Water Forum Proposal EIR

Modeling Technical Appendix G

Surface Water Resources, Inc.

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1. INTRODUCTION

Computer simulation models of water systems provide a means for evaluating changes in system characteristics such as carryover storage, reservoir water storage elevation, river flow, and power generation, as well as the effects of these changes on environmental parameters such as water temperature, early lifestage chinook salmon survival, and recreational opportunities. Tools used to evaluate operational alternatives and/or impacts of proposed projects include three types of U.S. Bureau of Reclamation (Reclamation) simulation models, which are:

(1) Project Simulation (PROSIM) model of the Central Valley Project (CVP) and State Water Project (SWP);

(2) Reclamation's water temperature models; and

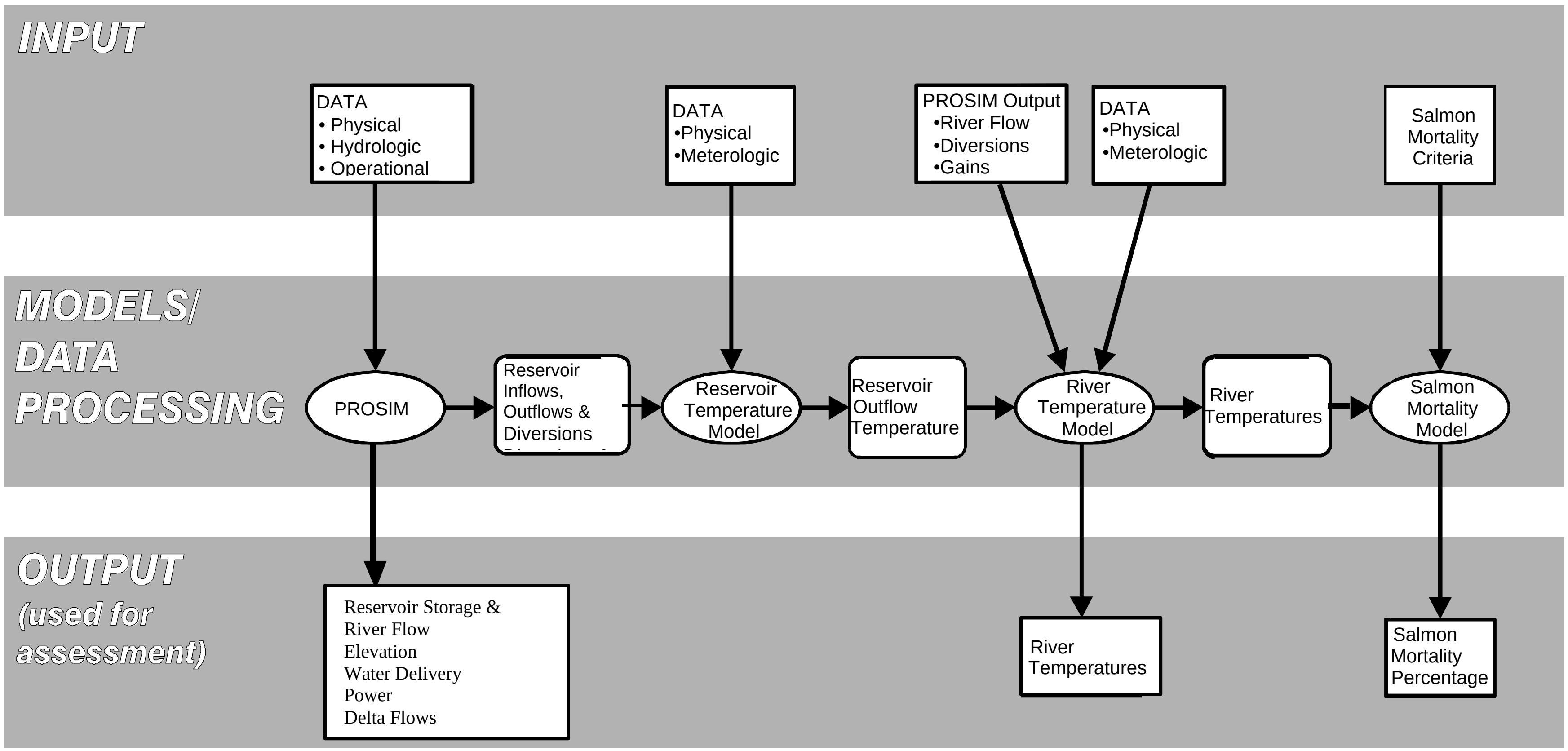
(3) Early lifestage chinook salmon mortality models for the Sacramento and American rivers.

PROSIM provides a monthly simulation of the CVP and SWP water and power operations. Output from PROSIM serves as input to the temperature models that simulate monthly Sacramento River and American River water temperatures. Temperature model output serves as input to the early lifestage chinook salmon mortality models. **Figure 1.1** displays a flowchart of the model process. The model flowchart displays the type of inputs used by each model, as well as model outputs available for assessment purposes.

This appendix describes the simulation models, CVP and SWP facilities represented in the modeling, model inputs, hydrologic, operational, and environmental assumptions, and documents the simulations performed for this EIR.

Figure 1.1

MODEL FLOW



2. MODELS

2.1 PROSIM MODEL

2.1.1 Model Description

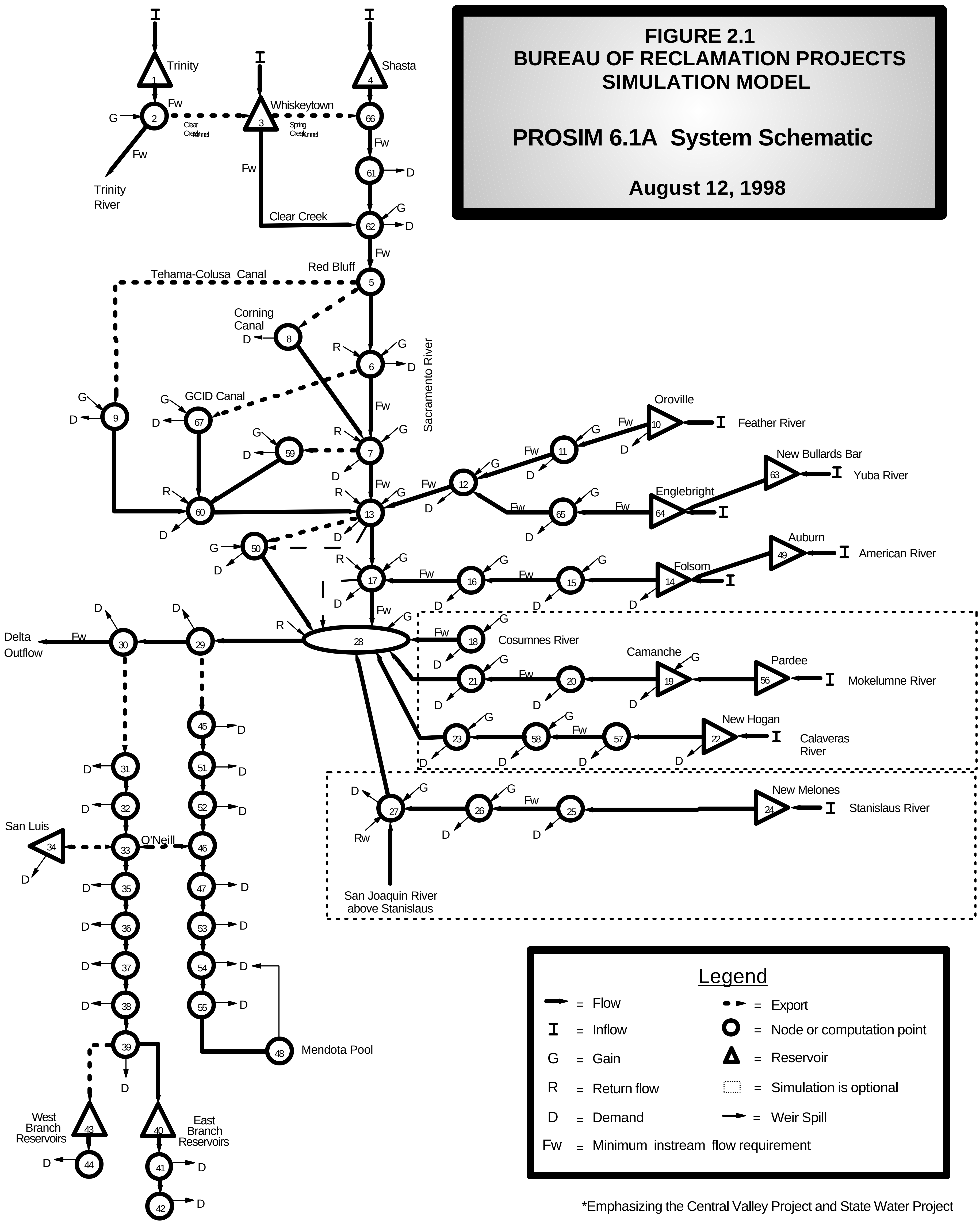
Reclamation's PROSIM model is a monthly "rule-and-demand-driven" computer simulation model of the CVP and SWP that mimics CVP and SWP operations and the hydrologic effects of those operations on the major Central Valley river systems. The model simulates system operations within the geographical area affected by CVP and SWP facilities, including the Sacramento-San Joaquin Delta (Delta). PROSIM is a linked-node model.

A network of 67 computation points, or nodes (**Figure 2.1**), represents river systems and project facilities. PROSIM uses a mass balance approach to simulate the occurrence, regulation, and movement of water from one node to another. At each node, various physical processes (e.g., surface water inflow or accretion, flow from another node, groundwater accretion or depletion, and diversion) can be simulated or assumed. Operational constraints, such as reservoir size and seasonal storage limits or minimum flow requirements, can be defined for each node.

PROSIM simulates monthly operations of the following water storage and conveyance facilities:

- Trinity, Whiskeytown, and Shasta/Keswick reservoirs (CVP);
- Spring Creek and Clear Creek tunnels (CVP);
- Oroville Reservoir (SWP);
- Folsom Reservoir and Lake Natoma (CVP);
- Tracy (CVP), Contra Costa (CVP), and Banks (SWP) pumping plants;
- San Luis Reservoir (shared by CVP and SWP); and
- East Branch and West Branch SWP reservoirs.

To varying degrees, conveyance facilities including the Tehama-Colusa, Corning, Folsom-South, Delta-Mendota, and California Aqueduct canals, also are defined by nodes. Other systems tributary to the Delta are modeled separately from PROSIM (e.g., the New Melones/Stanislaus River system and the San Joaquin River) and are incorporated as fixed input to a PROSIM node.



*Emphasizing the Central Valley Project and State Water Project

The model simulates one month of operation at a time, sequentially from one month to the next, and from one year to the next. Each decision that the model makes regarding stream flow regulation is the result of defined operational requirements and constraints (e.g., flood control storage limitations, minimum instream flow requirements, Delta outflow requirements, diversion assumptions) or operational rules (e.g., preference among reservoirs for releasing water). Certain decisions, such as the definition of water year type, are triggered once a year, which leads to water delivery allocations and specific stream flow requirements. Other decisions, such as specific Delta outflow requirements, are dynamic from month-to-month. PROSIM output is represented by flow or storage conditions at each node on a mean monthly basis for the 70-year period of record (1922-1991).

PROSIM is well documented in the Central Valley Project Improvement Act (CVPIA), *Draft Programmatic Environmental Impact Statement (PEIS), Technical Appendix Volume Seven*. PROSIM documentation and a user guide is available from Reclamation's Mid-Pacific Regional Office. Reclamation also has an Internet Web site where the PROSIM model and user manual can be obtained. PROSIM Version 60A was used for all hydrologic modeling.

2.2 TEMPERATURE MODELS

2.2.1 Overview

Reclamation has developed water temperature models for the Sacramento, Feather, and American rivers. The models have both reservoir and river components to simulate temperatures in five major reservoirs (Trinity, Whiskeytown, Shasta, Oroville, and Folsom); four downstream regulating reservoirs (Lewiston, Keswick, Thermalito, and Natoma); and three main river systems (Sacramento, Feather, and American).

These temperature models are designed to estimate water temperatures that would occur for conditions simulated by PROSIM. They are used to assess changes in average monthly temperature caused by changes in CVP/SWP operations.

Reclamation’s temperature models are well documented in the CVPIA *Draft PEIS Technical Appendix, Volume Nine*. These temperature models also are documented in the report titled: *U.S. Bureau of Reclamation Monthly Temperature Model Sacramento River Basin*, June 1990.

2.2.2 Reservoir Component

The reservoir models simulate monthly temperature profiles in five major reservoirs; Trinity, Whiskeytown, Shasta, Oroville, and Folsom. Vertical water temperature profile in a reservoir is simulated in one-dimension using monthly storage, inflow and outflow water temperature and flow rate, evaporation, precipitation, solar radiation, and average air temperature. The models also compute the water temperature of dam releases. Release temperature control measures in reservoirs, such as the penstock shutters in Folsom Reservoir and the temperature control device in Shasta Lake are incorporated in the models.

2.2.2.1 Model Code Modifications

The Folsom Reservoir temperature model was modified to simulate a Temperature Control Device (TCD) for the Folsom Dam Pumping Plant. This device has been authorized by Congress and should be in place in the next few years. The TCD was incorporated into the model by defining numerous levels from which Folsom Dam diversions could occur. The TCD is operated to maximize the use of warm water; thus, the diversion level is set as close to 25 feet below the reservoir water surface as possible.

Another modification, related to satisfying downstream temperature objectives, was incorporated into the Folsom Reservoir temperature model. Target temperature release objectives are used to control the shutter operation at Folsom Dam. Previously, the model improperly included Folsom Dam Pumping Plant diversions in the river water temperature calculations. Pumping Plant diversions are located at a relatively low level in the reservoir, and therefore often divert from the cold water pool. Previously, the model assumed this cold water was used to satisfy the target temperature release objective. The modification incorporated into the model corrects this error.

2.2.3 River Component

Release rate and temperature of regulating reservoir storage serve as the boundary conditions for the river model. The river temperature model computes water temperatures at 52 locations on the Sacramento River from Keswick Dam to Freeport, and at multiple locations on the Feather and American rivers. The river temperature model also calculates water temperature within Lewiston, Keswick, Thermalito, and Natoma reservoirs. This model is used to simulate temperatures in these reservoirs because they are relatively small bodies of water with short residence times, thereby having physical characteristics approximating those of riverine environments.

2.3 SALMON MORTALITY MODELS

Reclamation's chinook salmon mortality models produce a single estimate of early life stage chinook salmon mortality for each year of the simulation. This estimate consolidates calculations of salmon mortality for three separate early-life stages: (1) pre-spawned eggs; (2) fertilized eggs; and (3) pre-emergent fry. For the Sacramento River, the model computes mortality for each of the four chinook salmon runs; fall, late-fall, winter, and spring. For the American River, the model produces estimates of fall-run chinook salmon mortality. The mortality estimates are based on output temperatures from Reclamation's temperature models. Temperature units (TUs), defined as the difference between river temperatures and 32^{o}F, are accounted for on a daily basis by the mortality model, and are used to track life-stage development. For example, incubating eggs exposed to 42°F water for one day would experience 10 TUs. Eggs are assumed to hatch upon exposure to 750 TUs following fertilization. Similarly, the model assumes that fry emerge from the gravel after being exposed to 750 TUs following egg hatching into the pre-emergent fry stage.

3. FACILITY DESCRIPTIONS AND OPERATIONAL CONSIDERATIONS

3.1 TRINITY LAKE AND TRINITY RIVER

3.1.1 Facility Description

3.1.1.1 Trinity Dam and Trinity Lake

Trinity Dam is a zoned earthfill structure 538 feet high, 40 feet wide at the crest, and a 2,450 crest length. The reservoir located on the Trinity River near Weaverville, CA has a maximum storage capacity of 2,447 thousand acre feet (TAF) with a minimum active storage level of 303 TAF. The power generating plant consists of two Francis Turbines capable of generating a total of 140,000 kilowatts (kW) with a maximum power release of 3,900 cubic feet per second (cfs).

3.1.1.2 Lewiston Dam and Lake

Lewiston Dam is a zoned earthfill dam 91 feet high, 25 feet wide at the crest, and 745 feet long. Lewiston Lake is located on the Trinity River approximately seven miles downstream of Trinity Dam, and serves primarily to regulate flows from Trinity Lake. The power generating plant consists of a Francis Turbine capable of generating 350 kW with a maximum power release of 100 cfs. Water is also released from Lewiston Lake through Clear Creek Tunnel (CCT) to Whiskeytown Lake.

3.1.2 Operation

Trinity Lake is simulated in PROSIM to meet Safety of Dams criteria, minimum storage requirements, and instream flow requirements for the Trinity River. Releases through the CCT are made based on supply remaining after satisfying these requirements.

Lewiston Dam is represented as the diversion point for CCT and is assumed to have no storage operation. PROSIM uses a storage-release relationship to determine the timing and volume of the CCT releases. The storage-release function is a step-threshold function that determines monthly CCT release, based on storage in Shasta and Trinity Lakes.

3.1.3 Temperature Considerations

The reservoir temperature model simulates temperatures of water released from Trinity Lake for the three outlets: spillway, power plant, and power plant bypass outlet. The power plant bypass outlet and the power plant outlet level is at 2,100 feet and the bypass is at 1,999.5 feet.

3.2 WHISKEYTOWN LAKE EXPORTS

3.2.1 Facility Description

3.2.1.1 Whiskeytown Lake

Clair A. Hill Dam at Whiskeytown Lake is a zoned earthfill dam 537.5 feet high. The maximum storage capacity of Whiskeytown Lake is 241 TAF with a minimum active storage of 27.5 TAF. The minimum operating pool is 206 TAF. Whiskeytown Lake releases water to Clear Creek directly, and to Keswick Reservoir via the Spring Creek Tunnel (SCT).

3.2.1.2 Judge Frances Carr Powerhouse

Judge Frances Carr Powerhouse is located at the outlet of the CCT at the northwestern end of Whiskeytown Lake. This facility generates power from water exported from the Trinity River Basin through the CCT. The plant consists of two Francis Turbines capable of generating a total of 153,000 kW at a maximum release of 3,300 cfs.

3.2.1.3 Spring Creek Power Plant

Spring Creek Power Plant is located on the Spring Creek arm of Keswick Reservoir and generates power from water released through the SCT from Whiskeytown Lake. Water discharged from the plant flows into Keswick Reservoir. The plant consists of two Francis Turbines capable of generating a total of 190,000 kW with a maximum power release of 4,200 cfs. Spring Creek discharge is managed to minimize the build-up of heavy metal concentrations introduced to the Spring Creek arm of Keswick Reservoir by releases from Spring Creek Debris Dam.

3.2.2 Operation

Whiskeytown Lake is operated in PROSIM to satisfy environmental flow requirements in Clear Creek, meet Safety of Dams criteria, and regulate inflows from the CCT with outflow to the SCT. PROSIM operates Whiskeytown Lake to satisfy Safety of Dams criteria on a monthly basis.

3.2.3 Temperature Considerations

Whiskeytown Lake is equipped with two temperature curtains, one at the upstream end of the reservoir, and one at the SCT inlet. The purpose of the curtains is to force cooler water from CCT towards the bottom of the reservoir to reduce the mixing of the warm reservoir water with the inflowing water, thereby preserving cooler water from the lake bottom for release through the SCT. This permits an operation by which cold water can be moved from Trinity Lake through both the CCT and SCT to satisfy power requirements while minimizing adverse water temperature impacts in the Sacramento River.

3.3 SHASTA LAKE, KESWICK LAKE, AND SACRAMENTO RIVER

3.3.1 Facility Description

3.3.1.1 Shasta Dam and Lake

Shasta Dam on the Sacramento River is a curved concrete gravity-type dam 602 feet high, 883 feet thick at the base, 30 feet thick at the top, and 3,460 feet long. The maximum storage capacity of Shasta Lake is 4,568 TAF with a minimum active pool of 471 TAF. The minimum desirable storage is 1,900 TAF and minimum storage pool for regulation of downstream temperatures is 1,200 TAF. The Shasta Power Plant consists of five Francis Turbines capable of generating 572 MW with a maximum power discharge of 18,000 cfs.

3.3.1.2 Keswick Dam and Lake

Keswick Dam downstream of Shasta Dam is a concrete gravity structure 157 feet high, 20 feet wide at the crest, and 1,046 feet long. The lake serves as regulating reservoir for releases from Shasta Dam and Whiskeytown *via* the SCT, and Spring Creek Debris Dam. The Keswick Power Plant consists of three Francis Turbines with a total maximum capacity of 105,000 kW under a maximum power discharge of 16,000 cfs.

3.3.2 Operation

Shasta Dam and Lake on the Sacramento River serve to control floodwater and store surplus winter runoff for irrigation use in the Sacramento and San Joaquin valleys. Shasta is operated to provide for instream flow for fish, navigation in the Sacramento River, protection of the Delta from intrusion of saline ocean water, agriculture and municipal and industrial (M&I) water needs, and generation of hydroelectric energy. Keswick Dam and Lake serve to regulate Shasta Dam, SCT, and Spring Creek Debris Dam releases on a day-to-day basis. PROSIM (a monthly model) does not attempt to simulate the day-to-day operation.

PROSIM simulates the Red Bluff Diversion Dam, Corning Canal, Tehama-Colusa Canal, and numerous smaller diversions from the Sacramento River. Releases are made from Shasta Dam to satisfy these diversions while maintaining instream flow requirements.

PROSIM operates Shasta Dam by first observing requirements for flood control and minimum storage. PROSIM then releases water to satisfy instream flow and agricultural diversion requirements in the Sacramento River. Once PROSIM has operated the entire Central Valley Project to satisfy requirements upstream from the Delta, it may call for additional release from Shasta Lake for Delta needs. Shasta Lake's release for Delta needs is balanced with Folsom Reservoir release, based on the amount of storage in each reservoir.

3.3.3 Temperature Considerations

The Sacramento River Basin temperature model recognizes the presence of the temperature control device at Shasta Dam in accordance with design operating criteria and the *Shasta Outflow Temperature Control Planning Report/Environmental Impact Statement*. Output from the model is used to determine compliance with the *1993 Winter-Run Chinook Salmon Biological Opinion* criteria prescribed by the National Marine Fisheries Service (NMFS). These criteria define monthly water temperature objectives for the Sacramento River based on a Sacramento River hydrologic year type index.

3.4 OROVILLE LAKE AND FEATHER RIVER

3.4.1 Facility Description

3.4.1.1 Oroville Dam and Lake

Oroville Dam is 770 feet high and 6,920 feet long. Lake Oroville has a maximum storage capacity of 3,537 TAF with a minimum operating pool of 860 TAF. The E. Hyatt Power Plant is capable of generating a total of 813,000 kW at a maximum power discharge of 16,950 cfs.

3.4.1.2 Thermalito Facilities

The Thermalito storage facilities provide for off-stream storage of water from the Feather River. The system consists of three dams; Thermalito Diversion Dam, Thermalito Forebay Dam, and Thermalito Afterbay Dam. Storage capacity is 11.7 TAF in the forebay and 57 TAF in the afterbay. The Thermalito Diversion Dam generator design capacity is 3,000 kW at a maximum power discharge of 615 cfs while the Thermalito afterbay power generation capacity is 119,600 kW at a design flow of 16,900 cfs.

3.4.2 Operation

Oroville Dam and Lake on the Feather River serve to control floodwater and store surplus winter runoff for agriculture and M&I use in the Feather River Basin, San Joaquin Valley, and southern California. Oroville Dam is operated to provide instream flow for fish in the Feather River, protection of the Delta from intrusion of saline ocean water, agriculture and M&I water needs, and generation of hydroelectric energy. Thermalito Diversion Dam is used to regulate Oroville Dam releases on a day-to-day basis. PROSIM, a monthly time step model, does not attempt to simulate this day-to-day operation.

3.4.3 Temperature Considerations

The reservoir temperature model simulates release temperatures at Oroville Dam from its nine outlets; eight power outlets, one power plant bypass outlet, and the spillway.

Oroville Dam release temperatures provide the upstream conditions used in the Feather River temperature model.

3.5 UPPER AMERICAN RIVER, FOLSOM RESERVOIR, AND AMERICAN RIVER

3.5.1 Facility Description

3.5.1.1 Upper American River Basin

There are more than 20 reservoirs in the Upper American River Basin, ranging from about 400 acre-feet (af) to about 277,000 af. The upstream simulation is limited to nine reservoirs located on the Rubicon River, Gerle Creek, Pilot Creek, Silver Creek, Caples Creek, and the North, Middle, and South Forks of the American River. Several smaller creeks and diversions also are simulated.

Reservoirs in the upstream simulation have a combined storage of about 800,000 af including Lake Valley Reservoir (8,100 af), French Meadows Reservoir (133,700 af), Hell Hole Reservoir (208,400 af), Loon Lake (76,500 af), Stumpy Meadows (20,000 af), Union Valley Reservoir (277,000 af), Ice House Reservoir (46,000 af), Caples Lake (21,000 af), and Silver Lake (11,800 af).

3.5.1.2 Folsom Dam and Reservoir

Folsom Dam on the American River is a concrete gravity structure 340 feet high, 36 feet wide at the crest, and 1,400 feet long. The maximum storage capacity of Folsom Reservoir is 975 TAF with a minimum active storage of 90 TAF, which approximates the minimum power operating pool. The power plant consists of three Francis turbines capable of generating a total of 211,000 kW with a maximum power discharge of 8,600 cfs.

3.5.1.3 Nimbus Dam

Nimbus Dam is a concrete gravity structure 87 feet high, 28 feet wide and 1,093 feet long. Maximum storage capacity is 8.76 TAF. The Nimbus Power Plant consists of two Kaplan turbines capable of generating a total of 19,900 kW at a maximum power discharge of 5,500 cfs. Nimbus Dam impounds Lake Natoma and besides regulating Folsom releases to the American River, is the diversion location for the Folsom South Canal (FSC).

3.5.2 Operation

3.5.2.1 Upper American River Basin

The upstream reservoirs on the American River are operated to maintain minimum storage and flow requirements while providing water supply and power generation. The Department of Water Resources’ (DWR's) Upper American River Model was modified and used in conjunction with spreadsheet tools to simulate the Upper American River system. DWR’s model uses the U.S. Army Corps of Engineers’ (Corps) HEC-III program for hydrologic routing and storage accounting purposes, and spreadsheets to simulate operations including water rights diversions, storage releases for water rights diversions, storage releases for power generation and storage rights restrictions. Using this approach of coupling the HEC-III model and spreadsheets, sophisticated modeling of constraints and operations can be accomplished that are not possible to model in HEC-III alone. Upper American River operations can be dependent, in part, on conditions in the Lower American River simulated by PROSIM. When this dependency exists, iterative simulations of the Upper American River and PROSIM's Folsom/Lower American River operations must be performed.

Simulating the Upper American River utilized the Upper American River model developed by DWR for input to DWRSIM as described in the Central District Memorandum Report, *American River Watershed Model,* March 1984. In general, criteria for minimum storage requirements, minimum flow requirements, water rights related diversions, and certain storage operations are based on Folsom unimpaired inflow, Folsom storage conditions and CVP contract allocations. Modifications to the DWR's version of the HEC-III Upper American River model were made to the model structure and the input data in order to implement these requirements and determine reservoir operations. Output from the Upper American River simulations is used to provide PROSIM time series inflow data for Folsom Reservoir, and time series storage data for calculating "creditable" upstream storage space which will, at times, dictate additional flood control storage requirements for Folsom Reservoir.

Data used in DWR's HEC-III Upper American River simulation were developed by DWR except for the following assumptions/methodology. With the exception of diversion changes, the modifications to DWR's version of the model are isolated to the Middle Fork of the American River, the Rubicon River and Placer County Water Agency's (PCWA) Middle Fork Project (MFP) facilities. The diversion changes include deliveries to PCWA at the Auburn Dam site, Georgetown Divide Public Utilities District (GDPUD) at the Auburn Dam site, GDPUD at Pilot Creek and El Dorado Irrigation District (EID) at Lotus on the South Fork of the Upper American River.

3.5.2.2 Middle Fork Project

Middle Fork Project (MFP) storage is operated to maintain minimum storage and bypass flow requirements while providing water supplies and power generation. American River direct diversions, diversions to storage and related operations of the MFP storage for water rights diversions and power generation releases are constrained by water rights permits from the State Water Resources Control Board (SWRCB), contracts, and agreements between PCWA and Reclamation and Pacific Gas and Electric (PG&E). Minimum storage and bypass flow requirements are required by the Federal Energy Regulatory Commission (FERC) and SWRCB.

3.5.2.2.1 PCWA's Water Rights

- Maximum Diversion Rates and Diversion to Storage Volumes for Power Generation:

Source	Direct Diversion (All Year)	Diversion to Storage (Nov 1 - Jul 1)
Duncan Creek	200 cfs	25,000 af/yr
Middle Fork American River at French Meadows Dam	400 cfs	105,000 af/yr
Rubicon River at Hell Hole Dam	830 cfs	165,000 af/yr

(Note: Long Canyon facilities and Ralston interbay and afterbay facilities are not operated in the simulation)

- Maximum Volume and Restrictions on Diversion / Rediversion for Consumptive Use:

Maximum Volume	120,000 af/yr
Direct Diversion and Diversion to Storage Season	Nov 1 - Jul 1
Point of Diversion/Rediversion	Auburn Dam site & Folsom Dam

(Note: To accomplish full diversions required at either the Auburn Dam site or Folsom Dam in all seasons of the year, MFP will need to release for the rediversion of water during the Jul 1 - Nov 1 season)

At current level demands, only the PCWA diversion at the Auburn Dam site and the San Juan Water District (SJWD) diversion at Folsom Dam are considered in the operation of the MFP. At future level demands, the PCWA diversion at Auburn Dam, and the SJWD, City of Roseville, and Northridge Water District (NWD) diversions at Folsom Dam are considered in the operation of the MFP. SJWD, City of Roseville and NWD are assumed to have purchased PCWA water. The City of Roseville's actual PCWA water diversion is dependent on demand unmet by its CVP M&I contract allocation. Even though NWD may take its water from the Sacramento River in certain years, it is assumed that this arrangement is accomplished through a water exchange and the MFP is operated as if the diversion occurs from the American River.

3.5.2.2.2 Minimum Storage Requirements

- FERC Requirements:

French Meadows Reservoir	Jun 1 - Sep 30	Oct 1 - May 31
FUI $_{Oct\ 1\ -\ Sep\ 30}$ > 2,000,000 af	60,000 af	50,000 af
1,200,000 af < FUI $_{Oct\ 1\ -\ Sep\ 30}$ < 2,000,000 af	60,000 af	25,000 af
FUI $_{Oct\ 1\ -\ Sep\ 30}$ < 1,200,000 af	28,000 af	8,700 af

Hell Hole Reservoir

FUI $_{Oct\ 1\ -\ Sep\ 30}$ > 2,000,000 af	70,000 af	50,000 af
1,200,000 af < FUI $_{Oct\ 1\ -\ Sep\ 30}$ < 2,000,000 af	70,000 af	25,000 af
FUI $_{Oct\ 1\ -\ Sep\ 30}$ < 1,200,000 af	26,000 af	5,500 af

(FUI $_{Oct\ 1\ -\ Sep\ 30}$ = April forecast of Folsom unimpaired Inflow for the period from the previous October to the following September. Value is used as the FUI index for the following June - May period)

3.5.2.2.3 Minimum Bypass Flow Requirements

- FERC Requirements:

Duncan Creek Diversion Dam	Bypass	Season
FUI $_{Oct\ 1\ -\ Sep\ 30}$ > 1,000,000 af	8 cfs or natural flow	Jun 1 - May 31
FUI $_{Oct\ 1\ -\ Sep\ 30}$ < 1,000,000 af	4 cfs or natural flow	
French Meadows Reservoir		
FUI $_{Oct\ 1\ -\ Sep\ 30}$ > 1,000,000 af	8 cfs	Jun 1 - May 31
FUI $_{Oct\ 1\ -\ Sep\ 30}$ < 1,000,000 af	4 cfs	
Hell Hole Reservoir		
FUI $_{Oct\ 1\ -\ Sep\ 30}$ > 1,000,000 af	20 cfs	May 15 - Dec 14
	10 cfs	Dec 15 - May 14
FUI $_{Oct\ 1\ -\ Sep\ 30}$ < 1,000,000 af	10 cfs	Jun 1 - Oct 14
	6 cfs	Oct 15 - May 31
Oxbow		
Downstream of the confluence of the Middle Fork American River and the North Fork of the Middle Fork of the American River	75 cfs	

(FUI $_{Oct\ 1\ -\ Sep\ 30}$ = April forecast of Folsom unimpaired Inflow for the period from the previous October to the following September. Value is used as the FUI index for the following June - May period)

- SWRCB Requirements:

Auburn Dam site

Downstream of the Auburn Dam site to Folsom Reservoir (D-1400)	75 cfs

3.5.2.2.4 Reclamation February 20, 1963 Contract

1. In years when the April forecasted FUI $_{Oct\ 1\ -\ Sep\ 30}$ < 600,000 af, the MFP end-of-September storage will not exceed the previous year's end-of-September storage.

2. During the period of July 1 - December 31, the MFP end-of-month storage will not exceed the beginning-of-month storage if; natural inflow to French Meadows Reservoir plus diversions from Duncan Creek to French Meadows Reservoir exceeds 19,000 af in the month, and natural inflow to Hell Hole Reservoir plus diversions from the North and South forks of Long Canyon to Hell Hole Reservoir exceeds 45,000 af in the month; then MFP may increase storage in the MFP.

3.5.2.2.5 Informal MFP Operation Rules

Absent the temporary purchase of Water Forum mitigation water (ReOp water) from PCWA, the MFP is operated to:

1. Achieve a December 31 target MFP storage of 150,000 af.

2. Minimize spills from the MFP (which do not generate power) by making timely power releases and maintaining adequate available storage capacity through periods of high inflows.

3. Achieve June 30 storage as high as possible to maximize power generation capacity in all years and/or water supply availability in drier years. Water supply operations are given higher priority than power operations.

3.5.2.3 Folsom Dam

Folsom Dam and Reservoir is operated to control floodwater and store surplus winter runoff for agriculture and M&I use in the American River Basin and San Joaquin Valley. Folsom also is operated to provide instream flow for fish in the American River, protection of the Delta from intrusion of saline ocean water, and generation of hydroelectric energy. Because Nimbus Dam serves to regulate Folsom Dam releases on a day-to-day basis, PROSIM does not attempt to simulate this operation but does portray Nimbus as a diversion point for the FSC.

Folsom Reservoir is presently operated in accordance with the 400-670 TAF variable flood control diagram developed for the Sacramento Area Flood Control Agency (SAFCA) and described in the December 1993 Corps report *Folsom Dam And Lake Operation Evaluation*. These criteria recognize incidental flood control provided by available storage in upstream reservoirs (French Meadows, Hell Hole, and Union

Valley), such that the maximum Folsom Reservoir flood control reservation varies from 400 TAF to 670 TAF.

PROSIM operates Folsom Reservoir by first maintaining requirements for flood control and minimum storage, then releasing water to satisfy instream flow, diversion requirements in the Lower American River, and direct diversion from the Reservoir. Once PROSIM has operated the entire Central Valley Project to satisfy requirements upstream from the Delta, it may call for additional release from Folsom Reservoir for Delta needs. Folsom Reservoir's release for Delta needs is balanced with Shasta Lake release, based on the amount of storage in each reservoir. The CVP obligation to satisfy Delta requirements is shared with the SWP, based on the terms of the Coordinated Operating Agreement (COA).

3.5.3 Temperature Considerations

Lower American River water temperature modeling incorporates a 3-2-4 shutter configuration on the power penstock intakes at Folsom Dam and variable monthly target release temperatures. Target temperature release objectives are based on the best use of the available cold water for instream beneficial uses. Simulations of future conditions also incorporate a temperature control device (TCD) on the intake to the Folsom Dam Pumping Plant.

3.6 EAST SIDE STREAMS

East Side streams consist of the Cosumnes River, Mokelumne River, Calaveras River, and several smaller creeks. The East Side streams encompass the geographic area bounded by the American River on the north and the Stanislaus River to the south. Jenkinson Lake, a Federal project operated by El Dorado Irrigation District in cooperation with Reclamation, is located on the Cosumnes River and has a storage capacity of about 41,000 AF. Pardee and Camanche Reservoirs are located on the Mokelumne River and have a combined storage capacity of approximately 640,000 AF. The Mokelumne project is operated by EBMUD. New Hogan Dam is located on the Calaveras River and has a storage capacity of about 317,000 AF. This reservoir is operated by the U.S. Army Corps of Engineers.

Operation of East Side streams is not explicit in PROSIM. The combined flow from these rivers, as they enter the Delta are, however, an input to PROSIM. The flows used for all simulations are consistent with PROSIM version 60A.

3.7 SAN JOAQUIN RIVER

3.7.1 Operation

The simulation of the San Joaquin River at Vernalis is extracted from Reclamation's SANJASM model. This representation of the San Joaquin River Basin includes the

Stanislaus River and New Melones Dam, Tuolumne River and New Don Pedro Dam, Merced River and New Exchequer Dam, Chowchilla River and Buchanan Dam, Fresno River and Hidden Dam, and the San Joaquin River upstream to Friant Dam. The results from SANJASM are used in Reclamation's STANMOD model.

There is no integrated operation of San Joaquin Basin reservoirs; all reservoirs are owned and operated by different entities for local needs. PROSIM requires the flow at Vernalis on the San Joaquin River for its simulation. Flows used for all simulations are consistent with PROSIM version 60A.

3.8 DELTA

3.8.1 Facility Description

Facilities in the Delta include the Cross Channel Gate operated by the CVP, Banks Pumping Plant operated by the SWP, Tracy Pumping Plant operated by the CVP, and Delta channels. The SWP Banks Pumping Plant average monthly capacity with four pumps is 6,680 cfs (8,500 cfs in some winter months) in compliance with the Corps' October 31, 1981 Public Notice criteria. The CVP Tracy Pumping Plant capacity is 4,600 cfs, but physical constraints along the Delta Mendota Canal and at the re-lift pumps to O'Neill Forebay can restrict export capacity as low as 4,200 cfs in some months.

3.8.2 Operation

Once all tributaries to the Delta have been operated to satisfy upstream requirements, PROSIM simulates the Delta. PROSIM calculates the flow required to satisfy all Delta water quality control plan requirements. Once this is accomplished, the model determines if the Delta is in "surplus" water or "balanced" water conditions. The model then allocates available surplus to CVP and SWP export or allocates responsibility for additional upstream release based on this determination. CVP/SWP sharing of responsibility for Delta operations is described in the COA.

Of the numerous facilities in the Delta, PROSIM only operates the Cross Channel Gate, Contra Costa Pumping Plant, Tracy Pumping Plant and Banks Pumping Plant. Agricultural diversions for Delta lands are combined into one diversion for the entire area and identified as Net Delta Consumptive Use.

3.9 SOUTH OF DELTA

3.9.1 Facility Description

3.9.1.1 San Luis Reservoir

San Luis Reservoir is a joint CVP/SWP facility that stores water pumped from O'Neill Forebay until required to satisfy demands downstream of O'Neill. San Luis Reservoir has a maximum storage capacity of 2,047 TAF, of which the CVP uses 972 TAF and the SWP uses 1,067 TAF. The minimum power operating pool for this facility is 90 TAF. The power plant consists of eight Francis Turbines with a total capacity of 424,000 kW at a maximum power discharge of 11,000 cfs. Reclamation's portion of the generation design capacity is 186,000 kW.

3.9.1.2 O'Neill Forebay

O'Neill Forebay provides off-stream storage for water pumped from the Delta *via* the Delta-Mendota Canal and the Edmund G. Brown California Aqueduct. The reservoir has a maximum capacity of 56,400 TAF of which 29,500 TAF is dedicated to SWP storage. The combined power generating capacity of the six pump/generator units, which move water to and from the DMC, is 25,200 kW.

3.9.1.3 CVP - Delta Mendota Canal

The Delta Mendota Canal receives water from the Tracy Pumping Plant and carries it along the west side of the San Joaquin Valley for irrigation supply. The canal is 116 miles long and ends at the Mendota Pool about 30 miles from Fresno, California. At its head, the canal design capacity is 4,600 cfs, which gradually decreases to 3,211 cfs at its southern extremity.

3.9.1.4 SWP - West and East Branch Aqueducts

The Governor Edmund G. Brown California Aqueduct conveys water from the Delta to southern California through a series of canals, pipelines and tunnels extending 444 miles. The aqueduct has a variety of capacities ranging from 3,129 cfs at the southern extremity to 13,100 cfs downstream of O'Neill Forebay.

The West Branch Aqueduct conveys water for storage in Pyramid and Castaic reservoirs, which serve Los Angeles and other coastal cities. It consists of a total of 31.9 miles of canals, reservoirs, pipelines and tunnels, with a combined maximum storage capacity of 498 TAF.

The East Branch Aqueduct traverses the Antelope Valley and incorporates Silverwood Lake and Lake Perris for storage. This branch of the aqueduct system provides water to San Bernardino and Riverside counties. Maximum storage capacity in this portion of the system is 200 TAF.

3.9.2 Operation

South of Delta exports pumped at Tracy and Banks Pumping Plants are calculated monthly by summing the total project demands south of the Delta with the volume of water required to achieve target storage in San Luis Reservoir (target storage is specified monthly for both the CVP and SWP shares of San Luis). The volume is exported from the Delta to the extent possible consistent with export restrictions specified in the 1995 Bay-Delta Accord and prudent CVP/SWP operating policies.

4. PROSIM INPUTS

PROSIM requires multiple inputs that describe the physical representation and operational criteria for the CVP and SWP, as well as hydrologic data for the Delta, Sacramento, and San Joaquin basins.

4.1 PHYSICAL PARAMETERS

The physical representations of CVP and SWP facilities described in **3. FACILITY DESCRIPTIONS AND OPERATIONAL CONSIDERATIONS,** are input to PROSIM through several input files. In addition to the input, portions of the physical representation of the CVP and SWP are contained in the PROSIM FORTRAN source code. A master control file contains information describing the characteristics of each PROSIM node along with conveyance capacities of links connecting nodes. Reservoir capacities, minimum storage, and power plant capacities are contained in the reservoir input file. Physical parameters describing power plants and pump stations are contained in the power input files.

4.2 OPERATIONAL CRITERIA

Operational criteria include data governing the operation of reservoirs, environmental flow requirements, and federal and state operating policy. Operational criteria vary depending on the scenario simulated. Reservoir operating rules or operations policies may need to be adjusted to achieve an acceptable simulation. Operational criteria that differ between various simulations are discussed in **5. SIMULATIONS PERFORMED**.

4.2.1 Reservoir Operation Criteria

Reservoir operation parameters are established to achieve an appropriate water storage balance between project reservoirs. Balancing rules are used by the model for any condition where water needs can be satisfied from more than one reservoir. This forces the model to balance all CVP reservoirs north of the Delta (Trinity, Shasta, and Folsom) in pursuit of an acceptable operation. PROSIM must also balance the storage in northern CVP and SWP reservoirs with storage south of the Delta. This balancing is accomplished using target storages for San Luis Reservoir. When storage in CVP San Luis Reservoir is below its target, releases are made from CVP reservoirs north of the Delta. Likewise, SWP’s Oroville Dam north of the Delta will make releases when storage in SWP San Luis Reservoir is below its target.

Reservoir balancing north of the Delta is controlled by criteria that describe refill potential, minimum storage, and unconditional releases. These criteria, along with criteria to balance north and south of Delta storage, are input data that can be adjusted in the reservoir input file. For any simulation, these reservoir operation criteria are adjusted to achieve a reasonable representation of CVP and SWP operations.

4.2.2 Environmental Flow Requirements

4.2.2.1 *Trinity River*

For existing conditions simulations, instream flow requirements for the Trinity River are 340 TAF per year, in all year types, based on the May 8, 1991 decision of the Secretary of the Interior. Future level simulations use the instream flow requirements defined by the April 26, 1995 U.S. Fish and Wildlife Service 390-750 TAF Trinity River flow pattern. The 390-750 allocation to the Trinity River is based on available water supply, expressed in terms of Trinity Lake inflow for the given year.

4.2.2.2 *Clear Creek*

Flows in Clear Creek below Whiskeytown are in accordance with minimum instream flow requirements specified in the Department of Interior's Final Administrative Proposal on the Management of Section 3406(b)(2) dated November 20, 1997.

4.2.2.3 *Sacramento River Below Keswick Dam*

Flows in the Sacramento River below Keswick Dam are in accordance with minimum instream flow requirements specified in the Department of Interior's Final Administrative Proposal on the Management of Section 3406(b)(2) dated November 20, 1997.

4.2.2.4 Sacramento River at The Navigation Control Point

The Navigation Control Point (NCP) flow is a condition of CVP authorization, and requires Reclamation to maintain flows in the Sacramento River sufficient to support commercial navigation. The location of the NCP is defined as the Sacramento River at Wilkins Slough, located approximately 65 miles upstream of the City of Sacramento. Commercial navigation in the river above Sacramento has not existed for many years. Over the years, however, water diverters along the Sacramento River have become accustomed to the flow levels provided by the NCP requirement, and have established pump intakes at elevations commensurate with historic flow levels. The NCP flow has become a requirement associated with the ability to pump.

PROSIM establishes flow in the Sacramento River at the NCP based on available storage in Shasta Lake and "Delivery Level." "Delivery Level" is a function within the PROSIM model that is used to estimate overall water supply availability (based on system storage, forecasted inflow, desired carryover storage, and other parameters) and determine necessary shortages among project users (i.e., agriculture, M&I, and settlement users). Flows at the NCP are maintained at 5,000 cfs in high delivery years and can be reduced to 3,250 cfs during years when large deficiencies are imposed on Sacramento River diverters.

4.2.2.5 Feather River

Feather River instream flow requirements are: 1,700 cfs October through March of non-critical years; 1,200 cfs October through February and 1,000 cfs in March of critical years; and 1,000 cfs April through September in all year types. Critical years are defined as those years when the previous April through July unimpaired inflow to Lake

Oroville was below the historical average of 1,964 TAF. These required flows may be reduced by 25% if Lake Oroville storage drops below 1,500 TAF. Per the August 26, 1983 agreement between DWR and CDFG, the above minimum flow requirements may be modified further if releases exceed 2,500 cfs between October 15 and November 30. PROSIM's implementation of this criteria includes the exemption of flood control releases from the foregoing criteria (to the extent a monthly model can recognize short-term phenomena).

4.2.2.6 American River

Flows in the American River below Folsom Dam are set based on minimum instream flow requirements specified in the Department of Interior's Final Administrative Proposal on the Management of Section 3406(b)(2) dated November 20, 1997. Regardless of the flow requirement specified under (b)(2), State Water Resources Control Board Decision 893 monthly flow requirements are maintained as a minimum throughout the LAR, from Nimbus Dam to the mouth.

4.2.2.7 Delta

Environmental Requirements for the Delta are set based on the SWRCB May 1995 Water Quality Control Plan (WQCP) and the Department of the Interior's Final Administrative Proposal on the Management of Section 3406(b)(2) dated November 20, 1997.

The SWRCB May 1995 WQCP prescribes constraints/requirements in the Delta, including standards for salinity, dissolved oxygen, flow, and exports. Salinity and dissolved oxygen standards, for which there are no corresponding specified relationships to flow (i.e., flow-salinity or flow-dissolved oxygen relationships), are indirectly considered in the PROSIM model through the use of minimum Delta outflow requirements. PROSIM treats all flow standards specified in the WQCP as requirements that cannot be compromised.

The WQCP specifies standards based on year type and water availability, which may relax requirements during drier years. Standards, such as X2, vary depending on antecedent flow conditions. PROSIM determines the appropriate flow standard based on allowable adjustments/relaxations specified in the WQCP and sets Delta outflow requirements that ensure violations of these standards do not occur.

4.2.3 Delivery Logic

One of the most critical operating decisions for the CVP and SWP is the annual water supply allocation, which occurs in every March of the simulation. PROSIM uses perfect foresight to determine the water demand and available water supply for the forecast horizon (March through September). PROSIM then calculates water allocations by balancing available supply and demand over the forecast horizon. If the supply is greater than demand, then a full allocation is made. However, if demand is greater than supply, deficiencies are imposed. Additional reductions in water allocations are made to CVP users south of the Delta when it is determined that there are conveyance limitations through the Delta.

PROSIM imposes deficiencies by using a step function representing delivery levels. A delivery Level 1 indicates a full delivery. Increasing delivery levels indicate a decrease in water allocation. The imposition of deficiencies is consistent with PROSIM version 60A.

4.3 POWER

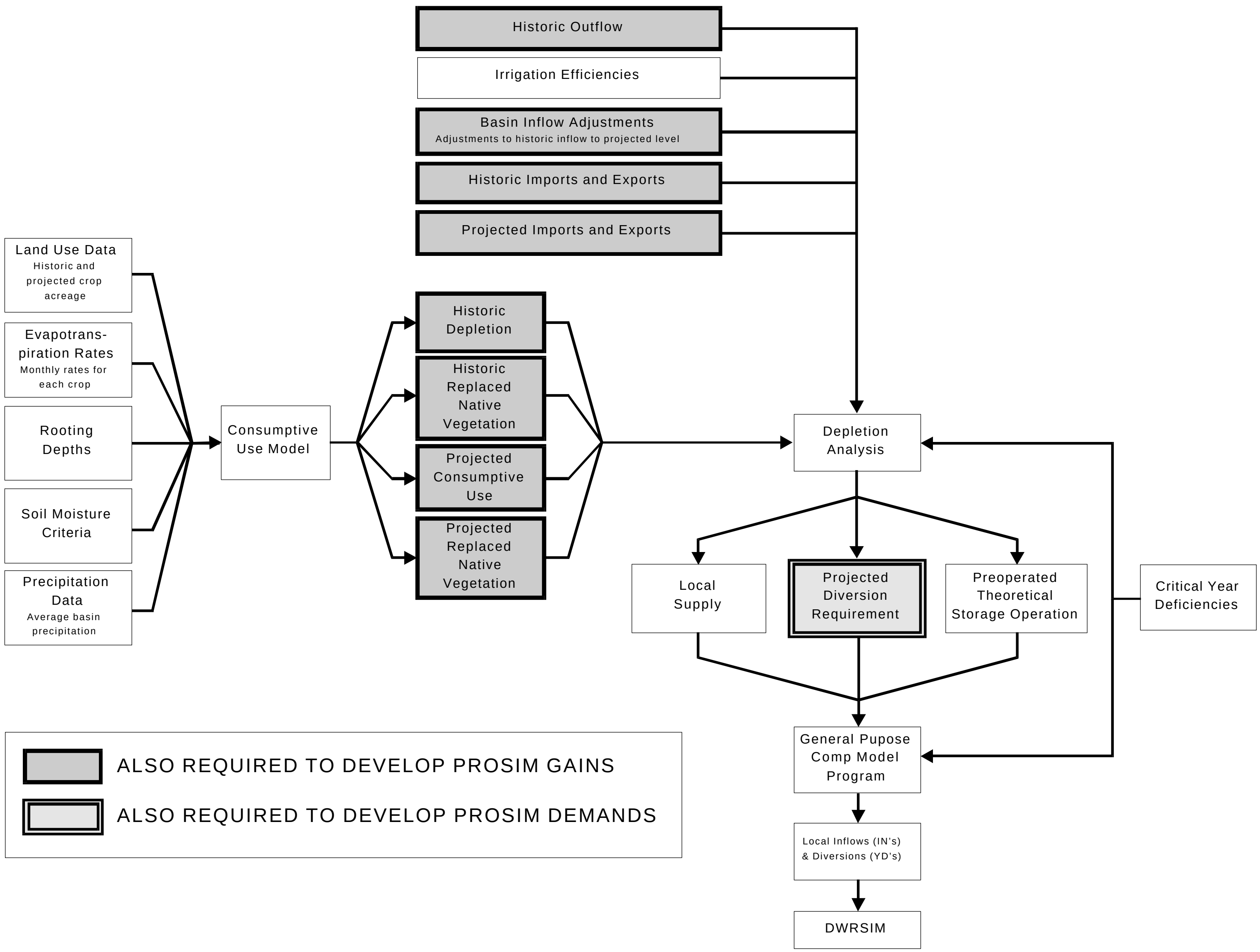
Data describing storage–efficiency and storage–capacity curves are contained in the power generation inputs for each federal facility simulated by PROSIM. CVP electrical loads for Project facilities are defined in the power input file. Power routines in PROSIM use this information to calculate generation, capacity, and energy requirements at the CVP load center.

4.4 HYDROLOGY

Stream gains, reservoir inflows, water diversion requirements, irrigation efficiency, and groundwater operation are components that make up the hydrology used in PROSIM. The hydrology is developed using the DWR hydrology development process, designed to adjust the historic sequence of monthly stream flows to represent a sequence of flows at a future level of development. Adjustments to historic water supplies are determined by imposing future level land use on historic meteorological and hydrologic conditions. The resulting hydrology represents the water supply available from Central Valley streams to the CVP and SWP at a future level of development. DWR's Consumptive Use (CU) and Depletion Analysis are the two major components of the hydrology development process; data and results from the CU and Depletion Analysis are structured for use in PROSIM. A flow chart representing the hydrology development process is presented in **Figure 4.3**.

Figure 4-3

DWR HYDROLOGY DEVELOPMENT PROCESS



The CU model determines water use in the Sacramento Valley and the Delta service area. It requires land use data, evapotranspiration rates, rooting depths, soil moisture criteria, and precipitation data as inputs. Using these inputs, the CU model produces water depletions and replaced native vegetation CU for both the historic and projected levels of development. CU model output is a major component of the input data used in the depletion analysis.

The depletion analysis determines the effect of future water diversions and reservoir operations for each Depletion Area (DA) tributary to the Delta. Analysis begins by removing the effects of actions that have historically influenced water supply in each DA, such as water projects and land use. The result is a natural water supply for each DA. Once natural water supply is determined, non-CVP and non-SWP water projects are imposed on each DA resulting in supply available at a future level of development. Future land use is then imposed to determine water diversion requirements. Withdrawals from theoretical storage are made when available supply is less than diversion requirements. Appropriate withdrawals are made from theoretical storage to ensure that full water diversion requirements are satisfied. The depletion analysis provides outputs containing available water supply, diversion requirement, and a theoretical storage operation for each DA.

Individual nodes in PROSIM represent depletion areas in the valley floor basins while depletion areas known as rim basins are represented as either inflow to reservoir nodes, or incorporated in gains for valley floor depletion areas. A map showing the DWR depletion areas is presented in **Figure 4.4**. All water entering, exiting, or stored within each depletion area is accounted for in the DWR hydrology process. These data are used to calculate all hydrologic inputs to PROSIM. The hydrologic data are input to PROSIM via the gains, inflow, groundwater, efficiency inputs, and demands,

4.4.1 Gains

Available water supply within each DA is represented in PROSIM's gains input data. PROSIM gains are calculated using inputs to the depletion analysis, and are calculated using the same approach as the depletion analysis. **Figure 4.3** indicates the components of the DWR hydrology process that are used to calculate PROSIM gains. Gains consist of accretions and depletions (water gain and loss) at a node and are not always positive. Gains, with the exception of the American River, are consistent with PROSIM version 60A.

Gains on the American River were developed by performing rainfall-runoff analyses and by incorporating seepage estimates produced from groundwater modeling. Gains are determined for three reaches of the Lower American River; Folsom Dam to Nimbus Dam, Nimbus Dam to H Street, and H Street to the mouth.

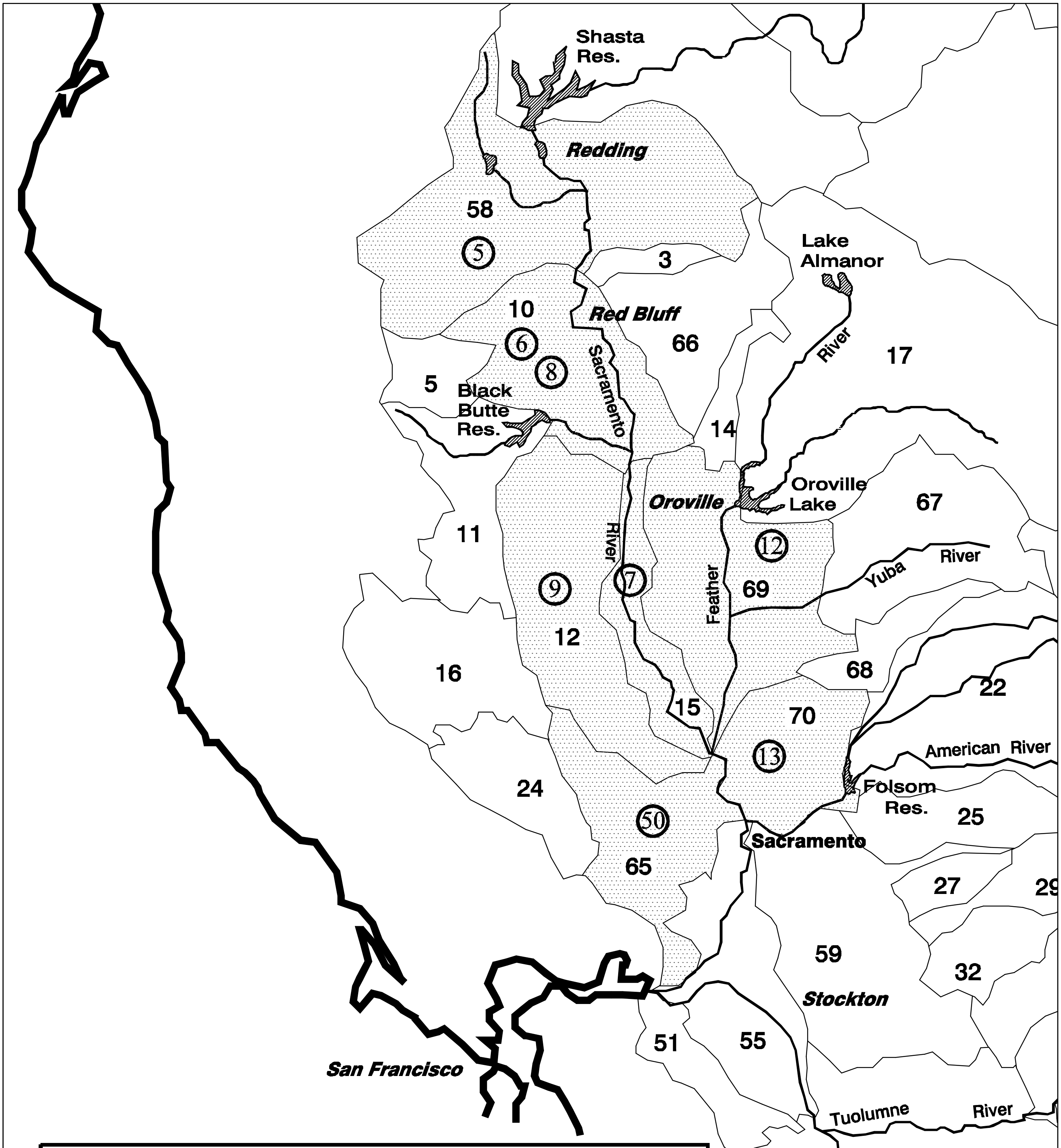


FIGURE 4.4 - DEPARTMENT OF WATER RESOURCES DEPLETION AREAS

Valley Floor

(5) PROSIM Node Number

Rainfall-runoff estimates for the American River from Folsom Dam to Nimbus Dam were provided by DWR, and were determined by relating drainage characteristics of the adjacent Dry Creek watershed to drainage at Lake Natoma. The rainfall-runoff estimates for both reaches below Nimbus Dam were determined employing methods developed by Dan Steiner on behalf of the County of Sacramento. Approximately 25,636 acres contribute to drainage entering the American River from Nimbus Dam to H Street and 16,219 acres contribute to drainage from H Street to the mouth. To determine the volume of runoff, precipitation data for DA 70 were multiplied by these respective areas with a 0.5 runoff coefficient applied.

4.4.2 Delta

Delta gains are developed and provided by DWR. Gains in the Delta are simply precipitation volumes.

4.4.3 Reservoir Inflow

Inflow to Trinity, Whiskeytown, and Shasta reservoirs are extracted directly from the DWR hydrology development process. Inflow to Lake Oroville is extracted from the DWR process. Flow through Kelly Ridge is added to Lake Oroville inflow because PROSIM has no means of properly introducing the flow into the Feather River downstream of Oroville Dam. Inflow to Folsom Reservoir is necessarily modified from the inflow used in the DWR process because of the iterative upstream operations required by the WFP and described in **3.5.2.1 Upper American River Basin**.

4.4.4 Groundwater

The groundwater operation in PROSIM is consistent with the DWR depletion analysis. Theoretical storage in the depletion analysis is drawn upon (groundwater pumping) whenever surface water supplies within a depletion area are insufficient to satisfy demands. No limits are placed on the volume of water that can be drawn from theoretical storage. The withdrawal is set to the volume necessary to fully satisfy demands. Diversion to theoretical storage is considered to be recharge. Ability to recharge theoretical storage, unlike theoretical storage withdrawals, is limited by hydrologic conditions.

Theoretical storage operations critical to PROSIM are restricted to valley floor depletion areas. Of the seven valley floor depletion areas represented by PROSIM nodes, five have a significant theoretical storage operation. These areas include DA 10, 12, 15, 69, and 65, as presented in **Figure 4.4**.

4.4.5 Efficiency and Return Flows

Basin efficiencies for each depletion area are used to determine diversion requirements based on consumptive use (CU) requirements. Diversions in excess of CU requirements enter the surface water system in the form of return flows. Demands are input to PROSIM in the form of diversion requirements. PROSIM uses efficiency factors for the sole purpose of determining the portion of diversion that will be realized as return flow. The efficiency values used are consistent with the DWR hydrology process.

4.4.6 Demands

Demands in PROSIM are classified as CVP project, SWP project, or non-project demands. CVP project demands are separated into several classes based on contract type. Demands also are designated by geographic location; Sacramento River Basin (CVP and non-project), Feather River Service Area (SWP and non-project), American River Basin (CVP), Delta, CVP south of Delta, and SWP south of Delta. All CVP demands, with the exception of the American River, are consistent with PROSIM version 60A.

4.4.6.1 Sacramento River Basin

Sacramento River CVP diversions serve the Central Valley for a variety of uses including agricultural, national wildlife refuge water supply, and M&I use. All CU demands, such as agricultural and M&I outdoor use, are determined using the DWR hydrology process. The DWR hydrology process does not address water requirements for wildlife refuges and non-consumptive demands, such as M&I indoor use. It is necessary to incorporate refuge and M&I demands into PROSIM because reservoirs must release water to satisfy these requirements. These demands are added to the demands determined by the DWR hydrology process.

Diversion requirements determined by the DWR hydrology process are used as the total demand for each DA represented in PROSIM. Total demand from the DWR hydrology process is disaggregated into project and non-project demands based on CVP contract amounts in each DA. Project demands are set to the minimum of the CVP contract amount or the total demand in the DA. Non-project demands are calculated as the total demand minus the CVP project demand. Non-project demands can be satisfied from direct stream diversions if adequate streamflow is available. Reservoir withdrawals are not made to satisfy these demands. Reservoirs will release water to satisfy project demands, up to the amount determined by PROSIM through delivery allocations.

Firm Level II national wildlife refuge water demands are used for both the Sacramento and San Joaquin Valleys.

M&I water diversion requirements are determined based on both recent historic diversions and contract amounts. Even though M&I diversion requirements are not included in the DWR hydrology development process, the CU portion is included. Therefore, efficiency factors are established to ensure that the appropriate volume of return flow enters the surface water system.

4.4.6.2 Feather River Service Area

Feather River Service Area (FRSA) demands are the only SWP demand north of the Delta. The FRSA users are entitled to approximately 1,000 TAF per year of Feather River water. The DWR hydrology process is used to determine these diversions. Deficiencies imposed on FRSA users, by the SWP, are determined in the DWR hydrology process and remain unchanged in PROSIM. Refuge water for Butte Creek Duck Club and M&I diversion for Yuba City and Butte County is added to the Feather River diversion requirement determined in the depletion analysis.

4.4.6.3 American River Basin

American River demands are predominantly for M&I use, and include diversions located upstream of and from Folsom Reservoir, Lake Natoma and the FSC, and the Lower American River.

All demands in the Lower American River are based on the Sacramento Area Water Forum assumptions. American River demands used in the simulations are addressed in **5. SIMULATIONS PERFORMED**.

The Upper American River system demands are modeled using the HEC-III model described previously, and are based on the Sacramento Area Water Plan Forum demands. Certain demands in the Lower American River require Middle Fork Project releases during July 1 through November 1. These demands represent water purchased from PCWA, and are operated in a manner consistent with PCWA water rights restrictions. Middle Fork Project operations are discussed in **3.5.2.2 Middle Fork Project**.

4.4.6.4 Delta

Diversions in the Delta include City of Vallejo, Contra Costa Water District, and Delta CU. Delta CU is determined in the DWR hydrology process. The CU model uses routines specific to the Delta, along with variable evapotranspiration (ET) rates to determine the Delta CU.

4.4.6.5 CVP South of Delta

South of Delta CVP demands include agricultural and M&I needs served from the San Luis Reservoir and Unit, the Cross Valley Canal, the Delta-Mendota Canal and Mendota Pool. In PROSIM, CVP demands south of the Delta are always set to contract amount and do not vary based on hydrologic conditions. These demands also contain exchange contractors, refuge water supplies and operational losses.

4.4.6.6 SWP South of Delta Demands

Demands are set per the Monterey Agreement criteria, which imposes demand deficiencies equally to both agricultural and M&I requests. They are calculated from the 1996 Table A entitlements assuming zero entitlements and deliveries to Santa Barbara and San Luis Obispo counties through the Coastal Aqueduct.

Maximum SWP Contractor deliveries are designed to vary in response to local wetness indices. As such, maximum deliveries are reduced in the wetter years, assuming greater availability of local water supplies. Deliveries to San Joaquin Valley agricultural contractors are reduced in wetter years using an index developed from annual Kern River inflows to Lake Isabella.

Deliveries to Metropolitan Water District of Southern California (MWDSC) are reduced in wetter years using the 10-station, two-year average precipitation index.

Maximum deliveries to all other SWP M&I Contractors are not adjusted for a wetness index. As a result of the use of wetness indices, the maximum delivery to SWP contractors varies by year. Actual demands input to PROSIM are dependent on level of development assumed for each simulation. The range of SWP demand assumptions are discussed in **5. Simulations Performed**.

5. SIMULATIONS PERFORMED

Study assumptions are developed to produce model simulations that reflect conditions appropriate for fulfilling California Environmental Quality Act (CEQA) and National Environmental Policy Act (NEPA) analysis requirements. The methods by which model simulations are performed and compared form the basis for many impact analyses. There were four simulations performed for this project:

- Base Condition
- Base with Water Forum Proposal (WFP)
- 2030 with WFP
- 2030 Constrained Alternative

Performing the four simulations required developing assumptions for both current conditions (nominally 1998) and future conditions (nominally 2030). The Current Condition hydrology uses 1995 land use projections, while 2020 land use projections are used for future condition hydrology. The Base Condition simulation employs Reclamation's 1997 operational criteria for flow and environmental requirements (e.g., temperature and instream flow objectives). Future condition simulations reflect an assumed operating criteria to meet anticipated flow and environmental requirements.

Any representation of CVP and SWP operations for 20 to 30 years in the future is speculative. This speculation is, however, necessitated by the environmental process; thus, assumptions about future operations are unavoidable. Drawing on knowledge of past and present CVP/SWP operations and applying a fairness principle to situations for which there is no precedence, a "reasonable" future operation was determined for the future condition simulations. Individual project operators will each have an opinion on the "goodness" of the operation, which reinforces the fact that there is no correct operation, only a range of reasonable operations.

Since the "reasonable" future operation is dependent on a fairness principle when competing demands for water cannot be resolved by current guidelines, some explanation of the principle is necessary. The allocation of the available water supply between water contractors and the environment in the future is difficult to identify. For the future condition simulations performed for this project, the sequence for allocating a limited water supply was as follows.

1. Delta requirements were met in all months of all years.

2. Trinity River flow requirements were met before any export to the Sacramento Basin.

3. Flow and storage requirements associated with the Sacramento River winter run salmon biological opinion was implemented to achieve a level of protection consistent with current operating policy.

4. Water contractor deliveries were diminished to achieve the preceding actions.

5.1 BASE CONDITION

This simulation is designed to represent how the CVP and SWP presently operate with existing obligations. The criteria used to guide operations of the CVP and SWP are consistent with criteria currently in place (October 1998). The hydrology used for the existing condition PROSIM model studies are consistent with the DWR hydrology titled D06A. This hydrology is based on 1995 land use projections published in DWR Bulletin 160-98.

5.1.1 Demands

5.1.1.1 Sacramento River Basin Including FRSA

Demands in the Sacramento River Basin are developed using the DWR hydrology process discussed in **4.4.5 Demands**. Demands vary depending on hydrologic conditions. However, annual average project agricultural demands are 3,500 TAF, and annual average non-project demands are 2,300 TAF.

5.1.1.2 American River Basin

American River demands for this simulation are based on Water Forum Proposal current use declarations. These demands are presented in **Table 5.1**.

5.1.1.3 Delta

Annual demands in the Delta include the City of Vallejo (16,000 AF), Contra Costa Water District (145,000 AF), and Delta CU (1,700 TAF average annual) based on DWR hydrology D06A.

5.1.1.4 CVP South of Delta

CVP demands south of the Delta are fixed at 3,260 TAF per year, based on contractual obligations. These demands include all CVP contracts south of the Delta plus firm Level II refuge supply and operational losses.

5.1.1.5 SWP South of Delta

SWP demands for this simulation vary from 3,530 TAF to 2,620TAF based on southern California wetness indices.

TABLE 5.1 - AMERICAN RIVER BASE CONDITION DEMANDS

Location	Demand	Demand Type
Upstream of Folsom Reservoir		
El Dorado Irrigation District	15,000	Water Rights

Georgetown	10,000	Water Rights
Placer County Water Agency	8,500	Water Rights
Total	33,500	
Folsom Reservoir *Represented by PROSIM Node 14*		
Northridge Water District	0	Water Rights
City of Folsom	15,000	Water Rights
Folsom State Prison	2,000	Water Rights
San Juan Suburban Water District (Placer County)	10,000	Water Rights
San Juan Suburban Water District (Sacramento County),	44,200	Water Rights/M&I Contract
El Dorado County Water Agency	0	M&I Contractor
El Dorado Irrigation District	5,000	M&I Contractor
Roseville, City of	23,000	M&I Contractor
Total	99,200	
Folsom South Canal *Represented at PROSIM Node 15*		
Southern California Water Co.	3,500	Water Rights
California Parks and Recreation	0	M&I Contract
SMUD	15,000	Water Rights
South Sacramento Count Agriculture	0	Ag Contractor
Losses	1,000	
Total	19,500	
From Below Nimbus Dam to H Street *Represented by PROSIM Node 16*		
Arcade Water District	2,000	Water Rights
Carmichael Water District	8,000	Water Rights
Sacramento, City of	50,000	Water Rights
Total	60,500	
American River at I5 *Represented at PROSIM Node 16*		
EBMUD	0	
	0	
Total	0	
Sacramento River below the American River Confluence *Represented by PROSIM Node 17*		
Sacramento, City of	45,000	Water Rights
Sacramento county Water Agency	0	
Total	45,000	

5.1.2 Temperature

The Base Condition simulation assumes optimal management of Folsom Reservoir's cold water pool. Variable target temperature release objectives are selected that reflect the capability of manipulating the Folsom Dam shutters to achieve the best possible conditions for steelhead and chinook salmon. Existing facilities at Folsom Dam are assumed for temperature control.

5.2 WFP

This simulation is designed to represent how the CVP and SWP would operate with the implementation of the Water Forum Proposal. The criteria used to guide operations of the CVP and SWP are consistent with criteria currently in place (October 1998). The hydrology used for the WFP condition PROSIM simulation are consistent with the DWR hydrology titled D06A. This hydrology is based on 1995 land use projections published in DWR Bulletin 160-98.

5.2.1 Water Forum Mitigation Water (MFP ReOp water) Operation

WFP simulations that include PCWA diversions at the Auburn Dam site, and/or City of Roseville diversions at Folsom Dam, have an associated mitigation (ReOp) water obligation. The ReOp water obligation is computed based on the same Folsom unimpaired index (FUI) as the delivery "wedge" is based ($FUI_{Mar\ 1\ -\ Sep\ 30} + 60$). The $FUI_{Mar\ 1\ -\ Sep\ 30} + 60$ is used in the hydrologic modeling as a surrogate for a $FUI_{Mar\ 1\ -\ Nov\ 30}$ forecast. ReOp release obligation is accomplished in all years.

PCWA	ReOp Amount
$FUI_{Mar\ 1\ -\ Sep\ 30} + 60 > 950$ af	0 af
400 af $< FUI_{Mar\ 1\ -\ Sep\ 30} + 60 < 950$ af	Linearly interpolated
$FUI_{Mar\ 1\ -\ Sep\ 30} + 60 < 400$ af	27,000 af
City of Roseville	
$FUI_{Mar\ 1\ -\ Sep\ 30} + 60 > 950$ af	0 af
400 af $< FUI_{Mar\ 1\ -\ Sep\ 30} + 60 < 950$ af	Linearly interpolated
$FUI_{Mar\ 1\ -\ Sep\ 30} + 60 < 400$ af	20,000 af

The following rules are used in operating the MFP for the ReOp water obligation:

1. ReOp water is released at a constant rate during the months of March through September.

2. MFP baseline releases (the releases from the MFP that would have normally occurred without prior or current ReOp water releases) are maintained throughout the period that begins ReOp until Folsom Reservoir reaches its flood control storage diagram.

3. As soon as Folsom Reservoir storage reaches the flood storage diagram, MFP is allowed to refill the hole in MFP storage by storing inflow (previously spilled) and reducing power releases that are not needed for any other purpose downstream.

4. If refill of the MFP “hole” is not achieved by the time a subsequent ReOp operation commences, the “hole” is carried through until the next refill opportunity following the ReOp release period.

5. If September ReOp water releases would reduce MFP storage to lower than minimum pool requirements, ReOp releases are delayed into October (only occurs in 1977). If failure to refill the "hole" in MFP created by previous ReOp release causes MFP project to drop below minimum pool requirements, partial refill may occur before Folsom Reservoir reaches the flood storage diagram.

5.2.2 Demands

5.2.2.1 Sacramento River Basin Including FRSA

Demands in the Sacramento River Basin are developed using the DWR hydrology process discussed in **4.4.5 Demands**. Demands vary depending on hydrologic conditions. However, annual average project agricultural demands are 3,500 TAF and annual average non-project demands are 2,300 TAF. Demands on the Sacramento River between the confluence of the Feather and the American rivers are increased by 35 TAF to reflect a diversion for PCWA under the WFP.

5.2.2.2 American River Basin

American River demands for this simulation are those of the WFP. These demands are presented in **Table 5.2** American River surface diversions to WFP purveyors are reduced based on the unimpaired inflow to Folsom Reservoir. When the March through September unimpaired inflow to Folsom Reservoir plus 60 TAF is less than 950 TAF, surface diversions by Water Forum purveyors are reduced. The magnitude of reductions varies for each purveyor based on the WFP. Specifics for each purveyor are contained in the *Water Forum – Draft Recommendations for the Agreement – January 1997.*

5.2.2.3 Delta

Annual demands in the Delta are the same as those described in Section 5.1.1.3 for the Base Condition.

5.2.2.4 CVP South of Delta

CVP demands south of the Delta are the same as those described in Section 5.1.1.4. for the Base Condition.

TABLE 5.2- AMERICAN RIVER WFP DEMANDS

Location	Demand	Demand Type
Upstream of Folsom Reservoir		
El Dorado Irrigation District	33,350	Water Rights
Georgetown	11,200	Water Rights
Placer County Water Agency	35,500	Water Rights
Total	80,050	
Folsom Reservoir		
Represented by PROSIM Node 14		

Northridge Water District	29,000	Water Rights
City of Folsom	34,000	Water Rights
Folsom State Prison	2,000	Water Rights
San Juan Suburban Water District (Placer County)	25,000	Water Rights
San Juan Suburban Water District (Sacramento County),	57,200	Water Rights/M&I Contract
El Dorado County Water Agency	7,500	M&I Contractor
El Dorado Irrigation District	7,550	M&I Contractor
Roseville, City of	54,900	M&I Contractor
Total	217,150	
Folsom South Canal *Represented at PROSIM Node 15*		
Southern California Water Co.	5,000	Water Rights
California Parks and Recreation	5,000	M&I Contract
SMUD	30,000	Water Rights
South Sacramento Count Agriculture	35,000	Ag Contractor
Losses	1,000	
Total	76,000	
From Below Nimbus Dam to H Street *Represented by PROSIM Node 16*		
Arcade Water District	11,200	Water Rights
Carmichael Water District	12,000	Water Rights
Sacramento, City of	96,300	Water Rights
Total	119,500	
American River at I5 *Represented at PROSIM Node 16*		
EBMUD	0	M&I Contract
	0	
Total	0	
Sacramento River below the American River Confluence *Represented by PROSIM Node 17*		
Sacramento, City of	34,300	Water Rights
Sacramento county Water Agency	45,000	
Total	79,300	

5.2.2.5 SWP South of Delta

SWP demands are the same as those described in Section 5.1.1.5 for the Base Condition.

5.2.3 Temperature

The WFP simulation assumes optimal management of Folsom Reservoir's cold water pool. Variable target temperature release objectives are selected that reflect the capability of manipulating the Folsom Dam shutters to achieve the best possible conditions for steelhead and chinook salmon. This simulation also assumes a TCD is in operation at the Folsom Dam Pumping Plant.

5.3 2030 WITH WFP

This simulation assumes 2030 conditions for all areas including the American River. The hydrology used for the 2030 WFP PROSIM model simulation is consistent with the

DWR hydrology titled D09A. This hydrology is based on 2020 land use projections published in DWR Bulletin 160-93.

5.3.1 Demands

5.3.1.1 Sacramento River Basin Including FRSA

Demands in the Sacramento River Basin are developed using the DWR hydrology process discussed in **4.4.5 Demands**. Demands vary depending on hydrologic conditions; however, annual average project agricultural demands are 3,560 TAF and annual average non-project demands are 2,470 TAF. Demands on the Sacramento River between the confluence of the Feather and the American rivers are increased by 35 TAF to reflect a diversion for PCWA under the WFP.

5.3.1.2 American River Basin

American River demands are based on the WFP and set to those in Table 5.3

5.3.1.3 Delta

Annual demands in the Delta include City of Vallejo (16,000 AF), Contra Costa Water District (145,000 AF), and Delta CU (1,700 TAF average annual) based on the DWR hydrology D09A.

5.3.1.4 CVP South of Delta

CVP Demands south of the Delta are fixed at 3,260 TAF per year, based on contractual obligations. These demands include all CVP contracts south of the delta plus Firm Level II refuge supply and operational losses.

5.3.1.5 SWP South of Delta

SWP demands for this simulation vary from 4,200 TAF to 3,410 TAF based on southern California wetness indices.

TABLE 5.3- AMERICAN RIVER 2030 WITH WFP DEMANDS

Location	Demand	Demand Type
Upstream of Folsom Reservoir		
El Dorado Irrigation District	33,350	Water Rights
Georgetown	11,200	Water Rights
Placer County Water Agency	35,500	Water Rights
Total	80,050	
Folsom Reservoir *Represented by PROSIM Node 14*		
Northridge Water District	29,000	Water Rights
City of Folsom	34,000	Water Rights
Folsom State Prison	2,000	Water Rights
San Juan Suburban Water District (Placer County)	25,000	Water Rights

San Juan Suburban Water District (Sacramento County),	57,200	Water Rights/M&I Contract
El Dorado County Water Agency	7,500	M&I Contractor
El Dorado Irrigation District	7,550	M&I Contractor
Roseville, City of	54,900	M&I Contractor
Total	217,150	
Folsom South Canal *Represented at PROSIM Node 15*		
Southern California Water Co.	5,000	Water Rights
California Parks and Recreation	5,000	M&I Contract
SMUD	30,000	Water Rights
South Sacramento Count Agriculture	35,000	Ag Contractor
Losses	1,000	
Total	76,000	
From Below Nimbus Dam to H Street *Represented by PROSIM Node 16*		
Arcade Water District	11,200	Water Rights
Carmichael Water District	12,000	Water Rights
Sacramento, City of	96,300	Water Rights
Total	119,500	
American River at I5 *Represented at PROSIM Node 16*		
EBMUD	112,000	M&I Contract
	0	
Total	112,000	
Sacramento River below the American River Confluence *Represented by PROSIM Node 17*		
Sacramento, City of	34,300	Water Rights
Sacramento county Water Agency	45,000	
Total	79,300	

5.3.2 Temperature

The 2030 With WFP simulation assumes optimal management of Folsom Reservoir's cold water pool. Variable target temperature release objectives are selected that reflect the capability of manipulating the Folsom Dam shutters to achieve the best possible conditions for steelhead and chinook salmon. This simulation also assumes a TCD is in operation at the Folsom Dam Pumping Plant.

5.4 2030 CONSTRAINED

This simulation assumes 2030 conditions for all areas except for the American River. The hydrology used for the 2030 Constrained PROSIM model simulations is consistent with the DWR hydrology titled D09A. This hydrology is based on 2020 land use projections published in DWR Bulletin 160-93. American River diversions are constrained to the lesser of existing conveyance capacity, future demand, or existing water right or contract.

5.4.1 Demands

5.4.1.1 Sacramento River Basin Including FRSA

Demands in the Sacramento River Basin are developed using the DWR hydrology process discussed in **4.4.5 Demands**. Demands vary depending on hydrologic conditions; however, annual average project agricultural demands are 3,560 TAF and annual average non-project demands are 2,470 TAF.

5.4.1.2 American River Basin

5.4.1.3 Delta

Annual demands are the same as those described in Section 5.3.1.3.

5.4.1.4 CVP South of Delta

CVP Demands south of the Delta are fixed are the same as those described in Section 5.3.1.4.

5.4.1.5 SWP South of Delta

SWP demands for this simulation are the same as those described in Section 5.3.1.5.

5.4.2 Temperature

The 2030 Constrained simulation is constant with the approach described in Section 5.3.2
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TABLE 5.4 - AMERICAN RIVER CONSTRAINED CONDITION DEMANDS

Location	Demand	Demand Type
Upstream of Folsom Reservoir		
El Dorado Irrigation District	15,080	Water Rights
Georgetown	10,400	Water Rights
Placer County Water Agency	21,000	Water Rights
Total	46,480	
Folsom Reservoir *Represented by PROSIM Node 14*		
Northridge Water District	0	Water Rights
City of Folsom	20,000	Water Rights
Folsom State Prison	2,000	Water Rights
San Juan Suburban Water District (Placer County)	25,000	Water Rights
San Juan Suburban Water District (Sacramento County),	44,200	Water Rights/M&I Contract
El Dorado County Water Agency	0	M&I Contractor
El Dorado Irrigation District	7,550	M&I Contractor
Roseville, City of	27,000	M&I Contractor
Total	125,750	
Folsom South Canal *Represented at PROSIM Node 15*		
Southern California Water Co.	10,000	Water Rights
California Parks and Recreation	5,000	M&I Contract
SMUD	30,000	Water Rights
South Sacramento Count Agriculture	0	Ag Contractor
Losses	1,000	
Total	46,000	
From Below Nimbus Dam to H Street *Represented by PROSIM Node 16*		
Arcade Water District	3,500	Water Rights
Carmichael Water District	12,000	Water Rights
Sacramento, City of	90,000	Water Rights
Total	105,500	
American River at I5 *Represented at PROSIM Node 16*		
EBMUD	112,000	
	0	
Total	112,000	
Sacramento River below the American River Confluence *Represented by PROSIM Node 17*		
Sacramento, City of	81,800	Water Rights
Sacramento county Water Agency	0	
Total	81,800	