Draft

Power and Energy Technical Report

Shasta Lake Water Resources Investigation, California

Prepared by:

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Acronyms and Abbreviations

Bay Area	San Francisco Bay Area
CEQA	California Environmental Quality Act
cfs	cubic feet per second
CVP	Central Valley Project
D-1641	SWRCB Water Right Decision Number D-1641
DEIS	Draft Environmental Impact Statement
Delta	Sacramento-San Joaquin Delta
DOE	U.S. Department of Energy
DWR	California Department of Water Resources
hp	horsepower
JPOD	Joint Point of Diversion
km	kilometer
LTG	LongTermGen
M&I	municipal and industrial
MW	megawatt
MWh	megawatt-hours
NEPA	National Environmental Policy Act
Oroville Facilities	Edward Hyatt Pumping-Generating Plant, Thermalito Diversion Dam Powerplant, and Thermalito Pumping-Generating Plants
RBPP	Red Bluff Pumping Plant
Reclamation	U.S. Department of the Interior, Bureau of Reclamation
Sierra Nevada Region	Sierra Nevada Customer Service Region
SLWRI	Shasta Lake Water Resources Investigation
SWP Power	SWP Power CA
SWP	State Water Project
SWRCB	State Water Resources Control Board
TCD	temperature control device
USACE	U.S. Army Corps of Engineers
Western	Western Area Power Administration

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Chapter 1
Affected Environment

This chapter describes the affected environment related to hydropower generation and pumping energy consumption associated with the dam and reservoir modifications proposed under the Shasta Lake Water Resources Investigation (SLWRI).

This technical report reviews output from hydropower modeling performed for the SLWRI Draft Environmental Impact Statement (DEIS), in compliance with the National Environmental Policy Act (NEPA) and California Environmental Quality Act (CEQA). The purpose of hydropower modeling for the DEIS is to identify potential impacts from the SLWRI on hydroelectric generation and pumping energy consumption of the facilities of the Central Valley Project (CVP) and State Water Project (SWP), which are operated by the U.S. Department of the Interior, Bureau of Reclamation (Reclamation), and California Department of Water Resources (DWR), respectively. The modeling tools used were LongTermGen (LTG) for the CVP system and SWP Power CA (SWP Power) for the SWP system.

Environmental Setting

The environmental setting includes the existing generating and pumping plants of the CVP and SWP.

For purposes of this analysis, the area around Shasta Lake and along the Sacramento River from Shasta Dam to Red Bluff is considered the primary study area (Figure 1-1). The area along the Sacramento River from Red Bluff to the Sacramento-San Joaquin Delta (Delta) and CVP/SWP service areas are considered the extended study area (Figures 1-2 and 1-3).

Shasta Lake belongs to the CVP Shasta Division, which includes Shasta Dam and Powerplant, and Keswick Dam, Reservoir, and Powerplant. Shasta Dam and Reservoir are located on the upper Sacramento River in Northern California, about 9 miles northwest of the City of Redding in Shasta County. The Shasta Division is a multipurpose project that provides irrigation water supply, municipal and industrial (M&I) water supply, flood control, hydropower generation, fish and wildlife conservation, and navigation.

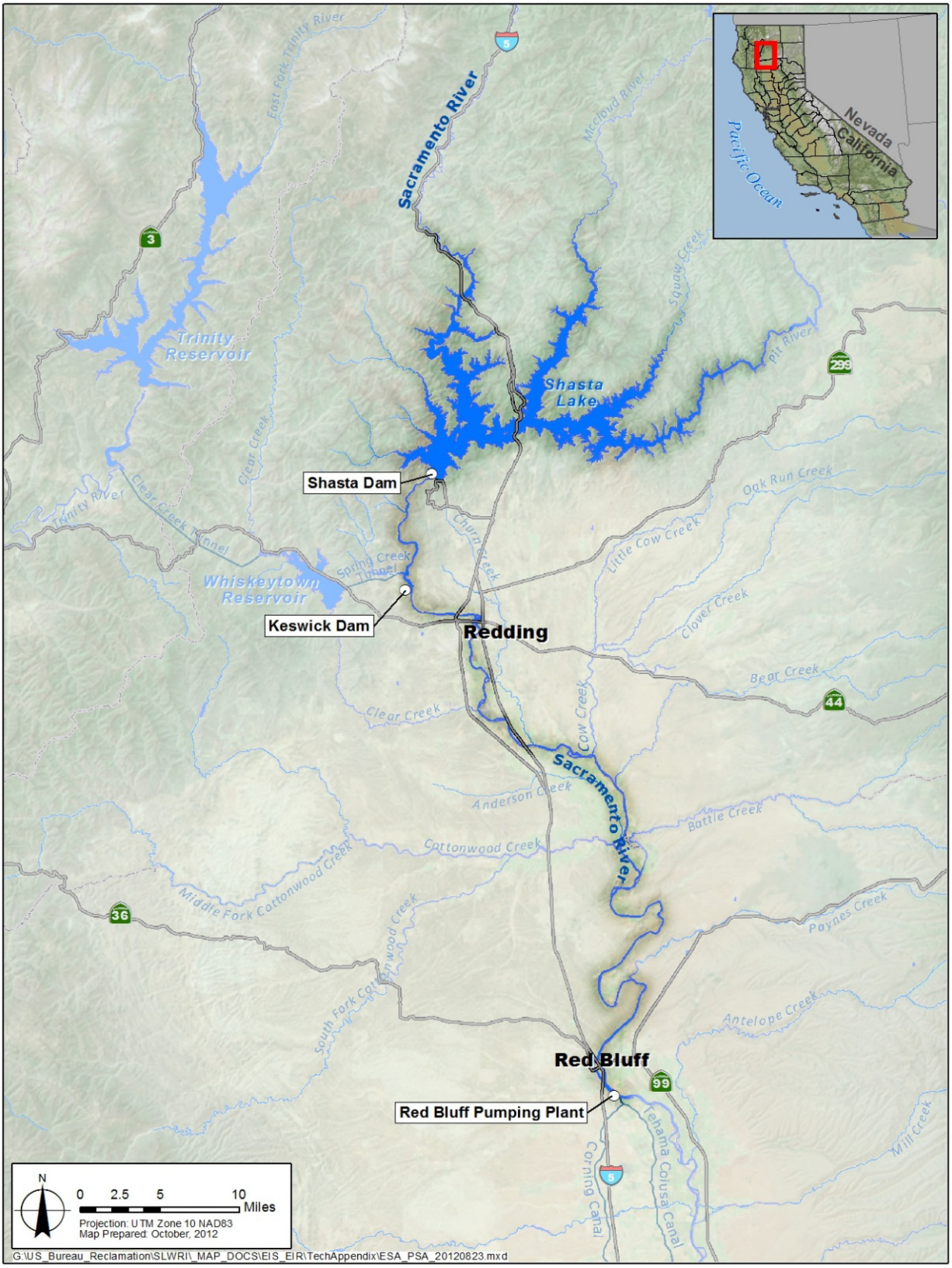

Figure 1-1. Shasta Lake Water Resources Investigation Primary Study Area, Shasta Lake and Vicinity and the Upper Sacramento River (Shasta Dam to Red Bluff)

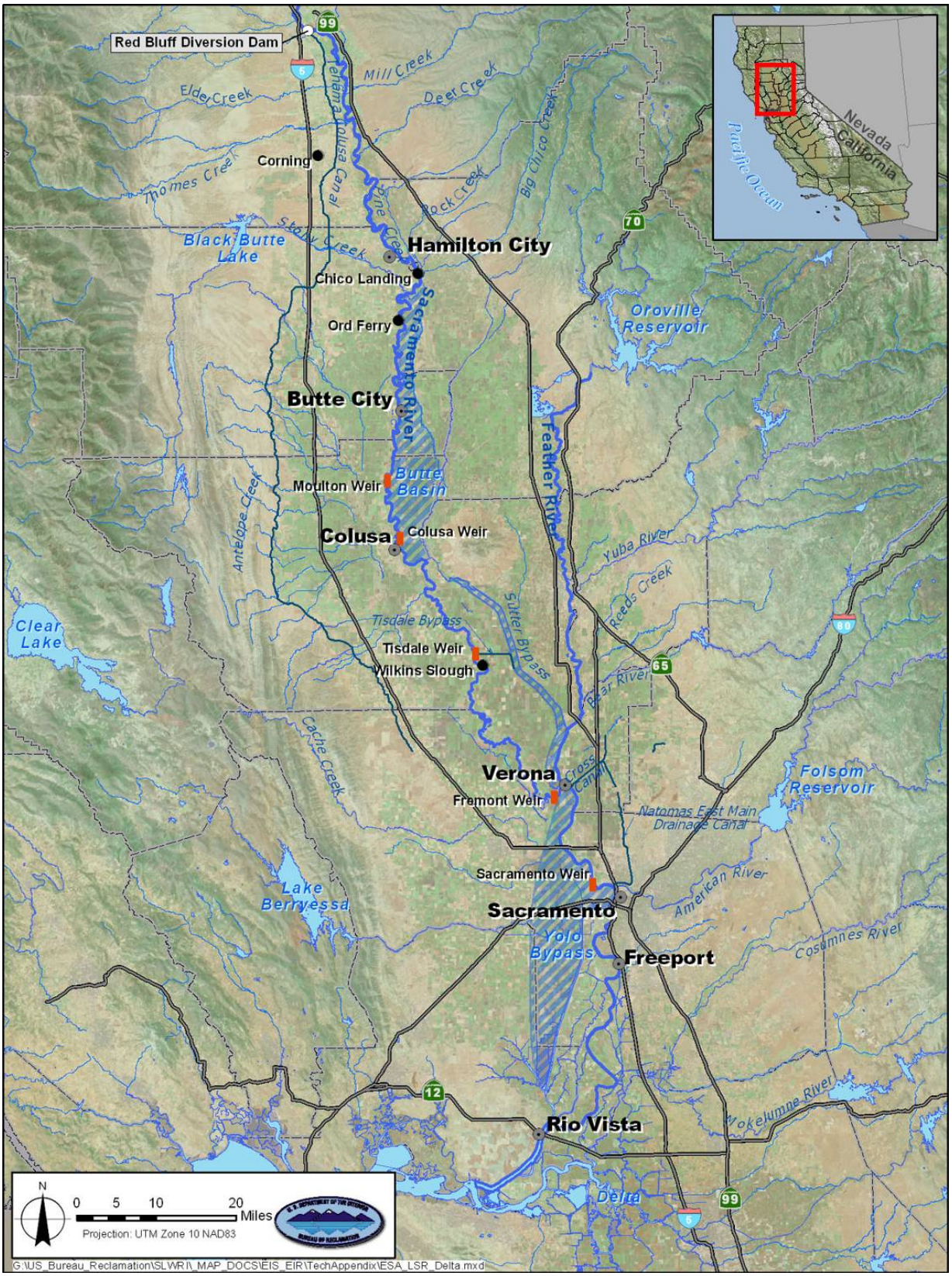

Figure 1-2. Shasta Lake Water Resources Investigation Extended Study Area, Lower Sacramento River and Delta

Figure 1-3. Shasta Lake Water Resources Investigation Extended Study Area, CVP/SWP Service Areas

The CVP is a multipurpose project[1] with 20 dams and reservoirs, 11 Powerplants, a major pumping plant and 500 miles of major canals, as well as conduits, tunnels, and related facilities. The Western Area Power Administration (Western), created in 1977 under the U.S. Department of Energy (DOE) Organization Act, markets and transmits electric power throughout 15 western states. Western's Sierra Nevada Customer Service Region (Sierra Nevada Region) markets and transmits power generated from the CVP and the Washoe Project[2] in excess of CVP use. Western follows a formal procedure for allocating CVP energy to "preference" customers. Those customers have 20-year contracts (which expire in 2024) for their share of CVP energy in excess of Reclamation's water pumping needs.

Table 1-1 shows the 11 CVP hydroelectric power plants, which have a maximum operation capability of 2,079 megawatts (MW) when all reservoirs are at their fullest. Historical annual power generation from Calendar Year 2001 through 2007 is shown in Table 1-1.

Table 1-1. Central Valley Project Power Plants, Capacities, and Historical Annual Generation

CVP Power Plants	Capacities (megawatt)	Net Annual Generation in One Calendar Year (megawatt-hour)						
		2001	2002	2003	2004	2005	2006	2007
Shasta Powerplant	676	1,647,122	1,869,359	2,235,472	2,082,197	1,902,107	2,648,325	1,914,175
Trinity Powerplant	140	403,236	370,216	560,571	582,907	404,581	653,440	364,532
Judge Francis Carr Powerplant	184	382,884	314,895	484,473	479,857	234,147	616,389	291,940
Spring Creek Powerplant	200	452,123	382,714	576,592	562,701	344,369	822,236	271,582
Keswick Powerplant	105	394,142	420,859	476,192	452,204	395,565	531,167	419,597
Lewiston Powerplant	0.35	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Folsom Powerplant	207	302,958	429,019	581,742	457,231	755,782	894,078	371,369
Nimbus Powerplant	17	41,637	54,156	67,832	51,987	72,311	77,728	41,262
New Melones Powerplant	383	380,309	370,996	364,414	335,355	372,876	910,222	469,679
O'Neill Pumping-Generating Plant	14.4	5,957	6,671	2,802	5,964	56	28	5,404
William R. Gianelli Pumping-Generating Plant (Federal share)	202	91,856	103,442	88,023	176,083	116,744	130,719	126,409

Source: Reclamation 2008
Key:
CVP = Central Valley Project
N/A – Records not available

[1] The CVP serves farms, homes, and industry in California's Central Valley as well as major urban centers in the San Francisco Bay Area (Bay Area); it is also the primary source of water for much of California's wetlands. In addition to delivering water for farms, homes, factories, and the environment, the CVP produces electric power and provides flood protection, navigation, recreation, and water quality benefits.

[2] The Washoe Project comprises drainage basins of the Truckee and lower Carson Rivers. The project coverage is west central Nevada (including the cities of Reno, Sparks, and Fallon, and the Town of Fernley) and a small portion of east central California in the vicinity of Lake Tahoe (including the cities of Truckee, and South Lake Tahoe and Tahoe City). The project was designed to improve the regulation of runoff from the Truckee and lower Carson River systems. It also provides fishery uses, flood protection, fish and wildlife benefits, and recreation development.

Major facilities of the SWP include 17 pumping plants, 8 hydroelectric power plants, 32 storage facilities, and 660-plus miles of aqueducts and pipelines. The SWP is also a multipurpose project.[3] The primary purpose of SWP power generation facilities is to meet energy requirements of the SWP pumping plants. To the extent possible, SWP pumping is scheduled during off-peak periods, and energy generation is scheduled during peak periods. Although the SWP uses more energy than it generates from its hydroelectric facilities, DWR has exchange agreements with other utility companies and has developed other power resources. DWR sells surplus power, when it is available, to minimize the net cost of pumping energy.

Table 1-2 summarizes power plant capacity and historical annual generation in Calendar Year 2004 for each plant. Table 1-3 shows the historical annual power consumption in Calendar Year 2004 for major SWP facilities.

Table 1-2. Major State Water Project Facilities, Capacities, and Historical Power Generation

Major SWP Facilities	Capacity (megawatt)	Energy Generated in Calendar Year 2004 (megawatt-hour)
Oroville Facilities	762	2,293,570
William R. Gianelli Pumping-Generating Plant (SWP share)	222	183,205
Alamo Powerplant	17	120,958
Mojave Siphon Powerplant	33	80,185
Devil Canyon Powerplant	276	1,281,780
Warne Powerplant	74	491,249

Source: DWR 2006
Key:
SWP = State Water Project

[3] The SWP conveys water from Northern California watersheds to urban, agricultural, and industrial use in the Bay Area, the San Joaquin Valley, the Central Coast, and Southern California. Besides water supply, other SWP benefits include flood control, recreation, fish and wildlife enhancement, power, and salinity control in the Delta.

Table 1-3. State Water Project Historical Power Consumption

Major SWP Facilities	Energy Used in Calendar Year 2004 (megawatt-hour)
Oroville Facilities (pumpback and station service)	26,715
North Bay Interim Pumping Plant	3
Cordelia Pumping Plant	10,831
Barker Slough Pumping Plant	11,299
South Bay Pumping Plant	100,593
Del Valle Pumping Plant	460
Harvey O. Banks Pumping Plant	892,609
William R. Gianelli Pumping-Generating Plant (SWP share)	297,007
Dos Amigos Pumping Plant (SWP share)	397,083
Buena Vista Pumping Plant	524,156
Teerink Pumping Plant	572,039
Chrisman Pumping Plant	1,268,283
Edmonston Pumping Plant	4,655,664
Alamo Powerplant (station service)	43
Pearblossom Pumping Plant	708,440
Pine Flat Powerplant	893
Mojave Siphon Powerplant (station service)	9
Devil Canyon Powerplant (station service)	6
Oso Pumping Plant	236,677
Warne Power Plant (station service)	686
Las Perillas Pumping Plant	0
Badger Hill Pumping Plant	20,952
Devil's Den Pumping Plant	24,067
Bluestone Pumping Plant	22,857
Polonio Pass Pumping Plant	23,929
Greenspot Pumping Plant	3,254
Crafton Hills Pumping Plant	2,638
Cherry Valley Pumping Plant	301

Source: DWR 2006
Key:
SWP = State Water Project

Shasta Lake and Vicinity

The Shasta Division of the CVP includes Shasta Dam, Lake, and Powerplant, and Keswick Dam, Reservoir, and Powerplant; it captures water from the Sacramento River Basin. As shown on Figure 1-4, Shasta Powerplant is located just below Shasta Dam as part of the Shasta Division. Water from the dam is released through five 15-foot penstocks leading to the five main generating units and two station service units with a maximum generation capacity of 584 MW. Shasta Powerplant is a peaking plant and generally runs when demand for electricity is high. Its power is dedicated first to meeting the requirements of CVP facilities. The remaining energy is marketed to various preference customers in Northern California. The 2007 net annual generation of Shasta Powerplant was 1,914,175 megawatt-hours (MWh).

Figure 1-4. Shasta Lake Water Resources Investigation Central Valley Project Generating and Pumping Facilities in the Primary Study Area

In 1987, downstream water temperature targets imposed to improve salmon spawning and rearing habitat required Reclamation to release water through the river outlet works, bypassing Shasta Powerplant and greatly reducing hydroelectric generation. In 1997, Reclamation constructed a selective withdrawal structure at Shasta Dam, known as a temperature control device (TCD), to control the temperature of water released through the powerhouse. This multilevel intake structure, installed in front of the existing power penstock intake structure on the face of Shasta Dam, enables the operators to withdraw water from selected levels of Shasta Reservoir. With the TCD, Reclamation can control the temperature of water released from Shasta Reservoir without sacrificing power production.

Upper Sacramento River (Shasta Dam to Red Bluff)

As shown in Figure 1-4, CVP power plants impacting the Sacramento River downstream from Shasta Reservoir but upstream from Red Bluff Pumping Plant (RBPP) are the Trinity, Lewiston, Judge Francis Carr, and Spring Creek powerplants of the Trinity River Division[4] and Keswick Powerplant of the Shasta Division. The Trinity River Division captures headwaters from the Trinity River basin and diverts water to the Sacramento River.

Trinity Dam stores water from the Trinity River in Trinity Reservoir and makes releases to the Trinity River through the Trinity Powerplant. Downstream, Lewiston Dam diverts water from the Trinity River into the Clear Creek Tunnel and through Judge Francis Carr Powerplant to Whiskeytown Reservoir. Lewiston Dam releases to the Trinity River are made through the Lesiston Powerplant. Some Whiskeytown Reservoir releases are made through the Spring Creek Power Conduit and Powerplant into Keswick Reservoir in the Shasta Division. The remainder of the releases from Whiskeytown Reservoir are made to Clear Creek. Releases from Keswick Reservoir are made through the Keswick Powerplant to the Sacramento River. The following are hydropower facilities of the Trinity Division:

- Trinity Powerplant, a peaking plant located at Trinity Dam, operates mostly during times of peak power demand. It has two units with a maximum capacity of 140 MW.

- Lewiston Powerplant at Lewiston Dam is operated in conjunction with spillway gates to maintain minimum flow in the Trinity River downstream from the dam. It has one unit with a maximum capacity of 0.350 MW.

[4] The CVP Trinity River Division consists of Trinity Dam and Trinity Reservoir, Trinity Powerplant, Lewiston Dam and Lake, Lewiston Powerplant, Clear Creek Tunnel, Judge Francis Carr Powerplant, Whiskeytown Dam and Lake, Spring Creek Tunnel and Powerplant, Spring Creek Debris Dam and Reservoir, and related pumping and distribution facilities.

- Judge Francis Carr Powerplant is a peaking plant at the outlet of Clear Creek Tunnel with two units and a total generation capacity of 184 MW.

- Spring Creek Powerplant, at the downstream end of the Spring Creek Tunnel, has two units and a maximum capacity of 200 MW.

Belonging to the Shasta Division, Keswick Dam and Reservoir function as the Shasta Powerplant's afterbay providing uniform flows to the Sacramento River. The Keswick Powerplant, located at Keswick Dam, is a run-of-the-river plant with three generating units for a total capacity of 105 MW.

Lower Sacramento River and Delta

Shown on Figure 1-5, the two CVP power plants impacting the Sacramento River between the RBDD and Delta are the Folsom and Nimbus powerplants. Both power plants belong to the Folsom Unit[5] on the American River.

Folsom Powerplant is a peaking Powerplant located at the foot of Folsom Dam on the north side of the American River. Water from the dam is released through three 15-foot-diameter penstocks to three generating units with a maximum capacity of 199 MW. Folsom Dam was constructed by the U.S. Army Corps of Engineers (USACE), and on completion, was transferred to Reclamation for coordinated operation as an integral part of the CVP. Folsom Powerplant provides a large degree of local voltage control and is being increasingly relied on to support local loads during system disturbances.

Nimbus Dam forms Lake Natoma to act as an afterbay for Folsom Powerplant. It allows dam operators to coordinate power generation and flows in the lower American River channel during normal reservoir operations. Lake Natoma has a surface area of 500 acres and its elevation fluctuates between 4 to 7 feet daily. Nimbus Powerplant, with two units and a maximum capacity of 13.5 MW, is a run-of-the-river plant and provides station service backup for Folsom Powerplant.

[5] The CVP Folsom Unit consists of Folsom Dam, Folsom Reservoir, Folsom Powerplant, Nimbus Dam, Lake Natoma, Nimbus Powerplant, and Nimbus Fish Hatchery.

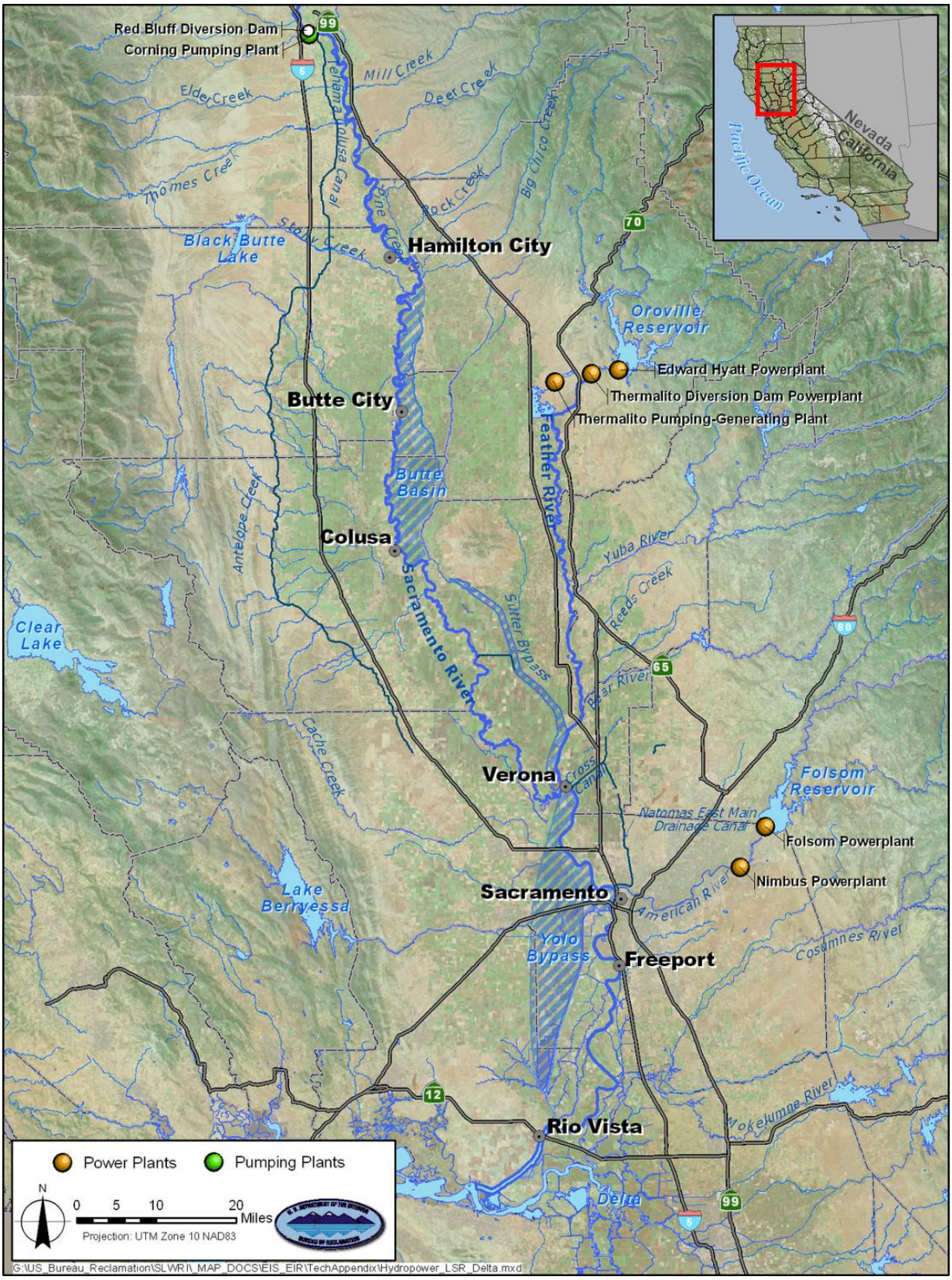

Figure 1-5. Shasta Lake Water Resources Investigation CVP and SWP Generating Facilities in the Extended Study Area, the Lower Sacramento River and Delta

Lake Oroville, the SWP's largest reservoir, stores winter and spring runoff from the Feather River watershed, and releases water for SWP needs. These releases generate power at three power plants: Edward Hyatt Pumping-Generating Plant, Thermalito Diversion Dam Powerplant, and Thermalito Pumping-Generating Plants (Oroville Facilities), as shown in Figure 1-5. DWR schedules releases through the Oroville Facilities to maximize the amount of energy produced when power values are highest. The Oroville Facilities are also capable of pump-back operations during off-peak times utilizing cheaper energy and releasing the pumped water during peak times when the hydropower production is more valuable. Energy prices primarily dictate hourly operations for the power generation facilities.

CVP/SWP Service Areas

There are a number of generation facilities and pumping facilities in the greater CVP/SWP service areas, beyond the specific geographies discussed above. These facilities are discussed below.

Generation Facilities

The CVP power plants located in the CVP service area include New Melones Powerplant in the New Melones Unit of the CVP East Side Division, and the William R. Gianelli and O'Neill Pumping-Generating Plants in the San Luis Unit of the CVP West San Joaquin Division, as shown on Figure 1-6. The latter two, with dual functions of generating electricity and pumping water, are jointly owned by Reclamation and DWR.

New Melones Dam was completed in 1979, and inundated the original Melones Dam and created New Melones Reservoir on the Stanislaus River. New Melones Powerplant, located on the north bank immediately downstream from the dam, is a peaking plant. The power plant contains two units and a maximum capacity of 300 MW.

The San Luis Unit, part of both the CVP and SWP, was authorized in 1960. Reclamation and the State of California constructed and operate this unit jointly; 45 percent of the total cost was contributed by the Federal Government and the remaining 55 percent by the State of California. The joint-use facilities are O'Neill Dam and Forebay, B.F. Sisk San Luis Dam, San Luis Reservoir, William R. Gianelli Pumping-Generating Plant, Dos Amigos Pumping Plant, Los Banos and Little Panoche reservoirs, and San Luis Canal from O'Neill Forebay to Kettleman City, together with the necessary switchyard facilities. The Federal-only portion of the San Luis Unit includes the O'Neill Pumping-Generating Plant and Intake Canal, Coalinga Canal, Pleasant Valley Pumping Plant, and San Luis Drain.

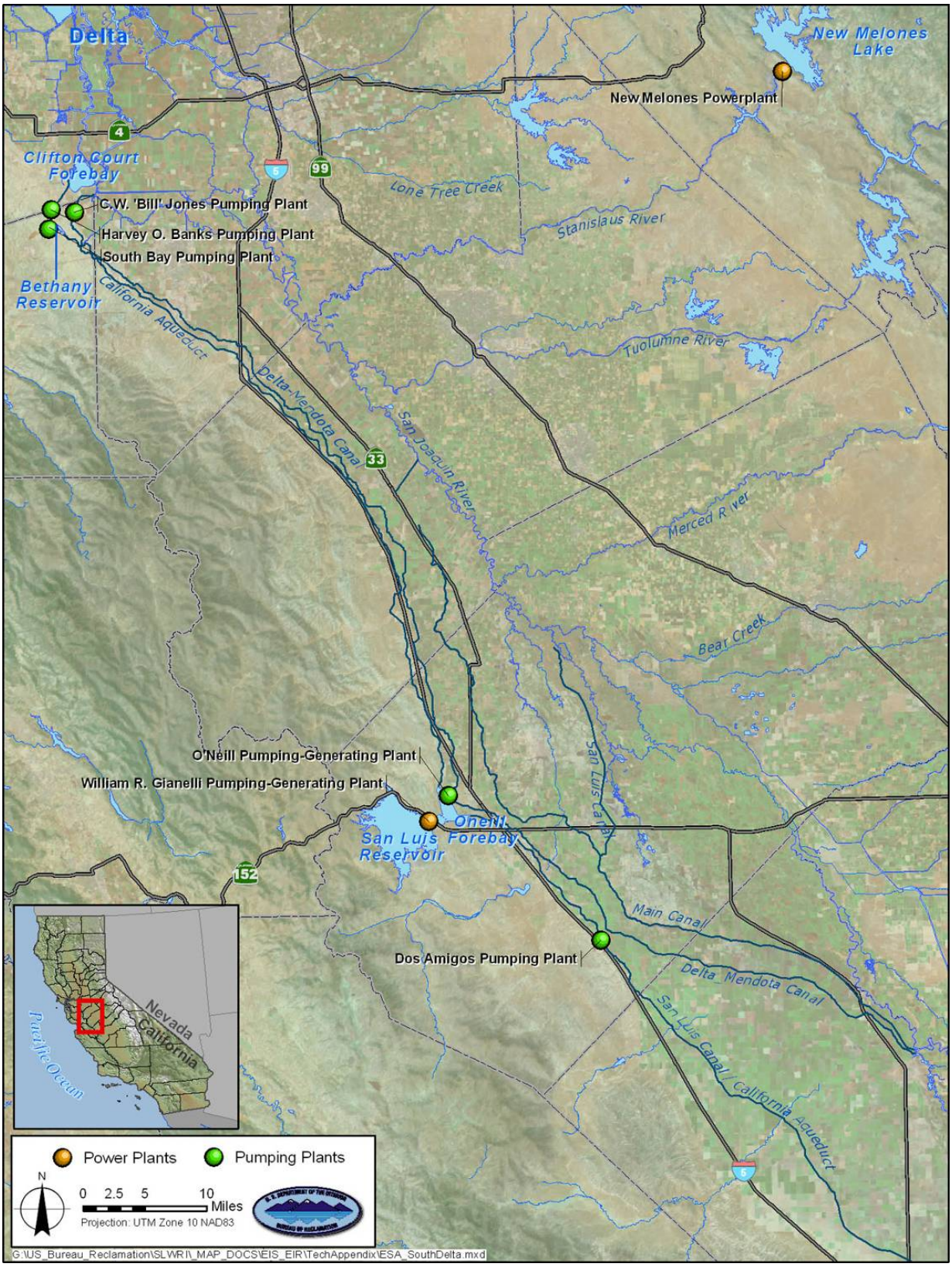

Figure 1-6. Shasta Lake Water Resources Investigation Central Valley Project Generating Facilities in the Extended Study Area South of the Delta

San Luis Reservoir serves as the major storage reservoir, and O'Neill Forebay acts as an equalizing basin, for the upper stage dual-purpose pumping-generating plant. O'Neill Pumping-Generating Plant takes water from the Delta-Mendota Canal and discharges it into the O'Neill Forebay, where the California Aqueduct (SWP feature) flows directly. The William R. Gianelli Pumping-Generating Plant lifts water from O'Neill Forebay and discharges it into San Luis Reservoir. During releases from the reservoir, these plants generate electric power by reversing flow through the turbines. Water for irrigation is released into the San Luis Canal and flows by gravity to Dos Amigos Pumping Plant, where the water is lifted more than 100 feet to permit gravity flow to the canal terminus at Kettleman City. The SWP canal system continues to southern coastal areas.

The O'Neill Pumping-Generating Plant consists of an intake channel, leading off the Delta-Mendota Canal, and six pumping-generating units. Normally, these units operate as pumps to lift water from 45 to 53 feet into the O'Neill Forebay; each unit can discharge 700 cubic feet per second (cfs) and has a rating of 6,000 horsepower (hp). Water is occasionally released from the forebay to the Delta-Mendota Canal, and these units then operate as generators; each unit has a generating capacity of about 4.2 MW.

William R. Gianelli Pumping-Generating Plant, the joint Federal-State facility located at San Luis Dam, lifts water by pump turbines from O'Neill Forebay into San Luis Reservoir. During the irrigation season, water is released from San Luis Reservoir back through the pump-turbines to the forebay and energy is reclaimed. Each of the eight pumping-generating units has a capacity of 63,000 hp as a motor and 53 MW as a generator. As a pumping plant to fill San Luis Reservoir, each unit lifts 1,375 cfs at a design dynamic head of 290 feet. As a generating plant, each unit passes 2,120 cfs at a design dynamic head of 197 feet.

The five SWP power plants are the jointly owned William R. Gianelli Pumping-Generating Plant, Alamo Powerplant, Mojave Siphon Powerplant, Devil Canyon Powerplant, and Warne Powerplant are Shown on Figure 1-7.

Figure 1-7. Shasta Lake Water Resources Investigation State Water Project and Central Valley Project Pumping and Generating Facilities in the CVP/SWP Service Areas of the Extended Study Area

They generate about one-sixth of the total energy used by the SWP. The Alamo Powerplant uses the 133-foot head between Tehachapi Afterbay and Pool 43 of the California Aqueduct to generate electricity. The Mojave Siphon Powerplant generates electricity from water flowing downhill after its 540-foot lift by Pearblossom Pumping Plant. The Devil Canyon Powerplant generates electricity with water from Silverwood Lake with more than 1,300 feet of head, highest water head[6] in a power plant in the SWP system. The Warne Powerplant uses the 725-foot drop from the Peace Valley Pipeline to generate electricity with its Pelton wheel turbines.

Pumping Facilities

CVP pumping plants to move water from the Delta to CVP service areas in the Central Valley include C.W. "Bill" Jones Pumping Plant, O'Neill and William R. Gianelli Pumping-Generating Plants, Dos Amigo Pumping Plant, and SWP Banks Pumping Plant, as shown on Figure 1-6. Table 1-4 shows the Calendar Year 2007 energy consumption of each of the plants. Reclamation constructed and operated the C.W. "Bill" Jones Pumping Plant. Harvey O. Banks Pumping Plant is an SWP facility; however, Reclamation has access to its pumping capacity through use of the Joint Point of Diversion (JPOD), described in State Water Resource Control Board (SWRCB) Water Right Decision 1641 (D-1641). The remaining plants, described previously, are joint-use facilities between the two agencies under the San Luis Unit.

Table 1-4. Major Central Valley Project Pumping Facilities and Historical Consumption

Major CVP Facilities	Energy Used in Calendar Year 2007 (megawatt-hour)
C.W. "Bill" Jones Pumping Plant	593,490
O'Neill Pumping-Generating Plant	75,377
William R. Gianelli Pumping-Generating Plant	510,019
Dos Amigos Pumping Plant	145,502
Banks Pumping Plant – Federal Share	39,647
Total	1,064,035

Source: Reclamation 2007

Key:
CVP = Central Valley Project

C.W. "Bill" Jones Pumping Plant, formerly Tracy Pumping Plant, is a component of the CVP Delta Division. Construction of the plant started in 1947 and was completed in 1951 with an inlet channel, pumping plant, and discharge pipes. Delta water is lifted 197 feet up and carried about 1 mile into the Delta-

6 Potential hydropower generation is a function of the hydraulic net head and rate of fluid flow. The net head is the actual head available for power generation and is used for computing the energy generated. The net head is the gross head minus the head losses due to intake structures, penstocks, and outlet works. The gross or static head is the vertical distance between the tailwater elevation and the forebay water surface elevation (i.e., the height of water in the reservoir relative to its height after discharge). The head losses are generally assumed 2 to 10 percent of the gross head, depending on the configuration of the powerhouse structure.

Mendota Canal. Each of the six pumps at C.W. "Bill" Jones Pumping Plant is powered by a 22,500 hp motor and is capable of pumping 767 cfs. The intake canal includes the C.W. "Bill" Jones Fish Screen, which was built to intercept downstream migrant fish to be returned to the main channel to resume their journey to the ocean.

Dos Amigo Pumping Plant is a joint CVP/SWP facility, located 17 miles south of O'Neill Forebay on the San Luis Canal. It lifts water 113 feet to permit gravity flow to the terminus at San Luis Canal at Kettleman City. The plant contains six pumping units, each capable of delivering 2,200 cfs at 125 feet of head.

Among the SWP pumping plants, plants that historically consumed most of the energy are William R. Gianelli Pumping-Generating Plant (SWP share), Harvey O. Banks Pumping Plant, Dos Amigos Pumping Plant (SWP share), Ira J. Chrisman Pumping Plant, and A.D. Edmonston Pumping Plant.

As shown on Figure 1-7, the Harvey O. Banks Pumping Plant is located 2.5 miles (4 kilometers (km)) southwest of Clifton Court Forebay on the California Aqueduct. The plant is the first pumping plant for the California Aqueduct and the South Bay Aqueduct. It provides the necessary head[7] for water in the California Aqueduct to flow for approximately 80 miles south past O'Neill Forebay and San Luis Reservoir to the Dos Amigos Pumping Plant (another jointly owned facility, as previously described). The Harvey O. Banks Pumping Plant initially flows into Bethany Reservoir, where the South Bay Aqueduct truly begins. The design head is 236 to 252 feet and installed capacity is 10,670 cfs with 333,000 hp.

Also shown on Figure 1-7, along the California Aqueduct, the Pearblossom, Chrisman, and Edmonston Pumping Plants historically consumed the highest amount of energy. The Pearblossom Pumping Plant lifts water about 540 feet and discharges the water 3,479 feet above mean sea level, the highest point along the entire California Aqueduct. The Chrisman and Edmonston Pumping Plants provide 524 and 1,970 feet of lift, respectively, to convey California Aqueduct water across the Tehachapi Mountains.

7 In pumping plants, the design head is the gross head plus the head losses due to intake structures

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Chapter 2
Modeling Results

As described in the SLWRI DEIS Chapter 23, extensive modeling was conducted to support technical analysis of the SLWRI. Modeling of the CVP and SWP hydropower systems was conducted using LongTermGen for the CVP and SWP Power for the SWP. These models are fully described in the Modeling Appendix. Detailed modeling results are presented in Attachment 18 of the Modeling Appendix.

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Chapter 3
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