RECLAMATION

Managing Water in the West

Long-Term
Central Valley Project
Operations Criteria and Plan
CVP-OCAP

U.S. Department of the Interior

Bureau of Reclamation

Mid-Pacific Region

Sacramento, California

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U. S. Department of the Interior
Bureau of Reclamation

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.

As public values related to water use and management have changed since the inception of the Central Valley Project, so have the needs which its operations must address. While continuing to carry out the legislated purposes for which the Central Valley Project was originally authorized and developed, the Bureau of Reclamation is committed to finding ways to respond to issues created by changing priorities for water.

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List of Abbreviations/Acronyms

ACID	Anderson-Cottonwood Irrigation District
af	acre-feet
af/yr	acre-feet per year
AFRP	Anadromous Fish Restoration Program
ANN	Artificial Neural Network
B2IT	CVPIA Section 3406 (b)(2) Implementation Team
CAISO	California Independent System Operator
CCC	Contra Costa Canal
CCWD	Contra Costa Water District
CEQA	California Environmental Quality Act
cfs	cubic feet per second
COA	Coordinated Operations Agreement
CRD	Contract Rate of Delivery
CVOO	Central Valley Operations Office
CVP	Central Valley Project
CVPIA	Central Valley Project Improvement Act
DCC	Delta Cross Channel

DFG	California Department of Fish and Game
DMC	Delta Mendota Canal
DO	dissolved oxygen
DOI	Department of the Interior
DWR	California Department of Water Resources
E/I Ratio	Export/Inflow Ratio
EBMUD	East Bay Municipal Utility District
EC	Electrical Conductivity
EID	El Dorado Irrigation District
EIS/EIR	Environmental Impact Statement/Environmental Impact Report
EPA	Environmental Protection Agency
ERP	Ecosystem Restoration Program
ESA	Endangered Species Act
EWA	Environmental Water Account
EWAT	Environmental Water Account Team
FRWA	Freeport Regional Water Authority
FRWP	Freeport Regional Water Project
ft/sec	feet per second
IPO	Interim Plan of Operations
JPOD	Joint Point of Diversion
KCWA	Kern County Water Agency
kW	kilo-watt
LADWP	Los Angeles Department of Water and Power
LP	linear programming
M&I	municipal and industrial
maf	million acre-feet
mg/l	milligrams per liter
MIDS	Morrow Island Distribution System
MILP	mixed integar linear programming
mm	millimeters
MOU	Memorandum of Understanding
mS/cm	millisiemens per centimeter (an indication of salinity)
MW	megawatt
MWD	Metropolitan Water District of Southern California
NBA	North Bay Aqueduct
NEPA	National Environmental Policy Act

NMFS	National Marine Fisheries Service
NOAA Fisheries	National Oceanic and Atmospheric Administration (formerly National Marine Fisheries Service [NMFS])
NOD	North of Delta
NWSRFC	National Weather Service River Forecast Center
OID	Oakdale Irrigation District,
PCWA	Placer County Water Agency
PEIS	Programmatic Environmental Impact Statement
PG&E	Pacific Gas & Electric Company
ppm	parts per million
ppt	parts per thousand
RBDD	Red Bluff Diversion Dam
Reclamation	U.S. Bureau of Reclamation
ROD	Record of Decision
RPA	resource protection area
RRDS	Roaring River Distribution System
RWQCB	Regional Water Quality Control Board
SAFCA	Sacramento Area Flood Control Agency
SCWA	Sacramento County Water Agency
SJRA	San Joaquin River Agreement
SMPA	Suisun Marsh Preservation Agreement
SMSCG	Suisun Marsh Salinity Control Gates
SMUD	Sacramento Municipal Utilities District
SOD	South of Delta
SRBS	Stanislaus River Basin Stakeholders
SRI	Sacramento River Index
SRPP	Spring-Run Chinook Salmon Protection Plan
SSJID	South San Joaquin Irrigation District
SVI	Sacrament Valley Water Supply Index
SWP	State Water Project
SWPOCO	SWP Operations Control Office
SWRCB	State Water Resources Control Board
taf	thousand acre-feet
TCD	temperature control device
TDS	total dissolved solids
TRD	Trinity River Division

USACE	U.S. Army Corps of Engineers
USFWS	U.S. Fish and Wildlife Service
VAMP	Vernalis Adaptive Management Plan
WOMT	Water Operations Management Team
WQCP	Water Quality Control Plan
WRESL	Water Resources Engineering Simulation Language

Purpose of Document

This document has been prepared to serve as a baseline description of the facilities and operating environment of the Central Valley Project (CVP) and State Water Project (SWP). The *Central Valley Project - Operations Criteria and Plan* (CVP-OCAP) identifies the many factors influencing the physical and institutional conditions and decision-making process under which the project currently operates. Regulatory and legal requirements are explained, alternative operating models and strategies described.

The immediate objective is to provide operations information for the Endangered Species Act, Section 7, consultation. The long range objective is to integrate CVP-OCAP into the proposed Central Valley document.

It is envisioned that CVP-OCAP will be used as a reference by technical specialists and policymakers in and outside Bureau of Reclamation (Reclamation) in understanding how the CVP is operated. The CVP-OCAP includes numeric and nonnumeric criteria and operating strategies. Emphasis is given to explaining the analyses used to develop typical operating plans for simulated hydrologic conditions.

All divisions of the CVP are covered by this document, including the Trinity River Division, Shasta and Sacramento River Divisions, American River Division, Delta Division, West San Joaquin Division, and Friant Division.

Chapter 1 Introduction

Overview of the Central Valley Project

California became interested in a comprehensive water plan for the State in the 1920s. The State wanted the water plan to accomplish conservation, flood control, storage, distribution, and uses for all California water. The legislature authorized a statewide water resources investigation in 1921. In 1922, the legislature, governor, and the electorate approved construction of the State Central Valley Water Project. However, because of difficulty in marketing the bonds, the project could not be undertaken by the State. After repeated attempts by State officials failed to obtain Federal grants or loans to aid in financing the project, the Federal Government was requested to undertake the construction of the Central Valley Project (CVP).

The first Federal authorization of the CVP was by the Rivers and Harbors Act of August 30, 1935. The CVP was reauthorized for construction, operation, and maintenance by the Secretary of the Interior pursuant to the Reclamation Act of 1902, as amended and supplemented (the Federal Reclamation laws) by the Rivers and Harbors Act of August 26, 1937. The 1937 act also 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 most recently reauthorized by the Central Valley Project Improvement Act (CVPIA), P.L. 102-575. The CVPIA modified the 1937 act and 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."

Overview of the State Water Project

After World War II, the State's population almost doubled and more water was needed in addition to that provided by the CVP. Following the devastating flood in 1955 in Northern and Central California, the California State Legislature appropriated emergency funds to the Department of Water Resources (DWR) to begin construction of the State Water Project (SWP). Full funding was obtained in 1960 upon voter approval of the California Water Resources Development Bond Act, known as the Burns-Porter Act. Based on the California Water Plan, plans for the SWP included a dam and reservoir on the Feather River near Oroville, a Sacramento-San Joaquin Delta cross channel, an electric power transmission system, an aqueduct to convey water from the Delta to the Bay Area, and an aqueduct to convey water to the San Joaquin Valley and Southern California.

Table 1–1 provides a list of laws, directives, and orders affecting CVP and SWP operation. In the statutes authorizing the construction, operation, and maintenance of the various divisions of the CVP, Congress has consistently included language directing the Secretary to operate the CVP as a single, integrated project.

Topography and Climate

The Central Valley Basin of California extends from about 500 miles in a northwest to southeast direction with an average width of about 120 miles. The topography of the Central Valley Basin is shown in Figure 1–1.

The basin is surrounded by mountains except for a single outlet to the west at the Carquinez Strait. The Central Valley floor occupies about one-third of the basin, is about 400 miles long, and averages about 50 miles wide. The Cascade Range and Sierra Nevada on the north and east rise in elevation to 14,000 feet, and the Coast Ranges on the west to as high as 8,000 feet. There are two major watersheds in the basin: the Sacramento River system in the north and the San Joaquin River system in the south. The two river systems join at the Sacramento-San Joaquin Delta where the waters are commingled before emerging through the Carquinez Strait into San Francisco Bay and then to the Pacific Ocean.

The climate in the Central Valley is characterized as Mediterranean, with long, warm, dry summers that provide ideal growing conditions for a wide variety of quality crops under irrigation. The winters are cool and moist. Severely cold weather does not occur, but temperatures drop below freezing occasionally in virtually all parts of the valley. Rainfall on the valley floor is light, and snow almost never occurs. Average annual precipitation decreases from north to south, with precipitation levels much greater in the mountain ranges surrounding the valley. About 80 inches of precipitation, much in the form of snow, occur annually at higher elevations in the northern ranges, and about 35 inches occur in the southern mountains. About 85 percent of the precipitation falls from November through April.

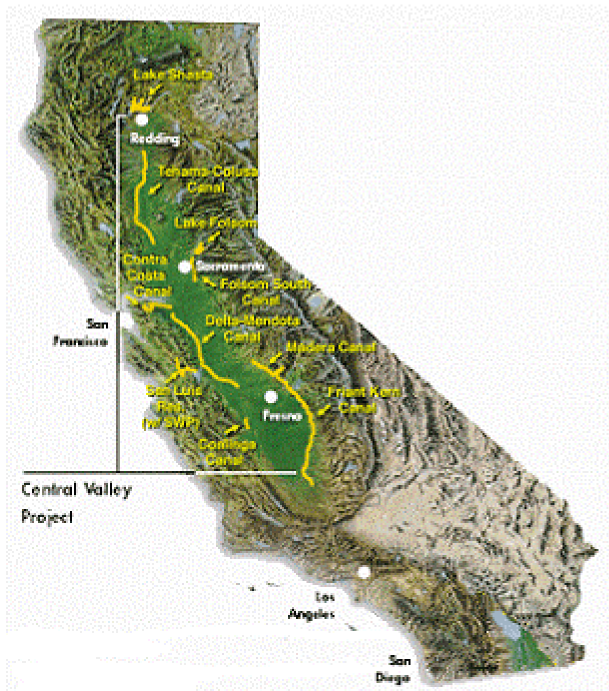


Figure 1–1 CVP Topographical Map

Legal and Statutory Authorities

Table 1–1 Laws, Directives, and Orders Affecting Central Valley Project (CVP) Operations

Law or Directive	Year	Effect on CVP
Reclamation Act	1902	Formed legal basis for subsequent authorization of the CVP.

Table 1–1 Laws, Directives, and Orders Affecting Central Valley Project (CVP) Operations

Law or Directive	Year	Effect on CVP
Rivers and Harbors Act	1935 1937 1940	First authorization of CVP for construction and provision that dams and reservoirs be used first for river regulation, improvement of navigation, and flood control; second for irrigation and domestic uses; and third for power.
Reclamation Project Act	1939	Provided for the repayment of the construction charges and authorized the sale of CVP water to municipalities and other public corporations and agencies, and plant investment, for certain irrigation water deliveries to leased lands.
Water Service Contracts	1944	Provided for the delivery of specific quantities of irrigation and municipal and industrial water to contractors.
Flood Control Act	1944	Authorized flood control operations for Shasta, Folsom, and New Melones Dams.
Water Rights Settlement Contracts	1950	Provided diverters holding riparian and senior appropriative rights on the Sacramento and American Rivers with CVP water to supplement water that historically would have been diverted from natural flows.
Grasslands Development Act	1954	Added authority for use of CVP water for fish and wildlife purposes. Also authorized development of works in cooperation with the State for furnishing water to Grasslands for waterfowl conservation.
Trinity River Act	1955	Provided that the operation of the Trinity River Division be integrated and coordinated with operation of other CVP features to allow for the preservation and propagation of fish and wildlife.
Reclamation Project Act	1956	Provided a right of renewal of long-term contracts for agricultural contractors for a term not to exceed 40 years.
Fish and Wildlife Coordination Act	1958	Provided for integration of Fish and Wildlife Conservation programs with Federal water resources developments; authorized Secretary of the Interior to include facilities to mitigate CVP-induced damages to fish and wildlife resources. Required consultation with the U.S. Fish and Wildlife Service.
San Luis Authorization Act	1960	Authorized San Luis Unit. Provided for financial participation of Reclamation in development of recreation.
Reclamation Project Act	1963	Provided a right of renewal of long-term contracts for municipal and industrial contractors.

Table 1–1 Laws, Directives, and Orders Affecting Central Valley Project (CVP) Operations

Law or Directive	Year	Effect on CVP
Auburn-Folsom South Unit Authorization Act	1965	Authorized Auburn-Folsom South Unit. Provided for financial participation of Reclamation in development of recreation.
Power Contract 2948A	1967	Provided banking agreements with the Pacific Gas and Electric Company of California (PG&E), under which excess CVP energy and capacity are sold to PG&E. PG&E in return delivers power to CVP customers. Contract now administered by the Western Area Power Administration.
National Environmental Policy Act (NEPA)	1969	Established policy, set goals, and provided means for ensuring that scientific analysis, expert agency participation, and public scrutiny and input are incorporated into the decision-making process regarding the actions of the Federal agencies.
Council on Environmental Quality Regulations	1970	Provided directives for compliance with NEPA.
State Water Resources Control Board (SWRCB) Decision 1379	1971	Established Delta water quality standards to be met by both the CVP and the SWP.
Endangered Species Act	1973	Provided protection for animal and plant species in danger of extinction (endangered) and those that may become so in the foreseeable future (threatened).
SWRCB Decision 1485	1978	Ordered the CVP and the SWP to guarantee certain conditions for water quality protection for agricultural, municipal and industrial, and fish and wildlife use.
Energy and Water Development Appropriation Act	1980	Provided for participation in stream rectification.
Energy and Water Development Appropriation Act	1980	Provided for energy and water development at New Melones Reservoir and archaeological recovery at the reservoir site.
Suisun Marsh Preservation and Restoration Act	1980	Established a cooperative agreement with the State of California to improve and manage Suisun Marsh.
Secretarial Decision on Trinity River Release	1981	Allocated CVP yield so that releases can be maintained at 340,000 acre-feet in normal water years, 220,000 acre-feet in dry years, and 140,000 acre-feet in critically dry years.
	Amended 1991	Released a minimum of 340,000 acre-feet annually for each dry or wetter water year. During each critically dry water year, 340,000 acre-feet will be released if possible.

Table 1–1 Laws, Directives, and Orders Affecting Central Valley Project (CVP) Operations

Law or Directive	Year	Effect on CVP
Corps of Engineers Flood Control Manuals for: Shasta Folsom New Melones	 1977 1959 1980	Prescribed regulations for flood control.
Corps of Engineers Flood Control Diagram for: Shasta Folsom New Melones	 1977 1986 1982	Outlined descriptions and data on flood potential and flood ratings.
Reclamation Reform Act	1982	Introduced the concept of full-cost pricing, including interest on the unpaid pumping plant investment, for certain irrigation water deliveries to leased lands.
Coordinated Operating Agreement (COA)	1986	Agreement between the U.S. Government and the State of California. Determined the respective water supplies of the CVP and the SWP while allowing for a negotiated sharing of Sacramento-San Joaquin Delta excess outflows and the satisfaction of in-basin obligations between the two projects.
Public Law 99-546	1986	Ensures repayment of plant-in-service costs at the end of FY 1980, by end of FY 2030. Department of the Interior (DOI) and Reclamation directed to include total costs of water and distributing and servicing it in CVP contracts (both capital and operations and maintenance costs).
SWRCB Orders 90-5, 91-1	1990 1991	Modified Reclamation water rights to incorporate temperature control objectives in Upper Sacramento River.
National Marine Fisheries Service Biological Opinion for Winter-Run Chinook Salmon	1992 1993 1995	Established operation under the Reasonable Prudent Alternative (RPA) for 1992 operations to protect winter-run Chinook salmon. Provided for "incidental taking" within the RPA.
Public Law 102-575, Title 34 Central Valley Project Improvement Act[jjg3]	1992	Mandated changes in management of the CVP, particularly for the protection, restoration, and enhancement of fish and wildlife.
Draft Water Rights Decision 1630	1992	SWRCB circulated a draft water rights order to modify Decision 1485 to protect Bay-Delta water quality.
U.S. Fish and Wildlife Service Biological Opinion for Delta Smelt and Sacramento Splittail	1993 1994 1995	Established operational criteria to protect Delta smelt.

Table 1–1 Laws, Directives, and Orders Affecting Central Valley Project (CVP) Operations

Law or Directive	Year	Effect on CVP
Bay-Delta Plan Accord and SWRCB Order WR 95-06	1994 1995	Agreement and associated SWRCB order to provide for operations of the CVP and SWP to protect Bay-Delta water quality. Also provided for further evaluation and development of a new Bay-Delta operating agreement, which is being pursued under the CALFED process.
Monterey Agreement	1995	Agreement between DWR and SWP contractors to manage contractor operations.
New Melones Interim Plan of Operations	1997	Interim operations plan for New Melones Reservoir.
San Joaquin River Agreement	1998 1999	Agreement for providing San Joaquin River flows and exports.
DOI Final Decision Accounting of CVPIA 3406 (b)(2)	1999 2003	Defined metrics and accounting for CVPIA 3406(b)(2) operations.
SWRCB Revised Water Right Decision 1641	2000	Revised order to provide for operations of the CVP and SWP to protect Bay-Delta water quality.
CALFED Record of Decision (ROD)	2000	Presented a long-term plan and strategy designed to fix the Bay-Delta.
Trinity River ROD	2000	Defined minimum flow regime of 369,000 acre-feet in critical dry years ranging to 816,000 acre-feet in wet years.
CVPIA ROD	2001	Implemented provisions of CVPIA including allocating 800,000 acre-feet of CVP yield for environmental purposes.
National Marine Fisheries Service Biological Opinion for Spring-Run Chinook Salmon and Steelhead	2001 2002 2004	Established criteria for operations to protect spring-run Chinook salmon and steelhead.

Components of CVP and SWP

The CVP is composed of some 20 reservoirs with a combined storage capacity of more than 11 million acre-feet, 11 powerplants, and more than 500 miles of major canals and aqueducts (Figure 1–2). These facilities are generally operated as an integrated project, although they are authorized and categorized in divisions (Figure 1–3). 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 purpose of the CVP was to provide water for irrigation throughout California's Central Valley. The CVPIA amended CVP authorizations in Section 3406(a) 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, operated and maintained by DWR, is composed of 17 pumping plants, 8 hydroelectric powerplants, 32 storage facilities, and more than 660 miles of aqueducts and pipelines. The SWP serves more than two-thirds of the State’s population and approximately 600,000 acres of irrigated farmland in the Feather River area, San Francisco Bay Area, San Joaquin Valley, Central California Coast, and Southern California. The SWP provides water supply to contracting agencies, flood control, recreation, fish and wildlife enhancement, power generation, and salinity control in the Sacramento-San Joaquin Delta.

Figure 1–2 shows the major water facilities in the Central Valley including Shasta Lake, Keswick Reservoir, and Red Bluff Diversion Dam on the Sacramento River; Trinity Lake on the Trinity River; Whiskeytown Reservoir on Clear Creek; Lake Oroville and Thermalito Afterbay on the Feather River; Folsom Lake and Folsom South Canal on the American River; New Melones Lake on the Stanislaus River; Millerton Lake on the San Joaquin River; Harvey O. Banks (SWP) and Tracy (CVP) pumping plants; the Contra Costa Canal and North Bay and South Bay aqueducts in the Delta; and the Delta-Mendota Canal, Governor Edmund G. Brown California Aqueduct, Friant-Kern and Madera canals, and San Luis Reservoir in the San Joaquin Valley.

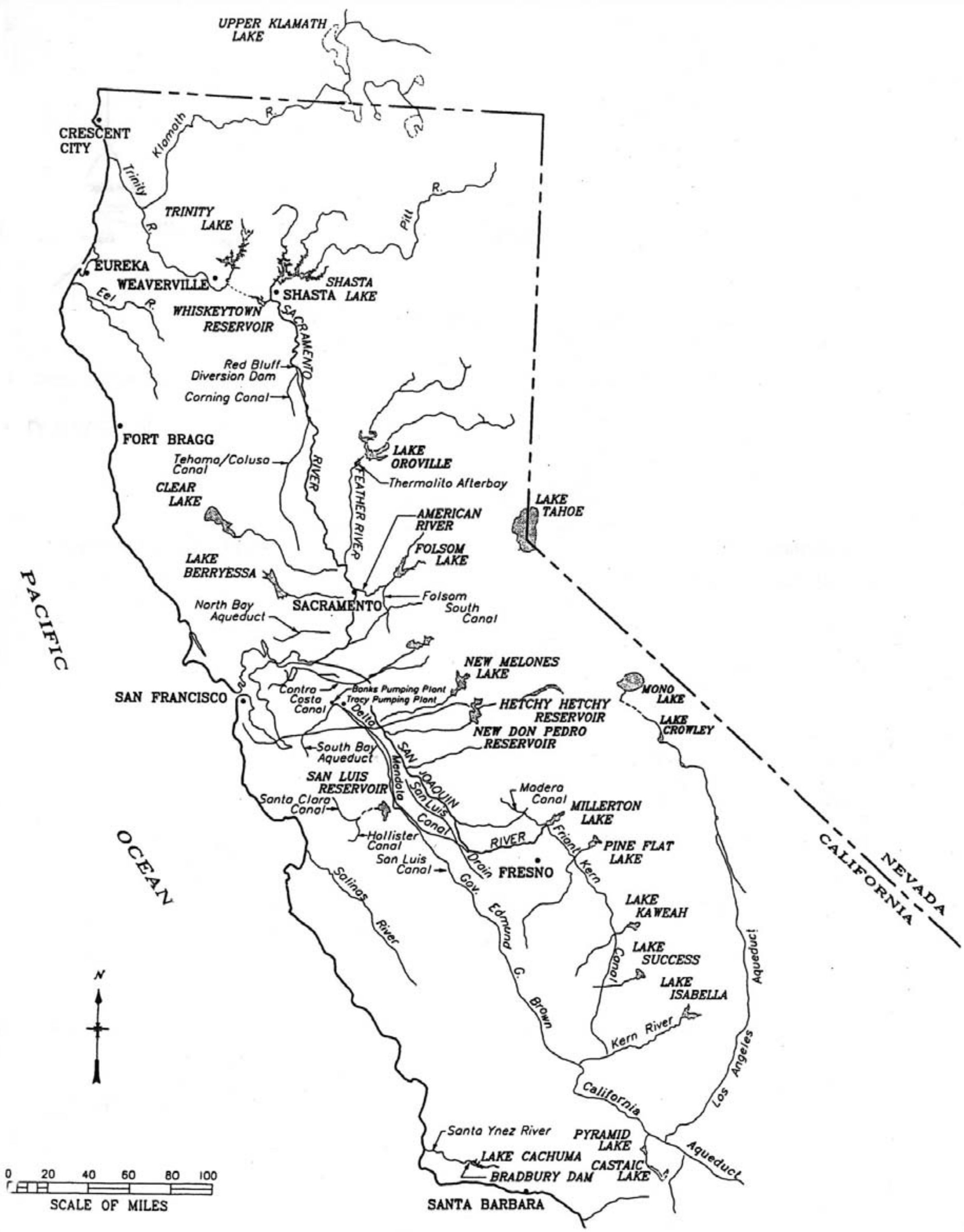
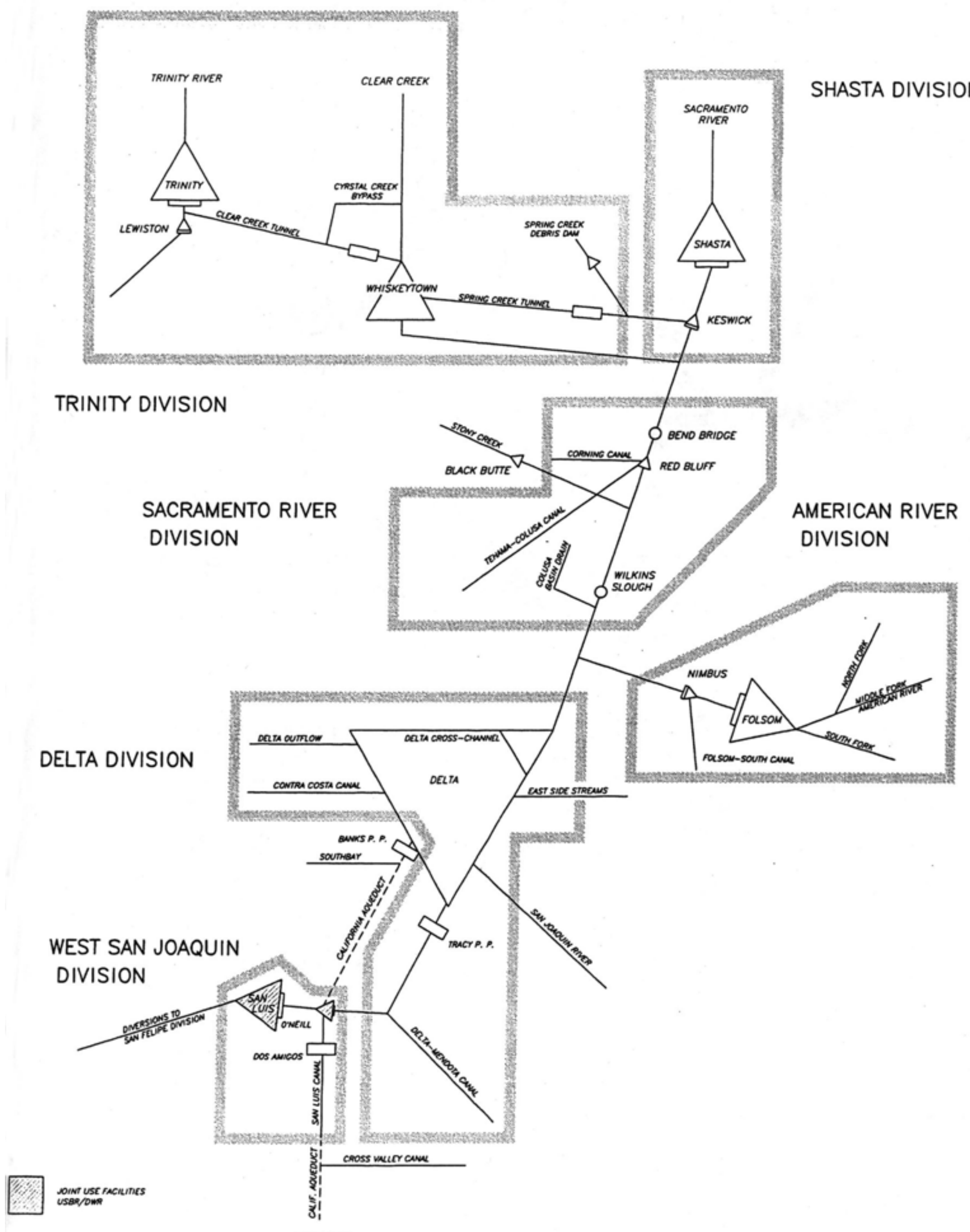


Figure 1–2 Major Components of the CVP including State Water Project

Divisions of CVP

Facilities in CVP are categorized by divisions and units as shown in Figure 1–3 and as listed in Figure 1–4.



Authorized divisions of the Central Valley Project

Figure 1–3 Central Valley Project Divisions

American River Division	Shasta Division
Auburn-Folsom South Unit	Keswick Dam and Reservoir
Folsom South Canal	Keswick Powerplant
Folsom Unit	Shasta Dam and Lake
Folsom Dam and Lake	Shasta Powerplant
Folsom Powerplant	
Nimbus Dam and Powerplant and Lake Natoma	**Trinity River Division**
	Buckhorn Dam
Delta Division	Clair A. Hill Whiskeytown Dam and Whiskeytown Lake
Contra Costa Canal	Clear Creek South Unit
Contra Loma Reservoir	Clear Creek Tunnel
Delta Cross Channel	Cow Creek Unit
Delta-Mendota Canal	Judge Francis Carr Powerhouse
Tracy Pumping Plant	Lewiston Dam, Lake, and Powerplant
	Spring Creek Debris Dam and Reservoir
East Side Division	Spring Creek Power Conduit and Powerplant
New Melones Unit	Trinity Dam and Powerplant and Trinity Lake
New Melones Dam, Lake, and Powerplant	
	West San Joaquin Division
Friant Division	San Luis Unit
Friant Dam and Millerton Lake	B.F. Sisk San Luis Dam and San Luis Reservoir*
Friant-Kern Canal	Coalinga Canal
Madera Canal	Dos Amigos Pumping Plant*
	Los Banos and Little Panoche Detention Dams and Reservoirs*
Sacramento River Division	O'Neill Dam and Forebay*
Black Butte Dam and Lake	O'Neill Pumping-Generating Plant
Sacramento Canals Unit	Pleasant Valley Pumping Plant
Corning Pumping Plant	
Corning Canal	

Red Bluff Diversion Dam Tehama-Colusa Canal **San Felipe Division** Hollister Conduit Pacheco Tunnel and Conduit San Justo Dam and Reservoir Santa Clara Tunnel	San Luis Canal* William R. Gianelli Pumping-Generating Plant* *Joint CVP/SWP Facility

Figure 1–4 Central Valley Project Facilities by Division

The divisions of the CVP are discussed briefly in the following sections.

Trinity River Division

Trinity River water is stored in Trinity Lake behind Trinity Dam. Releases from this reservoir are used to generate power at Trinity, Lewiston, Spring Creek, Judge Francis Carr, and Keswick Powerplants. Lewiston Dam regulates flows in the Trinity River to meet the fishery and temperature downstream requirements of the Trinity River Basin and provides a forebay for the transbasin diversion of flows through Clear Creek Tunnel to the Sacramento Basin. Water from the Trinity River commingles with Sacramento River water to provide irrigation service to lands in the Sacramento Valley and other CVP areas.

Shasta Division

Shasta Dam and Shasta Lake on the Sacramento River control floodwater and store surplus winter runoff for irrigation use in the Sacramento and San Joaquin Valleys. They also provide maintenance of navigation flows and conservation of fish in the Sacramento River, protection of the Delta from intrusion of saline ocean water, water for municipal and industrial (M&I) use, and generation of hydroelectric energy.

Sacramento River Division

The Red Bluff Diversion Dam (RBDD), the Corning Pumping Plant, and the Corning and Tehama-Colusa Canals are features of this division. The Sacramento Canals Unit was authorized to supply irrigation water to land in the Sacramento Valley.

American River Division

The American River Division includes the Folsom, and Auburn-Folsom South Units. Folsom Dam, Lake, and Powerplant; Nimbus Dam; Lake Natoma; and Nimbus Powerplant form the Folsom Unit and are on the American River. Folsom Dam regulates flow of the American River for irrigation, power, flood control, M&I use, water quality, fish and wildlife, recreation, and other purposes. Folsom South Canal, which originates at Lake Natoma, is the only constructed feature of the Folsom South Unit. The uncompleted Auburn Dam is also a part of this unit.

Delta Division

Delta Division facilities include the Contra Costa Canal (CCC), the Tracy Pumping Plant, the Delta-Mendota Canal (DMC), and the Delta Cross Channel (DCC), which is a controlled diversion channel between the Sacramento River and Snodgrass Slough. The CCC and the DMC convey water pumped from the Delta to Contra Costa County and the DMC and San Luis service areas of the CVP. The channel provides water to the intakes of CCC and DMC, improves the irrigation supplies in the Delta, and helps repel ocean salinity.

West San Joaquin Division

The San Luis Unit was authorized, then built and operated jointly with the State of California. The San Luis Unit consists of San Luis Dam and Reservoir (joint Federal-State facilities), O'Neill Dam and forebay (joint Federal-State facilities), O'Neill Pumping-Generating Plant (Federal facility), William R. Gianelli Pumping-Generating Plant (joint Federal-State facilities), San Luis Canal (joint Federal-State facilities), Dos Amigos Pumping Plant (joint Federal-State facilities), Coalinga Canal (Federal facility), Pleasant Valley Pumping Plant (Federal facility), and the Los Banos and Little Panoche Detention Dams and Reservoirs (joint Federal-State facilities).

Friant Division

Although the Friant Division is operated separately from the rest of the CVP, there are deliveries from the Delta provided to Cross Valley Canal. Under flood control from Millerton, water makes it to the Mendota pool. Thus, the Friant Division is covered by the CVP-OCAP. Friant Dam and Millerton Lake are on the San Joaquin River. The reservoir controls the San Joaquin River flows, provides downstream releases to meet requirements above Mendota Pool, and provides conservation storage and diversion into the Madera Canal and the Friant-Kern Canal.

East Side Division

The New Melones unit of this division consists of the New Melones Dam, Lake, and Powerplant on the Stanislaus River. Functions of this unit are flood control, irrigation and M&I water supply, power generation, fishery enhancement, water quality, and recreation. Although this division is part of the CVP, its operation is not included in the Coordinated Operating Agreement (COA), and it is operated as a separate feature.

San Felipe Division

The San Felipe Division includes Pacheco Tunnel and Santa Clara Tunnel, conveyance facilities, pumping plants, power transmission facilities, a regulating reservoir, and distribution facilities in Santa Clara and San Benito Counties. Deliveries to the San Felipe Division are made through San Luis Reservoir. In CVP-OCAP analyses, the operation of the San Felipe Division is treated simply as a water demand in San Luis Reservoir.

Division of SWP

SWP field divisions in are described in Figure 1–5.

Oroville Field Division	San Joaquin Field Division
Antelope Dam and Lake	Las Perillas Pumping Plant
Frenchman Dam and Lake	Badger Hill Pumping Plant
Grizzly Valley Dam and Lake Davis	Devil's Den Pumping Plant
Oroville Dam and Lake	Bluestone Pumping Plant
Hyatt Powerplant	Polonio Pass Pumping Plant
Thermalito Diversion Dam, Powerplant, and Pool	Tank Sites 1,2, & 5
Feather River Fish Barrier Dam, Pool, and Hatchery	Coastal Aqueduct
Thermalito Forebay and Dam	Buena Vista Pumping Plant
Thermalito Pumping-Generating Plant	Teerink Pumping Plant
Thermalito Afterbay and Dam	Chrisman Pumping Plant
	Edmonston Pumping Plant
	California Aqueduct Pools 22-40
Delta Field Division	
Barker Slough Pumping Plant	**Southern Field Division**
North Bay Aqueduct	Tehachapi Crossing and Afterbay
Cordelia Pumping Plant and Forebay	Oso Pumping Plant
Napa Turnout Reservoir	Quail Dam and Lake
Suisun Marsh Salinity Control Gates and other Marsh Facilities	Warne Powerplant
Clifton Court Dam and Forebay	Pyramid Dam and Lake
Skinner Fish Facility	Castaic Powerplant (operated by Los Angeles Department of Water and Power)
Banks Pumping Plant	Elderberry Forebay and Dam (operated by LADWP)
Bethany Dams and Reservoir	Castaic Dam, Lake, and Lagoon
South Bay Pumping Plant	Alamo Powerplant
South Bay Aqueduct	Pearblossom Pumping Plant
Del Valle Dam and Lake	Mojave Siphon Powerplant
Del Valle Pumping Plant	Cedar Springs Dam and Silverwood Lake
Santa Clara Terminal Reservoir	Devil Canyon Powerplant
California Aqueduct Pools 1- 8	Santa Ana Pipeline
	Perris Dam and Lake
San Luis Field Division	East Branch Extension Pipeline
O'Neill Dam and Forebay*	Greespont Pumping Station
Sisk Dam and San Luis Reservoir*	

Gianelli Pumping-Generating Plant* Dos Amigos Pumping Plant* Los Banos Detention Dam and Reservoir* Little Panoche Detention Dam and Reservoir* California Aqueduct Pools 9-21*	Crafton Hills Pumping Station and Reservoir Cherry Valley Pumping Station California Aqueduct Pools 41-66 *Joint CVP/SWP facility

Figure 1–5 State Water Project Facilities by Division

The SWP field divisions are discussed briefly in the following sections.

Oroville Field Division

The Oroville Field Division operates and maintains SWP facilities extending from the three upper Feather River lakes in Plumas County to the Oroville-Thermalito Complex on the Feather River. The facilities include three powerplants, two of which can either pump water or generate power; Lake Oroville; a forebay and afterbay; a fish hatchery (operated by the Department of Fish and Game); and a visitors center.

Delta Field Division

The Delta Field Division operates and maintains SWP facilities serving Solano, Napa, Alameda, and Santa Clara Counties. The Delta Field Division also operates and maintains the Suisun Marsh Salinity Control Gates and Clifton Court Forebay, Skinner Fish Salvage Facility, and Banks Pumping Plant in the Southern Delta.

San Luis Field Division

The San Luis Field Division operates and maintains the joint Federal-State facilities of O'Neill Forebay, San Luis Reservoir, Gianelli Pumping-Generating Plant, and Dos Amigos Pumping Plant. The San Luis Field Division also manages the Romero Visitors Center at the reservoir. Facilities extend from Merced to Kings County.

San Joaquin Field Division

The San Joaquin Field Division operates and maintains the stretch of the SWP from Kettlemen City in Kings County to Edmonston Pumping Plant in Kern County. The San Joaquin Field Division also operates the Coastal Branch serving San Luis Obispo and Santa Barbara Counties.

Southern Field Division

The Southern Field Division operates and maintains the East and West Branches of the SWP in Southern California. The East Branch includes the Alamo Powerplant, Mojave Siphon, Lake Silverwood, Devil Canyon Powerplant and the Santa Ana and East Branch Extension pipelines. The West Branch includes Quail Lake, Pyramid Lake, and Castaic Lake. These facilities are in Los Angeles, San Bernardino, and Riverside Counties.

Chapter 2 Project-Wide Operations Constraints and Objectives

Project-wide Constraints

Water Rights

State Water Resources Control Board (SWRCB) decisions and orders and the biological opinions for endangered species largely determine Delta regulatory requirements for water quality, flow, and operations. SWRCB Water Quality Control Plan (WQCP) and applicable water rights decisions, as well as other agreements considered in determining the operations of both the Central Valley Project (CVP) and the State Water Project (SWP).

Reclamation and the Department of Water Resources (DWR) have permits and licenses to appropriate water. SWRCB issued permits to Reclamation for much of the CVP pursuant to SWRCB Decision 990, adopted in February 1961. Reclamation was issued permits to divert water from the Trinity River pursuant to Permit Order 124. SWRCB issued DWR permits for the SWP pursuant to SWRCB Decision 1275, which was revised in SWRCB Decision 1291.

Water Service Contracts and Deliveries

Water Needs Assessment

Water needs assessments have been performed for each CVP water contractor eligible to participate in the CVP long-term contract renewal process. These water needs assessment serve to confirm a contractor’s past beneficial use and to 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 its available surface water and groundwater supplies.

As of June 2004, most of the contractor’s assessments have been finalized. However, a small number of assessments remain under analysis. These assessments either require additional information from the contractors or do not fit into the assumptions incorporated into the methodology used for the rest of the CVP. These contractors are primarily in the American River and San Felipe Divisions of the CVP. It is anticipated that all the assessments will be concluded by mid-June 2004. Because of the remaining assessments, the total supply required to meet the demands for the CVP cannot be determined at this time.

Even though the water assessments continue, assumptions for the future condition have been made for modeling purposes. The 2020 level of development’s demands includes higher amounts than the 2001 level of development’s demands on the American River and San Felipe Divisions.

CVP Municipal and Industrial (M&I) Shortage Policy

The CVP has 253 water service contracts (including the Sacramento River Water Settlement Contracts). Those water service contracts had many varying water shortage provisions. In some contracts, M&I and agricultural use shared shortages equally. In most of the larger M&I contracts, agricultural water was shorted 25 percent of its contract entitlement before M&I water was shorted, and then both shared shortages equally. Since 1991, Reclamation has been developing an M&I Water Shortage Policy applicable to all CVP M&I contractors.

This policy provides M&I water supplies with a 75 percent water supply reliability based on a contractor's historical use. (Historical use is defined as 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 non-CVP water. Before M&I water supplies are reduced, irrigation water supplies 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, and, because of limited water supplies during these times, M&I water allocation may be reduced below 75 percent of adjusted historical use. This recognizes that shortages to irrigation water supplies may harm permanent crops, such as trees and vines that are not easily replaced, and that there is a definite additional economic impact from the reliability. This policy also provides that M&I contractors are guaranteed, to the extent possible, sufficient water supplies to meet public health and safety, considering water supplies available to M&I contractors from other sources. It should be noted that this policy would apply only to that portion of CVP water identified as of September 30, 1994, as shown in Schedule A-12 of the 1996 Municipal and Industrial Water Rates book, and for those contract quantities specified in Section 206 of Public Law 101-514.

Shortages for South of Delta (SOD) and North of Delta (NOD) agricultural and M&I are the same.

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 have 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%

DWR Dry Year Purchase Program

DWR has undertaken a Dry Year Water Purchase Program whereby DWR, in years of reduced water supply, purchases water from willing sellers. During the 2001 and 2002 programs, the willing sellers were north of the Sacramento-San Joaquin Delta. The purchased water was made available to public agencies (generally water districts and municipalities) throughout California and was used to supplement their water supplies. The program is intended to reduce adverse economic impacts and hardship associated with water shortages. The program is open to all agencies and is not limited to SWP contractors. Water delivered under this program is generally delivered south of the Delta. The Reclamation States Emergency Drought Relief Act of 1991 authorizes the Secretary of the Interior to participate in water banks established by a state.

SWP contractors who purchase water under this program will move such water under provisions of their SWP contract that covers use of excess capacity in the SWP to move non-SWP water. Through implementation of contracts with the SWP contractors, the Department has established a priority for conveying such water over supplies for non-SWP uses. This priority has been acknowledged in the CALFED Record of Decision (ROD) Attachment 2, the Environmental Water Account (EWA) Operating Principles Agreement. Use of SWP conveyance facilities to meet SWP contractual and operational needs does affect the ability of the SWP to convey water for non-SWP uses.

Coordinated Operations Agreement (COA)

Background

The Agreement between the United States of America and the State of California for Coordinated Operation of the Central Valley Project and the State Water Project was authorized by PL 99-546 in 1986. It superseded a 1960 agreement and annual coordination agreements that had been implemented since the SWP came on-line. The COA is both an operations agreement and a water rights settlement. Its history extends back to Reclamation protests of SWP water rights applications around 1960. The purpose of the COA is to ensure that the CVP and the SWP each obtains its share of water from the Delta and bears its share of obligations to protect the other beneficial uses of water in the Delta and Sacramento Valley. Coordinated operation by agreed-on criteria can increase the efficiency of both the CVP and the SWP.

The CVP and SWP (collectively, the projects) use a common water supply in California's Central Valley. The projects have built water conservation and water delivery facilities in the Central Valley to deliver water supplies to affected water rights holders as well as project contractors. The projects' water rights are conditioned by the SWRCB to protect the beneficial uses of water within each respective project and jointly for the protection of beneficial uses in the Sacramento Valley and Sacramento-San Joaquin Delta Estuary. The COA memorializes these facts and objectives into an agreement for which the projects can use the water resources for project purposes and meet the common beneficial uses in the Sacramento Valley and Sacramento-San Joaquin Delta Estuary.

In summary, the COA defines the project facilities and their water supplies, it sets forth procedures for coordination of operations, it identifies formulas for sharing joint responsibilities for meeting Delta standards and other legal uses of water, it identifies how unstored flow will be shared, it sets up a framework for exchange of water and services between the SWP and CVP, and, finally, it provides for periodic review every 5 years.

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 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 Delta standards. (D-1485 ordered the CVP and SWP to guarantee certain conditions for water quality protection for agricultural, M&I, and fish and wildlife use.) Each project is obligated to ensure that water is available for these uses, but the degree of obligation depends 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 equal 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 (SWPOCO) 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), during excess water conditions, Reclamation and DWR have the responsibility to store and export as much water as possible, within physical and contractual limits. In these cases, no accounting for responsibility is required. However, during balanced water conditions, the projects share 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., balanced water conditions plus when exports exceed storage withdrawals), 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 daily to determine target Delta outflow for water quality, reservoir release levels necessary to meet in-basin demands, and 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 CVP and SWP obligations. This accounting allows for flexibility in operations and avoids the need to make daily changes in reservoir releases that originate several days travel time from the Delta. It also means that adjustments can be made "after the fact" rather than by prediction for the variables of reservoir inflow, storage withdrawals, and in-basin uses.

Although the accounting language of the COA provides the mechanism for determining the responsibility of each project, real-time operations dictate actions. For example, conditions in the

[1] These percentages were derived from negotiations between Reclamation and DWR

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 that the reasonable action is to increase upstream reservoir releases, the response will likely be to increase Folsom releases first. Water released from Lake Oroville requires about 3 days to reach the Delta and 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 be also be achieved immediately by increasing or decreasing project exports. As with changes in reservoir releases, imbalances in meeting project obligations are captured by 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 (that is, the project that provided more or exported less than its COA-defined share) may request that the other 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, very dry years may have long continuous periods of balanced conditions, and other years may have several periods of balanced conditions interspersed with excess water conditions. Account balances continue from one 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.

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, more generally, in the 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 SWRCB. The Central Valley Project Improvement Act (CVPIA) has changed how the CVP is operated, and Endangered Species Act (ESA) responsibilities have affected both the CVP and SWP operations. Significant changes since 1986 are listed below. Included after each item is how it relates to the COA and its general effect on the accomplishments of the CVP or SWP.

Sacramento River Temperature Control Operations

Temperature operations have constrained the pattern of storage and withdrawal of storage at Shasta, Trinity, and Whiskeytown, for the purpose of improving temperature control. They have also constrained rates of flow and changes in rates of flow below Keswick Dam in keeping with temperature requirements. Such constraints have reduced the CVP's capability to respond efficiently to changes in Delta export or outflow requirements. At times, temperature requirements have caused timing of CVP releases to be mismatched with Delta export capability, resulting in loss of water supply. At times, in accordance with Articles 6(h) and 6(i) of the COA, the SWP has exported water released by CVP for temperature control in the Sacramento River.

Trinity River Minimum Release Requirement Increases

Since 1986, Trinity River annual flows have been increased from a range of 140,000 to 340,000 acre-feet up to the current range of 368,600 to 452,600 acre-feet, and the proposed future range of 368,600 to 815,000 acre-feet. As a result, less Trinity water supply will be available for export to the Sacramento River to assist in meeting in-basin uses and exports. This results in a reduction in export CVP water supply and, to a lesser degree, SWP supplies. Shasta spills, which can benefit SWP supplies, occur less often because higher Trinity flows result in lower Shasta storage.

Sacramento River Winter-Run Chinook Salmon ESA Listing

The 1993 NOAA Fisheries' Biological Opinion included a Reasonable Prudent Alternative (RPA), which imposed storage, release, Delta Cross Channel (DCC) operation, and other operational constraints on the CVP and SWP unanticipated in the 1986 COA. These constraints modify the capability of the CVP and, at times, the SWP to fully exploit the release and export capabilities of the projects as assumed in the 1986 COA. The NOAA Fisheries Biological Opinion also introduced a combined CVP/SWP incidental take for the Delta export facilities, thereby extending CVP/SWP coordination to the ESA requirement to avoid take.

CVPIA 3406(b)(2) and Refuge Water Supplies (especially north of Delta refuge supplies)

CVPIA 3406(b)(2) implementation has resulted in a shift in the rates and timing of CVP reservoir releases to protect anadramous fish. This has reduced CVP water supply and, at times, enhanced SWP water supply because of the provisions of COA Articles 6(h) and 6(i). CVPIA led to Refuge Water Supply contracts, which, for Sacramento Valley Refuges, may increase the amounts of water delivered annually. These additional deliveries were not part of the 1986 COA. The additional refuge supplies, if treated as Sacramento Valley in-basin uses, may, at times, reduce the CVP and SWP supply available for Delta export.

Delta Smelt ESA Listing

The Delta smelt ESA listing resulted in U.S. Fish and Wildlife Service (FWS) Biological Opinions on CVP/SWP operations in 1993, 1994, and 1995 on CVP/SWP operations, and the South Delta Temporary Barriers Biological Opinion in 2001. The FWS Biological Opinion in 1994 contained provisions for X2, San Joaquin flows, export, and Delta flows that fed into the Bay-Delta Accord and Water Quality Control Plan, and, later, the San Joaquin River Agreement. The 1995 FWS Biological Opinion was based on operations including provisions to meet the Bay-Delta Accord, CVPIA implementation, and the new WQCP. Overall, these provisions reduced water supply available for export to the CVP and SWP.

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 incorporated into the 1995 WQCP and later, along with the Vernalis

Adaptive Management Program (VAMP), were implemented by D-1641. The actions the CVP and SWP take 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, no amendment of the COA or evaluation of the new Delta standards for consistency with Congressional directives has been undertaken. Significant new elements in the D-1641 standards include X2 standards, export/inflow (E/I) ratios, real-time DCC operation, San Joaquin flow standards, and recognition of the CALFED Ops Group process for flexibility in applying or relaxing certain standards.

SWP Monterey Agreement

The 1994 Monterey Agreement revised the water management strategy of the SWP and its contractors and eventually led to SWP contract amendments. The Monterey Agreement simplified allocation of SWP supplies among SWP contractors, reallocated 130,000 acre-feet of agricultural supply to M&I, aggregated several contractual obligations for water delivery into one water type (Article 21), and resulted in KCWA assumption of the Kern Water Bank. DWR is preparing an EIR to determine whether these contractual adjustments result in operational impacts in the Delta.

Sacramento River Spring-Run Chinook Salmon ESA Listing,

Beginning in 1999, NOAA Fisheries short-term biological opinions on CVP/SWP operations have resulted in use of DCC closures to protect spring-run Chinook. Additionally, at times actions have been taken to limit Delta exports in response to the assumed presence of spring-run Chinook and the accumulation of incidental take. Whether actions to protect spring-run Chinook have or will affect CVP or SWP supplies is uncertain because EWA has been used to compensate for reductions in exports. Spring-run Chinook is protected partly through dedication of project capabilities for that purpose, which may affect overall project accomplishments anticipated under the COA.

Steelhead Trout ESA Listing

Beginning in 1999, NOAA Fisheries short-term biological opinions on CVP/SWP operations have emphasized temperature conditions in streams with steelhead habitat, including the American, Feather, and Stanislaus Rivers. Flow stability at critical life stages is emphasized, and combined incidental take is quantified for CVP and SWP Delta exports. Renewed consultation is required for exceeding incidental take. Whether actions to protect steelhead have or will affect CVP or SWP supplies is uncertain. Steelhead is protected partly through dedication of project capabilities for that purpose, which may affect overall project accomplishments anticipated under the COA.

CALFED Environmental Water Account Implementation

Since the 2000-2001 water year, the CVP and SWP have implemented EWA in accordance with the EWA principles appended to the August 2000 CALFED ROD. The EWA principles dedicate certain capabilities of the CVP and SWP to assist in creating assets for the EWA, which may then be managed to enable the EWA Management Agencies to prescribe actions modifying CVP or SWP exports, releases, or DCC operations to enhance fish protection and foster recovery of Delta-dependent species. The capabilities of the CVP and SWP so dedicated to the EWA include dedicated SWP capacity, a 50 percent share of surplus export capacity, and 50 percent of the “state gain” derived from CVPIA or EWP flows.

North Bay Aqueduct

North Bay Aqueduct 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. This facility was not in the 1986 COA. No formal agreement exists covering its COA treatment, but it has been accounted de-facto as an in-basin use since its inception. DWR and USBR have proposed to account for these diversions as SWP export diversions.

Loss of 195,000 acre-feet 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. 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 acre-feet of replacement pumping has diminished the accomplishments anticipated by the CVP under the 1986 COA.

The implementation of the 1986 COA has continued, without change in its terms or provisions, despite the addition of these and other new features, laws, criteria, and considerations. As COA implementation has evolved in response to the many additional considerations, long-term capabilities of the projects to develop their water supplies has also changed. Also, the short-term capabilities and means available to the projects to implement the COA have become more constrained than envisioned in 1986. Since 1986, planning operations to meet exports and in-basin uses has been strained by the growth in demand for water, especially in the export service areas and by new operations requirements resulting from CVPIA, ESA, and the new Delta standards of D-1641. There is much more emphasis placed on reservoir release stability and temperature control, both of which can limit options for coordinated responses to real-time changes in in-basin and export needs. With growth in water demand, new Delta standards, and EWA operations, there is less surplus capacity available to the projects, which results in fewer options for adjusting to changing conditions by time-shifting exports. Finally, the prevalence of water transfers, and the CVP and SWP commitment to facilitate them, has also reduced surplus capacity available to the projects while adding new layers of complexity to coordination and operations planning.

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. It goes on to state that the parties shall:

- Compare the relative success that 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 goes on to state, "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."

Since 1986, there have been several efforts to institute a process to review and update the COA, but none has progressed beyond the identification of issues and superficial examination, perhaps because of the daunting scope, cost, commitment, and risks involved in following through on a COA review. Also complicating the task of planning, scoping, and carrying out the COA review is the universal interest that would exist among every stakeholder group with an interest in California water resources. Finally, if proposed changes in the COA went beyond the limited scope permitted by the existing agreement, Congressional re-authorization would be needed.

In December 1994, the State of California and United States of America, as well as many stakeholder interests, agreed to a new set of Sacramento-San Joaquin Delta Estuary Standards for the protection of beneficial uses in the Delta Estuary. Analysis performed in support of the Bay-Delta Accord estimated a potential 1.1 million acre-feet (maf) reduction to CVP-SWP water supplies during the critical drought period to meet the new standards. No COA review or delineation of project responsibility was performed as part of the Accord process. The water supply reduction estimates were simply reported as CVP-SWP reductions to delivery capability, not as individual project reductions to delivery capability.

Beginning in 1995, and continuing under SWRCB D-1641, the projects have operated to meet the revised Delta standards. Because of the initial 5 consecutive wet years in the Central Valley, the operational conflicts of meeting the new Delta standards without a review of COA have been minimal. Operational conflicts between the CVP and SWP may become more pronounced during dry hydrologic sequences (as has occurred since 2000) in the Central Valley. The changes to the CVP and SWP since 1986 suggest a COA review would be appropriate.

The August 2000 CALFED 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. During the summer and fall 2000, Reclamation and DWR began preparation for a comprehensive review of the COA. The Reclamation effort produced a preliminary plan, which identified a 6-year process, creation of a special office within the Mid-Pacific Region with six full-time equivalents (FTEs), and a total cost of $20 million. In April 2001, operations staff from both Reclamation and DWR began discussing the need to review the COA and ways to proceed with such discussions. In May 2002, several meetings were held among Reclamation, DWR, and CVP and SWP contractors to discuss status of the COA and to identify issues that warrant consideration in a review of the COA.

Currently, the CVOO and SWPOCO are addressing the COA on an ad-hoc basis. Such CVP-SWP operations make it difficult, if not impossible, to evaluate or ensure long-term equity in respective water operation burdens or water supplies. The SWP and CVP have a mutual need to formally address the COA, or in some type of operations agreement, the influences and factors that have changed the CVP-SWP operational environment since the early 1990s. It appears unlikely that a formal long-term COA revision can be achieved in the near future, nor should it be attempted at this time, given all the uncertainties and potential operations conflicts in today's dynamic regulatory environment.

SWRCB WQCP, SWRCB D-1641 and Sacramento - San Joaquin Delta CVP-SWP Operations Criteria

In August 1978, SWRCB adopted the WQCP for the Sacramento-San Joaquin Delta and Suisun Marsh, which established revised water quality objectives for flow and salinity in the Delta and Suisun Marsh. In D-1485, also adopted in August 1978, SWRCB required Reclamation and DWR to operate the CVP and SWP to meet all the 1978 WQCP objectives except some salinity objectives in the southern Delta. In 1991, the SWRCB adopted a WQCP that superseded parts of the 1978 WQCP, but SWRCB did not revise the water rights of DWR and Reclamation to reflect the objectives in the 1991 WQCP.

In March 1994, SWRCB convened a series of workshops to review Delta protection objectives in its 1991 WQCP for the Delta and to study the proposed standards issued by EPA. In mid-summer 1994, the California Water Policy Council and the Federal Ecosystem Directorate (EPA, NOAA Fisheries, FWS, and Reclamation) developed and signed a historic agreement for the Bay-Delta Estuary. The Framework Agreement between the Governor's Water Policy Council of the State of California and the Federal Ecosystem Directorate is included in Appendix F. One feature of the Framework Agreement was creation of the CALFED Ops Group to deal with coordination issues between SWP and CVP operations and requirements of endangered species biological opinions.

After nearly 9 months of workshops, SWRCB issued a draft WQCP for the Bay-Delta Estuary on December 15, 1994. This coincided with numerous urban, agricultural, and environmental interest groups and governmental agencies signing the Principles for Agreement on Bay-Delta Standards between the State of California and the Federal Government on December 15, 1994.

SWRCB used elements of the Principles for Agreement (with modifications) and recommendations from interested parties in preparing a new draft plan. Reclamation (with DWR consent) incorporated the standards in the Principles for Agreement into the biological assessments for winter-run and Delta smelt. On May 22, 1995, SWRCB adopted the WQCP for the San Francisco Bay/Sacramento-San Joaquin Delta Estuary (1995 Bay-Delta Plan). The 1995 Bay-Delta Plan superseded both the 1978 and 1991 WQCPs.

On December 29, 1999, SWRCB adopted (and on March 15, 2000, revised) Decision 1641, amending certain terms and conditions of the water rights of the SWP and CVP. D-1641 substituted certain objectives adopted in the 1995 Bay-Delta Plan for water quality objectives required to be met 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 standards for fish and wildlife protection, M&I water quality, agricultural water quality, and Suisun Marsh salinity. 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. D-1641 modified the Vernalis salinity standard under D-1422 to the corresponding Vernalis salinity objective in the 1995 Bay-Delta Plan. See Figure 2–1 below.

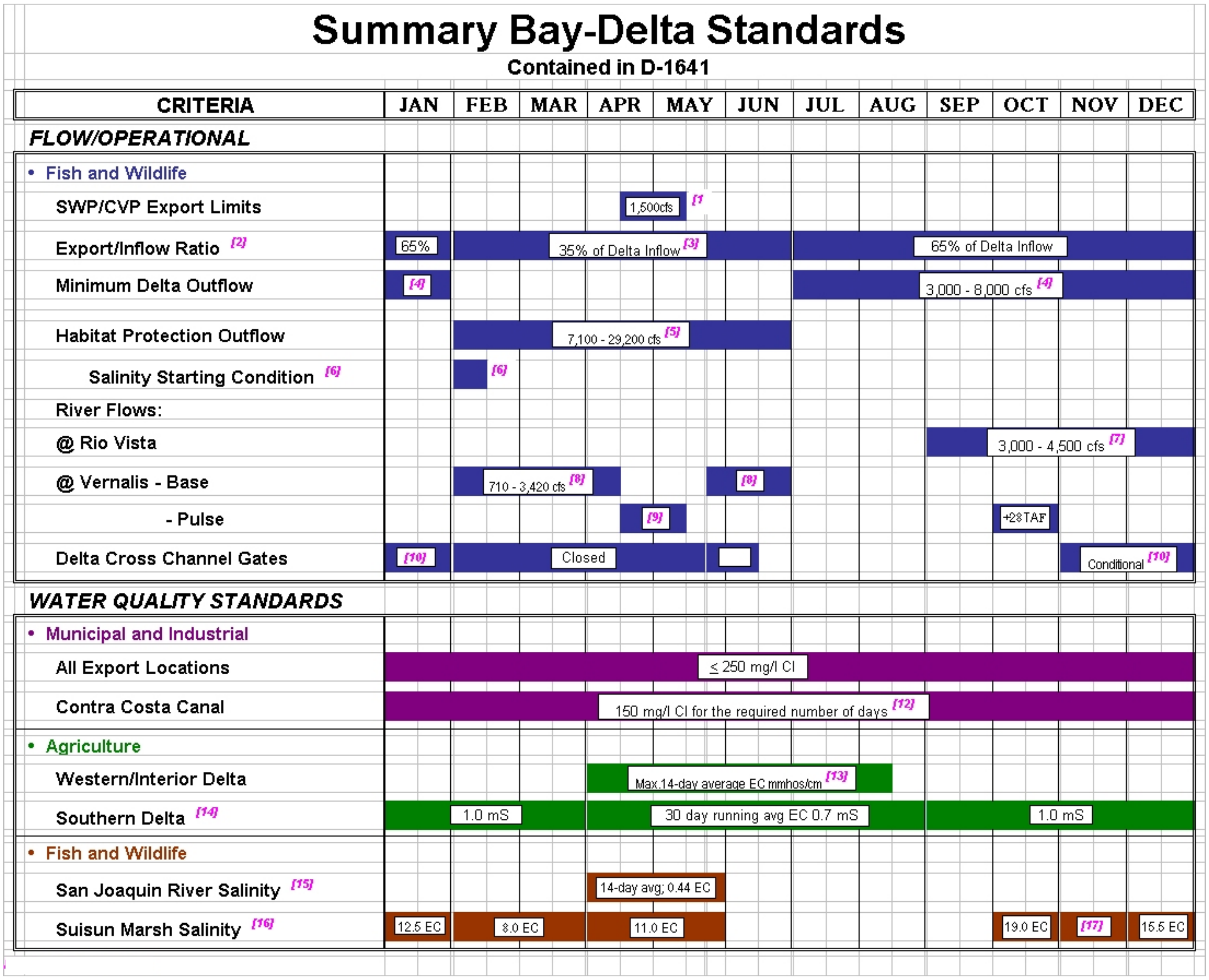


Figure 2–1 Summary Bay Delta Standards

Fish and Wildlife - SWRCB D-1641 CVP-SWP Operations Controlling Elements

Habitat Protection Outflow and Salinity Starting Conditions – (X2 Standards)

A major regulatory cornerstone of the 1995 WQCP is the development of water quality standards based on the geographical position of the 2-parts-per-thousand (ppt) isohale (aka X2). The geographical position of the 2-ppt isohale is considered significant to the biologically important entrapment zone of the estuary and the resident fishery. D-1641 standards create a systematic approach for CVP-SWP operations to influence the position of the X2 location. The key to the regulatory system is the concept of an “X2 day”. An X2 day can be operationally accomplished by the CVP-SWP meeting one of three potential equivalents. The three potential equivalents are:

- 2.64 mmhos/cm Electrical Conductivity (EC) at the desired geographic compliance location for the day.

- 14-day average of 2.64 mmhos/cm EC at the desired geographic compliance location
- A pre-determined Delta outflow equivalent for the desired X2 compliance location for the day

If any of these conditions are met, the day is included as a potential compliance X2 day.

The determination of the desired geographic compliance location and the required number of X2 days per month in the February to June time period is defined by regulatory standard tables (see Figure 2–2). The tables determine the required number of X2 days based on the previous month's "8RI" which is the estimated full natural runoff of the largest eight streams in the Sacramento-San Joaquin watershed. The Port Chicago standards are conditionally triggered only if the on the last day of the previous month, the 14-day mean EC is less than 2.64 mmhos/cm. Excess compliance days at the desired geographic compliance location from the previous month are allowed to be counted toward meeting the current month's regulatory required days.

D-1641 X2 requirements also contain a condition known as the "salinity starting gate" requirement. In all but very dry January conditions, the CVP-SWP project must ensure that the actual X2 water quality (on a daily or 14-day mean) is west of Collinsville for a least one X2 day during the February 1st to 14th time period. This requirement is conditional for some dry January conditions and is based on the CALFED Ops Group discretion. The fishery significance of the salinity starting gate is considered to place X2 generally west of CVP-SWP export influence and into the Suisun Marsh habitat environment.

TABLE A

Number of Days When Max. Daily Average Electrical Conductivity of 2.64 mmhos/cm Must Be Maintained. (This can also be met with a maximum 14-day running average EC of 2.64 mmhos/cm, or 3-day running average Delta outflows of 11,400 cfs and 29,200 cfs, respectively.) Port Chicago Standard is triggered only when the 14-day average EC for the last day of the previous month is 2.64 mmhos/cm or less. PMI is previous month's 8RI. If salinity/flow objectives are met for a greater number of days than required for any month, the excess days shall be applied towards the following month's requirement. The number of day's for values of the PMI between those specified below shall be determined by linear interpolation.

PMI	Chipps Island (Chipps Island Station D10)				
(TAF)	FEB	MAR	APR	MAY	JUN
≤ 500	0	0	0	0	0
750	0	0	0	0	0
1000	28*	12	2	0	0
1250	28	31	6	0	0
1500	28	31	13	0	0
1750	28	31	20	0	0
2000	28	31	25	1	0
2250	28	31	27	3	0
2500	28	31	29	11	1
2750	28	31	29	20	2
3000	28	31	30	27	4
3250	28	31	30	29	8
3500	28	31	30	30	13
3750	28	31	30	31	18
4000	28	31	30	31	23
4250	28	31	30	31	25
4500	28	31	30	31	27
4750	28	31	30	31	28
5000	28	31	30	31	29
5250	28	31	30	31	29
≥ 5500	28	31	30	31	30

*When 800 TAF < PMI < 1000 TAF, the number of days is determined by linear interpolation between 0 and 28 days.

PMI	Port Chicago (continuous recorder at Port Chicago)				
(TAF)	FEB	MAR	APR	MAY	JUN
0	0	0	0	0	0
250	1	0	0	0	0
500	4	1	0	0	0
750	8	2	0	0	0
1000	12	4	0	0	0
1250	15	6	1	0	0
1500	18	9	1	0	0
1750	20	12	2	0	0
2000	21	15	4	0	0
2250	22	17	5	1	0
2500	23	19	8	1	0
2750	24	21	10	2	0
3000	25	23	12	4	0
3250	25	24	14	6	0
3500	25	25	16	9	0
3750	26	26	18	12	0
4000	26	27	20	15	0
4250	26	27	21	18	1
4500	26	28	23	21	2
4750	27	28	24	23	3
5000	27	28	25	25	4
5250	27	29	25	26	6
5500	27	29	26	28	9
5750	27	29	27	28	13
6000	27	29	27	29	16
6250	27	30	27	29	19
6500	27	30	28	30	22
6750	27	30	28	30	24
7000	27	30	28	30	26
7250	27	30	28	30	27
7500	27	30	29	30	28
7750	27	30	29	31	28
8000	27	30	29	31	29
8250	28	30	29	31	29
8500	28	30	29	31	29
8750	28	30	29	31	30
9000	28	30	29	31	30
9250	28	30	29	31	30
9500	28	31	29	31	30
9750	28	31	29	31	30
10000	28	31	30	31	30
> 10000	28	31	30	31	30

Figure 2–2 Table A shows number of days when Max. Daily Average Electrical Conductivity of 2.64 mmhos/cm must be maintained

Export/Inflow Ratio Export Restrictions

Another significant regulatory cornerstone of the D-1641 standards is an export rate restriction standard known as the export/inflow (E/I) ratio. The E/I ratio is measured as the current average 3- day export rate for the SWP Clifton Court intake and CVP Tracy Pumping Plant divided by the estimated average inflow to the Delta over a 3- or 14-day period. The inflow parameter is required to be on a 14-day basis when hydrologic conditions are such that CVP-SWP exports are not supported by CVP-SWP reservoir storage withdrawals. This generally occurs during the winter and spring. The 3-day inflow parameter basis occurs when CVP-SWP exports are supported by CVP-SWP reservoir storage withdrawals, and generally occurs late spring through the first significant rains in the fall or winter. D-1641 standards for the E/I ratio generally require a ratio of 35 percent during February to June and 65 percent in all other months. The E/I standard is relaxed to 45 percent in February after the driest of January runoff conditions (8 River Index < 1.0), or may be relaxed to 45 percent after a January for which the 8 River Index is in the range 1.0 to 1.5, after consultation within the CALFED Ops Group. Relaxation of the E/I ratio requirement is also a management/water supply tool available to the Management Agencies by the EWA Principles Agreement.

The biological rationale of the E/I ratio requirement is to require the CVP-SWP export operations to avoid exporting the leading edge of increased inflows produced by rain events into the Delta environment. Prior to D-1641 E/I ratio standards, the CVP-SWP export operations often increased exports prior to the leading edge of increased Delta inflow based on anticipated inflow quantity and duration to the Delta and estimated incremental effects to the Delta water quality environment.

Minimum Delta Outflow

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

Figure 2–3 Minimum monthly average Delta outflow

D-1641 instituted a set of minimum monthly Delta outflow requirements (see Figure 2–3). The requirements are designed for the months outside of the February to June X2 period and are segregated by hydrologic year type. D-1641 standards use the Sacramento River 40-30-30 index methodology to designate the hydrologic year type. The standard is designed to be complementary to the X2 habitat standard by “regulating” the eastward movement of X2 during the summer timeframe based on hydrologic conditions. Wetter conditions have higher outflow requirements in the July-August timeframe. The standard also sets a minimum outflow requirement for fall/early winter, with minor relaxation for critical years or a dry December. The minimum monthly outflow standards also contain sub-month running average requirements designed to moderate or elevate protection levels when the monthly hydrologic conditions are dominated by a single Delta inflow event.

The regulatory combination of X2 standards, E/I ratio export restrictions, or minimum Delta outflow requirements creates a hydrologic dynamic regulatory environment of CVP-SWP operations controlling Delta requirements. When rain events change the anticipated hydrologic conditions to the Delta environment, the controlling Delta requirement can easily and quickly change from a minimum Delta outflow requirement or X2 habitat requirement to an E/I ratio limitation and subsequently back to a sub-month running average minimum Delta outflow requirement. Therefore, the value of projecting CVP-SWP export operations is limited to short time periods. Projecting CVP-SWP export operations over a season or annual basis is sensitive to the magnitude, duration, and season that significant Delta inflow events occur.

Sacramento River Rio Vista flow standards

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

Figure 2–4 Rio Vista minimum monthly average flow rate in cfs

D-1641 standards contain a requirement to maintain a monthly flow index at Rio Vista in the Sacramento River (see Figure 2–4), as well as sub-month running average limitations. The flow index applies to the fall months and is designed to maintain a sufficient net downstream flow in the lower Sacramento River environment for salmon migration. Rio Vista flow is a calculated flow index sensitive to Sacramento River flow at Freeport, Yolo Bypass flow, estimated gross channel depletion, estimated rainfall reduction in gross channel depletion, and DCC gate operation. Closure of the DCC gate increases the Rio Vista flow index by approximately 20 percent of the current Freeport flow rate. The Rio Vista flow index is not affected by CVP-SWP export operations. If the Rio Vista flow standard becomes a CVP-SWP operation controlling standard, project operators have the management choice of increasing flows from upstream reservoirs or to close the DCC gates to maintain compliance. Further detail on DCC operations is included under DCC Gate Operation later in this document.

San Joaquin River Base flow standards

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

Figure 2–5 Base Vernalis minimum monthly average flow rate in cfs

D-1641 standards contain a time period flow requirement at the Vernalis gauge location in the San Joaquin River (see Figure 2–5). The standard also has sub-month running average limitations. The requirement is determined based on the San Joaquin River “60-20-20” water year index at a 75 percent probability exceedance projection. For each year type, a higher flow rate and a lower flow rate are shown. The actual required flow rate for the time period is based on the required number of days that the X2 standard must comply at the Chipps Island geographic location. Therefore, a time period Vernalis base flow requirement may have a combination of the higher flows and the lower flows based on compliance with the X2 Chipps Island standard. The biological intent of this standard is to maintain a fractional component of the X2 Chipps Island standards to be contributed from the San Joaquin Basin and South Delta channels. The project operation and commitment to this standard are discussed later in the East Side Division in Chapter 3.

San Joaquin River Pulse Flow Requirement and CVP-SWP Export limitation

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.

Figure 2–6 Pulse Vernalis minimum monthly average flow rate in cfs

Maximum 3-day running average of combined export rate (cfs) which includes Tracy Pumping Plant and Clifton Court Forebay Inflow less Byron-Bethany

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.

Figure 2–7 Maximum 3-day running average of combined export rate (cfs)

D-1641 standards contain the requirements shown in Figure 2–6 to provide a month-long San Joaquin River pulse flow and CVP-SWP export limitation. The San Joaquin River spring pulse period's intent is to improve the escapement of juvenile salmon from the San Joaquin River system by providing improved river flows and reduced CVP-SWP export potential. The time period of the pulse flow is also typically coincident with a sensitive period of larval/juvenile Delta resident species. The San Joaquin River spring pulse requirements are controversial and were the subject of significant debate both technical and legal. To negotiate a potential 12-year settlement of the controversies and to continue to learn more about the technical unknowns of the spring pulse period concept, the Vernalis Adaptive Management Program (VAMP) was crafted. For the VAMP framework, the San Joaquin River spring pulse design is reworked into a combined set of experimental flows at Vernalis and CVP-SWP export rates (see Figure 2–7). The CVP's commitment to the San Joaquin River spring pulse flow component is discussed in the East Side Division section. The CVP-SWP commitment to the San Joaquin River spring pulse export commitment will be discussed for the CVP under the Department of the Interior Decision on Implementation of Section 3406 (b)(2) of the CVPIA for the Delta environment, and for the SWP under the EWA program in the Delta environment.

M&I Water Quality - SWRCB D-1641 CVP-SWP operations controlling elements

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

Figure 2–8 Minimum # of days that mean daily chlorides ≤ 150 mg/l

D-1641 M&I water quality standards are identical to the M&I standards in place under the D-1485 standards. The only regulatory change to the M&I standards under D-1641 is the use of the Sacramento Valley water supply index (SVI or "40-30-30") to determine the year type rather than the Unimpaired Sacramento River Index (SRI) used in D-1485 to determine year type. The standards require that several M&I points of diversion must have mean daily chloride levels of less than 250 milligrams per liter (mg/l) year round The standards also require that the Contra Costa Canal or Antioch Water Works have a required number of days at less than 150 mg/l chlorides as delineated by year type (see Figure 2-7). .

CVP-SWP operations to meet the operational requirements of D-1641 standards have generally improved the chloride concentrations at M&I locations. The water quality enhancement is due to the generally higher outflow requirements necessary to meet D-1641 fish and wildlife beneficial uses, such as the X2 standards, E/I ratios, and minimum Delta outflow requirements.

The maximum14-day running average of mean daily EC (mmhos/cm) depends on water year type.

	WESTERN DELTA				INTERIOR DELTA			
	Sac River @ Emmaton		SJR @ Jersey Point		Mokelumne R @ Terminous		SJR @ San Andreas	
Year Type	0.45 EC from April 1 to date shown	EC value from date shown to Aug15 *	0.45 EC from April 1 to date shown	EC value from date shown to Aug15 *	0.45 EC from April 1 to date shown	EC value from date shown to Aug15 *	0.45 EC from April 1 to date shown	EC value from date shown to 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.

Figure 2–9 Agricultural Water Quality - SWRCB D-1641 CVP-SWP operations controlling elements

D-1641 Western and Interior agricultural (Ag.) water quality standards (see Figure 2-8) are identical to the Ag. standards in place under the D-1485 standards. The only regulatory change to the Ag. standards under D-1641 is the use of the Sacramento Valley water supply index (SVI or “40-30-30”) to determine the year type rather than the Unimpaired SRI used in D-1485 to determine year type.

The Southern Delta Agricultural Water Quality standard was modified in D-1641 to be based on EC parameters rather than the total dissolved solids (TDS) parameter that was required in D-1422. The modified D-1641 standards specify that salinity shall be controlled on the San Joaquin River at Vernalis to a 30-day mean EC mmhos/cm of 0.7 for the irrigation season of April to August and 1.0 EC mmhos/cm for the non-irrigation season of September to March. D-1641 standards also address the application of the salinity standard to additional downstream compliance locations beginning in April 2005. The CVP’s commitment to the Southern Delta Agricultural water quality standards is discussed in the East Side Division section.

Joint Point Of Diversion (JPOD)

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. SWRCB conditioned the use of JPOD capabilities based on staged implementation and conditional requirements for each stage of implementation. The stages of JPOD in D-1641 are:

- Stage 1 – 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 that must be satisfied in order to implement JPOD.

All stages require a response plan to ensure that 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 that 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.

JPOD under excess conditions in the Delta is junior to Contra Costa Water District's 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 for Delta Smelt.

Stage 2 has the additional requirement to complete an operations plan to protect fish and wildlife and other legal users of water. This is commonly known as the Fisheries Response Plan.

Stage 3 has the additional requirement to protect water levels in the southern Delta under the operational conditions of the permanent South Delta Barrier program and an updated companion Fisheries Response Plan.

Reclamation and DWR intend to apply all the response plan criteria consistently for JPOD uses as well as water transfer uses.

The priority access to project facilities has been addressed in the CALFED EWA protocols. Stage 2 CVP JPOD has the same priority of use of excess Banks Pumping Plant capacity as the EWA program. Article 55 of SWP contracts gives the SWP contractors preferential use of excess Banks Pumping Plant capacity. Reclamation, in approving water transfers involving water from CVP water sources, including those that use SWP Article 55, will consider the potential effects on use of JPOD to move CVP reservoir storage releases.

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 VAMP period, the project with the deficit in San Luis storage may 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 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.

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 transfer parties 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 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 is 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 particular, parties to the transfer are responsible for providing for incremental changes in flows required to protect Delta water quality standards. Reclamation and DWR will work to facilitate transfers and will complete them in accordance with regulations and requirements.

Purchasers of water for water transfers may include Reclamation, DWR, SWP contractors, CVP contractors, other State and Federal agencies, and 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. 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 instream flows, CVP contractors south of the Delta, and wildlife refuge supplies. DWR and Reclamation cooperatively administer the Environmental Water Account. Although technically not a water transfer program, the Phase 8 Water Rights Settlement among Sacramento Valley water rights holders, Reclamation, DWR, and CVP and SWP export water users has characteristics of a transfer program in that water will be provided upstream of the Delta and increased exports will result. SWP and CVP 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 used by DWR to meet SWP entitlements.

The CVP and SWP may provide Delta export pumping for transfers using surplus capacity, up to the physical maximums of the pumps, consistent with prevailing operations constraints such as E/I ratio, conveyance or storage capacity, and 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 or other beneficial uses.

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 capacity for their own supplies. CVP has little surplus capacity except in the driest of 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 above-normal and wet years when demands may be lower and contractors have alternative supplies.

The availability of water for transfer and the demand for transfer water also may vary with hydrologic conditions. Accordingly, because many transfers are negotiated between willing buyers and sellers under prevailing market conditions, the price of water also may be a factor determining how much is transferred in a year. This document does not 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. In recent dry and critical years, water transfers from upstream locations to Delta export locations have ranged from approximately 175,000 acre-feet to more than 400,000 acre-feet. In the future, these quantities may increase. Water transfers may range as high as 800,000 acre-feet[2], depending on the severity of the water supply situation, cross-Delta capacity, and available supplies upstream.

Although supply, demand, and the price of water may at times be limiting factors, it would be reasonable to assume that in many years, all the available CVP and SWP capacity to facilitate transfers will be used.

Project Management Objectives

The CVP is the Mid-Pacific Region's largest project. Facilities are operated and maintained by local field offices, with operations overseen by the CVOO at the Joint Operations Center in Sacramento. 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.

Central Valley Project Improvement Act

Reclamation's evolving mission was written into law on October 30, 1992, with the passage by Congress and signing by President George Bush of Public Law 102-575, the Reclamation Projects Authorization and Adjustment Act of 1992. 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 acre-feet 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

[2] DWR's 1991 Drought Water Bank purchased over 800,000 acre-feet and conveyed approximately 470,000 acre-feet of purchased water across the Delta.

- Implementing fish passage measures at Red Bluff Diversion Dam
- Planning to increase the CVP yield
- Mandating firm water supplies for Central Valley wildlife refuges
- 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 January 9, 2001.

Operations of the CVP reflect provisions of the CVPIA, particularly Sections 3406(b)(1), (b)(2), and (b)(3). The Department of the Interior Decision on Implementation of Section 3406 (b)(2) of the CVPIA, October 5, 1999, provides the basis for implementing upstream and Delta actions with CVP delivery capability.

The VAMP assumes that San Joaquin River water will be acquired under Section 3406(b)(3) to support increased Vernalis flows during the pulse flow period. During the driest years, the flow is 2,000 cfs, while in the wettest years, the flow is 7,000 cfs. Depending on hydrologic conditions, additional water (above the commitment expressed in the San Joaquin River Agreement) may be needed to meet pulse flow or base flow objectives on the San Joaquin River. Proposed operations also include allocation of water to refuges through CVPIA.

CALFED

In June 1994, a "Framework Agreement" was signed setting forth the operating principles to develop a long-term solution to Bay-Delta problems. The Agreement laid the foundation for CALFED and for the signing of the Bay- Delta Accord on December 15, 1994, by Federal and State resource agencies and by stakeholders representing many water agencies and environmental organizations.

The first public meeting of the CALFED Ops Group was held in January 1995. Discussions about the responsibilities and decision-making process began immediately. Over 6 years, the group developed and refined its process. The CALFED Ops Group has been recognized within SWRCB D-1641, and elsewhere, as a forum for consultation on decisions to exercise flexibility that has been incorporated into the Delta standards for protection of beneficial uses (e.g., E/I ratios and some DCC closures). The CALFED Ops Group meets monthly. In 2000, the CALFED Water Operations Management Team (WOMT) was formed, consisting of management-level participants from Reclamation, DWR, NOAA Fisheries, Department of Fish and Game (DFG), and FWS. The WOMT meets weekly to provide a more timely forum for oversight and decision-making within the CALFED Ops Group process.

Phase I of CALFED was completed in September 1996 and focused on identifying and defining problems in the Bay-Delta system. Three alternatives were identified for further analyses in Phase II. Phase II developed a preferred program alternative and conducted a comprehensive programmatic environmental review process on a broad level. Phase III has begun the implementation portion of the program. It is expected to take 30 years to complete the largest and most comprehensive water management program in the world.

On June 9, 2000, Secretary of the Interior Bruce Babbitt and California Governor Gray Davis released "California's Water Future: A Framework for Action." The Framework delineated specific actions for the implementation of the proposed preferred alternative to meet CALFED goals and ensure a balanced approach to implementation. Stage 1 of Phase III covers the first 7 years of implementation, setting forth the direction and building the foundation for long-term actions. The Framework calls for more than $8.6 billion to be invested over the 7 years. Framework components are to be funded by both the Federal and State governments as cost-share partners.

The lead CALFED agencies released the Final Programmatic Environmental Impact Statement/Environmental Impact Report and the Preferred Alternative on July 21, 2000. This was followed by the signing of the ROD on August 28, 2000, which formally approved a long-term plan to restore the Bay-Delta ecosystem and improve water management. The ROD outlines commitments by the Federal and State governments and performance goals for CALFED.

The CALFED Environmental Water Account

The CALFED program was established to develop a long-term comprehensive plan for the Bay-Delta System with one component, the Ecosystem Restoration Program (ERP), focused on a comprehensive effort to restore the ecological health of the Bay-Delta ecosystem. The EWA is a cooperative management program whose purpose is to protect the fish of the Bay-Delta estuary through environmentally beneficial changes in SWP/CVP operations at no uncompensated water cost to the projects' water users. The EWA is intended to provide sufficient water (beyond what is available through regulatory actions related to project operations), combined with the ERP and the regulatory baseline, to address CALFED's fishery protection and restoration/recovery needs. This approach to fish protection requires the acquisition of alternative sources of project water supply, called the "EWA assets," to augment streamflows and Delta outflows, to modify exports to provide fishery benefits, and to replace the regular project water supply interrupted by the changes to project operations. The replacement water will compensate for reductions in deliveries relative to existing facilities, project operations, and the regulatory baseline that result from EWA actions.

FWS, NOAA Fisheries, DFG, Reclamation, and DWR entered into the Environmental Water Account Operating Principles Agreement (dated August 28, 2000), which established the EWA. The Management Agencies (FWS, NOAA Fisheries, and DFG) manage the EWA assets and exercise their biological judgment to recommend SWP/CVP operational changes beneficial to the Bay-Delta ecosystem or the long-term survival of fish species. The Project Agencies (Reclamation and DWR) cooperate with the Management Agencies in administering the EWA and making the operational changes proposed by the Management Agencies. The EWA provides commitments under the Federal and State Endangered Species Act for the first 4 years of Stage 1 (which covers the first 7 years of the CALFED program and sets forth the direction and builds the foundation for long-term actions).

On July 10, 2000, the U.S. Army Corps of Engineers (Corps) approved DWR's proposal to increase the maximum allowable daily diversion rate into Clifton Court Forebay during July, August, and September by 500 cfs. This proposed change to normal project operations is being addressed in a separate consultation in conjunction with Corps. This proposed change is included because it has been modeled into the forecasts on which this impact analysis is based. The proposed pumping increase is contingent on the following:

- The additional diversion will not increase the annual water supply for SWP. In addition, it can only be used to offset reduced diversions that occurred because of ESA or other actions to benefit fishery resources.
- Distribution of fish species of concern must be outside the influence of export facilities. Decisions concerning the potential for fisheries impacts would occur via the CALFED Ops process.
- All three temporary agricultural barriers must be in place and operating when diversions increase. Impacts to local water users must be avoided. During the first year, increased diversions will be avoided when adverse conditions occur downstream of the barriers.
- The operations of the SWP and CVP will comply with requirements of the SWRCB, ESA, and other regulatory and contractual requirements related to the Sacramento-San Joaquin Delta.

DWR and Reclamation have applied to the Corps for a permit to extend the use of the additional 500 cfs of Banks pumping to July, August, and September of 2003 and 2004.

Hydropower

Background

CVP power generation facilities include 11 hydroelectric powerplants with 38 generators and have a total maximum generating capacity of 2,071 megawatts (MW). The CVP also includes 856 circuit miles of high-voltage transmission lines needed to deliver CVP power. These transmission lines are operated by the Western Area Power Administration. CVP power is used throughout central and northern California, first to meet the authorized needs of the project including irrigation pumping, M&I pumping, fish and wildlife, and station service. Approximately 25 to 30 percent of the CVP total power generation is used to support these "Project Use" needs. Currently, Western markets the remaining power to Preference Power Customers, such as Federal agencies, military bases, municipalities, public utilities districts, irrigation and water districts, state agencies, rural electric cooperatives, and public transportation districts. In addition to providing peaking generation to the central and northern California power system, the CVP supplies many secondary benefits to the power system including VAR (magnetic or inductive power) support, regulation, spinning reserves, and black-start capabilities. CVP generation and transmission facilities are shown in Figure 2-11.

CVP facilities were constructed and are operated under Reclamation Law and the authorizing legislation for each facility. Initially, Reclamation projects were authorized under the Reclamation Act of 1902. This Act authorized projects to be developed solely for irrigation and reclamation purposes.

In 1906, Reclamation Law was amended to include power as a purpose of the projects if power was necessary for operation of the irrigation water supply facilities, or if power could be developed economically in conjunction with the water supply projects. The Act of 1906 allowed for lease of surplus power. Surplus power was described as power that exceeds the capacity and energy required to operate the Reclamation facilities (Project Use load). The Act of 1906 stipulated that surplus power would be leased with preference for municipal purposes.

Power supply was first authorized as a purpose for some CVP facilities in the Rivers and Harbors Act of 1937, which included authorization of the initial CVP facilities. The Act of 1937 defined the priorities for the purposes of the CVP as: 1) navigation and flood control, 2) irrigation and M&I water supplies, and 3) power supply.

The Reclamation Project Act of 1939 modified Reclamation Law for all Reclamation facilities, including the CVP. This Act reconfirmed the preference clause, and included the policy that the Federal government would market power to serve the public interest rather than to obtain a profit. The Trinity River Act of 1955 authorized construction of the Trinity River Division (TRD) and allocated up to 25 percent of the energy resulting from the TRD to Trinity County for use in Trinity County. The Rivers and Harbor Act of 1962 authorized the New Melones project and authorized up to 25 percent of the energy resulting from that project to Calaveras and Tuolumne Counties for use in those counties. Customers receiving energy under these authorizations are referred to as “First Preference” customers.

The CVPIA in 1992 modified the authorizations of the CVP making fish and wildlife mitigation a higher priority than power, and power and fish and wildlife enhancement equal priorities. The CVPIA also established the CVPIA Restoration Fund and required payments from CVP water contractors and Preference Power Customers to the fund.

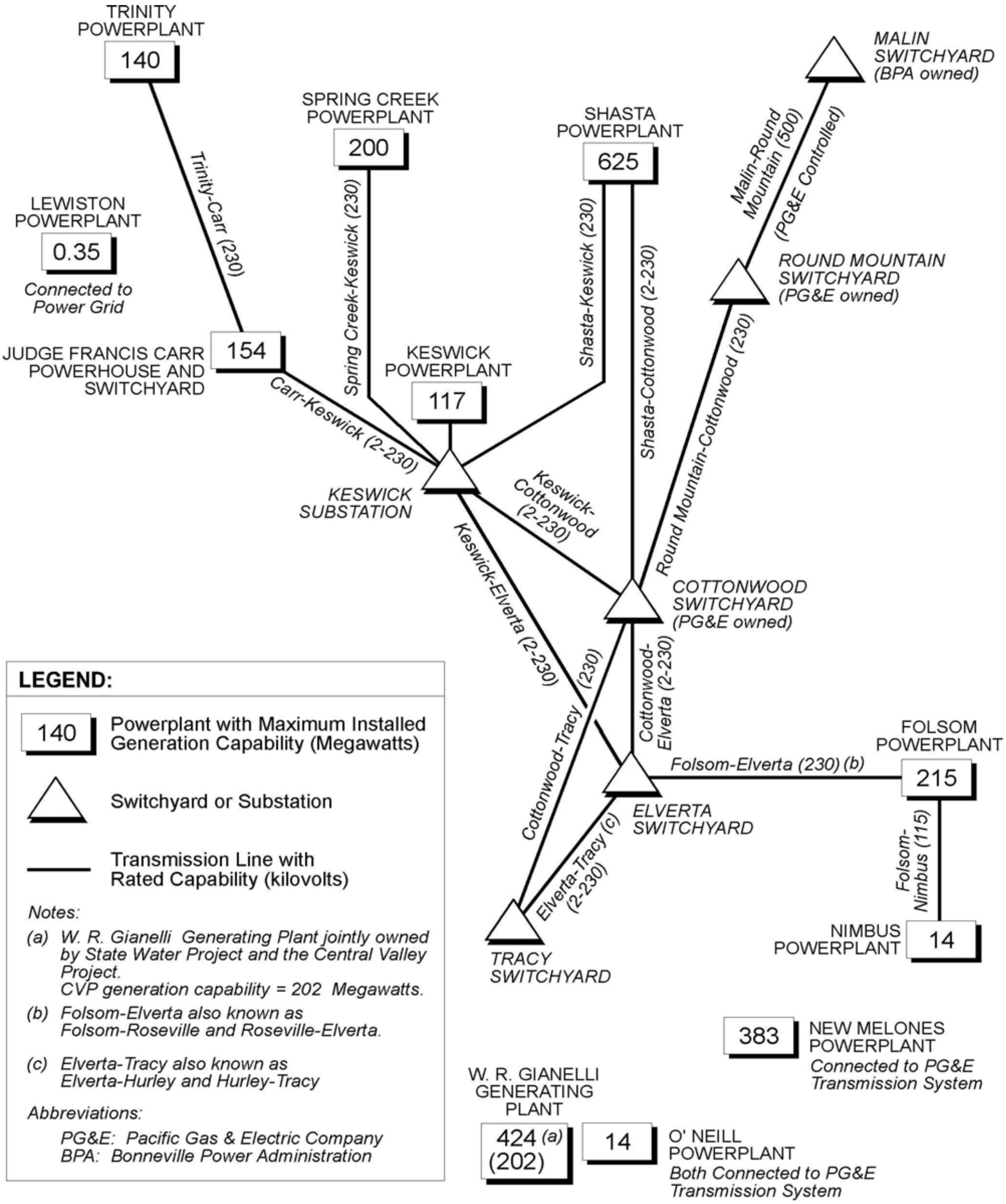


Figure 2–10 CVP Generation and Transmission Facilities

Power Marketing

Until 1977, Reclamation operated the CVP power generation and transmission facilities and marketed the power generated by the CVP facilities. In 1977, Western was established as part of the Department of Energy. Western operates, maintains, and upgrades the transmission grid that was constructed as part of the CVP. Western, as part of its marketing function, ensures that CVP Project Use loads are met by using a mix of generation resources including CVP generation and other purchased resources. Western also dispatches and markets power surplus to the CVP project needs to Preference Power Customers and other utilities.

Hydropower generation does not always occur during times of peak power loads of the CVP and Preference Power Customers. As originally conceived, the CVP included Federally constructed thermal generation and transmission as needed to ensure CVP loads were met at all times. It was determined that it would be more cost-effective to co-utilize generation and transmission facilities constructed by PG&E wherever possible to avoid duplication of facilities. In 1967, Reclamation and PG&E signed an agreement (Contract No. 14-06-200-2948A, or “Contract 2948A”) which allowed for the sale, interchange, and transmission of electrical power between the Federal government and PG&E. Under the terms of Contract 2948A, the generation of CVP hydropower is delivered to PG&E, along with Western power purchases. In return, PG&E supports firm power deliveries to CVP Project Use needs and Preference Power Customers. Power produced in excess of Project Use load and Preference Power Customer deliveries is delivered to PG&E under that agreement.

The CVP is operated whenever possible to optimize the use of generated power. Reclamation, Western, and PG&E work together daily comparing hydropower availability, total loads including PG&E loads, and availability of PG&E resources and transmission capabilities. Daily operations are pre-scheduled the previous day. The Reclamation control center determines the required hourly stream flows and releases from Keswick, Lewiston, Tulloch, and Nimbus Reservoirs to meet water demands, water quality requirements, and generation needs. Reclamation sends the information to the Western dispatch office, which coordinates with the PG&E dispatch center. All three entities confirm and, if necessary, adjust the schedule.

Western markets 1,470 MW of power to more than 70 Preference Power Customers in California, which include municipalities, a rural electric cooperative, Federal installations, State-owned installations, public utility districts, local water and irrigation districts, and a public transportation district.

Both Contract 2948A and the current marketing plan under which Western markets CVP power expire on December 31, 2004. Western, in consultation with its customers and other interested stakeholders, developed the 2004 Power Marketing Plan (Post-2004 Power Marketing Plan), which will be implemented beginning January 1, 2005. Previously, Western supplied customers with a fixed capacity and load factored energy allocation with minimum and maximum entitlements. Under the new plan, customers will receive the net power output of the project after project needs are met. This power resource is referred to as the “Base Resource.” The Post-2004 Power Marketing Plan allows existing customers to receive a percentage allocation of the Base Resource based primarily on their Contract Rate of Delivery (CRD). The Base Resource is a fundamental component of the new marketing plan.

Customers are generally divided in two groups for the Post-2004 Power Marketing Plan: Variable Resource Customers and Full Load Service Customers. Variable Resource Customers are the larger customers who will only receive their share of the project output, and for whom Western will not meet a specific load obligation. These customers will receive most of the Base Resource. Full Load Service Customers are generally smaller customers who will still have a specific load met by Western through a combination of their Base Resource share and additional purchases by Western on their behalf. These customers will receive a smaller percentage of the Base Resource.

Beginning in 2005, Western expects to have up to 72 CVP Preference Power Customers, which include existing Preference Power Customers and 13 new allottees, including, for the first time in the Sierra Nevada Region, four Indian Rancherias. Of the existing customers, four are First Preference entities.

As part of the deregulation of the electric power industry, the California Independent System Operator (CAISO) began operation in 1998. Prior to the CAISO, PG&E was the Control Area Operator for northern and central California, and under its integration contract with PG&E, the CVP had great flexibility in scheduling its loads and resources. Under the CAISO, scheduling requirements for power have changed significantly. Generation schedules now must be submitted several days prior to the actual day of operation. Changes made during the actual day of operation can result in penalties to the generator. Since the formation of the CAISO, PG&E has served as a "Scheduling Coordinator" for the CVP, and, under Contract 2948A, the CVP has not been subject to these scheduling requirements. With the expiration of Contract 2948A and the implementation of the new marketing plan, the CVP will lose much of its scheduling flexibility. Closer coordination between Western and Reclamation will be needed to meet existing and future scheduling requirements.

CVP Repayment

Revenue from CVP power generation is vital to project repayment and operation and maintenance expenses. Power rates for Preference Power Customers are determined by Western. These rates must be sufficient to pay all costs assigned to the CVP power purposes, including operation and maintenance and interest expenses. The revenues must be sufficient to recover the power investment of the CVP facilities within a 50-year period after the facilities become operational or as provided by Federal law. The revenues also must be sufficient to recover the investment in Federal transmission facilities and the cost of replacement of all power facilities within the service life of the facilities up to a maximum period of 50 years. Costs assigned to power also include costs assigned to the irrigation function beyond the ability to pay of certain CVP water contractors. In addition, pursuant to the CVPIA, Western collects required Restoration Fund payments from Preference Power Customers based on estimates made by Reclamation.

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Chapter 3 CVP Division Operations Constraints and Objectives

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 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.

The mean annual inflow to Trinity Lake from the Trinity River is about 1.2 million acre-feet. Historically, an average of about two-thirds of the annual inflow has been diverted to the Sacramento River Basin. 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 Shasta Dam and water released from Spring Creek Debris Dam.

Flood Control—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 million acre-feet from November through March. The Safety of Dams criteria begin to prescribe reservoir releases when storage in Trinity is forecast to exceed 2.0 million acre-feet during November through March.

The safety of dams release criteria specify that Judge Francis 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 cubic feet per second (cfs) below Lewiston Dam under safety of dams criteria because of local high water concerns and local bridge flow capacities until local inflows to Lewiston Lake plus Trinity Dam spillway flows exceed 6,000 cfs plus 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 ROD, the Federal District Court for the Eastern District of California issued a December 10, 2002, Order that directed the CVP to release 368,600 af during critical Trinity River inflow years and 452,000 af during all other conditions. This amount is scheduled in coordination with the FWS to best meet habitat, temperature, and sediment transport objectives in the Trinity Basin.

Temperature objectives for the Trinity River are set forth in State Water Resources Control Board (SWRCB) Water Rights Order 90-5. Temperature objectives vary by reach and by season. Between Lewiston Dam and Douglas City Bridge, the daily average temperature should not exceed 60°F from July 1 to September 14, and 56°F from September 15 to October 1. From October 1 to December 31, the daily average temperature should not exceed 56°F between Lewiston Dam and the confluence of the North Fork Trinity River. Reclamation consults with FWS in establishing a schedule of releases from Lewiston Dam (Figure 3–1) that can best achieve these objectives.

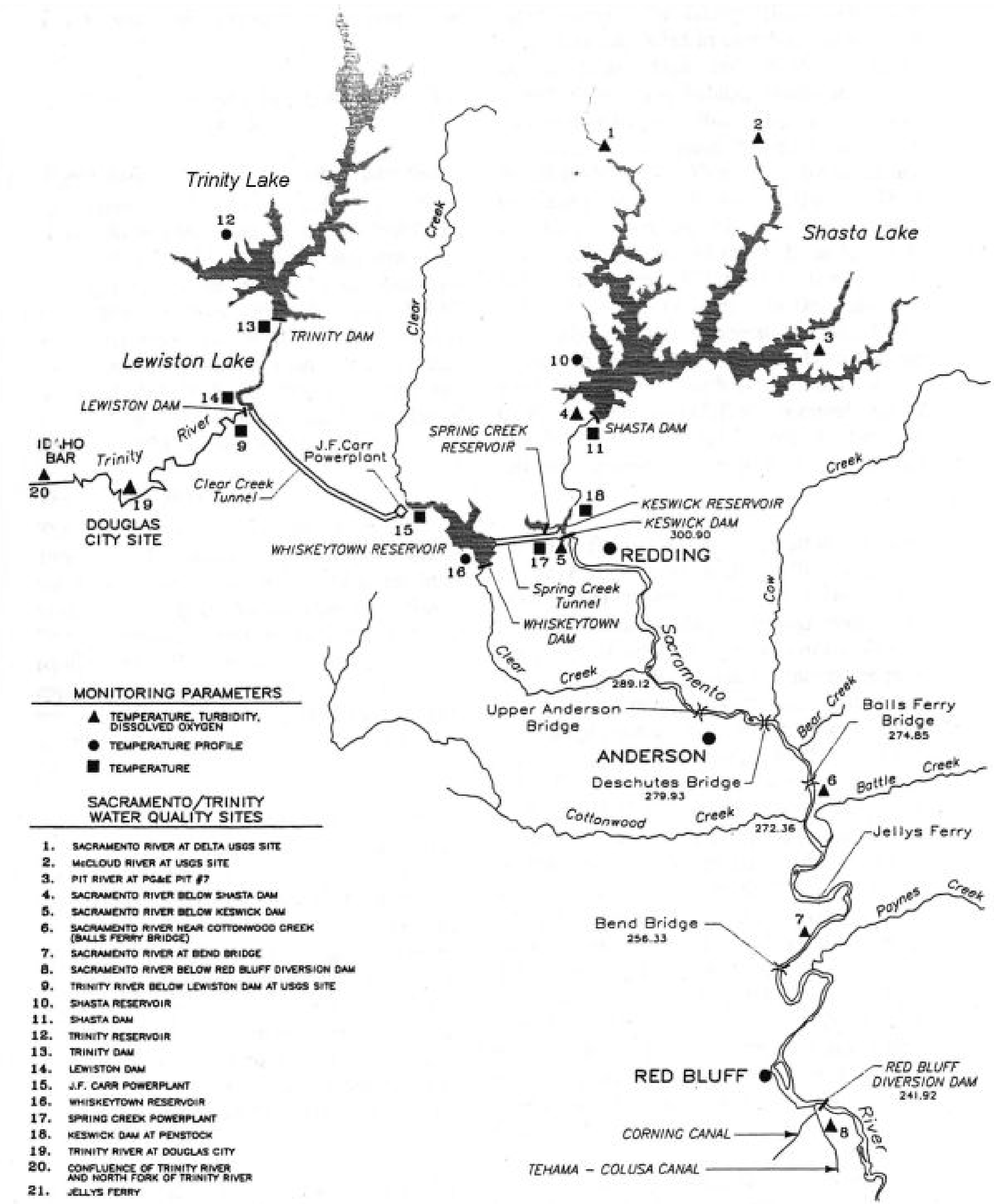

Figure 3–1 Sacramento-Trinity Water Quality Network (with river miles)

Transbasin Exports

Export of Trinity water to the Sacramento Basin provides increased water supply for the CVP and is a major source of CVP power generation. The amounts and timing of the Trinity exports are determined after consideration is given to forecasted Trinity water supply available and Trinity in-basin needs, including carryover storage. Trinity exports are also a key component of water temperature control operations on the upper Sacramento River.

The seasonal timing of Trinity exports is a result of a determination of 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 to 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 because of 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-acre-foot volume in late spring to create a thermal connection to Spring Creek Powerhouse before larger transbasin volumes are scheduled 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.

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 end of April, or early in May.

Hydropower Operations

Trinity Powerplant, located adjacent to the dam, houses two generators with a maximum powerplant operating capability of 140,000 kilo-watts (kW). Maximum powerplant release is 3,693 cfs.

Lewiston Dam is on the Trinity River, 7 miles downstream from Trinity Dam. Lewiston Reservoir functions as a regulating reservoir to control flow fluctuations downstream for Trinity Powerplant and as a forebay to Carr Powerplant. Lewiston Powerplant has one unit with a maximum operating capability of 350 kW. When operating at maximum capacity, Lewiston Powerplant releases 100 cfs.

Carr Powerplant is at the outlet of Clear Creek Tunnel, at the northwest extremity of Whiskeytown Reservoir. Water is diverted by Lewiston Dam via Clear Creek Tunnel through Carr Powerplant and into Whiskeytown Reservoir. The powerplant contains two generators with a maximum powerplant operating capability of 184,000 kW. The maximum powerplant release rate is 3,565 cfs.

Spring Creek Tunnel carries water from Whiskeytown Reservoir to Spring Creek Powerplant, on the Spring Creek arm of Keswick Reservoir. The powerplant houses two generators, with a maximum powerplant operating capability of 200,000 kW. The maximum powerplant release rate is 4,337 cfs.

Recreation

Though not an authorized purpose of the Trinity Division, recreational use of Trinity Lake, Lewiston Reservoir, Whiskeytown Lake, and the Trinity River is significant. Recreational considerations are factored into operational decisions when abnormal reservoir levels or river flows may be expected. In general, the use of recreational facilities is typically constrained only during dry or critically dry conditions.

Whiskeytown Reservoir Operations

Since 1964, a portion of the flow from the Trinity River Basin has been exported to the Sacramento River Basin through 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 (Figure 3–1). 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, are 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 acre-feet 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 Central Valley Project Improvement Act (CVPIA) Anadromous Fish Restoration Program (AFRP) objectives. Although Whiskeytown stores up to 241,000 acre-feet, this storage is not normally used as a source of water supply.

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, such as occurred in Table 3–1, occasionally result in spillway discharges to Clear Creek.

Table 3–1 Days in Flood Control for Whiskeytown and 40-30-30 Index from Water Year 1978 to 2002

Water Year	Days in Flood Control	40-30-30 Index
1978	5	AN
1979	0	BN
1980	0	AN
1981	0	D
1982	63	W
1983	81	W
1984	0	W
1985	0	D
1986	17	W
1987	0	D
1988	0	C
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 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 with the California Department of Fish and Game (DFG) established minimum flows to be released to Clear Creek at Whiskeytown Dam (see Table 3–2).
- A 1963 release schedule from Whiskeytown Dam, which 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 3–2 Minimum flows at Whiskeytown Dam from 1960 MOA with the California Department of Fish and Game

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
Normal year flow (cfs)	
January 1 - October 31	50
November 1 - December 31	100
Critical year flow (cfs)	
January 1 - October 31	30
November 1 - December 31	70

CVPIA 3406(b)(2) operations on Clear Creek

Actual instream flows below Whiskeytown Dam to Clear Creek will be determined in accordance with the Department of the Interior Decision on Implementation of Section 3406 (b)(2) of the CVPIA (Appendix A). Instream flow objectives below Whiskeytown Dam will be based on recommendations of FWS, NOAA Fisheries, and DFG pursuant to annual CVPIA Section 3406 (b)(2) Implementation Team (B2IT) coordination. Typical annual instream fishery considerations in Clear Creek include spawning flows for fall run Chinook salmon as well as water temperatures in summer 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 involving Townsend Flat Water Ditch Company and its shareholders, FWS, and Reclamation was reached. Townsend Flat Water Ditch Company had an annual diversion capability of up to 12,500 acre-feet of Clear Creek flows at Saeltzer Dam. With the dam removed, Reclamation, under the new agreement, will provide Townsend with up to 6,000 acre-feet of water annually. If the full 6,000 acre-feet is delivered, 900 acre-feet will be dedicated to (b)(2) according to the August 2000 agreement.

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. SCDD can store approximately 5,800 acre-feet of water. Operation of SCDD and Shasta Dam has allowed some control of the toxic wastes with dilution criteria. In January 1980, Reclamation, DFG, and SWRCB executed a Memorandum of Understanding (MOU) to implement actions to 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 buildup of metal concentrations in the Spring Creek arm of Keswick Reservoir, releases from the debris dam are coordinated with releases from Spring Creek Powerplant to keep the Spring Creek arm of Keswick Reservoir in circulation with the main waterbody of Keswick Lake.

The operation of Spring Creek Debris Dam is complicated during major heavy rainfall events. Spring Creek Reservoir can fill to uncontrolled spill elevations in a relatively short time period, on the order of 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 SCDD 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 are usually limited to areas immediately downstream of Keswick Dam. In the operational situation when Keswick releases are increased for flood control, Spring Creek Debris Dam releases are also increased 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 Shasta Division includes facilities that provide conservation of water in the Sacramento River for (1) flood control, (2) navigation maintenance, (3) agricultural water supplies, (4) municipal and industrial (M&I) water supplies, (5) hydroelectric power generation; (6) conservation of fish in the Sacramento River , and (7) protection of the Sacramento-San Joaquin Delta from intrusion of saline ocean water. The Shasta Division includes Shasta Dam, Lake, and Powerplant; Keswick Dam, Reservoir, and Powerplant; and the Shasta Temperature Control Device.

The Sacramento River Division, was authorized after completion of the Shasta Division. It includes facilities for the diversion and conveyance of water to CVP contractors on the west side of the Sacramento River. The division includes the Sacramento Canals Unit, which was authorized in 1950 and consists of the Red Bluff Diversion Dam (RBDD), the Corning Pumping Plant, and the Corning and Tehama-Colusa Canals.

The unit was authorized to supply irrigation water to more than 200,000 acres of land in the Sacramento Valley, principally in Tehama, Glenn, Colusa, and Yolo Counties. Black Butte Dam, operated by the Corps, also provides supplemental water to the Tehama-Colusa Canal, 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, with a maximum storage capacity of 4,552,000 acre-feet. 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, formed by the completion of Keswick Dam in 1950. It has a capacity of approximately 23,800 acre-feet 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's fish trapping facility operates in conjunction with the Coleman National Fish Hatchery on Battle Creek. During the construction of Shasta Dam, the Toyon Pipeline was constructed to supply water from the Sacramento River to the camp used to house the workers at Toyon. The pipeline remains in use today, supplying M&I water to small communities in the area.

Flood Control

Flood control objectives for Shasta Lake require that releases be restricted to quantities that will not cause downstream flows or stages to exceed specified levels. These include a flow of 79,000 cfs at the tailwater of Keswick Dam, and a stage of 39.2 feet in the Sacramento River at Bend Bridge gauging station, which corresponds to a flow of approximately 100,000 cfs. Flood control operations are based on regulating criteria developed by the Corps pursuant to the provisions of the Flood Control Act of 1944. Maximum flood space reservation is 1.3 million acre-feet, with variable storage space requirements based on an inflow parameter.

Flood control operation at Shasta Lake requires 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 sensitive to large rainfall events and produce large rates of runoff into the Sacramento River in short time periods. During large rainfall/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 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.

Flood control criteria for Keswick releases specify that releases should not be increased more than 15,000 cfs or decreased more than 4,000 cfs in a 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 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 NOAA Fisheries 1993 winter-run Chinook salmon biological opinion (see Table 3-3). An April 5, 1960, MOA between Reclamation and 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 been 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 3–3 Current minimum flow requirements and objectives (cfs) on the Sacramento River below Keswick Dam

Water year type	MOA	WR 90-5	MOA and Order 90-5	1993 NMFS winter-run Biological Opinion
Period	**Normal**	**Normal**	**Critically dry**	**All**
January 1 - February 28(29)	2,600	3,250	2,000	3,250
March 1 - March 31	2,300	2,300	2,300	3,250
April 1 - April 30	2,300	2,300	2,300	---*
May 1 - August 31	2,300	2,300	2,300	---*
September 1 - September 30	3,900	3,250	2,800	---*
October 1 - November 30	3,900	3,250	2,800	3,250
December 1 - December 31	2,600	3,250	2,000	3,250

* No regulation

The 1960 MOA between Reclamation and 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, 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 contained in the 1993 National Marine Fisheries Service (NOAA Fisheries) biological opinion required a minimum flow of 3,250 cfs from October 1 through March 31. Also, as part of the alternative, 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.

CVPIA 3406(b)(2) operations on the Upper Sacramento River

Actual minimum flows below Keswick Dam will be determined in accordance with the Department of the Interior Decision on Implementation of Section 3406 (b)(2) of the CVPIA (Appendix A). Instream flow objectives below Keswick Dam for October through April will be based on recommendations of FWS, NOAA Fisheries, and DFG pursuant to annual B2IT coordination.

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. There is currently no commercial traffic between Sacramento and Chico Landing, and 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 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 that specify 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 that inhabit 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, 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 that Reclamation shall operate Keswick and Shasta Dams and the Spring Creek Powerplant to meet a daily average water temperature of 56ºF at RBDD in the Sacramento River during periods when higher temperatures 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 (locations shown in Figure 3–1) 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 Area Power Administration, Department of Water Resources (DWR), and Hoopa Valley Indian Tribe.

Each year, with finite cold-water resources and competing demands usually an issue, the Temperature Task Group has devised 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. The TCD is designed to allow greater flexibility in the management of 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 powerplant 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 powerplant 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/early spring, the highest elevation gates possible are used to draw from the upper portions of the lake to conserve deeper colder resources (see Table 3–4). During late spring/summer, the operators begin the seasonal progression of opening deeper gates as Shasta Lake elevation decreases and cold-water resources are used. In late summer/fall, the TCD side gates are opened to use the remaining cold-water resources below the Shasta Powerplant elevation in Shasta Lake.

Table 3–4 Shasta Temperature Control Device Gates with Elevation and Storage

TCD Gates	Shasta Elevation with 35 feet of submergence	Shasta Storage (million acre-feet)
Upper Gates	1035	~3.65
Middle Gates	985	~2.50
Pressure Relief Gates	850	~0.67
Side Gates		

The seasonal progression of 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/fishery habitat management purposes. Recent operational experience has also demonstrated that the Shasta TCD has significant leaks inherent to TCD design and operational uncertainties that cumulatively impair the seasonal performance of the Shasta TCD to a greater degree than was anticipated in the analysis efforts to describe long-term Shasta TCD benefits.

ESA-related Upper Sacramento River Temperature Objectives.

In February 1993, NOAA Fisheries issued the long-term biological opinion for the operation of the Federal CVP and the State Water Project (SWP) for the Sacramento River winter-run Chinook salmon. The opinion includes a Reasonable and Prudent Alternative that addresses CVP operations criteria for temperature control objectives. The Shasta-Trinity Division section of the 1993 Reasonable and Prudent Alternative includes the following operational elements relating to temperature control objectives. That section of the alternative was not modified in the 1995 amendment to the biological opinion.

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 1 in 10 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 opinion 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 acre-feet.

The 1.9-million-acre-foot 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-acre-foot carryover is required. The opinion recognized that it may not be possible to maintain the minimum carryover of 1.9 million acre-feet in the driest 10 percent of hydrologic circumstances. If Reclamation forecasts that end-of-water-year storage levels in Shasta will drop below 1.9 million acre-feet, re-initiation of consultation is required prior to the first water allocation announcement for that year.

The current RPA sets a water temperature compliance location(s) for the time period April 15 through October 31 for winter-run needs based on a systematic set of Shasta carryover and annual hydrologic conditions.

The opinion segregates annual Shasta Reservoir carryover conditions and hydrologic conditions 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 opinion 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 or dry or critical hydrologic conditions, the opinion sets the compliance location at a farther upstream location of Jellys Ferry on the Sacramento River. For low carryover storage and critical or very critical hydrologic conditions, generally associated with extended drought conditions, the opinion 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.

Anderson-Cottonwood Irrigation District Diversion Dam

Since 1916, water has been diverted into the Anderson-Cottonwood Irrigation District (ACID) canal for irrigation along the west side of the Sacramento River between Redding and Cottonwood. The United States and ACID have signed a contract (No. 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 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 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 this 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 is reasonably possible each time it intends to install or remove boards from its diversion dam. Reclamation will similarly notify ACID each time it intends to change releases at Keswick Dam. In addition, during the irrigation season, ACID will notify Reclamation of the maximum flow that it believes the diversion dam, with the current setting of boards, can safely accommodate. Reclamation will notify ACID at least 24 hours in advance of a 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 each year, ACID erects the diversion dam. This consists of raising the steel superstructure, installing the walkway, and setting boards. Around November 1 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 5 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 because of changes in releases at Keswick Dam. When boards must be removed because of an increase at Keswick, the release may initially have to be decreased to allow work to be done safely. If an emergency exists, personnel from Reclamation's 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 a 1-hour period. Therefore, advance notification is important when scheduling decreases to allow for 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. Construction of RBDD was completed in 1964. Gates were first closed in 1967, coincidentally with the startup of the State pumps in the Delta. 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 a stilling basin servicing the Tehama-Colusa and Corning Canals.

The Tehama-Colusa Canal is a lined canal extending 111 miles south from RBDD to provide irrigation service on the west side of the Sacramento Valley in Tehama, Glenn, Colusa, and northern Yolo Counties. It 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 CVP contractors in Tehama County that cannot be served by gravity from the Tehama-Colusa Canal. Both canals are operated by the Tehama-Colusa Canal Authority. The gates are currently lowered May 15 to impound water for diversion and raised September 15 to allow river flow-through.

Since 1986, the RBDD gates have been raised during winter to allow passage of winter-run Chinook salmon. Since 1993, when the NMFS issued a biological opinion for winter-run Chinook salmon, the gates have been raised from September 15 through May 14 each year. This 8-month gates-up operation has eliminated passage impedance of upstream migration for species that 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 (Tehama-Colusa Canal Authority and Bureau of Reclamation, 2002).

Monitoring associated with the operation of the Red Bluff research pumping plant has shown the 8-month gates-up operation also substantially reduced or eliminated the excess losses of juvenile salmon attributable to predatory fish. These losses were primarily caused by Sacramento pike-minnows whose upstream spawning runs were impeded by the closed gates prior to the adoption of the current operations (Tucker et al, 1998 and 2003*).* These studies also demonstrated that juveniles pass safely under the gates when the predators are absent (Gaines and Martin, 2002). Concurrently, experiments have shown both types of pumps tested at the research pumping plant pass juvenile fish with less than 1.8 percent sub-lethal injury rates during 24-hour trials (Borthwick and Corwin, 2001*).*

Given this limited risk of injury to entrained juveniles, the low risk of entrainment (Borthwick and Corwin, 2001; FWS, 1998), and the failure of the spring-run Chinook to respond to complete removal of impediments to adult passage for an estimated 30 percent of the population, Reclamation continues to operate the RBDD using the 8-month gates-up procedures of the past 10 years. Reclamation also continues to use 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 Tehama-Colusa Canal.

This arrangement has successfully met the water demand for the past 10 years, but the supply has consistently been tight. Thus far, Reclamation has not had to use the provision of the Reasonable and Prudent Alternative of the winter-run biological opinion allowing up to one closure per year of the gates for up to 10 days. While mandatory use of this temporary gates closure provision has arguably been avoided thus far, it was used in 1997, a year with an exceptionally dry spring. Its use in another year was only avoided at the last minute by an exceptionally heavy, late storm. Reclamation will implement with NMFS a decision-making protocol to ensure such gate closure decisions can be made on short notice.

Hydropower Operations

Shasta Powerplant contains seven generating units, two of which are used for station service. Water is released through five penstocks leading to the generating units, which produce a maximum powerplant operating capability of 584,000 kW. The maximum powerplant release is approximately 18,000 cfs.

Keswick is a regulating reservoir for Shasta Lake and Trinity River Diversions, controlling flow fluctuations from the upstream dams and powerplants. Keswick Powerplant, located within the dam, houses three generating units with a maximum operating capability of 105,000 kW. Maximum release through Keswick Powerplant is approximately 16,000 cfs.

Recreation

Although not an authorized purpose, recreational use of Shasta Lake is significant with the prime recreation season extending from Memorial Day through Labor Day. To maximize recreational use, it is desirable to have Shasta Lake full by Memorial Day and at an elevation no less than 1,017 feet on Labor Day; however, these objectives are subject to priorities for use of water stored in Shasta Lake. This elevation corresponds to a drawdown of 50 feet below the top of the conservation pool and is just below the bottom of the flood control storage envelope. The drawdown rate varies, but is typically high during July and August in response to irrigation demands and temperature control operations. Customary patterns of storage and release typically result in acceptable water levels during the prime recreation season. Storage typically peaks in May, and significant drawdown usually does not occur until July and August. During drought periods, recreation opportunities at Shasta Lake are reduced because of hydrology and the drawdown required to meet CVP uses.

The seasonal operation patterns at Keswick Dam typically are sufficient to satisfy river recreation needs. During flood control operations, little recreational use occurs along the river.

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 more than 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 acre-feet.

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 acre-feet. Folsom Dam, 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, also operated by Reclamation as part of the CVP, began operation in 1955. Nimbus Dam creates Lake Natoma, which serves as a forebay for diversions to the Folsom South Canal. This 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 specific flood control responsibilities. The total upstream reservoir storage above Folsom Lake is approximately 820,000 acre-feet. Ninety percent of this upstream storage is contained by five reservoirs: French Meadows (136,000 acre-feet); Hell Hole (208,000 acre-feet); Loon Lake (76,000 acre-feet); Union Valley (271,000 acre-feet); and Ice House (46,000 acre-feet).

French Meadows and Hell Hole Reservoirs, located on the Middle Fork of the American River, are owned and operated by Placer County Water Agency (PCWA). PCWA provides wholesale water to agricultural and urban areas within Placer County. For urban areas, 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 PCWA. Loon Lake (also on the Middle Fork) and Union Valley, and Ice House Reservoirs on the South Fork are operated by Sacramento Municipal Utilities District (SMUD) for hydropower purposes.

American River Operations

Congress authorized the Corps to construct major portions of the American River Division. 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 in 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; Lake Natoma. The Auburn-Folsom South Unit of the American River Division was authorized in 1965 by Public Law 89-161 and includes Folsom South Canal.

Flood Control

Flood control requirements and regulating criteria are specified by Corps and described in the Folsom Dam and Lake, American River, California Water Control Manual (Corps, 1987). Flood control objectives for Folsom require that the dam and lake are operated to:

- Protect the City of Sacramento 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 a 2-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 Sacramento Area Flood Control Agency (SAFCA) sponsored flood control plan diagram for Folsom Reservoir.

Since 1996, Reclamation has operated according to modified flood control criteria, which reserve 400,000 to 670,000 acre-feet of flood control space in Folsom and a combination of upstream reservoirs. This flood control plan, which provides additional protection for the lower American River, is implemented through an agreement between Reclamation and SAFCA. The terms of the agreement allow some 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 the same as 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 limited to up to 32,000 cfs based on lake elevation. However, in general, the SAFCA plan diagram provides greater flood protection than the existing Corps plan for communities in the American River floodplain.

Required flood control space under the SAFCA plan 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 acre-feet. 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. 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.

CVPIA 3406(b)(2) operations on the Lower American River

Actual minimum flows below Nimbus Dam will be determined in accordance with the Department of the Interior Decision on Implementation of Section 3406 (b)(2) of the CVPIA (Appendix A). Instream flow objectives below Nimbus Dam for October through April will be based on recommendations of FWS, NOAA Fisheries, and DFG pursuant to annual B2IT coordination.

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 currently using draft criteria developed by DFG. The draft criteria have helped to reduce the incidence of anadromous fish stranding relative to historic operations. The operational downside of the draft criteria is that the ramping rates are relatively slow and can potentially have significant effects on 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, now known as the American River Operations Work Group, was formed in 1996 to assist in reviewing the criteria for flow fluctuations. Since that time, the group has addressed operational issues and the discussions have served as an aid toward 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.

Hydropower Operations

Folsom Powerplant contains three generating units, which have a maximum powerplant operating capability of 215,000 kW. Maximum powerplant release is 8,603 cfs.

Nimbus Dam backs up Lake Natoma, controlling flow fluctuations from Folsom Powerplant. Nimbus Powerplant is housed within the dam and includes two generating units with a maximum powerplant operating capability of 17,000 kW. Maximum powerplant release is 5,100 cfs.

Recreation

Both the lower American River and the lakes behind Folsom and Nimbus Dams provide significant recreation opportunities, principally boating and fishing in the lakes and rafting and fishing in the river. Folsom Lake Recreation Area, operated by the California Department of Parks and Recreation, is one of the State's most popular recreation areas, based on visitation. The greatest visitor use at Folsom occurs in years when the water levels are high enough to facilitate boat launching and boating activities on the lake, from Memorial Day through Labor Day. If hydrologic conditions allow and other operations requirements permit, adequate lake levels are maintained through Labor Day to provide access to boat launching ramps and marina facilities. In drier hydrologic conditions, lake levels may be adequate through the Fourth of July weekend. In some very dry years, recreation use cannot be given emphasis because of the basic conflict with other CVP project purposes. In 1990, during Safety of Dams construction work on Mormon Island Dam, material from the bed of Folsom Lake was excavated in the vicinity of Brown's Ravine Marina to increase the marina access under lower lake level conditions.

Delta Division

CVP Facilities

The CVP's Delta Division includes the Delta Cross Channel (DCC), the Contra Costa Water District (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 customers directly and to operate the CCWD's Los Vaqueros Project. The Tracy Pumping Plant diverts water from the Delta to the head of the Delta-Mendota Canal.

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 toward 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 Banks and Tracy Pumping Plants, (2) improve water quality in the southern Delta, and (3) reduce saline intrusion rates in the western Delta. During late fall, winter, and spring, the gates are often periodically closed to protect outmigrating 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 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 long, Reclamation tries to provide adequate notice of DCC closures so that boaters can plan for the longer excursion.

SWRCB D-1641 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. From February 1 through May 20, the gates are closed for fishery protection. The gates may also be closed for 14 days for fishery protection 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 Operations Group (Ops Group) also satisfies 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 continuously. The DCC is also usually open for the Memorial Day weekend, if this is possible from a fishery, water quality, and flow standpoint.

From 1996 to 2000, the CALFED Ops Group developed and implemented the Spring-Run Salmon Protection Plan (SRPP). The SRPP established environmental triggers that prompt the closure of the DCC gates as early as October. The SRPP depended on identifying when young spring-run salmon likely entered the Delta to trigger actions to avoid or minimize the effects of DCC and other project operations on their survival. This identification process depended on DFG and FWS fisheries and water quality monitoring to evaluate the distribution and movement of spring-run during the emigration season. The SRPP included “indicators of sensitive periods for salmon” such as hydrologic changes, detection of spring-run salmon or spring-run salmon surrogates at monitoring sites or the salvage facilities, and turbidity increases at monitoring sites to trigger the SRPP process. In November 2000, the SRPP was replaced by a CALFED Ops Group plan designed to provide broader protections for juvenile salmon emigrating through the Delta from October through January.

The Chinook Salmon Decision Process (also known as the Salmon Decision Tree). The decision tree is used by the fishery agencies and project operators to facilitate the complex coordination issues surrounding DCC gate operations and the purposes of fishery protection closures, Delta water quality, 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 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 for the near future.

A DCC Project Work Team has also been formed to develop recommendations for DCC operations. The goal of the work group is to develop operational guidance that will protect migrating fish from November through January and protect Delta water quality. Triggers for opening or closing the DCC gates will be based on real-time monitoring of the fish and Delta water quality targets. The work team is also studying the utility of operating the gates based on the tidal or diurnal cycle. The objective is to find opportunities to permit the transfer of water (gates open) with minimal concurrent transfer of fish into the central Delta. In recent years, the DCC Project Work Team has conducted several experiments to better demonstrate the actual biological and hydrodynamic effects of controlled DCC gate configuration and operations. Reclamation has operation concerns regarding the long-term frequency of DCC gate changes and the manual operation of the DCC facility. The DCC was not designed for frequent operational changes, and there are public safety issues involved at the site.

Tracy Pumping Plant

The CVP and SWP use the Sacramento River and channels in the Delta (Figure 3–2) to transport water to export pumping plants in the south Delta. The Tracy Pumping Plant, about 5 miles north of Tracy, consists of six pumps. The Tracy Pumping Plant is at the end of an earth-lined intake channel about 2.5 miles long. At the head of the intake channel, louver screens intercept fish, which are collected and transported by tanker trucks 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. The capacity limitations at the Tracy Pumping Plant are the result of a Delta-Mendota Canal freeboard constriction near O'Neill Forebay and the current water demand in the upper sections of the Delta-Mendota Canal.

Tracy Fish Collection Facility

The Tracy Fish Collection Facility uses behavioral barriers consisting of primary and secondary louvers to guide targeted fish into holding tanks before transport by hauling truck to release sites within the Delta. Hauling trucks contain an 8-parts-per-thousand (ppt) 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. A few years ago , Tracy Fish Collection Facility personnel noticed, upon facility inspection, significant decay of the transition boxes and conduits between the primary and secondary louvers. In fall/winter 2002, temporary rehabilitation of the transition boxes and conduits was performed. Extensive rehabilitation of the transition boxes and conduits is currently contemplated for installation 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 4 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. The 47.7-mile canal terminates in Martinez Reservoir. Two short canals, Clayton and Ygnacio, are integrated into the distribution system.

Rock Slough diversion capacity of 350 cfs gradually decreases to 22 cfs at the terminus. Historically, actual 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 Rock Slough Pumping Plant is directed under 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 Contra Costa Canal, 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-acre-foot Los Vaqueros Reservoir.

The water rights for the Los Vaqueros Project were approved by SWRCB D-1629. A NOAA Fisheries biological opinion for the Los Vaqueros winter-run Chinook salmon was provided on March 18, 1993. A FWS biological opinion for Los Vaqueros covering Delta smelt was provided on September 9, 1993, and clarified by letter on September 24, 1993. The FWS biological opinion requires CCWD to divert CVP water with a preference from the fish-screened Old River intake from January through August each year.

Due to the water quality objectives of the Los Vaqueros Project, CCWD’s total diversion from the Delta will be reduced during late summer and fall when Delta water quality and flows are the poorest of the annual cycle. Filling of Los Vaqueros Reservoir will only occur when Delta water quality conditions are good. Good water quality conditions in the Delta can occur generally from January to July.

Additionally, under the Los Vaqueros biological opinions, 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, and to not divert water to Los Vaqueros storage for an additional 45-day period in 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.

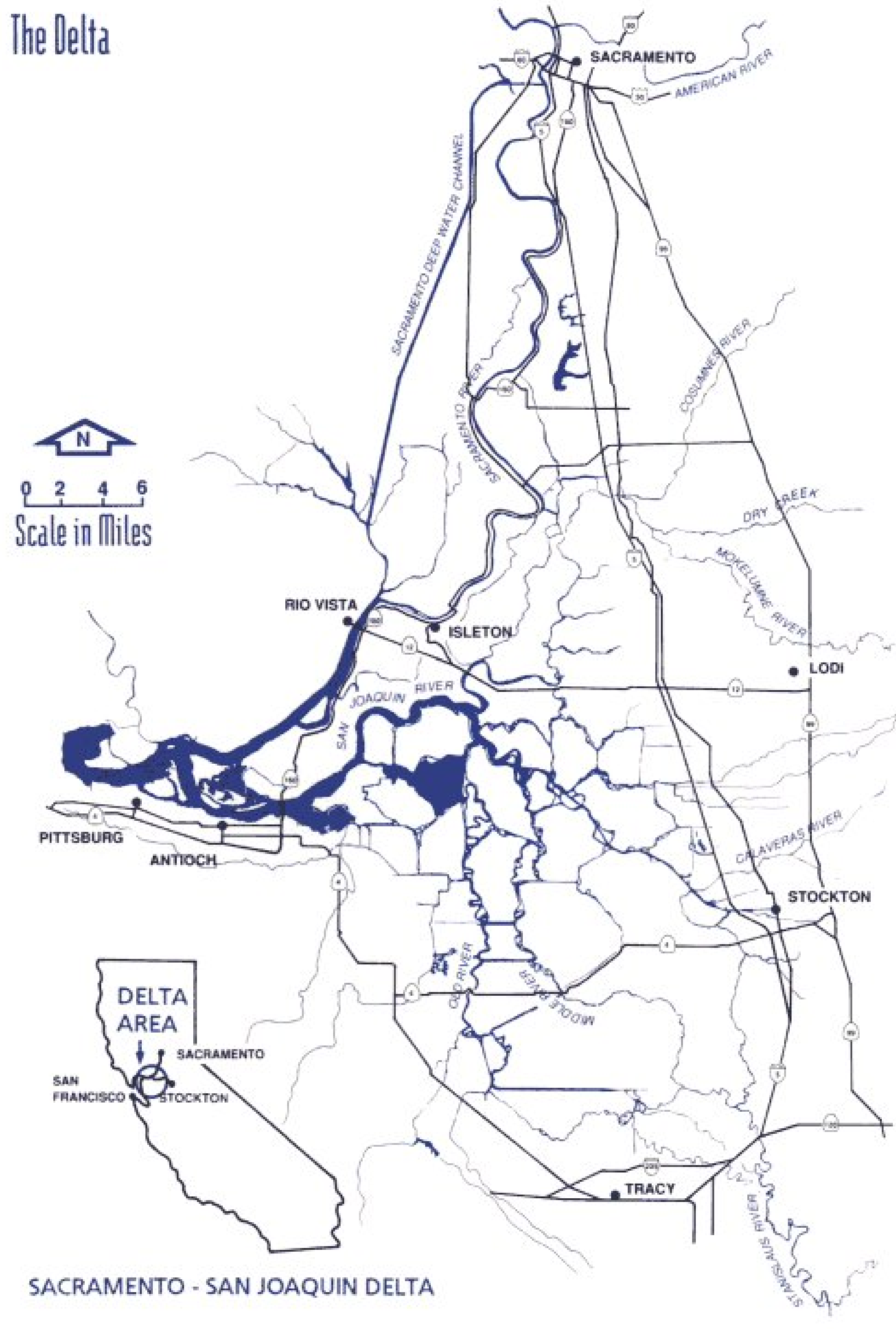

Figure 3–2 The Sacramento-San Joaquin Delta

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. The Tracy Pumping Plant is usually operated at a constant rate around the clock. When water supply supports it, the Tracy Pumping Plant is usually operated to the capacity limits of the Delta-Mendota Canal (between 4,000 and 4,600 cfs), except when restrictions are imposed by regulatory or fishery requirements. Daily diversions into Clifton Court Forebay are governed by agreement with the Corps. This agreement allows for daily diversion rates of about 13,250 acre-feet on a 3-day average and 13,870 acre-feet on a daily average[3].

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. Clifton Court Forebay is operated to minimize effects to water levels during the lowest ebb tide of the day. Banks Pumping Plant has 11 variable speed pumps, which are primarily run during off-peak power periods to convey water into the California Aqueduct.

CVPIA 3406(b)(2) operat*i*ons in the Delta

Increased export curtailment at the CVP Tracy Pumping Plant and increased CVP reservoir releases required to meet D-1641, as well as direct export reductions for fishery management 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 (Appendix A). Direct Tracy Pumping Plant export curtailment for fishery management protection will be based on recommendations of FWS, after consultation with Reclamation, DWR, NMFS, and DFG pursuant to annual B2IT coordination.

Environmental Water Account operations in the Delta

In accordance with the CALFED ROD, the EWA has been implemented to enhance the flexibility and forecastibility of CVP-SWP operations for fishery management, and to improve 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 fishery management tool to improve the passage and survival of fish species in the Delta environment and for specific seasonal planned fishery protection CVP-SWP operations. EWA protocols for the expenditure of water resources follow the guidance given in the CALFED ROD, and generally follow the given priority. EWA resources will be used to reduce SWP Banks Pumping Plant exports for fishery management protection above D-1641 requirements and to coordinate with the Interior Decision on Implementation of Section 3406(b)(2) of the CVPIA. EWA resources will be used to augment direct CVP Tracy Pumping Plant export curtailments for fishery management protection above the resources used in the Interior Decision on Implementation of Section 3406(b)(2) of the CVPIA.

3Up to an additional 500 cfs of diversion may be allowed from July through September as part of the EWA operations. See the section titled "The CALFED Environmental Water Account" for more details.

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 (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 Delta-Mendota Canal (DMC) and 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 acre-feet 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 instream 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. 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 California Aqueduct. During 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 San Luis Reservoir must be used to make up the difference.

Figure 3–3 San Luis Complex

San Luis Reservoir has little natural inflow, therefore, if it is to be used for a water supply, the water must be stored during fall and winter 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 important element of CVP operations.

Adequate storage in San Luis Reservoir must be maintained to ensure delivery capacity through Pacheco Pumping Plant to the San Felipe Division. Lower reservoir elevations can also result in turbidity and water quality treatment problems for the San Felipe Division users.

A typical San Luis Reservoir annual operation cycle starts with the CVP's share of the reservoir storage nearly empty at the end of August. Irrigation demands decrease in September, and the opportunity to begin refilling San Luis Reservoir depends on the available water supply in the northern CVP reservoirs and the pumping capability at Tracy Pumping Plant that exceeds water demands. Tracy Pumping Plant operations generally continue at the maximum diversion rates until early spring, unless San Luis Reservoir is filled or the Delta water supply is not available.

As outlined in the Department of the Interior Decision on Implementation of Section 3406 (b)(2) of the CVPIA, Tracy Pumping Plant diversion rates may be reduced during fill cycle of San Luis Reservoir for fishery management.

In April and May, export pumping from the Delta is limited by D-1641 San Joaquin River pulse periodstandards and B2/EWA fishery management during spring. During this same time, CVP-SWP irrigation demands increase.Consequently, by April and May, San Luis Reservoir has begun the annual drawdown cycle. In some exceptionally wet conditions when excess floodwater supplies from the San Joaquin River or Tulare Lake Basin occur in the spring, San Luis Reservoir may not begin its drawdown cycle until late spring.

In July and August, Tracy Pumping Plant diversion is at the maximum capability, and CVP water may be exported at Banks Pumping Plant 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 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 San Luis Reservoir at the same time the other is releasing water.

Total San Luis Unit annual water supply is contingent on coordination with the SWP needs and capabilities. When SWP facilities are used to support Joint Point of Diversion water for the CVP, it may be of little consequence to SWP operations, but extremely critical to CVP operations. The use of SWP facilities by the CVP is contingent on the ability of the SWP to meet its contractors' water supply commitments. Additionally, close coordination is required to ensure that water pumped into O'Neill Forebay by the two projects 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 joint 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 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.

Hydropower Operations

The San Luis Unit is a joint-use project of Reclamation and the State of California. Sierra Nevada Region’s scheduling discretion is limited to the O’Neill and W.R. Gianelli Pumping-Generating Plants. O’Neill has a maximum operating capability of 14,000 kW, and the Federal share of W.R. Gianelli is 202,000 kW.

San Felipe Division

Construction of the San Felipe Division of the CVP was authorized in 1967 (Figure 3–4). 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.

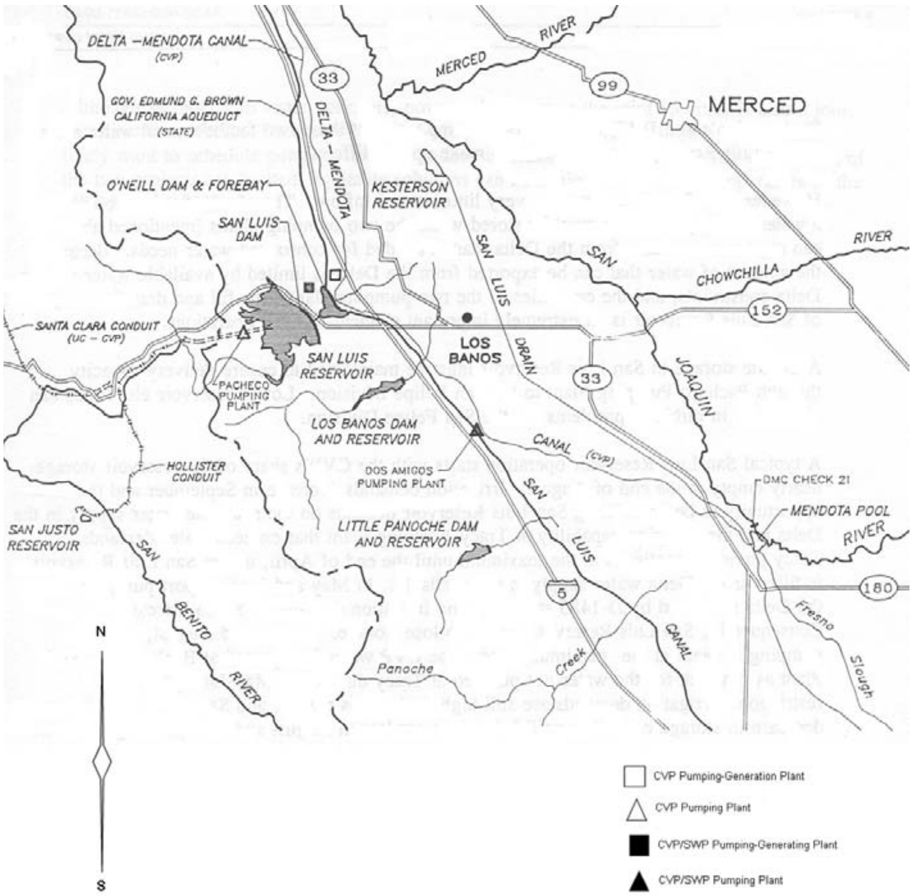

Figure 3–4 West San Joaquin Division and San Felipe Division

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.

East Side Division

New Melones Operations

The Stanislaus River originates in the western slopes of the Sierra Nevada range and drains a watershed of approximately 900 square miles. The average unimpaired runoff in the basin is approximately 1.2 million acre-feet per year; the median historical unimpaired runoff is 1.1 million acre-feet per year. Snowmelt contributes the largest portion of the flows in the Stanislaus River, with the highest runoff occurring in 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 was completed by Corps in 1978 and approved for filling in 1983 with a storage capacity of about 2.4 million acre-feet. New Melones Reservoir is 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 in accordance with a 1980 ROD before additional water supplies can be used out of the defined Stanislaus Basin.

New Melones Reservoir is operated primarily for 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 Corps operational guidelines. The original Melones Dam was constructed in 1924 and was operated in coordination with upstream storage facilities and Goodwin Dam downstream. The construction of New Melones Dam greatly enhanced flood control and storage capacity on the Stanislaus River.

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, upstream of New Melones Reservoir on the middle fork Stanislaus River; and Tulloch Dam and Powerplant, approximately 6 miles downstream of New Melones Dam on the mainstem Stanislaus River.

Releases from Donnells and Beardsley Dams affect inflows to New Melones Reservoir. Under contractual agreements between Reclamation and 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, approximately 1.9 miles downstream of Tulloch Dam.

Goodwin Dam, which was 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 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

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 to 1,500 cfs because of seepage problems in agricultural lands adjoining the river associated with flows above this level. Up to 450,000 acre-feet of the 2.4-million-acre-foot storage volume in New Melones Reservoir is dedicated for flood control and 10,000 acre-feet of Tulloch Reservoir storage is set aside for flood control. Based upon the flood control diagrams prepared by 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 water rights, instream fish and wildlife flow requirements (including Interior's CVPIA 3406(b)(2) fishery management objectives), D-1641 Vernalis flow requirements, dissolved oxygen (DO) requirements, D-1641 Vernalis water quality requirements, CVP contracts, and 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 that 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 that Reclamation release inflows to New Melones Reservoir of up to 654,000 acre-feet 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 acre-feet annually downstream of Goodwin Dam.

In 1988, following a year of low inflow to New Melones Reservoir, the 1972 Agreement and Stipulation 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 acre-feet 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 acre-feet, Reclamation provides all inflows plus one-third the difference between the inflow for that year and 600,000 acre-feet 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 acre-feet, and withdrawals are constrained by criteria in the Agreement.

Instream Flow Requirements

Under D-1422, Reclamation is required to release 98,000 acre-feet of water per year, with a reduction to 69,000 acre-feet 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 instream flows would range from 98,300 to 302,100 acre-feet 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 in 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 instream flow on the Stanislaus River of 155,700 acre-feet per year for spawning and rearing (Aceituno, 1993).

CVPIA 3406(b)(2) operations on the Stanislaus River

Instream fishery management flow volumes on the Stanislaus River, as part of the Interim Plan of Operations (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 instream flow goals. The fishery volume is then initially distributed based on modeled fish distributions and patterns used in the IPO. Actual instream 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.

Bay-Delta Vernalis Flow Requirements

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. Reclamation has committed to provide these flows to the best of its ability as demonstrated in the IPO during the interim period of the Bay-Delta Accord. The IPO describes the commitment Reclamation has 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 Water Quality Control Plan (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 be operated to maintain an average monthly total dissolved solids (TDS) level, commonly measured as a conversion from electrical conductivity, in the San Joaquin River at Vernalis as it enters the Delta. 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 because of 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. 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 millisiemen per centimeter (mS/cm) (approximately 455 ppm TDS) during April through August, and 1.0 mS/cm (approximately 650 ppm TDS) during September through March.

CVP Contracts

Reclamation has 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 acre-feet per year (based on a firm water supply) and two long-term water service contracts totaling 106,000 acre-feet 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, no water was made available from the Stanislaus River for delivery to CVP contractors prior to 1992.

New Melones Interim Plan of Operations

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 are thus unable to meet all the potential beneficial uses designated as purposes.

In 1996, the focus shifted to development of an IPO for 1997 and 1998. At an SRBS meeting on January 29, 1997, a final IPO 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 (see Table 3-5). It then allocates annual water release for instream fishery enhancement (1987 Fish and Game Agreement and CVPIA Section 3406(B)(2) management), D-1641 San Joaquin River water quality requirements (Water Quality), D-1641 Vernalis flow requirements (Bay-Delta), and use by CVP contractors (see Table 3-6).

Table 3–5 Inflow characterization for the New Melones Interim Plan of Operation

Annual water supply category	March-September forecasted inflow plus end-of-February storage (thousand acre-feet)
Low	0 – 1,400
Medium-low	1,400 – 2,000
Medium	2,000 – 2,500
Medium-high	2,500 – 3,000
High	3,000 – 6,000

Table 3–6 New Melones Interim Plan of Operation flow objectives (in thousand acre-feet)

Storage plus inflow		Fishery		Vernalis water quality		Bay-Delta		CVP contractors	
From	To	From	To	From	To	From	To	From	To
1,400	2,000	98	125	70	80	0	0	0	0
2,000	2,500	125	345	80	175	0	0	0	59
2,500	3,000	345	467	175	250	75	75	90	90
3,000	6,000	467	467	250	250	75	75	90	90

From inspection of the above IPO allocation structure, two key New Melones – Stanislaus River water policies are inferred:

1. When the water supply condition is determined to be in the “Low” IPO designation, no CVP operations guidance is given. It is assumed the Stanislaus River Basin Stakeholders group would convene and coordinate a practical strategy to guide New Melones Reservoir annual operations under the limited water supply conditions.
2. The IPO only supports meeting the D-1641 Vernalis Base flow standards from Stanislaus River water resources when the water supply conditions are determined to be in the “High” or “Medium-High” IPO designation, and then are limited to 75,000 acre-feet 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, the IPO fishery volume is reduced until the Vernalis salinity standard is met, or the IPO Fishery volume is reduced to that designated in the 1987 Fish and Game Agreement. 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 San Joaquin River Agreement (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-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 Vernalis Adaptive Management Program (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 from which flows will be provided on the San Joaquin River to meet the target flows for the 31-day pulse during April-May. Additional flows needed to meet the targets will be provided from other sources in the San Joaquin River 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 that 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 EIS/EIR. For purposes of CVP-SWP operations forecasts, the flows are 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 including available cold-water resources in New Melones Reservoir, Goodwin release rates for fishery flow management and water quality objectives, and residence time in Tulloch Reservoir as affected by local irrigation demand.

The current stated goal for water temperatures in the lower Stanislaus River is 65ºF at Orange Blossom Bridge for steelhead incubation and rearing during late spring and summer. This goal is often unachieved. Fall pulse attraction flows for salmon managed by FWS resources helps to bring cold-water resources from New Melones Reservoir into Tulloch Reservoir before the spawning season begins.

Hydropower Operations

New Melones Powerplant operations began in 1979. New Melones Powerplant consists of two generating units with a maximum operating capability of 383,000 kW. Maximum powerplant release is 8,928 cfs. Power generation occurs when reservoir storage is above the minimum power pool of 300,000 acre-feet. When possible, reservoir levels are maintained to provide maximum energy generation.

Recreation

The lower Stanislaus River and New Melones and Tulloch Reservoirs provide significant recreation opportunities, principally boating and fishing in the lakes and rafting and fishing in the river. Rafting interests are notified concerning Goodwin flow management during spring and fall pulse flows for rafting opportunities and safety concerns.

Friant Division

This Division operates separately from the rest of the CVP and is not integrated into the CVP OCAP. Friant Dam is 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 acre-feet. Completed in 1942, the dam is a concrete gravity structure, 319 feet high, with a crest length of 3,488 feet. Although the dam was completed in 1942, it wasn't placed into full operation until 1951.

The dam provides flood control on the San Joaquin River, provides downstream releases to meet senior water rights requirements above Mendota Pool, and provides conservation storage and diversion into Madera and Friant-Kern Canals. Water is delivered to a million acres of agricultural land in Fresno, Kern, Madera, and Tulare Counties via the Friant-Kern Canal south into Tulare Lake Basin and via the Madera Canal northerly to Madera and Chowchilla Irrigation Districts. 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 acre-feet, 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.

Chapter 4 State Water Project

Feather River

SWP Oroville Thermalito Complex

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 Thermalito Complex is shown on Figure 4–1. 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 acre-feet (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 acre-feet (maf).

A maximum of 17,000 cubic feet per second (cfs) can be released through Edward Hyatt Powerplant, located underground near the left abutment of Oroville Dam. Three of the six units are conventional generators driven by vertical-shaft, Francis-type turbines. The other three are motor-generators coupled to Francis-type, reversible pump turbines. The latter units allow pumped storage operations. The intake structure has an overflow type shutter system that determines the level from which water is drawn.

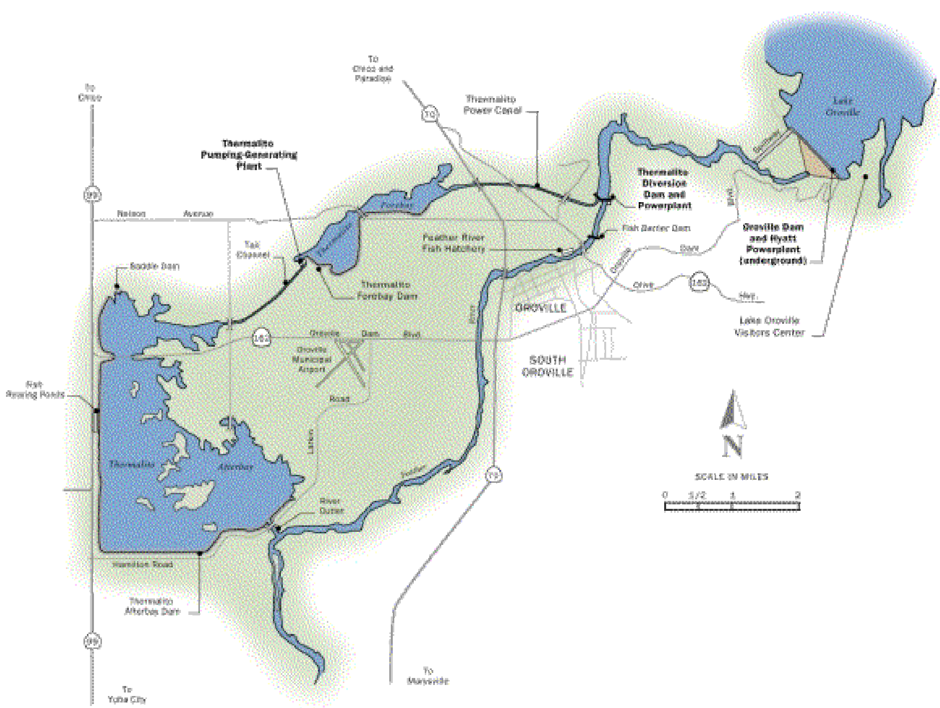

Figure 4–1 The Oroville-Thermalito Complex on the Feather River

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. 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 offstream regulating reservoir for Thermalito Powerplant. Thermalito Powerplant is a generating-pumping plant operated in tandem with 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 main factors that determine if a pumpback operation is economical. A pumpback operation most commonly occurs when energy prices are high during weekday on-peak hours and low during 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 State Water Project (SWP). The total capacity of Afterbay diversions during peak demands is 4,050 cfs.

The California Department of Fish and Game (DFG) operates the Feather River fish hatchery for the production of Chinook salmon and steelhead. The hatchery is located less than 1 mile downstream of the Thermalito Diversion Dam. Water is provided to the hatchery via pipeline from the diversion dam. A fish barrier dam is located across the low-flow section of the Feather River at the hatchery from where fish can make their way into the hatchery's fish ladder.

Temperature Control

The August 1983 agreement between California Department of Water Resources (DWR) and DFG, "Concerning the Operation of the Oroville Division of the State Water Project for Management of Fish & Wildlife" (Appendix B), sets criteria for flow and temperature for the low-flow section of the Feather River, the fish hatchery, and the reach of the Feather River below the river outlet to the confluence with the Sacramento River.

In addition to fish and wildlife obligations, a May 1969 agreement between DWR and the Joint Water Districts recognizes the rights of the Districts to water at temperatures reasonably related to achieving agricultural production that would have been available absent the construction of Oroville Dam. The 1985 agreement among DWR, Western Canal Water District, and Pacific Gas and Electric Company (PG&E) contains similar language (Appendix C).

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 U.S. Army Corps of Engineers (Corps). The federal government shared the expense of Oroville Dam, which provides up to 750,000 af of flood control space. The spillway, located on the right abutment of the dam, 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.

DWR Feather River Fish Studies

DWR initiated fish studies in the lower Feather River in 1991. The present program consists of several elements to monitor salmonid spawning, rearing, and emigration and to document presence and relative abundance of non-salmonid fishes. The focus and methods used for these studies could be altered in 2002 as a result of consultations with National Oceanic and Atmospheric Administration Fisheries (NOAA Fisheries – formerly National Marine Fisheries Service [NMFS]), DFG, and others to gather information needed to relicense the Oroville Facilities with the Federal Energy Regulatory Commission.

Sacramento-San Joaquin Delta- SWP Facilities

SWP facilities in the southern Delta include Clifton Court Forebay, John E. Skinner Fish Facility, and the Harvey O. Banks Pumping Plant. Clifton Court Forebay is a 31,000-acre-foot reservoir located in the southwestern edge of the Delta, about 10 miles northwest of the City of Tracy. Clifton Court Forebay 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 California Aqueduct. Diversions from Old River into Clifton Court Forebay are regulated by five radial gates. The John E. Skinner Delta Fish Protective Facility is located west of the Forebay 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 California Aqueduct. 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 toward 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 California Aqueduct. By means of 11 pumps, including two rated at 375-cfs capacity, five at 1,130-cfs capacity, and four at 1,067-cfs capacity, the plant provides the initial lift of water 244 feet into the aqueduct. 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, 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.

Clifton Court Forebay

Clifton Court Forebay is a regulated reservoir at the head of the California Aqueduct in the south Delta. Inflows to the forebay are controlled by radial gates, which are generally operated during the tidal cycle to reduce approach velocities, prevent scour in adjacent channels, and minimize water level fluctuation in the south Delta by taking water in through the gates at times other than low tide. 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 3 feet per second (ft/sec) to control erosion and prevent damage to the facility.

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). Daily pumping rates have ranged between 0 and 140 cfs during the last few years.

The NBA intake is located approximately 10 miles from the mainstem Sacramento River at the end of Barker Slough. Each of the 10 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/sec. The larger units were designed for a 0.5-ft/sec approach velocity, but actual approach velocity is about 0.44 ft/sec. The screens are routinely cleaned to prevent excessive head loss, thereby minimizing increased localized approach velocities.

South Delta Temporary Barriers

The South Delta Temporary Barriers are not a project element for purposes of this biological assessment or the resulting consultation. A description of the barriers 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 South Delta Temporary Barrier Project consists of installation and removal of temporary rock barriers at the following locations:

- Middle River near Victoria Canal, about 0.5 mile south of the confluence of Middle River, Trapper Slough, and North Canal.
- Old River near Tracy, about 0.5 mile east of the Delta-Mendota Canal 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, and 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 at both Middle River and Old River near Tracy barriers are tied open. After May 31, the Middle River, Old River near Tracy, and 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 dissolved oxygen (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.

Suisun Marsh

Suisun Marsh Salinity Control Gates

The Suisun Marsh Salinity Control Gates (SMSCG) are located about 2 miles northwest of the eastern end of Montezuma Slough, near Collinsville (Figure 6-2). 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 (the flashboards can be removed if emergency work is required, but removal 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 State Water Resources Control Board (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 1 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.

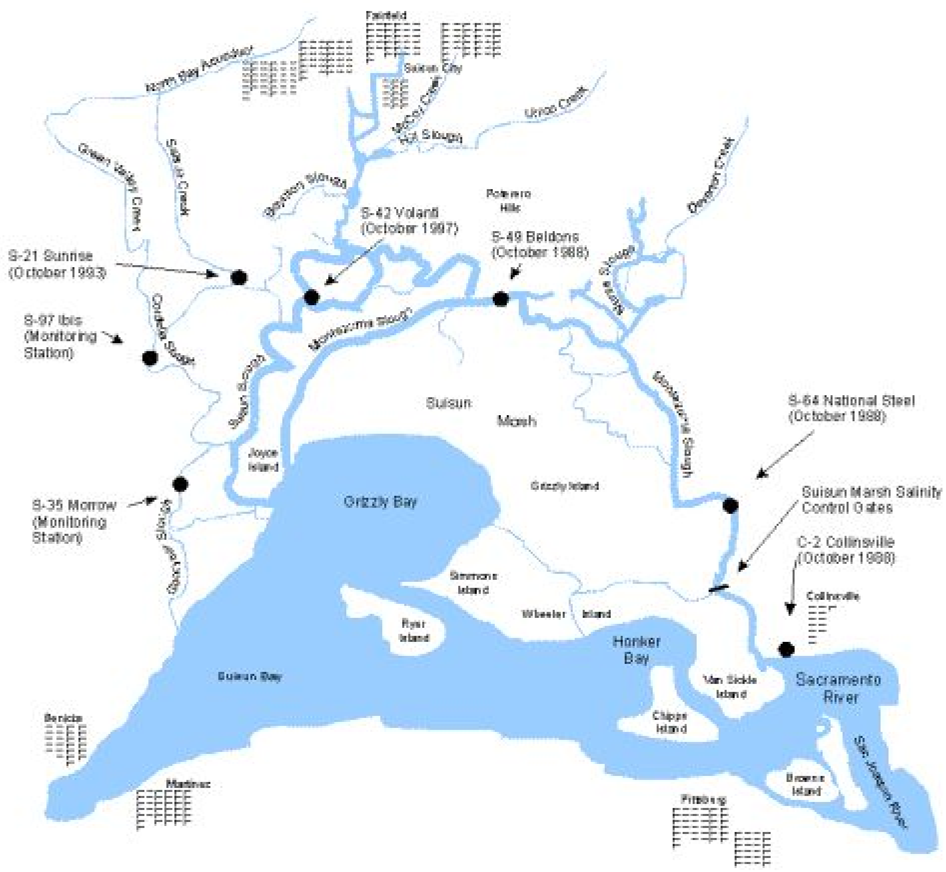

Figure 6-2 Suisun Bay and Suisun Marsh showing the location of the Suisun Marsh Salinity Control Gates and salinity control stations

The 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 millisiemens per centimeter (mS/cm) at any trigger station (2 mS/cm below the October standard)[4]. Trigger stations are S-35, S-42, S-49, and S-64 (Figure 6-3). 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

4 Since 1988, the SMSCG have been operated in September during five years (1989, 1990, 1993, 1994, and 1999), either for testing the effectiveness of gate operations, to help reduce channel salinity for initial flooding of managed wetlands during drought conditions, or to test salmon passage.

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 and 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-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 that the slots did not provide improved passage for salmon at the SMSCG. The reason(s) for this is yet 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 configuration (no slots) and when the flashboards and gates were out of the water.

Because preliminary results from the modified SMSCG test indicate that the slots are resulting in less passage than the original flashboards, the DWR and Reclamation 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. In 2001, the SMSCG Steering Group evaluated leaving the boat lock open as a means of providing unimpeded passage to adult salmon migrating upstream. Studies were completed during the 2001-2002 and 2002-2003 control seasons and plans are in place for the 2003-2004 control season. The studies included three phases in varying order each year:

1. Full Open Operation. The SMSCG flashboards are out, the gates are fixed in the up position, and the boat lock is closed.
2. Full Bore Operation with Boat Lock Open. The SMSCG flashboards are in, the gates are tidally operated, and the boat lock is held open.
3. Full Bore Operation with Boat Lock Closed. The SMSCG flashboards are in, the gates are tidally operated, and the boat lock is closed.

Roaring River Distribution System

The RRDS was constructed in 1979-80 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 that 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 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/sec 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, has 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 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 from drainage water discharges into Goodyear Slough. The M-Line ditch is approximately 1.6 miles long and the C-Line ditch is approximately 0.8 mile long.

The U.S. Fish and Wildlife Service (FWS) 1997 Biological Opinion included a requirement for screening the diversion of the MIDS. Reclamation and DWR continue to coordinate with FWS and NOAA Fisheries in developing 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 because any 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 and south of Wells Slough. The property owner is responsible for operation and maintenance of the gate. No impacts to fish are known to occur because of operation of the drain.

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Chapter 5 Operations Forecasting

Forecasting

The Project Purposes include water supply, flood control, environmental requirements, power generation, and recreation. A forecast model is used to represent these varied demands on the water system.

The operations forecast model is currently a Lotus 1-2-3 for Windows spreadsheet application designed to assist in the water and power operations planning of the Central Valley Project (CVP). An Excel spreadsheet forecast is in development. A monthly time step is used for what is usually a 1-year forecast period. Several variables are entered for half-month time increments to allow calculation of the special flow and Delta pumping conditions called for during the 31-day spring pulse flows that extend from mid-April to mid-May.

The State Water Project (SWP) also performs spreadsheet-based annual operations forecasts using a monthly time step. These forecasts are used to help plan SWP operations and determine allocations. Although separate forecasts are often required to analyze specific SWP or CVP operations, both projects work together so that hydrologic forecasts and assumptions are consistent between the various studies.

Use of the spreadsheet model initially requires the development of a set of input data to describe the hydrologic conditions, regulatory requirements, and certain of the operations objectives. The user may then interactively manipulate values that are presented on a set of “screens” referred to as the “reservoir” screen, the “Delta” screen, and the “split-month” screen. The “Reservoir” screen shows month-by-month how reservoir releases affect storage and river flows from Trinity, Whiskeytown, Shasta, Oroville, and New Melones reservoirs.

The “Delta” screen is used to examine variations in SWP and CVP Delta exports and the resulting consequences to Delta outflow, position of X2, or Rock Slough chlorides. As operations are varied, calculated Delta outflow is compared to required Delta outflow. Adjustments to Delta exports or reservoir releases are made to correct deficits between calculated and required Delta outflow. Calculated results for other parameters such as X2 and Export/Inflow (E/I) ratio are also manipulated to meet the appropriate standard through adjustments to Delta exports and reservoir releases.

The “split-month” screen comes into play in describing April-May operations. San Joaquin River flows above the Stanislaus confluence, Stanislaus flows, and Delta pumping at Tracy and Banks are entered for four separate periods, two each in April and May. This enables the user to specifically simulate the 31-day pulse flow period as occurring partly in April and partly in May. The user can also specify the starting date. The model separately calculates Vernalis flow, Delta outflow, and E/I ratio for each of the partial months.

The user of the model determines which factors constrain operations, given a particular set of inputs and assumptions. Ultimately, this determines what mixture of objectives is achievable by the project operations. The following list of considerations may affect operations decisions within any particular operations forecast being prepared. The water supply objective has several constraints on the system:

- Geography – most of the water supply is in the northern portion of the State and the largest demand is in the south.
- Hydrology – water supply is greatest in the winter and spring, and demand is greatest in the summer.
- Physical Capacity – concerns the reservoirs and pumping plants. The CVP has most of the storage in the northern reservoirs (Trinity at 2.4 maf, Shasta at 4.5 maf, Folsom at about 1.0 maf). The pumping at Tracy is limited to 4,100 to 4,600 cubic feet per second (cfs). The SWP has most of the pumping capacity and some storage north of the delta. The pumping at Banks is about 6,680 cfs and Oroville storage is 3.5 maf.
- Flood Control Requirements – each reservoir has different requirements and restricts upstream storage in the late fall through early spring. Flood control mandates release rates during flood control encroachment. Environmental obligations include water quality standards, minimum river flow requirements, Delta outflow requirements, and Endangered Species Act (ESA) curtailments.
- Contractual and Water Rights Requirements – the various categories of CVP water demands and the contractual amounts and deficiency criteria associated with each. These water demands may be categorized as Water Rights Settlement and Exchange Agreements, Municipal and Industrial Water Service Contracts, Legislative Mandates, Agricultural Water Service Contracts, and Delivery Losses.

Water rights settlement contracts and water service contracts are readily documented, consisting of agreements and contracts with specific terms and conditions. These terms and conditions may include deficiency provisions, terms for payment of water, repayment of capital obligations, etc. These terms and conditions vary depending on whether a contract is water rights, agricultural water service, or municipal and industrial type.

Water Demands

Estimated 2001 level demands for the CVP are about 3.5 million acre-feet (maf) for the Delta export service areas, and 3.3 maf for the Sacramento Basin demands (including the American Basin demand). Tables 5-1 and 5-2 give a breakdown of these demands. The U.S. Bureau of Reclamation (Reclamation) has water right settlement contracts totaling about 2.2 maf on the Sacramento River and San Joaquin River Exchange contracts plus other water rights settlement contracts on the San Joaquin River, which total about 0.9 maf. These annual contract amounts must be supplied in full, unless the forecasted Shasta inflow constitutes a “Critical” water year as described in the terms of these contracts. When Shasta inflow is “Critical,” San Joaquin Exchange contractors’ supplies may be limited to 650,000 acre-feet and Sacramento River and other San Joaquin water rights supplies may be reduced by 25 percent.

Table 5–1 Annual water demand in CVP- OCAP

Project	Regions	Millions of Acre-feet
SWP	Delta and South	3.8
	Feather River Service Area	1.0
CVP	Delta and South	3.5
	Sacramento Basin	3.4

Table 5–2 CVP-OCAP annual CVP deliveries by category of use (Units: million acre-feet)

	Water Rights	Project Agriculture	M&I	Refuge with Losses
Delta and South	.9	2.1	.3	.2
Sacramento Basin	2.2	.4	.5	.3
Total	3.1	2.5	.8	.5
NOTE: Water rights and Refuges subject to maximum 25 percent reduction in CVP-OCAP				

The other major components of the CVP water demands are: 1) Refuge water supplies, 2) Municipal and Industrial (M&I) water supplies, and 3) agricultural water service contracts. Water allocation policy for M&I contracts. Legislative requirements of the Central Valley Project Improvement Act (CVPIA) for refuge water deliveries provide a level of annual supply with no greater than 25 percent reductions (per the Draft M&I shortage policy). Agricultural water service contracts have no such limits on reductions in supplies. As can be inferred from Table 5-2, because of the limitations of reductions in all other components of CVP water demands, agricultural water service contracts are vulnerable to any and all reductions in supply that cannot be apportioned to Refuge, M&I, or Water Rights settlement contracts. Given the existing CVP operations criteria and the estimated 2001 level of demands, agricultural water service contracts South of the Delta seldom receive 100 percent of their contract supplies. In each of the last 5 years, CVP water deliveries have been limited because of insufficient supply, lack of conveyance capacity, or operational constraints on Delta pumping resulting from either endangered species protection or implementation of CVPIA actions using a portion of the CVP yield.

To operate the CVP efficiently, allocations for all types of water contractors must be combined with the pattern of requests for water. Schedules of water deliveries throughout the CVP must be coordinated with reservoir operations, release capability stream flow requirements from the northern CVP reservoirs, the capability to divert the water in the Delta, and the pattern of fill and drawdown of San Luis reservoir.

Central Valley Operations Office does a monthly forecast in a spreadsheet model. In the beginning of the water year, forecasts for 50 percent hydrology and 90 percent hydrology are calculated. As the difference between the hydrologies disappears, generally in May, only the 90 percent hydrology is used in the forecast. With the (b)(2) forecasts and the Environmental Water Account (EWA), a series of forecasts are made. A D-1485 base operation is done for (b)(2) accounting of conditions in 1992 (before CVPIA) including the winter-run Chinook salmon Biological Opinion. The second run is the updated Water Quality Control Plan (WQCP), D-1641 operation. The third run adds the (b)(2) actions to attain the 800,000 acre-feet (700,000 acre-feet in Dry years, and 600,000 acre-feet in Critical years). Then the EWA actions are added in a fourth run of the operations. The forecasts are coordinated closely with California Department of Water Resources (DWR) and their operations.

Determining Factors for CVP & SWP Allocations

Water deliveries to SWP and CVP contractors are made all year. Contractor delivery patterns peak during spring and summer and are satisfied by direct diversions from the Delta combined with releases from San Luis Reservoir and SWP reservoirs in southern California. At times, unused Delta pumping capacity may be available to move additional water for direct delivery, groundwater recharge, pre-irrigation, storage south of the Delta, or water transfers. Allocation of CVP and SWP water supplies for any given year is based primarily on six variables:

- Forecasted reservoir inflows and Central Valley hydrologic water supply conditions
- Current amounts of storage in upstream reservoirs and in San Luis Reservoir
- Projected water demands in the Sacramento Valley
- Instream and Delta regulatory requirements
- Annual management of 3406(b)(2) resources
- Efficient use of CVP-SWP export capacity through Joint Point of Diversion flexibility

Beginning each year (in December for SWP, and February for CVP), initial allocations of entitlement deliveries are determined based on the above criteria. Generally, allocations are updated monthly until May, although increases may occur later based on reservoir storage.

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.

Carryover Storage and Water Allocation

Providing the water needed for contractors' beneficial uses requires a strategy that recognizes two competing requirements: 1) the need to retain sufficient carryover storage to reduce the risks of future shortages and to ensure sufficient temperature control capability; and 2) the need to draw from storage in a given year to provide sufficient water delivery to avert health, safety, economic, and environmental hardship.

Since the implementation of the NOAA Fisheries Biological Opinion in 1993, CVP carryover storage is primarily an outcome of the annual balancing of the requirements to manage storage and releases that provide for upper Sacramento River temperature control with the use of CVP storage, diversion, and conveyance facilities to make water available for delivery.

Each individual CVP storage reservoir must also be operated to provide reasonable assurance that minimum storage, instream flows, diversion pools, and hydroelectric power pools can be sustained. These elements are considered in the determination of water allocations.

Storage targets and release objectives are re-evaluated annually for Folsom because of its high probability of refill and relatively small amount of usable conservation storage. For Trinity and New Melones, because of low refill probability, long-term capabilities are more of a concern. For New Melones, water supply may already be over-allocated; so sustainable yield is a concern. For Trinity, releases in the current year to assist in meeting Trinity River flows, water delivery, energy, and temperature control objectives must be balanced against retention of storage for use next year and beyond. Shasta's carryover is now mostly a byproduct of temperature control requirements on the upper Sacramento River, although use of Trinity Basin diversions can affect Shasta carryover.

Even in above normal runoff years, it may no longer be possible to meet all competing needs for CVP water, especially south of the Delta. However, even in drier years, if sufficient carryover storage is available, CVP water allocations may be met partly with withdrawals from reservoir storage. During prolonged droughts, all beneficial uses of CVP water are adversely affected. Both environmental and economic systems are stressed by the cumulative impacts of dry conditions, to a point where tolerance of continued drought is significantly weakened. When CVP storage is withdrawn to combat the effects of drought, the subsequent loss of carryover storage diminishes the capability of the system to mitigate the future impacts of a continuing drought.

Water Allocation Priorities and Categories

The water allocation process must consider the various categories of CVP water demands and the contractual amounts and deficiency criteria associated with each. These water demands may be categorized as follows:

- Water Rights Settlement Agreements
- Municipal and Industrial Water Service Contracts
- Legislative Mandates
- Agricultural Water Service Contracts
- Delivery Losses

Water rights settlement contracts and water service contracts are readily documented, consisting of agreements and contracts with specific terms and conditions. These terms and conditions may include deficiency provisions, terms for payment of water, repayment of capital obligations, etc. These terms and conditions vary depending on whether a contract is of water rights, agricultural water service, or M&I type.

Legislative mandates are exemplified by P.L. 102-575, which specified increased levels of supply and maximum deficiencies for wildlife refuges and management areas.

Delivery losses are included as a category of demand, because such losses will occur with the delivery of water and are in addition to contractual and other obligations.

The allocation of CVP water supplies can be portrayed as a two-tiered hierarchy, where all the above categories of water demands fall into one of two "groups," Group I and Group II. Under this allocation system, Group I water demands must be met first. Group I includes all categories of water demands with specifically defined minimum supplies. These include: 1) Sacramento River water rights and San Joaquin Exchange contracts, with associated minimum rates of delivery in "Critical" Shasta inflow years; 2) Refuge water supplies which must be provided at a minimum of 75 percent of supplies as prescribed in CVPIA, and CVPIA 3406(b)(2) as described in the May 9, 2003 Decision; 3) M&I water supplies, which are assumed to be sustained at 75 percent of maximum historical use, adjusted for growth (per the draft M&I shortage policy); and 4) conveyance, evaporation, and other such water delivery losses, which are incidental to the delivery of contractual supplies. Group II includes all other agricultural water service contracts. Group II water allocations are made only after Group I obligations have been met. Further, the supplies available to Group II are then apportioned according to contract entitlements that contain no minimum delivery provisions.

There are about 2.0 maf of such Group II water contracts for south of the Delta. Because of increases in certain Group I requirements over time (M&I and refuge water), and loss of some pumping opportunity resulting from recent changes in operations criteria, the potential for deficiencies to Group II exists every year.

Hardship and Critical Needs Water

"Hardship" water supplies were delivered to some CVP contractors in 1990 and 1991. Hardship water has been allocated to agricultural water service contractors to augment their supply to minimally sustain permanent crops (trees and vines) to avoid their permanent loss. Hardship water has been allocated to M&I contractors to help meet limited demands that cannot reasonably be met from other sources.

"Critical Needs" water was allocated in 1994 to both agricultural and M&I contractors north and south of the Delta. First, requests for critical needs water were solicited and screened. To be eligible, contractors had to have a current approved water conservation plan on file with Reclamation. The total amount of critical needs water allocated was determined as an amount that could be made available within the context of forecasted operations of the CVP for the remainder of water year 1994. It was, in effect, a partial re-distribution of water that had been withdrawn from water rights settlement allocations, when it was determined in May that 1994 would be a "Critical" Shasta inflow year. A total of about 150 thousand acre-feet (taf) was apportioned among those contractors whose critical needs requests were validated. More than 800 taf was requested.

Runoff Forecasts

The purpose of developing seasonal runoff forecasts is to gain as accurate as possible an assessment of the potential for runoff into each major CVP reservoir. This assessment includes the probable range of the total runoff for the particular water year and the distribution of runoff over time. The accurate estimation of runoff is probably the single most important factor in planning CVP operations.

Reclamation, DWR, and National Weather Service River Forecast Centers (NWSRFC) independently prepare forecasts of seasonal runoff for various streams in the Central Valley. Reclamation forecasts runoff into the following reservoirs shown in Table 5-3.

Table 5-3. Reclamation-forecasted runoff (CVP reservoirs)

Reservoir	River
Trinity	Trinity
Shasta	Sacramento
Folsom	American
New Melones	Stanislaus
Millerton	San Joaquin

Reclamation also uses DWR forecasts of the Water Supply Indexes used for classifying the water year according to the system adopted by the State Water Resources Control Board (SWRCB) and used for purposes of linking Delta standards to relative wetness of conditions. Three Indexes are used: the traditional Sacramento River Index, the Sacramento Valley Index (known as the 40/30/30 Index), and the San Joaquin Valley Index (known as the 60/20/20 Index). As a complement to those indexes, DWR also provides the eight–river index, which is a single-month composite index for the eight streams represented in the Sacramento and San Joaquin indexes. It is used in conjunction with certain D-1641 standards, including X2.

Use Of Multiple Linear Regression Models

The system Reclamation uses for forecasting runoff for CVP reservoirs consists of sets of multiple linear regression models. Those models were developed by analyzing historical data sets, which consist of measured monthly amounts of precipitation, measured snow water content, and calculated monthly amounts of runoff at the five reservoirs. The general form of the multiple linear regression models used to predict the runoff is an equation in which the estimate of runoff from the beginning of the current month through the remainder of the water year is a function of antecedent runoff, seasonal precipitation to date, and observed snow water content. No estimates of future precipitation or other predictive inputs are used in this process.

Forecast Confidence Limits

Confidence limits quantify the uncertainty of an estimate, such as the runoff forecast, by defining the upper and lower limit of a range of values that is expected, with a given probability, to include the actual runoff. Confidence limits on the seasonal runoff forecast are estimated by analyzing the error potential of the multiple linear regression models used. This analysis develops a probabilistic distribution based on the errors obtained by hindcasting the runoff of each historical year, using the same multiple linear regression models as were used to obtain the "most probable" forecast. This distribution of historical errors is assumed to adequately represent the probable accuracy of the current year's runoff forecast. However, in extremely wet or dry years, further special analyses may be warranted to more accurately define the confidence limits.

Customarily, the 90-percent and 10 percent exceedance forecasts are computed to define reasonable upper and lower bounds within which the actual runoff should fall 80 percent of the time. The estimation of runoff outside these limits becomes increasingly subject to error based on the limitations of the length of record for the historical data as well as the properties of the multiple linear regression models themselves.

Initially, because of low reservoir storage conditions during the 1987-1992 drought, then later as a result of the resource protection area (RPA) contained in NOAA Fisheries 1993 Biological Opinion, the 90 percent exceedance forecast of runoff for the CVP reservoirs has been used as a basis for decision-making on annual water allocation. A conservative estimate of runoff potential translates to a relatively low risk that CVP's initial water allocations would be later reduced, even if subsequent precipitation were well below normal. This approach to risk management is important to water users and other resource managers who must make a substantial commitment early in the year on the basis of estimates of the minimum water supply available. However, in conditions of high reservoir storage, a less conservative forecast may provide a more practical basis for operations decision-making.

Depending on prevailing hydrologic and storage conditions, one or more runoff forecasts will be developed for use as input data to Reclamation's operations forecasting model. Reclamation's current forecast procedures develop a total volumetric runoff forecast for the remainder of the water year for each major water supply reservoir. Typically, confidence limits will be computed for each reservoir's forecast so that a water year runoff will be estimated at the 90 percent, 50 percent, and 10 percent levels of exceedance probability. These water year forecasts are then distributed into monthly amounts, generally by using a pattern wherein each month's forecasted runoff has the same historical probability of exceedance. This pattern may be altered if factors such as antecedent runoff conditions or snowmelt potential indicate that a different distribution should be used.

Runoff forecasts are initially computed in February. They are based on precipitation and runoff conditions through January 31 plus February snow course measurements, which will normally be taken within a few days of the end of January. If necessary, these snow course measurements are then adjusted to represent end-of-the-month conditions of the snow water content. Forecasts are recomputed in March, April, and May using the same process but with different multiple linear regression equations and updated data inputs.

Forecasts may be performed earlier than February, but the potential inaccuracy of such early forecasts raises the possibility of large forecasting errors. For many water management purposes, it is less risky to use assessments of runoff potential that are derived simply from the statistical properties and the rankings of the historical runoff data. As shown on Figure 5-1, slightly more than 50 percent of the rainy season is past by February 1, and knowledge of runoff potential sufficiently outweighs the risks of inaccurate forecasts.

The final forecasts are computed in May of each water year, although adjustments to these forecasts will be made in subsequent months based on observed runoff, the actual timing of the peak of snowmelt runoff, and the shape of the recession of snowmelt runoff hydrography. Furthermore, in the American, Stanislaus, and San Joaquin River basins, the forecast of natural runoff must be converted to “operational reservoir inflow” by adjusting for the effects of regulation by upstream reservoirs, imports and exports from the basins, and consumptive use (if appropriate).

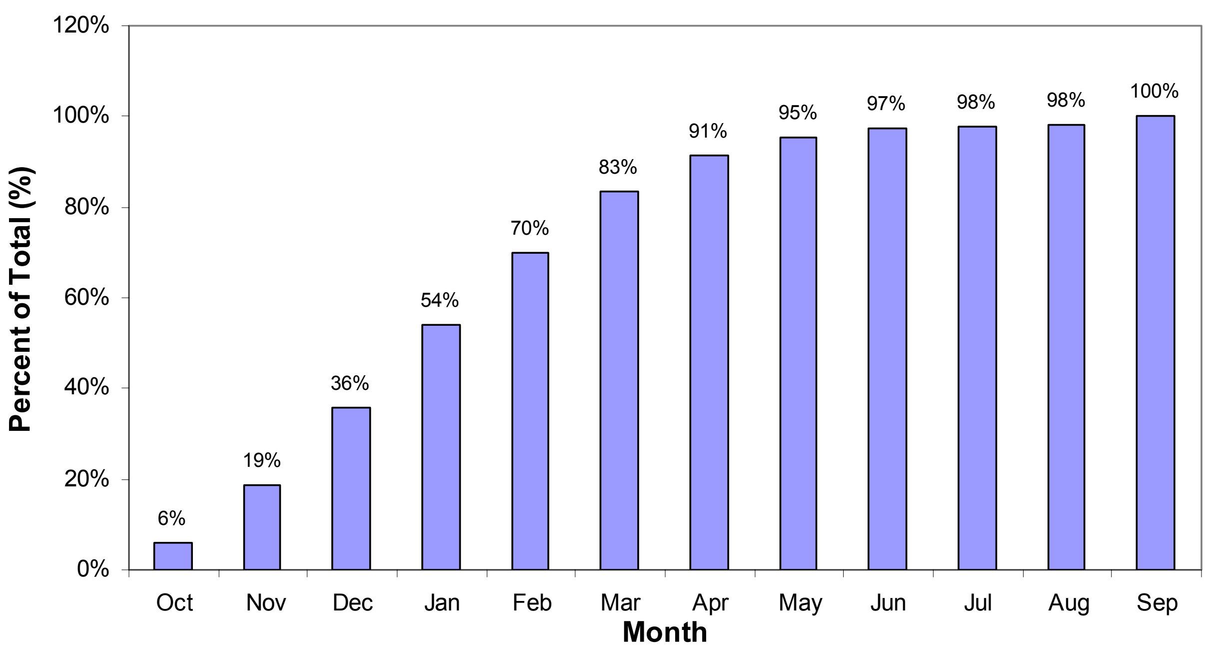

Figure 5-1 Typical Pattern of Precip Accumulation from Northern Sierra 8 Station Chronology (1921 to 2003

Accuracy of Runoff Forecasts

The accuracy of the runoff forecasts in any given year is highly dependent on the pattern of the precipitation in that year, a factor that cannot be well predicted. However, the patterns of precipitation and runoff in the Central Valley over many years have exhibited two important tendencies: the rainy season generally occurs between November and April and snowmelt runoff typically occurs between April and July.

Because of these generalized tendencies the accuracy or, conversely, the error potential of the water year runoff forecasts can be depicted as a "funnel diagram." The general tendency for forecast errors over time is that they tend to get smaller as the year proceeds and more information becomes "observed" and less remains to be "estimated."

Although no forecasts of runoff are developed past the end of each current water year, the characteristics of the baseflow runoff persist into the next water year, a particularly important factor during water years that depart significantly from the average. In these cases, expected amounts of runoff for October through January may be adjusted to account for the persistence of the previous water year's characteristics.

Consultations and Coordination

Reclamation, DWR, and National Weather Service River Forecast Center (NWSRFC) in Sacramento all prepare independent forecasts of runoff for each CVP water supply reservoir. Before final adoption of the runoff forecast for use in operations planning, Reclamation consults with and compares forecasts with personnel from these two agencies. Based on those consultations, Reclamation may decide to adjust its original forecast, or adopt a different forecast for use in operations planning. An important element of the forecast consultations is the discussion of any unique conditions of the current water year and how those conditions may affect the accuracy of the runoff forecasts. Since EWA began in 2000, it has become increasingly important within the CALFED Operations coordination process that Reclamation and DWR have a common forecast for operations planning purposes.

Most of the precipitation data used by Reclamation is collected or reported by either the DWR or the NWSRFC. All of the snow water content data are collected and reported by DWR's California Cooperative Snow Surveys. Reclamation has entered into annual agreements with each of these agencies, which help support data collection, processing and reporting, and runoff forecasting efforts.

Accretions and Depletions

Sacramento River

Another step in the forecasting process is determining Sacramento River accretions and depletions. This term refers to the difference between the amounts of water released to the Sacramento and its tributaries by the CVP and the SWP and the amount that flows past the City of Sacramento and into the Delta. Depending on the time of year and hydrologic conditions, this amount may represent a net gain (accretion) or a net loss (depletion). Accretions and depletions are forecasted for both short-term and long-term operational planning purposes.

Short-term forecasts (about 7 days or less in the future) are used to estimate inflows to the Delta at key points on the Sacramento River and to provide guidance to CVP operators on predicting release requirement from 5 to 7 days in advance (the maximum travel time from Keswick Dam to the Delta). Such short-term predictions of accretions and depletions may make use of: real-time flow data, temperature and weather forecasts, travel time, non-CVP reservoir releases, existing trends in accretions and depletions, and advice and input from some of the major irrigation districts using water on the Sacramento River.

Long-term forecasts of accretions and depletions are made to plan monthly or seasonal operations. For long-term forecasts, accretions and depletions are treated as monthly quantities and are customarily forecasted or estimated for 12 months into the future. The following discussion focuses on the long-term range forecasts of accretions and depletions.

Over a 12-month period, Sacramento River accretions and depletions are a function of countless natural phenomena, decisions made by CVP reservoir operators, and individual water user requirements. Some of these phenomena have an element of predictability, but a great deal of variability and uncertainty is associated with the long-term forecasts of accretions and depletions. When estimating beyond the end of the current irrigation season, historical patterns and the correlation between accretions and the upstream water supply provide almost the entire basis for the estimate.

One major hindrance in forecasting accretions and depletions is the relatively short historical period of records available that is representative of the present level of development and stream flow regulation in the Sacramento Valley. The construction and subsequent operation of the Tehama-Colusa Canal and New Bullards Bar Dam on the Yuba River have each had a major influence on the quantity and pattern of accretions and depletions in the Sacramento River. These newer facilities, which began operation during the 1970s, shorten the period of record from which to base comparisons and to formulate estimates of future accretions and depletions.

The net annual accretions and depletions have ranged from about 1.0 maf in 1977 to more than 20 maf in 1983. The range of these quantities, in addition to the scope and complexity of the other hydrologic processes affecting accretions and depletions within the Sacramento Valley, add to the problems of accurately forecasting accretions and depletions. Fortunately, certain predictable tendencies help to characterize the accretions and depletions. Furthermore, CVP operational considerations limit the range of accretions that have any practical effect on CVP operations to periods when the Delta has "balanced" conditions, or other active constraints such as export/inflow ratio. When "excess" conditions exist, the projects are storing and exporting as much water as possible. Thus, the accuracy of the estimate of accretions and depletions is significant to CVP operations only within the range that is associated with the CVP's capability to respond operationally. During winter months, this excludes many of the wetter conditions.

The characteristics used in estimating accretions and depletions include:

- The predictability of the rainy season (accretion) and the growing season (depletion)
- The quantifiable nature of reservoir regulation effects (including New Bullards Bar, South Yuba system, Black Butte, and Bear River)
- Physical limits to rates of depletion that are tied to the aggregate diversion capability and the irrigated acreage in the Sacramento Valley

- Contractual or water rights limitations to the overall water use of the Sacramento River during the course of a growing season
- Predictability of the timing and quantities of water associated with flooding and draining of rice fields

In the Sacramento Valley, irrigation is generally limited to the months of April through October. This complements the rainy season, November through March, although there may be significant overlap in many years. The irrigation season is dominated by depletions and usually results in a net depletion to the Sacramento River as a whole, although the influence of accretions from tributary inflow may still be significant.

The months of November through March are almost totally dominated by accretions in the Sacramento River. In estimating accretions and depletions, it is helpful to treat the irrigation season or the irrigation component of the accretions and depletions separately from the other hydrologic inputs. Early in the water year, the basis for estimating accretions and depletions is to select (using historical data) amounts and patterns that are consistent with the assumed water supply upstream of the reservoirs. History shows a high correlation between headwaters runoff and accretions. Early in the water year, historical patterns and amounts may adequately represent net depletion as well unless water use limitations or deficiencies are anticipated. In the Sacramento Valley during a normal year, about 4 maf are used for irrigation. Later in the water year, as the overall characteristics of the water year become better known, estimates may be refined by the knowledge of tributary runoff forecasts, current inflow conditions, basin saturation, and reservoir releases on the Yuba and possibly other streams.

Once the irrigation season begins, estimating accretions and depletions for the remainder of the season becomes a process of verification and adjustment of the expected quantities. In the absence of rainfall runoff, actual accretions and depletions become more predictable but remain a source of some uncertainty, even during the summer when monthly estimates may frequently be in error by 20 percent or more.

A relatively new effect on net accretions and depletions in the Sacramento River is use of diverted water for rice decomposition. This program, which has been in place for a few years, has significantly increased Sacramento River and Feather River diversions in October and November, as water is used to flood harvested rice fields to induce rice stubble decomposition as an alternative to burning.

San Joaquin River

San Joaquin River accretions and depletions have become increasingly important since the San Joaquin River Agreement (SJRA) and the D-1641 San Joaquin flow standards were implemented. Reclamation forecasts San Joaquin accretions in the same manner as for Sacramento River. For planning for Vernalis Adaptive Management Program (VAMP) flows, Reclamation consults and coordinates with the SJRA water providers to determine forecasts of flows entering the San Joaquin River from reservoir releases and from net accretions and depletions downstream of reservoir release points. During periods when flood control releases are made, which occur during approximately 50 percent of years on the San Joaquin system, Reclamation receives information on updated operations forecasts from the operators of other flood control projects contributing to the San Joaquin flow.

Forecasts of Delta Requirements

Forecasts of Delta requirements are perhaps the most difficult to make within the forecasting process for CVP operations. So many factors can influence conditions in the Delta that it is unlikely that any forecast will succeed in correctly identifying them all. For example, four major water diversion points are located in the Delta, with literally hundreds of minor water diverters. There are forecasted tide tables, but no long-term forecasts of barometric pressure that can affect the magnitude of the tides. Also, no long-term forecasts of daily meteorological events are made. Despite these limitations, forecasts of Delta requirements are necessary. Without the forecasts, planning for upstream reservoir operations and water deliveries south of the Delta would be impossible, and the reliability of the projects would be compromised.

Every month throughout the year has Delta water quality standards that must be met. Investigations by the CVP and SWP operators have provided estimates of the required daily Delta outflow necessary to meet these standards. Estimates of daily consumptive use by unmonitored diversions, evaporation, and consumptive use by riparian vegetation have also been established. This information, along with forecasted Delta inflows from sources other than the Sacramento and San Joaquin Rivers and informed guesses about tidal influences, provide the operators of the two projects with a baseline condition of Delta water needs.

With the baseline needs established, CVP Delta exports are then added to the total. Depending on the amount of CVP Delta exports and water quality conditions in the Delta, some amount of water in excess of exports, known as carriage water, may be required. Carriage water is that quantity necessary to counteract a degradation in Delta water quality caused by operating the export pumps. Thus, the Delta water requirements are equal to the baseline needs plus exports plus carriage water.

Once the Delta water requirements are established, the operators of the two projects estimate how much water must be released from CVP and SWP reservoirs to meet both the Delta requirements and the intervening depletions along the Sacramento and San Joaquin Rivers as they flow into the Delta.

Temperature Modeling for the Forecast

The Reclamation temperature models for the Sacramento and Feather Rivers (Rowell 1990) and the Stanislaus River (Rowell 1997) are used to forecast mean monthly temperatures in the corresponding rivers. The models are further described in Appendix IX of the 1997 Reclamation Draft CVPIA Programmatic Environmental Impact Statement (PEIS) (Reclamation, 1997). There are two basic elements in each of the models: a reservoir component, and a downstream river component. The CVO operations forecast model provides monthly project operations input to the temperature models for the 50 percent hydrology and 90 percent hydrology exceedance conditions for each of the forecasts.

The reservoir temperature component simulates 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 fish. 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 7 locations on the Sacramento River from Keswick Dam to Red Bluff, 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. Long-term monthly mean historical air temperatures and other climatic data for Shasta, Redding, Red Bluff, Oroville, Marysville, Folsom, Sacramento, New Melones, and Stockton were obtained from National Weather Bureau records and used to represent climatic conditions for the four river systems.

DWR contracted with UC Davis hydrologists to develop a water temperature model for the Feather River (Cook and Orlob, 2000). DWR has also contracted with Surface Water Resources, Inc. for model development related to the Federal Energy Regulatory Commission relicensing process underway for the Oroville Facilities. The resulting system of temperature models should be available to provide analyses for future biological assessments.

Modeling Limitations

The main limitation of the operations forecast and temperature models used is the time step. Mean monthly or weekly values do not reflect daily or other short-term variations that could occur due to dynamic flow and climatic conditions. 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, temperatures lower than those indicated by the model are 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 outputs a much cooler temperature than what 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 model results. Although limitations exist, the models used are the best available and any compounding effects caused by the limitations in the models are not as likely to be fully expressed in the 36-month period modeled.

Chapter 6 Analytical Approach and Methods

The purpose of this chapter is to detail the hydrologic and temperature models that were used in the trend analysis of Central Valley Project (CVP) and State Water Project (SWP) operations as operating critieria have changed since 1992. This chapter presents the detailed modeling assumptions regarding CVP and SWP operations used during the trend analysis and model limitations for the CALSIM II hydrologic model, temperature model, and fish mortality model. The effects of changing assumptions between model simulations for the trend analysis are presented in the following chapters on Upstream and North of the Delta Results, and Delta and South of the Delta Results. The last section in this chapter summarizes results shown in Chapters 7 and 8. Six CALSIM II simulations were run to identify impacts resulting from the CVP and SWP system changes. These six modeling runs are identified as follows:

- Study A: D1485 (1991)
- Study B: D1485 with Firm Refuge Level 2 (1992)
- Study C: D1485 with Firm Level 2 and Winter-Run Biological Opinion (1993)
- Study D: D1641 (1994)
- Study 1: D1641 with Central Valley Project Improvement Act (CVPIA) 3406 (b)(2) (1997)
- Study 3: Today: CVPIA 3406 (b)(2) with Environmental Water Account (EWA) (2004)

Study 1 and Study 3 are the same studies that are in the OCAP BA. All six studies use the same Level of Development (2001 LOD). The year in the study name refers to the year that the CVP and SWP started operating to the regultory requirements with the exception of Study A, where the projects had been operating to the requirements in the D1485 (1991) Study since 1978. Study A is used as a baseline to measure the other studies against.

The outputs of the six studies were then run through a temperature model that calculates mean monthly temperature results for the respective rivers in the CVP and SWP at various locations. The mortality model results show annual mortalities for various fish species in the rivers. The results from the six runs of the temperature and mortality models are compared to assess the impact of the regulatory requirements on the temperature and the fish species that are affected by the operational changes.

CALSIM II replaces both the DWRSIM and PROSIM CVP-SWP simulation models 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 on a monthly time step from water year 1922 to 1994. CALSIM II utilizes optimization techniques to route water through a network. A linear programming (LP)/mixed integer linear programming (MILP) solver determines an optimal set of decisions for each time period given a set of weights and system constraints (DWR 2002). The physical description of the system is expressed through a user interface with tables outlining the system characteristics. The priority weights and basic constraints are also entered in the system tables. The prgramming language used, Water Resources Engineering Simulation Language (WRESL), serves as an interface between the user and the LP/MILP solver, time-series database, and relational database. Specialized operating criteria are expressed in WRESL (DWR 2000).

The hydrology in CALSIM II was developed jointly by DWR and Reclamation. Water diversion requirements (demands), stream accretions and depletions, rim basin inflows, irrigation efficiency, return flows, non-recoverable losses, and groundwater operation are components that make up the hydrology used in CALSIM II. Sacramento Valley and tributary rim basin hydrologies are developed using a process designed to adjust the historical sequence of monthly stream flows to represent a sequence of flows at a future level of development. Adjustments to 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 and south-of-Delta CVP and SWP contractors. The delivery logic uses runoff forecast information, which incorporates uncertainty and standardized rule curves (i.e., Water Supply Index versus Demand Index Curve). The rule curves relate 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 south-of Delta SWP delivery is determined from water supply parameters and operational constraints. The CVP systemwide delivery and south-of-Delta delivery are determined similarly using water supply parameters and operational constraints with specific consideration for export constraints (DWR 2002).

CVPIA 3406 (b)(2) and Environmental Water Account Modeling

CALSIM II dynamically models CVPIA 3406(b)(2) and the EWA. CVPIA 3406(b)(2) accounting procedures 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 include SWRCB D-1641 and CVPIA 3406 (b)(2), among other elements. Given the task of simulating dynamic EWA operations, the reality of interdependent operational baselines embedded in EWA's Regulatory Baseline, and the fact that EWA operations are further dependent on operations under the Regulatory Baseline with and without EWA, a modeling analysis has been developed to dynamically integrate five operational baselines for each water year of the hydrologic sequence. These five baselines 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) are 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 6-1:

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 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.

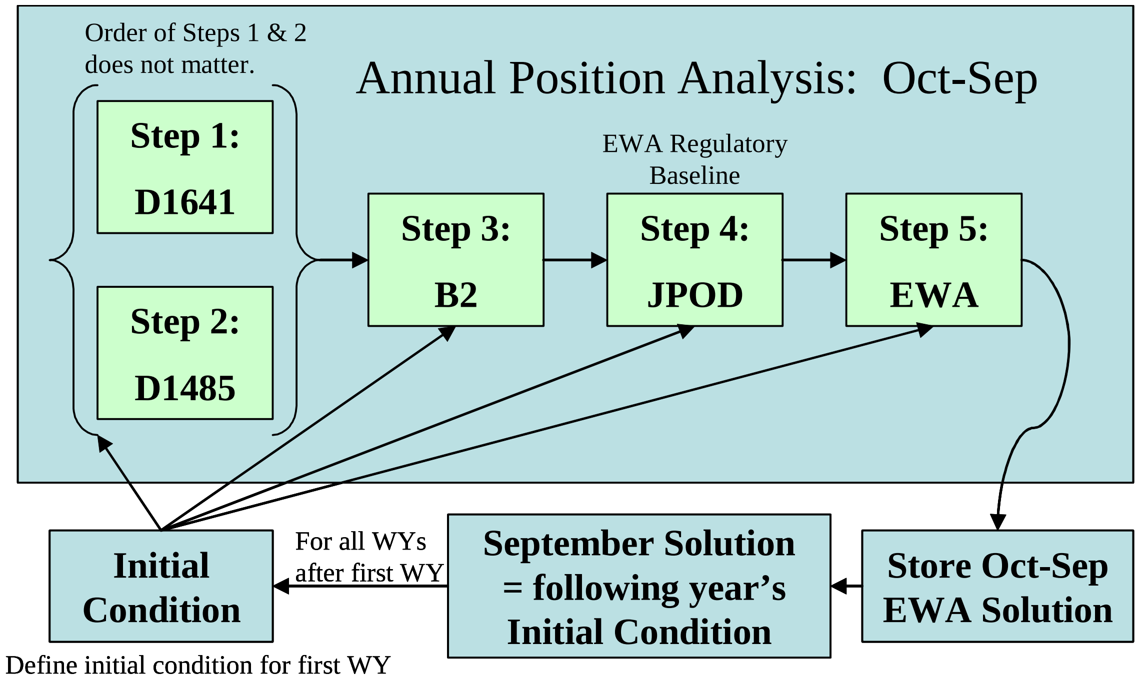

Figure 6-1. CALSIM II procedure to simulate EWA operations. (Note: Step 4 is named "JPOD" in the OCAP Today Studies and "SDIP" in the OCAP Future Studies.)

CVPIA (b)(2)

According to the 1992 CVPIA, the Central Valley Project must "dedicate and manage annually 800,000 acre-feet of Central Valley Project yield for the primary purpose of implementing the fish, wildlife, and habitat restoration purposes and measures authorized by this title; to assist the State of California in its efforts to protect the waters of the San Francisco Bay/Sacramento-San Joaquin Delta Estuary; and to help to meet such obligations as may be legally imposed upon the Central Valley Project under State or Federal law following the date of enactment of this title, including but not limited to additional obligations under the Federal Endangered Species Act." This dedicated and managed water or "(b)(2) water", as it is called, is water the U.S. Fish and Wildlife Service (FWS) has at its disposal to meet the CVP's WQCP obligations and meet any reqirements imposed after 1992. CVPIA 3406 (b)(2) water may be used to augment river flows and also to curtail pumping in the Delta to supplement the WQCP requirements.

To simulate the 3406 (b)(2) accounting, the model uses metrics calculated in the (b)(2) simulation. The metrics measure the flow increases and export decreases from D1485 to D1641 WQCP costs, and from D1485 to (b)(2), total (b)(2) costs. The following assumptions were used to model the May 2003 3406 (b)(2) Department of the Interior decision.

- Total (b)(2) fall costs are targeted for 200,000 acre-feet (af)
- Offset and reset are eliminated
- 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 Tulloch Reservoirs where (b)(2) water can be used to increase flow for fishery purposes. The assumptions 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 > 1900,000 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 and reduce the magnitude of the actions for this period.
- 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 > 1900,000 af and if remaining b2 account > projected coming WQCP costs.
  - Nimbus Releases: Action is on if Folsom Beginning-of-Month Storage > 300,000 af and if remaining b2 account > projected coming WQCP costs.
  - The export metric is total CVP pumping (Tracy + CVP Banks). Assumptions for using (b)(2) water for the following export reductions are:
    - Winter Actions (December thorugh 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 (i.e., FWS, NOAA Fisheries, and California Department of Fish and Game [DFG]) and two project agencies (i.e. Reclamation and DWR) share responsibility in the implementation and management of the EWA. The Management Agencies manage the EWA assets and exercise the biological judgment to recommend operation changes in the CVP and SWP that are beneficial to the Bay-Delta system. Together, the management and project Agencies form an EWA Team, or EWAT.

The objective of simulating EWA for OCAP modeling is to represent the functionality of the program in three ways: as it was designed in the CALFED ROD, as it has been implemented by

EWAT during Water Year (WY) 2001-2003, and as it is foreseen to be implemented in coming years by CALFED Operations. The EWA representation in CALSIM II simulations 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 South of Delta (SOD) debt
- Tracking and mitigating the effects of North of Delta (NOD) debt and NOD backed-up water
- Spilling carryover debt at SWP San Luis
- Wheeling assets from NOD to SOD for storage or usage
- Accounting system re-operation effects 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 Sac 40-30-30 Index.

- VAMP-period Export Reduction (April 15 – May 15):

  Definition: Reduce exports to a target-restriction level during the VAMP period, regardless of the export level under the Regulatory Baseline; target depends on San Joaquin River flow conditions.

  Trigger: All years. Taking action during the VAMP period has been a EWAT high priority in 2001-2003, and is therefore modeled as a high priority.

- Pre-VAMP "Shoulder-period" Export Reduction (April 1 – April 15):

  Definition: Extend the target-restriction level applied for VAMP period into the April 1 – April 15 period.

Trigger: Never. It was not simulated to occur based on actions implemented by EWAT from WY2001-2003 and in the foreseeable future.

- Post-VAMP “Shoulder-period” Export Reduction (May 16 – May 31):

  Definition: Extend the target-restriction level applied for VAMP period into the May 16 – May 31 period.

  Trigger: In any May if collateral exceeds debt at the start of May.

- June Export Reduction:

  Definition: Steadily relieve the constraint on exports from the target-restriction level of the post-VAMP period to the June Export-to-Inflow constraint level. Complete this steady relief on constraint during a 7-day period.

  Trigger: If the post-VAMP “Shoulder-period” Export Reduction was implemented and if collateral exceeds debt at the start of June.

The following assets are included in the OCAP modeling:

- Allowance for Carryover Debt (Replacing “One-Time Acquisition of Stored-Water Equivalent” defined in the CALFED ROD)
- Water Purchases, North and South of Delta
- 50 percent Gain of SWP Pumping of (b)(2)/ERP Upstream Releases
- 50 percent Dedication of SWP Excess Pumping Capacity (i.e., JPOD)
- Jul-Sep Dedicated Export Capacity at Banks

The role of these fixed and operational assets in mitigating the effects of EWA actions is dependent 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 200,000 af of stored water south of Delta. This SOD groundwater bank was excluded in the CALSIM II studies for OCAP given its absence in actual EWAT operations from WY2001-2003. Since development of this asset has been delayeed, EWAT developed a replacement asset (i.e., allowance for carryover debt and subsequent debt spilling) and operational procedures for managing this asset. OCAP modeling reflects EWAT guidelines for carrying over and spilling debt in the case of debt situated at SWP San Luis.

Several potential assets are excluded from the OCAP modeling with CALSIM II, and are addressed in CALSIM II post-processing through the EWA OCAP Modeling Chapter:

- Export/Inflow Ratio Flexibility
- Source-Shifting Agreements
- Exchanges

The impacts of actions on system operations is assessed in the OCAP modeling as EWA debt. Debt is defined as a reduction in project deliveries and/or storage relative to the EWA Regulatory Baseline (i.e., results from Step 4). CALSIM II tracks three general types of EWA debt:

- Deliveries to contractors south of Delta (SOD)
- Storage levels SOD

- Storage levels north of Delta (NOD)

Occurrence of SOD deliveries debt and subsequent failure to immediately pay back this debt are indicators 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 summation of end-of-month debt and stored water at SWP San Luis exceeded the summation of storage capacity and the "Article 21 deficit" (Figure 6-2); an Article 21 deficit represents demand minus what was delivered
- There was carried-over debt left to be spilled at SWP San Luis

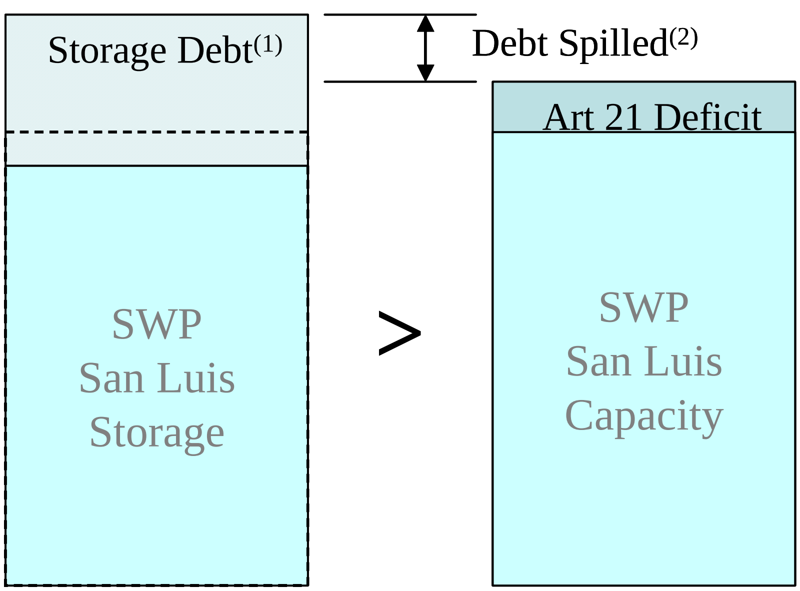

Figure 6-2 Conditions for spilling carried-over debt at SWP San Luis in CALSIM II.

Notes:

[1] *Since the Regulatory Baseline cannot exceed SWP San Luis Capacity (i.e., the dashed line in Stack A), then the debt above this capacity line must be carried-over debt. Therefore, this spill tool will only be applicable to erasing carried-over debt and will not affect "new" debt conditions from this year's actions.*

[2] *Spill amount is limited by the availability of excess capacity at Banks and surplus water in the Delta.*

CALSIM II Modeling Studies

Two Benchmark Studies (2001 and 2020 LOD) have been developed by staff from both DWR and Reclamation for the purpose of creating a CALSIM II study that is to be used as a basis for comparing project alternatives. Using the 2001 Level of Development Study, six studies were developed for the purposes of evaluating the impacts to the CVP and SWP system as operating regimes have changed since the 1992 OCAP. Table 6-1 shows the demands and the operating critieria in each of the six studies..

Table 6-1. Summary of Assumptions in the OCAP CALSIM II runs

	Level of Development	Article 21	Refuge Deliveries	Trinity Required Flows	D1485	Winter-Run B.O.	D1641	CVPIA 3406 (b)(2)	EWA
Study A D1485 (1991)	2001		Historical Level 2	340,000 af/yr	X				
Study B D1485 w/ Refuge Firm Level 2 (1992)	Same as above		Firm Level 2	Same as above	X				
Study C D1485 w/ Refuge Firm Level 2, and Winter Run B.O. (1993)	Same as above		Same as above	Same as above	X	X			
Study D D1641 (1994)	Same as above		Same as above	Same as above		X	X		
Study 1 D1641 w/ CVPIA 3406 (b)(2) (1997)	Same as above	X	Same as above	Same as above		X	X	X	
Study 3 Today CVPIA 3406 (b)(2) with EWA (2004)	Same as above	X	Same as above	369,000-453,000 af/yr		X	X	X	X

Study A represents the D1485 criteria that were operated to since 1978 and is assumed to be the study that will show maximum capability for deliveries. Study B layers Firm Refuge Level 2, and Study C adds the Winter Run Biological Opinion minimum flows and 1,900-taf Shasta Target storage criteria. Study D is a base D1641 simulation with Firm Level 2 Demands and Winter Run Biological Opinion requirements. Study 1 evaluates the effects of the Delta smelt Biological Opinion and (b)(2) operations. Study 3 was run to evaluate how EWA has impacted the system.

Table 6-2 shows the detailed assumptions of the six studies. The table illustrates specific operational changes regarding regulatory and operational rules. It also details assumptions within the major changes to operations in Table 6-1.

Table 6-2 Assumptions for the OCAP CALSIM II studies

	Study A	Study B	Study C	Study D	Study 1	Study 3
	D1485 (1991)	**D1485 w/ Refuge Firm Level 2 (1992)**	**D1485 w/ Refuge Firm Level 2, and Winter Run B.O. (1993)**	**D1641 (1994)**	**D1641 w/ CVPIA 3406 (b)(2) (1997)**	**Today CVPIA 3406 (b)(2) with EWA (2004)**
Period of Simulation	73 years (1922-1994)	Same	Same	Same	Same	Same
HYDROLOGY						
Level of Development (Land Use)	2001 Level, DWR Bulletin 160-98[a]	Same	Same	Same	Same	Same
Demands						
North of Delta (excluding American River)						
CVP	Land Use based, limited by Full Contract	Same	Same	Same	Same	Same
SWP (FRSA)	Land Use based, limited by Full Contract	Same	Same	Same	Same	Same
Non-Project	Land Use based	Same	Same	Same	Same	Same
CVP Refuges	Historic Level 2	Firm Level 2	Same as Study B	Same as Study B	Same as Study B	Same as Study B
American River Basin						
Water rights	2001[b]	Same	Same	Same	Same	Same
CVP	2001[b]	Same	Same	Same	Same	Same
San Joaquin River Basin						
Friant Unit	Regression of historical	Same	Same	Same	Same	Same
Lower Basin	Fixed annual demands	Same	Same	Same	Same	Same

Table 6-2 Assumptions for the OCAP CALSIM II studies

	Study A	Study B	Study C	Study D	Study 1	Study 3
	D1485 (1991)	**D1485 w/ Refuge Firm Level 2 (1992)**	**D1485 w/ Refuge Firm Level 2, and Winter Run B.O. (1993)**	**D1641 (1994)**	**D1641 w/ CVPIA 3406 (b)(2) (1997)**	**Today CVPIA 3406 (b)(2) with EWA (2004)**
Stanislaus River Basin	New Melones Interim Plan of Operations	Same	Same	Same	Same	Same
South of Delta						
CVP	Full Contract	Same	Same	Same	Same	Same
CCWD	140 TAF/YR[c]	Same	Same	Same	Same	Same
SWP (w/ North Bay Aqueduct)	3.0-4.1 MAF/YR	Same	Same	Same	Same	Same
SWP Article 21 Demand	None	None	None	None	MWDSC up to 50 TAF/month, Dec-Mar, others up to 84 TAF/month	Same as Study 1
FACILITIES						
Freeport Regional Water Project	None	None	None	None	None	None
Banks Pumping Capacity	6680 cfs	Same	Same	Same	Same	Same
Tracy Pumping Capacity	4200 cfs + deliveries upstream of DMC constriction	Same	Same	Same	Same	Same
REGULATORY STANDARDS						
Trinity River						
Minimum Flow below Lewiston Dam	Minimum flows of 340 TAF/yr all year types	Same as Study A	Same as Study A	Same as Study A	Same as Study A	Trinity (369-453 TAF/YR)
Clear Creek						

Table 6-2 Assumptions for the OCAP CALSIM II studies

	Study A	Study B	Study C	Study D	Study 1	Study 3
	D1485 (1991)	**D1485 w/ Refuge Firm Level 2 (1992)**	**D1485 w/ Refuge Firm Level 2, and Winter Run B.O. (1993)**	**D1641 (1994)**	**D1641 w/ CVPIA 3406 (b)(2) (1997)**	**Today CVPIA 3406 (b)(2) with EWA (2004)**
Minimum Flow below Whiskeytown Dam	Downstream water rights, 1963 Reclamation Proposal to FWS and NPS	Same as Study A	Same as Study A	Same as Study A	Same as Study A with FWS use of CVPIA 3406(b)(2) water	Same as Study 1
Upper Sacramento River						
Shasta Lake End-of-September Minimum Storage	None	None	SWRCB WR 1993 Winter-run Biological Opinion (1900 TAF)	Same as Study C	Same as Study C	Same as Study C
Minimum Flow below Keswick Dam	Flows for SWRCB WR 90-5	Same as Study A	Flows for SWRCB WR 90-5 and 1993 Winter-run B.O. temperature control	Same as Study C	Same as Study C, and FWS use of CVPIA 3406(b)(2) water	Same as Study 1
Feather River						
Minimum Flow below Thermalito Diversion Dam	1983 DWR, DFG Agreement (600 CFS)	Same	Same	Same	Same	Same
Minimum Flow below Thermalito Afterbay outlet	1983 DWR, DFG Agreement (1000 – 1700 CFS)	Same	Same	Same	Same	Same
American River						
Minimum Flow below Nimbus Dam	SWRCB D-893	Same as Study A	Same as Study A	Same as Study A	Same as Study A SWRCB D-893, and FWS use of CVPIA 3406(b)(2) water	Same as Study 1
Minimum Flow at H Street Bridge	SWRCB D-893	Same	Same	Same	Same	Same

Table 6-2 Assumptions for the OCAP CALSIM II studies

	Study A	Study B	Study C	Study D	Study 1	Study 3
	D1485 (1991)	**D1485 w/ Refuge Firm Level 2 (1992)**	**D1485 w/ Refuge Firm Level 2, and Winter Run B.O. (1993)**	**D1641 (1994)**	**D1641 w/ CVPIA 3406 (b)(2) (1997)**	**Today CVPIA 3406 (b)(2) with EWA (2004)**
Lower Sacramento River						
Minimum Flow near Rio Vista	SWRCB D-1641	Same	Same	Same	Same	Same
Stanislaus River						
Minimum Flow below Goodwin Dam	1987 Reclamation, DFG agreement	Same as Study A	Same as Study A	Same as Study A	Same as Study A with FWS use of CVPIA 3406(b)(2) water	Same as Study 1
Minimum Dissolved Oxygen	SWRCB D-1422	Same	Same	Same	Same	Same
Merced River						
Minimum Flow below Crocker-Huffman Diversion Dam	Davis-Grunsky (180 – 220 CFS, Nov – Mar), and Cowell Agreement	Same	Same	Same	Same	Same
Minimum Flow at Shaffer Bridge	FERC 2179 (25 – 100 CFS)	Same	Same	Same	Same	Same
Tuolumne River						
Minimum Flow at LaGrange Bridge	FERC 2299-024, 1995 (Settlement Agreement) (94 – 301 TAF/YR)	Same	Same	Same	Same	Same
San Joaquin River						
Maximum Salinity near Vernalis	None	None	None	SWRCB D-1641	Same as Study D	Same as Study D

Table 6-2 Assumptions for the OCAP CALSIM II studies

	Study A	Study B	Study C	Study D	Study 1	Study 3
	D1485 (1991)	**D1485 w/ Refuge Firm Level 2 (1992)**	**D1485 w/ Refuge Firm Level 2, and Winter Run B.O. (1993)**	**D1641 (1994)**	**D1641 w/ CVPIA 3406 (b)(2) (1997)**	**Today CVPIA 3406 (b)(2) with EWA (2004)**
Minimum Flow near Vernalis	None	None	None	SWRCB D-1641, and VAMP per San Joaquin River Agreement	Same as Study D	Same as Study D
Sacramento River-San Joaquin River Delta						
Delta Outflow Index (Flow and Salinity)	D-1485	Same as Study A	Same as Study A	SWRCB D-1641	Same as Study D	Same as Study D
Delta Cross Channel Gate Operation	D-1485	Same as Study A	Same as Study A	SWRCB D-1641	Same as Study D	Same as Study D
Delta Exports	D-1485	Same as Study A	Same as Study A	SWRCB D-1641	SWRCB D-1641, and FWS use of CVPIA 3406(b)(2) water	Same with Banks capacity shared 50 percent/50 percent with CVP and EWA
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
American River						
Folsom Dam Flood Control	Fixed 400 TAF Flood Control Diagram	Same as Study A	Same as Study A	Same as Study A	SAFCA, Interim-Reoperation of Folsom Dam, Variable 400/670 (without outlet modifications)	Same as Study 1

Table 6-2 Assumptions for the OCAP CALSIM II studies

	Study A	Study B	Study C	Study D	Study 1	Study 3
	D1485 (1991)	**D1485 w/ Refuge Firm Level 2 (1992)**	**D1485 w/ Refuge Firm Level 2, and Winter Run B.O. (1993)**	**D1641 (1994)**	**D1641 w/ CVPIA 3406 (b)(2) (1997)**	**Today CVPIA 3406 (b)(2) with EWA (2004)**
Flow below Nimbus Dam	Operations criteria corresponding to SWRCB D-893 required minimum flow	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
Stanislaus River						
Flow below Goodwin Dam	None	None	None	None	1997 New Melones Interim Operations Plan	Same as Study 1
San Joaquin River						
Flow near Vernalis	None	None	None	San Joaquin River Agreement in support of the Vernalis Adaptive Management Program	Same as Study D	Same as Study D
System-wide						

Table 6-2 Assumptions for the OCAP CALSIM II studies

	Study A	Study B	Study C	Study D	Study 1	Study 3
	D1485 (1991)	**D1485 w/ Refuge Firm Level 2 (1992)**	**D1485 w/ Refuge Firm Level 2, and Winter Run B.O. (1993)**	**D1641 (1994)**	**D1641 w/ CVPIA 3406 (b)(2) (1997)**	**Today CVPIA 3406 (b)(2) with EWA (2004)**
CVP Water Allocation						
CVP Settlement and Exchange	100 percent (75 percent in Shasta Critical years)	Same	Same	Same	Same	Same
CVP Refuges	100 percent (75 percent in Shasta Critical years)	Same	Same	Same	Same	Same
CVP Agriculture	100 percent - 0 percent based on supply (reduced by 3406(b)(2) allocation)	Same	Same	Same	Same	Same
CVP Municipal & Industrial	100 percent - 50 percent based on supply (reduced by 3406(b)(2) allocation)	Same	Same	Same	Same	Same
SWP Water Allocation						
North of Delta (FRSA)	Contract specific	Same	Same	Same	Same	Same
South of Delta	Based on supply; Monterey Agreement	Same	Same	Same	Same	Same
CVP/SWP Coordinated Operations						
Sharing of Responsibility for In-Basin-Use	1986 Coordinated Operations Agreement	Same	Same	Same	Same	Same
Sharing of Surplus Flows	1986 Coordinated Operations Agreement	Same	Same	Same	Same	Same

Table 6-2 Assumptions for the OCAP CALSIM II studies

	Study A	Study B	Study C	Study D	Study 1	Study 3
	D1485 (1991)	**D1485 w/ Refuge Firm Level 2 (1992)**	**D1485 w/ Refuge Firm Level 2, and Winter Run B.O. (1993)**	**D1641 (1994)**	**D1641 w/ CVPIA 3406 (b)(2) (1997)**	**Today CVPIA 3406 (b)(2) with EWA (2004)**
Sharing of Restricted Export Capacity	None	None	None	Equal sharing of export capacity under SWRCB D-1641	Same as Study D; use of CVPIA 3406(b)(2) only restricts CVP exports	Same as Study 1 EWA use restricts CVP and/or SWP as directed by CALFED Fisheries Agencies
Replacement Pumping	195 TAF	Same as Study A	Same as Study A	None	None	None
Transfers						
Dry Year Program	None	Same	Same	Same	Same	Same
Phase 8	None	Same	Same	Same	Same	Same
MWDSC/CVP Settlement Contractors	None	Same	Same	Same	Same	Same
CVP/SWP Integration						
Dedicated Conveyance at Banks	None	Same	Same	Same	Same	Same
NOD Accounting Adjustments	None	Same	Same	Same	Same	Same
CVPIA 3406(b)(2)	None	None	None	None	Dept of Interior 2003 Decision	
Allocation	None	None	None	None	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

Table 6-2 Assumptions for the OCAP CALSIM II studies

	Study A	Study B	Study C	Study D	Study 1	Study 3
	D1485 (1991)	**D1485 w/ Refuge Firm Level 2 (1992)**	**D1485 w/ Refuge Firm Level 2, and Winter Run B.O. (1993)**	**D1641 (1994)**	**D1641 w/ CVPIA 3406 (b)(2) (1997)**	**Today CVPIA 3406 (b)(2) with EWA (2004)**
Actions	None	None	None	None	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
Accounting Adjustments	None	None	None	None	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

Table 6-2 Assumptions for the OCAP CALSIM II studies

	Study A	Study B	Study C	Study D	Study 1	Study 3
	D1485 (1991)	**D1485 w/ Refuge Firm Level 2 (1992)**	**D1485 w/ Refuge Firm Level 2, and Winter Run B.O. (1993)**	**D1641 (1994)**	**D1641 w/ CVPIA 3406 (b)(2) (1997)**	**Today CVPIA 3406 (b)(2) with EWA (2004)**
CALFED Environmental Water Account	None	None	None	None	None	Modeled
Actions	None	None	None	None	None	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)
Assets	None	None	None	None	None	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 percent JPOD export capacity, acquisition of 50 percent of any CVPIA 3406(b)(2) releases pumped by SWP, flexing of Delta Export/Inflow Ratio (post-processed from CALSIM II results), dedicated 500 CFS pumping capacity at Banks in Jul – Sep

Table 6-2 Assumptions for the OCAP CALSIM II studies

	Study A	Study B	Study C	Study D	Study 1	Study 3
	D1485 (1991)	**D1485 w/ Refuge Firm Level 2 (1992)**	**D1485 w/ Refuge Firm Level 2, and Winter Run B.O. (1993)**	**D1641 (1994)**	**D1641 w/ CVPIA 3406 (b)(2) (1997)**	**Today CVPIA 3406 (b)(2) with EWA (2004)**
Debt restrictions	None	None	None	None	None	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.

Notes:

[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] See

for assumptions on 2001 LOD American River Demands

[c] Delta diversions include operations of Los Vaqueros Reservoir operations

Table 6-3 2001 American River Demand Assumptions
(Note that cuts are not made predicated on Inflow to Folsom for the 2001 Demands)

	ALLOCATION TYPE (MAXIMUM)					
Location / Purveyor	**CVP AG**	**CVP MI**	**CVP Settlement / Exchange**	**Water Rights / Non-CVP / No Cuts**	**CVP Refuge**	**Total**
Auburn Dam Site (D300)						
Placer County Water Agency	0	0	0	8,500	0	8,500
Total	**0**	**0**	**0**	**8,500**	**0**	**8,500**
Folsom Reservoir (D8)						
Sacramento Suburban	0	0	0	0	0	0
City of Folsom (includes P.L. 101-514)	0	0	0	20,000	0	20,000
Folsom Prison	0	0	0	2,000	0	2,000
San Juan Water District (Placer County)	0	0	0	10,000	0	10,000
San Juan Water District (Sac County) (includes P.L. 101-514)	0	11,200	0	33,000	0	44,200
El Dorado Irrigation District	0	7,550	0	0	0	7,550
El Dorado Irrigation District (P.L. 101-514)	0	0	0	0	0	0
City of Roseville	0	32,000	0	0	0	32,000
Placer County Water Agency	0	0	0	0	0	0
Total	**0**	**50,750**	**0**	**65,000**	**0**	**115,750**
Folsom South Canal (D9)						
So. Cal WC/ Arden Cordova WC	0	0	0	3,500	0	3,500
California Parks and Recreation	0	100	0	0	0	100
SMUD (export)	0	0	0	15,000	0	15,000
South Sacramento County Agriculture (export, SMUD transfer)	0	0	0	0	0	0

Table 6-3 2001 American River Demand Assumptions
(Note that cuts are not made predicated on Inflow to Folsom for the 2001 Demands)

	ALLOCATION TYPE (MAXIMUM)					
Location / Purveyor	**CVP AG**	**CVP MI**	**CVP Settlement / Exchange**	**Water Rights / Non-CVP / No Cuts**	**CVP Refuge**	**Total**
Canal Losses	0	0	0	1,000	0	1,000
Total	0	100	0	19,500	0	19,600
Nimbus to Mouth (D302)						
City of Sacramento	0	0	0	63,335	0	63,335
Arcade Water District	0	0	0	2,000	0	2,000
Carmichael Water District	0	0	0	8,000	0	8,000
Total	**0**	**0**	**0**	**73,335**	**0**	**73,335**
Sacramento River (D162)						
Placer County Water Agency	0	0	0	0	0	0
Total	**0**	**0**	**0**	**0**	**0**	**0**
Sacramento River (D167/D168)						
City of Sacramento	0	0	0	38,665	0	38,665
Sacramento County Water Agency (SMUD transfer)	0	0	0	0	0	0
Sacramento County Water Agency (P.L. 101-514)	0	0	0	0	0	0
EBMUD (export)	0	0	0	0	0	0
Total	**0**	**0**	**0**	**38,665**	**0**	**38,665**
Total	**0**	**50,850**	**0**	**166,335**	**0**	**217,185**

Temperature 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.

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.

CALSIM II and Temperature 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.

CALSIM II cannot completely capture the policy-oriented operation and coordination of 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 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 in the Hydrologic Modeling Methods section 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

The modeling results will be broken into three chapters. The results in this chapter will show a summary of long-term averages and critical drought-period averages (i.e., Water Years 1928 to 1934) in Table 6-4 for flows, storages, delta output, and deliveries. The rest of the results will reveal details of deliveries and allocations from the six CALSIM II runs comparatively The following chapters, Upstream and North of the Delta Effects will look at impacts to storages, river releases, temperature results, and NOD CVP deliveries for the six major streams in the CVP and SWP system. The Delta and SOD Effects will compare impacts to the Inflow, Outflow, and Exports among the six studies.

For more results, including month-by-year tables, exceedence charts, monthly averages by water year type, and monthly percentiles for selected CALSIM II outputs, refer to the CALSIM II Modeling Appendix. The appendix contains a comparison of all five studies simulated, direct two-study comparisons (includes month-by-year difference tables). The Temperature Modeling appendix includes temperature results from both the Bend Bridge and Balls Ferry compliance points. The appendix also includes mortality results for the Balls Ferry compliance runs. The appendix contains 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.

The results in the following chapters are generally shown in exceedence charts for a particular month or set of months, average and percentile monthly data, and on a sort-by-water-year-type for a month. The probability of exceedence charts show values on the y-axis with the percent of time (probability of exceedence) that the value was exceeded. An example, the end of September exceedence charts, shows the probability that the revervoir was able to carry over storage into the next water year for each of the five studies. The exceedence charts are also a good measure of trend between the studies, either higher or lower on average. Averages by water-year type are sorted on the 40-30-30 Sacramento Valley Index and show how average changes from Wet to Critical years. The 60-20-20 San Joaquin Valley Index was used for sorting temperature and CALSIM II output from the Stanislaus and San Joaquin Rivers. The percentile graphs show monthly values for the 50^{th}, 5^{th}, and 95^{th} percentiles for a given output variable and were used to indicate how flows are being effected by flood and minimum flow requirements.

Table 6-4 Long term and 1928 – 1934 averages for the six OCAP CALSIM II studies

	Study 1: D1485 (1991)		Study 2: D1485 (1992)		Study 3: D1485 (1993)		Study 4: D1641 (1994)		Study 5: D1641(1997)		Study 6: Today EWA	
	Average	28-34	Average	28-34	Average	28-34	Average	28-34	Average	28-34	Average	28-34
End of Sep Storages (TAF)												
Trinity	1463	810	1453	809	1440	805	1416	748	1418	790	1335	749
Whiskeytown	235	235	235	235	235	235	235	235	234	227	233	226
Shasta	2771	1818	2743	1756	2732	1776	2732	1679	2705	1595	2659	1616
Oroville	2196	1646	2188	1625	2225	1700	2070	1448	2085	1502	2079	1504
Folsom	538	485	535	463	531	437	528	408	545	454	535	452
New Melones	1578	1201	1581	1203	1581	1203	1387	905	1390	910	1389	966
CVP San Luis	228	277	198	273	224	327	226	279	213	296	231	305
SWP San Luis	224	267	222	270	245	269	383	347	401	318	355	320
Total San Luis	452	544	421	543	469	596	609	625	614	614	674	720
River Flows (cfs)												
Trinity Release	623	481	619	481	619	481	616	481	611	481	726	592
Clear Creek Tunnel	1040	738	1044	733	1045	739	1051	750	1054	736	944	642
Spring Creek Tunnel	1324	788	1328	783	1329	789	1335	800	1235	737	1127	648
Clear Creek Release	63	46	63	46	63	46	63	46	166	101	163	98
Keswick Release	8755	5947	8759	5960	8761	5965	8772	6015	8673	5994	8567	5926
Nimbus Release	3470	1941	3470	1959	3471	1960	3474	1972	3477	1962	3477	1995
Mouth of American	3341	1801	3341	1819	3341	1820	3345	1832	3347	1822	3347	1854
Red Bluff Diversion Dam	11196	7073	11212	7123	11215	7142	11233	7217	11251	7272	11150	7221
Wilkins Slough	9139	5506	9134	5475	9151	5495	9144	5567	9176	5624	9098	5571

Table 6-4 Long term and 1928 – 1934 averages for the six OCAP CALSIM II studies

	Study 1: D1485 (1991)		Study 2: D1485 (1992)		Study 3: D1485 (1993)		Study 4: D1641 (1994)		Study 5: D1641(1997)		Study 6: Today EWA	
	Average	28-34	Average	28-34	Average	28-34	Average	28-34	Average	28-34	Average	28-34
Feather Low Flow Channel	718	600	717	600	715	600	706	600	709	600	600	600
Flow Below Thermalito	4175	2320	4166	2317	4168	2287	4177	2325	4177	2317	4177	2330
Feather Flow Below Yuba Mouth	6284	3223	6276	3221	6278	3191	6286	3229	6287	3222	6285	3262
Feather Mouth	7499	3318	7490	3315	7492	3285	7500	3328	7500	3321	7499	3360
Sac at Freeport	22458	11683	22432	11677	22424	11666	22477	11776	22476	11815	22390	11827
Tulloch Release	556	271	555	270	555	269	605	313	604	311	604	311
Stanislaus Mouth	853	490	853	489	853	489	893	525	892	523	892	523
SJR Flow w/o Stanislaus	2856	1176	2854	1176	2854	1175	2869	1235	2866	1233	2866	1232
Flow at Vernalis	3674	1627	3671	1626	3671	1624	3727	1720	3723	1717	3723	1715
Mokelumne	2081	118	2076	118	2087	118	2064	134	2079	134	2060	142
Yolo Bypass	878	271	878	271	878	271	878	271	878	271	878	271
Delta Parameters												
SWP Banks (cfs)	4317	2797	4310	2774	4211	2612	4159	2367	4448	2608	4180	2417
CVP Banks (cfs)	275	120	276	110	273	127	121	52	109	52	180	72
Tracy (cfs)	3531	2555	3616	2627	3627	2539	3614	2457	3396	2336	3207	2155
Total Banks (cfs)	4592	2917	4587	2884	4484	2739	4281	2419	4557	2660	4499	2715
Cross Valley Pumping (cfs)	123	82	119	69	121	64	121	52	109	52	109	45
Sac Flow at Freeport (cfs)	22346	11683	22321	11677	22318	11666	22364	11776	22362	11815	22277	11827
Flow at Rio Vista (cfs)	17637	6045	17609	6040	17943	6653	18367	7285	18392	7325	18291	7324

Table 6-4 Long term and 1928 – 1934 averages for the six OCAP CALSIM II studies

	Study 1: D1485 (1991)		Study 2: D1485 (1992)		Study 3: D1485 (1993)		Study 4: D1641 (1994)		Study 5: D1641(1997)		Study 6: Today EWA	
	Average	**28-34**	**Average**	**28-34**	**Average**	**28-34**	**Average**	**28-34**	**Average**	**28-34**	**Average**	**28-34**
Excess Outflow (cfs)	13429	2432	13293	2348	13394	2460	11945	1281	12001	1213	12110	1282
Required Outflow (cfs)	6054	4061	6079	4099	6052	4171	7822	6015	7716	5996	7750	6072
X2 Position (km)	n/a	n/a	n/a	n/a	n/a	n/a	75.9	81.4	75.9	81.5	75.8	81.3
Yolo Bypass (cfs)	2055	118	2050	118	2061	118	2038	134	2053	134	2034	142
Mokelumne Flow (cfs)	869	271	869	271	869	271	869	271	869	271	869	271
SJR + Calaveras Flow (cfs)	3840	1699	3837	1699	3837	1697	3892	1791	3888	1788	3888	1786
Modeled Required DO (cfs)	5214	2889	5214	2889	5206	2889	7577	5753	7521	5755	7501	5749
Flow at Georgiana Slough (cfs)	3801	2383	3798	2382	3797	2381	3803	2395	3803	2400	3792	2402
DXC Flow (cfs)	2482	2815	2484	2815	2160	2194	1754	1677	1740	1670	1749	1689
Flow below DXC (cfs)	16063	6485	16040	6480	16360	7091	16807	7705	16818	7745	16736	7736
North Bay Aqueduct (cfs)	55	34	56	33	54	32	53	28	54	29	54	29
CCWD (cfs)	171	164	171	164	198	201	171	164	171	164	171	164
Total Inflow (cfs)	29109	13771	29077	13764	29085	13751	29163	13973	29171	14008	29068	14025
Total Outflow (cfs)	19483	6492	19372	6447	19446	6631	19768	7296	19717	7209	19860	7354
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]**
CVP												
North of Delta												
Agriculture	81%	36%	78%	29%	78%	25%	77%	20%	73%	15%	71%	11%
M&I	94%	75%	92%	71%	92%	69%	91%	67%	89%	64%	88%	60%

Table 6-4 Long term and 1928 – 1934 averages for the six OCAP CALSIM II studies

	Study 1: D1485 (1991)		Study 2: D1485 (1992)		Study 3: D1485 (1993)		Study 4: D1641 (1994)		Study 5: D1641(1997)		Study 6: Today EWA	
	Average	**28-34**	**Average**	**28-34**	**Average**	**28-34**	**Average**	**28-34**	**Average**	**28-34**	**Average**	**28-34**
South of Delta												
Agriculture	80%	36%	76%	29%	76%	25%	69%	20%	61%	15%	61%	11%
M&I	94%	75%	92%	71%	92%	69%	90%	67%	87%	64%	87%	60%
SWP												
Agriculture	83%	46%	83%	46%	80%	43%	80%	37%	80%	39%	80%	37%
M&I (non-MWD)	87%	53%	86%	52%	85%	49%	84%	43%	84%	44%	84%	42%
Metropolitan Water Dist.	83%	47%	83%	47%	81%	44%	80%	38%	81%	39%	81%	38%
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]
CVP												
North of Delta												
Agriculture	272	127	263	102	262	91	257	73	246	55	240	40
Settlement Contracts	1825	1745	1827	1745	1827	1745	1827	1746	1831	1747	1832	1747
M&I	31	29	30	29	30	29	30	28	30	28	30	27
Refuge	74	33	105	90	105	90	105	90	105	90	105	90
Total	2115	1934	2225	1967	2224	1955	2219	1937	2212	1919	2207	1905
South of Delta												
Agriculture	1454	648	1374	520	1375	463	1260	369	1102	279	1110	206
Exchange	851	739	851	739	851	739	847	736	847	736	847	736
M&I	133	107	131	101	131	99	128	96	123	92	124	86
Refuge	132	58	280	240	280	240	280	240	280	240	280	240
Total [b]	2753	1735	2819	1784	2821	1726	2699	1625	2536	1530	2545	1451

Table 6-4 Long term and 1928 – 1934 averages for the six OCAP CALSIM II studies

	Study 1: D1485 (1991)		Study 2: D1485 (1992)		Study 3: D1485 (1993)		Study 4: D1641 (1994)		Study 5: D1641(1997)		Study 6: Today EWA	
	Average	28-34	Average	28-34	Average	28-34	Average	28-34	Average	28-34	Average	28-34
SWP												
Metropolitan Water Dist.	1358	910	1356	900	1331	849	1306	734	1319	759	1317	730
Agriculture	910	520	908	515	882	486	874	420	885	434	708	338
M&I (non-MWD)	798	446	797	441	775	417	768	360	777	372	777	358
Article 21	0	0	0	0	0	0	0	0	175	141	168	168
Water Rights	185	185	185	185	185	185	185	185	185	185	185	185
Total[c]	3130	1941	3126	1920	3054	1816	3012	1579	3045	1630	2867	1490

Notes:
[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

Chapter 7 Upstream and North of Delta Effects

This chapter analyzes results of the six studies discussed in Chapter 8 and their differences for the Trinity, Sacramento, Feather, American, and Stanislaus Rivers. The analysis includes summary information on major reservoirs of each river, releases to rivers, and temperature results for rivers at selected locations. The second part of this chapter focuses on total Central Valley Project CVP surface-water deliveries for all contracts and allocations to municipal and industrial (M&I) and agricultural contracts.

Trinity River

The largest impact to Trinity Reservoir between the six studies is the increase in releases to the Trinity River in the Today Environmental Water Account (EWA) run where the annual minimum flow requirement increases from 340,000 acre-feet per year (af/yr) to 368,600 – 453,000 af/yr. The change in monthly releases on Figure 7-4 result from increased minimum flow requirements. Table 7-1 shows the increased flows causing a drop in carryover storage of 128 thousand acre-feet (taf) when compared to Study A. The increased flows also diminish the ability to have Trinity full at the end of May (Figure 7-2) and cause a constant decrease in the exceedance chart for carryover (end of September) storage (Figure 7-3). Figure 7-1 shows the chronology of Trinity storage with the Today EWA run consistently lower than the other five studies for the 72 years of simulation. The increased flows on the Trinity cause a decrease in the average Clear Creek diversion by 96 cubic feet per second (cfs). Figure 7-5 shows that the monthly 50th percentile is lower in almost all months in Study 3 versus the other Studies for Clear Creek Tunnel diversions by month.

The D1641 studies (Study D and 1) have the second largest impact to the Trinity River with a long-term average decrease in Trinity end of September storage of 45 to 46 taf when compared to Study A. The increase in Delta requirements pulls water out of Trinity Reservoir, and into the Sacramento River (see Table 7-1). Figure 7-5 shows that the increases to the diversion generally comes in the months of February to April and remains generally the same as the D1485 studies for the rest of the months.

Table 7-1 Differences of Carryover Storage for Trinity Reservoir, Releases to the River and Spring Creek Diversion from Study A

Long-term Average	Study A	B - A	C - A	D - A	1 - A	3 - A
End of Sep Storage (TAF)	1463	-9	-23	-46	-45	-128
River Release (cfs)	623	-4	-4	-7	-12	103
Clear Creek Tunnel (cfs)	1040	4	5	12	14	-96
28-34 Average						
End of Sep Storage (TAF)	810	-1	-5	-61	-20	-61
River Release (cfs)	481	0	0	0	0	111
Clear Creek Tunnel (cfs)	738	-4	1	12	-2	-96

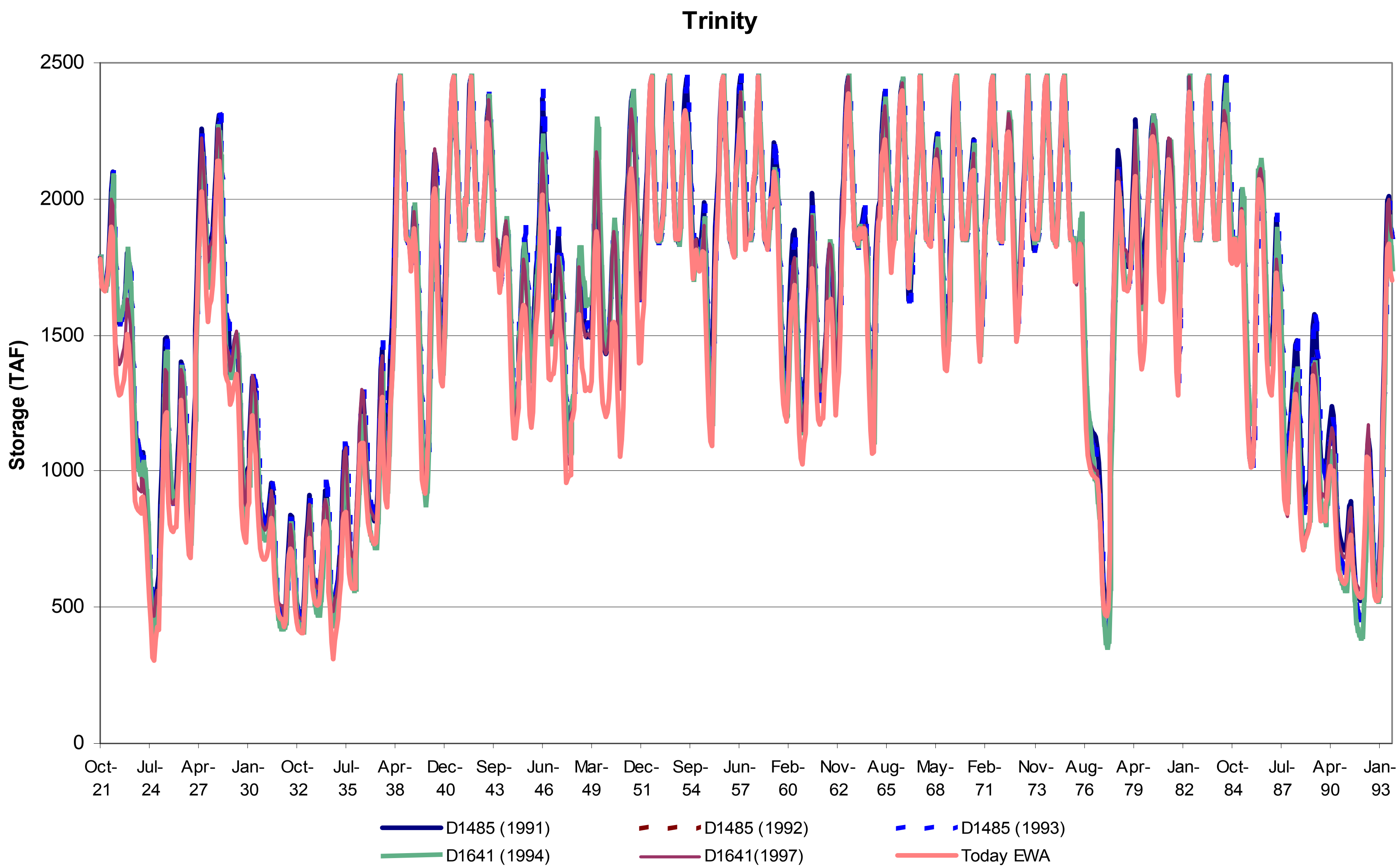

Figure 7-1 Chronology of Trinity Storages

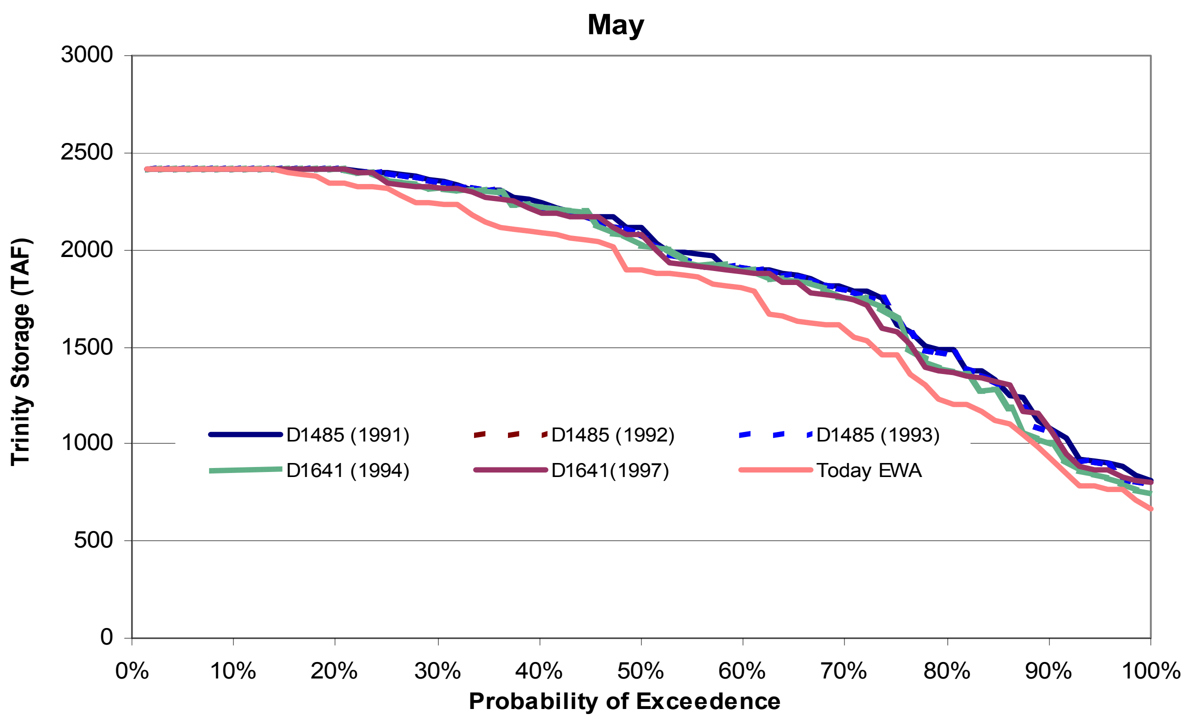

Figure 7-2 End of May Exceedance of Trinity Storage

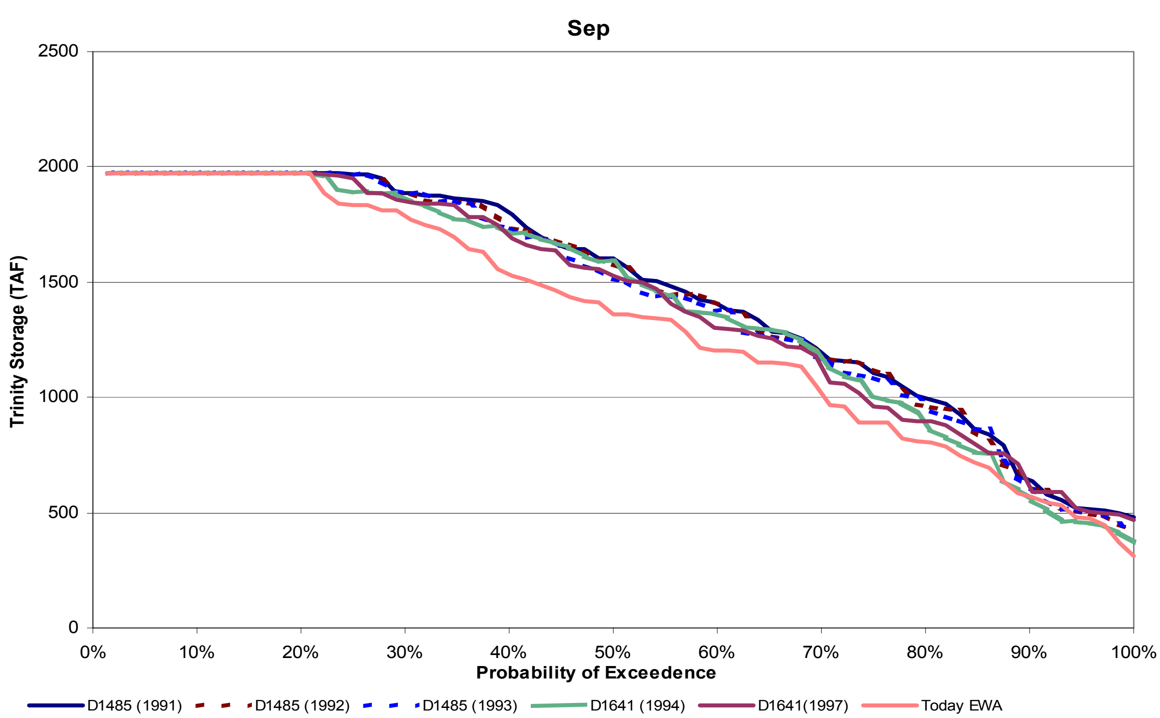

Figure 7-3 End of September Exceedance of Trinity Storage

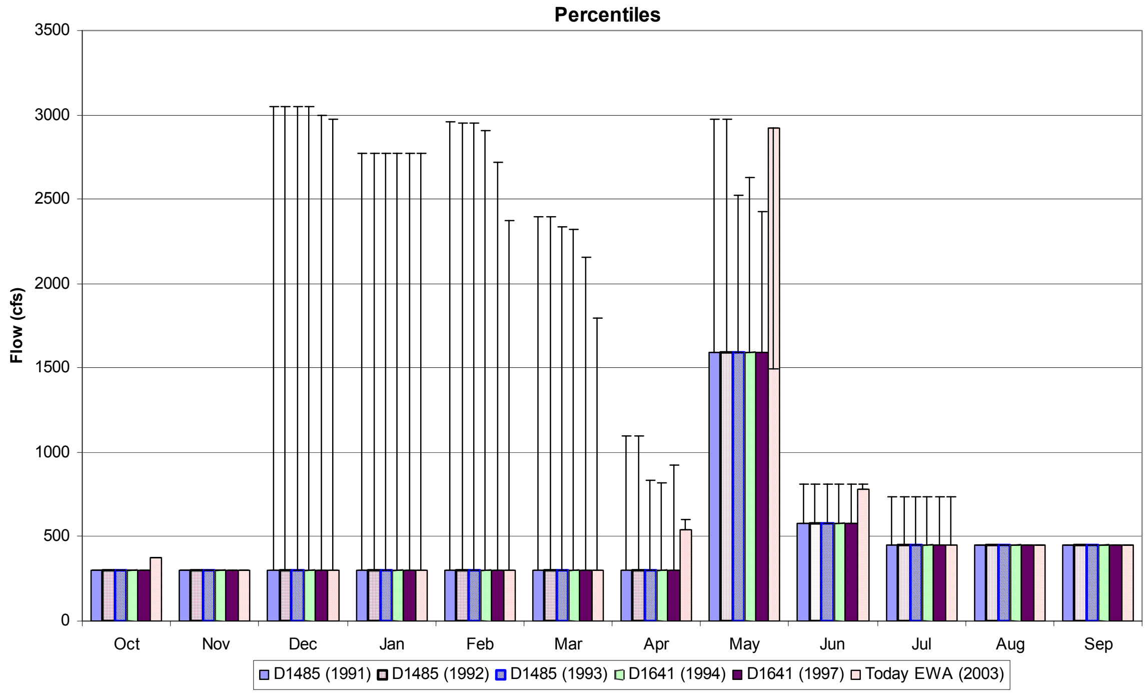

Figure 7-4 Monthly Percentiles of Releases to the Trinity River the bars represent the 50th percentile with the whiskers as the 5th and 95th percentile

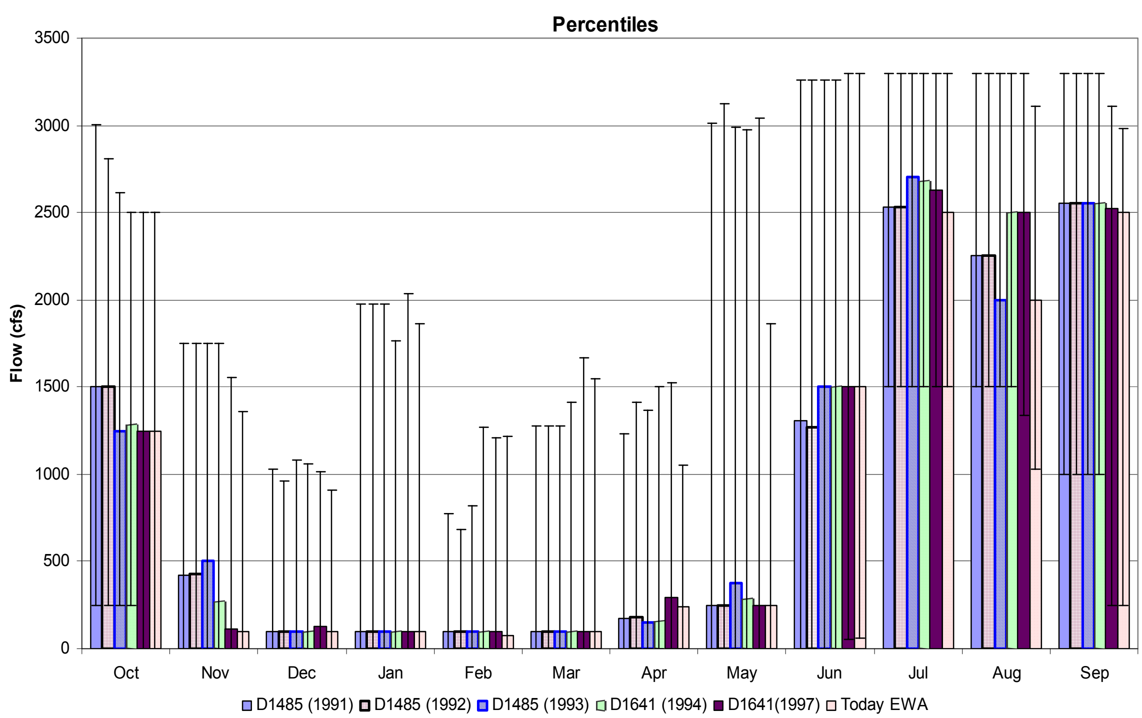

Figure 7-5 Monthly Percentiles of Clear Creek Tunnel flows the bars represent the 50th percentile with the whiskers as the 5th and 95th percentile

The monthly exceedance levels for selected temperatures on the Trinity River can be seen in Table 7-2 and Table 7-3 for Lewiston and Douglas City reaches, respectively. The effects of the increased flows on the Trinity in the Today EWA case cause temperatures at Lewiston and Douglas City in April, May, and June. The temperatures then increase in July and September in the Today EWA case. The temperatures between all six studies remain relatively the same during the months of November through March.

Figure 7-6 through Figure 7-11 show the monthly exceedance charts from May to October for the Douglas City reach. The May and June (Figure 7-6 and Figure 7-7) temperatures trend lower in Study 3, when compared to the other studies, from the increased minimum releases to the Trinity River. The July temperatures are, from an exceedance basis, virtually identical (Figure 7-8). The temperatures from August to October (Figure 7-9 to Figure 7-11) show that the temperatures increase for these months above the D1485 (1991) baseline, with the hotter temperatures exceeded more frequently from increased refuge deliveries in Study B, increased Delta outflow requirements in Study D, and the cumulative Today EWA simulation showing another increase in temperatures mainly attributable to the increased flows on the Trinity River.

Table 7-2 Monthly Temperature Exceedance Levels at Lewiston

	Oct				Nov				Dec			
Degrees F	**50**	**54**	**56**	**58**	**45**	**50**	**52**	**56**	**45**	**50**	**52**	**56**
D1485 (1991)	26.0%	9.0%	2.0%	1.0%	37.0%	3.0%	--	--	6.0%	--	--	--
D1485 (1992)	24.0%	9.0%	5.0%	1.0%	36.0%	3.0%	--	--	6.0%	--	--	--
D1485 (1993)	28.0%	10.0%	5.0%	2.0%	41.0%	3.0%	--	--	5.0%	--	--	--
D1641 (1994)	28.0%	12.0%	5.0%	1.0%	39.0%	3.0%	--	--	7.0%	--	--	--
D1641 (1997)	34.0%	11.0%	3.0%	1.0%	32.0%	3.0%	--	--	5.0%	--	--	--
Today EWA	37.0%	14.0%	4.0%	2.0%	34.0%	4.0%	--	--	5.0%	--	--	--
	Jan				**Feb**				**Mar**			
Degrees F	**45**	**50**	**52**	**56**	**45**	**50**	**52**	**56**	**45**	**50**	**52**	**56**
D1485 (1991)	2.0%	--	--	--	10.0%	--	--	--	76.0%	10.0%	3.0%	--
D1485 (1992)	2.0%	--	--	--	10.0%	--	--	--	77.0%	12.0%	3.0%	--
D1485 (1993)	2.0%	--	--	--	10.0%	--	--	--	79.0%	12.0%	3.0%	--
D1641 (1994)	2.0%	--	--	--	9.0%	--	--	--	77.0%	10.0%	3.0%	--
D1641 (1997)	2.0%	--	--	--	9.0%	--	--	--	75.0%	11.0%	3.0%	--
Today EWA	2.0%	--	--	--	9.0%	--	--	--	79.0%	12.0%	2.0%	--

Table 7-2 Monthly Temperature Exceedance Levels at Lewiston

	Apr				May				Jun			
Degrees F	**50**	**52**	**56**	**58**	**50**	**52**	**54**	**56**	**56**	**60**	**62**	**65**
D1485 (1991)	75.0%	60.0%	10.0%	4.0%	28.0%	3.0%	--	--	29.0%	17.0%	9.0%	1.0%
D1485 (1992)	74.0%	56.0%	11.0%	2.0%	27.0%	4.0%	--	--	29.0%	19.0%	10.0%	1.0%
D1485 (1993)	78.0%	59.0%	12.0%	5.0%	26.0%	4.0%	--	--	23.0%	16.0%	7.0%	1.0%
D1641 (1994)	71.0%	54.0%	11.0%	4.0%	30.0%	4.0%	--	--	21.0%	14.0%	11.0%	2.0%
D1641 (1997)	68.0%	50.0%	6.0%	2.0%	27.0%	3.0%	--	--	15.0%	10.0%	5.0%	--
Today EWA	61.0%	30.0%	--	--	8.0%	2.0%	--	--	19.0%	6.0%	0.0%	--
	Jul				**Aug**				**Sep**			
Degrees F	**56**	**60**	**62**	**65**	**56**	**60**	**62**	**65**	**56**	**60**	**62**	**65**
D1485 (1991)	3.0%	3.0%	2.0%	2.0%	5.0%	--	--	--	10.0%	--	--	--
D1485 (1992)	4.0%	3.0%	2.0%	2.0%	7.0%	--	--	--	11.0%	2.0%	--	--
D1485 (1993)	3.0%	3.0%	2.0%	2.0%	8.0%	--	--	--	14.0%	4.0%	1.0%	--
D1641 (1994)	3.0%	3.0%	2.0%	2.0%	9.0%	1.0%	--	--	14.0%	3.0%	1.0%	--
D1641 (1997)	2.0%	1.0%	1.0%	1.0%	8.0%	1.0%	--	--	14.0%	4.0%	--	--
Today EWA	7.0%	2.0%	1.0%	1.0%	14.0%	3.0%	1.0%	--	16.0%	6.0%	3.0%	--

Table 7-3 Monthly Temperature Exceedance Levels at Douglas City

	Oct				Nov				Dec			
Degrees F	**50**	**54**	**56**	**58**	**45**	**50**	**52**	**56**	**45**	**50**	**52**	**56**
D1485 (1991)	60.0%	11.0%	2.0%	1.0%	30.0%	3.0%	--	--	3.0%	--	--	--
D1485 (1992)	57.0%	12.0%	2.0%	1.0%	29.0%	2.0%	--	--	3.0%	--	--	--
D1485 (1993)	61.0%	12.0%	3.0%	1.0%	33.0%	4.0%	--	--	3.0%	--	--	--
D1641 (1994)	60.0%	15.0%	4.0%	1.0%	30.0%	3.0%	--	--	3.0%	--	--	--
D1641 (1997)	65.0%	15.0%	5.0%	1.0%	34.0%	2.0%	--	--	4.0%	--	--	--
Today EWA	65.0%	16.0%	6.0%	1.0%	30.0%	2.0%	--	--	4.0%	--	--	--
	Jan				**Feb**				**Mar**			
Degrees F	**45**	**50**	**52**	**56**	**45**	**50**	**52**	**56**	**45**	**50**	**52**	**56**
D1485 (1991)	--	--	--	--	7.0%	--	--	--	86.0%	3.0%	1.0%	--
D1485 (1992)	--	--	--	--	7.0%	--	--	--	86.0%	3.0%	1.0%	--
D1485 (1993)	--	--	--	--	8.0%	--	--	--	86.0%	3.0%	2.0%	--
D1641 (1994)	--	--	--	--	7.0%	--	--	--	88.0%	3.0%	2.0%	--
D1641 (1997)	--	--	--	--	8.0%	--	--	--	85.0%	3.0%	--	--
Today EWA	--	--	--	--	7.0%	--	--	--	88.0%	3.0%	--	--

Table 7-3 Monthly Temperature Exceedance Levels at Douglas City

	Apr				May				Jun			
Degrees F	**50**	**52**	**56**	**58**	**50**	**52**	**54**	**56**	**56**	**60**	**62**	**65**
D1485 (1991)	90.0%	72.0%	7.0%	--	89.0%	53.0%	13.0%	--	92.0%	45.0%	22.0%	5.0%
D1485 (1992)	90.0%	72.0%	7.0%	--	89.0%	50.0%	12.0%	--	92.0%	43.0%	22.0%	5.0%
D1485 (1993)	92.0%	72.0%	5.0%	--	89.0%	54.0%	12.0%	--	91.0%	41.0%	19.0%	4.0%
D1641 (1994)	90.0%	71.0%	5.0%	--	91.0%	55.0%	10.0%	--	91.0%	39.0%	16.0%	7.0%
D1641 (1997)	89.0%	70.0%	4.0%	--	89.0%	55.0%	12.0%	--	91.0%	29.0%	12.0%	3.0%
Today EWA	90.0%	57.0%	1.0%	--	46.0%	11.0%	3.0%	0.0%	81.0%	26.0%	11.0%	--
	Jul				**Aug**				**Sep**			
Degrees F	**56**	**60**	**62**	**65**	**56**	**60**	**62**	**65**	**56**	**60**	**62**	**65**
D1485 (1991)	98.0%	72.0%	25.0%	3.0%	95.0%	23.0%	8.0%	--	19.0%	3.0%	1.0%	--
D1485 (1992)	98.0%	71.0%	24.0%	4.0%	96.0%	23.0%	8.0%	--	19.0%	5.0%	1.0%	--
D1485 (1993)	98.0%	74.0%	22.0%	3.0%	95.0%	24.0%	10.0%	--	20.0%	6.0%	3.0%	--
D1641 (1994)	98.0%	69.0%	25.0%	3.0%	96.0%	26.0%	10.0%	0.0%	21.0%	7.0%	2.0%	--
D1641 (1997)	98.0%	67.0%	26.0%	2.0%	94.0%	25.0%	10.0%	--	21.0%	5.0%	3.0%	--
Today EWA	98.0%	69.0%	33.0%	3.0%	95.0%	31.0%	16.0%	3.0%	26.0%	9.0%	5.0%	--

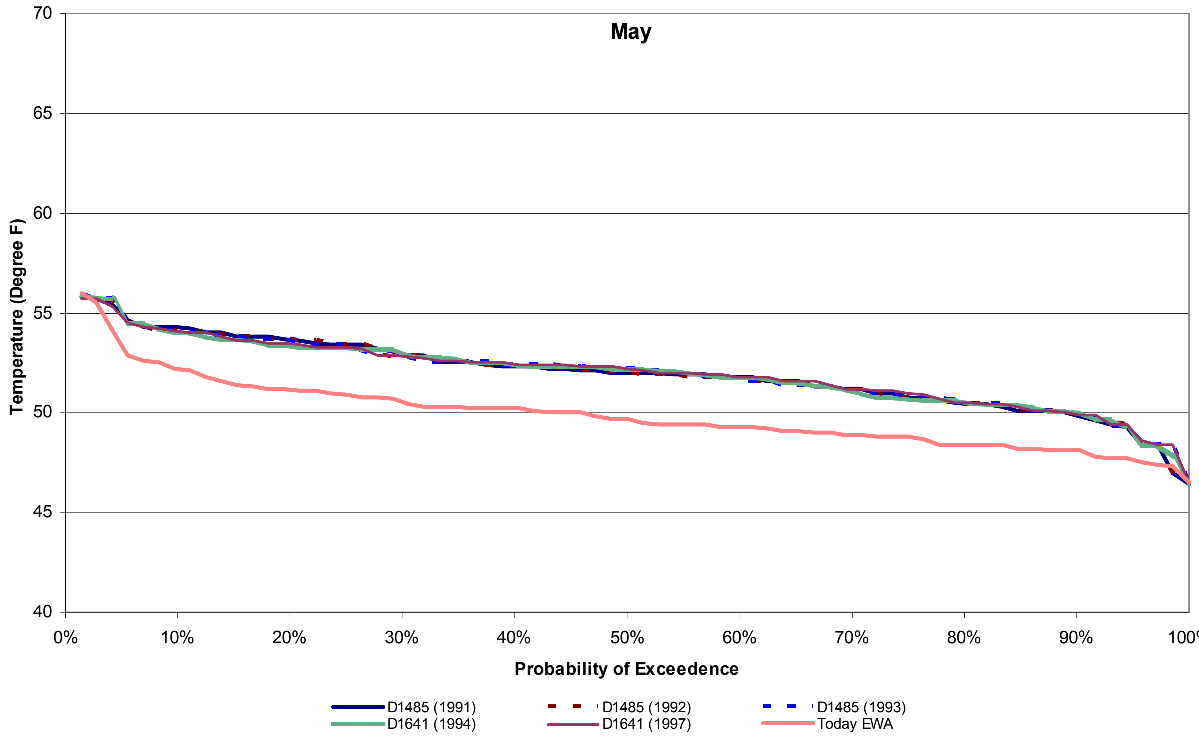

Figure 7-6 May Temperature Exceedance Chart at Douglas City

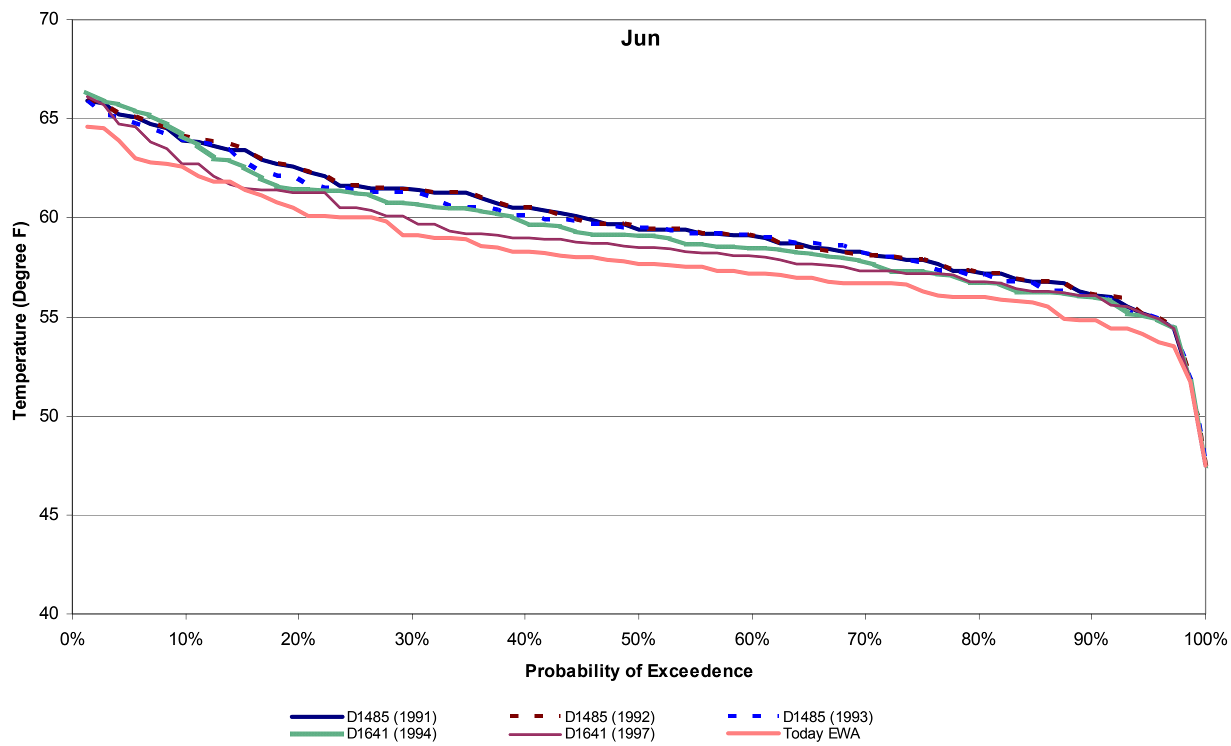

Figure 7-7 June Temperature Exceedance Chart at Douglas City

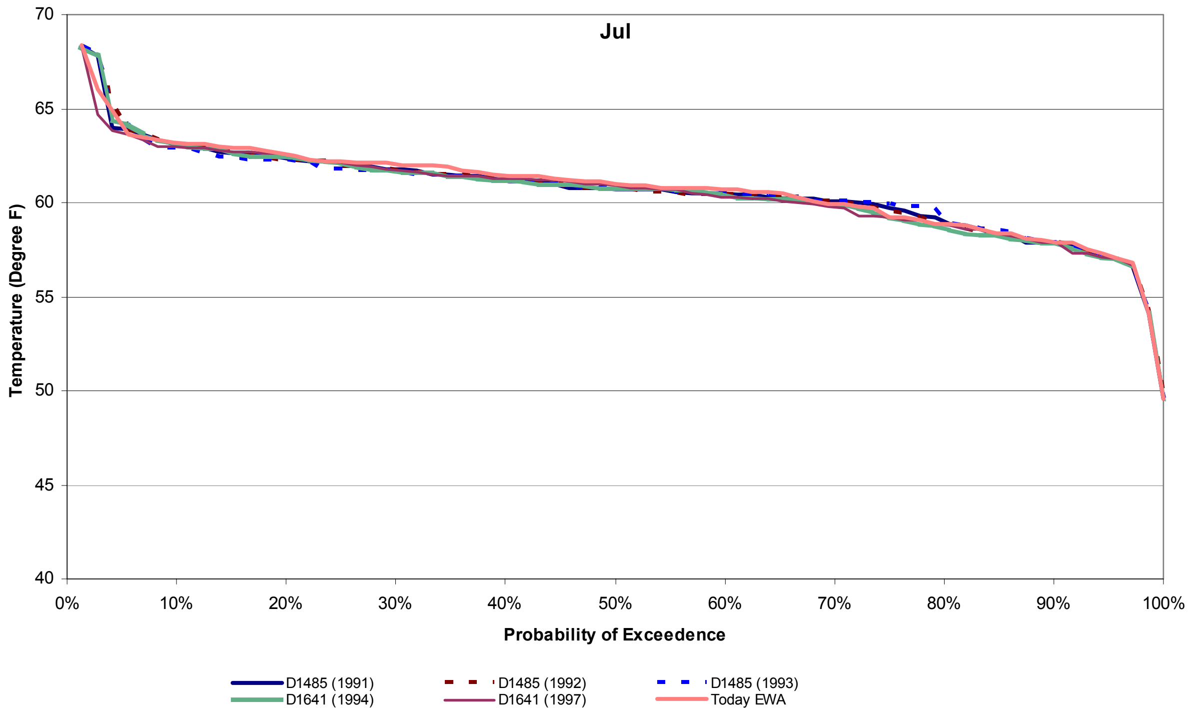

Figure 7-8 July Temperature Exceedance Chart at Douglas City

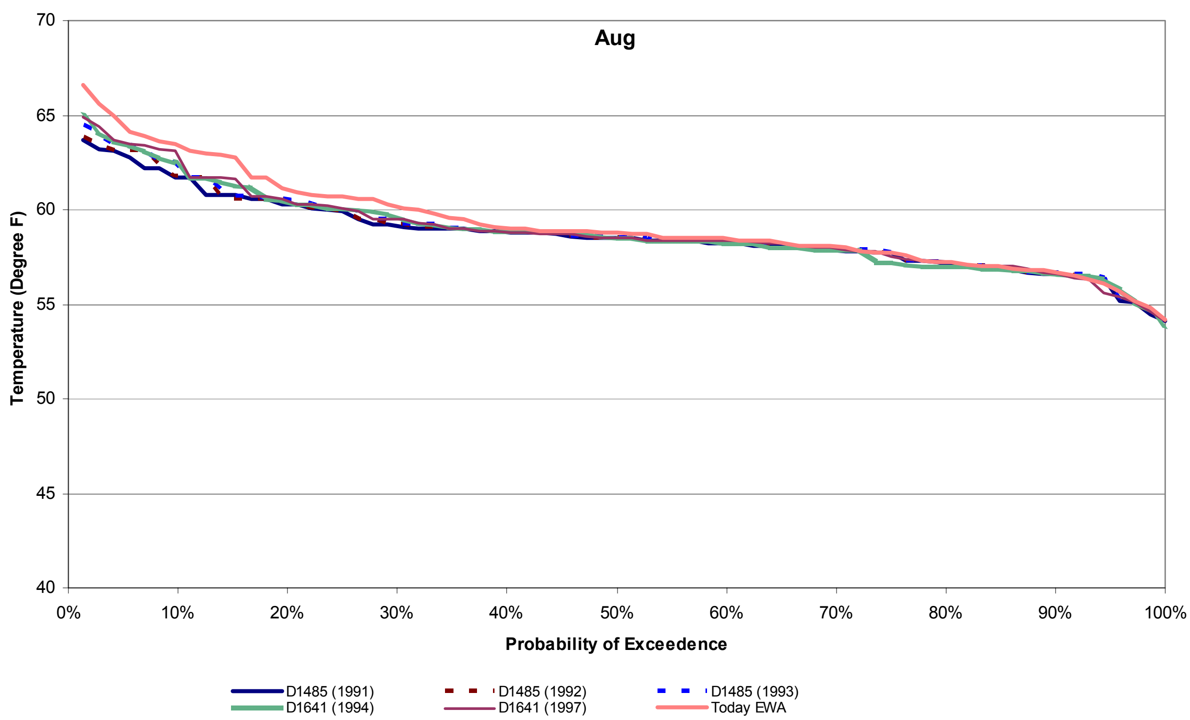

Figure 7-9 August Temperature Exceedance Chart at Douglas City

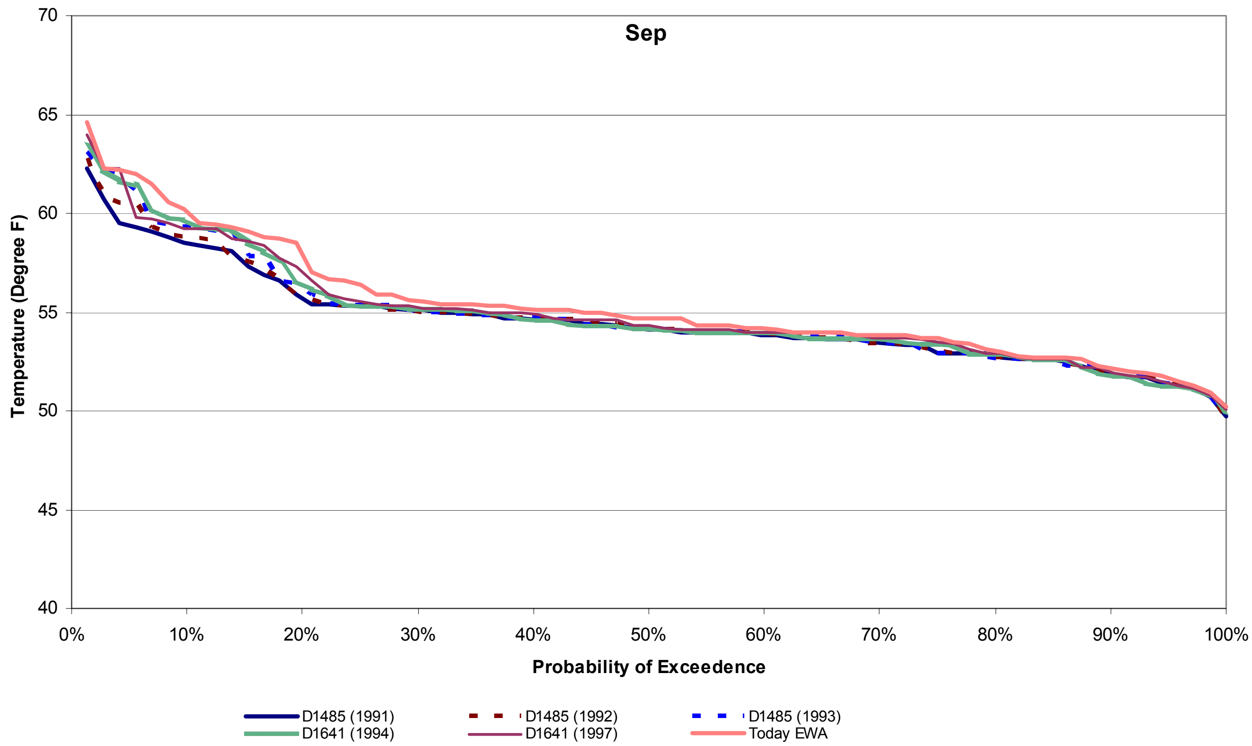

Figure 7-10 September Temperature Exceedance Chart at Douglas City

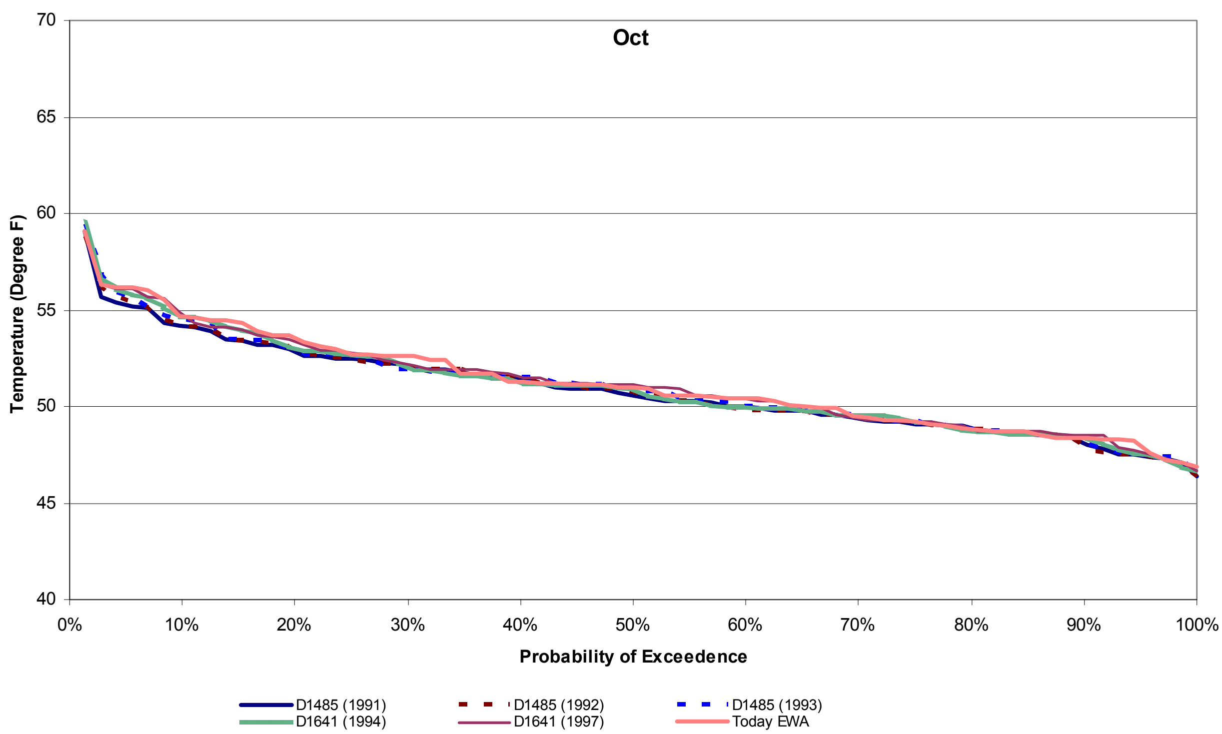

Figure 7-11 October Temperature Exceedance Chart at Douglas City

Clear Creek

The largest impact to flows on Clear Creek is in Studies 1 and 3 from the Central Valley Project Improvement Act (CVPIA) 3406 b(2) operations increasing the flows on a long term average basis by 100 cfs and 52 to 56 cfs in the 1928 to 1934 drought period (see Table 7-4). The increased flows on Clear Creek and the Trinity River cause a cumulative decrease in Spring Creek Tunnel imports of 197 cfs on a long-term average and 140 cfs for the drought period. Figure 7-12 shows the monthly percentiles for releases to Clear Creek; the increased monthly flows from CVPIA 3406 b(2) can be seen. Figure 7-13 shows the percentiles for Spring Creek Tunnel flows. From Figure 7-13, the late-fall and winter months (October to February) show a decrease in the flows through Spring Creek Tunnel, especially in the 95th percentiles from D1485 (1991) study to the Today EWA study. For the months of March to September, the percentiles decrease generally in the D1641 (1994) to the Today EWA study when compared to the three D1485 studies.

Table 7-5 shows the monthly temperature exceedance values for selected temperatures below Igo. From the months of December to September, the temperatures are cooler in the D1641 (1997) and Today EWA runs with the increased releases on Clear Creek. The months of October and November show higher temperatures in the D1641 (1997) and the Today EWA studies when compared to the other four.

Table 7-4 Long-term Average and 28 –34 Average Differences: Clear Creek Tunnel, Clear Creek, and Spring Creek Tunnel Flows

Long term Average	Study A	B - A	C - A	D - A	1 – A	3 - A
Clear Creek Tunnel (cfs)	1040	4	5	12	14	-96
Clear Creek Flow (cfs)	63	0	0	0	103	100
Spring Creek Tunnel (cfs)	1324	4	5	12	-89	-197
28-34 Average						
Clear Creek Tunnel (cfs)	738	-4	1	12	-2	-96
Clear Creek Flow (cfs)	46	0	0	0	56	52
Spring Creek Tunnel (cfs)	788	-5	1	12	-51	-140

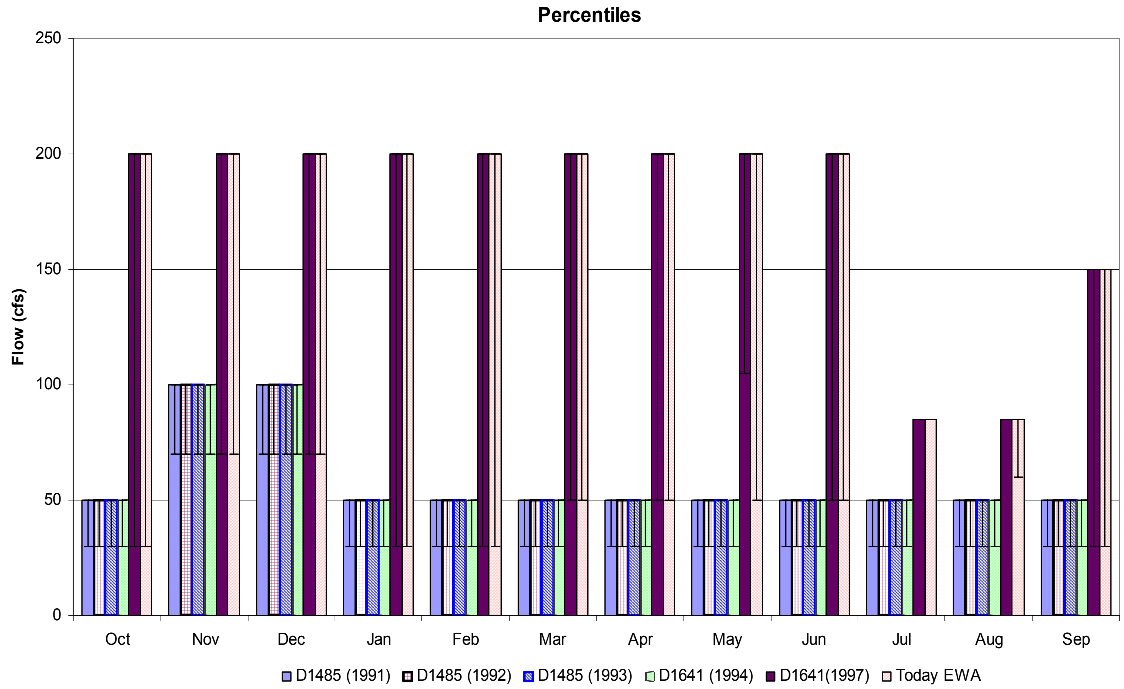

Figure 7-12 Monthly Percentiles of Clear Creek flows the bars represent the 50th percentile with the whiskers as the 5th and 95th percentile

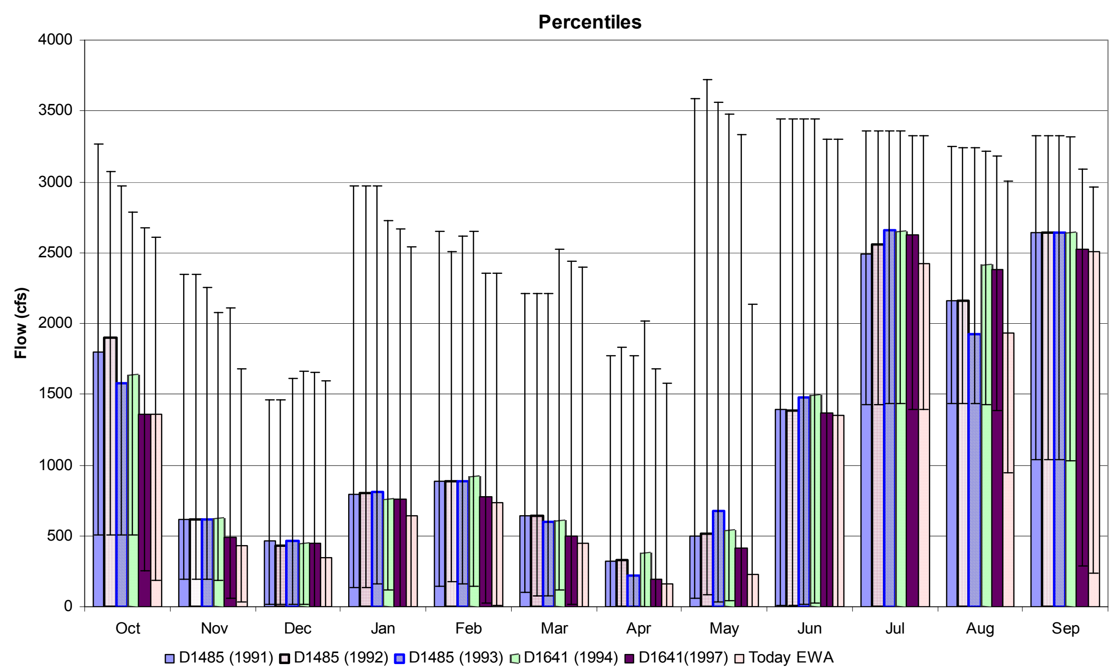

Figure 7-13 Monthly Percentiles of Spring Creek Tunnel flows the bars represent the 50th percentile with the whiskers as the 5th and 95th percentile

Table 7-5 Monthly Temperature Exceedance Levels Below Igo

Degrees F	Oct				Nov				Dec			
	50	52	54	56	48	49	50	51	45	47	49	50
D1485 (1991)	94.0%	51.0%	5.0%	1.0%	81.0%	61.0%	26.0%	4.0%	98.0%	33.0%	8.0%	1.0%
D1485 (1992)	93.0%	51.0%	5.0%	1.0%	81.0%	60.0%	22.0%	5.0%	98.0%	34.0%	6.0%	1.0%
D1485 (1993)	94.0%	50.0%	6.0%	1.0%	84.0%	62.0%	24.0%	6.0%	98.0%	37.0%	8.0%	1.0%
D1641 (1994)	94.0%	53.0%	6.0%	1.0%	85.0%	64.0%	27.0%	5.0%	98.0%	37.0%	6.0%	2.0%
D1641 (1997)	95.0%	62.0%	20.0%	3.0%	96.0%	88.0%	70.0%	44.0%	99.0%	48.0%	15.0%	4.0%
Today EWA	96.0%	70.0%	22.0%	3.0%	97.0%	88.0%	68.0%	48.0%	99.0%	55.0%	17.0%	5.0%
Degrees F	**Jan**				**Feb**				**Mar**			
	42	**44**	**45**	**46**	**44**	**46**	**47**	**48**	**47**	**48**	**50**	**51**
D1485 (1991)	100.0%	86.0%	51.0%	8.0%	100.0%	81.0%	55.0%	12.0%	96.0%	89.0%	44.0%	12.0%
D1485 (1992)	100.0%	87.0%	54.0%	8.0%	100.0%	82.0%	54.0%	12.0%	96.0%	89.0%	44.0%	13.0%
D1485 (1993)	99.0%	87.0%	55.0%	8.0%	100.0%	82.0%	55.0%	11.0%	97.0%	89.0%	43.0%	13.0%
D1641 (1994)	100.0%	87.0%	54.0%	8.0%	100.0%	82.0%	55.0%	10.0%	96.0%	89.0%	44.0%	14.0%
D1641 (1997)	99.0%	84.0%	31.0%	9.0%	90.0%	39.0%	14.0%	5.0%	60.0%	30.0%	5.0%	2.0%
Today EWA	100.0%	82.0%	36.0%	12.0%	90.0%	40.0%	17.0%	7.0%	60.0%	34.0%	8.0%	2.0%
Degrees F	**Apr**				**May**				**Jun**			
	49	**52**	**54**	**56**	**46**	**53**	**56**	**60**	**47**	**55**	**58**	**63**
D1485 (1991)	99.0%	67.0%	31.0%	2.0%	--	100.0%	60.0%	3.0%	--	97.0%	51.0%	2.0%
D1485 (1992)	99.0%	65.0%	31.0%	2.0%	--	99.0%	60.0%	2.0%	--	97.0%	51.0%	2.0%

Table 7-5 Monthly Temperature Exceedance Levels Below Igo

D1485 (1993)	99.0%	65.0%	31.0%	2.0%	--	99.0%	61.0%	3.0%	--	95.0%	51.0%	2.0%
D1641 (1994)	99.0%	65.0%	31.0%	2.0%	--	99.0%	60.0%	3.0%	--	97.0%	51.0%	1.0%
D1641 (1997)	41.0%	8.0%	4.0%	0.0%	99.0%	5.0%	2.0%	--	99.0%	11.0%	4.0%	--
Today EWA	43.0%	8.0%	4.0%	1.0%	99.0%	6.0%	2.0%	--	99.0%	14.0%	5.0%	--
Degrees F	**Jul**				**Aug**				**Sep**			
	52	**55**	**59**	**64**	**51**	**54**	**55**	**60**	**51**	**53**	**55**	**58**
D1485 (1991)	--	97.0%	48.0%	4.0%	--	96.0%	87.0%	11.0%	98.0%	82.0%	36.0%	5.0%
D1485 (1992)	--	98.0%	50.0%	4.0%	--	96.0%	87.0%	11.0%	98.0%	82.0%	36.0%	5.0%
D1485 (1993)	--	98.0%	50.0%	3.0%	--	96.0%	89.0%	11.0%	98.0%	84.0%	36.0%	5.0%
D1641 (1994)	--	98.0%	51.0%	4.0%	--	98.0%	89.0%	11.0%	99.0%	82.0%	38.0%	4.0%
D1641 (1997)	95.0%	55.0%	4.0%	--	99.0%	68.0%	48.0%	2.0%	85.0%	46.0%	10.0%	5.0%
Today EWA	94.0%	53.0%	1.0%	--	99.0%	58.0%	41.0%	5.0%	81.0%	34.0%	12.0%	5.0%

Sacramento River

Impacts to Shasta Reservoir can be seen in the end of September storage long-term and drought period as measured from the D1485 (1991) baseline through the Today EWA study (see Table 7-6). Comparing the D1485 (1991) to the 1992 and 1993 D1485 studies in Table 7-6, Shasta is drawn down more because of the increased refuge deliveries. The D1641 (1994) run has the same long-term average impact as the D1485 (1993) run but requires more water in the drought period. Figure 7-14 shows the chronology of Shasta Storage with the Today EWA study trending the lowest. Also, from the chronology, the D1641 1994 and 1997 studies run lower than the three D1485 studies because of increased Delta requirements in the spring and loss of imports from the Trinity River. The end of May exceedance chart for Shasta appears on Figure 7-15; the amount of available storage at the end of May is constantly less in the D1641 (1997) and Today EWA runs because of 3406 b(2) operations and reductions in imports from the Trinity River. Figure 7-16 shows the end of September exceedance chart where the exceedance levels between all six studies remain relatively the same until the 60 percent exceedance level when Today EWA carryover storage values drop below the others.

Figure 7-17 shows the monthly percentiles for Keswick Releases to the Sacramento River. The 50th percentiles show the most variation in releases, with October showing higher releases on the three D1485 runs than the other D1641 and EWA runs. December through March show increased releases in the D1641 (1994) with the 3406 b(2) increasing the releases further during these months in the D1641 (1997) and Today EWA run.

Table 7-6 Long-term Average and 28 –34 Average Differences: Clear Creek Tunnel, Clear Creek, and Spring Creek Tunnel Flows

Long-term Average	Study A	B - A	C - A	D - A	1 – A	3 - A
Spring Creek Tunnel (cfs)	1324	4	5	12	-89	-197
Shasta EOS (TAF)	2771	-29	-40	-40	-66	-112
Keswick Releases (cfs)	8755	4	6	17	-82	-188
28-34 Average						
Spring Creek Tunnel (cfs)	788	-5	1	12	-51	-140
Shasta EOS (TAF)	1818	-62	-42	-139	-223	-202
Keswick Releases (cfs)	5947	13	18	68	48	-21

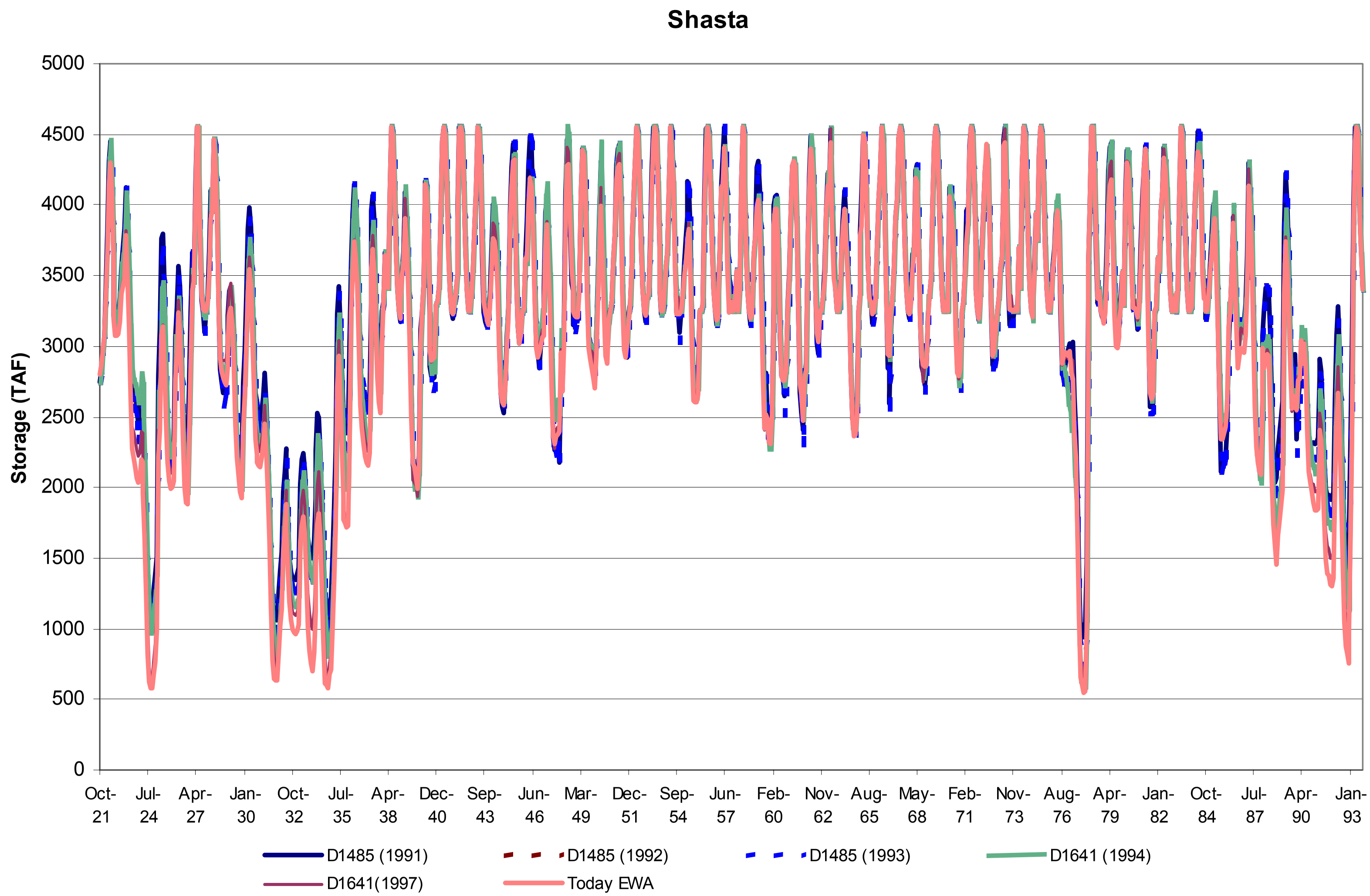

Figure 7-14 Chronology of Shasta Storage

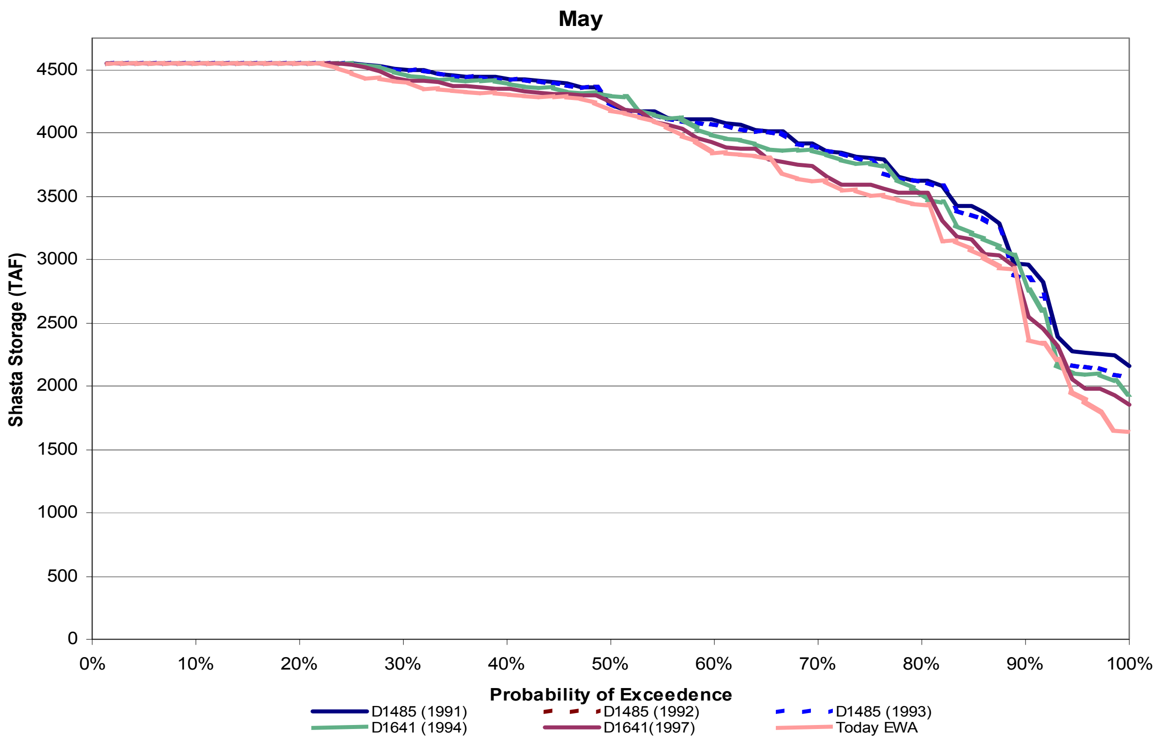

Figure 7-15 Shasta End of May Exceedance

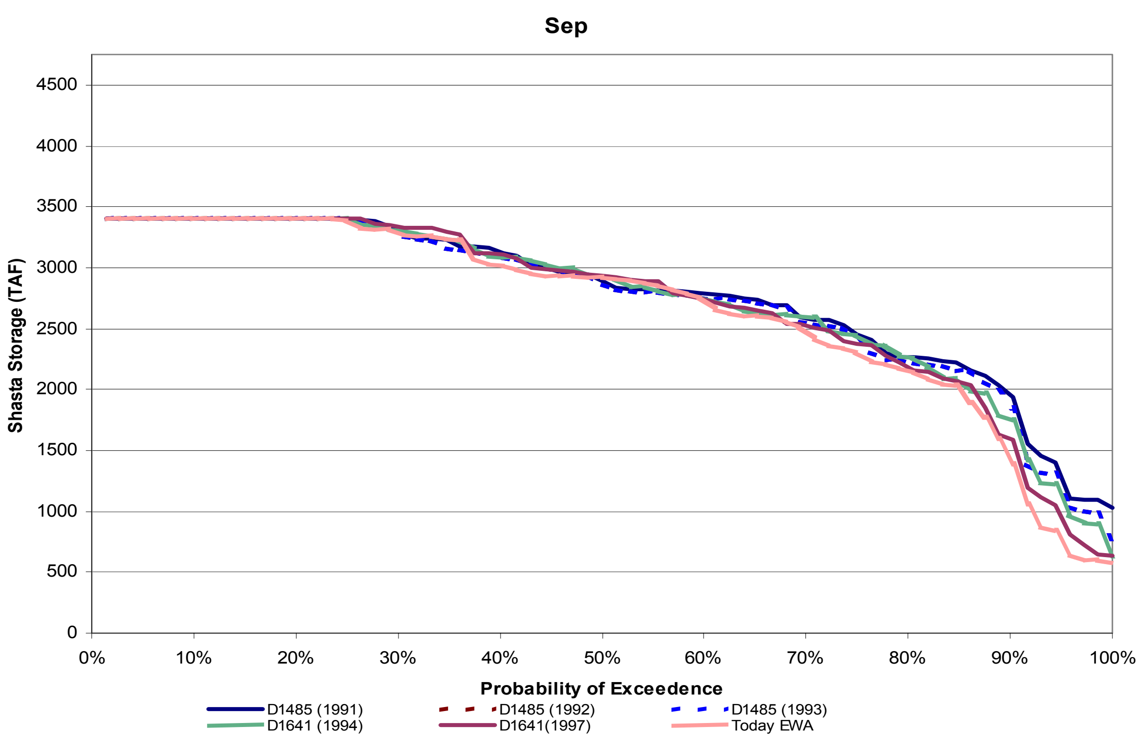

Figure 7-16 Shasta End of September Exceedance

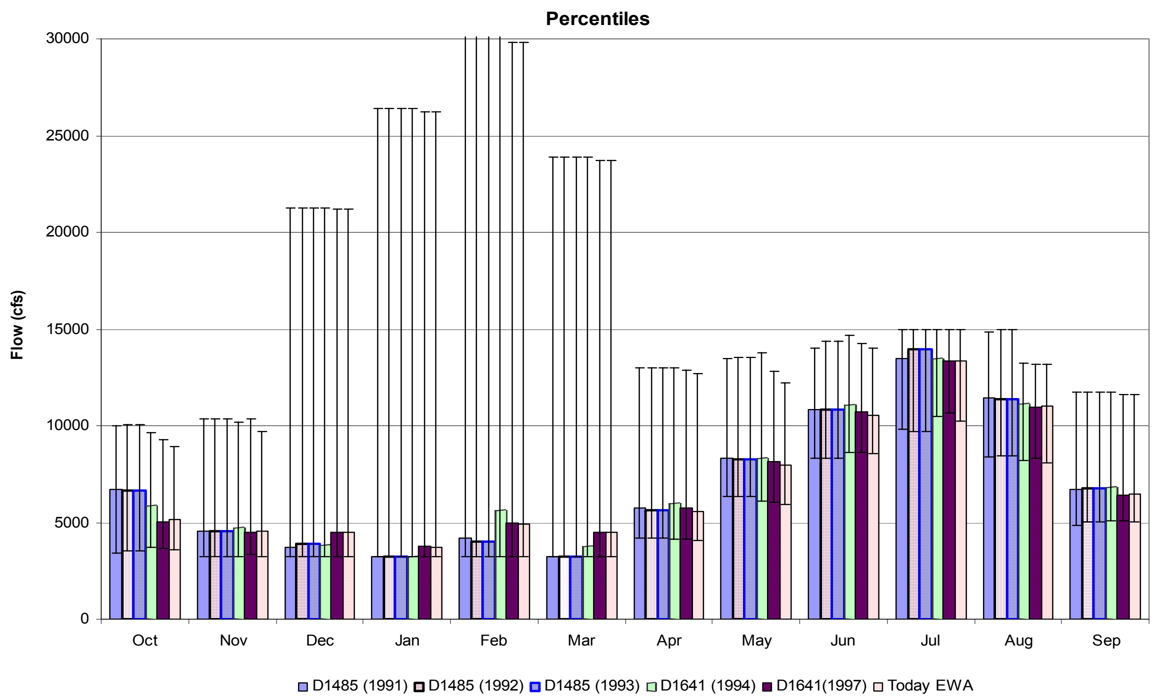

Figure 7-17 Monthly Percentiles of Keswick Releases the bars represent the 50th percentile with the whiskers as the 5th and 95th percentile

Figure 7-18 to Figure 7-23 show the monthly exceedance charts for temperatures on the Sacramento River at Bend Bridge. The Today EWA run trends higher for almost all the exceedance levels of the six monthly charts because of the reduction in cold water being imported from the Trinity River. The July to October charts (Figure 7-20 to Figure 7-23) show that the hotter temperatures are exceeded more frequently from the D1485 (1991) baseline, first with the additional deliveries for refuges in Studies B and C. Additional Delta Outflow requirements increase the temperatures in the D1641 (1994) when measured against Studies B and C. The temperatures increase further from the increased flow requirements for the 3406 b(2) operations in Study 1 that reduce the available storage and cold water pool in Shasta. The decrease in Trinity imports to the Sacramento increases the later summer temperatures in the Today EWA run.

Table 7-7, Table 7-8, and Table 7-9 show the monthly exceedance levels for selected temperatures for Bend Bridge, Jellys Ferry and Balls Ferry reaches of the Sacramento River. The tables indicate that the general trend is for exceedance levels to stay relatively the same from November through April, with some exception of the middle-range temperatures in November and February in Studies D, 1 and 3, where the temperatures in the reaches get warmer. The most dramatic shift in temperatures in the six OCAP runs in the three reaches comes in the July through October when the warmer temperatures are exceeded more frequently as the Studies go from the D1485 (1991) study through to the Today EWA run because of decreasing storage conditions from refuge deliveries, increased springtime Delta requirements, 3406 b(2) increased releases from Keswick, and decreased Trinity imports.

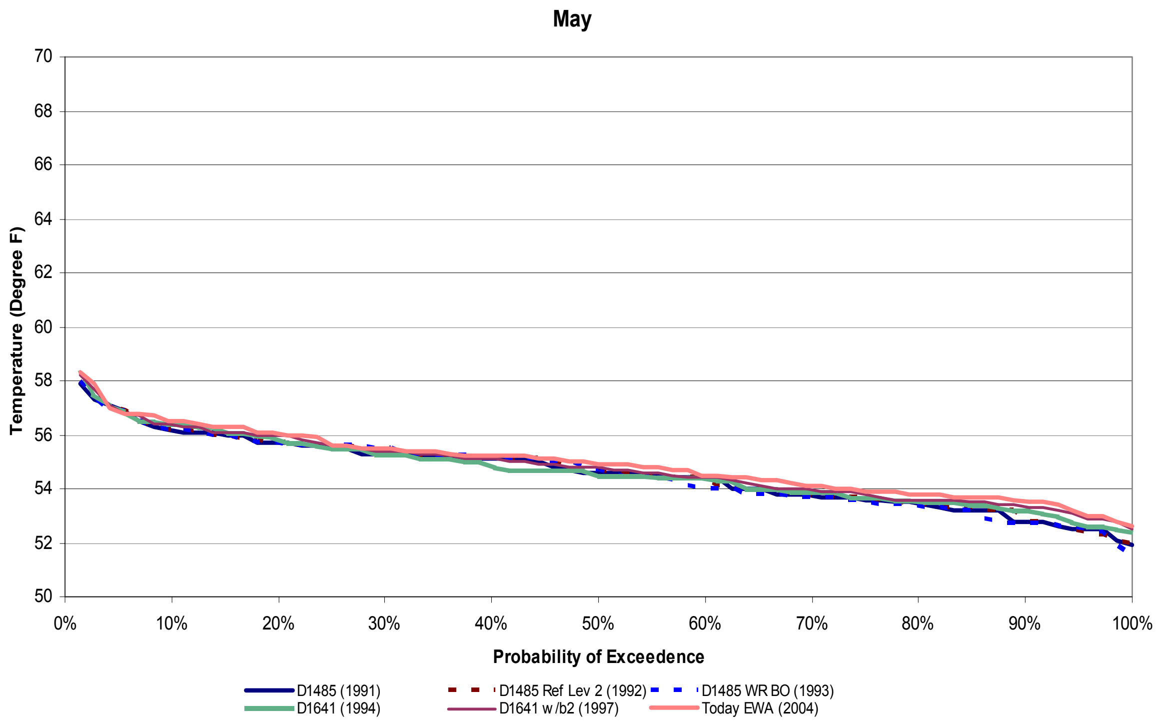

Figure 7-18 May Temperature Exceedance Chart at Bend Bridge

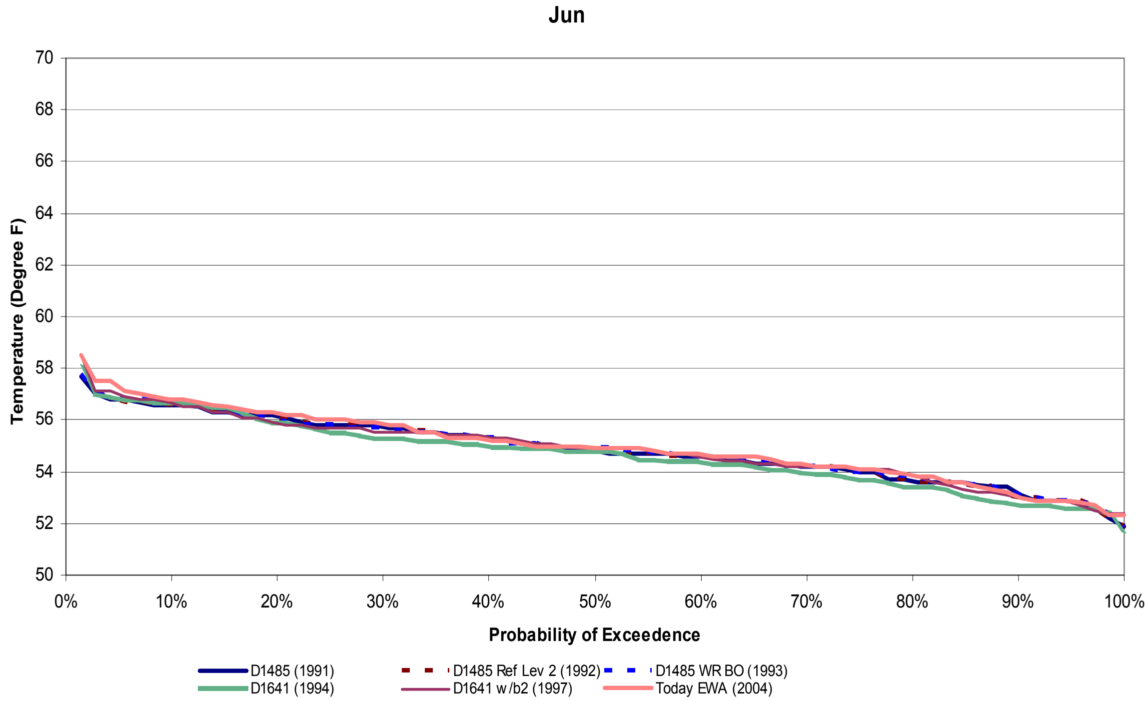

Figure 7-19 June Temperature Exceedance Chart at Bend Bridge

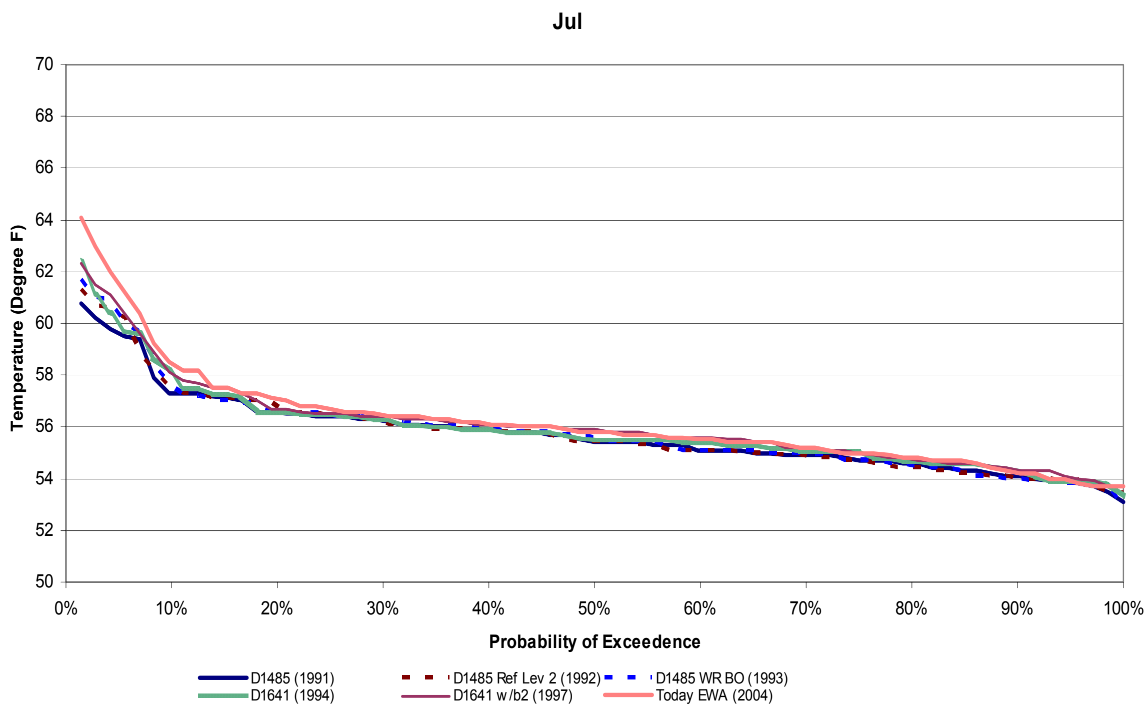

Figure 7-20 July Temperature Exceedance Chart at Bend Bridge

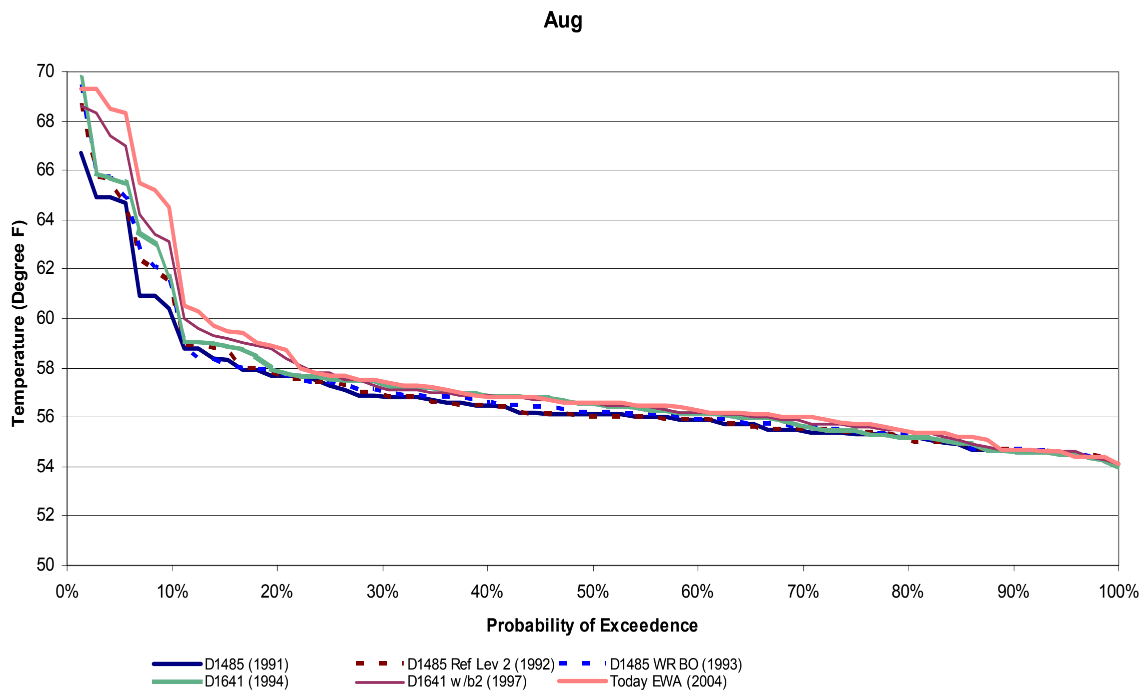

Figure 7-21 August Temperature Exceedance Chart at Bend Bridge

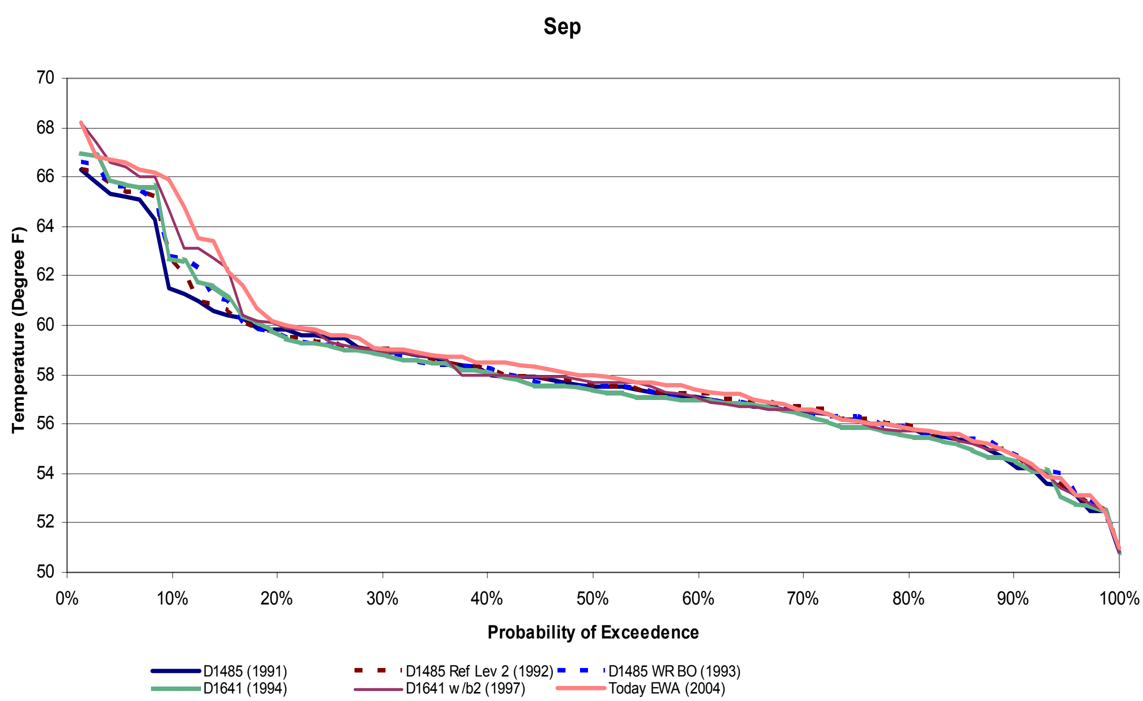

Figure 7-22 September Temperature Exceedance Chart at Bend Bridge

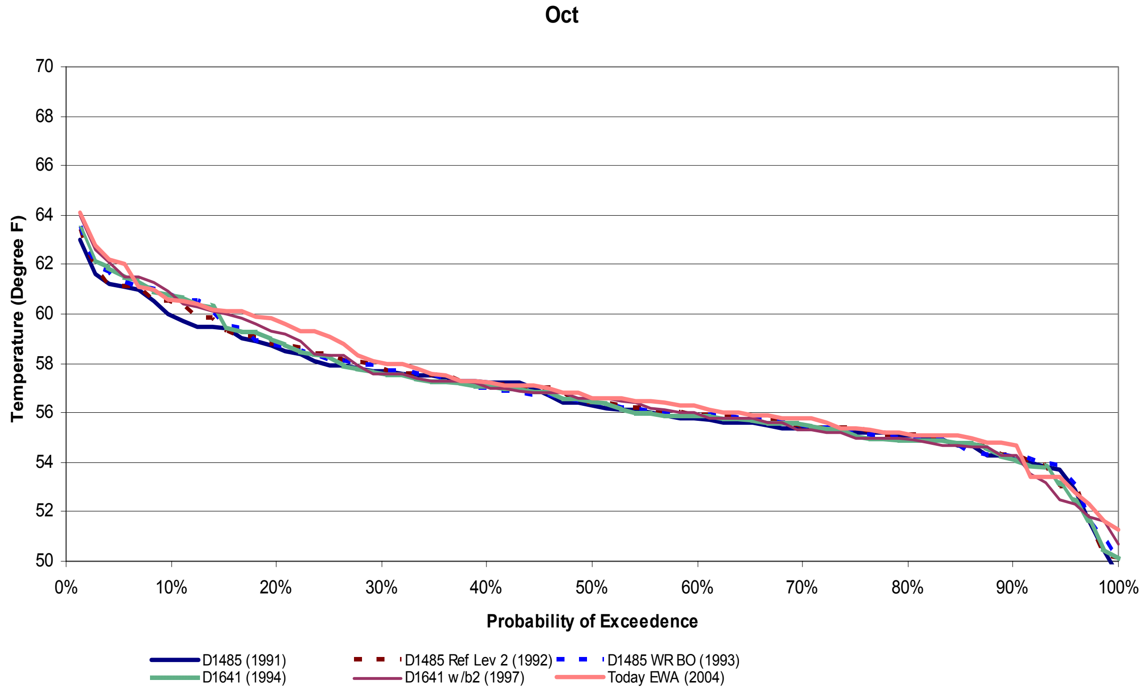

Figure 7-23 October Temperature Exceedance Chart at Bend Bridge

Table 7-7 Monthly Temperature Exceedance Levels for Bend Bridge

	Oct				Nov				Dec			
	52	**56**	**58**	**60**	**52**	**56**	**58**	**60**	**52**	**56**	**58**	**60**
D1485 (1991)	97.0%	55.0%	24.0%	9.0%	68.0%	7.0%	--	--	--	--	--	--
D1485 Ref Lev 2 (1992)	97.0%	58.0%	28.0%	11.0%	67.0%	6.0%	--	--	--	--	--	--
D1485 WR BO (1993)	97.0%	58.0%	27.0%	13.0%	65.0%	7.0%	--	--	1.0%	--	--	--
D1641 (1994)	97.0%	55.0%	26.0%	14.0%	75.0%	7.0%	--	--	--	--	--	--
D1641 w/b2 (1997)	97.0%	60.0%	27.0%	15.0%	75.0%	8.0%	--	--	0.0%	--	--	--
Today EWA (2004)	98.0%	64.0%	31.0%	17.0%	75.0%	8.0%	--	--	0.0%	--	--	--
	Jan				**Feb**				**Mar**			
	52	**56**	**58**	**60**	**52**	**56**	**58**	**60**	**52**	**56**	**58**	**60**
D1485 (1991)	--	--	--	--	--	--	--	--	48.0%	1.0%	--	--
D1485 Ref Lev 2 (1992)	--	--	--	--	--	--	--	--	48.0%	--	--	--
D1485 WR BO (1993)	--	--	--	--	--	--	--	--	50.0%	1.0%	--	--
D1641 (1994)	--	--	--	--	--	--	--	--	47.0%	1.0%	--	--
D1641 w/b2 (1997)	--	--	--	--	--	--	--	--	47.0%	1.0%	--	--
Today EWA (2004)	--	--	--	--	--	--	--	--	48.0%	1.0%	--	--
	Apr				**May**				**Jun**			
	52	**56**	**58**	**60**	**52**	**56**	**58**	**60**	**52**	**56**	**58**	**60**
D1485 (1991)	92.0%	0.0%	--	--	100.0%	16.0%	--	--	100.0%	21.0%	--	--
D1485 Ref Lev 2 (1992)	92.0%	0.0%	--	--	100.0%	15.0%	0.0%	--	100.0%	20.0%	--	--
D1485 WR BO (1993)	93.0%	0.0%	--	--	99.0%	15.0%	0.0%	--	100.0%	20.0%	--	--
D1641 (1994)	89.0%	2.0%	--	--	--	17.0%	1.0%	--	100.0%	18.0%	0.0%	--
D1641 w/b2 (1997)	91.0%	0.0%	--	--	--	20.0%	1.0%	--	#N/A	18.0%	1.0%	--
Today EWA (2004)	91.0%	0.0%	--	--	--	22.0%	2.0%	--	#N/A	26.0%	1.0%	--

Table 7-7 Monthly Temperature Exceedance Levels for Bend Bridge

	Jul				Aug				Sep			
	56	58	60	62	56	58	60	62	56	58	60	62
D1485 (1991)	36.0%	7.0%	3.0%	--	57.0%	16.0%	9.0%	6.0%	78.0%	40.0%	17.0%	9.0%
D1485 Ref Lev 2 (1992)	33.0%	8.0%	5.0%	--	55.0%	17.0%	10.0%	7.0%	79.0%	41.0%	16.0%	10.0%
D1485 WR BO (1993)	37.0%	8.0%	5.0%	--	58.0%	16.0%	10.0%	8.0%	77.0%	41.0%	16.0%	12.0%
D1641 (1994)	36.0%	9.0%	4.0%	1.0%	67.0%	19.0%	10.0%	9.0%	73.0%	41.0%	18.0%	11.0%
D1641 w/b2 (1997)	46.0%	9.0%	5.0%	1.0%	67.0%	22.0%	10.0%	9.0%	76.0%	41.0%	20.0%	15.0%
Today EWA (2004)	46.0%	12.0%	7.0%	3.0%	71.0%	22.0%	12.0%	10.0%	78.0%	50.0%	20.0%	15.0%

Table 7-8 Monthly Temperature Exceedance Levels at Jellys Ferry

	Oct				Nov				Dec			
	52	**56**	**58**	**60**	**52**	**56**	**58**	**60**	**52**	**56**	**58**	**60**
D1485 (1991)	97.0%	54.0%	23.0%	9.0%	69.0%	7.0%	--	--	--	--	--	--
D1485 Ref Lev 2 (1992)	97.0%	55.0%	27.0%	11.0%	67.0%	7.0%	--	--	--	--	--	--
D1485 WR BO (1993)	97.0%	55.0%	27.0%	13.0%	67.0%	7.0%	--	--	1.0%	--	--	--
D1641 (1994)	97.0%	54.0%	25.0%	14.0%	77.0%	8.0%	--	--	--	--	--	--
D1641 w/b2 (1997)	97.0%	57.0%	26.0%	13.0%	76.0%	8.0%	--	--	1.0%	--	--	--
Today EWA (2004)	98.0%	62.0%	30.0%	16.0%	77.0%	8.0%	--	--	1.0%	--	--	--
	Jan				**Feb**				**Mar**			
	52	**56**	**58**	**60**	**52**	**56**	**58**	**60**	**52**	**56**	**58**	**60**
D1485 (1991)	--	--	--	--	--	--	--	--	48.0%	1.0%	--	--
D1485 Ref Lev 2 (1992)	--	--	--	--	--	--	--	--	48.0%	--	--	--
D1485 WR BO (1993)	--	--	--	--	--	--	--	--	48.0%	1.0%	--	--
D1641 (1994)	--	--	--	--	--	--	--	--	47.0%	1.0%	--	--
D1641 w/b2 (1997)	--	--	--	--	--	--	--	--	47.0%	0.0%	--	--
Today EWA (2004)	--	--	--	--	--	--	--	--	48.0%	1.0%	--	--
	Apr				**May**				**Jun**			
	52	**56**	**58**	**60**	**52**	**56**	**58**	**60**	**52**	**56**	**58**	**60**
D1485 (1991)	89.0%	--	--	--	98.0%	6.0%	--	--	98.0%	10.0%	--	--
D1485 Ref Lev 2 (1992)	89.0%	--	--	--	98.0%	6.0%	--	--	98.0%	10.0%	--	--
D1485 WR BO (1993)	89.0%	--	--	--	97.0%	6.0%	--	--	99.0%	12.0%	--	--
D1641 (1994)	86.0%	--	--	--	100.0%	10.0%	--	--	99.0%	12.0%	--	--
D1641 w/b2 (1997)	86.0%	--	--	--	--	9.0%	--	--	99.0%	10.0%	--	--
Today EWA (2004)	88.0%	--	--	--	--	13.0%	--	--	98.0%	15.0%	--	--

Table 7-8 Monthly Temperature Exceedance Levels at Jellys Ferry

	Jul				Aug				Sep			
	56	58	60	62	56	58	60	62	56	58	60	62
D1485 (1991)	24.0%	7.0%	1.0%	--	40.0%	13.0%	9.0%	6.0%	72.0%	37.0%	16.0%	9.0%
D1485 Ref Lev 2 (1992)	24.0%	6.0%	4.0%	--	41.0%	15.0%	10.0%	6.0%	73.0%	37.0%	15.0%	10.0%
D1485 WR BO (1993)	23.0%	8.0%	4.0%	--	46.0%	11.0%	9.0%	7.0%	74.0%	36.0%	16.0%	11.0%
D1641 (1994)	24.0%	8.0%	3.0%	1.0%	53.0%	18.0%	10.0%	8.0%	70.0%	36.0%	17.0%	11.0%
D1641 w/b2 (1997)	26.0%	8.0%	5.0%	0.0%	55.0%	20.0%	10.0%	9.0%	73.0%	36.0%	17.0%	14.0%
Today EWA (2004)	29.0%	9.0%	6.0%	3.0%	57.0%	21.0%	10.0%	10.0%	74.0%	43.0%	18.0%	14.0%

Table 7-9 Monthly Temperature Exceedance Levels at Balls Ferry

	Oct				Nov				Dec			
	52	56	58	60	52	56	58	60	52	56	58	60
D1485 (1991)	97.0%	49.0%	24.0%	9.0%	78.0%	11.0%	--	--	2.0%	--	--	--
D1485 Ref Lev 2 (1992)	97.0%	52.0%	28.0%	10.0%	76.0%	11.0%	--	--	2.0%	--	--	--
D1485 WR BO (1993)	97.0%	50.0%	29.0%	14.0%	74.0%	11.0%	--	--	2.0%	--	--	--
D1641 (1994)	95.0%	49.0%	25.0%	14.0%	82.0%	12.0%	1.0%	--	2.0%	--	--	--
D1641 w/b2 (1997)	94.0%	51.0%	25.0%	16.0%	83.0%	10.0%	2.0%	--	2.0%	--	--	--
Today EWA (2004)	96.0%	55.0%	31.0%	18.0%	84.0%	12.0%	3.0%	--	2.0%	--	--	--
	Jan				**Feb**				**Mar**			
	52	**56**	**58**	**60**	**52**	**56**	**58**	**60**	**52**	**56**	**58**	**60**
D1485 (1991)	--	--	--	--	0.0%	--	--	--	46.0%	1.0%	--	--
D1485 Ref Lev 2 (1992)	--	--	--	--	1.0%	--	--	--	46.0%	--	--	--
D1485 WR BO (1993)	--	--	--	--	1.0%	--	--	--	46.0%	1.0%	--	--
D1641 (1994)	--	--	--	--	1.0%	--	--	--	44.0%	1.0%	--	--
D1641 w/b2 (1997)	--	--	--	--	1.0%	--	--	--	43.0%	1.0%	--	--
Today EWA (2004)	--	--	--	--	1.0%	--	--	--	46.0%	1.0%	--	--
	Apr				**May**				**Jun**			
	52	**56**	**58**	**60**	**52**	**56**	**58**	**60**	**52**	**56**	**58**	**60**
D1485 (1991)	60.0%	--	--	--	51.0%	--	--	--	55.0%	--	--	--
D1485 Ref Lev 2 (1992)	58.0%	--	--	--	51.0%	--	--	--	55.0%	--	--	--
D1485 WR BO (1993)	60.0%	--	--	--	50.0%	--	--	--	55.0%	--	--	--
D1641 (1994)	55.0%	--	--	--	51.0%	--	--	--	53.0%	--	--	--
D1641 w/b2 (1997)	58.0%	--	--	--	55.0%	--	--	--	60.0%	--	--	--
Today EWA (2004)	61.0%	--	--	--	61.0%	--	--	--	58.0%	--	--	--

Table 7-9 Monthly Temperature Exceedance Levels at Balls Ferry

	Jul				Aug				Sep			
	56	**58**	**60**	**62**	**56**	**58**	**60**	**62**	**56**	**58**	**60**	**62**
D1485 (1991)	7.0%	3.0%	--	--	18.0%	9.0%	6.0%	5.0%	51.0%	27.0%	10.0%	8.0%
D1485 Ref Lev 2 (1992)	6.0%	5.0%	--	--	19.0%	10.0%	7.0%	6.0%	51.0%	24.0%	11.0%	9.0%
D1485 WR BO (1993)	8.0%	5.0%	1.0%	--	22.0%	10.0%	8.0%	6.0%	48.0%	22.0%	13.0%	9.0%
D1641 (1994)	9.0%	5.0%	1.0%	--	20.0%	10.0%	9.0%	7.0%	47.0%	22.0%	14.0%	9.0%
D1641 w/b2 (1997)	9.0%	5.0%	1.0%	--	23.0%	11.0%	10.0%	7.0%	54.0%	25.0%	16.0%	12.0%
Today EWA (2004)	12.0%	6.0%	4.0%	1.0%	23.0%	15.0%	10.0%	9.0%	61.0%	27.0%	17.0%	14.0%

Feather River

Figure 7-24 shows the chronology of Oroville storage for the six runs. The D1485 studies A, B, and C trend higher than in Studies D, 1, and 3 as indicated by the chronology, as well as the end-of-May and end-of-September Oroville storages on Figure 7-25 and Figure 7-26, respectively. Table 7-10 shows that the largest impact to Oroville is in Study D from the increased Delta outflow requirements. Studies 1 and 3 have the same requirements, but in Study 1, the State can pump more abandoned CVP water than in Study D, and Study 3 has export restrictions at Banks from the EWA program. Figure 7-27 shows the percentiles for monthly flows below Thermalito; the increase in releases from Oroville occur April through August to meet Delta requirements in spring and for increased pumping in summer because of the Springtime export restrictions in the Studies D, 1, and 3 versus Studies A, B, and C.

Table 7-10 Long-term Average and 28 –34 Average Differences of Oroville End of September Storage and Flow Below Thermalito

Long term Average	Study A	B - A	C - A	D - A	1 - A	3 - A
Oroville EOS (TAF)	2196	-8	29	-125	-111	-117
Below Thermalito (cfs)	8755	4	6	17	-82	-188
28-34 Average						
Oroville EOS (TAF)	1646	-21	54	-198	-144	-142
Below Thermalito (cfs)	5947	13	18	68	48	-21

Table 7-11 shows the monthly temperature exceedance levels for selected temperatures. On Table 7-11, the three D1485 studies generally have the same temperatures. The D1641 runs and the EWA have generally higher temperatures in all months, with the exception of December, January, and June.

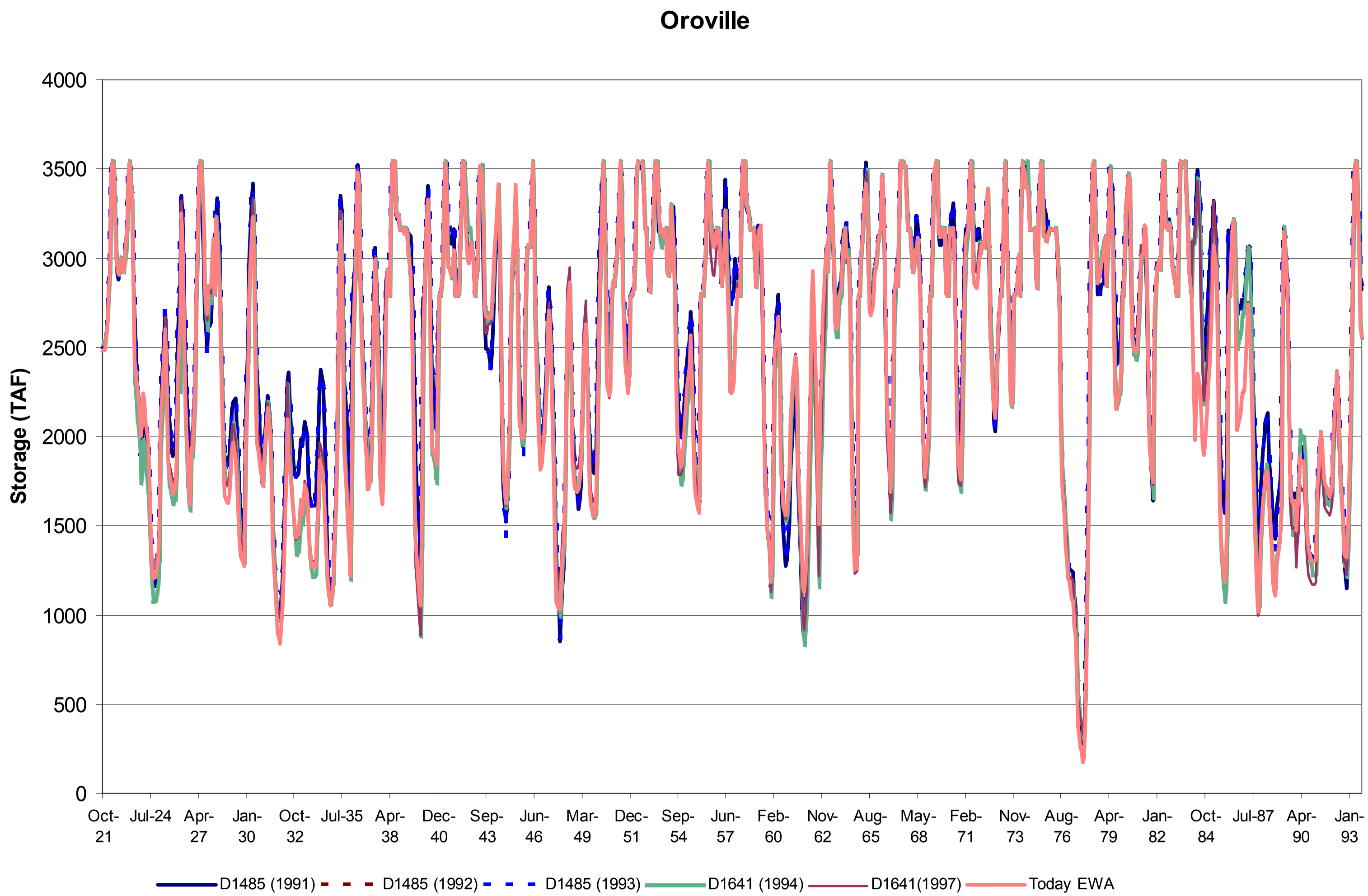

Figure 7-24 Chronology of Oroville Storage

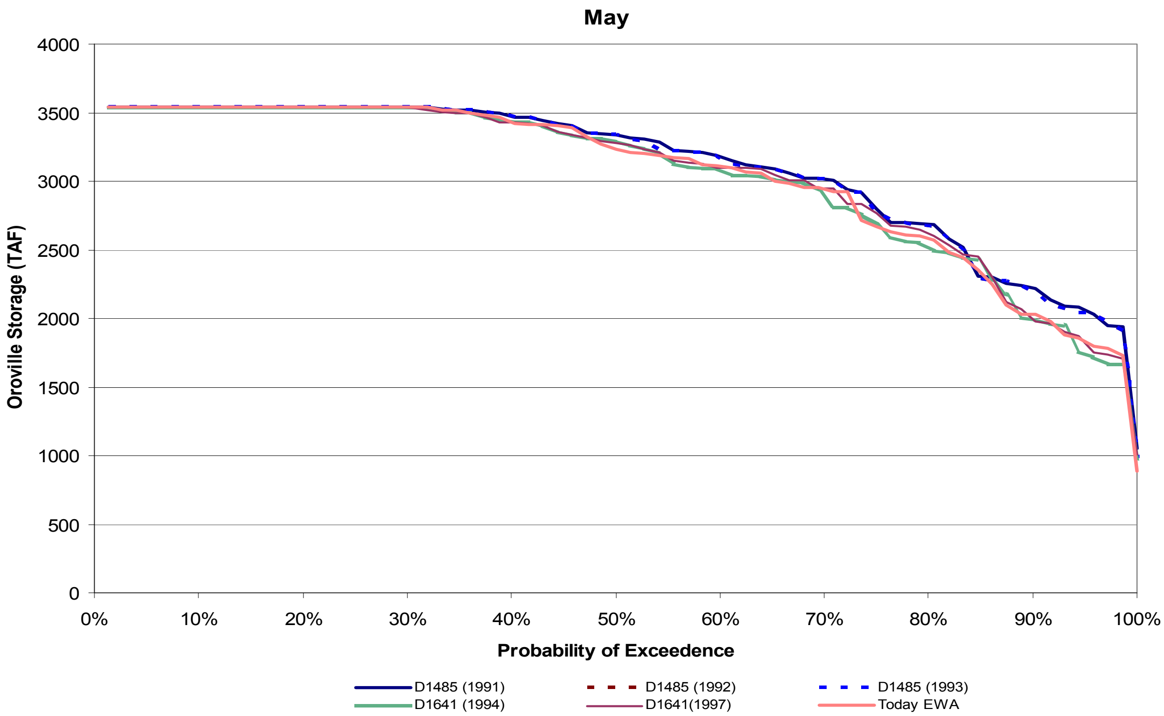

Figure 7-25 Oroville End of May Exceedance Chart

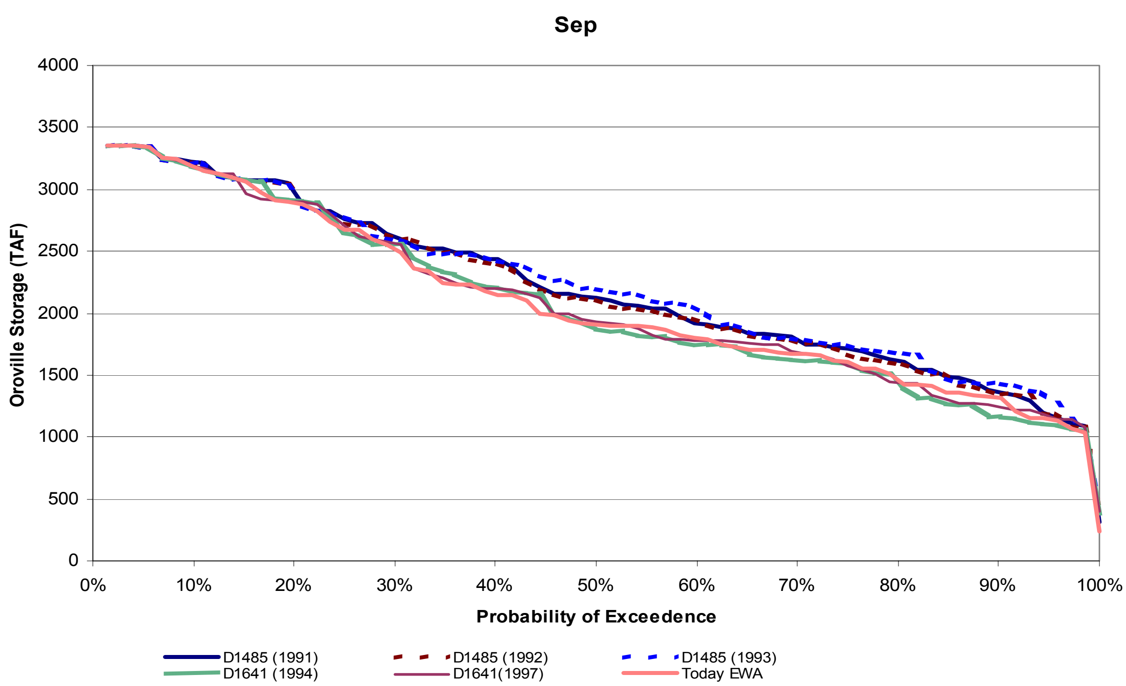

Figure 7-26 Oroville End of September Exceedance Chart

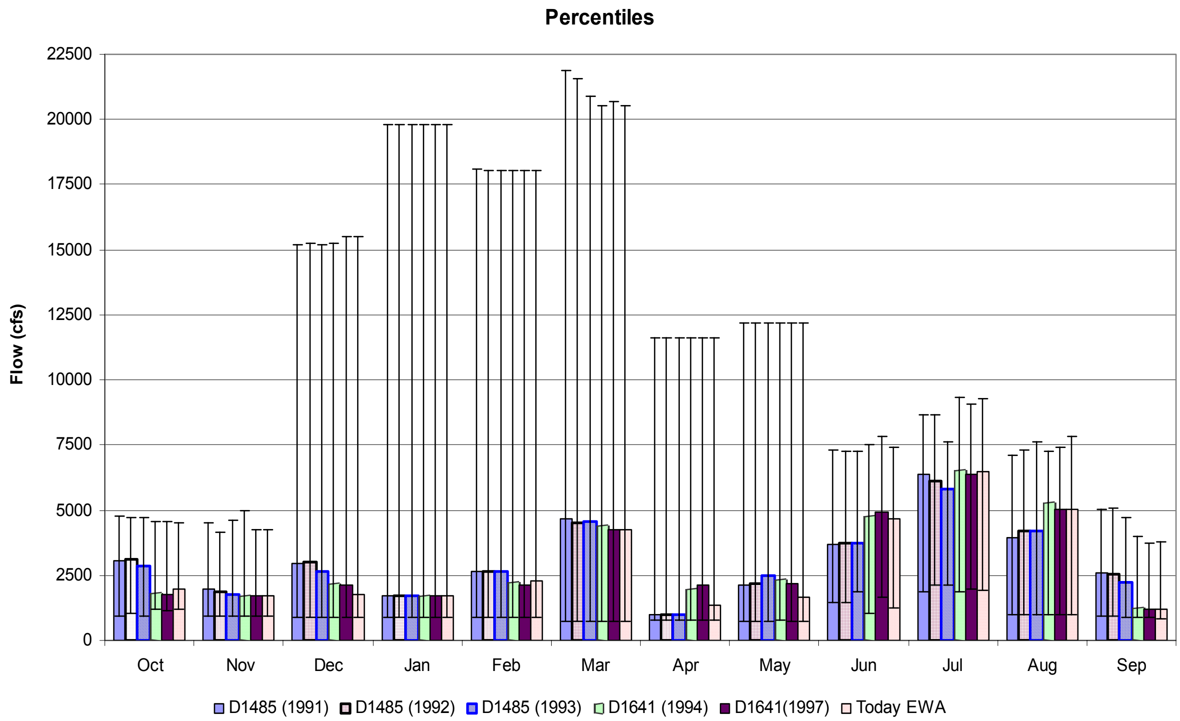

Figure 7-27 Monthly Percentiles of Feather River Flow Below Thermalito; the bars represent the 50th percentile with the whiskers as the 5th and 95th percentile

Table 7-11 Monthly Temperature Exceedance Levels Below Thermalito

	Oct				Nov				Dec			
Degrees F	**56**	**60**	**63**	**65**	**50**	**52**	**54**	**56**	**43**	**46**	**48**	**51**
D1485 (1991)	98.0%	32.0%	2.0%	1.0%	100.0%	74.0%	29.0%	5.0%	95.0%	71.0%	30.0%	2.0%
D1485 (1992)	58.0%	34.0%	2.0%	1.0%	100.0%	74.0%	27.0%	5.0%	95.0%	71.0%	31.0%	2.0%
D1485 (1993)	98.0%	36.0%	2.0%	1.0%	100.0%	74.0%	27.0%	4.0%	95.0%	71.0%	30.0%	2.0%
D1641 (1994)	98.0%	43.0%	2.0%	1.0%	99.0%	74.0%	30.0%	4.0%	95.0%	64.0%	29.0%	2.0%
D1641 (1997)	99.0%	42.0%	2.0%	1.0%	99.0%	74.0%	30.0%	4.0%	95.0%	65.0%	29.0%	2.0%
Today EWA	98.0%	39.0%	3.0%	1.0%	99.0%	74.0%	30.0%	4.0%	95.0%	65.0%	29.0%	2.0%
	Jan				**Feb**				**Mar**			
Degrees F	**42**	**45**	**47**	**49**	**47**	**49**	**52**	**53**	**49**	**52**	**55**	**58**
D1485 (1991)	97.0%	75.0%	37.0%	6.0%	97.0%	65.0%	14.0%	3.0%	100.0%	67.0%	19.0%	1.0%
D1485 (1992)	97.0%	75.0%	37.0%	5.0%	97.0%	64.0%	13.0%	3.0%	100.0%	65.0%	19.0%	1.0%
D1485 (1993)	97.0%	77.0%	37.0%	5.0%	97.0%	67.0%	13.0%	3.0%	100.0%	65.0%	20.0%	1.0%
D1641 (1994)	97.0%	75.0%	37.0%	3.0%	97.0%	64.0%	13.0%	3.0%	100.0%	67.0%	23.0%	1.0%
D1641 (1997)	97.0%	75.0%	36.0%	3.0%	97.0%	64.0%	15.0%	3.0%	100.0%	67.0%	24.0%	1.0%
Today EWA	97.0%	75.0%	36.0%	5.0%	97.0%	64.0%	11.0%	3.0%	100.0%	67.0%	24.0%	2.0%
	Apr				**May**				**Jun**			
Degrees F	**52**	**55**	**58**	**61**	**58**	**60**	**65**	**69**	**62**	**66**	**69**	**71**
D1485 (1991)	99.0%	85.0%	27.0%	4.0%	97.0%	89.0%	9.0%	1.0%	99.0%	70.0%	17.0%	3.0%
D1485 (1992)	99.0%	85.0%	27.0%	1.0%	97.0%	89.0%	10.0%	1.0%	99.0%	70.0%	17.0%	3.0%
D1485 (1993)	99.0%	85.0%	27.0%	4.0%	97.0%	89.0%	9.0%	1.0%	99.0%	70.0%	18.0%	2.0%
D1641 (1994)	99.0%	85.0%	30.0%	3.0%	97.0%	88.0%	10.0%	1.0%	99.0%	58.0%	7.0%	3.0%
D1641 (1997)	99.0%	85.0%	34.0%	5.0%	97.0%	89.0%	12.0%	1.0%	99.0%	55.0%	7.0%	3.0%
Today EWA	99.0%	85.0%	33.0%	3.0%	97.0%	89.0%	13.0%	1.0%	99.0%	60.0%	10.0%	3.0%

	Jul				Aug				Sep			
Degrees F	**67**	**70**	**73**	**76**	**66**	**69**	**72**	**74**	**60**	**64**	**66**	**70**
D1485 (1991)	100.0%	37.0%	9.0%	1.0%	100.0%	64.0%	8.0%	3.0%	100.0%	58.0%	16.0%	1.0%
D1485 (1992)	100.0%	46.0%	9.0%	2.0%	99.0%	63.0%	7.0%	3.0%	100.0%	60.0%	17.0%	1.0%
D1485 (1993)	99.0%	48.0%	11.0%	1.0%	98.0%	58.0%	10.0%	5.0%	100.0%	65.0%	19.0%	1.0%
D1641 (1994)	94.0%	43.0%	10.0%	1.0%	96.0%	47.0%	12.0%	4.0%	100.0%	74.0%	19.0%	1.0%
D1641 (1997)	96.0%	40.0%	10.0%	1.0%	96.0%	51.0%	14.0%	3.0%	100.0%	72.0%	20.0%	1.0%
Today EWA	94.0%	40.0%	11.0%	1.0%	95.0%	46.0%	15.0%	3.0%	100.0%	72.0%	22.0%	1.0%

American River

Figure 7-28 shows the chronology of Folsom storage. Figure 7-28 and Table 7-12 show that Folsom Reservoir is most affected in the 1928 to 1934 drought period, as regulatory requirements in each of the five studies after Study A have put more demand on storage. May storages are decreased with probability of being full in May dropping by about 5 percent in the D1641 1994 and 1997 studies, as well as the Today EWA studies, compared to the D1485 studies. This is because of increased Delta outflow requirements and 3406 b(2) increased minimum flow (see Figure 7-29). The end of September storages, Figure 7-30, are generally the same with regard to exceedance because of increased summer flows in the D1485 studies (see Figure 7-31 for the percentiles of monthly releases).

Table 7-12 Long-term Average and 28 –34 Average Differences of Folsom End of September Storage and Nimbus Releases

Long-term Average	Study A	B - A	C - A	D - A	1 - A	3 - A
Folsom EOS (TAF)	538	-3	-7	-10	7	-3
Nimbus Release (cfs)	8755	4	6	17	-82	-188
28-34 Average						
Folsom EOS (TAF)	485	-21	-47	-77	-31	-33
Nimbus Release (cfs)	1941	19	19	31	22	55

The exceedance levels for monthly temperatures at Nimbus and Watt are shown in Table 7-13 and Table 7-14, respectively. The D1485 studies A, B, and C, do not reveal minor differences from one another. The D1641 (1994) Study D shows higher temperatures in the late summer at both compliance points when compared to Studies A, B and C. The two runs with 3406 b(2) operations, the D1641 (1997) and Today EWA studies, show warmer temperatures that start in April and continue into January.

The May through October monthly exceedance charts are shown on Figure 7-32 through Figure 7-37 for Watt Avenue. With the exception of May, when the temperatures are virtually identical, and September, the hotter temperatures are exceeded more frequently in Studies D, 1, and 3 when compared to the base Study A. Studies B and C show basically the same temperatures with some slight variation compared to Study A. Study 1 shows higher temperatures than Study D and Study 3 from the increased 3406 b(2) flow requirements reducing the cold water pool in Folsom Lake.

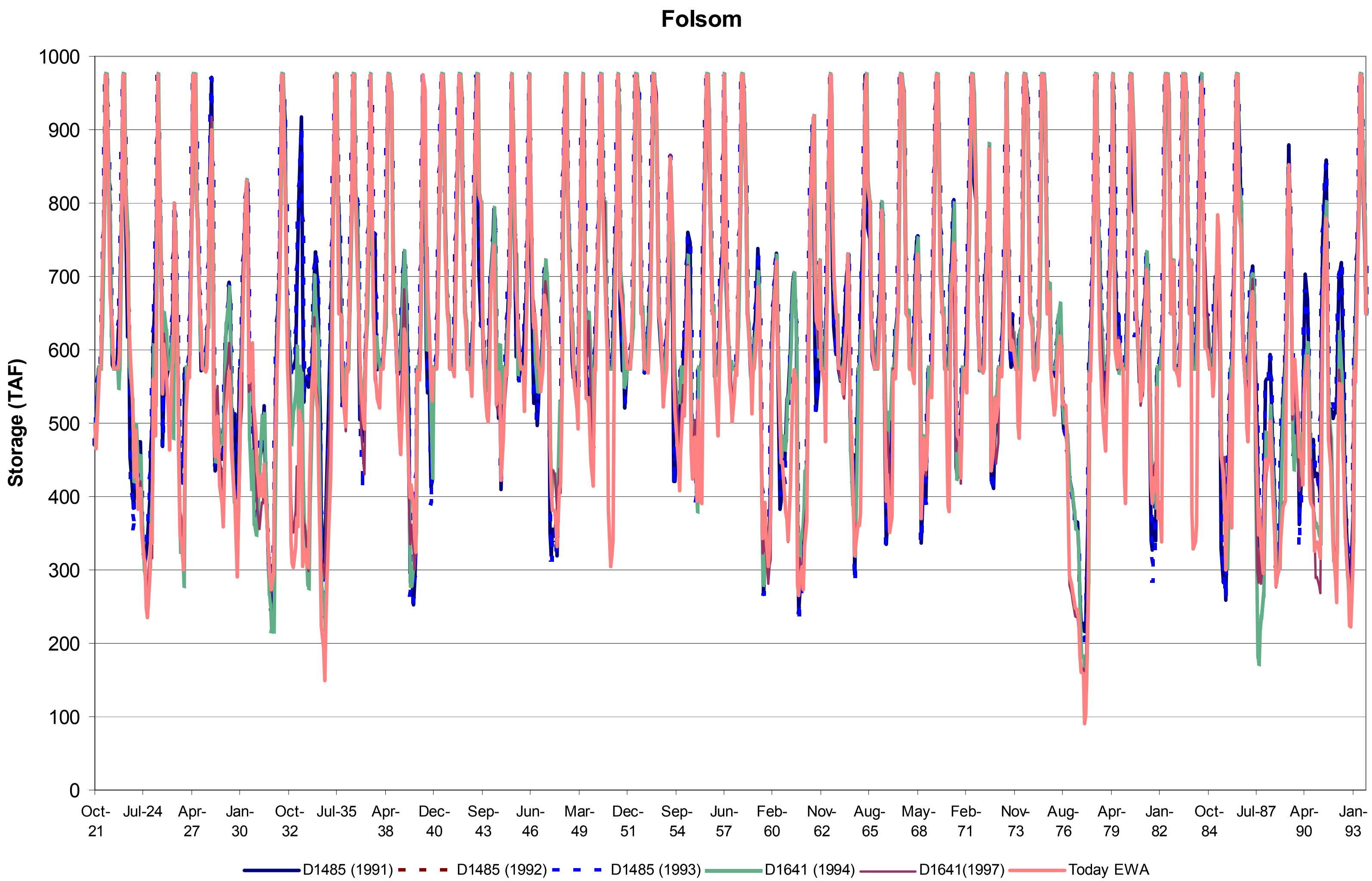

Figure 7-28 Chronology of Folsom Storage

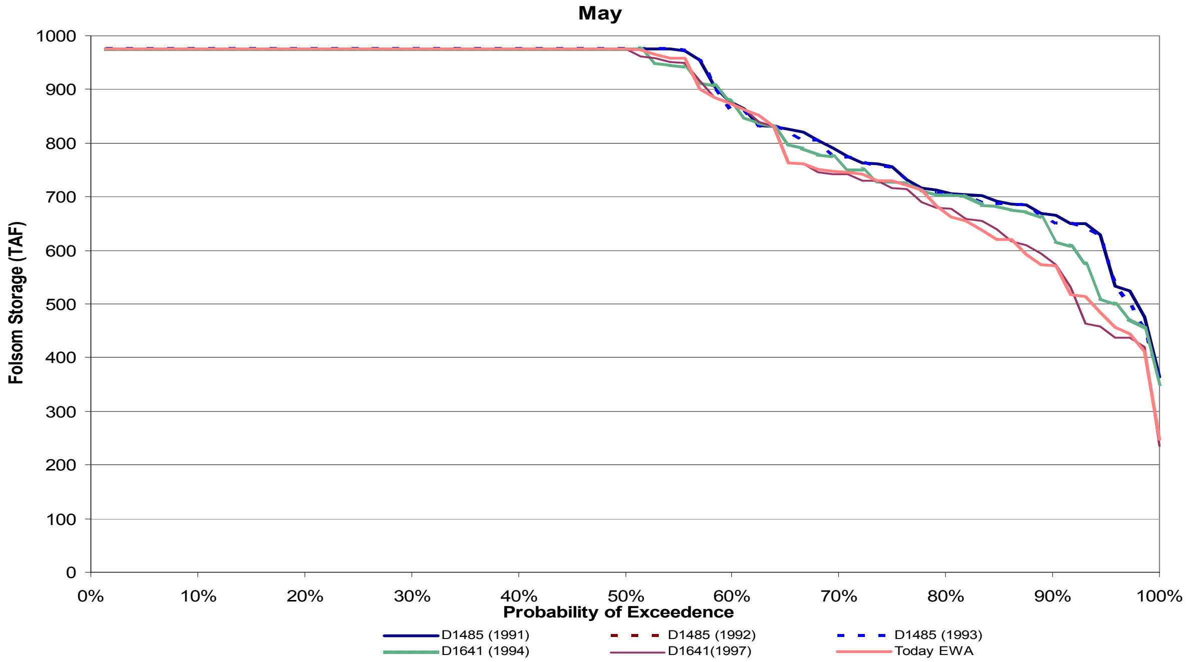

Figure 7-29 Folsom End of May Storage Exceedance

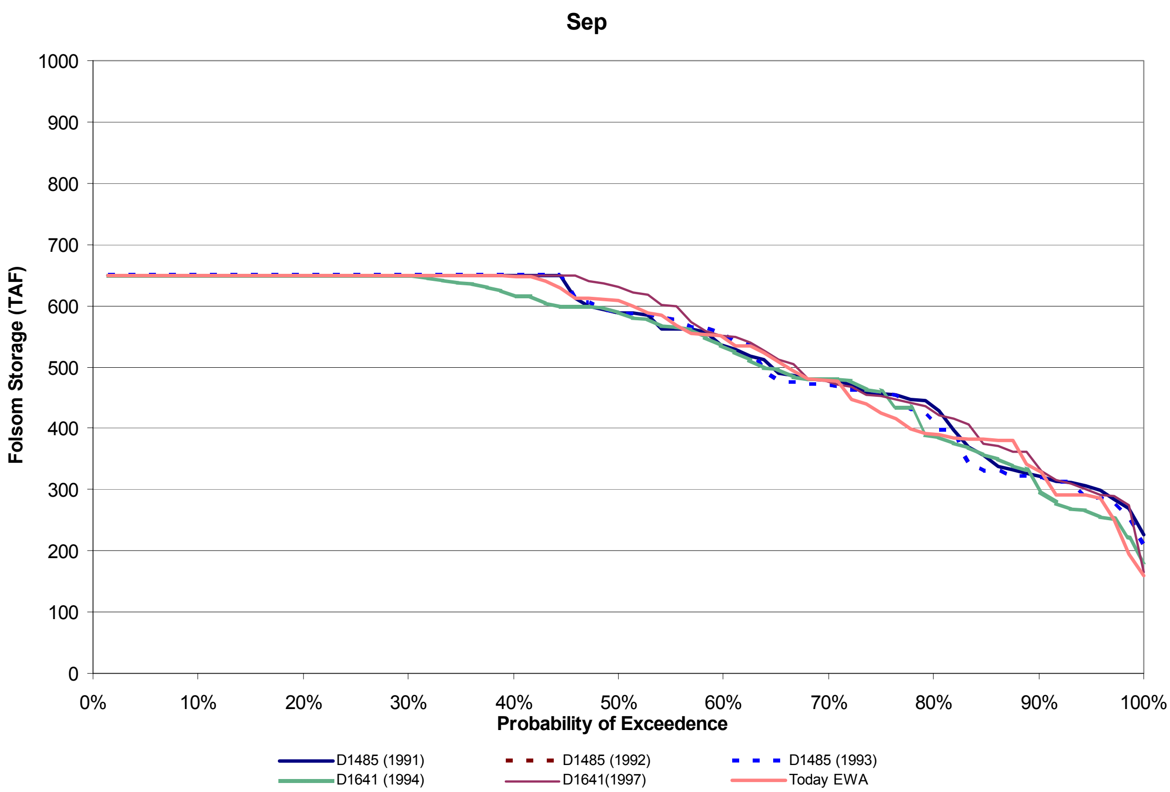

Figure 7-30 Folsom End of September Storage Exceedance

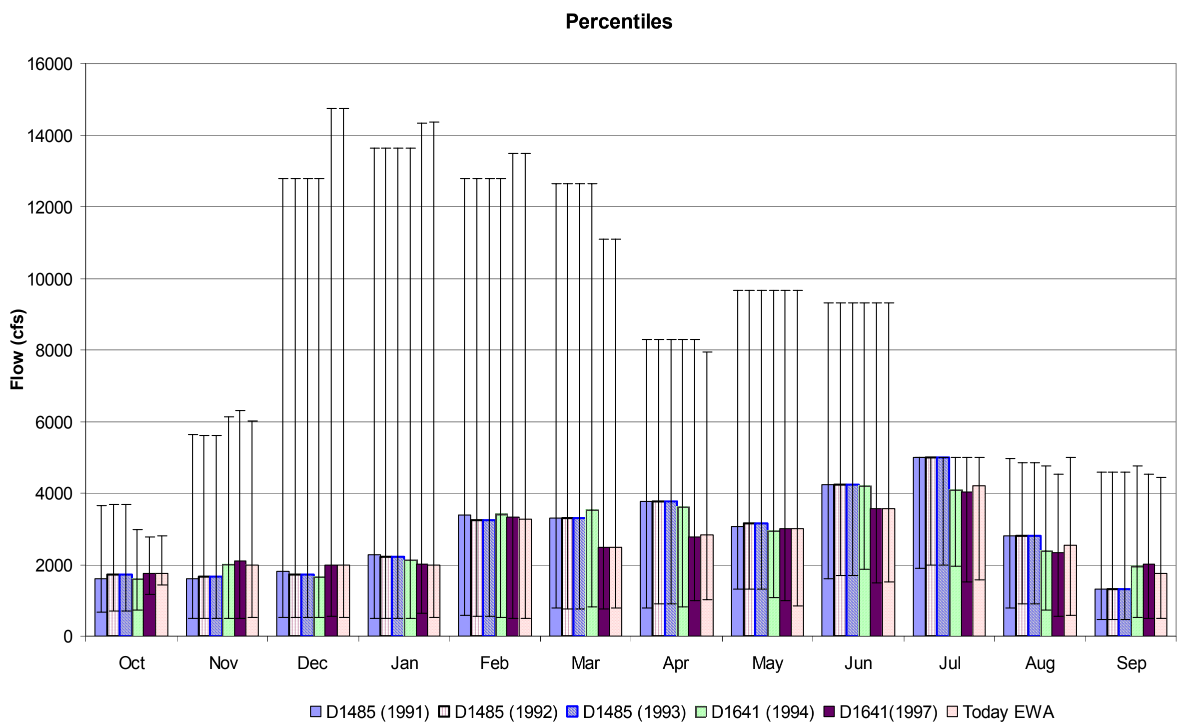

Figure 7-31 Monthly Percentiles of Nimbus Release the bars represent the 50th percentile with the whiskers as the 5th and 95th percentile

Table 7-13 Monthly Temperature Exceedance at Nimbus

	Oct				Nov				Dec			
Degrees F	**56**	**58**	**60**	**62**	**54**	**56**	**58**	**60**	**54**	**56**	**58**	**60**
D1485 (1991)	--	37.0%	20.0%	7.0%	91.0%	54.0%	13.0%	1.0%	1.0%	--	--	--
D1485 (1992)	--	39.0%	20.0%	9.0%	92.0%	52.0%	13.0%	1.0%	1.0%	--	--	--
D1485 (1993)	--	41.0%	23.0%	8.0%	91.0%	50.0%	15.0%	2.0%	1.0%	--	--	--
D1641 (1994)	100.0%	40.0%	20.0%	14.0%	92.0%	54.0%	16.0%	2.0%	1.0%	--	--	--
D1641 (1997)	100.0%	40.0%	23.0%	15.0%	97.0%	67.0%	25.0%	6.0%	2.0%	--	--	--
Today EWA	100.0%	39.0%	23.0%	15.0%	97.0%	68.0%	24.0%	5.0%	2.0%	--	--	--
	Jan				**Feb**				**Mar**			
Degrees F	**54**	**56**	**58**	**60**	**54**	**56**	**58**	**60**	**54**	**56**	**58**	**60**
D1485 (1991)	--	--	--	--	2.0%	--	--	--	37.0%	6.0%	3.0%	--
D1485 (1992)	--	--	--	--	2.0%	--	--	--	36.0%	6.0%	3.0%	--
D1485 (1993)	--	--	--	--	2.0%	--	--	--	37.0%	6.0%	3.0%	--
D1641 (1994)	--	--	--	--	2.0%	--	--	--	30.0%	4.0%	2.0%	--
D1641 (1997)	--	--	--	--	2.0%	--	--	--	24.0%	6.0%	1.0%	--
Today EWA	--	--	--	--	1.0%	--	--	--	24.0%	5.0%	1.0%	--
	Apr				**May**				**Jun**			
Degrees F	**56**	**58**	**60**	**62**	**62**	**65**	**68**	**70**	**62**	**65**	**68**	**70**
D1485 (1991)	60.0%	33.0%	12.0%	8.0%	35.0%	12.0%	--	--	99.0%	45.0%	4.0%	1.0%
D1485 (1992)	60.0%	33.0%	13.0%	7.0%	35.0%	12.0%	2.0%	--	99.0%	46.0%	2.0%	1.0%
D1485 (1993)	60.0%	33.0%	12.0%	7.0%	35.0%	12.0%	--	--	99.0%	46.0%	4.0%	1.0%
D1641 (1994)	62.0%	31.0%	11.0%	6.0%	37.0%	11.0%	1.0%	--	99.0%	40.0%	3.0%	0.0%
D1641 (1997)	65.0%	30.0%	14.0%	6.0%	39.0%	11.0%	3.0%	--	99.0%	47.0%	7.0%	2.0%
Today EWA	66.0%	31.0%	13.0%	4.0%	38.0%	11.0%	3.0%	--	99.0%	47.0%	7.0%	2.0%

Table 7-13 Monthly Temperature Exceedance at Nimbus

	Jul				Aug				Sep			
Degrees F	**65**	**68**	**70**	**72**	**65**	**68**	**70**	**72**	**65**	**68**	**70**	**72**
D1485 (1991)	99.0%	9.0%	2.0%	--	98.0%	26.0%	7.0%	1.0%	67.0%	33.0%	7.0%	--
D1485 (1992)	98.0%	7.0%	2.0%	--	98.0%	22.0%	7.0%	2.0%	66.0%	29.0%	5.0%	--
D1485 (1993)	99.0%	6.0%	1.0%	--	99.0%	22.0%	8.0%	1.0%	66.0%	25.0%	6.0%	--
D1641 (1994)	99.0%	8.0%	2.0%	--	100.0%	28.0%	8.0%	4.0%	65.0%	20.0%	2.0%	--
D1641 (1997)	98.0%	12.0%	5.0%	1.0%	98.0%	33.0%	13.0%	7.0%	67.0%	16.0%	3.0%	--
Today EWA	100.0%	10.0%	4.0%	0.0%	98.0%	27.0%	15.0%	5.0%	70.0%	17.0%	--	--

Table 7-14 Monthly Temperature Exceedance Levels at Watt Avenue

	Oct				Nov				Dec			
Degrees F	**58**	**60**	**62**	**64**	**54**	**56**	**58**	**60**	**54**	**56**	**58**	**60**
D1485 (1991)	70.0%	28.0%	12.0%	2.0%	82.0%	31.0%	6.0%	--	--	--	--	--
D1485 (1992)	70.0%	29.0%	12.0%	4.0%	84.0%	34.0%	8.0%	--	--	--	--	--
D1485 (1993)	71.0%	30.0%	14.0%	3.0%	84.0%	37.0%	5.0%	--	--	--	--	--
D1641 (1994)	73.0%	29.0%	15.0%	9.0%	86.0%	31.0%	7.0%	1.0%	--	--	--	--
D1641 (1997)	68.0%	26.0%	15.0%	6.0%	91.0%	53.0%	19.0%	2.0%	--	--	--	--
Today EWA	72.0%	27.0%	14.0%	8.0%	89.0%	57.0%	19.0%	2.0%	--	--	--	--
	Jan				**Feb**				**Mar**			
Degrees F	**54**	**56**	**58**	**60**	**54**	**56**	**58**	**60**	**54**	**56**	**58**	**60**
D1485 (1991)	--	--	--	--	3.0%	--	--	--	47.0%	11.0%	3.0%	1.0%
D1485 (1992)	--	--	--	--	3.0%	--	--	--	47.0%	10.0%	3.0%	1.0%
D1485 (1993)	--	--	--	--	3.0%	--	--	--	47.0%	10.0%	3.0%	1.0%
D1641 (1994)	--	--	--	--	2.0%	--	--	--	43.0%	9.0%	2.0%	1.0%
D1641 (1997)	--	--	--	--	3.0%	--	--	--	38.0%	8.0%	2.0%	--
Today EWA	--	--	--	--	2.0%	--	--	--	38.0%	8.0%	2.0%	--
	Apr				**May**				**Jun**			
Degrees F	**56**	**60**	**62**	**65**	**62**	**65**	**68**	**70**	**62**	**65**	**68**	**70**
D1485 (1991)	72.0%	20.0%	11.0%	--	48.0%	19.0%	6.0%	--	--	65.0%	23.0%	2.0%
D1485 (1992)	72.0%	20.0%	10.0%	--	48.0%	19.0%	6.0%	--	--	65.0%	24.0%	2.0%
D1485 (1993)	72.0%	20.0%	11.0%	--	47.0%	19.0%	6.0%	--	--	65.0%	21.0%	2.0%
D1641 (1994)	71.0%	19.0%	9.0%	--	49.0%	17.0%	6.0%	--	--	64.0%	13.0%	2.0%
D1641 (1997)	72.0%	20.0%	10.0%	--	47.0%	16.0%	5.0%	1.0%	--	65.0%	22.0%	7.0%
Today EWA	74.0%	22.0%	10.0%	--	47.0%	16.0%	5.0%	1.0%	--	65.0%	20.0%	7.0%
	Jul				**Aug**				**Sep**			

Table 7-14 Monthly Temperature Exceedance Levels at Watt Avenue

Degrees F	65	68	70	72	65	68	70	72	65	68	70	72
D1485 (1991)	--	26.0%	9.0%	2.0%	--	51.0%	26.0%	6.0%	91.0%	46.0%	16.0%	3.0%
D1485 (1992)	--	24.0%	7.0%	2.0%	--	48.0%	23.0%	7.0%	93.0%	41.0%	15.0%	1.0%
D1485 (1993)	--	26.0%	9.0%	2.0%	--	48.0%	22.0%	5.0%	93.0%	44.0%	15.0%	2.0%
D1641 (1994)	--	33.0%	8.0%	2.0%	--	64.0%	29.0%	8.0%	93.0%	34.0%	7.0%	0.0%
D1641 (1997)	--	36.0%	14.0%	5.0%	--	58.0%	30.0%	12.0%	93.0%	26.0%	11.0%	0.0%
Today EWA	--	30.0%	11.0%	5.0%	--	50.0%	26.0%	13.0%	93.0%	30.0%	7.0%	--

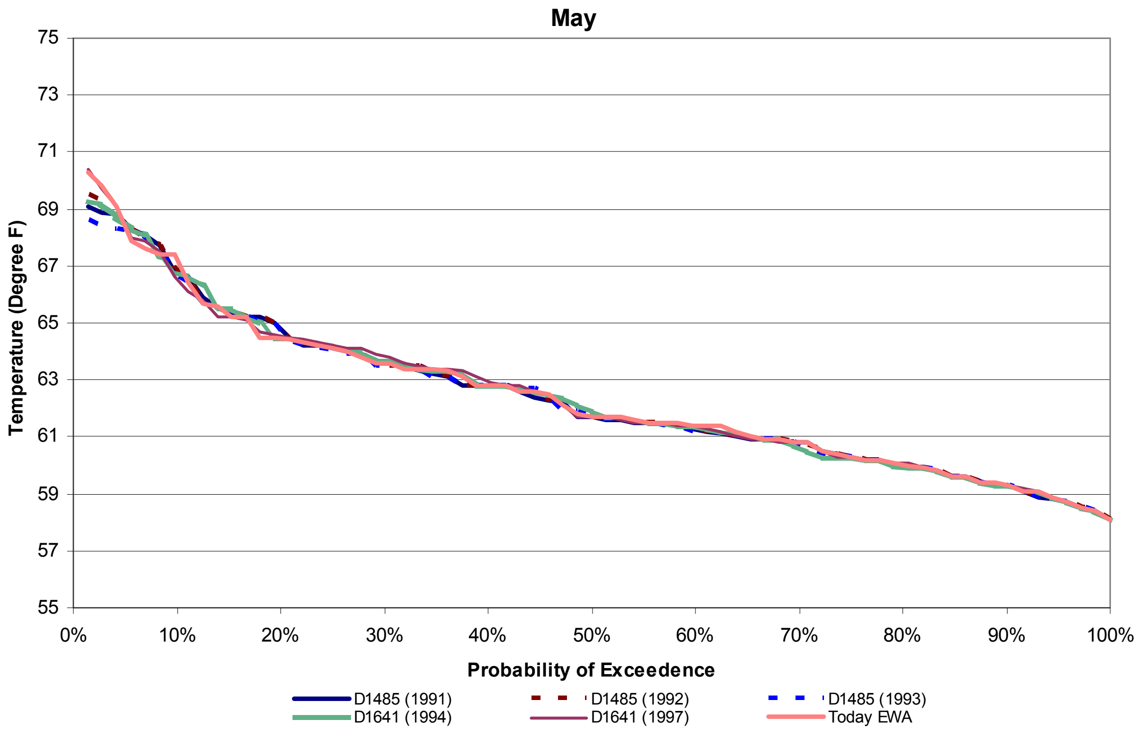

Figure 7-32 May Temperature Exceedance Chart at Watt Ave

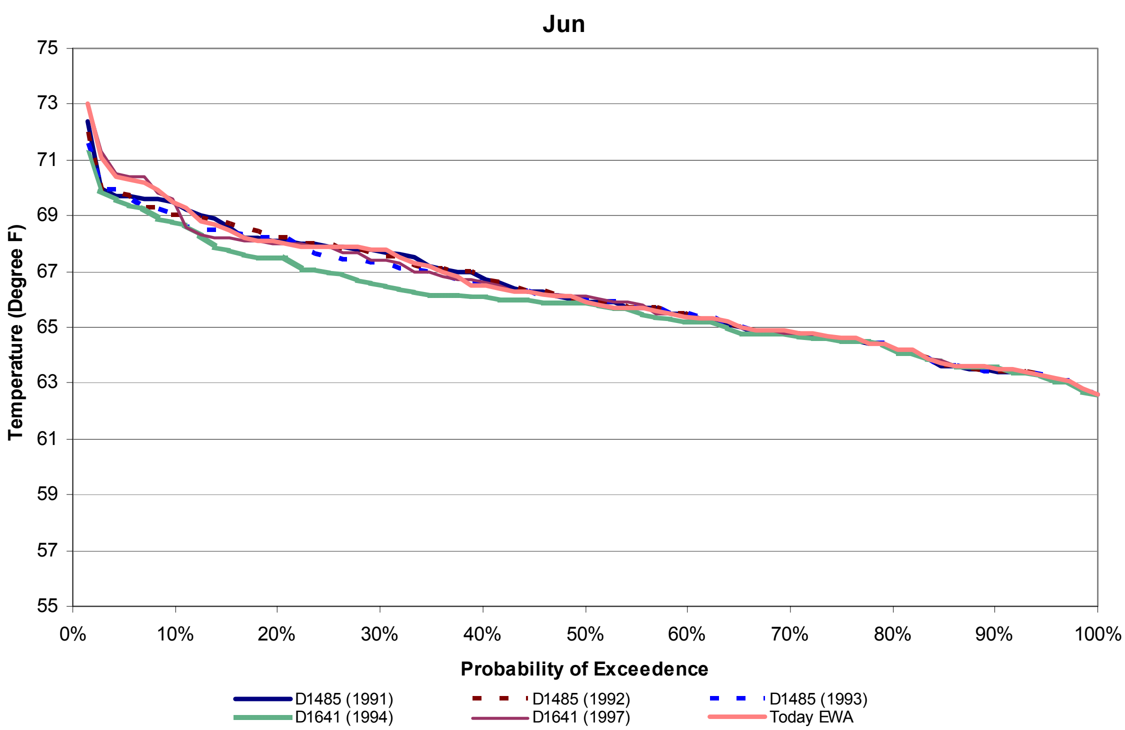

Figure 7-33 June Temperature Exceedance Chart at Watt Ave

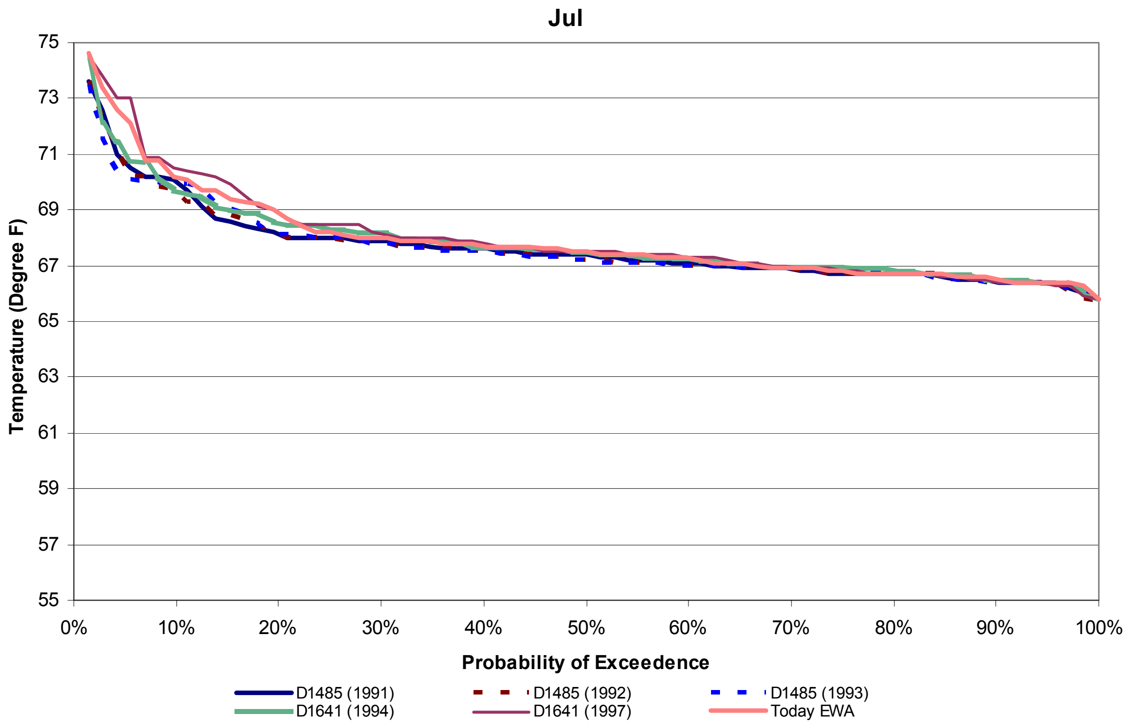

Figure 7-34 July Temperature Exceedance Chart at Watt Ave

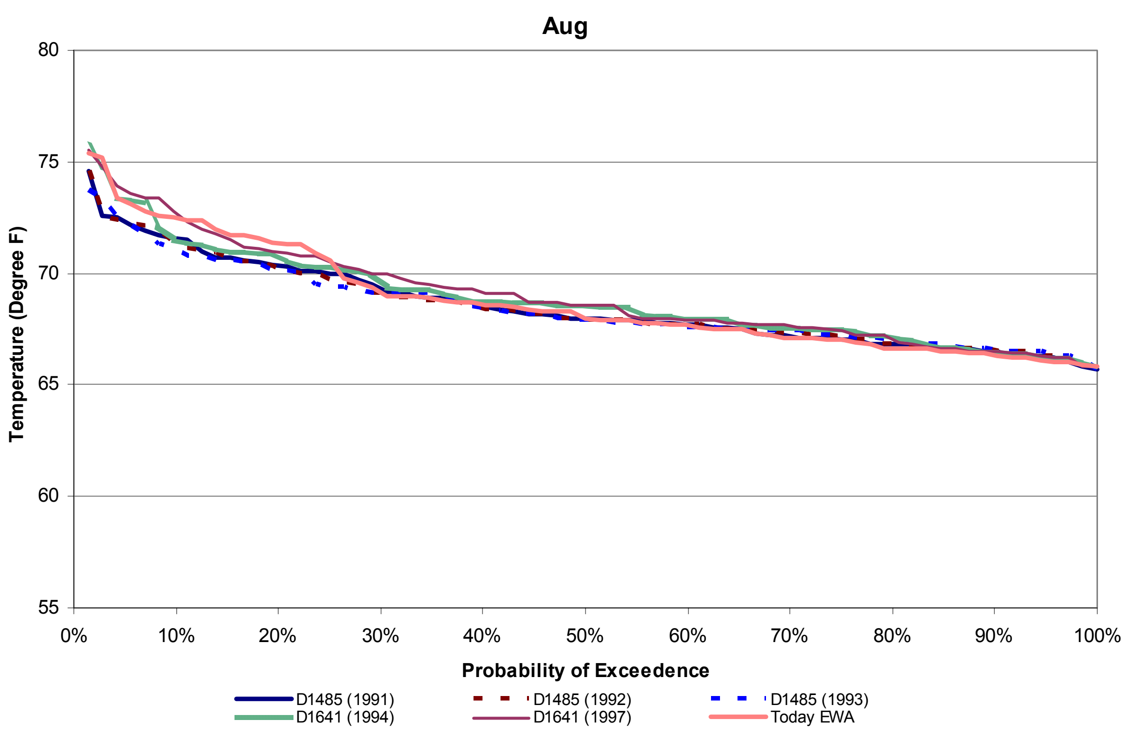

Figure 7-35 August Temperature Exceedance Chart at Watt Ave

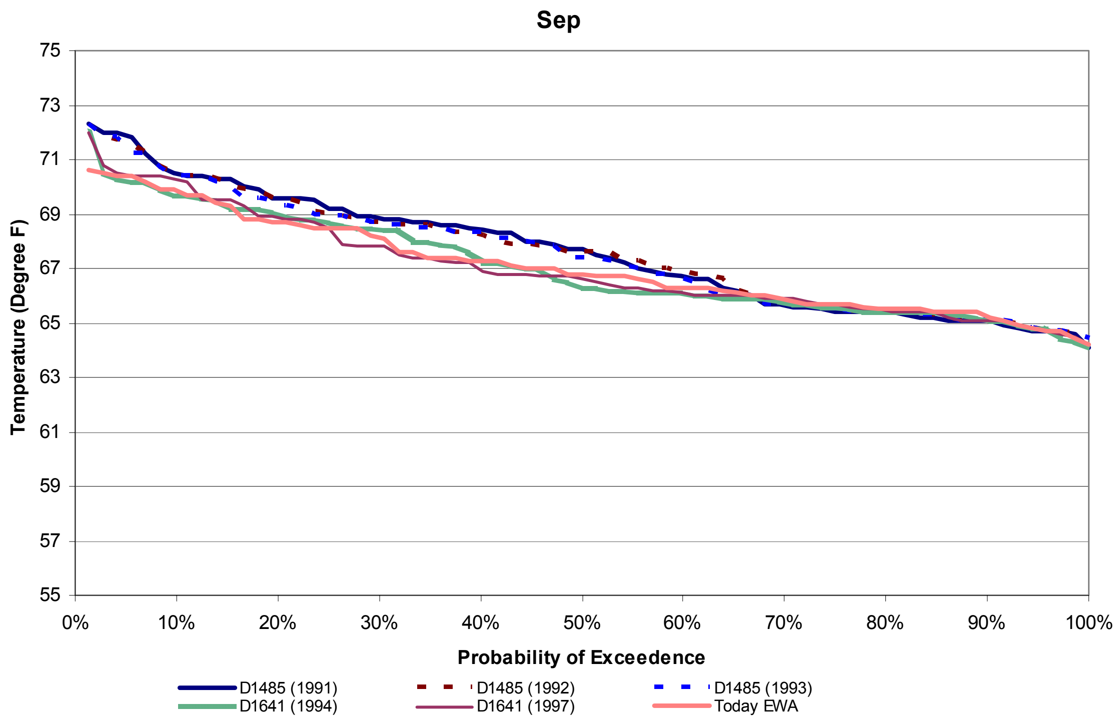

Figure 7-36 September Temperature Exceedance Chart at Watt Ave

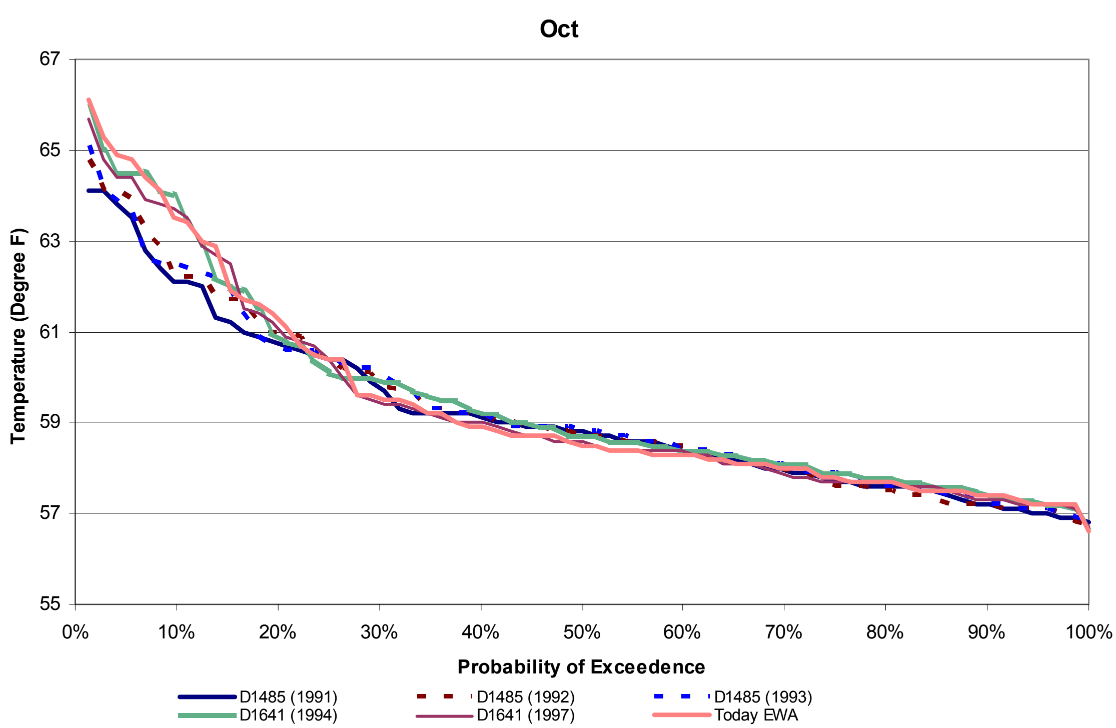

Figure 7-37 October Temperature Exceedance Chart at Watt Ave

Stanislaus River

The operations on the Stanislaus River change the most when the flow requirements increase from the D1485 studies to the D1641 (1994), D1641 (1997), and the Today EWA run. The flow requirements increase most in Studies D, 1 and 3 during April and May for the pulse flows, and in October for the fish attraction flows (see Figure 7-41 for percentiles of Goodwin releases). The impact to New Melones storage can be seen on Figure 7-38, Figure 7-39, and Figure 7-40 for the end-of-May and end-of-September storages. The long-term average end-of-September storage decreases by about 190 taf, and the 1928 to 1934 drought period shows a decrease of up to 296 taf, on average, in Studies D, 1 and 3 when compared to Study A.

Table 7-15 Long-term Average and 28 –34 Average Differences of New Melones End-of-September Storage and Goodwin Releases

Long-term Average	Study A	B - A	C - A	D - A	1 - A	3 - A
New Melones EOS (TAF)	1578	3	3	-192	-188	-189
Goodwin Release (cfs)	556	0	0	49	49	48
28-34 Average						
New Melones EOS (TAF)	1201	2	2	-296	-291	-235
Goodwin Release (cfs)	271	-1	-1	42	41	40

The increase in flow requirements causes the temperatures at Orange Blossom to decrease in the months of April to October but are higher the rest of the months (see Table 7-16 for monthly temperature exceedance levels at Orange Blossom).

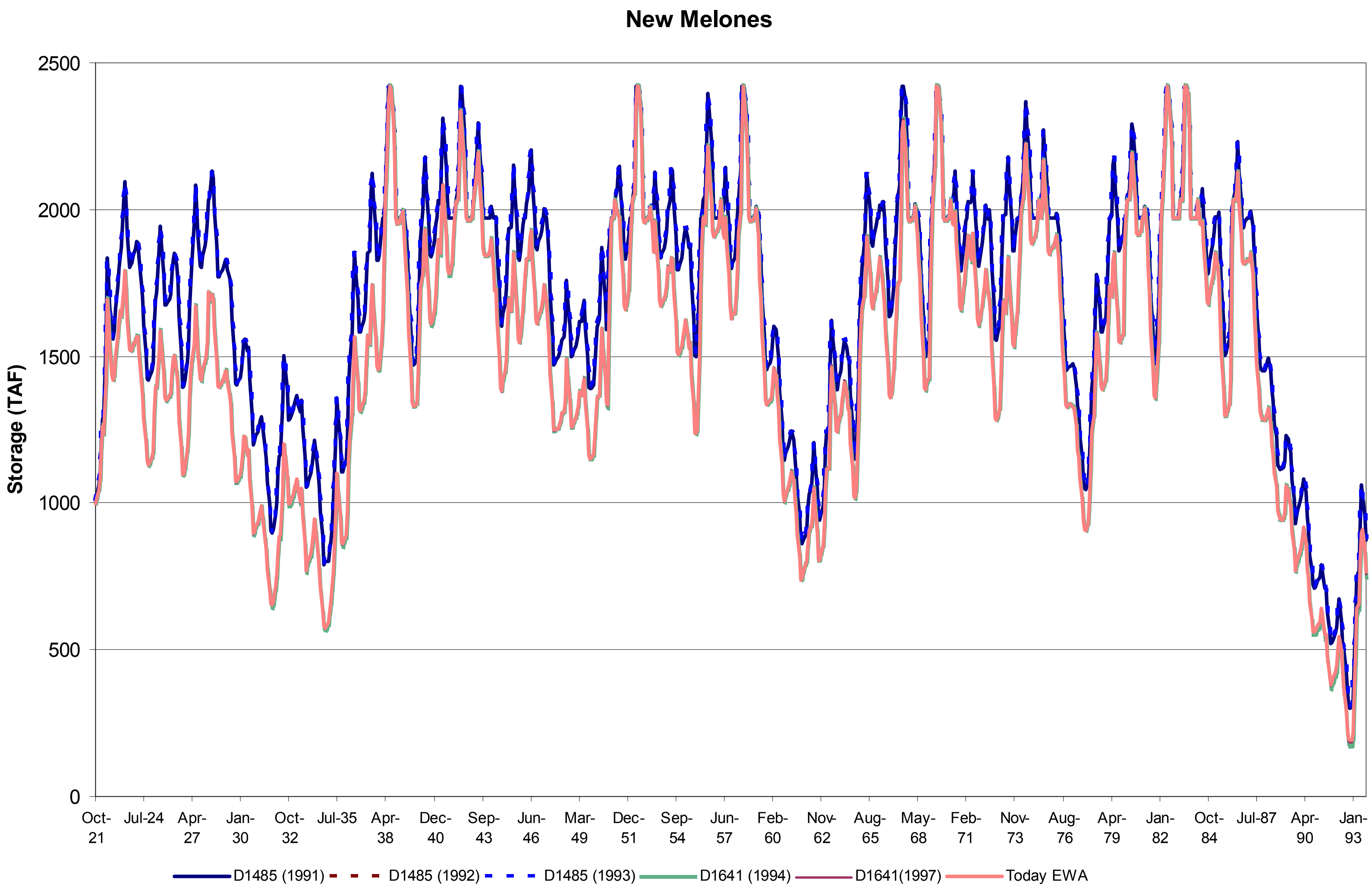

Figure 7-38 New Melones Storage Chronology

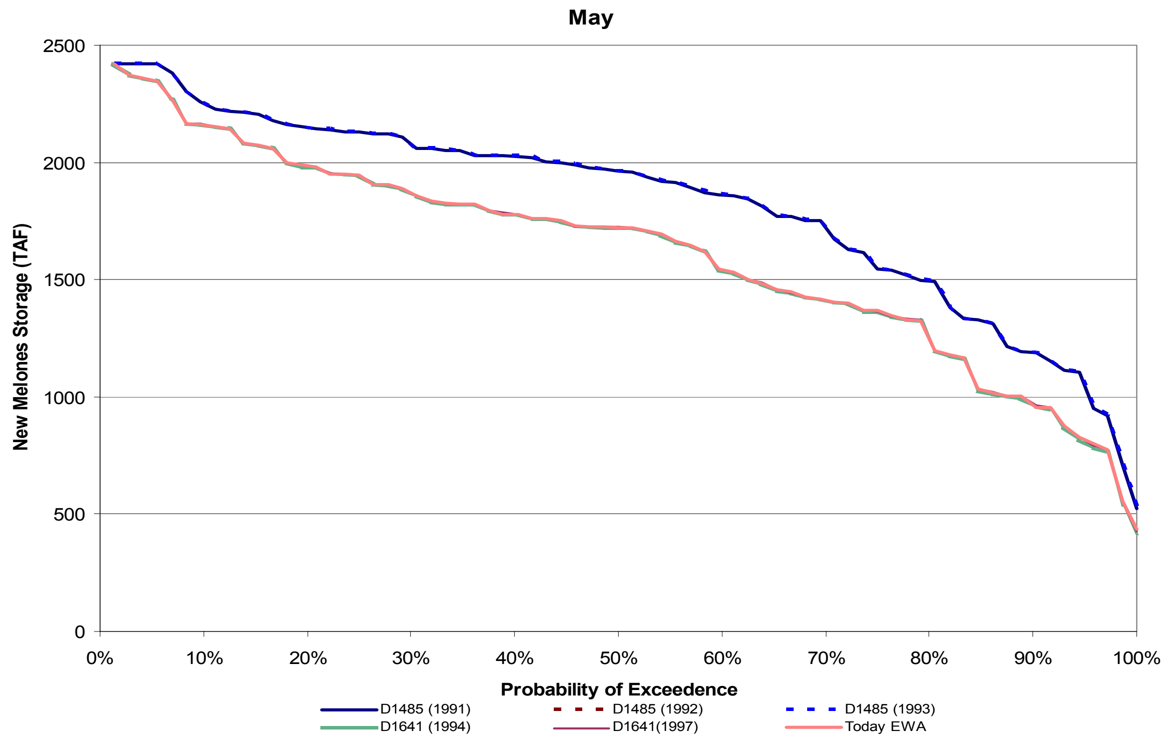

Figure 7-39 New Melones End of May Exceedance Chart

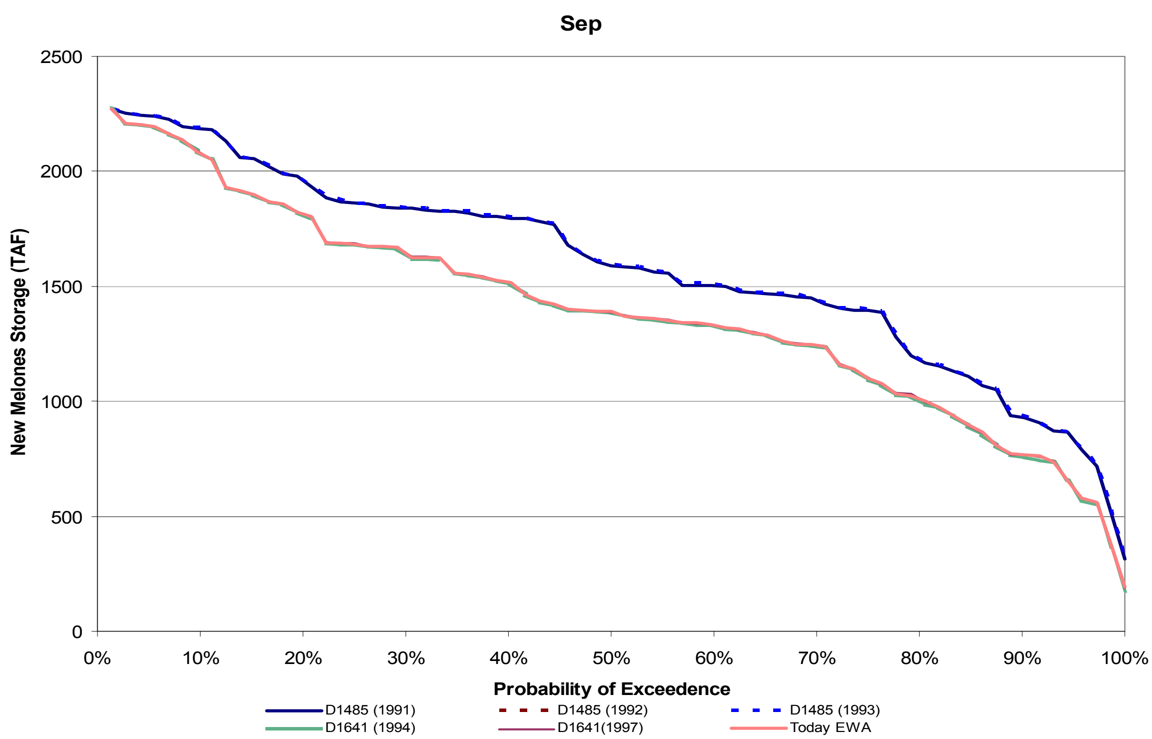

Figure 7-40 New Melones End of September Exceedance Chart

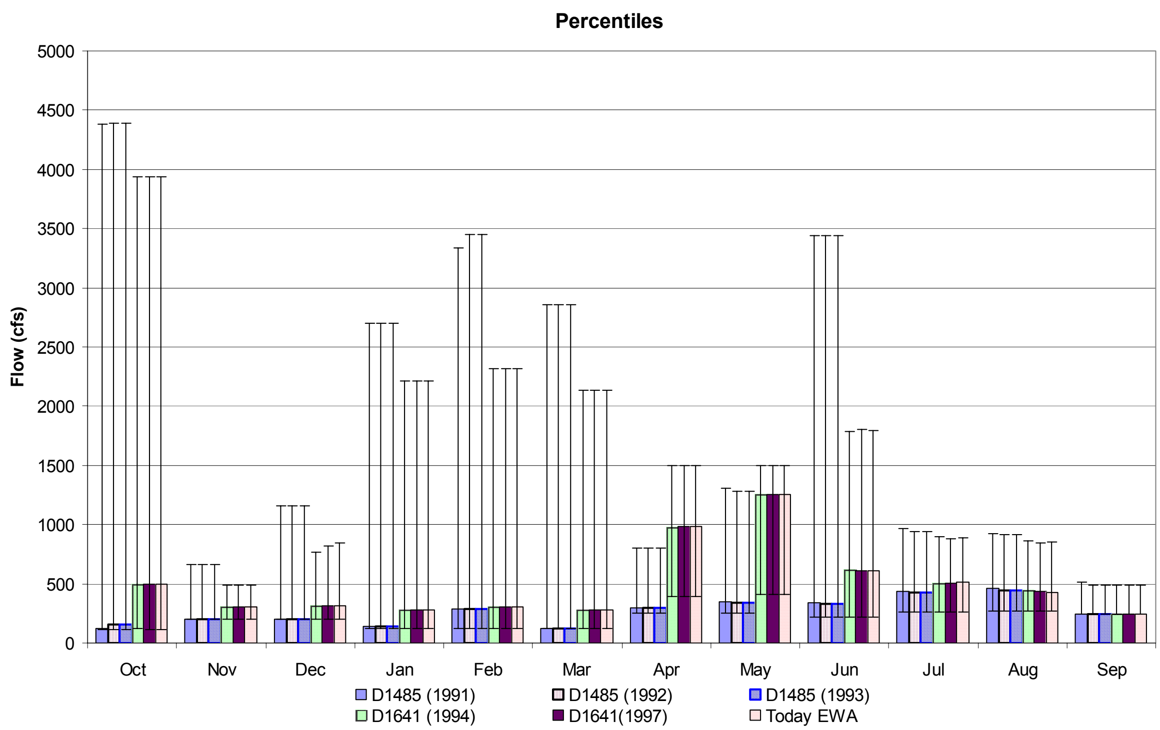

Figure 7-41 Percentiles of Goodwin Monthly Releases; the bars represent the 50th percentile with the whiskers as the 5th and 95th percentile

Table 7-16 Monthly Temperature Exceedance Levels at Orange Blossom

	Oct				Nov				Dec			
Degrees F	**54**	**56**	**60**	**62**	**52**	**54**	**56**	**57**	**47**	**49**	**51**	**52**
D1485 (1991)	96.0%	85.0%	13.0%	3.0%	99.0%	77.0%	16.0%	6.0%	96.0%	72.0%	18.0%	5.0%
D1485 (1992)	96.0%	85.0%	11.0%	3.0%	99.0%	77.0%	16.0%	6.0%	96.0%	72.0%	18.0%	5.0%
D1485 (1993)	96.0%	85.0%	12.0%	3.0%	99.0%	77.0%	16.0%	6.0%	96.0%	72.0%	18.0%	5.0%
D1641 (1994)	95.0%	84.0%	9.0%	4.0%	99.0%	81.0%	20.0%	8.0%	100.0%	78.0%	26.0%	8.0%
D1641 (1997)	95.0%	84.0%	9.0%	4.0%	99.0%	81.0%	20.0%	8.0%	100.0%	78.0%	26.0%	8.0%
Today EWA	95.0%	84.0%	8.0%	4.0%	99.0%	81.0%	22.0%	8.0%	99.0%	79.0%	26.0%	8.0%
	Jan				**Feb**				**Mar**			
Degrees F	**42**	**46**	**50**	**51**	**46**	**48**	**50**	**52**	**48**	**52**	**54**	**57**
D1485 (1991)	99.0%	74.0%	5.0%	2.0%	97.0%	74.0%	33.0%	13.0%	93.0%	58.0%	26.0%	5.0%
D1485 (1992)	99.0%	74.0%	5.0%	2.0%	97.0%	72.0%	33.0%	13.0%	93.0%	58.0%	26.0%	5.0%
D1485 (1993)	99.0%	74.0%	5.0%	2.0%	97.0%	72.0%	33.0%	13.0%	93.0%	58.0%	26.0%	5.0%
D1641 (1994)	99.0%	79.0%	7.0%	2.0%	98.0%	76.0%	34.0%	10.0%	98.0%	54.0%	15.0%	4.0%
D1641 (1997)	100.0%	79.0%	7.0%	2.0%	98.0%	76.0%	34.0%	10.0%	98.0%	54.0%	15.0%	4.0%
Today EWA	100.0%	79.0%	7.0%	2.0%	98.0%	76.0%	34.0%	10.0%	98.0%	54.0%	15.0%	4.0%

Table 7-16 Monthly Temperature Exceedance Levels at Orange Blossom

	Apr				May				Jun			
Degrees F	**49**	**52**	**55**	**57**	**52**	**55**	**58**	**60**	**53**	**55**	**60**	**64**
D1485 (1991)	--	83.0%	43.0%	15.0%	99.0%	71.0%	43.0%	6.0%	98.0%	92.0%	65.0%	3.0%
D1485 (1992)	--	82.0%	43.0%	15.0%	99.0%	71.0%	43.0%	6.0%	98.0%	92.0%	65.0%	3.0%
D1485 (1993)	--	83.0%	43.0%	15.0%	99.0%	71.0%	43.0%	6.0%	98.0%	92.0%	65.0%	3.0%
D1641 (1994)	98.0%	57.0%	15.0%	4.0%	89.0%	45.0%	7.0%	3.0%	97.0%	92.0%	48.0%	1.0%
D1641 (1997)	98.0%	57.0%	15.0%	4.0%	90.0%	45.0%	7.0%	3.0%	97.0%	92.0%	51.0%	1.0%
Today EWA	98.0%	57.0%	15.0%	4.0%	90.0%	45.0%	7.0%	3.0%	97.0%	92.0%	50.0%	1.0%
	Jul				**Aug**				**Sep**			
Degrees F	**57**	**60**	**61**	**63**	**56**	**58**	**60**	**65**	**57**	**58**	**60**	**63**
D1485 (1991)	95.0%	51.0%	34.0%	5.0%	99.0%	75.0%	38.0%	1.0%	98.0%	97.0%	53.0%	4.0%
D1485 (1992)	96.0%	54.0%	39.0%	5.0%	99.0%	77.0%	39.0%	1.0%	98.0%	97.0%	53.0%	4.0%
D1485 (1993)	95.0%	54.0%	37.0%	5.0%	99.0%	75.0%	39.0%	1.0%	98.0%	97.0%	53.0%	4.0%
D1641 (1994)	95.0%	47.0%	27.0%	5.0%	97.0%	84.0%	40.0%	2.0%	97.0%	91.0%	55.0%	5.0%
D1641 (1997)	95.0%	47.0%	31.0%	5.0%	97.0%	86.0%	43.0%	2.0%	97.0%	91.0%	54.0%	5.0%
Today EWA	95.0%	46.0%	30.0%	5.0%	97.0%	85.0%	43.0%	1.0%	97.0%	91.0%	54.0%	5.0%

North of Delta Deliveries

This section only covers NOD CVP deliveries and not deliveries to the SWP, which are displayed in the Delta and South of Delta Chapter. Figure 7-42 shows the chronology of total NOD CVP deliveries including deliveries to Settlement Contractors and Refuges. Most of the impacts to deliveries occur in the two long-term drought periods: 1928 to 1934 and 1987 to 1992. The CVP Agriculture and M&I contractors are the deliveries that are affected most from the increase in requirements and deliveries to the refuges. Figure 7-43 shows that the Agriculture allocation decreases from the D1485 (1991) study as the regulatory requirements increase, with the probability of reaching 100 percent allocations changing from 54 percent of the time to 47 percent of the time in the D1485 (1991) study and Today EWA study, respectively. The M&I allocations also drop in the frequency of 100 percent allocation, and the minimum allocation decreases from 60 percent to 50 percent between the D1485 (1991) study compared to the D1485 (1992), D1641 (1994), D1641 (1997), and the Today EWA studies. The averages for deliveries and allocations are shown in Table 8-4.

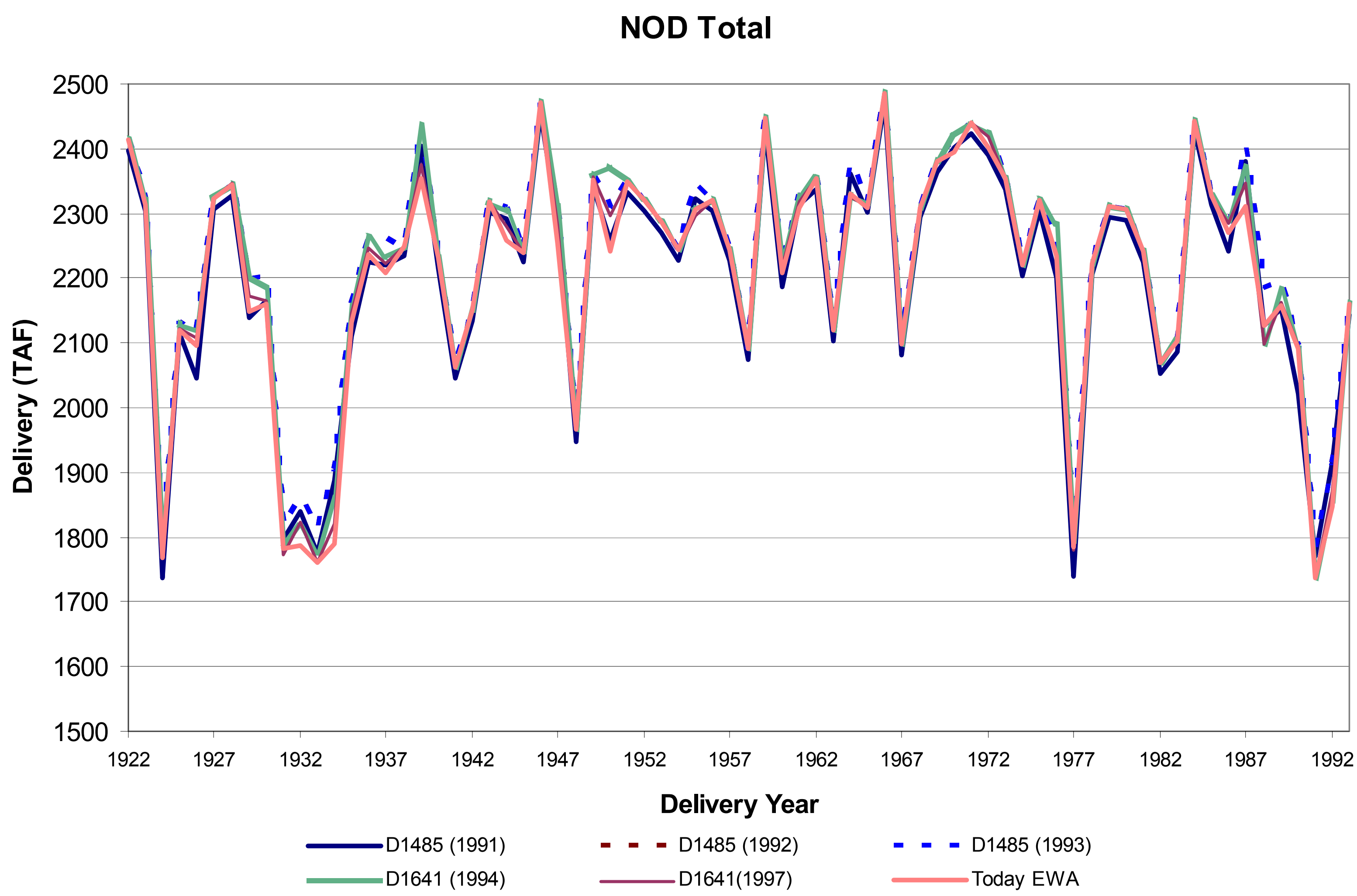

Figure 7-42 Chronology of Total North of Delta CVP Deliveries

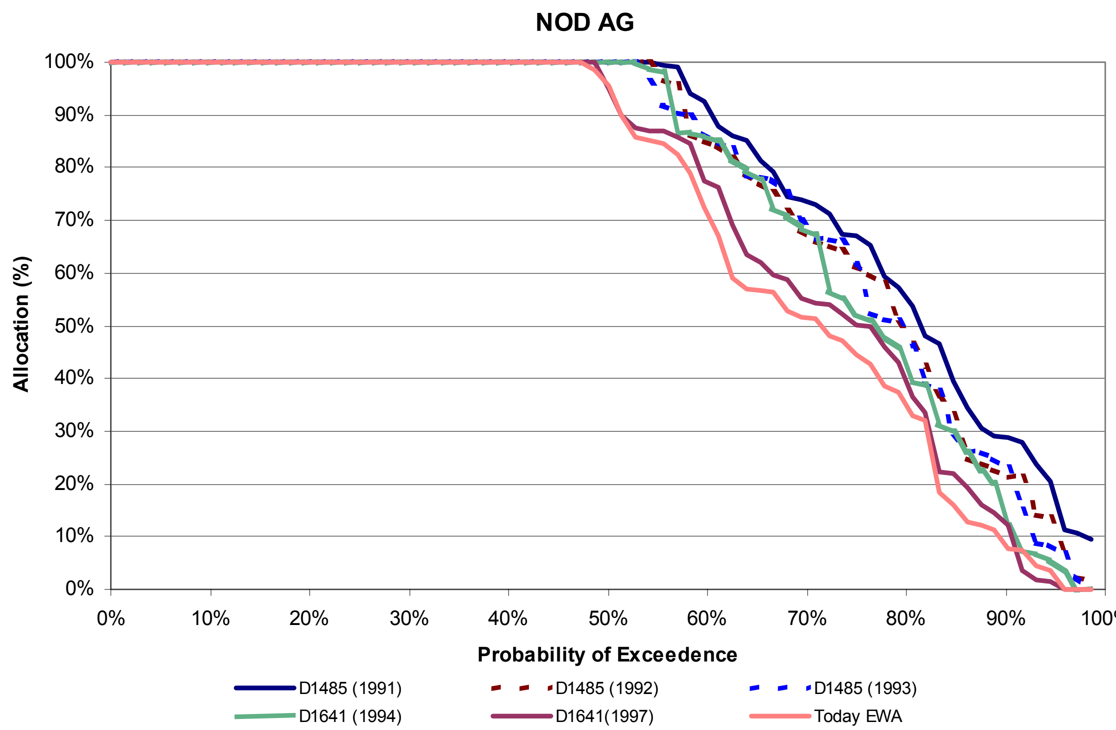

Figure 7-43 North of Delta CVP Agriculture Allocation Exceedance Chart

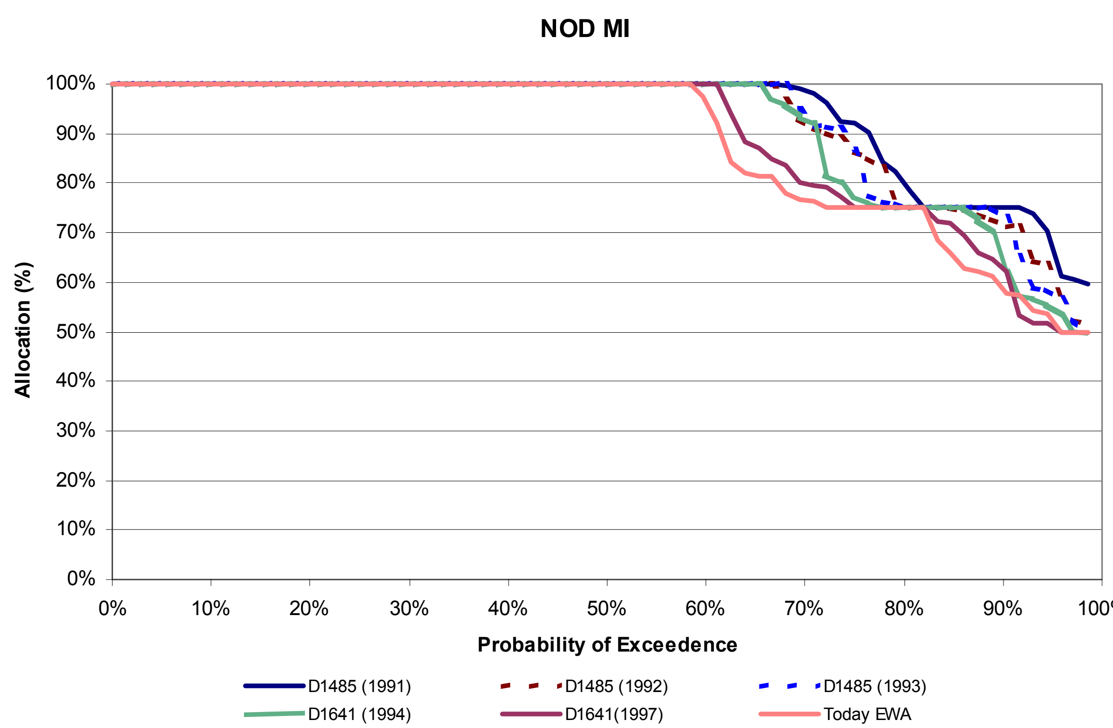

Figure 7-44 North of Delta CVP M&I Allocation Exceedance Chart

Conclusions

Following are conclusions derived from the modeling results on Upstream and North of Delta Effects in the six-study trend analysis:

- The Trinity River is affected most by the loss of storage from the increased flow requirements in the Today EWA study and causes higher temperatures from August to October. The increased Delta requirements also increase the late-summer to fall temperatures by pulling more water through Clear Creek and Spring Creek Tunnels into the Sacramento River System.
- The Sacramento River system experiences a jump in later summer temperatures and loss of Shasta Storage from the increased flows on the Trinity River, increased Delta requirements in the D1641 studies, 3406 b(2) increased flows, and Firm Level 2 refuge deliveries.
- The largest impact to Oroville is in Study D from the increase in Delta requirements from the D1641 decision.
- The storage in the American River system is affected by the increased releases from Nimbus in response to 3406 b(2). The increased flows decrease the amount of storage in Folsom at the end of May and increase late summer temperatures on the American River.
- The operations on the Stanislaus River change the most between the D1485 studies and the D1641 (1994), D1641 (1997), and the Today EWA run. The flow requirements increase most in Studies 1 and 3 during April and May for the pulse flows, and in October for the fish attraction flows.
- The Agriculture allocation decreases from the D1485 (1991) study as the regulatory requirements increase with the probability of reaching 100 percent allocations changing from 54 percent of the time to 47 percent of the time in the D1485 (1991) study and Today EWA study, respectively. The M&I allocations also drop in the frequency of 100 percent allocation, and the minimum allocation decreases from 60 percent to 50 percent between the D1485 (1991) study compared to the D1485 (1992), D1641 (1994), D1641 (1997), and the Today EWA studies.

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Chapter 8 Delta and South of Delta Effects

This chapter analyzes the effects to the Delta and South of Delta (SOD) Operations for the six OCAP runs with the D1485 scenario as the base study for comparison. The components that were analyzed are total Delta inflow, Delta outflow, Delta exports, Central Valley Project (CVP) and State Water Project (SWP) SOD deliveries, and changes in operations to filling and low point of San Luis Reservoir for the CVP and SWP.

Delta Inflow

Table 8-1 shows the long-term and water year type annual averages for total Delta inflow. The average inflow goes down in Studies B and C compared to Study A because of the increase from deliveries to refuges in the North of Delta (NOD). Studies D and 1 show an increase in Delta inflow over studies A, B, and C from increased outflow requirements in the D1641 simulations. Study 3 shows a decrease in inflow from a decrease in pumping caused by EWA pumping restrictions. The chronology of total Delta inflow is shown on Figure 8-1. Figure 8-2 shows the monthly percentiles of Delta Inflows.

Table 8-1 Annual Total Delta Inflow for Study A Long-term Average and by Water Year Type with Differences from the Other OCAP Studies

40-30-30 Index	Study A	B - A	C - A	D - A	1 - A	3 - A
Average	21058	-23	-21	36	42	-32
Wet	35030	-33	17	-131	-69	-224
Above Normal	24066	-86	-112	2	-70	-72
Below Normal	16686	4	-17	202	232	102
Dry	12979	-21	-69	103	42	-33
Critical	8966	17	55	78	110	200

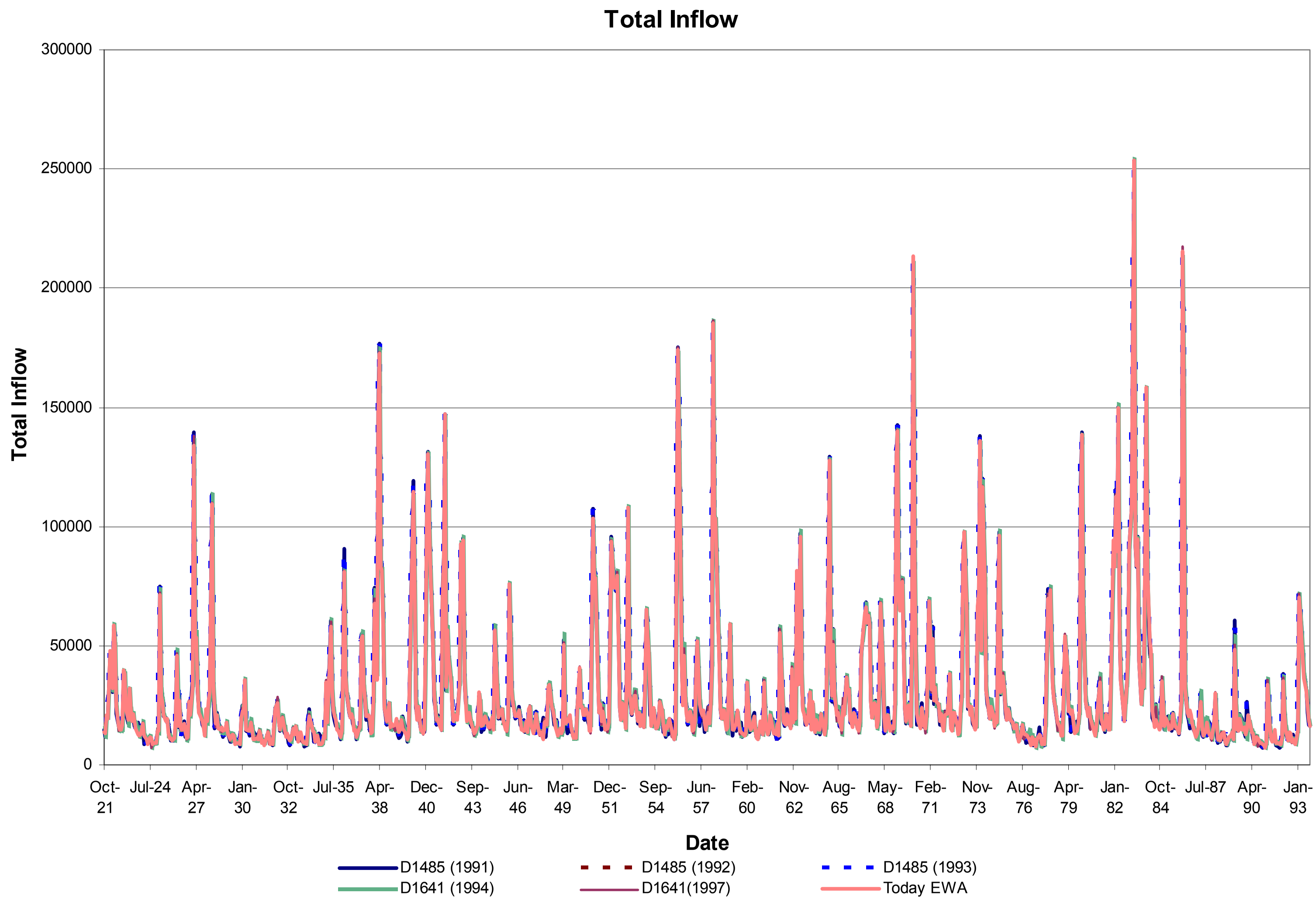

Figure 8-1 Chronology of Total Delta Inflow

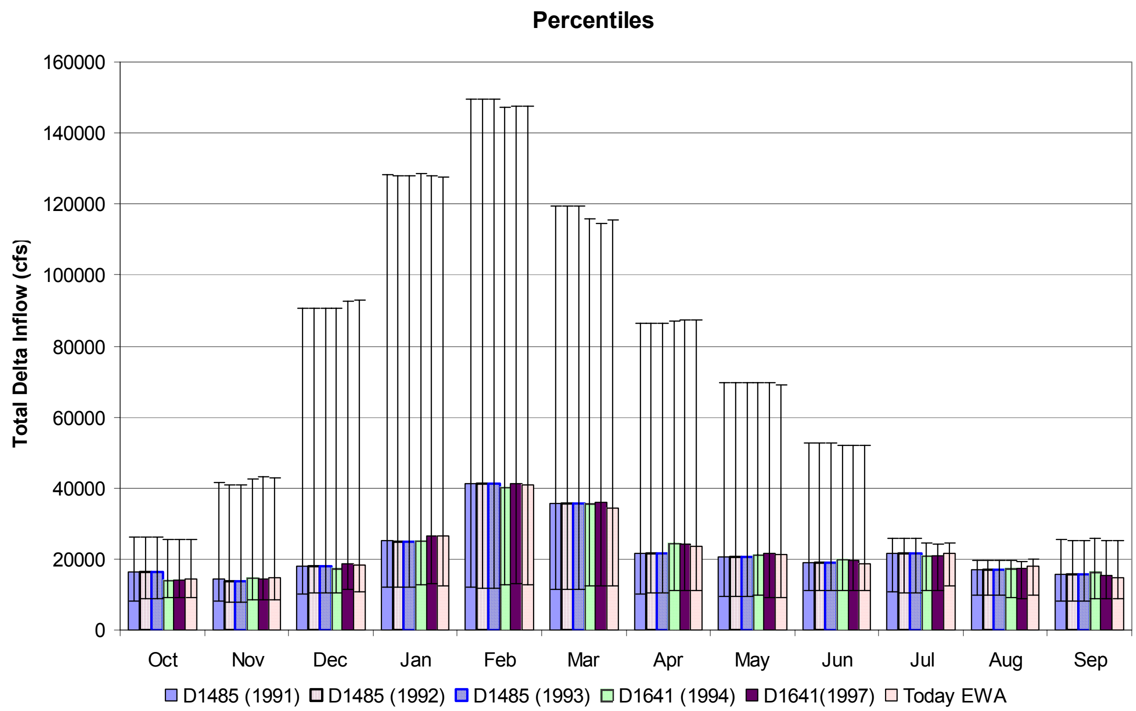

Figure 8-2 Percentiles of Total Delta Inflow; the bars represent the 50th percentile with the whiskers as the 5th and 95th percentile

Delta Outflow

Table 8-2 shows that the required Delta outflow increases significantly in Studies D, 1, and 3 because of increased D1641 outflow requirements. The increase in outflow requirements is more of a factor in Below Normal, Dry, and Critical years as seen in the Total Outflow numbers in the table. Decreases in total Delta outflow in the Wet and Above Normal years are because of decreases in storage going into fall and winter and causing less flood flows to reach the Delta.

Figure 8-3 shows the chronology of total Delta outflow. The chronology shows the peaks being capped off by Study A. Figure 8-4 and Figure 8-5 show the monthly percentiles for the required and total Delta outflows. Most of the increased requirements from the D1641 requirements in Studies D, 1, and 3 come in the months of January through April, as shown by the 50th percentile with the 95th percentiles continuing to be higher for the studies with D1641 requirements because of the X2 requirements when compared to the D1485 studies.

Table 8-2 Annual Long-term and Water Year Type Averages (taf) for Required and Total Delta Outflow Study A, With Differences from the Five Remaining OCAP Studies

40-30-30 Index	Study A	B - A	C - A	D - A	1 - A	3 - A
Required Outflow						
Average	4383	17	-2	1265	1188	1213
Wet	5412	9	-1	1479	1430	1402
Above Normal	4801	18	1	1871	1843	1857
Below Normal	4418	22	-30	1089	916	957
Dry	3744	25	-5	962	862	915
Critical	2922	15	31	970	949	1026
Total Outflow						
Average	14102	-80	-27	194	158	262
Wet	27525	-110	-64	-245	-248	-166
Above Normal	16575	-155	-88	-38	-46	159
Below Normal	9187	-58	-60	391	345	441
Dry	6103	-53	-23	481	388	521
Critical	4117	-23	132	574	542	565

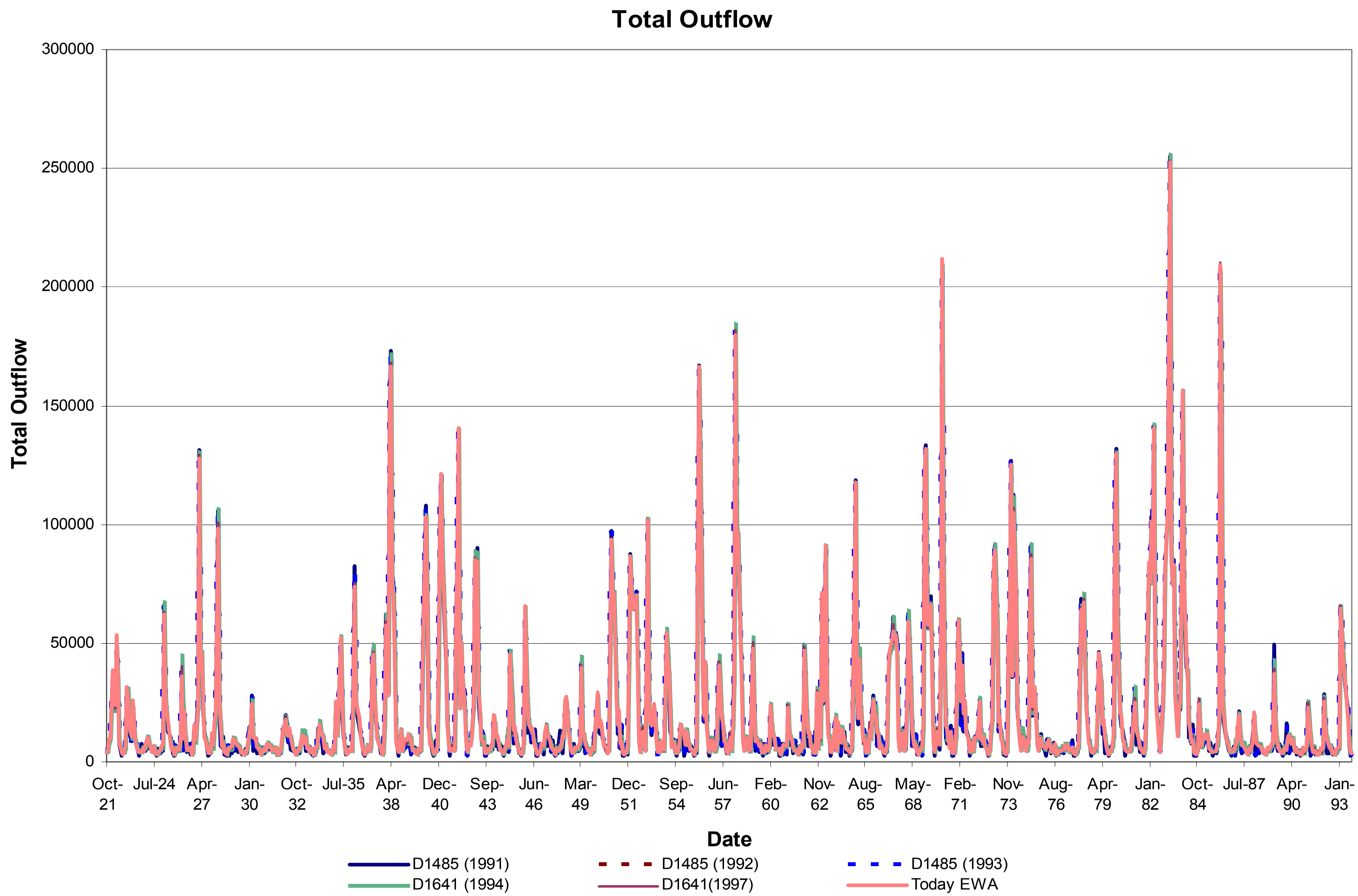

Figure 8-3 Chronology of Total Delta Outflow Requirements

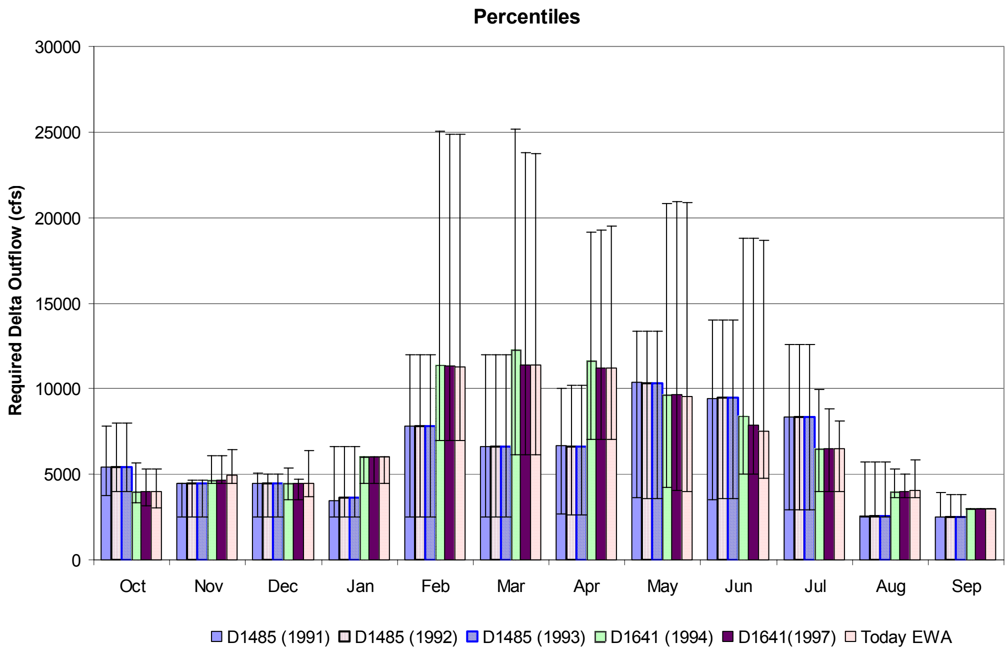

Figure 8-4 Percentiles of Required Delta Outflow; the bars represent the 50th percentile with the whiskers as the 5th and 95th percentile

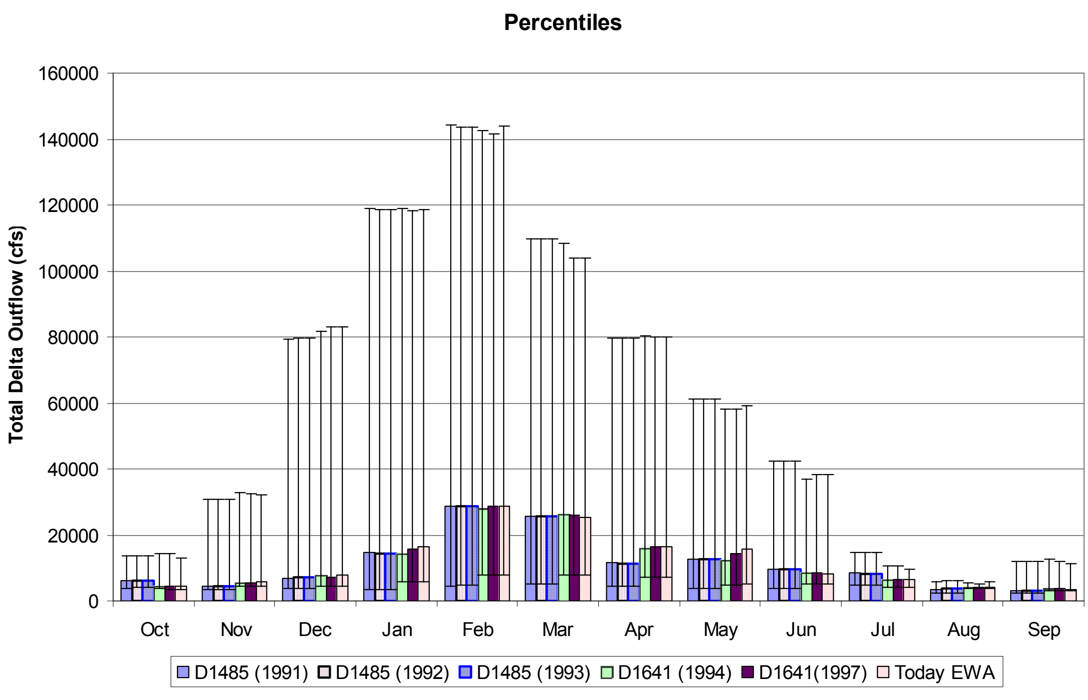

Figure 8-5 Percentiles of Total Delta Outflow; the bars represent the 50th percentile with the whiskers as the 5th and 95th percentile

Exports

This section examines exports from Tracy pumping, Federal Banks, and State Banks. Figure 8-6 shows the total annual pumping of Tracy and Banks combined in thousands of acre-feet (taf) for every water year of simulation.

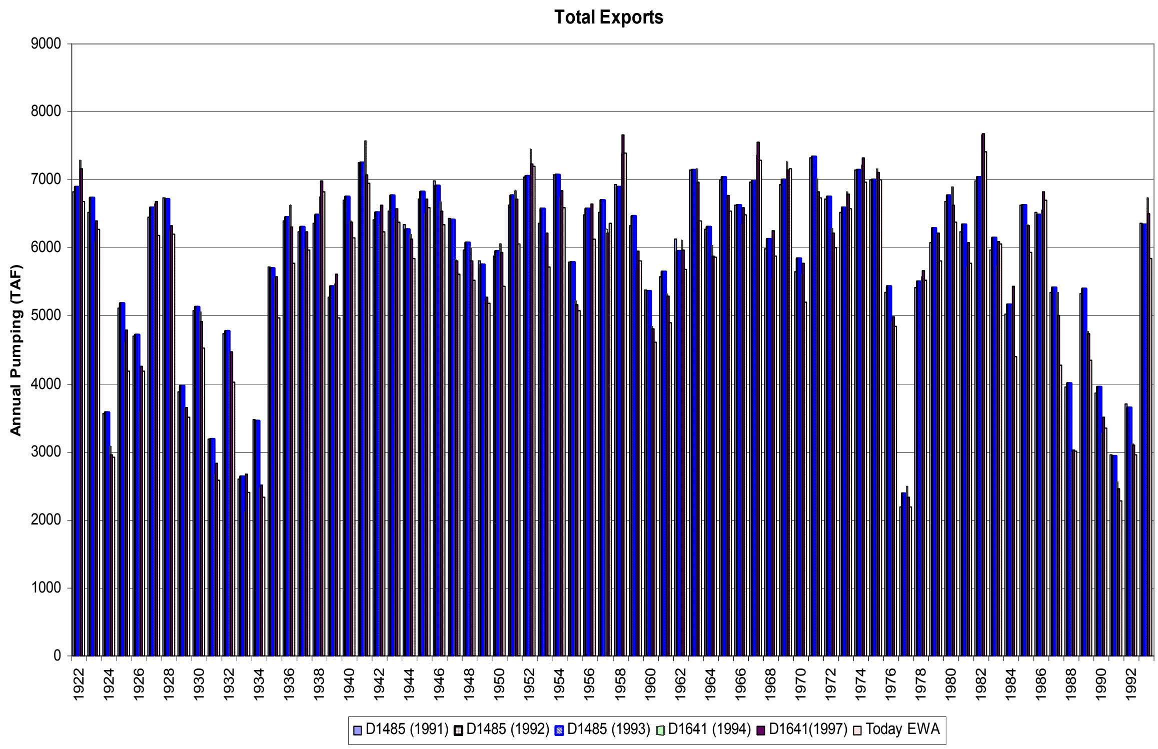

Figure 8-6 Chronology of Total Annual pumping at Banks and Tracy

Tracy Pumping

Table 8-3 shows the long-term and water year type average annual pumping at Tracy. In Table **8-3** and on Figure 8-7, Studies A, B, and C show the highest pumping rates, with decreases in annual pumping coming from Studies 1 and 3 as a result of 3406 b(2) cuts and EWA when compared to Study A. Study D has the higher pumping rates in Wet and Above Normal years because of the ability to pump above 3,000 cubic feet per second (cfs) in May and June (see Figure 8-8 for monthly percentile pumping).

Table 8-3 Annual Tracy Pumping (taf) for Study A and Differences Between Study A and the Remaining Five OCAP Studies

40-30-30 Index	Study A	B - A	C - A	D - A	1 - A	3 - A
Average	2550	61	67	61	-97	-235
Wet	2799	79	104	180	-69	-191
Above Normal	2771	61	27	134	-96	-199
Below Normal	2693	53	104	60	-73	-217
Dry	2557	48	62	-42	-143	-339
Critical	1680	58	-9	-78	-116	-223

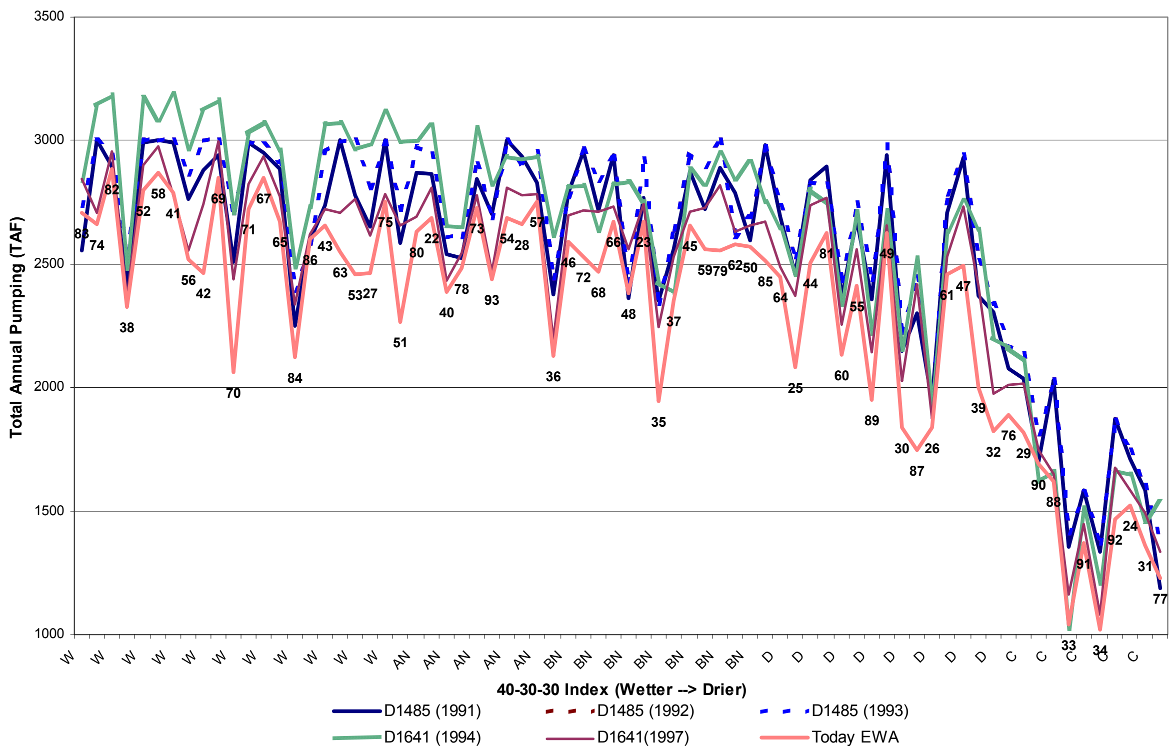

Figure 8-7 Annual Tracy Pumping Sorted by Water Year Type

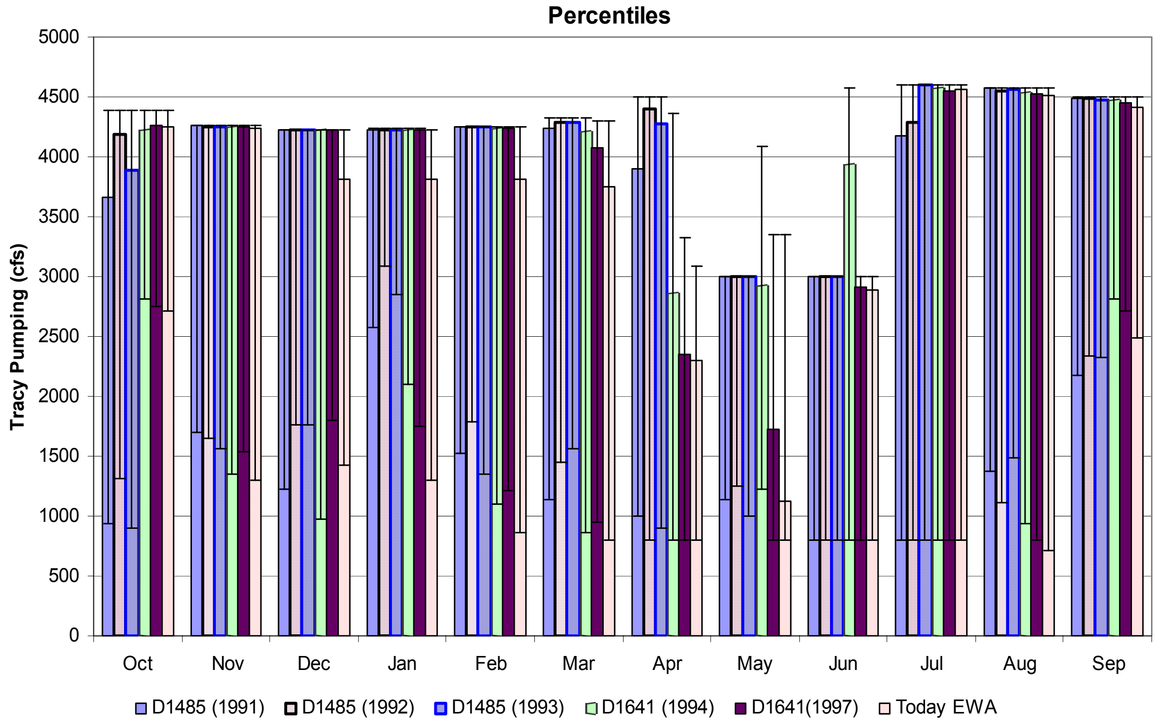

Figure 8-8 Monthly Percentiles of Tracy Pumping; the bars represent the 50th percentile with the whiskers as the 5th and 95th percentile

Federal Banks

The CVP is impacted most in Studies D and 1 from the loss of replacement pumping in the D1485 studies (see Table 8-4). Some of the loss is made up in Study 3 by JPOD wheeling from the EWA runs. Figure 8-9 shows the annual exceedance chart for Federal Banks pumping, which shows the same trend as described above.

Table 8-4 Annual Long-term and Water Year Type Federal Pumping at Banks

40-30-30 Index	Study A	B - A	C - A	D - A	1 - A	3 - A
Average	200	1	-1	-113	-121	-68
Wet	226	-3	-7	-151	-159	-75
Above Normal	240	30	27	-131	-140	-75
Below Normal	217	2	-8	-104	-112	-47
Dry	218	-10	-1	-114	-124	-99
Critical	66	-2	-7	-32	-39	-31

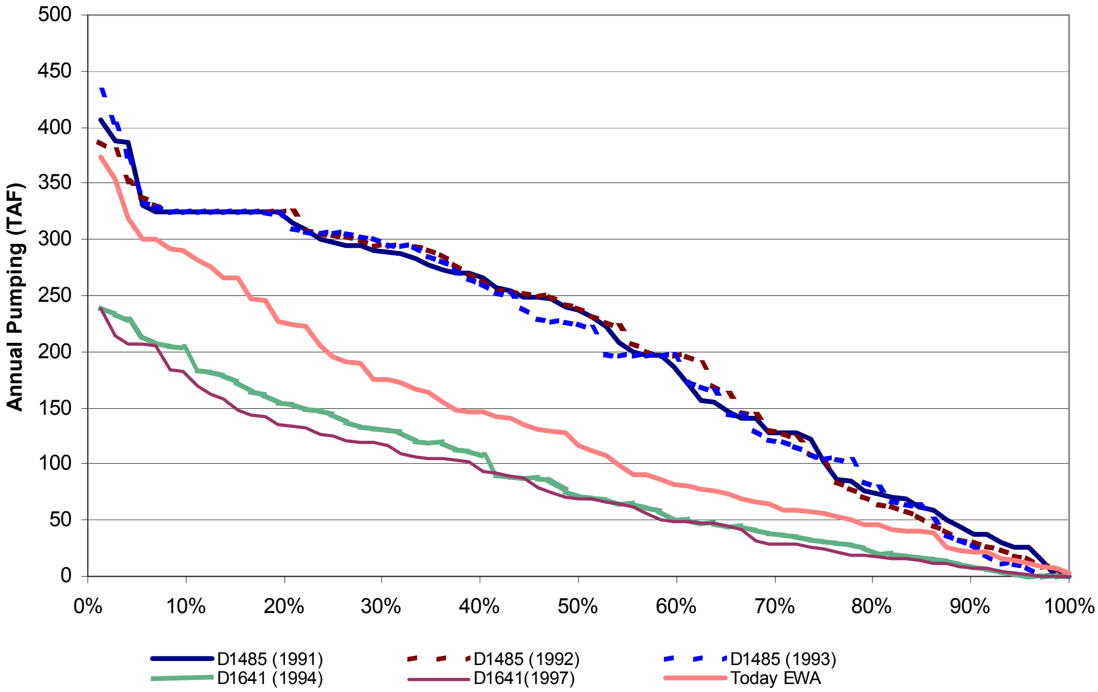

Figure 8-9 Annual Federal Banks Exceedance Chart

State Banks

Most of the impact to State Banks pumping occurs in the Dry and Critical years, as indicated by all six studies (see Table 8-5). In Table 8-5, Study C has a dropoff in average annual pumping in all water year types when compared to Study A. Studies 1 and 3 show increased pumping in the Wet years from increased availability of CVP water from 3406 b(2) upstream releases. Figure 8-10 shows the same trend as Table 8-5 but also gives a reference in the variability of pumping within water year types. Figure 8-11 shows the monthly percentile of State Banks pumping.

Table 8-5 Annual Long-term and Water Year Type State Pumping at Banks

40-30-30 Index	Study A	B – A	C - A	D - A	1 - A	3 - A
Average	3112	-5	-77	-105	103	-93
Wet	3616	1	-36	86	407	142
Above Normal	3534	-23	-94	37	212	-33
Below Normal	3398	8	-68	-144	72	-148
Dry	2855	-5	-120	-220	-77	-235
Critical	1778	-17	-88	-381	-274	-323

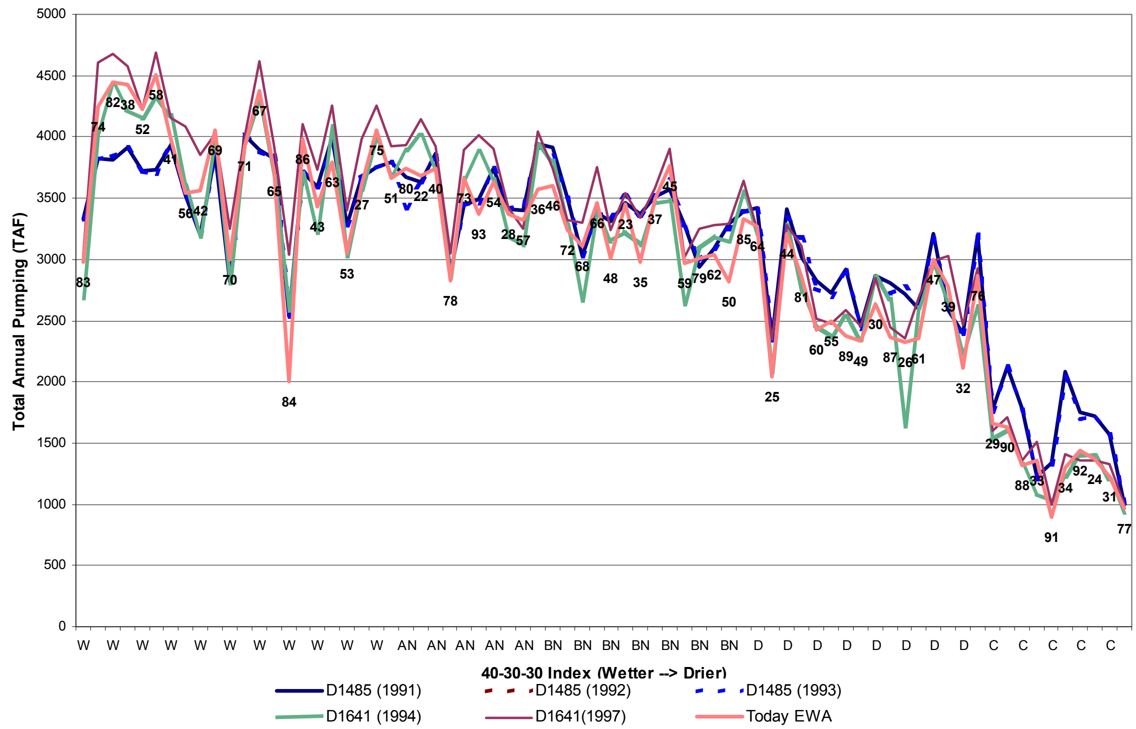

Figure 8-10 Annual State Banks Pumping Sorted by Water Year Type

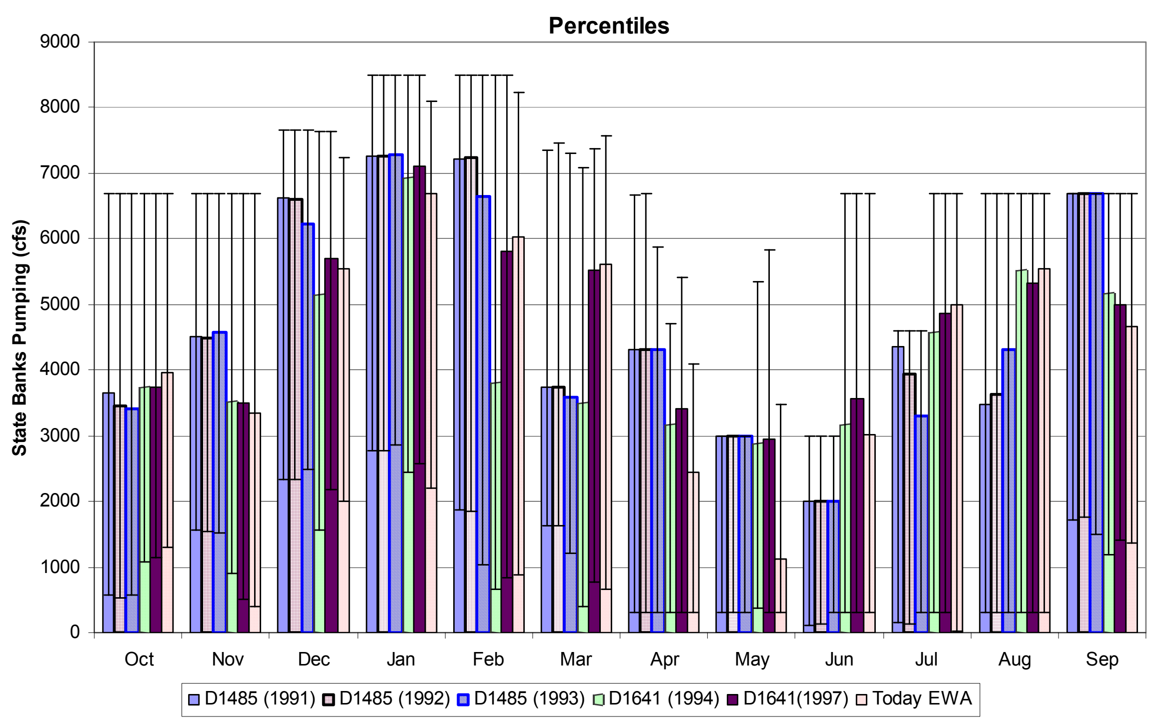

Figure 8-11 Monthly Percentiles of State Banks Pumping; the bars represent the 50th percentile with the whiskers as the 5th and 95th percentile

CVP San Luis

The impacts to the CVP portion of San Luis Reservoir filling can be seen in Table 8-6 and Table 8-7. Compared to the baseline D1485 (1991) refuge, deliveries in D1485 (1992) drop from filling in 31 of the 72 years of simulation to 23 years in the D1485 (1992) studies. The D1641 (1997) and Today EWA studies show that the frequency of filling increases relative to the D1485 (1992) study. In comparing the other five studies to the D1485 (1991) study, the average month that the reservoir fills gets pushed back toward March, and the average number of months that CVP San Luis can remain full is decreased.

Table 8-6 Number of Years Out of 72 CVP San Luis Filled, Average Month San Luis First Filled (using water years – i.e. 5 = February and 6 = March), and Average Number of Months CVP San Luis Remained Full

Study Name	Number of Years Filled	Average First Month of Fill	Average Number of Months Full
D1485 (1991)	31	5.3	2.5
D1485 (1992)	23	6.0	1.8
D1485 (1993)	24	5.9	2.0
D1641 (1994)	24	5.5	2.5
D1641 (1997)	27	5.6	2.0
Today EWA	30	5.5	1.7

Table 8-7 Percent of the Time Each Month that CVP San Luis was Full

	Jan	Feb	Mar	Apr	May
D1485 (1991)	13%	25%	35%	32%	3%
D1485 (1992)	4%	10%	17%	24%	3%
D1485 (1993)	6%	13%	17%	26%	3%
D1641 (1994)	10%	14%	22%	17%	14%
D1641(1997)	6%	13%	31%	15%	6%
Today EWA	4%	8%	31%	15%	7%

In all studies, the low point happened more frequently in August (Table 8-8). Some shifts did occur because of the Firm Refuge deliveries that started in the D1485 (1992) and D1485 (1993) studies. Figure 8-12 shows the exceedance chart for the low-point value of all 72 years of simulation.

Table 8-8 Percent of Times Low Point Occurred in July, August, or September

Study Name	July	Aug	Sep
D1485 (1991)	17%	78%	6%
D1485 (1992)	25%	68%	7%
D1485 (1993)	15%	78%	7%
D1641 (1994)	3%	94%	3%
D1641(1997)	3%	90%	7%
Today EWA	4%	83%	13%

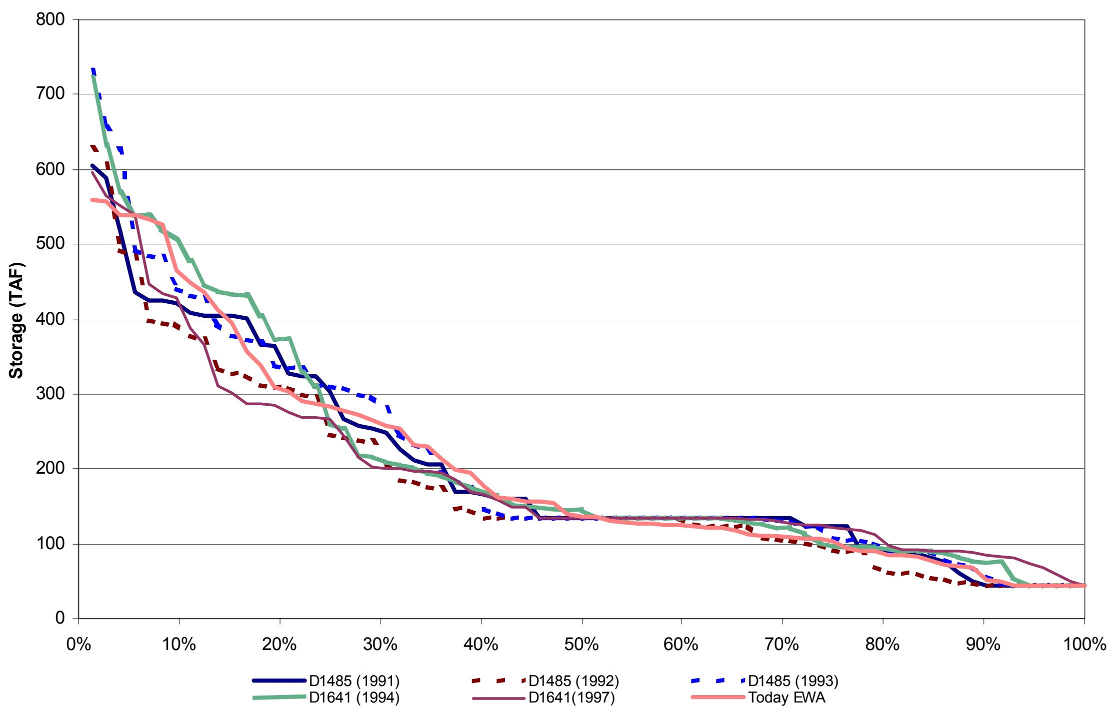

Figure 8-12 Exceedance of Annual Low Point for CVP San Luis from July – September

SWP San Luis

The frequency of SWP San Luis filling is greatest in Studies A, B, C, and 1 (see Table 8-9). Studies D, 1, and 3 show that filling occurs earlier than in the other three studies. The number of months that the SWP share stays full is greater in Studies D and 1, with the pumping restrictions in the Today EWA run causing a decrease in frequency, and average duration of being full dropping off when compared to the D1641 1994 and 1997 studies. Table 8-10 shows the percent that SWP San Luis was full each month.

Table 8-9 Number of Years Out of 72 SWP San Luis Filled, Average Month San Luis First Filled (using water years – i.e. 4 = January and 5 = February), and Average Number of Months SWP San Luis Remained Full

	Number of Years Filled	Average First Month of Fill	Average Number of Months Full
D1485 (1991)	54	5.2	2.6
D1485 (1992)	52	5.2	2.7
D1485 (1993)	55	5.1	2.7
D1641 (1994)	48	4.2	3.4
D1641(1997)	52	4.2	3.4
Today EWA	33	4.2	2.3

Table 8-10 Percent of the Time Each Month SWP San Luis Was Full

	Jan	Feb	Mar	Apr	May
D1485 (1991)	17%	38%	69%	60%	3%
D1485 (1992)	15%	38%	69%	57%	3%
D1485 (1993)	17%	47%	71%	58%	3%
D1641 (1994)	31%	50%	60%	31%	15%
D1641(1997)	31%	57%	67%	35%	14%
Today EWA	14%	14%	40%	6%	0%

Low point generally occurs most frequently in August for Studies A, B, and C. The D1641 studies and the Today EWA study have the low point occur more frequently in September. Figure 8-13 shows the exceedance of low-point values among the six studies.

Table 8-11 Percent of Times Low Point Occurred in July, August, or September

	July	Aug	Sep
D1485 (1991)	10%	69%	21%
D1485 (1992)	8%	67%	25%
D1485 (1993)	10%	69%	21%
D1641 (1994)	6%	44%	50%
D1641(1997)	4%	42%	54%
Today EWA	17%	42%	42%

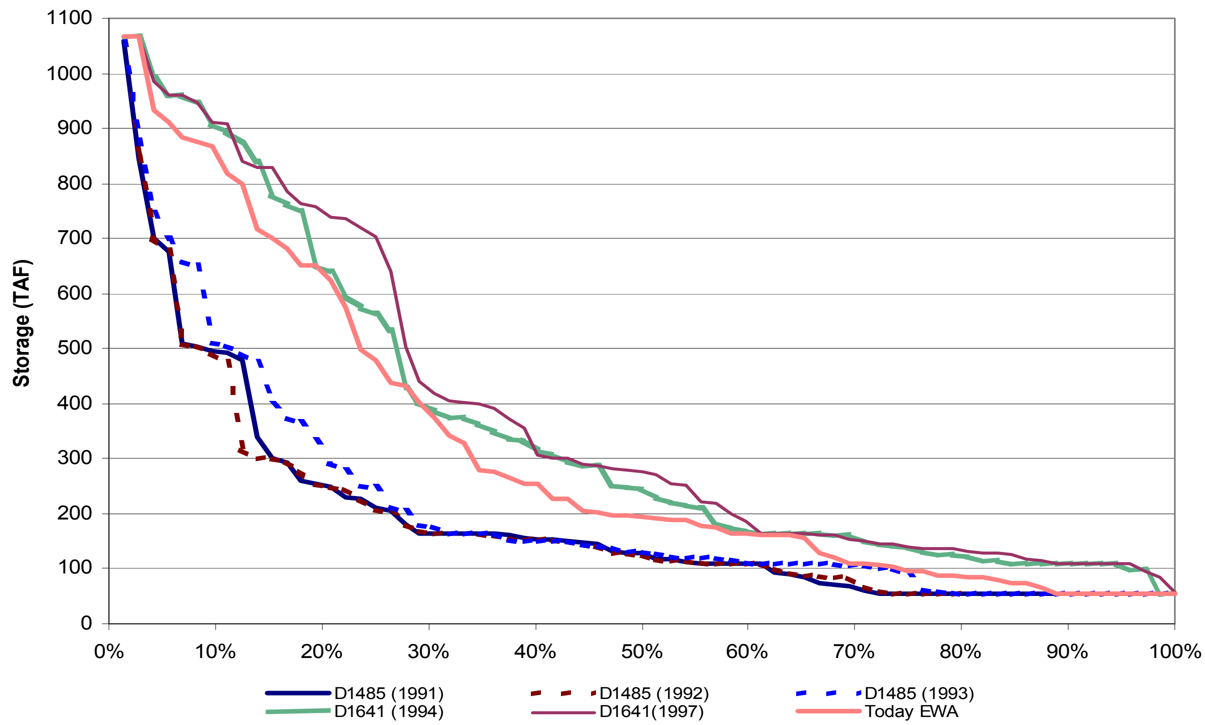

Figure 8-13 Exceedance Chart of Annual SWP San Luis Low Point in July – September

South of the Delta Deliveries

CVP

The chronology of total SOD CVP Deliveries is shown on Figure 8-14. The chronology shows that the Today EWA study generally delivers less water than the other five studies. The ability to deliver water in the drought periods also decreased in the D1641 (1994), D1641 (1997), and Today EWA studies when compared to the three D1485 studies.

Figure 8-15 and Figure 8-16 show the SOD Agricultural and Municipal and Industrial (M&I) allocations, respectively. From Study A to Study 3, the allocations get lower with each additional regulatory requirement.

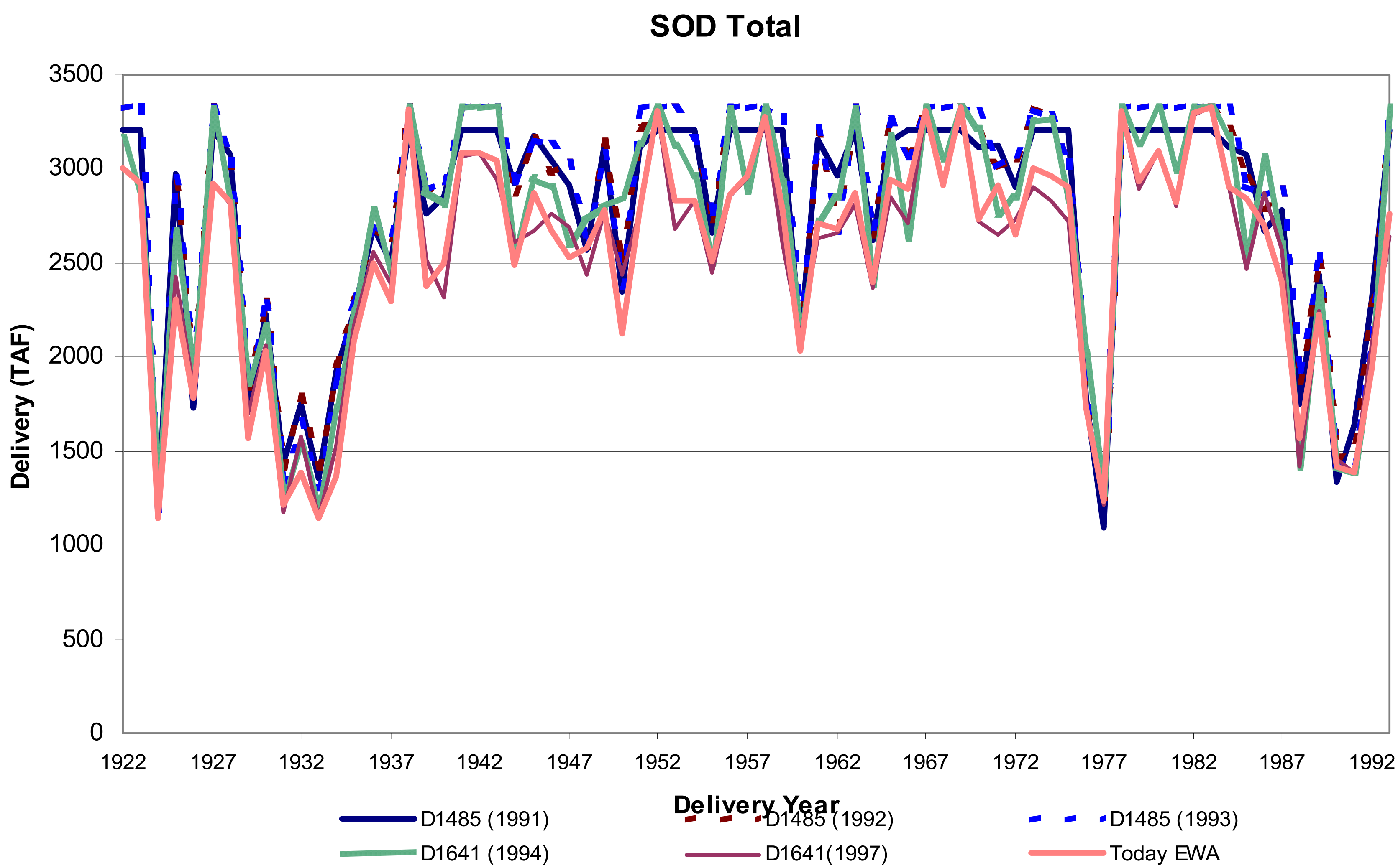

Figure 8-14 Chronology of Total SOD CVP Deliveries

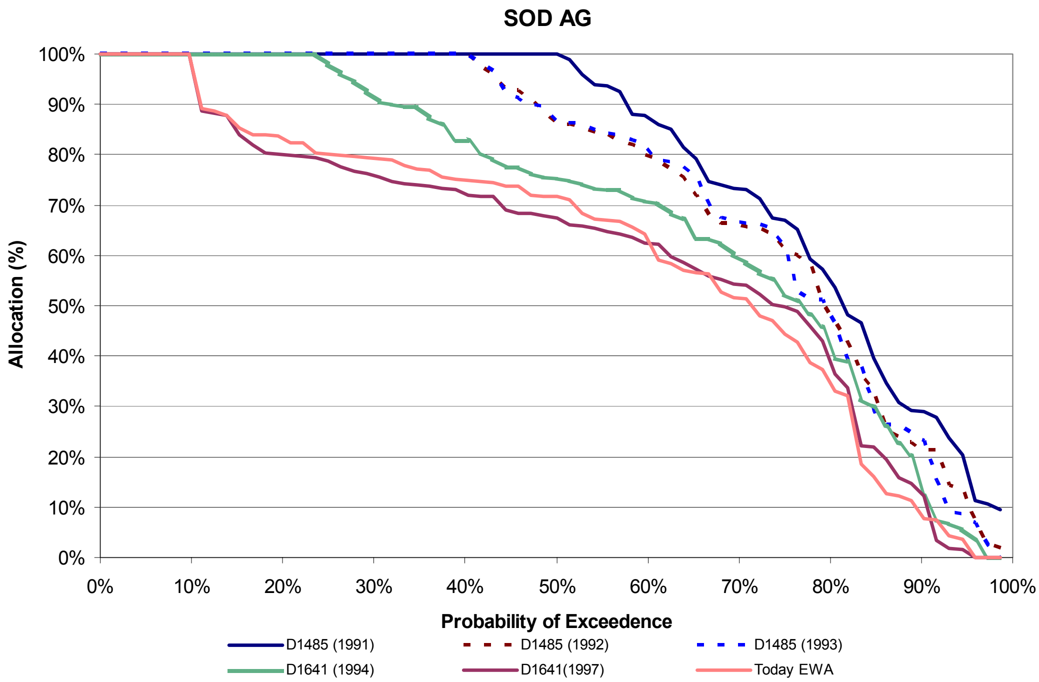

Figure 8-15 CVP SOD Agricultural Allocation Exceedance Chart

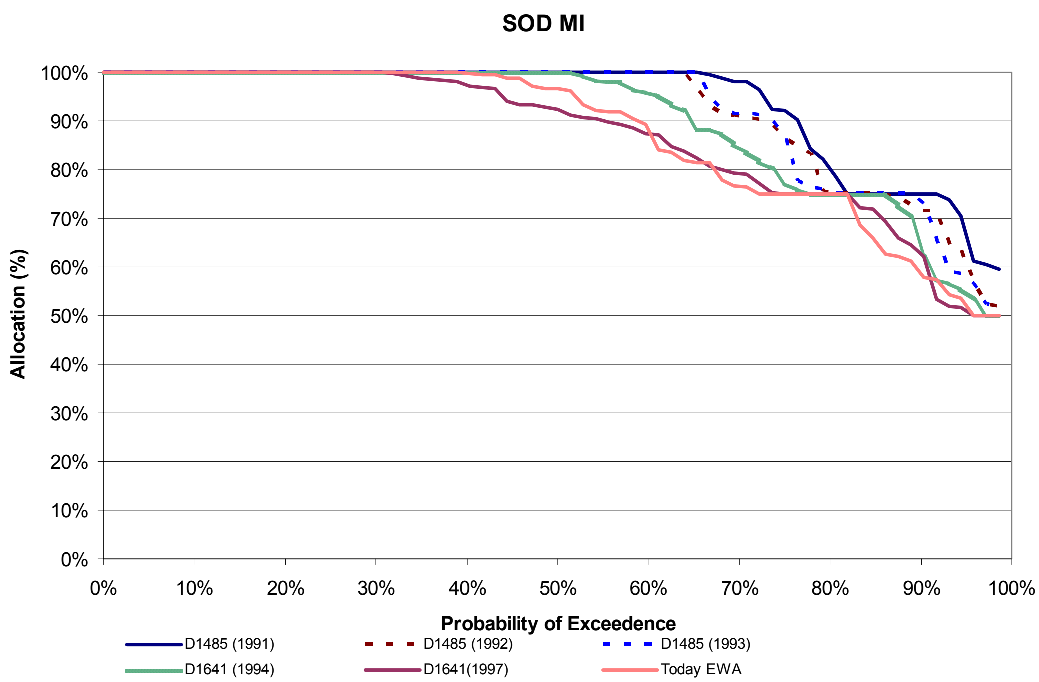

Figure 8-16 CVP SOD M&I Allocation Exceedance Chart

SWP

The chronology of total SOD SWP Deliveries is shown on Figure 8-17. The chronology shows that the Today EWA study generally delivers less water than the other five studies. The ability to deliver water in the drought periods also decreased in the D1641 (1994), D1641 (1997), and Today EWA studies when compared to the three D1485 studies.

Figure 8-18, Figure 8-19, and Figure 8-20 show the SOD Metropolitan Water District of Southern California (MWD), other M&I, and Agricultural allocations, respectively. From Study A to Study 3, the allocations get lower with each addition regulatory requirement.

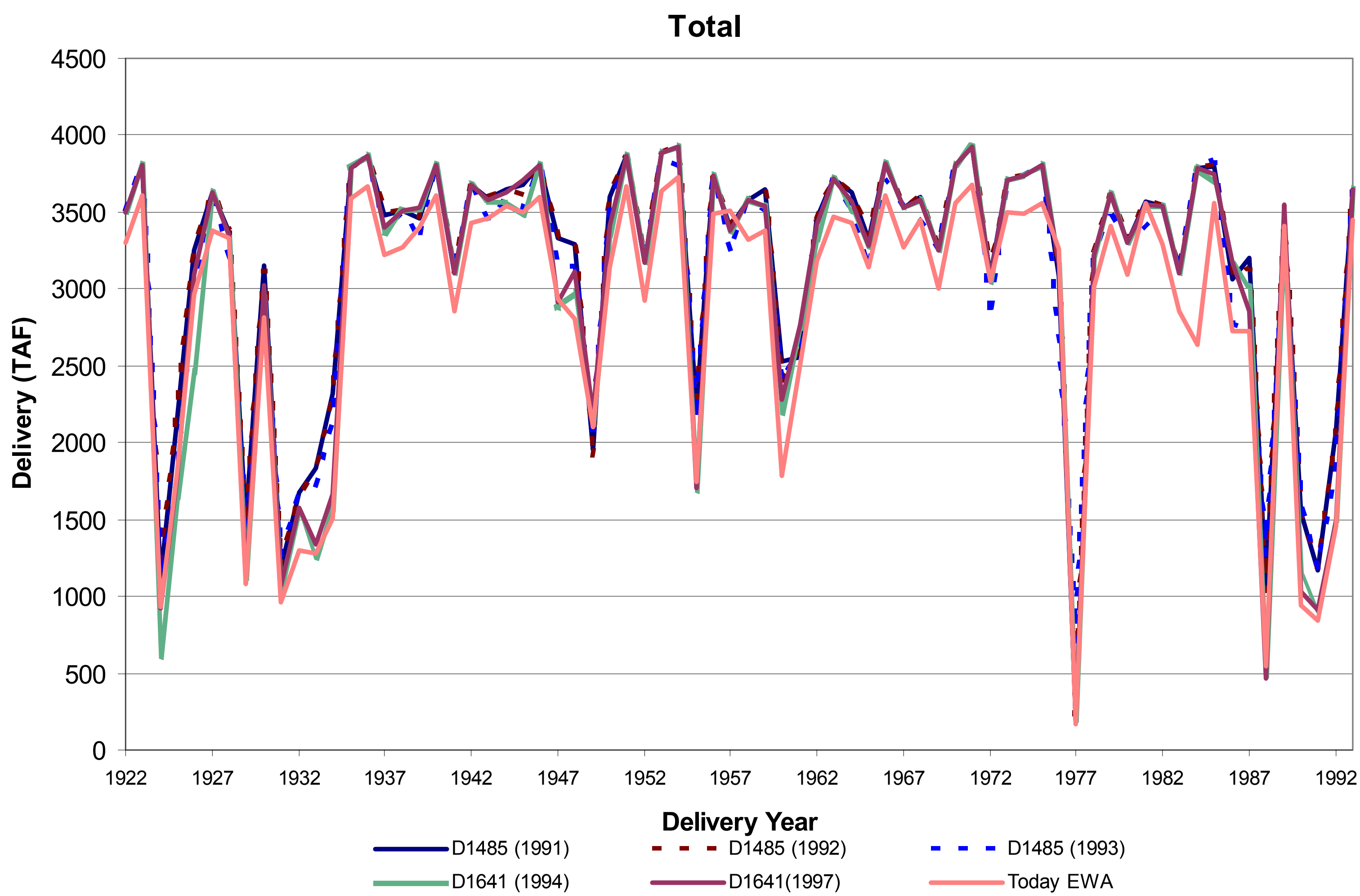

Figure 8-17 Chronology of Total SWP Deliveries

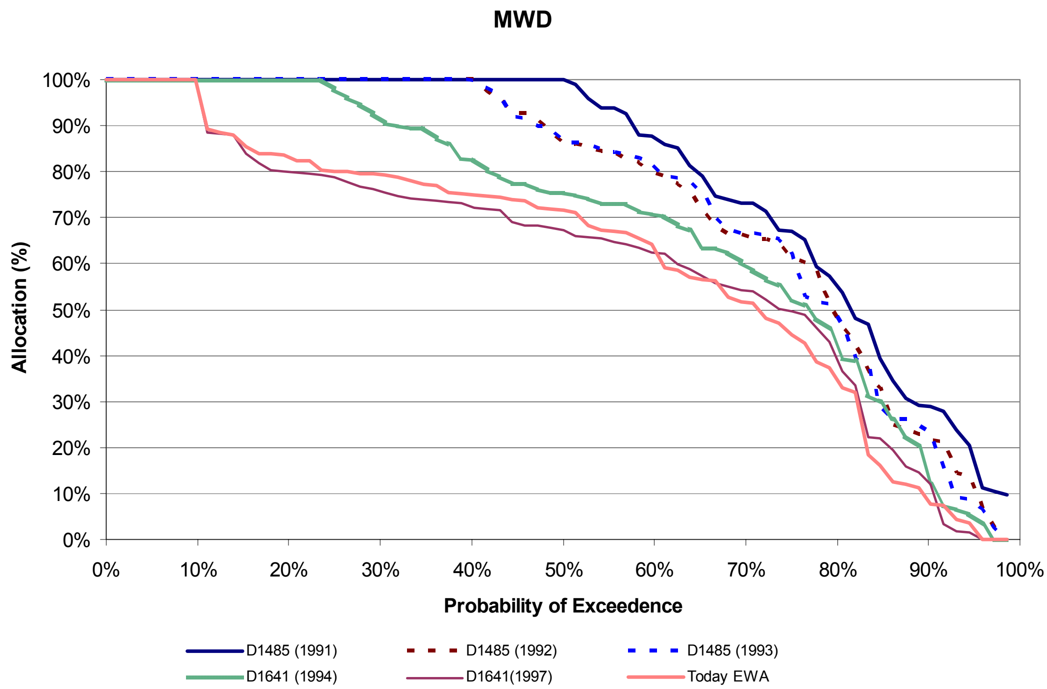

Figure 8-18 Annual MWD Allocation Exceedance Chart

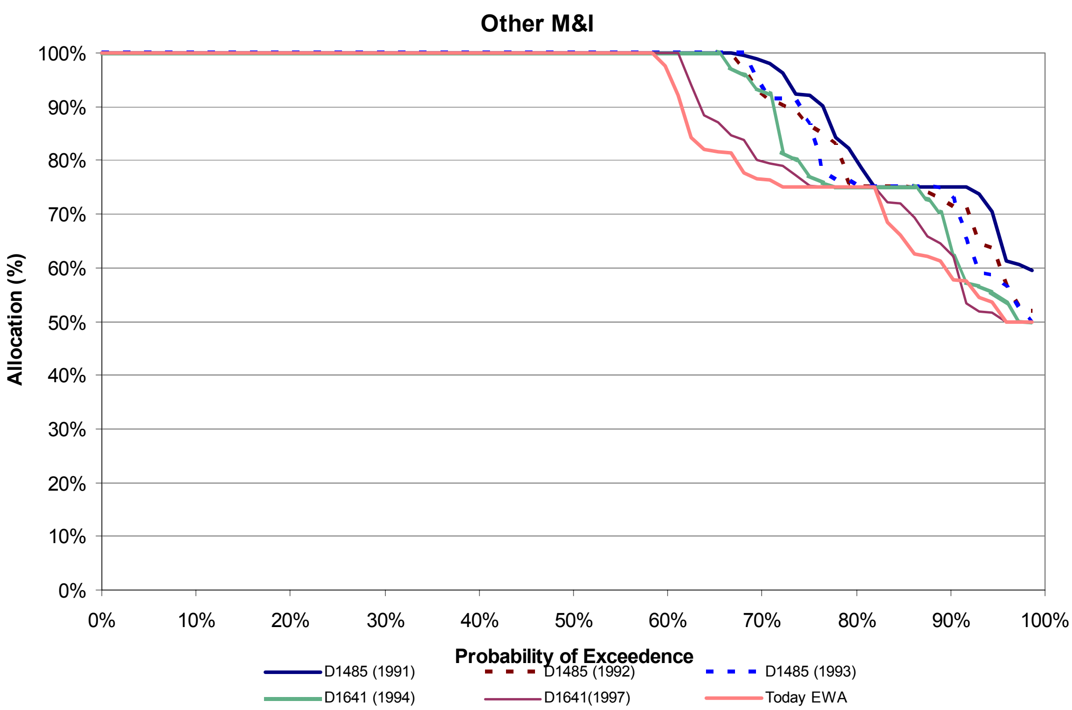

Figure 8-19 Annual non-MWD M&I Allocation Exceedance Chart

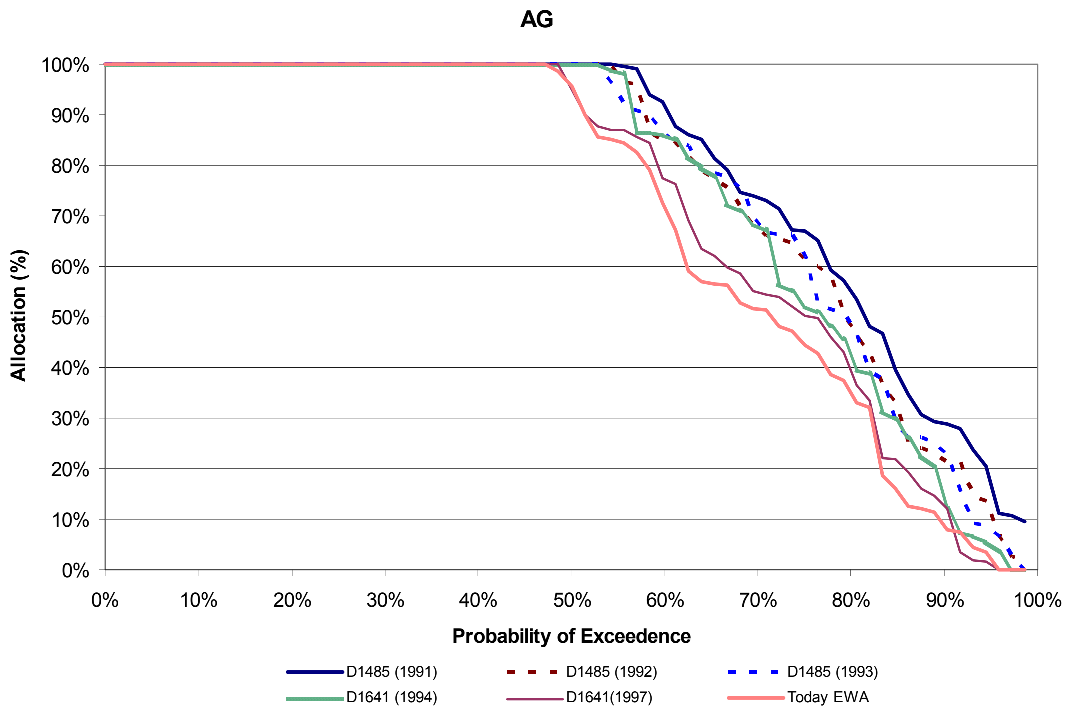

Figure 8-20 Annual SWP Agricultural Allocation Exceedance Chart

Conclusions

Conclusions on Delta and SOD modeling results include the following:

- The average inflow goes down in Studies B and C compared to Study A because of the increase from deliveries to refuges in the NOD. Studies D and 1 show an increase in Delta inflow over studies A, B, and C from increased outflow requirements in the D1641 simulations.
- Delta outflow increases significantly in Studies D, 1, and 3 because of the increased D1641 outflow requirements. The increase in outflow requirements is more of a factor in Below Normal, Dry, and Critical years.
- Studies A, B, and C show the highest pumping rates, with decreases in annual pumping coming in Studies 1 and 3 from 3406 b(2) cuts and EWA when compared to Study A.
- The CVP is impacted most in Studies D and 1 from the loss of replacement pumping in the D1485 studies. Some of the loss is made up in Study 3 by JPOD wheeling from the EWA runs.
- Most of the impact to State Banks pumping occurs in the Dry and Critical years when looking at all six studies. Study C has a drop off in average annual pumping in all water year types when compared to Study A. Studies 1 and 3 show increased pumping in the Wet years from increased availability of CVP water from 3406 b(2) upstream releases but also have the highest decreases in average annual pumping.

- The ability of the CVP's share of San Luis to fill and duration of staying full is limited from the loss of replacement pumping in the D1485 studies, and export restrictions from the 3406 b(2) and EWA programs.
- Studies D, 1, and 3 show that filling occurs earlier than in the three D1485 studies. The number of months that the SWP share stays full is greater in Studies D and 1 with the pumping restrictions in the Today EWA run causing a decrease in frequency, and average duration of being full dropping off when compared to the D1641 1994 and 1997 studies.