Appendix C Facility Descriptions and Operations

Reinitiation of Consultation on the Coordinated Long-Term Operation of the Central Valley Project and State Water Project

This appendix describes the surface water resources, water supplies, and facilities within the Central Valley Project (CVP) and State Water Project (SWP) in the project area. The facilities and current operations are described under the No Action Alternative. Operations of some facilities would change under the action alternatives, as described in the Alternatives Appendix. Some facilities that would not be affected by any of the alternatives analyzed in this document have been included as supplementary information. The appendix is intended to provide relevant background information about the facilities and their operations.

C.1 Introduction

This section provides an overview of the CVP and of the SWP facilities. The sections that follow provide an overview of hydrologic conditions and CVP and SWP facilities and operations in the Trinity River, Sacramento Valley, San Joaquin Valley, and the Delta and Suisun Marsh.

C.1.1 Overview of the Central Valley Project

The 1935 Rivers and Harbors Act authorized Reclamation to take over the CVP from the State of California and its initial features were authorized for construction. In 1937, the Rivers and Harbors Act reauthorized the CVP under Reclamation Law. The 1937 Act and subsequent authorizations completed CVP facilities, that include:

- Trinity and Lewiston dams on the Trinity River.
- Shasta and Keswick dams on the Sacramento River.
- Red Bluff Pumping Plant on the Sacramento River to deliver water into the Tehama-Colusa Canal and the Corning Canal.
- Folsom and Nimbus dams on the American River and the Folsom-South Canal.
- Delta Cross Channel (DCC) in the Delta.
- Rock Slough Intake to deliver water into the Contra Costa Pumping Plant, Contra Costa Canal, and Contra Loma Reservoir.
- Friant Dam along the San Joaquin River to deliver water into the Friant-Kern and Madera.

- C.W. Jones Pumping Plant (Jones Pumping Plant) (previously known as the Tracy Pumping Plant) in the south Delta to deliver water into the Delta-Mendota Canal and Mendota Pool.
- Delta-Mendota Canal(DMC)/California Aqueduct Intertie downstream of the CVP Jones Pumping Plant and the SWP Banks Pumping Plant.
- San Felipe Division, including San Luis Reservoir-related facilities, consisting of the O'Neill Forebay, Pumping Plant, and Canal; Coalinga Canal, Pleasant Valley Pumping Plant, and San Luis Drain. The O'Neill Forebay is operated in coordination with the SWP. The SWP facilities operated in coordination with the CVP include the B.F. Sisk San Luis Dam (the major dam that forms San Luis Reservoir), San Luis Canal, Los Banos and Little Panoche dams, and associated pumping plants.
- Pacheco Tunnel and Conduit to deliver water from the San Luis Reservoir into the San Justo Dam and Reservoir, Hollister Conduit, and Santa Clara Tunnel and Conduit.
- New Melones Dam along the Stanislaus River.

The CVP reservoirs are listed in Table C.1-1, Major Central Valley Project and Orland Project Reservoirs, and shown on Figures C.1-1 through C.1-5. Table C.1-1 also includes reservoirs of the Bureau of Reclamation Orland Project (which are not part of CVP) because these reservoirs also affect hydrology of Stony Creek, a tributary to the Sacramento River.

Table C.1-1. Major Central Valley Project and Orland Project Reservoirs

Project	Reservoir	Dam	Stream	Year Initiated	Capacity (acre-feet)
CVP	Millerton Lake	Friant	San Joaquin River	1942	524,000
CVP	Shasta Lake	Shasta	Sacramento River	1945	4,552,000
CVP	Keswick Reservoir	Keswick	Sacramento River	1950	23,772
CVP	Trinity Lake	Trinity	Trinity River	1962	2,447,650
CVP	Lewiston Reservoir	Lewiston	Trinity River	1963	14,660
CVP	Spring Creek Reservoir	Spring Creek Debris Dam	Spring Creek (tributary of Sacramento River)	1963	5,874
CVP	Whiskeytown Lake	Whiskeytown	Clear Creek (tributary of Sacramento River)	1963	241,100
CVP	Folsom Lake	Folsom	American River	1956	967,000
CVP	Lake Natoma	Nimbus	American River	1955	9,000
CVP	Contra Loma Reservoir	Contra Loma	Off-Stream	1967	2,627
CVP	Martinez Reservoir	Martinez	Wildcat Creek	1938	268
CVP	San Luis Reservoir	B.F. Sisk	San Luis Creek	1967	2,041,000
CVP	O’Neill Forebay	O’Neill	San Luis Creek	1967	56,400
CVP	Los Banos Creek Reservoir	Los Banos Detention	Los Banos Creek	1965	34,600
CVP	Little Panoche Creek Reservoir	Little Panoche Detention	Little Panoche Creek	1966	5,580
CVP	San Justo Reservoir	San Justo	Offstream	1985	10,300
CVP	Funks Reservoir	Funks	Funks Creek	1976	2,460
CVP	New Melones Reservoir	New Melones	Stanislaus River	1979	2,400,000
CVP	Hensley Lake	Hidden	Fresno River	1975	90,000
CVP	H.V. Eastman Lake	Buchanan	Chowchilla River	1975	150,000
Orland	East Park Reservoir	East Park	Little Stony Creek (tributary of Sacramento River)	1910	51,000
Orland	Stony Gorge Reservoir	Stony Gorge	Stony Creek (tributary of Sacramento River)	1928	50,350

Sources: California Department of Water Resources (DWR) 2014b; U.S. Department of the Interior Bureau of Reclamation (Reclamation) 1994, 2014a, 2014b.
Note: CVP = Central Valley Project; Orland = Orland Project

Figure C.1-1. California Major Water Supply Facilities

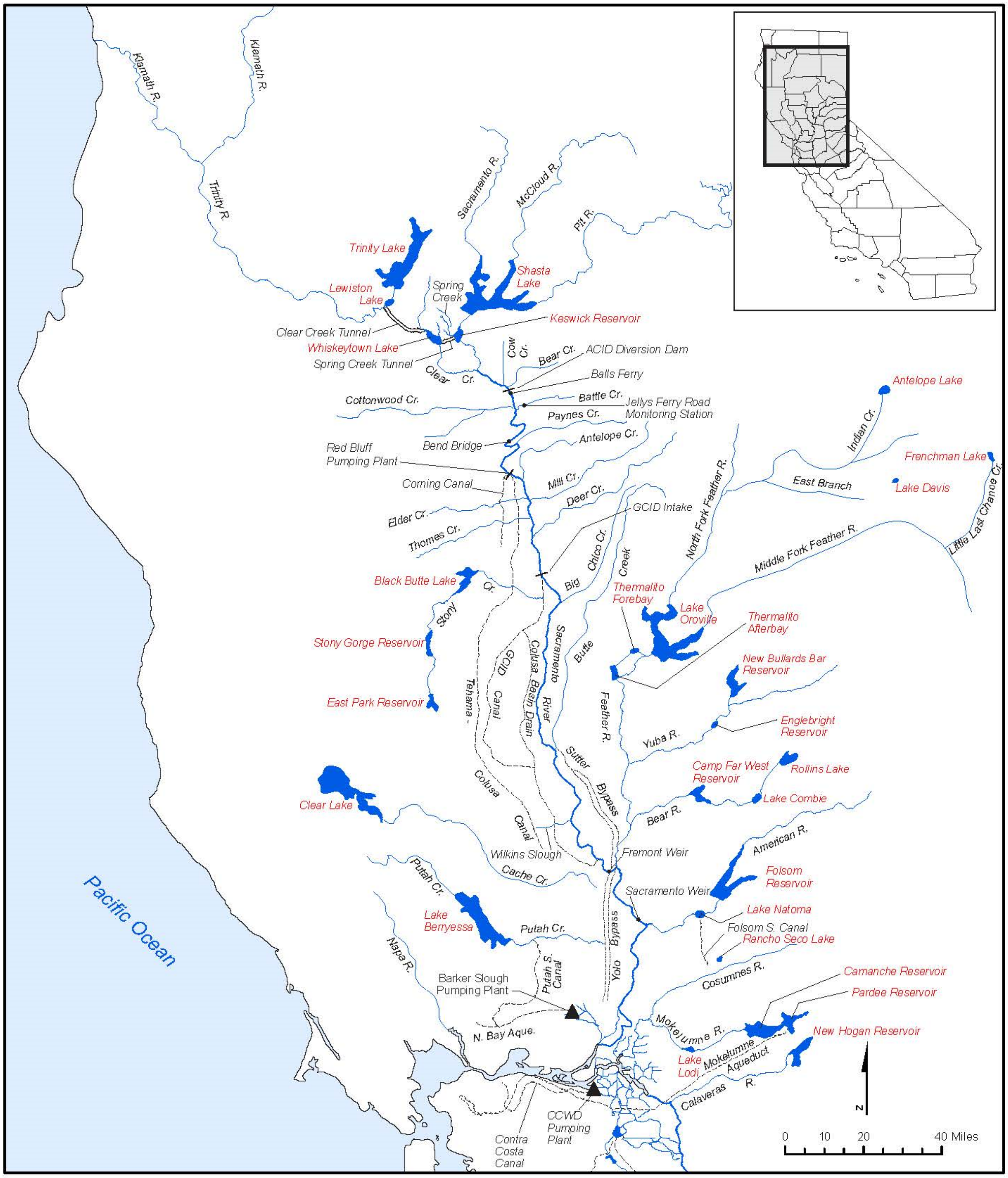

Figure C.1-2. Northern California Major Water Supply Facilities

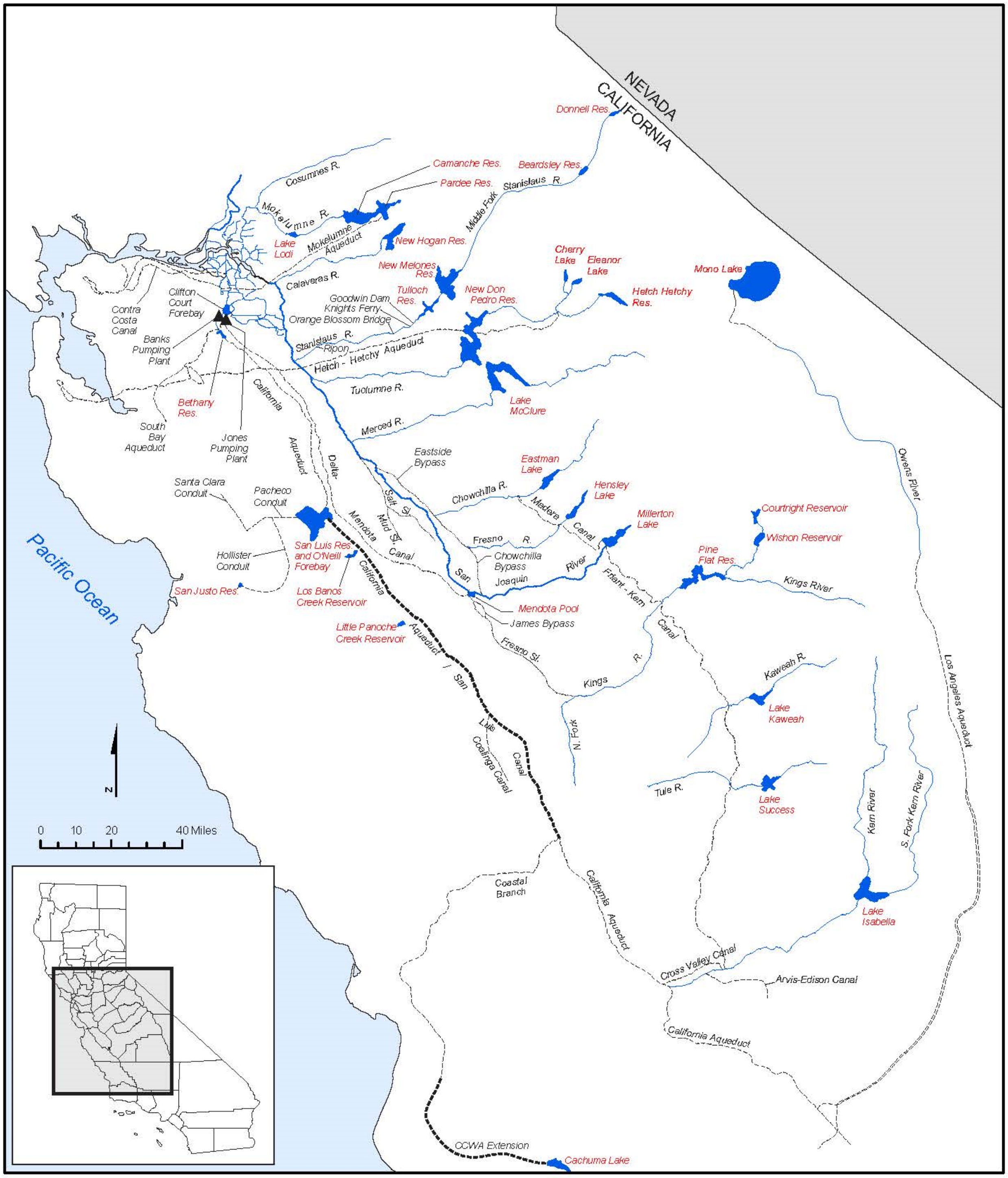

Figure C.1-3. San Joaquin Valley and Tulare Lake Major Water Supply Facilities

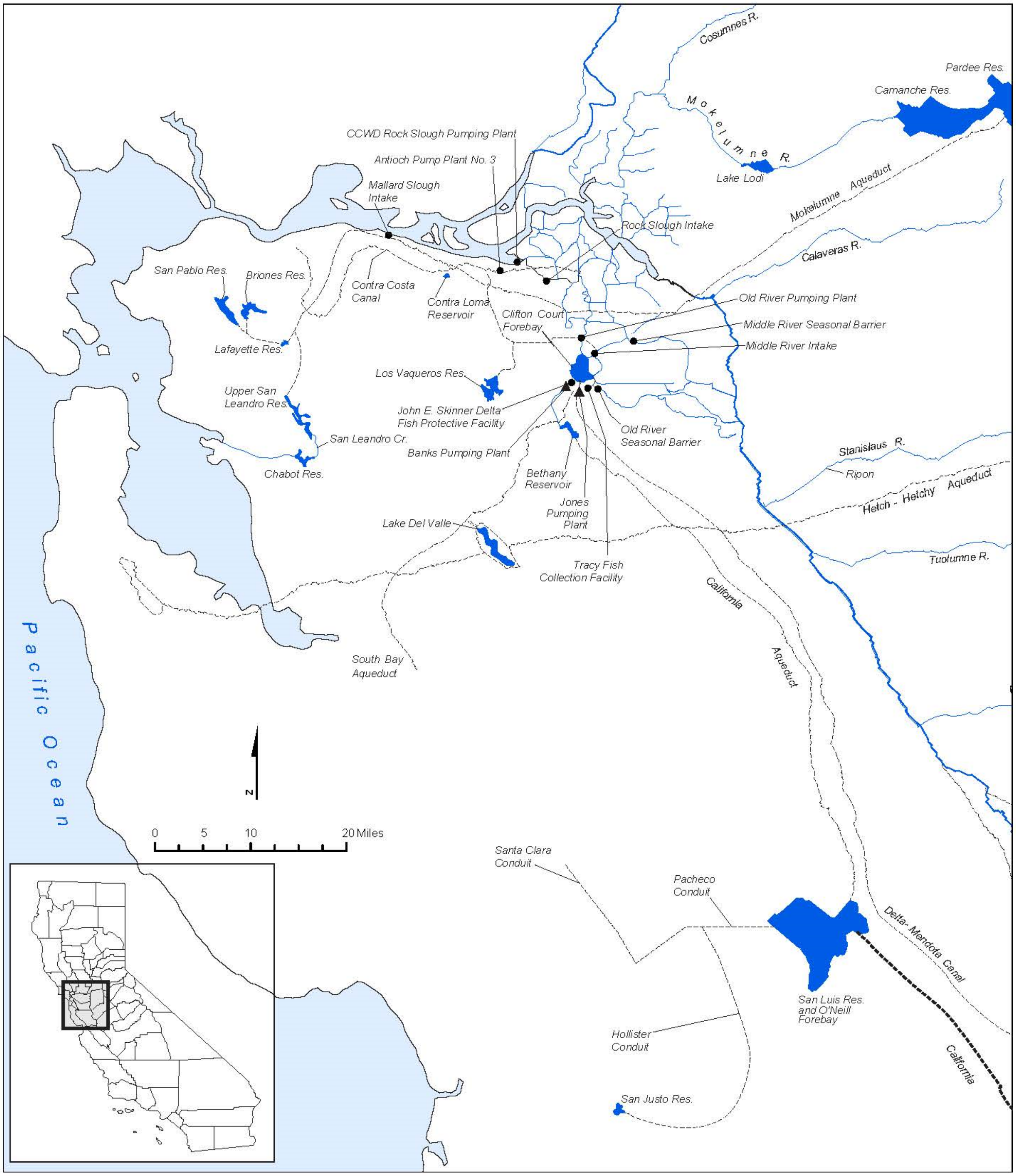

Figure C.1-4. San Francisco Bay Area Major Water Supply Facilities

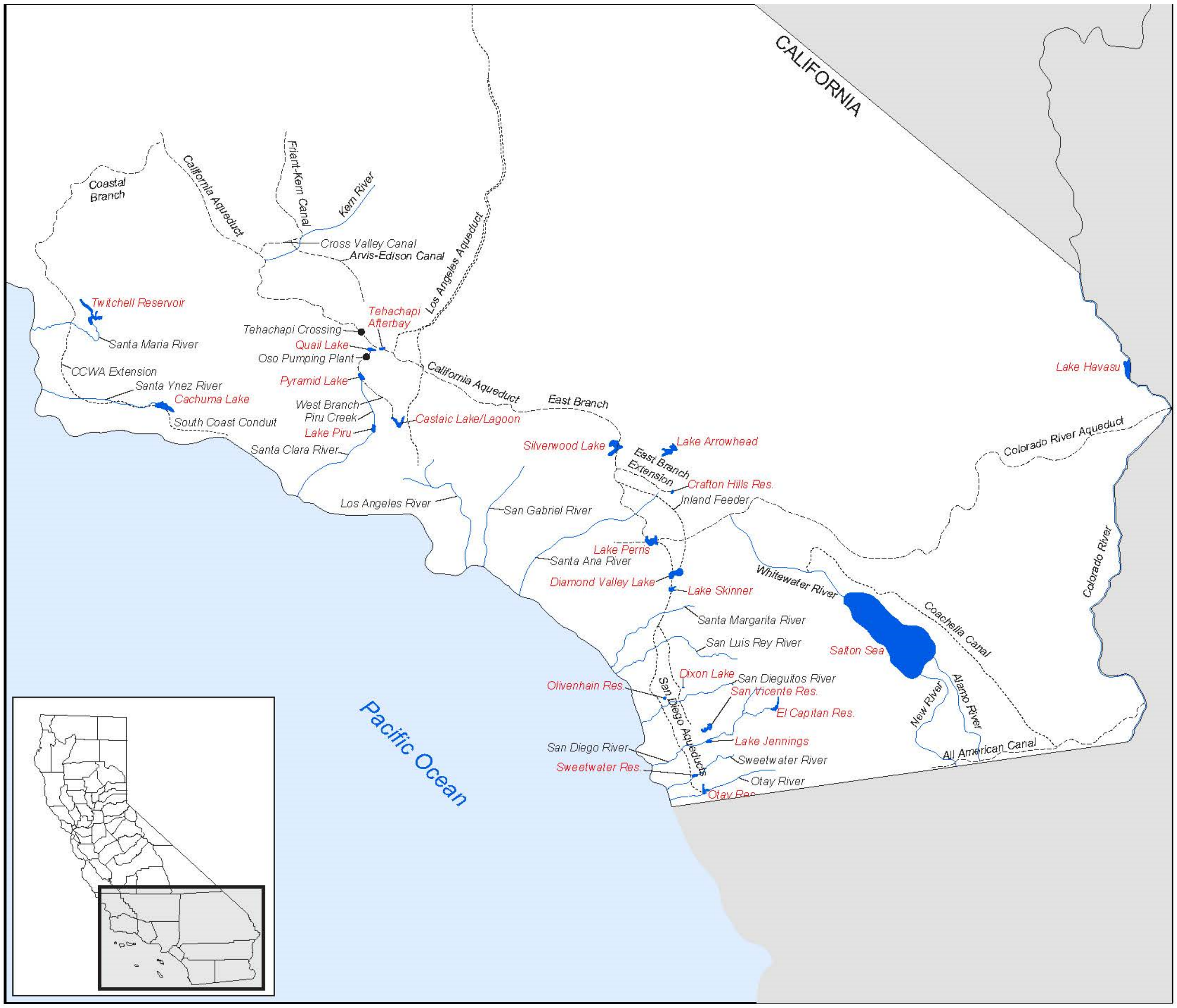

Figure C.1-5. Central Coast and Southern California Major Water Supply Facilities

C.1.2 Overview of the State Water Project

As the CVP facilities were being constructed after World War II, the state began investigations to meet additional water needs through development of the California Water Plan. In 1957, DWR published *Bulletin 3* that identified new facilities to provide flood control in northern California and water supplies to the San Francisco Bay Area, San Joaquin Valley, San Luis Obispo and Santa Barbara Counties in the Central Coast Region, and southern California (DWR 1957, 2012; Reclamation 2011a). The study identified a seasonal deficiency of 2.675 million acre-feet (MAF)/year in 1950 that resulted in groundwater overdraft throughout many portions of California. The report described facilities to meet the water demands and reduce groundwater overdraft, including facilities that would become part of the SWP.

In 1960, California voters authorized the Burns-Porter Act to construct the initial SWP facilities. The SWP facilities, as shown on Figures C.1-1 through C.1-5, include:

- Antelope Lake, Lake Davis, and Frenchman Lake on the upper Feather River upstream of Oroville Dam.
- Oroville Dam and Thermalito Diversion Dam on the Feather River.
- Barker Slough Pumping Plant in the north Delta which delivers water to the North Bay Aqueduct (NBA).
- Clifton Court Forebay (CCF) and Harvey O. Banks Pumping Plant (Banks Pumping Plant) in the south Delta, which delivers water into the Bethany Forebay and California Aqueduct.
- South Bay Pumping Plant to deliver water from Bethany Forebay to the South Bay Aqueduct (SBA) and Lake Del Valle.
- San Luis Reservoir-related facilities, including the SWP facilities B.F. Sisk San Luis Dam (the major dam that forms San Luis Reservoir), San Luis Canal, Los Banos and Little Panoche dams, and associated pumping plants, and the CVP O'Neill Forebay. These facilities are operated in coordination between the SWP and CVP.
- California Aqueduct to deliver water to the San Joaquin Valley, Central Coast, and southern California. The California Aqueduct extends from the Banks Pumping Plant to San Luis Reservoir and continues to Lake Perris in Riverside County. The California Aqueduct reach in southern California also includes Quail Lake, Pyramid Lake, Castaic Lake, Silverwood Lake, Crafton Hills Reservoir, and Lake Perris.
- The Coastal Branch of the California Aqueduct to deliver water from the California Aqueduct to San Luis Obispo and Santa Barbara counties.

Major SWP reservoirs are listed in Table C.1-2, State Water Project Reservoirs.

Table C.1-2. State Water Project Reservoirs

Reservoir	Dam	Stream	Year Initiated	Capacity (acre-feet)
Frenchman Lake	Frenchman	Little Last Chance Creek (tributary of Feather River)	1961	55,477
Antelope Lake	Antelope	Indian Creek (tributary of Feather River)	1964	22,566
Lake Davis	Grizzly Valley	Big Grizzly Creek (tributary of Feather River)	1966	83,000
Oroville Reservoir	Oroville	Feather River	1968	3,537,577
Thermalito Pool	Thermalito Diversion	Feather River	1967	13,328
Thermalito Forebay	Thermalito Forebay	Cottonwood Creek (tributary of Feather River)	1967	11,768
Thermalito Afterbay	Thermalito Afterbay	Feather River	1967	57,041
CCF	CCF	Old River	1970	29,000
Bethany Forebay	Bethany Forebay	Italian Slough	1961	5,250
Patterson Reservoir	Patterson	Offstream	1962	98
Lake Del Valley	Del Valle	Arroyo Valle	1968	77,100
Quail Lake	No dam	Offstream	Historic	5,654

Reservoir	Dam	Stream	Year Initiated	Capacity (acre-feet)
Pyramid Lake	Pyramid	Piru Creek	1973	180,000
Castaic Lake	Castaic	Castaic Creek	1973	323,700
Silverwood Lake	Cedar Springs	Mojave River (West Fork)	1971	78,000
Crafton Hills Reservoir	Crafton Hills	Yucaipa Creek	2001	130
Lake Perris	Perris	Bernasconi Pass	1973	131,452

Sources: DWR 2014b, 2014c.

C.1.3 Other Major Water Supply and Flood Management Reservoirs

During the past 100 years, numerous water supply, flood management, and hydroelectric generation reservoirs were constructed throughout California. Many of these projects were constructed on tributaries to the Sacramento and San Joaquin rivers and tributaries to the Tulare Lake Basin. Operations of these non-CVP and non-SWP reservoirs affect flow patterns into the Sacramento and San Joaquin rivers and the Delta.

Major non-CVP and non-SWP reservoirs in the Sacramento Valley and San Joaquin Valley watersheds, generally with storage capacities greater than 100,000 acre-feet, which could affect operations of CVP or SWP reservoirs or Delta facilities or could be affected by operations of the CVP or SWP, are listed in Table C.1-3, Major Non-Central Valley Project and Non-State Water Project Reservoirs in the Sacramento Valley Watershed Considered, and Table C.1-4, Major Non-Central Valley Project and Non-State Water Project Reservoirs in the San Joaquin Valley Watersheds Considered.

Table C.1-3. Major Non-Central Valley Project and Non-State Water Project Reservoirs in the Sacramento Valley Watershed Considered

Owner	Reservoir	Dam	Stream	Year Initiated	Capacity (acre-feet)
U.S. Army Corps of Engineers	Black Butte Reservoir	Black Butte	Stony Creek (tributary of Sacramento River)	1963	143,700
Yuba County Water Agency	Bullards Bar Reservoir	New Bullards Bar	Yuba River (North Fork)	1970	969,600
U.S. Army Corps of Engineers	Englebright Reservoir	Englebright	Yuba River	1941	70,000
South Sutter Water District	Camp Far West Reservoir	Camp Far West	Bear River	1963	104,500
Pacific Gas & Electric Company	Bucks Lake	Bucks Storage	Bucks Creek (tributary of Feather River)	1928	103,000
Pacific Gas & Electric Company	Lake Almanor	Lake Almanor	Feather River (North Fork)	1927	1,308,000
South Feather Water And Power Agency	Little Grass Valley Reservoir	Little Grass Valley	Feather River (South Fork)	1961	93,010
Pacific Gas & Electric Company	Salt Springs Reservoir	Salt Springs	Mokelumne River (North Fork)	1931	141,900
East Bay Municipal Utility District	Pardee Lake	Pardee	Mokelumne River	1929	209,950
East Bay Municipal Utility District	Camanche Lake	Camanche	Mokelumne River	1963	417,120

Owner	Reservoir	Dam	Stream	Year Initiated	Capacity (acre-feet)
Sacramento Municipal Utility District	Union Valley Reservoir	Union Valley	Silver Creek (tributary of American River)	1963	230,000
Placer County Water Agency	French Meadows Reservoir	L. L. Anderson	American River (Middle Fork)	1965	136,400
Placer County Water Agency	Hell Hole Reservoir	Lower Hell Hole	Rubicon River (tributary of American River)	1966	208,400

Sources: DWR 2014b, 2014c.

Table C.1-4. Major Non-Central Valley Project and Non-State Water Project Reservoirs in the San Joaquin Valley Watersheds Considered

Owner	Reservoir	Dam	Stream	Year Initiated	Capacity (acre-feet)
Southern California Edison Company	Lake Thomas A. Edison	Vermilion Valley	Mono Creek (tributary of San Joaquin River)	1954	125,000
Southern California Edison Company	Shaver Lake	Shaver Lake	Stevenson Creek (tributary of San Joaquin River)	1927	135,283
Merced Irrigation District	Lake McClure	New Exchequer	Merced River	1967	1,032,000
San Francisco Public Utilities Commission	Cherry Lake	Cherry Valley	Cherry Creek (tributary of Tuolumne River)	1956	273,500
San Francisco Public Utilities Commission	Hetch Hetchy Reservoir	O' Shaughnessy	Tuolumne River	1923	360,000
Turlock Irrigation District	New Don Pedro Reservoir	New Don Pedro	Tuolumne River	1971	2,030,000
Calaveras County Water District	New Spicer Meadow Reservoir	New Spicer Meadow	Highland Creek (tributary of Stanislaus River)	1989	190,000
Tri-Dam Project	Donnells Reservoir	Donnells	Stanislaus River (Middle Fork)	1958	56,893
Tri-Dam Project	Beardsley Reservoir	Beardsley	Stanislaus River (Middle Fork)	1957	77,600
Tri-Dam Project	Tulloch Reservoir	Tulloch	Stanislaus River	1958	68,400
Oakdale Irrigation District and South San Joaquin Irrigation District	Goodwin Diversion	Goodwin	Stanislaus River	1912	500
South San Joaquin Irrigation District	Woodward Reservoir	Woodward	Simmons Creek (tributary of Stanislaus River)	1918	35,000
U.S. Army Corps of Engineers	New Hogan Lake	New Hogan	Calaveras River	1963	317,000

Sources: DWR 2014b, 2014c.

Major reservoirs used to store CVP and SWP water supplies in the San Francisco Bay Area, Central Coast and Southern California regions are shown on Figures C.1-4 and C.1-5 and listed in Tables C.1-5, Major Non-Central Valley Project and Non-State Water Project Reservoirs in the San Francisco Bay Area Region Used to Store Central Valley Project and/or State Water Project Water, Table C.1-6, Major Non-Central Valley Project and Non-State Water Project Reservoirs in the Central Coast Region Used to Store State Water Project Water, and Table C.1-7, Major Non-Central Valley Project and Non-State Water Project Reservoirs in the Southern California Region Used to Store State Water Project Water.

Table C.1-5. Major Non-Central Valley Project and Non-State Water Project Reservoirs in the San Francisco Bay Area Region Used to Store Central Valley Project and/or State Water Project Water

Owner	Reservoir	Dam	Stream	Year Initiated	Capacity (acre-feet)
Contra Costa Water District	Los Vaqueros Reservoir	Los Vaqueros	Kellogg Creek	1997	160,000
East Bay Municipal Utility District	Briones Reservoir	Briones	Bear Creek	1964	67,520
East Bay Municipal Utility District	San Pablo Reservoir	San Pablo	Bear Creek	1964	38,600
East Bay Municipal Utility District	Lafayette Reservoir	Lafayette	Marsh Creek	1963	4,250
East Bay Municipal Utility District	Upper San Leandro Reservoir	Upper San Leandro	San Leandro Creek	1977	37,960
East Bay Municipal Utility District	Chabot Reservoir	Chabot	San Leandro Creek	1892	10,281

Sources: DWR 2014b, 2014c; East Bay Municipal Utility District (EBMUD) 2016; City and County of San Francisco 2009; Santa Clara Valley Water District (SCVWD) 2016.

Note:

[a] Anderson Reservoir capacity is restricted due to California Department of Safety and Dams (SCVWD 2016).

Table C.1-6. Major Non-Central Valley Project and Non-State Water Project Reservoirs in the Central Coast Region Used to Store State Water Project Water

Owner	Reservoir	Dam	Stream	Year Initiated	Capacity (acre-feet)
Bureau of Reclamation	Cachuma Lake	Bradbury	Santa Ynez River	1953	205,000

Sources: DWR 2014b; Reclamation 2014c.

Table C.1-7. Major Non-Central Valley Project and Non-State Water Project Reservoirs in the Southern California Region Used to Store State Water Project Water

Owner	Reservoir	Dam	Stream	Year Initiated	Capacity (acre-feet)
United Water Conservation District	Lake Piru	Santa Felicia	Piru Creek	1955	100,000
Metropolitan Water District Of Southern California	Diamond Valley Lake	Diamond Valley Lake	Domenigoni Valley Creek	2000	800,000
Metropolitan Water District Of Southern California	Lake Skinner	Robert A Skinner	Tucalota Creek	1973	43,800

Owner	Reservoir	Dam	Stream	Year Initiated	Capacity (acre-feet)
Rancho California Water District	Vail Lake	Vail	Temecula Creek	1949	51,000
City of Escondido	Dixon Lake	Dixon	Escondido Creek	1970	2,500
San Diego County Water Authority	Olivenhain Reservoir	Olivenhain	Escondido Creek	2003	24,900
City of San Diego	Lake Hodges	Lake Hodges	San Dieguito River	1918	37,700
City of San Diego	San Vicente Reservoir	San Vicente	San Vicente Creek	1943	249,358
City of San Diego	El Capitan Reservoir	El Capitan	San Diego River	1934	112,800
Helix Water District	Lake Jennings	Chet Harritt	Quail Canyon Creek	1962	9,790
Sweetwater Authority	Sweetwater Reservoir	Sweetwater	Sweetwater River	1888	27,700
City of San Diego	Murray Reservoir	Murray	Off-stream	1918	4,818
City of San Diego	Morena Reservoir	Morena	Cottonwood Creek	1912	50,694
City of San Diego	Lower Otay Reservoir	Savage	Otay River	1919	47,061

Sources: DWR 2014b, 2014c; City of San Diego 2019a, 2019b, 2019c, 2019d; San Diego County Water Authority 2019; San Diego County Water Authority (SDCWA) and U.S. Army Corps of Engineers (USACE) 2008.

Major reservoirs used to store CVP and SWP water supplies in the San Francisco Bay Area, Central Coast, and Southern California regions are shown on Figures C.1-4 and C.1-5 and listed in Tables C.1-5, C.1-6, and C.1-7.

C.2 Trinity River Region

The Trinity River Region includes the area along the Trinity River from Trinity Lake to the confluence with the Klamath River; and along the lower Klamath River from the confluence with the Trinity River to the Pacific Ocean. The Trinity River Region includes Trinity Lake, Lewiston Reservoir, the Trinity River between Lewiston Reservoir and the confluence with the Klamath River, and along the lower Klamath River.

C.2.1 Trinity River Watershed

The Trinity River watershed extends over approximately 1,897,600 acres and ranges in elevation from over 9,000 feet above sea level in the headwaters area to less than 300 feet at the confluence of the Trinity River with the Klamath River (California North Coast Regional Water Quality Control Board [NCRWQCB] et al. 2009; U.S. Fish and Wildlife Service (USFWS) [USFWS] et al. 1999). Average precipitation in the Trinity River watershed ranges from 30 to 70 inches per year, with a long-term average of approximately 62 inches per year. Over 90 percent of the precipitation has historically occurred between October and April. Precipitation ranges from mostly snow at higher elevations to mostly rain near the confluence with the Klamath River.

The Trinity River includes the mainstem, North Fork Trinity River, South Fork Trinity River, New River, and numerous smaller streams (NCRWQCB et al. 2009; USFWS et al. 1999). The mainstem of the

Trinity River flows 170 miles to the west from the headwaters to the confluence with the Klamath River. The CVP Trinity and Lewiston dams are located at approximately River Miles 105 and 112, respectively; and upstream from the confluences of the Trinity River and the North Fork, South Fork, and New River. Flows on the North Fork, South Fork, and New River are not affected by CVP facilities. The Trinity River flows approximately 112 miles from Lewiston Dam to the Klamath River through Trinity and Humboldt counties and the Hoopa Indian Reservation within Trinity and Humboldt counties.

Trinity Lake, a CVP facility on the Trinity River formed by the Trinity Dam, was constructed by 1962. The 2.4-MAF reservoir is located approximately 50 miles northwest of Redding (USFWS et al. 1999). Lewiston Reservoir, a CVP facility on the Trinity River formed by Lewiston Dam, was constructed by 1963 and is located 7 miles downstream of the Trinity Dam. Lewiston Reservoir is used as a regulating reservoir for downstream releases to the Trinity River and to Whiskeytown Lake, located in the adjacent Clear Creek watershed. Water is diverted from the lower outlets in Trinity Lake to Lewiston Reservoir to provide cold water to Trinity River. There are no other major dams in the Trinity River watershed.

Prior to completion of Trinity and Lewiston dams, flows in the Trinity River were highly variable and could range from over 100,000 cubic feet per second (cfs) in the winter and spring to 25 cfs in the summer and fall (USFWS et al. 1999). Total annual flow volume at Lewiston (immediately downstream of the current location of Lewiston Dam) ranged from 0.27 to 2.7 MAF with a long-term average of 1.2 MAF.

A large portion of the Trinity River flows upstream of Trinity Lake and Lewiston Dam is exported to the Sacramento River watershed through CVP facilities. The reduction in flows in the Trinity River initially caused substantial reductions in the Trinity River fish populations (Department of the Interior [DOI] 2000). In response to the reductions in fish populations, Congress enacted legislation and directed that restoration actions be evaluated for the Trinity River. In December 2000, the DOI adopted the Trinity River Mainstem Fishery Restoration Record of Decision (ROD) (Trinity River ROD), which restored Trinity River flow and habitat to produce a healthy, functioning alluvial river system. The Trinity River ROD included physical channel rehabilitation; sediment management; watershed restoration; and variable annual instream flow releases from Lewiston Dam based on forecasted hydrology for the Trinity River Basin as of April 1st each year that range from 368,600 acre-feet/year in critically dry years to 815,000 acre-feet/year in extremely wet years.

Additional water releases periodically occur into the Trinity River as part of flood control operations and to provide other flow releases (NCRWQCB et al. 2009; Reclamation 2011a). Although flood control is not an authorized purpose of the Trinity River Division, flood control benefits are provided through normal operations. The Reclamation Safety of Dams release criteria generally provide for maximum storage in Trinity Lake of 2.1 between November and March. Initial flood releases are discharged from Trinity Lake into Lewiston Reservoir, and then, through the powerplant and into Whiskeytown Lake in the Clear Creek watershed. To reduce the potential for flooding on the Trinity River, releases into Trinity River generally are less than 11,000 cfs from Lewiston Dam (under Safety of Dams criteria) due to local high-water concerns in the floodplain and local bridge flow capacities. Reclamation has periodically released water from Lewiston Dam into the Trinity River to improve late summer flow conditions to avoid fish die-offs in the lower Klamath River or for tribal requirements along the Trinity River (DOI 2014; Trinity River Restoration Program [TRPP] 2014).

Temperature objectives for the Trinity River are set forth in State Water Resources Control Board (SWRCB) Water Rights Order 90-5, as summarized below. These objectives vary by reach and by season. Between Lewiston Dam and Douglas City Bridge, the daily average temperature should not exceed 60 degrees Fahrenheit (°F) from July 1 to September 14, and 56°F from September 15 to September 30.

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.

Water storage volumes and water storage elevations for Trinity Lake for Water Years 2001 through 2018 are presented on Figures C.2-1 and C.2-2 (DWR 2018a, 2018b). Trinity Lake storage varies in accordance with upstream hydrology and downstream water demands and instream flow requirements. Reclamation maintains at least 600 thousand acre-feet (TAF) in Trinity Reservoir, except during the 10 to 15 percent of the years when Shasta Lake is also drawn down.

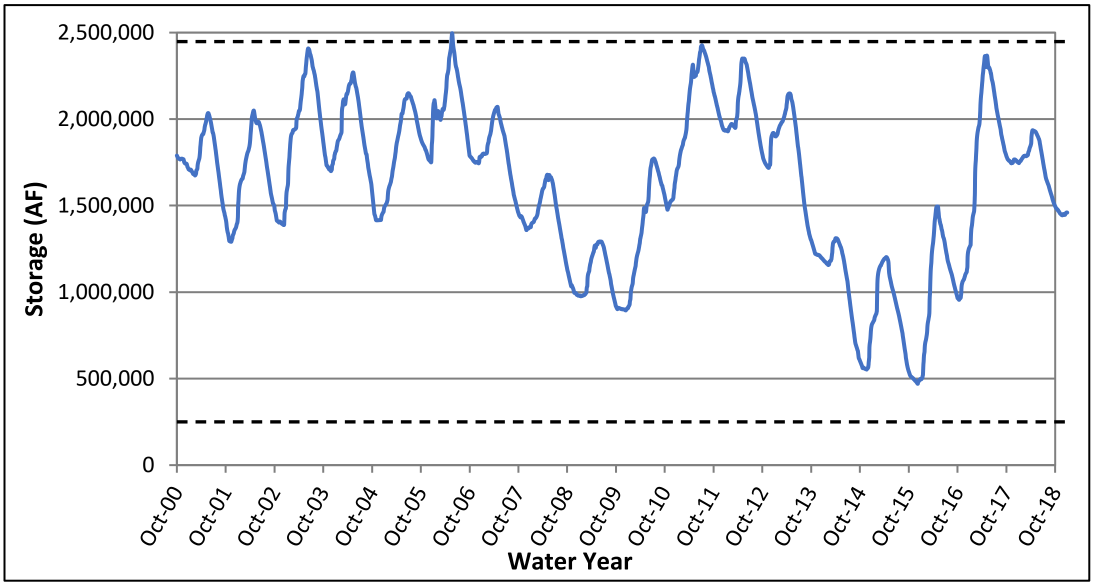

Figure C.2-1. Trinity Lake Storage

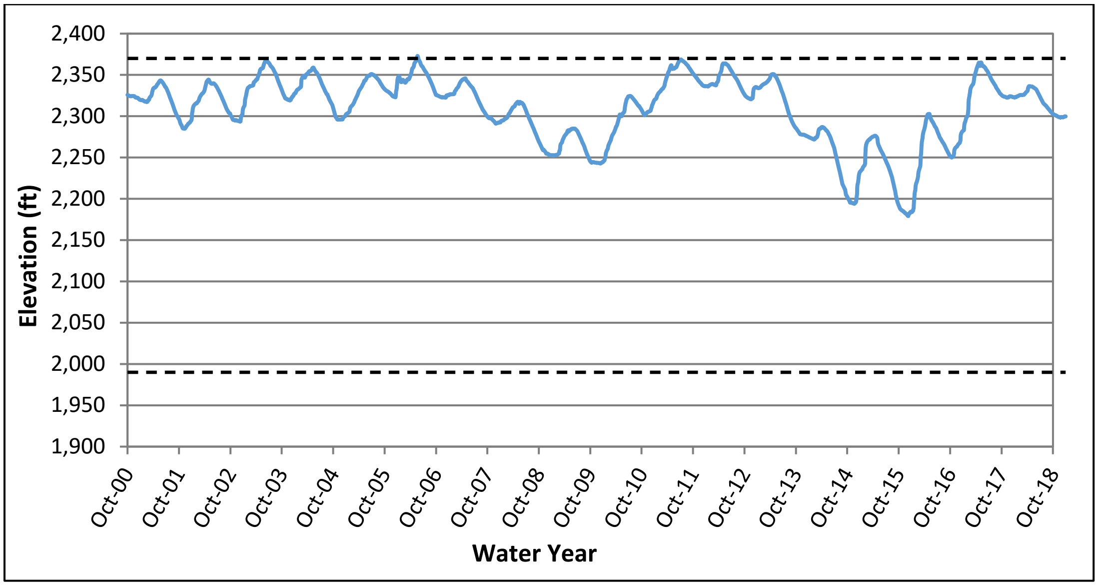

Figure C.2-2. Trinity Lake Elevation

Historical water storage volumes and water storage elevations in Lewiston Reservoir for Water Years 2001 through 2018 are presented on Figures C.2-3 and C.2-4 (DWR 2018c, 2018d). The Lewiston Reservoir water storage volume is more consistent throughout the year because this reservoir is used to regulate flow releases to the powerplant and other downstream uses; and not to provide long-term water storage.

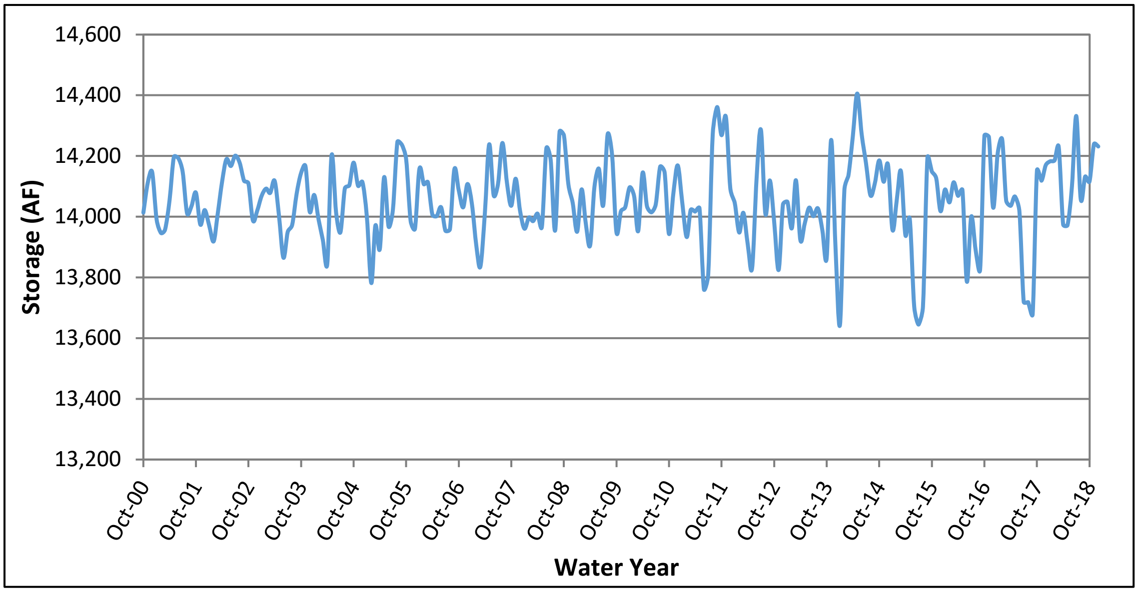

Figure C.2-3. Lewiston Reservoir Storage

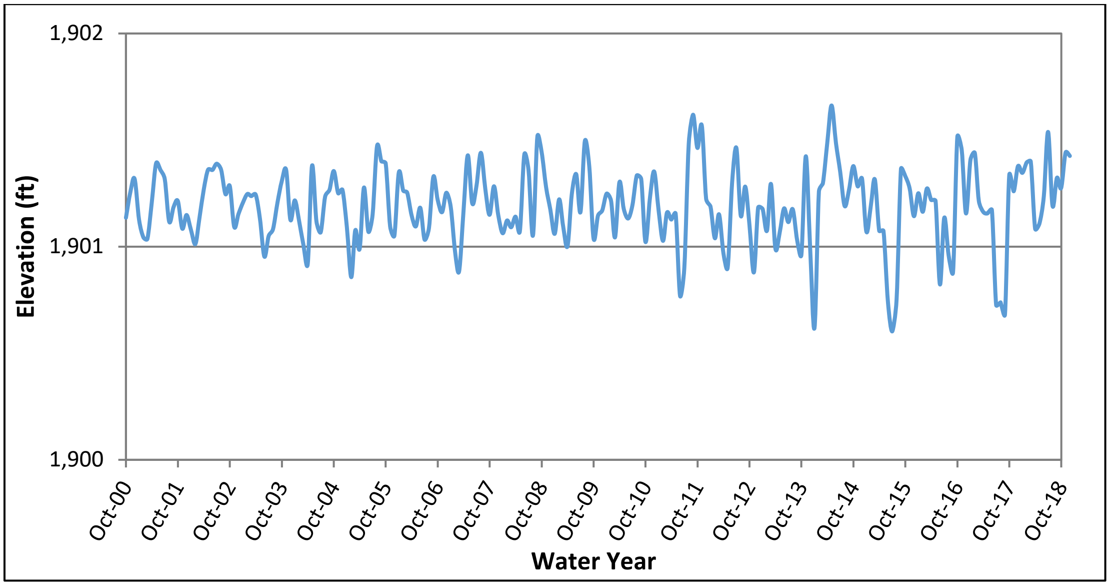

Figure C.2-4. Lewiston Reservoir Elevation

Trinity River flows downstream of Lewiston Reservoir at Douglas City are presented on Figure C.2-5 (DWR 2018e). The flow record is limited at the Douglas City gauge to 2003 through 2018. The mean monthly flows reflect the wet year pattern in 2006 and the drier year patterns in 2008 and 2009.

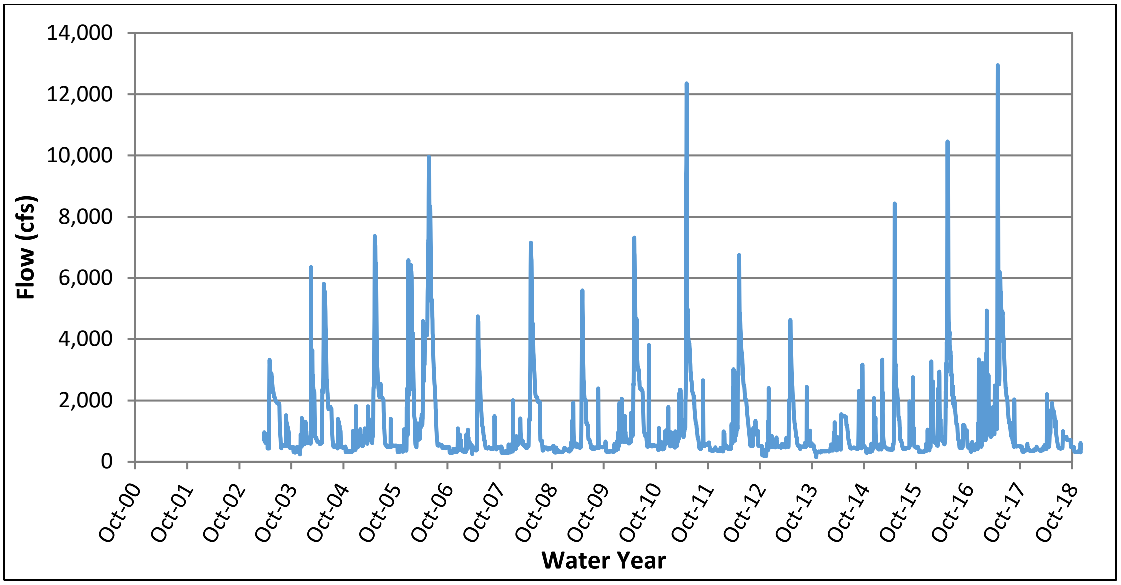

Figure C.2-5. Trinity River Near Douglas City

C.2.2 Trinity River Division Operations

Natural flows began to be stored along the Trinity River in November 1960, affecting river hydraulic function. 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. The Trinity River Division includes the Trinity River and Dam, Lewiston Dam, Whiskeytown Reservoir and Dam, Clear Creek, and Spring Creek and Debris Dam. Trinity Dam is located on the Trinity River and regulates the flow from a drainage area of approximately 720 square miles. The dam was completed in 1962, forming Trinity Lake, which has a maximum storage capacity of approximately 2.4 million acre-feet (MAF).

Water is diverted from the Trinity River at Lewiston Dam via the Clear Creek Tunnel and passes through the Judge Francis Carr Powerhouse as it is discharged into Whiskeytown Lake on Clear Creek. From Whiskeytown Lake, water is released through the Spring Creek Power Conduit to the Spring Creek Power Plant and into Keswick Reservoir. Water diverted from the Trinity River, plus a portion of Clear Creek flows, is diverted through the Spring Creek Power Conduit into Keswick Reservoir and Whiskeytown Dam providing flow to Clear Creek below.

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 TAF 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.

The mean annual inflow to Trinity Lake is 1.26 MAF per year (water years 2001–2017). From water year 1965 through 1980, an average of 80% of inflow was diverted. Under a secretarial decision, an average of 61% of inflow was diverted for water years 1981 through 2000. Under a second secretarial decision, an average of 51% of inflows has since been diverted (water years 2001–2017).

C.2.2.1 *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.

The Safety of Dams release criteria specify that Carr power plant capacity 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 often at concern levels. Under such high-water conditions, the water that would otherwise move through the Carr power plant is routed to the Trinity River so as to avoid exacerbating any flooding concerns on the Sacramento River side. Total river releases are capped at 11,000 cfs from Lewiston Dam (under Safety of Dams criteria) due to local high-water concerns in the floodplain and local bridge flow capacities. The Safety of Dams criteria provide seasonal storage targets and recommended releases November 1 to March 31.

C.2.2.2 *Fish and Wildlife Requirements on Trinity River*

Based on the Trinity River ROD, 368.6 TAF to 815 TAF is allocated annually for Trinity River flows, depending on water year type. This amount is scheduled in coordination with USFWS and other in-basin partners to best meet habitat, temperature, and sediment transport objectives in the Trinity Basin.

Water temperature objectives for the Trinity River are set forth in SWRCB Water Rights Order 90-5, as summarized in Table C.2-1, Water Temperature Objectives for the Trinity River during the Summer, Fall, and Winter as Established by the California Regional Water Quality Control Board North Coast Region. These objectives vary by reach and by season. Between Lewiston Dam and Douglas City Bridge, the daily average temperature should not exceed 60 degrees Fahrenheit (°F) from July 1 to September 14, and 56°F from September 15 to September 30. 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.

Table C.2-1. Water Temperature Objectives for the Trinity River during the Summer, Fall, and Winter as Established by the California Regional Water Quality Control Board North Coast Region

	Temperature Objective (°F)	
Date	**Douglas City (RM 93.8)**	**North Fork Trinity River (RM 72.4)**
July 1 through September 14	60	–
September 15 through September 30	56	–
October 1 through December 31	–	56

RM = river mile

The Long-Term Plan to Protect Adult Salmon on the Lower Klamath River ROD, dated April 20, 2017, includes supplemental flows from Lewiston Dam to prevent a disease outbreak (*Ichthyophthirius multifiliis*) in the lower Klamath River in years when the flow in the lower Klamath River is projected to be less than 2,800 cfs. The water for these supplemental flows would come from water stored in Trinity Reservoir, with releases of not less than 50 TAF. The three flow augmentation components include:

1. a preventive base-flow release that targets increasing the base flow of the lower Klamath River to 2,800 cfs from mid-August to late September to improve environmental conditions;

2. a one-day preventive pulse flow (targeting 5,000 cfs in the lower Klamath River) to be used as a secondary measure to alleviate continued poor environmental conditions and signs of *Ichthyophthirius multifiliis* infection in the lower Klamath River; and
3. a five-day emergency pulse flow (targeting 5,000 cfs in the lower Klamath River) to be used on an emergency basis as a tertiary treatment, to avoid a significant die-off of adult salmon when the first two components are not successful at meeting intended objectives.

C.2.2.3 *Transbasin Diversions*

Diversion of Trinity water to the Sacramento Basin provides water supply and major hydroelectric power generation for the CVP and plays a key role in water temperature control in the Trinity River and upper Sacramento River.

The seasonal timing of Trinity exports, detailed in Table C.2-2, Average Trinity Lake Inflow, Release, and Export for Water Years 2001–2017, is a result of determining how to make best use of a limited volume of Trinity export (in concert with releases from Shasta Lake) to help conserve cold water pools and meet temperature objectives on the upper Sacramento and Trinity Rivers, as well as power production economics. A key consideration in the export timing determination is the thermal degradation that occurs in Whiskeytown Lake due to the long residence time of transbasin exports in the lake.

Table C.2-2. Average Trinity Lake Inflow, Release, and Export for Water Years 2001–2017

Month	Average Trinity Lake Inflow (AF)	Average Release to Trinity River (AF)	Average Export to CVP (AF)
January	128,945	30,591	15,349
February	147,763	21,423	19,385
March	194,151	21,209	27,709
April	200,039	41,497	36,030
May	237,307	218,873	44,001
June	128,484	110,756	84,820
July	38,753	51,835	114,410
August	11,294	37,399	108,121
September	6,659	38,170	84,144
October	17,921	23,416	61,594
November	34,837	18,777	28,253
December	116,490	19,486	19,282

AF = acre-feet

To minimize the thermal degradation effects, transbasin export patterns are typically scheduled to provide an approximate 120 TAF volume to occur in late spring to create a thermal connection to the Spring Creek Powerhouse before larger transbasin volumes are scheduled to occur during the hot summer months. Typically, the water flowing from the Trinity Basin through Whiskeytown Lake must be sustained at fairly high rates to avoid warming and to function most efficiently for temperature control. The time period for which effective temperature control releases can be made from Whiskeytown Lake may be compressed when the total volume of Trinity water available for export is limited.

Export volumes from Trinity are made in coordination with the operation of Shasta Lake. Other considerations affecting the timing and magnitude of Trinity exports are power generation demand, and the maintenance schedule of the diversion works and generation facilities.

Maximum storage levels generally occur in April or May. Reclamation maintains at least 600 TAF in Trinity Reservoir, except during the 10 to 15 percent of the years when Shasta Lake is also drawn down. Reclamation addresses end-of-water-year carryover on a case-by-case basis in dry and critically dry water year types with considerations provided by the USFWS and the National Marine Fisheries Service (NMFS) through the Water Operations Management Team.

C.2.3 Lower Klamath River from Trinity River Confluence to the Pacific Ocean

The Klamath River watershed extends over 15,600 square miles from southern Oregon to northern California, and ranges in elevation from over 9,500 feet above sea level near the headwaters to sea level at the Pacific Ocean (USFWS et al. 1999). The Klamath River watershed is generally divided into two or three subbasins. For the purpose of this study, the upper Klamath River basin extends over 60 miles from the headwaters to Iron Gate Dam (DOI and Department of Fish and Game [now known as the California Department of Fish and Wildlife, CDFW] [DFG] 2012).

The lower Klamath River basin extends 190 miles from Iron Gate Dam to the Pacific Ocean. Four major tributaries flow into the lower Klamath River, including Shasta, Scott, Salmon, and Trinity rivers. The lower Klamath River flows 43.5 miles from the confluence with the Trinity River to the Pacific Ocean (USFWS et al. 1999). Downstream of the Trinity River confluence, the Klamath River flows through Humboldt and Del Norte counties and through the Hoopa Indian Reservation, Yurok Indian Reservation, and Resighini Indian Reservation within Humboldt and Del Norte counties (DOI and DFG 2012).

The Trinity River is the largest tributary to the Klamath River (DOI and DFG 2012). There are no dams located in the Klamath River watershed downstream of the confluence with the Trinity River. The western portion of the Klamath River watershed receives substantial rainfall during the winter months. Average precipitation in the western portion of the watershed ranges from 60 to 125 inches per year (DWR 2013a). Due to the heavy precipitation and the upstream water supply projects in the Klamath River, approximately 85 percent of the flows in the lower Klamath River occur due to runoff in the lower watershed during the winter months (DOI and DFG 2012).

The Klamath River estuary extends from approximately 5 miles upstream of the Pacific Ocean (DOI and DFG 2012). This area is generally under tidal effects and salt water can occur up to 4 miles from the coastline during high tides in summer and fall when Klamath River flows are low. Klamath River flows at Klamath within the Klamath River estuary are affected by tidal influence within the estuary, as presented on Figure C.2-6 (DWR 2018f).

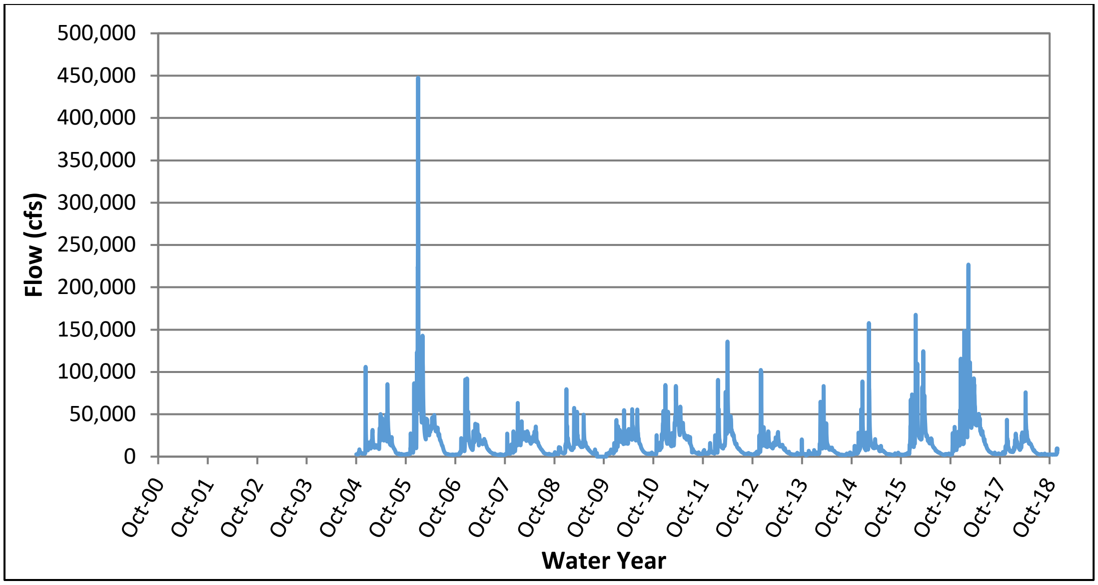

Figure C.2-6. Klamath River Near Klamath

C.3 Sacramento Valley

Rivers in the Sacramento Valley that could be affected by changes in CVP and SWP operations include the following:

- Clear Creek from Whiskeytown Reservoirs to the confluence with the Sacramento River
- Sacramento River from Shasta Lake to the confluence with the San Joaquin River in the Delta
- Feather River from upstream of Oroville Reservoir to the confluence with the Sacramento River
- Yuba River from New Bullards Bar Reservoir to the confluence with the Feather River
- Bear River from Camp Far West Reservoir to the confluence with the Feather River
- American River from Folsom Lake to the confluence with the Sacramento River

Flows from smaller tributaries to the Sacramento River and the Cosumnes and Mokelumne rivers in the Sacramento Valley contribute substantial flows into the Sacramento River and affect CVP and SWP operations; however, flows in these rivers would not be affected by changes in CVP and SWP operations. Therefore, hydrologic conditions on these water bodies are not described.

The Sacramento River watershed encompasses an area over 15,360,000 acres in the northern portion of the Central Valley; extends from the foothills of the Coast Ranges and Klamath Mountains on the west; extends from the foothills of the Sierra Nevada and Cascade Range on the east; and extends through the Delta on the south (Reclamation 2013a).

Ground surface elevations in the northern portion of the Sacramento River watershed range from approximately 14,000 feet above mean sea level in the headwaters of the Sacramento River to approximately 1,070 feet at Shasta Lake (Reclamation 2013a). In the mountains surrounding the valley, annual average precipitation generally ranges between 60 and 70 inches up to 90 inches, with snow prevalent at higher elevations. The floor of the Sacramento Valley is relatively flat, with elevations ranging from approximately 60 to 300 feet above mean sea level. This area is characterized by hot dry summers and mild winters. Average precipitation ranges from 15 to 20 inches per year, falling mostly as rain.

The Sacramento River flows approximately 351 miles from the north near Mount Shasta to the confluence with the San Joaquin River at Collinsville in the western Delta (Reclamation 2013a). The Sacramento River receives contributing flows from numerous major and minor streams and rivers that drain the east and west sides of the basin. The Sacramento River also receives imported flows from the Trinity River watershed, as discussed above. The volume of flow increases as the river progresses southward and is increased considerably by the contribution of flows from the Feather River and the American River.

C.3.1 Upper Sacramento River Watershed Hydrology

The portion of the watershed upstream of Keswick Dam includes the McCloud River, Pit River, Squaw Creek, headwaters of the Sacramento River, and Goose Lake basins. The Goose Lake basin is located within the Pit River watershed; however, water rarely spills from Goose Lake into the Pit River. The last recorded spill occurred in 1880 (Reclamation 2013a). Long-term average annual inflows into Shasta Lake are approximately 4.875 MAF between the mid-1940s and 2010.

The McCloud River watershed extends over approximately 402,000 acres (Reclamation 2013a). The McCloud River flows approximately 59 miles from the headwaters in Moosehead Creek located southeast of Mount Shasta, through McCloud Reservoir, and into Shasta Lake. McCloud Reservoir is operated primarily to generate hydroelectric power. The Pit River watershed extends over approximately 3,008,000 acres along the north and south forks of the Pit River basins and includes 21 named tributaries and numerous smaller tributaries (Reclamation 2013a). Pacific Gas and Electric Company operate several hydropower diversions and reservoirs within the Pit River watershed.

The Squaw Creek watershed extends over approximately 66,000 acres located to the east of Shasta Lake (Reclamation 2013a).

The Sacramento River extends approximately 40 miles from the headwaters to Shasta Lake downstream of the town of Delta (Reclamation 2013a). The basin extends into portions of Mount Shasta and the Trinity and Klamath mountains.

C.3.2 Clear Creek Watershed

The Clear Creek watershed is 238 square miles, extending from the Trinity Mountains to the confluence with the Sacramento River downstream of the City of Redding (DWR 1986a and Western Shasta Resource Conservation District [WSRCD] 2004). Hydrology in the watershed is divided into the upper 238-square mile watershed upstream of Whiskeytown Dam at River Mile 18.1, and the lower 49 square miles watershed downstream of the dam. Clear Creek flows approximately 17 miles from the Trinity Mountains into Whiskeytown Lake. Clear Creek continues for 18.1 miles downstream of Whiskeytown Lake into the Sacramento River downstream of the CVP Keswick Dam and south of the City of Redding.

C.3.2.1 *Whiskeytown Lake*

Whiskeytown Dam, a CVP facility constructed by 1963, is the only dam on Clear Creek and is located approximately 16.5 miles downstream of the headwaters (Reclamation 1997). Whiskeytown Lake, which is formed by the dam, has a storage capacity of 0.241 MAF and regulates runoff from Clear Creek and diversions from the Trinity River watershed. Flows from Lewiston Reservoir in the Trinity River watershed are diverted to Whiskeytown Lake through the Clear Creek Tunnel. Currently, the Clear Creek

Tunnel between Lewiston Reservoir and Whiskeytown Lake has a capacity of 3,200 cfs (Reclamation 2011b).

Water from Whiskeytown Lake is released to the Sacramento River through the Spring Creek Tunnel which conveys water to the Spring Creek Conduit, and then to Keswick Reservoir. Water from Whiskeytown Lake also is released into Clear Creek directly from Whiskeytown Lake; or during high flow conditions (e.g., flood flows), from a Glory Hole within Whiskeytown Lake through a conduit into Clear Creek. Most of the flows are released through the Spring Creek Tunnel and Powerplant to Keswick Reservoir. These flows into Keswick Reservoir provide cold water flows that reduce temperatures in the upper Sacramento River, especially during the fall months. Water also is discharged from Whiskeytown Lake to Clear Creek to provide for instream flows and water for users located in the CVP Clear Creek South Unit within, or adjacent to, the Clear Creek watershed.

The capacity of the outlet from Whiskeytown Dam that conveys water to Clear Creek is 1,240 cfs when the water elevation in Whiskeytown Lake is at 1,220.5 feet. To provide flows into Clear Creek in excess of 1,240 cfs, the Whiskeytown Reservoir water elevations need to be raised higher than 1,220 feet to allow water to flow through the Glory Hole spillway, as described below (CALFED Bay-Delta Program [CALFED] 2004; Reclamation 2009a).

Water storage volume and water storage elevations related to Whiskeytown Lake for Water Years 2001 through 2018 are presented on Figures C.3-1 and C.3-2 (DWR 2018g, 2018h). Whiskeytown Lake storage is relatively constant due to agreements between Reclamation and the National Park Service to maintain certain winter and summer lake elevations for recreation. Whiskeytown Lake outflow variations were greater prior to 2006 when Trinity River restoration flows were implemented which reduced the amount of water available for conveyance to CVP water users. In addition, hydrologic conditions in the years following 2006 were drier than the water years between 2001 and 2006.

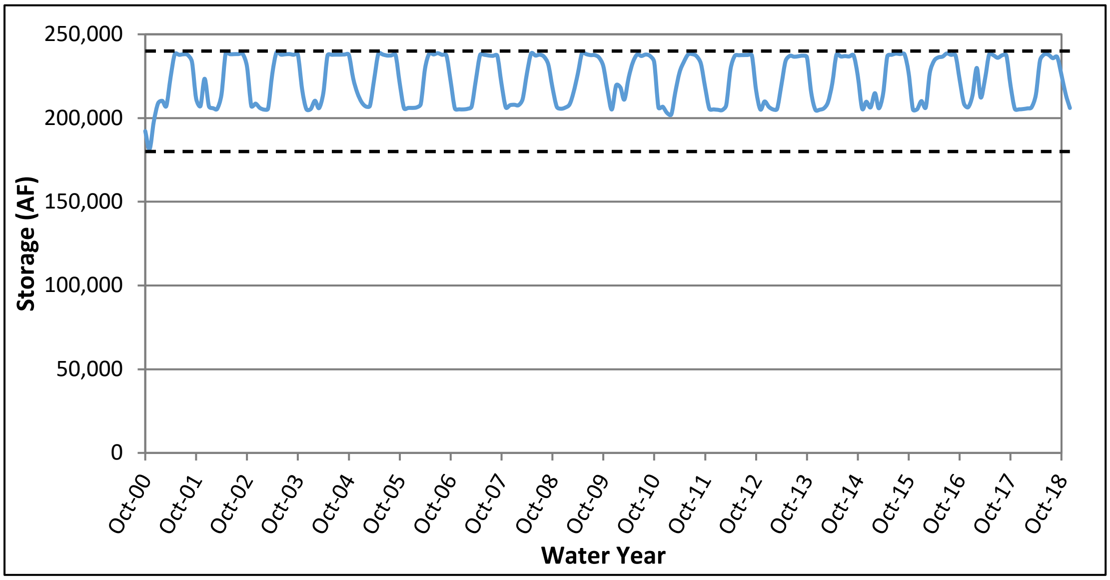

Figure C.3-1. Whiskeytown Lake Storage

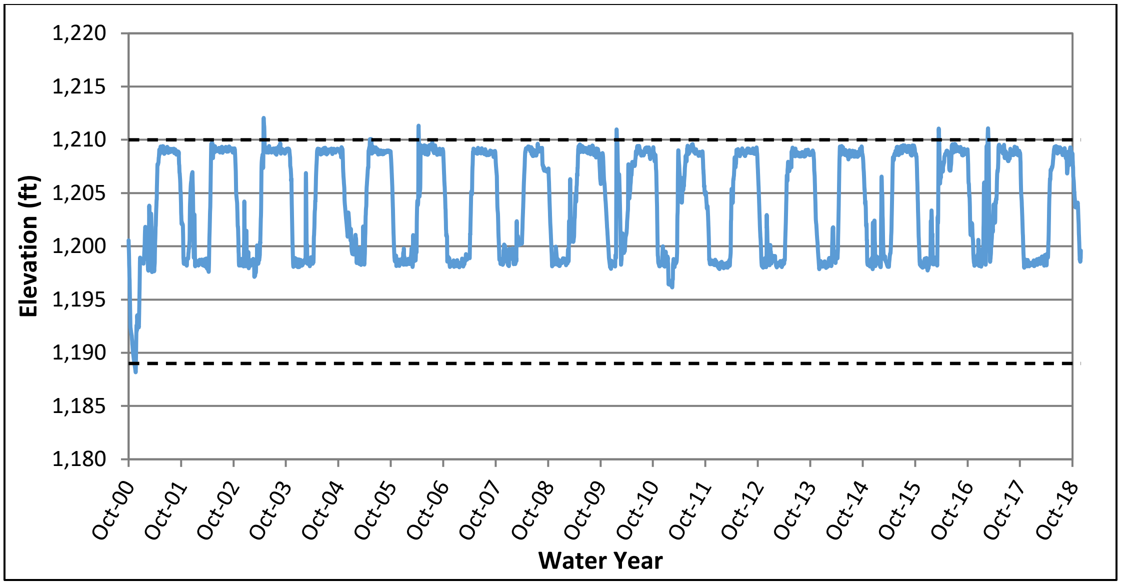

Figure C.3-2. Whiskeytown Lake Elevation

C.3.2.1.1 Whiskeytown Reservoir Operations

Whiskeytown Reservoir 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. Although it stores up to 241 TAF, this storage is held fairly constant from May through October in most years. Two fully functional water temperature curtains exist in Whiskeytown Reservoir. These curtains have been subject to repairs since their initial installation in 1993. The purpose of these curtains is to improve passage of cold source water through the reservoir during the warm months of the year for downstream cold-water needs (i.e., threatened and endangered fish). The Oak Bottom Temperature Control Curtain or OBTCC is located in the upstream portion of the reservoir and the Spring Creek curtain is located in front of the Spring Creek tunnel at the eastern end of Whiskeytown Reservoir.

C.3.2.1.2 Historic Spillway Flows below Whiskeytown Lake

Whiskeytown Lake storage is annually drawn down by approximately 35 TAF during the wet season (November through April) to assist in regulating excessive winter storm runoff. Heavy rainfall events occasionally result in glory hole discharges to Clear Creek, as shown in Table C.3-1, Days of Spilling below Whiskeytown and 40-30-30 Index from Water Year 1978 to 2012, below.

Table C.3-1. Days of Spilling below Whiskeytown and 40-30-30 Index from Water Year 1978 to 2012

Water Year	Days of Spilling	40-30-30 Index
1978	5	AN
1979	0	BN
1980	0	AN
1981	0	D
1982	63	W
1983	81	W
1984	0	W
1985	0	D

Water Year	Days of Spilling	40-30-30 Index
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
2003	8	AN
2004	0	BN
2005	0	AN
2006	4	W
2007	0	D
2008	0	C
2009	0	D
2010	6	BN
2011	0	W
2012	0	BN

Notes: W = Wet Year Water Year Type; AN = Above Normal Water Year Type; BN = Below Normal Water Year Type; D = Dry Water Year Type; and C = Critical Dry Water Year Type.

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.

C.3.2.2 *Clear Creek*

Substantial modifications of the Clear Creek stream channel occurred due to placer mining activities from the mid-1800s through the early 1900s. In addition, several irrigation diversions were constructed along the lower Clear Creek reach during the late 1800s and early 1900s. One of the largest diversions was the 15-foot-high, 200-foot-wide McCormick-Saeltzer Dam constructed in 1903 at River Mile 6.5 (approximately 12 miles downstream of Whiskeytown Dam). The downstream of Whiskeytown Dam was constructed upstream of a steep gorge along Clear Creek and removed in 2001. More recent channel modifications occurred in the lower Clear Creek due to gravel extraction activities from the 1950s to 1970s.

Construction of Whiskeytown Dam modified the hydraulics, gravel loading, and sediment transport in the lower Clear Creek. The overall average annual flow in the lower Clear Creek was reduced by 87 percent following construction of the dam (DWR 1984, 1986a). The dam also reduced gravel loading into the lower Clear Creek and the frequency of high flow events that move the gravel and remove fine sediments from riffles. This change in hydrology and loss of gravel loading adversely affected the salmonid habitat downstream of Whiskeytown Dam, including compaction of riffles with sand. Recently, minimum flow releases from Whiskeytown Lake into Clear Creek occur in accordance with Federal and state requirements (DWR 1984b). Historical flow data has been collected since 1941 at the Igo Gage at River Mile 10.9 (approximately 7.2 miles downstream of Whiskeytown Dam) (DWR 1986a and WSRCD 2004).

Since the early 1980s, numerous studies were conducted to evaluate methods to rehabilitate and/or restore habitat along lower Clear Creek. In the 1990s, additional studies were conducted following the adoption of the 1992 Central Valley Project Improvement Act (CVPIA). In 1998, a watershed management plan prepared by the WSRCD evaluated methods to achieve healthy fish populations, diverse biological habitats, recreational opportunities, clean and safe conditions for visitors, and protection of property rights developed by the Lower Clear Creek Coordinated Resource Management and Planning Group of local landowners, stakeholders, and agencies (WSRCD 1998). The recommendations included the following:

- Removal of the McCormick-Saeltzer Dam.
- Inject gravel downstream of Whiskeytown Dam and reconstruct gravel channels below McCormick-Saeltzer Dam to reduce stranding.
- Modify water release patterns from Whiskeytown Dam.
- Reduce exotic vegetation along Clear Creek.
- Reduce sands in Clear Creek through erosion control programs in the lower watershed.

This and other studies led to the formation of the Lower Clear Creek Floodway Rehabilitation Project that was implemented under CVPIA (CALFED 2004, WSRCD 2003). Initial actions under this program included gravel augmentation initiated in 1996, increase in Whiskeytown Dam releases initiated in 2001, removal of the McCormick-Saeltzer Dam in 2001, reconstruction and revegetation of the floodway, and reduction of watershed erosion.

Following the removal of the McCormick-Saeltzer Dam, extensive geomorphological studies have been conducted to recommend approaches for restoration of the channel and adjacent floodplain downstream of the McCormick-Saeltzer Dam site. Based upon hydrological data collected at the Igo gage, one of the studies discussed that peak flow events in lower Clear Creek following completion of Whiskeytown Dam occur about once every 3 years; although, the pre-dam frequency was approximately once every 2 years. Clear Creek flows at Igo between 2001 and 2018 are presented on Figure C.3-3 14 (DWR 2018i). High flow events: 1) naturally moved gravel placed downstream of Whiskeytown Dam and along Clear Creek; 2) developed and maintained Clear Creek channel and adjacent floodplain habitat for spring-run and fall-run Chinook Salmon and steelhead; 3) created and maintained deep pools in the channel to support spawning of spring-run Chinook Salmon and steelhead, and create appropriate salmonid habitat within and along Clear Creek; and 4) established and maintained nesting and foraging habitat for neotropical migrant birds, native resident birds, and amphibians.

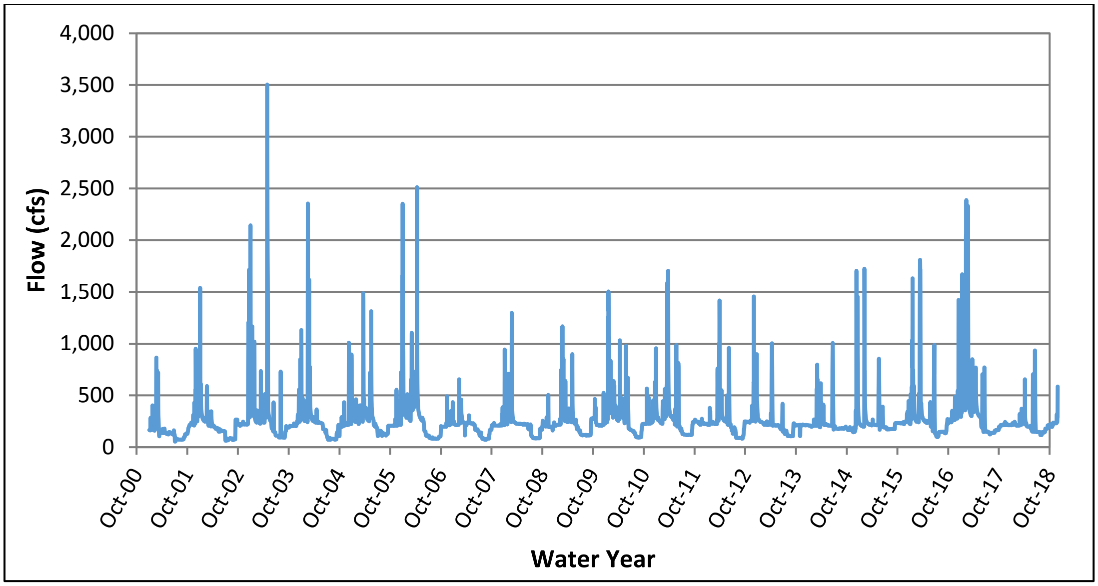

Figure C.3-3. Clear Creek Near Igo

Following removal of McCormick-Saeltzer Dam, the Clear Creek channel and adjacent floodplain geomorphology changed. The Clear Creek channel capacity is generally about 3,000 cfs. The 2004 studies indicated that flows in excess of 3,000 cfs are required to overflow from the Clear Creek channel onto the adjacent floodplains. The study discussed that during pre- and post-Whiskeytown periods, the 5-year flood event at Igo decreased from 9,000 to 3,400 cfs and the 2.5-year flood event decreased from 6,200 to 1,800 cfs. Therefore, the study discussed that flows in excess of 5,000 cfs did not occur more frequently than 3 times in 10 years (CALFED 2004).

C.3.2.2.1 Fish and Wildlife Requirements on Clear Creek

CVPIA (b)(2) operations and water rights permits issued by the SWRCB for diversions from Trinity River and Clear Creek specify minimum downstream releases from Lewiston and Whiskeytown Dams, respectively. The following agreements govern releases from Whiskeytown Lake:

- A 1960 Memorandum of Agreement (MOA) with CDFW established minimum flows to be released to Clear Creek at Whiskeytown Dam, as summarized in Table C.3-2, Minimum Flows at Whiskeytown Dam.
    - A 1963 release schedule for Whiskeytown Dam was developed with USFWS and implemented, but never finalized. Although this release schedule was never formalized, Reclamation has used this flow schedule for minimum flows since May 1963.
    - Water rights permit modification in 2002 that allowed release of water from Whiskeytown Lake into Clear Creek for the purposes of maintenance of fish and wildlife resources as provided for in Provision 2.1 of Instream Flow Preservation Agreement by and among Reclamation, USFWS, and CDFW, dated August 11, 2000.
    - Dedication of (b)(2) water on Clear Creek provides instream flows below Whiskeytown Dam greater than the minimum flows (that would have occurred under pre-CVPIA conditions). Instream flow objectives are usually taken from the Anadromous Fish Restoration Program, in consideration of spawning and incubation of fall-run Chinook Salmon. Augmentation in the summer months is usually in consideration of water temperature objectives for steelhead and in late summer for spring-run Chinook Salmon.

The 2009 NMFS *Biological Opinion* (BO) *Reasonable and Prudent Alternative* (RPA) (NMFS 2009) requires Reclamation to release spring attraction flows for adult spring-run Chinook Salmon (Action I.1.1) and channel maintenance flows in Clear Creek (Action I.1.2); and to continue gravel augmentation programs initiated under CVPIA. The spring attraction flows are to be released from Whiskeytown Lake into Clear Creek in at least two pulse flows of at least 600 cfs, each lasting at least 3 days, in May and June.

Under the 2009 NMFS BO RPA, the channel maintenance flows are to be released at a minimum flow of 3,250 cfs for 24 hours, which exceeds the 1,240 cfs capacity of the Whiskeytown Dam outlet to Clear Creek. This action is to occur seven times in a ten-year period. Therefore, to provide channel maintenance flows, the Whiskeytown Lake water elevation must be increased to provide flow of water over the Glory Hole inlet. The Glory Hole is designed to operate with the higher water elevations expected during flood events. However, during non- flood periods, raising the water elevations and operating the Glory Hole inlet can cause safety concerns for recreationists along the Whiskeytown Lake shoreline.

Table C.3-2. Minimum Flows at Whiskeytown Dam

Period	Minimum flow (cfs)
1960 MOA with CDFW	
January 1–February 28(29)	50
March 1–May 31	30
June 1–September 30	0
October 1–October 15	10
October 16–October 31	30
November 1–December 31	100
1963 USFWS Proposed Normal year flow	
January 1–October 31	50
November 1–December 31	100
1963 USFWS Proposed Critical year flow	
January 1–October 31	30
November 1–December 31	70
2002 Water Right Modification for Critical year flow	
January 1–October 31	50
November 1–December 31	70

C.3.2.2.2 Spring Creek Debris Dam Operations

The Spring Creek Debris Dam (SCDD) is a feature of the Trinity Division of the CVP. It was constructed to regulate runoff containing debris and acid mine drainage from Spring Creek, a tributary to the Sacramento River that enters Keswick Reservoir. The SCDD can store approximately 5.8 TAF of water. Operation of SCDD and Shasta Dam has allowed some dilution. In January 1980, Reclamation, CDFW, and SWRCB executed a Memorandum of Understanding (MOU) to implement actions that protect the Sacramento River system from heavy metal pollution from Spring Creek and adjacent watersheds.

The MOU states that Reclamation agrees to operate to dilute releases from SCDD (according to the criteria and schedules provided), provided that such operation would not cause flood control parameters on the Sacramento River to be exceeded and would 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, CDFW and RWQCB also collect and analyze samples on an as-needed basis. Due to more extensive monitoring, improved sampling and analysis techniques, and continuing cleanup efforts in the Spring Creek drainage basin, Reclamation now operates SCDD to target the more stringent Central Valley Region Water Quality Control Board Plan (CVRWQCB 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 CVRWQCB Basin Plan standards of 0.0056 milligrams per liter (mg/L) dissolved copper and 0.016 mg/L dissolved zinc. Release rates are estimated from a mass balance calculation of the copper and zinc in the debris dam release and in the river.

In order to minimize the build-up of metal concentrations in the Spring Creek arm of Keswick Reservoir, releases from the debris dam are coordinated with releases from the Spring Creek Power Plant to keep the Spring Creek arm of Keswick Reservoir in circulation with the main water body of Keswick Lake.

The operation of SCDD is complicated during major heavy rainfall events. SCDD reservoir can fill to uncontrolled spill elevations in a relatively short time period, anywhere from days to weeks. Uncontrolled spills at SCDD can occur during major flood events on the upper Sacramento River and also during localized rainfall events in the Spring Creek watershed. 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 SCDD. In this operational situation, high metal concentration loads during heavy rainfall are usually limited to areas immediately downstream of Keswick Dam because of the high runoff entering the Sacramento River, adding dilution flow. In the operational situation when Keswick releases are increased for flood control purposes, SCDD releases are also increased to reduce spill potential.

In the operational situation when heavy rainfall events would fill SCDD and Shasta Lake would 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 CVRWQCB 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.

C.3.3 Shasta and Sacramento River Divisions

C.3.3.1 *Facilities*

C.3.3.1.1 CVP Shasta Division

The Shasta Division includes Shasta Dam, Lake, and Power Plant; Keswick Dam, Reservoir, and Power Plant, and the Shasta Temperature Control Device. The CVP's Shasta Division includes facilities that conserve water in the Sacramento River for:

- Flood control
- Navigation maintenance
- Agricultural water supplies

- M&I water supplies
- Hydroelectric power generation
- Conservation of fish in the Sacramento River
- Protection of the Delta from intrusion of saline ocean water.

The CVP Shasta and Keswick dams are located at approximately Sacramento River Miles 308 and 299, respectively. Shasta Lake, a CVP facility on the Sacramento River formed by Shasta Dam, is located near Redding. Shasta Dam is located on the Sacramento River just below the confluence of the Sacramento, McCloud, and Pit Rivers. The dam regulates the flow from a drainage area of approximately 6,649 square miles. Shasta Dam was completed in 1945, forming Shasta Lake, which has a maximum storage capacity of 4.552 MAF. Water in Shasta Lake is released through or around the Shasta Power Plant 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.

Historical water storage volumes and water storage elevations for Shasta Lake for Water Years 2001 through 2018 are presented on Figures C.3-4 and C.3-5 (DWR 2018j, 2018k). Shasta Lake storage varies in accordance with upstream hydrology and downstream water demands and instream flow requirements. For example, storage declined during the drier years in 2008 and 2009.

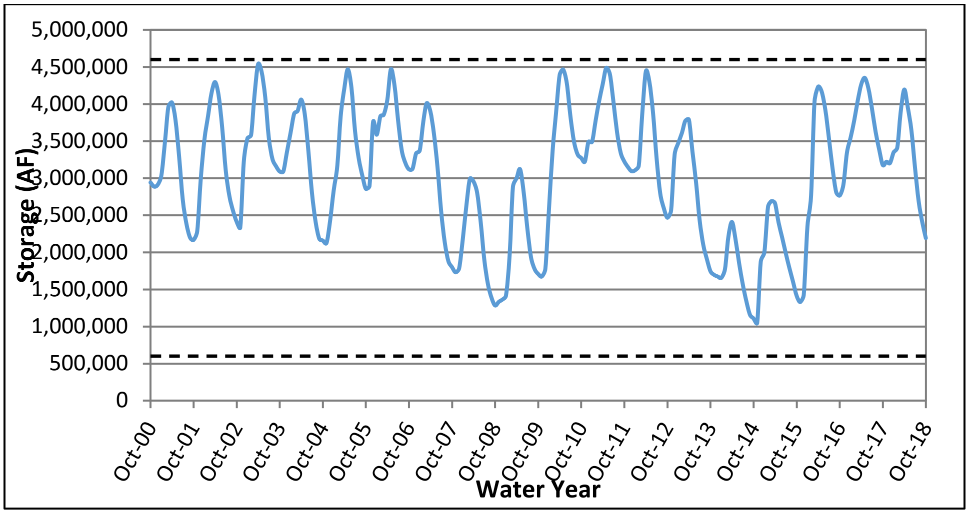

Figure C.3-4. Shasta Storage

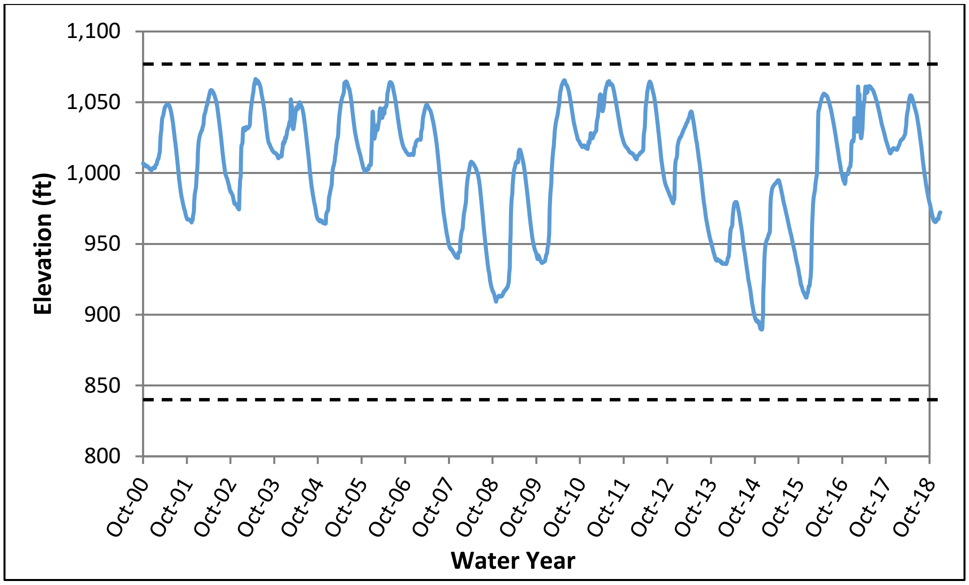

Figure C.3-5. Shasta Elevation

Keswick Reservoir was formed by the completion of Keswick Dam in 1950. It has a capacity of approximately 23.8 TAF and serves as an afterbay for releases from Shasta Dam and for discharges from the Spring Creek Power Plant. A temperature control device at Shasta Dam was constructed between 1996 and 1998 to provide cold water without power bypass to the Sacramento River downstream of Keswick Reservoir. All releases from Keswick Reservoir are made to the Sacramento River from Keswick Dam. The dam has a fish trapping facility that operates in conjunction with the Coleman National Fish Hatchery on Battle Creek.

The Keswick Reservoir water storage volume is more consistent throughout the year because this reservoir is used to regulate flow releases to the powerplant and other downstream uses and not to provide long-term water storage, as shown on Figures C.3-6 and C.3-7 (DWR 2018l, 2018m).

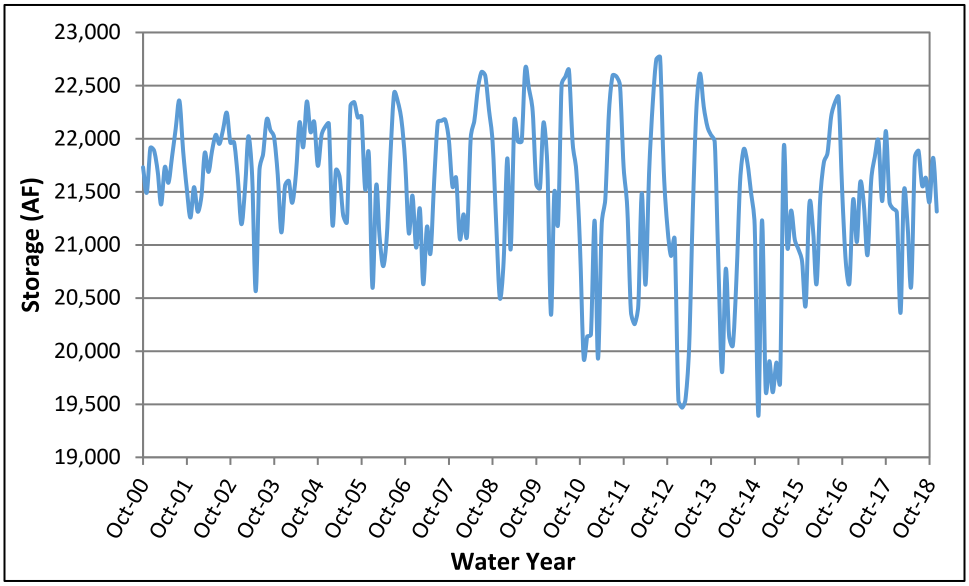

Figure C.3-6. Keswick Reservoir Storage

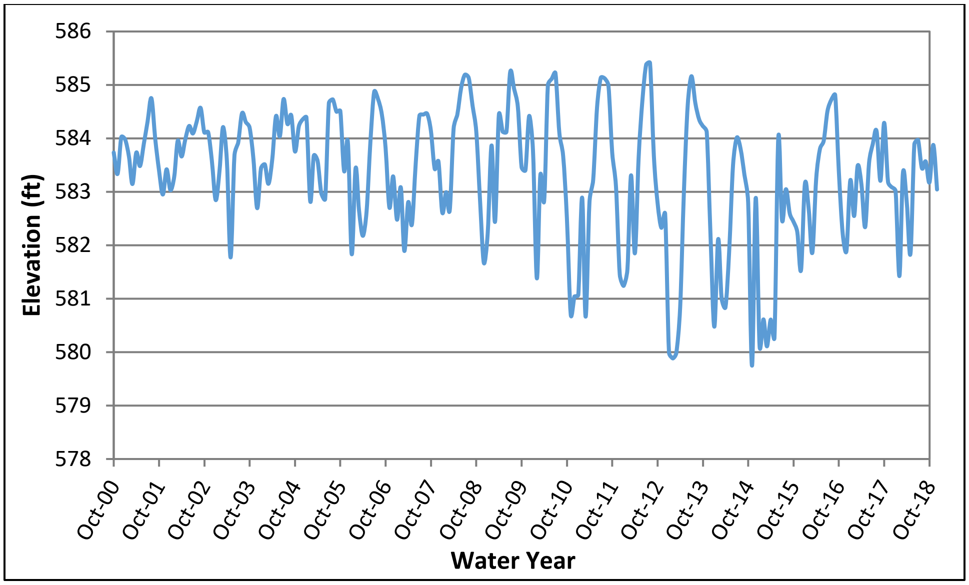

Figure C.3-7. Keswick Reservoir Elevation

C.3.3.1.2 CVP Sacramento River Division

The Sacramento River Division was authorized after completion of the Shasta Division. The Sacramento River Division 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 Pumping Plant, the Corning Pumping Plant, and the Corning and Tehama-Colusa Canals. Total authorized diversions for the Sacramento River Division are approximately 2.8 MAF. Historically the total diversion has varied from 1.8 MAF in a critically dry year to the full 2.8 MAF in a wet year, including diversions by Sacramento River Settlement contractors and CVP water service contractors. Sacramento River Settlement contractors divert water under their own water rights and through their own facilities.

The Sacramento Canals Unit was authorized to supply irrigation water to over 200,000 acres of land in the Sacramento Valley, principally in Tehama, Glenn, Colusa, and Yolo counties. Black Butte Dam, which is operated by the USACE, also provides supplemental water to the Tehama-Colusa Canals as it crosses Stony Creek. The operations of the Shasta and Sacramento River divisions are presented together because of their operational inter-relationships.

Sacramento River from Keswick Dam to the Delta

Water released from Shasta Dam travels approximately 245 miles over three to four days to the northern Delta boundary near Freeport (Reclamation 2013a). The upper reach of the Sacramento River flows for approximately 60 miles from Keswick Dam to Red Bluff; and the middle reach of the Sacramento River flows approximately 160 miles from Red Bluff to the confluence with the Feather River. The lower reach of the Sacramento River flows for approximately 20 river miles between the confluence with the Feather River and Freeport, immediately downstream of the confluence with the American River.

Moderately high releases (greater than 10,000 cfs) are typically sustained during the major irrigation season of June through September. Flows are released in the fall months from CVP and SWP reservoirs to meet water temperature criteria for winter-run Chinook Salmon spawning and incubation, to provide suitable habitat for spring-run and early returning fall-run Chinook Salmon, provide water supplies to rice farms for rice stubble decomposition, and to provide water for wildlife refuges.

Sacramento River from Keswick Dam to Red Bluff

The Sacramento River between Keswick Dam and the City of Red Bluff flows through the northern foothills of the Sacramento Valley. Flows are influenced by outflow from Keswick Reservoir and inflows from Clear Creek (described above); and Cow Creek, Bear Creek, Cottonwood Creek, Battle Creek, and Paynes Creek which provide 15 to 20 percent of the flows in this reach as measured at Bend Bridge. There are several moderate major diversions along the Sacramento River upstream of Red Bluff, including the CVP Wintu Pumping Plant to provide water for the Bella Vista Water District, and the Anderson-Cottonwood Irrigation District Diversion. Both of these diversions near Redding provide water to agricultural, municipal, and industrial water users (Reclamation 1997). No major storage or diversion structures have been constructed in the tributary watersheds in this reach of the Sacramento River, although several small diversions for irrigation, domestic use, and hydroelectric power generation are present (Reclamation 1997). Flow patterns on one major tributary in this reach, Battle Creek, are undergoing changes as the Battle Creek Salmon and Steelhead Restoration Project is implemented to restore ecological processes along 42 miles of Battle Creek and 6 miles of tributaries while minimizing reductions to hydroelectric power generation through the decommissioning of five powerplants.

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. An April 5, 1960 Memorandum of Agreement between Reclamation and CDFW originally established flow objectives in the Sacramento River for the protection and preservation of fish and wildlife resources. The agreement provided for minimum releases into the natural channel of the Sacramento River at Keswick Dam for normal and critically dry years. Since October 1981, Keswick Dam has operated based on a minimum release of 3,250 cfs for normal years from September 1 through the end of February, in accordance with an agreement between Reclamation and CDFW. This release schedule was included in SWRCB Order 90-05, which maintains a minimum release of 3,250 cfs at Keswick Dam and Red Bluff Pumping Plant from September through the end of February in all water years except critically dry years.

Generally, releases from Keswick Reservoir are implemented to comply with 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 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. Reclamation attempts to establish a base flow that minimizes release fluctuations to reduce impacts to fisheries and bank erosion from October through December.

Sacramento River from Red Bluff to the Delta

Between Red Bluff and Colusa, the Sacramento River is a meandering stream, migrating through alluvial deposits between widely spaced levees. From Colusa to the northern boundary of the Delta near Freeport, flows increase due to the addition of the Feather and American rivers flows.

Major streams entering the Sacramento River between Red Bluff and the Feather River include Antelope, Elder, Mill, Thomes, Deer, Stony, Big Chico, and Butte creeks. No major storage or diversion structures have been constructed on Antelope, Elder, Mill, and Thomes creeks, although several small seasonal diversions for irrigation, domestic use, and hydroelectric power generation are present (Reclamation 1997). Non-CVP and non-SWP diversion dams are located on Deer, Big Chico, and Butte creeks.

Stony Creek flows are controlled by East Park Dam, Stony Gorge Dam, and Black Butte Dam (Reclamation 1997). East Park and Stony Gorge reservoirs store surplus water for irrigation deliveries and are operated by Reclamation as part of the Orland Project which is independent of the CVP. Black Butte Dam is operated by USACE for flood control and irrigation supply. Black Butte Dam operations are coordinated with the CVP. The Glenn-Colusa Irrigation District (GCID) canal, which crosses Stony Creek downstream of Black Butte Dam, includes a seasonal gravel dam constructed across the creek on the downstream side of the canal.

The Sacramento River between Red Bluff and Chico Landing, the Sacramento River Flood Control Project has provided bank protection and incidental channel modification since 1958 (DWR 2013b). Between Chico Landing and Colusa, the flood management facilities consist of levees and overflow areas. Black Butte Reservoir regulates Stony Creek flood flows, which enter the Sacramento River downstream of Hamilton City. Right bank levees from Ord Ferry through Colusa prevent Sacramento River flood water from entering the Colusa Basin, except when flows exceed 300,000 cfs near Ord Ferry (DWR 2013b). Three flood relief weirs along the right bank, downstream of Chico Landing, allow flood flows to spill into the Butte Basin Overflow Area. The left bank levee begins midway between Ord Ferry and Butte City and extends south through Verona and includes the Moulton and Colusa weirs that allow flood flows to spill into the Butte Basin Overflow Area. The natural Sutter Basin overflow (Sutter Bypass) to the east of the Sacramento River and downstream of the Sutter Buttes was included in the Sacramento River Flood Control Project. The Sutter Bypass conveys floodwaters from the Butte Basin Overflow

Area, Butte Creek, Wadsworth Canal, and Reclamation Districts 1660 and 1500 drainage plants, state drainage plants, and Tisdale Weir to the confluence of the Sacramento and Feather rivers. Downstream of Colusa, Reclamation Districts 70, 108, and 787 pump flood waters from adjacent closed basin lands into the river.

The Colusa Basin Drain provides drainage for a large portion of the irrigated lands on the western side of the Sacramento Valley in Glenn, Colusa, and Yolo counties; and supplies irrigation water to lands in this area. Water from the drain is discharged to the Sacramento River through the Knights Landing Outfall, a gravity flow structure and prevents the Sacramento River from flowing into the Colusa Basin.

Recent mean daily flows in the Sacramento River at Bend Bridge (near Red Bluff), Vina Bridge (near Tehama), Hamilton City, Wilkins Slough (upstream of the Feather River confluence), Verona (downstream of the Feather River confluence), and Freeport (downstream of the American River Confluence and near the northern boundary of the Delta), are presented on Figures C.3-8 through C.3-13 (DWR 2018n, 2018o, 2018p, 2018q, 2018r, 2018s).

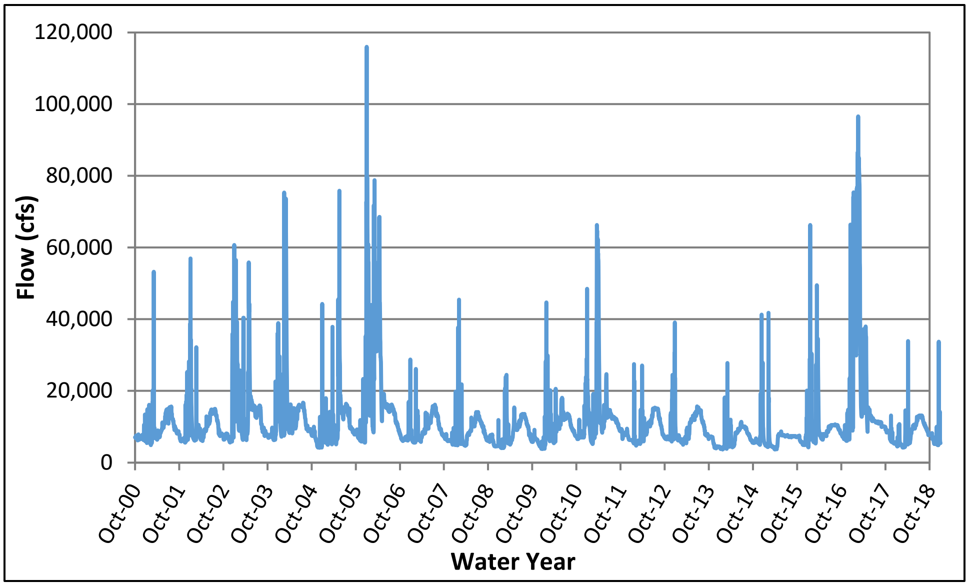

Figure C.3-8. Sacramento River at Bend Bridge

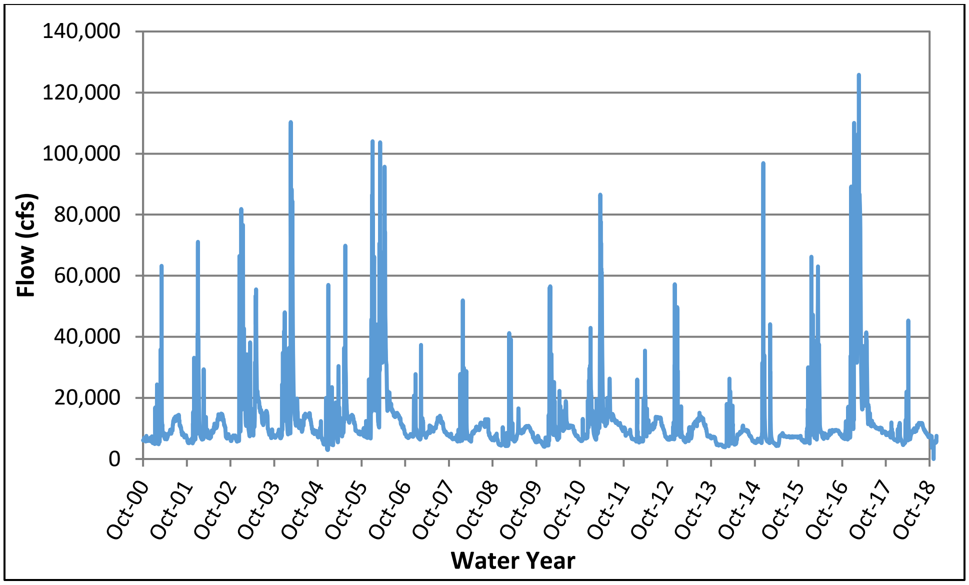

Figure C.3-9. Sacramento River at Vina Bridge

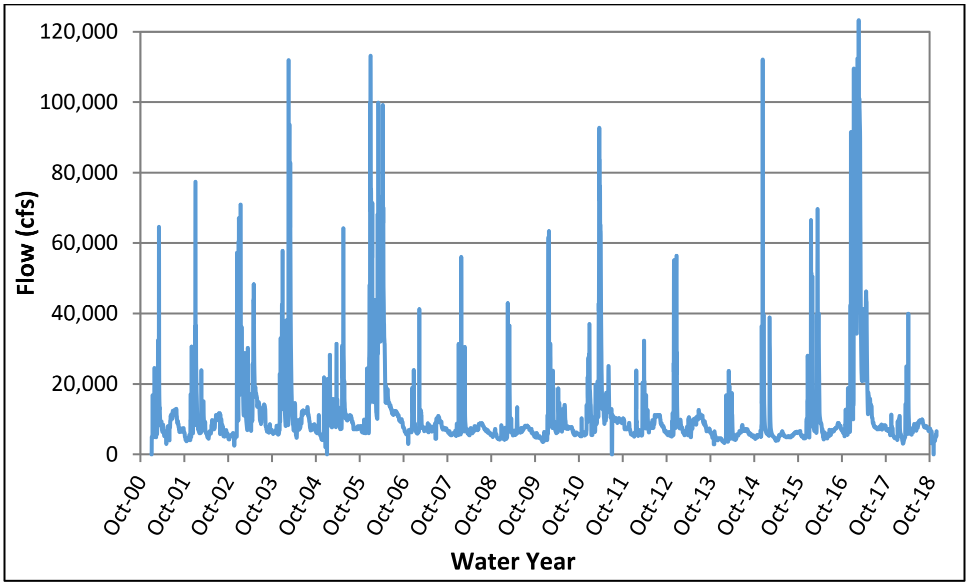

Figure C.3-10. Sacramento River at Hamilton City

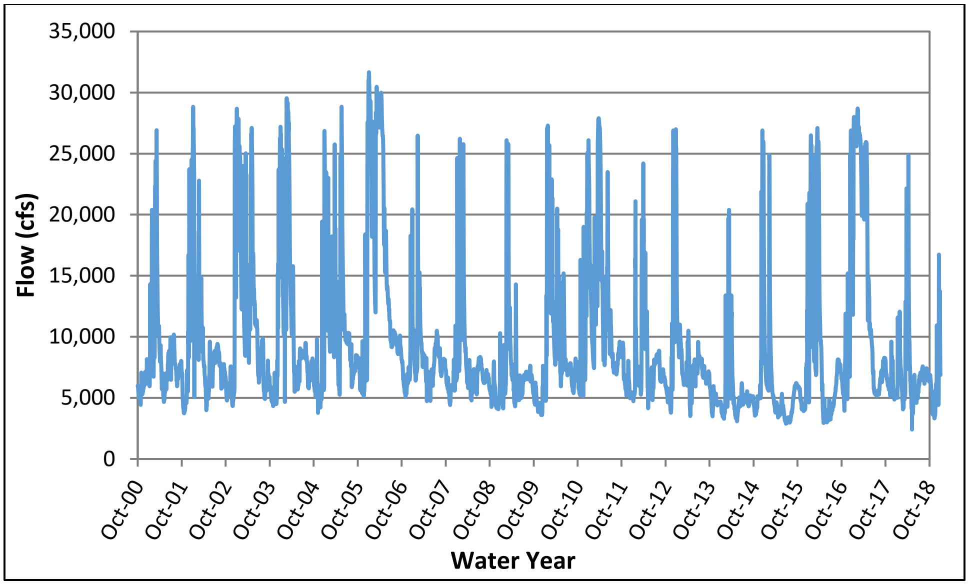

Figure C.3-11. Sacramento River at Wilkins Slough

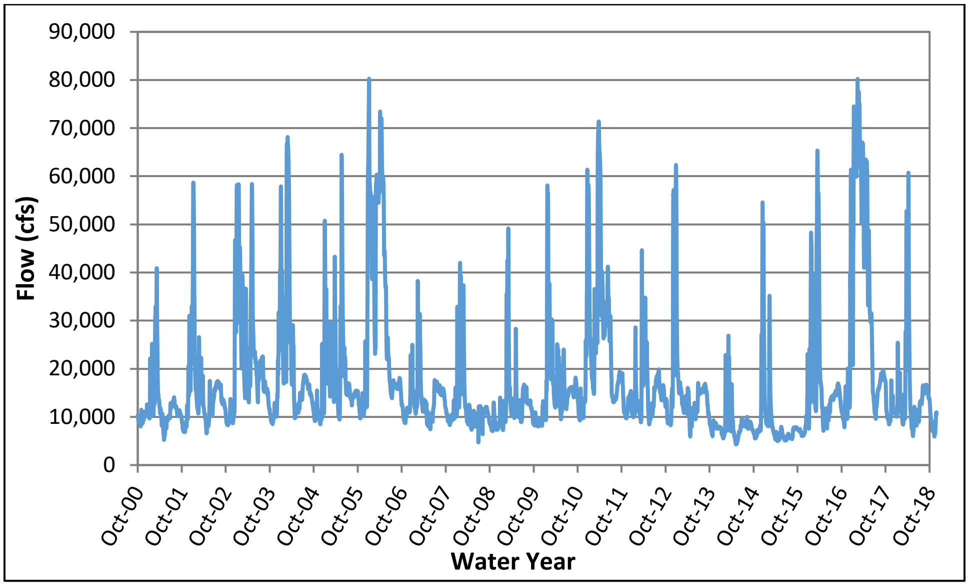

Figure C.3-12. Sacramento River at Verona

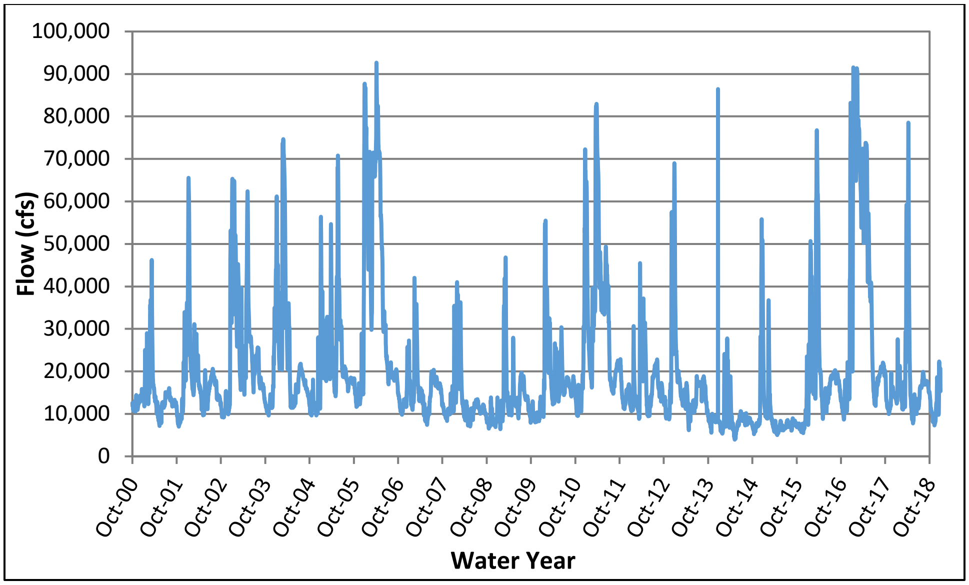

Figure C.3-13. Sacramento River at Freeport

Flows in the Sacramento River generally peak during winter and spring storm events. Upstream of Hamilton City, sharp increases in flow occur during rainfall events, such as events in February 2004, December 2005/January 2006, and January 2010. Downstream of Hamilton City, the high flow events occur over a longer period of time as water flows into the river from the tributaries.

Major Diversions

Major diversions in this reach of the Sacramento River include the CVP Red Bluff Pumping Plant, GCID intake, and individual diversions for the CVP Sacramento River Settlement Contractors.

The Red Bluff Pumping Plant was completed in August 2012 to improve fish passage conditions on the Sacramento River by removing the Red Bluff Diversion Dam, and to continue to divert water from the Sacramento River into the Tehama-Colusa and Corning canals. The facility includes a 1,118-foot-long flat-plate fish screen, intake channel, 2,500 cfs capacity pumping plant and discharge conduit to divert water from the Sacramento River into the Tehama-Colusa and Corning canals. In 2011, the dam gates were permanently placed in the open position for free migration of fish while ensuring continued water deliveries by way of the Red Bluff Pumping Plant.

The GCID Main Pump Station is located near Hamilton City to divert water into the GCID Canal that conveys water to over 130,000 acres, including the USFWS Sacramento National Wildlife Refuge; and terminates at the Colusa Basin Drain near Williams. In 2001, the GCID Fish Screen was completed in addition to several canal improvements to allow year-round water deliveries.

C.3.3.2 *CVP Shasta and Sacramento River Divisions Operations*

C.3.3.2.1 Flood Control

Flood control objectives for Shasta Lake require that releases be restricted to quantities that would 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 USACE pursuant to the provisions of the Flood Control Act of 1944. Maximum flood space reservation is 1.3 MAF, with variable storage space requirements based on an inflow parameter. Flood control operation at Shasta Lake requires forecasting runoff conditions into Shasta Lake and runoff conditions of unregulated creek systems downstream from Keswick Dam as far in advance as possible. A critical element of upper Sacramento River flood operations is the local runoff entering the Sacramento River between Keswick Dam and Bend Bridge.

The unregulated creeks (major creek systems are Cottonwood Creek, Cow Creek, and Battle Creek) in this reach of the Sacramento River can be very sensitive to a large rainfall event and produce high rates of runoff into the Sacramento River in short time periods. During large rainfall and flooding events, the local runoff between Keswick Dam and Bend Bridge can exceed 100,000 cfs.

The travel time required for release changes at Keswick Dam to affect Bend Bridge flows is approximately 8 to 10 hours. If the total flow at Bend Bridge is projected to exceed 100,000 cfs, the release from Keswick Dam is decreased to maintain Bend Bridge flow below 100,000 cfs. As the flow at Bend Bridge is projected to recede, the Keswick Dam release is increased to evacuate water stored in the flood control space at Shasta Lake. Changes to Keswick Dam releases are scheduled to minimize rapid fluctuations in the flow at Bend Bridge.

The flood control criteria for Keswick releases specify that releases should not be increased more than 15,000 cfs or decreased more than 4,000 cfs in any 2-hour period. The restriction on the rate of decrease is intended to prevent sloughing of saturated downstream channel embankments caused by rapid reductions in river stage. In rare instances, the rate of decrease may have to be accelerated to avoid exceeding critical flood stages downstream.

C.3.3.2.2 Fish and Wildlife Requirements in the Sacramento River

Historical Perspective

Reclamation operates the Shasta, Sacramento River, and Trinity River divisions of the CVP to meet (to the extent possible) the provisions of SWRCB Order 90-5. An April 5, 1960, MOA between Reclamation and CDFW 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 (Table C.3-3, Minimum Flow Requirements and Objectives (cfs) on the Sacramento River below Keswick Dam). Since October 1981, Keswick Dam has operated based on a minimum release of 3,250 cfs for normal years from September 1 through the end of February, in accordance with an agreement between Reclamation and CDFW. This release schedule was included in SWRCB Order 90-05, which maintains a minimum release of 3,250 cfs at Keswick Dam and Red Bluff Pumping Plant from September through the end of February in all water years except critically dry years.

Dedication of (b)(2) water on the Sacramento River provided instream flows below Keswick Dam greater than those that would have occurred under pre-CVPIA conditions, e.g. the fish and wildlife requirements specified in SWRCB Order 90-5 and the temperature criteria formalized in the 1993 NMFS winter-run Chinook Salmon BO as the base (NMFS 1993). Instream flow objectives from October 1 to April 15 (typically April 15 is when water temperature objectives for winter-run Chinook Salmon become the determining factor) were usually selected to minimize dewatering of redds and provide suitable habitat for salmon spawning, incubation, rearing, and migration.

Table C.3-3. Minimum Flow Requirements and Objectives (cfs) on the Sacramento River below Keswick Dam

Period	MOA	Water Rights 90-5	MOA and Water Rights 90-5
Water Year Type	Normal	Normal	Critically Dry
January 1–February 28(29)	2,600	3,250	2,000
March 1–March 31	2,300	2,300	2,300
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
December 1–December 31	2,600	3,250	2,000

MOA = Memorandum of Agreement; cfs = cubic feet per second

The 1960 MOA between Reclamation and CDFW provides that releases from Keswick Dam (from September 1 through December 31) are made with minimum water level fluctuation or change to protect salmon to the extent compatible with other operations requirements.

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 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 would meet flow needs. Reclamation attempts to establish a base flow that minimizes release fluctuations to reduce impacts to fisheries and bank erosion from October through December.

The Connelly-Areias-Chandler Rice Straw Burning Reduction Act of 1991 changed agricultural water diversion practices along the Sacramento River and has affected Keswick Dam release rates in the fall. This program is generally known as the Rice Straw Decomposition and Waterfowl Habitat Program. Prior to this change, the preferred method of clearing fields of rice stubble was to systematically burn it. Today, rice field burning has been phased out due to air quality concerns and has been replaced in some areas by a program of rice field flooding that decomposes rice stubble and provides additional waterfowl habitat. The result has been an increase in water demand to flood rice fields in October and November, which has increased the need for higher Keswick releases in all but the wettest of fall months.

C.3.3.2.3 Minimum Flow for Navigation as Measured at Wilkins Slough

Historical commerce on the Sacramento River resulted in a CVP authorization to maintain minimum flows of 5,000 cfs at Chico Landing to support navigation in accordance with references to Sacramento River Division operations in the River and Harbors Act of 1935 and the Rivers and Harbors Act of 1937. Currently, there is no commercial traffic between Sacramento and Chico Landing, and USACE 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 and cannot easily divert when lower river elevations occur with lower flows. 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 and use of screened diversions.

At flows below 5,000 cfs at Wilkins Slough, diverters have reported increased pump cavitation as well as greater pumping head requirements. Diverters are able to operate for extended periods at flows as low as 4,000 cfs at Wilkins Slough, but pumping operations become severely affected and some pumps become inoperable at flows lower than this. Flows may drop as low as 3,500 cfs for short periods while changes are made in Keswick releases to reach target levels at Wilkins Slough.

C.3.3.2.4 Water Temperature Operations in the Upper Sacramento 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 Power Plant. The temperature of water released from Shasta Dam and the Spring Creek Power Plant 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. Water temperature in the upper Sacramento River is governed by current water rights permit requirements.

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 stated that Reclamation shall operate Keswick and Shasta Dams and the Spring Creek Power Plant to meet a daily average water temperature of 56°F as far downstream in the Sacramento River as practicable during periods when higher temperature would be harmful to fisheries. The optimal control point is the Red Bluff Pumping Plant.

Under the orders, the water temperature compliance point may be modified when the objective cannot be met at Red Bluff Pumping Plant. In addition, SWRCB Order 90-05 modified the minimum flow requirements initially established in the 1960 MOA for the Sacramento River below Keswick Dam. The water right orders also recommended the construction of a Shasta Temperature Control Device (TCD) to improve the management of the limited cold-water resources.

Pursuant to SWRCB Orders 90-05 and 91-01, Reclamation configured and implemented the Sacramento-Trinity Water Quality Monitoring Network to monitor temperature and other parameters at key locations in the Sacramento and Trinity Rivers. 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, NMFS, USFWS, CDFW, Western, DWR, and the Hoopa Valley Indian Tribe.

Each year, with finite cold-water resources and competing demands usually an issue, the Sacramento River Temperature Task Group devise 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 SWRCB issued the orders, those plans have included modifying the Red Bluff Pumping Plant compliance point to make best use of the cold-water resources based on the location of spawning Chinook Salmon. These modifications occurred in 2012. Reports are submitted periodically to SWRCB over the temperature control season defining our temperature operation plans. SWRCB has overall authority to determine if the plan is sufficient to meet water right permit requirements.

C.3.3.2.5 Fish and Wildlife Requirements

The 2009 NMFS BO RPA Action I.2.1 requires Reclamation to achieve the following carryover storage performance measures for Shasta Lake to maintain the cold-water volume needed to meet downstream temperature requirements:

- 87 percent of the years: 2,200 TAF end-of-September storage

- 82 percent of the years: 2,200 TAF end-of-September storage and 3,800 TAF end-of-April storage in following year
- 40 percent of the years: 3,200 TAF end-of-September storage

The 2009 NMFS BO RPA requires Reclamation to achieve the following temperature requirements over a ten-year running average.

- 95 percent of the years: Clear Creek temperature compliance
- 85 percent of the years: Ball's Ferry temperature compliance
- 40 percent of the years: Jelly's Ferry temperature compliance
- 15 percent of the years: Bend Bridge temperature compliance

From November through February, if the end-of-September storage in Shasta Lake is equal to or greater than 2,400 TAF by October 15, Reclamation is required to work with NMFS, and CDFW to develop a release schedule that would consider the need to maintain flood control space in Shasta Lake (which results in a maximum storage of 3,250 TAF at the end-of-November), and the need to provide stable Sacramento River flows and elevations during this period. If the end-of-September storage in Shasta Lake is between 1,900 and 2,400 TAF, a monthly release schedule for this period must be developed to consider maintaining Keswick Reservoir releases between 3,250 and 7,000 cfs; flows to support fall-run Chinook Salmon in accordance with the CVPIA AFRP guidelines; and provide for conservative Keswick Reservoir releases in drier years. If end-of-September storage in Shasta Lake is less than 1,900 TAF, Keswick Reservoir releases are reduced to 3,250 cfs in early October unless the flows are needed for temperature compliance, and if needed, reduce discretionary deliveries; and develop projected monthly deliveries for the period to maintain releases of 3,250 cfs, and if needed, reduce CVP and SWP Delta exports to meet Delta outflow and other legal requirements.

From April 15 through May 15, water temperatures are to be maintained at 56° F between Ball's Ferry and Bend Bridge. In addition, in March, Reclamation uses projections of CVP water availability, based upon a 90 percent forecast, to project the ability to meet temperature compliance at Ball's Ferry and achieve an end-of September storage in Shasta Lake of 2,200 TAF. If the projections indicate that only one of the objectives can be met, releases from Keswick Reservoir would be reduced to 3,250 cfs unless another release pattern is agreed upon with NMFS. The release pattern would consider actions to maintain monthly average flows for Reclamation's non-discretionary delivery obligations; provide flows for the biological needs of spring life stages of species addressed in the 2009 NMFS BO; and approaches, including reductions in Delta exports, to meet Delta outflow and other legal requirements while not reducing Keswick Reservoir releases. If the projections indicate that the Clear Creek temperature compliance point or the 1,900 TAF end-of-September Shasta Lake storage cannot be met, Reclamation would develop a plan to manage the cold-water pool in Whiskeytown Reservoir and Shasta Lake through several operational changes, including a reduction in the Wilkins Slough flow criteria (discussed above) to 4,000 cfs.

For operations from May 15 through October, Reclamation would develop a Temperature Management Plan to achieve temperatures of 56° F or less at compliance locations between Ball's Ferry and Bend Bridge.

C.3.3.2.6 Shasta Temperature Control Device

Construction of the TCD at Shasta Dam was completed in 1997. This device is designed for greater flexibility in managing the cold-water reserves in Shasta Lake while enabling hydroelectric power generation to occur and to improve salmon habitat conditions in the upper Sacramento River. The TCD is also designed to enable selective release of water from varying lake levels through the power plant in order to manage and maintain adequate water temperatures in the Sacramento River downstream of Keswick Dam.

Prior to construction of the Shasta TCD, Reclamation released water from Shasta Dam's low-level river outlets to alleviate high water temperatures during critical periods of the spawning and incubation life stages of the winter-run Chinook Salmon stock. 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. Releases through the low-level outlets bypass the power plant and result in a loss of hydroelectric generation at the Shasta Power Plant.

The seasonal operation of the TCD is generally as follows: during mid-winter and early spring the highest possible elevation gates are utilized to draw from the upper portions of the lake to conserve deeper colder resources. During late spring and summer, the operators begin the seasonal progression of opening deeper gates as Shasta Lake elevation decreases and cold-water resources are utilized. In late summer and fall, the TCD side gates are opened to utilize the remaining cold-water resource below the Shasta Power Plant elevation in Shasta Lake. Table C.3-4, Shasta Temperature Control Device Gates with Elevation and Storage, shows TCD gates with associated elevations and storages.

Table C.3-4. Shasta Temperature Control Device Gates with Elevation and Storage

TCD Gates	Shasta Elevation with 35 feet of Submergence (feet)	Shasta Storage (MAF)
Upper Gates	1,035	~3.65
Middle Gates	935	~2.50
Pressure Relief Gates	840	~0.67
Side Gates	720*	~0.01

*Low level intake bottom
TCD = Temperature Control Device; MAF = million acre-feet

The seasonal progression of the Shasta TCD operation is designed to maximize the conservation of cold-water resources deep in Shasta Lake, until the time the resource is of greatest management value for fishery management purposes. Recent operational experience with the Shasta TCD has demonstrated significant operational flexibility improvement for cold water conservation and upper Sacramento River water temperature and fishery habitat management purposes. Recent operational experience has also demonstrated the Shasta TCD has significant leaks that are inherent to TCD design. Also, operational uncertainties cumulatively impair the seasonal performance of the Shasta TCD to a greater degree than was anticipated in previous analysis and modeling used to describe long-term Shasta TCD benefits.

C.3.3.2.7 CVPIA 3406 (b)(2) on the Upper Sacramento River

Dedication of (b)(2) water on the Sacramento River provides instream flows below Keswick Dam greater than those that would have occurred under pre-CVPIA conditions, e.g., the fish and wildlife requirements specified in SWRCB Order 90-5 and the temperature criteria formalized in the 1993 NMFS winter-run Chinook Salmon BO (NMFS 1993) as the base. Instream flow objectives from October 1 to April 15 (typically April 15 is when water temperature objectives for winter-run Chinook Salmon become the determining factor) are usually selected to minimize dewatering of redds and provide suitable habitat for salmonid spawning, incubation, rearing, and migration.

C.3.3.3 *Anderson-Cottonwood Irrigation District Diversion Dam*

Anderson Cottonwood Irrigation District (ACID) holds senior water rights and has diverted into the ACID Canal for irrigation along the west side of the Sacramento River between Redding and Cottonwood since 1916. The United States and ACID signed a contract providing for Project water service and agreement on diversion of water. ACID diverts to its main canal (on the right bank of the river) from a diversion dam located in Redding about 5 miles downstream from Keswick Dam.

Close coordination between Reclamation and ACID is required for regulation of river flows to ensure safe operation of ACID's diversion dam during the irrigation season. The irrigation season for ACID runs from April through October. Keswick release rate decreases required for the ACID operations are limited to 15 percent in a 24-hour period and 2.5 percent in any one hour. Therefore, advance notification is important when scheduling decreases to allow for the installation or removal of the ACID diversion dam.

C.3.3.4 *Tehama-Colusa Canal Authority Operations*

The intake for the Tehama-Colusa Canal and the Corning Canal is located on the Sacramento River approximately 2 miles southeast of Red Bluff. Water is diverted through fish passage facilities along the Sacramento River and lifted by a 2,500 cfs pumping plant into a settling basin for continued conveyance in the Tehama-Colusa Canal and the Corning Canal. Reclamation operates the pumping plant in accordance with BOs issued by USFWS and NMFS specifically for the Red Bluff Pumping Plant.

The Tehama-Colusa Canal is a lined canal extending from the settling basin 111 miles south from the Red Bluff Pumping Plant and provides irrigation service on the west side of the Sacramento Valley in Tehama, Glenn, Colusa, and northern Yolo counties. Construction of the Tehama-Colusa Canal began in 1965, and it 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 provide water to the CVP contractors in Tehama County that could not be served by gravity from the Tehama-Colusa Canal. The Tehama-Colusa Canal Authority (TCCA) operates both the Tehama-Colusa and Corning canals.

C.3.4 Feather River Watershed

The Feather River, with a drainage area of 3,607 square miles on the east side of the Sacramento Valley, is the largest tributary to the Sacramento River below Shasta Dam (Reclamation 1997, DWR 2007a). The Feather River enters the Sacramento River from the east at Verona. The total flow is provided by the Feather River and tributaries, which include the Yuba and Bear rivers.

C.3.4.1 *Lower Yuba River*

The Yuba River watershed extends over 1,339 square miles in the Sierra Nevada. The Yuba River is a major tributary to the Feather River, and historically has contributed over 40 percent of the lower Feather River flows (Reclamation 1997). The major reservoir in the watershed is the 970-TAF New Bullards Bar Reservoir that is owned and operated by the Yuba County Water Agency to provide flood control, water storage, and hydroelectric generation (Yuba County Water Agency [YCWA] 2012). The Yuba River watershed also includes over 400 TAF additional storage in reservoirs located upstream of New Bullards Bar Reservoir.

Water is diverted from New Bullards Bar Reservoir through the Colgate Tunnel and Powerhouse and discharged into the Yuba River. The 70-TAF Englebright Lake is formed by the Harry L. Englebright Dam downstream of New Bullards Dam. Englebright Lake was constructed by the California Debris Commission to trap and store sediment from historical hydraulic mining sites in the upper watershed and provide recreation and hydroelectric generation opportunities (USACE 2013). Following decommissioning of the California Debris Commission in 1986, administration of Englebright Dam and Lake was assumed by USACE (USACE 2012, 2013, 2014). Major water diversions from the Yuba River occur 12.5 miles downstream of Englebright Dam at Daguerre Point Dam. Water transfers have occurred between Yuba County Water Agency and other water agencies, including CVP and SWP water users, since 2008 under the Lower Yuba River Accord (Lower Yuba River Accord, River Management Team 2013).

C.3.4.2 *Oroville Complex*

DWR holds contracts with 29 public agencies in Northern, Central, and Southern California for water supplies from the SWP. Water stored in the Lake Oroville facilities, along with excess water available in the Delta, is captured in the Delta and conveyed through several facilities to SWP water contractors.

The SWP is operated to provide flood control, meet Delta requirements and provide water for agricultural, M&I, recreational, and environmental purposes. Water is stored in Lake Oroville and released to serve three Feather River area water contractors and two water contractors served from the NBA, and 24 SWP contractors in the SWP service areas in the south San Francisco Bay Area, San Joaquin Valley, and Southern California. In addition to exporting portions of water released from Lake Oroville, the Clifton Court/Banks Pumping Plant complex diverts natural surplus flow available in the Delta. Water exported at Banks PP is conveyed into storage at San Luis Reservoir or is delivered directly to SWP member agencies south of the Delta via the California Aqueduct and its associated facilities.

C.3.4.2.1 Facilities

Oroville Dam and its related facilities comprise a multipurpose complex. The reservoir stores winter and spring runoff, which is released into the Feather River to meet the Project's needs, Delta requirements, and fish and wildlife protection. The Oroville Complex also provides power generation (including pumpback operations) flood control storage, and recreation opportunities.

The Oroville Project creates a lake with a maximum surface area of 15,810 acres, has a total storage capacity of 3,538 TAF, 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 MAF. Historical water storage volumes and water storage elevations for Lake Oroville for Water Years 2001 through 2018 are presented on Figures C.3-14 and C.3-15 (DWR 2018t, 2018u).

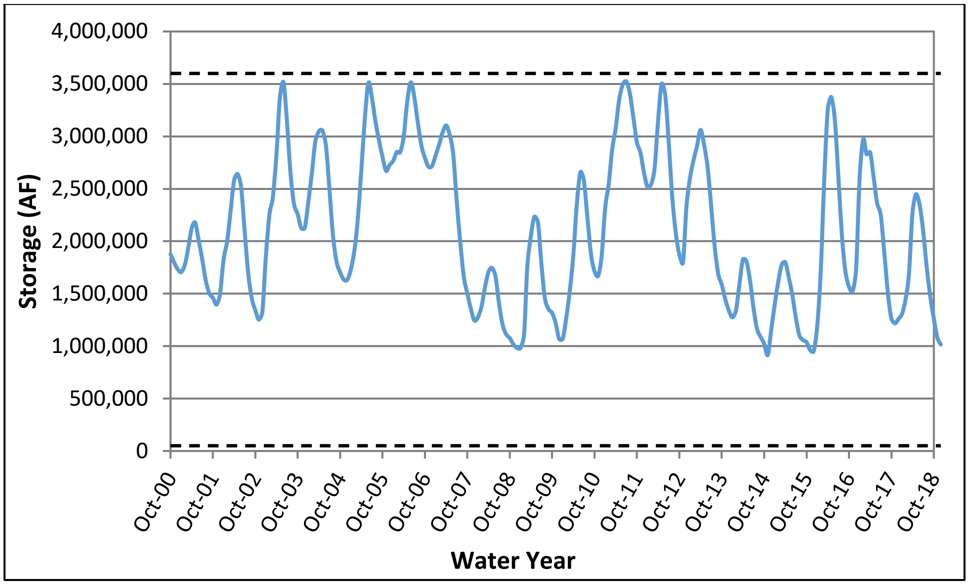

Figure C.3-14. Lake Oroville Storage

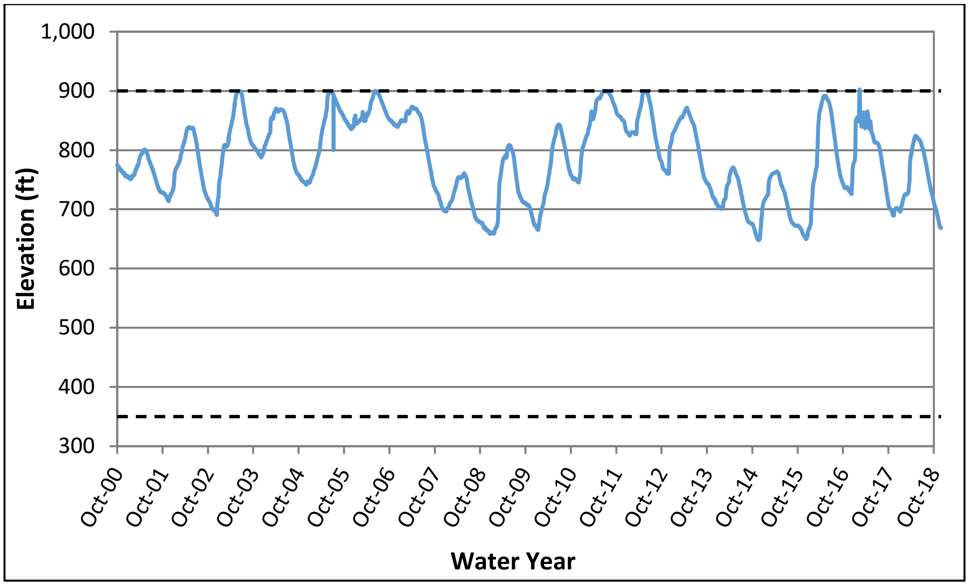

Figure C.3-15. Lake Oroville Elevation

A maximum of 16,950 cfs can be released through the Edward Hyatt Power Plant, located underground near the left abutment of Oroville Dam. Three of the six units are conventional generators driven by vertical-shaft, Francis-type turbines. The other three are motor-generators coupled to Francis-type, reversible pump turbines. The latter units allow pumped storage operations. The intake structure has an overflow type shutter system that determines the level from which water is drawn.

Approximately 4 miles downstream of Oroville Dam and Edward Hyatt Power Plant 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. Water storage volumes and water storage elevations for Thermalito Reservoir for Water Years 2001 through 2018 are presented on Figures C.3-16 and C.3-17 (DWR 2018v, 2018w).

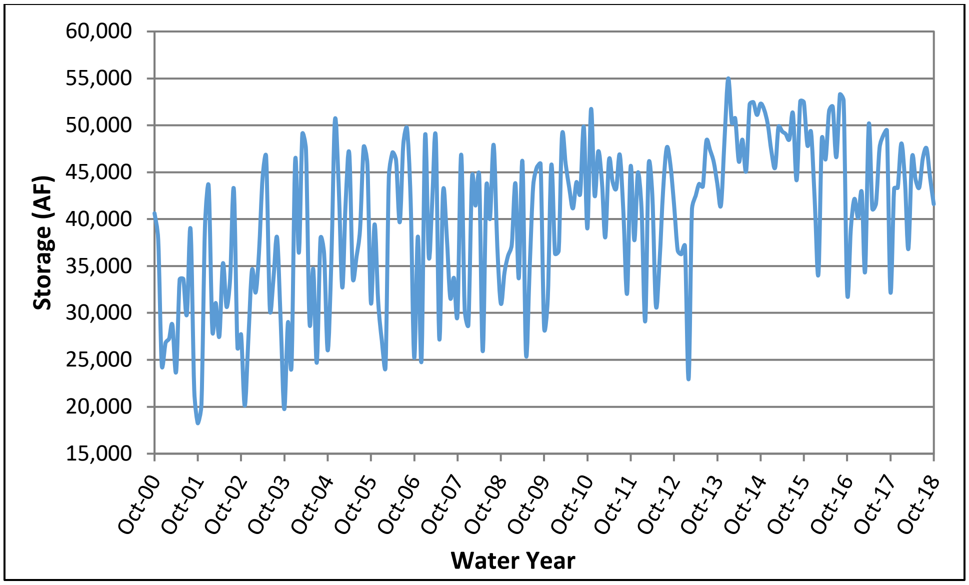

Figure C.3-16. Thermalito Reservoir Storage

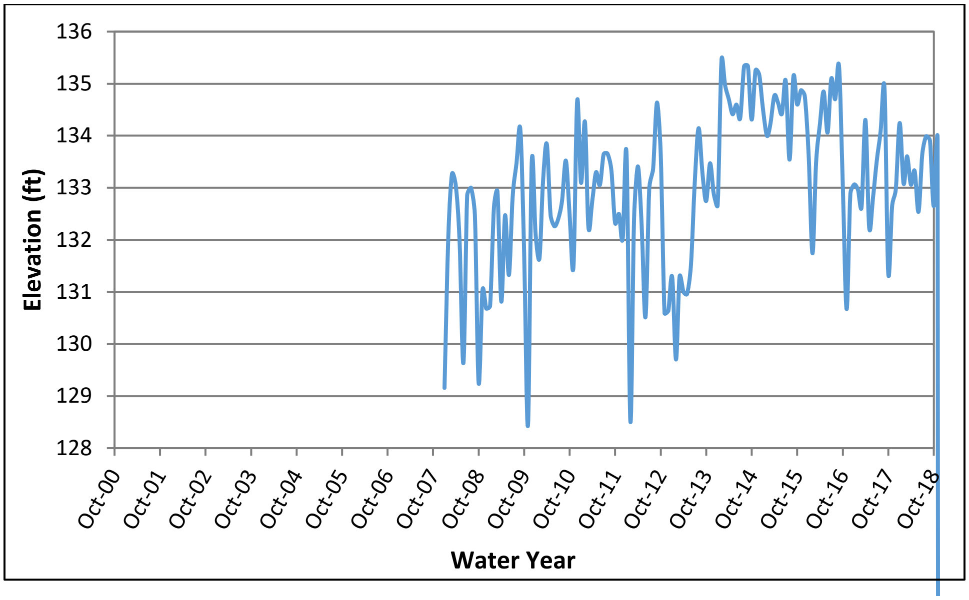

Figure C.3-17. Thermalito Reservoir Elevation

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 (Thermalito Diversion Pool) for Edward Hyatt Power Plant. 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 Power Plant, with a capacity of 615 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 TAF), which is the off-stream regulating reservoir for Thermalito Power Plant.

Thermalito Power Plant is a generating-pumping plant operated in tandem with the Edward Hyatt Power Plant. Energy prices and availability have historically been the two main factors that determine if pumpback operations are desirable for economic benefits. Pumpback operations typically occurred during off-peak hours when energy prices are lower. However, due to recent changes in the energy market (i.e. solar power contributions) and a desire to reduce operational stress on aging infrastructure, pumpback operations have been very infrequent in recent history. The Oroville Thermalito Complex has a capacity of approximately 17,000 cfs through the power plants. Water is returned to the Feather River via the Thermalito Afterbay river outlet.

Five agricultural districts divert water directly from the Thermalito Afterbay under the terms of water right settlement agreement with DWR. The diversion facilities replace the historic river diversion used by the local districts prior to the construction of the Thermalito Complex. The total capacity of afterbay diversions during peak demands is 4,050 cfs.

Feather River mean daily flows from Water Years 2001 through 2018 are presented in Figure C.3-18 (DWR 2018x).

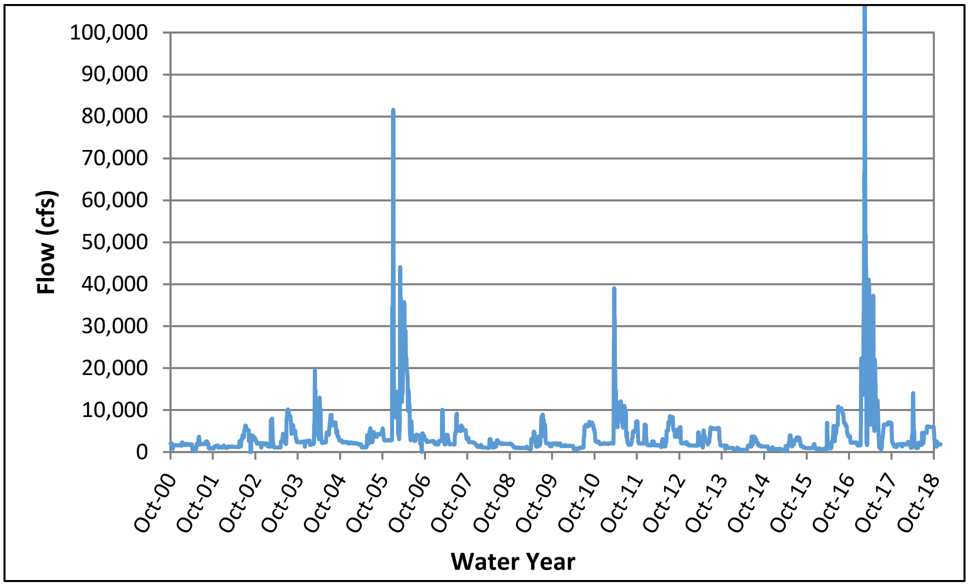

Figure C.3-18. Feather River Near Gridley

The Feather River Fish Hatchery (FRFH) provides mitigation for the construction of Oroville Dam, rears Chinook Salmon and steelhead and is operated by CDFW. Both indirect and direct take resulting from FRFH operations will be authorized through Section 4(d) of the Endangered Species Act through NMFS-approved Hatchery and Genetic Management Plans (HGMPs). DWR and CDFW are jointly preparing HGMPs for the spring and fall-run Chinook Salmon and steelhead production programs at the Feather River Fish Hatchery.

C.3.4.2.2 Flow Requirements

DWR maintains a minimum flow of 600 cfs within the Feather River Low Flow Channel as required by the 1983 CDFW Agreement (except during flood events when minimum flows are governed by USACE’s Water Control Manual and under certain other conditions as described in the 1984 Federal Energy Regulatory Commission [FERC] order). Downstream of the Thermalito Afterbay Outlet, in the High Flow Channel per the license and the 1983 CDFW Agreement, minimum releases for flows in the Feather River are 1,000 cfs from April through September and 1,700 cfs from October through March, when the April-to-July unimpaired runoff in the Feather River is greater than 55 percent of normal. When the April-to-July unimpaired runoff is less than 55 percent of normal, the minimum flow requirements are 1,000 cfs from March to September and 1,200 cfs from October to February. The 1983 CDFW

Agreement also states that if the April 1 runoff forecast in a given year indicates that the reservoir level would be drawn down to 733 feet, water releases for fish may be reduced, but not by more than 25 percent.

In addition, according to the 1983 Agreement, during the period of October 15 to November 30, if the average highest 1-hour flow of combined releases exceeds 2,500 cfs, then the minimum flow must be no lower than 500 cfs less than that flow through the following March 31 (with the exception of flood management, accidents, or maintenance.) In practice, flows are maintained below 2,500 cfs from October 15 to November 30 to prevent spawning in the overbank areas.

Flow Change Rates

Maximum allowable ramp-down release requirements are intended to prevent rapid reductions in water levels that could potentially cause dewatering and stranding of juvenile salmonids and other aquatic organisms. Ramp-down release requirements to the Low Flow Channel during periods outside of flood management operations, and to the extent controllable during flood management operations, are shown in Table C.3-5, Lower Feather River Ramping Rates.

Table C.3-5. Lower Feather River Ramping Rates

Releases to the Feather River Low Flow Channel (cfs)	Rate of Decrease (cfs)
5,000 to 3,501	1,000 per 24 hours
3,500 to 2,501	500 per 24 hours
2,500 to 600	300 per 24 hours

Source: NMFS 2004.

C.3.4.2.3 Water Temperature Requirements

The temperature of the water released from Oroville Dam is in accordance with the temperature requirements for the FRFH, under the August 1983 CDFW Agreement titled Concerning the Operation of the Oroville Division of the State Water Project for Management of Fish and Wildlife, and the 2004 NMFS Biological Opinion for Robinson Riffle, while also conserving the cold-water pool in Lake Oroville.

Water is withdrawn from Lake Oroville at depths that provide sufficiently cold water to meet the FRFH and Robinson Riffle temperature targets. The reservoir depth from which water is released initially determines the river temperatures, but atmospheric conditions, which fluctuate from day to day, influence downstream river temperatures. In order to conserve the cold-water pool during dry years, DWR strives to meet the Robinson Riffle temperatures by increasing releases to the low flow channel rather than releasing colder water.

DWR has taken various other temperature management actions to achieve the water temperature requirements, including curtailing pumpback operations, removing shutters at the intakes of the Hyatt Pumping-Generating Plant, releasing flow through the river valves (for FRFH only), and increasing flows at the Thermalito Diversion Dam to the Low Flow Channel (for Robinson Riffle only).

DWR plans to manage its cold-water storage and its intake shutters to avoid the need for flows through the river valve in order to meet its temperature obligations. Other than local diversions, outflow from the Oroville Project is released to the Feather River at the Low Flow Channel and Thermalito Afterbay.

Temperature Requirements for Robinson Riffle

The 2004 NMFS Biological Opinion for Robinson Riffle requires DWR to provide water temperatures at Robinson Riffle at or lower than 65 degrees Fahrenheit (maximum allowable daily average) from June 1 through September 30. There is no Robinson Riffle requirement from October 1 through May 30.

Temperature Requirements for FRFH

The 1983 Agreement requires DWR to provide suitable Feather River water temperatures for salmon on a year-round basis. Current FRFH intake water temperatures, as required by the 1983 CDFW and DWR Agreement are shown in Table C.3-6, Feather River Fish Hatchery Temperature Requirements.

Table C.3-6. Feather River Fish Hatchery Temperature Requirements

Period of Year	Temperature (°F)
April 1–May 15	51 (±4°F Allowed)
May 16–May 31	55 (±4°F Allowed)
June 1–June 15	56 (±4°F Allowed)
June 16–August 15	60 (±4°F Allowed)
August 16–August 31	58 (±4°F Allowed)
September 1–September 30	52 (±4°F Allowed)
October 1–November 30	51 (±4°F Allowed)
December 1–March 31	No greater than 55

C.3.4.2.4 Flood Control

Flood control operations at Oroville Dam are conducted in accordance with the requirements set forth by USACE. The Federal Government shared the expense of Oroville Dam, which provides up to 750 TAF of flood control space. For the 2018/2019 flood season, variable flood management storage based on dry and wet ground conditions will be used. Flood control storage ranges from 412,000 acre-feet (elevation 872.8 feet) to 920,000 acre-feet (elevation 835.5 feet) through February as dictated by the enhanced flood control diagram shown in Figure C.3-19. Elevations taper up to the 1970 Water Control Manual (WCM) elevations at the end of March, and then the refill period starts.

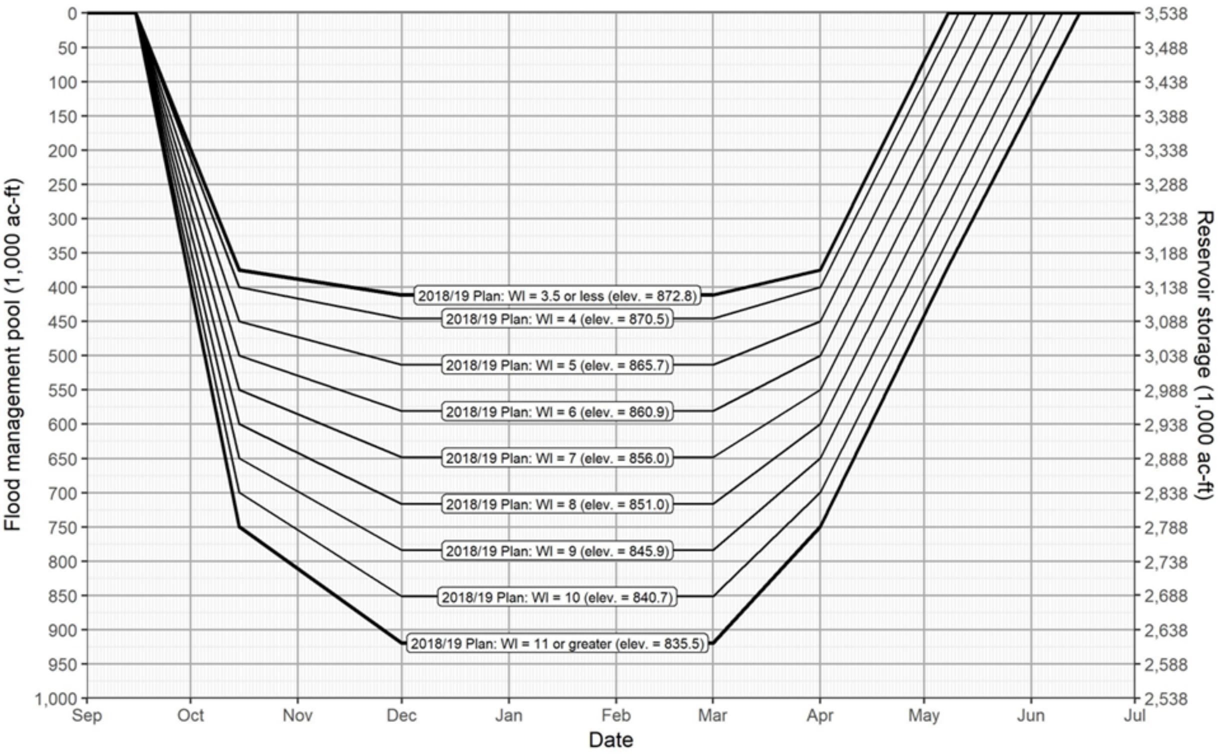

Figure C.3-19. Oroville Dam Flood Control Diagram

The spillway is located on the right abutment of the dam and has two separate elements: a controlled gated outlet and an emergency uncontrolled spillway. The gated control structure releases water to a concrete-lined chute that extends to the river. The uncontrolled emergency spill flows over a recently completed concrete apron.

C.3.4.2.5 Federal Energy Regulatory Commission Relicensing of the Oroville Project

The original FERC license to operate the Oroville Project expired in January 2007. Since 2007, annual license renewals have been issued, requiring DWR to operate to the original FERC license conditions. The new FERC license has not yet been adopted by the Commission. Until a new license for the Oroville Project is issued by FERC, DWR will continue to operate the Oroville facilities in accordance with the current (original) license conditions.

C.3.5 Yolo Bypass

Flows from the Sacramento River, Feather River, Sutter Bypass, and Natomas Cross Canal join upstream of Verona on the Sacramento River. When the Sacramento River flows exceed 62,000 cfs, flows spill over the Fremont Weir into the Yolo Bypass. The Yolo Basin was a natural overflow area located to the west of the Sacramento River. The Sacramento River Flood Control Project modified the basin by confining the extent of overflow through a leveed bypass and allowing flood flows to enter the Yolo Bypass from the Sacramento River over the Fremont and Sacramento weirs. The Yolo Bypass conveys floodwaters around the Sacramento metropolitan area and reconnects to the Sacramento River at Rio Vista (DWR 2013b). Tributaries within the Yolo Bypass include the Cache Creek Detention Basin, Willow Slough, and Putah Creek.

Flows also enter the Yolo Bypass from the Colusa Basin, including from the Colusa Basin Drain through the Knights Landing Ridge Cut. In 2011 and 2012, construction at the outfall gates required water from the Colusa Basin Drain to be diverted into the Yolo Bypass. These events temporarily resulted in a fall pulse flow in the Yolo Bypass that increased the volume of flow by more than 300 to 900 percent (Frantzich 2014).

Mean daily flows into the Yolo Bypass at Fremont Weir are presented on Figure C.3-20 (DWR 2018y). Between 2002 and 2018, flows have entered the Yolo Bypass at Fremont Weir during 19 periods, including:

- January 2002 – spill continued for 7 days with flows up to 30,000 cfs
    - January 2003 – spill continued for 6 days with flows up to 22,000 cfs
    - May 2003 – spill continued for 1 day with flows up to 100 cfs
    - January 2004 – spill continued for 3 days with flows up to 3,000 cfs
    - February 2004 – spill continued for 20 days with flows up to 79,000 cfs
    - May 2005 – spill continued for 4 days with flows up to 35,000 cfs
    - January/February 2006 (2 events) – spill continued for a total of 37 days with flows up to 205,000 cfs
    - March/April/May 2006 – spill continued for 65 days with flows up to 96,000 cfs
    - January 2010 – spill continued for 4 days with flows up to 5,000 cfs
    - December 2010 – spill continued for 4 days with flows up to 9,000 cfs
    - March/April 2011 – spill continued for 24 days with flows up to 85,000 cfs
    - December 2012 – spill continued for 5 days with flows up to 26,000 cfs
    - March 2016 – spill continued for 10 days, with flows up to 62,000 cfs
    - December 2016 – spill continued for 4 days, with flows up to 27,000 cfs
    - January 2017 – spill continued for 62 days, with flows up to 180,000 cfs
    - March 2017 – spill continued for 12 days, with flows up to 177,000 cfs
    - April/May 2017 – spill continued for 25 days, with flows up to 41,000 cfs
    - April 2018 – spill continued for 3 days with flows up to 16,000 cfs

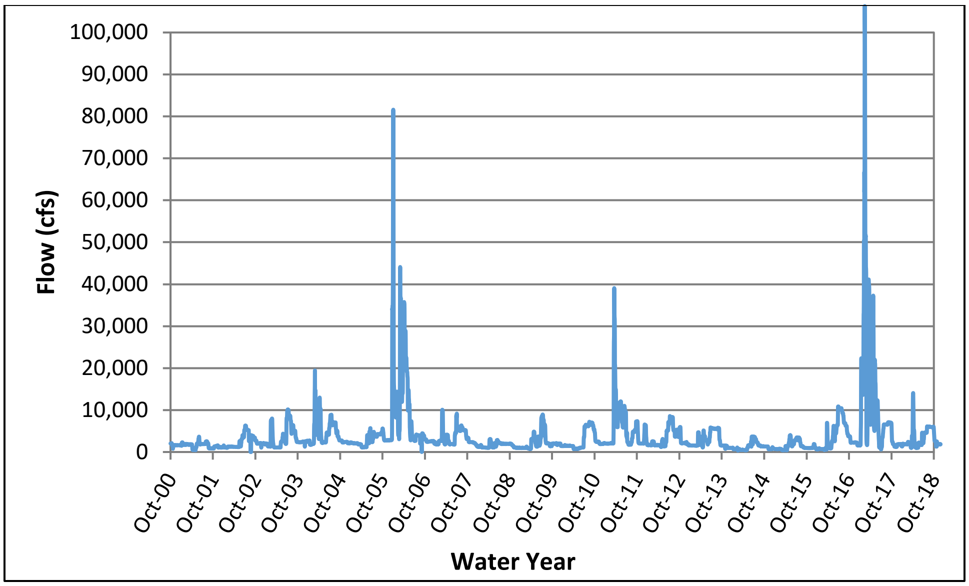

Figure C.3-20. Yolo Bypass over Fremont Weir

Reclamation is currently working on the Yolo Bypass Fish Passage Improvement Project.

C.3.6 American River from Folsom Lake to Sacramento River

The American River watershed extends over 1,895 square miles and contributes approximately 15 percent of the flow in the lower Sacramento River.

C.3.6.1 *Facilities*

The American River Division includes facilities that provide storage and conveyance of water on the American River for flood control, fish and wildlife protection, recreation, protection of the Delta from intrusion of saline ocean water, irrigation and M&I water supplies, and hydroelectric power generation. Initially authorized features of the American River Division included Folsom Dam, Lake, and Power Plant; Nimbus Dam and Power Plant, and Lake Natoma.

C.3.6.1.1 Upper American River Basin

Although Folsom Reservoir is the main storage and flood control reservoir on the American River, numerous other small non-federal reservoirs in the upper basin provide hydroelectric generation and water supply. None of the upstream reservoirs have any specific flood control responsibilities but Placer County Water Agency (PCWA) and SMUD reservoirs are considered to provide flood storage space when they have it. The total upstream reservoir storage above Folsom Reservoir is approximately 820 TAF. Ninety percent of this upstream storage is contained by five reservoirs: French Meadows (136 TAF); Hell Hole (208 TAF); Loon Lake (76 TAF); Union Valley (271 TAF); and Ice House (46 TAF). Reclamation has agreements with the operators of some of these reservoirs to coordinate operations for releases.

French Meadows and Hell Hole reservoirs, located on the Middle Fork of the American River, are owned and operated by PCWA. The PCWA provides wholesale water to agricultural and urban areas within Placer County. For urban areas, PCWA operates water treatment plants and sells both wholesale raw water and treated water to municipalities that provide retail delivery to their customers. The cities of Rocklin and Lincoln receive water from PCWA, Loon Lake, and Union Valley and Ice House reservoirs on the South Fork of the American River, are all operated by the Sacramento Municipal Utilities District (SMUD) for hydropower purposes.

C.3.6.1.2 Folsom Dam and Reservoir

Reclamation's Folsom Reservoir, the largest reservoir in the American River watershed, has a capacity of 967 TAF. Folsom Dam, located approximately 30 miles upstream from the confluence with the Sacramento River, is operated as a major component of the CVP. The facility serves water to M&I users in Placer and Sacramento counties.

Table C.3-7, Annual Water Deliveries- American River Division, provides Reclamation's annual water deliveries for the period 2000 through 2010 in the American River Division. The totals reveal an increasing trend in water deliveries over that period. For this EIS under the No Action Alternative, the American River Division water demands are modeled assuming that water users can utilize their full contract/agreement values with average annual deliveries of about 800 TAF per year. The American River contractors are not currently using this volume, but it is anticipated that due to fast growth and new water agreements, the actual usage (as projected by their Urban Water Management Plans) could increase to about 650 to 800 TAF/year over the next 10 years, depending upon growth rates and implementation of water demand reduction measures.

Table C.3-7. Annual Water Deliveries- American River Division

Year	Water Delivery (TAF)*
2000	174
2001	223
2002	221
2003	270
2004	266
2005	297
2006	280
2007	113
2008	233
2009	260
2010	125
2011	269
2012	279

Notes:
* Annual water delivery data has been enhanced and the annual totals include CVP contracts, water rights (including water rights for the City of Sacramento), and other deliveries (e.g. Folsom South Canal losses)
TAF = thousand acre-feet

C.3.6.1.3 Nimbus Dam and Lake Natoma

Nimbus Dam creates Lake Natoma, a forebay built to re-regulate flows of the American River and to direct water into the CVP Folsom South Canal. Releases from Nimbus Dam to the American River pass through the Nimbus Powerplant when releases are less than 5,000 cfs or the spillway gates for higher flows. The American River flows 23 miles between Nimbus Dam and the confluence with the Sacramento River. Water storage volumes and water storage elevations for Folsom Lake and Lake Natoma for Water Years 2001 through 2018 are presented on Figures C.3-21 through C.3-24 (DWR 2018z, 2018aa, 2018ab, 2018ac). Mean daily flows in American River at Fair Oaks, downstream of Nimbus Dam are presented in Figure C.3-25 (DWR 2018ad).

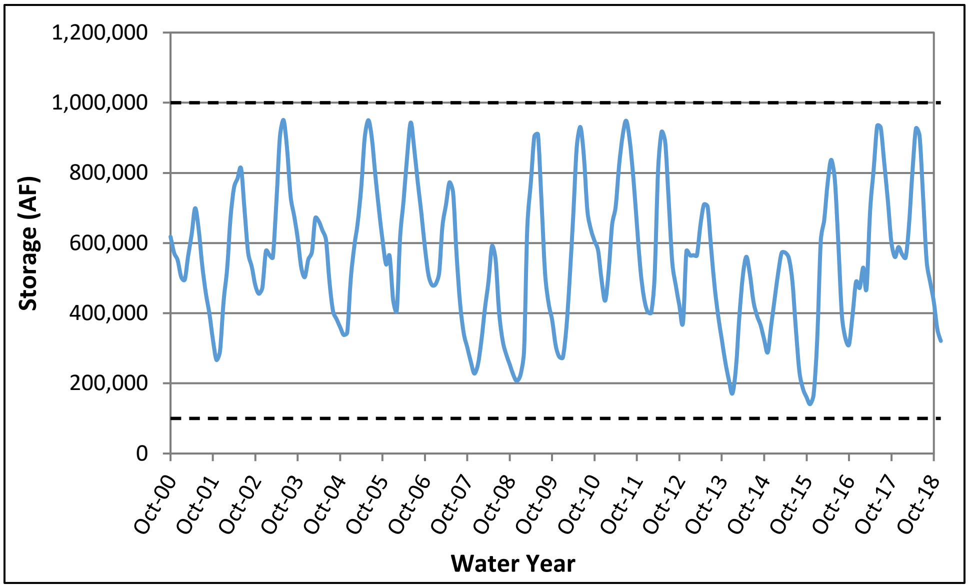

Figure C.3-21. Folsom Lake Storage

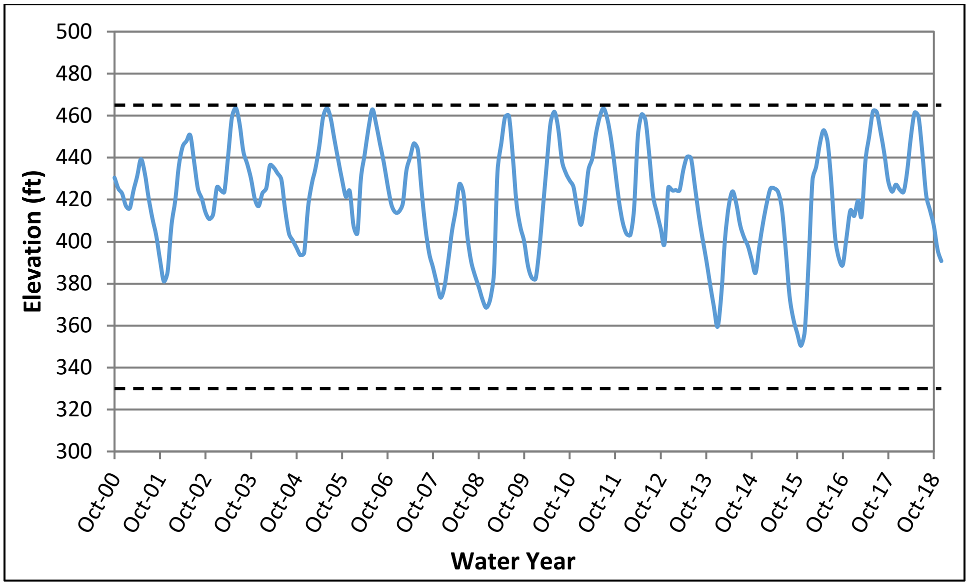

Figure C.3-22. Folsom Lake Elevation

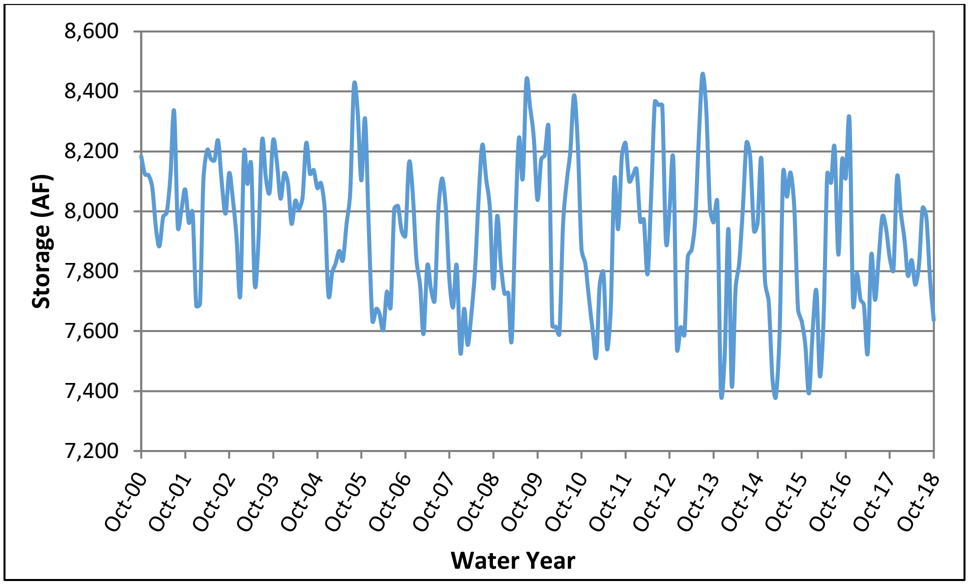

Figure C.3-23. Lake Natoma Storage

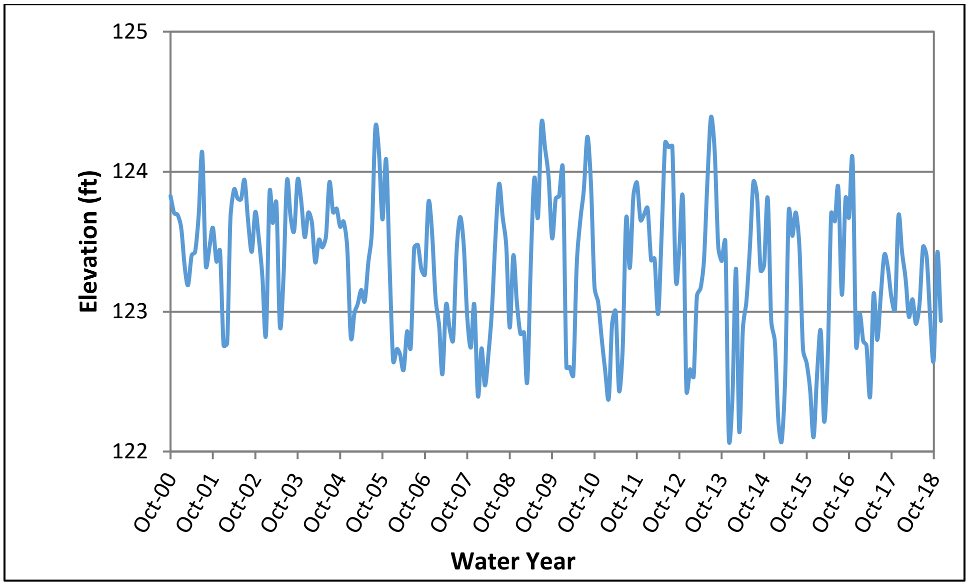

Figure C.3-24. Lake Natoma Elevation

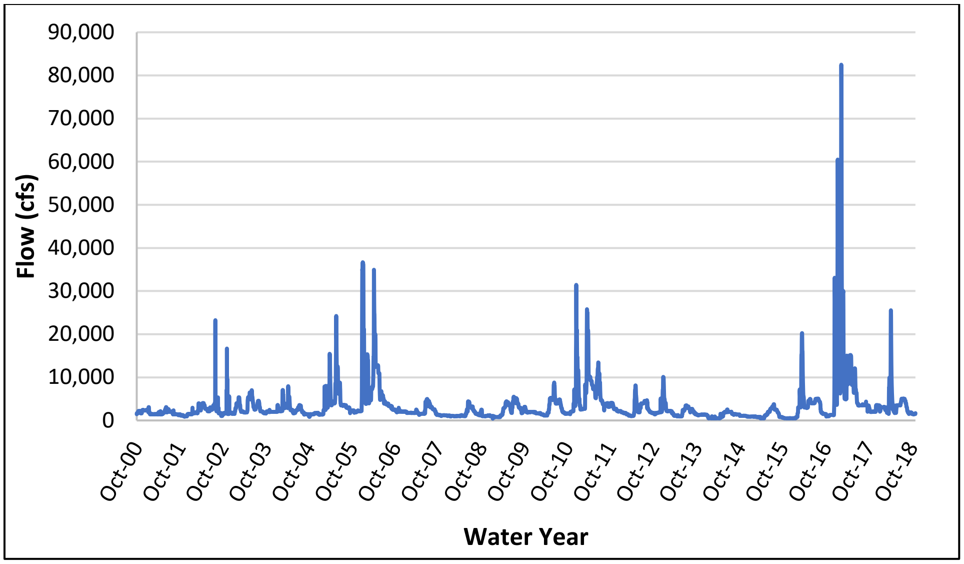

Figure C.3-25. American River at Fair Oaks

C.3.6.1.4 Diversion Management

The American River Operations Group is a public forum consisting of Reclamation, fisheries agencies, and other interested parties. Since 1996 the group has provided input on a number of operational issues and has served as a discussion forum for topics such as adaptively managing releases, including flow fluctuation and stability, and managing water temperatures in the Lower American River to meet the needs of salmon and steelhead.

Water is diverted to municipal and industrial water users, including water rights holders, upstream of Folsom Dam, from the Folsom South Canal, and from the American River downstream of Folsom Dam. During recent critically dry years it was feared that water elevations in Folsom Lake would become too low for adequate operation of diversion facilities; as a precaution Reclamation provided temporary barges with intake and conveyance facilities to divert water from the lake to the adjacent water users. To date the barges have not been necessary to provide water conveyance.

C.3.6.2 *Operations in the Lower American River*

Releases to the lower American River are governed by multiple factors. Minimum releases are set based on the Flow Management Study minimum river release. Releases above the minimum river release can be required for many reasons; instream temperature control, releases to help meet delta outflow or salinity requirements, flood control releases and export needs.

C.3.6.2.1 Flood Control

Historical Perspective

Flood control requirements and regulating criteria for October 1 through May 31 are specified by USACE and described in the *Folsom Dam and Lake, American River, California Water Control Manual* (USACE 1987). Flood control objectives for the Folsom unit require that the dam and lake be 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 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 capacity for flood control is a function of the date only, with full flood reservation capacity required from November 17 through February 7. Beginning February 8 and continuing through April 20, flood reservation capacity is a function of both date and current hydrologic conditions in the basin.

If the inflow into Folsom Reservoir causes the water elevation to encroach into the capacity 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 would not be increased more than 15,000 cfs or decreased more than 10,000 cfs during any two-hour period.
- Flood control requirements override other operational considerations in the fall and winter period. Consequently, short-term changes in river releases may occur.

Since 1996, Reclamation has operated according to modified flood control criteria, which reserve 400 to 670 TAF of flood control space in Folsom Reservoir in combination with empty reservoir space in Hell Hole, Union Valley, and French Meadows, to be treated as if it were available in Folsom Reservoir. This flood control plan, which provides additional protection for the Lower American River, is implemented through an agreement between Reclamation and Sacramento Area Flood Control Agency (SAFCA). The terms of the agreement allow some of the empty reservoir space in Hell Hole, Union Valley, and French Meadows to be treated as if it were available in Folsom Reservoir.

Following significant flood events in February 1986 and January 1997, the lower American River flooding issues were analyzed; and revised flood operations criteria were developed by SAFCA. The SAFCA release criteria are generally equivalent to the USACE plan, except the SAFCA diagram may prescribe flood releases earlier than the USACE plan. The SAFCA diagram also relies on Folsom Dam outlet capacity to make the earlier flood releases. The outlet capacity at Folsom Dam is currently limited to 32,000 cfs based on lake elevation. However, in general the SAFCA plan diagram provides greater flood protection than the existing USACE plan for communities in the American River floodplain.

Required flood control space under the SAFCA diagram begins 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 TAF. From April 21 to June 1, the required flood reservation is a function of the date only, with Folsom Reservoir storage permitted to fill completely on June 1.

C.3.6.3 *Current Status*

Reclamation and USACE constructed an auxiliary spillway under the Joint Federal Project, at Folsom Dam in accordance with the recommendations of the Water Control Manual Update (Reoperation Study). The USACE is also implementing increased system capabilities provided by the authorized features of the Common Features Project to strengthen the American River levees to convey up to 160,000 cfs and completion of the authorized Folsom Dam Mini-Raise Project. The spillway work is complete, and the facility has been transferred to Reclamation for operation and maintenance. This spillway allows Reclamation to release higher flows for flood control purposes while the reservoir storage is lower than we were previously able to do. This should help reduce peak releases from moderate events by allowing us to release earlier in the event thus preventing reservoir storage from encroaching significantly into the flood control pool.

USACE and Reclamation, as the National Environmental Policy Act (NEPA) cooperating agency, have completed a Folsom Dam Reoperation Study to develop, evaluate, and recommend changes to the flood control operations of the Folsom Dam project that would further the goal of reduced flood risk for the Sacramento area. Operational changes may be necessary to fully realize the flood risk reduction benefits of the additional operational capabilities created by completion of the Joint Federal Project, and the increased system capabilities provided by the implemented and authorized features of the Common Features Project (a project being carried out by USACE and designed to strengthen the American River levees so they can safely pass a flow of 160,000 cfs); and those anticipated to be provided by completion of the authorized Folsom Dam MiniRaise Project. The Folsom Dam Reoperation Study considers improved forecasts from the National Weather Service. USACE, in cooperation with Reclamation (and DWR as the California Environmental Quality Act (CEQA) lead and SAFCA as the local partner), is consulting with USFWS and NMFS relative to any changes to American River and/or system-wide CVP operations that may result.

The new WCM utilizes forecasted inflow as the criteria for determining flood control releases. There are criteria for total forecasted inflow on a 5 day out, 3 day out, 2 day out, and 1 day out basis. This is a first of its kind flood control diagram. Historically the flood control diagrams were based on current storage and current inflows to the reservoir, with a resulting action specified. Our new manual looks ahead five days and considers the forecasted inflow volume for the total of those five days. If that volume exceeds a threshold, a flood control release is specified. This is being termed a “blue sky release” because the release may occur before rainfall begins. The concept is to pre-emptively draw the reservoir down in anticipation of high inflows, thus providing space to store the rain event when it arrives. This will allow Reclamation to pass higher precipitation events with lower peak releases which relieves stress on the downstream levees and provides a higher level of flood protection to downstream areas.

The WCM is complete, the USFWS and NMFS are currently providing biological reviews of the WCM. At this time, Reclamation is operating to the new WCM under a temporary one-year order from USACE.

Additional information related to the flood control criteria for Folsom Dam operations is included by reference to documents prepared by USACE and SAFCA.

C.3.6.3.1 American River Flows to Meet Delta Salinity Requirements

Folsom Reservoir is also operated by Reclamation to release water to help meet Delta salinity and flow objectives established to improve fisheries conditions. Weather conditions combined with tidal action and local accretions from runoff and return flows can quickly affect Delta salinity conditions and require increases in Delta inflow to maintain salinity standards, as described below. In accordance with Federal and state regulatory requirements, the CVP and SWP are frequently required to release water from upstream reservoirs to maintain Delta water quality. Because Folsom Lake is located closer to the Delta than Lake Oroville and Shasta Lake, if the need for salinity control is immediate, releases may be made first from Folsom Reservoir. As water from the other reservoirs arrives in the Delta, Folsom Reservoir releases can be reduced. In general, however, as the CVP is operated as an integrated project, releases to meet downstream needs are sourced from multiple locations, e.g. both Shasta Reservoir and Folsom Reservoir, and SWP contributions from Lake Oroville. Water released from Lake Oroville and Shasta Lake generally reaches the Delta in approximately three and five days, respectively. Travel time is taken into consideration when release decisions are made as part of operating as an integrated project.

C.3.6.3.2 Fish and Wildlife Requirements in the Lower American River

Flow Requirements

The minimum allowable flows in the Lower American River are defined by SWRCB Water Right 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 SWRCB Water Quality Control Plan 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.

In July 2006, Reclamation, the Sacramento Area Water Forum and other stakeholders completed a draft technical report establishing a flow and temperature regime intended to improve conditions for fish in the lower American River (i.e., the Lower American River Flow Management Standard). Minimum flow requirements during October, November, and December are primarily intended to address fall-run Chinook Salmon spawning, and flow requirements during January and February address fall-run Chinook Salmon egg incubation and steelhead spawning. From March through May, minimum flow requirements are primarily intended to facilitate steelhead spawning and egg incubation, as well as juvenile rearing and downstream movement of fall-run Chinook Salmon and steelhead. The June through September flows are designed to address over-summer rearing by juvenile steelhead, although this period partially overlaps with adult fall-run Chinook Salmon immigration. Reclamation began operating to the Flow Management Standard immediately thereafter.

Water Temperature Requirements

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 Salmon spawning and incubation starting in late October or early November.

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.

Selective withdrawal capability on the Folsom Dam Urban Water Supply Pipeline (also known as the M&I TCD) became operational in 2003. A telescoping control gate allows for selective withdrawal of water to provide additional flexibility to conserve cold water for downstream use. The TCD is operated during the summer months and delivers water that is slightly warmer than that which could be used to meet downstream requirements, but not so warm as to cause significant treatment issues.

During the late 1960s, Reclamation designed a modification to the trash rack structures to provide selective withdrawal capability at Folsom Dam through the Folsom Power Plant.

The steel trash racks are now equipped with three groups of shutters that allow operators to pull water from various elevations, which are different temperatures when the lake is stratified. The shutters can be different at different locations on each of the three penstocks, allowing operators to blend water at different temperatures to meet downstream requirements.

Only in wetter hydrologic conditions is the volume of cold water sufficient to meet the majority of the water temperature objectives. Therefore, significant operations tradeoffs and flexibilities are part of an annual planning process for coordinating an operation strategy that realistically manages the limited cold-water resources available.

Hatchery Concerns

Reclamation-owned Nimbus Fish Hatchery, located just downstream of Nimbus Dam, is a mitigation facility that produces Chinook Salmon and Steelhead. A fish diversion weir at the hatchery blocks Chinook Salmon from continuing upstream and guides them to the hatchery fish ladder entrance. Installing the weir requires flows to be lowered for less than a week in early to mid-September. The hatchery also has water temperature concerns, especially June through September. Reclamation considers the Nimbus Fish Hatchery needs when balancing the cold-water pool for fish spawning in the river during fall.

Delta Needs

Folsom Reservoir can be operated to release water to meet Delta water quality and flow objectives to improve fisheries conditions, including releases for salinity objectives. When Delta needs require an increase upstream reservoir releases, then Folsom Reservoir often releases first because the released water would reach the Delta (in about one day) before flows released from other CVP and SWP reservoirs would get there. Lake Oroville water releases require about 3 days to reach the Delta, while water released from Shasta Lake requires 5 days to travel from Keswick Reservoir to the Delta. As water from the other reservoirs arrives in the Delta, Folsom Reservoir releases can be adjusted downward. It should be noted that Folsom Reservoir does not always release first for anticipated Delta needs. The CVP is operated as in integrated project, and releases from Shasta and Folsom are coordinated with releases from Oroville for the SWP contribution to meeting Delta standards. Many factors are considered when making a determination of which reservoir to release from first. Current storage, current releases, temperature control objectives, cold water pool volume in all reservoirs, Coordinated Operations Agreement (COA) balance, and anticipated future demands are all considered when determining which reservoir(s) to release from, and how much to release from each reservoir.

The real-time implementation of flow objectives and meeting SWRCB D-1641 Delta standards with the limited water resources of the Lower American River requires a significant coordination effort to manage the cold-water resources at Folsom Dam and Reservoir. Reclamation consults with USFWS, NMFS, and CDFW through American River Operations Group when these types of difficult decisions are needed.

Water Delivery Requirements

American River allocations to contractors and water settlement contractors is a function of storage in Folsom Reservoir and projected inflow for the water year. Default allocation is 100 percent, unless forecasted end of September storage is so low that the system would not be support that allocation. During the recent drought period, many M & I contractors on the American River were allocated what is referred to as Health and Safety allocations, this is a minimal amount that will maintain all essential functions, with rationing imposed.

C.4 San Joaquin Valley

The San Joaquin Valley is divided into two major drainage basins. The northern drainage basin extends from the San Joaquin River along the southern boundary of the Delta, along lands adjacent to the San Joaquin River from the northern drainage of the San Joaquin River in Madera County to the southern drainage in Fresno County (DWR 2013a). The northern drainage basin includes the San Joaquin River; five major tributaries that flow from westward from the Sierra Nevada, including Fresno, Chowchilla, Tuolumne, Merced, Stanislaus, and Calaveras rivers; and three major creeks that flow eastward from the Coast Range, including Del Puerto, Orestimba, and Panoche Creek. All flows in the San Joaquin River flow westward to the Delta.

The southern drainage basin (also known as the Tulare Lake Basin) extends into the southern San Joaquin Valley between the Sierra Nevada on the east, Tehachapi Mountains on the south, and the Coast Rage on the west (DWR 2013a). The southern basin includes four major tributaries, including Kings, Kaweah, Tule, and Kern rivers, which drain towards three ancient lakes on the valley floor, including the Tulare, Buena Vista, and Goose lakes. Flows into these lakes have declined as water supply projects and agricultural development has occurred. The northern and southern drainage basins are generally hydrologically separated by a low, broad ridge that extends across the San Joaquin Valley between the San Joaquin and Kings rivers. However, in flood years, water flows from the Kings River through the James Bypass and Fresno Slough into the San Joaquin River near Mendota; therefore, the basins become hydrologically connected.

Flows from Fresno, Chowchilla, Tuolumne, Merced, Calaveras, Kings, Kaweah, Tule, and Kern rivers also contribute substantial flows into the San Joaquin Valley and affect operations of CVP and SWP water users and operations.

C.4.1 San Joaquin River

The San Joaquin River flows 100 miles from Friant Dam to the Delta. Flows in the upper San Joaquin River are regulated by the CVP Friant Dam which forms Millerton Lake. Flows downstream of Friant Dam are influenced by flows from tributary rivers and streams, as described below; including CVP operations of New Melones Reservoir on the Stanislaus River.

C.4.1.1 *Millerton Lake*

Friant Dam is a concrete gravity structure located on the San Joaquin River, 25 miles northeast of Fresno where the San Joaquin River exits the Sierra foothills and enters the valley. Several reservoirs in the upper portion of the San Joaquin River watershed, including Mammoth Pool and Shaver Lake, affect the inflow to Millerton Lake. Millerton Lake provides flood control capacity on the San Joaquin River, provides downstream releases to meet senior water rights requirements above Mendota Pool, and provides conservation storage as well as diversion into Madera and Friant-Kern Canals.

Millerton Lake has a volume of 524 TAF, a surface area of 4,905 acres, and an elevation of 580.6 feet above mean sea level (North American Vertical Datum of 1988 (NAVD 88) at top of active storage (Reclamation 2008). The flood pool elevation is 587.6 while the maximum observed water surface elevation was 583, experienced during the January 1997 flood. Recent water storage volumes and elevations for Water Years 2001 through 2018 in Millerton Lake are presented on Figures C.4-1 through C.4-2 (DWR 2018ae, 2018af). Outflow from Millerton Lake for these Water Years is presented in Figure C.4-3 (DWR 2018ag).

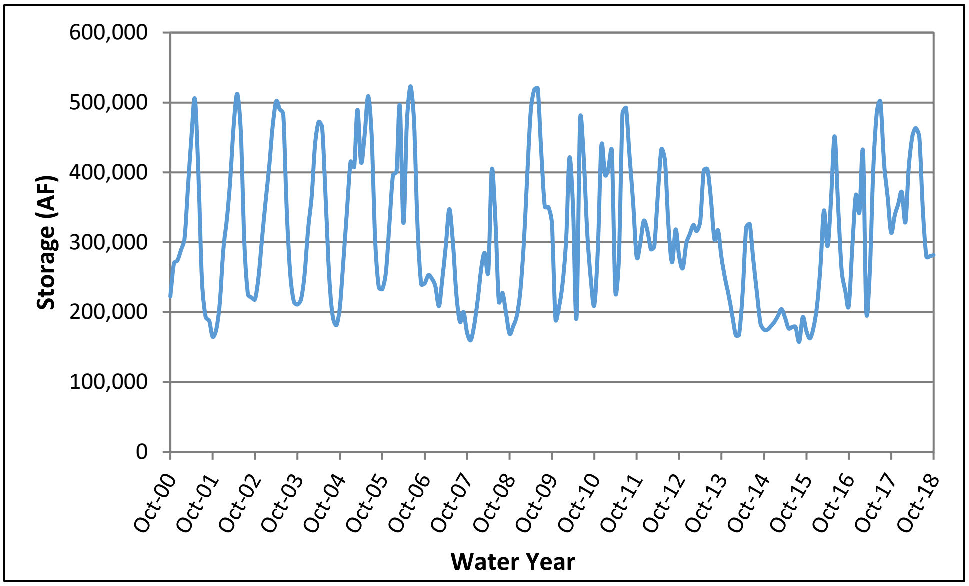

Figure C.4-1. Millerton Lake Storage

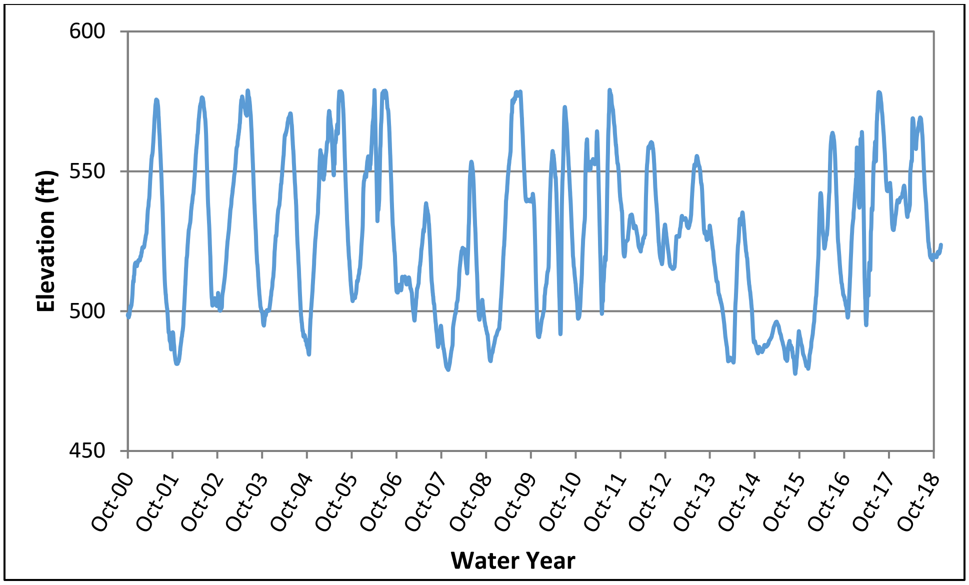

Figure C.4-2. Millerton Lake Elevation

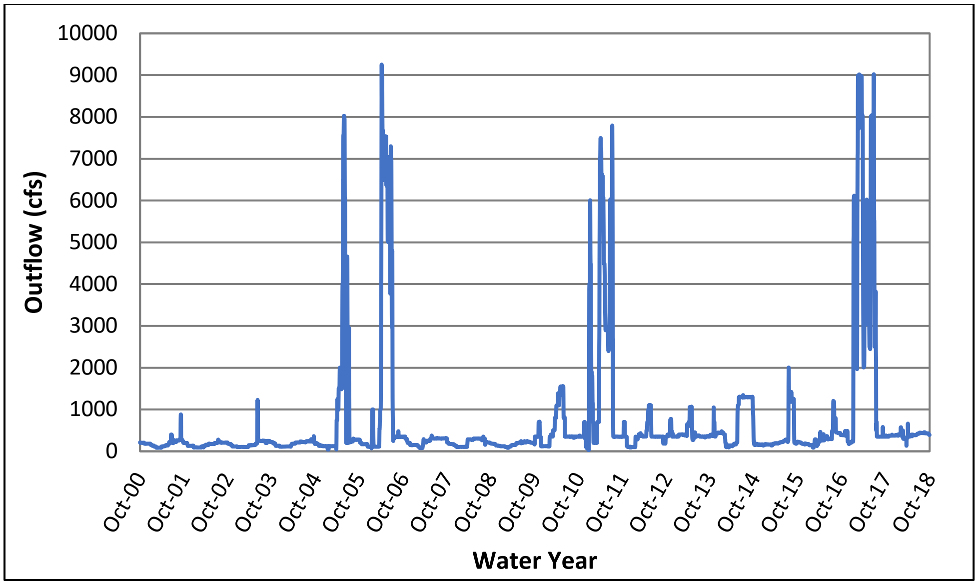

Figure C.4-3. Millerton Lake Outflow

The minimum operating storage of Millerton Lake is 130 TAF, resulting in active available conservation storage of about 390 TAF. The minimum operating storage allows for diversion from dam outlets to the Friant-Kern canal (elevation 466.6), Madera canal (elevation 448.6), and the San Joaquin River (elevation 382.6). The reservoir has three small dikes to close low areas along the reservoir rim, one of which is located in the Millerton Lake State Recreation Area. Millerton Road, a two-lane paved secondary highway, passes over these dikes.

Friant Dam is the principal flood damage reduction facility on the San Joaquin River and is operated to maintain combined releases to the San Joaquin River at or below a flow objective of 8,000 cfs. Several flood events in the past few decades have resulted in flows greater than 8,000 cfs downstream from Friant Dam and, in some cases, flood damages resulted. Flood control storage space in Millerton Lake is based on a complex formula, which considers storage in upstream reservoirs, forecasted snowmelt, and time of year. Flood management releases occur approximately once every 3 years and are managed based on downstream channel design capacity to the extent possible.

C.4.1.2 *San Joaquin River Restoration Program: Friant Dam to Confluence of Merced River*

In 2006, parties to Natural Resources Defense Council et al., v. Rodgers, et al., executed a stipulation of settlement that called for a comprehensive long-term effort to restore flows to the San Joaquin River from Friant Dam to the confluence of the Merced River and a self-sustaining Chinook Salmon fishery while reducing or avoiding adverse water supply impacts. The San Joaquin River Restoration Program implements the settlement consistent with the San Joaquin River Restoration Settlement Act in Public Law 111-11. The USFWS issued a Programmatic BO for the implementation of the San Joaquin River Restoration Program on August 21, 2012 and NMFS issued a Programmatic BO on September 18, 2012 for San Joaquin River Restoration Program flow releases of up to 1,660 cfs from Millerton Lake into the San Joaquin River. The settlement-required flow targets for releases from Millerton Lake include six water year types for releases depending upon available water supply as measures of inflow to Millerton Lake. The Millerton Lake releases include the flexibility to reshape and retime releases forwards or backwards by 4 weeks during the spring and fall pulse periods. Flood flows may potentially occur and meet or exceed the Settlement flow targets. If flood flows meet the settlement flow targets, then

Reclamation would not release additional water from Millerton Lake. The San Joaquin River channel downstream of Friant Dam currently lacks the capacity to convey flows to the Merced River and releases are limited accordingly.

The San Joaquin River Restoration Program Restoration Area includes five distinct reaches of the San Joaquin River and portions of the flood management system (Figure C.4-4): Reach 1: Friant Dam to Gravelly Ford, Reach 2: Gravelly Ford to Mendota Dam, Reach 3: Mendota Dam to Sack Dam, Reach 4: Sack Dam to Eastside Bypass Confluence, Reach 5: Eastside Bypass Confluence to Merced River, and Chowchilla, Eastside, and Mariposa Flood Bypasses. San Joaquin River flows from Water Years 2001 through 2018 at Gravelly Ford, near Dos Palos, near Washington Road, at Bifurcation Structure, at Freemont Ford Bridge are presented in Figures C.4-5 through C.4-10 (DWR 2018ah, 2018ai, 2018aj; Reclamation 2018a, 2018b, 2018c).

Figure C.4-4. San Joaquin River Restoration Area River Reaches

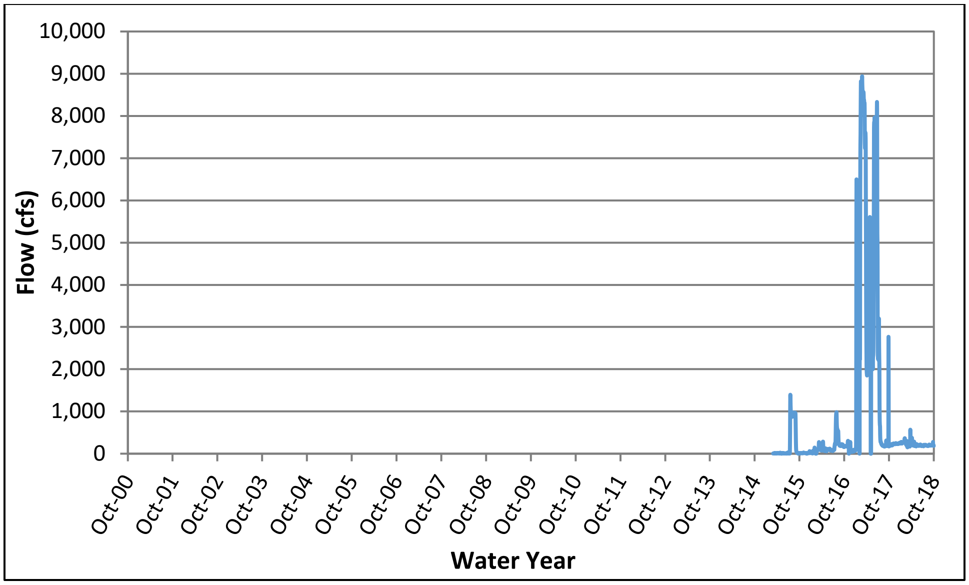

Figure C.4-5. San Joaquin River at Gravelly Ford

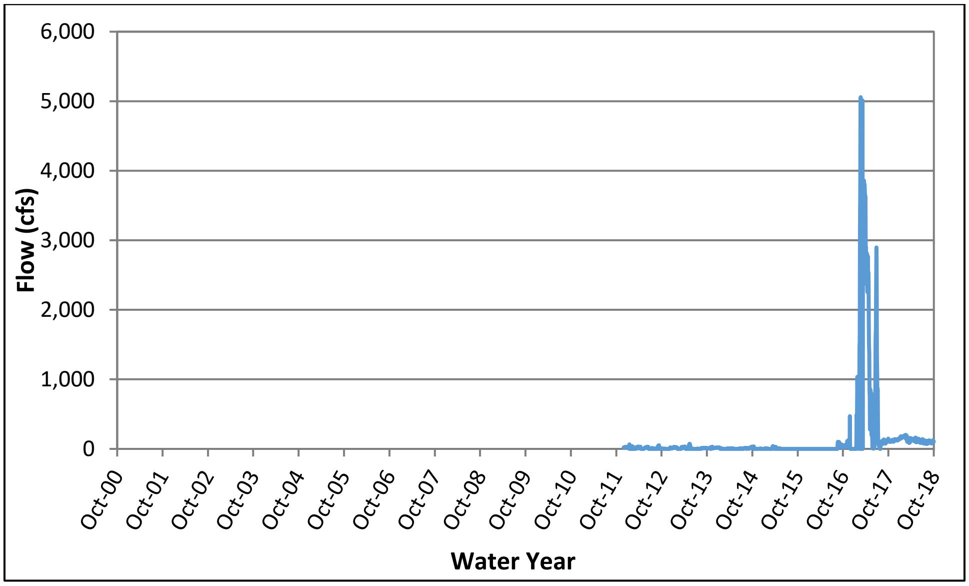

Figure C.4-6. San Joaquin River Near Dos Palos

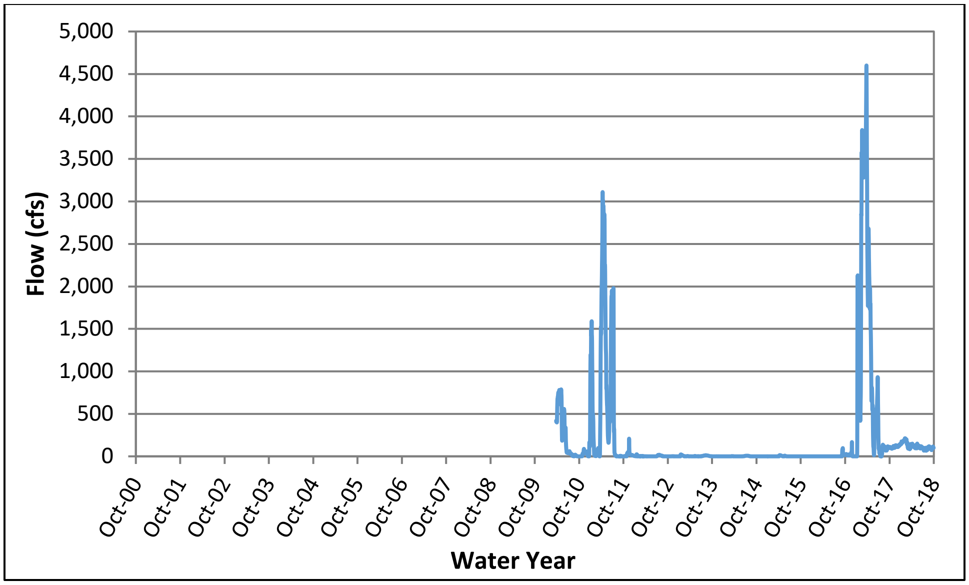

Figure C.4-7. San Joaquin River near Washington Rd

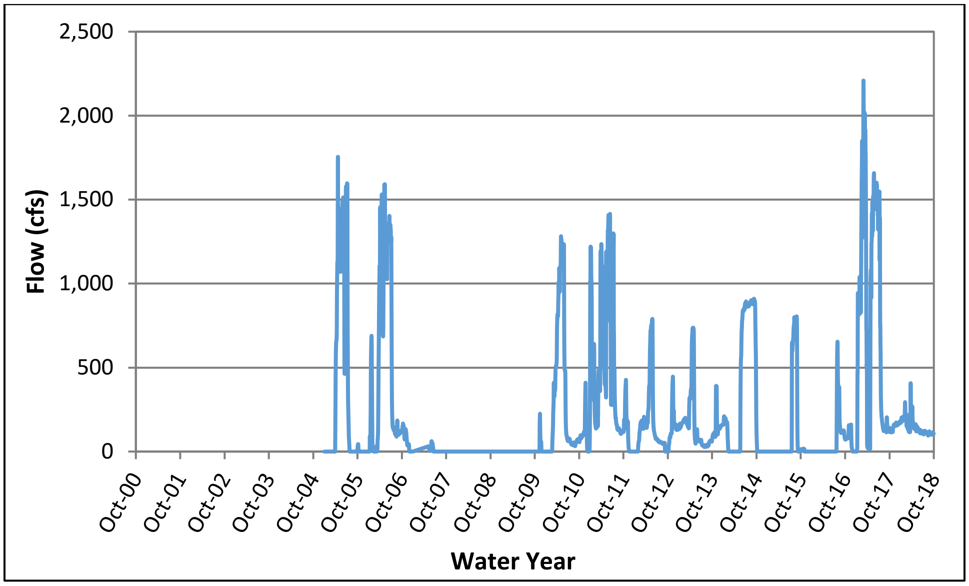

Figure C.4-8. San Joaquin River at Bifurcation Structure

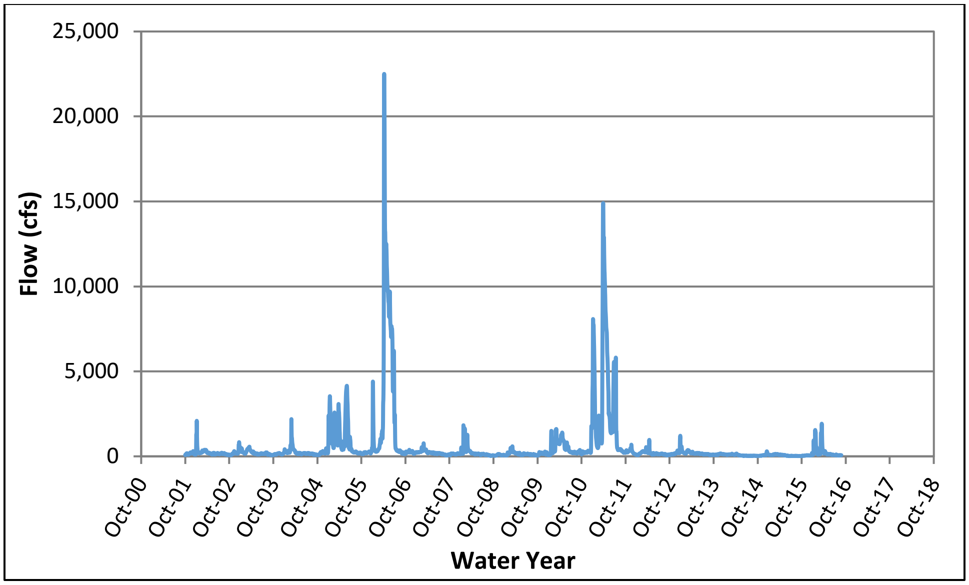

Figure C.4-9. San Joaquin River at Freemont Ford Bridge

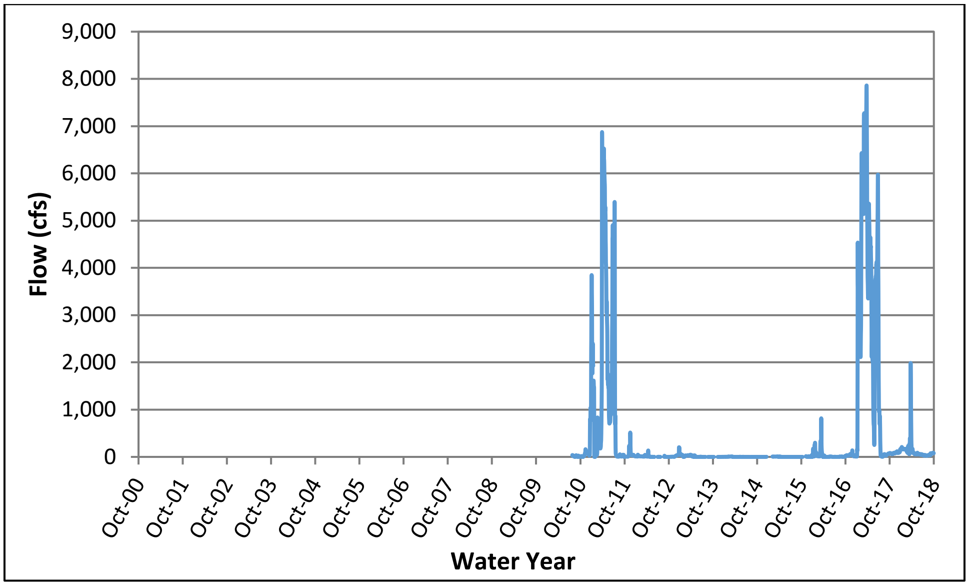

Figure C.4-10. Eastside Bypass Below Mariposa Bypass

C.4.1.2.1 Reach 1 – Friant Dam to Gravelly Ford

Reach 1 conveys continuous flows approximately 39 miles through an incised, gravel-bedded channel to Gravelly Ford, forming part of the boundary between Fresno and Madera counties. Releases are made at Friant Dam to comply with Holding Contract requirements along Reach 1. Streamflow of at least 5 cfs is maintained past the last diversion near Gravelly Ford, with no requirements for streamflow into Reach 2. Reach 1 is the only reach in the Restoration Area with exposed gravel and a river gradient suitable for Chinook salmon spawning. Extensive gravel mining in Reach 1A and the upper portion of Reach 1B has left many pits, some connected to the river, within the historical floodplain. An average of 117,000 acre-feet of water per year is released from Friant Dam into Reach 1 for riparian water users. Reach 1 is subdivided into two subreaches, 1A and 1B, at SR 99.

The objective release from Friant Dam into Reach 1 is 8,000 cfs. Reach 1 of the San Joaquin River is hydraulically connected to 190 acres of sand and aggregate mining pits, with an additional 1,170 acres of pits in the surrounding floodplain (McBain and Trush 2002). These pits can attenuate flow and increase evaporation through ponding. There are no storage facilities in Reach 1. Ten major road crossings in this reach can affect flow stage (McBain and Trush 2002). Agricultural return flows in Reach 1 are minor but have reached up to 300 cfs on occasion (U.S. Environmental Protection Agency [EPA] 2007). Stormwater runoff from the Fresno Metropolitan Area is managed by the Fresno Metropolitan Flood Control District. All but five of the District's 161 drainage basins route stormwater to retention and detention facilities, limiting the urban surface runoff into Reach 1.

Reach 1A. Flows within Reach 1A are predominantly influenced by releases from Friant Dam, along with diversions and seepage losses. Mining pits in Reach 1 are primarily located in Reach 1A. Eighty-four water diversions are located along this reach, not all of which are active on a regular basis. Cottonwood Creek and Little Dry Creek, two intermittent streams, join the San Joaquin River in Reach 1A. Cottonwood Creek, draining 35.6 square miles, flows in from the north near the base of Friant Dam. Little Dry Creek, draining 57.9 square miles, joins the San Joaquin River from the south approximately 8 miles downstream from Friant Dam. Flows in Little Dry Creek can be augmented from the Big Dry Creek flood control reservoir (McBain and Trush 2002). Flows from these two creeks must be included in the 8,000 cfs Reach 1A capacity limits when determining releases from Friant Dam.

Since 1949, Reclamation has made average annual releases of approximately 117 TAF from Friant Dam to the San Joaquin River to comply with Holding Contract requirements upstream from Gravelly Ford. Additional river flows occur during years when releases are made to the San Joaquin River for flood management purposes or for the San Joaquin River Restoration Program.

Reach 1B. Flows within Reach 1B are predominantly influenced by inflow from Reach 1A, diversions and seepage losses. Fifteen water diversions are located along this reach, not all of which are active on a regular basis.

C.4.1.2.2 Reach 2 – Gravelly Ford to Mendota Dam

Reach 2 marks the end of the incised channel and is a meandering channel of low gradient. Reach 2 meanders approximately 24 miles across the sandy alluvial fan of the San Joaquin River between Gravelly Ford and Mendota Dam and is subdivided into two subreaches, 2A and 2B, at the Chowchilla Bypass Bifurcation Structure. Reach 2 is typically dry; flows reach the Mendota Pool from Reach 2B or from the Fresno Slough only during periods of flood management releases. Flood flows in the San Joaquin and/or Kings rivers occurred at the Mendota Pool in 1997, 2001, 2005, 2006, 2011, and 2017. Additionally, flows released by the San Joaquin River Restoration Program have at times been recaptured in Mendota Pool due to downstream capacity constraints. At all other times, the Delta-Mendota Canal (DMC) is the primary source of water to the Mendota Pool. The Mendota Pool provides no long-term storage for water supply operations or flood management. Reach 2 ends at Mendota Dam, and the Mendota Pool backwater extends up a portion of this subreach. The Mendota Pool delivers water to the San Joaquin River Exchange Contractors Water Authority, other CVP contractors, wildlife refuges and management areas, and State water authorities.

Reach 2A. Reach 2A is typified by the accumulation of sand caused in part by backwater effects of the Chowchilla Bypass Bifurcation Structure and by a lower gradient relative to Reach 1. Reach 2A has a design channel capacity of 8,000 cfs to accommodate controlled releases from Friant Dam. Under steady-state conditions (i.e., losses are calculated under extended periods of steady flow), flow does not reach the Chowchilla Bypass Bifurcation Structure when discharge at Gravelly Ford is less than 75 cfs (McBain and Trush 2002). Agricultural return flows within this reach are minor. Ten water diversions are located along this reach. Reach 2A has also been subject to local sand mining, although this has not caused the extensive channel degradation seen in Reach 1.

Reach 2B. Reach 2B is a sandy channel extending into the Mendota Pool. The design conveyance capacity of this reach is 2,500 cfs, but significant seepage has been observed at flows above 1,300 cfs (San Joaquin River Resources Management Coalition [RMC] 2007). The Mendota Pool Bypass and Reach 2B Project will expand the channel capacity of this reach. Agricultural return flows within this reach are minor. Reach 2B ends at Mendota Dam, and Mendota Pool backwater extends up a portion of this reach. Twenty-nine water diversions are located along this reach. One major road crossing in this reach can affect flow stage. The DMC typically conveys 2,500 to 3,000 cfs to the Mendota Pool during the irrigation season.

Mendota Dam. Mendota Dam, built in 1917, is owned and operated by the Central California ID. Mendota Dam is a flashboard and buttress dam 23 feet high and 485 feet long; the crest elevation is 168.5 17 feet. The Dam is located at the confluence of the San Joaquin River and Fresno Slough, serves as a forebay for diversions to the Main and Outside canals, and is the termination of the Delta-Mendota Canal, which conveys CVP water from the Delta. Fresno Slough connects the Kings River to the San Joaquin River and delivers water to the south from Mendota Pool during irrigation season and delivers water to the Mendota Pool and San Joaquin River from the Kings River when the Kings River is flooding. The 50-TAF Mendota Pool is a small reservoir, with approximately 8,500 acre-feet of storage, created by the 23-foot-high Mendota Dam (Reclamation 2004). The Mendota Pool does not provide any appreciable flood storage. The water surface elevation in the pool is maintained by a set of gates and flashboards that are manually opened/removed in advance of high-flow conditions. This process lowers the water level in the pool for passing high flows to reduce seepage impacts to adjacent lands but prevents diversions on Fresno Slough from the Delta-Mendota Canal and San Joaquin River flows. A fish ladder exists at Mendota Dam, but has been inoperable for the last several decades. The Mendota Pool Bypass and Reach 2B Project will provide fish passage around Mendota Pool.

Cyclically, the Mendota Pool fills with sediment during infrequent high-flow releases from Friant Dam. During times of high flows, some unknown portion of this sediment is able to flush and route downstream when flashboards have been pulled, restoring much of the Mendota Pool storage capacity. If the flashboards are not pulled before a high-flow event from either the San Joaquin River or Fresno Slough, the increased water surface elevations cause seepage problems on upstream and adjacent properties. Recent mean daily flows in the San Joaquin River at Mendota are presented on Figure C.4-11 (DWR 2018al).

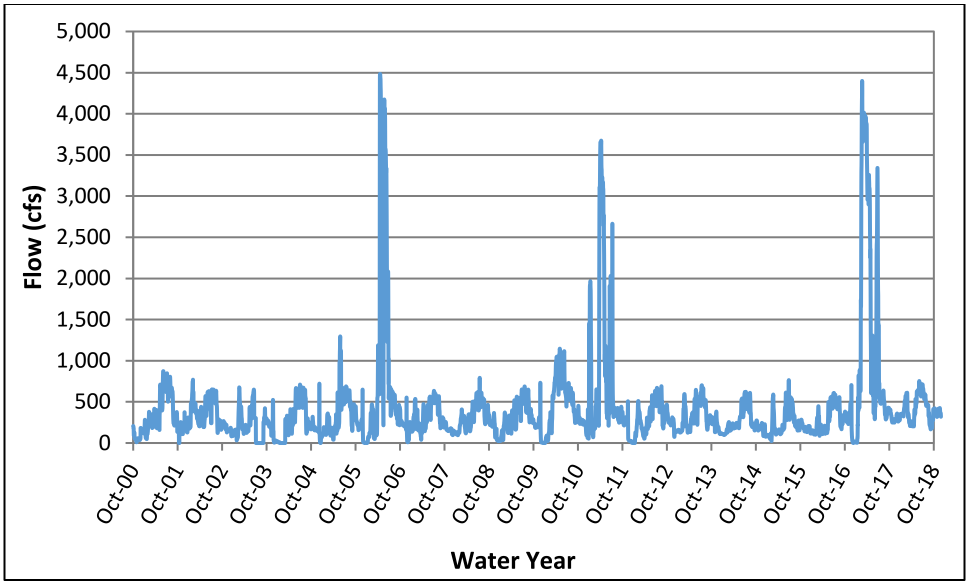

Figure C.4-11. San Joaquin River Near Mendota

C.4.1.2.3 Reach 3 – Mendota Dam to Sack Dam

Reach 3 begins at Mendota Dam and extends approximately 23 miles downstream to Sack Dam. Reach 3 conveys flows of up to 800 cfs from the Mendota Pool for diversion to the Arroyo Canal at Sack Dam, maintaining flow year-round in a meandering channel with a sandy bed. The Fresno Slough and Mendota Pool convey flood flows from the Kings River to this reach. Irrigation canals bound this reach for most of its length. In some portions, lands within the floodway are actively used for agricultural production and are protected by local or interior levees.

Reach 3 flows 23 miles along a sandy channel from Mendota Dam to Sack Dam. The design capacity of Reach 3 is 4,500 cfs; however, anecdotal evidence suggests that seepage and associated flooding may begin at sustained flows above 800 cfs (RMC 2007). The San Joaquin River Restoration Program is actively pursuing seepage easements and projects in this reach. Significant bed lowering has been measured within Reach 3; however, the extent of this lowering that is due to subsidence from groundwater overdraft, or to human-induced sediment and hydrology modification within the channel, is unknown (McBain and Trush 2002). Flows within this reach predominantly consist of water conveyed from the Delta by the DMC and released from the Mendota Pool for diversion.

Sack Dam is a 5-foot-high concrete and wood diversion structure delivering water to the Arroyo Canal on the west side of the river (RMC 2003). No operational storage for water supply exists within this reach. The Arroyo Canal and Sack Dam Fish Passage Project of the San Joaquin River Restoration Program will screen Arroyo Canal and provide for fish passage over the site of Sack Dam. Flows of 500 to 600 cfs are typically released from the Mendota Pool for downstream diversions at Sack Dam. Flows greater than required for diversions (such as during flood events) spill over Sack Dam into the San Joaquin River downstream into Reach 4A. Seven water diversions are located in this reach. One major road crossing in this reach can affect flow stage.

C.4.1.2.4 Reach 4 – Sack Dam to Eastside Bypass Confluence

Reach 4 runs approximately 46 miles from Sack Dam to the confluence of the Eastside Bypass. Historically, flows within much of this reach were predominantly agricultural return flows, and large sections of this reach were dry. Since 2016, Restoration Flows have re-wet Reach 4A and Restoration Flows are maintained at low levels year-round.

Reach 4 is subdivided into three subreaches: 4A, 4B1, and 4B2. 4A begins at Sack Dam and extends to the Sand Slough Control Structure; 4B1 extends from the Sand Slough Control Structure to the Mariposa Bypass confluence; and 4B2 begins at the confluence of the Mariposa Bypass and extends to the confluence of the Eastside Bypass. The Sand Slough Control Structure controls the flow split between the mainstem San Joaquin River and Eastside Bypass. A headgate is also present at the entrance to Reach 4B1 of the San Joaquin River. Reach 4 subreaches have different characteristics and design capacities, as discussed below.

Reach 4A. The design channel capacity in this reach is approximately 4,500, beginning at Sack Dam and extending to the Sand Slough Control Structure. The channel below Sack Dam has flow during the agricultural season (agricultural return flows) and during upstream flood releases, in addition to Restoration Flows. Four water diversions are located along this reach. This subreach has experienced bed lowering similar to that discussed for Reach 3.

Reach 4B1. This reach has a design capacity of 1,500 cfs, and the Sand Slough Control Structure is designed to maintain this design discharge; although current operations recommend discharge past the control structure to be 300 to 400 cfs because of reduced capacity in the channel. Thus, actual operations keep the gates of the San Joaquin River headgates closed, diverting all flow from Reach 4B1 to the Eastside Bypass (McBain and Trush 2002). Reach 4B1, therefore, is dry until downstream agricultural return flows contribute to its baseflow, although this flow is often pumped and reused for irrigation.

Reach 4B2. The design channel capacity of Reach 4B2 is 10,000 cfs. The channel carries tributary and flood flows from the Mariposa Bypass. No operational storage for water supply exists within this reach. Two water diversions are located along this reach.

C.4.1.2.5 Reach 5 – Eastside Bypass Confluence to Merced River

Reach 5 of the San Joaquin River extends approximately 18 miles from the confluence of the Eastside Bypass downstream to the Merced River confluence. The design capacity of Reach 5 is 26,000 cfs; no significant capacity constraints have been identified in this reach. Reach 5 receives flow from Reach 4B2 and the Eastside Bypass. Agricultural and wildlife management area return flows also enter Reach 5 via Mud and Salt sloughs, which drain the west side of the San Joaquin Valley. Three major road crossings within this reach can affect flow stage. San Joaquin River Flood Control Project levees confine Reach 5. West bank levees end at Salt Slough while the east bank levees continue to the Merced River confluence. There are four water diversions in this reach.

C.4.1.2.6 Flood Bypasses – Chowchilla, Eastside, and Mariposa

The State constructed the San Joaquin River Flood Control Project which includes flood damage reduction structures and facilities within the Restoration Area. Construction of the original State system was initiated in 1959 and completed in 1966. These improvements were coordinated with the Federal Government to ensure the effectiveness of the Federal portion of the project. The bypass system consists primarily of man-made channels (Eastside, Chowchilla, and Mariposa bypasses), which divert and carry flood flows from the San Joaquin River at Gravelly Ford, along with inflows from the Kings River and other tributaries, downstream to the mainstem just above Merced River. The system consists of about 193 miles of levees, several control structures, and other appurtenant facilities, and about 80 miles of surfacing on existing levees. Operations and maintenance (O&M) of the completed State upstream bypass features of the project are accomplished by the Lower San Joaquin Levee District. The flood damage reduction structures and facilities within the Restoration Area are described below.

The Chowchilla, Eastside, and Mariposa bypasses convey flood flows from the San Joaquin and Kings rivers. Tributaries to the Chowchilla Bypass include the Fresno River and Berenda Slough. The Chowchilla Bypass extends to the confluence of Ash Slough, which marks the beginning of the Eastside Bypass. Eastside Bypass Reach 1 extends from Ash Slough to the Sand Slough Bypass confluence and receives flows from the Chowchilla River. Eastside Bypass Reach 2 extends from the Sand Slough Bypass confluence to the head of the Mariposa Bypass. Eastside Bypass Reach 3 extends from the head of the Mariposa Bypass to the head of Reach 5 and receives flows from Deadman, Owens, and Bear creeks. The Mariposa Bypass extends from the Mariposa Bypass Bifurcation Structure to the head of Reach 4B2. A drop structure is located near the downstream end of the Mariposa Bypass that dissipates energy from flows before flows enter the mainstem San Joaquin River.

Chowchilla Bypass and Bypass Bifurcation Structure. As a component of the Lower San Joaquin River and Tributaries Project, the Chowchilla Bypass begins at the Chowchilla Bypass Bifurcation Structure in the San Joaquin River and runs northwest, parallel to the San Joaquin River, to the confluence of the Fresno River, where the Chowchilla Bypass ends and becomes the Eastside Bypass. The design channel capacity of the Chowchilla Bypass is 5,500 cfs. The bypass is constructed in highly permeable soils, and much of the initial flood flows infiltrate and recharge groundwater. The Chowchilla Bypass Bifurcation Structure is a gated structure that controls the proportion of flood flows between the Chowchilla Bypass and Reach 2B of the San Joaquin River. The Chowchilla Bypass Bifurcation Structure is operated to keep flows in Reach 2B at a level less than 2,500 cfs because of channel capacity limitations, though significant seepage has been observed at flows above 1,300 cfs (RMC 2007), and the Mendota Pool Bypass and Reach 2B Project will increase the capacity of Reach 2B. Historically, releases from the Chowchilla Bypass Bifurcation Structure to Reach 2B were limited to the 1,300 cfs capacity of Reach 2B, or to flows that would not exceed the capacity of Reaches 3 and 4A when combined with Kings River flood flows and irrigation delivery flows from Mendota Pool.

Eastside Bypass and Control Structure. The Eastside Bypass extends from the confluence of the Fresno River and the Chowchilla Bypass to its confluence with the San Joaquin River at the head of Reach 5. The Eastside Bypass is subdivided into three reaches. Eastside Bypass Reach 1 gradually increases in design channel capacity from 10,000 cfs to 17,000 cfs as it receives flows from the Fresno River, Berenda Slough, and Ash Slough, and ends at the downstream end of the Sand Slough Bypass, where it intercepts flows from the Chowchilla River. Eastside Bypass Reach 2, with a design channel capacity of 16,500 cfs, extends from the Sand Slough Bypass confluence to the Mariposa Bypass Bifurcation Structure at the head of the Mariposa Bypass and the Eastside Bypass Control Structure. Eastside Bypass Reach 3, with a design channel capacity of 13,500 cfs at the Eastside Bypass Control Structure, and a design channel capacity of 18,500 cfs at its confluence with Bear Creek, extends from the Eastside Bypass Control Structure to the head of Reach 5 of the San Joaquin River, and receives flows from Deadman, Owens, and Bear creeks. The gated Eastside Bypass Control Structure works in coordination with the Mariposa Bypass Bifurcation Structure to direct flows to either Eastside Bypass Reach 3 or to the Mariposa Bypass. The channel capacities described above are design capacities; current capacities may be reduced due to subsidence of Eastside Bypass levees. Eastside Bypass Reach 3 ultimately joins with Bear Creek to return flows to the San Joaquin River.

Sand Slough Control Structure/San Joaquin River Headgates. The Sand Slough Control Structure, located in the short connection between the San Joaquin River at mile post 168.5 and the Eastside Bypass between Eastside Bypass Reaches 1 and 2, is an uncontrolled weir working on coordination with the San Joaquin River Headgates to control the flow split between the mainstem San Joaquin River and the Eastside Bypass. The Sand Slough Control Structure diverts flows from the San Joaquin River to the Eastside Bypass, and the San Joaquin River Headgates control the timing and quantity of flows entering Reach 4A of the San Joaquin River into Reach 4B1. The operating rule for the control structure and headgates is to divert the first 50 cfs of San Joaquin River flow to Sand Slough, and then equally divide flow in excess of 50 cfs to Sand Slough and Reach 4B1. Historical operations have kept the headgates closed for many years, diverting all flood flows to Sand Slough (RMC 2007).

Mariposa Bypass and Bypass Bifurcation Structure. The Mariposa Bypass Bifurcation Structure controls the proportion of flood and Restoration flows that continue down the Eastside Bypass or return the San Joaquin River through the Mariposa Bypass to Reach 4B2. The Mariposa Bypass delivers flow back into the San Joaquin River from the Eastside Bypass at the head of Reach 4B2. Of 14 bays on the Mariposa Bypass Bifurcation Structure, eight are gated. The operating rule for the Mariposa Bypass is to divert all flows to the San Joaquin River when flows in the Eastside Bypass above the Mariposa Bypass are less than 8,500 cfs, with flows greater than 8,500 cfs remaining in the Eastside Bypass, eventually discharging back into the San Joaquin River at the Bear Creek Confluence at the end of Reach 4B2 of the San Joaquin River. Eastside Bypass below Mariposa Bypass flows are presented in Figure C.4-10 (DWR 2018ak).

However, actual operations have deviated from this rule, flows of up to 2,000 cfs to 3,000 cfs have historically remained in the Eastside Bypass, and approximately one-quarter to one-third of the additional flows are released to the Mariposa Bypass (McBain and Trush 2002). Flood flows not diverted to the San Joaquin River via the Mariposa Bypass continue down the Eastside Bypass and are returned to the San Joaquin River via Bravel Slough and Bear Creek. Restoration Flows continue down the Eastside Bypass. Bravel Slough reenters the San Joaquin River at mile post 136 and is the ending point of the bypass system.

C.4.1.3 *San Joaquin River from Merced River to the Delta*

Flows in the San Joaquin River below the Merced River confluence to the Delta are controlled in large part by releases from reservoirs, located on the tributary systems, to satisfy contract deliveries and instream flow requirements, as well as operational agreements such as D-1641. Recent mean daily flows in the San Joaquin River at Vernalis (located at the southeastern boundary of the Delta) are presented on Figure C.4-12 (DWR 2018am).

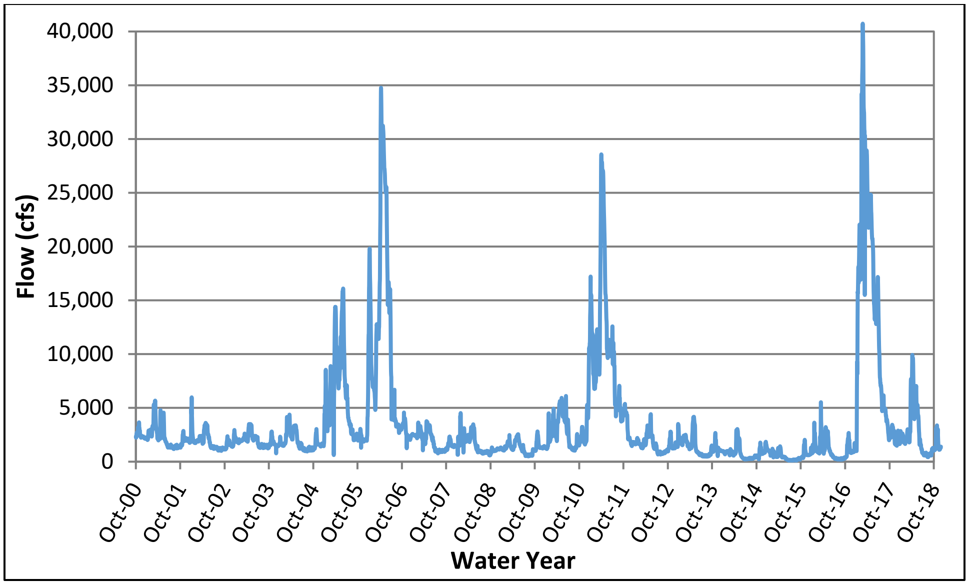

Figure C.4-12. San Joaquin River at Vernalis

C.4.1.3.1 Merced River

The Merced River flows west out of the Sierra Nevada to its confluence with the San Joaquin River at the end of Reach 5. Merced River stream flows are regulated primarily by New Exchequer and McSwain dams, which form Lake McClure and Lake McSwain, respectively. The Crocker-Hoffman Diversion Dam is located downstream from New Exchequer and McSwain dams. Lake McClure is a water supply, hydropower, and flood control reservoir and Lake McSwain is a regulating reservoir approximately 6 miles downstream from Lake McClure. Both reservoirs are owned and operated by the Merced ID. Minimum flow standards were established in 1964 (Project No. 2179) by a FERC license and, in addition, the Davis-Grunsky Contract No. D-GGR17 between Merced ID and DWR. During high-flow events, a portion of Merced River flows are conveyed to the San Joaquin River through Merced Slough.

C.4.1.3.2 Tuolumne River

The Tuolumne River enters the San Joaquin River downstream from the Merced River. The largest reservoir on the Tuolumne River is New Don Pedro Lake, owned and operated by the Turlock Irrigation District and Modesto Irrigation District for water supply, hydropower, and flood control purposes. La Grange Reservoir below New Don Pedro Lake is also jointly owned by the two irrigation districts and is operated as a diversion dam. The 1995 New Don Pedro Settlement Agreement contains instream flow requirements on the Tuolumne River for the anadromous fishery downstream from the project (FERC 2009).

The Stanislaus River and associated facilities and operations are described below.

C.4.2 Stanislaus River and the East Side Division

The East Side Division encompasses portions of the Stanislaus and San Joaquin River Systems and includes New Melones Dam, Tulloch Dam, Goodwin Dam, and smaller Diversion Dams and associated Reservoirs.

The Stanislaus River originates in the western slopes of the Sierra Nevada and drains a watershed of approximately 900 square miles. The median annual unimpaired runoff in the basin is approximately 1.08

MAF per year (SWRCB 2012). Snowmelt from March through early July contributes the largest portion of the flows in the Stanislaus River, with the highest runoff occurring in the months of April, May, and June.

C.4.2.1 *Early Water Development*

Agricultural water supply development in the Stanislaus River watershed began in the 1850s and has significantly altered the basin's hydrologic conditions. Prior to 1856, the San Joaquin Water Company constructed a diversion dam on the Stanislaus River immediately downstream of the present-day location of Tulloch Dam and used the diversion dam to distribute water for irrigation and other uses in the Knights Ferry Area. Beginning in 1856, a series of water and power companies constructed several water supply and power facilities in the Stanislaus River watershed.

The San Joaquin Water Company was sold to the Tulloch family in the late 1800s, and in 1910, Oakdale Irrigation District (OID) and South San Joaquin Irrigation District (SSJID) bought the Tulloch water rights and physical distribution system. In 1913, OID and SSJID jointly constructed Goodwin Diversion Dam, an 80-foot tall double concrete arch dam, to divert Stanislaus River water (up to 1,816.6 cfs daily) into their respective canals for distribution into their respective service areas for irrigation. Despite its height, Goodwin Diversion Dam is a re-operating reservoir, not a storage reservoir, because a full reservoir is needed to allow diversion to these canals.

To address their lack of storage, OID and SSJID joined with The Pacific Gas and Electric Company in 1925 to construct the Melones Dam and Powerhouse (110 TAF capacity) approximately 12.3 river miles upstream of the Goodwin Diversion Dam. Water released from Melones was diverted at Goodwin Diversion Dam for delivery into OID and SSJID's distribution systems.

In 1955, OID and SSJID agreed to construct three new facilities, including the Donnells Dam and Reservoir (64,500 TAF capacity) and Beardsley Dam and Reservoir (97.5 TAF capacity) upstream of Melones Dam, and the Tulloch Dam and Reservoir (54.663 TAF capacity), downstream of Melones Dam. Construction of the three facilities, collectively referred to as the Tri-Dam Project, was completed in 1957 and the facilities became operational in 1958. As part of the construction of the Tri-Dam project, Goodwin Diversion Dam was raised to create an afterbay to regulate discharge from Tulloch. From 1985–1990, the Calaveras County Water District constructed the North Fork Stanislaus Hydroelectric Project, which included the construction of New Spicer Reservoir (189 TAF capacity) in 1989. This was a joint development project by Northern California Power Agency and Calaveras County Water District. Calaveras County Water District is the licensee and Northern California Power Agency is the project operator.

Twenty ungauged tributaries contribute flow to the lower portion of the Stanislaus River below Goodwin Dam. These streams provide intermittent flows, occurring primarily during the months of November through April. Agricultural return flows, as well as operational spills from irrigation canals receiving water from both the Stanislaus and Tuolumne Rivers, enter the lower portion of the Stanislaus River. In addition, a portion of the flow in the lower reach of the Stanislaus River originates from groundwater accretions. There are also approximately 48 TAF of annual riparian water rights in the Stanislaus River downstream of Goodwin Dam.

C.4.2.2 *Federal Water Development*

In the Flood Control Act of December 1944, Congress authorized construction of a dam to replace Melones Dam to help alleviate serious flooding problems along the Stanislaus and Lower San Joaquin Rivers. In the Flood Control Act of October 1962, Congress reauthorized the project, and expanded it to be a multipurpose facility to be built by USACE and operated by the Secretary of the Interior as the New Melones Unit of the Eastside Division of the CVP. Dam and reservoir construction began in 1966 and, after being halted from 1972 to 1974, was completed by USACE in 1978, with a storage capacity of 2.4 MAF.

In 1972, Reclamation applied for the assignment of two state-filed water rights and two new water rights for the New Melones Project. These applications were protested by several parties and mostly resolved through protest settlement agreements. In 1973, SWRCB Decision 1422 (D-1422) initially approved less than 600 TAF in storage for power, senior water rights, water quality, and fish and wildlife protection and enhancement, citing a lack of demonstrated demand and protection of upstream recreation as a reason not to grant consumptive use rights for new demands without further demonstration of a demand for this water.

To demonstrate the consumptive use demands, in 1980 Reclamation produced a Stanislaus River Water Allocation and an EIS for the proposed water allocation of the New Melones Unit. The documents describe preferred and alternative boundaries of the Stanislaus River Basin, the anticipated project yield for 2020 conditions, the current and anticipated future needs of such basin, the determination of an available “interim” supply until the full buildup of in-basin needs, and an anticipated “firm yield” once full in-basin demand was established. The ROD described that New Melones Reservoir would generate a water supply yield of 230 TAF in 2000, and 180 TAF in 2020; assuming maximum annual releases of 70 TAF for water quality and 98 TAF for downstream fishery. For the interim supply, 85 TAF would be available in the year 2000, diminishing to zero at full in-basin demand. For the firm supply, the Secretary determined that there would be 49 TAF available in 2020 after in-basin demands were met. In 1983, Reclamation entered into a long-term water service contract with Central San Joaquin Water Conservation District for 49 TAF of firm supply and an interim supply of 31 TAF, and a long-term water service contract totaling 75 TAF of interim water with Stockton East Water District. Reclamation then successfully applied to have D-1422 amended to allow up to full storage for demonstrated power and consumptive use demands in the same year, and New Melones briefly filled to its capacity of 2.4 MAF for the first time.

In 1984, Reclamation applied for the assignment of the direct diversion portion of one of the state water right filings, to be able to serve contracts water at times when New Melones is filling. The application was again protested, with protests largely settled through protest settlement agreements. The direct diversion right was granted in D-1616 in 1988. D-1616 continued water quality requirements and included a new fish and wildlife protest settlement agreement. A later revision added a requirement to study downstream steelhead/trout needs.

In 1995 and in 2000, water rights decisions related to updates of the San Francisco Bay/Sacramento–San Joaquin River Delta Water Quality Control Plan added flow requirements at Vernalis and partial responsibility for interior Delta water quality to CVP water rights.

C.4.2.3 *Reservoir Operations*

The operating criteria for New Melones Reservoir are constrained by water rights requirements, flood control operations, contractual obligations, and federal requirements under the Federal Endangered Species Act (ESA) and CVPIA. Reclamation must operate New Melones Reservoir to meet senior water rights and in-basin demands. Senior water rights are defined for both current and future upstream water right holders in accordance with the SWRCB Decision 1422 (D-1422) and Decision 1616 (D-1616); through protest settlement agreements with Tuolumne and Calaveras Counties; and for current downstream water right holders and riparian rights whose priorities are either senior to Reclamation or senior to appropriative rights in general, respectively. Reclamation also is required to make full contract amounts available to Stockton East Water District and Central San Joaquin Water Conservation District except for when contractual shortage provisions apply.

Tulloch Reservoir is owned and operated by the Tri-Dams Project for recreation, power, and flow re-regulation of New Melones Reservoir releases. Water released by Tulloch Reservoir and Powerplant flows downstream to Goodwin Reservoir where water is either diverted to canals to serve, Oakdale Irrigation District, South San Joaquin Irrigation District, and Stockton East Water District; or released from Goodwin Reservoir to the lower Stanislaus River (SWRCB 2012).

Below Goodwin Dam, the lower Stanislaus River flows approximately 40 miles to the confluence with the San Joaquin River. Agricultural return flows and operational spills from irrigation canals also enter the lower Stanislaus River.

Reservoir storage varies in accordance with upstream hydrology and downstream water demands and instream flow requirements. Recent water storage volumes and elevations for Water Years 2001 through 2018 in New Melones and Goodwin reservoirs are presented on Figures C.4-13 through C.4-16 (DWR 2018an, 2018ao, 2018ap, 2018aq). Recent mean daily flows in the Stanislaus River downstream of Goodwin Dam are presented on Figure C.4-17 (DWR 2018ar).

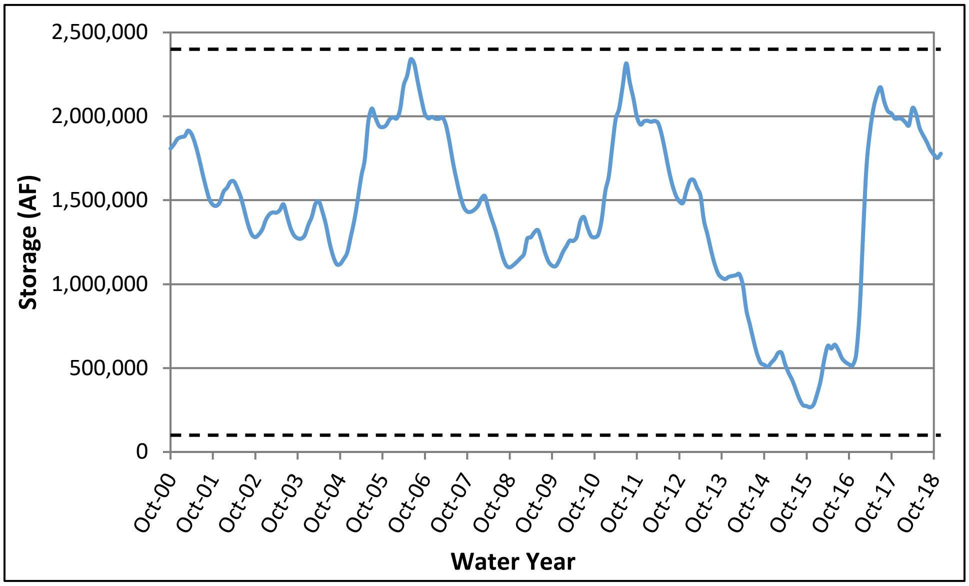

Figure C.4-13. New Melones Reservoir Storage

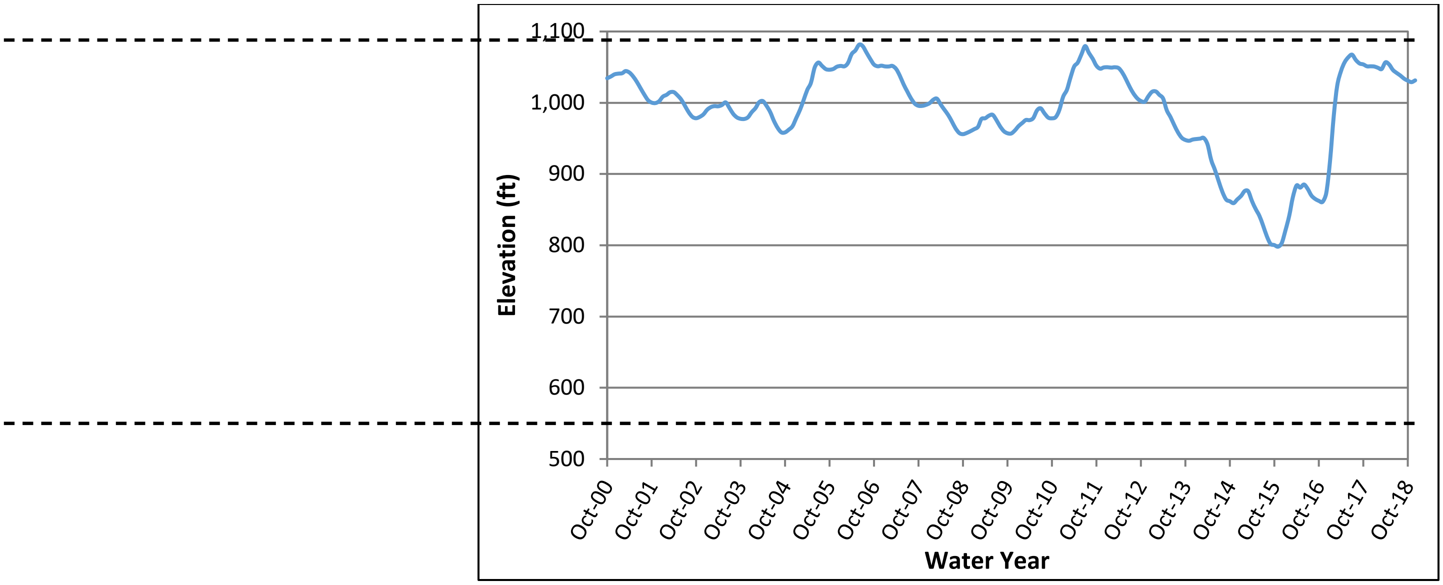

Figure C.4-14. New Melones Reservoir Elevation

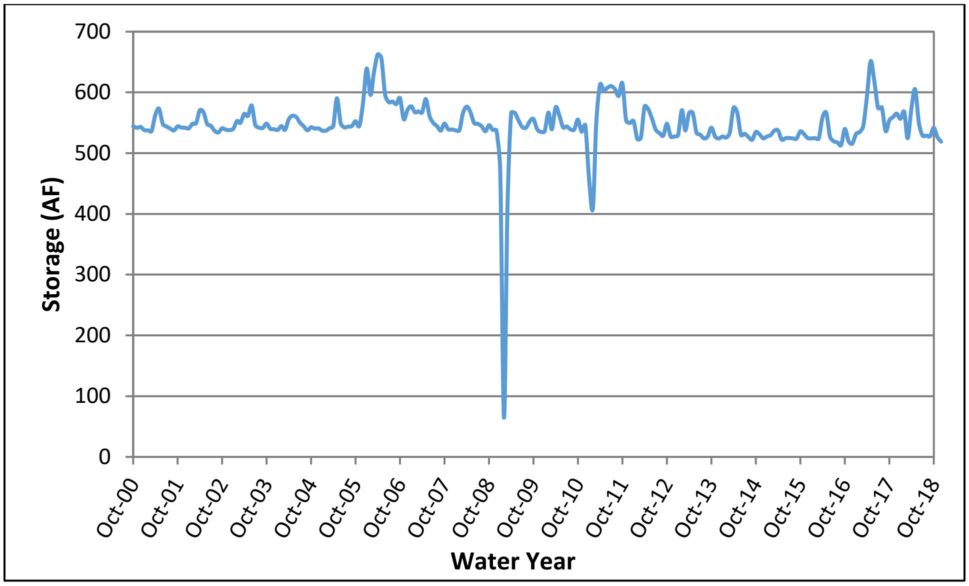

Figure C.4-15. Goodwin Reservoir Storage

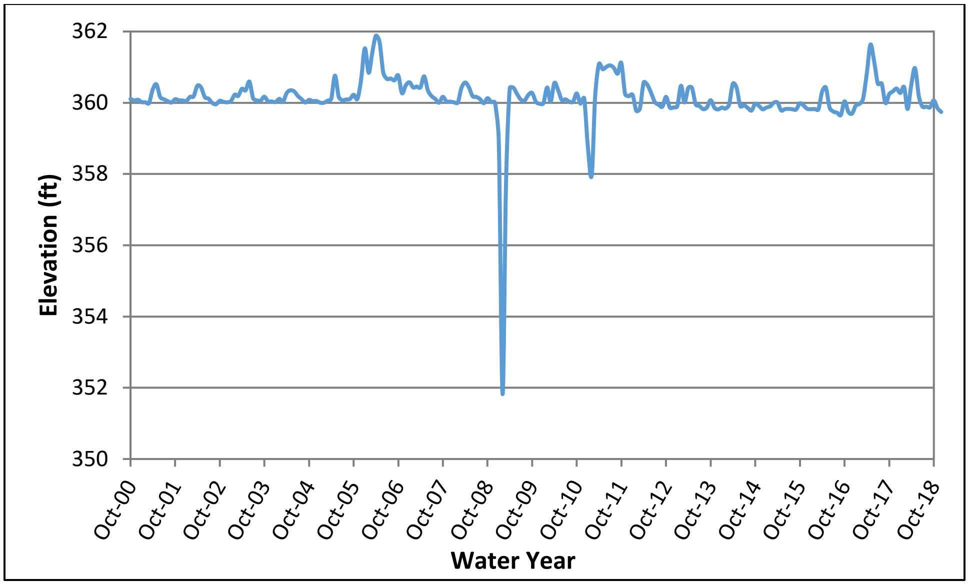

Figure C.4-16. Goodwin Reservoir Elevation

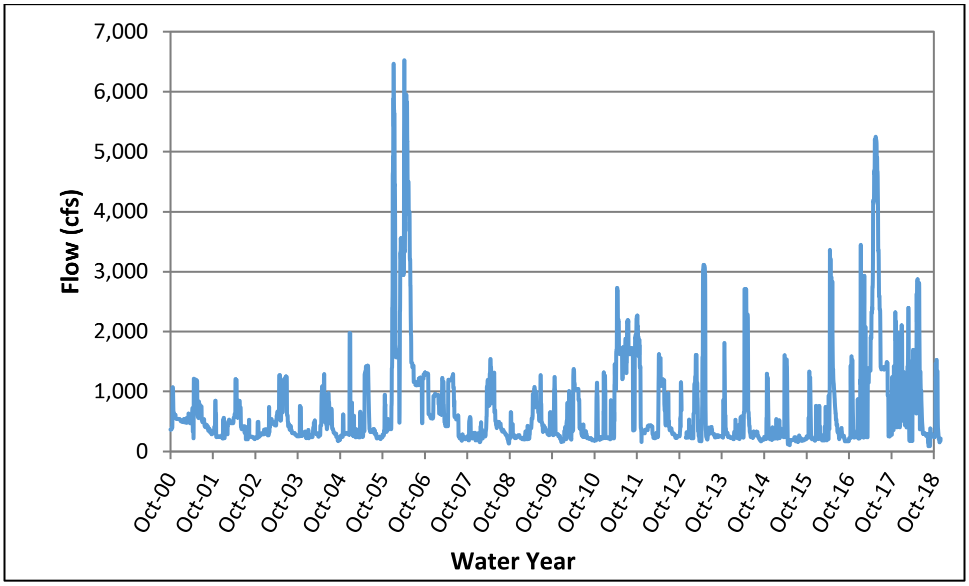

Figure C.4-17. Stanislaus River at Orange Blossom Bridge

C.4.2.3.1 Flood Control

The New Melones Reservoir flood control operation is coordinated with the operation of Tulloch Reservoir. The flood control objective is to maintain flood flows at the Orange Blossom Bridge at less than 8,000 cfs. When possible, however, releases from Tulloch Dam are maintained at levels that would not result in long-term downstream flows in excess of 1,500 cfs because of the past reported potential for seepage in agricultural lands adjoining the river associated with flows above this level. Up to 450 TAF of the 2.4 MAF storage volume in New Melones Reservoir is dedicated for flood control and 10 TAF of Tulloch Reservoir storage is set aside for flood control. Based upon the flood control diagrams prepared by USACE, part or all of the dedicated flood control storage may be used for conservation storage (storing allocated, excess waters), depending on the time of year and the current flood hazard.

C.4.2.3.2 Water Rights Requirements

The operating criteria for New Melones Reservoir are constrained by water rights requirements, flood control operations, contractual obligations, and federal requirements under the ESA and CVPIA.

Terms and conditions of Reclamation's water rights define the limitations within which Reclamation can directly divert water or divert water to storage, after senior water rights and in-basin demands are met. Senior water rights are both current and future upstream water right holders (whose priority is reserved in D-1422 and D-1616 and through protest settlement agreements with Tuolumne and Calaveras Counties), and current downstream water right holders and riparian rights (whose priorities are either senior to Reclamation or senior to appropriative rights in general, respectively). In-basin, instream demands include water quality and flow in the lower Stanislaus River and in part in the lower San Joaquin River and Delta (in that the Stanislaus River contributes to these systems). Downstream demands are first met, to the degree possible, by bypassing natural inflow through New Melones Reservoir. When natural flow is insufficient, stored water is released to meet demands specified either through calculated riparian demand, downstream instream objectives, or protest settlement agreements. Whenever possible, multiple demands are met with the same flow.

C.4.2.3.3 Senior Water Rights: Protest Settlement Agreements

Reclamation's application for assignment of state water right filings in the early 1970s was protested by future in-basin users, senior water rights holders, and the CDFW. To resolve the senior water rights' protest, Reclamation entered into a 1972 Agreement and Stipulation with OID, and SSJID. The 1972 Agreement and Stipulation specifies that it satisfies the yield for consumptive purposes of the OID and SSJID water rights on the Stanislaus River, through the provision of up to a maximum of 654 TAF per year of either natural inflow to New Melones Reservoir or water stored in New Melones for diversion at Goodwin Dam for direct use by OID and SSJID and for storage in Woodward Reservoir (36 TAF capacity).

In 1988, following a year of low inflow to New Melones Reservoir, the Agreement and Stipulation among Reclamation, OID, and SSJID was renegotiated, resulting in an agreement that depended less on actual inflow and more on Reclamation's storage in New Melones, in order to provide a more reliable, albeit slightly smaller maximum, supply. The 1988 agreement commits Reclamation to provide water in accordance with a formula based on inflow and storage of up to 600 TAF each year for diversion at Goodwin Dam by OID and SSJID to meet their demands. 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 carried over for use in subsequent years, depending on storage/flood control conditions in New Melones. This conservation account has a maximum volume of 200 TAF, and withdrawals are constrained by criteria in the agreement.

C.4.2.3.4 In-Basin Requirements in the Lower Stanislaus River

Based on a protest settlement agreement between Reclamation and CDFW, SWRCB D-1422 required Reclamation to bypass or release 98 TAF of water per year (69 TAF in critical years) through New Melones Reservoir to the Stanislaus River on a distribution pattern to be specified each year by CDFW for fish and wildlife purposes. Based on a second protest settlement agreement in 1987, SWRCB D-1616 as amended required 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 were to range from 98.3 to 302.1 TAF per year. The exact quantity to be released each year was to be determined based on a formulation involving storage, projected inflows, projected water supply, water quality demands, projected CVP contractor demands, and target carryover storage. Because of dry hydrologic conditions during the 1987 to 1992 drought period, the ability to provide increased releases was limited. USFWS published the results of a 1993 study, which recommended a minimum instream flow on the Stanislaus River of 155.7 TAF per year for spawning and rearing (USFWS 1993).

The study period is near completion with all but one study (outlined in the 1987 agreement) completed at the time of this document. Reclamation is proposing a new plan of operations. This new plan is explained below and will replace the former CDFW and D-1641 downstream release requirements and satisfy ESA obligations.

Reclamation's New Melones water rights require that water be bypassed through or released from New Melones Reservoir to maintain applicable dissolved oxygen (DO) standards to protect the salmon fishery in the Stanislaus River. The 2004 San Joaquin Basin 5C Plan (Central Valley Regional Water Quality Control Board) designates the lower Stanislaus River with cold water and spawning beneficial uses, which have a general water quality objective of no less than 7 mg/L DO. This objective is therefore applied through the water rights to the Stanislaus River near Ripon.

C.4.2.3.5 Water Temperature Requirements

Water temperatures in the lower Stanislaus River are affected by many factors and operational tradeoffs. These include available cold-water resources in New Melones reservoir, Goodwin release rates for fishery flow management, ambient air conditions, and residence time in Tulloch Reservoir, as affected by local irrigation demand

C.4.2.3.6 Fish and Wildlife Requirements on the Stanislaus River

The 2009 NMFS BO RPA requires Reclamation to adaptively manage available flows to meet minimum instream flow, ramping flow, pulse flow, floodplain inundation, and geomorphic and function flow patterns, through the following actions. The available flows to meet the 2009 NMFS BO RPA are defined following compliance with water rights' needs.

- Minimum base flows to optimize available steelhead habitat for adult migration, spawning, and juvenile rearing by water year type, as measured downstream of Goodwin Dam, as specified in Appendix 2-E of the 2009 NMFS BO RPA.
- Fall pulse flows to improve instream conditions.
- Winter instability flows to simulate natural variability in the winter hydrograph and to enhance access to varied rearing habitats.
- Channel forming and maintenance flows in the 3,000 to 5,000 cfs range in above normal and wet years to maintain spawning and rearing habitat quality after March 1 to protect incubating eggs and to provide outmigration flow cues and late spring flows.
- Outmigration flow cues to enhance likelihood of anadromy.
- Late spring flows for conveyance and maintenance of downstream migratory habitat quality in the lowest reaches and into the Delta. Flows also are released to meet the following temperature requirements (see 2009 NMFS BO RPA for exception criteria) to protect steelhead. • October 1 (or initiation of fall pulse flow) through December 31: 56° F at Orange Blossom Bridge

- January 1 through May 31: 52° F at Knights Ferry and below 55° F at Orange Blossom Bridge
- June 1 through September 30: 65° F at Orange Blossom Bridge

Reclamation is also required to evaluate an approach to operate New Melones Reservoir flow releases to achieve floodplain inundation flows and improved freshwater migratory habitat for steelhead. Reclamation also participates in gravel augmentation to improve spawning habitat.

2009 NMFS BO RPA flows described above are often accounted for dedication of CVPIA 3406 (b)(2) water on the Stanislaus River below Goodwin Dam.

C.5 Delta and Suisun Marsh

The Delta and Suisun Marsh area constitutes a natural floodplain that covers 1,315 square miles and drains approximately 40 percent of the state (DWR 2013a). The Delta and Suisun Marsh have a complex web of channels and islands and is located at the confluence of the Sacramento and San Joaquin rivers.

Historically, the natural Delta system was formed by water inflows from upstream tributaries in the Delta watershed and outflow to Suisun Bay and San Francisco Bay. In the late 1800s, local land reclamation efforts in the Delta resulted in the construction of channels and levees that began altering the Delta's surface water flows. Over time, the natural pattern of water flows continued to change as the result of upper watershed diversions and the construction of facilities to divert and export water through the Delta to areas where supplemental water supplies are needed, including densely populated areas such as San Francisco and Southern California and agricultural regions such as the San Joaquin Valley and Tulare Lake. The SWP and CVP use the Delta as the hub of their conveyance systems to deliver water to large pumps located in the southern Delta.

Inflows to the Delta occur primarily from the Sacramento River system and Yolo Bypass, the San Joaquin River, and other eastside tributaries such as the Mokelumne, Calaveras, and Cosumnes rivers. In general, in any given year, approximately 77 percent of water enters the Delta from the Sacramento River, approximately 15 percent enters from the San Joaquin River, and approximately 8 percent enters from the eastside tributaries (DWR 1994). The Delta is tidally influenced; rise and fall varies from less than 1 foot in the eastern Delta to more than 5 feet in the western Delta (DWR 2013a).

Water quality in the Delta is highly variable and strongly influenced by inflows from the rivers and by seawater intrusion into the western and central portions of the Delta during periods of low outflow that may be affected by high volumes of export pumping. The concentrations of salts and other materials in the Delta are affected by river inflows, tidal flows, agricultural diversions, drainage flows, wastewater discharges, water exports, cooling water intakes and discharges, and groundwater accretions. Seawater intrusion into the Delta is dependent on tidal conditions, inflows to the Delta, and Delta channel geometry. Delta channels are typically less than 30 feet deep, unless dredged, and vary in width from less than 100 feet to more than 1 mile. Although some channels are edged with riparian and aquatic vegetation, steep mud or rip-rap covered levees border most channels. To enhance flow and aid in levee maintenance, vegetation is often removed from the channel margins. The tidal currents carry large volumes of seawater back and forth through the San Francisco Bay-Delta Estuary with the tidal cycle. The mixing zone of salt and fresh water can shift 2 to 6 miles daily depending on the tides and may reach far into the Delta during periods of low inflow.

The CVP's Delta Division consists of the CVP facilities in and south of the Sacramento-San Joaquin Rivers Delta, including the DCC, the Contra Costa Canal and Pumping Plants, Contra Loma Dam, Martinez Dam, the C.W. “Bill” Jones Pumping Plant (formerly Tracy Pumping Plant), the Tracy Fish Collection Facility (TFCF), the DMC, and Delta-Mendota Canal/California Aqueduct Intertie. Collectively these facilities are used to divert, convey and store water for irrigation, M&I, and fish and wildlife uses in the San Joaquin Valley, Santa Clara Valley, Contra Costa County, and San Benito County.

Salinity objectives adopted by the SWRCB were established to protect beneficial uses, including agricultural and municipal water supplies, and fisheries. The CVP and SWP facilities are operated to comply with the requirements that would protect the Delta water quality; operational requirements affect the hydrology in the Delta.

Hydrological conditions in the Delta and Suisun Marsh are substantially affected by structures that route water through the Delta towards the major Delta water diversions in the south Delta, including the CVP Jones Pumping Plant and the SWP Banks Pumping Plant. Structures that change flows in Delta channels include the DCC, the Suisun Marsh Salinity Control Gates, and temporary barriers in the south Delta. Diversion patterns for the major facilities also are regulated to maintain Delta water quality and to protect fish that are listed as threatened or endangered species under ESA in accordance with the SWRCB D-1641, 2008 USFWS BO, and the 2009 NMFS BO. The diversion patterns are implemented to maintain the ratio of exports at the Banks and Jones Pumping Plants to the Delta inflow (known as the E:I ratio); to maintain the ratio of San Joaquin River inflow to exports at the Banks and Jones Pumping Plants (known as the San Joaquin River I:E ratio); and to limit net reverse flow in Old and Middle rivers (known as the OMR criteria). Operations of the Jones and Banks pumping plants are affected by downstream CVP and SWP water demands and reservoir operations in San Luis Reservoir that is jointly used by the CVP and SWP.

To meet the Delta water quality requirements and water rights requirements of users located upstream of the Delta, the CVP and SWP are operated in a coordinated manner in accordance with COA, as described in the below section.

C.5.1 Delta Cross Channel

The DCC is a gated diversion channel in the Sacramento River near Walnut Grove and Snodgrass Slough. When the gates are open, water flows from the Sacramento River through the cross channel to channels of the lower Mokelumne and San Joaquin Rivers toward the interior Delta. The DCC operation improves water quality in the interior Delta by improving circulation patterns of good quality water from the Sacramento River towards Delta diversion facilities.

Reclamation operates the DCC in the open position to (1) improve the movement of water from the Sacramento River to the export facilities at the Banks and Jones Pumping Plants, (2) improve water quality in the southern Delta, and (3) reduce salt water intrusion rates in the western Delta. During the late fall, winter, and spring, the gates are often periodically closed to protect out migrating salmonids from entering the interior Delta. In addition, whenever flows in the Sacramento River at Sacramento reach 20,000 to 25,000 cfs (on a sustained basis) the gates are closed to reduce potential scouring and flooding that might occur in the channels on the downstream side of the gates.

Flow rates through the gates are determined by Sacramento River stage and are not affected by export rates in the south Delta. The DCC also serves as a link between the Mokelumne River and the Sacramento River for small crafts and is used extensively by recreational boaters and fishermen whenever it is open.

C.5.1.1 *Delta Cross Channel Operations*

- The SWRCB D-1641 requires closure of the DCC gates for fisheries protection as follows.
- From November through January, the DCC may be closed for up to 45 days for fishery protection purposes.
- From February 1 through May 20, the gates are closed for fishery protection purposes.
- The gates may also be closed for 14 days for fishery protection purposes during the May 21 through June 15 period.

Reclamation determines the timing and duration of the closures after discussion with USFWS, CDFW, and NMFS. These discussions occur through the Water Operations Management Team (WOMT) as part of the weekly review of CVP and SWP operations.

WOMT 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 when considering the timing of DCC closures. However, the overriding factors are current water quality conditions in the interior and western Delta. From mid-June to November, Reclamation usually keeps the gates open on a continuous basis. The DCC is also usually opened for the busy recreational Memorial Day weekend, if this is possible from a fishery, water quality, and flow standpoint.

The Salmon Decision Process is used by the fishery agencies and Project operators to facilitate the coordination issues surrounding DCC gate operations and the purposes of fishery protection closures, Delta water quality, and/or export reductions. Inputs such as fish life stage and size development, current hydrologic events, fish indicators (such as the Knight’s Landing Catch Index and Sacramento Catch Index), and salvage at the export facilities, as well as current and projected Delta water quality conditions, are used to determine potential DCC closures and/or export reductions. The Salmon Decision Process includes “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, which trigger the Salmon Decision Process.

The 2009 NMFS BO RPA Action IV.1.2 requires Reclamation to close the DCC for additional days from October 1 through November 30; December 1 through December 14, unless closures cause adverse impacts on water quality conditions; and December 15 through January 31, if fish are present.

C.5.2 Temporary Agricultural Barriers

DWR initiated the South Delta Temporary Barrier Project (TBP) in 1991. Currently, DWR has permits extending the TBP through 2022. The TBP BO issued in 2018 by USFWS and NMFS to USACE are mandatory requirements of the 5-year 404 permit for construction and removal of the barriers. USACE issued separate permits for both the agricultural barriers and the Head of Old River (HOR) barrier that run through 2022. The CDFW issued two permits; the Incidental Take Permit and the Streambed Alteration Agreement, providing coverage through 2021, and finally, the 401 Water Quality Certification from the Regional Water Quality Control Board provides coverage through 2022.

The project consists of four rock barriers across south Delta channels. In various combinations, these barriers improve water levels for agricultural diversions and conditions for San Joaquin River origin salmonids in the south Delta. The existing TBP consists of the seasonal installation and the removal of temporary rock barriers at the following locations:

- Middle River near the Victoria Canal, about 0.5 miles south of the confluence of Middle River, Trapper Slough, and North Canal.

- Old River near Tracy, about 0.5 miles east of the DMC intake.
- Grant Line Canal near Tracy Boulevard Bridge, about 400 feet east of Tracy Boulevard Bridge.
- HOR at the confluence of Old River and San Joaquin River.

The temporary barriers on Middle River, Old River near Tracy, and the Grant Line Canal (GLC) are referred to as the agricultural barriers (ag barriers) which are flow control facilities designed to improve water levels and circulation for agricultural diversions and are in place during the irrigation season. The installation of the ag barriers is coordinated with the installation of the spring HOR barrier that is authorized by the Central Valley Project Improvement Act because of its benefits to salmon.

If the spring HOR barrier is installed, installation of the ag barriers can begin as early as March 1, the same starting day of the HOR barrier, but the ag barriers must be closed before the closing of the HOR barrier to protect south Delta agricultural diverters from water level impacts associated with reduced flows from the San Joaquin River into Old River. The Middle River and Old River near Tracy barriers must be closed before the closing of the HOR barrier; however, the GLC barrier is only partially closed due to the presence of the Delta smelt in the area during the spring. Prior to requesting permission to fully close GLC, a need for full closure must be demonstrated through documented water level complaints. In late May to early June, the USFWS upon evaluating the status of the Delta smelt, will typically grant permission to close the GLC barrier.

The operation of the spring HOR barrier begins on April l 1 and lasts until May 31. Starting on June 1, the removal operation of the HOR barrier begins. If the spring HOR barrier is not installed within a given year—usually due to high flows—the installation of the ag barrier may be delayed until early May. Another installation of the HOR barrier takes place in the fall around mid-September at the discretion of CDFW. This installation is to provide increased attractive flows for up-migrating adult salmonids and to increase the dissolved oxygen levels in the Stockton Deep Water Ship Channel. All the barriers must be completely removed by November 30th.

Any rock barrier operating on or after September 15 must be notched by September 15. The ag barriers must be notched to allow for the passage of adult salmon. At the GLC barrier, flashboards would be removed at the southern end of the barrier to form a notch. Detailed barrier installation and operation requirements are summarized in Table C.5-1 through C.5-3

Table C.5-1. HOR Barrier Installation and Operation Schedule.

Schedule	Activity
March 1	Spring installation of rock barrier may begin.
April 1-May 31	Full closure and/or operation of the spring barrier may occur.
	If a barrier at HOR is installed and the GLC barrier is breached due to Delta Smelt concerns OR: • the GLC barrier cannot be closed when the need is clearly demonstrated by DWR, • the HOR barrier must be breached and removed as soon as possible, unless otherwise instructed by the CDFW, NMFS and USFWS.
May 15-May 31	Full closure and/or operation may continue, at the discretion of the CDFW, NMFS and USFWS.
On or after September 1	Fall barrier installation may begin at the discretion of CDFW, NMFS and USFWS.

Schedule	Activity
November 30	Barrier must be completely removed.

Table C.5-2. Agricultural barrier installation and operation schedule, for years when the spring HOR barrier is not installed

	Middle River	Old River near Tracy	GLC
May 1	Installation may begin.	Installation may begin.	Installation may begin.
May 15 to May 31	Full operation and closure may occur if: • the need for Middle River full operation is clearly demonstrated by DWR through forecasting water levels by delta modeling and by actual stage data collected in the field (such data shall be provided to the DFG, NMFS and USFWS one week in advance of closing the flapgates).	Full operation and closure may occur if: • the need for Old River near Tracy full operation is clearly demonstrated by DWR through forecasting water levels by delta modeling and by actual stage data collected in the field (such data shall be provided to the DFG, NMFS and USFWS one week in advance of closing the flapgates).	Full operation and closure may occur if: the need for GLC full operation is clearly demonstrated by DWR through forecasting water levels by delta modeling and by actual stage data collected in the field (such data shall be provided to the DFG, NMFS and USFWS two weeks in advance of closing the flapgates and center sections of the barrier). AND: the incidental take concern level for delta smelt at the SWP/CVP facilities has not been reached. If the incidental take concern limit is reached at the SWP/CVP facilities and if reductions in project exports are determined to be inadequate to protect delta smelt, the DFG, NMFS and USFWS may require the flap gates to be tied in the open position and the center section to be removed.
June 1 to November 30	Full operation and closure may occur. Barrier elevation can be raised from 3.3 feet NAVD 88 to 4.3 feet NAVD 88 with DFG and USFWS approval.	Full operation and closure may occur.	Full operation and closure may occur. If the incidental take concern limit is reached at the SWP/CVP facilities and if reductions in project exports are determined to be inadequate to protect delta smelt, the DFG, NMFS and USFWS may require the flap gates to be tied in the open position and the center section to be removed.
September 15	Barrier must be notched to allow passage of adult salmon.	Barrier must be notched to allow passage of adult salmon.	Barrier must have enough flashboards removed to allow passage of adult salmon.
November 30	Barrier must be completely removed.	Barrier must be completely removed.	Barrier must be completely removed.

Table C.5-3. Agricultural barrier installation and operation schedule, for years when the spring HOR barrier is installed

	Middle River	Old River near Tracy	GLC
May 1	Installation may begin.	Installation may begin.	Installation may begin.
May 15 to May 31	Full operation and closure may occur if: • the need for Middle River full operation is clearly demonstrated by DWR through forecasting water levels by delta modeling and by actual stage data collected in the field (such data shall be provided to the DFG, NMFS and USFWS one week in advance of closing the flapgates).	Full operation and closure may occur if: • the need for Old River near Tracy full operation is clearly demonstrated by DWR through forecasting water levels by delta modeling and by actual stage data collected in the field (such data shall be provided to the DFG, NMFS and USFWS one week in advance of closing the flapgates).	Full operation and closure may occur if: the need for GLC full operation is clearly demonstrated by DWR through forecasting water levels by delta modeling and by actual stage data collected in the field (such data shall be provided to the DFG, NMFS and USFWS two weeks in advance of closing the flapgates and center sections of the barrier). AND: the incidental take concern level for delta smelt at the SWP/CVP facilities has not been reached. If the incidental take concern limit is reached at the SWP/CVP facilities and if reductions in project exports are determined to be inadequate to protect delta smelt, the DFG, NMFS and USFWS may require the flap gates to be tied in the open position and the center section to be removed.
June 1 to November 30	Full operation and closure may occur. Barrier elevation can be raised from 3.3 feet NAVD 88 to 4.3 feet NAVD 88 with DFG and USFWS approval.	Full operation and closure may occur.	Full operation and closure may occur. If the incidental take concern limit is reached at the SWP/CVP facilities and if reductions in project exports are determined to be inadequate to protect delta smelt, the DFG, NMFS and USFWS may require the flap gates to be tied in the open position and the center section to be removed.
September 15	Barrier must be notched to allow passage of adult salmon.	Barrier must be notched to allow passage of adult salmon.	Barrier must have enough flashboards removed to allow passage of adult salmon.
November 30	Barrier must be completely removed.	Barrier must be completely removed.	Barrier must be completely removed.

In addition to allowing construction and removal of the barriers, the permits also give DWR coverage for scientific studies that may take endangered fish species. According to NMFS and USFWS BO requirements, actions for each upcoming year—including barrier type, timing, and any scientific studies planned—must be submitted to USACE by October 1 of each year. USACE requires NMFS and USFWS to append the actions for the upcoming year to the current BOs.

In 2009 and 2010, an experimental non-physical barrier was installed in lieu of the HOR spring rock barrier with the intention of deterring out-migrating juvenile salmonids from entering Old River. This experimental barrier is a patented technology using sound and light as a deterrent. Although high flows prohibited installation of the non-physical barrier in 2011, a without-barrier study of predator behavior was conducted. In 2012, a rock barrier with eight culverts was installed in the spring. The rock barrier with eight culverts is expected to be installed each spring unless installation is prevented by high flows in the San Joaquin River, or if new studies conclude the spring HOR barrier does not provide salmonid protections previously assumed.

To improve water circulation and quality, DWR coordinated with the South Delta Water Agency and Reclamation in 2007 to manually tie open the culvert flap gates at the Old River near Tracy barrier to improve water circulation and untie them when water levels fell unacceptably. This operation is expected to continue in subsequent years as needed to improve water quality. In addition, DWR consulted with USACE and received USFWS and NMFS approval to raise the Middle River weir height by 1 foot. The weir height can be raised during the summer irrigation season only after the Delta smelt concerns have passed. The requested modification was approved late in the 2010 irrigation season. The weir height has been raised every year since 2010 except in 2011 and 2017 due to high flow conditions in the south Delta. Upon notification and analysis of effects, current environmental permits allow for changes in the type and numbers of culverts through the barrier as well as weir elevations.

In the absence of permanent operable gates to replace the rock barriers, the TBP will continue to be planned and permitted. Computer model forecasts, real-time monitoring, and coordination with local, state, federal agencies, and stakeholders will help determine if the temporary rock barriers operations need to be modified during the transition period.

C.5.2.1 *Conservation Strategies and Mitigation Measures*

DWR has complied with the various measures and conditions required by regulatory agencies under past and current permits to avoid, minimize, and compensate for the TBP impacts. An ongoing monitoring plan is implemented each year that the barriers are installed, and an annual monitoring report is prepared to summarize the activities. The monitoring elements include fisheries monitoring, water quality analysis, salmon smolt survival investigations, barrier effects on SWP and CVP entrainment, Swainson's Hawk monitoring, water elevation, water quality sampling, and hydrodynamic modeling.

The 2008 NMFS BO for the TBP requires a fishery monitoring program using biotelemetry techniques to examine the movements and survival of juvenile salmon and juvenile steelhead through the channels of the south Delta. Further the NMFS Biological Opinion for the long-term operations of the CVP and SWP required an evaluation of salmonid smolt survival and predation prior to requesting consultation for permanent operable gates. Information gained as part of the 2009 pilot study was used to develop the full-scale study that started in 2010. 2011 was the third and final year of the mandated studies. The study has been finalized and will be submitted to NMFS in late 2018. Additional studies of predatory fish behavior at the Head of Old River began in 2011 as required by CDFW. Studies continued and included a multi-year study lead by NMFS that looked at the predator and prey interactions on the San Joaquin River near the Head of Old River. The study showed that predatory fish removals did not significantly improve salmon out-migration survival in the stretch of the San Joaquin River between the Head of Old River and Stockton.

The current CDFW incidental take permit provides California Endangered Species coverage through 2021 and requires that all impacts on California Endangered Species be fully mitigated. This permit requires mitigation for all shallow water habitat impacts and required the purchase of 2.49 acres of shallow water habitat credits. TBP purchased a total of 3.0 acres from Liberty Island Holdings I, LLC for salmonid/smelt restoration conservation credits to satisfy anticipated mitigation requirements. The TBP has been mitigating for impacts over many years and in addition to numerous habitat bank credit purchases, DWR operates fish screens to offset TBP impacts at Sherman Island.

C.5.3 Delta Water Diversions

Water diversions in the Delta include the CVP Jones Pumping Plant, the SWP Banks Pumping Plant, the CVP Contra Costa Canal Pumping Plant at Rock Slough, the SWP Barker Slough Pumping Plant for the North Bay Aqueduct, Contra Costa Water District intakes on Mallard Slough, Old River, and Victoria Canal, and over 1,800 municipal and agricultural diversions for in-Delta use (DWR 2010). Also included are the City of Stockton Municipal Area intake and the Freeport Regional Water Authority intake.

Delta channels have been modified to allow transport of Delta inflow to the diversions throughout the Delta, including the CVP and SWP south Delta intakes, and to reduce the effects of pumping on the direction of flows and salinity intrusion within the Delta. The conveyance of water from the Sacramento River southward through the Delta to the CVP and SWP south Delta intakes is aided by the DCC, a constructed, gated channel that conveys water from the Sacramento River to the Mokelumne River.

C.5.3.1 *Diversion Facilities*

C.5.3.1.1 SWP North Bay Aqueduct – Barker Slough Intake

The Barker Slough Pumping Plant diverts water from Barker Slough into the NBA for delivery to the Solano County Water Agency and the Napa County Flood Control and Water Conservation District (NBA water contractors).

The NBA intake is located approximately 10 miles from the main stem Sacramento River at the end of Barker Slough. Water quality in Barker Slough becomes degraded during winter and spring rainfall events. The Barker Slough drainage basin is characterized by grazing lands, erodible soils, and urban uses. Rainfall runoff can include elevated levels of coliform bacteria, organic matter, turbidity, and pollutants. The water is costly to treat to meet drinking water standards.

C.5.3.1.2 Clifton Court Forebay

CCF is a 31 TAF reservoir located in the southwestern edge of the Delta, about 10 miles northwest of the city of Tracy. CCF provides storage to allow off-peak pumping of water exported through Banks Pumping Plant, 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 CCF are regulated by five radial gates.

Clifton Court Forebay Aquatic Weed and Algal Bloom Control Program

Excessive growth of submerged aquatic weeds in CCF can cause severe head loss and pump cavitation at Banks Pumping Plant when the stems of rooted plants break free, combine into “mats,” and accumulate on the primary and secondary trash racks. This mass of uprooted and fragmented vegetation essentially forms a watertight plug at the trash racks and vertical louver array. The resulting blockage necessitates a reduction in the water pumping rate to prevent potential equipment damage through pump cavitation. Cavitation creates excessive wear and deterioration of the pump impeller blades. Excessive floating weed mats also block the passage of fish into the Skinner Fish Facility, thereby reducing the efficiency of fish salvage operations. Algal blooms have occurred in CCF that produce compounds that cause unpleasant tastes and odors to finished drinking water.

Mechanical methods are implemented to manually remove aquatic weeds. A debris boom and an automated weed rake system continuously remove weeds entrained on the trash racks. During high weed load periods in late summer and fall when the plants senesce and fragment, boat-mounted harvesters are operated on an as-needed basis to remove aquatic weeds in the Forebay and the intake channel upstream of the trash racks and louvers. The objective is to decrease the weed load on the trash racks and to improve flows in the channel. Effectiveness is limited due to the sheer volume of aquatic weeds and the limited capacity and speed of the harvesters. Harvesting rate for a typical machine ranges from 0.5 to 1.5 acres per hour or 4 to 12 acres per day. Actual harvest rates may be lower due to travel time to off-loading site, unsafe field conditions such as high winds, and equipment maintenance.

DWR applies copper-based herbicides to control aquatic weeds and algal blooms on an as-needed basis dependent upon the level of vegetation biomass or concentration of taste and odor compounds. Aquatic weed treatment areas are typically about 900 acres, and no more than 50% of the 2,180 total surface acres.

Treatment areas for cyanobacteria blooms have varied considerably in past years. Treatment area is based on the distribution of the benthic algal bloom.

Applications of copper herbicides are applied at a concentration of 1 ppm. Applications for algal control are applied at a concentration of 0.2 to 1 ppm. Treatment is only permitted from July 1 to August 31.

Clifton Court Forebay Predation Studies

DWR has conducted the following studies on predation at CCF:

- *Clifton Court Forebay Predation Study Project Report* (DWR 2010a)
- *2013 CCF Predation Study Annual Progress Report* (DWR 2015)
- *2014 CCF Predation Study Annual Progress Report* (DWR 2016a)
- *2015 CCF Predation Study Annual Progress Repor*t (DWR 2017a)
- 2016 CCF Predation Study Annual Progress Report (DWR 2018a)
- *Quantification of Pre-Screen Loss of Juvenile Steelhead in Clifton Court Forebay* (DWR 2009)
- *2007-2008 Fish Release Site Predation Study* (“CHTR Element 2”) Report (DWR 2010)
- *2016 CCF Predator Reduction Electrofishing Study Annual Report* (DWR 2016)
- *2017 CCF Predator Reduction Electrofishing Study Annual Report* (DWR 2017)
- *2018 CCF Predator Reduction Electrofishing Study Annual Report* (DWR 2018b)

Prescreen Loss

Pre-screen loss estimates for Chinook Salmon developed in the past 10 years are largely consistent with the historical studies outlined in DWR Interagency Ecological Program (IEP) (1997) which ranged from 63-99%. A summary of the findings of several contemporary studies are outlined below:

- *Quantification of Pre-Screen Loss of Juvenile Steelhead in Clifton Court Forebay* (DWR 2009)
    - Steelhead: This study calculated pre-screen loss rates from paired releases of passive integrated transponder PIT and acoustic tagged fish released at the CCF radial gates and at the Skinner Fish Facility trash rack. Pre-screen loss was calculated as 82±3% and 78±4% (when adjusted for emigration from CCF).

- *Pre-screen loss and fish facility efficiency for Delta Smelt at the South Delta's State Water Project, California* (Castillo et al 2012)
    - Delta Smelt: This study used releases of cultured, Calcein-marked juvenile and adult Delta Smelt released at the CCF radial gates and at the entrance to the Skinner Fish Facility. Pre-screen loss of adult Delta Smelt ranged from 89.9% to 100%. Pre-screen loss of juvenile Delta Smelt was 99.9%.
- *2013 CCF Predation Study Annual Progress Report* (DWR 2015)
    - Fall-run Chinook Salmon: This study utilized releases of PIT tagged, fall-run Chinook Salmon released at the radial gates and the Skinner Fish Facility in April and May of 2013. A pre-screen loss rate of 81.14% was reported, ranging from 41% to 100%.
- *Preliminary SWP Chinook Salmon Survival Estimates for Water Year 2016* (DWR 2016c)
    - Chinook Salmon: This study utilized PIT tagged late-fall and fall run Chinook Salmon released at the CCF radial gates from January through May of 2016. Monthly estimates of mean Pre-screen Loss ranged from 75% to 91%, with a season mean estimate of 91%.
- *Skinner Evaluation and Improvement Study 2017 Annual Report* (DWR 2019)
    - Chinook Salmon. This study utilized releases of PIT and acoustic tagged fall and late-fall run Chinook Salmon released at the CCF radial gates and at the head of the Skinner Fish Facility. Pre-screen loss was estimated as 77.16% for all races combined. Pre-screen loss was estimated as 56.07% (26.1% to 88.5%) for late-fall run Chinook Salmon, and 92.1% (92.1% to 98.5%) for fall run Chinook Salmon.

Measures to Reduce Mortality of ESA-Listed Fish Species

DWR plans to continue implementation of projects to reduce mortality of ESA listed fish species in response to the NMFS letter dated April 9, 2015, requiring that DWR immediately implement interim measures to improve predator control until an acceptable alternative can be implemented. These interim measures that could be implemented include: (a) electro-shocking and relocating predators; (b) controlling aquatic weeds; (c) implementing the "Predatory Fish Relocation Study;" and (d) operational changes when listed species are present.

DWR recently completed work at the Curtis Landing Fish Release Site, the Fish Science Building and Warehouse, and two new fish release sites as part of its ongoing efforts to improve the survival of ESA listed and other Delta fish species. DWR also constructed new fish friendly count and transfer buckets, added an epoxy coating to the holding tanks, and refurbished the holding tank screens to prevent fish losses.

C.5.3.1.3 SWP John E. Skinner Delta Fish Protective Facility

The John E. Skinner Delta Fish Protective Facility is located west of the CCF, 2 miles upstream of the Banks 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 towards the pumps. These fish pass through a secondary system of screens and pipes into seven holding tanks, where a subsample is counted and recorded. The salvaged fish are then returned to the Delta in oxygenated tank trucks.

SWP John E. Skinner Delta Fish Protective Facility Operations

Louver Operations

Louver efficiency estimates for Chinook Salmon developed in the past 10 years are largely consistent with the findings of the original testing program for the Skinner Fish Facility (Skinner 1974) and used by CDFW to calculate loss. A summary of the findings of several contemporary studies are outlined below:

- *Quantification of Pre-Screen Loss of Juvenile Steelhead in Clifton Court Forebay* (DWR 2009)
    - Steelhead: This study determined efficiency for steelhead trout using releases of PIT tagged steelhead released at the Skinner Fish Facility trash rack. The study reported two estimates of efficiency; 74% (17 to 100 %) and 82% (19 to 100%). The latter value incorporates an estimate of emigration from the study area (e.g. "swim out") which was documented in the study.
- *Pre-screen loss and fish facility efficiency for Delta Smelt at the South Delta's State Water Project, California* (Castillo et al 2012)
    - Delta Smelt: This study used releases of cultured, Calcein-marked juvenile and adult Delta Smelt released at the Skinner Fish Facility trash rack. Adult Delta Smelt efficiency was reported to range from 36% to 89%, while juvenile efficiency ranged from 24% to 30%.
- *Skinner Evaluation and Improvement Study 2017 Annual Report* (DWR 2019)
    - Chinook Salmon: This study utilized releases of PIT and acoustic tagged, fall run and late-fall run Chinook Salmon released at the Skinner Fish Facility when the radial gates were open from January through June. Pre-screen loss was estimated to be 56.07% (ranging 26.1% to 88.5%) for late-fall run and 92.1% (ranging 92.1% to 98.5%) for fall run Chinook Salmon. Whole facility efficiency was reported as 81.7% (ranging 77.9% to 86.2%) and 55.0% (ranging 54.3% and 55.7%) for "Salmon" and "Striped Bass" Operating Criteria, respectively.

The Skinner Fish Facility was built with a modular design including multiple primary louver bays that can be isolated, two secondary channels, and two holding tank buildings. Under most circumstances, this design effectively mitigates fish losses as a result of routine maintenance and cleaning, and mechanical breakdowns. Maintenance, cleaning, and breakdowns normally result in a reduction in overall available capacity rather than exports without salvage.

However, in the event of an unplanned outage (e.g. a power loss), attempts are made to immediately rectify the issue through changes in either the configuration of the facility (e.g. changing bays) or backup systems (e.g. alternate power source) and CDFW is notified. In the event of an unplanned outage lasting greater than 1 hour, CDFW is immediately consulted and/or Banks exports may be temporarily halted.

Planned outages are typically scheduled to avoid periods of unscreened water export. For example, major maintenance activities are scheduled in the spring during a 1-week complete shutdown of Banks Pumping Plant coinciding with NMFS 2009 BO RPA Action IV.2.1 (previously VAMP). During other periods, export capacity of the facility is reduced accordingly.

The duration and frequency of louver cleaning operations fluctuates significantly due to a number of factors including pumping schedule, high fish counts, flow rates, debris loads, environmental factors, and staffing. In general:

- Cleaning of individual primary louver bays is performed weekly. It takes a minimum of 2 hours to clean each bay, and bays are isolated during cleaning to prevent fish losses. Cleaning is performed by lifting individual louver panels using a gantry crane and pressure washing them from both front and back.

- Cleaning of the secondary channels is performed twice weekly and is also used as a predator flush. It generally takes 30-60 minutes to clean each secondary bay. During cleaning, each channel is dewatered, and the louver or screen panels are pressure washed from each side using a fire hose. After the panels have been washed, the primary bypass valve(s) at the head each bay are opened rapidly to flush predators and debris into a holding tank for removal.

Operations and Monitoring

Approximately 52 different species of fish are entrained into the Skinner Fish Facility (and the TFCF, discussed below) each year; however, the total numbers are significantly different for the various species salvaged. Also, it is difficult, if not impossible, to determine exactly how many safely make it all the way to the collection tanks, to be transported back to the Delta. Hauling trucks, used to transport salvaged fish to release sites, inject oxygen and contain an eight parts per thousand salt solution to reduce stress.

When south Delta hydraulic conditions allow, and within the original design criteria for the fish collection facilities, the louvers are operated based on the Biological Opinion objectives of achieving water approach velocities: for striped bass velocities of as close to 1 foot per second (ft/s) as possible from May 15 through October 31, and for salmon velocities of approximately 3 to 3.5 feet per second (ft/s) from November 1 through May 14.

Fish passing through the facility are sampled at intervals of 30 minutes every 2 hours year round. Fish observed during sampling intervals are identified by 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 in the North Delta away from the pumps. In addition, fish collection facility personnel monitor for the presence of spent female Delta Smelt in anticipation of expanding the salvage operations to include sub-20 millimeter (mm) larval Delta Smelt detection.

Fish collection facility personnel monitor for the presence of spent female Delta Smelt by euthanizing all adult Delta Smelt that are collected in the 30-minute fish count, determine the gender and the gonadal or sexual maturation stage of the Delta Smelt, and determining if the eggs have reached Stage IV, the stage when eggs are ready for release (0.9-10 mm in diameter and easily stripped). Stages V (i.e. post-vitellogenic stage) and VI (i.e. post-ovulatory or “spent” stage) are expected soon after Stage IV observation. Stages are determined and reported real-time when a biologist is present or the following morning after smelt detection and collection. Stage or gonad maturation is determined using egg stage descriptions from Mager (1996).

Larval smelt sampling at the fish collection facilities commences once a trigger is met (detection of a spent female at CVP/SWP being one of three triggers). Fish count screen with a 2.4 mm mesh size opening is replaced with one that has a mesh size of 0.5 mm in order to retain larval fish. Sampling is done 4 times a day (04:00, 10:00, 16:00, 22:00) and all larval smelt are identified to species and reported the day after collection.

Survival and Mortality

The effects of Collection, Handling, Trucking, and Release operations have been evaluated in a number of studies at the Skinner Delta Fish Protective Facility, as outlined below. No attempt has been made to quantify post-release survival due to logistical challenges and because it likely fluctuates wildly based on a number of factors including, but not limited to, the number of fish being released, season, and frequency of release.

- Effects on Handling and Trucking on Chinook Salmon, Striped Bass, American Shad, Steelhead Trout, Threadfin Shad, and White Catfish Salvaged at the John E. Skinner Delta Fish Protective Facility (DWR IEP 1989)
    - Chinook Salmon: This study found that survival rates for Chinook Salmon were never less than 98% and in most cases was 100%. The loss equation used by CDFW to calculate SWP losses utilizes this 2% value.
    - Steelhead trout: Showed no detrimental effects from the handling and trucking process.
- Acute mortality and injury of Delta Smelt Associated with Collection, Handling, Transport, and Release at the State Water Project Fish Salvage Facility (DWR IEP 2013)
    - Adult Delta Smelt: Mean survival rates at 0 and 48 hours after exposure to the collection and handling only or full collection, handling, transport, release (CHTR) process were high, averaging above 93%. No significant differences in survival were detected at 48 hours among control, CH, and CHTR groups.
- Evaluation of Injury and Mortality in a Fish Release Pipe (DWR 2010b)
    - Chinook Salmon: This study found that survival of juvenile Chinook Salmon exposed to a mock salvage release was 99.2%, 97.4%, and 98.4% in trials with no debris, moderate debris, and heavy debris, respectively. There was no significantly detectable effect on survival from the release process.
    - Adult Delta Smelt: This study found that survival of Adult Delta Smelt exposed to a mock salvage release was 98.7%, 97.1%, and 95.2% in trials with no debris, moderate debris, and heavy debris, respectively. There was no significantly detectable effect on survival from the release process.

C.5.3.1.4 SWP Harvey O. Banks Pumping Plant

The Harvey O. Banks (Banks) Pumping Plant is in the south Delta, about 8 miles northwest of Tracy and marks the beginning of the California Aqueduct. The plant provides the initial lift of water 244 feet into 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. Even though the installed capacity of Banks Pumping Plant is 10,670 cfs, the maximum conveyance capacity of the California Aqueduct limits the pumping rate to 10,300 cfs.

Permits issued by USACE regulate the rate of diversion of water into CCF for pumping at Banks. This diversion rate is normally restricted to 6,680 cfs as a three-day average inflow to CCF and 6,993 cfs as a one-day average inflow to CCF. CCF diversions may be greater than these rates between December 15 and March 15, when the inflow into CCF may be augmented by one-third of the San Joaquin River flow at Vernalis when those flows are equal to or greater than 1,000 cfs.

Diversion Increase During July, August, and September

During the months of July, August, and September, the maximum allowable daily diversion rate into CCF was increased from 13,870 acre-feet to 14,860 acre-feet and 3-day average diversions from 13,250 acre-feet to 14,240 acre-feet (500 cfs per day equals 990 acre-feet per day). The increase in diversions was originally permitted in 2000 and was subsequently extended through 2020. The purpose of this diversion increase into CCF for use by the SWP is to recover export reductions made due to actions taken to benefit fisheries resources. The increased diversion rate does not result in any increase in water supply deliveries above those that would occur in the absence of the increased diversion rate. This increased diversion over the 3-month period could result in an amount not to exceed 90 TAF each year.

Variations to hydrologic conditions coupled with regulatory requirements may limit the ability of the SWP to fully utilize increased diversion rates. Also, facility capabilities may limit the ability of the SWP to fully utilize the increased diversion rate.

Implementation of this action is contingent on meeting the following conditions:

- The increased diversion rate would not result in greater annual SWP water supply allocations than would occur in the absence of the increased diversion rate. Water pumped due to the increased capacity would only be used to offset reduced diversions that occurred or would occur because of ESA or other, similar protective actions taken to benefit fisheries.
- Use of the increased diversion rate would be in accordance with all terms and conditions of existing BOs governing SWP operations.
- All three temporary agricultural barriers (Middle River, Old River near Tracy and Grant Line Canal) must be in place and operating when SWP diversions are increased.
- Prior to the start of, or during any time when the SWP has increased its diversion rate between July 1 and September 30, if the combined salvage of listed fish species reaches a level of concern, the Data Assessment Team (DAT) will convene to assess the need to modify the planned increase in SWP diversion rates. If DAT does not concur with the continued use of the increased SWP diversion rate, then the issue will be elevated to the WOMT. The WOMT will consider the DAT assessment as to whether the use of the SWP increased diversion rate should continue or be suspended. If the WOMT is unable to reach agreement on the operation, the relevant fish regulatory agency will determine whether the 500cfs increased diversion is or continues to be implemented.

C.5.3.1.5 CVP Jones Pumping Plant and Tracy Fish Collection Facility

The CVP's Jones Pumping Plant, located about 5 miles north of Tracy, has six available pumps. The Jones Pumping Plant has a physical capacity of approximately 5,200 cfs and sits at the end of an earth-lined intake channel about 2.5 miles long. Because of limited capacity in the Delta Mendota Canal, the facilities in which water pumped at Jones flows, the current, maximum pumping capacity at Jones is approximately 4,600 cfs. That capacity is available when Reclamation accesses the Delta-Mendota Canal/California Aqueduct Intertie, Jones Pumping Plant can be operated to its permitted capacity of 4600 cfs.

The TFCF is located in the south-west portion of the Delta at the head of the intake channel for the Jones Pumping Plant. The TFCF uses behavioral barriers consisting of primary louvers and four rotating traveling screens aligned in a single row 7 degrees to the flow of the water, to guide entrained fish into holding tanks before transport by truck to release sites at the confluence of the Delta. The TFCF was designed to handle smaller fish (<200 millimeters [mm]) that would have difficulty fighting the strong pumping plant induced flows since the intake is essentially open to the Delta and also impacted by tidal action.

The primary louvers are located in the primary channel just downstream of the trash rack structure. The traveling water screen is located in the secondary channel. The louvers allow water to pass through onto the pumping plant but the openings between the slats are tight enough and angled against the flow of water so as to prevent most fish from passing between them and to, instead, enable the fish to enter one of four bypass entrances along the louver arrays.

The "Operations and Monitoring" discussion for the Skinner Fish Facility also applies to the TFCF. When south Delta hydraulic conditions allow, and within the original design criteria for the TFCF, the louvers are operated based on the Biological Opinion objectives of achieving water approach velocities: for striped bass velocities of approximately 1 foot per second (ft/s) from May 15 through October 31, and for salmon velocities of approximately 3 feet per second (ft/s) from November 1 through May 14.

CDFW is leading studies of fish survival during the collection, handling, transportation, and release process, examining Delta Smelt injury, stress, survival, and predation. Thus far it has presented initial findings at various interagency meetings (IEP, Central Valley Fish Facilities Review Team, and American Fisheries Society) showing relatively high survival and low injury. DWR has concurrently been conducting focused studies examining the release phase of the salvage process including a study examining predation at the point of release and a study examining injury and survival of Delta Smelt and Chinook Salmon through the release pipe. Based on these studies, improvements to release operations and/or facilities, including improving fishing opportunities in CCF to reduce populations of predator fish, have been implemented.

CDFW and USFWS evaluated pre-screen loss and facility/louver efficiency for juvenile and adult Delta Smelt at the Skinner Fish Facility of the SWP. DWR also conducted pre-screen loss and facility efficiency studies for steelhead and has ongoing studies to evaluate losses for Chinook Salmon.

Tracy Fish Collection Facility Operations

Louver Operations

Louver Efficiency

Louver efficiency at the TFCF is dependent on the flow and velocities, fish species, and the fish size (life stage). The number of pumps (units) running at the Jones Pumping Plant (JPP) dictates the flow and velocity at the TFCF. There are 6 units at Jones Pumping Plant but a maximum of 5 can used; each unit increases the velocity through the TFCF primary channel about 0.5 ft/sec.

For juvenile Chinook Salmon, the most recent whole facility efficiency evaluations completed using acoustic tag telemetry suggests that primary louver efficiency ranges from 50-100% with an average of approximately 88.7% (Reclamation 2017, Wu et al. in progress). At higher pumping regimes of 4-5 Jones Pumping Plant units, for juvenile Chinook Salmon, louver efficiency was high at 71.4-100 % (Reclamation 2017).

For adult Delta Smelt, louver efficiency is 13% at high pumping regime of 5 units (3 ft/sec; Reclamation 2004). At lower pumping regime of 1 unit (~1 ft/sec), the louver efficiency improves to 34.2-82.5% (Reclamation 2004; Bridges et al., 2019 in press).

For juvenile Delta Smelt (32–40 mm FL), louver efficiency as low as 22% was observed in a bulk fish release study in 2010 (Bridges, unpublished data). Furthermore, in a comparison of wild non-smelt larval salvage at varying secondary channel velocities (1 vs 3 ft/sec) in 2012, more larvae were diverted by the louvers at the slower velocity (Reyes, unpublished data).

The equations used to calculate salmon louver efficiency at the TFCF were based on unpublished findings calculated almost 5 decades ago at Skinner and were not based on any work done at the TFCF. Below is the salmon loss calculation containing a louver efficiency estimate for Chinook salmon less than 101 mm FL and greater than 101 mm FL (Aasen 2013):

- If Length < 101 mm → ENCOUNT = SALVAGE/EFF1;
- If Length > 100 mm → ENCOUNT = SALVAGE/EFF2;

- EFF1 = 0.630 + [0.0494 * (Primary Channel Flow /[Primary Channel Depth*Width])]
- EFF2 = 0.568 + [0.0579 * (Primary Channel Flow /[Primary Channel Depth*Width])]

Louver Cleaning Procedures

Loss due to cleaning is not quantified in the current loss calculation. However, TFCF operators estimate that approximately 6.7% of juvenile Chinook Salmon that encounter the louvers are lost through the louvers when they are lifted for cleaning and approximately 33.3% of louver loss occurs during louver cleaning activity (Reclamation 2017). This value, however, is preliminary and needs further verification. A Tracy Fish Facility Improvement Program study plan is currently being developed to study the amount of loss occurring during louver cleaning.

The current primary louver cleaning procedures and operations involve lifting each individual louver panel, 36 total, out of the water in order to spray wash the debris. Generally, each primary louver panel is lifted and lowered back into place three times per day (generally at 0600-0800, 1400-1600, and 2300-0100), although frequency of cleaning may be increased or decreased according to pumping rate and debris loads (details in the next paragraph). It takes approximately 3-7 minutes to lift, spray clean, and lower each louver panel back into place. While export pumping may be reduced to address damaged louver panels, issues during cleaning, or other maintenance scenarios where facilities are not capable of effectively salvaging fish, complete shutdown of pumping usually does not occur due to issues related to the primary louvers.

Although no official SOP exists specifying the timing of louver cleaning, TFCF operators follow certain “guidelines”:

- At 5 Jones Pumping Plant units, louvers are cleaned before the incoming tide as much as possible. The morning day shift usually begin cleaning as soon as they start their work, around 0600. During high debris periods, operators monitor differentials and clean before any problems arise. At a minimum, all 36 louver panels are cleaned 2-3 times a day but during heavy debris loads, operators clean 3-6 times a day.
- At 2-4 Jones Pumping Plant units, operators determine when to clean and making sure the louvers do not reach 1 ft differential.
- At 1 Jones Pumping Plant unit, operators will normally clean periodically during the incoming tide.

Generally, each primary louver panel is lifted, sprayed clean, and lowered back into place three times per day (generally 0600-0800, 1400-1600, and 2300-0100), although frequency of cleaning may be increased or decreased according to pumping rate and debris loads. As described above, cleaning frequency can be as high as 3-6 times per day during 5-unit Jones Pumping Plant operation and during high debris periods. The 2018 louver cleaning data (Table C.5-4, Primary Louver Cleaning Time (2018)) suggests less frequent cleaning is required in early summer (low averages of 60 minutes per day) and much higher during the winter months (high averages of 440 minutes per day). This means that there is a louver panel lifted 1-7.5 hours per day depending on season, pumping rates, and debris loads.

Table C.5-4. Primary Louver Cleaning Time (2018)

Month	Average Daily Cleaning Time (minutes)
January	240
February	131

March	112
April	64
May	76
June	138
July	274
August	310
September	200
October	440
November	270
December	370

Secondary bypasses are not cleaned, although they are shut during cleaning of the primary louvers to prevent excessive debris from entering the holding tanks. When operators clean primary louver panels 1-9 (upstream-downstream) they close secondary bypass #1. When operators clean primary louver panels 10-18, operators close secondary bypass #2, while secondary bypass #3 is closed when they clean louver panels 19-27, and secondary bypass #4 is closed when they clean panels 28-36.

Prescreen Loss

"Pre-screen loss rate" is defined as "the rate of loss to entrained salmon during movement from the trash racks to the primary louvers" (Aasen 2013). In essence, the "pre-screen loss rate" is the predation rate within the primary channel. Although Chinook Salmon mortality has been observed in front of the TFCF trash rack (Natural Resources Scientists, Inc. 2010), this mortality is not included in the pre-screen loss calculation since this is outside of the area between the trash rack and primary louvers. Currently, a 15 percent pre-screen loss rate due to predation is an agreed upon placeholder value (DWR 1986b) but is yet to be fully verified. For this placeholder, the predation rate within the primary channel is currently being verified with the use of predation detection acoustic tags.

Prescreen loss at the TFCF is dependent on fish species, fish size (life-stage), and predator load within the primary channel. In addition, it appears that prescreen loss may be correlated with pumping rates (water velocity) and/or turbidity, although more data needs to be collected to adequately determine these relationships. Data from Reclamation (2017) and Wu et al. (In Progress) suggest that prescreen loss ranges from 0-40% for juvenile Chinook Salmon. Low estimates of pre-screen loss (assuming all unknown fates in the primary channel are non-participants) from these studies average approximately 14.0%, while high estimates of prescreen loss (assuming all unknown fates in the primary channel are losses to predation) average approximately 15.9%. Therefore, preliminary results indicate that the predation rate (or prescreen loss) may be close to the 15 percent placeholder value mentioned above (Reclamation 2017, Wu et al., in progress).

In an experiment several years ago (to be published this year as Reclamation 2019), Reclamation removed (by gillnetting) all predators from the primary channel and improved facility efficiency for Delta Smelt by 16.7% from 9.3% to 26%. This improvement of 16.7% is due almost entirely to the removal of predators.

Survival and Mortality

Salvage of fish occurs at the TFCF 24 hours per day, 365 days per year. Fish are salvaged in flow-through holding tanks (6.1-m diameter, 4.7-m deep) that provide continuous flows of water (Reclamation 2008). Fish are maintained in these holding tanks for 8-24 hours, depending on the species of fish that are being salvaged, the number of fish salvaged, and debris load. The number of fish that are salvaged in TFCF holding tanks is generally estimated by performing a 30 minute fish-count subsample every 120 minutes (2 hours). The number of each species of fish collected in the subsample is determined and then multiplied by 4 (120 pumping minutes/30 minute fish-count subsample = expansion factor of 4) to estimate the total number of each species of fish, as well as the total number of fish, that were salvaged in TFCF holding tanks during the 120 minute period. Pumping minutes and fish-count minutes could potentially deviate from 120 minutes and 30 minutes, respectively, which would change the expansion factor used to estimate total fish salvage.

If no Chinook Salmon, Steelhead, or Delta Smelt are salvaged, fish can be maintained in TFCF holding tank for up to 24 hours. If a Chinook Salmon or Steelhead is collected during fish-counts, fish can only be maintained in TFCF holding tanks for up to 12 hours. If a Delta Smelt is collected during fish-count, salvaged fish may only be held in TFCF holding tanks for up to 8 hours. When fish can be maintained in TFCF holding tanks for 24 hours, fish transport (fish-haul) generally occurs at approximately 0700 each day. When two fish-hauls per day are necessary, fish hauls generally occur at 0700 and 2130 each day. When three fish-hauls are necessary, they are usually completed at 0700, 1500, and 2130 each day. Fish-haul is also dictated by the Bates Tables which uses size classes, species, and water temperature as indicators for when to conduct a fish-haul.

During normal operations, salvaged fish are transported approximately 49.9 km and released at one of two Reclamation release sites near the confluence of the Sacramento and San Joaquin Rivers (Antioch Fish Release Site and Emmaton Fish Release Site). In general, the Emmaton Fish Release Site is used for fish-hauls performed during daytime hours and the Antioch Fish Release Site is used for fish-hauls performed during nighttime hours. This is done for safety and security reasons as the Antioch Fish Release Site has a gate that can be locked behind the operator after he/she enters the release site area. Upon arrival at release sites, operators measure certain important water quality parameters (dissolved oxygen, salinity, and temperature) prior to releasing fish. This is done to verify that water quality parameters remain acceptable during fish transport.

Salmon loss due to handling and trucking are generally low and are based on CDFW trucking and handling studies. Salmon loss is < 2 percent for salmon < 100 mm and zero percent for salmon > 100 mm (Aasen 2013, DWR IEP 1989). The survival of Delta Smelt following salvage and return are relatively high based and are also based on handling and trucking studies by CDFW (DWR 2005, DWR IEP 2013, DWR 2010b).

Estimates of post-release survival and mortality are currently not available, although predation rates at and near release sites are being investigated by Reclamation (Fullard et al. In Progress) and results are anticipated within the next couple of years. It is hypothesized that loss to predation is the main source of post release mortality.

C.5.3.1.6 Delta Mendota Canal, San Luis Unit, and California Aqueduct

Water Demands

Water provided to the DMC and San Luis Unit primarily meet demands from three types of contractors: CVP water service contractors (including both agricultural and municipal and industrial (M&I), exchange contractors, and wildlife refuge contractors. Distinct relationships exist between Reclamation and each of these three groups.

Exchange contractors “exchanged” their senior rights to water in the San Joaquin River for a CVP water supply generally provided from the Delta. Reclamation provides water supply to meet the 840 TAF per annum Exchange Contract, with a maximum reduction under the Shasta critical year criteria to an annual water supply of 650 TAF.

South of Delta CVP 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 after senior obligations are met. The CVP also contracts with refuges to provide water supplies to specific managed lands for wildlife purposes. These contracts are reduced under Shasta critical year criteria up to 25 percent.

The CVP also contracts with refuges to provide water supplies to specific managed lands for wildlife purposes. These contracts are also subject to the availability of CVP water supplies, but may be reduced under Shasta critical year criteria, up to 25 percent.

To achieve the best operation of the CVP, it is necessary to combine the contractual demands of these three types of contractors to achieve an overall pattern of requests for water. In most years, sufficient supplies are not available to meet all water demands because of reductions in CVP water supplies primarily due to restrictions placed on Delta pumping. In some dry or critically dry years, water deliveries are limited because there is insufficient storage in northern CVP reservoirs to meet all instream fishery objectives, including water temperatures, and to make additional water deliveries via the Jones Pumping Plant. Scheduling of water demands and the releases of water supplies from the northern CVP to meet those demands, is a CVP operational objective that is intertwined with Trinity, Sacramento, and American River operations.

Delta-Mendota Canal/California Aqueduct Intertie

The DMC/California Aqueduct Intertie between the DMC and the California Aqueduct allows water to flow in both directions between the CVP and SWP conveyance facilities. The DMC/California Aqueduct Intertie achieves multiple benefits, including meeting current water supply demands, allowing for the maintenance and repair of the CVP Delta export and conveyance facilities, and providing operational flexibility to respond to emergencies. The DMC/California Aqueduct Intertie can be used under one of the following three different scenarios:

- Up to 467 cfs may be pumped from the DMC to the California Aqueduct to ease DMC conveyance constraints related to Jones Pumping Plant capacity limitations.
- Up to 467 cfs may be pumped from the DMC to the California Aqueduct to minimize impacts on water deliveries due to temporary restrictions in flow or water levels on the lower DMC (south of the Intertie) or the upper California Aqueduct (north of the Intertie) for system maintenance or due to an emergency shutdown.
- Up to 900 cfs may be conveyed from the California Aqueduct to the DMC using gravity flow to minimize impacts on water deliveries due to temporary restrictions in flow or water levels on the lower California Aqueduct (downstream of the Intertie) or the upper DMC (upstream of the Intertie) for system maintenance or for an emergency shutdown.

San Luis Reservoir

The 2.027-MAF San Luis Reservoir, formed by Sisk Dam, is jointly operated by Reclamation and DWR, with approximately 0.965 MAF used by the CVP and 1.062 MAF used by the SWP. Water generally is diverted into San Luis Reservoir during late fall through early spring when irrigation water demands of CVP and SWP water users are low and are being met by Delta exports. Water storage volumes and water storage elevations for San Luis Reservoir for Water Years 2001 through 2018 are presented on Figures C.5-1 and C.5-2 (DWR 2018as, 2018at).

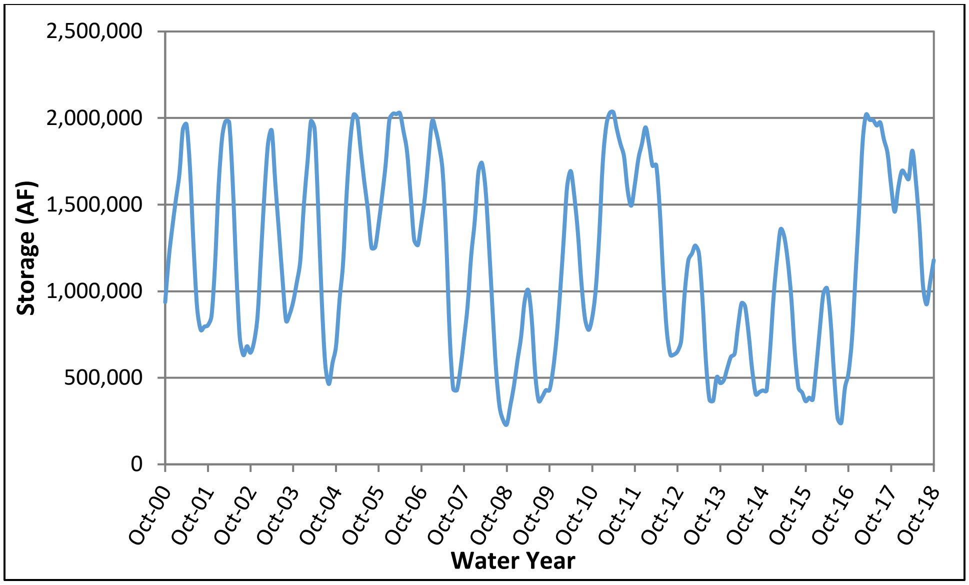

Figure C.5-1. San Luis Reservoir Storage

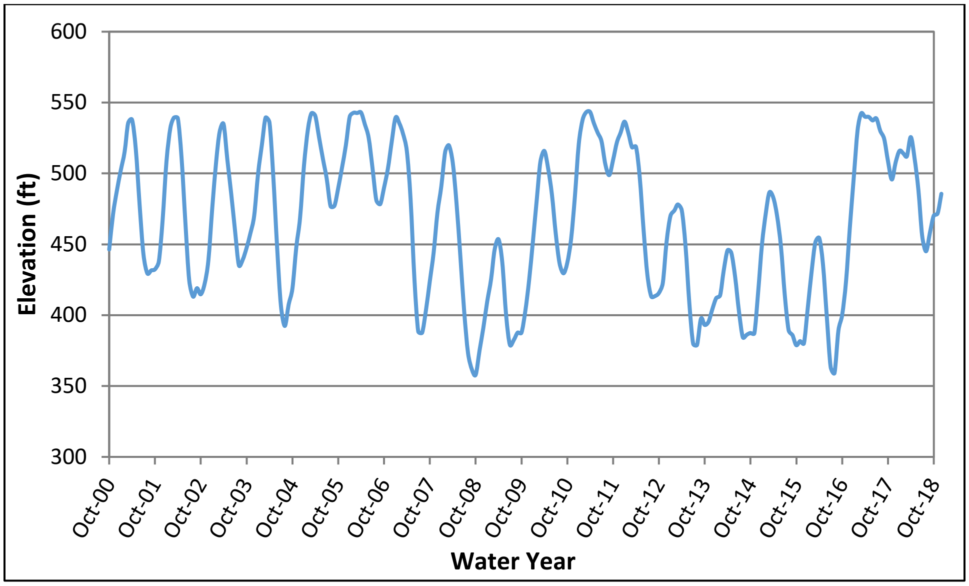

Figure C.5-2. San Luis Reservoir Elevation

The San Luis Complex consists of the following:

- O’Neill Pumping-Generating Plant (CVP facility)
- William R. Gianelli Pumping-Generating Plant (joint CVP and SWP facility)
- San Luis Canal (joint CVP and SWP facility)
- Dos Amigos Pumping Plant (joint CVP and SWP facility)
- Coalinga Canal (CVP facility)
- Pleasant Valley Pumping Plant (CVP facility)
- Los Banos and Little Panoche Detention Dams and Reservoirs (joint CVP and SWP facilities)

The CVP diverts water from San Luis Reservoir by the Pacheco Pumping Plant through the Pacheco Tunnel and Pacheco Conduit that conveys water to CVP water service contractors in Santa Clara and San Benito counties.

When all SWP demands are met, including diversion to storage facilities south of the Delta and Table A demands, and the Delta is in excess conditions, DWR would use available excess pumping capacity at Banks Pumping Plant to make excess water supplies, called Article 21 water under the long-term SWP water supply contracts, available to the SWP Contractors. Article 21 of the SWP water contracts describes the conditions under which water can be delivered in addition to the amounts specified in Table A of the contracts.

Unlike Table A water, which is an allocated annual SWP supply made available for scheduled delivery throughout the year, Article 21 water is an interruptible water supply made available only when certain conditions exist. However, while not a dependable supply, Article 21 water is an important part of the total SWP supplies provided to the SWP contractors. As with all SWP water, Article 21 water is pumped consistent with the existing terms and conditions of SWP water rights permits and is pumped from the Delta under the same environmental, regulatory, and operational constraints that apply to all SWP operations.

Article 21 water is only available as long as the required conditions exist as determined by DWR. As Article 21 deliveries are in addition to scheduled Table A deliveries, this supply is delivered to SWP contractors that can, on relatively short notice, put it to beneficial use. SWP contractors have used Article 21 water to meet needs such as additional short-term irrigation demands, replenishment of local groundwater basins, short-term substitution of local supplies and storage in local surface reservoirs for later use by the requesting SWP contractor, all of which provide SWP contractors with opportunities for better water management through more efficient coordination with their local water supplies. Allocated Article 21 water to a SWP contractor cannot be transferred.

Article 21 water is typically offered to SWP contractors on a short-term (daily or weekly) basis when all of the following conditions exist: the SWP share of San Luis Reservoir is physically full, or projected to be physically full; other SWP reservoirs south of the Delta are at their storage targets or the SWP conveyance capacity to fill these reservoirs is maximized; the Delta is in excess condition; current Table A and SWP operational demands are being fully met; and Banks Pumping Plant has export capacity beyond that which is needed to meet all Table A and other SWP operational demands. The increment of available unused Banks Pumping Plant capacity is offered as the Article 21 delivery capacity. SWP contractors then indicate their desired rate of delivery of Article 21 water. DWR allocates the available Article 21 water in proportion to the requesting SWP contractors annual Table A amounts if requests exceed the amount offered. Deliveries can be discontinued at any time when SWP operations change. In the modeling for Article 21, deliveries are only made in months when the SWP share of San Luis Reservoir is full. In actual operations, Article 21 may be offered a short period in advance of actual filling.

By April or May, demands from both agricultural and M&I SWP Contractors usually exceed the pumping rate at Banks Pumping Plant, and releases from San Luis Reservoir to the SWP facilities are needed to supplement the Delta pumping at Banks Pumping Plant to meet SWP contractor demands for Table A water.

California Aqueduct

Banks Pumping Plant lifts water into the California Aqueduct, which then flows to Bethany Reservoir. From Bethany Reservoir, the South Bay Pumping Plant lifts water into the South Bay Aqueduct to supply portions of Alameda and Santa Clara counties. The South Bay Aqueduct provided initial deliveries in 1962 and has been fully operational since 1965. South Bay Aqueduct facilities include Lake Del Valle and Patterson Reservoir.

From Bethany Reservoir, the 444-mile-long California Aqueduct conveys water to the primarily agricultural lands of the San Joaquin Valley and the mainly urban regions of Southern California. The first SWP deliveries to San Joaquin Valley contractors began in 1968. The first SWP deliveries to southern California began in 1972. The California Aqueduct winds along the west side of the San Joaquin Valley. It transports water to O'Neill Forebay. Water in the Forebay can be released to the San Luis Canal or pumped into San Luis Reservoir by the Gianelli Pumping Plant. San Luis Reservoir has a storage capacity of more than 39 MAF and is a joint facility of the DWR and Reclamation. The SWP's share of the reservoir's gross storage is about 1,062,180 af. DWR generally pumps water through the Gianelli Pumping-Generating Plant into San Luis Reservoir during late fall through early spring for temporary storage until water is released to meet late-spring and summer peaking demands of SWP contractors.

SWP water pumped directly from the Delta and water eventually released from San Luis Reservoir continues to flow south in the San Luis Canal, a portion of the California Aqueduct jointly used by the SWP and CVP. The joint use ends near Kettleman City, and the SWP portion of the California Aqueduct continues. As the water flows through the San Joaquin Valley, numerous turnouts convey the water to farmlands within the service areas of the SWP and CVP. Along its journey, four pumping plants—Dos Amigos, Buena Vista, Teerink, and Chrisman—lift the water more than 1,000 feet before it reaches the foot of the Tehachapi Mountains.

In the San Joaquin Valley near Kettleman City, Phase I of the Coastal Branch Aqueduct serves agricultural areas west of the California Aqueduct. The Coastal Branch's Phase II extended the conveyance facility to serve M&I water users in San Luis Obispo and Santa Barbara counties. Phase II became operational in 1997.

The remaining water conveyed by the California Aqueduct is delivered to Southern California, home to about one-half of California's total population. Before this water can be delivered, the water must first cross the Tehachapi Mountains. Pumps at Edmonston Pumping Plant, situated at the foot of the mountains, raise the water 1,926 feet—the highest single lift of any pumping plant in the world. From there, the water enters about 8 miles of tunnels and siphons as it flows into Antelope Valley, where the California Aqueduct divides into two branches; the East Branch and the West Branch.

The East Branch carries water through the Tehachapi East Afterbay, Alamo Powerplant, Pearblossom Pumping Plant, and Mojave Siphon Powerplant into Silverwood Lake in the San Bernardino Mountains, which stores 73,000 af. From Silverwood Lake, water flows through the San Bernardino Tunnel into Devil Canyon Powerplant. Water continues down the East Branch to Lake Perris, the terminus of the East Branch. Lake Perris lies just east of Riverside, has a capacity of 131,500 af, and serves as a regulatory and emergency water supply facility for the East Branch.

Phase I of the East Branch Extension of the California Aqueduct was completed in 2003 and provides conveyance facilities to deliver SWP water to San Gorgonio Pass Water Agency, and to the eastern portion of the San Bernardino Valley Municipal Water District, which will deliver water to areas such as Yucaipa, Calimesa, Beaumont, Banning, and other communities. The East Branch Extension is comprised of a combination of existing San Bernardino Valley Municipal Water District facilities and newly constructed SWP facilities. While the new pipelines were designed for the ultimate conveyance capacity, the installed Phase I pumping capacity is less than one-half the ultimate capacity—enough to meet the immediate foreseeable demand for SWP water. Phase II will bring the extension to its ultimate storage and conveyance capacity with new pipelines, pumping, and storage facilities. Currently, the DWR is in the planning stages of Phase II. A feasibility study and a Phase II Project Environmental Impact Report are being concurrently developed.

At the bifurcation of the California Aqueduct in Antelope Valley, the West Branch carries water through Oso Pumping Plant, Quail Lake, Lower Quail Canal, and William E. Warne Powerplant into Pyramid Lake in Los Angeles County. From there, water flows through the Angeles Tunnel, Castaic Powerplant, Elderberry Forebay, and Castaic Lake, terminus of the West Branch. Castaic Lake is located north of Santa Clarita, has a capacity of 324,000 af, and is a regulatory and emergency water supply facility for the West Branch. Castaic Powerplant is owned and operated by Los Angeles Department of Water and Power.

C.5.3.1.7 Contra Costa Water District Facilities

Contra Costa Water District (CCWD) diverts water from the Delta for irrigation and M&I uses under its CVP contract, under its own water right permits and license issued by the SWRCB, and under East Contra Costa Irrigation District’s pre-1914 water right. CCWD’s water system includes the Mallard Slough, Rock Slough, Old River, and Middle River (on Victoria Canal) intakes; the Contra Costa Canal and shortcut pipeline; and the Los Vaqueros Reservoir. The Rock Slough Intake facilities, the Contra Costa Canal, and the shortcut pipeline are owned by Reclamation and operated and maintained by CCWD under contract with Reclamation. Reclamation completed construction of a fish screen at the Rock Slough Intake in 2011. Federal legislation providing the authority for Reclamation to transfer title of the facilities was passed by Congress and signed by the President in March 2019. CCWD and Reclamation are beginning the title transfer process, which includes conducting the required environmental and property record review to execute the transfer. The process is anticipated to take approximately two years to complete. Mallard Slough Intake, Old River Intake, Middle River Intake, and Los Vaqueros Reservoir are owned and operated by CCWD.

The Mallard Slough Intake is located at the southern end of a 3,000-foot-long channel running south from Suisun Bay, near Mallard Slough (across from Chipps Island). The Mallard Slough Pump Station was refurbished in 2002, which included constructing a positive barrier fish screen at this intake. The Mallard Slough Intake can pump up to 39.3 cfs. CCWD’s water right license and permit (License No. 10514 and Permit No. 19856) authorize diversions of up to 26,780 acre-feet per year at Mallard Slough. However, this intake is not used when salinity is high at this location. Pumping at the Mallard Slough Intake since 1993 has on average accounted for about 3 percent of CCWD’s total diversions. Water diverted at the Mallard Slough Intake reduces CCWD’s diversion of CVP water at its other intakes.

The Rock Slough Intake is located about four miles southeast of Oakley. Water is pumped west from Rock Slough through a positive barrier fish screen into the Contra Costa Canal using Pumping Plants #1 through #4. The fish screen at this intake was designed in accordance with the CVPIA and the 1993 USFWS BO for the Los Vaqueros Project to reduce take of fish through entrainment at the Rock Slough Intake. The Contra Costa Canal is 48 miles long. CCWD’s Contra Costa Canal Replacement Project replaces the 4-mile long, earth-lined portion of the Contra Costa Canal between the Rock Slough Fish Screen and Pumping Plant #1 with a buried 10’-diameter concrete pipe. The remaining 44 miles of the Contra Costa Canal after Pumping Plant #1 are concrete-lined. The earth-lined portion of the Contra Costa Canal is subject to water quality degradation due to seepage into the canal from saline groundwater in the area, as well as seepage losses where the groundwater table is lower than canal water levels. Replacing the open channel with a buried pipe also eliminates evaporative losses. Removal of the open water facility also improves public safety, system security, and flood control, which are needed in light of the developing and planned urbanization in the vicinity. As of late 2018, approximately 3 miles of the earth-lined portion of the Canal has been replaced (from Pumping Plant #1 to the east) and the flood isolation structure near the fish screen has also been completed. Pumping Plant #1 has a permitted capacity to pump up to 350 cfs into the

Canal. Diversions at Rock Slough Intake are typically taken under CVP contract or under East Contra Costa Irrigation District's pre-1914 water right. CCWD diverts approximately 30 percent to 50 percent of its total annual supply through the Rock Slough Intake, depending upon water quality in a given year.

Construction of the Old River Intake was completed in 1997 as a part of the Los Vaqueros Project. The Old River Intake is located on Old River near State Route 4. The intake has a positive-barrier fish screen and a pumping capacity of 250 cfs and can pump water via pipeline either to the Contra Costa Canal or to Los Vaqueros Reservoir. Diversions at Old River to the Contra Costa Canal are typically taken under CVP contract or under local water rights. Pumping to storage in Los Vaqueros Reservoir is limited to 200 cfs by the terms of the Los Vaqueros Project BOs and by the SWRCB water right decision for the Los Vaqueros Project (D-1629). Diversions to storage in Los Vaqueros Reservoir are typically taken under CVP contract or under CCWD's Los Vaqueros water right permit (Permit 20749). The CCWD's water diversions that are not made at Rock Slough are diverted at the Middle River and Old River intakes, as determined primarily by the CCWD water quality goals described below.

In 2010, CCWD completed construction of the Middle River Intake (formerly referred to as the Alternative Intake Project) on Victoria Canal. The Middle River Intake has a capacity of 250 cfs capacity, with positive-barrier fish screens and a conveyance pipeline to CCWD's conveyance facilities near its Old River Intake. Similar to the Old River Intake, the Middle River Intake can be used either to pump to the Contra Costa Canal or to fill the Los Vaqueros Reservoir. Diversions to the Contra Costa Canal are typically taken under CVP contract, while diversions to storage in the Los Vaqueros Reservoir can be taken either under CVP contract or under CCWD's Los Vaqueros water right (Permit 20749).

CCWD operates its intake facilities to meet its delivered water quality goals and to protect listed species. The choice of which intake to use at any given time is based in large part upon salinity at the intakes, consistent with fish protection requirements in the BOs for the Middle River Intake and the Los Vaqueros Project. The Middle River Intake was built as a project to improve the water quality delivered to the CCWD service area, and does not increase CCWD's average annual diversions from the Delta. However, it can alter the timing and pattern of CCWD's diversions, because Middle River Intake salinity tends to be lower in the late summer and fall than salinity at CCWD's other intakes. This allows CCWD to decrease winter and spring diversions while still meeting water quality goals in the summer and fall through use of the new intake.

Los Vaqueros Reservoir is an off-stream reservoir in the Kellogg Creek watershed to the west of the Delta. Originally constructed as a 100 TAF reservoir in 1997 as part of the Los Vaqueros Project, the facility is used to improve delivered water quality and emergency storage reliability for CCWD's customers. Los Vaqueros Reservoir is filled with Delta water from either the Old River Intake or the Middle River Intake, when salinity in the Delta is low. When Delta salinity is high, typically in the fall months, CCWD releases low salinity water from Los Vaqueros Reservoir to blend with direct diversions from its Delta intakes to meet CCWD water quality goals. Releases from Los Vaqueros Reservoir are conveyed to the Contra Costa Canal via a pipeline. Water released from Los Vaqueros Reservoir does not re-enter Delta channels.

In 2012, Los Vaqueros Reservoir was expanded from 100 TAF to a total storage capacity of 160 TAF to provide additional water quality and water supply reliability benefits and maintain the initial functions of the reservoir. With the expanded reservoir, CCWD's average annual diversions from the Delta remain the same as they were with the 100 TAF reservoir. A feasibility study is ongoing to evaluate whether an additional expansion of this reservoir to 275 TAF is in the federal interest.

CCWD diverts approximately 127 TAF per year in total. Approximately 110 TAF is CVP contract supply. In winter and spring months when the Delta is relatively fresh (generally January through July), deliveries to the CCWD service area are made by direct diversion from the Delta. In addition, when salinity is low enough, Los Vaqueros Reservoir is filled at a rate of up to 200 cfs from the Old River Intake and Middle River Intake. The BOs for the Los Vaqueros Project, CCWD's Incidental Take Permit issued by CDFW, and SWRCB D-1629 include fisheries protection measures consisting of a 75-day period during which CCWD does not fill Los Vaqueros Reservoir (no-fill period) and a concurrent 30-day period during which CCWD halts all diversions from the Delta (no-diversion period), provided that Los Vaqueros Reservoir storage is above emergency levels. During the no-diversion period, CCWD customer demand is met by releases from Los Vaqueros Reservoir. The default dates for the no-fill and no-diversion periods are March 15 through May 31 and April 1 through April 30, respectively. USFWS, NMFS, and CDFW can change these dates to best protect the subject species. CCWD coordinates the filling of Los Vaqueros Reservoir with Reclamation and DWR to avoid water supply impacts on other CVP and SWP customers.

In addition to the 75-day no-fill period and the concurrent no-diversion 30-day period, CCWD operates to an additional term in the Incidental Take Permit issued by CDFW that provides for an additional no-fill period of up to 15 days. Under this term, CCWD shall not divert water to storage in Los Vaqueros Reservoir for 15 days from February 14 through February 28, provided that reservoir storage is at or above 90 TAF on February 1. If reservoir storage is at or above 80 TAF on February 1, but below 90 TAF, CCWD shall not divert water to storage in Los Vaqueros Reservoir for 10 days from February 19 through February 28. If reservoir storage is at or above 70 TAF on February 1, but below 80 TAF, CCWD shall not divert water to storage in Los Vaqueros Reservoir for 5 days from February 24 through February 28. These dates can be changed to better protect Delta fish species, at the direction of CDFW.

CCWD's operation of the diversion, storage, and conveyance facilities to divert water under CCWD's water rights and under CVP water rights pursuant to CCWD's CVP water service contract meets the permitting requirements of the ESA through BOs issued by USFWS and NMFS that are specific to the CCWD system. The NMFS BO issued on March 18, 1993 and USFWS BO issued on September 9, 1993 address the operation of the Los Vaqueros Project, including the Los Vaqueros Reservoir and the Mallard Slough, Rock Slough, and Old River intakes. NMFS BO 2005/00122 issued on July 13, 2007, and USFWS BO issued on April 27, 2007 and amended on May 16, 2007, address the Middle River Intake operations. Concurrence that CCWD's operations consistent with expansion of Los Vaqueros Reservoir to 160 TAF are not likely to adversely affect listed Delta fish species was provided by NMFS on October 15, 2010 and USFWS on November 1, 2010. Biological opinions for operation and maintenance of the Rock Slough Fish Screen were issued by NMFS on June 29, 2017 and USFWS on November 2, 2017.

C.5.3.2 *Regulatory Limitations on Operations of Delta Water Diversions*

Operations of the CVP and SWP are implemented in accordance with SWRCB water rights and water quality decisions, including SWRCB D-1641, and the 2008 USFWS BO and 2009 NMFS BO.

C.5.3.2.1 Decision 1641

The SWRCB adopted the 1995 Bay-Delta Plan on May 22, 1995, which became the basis of SWRCB D-1641 (adopted on December 29, 1999 and revised on March 15, 2000). The SWRCB D-1641 amended certain terms and conditions of the SWP and CVP water rights to include flow and water quality objectives to assure protection of beneficial uses in the Delta and Suisun Marsh. SWRCB also grants conditional changes to points of diversion for the CVP and SWP under SWRCB D-1641. The requirements in SWRCB D-1641 address the standards for fish and wildlife protection, water supply water quality, and Suisun Marsh salinity. These objectives include specific Delta outflow requirements throughout the year, specific export limits in the spring, and export limits based on a percentage of estuary inflow throughout the year. The water quality objectives are designed to protect agricultural, municipal and industrial, and fishery uses, and vary throughout the year and by water year type. D-1641 limits CVP and SWP exports at Banks and Jones Pumping Plants as a percentage of total Delta inflow (i.e., the export to inflow ratio or "E/I"). The maximum E/I set by D-1641 is 65% July through January and 35% February through June. The 35% E/I from February to June required in D-1641 was a significant change from D-1485. This spring requirement reduced the availability of "unstored" flow for export and storage in San Luis Reservoir. February to June became an unreliable season for conveying water across the Delta. Spring X2 reduced the "unstored flow" availability by dedicating a significant block of water to Delta outflow/salinity goals. The "spring X2" Delta outflow is specified from February through June to maintain freshwater and estuarine conditions in the western Delta to protect aquatic life. The criteria require operations of the CVP and SWP upstream reservoir releases and Delta exports in a manner that maintains a salinity objective at an "X2" location. X2 refers to the horizontal distance from the Golden Gate Bridge up the axis of the Delta estuary to where tidally averaged near-bottom salinity concentration of 2 parts of salt in 1,000 parts of water occurs; the X2 standard was established to improve shallow water estuarine habitat in the months of February through June and relates to the extent of salinity movement into the Delta (DWR, Reclamation, USFWS and NMFS 2013). The location of X2 is important to both aquatic life and water supply beneficial uses.

The Delta outflow and salinity goals under D-1641 requires reservoir releases at times. The effect of D-1641 shifted the export season to the summer, and the CVP and SWP entered the fall with lower reservoir levels and less need for flood releases in the fall and winter.

A Vernalis flow and salinity requirement was imposed for the San Joaquin Basin. D-1641 imposed a salinity standards for the San Joaquin Basin and also included requirements at Vernalis for both base flows and a large spring pulse flow, however it did not address how the requirement would be shared between the three major San Joaquin tributaries. In order to avoid protests and the need to immediately revise D-1641 to assign responsibility, the parties entered into the San Joaquin River Agreement (SJRA), which included flow commitments from all three tributaries, funding commitments, transfers and voluntary demand reductions. The agreement ended in 2009 but was extended to 2012.

Mean daily Delta outflow flows for Water Years 2001 through 2018 are presented on Figure C.5-3 (DWR 2018au). Mean daily flows for Water Years 2001 through 2018 are presented on Figures C.5-4 through C.5-9 for diversions at Jones, Banks, Barker Slough, and Contra Costa Canal Rock Slough Intake; and Contra Costa Water District intakes at Old River and Middle River (DWR 2018av, 2018aw, 2018ax, 2018ay, 2018az, 2018ba).

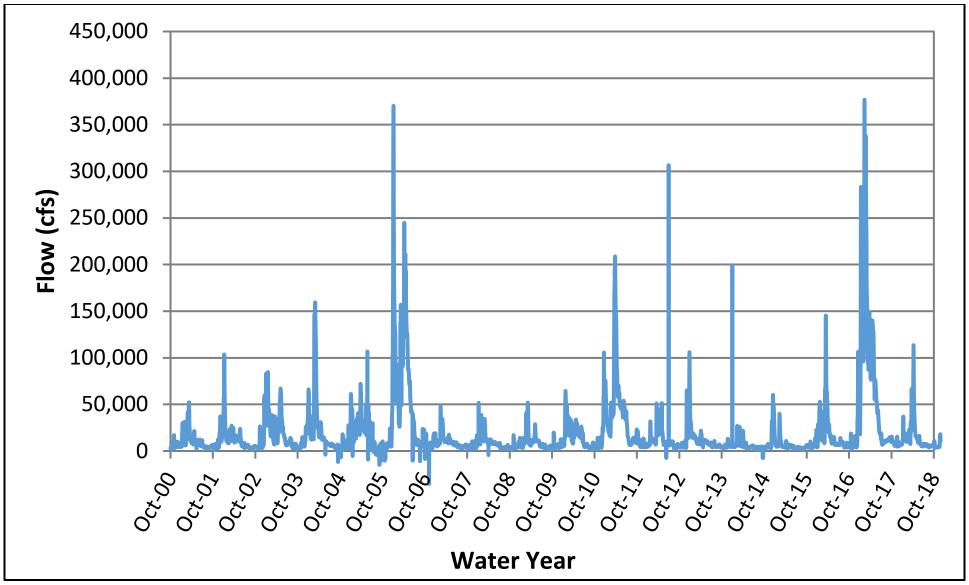

Figure C.5-3. Delta Outflow

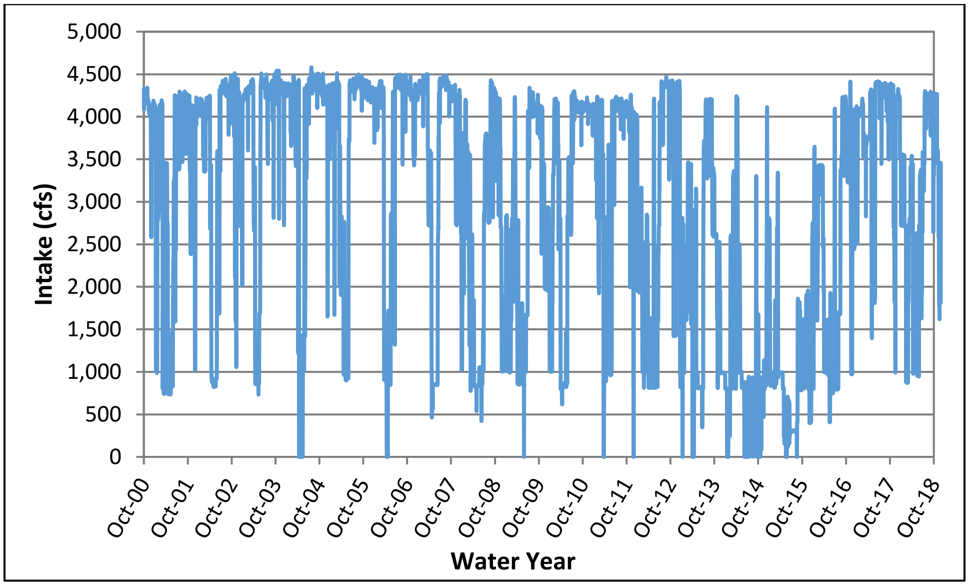

Figure C.5-4. Jones Pumping Plant

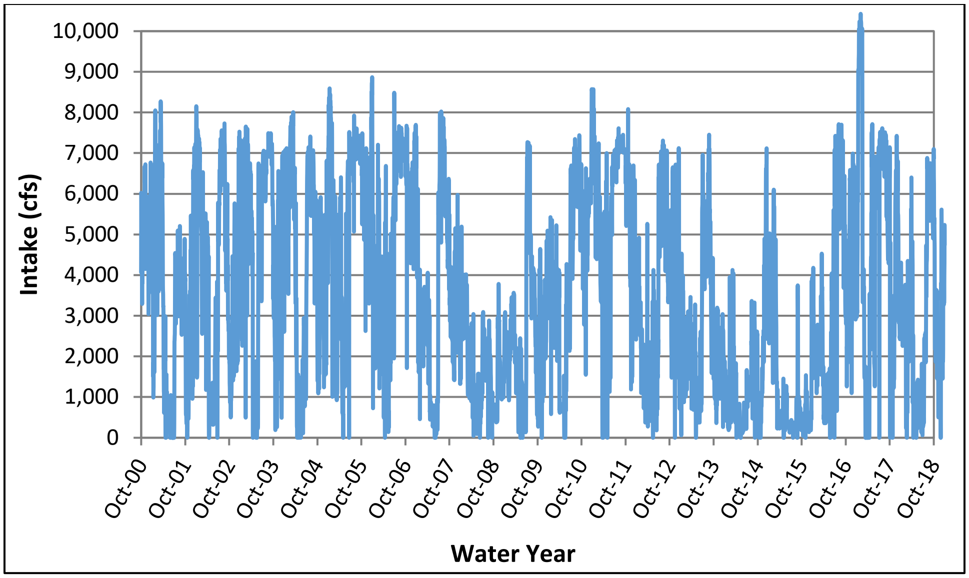

Figure C.5-5. Banks Pumping Plant

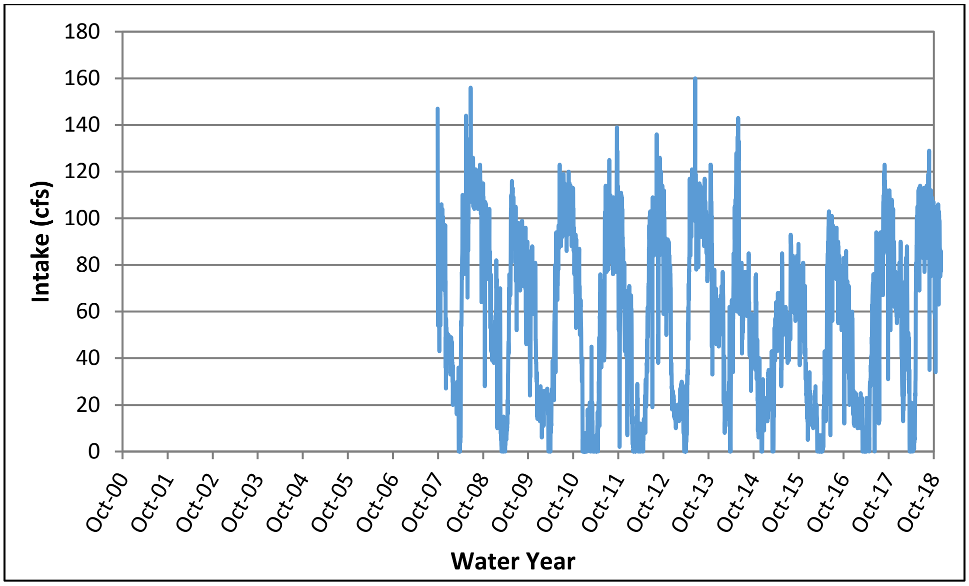

Figure C.5-6. Barker Slough Pumping Plant

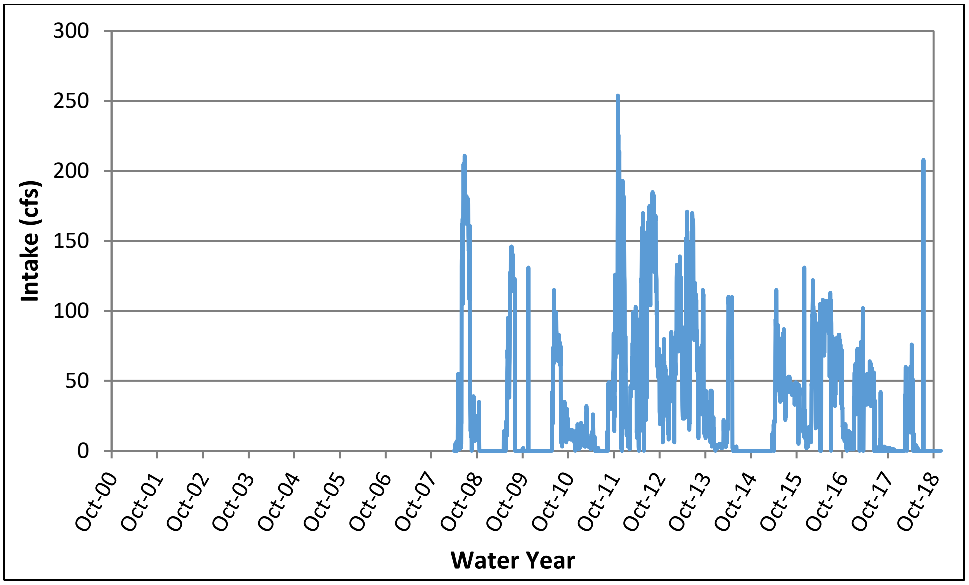

Figure C.5-7. Contra Costa Canal Rock Slough Intake

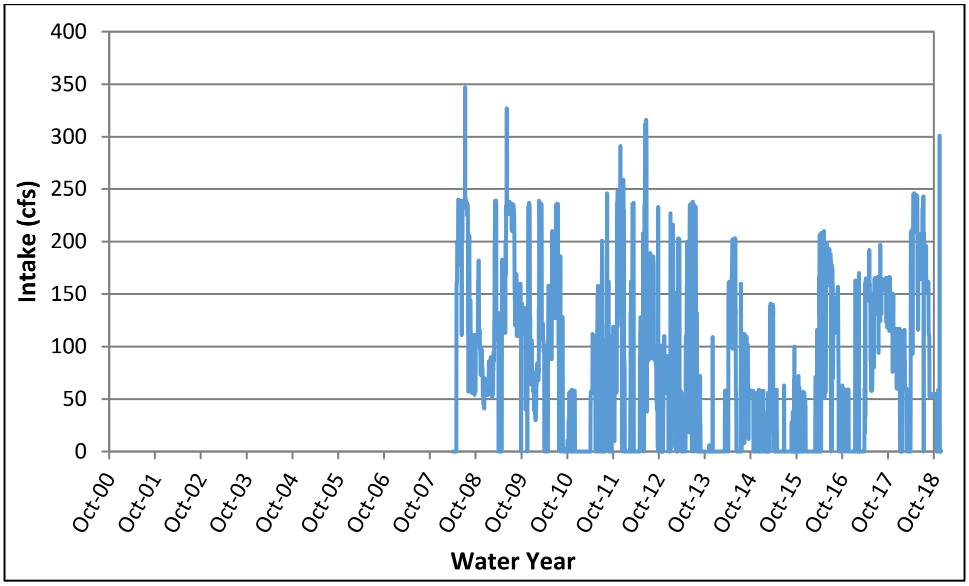

Figure C.5-8. Contra Costa Water District Old River Intake

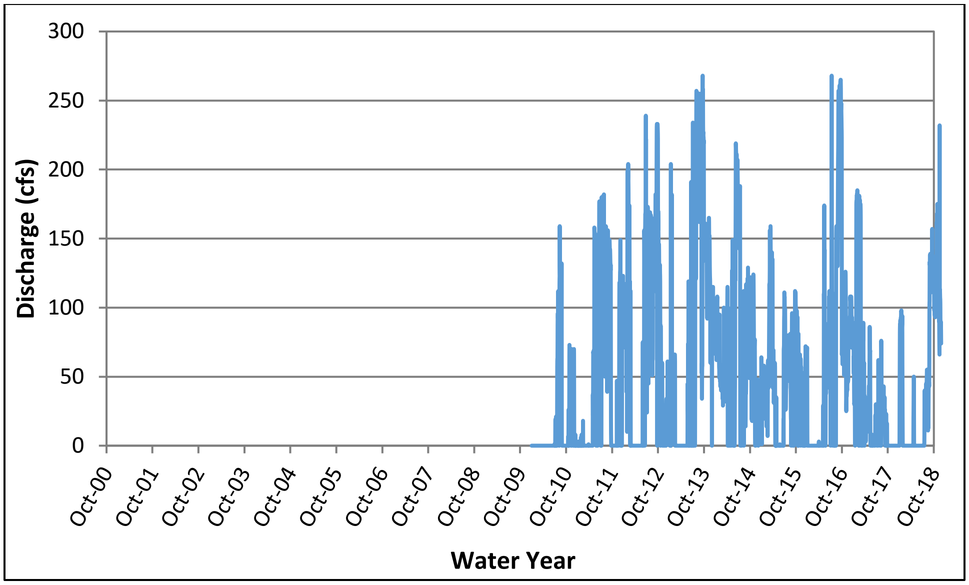

Figure C.5-9. Contra Costa Water District Middle River Intake

C.5.3.2.2 Joint Point of Diversion

SWRCB D-1641 authorized the SWP and CVP to jointly use both Jones and Banks pumping plants in the southern Delta, with conditional limitations and required response coordination plans (referred to as Joint Point of Diversion [JPOD]). Use of JPOD is based on staged implementation and conditional requirements for each stage of implementation. The stages of JPOD in SWRCB D-1641 are:

- Stage 1—for water service to a group of CVP water service contractors (Cross Valley contractors, San Joaquin Valley National Cemetery and Musco Family Olive Company), and to recover export reductions implemented to benefit fish;
- Stage 2—for any purpose authorized under the current CVP and SWP water right permits; and
- Stage 3—for any purpose authorized, up to the physical capacity of the diversion facilities.

In general, JPOD capabilities are used to accomplish four basic CVP and SWP objectives:

- When wintertime excess pumping capacity becomes available during Delta excess conditions and total CVP and SWP San Luis storage is not projected to fill before the spring pulse flow period, the Project with the deficit in San Luis storage may elect to pursue the use of JPOD capabilities;
- When summertime pumping capacity is available at Banks Pumping Plant and CVP reservoir conditions can support additional releases, the CVP may elect to use JPOD capabilities to enhance annual CVP south of Delta water supplies;
- When summertime pumping capacity is available at Banks or Jones Pumping Plant to facilitate water transfers, JPOD may be used to further facilitate the water transfer; and
- During certain coordinated CVP and SWP operation scenarios for fishery entrainment management, JPOD may be used to shift CVP and SWP exports to the facility with the least fishery entrainment impact while minimizing export at the facility with the most fishery entrainment impact.

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 water elevations in the southern Delta will not be lowered to the injury of local riparian water users (Water Level Response Plan); and a response plan to ensure the water quality in the southern and central Delta will not be significantly degraded through operations of the JPOD to the injury of water users in the southern and central Delta. Stage 2 has an additional requirement to complete an operations plan that will protect fish and wildlife and other legal users of water (Fisheries Response Plan). Stage 3 has an additional requirement to protect water levels in the southern Delta. All JPOD diversions under excess conditions in the Delta are junior to CCWD water right permits for the Los Vaqueros Project and must have an X2 location west of certain compliance locations consistent with the 1993 Los Vaqueros BO for Delta smelt.

C.5.3.2.3 Old and Middle River Reverse Flow Management

The 2008 USFWS BO and the 2009 NMFS BO restrict CVP and SWP diversions to reduce reverse flows in OMR. OMR flow for Water Years 2001 through 2018 is presented in Figure C.5-10 (U.S. Geological Survey [USGS] 2018a, 2018b).

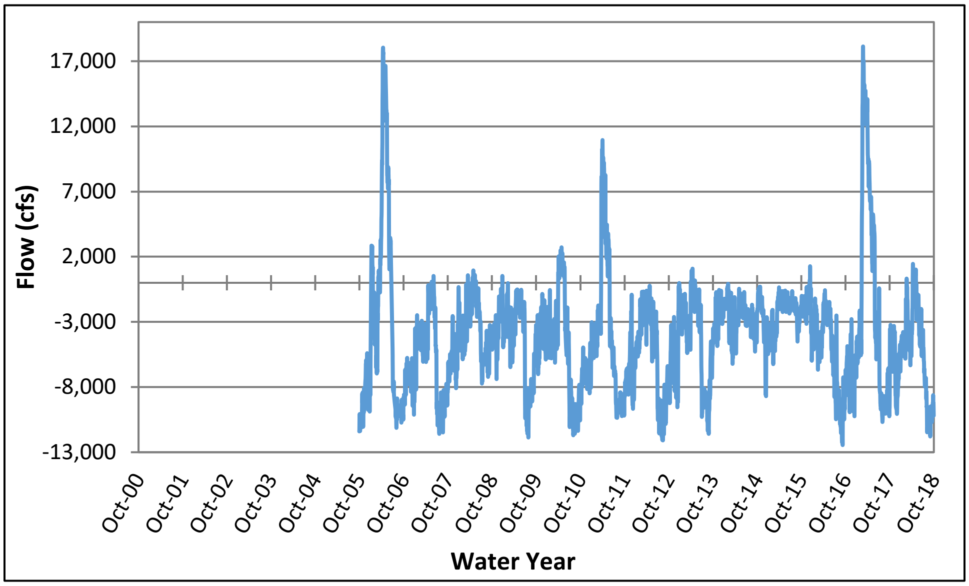

Figure C.5-10. OMR Flow (CFS)

2008 USFWS BO OMR Criteria

The 2008 USFWS BO limits reverse OMR flows as prescribed in the following three actions.

Action 1: to protect adult Delta Smelt migration and entrainment. Limits exports so that the average daily OMR flow is no more negative than 2,000 cfs for a total duration of 14 days, with a 5-day running average no more negative than -2,500 cfs (within 25 percent).

- December 1 to December 20 – Based upon turbidity data from turbidity stations (Prisoner's Point, Holland Cut, and Victoria Canal) and salvage data from CVP and SWP fish handling facilities at the south Delta intakes, and other parameters important to the protection of Delta Smelt including, but not limited to, preceding conditions of X2, Fall Midwater Trawl (FMWT) Survey, and river flows.
- After December 20 – The action would begin if the 3-day average turbidity at Prisoner's Point, Holland Cut, and Victoria Canal exceeds 12 nephelometric turbidity units (NTU).

- Triggers are based on:
  - Three-day average of 12 NTU or greater at all three turbidity stations; or
  - Three days of Delta Smelt salvage after December 20 at either facility or cumulative daily salvage count that is above a risk threshold based upon the "daily salvage index" approach reflected in a daily salvage index value of greater than or equal to 0.5 (daily Delta Smelt salvage is greater than one-half prior year FMWT index value). The window for triggering Action 1 concludes when either off-ramp condition described below is met. These off-ramp conditions may occur without Action 1 ever being triggered. If this occurs, then Action 3 is triggered, unless the Service concludes on the basis of the totality of available information that Action 2 should be implemented instead.
- Action 1 offramps when water temperature reaches 12 degrees Celsius (°C) based on a three station daily mean at the temperature stations: Mossdale, Antioch, and Rio Vista; or the onset of spawning based upon the presence of spent females in the Spring Kodiak Trawl Survey or at the CVP or SWP fish handling facilities.

Action 2: to protect adult Delta Smelt migration and entrainment. An action implemented using an adaptive process to tailor protection to changing environmental conditions after Action 1. As in Action 1, the intent is to protect pre-spawning adults from entrainment and, to the extent possible, from adverse hydrodynamic conditions. The range of net daily OMR flows would be no more negative than -1,250 to -5,000 cfs. Depending on extant conditions, specific OMR flows within this range are recommended by the USFWS Smelt Working Group (SWG) from the onset of Action 2 through its termination. The SWG would provide weekly recommendations based upon review of the sampling data, from real-time salvage data at the CVP and SWP, and utilizing most up-to-date technological expertise and knowledge relating population status and predicted distribution to monitored physical variables of flow and turbidity. The USFWS makes the final determination.

- Action 2 begins immediately following Action 1. If Action 1 is not implemented based upon triggers, the SWG may recommend a start date for Action 2.
- Action 2 is suspended when whenever a 3-day flow average is greater than or equal to 90,000 cfs in Sacramento River at Rio Vista and 10,000 cfs in San Joaquin River at Vernalis. Once such flows have abated, the OMR flow requirements of Action 2 are restarted.
- Offramps for Action 2 are related to water temperature reaches 12°C based on a three-station daily average at the temperature stations: Rio Vista, Antioch, and Mossdale; or the onset of spawning based upon the presence of a spent female in the Spring Kodiak Trawl Survey or at the CVP or SWP fish handling facilities.

Action 3: to protect larval and juvenile Delta Smelt. Minimize the number of larval Delta Smelt entrained at the facilities by managing the hydrodynamics in the Central Delta flow levels pumping rates spanning a time sufficient for protection of larval Delta Smelt. Net daily OMR flow would be no more negative than -1,250 to -5,000 cfs based on a 14-day running average with a simultaneous 5-day running average within 25 percent of the applicable requirement for OMR. Depending on extant conditions, specific OMR flows within this range are recommended by the SWG from the onset of Action 3 through its termination.

- Action 3 begins when temperature reaches 12°C based on a three-station average at the temperature stations: Mossdale, Antioch, and Rio Vista; or onset of spawning based upon the presence of a spent female in the Spring Kodiak Trawl Survey or at the CVP or SWP fish handling facilities.
- Action 3 offramps by June 30; or if water temperature reaches a daily average of 25°C for three consecutive days 10 at CCF.

2009 NMFS BO OMR Criteria

The 2009 NMFS BO includes OMR criteria (Action IV.2.3) to protect juvenile salmonids during winter and spring emigration downstream into the San Joaquin River, and to increase survival of salmonids and Green Sturgeon entering the San Joaquin River from Georgiana Slough and the lower Mokelumne River by reducing the potential for entrainment at the south Delta intakes. The action is implemented from January 1 through June 15 to limit negative flows to -2,500 to -5,000 c fs in Old and Middle Rivers, de pending on the presence of salmonids. The reverse flow would be managed within this range to reduce flows toward the pumps during periods of increased salmonid presence. The negative flow objective within the range shall be determine based on the following decision tree:

Date	Action Triggers	Action Responses
January 1 – June 15	January 1 – June 15	-5,000 cfs
January 1 – June 15 First Stage Trigger (increasing level of concern)	Daily SWP/CVP older juvenile loss density (fish per TAF) is 1) greater than incidental take limit divided by 2000, with a minimum value of 2.5 fish per TAF, or 2) daily loss is greater than daily measured fish density divided by 12 TAF, of 3) Coleman National Fish Hatchery coded wire tag late-fall run or Livingston Stone National Fish Hatchery coded wire tag winter-run cumulative loss greater than 0.5%, or 4) daily loss of wild steelhead (intact adipose fin) is greater than the daily measured fish density divided by 12 TAF.	-3,500 cfs for minimum of 5 days; and up to -5,000 cfs other times
January 1 – June 15 Second Stage Trigger (analogous to high level of concern)	Daily SWP/CVP older juvenile loss density (fish per TAF) is 1) greater than incidental take limit divided by 1000, with a minimum value of 2.5 fish per TAF, or 2) daily loss is greater than daily fish density divided by 8 TAF, or 3) Coleman National Fish Hatchery coded wire tag late-fall run or Livingston Stone National Fish Hatchery coded wire tag winter-run cumulative loss greater than 0.5%, or 4) daily loss of wild steelhead (intact adipose fin) is greater than the daily measured fish density divided by 8 TAF.	-2,500 cfs for minimum of 5 days; and up to -5,000 cfs other times
End of Triggers	Continue action until June 15 or until average daily water temperature at Mossdale is greater than 72°F (22°C) for 7 consecutive days (1 week), whichever is earlier.	No OMR restriction.

Updated Incidental Take Statement

In January 2019, USFWS modified the take quantification methodology of the Incidental Take Statement for the federally threatened delta smelt in the 2008 USFWS BO. In recent years it has become clear that surveys are reaching their detection limits given the declining population of delta smelt, and in 2018, the FMWT Index was zero, indicating that the FMWT Index may no longer provide an accurate predictor of incidental take. In its place, USFWS has determined that an appropriate incidental take surrogate for individual delta smelt to be the ecological condition created by less negative OMR flow that reduces entrainment of delta smelt into the South Delta. When turbidity is high, OMR flow of approximately -5000 cfs, or more positive as necessary, creates an appropriate ecological condition. When turbidity conditions are low, there is no relationship between OMR flow and the proportion of the delta smelt population entrained. The risk of high entrainment will continue to be minimized via the active real time management of OMR flow and turbidity in the south Delta. It has been demonstrated that implementation of OMR flow of no more negative than -5000 cfs, particularly in conjunction with NMFS RPA actions has reduced the entrainment of delta smelt. However, this newer information shows that there are situations in which the management of OMR flow does not demonstrably affect delta smelt entrainment. This latter condition provides circumstances in which USFWS believes that operational flexibility to allow for OMR flow more negative than -5000 cfs for short periods can be implemented without generating entrainment losses higher than those the USFWS analyzed in its 2008 BO.

C.5.3.2.4 Fall X2

The 2008 USFWS BO also includes an additional Delta salinity requirement in September through November in wet and above normal water years (Action 4). This requirement is frequently referred to as "Fall X2." The action requires that in September and October, 2 Practical Salinity Units (psu) salinity is maintained at 74 kilometers (km) during wet years, and 81 km during above normal water years when the preceding year was wet or above normal based upon the Sacramento Basin 40-30-30 index in the SWRCB D-1641. In November of these years, there is no specific X2 requirement, however there is a requirement that all inflow into SWP and CVP upstream reservoirs be conveyed downstream to augment delta outflow to maintain X2 at the locations in September and October.

If storage increases during November under this action, the increased storage volume is to be released in December in addition to the requirements under SWRCB D-1641 net Delta Outflow Index.

C.5.3.2.5 San Joaquin River Inflow: Export Ratio

The 2009 NMFS BO Action IV.2.1 requires south Delta exports at Banks and Jones Pumping Plants to be reduced during April and May to protect emigrating steelhead from the lower San Joaquin River into the south Delta channels and intakes. The inflow:export ratio from April 1 through May 31 specifies that Reclamation operates the New Melones Reservoir to maintain the 2009 NMFS BO flow schedule for the Stanislaus River at Goodwin in accordance with Action III.1.3 and Appendix 2-E of the BO. In addition, the CVP and SWP pumps are operated to meet the following ratios, based upon a 14-day running average.

San Joaquin Valley Classification	San Joaquin River flow at Vernalis (cfs): CVP and SWP combined export ratio (cfs)
Critically dry	1:1
Dry	2:1
Below normal	3:1
Above normal	4:1
Wet	4:1
Vernalis flow equal to or greater than 21,750 cfs	Unrestricted exports until flood recedes below 21,750 cfs.

During multiple dry years, the ratio would be limited to 1:1 if the New Melones Index related to storage is less than 1,000 TAF and the sum s of the "indicator" numbers established for water year classifications in SWRCB D-1641 (based on the San Joaquin Valley 60-20-20 Water Year Classification in SWRCB D-1641) is greater than 6 for the past two years and the current year. The indicator numbers are 1 for a critically dry year, 2 for a dry year, 3 for a below normal year, 4 for an above normal year, and 5 for a wet year.

Implementation of the inflow:export ratio under all conditions would allow a minimum pumping rate of 1,500 cfs to meet public health and safety needs of communities that solely rely upon water diverted from the CVP and SWP pumping plants.

C.5.3.2.6 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. Parties seeking water transfers generally acquire water from sellers who have available surface water who can make the water available through releasing previously stored water, pump groundwater instead of using surface water; fallow crops or substitute a crop that uses less water in order to reduce normal consumptive use of surface diversions. Water transfers (addressed in this document) occur when a water right holder within the Sacramento-San Joaquin River watershed undertakes actions to make water available for transfer. The SWP does not address the upstream operations that may be necessary to make water available for transfer. Nor does this document address the impacts of water transfers on terrestrial species.

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 to the buyer. Additionally, Reclamation and DWR must coordinate review of the transfer proposals and Project operations to assure that the Projects are not impacted including the ability to exercise their own water rights or to meet their legal and regulatory requirements are not diminished or limited in any way. To avoid impacts to Delta water quality the individual transfer is assessed a carriage water loss to account for flows required to avoid impacts to Delta water quality or flow objectives. All transfers would be in accordance with all existing regulations and requirements.

Purchasers of water for transfers may include Reclamation, CVP water contractors, DWR, SWP water contractors, other State and Federal agencies, and other parties. Reclamation and DWR have operated water acquisition programs in the past to provide water for environmental programs and additional supplies to CVP water contractors, SWP water contractors, and other parties. Past transfer programs include the following.

- DWR administered the 1991, 1992, 1994, and 2009 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, and to augment water supplies for CVP contractors south of the Delta and wildlife refuges. Reclamation administers the CVPIA Water Acquisition Program for Refuge Level 4 supplies and fishery instream flows.
- DWR is a signatory to the Yuba River Accord Water Transfer Agreement through 2025 that provides fish flows on the Yuba River and also water supply that is exported at DWR and Reclamation Delta facilities for the CVP and SWP operations and for the SWP and CVP contractors.
- In the past, CVP contractors and SWP water contractors have independently acquired water and arranged for pumping and conveyance through SWP and CVP facilities.

Lower Yuba River Accord

The Lower Yuba River Accord (Yuba Accord) consists of three sets of agreements designed to protect and enhance fisheries resources in the Lower Yuba River, increase local water supply reliability, provide

DWR with increased operational flexibility for protection of Delta fisheries resources, and provide added dry-year water supplies to CVP and SWP water contractors. These agreements are:

- The Lower Yuba River Fisheries Agreement (Fisheries Agreement).
- Agreements for the Conjunctive Use of Surface and Groundwater Supplies (Conjunctive Use Agreements).
- Agreement for the Long-term Purchase of Water from Yuba County Water Agency by DWR (Water Purchase Agreement).

The Fisheries Agreement is the cornerstone of the Yuba Accord. It was developed by state, federal, and consulting fisheries biologists, fisheries advocates, policy representatives, and the Yuba County Water Agency (YCWA). Compared to the interim flow requirements of the SWRCB Revised Water Right Decision 1644 (RD-1644), the Fisheries Agreement establishes higher minimum instream flows during most months of most water years.

To assure that YCWA's water supply reliability is not reduced by the higher minimum instream flows and water transfers, it and seven of its member units have signed conjunctive use agreements. These agreements establish a conjunctive use program that facilitates the integration of the surface water and groundwater supplies of the seven local irrigation districts and mutual water companies that YCWA serves in Yuba County. Integration of surface water and groundwater allows YCWA to increase the efficiency of its water management.

Under the Water Purchase Agreement, DWR administers the water transfer activities. The Water Transfer Agreement allows DWR to purchase water from YCWA to generally offset water costs resulting from export restrictions in winter and spring each year to benefit Delta Smelt and out-migrating San Joaquin River salmonids. This quantity of water is known as "Component 1 Water" under the Water Purchase Agreement and is quantified as the first 60 TAF of surface water above a defined baseline that Yuba releases each year. Assuming a 20 percent carriage water cost, approximately 48 TAF would reach the export pumps to produce a mitigation offset of approximately 48 TAF of reduced exports.

Additional water supplies purchased by the SWP water contractors and/or CVP contractors under the Water Purchase Agreement are administered by DWR as a water transfer program in drier years. These supplies include: (a) Component 2 water (15 TAF per year [TAF/year] in Dry Years and up to 30 TAF/year in Critical Years); (b) Component 3 water (up to 40 TAF/year in specified lower SWP or CVP allocation years); and (c) Component 4 water (additional water that YCWA makes available from surface-water supplies and its groundwater substitution program). The San Luis and Delta-Mendota Water Authority is a Participating Contractor to provide benefits to certain of its member CVP contractors.

CEQA review for all of the Yuba Accord agreements (Fisheries, Water Purchase, and Conjunctive Use) was completed in 2007 and these agreements were fully executed between late 2007 and early 2008. SWRCB approved the instream flow schedules and water transfer aspects of the Yuba River Accord, with some corrections, on March 18, 2008. The Fisheries Agreement terminates when FERC issues a new long-term FERC license for the Yuba River Development Project. The Water Purchase Agreement will terminate on December 31, 2025, but the amounts of water that YCWA will transfer under the agreement after FERC issues a new long-term license for the Yuba River Development Project will be subject to negotiation by the parties to the agreement. The Conjunctive Use Agreements will terminate when the Fisheries Agreement and Water Purchase Agreement terminate. It is assumed in this EIS that the existing or similar agreements will be renewed by 2030.

Transfer Capacity

It is expected that water transfer programs for environmental and water supply augmentation will continue in some form, and that in most years (all but the driest), the scope of annual water transfers of water exported through the Delta will be limited by available Delta pumping capacity, and exports for transfers will be limited to the months of July-September. As such, looking at an indicator of available transfer capacity in those months is one way of estimating an upper boundary to the effects of transfers on an annual basis.

The CVP and SWP may provide Delta export pumping for transfers using pumping capacity at Banks and Jones pumping plants beyond that which is being used to deliver Project water supply, up to the diversion capacity, consistent with existing operational and regulatory restrictions.

The surplus capacity available for transfers varies a great deal with hydrologic conditions. In general, as hydrologic conditions get wetter, surplus capacity diminishes because the CVP and SWP are more fully using export pumping capacity for Project supplies. The CVP's Jones Pumping Plant has little surplus capacity, except in the driest hydrologic conditions. The SWP has the most surplus capacity in critical and some dry years, less or sometimes none in most median hydrologic conditions, and some surplus again in some above normal and wet years when demands may be lower because some water users may have alternative supplies.

The availability of water for transfer and the demand for transferred water may also vary with hydrologic conditions. Accordingly, since many transfers are negotiated between willing buyers and sellers under prevailing market conditions, price of water also may be a factor determining how much is transferred in any year. This document does not attempt to identify how much of the available and useable surplus export capacity of the CVP and SWP would actually be used for transfers in a particular year but given the recent history of water transfer programs and requests for individual water transfers, trends suggest a growing reliance on transfers to meet dry year water demands.

Under both the present and future conditions, capability to export transfers would often be capacity-limited, except in Critical and some Dry years. In Critical and some Dry years, both Banks and Jones pumping plants would likely have surplus capacity for transfers. As a result, export capacity is less likely to limit transfers in these years. During such years, low Project exports and high demand for water supply could make it possible to transfer significant amounts of transfer water when upstream water supplies are available.

Exports for Transfers

Although transfers may occur at any time of year, the 2008 USFWS BO and 2009 NMFS BO address proposed exports for transfers during only the months July through September. For transfers outside those months, or in excess of the maximum amounts (listed below), separate consultations would be required with the USFWS and NMFS. Based on the estimates of available capacity for export of transfers during July through September, and in recognition of the many other possible operational contingencies and constraints that may limit actual use of that capacity for transfers, as follows.

- Critical Water Year: Maximum Transfer Amount is 600 TAF
- Dry Water Year following Critical Water Year: Maximum Transfer Amount is 600 TAF
- Dry Water Year following Dry Water Year: Maximum Transfer Amount is 600 TAF
- All Other Water Years: Maximum Transfer Amount is 360 TAF

C.5.3.2.7 Coordinated Operation Agreement

The CVP and SWP are operated in a coordinated manner in accordance with Public Law 99-546 (October 27, 1986), directing the Secretary to execute the COA. The CVP and SWP are also operated under the SWRCB decisions and water right orders related to the CVP's and SWP's water right permits and licenses to appropriate water by diverting to storage, by directly diverting to use, or by re-diverting releases from storage later in the year or in subsequent years.

The CVP and SWP are permitted by SWRCB to store water, divert water and re-divert CVP and SWP water that has been stored in upstream reservoirs. The CVP and SWP have built water storage and water delivery facilities in the Central Valley to deliver water supplies to CVP and SWP contractors, including senior water users. The CVP's and SWP's water rights are conditioned by the SWRCB to protect the beneficial uses of water within the watersheds.

As conditions of the water right permits and licenses, SWRCB requires the CVP and SWP to meet specific water quality objectives within the Delta. Reclamation and DWR coordinate operation of the CVP and SWP, pursuant to the COA, to meet these and other operating requirements. The COA is an agreement between the Federal government and the State of California for the coordinated operation of the CVP and SWP. The agreement suspended a 1960 agreement and superseded annual coordination agreements that had been implemented following construction of the SWP.

Through the COA, Reclamation and DWR share the obligation for meeting 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 provisions of Exhibit A of the COA [SWRCB Delta standards]. Each project is obligated to ensure water is available for these uses. The respective degree of obligation is dependent on several factors, as described below.

Balanced water conditions are defined in the COA as periods when it is mutually 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 mutually agreed that releases from upstream reservoirs plus unregulated flow exceed Sacramento Valley in-basin uses plus exports. Reclamation's Central Valley Operations Office and DWR's SWP Operations Control Office jointly decide when balanced or excess water conditions exist. During balanced water conditions, the projects share the responsibility in meeting in-basin uses.

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) of the COA, Reclamation and DWR have the responsibility (during excess water conditions) to store and export as much water as possible, within physical, legal, and contractual limits.

Implementation of the COA principles has continuously evolved since 1986 as changes have occurred to CVP and SWP facilities, to operating criteria, and to the overall physical and regulatory environment. For example, updated water quality and flow standards adopted by the SWRCB, CVPIA, and ESA responsibilities have affected both CVP and SWP operations. The 1986 COA incorporated D-1485 provisions regarding Delta salinity, outflow, and export restrictions and provided a methodology to incorporate future regulatory changes, like Delta salinity requirements. Both D-1641 and the 2008 and 2009 biological opinions included various export restrictions that were not explicitly addressed in the 1986 COA. Prior to 2019, the available export capacity as a result of these export restrictions was shared between the projects in the absence of a formal update.

In December 2018, Reclamation and DWR modified four key elements of the COA to address changes since COA was originally signed: (1) in-basin uses; (2) export restrictions; (3) CVP use of Banks Pumping Plant up to 195,000 acre-feet per year; and (4) the periodic review. COA sharing percentages for meeting Sacramento Valley in-basin uses now vary from 80 percent responsibility of the United States and 20 percent responsibility of the State of California in wet year types to 60 percent responsibility of the United States and 40 percent responsibility of the State of California in critical year types. In a dry or critical year following two dry or critical years, the United States and State will meet to discuss additional changes to the percentage sharing of responsibility to meet in-basin use. When exports are constrained, and the Delta is in balanced conditions, Reclamation may pump up to 65 percent of the allowable total exports with DWR pumping the remaining capacity. In excess conditions, these percentages change to 60/40.

C.5.3.2.8 Accounting and Coordination of Operations

Reclamation and DWR coordinate on a daily basis to determine target Delta outflow for water quality, reservoir release levels necessary to meet in-basin demands, schedules for joint use of the San Luis Unit facilities, and for the use of each other’s facilities for pumping and wheeling. During balanced water conditions, daily water accounting is maintained for the CVP and SWP obligations. This accounting allows for flexibility in operations and avoids the necessity of daily changes in reservoir releases that originate several days’ travel time from the Delta.

The accounting language of the COA provides the mechanism for determining the responsibility of each project for Delta outflow influenced standards; however, real-time operations dictate actions. For example, conditions in the Delta can change rapidly. Weather conditions combined with tidal action can quickly affect Delta salinity conditions, and therefore, the Delta outflow required to maintain standards. If, in this circumstance, it is decided the reasonable course of action is to increase upstream reservoir releases, then the response may be to increase Folsom Reservoir releases first because the released water will reach the Delta before flows released from other CVP and SWP reservoirs. Lake Oroville water releases require about three days to reach the Delta, while water released from Shasta Lake requires five days to travel from Keswick Reservoir to the Delta. As water from the other reservoirs arrives in the Delta, Folsom Reservoir releases can be adjusted downward. Any imbalance in meeting each project’s initial shared obligation would be captured by the COA accounting.

Reservoir release changes are one means of adjusting to changing in-basin conditions. Increasing or decreasing project exports can also immediately achieve changes to Delta outflow. As with changes in reservoir releases, imbalances in meeting the CVP and SWP initial shared obligations are captured by the COA accounting.

The duration of balanced water conditions varies from year to year. Some very wet years have had no periods of balanced conditions, while very dry years may have had long continuous periods of balanced conditions, and still other years may have had several periods of balanced conditions interspersed with excess water conditions.

C.5.4 Joint Facilities in Suisun Marsh

Since the early 1970s, the California Legislature, SWRCB, Reclamation, CDFW, Suisun Resource Conservation District, DWR, and other agencies have worked to preserve beneficial uses of Suisun Marsh in mitigation for perceived impacts of reduced Delta outflow on the salinity regime. Early on, salinity standards were set by SWRCB to protect alkali bulrush production, a primary waterfowl plant food. The most recent standard under SWRCB D-1641 acknowledges that multiple beneficial uses deserve protection.

A contractual agreement among DWR, Reclamation, CDFW, and Suisun Resource Conservation District contains provisions for DWR and Reclamation to mitigate the effects on Suisun Marsh channel water salinity from SWP and CVP operations and other upstream diversions. The Suisun Marsh Preservation Agreement requires DWR and Reclamation to meet salinity standards, sets a timeline for implementing the Plan of Protection, and delineates monitoring and mitigation requirements. In addition to the contractual agreement, SWRCB D-1485 codified salinity standards in 1978, which have been carried forward to SWRCB D-1641.

There are two primary physical mechanisms for meeting salinity standards set forth in SWRCB D-1641 and the Suisun Marsh Preservation Agreement: (1) the implementation and operation of physical facilities in the Marsh; and (2) management of Delta outflow (i.e., facility operations are driven largely by salinity levels upstream of Montezuma Slough and salinity levels are highly sensitive to Delta outflow). Physical facilities, described below, have been operating since the early 1980s and have proven to be a highly reliable method for meeting standards.

C.5.4.1 *Suisun Marsh Salinity Control Gates*

The Suisun March Salinity Control Gates (SMSCG) are located on Montezuma Slough about 2 miles downstream from the confluence of the Sacramento and San Joaquin Rivers, near Collinsville. The objective of Suisun Marsh Salinity Control Gate operation is to decrease the salinity of the water in Montezuma Slough. The gates control salinity by restricting the flow of higher salinity water from Grizzly Bay into Montezuma Slough during incoming tides and retaining lower salinity Sacramento River water from the previous ebb tide. Operation of the gates in this fashion lowers salinity in Suisun Marsh channels and results in a net movement of water from east to west.

When Delta outflow is low to moderate and the gates are not operating, tidal flow past the gate is approximately 5,000 to 6,000 cfs while the net flow is near zero. When operated, flood tide flows are arrested while ebb tide flows remain in the range of 5,000 to 6,000 cfs. The net flow in Montezuma Slough becomes approximately 2,500 to 2,800 cfs. The USACE permit for operating the SMSCG requires that it be operated between October and May only when needed to meet Suisun Marsh salinity standards. Historically, the gate has been operated as early as October 1, although in some years (e.g., 1996) the gate was not operated at all. When the channel water salinity decreases sufficiently below the salinity standards, or at the end of the control season, the project provides unrestricted movement through Montezuma Slough. Details of annual gate operations can be found in Summary of Salinity Conditions in Suisun Marsh During Water Years 1984–1992 (DWR 1994), or the Suisun Marsh Monitoring Program Data Summary produced annually by DWR's Division of Environmental Services.

The approximately 2,800 cfs net flow induced by SMSCG operation is effective at moving the salinity downstream in Montezuma Slough. Salinity is reduced by roughly 100 percent at Belden's Landing, and by lesser amounts farther west along Montezuma Slough. At the same time, the salinity field in Suisun Bay moves upstream as net Delta outflow (measured nominally at Chipps Island) is reduced by gate operation. Net outflow through Carquinez Strait is not affected.

The SMSCG are operated during the salinity control season, which spans from October to May. Operational frequency is affected by hydrologic conditions, weather, Delta outflow, tide, fishery considerations, and other factors. The gates have also been operated for scientific studies. After discussions with NMFS based on study findings, the boat lock portion of the gate is now held open at all times during SMSCG operation to allow for continuous salmon passage opportunity. Adaptive management of the gates continues to improve, and salinity standards have been met with less frequent gate operation since 2006. In low outflow years gate operation was used from 35 to 42 days. The operation was limited to 17 to 69 days in 2009, 2010, 2011 and 2013. Assuming no significant long-term changes in the drivers mentioned above, it is expected that gate operations will remain at current levels (17 to 69 days per year) except perhaps during the most critical hydrologic conditions and other conditions that affect Delta outflow.

C.5.4.1.1 SMSCG Fish Passage Studies

The SMSCG were constructed and operate under USACE Permit 16223E58, which includes a special condition to evaluate the nature of delays to migrating fish. Ultrasonic telemetry studies in 1993 and 1994 showed that the physical configuration and operation of the gates during the control season have a negative effect on adult salmonid passage (DWR IEP 1996).

The Department coordinated additional fish passage studies in 1998, 1999, 2001, 2002, 2003, and 2004. Migrating adult fall-run Chinook Salmon were tagged and tracked by telemetry in the vicinity of the SMSCG to assess potential measures to increase the salmon passage rate and decrease salmon passage time through the gates. a

Results in 2001, 2003, and 2004 indicate that leaving the boat lock open during the Control Season when the flashboards are in place at the SMSCG and the radial gates are tidally operated provides a nearly equivalent fish passage to the noncontrol season configuration when the flashboards are out and the radial gates are open. This approach minimizes delay and blockage of adult Sacramento River winter-run Chinook Salmon, Central Valley spring-run Chinook Salmon, and Central Valley Steelhead migrating upstream during the Control Season while the SMSCG is operating. However, the boat lock gates may be closed temporarily to stabilize flows to facilitate safe passage of watercraft through the facility.

C.5.4.2 *Roaring River Distribution System*

The Roaring River Distribution System (RRDS) is located in the southeastern Suisun Marsh and was constructed by the DWR and Reclamation in 1979 to mitigate for the effects on Marsh channel water salinity caused by Central Valley Project and State Water Project operations. The distribution system is used to convey less saline water from Montezuma Slough to managed 5,000 acres of private and 3,000 acres of CDFW managed wetlands on Simmons, Hammond, Van Sickle, Wheeler, and Grizzly Islands.

Salinity control is mandated by SWRCB, Suisun Marsh Protection Plan (BCDC 1976), Plan of Protection for Suisun Marsh (DWR 1984b) and associated Environmental Impact Report, and in response to D-1485, Order 7, superseded by D-1641. DWR and Reclamation are required under the Suisun Marsh Preservation Agreement (Reclamation et al. 1987) to operate and maintain the RRDS to provide lower salinity water to adjacent State and private landowners in the Marsh.

Diversions from Montezuma Slough typically occur from August through June. Water is diverted from RRDS to the managed wetlands and circulated. The water is drained from the managed wetlands in spring, taking with it salts from the soil.

The RRDS includes an intake structure from Montezuma Slough consisting of eight 60-inch culverts with flap gates and slide gates. Managed wetlands north and south of the RRDS receive water, as needed, through publicly and privately-owned turnouts on the system. Between 1981 and 1982 fish screens were placed over the intake according to California Department of Fish and Wildlife (CDFW) standards. After the listing of Delta Smelt, RRDS diversion rates have been controlled to maintain an average approach velocity below 0.7 ft/s at the intake fish screen. The intake discharges to the 40-acre Hammond Island pond at the southeast corner of CDFW property. Motorized slide gates in Montezuma Slough and flap gates in the pond control flows through the culverts into the pond. A manually operated flap gate and flashboard riser are located at the confluence of Roaring River and Montezuma Slough to allow drainage back into Montezuma Slough for controlling water levels in the distribution system and for flood protection. DWR owns and operates this drain gate to ensure the Roaring River levees are not compromised during extremely high tides. Approximately 8 miles of channel run from Hammond Island pond to the western edge of Simmons Island. Several turnouts along RRDS are operated and maintained by the DFW and adjacent private landowners.

DWR conducts routine maintenance of the system, primarily maintaining the levee roads and fish screens. RRDS, like other levees in the marsh, have experienced subsidence.

C.5.4.3 *Morrow Island Distribution System*

The Morrow Island Distribution System was constructed in 1979 and 1980 in the southwestern Suisun Marsh as part of the Initial Facilities in the Plan of Protection for the Suisun Marsh. The contractual requirement for Reclamation and DWR is to provide water to the ownerships so that lands may be managed according to approved local management plans. The system was constructed primarily to channel drainage water from the adjacent managed wetlands for discharge into Suisun Slough and Grizzly Bay. This approach increases circulation and reduces salinity in Goodyear Slough.

The Morrow Island Distribution System is used year-round, but most intensively from September through June. When managed wetlands are filling and circulating, water is tidally diverted from Goodyear Slough just south of Pierce Harbor through three 48-inch culverts. Drainage water from Morrow Island is discharged into Grizzly Bay by way of the C-Line Outfall (two 36-inch culverts) and into the mouth of Suisun Slough by way of the M-Line Outfall (three 48-inch culverts), rather than back into Goodyear Slough. This helps prevent increases in salinity due to drainage water discharges into Goodyear Slough. The M-Line ditch is approximately 1.6 miles long and the C-Line ditch is approximately 0.8 miles long.

Reclamation and DWR operate the Goodyear Slough Outfall to improve water circulation in the marsh. This structure consists of four 48-inch diameter culverts with flap gates designed to drain water from the southern end of Goodyear Slough into Suisun Bay. On flood tides, the gates reduce the amount of tidal inflow into Goodyear Slough.

C.5.4.4 *Suisun Marsh Wildlife Habitat Management, Preservation, and Restoration Plan*

The Suisun Marsh Habitat Management, Preservation, and Restoration Plan (SMP) was developed by the Suisun Principal Agencies including USFWS, Reclamation, CDFW, DWR, NMFS, and Suisun Resource Conservation. The SMP is a 30-year comprehensive plan designed to address the various conflicts regarding use of Marsh resources, with the focus on achieving an acceptable multi-stakeholder approach. The plan balances the benefits of tidal wetland restoration with other habitat uses in the Marsh by evaluating alternatives that provide a politically acceptable change in Marshwide land uses, such as salt marsh harvest mouse habitat, managed wetlands, public use, and upland habitat. The SMP is intended to address the full range of issues in the Marsh, which are linked geographically, ecologically, and ideologically. The objectives of the SMP are to:

1. Implement the CALFED Ecosystem Restoration Program Plan restoration target for the Suisun Marsh ecoregion of 5,000 to 7,000 acres of tidal marsh and protection and enhancement of 40,000 to 50,000 acres of managed wetlands;
2. Maintain the heritage of waterfowl hunting and other recreational opportunities and increase the surrounding communities' awareness of the ecological values of Suisun Marsh;
3. Maintain and improve the Suisun Marsh levee system integrity to protect property, infrastructure, and wildlife habitats from catastrophic flooding; and

4. Protect and, where possible improve, water quality for beneficial uses in Suisun Marsh, including estuarine, spawning, and migrating habitat uses for fish species as well as recreational uses and associated wildlife habitat.

In June of 2013, the USFWS issued a BO (File Number: 08ESMF00-2012-F-0602-2) to the Bureau of Reclamation that addresses the effects of the SMP on the endangered threatened along with their designated critical habitat. The SMP BO analyses both a project-level plan for managed wetlands and a programmatic action for tidal restoration. Tidal wetland restoration helps achieve the restoration goals established for the Marsh by the CALFED Ecosystem Restoration Program Plan, San Francisco Bay Area Wetlands Ecosystem Goals Project, and the USFWS's Draft Recovery Plan for Tidal Marsh Ecosystems of Northern and Central California for the Suisun Bay Area Recovery Unit. The BO details requirements for proposed tidal marsh restoration projects that maybe appended to the BO.

C.5.5 Non-CVP and SWP Reservoirs that Store CVP and SWP Water

The CVP and SWP water is delivered to water agencies. Some of those water agencies store the water in regional and local reservoirs. These reservoirs frequently store non-CVP and SWP water supplies, including local runoff or water diverted under separate water rights or contracts. The capacities of these reservoirs are listed in Tables C.1-5, C.1-6, and C.1-7.

In the San Francisco Bay Area Region, CVP water is stored in the Contra Costa Water District Los Vaqueros Reservoir and the East Bay Municipal Utility District Upper San Leandro, San Pablo, Briones, and Lafayette reservoirs and Lake Chabot. The Los Vaqueros Reservoir, as previously described, also stores water diverted from the Delta under separate water rights. The East Bay Municipal Utility District reservoirs primarily store water diverted under water rights on the Mokelumne River.

In the Central Coast Region, a portion of the SWP water supply diverted in the Coastal Branch can be stored in Cachuma Lake for use by southern Santa Barbara County communities. Cachuma Lake is a facility owned and operated by Reclamation in Santa Barbara County as part of the Cachuma Project (not the CVP).

In the Southern California Region, SWP water is stored in the Metropolitan Water District of Southern California's Diamond Valley Lake and Lake Skinner; United Water Conservation District's Lake Piru; City of Escondido's Dixon Lake; City of San Diego's San Vicente, El Capitan, Lower Otay, Hodges, and Murray reservoirs; Helix Water District's Lake Jennings; Sweetwater Authority's Sweetwater Reservoir; and San Diego County Water Authority's Olivenhain Reservoir. There are future plans to expand local and regional water surface water storage.

C.5.6 Water Supplies Used by Central Valley Project and State Water Project Water Users

The CVP and SWP water supplies are the only water supplies available to some water users, many of the CVP Sacramento River Settlement Contractors, communities near Redding (Centerville, Clear Creek, and Shasta community services districts; Shasta County Water Agency), communities in the San Joaquin Valley (cities of Avenal, Coalinga, and Huron), and some communities served by the Antelope Valley-East Kern Water Agency. Other CVP and SWP water users rely upon other surface water supplies and groundwater. However, when the CVP and SWP water supplies are limited due to climate conditions and hydrology, the other surface water supplies are also limited.

Several CVP and SWP water users also rely upon other imported water supplies, including water from Solano Project (used by the Solano County Water Agency), San Francisco Public Utilities Commission (used by portions of the service areas of Alameda County Water District, Santa Clara Valley Water District, and Zone 7 Water Agency), and the Colorado River (used by portions of the service area of the Metropolitan Water District of Southern California and Coachella Valley Water District). These surface water supplies are also subject to reductions due to hydrologic conditions. In the case of water users that rely upon Colorado River water supplies, Delta water is used to dilute the salts and trace elements (e.g., selenium) in the Colorado River water in addition to providing direct water supplies (Reclamation 2012).

In response to recent reductions in CVP and SWP water supply reliability, water agencies have been improving regional and local water supply reliability through enhanced water conservation efforts, wastewater effluent and stormwater recycling, construction of surface water and groundwater storage facilities, and construction of desalination treatment plants for brackish water sources and ocean water sources. In addition, many agencies have constructed conveyance facilities to allow sharing of water supplies between communities, including the recent Bay Area Regional Water Supply Reliability project that provided conveyance opportunities between several CVP and SWP water users in the San Francisco Bay Area Region.

Water conservation is an integral part of water management in the study area. Water use efficiency programs and initiatives reduce the need for more expensive water supplies by facilitating the efficient use of existing water supplies. For example, a cost-effective component of many water plans is to reduce water use through educational tools that include commercial and residential guidance for water efficient landscapes, water use calculators for agricultural and municipal users, and conservation websites. All of these efforts are implemented to meet the statewide goals to reduce municipal per capita water use by 20 percent by 2020 and to optimize agricultural water use efficiency.

Water transfers also are an integral part of water management. Historically, water transfers primarily were in-basin transfers (e.g., Sacramento Valley water seller to Sacramento Valley water user) (Reclamation 2013b; DWR, Reclamation, USFWS and NMFS 2013). However, between 2001 and 2012, water transfers from the Sacramento Valley to the areas located south of the Delta of up to 298,806 acre-feet occurred (not including water transfers under the Environmental Water Account Program in the early 2000s) (DWR, Reclamation, USFWS and NMFS 2013). These transfers occurred in drier years. In the 2012 and 2013, the following types of water transfers occurred (DWR and Reclamation 2015).

Until recently, most of the water transfers extended for one or two years. In 2008, one of the first long-term water transfer agreements was approved by the SWRCB for the Lower Yuba River Accord. The plan was designed to protect and enhance fisheries resources in the Lower Yuba River, increase local water supply reliability, provide DWR with increased operational flexibility for protection of Delta fisheries resources, and provide added dry-year water supplies to CVP and SWP water users. In 2013, Reclamation approved an overall program for a 25-year period (2014 to 2038) to transfer up to 150,000 acre-feet per year of water from the San Joaquin River Exchange Contractors Water Authority to DOI for refuge water supplies or CVP and SWP water users (Reclamation 2013b). Reclamation is currently planning a long-term water transfer program between water sellers in the Sacramento Valley and water users located in the San Francisco Bay Area and south of the Delta (Reclamation 2014b).

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