Appendix F.1

Hydrologic and Water Quality Modeling

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TABLE OF CONTENTS

Tables

Figures

F.1.1 Introduction

This appendix includes a description of the hydrologic and water quality modeling methods and assumptions used to evaluate the LSJR alternatives. The Department of Water Resources' (DWR) CALSIM[1] Water Resources Simulation Model was used to provide the baseline conditions for 1922–2003. The State Water Resource Control Board (State Water Board) developed the Water Supply Effects (WSE) model to simulate the LSJR alternatives and determine the effects on reservoir operations, water supply diversions, and river flow for each of the eastside tributaries (Stanislaus, Tuolumne, and Merced Rivers) and flow at Vernalis on the San Joaquin River (SJR). The WSE model includes estimates of monthly salinity (EC) at Vernalis. The SJR Basin Water Temperature Model, developed from the HEC-5Q model (created by the U.S. Bureau of Reclamation [USBR]), was used to evaluate temperate effects caused by changes in reservoir storage and river flow.

The monthly and annual results from the WSE reservoir operations and water temperature models were used to assess the impacts of the LSJR alternatives for resource areas in the SED that are affected by reservoir operations and flows, including: flooding, sediment, and erosion (Chapter 6); aquatic resources (Chapter 7); terrestrial biological resources (Chapter 8); recreational resources (Chapter 10); and energy and climate change (Chapter 14). Results showing the annual changes in water supply deliveries from the three eastside tributaries were used to analyze impacts related to groundwater (Chapter 9), agricultural resources (Chapter 11), and economic analyses (Chapter 18). Both the modeling methods and the results from the models for the baseline conditions and the three LSJR alternatives are provided in this appendix.

Flow changes in the three eastside tributaries would also cause salinity changes in the SJR at Vernalis and in the southern Delta. These salinity effects were also estimated with the WSE model.

F.1.2 Water Supply Effects Modeling

The CALSIM model of monthly reservoir operations and flows calculated for baseline conditions was used to assess hydrology impacts in the SED, and the water supply effects of the LSJR alternatives were analyzed using the WSE model. The scientific basis for the WSE model is described in Appendix C, *Technical Report on the Scientific Basis for Alternative San Joaquin River Flow and Southern Delta Salinity Objectives*. The methodologies used in the WSE were previously described in Appendix C and are included below to incorporate any changes to the inputs since it was published. Because changes in the LSJR alternatives would lead to changes in the tributary reservoir operations, flood control releases would likely change, and water supply diversions for baseline beneficial uses would also likely change. The WSE model was used to estimate the changes in reservoir operations, river flow, and surface water diversions that would result from the LSJR alternatives.

[1] CALSIM is a generalized water resources simulation model for evaluating operational alternatives of the State Water Project/Central Valley Project system. CALSIM II is the latest application of the generic CALSIM model to simulate SWP/CVP operations. CALSIM and CALSIM II are products of joint development between DWR and USBR. This document uses CALSIM and CALSIM II interchangeably.

F.1.2.1 Water Supply Effects Methods

CALSIM Modeling for Baseline

The monthly hydrology results from the CALSIM San Joaquin River Water Quality Module were used for describing baseline conditions and several inputs to the WSE model. USBR developed the CALSIM SJR module to simulate monthly flows, reservoir storages, and water supply deliveries in the SJR Basin. It is used as part of the CALSIM planning model for the Central Valley Project (CVP) and State Water Project (SWP) that calculates reservoir operations and Delta operations for a specified set of water resources and level of development (i.e., demands) and regulatory requirements using the historical sequence of hydrologic conditions 1922–2003. The CALSIM SJR module estimates the diversions on each tributary based on runoff and reservoir storages. The CALSIM SJR module calculates annual Stanislaus River diversions using the end-of-February storage plus actual March–September reservoir inflow (perfect foresight). The diversions and releases from the Tuolumne and Merced Rivers are estimated from the annual runoff (perfect forecast). The CALSIM SJR module uses a series of monthly flows to calculate flows and salinity at the mouth of each eastside tributary and along the SJR.

The CALSIM model includes the Upper SJR watershed inflows to Millerton Reservoir, the inflows to the Fresno and Chowchilla Rivers, and the inflows to Lake McClure on the Merced River, New Don Pedro Reservoir on the Tuolumne River, and New Melones Reservoir on the Stanislaus River. These inflows have been modified from the unimpaired runoff by upstream reservoir operations and, on the Tuolumne, by upstream diversion to the San Francisco Hetch Hetchy aqueduct.

The CALSIM "Current Conditions" case in the recent DWR report (DWR 2010) provided the results for baseline monthly flows, reservoir storage levels, and diversions. A more complete description of the CALSIM modeling assumptions is given later in this appendix. This selected CALSIM case included a representation of the December 2008 U.S. Fish & Wildlife Service (USFWS) and the June 2009 National Marine Fisheries Service (NMFS) biological opinions (BO) on the OCAP for the CVP and SWP. Calculations for the Vernalis Adaptive Management Program (VAMP) flows were included in this CALSIM case. The CALSIM case included the NFMS Reasonable and Prudent Alternative (RPA) required Stanislaus River flows and simulated some (but not all) of the Water Rights Decision 1641 (D-1641) Vernalis objective flows to be released from New Melones Reservoir. The VAMP April 15–May 15 Vernalis pulse flows were released from either New Melones Dam or New Exchequer Dam.

Appendix F.2, *Evaluation of Historical Flow and Salinity Measurements of the Lower San Joaquin River and Southern Delta*, contains an analysis of historical SJR flow and salinity. It compares baseline conditions measured monthly average SJR flows at Vernalis with the CALSIM results for water years 1984–2003. This covers a period during which actual operations in the watershed were relatively similar to those modeled in the CALSIM representation of current conditions. All major eastside dams were completed and filled, and their combined effect on flows at Vernalis are present in the actual data. CALSIM model output ends with water year 2003. The comparison of CALSIM results with recent historical flow and EC data demonstrates that the monthly model provides a reasonable (accurate) representation of the baseline SJR flow and EC conditions.

WSE Model for LSJR Alternatives

The WSE model is a monthly spreadsheet model that calculates the adjustments in monthly flows, reservoir storage levels, and water supply diversions for each eastside tributary based upon user-specified target flows, other user defined inputs, output from CALSIM II, and flood storage rules. User defined inputs to the model include the following.

- Months for which flow targets are to be set.
- Monthly flow targets as a percentage of unimpaired monthly flow for each eastside tributary (uniform values were used for the SED LSJR alternatives).
- Monthly maximum and minimum flows for each eastside tributary, based on tributary channel capacities and flood control limits and minimum acceptable fish-habitat flows (constant values were used for each tributary).
- Maximum annual water supply diversion (demand) for each eastside tributary based on CALSIM II maximum diversion.
- Reservoir storage and diversion balancing rule-curves for each eastside tributary reservoir based on end-of-January storage behind dams (New Melones, New Don Pedro, and New Exchequer).
- Minimum annual end-of-September storage (no calculations based on this input; provides only a reference line).

Other inputs not defined by the user include the following.

- Baseline CALSIM II flows at the eastside tributary confluences with the SJR for calculating effects to river flows due to LSJR alternatives.
- Baseline CALSIM II monthly surface water diversions for each eastside tributary for calculating effects to diversions due to LSJR alternatives.
- CALSIM II inflows to each major reservoir (New Melones, New Don Pedro, and Lake McClure).
- CALSIM II evaporation from each major reservoir
- CALSIM II accretions/depletions downstream from each major reservoir.
- CALSIM II monthly diversion patterns used to distribute the annual diversions on each eastside tributary.
- Flood storage rule curves at each major reservoir.

Output from the WSE model, including annual and monthly diversions, river flows, and reservoir storage, is compared to CALSIM II baseline conditions to assess the effects of the LSJR alternatives.

Calculation of Flow Targets

In general, the WSE model calculates monthly flow targets for each eastside tributary based on the user-specified percent of unimpaired monthly flow. These can be variable between tributaries and month, although uniform values (20%, 40%, and 60% unimpaired flow) [2] are used for each of the tributaries and for each month for the SED LSJR alternatives. The monthly unimpaired flow for water years 1922– 2003 available from DWR (2007) are estimates of flow that would have entered each of the major upstream reservoirs. This is used as the unimpaired flow for each eastside

[2] Any reference in this appendix to 20% unimpaired, 40% unimpaired, and 60% unimpaired is the same as LSJR Alternative 2, LSJR Alternative 3, and LSJR Alternative 4, respectively. Any reference to 1.0 EC objective and 1.4 EC objective is the same as SDWQ Alternative 2 and SDWQ Alternative 3, respectively.

tributary because there are no estimates of the unimpaired flow for the tributaries at their confluences with the SJR, where the flow objectives are being established. The entire valley floor component of unimpaired flow is roughly 3 percent of the unimpaired flows of the major LSJR tributaries; thus, the component of unimpaired flow that would otherwise be associated with accretions and other inputs downstream of the major reservoirs is not expected to significantly alter the amount or timing of these flows. The unimpaired flows at the major dams are, therefore, considered adequate for the purpose of establishing flow objectives.

The model allows for specifying minimum and maximum monthly flows for each eastside tributary. Minimum flows are selected to limit adverse fishery effects in months with low unimpaired flow, and maximum flows are selected to limit flooding effects and reduce water supply effects from extremely high target flows. The selected minimum monthly flows are: 150 cubic feet per second (cfs) for the Stanislaus River, 200 cfs for the Tuolumne River, and 150 cfs for the Merced River. These minimum flows generally reflect the baseline regulatory requirements for minimum flows February–June.

The selected maximum monthly flows are: 2,500 cfs for the Stanislaus River; 3,500 cfs for the Tuolumne River; and 2,000 cfs for the Merced River. These maximum flows generally reflect the median unimpaired flows in these three tributaries February–June. The model calculates and releases additional flow when required to maintain reservoirs below U.S. Army Corps of Engineers (USACE) flood control storage requirements. Because of these adjustments, the overall percentage of unimpaired flow calculated by the WSE model might be slightly different than the user-defined percent of unimpaired flow. For months outside of the February–June period, the target flows for the model are set to the CALSIM II monthly flow.

As described above, the flow target at the mouth of each eastside tributary, QF_t, for a particular month is calculated as:

$$QF_t = UF_t \times Fa \begin{Bmatrix} \text{such that} & (UF_t \times Fa) \le Qmx_t \\ \text{and} & (UF_t \times Fa) \ge Qmn_t \end{Bmatrix} \qquad \text{(Eqn. F.1-1)}$$

where:

UF_t is the DWR (2007a) unimpaired flow at time t;

Fa is the target percentage of unimpaired flow defined by the user; and

Qmx_t and Qmn_t are the user defined maximum and minimum monthly flows, respectively, at time t.

Calculation of Water Supply Effects

After the WSE model calculates target flows in each of the three eastside tributaries, it calculates the surface water diversions and the reservoir releases needed to: (1) meet these target flows; (2) satisfy the specified surface water diversions; and (3) maintain storage levels within minimum pool and flood control limits. The major reservoir storage level is then calculated using a flow balance equation to determine resulting changes in storage. These calculations are performed monthly using hydrologic conditions for water years 1922–2003. The monthly water supply diversions are calculated as a specified monthly fraction of the annual diversion volume. The maximum diversion (demand) is specified for each eastside tributary. The WSE model assumed maximum diversions of 750 thousand acre-feet per year (TAF/y) for the Stanislaus River, 1,100 TAF/y for the Tuolumne

River, and 625 TAF/y for the Merced River. The monthly diversion pattern, based on the median CALSIM II monthly diversions, was similar for each river, with about 65 percent (Stanislaus and Tuolumne) to 75 percent (Merced) diverted in May–August. The annual diversion volume is calculated from a user-specified curve that gives the annual diversion fraction as a linear function of the end-of-January storage for each tributary. This rule curve requires the annual diversion to be reduced at lower storage levels. A more restrictive storage-diversion rule curve will be needed to meet higher flow objectives. For example, the specified storage-diversion curve for the Merced River with the LSJR Alternative 2 was full delivery when the end-of-January storage was 675 TAF (maximum flood control level) but was reduced to 40 percent of full delivery when the end-of-January storage was 100 TAF.

Surface Water Diversions

The surface water diversions, D_t, for a particular month are calculated using:

$$D_t = D_{\max} \times Ka_t \times Kb \qquad \text{(Eqn. F.1-2)}$$

where:

$D_{\max}$ is the maximum annual diversion for each tributary defined by the user (default values are 750 TAF on the Stanislaus River, 1,100 TAF on the Tuolumne River, and 625 TAF on the Merced River).

Ka_t is the monthly diversion pattern used to distribute the annual diversions for each month at period t (derived from CALSIM II output using the median monthly sum of diversions on each tributary).

Kb is the percent of maximum diversions for each year set by a user-defined diversion delivery rule curve of January storage level in the major reservoir of the associated river. The storage at time t is input to the rule curve, and the corresponding percent of maximum diversions (*Kb*) to be delivered over the following 12 months is interpolated as a straight line between points defined by the user on the rule curve. This curve allows for a greater percentage of diversions at higher storage levels and requires diversions to be reduced at lower storage levels. As the percentage of unimpaired increases in a specific LSJR alternative, a more restrictive diversion delivery rule curve will be needed to meet the flow targets and maintain reservoir storage.

Reservoir Releases

The reservoir release needed to satisfy the target flow and diversions is determined on each eastside tributary as:

$$R_t = QF_t + D_t + RS_t - QAC_t \qquad \text{(Eqn. F.1-3)}$$

where:

RS_t is the additional reservoir spill release required to stay below flood stage (as defined by the USACE flood storage curves); and

QAC_t is the sum of CALSIM II accretions (including return flows) and depletions downstream of the major dam in month t. Accretions and return flows are assumed unchanged with respect to CALSIM II.

Reservoir Storage Levels

Storage levels behind the major dams are initially set to CALSIM II levels at the end of September, 1921. The reservoir storage at the end of the following month, and each subsequent month, S_t, is calculated with a water balance equation on each tributary using:

$$S_t = S_{t-1} + QINF_t - R_t - EV_t \qquad \textit{(Eqn. F.1-4)}$$

where:

S_{t-1} is the storage of the previous month;

$QINF_t$ is the CALSIM II inflow to each major reservoir; and

EV_t is the CALSIM II evaporation from the major reservoir at time t. Because the magnitude of evaporation from the reservoir surface is minimal compared to the changes in flows, and the change in reservoir evaporation due to the LSJR alternatives would be inconsequential, it was assumed equal to the baseline.

River Flows

The flow achieved by the WSE model at the confluence of each of the three eastside tributaries with the SJR is determined as follows:

$$Q_t = QF_t + RS_t = R_t - D_t + QAC_t \qquad \textit{(Eqn. F.1-5)}$$

Outside of the February –June period, Q_t is generally identical to the CALSIM II flow, but it may include additional flood spills triggered by a higher storage calculated by the WSE model relative to CALSIM II.

Comparison of WSE Model to CALSIM II

Described below are the steps that were taken to compare the WSE model with the CALSIM II baseline results. By using CALSIM II baseline inputs and the modified approach for estimating water supply diversions in the WSE model, the WSE model will result in a similar outcome as CALSIM II.

The WSE model results were summarized with four graphs that show annual values for the 1922–2003 simulations period. The annual values were sorted to show the distribution of annual values as the maximum to the minimum values (i.e., exceedance plots) or as the minimum to the maximum values (i.e., cumulative distribution plots). Figure F.1-1 shows the annual WSE results for the Stanislaus River and New Melones Reservoir compared to the CALSIM baseline values. Graph a) shows the annual water supply diversions; graph b) shows the carryover (i.e., end of September) storage in New Melones Reservoir; graph c) shows the February–June flow volume released from the reservoir; and graph d) shows the pattern of January storage and water supply diversions that was selected for the WSE model case (lines) with the CALSIM baseline values shown for reference. Figure F.1-2 shows the annual WSE results for the Tuolumne River and New Don Pedro Reservoir compared to the CALSIM baseline values. Figure F.1-3 shows the annual WSE results for the Merced River and Lake McClure compared to the CALSIM baseline values.

To compare the WSE model results with the CALSIM baseline results, several cases were run to determine the approximate percentage of unimpaired flow targets that was most similar to the CALSIM II baseline river flows for each of the three eastside tributaries. This was done by comparing the distributions of the WSE and CALSIM II February–June modeled flows. The target percentage of unimpaired flow for the WSE model was adjusted until the distribution of February-June flows generally matched the CALSIM II flow distribution. The results of CALSIM II February–June flows closely match the WSE model results for the LSJR Alternative 3 flow targets on the Stanislaus River and for the LSJR Alternative 2 targets on both the Tuolumne and Merced Rivers.

In the second step, the end of January storage verses annual diversion "rule curve" was developed to match the CALSIM II relationship between January storage levels and annual diversions for the major reservoirs on each tributary. The CALSIM II annual diversions were divided by the maximum annual diversion determined for each tributary, resulting in a percent of maximum annual diversion actually delivered each year. This result was then plotted against the January storage for the CALSIM baseline results. The WSE storage-diversion rule-curve was adjusted to provide a similar distribution of annual water supply diversions. The "rule-curve" results in a lower percentage of the maximum annual diversion being delivered when the January storage is lower. In general, substantial cutbacks to diversions are necessary when reservoir storage is less than roughly one half of the full capacity. Using the CALSIM II baseline results as a guide, diversion delivery rule curves were developed that resulted in annual diversions that were similar to those of CALSIM II. The WSE rule curves were also adjusted to match the end-of-September storages (carryover storage) from the CALSIM II model. Minimum allowable storage levels were specified for each reservoir and used as a reference line to tally the number of times storage fell below this level.

The comparison of results demonstrate that the WSE method for estimating annual water supply diversions from the January storage values can give results that are similar to the CALSIM II baseline values. The WSE model was needed for assessing the LSJR alternatives because CALSIM does not include the option of setting monthly downstream flow targets as a fraction of the unimpaired flows.

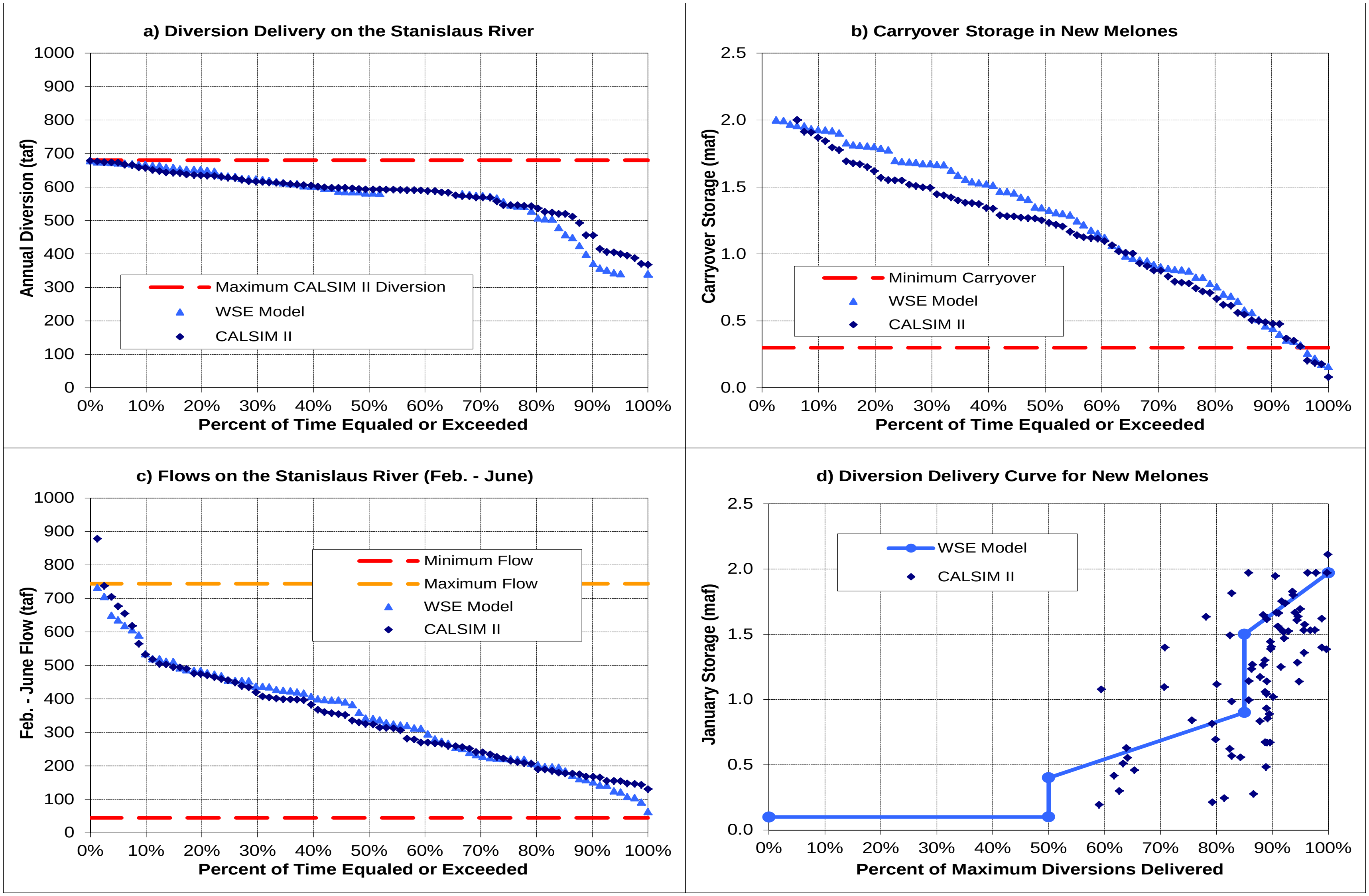


Figure F.1-1. Comparison of WSE Model Against CALSIM II Output on the Stanislaus River for a) Annual Diversion Delivery, b) End-of-September Storage, c) Flow at CALSIM II Node 528, d) Diversion Delivery Rule Curve Based on January Storage Level

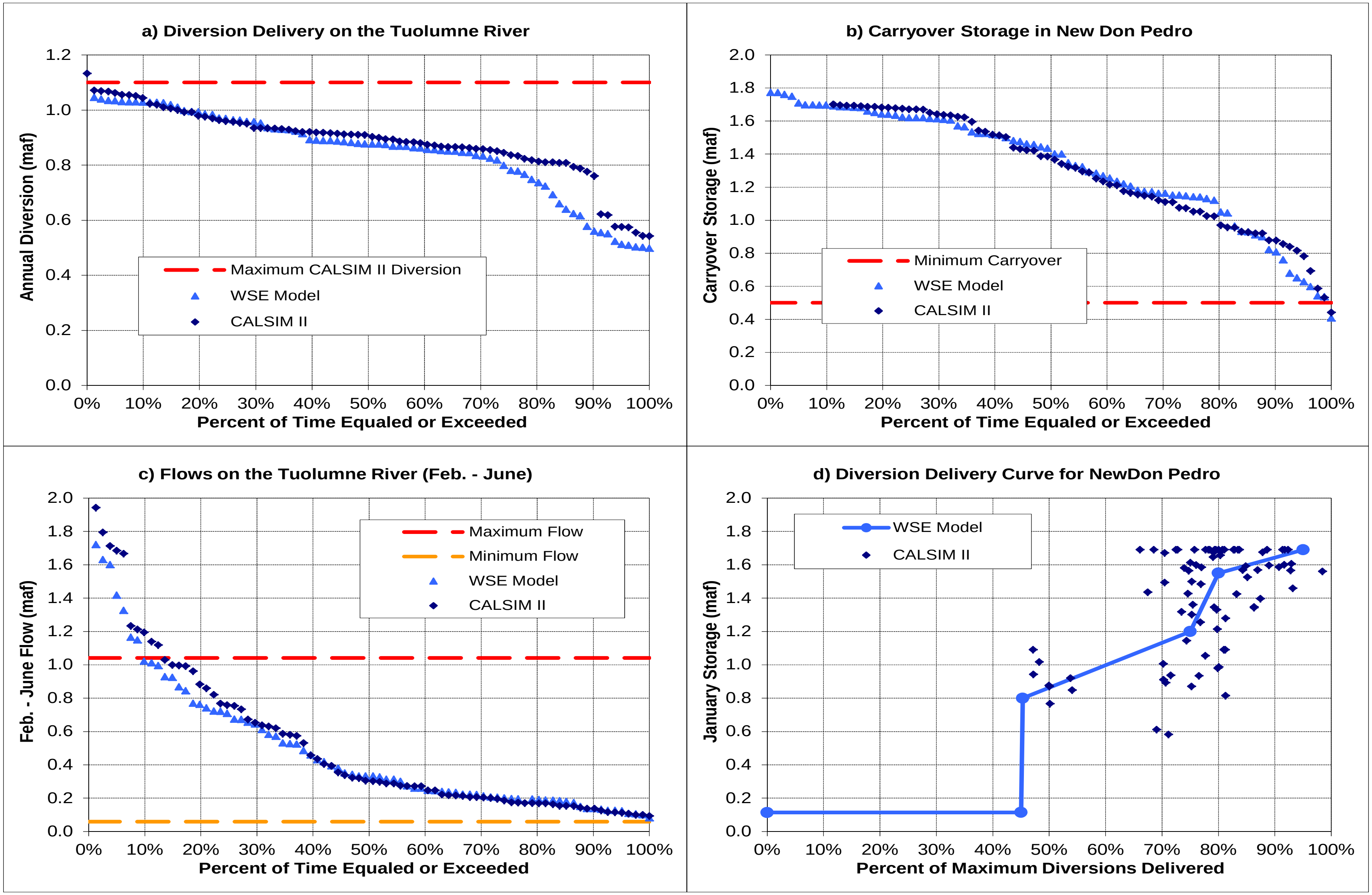


Figure F.1-2. Comparison of WSE Model Against CALSIM II Output on the Tuolumne River for a) Annual Diversion Delivery, b) End-of-September Storage, c) Flow at CALSIM II Node 528, d) Diversion Delivery Rule Curve Based on January Storage Level

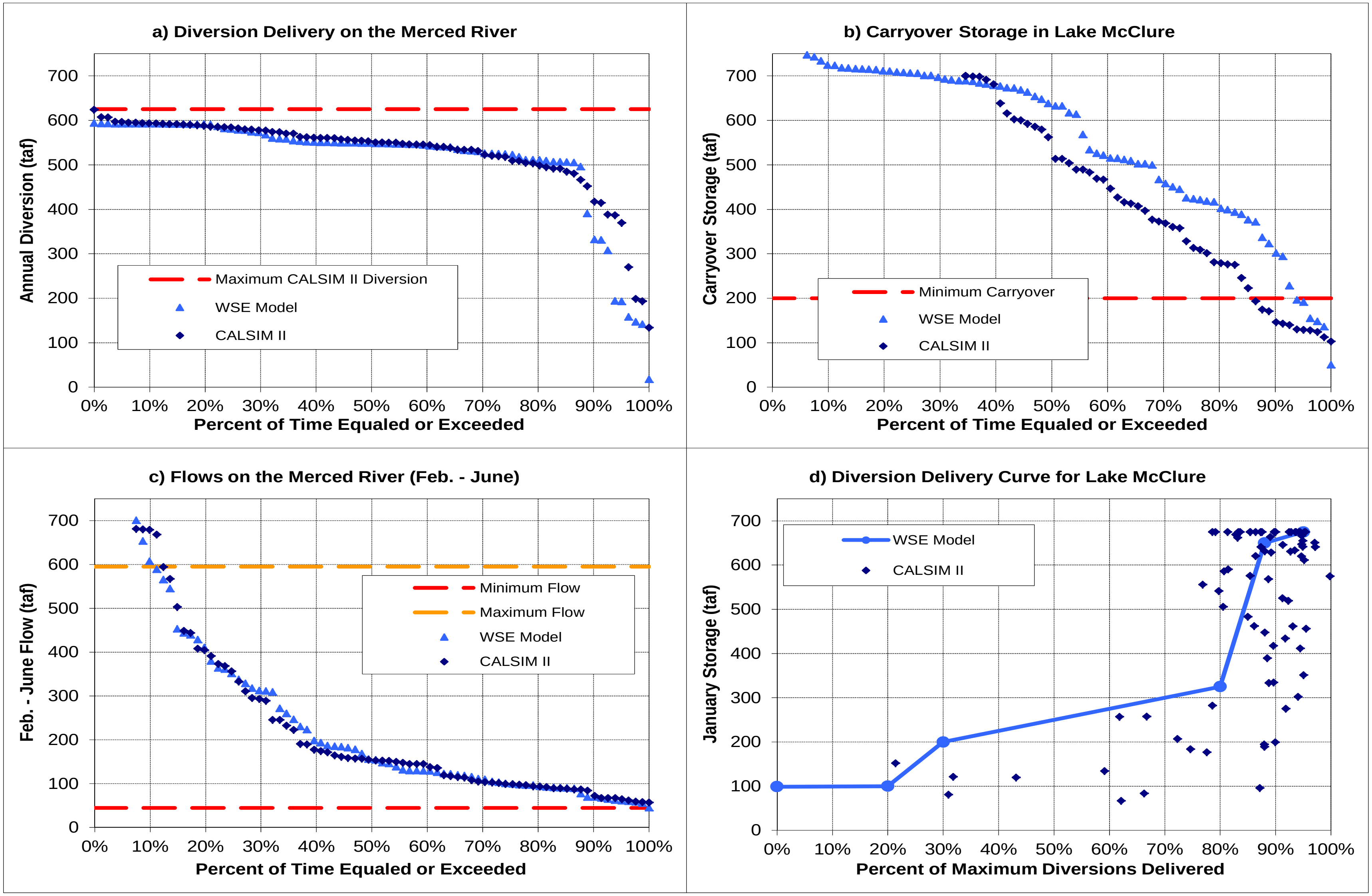


Figure F.1-3. Comparison of WSE Model Against CALSIM II Output on the Merced River for a) Annual Diversion Delivery, b) End-of-September Storage, c) Flow at CALSIM II Node 528, d) Diversion Delivery Rule Curve Based on January Storage Level

Model Inputs for Impacts Analysis

The WSE model was used to estimate the resulting flows, diversions, and reservoir operations of the LSJR alternatives and compared to the CALSIM II baseline conditions to assess effects of the LSJR alternatives. The following sets of inputs were used in the WSE model for calculating the impacts of the LSJR alternatives.

- Table F.1-1 contains the minimum monthly flow requirements and maximum trigger levels for each of the three eastside tributaries. The target percent unimpaired flow requirements for a particular LSJR alternative only applies when flows are below the specified trigger level on each tributary. This eliminates the percentage unimpaired flow requirement when flows are above a level that could potentially contribute to flooding or other negative downstream effects; however, reservoir flood-control releases, as required by USACE, could otherwise cause river flows to exceed these limits. Flows must not drop below specified levels on each tributary, and together must maintain a minimum flow on the SJR at Vernalis for the protection of fisheries in the tributaries and LSJR.
- Tables F.1-2a through F.1-2c show the user-defined diversion delivery rule curves used in this analysis for each of the three main reservoirs (New Melones, New Don Pedro, and Lake McClure). These rule curves relate the end of January storage each year to the allowable total surface water diversions (as a percentage of the maximum allowable annual diversion) for the remainder of that year, starting in February and ending the following January. In their respective tables, January storage for each reservoir is divided into four levels with corresponding annual cutback percentages for diversions. The first and fourth levels represent maximum storage and dead-pool (minimum) storage for each reservoir. The curves were developed iteratively to maximize diversions and minimize the number of years resulting in carryover storage lower than 300 TAF, 500 TAF, and 200 TAF for New Melones, New Don Pedro, and Lake McClure Reservoirs, respectively. Maximum allowable annual surface water diversions were established at 750 TAF, 1,100 TAF, and 625 TAF on the Stanislaus, Tuolumne, and Merced Rivers, respectively, based on the maximum diversion rates allowed in the CALSIM model.
- Table F.1-3 shows how the annual allowable surface water diversions (as determined by the diversion delivery rule curve describe above) are distributed across each month of the year starting in February and ending the following January. As explained above, the monthly diversion distribution patterns used for each of the eastside tributaries are derived from the same pattern exhibited in the CALSIM baseline model run.
- Table F.1-4 contains the flood control storage limitations used in the WSE model for New Melones, New Don Pedro, and Lake McClure Reservoirs. These are based on a monthly interpretation of USACE flood control curves for each reservoir. When storage would otherwise be greater than these limitations, the WSE model releases additional flow to bring the storage levels down to the limitation.

Table F.1-1. Minimum Monthly Flow Requirements and Maximum Trigger Levels Input to WSE Model (February–June) for Each LSJR Alternative

Calendar Month	Minimum Monthly Flow (cfs)			Maximum Trigger Flow (cfs)		
	Stanislaus	Tuolumne	Merced	Stanislaus	Tuolumne	Merced
2	150	200	150	2,500	3,500	2,000
3	150	200	150	2,500	3,500	2,000
4	150	200	150	2,500	3,500	2,000
5	150	200	150	2,500	3,500	2,000
6	150	200	150	2,500	3,500	2,000

Notes: No flows set for July through January as no changes from baseline flow are made in those months.
cfs = cubic feet per second

Table F.1-2a. Stanislaus River Diversion Delivery (Cutback) Curves at New Melones Reservoir for each LSJR Alternative

New Melones (Stanislaus)	20% Unimpaired Flow		60% Unimpaired Flow		40% Unimpaired Flow	
	Storage (TAF)	Delivery (%)	Storage (TAF)	Delivery (%)	Storage (TAF)	Delivery (%)
Level 1	1,970	100%	1,970	100%	1,970	80%
Level 2	1,500	95%	100	40%	100	30%
Level 3	100	50%	99	0%	99	0%
Level 4	99	0%	NA	NA	NA	NA

Table F.1-2b. Tuolumne River Diversion Delivery (Cutback) Curves at New Don Pedro Reservoir for Each LSJR Alternative

New Don Pedro (Tuolumne)	20% Unimpaired Flow		40% Unimpaired Flow		60% Unimpaired Flow	
	Storage (TAF)	Delivery (%)	Storage (TAF)	Delivery (%)	Storage (TAF)	Delivery (%)
Level 1	1,690	95%	1,690	80%	1,690	65%
Level 2	1,000	55%	1,000	45%	1,000	30%
Level 3	115	20%	115	10%	115	0%
Level 4	114	0%	114	0%	NA	NA

Table F.1-2c. Merced River Diversion Delivery (Cutback) Curves at Lake McClure for Each LSJR Alternative

Lake McClure (Merced)	20% Unimpaired Flow		40% Unimpaired Flow		60% Unimpaired Flow	
	Storage (TAF)	Delivery (%)	Storage (TAF)	Delivery (%)	Storage (TAF)	Delivery (%)
Level 1	675	95%	675	85%	675	75%
Level 2	100	40%	100	30%	100	20%
Level 3	99	0%	99	0%	99	0%
Level 4	NA	NA	NA	NA	NA	NA

Table F.1-3. Monthly Distribution Pattern (Starting in February through the Following January) for Annual Allowable Diversions on Each Tributary

Calendar Month	Stanislaus (% of annual)	Tuolumne (% of annual)	Merced (% of annual)
2	1.5%	2.1%	0.2%
3	4.7%	5.1%	3.3%
4	10.9%	11.1%	10.3%
5	15.4%	15.0%	16.1%
6	16.1%	15.4%	19.7%
7	17.4%	18.3%	21.3%
8	16.0%	15.7%	17.4%
9	9.3%	8.6%	8.2%
10	4.1%	4.8%	3.0%
11	2.0%	0.7%	0.2%
12	1.3%	1.0%	0.2%
1	1.3%	2.1%	0.1%
Total	100%	100%	100%

Table F.1-4. Monthly Flood Control Storage Limitations Applied to New Melones, New Don Pedro, and Lake McClure Reservoirs in the WSE Model

Calendar Month	New Melones (TAF)	New Don Pedro (TAF)	Lake McClure (TAF)
1	1,970	1,690	674.6
2	1,970	1,690	674.6
3	2,030	1,690	735
4	2,220	1,718	845
5	2,420	2,002	970
6	2,420	2,030	1,024
7	2,300	2,030	1,024
8	2,130	2,030	1,024
9	2,000	1,773	850
10	1,970	1,690	674.6
11	1,970	1,690	674.6
12	1,970	1,690	674.6

Based on monthly interpretation of USACE defined flood curves.

Maximum storage volume (to spillway) in New Melones = 2,420 TAF; New Don Pedro = 2,030 TAF; and Lake McClure = 1,024 TAF

F.1.2.2 Water Supply Effects Results

This section summarizes the modeled results for reservoir operations, surface water diversions, and river flows and contains detailed results for the baseline conditions and for each LSJR alternative by geographic area (e.g., three eastside tributaries, LSJR).

For additional detail, Section F.9 contains the monthly model outputs for reservoir storage and stream flow for the baseline conditions and LSJR Alternatives 2, 3, and 4 over the 1922–2003 period. These model results are presented by water year in a month x water year format.

The model output presented in this appendix was developed with a version of the WSE model that was later modified to incorporate minor improvements to the calculations. The differences between the two versions of the WSE model led to little or no difference in the output used elsewhere in the SED.

Summary of Model Results

Summarized below are the resulting effects to reservoir operations including monthly storage, carryover storage (end-of-September), average change in reservoir release, annual water diversions, and river flows for LSJR Alternatives 2, 3, and 4 compared to baseline in the three eastside tributaries. Following the summary, more detailed results are discussed for the baseline conditions and LSJR Alternatives 2, 3, and 4.

Reservoir Storage

Reservoir storage and release is used for calculation of hydropower generation effects and is used as input to temperature modeling. The end-of-September storage is generally an indicator of potential effects to stream temperature. Falling below a certain level of storage may result in increased temperatures at a time when fish are vulnerable (e.g., during the fall spawning season). Average carryover storage is presented in Table F.1-5a for the entire 82-year modeling period and in Table F.1-5b for the critically dry years only. The tables show that even for the critically dry years, the WSE model was able to maintain or increase the average carryover storage with respect to the baseline.

Figures F.1-4a through F.1-4c display the CALSIM and WSE monthly storage results for the LSJR alternatives (20%, 40%, and 60% unimpaired flows) are shown three tributary reservoirs for water years 1922–2003. The monthly flood control storage levels and the monthly unimpaired flows are shown for reference. There is always a seasonal variation in storage (spring inflows and summer diversions) and the reservoir storage is generally filled in wet years and is generally emptied (drawn down) in dry years. The estimated storage patterns for the LSJR alternatives are similar to the CALSIM baseline storage values. This is because the primary goals in the modeling were to: (1) choose the reservoir diversion delivery curves such that the carryover storage in the reservoirs were not worse than the baseline conditions, (2) keep the number of times the reservoir fell below a given reference generally equal to the number of times it occurred in the baseline, and (3) keep from running the reservoirs to dead-pool in the worst and/or second worst case

The reservoir releases and storage elevations are used for calculating hydropower generation effects. The reservoir elevations are calculated from storage-elevation curves (equations). The reservoir releases are calculated as the sum of water supply diversions plus the release flow needed to meet the specified flow target near the LSJR confluence plus any flood control releases needed to maintain the maximum flood control storage. The reservoir release flows may be altered outside of the February–June period because the water supply diversions are adjusted over the entire year and because these adjustments in the target flows and water supply diversions may increase the baseline flood control releases in subsequent months.

Table F.1-5a. Average Carryover Storage within the Three Major Reservoirs over the 82-Year Modeling Period

LSJR Alternative	New Melones	New Don Pedro	Lake McClure
Baseline	1,166	1,324	496
20% Unimpaired Flow	1,314	1,385	559
40% Unimpaired Flow	1,172	1,328	529
60% Unimpaired Flow	1,198	1,333	504

Table F.1-5b. Average Carryover Storage During Critically Dry Years within the Three Major Reservoirs over the 82-Year Modeling Period

LSJR Alternative	New Melones	New Don Pedro	Lake McClure
Baseline	558	850	177
20% Unimpaired Flow	579	867	275
40% Unimpaired Flow	552	818	265
60% Unimpaired Flow	631	831	250
Notes: Sixteen years were classified as Critically Dry from 1922 through 2003.			

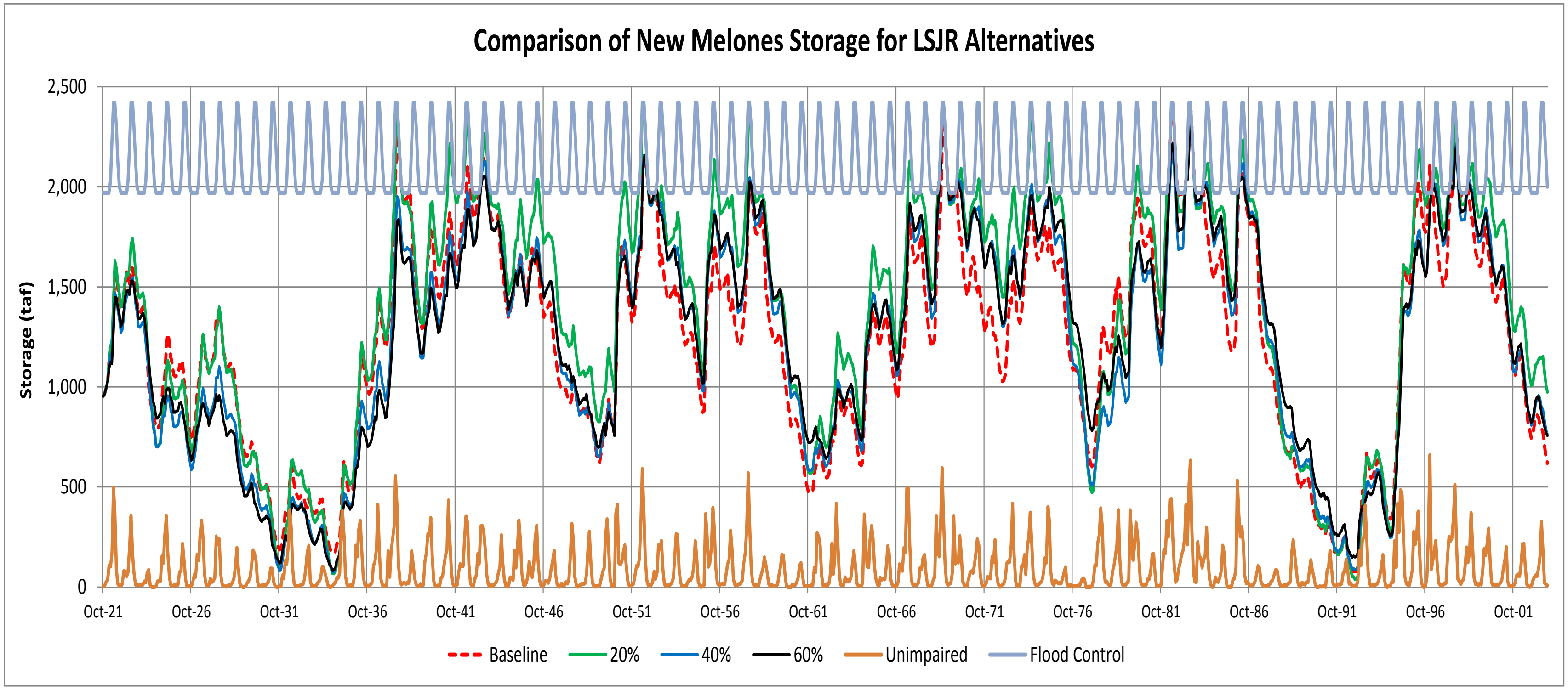


Figure F.1-4a. Comparison of CALSIM Baseline and WSE Model Results for LSJR Alternatives 2, 3, and 4 (20%, 40%, 60% Unimpaired Flow): New Melones Reservoir Storage and Stanislaus River Unimpaired Flows for 1922–2003

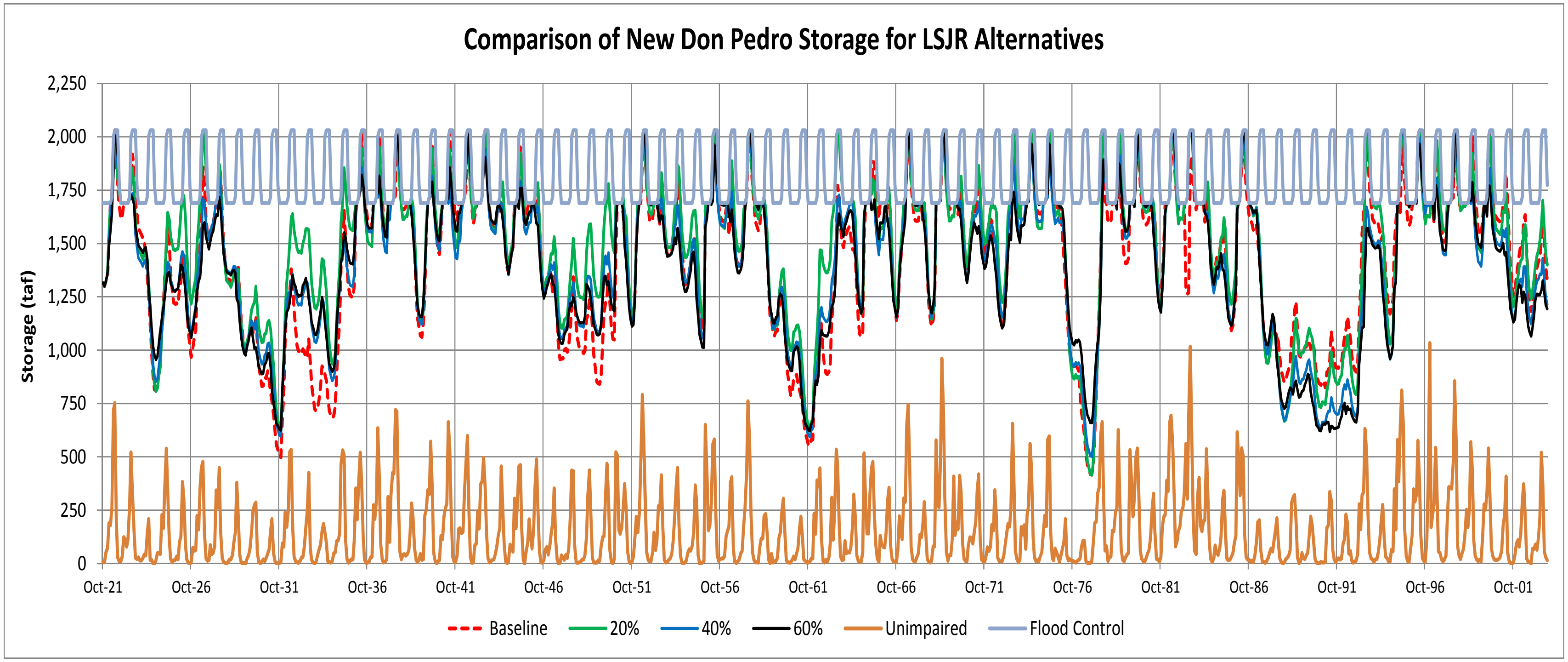


Figure F.1-4b. Comparison of CALSIM Baseline and WSE Model Results for LSJR Alternatives 2, 3, and 4 (20%, 40%, 60% Unimpaired Flow): New Don Pedro Reservoir Storage and Tuolumne River Unimpaired Flows for 1922–2003

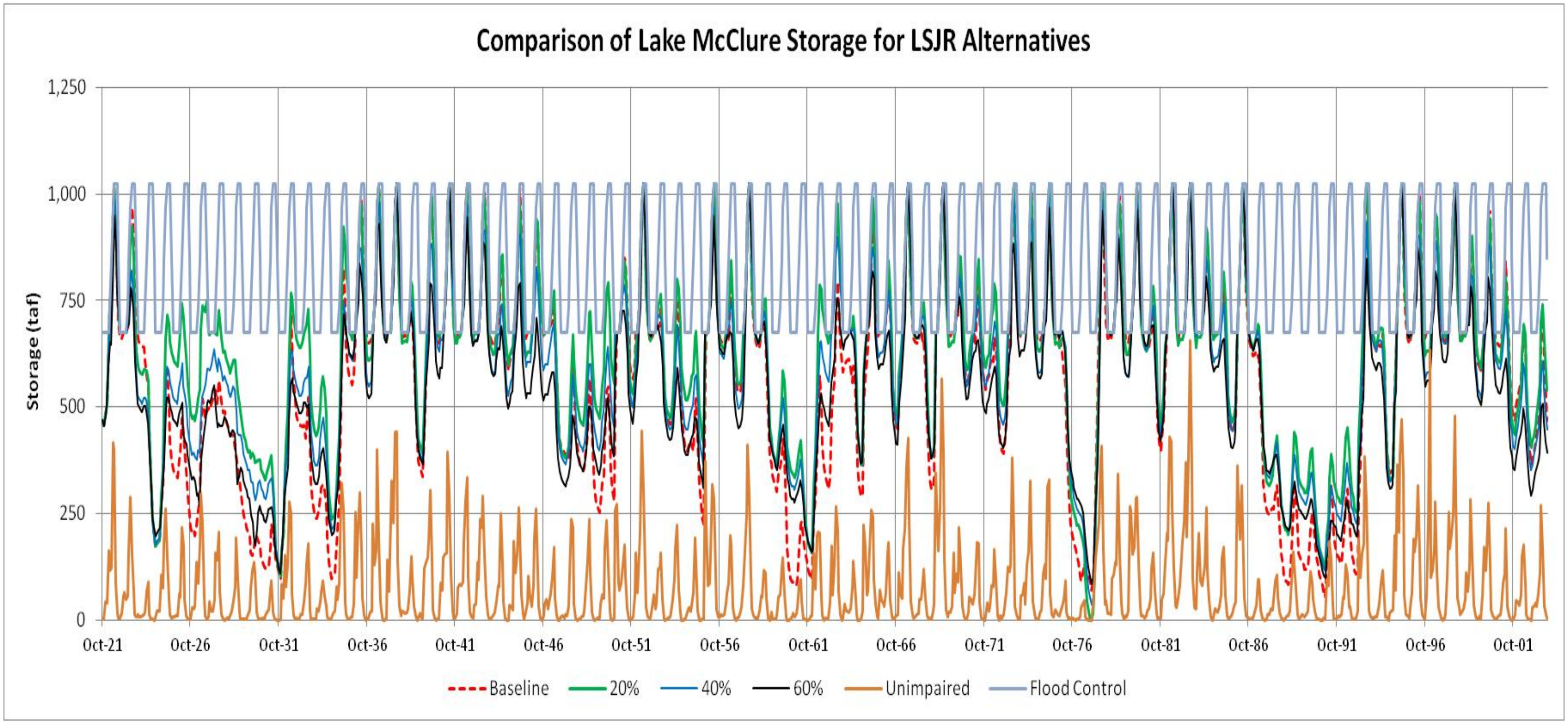


Figure F.1-4c. Comparison of CALSIM Baseline and WSE Model Results for LSJR Alternatives 2, 3, and 4 (20%, 40%, 60% Unimpaired Flow): Lake McClure Storage and Merced River Unimpaired Flows for 1922–2003

River Flows

Table F.1-6 contains a summary of the average annual effects of the LSJR alternatives on river flows (flow volumes, TAF) as compared to the baseline flows for each eastside tributary and near Vernalis on the SJR. River flows are different from the baseline for February–June when the downstream target flows are modified for the LSJR alternatives; some changes in flood control releases were simulated in other months.

Figures F.1-5a through F.1-5d show the simulated monthly flows in the Stanislaus, Tuolumne, and Merced Rivers near the confluence with the SJR and the SJR at Vernalis for water years 1984–2003. The unimpaired flows are shown for comparison. The baseline flows are generally low in many months each year until runoff is high enough to increase reservoir storage and cause flood-control releases (in wet years). As the percentage of unimpaired flow increases, the resulting river flow approaches unimpaired flow until the maximum channel flow is reached. In general, the flows are only capped by these maximum flows in LSJR Alternative 4 in each of the tributaries, and occasionally by LSJR Alternative 3 in the Stanislaus River. The maximum flows were set to 2,500 cfs in the Stanislaus River, 3,500 cfs in the Tuolumne River, and 2,000 cfs in the Merced River. The simulated river flows will be described in more detail in the following sections.

Table F.1-6. Average Annual Stream Flow Effects on the Eastside Tributaries and Near Vernalis for the LSJR Alternatives February–June

LSJR Alternative	Stanislaus River near Ripon (TAF)	Tuolumne River near Modesto (TAF)	Merced River near Stevinson (TAF)	SJR near Vernalis (TAF)
Baseline	355 / (100%)	540/ (100%)	270/ (100%)	1804/ (100%)
20% Unimpaired Flow	-103 / (-29%)	-21 / (-4%)	-6 / (-2%)	-130 / (-7%)
40% Unimpaired Flow	3 / (1%)	149 / (28%)	74 / (27%)	227 / (13%)
60% Unimpaired Flow	115 / (32%)	291 / (54%)	149 / (55%)	555 / (31%)

Notes: Resulting flow effects on the tributaries are as calculated near the LSJR confluence, specifically at Ripon, Modesto, and Stevinson.

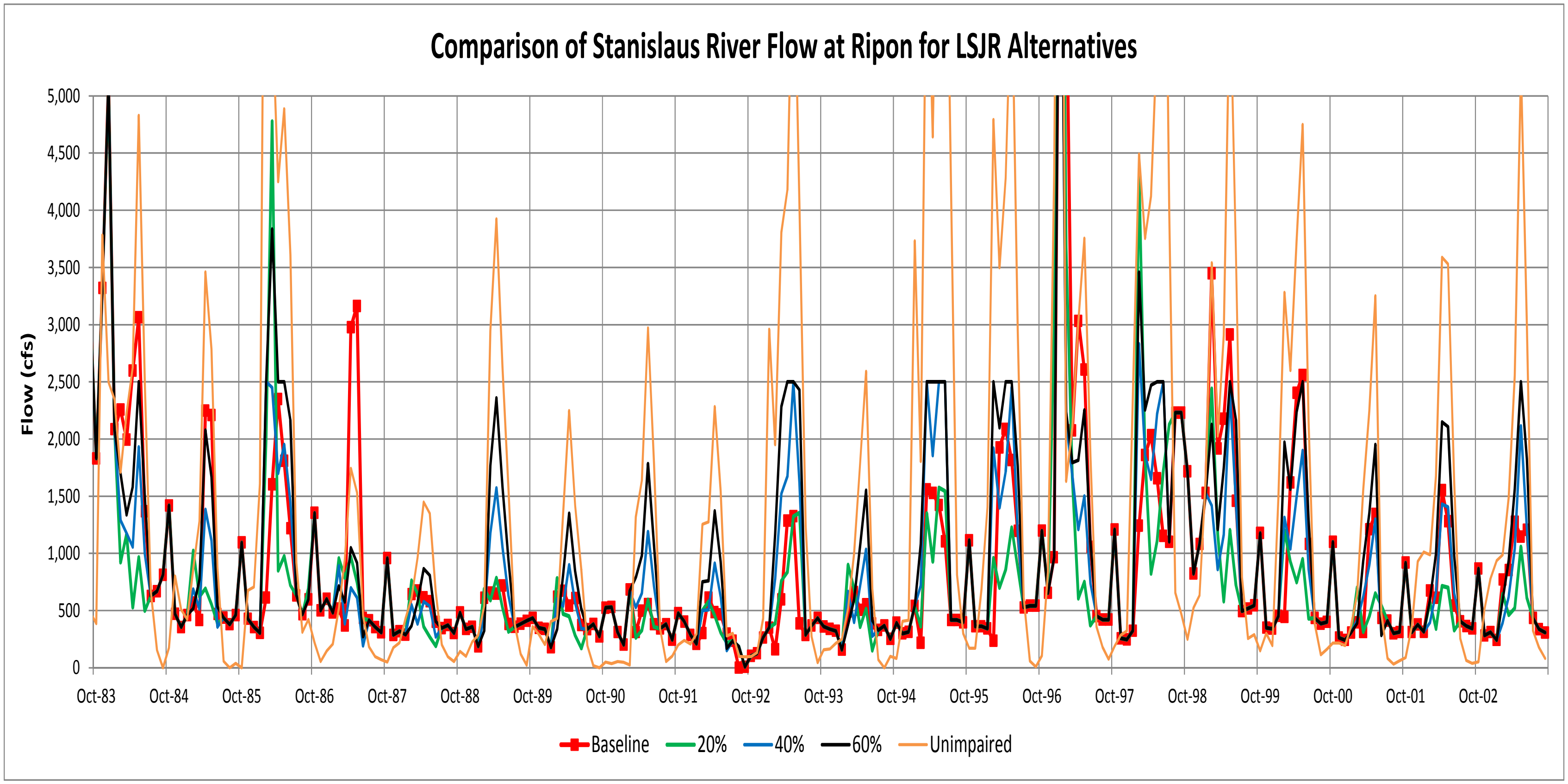


Figure F.1-5a. Comparison of Monthly Stanislaus River Flows for Baseline Conditions and LSJR Alternatives 2, 3, and 4 (20%, 40%, 60% Unimpaired Flow) for Water Years 1984–2003

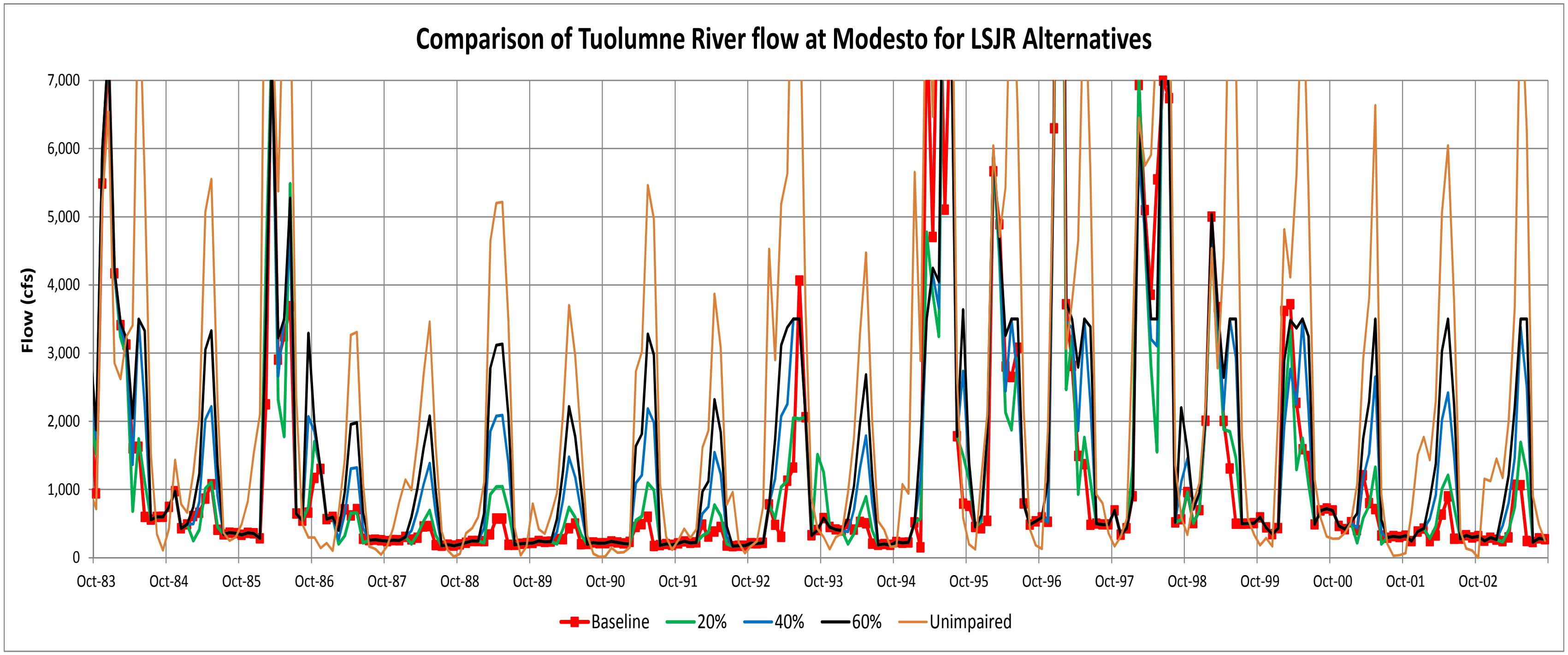


Figure F.1-5b. Comparison of Monthly Tuolumne River Flows for Baseline Conditions and LSJR Alternatives 2, 3, and 4 (20%, 40%, 60% Unimpaired Flow) for Water Years 1984–2003

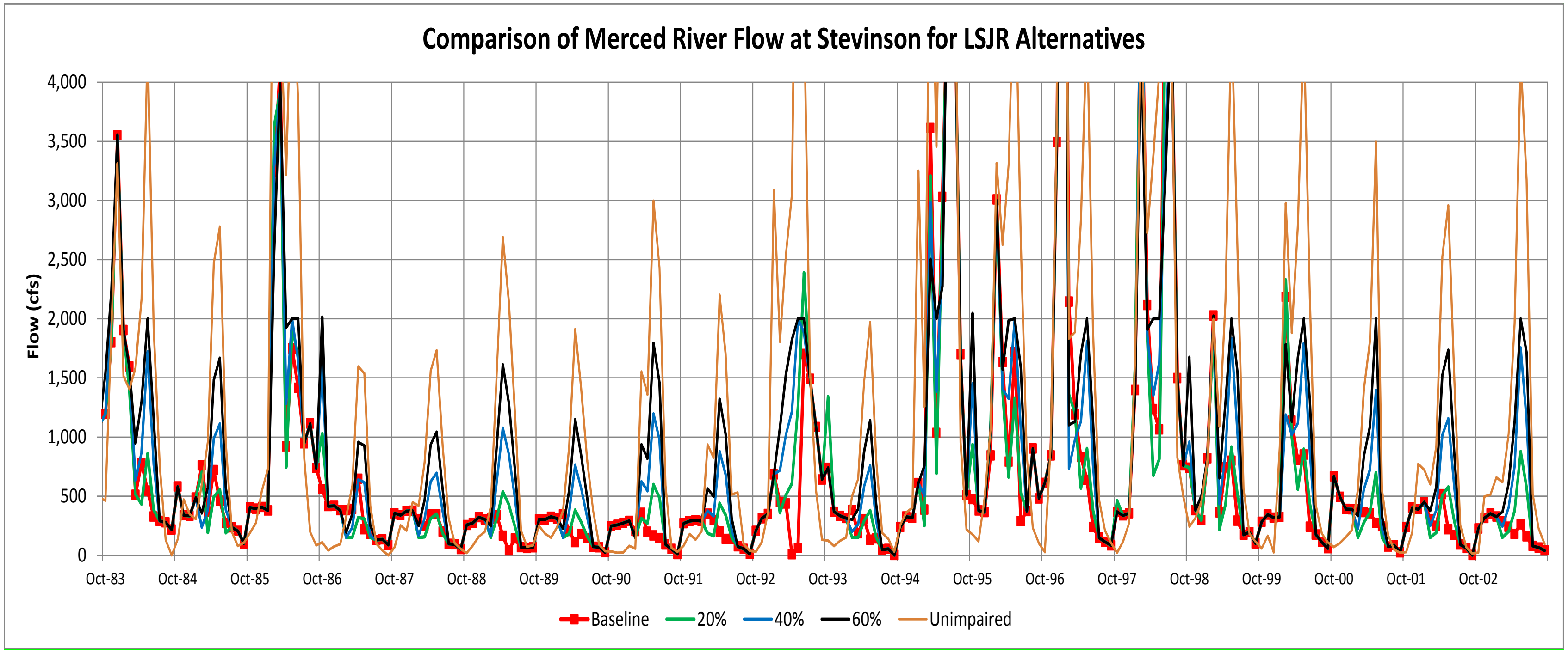


Figure F.1-5c. Comparison of Monthly Merced River Flows for Baseline Conditions and LSJR Alternatives 2, 3, and 4 (20%, 40%, 60% Unimpaired Flow) for Water Years 1984–2003

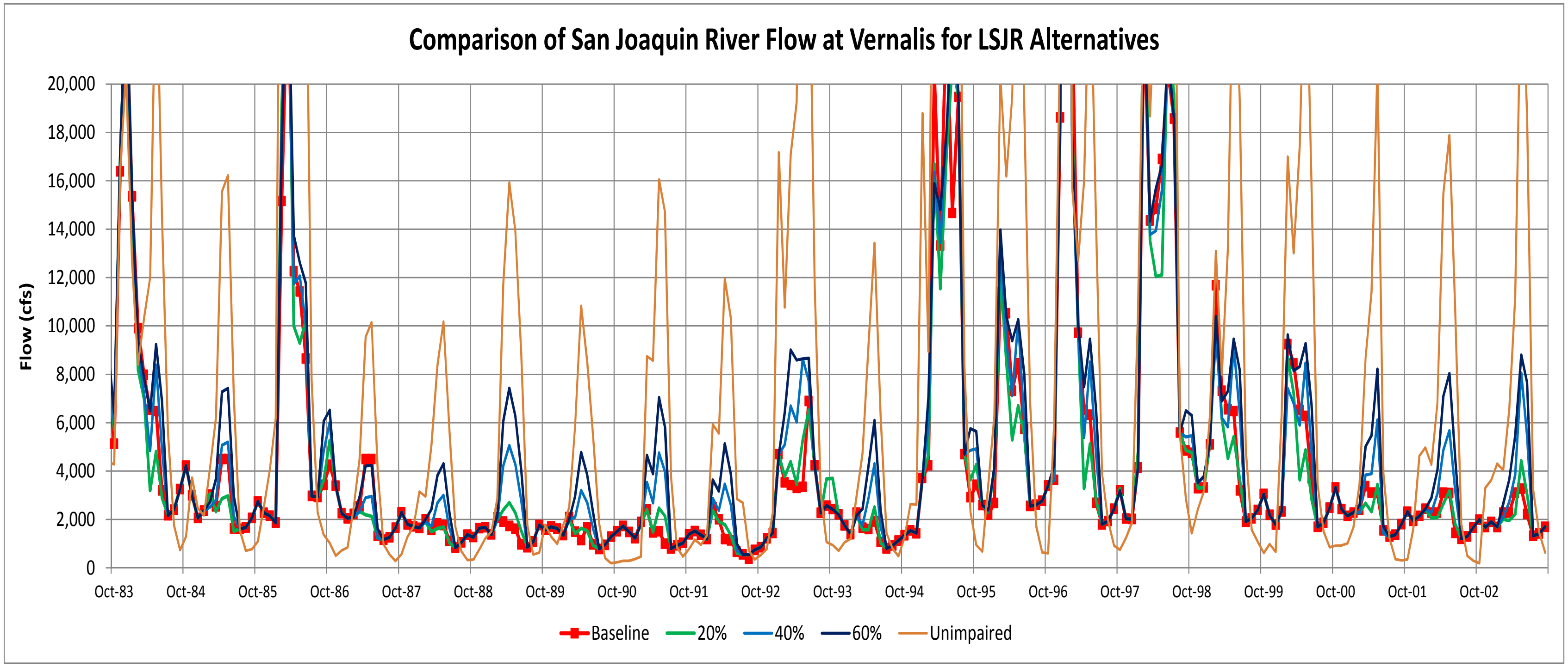


Figure F.1-5d. Comparison of Monthly SJR at Vernalis Flows for Baseline Conditions and LSJR Alternatives 2, 3, and 4 (20%, 40%, 60% Unimpaired Flow) for Water Years 1984–2003

Surface Water Diversions

Table F.1-7 contains a summary of the effects to diversions for each eastside tributary and for the plan area of the LS alternatives as compared to the baseline for the 82-year modeling period. Table F.1-8 shows the annual cumulative distribution (range) for the LSJR alternatives as compared to the CALSIM baseline water supply diversions and deficits (maximum demand minus delivery) for each tributary. The annual values are summarized with the minimum and maximum and average, as well as the 10 percent increments of the distribution of values (i.e., range). The range of annual unimpaired flow for each tributary is shown for comparison. Additional detail is discussed in the following sections for LSJR Alternatives 2, 3, and 4 and the baseline.

Table F.1-7. Average annual water supply effects on the eastside tributaries and plan area totals for the LSJR alternatives for the 82-year modeling period

LSJR Alternative	Stanislaus (TAF)/ (%)	Tuolumne (TAF) / (%)	Merced (TAF / (%)	LSJR Plan Area (TAF)/ (%)
Baseline	577 / 100%	885 / 100%	527 / 100%	1989 / 100%
20% Unimpaired Flow	72 / 12%	-6 / <-1%	-10 / -2%	64 / 3%
40% Unimpaired Flow	-8 / -1%	-173 / -20%	-87 / -16%	-268 / -13%
60% Unimpaired Flow	-121 / -21%	-329 / -37%	-163 / -31%	-613 / -31%

Annual Summary of Results

The CALSIM Baseline and the LSJR Alternatives for each tributary can be summarized with the distribution of the annual carryover storage (end-of-September), the distribution of annual water supply deliveries, and the distribution of annual or February-June river flows (volume).

Figure F.1-6a shows the comparison of the distribution of carryover storages in the three reservoirs for the CALSIM baseline and LSJR alternatives. Because the WSE model was used to balance changes in the specified river target flows with changes in the water supply diversions, the distribution of carryover storages did not change substantially for the three tributary reservoirs. LSJR Alternative 2 (20% unimpaired flow targets) did allow the tributary reservoir storages to increase in the majority of years compared to the CALSIM baseline conditions.

Figure F.1-6b shows the comparison of the distribution of annual water supply diversions from the three tributaries for the CALSIM baseline and LSJR alternatives. Because the WSE model was used to balance changes in the specified river target flows with changes in the water supply diversions, the distribution of annual deliveries was increased somewhat for LSJR Alternative 2 (20% unimpaired flow targets), was reduced for LSJR Alternative 3 (40% unimpaired flow targets) and was reduced substantially for LSJR Alternative 4 (60% unimpaired flow targets) in the majority of years compared to the CALSIM baseline conditions.

Figure F.1-6c shows the comparison of the distribution of February-June river flow (volume) for each tributary and for the San Joaquin River at Vernalis for the CALSIM baseline and LSJR alternatives. The Stanislaus River February-June flow volumes were generally reduced from the baseline flows for LSJR Alternative 2 (20% unimpaired flow targets), were similar for LSJR Alternative 3 (40% unimpaired flow targets) and were increased for LSJR Alternative 4 (60% unimpaired flow targets). The Tuolumne River February-June flow volumes were generally similar to the baseline flows for LSJR Alternative 2, were increased for LSJR Alternative 3, and were increased more for LSJR Alternative 4. The Merced River February-June flow volumes were generally similar to the baseline flows for LSJR Alternative 2, were increased for LSJR Alternative 3, and were increased more for LSJR Alternative 4. The maximum monthly target flows sometimes limited the flow volumes in high runoff months. The SJR at Vernalis February-June flow volumes were generally similar to the baseline flows for LSJR Alternative 2, were increased for LSJR Alternative 3, and were increased more for LSJR Alternative 4.

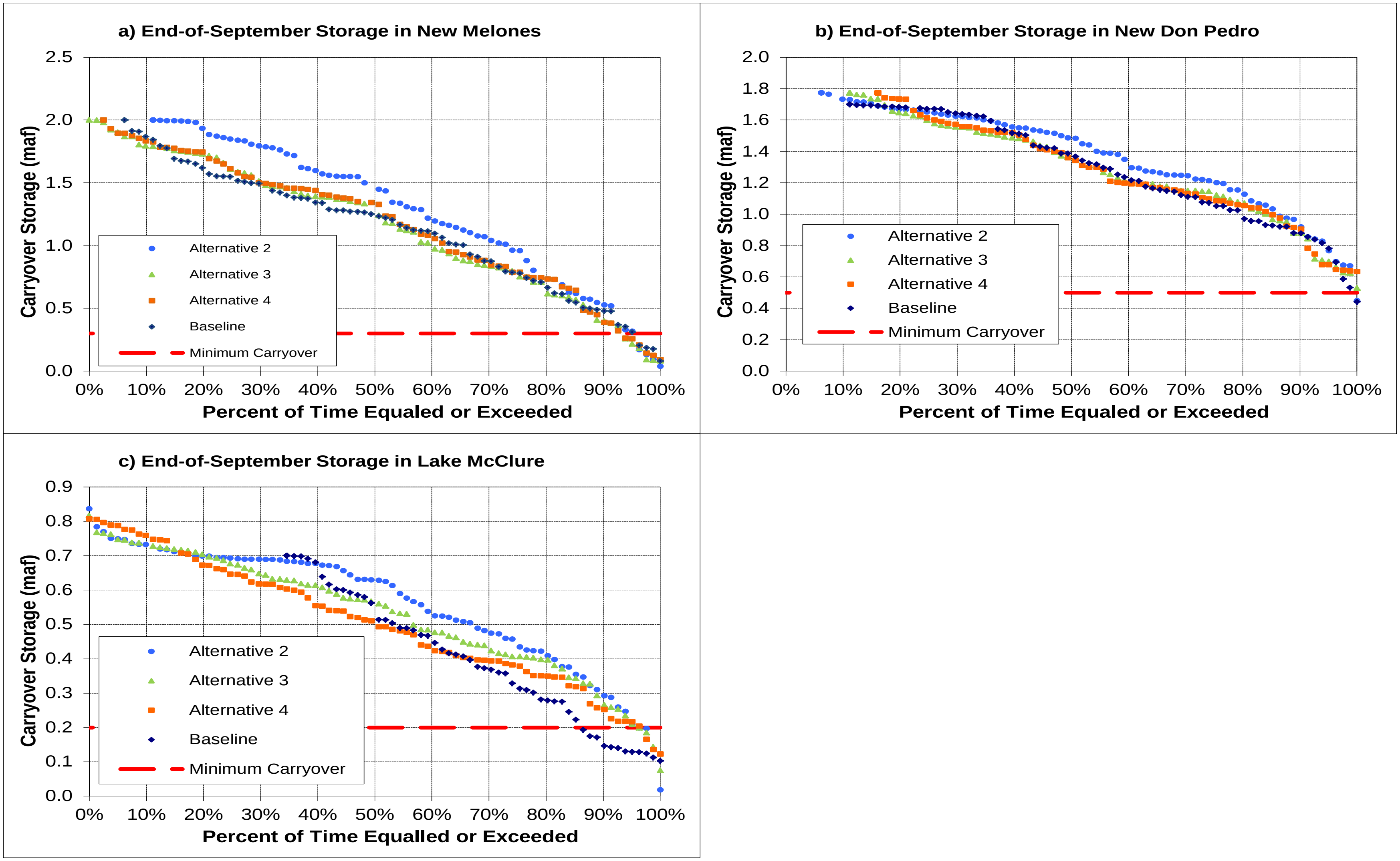


Figure F.1-6a. Annual Distributions of Carryover Storage for the CALSIM Baseline and the LSJR Alternatives at (a) New Melones, (b)New Don Pedro, and (c) Lake McClure for 1922–2003.

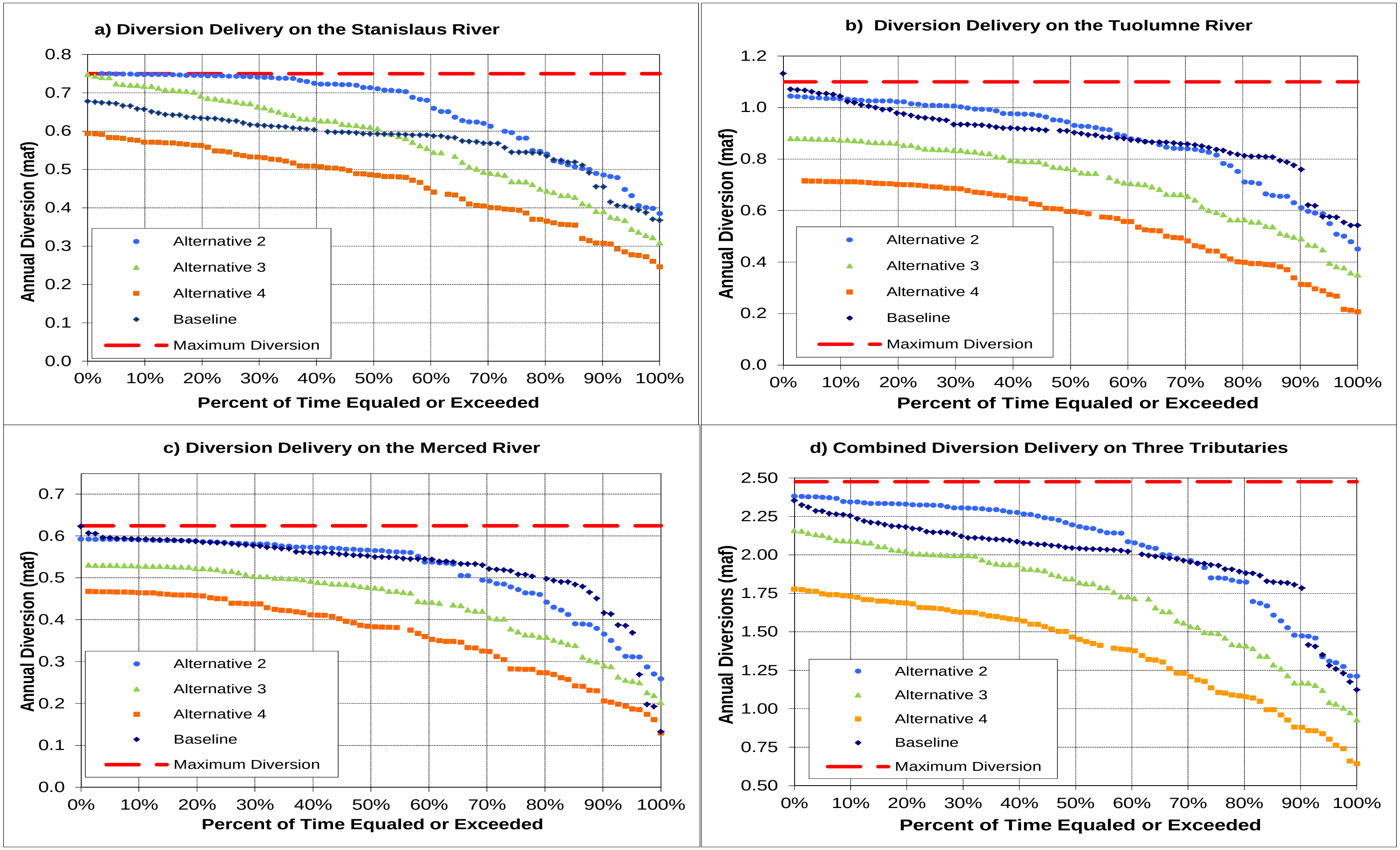


Figure F.1-6b. Annual Distributions of Water Supply Delivery for the CALSIM Baseline and the LSJR Alternatives from: a) Stanislaus River, b) Tuolumne River, c) Merced River and d) Combined Delivery for 1922–2003.

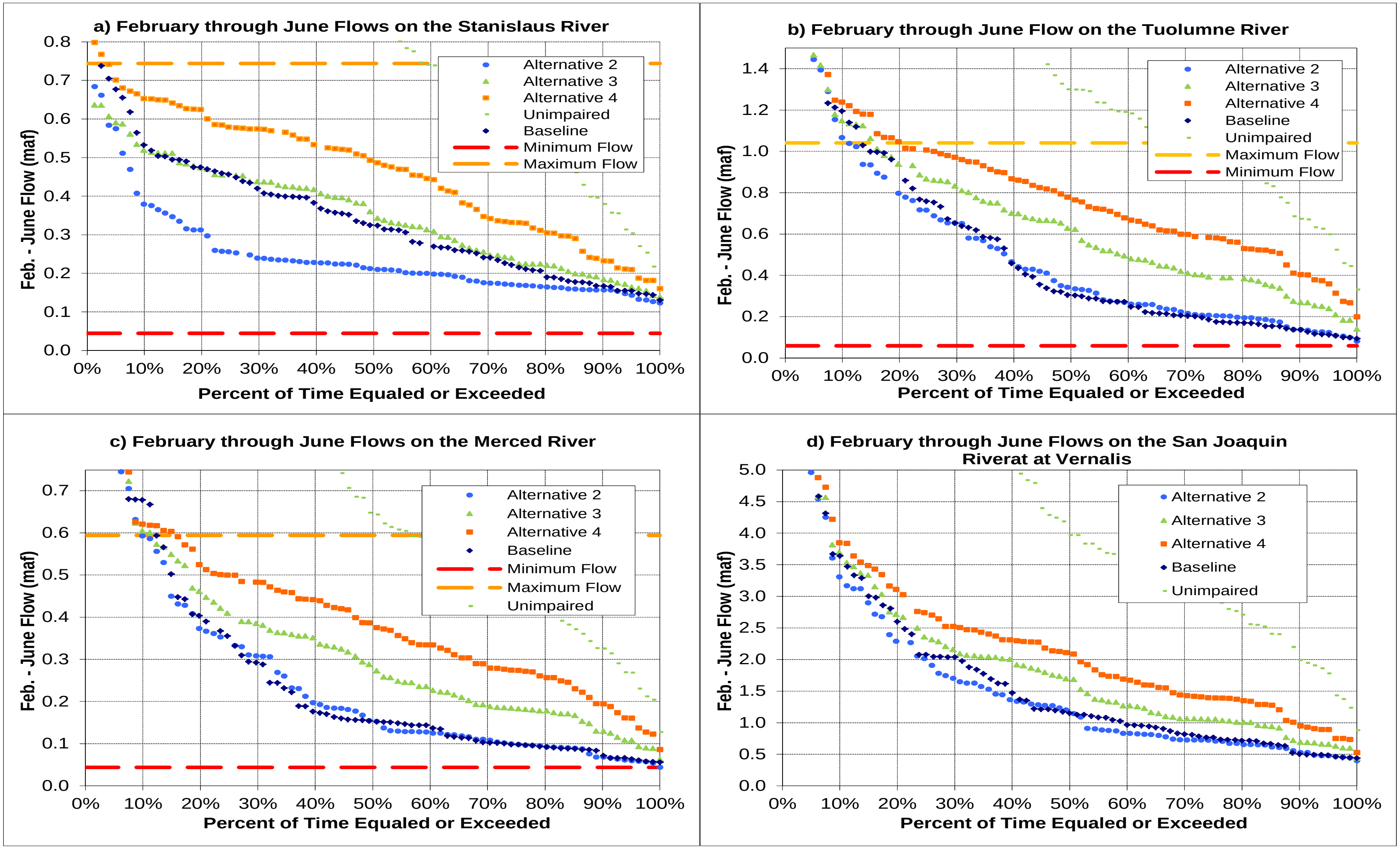


Figure F.1-6c. Annual Distributions of February-June River Flow Volume (TAF) for the CALSIM Baseline and the LSJR Alternatives for: a) Stanislaus River, b) Tuolumne River, c) Merced River, and d) San Joaquin River at Vernalis for 1922–2003.

Table F.1-8. Annual Water Supply Diversions for the CALSIM Baseline and the LSJR Alternatives

		Stanislaus Diversions					Tuolumne Diversions					Merced Diversions			
	Unimpaired	Baseline	20%	40%	60%	Unimpaired	Baseline	20%	40%	60%	Unimpaired	Baseline	20%	40%	60%
minimum	155	368	383	309	234	384	542	451	350	208	151	134	260	203	130
10%	456	455	483	390	302	835	762	613	491	316	408	421	368	292	209
20%	591	537	536	445	358	1,052	814	719	564	400	489	499	446	359	274
30%	679	568	606	488	393	1,165	858	839	645	483	561	525	489	408	325
40%	891	589	655	546	443	1,413	877	884	703	545	668	545	539	442	354
50%	1,092	593	705	608	481	1,776	906	938	761	596	895	552	567	477	385
60%	1,260	603	721	630	506	2,031	920	976	794	648	1,080	561	573	491	413
70%	1,362	615	738	662	525	2,197	935	1,005	834	686	1,165	578	582	504	439
80%	1,560	634	743	685	560	2,486	978	1,023	859	701	1,399	588	589	523	458
90%	1,916	656	746	716	571	3,099	1,042	1,034	874	712	1,712	593	592	529	465
maximum	2,950	678	750	740	594	4,632	1,132	1,045	880	715	2,786	624	594	531	469
average	1,118	577	649	569	456	1,849	885	879	712	556	956	527	517	440	364
		Stanislaus Deficits					Tuolumne Deficits					Merced Deficits			
max		382	367	441	516		558	649	750	892		466	340	397	470
90%		295	267	360	448		338	487	609	784		179	232	308	391
80%		213	214	305	392		286	381	536	700		101	154	241	326
70%		182	144	262	357		242	261	455	617		75	111	192	275
60%		161	95	204	307		223	216	397	555		55	61	158	246
50%		157	45	142	269		194	162	339	504		48	33	123	215
40%		147	29	120	244		180	124	306	452		39	27	109	187
30%		135	12	88	225		165	95	266	414		22	18	96	161
20%		116	7	65	190		122	77	241	399		12	11	77	142
10%		94	4	34	179		58	66	226	388		7	8	71	135
min		72	-	10	156		-32	55	220	385		-24	6	69	131
average		173	101	181	294		215	221	388	544		73	83	160	236

CALSIM Baseline Conditions Results

The tributary reservoir storage, water supply diversions, and river flows simulated with the CALSIM monthly reservoir operations model are considered the baseline conditions. The SJR upstream of the Merced River confluence is assumed to remain unchanged and equal to the baseline conditions for LSJR Alternatives 2, 3, and 4.

Upper and Middle San Joaquin River

Table F. 1-9a shows the monthly and annual cumulative distribution (range) for the CALSIM simulated SJR flows upstream of the Merced River. This flow originates from upstream flood-control releases at Friant Dam or from the Fresno and Chowchilla Rivers, local runoff from the Bear River in the vicinity of Merced, wetlands releases from the Grasslands wildlife refuges, and agricultural drainage from irrigated lands in this upstream portion of the SJR watershed. The CALSIM model estimates monthly flows that are nearly identical in more than 50 percent of the years (clearly assumed values) with median monthly flows that are less than 500 cfs in most months and less than 1,000 cfs in all months. The highest flows are in February and March. Flows of more than 1,000 cfs are estimated for about 10 percent of the years for December–June.

Table F.1-9a. CALSIM-Simulated Baseline Monthly Cumulative Distributions of SJR above the Merced Flow (cfs) for 1922–2003 [Same for all LSJR alternatives]

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	Annual (TAF)
SJR above Merced Flow (cfs)													
Minimum	209	366	321	258	566	330	190	256	278	255	236	495	247
10%	217	421	402	313	623	503	289	335	354	306	255	510	289
20%	259	485	404	329	677	551	361	421	371	306	282	639	324
30%	259	485	420	362	713	583	413	500	388	322	282	639	335
40%	259	501	436	394	795	687	456	526	405	322	282	639	355
50%	262	502	453	451	921	757	597	559	438	322	282	639	399
60%	275	546	485	540	1,084	989	746	620	465	332	282	639	521
70%	275	622	541	828	1,529	1,259	885	675	511	355	298	639	583
80%	275	679	654	1,558	2,806	1,804	1,478	857	573	371	298	656	1,007
90%	290	791	1,121	2,381	6,210	4,655	4,729	4,690	1,941	418	312	656	1,619
Maximum	718	3,509	8,666	22,197	15,241	16,165	12,065	10,667	10,687	5,367	347	673	5,665
Average	270	637	909	1,382	2,192	1,813	1,551	1,403	1,003	531	285	629	760

Merced River

Figure F.1-7a illustrates the basic water supply need for seasonal storage in Lake McClure to increase the water supply delivery in the summer months when the unimpaired runoff is less than the monthly demands for irrigation water. Because agricultural use requires a specified monthly pattern of water deliveries to satisfy crop needs (transpiration), seasonal storage is needed to extend the period when unimpaired runoff could be (directly) diverted for irrigation. For the Merced River, the monthly demands are less than the 10 percent cumulative monthly runoff in the winter and spring months to May. The June demand is equal to the 50 percent cumulative runoff, and the July–October demands are greater than the 90 percent cumulative runoff. Reservoir storage is needed to satisfy the June demand in about half of the years, and reservoir storage is needed in 90 percent of the years to satisfy the July–October demands.

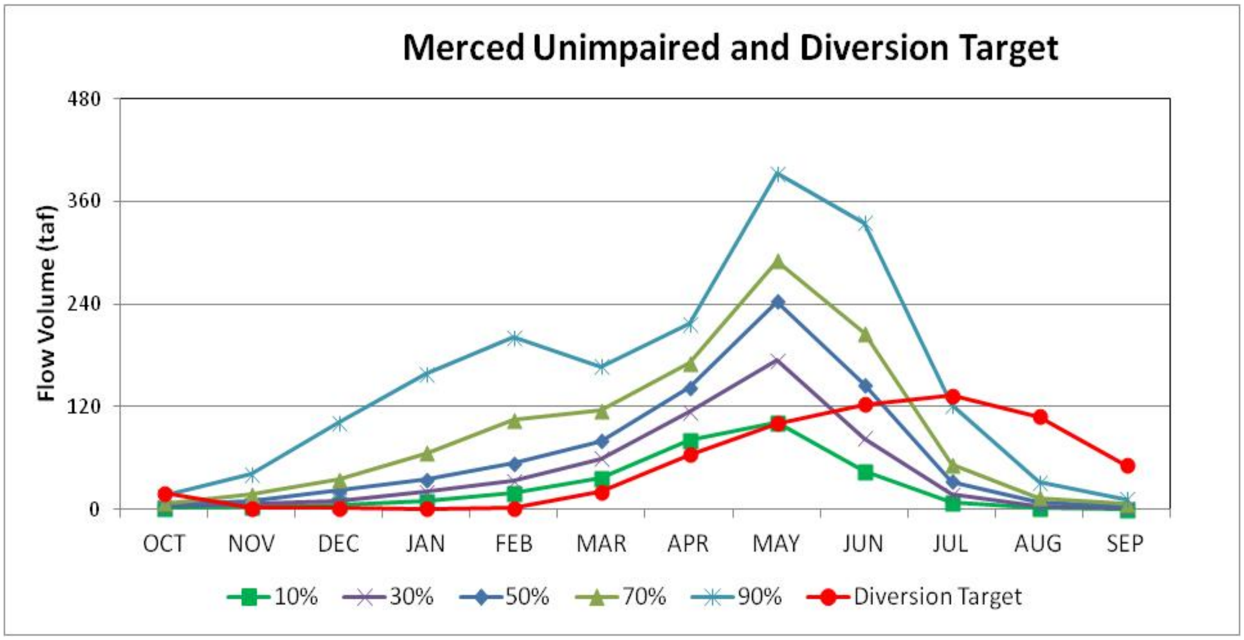


Figure F.1-7a. Monthly Merced River Unimpaired Runoff Compared to Monthly Water Supply Demands

The inflow to Lake McClure is the Merced unimpaired runoff. Table F.1-9b shows the monthly cumulative distribution (range) for the CALSIM simulated Lake McClure storage (TAF). These monthly storage patterns are similar to the historical storage observed since the New Exchequer Dam was completed in 1965. The maximum storage of 1,024 TAF was simulated in about 20 percent of the years in June. Storage is limited for flood control in the other months. The maximum storage is 675 TAF October–February. The median monthly storage levels were relatively high, with more than 500 TAF in all months and more than 600 TAF January–July. The minimum carryover storage (end-of-September) was 103 TAF (10 percent of capacity), the 10 percent cumulative carryover storage was 150 TAF (15 percent of capacity) and the 20 percent carryover storage was 279 TAF (27 percent of capacity). The 50 percent cumulative carryover storage was above 500 TAF (50 percent of capacity). Figure F.1-7b shows the Lake McClure carryover storage for the baseline conditions (simulated by CALSIM) and compares the historical carryover storage for reference. The CALSIM results reflect the historical periods of low runoff (reduced storage) and the periods of high runoff (with maximum carryover storage of 700 TAF). Many of the carryover storage values are at the maximum allowed storage for flood control.

Table F.1-9b. CALSIM-Simulated Baseline Monthly Cumulative Distributions of Lake McClure Storage (TAF) for 1922–2003

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
Lake McClure Storage (TAF)												
Minimum	86	70	81	67	56	94	93	108	134	120	107	103
10%	137	131	128	177	214	260	284	311	291	223	170	149
20%	253	241	249	277	337	378	407	506	520	420	322	279
30%	348	347	368	422	441	494	523	592	585	498	408	370
40%	425	445	464	522	596	622	636	691	671	561	478	455
50%	519	527	559	601	642	678	693	752	771	686	586	538
60%	630	627	630	641	675	702	731	852	887	800	709	664
70%	662	651	651	665	675	735	781	946	991	910	770	700
80%	662	656	667	675	675	735	818	970	1,024	910	770	700
90%	662	669	675	675	675	735	845	970	1,024	910	770	700
Maximum	662	675	675	675	675	735	845	970	1,024	910	770	700
Average	467	466	479	500	529	570	622	720	737	645	543	496

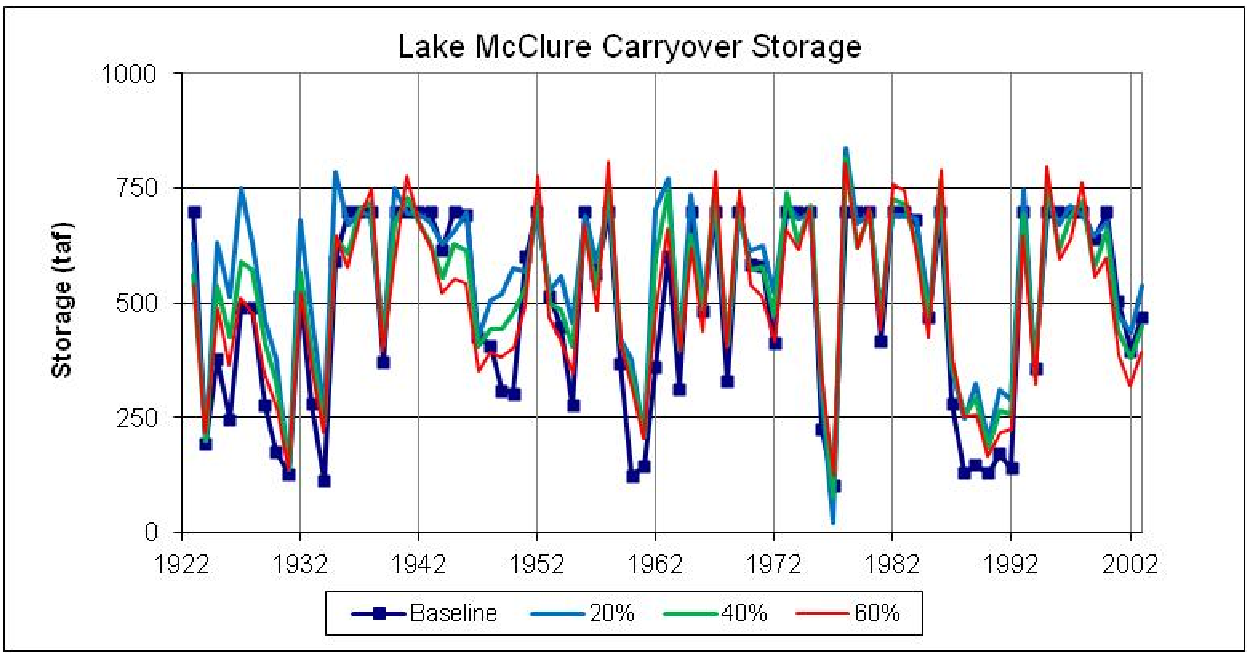


Figure F.1-7b. Comparison of WSE-Calculated Lake McClure Carryover storage (TAF) for Baseline Conditions and LSJR Alternatives 2, 3, and 4 (20%, 40%, and 60% Unimpaired Flow) for 1922–2003

The reservoir storage values correspond to surface elevations that can be calculated with a simple equation, estimated from the reservoir geometry data (i.e., elevation, surface area, volume). The Lake McClure elevation is estimated as:

$$\text{Elevation (feet msl)} = 400 + 5.3569 \times \text{Lake McClure storage (AF)}^{0.3226} \qquad \textit{(Eqn. F.1-6)}$$

The surface elevation is an important variable for evaluating hydroelectric energy generation at the dam, boat dock access and recreation uses, reservoir fish habitat, and exposure of cultural resources during extreme drawdown periods. Using this equation, the storages can be converted to surface elevations for these resource evaluations. The surface elevation is about 625 feet for a storage volume of 100 TAF (10 percent volume), 675 feet for a storage volume of 200 TAF, and about 767 feet for a storage volume of 500 TAF (50 percent of storage). The storage is about 867 feet for a maximum storage of 1,024 TAF. Table F.1-9c shows the monthly cumulative distribution of Lake McClure water surface elevations (feet mean sea level [msl]) for the CALSIM baseline.

Table F.1-9c. CALSIM-Simulated Baseline Monthly Cumulative Distributions of Lake McClure Water Surface Elevations (feet msl) for 1922–2003

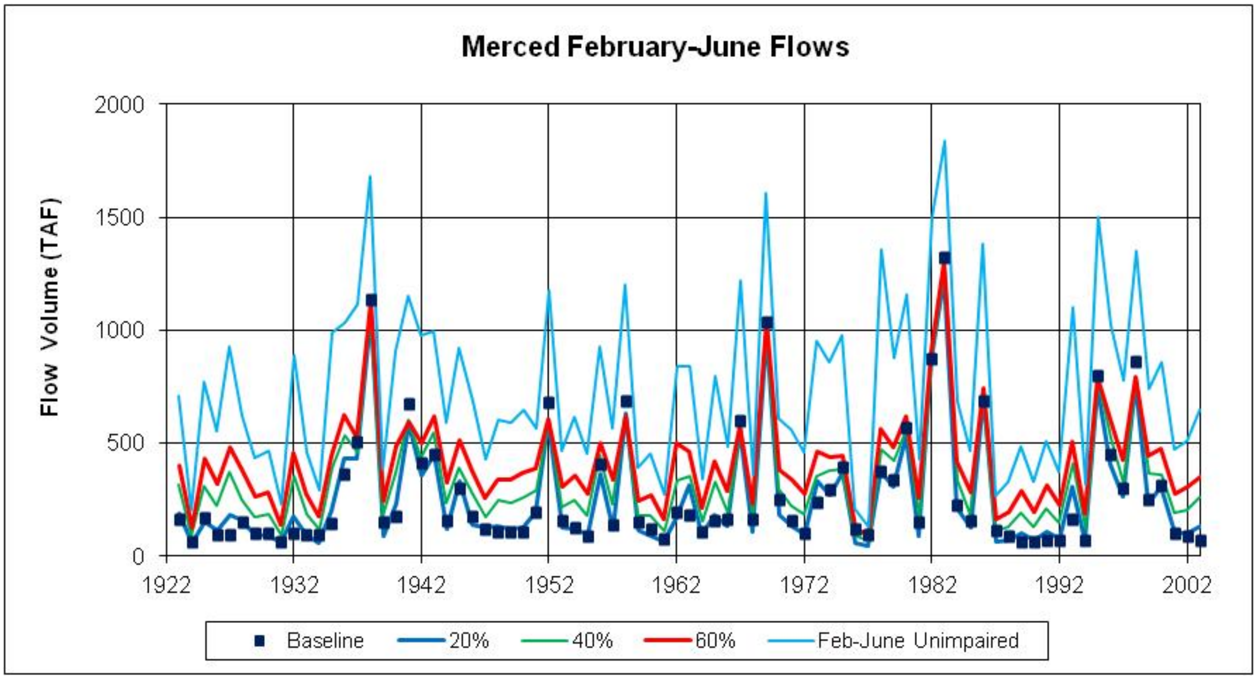
	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
Lake McClure Elevation (feet)												
CALSIM Baseline												
Minimum	636	626	633	624	616	641	640	649	661	655	648	646
10%	662	660	658	679	693	708	716	724	718	696	676	667
20%	706	702	705	713	731	742	749	772	775	752	727	714
30%	734	734	739	753	757	770	776	790	789	770	749	740
40%	753	758	763	776	791	796	799	809	806	784	766	761
50%	775	777	783	792	800	807	810	820	824	808	789	779
60%	798	797	798	800	806	811	817	837	843	829	813	804
70%	804	802	802	805	806	817	825	852	859	847	824	811
80%	804	803	805	806	806	817	832	856	864	847	824	811
90%	804	805	806	806	806	817	836	856	864	847	824	811
Maximum	804	806	806	806	806	817	836	856	864	847	824	811
Average	756	755	758	764	771	780	791	809	811	794	773	763

Table F.1-9d shows the monthly and annual cumulative distribution (range) for the CALSIM simulated Merced River flows at Stevinson. These Merced River monthly flows are similar to the historical flows observed since the New Exchequer Dam was completed. The median monthly flows were lowest (less than 200 cfs) July–September and were highest January–June, with average flows of 750–1,150 cfs generally caused by high flood-control releases in a few years. The median monthly baseline conditions flows were 504 cfs in February, 377 cfs in March, 670 cfs in April, 513 cfs in May, and 267 cfs in June. The range of annual Merced River flows was 182 TAF (10 percent cumulative) to 1,101 TAF (90 percent cumulative), with a median flow of 300 TAF and an average flow of 505 TAF. Figure F.1-7c shows the annual sequence of February–June flows on the Merced River for baseline conditions and the LSJR alternatives. The February–June unimpaired runoff for each year is shown for comparison.

The baseline Merced River annual diversions (water supply deliveries) ranged from 421 TAF (10 percent cumulative) to 593 TAF (90 percent cumulative), with a median annual diversion of 552 TAF and an average annual diversion of 527 TAF. Figure F.1-7d shows the CALSIM simulated baseline conditions and the WSE simulated sequence of annual Merced River diversions for the LSJR alternatives. The top graph shows the annual diversion in comparison to the annual unimpaired runoff volumes; the bottom graph shows the annual diversions in comparison to the maximum water supply demand of 600 TAF/y. The maximum water supply diversion of 600 TAF for the Merced River was estimated from the historical record combined with the CALSIM results. Water supply deficits were estimated using this maximum water supply target. Impacts were estimated from the CALSIM diversions, which included deficits in many years. The baseline Merced River water supply deficits ranged from 7 TAF (10 percent) to 179 TAF (90 percent) with a median deficit of 48 TAF and an average deficit of 73 TAF, about 12 percent of the assumed maximum water supply.

Table F.1-9d. CALSIM-Simulated Baseline Monthly Cumulative Distributions of Merced River at Stevinson Flow (cfs) for 1922–2003

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	Annual (TAF)
Merced at Stevinson Flow (cfs)													
Minimum	206	258	133	270	205	186	9	20	29	35	35	2	139
10%	266	316	323	330	322	271	203	169	132	68	54	31	182
20%	283	346	354	377	380	304	356	219	146	90	74	54	198
30%	308	365	375	393	407	335	508	283	176	117	100	69	221
40%	337	380	385	410	445	356	626	359	238	160	123	80	274
50%	359	387	396	435	504	377	670	513	267	175	159	92	300
60%	425	397	409	482	726	468	733	622	311	224	201	134	431
70%	481	409	424	618	978	661	803	784	441	304	811	445	557
80%	609	424	457	1,232	1,981	1,135	902	1,165	1,644	1,119	1,060	566	783
90%	741	528	1,081	1,775	2,998	1,836	1,036	2,627	3,071	2,209	1,233	640	1,101
Maximum	1,344	1,802	3,551	9,912	5,205	6,069	4,921	5,555	7,343	5,943	2,444	1,369	2,457
Average	453	437	593	898	1,158	837	742	882	927	701	473	271	505



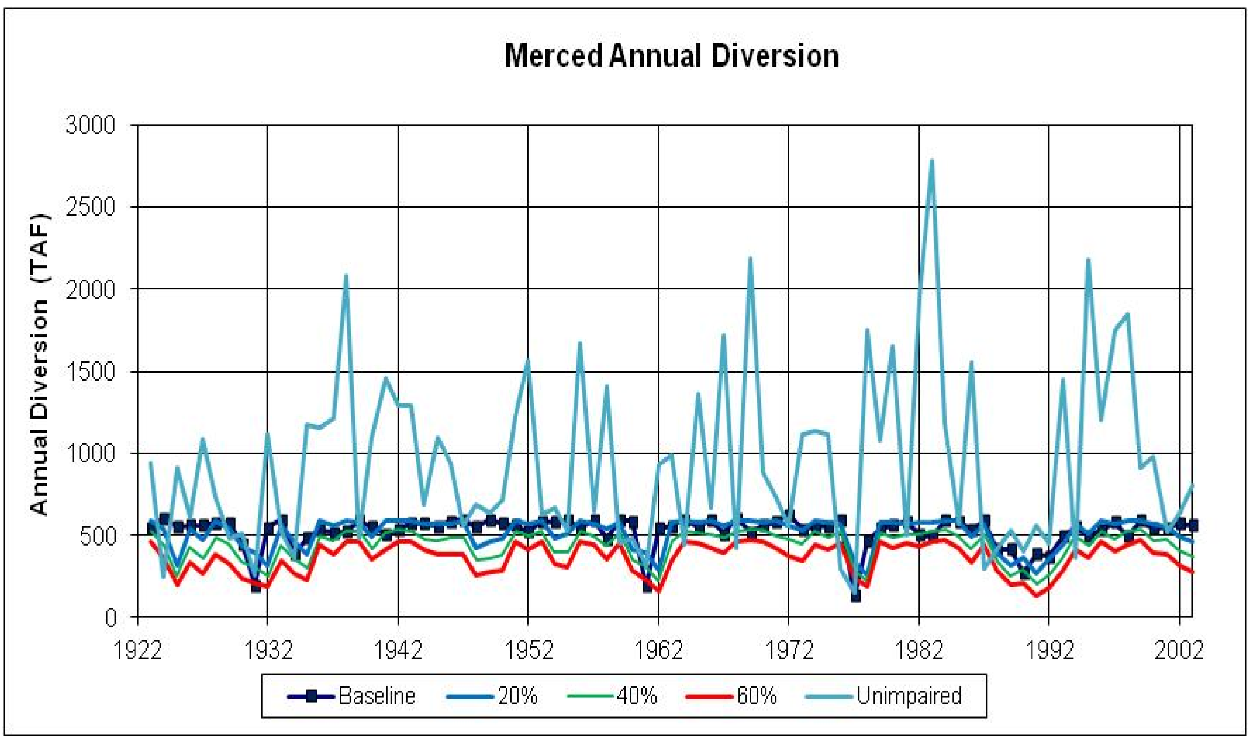


Figure F.1-7c. Comparison of WSE-Calculated Merced River February–June Flow Volumes (TAF) for Baseline Conditions and LSJR Alternatives 2, 3, and 4 (20%, 40%, and 60% Unimpaired Flow) for 1922–2003

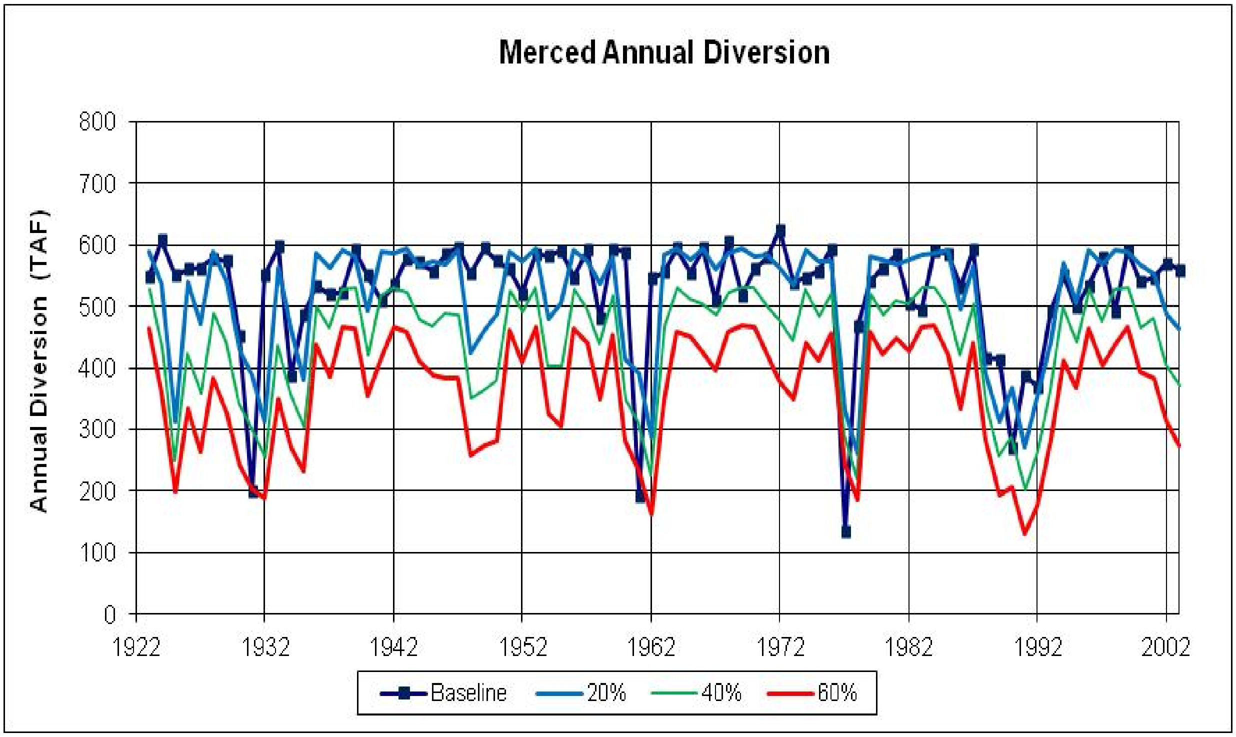


Figure F.1-7d. Merced River Annual Unimpaired Runoff and WSE-Calculated Annual Water Supply Diversions for Baseline Conditions and LSJR Alternatives 2, 3, and 4 (20%, 40%, and 60% Unimpaired Flow) for 1922–2003

Tuolumne River

Figure F.1-8a illustrates the basic water supply need for seasonal storage in New Don Pedro Reservoir to increase the water supply delivery in the summer months when the unimpaired runoff is less than the monthly demands for irrigation water. Because agricultural use requires a specified monthly pattern of water deliveries to satisfy crop needs (transpiration), storage is needed to extend the period when unimpaired runoff could be (directly) diverted for irrigation. For the Tuolumne River, the monthly demands are less than the 10 percent cumulative monthly runoff in the winter and spring months to May. The June demand is equal to the 30 percent cumulative runoff, but the July-October demands are equal or greater than the 90 percent cumulative monthly runoff. Reservoir storage is needed to satisfy the June demand in about half of the years, and is needed to satisfy the July–October demands in about 90 percent of the years.

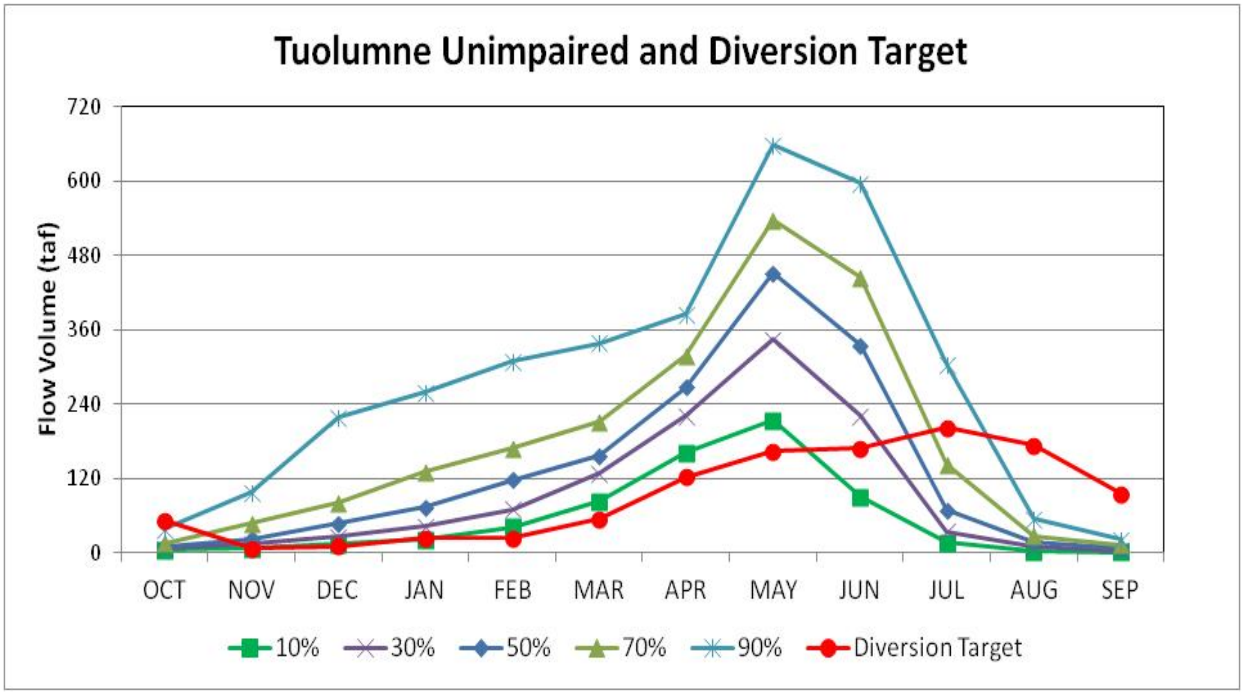


Figure F.1-8a. Monthly Tuolumne River Unimpaired Runoff Compared to Monthly Water Supply Demands

The upstream operations of the SFPUC seasonally shift and reduce the inflow to New Don Pedro Reservoir. Table F.1-9e gives the monthly and annual cumulative distribution (range) for the CALSIM inflow to New Don Pedro Reservoir (TAF). The median annual inflow was 1,496 TAF and the average annual inflow was 1,586 TAF. Table F.1-9f gives the monthly and annual cumulative distributions of the differences between the Tuolumne unimpaired runoff and the New Don Pedro Reservoir inflow, which represent the upstream SFPUC diversions and reservoir filling (TAF). The changes from the unimpaired runoff were relatively small in most months, with maximum reductions caused by diversions to storage in the spring months of April–June. The median monthly upstream diversions were 73 TAF in April, 123 TAF in May, and 44 TAF in June. The negative diversions represent flood-control storage reductions in the upstream reservoirs. The median and average annual upstream diversions were both 263 TAF, indicating that the annual San Francisco Public Utilities Commission (SFPUC) diversions were evenly distributed. The 10 percent annual diversion was 201 TAF, and the 90 percent annual diversion was 307 TAF.

Table F.1-9e. CALSIM-Simulated Baseline Monthly Cumulative Distributions of New Don Pedro Reservoir Inflow (TAF) for 1922–2003

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	Annual
New Don Pedro Inflow (TAF)													
Minimum	5	5	7	6	9	11	20	31	9	9	12	10	223
10%	9	9	18	23	44	73	99	105	40	18	16	21	601
20%	11	11	23	30	64	101	126	169	76	21	18	22	829
30%	13	13	38	39	79	116	154	215	156	26	21	23	902
40%	14	15	43	55	100	140	173	261	210	35	24	25	1,146
50%	16	17	54	67	141	163	191	286	279	52	28	28	1,496
60%	17	26	63	96	172	198	224	315	325	80	29	31	1,742
70%	19	29	82	134	205	230	247	354	371	119	32	33	1,931
80%	23	48	106	188	243	248	270	448	452	166	36	34	2,255
90%	29	66	191	262	313	306	290	528	555	278	41	38	2,804
Maximum	162	430	578	978	547	559	576	852	965	615	184	94	4,438
Average	20	37	90	123	160	186	200	308	294	107	31	29	1,586

Table F.1-9f. CALSIM-Simulated Baseline Monthly Cumulative Distributions of SFPUC Upstream Diversions and Reservoir Operations (TAF) for 1922–2003

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	Annual
San Francisco PUC Tuolumne River Diversions (TAF)													
Minimum	-18	-5	-99	-96	-97	-91	-64	11	-1	-14	-24	-35	130
10%	-7	-2	-32	-25	-59	-49	16	52	25	-2	-14	-21	201
20%	-7	-1	-20	-13	-32	-20	38	73	28	1	-13	-21	226
30%	-6	1	-12	-5	-25	-11	55	89	31	6	-13	-20	243
40%	-6	2	-2	0	-14	2	61	102	38	19	-11	-20	256
50%	-5	5	2	4	-8	6	73	123	44	22	-9	-19	263
60%	-4	10	3	6	-2	12	85	152	54	25	-6	-18	273
70%	-3	16	8	11	3	23	97	168	65	25	-3	-17	284
80%	0	21	13	19	7	35	108	206	75	26	2	-16	293
90%	3	30	23	29	19	43	125	246	92	26	15	-11	307
Maximum	15	92	74	88	69	118	194	341	231	44	34	10	435
Average	-3	11	-1	1	-13	4	73	139	58	17	-4	-17	263

Table F.1-9g shows the monthly cumulative distribution (range) for the CALSIM simulated New Don Pedro storage (TAF). These monthly storage patterns are similar to the historical reservoir storage observed since New Don Pedro Dam was completed in 1964. The maximum storage was simulated in only about 10 percent of the years in June. Storage is limited for flood control in the other months. The maximum storage is 1,690 TAF October–March. The median monthly storage levels were relatively high, with more than 1,500 TAF January–July, and with more than 1,300 TAF August–December. The minimum carryover storage (September) was about 442 TAF (20 percent of capacity) and the 30 percent cumulative carryover storage values were above 1,000 TAF (50 percent of capacity). Figure F.1-8b shows the New Don Pedro carryover storage for baseline conditions and the LSJR alternatives (simulated by CALSIM) and compares the historical carryover storage for reference. The CALSIM results reflect the historical periods of low runoff (reduced storage) and the periods of high runoff (with maximum carryover storage of 1,700 TAF). Many of the carryover storage values are at the maximum allowed storage for flood control.

Table F.1-9g. CALSIM-Simulated Baseline Monthly Cumulative Distributions of New Don Pedro Storage (TAF) for 1922–2003

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
New Don Pedro Storage (TAF)												
Minimum	420	416	467	582	768	803	708	660	600	524	463	442
10%	844	838	875	895	993	1,028	1,072	1,061	1,113	1,005	906	877
20%	974	994	998	1,009	1,099	1,180	1,224	1,253	1,304	1,159	1,033	980
30%	1,071	1,090	1,193	1,263	1,341	1,360	1,409	1,456	1,473	1,309	1,165	1,113
40%	1,176	1,218	1,326	1,375	1,519	1,537	1,502	1,537	1,607	1,437	1,294	1,223
50%	1,327	1,360	1,442	1,512	1,609	1,690	1,631	1,611	1,751	1,608	1,459	1,377
60%	1,461	1,465	1,540	1,586	1,661	1,690	1,664	1,710	1,823	1,727	1,588	1,515
70%	1,595	1,583	1,590	1,654	1,690	1,690	1,690	1,788	1,953	1,861	1,713	1,640
80%	1,616	1,609	1,635	1,690	1,690	1,690	1,706	1,827	2,015	1,910	1,760	1,682
90%	1,635	1,665	1,690	1,690	1,690	1,690	1,713	1,909	2,030	1,910	1,772	1,700
Maximum	1,661	1,690	1,690	1,690	1,690	1,690	1,713	2,002	2,030	1,910	1,790	1,700
Average	1,278	1,289	1,336	1,384	1,449	1,479	1,478	1,553	1,635	1,519	1,389	1,324

The reservoir storage values correspond to surface elevations that can be calculated with a simple equation, estimated from the reservoir geometry data (i.e., elevation, surface area, volume). The New Don Pedro Reservoir elevation is estimated as:

$$\text{Elevation (feet msl)} = 350 + 4.4173 \times \text{New Don Pedro storage (AF)}^{0.3226} \qquad \textit{(Eqn. F.1-7)}$$

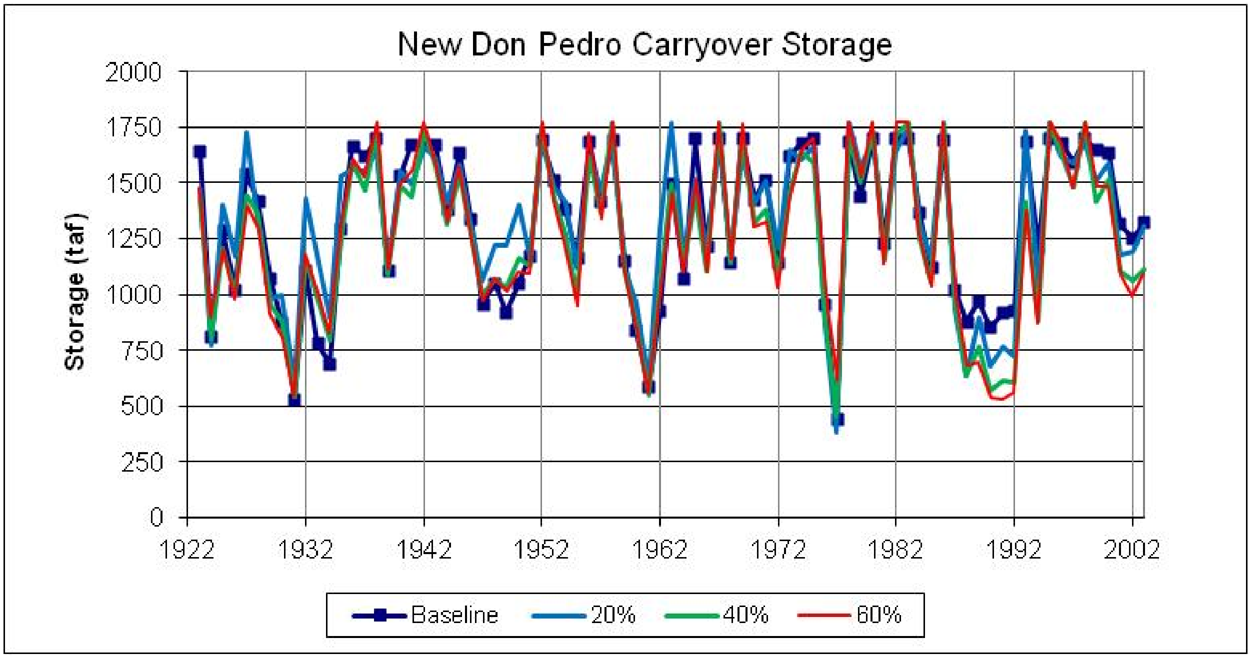


Figure F.1-8b. Comparison of WSE-Calculated New Don Pedro Reservoir Carryover storage (TAF) for Baseline Conditions and LSJR Alternatives 2, 3, and 4 (20%, 40%, and 60% Unimpaired Flow) for 1922–2003

The surface elevation is an important variable for evaluating hydroelectric energy generation at the dam, boat dock access and recreation uses, reservoir fish habitat, and exposure of cultural resources during extreme drawdown periods. Using this equation, the storages can be converted to surface elevations for these resource evaluations. The surface elevation is about 588 feet for a storage volume of 200 TAF (10 percent volume), 662 feet for a storage volume of 500 TAF, and about 733 feet for a storage volume of 1,000 TAF (50 percent volume). The storage is about 830 feet for a maximum storage of 2,030 TAF. Table F.1-9h shows the monthly cumulative distributions for the CALSIM simulated New Don Pedro Reservoir water surface elevations (feet).

Table F.1-9h. CALSIM-Simulated Baseline Monthly Cumulative Distributions of New Don Pedro Water Surface Elevations (feet msl) for 1922–2003

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
New Don Pedro Elevation (feet)												
CALSIM Baseline												
Minimum	639	638	647	666	693	698	685	678	669	657	646	642
10%	703	703	708	710	722	727	732	731	737	724	712	708
20%	720	723	723	724	735	745	750	753	758	742	727	721
30%	732	734	746	754	762	765	770	775	776	759	743	737
40%	744	749	761	766	781	783	779	783	790	773	757	750
50%	761	765	773	780	790	798	792	790	804	790	775	766
60%	775	775	783	788	795	798	796	800	811	802	788	781
70%	789	787	788	795	798	798	798	807	823	814	800	793
80%	791	790	793	798	798	798	800	811	828	819	805	797
90%	793	796	798	798	798	798	800	819	830	819	806	799
Maximum	795	798	798	798	798	798	800	827	830	819	808	799
Average	753	754	760	765	772	776	776	783	791	779	765	758

Table F.1-9i shows the monthly and annual cumulative distribution (range) for the CALSIM simulated Tuolumne River Flows at Modesto. These Tuolumne River flows are similar to the historical flows observed since the New Don Pedro Federal Energy Regulatory Commission (FERC) license was amended with higher release flows in 1995. The median monthly flows were 400-750 cfs in all months except April and May. The median monthly baseline conditions flows were 606 cfs in February, 760 cfs in March, 1,505 cfs in April, 1,311 cfs in May, and 454 cfs in June. Flood-control releases were simulated in February–June for about 50 percent of the years. The range of annual Tuolumne River flows was 281 TAF (10 percent cumulative) to 1,803 TAF (90 percent cumulative), with a median annual flow of 521 TAF and an average annual flow of 866 TAF. Figure F.1-8c shows the annual sequence of February–June flows on the Tuolumne River for the baseline conditions, as simulated with the CALSIM model. The February–June unimpaired runoff for each year is shown for comparison.

Table F.1-9i. CALSIM-Simulated Baseline Monthly Cumulative Distributions of Tuolumne River at Modesto Flow (cfs) for 1922–2003

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	Annual (TAF)
Tuolumne at Modesto Flow (cfs)													
Minimum	194	206	217	208	152	245	381	398	170	169	167	153	194
10%	285	246	257	316	307	344	530	532	247	237	257	243	281
20%	390	324	327	427	454	444	742	796	300	299	326	323	354
30%	457	382	412	436	484	490	877	898	351	339	349	353	401
40%	480	447	434	518	519	595	1,080	1,082	377	378	379	369	454
50%	537	460	457	552	606	760	1,505	1,311	454	418	402	409	521
60%	602	479	520	599	801	1,324	1,822	1,426	582	523	485	507	756
70%	691	525	595	691	2,016	3,109	2,317	1,576	733	576	553	567	1,115
80%	733	614	626	1,115	3,429	3,709	3,105	1,790	2,805	1,067	568	585	1,404
90%	808	760	1,119	3,050	4,916	4,849	4,467	4,826	4,410	3,479	618	661	1,803
Maximum	3,175	5,485	7,476	17,735	7,111	16,125	9,183	9,501	8,518	8,341	2,862	2,367	4,119
Average	597	574	831	1,262	1,684	2,117	1,982	1,819	1,435	1,103	476	482	866

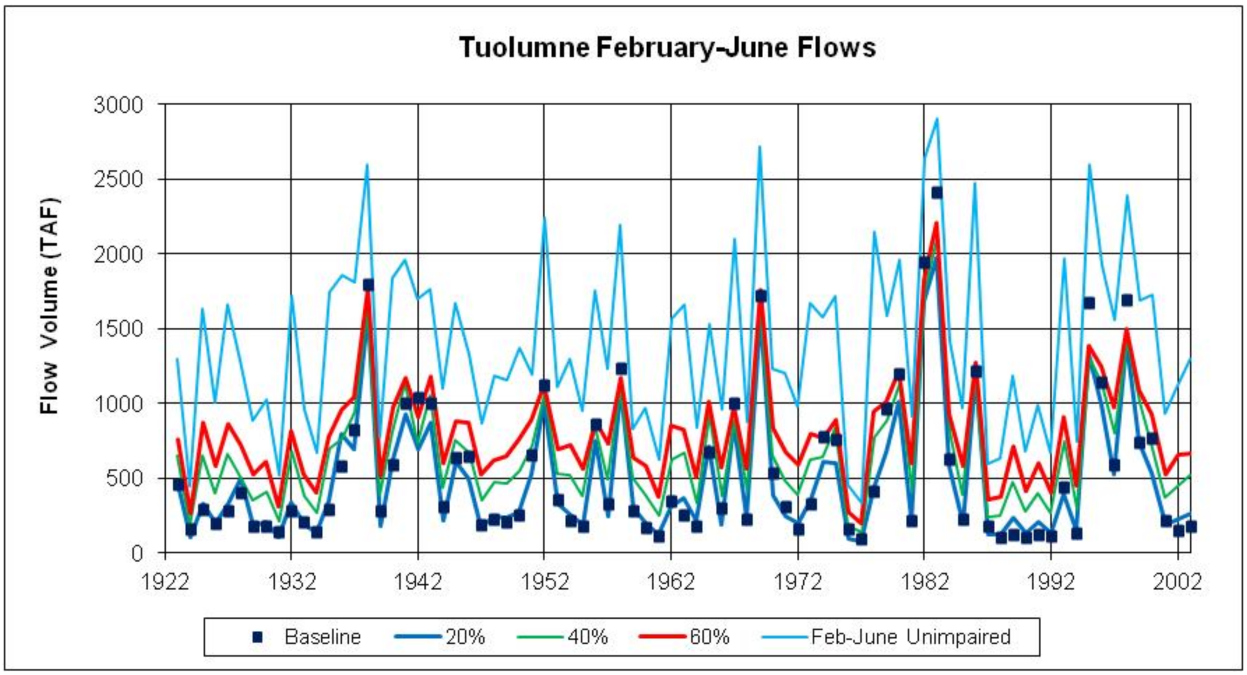
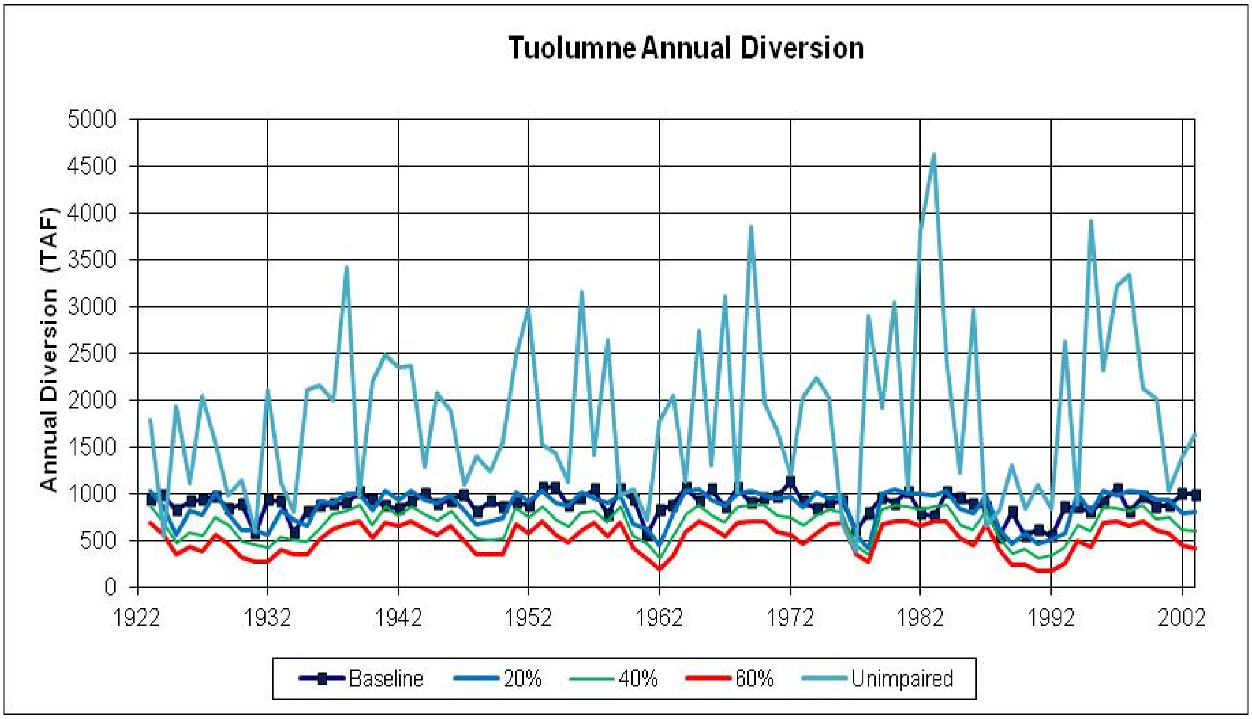


Figure F.1-8c. Comparison of WSE-Calculated Tuolumne River February–June Flow Volumes (TAF) for Baseline Conditions and LSJR Alternatives 2, 3, and 4 (20%, 40%, and 60% Unimpaired Flow) for 1922–2003

The baseline Tuolumne River annual diversions (water supply deliveries) ranged from 762 TAF (10 percent cumulative) to 1,042 TAF (90 percent cumulative) with a median annual diversion of 906 TAF and an average annual diversion of 885 TAF. Figure F.1-8d shows the CALSIM simulated baseline conditions and the WSE simulated sequence of annual Tuolumne River diversions for the LSJR alternatives. The top graph shows the annual diversion in comparison to the annual unimpaired runoff volumes; the bottom graph shows the annual diversions in comparison to the maximum water supply demand of 1,100 TAF/y. The maximum water supply diversion of 1,100 TAF for the Tuolumne River was estimated from the historical record combined with the CALSIM results. Water supply deficits were estimated using this maximum water supply target. Impacts were estimated from the CALSIM diversions, which included deficits in many years. The baseline Tuolumne River water supply deficits ranged from 58 TAF (10 percent) to 338 TAF (90 percent) with a median deficit of 194 TAF and an average deficit of 215 TAF, about 20 percent of the assumed maximum water supply.



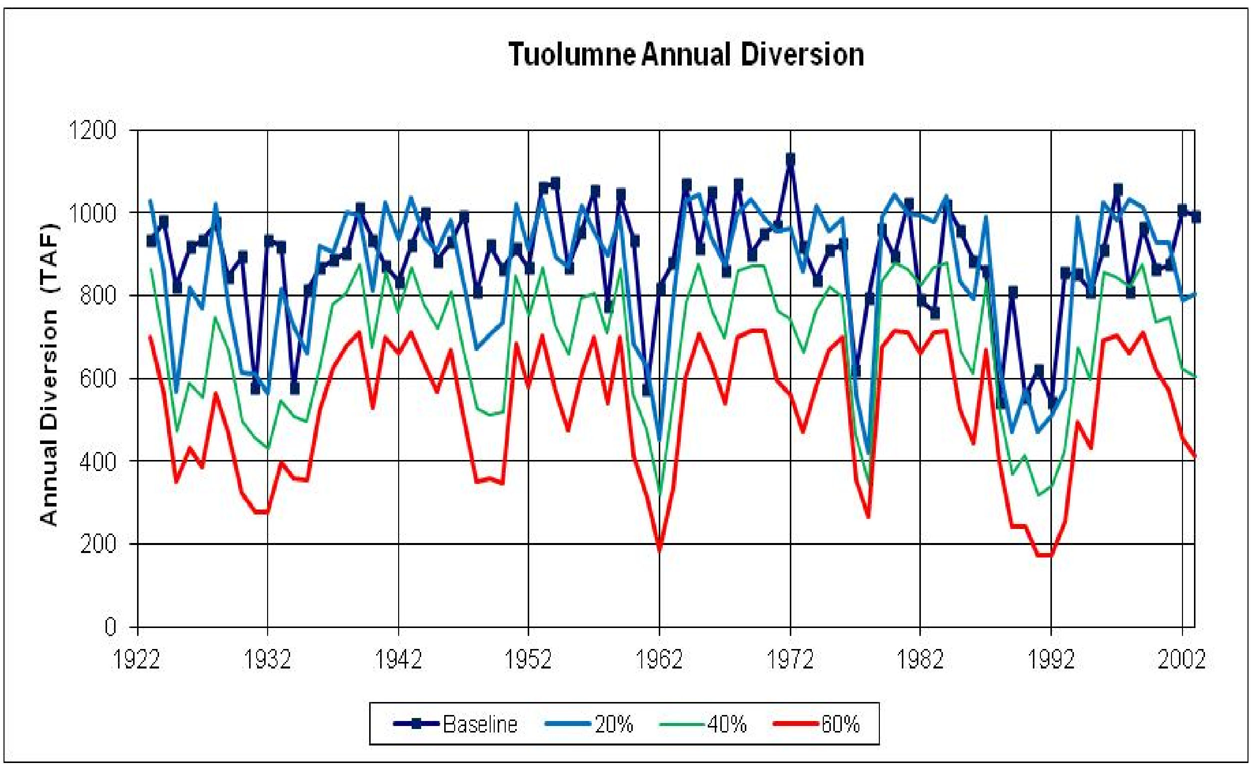


Figure F.1-8d. Tuolumne River Annual Unimpaired Runoff and WSE-Calculated Annual Water Supply Diversions for Baseline Conditions and LSJR Alternatives 2, 3, and 4 (20%, 40%, and 60% Unimpaired Flow) for 1922–2003

Stanislaus River

Figure F.1-9a illustrates the basic water supply need for seasonal storage in New Melones Reservoir to increase the water supply delivery in the summer months when the unimpaired runoff is less than the monthly demands for irrigation water. Because agricultural use requires a specified monthly pattern of water deliveries to satisfy crop needs (transpiration), storage is needed to extend the period when unimpaired runoff could be (directly) diverted for irrigation. For the Stanislaus River, the monthly demands are less than the 10 percent cumulative monthly runoff in the winter and spring months to April or May. The June demand is equal to the 50 percent cumulative runoff, and the July–October demands are greater than the 90 percent cumulative runoff. Reservoir storage is needed to satisfy the June demand in about half of the years and is needed to satisfy the July–October demands in about 90 percent of the years.

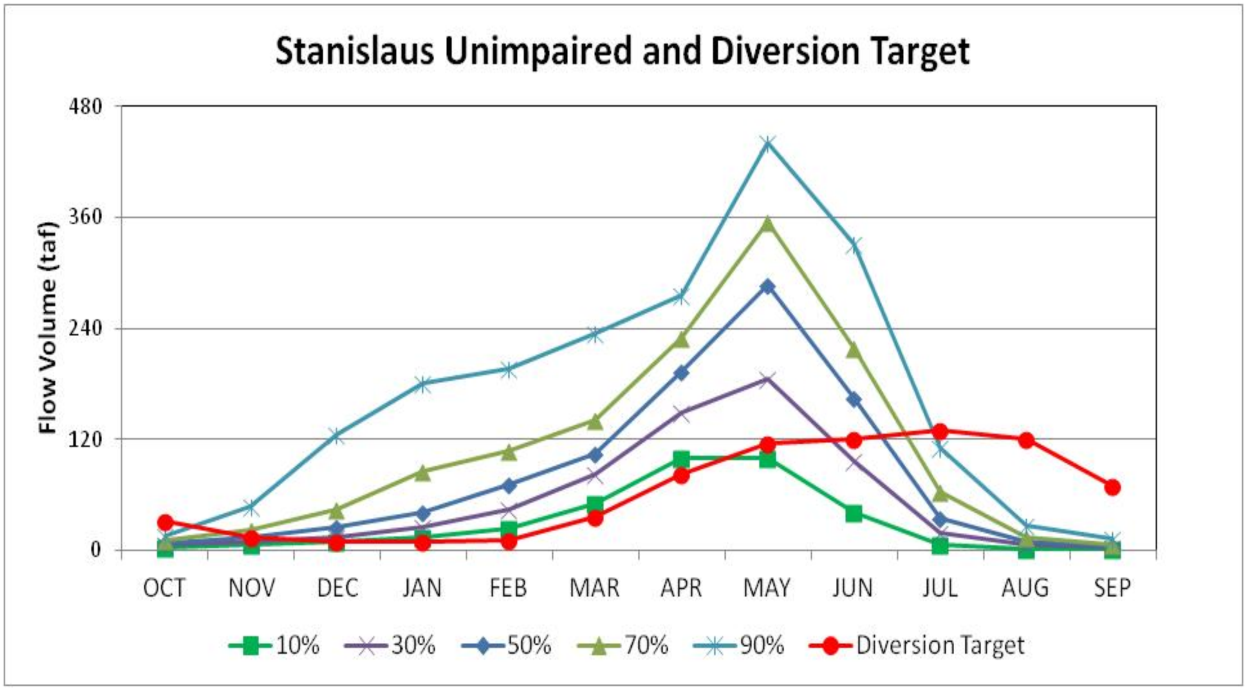


Figure F.1-9a. Monthly Stanislaus River Unimpaired Runoff Compared to Monthly Water Supply Demands

Upstream reservoir operations for seasonal storage and hydroelectric energy generation shift the monthly inflows to New Melones Reservoir but do not change the annual inflow. Table F.1-9j shows the monthly cumulative distribution (range) for the CALSIM simulated New Melones storage (TAF). These monthly storage patterns are similar to the historical range observed since New Melones filled in 1982. The maximum storage of 2,420 TAF was simulated in just a few years in June. Storage is limited to less than 2,000 TAF October–March. The median monthly storage levels were all higher than 1,200 TAF (50 percent of capacity). The minimum carryover storage (end-of-September) was 80 TAF (3 percent of capacity), but the 10 percent cumulative carryover storage was 479 TAF (20 percent of capacity). The 50 percent cumulative carryover storage was 1,242 TAF (50 percent of capacity). Figure F.1-9b shows the New Melones carryover storage for the baseline conditions and compares the historical carryover storage for reference. The CALSIM results reflect the historical periods of low runoff (reduced storage) and the periods of high runoff (with maximum carryover storage of 2,000 TAF). Many of the carryover storage values are at the maximum allowed storage for flood control.

Table F.1-9j. CALSIM-Simulated Baseline Monthly Cumulative Distributions of New Melones Storage (TAF) for 1922–2003

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
New Melones Storage (TAF)												
Minimum	80	80	95	193	228	239	231	155	115	80	80	80
10%	474	475	477	514	547	526	488	567	605	578	516	479
20%	654	633	659	677	752	825	813	836	811	755	696	673
30%	859	880	922	988	993	1,023	1,012	1,020	1,020	971	904	875
40%	1,061	1,055	1,092	1,138	1,151	1,206	1,195	1,221	1,257	1,199	1,136	1,103
50%	1,198	1,207	1,232	1,291	1,377	1,406	1,381	1,384	1,406	1,352	1,282	1,242
60%	1,300	1,307	1,387	1,458	1,545	1,575	1,520	1,489	1,505	1,459	1,377	1,341
70%	1,434	1,443	1,473	1,551	1,643	1,678	1,678	1,609	1,619	1,600	1,520	1,479
80%	1,575	1,595	1,613	1,659	1,769	1,805	1,762	1,779	1,763	1,728	1,651	1,608
90%	1,816	1,814	1,827	1,826	1,942	1,972	1,860	1,983	2,076	1,990	1,900	1,866
Maximum	1,955	1,965	1,964	2,110	1,970	2,030	2,220	2,346	2,420	2,300	2,130	2,000
Average	1,132	1,141	1,174	1,229	1,288	1,321	1,295	1,310	1,334	1,278	1,204	1,166

The reservoir storage values correspond to surface elevations that can be calculated with a simple equation, estimated from the reservoir geometry data (i.e., elevation, surface area, volume). The New Melones Reservoir elevation is estimated as:

$$\text{Elevation (feet msl)} = 590 + 1.5634 \times \text{New Melones storage (AF)}^{0.3922} \qquad \textit{(Eqn. F.1-8)}$$

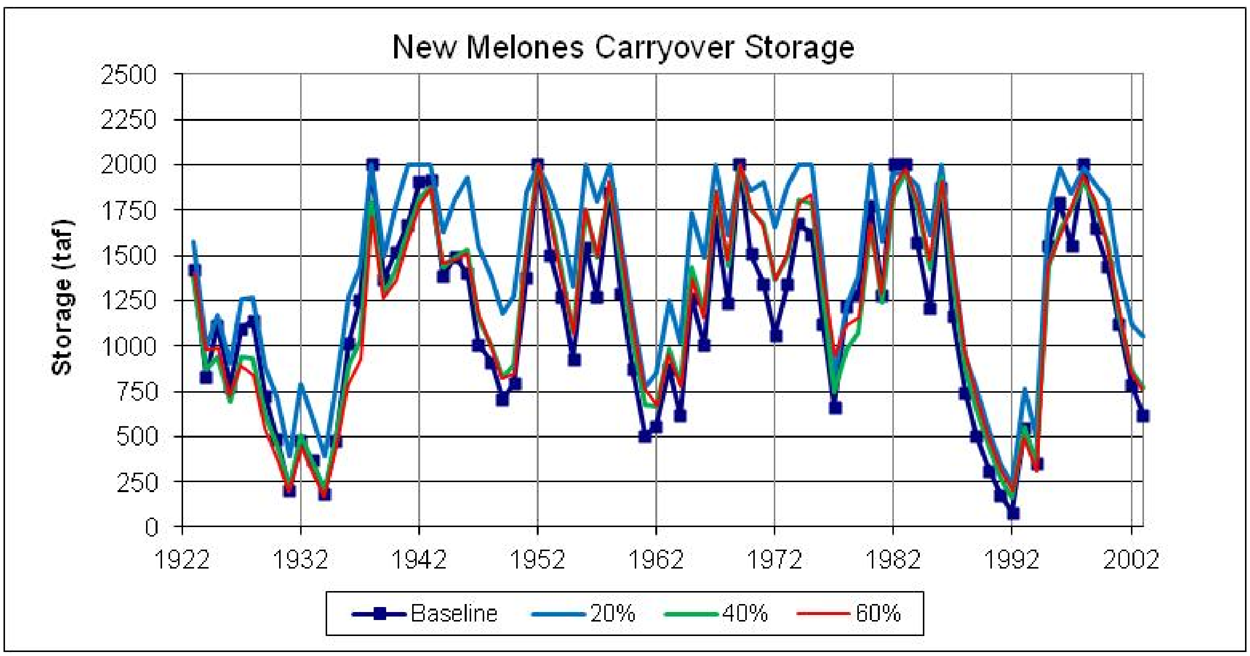


Figure F.1-9b. Comparison of WSE-Calculated New Melones Reservoir Carryover storage (TAF) for Baseline Conditions and LSJR Alternatives 2, 3, and 4 (20%, 40%, and 60% Unimpaired Flow) for 1922–2003

The surface elevation is an important variable for evaluating hydroelectric energy generation at the dam, boat dock access and recreation uses, reservoir fish habitat, and exposure of cultural resources during extreme drawdown periods. Using this equation, the storages can be converted to surface elevations for these resource evaluations. The surface elevation is about 795 feet for a storage volume of 250 TAF (10 percent volume), 860 feet for a storage volume of 500 TAF, and about 970 feet for a storage volume of 1,200 TAF (50 percent volume). The storage is about 1090 feet for a maximum storage of 2,420 TAF. Table F.1-9k shows the monthly cumulative distributions for the CALSIM simulated New Melones Reservoir water surface elevations (feet).

Table F.1-9k. CALSIM-Simulated Baseline Monthly Cumulative Distributions of New Melones Water Surface Elevations (feet msl) for 1922–2003

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
New Melones Elevation (feet) - CALSIM Baseline												
Minimum	712	712	722	771	784	788	785	755	734	712	712	712
10%	853	853	853	861	868	864	856	872	879	874	862	854
20%	888	885	889	893	905	917	915	919	915	906	896	892
30%	922	926	932	941	942	946	944	945	945	939	929	925
40%	951	950	955	961	963	969	968	971	975	968	961	956
50%	968	969	972	979	989	992	990	990	992	986	978	974
60%	980	981	990	998	1,007	1,010	1,005	1,001	1,003	998	989	985
70%	996	996	1,000	1,008	1,017	1,021	1,021	1,014	1,015	1,013	1,005	1,000
80%	1,010	1,012	1,014	1,019	1,029	1,033	1,029	1,030	1,029	1,026	1,018	1,014
90%	1,034	1,034	1,035	1,035	1,045	1,048	1,038	1,049	1,057	1,050	1,042	1,038
Maximum	1,047	1,047	1,047	1,060	1,048	1,053	1,069	1,079	1,085	1,076	1,062	1,051
Average	948	949	954	962	969	973	970	972	973	966	957	952

Table F.1-9l shows the monthly and annual cumulative distribution (range) for the CALSIM simulated Stanislaus River flows at Ripon. These Stanislaus River flows are similar to the historical flows observed since the New Melones Dam was filled in 1982, although the required flow releases have increased since 1998 with the Anadromous Fish Restoration Program (AFRP) and the Vernalis Adaptive Management Program (VAMP). The median monthly baseline conditions flows were less than 500 cfs July–February, except the required pulse flow in late October increased the median flow to about 1,000 cfs. The median monthly flows were 491 cfs in February, 667 cfs in March, 1,625 cfs in April, 1,516 cfs in May, and 718 cfs in June. The high April and May flows are the result of the NMFS flow requirements that extend the VAMP flows to a two-month pulse flow. Flood-control releases in February–June were simulated in only about 10 percent of the years. The range of annual Stanislaus River flows was 326 TAF (10 percent cumulative) to 902 TAF (90 percent cumulative), with a median annual flow of 524 TAF and an average annual flow of 609 TAF. The baseline release flow requirements (Department of Fish and Game [DFG], U.S. Fish and Wildlife Service [USFWS], and NMFS) provide relatively high Stanislaus River flows in February–June of most years. Figure F.1-9c shows the annual sequence of February–June flows on the Stanislaus River for the baseline conditions, as simulated with the CALSIM model. The February–June unimpaired runoff for each year is shown for comparison.

Table F.1-9l. CALSIM-Simulated Baseline Monthly Cumulative Distributions of Stanislaus River at Ripon Flow (cfs) for 1922–2003

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	Annual (TAF)
Stanislaus at Ripon Flow (cfs)													
Minimum	103	126	200	158	122	200	449	468	297	236	0	9	229
10%	496	282	250	216	235	314	629	601	407	363	365	312	326
20%	613	299	286	259	272	413	791	772	436	415	380	363	384
30%	980	324	311	296	398	559	1,125	1,113	447	432	393	393	429
40%	1,010	348	322	314	459	638	1,394	1,332	490	438	414	422	476
50%	1,071	364	349	335	491	667	1,625	1,516	718	448	439	434	524
60%	1,160	376	356	350	550	882	1,863	1,799	1,104	457	439	437	612
70%	1,212	423	385	381	597	1,504	2,086	1,956	1,223	509	460	479	668
80%	1,270	470	453	454	670	1,619	2,334	2,386	1,349	585	510	544	719
90%	1,379	546	512	571	1,137	1,914	2,553	2,606	1,521	689	592	668	902
Maximum	2,256	3,321	5,140	8,185	6,255	6,175	3,198	3,315	4,960	4,507	2,694	3,113	2,569
Average	1,037	446	467	584	727	1,055	1,620	1,603	920	554	518	560	609

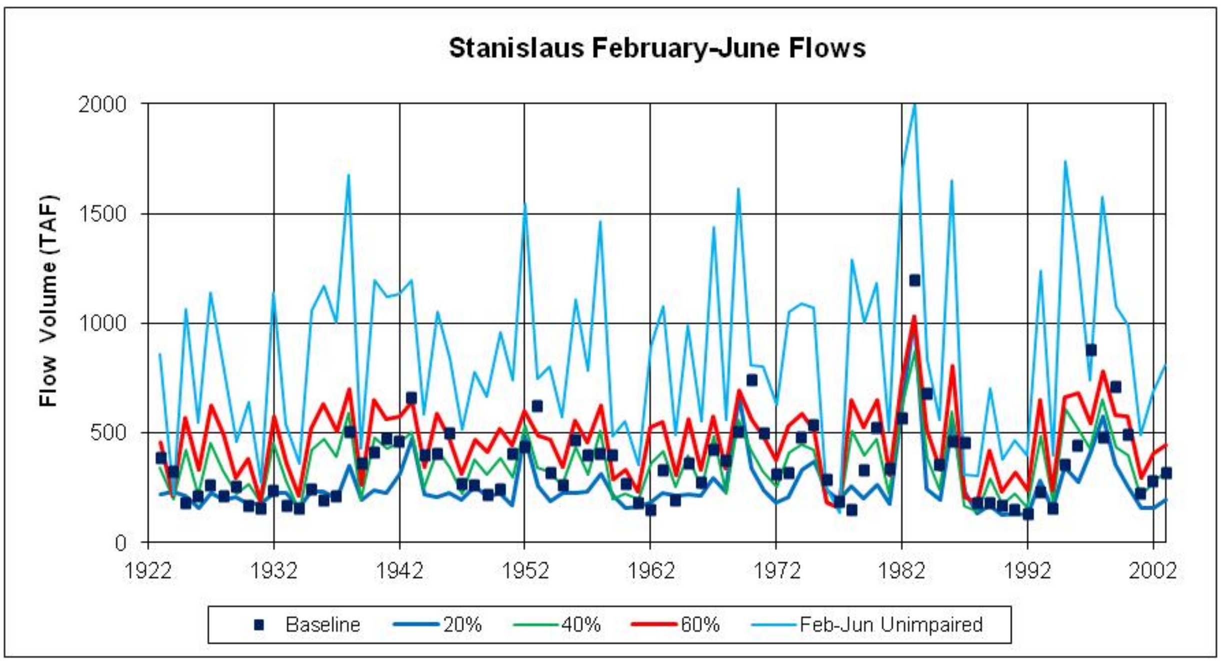
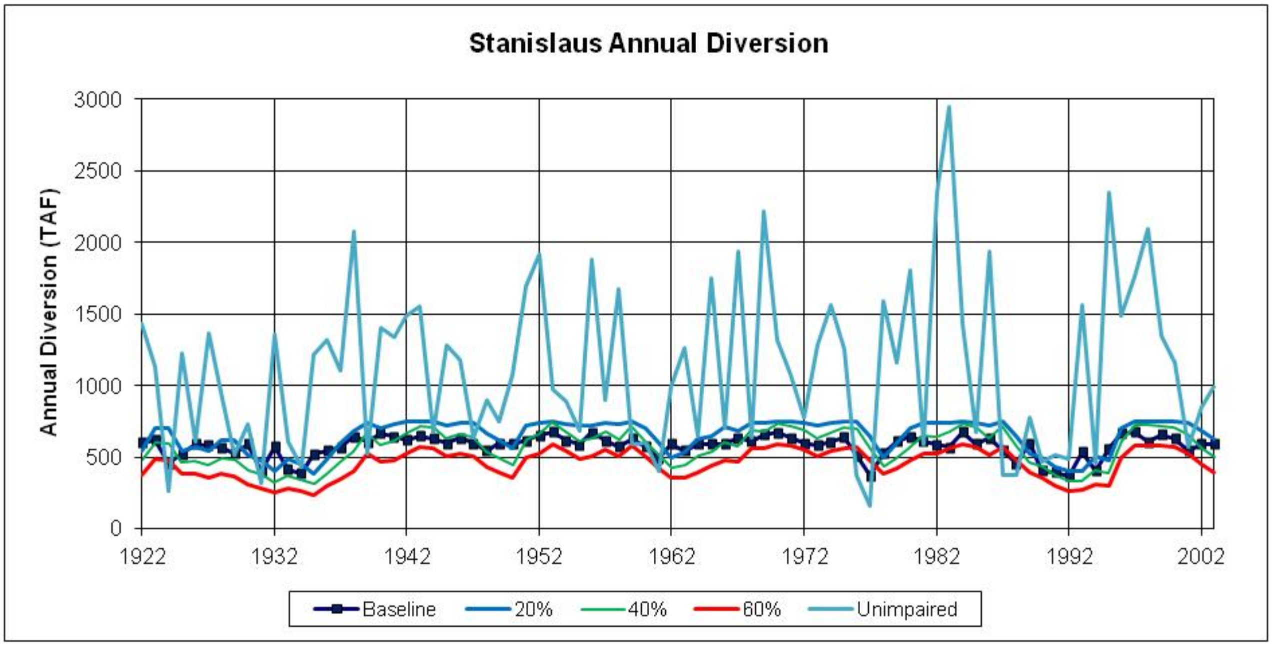


Figure F.1-9c. Comparison of WSE-Calculated Stanislaus River February–June Flow Volumes (TAF) for Baseline Conditions and LSJR Alternatives 2, 3, and 4 (20%, 40%, and 60% Unimpaired Flow) for 1922–2003

The baseline Stanislaus River annual diversions (water supply deliveries) ranged from 455 TAF (10 percent cumulative) to 656 TAF (90 percent cumulative) with a median annual diversion of 593 TAF and an average annual diversion of 577 TAF. Figure F.1-9d shows the CALSIM simulated baseline conditions and the WSE simulated sequence of annual Stanislaus River diversions for the LSJR alternatives. The top graph shows the annual diversion in comparison to the annual unimpaired runoff volumes; the bottom graph shows the annual diversions in comparison to the maximum water supply demand of 750 TAF/y. The maximum water supply diversion of 750 TAF for the Stanislaus River was estimated from the historical record, water contracts, and the CALSIM results.



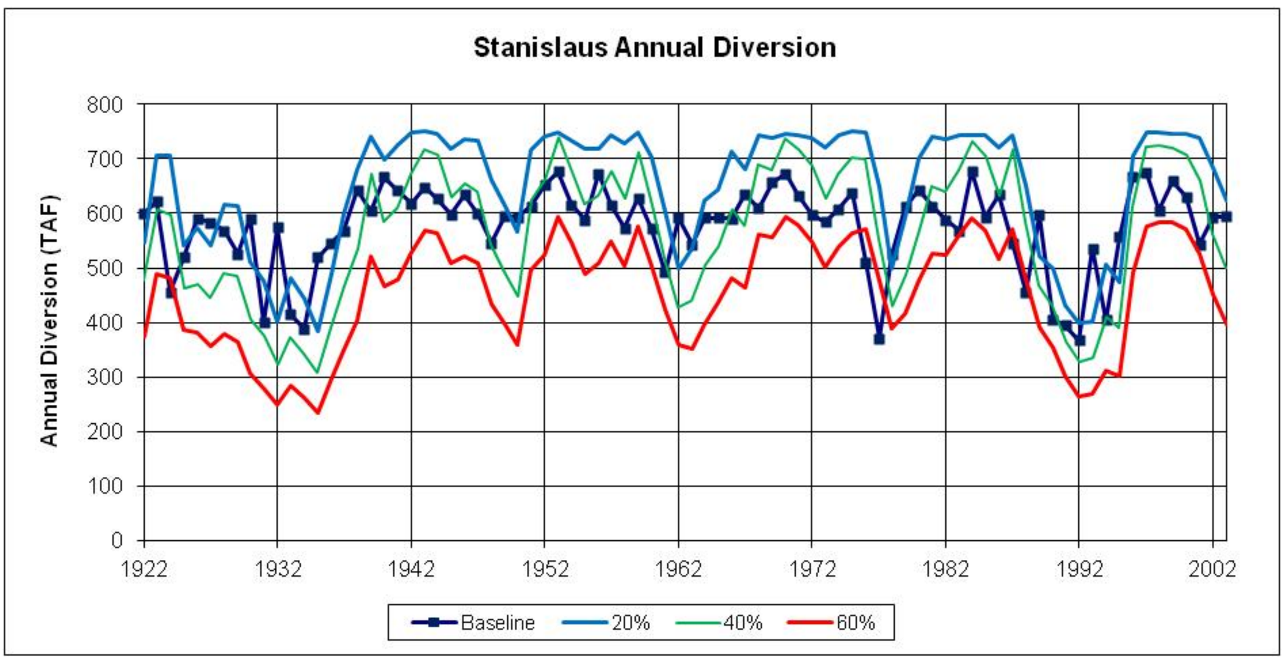


Figure F.1-9d. Stanislaus River Annual Unimpaired Runoff and WSE-Calculated Annual Water Supply Diversions for Baseline Conditions and LSJR Alternatives 2, 3, and 4 (20%, 40%, and 60% Unimpaired Flow) for 1922–2003

Water supply deficits were estimated using this maximum water supply target. Impacts were estimated from the CALSIM diversions, which included deficits in many years. The baseline Stanislaus River water supply deficits ranged from 94 TAF (10 percent) to 295 TAF (90 percent) with a median deficit of 157 TAF and an average deficit of 173 TAF, about 23 percent of the assumed maximum water supply.

San Joaquin River at Vernalis

Table F.1-9m shows the monthly and annual cumulative distribution (range) for the CALSIM simulated SJR flows at Vernalis, downstream of the Stanislaus River. These SJR flows are similar to the historical flows observed since the New Melones Dam was filled in 1982. The median monthly baseline conditions flows were between 2,000 and 3,000 cfs in October–January and were 3,420 cfs in February, 3,420 cfs in March, 5,213 cfs in April, 4,901 cfs in May, and 2,379 cfs in June. The higher median flows in April and May were caused by the assumed Vernalis pulse flows. High flows of greater than 10,000 cfs in February–June (i.e., reservoir flood-control releases) were simulated in only about 10 percent of the years. The range of annual SJR flows was 1,159 TAF (10 percent cumulative) to 5,715 TAF (90 percent cumulative), with a median annual flow of 2,072 TAF and an average annual flow of 3,080 TAF.

Table F.1-9m. CALSIM-Simulated Baseline Monthly Cumulative Distributions of SJR at Vernalis Flow (cfs) for 1922–2003

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	Annual (TAF)
SJR at Vernalis Flow (cfs)													
Minimum	849	1,218	1,362	1,192	1,865	1,352	1,143	1,138	664	553	368	743	882
10%	1,628	1,688	1,692	1,603	2,228	1,929	1,773	1,782	1,154	1,010	1,086	1,470	1,159
20%	2,187	1,814	1,803	1,776	2,278	2,147	3,107	3,091	1,461	1,263	1,289	1,670	1,503
30%	2,375	1,937	1,928	1,962	2,378	2,280	3,442	3,452	1,587	1,340	1,384	1,765	1,691
40%	2,533	2,011	1,991	2,169	2,507	2,651	4,500	4,500	1,903	1,480	1,469	1,850	1,904
50%	2,730	2,104	2,067	2,330	3,420	3,420	5,213	4,901	2,379	1,657	1,550	1,951	2,072
60%	3,049	2,263	2,172	2,457	4,390	4,977	6,276	5,704	3,109	1,865	1,781	2,237	2,807
70%	3,185	2,411	2,403	3,314	6,087	7,590	6,532	6,478	3,364	2,137	2,401	2,492	3,410
80%	3,397	2,669	2,852	5,021	9,538	8,715	7,762	7,383	7,109	3,544	2,796	2,767	4,309
90%	3,796	2,894	4,402	9,608	14,909	14,275	12,748	13,217	11,801	7,297	3,119	3,189	5,715
Maximum	7,564	16,392	24,108	60,104	34,205	48,426	27,279	25,442	27,911	24,308	9,146	7,945	16,065
Average	2,809	2,483	3,246	4,704	6,284	6,545	6,412	6,420	4,599	3,197	2,045	2,300	3,080

LSJR Alternative 2: 20% Unimpaired Flow

The Water Supply Effects (WSE) model was used to modify the tributary flows to meet LSJR Alternative 2. The February–June flows were equal to the monthly flow objectives (or higher if flood-control releases are necessary). The reservoir storage and water supply diversions were adjusted to satisfy these monthly flow objectives for each of the eastside tributaries. Flood releases in many years were reduced or eliminated because higher flows were released in February, March, and April to satisfy the flow objectives. Water supply diversions (annual volume) were reduced in some years to satisfy LSJR Alternative 2. The impact assessment was based on the comparison of the modified flows with the baseline conditions flows.

Merced River

Table F.1-10a shows the monthly cumulative distribution (range) for the WSE calculated Lake McClure storage (TAF) for LSJR Alternative 2. These monthly storage patterns are slightly different than the baseline conditions storage patterns because of different releases and different diversions from the reservoir. The median carryover storage was 629 TAF, about 90 TAF higher than the baseline median carryover storage of 538 TAF. Table F.1-10b shows the monthly and annual cumulative distribution (range) for the WSE calculated Lake McClure water surface elevations (feet msl) for LSJR Alternative 2. The median surface elevations were slightly different that the baseline elevations because of different releases and different diversions from the reservoir.

Table F.1-10a. WSE Results for Lake McClure Storage (TAF) for LSJR Alternative 2: 20% Unimpaired Flow

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
Lake McClure Storage (TAF)												
Minimum	0	0	17	113	124	201	205	187	162	98	44	19
10%	265	251	259	300	342	372	433	462	432	373	326	294
20%	369	372	385	432	479	519	573	660	667	552	452	412
30%	444	434	474	503	563	597	659	704	701	615	521	477
40%	501	493	565	586	652	680	728	772	746	659	576	530
50%	600	603	610	631	672	709	742	804	808	748	662	629
60%	630	631	632	641	675	723	772	893	923	834	726	676
70%	650	653	651	657	675	735	796	946	982	892	756	690
80%	666	662	664	674	675	735	820	970	1,024	906	765	699
90%	675	670	675	675	675	735	845	970	1,024	914	794	733
Maximum	675	675	675	675	675	735	845	970	1,024	978	894	837
Average	517	514	529	547	580	629	692	783	795	705	606	559

Table F.1-10b. WSE Results for Lake McClure Water Surface Elevations (feet msl) for LSJR Alternative 2: 20% Unimpaired Flow

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
Lake McClure Elevation (feet)												
20% Unimpaired												
Minimum	525	525	578	651	656	688	690	683	673	643	607	581
10%	712	707	708	720	732	740	755	762	755	740	728	719
20%	744	744	744	755	766	775	786	803	805	782	760	750
30%	759	758	765	771	784	791	803	812	811	795	775	766
40%	771	769	785	789	802	807	816	824	819	803	787	777
50%	792	792	794	798	806	813	819	829	830	820	804	798
60%	798	798	798	800	806	815	824	844	849	834	816	806
70%	802	802	802	803	806	817	828	853	858	844	821	809
80%	805	804	804	806	806	817	832	856	864	846	823	811
90%	806	805	806	806	806	817	836	856	864	847	828	817
Maximum	806	806	806	806	806	817	836	856	864	858	844	835
Average	771	770	773	777	785	795	807	823	824	808	789	779

Table F.1-10c shows the monthly cumulative distribution (range) for the WSE calculated Merced River target flows at Stevinson for LSJR Alternative 2. The target flow was below the assumed minimum flow of 150 cfs and was raised. None of the months had target flows that were above the assumed maximum of 2,000 cfs. The median target flows were 189 cfs in February, 265 cfs in March, 477 cfs in April, 792 cfs in May, and 491 cfs in June. Comparison to the baseline flows indicates that the target flows for LSJR Alternative 2 were less than the median baseline flows in February–April, and higher in May and June.

Table F.1-10c. Merced River Target Flows (cfs) for LSJR Alternative 2: 20% Unimpaired Flow

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
Merced Target Flow (cfs)												
Minimum	0	0	0	0	11	26	104	127	44	0	0	0
10%	0	0	0	0	66	118	269	330	145	0	0	0
20%	0	0	0	0	94	170	313	435	174	0	0	0
30%	0	0	0	0	119	194	378	566	276	0	0	0
40%	0	0	0	0	163	221	432	658	383	0	0	0
50%	0	0	0	0	189	265	477	792	491	0	0	0
60%	0	0	0	0	256	304	533	876	562	0	0	0
70%	0	0	0	0	377	376	576	946	691	0	0	0
80%	0	0	0	0	532	497	647	1,045	881	0	0	0
90%	0	0	0	0	724	545	728	1,261	1,127	0	0	0
Maximum	0	0	0	0	1,304	1,203	1,442	1,838	2,205	0	0	0
Average	0	0	0	0	305	329	494	784	574	0	0	0

Table F.1-10d shows the monthly cumulative distribution (range) for the WSE calculated Merced River flows at Stevinson for LSJR Alternative 2. The Merced River flows were generally changed only in the February-June period. The median monthly flows were 499 cfs in February, 265 cfs in March, 477 cfs in April, 792 cfs in May and 491 cfs in June. The cumulative distribution of monthly flows were higher than the target flows for the higher cumulative values, indicating that flood-control releases were required for LSJR Alternative 2 in about half of the years. LSJR Alternative 2 flows on the Merced River provided a more natural distribution of flows in February–June without changing the total volume of water released to the river.

Table F.1-8 shows the Merced River annual diversions for LSJR Alternative 2 ranged from 368 TAF (10 percent cumulative) to 592 TAF (90 percent cumulative) with a median annual diversion of 567 TAF and an average annual diversion of 517 TAF. The Merced River water supply deficits for LSJR Alternative 2 ranged from 8 TAF (10 percent) to 232 TAF (90 percent) with a median deficit of 33 TAF and an average deficit of 83 TAF. The average deficit was slightly (10 TAF) greater than the baseline conditions deficit.

Table F.1-10d. Merced River Flows at Stevinson (cfs) for LSJR Alternative 2: 20% Unimpaired Flow

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	Annual (TAF)
Merced at Stevinson Flow (cfs)													
Minimum	0	0	0	270	150	150	150	150	150	35	35	2	141
10%	266	313	323	330	150	150	269	330	150	68	54	31	183
20%	282	342	354	381	150	170	313	435	174	90	74	54	210
30%	308	364	375	395	175	194	378	566	276	117	100	69	233
40%	337	380	385	415	237	221	432	658	383	160	123	80	257
50%	372	387	399	457	499	265	477	792	491	175	159	92	308
60%	486	398	409	486	707	340	533	876	562	224	201	134	451
70%	655	411	433	618	964	583	576	955	713	304	811	445	631
80%	807	428	472	1,327	1,913	1,028	662	1,252	1,846	1,119	1,060	566	780
90%	1,099	636	1,181	1,891	3,191	1,651	753	2,420	2,825	2,209	1,233	640	1,064
Maximum	2,685	2,430	4,460	9,912	5,189	5,789	4,357	5,388	7,324	5,943	2,444	1,369	2,366
Average	565	467	648	942	1,080	719	569	1,039	1,029	701	473	271	513

Tuolumne River

Table F.1-10e shows the monthly cumulative distribution (range) for the WSE calculated New Don Pedro Reservoir storage (TAF) for LSJR Alternative 2. These monthly storage patterns are slightly different that the baseline conditions storage patterns because of different releases and different diversions from the reservoir. The median carryover storage was 1,409 TAF, very similar to the baseline median carryover storage of 1,377 TAF. Table F.1-10f shows the monthly cumulative distribution (range) for the WSE calculated New Don Pedro Reservoir surface water elevations (feet msl) for LSJR Alternative 2.

Table F.1-10e. WSE Results for New Don Pedro Storage (TAF) for LSJR Alternative 2: 20% Unimpaired Flow

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
New Don Pedro Storage (TAF)												
Minimum	420	417	473	625	746	809	806	741	652	556	481	448
10%	880	873	894	1,028	1,093	1,119	1,103	1,224	1,204	1,068	984	924
20%	1,103	1,098	1,125	1,167	1,274	1,388	1,420	1,456	1,468	1,325	1,192	1,132
30%	1,200	1,218	1,290	1,343	1,445	1,525	1,572	1,585	1,588	1,444	1,301	1,246
40%	1,268	1,295	1,381	1,448	1,560	1,653	1,672	1,689	1,632	1,472	1,370	1,317
50%	1,447	1,448	1,476	1,512	1,640	1,690	1,704	1,735	1,794	1,658	1,537	1,485
60%	1,495	1,504	1,559	1,577	1,690	1,690	1,718	1,769	1,875	1,781	1,635	1,554
70%	1,572	1,570	1,617	1,629	1,690	1,690	1,718	1,801	1,972	1,849	1,694	1,624
80%	1,612	1,634	1,649	1,683	1,690	1,690	1,718	1,914	2,030	1,900	1,750	1,668
90%	1,672	1,674	1,689	1,690	1,690	1,690	1,718	1,999	2,030	1,939	1,806	1,733
Maximum	1,690	1,690	1,690	1,690	1,690	1,690	1,718	2,002	2,030	2,030	1,973	1,773
Average	1,335	1,344	1,385	1,426	1,497	1,539	1,568	1,659	1,701	1,584	1,455	1,385

Table F.1-10f. WSE Results for New Don Pedro Water Surface Elevations (feet msl) for LSJR Alternative 2: 20% Unimpaired Flow

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
New Don Pedro Elevation (feet)												
20% Unimpaired												
Minimum	639	638	648	672	690	699	698	689	677	662	649	644
10%	708	707	710	727	735	738	736	750	747	732	721	714
20%	736	735	738	743	755	767	771	775	776	761	746	739
30%	747	749	757	763	773	782	786	788	788	773	758	752
40%	755	757	767	774	785	794	796	798	792	776	766	760
50%	774	774	777	780	793	798	799	802	808	795	783	778
60%	779	780	785	787	798	798	801	806	816	807	793	785
70%	786	786	791	792	798	798	801	809	824	813	798	792
80%	790	793	794	797	798	798	801	819	830	818	804	796
90%	796	796	798	798	798	798	801	827	830	821	809	802
Maximum	798	798	798	798	798	798	801	827	830	830	825	806
Average	760	761	765	770	778	782	785	794	797	786	772	765

Table F.1-10g shows the monthly cumulative distribution (range) for the WSE calculated Tuolumne River target flows at Modesto for LSJR Alternative 2. A few months had target flows below the assumed minimum of 200 cfs. None of the months had target flows that were above the assumed maximum of 3,500 cfs. The median target flows were 416 cfs in February, 514 cfs in March, 901 cfs in April, 1,469 cfs in May, and 1,129 cfs in June.

Table F.1-10g. Tuolumne River Target Flows (cfs) for LSJR Alternative 2: 20% Unimpaired Flow

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
Tuolumne Target Flow (cfs)												
Minimum	0	0	0	0	29	75	266	345	57	0	0	0
10%	0	0	0	0	146	275	542	694	301	0	0	0
20%	0	0	0	0	217	377	626	947	456	0	0	0
30%	0	0	0	0	252	418	740	1,124	742	0	0	0
40%	0	0	0	0	302	471	830	1,232	969	0	0	0
50%	0	0	0	0	416	514	901	1,469	1,129	0	0	0
60%	0	0	0	0	513	572	985	1,614	1,343	0	0	0
70%	0	0	0	0	606	690	1,074	1,748	1,495	0	0	0
80%	0	0	0	0	831	833	1,162	1,870	1,785	0	0	0
90%	0	0	0	0	1,111	1,103	1,294	2,142	2,009	0	0	0
Maximum	0	0	0	0	2,218	1,883	2,218	3,123	3,415	0	0	0
Average	0	0	0	0	526	618	920	1,452	1,183	0	0	0

Table F.1-10h shows the monthly cumulative distribution (range) for the WSE calculated Tuolumne River flows at Modesto for LSJR Alternative 2. The Tuolumne River flows were generally changed only in the February–June period. The cumulative distribution of monthly flows were higher than the target flows, indicating that flood-control releases were required in about half of the years. The median monthly flows were 578 cfs in February, 825 cfs in March, 1,031 cfs in April, 1,469 cfs in May, and 1,129 cfs in June. The LSJR Alternative 2 flows on the Tuolumne River provided a more natural distribution of flows February–June without changing the total volume of water released to the river.

Table F.1-8 indicates the Tuolumne River annual diversions for LSJR Alternative 2 ranged from 613 TAF (10 percent cumulative) to 1,034 TAF (90 percent cumulative) with a median annual diversion of 938 TAF and an average annual diversion of 879 TAF. The Tuolumne River water supply deficits for LSJR Alternative 2 ranged from 66 TAF (10 percent) to 487 TAF (90 percent) with a median deficit of 162 TAF and an average deficit of 221 TAF. The average deficit was slightly (6 TAF) greater than the baseline conditions deficit.

Table F.1-10h. Tuolumne River Flows at Modesto (cfs) for LSJR Alternative 2: 20% Unimpaired Flow

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	Annual (TAF)
Tuolumne at Modesto Flow(cfs)													
Minimum	194	208	217	208	200	200	266	345	200	169	167	153	185
10%	285	248	257	316	200	322	542	694	301	237	257	243	319
20%	390	331	327	427	220	411	632	947	456	299	326	323	368
30%	459	400	415	436	280	464	746	1,124	742	339	349	353	422
40%	482	449	439	518	397	585	902	1,232	969	378	379	369	478
50%	547	466	477	581	675	1,071	1,039	1,469	1,149	427	402	411	557
60%	654	494	531	620	892	1,721	1,252	1,614	1,400	536	485	515	828
70%	713	576	600	757	1,550	3,070	1,685	1,748	1,680	600	553	577	1,117
80%	751	644	743	1,670	3,037	3,417	2,492	1,870	2,723	1,066	568	596	1,379
90%	1,158	831	1,847	3,602	4,891	4,362	2,825	2,162	6,331	3,479	618	721	1,791
Maximum	3,175	5,945	8,050	17,734	7,183	9,186	7,800	6,054	13,584	8,340	2,862	4,008	3,794
Average	660	636	909	1,393	1,562	1,934	1,499	1,561	2,130	1,119	476	557	871

Stanislaus River

Table F.1-10i shows the monthly cumulative distribution (range) for the WSE model calculated New Melones Reservoir storage (TAF) for LSJR Alternative 2. These monthly storage patterns are slightly different than the baseline conditions patterns because of different February–June releases and different annual water supply diversions from the reservoir. The median storage values are about 200 TAF higher than the baseline storage because the river release flows were reduced. The median carryover storage was 1,424 TAF, compared to the baseline median carryover storage of 1,242 TAF. Table F.1-10j shows the monthly cumulative distributions (range) for the WSE model calculated New Melones Reservoir surface water elevations (feet msl) for LSJR Alternative 2.

Table F.1-10i. WSE Results for New Melones Storage (TAF) for LSJR Alternative 2: 20% Unimpaired Flow

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
New Melones												
Minimum	40	39	56	112	118	164	222	169	130	91	55	50
10%	494	499	499	565	579	606	582	544	631	606	559	534
20%	698	691	714	731	849	910	965	965	939	853	776	732
30%	981	1,001	1,023	1,071	1,122	1,106	1,077	1,139	1,200	1,147	1,076	1,038
40%	1,120	1,177	1,204	1,236	1,262	1,311	1,310	1,405	1,404	1,307	1,219	1,173
50%	1,357	1,363	1,446	1,514	1,566	1,617	1,662	1,685	1,633	1,575	1,478	1,424
60%	1,489	1,506	1,562	1,677	1,749	1,827	1,830	1,832	1,792	1,694	1,600	1,554
70%	1,705	1,726	1,754	1,811	1,880	1,889	1,919	1,952	2,002	1,913	1,827	1,774
80%	1,854	1,850	1,874	1,899	1,950	1,960	2,007	2,067	2,113	2,063	1,966	1,910
90%	1,914	1,915	1,921	1,941	1,970	2,030	2,089	2,202	2,327	2,252	2,116	1,996
Maximum	1,932	1,939	1,970	1,970	1,970	2,030	2,220	2,420	2,420	2,300	2,130	2,000
Average	1,258	1,267	1,297	1,347	1,393	1,433	1,458	1,512	1,533	1,459	1,369	1,314

Table F.1-10j. WSE Results for New Melones Water Surface Elevations (feet msl) for LSJR Alternative 2: 20% Unimpaired Flow

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
New Melones Elevation (feet)												
20% Unimpaired												
Minimum	678	676	693	733	736	759	782	761	742	720	693	688
10%	857	858	858	872	874	880	875	867	884	880	870	865
20%	896	895	899	902	921	930	938	938	934	921	909	902
30%	940	943	946	952	959	957	953	961	969	962	953	948
40%	958	966	969	973	976	982	982	992	992	981	971	965
50%	987	988	997	1,004	1,010	1,015	1,019	1,021	1,016	1,010	1,000	994
60%	1,001	1,003	1,009	1,021	1,028	1,035	1,035	1,035	1,032	1,022	1,013	1,008
70%	1,023	1,025	1,028	1,033	1,040	1,041	1,043	1,046	1,051	1,043	1,035	1,030
80%	1,037	1,037	1,039	1,042	1,046	1,047	1,051	1,056	1,060	1,056	1,048	1,043
90%	1,043	1,043	1,044	1,045	1,048	1,053	1,058	1,068	1,078	1,072	1,060	1,050
Maximum	1,045	1,045	1,048	1,048	1,048	1,053	1,069	1,085	1,085	1,076	1,062	1,051
Average	961	962	966	974	979	984	987	993	994	985	975	968

Table F.1-10k shows the monthly cumulative distribution (range) for the WSE calculated Stanislaus River target flows at Ripon for LSJR Alternative 2. Some months had target flows below the assumed minimum of 150 cfs. None of the months had target flows that were above the assumed maximum of 2,500 cfs. The median target flows were 256 cfs in February, 340 cfs in March, 649 cfs in April, 909 cfs in May, and 551 cfs in June. Comparison to the baseline flows indicates that the target flows for LSJR Alternative 2 were considerably less than the median baseline conditions flows.

Table F.1-10k. Stanislaus River Target Flows (cfs) for LSJR Alternative 2: 20% Unimpaired Flow

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
Stanislaus Target Flow (cfs)												
Minimum	0	0	0	0	4	42	118	143	37	0	0	0
10%	0	0	0	0	83	164	337	326	138	0	0	0
20%	0	0	0	0	111	230	414	529	195	0	0	0
30%	0	0	0	0	160	264	504	604	319	0	0	0
40%	0	0	0	0	198	314	579	770	420	0	0	0
50%	0	0	0	0	256	340	649	909	551	0	0	0
60%	0	0	0	0	350	403	698	1,052	646	0	0	0
70%	0	0	0	0	389	464	774	1,156	732	0	0	0
80%	0	0	0	0	461	523	856	1,273	836	0	0	0
90%	0	0	0	0	704	760	926	1,432	1,114	0	0	0
Maximum	0	0	0	0	1,916	1,350	1,455	1,935	2,124	0	0	0
Average	0	0	0	0	342	416	645	918	591	0	0	0

Table F.1-10l shows the monthly cumulative distribution (range) for the WSE calculated Stanislaus River flows at Ripon for LSJR Alternative 2. The Stanislaus River flows were generally changed only in the February–June period. The cumulative monthly flows were higher than the target flows, indicating that flood-control releases were required in some years. The median monthly flows were 788 cfs in February, 727 cfs in March, 725 cfs in April, 909 cfs in May, and 552 cfs in June. LSJR Alternative 2 target flows on the Stanislaus River provided a more natural distribution of flows in February–June but were 50 TAF/y lower than the baseline.

Table F.1-8 indicates the Stanislaus River annual diversions for LSJR Alternative 2 from 483 TAF (10 percent cumulative) to 746 TAF (90 percent cumulative) with a median annual diversion of 705 TAF and an average annual diversion of 649 TAF. The Stanislaus River water supply deficits for LSJR Alternative 2 ranged from 4 TAF (10 percent) to 267 TAF (90 percent) with a median deficit of 45 TAF and an average deficit of 101 TAF. The average deficit was 72 TAF smaller than the average baseline conditions deficit and about 13 percent of the assumed maximum diversion.

Table F.1-10l. Stanislaus River Flows at Ripon (cfs) for LSJR Alternative 2: 20% Unimpaired Flow

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	Annual (TAF)
Stanislaus at Ripon Flow (cfs)													
Minimum	103	126	200	158	342	247	313	270	150	236	185	9	234
10%	496	285	250	216	389	382	463	511	234	363	365	312	338
20%	613	301	286	259	479	446	567	551	328	415	380	363	373
30%	983	326	311	296	611	521	627	641	387	432	393	393	401
40%	1,016	350	327	314	704	625	697	770	454	438	414	422	415
50%	1,076	367	352	337	788	727	725	909	552	448	439	434	436
60%	1,172	380	357	354	898	784	800	1,052	657	457	439	437	454
70%	1,217	430	386	389	959	920	855	1,156	775	509	460	479	476
80%	1,296	470	456	472	1,050	1,032	908	1,273	1,013	585	516	544	545
90%	1,380	546	512	743	1,871	1,340	1,017	1,432	1,357	922	900	1,620	886
Maximum	2,256	3,321	5,140	10,528	4,354	5,846	2,318	2,609	5,543	4,507	2,693	3,113	2,393
Average	1,042	448	493	647	961	912	759	950	776	640	585	616	533

San Joaquin River at Vernalis

Table F.1-10m shows the monthly cumulative distribution (range) for the WSE calculated SJR at Vernalis flows for LSJR Alternative 2. The SJR at Vernalis flows were generally changed only in the February–June period. The median monthly SJR at Vernalis flows were 3,861 cfs in February, 3,179 cfs in March, 3,364 cfs in April, 4,403 cfs in May, and 2,972 cfs in June. LSJR Alternative 2 provided a more natural distribution of flows in February–June, although the annual average flow was about 65 TAF less (5 percent) than the average baseline conditions flow.

Table F.1-10m. SJR Flows at Vernalis (cfs) for LSJR Alternative 2: 20% Unimpaired Flow

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	Annual (TAF)
SJR at Vernalis Flow(cfs)													
Minimum	849	1,218	1,362	1,192	1,772	1,284	1,301	1,346	615	553	553	743	925
10%	1,628	1,688	1,692	1,603	2,060	1,836	1,811	1,965	1,124	1,010	1,086	1,470	1,241
20%	2,216	1,814	1,803	1,776	2,157	2,009	2,094	2,517	1,460	1,263	1,289	1,670	1,491
30%	2,378	1,937	1,928	1,970	2,274	2,326	2,454	2,981	1,845	1,340	1,384	1,765	1,654
40%	2,558	2,011	1,997	2,190	2,633	2,596	2,772	3,514	2,486	1,480	1,469	1,850	1,765
50%	2,785	2,104	2,089	2,366	3,861	3,179	3,364	4,403	2,972	1,657	1,550	1,951	2,091
60%	3,184	2,276	2,213	2,586	4,756	5,027	3,936	5,127	3,491	1,865	1,781	2,394	2,649
70%	3,402	2,448	2,411	3,599	5,974	6,569	4,600	5,702	4,030	2,137	2,401	2,523	3,255
80%	3,642	2,815	3,008	5,811	8,597	8,197	6,434	6,418	6,801	3,544	2,824	2,783	4,392
90%	4,238	3,158	4,545	11,135	15,354	13,390	11,387	12,107	13,413	7,668	3,965	3,956	5,674
Maximum	7,564	16,851	24,108	62,448	30,810	40,878	24,744	25,505	37,737	25,185	9,146	7,945	15,474
Average	2,974	2,578	3,407	4,941	6,319	6,101	4,896	5,665	5,252	3,299	2,113	2,431	3,015

LSJR Alternative 3: 40% Unimpaired Flow

The Water Supply Effects (WSE) model was used to modify the tributary flows to meet LSJR Alternative 3 flow objectives. The February-June flows were equal to the monthly flow objectives (or higher if flood-control releases are necessary). The reservoir storage and water supply diversions were adjusted to satisfy these monthly flow objectives for each tributary river. Flood releases in many years were reduced or eliminated because higher flows were released in February, March and April to satisfy the flow objectives. Water supply diversions (annual volume) were reduced in some years to satisfy the LSJR Alternative 3 flow objectives. The impact assessment was based on the comparison of the modified flows with the baseline conditions flows.

Merced River

Table F.1-11a shows the monthly cumulative distribution (range) for the WSE calculated Lake McClure storage (TAF) for LSJR Alternative 3. These monthly storage patterns are slightly different than the baseline storage patterns because of different releases and different diversions from the reservoir. The median carryover storage was 564 TAF, about 26 TAF lower than the baseline median carryover storage of 538 TAF. Table F.1-11b shows the monthly cumulative distributions (range) for the WSE calculated Lake McClure surface water elevations (feet msl) for LSJR Alternative 3.

Table F.1-11a. WSE Results for Lake McClure Storage (TAF) for LSJR Alternative 3: 40% Unimpaired Flow

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
Lake McClure Storage (TAF)												
Minimum	54	38	54	121	115	174	205	226	199	144	97	75
10%	252	246	239	273	306	338	393	420	388	328	278	268
20%	368	366	365	382	405	438	486	551	575	492	433	397
30%	403	393	417	468	498	542	563	617	603	537	458	428
40%	463	459	512	525	611	659	670	697	652	585	511	480
50%	535	541	557	584	644	681	713	737	725	658	583	564
60%	583	581	585	611	660	700	740	812	818	744	661	612
70%	614	621	625	633	675	725	763	869	898	814	698	647
80%	666	661	661	669	675	735	789	894	981	882	763	702
90%	675	675	675	675	675	735	811	969	1,024	921	793	733
Maximum	675	675	675	675	675	735	845	970	1,024	948	871	817
Average	496	494	504	523	559	602	647	717	728	655	569	529

Table F.1-11b. WSE Results for Lake McClure Water Surface Elevation (feet msl) for LSJR Alternative 3: 40% Unimpaired Flow

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
Lake McClure Elevation (feet)												
40% Unimpaired												
Minimum	616	602	616	655	652	678	689	697	688	665	643	630
10%	706	704	701	712	722	731	746	752	744	728	714	711
20%	739	739	738	743	749	757	768	782	787	769	755	747
30%	748	746	751	764	770	780	784	795	792	779	761	754
40%	762	761	773	776	794	803	805	811	802	789	773	766
50%	779	780	783	789	800	807	813	818	815	803	788	784
60%	788	788	789	794	804	811	818	831	832	819	804	794
70%	795	796	797	798	806	816	822	840	845	831	811	801
80%	805	804	804	805	806	817	827	844	858	842	822	811
90%	806	806	806	806	806	817	831	856	864	849	827	817
Maximum	806	806	806	806	806	817	836	856	864	853	841	832
Average	766	765	767	772	780	790	798	811	812	798	781	773

Table F.1-11c shows the monthly cumulative distribution (range) for the WSE calculated Merced River target flows at Stevinson for LSJR Alternative 3. Very few months had target flows below the assumed minimum of 150 cfs. A few months had target flows that were above the assumed maximum of 2,000 cfs. The median target flows were 379 cfs in February, 530 cfs in March, 955 cfs in April, 1,584 cfs in May, and 981 cfs in June. Comparison to the baseline flows indicates that the target flows for LSJR Alternative 3 were slightly lower than the median baseline flows in February, about two times as high in March–May and four times as high in June.

Table F.1-11c. Merced River Target Flows (cfs) for LSJR Alternative 3: 40% Unimpaired Flow

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
Merced Target Flow (cfs)												
Minimum	0	0	0	0	22	52	208	254	87	0	0	0
10%	0	0	0	0	133	237	538	660	290	0	0	0
20%	0	0	0	0	189	340	627	870	348	0	0	0
30%	0	0	0	0	238	388	757	1,131	553	0	0	0
40%	0	0	0	0	325	441	863	1,317	766	0	0	0
50%	0	0	0	0	379	530	955	1,584	981	0	0	0
60%	0	0	0	0	513	609	1,066	1,751	1,124	0	0	0
70%	0	0	0	0	755	753	1,152	1,892	1,383	0	0	0
80%	0	0	0	0	1,064	994	1,295	2,091	1,761	0	0	0
90%	0	0	0	0	1,449	1,090	1,456	2,521	2,255	0	0	0
Maximum	0	0	0	0	2,607	2,407	2,884	3,675	4,410	0	0	0
Average	0	0	0	0	609	657	989	1,568	1,148	0	0	0

Table F.1-11d shows the monthly cumulative distribution (range) for the WSE calculated Merced River flows at Stevinson for LSJR Alternative 3. The median monthly flows were 551 cfs in February, 530 cfs in March, 955 cfs in April, 1,584 cfs in May, and 981 cfs in June. The cumulative distribution of monthly flows were higher than the target flows for the higher flows, indicating that flood-control releases were required for LSJR Alternative 3 in about 20 percent of the years. The LSJR Alternative flows on the Merced River provided a more natural distribution of flows in February–June and increased the total volume of water released to the river by about 100 TAF.

Table F.1-8 shows that the Merced River annual diversions for LSJR Alternative 3 ranged from 292 TAF (10 percent cumulative) to 529 TAF (90 percent cumulative) with a median annual diversion of 477 TAF and an average annual diversion of 440 TAF. The Merced River water supply deficits for LSJR Alternative 3 ranged from 71 TAF (10 percent) to 308 TAF (90 percent) with a median deficit of 123 TAF and an average deficit of 160 TAF. The average deficit was 87 TAF greater than the average baseline deficit, and about 27 percent of the assumed maximum diversion.

Table F.1-11d. Merced River Flows at Stevinson (cfs) for LSJR Alternative 3: 40% Unimpaired Flow

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	Annual (TAF)
Merced at Stevinson Flow (cfs)													
Minimum	206	258	274	270	150	150	208	254	150	35	35	2	161
10%	266	316	331	330	152	237	538	660	290	68	54	31	241
20%	283	350	359	377	203	340	627	870	348	90	74	54	299
30%	309	366	380	393	261	388	757	1,131	553	117	100	69	335
40%	346	382	388	413	363	441	863	1,317	766	160	123	80	362
50%	364	388	404	442	551	530	955	1,584	981	175	159	92	438
60%	452	400	415	483	772	609	1,066	1,751	1,124	224	201	134	563
70%	607	414	435	618	1,063	815	1,152	1,892	1,383	304	811	445	698
80%	808	431	503	1,326	1,676	1,063	1,295	2,000	1,853	1,119	1,060	566	892
90%	1,106	596	1,162	1,892	2,823	1,439	1,456	2,228	2,485	2,209	1,233	640	1,049
Maximum	2,383	2,062	4,464	9,912	5,117	5,817	4,484	5,552	7,498	5,943	2,444	1,369	2,432
Average	558	457	649	936	1,036	846	1,012	1,571	1,297	701	473	271	592

Tuolumne River

The SFPUC water bank in New Don Pedro allows the SFPUC upstream reservoirs and aqueduct diversions to continue to operate during low flow conditions. LSJR Alternative 3 was assumed to not change these upstream SFPUC operations.

Table F.1-11e shows the monthly cumulative distribution (range) for the WSE calculated New Don Pedro Reservoir storage (TAF) for LSJR Alternative 3. These monthly storage patterns are slightly different that the baseline storage patterns because of different releases and different diversions from the reservoir. The median carryover storage was 1,352 TAF, very similar to the baseline median carryover storage of 1,377 TAF. Table F.1-11f compares the cumulative distribution of New Don Pedro carryover storage to the baseline carryover storage.

Table F.1-11e. WSE Results for New Don Pedro Storage (TAF) for LSJR Alternative 3: 40% Unimpaired Flow

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
New Don Pedro Storage (TAF)												
Minimum	504	502	559	634	659	695	714	715	697	616	554	528
10%	857	867	911	954	1,041	1,044	1,059	1,014	1,094	996	914	879
20%	1,044	1,040	1,065	1,105	1,165	1,277	1,295	1,309	1,310	1,200	1,115	1,071
30%	1,126	1,136	1,216	1,285	1,332	1,395	1,408	1,405	1,389	1,296	1,192	1,150
40%	1,184	1,213	1,304	1,361	1,497	1,565	1,536	1,532	1,495	1,374	1,262	1,211
50%	1,317	1,340	1,409	1,472	1,575	1,655	1,650	1,623	1,657	1,527	1,402	1,352
60%	1,433	1,437	1,495	1,540	1,648	1,690	1,685	1,676	1,711	1,671	1,547	1,485
70%	1,517	1,541	1,584	1,611	1,690	1,690	1,718	1,714	1,805	1,716	1,604	1,556
80%	1,595	1,614	1,638	1,679	1,690	1,690	1,718	1,822	1,939	1,841	1,712	1,645
90%	1,690	1,679	1,690	1,690	1,690	1,690	1,718	1,921	2,030	1,952	1,846	1,773
Maximum	1,690	1,690	1,690	1,690	1,690	1,690	1,718	2,002	2,030	2,030	1,946	1,773
Average	1,286	1,298	1,341	1,386	1,451	1,491	1,502	1,544	1,571	1,486	1,383	1,328

Table F.1-11f. WSE Results for New Don Pedro Water Surface Elevation (feet msl) for LSJR Alternative 3: 40% Unimpaired Flow

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
New Don Pedro Elevation (feet)												
40% Unimpaired												
Minimum	653	653	662	674	678	683	686	686	683	671	661	657
10%	705	706	712	718	728	729	731	725	735	723	713	708
20%	729	728	731	736	743	755	758	759	759	747	737	732
30%	738	740	749	756	761	768	770	769	768	758	746	741
40%	745	748	758	765	779	786	783	782	779	766	754	748
50%	760	762	770	776	787	795	794	792	795	782	769	764
60%	772	773	779	783	794	798	798	797	800	796	784	778
70%	781	783	788	790	798	798	801	800	809	801	790	785
80%	789	791	793	797	798	798	801	811	821	812	800	794
90%	798	797	798	798	798	798	801	820	830	823	813	806
Maximum	798	798	798	798	798	798	801	827	830	830	822	806
Average	754	756	760	766	773	777	778	782	784	775	765	759

Table F.1-11g shows the monthly cumulative distribution (range) for the WSE calculated Tuolumne River target flows at Modesto for LSJR Alternative 3. A few months had target flows below the assumed minimum of 200 cfs. A few months had target flows that were above the assumed maximum of 3,500 cfs. The median target flows were 832 cfs in February, 1,028 cfs in March, 1,802 cfs in April, 2,937 cfs in May, and 2,259 cfs in June. These target flows for LSJR Alternative 3 were considerably higher than the median baseline flows.

Table F.1-11g. Tuolumne River Target Flows (cfs) for LSJR Alternative 3: 40% Unimpaired Flow

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
Tuolumne Target Flow (cfs)												
Minimum	0	0	0	0	58	150	531	690	114	0	0	0
10%	0	0	0	0	292	550	1,084	1,388	602	0	0	0
20%	0	0	0	0	434	753	1,252	1,894	913	0	0	0
30%	0	0	0	0	504	837	1,481	2,248	1,485	0	0	0
40%	0	0	0	0	604	942	1,659	2,464	1,939	0	0	0
50%	0	0	0	0	832	1,028	1,802	2,937	2,259	0	0	0
60%	0	0	0	0	1,027	1,145	1,971	3,228	2,686	0	0	0
70%	0	0	0	0	1,211	1,380	2,147	3,496	2,990	0	0	0
80%	0	0	0	0	1,662	1,667	2,325	3,741	3,571	0	0	0
90%	0	0	0	0	2,223	2,206	2,588	4,284	4,018	0	0	0
Maximum	0	0	0	0	4,437	3,767	4,437	6,245	6,830	0	0	0
Average	0	0	0	0	1,051	1,236	1,840	2,903	2,365	0	0	0

Table F.1-11h shows the monthly cumulative distribution (range) for the WSE calculated Tuolumne River flows at Modesto for LSJR Alternative 3. The cumulative distribution of monthly flows were higher than the target flows, indicating that flood-control releases were required in about half of the years. The median monthly flows for LSJR Alternative 3 were 1,091 cfs in February, 1,324 cfs in March, 1,934 cfs in April, 2,937 cfs in May and 2,259 cfs in June. The LSJR Alternative 3 flows on the Tuolumne River provided a more natural distribution of flows in February–June and increased the total volume of water released to the river by 230 TAF.

Table F.1-8 indicates the Tuolumne River annual diversions for LSJR Alternative 3 ranged from 491 TAF (10 percent cumulative) to 874 TAF (90 percent cumulative) with a median annual diversion of 761 TAF and an average annual diversion of 712 TAF. The Tuolumne River water supply deficits for LSJR Alternative 3 ranged from 226 TAF (10 percent) to 609 TAF (90 percent) with a median deficit of 339 TAF and an average deficit of 388 TAF. The average deficit was 173 TAF greater than the average baseline deficit and about 35 percent of the assumed maximum diversion.

Table F.1-11h. Tuolumne River Flows at Modesto (cfs) for LSJR Alternative 3: 40% Unimpaired Flow

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	Annual (TAF)
Tuolumne at Modesto Flow(cfs)													
Minimum	194	206	217	208	200	200	531	690	200	169	167	153	243
10%	285	246	257	316	292	550	1,084	1,388	602	237	257	243	443
20%	390	324	327	427	439	809	1,264	1,894	913	299	326	323	554
30%	459	382	412	436	560	921	1,492	2,248	1,485	339	349	353	620
40%	482	447	437	518	749	1,056	1,683	2,464	1,939	378	379	369	688
50%	547	460	469	570	1,091	1,324	1,934	2,937	2,259	418	402	409	831
60%	628	479	529	610	1,401	1,942	2,124	3,228	2,686	523	485	511	998
70%	721	559	599	699	1,870	2,905	2,344	3,496	2,990	576	553	574	1,265
80%	1,000	628	739	1,747	3,226	3,351	2,651	3,500	3,500	1,066	568	595	1,525
90%	1,264	794	1,878	3,659	4,845	4,126	3,200	3,500	6,753	3,479	618	1,022	1,868
Maximum	3,175	5,959	7,482	17,734	6,735	9,282	8,105	6,457	13,779	8,340	2,862	2,735	3,983
Average	690	595	907	1,380	1,751	2,102	2,103	2,761	2,805	1,118	476	563	1,041

Stanislaus River

Table F.1-11i shows the monthly cumulative distribution (range) for the WSE calculated New Melones Reservoir storage (TAF) for LSJR Alternative 3. The median carryover storage was 1,282 TAF, about 40 TAF higher than the Baseline median carryover storage of 1,242 TAF. Table F.1-11j shows the monthly cumulative distributions (range) for the WSE calculated New Melones Reservoir surface water elevations (feet msl) for LSJR Alternative 3.

Table F.1-11i. WSE Results for New Melones Storage (TAF) for LSJR Alternative 3: 40% Unimpaired Flow

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
New Melones Storage (TAF)												
Minimum	76	76	86	123	139	178	226	166	142	116	91	93
10%	400	401	408	469	523	565	534	464	484	462	428	411
20%	615	620	646	691	751	796	814	847	823	739	680	646
30%	807	827	869	904	943	961	943	946	977	938	875	850
40%	950	971	1,038	1,103	1,174	1,194	1,156	1,120	1,165	1,110	1,045	1,004
50%	1,207	1,203	1,303	1,381	1,415	1,432	1,473	1,472	1,458	1,374	1,327	1,282
60%	1,351	1,364	1,377	1,473	1,564	1,599	1,605	1,656	1,638	1,541	1,453	1,402
70%	1,449	1,479	1,534	1,607	1,685	1,720	1,699	1,726	1,713	1,639	1,555	1,511
80%	1,674	1,678	1,690	1,697	1,799	1,829	1,800	1,871	1,918	1,874	1,785	1,745
90%	1,726	1,735	1,762	1,839	1,881	1,980	2,019	2,015	2,019	1,945	1,873	1,794
Maximum	1,921	1,921	1,931	1,957	1,970	2,030	2,083	2,306	2,420	2,300	2,130	1,993
Average	1,122	1,132	1,165	1,220	1,270	1,313	1,316	1,334	1,345	1,289	1,216	1,172

Table F.1-11j. WSE Results for New Melones Water Surface Elevation (feet msl) for LSJR Alternative 3: 40% Unimpaired Flow

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
New Melones Elevation (feet)												
40% Unimpaired												
Minimum	709	709	716	739	747	765	783	759	749	735	720	721
10%	835	835	837	851	863	872	865	850	855	850	842	838
20%	881	882	887	895	905	913	915	920	917	903	893	887
30%	914	917	924	929	935	937	935	935	940	934	925	921
40%	936	939	948	956	965	968	963	959	964	957	949	943
50%	969	969	981	990	993	995	1,000	1,000	998	989	984	978
60%	986	988	989	1,000	1,009	1,013	1,013	1,018	1,017	1,007	998	992
70%	997	1,000	1,006	1,014	1,021	1,025	1,023	1,025	1,024	1,017	1,008	1,004
80%	1,020	1,021	1,022	1,023	1,032	1,035	1,032	1,039	1,043	1,039	1,031	1,027
90%	1,025	1,026	1,029	1,036	1,040	1,049	1,052	1,052	1,052	1,046	1,039	1,032
Maximum	1,043	1,044	1,044	1,047	1,048	1,053	1,058	1,076	1,085	1,076	1,062	1,050
Average	945	946	951	959	965	971	971	972	973	966	957	951

Table F.1-11k shows the monthly cumulative distribution (range) for the WSE calculated Stanislaus River target flows at Ripon for LSJR Alternative 3. A few months had target flows below the assumed minimum of 150 cfs. Several months had target flows that were above the assumed maximum of 2,500 cfs. The median target flows were 511 cfs in February, 680 cfs in March, 1,297 cfs in April, 1,818 cfs in May, and 1,102 cfs in June. Comparison to the baseline flows indicates that the target flows for LSJR Alternative 3 were similar in February and March, but higher than the median baseline flows in April, May, and June.

Table F.1-11k. Stanislaus River Target Flows (cfs) for LSJR Alternative 3: 40% Unimpaired Flow

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
Stanislaus Target Flow (cfs)												
Minimum	0	0	0	0	7	85	235	286	74	0	0	0
10%	0	0	0	0	166	328	674	651	276	0	0	0
20%	0	0	0	0	222	459	828	1,058	390	0	0	0
30%	0	0	0	0	319	529	1,009	1,208	638	0	0	0
40%	0	0	0	0	396	627	1,159	1,539	840	0	0	0
50%	0	0	0	0	511	680	1,297	1,818	1,102	0	0	0
60%	0	0	0	0	699	807	1,396	2,104	1,292	0	0	0
70%	0	0	0	0	778	928	1,549	2,312	1,464	0	0	0
80%	0	0	0	0	921	1,046	1,711	2,546	1,671	0	0	0
90%	0	0	0	0	1,409	1,520	1,852	2,864	2,227	0	0	0
Maximum	0	0	0	0	3,832	2,700	2,911	3,871	4,248	0	0	0
Average	0	0	0	0	685	832	1,290	1,836	1,181	0	0	0

Table F.1-11l shows the monthly cumulative distribution (range) for the WSE calculated Stanislaus River flows at Ripon for LSJR Alternative 3. The monthly flows were higher than the target flows for some of the higher cumulative distribution values, indicating that flood-control releases were required in some years. The median monthly flows were 788 cfs in February, 774 cfs in March, 1,297 cfs in April, 1,818 cfs in May, and 1,102 cfs in June. LSJR Alternative 3 flows on the Stanislaus River provided a more natural distribution of flows in February–June and were generally similar to the annual baseline flows

Table F.1-8 indicates the Stanislaus River annual diversions for LSJR Alternative 3 ranged from 390 TAF (10 percent cumulative) to 716 TAF (90 percent cumulative), with a median annual diversion of 608 TAF and an average annual diversion of 569 TAF. The Stanislaus River water supply deficits for LSJR Alternative 3 ranged from 34 TAF (10 percent) to 360 TAF (90 percent) with a median deficit of 142 TAF and an average deficit of 181 TAF. The average deficit was slightly (8 TAF) greater than the average baseline deficit.

Table F.1-11l. Stanislaus River Flows at Ripon (cfs) for LSJR Alternative 3: 40% Unimpaired Flow

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	Annual (TAF)
Stanislaus at Ripon Flow (cfs)													
Minimum	103	126	200	158	317	329	471	286	150	236	185	9	271
10%	496	285	250	216	414	483	674	651	284	363	365	312	384
20%	613	301	286	259	511	541	828	1,058	421	415	380	363	436
30%	983	326	311	296	616	620	1,009	1,208	638	432	393	393	459
40%	1,016	350	327	314	686	664	1,159	1,539	840	438	414	422	518
50%	1,076	367	352	335	774	745	1,297	1,818	1,102	448	439	434	579
60%	1,172	380	357	350	815	824	1,396	2,104	1,292	457	439	437	615
70%	1,217	430	386	381	912	996	1,549	2,312	1,464	509	460	479	669
80%	1,296	470	456	454	1,196	1,177	1,711	2,500	1,671	585	510	544	729
90%	1,380	546	512	571	1,543	1,637	1,852	2,500	2,227	689	592	668	844
Maximum	2,256	3,321	5,140	8,184	2,832	4,480	2,500	2,500	4,357	4,645	2,705	3,113	2,237
Average	1,042	448	469	584	894	933	1,290	1,719	1,162	572	524	560	615

San Joaquin River at Vernalis

Table F.1-11m shows the monthly cumulative distribution (range) for the WSE calculated SJR at Vernalis flows for LSJR Alternative 3. The median monthly SJR at Vernalis flows were 3,764 cfs in February, 3,762 cfs in March, 5,226 cfs in April, 7,703 cfs in May, and 5,121 cfs in June. These median Vernalis flows were similar to the baseline flows in February–April but were about 2,500 cfs more in May and June. LSJR Alternative 3 provided a more natural distribution of flows in February–June, and the annual average flow volume was 265 TAF/y more than the average baseline flow volume at Vernalis (8 percent higher).

Table F.1-11m. SJR Flows at Vernalis (cfs) for LSJR Alternative 3: 40% Unimpaired Flow

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	Annual (TAF)
SJR at Vernalis Flow (cfs)													
Minimum	849	1,218	1,362	1,192	1,772	1,284	1,374	1,582	716	553	553	743	1,015
10%	1,628	1,688	1,692	1,603	2,087	1,907	2,708	3,117	1,598	1,010	1,086	1,470	1,426
20%	2,187	1,814	1,803	1,776	2,160	2,517	3,223	4,427	2,153	1,263	1,289	1,670	1,799
30%	2,375	1,937	1,928	1,962	2,436	2,850	3,888	5,231	3,148	1,340	1,384	1,765	1,998
40%	2,533	2,011	1,997	2,169	2,729	3,218	4,856	6,154	4,257	1,480	1,469	1,850	2,156
50%	2,730	2,104	2,067	2,330	3,764	3,762	5,226	7,703	5,121	1,657	1,550	1,951	2,590
60%	3,072	2,276	2,172	2,463	5,124	5,472	5,957	8,632	6,019	1,865	1,781	2,237	3,163
70%	3,320	2,445	2,427	3,599	6,931	6,834	6,764	9,155	6,693	2,137	2,401	2,523	3,664
80%	3,664	2,763	2,880	5,657	8,798	8,892	7,940	9,911	8,257	3,544	2,796	2,785	4,683
90%	4,475	2,985	4,545	11,384	14,529	12,951	11,867	14,597	13,518	7,297	3,119	3,678	5,829
Maximum	7,697	17,125	24,109	60,104	30,747	39,636	25,357	25,962	36,921	25,672	9,158	8,277	15,572
Average	2,989	2,522	3,376	4,859	6,397	6,417	6,473	8,166	6,581	3,229	2,052	2,381	3,345

LSJR Alternative 4: 60% Unimpaired Flow

The Water Supply Effects model was used to modify the tributary flows to meet LSJR Alternative 4 flow objectives. The February–June flows were equal to the monthly flow objectives (or higher if flood-control releases are necessary). The reservoir storage and water supply diversions were adjusted to satisfy these monthly flow objectives for each of the eastside tributaries. Flood releases in many years were reduced or eliminated because higher flows were released in February, March, and April to satisfy the flow objectives. Water supply diversions were reduced in many years to satisfy the LSJR Alternative 4 flow objectives. The impact assessment was based on the comparison of the modified flows with the baseline flows.

Merced River

Table F.1-12a shows the monthly cumulative distribution (range) for the WSE calculated Lake McClure storage (TAF) for LSJR Alternative 4. These monthly storage patterns are slightly different than the baseline storage patterns because of different releases and different diversions from the reservoir. The median carryover storage was 502 TAF, about 36 TAF lower than the baseline median carryover storage of 538 TAF. Table F.1-12b shows the monthly cumulative distributions (range) for the WSE calculated Lake McClure surface water elevations (feet msl) for LSJR Alternative 4.

Table F.1-12a. WSE Results for Lake McClure Storage (TAF) for LSJR Alternative 4: 60% Unimpaired Flow

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
Lake McClure Storage (TAF)												
Minimum	103	87	104	104	98	142	163	197	176	179	141	123
10%	234	223	219	242	286	302	322	365	323	290	254	253
20%	330	316	321	348	365	386	435	461	471	430	377	350
30%	377	372	385	428	447	482	489	505	520	467	420	394
40%	418	439	459	486	547	583	591	630	585	518	454	429
50%	488	490	509	536	600	636	657	679	654	596	527	502
60%	524	531	560	584	625	677	692	734	755	704	607	554
70%	587	598	599	626	675	689	714	800	815	772	674	618
80%	642	655	655	662	675	710	739	858	943	854	732	672
90%	675	673	675	675	675	733	765	935	1,024	933	824	758
Maximum	675	675	675	675	675	735	845	970	1,024	957	858	807
Average	470	469	480	499	530	564	590	658	668	611	538	504

Table F.1-12b. WSE Results for Lake McClure Surface Water Elevations (feet msl) for LSJR Alternative 4: 60% Unimpaired Flow

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
Lake McClure Elevation (feet) 60% Unimpaired												
Minimum	646	637	646	646	643	664	673	687	679	680	664	656
10%	700	696	695	702	716	721	727	738	727	718	706	706
20%	729	725	726	734	738	744	756	762	764	755	741	734
30%	742	740	744	754	759	767	768	772	775	763	752	746
40%	752	757	762	768	781	788	790	798	789	775	760	754
50%	768	769	773	779	792	799	803	807	802	791	777	771
60%	776	778	784	789	797	807	810	817	821	812	793	782
70%	789	791	792	797	806	809	814	829	831	824	806	795
80%	800	803	803	804	806	813	818	838	852	838	817	806
90%	806	806	806	806	806	817	823	851	864	850	833	821
Maximum	806	806	806	806	806	817	836	856	864	854	838	830
Average	760	759	762	767	774	781	787	799	800	789	774	767

Table F.1-12c shows the monthly cumulative distribution (range) for the WSE calculated Merced River target flows at Stevinson for LSJR Alternative 4. Very few months had target flows below the assumed minimum of 150 cfs. Several months had target flows that were above the assumed maximum of 2,000 cfs. The median target flows were 568 cfs in February, 795 cfs in March, 1,432 cfs in April, 2,376 cfs in May, and 1,472 cfs in June. Comparison to the baseline flows indicates that the target flows for LSJR Alternative 4 were similar to the median baseline flows in February, about two times as high in March, and about four times as high in April–June.

Table F.1-12c. Merced River Target Flows (cfs) for LSJR Alternative 4: 60% Unimpaired Flow

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
Merced Target Flow (cfs)												
Minimum	0	0	0	0	32	78	313	381	131	0	0	0
10%	0	0	0	0	199	355	808	989	435	0	0	0
20%	0	0	0	0	283	509	940	1,306	522	0	0	0
30%	0	0	0	0	357	582	1,135	1,697	829	0	0	0
40%	0	0	0	0	488	662	1,295	1,975	1,149	0	0	0
50%	0	0	0	0	568	795	1,432	2,376	1,472	0	0	0
60%	0	0	0	0	769	913	1,599	2,627	1,686	0	0	0
70%	0	0	0	0	1,132	1,129	1,728	2,838	2,074	0	0	0
80%	0	0	0	0	1,596	1,491	1,942	3,136	2,642	0	0	0
90%	0	0	0	0	2,173	1,634	2,184	3,782	3,382	0	0	0
Maximum	0	0	0	0	3,911	3,610	4,326	5,513	6,615	0	0	0
Average	0	0	0	0	914	986	1,483	2,352	1,722	0	0	0

Table F.1-12d shows the monthly cumulative distribution (range) for the WSE calculated Merced River flows at Stevinson for LSJR Alternative 4. The median monthly flows were 679 cfs in February, 795 cfs in March, 1,432 cfs in April, 2,000 cfs in May (assumed maximum), and 1,472 cfs in June. The monthly flows were higher than the target flows for only a few months, indicating that flood-control releases were required for LSJR Alternative 4 in only a few years. The LSJR Alternative 4 flows on the Merced River provided a more natural distribution of flows in February–June but increased the total volume of water released to the river by about 165 TAF.

Table F.1-12d. Merced River Flows at Stevinson (cfs) for LSJR Alternative 4: 60% Unimpaired Flow

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	Annual (TAF)
Merced at Stevinson Flow (cfs)													
Minimum	206	258	239	270	150	150	313	381	150	35	35	2	184
10%	266	316	327	330	216	355	808	989	435	68	54	31	302
20%	283	350	359	377	283	509	940	1,306	522	90	74	54	379
30%	309	367	377	393	371	582	1,135	1,697	829	117	100	69	423
40%	346	382	387	410	508	662	1,295	1,971	1,149	160	123	80	468
50%	364	388	399	435	679	795	1,432	2,000	1,472	175	159	92	559
60%	435	398	409	482	1,051	913	1,599	2,000	1,686	224	201	134	678
70%	580	410	430	618	1,554	1,129	1,728	2,000	2,000	304	811	445	773
80%	705	426	496	1,326	1,752	1,507	1,942	2,000	2,000	1,119	1,060	566	969
90%	1,652	528	1,165	1,893	2,430	1,666	2,000	2,000	2,808	2,209	1,233	640	1,050
Maximum	2,236	2,232	3,675	9,912	4,918	5,850	4,613	5,366	7,705	5,943	2,444	1,369	2,501
Average	620	448	627	935	1,126	1,052	1,443	1,810	1,586	701	473	271	669

Table F.1-8 shows that the Merced River annual diversions for LSJR Alternative 4 ranged from 209 TAF (10 percent cumulative) to 465 TAF (90 percent cumulative), with a median annual diversion of 385 TAF and an average annual diversion of 364 TAF. The Merced River water supply deficits for LSJR Alternative 4 ranged from 135 TAF (10 percent) to 391 TAF (90 percent) with a median deficit of 215 TAF and an average deficit of 236 TAF. The average deficit was 163 TAF greater than the average baseline deficit, and about 40 percent of the assumed maximum diversion.

Tuolumne River

The SFPUC water bank in New Don Pedro allows the SFPUC upstream reservoirs and aqueduct diversions to continue to operate during low flow conditions. LSJR Alternative 4 was assumed to not change these upstream SFPUC operations.

Table F.1-12e shows the monthly cumulative distribution (range) for the WSE calculated New Don Pedro Reservoir storage (TAF) for LSJR Alternative 4. These monthly storage patterns are slightly different that the Baseline storage patterns because of different releases and different diversions from the reservoir. The median carryover storage was 1,351 TAF, very similar to the Baseline median carryover storage of 1,377 TAF. Table F.1-12f shows the monthly cumulative distributions (range) for the WSE calculated New Don Pedro Reservoir surface water elevations (feet msl) for LSJR Alternative 4.

Table F.1-12e. WSE Results for New Don Pedro Storage (TAF) for LSJR Alternative 4: 60% Unimpaired Flow

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
New Don Pedro Storage (TAF)												
Minimum	623	622	649	654	653	663	662	618	643	640	632	635
10%	889	893	935	962	1,023	1,048	1,059	955	1,015	969	924	906
20%	1,030	1,027	1,074	1,127	1,187	1,250	1,250	1,274	1,238	1,158	1,078	1,055
30%	1,113	1,121	1,204	1,283	1,311	1,346	1,350	1,327	1,314	1,233	1,169	1,136
40%	1,176	1,222	1,296	1,371	1,474	1,508	1,467	1,423	1,438	1,332	1,235	1,195
50%	1,315	1,360	1,438	1,474	1,549	1,654	1,614	1,558	1,574	1,513	1,406	1,351
60%	1,473	1,477	1,480	1,583	1,657	1,690	1,639	1,647	1,647	1,615	1,534	1,513
70%	1,529	1,568	1,600	1,645	1,690	1,690	1,668	1,719	1,764	1,704	1,624	1,568
80%	1,686	1,675	1,677	1,690	1,690	1,690	1,711	1,796	1,950	1,890	1,785	1,734
90%	1,690	1,690	1,690	1,690	1,690	1,690	1,718	1,911	2,030	1,981	1,898	1,773
Maximum	1,690	1,690	1,690	1,690	1,690	1,690	1,718	2,002	2,030	2,030	1,985	1,773
Average	1,297	1,308	1,353	1,400	1,448	1,476	1,465	1,500	1,520	1,463	1,385	1,333

Table F.1-12f. WSE Results for New Don Pedro Surface Water Elevations (feet msl) for LSJR Alternative 4: 60% Unimpaired Flow

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
New Don Pedro Elevation (feet)												
40% Unimpaired												
Minimum	653	653	662	674	678	683	686	686	683	671	661	657
10%	705	706	712	718	728	729	731	725	735	723	713	708
20%	729	728	731	736	743	755	758	759	759	747	737	732
30%	738	740	749	756	761	768	770	769	768	758	746	741
40%	745	748	758	765	779	786	783	782	779	766	754	748
50%	760	762	770	776	787	795	794	792	795	782	769	764
60%	772	773	779	783	794	798	798	797	800	796	784	778
70%	781	783	788	790	798	798	801	800	809	801	790	785
80%	789	791	793	797	798	798	801	811	821	812	800	794
90%	798	797	798	798	798	798	801	820	830	823	813	806
Maximum	798	798	798	798	798	798	801	827	830	830	822	806
Average	754	756	760	766	773	777	778	782	784	775	765	759

Table F.1-12g shows the monthly cumulative distribution (range) for the WSE calculated Tuolumne River target flows at Modesto for LSJR Alternative 4. Very few months had target flows below the assumed minimum of 200 cfs. Many months had target flows that were above the assumed maximum of 3,500 cfs. The median target flows were 1,248 cfs in February, 1,542 cfs in March, 2,702 cfs in April, 4,406 cfs in May, and 3,388 cfs in June. These target flows for LSJR Alternative 4 were much higher than the median Baseline flows. The assumed maximum flow of 3,500 cfs limited the May and June target flows in about half of the years.

Table F.1-12g. Tuolumne River Target Flows (cfs) for LSJR Alternative 4: 60% Unimpaired Flow

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
Tuolumne Target Flow (cfs)												
Minimum	0	0	0	0	86	224	797	1,034	171	0	0	0
10%	0	0	0	0	438	826	1,626	2,081	903	0	0	0
20%	0	0	0	0	650	1,130	1,877	2,842	1,369	0	0	0
30%	0	0	0	0	756	1,255	2,221	3,371	2,227	0	0	0
40%	0	0	0	0	907	1,413	2,489	3,696	2,908	0	0	0
50%	0	0	0	0	1,248	1,542	2,702	4,406	3,388	0	0	0
60%	0	0	0	0	1,540	1,717	2,956	4,842	4,029	0	0	0
70%	0	0	0	0	1,817	2,070	3,221	5,244	4,485	0	0	0
80%	0	0	0	0	2,493	2,500	3,487	5,611	5,356	0	0	0
90%	0	0	0	0	3,334	3,309	3,882	6,427	6,028	0	0	0
Maximum	0	0	0	0	6,655	5,650	6,655	9,368	10,245	0	0	0
Average	0	0	0	0	1,577	1,854	2,760	4,355	3,548	0	0	0

Table F.1-12h shows the monthly cumulative distribution (range) for the WSE calculated Tuolumne River flows at Modesto for LSJR Alternative 4. The monthly flows were higher than the target flows in only a few years, indicating that flood-control releases were greatly reduced with LSJR Alternative 4. The median monthly flows for LSJR Alternative 4 were 1,486 cfs in February, 1,733 cfs in March, 2,702 cfs in April, 3,500 cfs in May, and 3,388 cfs in June. The LSJR Alternative 4 flows on the Tuolumne River provided a more natural distribution of flows in February–June but increased the total volume of water released to the river by 300 TAF, even with the maximum assumed target flow of 3,500 cfs.

Table F.1-12h. Tuolumne River Flows at Modesto (cfs) for LSJR Alternative 4: 60% Unimpaired Flow

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	Annual (TAF)
Tuolumne at Modesto Flow(cfs)													
Minimum	0	0	0	208	200	224	797	1,034	200	169	167	153	303
10%	246	244	251	316	438	826	1,626	2,081	903	237	257	243	580
20%	352	315	322	427	659	1,214	1,896	2,842	1,369	299	326	323	739
30%	457	380	403	436	840	1,356	2,237	3,371	2,227	339	349	353	797
40%	480	443	434	518	1,095	1,529	2,525	3,500	2,908	378	379	369	880
50%	537	454	457	570	1,486	1,733	2,702	3,500	3,388	418	402	409	1,008
60%	602	477	523	610	1,915	2,172	3,004	3,500	3,500	523	485	511	1,145
70%	696	525	599	728	2,513	2,942	3,221	3,500	3,500	576	553	574	1,302
80%	751	620	688	1,800	3,294	3,355	3,480	3,500	3,500	1,066	568	597	1,605
90%	1,349	810	1,885	3,252	4,661	4,228	3,500	3,500	6,690	3,479	618	1,426	1,931
Maximum	3,514	5,963	7,486	17,734	6,794	9,382	8,391	6,705	14,136	8,543	2,862	3,546	4,124
Average	689	592	874	1,355	2,017	2,327	2,730	3,254	3,278	1,123	476	634	1,167

Table F.1-8 indicates the Tuolumne River annual diversions for LSJR Alternative 4 ranged from 316 TAF (10 percent cumulative) to 712 TAF (90 percent cumulative) with a median annual diversion of 596 TAF and an average annual diversion of 556 TAF. The Tuolumne River water supply deficits for LSJR Alternative 4 ranged from 388 TAF (10 percent) to 784 TAF (90 percent) with a median deficit of 504 TAF and an average deficit of 544 TAF. The average deficit was 329 TAF greater than the average baseline deficit and about 50 percent of the assumed maximum diversion.

Stanislaus River

Table F.1-12i shows the monthly cumulative distribution (range) for the WSE calculated New Melones Reservoir storage (TAF) for LSJR Alternative 4. The median carryover storage was 1,344 TAF, about 100 TAF higher than the baseline median carryover storage of 1,242 TAF. Although the release flows were increased, the balancing method apparently reduced the diversions slightly more than the flows were increased. Table F.1-12j shows the monthly cumulative distributions (range) for the WSE calculated New Melones Reservoir surface water elevations (feet msl) for LSJR Alternative 4.

Table F.1-12i. WSE Results for New Melones Storage (TAF) for LSJR Alternative 4: 60% Unimpaired Flow

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
New Melones Storage (TAF)												
Minimum	84	85	96	135	142	171	218	176	155	136	113	104
10%	396	406	420	477	496	522	482	421	420	430	416	407
20%	713	711	722	745	788	815	795	845	841	805	771	748
30%	846	860	907	936	942	963	930	966	985	959	896	868
40%	1,022	1,032	1,088	1,182	1,213	1,224	1,197	1,191	1,212	1,165	1,110	1,079
50%	1,282	1,298	1,330	1,386	1,423	1,446	1,413	1,452	1,411	1,402	1,372	1,344
60%	1,391	1,407	1,433	1,517	1,573	1,598	1,576	1,620	1,597	1,539	1,475	1,436
70%	1,451	1,487	1,534	1,618	1,670	1,694	1,672	1,682	1,670	1,615	1,546	1,511
80%	1,678	1,687	1,735	1,777	1,831	1,848	1,804	1,798	1,854	1,845	1,791	1,747
90%	1,779	1,786	1,796	1,846	1,901	1,983	1,997	1,982	1,994	1,951	1,883	1,844
Maximum	1,935	1,938	1,950	1,970	1,970	2,030	2,104	2,346	2,420	2,300	2,130	2,000
Average	1,153	1,165	1,200	1,256	1,297	1,324	1,306	1,320	1,325	1,288	1,233	1,198

Table F.1-12j. WSE Results for Lake McClure Surface Water Elevations (feet msl) for LSJR Alternative 4: 60% Unimpaired Flow

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
New Melones Elevation (feet) *60% Unimpaired*												
Minimum	715	716	723	745	748	762	780	764	755	746	733	728
10%	834	836	840	853	857	863	854	840	840	842	839	837
20%	899	899	900	904	911	915	912	920	920	914	909	905
30%	920	922	930	934	935	937	933	938	941	937	928	924
40%	946	947	954	966	970	972	968	967	970	964	957	953
50%	978	980	984	990	994	997	993	997	993	992	989	986
60%	991	993	995	1,004	1,010	1,013	1,010	1,015	1,013	1,007	1,000	996
70%	997	1,001	1,006	1,015	1,020	1,022	1,020	1,021	1,020	1,014	1,007	1,004
80%	1,021	1,022	1,026	1,030	1,035	1,037	1,033	1,032	1,037	1,037	1,032	1,027
90%	1,030	1,031	1,032	1,037	1,042	1,049	1,050	1,049	1,050	1,046	1,040	1,037
Maximum	1,045	1,045	1,046	1,048	1,048	1,053	1,059	1,079	1,085	1,076	1,062	1,051
Average	950	952	957	964	969	973	970	971	971	966	960	956

Table F.1-12k shows the monthly cumulative distribution (range) for the WSE calculated Stanislaus River target flows at Ripon for LSJR Alternative 4. A few months had target flows below the assumed minimum of 150 cfs. Many months had target flows that were above the assumed maximum of 2,500 cfs. The median target flows were 767 cfs in February, 1,020 cfs in March, 1,946 cfs in April, 2,727 cfs in May, and 1,654 cfs in June. Comparison to the baseline flows indicates that the target flows for LSJR Alternative 4 were considerably higher than the median baseline flows in February and March, similar in April, and about two times as high in May and June.

Table F.1-12k. Stanislaus River Target Flows (cfs) for LSJR Alternative 4: 60% Unimpaired Flow

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
Stanislaus Target Flow (cfs)												
Minimum	0	0	0	0	11	127	353	429	111	0	0	0
10%	0	0	0	0	250	492	1,010	977	413	0	0	0
20%	0	0	0	0	332	689	1,242	1,587	585	0	0	0
30%	0	0	0	0	479	793	1,513	1,812	957	0	0	0
40%	0	0	0	0	594	941	1,738	2,309	1,260	0	0	0
50%	0	0	0	0	767	1,020	1,946	2,727	1,654	0	0	0
60%	0	0	0	0	1,049	1,210	2,093	3,156	1,938	0	0	0
70%	0	0	0	0	1,167	1,392	2,323	3,468	2,196	0	0	0
80%	0	0	0	0	1,382	1,569	2,567	3,819	2,507	0	0	0
90%	0	0	0	0	2,113	2,280	2,778	4,295	3,341	0	0	0
Maximum	0	0	0	0	5,747	4,050	4,366	5,806	6,373	0	0	0
Average	0	0	0	0	1,027	1,247	1,935	2,754	1,772	0	0	0

Table F.1-12l shows the monthly cumulative distribution (range) for the WSE calculated Stanislaus River flows at Ripon for LSJR Alternative 4. The monthly flows were higher than the target flows in only a few years, indicating that flood-control releases were greatly reduced with LSJR Alternative 4. The median monthly flows were 846 cfs in February, 1,020 cfs in March, 1,946 cfs in April, 2,500 cfs in May, and 1,654 cfs in June. The LSJR Alternative 4 flows on the Stanislaus River provided a more natural distribution of flows in February–June but increased the annual flow volume by 120 TAF compared to the baseline flows.

Table F.1-12l. Stanislaus River Flows at Ripon (cfs) for LSJR Alternative 4: 60% Unimpaired Flow

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	Annual (TAF)
Stanislaus at Ripon Flow (cfs)													
Minimum	103	126	200	158	323	371	353	429	171	236	185	9	331
10%	496	285	250	216	422	576	1,010	977	413	363	365	312	417
20%	613	301	286	259	519	726	1,242	1,587	585	415	380	363	525
30%	983	326	311	296	627	803	1,513	1,812	957	432	393	393	566
40%	1,016	350	327	314	713	941	1,738	2,309	1,260	438	414	422	637
50%	1,076	367	352	335	846	1,020	1,946	2,500	1,654	448	439	434	705
60%	1,172	380	357	350	1,110	1,210	2,093	2,500	1,938	457	439	437	749
70%	1,217	430	386	381	1,182	1,395	2,323	2,500	2,196	509	460	479	804
80%	1,296	470	456	454	1,740	1,657	2,500	2,500	2,498	585	510	544	863
90%	1,380	546	512	571	2,227	2,280	2,500	2,500	2,500	689	592	668	1,031
Maximum	2,256	3,321	5,140	8,184	3,458	5,533	2,500	2,500	4,493	4,982	3,015	3,113	2,436
Average	1,042	448	469	585	1,101	1,268	1,841	2,081	1,562	581	532	569	729

Table F.1-8 indicates the Stanislaus River annual diversions for LSJR Alternative 4 ranged from 302 TAF (10 percent cumulative) to 571 TAF (90 percent cumulative) with a median annual diversion of 481 TAF and an average annual diversion of 456 TAF. The Stanislaus River water supply deficits for LSJR Alternative 4 ranged from 179 TAF (10 percent) to 448 TAF (90 percent) with a median deficit of 269 TAF and an average deficit of 294 TAF. The average deficit was 121 TAF greater than the average baseline deficit and about 40 percent of the assumed maximum diversion.

San Joaquin River at Vernalis

Table F.1-12m shows the monthly cumulative distribution (range) for the WSE calculated SJR at Vernalis flows for LSJR Alternative 4. The median monthly SJR at Vernalis flows were 4,360 cfs in February, 4,901 cfs in March, 7,304 cfs in April, 8,865 cfs in May, and 7,270 cfs in June. These median Vernalis flows were much higher than the baseline flows in February–June. LSJR Alternative 4 provided a more natural distribution of flows in February–June, but the annual average flow volume was 615 TAF/y more than the average baseline flow volume at Vernalis (20 percent higher).

Table F.1-12m. SJR Flows at Vernalis (cfs) for LSJR Alternative 4: 60% Unimpaired Flow

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	Annual (TAF)
SJR at Vernalis Flow(cfs)													
Minimum	849	1,218	1,362	1,192	1,772	1,284	1,593	2,196	997	553	553	743	1,103
10%	1,628	1,688	1,692	1,603	2,117	2,352	3,904	4,433	2,130	1,010	1,086	1,470	1,685
20%	2,187	1,814	1,803	1,776	2,311	3,379	4,575	6,334	2,986	1,263	1,289	1,670	2,156
30%	2,375	1,937	1,928	1,962	2,841	3,695	5,490	7,523	4,479	1,340	1,384	1,765	2,392
40%	2,533	2,011	1,991	2,169	3,415	4,117	6,601	8,527	6,003	1,480	1,469	1,850	2,565
50%	2,730	2,104	2,089	2,349	4,360	4,901	7,304	8,865	7,270	1,657	1,550	1,951	3,065
60%	3,061	2,263	2,213	2,488	6,733	6,668	8,194	9,230	8,012	1,865	1,781	2,237	3,547
70%	3,320	2,427	2,427	3,599	8,476	7,821	8,951	9,806	8,540	2,137	2,401	2,523	4,033
80%	3,936	2,669	2,880	5,781	9,587	9,977	9,601	10,216	8,982	3,544	2,796	2,785	4,957
90%	5,366	2,976	4,544	11,746	14,842	14,302	13,959	14,314	14,555	7,297	3,119	4,841	6,209
Maximum	8,695	17,315	24,111	60,162	31,561	40,858	25,788	26,177	37,798	26,499	9,468	8,952	16,041
Average	3,091	2,528	3,350	4,889	7,057	7,272	8,118	9,277	7,791	3,248	2,059	2,549	3,694

F.1.3 Comparison of the Cumulative Distributions of Monthly Flows

The WSE model estimated the monthly flow in the three eastside tributary rivers and at SJR at Vernalis for the LSJR Alternative 2, 3, and 4 (20%, 40%, and 60% unimpaired flow, respectively). As described above, the calculated monthly flows for the 82-year CALSIM period (water years 1922–2003) were summarized in tables showing monthly cumulative distributions of flows in 10 percent increments.[3] These monthly cumulative distributions for LSJR Alternatives 2, 3, and 4 can be graphed and compared to the monthly cumulative distribution of baseline flows. This allows the overall effects of the LSJR alternatives to be summarized and compared for each month.

The monthly cumulative distributions of flows provide a good summary of the range of flows that would be observed over a number of years. These graphs summarize the probability of future monthly flow conditions under the LSJR Alternatives 2, 3, and 4. Over the next 10 or 20 years, the monthly flows or seasonal flows would tend to be evenly distributed within each of the 10 percent cumulative distribution segments. The range of monthly flows or seasonal flow volumes is not likely to change because the minimum flow would be controlled by minimum flow requirements, and the maximum flows would be controlled by the maximum flood-control storage (most runoff would be released). Therefore, most of the changes in the flows or flow volumes would occur from the 20 to the 80 percent cumulative distribution (middle 60 percent of years).

The differences between the monthly cumulative distributions of flows for the LSJR alternatives and the baseline conditions provide a summary of the general monthly flow changes. Although the WSE model simulates some relatively large increases or decreases in the monthly river flows, these individual monthly changes would generally balance one another over the 82-year sequence, resulting in much smaller shifts in the cumulative distribution of flows for each month or for the seasonal flow volume distribution. The comparison of monthly cumulative distributions of flows, rather than the individual monthly changes in flow, provides an appropriate measure of hydrologic changes resulting from the LSJR alternatives.

F.1.3.1 Merced River Flows

The monthly cumulative distributions for February–June flow (TAF) for each river were prepared for LSJR Alternatives 2, 3, and 4 as an overall summary of the February–June changes compared to baseline. Table F.1-13a gives the cumulative distribution values for the February–June flow volumes (TAF) on the Merced River (note Tables F.1-13b through d show the Tuolumne and Stanislaus Rivers and SJR at Vernalis). A flow volume of 60 TAF corresponds to a 5-month average flow of about 200 cfs; a flow volume of 150 TAF corresponds to an average flow of 500 cfs; a flow volume of 300 TAF corresponds to an average flow of 1,000 cfs.

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[3] These tables, which are a basic summary of river flow for the baseline and LSJR alternatives , were created by sorting the monthly flow values (82 for each month) from lowest to highest, and identifying the range of cumulative distribution values from 0 percent (minimum) to 100 percent (maximum), in 10 percent increments.

Table F.1-13a. Cumulative Distributions of February–June River Flow Volumes (TAF) on the Merced River for the WSE-simulated LSJR Alternatives and the CALSIM Baseline

	Merced River at Stevinson			
	Baseline	LSJR Alternative 2	LSJR Alternative 3	LSJR Alternative 4
0	58	45	64	87
10	74	69	129	194
20	93	93	179	255
30	104	109	188	280
40	140	128	228	331
50	154	154	281	379
60	175	198	345	437
70	296	311	382	483
80	403	372	462	525
90	670	591	607	618
100	1,320	1,230	1,275	1,306

Figure F.1-10a shows the Merced River cumulative distribution of the February–June flow volume (TAF) for the baseline and the LSJR alternatives for the 82-year period 1922–2003. These distributions were shown as similar "percent exceeded" curves in Figure F.1-6C (graph c). The baseline Merced River flow volumes ranged from a minimum (0 percent) of about 50 TAF to a maximum (100 percent) of 1,250 TAF. The baseline Merced River 20 percent flow volume was 93 TAF, the 50 percent (median) flow volume was 140 TAF, and the 80 percent flow volume was 403 TAF. The LSJR Alternative 2 Merced River flow volume distribution was very similar to the baseline flow distribution. The LSJR Alternative 3 Merced River flow volume distribution also ranged from about 50 TAF to about 1,250 TAF, but the 20 percent value was about 150 TAF, the 50 percent value was about 300 TAF, and the 80 percent value was 450 TAF; thus it was more than the baseline flows at these percentages. The LSJR Alternative 4 flow distribution had a similar range, and the 20 percent value was about 250 TAF, the 50 percent value was about 375 TAF, and the 80 percent value was 525 TAF.

Figure F.1-10b shows the Merced River cumulative distributions of February flows (cfs) for the baseline and LSJR alternatives. The baseline Merced River February flows ranged from about 200 to 5,000 cfs. The LSJR Alternative 2 and LSJR Alternative 3 Merced River February flows were less than the baseline for the 0 to 50 percent distribution and about the same as the baseline flows for higher runoff years. The LSJR Alternative 4 Merced River February flows were also less than the baseline for the 0 to 30 percent distribution and were slightly higher than the baseline for the 50 to 70 percent distribution. The Merced River February flows would not be greatly modified by the LSJR alternatives because Lake McClure is often at maximum storage capacity and February runoff is released; the release of this runoff would occur regardless of the LSJR alternatives.

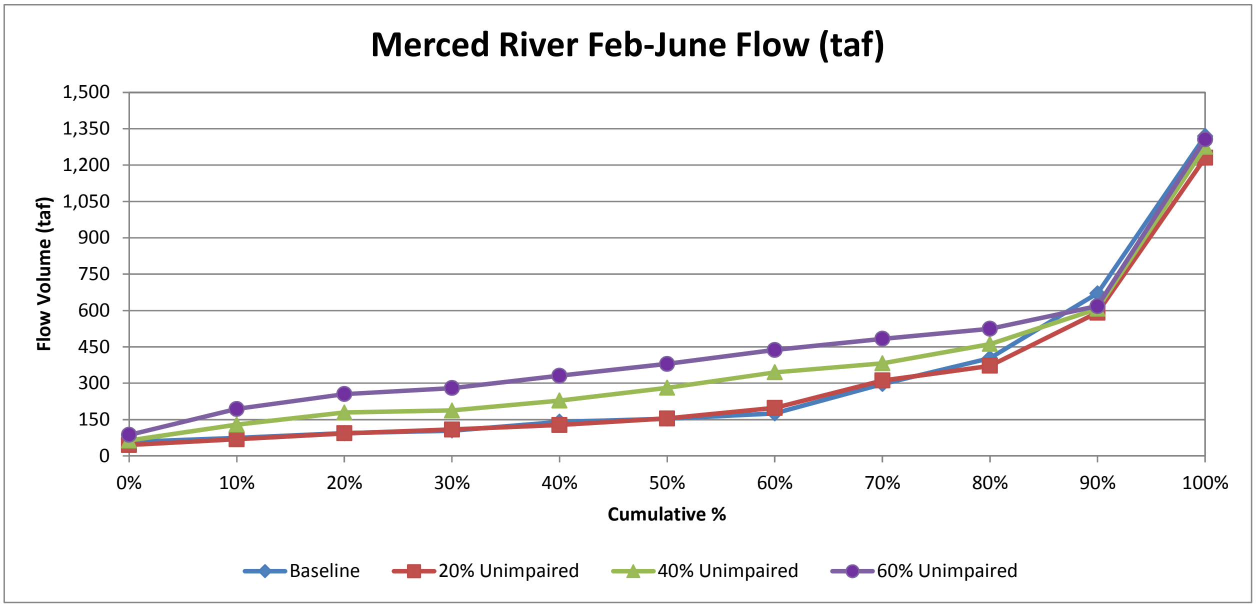


Figure F.1-10a. WSE-simulated Cumulative Distributions of Merced River February–June Flow Volumes (TAF) for LSJR Alternatives 2, 3, and 4 (20%, 40%, 60% Unimpaired Flow) and the CALSIM Baseline

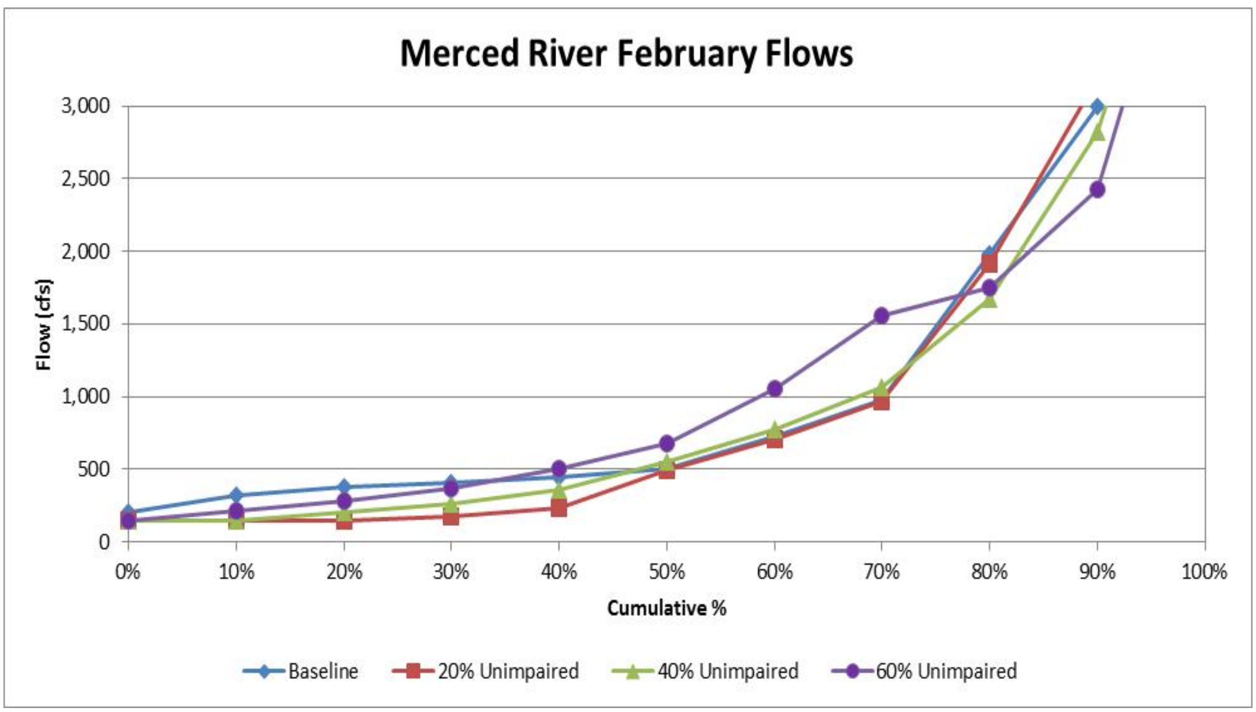


Figure F.1-10b. WSE-simulated Cumulative Distributions of Merced River February Flows (cfs) for the LSJR Alternatives2, 3, and 4 (20%, 40%, 60% Unimpaired Flow) and the CALSIM Baseline

Figure F.1-10c shows the Merced River cumulative distributions of March flows (cfs) for the baseline and LSJR alternatives. The baseline Merced River March flows ranged from about 200 to 6,000 cfs; the 20 percent baseline flow was 300 cfs, the 50 percent flow was about 400 cfs, and the 80 percent flow was about 1,100 cfs. The LSJR Alternative 2 Merced River March flows were slightly less than the baseline flows. The LSJR Alternative 3 Merced River March flows were slightly more than the baseline flows for the 30 to 70 percent distribution. The LSJR Alternative 4 Merced River March flows were about 250 to 500 cfs higher than the baseline flows. The Merced River March flows would not be greatly modified by the LSJR alternatives because Lake McClure is often at maximum storage capacity and most of the March runoff is released; the release of this runoff would occur regardless of the LSJR alternatives.

Figure F.1-10d shows the Merced River cumulative distributions of April flows (cfs) for the baseline and LSJR alternatives. The baseline Merced River April flows ranged from about 250 to 5,000 cfs; the 20 percent flow was 350 cfs, the 50 percent flow was about 700 cfs, and the 80 percent flow was 900 cfs. The LSJR Alternative 2 Merced River April flows were less than the baseline flows (100 to 250 cfs less). The LSJR Alternative 3 Merced River April flows were higher than the baseline flows (about 250 to 500 cfs more). The LSJR Alternative 4 Merced River April flows were considerably higher than the baseline flows (about 750 to 1,000 cfs). The changes in April flows with LSJR Alternatives 3 and 4 would be large enough to provide substantially higher flows conditions than with baseline flows.

Figure F.1-10e shows the Merced River cumulative distributions of May flows (cfs) for the baseline and LSJR alternatives. The baseline Merced River May flows ranged from about 200 to 5,500 cfs; the 20 percent flow was 225 cfs, the 50 percent flow was about 500 cfs, and the 80 percent flow was about 1,200 cfs. The LSJR Alternative 2 Merced River May flows were greater than baseline flows (about 250 cfs more). The LSJR Alternative 3 Merced River May flows were considerably higher than baseline flows. The LSJR Alternative 4 Merced River May flows were considerably higher than the baseline flows. The changes in May flows for LSJR Alternatives 3 and 4 are relatively large compared to baseline conditions.

Figure F.1-10f shows the Merced River cumulative distributions of June flows (cfs) for the baseline and LSJR alternatives. The baseline Merced River June flows ranged from about 100 to 7,500 cfs; the 20 percent flow was 150 cfs, the 50 percent flow was 250 cfs, and the 80 percent flow was about 1,500 cfs. The LSJR Alternative 2 Merced River June flows were slightly higher than baseline flows. The LSJR Alternative 3 Merced River June flows were higher than baseline flows (an average increase of about 250 to 750 cfs). The LSJR Alternative 4 Merced River June flows were much higher than baseline flows. The Merced River June flows would be increased substantially with LSJR Alternatives 3 and 4, because baseline releases for flood control in June were made in only about 20 percent of the years. The changes in June flows with LSJR Alternatives 3 and 4 would be relatively large when compared to baseline conditions.

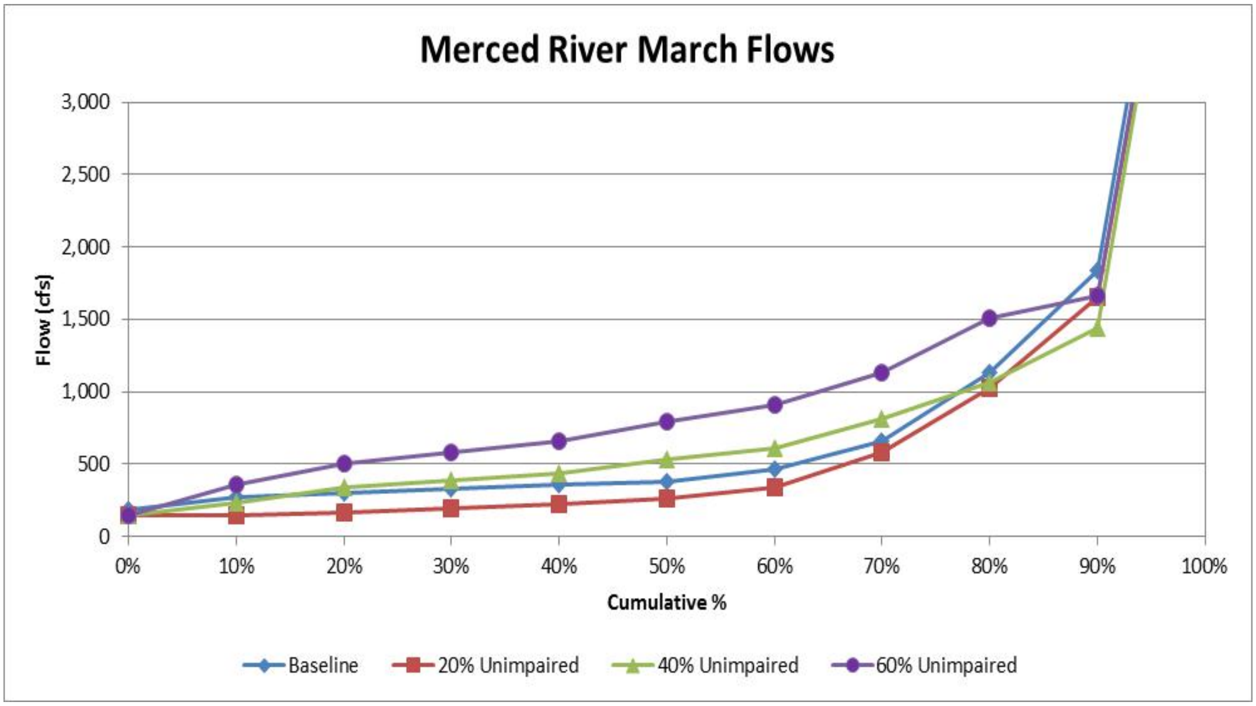


Figure F.1-10c. WSE-simulated Cumulative Distributions of Merced River March Flows (cfs) for LSJR Alternatives 2, 3, and 4 (20%, 40%, 60% Unimpaired Flow) and the CALSIM Baseline

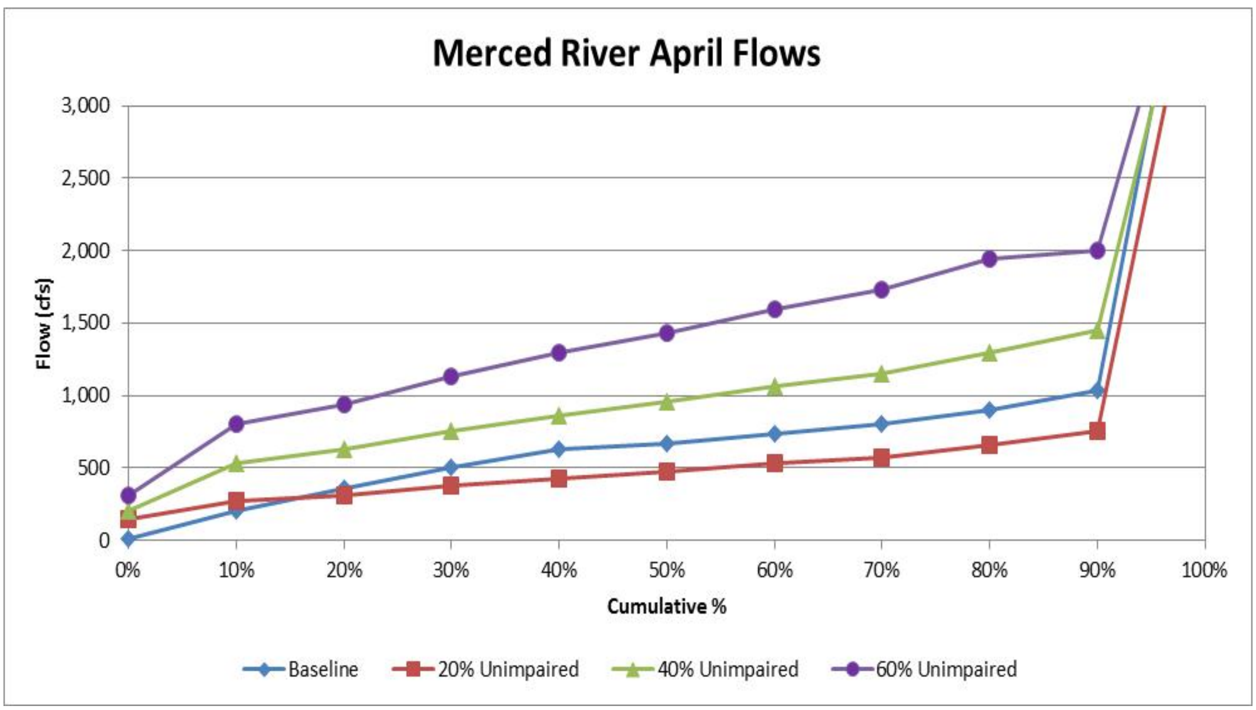


Figure F.1-10d. WSE-simulated Cumulative Distributions of Merced River April Flows (cfs) for LSJR Alternatives 2, 3, and 4 (20%, 40%, 60% Unimpaired Flow) and the CALSIM Baseline

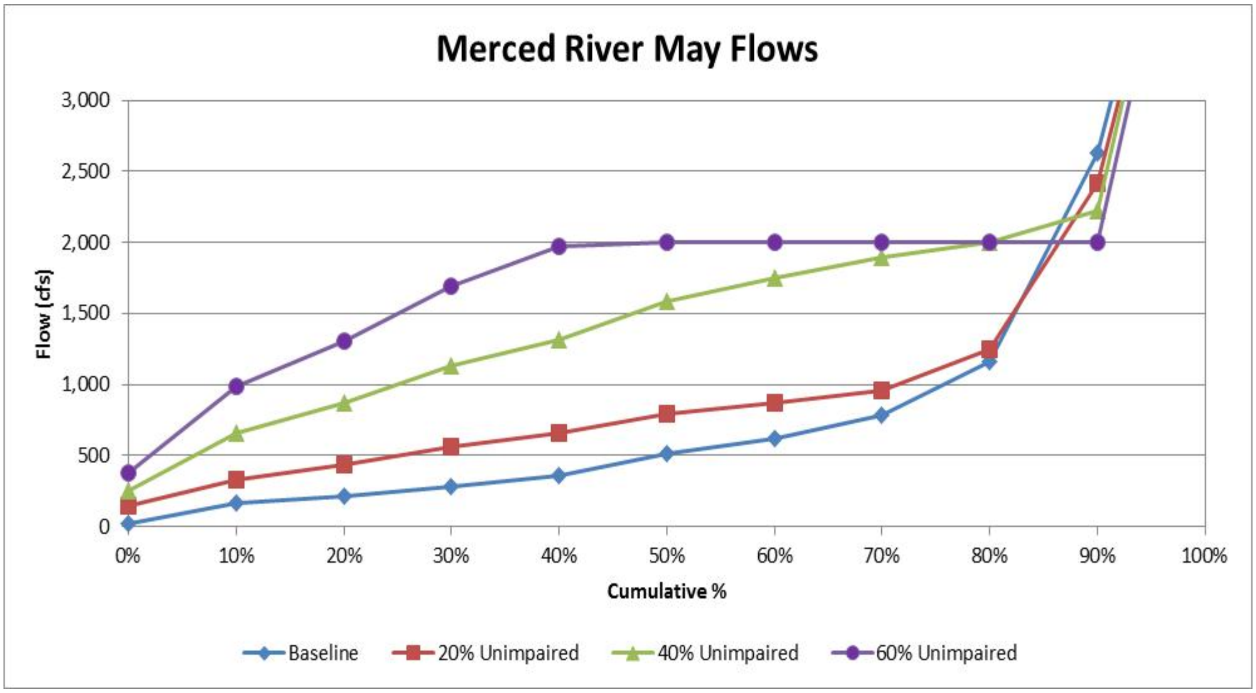


Figure F.1-10e. WSE-simulated Cumulative Distributions of Merced River May Flows (cfs) for LSJR Alternatives 2, 3, and 4 (20%, 40%, 60% Unimpaired Flow) and the CALSIM Baseline

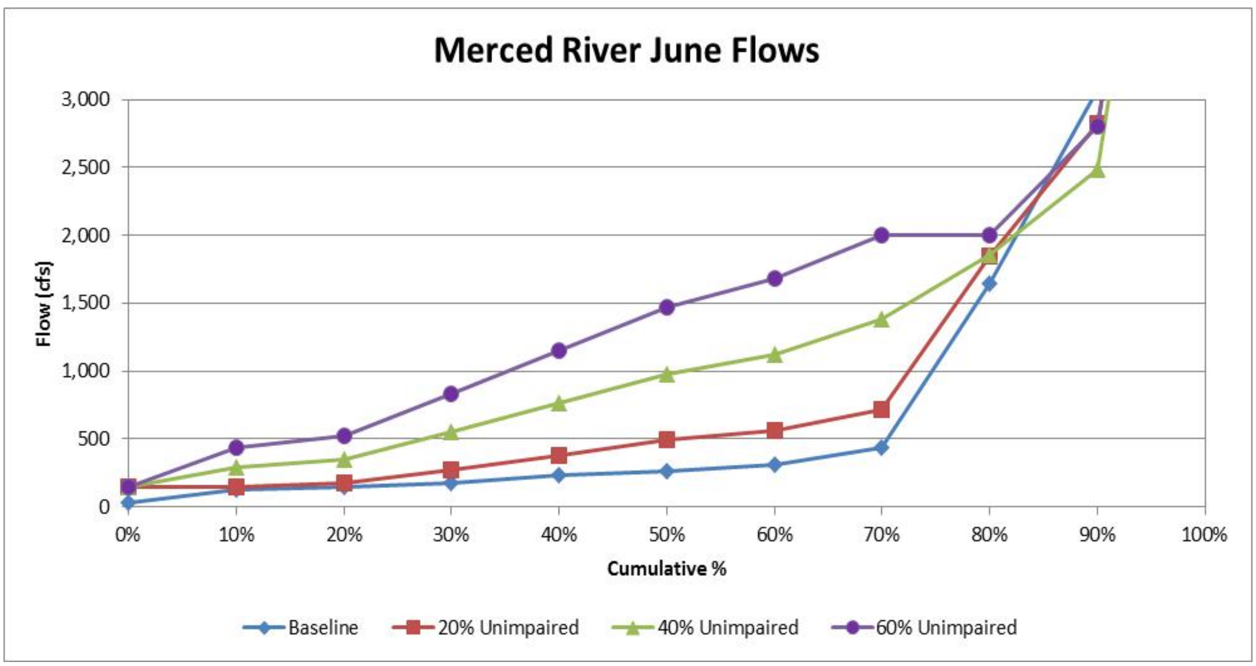


Figure F.1-10f. WSE-simulated Cumulative Distributions of Merced River June Flows (cfs) for LSJR Alternatives 2, 3, and 4 (20%, 40%, 60% Unimpaired Flow) and the CALSIM Baseline

F.1.3.2 Tuolumne River Flows

The monthly cumulative distributions for February–June flow (TAF) for the Tuolumne River was prepared for LSJR Alternatives 2, 3, and 4 as an overall summary of the February–June changes compared to baseline. Table F.1-13b gives the cumulative distribution values for the February–June flow volumes (TAF) on the Tuolumne River. A flow volume of 60 TAF corresponds to a 5-month average flow of about 200 cfs; a flow volume of 150 TAF corresponds to an average flow of 500 cfs; a flow volume of 300 TAF corresponds to an average flow of 1,000 cfs.

Table F.1-13b. Cumulative Distributions of February–June River Flow Volumes (TAF) on the Tuolumne River for the WSE-simulated LSJR Alternatives and the CALSIM Baseline.

	Tuolumne River at Modesto			
	Baseline	LSJR Alternative 2	LSJR Alternative 3	LSJR Alternative 4
0	93	81	138	197
10	137	136	267	401
20	169	193	380	530
30	204	216	409	590
40	255	262	482	666
50	302	337	623	768
60	450	457	693	864
70	653	649	820	962
80	876	793	940	1,036
90	1,190	1,053	1,150	1,232
100	2,386	2,014	2,151	2,231

Figure F.1-11a shows the cumulative distribution of the February–June Tuolumne River flow volumes (TAF) for the 82-year simulation period 1922–2003. The baseline and LSJR Alternative 2 flows were very similar, with a median baseline flow volume of 300 TAF, equivalent to an average flow of 1,000 cfs. The cumulative distribution of the LSJR Alternative 3 and 4 flows volumes for February–June were progressively higher than the baseline. The February–June flow volumes were dominated by flood-control releases in the highest runoff years (90 to 100 percent distribution).

Figure F.1-11b shows the cumulative distribution of Tuolumne River flows in February. The baseline February flows were relatively low, with a median of about 500 cfs. LSJR Alternative 2 flows were slightly lower than the baseline flows in most years. LSJR Alternative 3 flows were similar to the baseline flows, with a median of about 1,000 cfs and about 500 cfs more for the 50 to 60 percent distribution. LSJR Alternative 4 flows were considerably higher than the baseline flows.

Figure F.1-11c shows the cumulative distribution of Tuolumne River flows in March. The baseline March flows increased from a minimum of 250 cfs to a median of about 750 cfs. The baseline March flows increased rapidly to about 5,000 cfs for the 90 percent distribution. LSJR Alternative 2 March flows were similar to the baseline flows. LSJR Alternative 3 flows were higher than the baseline flows in the 0 to 50 percent distribution range and were similar to baseline March flows in higher runoff years because of flood-control releases. LSJR Alternative 4 flows were about 750 to 1,000 cfs higher than the baseline flows in the 10 to 60 percent distribution range. All of the baseline and alternative flows were similar for the 70 to 100 percent distribution range because of flood-control releases. Therefore, LSJR Alternatives 3 and 4 would have March flow increases in flows about half of the years.

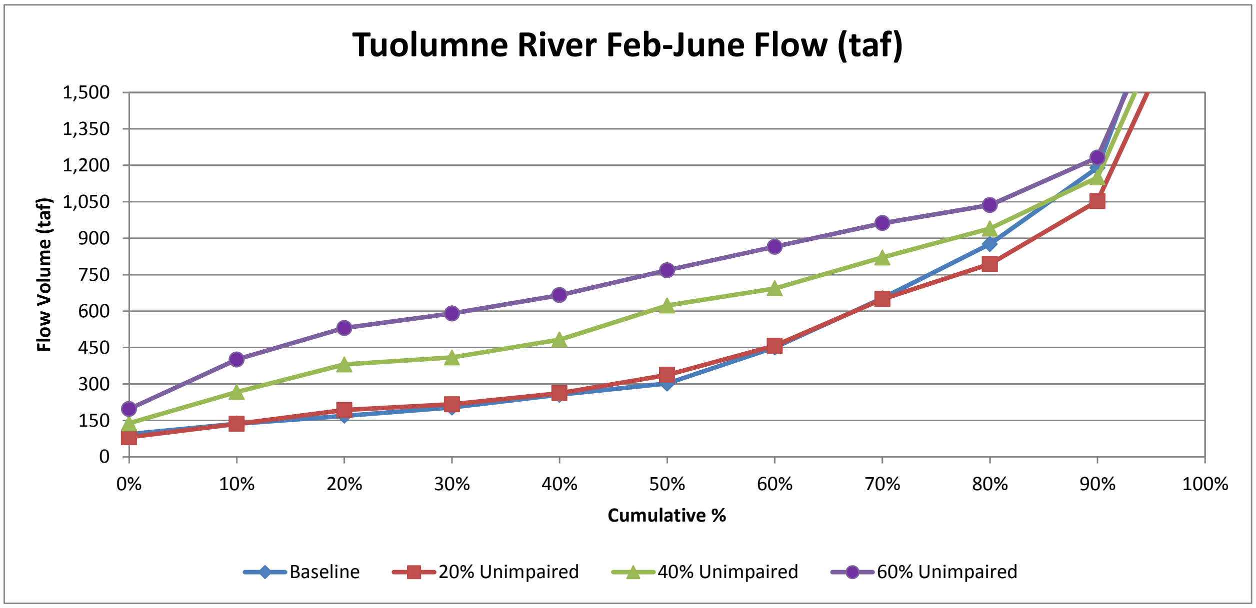


Figure F.1-11a. WSE-simulated Cumulative Distributions of Tuolumne River February–June Flow Volumes (TAF) for LSJR Alternatives 2, 3, and 4 (20%, 40%, 60% Unimpaired Flow) and the CALSIM Baseline

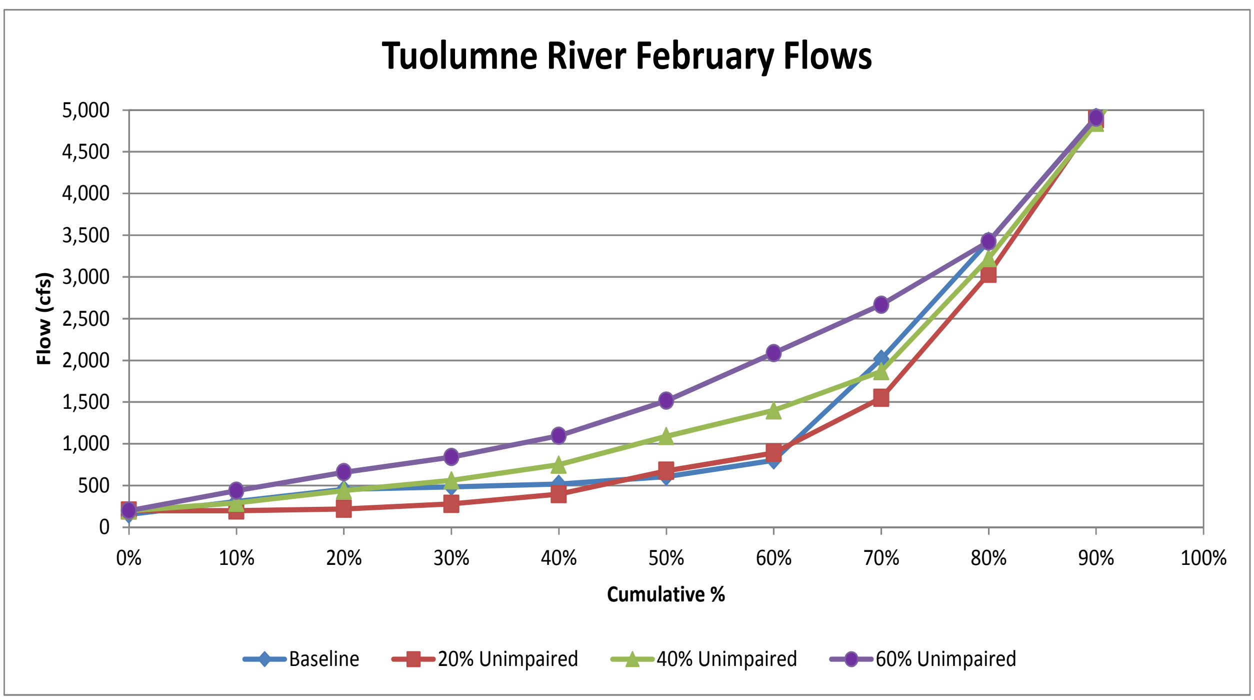


Figure F.1-11b. WSE-simulated Cumulative Distributions of Tuolumne River February Flows (cfs) for LSJR Alternatives 2, 3, and 4 (20%, 40%, 60% Unimpaired Flow) and the CALSIM Baseline

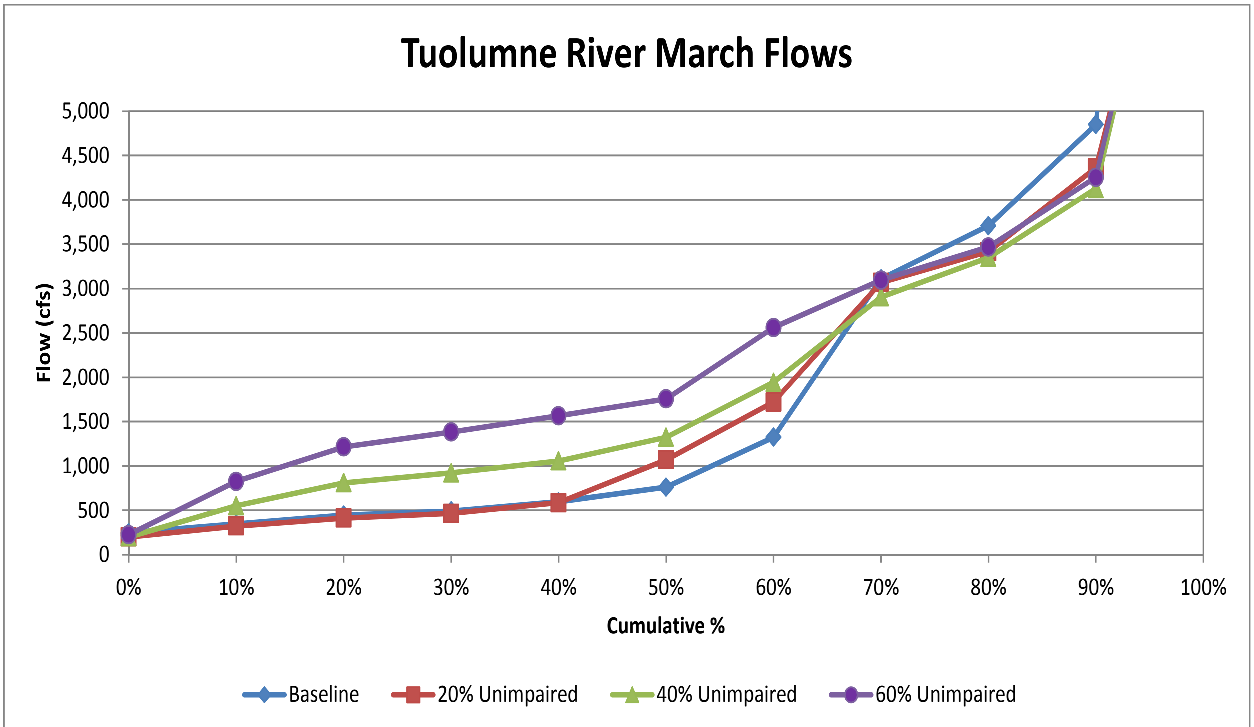


Figure F.1-11c. WSE-simulated Cumulative Distributions of Tuolumne River March Flows (cfs) for LSJR Alternatives 2, 3, and 4 (20%, 40%, 60% Unimpaired Flow) and the CALSIM Baseline

Figure F.1-11d shows the cumulative distribution of Tuolumne River flows in April. The baseline April flows increased from a minimum of about 500 cfs to a median of 1,500 cfs. LSJR Alternative 2 March flows were similar to the baseline flows for the 0 to 40 percent distribution, and were less than the baseline for the 50 to 100 percent distribution because of less flood-control releases. LSJR Alternative 3 flows were higher than baseline flows for the 10 to 60 percent distribution, with a median of about 2,000 cfs, and were lower than baseline flows for the 80 percent and 90 percent distribution (fewer flood-control releases). LSJR Alternative 4 April flows were generally substantially higher than the baseline, with a median April flow of about 2,750 cfs. LSJR Alternative 4 would have substantial April flows of 1,000 to 1,500 cfs in about 60 percent of the years and would be similar to baseline flows in the 80 to 90 percent range.

Figure F.1-11e shows the cumulative distribution of Tuolumne River flows in May. The baseline May flows increased from a minimum of 500 cfs to a median of 1,250 cfs, with a flow of 1,750 cfs at the 80 percent distribution and a flow of 5,000 cfs at the 90 percent distribution. LSJR Alternative 2 May flows were similar to the baseline flow. LSJR Alternative 3 May flows were much higher, with a median flow of 3,000 cfs and a flow of 3,500 cfs for the 70 to 90 percent distribution. LSJR Alternative 4 May flows were extremely high, with a 10 percent flow of 2,000 cfs and 20 percent flow of almost 3,000 cfs. LSJR Alternative 2 flows in May would have no changes from baseline flows, LSJR Alternative 3 would have an increase in May flows of 1,000 to 2,000 cfs the majority of the time (i.e., in the 10 to 80 percent distribution range), and the LSJR Alternative 4 would have an increase in May flows of 1,500 to 2,500 cfs the majority of the time.

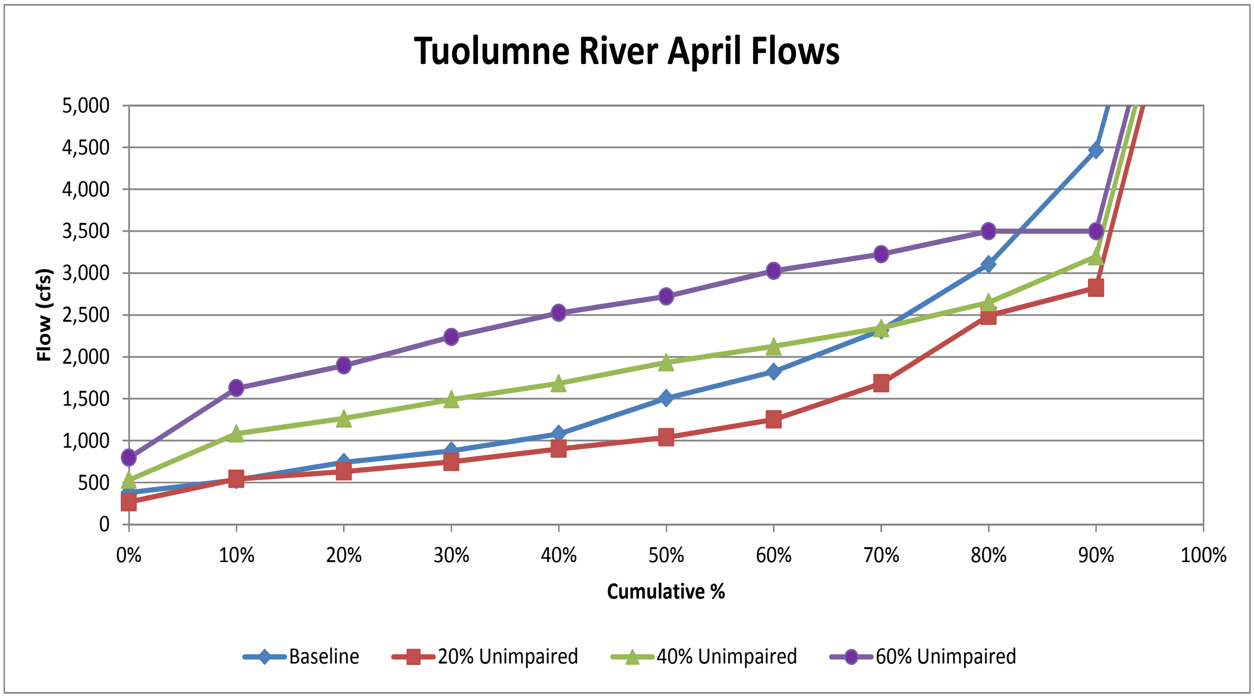


Figure F.1-11d. WSE-simulated Cumulative Distributions of Tuolumne River April Flows (cfs) for LSJR Alternatives 2, 3, and 4 (20%, 40%, 60% Unimpaired Flow) and the CALSIM Baseline

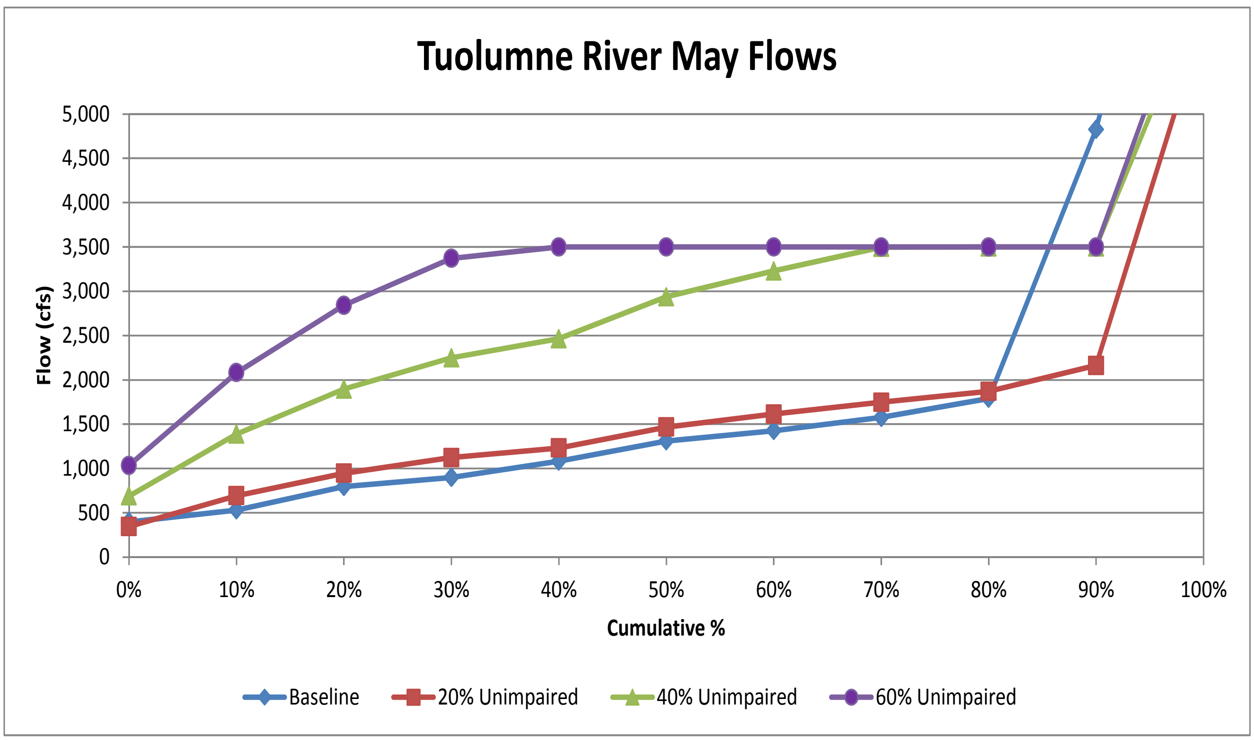


Figure F.1-11e. WSE-simulated Cumulative Distributions of Tuolumne River May Flows (cfs) for LSJR Alternatives 2, 3, and 4 (20%, 40%, 60% Unimpaired Flow) and the CALSIM Baseline

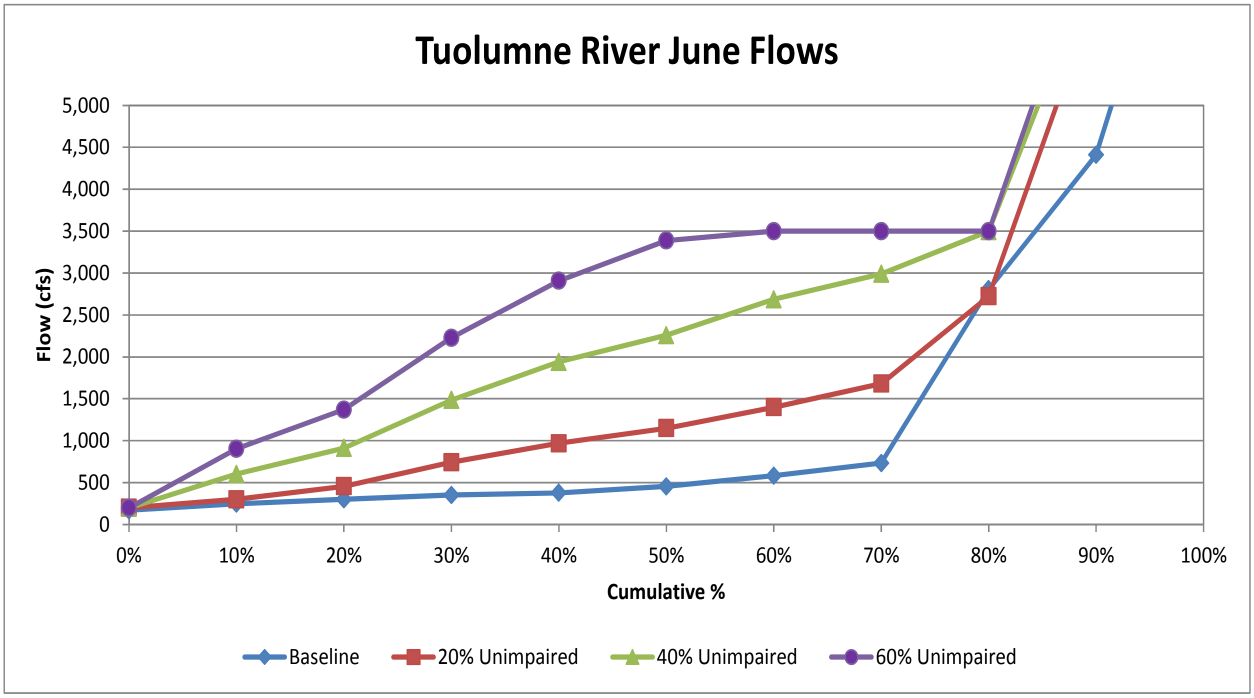


Figure F.1-11f. WSE-simulated Cumulative Distributions of Tuolumne River June Flows (cfs) for the LSJR Alternatives2, 3, and 4 (20%, 40%, 60% Unimpaired Flow) and the CALSIM Baseline

Figure F.1-11f shows the cumulative distribution of Tuolumne River flows in June. The baseline June flows were very uniform, increasing from a minimum of about 200 cfs to a median flow of 500 cfs, with a flow of 750 cfs at 70 percent cumulative distribution. The baseline 80 percent flow was 2,750 cfs and the 90 percent flow was 4,500 cfs. LSJR Alternative 2 flows were generally higher than the baseline flows, with a median flow of about 1,000 cfs. LSJR Alternative 3 flows were much greater than the baseline flows, with an increase of 500 cfs at the 20 percent distribution, an increase of 1,750 cfs at the 50 percent distribution, and an increase of 2,250 cfs a the 70 percent distribution. LSJR Alternative 4 June flows would be substantially greater than baseline flows, with a median flow of 3,500 cfs. Therefore, LSJR Alternatives 3 and 4 would have very substantial June flows most of the time (i.e., in about 80 percent of the years). The Tuolumne River flow increases in May and June are the largest under LSJR Alternatives 3 and 4.

F.1.3.3 Stanislaus River Flows

The monthly cumulative distributions for February–June flow (TAF) for the Stanislaus River was prepared for LSJR Alternatives 2, 3, and 4 as an overall summary of the February–June changes compared to baseline. Table F.1-13c gives the cumulative distribution values for the February–June flow volumes (TAF) on the Stanislaus River. A flow volume of 60 TAF corresponds to a 5-month average flow of about 200 cfs; a flow volume of 150 TAF corresponds to an average flow of 500 cfs; a flow volume of 300 TAF corresponds to an average flow of 1,000 cfs.

Table F.1-13c. Cumulative Distributions of February–June River Flow Volumes (TAF) on the Stanislaus River for the WSE-simulated LSJR Alternatives and the CALSIM Baseline.

	Stanislaus River at Ripon			
	Baseline	LSJR Alternative 2 ((20%	LSJR Alternative 3	LSJR Alternative 4
0	129	123	138	161
10	167	159	194	232
20	192	179	222	306
30	238	198	251	339
40	267	214	309	441
50	322	224	349	485
60	372	231	401	526
70	414	250	430	568
80	468	291	463	593
90	523	367	515	647
100	1,201	1,027	865	1,022

The LSJR alternatives are not expected to increase flows in each month compared to the baseline flows on the Stanislaus River. The baseline flows on the Stanislaus were determined from the NMFS RPA 3.1.3 (see Appendix D, *Evaluation of LSJR Alternative 1 and SDWQ Alternative 1 [No Project Alternative]* for additional information regarding this RPA) and emphasize the juvenile Chinook (i.e., smolt) outmigration flows in April and May. The baseline RPA flows in April and May are often much higher than LSJR Alternative 2 and higher than LSJR Alternative 3. The monthly flows on the Stanislaus River were also constrained by the required Vernalis EC objective. In some low runoff months, the LSJR alternative flows on the Merced and Tuolumne Rivers were reduced in the model; and, if the Vernalis EC objective controls the Vernalis flow, this reduced flow from the Merced and Tuolumne must be provided from New Melones releases to meet the Vernalis EC objective. During periods of high reservoir storage (maximum flood-control storage), most of the reservoir inflow would be released, and the river flow would be higher than the percentage of unimpaired flow required by the LSJR alternative. These flow constraints (salinity control and flood control) explain why the monthly flows on the Stanislaus River do not shift much from baseline when comparing the LSJR alternatives for the individual months or for the February–June period.

As shown below, the comparison of the cumulative distribution of Stanislaus River flows (cfs) show the greatest reductions from the baseline (which includes NMFS RPA 3.1.3) in the months of April and May. Flows in February, March, and June would more generally be increased with the LSJR alternatives.

Figure F.1-12a shows the cumulative distribution of the February–June Stanislaus River flow volumes (TAF) for the 82-year simulation period 1922–2003. For this five-month period, a flow volume of 150 TAF would be equivalent to an average flow of 500 cfs. This was the minimum average baseline Stanislaus River flow volume and was also the minimum February–June flow volume for the unimpaired flow and for LSRJ Alternatives 2, 3, and 4. The minimum flows are required for salinity control, as described above The salinity-control requirements would not allow the Stanislaus River flows to be reduced to the LSJR Alternative 2 flows in all months. The cumulative distributions of LSJR Alternatives 3 and 4 for February–June are progressively higher than LSJR Alternative 2, but the monthly flows are not always increased by the required flow increment as a result of the salinity requirement. The baseline flows are similar to the LSJR Alternative 3 flows. All of the LSJR Alternative flows are more similar to the baseline flows in the lower range of runoff years (0 to 30 percent distribution), and are closest to the respective LSJR alternative required flows in the 30 to 90 percent range of runoff years. The February–June flows are dominated by flood-control releases in a few of the highest runoff years (i.e., 90 to 100 percent distribution).

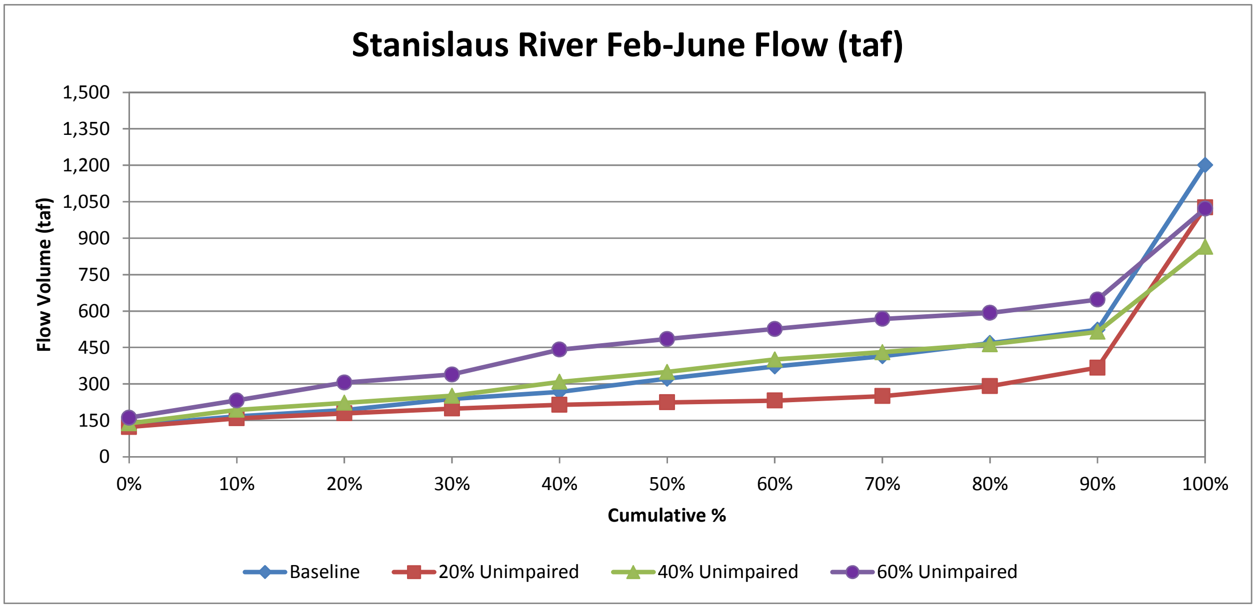


Figure F.1-12a. WSE-simulated Cumulative Distributions of Stanislaus River February–June Flow Volumes (TAF) for LSJR Alternatives 2, 3, and 4 (20%, 40%, 60% Unimpaired Flow) and the CALSIM Baseline

Figure F.1-12b shows the cumulative distribution of Stanislaus River flows in February. The baseline February flows are lower than the LSJR alternative flows. The LSJR alternative flows are very similar to each other because of the specified minimum flow (150 cfs), or the minimum flow required to meet the Vernalis EC objective. The distributions of February flows are greater than the baseline flows for LSJR Alternatives 2, 3, and 4, and each of these LSJR alternatives produces a similar distribution of February flows.

Figure F.1-12c shows the cumulative distribution of Stanislaus River flows in March. The baseline March flows were similar to LSJR Alternatives 2 and 3 in the 0 to 60 percent distribution range. LSJR Alternative 4 was about 200 to 250 cfs higher than the baseline flows in the 0 to 60 percent distribution range. But the baseline flows were higher than LSJR Alternatives 2 and 3 in the 70 to 90 percent distribution range. Therefore, LSJR Alternatives 2 and 3 would have reduced flows when compared to the baseline in March in about 20 to 30 percent of the years. LSJR Alternative 4 would have greater March flows when compared to baseline in approximately 60 percent of the years and would be similar to the baseline flows in about 20 to 30 percent of the years.

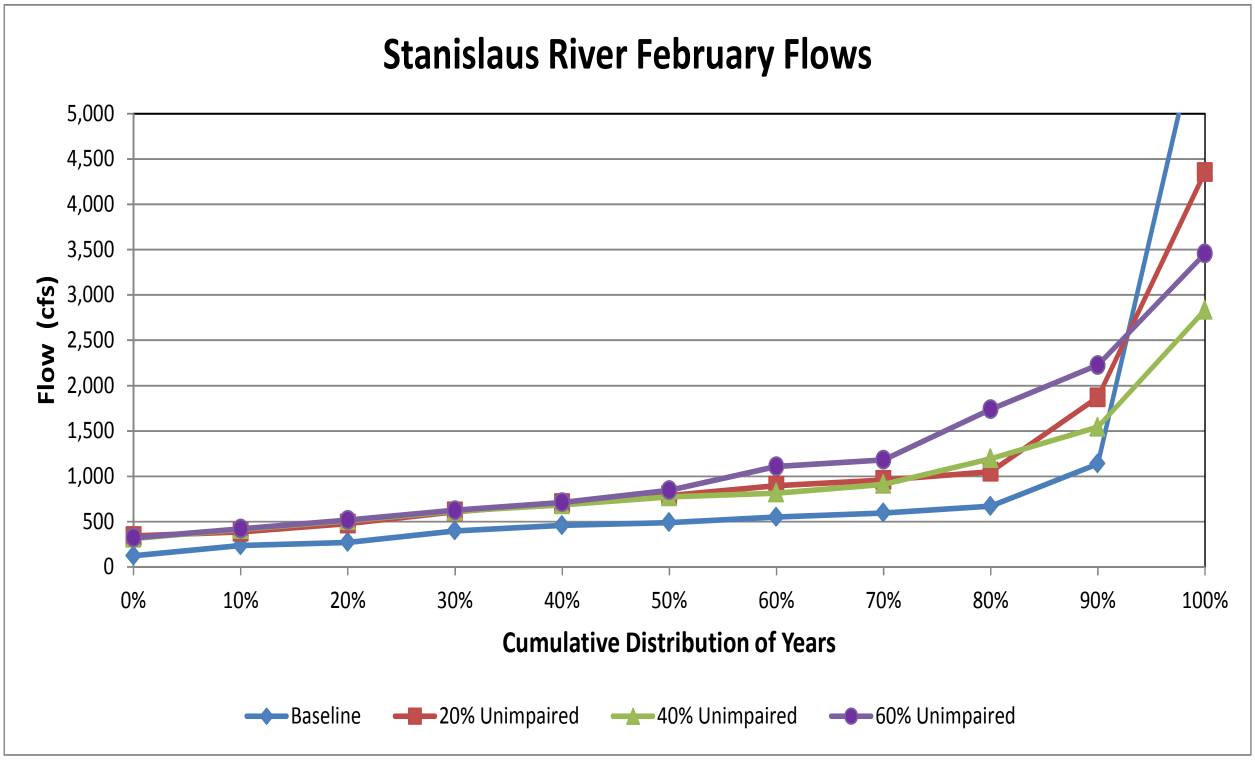


Figure F.1-12b. WSE-simulated Cumulative Distributions of Stanislaus River February Flows (cfs) for LSJR Alternatives 2, 3, and 4 (20%, 40%, 60% Unimpaired Flow) and the CALSIM Baseline

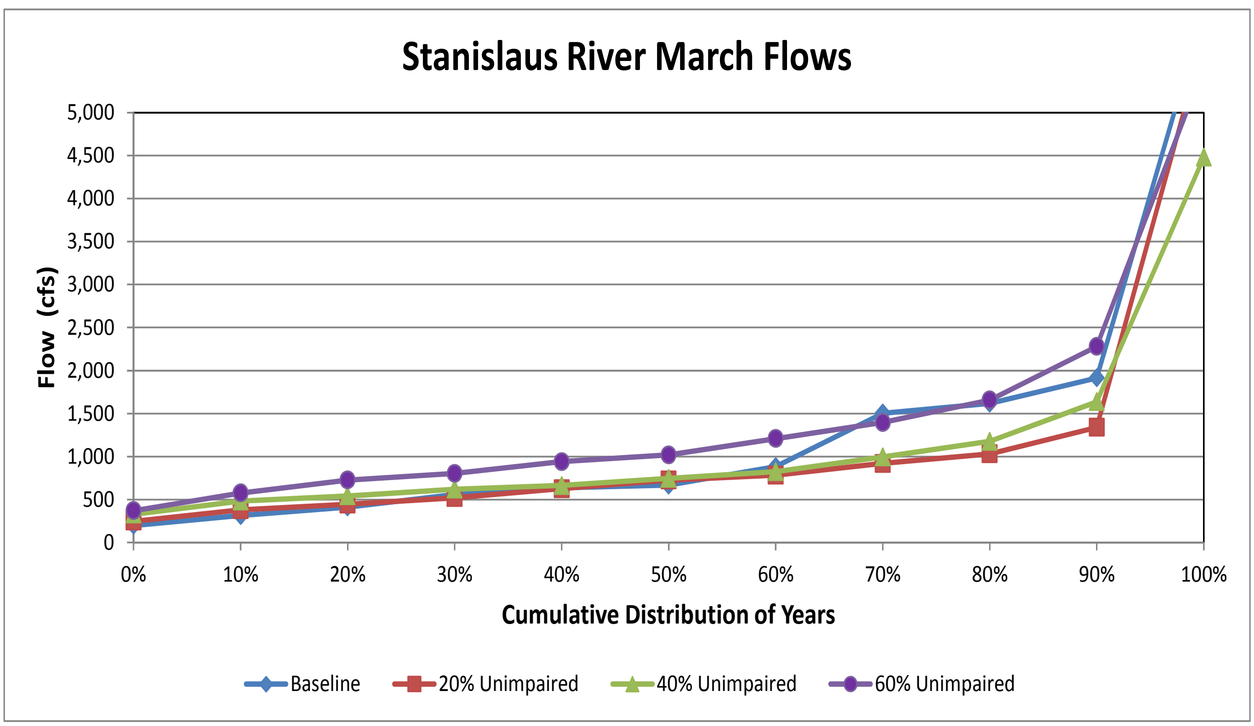


Figure F.1-12c. WSE-simulated Cumulative Distributions of Stanislaus River March Flows (cfs) for LSJR Alternatives 2, 3, and 4 (20%, 40%, 60% Unimpaired Flow) and the CALSIM Baseline

Figure F.1-12d shows the cumulative distribution of Stanislaus River flows in April. The baseline April flows were higher than the LSJR Alternative 2 flows in the entire range of runoff and were higher than LSJR Alternative 3 in the 40 to 100 percent distribution range. LSJR Alternative 4 flows were higher than the baseline in the majority of the years (i.e., 10 to 80 percent). Therefore, LSJR Alternative 2 April flows would have substantial flow reductions in all of the years and the LSJR Alternative 3 would have reduced flow impacts in most (60 to 70 percent) of the years.

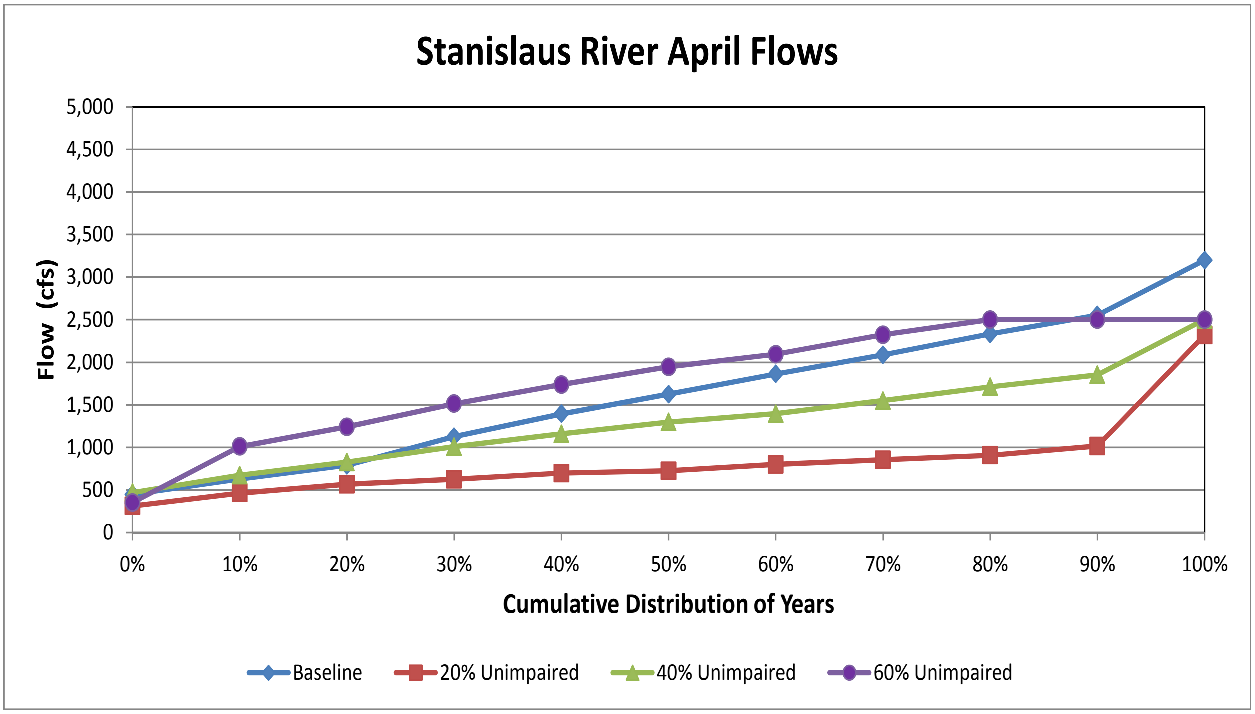


Figure F.1-12d. WSE-simulated Cumulative Distributions of Stanislaus River April Flows (cfs) for LSJR Alternatives 2, 3, and 4 (20%, 40%, 60% Unimpaired Flow) and the CALSIM Baseline

Figure F.1-12e shows the cumulative distribution of Stanislaus River flows in May. The baseline May flows were higher than the LSJR Alternative 2 flows for the entire range of runoff and slightly lower than the LSJR Alternative 3 flows the majority of the runoff. LSJR Alternative 4 flows were greater than the baseline flows in the 10 to 70 percent distribution range. Therefore, LSJR Alternative 2 May flows would have substantial flow reductions in all of the years, and LSJR Alternative 3 would have an increase in May flows in the 20 to 70 percent distribution range. LSJR Alternative 4 May flows would have an increase in flows in the 10 to 70 percent distribution range and would be similar to baseline flows in the 80 to 100 percent distribution range.

Figure F.1-12f shows the cumulative distribution of Stanislaus River flows in June. The baseline June flows were similar to LSJR Alternatives 2 and 3 flows in the 0 to 20 percent distribution range of years. LSJR Alternative 2 June flows would be reduced in the 50 to 80 percent distribution range. LSJR Alternative 4 flows would be greater than the baseline flow in the 40 to 90 percent distribution range. LSJR Alternative 4 would have higher flows in the 30 to 90 percent distribution range. Therefore, LSJR Alternatives 3 and 4 would have an increase in June flows in most years.

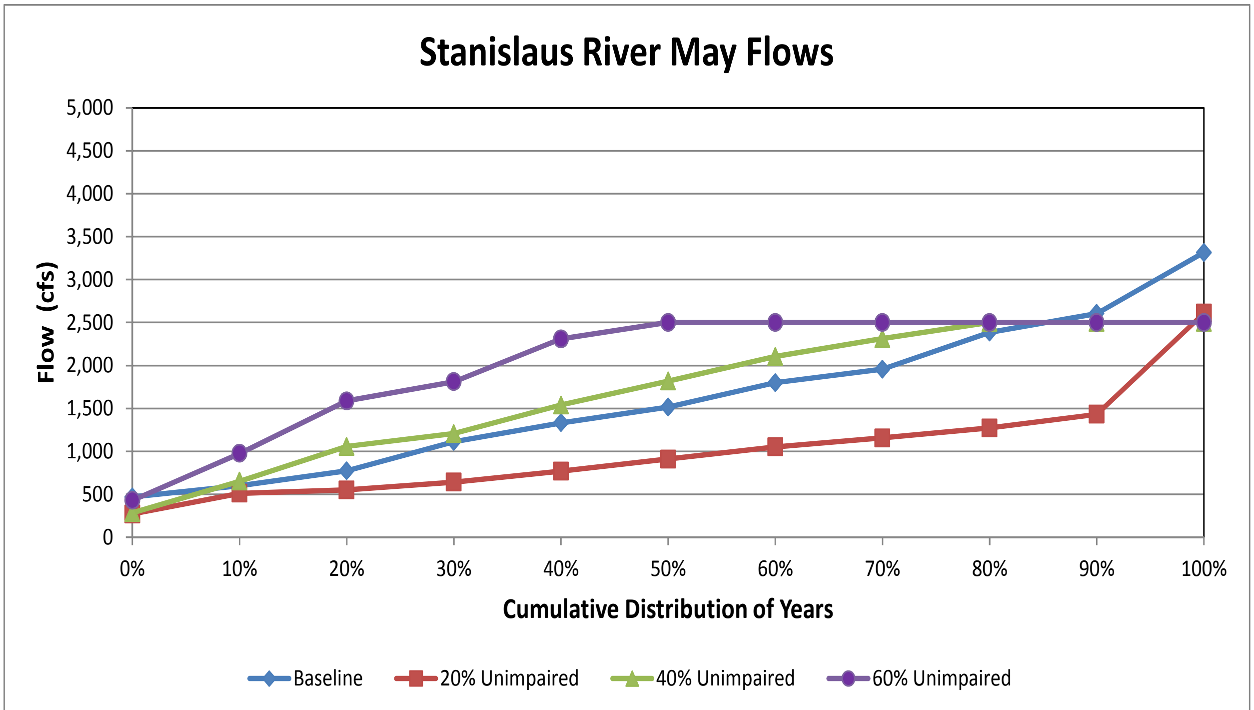


Figure F.1-12e. WSE-simulated Cumulative Distributions of Stanislaus River May Flows (cfs) for LSJR Alternatives 2, 3, and 4 (20%, 40%, 60% Unimpaired Flow) and the CALSIM Baseline

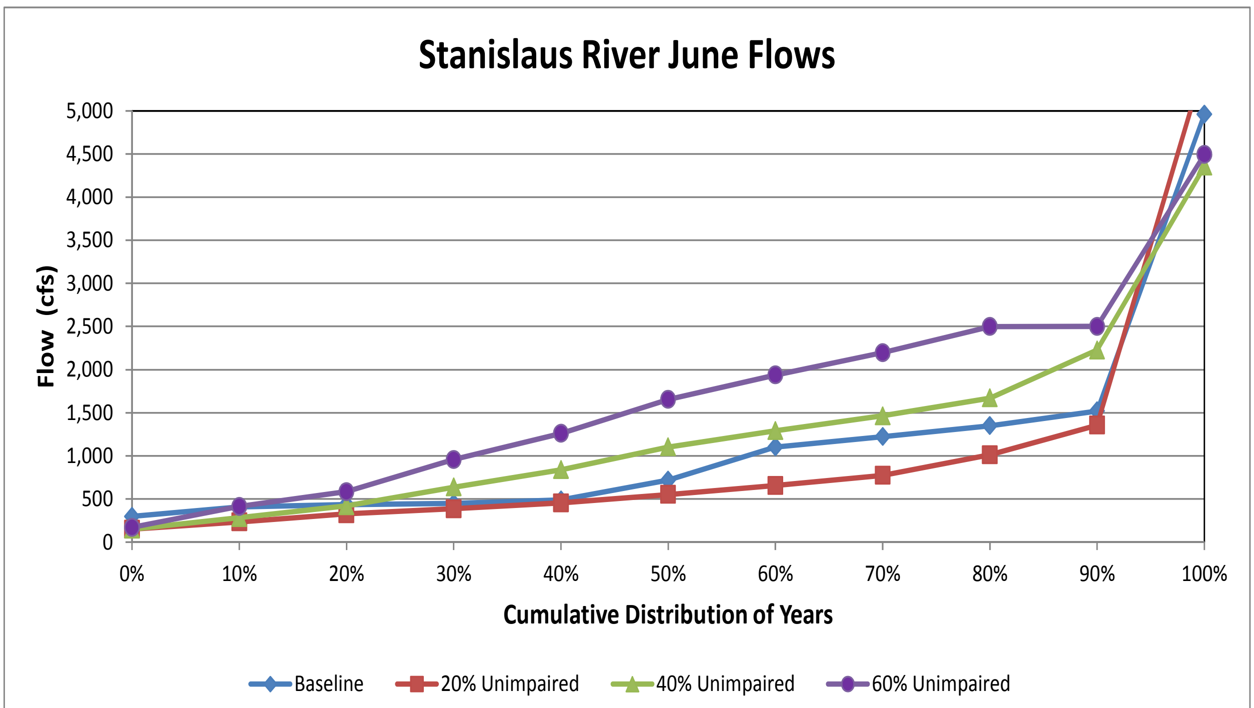


Figure F.1-12f. WSE-simulated Cumulative Distributions of Stanislaus River June Flows (cfs) for LSJR Alternatives 2, 3, and 4 (20%, 40%, 60% Unimpaired Flow) and the CALSIM Baseline

F.1.3.4 San Joaquin River at Vernalis Flows

The monthly cumulative distributions for February–June flow (TAF) for the SJR at Vernalis was prepared for LSJR Alternatives 2, 3, and 4 as an overall summary of the February–June changes compared to baseline. Table F.1-13d gives the cumulative distribution values for the February–June flow volumes (TAF). A flow volume of 60 TAF corresponds to a 5-month average flow of about 200 cfs; a flow volume of 150 TAF corresponds to an average flow of 500 cfs; a flow volume of 300 TAF corresponds to an average flow of 1,000 cfs.

Table F.1-13d. Cumulative Distributions of February–June River Flow Volumes (TAF) of SJR at Vernalis for the WSE-simulated LSJR Alternatives and the CALSIM Baseline.

	SJR at Vernalis			
	Baseline	LSJR Alternative 2	LSJR Alternative 3	LSJR Alternative 4
0	439	404	444	532
10	508	535	698	958
20	717	683	1,009	1,354
30	816	768	1,069	1,432
40	988	876	1,268	1,679
50	1,157	1,190	1,705	2,116
60	1,561	1,386	1,971	2,329
70	2,032	1,719	2,157	2,532
80	2,564	2,349	2,731	3,115
90	3,596	3,245	3,665	3,867
100	9,454	8,895	8,914	9,185

The SJR at Vernalis flows are the sum of the three eastside tributary flows; the LSJR flow from upstream of the Merced River; and flows from groundwater seepage, creeks, and other drainages that enter the SJR downstream of the Merced River. The SJR at Vernalis flows are also constrained by the Vernalis EC objective. The LSJR alternative flows at Vernalis would be controlled by the unimpaired flow requirements.

Figure F.1-13a shows the cumulative distribution of the February–June SJR at Vernalis flow volumes. For this 5-month period, a flow volume of 600 TAF would be equivalent to an average flow of 2,000 cfs. This was the minimum average baseline flow SJR at Vernalis, and was also the minimum February–June flow volume for LSJR Alternatives 2, 3, and 4. The baseline flows were very similar to LSJR Alternative 2 flows for the entire distribution of years. The cumulative distribution for LSJR Alternatives 3 and 4 for February–June were progressively higher than the baseline and LSJR Alternative 2, indicating that the flow at Vernalis would be relatively uniform for most years between LSJR Alternatives 3 and 4. LSJR Alternative 3 would increase the February–June SJR at Vernalis flow volume by about 450 TAF (1,500 cfs average flow) and LSJR Alternative 4 would increase the February–June SJR at Vernalis flow volume by about 900 TAF (3,000 cfs average flow) in most years. The February–June flow volumes were dominated by flood-control releases in about 10 percent of the years.

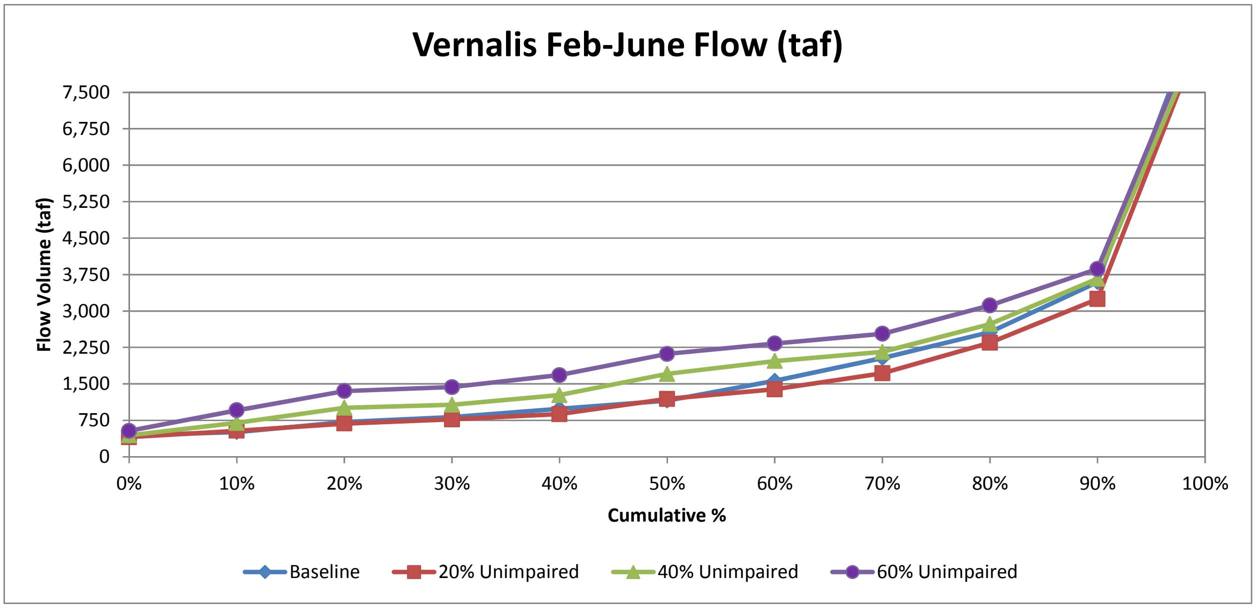


Figure F.1-13a. WSE-simulated Cumulative Distributions of San Joaquin River at Vernalis February–June Flow Volumes (TAF) for LSJR Alternatives 2, 3, and 4 (20%, 40%, 60% Unimpaired Flow) and the CALSIM Baseline

Figure F.1-13b shows the cumulative distribution of SJR at Vernalis flows in February. The February flows were about 2,500 cfs for the baseline and LSJR Alternatives 2, 3, and 4 for almost half of the time (i.e., the 0 to 40 percent distribution range of years). February flows were greater than 5,000 cfs in 40 percent of the years, and were greater than 10,000 cfs in 10 percent of the years. The baseline February flows were very similar to most of the LSJR alternative flows; only LSJR Alternative 3 and 4 flows were higher than the baseline flows for the 50 to70 percent distribution range. The LSJR alternative flows were very similar to each other because the flows in February were often lower than the minimum flow required for the Vernalis EC objective. There would be few changes in the SJR at Vernalis February flows for any of the alternatives.

Figure F.1-13b. WSE-simulated Cumulative Distributions of San Joaquin River at Vernalis February Flows (cfs) for LSJR Alternatives 2, 3, and 4 (20%, 40%, 60% Unimpaired Flow) and the CALSIM Baseline

Figure F.1-13c shows the cumulative distribution of SJR at Vernalis flows in March. The baseline March flows were similar to LSJR Alternatives 2 and 3 in most years. Only LSJR Alternative 4 was about 1,000 to 1,500 cfs higher than the baseline flows in the 20 to 80 percent distribution range. LSJR Alternative 4 would have an increase in March flows in 60 percent of the years.

Figure F.1-13d shows the cumulative distribution of SJR at Vernalis flows in April. The April baseline flows were higher LSJR Alternative 2 flows in most years (i.e., 20 to 90 percent distribution range). LSJR Alternative 3 flows were similar to the baseline flows. LSJR Alternative 4 flows were about 2,000 cfs higher than the baseline flows in the majority of the years (i.e., 10 to 80 percent distribution range). Therefore, LSJR Alternative 2 would have substantial April flow reductions in all years and LSJR Alternative 3 flows would be unchanged. LSJR Alternative 4 would have increased April flows in 70 percent of the years.

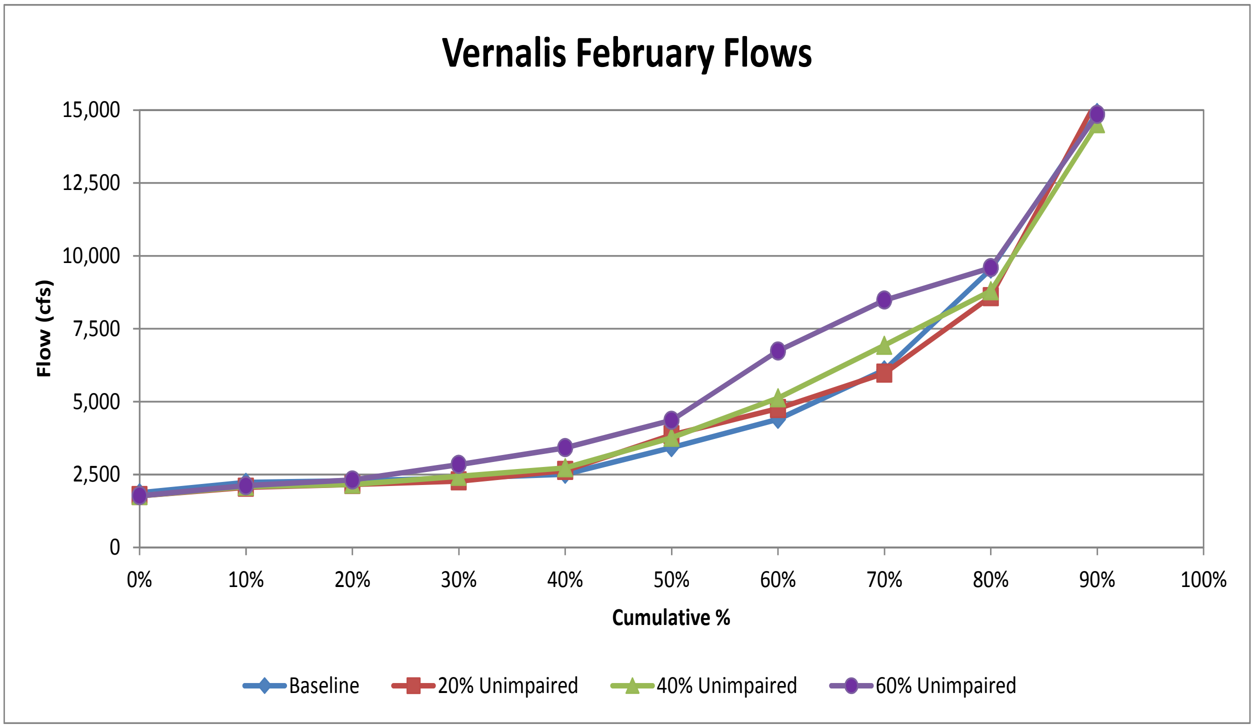


Figure F.1-13b. WSE-simulated Cumulative Distributions of San Joaquin River at Vernalis February Flows (cfs) for LSJR Alternatives 2, 3, and 4 (20%, 40%, 60% Unimpaired Flow) and the CALSIM Baseline

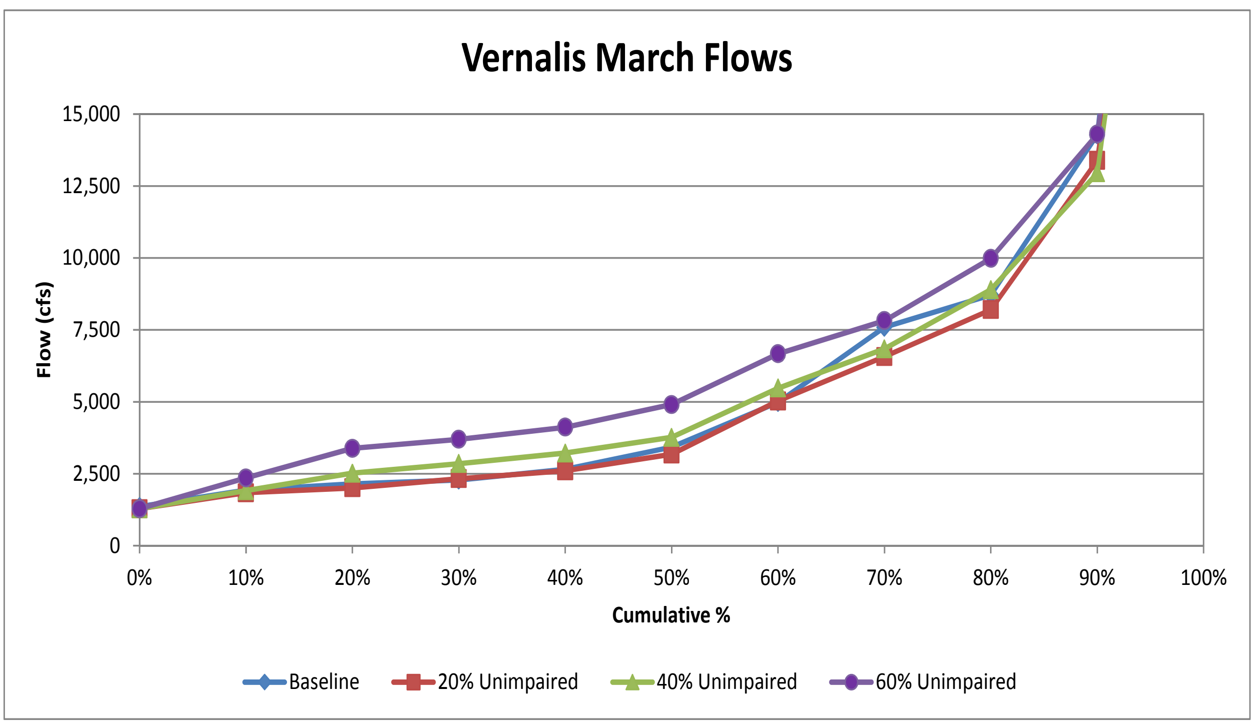


Figure F.1-13c. WSE-simulated Cumulative Distributions of San Joaquin River at Vernalis March Flows (cfs) for LSJR Alternatives 2, 3, and 4 (20%, 40%, 60% Unimpaired Flow) and the CALSIM Baseline

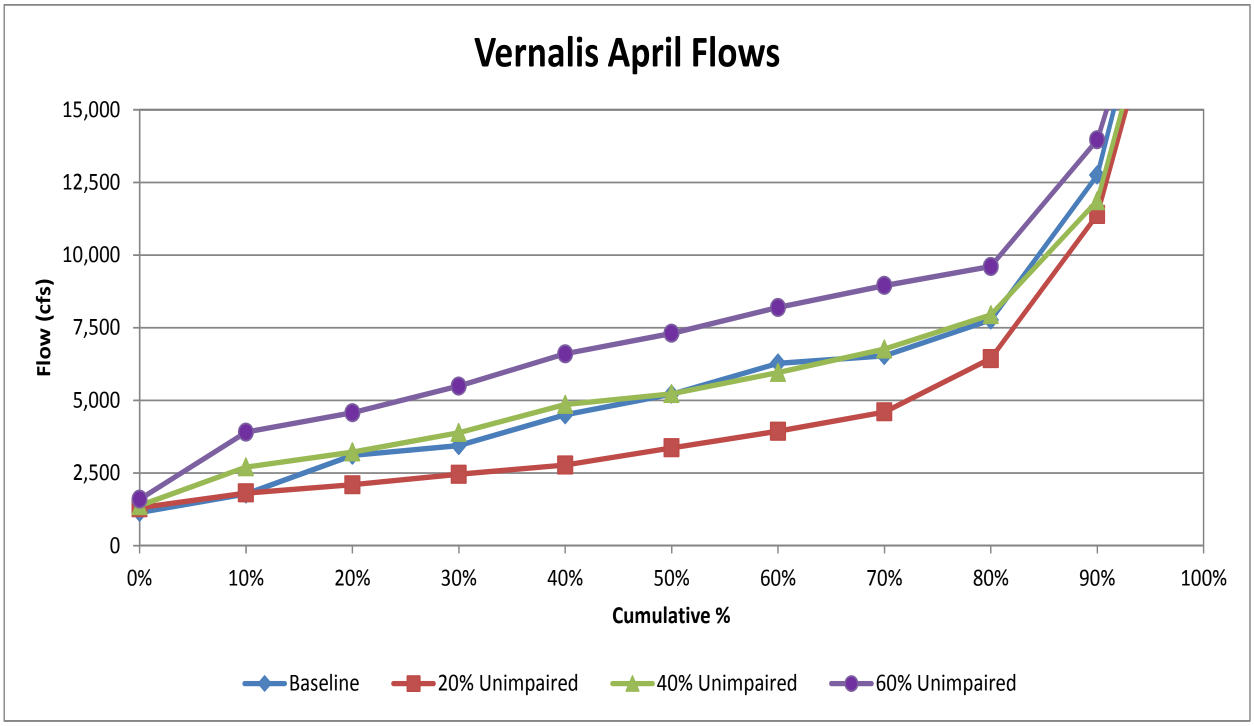


Figure F.1-13d. WSE-simulated Cumulative Distributions of San Joaquin River at Vernalis April Flows (cfs) for LSJR Alternatives 2, 3, and 4 (20%, 40%, 60% Unimpaired Flow) and the CALSIM Baseline

Figure F.1-13e shows the cumulative distribution of SJR at Vernalis flows in May. The median baseline May flows were 5,000 cfs. LSJR Alternative 2 flows were slightly lower (500 cfs) than the baseline flows. LSJR Alternative 3 flows were considerably higher than the baseline flows for the majority of the years (i.e., 10 to 90 percent distribution range). LSJR Alternative 4 May flows would increase by about 1,000 cfs for the 10 to 40 percent distribution range and would increase by about 2,000 cfs for the 50 to 80 percent distribution range. LSJR Alternative 4 May flows were much greater than the baseline flows. The increase in May flows was greater than 2,500 cfs for the majority of the years (i.e., 10 to 80 percent distribution range). This was the greatest increase in SJR at Vernalis flow for any of the 5 months for any of the LSJR alternatives.

Figure F.1-13f shows the cumulative distribution of SJR at Vernalis flows in June. The median baseline June flow was 2,500 cfs. LSJR Alternative 2 June flows were similar to the baseline June flows. LSJR Alternative 3 flows would be greater than the baseline flows, with the greatest increase simulated for the 30 to 70 percent distribution range. The median June flow increased to 5,000 cfs for LSJR Alternative 3 and to 7,500 cfs for LSJR Alternative 4. Therefore, LSJR Alternatives 3 and 4 would have substantial increases in June flows in most years.

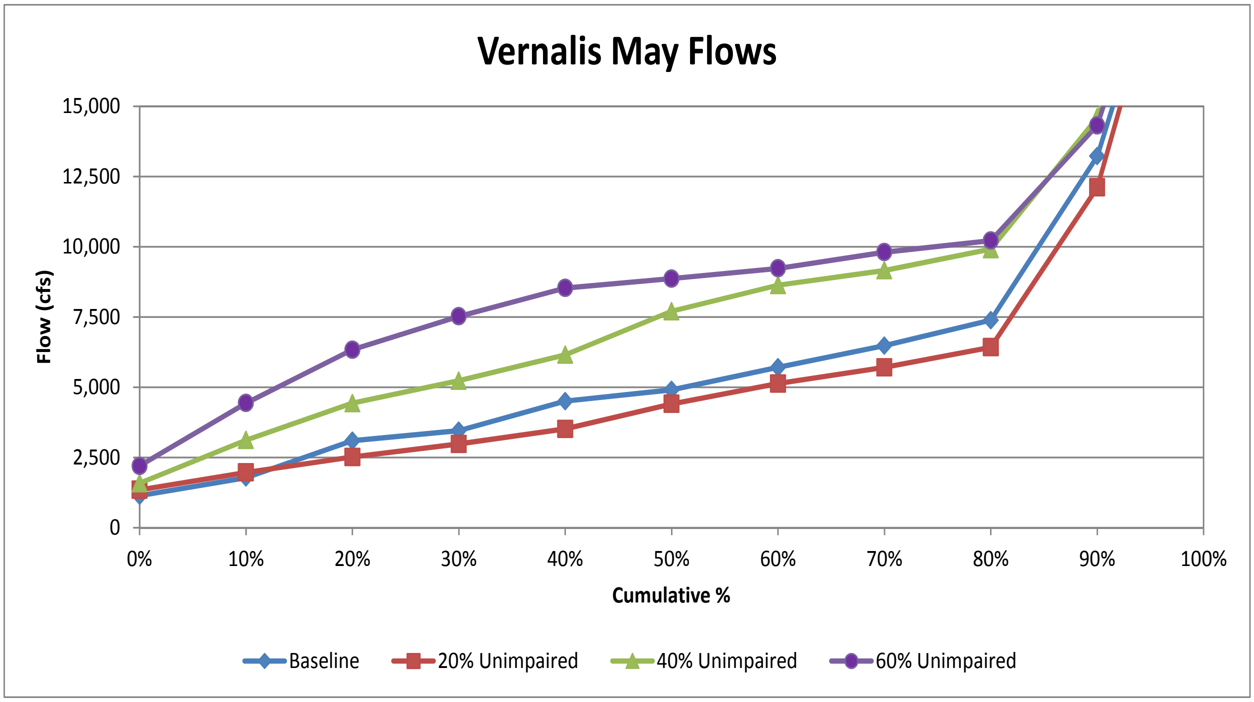


Figure F.1-13e. WSE-simulated Cumulative Distributions of San Joaquin River at Vernalis May Flows (cfs) for LSJR Alternatives 2, 3, and 4 (20%, 40%, 60% Unimpaired Flow) and the CALSIM Baseline

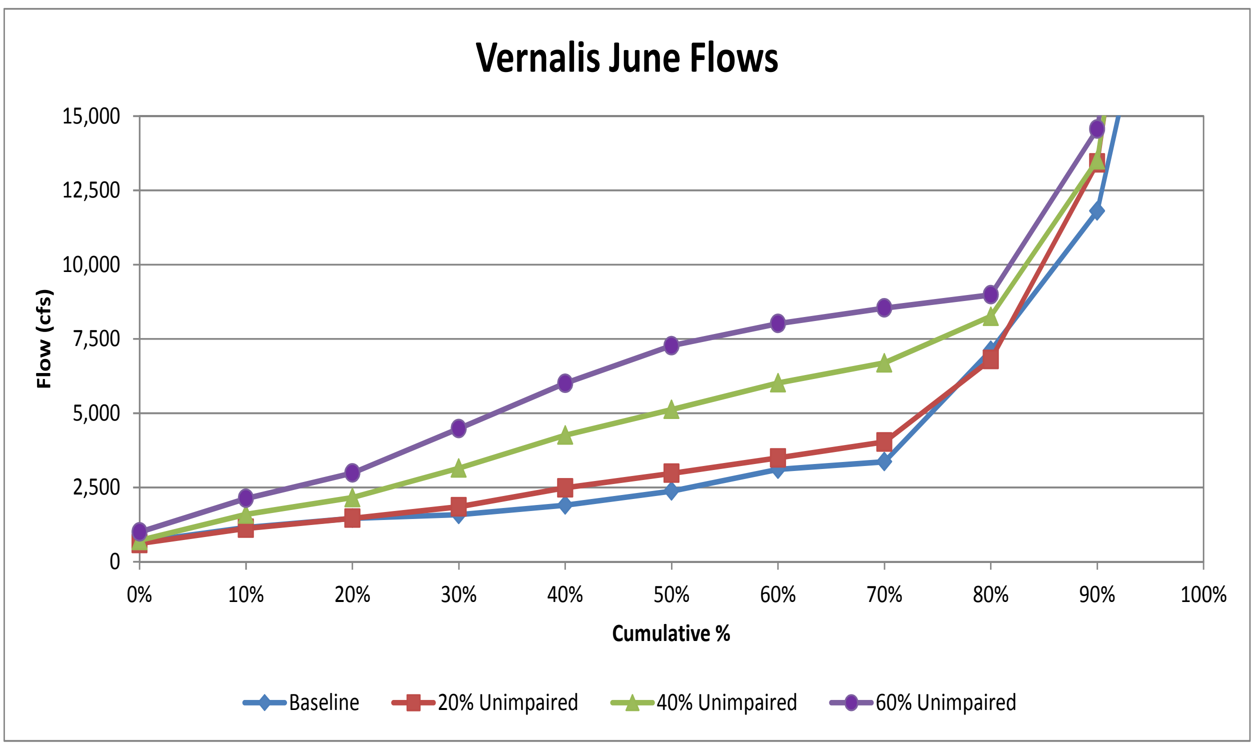


Figure F.1-13f. WSE-simulated Cumulative Distributions of San Joaquin River at Vernalis June Flows (cfs) for LSJR Alternatives 2, 3, and 4 (20%, 40%, 60% Unimpaired Flow) and the CALSIM Baseline

F.1.4 Salinity Modeling

This section contains the modeling methods and results of estimating the effects of the LSJR alternatives on salinity (EC) in the LSJR and southern Delta. Baseline conditions for the eastside tributaries and Vernalis were obtained from CALSIM II, southern Delta EC baseline was estimated using relationships, and the LSJR alternative effects were modeled using the WSE model output and several regression equations. Effects were determined by comparing the LSJR alternatives to baseline conditions. The salinity modeling calculated Vernalis EC effects by changing the three eastside tributary flows and assumes that all other sources of salinity remain the same, as depicted in the baseline conditions CALSIM results.

F.1.4.1 Salinity Modeling Methods

For evaluation of the LSJR alternatives, the salt balance terms included in the monthly CALSIM SJR model were assumed to remain unchanged. The monthly flows, EC values and salt loads upstream of the Merced River were assumed to remain the same as the baseline conditions. All of the diversions, inflows and salt loads along the SJR from the Merced River to Vernalis were assumed to remain the same. The Vernalis flows and EC values were adjusted in the WSE model for LSJR Alternatives 2, 3, and 4 according to the changes in the tributary flows.

The CALSIM model assumes constant flow-EC relationships (i.e., EC = a x flow $^{-b}$) for the SJR above the Merced, Tuolumne, and Stanislaus Rivers. The CALSIM model also assumes predetermined diversions along the SJR and fixed monthly salt loads and inflows from agricultural runoff, tile drainage, and shallow groundwater discharge to the SJR between the Merced River and Vernalis. The linkage between the Delta-Mendota Canal (DMC) water deliveries (moderately high salinity) and these drainage and groundwater inflows to the SJR are not quantified in the CALSIM SJR documentation (USBR 2004).

The salinity calculations in the WSE model are based on the baseline salinity mass-balance calculations from the CALSIM SJR module. Using a mass-balance approach, the tributary flow times the tributary EC is proportional to the mass of salt contributed by each of the eastside tributaries. If the tributary flow is changed during the February–June period, the salt load will change accordingly. A change in the tributary flow will also slightly change the tributary EC because more flow will dilute the tributary salt load (from agricultural drainage or groundwater discharge) and less flow will cause a slight increase in the tributary EC. The approximation used in the WSE model was to adjust the baseline EC as the inverse of the flow change ratio. For example, if the tributary flow were increased from 200 to 250 cfs (flow ratio of 1.25) then the EC would be reduced to 80% of the baseline EC (i.e., EC ratio of 0.8). The WSE model estimates the adjusted tributary EC as:

Adjusted Tributary EC = Baseline EC * (Baseline Flow/ Adjusted Flow) *(Eqn. F.1-9)*

The changes in the tributary flows are used to estimate the adjusted Vernalis EC. Because the tributary EC values are generally much less than the Vernalis EC, the change in the Vernalis EC is also proportional to the Vernalis flow ratio (Baseline Flow/Adjusted Flow). A Vernalis flow increase of 10 percent will reduce the Vernalis EC by almost 10 percent. A flow reduction of 10 percent will increase the EC by almost 10 percent. Flow reductions for the Stanislaus River were sometimes limited by the Vernalis EC objective, generally when the Vernalis flow was relatively low (less than 2,000 cfs). The WSE model calculated the allowable reduction in the Vernalis flow to be the ratio of the baseline EC to the Vernalis EC objective. For example, if the Vernalis EC is 650 µS/cm and the EC objective is 700 µS/cm, the Stanislaus flow (with an EC of about 100 µS/cm) could be reduced by 7 percent of the Vernalis flow.[4] If the Vernalis EC were 950 µS/cm and the EC objective were 1,000 µS/cm, the Stanislaus flow could be reduced by 5 percent of the Vernalis flow. Because the CALSIM model assumes that the target EC is 50 µS/cm less than the EC objective when salinity releases from New Melones Reservoir are required, the increased Stanislaus River releases are greater than they would need to be to just meet the Vernalis EC objectives.

Southern Delta EC Increments

In order to estimate the resulting EC at the interior Delta stations, a simplified approach was taken using historical data. Simple calculations of the southern Delta EC values were made based on the historical EC increases between Vernalis and the southern Delta stations for 1985–2010 (described in detail in Appendix F.2, *Evaluation of Historical Flow and Salinity Measurements of the Lower San Joaquin River and Southern Delta*). The EC increment can be described as the increase in salinity from the Vernalis station to the next station due to additional salt introduced downstream from Vernalis. These calculated EC increases between Vernalis and the southern Delta stations (Brandt Bridge, Union Island, and Tracy Boulevard) were assumed to be reasonable approximations for purposes of salinity impact assessment.

Figure F.1-14a shows the measured EC increments between Vernalis and Brandt Bridge or between Vernalis and Old River at Union Island as a function of the Vernalis flow. The measured EC increments generally are reduced when the Vernalis flow is higher. An example flow-dilution relationship is shown on the graph for 100,000/flow (cfs) and for 200,000/flow (cfs). Some EC increments are higher and some are lower, but this appears to be a reasonable approach for estimating the southern Delta EC based on the Vernalis EC and Vernalis flow. The review of the historical EC data suggested that the EC increment from Vernalis to Brandt Bridge or Old River at Middle River (Union Island) can be approximated with a flow-dilution relationship:

EC increase from Vernalis (µS/cm) = 100,000/ SJR flow at Vernalis (cfs) *(Eqn. F.1-10)*

[4] The analysis in Appendix F.1, *Hydrologic and Water Quality Modeling,* and Appendix F.2, *Evaluation of Historical Flow and Salinity Measurements of the Lower San Joaquin River and Southern Delta*, measures salinity (EC) using microSiemens per cm (µS/cm). Chapter 5, *Water Supply, Surface Hydrology, and Water Quality*, primarily measures salinity using deciSiemens dS/m. The conversion is 1 dS/m = 1000 µS/cm.

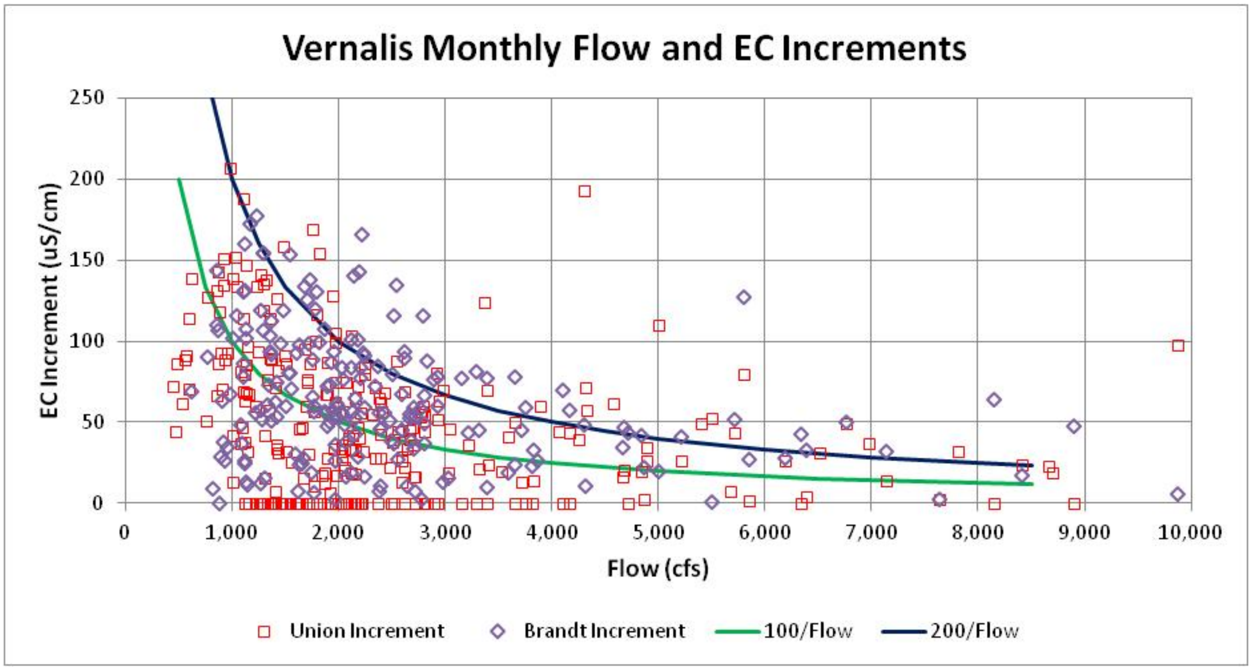


Figure F.1-14a. Historical Monthly EC Increments from Vernalis to Brandt Bridge and Union Island as a Function of Vernalis Flow (cfs) for WY 1985–2010

Therefore, for a flow of 1,000 cfs, the EC increase (EC increment) would be 100 µS/cm. For a flow of 2,000 cfs, the EC increase would be 50 µS/cm, and for a flow of 5,000 cfs, the EC increase would be 20 µS/cm. Figure F.1-14b shows the measured EC increments between Vernalis and Old River at Tracy Boulevard as a function of the Vernalis Flow. The measured EC increments generally are reduced when the Vernalis flow is higher. An example flow-dilution relationship is shown on the graph for 200,000/flow (cfs) and for 400,000/flow (cfs). The EC increase at Old River at Tracy Boulevard was assumed to be three times the EC increase at Brandt Bridge:

EC increase from Vernalis (µS/cm) = 300,000/ SJR flow at Vernalis (cfs) *(Eqn. F.1-11)*

The Tracy Boulevard station is most affected by agricultural drainage and limited tidal circulation in Old River between the City of Tracy Wastewater Treatment Plant discharge and the CVP Jones Pumping plant. These calculated EC increases were assumed for purposes of salinity impact assessment and could be modified if more accurate descriptions of the southern Delta salinity relationships are determined.

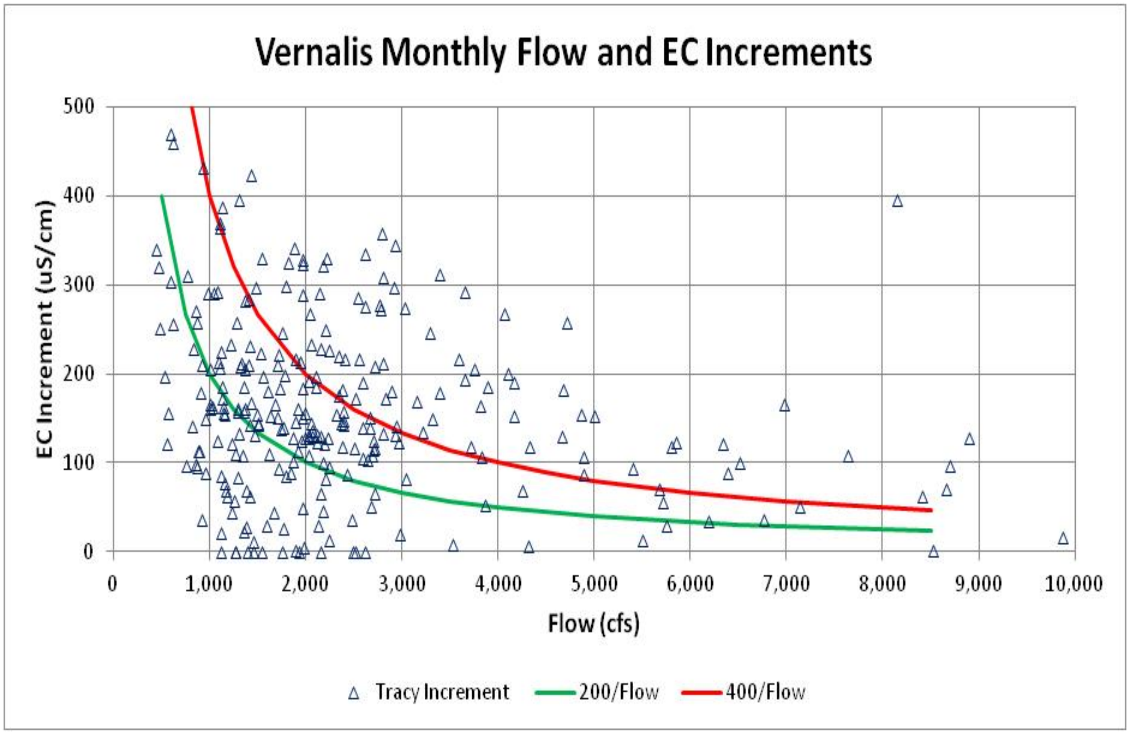


Figure F.1-14b. Historical Monthly EC Increments from Vernalis to Tracy Boulevard as a Function of Vernalis Flow (cfs) for WY 1985–2010

F.1.4.2 Salinity Modeling Results

Baseline Conditions

The CALSIM-simulated EC upstream of the Merced River and the EC at Vernalis are also considered the baseline salinity conditions. The flow and EC of the SJR upstream of the Merced River are assumed to remain the same for all of the LSJR alternatives because the additional flows from the San Joaquin River Restoration Program and the reduction in salinity from the San Luis Drain and Mud Slough resulting from the Grasslands Drainage Project Area (DPA) selenium reduction program cannot yet be determined with certainty. SWRCB recognizes that the flow is likely to increase slightly, and the salinity upstream of the Merced is likely to be substantially reduced by the Grasslands drainage project (for selenium removal). The CALSIM results for the SJR and eastside tributaries are summarized here using the monthly and annual cumulative distribution format tables for the period 1922–2003.

Table F.1-14a shows the CALSIM-estimated SJR EC values upstream of the Merced River. This is an important location because the combination of the flow and the salinity represents the simulated upstream salt load for the baseline conditions which was assumed to remain the same for LSJR Alternatives 2, 3, and 4. The median (50 percent) monthly EC ranges from about 1,200 µS/cm to about 1,900 µS/cm (in July). The maximum monthly EC values of 1,300 µS/cm to 2,600 µS/cm correspond to the lowest flows; the lowest monthly EC values of less than 1,000 µS/cm correspond to the highest flows. The last column in Table F.1-14a shows the annual salt load cumulative distribution (range) for the SJR above the Merced River (1000 tons). A factor of 0.65 was used to convert EC in units of μS/cm to total dissolved solids (TDS) in units of mg/l. The annual salt load above the Merced River ranged from about 427,000 tons (10 percent cumulative) to 790,000 tons (90 percent cumulative) with an average of about 570,000 tons. This upstream salt load accounts for about half of the annual salt load for the SJR at Vernalis (average of about 1,200,000 tons). The remainder of the salt load originates from tile drainage and shallow groundwater seepage to the SJR from below irrigated lands. It is important to compare the measured monthly SJR flow and EC upstream of the Merced River to confirm the CALSIM EC calculations. This comparison is shown and discussed in Appendix F.2, *Evaluation of Historical Flow and Salinity Measurements of the Lower San Joaquin River and Southern Delta*. The CALSIM monthly flows and EC values for the SJR above the Merced River provide a reasonable approximation of the historical measurements and a good basis for the baseline conditions SJR salinity calculations at Vernalis.

Table F.1-14a. CALSIM-Simulated Baseline Monthly Cumulative Distributions of SJR above the Merced EC (μS/cm) 1922–2003 [same for all LSJR alternatives]

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	Salt Load (1000 tons)
SJR Above Merced EC (μS/cm)													
Minimum	638	363	345	301	332	342	212	228	241	283	1,540	1,244	378
10%	1,440	1,072	979	494	491	617	324	319	624	1,665	1,634	1,262	428
20%	1,460	1,146	1,227	850	790	928	744	988	1,421	1,783	1,666	1,267	449
30%	1,461	1,225	1,336	1,082	1,045	1,122	1,060	1,195	1,537	1,831	1,679	1,277	458
40%	1,469	1,335	1,404	1,290	1,205	1,271	1,176	1,314	1,615	1,882	1,733	1,280	465
50%	1,504	1,366	1,451	1,400	1,292	1,437	1,334	1,398	1,674	1,925	1,733	1,281	495
60%	1,504	1,384	1,477	1,487	1,411	1,556	1,580	1,437	1,749	1,930	1,733	1,281	542
70%	1,504	1,397	1,505	1,555	1,488	1,768	1,647	1,509	1,823	1,933	1,733	1,282	584
80%	1,505	1,409	1,505	1,630	1,551	1,923	1,738	1,638	1,845	1,970	1,733	1,285	655
90%	1,558	1,439	1,535	1,669	1,632	1,978	1,952	1,778	1,899	1,994	1,746	1,330	790
Maximum	1,581	1,528	1,602	1,733	1,829	2,652	2,580	1,952	2,144	2,200	1,861	1,349	1,594
Average	1,476	1,281	1,333	1,238	1,197	1,408	1,283	1,267	1,530	1,807	1,715	1,282	572

The Merced River EC values in CALSIM are estimated from a flow-regression equation, described in Appendix F.2, *Evaluation of Historical Flow and Salinity Measurements of the Lower San Joaquin River and Southern Delta*. The baseline Merced River EC values range from about 85 μS/cm at high flow (above 750 cfs) to about 300 μS/cm at low flow (50 cfs). These EC values are similar to the measurements at Stevinson.

The Tuolumne River EC values in CALSIM are estimated from a flow-regression equation, described in Appendix F.2. The baseline Tuolumne River EC values range from about 100 μS/cm at high flow (above 1,500 cfs) to about 200 μS/cm at low flow (200 cfs). These EC values are similar to the measurements at Modesto.

The Stanislaus River EC values in CALSIM are estimated from a salt-balance equation, described in Appendix F.2. The baseline Stanislaus River EC values range from about 75 μS/cm at high flow (above 750 cfs) to about 150 μS/cm at low flow (250 cfs). These EC values are similar to the measurements at Ripon.

Table F.1-14b shows the monthly and annual cumulative distribution (range) for the CALSIM simulated SJR EC at Vernalis. These salinity concentrations at Vernalis are estimated from a monthly salt balance for the SJR between the Merced River and the Stanislaus River. The SJR salinity upstream of the Merced includes the agricultural drainage and wetlands drainage contributions from the Grasslands DPA. The salt balance includes groundwater seepage to the river from agricultural lands along the SJR and the low-salinity tributary river flows that provide a dilution of the SJR salinity. The loss of SJR salt load from the river diversions to the irrigation districts and riparian lands are included. These baseline conditions EC values satisfy the Vernalis EC objectives and are similar to the observed EC for the years since this EC objective was implemented in 1995 by the Bay-Delta Plan.

Table F.1-14b. CALSIM-Simulated Baseline Monthly Cumulative Distributions of SJR at Vernalis EC (µS/cm) 1922–2003

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
SJR at Vernalis EC (µS/cm)												
Minimum	190	161	226	229	178	220	183	151	208	227	185	233
10%	428	518	634	463	314	296	239	200	358	457	454	451
20%	454	548	750	584	363	322	293	286	435	577	485	486
30%	470	587	774	702	513	380	331	316	475	617	524	516
40%	480	612	805	770	668	561	352	339	498	639	580	542
50%	507	629	818	794	758	733	373	366	535	648	600	568
60%	529	651	833	816	887	861	407	408	636	648	615	585
70%	536	661	838	847	950	928	445	441	648	648	626	598
80%	571	682	846	861	950	950	468	463	649	649	640	613
90%	690	703	866	887	950	950	587	600	649	649	648	636
Maximum	777	797	895	950	950	958	684	682	650	688	1,051	906
Average	519	612	771	731	697	658	393	387	533	598	568	551

Table F.1-14c shows the monthly and annual cumulative distribution (range) for the CALSIM simulated salt loads for the SJR at Vernalis. The monthly salt loads (proportional to the flow time the EC values) ranged from about 50,000 tons to more than 250,000 tons in some high-flow spring months. The median monthly salt loads were 75,000–100,000 tons in October–January and 134,000 tons in February, 132,000 tons in March, 101,000 tons in April, 96,000 tons in May, and 73,000 tons in June. The median monthly salt loads were 50,000–60,000 tons in July–September. These salt loads are remarkably uniform throughout the year, increasing most dramatically with higher flows. The annual salt load at Vernalis ranged from 766,000 tons (10 percent cumulative) to 1,836,000 tons (90 percent cumulative) with a median salt load of 1,082,000 tons and an average of 1,231,000 tons.

Table F.1-14c. CALSIM-Simulated Baseline Monthly Cumulative Distributions of SJR at Vernalis Salt Load (1,000 tons) 1922–2003

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	Annual
SJR at Vernalis Salt Load (1,000 tons)													
Minimum	36	53	66	61	96	70	38	41	23	21	21	37	657
10%	60	64	78	75	112	99	60	60	41	35	38	50	776
20%	67	67	84	82	116	108	77	74	51	44	45	55	893
30%	69	69	87	89	120	117	82	80	56	47	47	57	955
40%	73	71	90	97	125	126	92	89	64	52	49	59	1,013
50%	75	72	92	99	134	132	101	96	73	58	51	61	1,080
60%	79	75	95	104	144	138	117	102	81	64	56	66	1,208
70%	81	76	99	129	151	145	128	117	94	72	68	70	1,317
80%	83	79	115	167	192	154	140	136	176	111	73	73	1,567
90%	87	83	153	221	290	251	159	154	229	181	77	78	1,836
Maximum	100	143	313	748	522	594	270	273	315	300	92	100	3,323
Average	74	74	109	132	166	156	110	106	102	82	57	63	1,231

The Vernalis EC results reveal an important assumption in the operations of New Melones Reservoir. In addition to the required environmental releases, New Melones releases additional water to reduce the Vernalis EC to below the objective. CALSIM uses a target EC of 950 µS/cm for September–March when the Vernalis EC objective is 1,000 µS/cm and a target of 650 µS/cm in the months when the Vernalis EC objective is 700 µS/cm. The baseline conditions results indicate that this maximum EC target is controlling the Vernalis flow (and the New Melones release) in February for about 30 percent of the years and is controlling the flows in March for about 20 percent of the years. The 650 µS/cm target is controlling flows in June for about 30 percent of the years, in July for about 50 percent of the years, and in August for about 10 percent of the years. The 50 µS/cm buffer requires about 7 percent of the Vernalis flow in months when the EC objective is 700 µS/cm and requires about 5 percent of the Vernalis flow when the EC objective is 1,000 µS/cm. The available EC data at Vernalis and at the southern Delta monitoring stations, along with the CALSIM salinity calculations, are described in Appendix F.2.

The southern Delta EC values were calculated for the baseline conditions assuming an average EC increase that was 100 µS/cm at a flow of 1,000 cfs and was reduced (i.e., dilution) at higher flows. The Old River at Tracy Boulevard EC was assumed to be increased by three times the Brandt Bridge increment. Table F.1-14d shows the calculated monthly cumulative distributions of the assumed EC increments between Vernalis and Brandt Bridge (and at Old River at Middle River) for the baseline flow conditions. The monthly median EC increments were 29 µS/cm in February and March, 19 µS/cm in April, 20 µS/cm in May, and 42 µS/cm in June, reflecting the median SJR dilution flows in these months.

Table F.1-14d. Calculated Baseline Monthly Cumulative Distributions of the EC Increment (µS/cm) from Vernalis to Brandt Bridge 1922–2003 (Average of 42 µS/cm)

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
Brandt Bridge EC Increment (µS/cm)												
Minimum	13	6	4	2	3	2	4	4	4	4	11	13
10%	26	35	23	10	7	7	8	8	8	14	32	31
20%	29	37	35	20	10	11	13	14	14	28	36	36
30%	31	41	42	30	16	13	15	15	30	47	42	40
40%	33	44	46	41	23	20	16	18	32	54	56	45
50%	37	48	48	43	29	29	19	20	42	60	65	51
60%	39	50	50	46	40	38	22	22	53	68	68	54
70%	42	52	52	51	42	44	29	29	63	75	72	57
80%	46	55	55	56	44	47	32	32	68	79	78	60
90%	61	59	59	62	45	52	56	56	87	99	92	68
Maximum	118	82	73	84	54	74	87	88	151	181	272	135
Average	40	46	45	40	28	30	25	25	46	60	62	50

Table F.1-14e shows the monthly cumulative distribution (range) for the calculated SJR at Brandt Bridge and Old River at Middle River EC for the baseline conditions. This EC is the calculated Vernalis EC plus the estimated EC increment from Vernalis to Brandt Bridge. The calculated EC at Brandt Bridge was greater than the baseline EC objectives in many months (132 of 984), because the assumed EC increase was often 25-50 µS/cm. The calculated EC at Brandt Bridge was greater than the EC objectives in 55 months in the February–June period. Table F.1-14f shows the calculated monthly cumulative distribution of the assumed EC increments between Vernalis and Tracy Boulevard for the baseline conditions. The monthly median EC increments were 88 µS/cm in February and March, 58 µS/cm in April, 61 µS/cm in May, and 126 µS/cm in June, reflecting the median SJR dilution flows in these months.

Table F.1-14e. Calculated Baseline Monthly Cumulative Distributions of SJR at Brandt Bridge and Old River at Middle River EC (µS/cm) 1922–2003

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
SJR at Brandt Bridge EC (µS/cm)												
Minimum	203	167	230	231	182	226	186	155	212	231	196	245
10%	455	553	661	475	320	308	246	208	367	471	486	482
20%	483	585	787	603	371	330	309	299	458	606	521	522
30%	501	629	814	731	526	392	348	334	505	672	566	556
40%	513	656	853	811	690	577	367	359	527	694	635	587
50%	545	675	866	838	785	762	392	385	571	707	664	621
60%	568	701	882	861	926	900	429	432	692	716	684	639
70%	579	712	892	900	991	969	471	472	711	723	699	654
80%	614	737	901	920	993	997	500	494	715	727	718	673
90%	752	762	924	943	995	1,002	647	655	735	746	740	704
Maximum	895	879	966	1,034	1,004	1,024	759	751	799	869	1,323	1,040
Average	560	659	815	772	725	687	418	412	580	658	630	602

Table F.1-14f. Calculated Baseline Monthly Cumulative Distributions of the EC Increment (µS/cm) from Vernalis to Old River at Tracy Boulevard 1922–2003 (Grand Average of 125 µS/cm)

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
Old River at Tracy Boulevard EC Increment (µS/cm)												
Minimum	40	18	12	5	9	6	11	12	11	12	33	38
10%	79	104	68	31	20	21	24	23	25	41	96	94
20%	88	112	105	60	31	34	39	41	42	85	107	108
30%	94	124	125	91	49	40	46	46	89	140	125	120
40%	98	133	138	122	68	60	48	53	97	161	168	134
50%	110	143	145	129	88	88	58	61	126	181	194	154
60%	118	149	151	138	120	113	67	67	158	203	204	162
70%	126	155	156	153	126	132	87	87	189	224	217	170
80%	137	165	166	169	132	140	97	97	205	237	233	180
90%	184	178	177	187	135	156	169	168	260	297	276	204
Maximum	353	246	220	252	161	222	262	264	452	542	815	404
Average	121	139	134	121	85	89	75	75	138	181	187	151

Table F.1-14g shows the monthly cumulative distribution (range) for the calculated Old River at Tracy Boulevard EC for the baseline conditions. The calculated EC at Tracy Boulevard was greater than the (baseline) EC objectives in many months (292 of 984), because the assumed EC increase was often 50-150 µS/cm. The calculated EC at Tracy Boulevard was greater than the EC objectives in 125 months (out of 410) in the February–June period. Because the baseline EC objectives are the same at the southern Delta stations, these baseline EC increments will cause many EC values at the southern Delta station to be greater than the EC objectives.

Table F.1-14g. Calculated Baseline Monthly Cumulative Distributions of Old River at Tracy Boulevard EC (µS/cm) 1922–2003

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
Old River at Tracy Boulevard Bridge EC (µS/cm)												
Minimum	229	179	238	234	191	232	194	164	219	239	217	271
10%	508	622	708	500	330	327	260	224	384	498	550	545
20%	542	658	857	639	388	352	333	330	491	662	592	594
30%	564	713	895	786	551	415	377	370	571	764	649	637
40%	578	744	947	892	735	608	400	400	598	801	748	677
50%	618	770	961	925	841	819	425	422	643	824	796	724
60%	646	800	983	951	1,012	981	476	470	803	851	820	747
70%	665	813	995	1,004	1,075	1,051	528	534	836	873	848	766
80%	711	848	1,010	1,036	1,080	1,090	565	558	847	886	869	791
90%	875	881	1,035	1,068	1,085	1,105	763	763	909	944	924	840
Maximum	1,130	1,044	1,113	1,202	1,111	1,172	910	921	1,100	1,230	1,866	1,310
Average	640	752	905	852	782	747	468	462	672	779	754	702

LSJR Alternative 2: 20% Unimpaired Flow

Table F.1-15a shows the WSE calculated monthly cumulative distribution (range) for the SJR at Vernalis EC for LSJR Alternative 2. The annual cumulative distribution of the SJR salt load (tons) at Vernalis is shown in the last column. These SJR at Vernalis EC values are calculated from the monthly flow changes on the three eastside tributaries and the CALSIM simulated baseline EC values for the SJR at Vernalis. The WSE calculated EC values are higher than the baseline EC values whenever the Vernalis flow was reduced and are lower than the baseline EC values whenever the Vernalis flow was increased. The EC changes were smallest when the baseline flow was high and the baseline EC was low. The median calculated SJR at Vernalis EC values for LSJR Alternative 2 were 719 in February, 761 µS/cm in March, 513 µS/cm in April, 407 µS/cm in May and 493 µS/cm in June. The median calculated SJR at Vernalis EC values were similar to the median baseline EC values in February–March and were lower in April–June. The WSE model allows the Vernalis EC to approach the EC objectives, while the baseline EC values are simulated to be 50 µS/cm below the EC objective.

Table F.1-15a. SJR at Vernalis EC (µS/cm) for LSJR Alternative 2: 20% Unimpaired Flow

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
SJR at Vernalis EC (µS/cm)												
Minimum	190	158	226	223	210	229	196	179	167	221	185	233
10%	386	493	621	396	306	328	275	227	318	425	370	360
20%	429	530	741	538	378	372	390	316	357	577	482	475
30%	453	577	766	677	480	428	450	347	384	617	524	509
40%	470	610	800	763	611	529	474	392	442	639	580	523
50%	495	627	817	784	719	761	513	407	493	648	600	568
60%	521	651	831	811	916	876	565	434	523	648	615	585
70%	536	661	838	847	996	981	624	479	597	648	626	598
80%	557	682	846	861	997	997	644	541	677	649	640	613
90%	690	703	866	887	997	997	674	641	696	649	648	636
Maximum	777	797	895	950	997	998	696	696	696	688	717	906
Average	502	603	761	715	702	686	506	423	493	594	557	538

The southern Delta EC values were calculated in the WSE model assuming an average EC increase that was 100 µS/cm at a flow of 1,000 cfs and was reduced (dilution of agricultural drainage and wastewater discharge) at higher flows. Table F.1-15b shows the monthly cumulative distribution (range) for the WSE calculated EC for the SJR at Brandt Bridge and Old River at Middle River for LSJR Alternative 2. Table F.1-15c shows the monthly cumulative distribution (range) for the WSE calculated EC for Old River at Tracy Boulevard for LSJR Alternative 2. The EC increment at Tracy Boulevard was assumed to be three times the EC increment at Brandt Bridge. The calculated EC in the southern Delta will only change in the February–June period when the tributary flows are adjusted. Because the monthly flows at Vernalis did not change by very much, the calculated EC values in the southern Delta did not change substantially for LSJR Alternative 2. However, whenever there was a reduction in the monthly Vernalis flow, there was an increase in the Vernalis EC and a further increase in the southern Delta EC estimates (less dilution of agricultural drainage and wastewater discharges). There were 176 months (99 in the February–June period) with calculated

EC greater than the baseline EC objectives at Brandt Bridge and 303 months (136 in the February–June period) at Tracy Boulevard. The southern Delta EC values were higher in many months because Vernalis flows were reduced in many months with LSJR Alternative 2.

Table F.1-15b. Calculated Monthly Cumulative Distributions of SJR at Brandt Bridge and Old River at Middle River EC (µS/cm) for LSJR Alternative 2: 20% Unimpaired Flow 1922–2003

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
SJR at Brandt Bridge EC (µS/cm)												
Minimum	203	164	230	224	215	239	200	185	170	225	196	245
10%	412	524	653	406	311	336	285	235	329	439	395	386
20%	456	565	778	557	390	382	406	336	377	606	518	512
30%	482	618	806	702	497	441	474	364	412	672	566	548
40%	501	654	845	803	632	549	509	414	467	694	635	565
50%	530	675	865	826	746	793	542	431	522	707	664	621
60%	561	701	880	854	953	915	592	459	558	716	684	639
70%	578	712	891	900	1,041	1,021	662	515	637	723	699	654
80%	607	737	901	920	1,043	1,043	685	578	764	727	718	673
90%	752	762	924	943	1,045	1,052	723	688	775	746	740	704
Maximum	895	879	966	1,034	1,054	1,075	771	761	859	869	898	1,040
Average	541	649	806	754	730	717	538	450	535	654	618	587

Table F.1-15c. Calculated Monthly Cumulative Distributions of Old River at Tracy Boulevard Bridge EC (µS/cm) for LSJR Alternative 2: 20% Unimpaired Flow 1922–2003

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
Old River at Tracy Boulevard Bridge EC (µS/cm)												
Minimum	229	176	238	227	226	260	208	194	175	233	217	271
10%	460	585	700	426	330	346	307	250	357	466	445	436
20%	512	636	845	601	404	396	437	378	437	662	589	585
30%	540	700	888	757	532	466	515	403	466	764	649	628
40%	564	743	936	880	680	588	559	453	530	801	748	647
50%	601	770	959	909	793	854	626	471	583	824	796	724
60%	639	800	982	941	1,025	991	662	522	651	851	820	747
70%	661	813	995	1,001	1,129	1,103	746	580	720	873	848	766
80%	705	848	1,010	1,036	1,136	1,143	773	651	900	886	869	791
90%	875	881	1,035	1,068	1,142	1,161	826	785	944	944	924	840
Maximum	1,130	1,044	1,113	1,202	1,167	1,231	925	891	1,184	1,230	1,259	1,310
Average	619	740	894	833	788	779	602	504	620	775	739	686

LSJR Alternative 3: 40% Unimpaired Flow

Table F.1-16a shows the monthly cumulative distribution (range) for the WSE calculated EC for the SJR at Vernalis for LSJR Alternative 3. The annual cumulative distribution of the SJR salt load (tons) at Vernalis is shown in the last column. The WSE calculated EC values were higher than the baseline EC values whenever the Vernalis flow was reduced and were lower than the baseline EC values whenever the Vernalis flow was increased. The median calculated SJR at Vernalis EC values for LSJR Alternative 3 were 677 in February, 637 µS/cm in March, 354 µS/cm in April, 262 µS/cm in May, and 335 µS/cm in June. The median calculated SJR at Vernalis EC values were 80 µS/cm less in February, 100 µS/cm less in March, similar in April, 100 µS/cm less in May, and 200 µS/cm les in June compared to the median baseline EC values.

The southern Delta EC values were calculated in the WSE model assuming an average EC increase that was 100 µS/cm at a flow of 1,000 cfs and was reduced (dilution) at higher flows. The EC increment at Tracy Boulevard was assumed to be three times the Brandt Bridge EC increment. Table F.1-116b shows the monthly cumulative distribution for the calculated SJR at Brandt Bridge and Old River at Middle River EC for LSJR Alternative 3. Table F.1-16c shows the monthly cumulative distribution for the calculated Old River at Tracy Boulevard EC for LSJR Alternative 3. Because the monthly flows at Vernalis generally increased for LSJR Alternative 3, the southern Delta EC values were usually reduced from the baseline in February–June, and there were fewer months with EC greater than the EC objectives. There were 123 months (46 in the February–June period) with calculated EC greater than the baseline EC objectives at Brandt Bridge and 225 months (58 in the February–June period) at Tracy Boulevard.

Table F.1-16a. SJR at Vernalis EC (µS/cm) for LSJR Alternative 3: 40% Unimpaired Flow

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
SJR at Vernalis EC (µS/cm)												
Minimum	187	156	226	229	221	231	193	174	170	218	184	0
10%	367	505	569	389	314	319	232	200	225	457	454	373
20%	427	546	720	536	372	357	289	224	241	577	485	484
30%	458	581	768	678	478	409	307	240	268	617	524	510
40%	478	610	805	768	527	487	330	249	312	639	580	530
50%	500	627	818	792	677	637	354	262	335	648	600	566
60%	529	651	831	816	863	715	384	275	368	648	615	585
70%	536	661	838	847	966	745	404	297	416	648	626	598
80%	571	682	846	861	996	828	432	331	447	649	640	613
90%	690	703	866	887	997	997	490	386	554	649	648	636
Maximum	777	797	895	950	997	998	686	667	696	688	717	906
Average	504	608	761	720	678	609	364	282	364	597	563	537

Table F.1-16b. Calculated Monthly Cumulative Distributions of SJR at Brandt Bridge and Old River at Middle River EC (µS/cm) for LSJR Alternative 3: 40% Unimpaired Flow 1922–2003

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
SJR at Brandt Bridge EC (µS/cm)												
Minimum	200	162	230	231	226	241	197	179	172	222	195	52
10%	391	539	589	398	323	328	242	213	241	471	486	398
20%	454	584	758	555	384	371	298	231	254	606	521	520
30%	487	622	806	702	490	422	322	253	288	672	566	549
40%	510	654	853	811	548	504	347	262	332	694	635	572
50%	537	675	866	835	703	663	378	275	357	707	664	618
60%	568	701	880	859	901	745	405	287	380	716	684	639
70%	579	712	891	900	1,006	779	432	315	447	723	699	654
80%	614	737	901	920	1,043	865	457	353	485	727	718	673
90%	752	762	924	943	1,045	1,048	525	420	612	746	740	704
Maximum	895	879	966	1,034	1,054	1,075	758	730	792	869	898	1,040
Average	543	654	805	760	706	636	385	299	393	658	624	586

Table F.1-16c. Calculated Monthly Cumulative Distributions of Old River at Tracy Boulevard Bridge EC (µS/cm) for LSJR Alternative 3: 40% Unimpaired Flow 1922–2003

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
Old River at Tracy Boulevard Bridge EC (µS/cm)												
Minimum	226	174	238	234	238	254	204	191	178	229	217	155
10%	438	606	640	417	334	346	261	226	271	498	550	448
20%	506	657	834	594	407	397	324	251	280	662	592	590
30%	546	704	888	757	514	444	353	272	322	764	649	627
40%	575	743	947	889	588	540	379	287	369	801	748	657
50%	612	770	961	920	755	716	416	301	397	824	796	721
60%	646	800	982	950	976	819	442	318	425	851	820	747
70%	665	813	995	1,004	1,090	855	481	350	477	873	848	766
80%	711	848	1,010	1,036	1,135	944	519	399	592	886	869	791
90%	875	881	1,035	1,068	1,141	1,148	595	487	748	944	924	840
Maximum	1,130	1,044	1,113	1,202	1,167	1,231	904	856	1,023	1,230	1,259	1,310
Average	622	746	893	840	762	690	428	332	452	779	746	686

LSJR Alternative 4: 60% Unimpaired Flow

Table F.1-17a shows the monthly cumulative distribution (range) for the WSE calculated EC for the SJR at Vernalis for LSJR Alternative 4. The annual cumulative distribution of the SJR salt load (tons) at Vernalis is shown in the last column. The median calculated SJR at Vernalis EC values for LSJR Alternative 4 were 575 in February, 496 μS/cm in March, 275 μS/cm in April, 228 μS/cm in May, and 268 μS/cm in June. The median calculated SJR at Vernalis EC values were considerably less than the median baseline EC values.

The southern Delta EC values were calculated in the WSE model assuming an average EC increase that was 100 μS/cm at a flow of 1,000 cfs and was reduced (dilution) at higher flows. The EC at Tracy Boulevard was assumed to be three times the EC increment at Brandt Bridge. Table F.1-17b shows the monthly cumulative distribution for the calculated SJR at Brandt Bridge and Old River at Middle River EC for LSJR Alternative 4. Table F.1-117c shows the monthly cumulative distribution for the calculated Old River at Tracy Boulevard EC for LSJR Alternative 4. Because the monthly flows at Vernalis were substantially increased in the February–June period for LSJR Alternative 4, the southern Delta EC values were reduced from the baseline, and there were fewer months with EC greater than the EC objectives. There were 44 months (34 in the February–June period) with calculated EC greater than the baseline EC objectives at Brandt Bridge and 203 months (36 in the February–June period) at Tracy Boulevard.

Table F.1-17a. SJR at Vernalis EC (μS/cm) for LSJR Alternative 4: 60% Unimpaired Flow

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
SJR at Vernalis EC (μS/cm)												
Minimum	171	155	226	229	213	224	177	162	153	212	180	0
10%	316	502	574	394	302	298	195	181	190	457	454	310
20%	404	548	707	528	339	319	231	205	206	577	485	484
30%	460	587	761	678	394	359	247	212	227	617	524	510
40%	479	612	800	767	444	415	258	223	249	639	580	530
50%	504	629	817	789	575	496	275	228	268	648	600	566
60%	529	651	831	816	694	540	294	236	303	648	615	585
70%	536	661	838	847	845	616	307	248	337	648	626	598
80%	571	682	846	861	939	641	328	263	360	649	640	613
90%	690	703	866	887	997	846	361	294	431	649	648	636
Maximum	777	797	895	950	997	998	598	494	696	688	717	906
Average	500	609	760	718	613	515	285	238	298	597	563	526

Table F.1-17b. Calculated Monthly Cumulative Distributions of SJR at Brandt Bridge and Old River at Middle River EC (µS/cm) for LSJR Alternative 4: 60% Unimpaired Flow 1922–2003

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
SJR at Brandt Bridge EC (µS/cm)												
Minimum	183	161	230	231	219	233	190	174	170	216	191	52
10%	336	536	600	403	311	308	208	193	203	471	486	330
20%	429	585	747	546	352	329	243	216	217	606	521	520
30%	490	629	802	702	402	371	261	222	238	672	566	549
40%	511	656	845	807	458	432	271	233	262	694	635	572
50%	543	675	865	833	598	518	288	239	278	707	664	618
60%	568	701	880	861	724	567	314	249	326	716	684	639
70%	579	712	892	900	878	646	324	260	360	723	699	654
80%	614	737	901	920	976	668	344	275	386	727	718	673
90%	752	762	924	943	1,044	888	385	309	472	746	740	704
Maximum	895	879	966	1,034	1,054	1,075	661	540	792	869	898	1,040
Average	538	655	804	758	638	537	301	251	321	657	624	574

Table F.1-17c. Calculated Monthly Cumulative Distributions of Old River at Tracy Boulevard Bridge EC (µS/cm) for LSJR Alternative 4: 60% Unimpaired Flow 1922–2003

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
Old River at Tracy Boulevard Bridge EC (µS/cm)												
Minimum	206	172	238	234	230	246	202	190	175	224	212	155
10%	375	603	653	423	323	328	232	216	227	498	550	371
20%	480	658	821	584	374	350	266	239	241	662	592	590
30%	549	712	881	757	421	397	280	244	263	764	649	627
40%	577	744	936	889	486	459	298	255	292	801	748	657
50%	618	770	959	916	644	558	315	260	308	824	796	721
60%	646	800	982	951	783	622	342	273	349	851	820	747
70%	665	813	995	1,004	946	703	361	282	408	873	848	766
80%	711	848	1,010	1,036	1,059	721	379	302	439	886	869	791
90%	875	881	1,035	1,068	1,138	972	434	354	554	944	924	840
Maximum	1,130	1,044	1,113	1,202	1,167	1,231	786	631	985	1,230	1,259	1,310
Average	616	747	893	838	688	582	333	277	366	778	746	672

F.1.5 Temperature Modeling

The water temperature model used for the SED analysis, the SJR Basin Water Temperature Model, is based on the USACE HEC-5Q river and reservoir hydraulic and water quality model (CalFed 2009). The model was developed through a series of CALFED/DFG grants, starting in 2000 with the development and calibration of the Stanislaus River Model. The model provides a great tool for evaluating the effects of reservoir operations (storage, elevation, diversions, and river releases) on the SJR tributaries and lower SJR water temperatures from the Stevinson stream gage upstream of the Merced River to Mossdale, downstream of Vernalis (CalFed 2009). The model simulates the reservoir stratification, release temperatures, and downstream river temperatures as a function of the inflow temperatures, reservoir geometry, outlet elevations, meteorology and river geometry. The tributary river models were calibrated independently of each other. The calibrated models were then used to calibrate the SJR temperatures. The tributary reservoir and river temperatures were calibrated with 1990–2007 data, including monthly reservoir temperature profile observations as well as hourly temperature measurements at several stations in each tributary river.

For use in the alternatives analysis in the SED, the calibration runs of the model were adjusted to match the CALSIM baseline conditions (reservoir storage and monthly river flows) to provide the SED baseline conditions. The historical daily inflows, diversions and outflows were adjusted (as monthly ratio) to match the CALSIM monthly inflows and reservoir storages. The simulated temperatures for the CALSIM baseline conditions were very similar to the simulated temperatures for the historical operations (i.e., calibration results). The analysis of water temperatures will focus on the simulated differences in the reservoir release temperatures and the downstream river temperatures for the baseline conditions and the LSJR alternatives.

F.1.5.1 Temperature Model Methods

Water Temperature Model Geometry

Figure F.1-15 is a schematic representation of the HEC-5 model for the SJR and three eastside tributaries, including Lake McClure, New Don Pedro Reservoir, and New Melones Reservoir. The application of HEC-5Q to the San Joaquin, Merced, Tuolumne, and Stanislaus Rivers computes the vertical distribution of temperature in the reservoirs and the longitudinal temperature distributions in the river reaches based on daily average flows and meteorology. Reservoirs represented in the model include McClure, McSwain, Merced Falls, and Crocker Huffman on the Merced River; New Don Pedro and La Grange on the Tuolumne River; and New Melones, Tulloch, and Goodwin on the Stanislaus River. The river geometry is specified from measured cross-section data for each 1-mile segment.

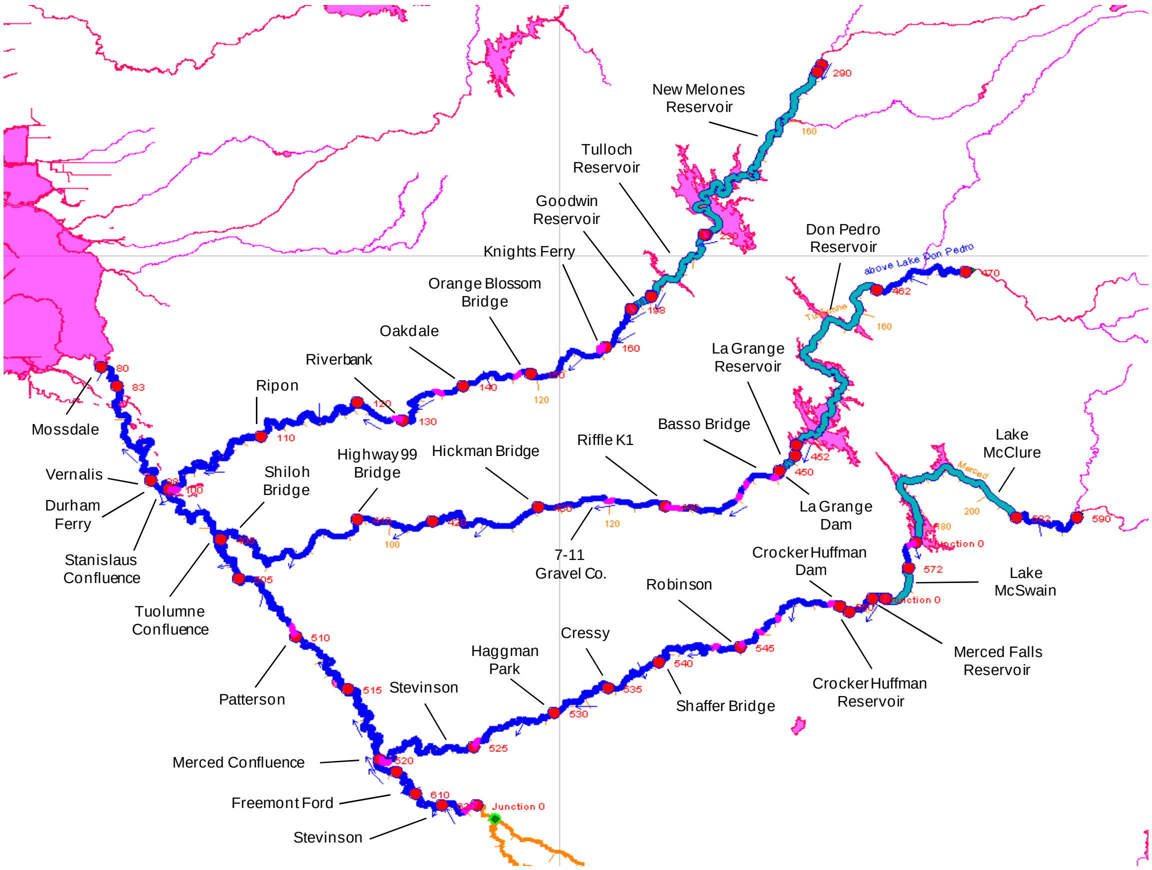


Figure F.1-15. The SJR Basin, Including the Stanislaus, Tuolumne, and Merced River Systems, as Represented in the HEC-5 Model (Source: CalFed 2009)

The river reaches are represented as a series of volume elements. The width, cross-sectional area, and depth vary with the flow using specified relationships developed from appropriate hydraulic computations using the measured river cross-sections. The reservoirs are simulated as a series of vertically stratified layers. The reservoir inflow distribution (vertical spread) and outlet distribution calculated from the water temperatures (density) and specified coefficients. Vertical advection of water and heat is simulated as a mass balance once the inflow and outflow from each layer is calculated. The balance between solar heating and wind or convective (i.e., cooling at surface) mixing control the surface layer mixed depth.

The river hydraulic model uses the standard one-dimensional river backwater calculations that solve the “Manning Equation” from the downstream end upriver. These calculations require river cross-sections to describe the local river channel geometry. The HEC-5 river geometry is simplified as the width at specified elevations for a range of elevations that should allow the maximum flow to be simulated. The hydraulic model can be used to determine the water elevations, with corresponding width and cross sectional area, for a range of flows. Because these sections are specified for various locations along the river, the full river geometry can be described for a range of flows. The sections can be summarized in geometry tables for the river; the river surface area (section width times river distance) and the river volume (cross-sectional area times river distance) can be determined for each section of the river or for the entire length.

Table F.1-18a gives the river geometry (surface area, volume, and depth) for the Stanislaus River for a range of flows from 250 to 10,000 cfs. The average velocity and the travel time from upstream to downstream can be calculated (from the volume, length, and flow). The travel time has been included in the table. For example, the Stanislaus River length is about 58 miles and has a surface area of 736 acres, which is equivalent to an average width of 105 feet at a flow of 250 cfs. The volume is 2,252 AF, so the average depth is 3.1 feet. At low flow there may be considerable volume of water in the pools upstream of riffles and runs. The river surface area can be used as an initial index of the fish habitat area; as the river flow increases, a larger portion of the channel and adjacent riparian corridor will flood, including river bars, benches and floodplains. The travel time for water at the low flow of 250 cfs would be about 4.5 days (109 hours). Warming will be rapid in the upstream portion of the river (during the first 1–2 days), because the difference between the equilibrium temperature and the release temperature will be greatest. At higher flows (above 2,500 cfs) there may be backwater areas or adjacent ponds that flood that were not included in the original cross sections used for the river hydraulic model; field surveys (aerial photography) should be used to confirm the river geometry and riparian flooding conditions. For the Stanislaus River, the HEC-5Q suggests that the surface area increases rather uniformly from 1,000 to about 5,000 cfs (200 acres per 1,000 cfs) and more slowly between 5,000 and 10,000 cfs (135 acres per 1,000 cfs). This suggests that river levees or incised channel sections constrain the average width of the river at the higher flows.

Table F.1-18a. Stanislaus River Geometry Calculated in the HEC-5Q Temperature Model (58-mile Length)

Flow (cfs)	Surface Area (acres)	Volume (AF)	Average Depth (feet)	Travel Time (hours)
250	736	2,252	3.1	109
500	799	2,938	3.7	71
1,000	913	4,199	4.6	51
1,500	1,040	5,702	5.5	46
2,000	1,166	7,225	6.2	44
2,500	1,284	8,703	6.8	42
3,000	1,387	10,096	7.3	41
4,000	1,567	12,793	8.2	39
5,000	1,731	15,391	8.9	37
10,000	2,394	27,020	11.3	33

Table F.1-18b gives the river geometry (surface area, volume, and depth) for the Tuolumne River for a range of flows from 250 to 10,000 cfs. The travel time has been included in the table. For example, the Tuolumne River length is about 53 miles and has a surface area of 745 acres, which is equivalent to an average width of 116 feet at a flow of 250 cfs. The volume is 2,623 AF, so the average depth is 3.5 feet. The travel time for water at the low flow of 250 cfs would be about 5.3 days (127 hours). Warming will be rapid in the upstream portion of the river (during the first 1–2 days), because the difference between the equilibrium temperature and the release temperature will be greatest. At a flow of 1,000 cfs, the Tuolumne River area is 933 acres (145 feet width) and the volume is 4,519 AF, so the average depth is 4.8 feet and the travel time is 55 hours (2.3 days). For the Tuolumne River, the HEC-5Q suggests that the surface area increases rather uniformly from 1,000 to about 4,000 cfs

(200 acres per 1,000 cfs) and more rapidly between 4,000 and 5,000 cfs (750 acres per 1,000 cfs) and continues to spread at a fairly high rate to 10,000 cfs (500 acres per 1,000 cfs).

Table F.1-18b. Tuolumne River Geometry Calculated in the HEC-5Q Temperature Model (53-mile Length)

Flow (cfs)	Surface Area (acres)	Volume (AF)	Average Depth (feet)	Travel Time (hours)
250	745	2,623	3.5	127
500	829	3,347	4.0	81
1,000	933	4,519	4.8	55
1,500	1,025	5,573	5.4	45
2,000	1,120	6,575	5.9	40
2,500	1,217	7,536	6.2	36
3,000	1,351	8,457	6.3	34
4,000	1,679	10,327	6.2	31
5,000	2,491	12,869	5.2	31
10,000	4,082	24,304	6.0	29

Table F.1-18c gives the river geometry (surface area, volume, and depth) for the Merced River for a range of flows from 250 to 10,000 cfs. The travel time has been included in the table. For example, the Merced River length is about 52 miles and has a surface area of 684 acres, which is equivalent to an average width of 109 feet at a flow of 250 cfs. The volume is 2,158 AF, so the average depth is 3.2 feet. At low flow there may be considerable volume of water in the pools upstream of riffles and runs. At a flow of 1,000 cfs, the Merced River area is 913 acres (145 feet width) and the volume is 4696 AF, so the average depth is 4.6 feet and the travel time is 51 hours (about 2 days). The Merced River continues to spread out at higher flows, indicating limited levees or channel incision compared to the Stanislaus River. The average depth remains about 5 feet for a flow of 2,000–10,000 cfs. At a flow of 5,000 cfs, the Merced River area is 3,320 acres. This is a wider river than the Stanislaus at this same flow.

Table F.1-18c. Merced River Geometry Calculated in the HEC-5Q Temperature Model (52-mile Length)

Flow (cfs)	Surface Area (acres)	Volume (AF)	Average Depth (feet)	Travel Time (hours)
250	684	2,158	3.2	104
500	815	3,099	3.8	75
1,000	1,114	4,696	4.2	57
1,500	1,341	6,156	4.6	50
2,000	1,570	7,598	4.8	46
2,500	1,818	9,036	5.0	44
3,000	2,102	10,473	5.0	42
4,000	2,698	13,266	4.9	40
5,000	3,320	15,983	4.8	39
10,000	3,610	17,283	4.8	21

New Melones Reservoir on the Stanislaus River has a crest elevation of 1,135 feet and a spillway crest of 1,088 feet. There are two elevations from which to withdraw water, in addition to the spillway. The power intakes are located at an elevation of 775 feet msl (top of the penstock) corresponding to a reservoir storage of about 200 TAF. The low-level outlet (two pipes) operates at lake elevations less than 785 feet. The old dam may affect the reservoir release temperatures at low elevations. The old dam has a crest elevation of 735 feet and a spillway elevation of 723 feet. The original outlet works are located at approximately 610 feet. When water surface elevations are above 785 feet, the power intake is used to generate hydropower. Below that elevation, the lower-elevation outlet must be used. For water levels from 785 feet to 728 feet (5 feet above the old dam spillway invert), all water is assumed to pass over the crest and/or the spillway of the old dam. Below 728 feet all flows must pass through the old dam's low elevation outlet. The outlet elevation affects the release temperature. New Melones spillway has never been used; it would be needed if releases greater than 7,700 cfs were required. Tulloch Reservoir downstream has a low-level power outlet with a capacity of 2,060 cfs; higher outflows pass through the gated spillway.

New Don Pedro Reservoir on the Tuolumne River has a maximum storage elevation of approximately 830 feet msl. The power intakes are located at an elevation of 535 feet (storage of about 75 TAF). The original Don Pedro Dam was inundated when the newer dam was completed. The old dam had a crest elevation of 607 feet and the spillway was located at 590 feet. Because the power outlet for the new dam is below the elevation of the old dam, all power releases must pass over the old dam, which is represented in the model as a submerged weir.

Lake McClure on the Merced River has a single outlet located in the old dam that has been incorporated into the new dam (New Exchequer). The power intakes are located at an elevation of 500 feet msl (storage of about 25 TAF). Lake McSwain, just downstream of Lake McClure, has approximately 10 TAF of storage. The outlet is located near the bottom at approximately 370 feet msl, 25 feet below the surface. The Lake McClure outlet temperature may be warmed in the three downstream regulating reservoirs before being released to the river at the Crocker-Huffman diversion dam (and Merced River Fish Hatchery).

Water Temperature Calibration Results

Equilibrium temperature and surface heat exchange coefficients were used to evaluate the net rate of heat transfer. Equilibrium temperature is defined as the water temperature at which the net rate of heat exchange between the water surface and the overlying atmosphere is zero. The coefficient of surface heat exchange is the rate at which heat is transferred to the water. All heat transfer mechanisms, except short-wave solar radiation, were applied at the water surface. Short-wave radiation penetrates the water surface and may affect water temperatures below the air-water interface. The heat exchange with the river bottom is a function of conductance and the heat capacity of the bottom sediment and has only a slight effect on diurnal temperature variation (i.e., behaves as slightly deeper water).

The model was calibrated using observed data within the period 1999–2007. The model used hourly meteorological data from three meteorological stations at Modesto, Merced, and Kesterson. Calibration was based on temperature profiles in the main reservoirs and time series of temperatures recorded in streams at several locations. Calibration of the reservoir temperatures was accomplished by comparing computed and observed vertical reservoirs temperature profiles both graphically and statistically. Some adjustments of the meteorological coefficients (e.g., wind speed function and solar radiation reflection) were necessary to match the seasonal surface temperatures in the reservoirs. Calibration of the river temperatures was accomplished by comparing computed and observed stream temperatures both graphically and statistically. Some adjustments of the meteorological coefficients (e.g., shading and river hydraulic parameters for width and depth) provided a very good match with daily temperatures along the three eastside tributaries and the LSJR. The model bias, defined as the difference between the average computed and observed temperatures, was 0.3, 0.7, 0.3 and 0.3°F for the four rivers, respectively. The seasonal temperature ranges were very accurately simulated at each of the river stations.

In October 2006, the initial SJR Basin Water Temperature Model and calibration results were favorably approved through a CALFED sponsored peer review process. The model was refined and enhanced to provide a planning and analysis tool for the SJR stakeholders. The completed model was presented to the SJR stakeholders and became available for public use (CalFed 2009). The model report and data files are available from:

http://www.rmanet.com/CalFed_Sep09/%20SJRTempModelReport_09.pdf

Figure F.1-16a shows the comparison of measured and simulated temperatures for the Stanislaus River at Goodwin Dam (river mile [RM] 58) for calendar years 1999–2007. This generally demonstrates the accuracy of the reservoir stratification and withdrawal simulations. The releases temperatures varied from about 50°F in the winter months to about 55–57°F in the fall months.

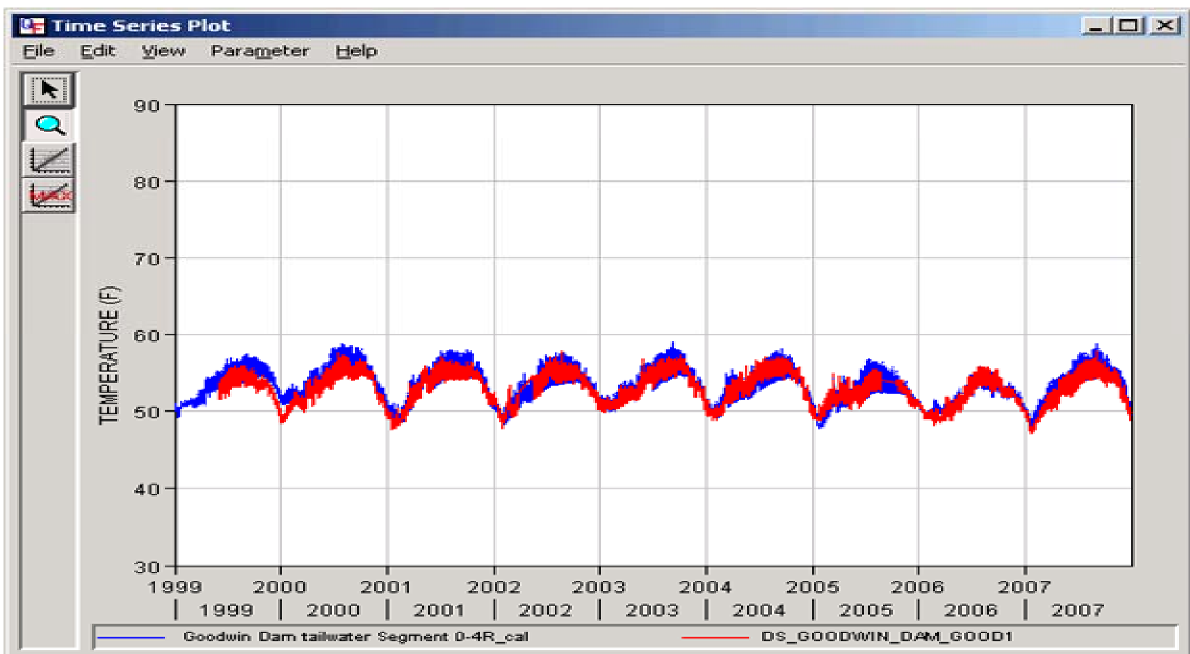


Figure F.1-16a. Comparison of Computed (Blue) and Observed (Red) Water Temperatures on the Stanislaus River Below Goodwin Dam (RM 58) for 1999-2007

Figure F.1-16b shows the comparison of measured and simulated temperatures at the mouth of the Stanislaus River downstream of Ripon. This demonstrates the general accuracy of the combination of river hydraulic calculations (i.e., depth and surface area) and the meteorological heating and solar radiation shading estimates. The river temperatures varied from about 45–50°F in the winter months to about 75–80°F in the summer months. There was considerable variation in the peak summer temperatures between years, with the lowest temperatures of about 75°F in the higher flow years of 1999 and 2006. Several of the years showed a distinct decrease in temperatures associated with the VAMP pulse flow release in mid-April to mid-May. The river temperatures were simulated to increase more rapidly during low flow conditions and to increase less during higher flows, such as during the VAMP period, with releases of about 1,500 cfs in several years. The effects of river flows on downstream warming will be described in more detail below in the evaluation of baseline conditions temperatures. The Stanislaus River temperatures were very accurately simulated for 1999–2007.

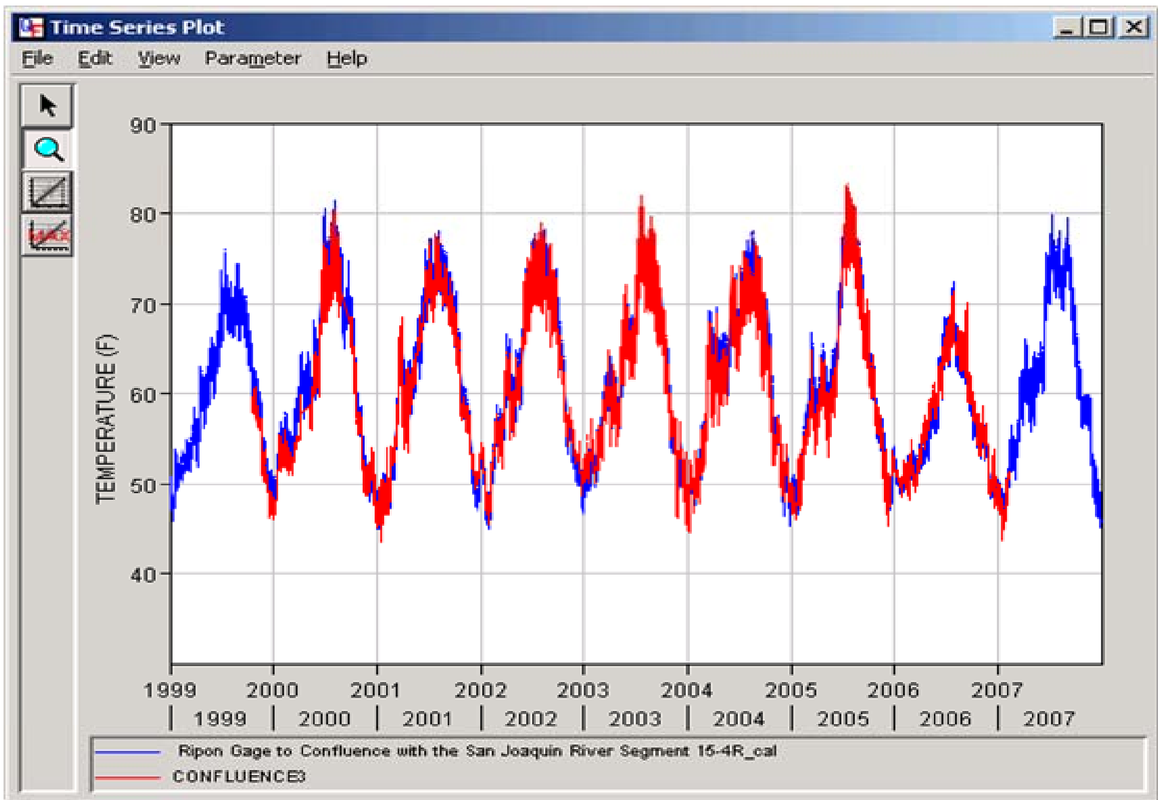


Figure F.1-16b.Comparison of Computed (Blue) and Observed (Red) Water Temperatures on the Stanislaus River above the SJR Confluence (RM 0) for 1999–2007

Figure F.1-17a shows the comparison of measured and simulated temperatures for the Tuolumne River at La Grange Dam (RM 52) for 1999–2007. The releases temperatures varied from about 50°F in the winter months to about 53–55 F in the fall months. The Tuolumne River temperatures were even less variable than release temperatures on the Stanislaus because the New Don Pedro Reservoir carryover storage generally remains high and because the La Grange regulating reservoir is small compared to the Tulloch and Goodwin regulating reservoirs on the Tuolumne River. Figure F.1-17b shows the comparison of measured and simulated temperatures at the mouth of the Tuolumne River at Shiloh Bridge (RM 3.4). The Tuolumne River temperatures varied from about 45–50°F in the winter months to about 80–85°F in the summer months. The Tuolumne River summer temperatures were slightly higher than the Stanislaus River summer temperatures, perhaps because of lower flows (longer travel time) or less shading along the Tuolumne River. The two river mouths are less than 5 miles apart and experience the same meteorology. The coolest summer temperatures were measured and simulated for 2005 and 2006. The Tuolumne River temperatures were very accurately simulated for 1999–2007.

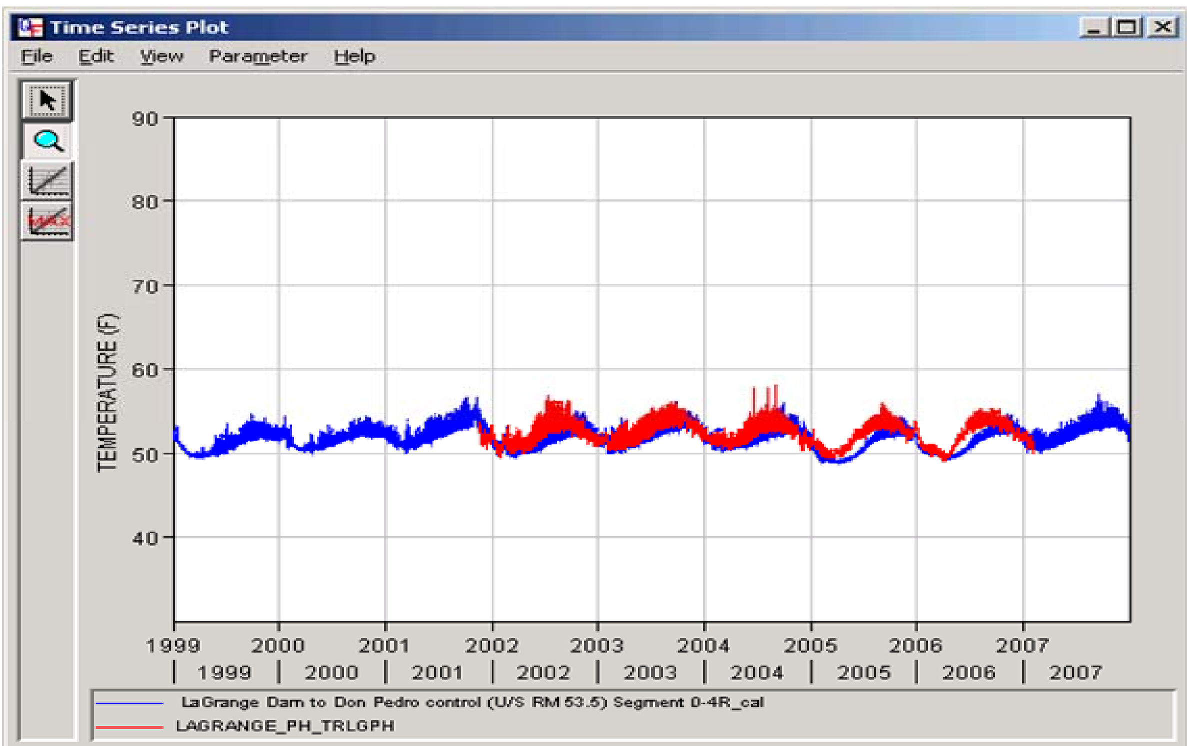


Figure F.1-17a. Comparison of Computed (Blue) and Observed (Red) Water Temperatures on the Tuolumne River below La Grange Dam (RM 52)

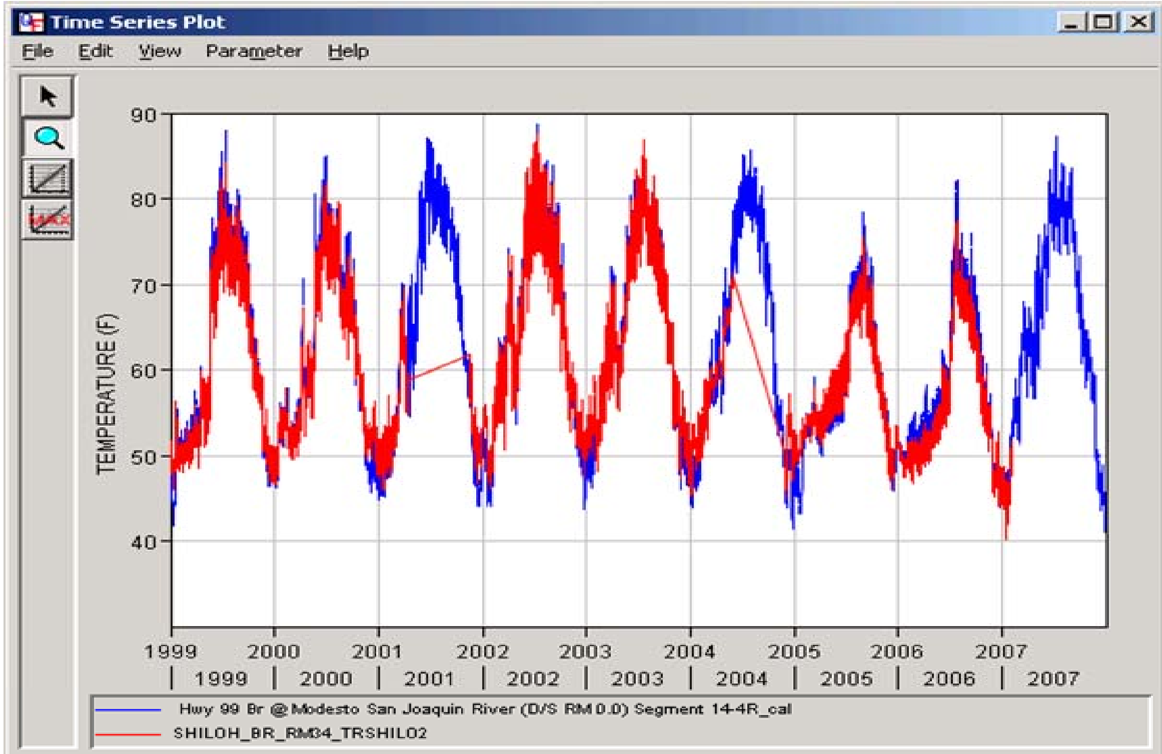


Figure F.1-17b. Comparison of Computed (Blue) and Observed (Red) Water Temperatures on the Tuolumne River at Shiloh Bridge (RM 3.4)

Figure F.1-18a shows the comparison of measured and simulated temperatures for the Merced River below McSwain Dam (RM 56) for 1999–2007. McSwain Dam is located about 6.5 miles below New Exchequer Dam. The releases temperatures varied from about 50°F in the winter months to about 57–60°F in the fall months. The Merced River release temperatures were more variable than on the Stanislaus or Tuolumne Rivers because Lake McClure carryover storage can be very low in dry years and because McSwain Dam is relatively shallow, with a volume of about 8 TAF. The travel time for a flow of 2,000 cfs (to the canals and river) would be about 2 days. The release temperature remained cooler in 2005 and 2006 when the runoff was higher and the reservoir storage remained higher in the fall. There may be additional warming in the reservoirs of Merced Falls (RM 55) and Crocker-Huffman (RM 52) diversion dams. Figure F.1-18b shows the comparison of measured and simulated temperatures at the mouth of the Merced River for 1999–2007. The Merced River temperatures varied from about 45–50°F in the winter months to about 80–85°F in the summer months. The Merced River temperatures were very similar to the Tuolumne River temperatures. The coolest temperatures were measured and simulated in 2005 and 2006. The Merced River temperatures were very accurately simulated for 1999–2007.

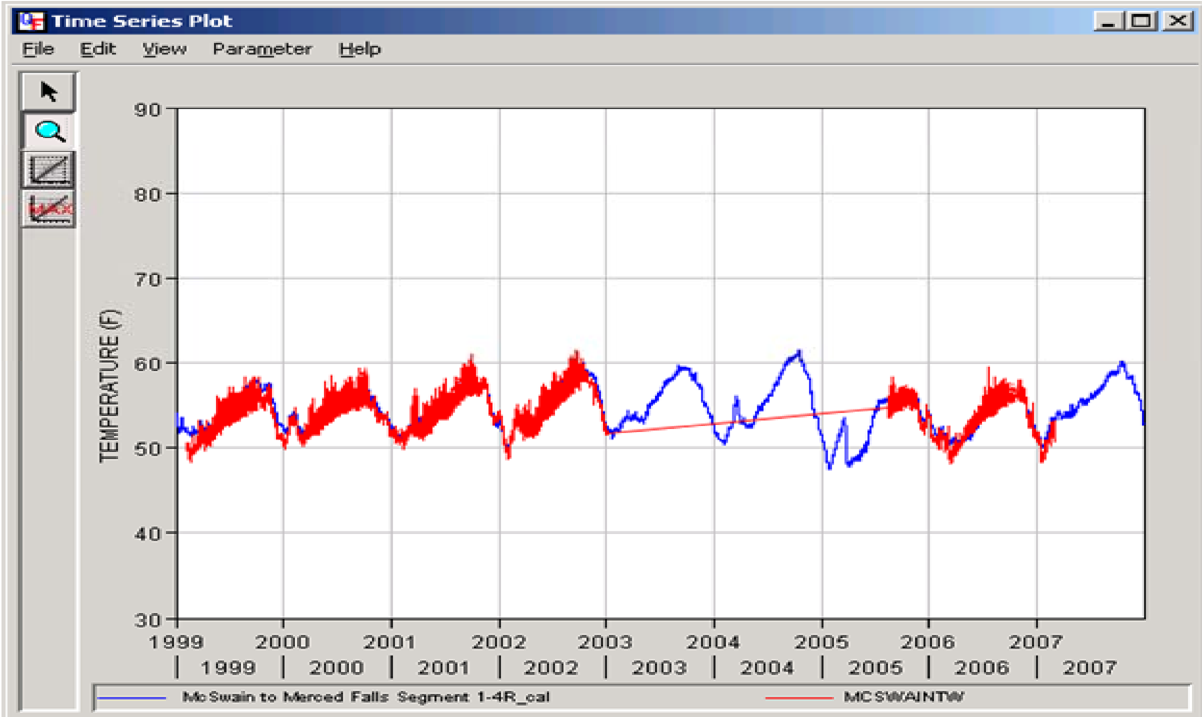


Figure F.1-18a. Comparison of Computed (Blue) and Observed (Red) Temperatures in the Merced River below McSwain Dam (RM 56)

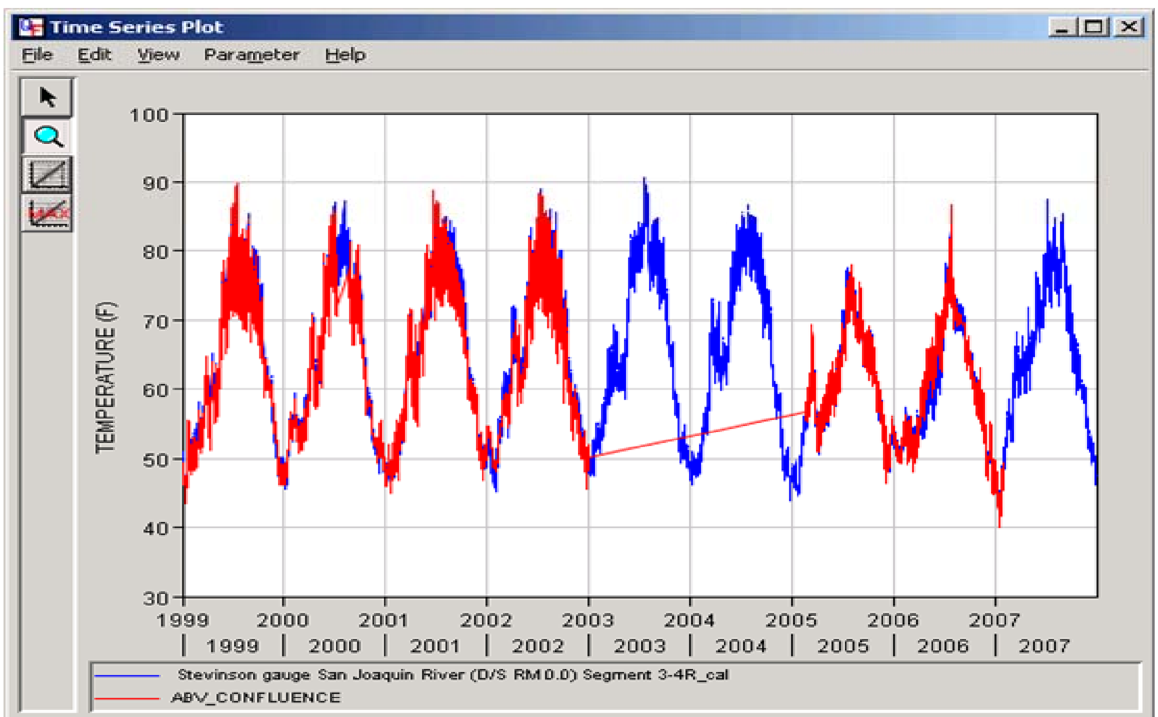


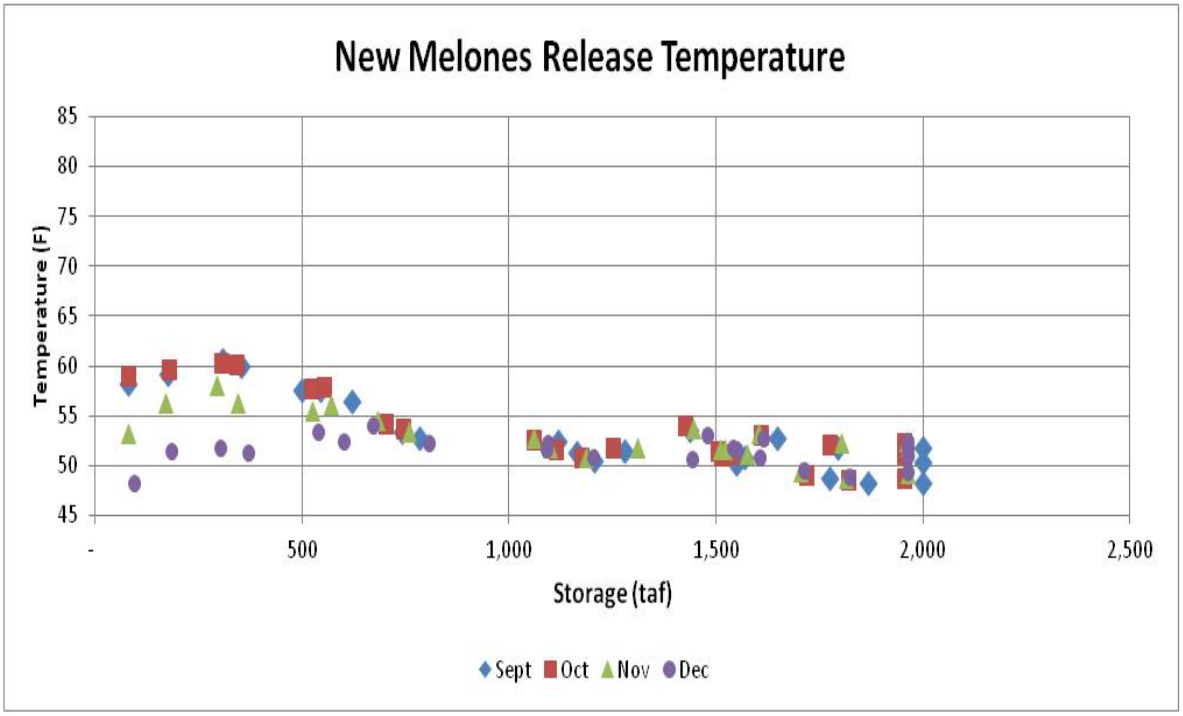
Figure F.1-18b. Comparison of Computed (Blue) and Observed (Red) Temperatures in the Merced River above the SJR Confluence (RM 0)

F.1.5.2 Temperature Model Results

Baseline Conditions Temperature Results

Stanislaus River Temperatures

Figure F.1-19a shows the simulated monthly average Stanislaus River temperatures below New Melones Reservoir and below Goodwin Dam in September–December for 1980–2003. The September temperatures at New Melones Reservoir were less than 55°F when New Melones storage was more than 750 TAF and increased to 60°F when New Melones storage was less than 500 TAF. The Goodwin temperatures were 55°F when New Melones storage was 2,000 TAF and increased to about 65°F when New Melones storage was 250 TAF or less. The October temperatures at New Melones were less than 55°F when storage was less than 750 TAF and were 60°F when storage was less than less than 500 TAF. The Goodwin temperatures were about 55°F when the storage was 1,500 TAF (or more) and increased to about 65°F as the storage decreased to 250 TAF (or less). The November temperatures at New Melones were less than 55°F when storage was greater than 500 TAF. The Goodwin temperatures were about 55°F when the storage was 1,500 TAF (or more) and increased to 60°F as the storage decreased to 500 TAF (or less). The December temperatures at New Melones and Goodwin were 50-55°F regardless of storage, because the reservoir was fully mixed, and the release temperatures were controlled by the meteorology and not the reservoir storage. New Melones carryover storage of at least 500 TAF would provide a Goodwin Dam release temperature of less than 60°F in October. The New Melones carryover storage (September) was less than 500 TAF in about 20 percent of the years.



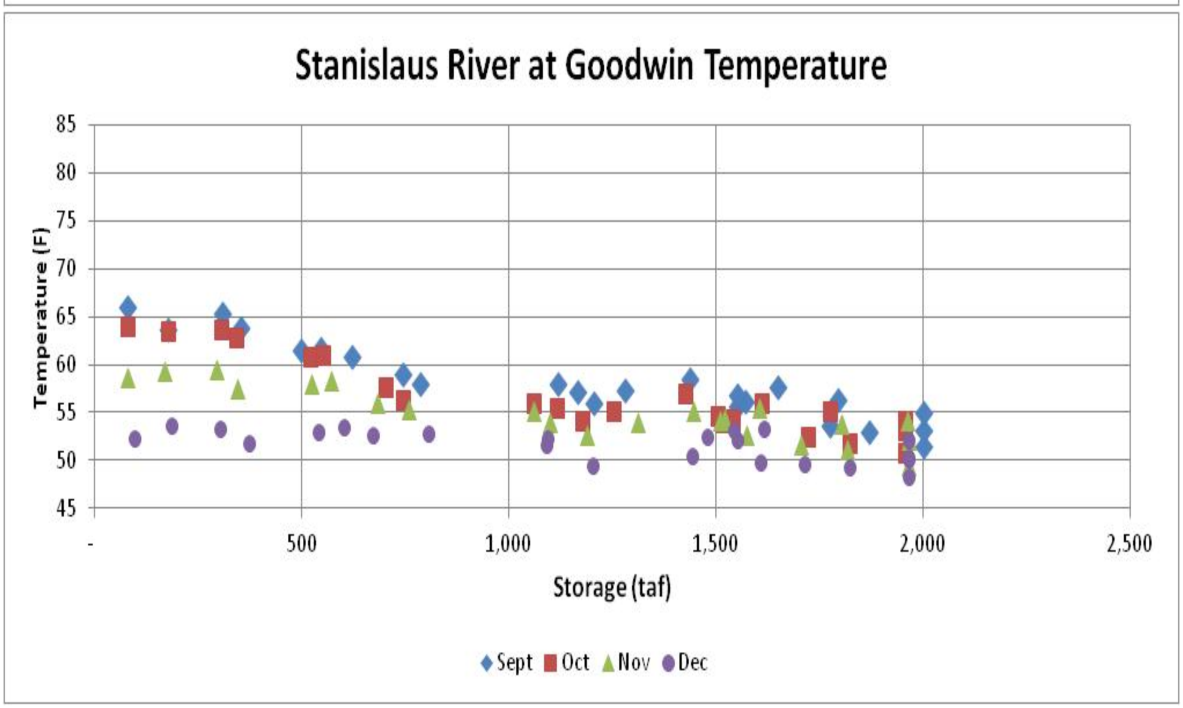


Figure F.1-19a. Effects of New Melones Storage on Stanislaus River Water Temperatures September–December at New Melones Dam and Goodwin Dam for Baseline Conditions 1980–2003

Figure F.1-19b shows the simulated monthly average Stanislaus River temperatures below New Melones Reservoir, below Goodwin Dam, at Riverbank and at the river mouth in January–March for 1980–2003 as a function of the river flow (at the mouth). In January, temperatures were controlled by the meteorology; water temperatures were 45°F–55°F in all years, and there was no downstream warming. In February, temperatures were controlled by meteorology, and all downstream temperatures were 50°F–60°F; there was slightly more warming when flows were less than 500 cfs. In March, temperatures were still largely controlled by meteorology; all temperatures were 50°F and 60°F. The downstream warming was less than 5°F when flows were greater than 1,500 cfs and were about 10°F when flows were less than 500 cfs.

Figure F.1-19c shows the simulated monthly average Stanislaus River temperatures below New Melones Reservoir, below Goodwin Dam, at Riverbank and at the river mouth in April–June for 1980–2003 as a function of the river flow (at the mouth). In April, temperatures were controlled by the meteorology and the flow; Goodwin temperatures were 50°F–55°F, and the mouth temperatures increased to 55°F to 60°F (warming of 5–7°F) when flows were greater than 1,000 cfs, and they were 60–65°F (warming of 10°F) when flow was about 500 cfs. In May, temperatures at Riverbank and the mouth were controlled by meteorology and flow. At flows of more than 1,500 cfs, Riverbank temperatures were 55°F, and mouth temperatures were 60°F. At a flow of 500 cfs, Riverbank temperatures were 65°F, and mouth temperatures were 70°F. In June, temperatures at Riverbank and the mouth were controlled by meteorology and flow. The average warming from Goodwin to Riverbank was about 5°F (55°F to 60°F) when the flow was 1,500 cfs, and it was 10–15°F (55°F–70°F) when the flow was 500 cfs. The mouth temperatures were about 65°F when flow was greater than 1,500 cfs and were about 70–75°F when flow was 500 cfs. Because of the relatively high spring flows on the Stanislaus (required by NMFS RPA), flows in April and May were greater than 500 cfs for the baseline conditions.

Figure F.1-19d shows the simulated monthly average Stanislaus River temperatures below New Melones Reservoir, below Goodwin Dam, at Riverbank and at the river mouth in July–September for 1980–2003 as a function of the river flow (at the mouth). In July, Goodwin temperatures were 55°F when the flow was 1,000 cfs and the temperatures were increased to 65°F when the flow was 250 cfs. The Riverbank temperatures were 65°F when the flow was 1,00 cfs and were 75°F when the flow was 250 cfs. The mouth temperatures in July were about 5°F warmer than the Riverbank temperatures. In August, river flows were generally 250–750 cfs, with Goodwin temperatures of 55–65°F, Riverbank temperatures of 65–75°F, and mouth temperatures of 70–80°F. The increase in temperature as flow was reduced from 750 to 250 cfs was about 5°F at each of the river locations. The September temperatures were similar to August temperatures, but the warming effects from reduced flows were stronger; the temperatures at Riverbank and the mouth were increased by about 10°F as flow was reduced from 750 to 250 cfs.

Figure F.1-19e shows the simulated monthly average Stanislaus River temperatures below New Melones Reservoir, below Goodwin Dam, at Riverbank and at the mouth in October–December for 1980-2003 as a function of the river flow (at the mouth). In October, there was a wide range of river flows that was dependent on reservoir storage (higher flood-control releases when storage was high). The meteorological warming from Goodwin to the mouth was about 5°F regardless of the flow; but the Goodwin temperatures were less than 55°F at flow higher than 1,000 cfs and were 60-65°F for flow of less than 500 cfs. November and December temperatures showed very little meteorological warming; all November temperatures were 50°F to 60°F and all December temperatures were 45°F to 55°F.

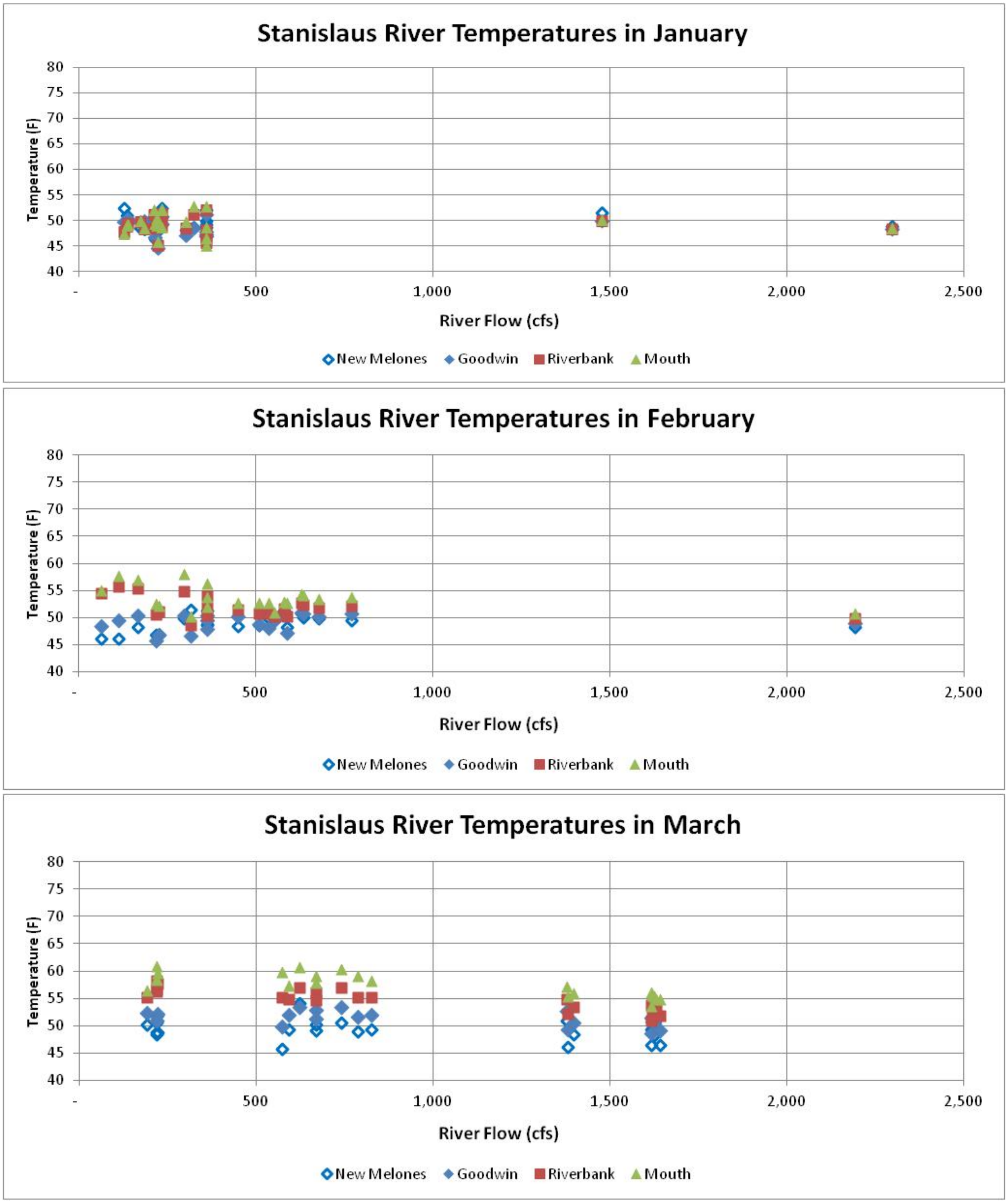


Figure F.1-19b. Effects of Stanislaus River Flow on Stanislaus River Water Temperatures January–March for Baseline Conditions 1980–2003

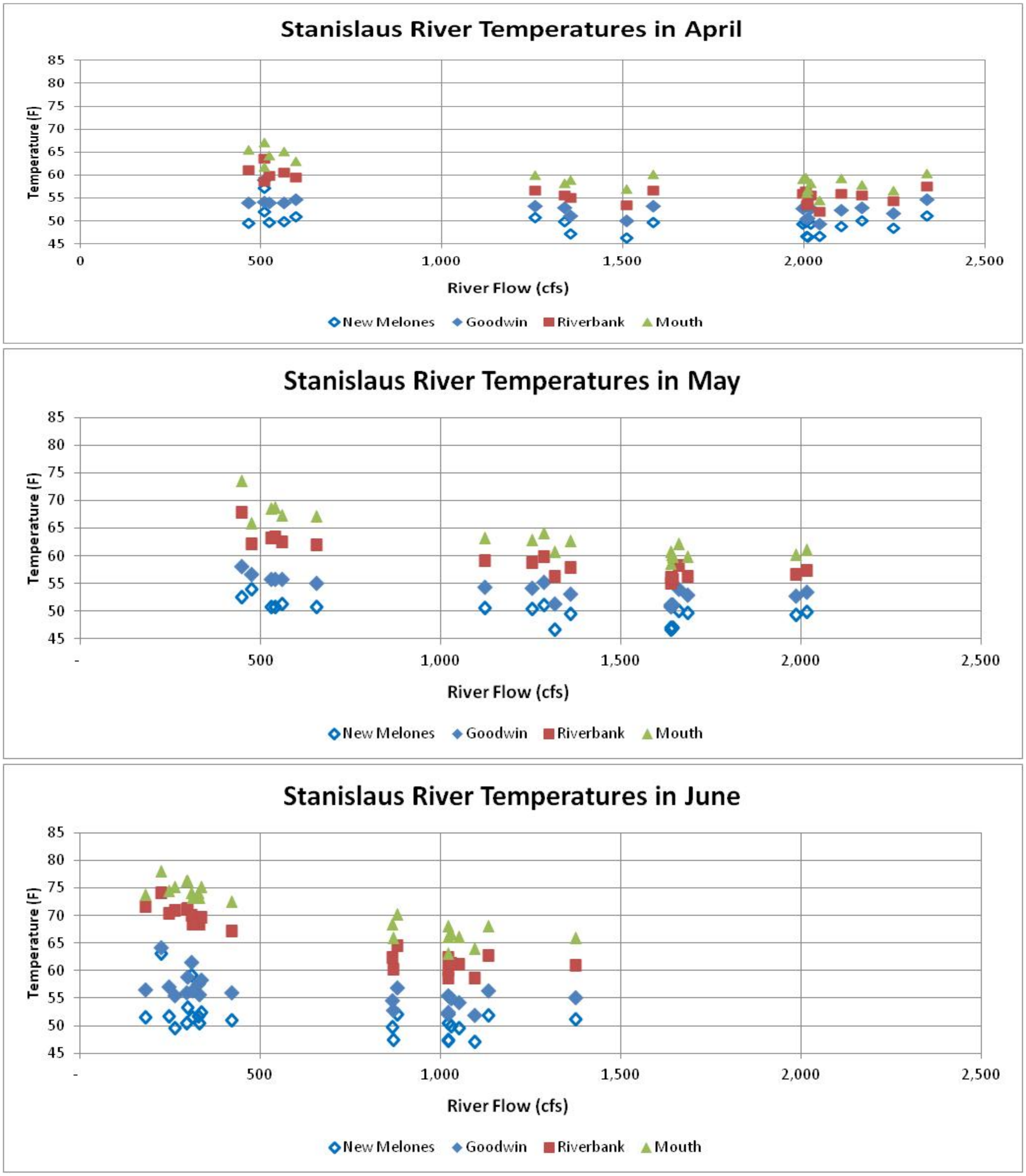


Figure F.1-19c. Effects of Stanislaus River Flow on Stanislaus River Water Temperatures April–June for Baseline Conditions 1980–2003

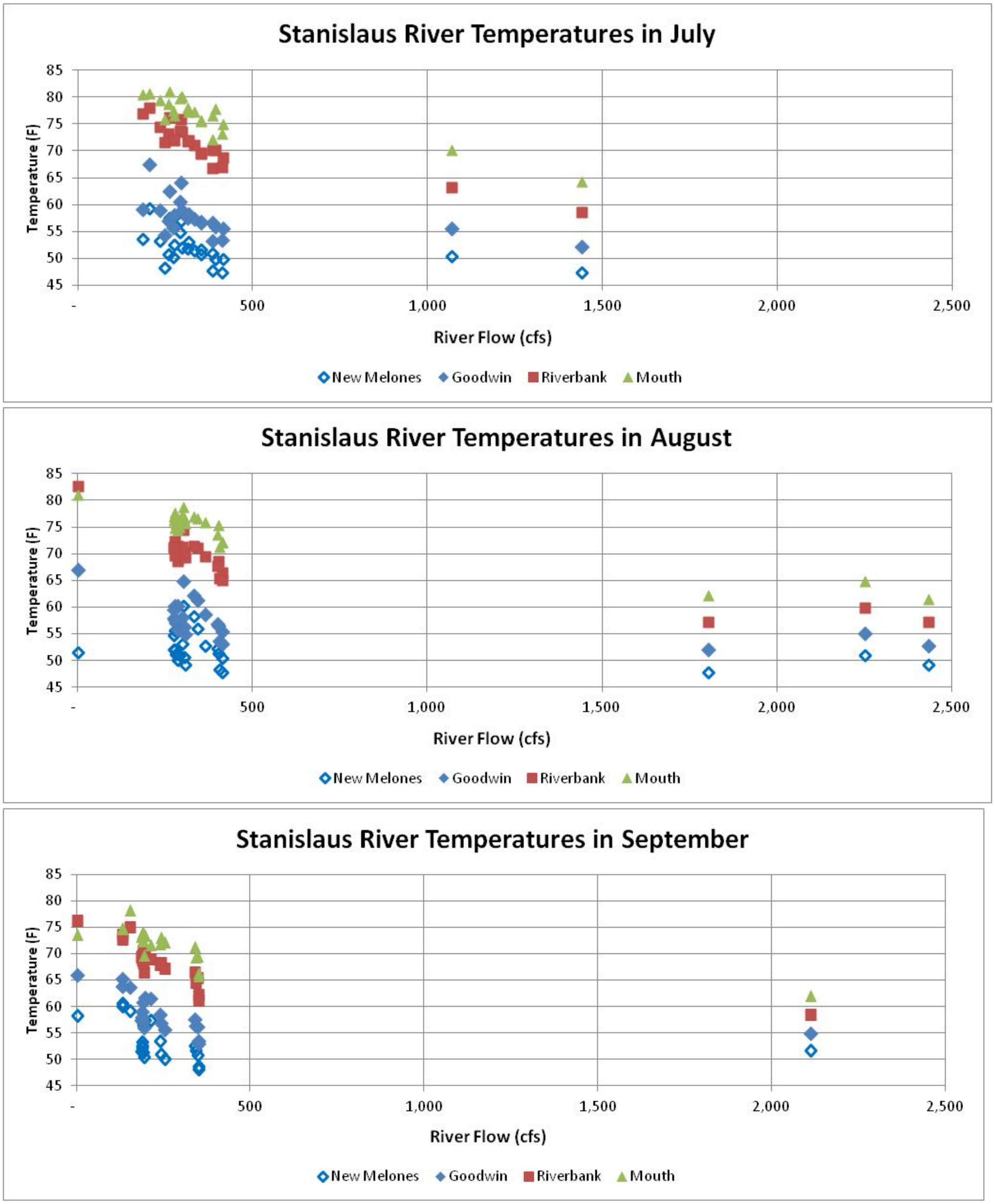


Figure F.1-19d. Effects of Stanislaus River Flow on Stanislaus River Water Temperatures July–September for Baseline Conditions 1980–2003

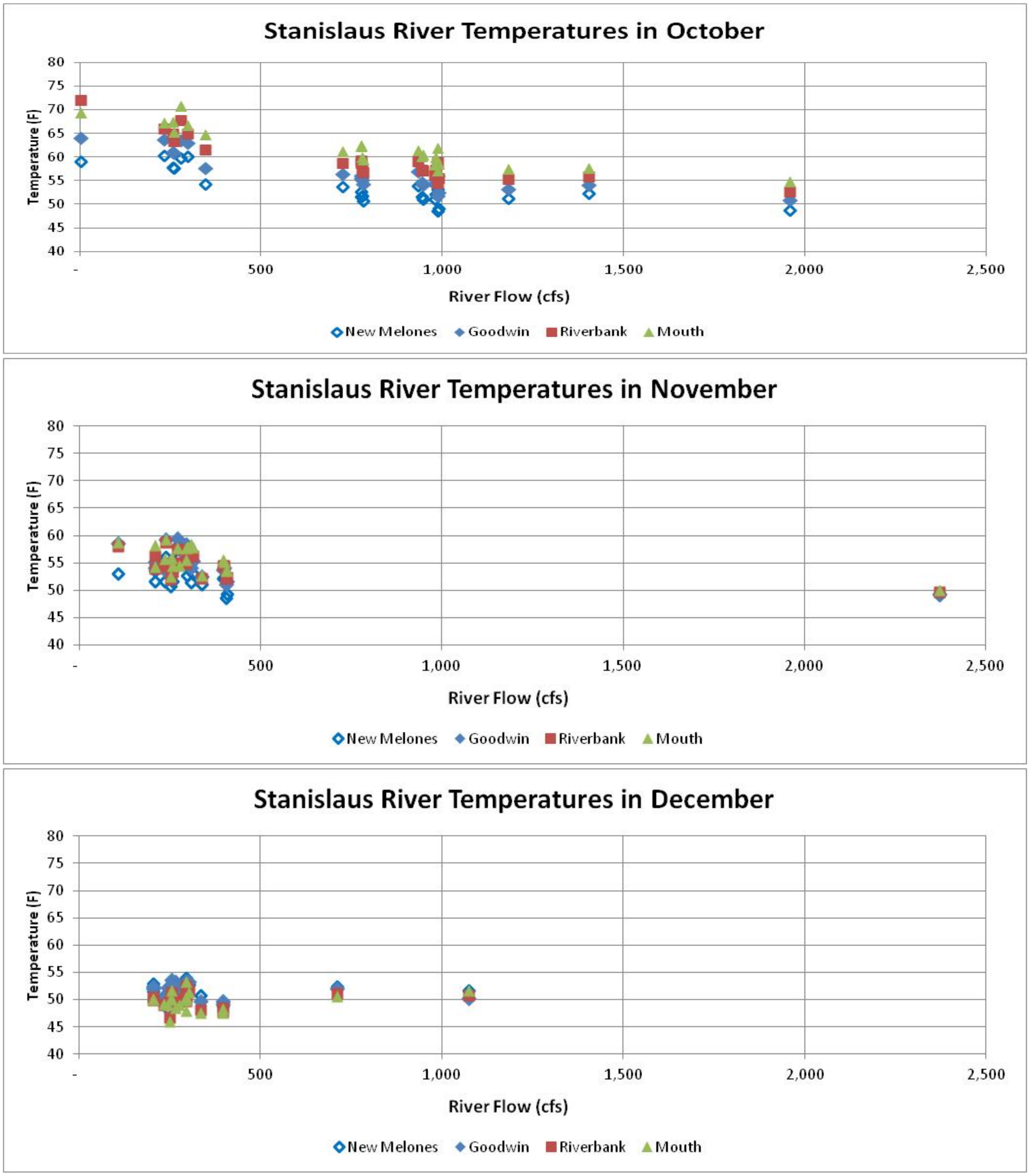


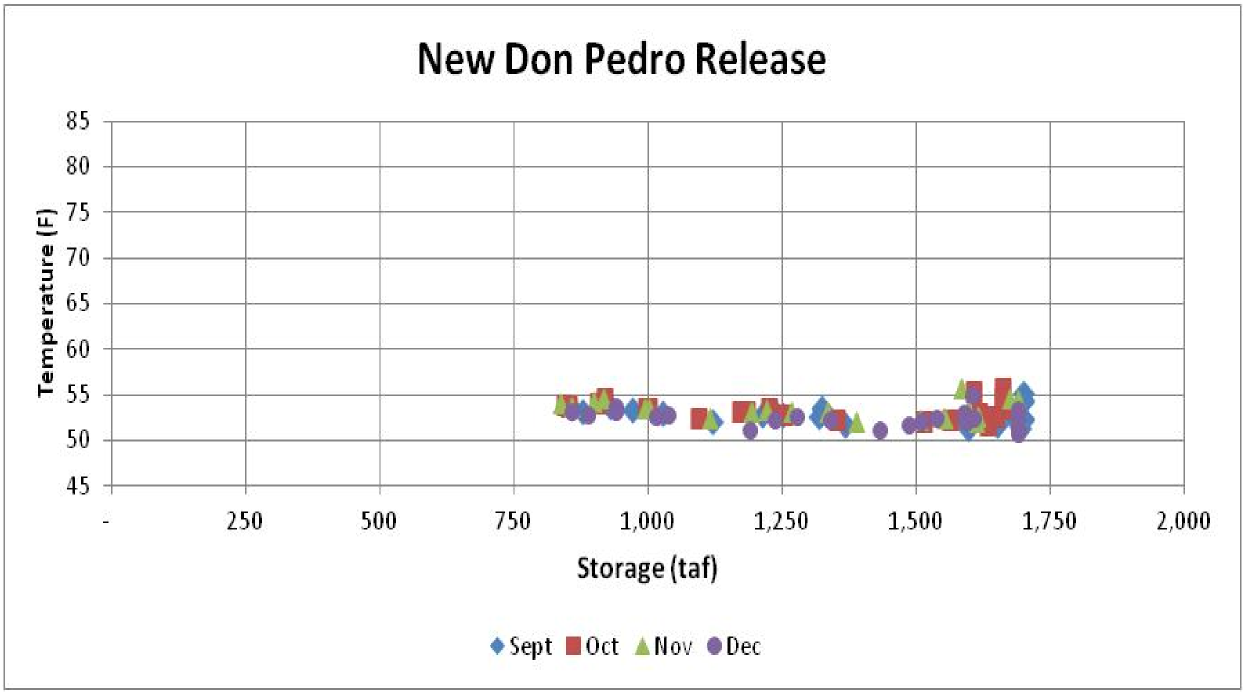
Figure F.1-19e. Effects of Stanislaus River Flow on Stanislaus River Water Temperatures October–December for Baseline Conditions 1980–2003

These temperature results illustrate the combination of factors controlling Stanislaus River temperatures. The New Melones and Goodwin release temperatures increases at low storage in September–November; the meteorological warming of downstream river temperatures is substantial from March–October; and the effects of reduced river flow on increased warming from April–September. Riverbank temperature was generally increased by 5°F when flow was reduced from 1,000 to 500 cfs in April–September. The mouth temperatures were about 5°F warmer than Riverbank temperatures in May–August.

Tuolumne River Temperatures

Figure F.1-20a shows the simulated monthly average Tuolumne River temperatures below New Don Pedro Dam and below La Grange Dam in September–December for 1980–2003. The September temperatures at New Don Pedro were about 50–55°F in all years because New Don Pedro storage was always quite high (greater than 800 TAF). The September temperatures at La Grange Dam were 1–2°F warmer. The October temperatures at New Don Pedro and at La Grange were about 55°F in all years. The November temperatures were also about 55°F in all years. The December temperatures were 50–55°F in all years. Although not simulated for the baseline conditions, New Don Pedro carryover storage of at least 500 TAF would likely provide La Grange Dam release temperatures of less than 60°F in September and October. Because the La Grange Dam is just 2.5 miles below New Don Pedro Dam, the warming in La Grange in September and October is small (1–2°F).

Figure F.1-20b shows the simulated monthly average Tuolumne River temperatures below New Don Pedro, below La Grange, at Waterford, and at the river mouth in April–June for 1980–2003 as a function of the river flow (at the mouth). Because the range of flows was greater (less than 500 to more than 2,500 cfs, the effects of flow on warming is more obvious for the Tuolumne River. In April, temperatures were controlled by the meteorology and the flow; La Grange temperatures were about 50°F, and the mouth temperatures increased 55°F–60°F (warming of 5–10°F) when flows were greater than 1,500 cfs and increased to 65–70°F (warming of 15°F) when flow was about 500 cfs. In May, temperatures at Waterford and the mouth were controlled by meteorology and flow. At flows of more than 1,500 cfs, Waterford temperatures were less than 60°F and mouth temperatures were less than 65°F. At a flow of 500 cfs, Waterford temperatures were 65°F and mouth temperatures were 70°F. In June, the average warming from La Grange to Waterford was 10°F when the flow was 1,500 cfs and was 20–25°F (55°F–80°F) when the flow was 500 cfs. The mouth temperatures were the same as the Waterford temperatures at flows of less than 500 cfs, indicating that equilibrium temperature was already reached at Waterford with no additional warming when flows were less than 500 cfs.



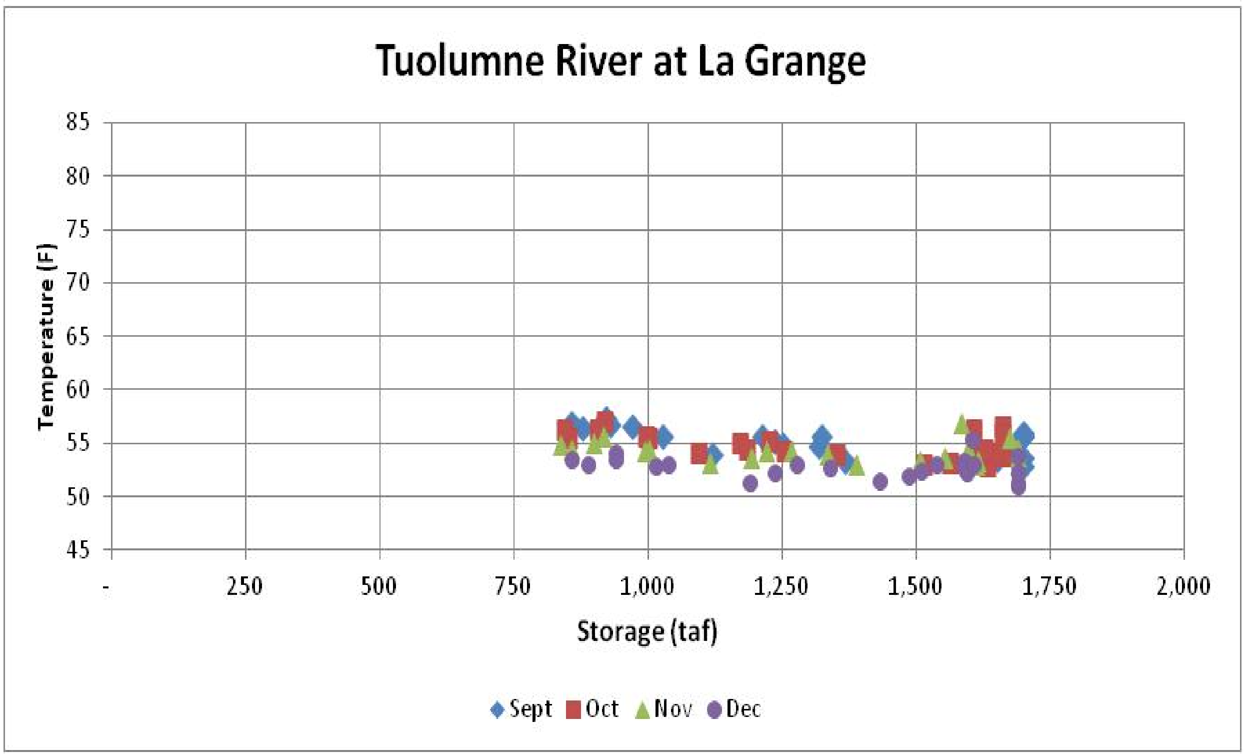


Figure F.1-20a. Effects of New Don Pedro Storage on New Don Pedro and La Grange Simulated Water Temperatures September–December for Baseline Conditions 1980–2003

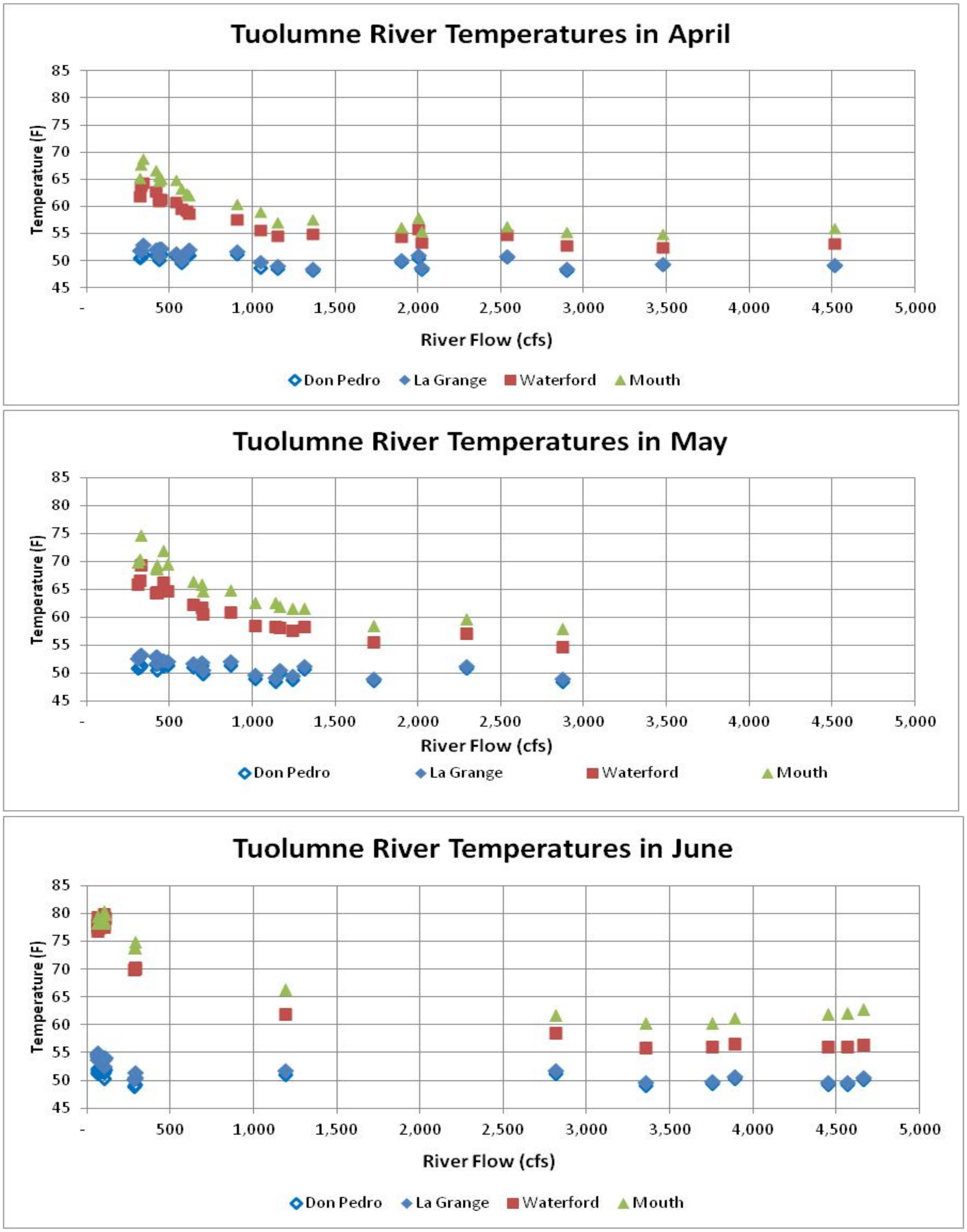


Figure F.1-20b. Effects of Tuolumne River Flow on Tuolumne River Water Temperatures April–June for Baseline Conditions 1980–2003

Figure F.1-20c shows the simulated monthly average Tuolumne River temperatures below New Don Pedro, below La Grange, at Waterford and at the mouth in July–September for 1980-2003 as a function of the river flow (at the mouth). In July, temperatures were controlled by the meteorology and the flow; La Grange temperatures were about 50°F (55°F for a flow of 250 cfs). At a flow of 2,000 cfs, the warming at Waterford was 10°F and the warming at the mouth was 15°F. At a flow of 500 cfs, the Waterford temperatures were 75°F (warming of 25°F), and the mouth temperatures were 80°F (warming of 30°F). At a flow of 250 cfs, the Waterford and mouth temperatures were 80–85°F (warming of 25–30°F). In August, temperatures at Waterford and the mouth were similar to the July temperatures. At flows of less than 500 cfs, the temperatures at Waterford and the mouth were the same (i.e., equilibrium temperature) and were 80°F–85°F. In September, La Grange temperatures were about 55°F, and the Waterford and mouth temperatures were 75–80°F for flows of less than 500 cfs. Because the La Grange temperatures were about the same and the meteorology was similar, the downstream warming at Waterford and the mouth were very similar, with equilibrium temperatures achieved at flows of less than 500 cfs. The warming was increased at lower flows, with warming at Waterford at about 10°F for a flow of 1,500 cfs, about 20°F for a flow of 500 cfs, and about 25°F for a flow of 250 cfs.

These temperature results illustrate the combination of factors controlling Tuolumne River temperatures. The New Don Pedro and La Grange temperatures were very uniform between 50°F and 55°F because the New Don Pedro storage did not drop below 750 TAF. The meteorological warming of downstream river temperatures was substantial March–October, with a maximum warming of about 30°F in July and August at flows of about 250 cfs. Higher river flows reduce the maximum warming; about half of the warming is observed with a flow of 1,500 cfs. The temperature effect of flows of 250–1,500 cfs is important because this is the typical range for the LSJR alternatives being evaluated. An increase of 250 cfs or more in March–June would have a substantial effect on reducing the downstream water temperatures at Waterford and the mouth of the Tuolumne River.

Merced River Temperatures

Figure F.1-21a shows the simulated monthly average Merced River temperatures at Lake McClure and below Crocker-Huffman Dam in September–December for 1980–2003. The September temperatures at Lake McClure ranged from 55°F to 65°F as the Lake McClure storage was reduced from 500 TAF to 125 TAF. The September temperatures at Crocker-Huffman Dam were sometimes about 5°F warmer than the McClure temperatures but were much warmer (70°F–75°F) when the river flow was less than 250 cfs. This extreme warming was not expected in Lake McSwain, which should remain stratified and allow the cool water from Lake McClure to flow beneath the surface layer. In general, there appears to be more warming along the Merced River between the Lake McClure release and the Crocker-Huffman release. This is because there are a total of four dams on the Merced River. In addition to New Exchequer Dam, there is Lake McSwain, which is the re-regulating dam with a small hydropower unit and is about 6.5 miles long and about 80 feet deep. Merced Falls Dam is the diversion dam for the Northside Canal and is 1 mile long and about 40 feet deep. The Crocker-Huffman Dam is the diversion dam for the Merced Irrigation District Main Canal and is 3 miles long and 20 feet deep.

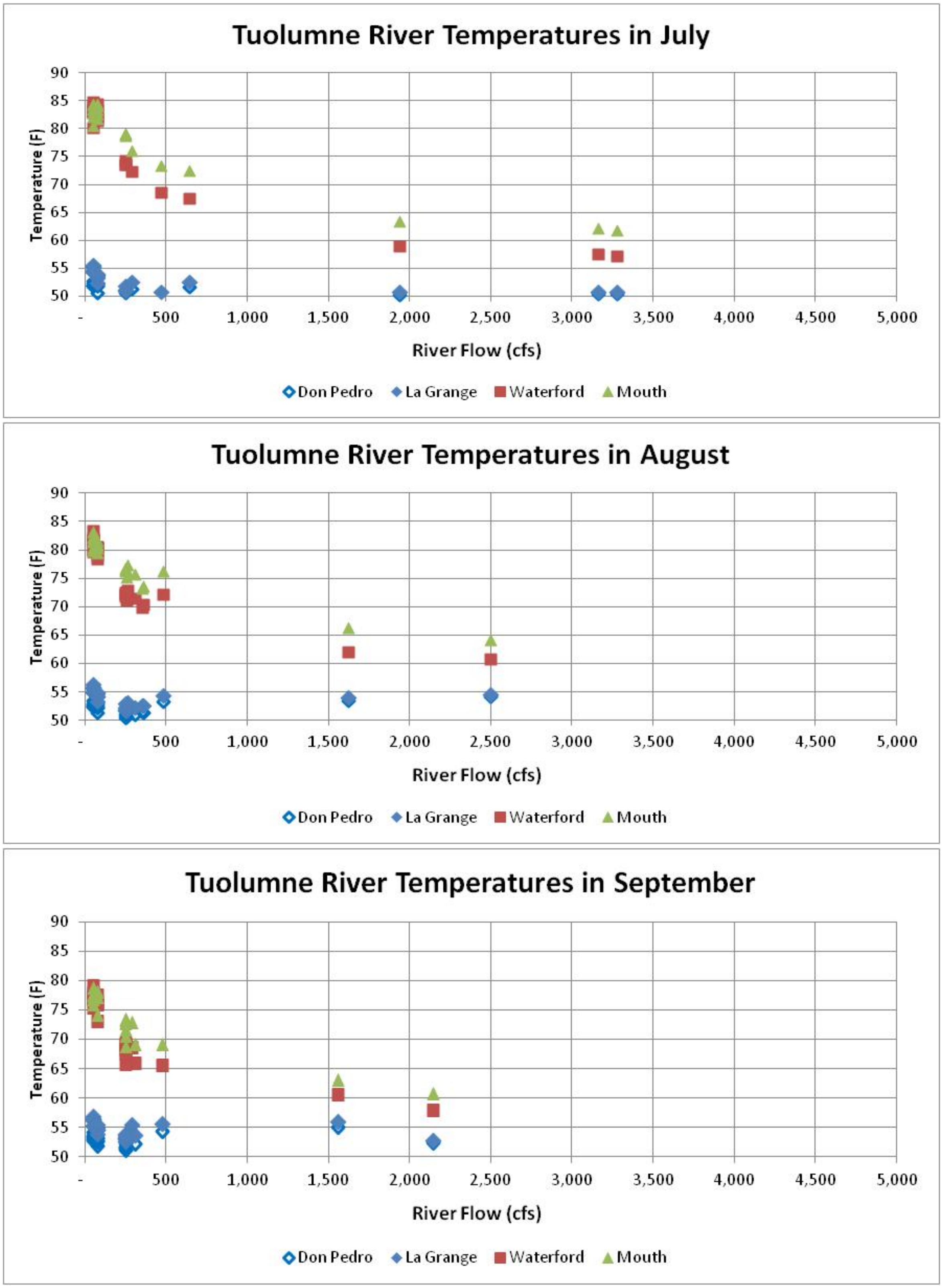
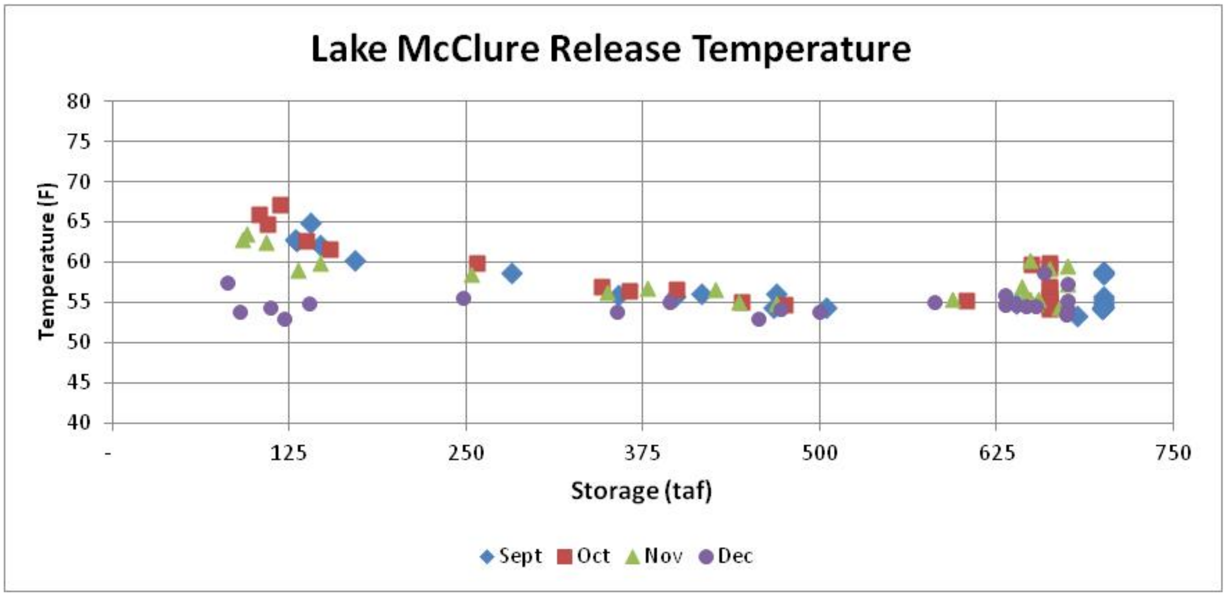


Figure F.1-20c. Effects of Tuolumne River Flow on Tuolumne River Water Temperatures July–September for Baseline Conditions 1980–2003



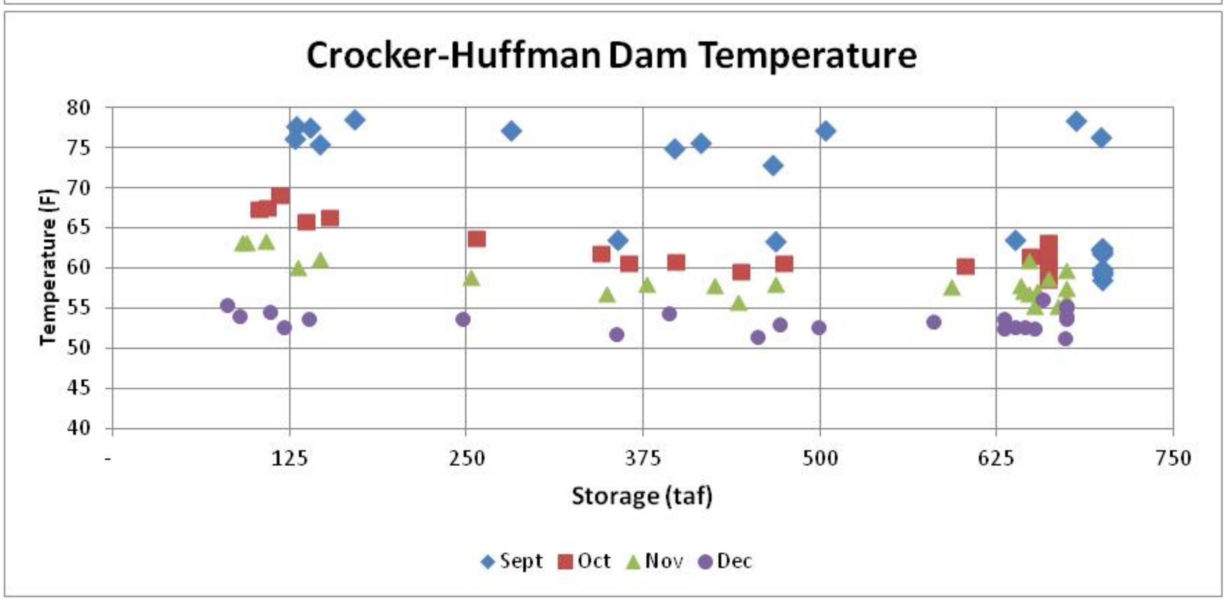


Figure F.1-21a. Effects of Lake McClure Storage on Lake McClure and Crocker-Huffman Release Temperatures September–December for Baseline Conditions 1980–2003

The Lake McClure release temperatures in October showed the same relationship with storage as the September temperatures. But the October temperatures at the Crocker-Huffman Dam were only about 5°F warmer. The simulated October temperatures at the Merced River Hatchery (located at the Crocker-Huffman Dam) would be less than 60°F if the McClure storage is greater than 375 TAF. The November temperatures at Lake McClure and at Crocker-Huffman were less than 60°F when the Lake McClure storage was greater than 250 TAF. The December temperatures at both locations were 50–55°F regardless of storage because the reservoir was fully mixed and the release temperatures were controlled by the meteorology and not the reservoir storage. Lake McClure carryover storage of at least 375 TAF would likely provide a Crocker-Huffman Dam release temperature of less than 60°F in October.

Figure F.1-21b shows the simulated monthly average Merced River temperatures below Lake McClure, below Crocker-Huffman, at Snelling and at the river mouth in April–June for 1980-2003 as a function of the river flow (at the mouth). Because the Merced River flow was generally less (100–2,000 cfs) in these months than for the other eastside tributaries, a greater effect of low flow on downstream warming was simulated for the Merced River. In April, temperatures were controlled by the meteorology and the flow; Crocker-Huffman temperatures were 50–55°F. The mouth temperatures increased to 60°F with a flow of 1,000, increased to 65°F with a flow of 500 cfs, and increased to 70°F with a flow of 250 cfs. In May, the mouth temperatures increased to 65°F with a flow of 1,000 cfs, increased to 70°F with a flow of 500 cfs, and increased to 75°F with a flow of 250 cfs. In June, the mouth temperatures increased to about 80°F with a flow of 250 cfs. There were no flows at 500 cfs or 1,000 cfs, but the effects of flow on warming can be assumed to be similar to that observed in April and May. The mouth temperatures were about 5°F warmer than at Snelling, indicating that equilibrium temperatures had not been reached at Snelling.

Figure F.1-21c shows the simulated monthly average Merced River temperatures below Lake McClure, below Crocker-Huffman, at Snelling, and at the river mouth in July–September for 1980–2003 as a function of the river flow (at the mouth). The summer flows in the Merced were very low (less than 100 cfs), and simulated temperatures at Snelling were high (85–90°F) in July, August, and September when flows were less than 100 cfs. Temperatures at the mouth in these months were less than at Snelling, suggesting that shading at the mouth was greater (i.e., lower equilibrium temperature) than at Snelling. At a flow of 1,000 cfs, the warming at Snelling and the mouth was much less—about 5°F at Snelling and about 10°F at the mouth in July and August. In September, with a flow of more than 500 cfs, the Crocker-Huffman temperatures were about 60°F, the Snelling temperatures were about 65°F, and the mouth temperatures were 70°F. But at low flows (less than 250 cfs), some of the simulated Crocker-Huffman temperatures were much higher (75°F). Regardless of the simulated Crocker-Huffman temperature, the Snelling temperatures were about 85°F, and the mouth temperatures were about 80°F.

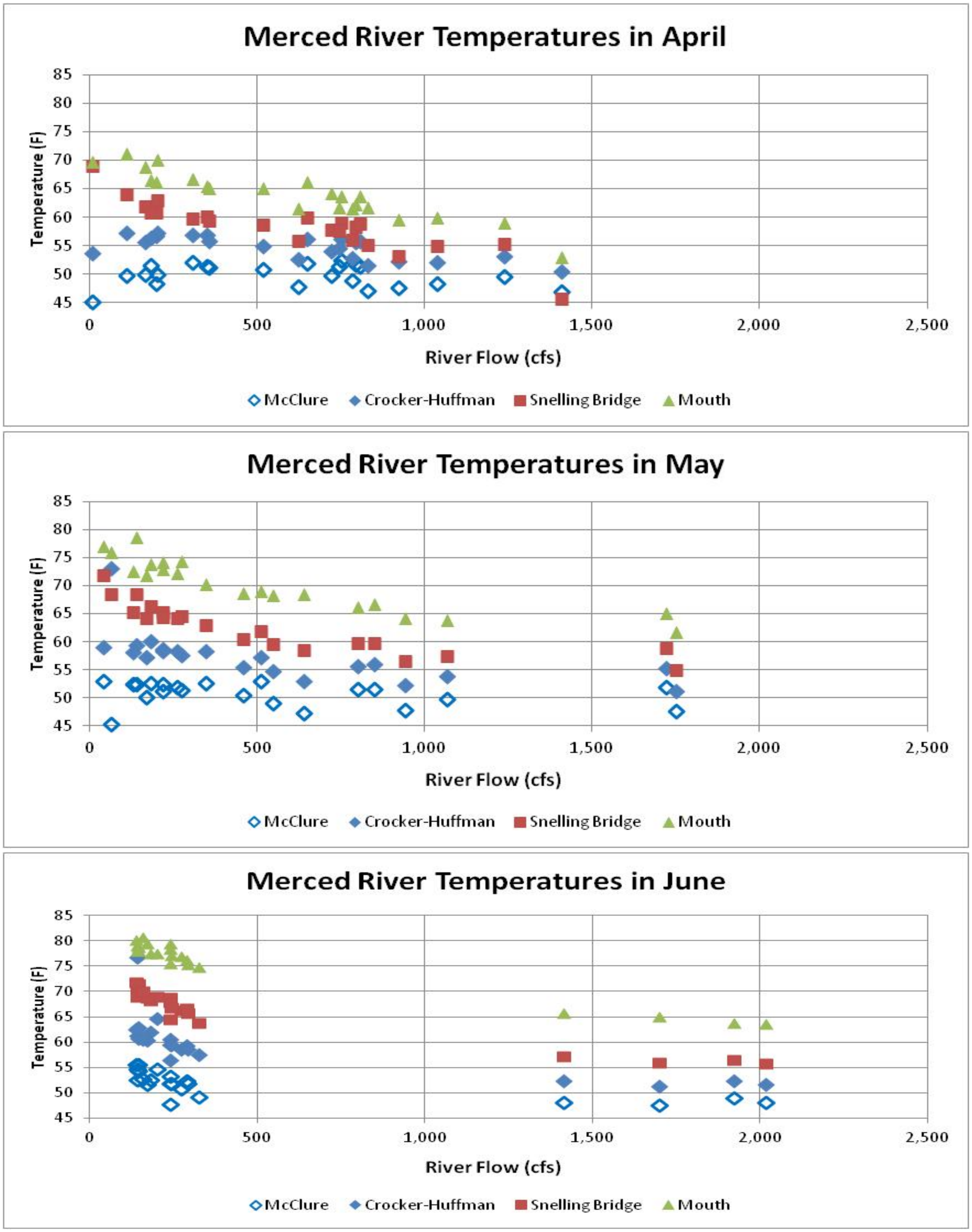


Figure F.1-21b. Effects of Merced River Flow on Merced River Water Temperatures in April–June for Baseline Conditions 1980–2003

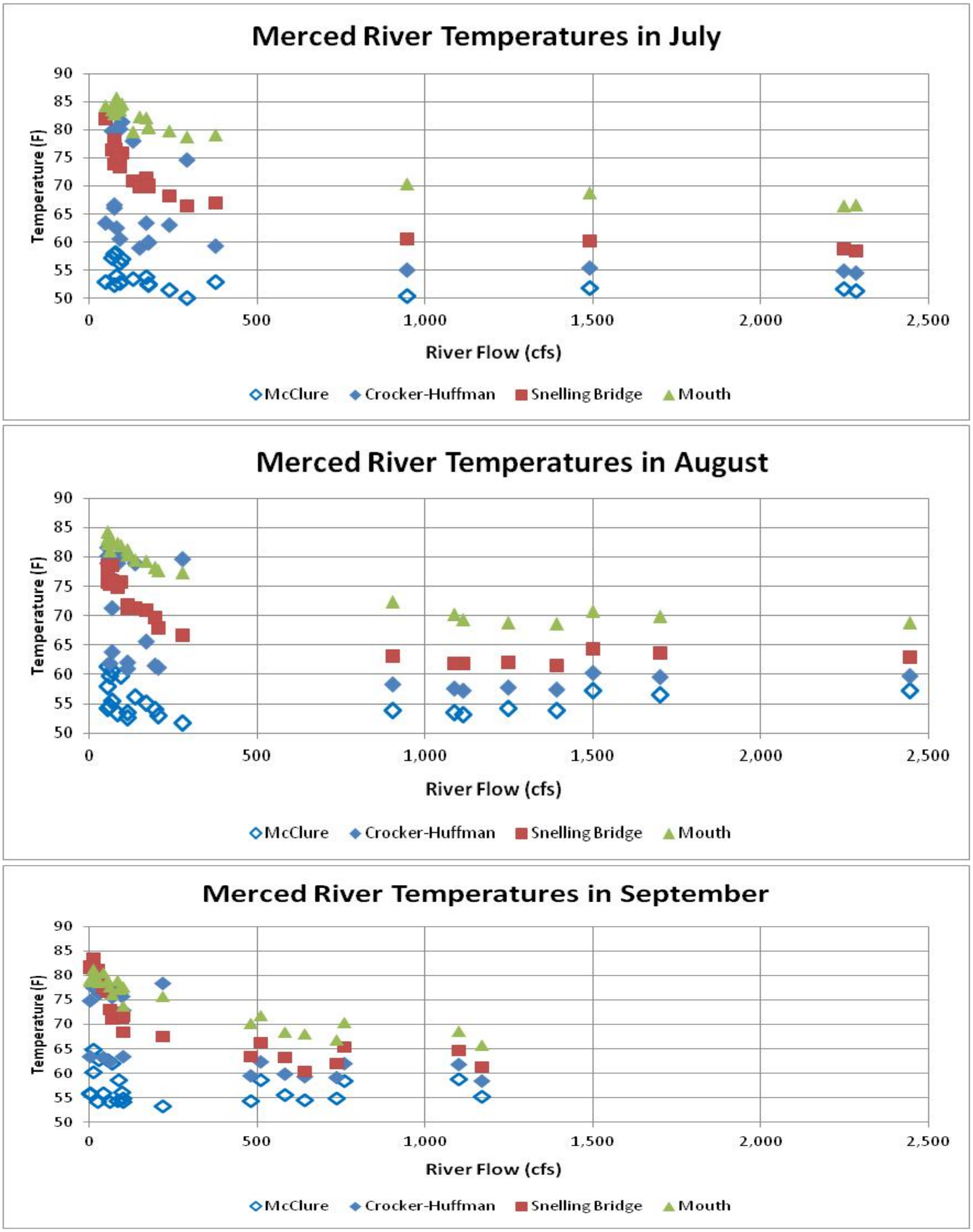


Figure F.1-21c. Effects of Merced River Flow on Merced River Water Temperatures July–September for Baseline Conditions 1980–2003

These temperature results illustrate the combination of factors controlling Merced River temperatures. The Lake McClure and Crocker-Huffman temperatures were strongly affected by low storage in August–November. The Crocker-Huffman temperatures were also sensitive to the release flow in July–October. The meteorological warming of downstream river temperatures was substantial in March–October, with maximum temperatures of 85–90°F in July and August at Snelling and 80–85°F at the mouth (increased shade). Higher river flows reduce the maximum downstream warming. For example, reducing the river flow from 1,000 to 500 cfs in April or May will allow the Merced River mouth temperatures to increase by about 5°F. Reducing the flow from 500 to 250 cfs will allow the mouth temperatures to increase another 5°F. The temperature effect of flows between 250 and 1,500 cfs is important because this is the typical range for the LSJR alternatives being evaluated. An increase of 250 cfs or more in March–June will have a substantial effect on reducing the downstream water temperatures at Snelling and the mouth of the Merced River.

LSJR Alternatives Temperature Results

Although the baseline monthly temperatures may be warmer than temperatures required for most suitable fish habitat conditions, the baseline temperatures are used for judging the effects of the LSJR alternatives. The SJR Basin Water Temperature Model results indicate the general relationship between flow and temperature in February–June, which are the only months with flow changes and the only months with temperature changes.

Stanislaus River Temperatures

Figure F.1-22a and 22b show the monthly average temperatures in the Stanislaus River at Riverbank (RM 33) simulated with the SJR Basin Water Temperature Model for the baseline conditions and the LSJR alternatives plotted as a function of the monthly river flow at Ripon for February–June. Riverbank is located about 25 miles downstream of Goodwin Dam (RM 58). For February, the temperatures were generally 50°F–60°F. The warmest temperatures corresponded to flows of less than 500 cfs. Although the unimpaired flow objectives generally increased many of the baseline conditions flows in February and resulted in a more uniform distribution of flows between 150 cfs (minimum target flow) and 2,500 cfs (maximum target flow), these flow changes in February had very little effect on Riverbank temperatures. Because there is little meteorological warming in February, river flow increases would not substantially reduce water temperatures.

In March, simulated temperatures in the Stanislaus River at Riverbank were 50°F when river flow was 2,500 cfs or more and generally increased to 60°F when river flows were 250 cfs. There was some variation in temperatures caused by the meteorological difference in the 24 years simulated with the temperature model. Although the distribution of March flows resulting from the LSJR alternatives were somewhat different from the baseline conditions flows, there were no substantial effects on water temperatures because meteorological warming at Riverbank was limited in March. The warmest temperatures of 60–62°F were simulated for low flows of 250–500 cfs; no temperatures of greater than 68°F were simulated in March.

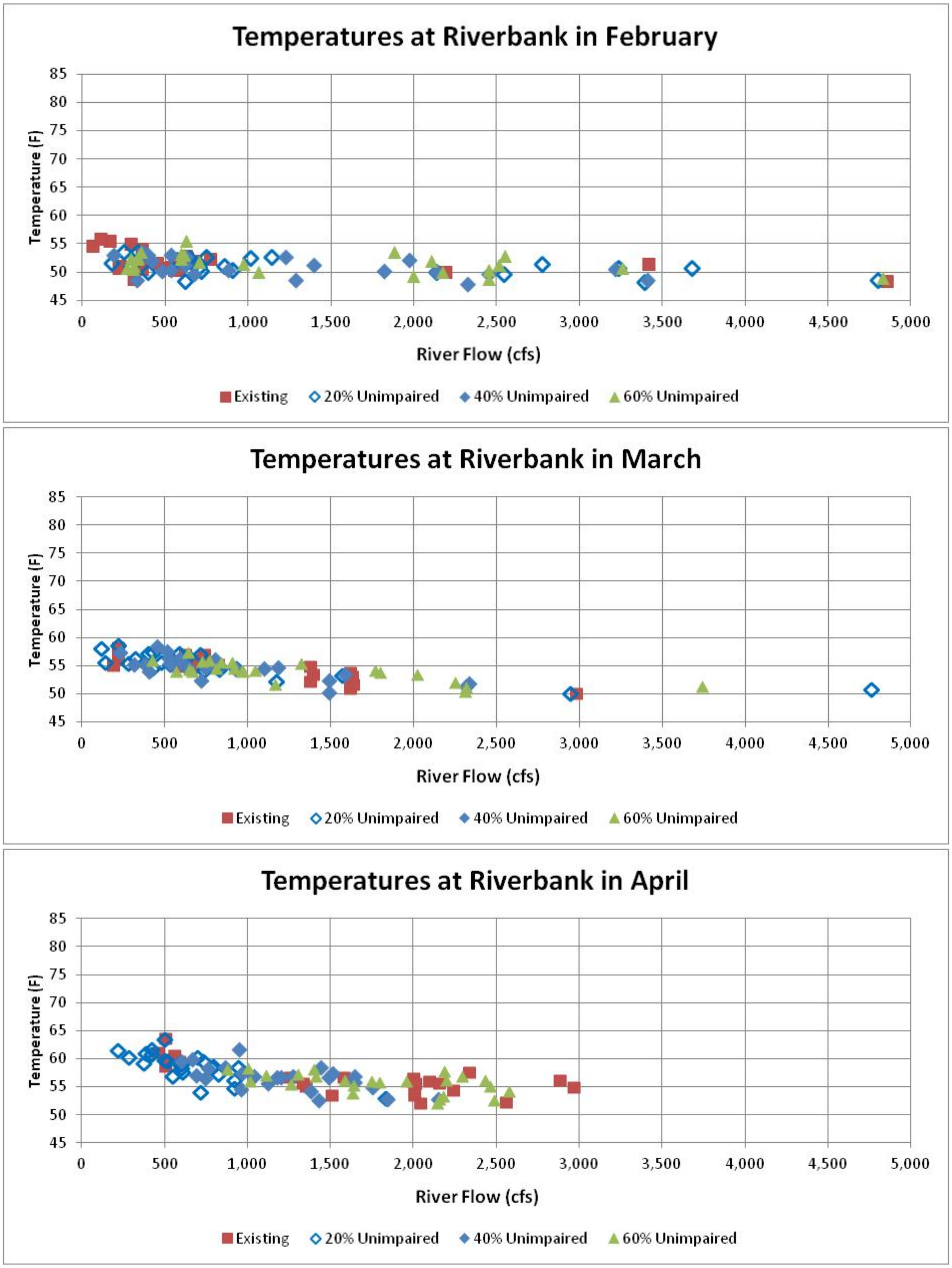
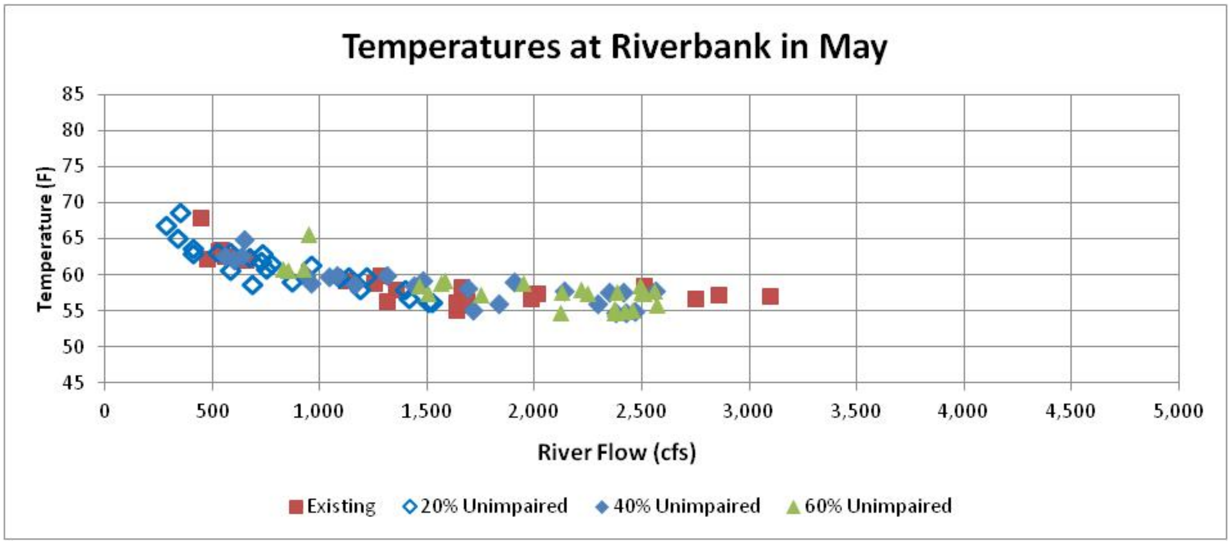


Figure F.1-22a. Effects of Stanislaus River Flows on Temperatures at Riverbank February–April for Baseline Conditions and LSJR Alternatives 2, 3, and 4 (20%, 40 %, 60% Unimpaired Flow) 1980–2003



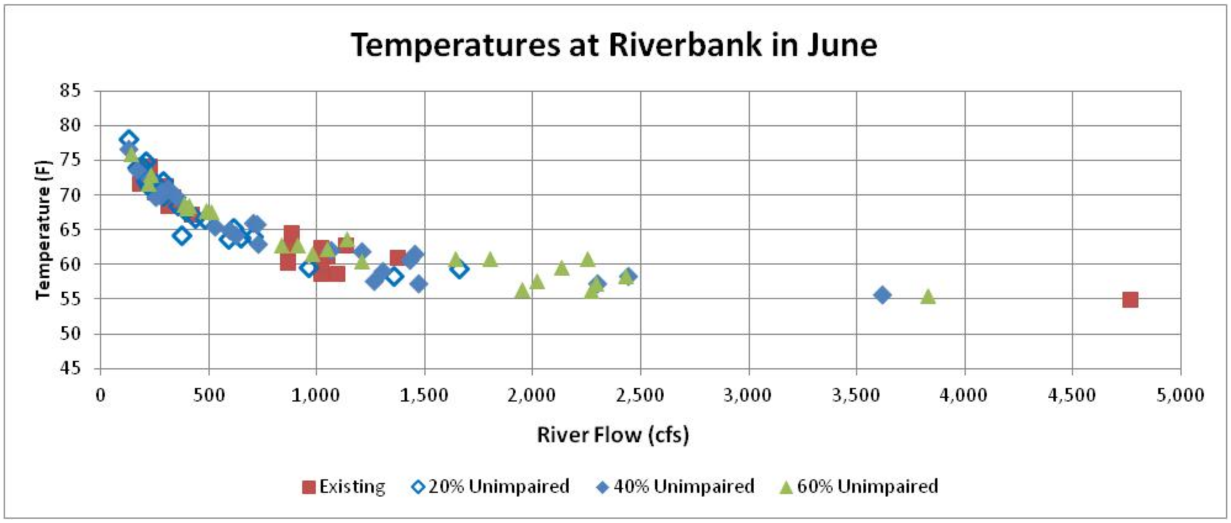


Figure F.1-22b. Effects of Stanislaus River Flows on Temperatures at Riverbank in May and June for Baseline Conditions and LSJR Alternatives 2, 3, and 4 (20%, 40%, 60% Unimpaired Flow) 1980–2003

In April, the range of simulated temperatures at Riverbank was 50°F–65°F, with the warmer temperatures of 60–65°F generally simulated for the lower flows (less than 1,000 cfs). Because the April flows were always greater than 500 cfs, no temperatures of greater than 68°F were simulated. In May, the range of simulated temperatures at Riverbank was 55°F–70°F, about 5°F warmer than in April. The warmer temperatures of 60–70°F in May were generally simulated for the lower flows (less than 1,000 cfs). Because the May flows were always greater than 500 cfs, few temperatures of greater than 68°F were simulated in May at Riverbank. In June, the flows were lower (lowest of about 250 cfs), and the temperatures were considerably warmer than in April and May. The range of June temperatures at Riverbank was 55°F at high flows to about 80°F at a flow of 250 cfs.

The Stanislaus River warming curves (flow vs. temperature) at Riverbank in May and June indicate that the temperature would be 65–70°F if the flow were greater than 500 cfs. A flow of 1,000 cfs would reduce the temperature in May or June to about 60–65°F. This indicates the general relationship between river flow and the water temperatures in the upstream portion of the

Stanislaus River and suggests that temperature effects from slightly reduced flows are not likely unless the flows are less than 500 cfs.

Table F.1-19 gives the monthly cumulative distribution of average simulated water temperatures in the Stanislaus River at Riverbank for 1980–2003 for the baseline conditions and for the LSJR alternatives. The baseline conditions average water temperatures at Riverbank indicate the normal seasonal warming January–July is about 20°F. The monthly increase in the average temperatures February–May was about 2°F per month, and the monthly increase May–July was about 5°F per month.

Table F.1-19. Monthly Distribution of Stanislaus River Water Temperatures at Riverbank 1980–2003 for Baseline Conditions and LSJR Alternatives 2, 3, and 4 (20%, 40%, 60% Unimpaired Flow)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Stanislaus River at Riverbank (RM 33) Temperatures for Baseline Conditions												
minimum	45.2	48.4	49.5	52.1	55.1	55.0	55.6	57.2	54.4	52.7	49.7	46.7
10%	46.7	50.0	51.3	53.6	56.0	59.1	64.5	61.5	59.3	55.4	52.2	48.1
20%	48.0	50.3	52.8	54.2	56.4	60.7	68.2	66.1	63.7	56.0	52.4	48.8
30%	48.4	50.7	53.3	55.1	56.8	61.3	69.7	68.5	66.4	57.0	53.9	49.7
40%	48.5	50.9	54.0	55.6	57.4	62.5	70.4	69.4	67.4	57.3	54.5	49.9
50%	48.9	51.5	55.0	56.0	57.9	65.9	71.8	69.6	68.3	58.7	55.0	50.0
60%	49.4	51.9	55.2	56.5	58.4	68.4	72.0	70.3	68.9	58.8	55.4	50.4
70%	49.8	52.3	55.4	56.9	59.4	69.7	73.3	71.2	69.6	60.1	56.3	50.7
80%	50.4	53.3	56.5	59.0	62.1	70.7	74.1	71.4	70.6	64.2	57.0	51.2
90%	51.2	54.8	57.1	60.4	63.1	71.3	76.2	72.1	73.4	65.7	57.7	51.4
Maximum	52.1	55.8	58.3	63.7	67.9	74.3	78.0	82.7	76.4	72.0	58.9	52.7
Average	49.0	51.8	54.5	56.5	58.9	65.5	70.6	68.9	67.2	59.6	54.9	50.0
Stanislaus River at Riverbank Temperatures for 20% Unimpaired Flow												
minimum	45.2	48.2	49.6	53.0	56.1	54.7	55.6	57.5	55.0	53.2	49.8	46.4
10%	46.8	48.8	51.3	55.2	57.2	59.5	62.7	61.6	59.6	55.1	51.8	48.0
20%	47.9	49.9	53.9	57.1	58.4	63.8	68.1	66.2	63.6	55.7	52.4	48.5
30%	48.3	50.4	54.6	58.3	59.5	64.2	69.1	68.0	65.9	56.5	53.5	49.4
40%	48.5	50.7	54.9	58.5	59.9	66.6	69.9	68.6	67.6	56.9	54.2	49.8
50%	48.8	51.0	55.4	59.1	61.2	68.1	70.4	69.3	68.0	58.0	54.7	50.0
60%	49.3	51.6	55.7	59.5	61.8	70.9	70.9	70.2	68.6	58.2	55.5	50.2
70%	49.8	52.2	56.5	59.9	62.9	71.4	72.1	70.4	69.3	60.0	56.1	50.8
80%	50.4	52.5	57.2	60.5	63.1	72.0	73.2	71.0	70.4	63.9	56.7	51.1
90%	51.1	52.7	57.4	61.4	64.7	74.2	74.0	72.3	72.9	65.6	57.4	51.4
Maximum	52.0	53.6	58.7	63.4	68.7	78.0	77.3	74.3	75.4	72.0	58.8	52.4
Average	48.9	51.1	55.1	58.7	61.1	67.6	69.6	68.2	67.0	59.4	54.7	49.8

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Stanislaus River at Riverbank Temperatures for 40% Unimpaired Flow												
minimum	45.2	47.9	49.5	52.6	54.7	55.6	55.5	57.3	55.0	53.2	49.9	46.5
10%	46.2	48.5	51.5	53.3	55.0	57.4	63.9	61.9	59.7	55.4	52.0	48.0
20%	48.0	49.6	52.5	54.8	56.0	58.8	67.6	66.3	64.2	55.9	52.5	48.8
30%	48.4	50.1	54.0	55.9	57.6	61.4	69.1	68.2	66.1	56.5	53.6	49.5
40%	48.5	50.3	54.6	56.7	57.9	62.3	69.7	68.7	67.7	57.6	54.7	49.6
50%	48.9	50.8	54.8	56.8	58.6	64.6	70.4	69.8	68.4	58.4	54.8	49.9
60%	49.3	51.2	55.2	56.9	59.1	65.7	71.0	70.5	69.0	58.6	55.8	50.4
70%	49.9	52.2	55.4	57.4	59.8	69.8	71.7	71.1	69.4	60.1	56.2	50.6
80%	50.4	52.6	56.3	58.4	60.0	70.2	73.5	71.3	71.2	64.4	57.2	51.2
90%	51.1	53.0	57.2	59.3	62.5	71.9	74.3	72.8	73.5	66.7	57.6	51.4
Maximum	52.1	53.5	58.6	61.7	64.9	76.7	77.8	77.3	75.8	72.0	58.9	53.3
Average	48.9	50.9	54.5	56.7	58.6	64.8	69.6	68.7	67.3	59.7	54.9	49.9
Stanislaus River at Riverbank Temperatures for 60% Unimpaired Flow												
minimum	45.2	47.9	49.5	52.1	54.6	55.6	55.4	57.1	55.0	53.1	49.8	46.5
10%	46.2	48.5	51.2	52.9	54.9	56.7	64.0	62.1	59.8	55.4	52.0	48.1
20%	48.0	49.3	51.8	54.2	55.6	58.0	67.6	66.6	64.5	56.0	52.6	48.9
30%	48.4	50.3	53.6	55.2	57.4	60.3	69.0	68.7	66.4	56.6	53.7	49.4
40%	48.6	50.5	53.8	55.8	57.4	60.9	69.8	69.3	68.1	57.7	54.4	49.7
50%	48.8	50.6	54.0	56.0	57.6	62.0	70.7	70.3	68.5	58.4	54.8	50.1
60%	49.3	51.8	54.1	56.1	58.0	62.8	71.3	71.0	69.3	58.7	55.9	50.3
70%	49.8	52.1	54.3	56.8	58.5	67.1	71.9	71.5	69.6	60.1	56.2	50.6
80%	50.4	52.4	55.2	57.0	59.0	67.7	73.5	71.9	71.5	63.8	56.7	51.3
90%	51.1	52.6	55.7	58.0	60.5	70.0	74.3	73.8	73.5	66.7	57.7	51.6
Maximum	52.1	53.5	57.4	59.2	64.4	75.5	76.4	77.1	77.9	72.0	60.6	53.2
Average	48.9	50.8	53.7	55.7	57.8	63.1	69.6	69.1	67.6	59.8	54.9	50.0
Effects on Average Stanislaus River Temperatures at Riverbank												
Baseline	49.0	51.8	54.5	56.5	58.9	65.5	70.6	68.9	67.2	59.6	54.9	50.0
20%	-0.1	-0.7	0.6	2.2	2.3	2.2	-0.9	-0.6	-0.2	-0.2	-0.2	-0.1
40%	-0.1	-0.8	0.0	0.1	-0.3	-0.7	-1.0	-0.2	0.1	0.1	0.0	0.0
60%	-0.1	-0.9	-0.8	-0.8	-1.0	-2.4	-0.9	0.2	0.4	0.2	0.0	0.0

Tuolumne River Temperatures

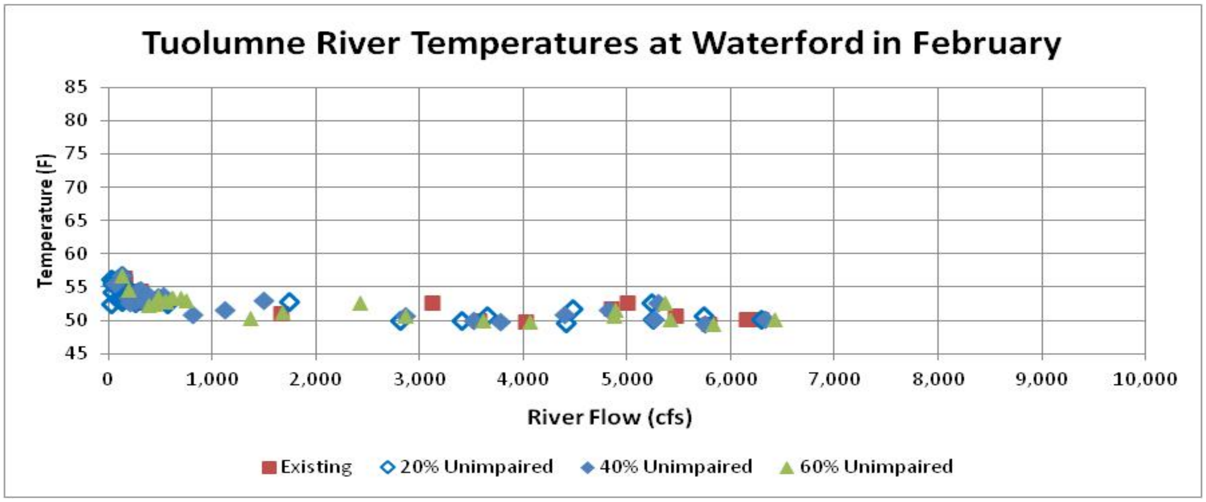
Figure F.1-23a and 23b shows the monthly average temperatures in the Tuolumne River at Waterford (RM 32) simulated with the SJR Water temperature model for the baseline conditions and the LSJR alternatives plotted as a function of the monthly river flow at Merced for February–June. Waterford is located about 20 miles downstream of La Grange Dam (RM 52). For February, the temperatures were generally 50°F–55°F. The warmest temperatures corresponded to flows of less than 1,000 cfs. Although the unimpaired flow objectives generally increased many of the baseline conditions flows in February and resulted in a more uniform distribution of flows between 250 cfs (minimum target flow) and 3,500 cfs (maximum target flow), these flow changes in February had very little effect on Waterford temperatures. Because there is little meteorological warming in February, river flow increases would not substantially reduce water temperatures.

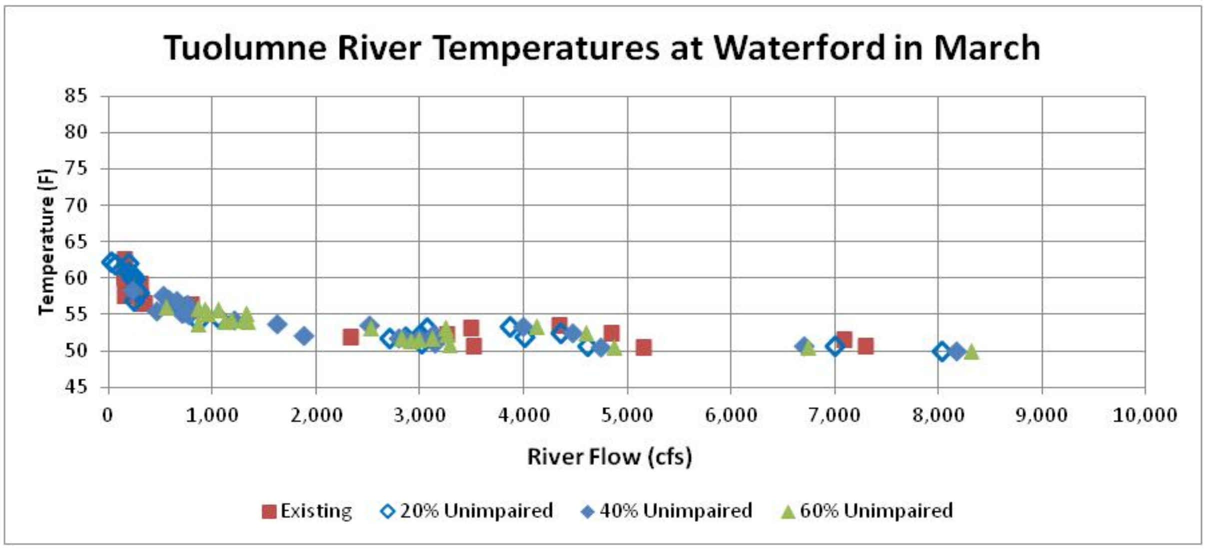
In March, simulated temperatures in the Tuolumne River at Waterford were 50–55°F when river flow was 2,500 cfs or more and generally increased to 60–65°F when river flows were 250 cfs. There was some variation in temperatures caused by the meteorological difference in the 24 years simulated with the temperature model. Although the distribution of March flows resulting from the LSJR alternatives were somewhat different from the baseline conditions flows, there no large effects on water temperatures because meteorological warming at Waterford was limited in March. The warmest temperatures of 60–65°F were simulated for low flows of 250–500 cfs.

In April, the range of simulated temperatures at Waterford was 50°F to 65°F, with warmer temperatures 60–65°F generally simulated for the lower flows (less than 500 cfs). Because the April flows were always greater than 250 cfs, no temperatures of greater than 65°F were simulated. In May, the range of simulated temperatures at Waterford was 55°F–70°F, about 5°F warmer than in April. The warmer temperatures of 60–70°F were generally simulated for the lower flows (less than 1,000 cfs). Because the May flows were always greater than 500 cfs, only a few temperatures of greater than 68°F were simulated in May at Waterford. In June, the flows were lower (about 250 cfs) and the temperatures were considerably warmer than in April and May. The range of June temperatures at Waterford was 55°F at high flows to about 80°F at a flow of 250 cfs. The range of June temperatures at Riverbank was 55°F at high flows to about 80°F at a flow of 250 cfs.

The Tuolumne River warming curves (flow vs. temperature) at Waterford in May and June indicate that the temperature would be 65–70°F if the flow were greater than 500 cfs. A flow of 1,000 cfs would reduce the temperature in May or June to about 60–65°F. This indicates the general relationship between river flow and the water temperatures in the upstream portion of the Tuolumne River and suggests that temperature effects from reduced flows are most likely for flows of less than 500 cfs.

Table F.1-20 gives the monthly cumulative distribution of average simulated water temperatures in the Tuolumne River at Waterford for 1980–2003 for the baseline conditions and for the LSJR alternatives. The baseline conditions average water temperatures at Waterford indicate the normal seasonal warming January–July is about 25°F. This maximum seasonal warming was about 5°F greater than for the Stanislaus River and may reflect the lower Tuolumne River flows (greater warming). The monthly increase in the average temperatures February–May was about 3°F per month, the monthly increase May–June was almost 10°F, and the increase June–July was about 5°F.





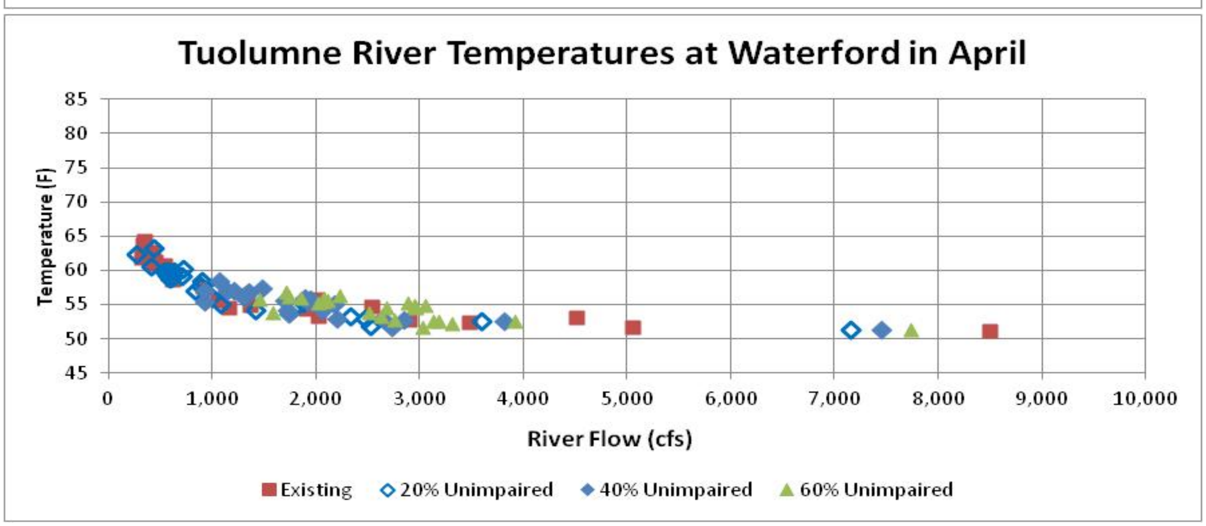
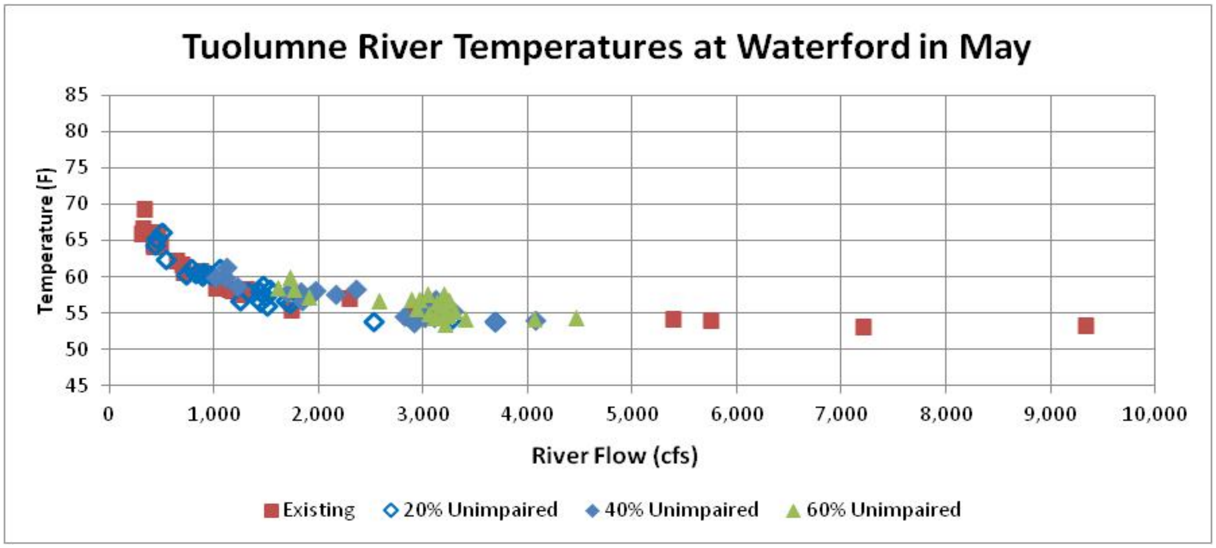


Figure F.1-23a. Effects of Tuolumne River Flows on Temperatures at Waterford in February–April for Baseline Conditions and LSJR Alternatives 2, 3, and 4 (20%, 40%, 60% Unimpaired Flow) 1980–2003



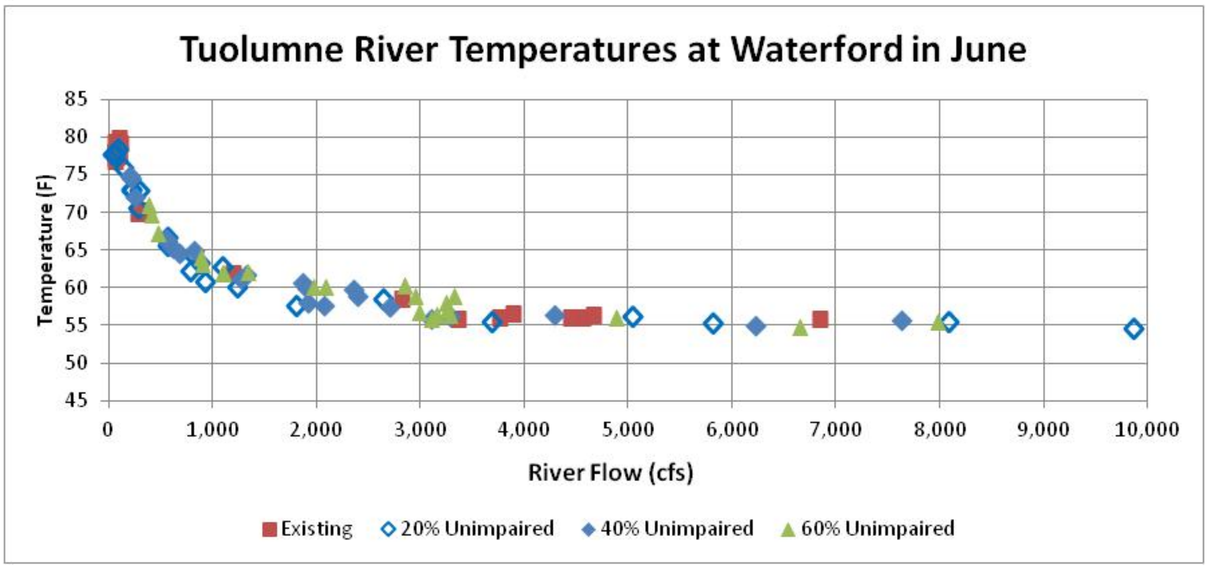


Figure F.1-23b. Effects of Tuolumne River Flows on Temperatures at Waterford in May and June for Baseline Conditions and LSJR Alternatives 2, 3, and 4 (20%, 40%, 60% Unimpaired Flow) 1980–2003

Table F.1-20. Monthly Distribution of Tuolumne River Water Temperatures at Waterford 1980–2003 for Baseline Conditions and LSJR Alternatives 2, 3, and 4 (20%, 40%, 60% Unimpaired Flow)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Tuolumne River at Waterford (RM 32) Temperatures for Baseline Conditions												
minimum	47.6	49.5	50.5	51.2	53.2	55.8	57.3	60.8	58.1	56.0	53.2	47.1
10%	48.4	50.0	50.7	52.6	54.1	56.0	58.1	70.0	65.6	59.4	53.4	47.8
20%	48.9	50.5	51.7	53.3	55.2	56.3	59.0	71.3	67.0	60.1	53.9	48.8
30%	49.1	51.6	52.2	54.6	57.6	58.3	68.6	72.1	68.3	60.4	54.7	49.1
40%	49.5	52.6	53.2	55.1	58.3	70.0	73.6	72.3	68.9	60.5	55.2	49.4
50%	49.7	52.9	56.4	56.7	59.5	73.6	77.3	75.7	71.2	62.3	55.4	49.7
60%	50.0	53.3	57.3	59.1	61.5	77.4	81.7	79.6	75.9	63.7	55.5	50.0
70%	50.6	54.1	59.3	60.8	64.3	77.6	82.9	80.5	76.3	65.2	55.6	50.8
80%	50.8	54.6	60.0	61.3	64.6	77.9	83.2	80.9	77.0	66.3	56.7	51.0
90%	51.6	55.3	60.6	62.6	66.1	78.9	84.0	81.8	77.5	67.4	57.0	52.1
Maximum	52.2	56.4	62.6	64.5	69.4	79.8	84.8	83.5	79.2	69.7	58.0	52.5
Average	49.9	52.8	55.8	57.4	60.2	69.2	74.0	75.4	71.5	62.8	55.3	49.9
Tuolumne River at Waterford (RM 32) Temperatures for 20% Unimpaired Flow												
minimum	47.7	49.6	50.0	51.5	53.9	54.5	57.2	60.2	58.2	56.3	53.3	47.0
10%	48.4	50.1	50.8	52.7	54.8	55.5	57.6	69.9	60.4	57.0	53.5	48.0
20%	48.8	50.5	51.8	53.9	56.5	56.6	58.8	71.5	65.1	59.4	53.8	48.8
30%	49.1	51.6	52.3	55.0	56.8	58.5	68.5	72.1	68.1	60.0	54.5	49.2
40%	49.4	52.6	53.3	57.2	58.0	61.2	72.7	72.2	68.8	60.2	55.1	49.6
50%	49.7	52.8	54.4	58.1	58.6	63.0	76.9	75.8	71.2	61.1	55.4	49.6
60%	50.0	53.1	56.6	59.1	60.2	65.3	81.3	79.5	75.9	63.6	55.6	50.0
70%	50.7	54.2	58.2	59.5	60.5	70.9	81.5	80.6	76.3	65.1	56.1	50.9
80%	50.9	55.2	60.3	60.0	61.2	73.0	81.8	81.0	76.8	66.9	57.0	51.0
90%	51.6	56.2	61.6	60.6	63.8	77.2	82.5	81.6	77.5	67.5	57.5	52.2
Maximum	53.1	56.7	62.3	63.3	66.1	78.5	83.6	83.5	79.3	69.6	58.0	52.8
Average	49.9	52.9	55.6	57.3	59.1	64.8	73.2	75.3	70.8	62.4	55.4	49.9
Tuolumne River at Waterford (RM 32) Temperatures for 40% Unimpaired Flow												
minimum	47.7	49.5	50.0	51.4	53.8	54.3	57.1	60.1	57.5	55.7	53.3	47.0
10%	48.4	50.0	50.7	52.7	54.2	55.6	57.5	70.0	59.3	57.7	53.6	48.0
20%	48.8	50.5	51.8	53.0	54.5	56.3	59.1	71.8	62.5	58.9	53.8	49.0
30%	49.1	50.9	52.1	54.2	54.9	57.4	68.8	72.2	68.1	59.8	54.6	49.3
40%	49.4	51.8	52.7	55.2	55.4	58.1	72.4	72.6	69.1	60.1	55.1	49.7
50%	49.6	52.7	53.6	55.6	56.6	59.9	76.2	75.9	71.4	61.3	55.4	49.8
60%	50.0	53.0	54.8	56.0	57.4	61.1	80.4	79.6	76.1	63.8	55.7	50.0
70%	50.7	53.4	55.4	56.4	57.8	64.5	80.7	80.8	76.5	65.4	56.3	50.9
80%	50.9	53.8	56.5	57.0	58.2	65.6	81.2	81.2	77.0	66.9	57.2	51.1
90%	51.6	54.5	57.0	57.1	59.5	70.3	82.1	81.9	77.8	68.0	57.7	52.1
Maximum	53.1	56.7	58.3	58.4	61.3	74.9	82.6	83.7	79.5	70.1	58.1	52.9
Average	49.9	52.4	53.9	55.2	56.6	61.4	72.8	75.5	70.6	62.4	55.5	50.0

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Tuolumne River at Waterford (RM 32) Temperatures for 60% Unimpaired Flow												
minimum	47.7	49.5	50.0	51.4	53.5	54.2	57.0	60.1	56.3	55.4	53.4	47.0
10%	48.3	50.0	50.7	52.4	54.3	55.6	57.4	70.1	58.5	57.3	53.5	48.0
20%	48.8	50.2	51.6	52.7	54.4	56.2	59.2	71.9	59.6	58.7	53.8	48.9
30%	49.1	50.8	51.8	53.2	54.8	56.6	68.8	72.3	68.2	59.8	54.3	49.3
40%	49.3	51.8	52.6	54.0	55.3	57.2	72.4	72.8	69.2	60.1	55.0	49.6
50%	49.6	52.4	53.3	54.8	56.3	58.9	76.0	76.1	71.5	61.1	55.4	49.8
60%	50.0	52.7	54.0	55.2	56.8	60.1	80.1	79.7	76.2	63.9	55.7	49.9
70%	50.7	52.8	54.3	55.5	56.9	61.8	80.5	81.0	76.7	65.5	56.0	50.9
80%	50.9	53.3	55.2	55.9	57.4	62.6	80.9	81.4	77.1	66.8	57.2	51.1
90%	51.6	53.6	55.6	56.1	58.1	66.3	81.8	82.0	77.9	68.1	57.8	52.1
Maximum	53.1	56.7	55.9	56.9	59.9	71.0	82.3	83.9	79.7	70.4	58.1	53.0
Average	49.9	52.1	53.2	54.4	56.1	59.9	72.7	75.6	70.3	62.4	55.5	50.0
Effects on Average Tuolumne River Temperatures at Waterford (RM 32)												
Baseline	49.9	52.8	55.8	57.4	60.2	69.2	74.0	75.4	71.5	62.8	55.3	49.9
20%	0.0	0.2	-0.2	-0.1	-1.1	-4.4	-0.8	-0.1	-0.7	-0.4	0.1	0.1
40%	0.0	-0.4	-1.9	-2.2	-3.6	-7.8	-1.2	0.1	-0.9	-0.4	0.2	0.2
60%	0.0	-0.7	-2.5	-3.0	-4.1	-9.3	-1.3	0.3	-1.2	-0.4	0.1	0.1

Merced River Temperatures

Figure F.1-24a and 24b show the monthly average temperatures in the Merced River at Highway 59 Bridge (RM 42) simulated for the baseline conditions and the LSJR alternatives, plotted as a function of the monthly river flow at Merced for February–June. Highway 59 Bridge is located about 10 miles downstream of the Crocker-Huffman Dam (RM 52). For February, the temperatures were generally 50°F–60°F. The warmest temperatures were simulated at flows of less than 250 cfs. Because there is little meteorological warming in February, river flow increases will not substantially reduce water temperatures.

In March, simulated temperatures in the Merced River at Highway 59 Bridge were 50–55°F when river flow was 2,000 cfs or more and generally increased to 60–65°F when river flows were 250 cfs. There was some variation in temperatures caused by the meteorological difference in the 24 years simulated with the temperature model. Although the distribution of March flows resulting from the LSJR alternatives were somewhat different from the baseline conditions flows, there were no large effects on water temperatures because meteorological warming at Highway 59 Bridge was limited in March. The warmest temperatures of 60–65°F were simulated for low flows of 250 cfs.

In April, the range of simulated temperatures at Highway 59 Bridge was 50°F–70°F, with warmer temperatures of 60–70°F simulated for the lower flows (less than 250 cfs). In May, the range of simulated temperatures at Highway 59 Bridge was 55°F–75°F, about 5°F warmer than in April. The warmer temperatures of 65–75°F were generally simulated for the lower flows (less than 250 cfs). In June, temperatures were considerably warmer than in April and May. The range of June temperatures at Highway 59 Bridge was 55°F at high flows to about 70–80°F at a flow of less than 250 cfs.

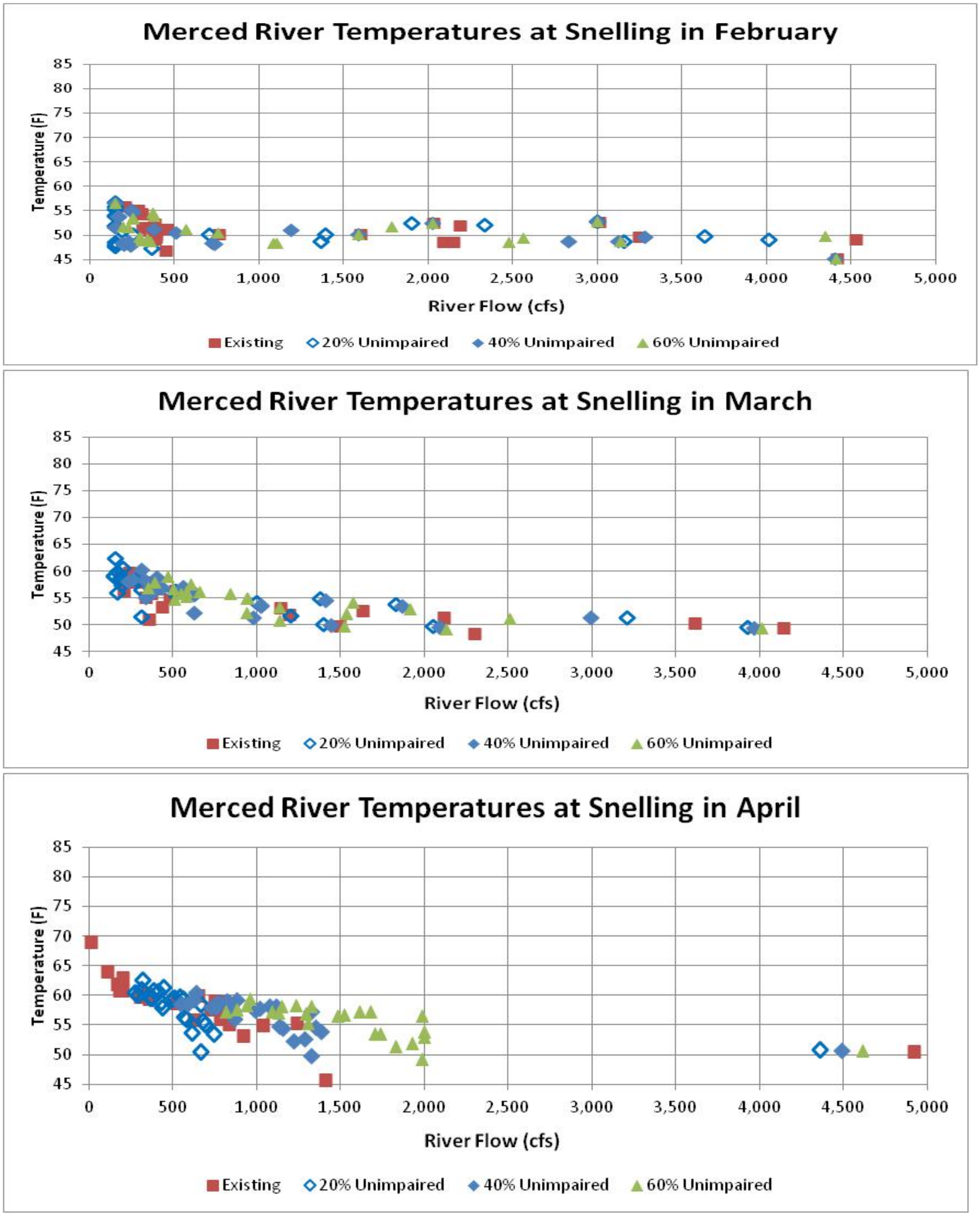
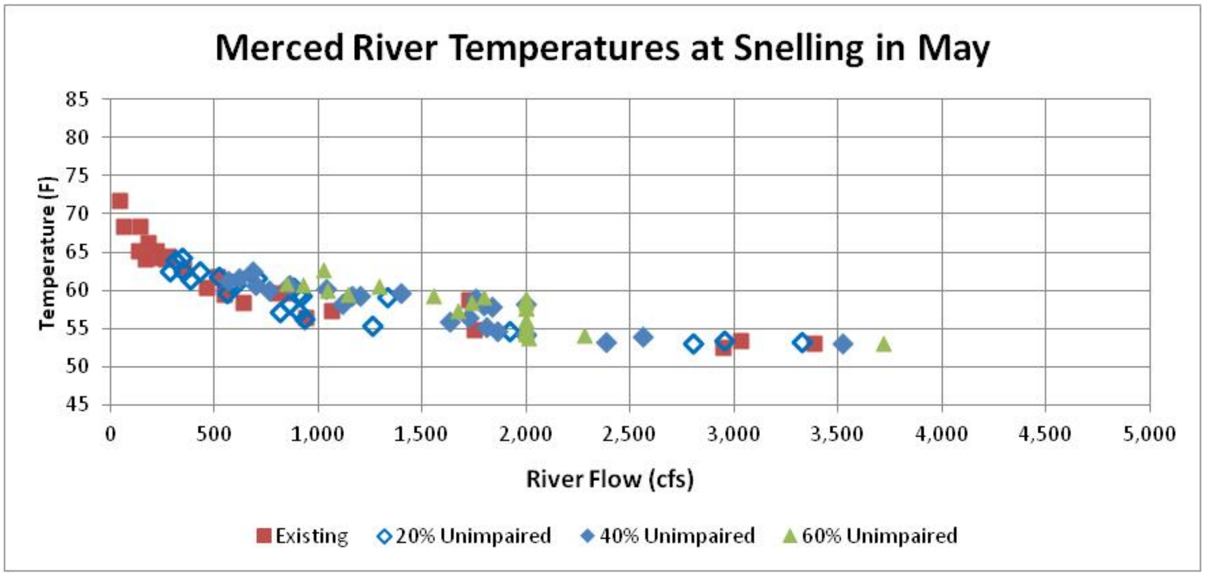


Figure F.1-24a. Effects of Merced River Flows on Temperatures at Snelling in February–April for Baseline Conditions and LSJR Alternatives 2, 3, and 4 (20%, 40%, 60% Unimpaired Flow) 1980–2003



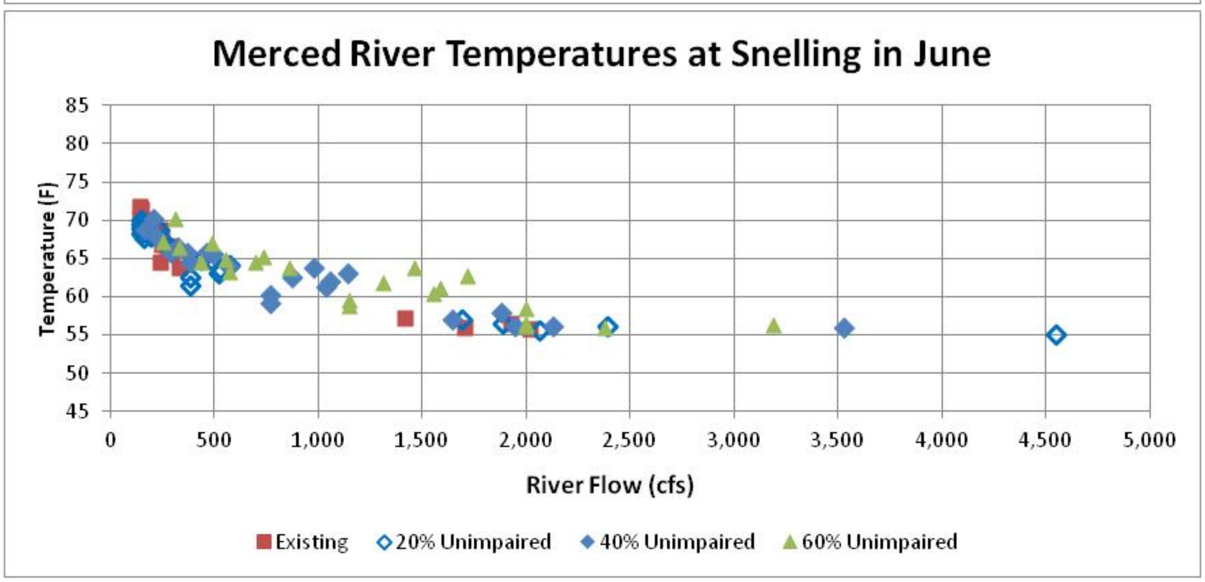


Figure F.1-24b. Effects of Merced River Flows on Temperatures at Snelling in May and June for Baseline Conditions and LSJR Alternatives 2, 3, and 4 (20%, 40%, 60% Unimpaired Flow) 1980–2003

The Merced River warming curves (flow vs. temperature) at Highway 59 Bridge in May and June indicate that the temperature would be 65–70°F in May and would be 70–75°F in June if the flow were about 250 cfs. A flow of 500 cfs would reduce the temperature in May to about 60°F and to about 65°F in June. This indicates the general relationship between river flow and the water temperatures in the upstream portion of the Merced River and suggests that temperature effects from reduced flows are most likely for flows of less than 500 cfs.

Table F.1-21 gives the monthly cumulative distribution of average simulated water temperatures in the Merced River at Highway 59 Bridge for 1980–2003 for the baseline conditions and for the LSJR alternatives. The baseline conditions average water temperatures at Highway 59 Bridge indicate the normal seasonal warming January–July is about 25°F. This maximum seasonal warming was about 5°F greater than for the Stanislaus River and may reflect the lower Merced River flows (greater warming) or less shade along the Merced River channel. The monthly increase in the average temperatures February–May was about 3°F per month, the monthly increase May–June was 5°F, and the increase June–July was about 5°F.

Table F.1-21. Monthly Distribution of Merced River Water Temperatures at Highway 59 1980–2003 for Baseline Conditions and LSJR Alternatives 2, 3, and 4 (20%, 40%, 60% Unimpaired Flow)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Merced River at Highway 59 Bridge (RM 42) Temperatures for Baseline Conditions												
minimum	42.1	45.1	45.9	45.8	52.6	54.5	58.6	61.6	60.4	49.3	50.7	46.5
10%	44.9	48.5	49.6	53.7	53.9	55.2	58.8	62.0	62.4	56.7	53.0	48.8
20%	46.6	49.1	50.8	55.2	57.0	56.3	59.8	63.1	64.3	59.8	54.3	49.1
30%	47.8	49.6	51.8	56.0	58.9	63.1	66.0	64.3	66.3	61.5	55.4	49.8
40%	48.2	50.1	53.2	57.9	59.7	66.0	68.7	68.2	69.1	62.0	56.3	50.5
50%	48.7	50.6	55.0	58.8	61.1	66.7	70.1	71.1	71.4	62.6	56.5	50.9
60%	48.9	51.3	56.3	59.4	63.9	68.2	71.4	71.8	72.4	63.9	56.9	51.3
70%	50.0	52.0	56.7	59.9	64.5	68.9	74.1	75.5	76.8	65.6	58.3	52.0
80%	52.0	52.6	58.0	60.8	65.3	69.3	75.5	75.8	80.4	67.2	60.6	53.0
90%	52.6	54.4	58.7	62.6	67.8	70.2	76.7	76.8	81.6	69.6	61.5	53.9
Maximum	52.8	55.8	59.7	69.0	71.9	71.9	82.0	78.7	83.6	70.1	63.8	55.6
Average	48.7	50.9	54.2	58.1	61.4	64.5	69.0	70.0	71.6	62.7	57.1	51.0
Merced River at Highway 59 Bridge (RM 42) Temperatures for 20% Unimpaired Flow Objective												
minimum	42.9	44.9	46.4	50.6	53.3	54.5	58.5	61.6	60.3	50.8	50.6	46.5
10%	45.0	47.8	49.9	53.6	53.9	55.3	58.9	62.1	62.4	57.7	53.2	48.7
20%	46.5	48.7	51.5	55.5	56.0	56.4	60.1	63.1	64.3	60.1	54.0	49.0
30%	47.8	49.0	53.7	56.4	57.3	61.2	65.6	64.3	66.1	60.6	55.4	49.8
40%	48.2	50.1	55.2	58.5	59.3	63.2	68.3	67.7	68.6	61.4	56.4	50.2
50%	48.6	50.2	56.1	59.4	59.7	64.5	69.7	70.5	70.8	62.2	56.4	50.8
60%	49.7	51.7	57.2	59.6	60.8	66.3	71.1	71.8	72.2	63.9	56.6	51.1
70%	50.4	52.2	58.4	59.8	61.6	67.8	74.3	75.0	75.6	64.3	57.8	51.6
80%	52.2	53.2	59.0	60.6	62.2	68.3	75.1	75.7	79.2	65.8	59.0	52.7
90%	52.6	54.9	59.7	61.0	62.7	69.0	76.4	76.4	81.4	67.3	59.4	53.9
Maximum	53.5	56.7	62.4	62.5	64.4	70.0	81.7	78.4	84.1	68.2	62.3	55.5
Average	48.9	50.9	55.5	58.0	59.2	63.3	68.8	69.7	71.3	62.1	56.5	50.9
Merced River at Highway 59 Bridge (RM 42) Temperatures for 40% Unimpaired Flow Objective												
minimum	42.7	45.1	46.4	49.7	53.2	54.4	58.8	61.6	60.3	48.6	50.6	46.4
10%	44.9	48.1	49.6	52.4	54.1	56.0	59.0	62.3	62.4	57.2	53.3	48.6
20%	46.5	48.4	51.3	54.2	54.6	56.8	60.2	63.3	64.4	59.5	54.0	49.0
30%	47.8	48.7	53.3	54.8	55.9	59.1	66.4	64.2	65.9	60.6	55.3	49.7
40%	48.2	49.7	53.8	57.3	58.0	61.5	69.1	68.8	69.5	61.1	56.0	50.1
50%	48.5	50.4	55.4	57.6	58.3	62.9	70.8	71.1	71.3	62.5	56.7	50.7
60%	49.6	51.2	56.1	58.0	59.3	64.0	71.5	73.3	73.4	63.9	56.9	51.0
70%	50.4	51.7	56.9	58.2	59.8	65.6	75.4	76.2	76.4	64.8	57.7	51.6
80%	52.0	53.2	57.7	58.7	60.5	65.8	77.0	77.0	80.1	66.2	59.1	52.6
90%	52.7	54.4	58.5	59.2	61.2	67.5	77.8	78.0	81.9	68.0	59.7	54.4

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Maximum	53.4	56.6	60.3	60.5	62.6	70.2	81.7	79.8	84.5	68.7	62.4	55.5
Average	48.8	50.7	54.6	56.5	57.9	62.1	69.6	70.5	71.8	62.1	56.6	50.9
Merced River at Highway 59 Bridge (RM 42) Temperatures for 60% Unimpaired Flow Objective												
minimum	42.6	45.1	46.3	49.3	53.1	54.4	58.8	61.6	60.2	48.2	50.6	46.4
10%	44.9	48.5	49.5	51.5	54.4	56.1	59.0	62.5	62.5	56.9	53.2	48.4
20%	46.4	48.8	51.1	53.3	54.6	56.5	60.6	63.3	64.4	59.1	53.9	49.0
30%	47.7	49.3	52.3	53.8	55.4	58.8	67.3	64.1	65.8	60.5	55.2	49.6
40%	48.0	49.6	53.6	56.5	57.5	60.7	70.1	69.9	70.4	61.5	55.9	49.9
50%	48.4	50.3	54.8	56.8	58.2	62.4	72.0	71.8	71.9	62.4	56.9	50.7
60%	49.5	51.5	55.2	57.2	58.7	63.7	72.3	74.6	74.6	63.9	57.0	50.9
70%	50.4	51.8	55.9	57.3	59.3	64.5	76.9	77.7	76.2	65.2	57.7	51.6
80%	51.9	53.0	56.4	57.8	59.8	65.0	79.1	78.6	81.1	66.7	59.3	52.6
90%	52.7	53.8	57.4	58.2	60.7	66.8	79.4	79.7	82.8	68.8	60.2	54.4
Maximum	53.2	56.5	59.0	59.4	62.8	70.2	82.0	81.1	84.8	69.8	62.6	55.5
Average	48.7	50.8	53.9	55.6	57.6	61.6	70.5	71.5	72.3	62.3	56.6	50.8
Effects on Average Merced River Temperatures at Highway 59 Bridge												
Baseline	48.7	50.9	54.2	58.1	61.4	64.5	69.0	70.0	71.6	62.7	57.1	51.0
20%	0.2	0.0	1.2	-0.2	-2.2	-1.3	-0.2	-0.3	-0.3	-0.6	-0.5	-0.1
40%	0.1	-0.1	0.4	-1.7	-3.4	-2.5	0.6	0.5	0.2	-0.6	-0.5	-0.2
60%	0.0	-0.1	-0.3	-2.5	-3.7	-2.9	1.5	1.5	0.7	-0.4	-0.4	-0.2

F.1.6 Potential Changes in Delta Exports and Outflow

Changes in SJR flow at Vernalis for LSJR Alternatives 2, 3, and 4 have been accurately estimated using the WSE model. The effects of these changes in SJR flow at Vernalis on southern Delta salinity have also been evaluated, based on approximate relationships between Vernalis flow and the salinity increases observed at the southern Delta salinity compliance stations. The changes in SJR flow at Vernalis will also change flow in the Delta channels, and may change southern Delta exports and Delta outflow. The changes in exports and Delta outflow could be analyzed by “running” the CALSIM model for LSJR Alternatives 2, 3, and 4. However, the CALSIM model does not currently include the option of using a specified fraction of the unimpaired flow as the required reservoir release flows, and cannot change Tuolumne or Merced diversions based on higher target release flows. Therefore, an approximate method for estimating the likely changes in south Delta pumping and Delta outflow is used. Changes in exports would affect water supply (beneficial uses) in the CVP and SWP service area south of the Delta; the salinity gradient (i.e., X2) in the western estuary (i.e., Suisun Bay and western Delta); and, could influence aquatic resources associated with salinity (i.e., low-salinity zone habitat distribution). The analysis below provides an accurate accounting of the two most likely changes in the Delta (exports and Delta outflow) that would result from changes in the LSJR flow at Vernalis. Further evaluation of these Delta outflow and export changes will be included in the State Water Board’s ongoing review of the 2006 Bay-Delta WQCP in Phases II, III and IV.

The existing CVP and SWP Delta pumping operations are determined by several rules and objectives that guide the daily Delta operations. Many of these rules are included in D-1641 (which implemented the 1995 Bay-Delta WQCP objectives). Several additional rules have been added by the 2008 USFWS BO and the 2009 NMFS BO for the CVP and SWP Operations Criteria and Plan (OCAP) which are included in the existing conditions baseline. The existing CVP and SWP Delta pumping operations are briefly summarized so that the possible changes in the southern Delta pumping can be identified for the LSJR alternatives. The likely changes in the existing south Delta exports are estimated to be small. The combination of the modeled SJR flow changes and the likely export changes will determine the likely changes in Delta outflow.

Delta operations under D-1641 can be simplified into two sets of rules; (1) rules controlling the maximum allowable exports and (2) rules controlling the minimum required Delta outflow. Several objectives control the allowable exports and several objectives control the minimum Delta outflow. Both the 2008 USFWS BiOp and the 2009 NMFS BiOp added pumping restrictions to limit reverse (negative) Old and Middle River (OMR) flows. There are two RPA from the 2009 NMFS BiOp that apply to the SJR inflow and associated south Delta pumping. The applicable Delta operational rules control the existing south Delta pumping and the potential for increased south Delta pumping as a result of the increased SJR flows at Vernalis with the LSJR alternatives.

The CVP permitted pumping capacity is 4,600 cfs, which requires use of the new DMC Intertie facility in the winter months. The SWP pumping capacity is constrained by the CCF diversion limits (Rivers and Harbors Section 10) of 6,680 cfs, with additional diversions of 1/3 of the San Joaquin River flow at Vernalis (with a maximum monthly pumping of 8,500 cfs assumed in CALSIM) between December 15 and March 15. SWP physical pumping capacity of 10,300 cfs is not currently permitted. The export/inflow ratio limits the CVP and SWP combined pumping to 65 percent of the Delta inflow July–January, and to 35 percent of the Delta inflow February–June. The 35 percent ratio in February is increased to 45 percent if the January runoff is low. An additional pumping limit imposed by the 2009 NMFS BO was an export limit that applies in April and May (a similar export restriction during VAMP applied for 31 days). This ratio effectively limits the combined export to 1,500 cfs for SJR inflows of less than 6,000 cfs. The exports are limited to 25 percent of the SJR inflow if the inflow is greater than 6,000 cfs.

The USFWS and NMFS BOs also introduced new limits on the reverse (negative) OMR flow in December–June of many years (adaptively managed based on temperature, turbidity, and fish monitoring). Because the southern Delta exports come from Old and Middle River channels and from Old River, the minimum OMR restrictions will limit exports. For example, an OMR limit of -2,000 cfs will restrict exports to about 2,000 cfs plus the head of Old River flow diverted from the SJR near Mossdale. About 50 percent of the SJR flow is diverted into Old River unless there is a physical barrier installed. The OMR limits will vary each year with fish and turbidity conditions; however, the CALSIM modeling assumed a monthly OMR limit that varied generally with the water year type.

Another possible constraint on Delta exports is related to the seasonal (monthly) water supply deliveries that are assumed for south of Delta CVP and SWP contractors. The San Luis Reservoir provides about 2,000 TAF of seasonal storage for meeting the peak summer water demands. The San Luis Reservoir storage space allows relatively high exports to continue through the fall and winter period. Without the San Luis Reservoir, exports would be reduced in the fall and winter to match the monthly water demands. Once San Luis Reservoir is filled, pumping is generally reduced to the monthly water demand, with some additional SWP exports for Article 21 deliveries to contractors with local storage capacity (e.g., surface reservoirs or groundwater storage).

The minimum required Delta outflow may limit the allowable exports, and would cause exports to be reduced in months when the SJR flow at Vernalis was reduced by the LSJR alternatives. Minimum monthly outflows are specified in D-1641 for each month, which often depend on the water year type (i.e., runoff conditions). For example, a minimum monthly outflow of 3,000 cfs is specified in September of all years. A minimum monthly outflow of 8,000 cfs is specified in July of wet and above normal water year types (about half of the years).

The second kind of rules that control Delta outflow are the maximum salinity objectives specified in D-1641 for each month or period. For example, EC objectives are specified at Emmaton and Jersey Point to protect agricultural diversions, and salinity (chloride) objectives are specified at the CCWD Rock Slough intake to protect drinking water supplies. Because Delta outflow is the major factor determining salinity within the Delta channels, these salinity objectives are satisfied by increasing Delta outflow (normally by reducing exports). The CALSIM model estimates the minimum monthly outflows required to meet the flow and salinity objectives.

The D-1641 February-June X2 objectives are another example of salinity requirements which are satisfied by adjusting Delta outflow. The maximum location of the 2 parts per thousand (ppt) salinity (i.e., upstream edge of estuarine salinity gradient) is specified (kilometers [km] upstream of the Golden Gate), based on the month and the (unimpaired) runoff in the previous month. This was formulated as an adaptive objective; the required monthly outflow increased with higher runoff conditions. D-1641 provides equivalent Delta outflows for the X2 objectives; X2 at Collinsville (81 km) can be satisfied with an outflow of 7,100 cfs and X2 at Chipps Island (75 km) can be satisfied with an outflow of 11,400 cfs. The 2008 USFWS BO included an additional outflow requirement for September and October of wet and above normal water year types (about half the years). The "Fall X2" rule requires X2 to be downstream of Collinsville (7,100 cfs outflow) in above normal years and downstream of Chipps Island (11,400 cfs outflow) in wet years.

F.1.6.1 Methods to Estimate Changes in Pumping and Delta Outflow

The possible exports and Delta outflow changes could be analyzed by re-running the CALSIM model for LSJR Alternatives 2, 3, and 4. However, the CALSIM model does not currently include the option of using a specified fraction of the unimpaired flow as the required reservoir release flows, and cannot change Tuolumne or Merced diversions based on higher target release flows. Therefore, an approximate method for estimating the potential change in south Delta pumping was used. SJR Vernalis flow changes were expected in the months of February-June, when the LSJR alternatives were simulated. Some increased reservoir flood control releases were simulated in some years (because of slightly higher reservoir storages). Changes in SJR flow at Vernalis would either change exports or change outflow. Based on the existing Delta objectives and RPA rules, the most likely changes each month were estimated from the CALSIM baseline Delta conditions (i.e., inflows, exports, Delta outflow, and required Delta outflow).

During the February-June period, the Delta outflow is regulated by the X2 objectives, the E/I ratio is 35 percent (45 percent in February in years with low January runoff), and minimum OMR is adaptively specified (by the smelt committee) between -5,000 and -2,000 cfs. Generally, an increase in the SJR flow at Vernalis during these months would allow increased exports equal to 35 percent of the increased SJR inflow. However, because of the likely OMR restrictions, the exports could be increased by the fraction of the SJR that is diverted into Old River, because this inflow does not change OMR. If the X2 objectives are limiting exports, all of the SJR flow increase could be pumped (without changing outflow).

The NMFS RPA 4.2.1 limits the exports to 1,500 cfs unless the SJR inflow is greater than 6,000 cfs in April and May. The maximum exports are limited to 25 percent of the SJR inflow at higher flows. It is therefore unlikely that the LSJR alternatives would result in increased exports during April or May. But if the Vernalis flow was greater than 6,000 cfs and the LSJR alternatives increased the flow to 7,000 cfs, for example, the pumping would increase by 250 cfs. Reductions in the SJR inflow would result in reduced pumping only if the pumping was greater than 1,500 cfs,

To determine the increment of export pumping each month requires an examination of the CALSIM baseline conditions that are controlling (limiting) exports. The potential change in export pumping was estimated by selecting the most likely limiting factor each month. In February, March, and June the OMR will likely limit exports, so the pumping change would be 50 percent of the SJR flow increment. In April and May, the NMFS RPA 4.2.1 will prevent any change in export pumping unless the SJR flow is greater than 6,000 cfs, and the change in pumping would be of 25 percent of the SJR increment only if the SJR baseline flow was greater than 6,000 cfs. From July to January, the most likely limit would be the E/I ratio of 65 percent. The minimum exports of 1,500 cfs prevented some reductions in months when the pumping was already at the minimum value; the maximum permitted export pumping of 11,280 cfs (11,780 cfs in July-September) prevented some increases in months when the baseline pumping was near the permitted pumping capacity. Reductions in the SJR flow at Vernalis would cause a reduction in exports of the same amount if the baseline Delta outflow was equal to the required Delta outflow. A more accurate monthly estimate requires that all possible limits be considered; this requires a more careful review of the monthly CALSIM results.

Changes in SJR flow at Vernalis would also cause changes in Delta outflow. Because the LSJR flow objectives could reduce the SJR flow at Vernalis in some months and increase the SJR flow at Vernalis flow in other months, the possibility of increased and decreased Delta outflow must be considered. The most likely effect on a decrease in the SJR flow at Vernalis would be that Delta outflow would be reduced, but the reduction in outflow would be less than the reduction in SJR flow because there would be less exports (as calculated above). The change in outflow each month would be the change at Vernalis minus the change in exports. However, reductions in the SJR flow at Vernalis cannot reduce the Delta outflow to less than the required Delta outflow (D-1641 objectives). If Delta outflow is the same as the required Delta outflow, reductions in SJR flow at Vernalis will cause exports to be reduced by the same amount.

The most likely effect of an increase in the SJR flow at Vernalis would be that any water not exported would increase Delta outflow. It is possible that an increase in Delta outflow might allow upstream reservoir releases to be reduced, with increased storage that could later be released for increased exports. However, a reduction in upstream reservoir releases (increase in storage) would generally not be possible if the Delta outflow was already greater than the required Delta outflow. In most spring months (February-June), the reservoir releases are controlled by maximum flood control storage or by minimum downstream flow requirements; otherwise the reservoir releases would be reduced in the CALSIM baseline. Because the E/I ratio is only 35 percent in these months, exports can only be increased by 35 percent of the increased reservoir releases; releases of stored water for exports are unlikely in these months. With the additional USFWS and NMFS restrictions on reverse

OMR flow in these months, reservoir releases are almost always reduced to the minimum possible for flood control and downstream minimum requirements.

The likely changes in the CALSIM baseline Delta outflow were calculated for each month for LSJR Alternatives 2, 3, and 4 to provide an initial estimate (preview) of the magnitude and frequency of the likely changes in Delta outflow. The CALSIM baseline outflow was not reduced below the required Delta outflow (exports would be reduced). The increase in SJR flow (minus the estimated increase in exports) was assumed to be the increase in Delta outflow in any month when baseline Delta outflow was already greater than the required Delta outflow. These increases in Delta outflow are expected to be beneficial for estuarine habitat and fish survival. As was done for estimating likely Delta export changes, the differences in the monthly cumulative distributions of Delta outflow were compared to the baseline distributions of Delta outflow to evaluate the likely effects in each month.

The annual and February-June cumulative distributions of SJR flow at Vernalis, south Delta exports, and Delta outflow are summarized in Table F.1-22a, F.1-22b and F.1-22c. The changes in the SJR inflows, Delta exports and Delta outflow estimated for LSJR Alternatives 2, 3, and 4 are also summarized in Table F.1-22a, F.1-22b, and F.1-22c. The monthly cumulative distributions of the likely changes in exports and outflow for the LSJR alternatives are described in more detail below. Table F.1-22a shows the CALSIM baseline annual SJR flow at Vernalis ranged from a minimum of 882 TAF to a maximum of 16,065 TAF, with an average of 3,080 TAF. The Vernalis flow during the February-June period ranged from a minimum of 439 TAF to a maximum of 9,454 TAF with an average of 1,800 TAF. Table F.1-22b shows the cumulative distribution of CALSIM baseline annual exports (CVP and SWP pumping) ranged from a minimum of 2,150 TAF to a maximum of 6,802 TAF, with an average of 4,820 TAF. Considering the February-June period, when most changes in Vernalis flows are expected with the LSJR alternatives, the CALSIM baseline total exports ranged from a minimum of 415 TAF to a maximum of 2,652 TAF, with an average of 1,347 TAF. Table F.1-22c shows the CALSIM baseline annual Delta outflow ranged from a minimum of 3,674 TAF to a maximum of 61,139 TAF, with an average of 15,915 TAF. The Delta outflow during the February-June period ranged from a minimum of 1,804 TAF to a maximum of 40,743 TAF with an average of 9,581 TAF.

Table F.1-22. Summary of Estimated Changes in San Joaquin River Flow at Vernalis (TAF), Delta Exports (TAF) and Delta Outflow (TAF)

A. Cumulative Distribution of Baseline and Changes in San Joaquin River Flow (TAF)

	CALSIM Baseline		20% Alternative		40% Alternative		60% Alternative	
	Annual SJR Flow (TAF)	Feb-June SJR Flow (TAF)	Annual SJR Flow Change	Feb-June SJR Flow Change	Annual SJR Flow Change	Feb-June SJR Flow Change	Annual SJR Flow Change	Feb-June SJR Flow Change
Minimum	882	439	44	-39	-493	-616	222	92
10%	1,159	508	82	22	-47	-67	526	449
20%	1,503	717	-12	-39	39	1	653	638
30%	1,691	816	-37	-54	94	43	701	616
40%	1,904	988	-139	-119	161	89	661	691
50%	2,072	1,157	19	23	236	163	993	959
60%	2,807	1,561	-158	-187	297	261	740	769
70%	3,410	2,032	-155	-328	386	316	623	500
80%	4,309	2,564	83	-235	506	478	648	552
90%	5,715	3,596	-41	-378	653	644	495	271
Maximum	16,065	9,454	-591	-635	890	878	-24	-269
Average	3,080	1,800	-65	-121	265	225	614	571
	Percentage Change		-2%	-7%	9%	12%	20%	32%

B. Cumulative Distribution of Baseline and Changes in South Delta Exports (TAF)

	CALSIM Baseline		20% Alternative		40% Alternative		60% Alternative	
	Annual Exports (TAF)	Feb-June Exports (TAF)	Annual Exports Change	Feb-June Exports Change	Annual Exports Change	Feb-June Exports Change	Annual Exports Change	Feb-June Exports Change
Minimum	2,150	415	-272	-265	76	40	89	52
10%	3,337	713	-96	-133	66	71	136	142
20%	4,196	876	-70	-82	91	54	144	137
30%	4,453	965	-36	-63	89	59	201	162
40%	4,656	1,080	-8	-27	118	68	216	143
50%	4,939	1,214	5	-4	24	133	129	231
60%	5,161	1,475	21	6	108	86	220	190
70%	5,361	1,574	28	20	138	81	266	185
80%	5,711	1,816	47	25	-4	-25	84	81
90%	6,063	2,105	74	43	2	28	79	74
Maximum	6,802	2,652	174	137	-89	-90	34	7
Average	4,820	1,347	-8	-27	66	48	161	135
	Percentage Change		0%	-2%	1%	4%	3%	10%

C. Cumulative Distribution of Baseline and Changes in Delta Outflow (TAF)

	CALSIM Baseline		20% Alternative		60% Alternative		40% Alternative	
	Annual Outflow (TAF)	Feb-June Outflow (TAF)	Annual Outflow Change	Annual Outflow Change	Feb-June Outflow Change	Feb-June Outflow Change	Annual Outflow Change	Feb-June Outflow Change
Minimum	3,674	1,803	-462	-86	-472	-50	-11	25
10%	5,420	2,693	-274	103	-325	153	350	380
20%	6,644	3,741	-207	77	-235	326	344	661
30%	7,659	4,447	-124	287	-176	145	596	397
40%	9,087	5,692	-84	294	-121	423	653	712
50%	10,899	6,698	-56	331	-81	240	561	598
60%	16,166	8,285	-19	274	-37	298	591	650
70%	20,833	11,372	20	267	-1	307	546	580
80%	25,340	14,578	85	236	33	67	489	319
90%	32,483	20,582	126	132	102	98	332	207
Maximum	61,139	40,743	462	-345	426	-389	-22	-167
Average	15,915	9,581	-57	200	-94	178	453	421
	Percentage Change		0%	-1%	1%	2%	3%	4%

F.1.6.2 Calculated Changes in Southern Delta Pumping and Delta Outflow

LSJR Alternative 2

Table F.1-23a shows the monthly cumulative distributions of SJR Vernalis flow for the existing conditions. These monthly distributions indicate the range of flows that can be expected over a number of years in each month. Because the monthly distribution tables give the 10 percent cumulative values, each flow has a probability of about 10 percent. The average annual SJR flow at Vernalis was 3,080 TAF/y and the average February-June SJR flow at Vernalis was 1,800 TAF for the CALSIM baseline conditions. A flow of 1,000 cfs for the entire year would be equivalent to 725 TAF, and a flow of 1,000 cfs for the February-June period would be equivalent to 300 TAF. Table F.1-23b shows the monthly cumulative distribution of the changes in the monthly Vernalis flows that were calculated with the WSE model of 1922–2003 (82 years) for the LSJR Alternative 2. Some of the monthly changes were quite large, and others were smaller, depending on the differences in WSE reservoir operations compared to the CALSIM baseline reservoir operations. The largest reductions were simulated in March, April, and May. The average monthly reductions were -444 cfs in March, -1,517 cfs in April, and -755 cfs in May. The changes in June resulted in an average increase of 653 cfs from the baseline flows. The average annual change in the SJR flow at Vernalis was a reduction of -65 TAF/y and the average February-June change in SJR flow at Vernalis was a reduction of -121 TAF/y for LSJR Alternative 2.

The distribution of monthly flow changes does not indicate whether the changes occurred in years with low baseline flows (larger effects) or in years with higher baseline flows (smaller effects). Table F.1-23c shows the monthly cumulative distributions of SJR Vernalis flows for LSJR Alternative 2. The changes in the monthly cumulative distributions can be identified by subtracting the baseline monthly cumulative distribution values from the adjusted LSJR Alternative 2 monthly cumulative distribution values. Table F.1-23d shows the changes in the monthly cumulative distribution values and indicates that the overall changes in the monthly distributions of Vernalis flows were generally much smaller than the individual monthly model changes. Many of the large monthly flow reductions were compensated by increases in other years.

Table F.1-23e shows the monthly cumulative distributions of combined CVP and SWP exports for the CALSIM baseline conditions. These monthly distributions indicate the range of monthly and annual exports that can be expected over a number of years. Table F.1-23f shows the monthly cumulative distribution of the changes in the exports that were estimated using the most likely monthly control factor. Some of the monthly export changes were quite large, and others were smaller, depending on the changes in the SJR inflows and the baseline Delta conditions and most likely limiting factors. The distribution of monthly export changes does not indicate whether the changes occurred in years with low baseline exports (larger effects) or in years with higher baseline exports (smaller effects). Table F.1-23g shows the monthly cumulative distributions of estimated exports for LSJR Alternative 2. The changes in the monthly cumulative distributions can be identified by subtracting the baseline monthly cumulative distribution values from the adjusted LSJR Alternative 2 monthly cumulative distribution values. Table F.1-23h shows the changes in the monthly cumulative distribution values and indicates that the overall changes in the monthly distributions of exports were generally much smaller than the distribution of individual monthly export changes. Many of the large monthly reductions in exports were compensated by increases in exports in other years.

Table F.1-23i shows the monthly cumulative distributions of Delta outflow for the CALSIM baseline. These monthly distributions indicate the range of Delta outflow that can be expected over a number of years in each month. The CALSIM baseline Delta outflow was highest in the months of January-May, with median monthly outflow of 15,000 to 35,000 cfs and 90 percent cumulative outflow values of 50,000 to 125,000 cfs. Table F.1-23j shows the monthly cumulative distributions of required Delta outflow for the CALSIM baseline. The required Delta outflow is generally less than 5,000 cfs in most months, with higher Delta outflow required in February-June (for X2 objective), in July for about half of the years (for D-1641 outflow objective), and in September, October, and November of about half the years (for USFWS RPA Component 3, fall habitat). Table F.1-23k shows the monthly distributions of the excess Delta outflow (outflow greater than the required outflow) for the CALSIM baseline. This generally indicates that in most years, the February-June outflows are greater than the required Delta outflow. Therefore, reductions in upstream reservoir releases to reduce the increased Delta outflow caused by increased SJR flow would not be likely.

Table F.1-23l shows the monthly cumulative distributions of the changes in Delta outflow that were estimated from the changes in SJR flow at Vernalis and the calculated export changes (limited by required Delta outflow) for the 20 percent flow objective. Some of the monthly outflow changes (reductions and increases) were quite large and other monthly outflow changes were smaller. The distribution of monthly outflow changes does not indicate whether the changes occurred in years with low baseline outflow (larger effects) or in years with higher baseline outflow (smaller effects). Table F.1-23m shows the monthly cumulative distributions of estimated Delta outflow for LSJR Alternative 2. The changes in the monthly cumulative distributions of outflow can be identified by subtracting the baseline monthly cumulative distribution values from the LSJR Alternative 2 monthly cumulative distribution values. Table F.1-23n shows the changes in the monthly cumulative distribution values and indicates that the overall changes in the monthly distributions of Delta outflow were generally much smaller than the distribution of individual monthly outflow changes. Many of the large monthly reductions in outflow were compensated by increases in outflow in other years.

Table F.1-23. Estimates of Changes in SJR Vernalis Flows and Southern Delta Export Pumping (cfs) for LSJR Alternative 2

A. Monthly Cumulative Distributions of SJR Flow at Vernalis for Existing Conditions (CALSIM)

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	Annual (TAF)
SJR at Vernalis Flow (cfs)													
Existing Conditions													
Minimum	849	1,218	1,362	1,192	1,865	1,352	1,143	1,138	664	553	368	743	882
10%	1,628	1,688	1,692	1,603	2,228	1,929	1,773	1,782	1,154	1,010	1,086	1,470	1,159
20%	2,187	1,814	1,803	1,776	2,278	2,147	3,107	3,091	1,461	1,263	1,289	1,670	1,503
30%	2,375	1,937	1,928	1,962	2,378	2,280	3,442	3,452	1,587	1,340	1,384	1,765	1,691
40%	2,533	2,011	1,991	2,169	2,507	2,651	4,500	4,500	1,903	1,480	1,469	1,850	1,904
50%	2,730	2,104	2,067	2,330	3,420	3,420	5,213	4,901	2,379	1,657	1,550	1,951	2,072
60%	3,049	2,263	2,172	2,457	4,390	4,977	6,276	5,704	3,109	1,865	1,781	2,237	2,807
70%	3,185	2,411	2,403	3,314	6,087	7,590	6,532	6,478	3,364	2,137	2,401	2,492	3,410
80%	3,397	2,669	2,852	5,021	9,538	8,715	7,762	7,383	7,109	3,544	2,796	2,767	4,309
90%	3,796	2,894	4,402	9,608	14,909	14,275	12,748	13,217	11,801	7,297	3,119	3,189	5,715
Maximum	7,564	16,392	24,108	60,104	34,205	48,426	27,279	25,442	27,911	24,308	9,146	7,945	16,065
Average	2,809	2,483	3,246	4,704	6,284	6,545	6,412	6,420	4,599	3,197	2,045	2,300	3,080

B. Monthly Cumulative Distributions of Changes in SJR Flow at Vernalis for LSJR Alternative 2

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	Annual (TAF)
Distribution of Changes in SJR at Vernalis Flow for 20% Objective (cfs)													
Minimum	0	0	0	0	-4,613	-7,548	-4,441	-6,184	-1,195	0	0	0	-591
10%	0	0	0	0	-1,158	-1,480	-3,309	-2,482	-393	0	0	0	-301
20%	0	0	0	0	-303	-1,001	-2,791	-1,865	-120	0	0	0	-229
30%	0	0	0	0	-147	-717	-2,291	-1,344	-98	0	0	0	-169
40%	0	0	0	0	-120	-304	-1,793	-1,069	-49	0	0	0	-126
50%	0	0	0	0	-113	-155	-1,293	-405	163	0	0	0	-52
60%	0	0	0	0	-102	-97	-1,035	-90	453	0	0	0	-20
70%	0	0	0	0	40	-70	-726	156	925	0	0	0	32
80%	0	0	0	33	384	42	-333	553	1,402	0	0	0	92
90%	559	45	98	1,363	901	471	-23	922	1,776	110	0	224	203
Maximum	2,945	5,055	6,175	2,396	6,777	2,572	976	1,955	9,825	1,559	1,321	3,572	532
Average	164	95	161	237	35	-444	-1,517	-755	653	102	67	131	-65

C. Monthly Cumulative Distributions of SJR Flow at Vernalis for LSJR Alternative 2

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	Annual (TAF)
SJR at Vernalis Flow for 20% Objective (cfs)													
Minimum	849	1,218	1,362	1,192	1,772	1,284	1,301	1,346	615	553	553	743	925
10%	1,628	1,688	1,692	1,603	2,060	1,836	1,811	1,965	1,124	1,010	1,086	1,470	1,241
20%	2,216	1,814	1,803	1,776	2,157	2,009	2,094	2,517	1,460	1,263	1,289	1,670	1,491
30%	2,378	1,937	1,928	1,970	2,274	2,326	2,454	2,981	1,845	1,340	1,384	1,765	1,654
40%	2,558	2,011	1,997	2,190	2,633	2,596	2,772	3,514	2,486	1,480	1,469	1,850	1,765
50%	2,785	2,104	2,089	2,366	3,861	3,179	3,364	4,403	2,972	1,657	1,550	1,951	2,091
60%	3,184	2,276	2,213	2,586	4,756	5,027	3,936	5,127	3,491	1,865	1,781	2,394	2,649
70%	3,402	2,448	2,411	3,599	5,974	6,569	4,600	5,702	4,030	2,137	2,401	2,523	3,255
80%	3,642	2,815	3,008	5,811	8,597	8,197	6,434	6,418	6,801	3,544	2,824	2,783	4,392
90%	4,238	3,158	4,545	11,135	15,354	13,390	11,387	12,107	13,413	7,668	3,965	3,956	5,674
Maximum	7,564	16,851	24,108	62,448	30,810	40,878	24,744	25,505	37,737	25,185	9,146	7,945	15,474
Average	2,974	2,578	3,407	4,941	6,319	6,101	4,896	5,665	5,252	3,299	2,113	2,431	3,015

D. Differences in Monthly Cumulative Distributions of SJR Flow at Vernalis for LSJR Alternative 2

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	Annual (TAF)
Minimum	0	0	0	0	-93	-68	158	208	-49	0	185	0	44
10%	0	0	0	0	-169	-93	38	183	-30	0	0	0	82
20%	29	0	0	0	-122	-138	-1,012	-574	-1	0	0	0	-12
30%	3	0	0	9	-104	46	-988	-471	258	0	0	0	-37
40%	24	0	7	22	126	-55	-1,728	-986	583	0	0	0	-139
50%	55	0	21	36	441	-241	-1,849	-498	592	0	0	0	19
60%	136	12	42	129	366	50	-2,340	-577	382	0	0	157	-158
70%	217	37	7	285	-112	-1,021	-1,932	-775	666	0	0	31	-155
80%	246	145	156	790	-941	-518	-1,328	-965	-308	0	27	15	83
90%	443	264	143	1,527	445	-885	-1,361	-1,110	1,612	371	846	767	-41
Maximum	0	459	0	2,344	-3,396	-7,548	-2,535	62	9,825	878	0	0	-591
Average	164	95	161	237	35	-444	-1,517	-755	653	102	67	131	-65

E. Monthly Cumulative Distributions of Exports for Existing Conditions (CALSIM)

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	Annual (TAF)
Minimum	3,188	1,100	3,570	3,331	1,100	1,100	1,100	1,100	964	900	1,467	2,940	2,150
10%	4,901	3,042	6,330	4,406	4,095	2,137	1,500	1,500	1,447	7,853	3,714	4,463	3,337
20%	5,445	4,494	7,134	5,031	4,826	4,425	1,500	1,500	2,673	9,779	8,457	6,697	4,196
30%	6,113	4,554	7,731	6,123	5,853	4,775	1,500	1,500	2,914	10,673	10,247	8,325	4,453
40%	6,400	5,092	8,085	6,398	6,499	5,466	1,500	1,500	3,298	11,261	10,535	8,875	4,656
50%	6,722	5,732	8,622	6,533	6,649	6,626	1,500	1,500	4,023	11,361	10,789	9,199	4,939
60%	7,047	6,818	9,472	6,747	7,645	7,381	1,569	1,500	4,920	11,398	11,324	9,549	5,161
70%	7,564	7,466	10,508	6,855	8,354	8,149	1,633	1,619	5,329	11,442	11,408	10,626	5,361
80%	8,382	8,001	11,204	7,918	9,600	9,197	1,940	1,846	7,068	11,522	11,653	11,053	5,711
90%	9,331	10,905	11,295	9,005	11,259	10,189	3,187	3,304	8,860	11,582	11,724	11,141	6,063
Maximum	11,067	10,943	11,899	12,725	12,743	11,869	8,861	10,527	11,244	11,668	11,751	11,170	6,802
Average	6,927	6,228	8,832	6,717	7,188	6,562	1,951	2,101	4,646	10,344	9,669	8,718	4,820

F. Monthly Cumulative Distributions of Estimated Changes in Exports for LSJR Alternative 2

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	Annual
Minimum	0	0	0	0	-2,307	-3,774	-1,110	-1,546	-597	0	0	0	-143
10%	0	0	0	0	-579	-740	-633	-436	-196	0	0	0	-63
20%	0	0	0	0	-152	-500	-301	-120	-60	0	0	0	-10
30%	0	0	0	0	-74	-358	-132	0	-49	0	0	0	-7
40%	0	0	0	0	-60	-152	-40	0	-24	0	0	0	-1
50%	0	0	0	0	-57	-78	0	0	81	0	0	0	7
60%	0	0	0	0	-51	-48	0	0	227	0	0	0	20
70%	0	0	0	0	20	-35	0	0	463	0	0	0	38
80%	0	0	0	16	192	21	0	0	701	0	0	0	68
90%	363	30	64	681	450	235	0	0	888	71	0	145	152
Maximum	1,914	3,286	4,014	1,198	3,388	1,286	102	469	4,913	1,013	859	2,322	413
Average	107	62	105	118	17	-222	-158	-112	326	66	44	85	26

G. Monthly Cumulative Distributions of Exports for LSJR Alternative 2

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	Annual (TAF)
Distribution of Estimated Exports for 20% Unimpaired													
Minimum	3,188	1,500	3,570	3,331	1,500	1,500	1,500	1,500	1,500	1,500	1,500	2,940	2,223
10%	4,901	3,042	6,330	4,406	4,054	2,058	1,500	1,500	1,500	8,298	3,822	4,570	3,357
20%	5,523	4,495	7,134	5,031	4,931	4,234	1,500	1,500	2,708	9,787	8,457	6,697	4,198
30%	6,113	4,555	7,731	6,250	5,333	4,720	1,500	1,500	2,934	10,728	10,247	8,325	4,468
40%	6,464	5,092	8,072	6,423	6,325	5,511	1,500	1,500	3,500	11,261	10,535	8,922	4,665
50%	6,964	5,732	8,703	6,533	6,589	6,479	1,500	1,500	4,094	11,369	10,809	9,199	4,975
60%	7,278	6,818	9,372	6,755	7,562	6,997	1,500	1,500	5,096	11,405	11,324	9,580	5,116
70%	7,806	7,466	10,491	6,976	8,064	8,139	1,500	1,500	5,685	11,493	11,408	10,626	5,364
80%	8,570	8,078	11,234	8,030	8,981	8,748	1,608	1,605	6,822	11,556	11,667	11,079	5,646
90%	9,331	10,905	11,280	9,515	10,434	10,106	2,847	3,027	10,180	11,648	11,739	11,168	5,986
Maximum	11,246	11,280	11,280	11,280	11,280	11,280	8,227	9,527	11,280	11,780	11,780	11,780	6,679
Average	7,034	6,261	8,821	6,774	6,922	6,341	1,818	2,005	4,881	10,391	9,676	8,779	4,809

H. Differences in Monthly Cumulative Distributions of Exports (cfs) for LSJR Alternative 2

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	Annual (TAF)
Change in Monthly Distributions of Exports for 20% Alternative													
Minimum	0	400	0	0	400	400	400	400	536	600	33	0	73
10%	0	0	0	0	-41	-79	0	0	53	445	108	107	21
20%	78	2	0	0	106	-191	0	0	35	8	0	0	2
30%	0	1	0	127	-520	-55	0	0	20	55	0	0	15
40%	65	0	-14	25	-174	44	0	0	202	0	0	47	10
50%	242	0	81	0	-60	-147	0	0	70	8	20	0	36
60%	231	0	-100	8	-84	-384	-69	0	176	7	0	31	-45
70%	242	0	-17	121	-290	-10	-133	-119	356	51	0	0	3
80%	188	78	30	113	-619	-449	-332	-241	-245	34	13	27	-65
90%	0	0	-15	510	-825	-83	-340	-278	1,319	66	15	26	-77
Maximum	179	337	-619	-1,445	-1,463	-589	-634	-1,000	36	112	29	610	-123
Average	107	33	-11	57	-266	-221	-133	-96	235	47	7	61	-11

I. Monthly Cumulative Distributions of Delta Outflow (cfs) for CALSIM Baseline

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	Annual (TAF)
CALSIM Baseline Outflow													
Minimum	3,000	3,500	3,500	5,294	7,714	7,239	7,100	4,000	4,000	4,000	3,000	3,000	3,674
10%	3,211	4,500	4,500	7,934	8,517	9,085	9,592	7,100	5,179	4,028	4,000	3,000	5,420
20%	4,000	4,500	4,501	9,556	13,145	12,545	11,207	9,437	6,197	5,000	4,000	3,000	6,644
30%	4,000	5,031	4,778	11,962	16,411	16,799	12,838	10,517	6,669	5,000	4,000	3,089	7,659
40%	4,000	6,284	5,513	17,328	22,591	20,919	15,177	12,390	7,100	6,500	4,000	3,156	9,087
50%	4,124	10,312	8,712	22,533	34,785	26,264	19,682	16,117	7,362	8,000	4,000	4,062	10,899
60%	6,226	11,681	12,022	28,979	50,856	33,673	26,489	19,456	8,618	8,000	4,000	11,570	16,166
70%	7,406	13,703	17,284	47,753	59,292	45,954	28,544	23,012	10,464	8,000	4,068	17,516	20,833
80%	7,812	15,288	34,690	67,258	77,702	62,997	49,247	31,176	14,945	9,113	4,314	19,668	25,340
90%	8,438	16,219	65,033	105,897	123,361	86,182	68,583	53,402	29,772	10,920	4,636	20,438	32,483
Maximum	30,367	78,671	156,591	278,807	221,709	259,451	139,426	84,630	72,464	37,607	18,474	25,532	61,139
Average	6,009	11,914	21,730	42,292	51,768	42,534	30,011	22,638	12,737	7,898	4,452	9,803	15,915

J. Cumulative Monthly Distributions of Required (Minimum) Delta Outflow (cfs) for CALSIM Baseline

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	Annual (TAF)
CALSIM Baseline Required Outflow													
Minimum	3,000	3,500	3,500	4,500	4,000	4,000	4,000	4,000	4,000	4,000	3,000	3,000	3,149
10%	3,000	3,500	3,500	4,500	5,081	4,711	4,025	4,000	4,000	4,000	3,000	3,000	3,669
20%	4,000	4,500	4,500	4,500	6,575	6,677	5,139	5,108	5,105	5,000	3,500	3,000	3,887
30%	4,000	4,500	4,500	4,500	7,454	7,419	6,273	6,087	5,626	5,000	3,500	3,000	4,001
40%	4,000	4,500	4,500	4,500	7,852	8,237	7,076	6,728	6,154	6,500	4,000	3,000	4,194
50%	4,000	4,500	4,500	4,500	8,329	8,938	7,527	7,205	6,431	6,500	4,000	3,000	4,309
60%	5,938	10,313	4,500	4,500	9,948	9,808	7,895	8,141	6,819	8,000	4,000	11,563	4,437
70%	7,188	12,021	4,500	4,500	11,745	10,478	8,716	9,217	7,100	8,000	4,000	13,469	4,544
80%	7,781	13,704	4,500	4,500	13,932	11,448	9,650	10,048	7,918	8,000	4,000	19,375	4,668
90%	8,266	15,301	4,500	4,500	14,786	13,104	10,929	12,296	9,898	8,000	4,000	20,156	4,840
Maximum	11,875	16,250	4,500	4,500	16,991	15,629	14,463	16,629	16,017	8,000	4,000	22,031	5,104
Average	5,433	8,251	4,347	4,500	9,573	9,028	7,641	7,919	6,855	6,500	3,744	9,438	4,269

K. Cumulative Monthly Distributions of Excess Delta Outflow (cfs) for CALSIM Baseline

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
CALSIM Baseline												
Min	0	0	0	0	0	0	0	0	0	0	0	0
10%	0	0	0	4,152	0	40	97	277	0	0	0	0
20%	0	0	514	5,407	3,096	4,237	2,959	1,601	0	0	0	0
30%	0	0	1,151	8,409	7,231	7,550	5,182	3,272	0	0	0	78
40%	0	387	2,113	13,026	16,346	11,875	6,513	4,943	0	0	0	401
50%	0	863	3,676	18,962	26,621	15,919	11,745	7,844	75	0	0	606
60%	98	1,474	7,224	27,160	40,012	25,152	17,144	11,635	1,428	55	647	853
70%	427	2,037	15,851	43,088	55,880	37,461	22,409	16,148	4,418	347	1,133	1,079
80%	832	3,113	31,141	62,611	71,877	55,946	42,565	20,542	8,103	2,095	1,384	4,872
90%	2,715	12,143	61,396	102,066	111,040	85,943	63,810	43,221	18,901	3,010	1,795	7,109
Max	26,878	74,378	152,063	276,015	212,736	255,101	135,160	74,738	68,453	29,702	12,427	22,677
Average	1,077	4,840	18,361	38,789	43,116	34,267	22,552	14,667	5,876	1,451	874	2,334

L. Cumulative Monthly Distributions of Changes in Delta Outflow (cfs) for LSJR Alternative 2

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	Annual (TAF)
Estimated Change in Outflow for 20% Unimpaired													
Minimum	-1	-1	0	0	-2,307	-3,774	-3,738	-4,638	-864	0	0	-1	-475
10%	0	0	0	0	-579	-740	-2,826	-2,482	-209	0	0	0	-293
20%	0	0	0	0	-216	-500	-2,438	-1,596	-115	0	0	0	-237
30%	0	0	0	0	-106	-358	-1,970	-1,228	-66	0	0	0	-186
40%	0	0	0	0	-63	-162	-1,630	-907	-43	0	0	0	-136
50%	0	0	0	0	-58	-97	-1,119	-384	81	0	0	0	-66
60%	0	0	0	0	-54	-53	-977	-90	227	0	0	0	-30
70%	0	0	0	0	20	-38	-725	156	463	0	0	0	-3
80%	0	0	0	12	192	21	-325	454	701	0	0	0	33
90%	196	16	34	477	450	235	-23	906	888	38	0	78	98
Maximum	1,031	1,769	2,161	838	3,388	1,286	976	1,955	4,913	546	462	1,250	254
Average	57	33	56	83	3	-226	-1,359	-643	310	36	24	46	-95

M. Monthly Cumulative Distributions of Delta Outflow (cfs) for LSJR Alternative 2.

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	Annual (TAF)
Estimated Delta Outflow for 20% Unimpaired													
Minimum	3,000	3,500	3,500	5,294	7,620	7,171	6,232	3,225	3,916	4,000	3,065	3,000	3,624
10%	3,211	4,500	4,500	7,934	8,409	8,983	8,899	6,987	5,035	4,028	4,000	3,000	5,309
20%	4,000	4,500	4,501	9,556	13,108	12,342	10,164	8,429	6,134	5,000	4,000	3,000	6,465
30%	4,000	5,031	4,781	11,962	16,358	16,732	11,141	9,663	6,931	5,000	4,000	3,089	7,650
40%	4,000	6,284	5,513	17,332	22,576	20,562	13,994	12,576	7,101	6,500	4,000	3,156	8,980
50%	4,335	10,312	8,712	22,533	34,626	26,021	16,697	15,840	7,615	8,000	4,000	4,062	10,841
60%	6,250	11,681	12,022	28,979	51,252	33,372	25,258	18,749	8,917	8,000	4,000	11,661	16,095
70%	7,406	13,703	17,301	47,896	59,732	45,937	27,566	21,703	10,882	8,287	4,172	17,591	20,726
80%	8,093	15,288	34,690	67,261	80,758	62,277	48,566	31,305	15,137	9,113	4,447	19,668	25,154
90%	8,438	16,236	65,056	105,919	123,802	85,802	66,705	52,372	30,617	10,920	4,658	20,561	32,415
Maximum	30,446	78,832	156,591	279,627	223,383	255,677	137,525	79,992	77,377	37,914	18,474	25,532	60,692
Average	6,066	11,947	21,786	42,374	51,771	42,308	28,652	21,995	13,048	7,933	4,475	9,849	15,820

N. Differences in Monthly Cumulative Distributions of Delta Outflow (cfs) for LSJR Alternative 2

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	Annual (TAF)
Changes in Monthly Distributions of Outflow for 20% Alternative													
Minimum	0	0	0	0	-94	-68	-868	-775	-84	0	65	0	-50
10%	0	0	0	0	-108	-102	-693	-113	-144	0	0	0	-111
20%	0	0	0	0	-37	-203	-1,043	-1,008	-63	0	0	0	-180
30%	0	0	3	0	-53	-68	-1,697	-855	262	0	0	0	-8
40%	0	0	0	4	-15	-357	-1,183	186	1	0	0	0	-107
50%	211	-1	0	0	-159	-243	-2,985	-276	253	0	0	0	-59
60%	24	0	0	0	397	-301	-1,231	-707	299	0	0	92	-71
70%	0	0	17	144	440	-18	-978	-1,309	418	287	104	75	-107
80%	281	0	0	3	3,057	-719	-681	129	193	0	133	0	-186
90%	0	18	24	22	442	-380	-1,878	-1,030	845	0	22	123	-68
Maximum	79	161	0	820	1,674	-3,774	-1,901	-4,638	4,913	307	0	0	-447
Average	57	33	56	83	3	-226	-1,359	-643	310	36	24	46	-95

The overall effects of changes in Vernalis flows caused by the LSJR Alternative 2 on the south Delta exports and on Delta outflow are most appropriately summarized by the shifts in the monthly cumulative distributions of flows, exports and outflow. Table F.1-22a gives the cumulative distributions of the annual and February-June SJR flow at Vernalis for the baseline and for LSJR Alternatives 2, 3, and 4. Table F.1-22b gives the cumulative distributions of the annual and February-June exports for the baseline and for LSJR Alternatives 2, 3, and 4. Table F.1-22c gives the cumulative distributions of the annual and February-June Delta outflow for the baseline and for LSJR Alternatives 2, 3, and 4. For LSJR Alternative 2, the WSE simulated average annual SJR flows at Vernalis were reduced by -65 TAF/y, and the average February-June Vernalis flows were reduced by 121 TAF/y. For LSJR Alternative 2, the annual exports were reduced by an average of -8 TAF/y, and the February-June exports were reduced by an average of -27 TAF/y. The average change in annual exports was estimated to be less than 1 percent and the average change in February-June exports was estimated to be about 2 percent. For LSJR Alternative 2, the annual outflow was reduced by an average of -57 TAF/y, and the February-June outflow was reduced by an average of -94 TAF/y. The average change in annual outflow was estimated to be less than 1 percent and the average change in February-June outflow was estimated to be about 1 percent. The results from this preliminary analysis indicate that about 22 percent of the February-June reductions in the SJR flow at Vernalis would cause a reduction in exports and 78 percent of the reductions in the SJR flow at Vernalis would cause a reduction in Delta outflow for LSJR Alternative 2.

LSJR Alternative 3

Table F.1-24a gives the difference in the monthly cumulative distributions of the SJR Vernalis flows for LSJR Alternative 3 compared to the monthly cumulative distributions for the baseline flows. The monthly cumulative distributions of Vernalis flows were generally increased in February-June; there were some reductions in the highest flows (reduced flood control releases in some years) and some increased flows in the summer months to maintain maximum flood control storage levels. The flow increases were most dramatic in May and June, with an average of about 1,750 cfs in May and about 2,000 cfs in June. The average increase in annual SJR flow was 265 TAF and the average increase in February-June SJR flow was 225 TAF for LSJR Alternative 3.

Table F.1-24b shows the estimated changes in the monthly cumulative distributions of exports for LSJR Alternative 3. Because the May exports are limited to about 1,500 cfs in most years, the increased SJR flows would not cause much of a change in exports during May. The largest change in exports was estimated for June, with an average increase of 803 cfs. The annual exports were increased by an average of 66 TAF/y, and the February-June exports were increased by an average of 48 TAF/y. The average change in annual exports was estimated to be 1.5 percent and the average change in February-June exports was estimated to be 4 percent.

Table F.1-24c shows the estimated changes in the monthly cumulative distributions of Delta outflow for LSJR Alternative 3. Because the April and May exports are limited to about 1,500 cfs in most years, most of the increased SJR flows in April or May would increase Delta outflow. The largest change in outflow was estimated for June. The annual outflow was increased by an average of 200 TAF/y, and the February-June Delta outflow was increased by an average of 178 TAF/y. The average change in annual outflow was estimated to be 1 percent and the average change in February-June outflow was estimated to be 2 percent. The results from this preliminary analysis indicate that about 21 percent of the February-June increases in the SJR flow at Vernalis would cause an increase in exports and 79 percent of the increases in the SJR flow at Vernalis would cause an increase in Delta outflow for LSJR Alternative 3.

Table F.1-24. Estimates of Changes in SJR Vernalis Flows and Southern Delta Export Pumping (cfs) for LSJR Alternative 3

A. Differences in Monthly Cumulative Distributions of SJR Flow at Vernalis for 40% Objective

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	Annual (TAF)
Minimum	0	0	0	0	-93	-68	231	444	53	0	185	0	134
10%	0	0	0	0	-141	-22	935	1,335	444	0	0	0	267
20%	0	0	0	0	-119	370	116	1,336	693	0	0	0	296
30%	0	0	0	0	58	570	446	1,779	1,561	0	0	0	307
40%	0	0	7	0	221	566	356	1,654	2,355	0	0	0	251
50%	0	0	0	0	344	342	13	2,801	2,742	0	0	0	518
60%	23	12	0	6	734	495	-319	2,928	2,910	0	0	0	357
70%	136	35	24	285	844	-756	232	2,677	3,329	0	0	31	254
80%	267	94	28	636	-741	176	178	2,527	1,148	0	0	18	374
90%	679	92	143	1,776	-381	-1,324	-881	1,379	1,717	0	0	488	114
Maximum	133	733	2	0	-3,458	-8,790	-1,921	519	9,010	1,364	11	332	-493
Average	180	39	130	155	113	-128	61	1,746	1,982	32	6	81	265

B. Differences in Monthly Cumulative Distributions of Export Pumping (cfs) for LSJR Alternative 3

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	Annual
Minimum	0	400	0	0	400	400	400	400	536	600	33	214	73
10%	0	0	0	0	-53	425	0	0	312	685	108	232	63
20%	78	9	0	0	178	-84	0	0	398	8	0	0	91
30%	30	1	0	52	-408	173	0	0	776	82	0	57	89
40%	65	0	198	25	1	174	0	39	1,168	0	0	0	118
50%	88	0	60	11	181	112	0	426	1,095	0	60	0	24
60%	210	0	-90	7	-238	114	-69	658	705	0	0	0	108
70%	278	0	-17	24	109	139	58	669	1,242	0	0	0	122
80%	201	0	30	122	-472	-316	44	632	357	0	0	0	-8
90%	80	0	-15	530	-763	-423	-220	345	1,372	0	0	3	2
Maximum	213	221	-619	-1,445	-1,463	-589	-480	-612	36	0	0	610	-89
Average	112	31	5	33	-203	-52	-9	252	803	28	4	45	63

C. Differences in Monthly Cumulative Distributions of Delta Outflow (cfs) for LSJR Alternative 3

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	Annual (TAF)
Changes in Monthly Distributions of Outflow for 40% Alternative													
Minimum	0	0	0	0	-94	-196	-618	-325	-84	-600	65	0	-86
10%	0	0	0	0	1,198	-142	360	1,171	562	0	0	0	103
20%	0	0	23	0	-215	-135	54	1,146	477	0	0	0	77
30%	0	0	3	0	414	331	-400	1,308	722	0	0	0	287
40%	0	0	94	0	36	-10	509	2,894	981	0	0	0	294
50%	0	-1	0	0	126	206	-990	2,592	1,392	0	0	0	331
60%	158	0	5	0	931	0	-395	1,596	1,666	0	0	138	274
70%	26	-8	81	150	265	364	562	1,651	1,443	0	16	398	267
80%	-1	0	30	124	3,242	-915	745	2,995	1,440	0	0	20	236
90%	241	195	67	50	2,826	-10	-237	152	1,536	0	0	153	132
Maximum	0	257	1	1,445	1,850	-4,986	-1,441	-3,928	5,573	477	4	116	-345
Average	67	8	125	102	302	-77	70	1,494	1,177	4	2	36	200

LSJR Alternative 4

Table F.1-25a gives the difference in the monthly cumulative distributions of the SJR Vernalis flows for LSJR Alternative 4 compared to the monthly cumulative distributions for the baseline flows. The monthly cumulative distributions of Vernalis flows were generally increased in February-June; there were some reductions in the highest flows (reduced flood control releases in some years) and some increased flows in the summer months to maintain maximum flood control storage levels. The flow increases were most dramatic in April, , 2,857 cfs in May and June, with an average of about 1,706 cfs in April , 2,857 cfs in May and 3,192 cfs in June. The average increase in annual SJR flow was 614 TAF/y and the February-June increase in SJR flow was 571 TAF/y for LSJR Alternative 4.

Table F.1-25b shows the estimated changes in the monthly cumulative distributions of exports for LSJR Alternative 4. Because the April and May exports are limited to about 1,500 cfs in most years, the increased SJR flows would not cause much of a change in exports during April and May. The largest change in exports was estimated for June, with an average increase of 1,158 cfs. The annual exports were increased by an average of 161 TAF/y, and the February-June exports were increased by an average of 135 TAF/y. The average change in annual exports was estimated to be 3 percent and the average change in February-June exports was estimated to be 10 percent.

Table F.1-25c shows the estimated changes in the monthly cumulative distributions of Delta outflow for LSJR Alternative 4. Because the April and May exports are limited to about 1,500 cfs in most years, the increased SJR flows would increase Delta outflow during April and May. The largest change in outflow was estimated for June. The annual outflow was increased by an average of 453 TAF/y, and the February-June outflow was increased by an average of 421 TAF/y. The average change in annual outflow was estimated to be 3 percent and the average change in February-June outflow was estimated to be 4 percent. The results from this preliminary analysis indicate that about 24 percent of the February-June increases in the SJR flow at Vernalis would cause an increase in exports and 76 percent of the increases in the SJR flow at Vernalis would cause an increase in Delta outflow for LSJR Alternative 4.

Table F.1-25. Estimates of Changes in SJR Vernalis Flows and Southern Delta Export Pumping (cfs) for LSJR Alternative 4

A. Differences in Monthly Cumulative Distributions of SJR Flow at Vernalis for 60% Objective

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	(TAF)
Minimum	0	0	0	0	-93	-68	450	1,059	333	0	185	0	222
10%	0	0	0	0	-111	423	2,131	2,651	976	0	0	0	526
20%	0	0	0	0	33	1,232	1,468	3,243	1,525	0	0	0	653
30%	0	0	0	0	463	1,415	2,048	4,071	2,892	0	0	0	701
40%	0	0	0	0	908	1,466	2,101	4,027	4,100	0	0	0	661
50%	0	0	21	20	940	1,481	2,091	3,964	4,890	0	0	0	993
60%	12	0	42	32	2,343	1,691	1,918	3,526	4,903	0	0	0	740
70%	136	16	24	285	2,389	231	2,419	3,329	5,176	0	0	31	623
80%	539	0	28	760	48	1,262	1,839	2,832	1,873	0	0	18	648
90%	1,570	82	142	2,138	-67	27	1,211	1,096	2,754	0	0	1,652	495
Maximum	1,131	923	4	58	-2,645	-7,568	-1,490	735	9,887	2,191	321	1,007	-24
Average	281	45	104	185	773	727	1,706	2,857	3,192	51	14	250	614

B. Differences in Monthly Cumulative Distributions of Export Pumping (cfs) for LSJR Alternative 4

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	Annual
Minimum	0	400	0	0	400	400	400	400	536	600	33	815	86
10%	0	0	0	0	181	642	0	0	652	685	108	232	135
20%	78	25	0	0	372	210	0	84	895	8	0	0	144
30%	67	4	0	56	-302	569	0	361	1,353	125	0	172	201
40%	109	30	208	25	91	653	108	632	1,755	0	0	0	216
50%	97	0	59	11	337	387	326	716	1,514	2	60	46	128
60%	217	0	-78	7	277	783	479	807	1,052	5	0	0	220
70%	292	0	-17	79	858	713	605	832	1,578	0	0	212	251
80%	303	0	0	144	158	330	460	708	834	0	0	27	80
90%	80	2	-15	530	-279	201	303	274	1,959	0	0	14	79
Maximum	213	143	-619	-1,445	-1,463	-589	-373	-656	36	0	0	610	34
Average	162	34	1	46	99	323	233	424	1,158	40	9	116	160

C. Differences in Monthly Cumulative Distributions of Delta Outflow (cfs) for LSJR Alternative 4

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	Annual (TAF)
Changes in Monthly Distributions of Outflow for 60% Alternative													
Minimum	0	0	0	0	-94	-196	-177	290	-82	-600	65	0	-11
10%	0	0	0	0	1,094	169	1,637	2,653	1,262	0	0	0	350
20%	0	0	23	0	13	267	1,369	3,019	1,094	0	0	0	344
30%	0	0	0	0	675	746	1,115	3,142	1,586	0	0	0	596
40%	0	0	94	0	147	270	2,086	4,338	1,946	0	0	0	653
50%	0	-1	0	0	365	682	760	3,332	3,002	0	0	0	561
60%	105	0	5	1	1,406	407	972	2,098	2,813	0	0	149	591
70%	94	4	82	157	762	885	2,030	2,432	2,674	0	16	669	546
80%	121	0	33	136	4,038	-628	2,244	3,742	2,429	0	0	20	489
90%	437	198	5	77	3,501	726	1,253	-347	2,408	0	0	492	332
Maximum	0	323	1	1,503	2,198	-3,784	-1,118	-3,845	6,450	767	112	352	-22
Average	120	11	103	119	668	404	1,473	2,433	2,034	10	4	134	453

F.1.7 Printed References

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Attachment: WSE Output

This attachment contains resulting flow and reservoir storage for the CALSIM II baseline and WSE model results of the three LSJR alternatives. The baseline is presented first followed by each of the alternatives and the preferred alternative. Tables 1 through 6contain the baseline results, tables 7 through 12 contain LSJR Alternative 2 (20% unimpaired flow),[1] Tables 13 through 18 contain LSJR Alternative 3 (40% unimpaired flow), and Tables 19 through 24 contain LSJR Alternative 4 (60% unimpaired flow). Flow results are presented for each tributary (Stanislaus, Tuolumne, and Merced Rivers) and the SJR at Vernalis. Storage results are presented for the three major reservoirs: New Melones, New Don Pedro, and New Exchequer (Lake McClure).

[1] Any reference in this appendix to 20% unimpaired, 40% unimpaired, and 60% unimpaired is the same as LSJR Alternative 2, LSJR Alternative 3, and LSJR Alternative 4, respectively. Any reference to 1.0 EC objective and 1.4 EC objective is the same as SDWQ Alternative 2 and SDWQ Alternative 3, respectively.

TABLES

Baseline

Table 1. Baseline End-of-Month Storage at New Melones on the Stanislaus River in TAF from 19 22 through 2003

YEAR	WYT	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1922	W	954	964	994	1,019	1,128	1,205	1,168	1,363	1,611	1,574	1,494	1,445
1923	AN	1,384	1,397	1,462	1,524	1,572	1,509	1,514	1,597	1,591	1,543	1,455	1,421
1924	C	1,375	1,369	1,384	1,399	1,387	1,313	1,164	999	939	893	843	832
1925	BN	793	794	804	814	950	1,027	1,053	1,206	1,264	1,228	1,151	1,115
1926	D	1,061	1,052	1,055	1,057	1,109	1,088	1,118	1,038	968	887	814	779
1927	AN	733	745	793	834	971	1,021	1,099	1,206	1,255	1,198	1,125	1,096
1928	BN	1,075	1,106	1,127	1,141	1,187	1,352	1,343	1,386	1,339	1,255	1,174	1,140
1929	C	1,094	1,101	1,111	1,117	1,116	1,079	1,004	909	875	811	749	720
1930	C	671	658	656	673	687	724	698	652	656	590	524	490
1931	C	484	497	496	510	500	461	405	328	291	256	217	203
1932	AN	189	192	240	275	387	377	351	524	601	578	516	476
1933	D	457	443	447	459	449	431	405	398	447	414	381	369
1934	C	371	374	391	417	435	438	385	301	268	234	195	185
1935	AN	171	171	178	213	228	239	376	567	635	586	516	478
1936	AN	475	481	492	567	744	820	932	1,113	1,182	1,128	1,055	1,019
1937	W	977	967	976	995	1,093	1,195	1,219	1,399	1,433	1,367	1,292	1,251
1938	W	1,201	1,203	1,284	1,359	1,541	1,678	1,778	2,047	2,257	2,216	2,126	2,000
1939	D	1,950	1,934	1,936	1,946	1,955	1,977	1,824	1,627	1,554	1,474	1,398	1,372
1940	AN	1,310	1,294	1,300	1,400	1,534	1,630	1,697	1,782	1,756	1,660	1,569	1,517
1941	W	1,454	1,444	1,478	1,530	1,615	1,654	1,665	1,819	1,871	1,814	1,725	1,669
1942	W	1,612	1,604	1,647	1,737	1,814	1,791	1,834	1,969	2,102	2,062	1,961	1,907
1943	W	1,843	1,860	1,882	1,970	1,970	2,030	2,108	2,143	2,145	2,067	1,973	1,912
1944	BN	1,844	1,831	1,828	1,827	1,837	1,861	1,722	1,595	1,579	1,505	1,421	1,382
1945	AN	1,345	1,380	1,407	1,443	1,571	1,584	1,538	1,610	1,672	1,617	1,531	1,493
1946	AN	1,459	1,488	1,573	1,636	1,691	1,672	1,620	1,653	1,615	1,525	1,438	1,400
1947	D	1,351	1,368	1,389	1,404	1,422	1,380	1,288	1,194	1,158	1,094	1,034	1,008
1948	BN	987	983	982	985	953	942	920	942	1,059	1,008	941	910
1949	BN	877	873	882	889	882	906	846	865	867	804	743	709

YEAR	WYT	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1950	BN	650	626	626	671	730	771	761	853	935	881	816	793
1951	AN	766	1,039	1,425	1,530	1,624	1,715	1,683	1,630	1,586	1,504	1,423	1,378
1952	W	1,325	1,339	1,391	1,530	1,620	1,656	1,690	1,985	2,167	2,154	2,066	2,000
1953	BN	1,918	1,918	1,933	1,970	1,970	1,915	1,763	1,607	1,665	1,620	1,539	1,497
1954	BN	1,438	1,440	1,453	1,468	1,475	1,512	1,449	1,470	1,447	1,376	1,306	1,269
1955	D	1,212	1,219	1,235	1,265	1,270	1,258	1,201	1,118	1,118	1,043	971	929
1956	W	874	880	1,125	1,385	1,503	1,504	1,482	1,604	1,709	1,664	1,578	1,549
1957	BN	1,487	1,484	1,498	1,517	1,548	1,571	1,419	1,383	1,444	1,377	1,309	1,272
1958	W	1,209	1,210	1,217	1,266	1,345	1,432	1,580	1,893	2,040	1,991	1,900	1,843
1959	D	1,771	1,766	1,775	1,801	1,855	1,874	1,706	1,494	1,434	1,361	1,289	1,288
1960	C	1,231	1,223	1,228	1,234	1,270	1,262	1,191	1,088	1,047	980	919	876
1961	C	806	821	835	840	831	805	764	710	653	594	535	505
1962	BN	474	475	476	484	566	601	622	660	716	672	602	559
1963	AN	547	549	566	621	734	727	762	949	1,009	967	898	875
1964	D	852	881	899	932	936	901	853	801	783	716	654	614
1965	W	609	626	838	1,043	1,151	1,208	1,263	1,308	1,375	1,353	1,299	1,264
1966	BN	1,198	1,231	1,263	1,301	1,334	1,356	1,283	1,252	1,189	1,113	1,045	1,002
1967	W	945	955	1,035	1,137	1,152	1,193	1,266	1,478	1,765	1,821	1,740	1,692
1968	D	1,622	1,630	1,639	1,662	1,718	1,763	1,627	1,480	1,429	1,350	1,275	1,233
1969	W	1,198	1,225	1,236	1,533	1,733	1,793	1,917	2,178	2,323	2,283	2,130	2,000
1970	AN	1,948	1,954	1,964	1,970	1,970	1,998	1,853	1,742	1,738	1,641	1,545	1,507
1971	BN	1,452	1,483	1,550	1,607	1,649	1,622	1,525	1,476	1,518	1,461	1,380	1,343
1972	D	1,284	1,302	1,350	1,386	1,395	1,360	1,264	1,256	1,222	1,156	1,091	1,064
1973	AN	1,028	1,034	1,060	1,172	1,316	1,432	1,419	1,508	1,534	1,455	1,373	1,338
1974	W	1,320	1,370	1,446	1,559	1,638	1,713	1,800	1,856	1,888	1,823	1,728	1,676
1975	W	1,634	1,643	1,666	1,693	1,757	1,807	1,758	1,679	1,808	1,741	1,663	1,618
1976	C	1,583	1,601	1,623	1,633	1,639	1,577	1,470	1,332	1,259	1,199	1,152	1,124
1977	C	1,087	1,088	1,086	1,077	1,042	976	900	831	800	743	684	665
1978	W	617	602	615	694	781	924	1,029	1,175	1,299	1,290	1,221	1,219
1979	AN	1,159	1,169	1,184	1,250	1,367	1,491	1,448	1,560	1,482	1,396	1,314	1,281

YEAR	WYT	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1980	W	1,245	1,261	1,272	1,575	1,826	1,843	1,841	1,880	1,942	1,925	1,829	1,776
1981	D	1,720	1,704	1,714	1,753	1,757	1,799	1,693	1,537	1,453	1,373	1,304	1,281
1982	W	1,252	1,310	1,442	1,647	1,950	2,030	2,220	2,346	2,410	2,300	2,130	2,000
1983	W	1,955	1,965	1,964	1,970	1,970	2,030	2,063	2,207	2,420	2,300	2,130	2,000
1984	AN	1,955	1,965	1,964	1,970	1,970	1,976	1,860	1,785	1,752	1,676	1,601	1,570
1985	D	1,539	1,574	1,607	1,615	1,645	1,678	1,575	1,448	1,382	1,299	1,230	1,206
1986	W	1,176	1,187	1,203	1,282	1,755	2,029	2,037	2,058	2,080	1,986	1,899	1,868
1987	C	1,821	1,815	1,822	1,815	1,808	1,833	1,634	1,371	1,292	1,231	1,182	1,165
1988	C	1,114	1,099	1,091	1,095	1,077	1,027	974	900	856	816	774	743
1989	C	702	683	672	671	654	698	665	614	593	543	494	500
1990	C	521	524	539	552	545	519	475	417	380	341	317	310
1991	C	306	293	304	299	267	304	289	276	255	215	177	177
1992	C	177	170	185	193	240	252	231	155	115	80	80	80
1993	W	80	80	95	244	350	479	482	567	669	638	578	546
1994	C	552	571	600	629	634	582	544	507	464	415	371	353
1995	W	342	345	371	557	651	900	1,004	1,243	1,484	1,611	1,566	1,550
1996	W	1,513	1,510	1,542	1,621	1,812	1,922	1,906	2,014	2,010	1,919	1,838	1,794
1997	W	1,774	1,802	1,964	2,110	1,970	1,990	1,841	1,770	1,718	1,639	1,565	1,551
1998	W	1,504	1,522	1,551	1,665	1,869	1,942	1,955	2,038	2,268	2,300	2,130	2,000
1999	AN	1,955	1,961	1,964	1,970	1,970	1,990	1,929	1,850	1,836	1,754	1,680	1,650
2000	AN	1,609	1,603	1,615	1,666	1,772	1,798	1,731	1,656	1,620	1,529	1,457	1,438
2001	D	1,426	1,445	1,479	1,492	1,519	1,555	1,497	1,404	1,329	1,244	1,165	1,118
2002	D	1,060	1,060	1,094	1,138	1,138	1,160	1,091	1,013	948	876	811	785
2003	BN	745	759	806	854	858	847	804	791	771	708	650	620

Table 2. Baseline Monthly Average Flow at Ripon on the Stanislaus River in cfs and February–June Flow Volume in TAF

YEAR	WYT	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	Feb-Jun [TAF]
1922	W	980	260	311	335	303	382	1,821	1,458	528	377	439	436	270
1923	AN	1,207	444	493	356	235	1,426	1,641	1,697	1,345	511	456	493	383
1924	C	1,341	367	311	280	543	639	1,870	1,919	406	404	428	423	324
1925	BN	1,009	439	395	297	236	282	1,212	802	421	442	439	434	177
1926	D	1,066	369	311	267	441	709	737	1,099	451	454	439	434	206
1927	AN	1,007	505	338	314	235	647	1,121	986	1,325	426	439	434	259
1928	BN	1,076	431	387	295	227	481	1,098	1,251	436	441	439	434	211
1929	C	1,060	302	280	295	475	581	1,223	1,464	448	421	428	423	252
1930	C	993	313	250	308	489	590	679	579	432	435	428	423	165
1931	C	528	293	246	187	558	672	480	481	413	418	404	375	155
1932	AN	506	296	432	215	122	900	995	469	1,412	408	439	434	234
1933	D	537	356	291	220	505	534	548	760	454	434	367	386	167
1934	C	525	291	338	214	461	637	449	612	430	405	404	375	155
1935	AN	504	302	289	230	294	914	789	785	1,224	554	439	434	241
1936	AN	550	290	256	250	643	337	728	497	971	476	439	437	189
1937	W	1,012	356	353	314	263	488	1,038	750	940	476	439	434	208
1938	W	1,066	404	427	321	506	2,027	2,278	1,946	1,616	718	556	1,925	504
1939	D	1,396	547	471	420	367	238	2,434	2,522	439	438	439	449	361
1940	AN	1,204	266	225	371	241	1,616	1,788	1,991	1,103	511	456	486	408
1941	W	1,260	475	459	454	432	1,794	1,832	2,107	1,633	632	469	469	470
1942	W	1,272	678	474	323	574	1,885	2,104	1,782	1,295	785	594	642	460
1943	W	1,363	573	459	1,148	2,366	3,408	1,967	1,822	1,428	615	593	629	655
1944	BN	1,364	572	584	543	588	468	2,557	2,387	625	480	461	441	399
1945	AN	1,224	378	385	390	401	1,522	1,626	1,834	1,276	568	517	523	401
1946	AN	1,256	353	225	552	494	1,506	2,587	2,429	1,202	450	481	497	495
1947	D	1,212	343	347	404	376	787	1,399	1,405	471	437	393	394	267
1948	BN	1,026	432	383	362	878	668	1,102	1,040	593	506	439	404	256
1949	BN	980	367	355	318	577	315	1,135	1,059	521	455	409	380	215

YEAR	WYT	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	Feb-Jun [TAF]
1950	BN	954	411	421	338	351	550	946	1,358	807	447	405	409	241
1951	AN	952	461	534	573	649	412	1,919	2,668	1,002	444	400	361	399
1952	W	1,105	331	272	312	229	1,603	1,967	1,702	1,699	887	639	781	435
1953	BN	1,347	525	514	759	1,166	1,515	3,057	3,315	1,248	616	451	480	618
1954	BN	1,239	342	333	351	513	483	1,805	1,996	438	436	393	356	314
1955	D	996	322	355	475	555	615	1,391	1,264	517	443	357	359	260
1956	W	1,005	381	370	762	562	1,561	2,266	1,960	1,361	613	484	463	465
1957	BN	1,212	325	312	342	529	595	2,517	2,381	598	449	439	431	398
1958	W	1,218	369	353	327	451	1,479	2,081	1,298	1,424	678	586	633	404
1959	D	1,302	450	493	434	368	475	2,684	2,591	467	422	401	435	396
1960	C	1,162	337	316	343	463	666	1,387	1,467	440	406	384	341	266
1961	C	920	354	356	326	652	691	634	600	410	361	382	312	178
1962	BN	421	373	377	210	255	294	628	858	423	451	411	403	148
1963	AN	522	393	353	258	722	1,305	797	1,083	1,527	498	451	437	325
1964	D	1,021	348	286	347	601	666	680	769	447	425	379	383	190
1965	W	495	388	250	369	142	314	1,672	2,451	1,345	436	513	479	357
1966	BN	1,248	374	351	386	467	388	1,624	1,564	455	440	361	350	270
1967	W	991	299	288	276	1,358	1,465	1,583	1,298	1,350	948	582	670	420
1968	D	1,424	351	379	380	451	371	2,386	2,451	446	431	386	371	368
1969	W	1,059	319	339	422	783	2,029	2,404	1,638	1,534	799	1,565	1,745	503
1970	AN	1,450	537	905	4,835	2,921	1,814	3,198	3,273	1,215	468	480	559	738
1971	BN	1,262	269	280	336	446	1,660	2,522	2,466	1,108	568	493	536	494
1972	D	1,440	248	200	349	585	1,157	1,455	1,425	457	448	378	368	306
1973	AN	992	391	397	304	463	295	1,519	1,834	1,094	448	452	503	312
1974	W	1,076	284	273	263	466	1,499	1,852	2,669	1,398	557	500	649	476
1975	W	1,354	370	478	349	236	1,625	2,141	3,208	1,595	589	582	603	533
1976	C	1,158	471	297	368	471	644	1,460	1,659	441	429	347	328	282
1977	C	957	324	313	286	704	651	692	733	337	303	355	241	185
1978	W	473	263	276	256	181	200	803	631	630	546	459	479	146

YEAR	WYT	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	Feb-Jun [TAF]
1979	AN	1,118	468	411	219	267	238	1,981	1,282	1,747	459	450	430	330
1980	W	1,201	372	250	226	721	1,787	2,420	2,058	1,616	690	646	756	518
1981	D	1,381	576	496	503	457	368	2,095	2,223	437	442	372	393	335
1982	W	1,056	294	322	381	254	3,151	2,907	1,724	1,303	1,679	1,967	3,096	564
1983	W	2,256	2,520	3,187	4,124	5,173	6,175	2,045	1,828	4,960	4,507	2,694	3,113	1,196
1984	AN	1,830	3,321	5,140	2,085	2,258	1,994	2,597	3,063	1,367	628	668	813	677
1985	D	1,419	471	356	461	569	416	2,247	2,210	470	437	380	460	355
1986	W	1,095	428	356	304	613	1,603	2,347	1,810	1,219	632	466	597	456
1987	C	1,353	501	601	483	517	370	2,977	3,163	435	415	355	309	449
1988	C	959	287	320	289	643	676	615	582	401	346	373	303	175
1989	C	483	339	358	186	612	657	647	718	383	357	384	410	180
1990	C	434	349	339	179	619	674	544	609	373	338	382	274	168
1991	C	524	530	311	202	683	313	499	557	379	343	381	245	144
1992	C	477	404	288	209	302	615	486	468	297	236	0	9	131
1993	W	103	126	265	351	160	598	1,286	1,324	388	288	368	434	227
1994	C	360	338	323	158	493	662	507	554	386	329	368	252	155
1995	W	394	300	314	541	218	1,560	1,528	1,423	1,105	418	418	397	352
1996	W	1,115	361	363	343	236	1,925	2,089	1,816	1,195	528	542	542	439
1997	W	1,198	655	966	8,185	6,255	2,075	3,032	2,607	1,056	452	421	421	879
1998	W	1,208	257	247	324	1,242	1,858	2,032	1,656	1,153	1,101	2,230	2,231	475
1999	AN	1,718	823	1,083	1,527	3,447	1,917	2,178	2,913	1,460	495	518	544	705
2000	AN	1,178	350	341	453	445	1,620	2,404	2,559	1,083	435	385	401	490
2001	D	1,100	264	243	308	397	311	1,210	1,344	436	412	301	313	222
2002	D	919	311	377	314	675	612	1,552	1,281	543	406	365	343	279
2003	BN	867	282	311	243	771	854	1,277	1,146	1,205	435	337	307	314

Table 3. Baseline End-of-Month Storage at New Don Pedro on the Tuolumne River in TAF from 1922–2003

YEAR	WYT	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1922	W	954	964	994	1,019	1,128	1,205	1,168	1,363	1,611	1,574	1,494	1,445
1923	AN	1,384	1,397	1,462	1,524	1,572	1,509	1,514	1,597	1,591	1,543	1,455	1,421
1924	C	1,375	1,369	1,384	1,399	1,387	1,313	1,164	999	939	893	843	832
1925	BN	793	794	804	814	950	1,027	1,053	1,206	1,264	1,228	1,151	1,115
1926	D	1,061	1,052	1,055	1,057	1,109	1,088	1,118	1,038	968	887	814	779
1927	AN	733	745	793	834	971	1,021	1,099	1,206	1,255	1,198	1,125	1,096
1928	BN	1,075	1,106	1,127	1,141	1,187	1,352	1,343	1,386	1,339	1,255	1,174	1,140
1929	C	1,094	1,101	1,111	1,117	1,116	1,079	1,004	909	875	811	749	720
1930	C	671	658	656	673	687	724	698	652	656	590	524	490
1931	C	484	497	496	510	500	461	405	328	291	256	217	203
1932	AN	189	192	240	275	387	377	351	524	601	578	516	476
1933	D	457	443	447	459	449	431	405	398	447	414	381	369
1934	C	371	374	391	417	435	438	385	301	268	234	195	185
1935	AN	171	171	178	213	228	239	376	567	635	586	516	478
1936	AN	475	481	492	567	744	820	932	1,113	1,182	1,128	1,055	1,019
1937	W	977	967	976	995	1,093	1,195	1,219	1,399	1,433	1,367	1,292	1,251
1938	W	1,201	1,203	1,284	1,359	1,541	1,678	1,778	2,047	2,257	2,216	2,126	2,000
1939	D	1,950	1,934	1,936	1,946	1,955	1,977	1,824	1,627	1,554	1,474	1,398	1,372
1940	AN	1,310	1,294	1,300	1,400	1,534	1,630	1,697	1,782	1,756	1,660	1,569	1,517
1941	W	1,454	1,444	1,478	1,530	1,615	1,654	1,665	1,819	1,871	1,814	1,725	1,669
1942	W	1,612	1,604	1,647	1,737	1,814	1,791	1,834	1,969	2,102	2,062	1,961	1,907
1943	W	1,843	1,860	1,882	1,970	1,970	2,030	2,108	2,143	2,145	2,067	1,973	1,912
1944	BN	1,844	1,831	1,828	1,827	1,837	1,861	1,722	1,595	1,579	1,505	1,421	1,382
1945	AN	1,345	1,380	1,407	1,443	1,571	1,584	1,538	1,610	1,672	1,617	1,531	1,493
1946	AN	1,459	1,488	1,573	1,636	1,691	1,672	1,620	1,653	1,615	1,525	1,438	1,400
1947	D	1,351	1,368	1,389	1,404	1,422	1,380	1,288	1,194	1,158	1,094	1,034	1,008
1948	BN	987	983	982	985	953	942	920	942	1,059	1,008	941	910
1949	BN	877	873	882	889	882	906	846	865	867	804	743	709
1950	BN	650	626	626	671	730	771	761	853	935	881	816	793

YEAR	WYT	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1951	AN	766	1,039	1,425	1,530	1,624	1,715	1,683	1,630	1,586	1,504	1,423	1,378
1952	W	1,325	1,339	1,391	1,530	1,620	1,656	1,690	1,985	2,167	2,154	2,066	2,000
1953	BN	1,918	1,918	1,933	1,970	1,970	1,915	1,763	1,607	1,665	1,620	1,539	1,497
1954	BN	1,438	1,440	1,453	1,468	1,475	1,512	1,449	1,470	1,447	1,376	1,306	1,269
1955	D	1,212	1,219	1,235	1,265	1,270	1,258	1,201	1,118	1,118	1,043	971	929
1956	W	874	880	1,125	1,385	1,503	1,504	1,482	1,604	1,709	1,664	1,578	1,549
1957	BN	1,487	1,484	1,498	1,517	1,548	1,571	1,419	1,383	1,444	1,377	1,309	1,272
1958	W	1,209	1,210	1,217	1,266	1,345	1,432	1,580	1,893	2,040	1,991	1,900	1,843
1959	D	1,771	1,766	1,775	1,801	1,855	1,874	1,706	1,494	1,434	1,361	1,289	1,288
1960	C	1,231	1,223	1,228	1,234	1,270	1,262	1,191	1,088	1,047	980	919	876
1961	C	806	821	835	840	831	805	764	710	653	594	535	505
1962	BN	474	475	476	484	566	601	622	660	716	672	602	559
1963	AN	547	549	566	621	734	727	762	949	1,009	967	898	875
1964	D	852	881	899	932	936	901	853	801	783	716	654	614
1965	W	609	626	838	1,043	1,151	1,208	1,263	1,308	1,375	1,353	1,299	1,264
1966	BN	1,198	1,231	1,263	1,301	1,334	1,356	1,283	1,252	1,189	1,113	1,045	1,002
1967	W	945	955	1,035	1,137	1,152	1,193	1,266	1,478	1,765	1,821	1,740	1,692
1968	D	1,622	1,630	1,639	1,662	1,718	1,763	1,627	1,480	1,429	1,350	1,275	1,233
1969	W	1,198	1,225	1,236	1,533	1,733	1,793	1,917	2,178	2,323	2,283	2,130	2,000
1970	AN	1,948	1,954	1,964	1,970	1,970	1,998	1,853	1,742	1,738	1,641	1,545	1,507
1971	BN	1,452	1,483	1,550	1,607	1,649	1,622	1,525	1,476	1,518	1,461	1,380	1,343
1972	D	1,284	1,302	1,350	1,386	1,395	1,360	1,264	1,256	1,222	1,156	1,091	1,064
1973	AN	1,028	1,034	1,060	1,172	1,316	1,432	1,419	1,508	1,534	1,455	1,373	1,338
1974	W	1,320	1,370	1,446	1,559	1,638	1,713	1,800	1,856	1,888	1,823	1,728	1,676
1975	W	1,634	1,643	1,666	1,693	1,757	1,807	1,758	1,679	1,808	1,741	1,663	1,618
1976	C	1,583	1,601	1,623	1,633	1,639	1,577	1,470	1,332	1,259	1,199	1,152	1,124
1977	C	1,087	1,088	1,086	1,077	1,042	976	900	831	800	743	684	665
1978	W	617	602	615	694	781	924	1,029	1,175	1,299	1,290	1,221	1,219
1979	AN	1,159	1,169	1,184	1,250	1,367	1,491	1,448	1,560	1,482	1,396	1,314	1,281
1980	W	1,245	1,261	1,272	1,575	1,826	1,843	1,841	1,880	1,942	1,925	1,829	1,776

YEAR	WYT	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1981	D	1,720	1,704	1,714	1,753	1,757	1,799	1,693	1,537	1,453	1,373	1,304	1,281
1982	W	1,252	1,310	1,442	1,647	1,950	2,030	2,220	2,346	2,410	2,300	2,130	2,000
1983	W	1,955	1,965	1,964	1,970	1,970	2,030	2,063	2,207	2,420	2,300	2,130	2,000
1984	AN	1,955	1,965	1,964	1,970	1,970	1,976	1,860	1,785	1,752	1,676	1,601	1,570
1985	D	1,539	1,574	1,607	1,615	1,645	1,678	1,575	1,448	1,382	1,299	1,230	1,206
1986	W	1,176	1,187	1,203	1,282	1,755	2,029	2,037	2,058	2,080	1,986	1,899	1,868
1987	C	1,821	1,815	1,822	1,815	1,808	1,833	1,634	1,371	1,292	1,231	1,182	1,165
1988	C	1,114	1,099	1,091	1,095	1,077	1,027	974	900	856	816	774	743
1989	C	702	683	672	671	654	698	665	614	593	543	494	500
1990	C	521	524	539	552	545	519	475	417	380	341	317	310
1991	C	306	293	304	299	267	304	289	276	255	215	177	177
1992	C	177	170	185	193	240	252	231	155	115	80	80	80
1993	W	80	80	95	244	350	479	482	567	669	638	578	546
1994	C	552	571	600	629	634	582	544	507	464	415	371	353
1995	W	342	345	371	557	651	900	1,004	1,243	1,484	1,611	1,566	1,550
1996	W	1,513	1,510	1,542	1,621	1,812	1,922	1,906	2,014	2,010	1,919	1,838	1,794
1997	W	1,774	1,802	1,964	2,110	1,970	1,990	1,841	1,770	1,718	1,639	1,565	1,551
1998	W	1,504	1,522	1,551	1,665	1,869	1,942	1,955	2,038	2,268	2,300	2,130	2,000
1999	AN	1,955	1,961	1,964	1,970	1,970	1,990	1,929	1,850	1,836	1,754	1,680	1,650
2000	AN	1,609	1,603	1,615	1,666	1,772	1,798	1,731	1,656	1,620	1,529	1,457	1,438
2001	D	1,426	1,445	1,479	1,492	1,519	1,555	1,497	1,404	1,329	1,244	1,165	1,118
2002	D	1,060	1,060	1,094	1,138	1,138	1,160	1,091	1,013	948	876	811	785
2003	BN	745	759	806	854	858	847	804	791	771	708	650	620

Table 4. Baseline Monthly Average Flow at Modesto on the Tuolumne River in cfs and February–June Flow Volume in TAF

YEAR	WYT	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	Feb-Jun [TAF]
1922	W	719	602	597	603	683	631	3,297	1,667	8,518	1,913	566	579	882
1923	AN	719	595	823	1,978	1,957	841	2,985	1,362	608	575	566	587	458
1924	C	732	605	580	579	606	584	527	523	342	331	342	353	155
1925	BN	428	442	440	427	454	473	1,642	1,755	470	380	389	408	288
1926	D	547	500	476	464	484	482	906	1,011	391	379	389	405	196
1927	AN	479	449	452	456	519	517	1,479	1,380	697	556	568	582	275
1928	BN	733	615	613	601	621	2,964	1,415	1,090	404	378	388	410	393
1929	C	547	495	477	468	498	474	742	808	349	333	341	363	171
1930	C	459	466	438	436	473	448	743	876	372	344	351	368	174
1931	C	457	453	449	437	465	440	532	527	345	334	344	354	138
1932	AN	424	437	430	427	525	463	1,424	1,417	697	577	568	578	272
1933	D	736	630	591	582	612	599	906	871	425	384	393	414	204
1934	C	482	471	451	434	461	442	530	523	347	331	341	353	137
1935	AN	435	445	437	436	468	429	1,544	1,665	707	562	565	587	289
1936	AN	733	609	597	593	674	3,470	3,274	1,433	660	611	565	582	574
1937	W	732	621	600	590	3,782	4,503	3,444	1,476	640	555	566	586	821
1938	W	732	618	1,922	1,613	7,111	7,817	5,429	5,416	4,410	3,684	572	597	1,794
1939	D	931	650	602	593	874	1,397	956	958	394	384	397	412	274
1940	AN	482	470	440	434	519	3,543	3,792	1,118	744	625	514	528	586
1941	W	640	526	755	1,268	5,011	4,925	4,499	1,205	1,276	2,545	618	547	999
1942	W	689	574	648	3,278	3,434	2,720	4,174	4,351	2,608	3,292	735	704	1,029
1943	W	814	641	627	3,422	3,255	6,231	3,720	1,494	1,999	1,073	501	436	996
1944	BN	753	584	626	650	763	983	1,519	1,280	490	414	405	359	303
1945	AN	526	453	389	529	2,133	3,969	2,435	1,496	536	688	634	572	631
1946	AN	684	466	3,746	2,702	3,020	3,174	1,992	1,794	782	637	600	580	638
1947	D	660	576	675	615	606	625	796	738	357	322	352	345	186
1948	BN	480	454	398	393	415	428	952	1,166	663	489	407	344	218
1949	BN	519	468	412	519	487	742	851	896	384	354	359	343	201

YEAR	WYT	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	Feb-Jun [TAF]
1950	BN	525	475	463	686	427	519	1,463	1,153	559	395	379	370	247
1951	AN	513	206	4,395	3,760	3,719	2,865	2,454	1,665	364	422	399	370	653
1952	W	461	400	475	846	643	3,807	4,598	5,070	4,408	3,733	617	591	1,119
1953	BN	680	479	517	734	1,275	642	1,950	1,774	334	519	433	400	355
1954	BN	460	400	391	397	383	459	1,097	1,064	439	373	379	369	206
1955	D	468	385	420	702	365	481	845	794	368	338	352	341	171
1956	W	395	372	441	6,886	4,167	3,171	2,249	1,464	3,372	2,933	681	574	859
1957	BN	697	478	491	518	551	616	1,970	1,812	393	399	408	405	320
1958	W	489	380	432	561	844	3,498	6,198	4,879	5,075	2,724	672	646	1,233
1959	D	753	519	581	624	964	1,299	981	957	362	349	333	366	272
1960	C	461	364	307	362	519	435	686	807	282	275	295	321	164
1961	C	310	330	282	337	346	385	465	436	246	236	256	235	112
1962	BN	298	314	323	314	941	510	1,942	1,903	370	358	396	408	338
1963	AN	464	273	315	425	493	245	1,626	1,291	485	527	500	515	247
1964	D	548	381	400	518	493	516	721	806	275	256	268	280	169
1965	W	343	266	234	2,740	3,543	3,038	3,135	1,314	361	543	565	717	672
1966	BN	585	491	2,109	1,104	2,041	1,097	836	861	251	246	242	242	298
1967	W	389	267	318	582	285	1,341	4,504	3,901	6,478	6,505	589	674	992
1968	D	645	449	485	515	484	894	1,068	901	347	350	338	330	222
1969	W	398	367	288	1,118	5,455	3,900	5,096	6,796	7,535	3,812	459	508	1,712
1970	AN	1,216	761	1,146	5,995	2,584	3,073	1,550	1,433	296	432	360	426	530
1971	BN	673	503	532	524	456	1,075	1,633	1,544	367	333	350	358	305
1972	D	515	322	524	367	345	387	803	738	284	276	286	284	154
1973	AN	315	451	522	524	826	593	1,623	1,368	1,010	484	509	512	323
1974	W	560	745	2,027	2,864	1,754	3,806	2,617	1,511	3,148	1,039	475	657	767
1975	W	1,068	1,088	789	643	2,318	3,655	2,337	1,628	2,700	1,262	558	569	753
1976	C	1,352	812	584	543	516	584	613	574	260	245	278	280	153
1977	C	284	309	322	295	303	305	383	398	176	170	167	153	93
1978	W	217	243	251	432	550	578	1,424	1,394	2,832	415	446	436	405

YEAR	WYT	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	Feb-Jun [TAF]
1979	AN	393	710	611	1,045	3,655	4,273	2,032	5,620	490	547	625	516	961
1980	W	609	813	877	3,071	6,760	3,798	2,383	2,097	5,065	3,500	567	697	1,195
1981	D	743	775	519	693	579	779	917	973	316	321	348	341	213
1982	W	439	421	600	685	6,677	5,622	9,183	6,364	4,838	3,679	592	2,367	1,942
1983	W	3,175	3,152	5,340	5,281	6,724	16,125	5,060	7,883	4,323	6,266	2,862	2,081	2,408
1984	AN	941	5,485	7,476	4,168	3,409	3,125	1,600	1,628	598	558	597	599	619
1985	D	743	974	430	489	609	658	865	1,077	408	340	367	359	216
1986	W	334	363	356	284	2,249	8,056	2,904	3,247	3,686	648	541	662	1,212
1987	C	1,169	1,300	566	596	523	708	620	710	276	256	265	253	170
1988	C	242	259	254	305	265	293	455	462	184	175	190	177	100
1989	C	194	220	245	244	243	340	575	574	188	187	203	212	115
1990	C	215	245	232	236	275	271	431	502	195	199	221	212	100
1991	C	214	239	223	208	232	449	491	600	170	183	201	188	117
1992	C	210	239	217	224	485	307	381	450	178	169	175	175	108
1993	W	213	208	217	781	481	305	1,126	1,319	4,064	2,059	326	404	435
1994	C	581	448	413	399	490	410	522	503	207	188	201	186	127
1995	W	230	218	223	518	152	7,988	4,702	9,501	5,103	8,341	1,781	792	1,667
1996	W	758	451	430	538	5,666	4,888	2,802	2,648	3,078	794	483	533	1,139
1997	W	592	525	6,295	17,735	3,718	2,811	1,491	1,371	482	499	486	486	581
1998	W	693	337	431	900	6,931	5,095	3,854	5,548	6,995	6,737	517	560	1,685
1999	AN	962	506	695	2,008	4,999	3,672	2,004	1,308	498	497	501	506	733
2000	AN	591	442	344	433	3,617	3,718	2,271	1,590	1,489	488	691	721	758
2001	D	692	465	418	518	400	1,207	798	713	326	293	314	300	207
2002	D	322	243	383	427	242	325	630	896	276	279	326	296	142
2003	BN	315	247	294	264	241	297	1,069	1,062	244	228	283	269	175

Table 5. Baseline End-of-Month Storage at New Exchequer on the Merced River in TAF from 1922–2003

YEAR	WYT	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1922	W	469	456	483	506	647	735	805	970	1,024	910	770	700
1923	AN	662	662	675	675	675	690	780	938	968	905	770	700
1924	C	662	654	646	641	639	609	574	548	445	330	236	193
1925	BN	173	178	184	189	275	316	399	560	584	506	420	377
1926	D	353	345	340	334	380	388	473	437	404	350	288	246
1927	AN	217	205	210	199	223	259	283	449	520	492	473	489
1928	BN	497	493	505	519	532	538	509	564	547	512	486	490
1929	C	471	458	445	434	435	433	400	387	359	330	310	276
1930	C	246	232	218	207	195	158	152	172	198	197	185	174
1931	C	146	138	127	121	126	124	171	226	207	171	141	128
1932	AN	110	99	161	194	336	389	422	591	714	652	560	513
1933	D	481	467	456	456	455	457	428	452	521	424	323	279
1934	C	252	238	240	257	288	309	318	304	268	195	137	112
1935	AN	98	104	111	176	213	274	498	695	824	738	640	593
1936	AN	568	561	552	576	675	735	845	945	987	909	770	700
1937	W	662	651	654	662	675	735	839	970	1,024	910	770	700
1938	W	662	652	675	675	675	735	845	970	1,024	910	770	700
1939	D	662	666	668	666	675	702	724	706	621	509	408	373
1940	AN	358	346	336	447	570	702	830	955	976	875	770	700
1941	W	662	650	675	675	675	735	845	970	1,024	910	770	700
1942	W	662	661	675	675	675	733	845	970	1,024	910	770	700
1943	W	662	675	675	675	675	735	845	969	1,003	910	770	700
1944	BN	662	650	642	645	675	728	697	825	842	760	664	616
1945	AN	586	604	620	628	675	735	793	938	1,021	910	770	700
1946	AN	662	675	675	675	675	720	777	923	919	829	735	692
1947	D	662	675	675	675	675	693	700	751	684	573	472	427
1948	BN	408	402	393	389	383	375	403	542	642	554	456	407
1949	BN	380	365	357	351	357	401	437	565	556	450	353	309

YEAR	WYT	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1950	BN	275	264	253	275	322	341	423	536	547	444	345	302
1951	AN	279	520	675	675	675	733	773	850	841	746	648	600
1952	W	573	565	608	675	675	735	845	970	1,024	910	770	700
1953	BN	662	653	665	675	675	676	689	691	737	660	560	514
1954	BN	481	469	459	462	492	562	633	746	707	600	493	447
1955	D	411	398	399	411	418	410	397	499	520	419	318	275
1956	W	241	227	595	675	675	735	805	970	1,024	910	770	700
1957	BN	662	656	649	647	671	681	660	753	811	712	612	562
1958	W	542	533	539	556	627	735	845	970	1,024	910	770	700
1959	D	662	649	636	642	675	682	684	668	600	483	380	368
1960	C	340	324	310	302	342	359	387	425	375	265	168	124
1961	C	99	90	89	81	84	94	166	226	231	192	157	143
1962	BN	121	108	102	96	243	287	399	496	573	504	409	360
1963	AN	334	319	308	333	489	520	559	704	796	737	647	602
1964	D	582	602	606	611	612	592	557	595	564	457	358	313
1965	W	292	294	501	568	609	639	724	838	948	910	770	700
1966	BN	662	675	675	675	675	704	749	800	728	619	523	483
1967	W	454	450	546	590	627	735	845	970	1,024	910	770	700
1968	D	662	653	649	651	675	682	649	653	588	470	371	328
1969	W	307	314	336	669	675	735	845	970	1,024	910	770	700
1970	AN	662	666	675	675	675	735	716	809	817	725	630	586
1971	BN	560	563	598	631	653	670	650	727	791	713	623	579
1972	D	552	543	566	575	596	617	607	665	647	538	443	413
1973	AN	398	393	410	462	575	671	734	964	1,024	910	770	700
1974	W	662	675	675	675	675	735	811	957	1,024	910	770	700
1975	W	662	653	652	663	675	735	744	919	1,024	910	770	700
1976	C	662	667	665	655	656	630	579	554	455	336	248	223
1977	C	198	180	165	152	137	102	93	108	134	120	107	103
1978	W	86	70	87	184	316	492	712	970	1,024	910	770	700
1979	AN	662	663	657	675	675	735	781	970	993	899	770	700

YEAR	WYT	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1980	W	662	653	652	675	675	735	817	958	1,024	910	770	700
1981	D	662	642	631	633	641	663	676	714	662	554	459	416
1982	W	398	426	472	586	675	735	845	970	1,024	910	770	700
1983	W	662	675	675	675	675	735	818	970	1,024	910	770	700
1984	AN	649	675	675	675	675	735	749	894	890	812	724	681
1985	D	662	669	673	675	675	696	726	774	714	605	508	467
1986	W	445	442	456	483	675	735	845	970	1,024	910	770	700
1987	C	662	644	630	620	623	631	618	612	527	415	322	281
1988	C	257	254	248	258	263	262	294	316	287	219	156	130
1989	C	103	92	90	83	92	168	252	311	288	216	159	146
1990	C	136	130	121	120	124	149	216	255	236	191	148	129
1991	C	109	95	81	67	56	132	178	266	316	256	197	171
1992	C	153	146	138	134	180	205	279	307	254	208	155	140
1993	W	118	108	111	282	367	501	641	946	1,024	910	770	700
1994	C	662	648	638	631	643	644	643	672	612	495	401	358
1995	W	345	349	356	541	597	735	845	970	1,024	910	770	700
1996	W	662	648	658	675	675	735	838	970	1,002	910	770	700
1997	W	662	675	675	675	675	735	783	925	925	833	743	699
1998	W	662	654	652	675	675	735	845	970	1,024	910	770	700
1999	AN	662	662	674	675	675	699	713	853	883	784	686	639
2000	AN	603	593	581	621	675	735	803	952	958	847	745	699
2001	D	662	652	645	641	654	713	745	841	750	635	535	504
2002	D	475	469	500	525	543	567	607	693	659	542	441	397
2003	BN	364	378	393	417	434	463	499	669	714	609	517	469

Table 6. Baseline Monthly Average Flow at Stevinson on the Merced River in cfs and February–June Flow Volume in TAF

YEAR	WYT	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	Feb-Jun [TAF]
1922	W	292	368	486	482	879	748	28	1,251	3,357	1,387	867	453	373
1923	AN	469	304	962	1,270	1,017	261	359	533	582	159	762	598	161
1924	C	593	385	382	396	320	273	239	171	29	54	36	49	62
1925	BN	282	419	425	428	689	421	922	533	214	116	77	54	165
1926	D	266	354	375	375	336	271	506	393	61	51	37	51	93
1927	AN	274	322	313	381	441	280	338	276	166	136	84	89	89
1928	BN	426	352	389	361	493	341	667	649	271	179	88	80	145
1929	C	296	387	387	408	435	328	638	129	129	49	54	92	98
1930	C	276	367	359	361	375	303	558	317	31	35	35	93	94
1931	C	276	385	372	382	408	292	89	98	82	87	41	75	57
1932	AN	266	363	475	469	691	383	483	20	94	109	57	58	99
1933	D	310	386	383	426	371	337	549	178	78	60	41	30	90
1934	C	298	383	405	466	469	311	453	216	113	85	36	29	92
1935	AN	282	389	409	580	428	587	703	369	230	182	100	55	138
1936	AN	368	410	385	428	2,896	665	811	1,508	132	108	807	441	356
1937	W	707	424	417	416	4,208	1,251	311	2,281	562	597	812	446	503
1938	W	442	401	2,035	1,341	4,928	4,767	1,521	3,341	4,530	2,238	1,159	596	1,132
1939	D	833	397	383	443	509	453	849	488	135	67	73	68	145
1940	AN	331	424	418	573	489	280	419	1,461	236	145	188	416	174
1941	W	459	427	1,286	1,340	3,119	1,858	842	3,103	2,347	1,749	1,069	508	668
1942	W	718	447	1,183	1,528	1,720	517	522	1,180	2,978	1,651	1,021	509	408
1943	W	494	549	783	2,172	1,974	3,163	910	1,046	435	534	941	490	448
1944	BN	475	459	436	414	532	345	902	343	391	172	136	88	150
1945	AN	357	489	446	441	2,769	834	714	603	148	878	937	421	293
1946	AN	840	640	1,862	1,067	829	469	741	562	303	170	129	81	172
1947	D	577	532	963	621	869	323	385	286	147	65	80	76	117
1948	BN	319	397	398	388	299	313	634	274	197	182	100	97	103
1949	BN	348	404	386	402	394	359	514	215	263	121	121	70	103

YEAR	WYT	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	Feb-Jun [TAF]
1950	BN	326	394	394	428	403	390	449	194	329	162	130	77	105
1951	AN	329	402	1,941	1,733	1,641	454	703	167	308	186	116	63	189
1952	W	347	417	460	1,986	1,317	1,922	1,245	3,703	3,081	1,943	1,231	621	679
1953	BN	450	428	334	1,080	727	358	784	513	190	140	126	55	152
1954	BN	360	405	403	406	439	277	692	329	277	167	131	81	119
1955	D	314	392	409	537	442	338	261	240	146	120	113	55	84
1956	W	311	386	133	3,072	1,983	498	840	1,104	2,383	1,954	1,152	610	404
1957	BN	580	422	409	411	406	364	674	501	332	195	154	81	136
1958	W	424	381	405	481	721	1,322	2,986	3,555	2,730	1,720	1,123	675	680
1959	D	483	395	382	395	564	335	875	547	172	107	116	94	148
1960	C	307	374	383	397	451	343	635	315	164	101	127	49	114
1961	C	286	365	387	372	395	321	166	200	143	70	55	40	72
1962	BN	264	341	359	360	681	975	788	314	446	253	182	78	190
1963	AN	346	362	376	376	410	467	960	682	454	277	194	158	178
1964	D	411	397	398	404	316	320	639	227	197	163	114	77	102
1965	W	346	356	528	1,780	497	355	527	748	444	309	1,448	634	153
1966	BN	474	866	812	1,055	724	346	692	636	257	206	165	79	157
1967	W	293	366	400	408	424	904	1,756	2,666	4,147	4,063	1,494	797	594
1968	D	747	411	330	382	500	358	1,036	509	249	196	177	130	158
1969	W	275	431	434	903	4,093	1,534	2,098	5,555	4,141	2,433	1,233	711	1,035
1970	AN	825	320	444	2,940	1,265	917	986	657	329	256	222	150	245
1971	BN	383	375	359	425	384	331	921	646	314	256	188	102	155
1972	D	359	386	423	270	340	263	408	365	281	240	222	18	99
1973	AN	309	412	432	474	889	652	640	1,091	639	600	1,038	574	233
1974	W	815	776	1,095	1,690	870	1,126	716	1,521	587	841	1,054	586	289
1975	W	667	350	409	307	2,026	1,073	793	680	2,074	1,163	1,062	533	391
1976	C	1,107	357	362	392	370	291	655	355	255	175	205	136	115
1977	C	354	311	322	373	253	234	561	281	173	106	81	44	89
1978	W	268	282	350	516	824	582	219	566	4,016	2,613	1,294	1,369	368

YEAR	WYT	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	Feb-Jun [TAF]
1979	AN	509	579	441	1,541	1,932	1,485	901	973	355	262	731	443	333
1980	W	698	374	392	3,976	4,525	1,490	621	940	2,019	2,284	1,248	583	567
1981	D	629	398	444	479	452	479	751	512	240	168	168	97	145
1982	W	401	405	414	484	2,088	2,297	4,921	3,385	1,922	2,249	1,390	1,170	873
1983	W	1,344	1,754	2,298	3,657	4,416	6,069	1,408	2,947	7,343	5,943	2,444	1,100	1,320
1984	AN	1,196	1,802	3,551	1,903	1,596	512	782	546	328	291	277	217	223
1985	D	580	338	334	488	759	371	721	459	274	236	206	100	152
1986	W	405	395	408	380	3,244	4,143	921	1,748	1,415	946	1,113	737	681
1987	C	558	416	418	381	380	393	648	218	183	130	135	87	108
1988	C	356	340	375	377	305	246	349	347	201	97	92	52	87
1989	C	256	274	322	304	310	339	165	41	142	68	62	67	59
1990	C	305	303	327	310	346	205	110	181	146	72	68	26	58
1991	C	248	258	274	292	205	359	200	168	146	91	54	10	64
1992	C	270	289	297	291	352	298	201	139	139	76	55	11	67
1993	W	206	313	350	684	449	438	9	63	1,702	1,492	1,085	640	158
1994	C	739	369	334	315	381	186	306	131	142	48	54	2	67
1995	W	239	327	317	611	386	3,613	1,035	3,031	5,130	4,891	1,700	509	797
1996	W	474	379	365	844	3,009	1,633	792	1,719	290	374	903	480	444
1997	W	613	845	3,494	9,912	2,144	1,191	830	639	240	149	114	84	295
1998	W	369	336	356	1,396	5,205	2,115	1,235	1,064	5,045	4,614	1,499	759	858
1999	AN	741	382	296	820	2,026	362	743	800	292	174	196	100	246
2000	AN	285	345	318	325	2,186	1,137	807	851	242	175	112	59	310
2001	D	668	496	392	389	391	365	356	275	244	74	84	25	97
2002	D	239	403	390	449	307	249	517	219	172	90	61	2	87
2003	BN	227	316	353	327	287	241	181	262	160	80	66	41	67

LSJR Alternative 2 (20% Unimpaired Flow)

Table 7. LSJR Alternative 2 End-of-Month Storage at New Melones on the Stanislaus River in TAF from 1922–2003

YEAR	WYT	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1922	W	954	964	994	1,027	1,131	1,197	1,237	1,429	1,631	1,595	1,519	1,470
1923	AN	1,400	1,409	1,474	1,536	1,566	1,558	1,598	1,712	1,742	1,680	1,580	1,524
1924	C	1,454	1,447	1,457	1,469	1,432	1,348	1,252	1,137	1,028	923	821	776
1925	BN	708	703	711	720	838	905	951	1,077	1,132	1,103	1,035	1,003
1926	D	945	941	945	948	993	997	1,032	1,005	937	849	771	729
1927	AN	679	687	735	777	894	957	1,058	1,181	1,264	1,211	1,145	1,119
1928	BN	1,068	1,094	1,115	1,131	1,146	1,286	1,316	1,399	1,356	1,262	1,174	1,129
1929	C	1,073	1,075	1,083	1,088	1,060	1,015	974	932	875	789	710	665
1930	C	611	607	604	621	617	664	677	654	664	603	542	505
1931	C	488	497	495	508	474	426	396	321	263	208	151	124
1932	AN	96	97	146	181	275	311	342	500	630	633	600	576
1933	D	563	560	566	581	542	502	485	475	488	428	373	340
1934	C	324	331	347	372	371	383	353	271	226	175	124	97
1935	AN	70	67	76	112	118	164	284	487	610	593	555	533
1936	AN	514	523	537	615	788	852	963	1,126	1,221	1,178	1,117	1,085
1937	W	1,035	1,037	1,047	1,067	1,157	1,250	1,286	1,441	1,491	1,418	1,339	1,295
1938	W	1,238	1,238	1,318	1,393	1,567	1,762	1,920	2,204	2,420	2,300	2,130	1,998
1939	D	1,926	1,915	1,916	1,925	1,900	1,873	1,846	1,764	1,668	1,562	1,463	1,400
1940	AN	1,326	1,317	1,321	1,419	1,530	1,655	1,764	1,913	1,925	1,830	1,738	1,682
1941	W	1,612	1,610	1,643	1,694	1,779	1,876	1,921	2,115	2,215	2,154	2,059	1,998
1942	W	1,926	1,921	1,962	1,970	1,970	2,028	2,096	2,245	2,385	2,300	2,130	2,000
1943	W	1,928	1,938	1,959	1,970	1,970	2,030	2,135	2,227	2,268	2,182	2,079	2,000
1944	BN	1,921	1,910	1,905	1,903	1,892	1,914	1,862	1,825	1,801	1,703	1,598	1,534
1945	AN	1,464	1,493	1,518	1,552	1,664	1,732	1,735	1,855	1,934	1,867	1,769	1,714
1946	AN	1,644	1,666	1,750	1,812	1,846	1,861	1,920	2,035	2,036	1,938	1,842	1,789
1947	D	1,719	1,736	1,755	1,768	1,753	1,748	1,722	1,655	1,587	1,479	1,381	1,331
1948	BN	1,274	1,264	1,261	1,262	1,230	1,203	1,212	1,215	1,304	1,237	1,158	1,116
1949	BN	1,061	1,065	1,073	1,078	1,054	1,068	1,072	1,099	1,097	1,018	945	903
1950	BN	843	828	827	873	928	962	978	1,100	1,191	1,133	1,069	1,032

YEAR	WYT	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1951	AN	978	1,247	1,634	1,739	1,844	1,933	1,957	2,023	2,000	1,899	1,801	1,744
1952	W	1,672	1,680	1,730	1,867	1,946	2,030	2,091	2,376	2,420	2,300	2,130	2,000
1953	BN	1,914	1,908	1,921	1,957	1,952	1,938	1,930	1,936	2,004	1,945	1,846	1,786
1954	BN	1,711	1,716	1,727	1,741	1,744	1,789	1,790	1,870	1,824	1,721	1,623	1,565
1955	D	1,504	1,504	1,519	1,547	1,533	1,509	1,471	1,407	1,385	1,284	1,190	1,131
1956	W	1,072	1,071	1,314	1,572	1,700	1,784	1,852	2,012	2,134	2,084	1,990	1,943
1957	BN	1,865	1,870	1,883	1,900	1,914	1,940	1,899	1,923	1,956	1,859	1,767	1,701
1958	W	1,602	1,609	1,614	1,662	1,739	1,864	2,023	2,279	2,420	2,300	2,130	2,000
1959	D	1,926	1,928	1,936	1,960	1,970	1,950	1,926	1,833	1,761	1,659	1,562	1,510
1960	C	1,434	1,431	1,434	1,438	1,458	1,473	1,461	1,403	1,341	1,237	1,143	1,075
1961	C	988	995	1,006	1,008	980	947	936	884	817	732	650	605
1962	BN	574	570	571	579	657	701	729	800	852	817	759	719
1963	AN	699	708	726	782	892	931	972	1,157	1,269	1,232	1,169	1,140
1964	D	1,088	1,114	1,133	1,166	1,154	1,128	1,110	1,072	1,039	952	875	821
1965	W	790	802	1,013	1,218	1,311	1,355	1,465	1,610	1,703	1,673	1,601	1,561
1966	BN	1,490	1,518	1,549	1,586	1,583	1,579	1,568	1,590	1,502	1,393	1,298	1,233
1967	W	1,172	1,175	1,254	1,354	1,415	1,501	1,603	1,796	2,062	2,127	2,049	2,000
1968	D	1,926	1,928	1,937	1,958	1,970	1,963	1,928	1,893	1,826	1,717	1,613	1,545
1969	W	1,487	1,507	1,516	1,811	1,970	2,030	2,213	2,420	2,420	2,300	2,130	1,985
1970	AN	1,913	1,912	1,921	1,925	1,970	2,030	2,020	2,067	2,091	1,984	1,876	1,820
1971	BN	1,750	1,774	1,839	1,895	1,920	1,935	1,942	1,990	2,038	1,961	1,861	1,803
1972	D	1,725	1,738	1,784	1,819	1,820	1,859	1,815	1,832	1,770	1,662	1,561	1,508
1973	AN	1,452	1,451	1,475	1,584	1,725	1,815	1,840	1,958	1,998	1,897	1,797	1,748
1974	W	1,690	1,730	1,804	1,917	1,961	2,030	2,153	2,300	2,343	2,260	2,130	2,000
1975	W	1,930	1,939	1,960	1,970	1,970	2,030	2,023	2,065	2,216	2,142	2,042	1,981
1976	C	1,910	1,928	1,947	1,954	1,940	1,894	1,802	1,707	1,579	1,463	1,358	1,292
1977	C	1,222	1,214	1,207	1,194	1,154	1,096	1,009	901	830	715	605	548
1978	W	492	473	485	563	640	742	827	955	1,071	1,075	1,021	1,015
1979	AN	961	968	985	1,052	1,161	1,264	1,306	1,434	1,433	1,343	1,262	1,223
1980	W	1,167	1,178	1,189	1,493	1,731	1,820	1,918	2,024	2,101	2,072	1,973	1,913

YEAR	WYT	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1981	D	1,855	1,847	1,856	1,893	1,867	1,868	1,852	1,792	1,697	1,588	1,494	1,447
1982	W	1,389	1,441	1,570	1,774	1,970	2,030	2,220	2,366	2,420	2,300	2,125	1,957
1983	W	1,876	1,879	1,877	1,881	1,970	2,030	2,102	2,245	2,420	2,298	2,120	1,951
1984	AN	1,891	1,894	1,892	1,896	1,970	2,030	2,050	2,110	2,116	2,026	1,936	1,886
1985	D	1,819	1,845	1,877	1,883	1,885	1,900	1,893	1,864	1,777	1,667	1,576	1,532
1986	W	1,482	1,485	1,500	1,577	1,970	2,030	2,108	2,183	2,233	2,138	2,046	2,000
1987	C	1,932	1,932	1,936	1,926	1,891	1,871	1,794	1,663	1,548	1,446	1,361	1,316
1988	C	1,236	1,214	1,201	1,201	1,173	1,137	1,090	1,015	948	869	795	742
1989	C	698	674	662	661	642	700	703	690	680	636	594	581
1990	C	583	585	600	613	596	604	580	521	473	409	363	338
1991	C	310	301	312	307	280	317	328	320	289	238	190	182
1992	C	165	163	178	187	222	230	222	169	130	91	55	50
1993	W	40	39	56	207	301	415	468	580	648	645	614	598
1994	C	601	619	651	682	664	628	600	540	486	409	340	305
1995	W	278	278	305	490	577	831	972	1,215	1,452	1,610	1,593	1,591
1996	W	1,563	1,573	1,608	1,688	1,835	2,010	2,058	2,172	2,184	2,094	2,009	1,959
1997	W	1,910	1,932	1,970	1,970	1,970	2,030	2,045	2,090	2,063	1,969	1,878	1,844
1998	W	1,791	1,802	1,830	1,942	1,970	2,030	2,095	2,148	2,333	2,300	2,124	1,987
1999	AN	1,912	1,912	1,913	1,917	1,970	2,030	2,065	2,094	2,116	2,026	1,941	1,895
2000	AN	1,852	1,851	1,861	1,911	1,970	2,030	2,042	2,036	2,016	1,919	1,839	1,804
2001	D	1,750	1,766	1,798	1,809	1,817	1,832	1,803	1,745	1,636	1,521	1,417	1,354
2002	D	1,286	1,279	1,311	1,353	1,356	1,397	1,389	1,346	1,274	1,177	1,093	1,052
2003	BN	1,007	1,015	1,062	1,109	1,118	1,138	1,143	1,143	1,150	1,077	1,009	974

Table 8. LSJR Alternative 2 Monthly Average Flow at Ripon on the Stanislaus River in cfs and February–June Flow Volume in TAF

YEAR	WYT	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	Feb-Jun [TAF]
1922	W	1,377	443	447	335	385	335	571	1,610	1,357	377	439	436	256
1923	AN	1,207	444	493	356	514	774	696	1,158	541	511	456	493	221
1924	C	1,341	367	311	280	1,010	1,067	913	555	345	404	428	423	233
1925	BN	1,009	439	395	297	551	390	877	1,158	578	442	439	434	212
1926	D	1,066	369	311	267	555	625	726	452	327	454	439	434	160
1927	AN	1,007	505	338	314	583	436	897	1,080	823	426	439	434	228
1928	BN	1,076	431	387	295	724	823	719	781	233	441	439	434	197
1929	C	1,060	302	280	295	944	804	775	638	329	421	428	423	207
1930	C	993	313	250	308	822	518	618	550	447	435	428	423	175
1931	C	528	293	246	187	973	963	313	299	405	418	404	375	174
1932	AN	506	296	432	215	459	381	686	1,252	1,005	408	439	434	227
1933	D	537	356	291	220	1,026	944	617	579	692	434	367	386	229
1934	C	525	291	338	214	790	595	384	548	332	405	404	375	157
1935	AN	504	302	289	230	503	288	1,059	1,233	837	554	439	434	234
1936	AN	550	290	256	250	716	501	968	1,080	649	476	439	437	235
1937	W	1,012	356	353	314	396	403	645	1,337	561	476	439	434	201
1938	W	1,066	404	427	321	634	781	1,022	1,808	1,558	2,071	1,877	1,925	348
1939	D	1,396	547	471	420	941	837	602	451	455	438	439	449	194
1940	AN	1,204	266	225	371	602	859	864	1,125	521	511	456	486	239
1941	W	1,260	475	459	454	389	524	618	1,408	783	632	469	469	224
1942	W	1,271	678	474	1,639	1,914	342	837	1,151	1,086	1,443	1,614	1,779	313
1943	W	1,363	573	459	2,366	2,310	3,074	1,028	904	660	615	593	784	473
1944	BN	1,364	572	584	543	894	515	970	842	413	480	461	441	217
1945	AN	1,224	378	385	390	659	316	699	1,083	773	568	517	523	210
1946	AN	1,256	353	225	552	817	728	800	995	454	450	481	497	226
1947	D	1,212	343	347	404	1,053	815	557	592	315	437	393	394	197
1948	BN	1,026	432	383	362	961	925	524	1,028	830	506	439	404	256
1949	BN	980	367	355	318	994	597	652	901	387	455	409	380	209

YEAR	WYT	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	Feb-Jun [TAF]
1950	BN	954	411	421	338	393	726	857	1,103	652	447	405	409	224
1951	AN	952	461	534	573	407	413	943	680	383	444	400	361	169
1952	W	1,105	331	272	312	369	768	1,123	1,919	3,897	2,446	1,837	1,709	485
1953	BN	1,347	525	514	759	1,198	1,037	702	625	776	616	451	480	257
1954	BN	1,239	342	333	351	679	472	887	849	302	436	393	356	190
1955	D	996	322	355	475	846	909	766	745	497	443	357	359	224
1956	W	1,005	381	370	762	355	394	723	1,288	1,019	613	484	463	227
1957	BN	1,212	325	312	342	774	738	881	914	635	449	439	431	235
1958	W	1,218	369	353	327	421	559	948	1,847	1,445	1,800	1,806	1,719	314
1959	D	1,302	450	493	434	1,105	1,157	566	533	231	422	401	435	213
1960	C	1,162	337	316	343	708	664	541	511	239	406	384	341	159
1961	C	920	354	356	326	937	925	363	390	192	361	382	312	166
1962	BN	421	373	377	210	342	247	911	816	692	451	411	403	180
1963	AN	522	393	353	258	778	418	524	1,356	736	498	451	437	227
1964	D	1,021	348	286	347	947	1,011	694	595	356	425	379	383	216
1965	W	495	388	250	369	371	626	800	995	823	436	513	479	217
1966	BN	1,248	374	351	386	1,079	883	689	543	405	440	361	350	213
1967	W	991	299	288	276	473	638	592	1,604	1,650	948	582	670	297
1968	D	1,424	351	379	380	1,249	948	842	524	283	431	386	371	229
1969	W	1,059	319	339	422	1,478	1,983	1,163	2,609	3,903	2,004	1,721	1,745	666
1970	AN	1,450	537	905	4,835	2,061	1,251	1,025	829	578	468	480	559	338
1971	BN	1,262	269	280	336	678	1,007	779	777	702	568	493	536	236
1972	D	1,440	248	200	349	720	491	790	764	255	448	378	368	181
1973	AN	992	391	397	304	461	410	709	1,356	565	448	452	503	210
1974	W	1,076	284	273	263	1,037	1,392	830	1,210	1,048	557	926	1,812	329
1975	W	1,354	370	478	593	1,343	1,134	1,271	1,304	1,116	589	582	603	367
1976	C	1,157	471	297	368	889	1,037	1,106	461	507	429	347	328	239
1977	C	957	324	313	286	816	772	827	672	150	303	355	241	192
1978	W	473	263	275	256	389	725	877	1,278	1,015	546	459	479	257

YEAR	WYT	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	Feb-Jun [TAF]
1979	AN	1,118	468	411	219	389	520	711	1,252	477	459	450	430	201
1980	W	1,201	372	250	226	894	442	679	1,044	1,357	690	646	756	264
1981	D	1,381	576	496	503	941	778	564	537	192	442	372	393	178
1982	W	1,056	294	322	381	2,124	3,156	2,318	1,434	1,355	1,801	1,967	3,096	619
1983	W	2,256	2,519	3,187	4,124	3,524	5,846	716	1,639	5,543	4,507	2,693	3,113	1,028
1984	AN	1,830	3,321	5,140	2,085	922	1,171	528	966	497	628	668	813	245
1985	D	1,419	471	356	461	1,024	622	692	556	387	437	380	460	194
1986	W	1,095	428	356	304	1,995	4,778	850	976	723	632	466	698	558
1987	C	1,353	501	601	483	958	786	970	748	429	415	355	309	231
1988	C	958	287	320	289	763	646	359	270	191	346	373	303	133
1989	C	483	339	358	186	690	589	786	527	316	357	384	410	173
1990	C	434	349	339	179	785	470	450	283	171	338	382	274	127
1991	C	524	530	311	202	675	263	326	595	356	343	381	245	131
1992	C	477	404	288	209	503	579	457	309	216	236	185	9	124
1993	W	103	126	265	351	389	761	837	1,324	1,355	288	368	434	280
1994	C	360	338	323	158	901	688	356	517	150	329	368	252	154
1995	W	394	300	314	541	360	1,350	928	1,574	1,546	418	418	397	347
1996	W	1,115	361	363	343	960	699	857	1,226	878	528	542	542	277
1997	W	1,198	655	2,957	10,528	3,675	1,665	605	751	370	452	421	421	411
1998	W	1,208	257	247	324	4,354	1,849	823	1,109	1,718	2,128	2,230	2,231	575
1999	AN	1,718	823	1,083	1,527	2,440	1,166	581	1,203	723	495	518	544	359
2000	AN	1,178	350	341	453	1,202	926	746	950	430	435	385	401	254
2001	D	1,100	264	243	308	702	312	450	651	543	412	301	313	157
2002	D	919	311	377	314	572	339	716	703	326	406	365	343	158
2003	BN	867	282	311	243	647	462	521	1,057	608	435	337	307	197

Table 9. LSJR Alternative 2 End-of-Month Storage at New Don Pedro on the Tuolumne River in TAF from 1922–2003

YEAR	WYT	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1922	W	1,314	1,300	1,325	1,364	1,550	1,687	1,718	1,930	2,030	1,935	1,806	1,740
1923	AN	1,689	1,690	1,690	1,690	1,690	1,690	1,718	1,787	1,851	1,764	1,604	1,530
1924	C	1,472	1,459	1,447	1,426	1,449	1,454	1,424	1,326	1,197	1,044	909	841
1925	BN	807	819	881	923	1,084	1,182	1,350	1,500	1,645	1,614	1,533	1,500
1926	D	1,471	1,467	1,474	1,475	1,554	1,646	1,718	1,723	1,631	1,468	1,329	1,263
1927	AN	1,218	1,255	1,299	1,336	1,497	1,592	1,705	1,856	2,030	1,972	1,846	1,773
1928	BN	1,690	1,690	1,690	1,690	1,690	1,690	1,718	1,870	1,813	1,628	1,469	1,390
1929	C	1,328	1,317	1,312	1,296	1,321	1,352	1,367	1,345	1,377	1,244	1,124	1,058
1930	C	1,014	1,003	1,042	1,064	1,123	1,188	1,209	1,225	1,298	1,200	1,110	1,067
1931	C	1,037	1,039	1,077	1,080	1,129	1,138	1,097	1,017	928	808	711	671
1932	AN	638	631	809	952	1,183	1,319	1,401	1,498	1,621	1,639	1,560	1,521
1933	D	1,477	1,459	1,463	1,455	1,501	1,526	1,568	1,567	1,564	1,437	1,312	1,251
1934	C	1,201	1,193	1,214	1,248	1,320	1,427	1,419	1,353	1,269	1,131	1,018	968
1935	AN	935	946	984	1,148	1,285	1,387	1,594	1,690	1,854	1,783	1,675	1,617
1936	AN	1,572	1,566	1,560	1,619	1,690	1,690	1,718	1,802	1,944	1,829	1,668	1,582
1937	W	1,515	1,499	1,494	1,487	1,690	1,690	1,718	1,788	1,952	1,821	1,678	1,602
1938	W	1,545	1,537	1,689	1,688	1,690	1,690	1,718	1,936	2,030	1,901	1,751	1,672
1939	D	1,613	1,615	1,628	1,627	1,678	1,690	1,712	1,678	1,554	1,373	1,222	1,154
1940	AN	1,127	1,124	1,189	1,341	1,593	1,690	1,718	1,799	1,943	1,796	1,665	1,594
1941	W	1,542	1,532	1,636	1,690	1,690	1,690	1,718	1,745	1,938	1,805	1,642	1,556
1942	W	1,489	1,482	1,564	1,560	1,690	1,690	1,718	1,912	2,030	1,915	1,766	1,683
1943	W	1,619	1,654	1,690	1,690	1,690	1,690	1,718	1,926	2,030	1,897	1,735	1,645
1944	BN	1,582	1,570	1,559	1,550	1,638	1,690	1,702	1,771	1,787	1,658	1,515	1,441
1945	AN	1,391	1,437	1,482	1,507	1,690	1,690	1,718	1,762	1,922	1,860	1,709	1,623
1946	AN	1,596	1,627	1,646	1,645	1,690	1,690	1,718	1,736	1,784	1,602	1,435	1,349
1947	D	1,288	1,305	1,336	1,346	1,400	1,451	1,452	1,530	1,462	1,315	1,187	1,127
1948	BN	1,104	1,104	1,141	1,149	1,157	1,245	1,342	1,412	1,523	1,443	1,339	1,292
1949	BN	1,255	1,248	1,246	1,238	1,272	1,456	1,533	1,588	1,590	1,461	1,347	1,296
1950	BN	1,254	1,250	1,251	1,282	1,444	1,582	1,675	1,697	1,779	1,658	1,542	1,483

YEAR	WYT	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1951	AN	1,457	1,690	1,690	1,690	1,690	1,690	1,718	1,640	1,622	1,450	1,294	1,214
1952	W	1,162	1,167	1,286	1,517	1,690	1,690	1,718	2,002	2,030	1,910	1,776	1,706
1953	BN	1,646	1,634	1,650	1,690	1,690	1,690	1,707	1,727	1,830	1,766	1,613	1,536
1954	BN	1,483	1,482	1,483	1,488	1,541	1,658	1,718	1,866	1,855	1,697	1,555	1,487
1955	D	1,436	1,434	1,451	1,484	1,540	1,626	1,651	1,653	1,568	1,410	1,268	1,200
1956	W	1,155	1,151	1,690	1,690	1,690	1,690	1,718	1,782	2,030	1,897	1,737	1,652
1957	BN	1,596	1,585	1,579	1,571	1,634	1,690	1,678	1,742	1,886	1,733	1,590	1,515
1958	W	1,468	1,463	1,478	1,500	1,655	1,690	1,718	2,002	2,030	1,919	1,784	1,715
1959	D	1,653	1,636	1,616	1,641	1,690	1,690	1,710	1,668	1,546	1,365	1,210	1,156
1960	C	1,102	1,096	1,121	1,118	1,247	1,314	1,367	1,380	1,293	1,173	1,076	1,033
1961	C	1,002	1,000	1,085	1,091	1,114	1,117	1,088	1,015	921	809	717	676
1962	BN	643	637	664	671	870	990	1,075	1,224	1,469	1,466	1,405	1,381
1963	AN	1,364	1,363	1,380	1,425	1,606	1,641	1,718	1,907	2,030	1,996	1,868	1,773
1964	D	1,690	1,690	1,690	1,690	1,690	1,690	1,704	1,689	1,621	1,445	1,293	1,220
1965	W	1,173	1,194	1,618	1,690	1,690	1,690	1,718	1,734	1,800	1,783	1,658	1,569
1966	BN	1,503	1,575	1,572	1,569	1,664	1,690	1,704	1,760	1,635	1,464	1,316	1,249
1967	W	1,200	1,231	1,382	1,481	1,569	1,690	1,718	2,002	2,030	1,921	1,806	1,730
1968	D	1,672	1,657	1,654	1,655	1,690	1,690	1,670	1,690	1,607	1,423	1,273	1,195
1969	W	1,145	1,171	1,258	1,690	1,690	1,690	1,718	2,002	2,030	1,896	1,746	1,663
1970	AN	1,606	1,608	1,629	1,626	1,690	1,690	1,697	1,782	1,813	1,671	1,525	1,448
1971	BN	1,391	1,431	1,516	1,580	1,652	1,690	1,704	1,763	1,865	1,758	1,618	1,550
1972	D	1,499	1,508	1,552	1,602	1,662	1,690	1,668	1,673	1,647	1,478	1,339	1,270
1973	AN	1,225	1,235	1,315	1,443	1,629	1,690	1,718	1,949	2,030	1,875	1,739	1,668
1974	W	1,620	1,690	1,688	1,686	1,690	1,690	1,718	1,929	2,030	1,879	1,719	1,638
1975	W	1,580	1,570	1,570	1,573	1,690	1,690	1,718	1,795	2,030	1,909	1,767	1,690
1976	C	1,629	1,638	1,655	1,629	1,636	1,637	1,581	1,445	1,299	1,122	983	919
1977	C	874	866	885	870	876	856	806	741	652	556	481	448
1978	W	420	417	473	625	791	994	1,159	1,433	1,881	2,030	1,973	1,773
1979	AN	1,690	1,690	1,690	1,690	1,690	1,690	1,718	1,974	2,030	1,854	1,693	1,614
1980	W	1,563	1,563	1,581	1,690	1,690	1,690	1,718	1,914	2,030	1,955	1,807	1,733

YEAR	WYT	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1981	D	1,669	1,652	1,646	1,651	1,690	1,690	1,718	1,689	1,610	1,432	1,291	1,223
1982	W	1,187	1,291	1,439	1,642	1,690	1,690	1,718	2,002	2,030	1,929	1,801	1,667
1983	W	1,593	1,620	1,617	1,614	1,690	1,690	1,718	2,002	2,030	2,030	1,900	1,764
1984	AN	1,690	1,690	1,687	1,685	1,690	1,690	1,687	1,734	1,786	1,639	1,475	1,388
1985	D	1,338	1,370	1,412	1,400	1,454	1,525	1,536	1,619	1,560	1,414	1,296	1,245
1986	W	1,217	1,236	1,310	1,376	1,690	1,690	1,718	2,002	2,030	1,962	1,833	1,773
1987	C	1,690	1,674	1,659	1,629	1,642	1,669	1,619	1,513	1,387	1,207	1,059	986
1988	C	941	939	976	1,028	1,090	1,102	1,058	992	934	827	739	699
1989	C	668	674	706	735	776	873	946	1,085	1,148	1,062	993	975
1990	C	988	990	1,016	1,028	1,074	1,102	1,075	1,054	1,012	901	808	768
1991	C	735	732	756	754	746	809	846	892	990	933	877	855
1992	C	841	843	870	883	960	1,004	1,010	1,068	1,017	958	875	829
1993	W	799	793	838	1,051	1,198	1,392	1,494	1,796	2,030	1,971	1,883	1,773
1994	C	1,690	1,676	1,667	1,663	1,684	1,689	1,635	1,564	1,468	1,296	1,155	1,085
1995	W	1,029	1,045	1,087	1,342	1,429	1,690	1,718	2,002	2,030	1,984	1,887	1,773
1996	W	1,690	1,671	1,690	1,690	1,690	1,690	1,718	2,002	2,030	1,897	1,735	1,656
1997	W	1,592	1,631	1,628	1,625	1,690	1,690	1,691	1,915	1,981	1,833	1,684	1,631
1998	W	1,568	1,559	1,559	1,690	1,690	1,690	1,718	1,872	2,030	1,939	1,798	1,716
1999	AN	1,654	1,664	1,677	1,673	1,690	1,690	1,718	1,765	1,921	1,778	1,624	1,548
2000	AN	1,483	1,473	1,459	1,533	1,690	1,690	1,718	1,924	2,001	1,837	1,694	1,625
2001	D	1,572	1,561	1,552	1,543	1,574	1,651	1,645	1,737	1,614	1,450	1,312	1,248
2002	D	1,204	1,213	1,285	1,340	1,389	1,420	1,428	1,568	1,587	1,448	1,331	1,276
2003	BN	1,240	1,275	1,332	1,399	1,442	1,468	1,512	1,583	1,701	1,569	1,453	1,400

Table 10. LSJR Alternative 2 Monthly Average Flow at Modesto on the Tuolumne River in cfs and February–June Flow Volume in TAF

YEAR	WYT	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	Feb-Jun [TAF]
1922	W	1,872	711	770	603	681	589	2,807	2,335	8,284	1,913	566	579	878
1923	AN	719	645	1,925	1,995	1,867	1,126	2,102	1,695	1,072	575	566	587	466
1924	C	732	605	580	579	200	200	467	680	200	331	342	353	105
1925	BN	428	442	440	427	817	540	1,176	1,750	1,183	380	389	408	327
1926	D	547	500	476	464	364	416	1,397	989	299	379	389	405	208
1927	AN	479	449	452	456	803	520	1,183	1,477	2,289	556	568	811	374
1928	BN	1,279	1,120	1,165	690	1,467	3,545	1,383	1,457	514	378	388	410	505
1929	C	547	495	477	468	200	322	497	1,229	756	333	341	363	181
1930	C	459	466	438	436	252	478	827	894	961	344	351	368	205
1931	C	456	453	449	437	200	215	518	680	200	334	344	354	109
1932	AN	424	437	430	427	834	559	823	1,704	1,791	577	568	578	343
1933	D	736	630	591	582	200	267	575	816	1,432	384	393	414	197
1934	C	482	471	451	434	324	488	625	485	319	331	341	353	134
1935	AN	435	445	437	436	385	446	1,563	1,727	1,718	562	565	587	350
1936	AN	733	609	597	593	5,672	3,418	2,635	1,691	1,311	611	565	582	875
1937	W	732	621	600	590	1,973	4,060	2,536	2,062	1,341	555	566	586	717
1938	W	732	618	1,922	1,613	6,992	7,268	4,003	2,342	7,631	3,684	572	597	1,671
1939	D	931	650	602	593	216	1,245	948	703	249	384	397	412	203
1940	AN	482	470	440	434	869	3,840	3,344	1,857	1,170	625	514	528	669
1941	W	640	526	755	2,678	4,922	4,375	2,568	2,157	1,798	2,545	618	547	935
1942	W	689	574	648	3,278	1,038	2,271	2,825	1,535	5,076	3,292	735	704	762
1943	W	814	641	785	3,638	3,166	5,681	2,820	1,610	1,714	1,073	501	436	894
1944	BN	753	584	626	650	278	1,065	551	1,483	897	414	405	359	259
1945	AN	526	453	389	529	2,521	3,515	1,868	1,480	1,553	688	634	572	651
1946	AN	684	466	3,746	2,702	2,133	2,788	1,655	1,587	891	637	600	580	539
1947	D	660	576	675	615	288	442	645	1,145	373	322	352	345	174
1948	BN	480	454	398	393	200	237	743	1,418	1,459	489	407	344	244
1949	BN	519	468	412	519	200	400	1,069	1,421	807	354	359	343	235

YEAR	WYT	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	Feb-Jun [TAF]
1950	BN	525	475	463	686	447	416	1,106	1,522	1,072	395	379	370	274
1951	AN	513	3,234	8,050	3,795	3,629	2,441	869	1,213	864	422	399	370	529
1952	W	461	400	475	846	907	3,412	3,243	3,843	6,317	3,733	617	591	1,067
1953	BN	680	479	517	1,293	1,186	1,298	907	842	1,391	519	433	400	334
1954	BN	460	400	391	397	367	693	1,434	1,457	622	373	379	369	275
1955	D	468	385	420	702	220	270	484	1,194	981	338	352	341	189
1956	W	395	372	795	7,363	4,081	3,125	1,545	1,821	2,796	2,933	681	574	797
1957	BN	697	478	491	518	447	870	581	1,236	1,361	399	408	405	270
1958	W	489	380	432	561	637	4,246	4,397	3,196	6,716	2,724	672	646	1,154
1959	D	753	519	581	624	1,874	1,757	753	755	467	349	333	366	331
1960	C	461	364	307	362	414	485	800	989	548	275	295	321	195
1961	C	310	330	282	337	200	231	555	716	410	236	256	235	127
1962	BN	298	314	323	314	839	452	1,307	1,177	1,499	358	396	408	314
1963	AN	464	273	315	425	1,113	364	1,040	1,737	3,164	527	500	998	441
1964	D	1,099	1,180	632	824	774	456	568	1,051	756	256	268	280	216
1965	W	343	266	234	4,390	3,453	2,865	2,742	1,460	1,600	543	565	717	716
1966	BN	585	491	2,109	1,104	270	775	1,005	1,155	289	246	242	242	211
1967	W	389	267	318	582	414	1,666	2,851	2,163	8,549	6,505	589	674	937
1968	D	645	449	485	515	1,004	1,307	629	937	474	350	338	330	261
1969	W	398	367	288	1,513	5,366	3,477	3,916	6,054	8,595	3,812	459	508	1,629
1970	AN	1,216	761	1,146	5,994	1,356	2,641	541	1,337	1,129	432	360	426	419
1971	BN	673	503	532	524	339	1,153	652	1,135	1,405	333	350	358	282
1972	D	515	322	524	367	271	726	524	1,119	739	276	286	284	204
1973	AN	315	451	522	524	670	1,810	1,005	2,130	1,518	484	509	512	430
1974	W	560	833	2,027	2,864	1,585	3,291	1,697	1,825	2,533	1,039	475	657	654
1975	W	1,068	1,088	789	643	933	3,193	2,086	1,893	2,770	1,262	558	569	654
1976	C	1,352	812	584	543	200	231	336	680	200	245	278	280	99
1977	C	284	309	322	295	200	200	266	345	353	170	167	153	81
1978	W	217	243	251	432	706	1,077	1,190	1,958	2,228	842	446	4,008	429

YEAR	WYT	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	Feb-Jun [TAF]
1979	AN	1,161	788	648	2,632	3,566	3,765	1,041	2,036	1,203	547	625	516	688
1980	W	609	813	877	5,467	6,674	3,280	1,775	1,617	4,170	3,500	567	697	1,039
1981	D	743	775	519	693	272	1,543	898	1,067	508	321	348	341	259
1982	W	439	421	600	685	5,737	5,097	7,800	4,279	6,332	3,679	592	2,367	1,736
1983	W	3,175	3,152	5,340	5,281	5,286	9,186	2,693	3,110	13,584	7,143	2,862	2,080	2,018
1984	AN	1,513	5,945	7,476	4,168	3,234	2,940	682	1,743	1,109	558	597	599	581
1985	D	743	974	430	489	248	410	1,015	1,109	454	340	367	359	195
1986	W	334	363	356	284	4,402	7,671	2,314	1,776	5,485	648	541	744	1,290
1987	C	1,701	1,300	566	596	200	322	652	660	218	256	265	253	123
1988	C	242	259	254	305	200	342	534	693	329	175	190	177	127
1989	C	194	220	245	244	220	927	1,039	1,044	696	187	203	212	237
1990	C	215	245	232	236	200	423	739	592	336	199	221	212	138
1991	C	214	239	223	208	200	546	605	1,093	992	183	201	188	207
1992	C	210	239	217	224	323	374	773	615	200	169	174	175	137
1993	W	213	208	217	781	580	1,038	1,126	2,052	2,034	2,059	326	1,514	410
1994	C	1,254	448	413	399	200	351	655	894	400	188	201	186	151
1995	W	230	218	223	518	576	4,774	3,862	3,243	10,748	8,340	1,781	1,507	1,394
1996	W	1,133	451	530	1,684	5,863	4,379	2,133	1,874	2,923	794	483	533	1,023
1997	W	592	525	6,295	17,734	2,467	3,255	931	1,763	1,129	499	486	486	568
1998	W	693	337	431	1,359	7,183	4,573	2,814	1,552	8,435	6,736	517	560	1,445
1999	AN	962	506	695	2,008	4,611	3,408	1,882	1,851	1,465	497	501	506	779
2000	AN	591	442	344	433	2,173	3,332	1,293	1,753	1,082	488	691	721	579
2001	D	692	465	418	518	216	582	763	1,327	200	293	314	300	187
2002	D	322	243	383	427	284	459	1,012	1,210	750	279	326	296	223
2003	BN	315	247	294	264	234	403	733	1,691	1,250	228	283	269	260

Table 11. LSJR Alternative 2 End-of-Month Storage at New Exchequer on the Merced River in TAF from 1922–2003

YEAR	WYT	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1922	W	469	456	483	506	664	735	767	919	1,024	926	795	731
1923	AN	675	674	675	675	675	702	765	894	922	853	710	631
1924	C	596	589	581	576	589	587	585	561	451	335	241	199
1925	BN	176	181	186	191	295	358	486	658	716	693	652	630
1926	D	614	607	603	597	648	678	744	707	669	617	554	513
1927	AN	486	474	479	468	489	524	542	683	737	728	724	749
1928	BN	675	670	675	675	675	673	669	726	706	662	630	631
1929	C	617	603	590	579	596	609	609	579	532	506	489	460
1930	C	434	421	408	396	397	381	393	384	371	372	375	376
1931	C	355	346	336	330	349	363	378	387	322	236	166	137
1932	AN	116	104	166	199	350	411	483	638	768	758	706	681
1933	D	661	648	638	639	649	673	686	694	730	626	519	473
1934	C	446	434	435	452	499	545	571	544	481	380	298	260
1935	AN	237	241	248	313	363	433	615	793	923	880	816	785
1936	AN	675	667	659	675	675	735	835	964	974	889	743	671
1937	W	620	609	613	620	675	735	812	970	1,021	908	768	699
1938	W	666	657	675	675	675	735	845	970	1,024	905	760	690
1939	D	650	654	656	654	675	725	793	785	696	577	470	426
1940	AN	412	401	391	502	625	733	845	970	994	907	814	751
1941	W	675	663	675	675	675	735	818	970	1,024	906	762	693
1942	W	651	650	663	663	675	735	826	950	1,024	906	763	695
1943	W	661	674	674	674	675	735	845	970	995	894	747	678
1944	BN	643	631	623	627	675	733	745	847	857	773	677	629
1945	AN	599	617	632	641	675	735	804	933	982	868	725	657
1946	AN	618	630	630	630	667	728	815	942	933	838	743	699
1947	D	669	675	675	675	675	712	738	774	699	578	470	422
1948	BN	399	393	384	380	389	407	456	573	670	614	543	505
1949	BN	483	470	462	457	479	535	611	721	725	638	556	521
1950	BN	496	484	474	496	552	587	679	771	792	705	617	577

YEAR	WYT	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1951	AN	555	675	675	675	675	735	791	841	823	721	617	567
1952	W	539	531	574	640	675	735	845	970	1,024	909	769	699
1953	BN	666	657	669	675	675	697	740	749	765	680	574	525
1954	BN	496	484	474	477	522	592	694	801	777	688	595	557
1955	D	530	518	518	531	553	571	580	665	678	587	496	457
1956	W	431	417	675	675	675	735	807	959	1,024	904	760	690
1957	BN	652	647	639	637	675	715	735	804	842	741	639	590
1958	W	562	554	559	576	670	735	845	970	1,024	917	786	720
1959	D	675	662	650	655	675	708	752	753	681	560	452	423
1960	C	400	385	371	363	418	460	525	586	561	481	409	378
1961	C	355	345	343	335	351	366	399	421	387	308	238	208
1962	BN	185	171	165	158	310	396	542	668	787	776	729	704
1963	AN	675	661	650	675	675	720	779	907	977	912	818	770
1964	D	675	675	675	675	675	681	689	712	666	552	444	398
1965	W	366	368	575	642	675	713	792	904	991	950	803	735
1966	BN	675	675	675	675	675	715	789	845	772	654	551	508
1967	W	483	479	575	619	668	735	845	970	1,024	914	777	711
1968	D	675	665	662	663	675	704	732	746	681	556	452	409
1969	W	382	388	410	675	675	735	845	970	1,024	903	759	688
1970	AN	642	645	654	654	675	735	762	855	853	755	657	613
1971	BN	588	591	626	659	675	709	737	803	846	762	668	625
1972	D	601	592	615	624	660	711	733	788	767	656	559	524
1973	AN	509	504	521	573	675	735	797	970	1,024	916	782	717
1974	W	669	675	675	675	675	735	815	970	1,024	899	754	684
1975	W	640	631	630	641	675	735	773	932	1,024	906	761	689
1976	C	647	652	650	640	655	663	655	641	545	423	328	292
1977	C	270	251	237	223	222	213	205	187	162	98	44	19
1978	W	-	-	17	113	261	428	597	854	1,024	978	894	837
1979	AN	675	675	669	675	675	735	793	969	978	876	742	673
1980	W	634	624	623	646	675	735	821	962	1,024	906	763	695

YEAR	WYT	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1981	D	661	642	631	633	658	696	739	784	732	620	523	482
1982	W	458	486	532	646	675	735	845	970	1,024	910	769	690
1983	W	646	658	658	658	675	735	821	970	1,024	909	766	690
1984	AN	638	664	664	664	675	735	789	919	905	819	726	683
1985	D	660	666	671	672	675	707	771	817	752	635	531	489
1986	W	467	464	478	505	675	735	845	970	1,024	926	799	733
1987	C	675	658	644	633	650	668	694	688	604	489	394	355
1988	C	325	321	315	325	341	371	408	433	404	335	272	247
1989	C	223	212	208	202	218	293	386	440	430	378	336	322
1990	C	314	309	300	299	315	347	395	402	359	289	225	197
1991	C	174	159	144	130	124	201	240	332	390	362	326	311
1992	C	291	285	278	274	329	362	430	453	402	356	304	288
1993	W	265	254	257	428	517	634	730	970	1,024	934	809	747
1994	C	675	661	651	645	668	678	686	683	619	495	396	347
1995	W	329	332	339	524	587	735	844	970	1,024	925	797	733
1996	W	675	662	671	675	675	735	829	970	982	884	740	669
1997	W	620	632	632	632	675	735	821	955	944	850	757	712
1998	W	675	666	665	675	675	735	845	954	1,024	908	766	691
1999	AN	656	655	668	668	675	714	754	891	902	795	691	644
2000	AN	612	602	590	630	675	735	806	948	939	827	726	678
2001	D	625	615	608	605	630	692	727	805	722	607	508	475
2002	D	443	436	467	493	519	551	621	695	669	566	476	435
2003	BN	405	418	434	458	482	518	559	702	742	657	579	538

Table 12. LSJR Alternative 2 Monthly Average Flow at Stevinson on the Merced River in cfs and February–June Flow Volume in TAF

YEAR	WYT	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	Feb-Jun [TAF]
1922	W	636	390	504	482	587	780	417	1,356	2,644	1,387	867	453	346
1923	AN	774	304	1,165	1,271	1,001	182	531	937	521	159	762	598	187
1924	C	593	385	382	396	150	150	225	296	150	54	36	49	58
1925	BN	282	419	425	428	382	250	605	849	494	116	77	54	154
1926	D	266	354	375	375	227	179	729	563	161	51	37	51	111
1927	AN	274	322	313	381	493	283	602	963	760	136	84	89	185
1928	BN	1,612	352	523	592	709	517	477	670	229	179	88	80	156
1929	C	296	387	387	408	150	153	262	628	326	49	54	92	91
1930	C	276	367	359	361	150	237	397	446	376	35	35	93	96
1931	C	276	385	372	382	150	150	249	299	150	87	41	75	60
1932	AN	266	363	475	469	528	257	440	904	844	109	57	58	178
1933	D	310	386	383	426	150	150	296	433	602	60	41	30	98
1934	C	298	383	405	466	162	211	309	182	150	85	36	29	61
1935	AN	282	389	409	580	180	280	924	1,047	867	182	100	55	198
1936	AN	1,791	410	385	564	4,601	459	736	973	548	108	807	441	429
1937	W	707	424	417	416	3,445	1,020	548	1,750	645	597	812	446	433
1938	W	442	401	2,111	1,341	4,912	4,482	955	3,190	4,463	2,238	1,159	596	1,067
1939	D	833	397	383	443	329	231	508	329	150	67	73	68	92
1940	AN	331	424	418	573	469	481	750	1,690	471	145	188	416	233
1941	W	1,159	427	1,508	1,341	3,103	1,576	531	2,452	2,282	1,749	1,069	508	587
1942	W	718	447	1,183	1,527	1,494	405	622	920	2,570	1,651	1,021	509	354
1943	W	494	549	783	2,172	1,962	3,068	949	1,076	511	534	941	490	451
1944	BN	475	459	436	414	190	263	269	813	447	172	136	88	120
1945	AN	357	489	446	441	2,982	694	524	859	692	878	937	421	334
1946	AN	840	640	1,862	1,067	150	267	649	852	383	170	129	81	139
1947	D	577	647	963	621	867	202	350	559	171	65	80	76	126
1948	BN	319	397	398	388	150	150	360	768	729	182	100	97	130
1949	BN	348	404	386	402	150	254	477	771	376	121	121	70	122

YEAR	WYT	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	Feb-Jun [TAF]
1950	BN	326	394	394	428	220	172	578	758	420	162	130	77	129
1951	AN	329	2,430	4,460	1,734	1,625	352	437	572	350	186	116	63	194
1952	W	347	417	460	1,986	702	1,659	753	3,620	3,086	1,942	1,231	621	593
1953	BN	450	428	334	1,143	717	150	403	397	531	140	126	55	129
1954	BN	360	405	403	406	173	322	571	725	249	167	131	81	123
1955	D	314	392	409	537	150	150	218	631	460	120	113	55	97
1956	W	311	386	1,927	4,363	1,968	477	518	1,038	2,106	1,954	1,152	610	362
1957	BN	580	422	409	411	214	205	296	651	592	195	154	81	117
1958	W	424	381	405	481	299	1,770	2,212	3,356	2,845	1,720	1,123	675	633
1959	D	719	395	382	395	792	179	397	364	171	107	116	94	111
1960	C	307	374	383	397	191	198	420	478	215	101	127	49	90
1961	C	286	365	387	372	150	150	282	309	150	70	55	40	62
1962	BN	264	341	359	360	573	241	665	670	689	253	182	78	168
1963	AN	572	362	376	394	3,195	198	440	872	706	277	194	158	311
1964	D	1,467	732	456	485	414	150	255	455	272	163	114	77	92
1965	W	346	356	528	1,780	633	224	555	842	813	309	1,448	634	182
1966	BN	918	1,069	813	1,055	708	211	534	592	158	206	165	79	130
1967	W	293	366	400	408	184	1,484	980	2,449	4,143	4,063	1,494	797	557
1968	D	822	411	330	382	733	156	316	394	168	196	177	130	105
1969	W	275	431	434	2,022	4,180	1,272	1,681	5,388	4,062	2,433	1,233	711	983
1970	AN	825	320	444	2,939	877	811	299	709	427	256	222	150	185
1971	BN	383	375	359	425	505	192	329	595	605	256	188	102	132
1972	D	359	386	423	270	150	267	269	543	323	240	222	18	94
1973	AN	309	412	432	474	1,087	976	440	2,161	869	600	1,038	574	331
1974	W	815	886	1,096	1,691	854	1,031	541	1,374	716	841	1,054	586	270
1975	W	667	350	409	307	1,617	991	329	1,015	2,266	1,163	1,062	533	368
1976	C	1,107	357	362	392	150	150	165	302	150	175	205	136	55
1977	C	354	311	322	373	150	150	150	150	155	106	81	44	45
1978	W	268	282	350	516	533	611	786	1,229	3,098	2,613	1,294	1,369	374

YEAR	WYT	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	Feb-Jun [TAF]
1979	AN	2,685	600	441	1,744	1,916	1,232	444	1,119	521	262	731	443	308
1980	W	698	374	392	3,976	4,008	1,393	578	930	2,062	2,284	1,248	583	530
1981	D	629	398	444	479	150	169	410	517	232	168	168	97	89
1982	W	401	405	414	484	3,153	2,048	4,357	3,327	1,884	2,249	1,390	1,170	877
1983	W	1,344	1,754	2,298	3,657	4,107	5,789	662	2,799	7,324	5,943	2,444	1,100	1,231
1984	AN	1,196	1,802	3,551	1,903	1,391	514	434	862	383	291	277	217	213
1985	D	580	338	334	488	704	192	494	556	192	236	206	100	126
1986	W	405	395	408	380	3,629	3,925	744	1,921	1,692	946	1,113	737	706
1987	C	1,028	416	418	381	150	150	319	309	150	130	135	87	64
1988	C	356	340	375	377	150	156	313	348	185	97	92	52	69
1989	C	256	274	322	304	150	312	538	429	245	68	62	67	101
1990	C	305	303	327	310	150	182	383	283	161	72	68	26	69
1991	C	248	258	274	292	150	312	272	598	487	91	54	10	110
1992	C	270	289	297	291	188	166	440	342	150	76	55	11	77
1993	W	206	313	350	684	360	511	608	1,258	2,389	1,492	1,085	640	307
1994	C	1,343	369	334	315	150	150	292	381	150	48	54	2	67
1995	W	239	327	317	611	252	3,209	692	2,954	5,242	4,891	1,700	509	746
1996	W	936	379	365	1,066	2,994	1,374	662	1,331	528	374	903	480	409
1997	W	613	845	3,494	9,912	1,363	1,199	568	904	383	149	114	84	262
1998	W	463	336	356	1,594	5,189	1,829	676	816	4,544	4,614	1,499	759	761
1999	AN	741	382	296	820	1,900	218	430	917	518	174	196	100	232
2000	AN	285	345	318	325	2,329	997	558	898	437	175	112	59	310
2001	D	668	496	392	389	150	280	363	699	150	74	84	25	99
2002	D	239	403	390	449	150	192	508	579	286	90	61	2	103
2003	BN	227	316	353	327	150	202	376	878	571	80	66	41	131

LSJR Alternative 3 (40% Unimpaired Flow)

Table 13. LSJR Alternative 3 End-of-Month Storage at New Melones on the Stanislaus River in TAF from 1922–2003

YEAR	WYT	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1922	W	954	964	994	1,027	1,110	1,160	1,174	1,323	1,469	1,446	1,382	1,340
1923	AN	1,273	1,284	1,350	1,413	1,451	1,465	1,473	1,531	1,545	1,501	1,417	1,370
1924	C	1,304	1,299	1,311	1,324	1,294	1,218	1,159	1,062	970	885	800	766
1925	BN	703	700	709	720	808	855	857	923	956	939	884	858
1926	D	804	802	806	810	858	874	878	840	792	723	663	631
1927	AN	585	595	645	688	774	815	872	944	994	958	907	890
1928	BN	843	871	894	910	950	1,046	1,047	1,101	1,067	994	927	894
1929	C	843	848	858	865	844	834	814	752	697	633	574	541
1930	C	493	491	490	508	522	564	551	510	510	467	422	395
1931	C	382	393	392	406	381	352	315	236	203	165	123	105
1932	AN	82	85	135	172	240	257	255	348	430	448	427	410
1933	D	400	399	406	422	386	375	365	337	327	287	250	228
1934	C	216	226	243	270	296	309	272	212	186	153	117	100
1935	AN	76	76	86	123	139	178	244	382	466	462	436	420
1936	AN	405	415	429	509	642	680	745	856	929	903	859	836
1937	W	790	794	806	827	897	972	983	1,087	1,126	1,076	1,018	986
1938	W	935	938	1,020	1,096	1,237	1,391	1,504	1,768	1,952	1,941	1,875	1,757
1939	D	1,691	1,683	1,686	1,697	1,687	1,685	1,630	1,541	1,464	1,370	1,280	1,223
1940	AN	1,151	1,143	1,148	1,247	1,326	1,403	1,473	1,571	1,571	1,496	1,423	1,378
1941	W	1,312	1,313	1,347	1,400	1,465	1,536	1,556	1,700	1,773	1,732	1,655	1,604
1942	W	1,537	1,535	1,578	1,668	1,734	1,774	1,800	1,890	1,977	1,945	1,849	1,794
1943	W	1,725	1,736	1,758	1,845	1,927	2,030	2,077	2,118	2,127	2,046	1,948	1,881
1944	BN	1,803	1,793	1,788	1,787	1,802	1,829	1,799	1,717	1,674	1,583	1,484	1,424
1945	AN	1,356	1,385	1,410	1,445	1,522	1,575	1,546	1,615	1,662	1,611	1,528	1,481
1946	AN	1,415	1,440	1,524	1,587	1,642	1,660	1,679	1,746	1,732	1,648	1,564	1,519
1947	D	1,452	1,471	1,491	1,505	1,515	1,527	1,490	1,402	1,343	1,252	1,169	1,128
1948	BN	1,075	1,067	1,065	1,068	1,037	1,034	1,026	985	1,044	999	939	909
1949	BN	858	865	874	881	864	896	875	865	860	802	749	718
1950	BN	664	651	652	699	749	795	772	845	916	879	833	807

YEAR	WYT	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1951	AN	758	1,029	1,417	1,524	1,607	1,675	1,695	1,733	1,702	1,616	1,533	1,483
1952	W	1,416	1,425	1,476	1,615	1,674	1,751	1,754	2,015	2,156	2,145	2,061	1,993
1953	BN	1,911	1,906	1,920	1,957	1,967	1,982	1,933	1,901	1,922	1,864	1,766	1,705
1954	BN	1,631	1,636	1,647	1,661	1,685	1,704	1,658	1,695	1,640	1,546	1,457	1,404
1955	D	1,345	1,347	1,362	1,392	1,392	1,395	1,372	1,279	1,245	1,162	1,085	1,036
1956	W	981	982	1,226	1,486	1,595	1,659	1,697	1,795	1,878	1,844	1,763	1,724
1957	BN	1,649	1,656	1,670	1,688	1,722	1,750	1,713	1,691	1,696	1,610	1,528	1,468
1958	W	1,372	1,380	1,385	1,434	1,490	1,585	1,699	1,931	2,045	2,012	1,933	1,878
1959	D	1,808	1,812	1,821	1,847	1,892	1,908	1,862	1,760	1,679	1,583	1,490	1,440
1960	C	1,366	1,364	1,367	1,371	1,409	1,428	1,394	1,319	1,258	1,169	1,090	1,030
1961	C	948	956	969	971	952	940	916	853	788	718	650	612
1962	BN	585	583	585	594	654	686	668	700	722	699	653	619
1963	AN	603	613	632	689	757	799	820	950	1,034	1,014	966	946
1964	D	899	927	947	981	980	976	964	908	873	807	750	706
1965	W	680	695	907	1,114	1,188	1,235	1,308	1,408	1,467	1,456	1,400	1,368
1966	BN	1,301	1,331	1,364	1,402	1,420	1,435	1,395	1,400	1,336	1,246	1,168	1,113
1967	W	1,056	1,062	1,141	1,243	1,300	1,351	1,429	1,583	1,815	1,897	1,836	1,796
1968	D	1,726	1,731	1,741	1,763	1,810	1,827	1,790	1,730	1,660	1,560	1,463	1,400
1969	W	1,344	1,365	1,374	1,670	1,840	1,963	2,083	2,306	2,413	2,300	2,130	1,990
1970	AN	1,921	1,921	1,931	1,936	1,970	2,030	2,032	2,029	2,019	1,913	1,806	1,750
1971	BN	1,680	1,704	1,770	1,826	1,861	1,895	1,882	1,887	1,899	1,827	1,731	1,675
1972	D	1,599	1,612	1,659	1,694	1,716	1,728	1,687	1,665	1,597	1,498	1,406	1,358
1973	AN	1,304	1,304	1,329	1,439	1,556	1,625	1,619	1,682	1,703	1,620	1,534	1,494
1974	W	1,441	1,483	1,558	1,672	1,737	1,815	1,896	1,979	2,011	1,940	1,847	1,793
1975	W	1,726	1,736	1,758	1,784	1,831	1,905	1,930	1,905	1,997	1,931	1,838	1,780
1976	C	1,712	1,731	1,750	1,758	1,748	1,723	1,666	1,568	1,452	1,345	1,248	1,186
1977	C	1,117	1,111	1,104	1,092	1,053	1,000	943	874	814	717	623	575
1978	W	523	506	520	599	655	715	756	819	885	901	857	858
1979	AN	806	815	832	901	989	1,066	1,080	1,149	1,137	1,067	1,003	975
1980	W	923	937	949	1,254	1,443	1,511	1,583	1,646	1,718	1,712	1,633	1,587

YEAR	WYT	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1981	D	1,533	1,528	1,539	1,578	1,568	1,588	1,550	1,470	1,378	1,285	1,204	1,166
1982	W	1,112	1,165	1,296	1,501	1,684	1,842	2,032	2,127	2,177	2,082	1,922	1,763
1983	W	1,686	1,691	1,691	1,696	1,883	2,030	2,065	2,165	2,420	2,300	2,130	1,967
1984	AN	1,909	1,914	1,913	1,917	1,970	2,030	2,020	2,021	1,999	1,910	1,821	1,771
1985	D	1,705	1,731	1,763	1,769	1,790	1,814	1,770	1,713	1,635	1,532	1,447	1,408
1986	W	1,359	1,363	1,378	1,456	1,822	2,030	2,068	2,097	2,119	2,039	1,962	1,931
1987	C	1,867	1,868	1,874	1,865	1,834	1,840	1,781	1,662	1,564	1,467	1,385	1,342
1988	C	1,263	1,241	1,229	1,229	1,214	1,198	1,145	1,064	1,003	937	874	826
1989	C	785	762	752	751	747	771	733	696	676	641	608	600
1990	C	603	607	623	636	631	637	594	528	481	429	394	376
1991	C	351	344	355	352	325	349	347	313	271	231	194	191
1992	C	177	177	192	202	238	255	226	166	142	116	91	93
1993	W	86	86	104	256	329	400	409	459	521	529	508	498
1994	C	504	523	556	588	584	570	532	456	410	349	296	270
1995	W	248	250	277	464	533	719	814	1,013	1,207	1,378	1,375	1,380
1996	W	1,355	1,367	1,402	1,484	1,577	1,714	1,721	1,774	1,784	1,710	1,640	1,599
1997	W	1,554	1,577	1,739	1,885	1,970	2,030	2,011	2,013	1,968	1,877	1,789	1,757
1998	W	1,705	1,716	1,744	1,857	1,970	2,030	2,049	2,037	2,180	2,214	2,042	1,907
1999	AN	1,834	1,834	1,836	1,840	1,950	2,030	2,033	1,993	1,976	1,890	1,810	1,767
2000	AN	1,724	1,724	1,735	1,784	1,838	1,893	1,865	1,806	1,767	1,677	1,603	1,572
2001	D	1,520	1,536	1,569	1,581	1,606	1,606	1,559	1,473	1,392	1,291	1,200	1,144
2002	D	1,080	1,074	1,107	1,150	1,165	1,192	1,154	1,088	1,016	941	877	847
2003	BN	808	818	866	915	940	956	943	897	888	835	787	764

Table 14. LSJR Alternative 3 Monthly Average Flow at Ripon on the Stanislaus River in cfs and February–June Flow Volume in TAF

YEAR	WYT	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	Feb-Jun [TAF]
1922	W	1,377	443	447	335	771	670	1,143	2,500	2,500	377	439	436	454
1923	AN	1,207	444	493	356	396	501	1,391	2,316	1,082	511	456	493	342
1924	C	1,341	367	311	280	924	1,020	471	553	345	404	428	423	198
1925	BN	1,009	439	395	297	1,102	781	1,754	2,316	1,156	442	439	434	425
1926	D	1,066	369	311	267	533	514	1,452	904	276	454	439	434	220
1927	AN	1,007	505	338	314	1,167	872	1,795	2,160	1,647	426	439	434	456
1928	BN	1,076	431	387	295	334	1,646	1,439	1,561	450	441	439	434	329
1929	C	1,060	302	280	295	848	329	672	1,275	659	421	428	423	225
1930	C	993	313	250	308	533	677	1,237	1,099	894	435	428	423	266
1931	C	528	293	246	187	848	729	625	598	276	418	404	375	182
1932	AN	506	296	432	215	918	761	1,371	2,500	2,010	408	439	434	455
1933	D	537	356	291	220	1,003	547	713	1,158	1,385	434	367	386	285
1934	C	525	291	338	214	324	657	672	449	282	405	404	375	143
1935	AN	504	302	289	230	339	455	2,117	2,466	1,674	554	439	434	424
1936	AN	550	290	256	250	1,433	1,002	1,936	2,160	1,297	476	439	437	469
1937	W	1,012	356	353	314	792	807	1,291	2,500	1,123	476	439	434	391
1938	W	1,066	404	427	321	1,268	1,561	2,044	2,500	2,500	718	556	1,925	590
1939	D	1,396	547	471	420	673	481	1,203	716	296	438	439	449	200
1940	AN	1,204	266	225	371	1,203	1,717	1,728	2,251	1,042	511	456	486	478
1941	W	1,260	475	459	454	778	1,047	1,237	2,500	1,566	632	469	469	428
1942	W	1,271	678	474	323	742	683	1,674	2,303	2,171	785	594	641	454
1943	W	1,363	573	459	1,148	850	2,391	2,057	1,808	1,284	615	593	629	504
1944	BN	1,364	572	584	543	452	449	672	1,685	827	480	461	441	246
1945	AN	1,224	378	385	390	1,318	631	1,398	2,166	1,546	568	517	523	420
1946	AN	1,256	353	225	552	477	748	1,600	1,991	907	450	481	497	344
1947	D	1,212	343	347	404	627	611	914	1,184	417	437	393	394	224
1948	BN	1,026	432	383	362	961	617	1,049	2,056	1,660	506	439	404	381
1949	BN	980	367	355	318	897	397	1,304	1,802	773	455	409	380	309

YEAR	WYT	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	Feb-Jun [TAF]
1950	BN	954	411	421	338	526	618	1,714	2,205	1,304	447	405	409	382
1951	AN	952	461	534	573	814	826	1,176	1,360	766	444	400	361	295
1952	W	1,105	331	272	312	737	924	2,245	2,500	2,487	887	639	781	535
1953	BN	1,347	525	514	759	920	572	1,405	1,249	1,553	616	451	480	339
1954	BN	1,239	342	333	351	317	943	1,775	1,698	605	436	393	356	322
1955	D	996	322	355	475	611	555	686	1,490	995	443	357	359	260
1956	W	1,005	381	370	762	709	787	1,371	2,500	1,902	613	484	463	438
1957	BN	1,212	325	312	342	439	755	914	1,828	1,270	449	439	431	313
1958	W	1,218	369	353	327	843	1,119	1,896	2,500	2,185	678	586	633	512
1959	D	1,302	450	493	434	475	591	995	748	457	422	401	435	195
1960	C	1,162	337	316	343	424	664	1,082	1,021	477	406	384	341	221
1961	C	920	354	356	326	806	648	726	781	383	361	382	312	199
1962	BN	421	373	377	210	684	494	1,822	1,633	1,385	451	411	403	360
1963	AN	522	393	353	258	1,556	436	1,049	2,500	1,472	498	451	437	417
1964	D	1,021	348	286	347	786	735	820	1,190	713	425	379	383	255
1965	W	495	388	250	369	742	651	1,600	1,991	1,647	436	513	479	397
1966	BN	1,248	374	351	386	728	657	1,378	1,086	276	440	361	350	246
1967	W	991	299	288	276	583	1,275	1,183	2,500	2,500	948	582	670	484
1968	D	1,424	351	379	380	661	585	968	1,047	471	431	386	371	224
1969	W	1,059	319	339	422	1,304	1,002	2,326	2,500	2,259	2,064	1,876	1,745	561
1970	AN	1,450	537	905	4,835	2,255	1,254	827	1,659	1,156	468	480	559	422
1971	BN	1,262	269	280	336	511	709	1,156	1,555	1,405	568	493	536	320
1972	D	1,440	248	200	349	363	982	834	1,529	511	448	378	368	255
1973	AN	992	391	397	304	922	820	1,418	2,500	1,129	448	452	503	407
1974	W	1,076	284	273	263	673	1,301	1,660	2,420	1,405	557	500	649	449
1975	W	1,354	370	478	349	511	930	827	2,500	2,232	589	582	603	421
1976	C	1,157	471	297	368	825	742	605	644	438	429	347	328	195
1977	C	957	324	313	286	816	772	503	286	242	303	355	241	155
1978	W	473	263	275	256	778	1,451	1,754	2,500	2,030	546	459	479	511

YEAR	WYT	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	Feb-Jun [TAF]
1979	AN	1,118	468	411	219	778	1,041	1,385	2,500	955	459	450	430	400
1980	W	1,201	372	250	226	1,787	885	1,358	2,088	1,802	690	646	756	474
1981	D	1,381	576	496	503	669	533	1,102	1,073	383	442	372	393	224
1982	W	1,056	294	322	381	2,370	1,646	2,500	2,500	1,687	1,679	1,967	3,096	636
1983	W	2,256	2,519	3,187	4,124	1,765	4,480	1,432	2,500	4,357	4,645	2,705	3,113	872
1984	AN	1,830	3,321	5,140	2,085	1,289	1,176	1,055	1,932	995	628	668	813	387
1985	D	1,419	471	356	461	688	514	1,385	1,112	356	437	380	460	242
1986	W	1,095	428	356	304	2,500	2,450	1,701	1,952	1,445	632	466	597	597
1987	C	1,353	501	601	483	892	384	699	611	192	415	355	309	164
1988	C	958	287	320	289	550	384	578	540	269	346	373	303	139
1989	C	483	339	358	186	455	1,177	1,573	1,054	632	357	384	410	294
1990	C	434	349	339	179	602	540	901	566	343	338	382	274	175
1991	C	524	530	311	202	675	527	652	1,190	713	343	381	245	224
1992	C	477	404	288	209	501	507	914	618	150	236	185	9	161
1993	W	103	126	265	351	778	1,522	1,674	2,500	1,620	288	368	434	487
1994	C	360	338	323	158	667	397	713	1,034	276	329	368	252	184
1995	W	394	300	314	541	720	2,500	1,855	2,500	2,500	418	418	397	607
1996	W	1,115	361	363	343	1,919	1,399	1,714	2,452	1,176	528	542	542	519
1997	W	1,198	655	966	8,184	2,143	1,681	1,210	1,503	739	452	421	421	431
1998	W	1,208	257	247	324	2,832	1,868	1,647	2,218	2,500	1,101	2,230	2,231	655
1999	AN	1,718	823	1,083	1,527	1,419	860	1,163	2,407	1,445	495	518	544	435
2000	AN	1,178	350	341	453	1,314	1,041	1,492	1,900	860	435	385	401	396
2001	D	1,100	264	243	308	413	625	901	1,301	302	412	301	313	213
2002	D	919	311	377	314	396	664	1,432	1,405	652	406	365	343	273
2003	BN	867	282	311	243	396	625	1,042	2,114	1,217	435	337	307	325

Table 15. LSJR Alternative 3 End-of-Month Storage at New Don Pedro on the Tuolumne River in TAF from 1922–2003

YEAR	WYT	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1922	W	1,314	1,300	1,325	1,364	1,515	1,623	1,718	1,879	2,030	1,960	1,853	1,773
1923	AN	1,690	1,690	1,690	1,690	1,690	1,690	1,718	1,708	1,733	1,676	1,543	1,482
1924	C	1,433	1,421	1,410	1,393	1,414	1,424	1,384	1,269	1,165	1,042	933	879
1925	BN	853	866	929	975	1,092	1,161	1,269	1,325	1,412	1,398	1,331	1,305
1926	D	1,281	1,277	1,285	1,288	1,352	1,431	1,461	1,444	1,372	1,256	1,157	1,112
1927	AN	1,079	1,118	1,165	1,207	1,328	1,402	1,467	1,558	1,711	1,691	1,598	1,556
1928	BN	1,517	1,548	1,584	1,594	1,651	1,690	1,718	1,813	1,759	1,615	1,490	1,429
1929	C	1,378	1,369	1,365	1,354	1,377	1,393	1,390	1,307	1,309	1,195	1,091	1,034
1930	C	994	984	1,024	1,048	1,096	1,138	1,123	1,103	1,138	1,062	992	960
1931	C	935	938	977	983	1,029	1,034	980	884	813	724	654	628
1932	AN	603	597	776	924	1,109	1,216	1,263	1,274	1,314	1,355	1,295	1,266
1933	D	1,228	1,211	1,216	1,211	1,261	1,285	1,324	1,315	1,270	1,195	1,114	1,078
1934	C	1,041	1,036	1,059	1,099	1,158	1,246	1,224	1,160	1,090	991	912	879
1935	AN	857	870	910	1,078	1,197	1,279	1,411	1,426	1,512	1,471	1,388	1,343
1936	AN	1,306	1,301	1,298	1,359	1,623	1,690	1,718	1,743	1,854	1,795	1,682	1,622
1937	W	1,569	1,556	1,554	1,553	1,690	1,690	1,718	1,716	1,818	1,707	1,581	1,515
1938	W	1,464	1,456	1,610	1,611	1,690	1,690	1,718	1,896	2,030	1,939	1,822	1,760
1939	D	1,690	1,690	1,690	1,690	1,690	1,690	1,670	1,611	1,492	1,334	1,202	1,145
1940	AN	1,124	1,122	1,188	1,342	1,547	1,690	1,718	1,718	1,814	1,692	1,582	1,523
1941	W	1,478	1,469	1,574	1,690	1,690	1,690	1,718	1,687	1,804	1,701	1,564	1,493
1942	W	1,433	1,428	1,511	1,511	1,646	1,690	1,718	1,845	2,030	1,948	1,828	1,761
1943	W	1,690	1,690	1,690	1,690	1,690	1,690	1,718	1,852	1,942	1,839	1,703	1,627
1944	BN	1,572	1,561	1,552	1,546	1,622	1,690	1,687	1,688	1,674	1,574	1,455	1,395
1945	AN	1,352	1,399	1,445	1,474	1,679	1,690	1,718	1,696	1,790	1,759	1,634	1,563
1946	AN	1,544	1,576	1,597	1,600	1,690	1,690	1,698	1,647	1,670	1,523	1,385	1,315
1947	D	1,263	1,282	1,314	1,328	1,370	1,400	1,379	1,410	1,342	1,222	1,117	1,070
1948	BN	1,054	1,055	1,094	1,105	1,116	1,197	1,265	1,270	1,317	1,264	1,183	1,149
1949	BN	1,118	1,113	1,112	1,108	1,141	1,310	1,346	1,345	1,330	1,237	1,155	1,122
1950	BN	1,090	1,086	1,089	1,125	1,267	1,391	1,442	1,404	1,456	1,375	1,293	1,254

YEAR	WYT	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1951	AN	1,238	1,653	1,690	1,690	1,690	1,690	1,686	1,558	1,515	1,373	1,243	1,177
1952	W	1,133	1,139	1,259	1,495	1,664	1,690	1,718	2,002	2,030	1,940	1,831	1,773
1953	BN	1,690	1,679	1,690	1,690	1,690	1,690	1,671	1,664	1,710	1,676	1,549	1,486
1954	BN	1,441	1,442	1,444	1,452	1,489	1,571	1,596	1,680	1,658	1,530	1,416	1,361
1955	D	1,319	1,318	1,337	1,373	1,421	1,501	1,522	1,482	1,371	1,251	1,142	1,092
1956	W	1,057	1,055	1,618	1,651	1,690	1,690	1,718	1,707	1,942	1,842	1,712	1,643
1957	BN	1,596	1,586	1,582	1,578	1,620	1,675	1,645	1,656	1,742	1,617	1,498	1,436
1958	W	1,396	1,393	1,409	1,434	1,558	1,690	1,718	2,002	2,030	1,953	1,847	1,773
1959	D	1,690	1,674	1,657	1,685	1,690	1,690	1,680	1,613	1,484	1,328	1,194	1,152
1960	C	1,104	1,099	1,125	1,126	1,234	1,276	1,295	1,264	1,162	1,063	984	951
1961	C	925	925	1,010	1,019	1,038	1,035	991	897	803	719	653	625
1962	BN	600	594	623	634	789	888	908	1,004	1,179	1,200	1,158	1,145
1963	AN	1,134	1,135	1,153	1,200	1,326	1,351	1,421	1,544	1,711	1,726	1,641	1,598
1964	D	1,562	1,611	1,628	1,652	1,680	1,688	1,689	1,637	1,552	1,410	1,287	1,231
1965	W	1,193	1,215	1,641	1,690	1,690	1,690	1,718	1,669	1,666	1,678	1,579	1,505
1966	BN	1,447	1,520	1,518	1,518	1,602	1,627	1,602	1,615	1,501	1,363	1,243	1,193
1967	W	1,152	1,185	1,338	1,440	1,509	1,619	1,718	1,945	2,030	1,952	1,864	1,773
1968	D	1,690	1,677	1,675	1,680	1,690	1,690	1,649	1,634	1,546	1,389	1,262	1,197
1969	W	1,154	1,181	1,270	1,690	1,690	1,690	1,718	2,002	2,030	1,926	1,802	1,734
1970	AN	1,684	1,688	1,690	1,690	1,690	1,690	1,679	1,700	1,683	1,564	1,437	1,371
1971	BN	1,320	1,361	1,447	1,514	1,571	1,631	1,627	1,646	1,694	1,623	1,513	1,462
1972	D	1,420	1,430	1,477	1,530	1,580	1,589	1,558	1,524	1,484	1,352	1,243	1,192
1973	AN	1,156	1,168	1,249	1,381	1,534	1,646	1,650	1,824	1,863	1,741	1,634	1,578
1974	W	1,538	1,615	1,614	1,616	1,685	1,690	1,718	1,856	1,963	1,849	1,721	1,657
1975	W	1,610	1,601	1,603	1,610	1,690	1,690	1,718	1,716	1,929	1,833	1,712	1,646
1976	C	1,592	1,602	1,620	1,597	1,604	1,600	1,544	1,392	1,270	1,126	1,014	966
1977	C	929	922	943	932	940	925	867	794	697	616	554	528
1978	W	504	502	559	712	841	981	1,083	1,273	1,657	1,845	1,800	1,773
1979	AN	1,690	1,690	1,690	1,690	1,690	1,690	1,694	1,885	1,912	1,766	1,632	1,566
1980	W	1,524	1,525	1,544	1,690	1,690	1,690	1,717	1,838	2,019	1,975	1,853	1,773

YEAR	WYT	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1981	D	1,690	1,674	1,669	1,678	1,690	1,690	1,691	1,618	1,531	1,380	1,262	1,207
1982	W	1,178	1,284	1,433	1,639	1,690	1,690	1,718	2,002	2,030	1,959	1,857	1,736
1983	W	1,670	1,690	1,689	1,689	1,690	1,690	1,718	1,996	2,030	2,030	1,918	1,773
1984	AN	1,690	1,690	1,688	1,688	1,690	1,690	1,665	1,628	1,640	1,522	1,384	1,311
1985	D	1,268	1,302	1,345	1,337	1,381	1,436	1,406	1,447	1,389	1,275	1,185	1,150
1986	W	1,129	1,150	1,225	1,295	1,663	1,690	1,718	1,924	2,030	1,996	1,896	1,773
1987	C	1,690	1,675	1,662	1,636	1,649	1,663	1,592	1,469	1,354	1,203	1,080	1,020
1988	C	983	982	1,020	1,075	1,128	1,123	1,057	961	897	805	731	698
1989	C	671	678	711	742	773	818	841	932	970	904	851	843
1990	C	861	864	891	905	945	955	903	871	835	755	688	663
1991	C	639	637	662	664	659	695	714	715	777	747	715	705
1992	C	698	701	731	746	808	838	817	862	830	802	747	715
1993	W	693	689	736	952	1,070	1,208	1,262	1,499	1,671	1,642	1,580	1,550
1994	C	1,516	1,503	1,496	1,496	1,512	1,508	1,444	1,356	1,276	1,151	1,051	1,002
1995	W	958	977	1,021	1,282	1,340	1,688	1,718	2,002	2,030	2,015	1,946	1,773
1996	W	1,690	1,672	1,690	1,690	1,690	1,690	1,718	1,927	1,998	1,895	1,759	1,695
1997	W	1,639	1,679	1,678	1,678	1,690	1,690	1,650	1,786	1,806	1,682	1,553	1,511
1998	W	1,455	1,447	1,447	1,610	1,690	1,690	1,718	1,808	2,030	1,977	1,869	1,773
1999	AN	1,690	1,690	1,690	1,690	1,690	1,690	1,718	1,686	1,779	1,664	1,535	1,472
2000	AN	1,415	1,406	1,394	1,471	1,646	1,690	1,682	1,809	1,850	1,721	1,607	1,554
2001	D	1,511	1,500	1,493	1,489	1,511	1,561	1,531	1,568	1,464	1,334	1,225	1,177
2002	D	1,141	1,152	1,225	1,284	1,321	1,333	1,299	1,390	1,390	1,282	1,192	1,150
2003	BN	1,123	1,160	1,218	1,288	1,323	1,334	1,357	1,355	1,430	1,335	1,251	1,216

Table 16. LSJR Alternative 3 Monthly Average Flow at Modesto on the Tuolumne River in cfs and February–June Flow Volume in TAF

YEAR	WYT	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	Feb-Jun [TAF]
1922	W	1,872	711	770	603	1,361	1,177	1,991	3,500	7,791	1,913	566	1,024	945
1923	AN	1,344	681	1,947	2,043	1,931	1,262	2,410	3,389	2,144	575	566	587	664
1924	C	732	605	580	579	285	247	934	1,360	200	331	342	353	183
1925	BN	428	442	440	427	1,635	1,080	2,353	3,500	2,366	380	389	408	653
1926	D	547	500	476	464	727	833	2,568	1,978	598	379	389	405	402
1927	AN	479	449	452	456	1,606	1,041	2,366	2,953	3,200	556	568	582	666
1928	BN	733	615	613	601	570	3,083	1,791	2,914	1,028	378	388	410	569
1929	C	547	495	477	468	288	644	995	2,459	1,512	333	341	363	356
1930	C	459	466	438	436	504	956	1,654	1,789	1,923	344	351	368	410
1931	C	456	453	449	437	324	429	1,035	1,360	329	334	344	354	209
1932	AN	424	437	430	427	1,669	1,119	1,647	3,409	3,500	577	568	578	681
1933	D	736	630	591	582	223	533	1,149	1,633	2,864	384	393	414	384
1934	C	482	471	451	434	648	976	1,250	969	639	331	341	353	268
1935	AN	435	445	437	436	771	891	3,126	3,454	3,435	562	565	587	700
1936	AN	733	609	597	593	2,448	2,572	3,204	3,383	2,622	611	565	582	854
1937	W	732	621	600	590	3,211	4,151	2,745	3,500	2,682	555	566	586	972
1938	W	732	618	1,922	1,613	5,687	7,439	4,391	3,500	7,496	3,684	572	597	1,696
1939	D	1,288	710	834	661	1,181	1,537	1,896	1,405	497	384	397	412	389
1940	AN	482	470	440	434	1,738	3,214	3,599	3,500	2,339	625	514	528	866
1941	W	640	526	755	1,713	4,985	4,511	2,877	3,500	3,500	2,545	618	547	1,149
1942	W	689	574	648	3,278	1,023	1,700	3,165	3,070	4,420	3,292	735	704	801
1943	W	1,061	1,259	1,395	3,701	3,230	5,817	3,128	3,220	2,373	1,073	501	436	1,062
1944	BN	753	584	626	650	556	931	1,102	2,966	1,795	414	405	359	444
1945	AN	526	453	389	529	2,197	3,471	2,184	2,960	3,106	688	634	572	832
1946	AN	684	466	3,746	2,702	1,385	2,942	2,339	3,175	1,781	637	600	580	698
1947	D	660	576	675	615	576	885	1,291	2,290	746	322	352	345	348
1948	BN	480	454	398	393	200	475	1,486	2,836	2,917	489	407	344	477
1949	BN	519	468	412	519	281	800	2,138	2,843	1,613	354	359	343	463

YEAR	WYT	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	Feb-Jun [TAF]
1950	BN	525	475	463	686	893	833	2,212	3,044	2,144	395	379	370	547
1951	AN	513	206	7,482	3,871	3,693	2,576	1,707	2,426	1,728	422	399	370	717
1952	W	461	400	475	846	1,029	3,120	3,550	4,243	6,742	3,733	617	638	1,124
1953	BN	1,187	479	627	1,999	1,249	1,434	1,815	1,685	2,783	519	433	400	535
1954	BN	460	400	391	397	735	1,386	2,346	2,914	1,244	373	379	369	519
1955	D	468	385	420	702	439	540	968	2,387	1,963	338	352	341	379
1956	W	395	372	441	6,886	3,477	3,278	1,896	3,500	3,500	2,933	681	574	938
1957	BN	697	478	491	518	893	1,002	1,163	2,472	2,722	399	408	405	494
1958	W	489	380	432	561	1,275	2,818	4,746	3,651	7,200	2,724	672	1,005	1,179
1959	D	1,242	519	581	624	2,723	1,869	1,506	1,509	934	349	333	366	504
1960	C	461	364	307	362	828	969	1,600	1,978	1,096	275	295	321	389
1961	C	310	330	282	337	331	462	1,109	1,431	820	236	256	235	250
1962	BN	298	314	323	314	1,678	904	2,615	2,355	2,998	358	396	408	628
1963	AN	464	273	315	425	2,226	729	1,667	3,474	3,112	527	500	515	666
1964	D	548	381	400	518	362	488	1,136	2,101	1,512	256	268	280	338
1965	W	343	266	234	4,826	3,517	3,001	3,051	2,921	3,200	543	565	717	931
1966	BN	585	491	2,109	1,104	540	950	2,010	2,309	578	246	242	242	384
1967	W	389	267	318	582	828	1,991	1,972	3,500	8,041	6,505	589	1,180	979
1968	D	1,178	449	485	515	1,490	1,429	1,257	1,874	948	350	338	330	420
1969	W	398	367	288	1,749	5,430	3,612	4,224	6,457	9,022	3,812	459	508	1,709
1970	AN	1,216	761	1,478	5,997	2,558	2,743	1,082	2,674	2,259	432	360	426	674
1971	BN	673	503	532	524	677	950	1,304	2,270	2,810	333	350	358	480
1972	D	515	322	524	367	542	1,184	1,049	2,238	1,479	276	286	284	392
1973	AN	315	451	522	524	1,340	1,125	1,741	3,500	2,689	484	509	512	622
1974	W	560	745	2,027	2,864	497	3,382	2,078	3,500	2,971	1,039	475	657	751
1975	W	1,068	1,088	789	643	1,653	3,304	2,338	3,500	3,500	1,262	558	569	858
1976	C	1,352	812	584	543	264	462	672	1,360	269	245	278	280	183
1977	C	284	309	322	295	200	200	531	690	706	170	167	153	139
1978	W	217	243	251	432	1,412	2,153	2,380	3,500	3,500	415	446	1,195	776

YEAR	WYT	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	Feb-Jun [TAF]
1979	AN	1,217	796	660	2,657	3,629	3,900	1,748	3,500	2,117	547	625	516	887
1980	W	609	813	877	4,924	6,735	3,416	2,104	3,233	3,500	3,500	567	1,027	1,130
1981	D	1,191	775	519	693	812	1,663	1,633	2,134	1,015	321	348	341	436
1982	W	439	421	600	685	5,742	5,231	8,105	4,676	6,755	3,679	592	2,367	1,812
1983	W	3,175	3,291	5,340	5,281	6,686	9,282	2,911	3,500	13,779	7,492	2,862	2,413	2,150
1984	AN	1,746	5,959	7,476	4,168	3,358	3,073	1,365	3,487	2,218	558	597	599	810
1985	D	743	974	430	489	497	820	2,030	2,218	907	340	367	359	389
1986	W	334	363	356	284	3,500	7,392	2,660	3,500	4,650	648	541	2,070	1,299
1987	C	1,846	1,300	566	596	266	644	1,304	1,321	437	256	265	253	239
1988	C	242	259	254	305	396	683	1,069	1,386	659	175	190	177	253
1989	C	194	220	245	244	439	1,854	2,077	2,088	1,391	187	203	212	473
1990	C	215	245	232	236	382	846	1,479	1,184	672	199	221	212	274
1991	C	214	239	223	208	200	1,093	1,210	2,186	1,983	183	201	188	403
1992	C	210	239	217	224	647	748	1,546	1,229	309	169	174	175	269
1993	W	213	208	217	781	1,160	2,075	2,252	3,500	3,500	2,059	326	404	749
1994	C	581	448	413	399	382	703	1,311	1,789	800	188	201	186	300
1995	W	230	218	223	518	1,152	3,500	4,148	3,660	11,192	8,340	1,781	2,735	1,417
1996	W	1,267	451	577	1,743	5,924	4,515	2,441	3,500	2,615	794	483	533	1,134
1997	W	592	525	6,295	17,734	3,473	3,362	1,862	3,500	2,259	499	486	486	860
1998	W	693	337	431	899	5,817	4,745	3,206	3,103	7,904	6,736	517	1,114	1,467
1999	AN	1,455	708	930	2,026	4,973	3,535	2,171	3,500	2,931	497	501	506	1,012
2000	AN	591	442	344	433	1,926	2,764	2,245	3,500	2,165	488	691	721	758
2001	D	692	465	418	518	432	1,164	1,526	2,654	370	293	314	300	372
2002	D	322	243	383	427	569	917	2,023	2,420	1,499	279	326	296	446
2003	BN	315	247	294	264	468	807	1,465	3,383	2,501	228	283	269	520

Table 17. LSJR Alternative 3 End-of-Month Storage at New Exchequer on the Merced River in TAF from 1922–2003

YEAR	WYT	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1922	W	469	456	483	506	631	706	719	842	998	913	793	734
1923	AN	675	674	675	675	675	692	730	812	821	766	633	560
1924	C	527	520	512	507	520	522	517	492	402	308	232	198
1925	BN	178	183	189	195	277	326	425	555	595	585	555	538
1926	D	523	516	512	507	546	568	603	550	526	498	455	424
1927	AN	401	389	394	383	377	398	392	492	523	538	554	589
1928	BN	590	586	599	613	635	605	583	614	600	577	562	572
1929	C	561	548	535	524	540	547	542	488	441	435	435	413
1930	C	390	377	364	353	352	324	322	300	282	301	320	328
1931	C	309	301	291	285	304	319	329	335	287	220	166	144
1932	AN	125	114	175	209	330	377	429	537	628	629	588	567
1933	D	549	537	527	527	538	558	567	569	594	518	434	398
1934	C	375	363	364	382	420	456	475	454	406	328	264	234
1935	AN	214	219	226	291	331	386	521	653	747	719	669	643
1936	AN	623	616	608	632	675	726	791	874	869	804	673	608
1937	W	559	549	553	560	675	735	790	948	980	887	765	704
1938	W	674	665	675	675	675	735	817	970	1,024	918	785	719
1939	D	675	675	675	673	675	713	755	735	653	545	447	407
1940	AN	394	384	374	485	581	662	753	872	882	810	731	673
1941	W	642	631	656	656	675	735	794	970	1,024	922	790	728
1942	W	675	674	675	675	675	726	785	862	981	875	741	677
1943	W	646	658	658	658	675	735	821	907	915	830	696	632
1944	BN	600	588	580	584	624	669	674	740	741	676	595	554
1945	AN	527	545	561	570	675	735	784	877	905	814	689	629
1946	AN	594	606	606	606	639	686	742	829	812	734	652	614
1947	D	587	599	599	599	632	660	677	696	631	534	444	405
1948	BN	385	380	370	367	376	392	426	508	576	534	476	443
1949	BN	424	411	403	397	419	462	521	599	599	533	469	441
1950	BN	420	408	398	420	464	492	561	624	641	576	508	476

YEAR	WYT	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1951	AN	457	675	675	675	675	724	760	786	760	671	577	532
1952	W	506	498	541	608	657	735	816	970	1,024	927	801	738
1953	BN	675	665	675	675	675	692	717	712	708	637	542	498
1954	BN	471	459	449	452	488	540	617	692	668	596	516	484
1955	D	460	447	448	461	482	498	505	568	575	506	433	403
1956	W	379	365	675	675	675	731	779	882	970	863	730	664
1957	BN	629	624	616	614	647	678	687	729	747	662	574	531
1958	W	505	497	502	519	597	709	845	970	1,024	938	823	765
1959	D	675	663	650	655	675	699	726	714	645	536	440	416
1960	C	395	380	366	358	402	434	481	523	498	432	371	345
1961	C	324	315	313	305	321	336	361	377	350	287	232	209
1962	BN	188	174	168	161	282	355	468	562	652	654	617	598
1963	AN	584	570	559	585	675	711	756	849	901	860	786	748
1964	D	675	675	675	675	675	681	680	685	636	534	438	397
1965	W	367	369	576	643	675	701	753	824	875	847	711	648
1966	BN	616	629	629	629	655	686	737	771	707	608	520	485
1967	W	462	459	555	599	638	731	822	970	1,024	930	806	746
1968	D	675	665	662	663	675	696	712	712	649	537	444	407
1969	W	381	388	410	675	675	735	845	970	1,024	916	783	717
1970	AN	673	675	675	675	675	735	749	807	790	702	612	573
1971	BN	550	553	587	621	649	675	692	735	758	693	614	578
1972	D	556	547	570	579	610	648	663	700	677	585	503	476
1973	AN	463	459	475	528	640	717	762	960	1,003	914	795	738
1974	W	675	675	675	675	675	735	789	916	943	832	697	633
1975	W	591	582	581	592	672	735	763	876	1,002	903	774	711
1976	C	670	675	673	663	675	680	667	643	557	445	358	327
1977	C	305	287	273	259	259	250	243	226	199	144	97	75
1978	W	54	38	54	150	270	400	526	742	985	948	871	817
1979	AN	675	675	669	675	675	735	773	905	895	807	683	619
1980	W	582	572	571	594	675	735	796	895	982	884	757	697

YEAR	WYT	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1981	D	666	647	636	639	661	690	715	738	684	585	498	462
1982	W	440	468	514	628	675	735	845	970	1,024	925	798	724
1983	W	675	675	675	675	675	735	787	970	1,024	920	786	715
1984	AN	665	675	675	675	675	730	764	849	824	750	667	628
1985	D	606	613	618	619	648	672	715	743	685	588	500	466
1986	W	447	444	459	485	675	735	821	953	1,024	941	827	768
1987	C	675	658	644	634	650	665	679	664	591	489	405	371
1988	C	343	339	334	344	359	381	404	417	386	329	275	253
1989	C	232	220	217	210	226	284	350	387	374	334	302	293
1990	C	287	281	272	272	288	311	344	347	310	257	207	185
1991	C	164	149	135	121	115	174	205	271	313	299	276	266
1992	C	248	243	236	232	276	301	353	368	331	305	267	258
1993	W	238	228	231	401	471	559	627	834	933	860	749	693
1994	C	660	646	637	630	652	657	655	639	581	472	386	343
1995	W	326	330	337	522	571	735	809	970	1,024	939	822	763
1996	W	675	662	671	675	675	735	796	906	899	814	681	615
1997	W	568	580	580	580	658	735	796	890	875	800	724	687
1998	W	658	649	648	670	675	735	811	881	1,024	922	791	722
1999	AN	675	674	675	675	675	703	723	813	805	710	617	575
2000	AN	544	534	522	562	673	735	783	887	872	783	699	659
2001	D	610	600	593	589	611	658	679	725	653	553	466	439
2002	D	409	403	434	459	480	502	551	602	576	491	415	381
2003	BN	353	366	383	407	426	452	480	585	608	544	482	449

Table 18. LSJR Alternative 3 Monthly Average Flow at Stevinson on the Merced River in cfs and February–June Flow Volume in TAF

YEAR	WYT	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	Feb-Jun [TAF]
1922	W	636	390	504	482	1,174	761	834	2,000	2,000	1,387	867	453	404
1923	AN	850	304	1,169	1,273	1,004	364	1,062	1,874	1,042	159	762	598	319
1924	C	593	385	382	396	150	150	450	592	150	54	36	49	90
1925	BN	282	419	425	428	763	501	1,210	1,698	988	116	77	54	308
1926	D	266	354	375	375	454	358	1,459	1,125	323	51	37	51	222
1927	AN	274	322	313	381	987	566	1,203	1,926	1,519	136	84	89	370
1928	BN	426	352	389	361	334	1,034	955	1,340	457	179	88	80	249
1929	C	296	387	387	408	158	306	524	1,256	652	49	54	92	175
1930	C	276	367	359	361	187	475	793	891	753	35	35	93	186
1931	C	276	385	372	382	150	169	497	598	150	87	41	75	94
1932	AN	266	363	475	469	1,057	514	881	1,808	1,687	109	57	58	356
1933	D	310	386	383	426	150	280	592	865	1,203	60	41	30	186
1934	C	298	383	405	466	324	423	618	364	222	85	36	29	116
1935	AN	282	389	409	580	360	559	1,849	2,000	1,734	182	100	55	391
1936	AN	368	410	385	428	3,862	651	1,472	1,945	1,096	108	807	441	535
1937	W	707	424	417	416	2,367	1,072	1,096	2,000	1,291	597	812	446	462
1938	W	442	401	2,249	1,343	4,915	4,515	1,539	2,893	4,669	2,238	1,159	596	1,098
1939	D	935	475	415	443	665	462	1,015	657	215	67	73	68	179
1940	AN	331	424	418	573	939	963	1,223	1,984	941	145	188	416	364
1941	W	459	427	1,286	1,340	2,774	1,616	1,062	2,254	2,525	1,749	1,069	508	605
1942	W	925	447	1,389	1,528	1,706	585	1,244	1,841	2,000	1,651	1,021	509	437
1943	W	494	549	783	2,172	1,688	3,106	1,472	1,900	1,022	534	941	490	550
1944	BN	475	459	436	414	327	527	538	1,626	894	172	136	88	236
1945	AN	357	489	446	441	1,700	751	1,049	1,717	1,385	878	937	421	391
1946	AN	840	640	1,862	1,067	238	533	1,297	1,704	766	170	129	81	274
1947	D	577	532	963	621	288	403	699	1,119	343	65	80	76	172
1948	BN	319	397	398	388	150	221	719	1,535	1,459	182	100	97	246
1949	BN	348	404	386	402	166	507	955	1,542	753	121	121	70	237

YEAR	WYT	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	Feb-Jun [TAF]
1950	BN	326	394	394	428	439	345	1,156	1,516	840	162	130	77	258
1951	AN	329	797	4,464	1,736	1,628	559	874	1,145	699	186	116	63	289
1952	W	347	417	460	1,986	452	1,413	1,385	3,361	3,356	1,942	1,231	621	602
1953	BN	979	428	379	1,239	720	267	807	794	1,062	140	126	55	216
1954	BN	360	405	403	406	346	644	1,143	1,451	497	167	131	81	246
1955	D	314	392	409	537	166	234	437	1,262	921	120	113	55	182
1956	W	311	386	1,096	4,365	1,970	572	1,035	2,000	1,929	1,954	1,152	610	448
1957	BN	580	422	409	411	295	410	592	1,301	1,183	195	154	81	227
1958	W	424	381	405	481	598	1,060	1,938	3,609	3,164	1,720	1,123	675	624
1959	D	1,501	395	382	395	804	358	793	729	343	107	116	94	179
1960	C	307	374	383	397	382	397	840	956	430	101	127	49	181
1961	C	286	365	387	372	150	195	565	618	296	70	55	40	110
1962	BN	264	341	359	360	1,145	481	1,331	1,340	1,378	253	182	78	337
1963	AN	346	362	376	376	1,586	397	881	1,743	1,412	277	194	158	356
1964	D	1,161	736	460	487	417	182	511	911	544	163	114	77	154
1965	W	346	356	528	1,780	653	449	1,109	1,685	1,627	309	1,448	634	330
1966	BN	474	866	812	1,055	230	423	1,069	1,184	316	206	165	79	194
1967	W	293	366	400	408	367	1,093	1,432	2,275	4,389	4,063	1,494	797	574
1968	D	1,425	411	330	382	742	312	632	787	336	196	177	130	168
1969	W	275	431	434	2,014	4,183	1,306	1,789	5,552	4,269	2,433	1,233	711	1,014
1970	AN	825	352	589	2,940	1,251	838	598	1,418	854	256	222	150	295
1971	BN	383	375	359	425	281	384	659	1,190	1,210	256	188	102	224
1972	D	359	386	423	270	236	533	538	1,086	645	240	222	18	184
1973	AN	309	412	432	474	900	748	881	2,000	1,351	600	1,038	574	352
1974	W	1,101	984	1,099	1,692	857	1,064	1,082	2,000	1,365	841	1,054	586	382
1975	W	667	350	409	307	778	1,004	659	2,000	2,000	1,163	1,062	533	386
1976	C	1,107	374	362	392	209	215	329	605	150	175	205	136	91
1977	C	354	311	322	373	150	150	208	254	309	106	81	44	64
1978	W	268	282	350	516	1,066	1,223	1,573	2,000	2,000	2,613	1,294	1,369	470

YEAR	WYT	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	Feb-Jun [TAF]
1979	AN	2,383	601	441	1,746	1,919	1,266	887	2,000	1,042	262	731	443	422
1980	W	698	374	392	3,976	3,121	1,442	1,156	1,861	1,943	2,284	1,248	583	567
1981	D	629	398	444	479	194	338	820	1,034	464	168	168	97	172
1982	W	401	405	414	484	2,829	2,087	4,484	3,519	2,127	2,249	1,390	1,170	895
1983	W	1,477	1,960	2,301	3,658	4,403	5,817	1,324	2,385	7,498	5,943	2,444	1,100	1,274
1984	AN	1,196	2,062	3,552	1,904	1,583	631	867	1,724	766	291	277	217	333
1985	D	580	338	334	488	238	384	988	1,112	383	236	206	100	187
1986	W	405	395	408	380	3,278	3,965	1,284	2,000	1,646	946	1,113	737	723
1987	C	1,631	416	418	381	150	234	639	618	168	130	135	87	109
1988	C	356	340	375	377	167	312	625	696	370	97	92	52	131
1989	C	256	274	322	304	166	625	1,076	859	491	68	62	67	194
1990	C	305	303	327	310	151	364	766	566	323	72	68	26	130
1991	C	248	258	274	292	150	625	544	1,197	975	91	54	10	211
1992	C	270	289	297	291	376	332	881	683	208	76	55	11	149
1993	W	206	313	350	684	720	1,021	1,217	2,000	1,882	1,492	1,085	640	410
1994	C	739	369	334	315	202	260	585	761	289	48	54	2	126
1995	W	239	327	317	611	504	2,987	1,385	2,557	5,453	4,891	1,700	509	776
1996	W	1,452	379	365	1,071	2,997	1,408	1,324	2,000	1,055	374	903	480	523
1997	W	613	845	3,494	9,912	735	980	1,136	1,808	766	149	114	84	325
1998	W	369	336	356	1,396	5,117	1,864	1,351	1,633	3,528	4,614	1,499	759	790
1999	AN	961	382	496	826	2,021	436	860	1,834	1,035	174	196	100	365
2000	AN	285	345	318	325	1,189	1,020	1,116	1,795	874	175	112	59	360
2001	D	668	496	392	389	223	559	726	1,399	222	74	84	25	189
2002	D	239	403	390	449	252	384	1,015	1,158	571	90	61	2	203
2003	BN	227	316	353	327	245	403	753	1,756	1,143	80	66	41	259

LSJR Alternative 4 (60% Unimpaired Flow)

Table 19. LSJR Alternative 4 End-of-Month Storage at New Melones on the Stanislaus River in TAF from 1922–2003

YEAR	WYT	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1922	W	954	964	994	1,027	1,091	1,125	1,117	1,284	1,447	1,444	1,398	1,367
1923	AN	1,305	1,317	1,385	1,449	1,478	1,482	1,463	1,528	1,529	1,505	1,441	1,405
1924	C	1,344	1,341	1,354	1,369	1,349	1,289	1,229	1,132	1,059	994	928	903
1925	BN	845	845	855	867	927	952	917	984	993	989	944	926
1926	D	874	873	879	884	918	922	892	840	799	745	699	675
1927	AN	634	646	696	740	796	814	839	903	918	898	861	852
1928	BN	808	839	862	880	912	962	933	957	927	875	825	803
1929	C	757	764	775	784	777	767	740	657	602	560	521	499
1930	C	455	456	457	477	493	519	480	420	409	383	354	336
1931	C	327	339	340	356	343	338	292	211	194	173	147	138
1932	AN	119	124	175	213	256	253	218	322	386	416	406	395
1933	D	388	389	397	413	386	390	369	319	282	258	235	221
1934	C	213	225	243	271	289	286	238	176	155	136	113	104
1935	AN	84	85	96	135	142	171	222	369	416	425	410	401
1936	AN	389	401	416	496	590	602	643	748	798	788	759	745
1937	W	702	708	721	744	793	849	836	958	983	954	916	895
1938	W	849	854	937	1,016	1,122	1,235	1,335	1,619	1,825	1,836	1,792	1,686
1939	D	1,625	1,620	1,624	1,637	1,647	1,638	1,563	1,475	1,414	1,346	1,280	1,237
1940	AN	1,171	1,167	1,174	1,274	1,320	1,355	1,391	1,492	1,480	1,425	1,370	1,336
1941	W	1,275	1,278	1,314	1,368	1,413	1,458	1,456	1,621	1,669	1,651	1,596	1,557
1942	W	1,495	1,496	1,540	1,632	1,680	1,706	1,699	1,799	1,889	1,883	1,810	1,768
1943	W	1,705	1,719	1,743	1,832	1,892	1,996	2,033	2,054	2,048	1,993	1,918	1,865
1944	BN	1,794	1,786	1,784	1,784	1,809	1,829	1,795	1,684	1,640	1,574	1,497	1,450
1945	AN	1,388	1,421	1,448	1,485	1,526	1,566	1,509	1,575	1,596	1,566	1,503	1,467
1946	AN	1,406	1,433	1,519	1,584	1,637	1,639	1,625	1,681	1,663	1,602	1,540	1,507
1947	D	1,446	1,467	1,489	1,505	1,524	1,524	1,474	1,370	1,320	1,252	1,190	1,161
1948	BN	1,113	1,108	1,108	1,112	1,087	1,105	1,076	1,024	1,051	1,024	981	960
1949	BN	914	922	933	942	939	963	913	875	862	820	782	760
1950	BN	710	699	701	749	786	818	758	826	872	851	819	801

YEAR	WYT	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1951	AN	756	1,029	1,418	1,526	1,589	1,638	1,637	1,653	1,620	1,557	1,495	1,458
1952	W	1,396	1,408	1,461	1,601	1,641	1,697	1,699	1,981	2,144	2,157	2,095	2,000
1953	BN	1,923	1,921	1,937	1,970	1,970	1,983	1,908	1,861	1,860	1,826	1,752	1,705
1954	BN	1,637	1,645	1,658	1,673	1,691	1,687	1,613	1,621	1,570	1,500	1,432	1,391
1955	D	1,338	1,343	1,360	1,391	1,405	1,416	1,386	1,267	1,223	1,162	1,106	1,068
1956	W	1,019	1,023	1,269	1,530	1,620	1,666	1,677	1,794	1,861	1,847	1,786	1,758
1957	BN	1,688	1,698	1,713	1,733	1,756	1,767	1,718	1,674	1,662	1,599	1,537	1,489
1958	W	1,398	1,409	1,416	1,467	1,501	1,567	1,659	1,910	2,024	2,013	1,954	1,909
1959	D	1,844	1,851	1,862	1,889	1,923	1,930	1,869	1,765	1,693	1,620	1,549	1,512
1960	C	1,443	1,444	1,449	1,455	1,482	1,486	1,431	1,342	1,284	1,214	1,153	1,103
1961	C	1,025	1,036	1,050	1,054	1,047	1,051	1,016	944	883	829	776	746
1962	BN	723	723	726	736	778	799	747	739	730	720	684	656
1963	AN	643	654	674	732	758	791	790	934	989	984	951	940
1964	D	896	926	947	982	996	1,013	988	912	874	827	787	754
1965	W	732	750	964	1,171	1,226	1,258	1,295	1,380	1,407	1,414	1,374	1,353
1966	BN	1,290	1,322	1,356	1,396	1,432	1,434	1,366	1,358	1,307	1,238	1,181	1,138
1967	W	1,086	1,094	1,176	1,279	1,322	1,339	1,394	1,565	1,816	1,918	1,875	1,845
1968	D	1,780	1,787	1,798	1,823	1,852	1,857	1,806	1,734	1,671	1,593	1,517	1,466
1969	W	1,415	1,438	1,450	1,747	1,882	1,981	2,104	2,346	2,420	2,300	2,130	2,000
1970	AN	1,935	1,938	1,950	1,956	1,970	2,028	2,022	1,990	1,969	1,888	1,803	1,761
1971	BN	1,697	1,724	1,792	1,850	1,872	1,892	1,860	1,838	1,830	1,782	1,709	1,667
1972	D	1,596	1,612	1,660	1,697	1,716	1,705	1,654	1,606	1,546	1,471	1,401	1,366
1973	AN	1,317	1,320	1,346	1,459	1,552	1,602	1,567	1,649	1,656	1,595	1,530	1,501
1974	W	1,453	1,497	1,574	1,689	1,755	1,800	1,847	1,945	1,957	1,909	1,838	1,796
1975	W	1,735	1,747	1,771	1,799	1,833	1,886	1,901	1,898	1,997	1,954	1,884	1,839
1976	C	1,777	1,798	1,819	1,829	1,831	1,832	1,780	1,682	1,597	1,512	1,435	1,385
1977	C	1,322	1,318	1,313	1,302	1,265	1,217	1,176	1,110	1,054	969	887	846
1978	W	797	781	796	876	911	929	929	999	1,043	1,066	1,029	1,033
1979	AN	983	992	1,010	1,079	1,147	1,195	1,176	1,255	1,227	1,169	1,117	1,095
1980	W	1,046	1,062	1,075	1,381	1,531	1,575	1,618	1,670	1,715	1,726	1,663	1,625

YEAR	WYT	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1981	D	1,576	1,573	1,584	1,625	1,631	1,640	1,582	1,489	1,406	1,334	1,273	1,247
1982	W	1,198	1,253	1,386	1,592	1,770	1,883	2,085	2,197	2,217	2,141	2,000	1,852
1983	W	1,779	1,786	1,787	1,794	1,942	2,030	2,036	2,154	2,420	2,300	2,130	1,978
1984	AN	1,925	1,932	1,933	1,939	1,970	2,027	2,001	1,989	1,960	1,897	1,831	1,794
1985	D	1,734	1,763	1,797	1,805	1,837	1,851	1,781	1,711	1,644	1,565	1,501	1,474
1986	W	1,431	1,438	1,455	1,534	1,902	2,030	2,033	2,046	2,043	1,983	1,924	1,903
1987	C	1,844	1,848	1,855	1,847	1,828	1,830	1,766	1,651	1,573	1,502	1,443	1,415
1988	C	1,342	1,323	1,312	1,315	1,312	1,289	1,230	1,148	1,096	1,047	1,001	963
1989	C	926	905	896	897	901	892	815	757	730	707	686	684
1990	C	691	696	713	726	737	731	670	598	554	516	493	483
1991	C	460	455	467	465	439	449	436	374	321	292	265	268
1992	C	256	257	274	284	307	311	262	192	178	162	148	155
1993	W	151	152	171	323	376	403	371	431	456	476	466	462
1994	C	471	491	524	557	571	550	502	409	371	328	291	275
1995	W	257	260	289	478	527	718	783	996	1,204	1,390	1,401	1,414
1996	W	1,393	1,406	1,443	1,526	1,587	1,687	1,661	1,730	1,724	1,671	1,621	1,591
1997	W	1,551	1,577	1,741	1,888	1,970	2,030	1,991	1,969	1,925	1,860	1,796	1,777
1998	W	1,731	1,745	1,775	1,890	1,970	2,013	1,998	1,990	2,156	2,214	2,064	1,942
1999	AN	1,874	1,877	1,881	1,887	1,959	2,024	2,007	1,982	1,945	1,882	1,824	1,793
2000	AN	1,756	1,759	1,771	1,822	1,840	1,869	1,812	1,737	1,694	1,628	1,575	1,556
2001	D	1,510	1,529	1,564	1,577	1,605	1,593	1,534	1,429	1,370	1,293	1,223	1,180
2002	D	1,121	1,118	1,153	1,198	1,203	1,215	1,147	1,053	980	923	876	857
2003	BN	822	834	884	934	949	951	919	865	836	801	770	756

Table 20. LSJR Alternative 4 Monthly Average Flow at Ripon on the Stanislaus River in cfs and February–June Flow Volume in TAF

YEAR	WYT	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	Feb-Jun [TAF]
1922	W	1,377	443	447	335	1,156	1,005	1,714	2,500	2,500	377	439	436	530
1923	AN	1,207	444	493	356	594	751	2,087	2,500	1,623	511	456	493	454
1924	C	1,341	367	311	280	775	861	706	829	345	404	428	423	211
1925	BN	1,009	439	395	297	1,653	1,171	2,500	2,500	1,734	442	439	434	569
1926	D	1,066	369	311	267	799	771	2,178	1,356	413	454	439	434	329
1927	AN	1,007	505	338	314	1,750	1,308	2,500	2,500	2,470	426	439	434	627
1928	BN	1,076	431	387	295	501	2,469	2,158	2,342	676	441	439	434	493
1929	C	1,060	302	280	295	625	429	1,008	1,913	988	421	428	423	297
1930	C	993	313	250	308	519	1,015	1,855	1,649	1,341	435	428	423	383
1931	C	528	293	246	187	631	429	938	898	252	418	404	375	187
1932	AN	506	296	432	215	1,377	1,142	2,057	2,500	2,500	408	439	434	574
1933	D	537	356	291	220	879	371	1,069	1,737	2,077	434	367	386	366
1934	C	525	291	338	214	486	986	1,008	673	423	405	404	375	214
1935	AN	504	302	289	230	508	683	2,500	2,500	2,500	554	439	434	521
1936	AN	550	290	256	250	2,149	1,503	2,500	2,500	1,946	476	439	437	634
1937	W	1,012	356	353	314	1,188	1,210	1,936	2,500	1,684	476	439	434	510
1938	W	1,066	404	427	321	1,901	2,342	2,500	2,500	2,500	718	556	1,925	701
1939	D	1,396	547	471	420	356	722	1,805	1,073	444	438	439	449	264
1940	AN	1,204	266	225	371	1,805	2,500	2,500	2,500	1,563	511	456	486	653
1941	W	1,260	475	459	454	1,167	1,571	1,855	2,500	2,349	632	469	469	565
1942	W	1,271	678	474	323	1,113	1,025	2,500	2,500	2,500	785	594	641	576
1943	W	1,363	573	459	1,148	1,275	2,500	2,500	2,500	1,926	615	593	629	642
1944	BN	1,364	572	584	543	323	673	1,008	2,500	1,240	480	461	441	348
1945	AN	1,224	378	385	390	1,977	947	2,097	2,500	2,319	568	517	523	585
1946	AN	1,256	353	225	552	529	1,122	2,400	2,500	1,361	450	481	497	476
1947	D	1,212	343	347	404	486	917	1,371	1,776	625	437	393	394	311
1948	BN	1,026	432	383	362	890	371	1,573	2,500	2,491	506	439	404	469
1949	BN	980	367	355	318	674	595	1,956	2,500	1,160	455	409	380	413

YEAR	WYT	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	Feb-Jun [TAF]
1950	BN	954	411	421	338	789	927	2,500	2,500	1,956	447	405	409	520
1951	AN	952	461	534	573	1,221	1,239	1,765	2,039	1,149	444	400	361	443
1952	W	1,105	331	272	312	1,106	1,386	2,500	2,500	2,500	887	639	1,462	600
1953	BN	1,347	525	514	846	1,148	712	2,107	1,874	2,329	616	451	480	487
1954	BN	1,239	342	333	351	475	1,415	2,500	2,500	907	436	393	356	470
1955	D	996	322	355	475	400	527	1,028	2,235	1,492	443	357	359	342
1956	W	1,005	381	370	762	1,064	1,181	2,057	2,500	2,500	613	484	463	559
1957	BN	1,212	325	312	342	659	1,132	1,371	2,500	1,906	449	439	431	455
1958	W	1,218	369	353	327	1,264	1,678	2,500	2,500	2,500	678	586	633	625
1959	D	1,302	450	493	434	713	849	1,492	1,122	686	422	401	435	290
1960	C	1,162	337	316	343	636	995	1,623	1,532	716	406	384	341	331
1961	C	920	354	356	326	606	449	1,089	1,171	575	361	382	312	232
1962	BN	421	373	377	210	1,026	742	2,500	2,449	2,077	451	411	403	526
1963	AN	522	393	353	258	2,334	654	1,573	2,500	2,208	498	451	437	549
1964	D	1,021	348	286	347	557	488	1,230	1,786	1,069	425	379	383	309
1965	W	495	388	250	369	1,113	976	2,400	2,500	2,470	436	513	479	565
1966	BN	1,248	374	351	386	421	986	2,067	1,630	413	440	361	350	332
1967	W	991	299	288	276	875	1,913	1,775	2,500	2,500	948	582	670	574
1968	D	1,424	351	379	380	991	878	1,452	1,571	706	431	386	371	336
1969	W	1,059	319	339	422	1,955	1,503	2,500	2,500	3,146	2,518	2,194	1,776	691
1970	AN	1,450	537	905	4,835	2,658	1,395	1,240	2,488	1,734	468	480	559	563
1971	BN	1,262	269	280	336	767	1,064	1,734	2,332	2,107	568	493	536	480
1972	D	1,440	248	200	349	449	1,473	1,250	2,293	766	448	378	368	377
1973	AN	992	391	397	304	1,383	1,229	2,128	2,500	1,694	448	452	503	534
1974	W	1,076	284	273	263	691	1,952	2,491	2,500	2,107	557	500	649	586
1975	W	1,354	370	478	349	767	1,395	1,240	2,500	2,500	589	582	603	505
1976	C	1,157	471	297	368	644	420	756	966	262	429	347	328	183
1977	C	957	324	313	286	816	748	353	429	363	303	355	241	160
1978	W	473	263	275	256	1,167	2,176	2,500	2,500	2,500	546	459	479	650

YEAR	WYT	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	Feb-Jun [TAF]
1979	AN	1,118	468	411	219	1,167	1,561	2,077	2,500	1,432	459	450	430	523
1980	W	1,201	372	250	226	2,500	1,327	2,037	2,500	2,500	690	646	756	649
1981	D	1,381	576	496	503	432	800	1,654	1,610	575	442	372	393	305
1982	W	1,056	294	322	381	2,500	2,469	2,500	2,500	2,500	1,679	1,967	3,096	742
1983	W	2,256	2,519	3,187	4,124	2,500	5,533	2,148	2,500	4,493	4,982	3,015	3,113	1,028
1984	AN	1,830	3,321	5,140	2,085	1,699	1,337	1,583	2,500	1,492	628	668	813	517
1985	D	1,419	471	356	461	519	771	2,077	1,669	534	437	380	460	334
1986	W	1,095	428	356	304	2,500	3,835	2,500	2,500	2,168	632	466	597	806
1987	C	1,353	501	601	483	714	576	1,049	917	272	415	355	309	210
1988	C	958	287	320	289	365	576	867	810	403	346	373	303	182
1989	C	483	339	358	186	324	1,766	2,359	1,581	948	357	384	410	421
1990	C	434	349	339	179	335	810	1,351	849	514	338	382	274	232
1991	C	524	530	311	202	675	790	978	1,786	1,069	343	381	245	318
1992	C	477	404	288	209	751	761	1,371	927	171	236	185	9	239
1993	W	103	126	265	351	1,167	2,283	2,500	2,500	2,430	288	368	434	652
1994	C	360	338	323	158	376	595	1,069	1,552	413	329	368	252	241
1995	W	394	300	314	541	1,080	2,500	2,500	2,500	2,500	418	418	397	665
1996	W	1,115	361	363	343	2,500	2,098	2,500	2,500	1,765	528	542	542	680
1997	W	1,198	655	966	8,184	2,236	1,793	1,815	2,254	1,109	452	421	421	547
1998	W	1,208	257	247	324	3,458	2,254	2,470	2,500	2,500	1,101	2,230	2,231	780
1999	AN	1,718	823	1,083	1,527	2,128	1,210	1,744	2,500	2,168	495	518	544	579
2000	AN	1,178	350	341	453	1,971	1,561	2,238	2,500	1,291	435	385	401	573
2001	D	1,100	264	243	308	389	937	1,351	1,952	282	412	301	313	296
2002	D	919	311	377	314	594	995	2,148	2,108	978	406	365	343	410
2003	BN	867	282	311	243	594	937	1,563	2,500	1,825	435	337	307	446

Table 21. LSJR Alternative 4 End-of-Month Storage at New Don Pedro on the Tuolumne River in TAF from 1922–2003

YEAR	WYT	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1922	W	1,314	1,300	1,325	1,364	1,481	1,561	1,637	1,822	2,030	1,990	1,909	1,773
1923	AN	1,690	1,690	1,690	1,690	1,690	1,690	1,718	1,726	1,713	1,686	1,578	1,532
1924	C	1,491	1,480	1,471	1,457	1,473	1,482	1,429	1,291	1,207	1,108	1,018	976
1925	BN	956	970	1,034	1,083	1,157	1,198	1,250	1,322	1,359	1,364	1,314	1,297
1926	D	1,278	1,275	1,284	1,289	1,337	1,398	1,392	1,338	1,274	1,188	1,114	1,084
1927	AN	1,058	1,099	1,147	1,193	1,273	1,323	1,340	1,424	1,585	1,597	1,531	1,505
1928	BN	1,474	1,506	1,544	1,558	1,601	1,634	1,631	1,718	1,662	1,551	1,456	1,411
1929	C	1,369	1,361	1,359	1,352	1,370	1,375	1,361	1,239	1,222	1,138	1,060	1,017
1930	C	986	977	1,018	1,046	1,083	1,104	1,058	1,008	1,012	967	922	905
1931	C	888	892	933	942	983	983	919	808	755	698	657	646
1932	AN	630	626	806	957	1,098	1,178	1,193	1,220	1,283	1,350	1,314	1,298
1933	D	1,267	1,251	1,257	1,255	1,302	1,317	1,337	1,299	1,238	1,188	1,130	1,105
1934	C	1,075	1,071	1,096	1,138	1,182	1,248	1,205	1,133	1,065	992	936	916
1935	AN	900	914	955	1,127	1,227	1,289	1,414	1,447	1,550	1,534	1,473	1,440
1936	AN	1,410	1,406	1,403	1,468	1,673	1,690	1,712	1,746	1,820	1,780	1,684	1,633
1937	W	1,585	1,572	1,572	1,573	1,690	1,690	1,718	1,739	1,816	1,734	1,632	1,579
1938	W	1,535	1,529	1,684	1,689	1,690	1,690	1,718	1,915	2,030	1,961	1,864	1,773
1939	D	1,690	1,690	1,690	1,690	1,690	1,690	1,631	1,554	1,446	1,318	1,212	1,170
1940	AN	1,156	1,156	1,224	1,381	1,539	1,680	1,718	1,740	1,788	1,693	1,605	1,558
1941	W	1,520	1,513	1,619	1,690	1,690	1,690	1,718	1,712	1,855	1,781	1,671	1,613
1942	W	1,562	1,557	1,642	1,646	1,690	1,690	1,714	1,828	2,030	1,964	1,858	1,773
1943	W	1,690	1,690	1,690	1,690	1,690	1,690	1,714	1,856	1,904	1,831	1,721	1,660
1944	BN	1,612	1,603	1,596	1,593	1,656	1,690	1,669	1,659	1,613	1,538	1,441	1,393
1945	AN	1,357	1,405	1,452	1,484	1,631	1,690	1,695	1,664	1,759	1,757	1,657	1,600
1946	AN	1,588	1,622	1,644	1,650	1,690	1,690	1,644	1,593	1,585	1,463	1,346	1,288
1947	D	1,243	1,262	1,296	1,313	1,342	1,354	1,314	1,300	1,237	1,149	1,071	1,039
1948	BN	1,032	1,034	1,074	1,089	1,100	1,175	1,218	1,208	1,248	1,227	1,173	1,154
1949	BN	1,131	1,127	1,128	1,127	1,156	1,309	1,298	1,279	1,240	1,176	1,118	1,098
1950	BN	1,073	1,071	1,075	1,115	1,235	1,342	1,346	1,306	1,320	1,270	1,216	1,191

YEAR	WYT	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1951	AN	1,184	1,600	1,690	1,690	1,690	1,690	1,654	1,485	1,415	1,303	1,200	1,147
1952	W	1,112	1,119	1,241	1,479	1,623	1,690	1,718	2,002	2,030	1,971	1,890	1,773
1953	BN	1,690	1,681	1,690	1,690	1,690	1,690	1,636	1,601	1,630	1,626	1,526	1,477
1954	BN	1,440	1,441	1,446	1,457	1,477	1,525	1,499	1,571	1,537	1,439	1,350	1,310
1955	D	1,275	1,276	1,296	1,335	1,375	1,448	1,460	1,380	1,239	1,154	1,073	1,040
1956	W	1,014	1,013	1,578	1,615	1,690	1,690	1,682	1,699	1,962	1,897	1,796	1,742
1957	BN	1,690	1,682	1,679	1,679	1,690	1,690	1,637	1,602	1,658	1,553	1,450	1,398
1958	W	1,363	1,361	1,378	1,406	1,498	1,658	1,718	2,002	2,030	1,986	1,909	1,773
1959	D	1,690	1,676	1,660	1,690	1,690	1,690	1,653	1,564	1,432	1,306	1,198	1,170
1960	C	1,130	1,126	1,154	1,158	1,245	1,265	1,252	1,182	1,071	999	943	923
1961	C	904	905	992	1,004	1,017	1,009	951	838	747	695	656	643
1962	BN	627	622	652	667	778	856	838	883	1,048	1,093	1,072	1,070
1963	AN	1,065	1,066	1,086	1,136	1,204	1,217	1,260	1,411	1,586	1,638	1,584	1,559
1964	D	1,532	1,583	1,602	1,631	1,652	1,653	1,640	1,551	1,448	1,338	1,243	1,203
1965	W	1,173	1,196	1,624	1,690	1,690	1,690	1,718	1,658	1,662	1,705	1,632	1,572
1966	BN	1,522	1,596	1,596	1,600	1,671	1,673	1,602	1,561	1,448	1,332	1,232	1,191
1967	W	1,156	1,190	1,344	1,449	1,498	1,555	1,616	1,867	2,030	1,982	1,919	1,773
1968	D	1,690	1,678	1,678	1,686	1,690	1,690	1,629	1,581	1,489	1,362	1,261	1,210
1969	W	1,174	1,203	1,293	1,690	1,690	1,690	1,718	2,002	2,030	1,956	1,859	1,773
1970	AN	1,690	1,690	1,690	1,690	1,690	1,690	1,665	1,660	1,602	1,513	1,411	1,360
1971	BN	1,316	1,359	1,446	1,517	1,559	1,598	1,573	1,547	1,579	1,537	1,453	1,416
1972	D	1,382	1,394	1,442	1,499	1,536	1,519	1,476	1,401	1,345	1,247	1,167	1,131
1973	AN	1,104	1,117	1,201	1,336	1,456	1,543	1,517	1,719	1,739	1,652	1,574	1,535
1974	W	1,504	1,582	1,584	1,589	1,649	1,690	1,697	1,862	1,965	1,884	1,785	1,737
1975	W	1,690	1,683	1,686	1,690	1,690	1,690	1,718	1,734	1,965	1,891	1,789	1,734
1976	C	1,686	1,690	1,690	1,669	1,672	1,660	1,597	1,423	1,312	1,190	1,098	1,061
1977	C	1,030	1,024	1,046	1,038	1,048	1,037	976	899	799	739	694	679
1978	W	661	659	717	872	964	1,042	1,087	1,291	1,688	1,892	1,860	1,773
1979	AN	1,690	1,690	1,690	1,690	1,690	1,690	1,661	1,876	1,866	1,750	1,641	1,590
1980	W	1,556	1,558	1,578	1,690	1,690	1,690	1,673	1,802	2,009	1,995	1,899	1,773

YEAR	WYT	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1981	D	1,690	1,675	1,672	1,684	1,690	1,690	1,660	1,546	1,454	1,333	1,240	1,199
1982	W	1,178	1,284	1,435	1,644	1,690	1,690	1,718	2,002	2,030	1,989	1,912	1,773
1983	W	1,690	1,690	1,690	1,690	1,690	1,690	1,718	2,002	2,030	2,030	1,944	1,773
1984	AN	1,690	1,690	1,690	1,690	1,690	1,690	1,642	1,630	1,601	1,513	1,401	1,342
1985	D	1,307	1,342	1,387	1,382	1,415	1,452	1,378	1,371	1,308	1,219	1,151	1,128
1986	W	1,114	1,136	1,213	1,286	1,657	1,690	1,703	1,935	2,030	2,027	1,954	1,773
1987	C	1,690	1,677	1,665	1,643	1,651	1,654	1,562	1,422	1,319	1,198	1,100	1,054
1988	C	1,025	1,025	1,065	1,123	1,168	1,149	1,066	949	886	820	767	746
1989	C	726	734	768	801	824	818	794	839	855	812	779	782
1990	C	807	810	838	855	888	881	805	763	735	687	648	638
1991	C	623	622	649	654	653	663	662	618	643	640	632	635
1992	C	635	639	670	689	736	751	703	736	722	725	696	679
1993	W	665	662	710	930	1,020	1,103	1,109	1,372	1,570	1,572	1,536	1,521
1994	C	1,495	1,484	1,478	1,481	1,491	1,474	1,390	1,273	1,196	1,103	1,029	996
1995	W	960	980	1,026	1,290	1,320	1,676	1,718	2,002	2,030	2,030	1,985	1,773
1996	W	1,690	1,674	1,690	1,690	1,690	1,690	1,688	1,921	1,966	1,893	1,783	1,733
1997	W	1,685	1,690	1,690	1,690	1,690	1,690	1,613	1,772	1,749	1,654	1,550	1,522
1998	W	1,473	1,466	1,468	1,634	1,690	1,690	1,717	1,806	2,030	2,005	1,921	1,773
1999	AN	1,690	1,690	1,690	1,690	1,690	1,690	1,708	1,702	1,786	1,701	1,598	1,549
2000	AN	1,500	1,492	1,481	1,562	1,684	1,690	1,628	1,772	1,767	1,658	1,562	1,519
2001	D	1,481	1,472	1,465	1,464	1,478	1,501	1,446	1,458	1,370	1,272	1,192	1,159
2002	D	1,132	1,144	1,219	1,282	1,307	1,298	1,223	1,272	1,253	1,176	1,112	1,085
2003	BN	1,066	1,103	1,163	1,237	1,263	1,258	1,260	1,280	1,325	1,265	1,212	1,193

Table 22. LSJR Alternative 4 Monthly Average Flow at Modesto on the Tuolumne River in cfs and February–June Flow Volume in TAF

YEAR	WYT	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	Feb-Jun [TAF]
1922	W	1,872	711	770	603	2,042	1,766	2,622	3,500	7,268	1,913	566	2,207	1,026
1923	AN	1,472	701	1,973	2,100	1,994	1,397	2,718	3,500	3,217	575	566	587	765
1924	C	732	605	580	579	428	371	1,402	2,039	200	331	342	353	268
1925	BN	428	442	440	427	2,452	1,620	3,500	3,500	3,500	380	389	408	868
1926	D	547	500	476	464	1,091	1,249	3,500	2,966	897	379	389	405	581
1927	AN	479	449	452	456	2,409	1,561	3,500	3,500	3,500	556	568	582	862
1928	BN	733	615	613	601	855	3,347	2,662	3,500	1,543	378	388	410	720
1929	C	547	495	477	468	432	966	1,492	3,500	2,269	333	341	363	522
1930	C	459	466	438	436	756	1,434	2,480	2,683	2,884	344	351	368	614
1931	C	456	453	449	437	486	644	1,553	2,039	494	334	344	354	314
1932	AN	424	437	430	427	2,503	1,678	2,470	3,500	3,500	577	568	578	818
1933	D	736	630	591	582	335	800	1,724	2,449	3,500	384	393	414	529
1934	C	482	471	451	434	972	1,464	1,875	1,454	958	331	341	353	402
1935	AN	435	445	437	436	1,156	1,337	3,500	3,500	3,500	562	565	587	778
1936	AN	733	609	597	593	3,500	3,478	3,500	3,500	3,500	611	565	582	1,047
1937	W	732	621	600	590	3,625	4,278	3,033	3,500	3,500	555	566	586	1,068
1938	W	732	618	1,922	1,613	7,123	7,539	4,619	3,500	8,120	3,684	572	1,260	1,832
1939	D	1,588	725	854	703	1,245	1,673	2,843	2,108	746	384	397	412	515
1940	AN	482	470	440	434	2,608	3,357	3,703	3,500	3,500	625	514	528	1,000
1941	W	640	526	755	2,495	5,049	4,646	3,185	3,500	3,500	2,545	618	547	1,179
1942	W	689	574	648	3,278	2,686	2,495	3,398	3,500	4,370	3,292	735	1,140	980
1943	W	1,333	1,270	1,409	3,732	3,293	5,952	3,500	3,500	3,500	1,073	501	436	1,181
1944	BN	753	584	626	650	834	1,594	1,654	3,500	2,692	414	405	359	620
1945	AN	526	453	389	529	3,295	2,827	2,864	3,500	3,500	688	634	572	951
1946	AN	684	466	3,746	2,702	2,354	3,054	3,500	3,500	2,672	637	600	580	901
1947	D	660	576	675	615	864	1,327	1,936	3,435	1,119	322	352	345	523
1948	BN	480	454	398	393	271	712	2,228	3,500	3,500	489	407	344	615
1949	BN	519	468	412	519	421	1,200	3,206	3,500	2,420	354	359	343	647

YEAR	WYT	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	Feb-Jun [TAF]
1950	BN	525	475	463	686	1,340	1,249	3,317	3,500	3,217	395	379	370	755
1951	AN	513	206	6,646	3,930	3,757	2,712	2,561	3,500	2,591	422	399	370	897
1952	W	461	400	475	846	1,544	2,596	3,874	4,665	7,191	3,733	617	1,882	1,194
1953	BN	1,322	479	674	2,059	1,313	1,570	2,722	2,527	3,500	519	433	400	695
1954	BN	460	400	391	397	1,102	2,078	3,500	3,500	1,865	373	379	369	723
1955	D	468	385	420	702	659	810	1,452	3,500	2,944	338	352	341	563
1956	W	395	372	441	6,886	2,920	3,431	2,843	3,500	3,500	2,933	681	574	972
1957	BN	927	478	491	518	1,490	1,995	1,744	3,500	3,500	399	408	405	733
1958	W	489	380	432	561	1,912	2,508	4,548	4,092	7,669	2,724	672	2,302	1,239
1959	D	1,383	519	581	658	2,872	2,003	2,259	2,264	1,402	349	333	366	640
1960	C	461	364	307	362	1,241	1,454	2,400	2,966	1,644	275	295	321	584
1961	C	310	330	282	337	497	693	1,664	2,147	1,230	236	256	235	374
1962	BN	298	314	323	314	2,517	1,356	3,500	3,500	3,500	358	396	408	855
1963	AN	464	273	315	425	3,338	1,093	2,501	3,500	3,500	527	500	515	825
1964	D	548	381	400	518	542	732	1,704	3,152	2,269	256	268	280	506
1965	W	343	266	234	4,607	3,581	3,136	3,359	3,500	3,500	543	565	717	1,015
1966	BN	585	491	2,109	1,104	810	1,425	3,015	3,464	867	246	242	242	577
1967	W	389	267	318	582	1,242	2,986	2,914	3,500	7,143	6,505	589	2,328	1,066
1968	D	1,303	449	485	515	1,656	1,562	1,886	2,810	1,422	350	338	330	561
1969	W	398	367	288	2,184	5,493	3,748	4,532	6,859	9,450	3,812	459	1,033	1,789
1970	AN	1,883	844	1,542	6,054	2,622	2,879	1,623	3,500	3,388	432	360	426	836
1971	BN	673	503	532	524	1,016	1,425	1,956	3,406	3,500	333	350	358	678
1972	D	515	322	524	367	814	1,776	1,573	3,357	2,218	276	286	284	588
1973	AN	315	451	522	524	2,009	1,688	2,612	3,500	3,500	484	509	512	794
1974	W	560	745	2,027	2,864	745	2,934	2,763	3,500	3,500	1,039	475	657	810
1975	W	1,190	1,088	789	757	3,142	3,403	2,563	3,500	3,500	1,262	558	569	960
1976	C	1,352	918	897	543	396	693	1,008	2,039	403	245	278	280	275
1977	C	284	309	322	295	200	224	797	1,034	1,059	170	167	153	199
1978	W	217	243	251	432	2,117	3,230	3,500	3,500	3,500	415	446	2,341	948

YEAR	WYT	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	Feb-Jun [TAF]
1979	AN	1,285	807	673	2,687	3,693	4,036	2,622	3,500	3,176	547	625	516	1,013
1980	W	609	813	877	5,544	6,796	3,551	3,156	3,500	3,500	3,500	567	2,035	1,221
1981	D	1,320	775	519	693	987	1,796	2,450	3,201	1,523	321	348	341	598
1982	W	439	421	600	685	5,904	5,364	8,408	5,071	7,175	3,679	592	2,913	1,897
1983	W	3,570	3,648	5,342	5,349	6,761	9,417	3,219	3,797	14,314	7,982	2,862	3,087	2,231
1984	AN	1,874	5,978	7,476	4,226	3,445	3,208	2,047	3,500	3,327	558	597	599	930
1985	D	743	974	430	489	745	1,229	3,045	3,327	1,361	340	367	359	584
1986	W	334	363	356	284	3,500	7,433	3,227	3,500	5,273	648	541	3,292	1,372
1987	C	1,979	1,300	566	596	400	966	1,956	1,981	655	256	265	253	359
1988	C	242	259	254	305	595	1,025	1,603	2,078	988	175	190	177	379
1989	C	194	220	245	244	659	2,781	3,116	3,132	2,087	187	203	212	710
1990	C	215	245	232	236	573	1,269	2,218	1,776	1,008	199	221	212	411
1991	C	214	239	223	208	200	1,639	1,815	3,279	2,975	183	201	188	599
1992	C	210	239	217	224	970	1,122	2,319	1,844	464	169	174	175	404
1993	W	213	208	217	781	1,739	3,113	3,378	3,500	3,500	2,059	326	404	912
1994	C	581	448	413	399	573	1,054	1,966	2,683	1,200	188	201	186	450
1995	W	230	218	223	518	1,729	3,500	4,248	4,051	11,607	8,579	1,781	3,637	1,504
1996	W	1,392	451	621	1,798	5,985	4,650	3,257	3,500	3,500	794	483	533	1,248
1997	W	592	1,130	6,295	17,792	3,756	3,492	2,793	3,500	3,388	499	486	486	1,006
1998	W	693	337	431	899	6,310	4,869	3,500	3,500	8,257	6,736	517	2,201	1,565
1999	AN	1,573	726	954	2,078	5,037	3,671	2,642	3,500	3,500	497	501	506	1,086
2000	AN	591	442	344	433	2,889	3,480	3,368	3,500	3,247	488	691	721	989
2001	D	692	465	418	518	648	1,747	2,289	3,500	555	293	314	300	528
2002	D	322	243	383	427	853	1,376	3,035	3,500	2,249	279	326	296	662
2003	BN	315	247	294	264	702	1,210	2,198	3,500	3,500	228	283	269	668

Table 23. LSJR Alternative 4 End-of-Month Storage at New Exchequer on the Merced River in TAF from 1922–2003

YEAR	WYT	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1922	W	469	456	483	506	599	652	647	780	948	876	767	713
1923	AN	675	675	675	675	675	683	696	780	771	728	607	539
1924	C	507	500	493	488	501	503	492	461	385	307	244	216
1925	BN	199	204	210	215	276	312	380	499	520	521	499	486
1926	D	473	466	462	457	483	498	510	437	422	413	387	363
1927	AN	343	331	336	326	292	299	267	378	400	436	468	511
1928	BN	515	511	524	539	551	493	454	461	455	455	459	477
1929	C	469	456	443	432	444	446	437	364	320	339	359	347
1930	C	328	315	302	291	285	246	230	197	176	217	253	269
1931	C	253	245	235	230	246	259	264	267	235	188	150	136
1932	AN	120	109	171	204	295	328	361	468	553	568	538	523
1933	D	507	494	485	485	495	509	510	500	506	449	380	351
1934	C	331	319	321	338	368	394	403	385	349	289	240	218
1935	AN	201	206	213	278	308	348	481	624	716	704	666	646
1936	AN	628	621	613	637	675	708	748	837	811	758	637	578
1937	W	531	521	524	532	667	717	748	919	928	852	743	689
1938	W	662	653	675	675	675	735	796	970	1,024	932	809	748
1939	D	675	675	675	673	675	701	720	689	613	518	431	396
1940	AN	385	375	365	476	546	599	661	789	785	728	660	608
1941	W	579	568	593	593	675	735	773	970	1,024	943	829	775
1942	W	675	674	675	675	675	710	739	815	947	854	731	673
1943	W	643	655	656	656	675	735	796	886	877	805	682	624
1944	BN	593	581	573	577	608	639	635	689	677	626	556	520
1945	AN	496	514	529	538	628	669	695	784	791	717	606	554
1946	AN	520	533	533	533	560	594	622	708	689	634	570	541
1947	D	517	529	530	530	555	574	581	582	528	452	381	350
1948	BN	334	328	319	316	325	337	360	428	482	460	418	393
1949	BN	376	363	356	350	367	398	438	502	498	451	403	382
1950	BN	363	352	342	365	397	417	462	510	521	477	425	401

YEAR	WYT	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1951	AN	385	626	675	675	675	709	726	726	691	616	533	493
1952	W	469	461	504	571	607	681	734	970	1,024	945	833	777
1953	BN	675	665	675	675	675	685	694	674	651	593	509	470
1954	BN	445	433	423	426	453	488	538	592	569	513	447	422
1955	D	400	387	388	401	418	430	434	474	473	425	369	347
1956	W	326	312	675	675	675	716	739	852	948	855	732	672
1957	BN	638	633	626	624	649	669	667	677	672	599	520	482
1958	W	457	449	455	472	533	616	758	970	1,024	957	858	807
1959	D	675	663	650	656	675	690	700	676	608	513	427	409
1960	C	389	375	360	353	386	408	437	459	435	383	334	313
1961	C	294	285	283	275	289	301	317	327	307	262	221	204
1962	BN	185	172	166	159	248	309	388	453	518	533	507	493
1963	AN	481	468	457	483	557	586	617	714	755	741	688	660
1964	D	637	657	661	666	675	678	668	657	604	517	432	397
1965	W	369	371	578	645	675	689	715	776	817	802	676	618
1966	BN	589	601	601	601	622	642	670	680	622	539	466	437
1967	W	416	413	509	553	582	645	712	891	1,024	949	841	788
1968	D	675	666	662	664	675	688	692	678	617	518	436	404
1969	W	380	387	409	675	675	720	823	970	1,024	930	807	746
1970	AN	675	675	675	675	675	723	726	758	728	653	575	540
1971	BN	519	522	557	590	611	627	633	653	656	608	543	513
1972	D	494	486	509	518	542	567	576	595	573	502	437	418
1973	AN	409	404	421	474	561	618	647	860	883	814	712	663
1974	W	620	632	633	633	659	708	739	880	887	794	674	617
1975	W	578	569	569	580	638	687	702	827	967	883	766	708
1976	C	670	675	674	663	675	676	660	626	550	452	376	349
1977	C	330	312	297	284	284	277	269	251	225	179	141	123
1978	W	103	87	104	200	289	384	487	709	959	928	857	806
1979	AN	675	675	669	675	675	733	751	893	864	789	677	618
1980	W	582	573	572	595	675	732	765	866	962	877	761	705

YEAR	WYT	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1981	D	675	656	645	647	665	685	691	692	635	548	472	440
1982	W	420	448	494	608	675	735	845	970	1,024	941	826	759
1983	W	675	675	675	675	675	735	754	970	1,024	933	810	744
1984	AN	675	675	675	675	675	712	727	806	770	709	637	603
1985	D	583	590	595	596	619	633	655	661	607	525	451	424
1986	W	407	404	419	445	675	735	791	937	1,005	940	841	789
1987	C	675	658	644	634	648	658	659	636	570	481	407	379
1988	C	353	349	344	354	364	379	389	389	359	314	269	253
1989	C	232	221	218	211	223	263	304	324	309	282	261	257
1990	C	253	247	239	238	250	265	284	282	252	216	181	166
1991	C	147	133	118	104	98	142	163	204	232	233	222	218
1992	C	203	197	190	187	220	238	273	282	256	248	227	225
1993	W	207	198	200	371	421	480	520	740	849	792	696	646
1994	C	616	602	593	586	602	603	592	567	518	428	358	322
1995	W	308	311	319	504	539	735	780	970	1,024	954	850	797
1996	W	675	662	672	675	675	727	755	875	849	778	655	594
1997	W	549	561	562	562	619	689	724	818	795	736	672	641
1998	W	614	606	605	627	675	735	782	843	1,024	941	825	763
1999	AN	675	675	675	675	675	692	693	782	755	674	592	555
2000	AN	526	517	504	544	621	679	702	804	777	704	633	599
2001	D	552	542	536	532	548	581	590	615	555	476	405	386
2002	D	359	353	384	410	424	438	466	496	471	406	345	319
2003	BN	294	307	324	348	360	378	393	499	508	464	419	394

Table 24. LSJR Alternative 4 Monthly Average Flow at Stevinson on the Merced River in cfs and February–June Flow Volume in TAF

YEAR	WYT	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	Feb-Jun [TAF]
1922	W	636	390	504	482	1,761	1,142	1,250	2,000	2,000	1,387	867	453	484
1923	AN	547	304	1,173	1,274	1,006	546	1,593	2,000	1,563	159	762	598	400
1924	C	593	385	382	396	156	185	676	888	150	54	36	49	124
1925	BN	282	419	425	428	1,145	751	1,815	2,000	1,482	116	77	54	429
1926	D	266	354	375	375	681	537	2,000	1,688	484	51	37	51	322
1927	AN	274	322	313	381	1,480	849	1,805	2,000	2,000	136	84	89	484
1928	BN	426	352	389	361	501	1,552	1,432	2,000	686	179	88	80	373
1929	C	296	387	387	408	238	459	786	1,883	978	49	54	92	262
1930	C	276	367	359	361	281	712	1,190	1,337	1,129	35	35	93	280
1931	C	276	385	372	382	205	254	746	898	202	87	41	75	139
1932	AN	266	363	475	469	1,585	771	1,321	2,000	2,000	109	57	58	459
1933	D	310	386	383	426	162	420	887	1,298	1,805	60	41	30	275
1934	C	298	383	405	466	486	634	928	546	333	85	36	29	175
1935	AN	282	389	409	580	540	839	2,000	2,000	2,000	182	100	55	443
1936	AN	368	410	385	428	3,954	976	2,000	2,000	1,644	108	807	441	627
1937	W	707	424	417	416	2,000	1,278	1,644	2,000	1,936	597	812	446	526
1938	W	442	401	2,050	1,344	4,918	4,548	2,000	2,716	4,876	2,238	1,159	596	1,129
1939	D	1,442	478	417	443	669	693	1,523	986	323	67	73	68	250
1940	AN	331	424	418	573	1,408	1,444	1,835	2,000	1,412	145	188	416	486
1941	W	459	427	1,286	1,340	1,644	1,669	1,593	2,170	2,856	1,749	1,069	508	592
1942	W	1,737	447	1,395	1,530	1,709	878	1,865	2,000	2,000	1,651	1,021	509	502
1943	W	494	549	783	2,172	1,647	3,140	2,000	2,000	1,533	534	941	490	618
1944	BN	475	459	436	414	490	790	807	2,000	1,341	172	136	88	328
1945	AN	357	489	446	441	1,988	1,103	1,573	2,000	2,000	878	937	421	514
1946	AN	840	640	1,862	1,067	357	800	1,946	2,000	1,149	170	129	81	376
1947	D	577	532	963	621	432	605	1,049	1,678	514	65	80	76	257
1948	BN	319	397	398	388	150	332	1,079	2,000	2,000	182	100	97	335
1949	BN	348	404	386	402	248	761	1,432	2,000	1,129	121	121	70	336

YEAR	WYT	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	Feb-Jun [TAF]
1950	BN	326	394	394	428	659	517	1,734	2,000	1,260	162	130	77	370
1951	AN	329	402	3,675	1,738	1,631	839	1,311	1,717	1,049	186	116	63	388
1952	W	347	417	460	1,986	678	1,532	2,000	2,248	3,636	1,942	1,231	621	607
1953	BN	1,664	428	384	1,241	723	400	1,210	1,190	1,593	140	126	55	305
1954	BN	360	405	403	406	519	966	1,714	2,000	746	167	131	81	358
1955	D	314	392	409	537	248	351	655	1,893	1,381	120	113	55	273
1956	W	311	386	239	4,367	1,973	859	1,553	2,000	2,000	1,954	1,152	610	501
1957	BN	580	422	409	411	443	615	887	1,952	1,775	195	154	81	341
1958	W	424	381	405	481	897	1,591	2,000	2,424	3,464	1,720	1,123	675	622
1959	D	2,236	395	382	395	815	537	1,190	1,093	514	107	116	94	247
1960	C	307	374	383	397	574	595	1,260	1,434	645	101	127	49	271
1961	C	286	365	387	372	184	293	847	927	444	70	55	40	162
1962	BN	264	341	359	360	1,718	722	1,996	2,000	2,000	253	182	78	501
1963	AN	346	362	376	376	1,869	595	1,321	2,000	2,000	277	194	158	461
1964	D	411	397	398	404	276	273	766	1,366	817	163	114	77	211
1965	W	346	356	528	1,780	697	673	1,664	2,000	2,000	309	1,448	634	421
1966	BN	474	866	812	1,055	346	634	1,603	1,776	474	206	165	79	291
1967	W	293	366	400	408	551	1,639	2,000	2,000	3,353	4,063	1,494	797	573
1968	D	2,153	411	330	382	752	468	948	1,181	504	196	177	130	231
1969	W	275	431	434	2,006	4,186	1,591	2,000	5,366	4,475	2,433	1,233	711	1,045
1970	AN	1,307	380	590	2,941	1,254	1,064	897	2,000	1,281	256	222	150	388
1971	BN	383	375	359	425	421	576	988	1,786	1,815	256	188	102	335
1972	D	359	386	423	270	355	800	807	1,630	968	240	222	18	275
1973	AN	309	412	432	474	1,350	1,122	1,321	2,000	2,000	600	1,038	574	465
1974	W	815	776	1,095	1,690	400	1,288	1,623	2,000	2,000	841	1,054	586	440
1975	W	667	350	409	307	1,167	1,269	988	2,000	2,000	1,163	1,062	533	444
1976	C	1,107	370	362	392	215	322	494	907	192	175	205	136	129
1977	C	354	311	322	373	150	150	313	381	464	106	81	44	87

YEAR	WYT	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	Feb-Jun [TAF]
1978	W	268	282	350	516	1,599	1,834	2,000	2,000	2,000	2,613	1,294	1,369	563
1979	AN	2,213	602	441	1,747	1,922	1,337	1,331	2,000	1,563	262	731	443	484
1980	W	698	374	392	3,976	3,134	1,522	1,734	2,000	2,000	2,284	1,248	583	619
1981	D	663	398	444	479	292	507	1,230	1,552	696	168	168	97	257
1982	W	401	405	414	484	2,475	2,127	4,613	3,714	2,373	2,249	1,390	1,170	912
1983	W	2,080	1,962	2,303	3,660	4,406	5,850	1,986	2,013	7,705	5,943	2,444	1,100	1,305
1984	AN	1,540	2,232	3,554	1,905	1,586	947	1,301	2,000	1,149	291	277	217	418
1985	D	580	338	334	488	357	576	1,482	1,669	575	236	206	100	280
1986	W	405	395	408	380	2,562	4,011	1,926	2,000	2,000	946	1,113	737	745
1987	C	2,015	416	418	381	194	351	958	927	252	130	135	87	161
1988	C	356	340	375	377	250	468	938	1,044	555	97	92	52	196
1989	C	256	274	322	304	248	937	1,613	1,288	736	68	62	67	290
1990	C	305	303	327	310	227	546	1,149	849	484	72	68	26	196
1991	C	248	258	274	292	150	937	817	1,795	1,462	91	54	10	312
1992	C	270	289	297	291	563	498	1,321	1,025	313	76	55	11	223
1993	W	206	313	350	684	1,080	1,532	1,825	2,000	2,000	1,492	1,085	640	505
1994	C	739	369	334	315	302	390	877	1,142	434	48	54	2	189
1995	W	239	327	317	611	756	2,504	2,000	2,277	5,695	4,891	1,700	509	794
1996	W	2,047	379	365	1,077	2,999	1,571	1,986	2,000	1,583	374	903	480	605
1997	W	613	845	3,494	9,912	1,102	1,132	1,704	2,000	1,149	149	114	84	424
1998	W	369	336	356	1,396	4,345	1,911	2,000	2,000	3,184	4,614	1,499	759	790
1999	AN	1,676	382	502	828	2,024	654	1,291	2,000	1,553	174	196	100	445
2000	AN	285	345	318	325	1,784	1,132	1,674	2,000	1,311	175	112	59	473
2001	D	668	496	392	389	335	839	1,089	2,000	333	74	84	25	278
2002	D	239	403	390	449	378	576	1,523	1,737	857	90	61	2	305
2003	BN	227	316	353	327	367	605	1,129	2,000	1,714	80	66	41	350