Appendix C1

Yuba River Development Project

Water Balance/Operations Model Documentation

Yuba River Development Project

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Yuba River Development Project

Yuba Accord Water Transfer Program Extension – Supplemental Environmental Impact Report

March 2023

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1.0 Introduction

Yuba County Water Agency (YCWA) owns and operates the Yuba River Development Project (YRDP or Project), located in the Yuba River basin. Project facilities are located on the main stem of the Yuba River, Middle Yuba River, and North Yuba River; and Oregon Creek, a tributary to the Middle Yuba River. The Yuba River is a tributary to the Feather River and is part of the Sacramento River Basin, which drains into the San Francisco Bay. The Project can store approximately 966,770 acre-feet (ac-ft) of water (gross storage) and can generate an average of about 1.4 million megawatt-hours of power annually. Figure 1.0-1 shows the location of Project facilities.

An operations model of the Project was developed as part of the FERC relicensing process (FERC Project No. 2246) to simulate current and future operations of the Project using historical hydrology to define a representative range of hydrological conditions, and to output resulting flows, reservoir storage and water-surface elevations, and power generation for use by the YCWA and Relicensing Participants in the relicensing process. The Yuba River Development Project Model (YRDPM or Model) is intended to be used as a comparative model rather than a predictive one to eliminate any biases or inconsistencies in upstream operations. Impacts of changes in operations are measured as the relative difference in model output as it compares to a basis of comparison.

The objective of this report is to describe the YRDPM, as used for the lower Yuba River Accord (Yuba Accord) Long Term Transfer Program extension Supplemental Environmental Impact Report (SEIR) analysis. Section 2 provides a high-level description of the watershed hydrology, and hydrologic indices used to determine water year types; Section 3 summarizes agricultural diversion demands; Section 4 presents and overview of the Model itself; Section 5 characterizes Project facilities, as they are represented in the Model; Section 6 characterized Project operations, as they are represented in the Model; Section 7 outlines the Model simulation process. This document is intended to document assumptions used in the Model.

2.0 Operations Model Input Hydrology

The Yuba River watershed drains approximately 1,339 square miles (sq-mi) (United States Geologic Survey [USGS] 2004) of the western slope of the Sierra Nevada, including portions of Sierra, Placer, Yuba, and Nevada counties, as shown in Figure 2.0-1. The Yuba River is a tributary of the Feather River, which in turn is a tributary of the Sacramento River. The watershed rises from an elevation of about 60 feet (ft) to about 8,590 ft above mean sea level (ft-msl). The annual unimpaired flow below Englebright Dam, as measured by the USGS at the Smartsville Gage (USGS gage 11418000) on the Yuba River has ranged from a high of 4.93 million acre-feet (MAF) in 1982 to a low of 0.37 MAF in 1977, with an average of about 2.36 MAF per year (1901 to 2010).[1] In general, runoff is nearly equally divided between runoff from rainfall during October through March and runoff from snowmelt during April through September.

The upper basins of the Middle Yuba and South Yuba rivers have been extensively developed for hydroelectric power generation and consumptive uses by Nevada Irrigation District (NID) and Pacific Gas and Electric Company (PG&E). Total storage capacity of about 307 thousand acre-feet (TAF) on the Middle Yuba and South Yuba rivers and associated diversion facilities enable both NID and PG&E to export an average of approximately 410 TAF per year from the Yuba River watershed to the Bear River and American River basins through the Yuba-Bear (YB) and Upper Drum-Spaulding (DS) projects, known collectively as the YB/DS project. In addition, the South Feather Water and Power Agency (SFWPA, previously known as the Oroville-Wyandotte Irrigation District) exports an average of about 70 TAF per year from Slate Creek (a tributary to the North Yuba River) to the Feather River Watershed through the South Fork Feather River Project (SFFRP). While these upper basins lie outside of the project study area, the described operations and exports can considerably reduce the water supply available to YCWA, particularly during dry and critical water years.

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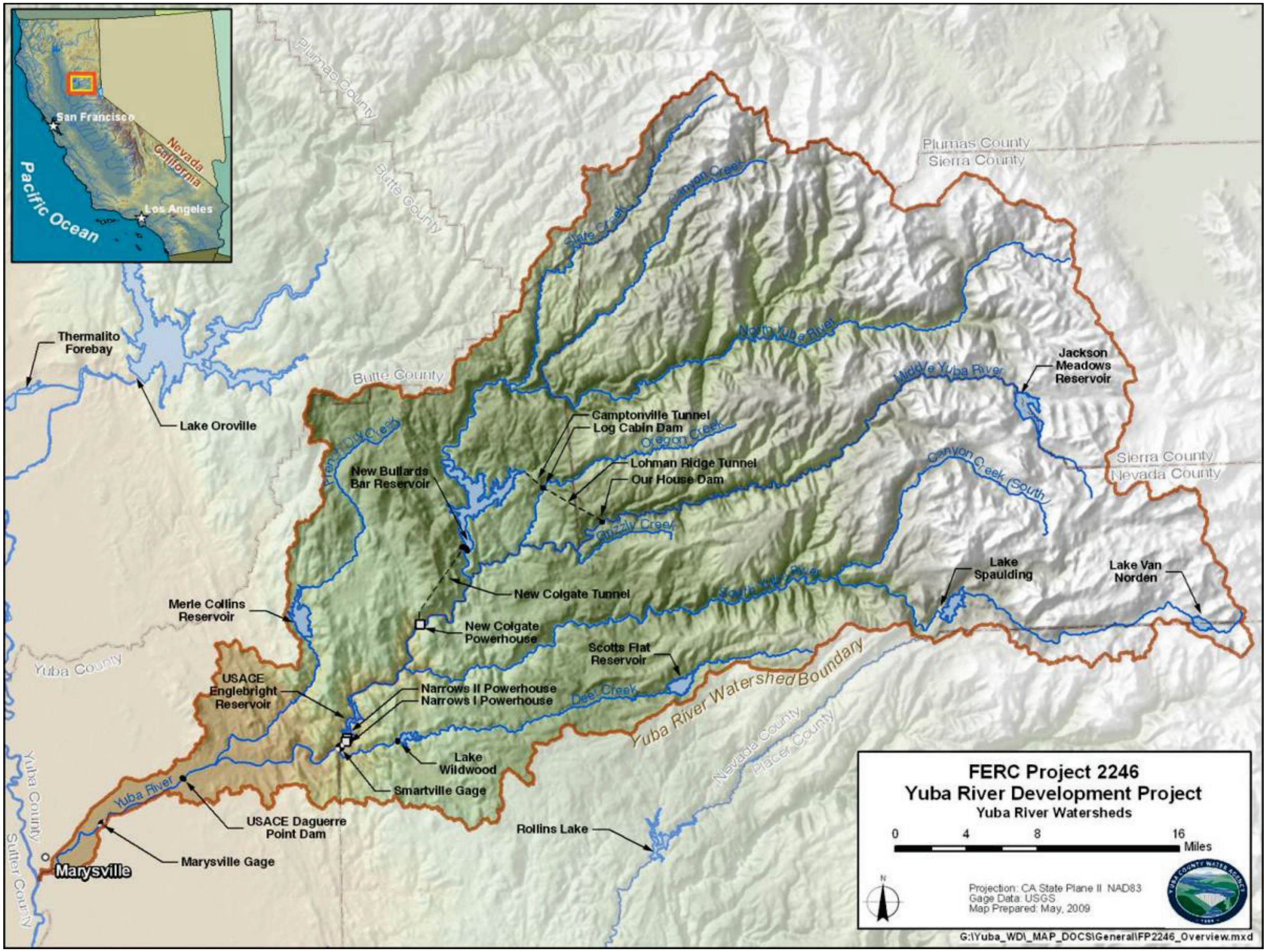
[1] Forecasted seasonal unimpaired flow at Smartsville is estimated each year by DWR and reported monthly in Bulletin 120, *Water Conditions in California*. Unimpaired flow at Smartsville is used in YCWA contracts for water delivery to senior water right holders on the lower Yuba River and is used in the calculation of the Yuba River Index, a hydrologic water year type index for the Yuba River, defined in State Water Resources Control Board Revised Decision 1644.



Source: MWH Americas, Inc.

Figure 2.0-1. Yuba River Watershed.

YCWA has compiled an input hydrology dataset for the Operations Model. It consists of a mix of historical gage data, representing inflow of major tributaries at upstream boundary conditions, and synthesized sub-basin accretion data at intermediate points within the basin. A complete description of the hydrology development and inputs to the Model is included in Appendix A, YRDPM Hydrology Report.

Figure 2.0-2 shows locations of Operations Model tributary inflows (listed in purple boxes) and locations of tributary accretions inputs (listed in red boxes). Locations with minimum instream flow requirements are listed in green boxes. Labels shown in Figure 2.0-2 for model inputs and outputs are consistent with model timeseries data found in the model input and output files.

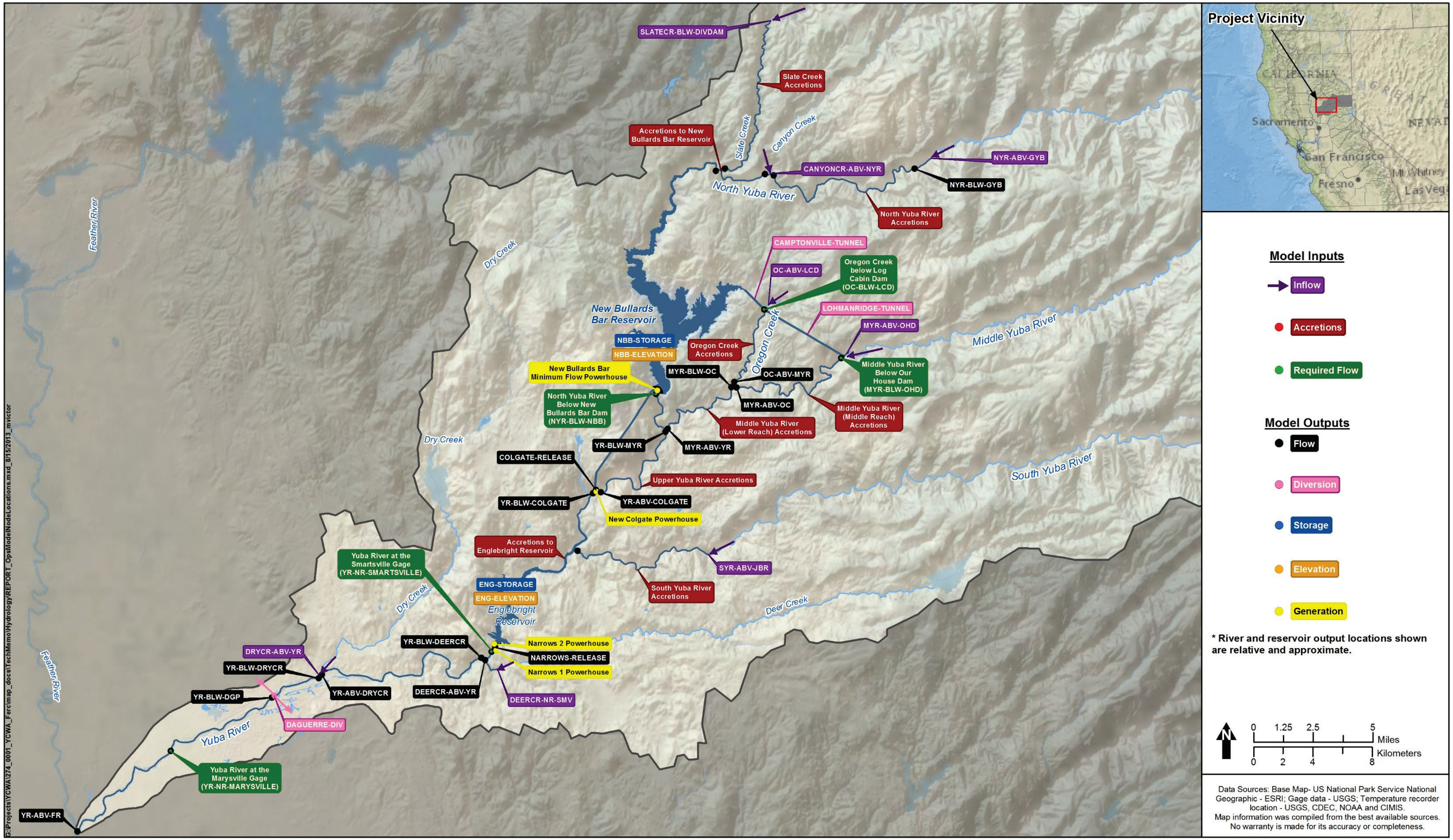


Figure 2.0-2. Yuba River Development Project Area Tributary Reaches

2.1 Water Year Types and Indices

Several hydrologic indices are used to characterize hydrologic water year types of the Yuba River. The Yuba River Index (YRI), which is incorporated into SWRCB Order Revised Decision 1644 (RD-1644), the North Yuba Index (NYI), which is incorporated into the Lower Yuba River Accord (Yuba Accord), the Smartsville Index, which is incorporated into the Final License Application (FLA) (YCWA 2014), and the Existing FERC Index, which is included in the original FERC license, are used to determine the governing flow requirement for their respective criteria.

Hydrologic Indices are selected by the user in the Operations Model for three regions: Below Englebright, North Yuba River and Middle Yuba/Oregon Creek. The index selected for Below Englebright determines the governing flow requirements in the Yuba River at Smartsville and at Marysville. The index selected for the North Yuba River determines the governing flow requirements in the North Yuba River below New Bullards Bar Dam. The index selected for the Middle Yuba/Oregon Creek determines the governing flow requirements in the Middle Yuba River below Our House Diversion Dam and in Oregon Creek below Log Cabin Diversion Dam. Hydrologic Indices for the three regions are selected by the user on the *Scenario Builder and Control* worksheet.

2.1.1 Yuba River Index

The YRI was developed in 2000 to describe the hydrology of the lower Yuba River. This index is a measure of the unimpaired river flows at Smartsville. The YRI was used to determine the water year types and the corresponding in-stream flow requirements under SWRCB RD-1644 (SWRCB 2003). .

The YRI is determined by applying weighting factors to runoff from different periods of the year as follows:

$$YRI = 0.2 YRI_{previous} + 0.3 R_{winter} + 0.5 R_{summer}$$

where:

$\mathrm{YRI}_{\mathrm{previous}}$ = YRI of previous year (maximum 1,400);

$\mathrm{R}_{\mathrm{winter}}$ = October through March unimpaired runoff at Smartsville; and

$\mathrm{R}_{\mathrm{summer}}$ = April through July unimpaired runoff at Smartsville.

YRI year types are determined as follows:

Wet	YRI greater than or equal to 1,230 TAF
Above Normal	YRI greater than or equal to 990 TAF
Below Normal	YRI greater than or equal to 790 TAF
Dry	YRI greater than or equal to 540 TAF
Critical	YRI less than 540 TAF

2.1.2 North Yuba Index

The NYI was developed for the Yuba Accord (YCWA 2007). This index provides a measure of available water in the North Yuba River that can be used to meet instream flow requirements and delivery requirements to member units on the lower Yuba River (since the YRI is based on unimpaired flows at Smartsville, including flows from the Middle and South Yuba rivers, it does not accurately represent the water available for storage by YCWA). The NYI comprises two components: (1) active storage in NBB at the start of the current water year (October 1), and (2) total actual and projected inflow into NBB for the current water year, including diversions from the Middle Yuba River and Oregon Creek to NBB.

The NYI is determined by adding the previous year's end-of-September active storage (storage greater than the FERC license minimum pool of 234 TAF) to the sum of actual and predicted inflows to NBB for the water year. NYI schedules are numbered 1 through 6 as indicators of specific hydrologic conditions to assign a flow requirement. A seventh schedule, which applies during the driest conditions, is called a Conference Year. The NYI values corresponding to the schedules from wettest to driest are as follows:

Schedule 1:	NYI greater than 1,400 TAF
Schedule 2:	NYI greater than 1,050 TAF
Schedule 3:	NYI greater than 930 TAF
Schedule 4:	NYI greater than 825 TAF
Schedule 5:	NYI greater than 690 TAF
Schedule 6:	NYI greater than 500 TAF
Conference Year:	NYI less than 500 TAF

Conference Year conditions apply to determine the required instream flows during an extremely dry year occurrence. The Conference Year provisions of the Yuba Accord include specified minimum daily flows and a set of conditions for further determining flows in the lower Yuba River. Current project operations use the NYI to determine minimum flow requirements on the lower Yuba River.

2.1.3 Smartsville Index

The Smartsville Index (SVI) is defined by published forecasts of annual unimpaired Yuba River flow near Smartsville and computed unimpaired flows for previous months. DWR publishes forecasts of annual volumes of unimpaired Yuba River flow near Smartsville in its Bulletin 120, Water Conditions in California, every year in early February, March, April and May. After the end of the WY (i.e., beginning of October), YCWA will use the actual annual volume of unimpaired Yuba River flow near Smartsville for the previous WY to determine the WY type used until the next forecast is released (i.e., in early February). Table 2.4-3 shows the Smartsville Hydrological Index thresholds and associated WY types.

SVI year types are determined as follows:

Wet	SVI greater than or equal to 3,240 TAF
Above Normal	SVI greater than or equal to 2,191 TAF
Below Normal	SVI greater than or equal to 1,461 TAF
Dry	SVI greater than or equal to 901 TAF
Critical	SVI less than 901 TAF

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2.1.4 Existing FERC Water Year Types

According to the original FERC license, required minimum water releases for fishery resources are subject to reductions in critical water years, which are defined as those water years for which the April 1 forecast by DWR's Bulletin 120 predicts that the annual unimpaired flow in the Yuba River at Smartville will be 50 percent or less of the 50-year average unimpaired flow (normal). Water release curtailments for critical water years are release reductions of 15, 20, and 30 percent when Yuba River unimpaired flow forecasts are 50, 45, and 40 percent, respectively, or less of normal. The critical water year provision is effective from the time of the forecast until April 1 of the following year.

The Existing FERC Water Year Types and associated thresholds are as follows:

A (No Curtailment)	Forecasted runoff greater than 50% of normal
B (15% Curtailment)	Forecasted runoff greater than 45% of normal
C (20% Curtailment)	Forecasted runoff greater than 40% of normal
D (30% Curtailment)	Forecasted runoff less than 40% of normal

The Existing FERC water year types are applied to the North Yuba River below New Bullards Bar Dam, the Middle Yuba River below Our House Diversion Dam, and on Oregon Creek below Log Cabin Diversion Dam.

3.0 Agricultural Demands

Various water districts, irrigation districts, and mutual water companies have contracts with YCWA for delivery of water. Some of the parties that receive water from YCWA also have their own appropriative rights for diversion of water from the Yuba River. This section provides an overview of the agricultural water demands met by the Project.

3.1 Member Units

Water diverted under YCWA's water right permits is delivered to Brophy Water District (BWD), Browns Valley Irrigation District (BVID), Cordua Irrigation District (CID), Dry Creek Mutual Water Company (DCMWC), Hallwood Irrigation Company (HIC), Ramirez Water District (RWD), South Yuba Water District (SYWD) and Wheatland Water District (WWD). BVID receives water at the Pumpline Diversion Facility, located on the north-side of the river, approximately one mile upstream from Daguerre Point Dam. CID, HIC, and RWD receive water through the Hallwood-Cordua Canal (North Canal), located on the north abutment of Daguerre Point Dam. BWD, SYWD, DCMWC, and WWD receive water through the Yuba Main Canal (South Canal), located on the south side of the Yuba River slightly upstream of the south abutment of Daguerre Point Dam.

3.1.1 Brophy Water District

Since 1985, all water from the Yuba River used by BWD has been delivered through the South Canal under contract with YCWA. BWD's contract with YCWA provides for a Base Project Water allocation of 43,470 ac-ft and a Supplemental Water allocation of 32,177 ac-ft.

3.1.2 Browns Valley Irrigation District

BVID holds a pre-1914 appropriative water right to divert up to 47.2 cfs of water year-round from the Yuba River for agricultural use. In addition, BVID holds post-1914 appropriative water rights on Dry Creek. These post-1914 appropriative rights allow for direct diversion and storage of water in Merle Collins Reservoir. BVID also has a contract with YCWA authorizing diversions of 9.5 TAF per year at its Pumpline diversion facility on the Yuba River to supplement BVID's diversions under its pre-1914 appropriative right when North Yuba River flows decrease below 47.2 cfs.

3.1.3 Cordua Irrigation District

CID holds a pre-1914 appropriative right to divert up to 75 cfs from the Yuba River for agricultural use, and 1940 and 1948 appropriative rights to divert an additional 90 cfs. CID also has a contract with YCWA for 12 TAF of Base Project Water. CID diverts all of its Yuba River water from Daguerre Point Dam through the North Canal.

3.1.4 Dry Creek Mutual Water Company

DCMWC receives all surface water deliveries from the South Canal under contract with YCWA. DCMWC began receiving water from YCWA in 1998; prior to 1998, the only water available to DCMWC was groundwater. DCMWC's contract with YCWA provides for a Base Project Water allocation of 13,682 ac-ft and a Supplemental Water allocation of 3,061 ac-ft.

3.1.5 Hallwood Irrigation Company

HIC has a pre-1914 appropriative right to divert 150 cfs from the Yuba River, and a 1940 appropriative right to divert 100 cfs from the Yuba River. In a settlement agreement with YCWA regarding its water right, HIC agreed to receive a Base Project water allocation of 78 TAF per year from YCWA from the North Canal at Daguerre Point Dam.

3.1.6 Ramirez Water District

RWD received water from CID from 1978 to 1992. Since 1992, RWD has received contract water from YCWA. RWD's contract with YCWA provides for a Base Project Water allocation of 14,790 ac-ft and a Supplemental Water allocation of 10,311 ac-ft. RWD receives water from the North Canal at Daguerre Point Dam.

3.1.7 South Yuba Water District

Areas of SYWD began receiving surface water from the South Canal in 1985 with an original contract amount of 33.9 TAF per year. Since 1992, SYWD has received all its surface water deliveries from the South Canal under contract with YCWA. Since 1996, SYWD's contract with YCWA provides for a Base Project Water allocation of 25,487 ac-ft and a Supplemental Water allocation of 18,843 ac-ft.

3.1.8 Wheatland Water District

WWD completed the Wheatland Project to deliver surface water to its farmers in 2009. The Wheatland Project was in two phases; the completed Phase 1 provides surface water to approximately 7,750 ac of the approximately 9,200 ac to be served upon completion of both phases. Under Phase 1, WWD's contract with YCWA provides for a total allocation (base and supplemental) of 23,092 ac-ft per year. The completion of Phase 2 will provide WWD with a total of 40,230 ac-ft per year.

3.2 Delivery Demands

For modeling purposes, historical land use, applied water, and delivery patterns were analyzed to develop two basin-wide daily diversion demands: a wet year demand and a dry year demand. Annual demands for two levels of development, a present and a future condition, were developed; in the present level of development case, only lands irrigable by existing infrastructure are included. For the future level of development case, the full area of WWD is considered irrigated by Yuba River water, all other district demands remain the same. Table 3.2-1 includes a summary of the synthetic annual delivery demands for each member unit, under present and future levels of development. The future development case is not used for the Accord extension SEIR.

Table 3.2-1. Synthetic annual delivery demand for YCWA Member Units.

YCWA Member Unit	Synthetic Annual Demand (ac-ft)			
	Present Level Development		Future Level Development	
	Wet Year	Dry Year	Wet Year	Dry Year
Brophy Water District	67,187	70,413	67,187	70,413
Browns Valley Irrigation District	34,723	36,383	34,723	36,383
Cordua Irrigation District	55,494	58,398	55,494	58,398
Dry Creek Mutual Water Company	15,552	16,034	15,552	16,034
Hallwood Irrigation Company	47,252	49,394	47,252	49,394
Ramirez Water District	24,295	25,596	24,295	25,596
South Yuba Water District	34,860	36,725	34,860	36,725
Wheatland Water District	11,835	12,139	31,651	32,667
Totals	**291,198**	**305,082**	**311,014**	**325,610**

Key:
ac-ft = acre-feet

Historical daily delivery patterns for 2003 through 2007 were evaluated to develop a wet and dry year delivery pattern which was then applied to the annual volumes developed using land use and applied water rates. In simulation, daily deliveries are aggregated into a single daily value, and are diverted at Daguerre Point Dam.

3.3 Diversion Shortage Provisions

Because of the range of water rights and contract conditions, deficiency provisions vary by Member Unit. Base Project Water allocations are tied to unimpaired Yuba River flow at Smartsville, and Supplemental Water Supplies are tied to availability. Several Member Units have water rights in addition to their contracts with YCWA that are not subject to deficiencies except under extreme conditions. Specific contract deficiency provisions are shown in Table 3.3-1.

Table 3.3-1. Yuba County Water Agency Water Supply Contracts – Deficiency Provisions

Category	Unimpaired Runoff Forecast [a]	Percentage of Settlement/ Contract Allocation Available
Pre-1914 Rights Settlements:		
(a) CID, HIC		
	$f \geq 40\%$	*100%*
	$f < 40\%$	*80%*
(b) BVID Forecasts		
	All	*100%*
YCWA Supply Contracts:		
(a) Base Supply	$85\% \leq f$	*100%*
	$50\% \leq f < 85\%$	*85%*
	$40\% \leq f < 50\%$	*70%*
	$f < 40\%$	*50%*
(b) Supplemental Supply	*All Forecasts*	*Determined annually by YCWA in its reasonable discretion considering forecasted runoff and operational conditions.*

Note: [a]. April 1 DWR forecast of unimpaired Yuba River runoff near Smartsville, in percentage of 50-year average

4.0 Model Overview

The YRDPM simulates Project operations on a daily timestep for a user-designated period of record. Using historical and synthesized hydrology, the YRDPM simulates user-defined operations using a consistent set of operational and physical constraints to determine the Project's response to a wide range of hydrologic conditions. Since the YRDPM is simulating historical hydrology against physical and regulatory conditions that did not necessarily exist at any given time in Project history, a direct comparison of model output against historical conditions would not be practical and could be very misleading. Comparison between model runs with different physical or regulatory conditions can, however, lead to an understanding of a potential range of effects associated with specific physical or regulatory changes.

4.1 Modeling Basics

The YRDPM was developed in Microsoft Excel, with almost all logic and computations written in Visual Basic for Applications (VBA). The model uses Hydrologic Engineering Center Data Storage System (HEC-DSS) for input and output timeseries storage and management.

4.1.1 Timestep

The YRDPM utilizes a daily timestep for Project operations simulation. Some of the decisions are made using a weekly volume, as described below. The model has the capability of simulating time periods from as long as 52 years of hydrology (water years 1970 through 2021) to as short a time interval as a single day, but all simulations must run through September 30. Internally, the model reads input and writes output to simulate as much as a single year at a time. Longer durations require subsequent internal iterations of reading input and writing output; however, from a user's perspective, multiple years and single years are managed in the same way.

4.1.2 YRDPM Model Coverage

The YRDPM model includes the following:

- The North Yuba River below Goodyears Bar
- Slate Creek above the Slate Creek Diversion Dam
- Canyon Creek at its confluence with the North Yuba River
- New Bullards Bar Dam and Reservoir
- The Middle Yuba River from immediately above Our House Dam
- Oregon Creek from immediately above Log Cabin Dam
- Our House Dam
- Log Cabin Dam
- The Lohman Ridge Tunnel
- The Camptonville Tunnel
- The South Yuba River below Jones Bar
- Deer Creek near Smartsville
- New Colgate Powerhouse

- New Bullards Bar Dam New Bullards Bar Minimum Flow Powerhouse
- Englebright Dam and Reservoir
- Narrows 1 and 2 powerhouses
- Daguerre Point Dam
- YCWA agricultural demands
- Smartsville gage
- Marysville gage
- Yuba River from the confluence of the North and Middle Yuba rivers to the Feather River

Figure 2.0-2 shows the hydrologic schematic for the YRDPM.

4.2 Inputs

YRDPM input is classified into two categories: hydrologic input and operations input.

4.2.1 Hydrologic Input

Hydrologic input to the YRDPM is read as a timeseries from a DSS file. Table 4.2-1 indicates the input description and its name in the input DSS file. A complete description of the hydrology development and inputs to the Model is included in Appendix A, YRDPM Hydrology Report.

Table 4.2-1. YRDPM Hydrologic Input Data and DSS Names.

Description	DSS Name
Accretions from Canyon Creek	*CANYON_CR_ACC*
Deer Creek Inflow	*DEER_CR*
Daguerre Point Agricultural Diversion Demand, Present and Future	*DGP_DEM*
Dry Creek Inflow	*DRY_CK*
Total Accretions to Englebright Reservoir	*ENG_ACC_TOTAL*
Accretions to the Englebright Reservoir Area	*ENG_RES_ACC*
Maximum Daily Pumping Volume for Groundwater Substitution Transfer, Present and Future	*GWS_MAX_PUMP*
Accretions to the Middle Yuba River below Oregon Creek	*LOWER_M_YUBA_LOW_ACC*
Accretions to the Middle Yuba River above Oregon Creek	*LOWER_M_YUBA_MID_ACC*
Accretions to the North Yuba River below Goodyears Bar	*LOWER_N_YUBA_ACC*
Accretions to Oregon Creek below Log Cabin Dam	*LOWER_OREGON_CK_ACC*
Accretions to Slate Creek below the Slate Creek Diversion Dam	*LOWER_SLATE_CR_ACC*
Accretions to the South Yuba River below Jones Bar	*LOWER_S_YUBA_ACC*
Middle Yuba River Inflow above Our House Dam	*M_YUBA*
Total Accretions to New Bullards Bar Reservoir	*NBB_ACC_TOTAL*
Accretions to the New Bullards Bar Reservoir Area	*NBB_RES_ACC*
North Yuba River Inflow above Goodyears Bar	*N_YUBA*
Oregon Creek Inflow above Log Cabin Dam	*OREGON_CK*
Slate Creek Inflow above the Slate Creek Diversion Dam	*SLATE_CR*
Slate Creek Inflow below the Slate Creek Diversion Dam	*SLATE_CR_BLW_DD*
South Yuba River Inflow at Jones Bar	*S_YUBA*
Accretions to the Yuba River above Colgate Powerhouse	*UPPER_YUBA_ACC*

4.2.2 Operations Input

Many user inputs are not timeseries and must be input by hand. Foundational parameters related to alternatives are set on the "Scenario Builder and Control" worksheet. Other variables can be set on the "Inputs-Constraints" worksheet. Timeseries inputs are either read in from the input DSS file or are specified on the "Inputs-Timeseries" worksheet.

Table 4.2-2 lists user-defined operations inputs for the YRDPM.

Table 4.2-2. Operations Inputs for the YRDPM.

Operations Input	**Description**
Scenario Builder and Control Variables	
Start Date	*Initial date of simulation.*
End Date	*Final date of simulation.*
Starting NBB Storage	*Initial storage of New Bullards Bar Reservoir.*
Starting Englebright Storage	*Initial storage of Englebright Reservoir.*
Starting Delivery Shortage	*To set initial condition delivery shortage if the simulation starts after the first day of the water year.*
Prev. Year 9/30 Storage (if not starting 10/1)	*To calculate the NYI if the simulation starts after the first day of the water year.*
Inflow to Date (if not starting on 10/1)	*To calculate the NYI if the simulation starts after the first day of the water year.*
Starting Maximum Flow Fluctuation Criteria	*Initializes the previous year's flow fluctuation criteria.*
Use Error Checking?	*Yes/No switch to select whether or not all error-checking will be used.*
Use Automatic Calculations Throughout?	*Yes/No switch to select whether or not automatic calculation is used in each simulation step*
Calculate Water Balance?	*Yes/No switch to select whether or not the model does a water balance check at key locations for each time step*
DSS Input File	*Path and file name of DSS file containing hydrologic input timeseries data*
DSS Output File	*Path and file name of DSS file for the model to write output to. Can be either a new file or an existing one*
Simulation Name	*Name used as the F-Part when writing output to the DSS output file*
Middle and South Yuba Timeseries:	*Selector for various options of Middle Yuba and South Yuba rivers' inflows*
Level of Development	*Level of development for agricultural diversion demand, present or future*
Primary NBB Target Operating Line	*New Bullards Bar Reservoir target operating line*
Secondary (Dry) NBB Target Operating Line	*New Bullards Bar Reservoir target operating line when forecast is drier than trigger volume (not used for Accord CEQA)*
B120 Trigger for Secondary (Less than):	*Trigger for secondary target operating line (not used for Accord CEQA)*
Instream Flow Requirements	*Controlling minimum instream flow requirements for Below Englebright, North Yuba River and Middle Yuba/Oregon Creek*
Hydrologic Index	*Hydrologic Index used for the Instream Flow Requirements for Below Englebright, North Yuba River and Middle Yuba/Oregon Creek*
Starting Year Type	*The hydrologic year-type for the starting date for Below Englebright, North Yuba River and Middle Yuba/Oregon Creek*
Inputs-Constraints Variables	
General Constraints	
Hydrologic Index Calculation	*Perfect Foresight/Bulletin 120 switch to define how the hydrologic index is calculated, either once a year with Perfect Foresight, or monthly from February through June with Bulletin 120*
Month When Water Year Type Changes, if Perfect Foresight is Selected	*Month to change year type when using perfect foresight. Not applicable for Accord CEQA*
Day of Month when Water Year Types Change, if Bulletin 120 is Selected	*Day of month to change the year type when using Bulletin 120 to determine the year type. Set to April for Accord CEQA*
GWS Pumping/Release Pattern	*Pattern for pumping groundwater and releasing it from storage uses 2005 Accord Pattern 1970 to 2000 and historical 2001 to 2021*
Groundwater Substitution for Schedule 6 Years	*Quantity of groundwater substitution transfer in Schedule 6 years. Set by Yuba Accord as 30,000 acre-feet.*
Groundwater Substitution Transfers	*Yes/No selector to identify if additional GWS transfers are simulated. Set to "YES" for Accord CEQA.*

New Bullards Bar Reservoir Constraints	
New Colgate Max	*Maximum release capacity of New Colgate Powerhouse*
New Bullards Bar Reservoir Maximum Storage	*Maximum storage of New Bullards Bar Reservoir, including surcharge space*
New Bullards Bar Reservoir Normal Max Elevation	*Normal maximum water-surface elevation in New Bullards Bar Reservoir*
Colgate Turbine Elevation	*Elevation of New Colgate Powerhouse turbines. Used to determine head differential and resulting generation.*
Violate FERC Minimum Pool to Meet Flow Requirements	*Yes/No switch to all NBB pool elevation to go lower than the FERC minimum pool in order to meet minimum flow requirements. A Yes selection does not allow for releases to Colgate Powerhouse below the FERC minimum pool.*
Flood Pool Buffer	*Buffer on flood pool, used to determine if New Colgate releases can be reduced for Englebright spill avoidance.*
New Bullards Bar Reservoir Flood Operations Constraints	
Maximum Flow Below Dam:	*Maximum release from New Bullards Bar Dam for flood management*
Maximum Flow in Marysville	*Maximum flow in Marysville for flood management*
Use ARC Spillway	*Yes/No switch to use ARC Spillway.*
Use Forecast-Based Flood Releases	*Yes/No switch to use forecast-based flood releases*
Number of Days of Forecast For Forecast-Based Operations	*Number of days of forecast if 'Use Forecast-Based Flood Releases' is turned on.*
Inflow Forecast/Hindcast Exceedance:	*Probability of forecast if "Use Forecast-Based Flood Releasees: is turned on*
Maximum Yuba River Flow for Colgate Generation	*Maximum Yuba River flow that can be used for Colgate generation. Restricts Colgate operations during high flow events.*
New Colgate PH Tailwater Depression System	*Yes/No switch to use FLA proposed tailwater depression system.*
New Bullards Bar Reservoir Spill Cessation	*Type of spill cessation mode to be implemented below NBB Dam*
Use Spill Overrides?	*Yes/No switch to trigger use of override timeseries to override normal YRDPM NBB Dam spill logic. Set to "Yes"*
New Bullards Bar Reservoir Carryover Storage Constraints	
Maximum Carryover Storage	*Greatest volume of computed minimum required end-of-September New Bullards Bar Reservoir storage*
Delivery Target (for Carryover Storage)	*Minimum allocation of agricultural deliveries for following year used to compute minimum required end-of-September New Bullards Bar Reservoir storage*
Maximum Delivery Deficiency	*Maximum deficiency of agricultural deliveries before reducing instream flows*
Carryover Storage Operation Buffer:	*Operational buffer to account for uncertainty in fall hydrology*
Annual Evaporation	*Estimate of New Bullards Bar Reservoir evaporation volume at low storage*
FERC Minimum Pool	*New Bullards Bar Reservoir FERC minimum pool storage volume. Reservoir storage will not be drawn below this storage volume.*
Englebright Reservoir Constraints	
Narrows 1 Capacity	*Maximum release capacity of Narrows 1 Powerhouse.*
Narrows 2 Capacity	*Maximum release capacity of Narrows 2 Powerhouse.*
Narrows Max	*Maximum combined flow of Narrows 1 and Narrows 2 powerhouses*
Apply Narrows 1 FERC License?	*Yes/No switch to operate Narrows 1 for Article 402 Smartsville Minimum flows. Set to "No"*
Narrows 1 & 2 Flow Split	*Defines which Powerhouse, Narrows 1 or Narrows 2, is given higher priority.*
Narrows 1 Min Release	*Minimum release from Narrows 1 Powerhouse due to efficiency limitations. Narrows 1 Powerhouse will not release lower flow.*
Narrows 2 Min Release	*Minimum release from Narrows 2 Powerhouse due to efficiency limitations. Narrows 2 Powerhouse will not release lower flow.*
Narrows Tailwater Elevation	*Assumed normal water-surface elevation of Yuba River for both Narrows 1 and Narrows 2 powerhouses. Used to determine head differential and resulting generation*
Englebright Dam Crest Elevation	*Englebright water-surface elevation at which spills will begin*
Englebright Minimum Pool Elevation	*Minimum storage target for Englebright Reservoir, currently defined by agreement with Englebright marinas.*
Target Englebright Storage	*Target storage in Englebright Reservoir – Colgate releases will either be increased or decreased to reach this storage*
Elevation Trigger for Max Narrows	*Elevation at which Narrows releases will increase to maximum to reduce storage to Target Englebright Storage*
Englebright Area	*Assumed area of Englebright Reservoir at 40,000 ac-ft of storage*
Englebright Spill Avoidance Forecast	*Number of look ahead days to see if a freshet is coming. If a storm is forecasted, Colgate releases are reduced.*

Englebright Inflow Threshold (for freshet avoidance)	*A Freshet is forecasted if inflow exceeds this threshold*
Maximum Colgate Release Reduction for Englebright Spill Avoidance	*Maximum reduction in New Colgate releases to avoid spills from Englebright Reservoir due to high flows on the Middle and South Yuba rivers*
Maintain Colgate Generation through Englebright Spill?	*If "Yes," maintain Colgate generation even if Englebright would spill. If "No," reduce Colgate to avoid spill.*
Maximum Colgate Reduction During Englebright Spill	*Maximum Colgate Reduction for freshet Englebright spill avoidance.*
Smartsville and Marysville Buffer	*Release buffer above the minimum flow to avoid minimum instream flow violation.*
Narrows 1 Annual Outage	*If "Yes," include annual outage. If "No," don't include annual outage.*
Narrows 1 Outage Duration	*Duration of outage.*
Narrows 1 Outage – Earliest Date	*If no spill is forecast on this state or later, initiate outage*
Narrows 2 Annual Outage	*If "Yes," include annual outage. If "No," don't include annual outage.*
Narrows 2 Outage Flow Threshold	*Flow must be below this threshold to initiate outage.*
Narrows 2 Outage Duration	*Duration of outage.*
Narrows 2 Outage – Earliest Date	*If no spill is forecast on this state or later and flow is less than the outflow flow threshold, initiate outage*
Englebright Release Flow Fluctuation Criteria	
Flow Fluctuation Criteria	*Englebright release flow fluctuation criteria, Existing FERC or FLA-Proposed Condition AR9*
Maximum September & October Release Above Minimums	*Maximum allowable Englebright release above minimum required flow in September and October*
September 15 to October 31 Flow Reduction	*Existing FERC maximum allowable reduction of flows below Englebright between September 15 and October 31. From the Narrows 2 Bypass FERC Amendment.*
November 1 to March 31 Maximum Flow Reduction	*Existing FERC maximum allowable reduction of flows below Englebright between November 1 and March 31. From the Narrows 2 Bypass FERC Amendment.*
Maximum Daily Flow Reduction	*Existing FERC maximum daily reduction in flow below Englebright Reservoir for any time of the year. From the Narrows 2 Bypass FERC Amendment.*
Maximum Daily Late Summer Flow Reduction	*Existing FERC maximum daily flow reduction in August and September. From the Narrows 2 Bypass FERC Amendment.*
Maximum September & October Release Above Minimums	*Existing FERC Maximum release above minimum required flow in September and October. From the Narrows 2 Bypass FERC Amendment.*
Amended FLA-Proposed Flow Fluctuation Criteria	*Table with Maximum September to December, and January to May flow reductions as a function of Base Flow.*
Log Cabin and Our House Dam Constraints	
Our House Release Buffer	*Used to add a buffer to required flow below Our House Dam*
Log Cabin Release Buffer	*Used to add a buffer to required flow below Log Cabin Dam*
Lohman Ridge Tunnel Capacity	*Physical capacity of Lohman Ridge Tunnel.*
Camptonville Tunnel Capacity	*Physical capacity of Camptonville Tunnel*
Our House Dam Sluice Gate Capacity	*Physical capacity of Our House Dam Sluice Gate*
Log Cabin Dam Sluice Gate Capacity	*Physical capacity of Log Cabin Dam Sluice Gate*
Sediment Transport Flow	*Pulse flows on the Middle Yuba River and Oregon Creek for sediment transport. Set to "None" for Project Extension SEIR.*
Recreational Flows	*Implement recreation days on the Middle Yuba River for boating flow. Set to "None" for Project Extension SEIR.*
Use Lohman Ridge Tunnel Flow to Meet Oregon Creek Flow Requirement	*Use of imported flow from the Middle Yuba River to meet Oregon Creek minimum flow. Set to "No"*
North Yuba River Water Rights	
Slate Creek Operations	*Defines which method is used to determine Slate Creek flows below the Slate Creek Diversion Dam, using model logic or historical flows*
YCWA North Yuba Water Right	*YCWA's water right to North Yuba River flows*
Maximum SFWPA Diversion Volume (Jan-Jul)	*Maximum cumulative volume of South Feather Water and Power diversions from the Slate Creek Tunnel above 300 cfs between January and July per SFWPA's water right.*
Meet all YCWA Water Rights Prior to Diversion?	*Yes/No switch to specify if SFWP can divert from Slate Creek if YCWA has met its water rights? If yes, then SFWP cannot divert from Slate Creek if YCWA is operating for minimum requirements on Yuba River unless North Yuba inflow exceeds YCWA water right amount.*
SFWP Flow Requirements	*Defines if SFWP diversions and minimum flows are according to current rules, or their proposed FERC requirement.*
NBB Minimum Flow Powerhouse Generation	

Min Flow Powerhouse Centerline El	*Elevation of NBB Min Flow Powerhouse turbine. Used to determine head differential and resulting generation.*
Min Flow Powerhouse Efficiency	*Constant efficiency of NBB Min Flow Powerhouse. Scales resulting generation to account for losses through the Powerhouse.*
Min Flow Powerhouse Capacity	*Maximum release and generation capacity of NBB Min Flow Powerhouse.*
Inputs - Timeseries Variables	
Yuba River Flow Requirements at Smartsville	*Daily average Yuba River flow requirement at Smartsville, as measured at the Smartsville gage, by Water Year type*
Yuba River Flow Requirement at Marysville	*Daily average Yuba River flow requirement at Marysville, measured at the Marysville gage, by Water Year type*
Target Operating Line	*Target storage in New Bullards Bar Reservoir. The model will make releases to reduce storage to this level, subject to an upper and lower buffer. Releases for target operating line are limited to non-spill releases. When New Bullards Bar Reservoir storage is between the Upper and Lower target lines, releases are linearly interpolated between maximum New Colgate capacity and releases for instream flow requirements.*
Volume (AF) above Target Line	*Added to Target Operating Line to define Upper Target Line. If New Bullards Bar Reservoir storage exceeds the Upper Target Line, releases will be made at full New Colgate Capacity*
Volume (AF) below Target Line	*Subtracted from Target Operating Line to define Lower Target Line. If New Bullards Bar Reservoir storage is less than the Lower Target Line, releases will be limited to meeting instream flow requirements.*
Minimum Requirement Below Our House Dam	*Required Middle Yuba River flow below Our House Dam by Water Year type.*
Instream Flow Requirement Below Log Cabin Dam	*Required Oregon Creek flow below Log Cabin Dam by Water Year type.*
Reservoir Evaporation Factors	*Monthly evaporation rate in inches for Englebright and NBB Reservoirs.*
New Bullards Bar Dam Minimum Release Requirements	*Release through the New Bullards Bar Minimum Flow Powerhouse at the base of New Bullards Bar Dam to meets instream flow requirements.*
Flow Requirement below Slate Creek Diversion Dam	*SFWPA monthly flow requirement on the Slate Creek below the Slate Creek Diversion Dam*
Maximum SFWP Diversion	*Monthly Values; 300 cfs except for December 1-July 1 (600 cfs)*
Default Groundwater Substitution Transfer Pumping and Release Pattern	*Pumping: Apr: 10%; May: 25%; Jun: 40%; Jul: 15%; Aug: 10%; Sep: 5%* *Release: Jun: 10%; Jul: 45%; Aug: 45%*
Narrows 1 FERC License Staff Recommendation Flow Requirements	*Article 402 Smartsville minimum flows.*

4.2.3 Outputs

The YRDPM outputs storage, flow, elevation, and generation information for all project components, as shown in Figure 2.0-2. Every simulation also includes without-Project output, representing the hydrology as if the Project had not been constructed (i.e., no Project facilities in place) but all other water projects in the basin are operating. Table 4.2-3 indicates the output description, and its name in a standard output DSS file. With-Project (W-PROJ) and without-Project (WO-PROJ) output variables are differentiated in the C Part of the DSS pathname.

Table 4.2-3. YRDPM Output and DSS Names. Greyed Values Indicate Variables That May not be Present in an Output File Based on Simulation Variables or Operational Parameters Chosen by the Model User.

Description	DSS Part B Pathname	DSS Data Type
Flow through the Camptonville Tunnel	CAMPTONVILLE	FLOW
Inflow at Canyon Creek above the North Yuba River	CANYONCR-ABV-NYR	FLOW
Generation from the New Colgate Powerhouse	COLGATE_GEN	ENERGY
Flow through the New Colgate Powerhouse	COLGATE_REL	FLOW
Critical recreation water-surface elevation for the Cottage Creek Boat Ramp	COTTAGE_CR_BR	ELEVATION
Agricultural Delivery Allocation	DAGUERRE_ALLOC	SHORTAGE
Agricultural Diversion Demand	DAGUERRE_DEM	FLOW
Agricultural Diversion	DAGUERRE_DIV	FLOW
Critical recreation water-surface elevation for the Dark Day Boat Ramp	DARK_DAY_BR	ELEVATION
Critical recreation water-surface elevation for erosion at the Dark Day Boat Ramp	DARK_DAY_BR_EROSION	ELEVATION
Flow at Deer Creek	DEERCR-ABV-YR	FLOW
Inflow at Deer Creek near Smartsville	DEERCR-NR-SMV	FLOW
Inflow at Dry Creek above Yuba River	DRYCR-ABV-YR	FLOW
Controlling flow requirement in the lower Yuba River	DS_REQ	FLOW
End-of-Day Water-Surface Elevation of Englebright Reservoir	ENG-ELEVATION	ELEVATION
Evaporation from Englebright Reservoir	ENG-EVAP	EVAPORATION
Inflows to Englebright Dam excluding North Yuba River above New Bullards Bar Dam	ENG-INFLOW	FLOW
Inflows to Englebright Reservoir excluding releases from New Bullards Bar Reservoir	ENG-INFLOW-TOTAL	FLOW
Operation flags providing insight into what is controlling Englebright Reservoir operations	ENG_OPFLAG	FLAG
Spills from Englebright Reservoir	ENG_SPILL	FLOW
Englebright Reservoir End-of-Day Storage	ENG_STORAGE	STORAGE
Water Balance Check around Englebright Reservoir	ENG-WBAL	SUM
Existing FERC year type	EXISTING FERC	YEARTYPE
Existing flow fluctuation criteria maximum flow for September 15 to October 31	FLOW_FLUC_MAX1	FLOW
Existing flow fluctuation criteria maximum flow for November through March	FLOW_FLUC_MAX2	FLOW
Critical recreation water-surface elevation for the Garden Point Boat-in Campground	GARDEN_POINT_BOAT-IN	ELEVATION
Groundwater pumping flow to support groundwater substitution transfers. Corresponds with a decrease in Daguerre Point Dam diversions	GWS-PUMPING	FLOW
Release of groundwater substitution transfer flow from New Bullards Bar Reservoir. Corresponds with an increase in flow at the Marysville gage	GWS-REL	FLOW
Log Cabin Dam low-level outlet release	LCD_LOW_LEVEL	FLOW
Flow in the Lohman Ridge Tunnel	LOMANRIDGE	FLOW
Total low-level release from New Bullards Bar Dam (NBB-DAM SEEPAGE plus MINFLOW-PH-RELEASE)	LOW-LEVEL-REL	FLOW
Critical recreation water-surface elevation for the Madrone Cove Boat-in Campground	MADRONE_COVE_BOAT-IN	ELEVATION
Generation at the Min Flow Powerhouse	MINFLOWHYDRO-GEN	ENERGY
Release through the Min Flow Powerhouse	MINFLOW-PH-REL	FLOW
Operation flags providing insight into what is controlling Our House Diversion Dam operations	MYR_OPFLAG	FLAG
Flow at the Middle Yuba River above Oregon Creek	MYR-ABV-OC	FLOW
Inflow at the Middle Yuba River above Our House Dam	MYR-ABV-OHD	FLOW
Flow at the Middle Yuba above the Yuba River	MYR-ABV-YR	FLOW
Flow at the Middle Yuba below Oregon Creek	MYR-BLW-OC	FLOW
Inflow accretions for the Middle Yuba River below Oregon Creek reach.	MYR-BLW-OC-ACC	FLOW
Release to the Middle Yuba River from Our House Dam	MYR-BLW-OHD	FLOW
Accretion inflow to the Middle Yuba Ribery below Our House Dam reach	MYR-BLW-OHD-ACC	FLOW

Description	DSS Part B Pathname	DSS Data Type
Minimum instream flow requirement at the Middle Yuba River below Our House Dam.	MYR-BLW-OHD-MIF	FLOW
Water Balance Check at the Marysville Gage	MRY-WBAL	SUM
Generation at the Narrows 1 Powerhouse	NARROWS1-GEN	ENERGY
Release through the Narrows 1 Powerhouse	NARROWS1-REL	FLOW
Bypass flow at either of the Narrows powerhouses; non-spill or generating flow	NARROWS2-BYPASS	FLOW
Generation at the Narrows 2 Powerhouse	NARROWS2-GEN	ENERGY
Release through the Narrows 2 Powerhouse	NARROWS2-REL	FLOW
Flag indicating what is driving the flow split between the Narrows 1 and 2 powerhouses	NARROWS-FLAG	FLAG
Combined generation at the Narrows 1 and 2 powerhouses	NARROWS-GEN-TOTAL	ENERGY
Combined flow through the Narrows 1 and 2 powerhouses	NARROWS_REL	FLOW
Accretion inflow to New Bullards Bar Reservoir	NBB-ACCRETIONS	FLOW
New Bullards Bar Reservoir water-surface area	NBB-AREA	AREA
Seepage flow from New Bullards Bar Dam	NBB-DAM SEEPAGE	FLOW
End-of-Day Water-Surface Elevation of New Bullards Bar Reservoir	NBB-ELEVATION	ELEVATION
Evaporation from New Bullards Bar Reservoir	NBB-EVAP	FLOW
End-of-Day Storage of the New Bullards Bar Reservoir Flood Pool	NBB-FLOOD-POOL	STORAGE
Total daily inflow into New Bullards Bar Reservoir	NBB-INFLOW-TOTAL	FLOW
Total North Yuba River flow above New Bullards Bar Dam	NBB-INFLOW	FLOW
Lower End-of-Day New Bullards Bar Reservoir Operating Line	NBB-LOWERTARGET-LINE	STORAGE
Total Daily Release from New Bullards Bar Reservoir	NBB-REL	FLOW
Spill from New Bullards Bar Reservoir	NBB-SPILL	FLOW
End-of-Day New Bullards Bar Storage	NBB-STORAGE	STORAGE
Upper End-of-Day New Bullards Bar Reservoir Operating Line	NBB-UPPERTARGET-LINE	STORAGE
Water Balance Check at New Bullards Bar Reservoir	NBB-WBAL	SUM
North Yuba Index Value	NORTH YUBA INDEX	INDEX
North Yuba Index year-type	NORTH YUBA INDEX	YEARTYPE
Flow at the North Yuba River above Canyon Creek	NYR-ABV-CANYONCR	FLOW
Inflow at the North Yuba River above Goodyears Bar	NYR-ABV-GYB	FLOW
Flow at the North Yuba River above New Bullards Bar Dam	NYR-ABV-NBB-DAM	FLOW
Flow at the North Yuba River below Canyon Creek	NYR-BLW-CANYONCR	FLOW
Flow at the North Yuba River below Goodyears Bar	NYR-BLW-GYB	FLOW
Accretion inflow to the North Yuba River below Goodyears Bar reach	NYR-BLW-GYB-ACC	FLOW
Flow at the North Yuba River below New Bullards Bar Dam	NYR-BLW-NBB	FLOW
Minimum instream flow requirement at the North Yuba River below New Bullards Bar Dam	NYR-BLW-NBB-MIF	FLOW
Flow at the North Yuba River below Slate Creek	NYR-BLW-SLATECR	FLOW
Flow at Oregon Creek above Log Cabin Dam	OC-ABV-LCD	FLOW
Flow at Oregon Creek above the Middle Yuba River	OC-ABV-MYR/OC-ABV-MYUBA	FLOW
Total releases to Oregon Creek from Log Cabin Dam	OC-BLW-LCD	FLOW
Accretion inflow to Oregon Creek below Log Cabin Dam reach	OC-BLW-LCD-ACC	FLOW
Minimum Instream Flow Requirement below Log Cabin Dam	OC-BLW-LCD-MIF	FLOW
Releases to Oregon Creek from Log Cabin Dam low-level outlet	OHD_LOW_LEVEL	FLOW
Critical recreation water-surface elevation for shoreline camping	SHORELINE_CAMPING	ELEVATION
Flow in Slate Creek above North Yuba River	SLATECR-ABV-NYR	FLOW
Inflow to Slate Creek from Slate Creek Diversion Dam releases	SLATECR-BLW-DIVDAM	FLOW
Accretion inflow to Slate Creek below Slate Creek Diversion Dam reach	SLATECR-BLW-DIVDAM-ACC	FLOW
Smartsville Index year-type	SMARTSVILLE INDEX	YEARTYPE
Inflow at the South Yuba River above Jones Bar gage	SYR-ABV-JBR	FLOW

Description	DSS Part B Pathname	DSS Data Type
Inflow at the South Yuba River above the Yuba River (SYR-ABV-JBR plus SYR-ABV-JBR-ACC)	SYR-ABV-YR	FLOW
Flow at the South Yuba River below Jones Bar gage	SYR-BLW-JBR	FLOW
Accretion inflow to the South Yuba River below Jones Bar gage reach	SYR-BLW-JBR-ACC	FLOW
Flow at the Yuba River above Colgate Powerhouse	YR-ABV-COLGATE	FLOW
Accretion inflow to the Yuba River above Colgate Powerhouse reach	YR-ABV-COLGATE-ACC	FLOW
Flow at the Yuba River above Dry Creek	YR-ABV-DRYCR	FLOW
Accretion inflow to the Yuba River above Englebright reach	YR-ABV-ENG-ACC	FLOW
Flow at the Yuba River above the Feather River	YR-ABV-FR	FLOW
Flow at the Yuba River below Colgate Powerhouse	YR-BLW-COLGATE	FLOW
Flow at the Yuba River below Deer Creek	YR-BLW-DEERCR	FLOW
Flow at the Yuba River below Daguerre Point Diversion Dam	YR-BLW-DGP	FLOW
Flow at the Yuba River below Dry Creek	YR-BLW-DRYCR	FLOW
Flow at the Yuba River below Englebright Dam	YR-BLW-ENG	FLOW
Flow at the Yuba River below Marysville gage	YR-BLW-MRY	FLOW
Flow at the Yuba River below the Middle Yuba River	YR-BLW-MYR	FLOW
Yuba River Index Value	YUBA RIVER INDEX	INDEX
Yuba River Index Year-Type	YUBA RIVER INDEX	YEARTYPE
Yuba River Flow at the Marysville Gage	YR-NR-MARYSVILLE	FLOW
Minimum Instream Flow Requirement at the Marysville Gage	YR-NR-MARYSVILLE-MIF	FLOW
Yuba River Flow at Smartsville	YR-NR-SMARTSVILLE	FLOW
Required Minimum Instream Yuba River Flow at Smartsville	YR-NR-SMARTSVILLE-MIF	FLOW

5.0 Characterization of Physical Facilities

The Project ranges in elevation from approximately 300 ft-msl to 2,050 ft-msl. In total, the Project includes: one dam and associated storage reservoir - New Bullards Bar; two diversion dams, Our House and Log Cabin; two diversion tunnels - Lohman Ridge and Camptonville; two power tunnels - New Colgate and Narrows 2; one penstock – New Colgate; and three powerhouses - New Colgate, New Bullards Bar Minimum Flow Powerhouse, and Narrows 2.

The Project does not include USACE's Englebright Dam and Reservoir or USACE's Daguerre Point Dam. The Project also does not include the Narrows 1 Powerhouse, which is located near the USACE's Englebright Dam and is part of YWA's Narrows 1 Project (FERC Project No. 1403).[2] However, since these facilities are integral parts of operations of the Projects, these facilities are included in the Operations Model.

The model simulates operations of the Project by routing inflows to New Bullards Bar Reservoir, Our House Dam, Log Cabin Dam, Englebright Reservoir and the Yuba River through the various facilities and features in the Project Area.

Inflows to Our House Dam on the Middle Yuba River are routed either to the lower Middle Yuba River, to ensure compliance with minimum flow requirements on the Middle Yuba River below Our House Dam, or into the Lohman Ridge Tunnel, flowing to Oregon Creek. There, the flow from the Lohman Ridge Tunnel is combined with Oregon Creek inflow to be released at Log Cabin Dam to either lower Oregon Creek, to ensure compliance with minimum flow requirements for Oregon Creek below Log Cabin Dam, or into the Camptonville Tunnel. Camptonville Tunnel flows are released into New Bullards Bar Reservoir. Releases to Oregon Creek combine with Middle Yuba River flows and local accretions to flow into the Yuba River.

On the North Yuba River, inflows above Goodyears Bar combine with Slate Creek inflows and local accretions to flow into New Bullards Bar Reservoir. All inflows to New Bullards Bar Reservoir are either stored or released to the North Yuba River or Yuba River below the Dam; a portion of the New Bullards Bar Reservoir releases are made to the North Yuba River to ensure compliance with a requirement on the North Yuba River below New Bullards Bar Reservoir, the remainders are released several miles downstream from New Colgate Powerhouse to the Yuba River. Releases to the North Yuba River combine with flows from the Middle Yuba River to form the headwaters of the Yuba River.

Several miles downstream of the confluence of the North and Middle Yuba rivers, Yuba River flows combine with releases from New Colgate Powerhouse to flow into Englebright Reservoir where they are combined with inflow from the South Yuba River and from local accretions. Releases to the Yuba River from Englebright Reservoir are made through either PG&E's Narrows 1 Powerhouse, YCWA's Narrows 2 Powerhouse, or as spill.

The Smartsville gage (USGS gage 11418000), located on the Yuba River below Englebright Dam, is an important compliance location; both the Lower Yuba River Accord (Yuba Accord) (SWRCB

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[2] The FERC license for PG&E Narrows 1 Project expires on January 31, 2023 (FERC 2003).

2008) and the SWRCB Revised Decision 1644 (RD-1644) (SWRCB 2003) include minimum instream flows at this gage. Flows at the Smartsville gage combine with flows from Deer Creek and Dry Creek before flowing through the Yuba Goldfields to Daguerre Point Dam, the site for YCWA agricultural diversions. The Marysville gage (USGS gage 11421000), located approximately five miles below Daguerre Point Dam, is the other key compliance location for the Yuba Accord and RD-1644. The Yuba River meets the Feather River in the City of Marysville, six miles downstream of the Marysville gage.

5.1 Our House Dam and Lohman Ridge Tunnel

Our House Diversion Dam is a 130- foot-radius, double curvature, concrete arch dam located on the Middle Yuba River 12 mi upstream of its confluence with the North Yuba River. The dam is 70 ft high with a crest length of 368 ft, a crest elevation of 2,049 ft, and a drainage area of 144.8 sq-mi. The dam has an impoundment capacity of 280 ac-ft, but storage and water levels do not fluctuate under Project operations. The YRDPM operates the impoundment as daily inflow equals outflow. The diversion dam has two outlets: 1) a 5-foot diameter steel pipe controlled by a slide gate on the upstream face of the dam with a maximum capacity of 800 cfs and a centerline elevation of 1,990 ft; and 2) a 24-inch diameter release pipe, with a maximum capacity of 60 cfs and a centerline elevation of 2,000 ft. The diversion dam has a spillway capacity of 60,000 cfs.

The Lohman Ridge Diversion Tunnel is 12.5 ft high by 12.5 ft wide and conveys a maximum flow of 860 cfs through its 19,410 ft length (90% unlined and 10% lined) to Oregon Creek.

Middle Yuba River inflows are introduced to the model above Our House Dam. Our House Dam splits Middle Yuba River inflows to two paths: the Lohman Ridge Tunnel or the Middle Yuba River below Our House Dam. The Lohman Ridge Tunnel releases into Oregon Creek above Log Cabin Dam, and the Middle Yuba River joins with the North Yuba River to form the Yuba River. Maximum flow in the Lohman Ridge Tunnel is assumed to be 860 cfs. Maximum flow through the Our House Dam sluice gate is assumed to be 600 cfs. There is no limitation on maximum flow below Our House Dam.

The Lohman Ridge Tunnel and Our House Dam sluice gate maximum flow capacity are specified on the *Inputs-Constraints* worksheet.

5.2 Log Cabin Dam and Camptonville Tunnel

Log Cabin Diversion Dam is a 105-ft-radius, concrete arch dam on Oregon Creek that has a drainage area of 29.1 sq-mi and a maximum spillway capacity of 12,000 cfs. The dam has an impoundment capacity of 90 ac-ft, but storage and water levels do not fluctuate under Project operations. The YRDPM operates the impoundment as daily inflow equals outflow. The diversion dam has two outlets: 1) a 5-ft diameter steel pipe controlled by a slide gate on the upstream face of the dam with a maximum capacity is 540 cfs; and 2) an 18-inch diameter release pipe, with a maximum capacity of 13 cfs, located above the low-level outlet and controlled by a downstream gate valve operated by hand.

The Camptonville Diversion Tunnel is 6,107 ft long and has the capacity to convey 1,100 cfs of water to New Bullards Bar Reservoir. The first 4,275 ft of the conduit is an unlined, horseshoe tunnel 14.5 ft wide by 14.5 ft high, becoming a lined, horseshoe tunnel 11.7 ft wide by 13 ft high for the remaining 1,832 ft.

Oregon Creek inflows are introduced to the model above Log Cabin Dam. Log Cabin Dam also receives flows from the Lohman Ridge Tunnel. Inflows to Log Cabin Dam are split to either the Camptonville Tunnel, which flows into New Bullards Bar Reservoir, or to Oregon Creek, which later joins the Middle Yuba River below Our House Dam. Maximum flow capacity of the Camptonville Tunnel is assumed to be 1,100 cfs. Maximum flow through the Log Cabin Dam sluice gate is assumed to be 540 cfs. There is no limitation on maximum flow below Log Cabin Dam.

The Camptonville Tunnel and Log Cabin Dam sluice gate maximum flow capacity are specified on the *Inputs-Constraints* worksheet.

Historically, flow from the Middle Yuba River is used to meet minimum instream flow below Log Cabin Dam when natural inflow to Log Cabin Dam is less that the minimum instream flow requirement and water is being diverted from the Middle Yuba River to Oregon Creek through the Lohman Ridge Tunnel. There is a Yes/No toggle on the *Inputs-Constraints* worksheet for the model user to select to use Lohman Ridge Tunnel flow to Meet Oregon Creek flow Requirement. The default value for this toggle is Yes.

5.3 Slate Creek Diversion Dam

Inflows from Slate Creek to the Slate Creek Diversion Dam are subject to diversion to the South Feather River via the Slate Creek Tunnel. YCWA's and SFWPA's water rights, and minimum instream flow requirement below the Slate Creek Diversion Dam determine how much flow is diverted versus how much flow is released to Slate Creek below the Diversion Dam. Water released to Slate Creek below the Diversion Dam is inflow to the Project. The model has two modes of simulating Slate Creek inflows to the Project, the model can use either the timeseries of historical inflows below the Slate Creek Diversion Dam; or inflows above the Slate Creek Diversion Dam are diverted according to SFWPA and YCWA water rights, and minimum flow requirements below Slate Creek Diversion Dam.

Using the "Historical Flows" option, Slate Creek flows below the Slate Creek Diversion Dam at USGS gage 11413300 are used as the inflow to the model. These inflows are added to synthetic accretions to represent inflows to the North Yuba River.

Using the "Operate Slate Creek" option, historical Slate Creek flow above the Slate Creek Diversion Dam is determined by adding USGS gage 11413300 (Slate Creek below the Slate Creek Diversion Dam) and USGS gage 11413250 (Slate Creek Tunnel below the Slate Creek Diversion Dam). The diversion amount is determined, subject to SFWP and YCWA's water rights and FERC licenses; and the maximum capacity of the Slate Creek Tunnel of 600 cfs.

5.4 New Bullards Bar Reservoir

New Bullards Bar Dam is a 1,110 foot-radius, double curvature, concrete arch dam located on the North Yuba River about 2.4 mi upstream of its confluence with the Middle Yuba River. The dam is 645 ft high with a maximum elevation of 1,965 ft-msl. The dam includes one low-level outlet - a 72-inch Hollow Jet Valve, with an invert elevation of 1,395 ft-msl, has a maximum design capacity of about 3,500 cfs at full reservoir pool, and an actual capacity of 1,250 cfs (the release capacity is limited to 1,250 cfs due to valve vibrations at greater release rates).

The reservoir has a gross storage capacity of 966,103 ac-ft with a FERC minimum operating storage of 234,000 ac-ft, leaving 732,103 ac-ft of regulated capacity. YCWA typically operates New Bullards Bar Reservoir by capturing winter and spring runoff from rain and snowmelt for release later in the year. Consequently, New Bullards Bar Reservoir reaches its peak storage at the end of the spring runoff season, and then is gradually drawn down as storage is released to the Yuba River. Releases are made through both the New Bullards Bar Minimum Flow Powerhouse at the base of the dam and to the Yuba River through the New Colgate Power Tunnel and New Colgate Powerhouse on the Yuba River. The reservoir usually reaches its lowest elevation in early to mid-winter. The annual drawdown in normal water years is about 90 ft. The reservoir does not undergo significant daily changes in elevation.

New Bullards Bar Reservoir is used to provide irrigation water supply to about 90,000 ac of farmland in western Yuba County. Releases of water from storage are made through the spring and summer to provide flows diverted at USACE's Daguerre Point Dam at RM 11.6 on the Yuba River. Water is released from storage in the fall for diversion at USACE's Daguerre Point Dam for rice stubble decomposition and waterfowl habitat.

New Bullards Bar Reservoir is also the main flood control facility for the Yuba River area. 170,000 ac-ft of storage capacity, or approximately 23 percent of the usable capacity of the reservoir, is reserved from October through May for flood protection purposes.

In addition to providing flood protection, power, and downstream water supply, YCWA pumps water directly from New Bullards Bar Reservoir to supply water to the Cottage Creek Water Treatment Plant for domestic and recreation uses adjacent to the reservoir. Pumping averages approximately 6 ac-ft per year. This relatively small volume of pumping does not affect Project operations.

Simulation of New Bullards Bar Reservoir includes an elevation-storage-surface area curve defining reservoir storage and surface area for elevations ranging from 1,360 feet ft-msl to 1,965 ft-msl. Simulated inflows to New Bullards Bar Reservoir come from the following:

- The North Yuba River
- Local accretions
- The Camptonville Tunnel

5.4.1 Reservoir Releases

Releases from New Bullards Bar Reservoir are made through one or more of the following outlets:

- New Colgate Powerhouse
- New Bullards Bar Minimum Flow Powerhouse
- New Bullards Bar Primary Spillway
-
- Low-level flood control outlet (optional)

Decisions about which outlet to use are made based on reservoir storage volume relative to several operation curves described later in this report. The New Colgate Powerhouse has a maximum release capacity of 3,430 cfs, the New Bullards Bar Minimum Flow Powerhouse has a maximum capacity of 6 cfs. The Primary Spillway releases are governed by curves relating water-surface elevation to maximum release, as shown in Table 5.4-1.

Table 5.4-1. New Bullards Bar Reservoir Maximum Release.

Elevation (ft-msl)	**Maximum Primary Spillway and Powerhouse Release (cfs)**
1,730	*3,430*
1,870	*3,430*
1,874	*3,430*
1,878	*3,430*
1,882	*3,430*
1,886	*3,430*
1,890	*3,430*
1,895	*3,430*
1,898	*3,430*
1,902	*3,871*
1,905	*6,993*
1,910	*12,993*
1,915	*19,918*
1,920	*27,624*
1,925	*38,794*
1,930	*50,316*
1,935	*64,714*
1,940	*79,521*
1,945	*96,748*
1,950	*114,485*
1,955	*134,333*
1,960	*153,795*
1,965	*160,840*

Column 2 Source: USACE, New Bullards Bar Reservoir, Reservoir Regulation for Flood Control, June 1972.

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Key:
cfs = cubic feet per second
ft-msl=feet above mean sea level

Minimum instream flow requirements below New Bullards Bar Dam are defined on the *Inputs-Timeseries* worksheet and are selected for simulation by the user on the *Scenario Builder and*

Control worksheet. The New Colgate Powerhouse and Minimum Flow Powerhouse maximum flow capacities are specified on the *Inputs-Constraints* worksheet. The Primary Spillway and ARC Spillway maximum flow capacities by water-surface elevation are specified on the *NBB Pool* worksheet.

5.4.2 New Colgate Powerhouse Generation

The New Colgate Powerhouse contains two Voith Siemens Pelton-type turbines with a total capacity of 340 MW under a design head of 1,306 ft and a rated flow of 3,430 cfs. The powerhouse receives water from the New Colgate Power Tunnel and Penstock. The New Colgate Power Tunnel and Penstock is 5.2 mi long and composed of four different types of conveyance structures: an unlined horseshoe tunnel 26 ft square; a lined horseshoe tunnel 20 ft wide and 14.5 ft high; a lined circular tunnel 14 ft in diameter; and 2,809 ft of steel penstock with a diameter ranging from 9 ft to 14.5 ft.

The model calculates New Colgate hydropower generation as a function of flow through the powerhouse and the water-surface elevation of New Bullards Bar Reservoir. Actual load-flow and efficiency curves for the powerhouse were unavailable, so empirical head, flow, and power generation data were analyzed to create both load-flow curves and the methodology for calculation of turbine performance under changing reservoir pool elevation conditions.

Observed mean daily water-surface elevations for New Bullards Bar Reservoir were available for the full POR of the Project, but to develop the best possible relationship, it was decided that hourly power generation and flow should be used; data for 2002 through 2008 were compiled and evaluated. For purposes of this evaluation, daily change in reservoir elevation is considered insignificant compared to the variability of hourly head and flow. While additional water years of data were available, it was desired to analyze a period with roughly consistent operations for the entire period of record, so hourly data from water years 2002 to 2008 for New Colgate Powerhouse was determined to provide a sufficiently large dataset.

The gross head was calculated as the difference between the respective daily observed reservoir water-surface elevation and the Pelton turbine centerline elevation at New Colgate Powerhouse. For calculation purposes, head was assumed to remain constant throughout the day.

Microsoft Excel and HEC-DSS were used to organize and group the power generation, flow, and gross head data by date and respective hour. New Colgate hourly powerhouse generation was calculated as the combined generation of both units. Efficiency was calculated for each hour by solving for efficiency in the power equation, as described below.

$$P = \frac{\eta Q H}{11.815}$$

Where:

P = Power generation (kW)
Q = flow through the powerhouse (cfs)
H = Gross head through the powerhouse (ft)
η = Total system efficiency

The efficiency is the percentage of the measured power generation to the maximum power that could be generated with 100 percent component efficiencies and zero head losses within the conveyance system. For this study, the maximum efficiency is a function of the total gross head, making this the total system efficiency, not the powerhouse or turbine unit efficiency. By using the overall system efficiency, component and conveyance headlosses were not calculated. System efficiencies are provided as check and discussion points but were not incorporated into the model directly.

Large portions of missing data for head or flow were observed within the dataset, making those hourly points unusable for analysis. Extreme outliers, or points outside of the powerhouse operating limits, were observed and were also removed from the dataset. This included hourly data with efficiencies of less than 20 percent or greater than 120 percent and New Colgate Powerhouse flows less than 100 cfs or greater than 3,500 cfs. Flows greater than 1,500 cfs with efficiencies less than 50 percent were also removed. The resulting filtered dataset had over 54,000 hours of measured generation, flow, and gross head data for New Colgate.

Affinity laws, also referred to as similarity rules or laws, express the mathematical relationship between many of the physical, hydraulic, and operational parameters of geometrically similar (homologous) pumps and turbines (Arndt and Gulliver 1991). These laws are a set of equations and assumptions derived from fluid mechanics and hydraulics principles used to estimate performance of a pump or turbine in comparison to other homologous pumps or turbines (Zipparro and Hasen 1993). These rules are most often used in physical modeling or system sizing. For this analysis, the equations were adapted to evaluate performance of a single turbine under different operating conditions.

With any known operating point for any pump or turbine, the affinity laws can be modified algebraically into the following equations that estimate the power and flow to a new head with the same efficiency as the original known operating point (Brown 1965).

Adjustment for power generation at new head (Brown 1965):

$$P_2 = P_1\sqrt{\left(\frac{H_2}{H_1}\right)^3}$$

Adjustment for flow at new head (Brown 1965):

$$Q_2 = Q_1\sqrt{\frac{H_2}{H_1}}$$

Where:

P_1 = Known power generation at known head (MW)

P_2 = Adjusted power generation under new head (MW)

H_1 = known head (ft)

H_2 = New head (ft)

Q_1 = Known flow at known head (cfs)

Q_2 = Adjusted flow at new head (cfs)

Load-flow curves are based on a set static head. The above equations adjust power and flow from any single point on the load-flow curve based on changes in head with no loss in efficiency. In order to create new load-flow curves for New Colgate Powerhouse, this process was performed in reverse. The empirical power generation and flow values were adjusted based on the affinity equations to a new reference head. The resulting dataset of adjusted flow and power generation represent points on the new load-flow curve at the gross normal head of 1,390 ft for New Colgate Powerhouse.

The extremely large dataset of over 54,000 points was difficult to manage and analyze, so power generation and flow data were averaged into 10 cfs incremental ranges, from the lowest operational flow to the maximum powerhouse or tunnel rated flow. This reduced the number of points within the dataset to less than 400 while maintaining acceptable data resolution. This became the working dataset for the steps outlined below.

After plotting the averaged load-flow curve, it was observed that there were still outliers that needed to be eliminated, specifically local maximum points on the load-flow curve. In a hydropower facility, power generation increases with an increase in flow within normal operating limits. Local maximums that do not conform to these general principles prove problematic for modeling and optimization.

In order to remove these inconsistencies, a data smoothing technique using a gaussian (bell curve) weighting method was applied to create a weighted average for the values of the power generation values. This method applies a weighted average using the averaged power generation corresponding to 20 data points, or 200 cfs, above and below each point. The weights vary between one (at the hourly power generation data being analyzed) to near zero (at the upper and lower limits). The analyzed data point and those data points immediately adjacent to it have the greatest values. The weights then depreciate significantly before becoming near zero at the upper and lower limits.

The Gaussian smoothing technique better represents the empirical generation and flow data than any linear, logarithmic, or polynomial regression for the entire curve, but does not function accurately within 200 cfs of the end of the lower and upper flow limits. A linear regression was performed on the lower 300 cfs at each facility and the results were used to calculate the power generation at the lower 200 cfs of the flow limit at the New Colgate Powerhouse. For the upper flow limits, a quadratic function was fit to the upper 400 cfs for the New Colgate facility.

The final load flow curves are the combination of the Gaussian smoothing technique results and the calculated regressions at the upper and lower 200 cfs of flow. Using this revised load-flow curve, efficiencies were calculated using the power equation described above and an efficiency-flow curve was created for each facility. The New Colgate load-flow and efficiency curves are in Figures 5.4-1 and 5.4-2 below.

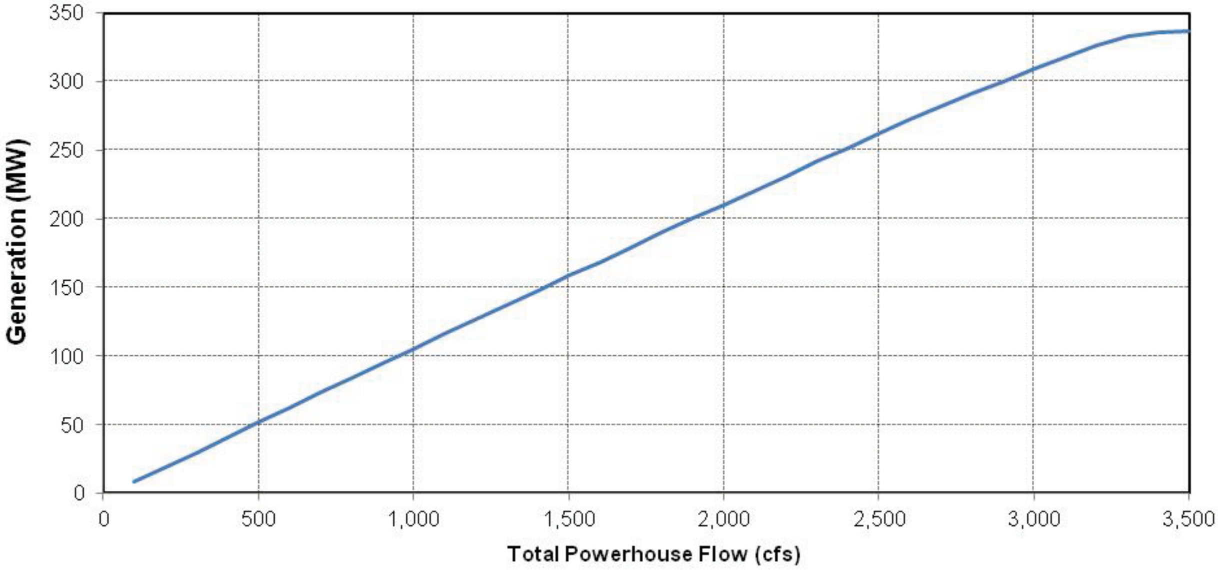

Figure 5.4-1. New Colgate Powerhouse Load-Flow Curve at Gross Head 1,396 ft.

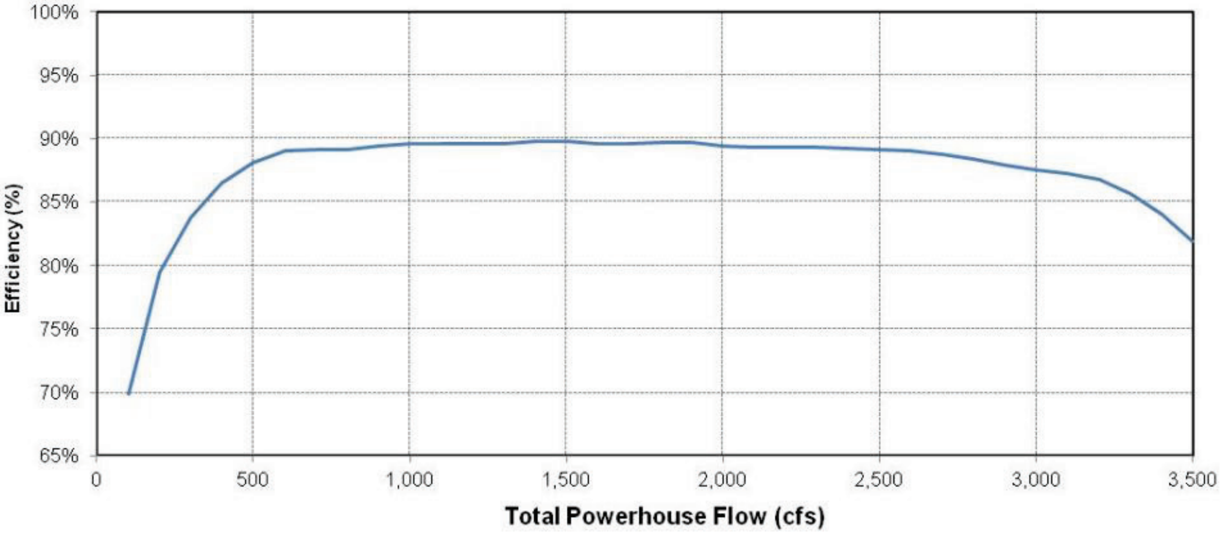

Figure 5.4-2. New Colgate Efficiency Curve at Gross Head 1,396 ft.

The flow-efficiency curve shown in Figure 5.4-2 is typical of Pelton turbines. The six-jet Pelton turbine design at New Colgate powerhouse allows operators to run each turbine with any number of jets to maximize efficiency. For the New Colgate powerhouse, with two six-jet Pelton units, operations could range from one jet operating at minimum flows to all six jets in both units operating at the maximum rated discharge. Each combination of jets will have its own associated efficiency curve if allowed to operate under a full range of conditions. As the flow increases or decreases, the number of jets in operation is changed to maximize the efficiency and power production.

The ability of the six-jet Pelton turbine to maintain a high, relatively steady efficiency curve results in a near linear load-flow curve, as shown in Figure 5.4-1. The diminishing increase in power production as the flow approaches the upper limits of discharge is attributed to the combined dip in the turbine efficiency curve and the effects of frictional head loss within the conveyance system. Head loss is a function of the flow velocity squared and becomes more pronounced when flows approach capacity.

Load-flow and flow-efficiency data for normal-gross head are in the *Power Gen* worksheet. Affinity laws are used to adjust generation rates to different head values. Generation calculations are performed in the model VBA code in the PowerGen subroutine.

When Yuba River flow upstream of the New Colgate Powerhouse reaches approximately 20,000 cfs, foam and backsplash cause uneven resistance to free rotation of the turbines which causes vibration. Consequently, the rate of powerhouse release must be reduced, and at high stages, operation of the turbines must cease.

Generation calculations are performed in the model VBA code in the PowerGen subroutine.

5.4.3 Minimum Flow Powerhouse Generation

Minimum flow powerhouse generation is calculated in the model using the Power equation:

$$P = \frac{\eta QH}{11.815}$$

Where:

P = Power generation (kW)
Q = flow through the powerhouse (cfs)
H = Gross head through the powerhouse (ft)
η = Total efficiency

Flow through the powerhouse is calculated as the minimum required flow below New Bullards Bar Dam minus seepage or maximum flow capacity, whichever is less; gross head through the powerhouse is the water-surface elevation of New Bullards Bar Reservoir minus the minimum flow powerhouse centerline elevation; and total efficiency is assumed to be constant. The minimum flow powerhouse centerline elevation and the total system efficiency are specified on the *Inputs-Constraints* worksheet.

Total system efficiency is estimated at 80% based on an analysis of historical generation data. Because of the uncertainty of seepage flow through the dam, and the corresponding flow through the minimum flow powerhouse, a constant efficiency was deemed an appropriate simplification. Efficiency normally varies with flow and head.

Generation calculations are performed in the model VBA code in the PowerGen subroutine.

5.4.4 Dam Seepage

Minimum flow on the North Yuba River downstream of New Bullards Bar Dam is met through a combination of releases from the New Bullards Bar Minimum Flow Powerhouse and seepage from the New Bullards Bar Dam. Seepage below the dam is measured regularly.

To represent seepage in the model, total seepage data from October 1997 through December 2012 were analyzed to generate a regression equation relating water-surface elevation to flow, shown in Figure 5.4-3. The resulting regression equation is:

$$Q = 0.002118e^{0.012988*H}$$

Where:

Q = Total New Bullards Bar Dam seepage flow (cfs)
H = Gross head through the system (ft)

Gross head is the difference between the water-surface elevation of New Bullards Bar Reservoir and the minimum flow powerhouse centerline elevation. The seepage flow regression equation can be found in the model VBA code in the Operations subroutine.

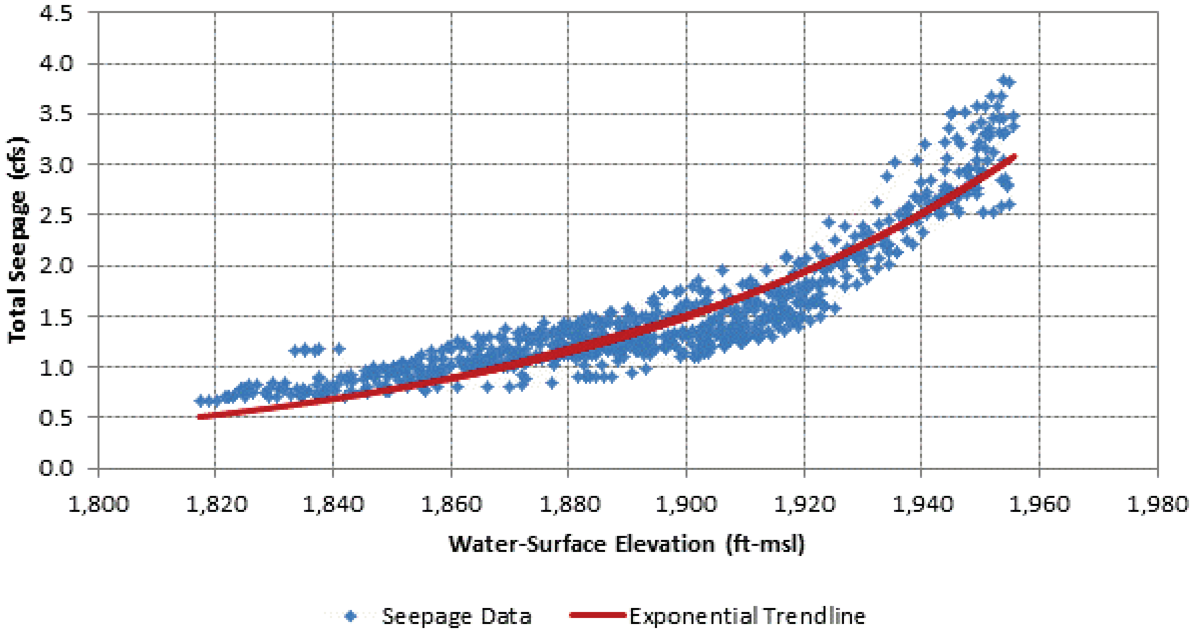

Figure 5.4-3. New Bullards Bar Dam Seepage Data and Exponential Curve Fit to the Seepage Data.

5.4.5 Evaporation

Evaporation from New Bullards Bar Reservoir is assumed to follow a monthly pattern, as shown in Table 5.4-3. YRDPM looks up New Bullards Bar Reservoir's water-surface area based on the reservoir's storage and multiplies it by the daily evaporation rate to compute a daily evaporation volume.

Table 5.4-3. New Bullards Bar Reservoir Monthly Evaporation Factors.

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Monthly Evaporation Rate (in)	*4.31*	*1.67*	*1.04*	*0.93*	*1.70*	*2.44*	*3.21*	*4.13*	*6.48*	*7.78*	*7.24*	*5.08*
Daily Evaporation Rate (ft)	*0.0116*	*0.0046*	*0.0028*	*0.0025*	*0.0051*	*0.0066*	*0.0089*	*0.0111*	*0.0180*	*0.0209*	*0.0195*	*0.0141*

Source: *DWR HEC-3 Yuba River Watershed Model. January 1985*
Key:
in = inches
ft = feet

Monthly evaporation rates are defined in the model on the *Inputs-Timeseries* worksheet. Daily evaporation is calculated in the model VBA code in the Operations subroutine.

5.5 Englebright Reservoir

Englebright Dam and Reservoir were constructed in 1941 by the USACE to capture sediment produced by upstream hydraulic mining activities. The reservoir is situated downstream of the New Colgate Powerhouse. The average annual inflow to Englebright Reservoir, excluding releases from New Bullards Bar Reservoir, is approximately 400 TAF (thousand acre-feet). Englebright Reservoir has a total storage capacity of approximately 70 TAF but provides limited conservation storage because the reservoir is used to attenuate power-peaking releases from New Colgate Powerhouse. Englebright Reservoir is used extensively for recreation.

Simulation of Englebright Reservoir includes a stage-storage curve defined for 0.01-ft water-surface elevation increments between 500 ft-msl and 550 ft-msl. Simulated inflows come from the following:

- The Yuba River
- The South Yuba River
- Local accretions.

5.5.1 Reservoir Releases

Englebright Dam has no low-level outlet. Releases are made through one or more of the following outlets:

- Narrows 1 Powerhouse
- Narrows 2 Powerhouse
- Powerhouse bypasses, which are aggregated for purposes of modeling
- Spill over the dam crest

YCWA operates Narrows 1 and 2 for hydropower efficiency and to maintain relatively constant flows in the Yuba River below Englebright Dam. Spills over the dam crest are uncontrolled and are a function of reservoir water-surface elevation. Table 5.5-1 shows the maximum release from Englebright Reservoir, as a function of water-surface elevation.

Table 5.5-1. Maximum Englebright Reservoir Release by Elevation.

Elevation (ft-msl)	Maximum Spillway and Powerhouse Release (cfs)
516	*4,130*
527	*4,136*
528	*5,410*
529	*8,220*
530	*11,970*
531	*16,730*
532	*22,430*
533	*28,430*
534	*35,330*
535	*43,030*
540	*92,130*
545	*155,130*
550	*185,130*

Source: Yuba County Water Agency
Key:
ft-msl = feet above mean-sea level
cfs=cubic feet per second

Englebright Reservoir's range of operable water-surface elevations is 516 ft-msl to 527 ft-msl. When water-surface levels in Englebright Reservoir reach 516 ft-msl, the launch ramps at the Skipper's Cove Marina become unusable. Englebright Dam's spillway crest is at 527 ft-msl.

Releases through the Narrows 1 Powerhouse are limited to a maximum of 730 cfs; and releases through the Narrows 2 Powerhouse are limited to 3,400 cfs, for a maximum generating flow of 4,130 cfs. Due to efficiency limitations, Narrows 2 Powerhouse is not generally operated below 900 cfs, though it has recently operated as low as 700 cfs, if needed. Decisions about which powerhouse is used for releases are made based on the desired release rate, as described later in this report. Since there are no mechanisms to control flows over the dam crest, the YRDPM includes a curve relating water-surface elevation over the dam crest to the rate of spill.

Minimum instream flow requirements below Englebright Dam are defined on the *Inputs-Timeseries* worksheet and are selected for simulation by the user on the *Scenario Builder and Control* worksheet. The Narrows 1 and Narrows 2 Powerhouse maximum flow capacities are specified on the *Inputs-Constraints* worksheet. The spillway flow capacity by reservoir elevation is specified on the *Englebright Pool* worksheet.

5.5.2 Narrows 1 Powerhouse Generation

Narrows 1 Powerhouse is a 12 MW facility, with a discharge capacity of approximately 730 cfs and a bypass flow capacity (when the generator is not operating) of 540 cfs.

The relationship between Englebright Reservoir elevation and Narrows 1 flow and generation are based on a 1941 flow test. The resulting Narrows 1 load-flow curve is below in Figures 5.5-1.

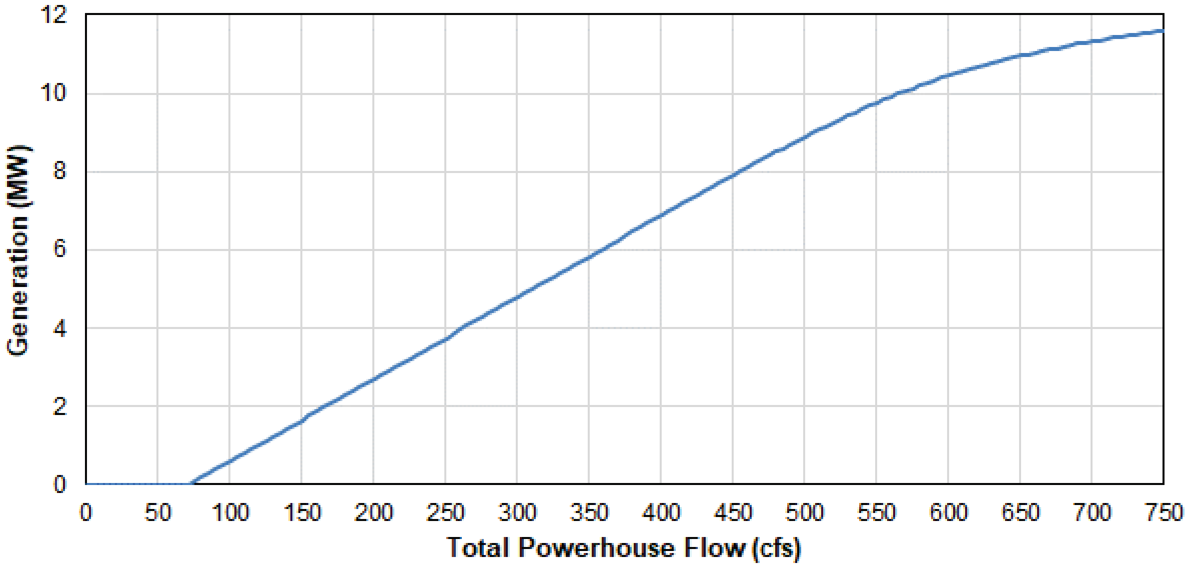

Figure 5.5-1. Narrows 1 Powerhouse Load-Flow Curve at Static Head 235 ft.

5.5.3 Narrows 2 Powerhouse Generation

Narrows 2, which is part of the Project, is a 50 MW facility, with a discharge capacity of approximately 3,400 cfs and a bypass flow capacity of 3,000 cfs.

Narrows 2 Powerhouse historical hourly generation data for 1995 through 2010 were evaluated to develop flow-head-efficiency relationships. Hourly Data were removed under the following conditions: 1) flows of less than 600 cfs; 2) flows greater than 3,600 cfs; or 3) flows greater than 1,500 cfs with efficiencies less than 50%. Additional hourly data were removed when total Englebright Dam releases exceeded 5,000 cfs to minimize the uncertainty related to tailwater affects. The final dataset included over 100,000 points, so Gaussian smoothing was used. The resulting Narrows 2 load-flow and flow-efficiency curves are below in Figures 5.5-2 and 5.5-3, respectively. Narrows 2 Powerhouse has a typical efficiency curve associated with a single Francis Turbine characterized by a single maximum efficiency point and a steady decrease in efficiency as flows increase beyond the maximum efficiency point.

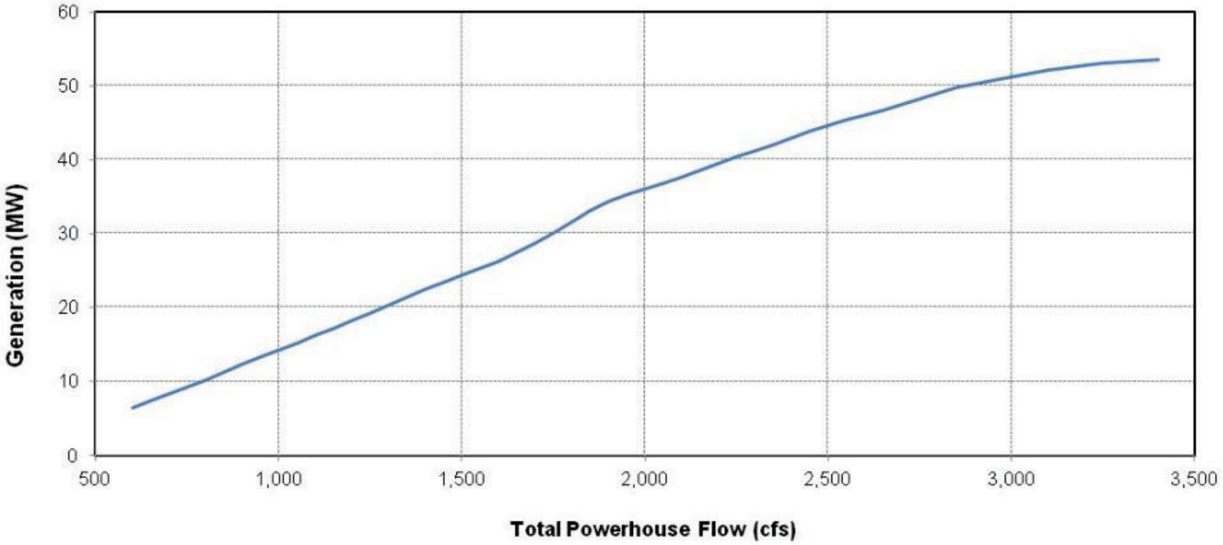

Figure 5.5-2. Narrows 2 Powerhouse Load-Flow Curve at Gross Head 240 ft.

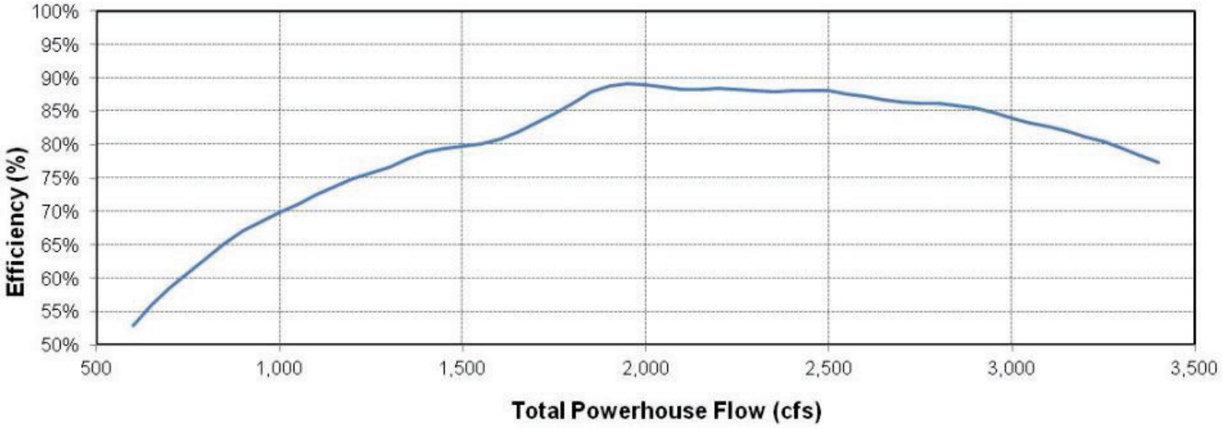

Figure 5.5-3. Narrows 2 Efficiency Curve at Gross Head 240 ft.

Narrows 2 load-flow and flow-efficiency data for normal-gross head are located in the *Power Gen* worksheet. Affinity laws, described in Section 5.4.2, are used to adjust generation rates to different head values. Generation calculations are performed in the model VBA code in the PowerGen subroutine.

5.5.4 Evaporation

Simulation of Englebright Reservoir includes flow losses due to evaporation. Since there is little variation in Englebright Reservoir water-surface area, evaporation varies only by month; it is not dependent upon reservoir storage. Table 5.5-2 shows the monthly Englebright Reservoir evaporation rates.

Table 5.5-2. Englebright Reservoir Monthly Evaporation Factors.

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Monthly Evaporation Rate (in)	*5.03*	*1.95*	*1.21*	*1.09*	*1.99*	*2.85*	*3.75*	*4.83*	*7.58*	*9.09*	*8.46*	*5.94*
Daily Evaporation Rate (ft)	*0.0135*	*0.0054*	*0.0033*	*0.0029*	*0.0059*	*0.0077*	*0.0104*	*0.0130*	*0.0211*	*0.0244*	*0.0227*	*0.0165*

Source: *DWR HEC-3 Yuba River Watershed Model. January 1985*
Key:
in = inches
ft=feet

Monthly evaporation rates are defined in the model on the *Inputs-Timeseries* worksheet. Daily evaporation is calculated in the *Englebright Pool* worksheet.

5.6 Daguerre Point Dam

USACE's Daguerre Point Dam, a weir-type dam, was constructed by the California Debris Commission to prevent hydraulic mining debris from the Yuba River watershed from flowing into the Feather and Sacramento rivers. The dam, which was constructed in 1906 and rebuilt in 1964 following damage from floods, has no appreciable storage capacity. Daguerre Point Dam is used by YCWA to provide for gravity diversion of agricultural water supply to its Member Units. Releases to the Yuba River below the dam are made either through a fish ladder at each end of the dam or over the dam's crest. See Section 3 for discussion of agricultural demands met by YCWA at Daguerre Point Dam.

6.0 Characterization of Operational Rules

As a deterministic model, the YRDPM must prescribe specific actions for all observed and anticipated conditions. Much of this logic is handled through VBA scripting, while other portions are managed through Excel formulas. This section provides a narrative description of the general operational logic for each facility.

6.1 Our House Dam Operations

Our House Dam makes releases through a valve near its base to meet instream flow requirements in the Middle Yuba River below Our House Dam, diverts additional flows into the Lohman Ridge Tunnel and spills any additional flows over the dam to the Middle Yuba River.

Simulation of Our House Dam includes an Operations Flag indicating the controlling operation. Table 6.1-1 shows the Operations Flags at Our House Dam.

Table 6.1-1. Our House Dam Operations Flags.

Operations Flag	Description
Releases for Flows Below Our House Dam (OpFlag)	
1	*Minimum instream flow control*
2	*Inflow=outflow flow control (inflow<min req flow)*
3	*Spill flow control*
3.5	*spill cessation flow control*
4	*Sediment pulse flow control*
4.5	*Combined sediment pulse flow/spill flow control*
5	*Recreation flow Control*
6	*Combined sediment-pulse/recreation flow control*
7	*Natural flow control (tunnels closed)*
7.4	*Combined natural flow/sediment pulse flow control*
7.5	*Combine natural flow/recreation flow control*
7.6	*Combined natural flow/sediment pulse flow/recreation flow control*
0	*Something else*

6.1.1 Instream Flow Requirements

YCWA operates to meet a minimum flow or all-natural inflow up to the minimum flow in the Middle Yuba River below Our House Dam. For each day of simulation, the YRDPM determines the appropriate flow requirement, and releases either the natural inflow or the minimum flow, whichever is less, to the Middle Yuba River. In the case that releases are made to meet the minimum flow, a buffer flow is added, if available, to emulate real-world operations ensuring sufficient flow reaches the gage.

Minimum instream flow requirements below Our House Dam are defined on the *Inputs-Timeseries* worksheet and are selected for simulation by the user on the *Scenario Builder and Control* worksheet. The buffer flow is specified on the *Inputs-Constraints* worksheet.

6.1.2 Diversions

Once minimum flows have been met, inflows to Our House Dam up to the tunnel capacity are diverted through the Lohman Ridge Tunnel to Oregon Creek. The Lohman Ridge Tunnel maximum capacity is specified on the *Inputs-Constraints* worksheet.

6.1.3 Spill Cessation

On the *Inputs-Constraints* worksheet, there is a spill cessation mode toggle button. This toggle button was added during the FERC relicensing process to activate spill cessation proposals by YCWA and relicensing participants.

The existing FERC license does not include a spill cessation schedule for Our House Dam, and while spill cessation is proposed in the new FERC license, the Accord Extension modeling assumed the existing FERC requirements remained in effect.

6.2 Log Cabin Dam Operations

Log Cabin Dam makes releases through a valve at its base to meet instream flow requirements in Oregon Creek below Log Cabin Dam, diverts additional flows into the Camptonville Tunnel, and spills any additional flows over the dam to Oregon Creek.

6.2.1 Instream Flow Requirements

A minimum flow, or all-natural inflow plus diversions from Our House Dam (up to the minimum flow) is released to Oregon Creek from Log Cabin Dam. For each day of simulation, the YRDPM determines the appropriate flow requirement, and releases either the inflow or the minimum flow, whichever is less, to Oregon Creek. In the case that releases are made to meet the minimum flow, a buffer flow is added, if available, to emulate real-world operations ensuring sufficient flow reaches the gage.

Minimum instream flow requirements below Log Cabin Dam are defined on the *Inputs-Timeseries* worksheet and are selected for simulation by the user on the *Scenario Builder and Control* worksheet. The buffer flow is specified on the *Inputs-Constraints* worksheet.

6.2.2 Diversions

Once minimum flows have been met, inflows to Log Cabin Dam up to the tunnel capacity of 1,100 cfs are diverted through the Camptonville Tunnel to New Bullards Bar Reservoir. The Camptonville Tunnel maximum capacity is specified on the *Inputs-Constraints* worksheet.

6.3 Slate Creek Diversion Dam Operations

There are two available operational modes for the Slate Creek Diversion Dam. The purpose of each operational mode is to determine how much flow from Slate Creek is released to the YRDP as opposed to diverted to South Feather Water and Power Agency (SFWPA). Since the YRDPM is intended to be used in a comparative model rather than a predictive one, inconsistencies in upstream operations would not necessarily be a problem; however, two simulation modes were added to avoid any perceived problems. For purposes of the Accord Extension analysis, Slate Creek operations were used rather than historical flows.

6.3.1 Historical Flows

Under the Historical Flows mode, the timeseries of historical flows below the Slate Creek Diversion Dam is input to the model as an inflow to the Project. In this case, the YRDPM does not simulate any diversions to the Slate Creek Tunnel: the Slate Creek Diversion Dam is not a part of the simulation.

6.3.2 Operate Slate Creek

Under the Operate Slate Creek mode, YCWA's and SFWPA's water rights, and user-defined minimum instream flow requirements below the diversion dam are used to allocate releases to

Slate Creek and diversions to the Slate Creek Tunnel using historical inflows to the Slate Creek Diversion Dam. SFWPA water rights allow a diversion of up to 300 cfs year around, with an additional 300 cfs between January 1 and July 1, so long as the total volume diverted above the initial 300 cfs is less than 35,000 ac-ft (this volume threshold is a variable set by the model user).

The Operate Slate Creek option requires four additional user inputs. The first input, "YCWA North Yuba Water Right:" indicates the amount of initial flow on the North Yuba River above New Bullards Bar Dam that must be available to YCWA; if New Bullards Bar Reservoir inflows are less than this amount, SFWPA cannot divert at the Slate Creek Diversion Dam. The default value for this variable is 800 cfs, according to existing YCWA water rights. The second input, "Maximum SFWP Diversion Volume (Jan-Jul):" is the total allowable volume of diverted flow between January 1 and July 1, above the 300 cfs base flow diversion. The default value for this variable is 35,000 ac-ft, according to existing SFWPA water rights. The third input, "Meet All YCWA Water Rights Prior to Diversion?" further limits SFWPA diversions by precluding SFWPA diversions when YCWA is operating to meet instream flow requirements on the Yuba River. The default value for this variable is No. Historically, SFWPA has diverted water without YCWA's North Yuba water right being met first. The fourth input, "SFWP Flow Requirements" Indicates with minimum instream flow requirement time series is used to define the minimum instream flow requirement. The model come preloaded with the current FERC license minimum flows (Current) and the proposed FERC license minimum flows (SFWP FERC License). The Current FERC license minimum flows were used for the Accord Extension analysis.

The Slate Creek simulation mode is selected on the *Inputs-Constraints* worksheet, along with other Operate Slate Creek mode input variables. Time series' of monthly minimum instream flow requirements are defined on the *Inputs-Timeseries* worksheet.

6.4 New Bullards Bar Reservoir Operations

As the primary water supply reservoir in the Project, New Bullards Bar Reservoir operations are complex and affected by a range of constraints, both within the reservoir, and downstream of New Bullards Bar Dam. The YRDPM computes required releases, and then distributes those releases to the various outlets. Included in the simulation are the New Colgate Powerhouse, the New Bullards Bar Minimum Flow Powerhouse, the New Bullards Bar Dam spillway, and the New Bullards Bar Dam ARC Spillway. The New Bullards Bar Minimum Flow Powerhouse is operated to meet minimum instream flow requirements below NBB Dam, any additional non-spill releases are made through the New Colgate Powerhouse. The primary and ARC spillways are only used during flood management operations, and only after all other release options have been fully used.

6.4.1 Flood Management

New Bullards Bar Reservoir must be operated from September 16 to May 31 to comply with Part 208 "*Flood Control Regulations, New Bullards Bar Dam and Reservoir, North Yuba River, California,*" pursuant to Section 7 of the Flood Control Act of 1944 (58 Stat. 890). Under the contract between the United States and YCWA entered on May 9, 1966, YCWA agreed to reserve 170,000 ac-ft of storage space for flood management in New Bullards Bar Reservoir in accordance with rules and regulations enumerated in the Hydrology Report on Reservoir Regulation for Flood

Control (USACE 1972). The seasonal flood storage space allocation schedule is presented in Table 6.4-1. If simulated storage at any point in the simulation exceeds the maximum allowable storage, also shown in Table 6.4-1, the YRDPM will make maximum releases from New Bullards Bar Reservoir through the New Colgate Powerhouse, New Bullards Bar Reservoir spillway, and ARC Spillway, if used, subject to downstream flow limitations and outlet capacities, to reduce storage to the maximum allowable.

Table 6.4-1. New Bullards Bar Reservoir Flood Reservation Storage.

	Oct	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**
End of Month Storage Allocation (TAF)	*170*	*170*	*170*	*170*	*170*	*170*	*70*	*0*	*0*	*0*	*0*	*56*
End of Month Maximum Allowable Storage (TAF)	*796*	*796*	*796*	*796*	*796*	*796*	*896*	*966*	*966*	*966*	*966*	*910*

Source: United States Army Corps of Engineers, New Bullards Bar Reservoir, Reservoir Regulation for Flood Control, June 1972
Key:
TAF = Thousands of acre-feet

The release rate is determined by adding the forecasted volume of the current day's inflow to the end of the previous day's storage. If the forecasted storage exceeds the maximum allowable storage, the volume above the line is compared to the various release mechanisms, and releases are made from the reservoir. The first block of water is assumed to be released through New Colgate Powerhouse up to its full capacity of 3,430 cfs. Any remaining volume of water is assumed released through the New Bullards Bar Reservoir Spillway and/or ARC Spillway and is subject to the maximum release rates shown in Table 5.4-1. If the forecasted storage volume would not require spillway releases to reach the maximum allowable storage, and assuming no spill would occur at Englebright Reservoir, all releases would be made through the New Colgate Powerhouse down to the Target Operating Line (TOL), described below in Section 6.4.2.

In addition to reservation of flood control space in New Bullards Bar Reservoir, flood management regulations include rules governing ramping rates as well as target maximum flows in the Yuba River and the Feather River below the confluence with the Yuba River (USACE 1970; USACE 1972). New Bullards Bar Reservoir is operated for the following maximum flows:

- 50,000 cfs on the North Yuba River below New Bullards Bar Dam
- 120,000 cfs on the Yuba River at Marysville
- 300,000 cfs on the Feather River below the Yuba River
- 320,000 cfs on the Feather River below the Bear River

YCWA operates the Narrows 1 and 2 powerhouses at Englebright Dam to utilize storage in USACE's Englebright Reservoir to capture winter storm "freshets" and reduce storm flows on the Yuba River below Englebright Dam. This operation is accomplished by evacuating storage space in USACE's Englebright Reservoir in anticipation of storm peak flows.

At times when New Bullards Bar Reservoir is not threatening to encroach the flood reservation pool, the YRDPM may modify New Bullards Bar Reservoir operations to avoid spilling Englebright Reservoir. These operations are described in Section 6.5.3, Flood Management.

Monthly flood management pool volumes are defined on the *Inputs-Timeseries* worksheet. Maximum flows in the North Yuba River below NBB Dam and in the Yuba River at Marysville are defined on the *Inputs-Constraints* worksheet. Maximum flow limitations in the Feather River are not represented in the model because flows in the Feather River are not simulated.

Pre-releases prior to large flood events using forecasts can be triggered using the "Use Forecast-Based Flood Releases" toggle on the *Inputs-Constraints* worksheet.

6.4.2 Target Operating Line

When hydrologic conditions are such that reservoir operations to meet minimum requirements would result in excessively high reservoir storage, New Bullards Bar Reservoir operations are governed by the TOL. Like the Flood Management Line, the YRDPM makes releases based on the previous day's storage and forecasted current day inflows to meet the TOL. Unlike the Flood Management Line, the TOL is only a target, and as such, the YRDPM utilizes a buffer to mimic the actual operations of the Project within a desired proximity to the TOL versus the more variable release pattern that is associated with strictly operating to a TOL. The YRDPM only makes releases through the New Colgate Powerhouse and the New Bullards Bar Minimum Flow Powerhouse to achieve the TOL; as long as New Bullards Bar Reservoir storage does not exceed the flood management line, the New Bullards Bar Reservoir spillway is not used. The TOL and its buffers are determined through iteration to approximate historical operations, and through discussions with project operations planners.

As previously mentioned, the TOL includes a buffer extending both above and below the TOL, as shown in Table 6.4-3. If New Bullards Bar Reservoir storage is forecasted to be at or below the lower edge of the TOL buffer, New Bullards Bar Reservoir releases are determined based wholly on meeting minimum downstream requirements. If New Bullards Bar Reservoir storage is forecasted to be at or above the upper edge of the TOL buffer, New Bullards Bar Reservoir releases are made at the maximum New Colgate Powerhouse release rate not resulting in a spill at Englebright Reservoir. For forecasted storage between the two buffer lines, a linear interpolation between releases for minimum downstream requirements and maximum release is used as the New Bullards Bar Reservoir release rate.

Table 6.4-3. Example New Bullards Bar Reservoir Storage Target Operating Line and Buffers.

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
End of Month Upper TOL Storage (TAF)	*680*	*730*	*730*	*730*	*750*	*780*	*880*	*966*	*920*	*835*	*725*	*850*
End of Month TOL Storage (TAF)	*660*	*660*	*660*	*660*	*680*	*750*	*850*	*940*	*920*	*825*	*715*	*650*
End of Month Lower TOL Storage (TAF)	*650*	*630*	*630*	*630*	*650*	*720*	*820*	*840*	*840*	*785*	*700*	*648*

Source: Model iterations and through consultation with YRDP operations planners
Key:
TAF = Thousands of acre-feet

NBB TOL monthly storage is defined on the *Inputs-Timeseries* worksheet and selected for simulation on the *Scenario Builder and Control* worksheet. Monthly buffer volumes above and below the TOL are also defined on the *Inputs-Timeseries* worksheet.

6.4.3 Carryover Storage

To protect against multi-year droughts, YRDPM simulation of New Bullards Bar Reservoir includes a carryover storage target for the end of September each year. Reservoir carryover storage is used to make up the difference between the available surface water supply and system demands (diversion demands, instream flow requirements and system operational losses) under dry conditions. For modeling purposes, the determination of the end-of-September carryover storage requirement is based on the current year's and the previous 4 years' water year volume of unimpaired Yuba River flow at Smartsville. If the cumulative 1-, 2-, 3-, 4-, or 5-year volume of unimpaired flow falls below a specified threshold on the Carryover Storage worksheet, the year is determined to have a reduced carryover storage requirement. The thresholds for triggering a lower carryover storage requirement are shown in Table 6.4-4.

Table 6.4-4. Water Year Volumes for Determination of a Multi-Year Drought Based on Cumulative Water Year Yuba River Unimpaired Flow at Smartsville

Drought Duration (Years)	Cumulative Unimpaired Flow Volume (TAF)
1	900
2	2,360
3	4,380
4	5,840
5	7,300

Notes:
Multi-Year drought volumes based on Smartsville Index volumes defined in Section 2.1.3.
- *1-year volume is based on a single Critical year*
- *2-year volume is based on a Critical year and a Dry year*
- *3-year volume is based on three Dry years*
- *4-year volume is based on four Dry years*
- *5-year volume is based on five Dry years*

If simulated end-of-September (EOS) New Bullards Bar reservoir storage falls below the Carryover storage target, Daguerre Point Dam diversions are reduced so that simulated EOS storage meets the carryover storage target and the New Bullards Bar Reservoir operations module is rerun. The YRDPM will iterate, modifying Daguerre Point Dam diversions, until the carryover storage target is met, as long as Daguerre Point Dam diversions do not drop to less than a specified percentage of demand (specified on the *Scenario Builder and Contro*l worksheet).

The maximum carryover storage, maximum delivery shortage, FERC minimum pool storage, carryover storage operational buffer, and NBB annual evaporation are specified on the *Inputs-Constraints* worksheet. The default maximum carryover storage 440 TAF, the default delivery target is 50%, the default FERC minimum pool volume is 234 TAF, the default carryover storage operational buffer is 151 TAF, and the default NBB annual evaporation is 15 TAF. The carryover storage requirement is 440 TAF by default but can be reduced to the sum of the FERC minimum pool + NBB evaporation + operational buffer (400 TAF) based on the criteria in Table 6.4-4. Carryover storage calculations are performed in the *Carryover Storage* worksheet.

6.4.4 Inactive Pool

New Bullards Bar Reservoir's inactive pool is specified in its initial FERC license as 234 TAF. If storage drops below the inactive pool, downstream minimum flow requirement will continue to be met. All other discretionary releases cease until the reservoir storage rises above the inactive pool.

The FERC minimum pool storage is specified on the *Inputs-Constraints* worksheet.

6.4.5 Englebright Storage

The YRDPM operates New Bullards Bar Reservoir to maintain Englebright Reservoir within the range of elevations described in Section 6.5. Without any consideration for power generation or flood management, the YRDPM releases a sufficient volume of water from New Bullards Bar Reservoir storage to ensure the end-of-day storage at Englebright Reservoir is the same as the previous end-of-day storage, while meeting downstream flow requirements and diversion demands. New Bullards Bar Reservoir operations include some consideration for flood management at Englebright Reservoir, as discussed in Section 6.5.3.

6.4.6 Spill Cessation

On the *Inputs-Constraints* worksheet, there is a spill cessation mode toggle button. The existing FERC license does not include a spill cessation schedule for New Bullards Bar Dam, and while spill cessation is proposed in the new FERC license,

6.5 Englebright Reservoir Operations

While Englebright and New Bullards Bar reservoirs are operated conjunctively to meet downstream flow requirements and diversion demands, simulated Englebright Reservoir releases through the Narrows 1 and Narrows 2 powerhouses are operated to minimize daily fluctuations in Yuba River flows. Additionally, release decisions for downstream demands are made at Englebright Dam; New Bullards Bar Reservoir releases are generally used to maintain storage in Englebright Reservoir.

Simulation of Englebright Reservoir includes an Operations Flag indicating the controlling operation of Englebright Reservoir. Table 6.5-1 shows the Operations Flags at Englebright Reservoir.

Table 6.5-1. Englebright Reservoir Operations Flags.

Operations Flag	Description
	Releases for Flows Below Englebright Dam (DS_Req)
0	*Englebright release control does not control due to Deer Creek and Dry Creek inflows, NBB minimum flow controls*
1	*Releases for Marysville Pulse Flows (DS_Req_Pulse)*
2	*Releases for minimum instream flows (DS_Req_MIF)*
2.1	*Marysville Control*
2.2	*Smartsville Control*
2.3	*Unimpaired Flow Control (DS_Req_Unimp)*
2.4	*Unimpaired Flow Control in excess of Narrows or Colgate release capacity (DS_Req_Unimp)*
2.41	*Unimpaired Flow Control in excess of Narrows release capacity*
2.42	*Unimpaired Flow Control in excess of Colgate release capacity*
3	*Releases for ramping rate requirements (DS_Req_RR)*

3.1	*Ramping Rate Table controls*
3.2	*70% of previous days flow controls*
3.3	*Maximum August*
4	*Releases for flow fluctuation requirements (DS_Req_FF)*
5	*Englebright storage management*
5.1	*Englebright spill due to local inflows*
5.2	*Englebright storage exceeds threshold elevation*
5.3	*Englebright local inflow exceeds Narrows capacity, Colgate shut off to reduce spill*
5.4	*Englebright local inflow + NBB release exceeds Narrows capacity, Colgate backed off to eliminate spill at Englebright*
5.5	*Forecasted freshet, reduce Colgate releases to clear space ahead of event*
5.6	*Englebright storage + inflow exceeds DS_Req, No Colgate releases*
Releases for New Bullards Bar Reservoir Storage Management (US_Req)	
11	*Releases for conservation pool encroachment (US_Req_Spill)*
12	*Releases for storage above the upper target line (US_Req_MaxColg)*
13	*Releases for storage between the upper and lower target lines (US_Req_Storage)*
13.1	*Releases constrained up fall maximum flow*
14	*Releases for lower Yuba requirements (US_Req_LYR)*
15	*Releases for Forecast (US_Req_FCO)*
16	*Releases for spill cessation requirements (US_Req_SC)*
17	*Releases for NBB Dead Pool (US_Req_DP)*
18	*NBB at or below dead pool (US_Req_DP)*
19	*Spill Overrides control NBB releases*

6.5.1 Instream Flow Requirements

Englebright Reservoir always makes releases to meet instream flow requirements at the Smartsville and Marysville gages, and irrigation diversions from Daguerre Point Dam. The minimum release from Englebright Reservoir is either the flow requirement at Smartsville gage, or the sum of the Marysville gage requirement and Daguerre Point Dam irrigation demands less inflows from Deer and Dry creeks, whichever is greater.

Minimum instream flow requirements below Englebright Dam at Smartsville and at Marysville are defined on the *Inputs-Timeseries* worksheet and are selected for simulation by the user on the *Scenario Builder and Control* worksheet.

6.5.2 Flow Fluctuation Requirements

In addition to instream flow requirements, Englebright releases are constrained by flow fluctuation requirements. Two flow fluctuation criteria are setup in the model: as defined in the Narrows 2 Bypass FERC Amendment (Existing FERC) (FERC 2005); and as proposed in the FLA (Proposed Condition AR9) (YCWA 2014). The flow fluctuation requirement is selected on the *Inputs-Constraints* worksheet.

Under the existing FERC flow fluctuation requirement, the YRDPM computes the maximum 5-day Englebright Reservoir non-spill release volume for the period of September 15-October 31 and ensures Englebright releases do not drop to less than 55% of the maximum 5-day average release. Between November 1 and March 31, the YRDPM computes the maximum 5-day average non-spill release and ensures Englebright Reservoir releases do not drop below 65% of this flow, or the flow established for September 15 through October 31. Existing FERC flow fluctuation criteria are defined on the *Inputs-Constraints* worksheet.

New flow fluctuation criteria are proposed under the new FERC license, but Yuba Accord Extension modeling assumed the existing FERC requirements remained in effect.

6.5.3 Flood Management

While Englebright Reservoir has no flood management requirements, YCWA operates New Bullards Bar Reservoir to avoid spilling Englebright Reservoir. If forecasts indicate a relatively small storm, or a "freshet" is coming, New Colgate Powerhouse releases are reduced by a user-defined percentage, creating space in Englebright Reservoir for increased runoff from the Middle and South Yuba rivers.

To simulate spill avoidance operations at Englebright Reservoir, the YRDPM evaluates Englebright inflow from the South and Middle Yuba rivers and accretions each day for four subsequent days against Narrows 1 and 2 release capacities. If there is insufficient capacity to release the daily inflows New Colgate releases are reduced by a "Colgate Spill Avoidance Factor" normally set at 70%. By applying this reduction factor four days before a storm event would occur, it provides time for Englebright Reservoir storage to be reduced, creating space to capture the storm and avoid spills at Englebright dam. In some situations, spills are unavoidable, in which case application of the spill avoidance factors would reduce the volume of spill. The YRDPM always checks to make sure all Narrows 1 and 2 powerhouse capacity is used prior to releasing any spills over Englebright Dam. Maximum Colgate Powerhouse release reduction for Englebright spill avoidance is defined on the *Inputs-Constraints* worksheet.

6.5.4 Power Generation

Englebright Reservoir releases are set based on downstream demands in drier times of all years and most of the time in dryer years, in wetter years and the winter of most years, releases are made at relatively constant rates that are determined by the amount of uncontrolled flow into Englebright Reservoir plus planned releases from New Bullards Bar Reservoir. Since the YRDPM operates on a daily timestep rather than an hourly one, most power generation-related operations are not a part of the YRDPM. However, limited power generation operations are included.

Generating releases from Englebright Reservoir can be made through either the Narrows 1 or Narrows 2 powerhouses. The YRDPM has four simulation modes for splitting Englebright Reservoir releases into the two powerhouses: 1) Narrows 2 Preference; 2) Narrows 1 Preference, 3) 2016 Coordinated Operations Agreement, and 4) 2021 Operations. Under the Narrows 2 Preference setting, all available Narrows 2 Powerhouse capacity (3,400 cfs) is used before releases are made through the Narrows 1 Powerhouse, up to the Narrows 1 Powerhouse's full capacity (730 cfs). Under the Narrows 1 Preference setting, the order is reversed, and all Narrows 1 Powerhouse capacity is used before any releases are made through the Narrows 2 Powerhouse. Under the 2016 Coordinated Operations Agreement, the first 700 cfs of release is made through the Narrows 1 Powerhouse; when releases are between 701 cfs and 2,800 cfs, all releases are made through the Narrows 2 Powerhouse. Releases above 2,800 cfs use full Narrows 1 Powerhouse capacity, and the remainder is made through the Narrows 2 Powerhouse. Under the 2021 Operations, Narrows 1 is maximized, and the Narrows 2 Full-Flow Bypass and Narrows 2 Powerhouse are used to make up the remaining flow. Powerhouse preference is selected on the *Inputs-Constraints* worksheet. The 2021 Operations selection is used for the Accord Extension SEIR analysis.

Simulation of Englebright power generation includes an Operations Flag indicating the controlling operation of Narrows 1 and Narrows 2 powerhouses. Table 6.5-2 shows the Power Generation Flags for Englebright Reservoir.

Table 6.5-2. Englebright Power Generation Flags.

Operations Flag	Description
Releases for Narrows 1 and Narrows 2 Powerhouses (Flag)	
0	*Starting condition*
1	*Total Narrows releases are less than the Narrows 1 capacity, all releases are made through Narrows 1*
11	*All Flow Above Narrows 2 Minimum Capacity Through Narrows 2*
12	*Flows in both Narrows 1 and 2, Narrows 2 filled first*
22	*Minimum flow through Narrows 2, balance through Narrows 1*
23	*Flows in both Narrows 1 and 2*

6.6 Daguerre Point Dam Deliveries

Two DSS input time series of aggregated delivery demands are available in the model, representing present level of development and future level of development. Even though diversions occur from three distinct locations in the Lower Yuba River, for simulation purposes all agricultural diversions for YCWA member units are assumed to occur at Daguerre Point Dam. Development of the delivery demands time series is presented in Section 3.2.

Under normal conditions, Englebright Reservoir operations release sufficient water to meet or exceed flow requirements at Smartsville, or flow requirements at Marysville plus delivery demands at Daguerre Point Dam. Under relatively wet conditions, releases may be made from New Bullards Bar Reservoir to meet an EOS target storage; under these conditions, flows at Smartsville and Marysville will likely be in excess of the regulatory minimum, and full deliveries would be made at Daguerre Point Dam. Under extremely dry conditions, releases to meet minimum flow requirements at Marysville and diversions to meet full demands at Daguerre Point Dam could result in New Bullards Bar Reservoir dropping below the EOS carryover storage requirement.

The YRDPM meets the full diversion demand at Daguerre Point Dam if the resulting end-of-September carryover storage in New Bullards Bar Reservoir is above the delivery carryover storage required, as described in Section 6.4.3. Delivery deficiencies, up to a user-defined maximum, are allowed by the model to maintain delivery Carryover Storage requirements. The YRDPM will reduce Daguerre Point Dam diversions by a volume equivalent to the difference between the simulated EOS New Bullards Bar Reservoir storage and the carryover storage requirement and re-simulate New Bullards Bar Reservoir operations. Any reductions in Daguerre Point Dam delivery are applied only to periods when the Marysville flow requirement is controlling Englebright Reservoir operations; if Smartsville requirements are controlling Englebright Reservoir releases, no reductions in delivery can be applied. The reduction in delivery, or shortage, is computed as a percentage and applied to diversions from April 1 through

March 31. If the maximum allowable deficiency is reached, New Bullards Bar Reservoir is drawn down below the Carryover Storage requirement, as necessary.

The level of development, present or future, is selected on the *Scenario Builder and Control* worksheet. Maximum allowable deficiency (Maximum Deficiency) is defined on the *Inputs-Constraints* tab. Present and Future delivery demand time series are located in the DSS input file.

6.7 Water Transfers

Water transfers have historically been an important component of Project operations. Currently, under the Yuba Accord, stored water transfers are accounted for within releases to meet Yuba Accord flow schedules, or to meet the EOS storage target in New Bullards Bar Reservoir.

Groundwater substitution transfers are made by YCWA in coordination with its Member Units, whereby the member units would pump groundwater rather than divert surface water for a portion of their demand. The YRDPM represents groundwater substitution transfers with a pattern for diversion reductions, and a pattern for release of the groundwater substitution transfer volume from New Bullards Bar Reservoir, both of which are specified on the *Inputs-Timeseries* worksheet. The Accord includes a mandatory 30 TAF of groundwater substitution transfers in Schedule 6 years, no additional groundwater substitution transfers are included under the Accord Extension SEIR modeling.

7.0 Model Simulation Process

The YRDPM includes a series of routines. The primary model controls are contained on the *Scenario Builder and Control* worksheet. Most scenario-specific user inputs are managed on *Inputs-Constraints* worksheet. After ensuring all variables/inputs are correct, the user clicks the button labeled, "Run Model," on the *Scenario Builder and Control* worksheet to start the YRDPM. Starting the YRDPM triggers a series of routines described below in the order they are executed.

- RunModel – Initiated by the "Run Model" button. Collects input information, computes period of record information, determines water year, the number of days in the water year, "calls" other subroutines and passes the water year and number of days those subroutines.
- ClearYear – Initiated by the RunModel routine. Clears all of the computation data from the spreadsheet from previous simulations.
- DateSet – Initiated by the RunModel routine. Sets up the date column on each worksheet for each year of simulation.
- Load_DSS_Data_Click – Initiated by the RunModel routine. Executes the Load_DSS_Data routine.
- Load_DSS_Data – Initiated by the Load_DSS_Data_Click routine. Uses the HEC dynamic link libraries (DLL) to read information from a user-specified input DSS file and write it to locations specified on the *DSS_Index* worksheet.
- DSSFile_Open – Initiated by the Load_DSS_Data routine. Uses the HEC DLL to open the user-specified DSS file.
- StartingConditions – Initiated by the RunModel routine. Sets up conditions for subsequent routines, including carrying over information from previous years' simulation like storages or delivery allocations.
- YearType – Initiated by RunModel routine. Determines the year type index and Water Year Types for the Middle Yuba and Oregon Creek and writes it to the *WY Types* worksheet.
- LogCabin_OurHouse – Initiated by RunModel routine. Simulates operations of Log Cabin and Our House dams, allocating inflows to either meeting flow requirements below the dams or for diversion into the dams' respective tunnels. Output is written to the *Log Cabin_Our House* worksheet.
- SpillCessation – Initiated by RunModel routine. Simulates spill cessations, if activated, for Log Cabin and/or Our House dams that must occur prior to simulation of NBB Reservoir. Output is written to the *Log Cabin_Our House* worksheet.
- YearType – Initiated by RunModel routine. Determines the year type index and Water Year Type for the North Yuba River and the Yuba River below Englebright and writes it to the *WY Types* worksheet.
- LowerYubaFlowReqs – Initiated by RunModel routine. Computes the lower Yuba River flow requirements.

- NBBReleases – Initiated by RunModel routine. Writes New Bullards Bar Reservoir operating storage lines and evaporation rates to NBB Pool worksheet.
- Operations – Initiated by RunModel routine. Makes an initial simulation of NBB and Englebright to determine periods when SFWP diversions must be curtailed.
- DiversionDef – Initiated by RunModel routine. Makes an initial simulation to compute diversion deficiencies at Daguerre Point Dam in case carryover storage targets are not met.
- SlateCreek – Initiated by RunModel routine. Simulates Slate Creek Diversion Dam operations. Ouput is written to the *Slate Creek* worksheet.
- SpillCessation – Initiated by RunModel routine. Simulates spill cessations, if activated, for Log Cabin and/or Our House dams that must occur prior to simulation of NBB Reservoir but after calculation of the NYI. Output is written to the *Log Cabin_Our House* worksheet.
- Transfers – Initiated by RunModel routine. If groundwater substitution transfers are included in the simulation, calculates changes in operations for transfers
- NoTransfers – Initiated by RunModel routine. If groundwater substitution transfers are not included in the simulation, fills in transfer output when no transfers are selected. Includes 30 TAF of groundwater substitution transfer for Schedule 6 years when running the Yuba River Accord or FLA Proposed instream flow requirement below Englebright.
- LowerYubaFlowReqs – Initiated by RunModel routine. Computes flow requirements for the Yuba River below Englebright Reservoir at Smartsville and Marysville based on the YRI or NYI year type.
- NBBReleases – Initiated by RunModel routine. Sets up the *NBB Pool* worksheet for use in later routines. Writes New Bullards Bar Reservoir operating storage lines and evaporation rates to the *NBB Pool* worksheet.
- Operations – Initiated by RunModel routine. Primary operational simulation routine. It makes almost all release decisions for New Bullards Bar and Englebright reservoirs based on rules specified within the code and user inputs, including spill cessation below New Bullards Bar Dam. After determining initial releases from New Bullards Bar Reservoir based on flow requirements below Englebright and New Bullards Bar Reservoir storage conditions, the routine makes modifications to New Bullards Bar Reservoir releases to accommodate Englebright storage fluctuations and flow fluctuation limitations below Englebright. Output is written to the *NBB Pool* and *Englebright Pool* worksheets.
- DiversionDef – Initiated by RunModel routine. Using end-of-September storage computed by Operations routine assuming full irrigation deliveries at Daguerre Point Dam, the DiversionDef routine applies a reduction in diversions to ensure New Bullards Bar Reservoir storage is at or above the carryover storage requirement. If there are any reductions in deliveries, the Operations and DiversionDef routines are rerun. Output is written to the *Diversions* and *Output* worksheets.
- SpillCessation – Initiated by RunModel routine. Simulates spill cessations, if activated, for Log Cabin and/or Our House dams that must occur after the simulation of NBB and Englebright reservoirs. Output is written to the *Log Cabin_Our House* worksheet.

- Operations – Initiated by RunModel routine. Revises release decisions for New Bullards Bar and Englebright reservoirs if spill cessation below Log Cabin and/or Our House dams is applied after the simulation of NBB and Englebright reservoirs. Output is written to the *NBB Pool* and *Englebright Pool* worksheets.
- DiversionDef – Initiated by RunModel routine. Revises water delivery deficits at Daguerre Point Dam if spill cessation below Log Cabin and/or Our House dams is applied after the simulation of NBB and Englebright reservoirs. Output is written to the *Diversions* and *Output* worksheets.
- ColgateOps – Initiated by RunModel routine. Recomputes New Colgate Powerhouse releases based on user-defined Weekly Generation Factors pattern if "Use Weekly Power Generation Factors?:" is set to yes on the *Scenario Builder and Control* worksheet. The routine re-computes Englebright Reservoir storage accordingly. Output is written to the *Colgate* worksheet.
- ColgateEngStorageCheck – Initated by RunModel. Checks Englebright Reservoir storage against water-surface elevation rules and makes additional adjustments to New Bullards Bar Reservoir releases to ensure Englebright Reservoir levels do not violate any rules if "Use Weekly Power Generation Factors?:" is set to yes on the *Scenario Builder* and *Control* worksheet. Output is written to the *Colgate* worksheet.
- LowerYubaRiverFlow – Initiated by RunModel routine. Computes Yuba River flows based on Englebright releases, Daguerre Point Dam diversions, and various inflows. Output is written to the *LYR Flows* and *Output* worksheets.
- NarrowsSplit – Initiated by RunModel routine. Splits previously-determined Englebright Reservoir power releases into Narrows 1 and Narrows 2 powerhouse releases based on user-provided information on the *Inputs-Constraints* worksheet. Output is written to the *Narrows* and *Output* worksheets.
- PowerGen – Initiated by RunModel routine. Computes power generation at New Colgate, Narrows 1 and Narrows 2 powerhouses based on head and flow using Affinity Laws and user-provided information on the *Inputs-Constraints* worksheet. Output is written to the *Power Gen* and *Output* worksheets.
- AnnualDataGrabber – Initiated by RunModel routine. Reads data from various worksheets and writes it to the *Annual Data* worksheet. WaterBalance – Initiated by RunModel routine. Checks to ensure water balance is maintained at New Bullards Bar and Englebright reservoirs and at Marysville if "Calculate Water Balance?:" is set to yes on the *Scenario Builder* and *Control* worksheet. Output is written to the *WBalance* and *Output* worksheets.
- FebMayWYInflowForecast – Initiated by RunModel routine. Computes NYI based inflow forecasts using B120 data for Feb through May. Added for informational purposes during FERC relicensing. Output is written to the *WY Types* and *Output* worksheets.
- WithoutProject – Initiated by RunModel routine. Calculates without-Project conditions. Output is written to the *Without Project* worksheet.

- ReachOutput – Initiated by RunModel routine. Computes and writes with-Project and without-Project reach flow for all project reaches based on previously determined flows. Output is written to the *Reach Output* worksheet.
- Recreation_WSE – Initiated by RunModel routine. Writes key NBB recreation elevations to the *Output* worksheet.
- Write_DSS_Data – Initiated by RunModel routine. Opens a user-specified DSS file using the DSSFile_Open routine, writes output to the DSS file using HEC DLL information and closes the DSS file. Write_DSS_Data is called twice: first to write data from the *Reach Output* worksheet and second to write data from the *Output* worksheet. Both are written to a common output file specified on the *Scenario Builder and Control* worksheet

Except for the RunModel routine, YRDPM routines are set up to simulate up to one year at a time. Multi-year simulations are managed within the RunModel routine; it will loop one year at a time until the full simulation period has been completed.

8.0 References

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Appendix C2

Yuba River Development Project Model

YRDPM Hydrology Report

YUBA WATER AGENCY

Yuba River Development Project Model
Appendix A
YRDPM Hydrology Report

April, 2023

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LIST OF ABBREVIATIONS AND ACRONYMS

Term	Definition
AF	Acre-feet
cfs	cubic feet per second
DS	Pacific Gas & Electric Company's Upper Drum-Spaulding Project
DWR	California Department of Water Resources
FERC	Federal Energy Regulatory Commission
HEC	U.S. Army Corps of Engineers' Hydrology Engineering Center.
MAF	million acre-feet
msl	above mean sea level
NBB	New Bullards Bar Reservoir
NID	Nevada Irrigation District
PG&E	Pacific Gas and Electric Company
POR	period of record
SFFRP	South Fork Feather River Project
SFWPA	South Feather Water and Power Agency
SWRCB	State Water Resources Control Board
TAF	thousand acre-feet
USACE	U.S. Army Corps of Engineers
USGS	U.S. Geological Survey
YB	Nevada Irrigation District's Yuba-Bear Project
YWA	Yuba County Water Agency
YRDP	Yuba River Development Project

SECTION 1

INTRODUCTION

The purpose of this document is to describe the relevant hydrology of the Yuba River Watershed that affects, or is affected by, the Yuba River Development Project (YRDP), Federal Energy Regulatory Commission (FERC) Project No. 2246, and to describe the methodologies for compiling relevant hydrologic information into a data set that will be used by Yuba County Water District (YWA) to support modeling and environmental studies.

1.1 The Yuba River Watershed

The Yuba River watershed drains approximately 1,339 square miles (USGS 2004) of the western slope of the Sierra Nevada, including portions of Sierra, Placer, Yuba, and Nevada counties, as shown in Figure 1.1-1. The Yuba River is a tributary of the Feather River, which in turn is a tributary of the Sacramento River. The watershed rises from an elevation of about 60 feet to about 8,590 feet above mean sea level (msl). The annual unimpaired flow at the Smartsville Gage on the lower Yuba River has ranged from a high of 5.58 million acre-feet (MAF) in 2017 to a low of 0.37 MAF in 1977, with an average of about 2.35 MAF per year (1901 to 2021).[1] In general, runoff is nearly equally divided between runoff from rainfall during October through March and runoff from snowmelt during April through September.

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[1] The forecasted seasonal unimpaired flow at Smartsville is estimated each year by the California Department of Water Resources and reported monthly in Bulletin 120, *Water Conditions in California*. The unimpaired flow at Smartsville is used in Yuba County Water Agency contracts for water delivery to senior water right holders on the lower Yuba River, and is used in the calculation of the Yuba River Index, a hydrologic water year type index for the Yuba River, defined in State Water Resources Control Board Revised Decision 1644.

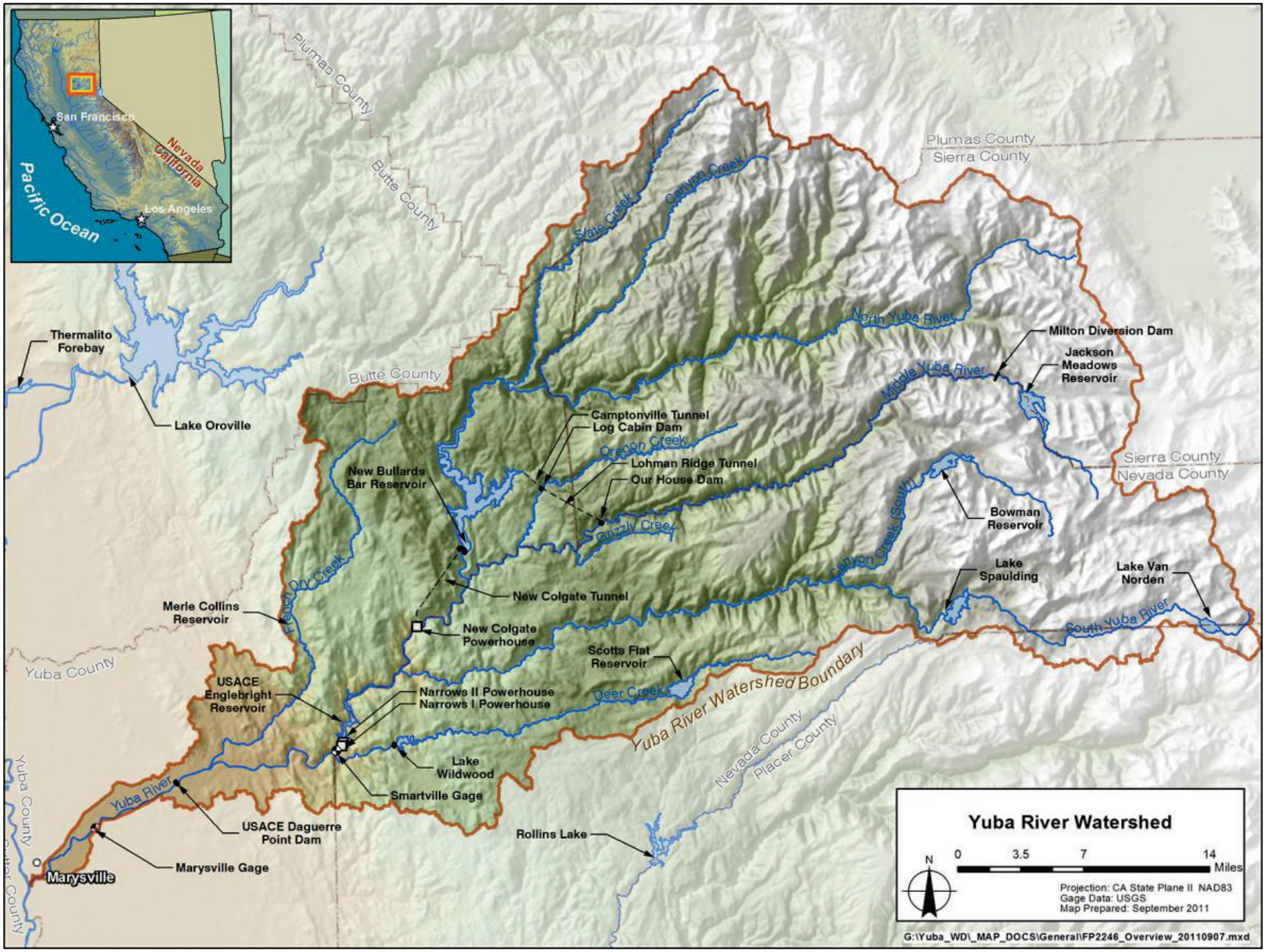

Figure 1.1-1. Yuba River Watershed

The upper basins of the Middle Yuba and South Yuba rivers have been extensively developed for hydroelectric power generation and consumptive uses by Nevada Irrigation District (NID) and Pacific Gas and Electric Company (PG&E). Total storage capacity of about 307 thousand acre-feet (TAF) on the Middle Yuba and South Yuba rivers and associated diversion facilities enable both NID and PG&E to export an average of approximately 410 TAF per year from the Yuba River watershed to the Bear River and American River basins through the Yuba-Bear (YB) and Upper Drum-Spaulding (DS) projects, known collectively as the YB-DS projects. In addition, the South Feather Water and Power Agency (SFWPA, previously known as the Oroville-Wyandotte Irrigation District) exports an average of about 70 TAF per year from Slate Creek (a tributary to the North Yuba River) to the Feather River Watershed through the South Fork Feather River Project (SFFRP). While these upper basins lie outside of the project study area, the described operations and exports can considerably reduce the water supply available to the lower Yuba River, particularly during dry and critical water years.

The U.S. Army Corps of Engineers (USACE) and YWA own storage facilities in the lower reaches of the Yuba River watershed. Two of the lower Yuba River facilities, Englebright Dam and Daguerre Point Dam, were originally constructed by the California Debris Commission, a Federal and State partnership, for debris control, and now are operated and maintained by the USACE. The YRDP, constructed and operated by YWA, is a multiple-use project that provides flood control, power generation, irrigation, recreation, and protection and enhancement of fish and wildlife. It includes Our House and Log Cabin diversion dams, New Bullards Bar Dam and Reservoir, New Colgate Powerhouse, and Narrows 2 Powerhouse. Englebright Dam and Reservoir and Daguerre Point Dam are not part of the YRDP. Englebright Dam is used by YWA and PG&E to regulate releases from New Colgate Powerhouse to the lower Yuba River, and Daguerre Point Dam is used by YWA to divert water to its member units.

1.2 Summary of Hydrologic Analysis

YWA inflows to the Project Area[2] are a combination of both gaged tributary inflows and ungaged accretions. Gaged tributary flows are discussed in Section 2 for the following major tributaries:

- North Yuba River
- Slate Creek
- Middle Yuba River
- South Yuba River
- Oregon Creek
- Deer Creek

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[2] For the purposes of this document, the Project Area is defined as the area within the FERC Project Boundary and the land immediately surrounding the FERC Project Boundary (i.e., within about 0.25 mile of the FERC Project Boundary) and includes Project-affected reaches between facilities and downstream to the next major water controlling feature or structure, USACE's Daguerre Point Dam.

Ungaged accretions and the methodologies used to compute them are discussed in Section 3. Subbasin ungaged accretions are discussed as either inflows to New Bullards Bar Reservoir (NBB), Englebright Reservoir, or the lower Yuba River and the components of flow that make up these three subbasin accretions.

Yuba River flows are affected by the upstream projects including NID's Yuba-Bear Project, PG&E's Drum-Spaulding Project, and SFWPA's South Fork Feather River Project in addition to the YRDP. Section 4 includes a discussion of the calculation of unimpaired flows throughout the basin, including from the upstream projects. Section 5 includes a discussion of hydrologic analysis at four locations for three hydrologic conditions: a natural, unimpaired condition reflecting hydrology in the watershed without any human impairments, a non-YRDP condition reflecting hydrology in the watershed without the YRDP, and a period of record (POR) condition reflecting YRDP operations and facilities since construction was completed in 1969. The hydrologic analysis is provided for the following four locations:

- North Yuba River at New Bullards Bar Dam site
- Middle Yuba River at its confluence with the North Yuba River
- South Yuba River at its confluence with the Yuba River
- Yuba River at Smartsville

Figure 1.2-1 shows the Project Area tributary reaches and the major tributary inflows (listed in blue boxes) and locations where tributary accretions are calculated (listed in black boxes) as used in hydrologic analysis.

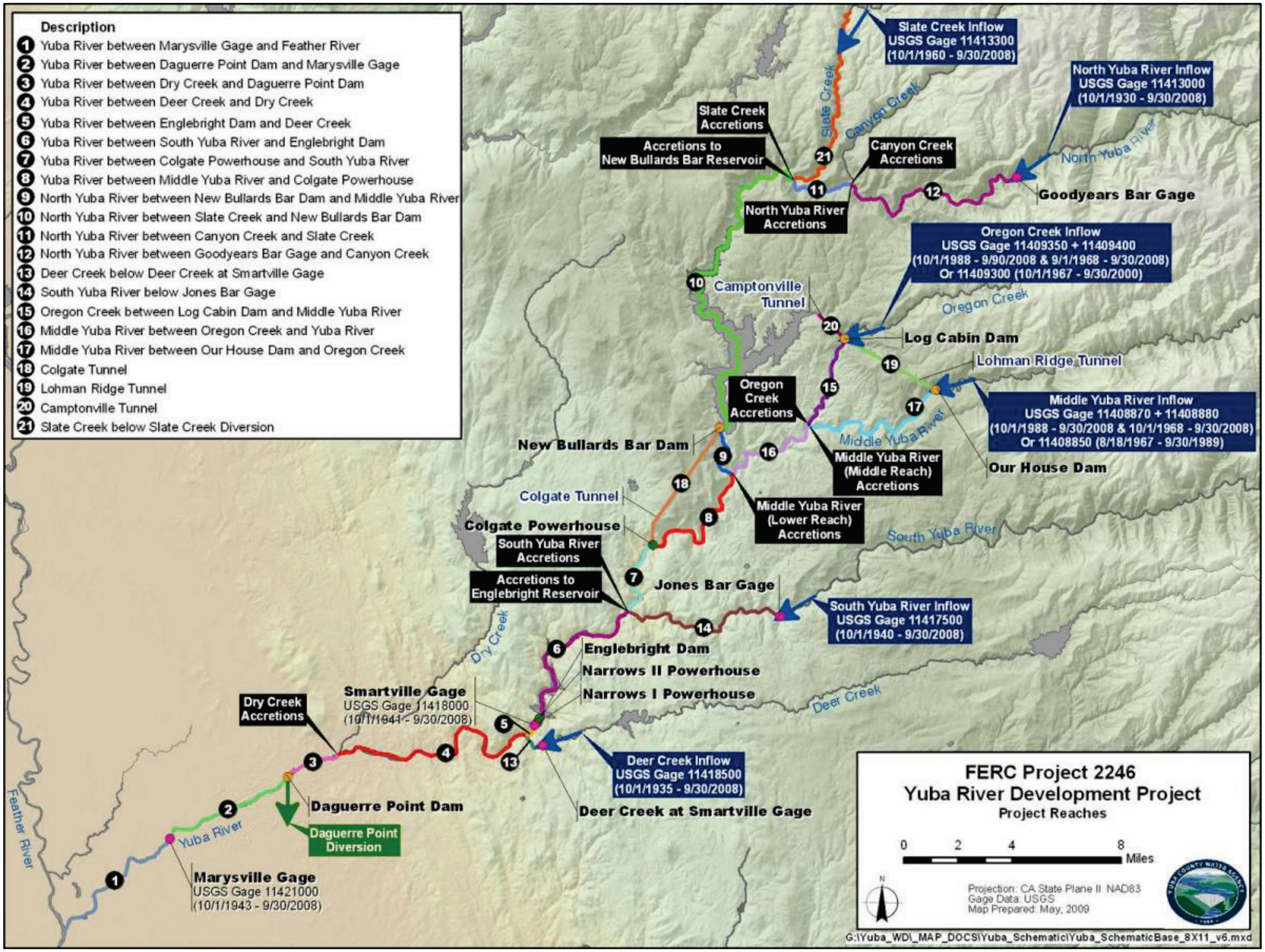

Figure 1.2-1. YRDP Project Area Tributary Reaches

SECTION 2

MAJOR TRIBUTARY FLOWS

This section describes flows from the upper Yuba River watershed to gaging locations on major reaches tributary to the Project Area. Flows in the Yuba River and its tributaries have been gaged by several agencies for varying lengths of time. Generally, a reliable mean daily flow record for major watershed streams exists from 1969 to the present day. Given the availability and reliability of these gaged flow data, flow measurements for the POR of October 1969 through September 2020 were selected for inclusion in the compiled hydrologic data set for inflows to the YRDP Project Area. Since the U. S. Geological Survey (USGS) annually verifies the data recorded at its gages and USGS gage data are available throughout the selected POR, data from USGS gages on each of the major watershed tributaries were selected for the hydrologic data set. All USGS gage data was acquired from the USGS National Water Information System (USGS 2021). USGS gages used for the hydrologic data set of flows are described in Table 2.0-1. Not all listed gages are currently monitored. Figure 2.0-1 shows the network of USGS gages in the vicinity of the Project; not all gages shown were used for the hydrologic data set.

Table 2.0-1. USGS Gages Used to Determine Major Tributary Flows

Gage Number	Tributary	Period of Record	Gage Name
11413000	North Yuba River	10/1/30-Present	North Yuba River Below Goodyears Bar
11413300	Slate Creek	10/1/60-Present	Slate Creek Below Diversion Dam, Near Strawberry Valley
11409300	Oregon Creek	10/1/67-9/30/00	Oregon Creek At Camptonville
11409350	Oregon Creek	10/1/88-Present	Camptonville Tunnel At Intake, Near Camptonville
11409400	Oregon Creek	9/1/68-Present	Oregon Creek Below Log Cabin Dam, Near Camptonville
11408850	Middle Yuba River	8/18/67-9/30/89	Middle Yuba River Near Camptonville
11408870	Middle Yuba River	10/1/88-Present	Lohman Ridge Tunnel At Intake, Near Camptonville
11408880	Middle Yuba River	10/1/68-Present	Middle Yuba River Below Our House Dam, Near Camptonville
11417500	South Yuba River	10/1/40-Present	South Yuba River At Jones Bar, Near Grass Valley
11418500	Deer Creek	10/1/35-Present	Deer Creek Near Smartsville
11418000	Yuba River	10/1/41-Present	Yuba River Below Englebright Dam, Near Smartsville
11421000	Yuba River	10/1/43-Present	Yuba River Near Marysville

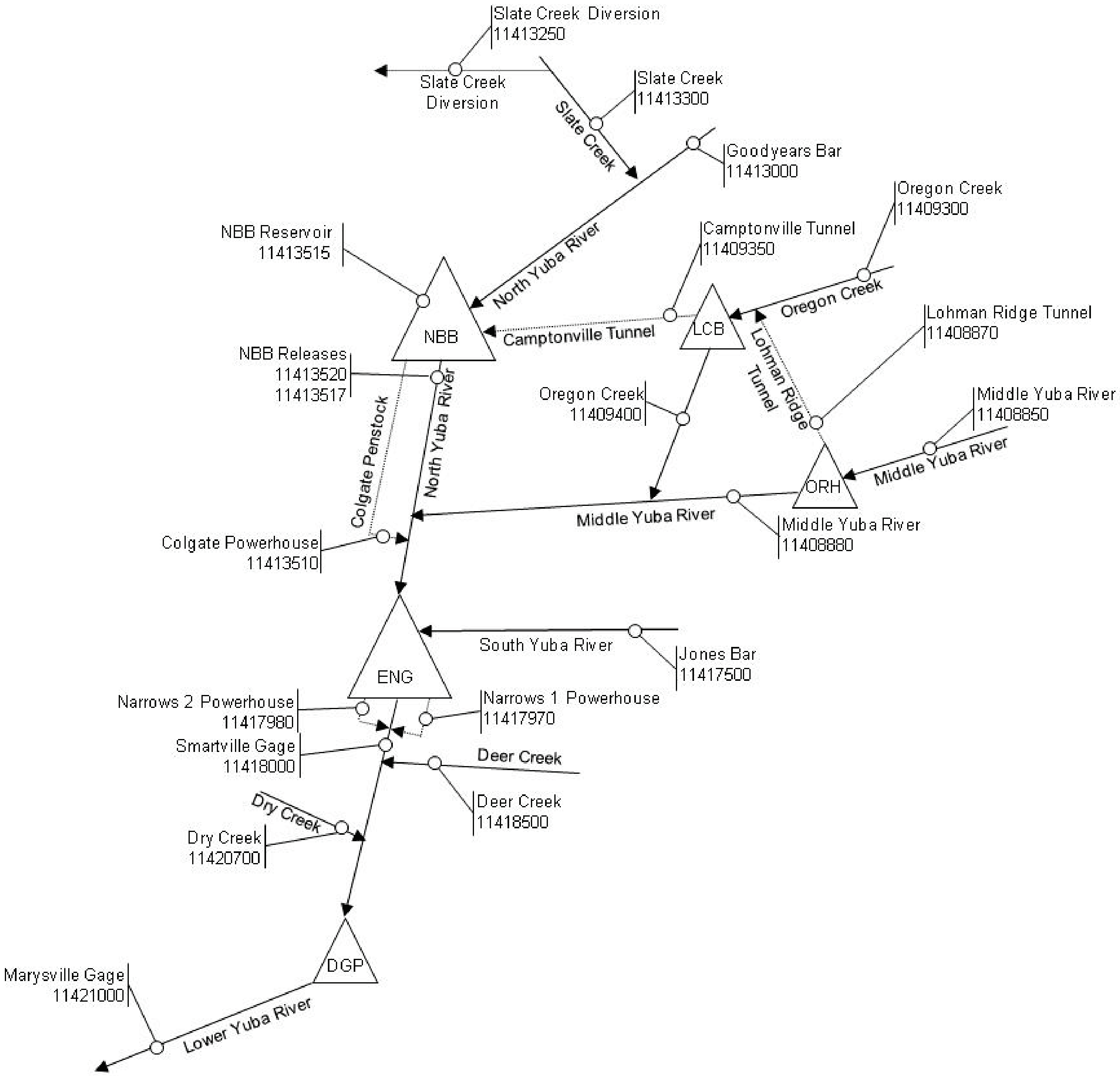

Figure 2.0-1. Schematic of Lower Yuba River USGS Gage Network

Hydrologic analysis relied on gages listed in Table 2.0-1 along with the synthesis of local accretions[3] to key subbasin locations from ungaged tributaries, as described in Section 3, to complete the data set. The synthesis of accretions is needed for intermediate locations within the

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[3] The term accretions is used in this document to mean runoff to a stream that is below a gaging point; therefore is not directly measured and must be determined through some other hydrologic analysis method.

project area to provide a detailed, accurate flow record for YRDP facility locations. Gages were selected for this analysis based on their locations in the stream network, and the period of record of available historical data for the gage.

2.1 North Yuba River

The upper extent of the North Yuba River is at Yuba Pass (elevation 6,701 feet msl) near State Highway 49 in Sierra County. The river flows parallel to the state highway as far as Downieville, where it diverges from the highway and flows westward into NBB. The North Yuba River terminates at its confluence with the Middle Yuba River, approximately 2 miles downstream from New Bullards Bar Dam, at which point the combined flow of the two rivers becomes the Yuba River. The total area of the North Yuba River watershed is approximately 491 square miles and includes portions of Yuba, Sierra, and Plumas counties. The record of daily flow data from the primary gage in the watershed, Goodyears Bar (USGS Gage 11413000) at approximately 2,453 feet msl, extends from October 1, 1930 through the present and represents drainage from a watershed area of approximately 250 square miles. There are no major impairments on the North Yuba River above Goodyears Bar that substantially affect river flow. Canyon Creek, an ungaged tributary to the North Yuba River, with a subbasin of approximately 61 square miles, flows into the North Yuba River approximately 8 miles downstream from Goodyears Bar. Similar to the North Yuba River subbasin above Goodyears Bar, the Canyon Creek subbasin is predominantly snowmelt-fed and has no upstream impairments. Slate Creek, discussed in Section 2.2, flows into the North Yuba River approximately 12 miles below Goodyears Bar. A smaller tributary, Deadwood Creek, joins the North Yuba River approximately 0.5 miles below Slate Creek. The Deadwood Creek subbasin is approximately 6.7 square miles and is relatively low in elevation; accordingly, it is mainly a rainfall-fed subbasin. Flows are gaged at a small hydropower plant on the creek, the Deadwood Creek Plant (USGS Gage 11413320), which has a gage record from October 1, 1994, through the present. Figure 2.1-1 shows a schematic of the North Yuba River and its primary tributaries.

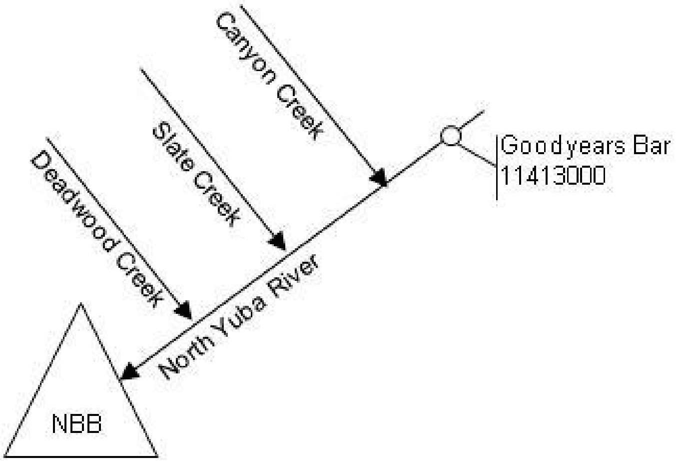

Figure 2.1-1. Gage Network of the North Yuba River

The North Yuba River subbasin is a predominantly snowmelt-fed stream, with peak flows occurring from March through May. On a long-term average basis, North Yuba River flows are lowest from August through October. Average monthly North Yuba River flows at Goodyears Bar are shown in Table 2.1-1.

Table 2.1-1. Historical Average Monthly North Yuba River Flow at Goodyears Bar.

Location	Average[2] Monthly Inflow (cfs)												Total (TAF)
	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	
North Yuba River Inflow[1]	174	355	672	941	998	1,246	1,385	1,701	1,046	362	183	150	555

Notes:
[1] North Yuba River below Goodyears Bar flow from USGS Gage 11413000
[2] Period of record is 10/1/1969-9/30/2020
Key: cfs = cubic feet per second TAF = thousand acre-feet USGS=U.S. Geological Survey

2.2 Slate Creek

Slate Creek originates near the town of La Porte, in the northern portion of the Yuba River watershed. The Slate Creek subbasin is approximately 61 square miles. SFWPA diverts flows from Slate Creek into the Feather River Basin near Strawberry Valley via the Slate Creek Tunnel at approximately 3,500 feet msl. Approximately 49 square miles of the Slate Creek subbasin is above the Slate Creek Tunnel. The Slate Creek Tunnel has a maximum capacity of 848 cubic feet per second (cfs), and its flow has been measured at USGS Gage 11413250 since October 1, 1962. Slate Creek joins the North Yuba River approximately 0.5 miles upstream from the normal high-water mark of NBB. Slate Creek flows have been continuously gaged below the Slate Creek Tunnel by USGS Gage 11413300 since October 1, 1960. Figure 2.2-1 shows the gage network on Slate Creek.

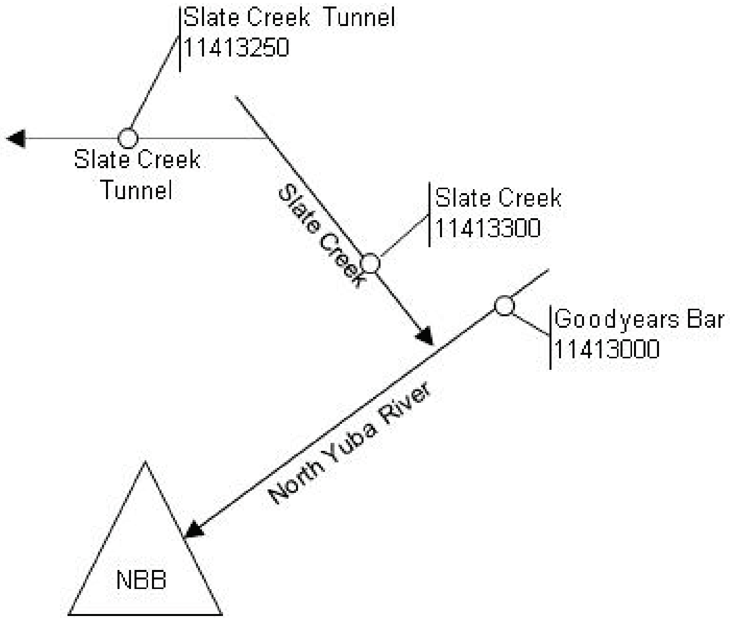

Figure 2.2-1. Gage Network of Slate Creek flows to New Bullards Bar

Like the North Yuba River subbasin, the Slate Creek subbasin above the Slate Creek Tunnel, as measured at USGS Gage 11413300, is predominantly snowmelt-fed. Peak flows on Slate Creek generally occur from January through March, and low flows generally occur between July and September. Peak diversions to the Feather River Basin through the Slate Creek Tunnel typically occur in March and May, before 1985, SFWPA diverted Slate Creek flows year around, but diversions since 1985 have typically been limited to December through June.

Slate Creek flows below the Slate Creek Diversion Dam are determined from the historical records at the Slate Creek gage, USGS Gage 11413300. Average monthly flows at this gage are shown in Table 2.2-1.

Table 2.2-1. Historical Average Monthly Slate Creek Flows below the Slate Creek Tunnel.

Location	Average[1] Monthly Inflow (cfs)												Total (TAF)
	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	
Slate Creek Inflow[2]	16	54	133	181	194	233	187	173	53	14	11	10	76

Notes:

[1] Period of record: 10/1/1969-9/30/2020

[2] Slate Creek below Diversion Dam flow from USGS Gage 11413300

Key: cfs=cubic feet per second TAF = Thousand acre-feet USGS=U.S. Geological Survey

2.3 Middle Yuba River

Flows in the Middle Yuba originate from snowmelt and rainfall runoffs above the largest upper watershed impoundment, Jackson Meadows Reservoir, with a dam crest of elevation 6,044.5 feet msl, in Sierra County. Most of the upper Middle Yuba River is confined by narrow, steep canyons which continue downstream to the 75-foot-high Our House Dam, the upper extent of the YRDP on the Middle Yuba River, located southwest of Camptonville near the Sierra/Nevada County line. Approximately 12 miles below Our House Dam, the Middle Yuba River joins the North Yuba River to form the Yuba River.

The Middle Yuba River watershed, including its major tributary Oregon Creek, covers approximately 210 square miles, with elevations ranging from 1,120 feet msl to 7,200 feet msl. There are several impairments on the upper Middle Yuba River that are part of the NID Yuba-Bear Project (FERC Project No. 2266). A portion of Middle Yuba River flows are diverted into the South Yuba River subbasin through the Yuba-Bear Project's Milton-Bowman Tunnel at NID's Milton Diversion Dam. The Yuba-Bear Project is operated to meet minimum Middle Yuba River in-stream flow requirements below the Milton Diversion Dam. Releases from the Milton Diversion Dam and runoff from the area below the dam flow to Our House Dam at crest elevation 2,030 feet msl. Inflow at Our House Dam is partially diverted to Oregon Creek through the Lohman Ridge Tunnel. Oregon Creek joins the Middle Yuba River approximately 8.5 miles below Our House Dam, and the Middle Yuba River joins the North Yuba River below NBB to form the Yuba River. Approximately 23 square miles of the Middle Yuba River watershed lie below Our House Dam.

Inflow to Our House Dam from the Middle Yuba River is determined from three gages. Before 1989, USGS Gage 11408850 recorded Middle Yuba River flows approximately 3.25 miles above the Dam, near Camptonville. Since 1989, Middle Yuba inflows to the Our House Dam are determined by adding the flow below Our House Dam, measured at USGS Gage 11408880, to Lohman Ridge Tunnel flows, measured at USGS Gage 11408870. Figure 2.3-1 shows the gage network for the Middle Yuba River around Our House Dam.

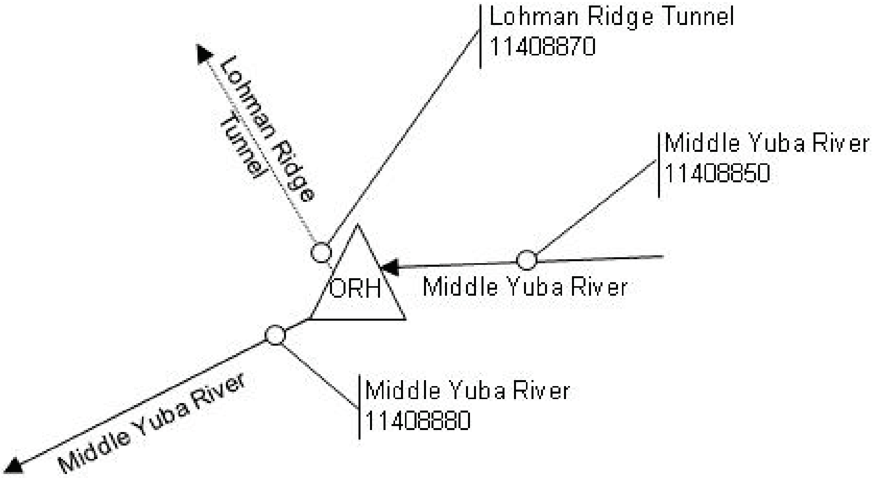

Figure 2.3-1. Gage Network of Middle Yuba River around Our House Dam

Using the methodology described above to compute the inflow to this location, a continuous record of daily data from October 1, 1969 to September 30, 2020 was computed. Since the watershed contributing to USGS Gage 11408850 is slightly smaller than USGS Gage 11408880 (136 square miles for USGS Gage 11508850 compared to 145 square miles for USGS Gage 11408880), flows were assumed to be directly proportional to the size of the watershed so flows from USGS Gage 11408850 were increased by the factor of 145/136. Computed average monthly inflows to Our House Dam are shown in Table 2.3-1.

Table 2.3-1. Historical Average Monthly Middle Yuba River Flows above Our House Dam.

Location	Average Monthly Inflow (cfs)												Total (TAF)
	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	
Middle Yuba River Inflow[1]	49	144	335	516	542	635	616	602	327	92	42	36	237

Notes:

[1] Middle Yuba River above Our House Dam flow from:
USGS Gage 11408850 * 145/136 (10/1/1969 through 9/30/1989)
USGS Gages 11408870+11408880 (10/1/1989 through 9/30/2020)

Key: cfs = cubic feet per second TAF = Thousand acre-feet USGS=U.S. Geological Survey

2.4 South Yuba River

The headwaters of the South Yuba River originate at elevation 9,000 feet msl in Placer County near Castle Peak and Donner Lake. The South Yuba River is subject to multiple upstream impairments before it joins the Yuba River in Englebright Reservoir. Primary upstream impairments are NID's Yuba-Bear Project (FERC Project No. 2266), and PG&E's Drum-Spaulding Project (FERC Project No. 2310). Flow from the Middle Yuba River is diverted to the South Yuba River via the Milton-Bowman Tunnel to Bowman Reservoir and then through the Bowman-Spaulding Tunnel to Lake Spaulding, and flow from the South Yuba River is diverted into the Bear and American river basins via the Drum Canal and South Yuba Canal. Remaining South Yuba River flow joins the Yuba River in Englebright Reservoir. Flows on the lower South Yuba River have been continuously measured at Jones Bar gage (USGS Gage 11417500), located approximately 7 miles upstream from the confluence of the Yuba River and South Yuba River, since April 1, 1959. Of the approximately 352-square-mile South Yuba River watershed, approximately 42 square miles lie below Jones Bar gage. Figure 2.4-1 shows the gage network of the lower South Yuba River.

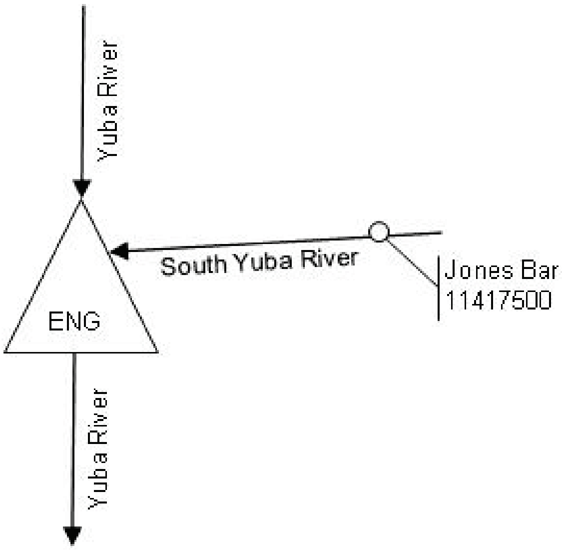

Figure 2.4-1. Gage Network of the Lower South Yuba River

Flows from the upper reaches of the South Yuba River are determined from historical daily flow data measured at Jones Bar gage (USGS Gage 11417500) from October 1, 1969 through September 30, 2020. Average annual South Yuba River flow at this location is approximately 312 TAF, with peak flows occurring from April through June, corresponding to the snowmelt season. Low flows on the South Yuba River generally occur from July through mid-December. Table 2.4-1 shows the historical average monthly flow from the South Yuba River, measured at Jones Bar gage.

Table 2.4-1. Historical Average Monthly South Yuba River Flows at Jones Bar.

Location	Average[1] Monthly Inflow (cfs)												Total (TAF)
	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	
South Yuba River Inflow 2	65	187	473	721	783	858	749	831	628	132	47	47	332

Notes:
[1] Period of Record: 10/1/1969 through 9/30/2020
[2] South Yuba River at Jones Bar flow from USGS Gage 11417500
Key: cfs = cubic feet per second TAF = Thousand acre-feet USGS=U.S. Geological Survey

2.5 Oregon Creek

Oregon Creek is entirely contained within the Middle Yuba River watershed and originates near elevation 4,455 feet msl. Log Cabin Dam, a 55-foot-high dam, diverts flows from Oregon Creek to NBB through the Camptonville Tunnel. Log Cabin Dam is approximately 4 miles upstream from Oregon Creek's confluence with the Middle Yuba River. Oregon Creek flow above Log Cabin Dam is a combination of outflow from the Lohman Ridge Tunnel, originating at Our House Dam on the Middle Yuba River, and Oregon Creek flow. Above the outfall of the Lohman Ridge Tunnel, Oregon Creek is free of impairments. As a result, it is a useful index watershed for characterizing rainfall runoff to compute accretions in other similar watersheds. Of the approximately 35 square miles of the Oregon Creek watershed, about 6 square miles lie below Log Cabin Dam.

Between October 1, 1921 and September 30, 1969, Oregon Creek flows to Log Cabin Dam were gaged by USGS Gage 11409500, located approximately 3.5 miles downstream of the Log Cabin Diversion Dam. Between October 1, 1968 and September 30, 2000, Oregon Creek flows to Log Cabin Dam were gaged by USGS Gage 11409300, located approximately 1.5 miles upstream of the Lohman Ridge Tunnel outfall. Since September 2000, Oregon Creek flows to Log Cabin Dam are calculated by adding flows below Log Cabin Dam, measured by USGS Gage 11409400, to Camptonville Tunnel flows, measured by USGS Gage 11409350, and subtracting Lohman Ridge Tunnel flows, measured at USGS Gage 11408870. Figure 2.5-1 shows the gage network for Oregon Creek.

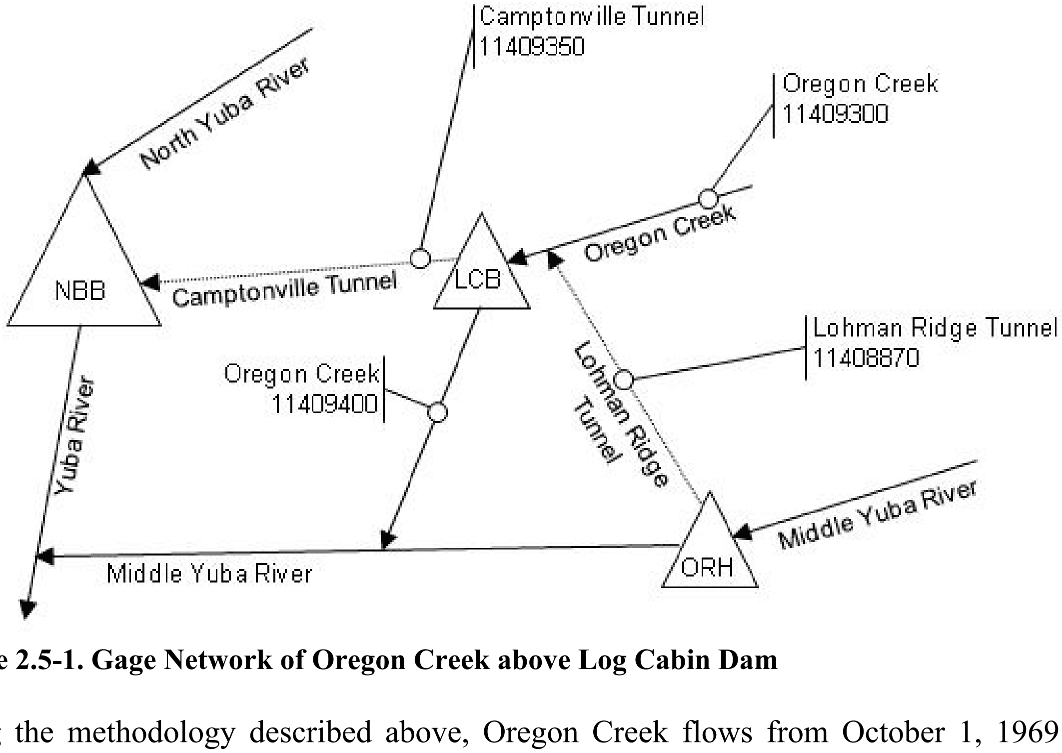

Figure 2.5-1. Gage Network of Oregon Creek above Log Cabin Dam

Using the methodology described above, Oregon Creek flows from October 1, 1969 through September 30, 2020 were computed; however, in some periods, gaging errors resulted in obviously incorrect values, such as negative or very large values. These errors were manually corrected for periods shown in Table 2.5-1. Since the watershed contributing to USGS Gage 11409300 is slightly smaller than USGS Gage 11409400 (23 square miles for USGS Gage 11509000 compared to 29.1 square miles for USGS Gage 11409400), flows were assumed to be directly proportional to the size of the watershed so flows from USGS Gage 11409300 were increased by the factor of 29.1/23.

Table 2.5-1. Corrections to Computed Historical Oregon Creek Flows above Log Cabin Dam.

Date	Original Value (cfs)	Revised Value (cfs)	Rationale
11/21/2001	-1.4	4.0	Replaced with previous day's value
11/28/2001	-1.0	3.0	Replaced with previous day's value
11/29/2001	0.0	3.0	Replaced with previous day's value
11/07/2002	-0.5	3.0	Replaced with previous day's value
06/30/2003	-0.2	0.8	Replaced with previous day's value
07/01/2003	-0.2	0.8	Replaced with previous day's value
7/15-8/2/2003	Varied	2.0	Used previous year's corresponding flow
6/1-6/4/2004	Varied	9.0	Used previous year's corresponding base flow
10/17/2004	-2.3	2.0	Replaced with previous day's value
10/19/2004	-2.0	4.0	Replaced with previous day's value
11/03/2004	-1.1	1.0	Replaced with previous day's value
01/14/2005	-34.0	45.0	Replace with average of surrounding days
5/19/2005	1,017	617.0	Corrected obvious Lohman Ridge Tunnel flow error
6/19-7/18/2006	Varied	Varied	Replaced with historic 2000 receding flows
4/3-4/21/2007	Varied	Varied	Replaced with historic 1989 receding flows
5/15-5/29/2007	Varied	Varied	Replaced with historic 1991 receding flows
5/27/2008	-1.0	5.0	Replaced with previous day's value
5/30-6/8/2008	Varied	4.00	Replaced with recent flow trend
9/30/2008	-7.2	1.7	Replaced with previous day's value
10/14/2009	-3.2	3.0	Slight increase over previous day
10/21/2009	-7.9	7.0	Average of surrounding days

Key: cfs = cubic feet per second

Oregon Creek is a rainfall-dominated basin: peak flows occur from January through May, and low flows occur from June through November. Table 2.5-2 shows the historical average monthly Oregon Creek inflow.

Table 2.5-2. Historical Average Monthly Oregon Creek Flows above Log Cabin Dam.

Location	Average Monthly Inflow (cfs)												Total (TAF)
	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	
Oregon Creek Inflow[1]	6	32	97	160	177	191	129	71	25	7	3	3	54

Notes:
[1] Oregon Creek above Log Cabin Dam flow from:
USGS Gage 11409300 * 29.1/23 (10/1/1969 through 9/30/2000)
USGS Gages 11409350+11409400-11408870 (10/1/2000 through 9/30/2020)

Key: cfs = cubic feet per second TAF = Thousand acre-feet USGS=U.S. Geological Survey

2.6 Deer Creek

Deer Creek originates in Nevada County, and in addition to natural runoff, receives flows from the South Yuba River by way of PG&E's Drum-Spaulding Project. The approximately 89-square-mile Deer Creek watershed is primarily rainfall-fed; its natural flows are augmented by diversions from the South Yuba River via the South Yuba Canal. Several canals divert flow from Deer Creek to the Bear River watershed. Deer Creek is subject to impoundment in NID's Scotts Flat Reservoir and in Lake Wildwood before it flows into the Yuba River near Smartsville, below Englebright Reservoir. Historical Deer Creek flows near Smartsville have been measured since October 1, 1935 at USGS Gage 11418500, approximately 1 mile upstream from the confluence of Deer Creek with the Yuba River. The watershed contributing to Deer Creek flow below the Deer Creek gage is approximately 5 square miles, and is discussed in Section 3.3. Figure 2.6-1 shows the gage network for Deer Creek near Smartsville.

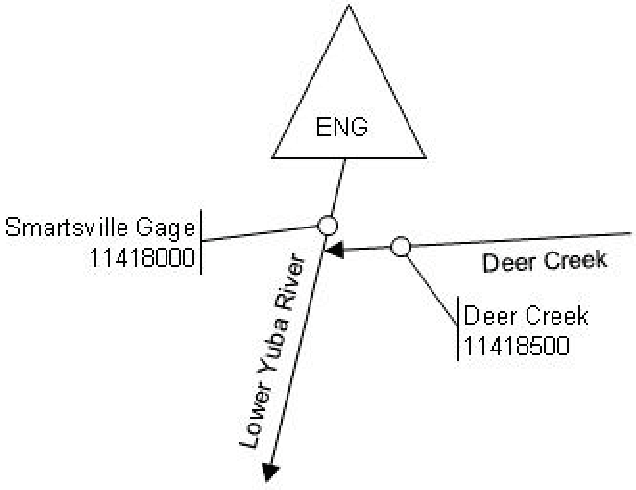

Figure 2.6-1. Gage Network of Deer Creek Flow near Smartsville.

As a result of upstream impairments to Deer Creek, its inflows to the Yuba River do not follow a natural streamflow hydrograph. Peak flows typically occur from December through April, and low flows typically occur from June through October. Table 2.6-1 shows average historical monthly Deer Creek flow at the Deer Creek gage.

Table 2.6-1. Historical Average Monthly Deer Creek Flows near Smartsville.

Location	Average[1] Monthly Inflow (cfs)												Total (TAF)
	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	
Deer Creek Inflow[2]	35	47	146	261	321	317	165	62	16	6	4	6	83

Notes:
[1] Period of Record: 10/1/1969 through 9/30/2020
[2] Deer Creek near Smartsville flow from USGS Gage 11418500
Key: cfs=cubic feet per second TAF=thousand acre-feet USGS=U.S. Geological Survey

SECTION 3
UNGAGED ACCRETIONS

This section describes accretions to New Bullards Bar Reservoir, Englebright Reservoir, the lower Yuba River, and Dry Creek below the locations described in Section 2 to complete the calculation of inflows to the Project Area. While the majority of the tributaries to the Yuba River are gaged, there is a considerable amount of inflow to the Yuba River not directly gaged by streamflow measurement. Using the methodologies discussed below, ungaged accretions are computed for all Project Reaches below the major tributary inflows discussed in Section 2.

Without direct streamflow gage data, several methods were examined to estimate accretions. Methodologies examined to compute accretions included the following:

1. Computation of accretions using a simple mass balance equation. This method consists of subtracting the volume of periodic flow at a measured upstream location from a measured downstream location to determine the volume of intervening additional flow.
2. Computation of accretions using statistical regressions. This method consists of using statistical methods to determine a numerical relationship between a watershed with known characteristics and measured flows and the area of interest.
3. Computation of accretions using an area-weighted scaling of a known, comparable watershed flow and applying a precipitation-based adjustment. This method consists of multiplying known flows of one watershed with similar physical characteristics by the ratio of the area and precipitation of the watershed with measured flows to the area and precipitation of the watershed of interest.

After an analysis of the accuracy of the three methods for computation of inflows to New Bullards Bar Reservoir, the area-weighted scaling methodology was determined to be the most applicable to the Yuba River subbasin accretions, except for large flood event when mass balance was used. Figure 3.0-1 shows the Yuba River watershed and the subbasins included in analysis. Similarly, Figure 3.0-2 shows the Yuba River watershed and the average annual precipitation for each subbasin based on a 30-year average, computed on a 4-kilometer grid by the Parameter-Elevation Regressions on Independent Slopes Model. Subbasin accretions are described based on their location within the subbasin; North Yuba River, Slate Creek, and Canyon Creek accretions are included in the discussion of NBB accretions; Oregon Creek, Middle Yuba River, South Yuba River, and Yuba River accretions are included in the discussion of Englebright accretions; and Dry and Deer Creek and lower Yuba River accretions are included in the lower Yuba River accretions discussion.

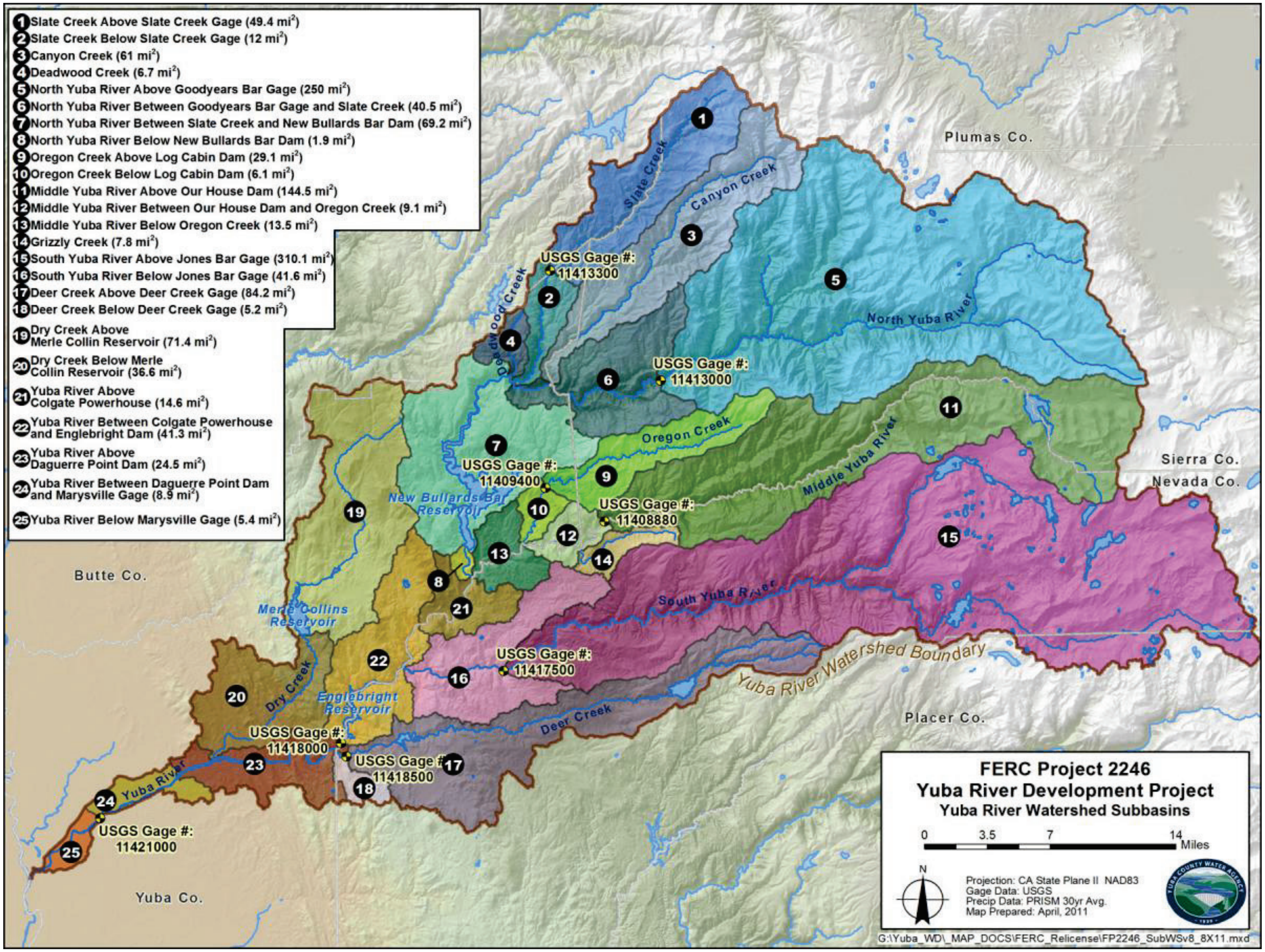

Figure 3.0-1. Yuba River Watershed and Subbasins

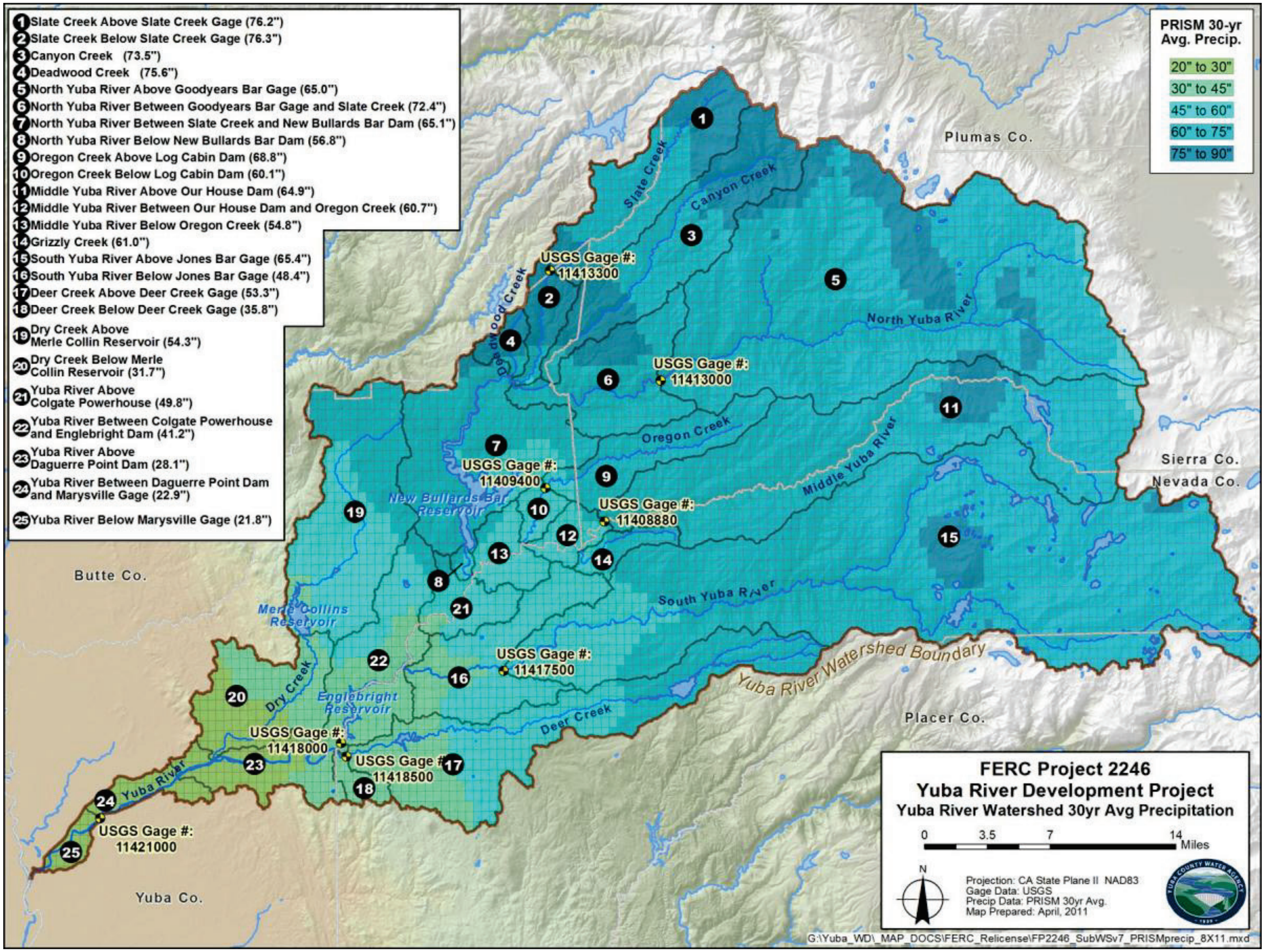

Figure 3.0-2. Yuba River Watershed and Subbasin Average Annual Precipitation

3.1 Accretions to New Bullards Bar Reservoir

As previously discussed, New Bullards Bar Reservoir receives inflows from several tributaries, including the largely unimpaired mainstem North Yuba River as well as its primary tributaries, Slate Creek, Canyon Creek, and Deadwood Creek. While Canyon Creek and Deadwood Creek are essentially unimpaired, SFWPA diverts from Slate Creek into the Feather River watershed. The North Yuba River watershed is generally snowmelt-dominated at higher elevations and rainfall-dominated at lower elevations, as shown in Table 3.1-1.

Table 3.1-1. New Bullards Bar Reservoir Tributaries.

Subbasin	Area (square miles)	Average Annual Precipitation (inches)	Major Source
North Yuba River above Goodyears Bar	250	65.0	snow
Slate Creek above the Slate Creek gage	49.4	76.2	snow
Canyon Creek	61	73.5	snow
North Yuba River between Goodyears Bar and Slate Creek	40.5	72.4	rain
North Yuba River between Slate Creek and New Bullards Bar Dam	69.2	65.1	rain
Slate Creek below Slate Creek gage	12	76.3	rain
Deadwood Creek	6.7	75.6	rain
Total	488.8	68.3	--

Although there are gages on the upper North Yuba River and upper Slate Creek, the lower reaches of these two tributaries, Canyon Creek, and Deadwood Creek, are ungaged. Table 3.1-1 includes some information about NBB tributaries.

As shown in Table 3.1-1, the total area of watershed above NBB is 488.8 square miles. Of this area, 190 square miles or 39 percent is not directly measured by streamflow gage and makes up the accretion area to be synthesized. Three methods of calculating the accretions to NBB were completed. These methods are described in the following sections. One of these methods, the area-weighted scaling method was selected as the best method for accurately calculating daily flow for the POR.

3.1.1 Calculation of Accretions to New Bullards Bar Reservoir Using Mass Balance Methodology

Total daily accretion flow to NBB is calculated using a simple reservoir mass balance equation:

$$NBB\ accretions = NBB\ storage + NBB\ releases - NBB\ gaged\ inflows$$

The components of this equation were defined as follows:

- NBB storage = daily New Bullards Bar Reservoir storage change (USGS Gage 11413515)
- NBB releases = sum of the following daily flows:

  - NBB releases to the Colgate Tunnel (USGS Gage 11413510)
  - NBB minimum flow releases, spills and other releases (USGS Gage 11413520 and data from YWA gages)
- NBB gaged inflows = sum of the following daily flows:
  - North Yuba River above Goodyears Bar (USGS Gage 11413000)
  - Slate Creek above Slate Creek gage (USGS Gage 11413300)
  - Camptonville Tunnel (USGS Gage 11408870 from 1988 to present; calculated using USGS Gages 11409300 and 11409400 on Oregon Creek, 11408850 on the Lohman Ridge Tunnel, and 11408850 and 11408880 on the Middle Yuba River from 1969 to 1988)

Storage in NBB is calculated by measuring the water-surface elevation in the reservoir and converting this to a storage value by using an elevation-versus-storage table that has been established for the reservoir. Although the elevation measurement is made to within one hundredth of a foot, the large surface area of the reservoir makes the daily variation of this measurement rather large and results in a highly variable accretion flow value. To facilitate accretions calculations, total daily accretions were smoothed using 7-day average data for reservoir storage, total inflows, and total releases.[4] However, even using the centered 7-day average data resulted in the calculation of many accretions that were below zero. Given that the Yuba River above the Reservoir and its tributaries are believed to comprise of mostly accretions, it is not likely that seepage losses to groundwater have a large influence on ungaged flows above New Bullards Bar which would be the mechanism that could result in negative values. Therefore, the result of negative accretions is most likely due to the accumulation of data errors. Possible data errors used in accretion calculations include:

- Error in the reservoir stage data used to calculate reservoir storage due to wind or other factors that make the stage measurement inconsistent;
- Measurement error of NBB non-spill releases due to location of the NBB gage close to the dam outlet, where turbulent flow may occur;
- Measurement error of NBB spill releases; and/or
- Measurement error at each USGS gage.

3.1.2 Estimation of Accretions to New Bullards Bar Reservoir Using Statistical Regression Methodology

NBB accretions were also estimated using the following linear regression, including terms for both snowmelt- and rainfall-dominated watersheds:

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[4] Smoothing was also attempted using a running 7-day average, but it did not smooth as well as the centered average.

$$Q_{ungaged} = xQ_{snow,index\,flow} + yQ_{rain,index\,flow}$$

In this regression, the snow and rain index flows were the daily flows on the North Yuba River at Goodyears Bar and on Oregon Creek above Log Cabin Dam, respectively. Using the Solver tool in Microsoft Excel, the coefficients x and y were computed to minimize the difference between the calculated NBB accretions and the NBB accretions estimated by the linear regression. The coefficients were optimized as the following:

- $x = 0.26$; and
- $y = 4.39$.

These coefficients suggest that NBB accretions consist of one part snow to 16 parts rain, which is in agreement with the fact that most ungaged flows above the reservoir occur at relatively lower elevations in the watershed, which are typically rainfall-driven. This method provided reasonable results for all time periods.

3.1.3 Estimation of Accretions to New Bullards Bar Reservoir using Area-Weighted Flow Methodology

The USGS proposes the following area-weighted relationship between ungaged and gaged flows (Q), drainage areas (A), and Precipitation (P) within a single watershed (USGS 2007):

$$Q_{ungaged} = \left(\frac{A_{ungaged}}{A_{gaged}}\right) \times \left(\frac{P_{ungaged}}{P_{gaged}}\right) \times Q_{gaged}$$

This equation is applied to the North Yuba River watershed by including components for both the snowmelt- and rainfall-dominated parts of the watershed:

$$\begin{aligned} Q_{ungaged} = {} & \left(\frac{A_{ungaged,snow}}{A_{gaged,snow}}\right) \times \left(\frac{P_{ungaged,snow}}{P_{gaged,snow}}\right) \times Q_{gaged,snow} \\ & + \left(\frac{A_{ungaged,rain}}{A_{gaged,rain}}\right) \times \left(\frac{P_{ungaged,rain}}{P_{gaged,rain}}\right) \times Q_{gaged,rain} \end{aligned}$$

To solve for accretions to NBB ($Q_{ungaged}$), the upper North Yuba River watershed, described in Section 2.1, was chosen as the index snowmelt-dominated gaged watershed because of the following:

- The majority of its annual flow volume originates as snowmelt;
- Its flows are unimpaired by storage reservoirs or diversion dams;
- It is the largest unimpaired watershed above NBB; and
- Its gage has a long POR (1930 to present).

Although it is not part of the North Yuba River watershed and its flows do not contribute to NBB storage, the upper Oregon Creek watershed, described in Section2.5, was chosen as the index rainfall-dominated gaged watershed for the following reasons:

- Its flows are rainfall-dominated (most of the watershed is below 5,000 feet msl);
- It is unimpaired by upstream dams or reservoirs; and
- Flow data is available for the POR of analysis (1969 to present).

The total gaged and ungaged snowmelt- and rainfall-dominated areas and precipitations are shown in Table 3.1-1. The total ungaged snowmelt-dominated area above NBB ($A_{ungaged,snow}$) is defined as the area of the Canyon Creek watershed. The total ungaged rainfall-dominated area above NBB ($A_{ungaged,rain}$) is defined as the sum of the following watershed areas:

- North Yuba River between Slate Creek and Goodyears Bar (USGS Gage 11413000);
- North Yuba River between Slate Creek and New Bullards Bar Dam;
- Slate Creek below Slate Creek gage (USGS Gage 11413300); and
- Deadwood Creek.

The ratio of the area and precipitation of the Canyon Creek subbasin to the area and precipitation of the North Yuba River above Goodyears Bar is 0.28. The ratio of the area and precipitation of ungaged rainfall-dominated basins to the area and precipitation of the Oregon Creek above Log Cabin Dam subbasin is 4.42. These two ratios were multiplied by the daily flows from the Goodyears Bar gage and Oregon Creek above Log Cabin Dam, respectively, to compute accretions to the subbasin above New Bullards Bar Dam for the POR.

3.1.4 Comparison of Accretions Calculation and Estimations

Comparing accretions from the statistical regression and area-weighted flow methodologies with those from the mass balance methodology showed the two estimation methods were well correlated with the mass balance method. A comparison of the coefficients for North Yuba River flow at Goodyears Bar and Oregon Creek above Log Cabin indicate the area-weighted methodology yields very similar values to those determined through a statistical analysis. Comparing the accumulated flow volumes of the area-weighted flow method and the mass balance method indicates a consistent comparison of the two methods through time. Figure 3.1-1 shows the accumulated mass plot comparing the two methods. Since the area-weighted flow methodology is a published approach, and represents hydrologic processes rather than a mathematical solution, it was selected as the most appropriate methodology to estimate accretions to the North Yuba River above New Bullards Bar Dam.

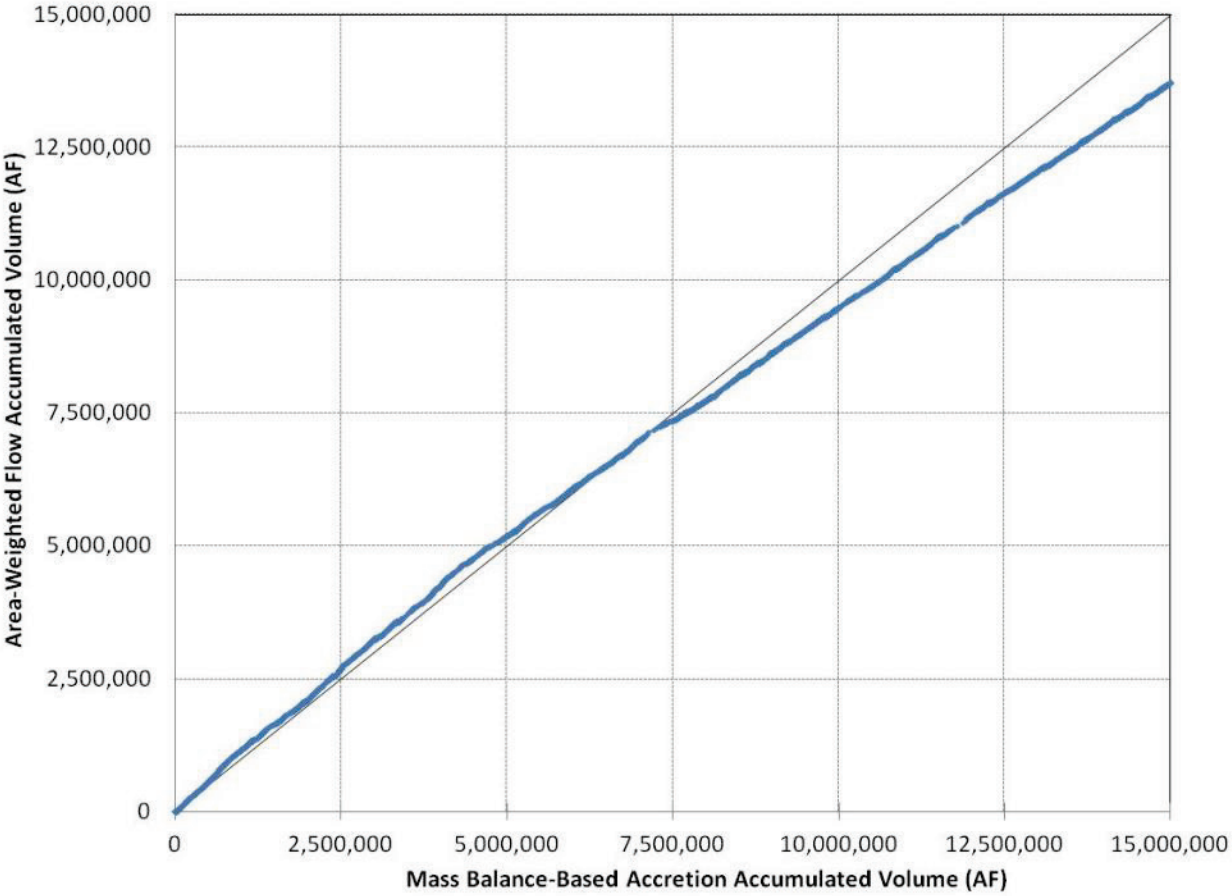

Figure 3.1-1. Comparison of Accumulated Volumes for Various Methodologies of Estimating Accretions to New Bullards Bar Reservoir

An assessment of potential gaging error showed that application of a small variance in the Colgate Powerhouse gage (USGS 11413510) readings, as shown in Table 3.1-2, would improve the overall alignment of the area-weighted flow accumulated volume with the mass balance-based approach. Figure 3.1-2 shows the comparison of the accumulated volumes with the adjustment to the Colgate Powerhouse gage.

Table 3.1-2. Applied Colgate Powerhouse Gage Correction Factors

Period (Water Year)	Factor
1971-1980	101%
1981-1994	95%
1995-2002	94%
2003-2010	97%

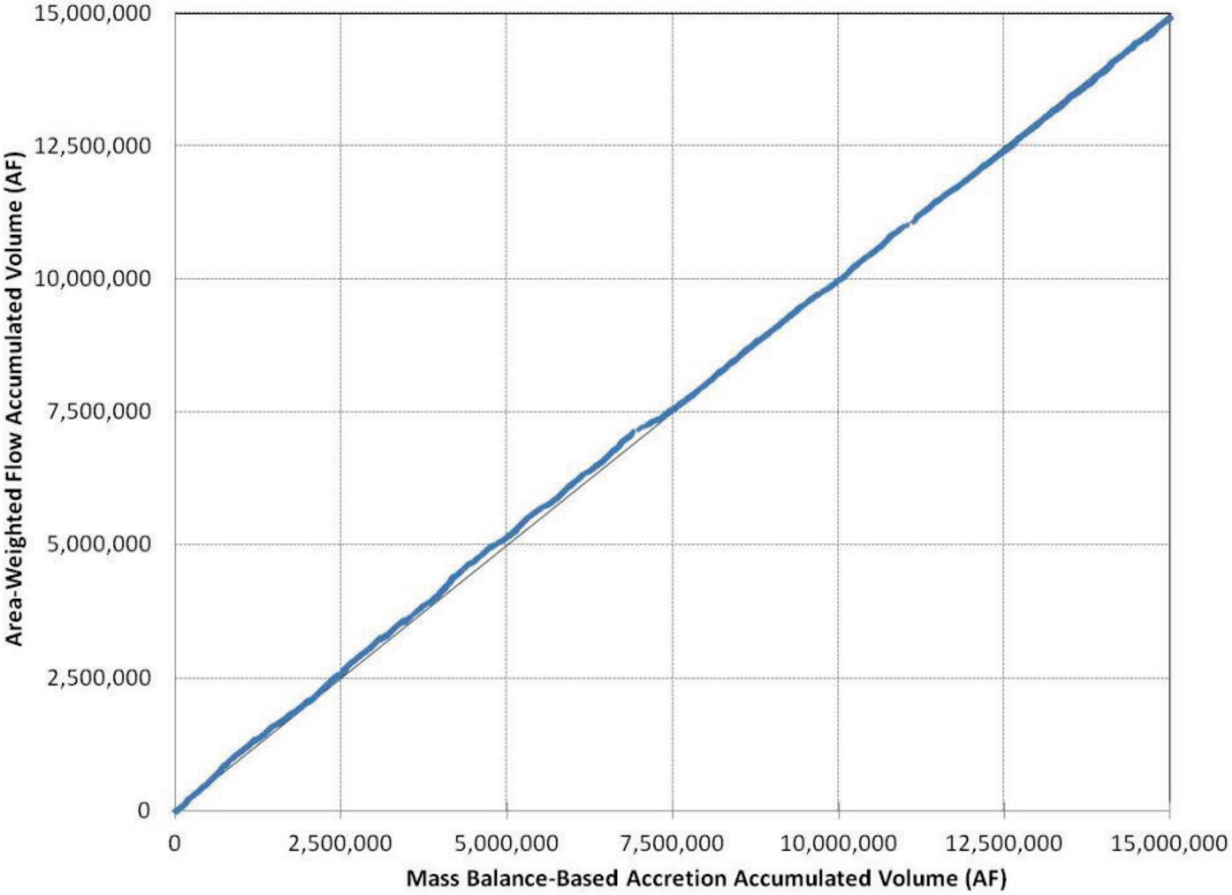

Figure 3.1-2. Comparison of Accumulated Volumes for Various Methodologies of Estimating Accretions to New Bullards Bar Reservoir with Colgate Powerhouse Gage Correction

This correction suggests differences between methods for computing accretions can be explained by potential small gaging errors. Similarly, this indicates the area-weighted flow method described in Section 3.1.3 can successfully be used to compute accretions within acceptable ranges of gaging error. It should be noted that the review of gage error is used to demonstrate the area-weighted flow method attains similar results as the mass-balance method, as shown in Figure 3.1.2, when a small gage correction factor is applied. It is not implied that there is error in the USGS gages, rather that differences between the two methodologies are within reasonable amounts. No adjustments are proposed to the area-weighed method results to compute the final accretions beyond the calculation described in Section 3.1.3.

3.1.5 Computation of Ungaged Accretions to North Yuba River above New Bullards Bar Dam Subbasins

Using the area-weighted flow methodology described above, accretions to the North Yuba River above New Bullards Bar Dam can be computed at a subbasin scale. The watershed of the North Yuba River above New Bullards Bar Dam can be divided into several smaller ungaged subbasins. Comparing the areas of the subbasins with an index watershed and multiplying the index watershed flow by the ratio of their areas and precipitations yields the contribution of that subbasin to the total ungaged accretions from the North Yuba River above New Bullards Bar Dam. Since it is so small, Deadwood Creek is included in the North Yuba River between Slate Creek and New Bullards Bar Dam calculation. Table 3.1-3 shows these subbasins, their areas, average annual precipitations, and their index watersheds.

Table 3.1-3. Ungaged North Yuba River above New Bullards Bar Dam Subbasins.

Subbasin	Area (Square Miles)	Average Annual Precipitation (inches)	Index Watershed	Area-Weighting Ratio
North Yuba River between Goodyears Bar and Slate Creek	40.5	72.4	Oregon Creek above Log Cabin Dam	1.46
Canyon Creek	61	73.5	North Yuba River above Goodyears Bar	0.28
Slate Creek Below Slate Creek Gage	12	76.3	Oregon Creek above Log Cabin Dam	0.45
North Yuba River between Slate Creek and New Bullards Bar Dam	76	66.0	Oregon Creek above Log Cabin Dam	2.50
Total Area Indexing Oregon Creek	128.5	69.0	--	4.42
Total Area Indexing North Yuba River	61	73.5	--	0.28
Total Ungaged Area	189.5	70.4	--	--

To confirm all areas were accounted for, subbasin accretions were compared with total ungaged North Yuba River accretions above New Bullards Bar Dam. The total accretion value for all subbasins agreed with the North Yuba River accretion value. Figure 3.1-3 shows the subbasins used to determine ungaged accretions.

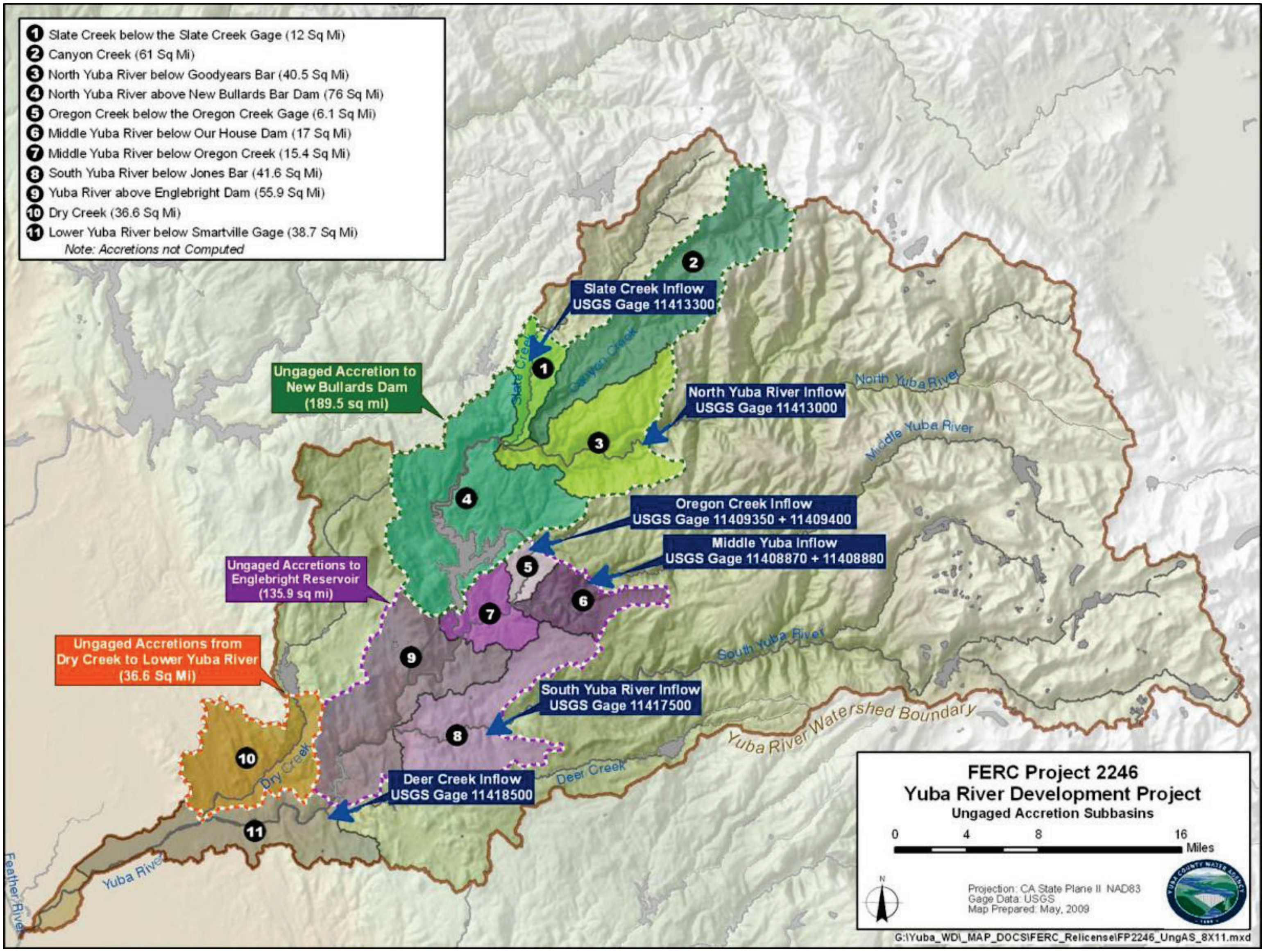

Figure 3.1-3. Yuba River Ungaged Accretion Subbasins

North Yuba River Accretions

Accretions were computed for the North Yuba River between Goodyears Bar and Slate Creek using the methodology described above, comparing the area and precipitation of the North Yuba River subbasin between Goodyears Bar and Slate Creek with the area, precipitation and flow of Oregon Creek above Log Cabin Dam. Table 3.1-4 shows the computed monthly average accretions to the North Yuba River between Goodyears Bar and Slate Creek.

Table 3.1-4. Monthly Average Accretions to the North Yuba River between Goodyears Bar and Slate Creek.

Location	Average[1] Monthly Accretions (cfs)												Total (TAF)
	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	
North Yuba River Accretions[2]	5	9	47	142	239	262	280	189	105	37	11	5	80

Notes:
[1] Period of Record: 10/1/1969 through 9/30/2020
[2] North Yuba River below Goodyears Bar accretions computed for the reach between Goodyears Bar and Slate Creek using methodology described in Section 3.1.5.
Key: cfs=cubic feet per second TAF=thousand acre-feet

Canyon Creek Accretions

Accretions were computed for Canyon Creek using the methodology described above, comparing the area of the Canyon Creek subbasin with the area and flow of the North Yuba River above Goodyears Bar. Table 3.1-5 shows the computed monthly average accretions to the Canyon Creek.

Table 3.1-5. Monthly Average Accretions to Canyon Creek.

Location	Average[1] Monthly Accretions (cfs)												Total (TAF)
	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	
Canyon Creek Accretions[2]	42	48	98	185	271	281	344	382	469	289	100	50	154

Notes:
[1] Period of Record: 10/1/1969 through 9/30/2020
[2] Canyon Creek accretions computed using methodology described in Section 3.1.5.
Key: cfs=cubic feet per second TAF=thousand acre-feet

Slate Creek Accretions

Accretions were computed for Slate Creek for the reach between the Slate Creek Diversion Dam and Slate Creek's confluence with the North Yuba River using the methodology described above, comparing the area of the subbasin contributing to Slate Creek between the Slate Creek Diversion Dam and Slate Creek's confluence with the North Yuba River with the area and flow of Oregon Creek above Log Cabin Dam. Table 3.1-6 shows the computed monthly average accretions to Slate Creek between the Slate Creek Diversion Dam and the Slate Creek's confluence with the North Yuba River.

Table 3.1-6. Monthly Average Accretions to Slate Creek between the Slate Creek Diversion Dam and Slate Creek's Confluence with the North Yuba River.

Location	Average[1] Monthly Accretions (cfs)												Total (TAF)
	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	
Slate Creek Accretions[2]	2	3	15	44	75	82	87	59	33	12	3	2	25

Notes:
[1] Period of Record: 10/1/1969 through 9/30/2020
[2] Slate Creek below Slate Creek Diversion Dam accretions computed for the reach between the Slate Creek Diversion Dam and Slate Creek's confluence with the North Yuba River using methodology described in Section 3.1.5.
Key: cfs=cubic feet per second TAF=thousand acre-feet

Accretions to New Bullards Bar Reservoir

Accretions were computed for the subbasin contributing to inflows directly to NBB and the North Yuba River below the Slate Creek confluence using the methodology described above, comparing the area of the subbasin contributing to NBB with the area and flow of Oregon Creek above Log Cabin Dam. Table 3.1-7 shows the computed monthly average accretions to NBB.

Table 3.1-7. Monthly Average Accretions New Bullards Bar Reservoir.

Location	Average[1] Monthly Accretions (cfs)												Total (TAF)
	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	
Accretions to New Bullards Bar Reservoir[2]	8	16	80	243	409	447	478	322	179	63	18	9	136

Notes:
[1] Period of Record: 10/1/1969 through 9/30/2020
[2] New Bullards Bar Reservoir accretions computed for the area between the confluence of the North Yuba River and Slate Creek and New Bullards Bar Dam using methodology described in Section 3.1.5.
Key: cfs=cubic feet per second TAF=thousand acre-feet

3.1.6 Computation of New Bullards Bar Reservoir Evaporation

Evaporation from NBB is a notable factor in Yuba River hydrologic analysis. Since direct measurement of evaporation is impractical, quantification of evaporative losses from the reservoir relies upon previous analyses. As a part of the development of a USACE Hydrologic Engineering Center (HEC)-3 model, the California Department of Water Resources (DWR) developed a monthly pattern of evaporation for NBB. Table 3.1.8 has the monthly evaporation rates from the HEC-3 model.

Table 3.1-8. Monthly Evaporation Rates for New Bullards Bar Reservoir.

Location	Monthly Evaporation Rate (inches)											
	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
New Bullards Bar Reservoir	4.31	1.67	1.04	0.93	1.7	2.44	3.21	4.13	6.48	7.78	7.24	5.08

Notes: From DWR HEC-3 Yuba River Watershed Model. January 1985

Applying these reservoir evaporation rates to historical daily NBB water surface areas yields historical evaporation volumes. Table 3.1-9 shows historical monthly average NBB evaporation, based on published evaporation rates.

Table 3.1-9. Historical Monthly Average New Bullards Bar Reservoir Evaporation.

Location	Average[1] Monthly Evaporation (cfs)												Total (TAF)
	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	
New Bullards Bar Reservoir[2]	20	8	5	4	9	12	18	24	39	44	37	25	15

Notes:
[1] Period of Record: 10/1/1969 through 9/30/2020
[2] New Bullards Bar Reservoir evaporation computed by multiplying reservoir evaporation rates from Table 3.1-7 with historical reservoir water surface areas.
Key: cfs = cubic feet per second TAF= thousand acre-feet

3.2 Accretions to Englebright Reservoir

Accretions to Englebright Reservoir and the Yuba River below New Bullards Bar Dam contribute to the operations of Englebright Dam. Therefore, they need to be accounted for when determining flows within the Project Area. In a similar process to the one used to determine North Yuba River accretions to NBB, accretions to Englebright Reservoir were computed using a mass balance methodology, using change in storage and releases from Englebright Dam to compute total inflow to the reservoir. Local accretions were computed by subtracting known inflows from Oregon Creek and the Middle and South Yuba rivers. . Changes in Englebright Reservoir elevation and storage are highly variable, since Englebright Reservoir is used as a regulating afterbay to NBB and the surface area of Englebright Reservoir is relatively small compared with flows from NBB releases.. During normal operations, releases from Englebright Dam to the lower Yuba River are kept at a relatively consistent rate throughout a week, but releases from NBB are highly variable, reflecting changing release rates for power generation. Due to the high degree of daily and hourly variation of Englebright Reservoir storage, using daily storage values to compute accretions to Englebright Reservoir leads to extremely inconsistent values. In an effort to smooth accretions, a 7-day average storage, release, and gaged inflow was used to compute accretions to Englebright Reservoir:

$$\text{Englebright accretions} = \text{Englebright storage} + \text{Englebright releases} - \text{Englebright gaged inflows}$$

The components of the mass balance were defined as follows:

- Englebright storage = daily storage Reservoir change data (data from YWA)
- Englebright Dam releases = flow below Englebright Dam at Smartsville (data from USGS Gage 11418000)
- Englebright Dam gaged inflows = sum of the following daily flows:
    - NBB minimum flow releases, spills and other releases (data from USGS Gage 11418000 and YWA gages)
    - NBB releases to the Colgate Tunnel (data from USGS Gage 11413510)

- Oregon Creek above Log Cabin Dam (data from USGS Gage 11409300 from 1969 to 2000; calculated using USGS Gages 11409350, 11409400, and 11408870 from 2000 to present)
- Middle Yuba River above Our House Dam (data from USGS Gage 11413000)
- South Yuba River at Jones Bar (data from USGS Gage 11413300)

Despite the use of the 7-day average for flows and storage, resulting accretions remain more variable than would be expected in a natural system. Accordingly, the area-weighted flow methodology validated for computing accretions to the North Yuba River above New Bullards Bar Dam is applied to compute Yuba River accretions above Englebright Dam. Due to the lower elevations of the ungaged basins tributary to the Yuba River above Englebright Dam, no snowmelt component is included; instead, only the rain-fall aspect of the methodology for the North Yuba River tributaries is used.

$$Q_{ungaged} = \left(\frac{A_{ungaged,rain}}{A_{gaged,rain}}\right) \times \left(\frac{P_{ungaged,rain}}{P_{gaged,rain}}\right) \times Q_{gaged,rain}$$

Since NBB accretions estimated using an Oregon Creek index correlate well with the mass-balance calculated NBB accretions, a similar assumption is used to compute accretions to Englebright Reservoir and the Oregon Creek watershed above Log Cabin Dam is used as the gaged index area having representative rainfall-dominated unimpaired flows. The ungaged area is defined as the sum of the areas summarized in Table 3.2-1.

Table 3.2-1. Sources of Inflows to Englebright Reservoir.

Subbasin	Area (square miles)	Average Annual Precipitation (inches)	Area-Weighting Ratio
North Yuba River below NBB	2	56.8	0.054
Oregon Creek above Log Cabin Dam	29	68.8	Gaged
Oregon Creek below Log Cabin Dam	6	60.1	0.183
Middle Yuba River above Our House Dam	144	64.9	Gaged
Middle Yuba River between Our House Dam and Oregon Creek	9	60.7	0.276
Middle Yuba River below Oregon Creek	14	54.8	0.369
South Yuba River above Jones Bar Gage	310	65.4	Gaged
South Yuba River below Jones Bar Gage	42	48.4	1.006
Yuba River above Colgate Powerhouse	15	49.8	0.363
Yuba River between Colgate Powerhouse and Englebright Dam	41	41.2	0.850
Total Ungaged Area	136	49.2	3.339

3.2.1 Comparison of Englebright Accretions Calculation and Estimation

The lack of correlation between the two timeseries is likely due primarily to errors in the data used in the summation methodology as described above. Possible sources of error include:

- Error in the reservoir stage data used to calculate reservoir storage due to wind or other factors that make the stage measurement inconsistent;
- Measurement error of Englebright Dam non-spill releases due to location of the Englebright Dam gage close to the dam outlet, where turbulent flow may occur;
- Inaccurate gaging of Englebright Dam spill releases, especially because Englebright Dam spills often; and/or
- Measurement error of at each USGS gage, particularly the Colgate Powerhouse releases and the Smartsville gage.

When comparing accretions determined through the mass-balance methodology with those determined using the area-weighted flow methodology, there is a notable disparity in accumulated volume. As shown in Figure 3.2-1, the difference in rate of accumulated volume between the two methodologies varies greatly in total and through time. This suggests a variable gage error through time. The assumed source of most of the differences between these two methods are gage errors associated with the Colgate Powerhouse and Smartsville gages used in the mass balance calculation. Since the volume of flow measured by these gages is significantly greater than the volume of flow otherwise calculated as an accretion, these two gages are the likely source of differences. For example, while the accumulated flow of the mass balance accretion totals approximately 3 MAF, the total flow measured at the Smartsville gage is about 67 MAF, or more than 20 times the amount of flow that is being evaluated. Therefore, an error in gage measurement of 5% at the Smartsville gage, considered by the USGS to have a “good” stream gage rating, would result in as much as 3.35 MAF (5% of 67 MAF) of accumulated error.

Using the Colgate Powerhouse correction factors described in Section 3.1.4 and identifying approximate errors of Smartsville gage flows according to obvious breakpoints, a substantially improved agreement between the two methodologies was reached. Figure 3.2-2 shows the comparison of accumulated volume after applying the gage correction factors shown in Table 3.2-2.

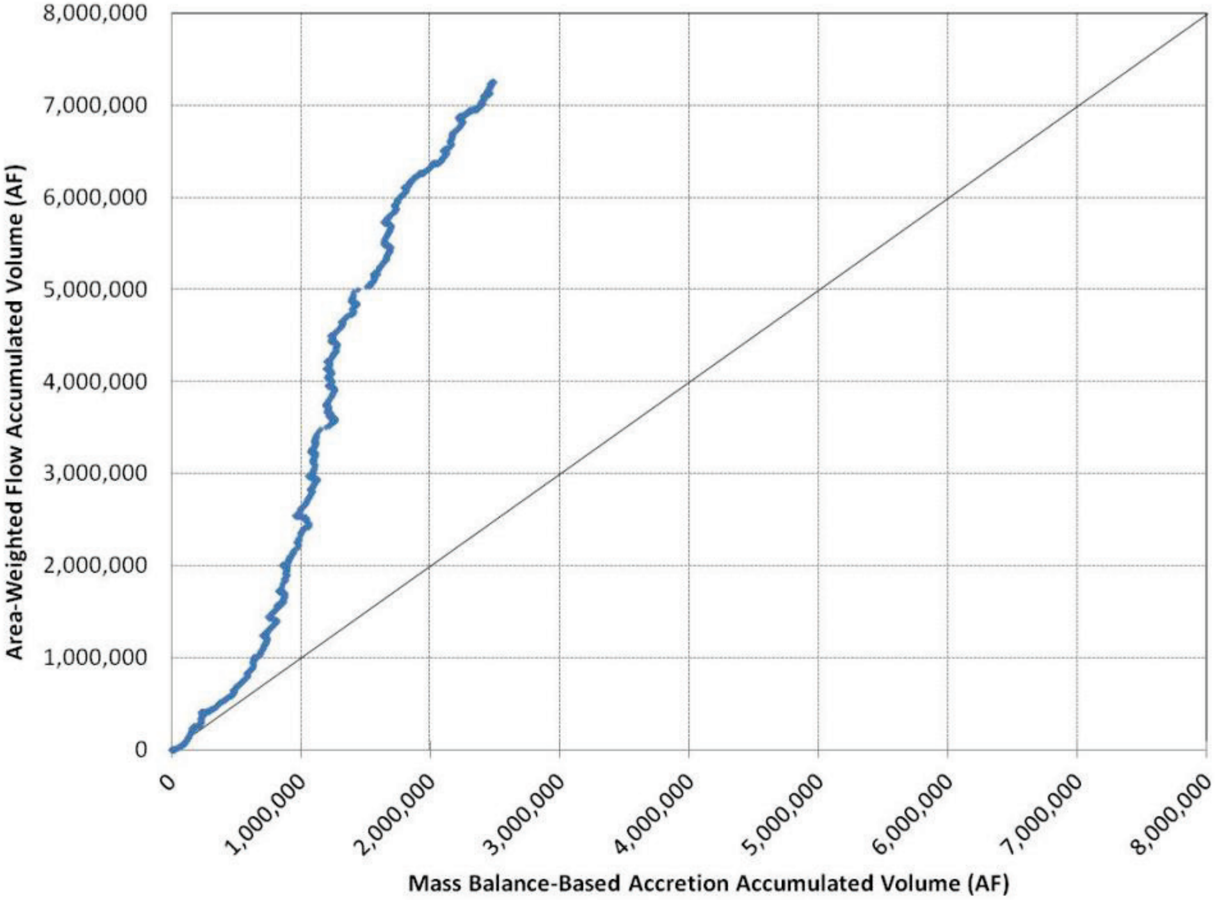

Figure 3.2-1. Comparison of Accumulated Volumes for Various Methodologies of Estimating Accretions to Englebright Reservoir

Table 3.2-2. Applied Smartsville Gage Correction Factors

Period (Water Year)	Correction
1971-1977	106%
1978-1994	108%
1995-2010	102%

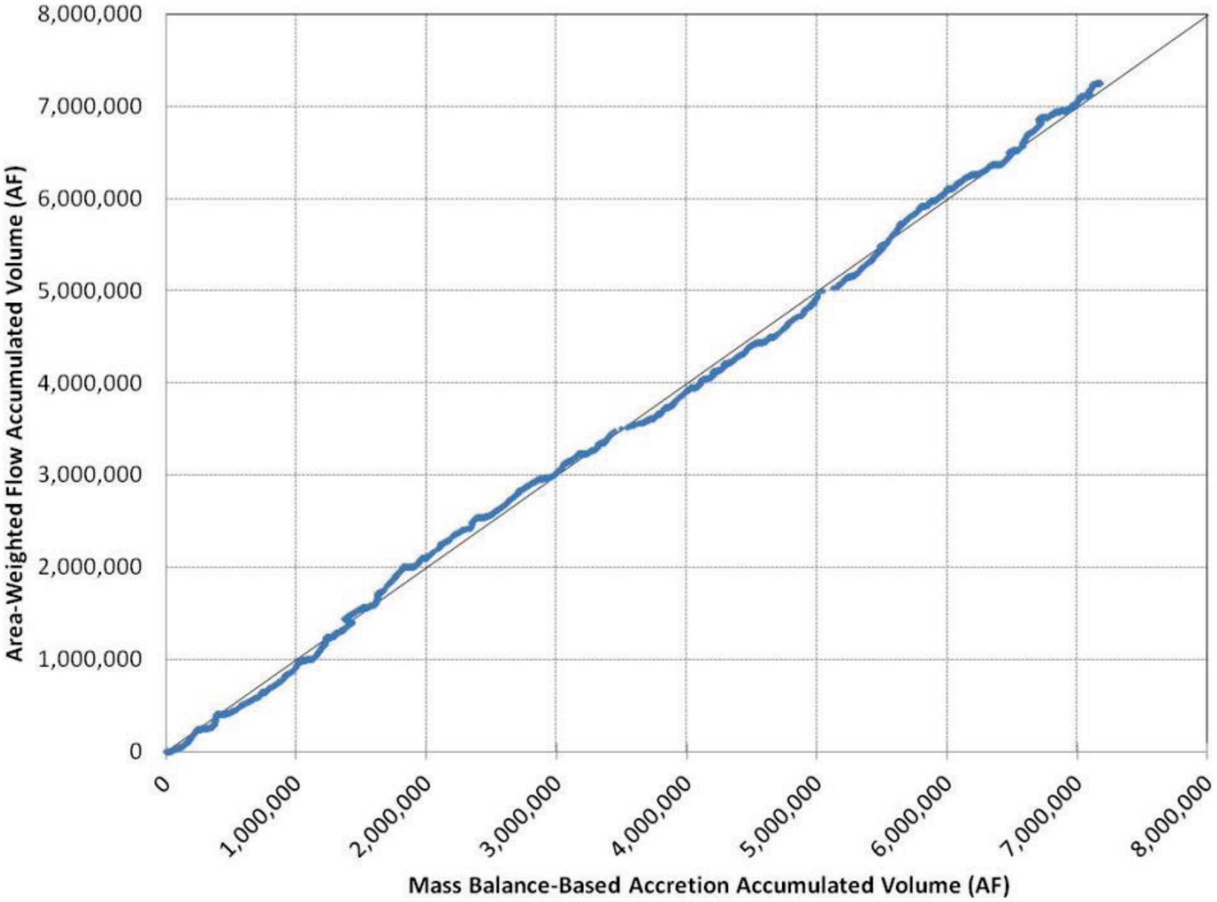

Figure 3.2-2. Comparison of Accumulated Volumes for Various Methodologies of Estimating Accretions to Englebright Reservoir with Gage Correction Factors

As described in Section 3.1.4, this correction suggests differences between methods for computing accretions can be explained by potential small gaging errors. It is also reasonable to assume gage accuracy can be affected by hydrologic events. This also indicates the area-weighted flow method described in Section 3.2.1 can successfully be used to compute accretions within acceptable ranges of gaging error.

3.2.2 Computation of Ungaged Accretions from Subbasins to the Yuba River above Englebright Dam

As described in Section 3.1.5, using the area-weighted flow methodology, ungaged Yuba River accretions above Englebright Dam can be allocated to individual subbasins. Table 3.2-1 shows the ungaged subbasins contributing to total ungaged Yuba River accretions above Englebright Dam. Oregon Creek above Log Cabin Dam is used as the index watershed for all subbasins.

As computed for the ungaged North Yuba River accretions above New Bullards Bar Dam, ungaged Yuba River accretions above Englebright Dam from the individual subbasins are added together and compared to the total Yuba River accretions above Englebright Dam to ensure all areas have been included.

Middle Yuba River (Middle Reach) Accretions

Accretions were computed for the Middle Yuba River between Our House Dam and Oregon Creek using the methodology described above, comparing the area of the Middle Yuba River between Our House Dam and Oregon Creek with the area and flow of Oregon Creek above Log Cabin Dam. Table 3.2-3 shows the computed monthly average accretions to the Middle Yuba River between Our House Dam and Oregon Creek.

Table 3.2-3. Monthly Average Accretions to the Middle Yuba River between Our House Dam and Oregon Creek.

Location	Average[1] Monthly Accretions (cfs)												Total (TAF)
	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	
Middle Yuba River (Middle Reach) Accretions[2]	2	3	16	50	85	95	98	66	37	13	4	2	28

Notes:

[1] Period of Record: 10/1/1969 through 9/30/2020

[2] Middle Yuba River below Our House Dam accretions computed for the reach between Our House Dam and Oregon Creek using methodology described in Section 3.2.2.

Key: cfs=cubic feet per second TAF=thousand acre-feet

Middle Yuba River (Lower Reach) Accretions

Accretions were computed for the Middle Yuba River below Oregon Creek using the methodology described above, comparing the area of the Middle Yuba River below Oregon Creek with the area and flow of Oregon Creek above Log Cabin Dam. Table 3.2-4 shows the computed monthly average accretions to the Middle Yuba River below Oregon Creek.

Table 3.2-4. Monthly Average Accretions to the Middle Yuba River below Oregon Creek.

Location	Average[1] Monthly Accretions (cfs)												Total (TAF)
	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	
Middle Yuba River (Lower Reach) Accretions	1	2	12	36	61	68	71	48	26	9	3	1	20

Notes:

[1] Period of Record: 10/1/1969 through 9/30/2020

[2] Middle Yuba River below Oregon Creek accretions computed for reach between Oregon Creek and the confluence of the Middle Yuba River and the North Yuba River using methodology described in Section 3.2.2.

Key: cfs=cubic feet per second TAF=thousand acre-feet

Oregon Creek Accretions

Accretions were computed for Oregon Creek below Log Cabin Dam using the methodology described above, comparing the area of Oregon Creek below Log Cabin Dam with the area and flow of Oregon Creek above Log Cabin Dam. Table 3.2-5 shows the computed monthly average accretions to Oregon Creek below Log Cabin Dam.

Table 3.2-5. Monthly Average Accretions to the Oregon Creek below Log Cabin Dam.

Location	Average[1] Monthly Accretions (cfs)												Total (TAF)
	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	
Oregon Creek Accretions[2]	1	1	6	18	30	34	35	24	13	5	1	1	10

Notes:

[1] Period of Record: 10/1/1969 through 9/30/2020

[2] Oregon Creek below Log Cabin accretions computed for the reach between Log Cabin and the confluence of the Oregon Creek and the Middle Yuba River using methodology described in Section 3.2.2.

Key: cfs=cubic feet per second TAF=thousand acre-feet

South Yuba River Accretions

Accretions were computed for the South Yuba River below Jones Bar using the methodology described above, comparing the area of the South Yuba River below Jones Bar with the area and flow of Oregon Creek above Log Cabin Dam. Table 3.2-6 shows the computed monthly average accretions to the South Yuba River below Jones Bar.

Table 3.2-6. Monthly Average Accretions to the South Yuba River below Jones Bar.

Location	Average[1] Monthly Accretions (cfs)												Total (TAF)
	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	
South Yuba River Accretions[2]	3	6	32	98	166	185	192	130	72	25	7	3	55

Notes:

[1] Period of Record: 10/1/1969 through 9/30/2020

[2] South Yuba River below Jones Bar accretions computed for Oregon Creek between Jones Bar and the confluence of the South Yuba River and the Yuba River using methodology described in Section 3.2.2.

Key: cfs=cubic feet per second TAF=thousand acre-feet

Accretions to Englebright Reservoir

Accretions were computed the subbasin contributing to inflows directly to Englebright Reservoir below the Middle Yuba River using the methodology described above, comparing the area of the subbasin contributing to Englebright Reservoir with the area and flow of Oregon Creek above Log Cabin Dam. Table 3.2-7 shows the computed monthly average accretions to Englebright Reservoir.

Table 3.2-7. Monthly Average Accretions to Englebright Reservoir.

Location	Average[1] Monthly Accretions (cfs)												Total (TAF)
	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	
Accretions to Englebright Reservoir[2]	4	7	39	115	199	219	229	155	88	30	9	4	66

Notes:

[1] Period of Record: 10/1/1969 through 9/30/2020

[2] Englebright Reservoir accretions computed for the area between the Middle Yuba River and Englebright Dam using methodology described in Section 3.2.2.

Key: cfs=cubic feet per second TAF=thousand acre-feet

3.2.3 Computation of Englebright Reservoir Evaporation

Similar to NBB, Englebright Reservoir evaporation can play a substantial role in the hydrologic analysis of the watershed. Since Englebright Reservoir's water surface elevation does not have a dramatic seasonal or monthly change, a constant water surface area of 810 acres is used for analysis. Monthly evaporation rates for Englebright Reservoir, published by DWR as part of the HEC-3 model of the Yuba River watershed, are shown in Table 3.2-8.

Table 3.2-8. Monthly Englebright Reservoir Evaporation Rates.

Location	Monthly Evaporation Rate (inches)											
	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Englebright Reservoir	5.03	1.95	1.21	1.09	1.99	2.85	3.75	4.83	7.58	9.09	8.46	5.94

Source: From DWR HEC-3 Yuba River Watershed Model. January 1985

Applying the monthly evaporation rates to the constant reservoir surface area yields average monthly evaporation volumes, as shown in Table 3.2-9.

Table 3.2-9. Monthly Englebright Reservoir Evaporation Volumes.

Location	Monthly Evaporation (AF)												Total
	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	
Englebright Reservoir[1]	401	340	132	82	74	134	192	253	326	512	614	571	3,629

Notes:

[1] Englebright Reservoir evaporation computed by multiplying reservoir evaporation rates from Table 3.2-7 with reservoir surface area of 810 acres.

Key: AF= acre-feet

3.2.4 Accretion Correction for Large Flood Events

The area-weighted scaling method used to calculate reservoir accretion was validated using gage summation. Gage summation is the sum of the change in reservoir storage plus gaged outflows minus gage inflow. The remainder of this calculation is the ungaged accretion. A comparison of daily average accretion values calculated by gage summation and by area-weighted scaling showed that the area-weighted scaling method characterized accretion well overall, except during large flood events resulting in an underestimation of local reservoir accretion. Accretion values for large flood events were corrected to represent the gage summation accretion values rather than the area-weighted scaling accretion values. The corrections were applied for at least 1 week prior to the peak inflow and 1 week after the peak inflow unless additional days were needed for both accretion methods to converge. Dates where corrections were applied include:

- February 10, 1986 – February 24, 1986;
- March 3, 1995 – March 17, 1995;
- December 25, 1996 – January 8, 1997;
- December 19, 2005 – January 7, 2006;
- January 1, 2017 – January 15, 2017; and
- February 2, 2017 – February 16, 2017.

For each reservoir, multiple sub-basins contribute to ungaged accretion. Gage summation accretion was distributed between sub-basins by using their relative contribution to the total area-weighted scaling reservoir accretion.

Figures 3.2-3 through 3.2-8 show a comparison of calculated accretion using gage summation and area-weighted scaling for New Bullard Bar Reservoir for the storms listed above. Figures 3.2-9 through 3.2-14 show a comparison of calculated accretion using gage summation and area-weighted scaling for Englebright Reservoir for the storms listed above.

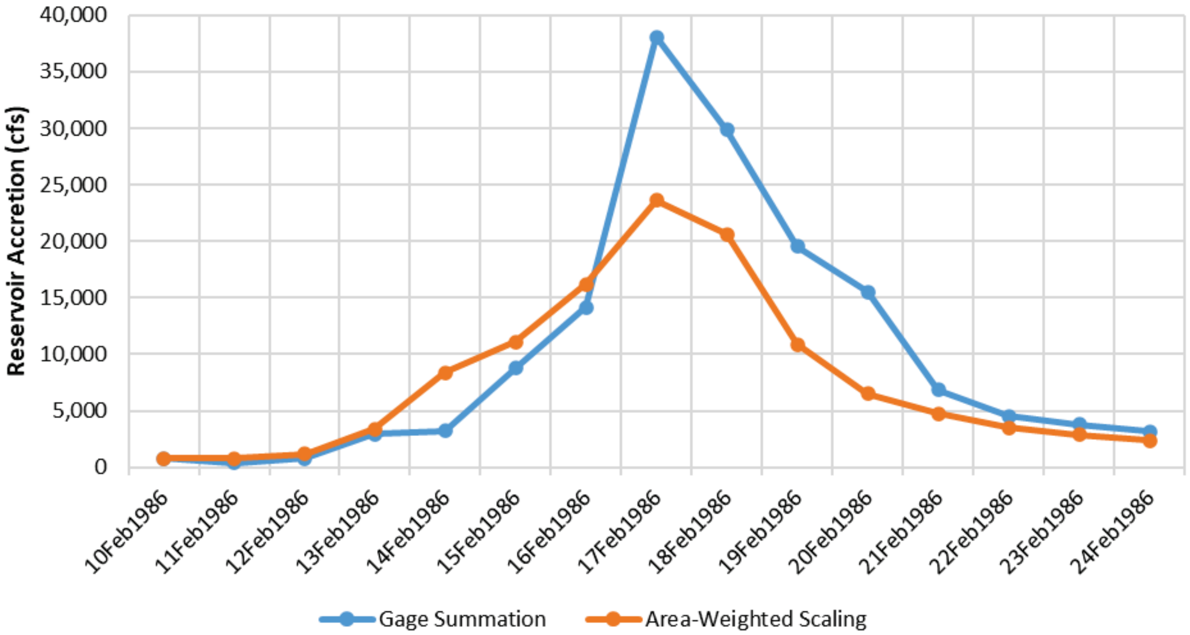

Figure 3.2-3. Comparison of calculated accretion using gage summation and area-weighted scaling for New Bullard Bar Reservoir, February 10 through 24, 1986.

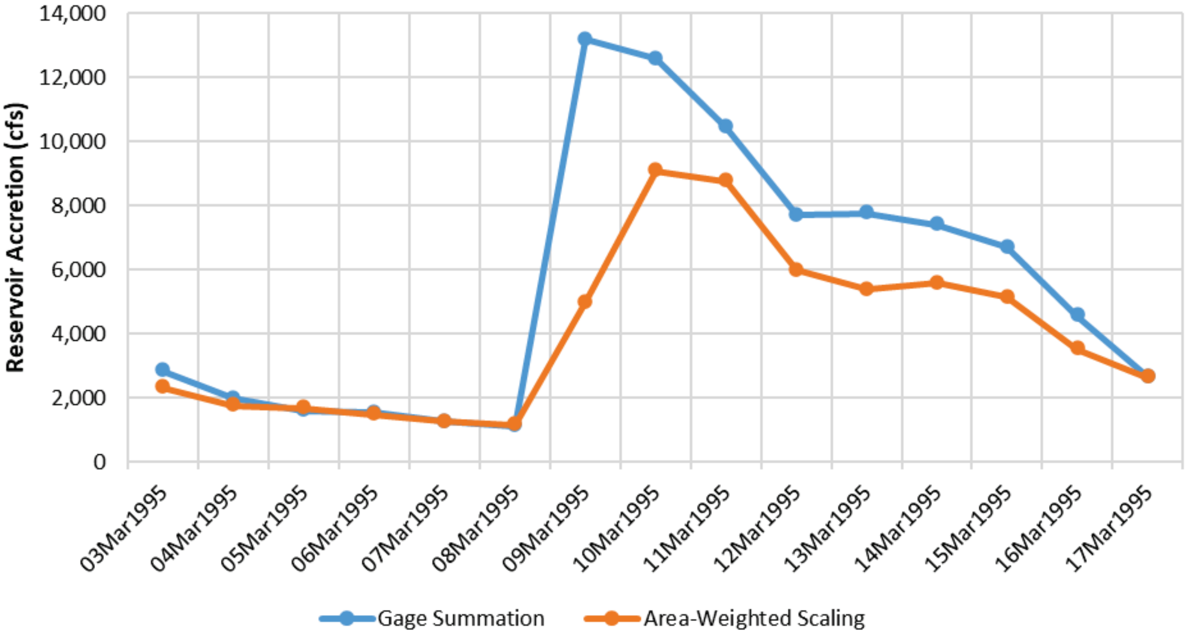

Figure 3.2-4. Comparison of calculated accretion using gage summation and area-weighted scaling for New Bullard Bar Reservoir, March 3 through March 17, 1995.

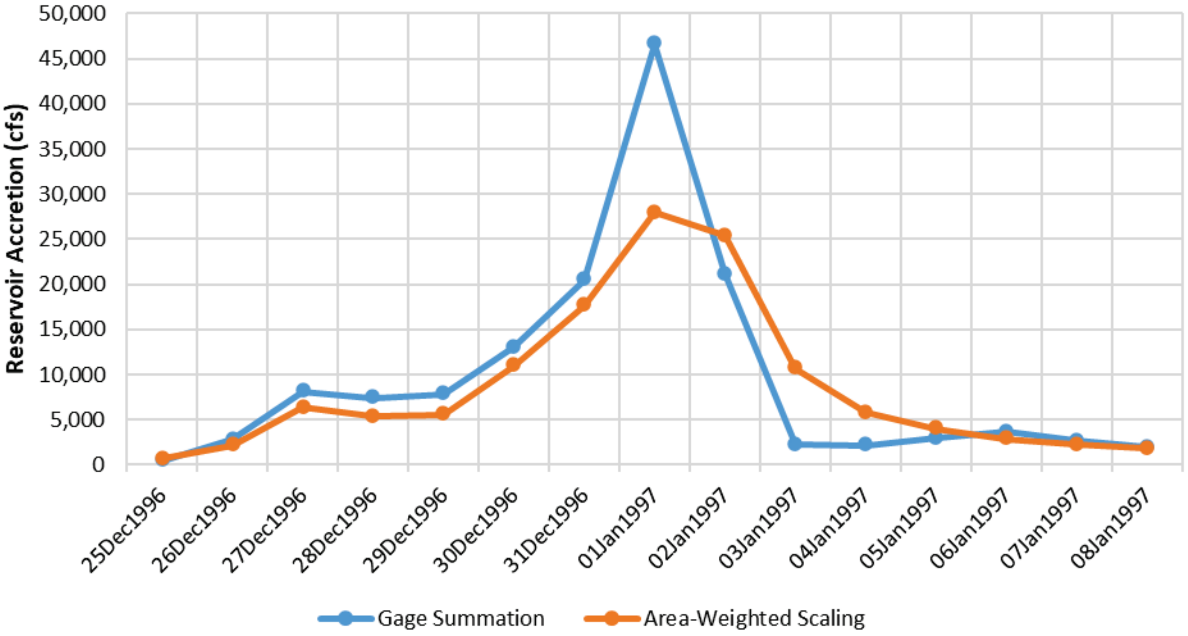

Figure 3.2-5. Comparison of calculated accretion using gage summation and area-weighted scaling for New Bullard Bar Reservoir, December 25, 1996 through January 8, 1997.

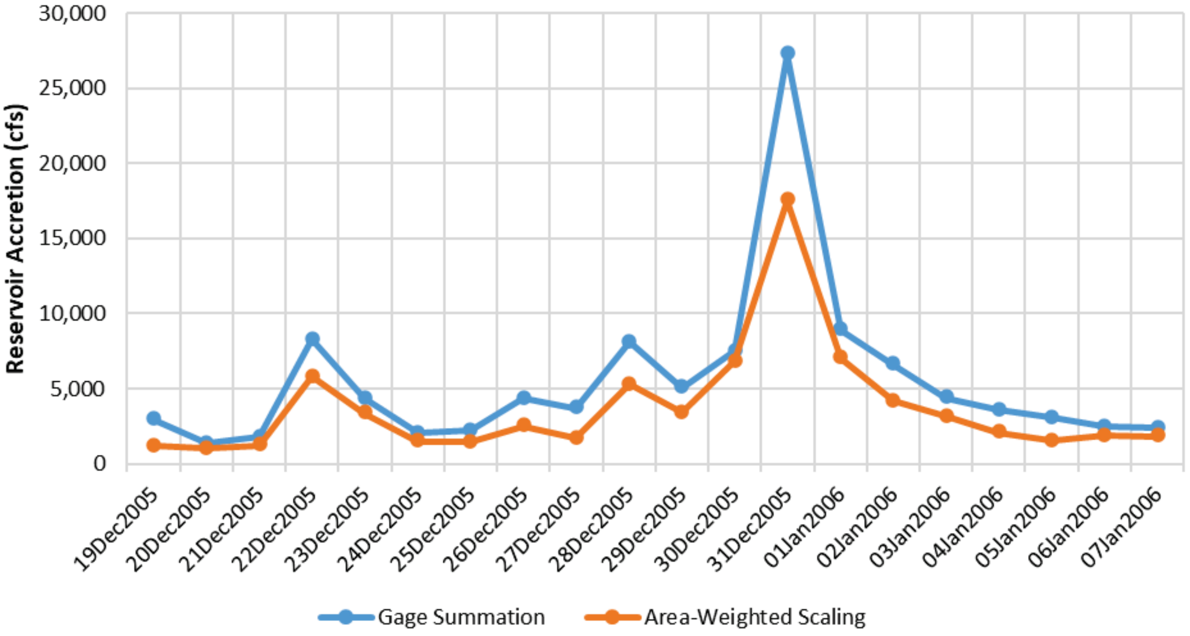

Figure 3.2-6. Comparison of calculated accretion using gage summation and area-weighted scaling for New Bullard Bar Reservoir, December 19, 2006 through January 7, 2006.

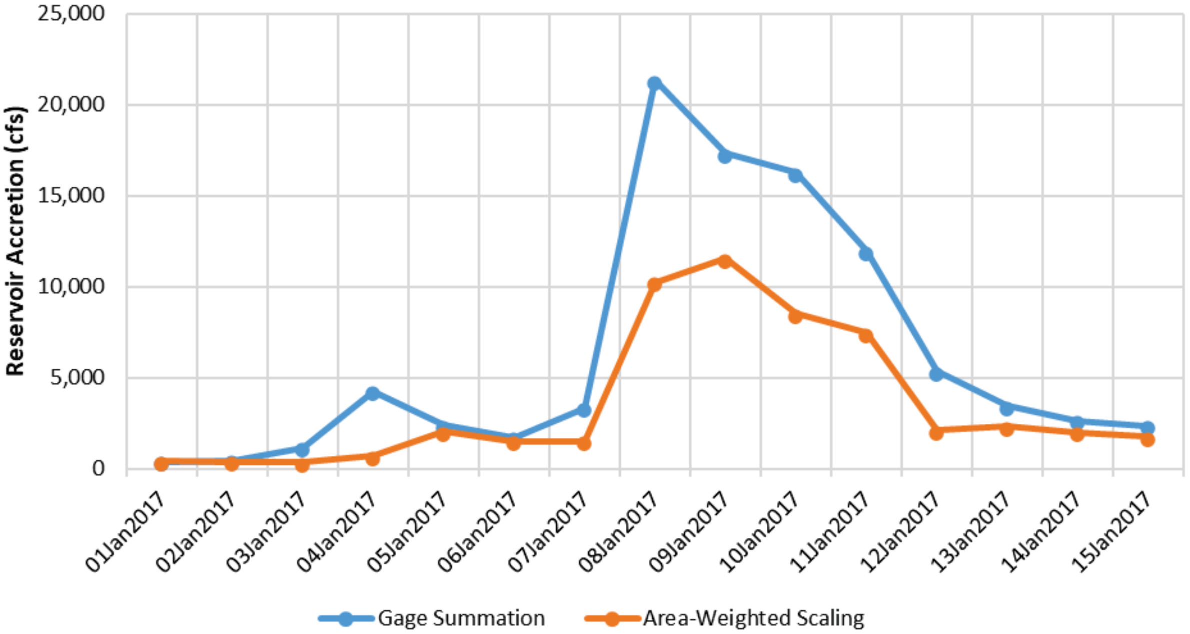

Figure 3.2-7. Comparison of calculated accretion using gage summation and area-weighted scaling for New Bullard Bar Reservoir, January 1 through February 15, 2017.

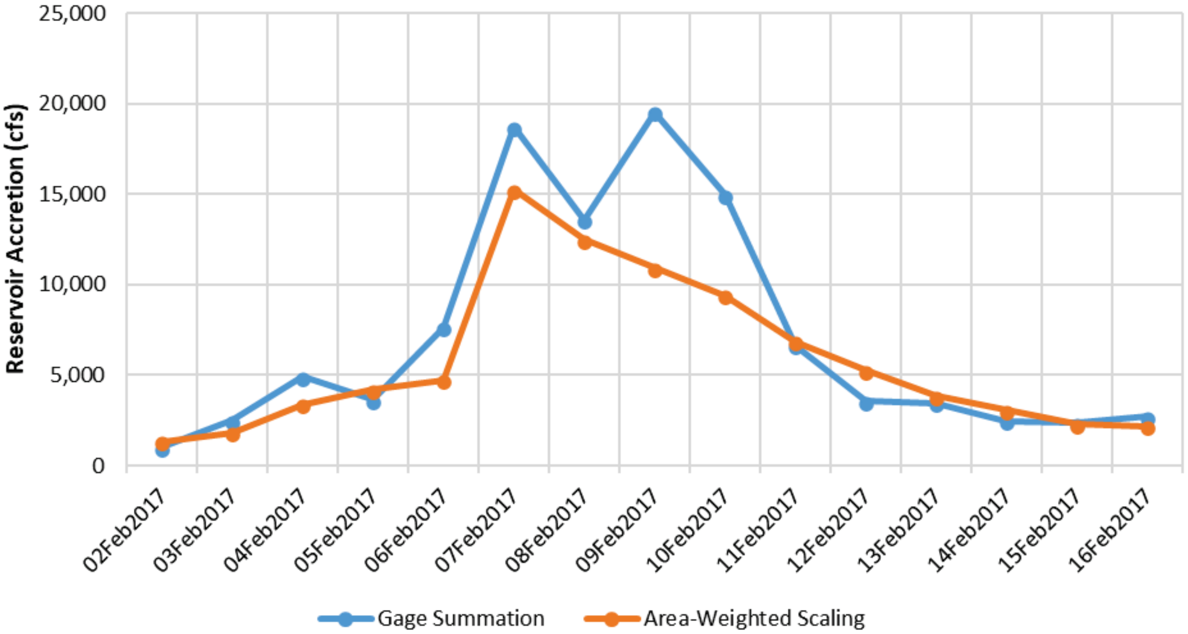

Figure 3.2-8. Comparison of calculated accretion using gage summation and area-weighted scaling for New Bullard Bar Reservoir, February 7 through February 16, 2017.

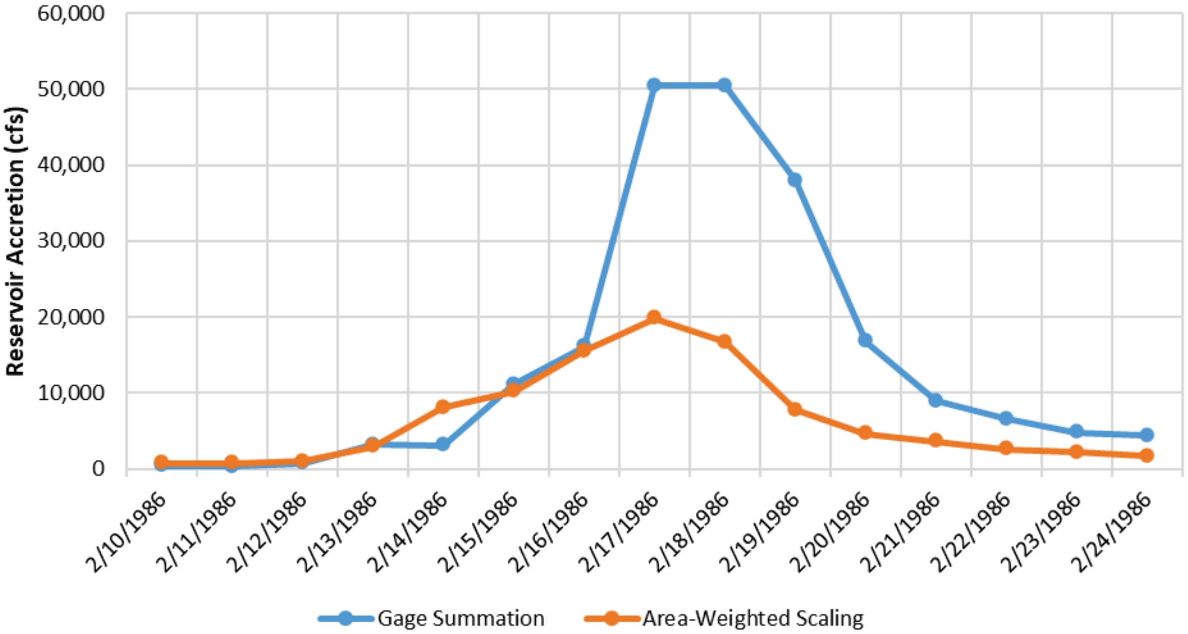

Figure 3.2-9. Comparison of calculated accretion using gage summation and area-weighted scaling for Englebright Reservoir, February 10 through 24, 1986.

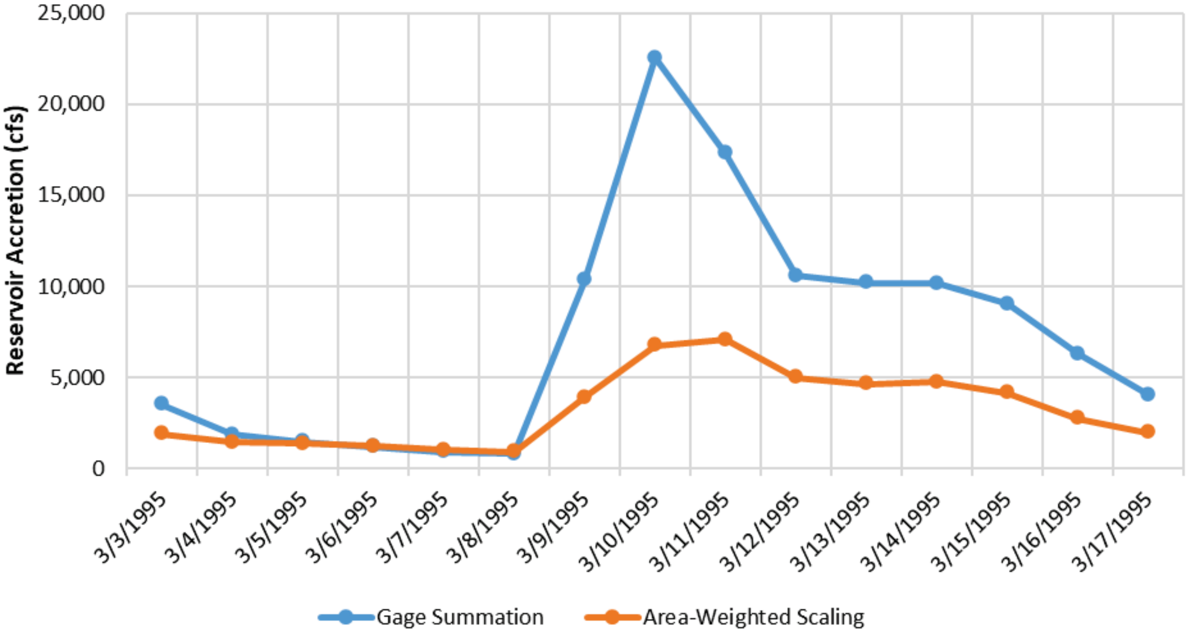

Figure 3.2-10. Comparison of calculated accretion using gage summation and area-weighted scaling for Englebright Reservoir, March 3 through March 17, 1995.

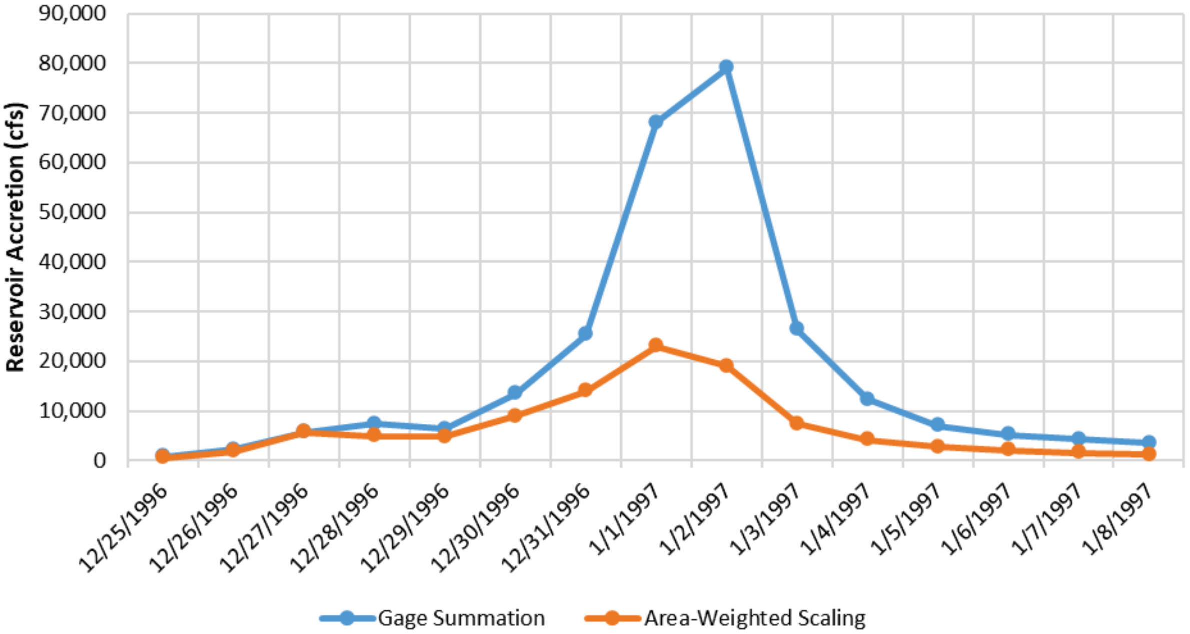

Figure 3.2-11. Comparison of calculated accretion using gage summation and area-weighted scaling for Englebright Reservoir, December 25, 1996 through January 8, 1997.

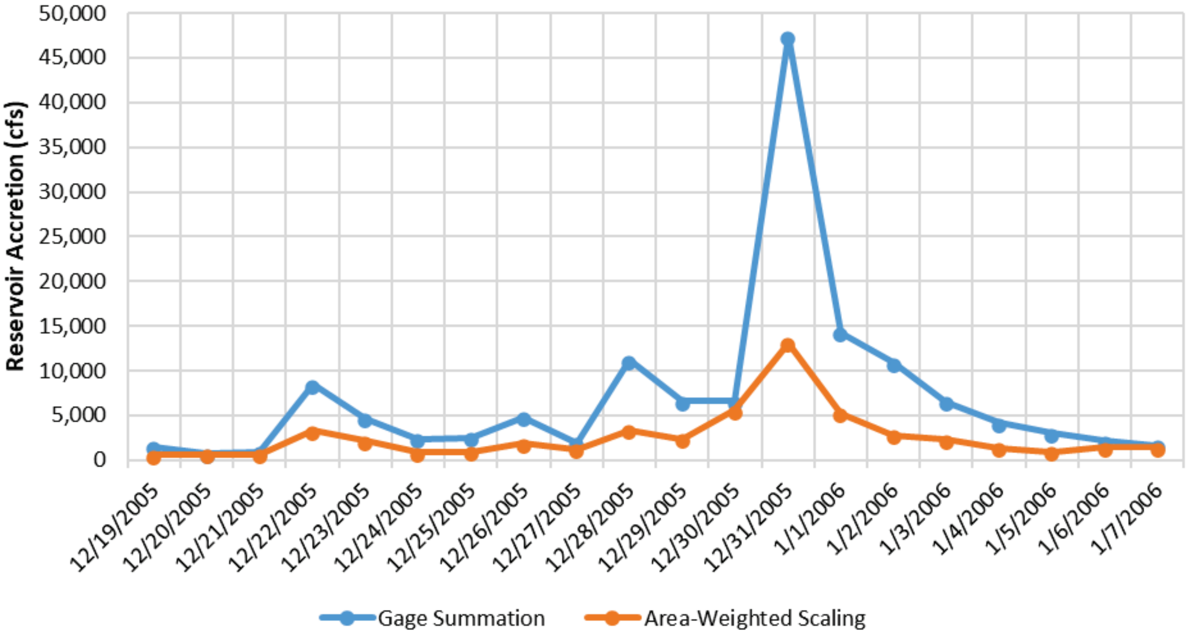

Figure 3.2-12. Comparison of calculated accretion using gage summation and area-weighted scaling for Englebright Reservoir, December 19, 2006 through January 7, 2006.

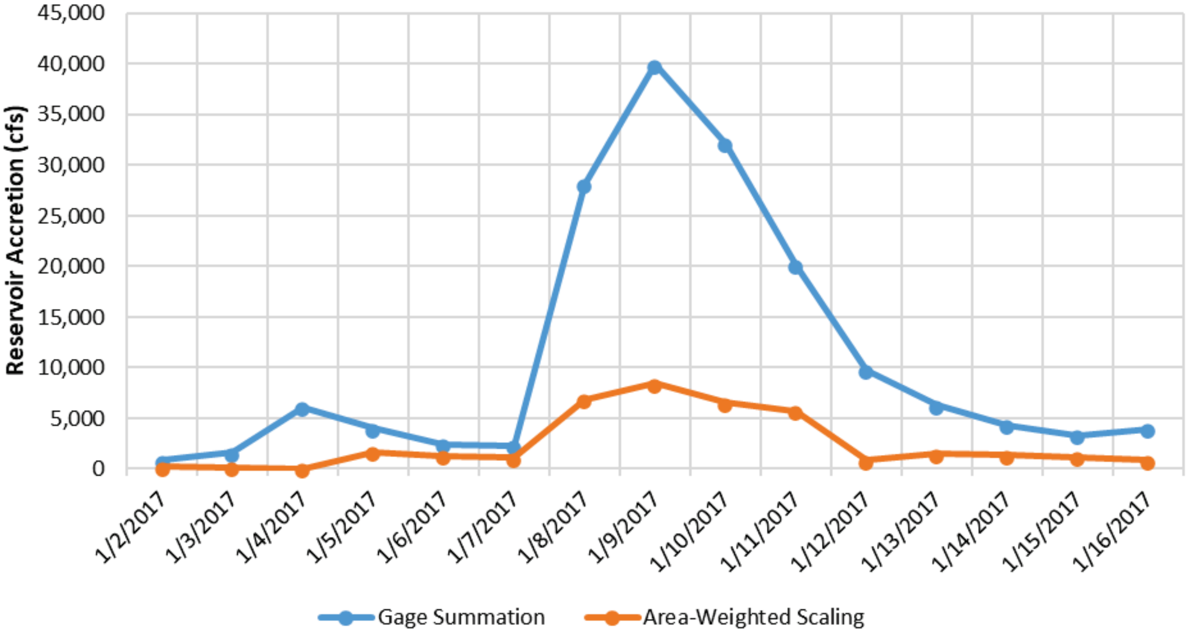

Figure 3.2-13. Comparison of calculated accretion using gage summation and area-weighted scaling for Englebright Reservoir, January 2 through February 16, 2017.

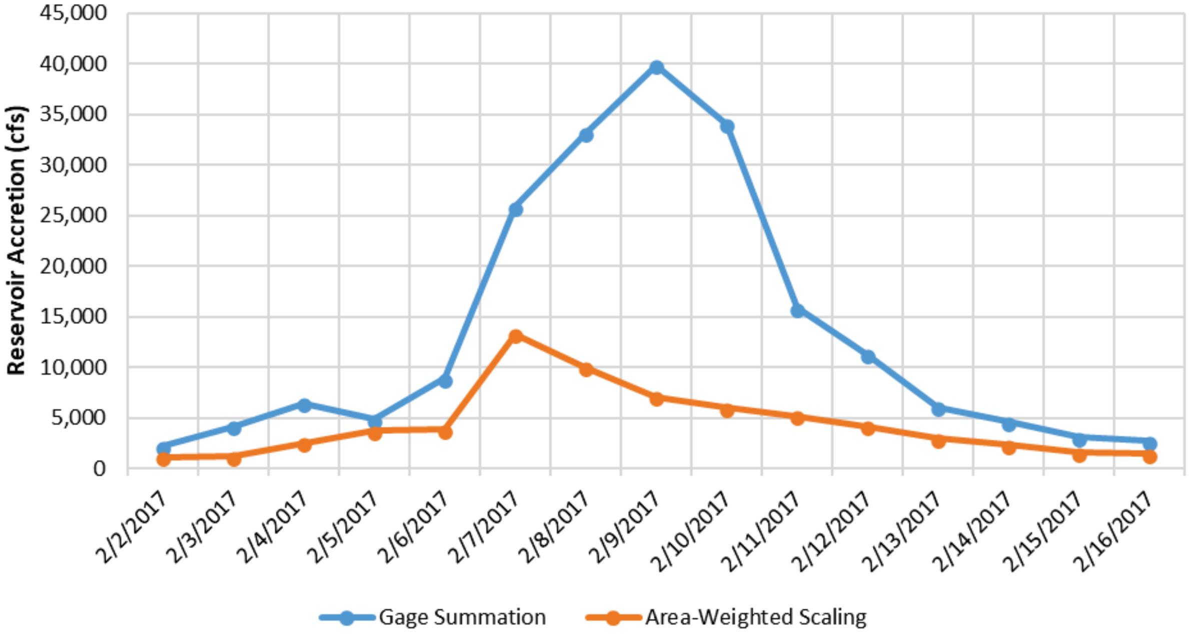

Figure 3.2-14. Comparison of calculated accretion using gage summation and area-weighted scaling for Englebright Reservoir, February 2 through February 16, 2017.

3.3 Lower Yuba River Accretions

This section describes accretions to the lower Yuba River. The Lower Yuba River is defined as the reach between Englebright Dam and the confluence of the Yuba River and the Feather River. Lower Yuba River accretions and depletions were calculated using the mass balance approach discussed in the NBB and Englebright Reservoir sections above. The positive ungaged flows calculated using this mass balance are considered to be accretions, and the negative ungaged flows as depletions.

$$MRY_{accretions} = \left(MRY_{gage} + DGP\right) - \left(DC_{gage} + SM_{gage}\right)$$ where

$MRY_{accretions}$= lower Yuba River accretions;

MRY_{gage} = Marysville gage flows;

DGP = Daguerre Point Dam diversions;

DC_{gage} = Deer Creek gage flows; and

SM_{gage} = Smartsville gage flows.

The Marysville, Deer Creek and Smartsville flows are from USGS gages 11421000, 11418500, and 11418000, respectively. Daguerre Point Dam diversions are from YWA records of daily deliveries to YWA's member units. While there are USGS gages on the three YWA Daguerre Point Dam diversions (Hallwood-Cordua Canal, Pumpline Diversion and Brophy-South Yuba Canal), the USGS gage period of record is less complete and shorter than YWA's diversion records, so diversion records were used in this analysis instead.

Accretions in the lower Yuba River watershed are dependent on several factors including the following:

- Precipitation;
- The Yuba Goldfields;
- Seepage losses; and
- Inflows from the Dry Creek watershed.

While precipitation would be expected to have a noticeable effect, there is no clear correlation between precipitation and increased accretions. While Yuba River flows are typically higher immediately following precipitation events, this is most likely due to accumulated inflows from the upper basin. Within the lower basin, however, accretions do not generally reflect precipitation events.

The Yuba Goldfields are an approximately 8-mile-long reach of the river, distinguished by large mounds of cobbled rock. The Yuba Goldfields have been subject to more than 100 years of dredging and the result is a reservoir, of sorts, with an estimated 500 TAF of storage. Based on anecdotal evidence, the Yuba Goldfields fill during high-flow periods, and discharge to the river during low-flow periods. While there is some correlation between flow at Smartsville and the amount of accretions or depletions in the lower Yuba River, the correlation is relatively weak and is not reliable for the observed range of conditions of the lower Yuba River. In addition, river depletions due to the Yuba Goldfields during high-flow periods are of less concern than would be if they occurred during low-flow periods, when flow contributions are more critical.

Accretions and depletions in the lower Yuba River due to seepage losses are similarly difficult to quantify. While it is well known that there is interaction between the surface water and groundwater resources of Yuba County, no quantifiable relationship has yet been determined.

While inflows from Dry Creek are discussed in Section 3.4, within the context of the computed lower Yuba River accretions described above, there is no clear relationship between gaged Dry Creek flows and the computed lower Yuba River accretions for the available POR.

Despite application of several methods of analysis of lower Yuba River accretions, no reasonable results were achieved. As part of the analysis process, estimates of lower Yuba River accretion rates were compared to historic flow in the river and were generally found to be less than 5 percent of the river flow. Since the actual contribution to Yuba River flows from these accretions is minimal, the effect of these accretions on operations of the YRDP was examined. Releases from New Bullards Bar and Englebright reservoirs overwhelm computed accretions and depletions of the lower Yuba River. Accordingly, although project operations may include some minimal buffering for accretions and depletions in the lower Yuba River, the actual volume of accretions and depletions is within the gage error and can thus be ignored in analysis of the basin.

3.4 Dry Creek

Dry Creek flows near the western edge of Yuba County; its watershed is approximately 108 square miles, with its headwaters near the town of Challenge at elevation 3,155 feet msl. Flowing generally southward, Dry Creek flows are captured by Merle Collins Reservoir, a 57 TAF reservoir at approximately 1,160 feet msl formed by Virginia Ranch Dam. Merle Collins Reservoir is owned and operated by Browns Valley Irrigation District. Dry Creek is approximately 12 miles long from Virginia Ranch Dam to the confluence with the Yuba River. Dry Creek releases from Merle Collins Reservoir are augmented by accretions from local runoff and agricultural return flows, flowing into the Yuba River approximately 10 miles below Englebright Dam. Thirty-seven square miles of the Dry Creek watershed lie below Merle Collins Reservoir. Available flow records from 1964 through 1980 indicate Dry Creek flows to the Yuba River are about 55 TAF per year, with peak flows occurring from January through April and low flows occurring from June through October.

Dry Creek flows below Merle Collins Reservoir were measured by USGS Gage 11420700, approximately 5 miles upstream from Dry Creek's confluence with the Yuba River, from August 1, 1964 through October 3, 1980, but since 1980, no flow records exist. As a result of this limited POR, it has been determined that Dry Creek flows to the Yuba River must be calculated by synthesis of data from a similar watershed. Several methods for deriving Dry Creek flows were examined, including the area-weighted flow methodology described in Section 3.1.3, an area-precipitation-based methodology, and a statistical correlation using existing gage data. The area-weighted flow methodology using the Oregon Creek watershed used for other sub-watershed areas was attempted, but it was abandoned due to a lack of correlation with available data. Although the area-weighted flow methodology using the Oregon Creek watershed worked well in other parts of the Yuba River Basin, there are considerable differences in watershed characteristics between Oregon Creek and Dry Creek, invalidating a comparison between the two. The area-precipitation method, which was also examined, did not adequately characterize local runoff from Dry Creek due to the complex nature of its watershed at lower elevations. Historical records indicate year-around flow in Dry Creek, whereas the area-precipitation method only yields flow during precipitation events.

Due to its watershed's similarity to Dry Creek's watershed, Deer Creek was selected as a representative watershed for Dry Creek; both watersheds are subject to multiple impairments, the impairments and watersheds have similar characteristics. Both receive runoff from elevations ranging from 140 feet msl to 1,208 feet msl, and both creeks receive considerable local runoff from agricultural or other non-precipitation-based sources.

A comparison of data from the available POR of Dry Creek with the same POR of Deer Creek near Smartsville gage (USGS Gage 11418500) indicates similar flow patterns. A correlation of all daily flows from the Deer Creek gage with flows from the Dry Creek gage yields a relationship indicating Dry Creek flows are approximately 68 percent of Deer Creek flows, and developing monthly coefficients slightly improved the accuracy of the relationship. The resulting equation is the following:

$$A \times Deer\ Creek\ Flow + B = Dry\ Creek\ Flow$$

Table 3.4-1 includes the monthly coefficients, A and B. From January through May, the Deer Creek coefficient dominates the relationship, corresponding to periods of rainfall runoff. From June through December, flows in Dry Creek are essentially the same from year to year, with little correlation to Deer Creek flows. During this period, Dry Creek flows are primarily composed of releases from Merle Collins Reservoir.

Table 3.4-1. Monthly Coefficients for Computing Dry Creek Flow from Deer Creek Gage Data.

Coefficient	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
A	0.70	0.73	1.02	0.84	0.33	0.06	0.18	-0.08	0.01	0.08	0.15	0.19
B	0.00	0.00	0.00	0.00	0.00	6.69	6.23	7.20	6.38	5.15	1.30	12.51

Table 3.4-2 shows the monthly average computed accretions from Dry Creek.

Table 3.4-2. Monthly Average Computed Dry Creek Accretions to the Yuba River.

Location	Average[2] Monthly Flow (cfs)												Total (TAF)
	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	
Dry Creek Accretions[1]	6	8	8	40	184	235	323	139	20	8	7	7	59

Notes:

[1] Dry Creek accretions to the Yuba River computed using methodology described in Section 3.4

[2] Period of record is 10/1/1969-9/30/2020

Key: cfs = cubic feet per second TAF = thousand acre-feet

SECTION 4

UNIMPAIRED FLOWS

As previously described, flows on the Yuba River are impaired by the YRDP, the SFFRP, the YB and the DS projects. Unimpaired flow would be the flow if neither those projects, nor any other artificial impoundments or diversions were present in the basin. This section describes the computation of unimpaired flows from the North, Middle, and South Yuba rivers and the total Yuba River flow at Smartsville.

4.1 North Yuba River

Determination of unimpaired flows from the North Yuba River is relatively straightforward due to the Goodyears Bar gage (USGS 11413000), the two gages on Slate Creek and the Slate Creek Diversion (USGS 11413300 and 11413250, respectively), and the computation of accretions as described in Section 3.1.

Unimpaired North Yuba River flow at the New Bullards Bar Dam site is computed by adding Goodyears Bar gaged flow, Slate Creek and Slate Creek Diversion gaged flows, and accretions from Canyon Creek, Slate Creek, the North Yuba River, and to the New Bullards Bar Reservoir area. Since the Middle and South Yuba rivers only have unimpaired data available for the period of 10/1/1975 through 9/30/2008, unimpaired North Yuba River flows are computed for a similar POR. Table 4.1-1 shows the computed monthly average unimpaired Yuba River flow at the New Bullards Bar Dam site.

Table 4.1-1. Computed Monthly Average Unimpaired North Yuba River Flow at New Bullards Bar Dam.

Location	Average[9] Monthly Flow (cfs)												Total (TAF)
	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	
North Yuba River Inflow[1]	171	338	656	907	1,015	1,218	1,330	1,704	984	350	181	152	543
Slate Creek Inflow[2]	15	42	133	161	200	198	156	159	34	12	11	10	68
North Yuba River Accretions[3]	5	9	43	138	234	278	280	195	116	38	10	5	81
Canyon Creek Accretions[4]	43	47	93	181	250	280	336	367	470	272	97	50	150
Slate Creek Accretions[5]	2	3	13	43	73	87	87	61	36	12	3	2	25
Accretions to New Bullards Bar Reservoir[6]	8	15	74	236	400	475	477	333	197	64	17	8	138
Slate Creek Diversion[7]	7	48	84	138	161	234	231	186	94	20	2	1	73
Total Inflow[8]	251	501	1,096	1,806	2,333	2,770	2,897	3,006	1,932	767	321	228	1,078

Notes:

[1] North Yuba River at Goodyears Bar flow from USGS Gage 11413000

[2] Slate Creek flow from USGS Gage 11413300

[3] North Yuba River accretions between Goodyears Bar and the confluence of the North Yuba River and Slate Creek as described in Section 3.1.5.

[4] Canyon Creek accretions as described in Section 3.1.5.

[5] Slate Creek accretions between USGS Gage 11413300 and the confluence of Slate Creek and the North Yuba River as described in Section 3.1.5.

[6] North Yuba River accretions to the New Bullards Bar Reservoir area as described in Section 3.1.5.

[7] Slate Creek Diversion flow from USGS Gage 11413250

[8] Total Inflow is the sum of gaged flows and accretions

[9] Period of record is 10/1/1975-9/30/2008

Key: cfs = cubic feet per second TAF = thousand acre-feet USGS=U.S. Geological Survey

4.2 Middle Yuba River

Unimpaired Middle Yuba River flow requires analysis of unimpaired Middle Yuba River flow from the upper watershed to the Milton Diversion Dam plus accretions between the Milton Diversion Dam and Our House Dam, shown in Figure 4.2-1. Unimpaired Middle Yuba River flow at the Milton Diversion Dam was obtained through data prepared by NID for the Yuba-Bear Project FERC relicensing. The POR of data provided by NID for these flows is October 1, 1975 through September 30, 2008.

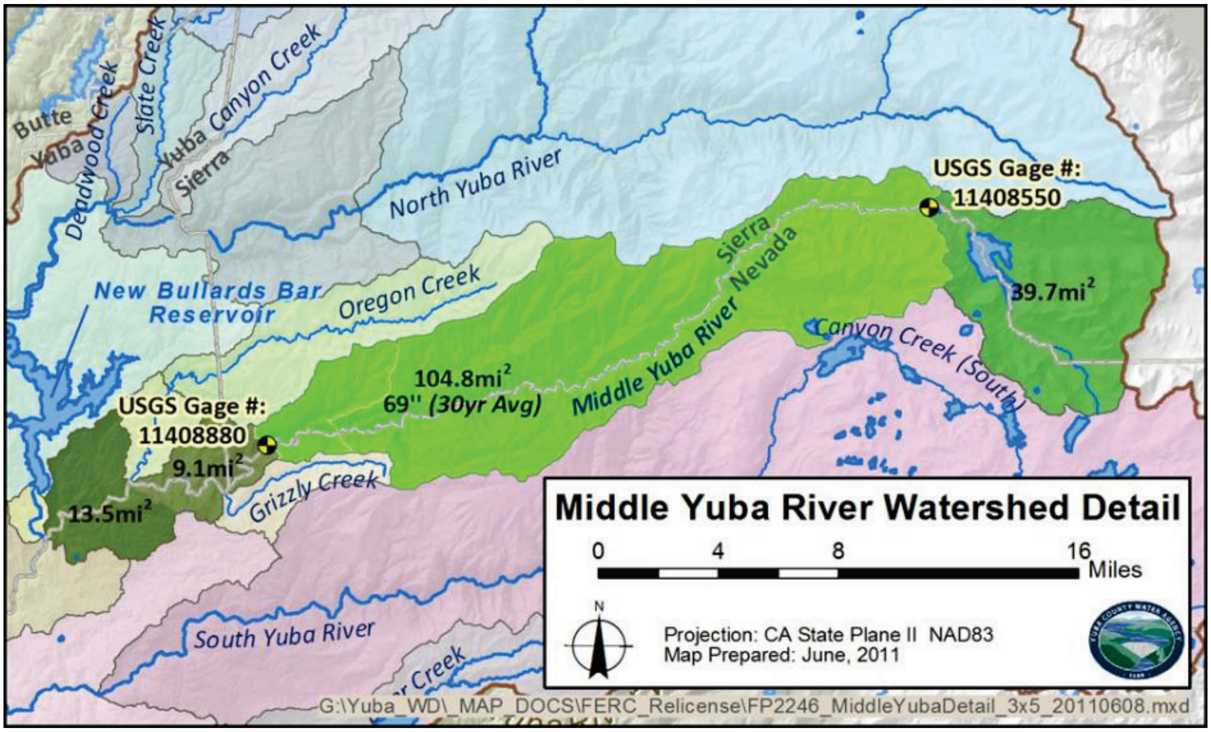

Figure 4.2-1. Middle Yuba River Subbasin between Milton Diversion Dam and Our House Dam

Middle Yuba River accretions between Milton Diversion Dam and Our House Dam were computed using gage data from below Milton Diversion Dam (USGS 11408550) and the computed inflows to Our House Dam, as described in Section 2.3. Gage data at Milton Diversion Dam was only available for the POR of October 1, 1987 through September 30, 2007. Based on the POR collected, Middle Yuba River accretions between the Milton Diversion Dam and Our House Dam were determined for the full POR through the area-weighted flow approach described in Section 3.1.5, using Oregon Creek as a representative watershed. The watershed area between the Milton Diversion Dam and Our House Dam is 104.8 square miles and has an average annual precipitation of 69 inches. When compared to Oregon Creek's watershed above Log Cabin Dam, the ratio of flow is 3.612. The synthesized inflows compared very well with those computed using available gage data.

Since there are no impairments to Oregon Creek upstream of Log Cabin Dam; Oregon Creek inflows to Log Cabin Dam can be considered unimpaired flows. Adding the unimpaired flow of the Middle Yuba River at Our House Dam, unimpaired Oregon Creek flow, calculated Middle Yuba River accretions below Our House Dam, and calculated Oregon Creek accretions below Log Cabin yields the unimpaired Middle Yuba River flow at its confluence with the North Yuba River. Table 4.2-1 shows the monthly average unimpaired Middle Yuba River flow at its confluence with the North Yuba River.

Table 4.2-1. Monthly Average Unimpaired Middle Yuba River Flow at its Confluence with the North Yuba River.

Location	Average[8] Monthly Flow (cfs)												Total (TAF)
	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	
Middle Yuba River above Milton Diversion Dam[1]	12	44	82	88	103	144	259	434	224	46	9	8	88
Middle Yuba River (Upper Reach) Accretions[2]	21	106	341	577	685	689	481	285	92	25	12	12	200
Oregon Creek Inflow[3]	6	29	94	160	190	191	133	79	26	7	3	3	55
Middle Yuba River (Middle Reach) Accretions[4]	2	3	15	49	82	97	98	68	40	13	4	2	28
Middle Yuba River (Lower Reach) Accretions[5]	1	2	11	35	59	70	70	49	29	9	3	1	20
Oregon Creek Accretions[6]	1	1	5	17	29	35	35	24	14	5	1	1	10
Total Inflow[7]	42	186	549	925	1,148	1,226	1,077	940	426	105	32	27	402

Notes:

[1] Unimpaired Middle Yuba River flow at Milton Diversion Dam from NID Yuba-Bear Project Relicensing

[2] Middle Yuba River accretions between Milton Diversion Dam and Our House Dam computed using the methodology described in Section 3.1.5.

[3] Oregon Creek flow above Log Cabin Dam from USGS Gages 11409300, 11408870, 11409350, and 11409400 as described in Section 2.5

[4] Middle Yuba River accretions between Our House Dam and the confluence of the Middle Yuba River and Oregon Creek, as shown in Table 3.2-2

[5] Middle Yuba River accretions between the confluence of the Middle Yuba River and Oregon Creek and the confluence of the Middle Yuba River and the Yuba River, as described shown in Table 3.2-3

[6] Oregon Creek accretions between Log Cabin Dam and the confluence of the Middle Yuba River and Oregon Creek, as shown in Table 3.2-4

[7] Total inflow is the sum of gaged flows and accretions

[8] Period of record is 10/1/1975-9/30/2008

Key: cfs = cubic feet per second TAF = thousand acre-feet USGS=U.S. Geological Survey

4.3 South Yuba River

Historical unimpaired South Yuba River flow is computed by adding the unimpaired South Yuba River flow at Langs Crossing and Canyon Creek below Bowman Lake, as reported by PG&E in their FERC relicensing of the Drum-Spaulding Project, with South Yuba River and Canyon Creek accretions above Jones Bar. Unimpaired South Yuba River flow at Langs Crossing and Canyon Creek flow below Bowman Lake was provided for the period of October 1, 1975 through September 30, 2008. Accretions between the upstream locations and Jones Bar were computed using historical gage information from South Yuba River at Langs Crossing (USGS 11414250), Canyon Creek below Bowman Reservoir (USGS 11416500) and South Yuba River at Jones Bar (11417500) for the full period of record. Figure 4.3-1 shows the subbasin between Bowman Lake, Langs Crossing, and Jones Bar.

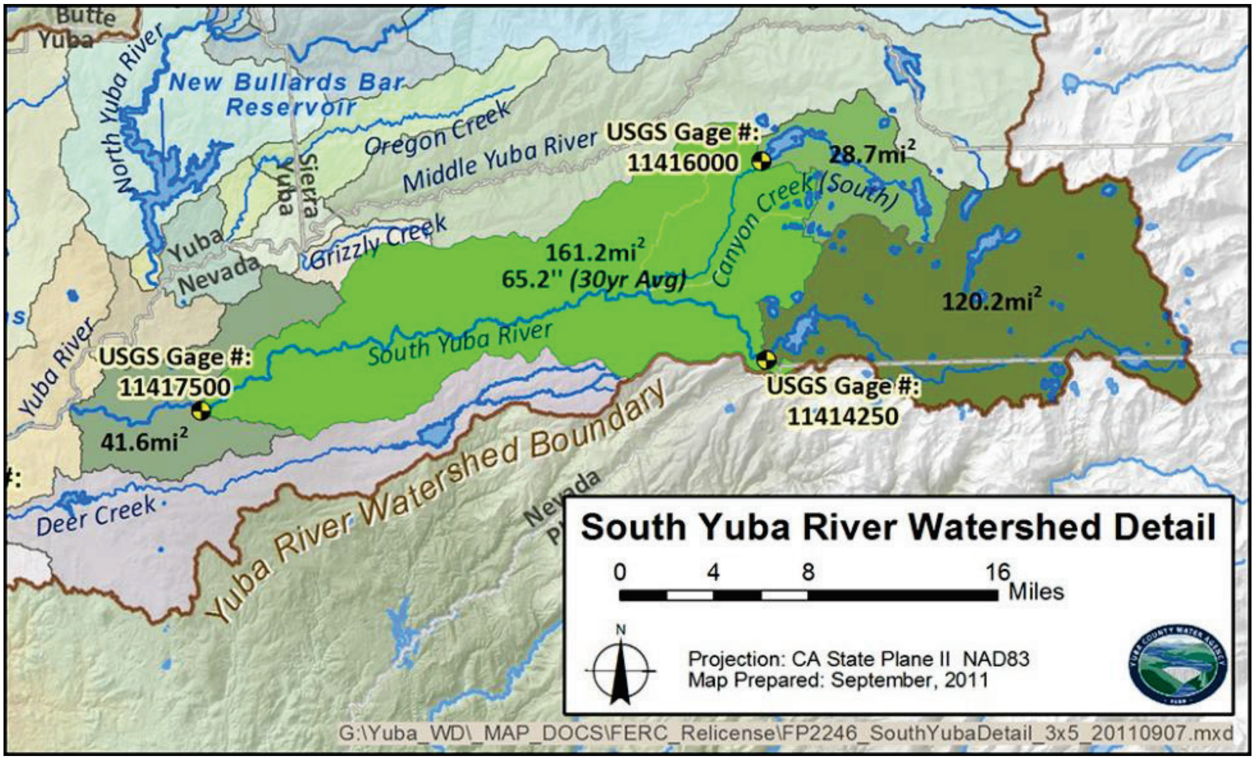

Figure 4.3-1. South Yuba River Subbasin between Canyon Creek, Langs Crossing, and Jones Bar

South Yuba River accretions below Jones Bar were computed using the process described in Section 3.2-2. Table 4.3-1 shows the monthly average unimpaired South Yuba River flow at its confluence with the Yuba River.

Table 4.3-1. Monthly Average Unimpaired South Yuba River Flow at its Confluence with the Yuba River.

Location	Average[4] Monthly Flow (cfs)												Total (TAF)
	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	
South Yuba River at Langs Crossing[1]	45	182	333	363	430	677	1,152	1,757	922	199	20	15	368
Canyon Creek at Bowman Reservoir[2]	11	47	86	94	111	177	294	414	202	39	4	4	90
South Yuba River (Upper) Accretions[3]	48	128	342	541	662	682	500	351	147	61	36	35	212
South Yuba River (Lower) Accretions[3]	3	6	30	95	161	191	192	134	79	26	7	3	56
Total Inflow[4]	107	363	791	1,093	1,364	1,727	2,138	2,656	1,350	325	67	57	726

Notes:

[1] South Yuba River at Langs Crossing from PG&E Drum Spaulding FERC relicensing

[2] Canyon Creek at Bowman Reservoir from PG&E Drum Spaulding FERC relicensing

[3] Accretions on the South Yuba River between Jones Bar and the confluence of the South Yuba River and the Yuba River as shown in Table 3.2-5.

[4] Total inflow is the sum of gaged flows and accretions

[5] Period of record is 10/1/1975-9/30/2008

Key: YRDP = Yuba River Development Project cfs = cubic feet per second TAF = thousand acre-feet

4.4 Unimpaired Yuba River flow at Smartsville

Adding unimpaired flows from the North Yuba, Middle Yuba, and South Yuba rivers with the computed accretions to the Yuba River above Englebright Dam and to Englebright Reservoir yields unimpaired Yuba River flows at Smartsville. Also, DWR has computed monthly unimpaired flows for the Yuba River at Smartsville for each month from October 1901 through the present date. Table 4.4-1 shows the computed and DWR published monthly average unimpaired Yuba River flow at Smartsville. Figure 4.4-1 shows a comparison of the annual volumes for the synthesized and DWR-Published unimpaired Yuba River flow at Smartsville.

Table 4.4-1. Monthly Average Unimpaired Yuba River Flow at Smartsville.

Location	Average[7] Monthly Flow (cfs)												Total (TAF)
	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	
North Yuba River[1]	251	501	1,096	1,806	2,333	2,770	2,897	3,006	1,932	767	321	228	1,078
Middle Yuba River[2]	42	186	549	925	1,148	1,226	1,077	940	426	105	32	27	402
South Yuba River[3]	110	387	856	1,159	1,394	1,727	2,080	2,601	1,297	306	63	57	726
Accretions to Englebright Reservoir[4]	4	7	37	120	202	240	242	169	100	32	9	4	70
Total Unimpaired Flow[5]	405	1,057	2,473	3,944	5,048	5,963	6,354	6,771	3,807	1,229	429	316	2,275
DWR Unimpaired Flow[6]	479	1,470	3,236	4,672	5,537	5,984	5,640	6,123	2,997	907	329	304	2,266

Notes:
[1] North Yuba River at New Bullards Bar Dam Site, as shown in Table 4.1-1
[2] Middle Yuba River at its Confluence with North Yuba River, as shown in Table 4.2-1
[3] South Yuba River at its Confluence with Yuba River as shown in Table 4.3-1
[4] Accretions to Englebright Reservoir area as shown in Table 3.2-6
[5] Total Inflow is the summation of tributary flow and accretions
[6] DWR Unimpaired Flow is the full-natural Yuba River flow at Smartsville, as published by DWR Snow Surveys Section.
[7] Period of record is 10/1/1975-9/30/2008
Key: cfs = cubic feet per second TAF = thousand acre-feet

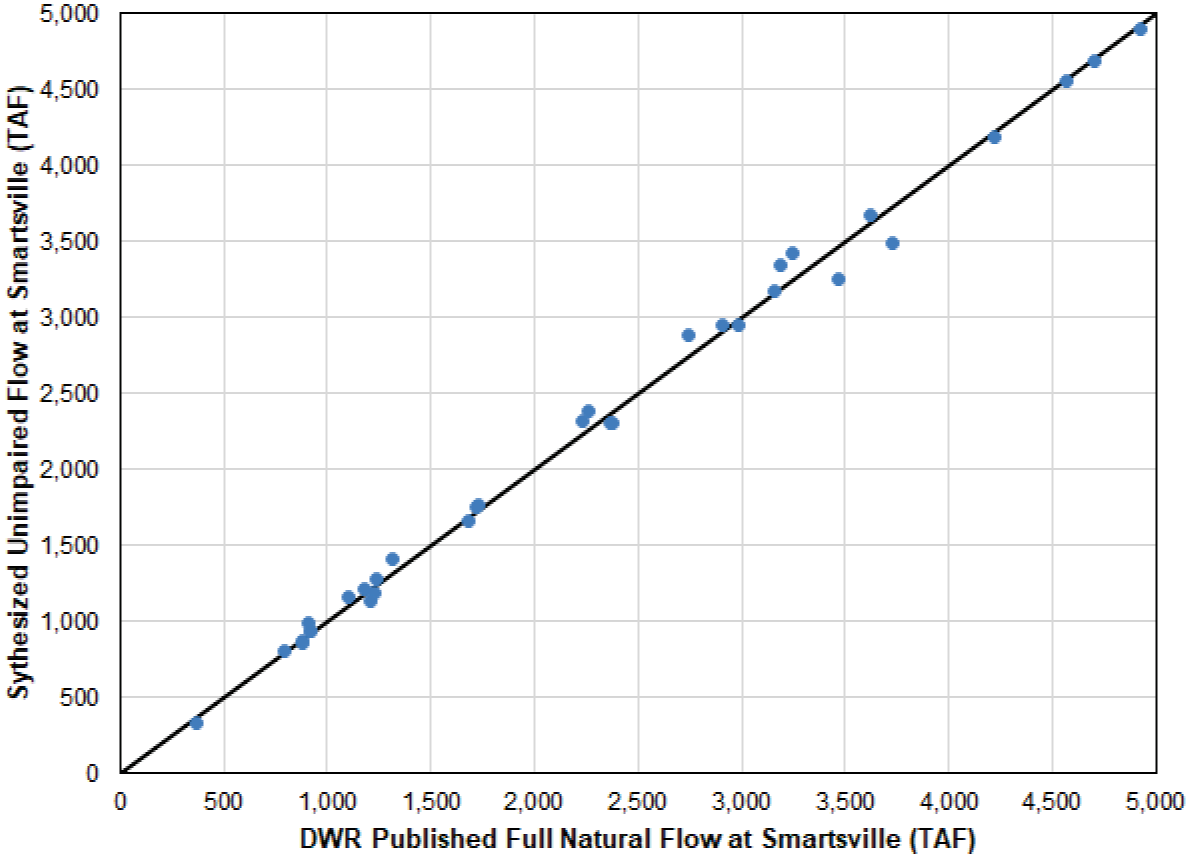

Figure 4.4-1. Comparison of Historical and Synthetic Annual Volume of Unimpaired Flow at Smartsville (WY 1975-2008).

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SECTION 5

ACCUMULATED FLOWS

Yuba River flows are affected by operation of the upstream projects (PG&E's DS Project, NID's YB Project, and SFWPA's SFFRP), and operation of the YRDP. Each project affects both the timing and the volume of flow in the Yuba River. The following three conditions are compared:

- Historical flows with all YRDP features in place
- Calculated flows occurring without YRDP facilities
- Unimpaired flows occurring under natural conditions

Summaries of monthly average flows under each condition at the following key locations are described below:

- The North Yuba River at the New Bullards Bar Dam Site
- The Middle Yuba River at its confluence with the North Yuba River
- The South Yuba River at its confluence with the Yuba River

Yuba River tributary flows after the construction of the YRDP are easily determined through a summation of historical gage data and computed accretions. An estimation of Yuba River tributary flows that would have occurred without the construction of the YRDP can be computed by adding the tributary inflows described above with computed accretions. The estimation of Yuba River tributary flows without any projects, also known as unimpaired flow, is computed as described in Section 4. The unimpaired flow calculation uses a shorter POR than is used for analysis of the YRDP; this difference in POR can result in minor flow average differences described in the following sections.

5.1 North Yuba River at New Bullards Bar Dam

Yuba River flow at New Bullards Bar Dam is a combination of gaged flows on the North Yuba River at Goodyears Bar and on Slate Creek below the Slate Creek Diversion Dam, and accretions from Canyon Creek, the North Yuba River, and lower Slate Creek. Historical monthly average North Yuba River at the New Bullards Bar Dam site flows are computed as inflows to NBB.

Table 5.1-1. Historical Monthly Average North Yuba River Flow at New Bullards Bar Dam.

Location	Average[2] Monthly Flow (cfs)												Total (TAF)
	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	
New Bullards Bar Reservoir Inflow[1]	274	805	1,766	2,469	2,794	3,381	3,108	2,887	1,613	543	263	207	1,210

Notes:

[1] New Bullards Bar Reservoir inflow is computed as reservoir releases plus change in storage. Historical New Bullards Bar Reservoir storage and releases from YWA

[2] Period of record is 10/1/1969-9/30/2020

Key: cfs = cubic feet per second TAF = thousand acre-feet

In the absence of the YRDP, flow in the North Yuba River at the New Bullards Bar Dam site would be a combination of flow at Goodyears Bar, accretions to the North Yuba River between Goodyears Bar and Canyon Creek, Canyon Creek accretions, accretions to the North Yuba River between Canyon Creek and Slate Creek, Slate Creek flow below the Slate Creek Diversion Dam, accretions to Slate Creek below the Slate Creek Diversion Dam, and accretions to NBB area below Slate Creek. The difference between the historical condition and the non-YRDP condition would be the absence of flow from the Camptonville Tunnel into NBB without the YRDP. Table 5.1-2 shows the computed monthly average North Yuba River flow at the New Bullards Bar Dam site without the YRDP.

Table 5.1-2. Computed Monthly Average North Yuba River Flow at New Bullards Bar Dam in the Absence of the YRDP.

Location	Average[8] Monthly Flow (cfs)												Total (TAF)
	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	
North Yuba River Inflow[1]	174	355	672	941	999	1,246	1,385	1,701	1,046	362	183	150	555
Slate Creek Inflow[2]	16	54	133	181	194	233	187	173	53	14	11	10	76
North Yuba River Accretions[3]	5	9	47	142	239	262	280	189	105	37	11	5	80
Canyon Creek Accretions[4]	42	48	98	185	271	281	344	382	469	289	100	50	154
Slate Creek Accretions[5]	2	3	15	44	75	82	87	59	33	12	3	2	25
Accretions to New Bullards Bar Reservoir[6]	8	16	80	243	409	447	478	322	179	63	18	9	136
Total Inflow[7]	247	485	1,044	1,737	2,188	2,551	2,761	2,826	1,884	777	326	226	1,026

Notes:

[1] North Yuba River below Goodyears Bar flow from USGS Gage 11413000 as shown in Table 2.1-1

[2] Slate Creek below Slate Creek Diversion flow from USGS Gage 11413300 as shown in Table 2.1-2

[3] North Yuba River accretions between Goodyears Bar and the confluence of the North Yuba River and Slate Creek as shown in Table 3.1-4.

[4] Canyon Creek accretions as shown in Table 3.1-5.

[5] Slate Creek accretions between the Slate Creek Diversion Dam and the confluence of Slate Creek and the North Yuba River as shown in Table 3.1-6.

[6] Accretions to the New Bullards Bar Reservoir area as shown in Table 3.1-7.

[7] Total Inflow is the sum of gaged flows and accretions

[8] Period of record is 10/1/1969-9/30/2020

Key: cfs = cubic feet per second TAF = thousand acre-feet USGS=U.S. Geological Survey

Table 5.1-3 shows a comparison of monthly average North Yuba River flow at the New Bullards Bar Dam site under historical conditions, under a non-YRDP condition, and under an unimpaired condition.

Table 5.1-3. Comparison of Monthly Average North Yuba River Flow at New Bullards Bar Dam Site under Various Developmental Conditions.

Location	Average[4] Monthly Flow (cfs)												Total (TAF)
	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	
Historical Conditions[1]	274	805	1,766	2,469	2,794	3,381	3,108	2,887	1,613	543	263	207	1,210
Non-YRDP Conditions[2]	247	485	1,044	1,737	2,188	2,551	2,761	2,826	1,884	777	326	226	1,026
Unimpaired Condition[3]	251	501	1,096	1,806	2,333	2,770	2,897	3,006	1,932	767	321	228	1,078

Notes:

[1] Historical Conditions reflect historical reservoir inflows as observed and described in Table 5.1-1

[2] Non-YRDP Conditions reflects computed inflow consisting of gaged flows and computed accretions, as computed in Table 5.1-2

[3] Unimpaired Condition reflects computed inflow consisting of gaged flows and computed accretions, as computed in Table 4.1-1

[4] Period of record is 10/1/1969-9/30/2020 for the Current and Non-YRDP conditions and 10/1/1975-9/30/2008 for the Unimpaired Condition

Key: YRDP = Yuba River Development Project cfs = cubic feet per second TAF = thousand acre-feet

5.2 Middle Yuba River at its Confluence with the North Yuba River

Middle Yuba River flow at its confluence with the North Yuba River reflects flows from both the Middle Yuba River and Oregon Creek. Historical flows, reflecting operations of the YRDP and diversions through the Lohman Ridge and Camptonville tunnels to New Bullards Bar Reservoir, are computed by adding gaged Middle Yuba River and Oregon Creek flows below Our House and Log Cabin dams, respectively, with computed accretions to the Middle Yuba River and Oregon Creek. Table 5.2-1 shows historical monthly average Middle Yuba River flow at its confluence with the North Yuba River.

Table 5.2-1. Historical Monthly Average Middle Yuba River Flow at its Confluence with the North Yuba River.

Location	Average[7] Monthly Flow (cfs)												Total (TAF)
	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	
Middle Yuba River Below Our House Dam[1]	31	66	155	276	204	198	149	208	106	34	31	30	89
Oregon Creek Below Log Cabin Dam[2]	6	14	44	69	46	35	26	17	21	8	6	5	18
Middle Yuba River (Middle Reach) Accretions[3]	2	3	16	50	85	95	98	66	37	13	4	2	28
Middle Yuba River (Lower Reach) Accretions[4]	1	2	12	36	61	68	71	48	26	9	3	1	20
Oregon Creek Accretions[5]	1	1	6	18	30	34	35	24	13	5	1	1	10
Total Inflow[6]	41	87	233	449	426	430	379	363	203	69	45	39	166

Notes:

[1] Middle Yuba River below Our House Dam flow from USGS Gage 11408880

[2] Oregon Creek below Log Cabin Dam flow from USGS Gage 11409400

[3] Middle Yuba River above Oregon Creek accretions computed for reach between Our House Dam and Oregon Creek as shown in Table 3.2-3

[4] Middle Yuba River below Oregon Creek accretions computed for reach between Oregon Creek and confluence with North Yuba River as shown in Table 3.2-4

[5] Oregon Creek accretions computed for Oregon Creek between Log Cabin Dam and confluence with Middle Yuba River as shown in Table 3.2-5

[6] Total Inflow is the sum of gaged flows and accretions

[7] Period of record is 10/1/1969-9/30/2020

Key: USGS = U.S. Geologic Survey cfs = cubic feet per second TAF = thousand acre-feet

Without the YRDP, flows that are otherwise diverted from the Middle Yuba River through the Lohman Ridge Tunnel to Oregon Creek and from Oregon Creek through the Camptonville Tunnel to New Bullards Bar Reservoir would remain in Middle Yuba River subbasin. Flows diverted from the Middle Yuba River upstream of Our House Dam would remain unavailable to the lower Middle Yuba River. Middle Yuba River flows at its confluence with the North Yuba River would be the sum of the flow from the Middle Yuba River above Our House Dam and Oregon Creek above Log Cabin Dam with accretions to the Middle Yuba River and Oregon Creek below Our House and Log Cabin dams, respectively. Table 5.2-2 shows the monthly average flow in the Middle Yuba River at its confluence with the North Yuba River if the YRDP had not been constructed.

Table 5.2-2. Computed Monthly Average Flow on the Middle Yuba River at its Confluence with the North Yuba River in the Absence of the YRDP.

Location	Average[7] Monthly Flow (cfs)												Total (TAF)
	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	
Middle Yuba River Inflow[1]	49	144	335	516	542	635	616	602	327	92	42	36	237
Oregon Creek Inflow[2]	6	32	97	160	177	191	129	71	25	7	3	3	54
Middle Yuba River (Middle Reach) Accretions[3]	2	3	16	50	85	95	98	66	37	13	4	2	28
Middle Yuba River (Lower Reach) Accretions[4]	1	2	12	36	61	68	71	48	26	9	3	1	20
Oregon Creek Accretions[5]	1	1	6	18	30	34	35	24	13	5	1	1	10
Total Inflow[6]	59	183	466	780	895	1,022	948	811	428	126	53	43	349

Notes:

[1] Middle Yuba River flow above Our House Dam from USGS Gages 11408850, 11408870, and 44108880 as described in Section 2.3

[2] Oregon Creek flow above Log Cabin Dam from USGS Gages 11409300, 11408870, 11409350, and 11409400 as described in Section 2.5

[3] Middle Yuba River accretions between Our House Dam and the confluence of the Middle Yuba River and Oregon Creek, as shown in Table 3.2-3

[4] Middle Yuba River accretions between the confluence of the Middle Yuba River and Oregon Creek and the confluence of the Middle Yuba River and the Yuba River, as described shown in Table 3.2-4

[5] Oregon Creek accretions between Log Cabin Dam and the confluence of the Middle Yuba River and Oregon Creek, as shown in Table 3.2-5

[6] Total Inflow is the sum of gaged flows and accretions

[7] Period of record is 10/1/1969-9/30/2020

Key: cfs = cubic feet per second TAF = thousand acre-feet USGS=U.S. Geological Survey

Table 5.2-3 shows a comparison of the total inflows from Tables 5.2-1 through 5.2-3. The periods of record of the unimpaired flow is different from the other two flows, however, since all three are long-term averages, the information in the tables remains illustrative of relative flows under each condition.

Table 5.2-3. Comparison of Monthly Average Middle Yuba River Flow at its Confluence with the North Yuba River under Various Developmental Conditions.

Location	Average[4] Monthly Flow (cfs)												Total (TAF)
	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	
Historical Conditions[1]	41	87	233	449	426	430	379	363	203	69	45	39	166
Non-YRDP Conditions[2]	59	183	466	780	895	1,022	948	811	428	126	53	43	349
Unimpaired Condition[3]	42	186	549	925	1,148	1,226	1,077	940	426	105	32	27	402

Notes:

[1] Historical Conditions reflect historical reservoir inflows as observed and described in Table 5.2-1

[2] Non-YRDP Conditions reflects computed inflow consisting of gaged flows and computed accretions, as computed in Table 5.2-2

[3] Unimpaired Condition reflects computed inflow consisting of gaged flows and computed accretions, as computed in Table 4.2-1

[4] Period of record is 10/1/1969-9/30/2020 for the Current and Non-YRDP conditions and 10/1/1975-9/30/2008 for the Unimpaired Condition

Key: YRDP = Yuba River Development Project cfs = cubic feet per second TAF = thousand acre-feet

5.3 South Yuba River at its Confluence with the Yuba River

Since the YRDP does not affect flows in the South Yuba River, historical flows would be the same as those without the YRDP. Those flows would be the sum of the historical flow at Jones Bar and accretions between Jones Bar and the confluence of the South Yuba River and the Yuba River. Unimpaired flows would differ through the inclusion of flows otherwise diverted out of the South Yuba River subbasin by PG&E's Drum-Spaulding Project. Table 5.3-1 shows the historical monthly average flow on the South Yuba River at its confluence with the Yuba River.

Table 5.3-1. Historical Monthly Average South Yuba River Flow at its Confluence with the Yuba River.

Location	Average[4] Monthly Flow (cfs)												Total (TAF)
	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	
South Yuba River Inflow[1]	65	187	473	721	783	858	749	831	628	132	47	47	332
South Yuba River Accretions[2]	3	6	32	98	166	185	192	130	72	25	7	3	55
Total Inflow[3]	68	194	505	819	949	1,043	941	961	700	158	55	50	387

Notes:

[1] South Yuba River flow at Jones Bar from USGS Gage 11417500 as described in Section 2.4

[2] Accretions on the South Yuba River between Jones Bar and the confluence of the South Yuba River and the Yuba River as shown in Table 3.2-5.

[3] Total inflow is the sum of gaged flows and accretions

[4] Period of record is 10/1/1969-9/30/2020

Key: YRDP = Yuba River Development Project cfs = cubic feet per second TAF = thousand acre-feet

Table 5.3-2 shows a comparison of the historical and unimpaired South Yuba River flows at its confluence with the Yuba River. The periods of record of the unimpaired flow is different from the historical flow, however, since both are long-term averages, the information in the tables remains illustrative of relative flows under each condition.

Table 5.3-2. Comparison of Monthly Average South Yuba River Flow at its Confluence with the Yuba River under Various Developmental Conditions.

Location	Average[3] Monthly Flow (cfs)												Total (TAF)
	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	
Historical Conditions[1]	68	194	505	819	949	1,043	941	961	700	158	55	50	387
Unimpaired Condition[2]	107	363	791	1,093	1,364	1,727	2,138	2,656	1,350	325	67	57	726

Notes:

[1] Historical Conditions reflect historical reservoir inflows as observed and described in Table 5.3-1

[2] Unimpaired Condition reflects computed inflow consisting of gaged flows and computed accretions, as computed in Table 4.3-1

[3] Period of record is 10/1/1969-9/30/2020 for the Historical Conditions and 10/1/1975-9/30/2008for the Unimpaired Condition

Key: cfs = cubic feet per second TAF = thousand acre-feet

5.4 Yuba River at Smartsville

Yuba River flow at Smartsville is regarded by several agencies, including YWA, PG&E, and DWR, as the key indicator of Yuba River Watershed flow. The USGS has published daily gage data at USGS Gage 11418000 since October 1941. Table 5.4-1 shows the historical monthly average Yuba River flow at Smartsville for the POR.

Table 5.4-1. Historical Monthly Average Yuba River Flow at Smartsville.

Location	Average[2] Monthly Flow (cfs)												Total (TAF)
	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	
Yuba River at Smartsville[1]	1,288	1,479	2,333	3,574	3,495	3,585	2,919	3,182	2,637	2,048	2,022	1,419	1,790

Notes:
[1] Yuba River at Smartsville flow from USGS Gage 11418000
[2] Period of record is 10/1/1969-9/30/2020
Key: cfs = cubic feet per second TAF = thousand acre-feet

Adding flows from the North Yuba, Middle Yuba, and South Yuba rivers with the computed accretions to the Yuba River above Englebright Reservoir and to Englebright Reservoir yields Yuba River flows without the YRDP. Table 5.4-2 shows the computed monthly average Yuba River flow at Smartsville without the YRDP.

Table 5.4-2. Monthly Average Yuba River Flow at Smartsville without the YRDP.

Location	Average[6] Monthly Flow (cfs)												Total (TAF)
	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	
North Yuba River[1]	247	485	1,044	1,737	2,188	2,551	2,761	2,826	1,884	777	326	226	1,026
Middle Yuba River[2]	59	183	466	780	895	1,022	948	811	428	126	53	43	349
South Yuba River[3]	68	194	505	819	949	1,043	941	961	700	158	55	50	387
Accretions to Englebright Reservoir[4]	4	7	39	115	199	219	229	155	88	30	9	4	66
Total Flow[5]	377	869	2,055	3,451	4,231	4,835	4,880	4,753	3,100	1,091	443	323	1,828

Notes:
[1] North Yuba River at New Bullards Bar Dam Site, as shown in Table 5.1-2
[2] Middle Yuba River at its Confluence with North Yuba River, as shown in Table 5.2-2
[3] South Yuba River at its Confluence with Yuba River as shown in Table 5.3-1
[4] Accretions to Englebright Reservoir area as shown in Table 3.2-6
[5] Total Inflow is the summation of tributary flow and accretions
[6] Period of record is 10/1/1969-9/30/2020
Key: cfs = cubic feet per second TAF = thousand acre-feet

Table 5.4-3 shows a comparison of the total Yuba River flows at Smartsville from Tables 5.4-1 and 5.4-2. The periods of record of the unimpaired flow is different from the other two flows, however, since all three are long-term averages, the information in the tables remains illustrative of relative flows under each condition. Since the YRDP does not divert water out of the basin above Smartsville, differences between the annual flow volume with and without the YRDP are reflective of several factors including gage error and evaporation. The average annual difference in flow between Historical Conditions and Non-YRDP Conditions is approximately 38 TAF. USGS acknowledges its gages have a margin of error of 5 to 10 percent (USGS 1992); the 38 TAF difference mentioned above would represent a 2 percent error in average annual Yuba River flow volume at Smartsville.

Table 5.4-3. Comparison of Monthly Average Yuba River Flow at Smartsville under Various Developmental Conditions.

Location	Average[4] Monthly Flow (cfs)												Total (TAF)
	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	
Historical Conditions[1]	1,288	1,479	2,333	3,574	3,495	3,585	2,919	3,182	2,637	2,048	2,022	1,419	1,790
Non-YRDP Conditions[2]	377	869	2,055	3,451	4,231	4,835	4,880	4,753	3,100	1,091	443	323	1,828
Unimpaired Condition[3]	403	1,057	2,473	3,944	5,048	5,963	6,354	6,771	3,807	1,229	429	316	2,275

Notes:

[1] Historical Conditions reflect historical reservoir inflows as observed and described in Table 5.4-1

[2] Non-YRDP Conditions reflects computed inflow consisting of gaged flows and computed accretions, as computed in Table 5.4-2

[3] Unimpaired Condition reflects computed inflow consisting of gaged flows and computed accretions, as computed in Table 4.4-1

[4] Period of record is 10/1/1969-9/30/2010 for the Current and Non-YRDP conditions and 10/1/1975-9/30/2008 for the Unimpaired Condition

Key: YRDP = Yuba River Development Project cfs = cubic feet per second TAF = thousand acre-feet

SECTION 6

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Appendix C3

Modeling Data

Appendix C3

Model Version: YRDPM Version 3.102
Simulation Period: Water Year 1970 to 2021

Groundwater Substitution Transfers (Pumping Volume in TAF)

1970 to 1994 from LYRBM Sim 19.3 Scenario 3 used in 2007 Accord EIR. 1995 to 2021 from YWA historical GWS transfers.

Year	Year Type	Pumping Volume	Year	Year Type	Pumping Volume	Year	Year Type	Pumping Volume
1971	Wet	-	1981	Dry	90	1991	Critical	60
1972	Below Normal	-	1982	Wet	-	1992	Critical	30
1973	Above Normal	-	1983	Wet	-	1993	Above Normal	-
1974	Wet	-	1984	Wet	-	1994	Critical	90
1975	Wet	-	1985	Dry	68	1995	Wet	-
1976	Critical	90	1986	Wet	-	1996	Wet	-
1977	Critical	-	1987	Dry	90	1997	Wet	-
1978	Above Normal	-	1988	Critical	60	1998	Wet	-
1979	Below Normal	-	1989	Dry	30	1999	Wet	-
1980	Above Normal	-	1990	Critical	90	2000	Above Normal	-

Year	Year Type	Pumping Volume	Year	Year Type	Pumping Volume
2001	Dry	62	2011	Wet	-
2002	Dry	57	2012	Below Normal	-
2003	Above Normal	-	2013	Dry	57
2004	Below Normal	-	2014	Critical	57
2005	Above Normal	-	2015	Critical	-
2006	Wet	-	2016	Below Normal	-
2007	Dry	-	2017	Wet	-
2008	Critical	50	2018	Below Normal	16
2009	Dry	100	2019	Wet	-
2010	Below Normal	68	2020	Dry	77

** Note – No transfer pumping occurred in 1970 or 2021. Pumping in Schedule 6 years occurs automatically if Schedule 6 results in the simulation. The Proposed Extension/Existing Condition simulation results in a Schedule 6 for 2015 – 30TAF of pumping not shown in the table*

Resulting Yuba Accord Water Year Type Schedules

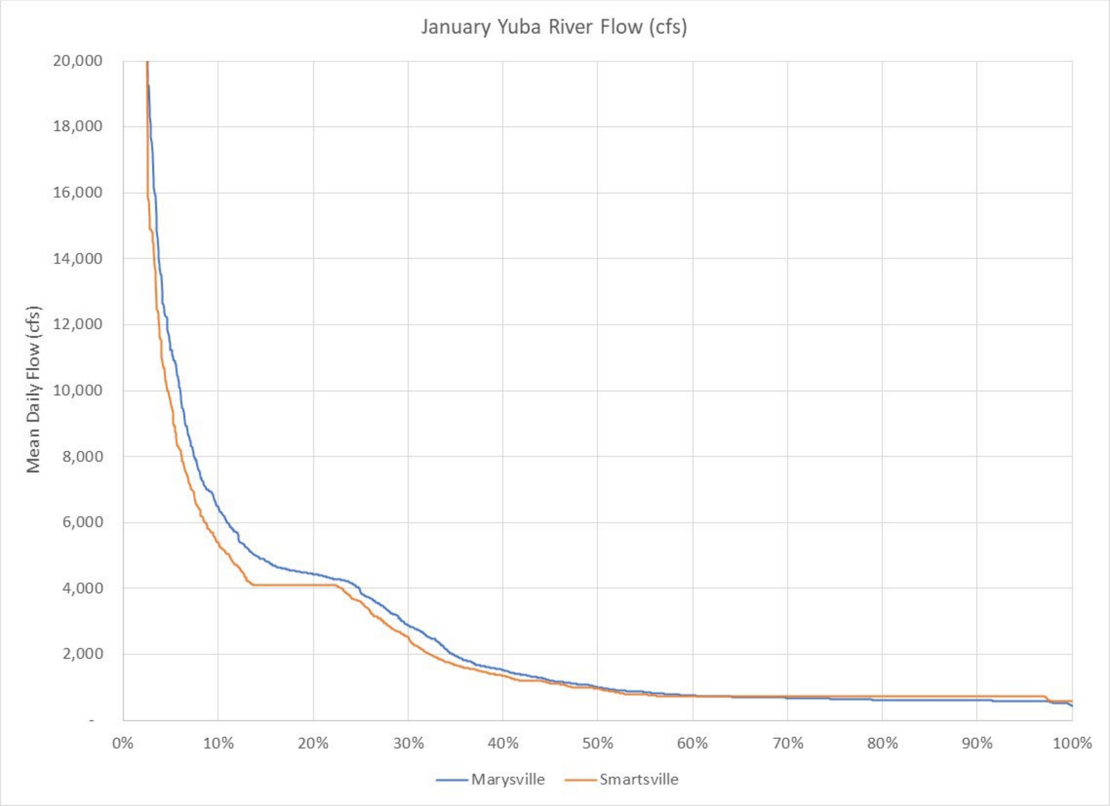
Year Type Schedule	Count	Percent of Total
1	32	62%
2	10	19%
3	4	8%
4	1	2%
5	3	6%
6	1	2%
Conference Year	1	2%
TOTAL	52	100%

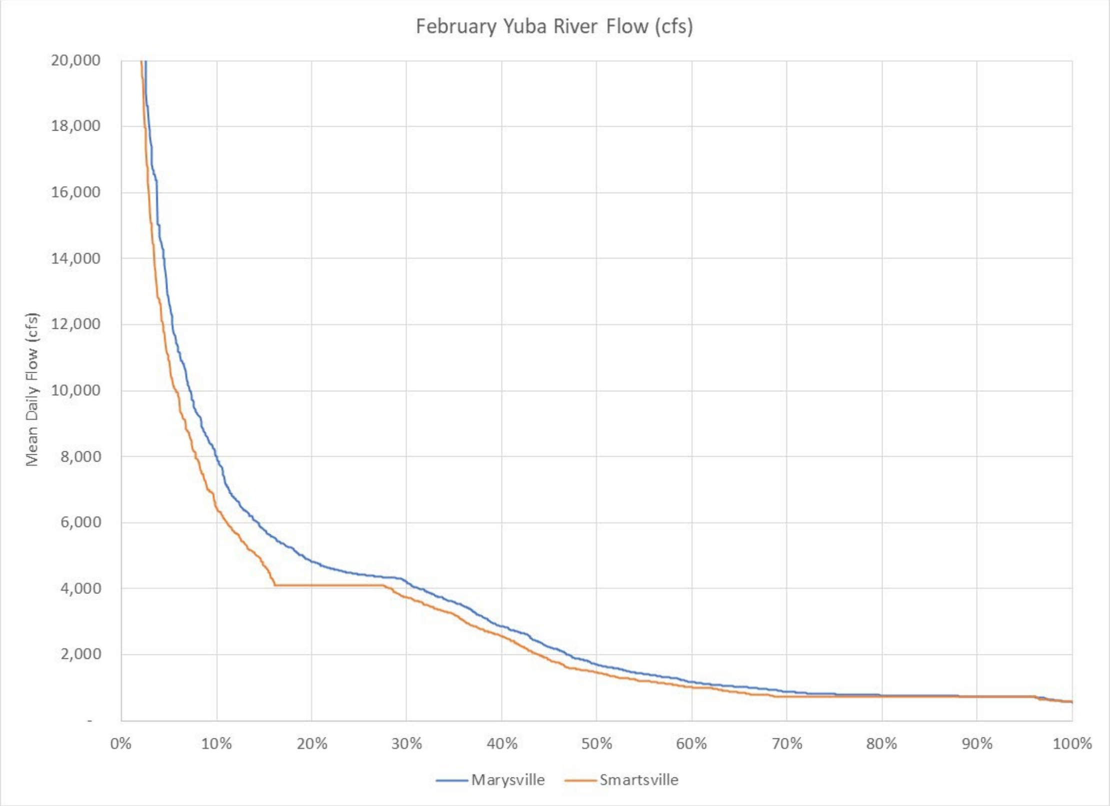
Existing Condition/Proposed Extension Yuba River at Marysville (Yuba River Outflow) Flow

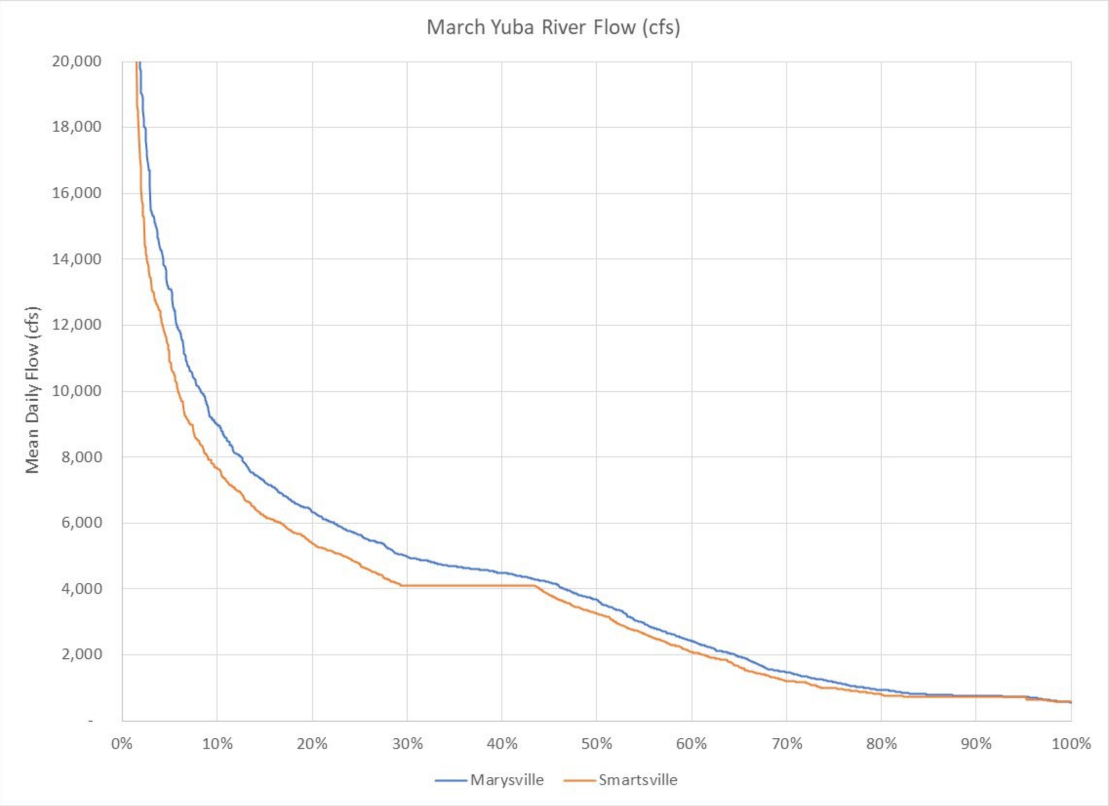
Average Monthly Flow by Year Type (Sacramento Valley Index) (CFS)

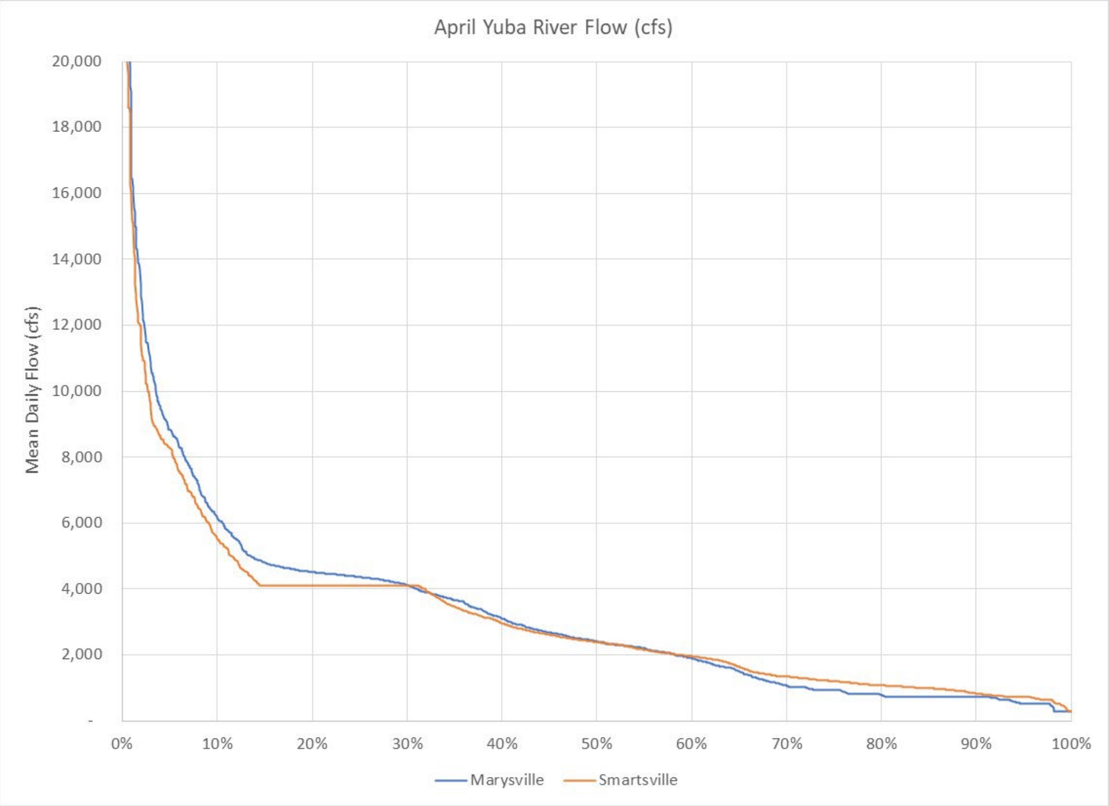
Water Year Type	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Wet	555	1,204	4,206	7,253	8,511	7,844	5,646	5,295	4,403	2,079	1,550	735
Above Normal	519	534	1,032	4,432	4,525	5,030	3,429	3,831	2,974	1,488	1,033	590
Below Normal	515	617	756	1,257	1,572	4,574	3,373	2,546	2,027	1,018	852	556
Dry	525	679	1,162	933	1,372	2,355	1,722	1,615	934	1,066	975	546
Critical	519	546	631	720	992	1,065	727	730	586	843	778	455

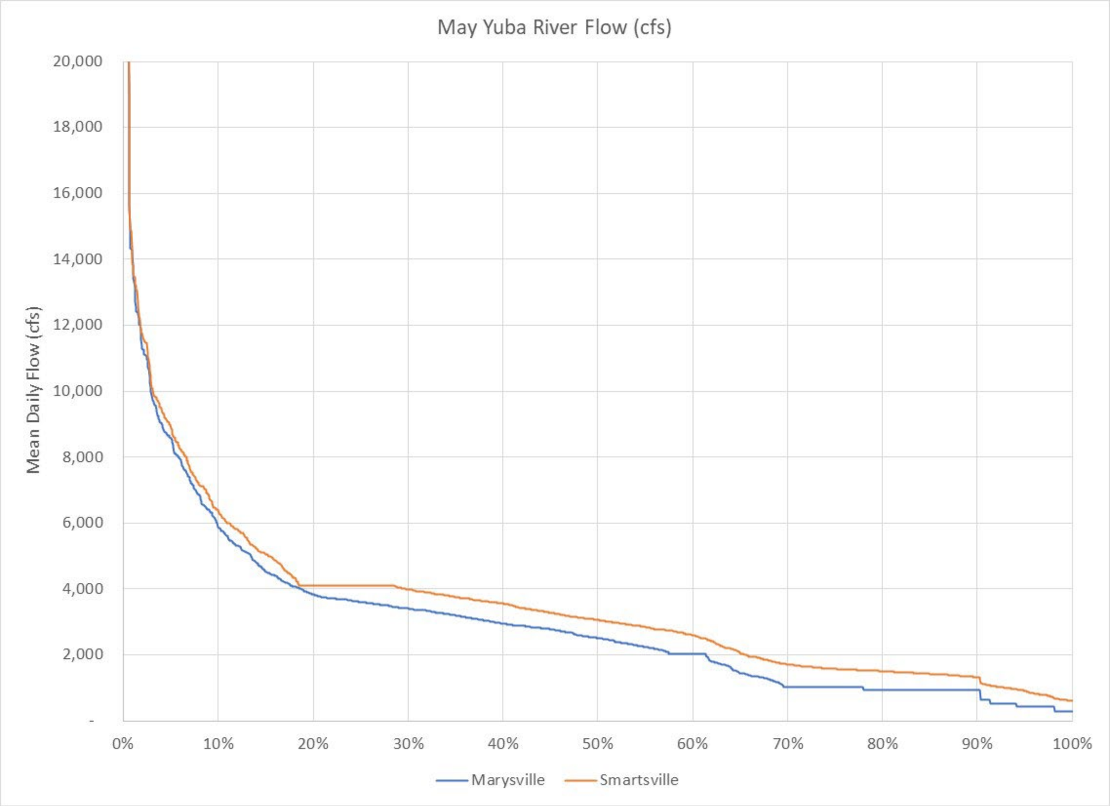
Existing Condition/Proposed Extension Simulation Resulting lower Yuba River Flow (cfs) Exceedance Probability by Month

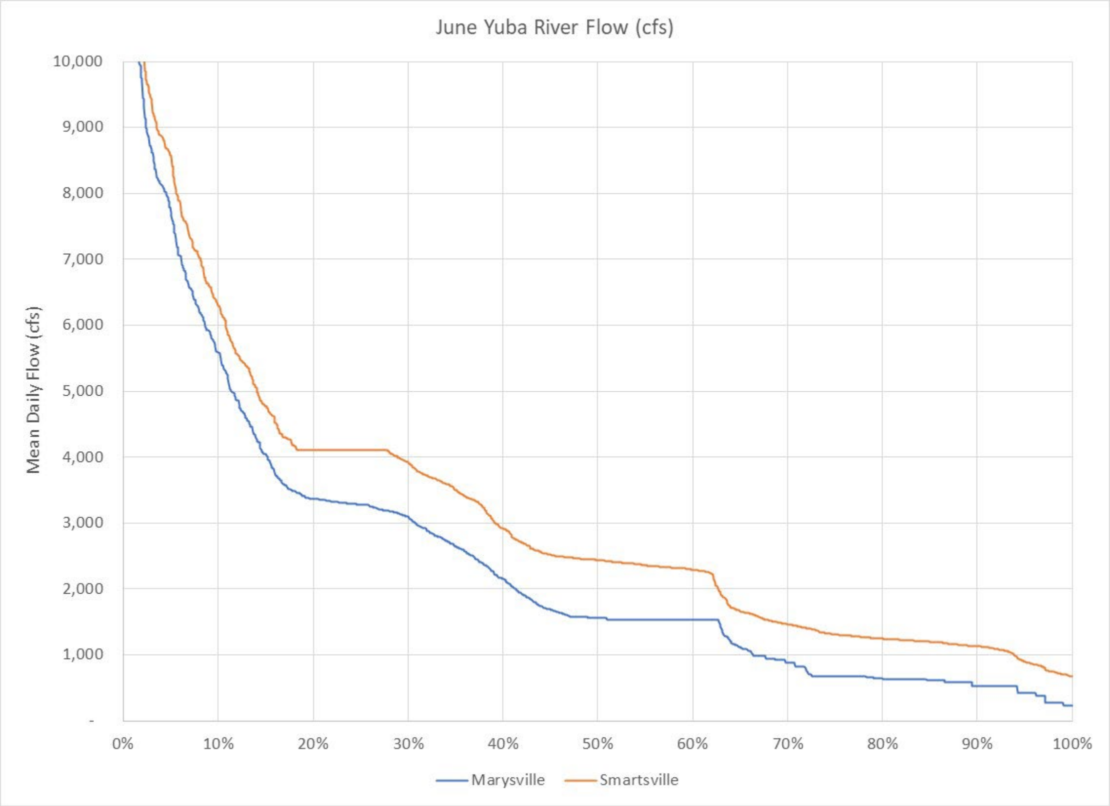


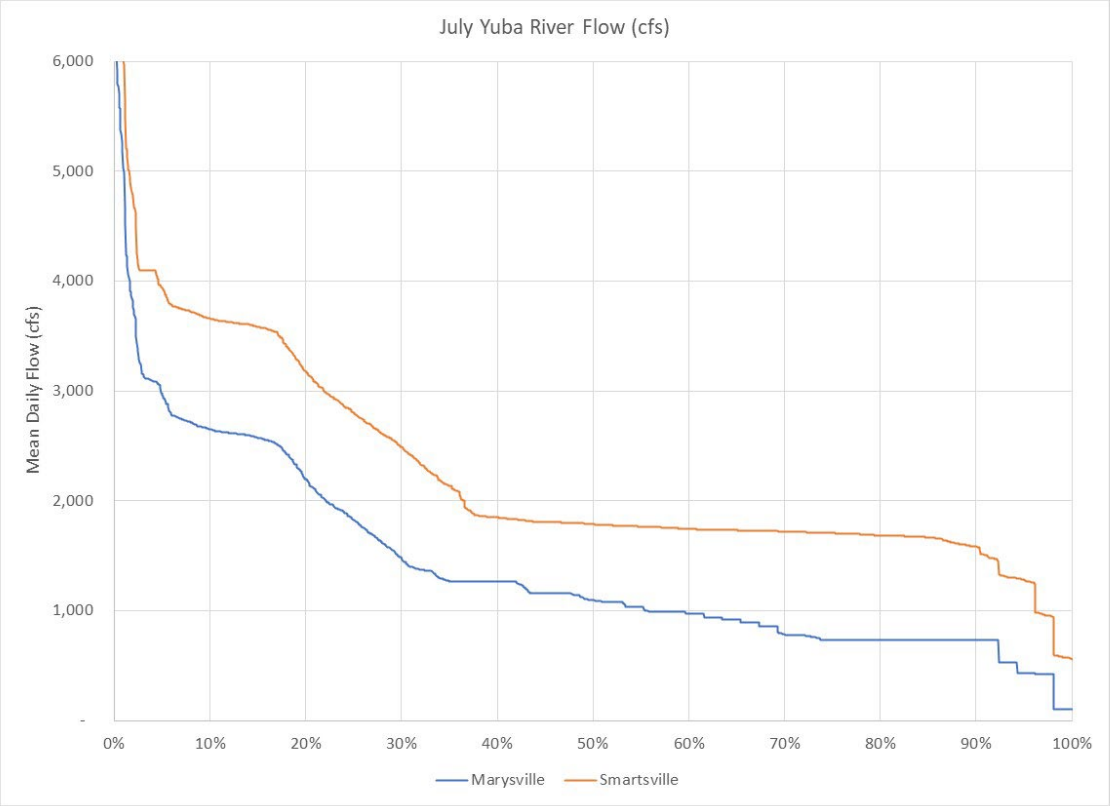


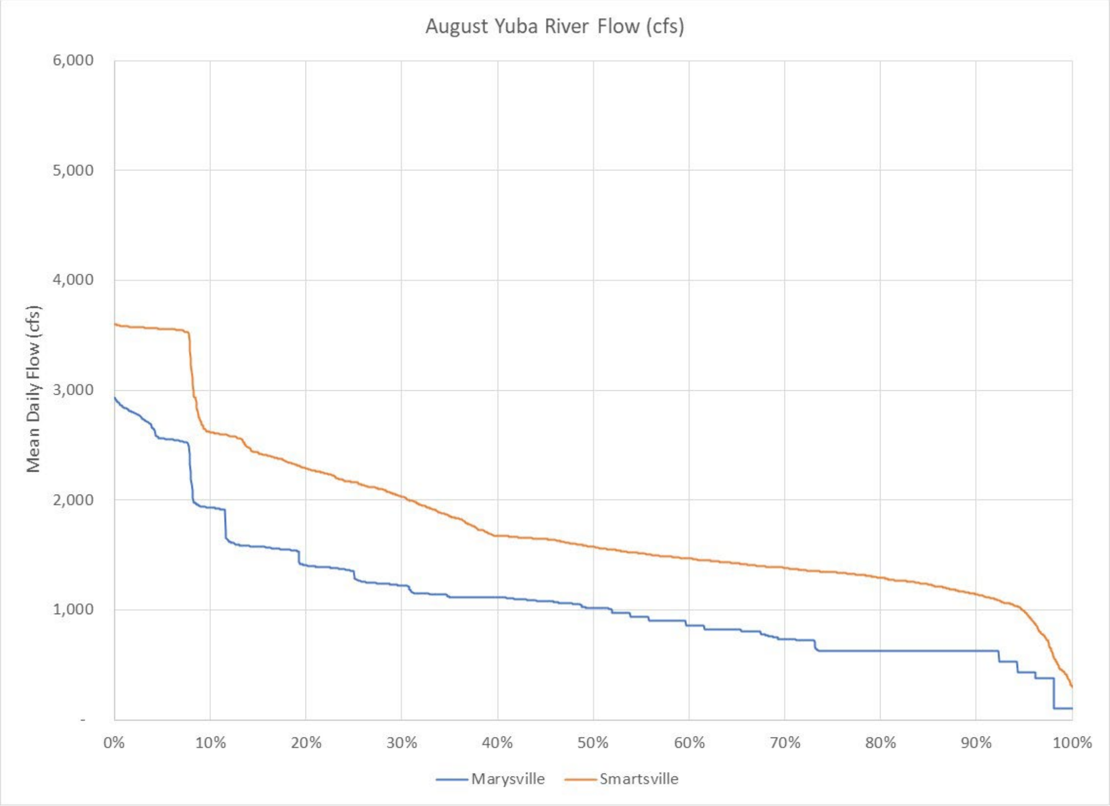

March Yuba River Flow (cfs)
Mean Daily Flow (cfs)
20,000
18,000
16,000
14,000
12,000
10,000
8,000
6,000
4,000
2,000
-
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Marysville
Smartsville


April Yuba River Flow (cfs)
Mean Daily Flow (cfs)
20,000
18,000
16,000
14,000
12,000
10,000
8,000
6,000
4,000
2,000
-
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Marysville
Smartsville

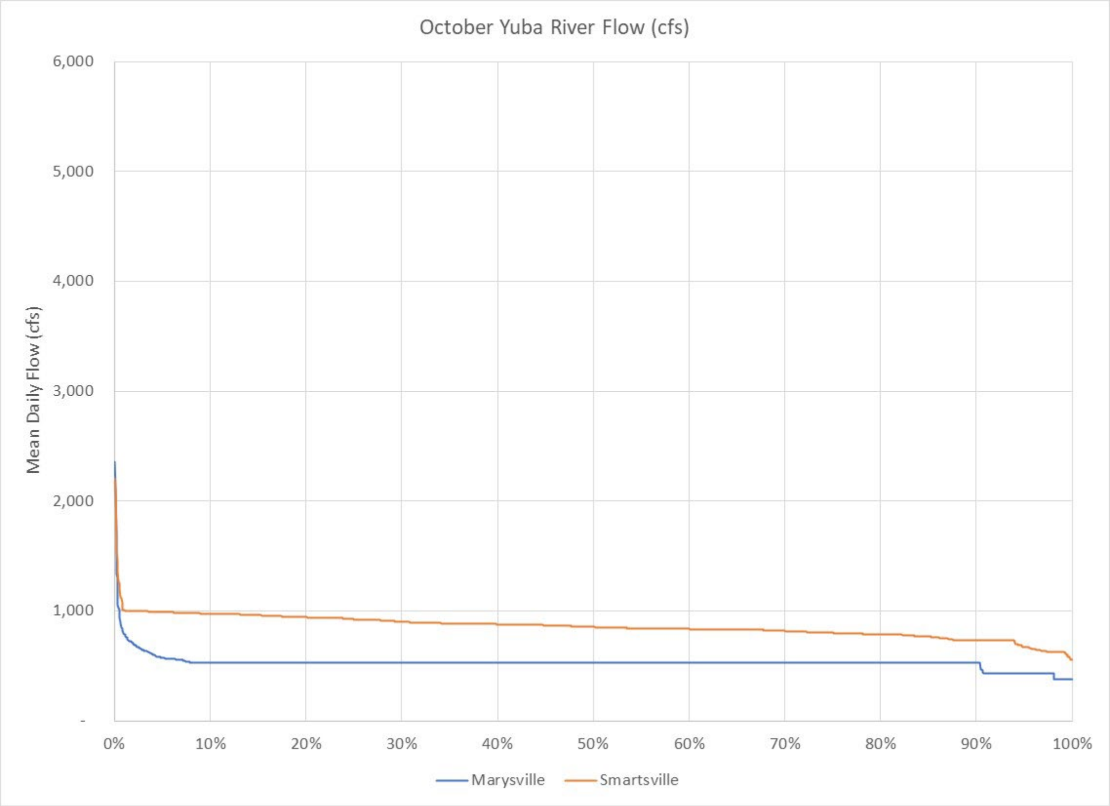

May Yuba River Flow (cfs)
Mean Daily Flow (cfs)
20,000
18,000
16,000
14,000
12,000
10,000
8,000
6,000
4,000
2,000
-
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Marysville
Smartsville

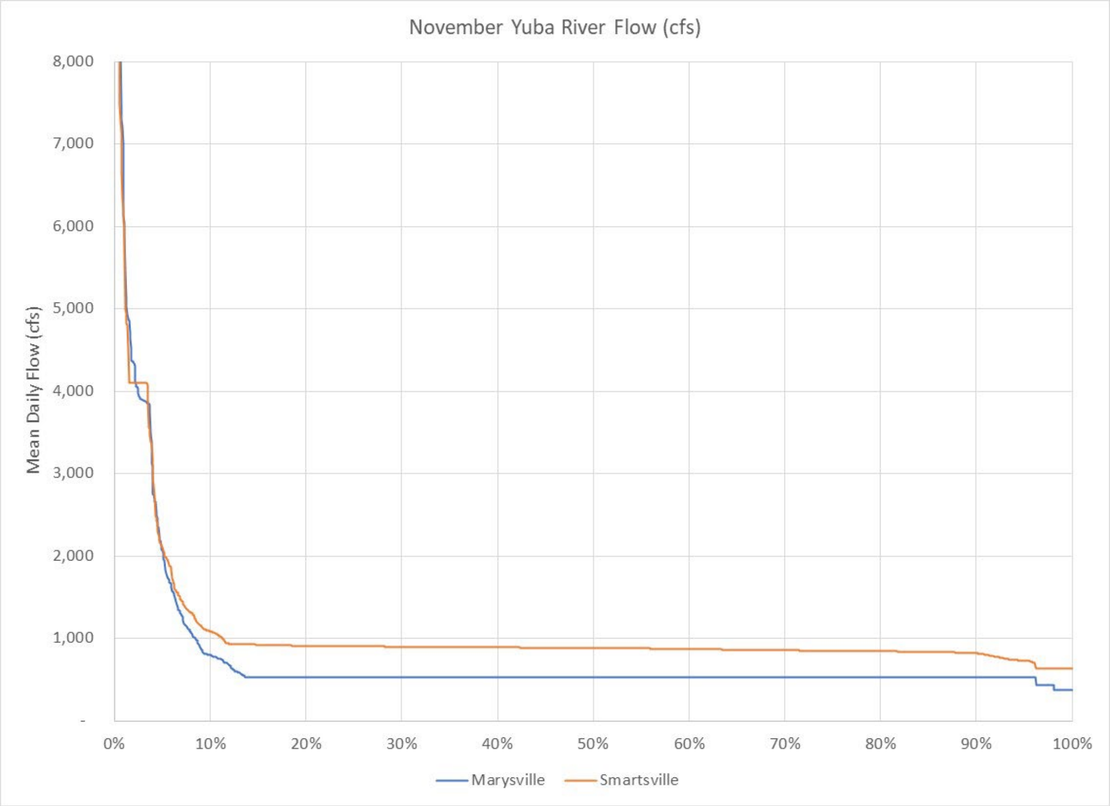

June Yuba River Flow (cfs)
Mean Daily Flow (cfs)
10,000
9,000
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
-
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Marysville
Smartsville

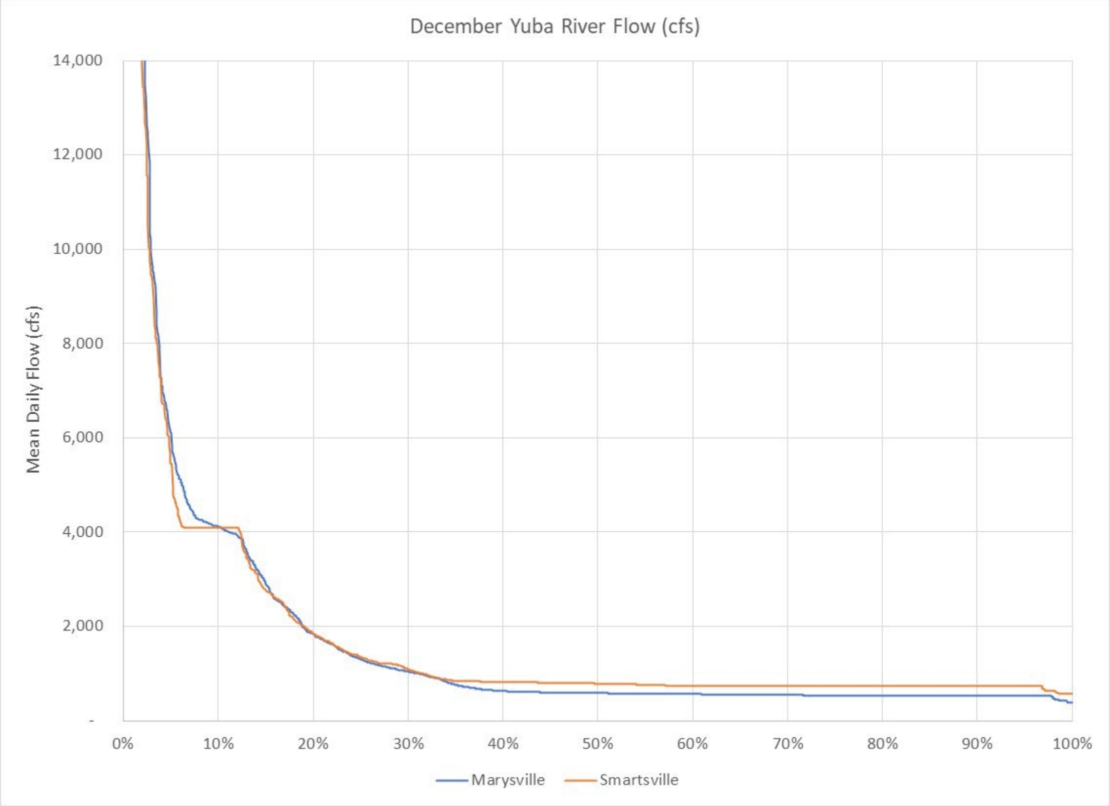

July Yuba River Flow (cfs)
Mean Daily Flow (cfs)
6,000
5,000
4,000
3,000
2,000
1,000
-
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Marysville
Smartsville


August Yuba River Flow (cfs)
Mean Daily Flow (cfs)
6,000
5,000
4,000
3,000
2,000
1,000
-
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Marysville
Smartsville


September Yuba River Flow (cfs)
Mean Daily Flow (cfs)
2,000
1,800
1,600
1,400
1,200
1,000
800
600
400
200
-
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Marysville
Smartsville


October Yuba River Flow (cfs)
Mean Daily Flow (cfs)
6,000
5,000
4,000
3,000
2,000
1,000
-
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Marysville
Smartsville


November Yuba River Flow (cfs)
Mean Daily Flow (cfs)
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
-
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Marysville
Smartsville


December Yuba River Flow (cfs)
Mean Daily Flow (cfs)
14,000
12,000
10,000
8,000
6,000
4,000
2,000
-
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Marysville
Smartsville