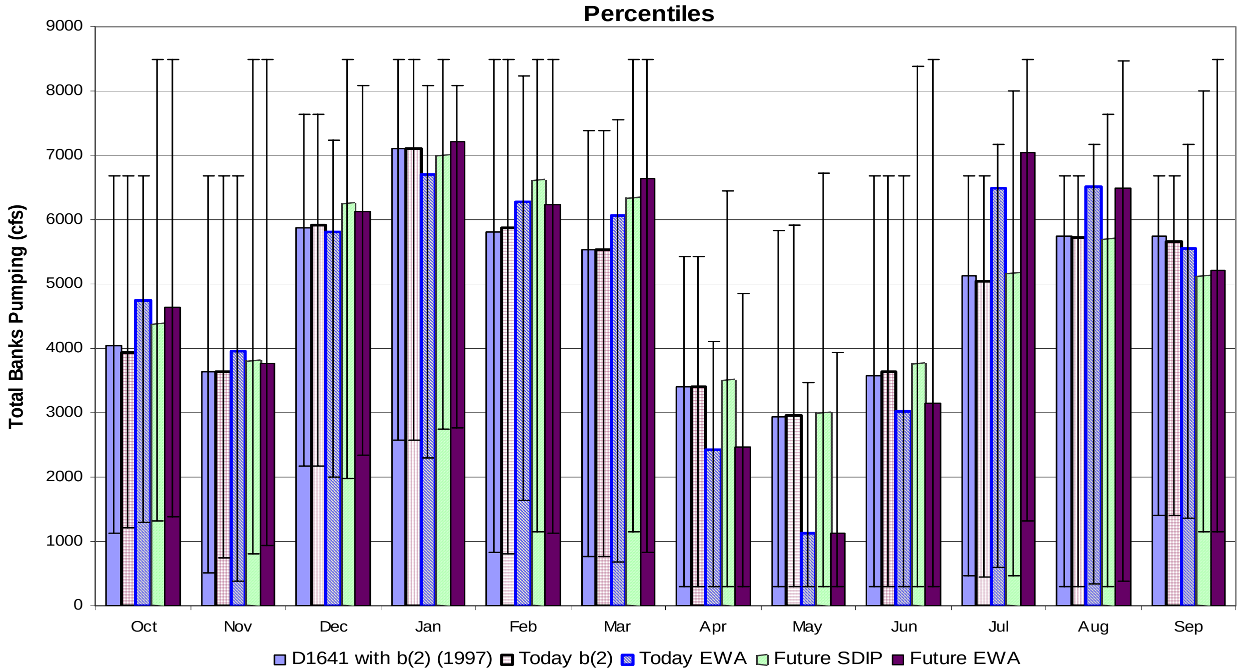


Figure 12–67 Banks Pumping 50th Percentile Monthly Releases with the 5th and 95th as the bars

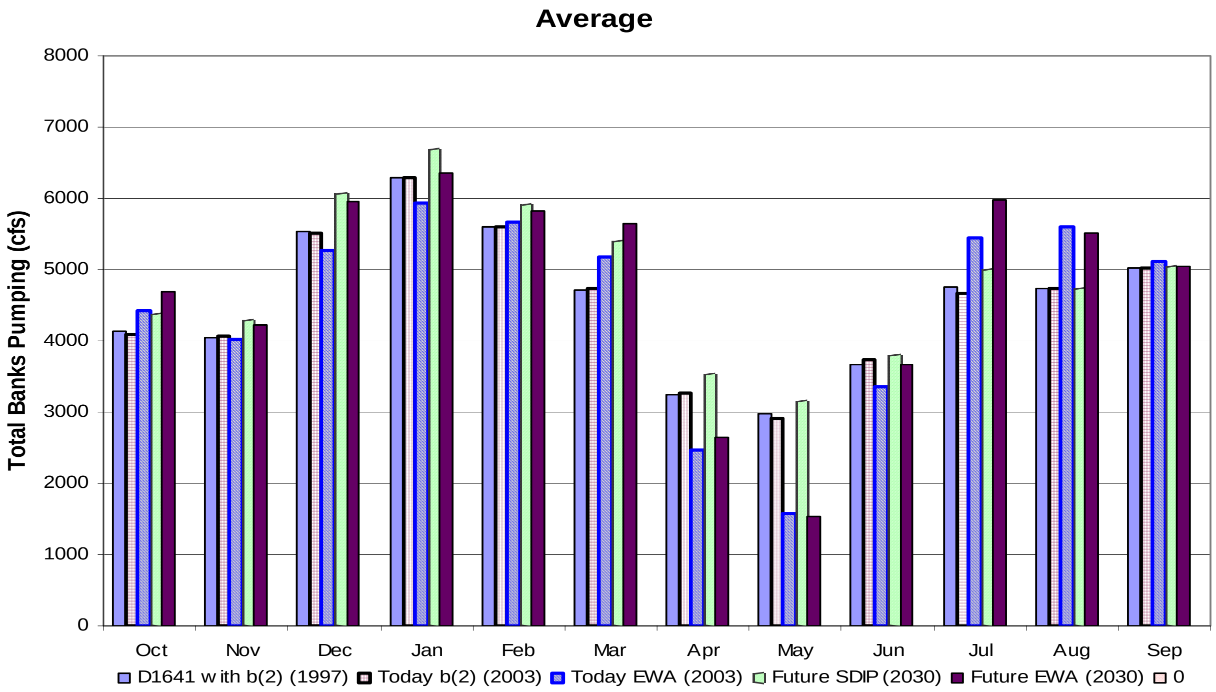


Figure 12–68 Average Monthly Banks Pumping

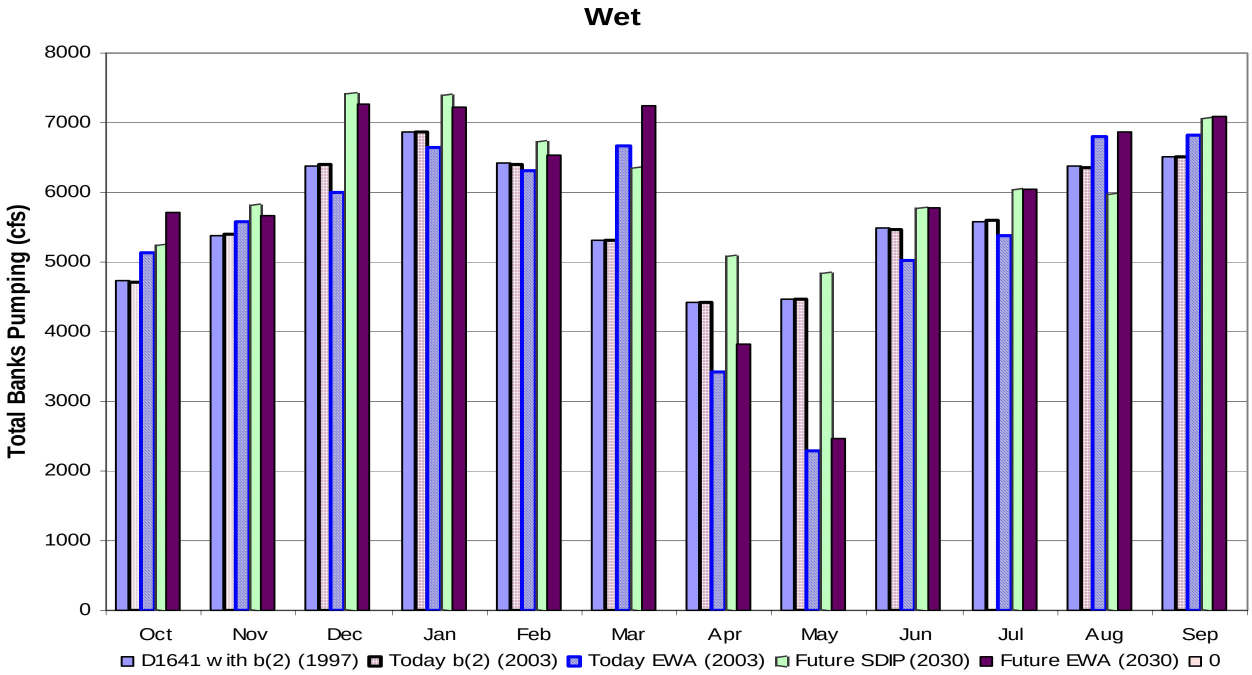


Figure 12–69 Average wet year (40-30-30 Classification) monthly Banks Pumping

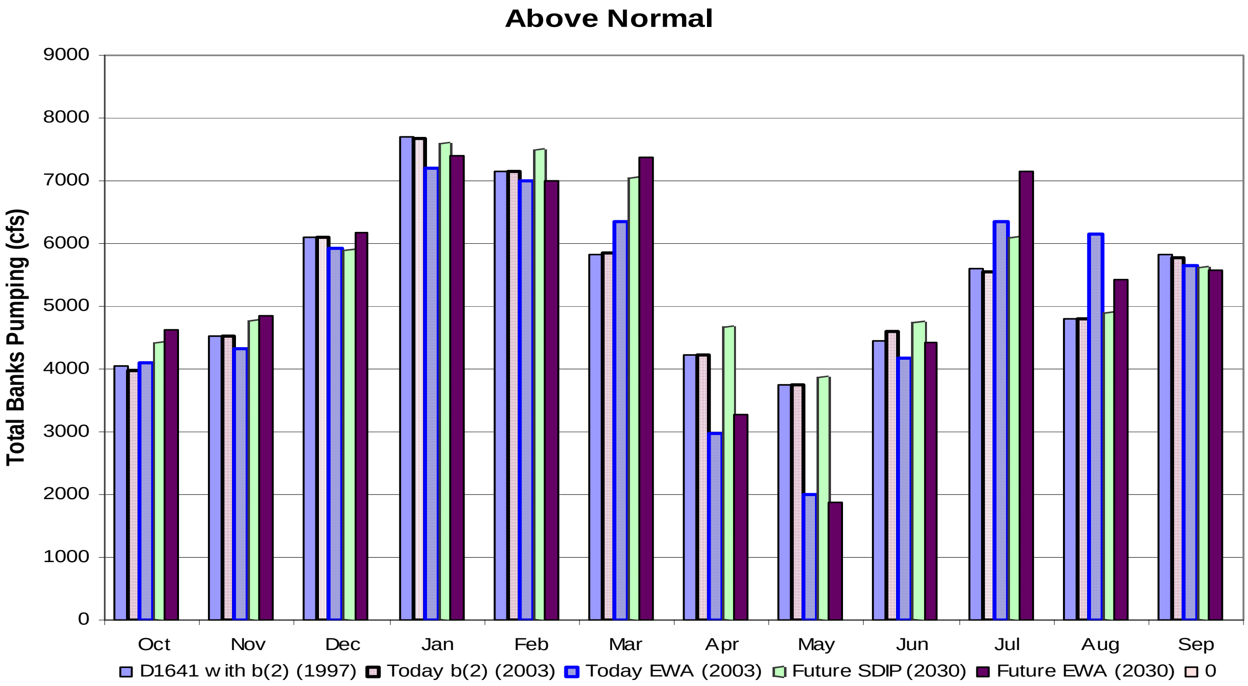


Figure 12–70 Average above normal year (40-30-30 Classification) monthly Banks Pumping

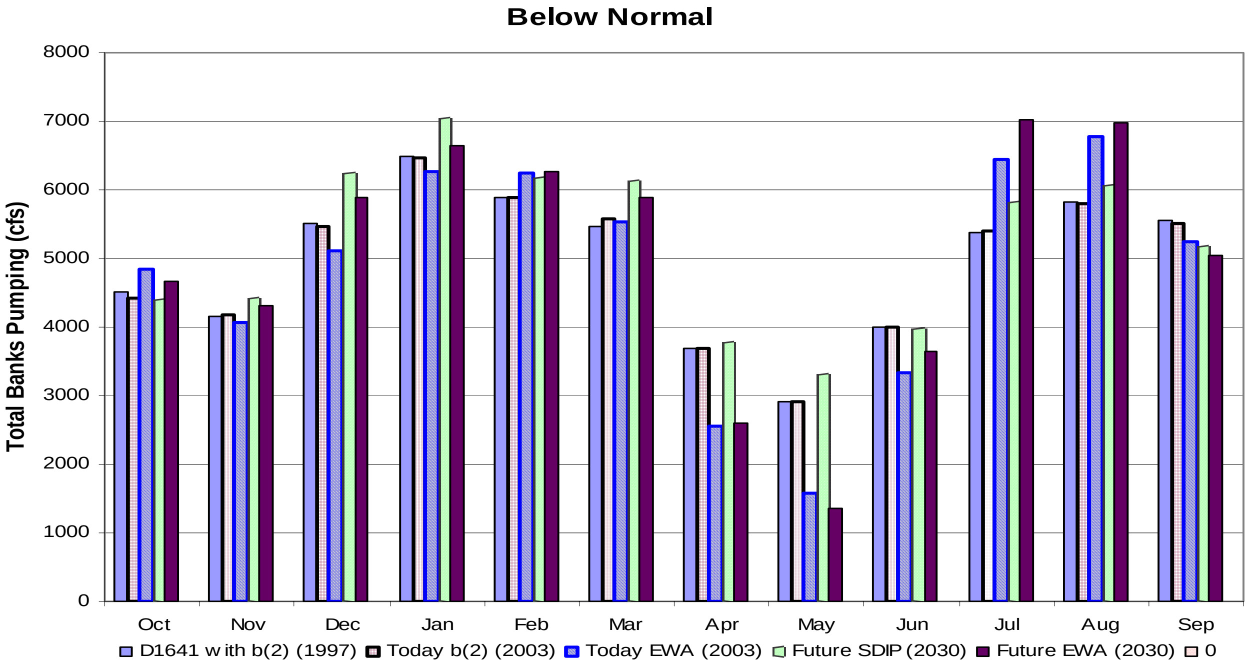


Figure 12–71 Average below normal year (40-30-30 Classification) monthly Banks Pumping

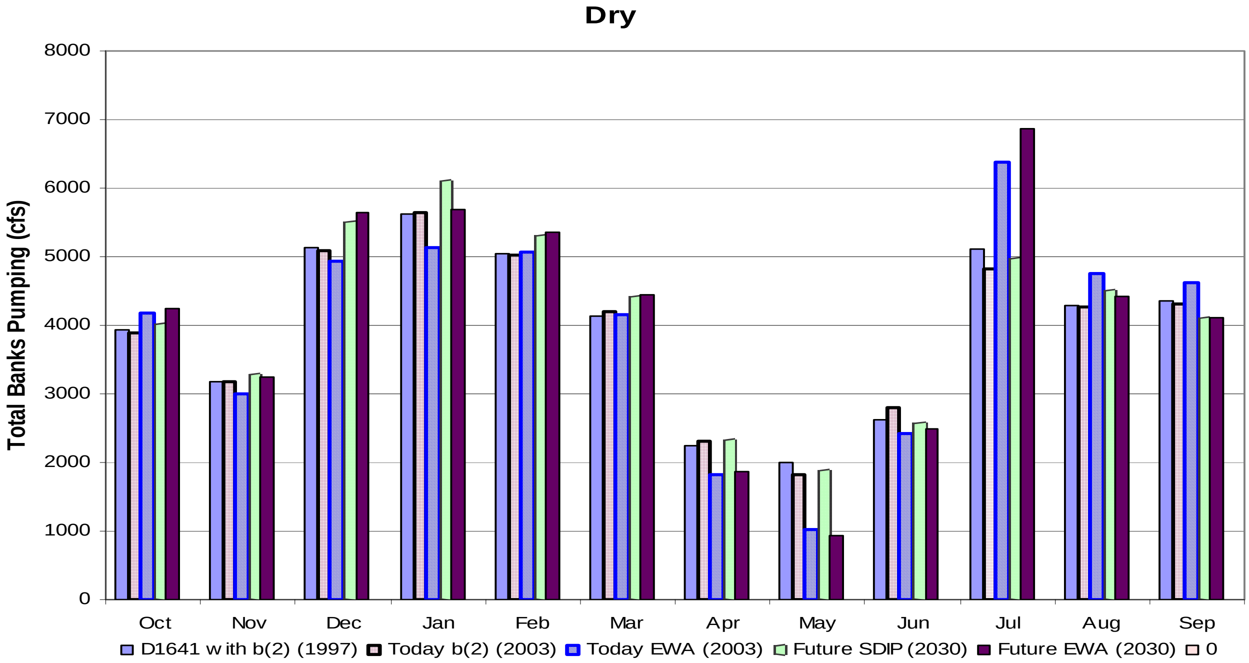


Figure 12–72 Average dry year (40-30-30 Classification) monthly Banks Pumping

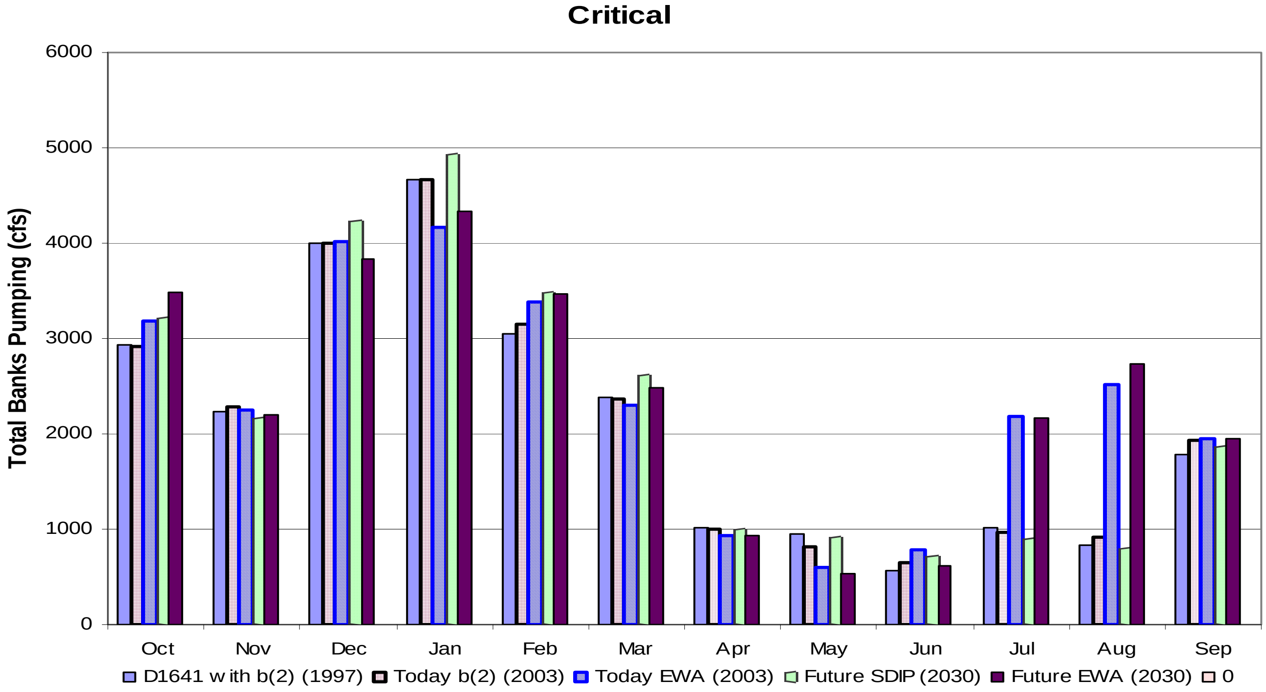
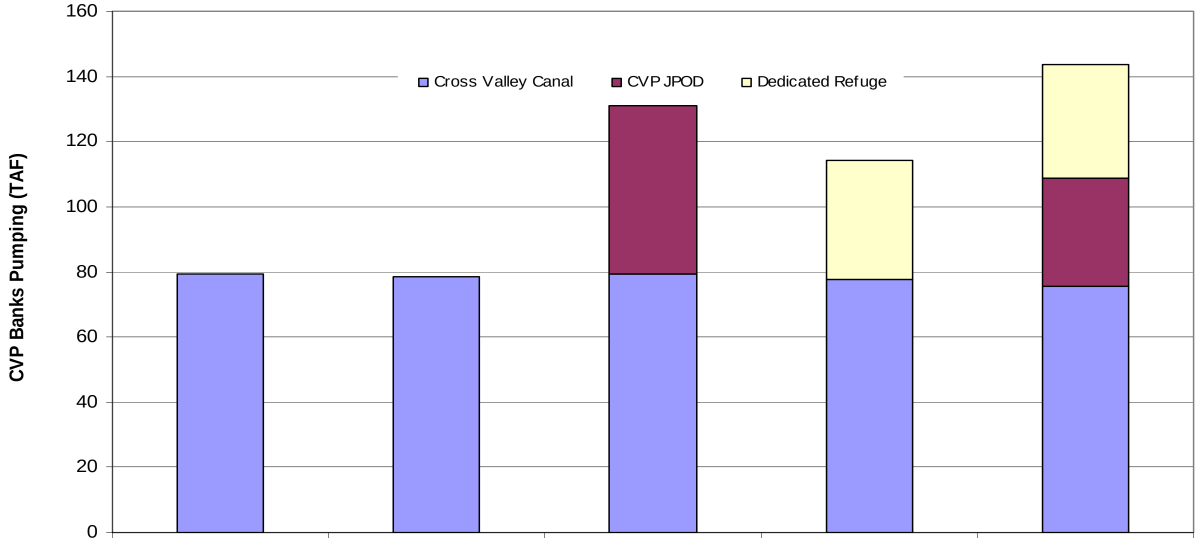


Figure 12–73 Average critical year (40-30-30 Classification) monthly Banks Pumping

Federal Banks Pumping

Figure 12–74 shows the annual average use of Banks pumping for the CVP by study. The average joint point of diversion (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.

Federal pumping at Banks generally occurs in the late summer months (Figure 12–75 through Figure 12-81). 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 6,680 cfs to 8,500 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.



	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 12–74 Average use of Banks pumping for the CVP

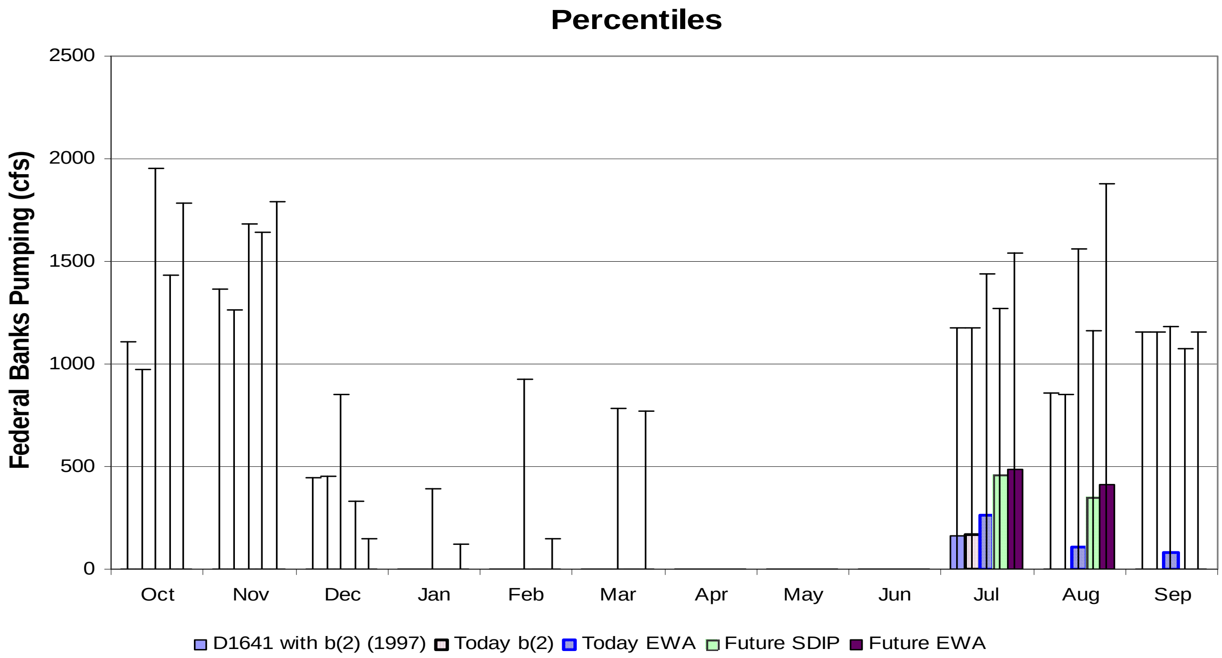


Figure 12–75 Federal Banks Pumping 50th Percentile Monthly Releases with the 5th and 95th as the bars

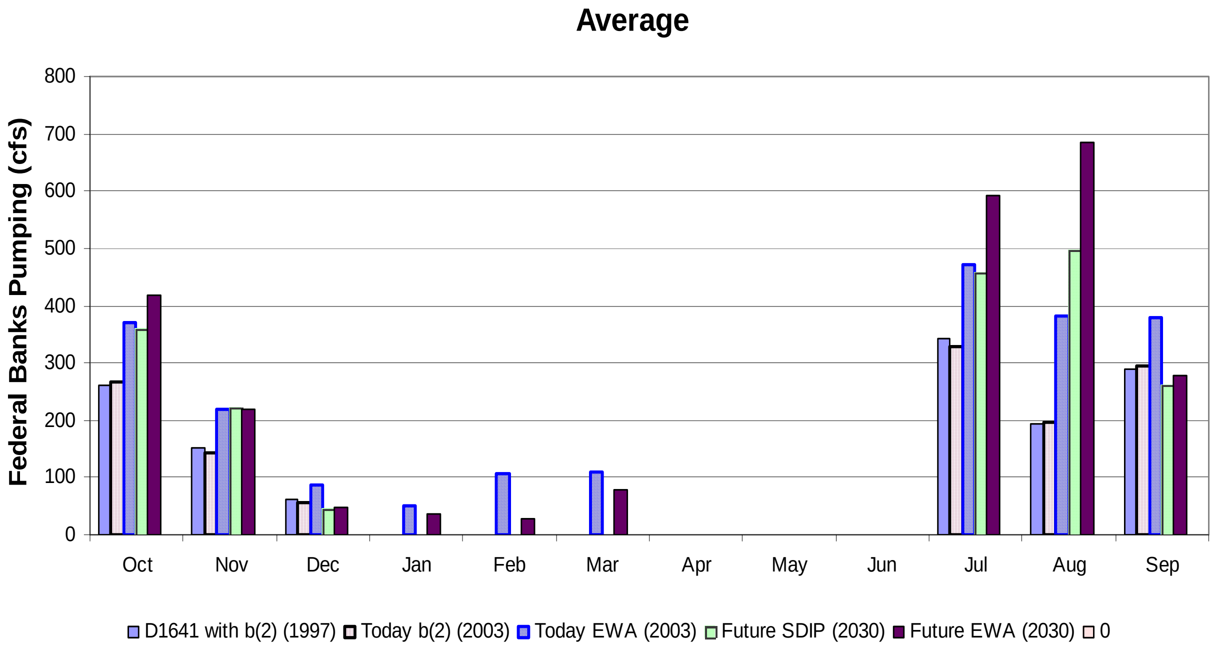


Figure 12–76 Average Monthly Federal Banks Pumping

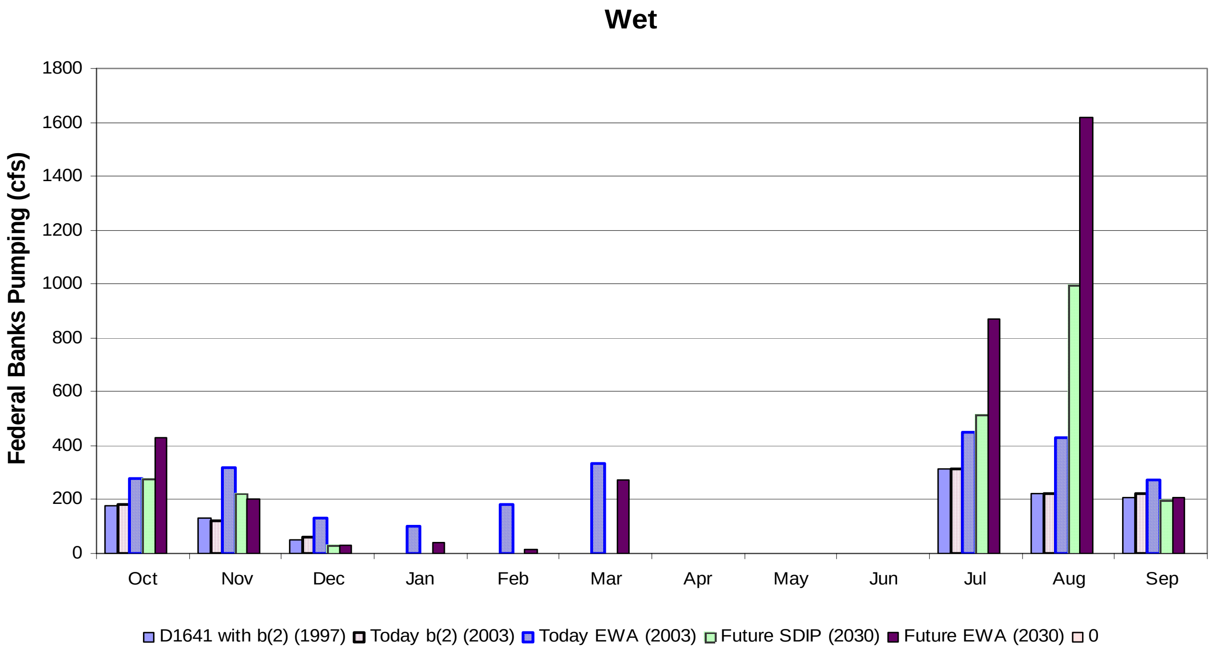


Figure 12–77 Average wet year (40-30-30 Classification) monthly Federal Banks Pumping

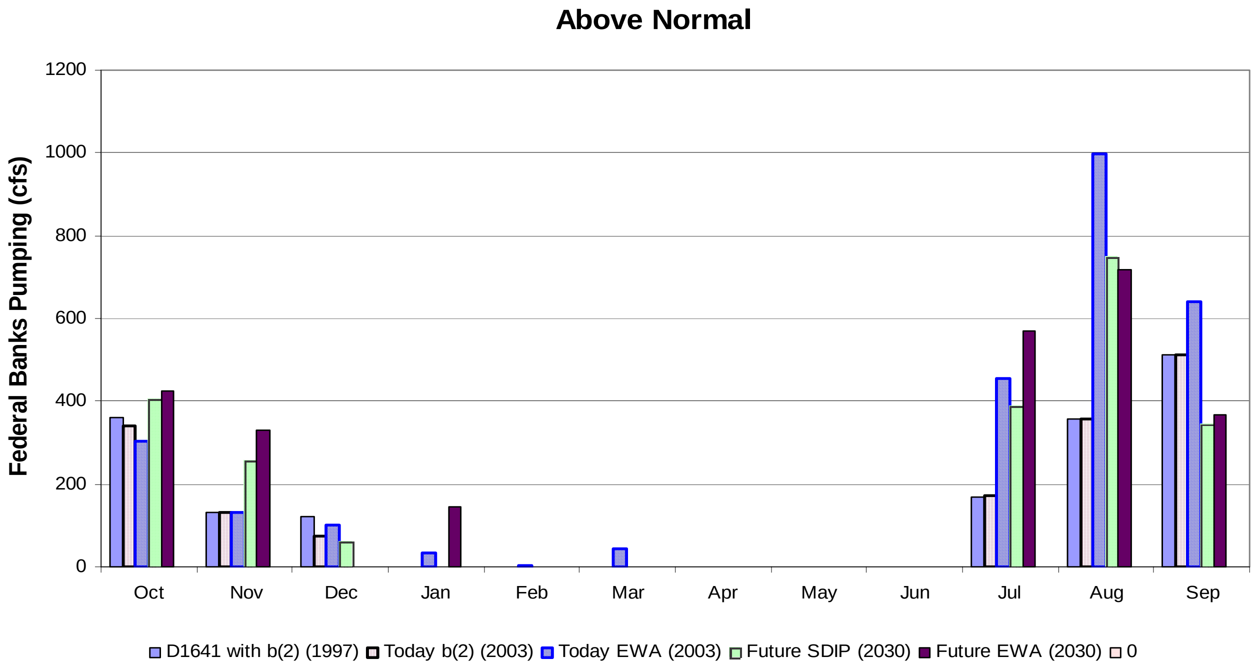


Figure 12–78 Average above normal year (40-30-30 Classification) monthly Federal Banks Pumping

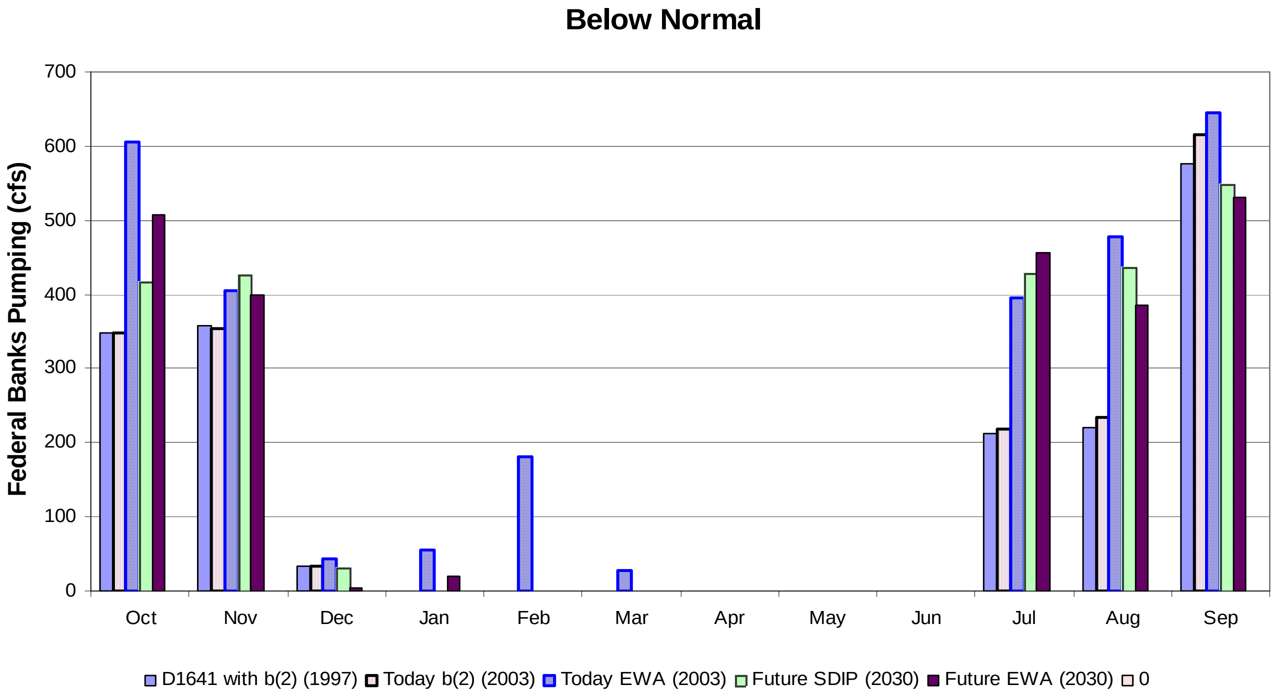


Figure 12–79 Average below normal year (40-30-30 Classification) monthly Federal Banks Pumping

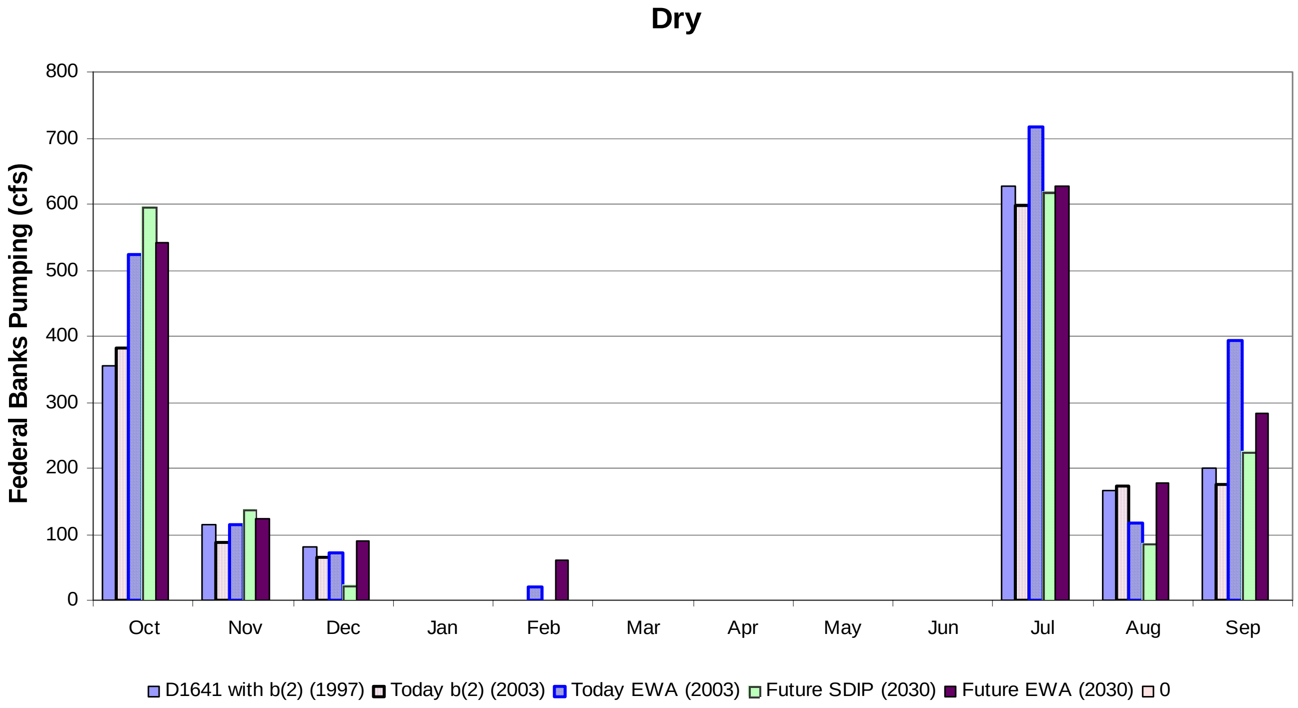


Figure 12–80 Average dry year (40-30-30 Classification) monthly Federal Banks Pumping

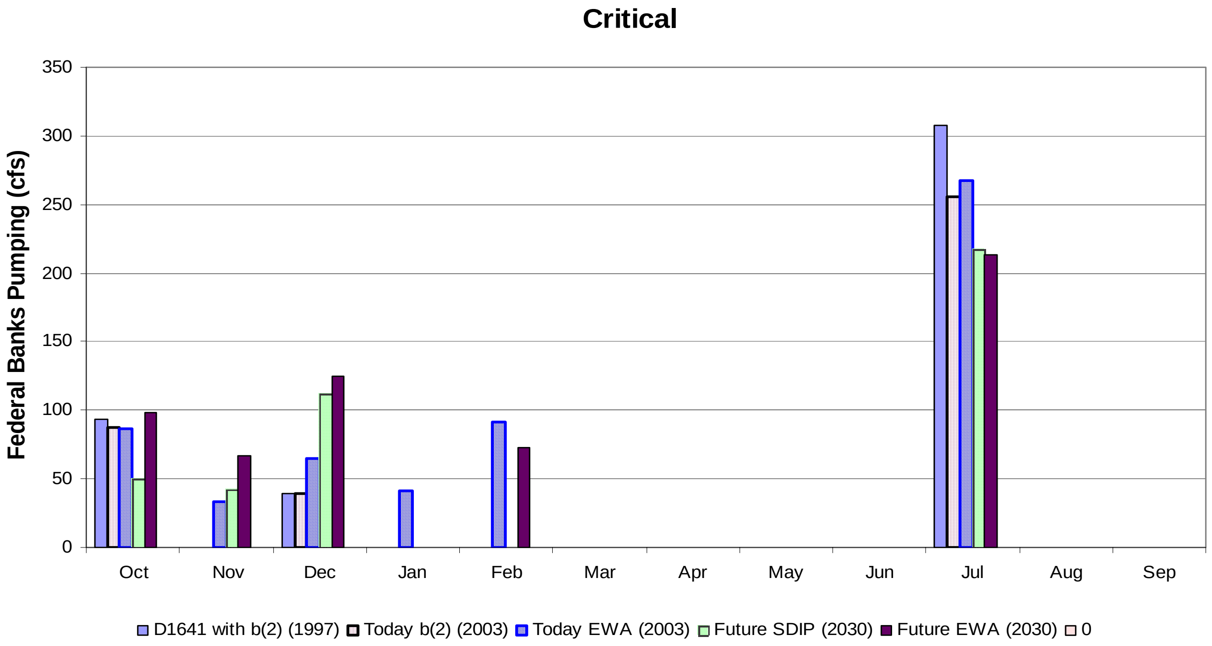


Figure 12–81 Average critical year (40-30-30 Classification) monthly Federal Banks Pumping

Contra Costa Water District and North Bay Aqueduct Diversions

Diversions from CCWD and NBA increased from the 2001 LOD to the 2020 LOD (Table 12–15). Monthly average diversions at NBA 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 12–82 and Figure 12–83). Most of the diversions occur during the late summer months and extend into October for the NBA. CCWD's pattern peaks in June, decreases during the summer, and then stays around 200 cfs during the winter period.

Table 12–15 Average Annual 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 Annual Average	0	0	11	11	11
CCWD Long-term Average	0	0	34	34	34
CCWD 28-34 Annual Average	0	0	29	29	29

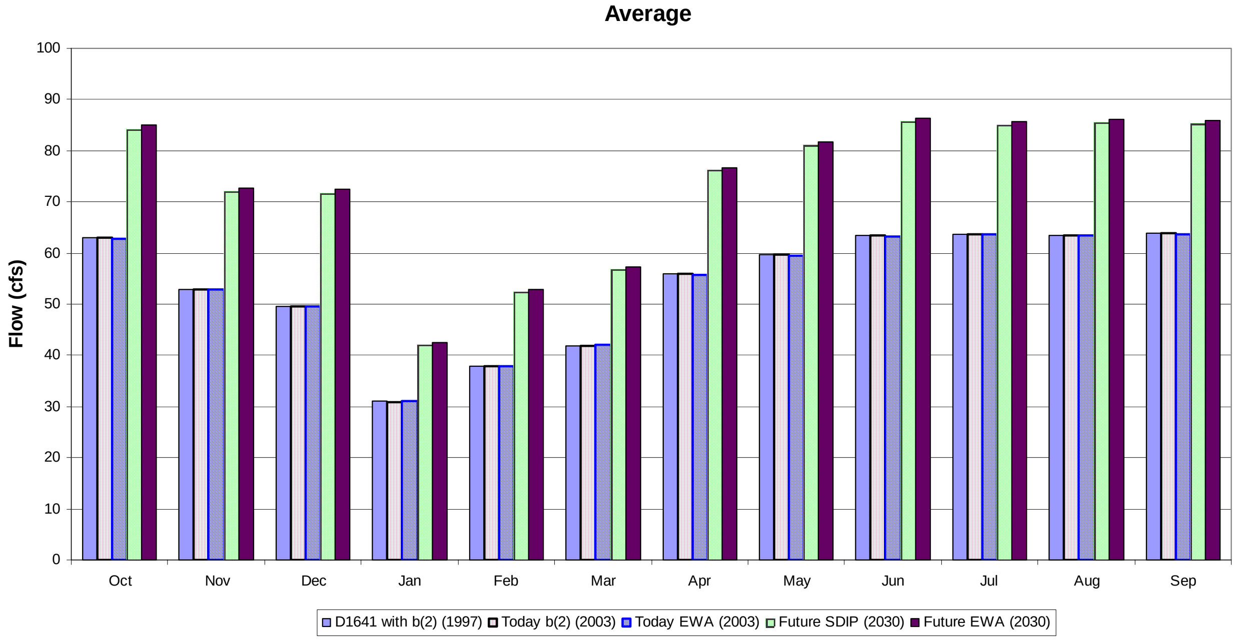


Figure 12–82 Average Monthly North Bay Aqueduct Diversions from the Delta

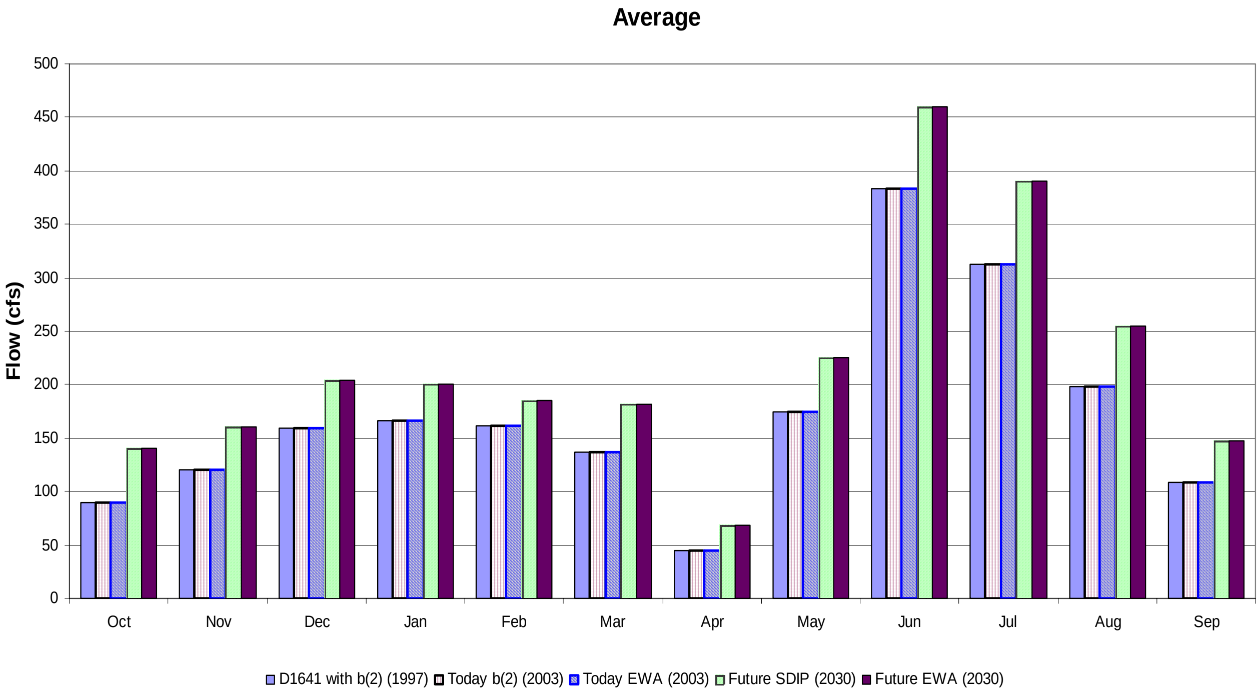


Figure 12–83 Average Monthly Contra Costa Water District Diversions from the Delta

San Luis Low Point

The calculation of low point in San Luis for both the CVP and SWP CALSIM II uses drain targets for end-of-September storage and are set in May of each year. The drain targets are a function of the end of April's Shasta plus Folsom storage for the CVP and Oroville storage for the SWP, as seen in Table 12–16. Low point in the model is a soft constraint because if the deliveries are greater than what can be supplied by a combination of pumping from the Delta and water in San Luis, the model will use additional water from San Luis below rule curve to meet the deliveries without violating San Luis dead pool storage. The dead pool storages for each of the projects are 45 taf for the CVP and 55 taf for the SWP in CALSIM II.

Table 12–16 CVP and SWP San Luis Drain Targets in CALSIM II

Shasta + Folsom Apr (taf)	CVP Drain Target (taf)	Oroville Apr Storage (taf)	SWP Drain Target (taf)
>4000	135	>3000	165
<3500	90	<2000	110

Figure 12–84 and Figure 12–85 show the annual end-of-month storage in the CVP and SWP portions of San Luis, respectively. The end-of-month storage values are a minimum for July through September. Because the model's time step is a month, only the end-of-month storage can be used as an indication for low point. In actual operations the low point could occur in any given day of the month. Looking at Figure 12–84, once the model dips below the 135 taf drain target, the model goes beyond the 90 taf drain target up to 20 percent of the time in the Today EWA study. The SWP low point chart (Figure 12–85) in the Future EWA case goes to dead pool in 18 percent of the years.

The drain targets in Table 12–16 and the low point values discussed in this section represent only planning model targets used to try and mimic how the CVP and SWP portions of San Luis are operated. Actual daily operations of San Luis reservoir include other variables that a monthly time step and rule-based simulation model cannot capture. Operation of San Luis could also be more or less aggressive in any given year, in the drier years especially, to try and fulfill the demands on the CVP and SWP system south of the Delta. The model also does not show how San Luis is operated jointly between the two projects in order to maintain a total reservoir level.

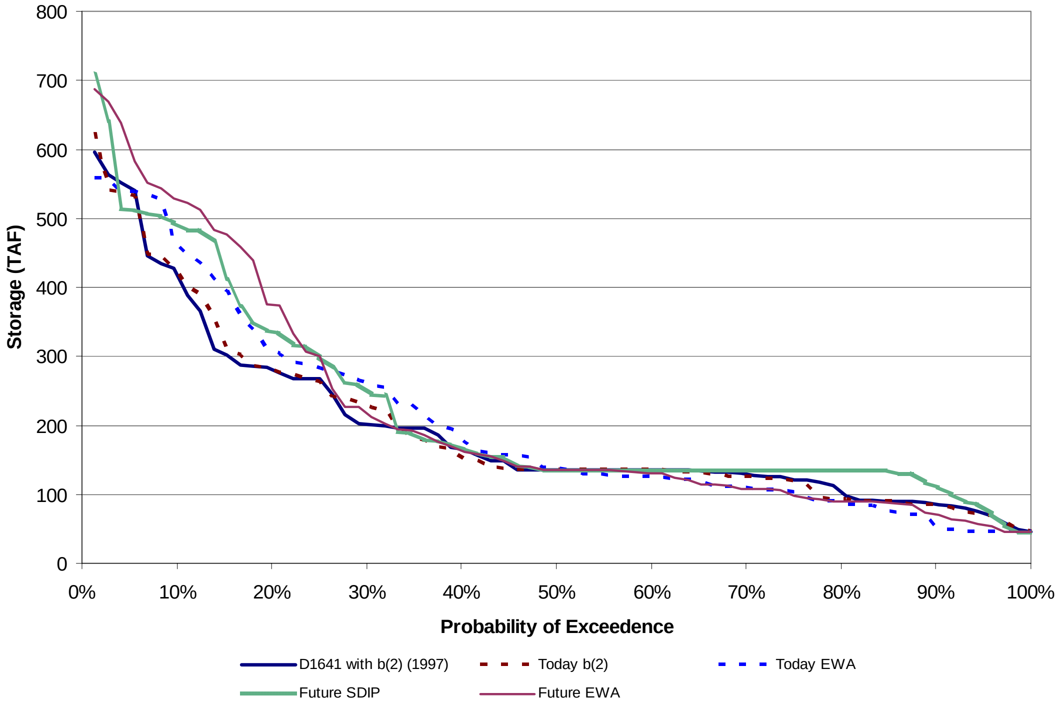


Figure 12–84 Exceedance of minimum end of month CVP San Luis for July – Sep that represents low point in CALSIM II

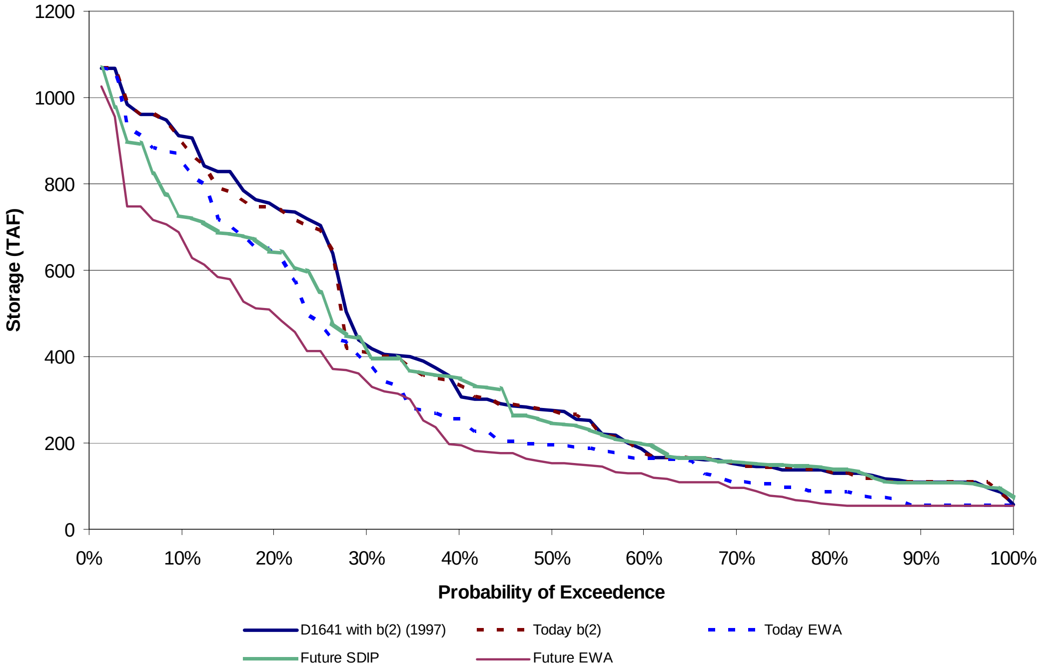


Figure 12–85 Exceedance of minimum end of month SWP San Luis for July – Sep that represents low point in CALSIM II

Figure 12–86 to Figure 12–88 illustrate the end-of-month total storage in San Luis from July to September. The total San Luis values show the combined CVP and SWP storage with EWA storage included for the Today EWA and Future EWA studies. Figure 12–87 indicates that the low point for the combined operation of San Luis will generally occur in August, with the lower storage values being exceeded more frequently than shown in Figure 12–86 and Figure 12–88. The figures also indicate that the EWA runs will generally contain more water due to the additional pumping in the late summer for the wetter years. The soft constraint of combining the drain targets in Table 12–16 to 300 taf is only a factor in the Future SDIP study due to 8,500 cfs pumping capacity at Banks and lack of EWA pumping restrictions. For the Today runs with Banks pumping capacity of 6,680 cfs and the EWA pumping restrictions in the Future EWA run, the 300 taf drain target will be exceeded in August in approximately 15 to 25 percent of the years.

Upstream Reservoir Coordination

After reviewing the future modeling, the times when Oroville storage is less than 1,500,000 af and Shasta is over 2,400,000 af only occurs twice (1961 and 1962). Because this only happened about 3 percent of the years covered by the available data, the conditions seem rare for this to happen more frequently.

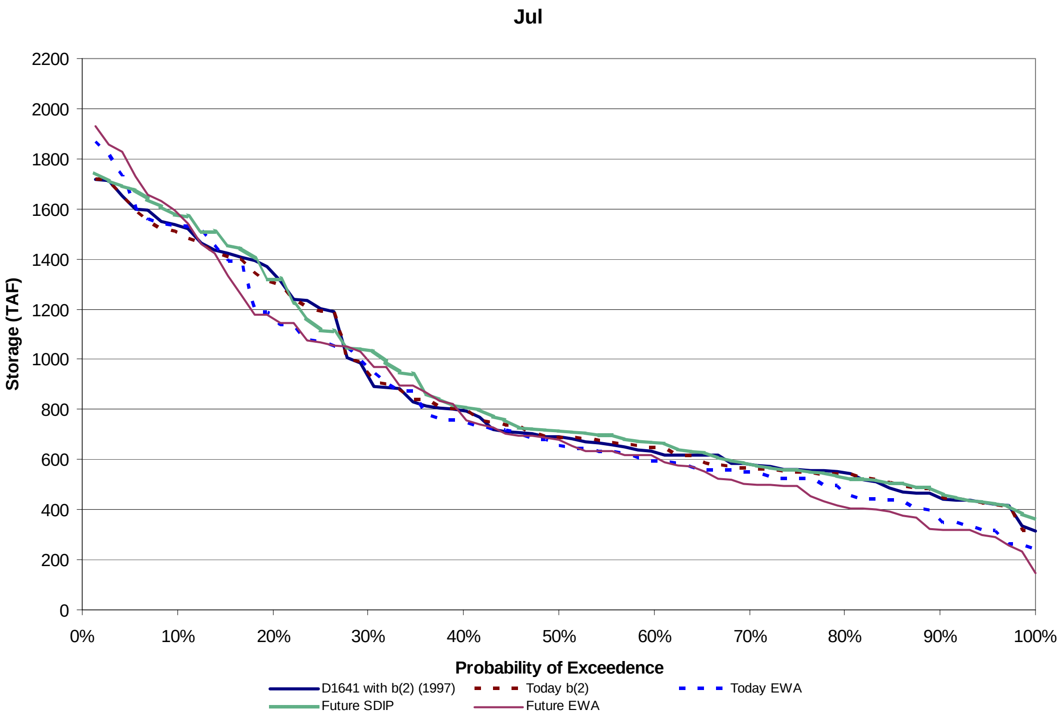


Figure 12–86 Exceedance chart of end of July storages in Total San Luis

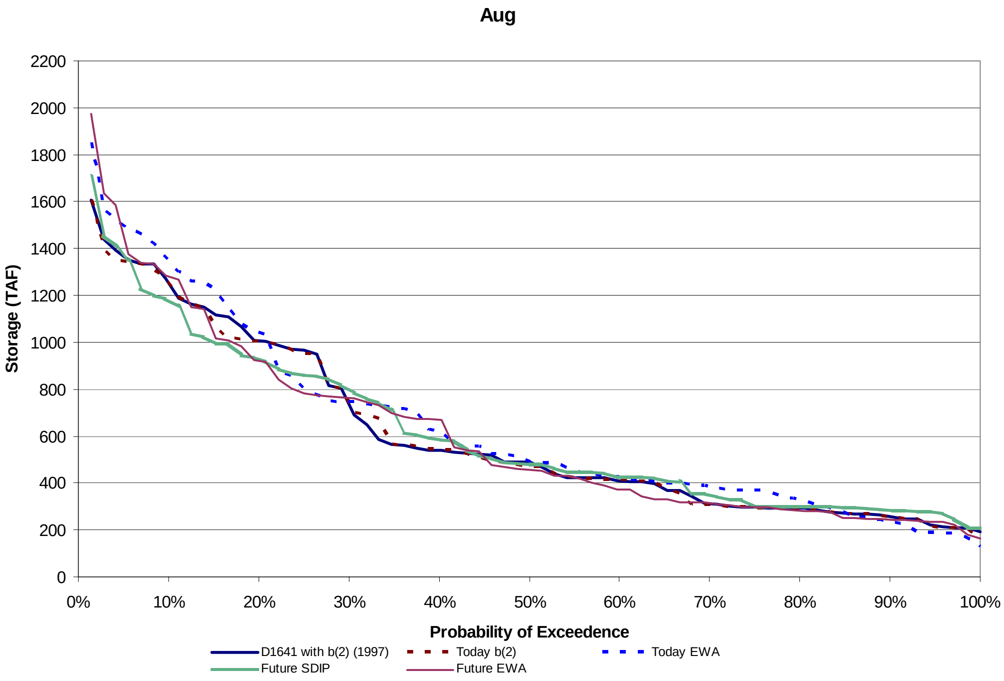


Figure 12–87 Exceedance chart of end of August storages in Total San Luis

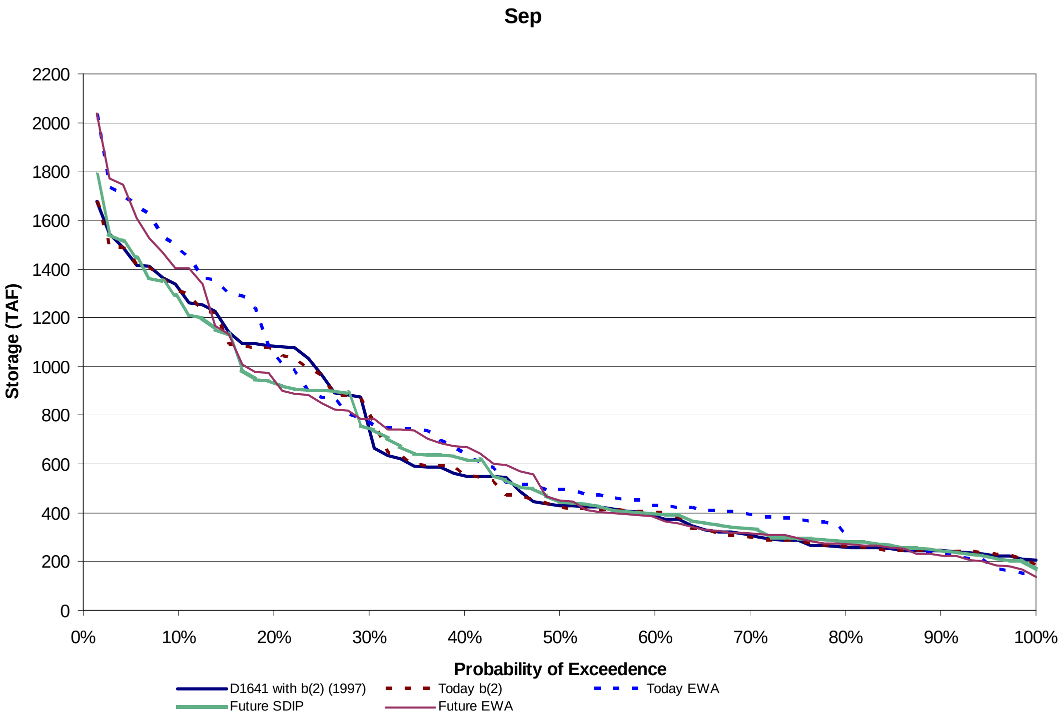


Figure 12–88 Exceedance chart of end of September storages in Total San Luis

Water Transfers

Water transfers would increase Delta exports from 200,000 to 600,000 af in about 80 percent 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 when 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 E/I ratio and is limited by either the total physical or permitted capacity and does 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.

From Figure 12–89 and Figure 12–90 show the available export capacity for the Today 3406 (b)(2) study at 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 12–91 and Figure 12–92 show the total available export capacity from highest to lowest for 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 12–89 and Figure 12–91 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 3406 (b)(2) study, in approximately 80 percent of the years the available capacity at Banks for transfer ranges from about 60 to 460 taf (if the 90 taf dedicated for EWA is included). In most years, approximately 80 percent of 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 (see Figure 12–90 and Figure 12–92) 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 its ability to move through the Delta.

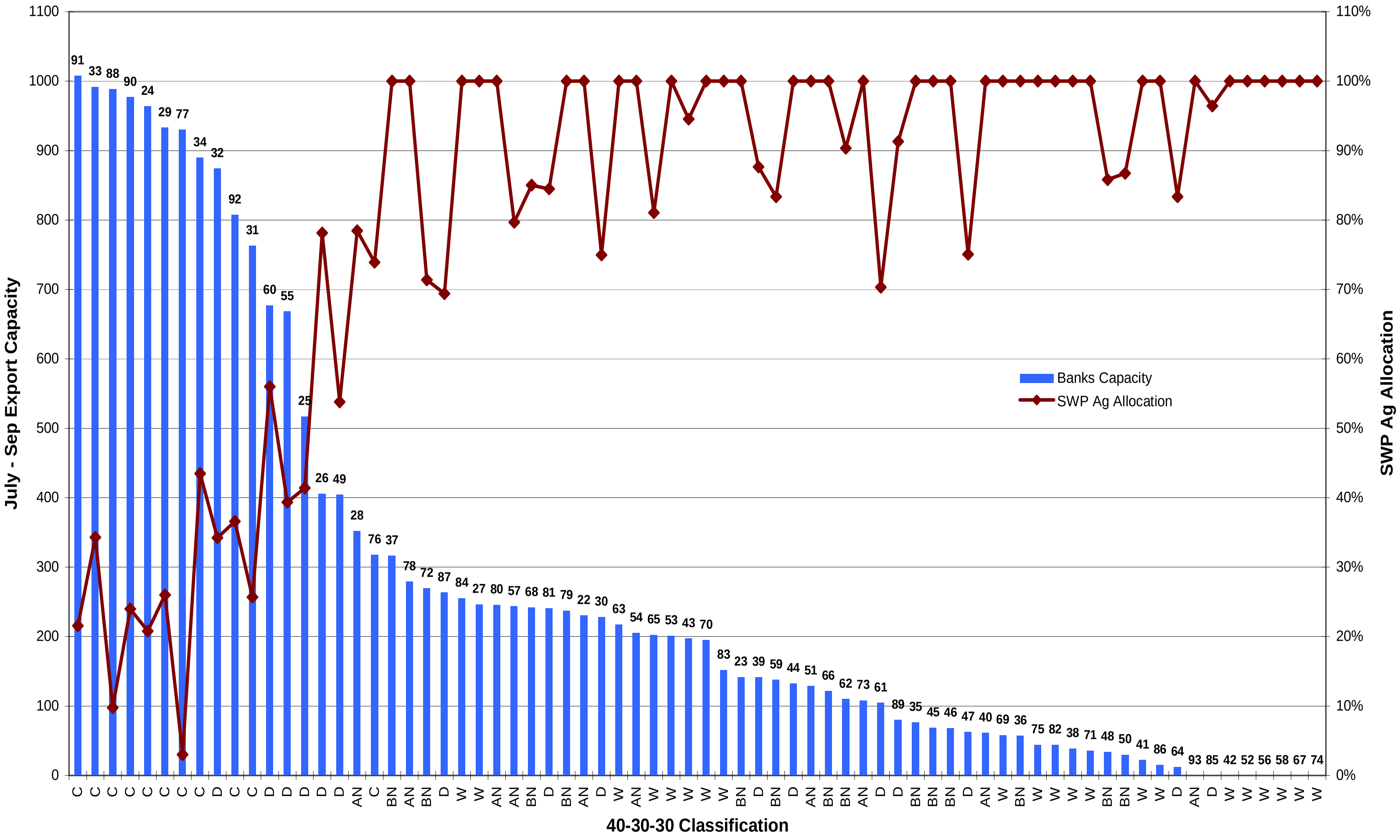


Figure 12–89 Total Banks pumping for July – September capacity in the Today b(2) Study sorted from highest to lowest with the corresponding SWP Allocation

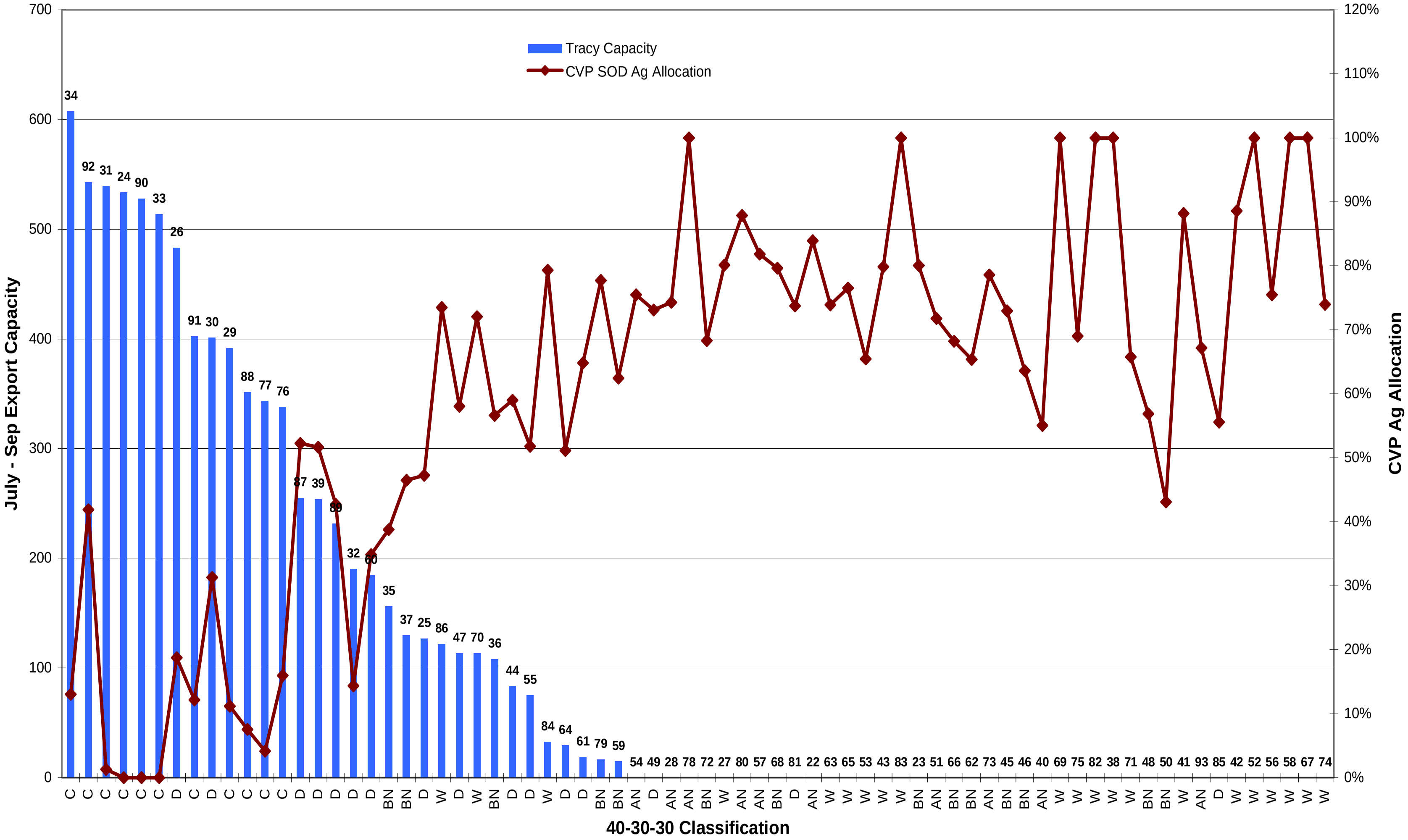


Figure 12–90 Total Tracy pumping for July – September capacity in the Today b(2) Study sorted from highest to lowest with the corresponding CVP south of Delta Ag Allocation

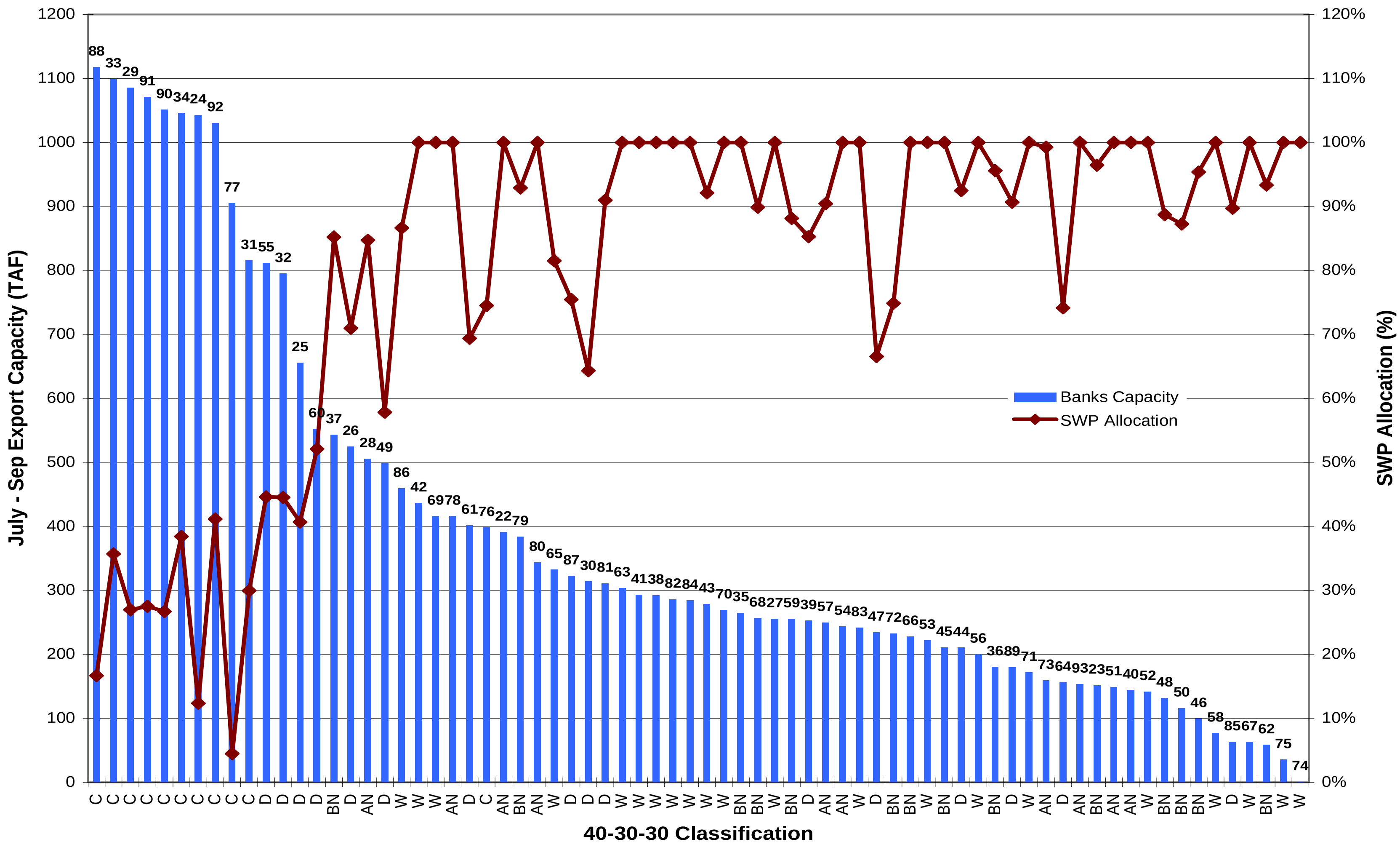


Figure 12–91. Total Banks pumping for July – September capacity in the Future SDIP Study sorted from highest to lowest with the corresponding SWP Allocation

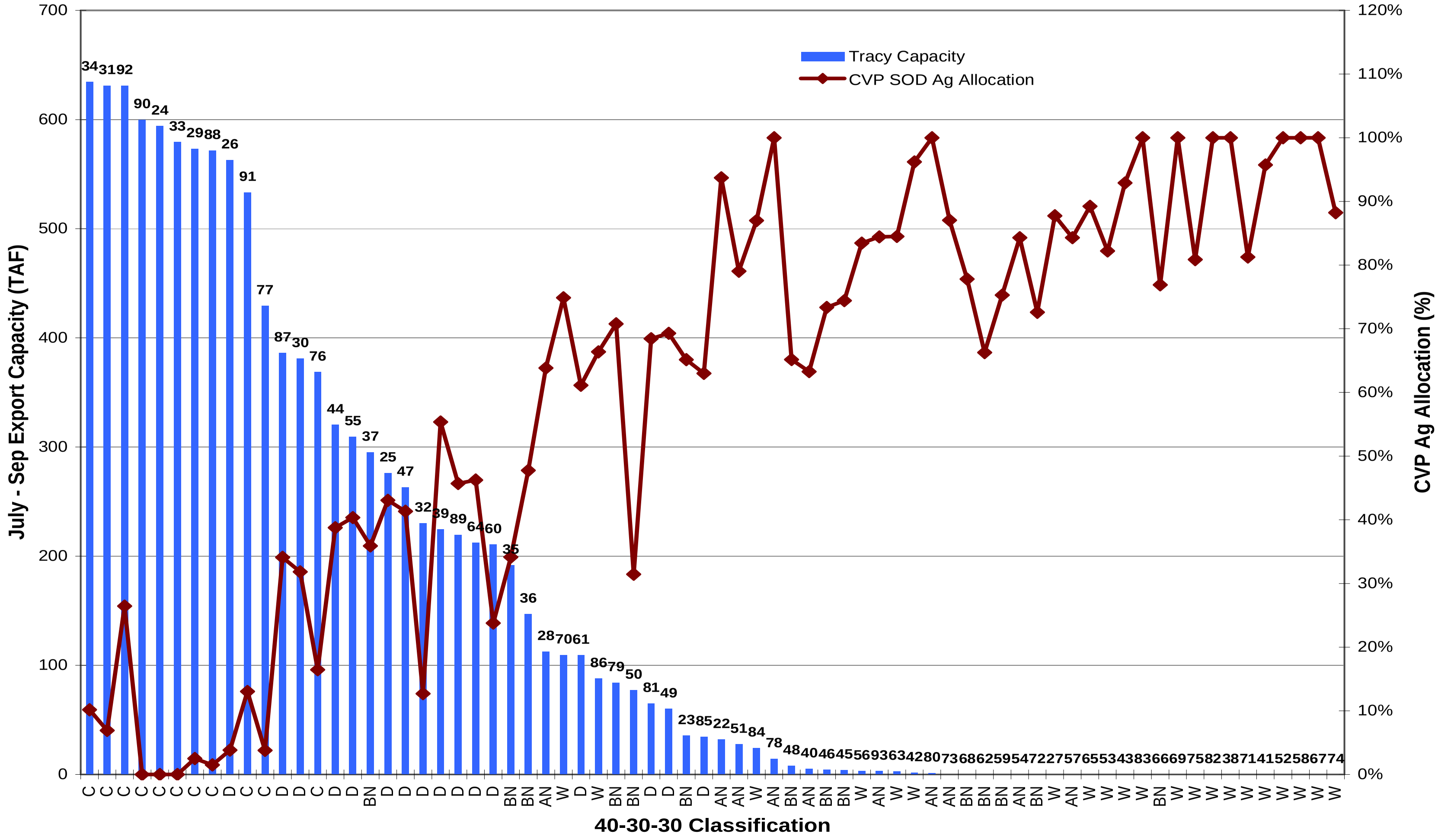


Figure 12–92 Total Tracy pumping for July – September capacity in the Future SDIP Study sorted from highest to lowest with the corresponding CVP south of Delta Ag Allocation.

Chapter 13 Summary of Effects Analysis and Effects Determination

Formal Consultation Items

Trinity Effects

Upstream effects of Trinity are summarized in Chapter 9. Trinity information begins on page 9-1 to 9-12. Clear Creek information begins on page 9-12 to 9-19 and Sacramento information begins on page 9-20 to 9-41.

In the U.S. Fish and Wildlife Service (FWS) October 12, 2000 Biological Opinion (BO) for Trinity there is a reasonable and prudent measure (RPM) about maintaining X2 in the February through June 30 at no more than 0.5 kilometers (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 the maps of the Delta similat to those for the Trinity analyses. An analyses of X2 was also done (see Chapter 10).

Although the proposed changes in Central Valley Project (CVP) operations resulting from implementation of the Trinity River Record of Decision (ROD) flows will result in less flows down the Sacramento River, this change in flows is anticipated to result in minimal effects to Delta smelt and Delta smelt habitat. Flows to the Sacramento River measured at Keswick will be reduced (Table 13–1) and the timing of water movement into and through the Sacramento watershed would change as a result of these changes in CVP operations. The reduction in flows could have an additional small effect on the location on X2, which in turn could affect Delta smelt. Smelt are usually distributed around the location of X2 from February through June. An upstream movement of X2 could cause smelt to be distributed further upstream into the east and south Delta, where they could be more susceptible to entrainment at the export facilities, as well as entrainment at local diversions in the Delta and mortality due to high temperatures or predation.

The updated CH2M HILL analysis took X2 location outputs from CALSIM II modeling. These outputs (see Appendix I) show that upstream movements of X2 greater than ½ km due to increased flows in the Trinity River occurred in 26 months. The Bureau of Reclamation (Reclamation) and FWS then analyzed the upstream movements of X2 and ruled out upstream movements in X2 in wet years or in dry years. In wet years, X2 is located in Suisun Bay, which is the preferred location for Delta smelt and provides shallow water habitat for Delta smelt. An upstream movement of ½ km in wet years would result in an X2 location in Suisun Bay, which would not be significant for Delta smelt because substantial high- quality habitat would still be available. In dry years, X2 is located upstream of the confluence of the Sacramento and San Joaquin rivers and the habitat available to smelt is poor. When X2 is located this far upstream, smelt would already be susceptible to entrainment or mortality due to high temperatures. An upstream movement of X2 of ½ km would not be significant when it is located upstream of the confluence because smelt habitat is already poor and the upstream movement does not result in any substantial additional loss of habitat or increase in adverse effects. By ruling out these years, Reclamation and FWS determined that there were 2 months where the upstream movement of X2 could result in a substantial loss of habitat for Delta smelt.

Table 13–1 Reduced Sacramento River flows measured at Keswick

Average Annual Keswick Releases (TAF)					
Water Year Type	**D1641 with b(2) (1997)**	**Today b(2)**	**Today EWA**	**Future b(2)**	**Future EWA 6680 cfs**
Average	6270	6190	6193	6053	6053
Wet	8658	8534	8525	8217	8221
Above Normal	6309	6262	6281	6244	6230
Below Normal	5384	5321	5322	5269	5240
Dry	5103	5024	5019	4897	4906
Critical	4499	4450	4478	4427	4455
Average Difference from D1641 with b(2) (1997)					
Water Year Type	**D1641 with b(2) (1997)**	**Today b(2)**	**Today EWA**	**Future b(2)**	**Future EWA 6680 cfs**
Average	6270	-1.3%	-1.2%	-3.5%	-3.5%
Wet	8658	-1.4%	-1.5%	-5.1%	-5.0%
Above Normal	6309	-0.8%	-0.4%	-1.0%	-1.2%
Below Normal	5384	-1.2%	-1.2%	-2.1%	-2.7%
Dry	5103	-1.6%	-1.7%	-4.0%	-3.9%
Critical	4499	-1.1%	-0.5%	-1.6%	-1.0%

American River Effects and Freeport Project

Summarized modeling appears on page 9-51 to page 9-64. Table 9-12 is a summary of deliveries on the American River. Figures 9-55 and 9-56 summarize the Freeport project deliveries. Mokelumne summary information is found on page 9-64.

Intertie Effects

Intertie effects are summarized in Chapter 10 under Tracy Exports (see page 10-62 to page 10-67). Intertie is added in the future model runs to bring Tracy to the full capacity of 4,600 cfs.

Delta Effects

X2 changes are found on page 10-23 to 10-36. As discussed above, in the Trinity there was a more extensive look at X2. A comparison between Study 1 and both Study 4a and Study 5a was used. The differences were made into GIS maps. A review of the data reduced the list of timeframes of concern. Export/Inflow (E/I) ratio is found on page 10-36 to page 10-46.

Inflow is found on page 10-51 to page 10-56. Outflow is found on page 10-56 to page 10-62. With changes in the upstream system both in the Trinity and American upstream systems, there are changes to the Delta inflow and outflow.

North Bay Aqueduct (NBA) is discussed on page 10-46. NBA diversions in the model (see Figure 10-90) and Rock Slough, and Old River Diversions (see Figure 10-91) are discussed in Chapter 10. Discussion of the NBA and Contra Costa Water District (CCWD) diversions is found on page 10-76.

For a discussion of joint point of diversion (JPOD), also called Federal Banks pumping, see page 10-72 to 10-76. Although we don’t show it in the modeling, there is also JPOD for the State to pump at Tracy.

Water Transfers Effects

See a summary on page 10-78 to page 10-82.

Early consultation Items

Summary information for Banks at 8,500 cfs in the Future study can be found on page 12-61 to page 12-64. The CALSIM modeling does not include the permanent barriers.

There is an assumption of the Environmental Water Account (EWA) in the future analyses; however, 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 (af) of CVP pumping at Banks for refuges, and up to 75,000 af of CVP releases made for the State Water Project (SWP) Delta water quality. See discussion of the Federal Banks exports on page 12-65 to page 12-69.

San Luis low-point discussion is found on page 12-71 to page 12-73.

Upstream reservoir coordination discussion is found on page 12-73.

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. Operation 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 cubic feet per second (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 as a result of project operations.

Clear Creek

Whiskeytown Reservoir releases will provide adequate flows for passage and spawning in most years. During some years additional Central Valley Project Improvement Act (CVPIA) 3406 (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 as a result of 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 as a result of 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 River 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 provides a source of the anadromous form of the species for those times when San Joaquin migratory conditions are poor. 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 as a result of 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 af) of the amount of water diverted at Freeport will be made available for Camanche Reservoir releases to the Mokelumne on a schedule determined by the California Department of Fish and Game (DFG) and FWS. Based on this information, conditions for steelhead in the river upstream of Woodbridge Dam should improve in the future. Delta inflow from the Mokelumne River 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 data assessment team (DAT) 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 NBA, the Delta Cross Channel (DCC), Rock Slough Diversion, and the Suisun Marsh Salinity Control Gates (SMSCG)) 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 as a result of project operations.

Central Valley Winter–run, Spring–run (and Fall/late fall–run for essential fish habitat) 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 percent 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 3406 (b)(2) water may be needed for better attraction and upstream migration conditions for spring–run and fall–run fish. 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 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 Vernalis Adaptive Management Program (VAMP) period. No changes in operations are proposed for the Stanislaus River.

Feather River

Flow and water temperature conditions should generally be 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 percent in all year types except during wet years at Banks without EWA when spring run-sized loss increases by an average of 14.6 percent and steelhead loss increases by 10.2 percent (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 watch 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 cohort replacement rate (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 uses 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 today’s operations, the Bureau of Reclamation (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, (3) changes in the E/I ratio, and (4) NBA for both the Formal and Early Consulation effects to Delta Smelt.

Salvage is not a particularly reliable index for 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, in different regions, in different years. Delta smelt also present no good stock-recruit relationships.There will be a small percentage of future years when large delta smelt entrainment episodes occur. There will likewise be years when export impacts are far smaller than what is predicted. Entrainment episodes are more likely to occur in dry years; however, they might occur in any water-year type.

Formal Consultation

(1) Changes in expected direct entrainment loss at the CVP and SWP export facilities.

a. Salvage of adult delta smelt

In general, there were median increases of 6-9 percent in CVP pumping during December through February in case #4a, with March generally featuring a decrease. With the exception of February, there is a general decrease in CVP pumping during the same months in case #5a. Except for March, median SWP pumping in case #4a was usually almost unchanged in the winter months in #4a; in March, there were increases of up to 22 percent (in Above Normal years). The differences reveal that the use of environmental water in #5a substantially reduces median pumping with respect to #4a, resulting in median pumping rates that are often smaller than in the base Model Case. Because we expect future fish salvage numbers to vary in proportion to changes in pumping rate, we expect minor increases in adult delta smelt salvage in #4a in most water year types, and minor decreases in adult salvage in #5a in most water year types.

b. Salvage of juvenile delta smelt

Both CVP and SWP pumping is generally flat or declining under both #4a and #5a, with corresponding reductions in predicted. There is an especially large difference (35.6 percent) between SWP pumping in #4a vs. #5a in May of Below Normal years, attributable to the use of environmental water in #5a. In all, there appears to be either a trivial net increase or a small net decrease in #4a and #5a juvenile delta smelt salvage relative to the base Case.

(2) Upstream movements of X2 predicted in the future model cases reach one kilometer or more only occasionally. In some cases upstream movements observed in case #4a are erased or reduced in case #5a. In a few cases the upstream movement is larger in case #5a. There were a few movements from the west to the east side of Chipps Island, but these were of small magnitude. In general, the largest differences among the Model Cases appear to be attributable to the use of environmental water in Case #5a.

The seasonally averaged differences between future cases and the base case are close to zero, and 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 – during 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. Given that there were few differences much larger than one kilometer in these comparisons, 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 affect delta smelt vulnerability increases.

(3) Exceedance plots of the Export-Inflow ratio (E/I) reveal that in both cases #4a and #5a 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 #4a or #5a to create delta smelt-protective concerns.

(4) NBA diversions do not appear to have had a substantial effect on Delta smelt. The proposed operations are fairly similar, indicating that the effect of NBA on smelt will continue to be relatively low.

Early Consultation

(1) Changes in expected direct entrainment loss at the CVP and SWP export facilities.

a. Salvage of adult delta smelt

In general, there is a 7-10 percent increase in median pumping in typical years at the CVP in model case #4, while there is either no change or a trivial decrease when EWA actions are included in case #5 (Tables 12-3 to 12-12). There are smaller increases of 1.9 – 8.9 percent at the CVP in Critically Dry years in #4; the corresponding months in #5 feature either reductions in pumping relative to the base case or no change. March is exceptional in #4, with up to a 10.8 percent decrease in pumping (relative to #1) in the wetter months.

At the SWP facility, median pumping winter pumping rate changes in wetter years ranged as high as +18 percent in December in #4 and +24.8 percent in March in #5, though most of the other wetter-year changes are +10 percent or less. In drier years median changes varied between zero and +14.4 percent, with several values above +10 percent.

In all, predicted adult salvage at the CVP differs very little in #4 and #5 from #1, and there are consistent increases of up to a few hundred individuals under both #4 and #5 at the SWP.

b. Salvage of juvenile delta smelt

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 were larger reductions of up to 58.1 percent in median Banks pumping in April and May that are attributable to the EWA actions modeled 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).

(2) Upstream movements of X2 predicted in the future model cases reach one kilometer or more only occasionally. In some cases upstream movements observed in case #4 were reduced or erased in case #5. In a few cases the upstream movement is larger in cases #5 and #5a. There were a few movements from the west to the east side of Chipps Island, but these were of small magnitude. In general, the largest differences among the Model Cases appear to be attributable to the use of environmental water in Case #5.

The seasonally averaged differences between future cases and the base case are close to zero, and 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 – during 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. Given that there were few differences much larger than one kilometer in these comparisons, 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 affect delta smelt vulnerability increases.

(3) 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.

Summary of Beneficial Effects

A summary of the CVPIA and CALFED Bay-Delta Program (CALFED) actions is in Chapter 15. CVPIA Section 3406 (b)(2) and CALFED EWA assist the projects with the VAMP actions. Adaptive Management is summarized in Chapter 2.

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 (BA). Future Federal actions that are unrelated to the proposed action are not included because they require separate Federal Endangered Species Act (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 toward 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 river 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 may affect, and is likely to adversely affect, 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 those 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 may affect, and are likely to adversely affect, 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 affect, 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 may affect, and is likely to adversely affect, Central Valley spring-run Chinook. 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.

Chapter 14 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 National Marine Fisheries Service (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 (*Engraulis mordax*) and starry flounder (*Platichthys stellatus*) 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 EFH consultation as a result (PFMC 1998a, 1998c).

The fall/late fall-run Chinook salmon is a candidate species and information is found in Chapters 4 and 5 of this document for EFH.

Identification of Essential Fish Habitat

EFH 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 EFH for all coastal pelagic species, including the central subpopulation of the northern anchovy (PFMC 1998a). EFH 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).

The proposed operation by the Bureau of Reclamation (Reclamation) is described in Chapter 3 of the Biological Assessment (BA) for the Central Valley Project (CVP) Operating Criteria and Plan (OCAP). The Bay/Delta provides habitat for northern anchovy and starry flounder, which are covered under the EFH provisions of Magnuson-Stevens Act, but are not listed under the Endangered Species Act (ESA). The proposed operation by the California Department of Water Resources (DWR) 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^{o} C to 26^{o} C (50^{o} F to 78.8^{o} 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^{o} C (50^{o} 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 parts per trillion [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 Area 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 seawater 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 1 year of age (71 to 100 mm) and all are nature at 2 to 3 years. Maximum age is 7 years, but most live for 4 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 1 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). State Water Project (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 kilometers (km) up coastal rivers to the outer continental shelf at 375 meters (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 (DFG 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 centimeter (cm) fish can produce 11,000,000 eggs (DFG 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 (DFG 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 2 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 2 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 3 years, but some may not mature until 45 cm and 4 to 6 years. Males begin maturing at 2 years and 22 cm, but some may not reach maturity until 4 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 NOAA Fisheries is proposing to amend the fishery plan to identify and describe EFH 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. There are no records of northern anchovy salvage at the CVP or SWP fish salvage facilities.

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 14–1). Most salvage occurs in May, June, and July. The salvaged flounder are young of year fish with the largest fish 3 to 4 inches long (Lloyd Hess, pers comm.). 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 14–1 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 EFH. 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 environmentally sensitive unit (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 to 2001 is shown in Figure 14–1.

Figure 14–2 shows Chinook salmon in-river escapement estimates by watershed from 1995 to 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.

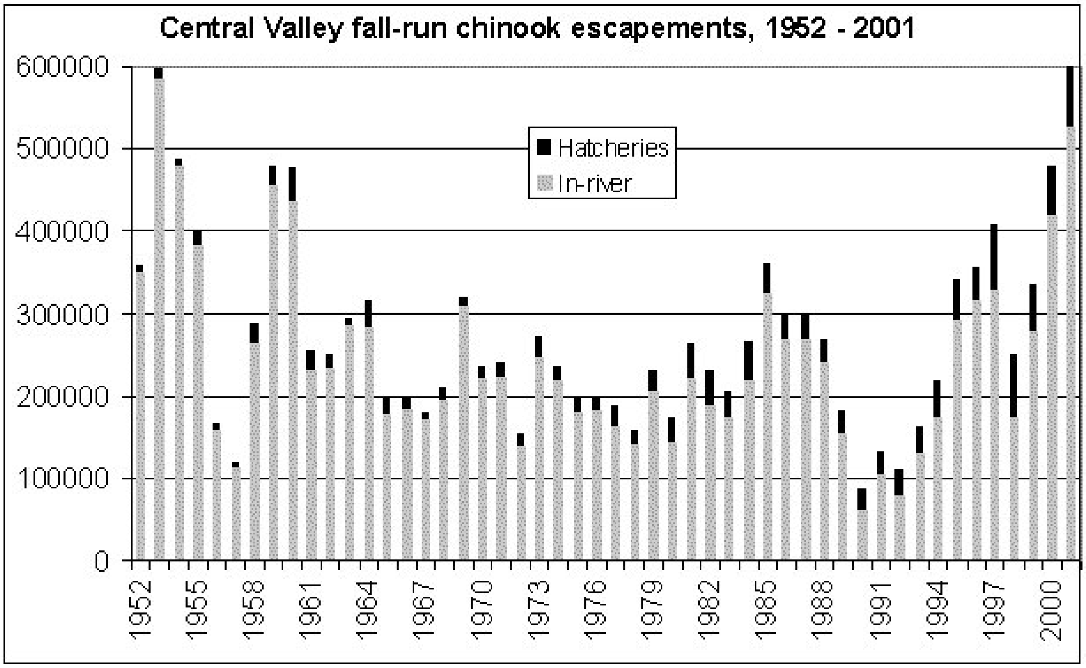


Figure 14–1 Central Valley fall-run Chinook salmon escapements, 1952-2001. Source: DFG data.

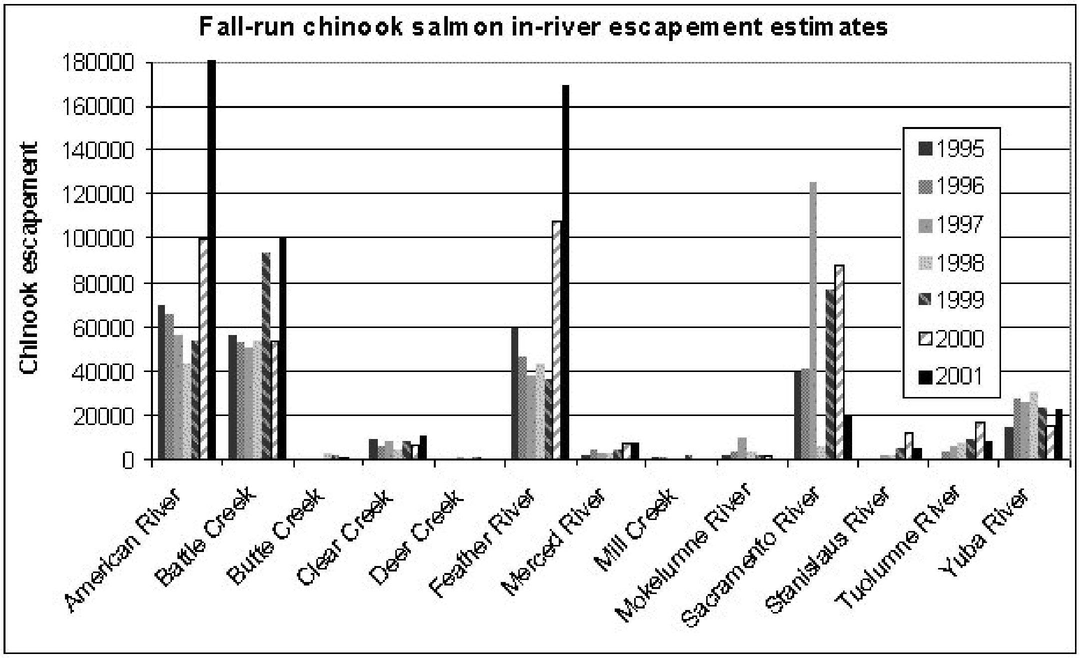


Figure 14–2 Fall-run Chinook salmon in-river escapement estimates in the California Central Valley, 1995-2001. Source: Interior (2001).

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 Central Valley Project Improvement Act (CVPIA) doubling goal. The CVPIA set the baseline anadromous fisheries production level as the average attained from 1967 to 1991. Progress toward production targets is assessed using a modification of the Pacific Salmon Commission's (1996) rebuilding assessment methods when a minimum of 5 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 14–2 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 14–2 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 5 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), 6 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 14–3). Increased minimum flow releases are thought to be one factor responsible for the increased number of spawners during that year (Figure 14–4). 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 cubic feet per second (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.

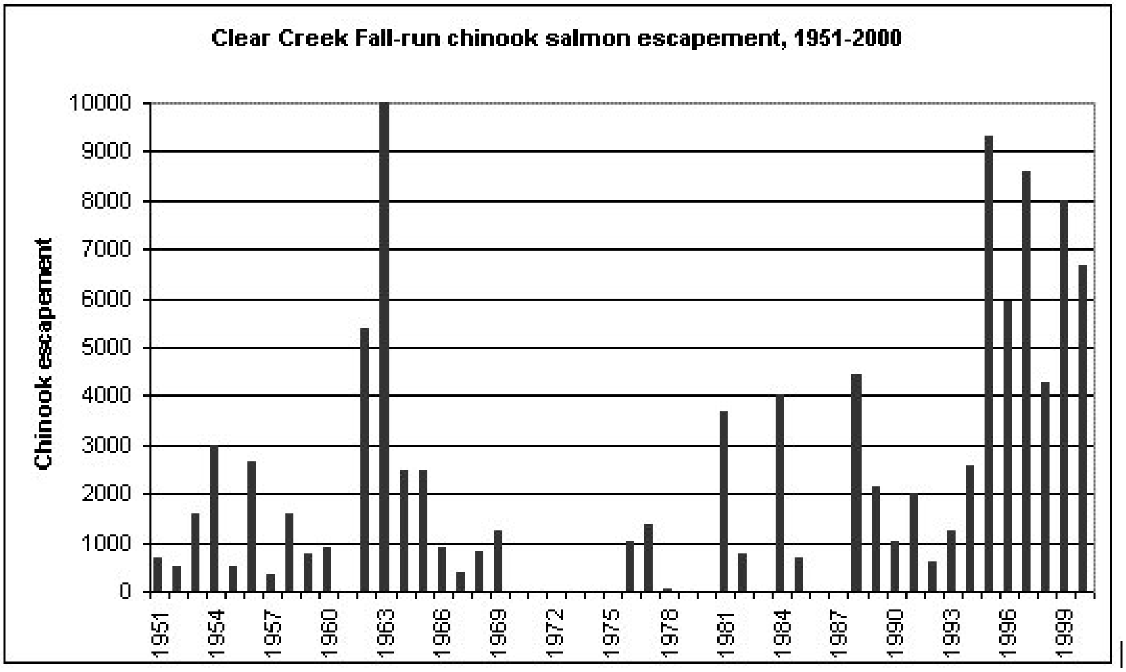


Figure 14–3 Clear Creek fall-run Chinook salmon escapement, 1951-2000. Source: DFG data.

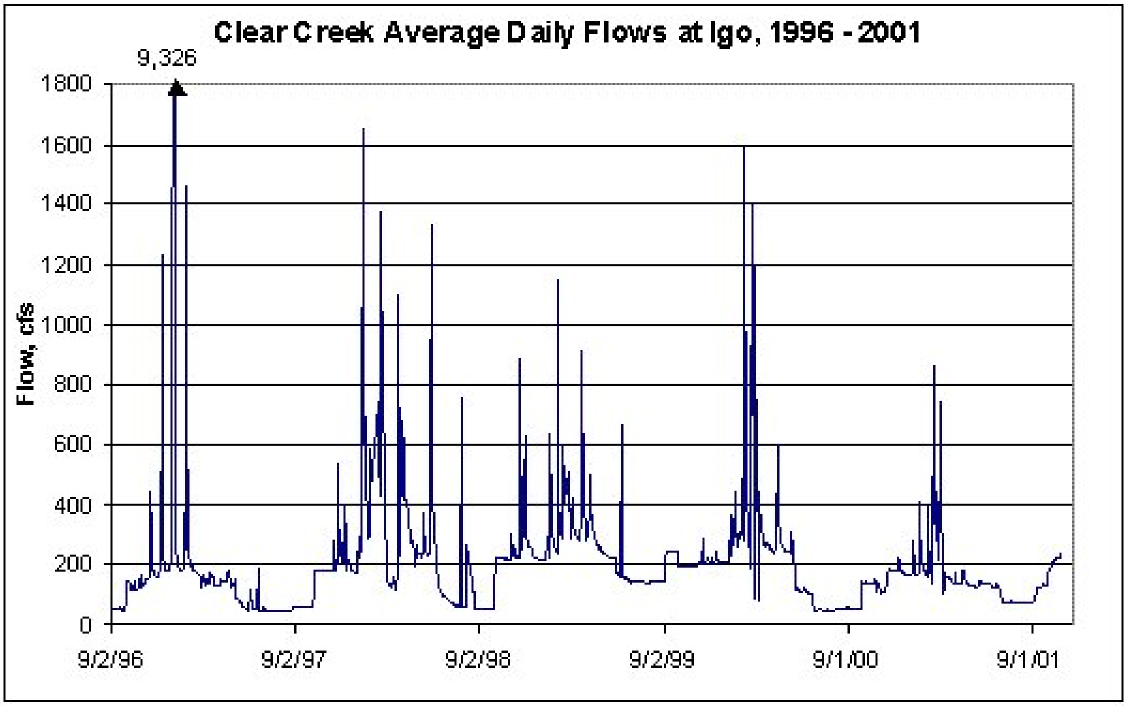


Figure 14–4 Average daily flow in Clear Creek, 1996-2001.

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 14–5. 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.

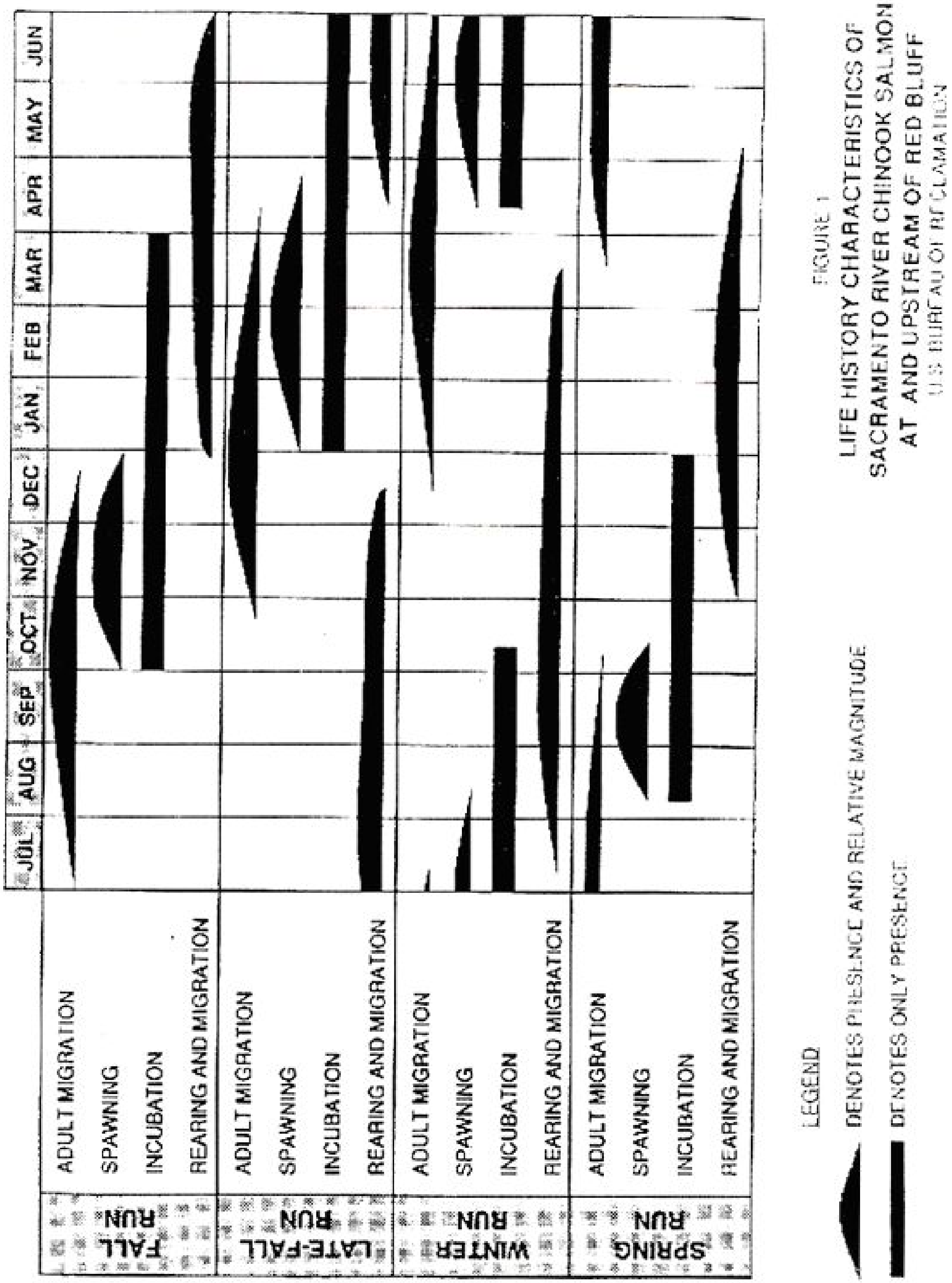


Figure 14–5 Life cycle timing for Sacramento River Chinook salmon. Adapted from Vogel and Marine (1991).

Fall-run are entering the river as spring-run are spawning. Fall-run Chinook salmon escapement is shown in Figure 14–6; the hydrograph since 1993 is in Figure 14–7.

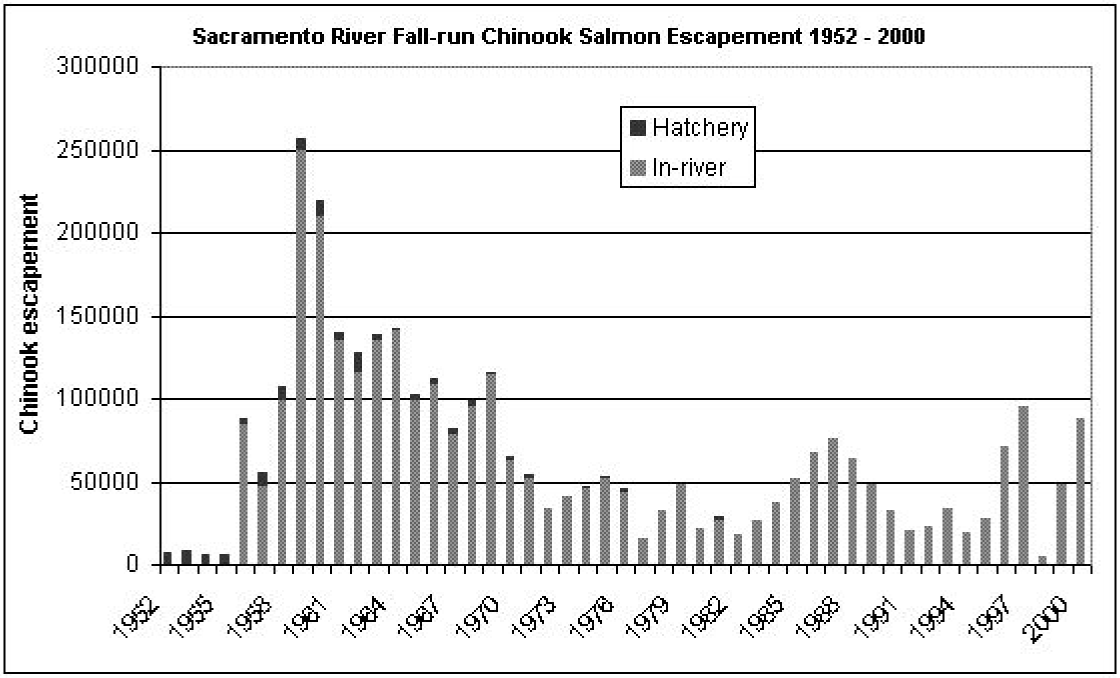


Figure 14–6 Fall-run Chinook salmon escapement in the Sacramento River.

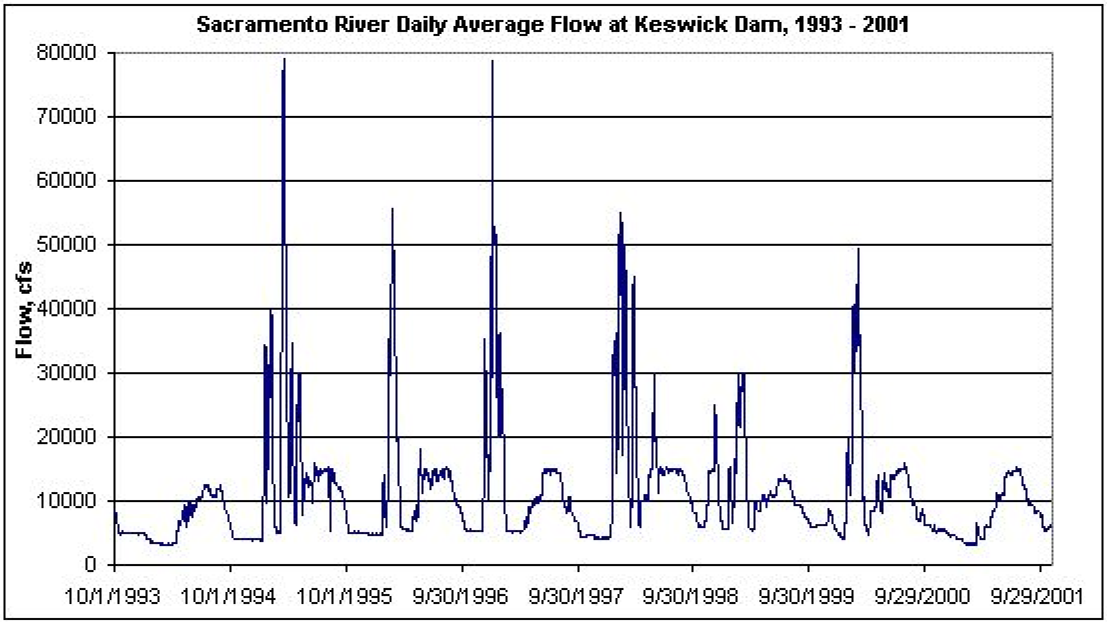


Figure 14–7 Sacramento River daily average flow at Keswick Dam from 1993-2001.

Sacramento River water temperature is controlled primarily by using releases from Shasta Lake through the Temperature Control Device (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 7 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 14–8). Peaks in escapement over 60,000 fish occurred in 1973, 1974, 1981, 1985, 1995, 1996, 1998, and 2000. Low escapements, less than 20,000, 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.

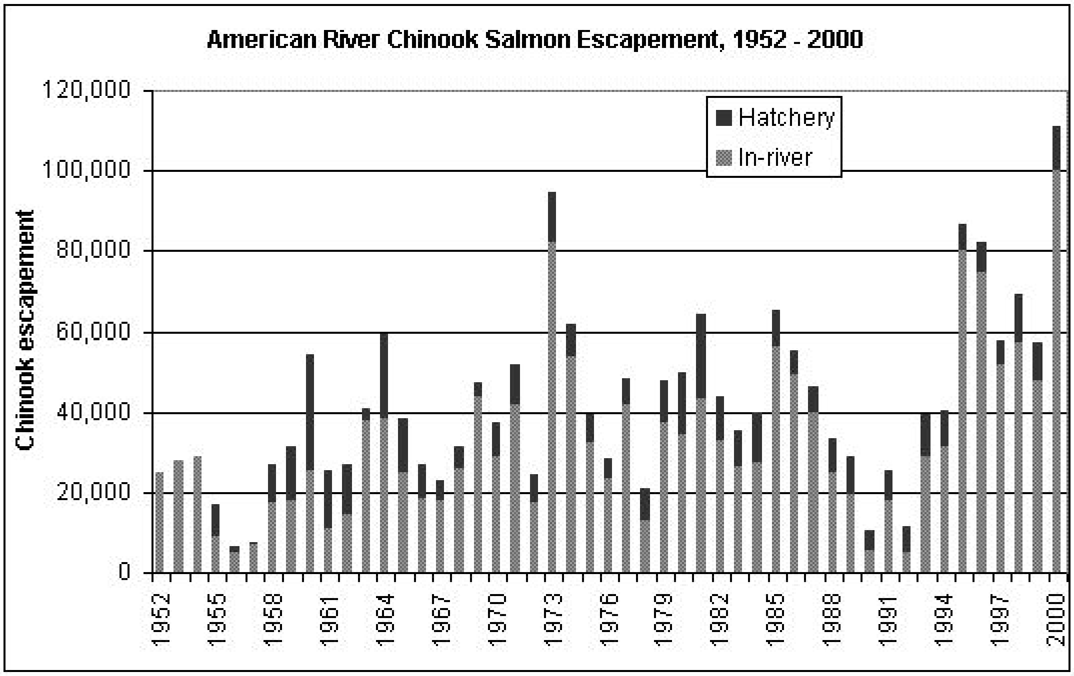


Figure 14–8 American River Chinook salmon escapement estimates, 1952-2000.

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 U.S. Fish and Wildlife Service (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.

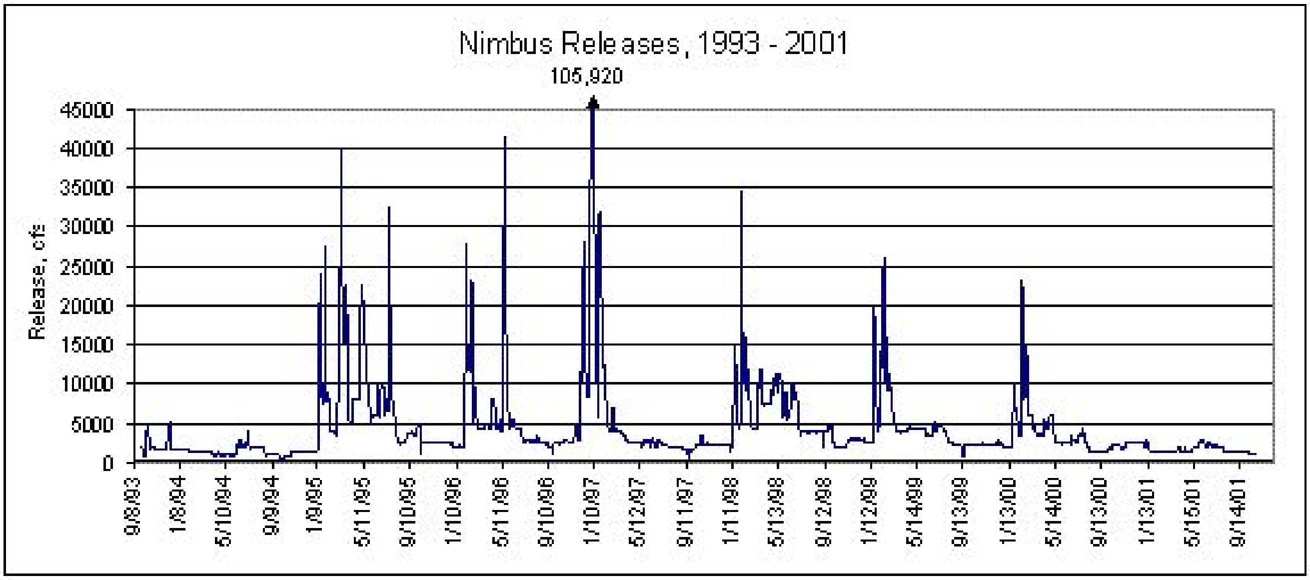
The period of concern for flow fluctuations causing stranding of redds and juvenile Chinook in the American River extends from the initiation of spawning at about the beginning of November until juveniles have emigrated from the river, generally by the end of June. Figure 14–9 shows American River flows from 1993 to 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 14–3 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.



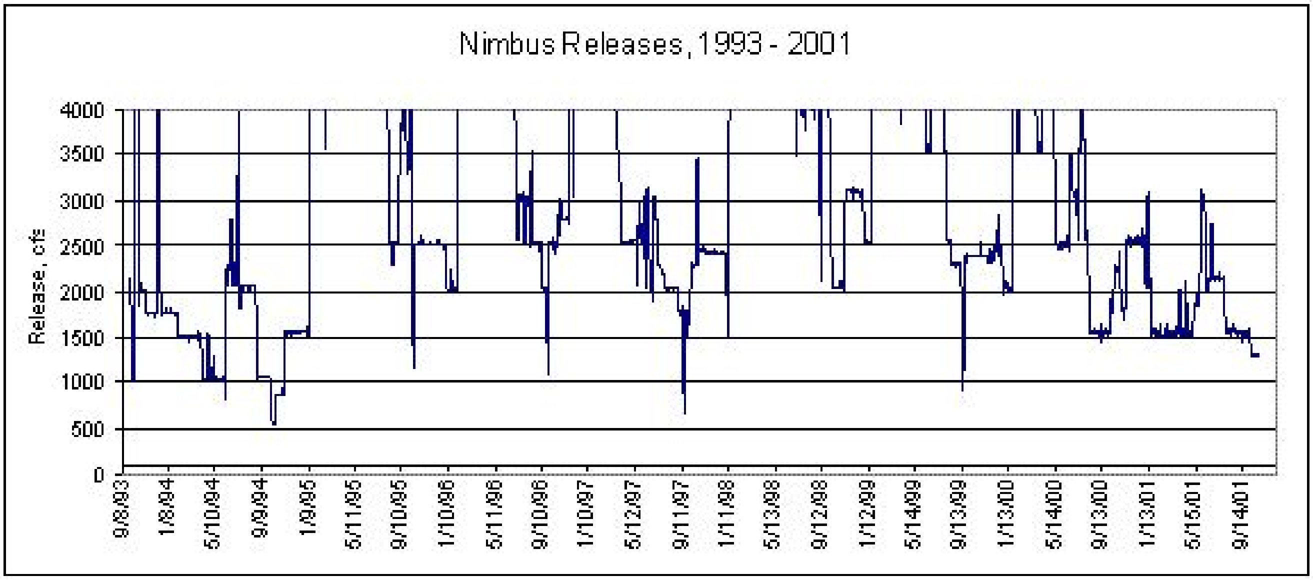


Figure 14–9 American River flows as released from Nimbus Dam, 1993-2001. The top chart shows the entire hydrograph. The bottom chart shows a close-up of the 0 to 4000 cfs range.

Table 14–3 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
1,000	62
1,200	71
1,400	78
1,600	82
1,800	84
2,000	83
2,200	81
2,400	78
2,600	74
2,800	69
3,000	65
3,200	60
3,400	56
3,600	52
3,800	48
4,000	45
4,200	42
4,400	38
4,600	36
4,800	33
5,000	31
5,200	28
5,400	26
5,600	25
5,800	23
6,000	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 northernmost major tributary to the San Joaquin River. Average monthly unimpaired flows at New Melones Dam are approximately 96,000 acre-feet. These flows are reduced to approximately 57,000 acre-feet 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 40 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 River as early as May. Stanislaus River Chinook escapements have averaged 5,556 and ranged from 0 to 35,000 between 1947 and 2000 (Figure 14–10). Peaks in escapement of over 10,000 fish occurred in the late 1940s, early ‘50s, late ‘60s, 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 1 to 4 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 14–11 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.

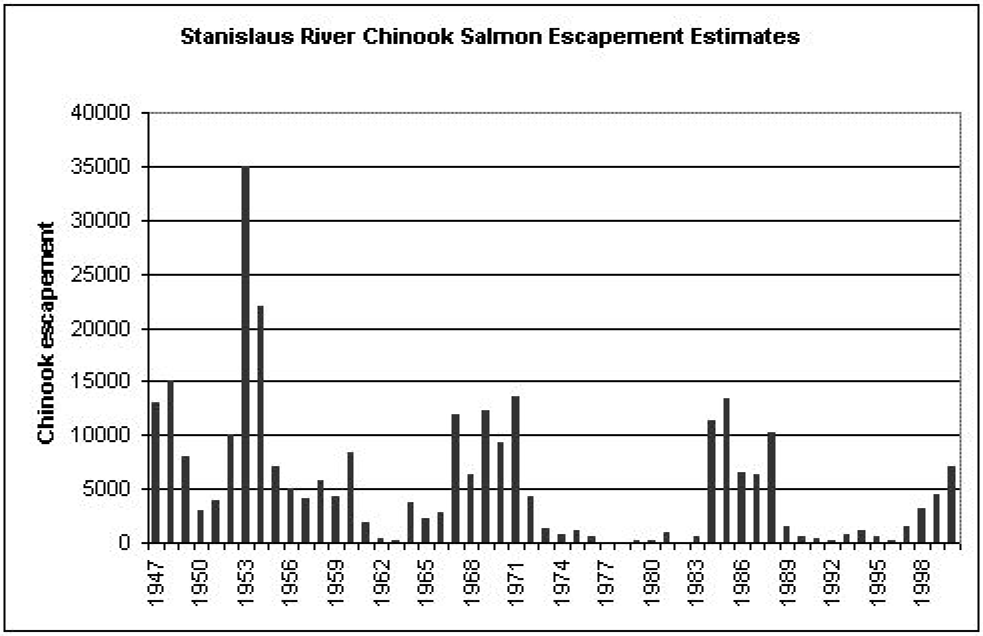


Figure 14–10 Chinook salmon escapement in the Stanislaus River, 1947-2000.

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.

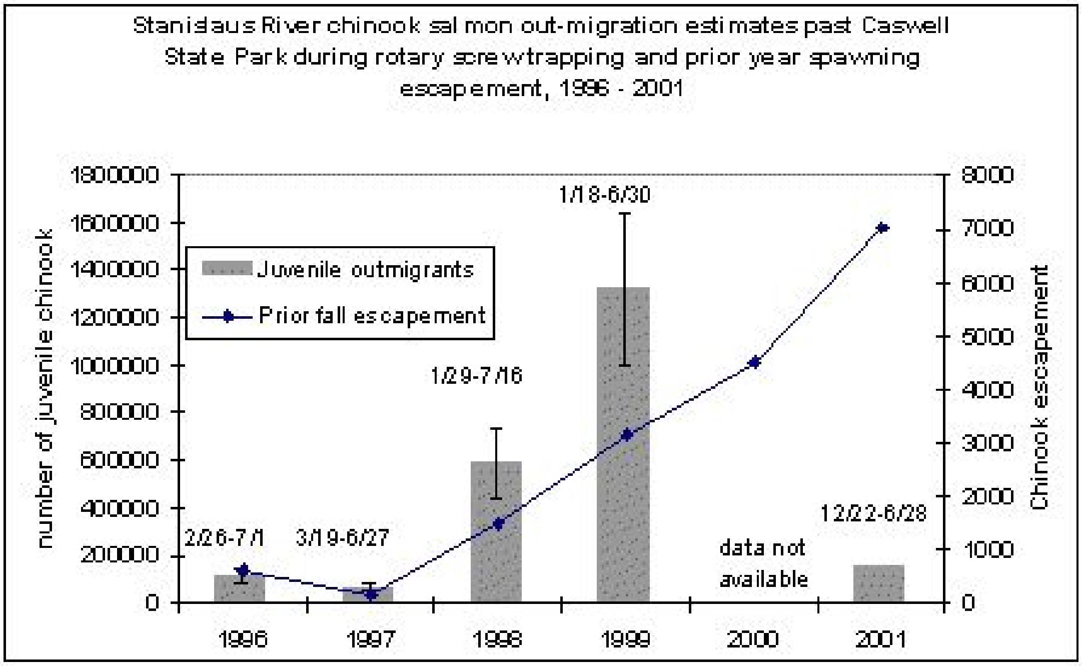


Figure 14–11 Stanislaus River Chinook salmon out-migration estimates past Caswell State Park during rotary screw trapping and prior year spawning escapement, 1996-2001.

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 14–12). The 20-year flood flow has been decreased by eight times compared to the historic flow. Moderate flows of around 300 to 600 cfs have been extended out through much of the year to provide better water quality in the Stanislaus River 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.

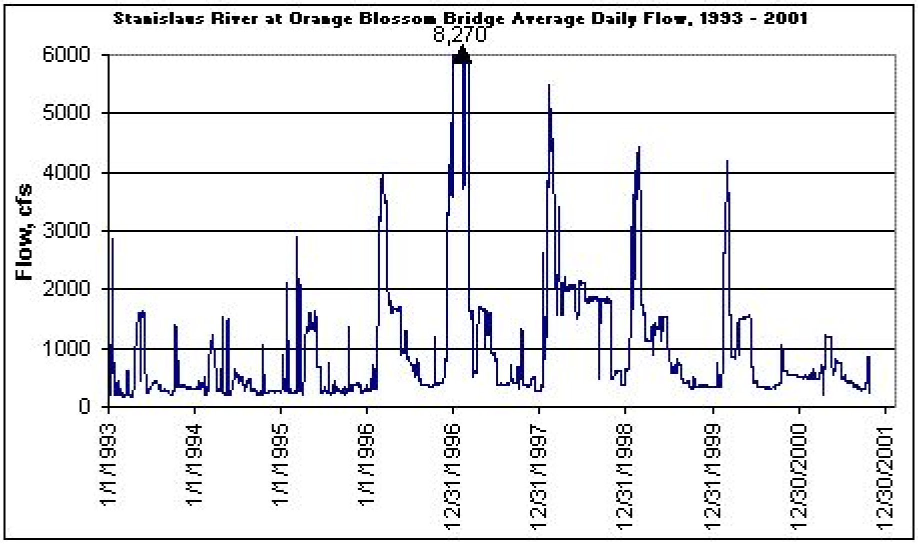


Figure 14–12 Stanislaus River flow at Orange Blossom Bridge, 1993-2001.

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 14–4 gives the resulting instream flow recommendations for Chinook salmon.

Studies are underway in the Stanislaus River to determine the best springtime flow regimes to maximize survival of juvenile Chinook. The studies utilize survival estimates from marked hatchery fish released at various flows(Table 14–5). These tests took place during the VAMP flows which occur after the peak outmigration period from the Stanislaus River.

Table 14–4 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.

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

Source: Aceituno 1993.

Table 14–5 Stanislaus River summary of past smolt survival tests.

Stanislaus River Summary of Past Smolt Survival Tests

Year	tag codes	Rel. Start	Rel. End	Flow at OBB (cfs)	Avg. Temp at Ripon1	Rel. Location	# Released	Release Length (mm)	Recoveries at Oakdale	Survival to Oak RST	Recoveries at Caswell	Survival to Cas RST	Recoveries at Mossdale2	Riverwide 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 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 14–13). 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).

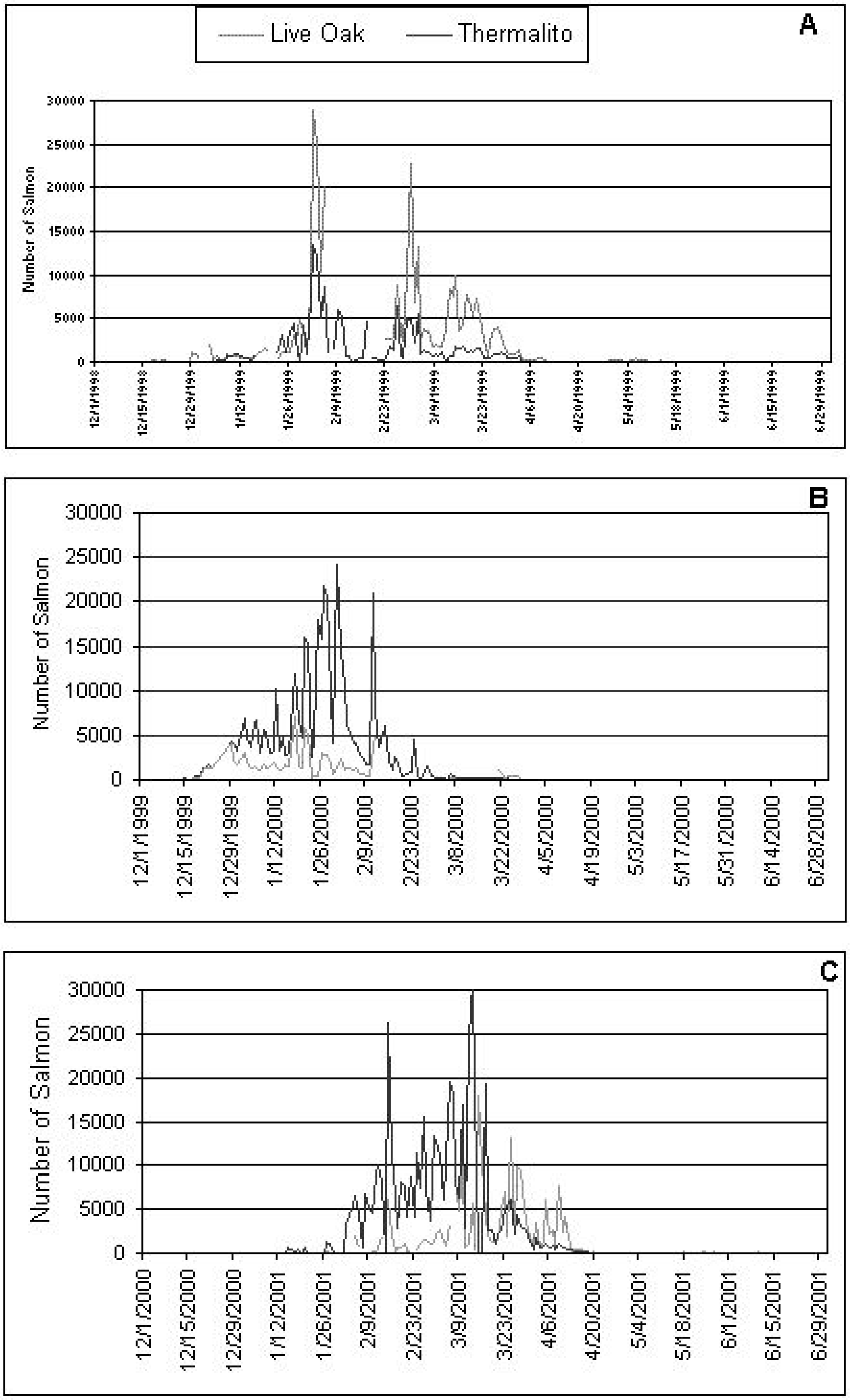


Figure 14–13 Daily catch distribution of fall-run Chinook salmon caught at Live Oak and Thermalito rotary screw traps during 1998, 1999, and 2000 (trapping years a, b, and c, respectively).

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 14–14). 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 (FRH) was opened in 1967 to compensate for the loss of upstream habitat by the construction of Oroville Dam. The facility is operated by the California Department of Fish and Game (DFG) and typically spawns approximately 10,000 adult salmon each year (Figure 14–14). Until the 1980s, the majority of the young hatchery salmon was released into the Feather River (Figure 14–15). 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 14–16). Mean total flow is presently lower than historical levels during February through June, but higher during July through January.

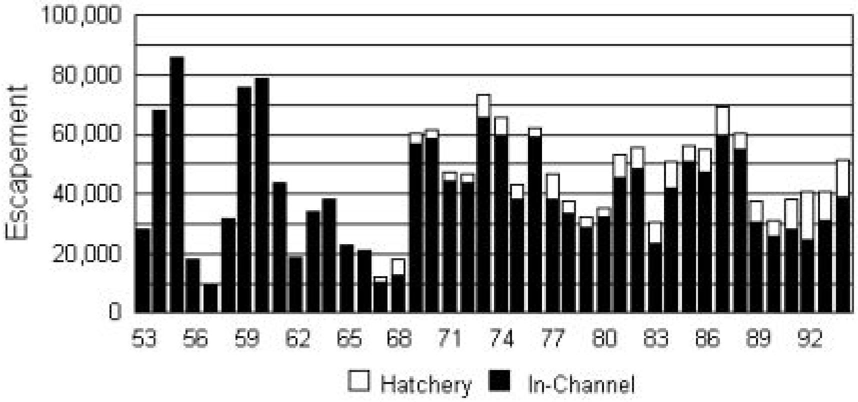


Figure 14–14 Escapement of fall-run Chinook salmon (1953-94) in the FRH and channel.

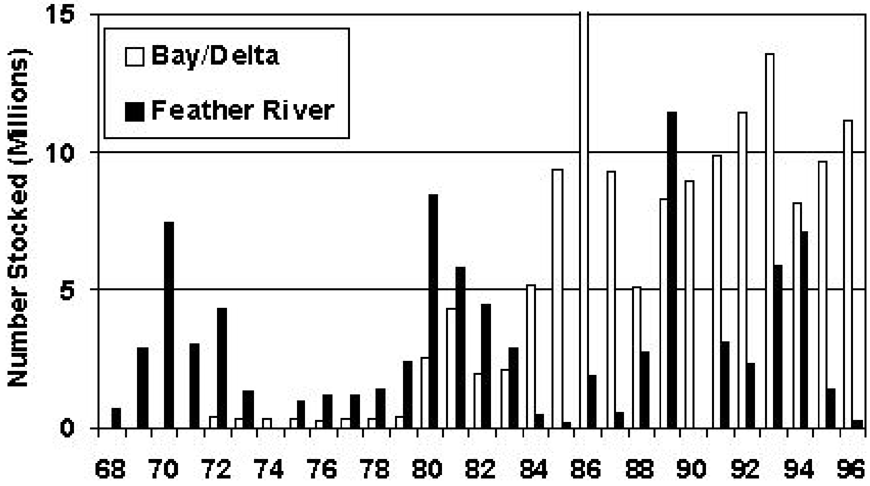


Figure 14–15 Stocking rates of juvenile salmon from the FRH into river and Bay-Delta locations.

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.

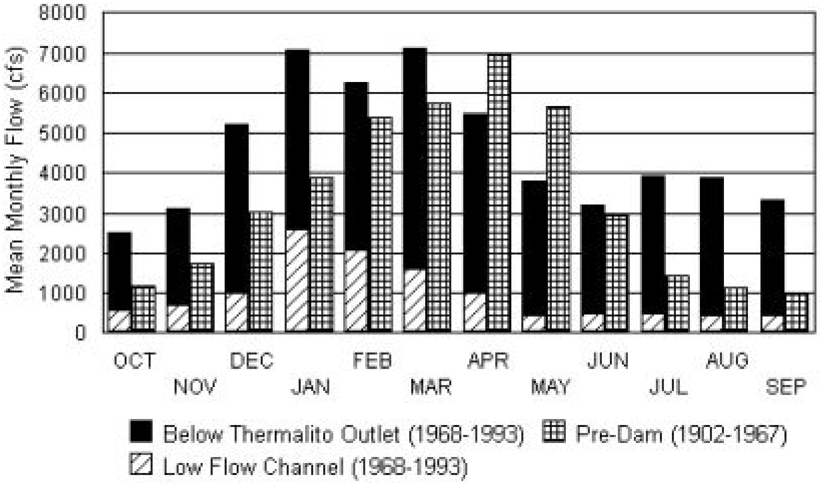


Figure 14–16 Mean monthly flows (cfs) in the Feather River for the pre-Oroville Dam (1902-67) and post-Oroville Dam (1968-93) periods.

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 14–17) (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 3 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 attempting 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.

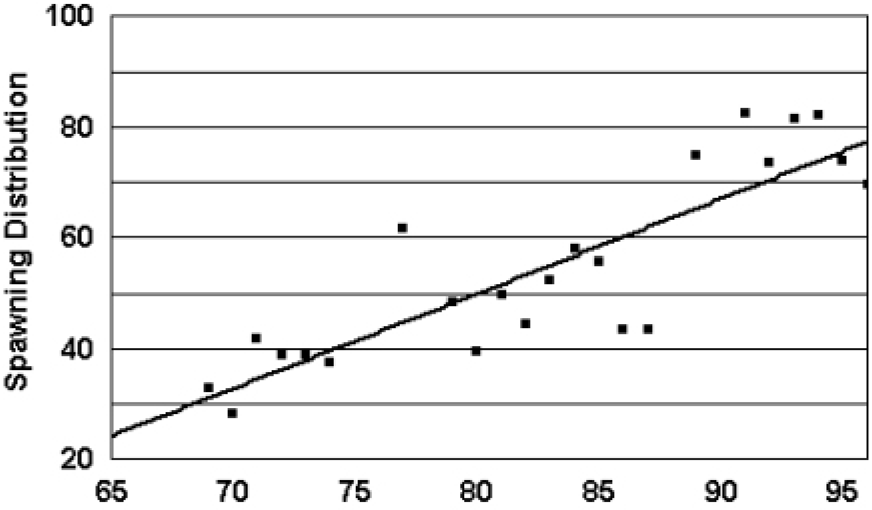


Figure 14–17 The percentage of salmon spawning in the Feather River low flow channel for 1969-96. The increase is significant at the *P* < 0.001 level.

Currently several studies are underway to evaluate salmon and steelhead populations in the Feather River. Since fall 2000, DWR in cooperation with DFG has collected 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 the 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 through June 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 Essential Fish Habitat

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 River 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 14–18).

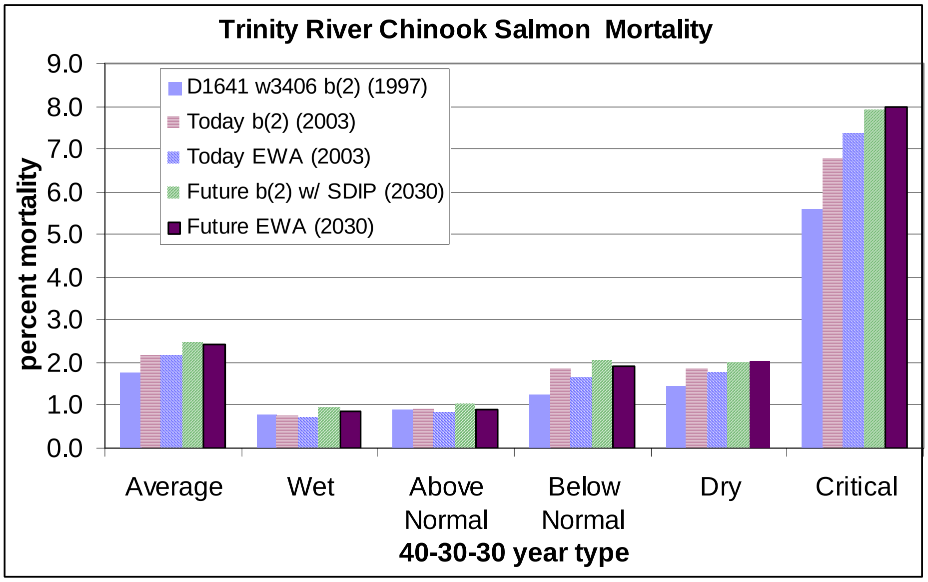


Figure 14–18 Percent mortality of Chinook salmon from egg to fry in the Trinity River based on water temperature by water year type.

Summary of Effects on Essential Fish Habitat for Fall-run and Late Fall-run Chinook Salmon

Mortality model outputs for fall-run and late fall-run Chinook are included in the sections below. See Figure 14–19 to Figure 14–23.

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. See Figure 14–19 for fall-run and Figure 14–20 for late fall-run mortality.

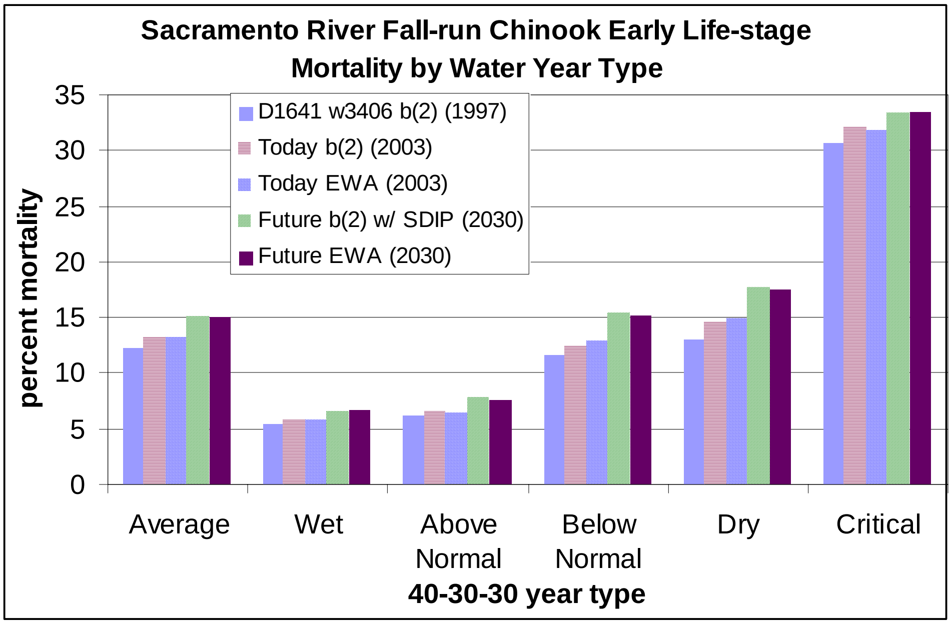


Figure 14–19 Sacramento River fall-run Chinook early life-stage mortality by water year type.

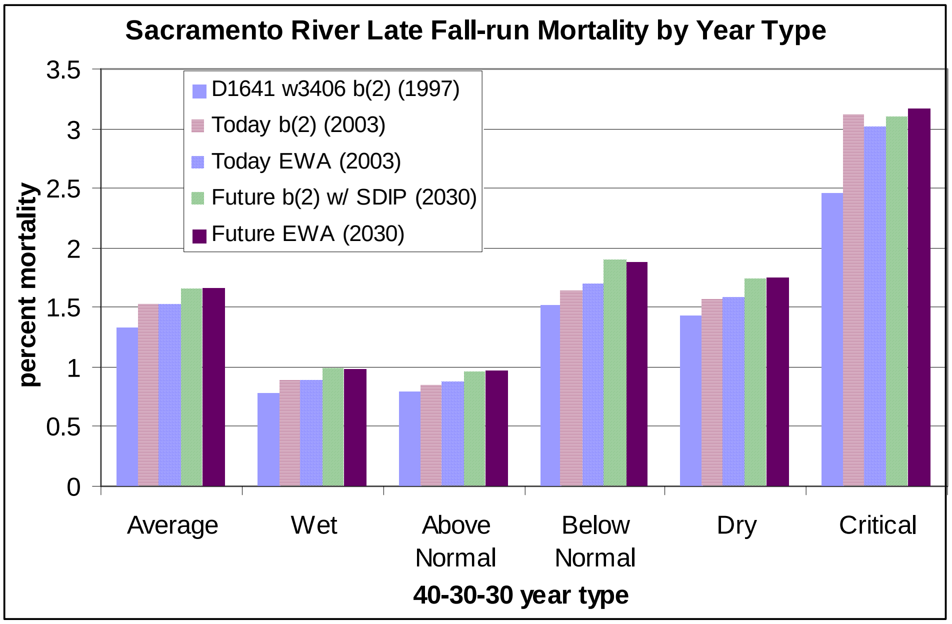


Figure 14–20 Sacramento River late fall-run mortality by year type.

Clear Creek

Temperatures and flows are generally suitable year round in Clear Creek for fall-run Chinook. No adverse 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. See Figure 14–21.

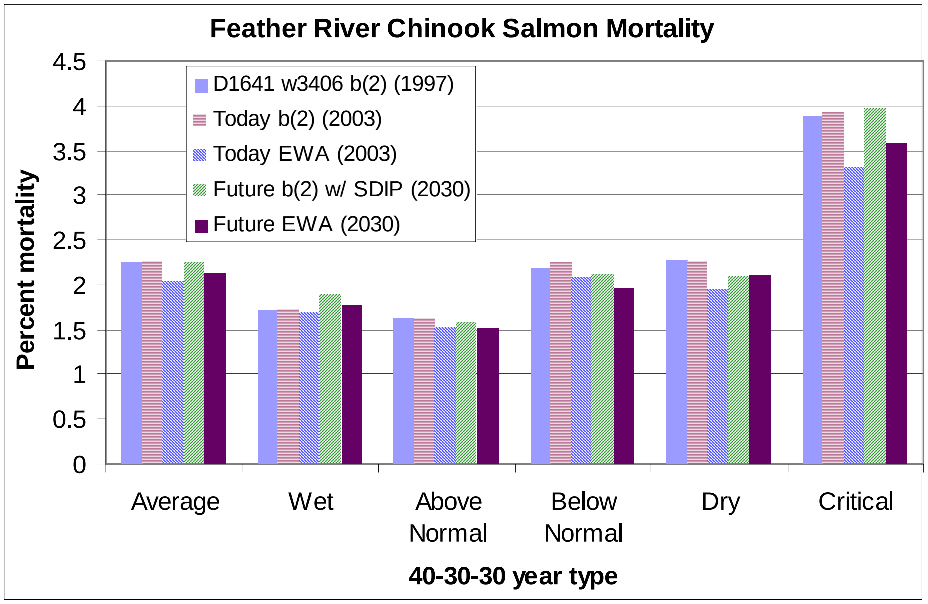


Figure 14–21 Feather River Chinook salmon mortality.

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. See Figure 14–22.

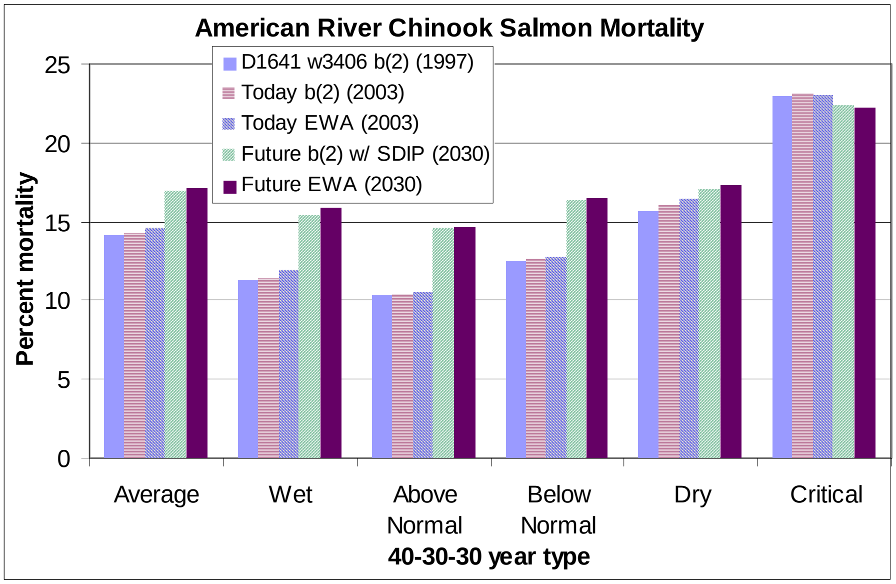


Figure 14–22 American River Chinook salmon mortality.

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. See Figure 14–23.

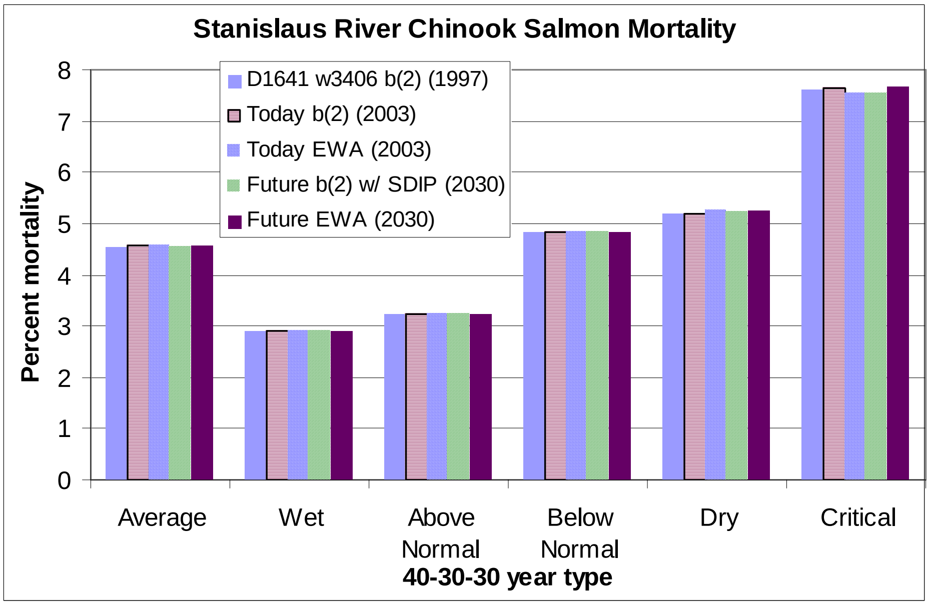


Figure 14–23 Stanislaus River Chinook salmon mortality

Delta

Fall-run 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 adversely affect the EFH of fall-run and late fall-run Chinook. Chinook salmon EFH in the Trinity River should benefit from the Trinity River Record of Decision (ROD) flows and other habitat improvement measures.

Essential Fish Habitat Conservation Measures for Chinook Salmon

The following are conservation measures being implemented that could be considered specifically addressing EFH for Chinook salmon. Additional ongoing measures to make habitat better for Chinook are described in Chapter 13.

Folsom Dam Temperature Shutter Mechanization

Folsom Dam restricts salmon and steelhead life cycles to the 23-mile Lower American River precluding the fish from migrating to their upstream natal spawning grounds. Cold water is necessary to sustain existing spawning and rearing salmon and steelhead populations below the dam. To manage Lower American River water temperature, cold water from varying depths in Folsom Lake is withdrawn via shutters located at different elevations on the penstock inlet. The restoration feature would modify and automate the temperature shutters to allow for the flexibility and timeliness needed to optimize management of the coldwater pool to sustain the downstream fishery, including fall-run Chinook. This project was authorized by Congress in 2003 as a part of a multi-purpose (flood control, ecosystem restoration, and dam safety) project and is awaiting appropriations.

Spawning Gravel Enhancement

Reclamation manages spawning gravel injections below CVP dams on the Sacramento, American, and Stanislaus rivers in cooperation with the FWS. This ongoing program is funded yearly and projects are implemented in the three rivers as the need is identified. Spawning benefits have been documented in each of the rivers. Additionally, monitoring on the Stanislaus has identified benefits of enhanced rearing habitat created by the new gravel for juvenile salmon and steelhead.

Stanislaus Temperature Model

Reclamation cooperates with funding development of a water temperature model on the Stanislaus River. The model can be used to identify optimization strategies for coldwater from New Melones Reservoir relative to life cycle needs of salmon and steelhead.

American River Operations Group

Reclamation facilitates the American River Operations Group, a group of stakeholders and biologists who makes recommendations to Reclamation relative to fisheries conditions in the river.

Sacramento River Temperature Control Task Group

This group makes recommendations on how to manage water temperatures throughout the summer in the upper Sacramento River relative to relative to fisheries conditions and coldwater pool storage in Shasta Reservoir.

Chapter 15 Ongoing Actions to Address State Water Project and Central Valley Project Impacts

The California Department of Water Resources (DWR) and Bureau of Reclamation (Reclamation) work with the California Department of Fish and Game (DFG), U.S. Fish and Wildlife Service (FWS), and National Marine Fisheries Service (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 State Water Project (SWP) and Central Valley Project (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 Central Valley Project Improvement Act (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, improvement of 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 establish a diversion screening program.

A summary of the actions completed in these past 10 years is provided below in Table 15–1. A more detailed narrative discussion of these efforts and of the progress toward achieving CVPIA goals follows. This discussion contains information from a draft 10-year report being prepared by Reclamation and FWS.

Table 15–1 Summary of CVPIA accomplishments – 1992–2002

PROGRAM OR PROJECT	STATUS
Anadromous Fish – Habitat Restoration	
Anadromous Fish Restoration Program (AFRP)	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 to 2002
Clear Creek Fishery Restoration	Removed Saeltzer Dam and diversion, increased flows, restored 2 miles of stream channel and 68 acres of floodplain, added 54,000 tons of spawning gravel, constructed 152 acres of shaded fuelbreak, and treated 12 miles of roadway for 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 environmental impact report/environmental impact statement (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, including a 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 (CCC); 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 (TCD)	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 Irrigation District (ID) Fish Passage	Modified dam and operations to improve fish passage; designed new fish ladders and screens.
Glenn-Colusa ID Pumping Plant	Constructed fish screen for 3,000 cubic feet per second (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, enhanced 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 2,200 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 and 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 re-establish anadromous fish from Friant Dam to Bay-Delta Estuary; Congress dropped funding because of public opposition to continued study
Stanislaus River Basin Water Needs	Prepared Stanislaus and Calaveras river water use program and Federal Endangered Species Act (ESA) report; additional studies ongoing concurrent with development of Stanislaus River long-term management plans
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 geographic information system (GIS) database to identify potential water supply sources.

PROGRAM OR PROJECT	STATUS
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, and 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 overreliance 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 approximately $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:

- Screening of unscreened water diversions in Suisun Marsh (8 screens), Butte Creek (2 screens), and San Joaquin tributaries (6 to 10 screens)
- Enhanced law enforcement efforts to reduce illegal harvest in the Bay-Delta and upstream in the Sacramento-San Joaquin basins (2 projects)
- Seasonal barriers to guide salmon away from undesirable spawning habitat or migration pathways (2 projects)
- Water exchange projects on Mill and Deer Creeks to provide salmonid passage flows for adult spawners and out-migrant young (2 projects)
- Fish ladders for improved upstream passage on Butte Creek (2 projects)

- Spawning gravel replacement and maintenance on the Sacramento system (2 projects) and San Joaquin tributaries (7 projects)
- 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)
- Salmon and steelhead hatchery production projects (3 projects)
- 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 focuses 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 15–2.

Table 15–2 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 in Table 15–3. The DFG estimates reflect the average annual benefits of each project over its life based on recent historical conditions.

Table 15–3 Predicted annual spring-run benefits of approved Four Pumps mitigation projects (in smolt equivalents)

Project	Credits
Warden overtime (revised estimate for 2003–2004)	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 was 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. Table 5-4 lists the actual Four Pumps spring-run mitigation credits that have been produced by each of implemented projects during the last 6 years.

Table 15–4 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 were 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 15–5 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 5 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 July 29, 1998, 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 provided 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 provided over $3 million in funding during Federal fiscal years 1998 through 2002to DFG, which was used for projects that offset and replaced direct losses of fishery resources resulting from the operation of the Tracy Pumping Plant. A revised agreement between Reclamation and DFG is being negotiated and may be formally integrated into the Tracy Pumping Plant Mitigation Program identified in Section 3406(b)(4) of the CVPIA.

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 30 reports have been completed or are 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.

Reclamation is doing research efforts on-site at Tracy and in Reclamation’s lab in Denver to test and demonstrate new technologies to be used in the south Delta for improved fish protection.

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 provides 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 5 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

Fish bypass transition boxes have deteriorated and were replaced in May 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. Additional hydraulic testing will be scheduled in the fall of 2004.

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.

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 per 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 SWP and CVP 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 SWP 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 [EWA]). Meanwhile, work is underway on an EIR 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 have 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. Approximately 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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