Appendix F.1

Hydrologic and Water Quality Modeling

Appendix F.1
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Tables

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Acronyms and Abbreviations

AF	acre-feet
AF/y	acre feet per year
AN	above normal
AWMPs	Agricultural Water Management Plans
BN	below normal
BO	biological opinion
C	critically dry
CAD	Cowell Agreement Diversion
CCSF	City and County of San Francisco
CDFW	California Department of Fish and Wildlife
cfs	cubic feet per second
CSJWCD	Central San Joaquin Water Conservation District
CUAW	Consumptive Use of Applied Water
CVP	Central Valley Project
D	dry
DWR	Department of Water Resources
FERC	Federal Energy Regulatory Commission
HEC	Hydrologic Engineering Center
HOR	Head of Old River
HWMS	Hydrologic Water Quality Modeling System
LSJR	Lower San Joaquin River
M&I	municipal and industrial
Merced ID	Merced Irrigation District
mmhos/cm	millimhos per centimeter
MID	Modesto Irrigation District
MSL	mean sea level
NMFS	National Marine Fisheries Service
NMI	New Melones Index
NWR	National Wildlife Refuge
OCAP	Operations Criteria and Plan
OID	Oakdale Irrigation District
OMR	Old and Middle River
ppt	parts per thousand
RPAs	Reasonable and Prudent Alternatives
SED	substitute environmental document
SEWD	Stockton East Water District
SJR	San Joaquin River

SJRA	San Joaquin River Agreement
SJRRP	San Joaquin River Restoration Program
SOI	Sphere of Influence
SSJID	South San Joaquin Irrigation District
State Water Board or SWRCB	State Water Resources Control Board
SWP	State Water Project
TAF	thousand acre feet
TAF/y	thousand acre-feet per year
TID	Turlock Irrigation District
USACE	U.S. Army Corps of Engineers
USBR	U.S. Bureau of Reclamation
USEPA	U.S. Environmental Protection Agency
VAMP	Vernalis Adaptive Management Plan
W	wet
WSE	Water Supply Effects
WTP	Water Treatment Plant

F.1.1 Introduction

This appendix includes a description of the hydrologic, water supply, and water quality modeling methods and assumptions used to evaluate the Lower San Joaquin River (LSJR) alternatives in this recirculated substitute environmental document (SED). The primary models used were the Water Supply Effects (WSE) spreadsheet model and the San Joaquin River Basin-Wide Water Temperature Model (CALFED 2009; CDFW 2013). The State Water Resources Control Board (State Water Board or SWRCB) developed the WSE model, based on the CALSIM II framework, in order to evaluate, under baseline conditions and each of the LSJR alternatives, effects on reservoir operations, water supply diversions, and river flow for each of the eastside tributaries (Stanislaus, Tuolumne, and Merced Rivers) and flow and salinity at Vernalis on the San Joaquin River (SJR). The San Joaquin River Basin-Wide Water Temperature Model, developed using the U.S. Army Corps of Engineers (USACE) Hydrologic Engineering Center's HEC-5Q water quality model, was used in coordination with the WSE model results to evaluate temperature effects caused by the LSJR alternatives. Both the modeling methods and results for baseline conditions and the three LSJR alternatives are described in this appendix. This appendix includes some assumptions regarding minimum levels of groundwater pumping that offset surface water demands but does not describe effects on groundwater resources, which are described in Appendix G, *Agricultural Economic Effects of the Lower San Joaquin River Flow Alternatives: Methodology and Modeling Results*.

The monthly and annual results from the WSE model and San Joaquin River Basin-Wide Water Temperature Model were used to assess the potential impacts of the LSJR alternatives on resource areas discussed in the SED that are affected by reservoir operations and streamflows. These resource areas are: flooding, sediment, and erosion (Chapter 6); aquatic biological resources (Chapter 7); terrestrial biological resources (Chapter 8); recreational resources and aesthetics (Chapter 10); cultural resources (Chapter 12), and energy and greenhouse gases (Chapter 14). Results showing the annual changes in water supply deliveries from the three eastside tributaries were used to analyze impacts related to groundwater resources (Chapter 9), agricultural resources (Chapter 11), service providers (Chapter 13), and economic analyses (Chapter 20).

As described in more detail in Chapter 3, *Alternatives Description*, LSJR Alternatives 2, 3, and 4 would also include adaptive implementation intended to optimize flows to achieve the narrative objective while allowing for consideration of other beneficial uses, provided that these other beneficial uses do not reduce intended benefits to fish and wildlife. There are four methods of adaptive implementation, detailed in Chapter 3, *Alternatives Description*, that allow for an adjustment of the volume of water required under LSJR Alternatives 2, 3, and 4. In general, the methods are as follows: method 1, increasing or decreasing the percent of unimpaired flow required by 10 percent, depending on the LSJR alternative selected; method 2, adjusting the percent of unimpaired flow either within or between the months of February–June; method 3, adjusting the percent of unimpaired flow outside of February–June, depending on the LSJR alternative selected; and method 4, maintaining a minimum base flow in the SJR at Vernalis at all times during the February–June period. The operational changes made using the adaptive implementation methods above may take place on either a short-term (e.g., monthly or annually) or a longer-term basis.

The Stanislaus, Tuolumne, and Merced Working Group (STM Working Group), composed of State Water Board staff, fishery agencies, and water users, will assist with implementation, monitoring, and assessment activities for the unimpaired flow objectives and with developing biological goals to help evaluate the effectiveness of the unimpaired flow objectives and adaptive implementation actions.

The quantitative results in the figures, tables, and text of Sections F.1.2.5 through F.1.2.7 of this appendix present primarily WSE modeling of the specified minimum unimpaired flow requirement of each LSJR alternative (i.e., 20, 40, or 60 percent of unimpaired flow). As such, any reference in this appendix to 20, 40, and 60 percent unimpaired flow is the same as LSJR Alternative 2, 3, and 4, respectively. Unimpaired flow represents the water production of a river basin, unaltered by upstream diversions, storage, or by export or import of water to or from other watersheds. It differs from natural flow because unimpaired flow is the flow that occurs at a specific location under the current configuration of channels, levees, floodplain, wetlands, deforestation and urbanization.

Modeling was also performed to provide data at 30 percent and 50 percent of unimpaired flow to evaluate the three adaptive implementation approaches. For example, figures, tables, and text in Sections F.1.2.2 and F.1.2.3, and the summary tables throughout the appendix, present WSE modeling of the 30 and 50 percent unimpaired flow to show the effect of the adaptive implementation approach 1. In addition, modeling at 40, 50, and 60 percent unimpaired flow allowed for retention of water to maintain carryover storage in the reservoirs to show the effect of adaptive implementation approaches 2 and 3.

Table F.1.1-1 summarizes the different unimpaired flows that could be required under each LSJR alternative as part of the minimum unimpaired flow that is part of the Program of Implementation or as a possible minimum or maximum range as part of the three adaptive implementation approaches. As mentioned previously, any reference in this appendix to 20, 40, and 60 percent unimpaired flow is the same as LSJR Alternative 2, 3, and 4, respectively.

Table F.1.1-1. Introduction: Percent Unimpaired Flows by LSJR Alternative

Percent Unimpaired Flow	LSJR Alternative 1 (No Project)	LSJR Alternative 2	LSJR Alternative 3	LSJR Alternative 4
20%	NA	X	NA	NA
30%	NA	X	X	NA
40%	NA	NA	X	NA
50%	NA	NA	X	X
60%	NA	NA	NA	X

The No-Project Alternative is discussed in Chapter 15, *No Project Alternative (LSJR Alternative 1 and SDWQ Alternative 1)*, and Appendix D, *Evaluation of the No Project Alternative (LSJR Alternative 1 and SDWQ Alternative 1)*.

F.1.2 Water Supply Effects Modeling—Methods

This section describes the development of the WSE spreadsheet model, the assumptions used to model baseline and LSJR alternative conditions, and results of the modeling. The initial scientific basis and methodologies for the WSE model are described in Appendix C, *Technical Report on the Scientific Basis for Alternative San Joaquin River Flow and Southern Delta Salinity Objectives*. The additions and refinements to the WSE methodologies are described in this appendix. WSE modeling results highlight the changes in reservoir operations, river flow, and surface water diversions that would result from the LSJR alternatives as compared to baseline. These results are also referenced in other chapters in the SED, as stated in Section F.1.1, *Introduction*.

The WSE model was developed rather than using CALSIM/CALSIM II[1] because CALSIM, a widely-accepted planning-level modeling tool for Central Valley water managers, 1) does not easily allow setting of monthly downstream flow targets as a fraction of the unimpaired flows, 2) it is difficult to change operations and assess those changes rapidly, and 3) it is not readily understood by a wide variety of users. By using a spreadsheet as the platform for the WSE model, it can be easily understood by a wide variety of users, can rapidly assess alternatives for reservoir operations, and can rapidly assess effects of alternatives for flow requirements. Because the WSE model uses the same node framework, hydrologic input, and similar mechanics and assumptions as CALSIM II, it can produce similar results to CALSIM II given similar operational inputs. The WSE model is considered an equivalent tool to CALSIM II for the purposes of this comparative water balance analysis and is sufficiently representative of baseline and potential future conditions for the programmatic-level planning needed to assess the plan amendments described in Chapter 3, *Alternatives Description*.

As is with many programmatic level operations models, the WSE model is not designed to precisely re-create historical conditions, nor can it precisely predict the potential future operations of the system. Real-time operational decisions made by directors and water planners do not always follow logic that can be input to a model, and thus would differ from a modeled result. As similarly stated (OTA 1982),

> Human behavior cannot be analyzed in the same sense as interactions that take place in the physical sciences. Human interactions may be extremely complex, and involve many factors not readily subject to quantification. At best, social scientists can estimate statistical variations in human behaviors under a set of assumed conditions.

Furthermore, planning level models are not meant to model precise conditions, but rather aid in planning by presenting a set, or sets of conditions that represent the likelihood of future conditions based on actual hydrologic events that span both drought and flood sequences. Other modeling efforts have stated similarly, as in the Federal Energy Regulatory Commission (FERC) report for hydrology modeling related to the Tuolumne River (SFPUC 2007), that

> While the modeling tool uses information on actual historical hydrology, it does not "predict" or necessarily precisely depict the past, historical operation of the system. The historical operation of the system in an actual year will differ from the operations simulated by the model for that year as a result of day-to-day adjustments made by the system operators, who constantly modify operations throughout the year to respond to changing conditions related to weather, demand, water quality, or facilities conditions (e.g., maintenance or unplanned facilities outages)…The objective of using the modeling tool is to assess the effect of system changes on future operations over a broad range of realistic hydrologic conditions.

The primary utility of a planning-level model is in comparative analysis, where the physical system is represented at a sufficient level of precision in order to accurately represent the most important effects of perturbations in the system. In this case, the WSE model is configured to determine, first and foremost, the change from baseline of water supply stored and available to meet diversion demands as a result of alternatives incorporating streamflow requirements.

[1] CALSIM is a generalized water resource simulation model for evaluating operational alternatives of the State Water Project/Central Valley Project system (USBR 2005). 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 the Department of Water Resources and the U.S. Bureau of Reclamation. This appendix uses CALSIM and CALSIM II interchangeably.

The WSE model is a monthly spreadsheet model that calculates the monthly flows, reservoir storage levels, and water supply diversions for each eastside tributary based upon user-specified target flows, other user defined inputs, input from CALSIM II, and flood storage rules. The general approach is to calculate available water for diversion in each water year based on inflows, net available water from storage after carryover guidelines, and after streamflow targets are met. 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.
- Monthly minimum flows for each eastside tributary.
- Minimum annual surface water diversion (can supersede storage guidelines).
- Annual end-of-September storage guidelines.
- Maximum annual allowable draw[2] from reservoirs as a fraction of the available storage.

Other inputs not defined by the user included the following:

- CALSIM II inflows to each major reservoir (New Melones, New Don Pedro, and Lake McClure), and SJR inflow from upstream of the Merced River confluence near Newman.
- CALSIM II evaporation rates from each major reservoir
- CALSIM II accretions/depletions downstream from each major reservoir including diversions.
- CALSIM II Consumptive Use of Applied Water (CUAW) monthly values. Translation from CUAW to diversion demand was based on updated estimates of district water balance components.
- CALSIM II flood storage rule curves at each major reservoir.

The sections below describe the calculation methodologies for flow targets, surface water demands, diversion deliveries, and the river and reservoir water balances; the development process for the WSE-CALSIM baseline scenario; and the development of inputs and assumptions for the WSE CEQA baseline and LSJR alternative simulations. Output data from the WSE model LSJR alternative simulations, including annual diversions, monthly river flows, and monthly reservoir storage, are compared to baseline conditions to assess the effects of the LSJR alternatives and intermediate simulations (i.e., 30 percent and 50 percent unimpaired flow) in Section F.1.2.2, *Water Supply Effects Model Results*.

F.1.2.1 U.S. Bureau of Reclamation CALSIM II SJR Module

The WSE model had its origin in the CALSIM II SJR module node framework. The U.S. Bureau of Reclamation (USBR) developed the CALSIM II SJR module to simulate monthly flows, reservoir storages, and water supply deliveries in the SJR Basin subject to specific requirements. The module is part of the larger CALSIM II planning model for the entire 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

[2] *Allowable draw* in this case refers to a reservoir modeling parameter that determines the available water allocation. This is not intended in a regulatory sense but, rather, to provide an example of reservoir operations to meet both streamflow requirements and carryover storage guidelines and preserve a portion for the following year’s supply as well as maintaining cold pool.

historical sequence of hydrologic conditions 1922–2003. The CALSIM II SJR module encompasses the SJR Basin from the Upper SJR at Millerton Reservoir to Vernalis, including all tributaries to the LSJR.

The watershed inflows to Millerton Reservoir, 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 are the primary boundary conditions of the SJR module. In the module, these inflows have been modified from the unimpaired runoff by upstream reservoir operations. The New Melones inflows, developed by USBR, are a combination of planning study inflows and actual recorded inflows for recent years. The New Don Pedro inflows, provided by CCSF are a result of a long-term simulation of current project operations for the period prior to 1996 and actual computed inflow since 1996. The Lake McClure inflows were estimated using the Lake McClure outflows adjusted for change in storage and evaporation in Lake McClure (USBR 2005).

Subject to the calculated inflows, the CALSIM II SJR module estimates the reservoir operations, diversions and river flows on each tributary to the LSJR, considering flow requirements, municipal and agricultural demands, and other operational constraints like flood control. It calculates annual available river diversions using the end-of-February storage plus actual March–September reservoir inflow (perfect foresight) on the Stanislaus and Merced Rivers, and March storage plus April–July reservoir inflows on the Tuolumne River. Flow requirements also factor in to the available diversions by reducing the amount of surface water available by the volume required to be released. On the Stanislaus River, the USBR also delivers water to CVP contractors, primarily based on a lookup table that determines the availability of water as related to the New Melones Index (NMI) and allows up to a maximum of 155 thousand acre feet (TAF) to be delivered annually.

The State Water Board used the SJR module (USBR 2013a, 2013b) and made minor adjustments to operations on the Stanislaus River and Vernalis pulse flow requirements. The first Stanislaus operations adjustment included an updated representation of the National Marine Fisheries Service (NMFS) Biological Opinion Stanislaus River Reasonable and Prudent Alternative (RPA), including Action 3.1.3 (NMFS BO) Table 2E flow requirements (i.e., lookup table), which are based on the NMI (NMFS 2009). The second adjustment was to allow full CVP/SWP diversions (Stockton East Water District and Central San Joaquin Water Control District) up to 155 TAF/y, if available, by using a diversion delivery schedule based on the NMI (Table F.1.2-1). The third adjustment (conducted by USBR) fixed a bug related to the Vernalis pulse flow calculation where, in the DWR 2009 Delivery Reliability Report, flows had overestimated the pulse volumes in April and May. The last adjustment to the Stanislaus operations was to begin the model with a New Melones Reservoir starting storage of 1,000,000 acre-feet (AF) on October 1, 1922, instead of 1,700,000 AF.

Table F.1.2-1. Stanislaus River Combined CVP Contractor (Stockton East Water District [SEWD] and Central San Joaquin Water Conservation District [CSJWCD]) Diversion Delivery Curves Based on New Melones Index Used in the WSE Model

New Melones Index (TAF)	SEWD Delivery (TAF)	CSJWCD Delivery (TAF)	Total (TAF)
> 1,800	75	80	155
1,400–1,800	10	49	59
0–1,400	10	0	10

The State Water Board CALSIM case includes the D-1641 base flow and salinity objective at Vernalis to be released from New Melones Reservoir. The VAMP April 15–May 15 Vernalis pulse flows are released based on the San Joaquin River Agreement (SJRA) distribution schedule from either New Melones Reservoir, New Don Pedro Reservoir, or Lake McClure. In the State Water Board CALSIM case, other than VAMP pulse flows, the minimum flows on the Tuolumne and Merced River were based on the current requirements by FERC, the Davis-Grunsky Agreement, CDFW Settlement Agreement for the Tuolumne River, and the Cowell Agreement. This model version did not include San Joaquin River Restoration Program (SJRRP) flow releases.

Appendix C, *Technical Report on the Scientific Basis for Alternative San Joaquin River Flow and Southern Delta Salinity Objectives*, contains an analysis of historical SJR flow and salinity. It compares 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 is present in the actual data. CALSIM model output ends with water year 2003. The comparison of CALSIM results with recent historical flow and EC (salinity) data demonstrates that it provides a reasonable (accurate) representation of the baseline SJR flow and EC conditions.

F.1.2.2 Development of the WSE Model Baseline and Alternative Assumptions

This section contains the assumptions and methods used to develop the WSE model baseline and Alternative scenarios. In addition, this section also describes the static inputs to the calculations above.

The WSE model baseline conditions were developed such that they would corroborate with CALSIM II SJR module results, both subject to a similar set of assumptions and rules and, thus, demonstrating the efficacy of the WSE model. The State Water Board conducted CALSIM II modeling using the CALSIM II SJR module supplied by USBR (USBR 2013a, 2013b). This version of the model contained many of the same assumptions and inputs as the CALSIM II “Current Conditions” case used in the DWR 2009 Delivery Reliability Report (DWR 2010), a version of CALSIM II which closely represents the baseline conditions over 82 years of historical climate. Differences between CALSIM II and the WSE model are described below.

CALSIM was used for corroboration because it is a widely accepted and rigorously reviewed planning model for the Central Valley, and contains a longer available dataset for comparison than historical data alone. Furthermore, as the observed historical conditions become increasingly different than current conditions reaching farther back in history, corroboration with a baseline conditions model becomes more appropriate than calibration to historical data.

The WSE CALSIM-baseline results set is the baseline WSE model run that best matches CALSIM II levels of demand and water balance parameters, while the WSE CEQA-baseline incorporates adjusted levels of demand and water balance parameters based on the best available information, including recent published data from Agricultural Water Management Plans.

The WSE CEQA-baseline version was developed to better model baseline conditions representative of the 2009 existing environment, and most consistent with the definition of baseline conditions. The primary changes from WSE CALSIM-baseline to WSE CEQA-baseline were related to estimates of demand as described in Tables F.1.2-12, F.1.2-13, and F.1.2-15. In addition, the level of Merced Cowell Agreement diversions is changed from CALSIM levels to full diversion according to Table F.1.2-7. The only other difference is that under CALSIM mode the Stanislaus minimum monthly flow requirement given in Table F.1.2-4 is chosen based on NMI calculated from the CALSIM Storage levels, while under CEQA-baseline the storage is calculated from equation F.1-8. Figure F.1.2-1 illustrates the relationship between SWRCB-CALSIM II, WSE model with CALSIM parameters for corroboration purposes, and WSE model CEQA-baseline used for alternatives analysis.

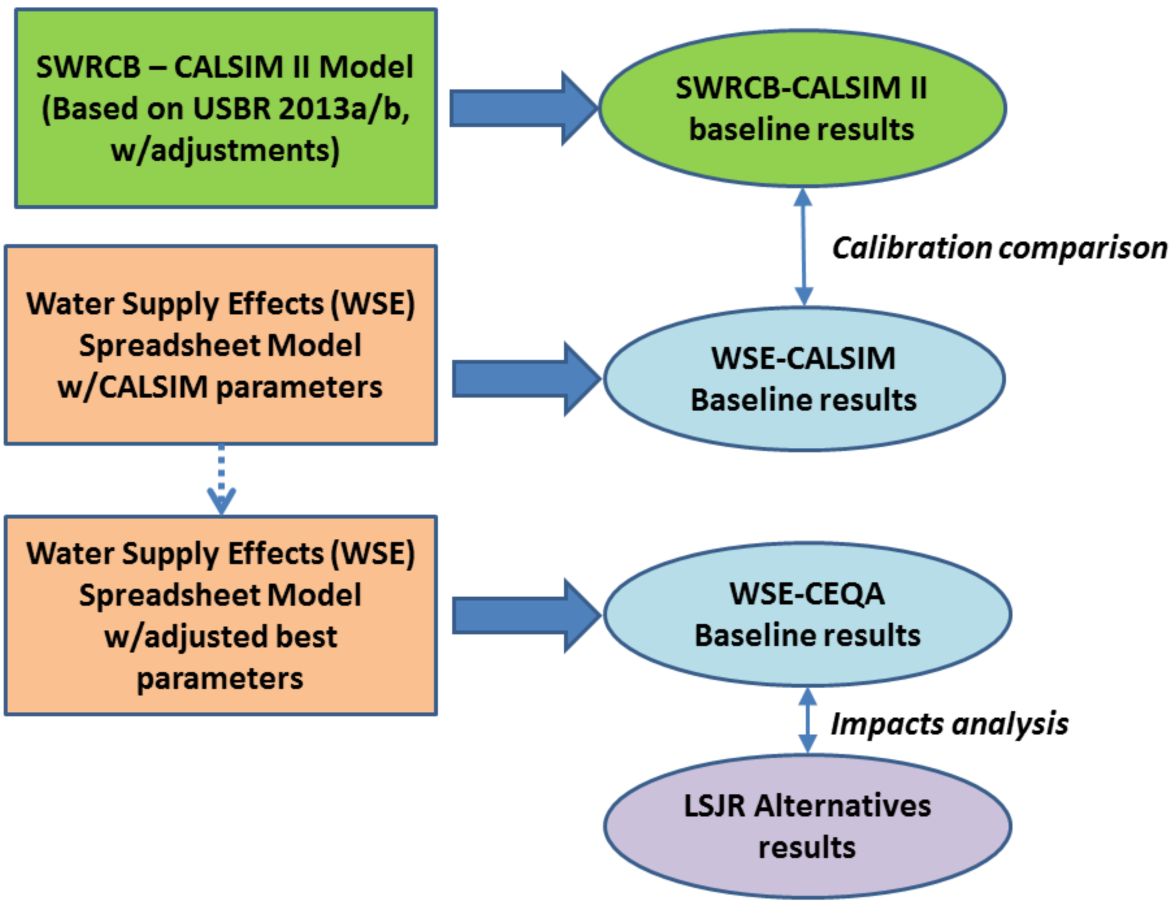


Figure F.1.2-1. Illustration of Differing Model Configurations Described in This Appendix

Table F.1.2-2, below, describes the differences in baseline assumptions for DWR DRR 2009 CALSIM II, USBR CALSIM II, the adapted version referred to herein as *SWRCB-CALSIM II*, and WSE baseline (used in this recirculated SED analysis). Based on comments received on the 2012 Draft SED and further study, the 2012 Draft SED WSE model has been revised, as described in Table F.1.2-3.

Table F.1.2-2. DWR DRR CALSIM II, USBR CALSIM II, SWRCB CALSIM II, and WSE Baseline Model Assumptions

CALSIM II and Baseline Model Assumptions	DWR DRR CALSIM II (used for 2012 Draft SED baseline)	USBR CALSIM II	SWRCB CALSIM II	WSE – Baseline[a]
Diversion Delivery Method	Stan: Feb storage plus Mar–Sep inflow Tuol: Mar storage plus Apr–Jul inflow Mer: Mar storage plus Apr–Sep inflow	Unchanged	Unchanged	Index of March 1 storage plus Apr–Sep inflow with WSE allocation scheme
SJRRP	Not Included	Included	Not included	Not included
VAMP and VAMP Base	Included – double step with split responsibility based on schedule	Included – single step, Merced fully responsible	Included – double step with split responsibility based on schedule	Included – double step with split responsibility(uses CALSIM VAMP pulse flow values)
D-1641 Base Flow (including X2) Feb–Jun	Included	Included	Included	Included
D-1641 Pulse Flow (including X2) Apr–May	Not Included	Not Included	Not included (VAMP instead)	Not included (VAMP instead)
D-1641 Vernalis EC (12 months)	Included	Included	Included	Included
New Melones Starting Storage	1,000 TAF	1,700 TAF	1,000 TAF	1,000 TAF
Stanislaus Minimum Flows Stanislaus RPA	Included – although has errors	Included – errors fixed (contains off-ramp in drought sequence)	Included – errors fixed (no off-ramp)[b]	Included – errors fixed (no off-ramp)[b]
Tuolumne Minimum Flows 1995 FERC	Included	Included	Included	Included
Merced Minimum Flows	Davis-Grunsky/FERC/Cowell	Davis-Grunsky/ FERC/Cowell	Davis-Grunsky/FERC/Cowell	Davis-Grunsky/ FERC/Cowell

CALSIM II and Baseline Model Assumptions	DWR DRR CALSIM II (used for 2012 Draft SED baseline)	USBR CALSIM II	SWRCB CALSIM II	WSE – Baseline[a]
Stanislaus Annual Irrigation Year (Mar–Feb) Diversions from 1922 to 2003	2005 level of development Max ~560 TAF SSJID/OID + Max ~117 TAF SEWD/CSJWCD + ~20 TAF Riparian	2020 level of development Max ~590 TAF SSJID/OID + Max ~155 TAF SEWD/CSJWCD + ~20 TAF Riparian	2020 level of development Max ~590 TAF SSJID/OID + Max ~155 TAF SEWD/CSJWCD + ~20 TAF Riparian	CALSIM LOD2020/modified Max ~594 TAF SSJID/OID + Max ~155 TAF SEWD/CSJWCD + ~20 TAF Riparian
Tuolumne Annual Irrigation Year (Mar–Feb) Diversions from 1922 to 2003	2005 level of development Max ~1,094 TAF MID/TID + ~8 TAF Riparian	2020 level of development Max ~1,107 TAF MID/TID + ~7 TAF Riparian	2020 level of development Max ~1,107 TAF MID/TID + ~7 TAF Riparian	CALSIM LOD2020/modified Max ~1,025 TAF MID/TID + ~7 TAF Riparian
Merced Annual Irrigation Year (Mar–Feb) Diversions from 1922 to 2003	2005 level of development Max ~543 TAF Merced ID + ~26 TAF Cowell + ~41 TAF Riparian	2020 level of development Max ~528 TAF Merced ID + ~25 TAF Cowell + ~41 TAF Riparian	2020level of development Max ~528 TAF Merced ID + ~25 TAF Cowell + ~41 TAF Riparian	CALSIM LOD2020/modified Max ~542 TAF Merced ID + ~94 TAF Cowell + ~41 TAF Riparian
Operational Maximum Flow[c]	1,500 cubic feet per second (cfs) in Stanislaus River	Stan max flow removed	Stan max flow removed	9,999 cfs on all three tributaries

[a.] All of these parameters are equivalent in WSE versions described as "WSE-CALSIM baseline" and "WSE-CEQA baseline," with the exception of the adjustment factors for CUAW demand.

[b.] The RPA used in modeling is based on the NMI, and thus, as the cumulative distribution of storage changes, so would the RPA required flow (can potentially be different within the alternatives).

[c.] Flow maximum may be exceeded in spill events for flood control.

Table F.1.2-3. WSE Modeling Assumptions

WSE Modeling Assumptions	Old Version WSE (2012 Draft SED version for comparison)	WSE – Baseline	WSE – Alternatives
Diversion Delivery Method	End-of-January storage sets diversion for Feb–Jan	Index of storage plus inflow with minimum allocation, and maximum of available water	Index of storage plus inflow with minimum allocation, and maximum of available water
SJRRP	Not Included	Not Included	Not Included
VAMP	Not Included	Included – double step with split responsibility based on schedule (uses CALSIM determined VAMP flow)	VAMP not included (expired)
D-1641 Base Flow (including X2) Feb–JunS	Not Included	Included – responsibility assigned to New Melones Res.	Included – responsibility assigned to New Melones Res.
D-1641 Pulse Flow (including X2) Apr–May	Not Included	Superseded by VAMP	D-1641 in effect
D-1641 Vernalis WQ (12 months)	Included – responsibility assigned to New Melones Res.	Included – Responsibility assigned to New Melones Res.	Included – responsibility assigned to New Melones Res.
New Melones Starting Storage	1,000 TAF	1,000 TAF	1,000 TAF
Stanislaus Minimum Flows Stanislaus RPA	Included with errors – %UF Feb–Jun (CALSIM other months)	Included year-round – errors fixed (no off-ramp)[a]	Greater of %UF or RPA during objective months; RPA other months[1]
Tuolumne Minimum Flows 1995 FERC	Not Included – %UF Feb–Jun (CALSIM other months)	FERC year-round	Greater of %UF or FERC during objective months; FERC other months
Merced Minimum Flows	Not Included – %UF Feb–Jun (CALSIM other months)	Included year-round using generalized minimum flow similar to Davis-Grunsky/FERC/Cowell	%UF or generalized minimum flow based on Davis-Grunsky/FERC/Cowell during objective months; baseline minimum flow in other months
Stanislaus Annual Irrigation Year (Mar–Feb) Diversions	Max 750 TAF	Max ~594 TAF SSJID/OID + Max ~155 TAF SEWD/CSJWCD + ~20 TAF Riparian	Max ~589 TAF SSJID/OID + Max ~155 TAF SEWD/CSJWCD + ~20 TAF Riparian
Tuolumne Annual Irrigation Year (Mar–Feb) Diversions	Max 1,100 TAF	Max ~1025 TAF MID/TID + ~7 TAF Riparian	Max ~995 TAF MID/TID + ~7 TAF Riparian

WSE Modeling Assumptions	Old Version WSE (2012 Draft SED version for comparison)	WSE – Baseline	WSE – Alternatives
Merced Annual Irrigation Year (Mar–Feb) Diversions	Max 625 TAF (only 2 years CALSIM diverted up to 625)	Max ~542 TAF Merced ID + ~94 TAF Cowell + ~41 TAF Riparian	Max ~532 TAF Merced ID + ~94 TAF Cowell + ~41 TAF Riparian
Flood Storage Curve	Stanislaus: same as CALSIM; Tuolumne: does not factor in conditional storage; Merced: greater storage capacity in July–September than CALSIM)	Stanislaus: same as CALSIM Tuolumne: Same as CALSIM (conditional time series) Merced: Same as CALSIM	Stanislaus: same as CALSIM Tuolumne: Same as CALSIM (conditional time series) Merced: Same as CALSIM
Channel Maximum Flows	2,500 cubic feet per second (cfs); 3,500 cfs; 2,000 cfs	9,999 cfs; 9,999 cfs; 9,999 cfs	9,999 cfs; 9,999 cfs; 9,999 cfs

[a.] The RPA used in modeling is based on the NMI, and thus, as the cumulative distribution of storage changes, so would the RPA required flow (could be quite different for the alternatives).

Modifications were incorporated into the original WSE modeling based on public comments received on the 2012 Draft SED. These modifications can be summarized as follows:

- CALSIM representation of baseline is no longer used directly in the SED. The WSE model was modified to provide a representation of baseline conditions, and is now used to model both the baseline and the LSJR alternatives for the purpose of impacts analysis in the SED. The WSE model representation of baseline includes the assumptions listed below, and except for the VAMP minimum flow requirements (first item below), all the other assumptions apply to the WSE modeling of the LSJR alternatives as well.
    - Vernalis Adaptive Management Plan (VAMP) minimum flow requirements per the San Joaquin River Agreement (USBR and SJRGA 1999 [EIS/EIR for SJRA]).
    - Stanislaus RPA 3.1.3 minimum streamflows at Goodwin Dam required by Biological Opinion Table 2E as a function of NMI (NMFS 2009)
    - Stanislaus River maximum diversions based on a 155 TAF total for SEWD and CSJWCD (USBR 2013a; USBR 2013b) and 600 TAF for SSJID and OID per the 1988 Stipulated Agreement with USBR (USBR and OID 1988).
    - The model no longer waives the minimum February–June percentage of unimpaired flow requirements during high flow events.
    - Future anticipated San Joaquin River Restoration Program flows are not included.
- The WSE model now also calculates flow in each tributary for the months of July–January, as opposed to relying on CALSIM output for those months as was done in the 2012 Draft SED, in addition to the February–June period. These flows are based on the minimum flow requirements applicable to each tributary and Vernalis, plus any reservoir releases needed to maintain compliance with flood storage curves. The model still, however, uses estimates of reservoir inflows, downstream accretions and depletions, demands, and other inputs as developed by USBR for the CALSIM model.
- WSE modeling of the LSJR alternatives in the 2012 Draft SED was configured to closely match the baseline condition of end-of-September storage levels in the main reservoirs on each tributary. To better simulate diversion priorities and reservoir operations, the modified WSE model now calculates the amount of water available for diversion each year based on the sum of available end-of-February storage plus March–September inflows (using foresight), less the sum of March–September river flow requirements and end-of-September minimum storage guidelines (the latter subject to annual diversion minimum constraints that supersede the guidelines in times of major shortage). Available water is then compared against estimates of demand (primarily agricultural irrigation) for the year, with the lesser determining the amount diverted.
- Minimum end-of- September storage guidelines storage conditions that maintain coldwater reserves adequate to ensure there are no temperature-related impacts on fisheries resulting from lower reservoir levels due to project alternatives. These minimum storage guidelines were modeled to be waived if certain minimum levels of diversion could not be met, as described in the below section, Calculation of Available Water for Diversion. Diversion demands for major irrigation districts are derived from annually- and monthly-varying CUAW demands from CALSIM, with operational efficiency estimates derived from Agricultural Water Management Plans (AWMPs), and total diversion and use adjusted for best match to AWMP surface water use data and district operations models. For smaller diversions, CALSIM values for diversions are used directly.

- With all of the above revisions, and by adjusting the overall demands for each river, the WSE model was calibrated for best match to SWRCB CALSIM baseline diversions, streamflows, and reservoir levels. This exercise demonstrated the WSE model's effectiveness in representing system dynamics similarly to the CALSIM model.
- Next, some water budget quantities in the WSE model were improved based on published estimates of reservoir losses, municipal and industrial water use, and other factors described in Appendix F.1. The final WSE baseline used in alternatives analysis includes all of the above changes, but with additional revisions to improved parameters. This is denoted as "CEQA Mode," and differs slightly from the original CALSIM baseline.
- In some water year types, a portion of LSJR alternative instream flow requirement was "shifted" outside of the February–June period to summer or fall months in order to reduce further any temperature impacts in those months caused by lower reservoir levels.
- Maximum streamflows (aka "flow caps") in downstream reaches were removed from the WSE model.

F.1.2.3 Calculation of Flow Targets

Generally, the WSE model calculates monthly flow targets for each eastside tributary based on the existing regulatory minimum flow schedules or user-specified percent of unimpaired monthly flow. The percentage of unimpaired flow could be variable between tributaries and months, although uniform values (20, 40, and 60 percent unimpaired flow) were used for each of the tributaries and for each month for the LSJR alternatives. Monthly unimpaired flows for water years 1922–2003 available from the Department of Water Resources (DWR 2007) are estimates of unimpaired flows upstream of the major reservoirs. These DWR estimates of unimpaired flows were used as unimpaired flow indices for the entirety of each eastside tributary because there are no estimates of unimpaired inflow to the tributaries between the major reservoirs and the LSJR, where the flow objectives are being established. Furthermore, based on information from DWR (DWR 2007), the entire Central Valley floor component of unimpaired flow (i.e., downstream of the major reservoirs) is roughly 3 percent of the unimpaired flows of the three eastside 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 reservoirs are therefore considered adequate for the purpose of establishing flow objectives. Proposed percentages of unimpaired flow are considered an additional requirement, and thus the greater of either the baseline flow requirements or the unimpaired flow requirement was selected for each month.

The February–June minimum instream flow requirement is calculated as a percentage of that month's unimpaired flow, for each month in February–June. For example, the unimpaired flow volume in the Stanislaus River in February 2003 was 55 TAF. An unimpaired flow of 40 percent would be 22 TAF (a monthly average of 396 cfs) for the month of February. Each month is calculated individually. Higher flows such as flood spills would meet the requirement during the month of the spills, but the surplus would not apply to successive months that would still need to meet the minimum flow.

The model allows for specifying maximum and minimum monthly flows for each eastside tributary and at Vernalis. Maximum flows could be selected to limit flooding effects and reduce water supply effects from extremely high target flows. However, for baseline and the alternatives, there were no maximum flow levels specified in the WSE model. The minimum monthly flows for each alternative and the baseline have been set to the existing (baseline) regulatory minimum flow requirements within each tributary. These existing flow requirements generally apply to the release of flows at the re-regulating or diversion dams on the Stanislaus, Tuolumne, and the Merced Rivers (Goodwin Dam, La Grange Dam, and Crocker Huffman Dam, respectively), while the WSE model sets flow requirements at the confluences with the LSJR. Minimum flow requirements at the confluences were determined by translating the existing upstream requirements using CALSIM accretions and depletions of flow between the dams and downstream. This allows for meeting existing requirements upstream while also allowing the unimpaired flow requirements to be specified near the confluences.

On the Stanislaus River, the existing minimum flow requirement is from the 2009 National Marine Fisheries Service (NMFS) biological opinion (BO) Stanislaus River Reasonable and Prudent Alternatives (RPAs), including Action 3.1.3 (NMFS 2009). These flows have been interpreted as monthly flow totals by the WSE model as shown in Table F.1.2-4, preserving the total volumes and including pulse flows. The schedule was based on the NMI, (a value set each year as the March 1 storage plus projected inflows to the New Melones Reservoir through September). The WSE model calculates the NMI each year as the end-of-February storage in New Melones plus the total of anticipated New Melones inflow March–September (available water supply through the end of the water year). New Melones inflows, an input to CALSIM II, are a combination of planning study inflows and actual recorded inflows for recent years (USBR 2004). As this flow schedule is dependent on storage, changes in storage relative to baseline result in changes to the flow requirement relative to baseline.

Table F.1.2-4. Minimum Monthly Flow Requirements at Goodwin Dam on the Stanislaus River per NMFS BO Table 2E

New Melones Index	Minimum Monthly Flow (TAF) by New Melones Index				
	> 3,000	> 2,500	> 2,000	> 1,400	> 0
Calendar Month					
1	22	14.3	13.9	13.5	13.1
2	20.2	13.1	13.1	12.3	11.9
3	101.2	93.4	12.3	12.3	12.3
4	97	83.2	92.3	45.5	27.3
5	120.2	95.4	76.2	38.7	24.6
6	65.3	55.8	21.6	11.9	8.9
7	26.3	18.4	15.3	12.3	9.2
8	24.6	18.4	15.3	12.3	9.2
9	23.8	17.8	14.9	11.9	8.9
10	51.7	48.9	47.5	34.8	35.8
11	17.8	11.9	11.9	11.9	11.9
12	18.4	12.3	12.3	12.3	12.3
Annual	588.5	482.8	346.5	229.6	185.3

Notes:

Sum of daily values in Appendix 2E of NMFS BO (NMFS 2009).

New Melones Index is the sum of March 1st Storage in New Melones plus projected inflow through September.

TAF = thousand acre feet per month

On the Tuolumne River, the existing minimum flow requirement is the 1995 FERC minimum flow requirement at La Grange Dam established in 1995 by Article 37 of the FERC license (Project Number 2299) in the settlement agreement between USBR and the California Department of Fish and Wildlife (CDFW). Table F.1.2-5 contains the monthly flow schedule as interpreted by the WSE model by water year type. As this is a total monthly flow, the pulse flows are retained in the monthly volumes. The schedule uses the SJR 60-20-20 water year type index, as defined by Water Rights Decision D-1641 (SWRCB 2000). The WSE model uses the historical water year type Water Supply Indices to determine the required flows in any given year over the 82-year model sequence.

Table F.1.2-5. Minimum Monthly Flow Requirements at La Grange Dam on the Tuolumne River per 1995 FERC Settlement Agreement

	Minimum Monthly Flow (TAF) by San Joaquin Basin (60-20-20) Water Year Type Index						
Index	> 3,100	> 2,700	> 2,400	> 2,200	> 2,000	> 1,500	> 0
Calendar Month							
1	18.4	10.8	11.1	9.2	9.2	9.2	9.2
2	16.7	9.7	10.0	8.3	8.3	8.3	8.3
3	18.4	10.8	11.1	9.2	9.2	9.2	9.2
4	63.1	40.6	28.8	27.6	25.4	19.1	14.6
5	63.1	40.6	28.8	27.6	25.4	19.1	14.6
6	14.9	4.5	4.5	4.5	3.0	3.0	3.0
7	15.4	4.6	4.6	4.6	3.1	3.1	3.1
8	15.4	4.6	4.6	4.6	3.1	3.1	3.1
9	14.9	4.5	4.5	4.5	3.0	3.0	3.0
10	24.4	13.2	12.7	9.2	9.2	7.7	7.7
11	17.9	10.4	10.7	8.9	8.9	8.9	8.9
12	18.4	10.8	11.1	9.2	9.2	9.2	9.2
Annual	300.9	165.0	142.5	127.5	117.0	103.0	94.0

Notes:
Monthly interpretation of 1995 FERC Settlement Agreement including pulse flows (FERC 1995).
San Joaquin Valley water year type index (60-20-20) as defined by D-1641 (SWRCB 2000).
TAF = thousand acre-feet per month

On the Merced River, the existing minimum flow requirement is a combination of the FERC (Project Number 2179) requirements and the 1967 Davis-Grunsky Contract (DWR 1967). Table F.1.2-6 contains the WSE model interpretation of the minimum flow requirement. To develop Merced River minimum flows in the WSE model, the highest of the FERC or Davis-Grunsky flows in a given month is selected and assumed to be the same in all years. The "normal year" FERC schedule is used to simplify the requirement between Normal and Dry. An additional release of 12,500 AF in October was also required on top of the FERC minimum flow requirement to satisfy the CDFW fall fishery pulse flow requirement. The Cowell Agreement Diversion (CAD) release requirements, presented in Table F.1.2-7, are not factored into the flow target, but they are included in release and diversion requirements discussed below. CAD releases are released from Crocker-Huffman Dam, but are entirely diverted, and do not contribute to minimum flows at the confluence with the LSJR.

Table F.1.2-6. Minimum Monthly Flow Requirements and Modeled Flow Requirement at Shaffer Bridge on the Merced River per FERC 2179 License, Article 40 and 41

	FERC (cfs)	FERC (cfs)	Davis-Grunsky (cfs)	Davis-Grunsky (cfs)	Modeled (cfs)
Calendar Month	Normal Year	Dry Year	Normal Year	Dry Year	All Years[1]
1	75	60	220	180	220
2	75	60	220	180	220
3	75	60	220	180	220
4	75	60	Not Applicable	Not Applicable	75
5	75	60			75
6	25	15			25
7	25	15			25
8	25	15			25
9	25	15			25
10	50	38			280[1]
11	100	75	220	180	220
12	100	75	220	180	220

Notes:

For simplification, and due to inconsistencies with CALSIM II, Normal Year minimum flows on the Merced River were assumed for all years.

[1] Includes additional CDFW fall fishery release of 12,500 acre-feet in October.

cfs = cubic feet per second (monthly average)

Table F.1.2-7. Monthly Cowell Agreement Diversions on the Merced River between Crocker-Huffman Dam and Shaffer Bridge

Calendar Month	Modeled Cowell Agreement Release (cfs)
1	50
2	50
3	100
4	175
5	225
6	250
7	225
8	175
9	150
10	50
11	50
12	50
Annual (TAF)	94

Notes:

Cowell Agreement release assumed to be fully released by Merced Irrigation District at Crocker-Huffman Dam and fully diverted before Shaffer Bridge.

TAF = thousand acre-feet per month; cfs = cubic feet per second

Two factors result in releases that may be different from the unimpaired flow objectives. The first is that the model calculates and releases additional flow, as described below, when required to maintain reservoirs below CALSIM flood control storage requirements, also known by the general term “spill.” The second, as described in Appendix K, *Revised Water Quality Control Plan*, is that as part of adaptive implementation, flows can be shifted outside of the February–June period and into the summer and fall to provide for temperature control, to reduce likelihood of negative effects, and to increase the overall potential benefit. This flow shift, described in further detail later in this appendix, is not part of the unimpaired flow objective. However, the calculation in the modeling attenuates the target volume by the amount to be shifted and increases July–November flows by increasing the minimum flow target. Because of these adjustments, the WSE model calculates flows that can be lower or higher than the specified percent of unimpaired flow or minimum flow.

As described above, the flow target at the mouth of each eastside tributary, $\mathbf{QF_t}$, for a particular month, **t**, is calculated as:

$$QF_t = Min(Max(UF_t * Fa_t, Qmn_t), Qmx_t) \qquad \text{(Eqn. F.1-1)}$$

Where:

$\mathbf{UF_t}$ is the DWR monthly unimpaired flow for month **t** (DWR 2007);

$\mathbf{Fa_t}$ is the monthly target percentage of unimpaired flow defined by the user; and

$\mathbf{Qmx_t}$ and $\mathbf{Qmn_t}$ are the user defined maximum and minimum regulatory defined monthly flows, for month **t**. In any given month, the flow target is the highest target set for that month (e.g., if percent of unimpaired flow was lower than the minimum, the minimum would be the target).

If flows are to be shifted outside of the February–June period, $\mathbf{QF_t}$ is adjusted accordingly.

With the flow target defined, WSE then performs an initial flow routing on each tributary prior to making any releases from the rim dams. This routing takes into account any accretions/depletion, stream inflows, non-district and non-riparian diversions, and return flows that occur before the confluence with the San Joaquin River. These inflow timeseries are taken directly from CALSIM II. Since this routing is intended to identify how each tributary is affected by the CALSIM II inflow timeseries, the flow may be negative. If any negative flows are found, the tributary’s rim dam must release enough water to eliminate them. Depending on the location of the negative flow along the tributary this release may count towards any flow requirements upstream. From here WSE operates the rim dams to meet the flow target defined above. First, WSE releases enough water to meet the unimpaired flow requirement at the confluence for the February–June period. Second, WSE releases water to meet each tributaries minimum flow requirement at the downstream regulating reservoirs (Crocker-Huffman, La Grange, and Goodwin) in all months, unless it was already satisfied with one of the previous releases. Finally, WSE makes any flow shifting releases. On the Merced River there is also an additional release on top of the others to meet the Cowell Agreement flow requirement at Crocker Huffman.

The WSE model also contains a user-defined flow target for the SJR at Vernalis that, if not met by the tributary releases, requires additional releases to meet the Vernalis minimum. The user may select among D-1641 pulse and base flow and salinity at Vernalis, VAMP pulse flows, and/or a user defined minimum to be met at Vernalis. Tables F.1.2-8 and F.1.2-9 contain the D-1641 and VAMP Vernalis flow schedules as interpreted by the WSE model. When activated in the model, the D-1641 pulse and base flows and salinity only require additional releases from the Stanislaus River. Additional pulse flows to meet VAMP, if activated, were distributed to each tributary according to Table F.1.2-10. The user-defined minimum at Vernalis distributes any additional flow, if needed, to each of the three eastside tributaries based on their unimpaired flow contribution as 29, 47, and 24 percent from the Stanislaus, Tuolumne, and Merced Rivers respectively. The Vernalis flow and water quality requirements are discussed in more detail in Appendix C, *Technical Report on the Scientific Basis for Alternative San Joaquin River Flow and Southern Delta Salinity Objectives*.

Table F.1.2-8. D-1641 Minimum Monthly Flow Requirements and Maximum Salinity Concentration in the SJR at Airport Way Bridge Near Vernalis

Calendar Month	Minimum Monthly Flow (TAF) by San Joaquin River Basin (60-20-20) Water Year Type			Maximum Salinity Concentration	
60-20-20 Water Year Type[2]	Feb 1–April 14 and May 16–June 30[1] (cfs)	April 15–May 15[1] (cfs)	October (cfs)	April–Aug (mmhos/cm)	Sep–March (mmhos/cm)
W	2,130/3,420	7,330/8,620	2,000	0.7	1.0
AN	2,130/3,420	5,730/7,020	2,000	0.7	1.0
BN	1,420/2,280	4,620/5,480	2,000	0.7	1.0
D	1,420/2,280	4,020/4,880	2,000	0.7	1.0
C	710/1,140	3,110/3,540	2,000	0.7	1.0

Notes:

[1] Greater flow used when required X2 position is at or west of Chipps Island (km 75). The required X2 position was determined by CALSIM and used in the WSE for each alternative and the baseline. The X2 standard, introduced in the 1995 Bay-Delta Plan, refers to the position at which 2 parts per thousand (ppt) salinity occurs in the Delta estuary and is designed to improve shallow-water fish habitat in the spring of each year and can limit export pumping.

[2] San Joaquin Valley Water Year Type Index (60-20-20) as defined by D-1641 (SWRCB 2000).

cfs = cubic feet per second

mmhos/cm = millimhos per centimeter

W = wet

AN = above normal

BN = below normal

D = dry

C = critically dry

Table F.1.2-9. VAMP Minimum Pulse Flow Requirements in the SJR at Airport Way Bridge near Vernalis

60-20-20 Water Year Type[2]	Minimum Monthly Flow (TAF) by San Joaquin Basin (60-20-20) Water Year Type		
	60-20-20 Index Indicator Value (cfs)	Existing Flow (cfs)	VAMP Pulse Target Flow (April 15–May 15)[1] (cfs)
C	1	0–1,999	2000
D	2	2,000–3,199	3,200
BN	3	3,200–4,449	4,450
AN	4	4,450–5,699	5,700
W	5	5,700–7,000	7,000

Notes:

[1] According to San Joaquin River Agreement, if the sum of current year's index and previous year's index is 7 or greater, a double step is required (next highest target level); if less than 4, no target is required (USBR and SJRGA 1999).

[2] San Joaquin Valley water year type index (60-20-20) as defined by D-1641 (SWRCB 2000).

cfs = cubic feet per second

Table F.1.2-10. Division of VAMP Additional Flow per Tributary According to the SJR Agreement

	Division of VAMP Pulse Flow Water (AF)				
	First 50,000 AF	Next 23,000 AF	Next 17,000 AF	Next 20,000 AF	Totals
Merced	25,000	11,500	8,500	10,000	55,000
OID/SSJID	10,000	4,600	3,400	4,000	22,000
Exchange Contractors	5,000	2,300	1,700	2,000	11,000
MID/TID	10,000	4,600	3,400	4,000	22,000

AF = acre-feet

OID = Oakdale Irrigation District

SSJID = South San Joaquin Irrigation District

MID = Modesto Irrigation District

TID = Turlock Irrigation District

Source: USBR and SJRGA 1999

F.1.2.4 Calculation of Monthly Surface Water Demand

Monthly surface water demand is a set time series based on CALSIM II CUAW. It varies monthly and from year to year dependent on climatic factors and is unchanged among simulations. CUAW was calculated by USBR for various regions throughout the plan area using the DWR consumptive use model (USBR 2005) and is an input to CALSIM II. USBR developed these estimates based on land use data, crop surveys, information from irrigation districts, and from river gages. In CALSIM this value is then expanded by various factors representing components of the overall water balance, including evaporation, seepage, and operational spills to determine the ultimate volume of water diverted from surface water.

Because CUAW represents the portion of applied water consumed by crops, it excludes losses that occur on the field and in the distribution system and excludes operational spills required to meet all delivery turnouts throughout the districts and contractor canals. Therefore, the total district surface water demand along each tributary is determined as the sum of CUAW demand, deep percolation losses, distribution losses, operational spills and returns, any municipal and industrial (M&I) surface water demands, and regulating reservoir seepage. For Merced Irrigation District (Merced ID) Sphere of Influence (SOI) deliveries to Stevinson and other areas are also included in the total diversion demand estimate. In addition, as the irrigation districts fulfill a portion of their applied water demand by maintaining a certain minimum level of groundwater pumping in all years, these minimum pumping levels are subtracted from CUAW demand. Figure F.1.2-2 shows a schematic representation of the components of the WSE generalized irrigation district water balance and a summary of annual average components under the baseline condition.

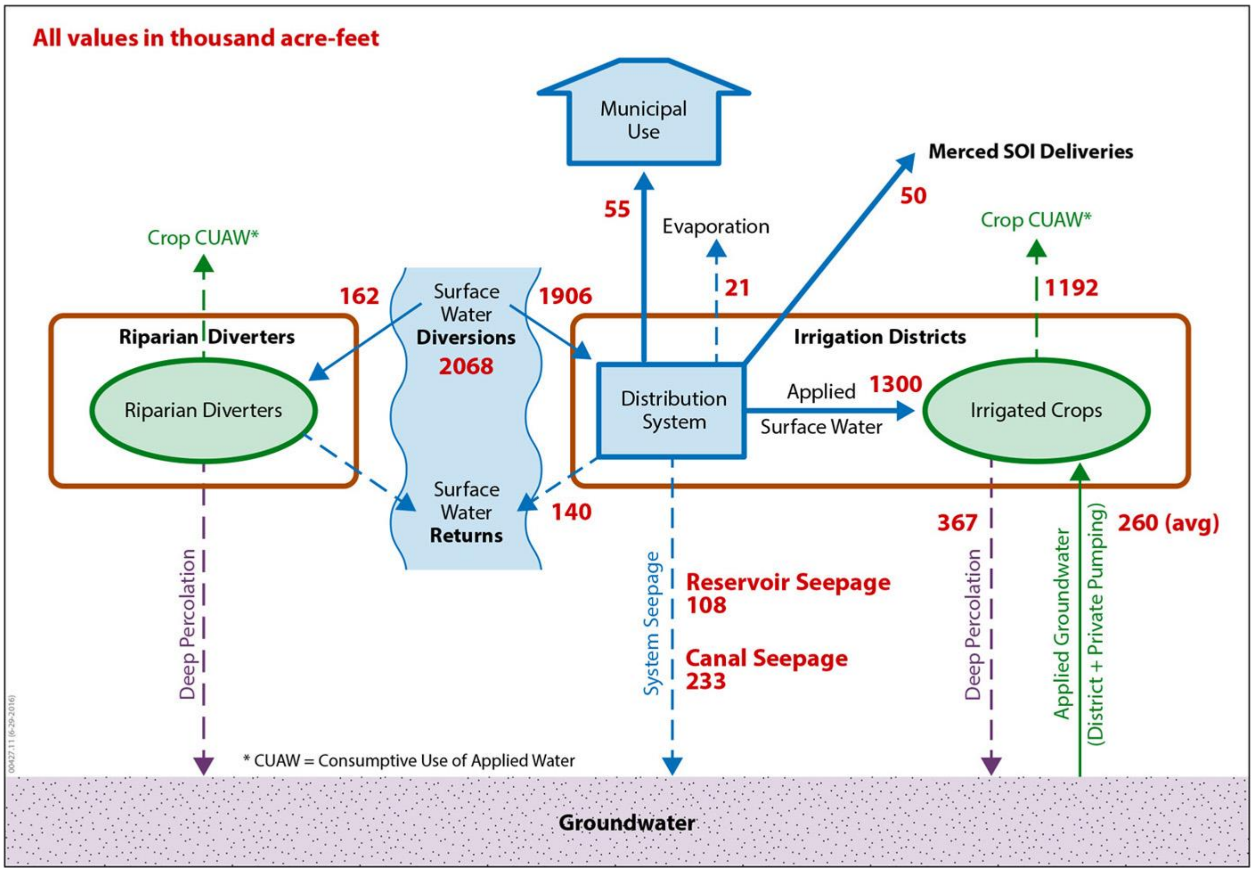


Figure F.1.2-2. Average Annual Baseline Water Balance for the Combined Stanislaus, Tuolumne, and Merced Rivers below the Major Rim Dams

Deep Percolation and Distribution Losses

Deep percolation represents a fraction of applied water that is not consumptively used, and instead seeps into groundwater. In WSE, deep percolation factors represent the proportion of deep percolation to CUAW, in other words, how much water percolates compared to how much is consumed by the crops. Estimates of district CUAW and deep percolation have been obtained from irrigation district Agricultural Water Management Plans (AWMPs) and used to calculate the deep percolation factors, shown in Table F.1.2-11. Deep percolation demand is calculated by multiplying each districts CUAW demand by its associated deep percolation factor.

Distribution losses represent the portion of water that is lost from the district distribution system, either as leakage or evaporation. In WSE the distribution loss factors represent the proportion of distribution losses to other surface water demands, not including municipal and industrial (M&I) demands or demands associated with losses from regulating reservoirs. Derivation of the distribution loss factors is based on information obtained from the AWMPs summarized in Table F.1.2-11. Distribution Loss demand is calculated for each district by taking the sum of CUAW, deep percolation, operational spills, and SOI demands; subtracting minimum groundwater pumping; and multiplying the total by its associated distribution loss factor.

Table F.1.2-11. Calculation of Deep Percolation Factors and Distribution Loss Factors

		Irrigation Districts				
		SSJID[a,b]	OID[c]	MID[d,e]	TID	Merced ID
Sources		Table 5-1, SSJID AWMP	Table 5-13 through 5-16, OID AWMP	Table 44, 47, and 48, MID AWMP	Table 4.6, 4.8, and 4.9, TID AWMP	Table 5.20, 5.21, and 5.22, Merced ID AWMP
Consumptive Use of Applied Water (CUAW)	AF/y	152,454	128,884	153,067	349,690	237,838
Deep Percolation of Applied Water (DP)	AF/y	42,321	24,496	58,132	159,111	60,116
Operational Spills/Returns (OS)	AF/y	19,847	48,884	29,768	60,019	33,116
GW pumping (GWP)	AF/y	45,260	26,372	28,017	99,769	63,021
Sphere of Influence Deliveries (SOI)	AF/y	NA	NA	NA	NA	74,712
Conveyance Evaporation (CEV)	AF/y	542	3,682	2,100	1,503	9,846
Conveyance Seepage (CES)	AF/y	28,317	47,203	8,000	36,209	98,526
Deep Percolation Factor	(DP)/(CUAW)	0.28	0.19	0.38	0.46	0.25

		Irrigation Districts				
		SSJID[a,b]	OID[c]	MID[d,e]	TID	Merced ID
Sources		Table 5-1, SSJID AWMP	Table 5-13 through 5-16, OID AWMP	Table 44, 47, and 48, MID AWMP	Table 4.6, 4.8, and 4.9, TID AWMP	Table 5.20, 5.21, and 5.22, Merced ID AWMP
Distribution Loss Factor	(CEV+CES)/ (CUAW+DP+ OS+SOI-GWP)	0.17	0.29	0.05	0.08	0.32

Notes:

[a.] South San Joaquin ID operational spill/returns are the sum of lateral spills (17,029 AF, Table 5-1), Lateral Seepage (8,165 AF, Table 5-1), and Tailwater (2,541 AF, Table 5-1).

[b.] South San Joaquin ID conveyance seepage is the sum of main canal seepage (20,152 AF, Table 5-1) and lateral seepage (8,165 AF, Table 5-1).

[c.] Oakdale ID GW pumping is the sum of district GW pumping (7,084 AF, Table 5-13) and private GW pumping (19,288 AF, Table 5-15).

[d.] Modesto ID consumptive use of applied water was determined using the Crop ET (173,179 AF, Table 44) and subtracting annual effective precipitation (20,112 AF, Table 47).

[e.] Modesto ID GW pumping is the sum of district GW pumping (20,057 AF, Table 47) and private GW pumping (7,960 AF, Table 48)

AF/y = acre feet per year

Operational Spills and Returns

Operational spills and returns represent water diverted by the districts that returns to the river. Excess flow often is used to maintain constant pressure head in the distribution system and maintain delivery. This water is eventually spilled or released from the distribution system and returned to the river. Operational spills and returns are modeled as a constant timeseries of monthly demands identical to CALSIM II return flow timeseries. In CALSIM II each district may have several return flow timeseries, so for incorporation into the WSE total demand calculation, these return flows have been aggregated into a single timeseries for each district. These flows return to the flow node framework in the same location as in CALSIM (i.e., not aggregated).

Other Surface Water Demands

Other surface water demands accounted for in WSE include Woodward, Modesto, and Turlock Reservoir Seepage; Modesto City M&I demands; and Merced ID Sphere of Influence (SOI) demands. CALSIM II represents these demands as constant annual volumes distributed in the same monthly patterns every year. After some analysis, it has been determined that CALSIM II estimates for these annual demands can be refined to represent baseline conditions. Effort was made to acquire more accurate and up-to-date estimates for these parameters, which are shown in Table F.1.2-12. On the left of the table are shown the original CALSIM II estimates, and on the right are estimates derived from more recent sources such as irrigation district AWMPs, information request response letters from the irrigation districts, and the Merced Operations model released as part of Merced ID’s FERC relicensing process (FERC 2015). In addition, another M&I demand was added for SSJID to represent Degroot Water Treatment Plant (WTP) based on information in the SSJID AWMP (SSJID 2012). With these new parameters, WSE diverges slightly from the CALSIM calibration and representation of baseline; therefore, separate modes were created, one, CALSIM mode, to try and replicate CALSIM II operations using all the CALSIM II parameters and another, CEQA mode, to model the LSJR alternatives with more up-to-date information, representing the most appropriate baseline determined by SWRCB.

Woodward Reservoir, Modesto Reservoir, and Turlock Reservoir are regulating reservoirs used by the districts to provide off stream storage for diversions and regulate irrigation water deliveries. Woodward Res. serves South San Joaquin Irrigation District (SSJID), Modesto Res. serves Modesto Irrigation District (MID), and Turlock Res. serves Turlock Irrigation District (TID). To keep these reservoirs in operation, water losses to seepage must be replaced. These terms also include any seepage losses from the upstream conveyance systems. In WSE these, annual demands are of the same quantity and distributed in the same monthly pattern as in CALSIM.

The City of Modesto has an agreement with MID to purchase Tuolumne River water from the district to reduce the city's reliance on groundwater. In WSE, this annual demand is distributed in the same monthly pattern as it is distributed in CALSIM. Operation of the Degroot WTP began in 2005, and it serves the cities of Manteca, Lathrop, and Tracy with Stanislaus river water delivered from SSJID. This demand was not included in CALSIM II because it came online after the model was constructed. In WSE, this demand is represented as a constant annual volume distributed equally over all months. In WSE, M&I surface water demands are assumed to be diverted directly from the district's regulating reservoir and do not pass through the district's distribution system, so they are not considered in the calculation of distribution losses shown above.

Table F.1.2-12. Other Annual Demands for Each Irrigation District

		WSE CALSIM Mode		WSE CEQA Mode	
Parameters	Irrigation District	Annual Total (TAF/y)	Source	Annual Total (TAF/y)	Source
Woodward Reservoir Losses	SSJID	62	CALSIM	29.5	SSJID AWMP
Modesto Reservoir Losses	MID	55	CALSIM	31.2	MID AWMP
Turlock Reservoir Losses	TID	92	CALSIM	46.8	TID Info Request
Modesto M&I Demand	MID	65	CALSIM	30.0	MID AWMP
Degroot WTP M&I Demand	SSJID	15.7	SSJID AWMP	15.7	SSJID AWMP
Merced Sphere of Influence (SOI) Demands[a]	Merced ID	81.4	CALSIM	68	Merced Operations Model

Notes:

[a] Merced SOI demands include Merced National Wildlife Refuge (15 TAF/y, both modes), Stevinson (26.4 TAF/y CALSIM, 24 TAF/y CEQA), El Nido (40 TAF/y CALSIM, 13 TAF/y CEQA), and other SOI demand (0 TAF/y CALSIM, 16 TAF/y CEQA).

TAF/y = thousand acre-feet per year

Merced ID SOI demands occur outside of the district, but share the districts distribution system. The SOI demands include the Stevinson Entitlement, required deliveries to Bear Creek in the Merced National Wildlife Refuge (NWR) as part of the districts FERC license, deliveries to El Nido, and water sales by Merced ID to other nearby entities (Merced ID 2013). Because these demands share the district's distribution system, they are included in calculations of distribution loss demand. El Nido was actually incorporated into the district in 2005 (Merced ID 2013); however, CALSIM II represents them separately from the district. Since the demands are aggregated into a single total demand for the district in WSE, it is unnecessary to separate El Nido from the other SOI demands. In WSE, the surface water demand for Merced NWR is modeled using the CALSIM II monthly demand timeseries, while the rest of the annual SOI demand is distributed over the water year in the same monthly proportions as Merced ID CUAW demand.

Minimum Groundwater Pumping

In each irrigation district there is a minimum amount of groundwater pumping that is assumed to occur every year regardless of surface water availability, either because the surface water distribution system doesn't reach some areas, or because the timing of diversions does not meet the growers needs. In WSE, Merced ID minimum groundwater pumping is a constant annual volume distributed over each water year based on the districts CUAW demand. For SSJID, Oakdale Irrigation District (OID), MID, and TID the minimum groundwater pumping is a constant annual volume distributed based on CALSIM II's repeating monthly pattern for minimum groundwater pumping in each corresponding district. After analysis, it was determined to use updated information to represent minimum groundwater pumping for baseline conditions. Table F.1.2-13 shows the annual volume of minimum groundwater pumping used in CALSIM II and estimates based on more recent information, from the AWMPs and the information request response letters from the irrigation districts.

Table F.1.2-13. Annual Minimum Groundwater Pumping Estimates for Each Irrigation District

		CALSIM Mode		CEQA Mode	
Parameter	Irrigation District	Annual Total (TAF/y)	Source	Annual Total (TAF/y)	Source
Minimum Groundwater Pumping	SSJID	52.0[a]	CALSIM	25.6	SSJID Info Request
	OID	20.0[a]	CALSIM	18.3	OID Info Request
	MID	38.5	CALSIM	12.0	MID Info Request
	TID	157.5	CALSIM	80.6	TID AWMP
	Merced ID	54.0	CALSIM	37.0	Merced ID AWMP

Notes:

[a.] SSJID minimum GW pumping to CALSIM district node 522 includes minimum GW pumping for the portion of OID on the north side of the Stanislaus, and OID CALSIM represents only OID south. Minimum GW pumping to CALSIM district node 530 on the south side of the Stanislaus.

TAF/y = thousand acre-feet per year

Irrigation District Diversion Data

For the modern era, irrigation districts report some of their diversion data in their AWMPs. Table F.1.2-14, below, shows a sample of the historical diversions of the irrigation districts published in the 2012 AWMPs and 2015 updates. Diversions are a result of total surface water demands, as described above, and water availability as a function of the available inflows and storage.

Table F.1.2-14. Sample of Irrigation District Diversion Data Reported in AWMPs

Water Year	WY Type	SSJID	OID	MID	TID[a]	Merced ID
2000	AN	229,632				483,391
2001	D	217,940				465,222
2002	D	249,271				470,156
2003	BN	228,117				431,926
2004	D	262,500				463,744
2005	W	204,501	223,706			468,724
2006	W	222,390	225,614			484,759
2007	C	249,569	261,896	296,000	499,137	430,739
2008	C	252,483	244,606	288,000	441,466	312,072
2009	BN	244,059	234,424	267,300	466,063	
2010	AN	223,202	217,143	264,633[b]	531,107	
2011	W	219,289	218,147	315,912[b]	537,685	
Average		233,579	232,219	286,369	495,092	445,637

a. In the 2012 AWMP, TID reports diversions measured below Turlock Reservoir, not from the river.
b. Modesto ID in the 2015 update AWMP reports 2010 and 2011 diversion totals as 261,728 AF and 282,640 AF, respectively.
Sources:
SSJID AWMP 2015; OID AWMP 2012; MID AWMP 2012; TID AWMP 2012; Merced ID AWMP 2012

Comparison of Surface Water Demands

Under WSE-CALSIM mode, an adjustment factor was applied to each river's CUAW demand to align the resulting annual diversions to the magnitude and distribution of total annual diversions calculated by SWRCB-CALSIM II. Similarly, under WSE-CEQA mode, a factor was applied to the CUAW demand on each river so that the total annual diversions would be consistent with the diversion levels represented in the Merced, Tuolumne, and Stanislaus operations models (MID 2015; MID and TID 2013; SJTA 2012).[3] Table F.1.2-15 contains the final adjustment factors applied to CUAW demand for each irrigation district to determine the total surface water demand time series from each river.

[3] Stanislaus, Tuolumne, and Merced Operations Models may differ from CALSIM and WSE in their system representation of inflows, allocations, assumptions, and dynamics, but Operations Models diversions are t sufficiently representative of baseline irrigation district diversions (meeting full demands when possible, otherwise limited by water availability), as represented by the districts themselves. They are more up to date than available CALSIM CUAW representations. CALSIM CUAW is utilized within WSE, adjusted as described above, because the time series of CALSIM CUAW is essential to representing the inter-annual pattern of demand that varies as a function of weather conditions. Primarily, the most important aspect is characterization of maximum demand. Stanislaus Operations Model and CALSIM maximum demands are in excess of recent irrigation diversions, but are considered to account for some exercise of OID/SSJID entitlements under the 1988 Agreement that would take the form of water transfers or sales not considered in the model. Tuolumne maximum demands in the FERC Tuolumne Operations model are lower than either CALSIM or long-term historical diversions, but match more closely with recent AWMP reported diversions, so WSE-CEQA diversions have been adjusted downward accordingly. Merced ID maximum diversions in the Merced Operations Model are similar to CALSIM, but these levels of demand can be met less often in the CALSIM and WSE allocation schemes. The recent drought has illustrated that zero allocations do occur for Merced ID based on low available storage in New Exchequer Reservoir.

Table F.1.2-15. Adjustment Factors Applied to CUAW Demands

	Irrigation District				
CUAW Multiplier	SSJID	OID	MID	TID	Merced ID
WSE-CALSIM Mode Adjustment Factor[a]	1.09	1.09	1.15	1.15	1.17
WSE-CEQA Mode Adjustment Factor[b]	1.09	1.09	1.08	1.08	1.19

[a.] Adjustment factors were developed during corroboration with SWRCB-CALSIM II as a final adjustment to best match SWRCB-CALSIM II deliveries for baseline conditions.

[b.] Adjustment factors were developed to match WSE annual diversions under WSE-CEQA baseline conditions to the annual diversions as seen in the baseline runs for the operations models.

TAF/y = thousand acre-feet per year

Once again, these factors are applied to CUAW demand at the field scale, which then are expanded by the addition of percolation, distribution losses, and operational spills/returns, so that total surface demand is determined. Total surface demand fluctuates based on the climactic factors that affect CUAW demand, but diversion to meet this demand is subject to allocation of available water. These adjustments to global demand for each tributary, combined with the best available efficiency data as described in prior sections, were required to best match the diversion time-series and distributions in CALSIM, and likewise in WSE-CEQA mode to match diversions from the Operation Models. Although AWMP data are far from complete, they offer a snapshot for comparison of recent conditions to the modeled baseline assumptions over 82 years. These comparisons are shown in Table F.1.2-16 and Figure F.1.2-3 for district diversions from the Stanislaus River, in Table F.1.2-17 and Figure F.1.2-4 for district diversions from the Tuolumne River, and Table F.1.2-18 and Figure F.1.2-5 for district diversions from the Merced River. Additional tables of annual components of reservoir release, streamflow and diversions are shown in Attachment 1 to this appendix.

Table F.1.2-16. Annual Irrigation Year (Mar–Feb) Diversions from the Stanislaus River by OID/SSJID, as Represented by USGS Observed, CALSIM, Stanislaus Operations Model, WSE-CALSIM Baseline, WSE-CEQA Baseline, and AWMP Data

Diversion Statistics Results Set	Max (TAF)	75th (TAF)	Median (TAF)	25th (TAF)	Min (TAF)
USGS Observed (1988–2003)	564	512	482	458	373
SWRCB-CALSIM Baseline (1971–2003)	588	533	505	481	256
Stanislaus Operations RPA (1971–2003)[a]	600	529	508	469	381
WSE w/CALSIM parameters (1971–2003)	587	531	511	474	244
WSE – CEQA Baseline (1971–2003)	589	531	511	474	232
AWMP Data (2005–2011)	511	488	448	439	428

[a] Stanislaus operations model annual diversions are totaled by water year.

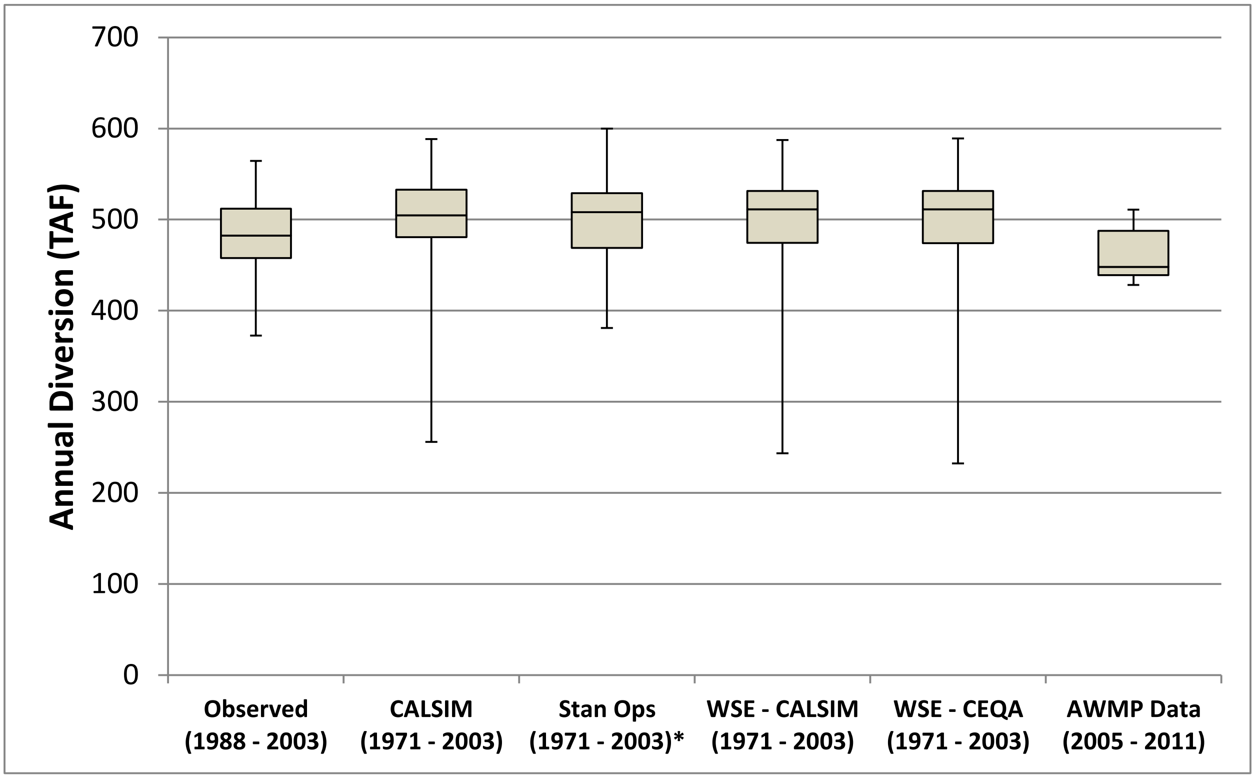


Figure F.1.2-3. Annual Irrigation Year (Mar–Feb) Diversions from the Stanislaus River by OID/SSJID, as represented by USGS Observed, SWRCB-CALSIM, Stanislaus Operations Model (*Statistics are for Annual Water Year Diverions), WSE-CALSIM Baseline, WSE-CEQA Baseline, and AWMP Data

Table F.1.2-17. Annual Irrigation Year (Mar–Feb) Diversions from the Tuolumne River by MID/TID, as Represented by USGS Observed, SWRCB-CALSIM, Tuolumne Operations Model, WSE-CALSIM Baseline, WSE-CEQA Baseline, and AWMP Data

Diversion Statistics Results Set	Max (TAF)	75th (TAF)	Median (TAF)	25th (TAF)	Min (TAF)
USGS Observed (1971–2003)	1,201	997	933	800	396
SWRCB-CALSIM Baseline (1971–2003)	1,107	957	873	808	511
WSE w/CALSIM parameters (1971–2003)	1,050	931	889	810	550
WSE CEQA Baseline (1971–2003)	1,025	886	844	771	550
Tuolumne Ops Model (1971–2003) FERC Baseline	960	893	838	782	640
AWMP Data (2007–2011)[a]	900	843	842	780	776

[a] Because TID does not report reservoir losses in AWMP, 46.8 TAF added for estimate for additional diversion

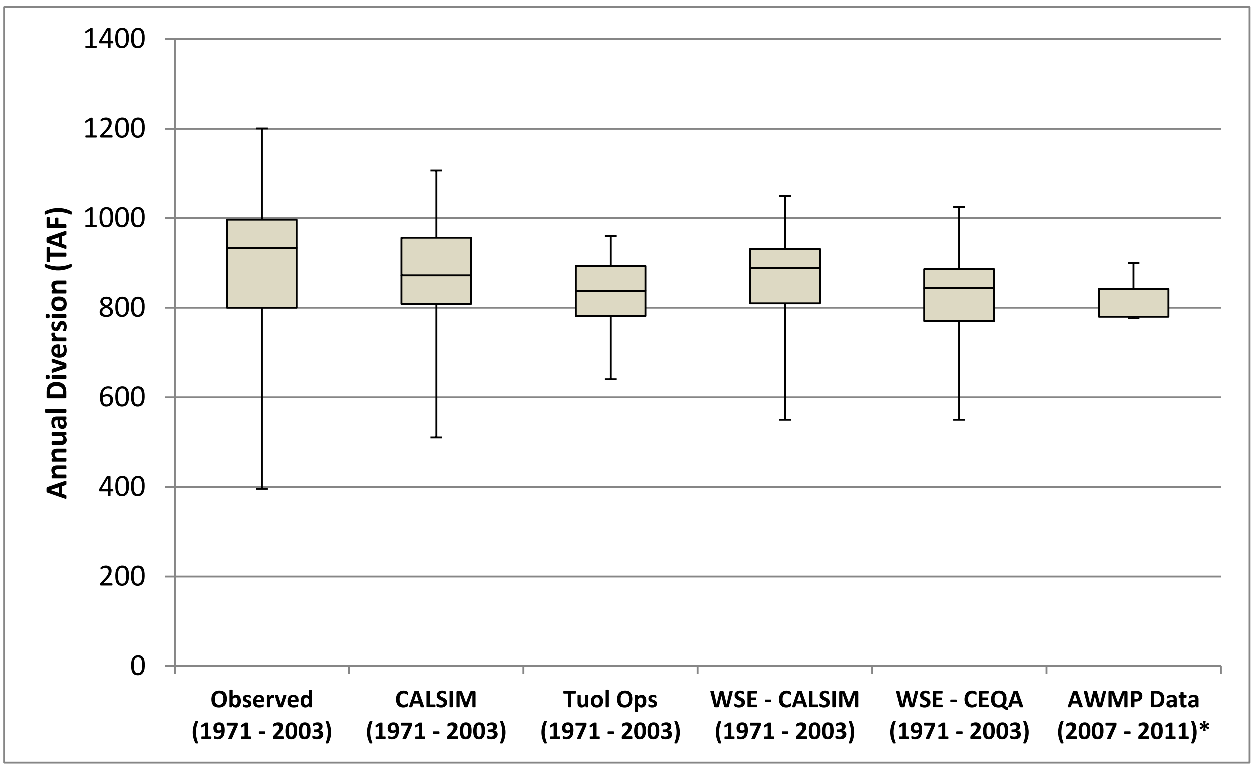


Figure F.1.2-4. Annual Irrigation Year (Mar–Feb) Diversions from the Tuolumne River by MID/TID , as represented by USGS Observed, CALSIM, Stanislaus Operations Model, WSE w/CALSIM parameters, WSE-CEQA Baseline, and AWMP Data (*w/46.8 TAF added for Turlock Res. losses)

Table F.1.2-18. Annual Irrigation Year (Mar-Feb) Diversions from the Merced River by Merced ID, as Represented by Observed, CALSIM, Merced Operations Model, WSE w/CALSIM parameters, WSE-CEQA Baseline, and AWMP Data

Diversion Statistics Results Set	Max (TAF)	75th (TAF)	Median (TAF)	25th (TAF)	Min (TAF)
SWRCB CALSIM Baseline D561 (1971–2003)	528	493	462	432	42
WSE w/CALSIM parameters D561 (1971–2003)	542	501	456	414	14
WSE CEQA Baseline D561 (1971–2003)	542	503	467	424	3
Merced Ops Model/Observed (1970–2003)	535	498	477	456	60
AWMP Data (2000–2008)	485	470	465	432	312

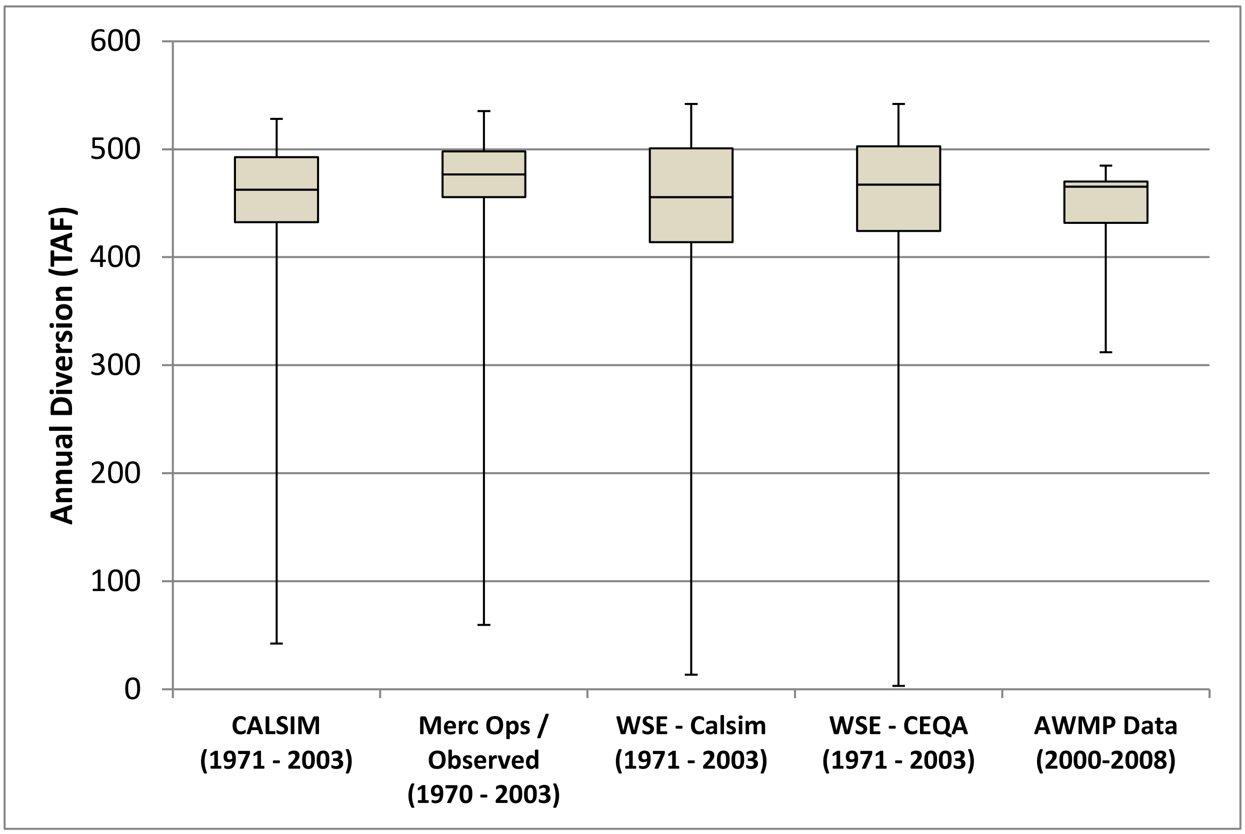


Figure F.1.2-5. Annual Irrigation Year (Mar–Feb) Diversions from the Merced River by Merced ID, as Represented by SWRCB-CALSIM Baseline, Merced Operations Model, WSE-CALSIM Baseline, WSE-CEQA Baseline, and AWMP Data

CVP Contractor Demands

The CVP contractors, Stockton East Water District (SEWD) and Central San Joaquin Water Conservation District (CSJWCD) are treated differently compared to the other districts. Their demands are represented as a constant annual volume of 155 thousand acre-feet per year (TAF/y) (with 80 TAF/y for CSJWCD and 75 TAF/y for SEWD) based on information from USBR (USBR 2013a, 2013b). This demand is distributed over the year in a monthly pattern, as shown in Table F.1.2-19.

Table F.1.2-19. CVP Contractor Monthly Diversion Schedule

	SEWD/CSJWCD	
Month	Monthly Demand Pattern (% of Annual)	Modeled Demand (TAF)
January	3%	5
February	3%	5
March	4%	6
April	4%	6
May	11%	17
June	18%	27
July	20%	31
August	15%	24
September	9%	13
October	5%	8
November	4%	7
December	4%	6
Total	100%	155

Minor, Riparian, and Cowell Agreement Diversion Demands

Finally, minor and riparian demands represent diverters with riparian rights or smaller diversions along each tributary. In WSE, these demands are modeled using the monthly timeseries of diversions taken from CALSIM II (D528 and D545) and are kept separate from the district demands. The CAD demands are also treated as minor and riparian demands in WSE. However, the SWRCB-CALSIM II timeseries of CAD diversions (D528) does not fully divert the Cowell Agreement Flow described in Table F.1.2-7. Under CEQA mode in WSE the monthly CAD demands were increased so that they would equal that month's Cowell Agreement Flow Release.

F.1.2.5 Calculation of Available Water for Diversion

As a part of the modeling analysis, it has been necessary to utilize certain reservoir constraints and parameters that determine allocation of available water for diversions, both in baseline and alternatives scenarios. These parameters are central to the model's determination of when there is available water to meet full irrigation demands and, at other times, when there is not adequate water supply from inflow and reservoir storage, which, in turn, requires diminished allocations of water to diversions while preserving a reserve of storage supply for future years.

The analysis contained in this SED provides LSJR alternatives that represent examples of system operation to determine the significance of impacts, pursuant to CEQA. Selection of appropriate parameters has first been made to represent baseline conditions most closely in terms of diversion allocations and reservoir operations, similar to those in the CALSIM baseline scenario. Under additional streamflow requirements of the LSJR alternatives, changes in water availability require adjustment of parameters to ensure feasibility for the 82-year simulation so that the reservoirs are not drained entirely in the worst droughts of record. In addition, carryover storage guidelines have been increased for New Melones Reservoir and New Exchequer Reservoir to minimize impacts on instream temperature that would be caused by lower reservoir levels and a limited coldwater pool. These operational constraints, as components of modeling simulations, do not by themselves comprise a plan of implementation or otherwise carry the weight of regulatory requirements. Rather, they are included as elements of the modeling simulation to evaluate the feasibility of the LSJR alternatives. An implementation plan developed in a future proceeding would need to identify and evaluate supply, storage, and temperature conditions and appropriate operational objectives, to best protect beneficial uses and avoid adverse effects where feasible.

In WSE, the following operational parameters are used to govern reservoir operations and determination[4] of the available water for diversion and use:

- Maximum Storage Levels (Flood Curves): The maximum level allowable in the reservoir is set equal to the CALSIM flood control levels in New Melones and New Don Pedro Reservoirs (including conditional storage, when applicable) and Lake McClure. The model assumes projected filling above these levels will be evacuated within that month to maintain at or below these maximum operating levels. These flood curves are based on USACE requirements, but with some differences (USBR 2005).
- Minimum End-of-September Storage: A minimum end-of-September storage guideline was developed by iteration in order to determine levels protective of coldwater pool and river temperatures in the summer and fall. Projected end-of-September storage for a given year is reduced by this value to determine the amount of storage supply available for diversion for that year.
- Minimum Diversion Level (Minimum End-of-September Relaxation): Diversions can override the end-of September storage guideline and draw additional water from storage in the event the available surface water for diversion is less than a specified minimum level. This in effect is a relaxation in certain years to the end-of-September storage guideline. The minimum level constraint was set after trial and error to ensure there were no significant temperature impacts.
- Maximum Allowable Draw from Storage: The model constrains the percentage of the available storage (after holding back for minimum end-of-September storage) that is available for diversion over the irrigation season. This limits the amount of storage that can be withdrawn to reduce potential effects on river temperatures by protecting carryover storage and the

[4] Determination of available water to supply demand is a modeling necessity to represent baseline conditions and operational envelopes for LSJR alternatives; however, these parameters, including “Maximum Allowable Draw from Storage,” *do not* represent regulatory requirements of how the reservoir storage and use system must be operated—rather, alternatives are examples of system operation that illustrate most likely water availability as a function of additional constraints of instream flow requirements. To some extent, carryover storage guidelines have been increased over baseline to reduce indirect temperature effects that would otherwise occur because of lower storage levels. Implementation most likely will require further optimization of these parameters with balanced consideration of desired temperatures and tradeoffs with other resource values.

coldwater pool in the reservoirs leading into a drought sequence. Baseline "allowable draw" was determined empirically to match CALSIM patterns of allocations, similar to how a "delivery versus carryover risk curve" might be used.

- End-of-Drought Storage Refill Requirement (only needed in alternatives with 40+ percent of unimpaired flow, not in baseline): When reservoir levels are very low (typically after a drought sequence), the model limits the amount of inflow that can be allocated for diversion in a subsequent wet year(s). By reducing the amount of inflow that can be diverted in such years, reservoirs and associated coldwater pools recover more quickly after a drought. Without such a requirement, reservoirs otherwise would remain lower for longer after a drought, causing associated temperature impacts.

Calculation of available water proceeds as follows:

After the instream flow and other environmental release requirements are satisfied, the available water for diversions is calculated for each year's growing season. Available water for diversion is the amount of projected inflow plus carryover storage adjusted downward by the amount of required flow releases, the first estimate of reservoir evaporation, and the end-of-September storage guidelines.

Equation F.1-2 shows the calculation to determine available water for diversion, $W_{avail,GS}$:

$$W_{avail,GS} = \overbrace{K_{Stor} * \left(S_a - EOS_{req}\right)}^{Available\ \ Storage} + \overbrace{\sum_{n=a+1}^{b} (QINF_n - ER_n - EV_n)}^{Available\ \ Inflow} \qquad \text{(Eqn. F.1-2)}$$

Where:

K_{Stor} is the percentage of the available storage at the tributary's major reservoir that would be available for diversion over the growing season. In general, this value limits the amount of storage that can be withdrawn, reducing potential impacts on river temperatures by protecting the reservoir's coldwater pool.

S_a is the ending storage at the tributary's major reservoir for month **a.** Month **a** is selected by the user and represents the last month prior to the start of the growing season; **a** = 2 (February) for the baseline and alternative simulations.

EOS_{req} is the minimum end-of-September carryover storage guideline at the tributary's major reservoir that would protect coldwater pool and river temperatures in the summer and fall.

QINF is the forecast CALSIM II inflow to the tributary's major reservoir over the growing season, from month **a**+1 to month **b**. Month **b** is also selected by the user and represents the final month of the growing season; **b** = 9 (September) for the baseline and alternative simulations. The inflow time series for each reservoir was developed by DWR and USBR outside of CALSIM II as an input to CALSIM II. The New Melones Reservoir inflows, developed by USBR, are a combination of planning study inflows and actual recorded inflows for recent years; the New Don Pedro Reservoir inflows, provided by the City and County of San Francisco (CCSF), are a result of a long-term simulation of current project operations for the period prior to 1996 and actual computed inflow since 1996. The Lake McClure inflows were estimated using the Lake McClure outflows adjusted for change in storage and evaporation in Lake McClure (USBR 2005).

ER is the sum of monthly reservoir releases over the growing season to meet all instream flow and environmental requirements for the tributary. This includes reservoir releases to meet the depletions along the river, the unimpaired flow requirement, the tributary minimum flows, the flow shifting requirements, the CAD flow requirement on the Merced, VAMP, D1641, and Vernalis minimum flow and EC.

EV is forecast total evaporation from the tributary's major reservoir over the growing season. For this available water calculation, the monthly evaporation timeseries is taken directly from CALSIM values.[5]

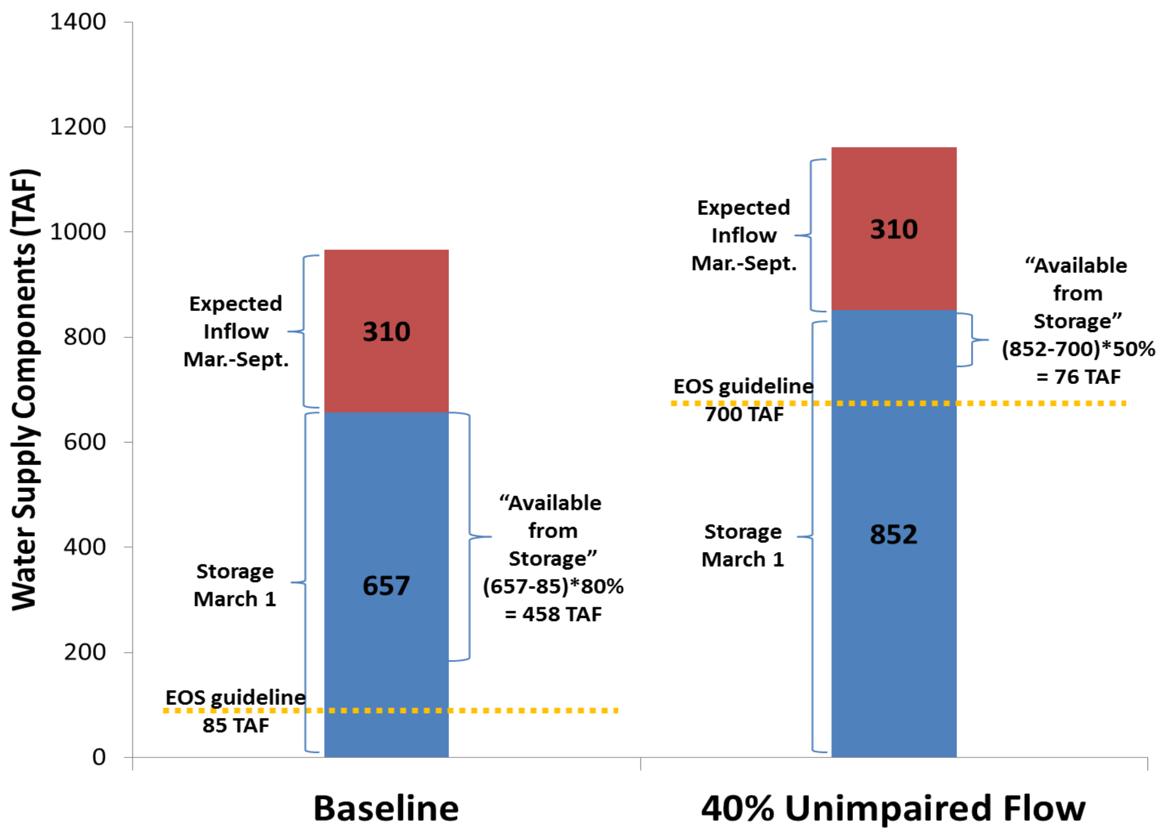


Figure F.1.2-6. Illustration of Available Storage Calculation for the Example Year 1991

[5] CALSIM seasonal evaporation quantities (based on CALSIM baseline reservoir volumes and rates) are sufficient for a first-order estimate of available water for diversion. After the allocation of available water is performed, the final water balance is calculated, with the monthly evaporation calculation based on the actual reservoir volume and surface area, using the CALSIM rates. This approach was a method to avoid circular references in Excel.

Table F.1.2-20. Baseline End-of-September Storage Guidelines, Maximum Draw from Storage, and Minimum Diversion Variables for the Eastside Tributaries

Variable	Stanislaus River	Tuolumne River	Merced River
End-of-September Storage Guideline (TAF)	85	800	115
Maximum Draw from Storage (% of available storage)	80%	65%	80%
Minimum Diversion (TAF)	0	550	0

Evaporation

For the three major reservoirs, evaporation is a function of the evaporation rate and the surface area of the reservoirs. CALSIM rates are used for each month of the simulation, and the area of each reservoir is recalculated by WSE using a volume/area relationship. Note that in order to prevent circular references, the available water allocation is made using CALSIM estimates of evaporation (based on SWRCB-CALSIM baseline, the evaporation from reservoirs based on levels in that scenario), while the final water balance is performed with evaporation recalculated more precisely by WSE, based on the volume-area relationships contained in Tables F.1.2-21a, F.1.2-b, and F.1.2-c.

Table F.1.2-21a. Area/Volume Relationship for New Melones Reservoir for Calculating Evaporation

Elevation (ft. MSL)	Storage (TAF)	Area (acres)
500.00	0.98	2
700.00	53.90	1,217
760.00	160.55	2,374
808.00	299.52	3,446
920.00	846.52	6,485
992.00	1,398.83	8,901
1,049.50	1,969.50	10,962
1,088.00	2,419.52	12,442
1,100.00	2,571.83	12,949
1,123.40	2,871.00	14,011

Table F.1.2-21b. Area/Volume Relationship for New Don Pedro Reservoir for Calculating Evaporation

Elevation (ft. MSL)	Storage (TAF)	Area (acres)
300.00	2.00	2
524.00	100.00	1,752
628.00	400.00	4,116
683.00	700.00	5,983
725.00	1,000.00	7,675
760.00	1,300.00	9,270
791.00	1,600.00	10,800
820.00	1,900.00	12,283
847.00	2,200.00	13,732
872.00	2,500.00	15,151

Table F.1.2-21c. Area/Volume Relationship for New Exchequer Reservoir for Calculating Evaporation

Elevation (ft. MSL)	Storage (TAF)	Area (acres)
400.00	2.00	2
618.00	100.00	1,368
674.00	200.00	2,156
713.00	300.00	2,852
758.00	450.00	3,813
793.00	600.00	4,718
823.00	750.00	5,589
848.00	900.00	6,434
871.00	1,050.00	7,261
891.00	1,200.00	8,073

Table F.1.2-22. Annual Average Evaporation for New Melones, New Don Pedro, and New Exchequer Reservoirs for Baseline and LSJR Alternatives

Scenario	Parameter	New Melones	New Don Pedro	New Exchequer
ALL	Avg. annual inflow (TAF)	1,087	1,586	965
BASELINE	Avg. annual evap (TAF)	50	61	21
20%UF	Avg. annual evap (TAF)	54	61	22
30%UF	Avg. annual evap (TAF)	53	60	22
40%UF	Avg. annual evap (TAF)	52	58	21
50%UF	Avg. annual evap (TAF)	50	57	21
60%UF	Avg. annual evap (TAF)	49	56	20

WSE Model Operational Parameters for the LSJR Alternatives

After a baseline WSE model was developed, it was modified to estimate the resulting flows, diversions, and reservoir operations of the LSJR alternatives by adjusting the parameters in Tables F.1.2-23a, F.1.2-23b, and F.1.2-23c to incorporate the alternative flow requirements. The following sets of inputs were used in the WSE model for the alternatives and intermediate simulations, ranging from 20 percent of unimpaired flow to 60 percent of unimpaired flow.

Table F.1.2-23a. Minimum Diversion, Minimum September Carryover Guideline, Maximum Draw from Storage, and Flow Shifting for the Stanislaus River

	Baseline	20% Unimpaired Flow	30% Unimpaired Flow	40% Unimpaired Flow	50% Unimpaired Flow	60% Unimpaired Flow
Minimum District Diversion (TAF, % of District Max)	0 TAF	210 TAF (35%)	210 TAF (35%)	210 TAF (35%)	180 TAF (30%)	180 TAF (30%)
Minimum September Carryover Guideline (TAF)	85	700	700	700	700	700
Maximum Storage Draw (% of Mar 1 minus Sep guideline)	80%	80%	70%	50%	45%	35%
Flow Shifting to Fall[a]	NA	None	None	Yes	Yes	Yes
End-of-Drought Storage Refill	NA	100%	100%	70%	50%	50%
Vernalis Minimum[b] Feb–Jun (cfs)	D-1641/ VAMP	1,000	1,000	1,000	1,000	1,000

TAF = thousand acre feet

cfs = cubic feet per second

[a] In the alternatives, the shifting of a portion of unimpaired flow requirement was completed during wet years, designed to allow only a percentage of diversions in the qualifying years (if storage was within 10% of the guideline September storage and inflow was projected to be higher than average).

[b] For unimpaired flow alternatives, the Stanislaus River is assumed to provide 29 percent of additional releases necessary to meet the Vernalis minimum flow requirement based on its long-term fraction of unimpaired flow among the three eastside tributaries.

Table F.1.2-23b. Minimum Diversion, Minimum September Carryover Guideline, Maximum Draw from Storage, and Adaptive Implementation for the Tuolumne River

	Baseline	20% Unimpaired Flow	30% Unimpaired Flow	40% Unimpaired Flow	50% Unimpaired Flow	60% Unimpaired Flow
Minimum District Diversion (TAF, % of District Max)	550 TAF (50%)	363 TAF (33%)	363 TAF (33%)	363 TAF (33%)	275 TAF (20%)	275 TAF (20%)
Minimum September Carryover Guideline (TAF)	800	800	800	800	800	800
Maximum Storage Draw (% of Mar 1 minus Sep guideline)	65%	60%	55%	50%	45%	35%
Flow Shifting to Fall[a]	NA	None	None	Yes	Yes	Yes
Drought End Storage Refill	NA	100%	100%	70%	50%	50%
Vernalis Minimum[b] Feb–Jun (cfs)	D-1641/ VAMP	1,000	1,000	1,000	1,000	1,000

TAF = thousand acre feet; cfs = cubic feet per second

[a] In the alternatives, the shifting of a portion of unimpaired flow requirement was completed during wet years, designed to allow only a percentage of diversions in the qualifying years (if storage was within 10% of the guideline September storage and inflow was projected to be higher than average).

[b] For unimpaired flow alternatives, the Tuolumne River is assumed to provide 47 percent of additional releases necessary to meet the Vernalis minimum flow requirement based on its long-term fraction of unimpaired flow among the three eastside tributaries.

Table F.1.2-23c. Minimum Diversion, Minimum September Carryover Guideline, Maximum Draw from Storage, and Flow Shifting for the Merced River

	Baseline	20% Unimpaired Flow	30% Unimpaired Flow	40% Unimpaired Flow	50% Unimpaired Flow	60% Unimpaired Flow
Minimum District Diversion (TAF, % of District Max)	0 TAF	78 TAF (15%)	78 TAF (15%)	78 TAF (15%)	78 TAF (15%)	78 TAF (15%)
Minimum September Carryover Guideline (TAF)	115 TAF	300	300	300	300	300
Maximum Storage Draw (% of Mar 1 minus Sep guideline)	80%	70%	60%	50%	45%	35%
Shifting to Fall[a]	NA	None	None	Yes	Yes	Yes
Drought End Storage Refill	NA	100%	100%	100%	50%	50%
Vernalis Minimum[b] Feb–Jun (cfs)	D-1641/ VAMP	1000	1000	1000	1000	1000

TAF = thousand acre feet

cfs = cubic feet per second

[a] In the alternatives, the shifting of a portion of unimpaired flow requirement was completed during wet years, designed to allow only a percentage of diversions in the qualifying years (if storage was within 10% of the guideline September storage and inflow was projected to be higher than average).

[b]For unimpaired flow alternatives, the Merced River is assumed to provide 24 percent of additional releases necessary to meet the Vernalis minimum flow requirement based on its long-term fraction of unimpaired flow among the three eastside tributaries.

F.1.2.6 Calculation of Surface Water Diversion Allocation

In WSE, for each tributary and irrigation year (March–February) monthly diversions are calculated in four steps:

1. During the initial flow routing mentioned above, if the flow available from inflows at any reach with a diversion demand is greater than the flow requirement at that reach, the excess can be used to satisfy the diversion demand. This prevents water already in the river that is not contributing to any flow requirements from being wasted.
2. Riparian and minor demands are fully met, because these diverters are considered senior[6] to appropriative ones. The water available for the districts during the growing season, $\mathbf{DW}_{\mathbf{avail,GS}}$, is calculated by subtracting Riparian growing season diversion from $\mathbf{W}_{\mathbf{avail,GS}}$.
3. The district diversion during the growing season, $\mathbf{Div}_{\mathbf{GS}}$, is calculated as the minimum of annual district demand, maximum annual district diversion, and available water for the districts, as shown in equation F.1-3:

[6] For the purposes of WSE modeling, CALSIM diversions D528 and D545 are considered to be riparian and senior in priority and given full allocation. The bases of right for these diversions have not yet been confirmed. In any case, these diversions are small in comparison to overall system diversions.

$$Div_{GS} = Min\left(Dmx_{GS},\ DW_{avail,GS},\ Dem_{GS}\right) \qquad \text{(Eqn. F.1-3)}$$

Where:

$\mathbf{Dmx_{GS}}$ is the maximum allowable diversion over the growing season. For the Stanislaus the annual maximum district diversion is distributed over the irrigation year based on the monthly demands and then summed over the growing season. For the Tuolumne and Merced the annual maximum district diversion was distributed monthly based on a repeating yearly pattern based on typical monthly fractions in CALSIM over the growing season.

$\mathbf{Dem_{GS}}$ is the total growing season diversion demand. In general, demand is the limiting volume during wet years, while available surface water is the limiting factor during dryer years.

On the Stanislaus there is an additional constraint to represent the growing season allowable diversion under the 1988 Agreement, $\mathbf{D_{1988}}$. This agreement stipulates that SSJID and OID will receive the first 600 TAF/y of inflow to New Melones or if the inflow is less than 600 TAF/y they will receive the Inflow plus 1/3 x (600 minus inflow) (SSJID 2012). In WSE this annual total is distributed over the irrigation year based on the monthly demands and then summed over the growing season to determine $\mathbf{D_{1988}}$.

4. Finally, the total growing season diversion is distributed monthly to determine $\mathbf{Div_t}$, the diversion in month **t**. It is assumed that the same proportion of demand met in the growing season as a whole will be met in all months over the irrigation year. Equation F.1-4A shows the calculation:

$$Div_t = \overbrace{Div_{GS} / Dem_{GS}}^{delivery\ \ proportion} * Dem_t * K_{Refill} \qquad \text{(Eqn. F.1-4A)}$$

Where:

$\mathbf{Dem_t}$ is the district demand in month **t**.

$\mathbf{K_{Refill}}$ is a reservoir refill user specified parameter between 0 and 1 that reduces diversion in an effort to help refill the major reservoirs at the end of a drought. This parameter is activated if: 1) storage in the major reservoir at the end of the previous October was less than $\mathbf{EOS_{req}}$ plus 10 percent and 2) inflow to the major reservoir over the growing season will be greater than an inflow trigger set by the user. This diversion cut will continue over the entire irrigation year (March–February) unless the reservoir reaches the flood curve at which point the cut will end for the rest of the year. However, if the calculated growing season diversion is less than the user defined minimum annual diversion, monthly diversion will be determined using Eqn. F.1-4B:

$$Div_t = \overbrace{Dmn\% * Dmx_{IY}}^{min\ \ annual\ \ diversion} * \frac{Dem_t}{Dem_{IY}} \qquad \text{(Eqn. F.1-4B)}$$

Where:

Dmn% is the minimum annual district diversion as a percent of maximum annual diversion. This variable allows the diversion to override the end-of September storage guideline and draw additional water from storage in the event the available surface water for diversion is less than the minimum diversion level. Because this allows additional diversion, this variable could also be considered a relaxation in some years to the end-of-September storage guideline. The minimum diversion rates were set for the baseline such that resulting diversion and storage were similar to the results of CALSIM. As the unimpaired flow requirement increased, the minimum diversion level was lowered to help balance the reservoir, reduce potential temperature impacts, and ultimately maximize diversions.

Dmx_{IY} is the maximum annual district diversion over the irrigation year. The maximum district diversion on each tributary is 600 TAF/y for the Stanislaus River, 1,100 TAF/y for the Tuolumne River, and 542 TAF/y for the Merced River. These values did not change among simulations and were held constant for each year.

Dem_{IY} is the total district demand over the irrigation year.

CVP Contractor Diversion

On the Stanislaus, diversion to the CVP contractors (SEWD and CSJWCD) is calculated differently than for the other irrigation districts. The contractors receive diversion only after the senior district has received its allocation of water based on the above calculations. The water available to the contractors during the growing season would be **$DW_{avail,GS}$**, minus any diversion to the senior districts. Growing season water allocation to the contractors, **$CDiv_{GS}$**, is shown in equation F.1-5, which is then distributed monthly, **$CDiv_t$**, in equation F.1-6:

$$CDiv_{GS} = Min\left(DW_{avail,GS} - Div_{GS}, CDem_{GS}\right) \quad \text{(Eqn. F.1-5)}$$

$$CDiv_t = Min\left(CK_{cut}, \frac{CDiv_{GS} * K_{Refill}}{CDem_{GS}}\right) * CDem_t \quad \text{(Eqn. F.1-6)}$$

Where:

$CDem_{GS}$ and **$CDem_t$** are the total contractor water demand on the Stanislaus River over the growing season and in month **t**, respectively.

CK_{cut} is a user defined allocation factor based on the NMI (Table F.1.2-1 in the prior section). This factor supersedes the calculated allocation based on water availability and demand unless the calculated allocation is smaller**.**

F.1.2.7 Calculation of River and Reservoir Water Balance

Once the annual diversion is calculated, WSE begins a final flow routing through the rivers to Vernalis including deliveries from the reservoirs to diversions. Because there are requirements at Vernalis that depend on the flows from the tributaries, the model conducts multiple routing cycles to determine the required release from the three major reservoirs. The first cycle determines the flow that would occur at Vernalis assuming there were no requirements at Vernalis and no flood releases. During the first cycle the resulting Vernalis flow is checked against the minimum flow requirement at Vernalis and additional flow requirements are distributed among the tributaries if needed, as described earlier under Calculations of Flow Targets. The second cycle determines the resulting flow at Vernalis while including the Vernalis minimum flow requirement, VAMP requirements, and flood control flows from the Merced and Tuolumne. During the Second cycle Vernalis flow is checked against D1641 and then salinity requirements. If either D1641 or Vernalis Salinity is not met, any additional flow needed is taken from the Stanislaus River. The final cycle re-calculates the tributary and SJR flows through to Vernalis, including all required releases, diversions, and flood spills. The equations below describe the reservoir and river flow calculations.

Required Reservoir Releases

The required reservoir release needed to satisfy the target flows and diversions is determined monthly on each eastside tributary as the sum of flow requirement, diversion, and flood control release:

$$R_t = ER_t + Div_t + CDiv_t + RipD_t + F_t \qquad \text{(Eqn. F.1-7)}$$

Where:

$\mathbf{ER_t}$ is the environmental flow release.

$\mathbf{Div_t}$ is the irrigation district diversion, $\mathbf{Cdiv_t}$ is the CVP contractor diversion (only on the Stanislaus), and $\mathbf{RipD_t}$ is the riparian diversion (does not includes CAD diversions on the Merced as those are accounted for in $\mathbf{ER_t}$).

$\mathbf{F_t}$ is the additional reservoir spill release required to stay below flood stage in New Melones and New Don Pedro Reservoirs (as defined by the CALSIM flood storage curves in Table F.1.2-24) and the discretionary hydropower operations level in Lake McClure. Spills are only necessary in months when storage would otherwise exceed flood control limits.

Table F.1.2-24. CALSIM End-of-Month Flood Control Storage Limitations Applied to New Melones Reservoir, New Don Pedro Reservoir, and Lake McClure in the WSE Model

Calendar Month	New Melones[a] (TAF)	New Don Pedro[b] (TAF)	Lake McClure[c] (TAF)
1	1,970	---[b]	674.6
2	1,970	---[b]	674.6
3	2,030	---[b]	735
4	2,220	---[b]	845
5	2,420	---[b]	970
6	2,420	---[b]	1,024
7	2,300	---[b]	910
8	2,130	---[b]	770
9	2,000	---[b]	700
10	1,970	---[b]	674.6
11	1,970	---[b]	674.6
12	1,970	---[b]	674.6

Notes:

[a]. Maximum storage volume (to spillway) in New Melones Reservoir is 2,420 TAF.

[b] "New Don Pedro Reservoir flood control constraints (reserved storage) are included in CALSIM II as a time series. The time series reflects end-of-month rain-flood reservation space and conditional reservation space during the snowmelt season per COE requirements" (USBR 2005). This 82-year monthly CALSIM time series is referenced by the WSE model for each month. Maximum storage in New Don Pedro Reservoir is 2,030 TAF.

[c] Maximum storage volume in Lake McClure is 1,024 TAF.

Reservoir Storage Levels

Storage levels behind the major dams are initially set the same as CALSIM II levels at the end of September, 1921 (951TAF in New Melones, 1,313 TAF in New Don Pedro, and 469 TAF in Lake McClure). As with CALSIM II, the maximum level allowable in the reservoir is set equal to the flood control levels in New Melones and New Don Pedro Reservoirs (including conditional storage, when applicable) and Lake McClure, (Table F.1.2-24). The model assumes projected filling above these levels will be evacuated within that month to maintain at or below these maximum operating levels. The reservoir storage at the end of each subsequent month, $\mathbf{S_t}$, is calculated with a water balance equation on each tributary using:

$$S_t = S_{t\text{-}1} + QINF_t - R_t - EV_t \quad \text{(Eqn. F.1-8)}$$

Where:

$\mathbf{S_{t-1}}$ is the ending storage of the previous month.

$\mathbf{QINF_t}$ is the CALSIM II inflow to each major reservoir described above in Equation F.1-2; and

$\mathbf{EV_t}$ is the evaporation from the major reservoir at time **t**. WSE evaporation is calculated using the CALSIM II evaporation rates multiplied by the reservoir surface area at time t.

River Flows

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

$$Q_t = R_t - Div_t - CDiv_t - RipD_t + QAC_t \quad \text{(Eqn. F.1-9)}$$

The flow resulting at Vernalis, QVt, is calculated as follows:

$$QV_t = QN_t + \sum (Q_t\ 3\ tributaries) - Dv_t + QACv_t \quad \text{(Eqn. F.1-10)}$$

Where:

$\mathbf{QAC_t}$ is the sum of CALSIM II accretions (including natural and return inflows) and depletions between the major dam and the mouth of the river in month **t**. Accretions/depletions and return flows are unchanged for each alternative and the baseline.

$\mathbf{QN_t}$ is the SJR inflow from upstream of the Merced River near Newman. The flow is set equal to CALSIM II estimates and is assumed unchanged for the alternatives and baseline.

$\mathbf{Dv_t}$ is the sum of diversions along the LSJR from the Merced River to Vernalis. The values are assumed equal to CALSIM II and assumed not affected by changes due to the project and the alternatives, with the following exception: In some months under WSE baseline conditions the CALSIM II diversions on the San Joaquin between the Merced and Tuolumne are reduced, because the flow released from the Merced is not enough to meet it all.[7]
To protect the assumption that these diversions are not affected by changes due to the

[7] CALSIM D620B has a maximum diversion quantity of 267 TAF/month. For WSE CEQA baseline, D620B is attenuated when water is not available from the Merced River and Upper SJR combined. This adjustment averages -3.2 percent over the 82-year study period, up to a maximum of -33 percent. This attenuation is identical in the alternative scenarios.

project and the alternatives, these baseline reductions are maintained in each of the alternatives.

$QACv_t$ is the sum of accretions and depletions along the LSJR from the Merced River to Vernalis. Accretions and depletions are equal to those of CALSIM II and assumed unchanged for each alternative and the baseline.

Shifting of Flow Requirement

As a result of instream flow requirements in the February–June period, reservoir levels in modeling scenarios are generally lower than baseline, which can cause a reduced magnitude and frequency of reservoir spill in wet years. In addition, reservoir levels generally lower than baseline can result in elevated temperatures in summer and fall when rivers are at FERC or RPA minimum flows. The combined effects of smaller, less-frequent spills and lower reservoir levels would cause an undesirable result of elevated temperatures when compared to baseline, in the absence of additional flow measures, for alternatives of 40 percent unimpaired flow or greater. Therefore, it was determined, as a part of adaptive implementation, to shift a quantity of flow from the February–June period to the July–November period in certain year types so that LSJR alternative scenarios would have a negligible impact on instream temperatures.

All modeling scenarios described in this Recirculated SED for alternatives of 40 percent or greater of unimpaired flow incorporate some shifting of the flow requirement in certain water year types from the February–June period to the July–November period, not to exceed 25 percent of the quantity determined by the percent of unimpaired flow (e.g., in the 40 percent of unimpaired flow alternative, flow shifting would not exceed 10 percent of the overall unimpaired flow). The generalized concept of shifting a portion of the unimpaired flow requirement is shown in Figure F.1.2-7, below.

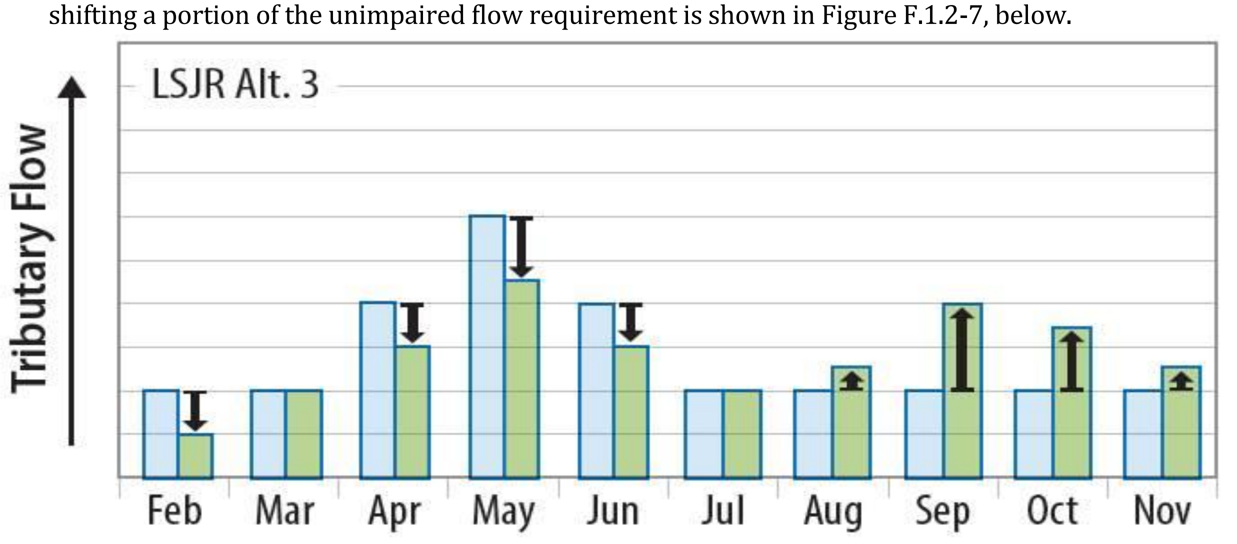


Figure F.1.2-7. Generalized Illustration of Shifting of Flow Requirement to Summer and Fall

The amount of shifted flow was determined by iteration to find appropriate quantities of flow in the summer and fall months that would mitigate increases of temperature under LSJR alternatives. Shifting up to 25 percent of the flow requirement was found to minimize these increases while preserving the benefits of the February–June flows. Generally, these flow quantities were found to reduce temperature impacts to less than 10 percent change from the number of days that exceed the EPA 7DADM temperature criteria for anadromous fish life stages (see fish temperature discussion in Chapter 7, *Aquatic Biological Resources*) and, in most months, completely ameliorate the impact compared to baseline in the three tributaries.

The shifted flow targets in July–September are in the form of additional flow to meet a target flow, in cubic feet per second, in the confluence reach of each of the three tributaries, as described in Table F.1.2-25, below.

Table F.1.2-25. Instream Flow Targets July–November that Determine Necessary Volume of Flow Shifting from the February–June Period for the (a) Stanislaus, (b) Tuolumne, and (c) Merced Rivers for Each Water Year Type

A. Stanislaus Minimum Flow by Water Year Type and Month					
WYT	July (cfs)	August (cfs)	September (cfs)	October (cfs)	November (cfs)
W	800	500	800	1,400	—
AN	—	—	—	1,200	—
BN	—	—	—	1,000	—
D	—	—	—	1,000	—
C	—	—	—	1,000	—
B. Tuolumne Minimum Flow by Water Year Type and Month					
WYT	July (cfs)	August (cfs)	September (cfs)	October (cfs)	November (cfs)
W	1,200	600	1,000	1,000	1,000
AN	—	—	—	—	—
BN	—	—	—	—	—
D	—	—	—	—	—
C	—	—	—	—	—
C. Merced Minimum Flow by Water Year Type and Month					
WYT	July (cfs)	August (cfs)	September (cfs)	October (cfs)	November (cfs)
W	600	600	600	800	800
AN	200	200	200	—	—
BN	—	—	—	—	—
C	—	—	—	—	—
D	—	—	—	—	—

Shifted flow quantities, determined as the amount of additional flow release necessary to meet minimum instream flow shifting targets, in addition to the flow already present in these months, have been deducted from the percent unimpaired flow requirements in the February–June period. These deductions are in proportion to each month's contribution to the total unimpaired flow requirement for February–June. Total quantities shifted in each water year type for 40 percent, 50 percent, and 60 percent of unimpaired flow alternatives are shown for each tributary in Table F.1.2-26, below

Table F.1.2-26. Average Quantity of Flow Shifted to Fall for the Stanislaus, Tuolumne, and Merced Rivers for Each Water Year Type

Water Year Type	Stanislaus Annual Flow Shifting (TAF)			Tuolumne Annual Flow Shifting (TAF)			Merced Annual Flow Shifting (TAF)		
	40% alt	50% alt	60% alt	40% alt	50% alt	60% alt	40% alt	50% alt	60% alt
W	51	51	52	102	102	102	105	116	120
AN	17	17	18	0	0	0	11	11	11
BN	8	9	9	0	0	0	0	0	0
D	10	11	13	0	0	0	0	0	0
C	4	5	5	0	0	0	0	0	0
Average	21	22	23	29	29	29	32	35	36

WSE Model CALSIM-Baseline Comparison to CALSIM II

Described below are the steps taken to compare the WSE model with SWRCB-CALSIM II model run and develop the WSE CALSIM-baseline simulation. By using some CALSIM II inputs and a similar approach for estimating water supply diversions in the WSE model, the WSE model CALSIM-baseline results are similar to CALSIM II and considered sufficient to demonstrate that the model is adequate to determine water supply effects comparable with CALSIM II, but with the additional flexibility of the spreadsheet approach.

Three variables were used to calibrate the WSE model baseline with the CALSIM II representation of baseline: (1) demand adjustment factors that globally scale the monthly-variable CUAW demand for each tributary, (2) end-of-September storage guidelines, and (3) maximum draw from storage. After numerous iterations, these variables were set such that the baseline storage and diversion results were most similar to CALSIM II results. First, the maximum draw from storage in any given year (as a percentage of the March 1 storage minus end-of-September storage) was limited (down from 100 percent) to a level causing reservoir dynamics comparable to those seen in CALSIM II (similar to the application of a delivery versus carryover-risk curve). After iterating, the maximum draw from storage was set at 80, 65, and 80 percent on the Stanislaus, Tuolumne, and Merced Rivers respectively.

Second, the baseline end-of-September storage guidelines were set to be 85,000 AF, 800,000 AF, and 115,000 AF in New Melones Reservoir, New Don Pedro Reservoir, and Lake McClure respectively. These values effectively work so that WSE closely matches the storages for each of the reservoirs in the CALSIM II results.

Lastly, adjustment factors were applied through iteration to the calculated surface water demand values as described above, until the resulting WSE model storage and annual diversions matched the CALSIM II model results. During the iteration process, results were judged based on how well the maximum, minimum, and quartiles of the resulting WSE monthly diversion timeseries matched with the same parameters from the CALSIM II diversion results. The resulting factors are listed in Table F.1.2-15. These factors are similar to the "turnout factor" used in CALSIM to calibrate to river gage and delivery data during development. Additionally, under WSE CALSIM-baseline a minimum annual diversion of 550,000 AF (or ~50 percent of the annual maximum diversion), was needed on the Tuolumne River to bring diversion and storage results into alignment with CALSIM. Table F.1.2-20 contains the end-of-September storage targets, maximum draw from storage, and minimum diversion levels set in the WSE CALSIM-baseline that resulted in a close match of the CALSIM model results.

Because flows are largely dictated by minimum requirements on each river and only differ if flood control evacuation is necessary, this variable did not need to be adjusted through iterations; however, they were checked on a monthly time step to verify corroboration with historical and CALSIM II modeled flows (Figures F.1.2-8a, F.1.2-8b, F.1.2-8c). Flows match CALSIM closely for all three tributaries.

The WSE CALSIM-baseline simulation and CALSIM II results are compared using several graphs that show annual values for the 1922–2003 period. The annual values were sorted to show the distribution of annual values as the maximum to the minimum values (i.e., exceedance plots). Figures F.1.2-9a, F.1.2-9b, F.1.2-9c, and F.1.2-9d show the annual WSE results for the Stanislaus River and New Melones Reservoir compared to the CALSIM II baseline values. Figure F.1.2-9a shows the February–June flow volume at the confluence; Figure F.1.2-9b shows the carryover (i.e., end-of-September) storage in New Melones Reservoir; Figure F.1.2-9c shows the annual water supply diversions; and Figure F.1.2-9d shows February–June flow volume at the confluence as a percentage of unimpaired flow volume. Figures F.1.2-10a, F.1.2-10b, F.1.2-10c, and F.1.2-10d show the same annual WSE results for the Tuolumne River and New Don Pedro Reservoir compared to the CALSIM values. Figures F.1.2-11a, F.1.2-11b, F.1.2-11c, and F.1.2-11d show the same annual WSE results for the Merced River and Lake McClure compared to the CALSIM values. Figure F.1.2-12a shows the annual WSE results for total diversions from the three tributaries compared to CALSIM II results, while Figures F.1.2-12b and F.1.2-12c show annual WSE results for February–June flow at Vernalis compared to CALSIM II results. Figures F.1.2-13, F.1.2-14, and F.1.2-15 show the same comparisons of diversion, flow, and storage as annual time series for the Stanislaus, Tuolumne, Merced, and San Joaquin Rivers respectively.

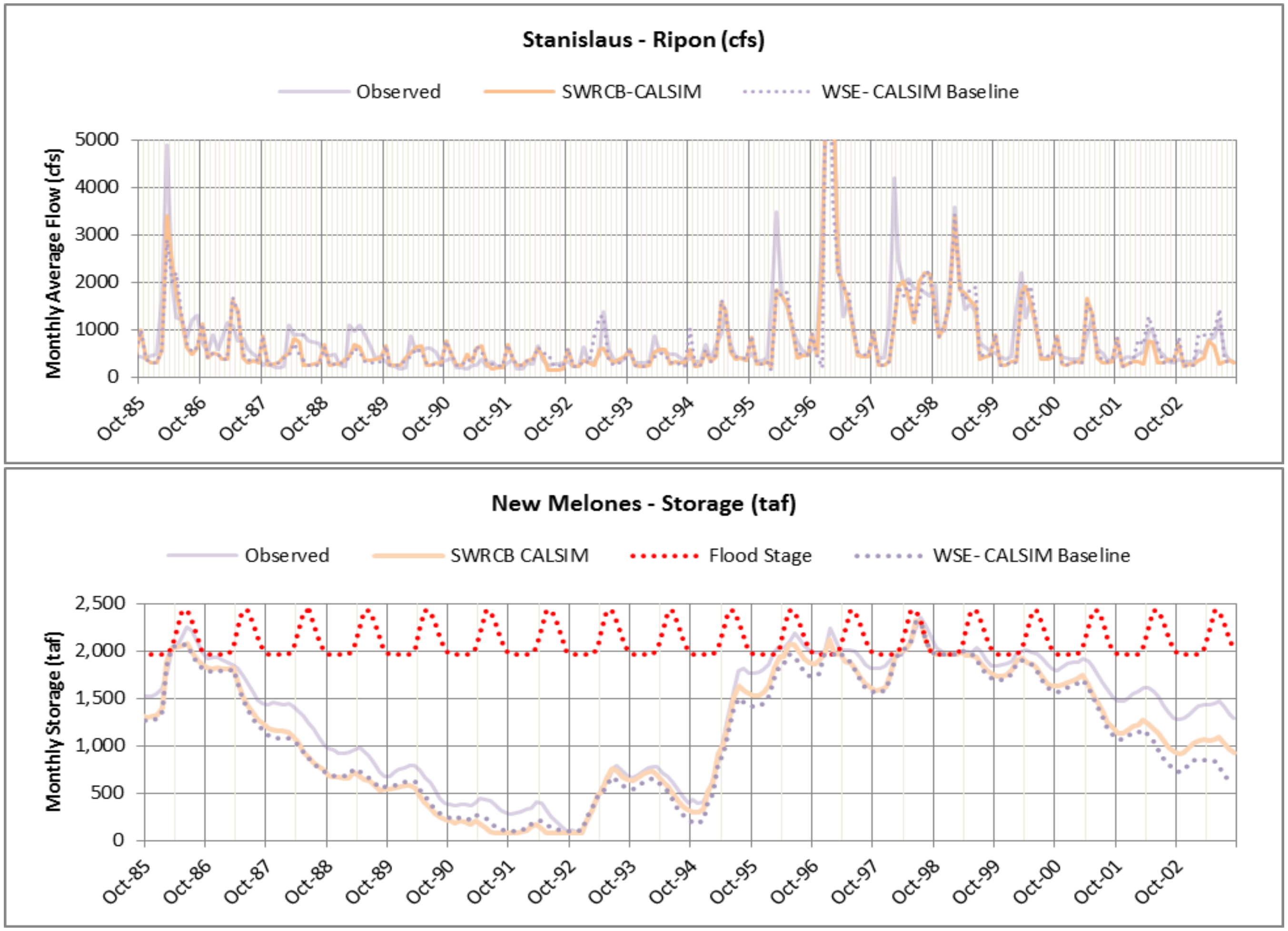
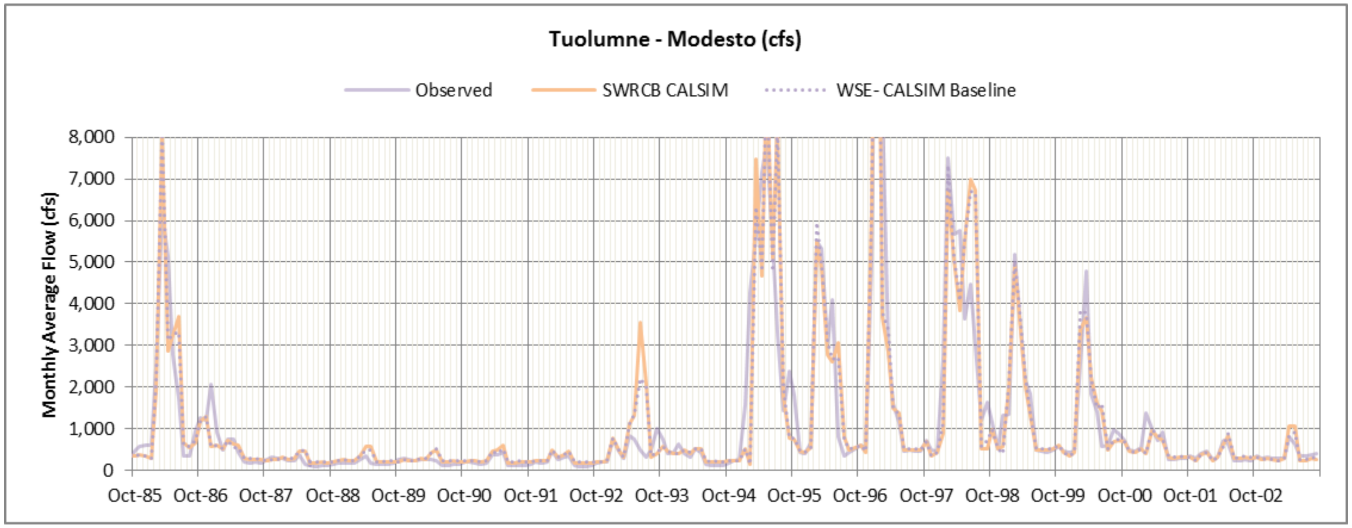


Figure F.1.2-8a. Monthly Comparison of WSE CALSIM-Baseline Flow and Storage Results to Historical Gage Data and SWRCB-CALSIM Model Results on the Stanislaus River



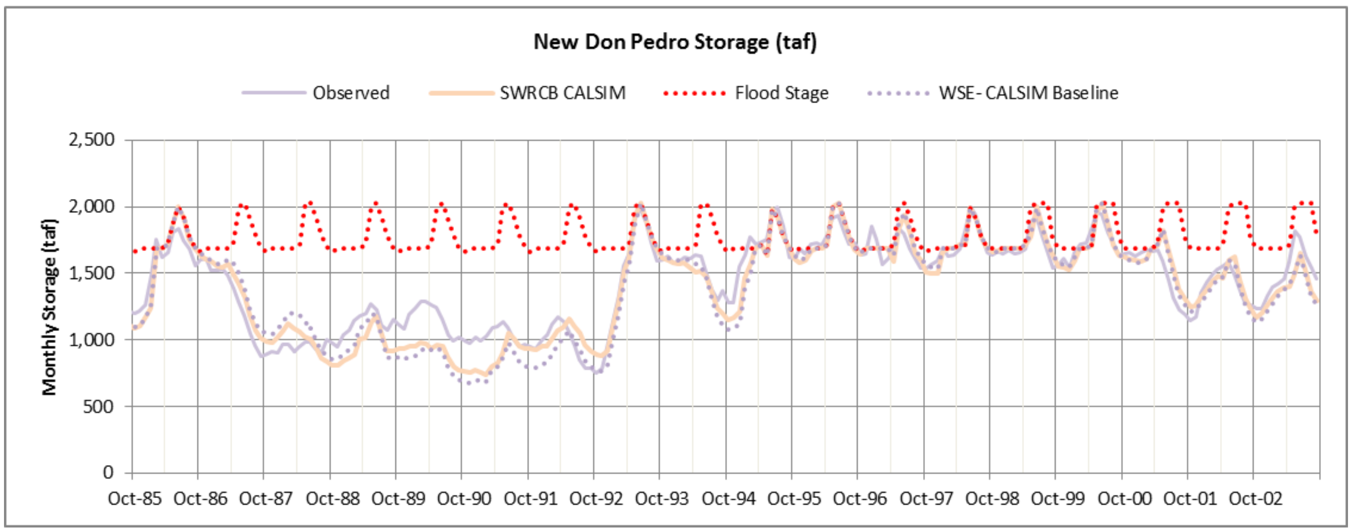
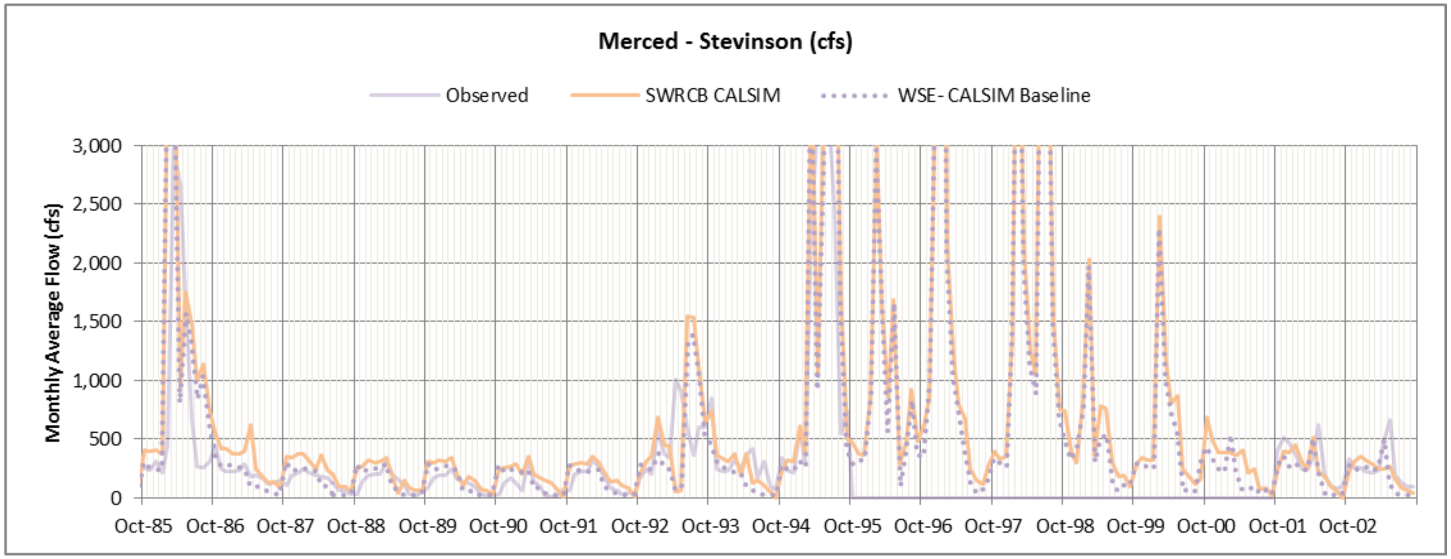


Figure F.1.2-8b. Monthly Comparison of WSE CALSIM-Baseline Flow and Storage Results to Historical Gage Data and SWRCB-CALSIM Model Results on the Tuolumne River



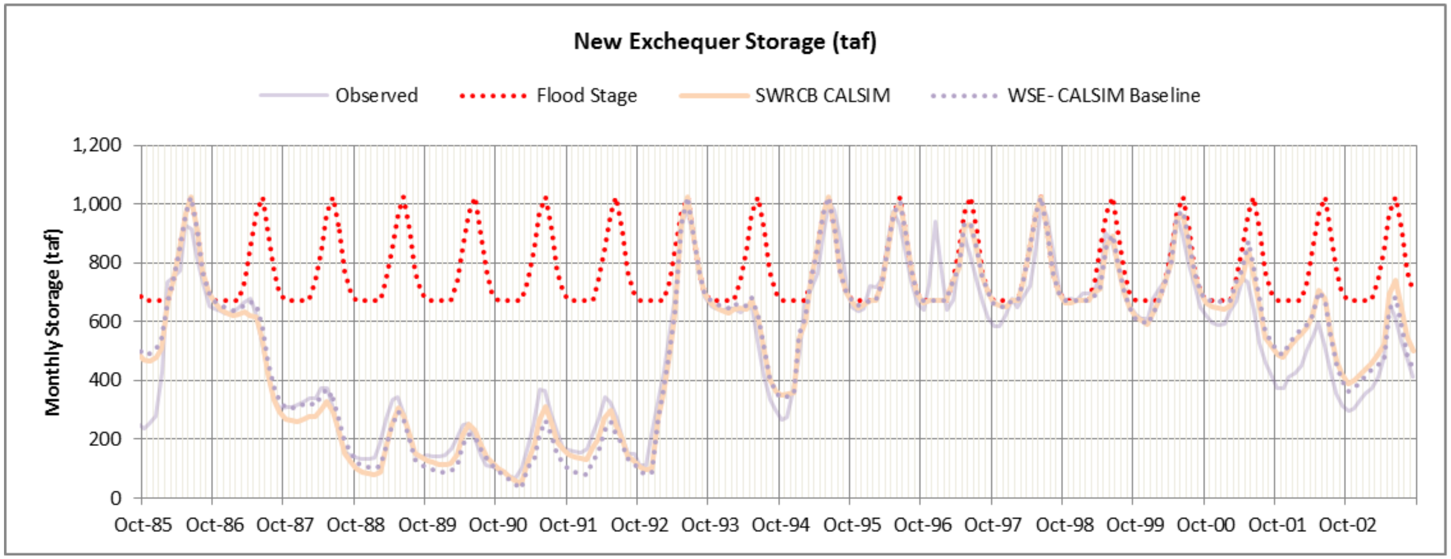


Figure F.1.2-8c. Monthly Comparison of WSE CALSIM-Baseline Flow and Storage Results to Historical Gage Data and SWRCB-CALSIM Model Results on the Merced River

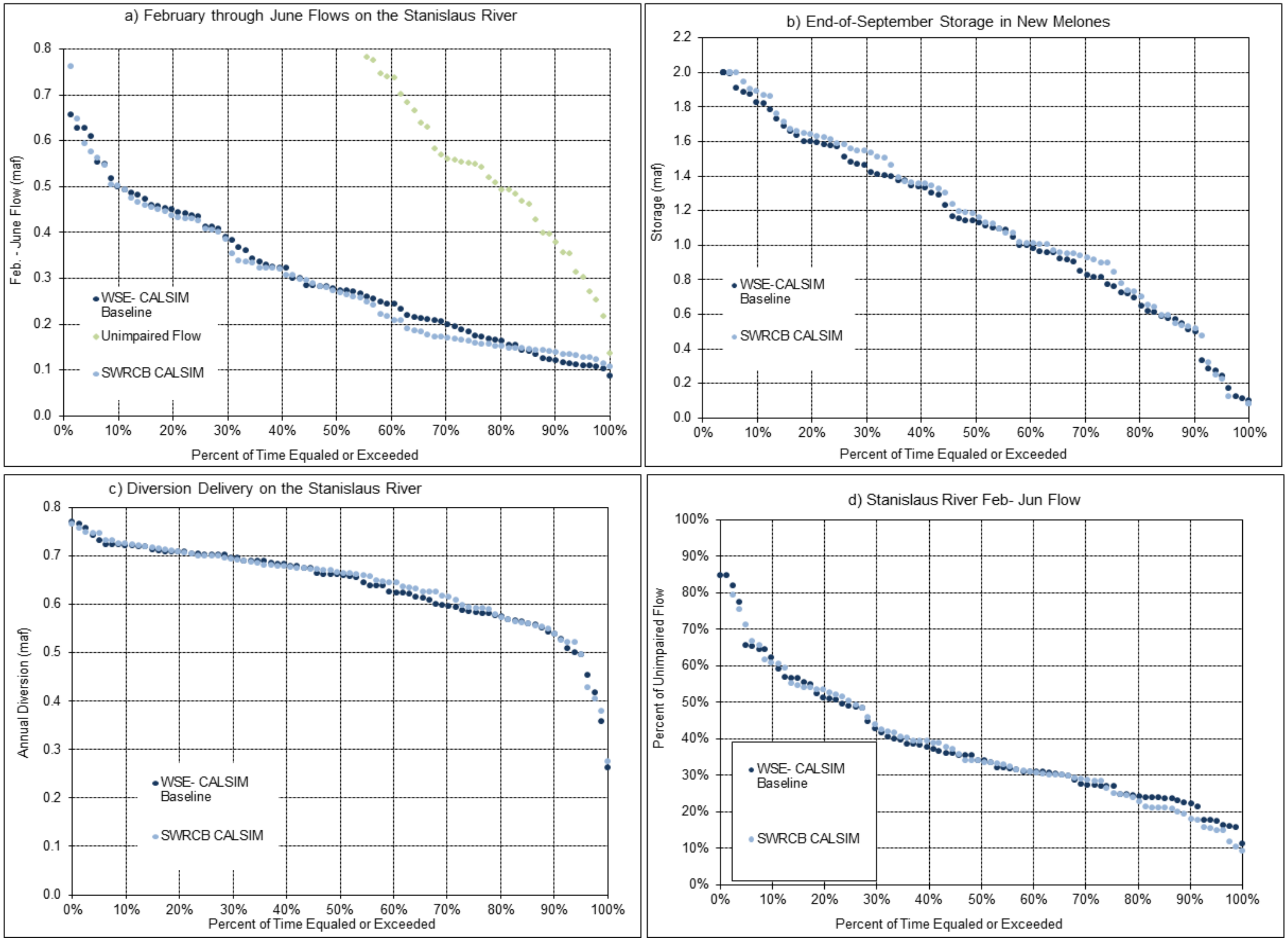


Figure F.1.2-9. Comparison of WSE CALSIM-Baseline with SWRCB-CALSIM output on the Stanislaus River for (a) February–June Flow at Ripon, (b) End-of-September Storage, (c) Annual Diversion Delivery, (d) February–June at Ripon as a Percentage of Unimpaired Flow

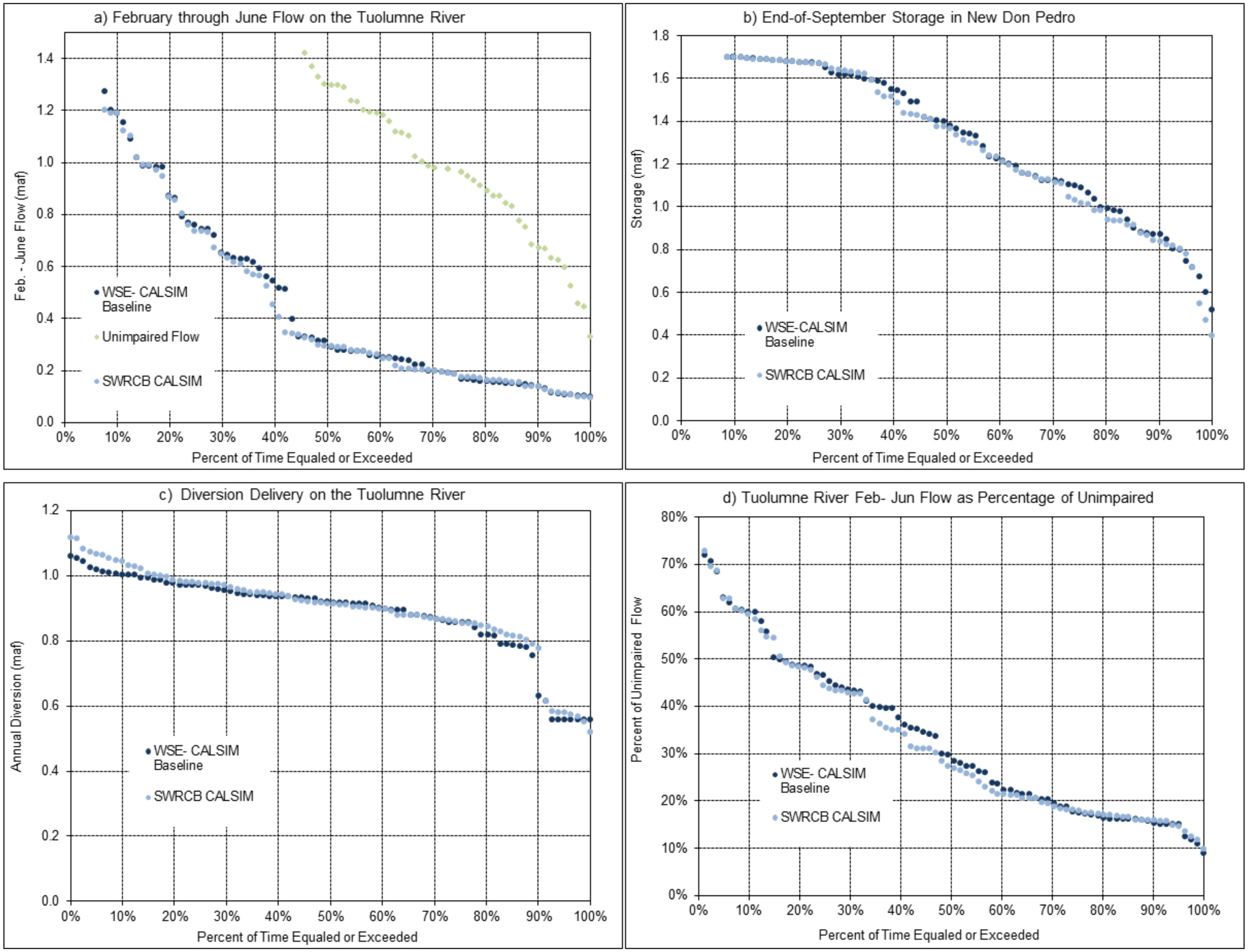


Figure F.1.2-10. Comparison of WSE CALSIM-Baseline with SWRCB-CALSIM Output on the Tuolumne River for (a) February–June Flow at Modesto, (b) End-of-September Storage, (c) Annual Diversion Delivery, (d) February–June at Modesto as a Percentage of Unimpaired Flow

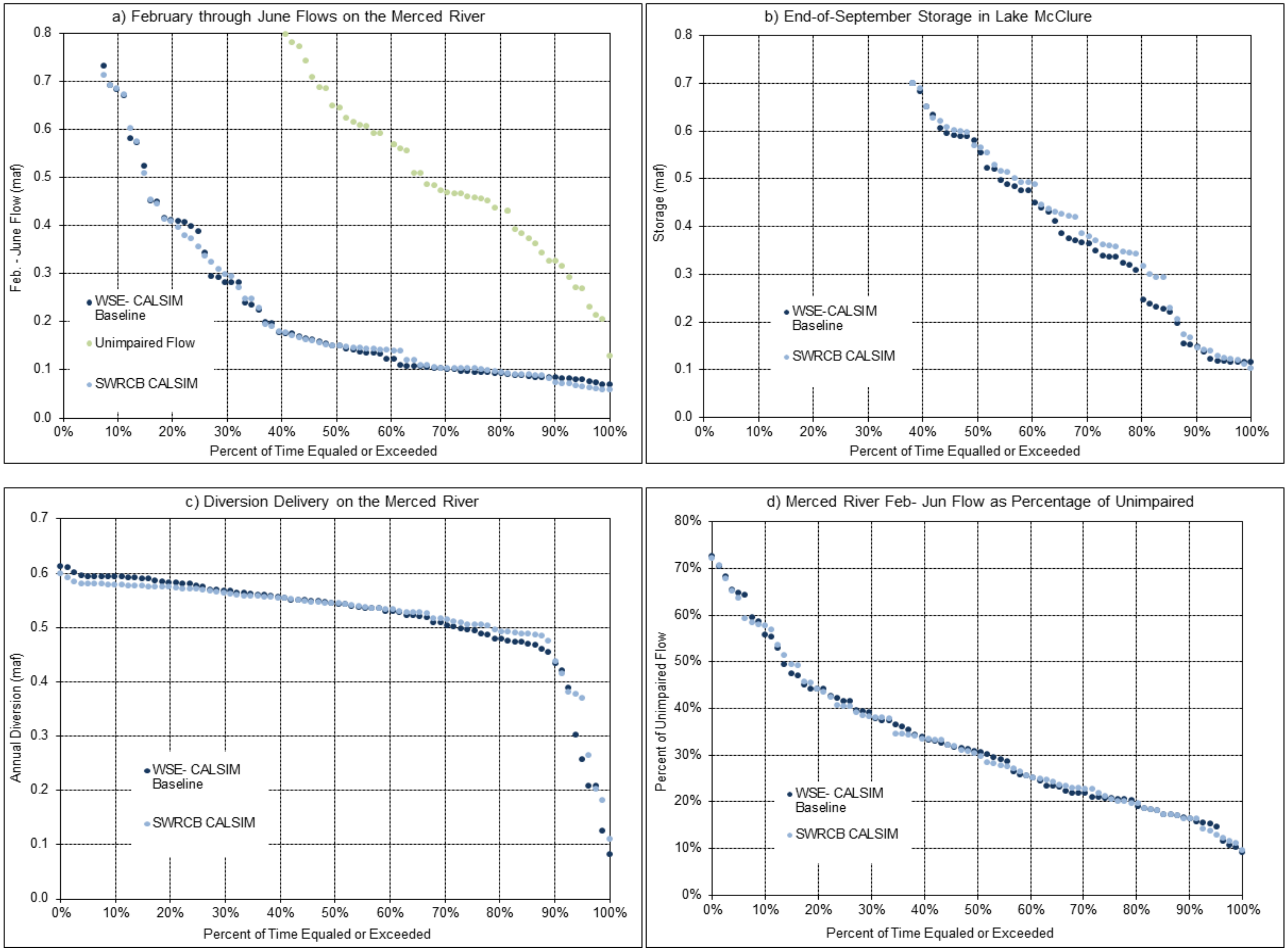


Figure F.1.2-11. Comparison of WSE CALSIM-Baseline with SWRCB CALSIM Output on the Merced River for (a) February–June Flow at Stevinson, (b) End-of-September Storage, (c) Annual Diversion Delivery, (d) February–June Flow at Stevinson as a Percentage of Unimpaired Flow

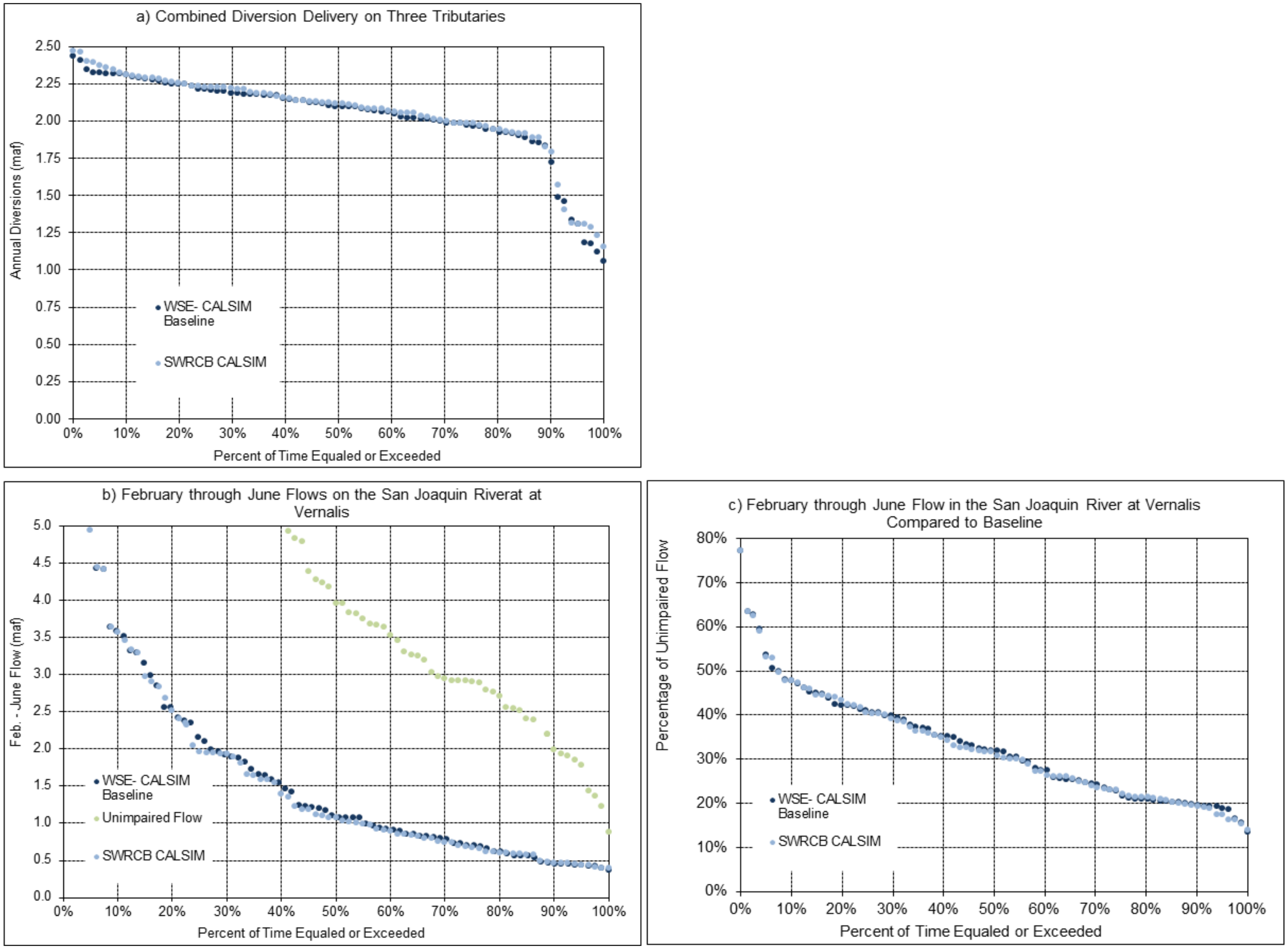


Figure F.1.2-12. Comparison of WSE CALSIM-Baseline with SWRCB-CALSIM Output for (a) Annual Diversion Delivery from All Three Major Tributaries, (b) Flow at Vernalis, (c) February–June Flow at Vernalis as a Percentage of Unimpaired Flow

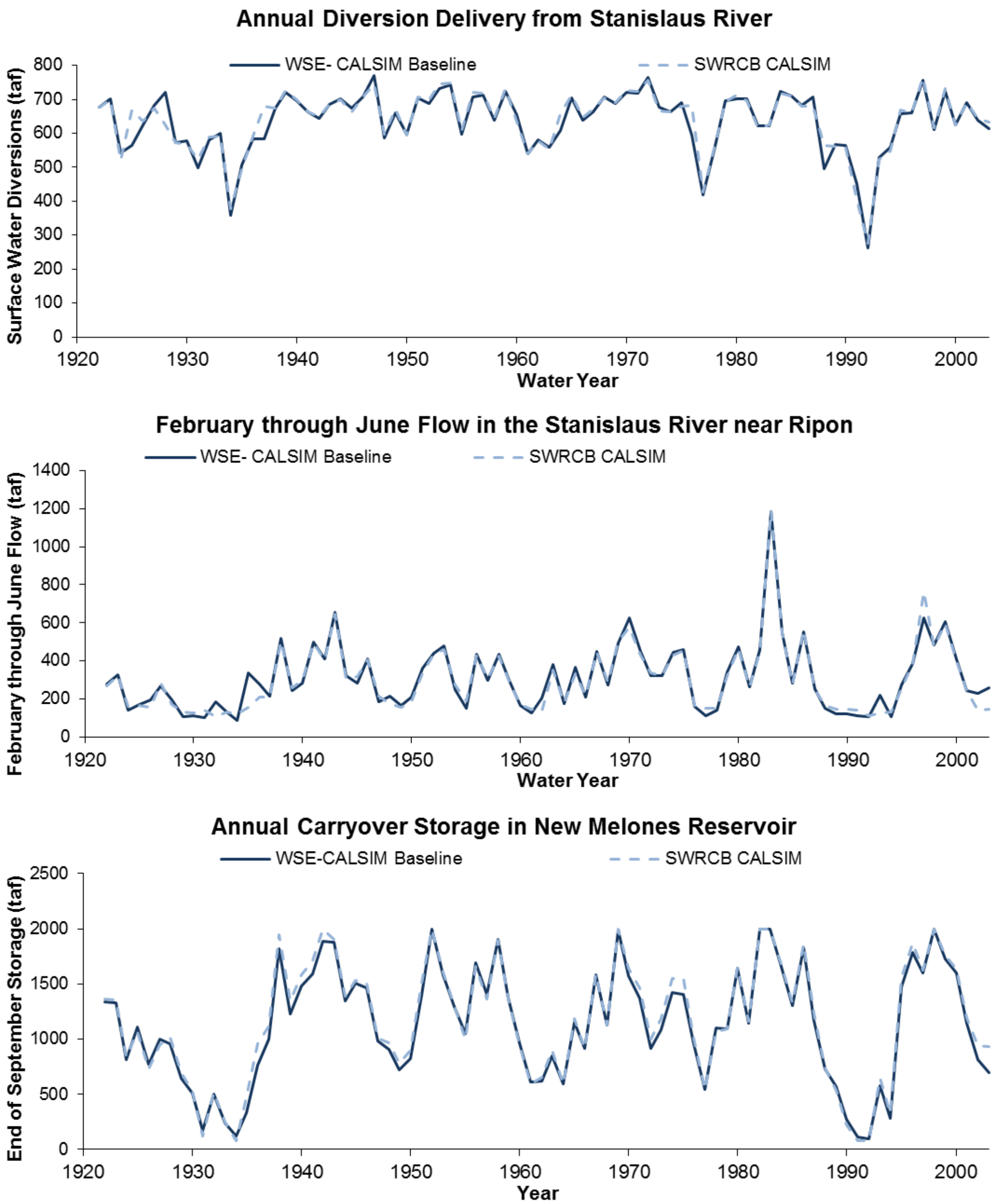


Figure F.1.2-13. Annual WSE CALSIM-Baseline Results for Stanislaus River Diversions, Flow, and Reservoir Operations Compared to SWRCB-CALSIM Results

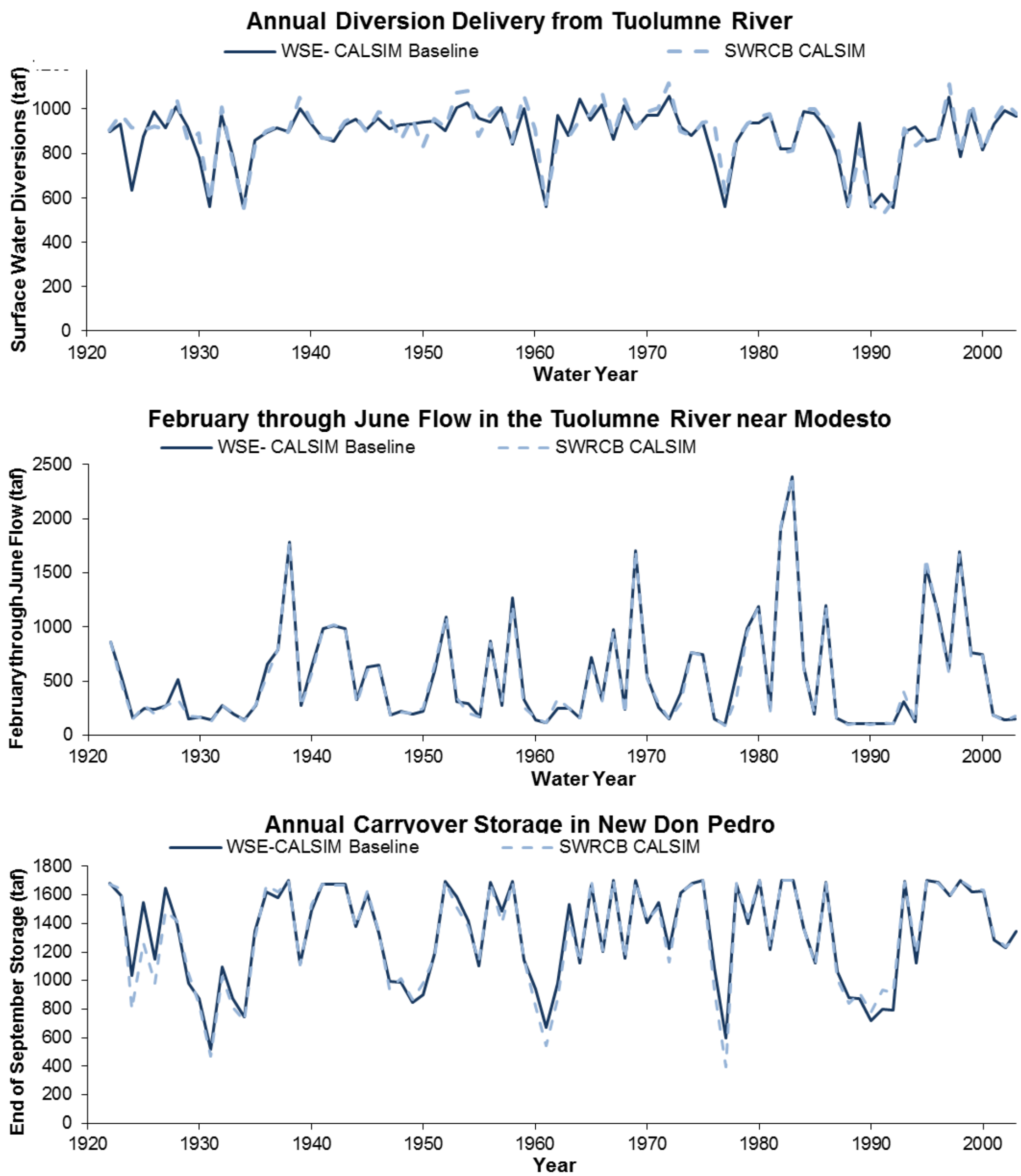


Figure F.1.2-14. Annual WSE CALSIM-Baseline Results for Tuolumne River Diversions, Flow, and Reservoir Operations Compared to SWRCB CALSIM Results

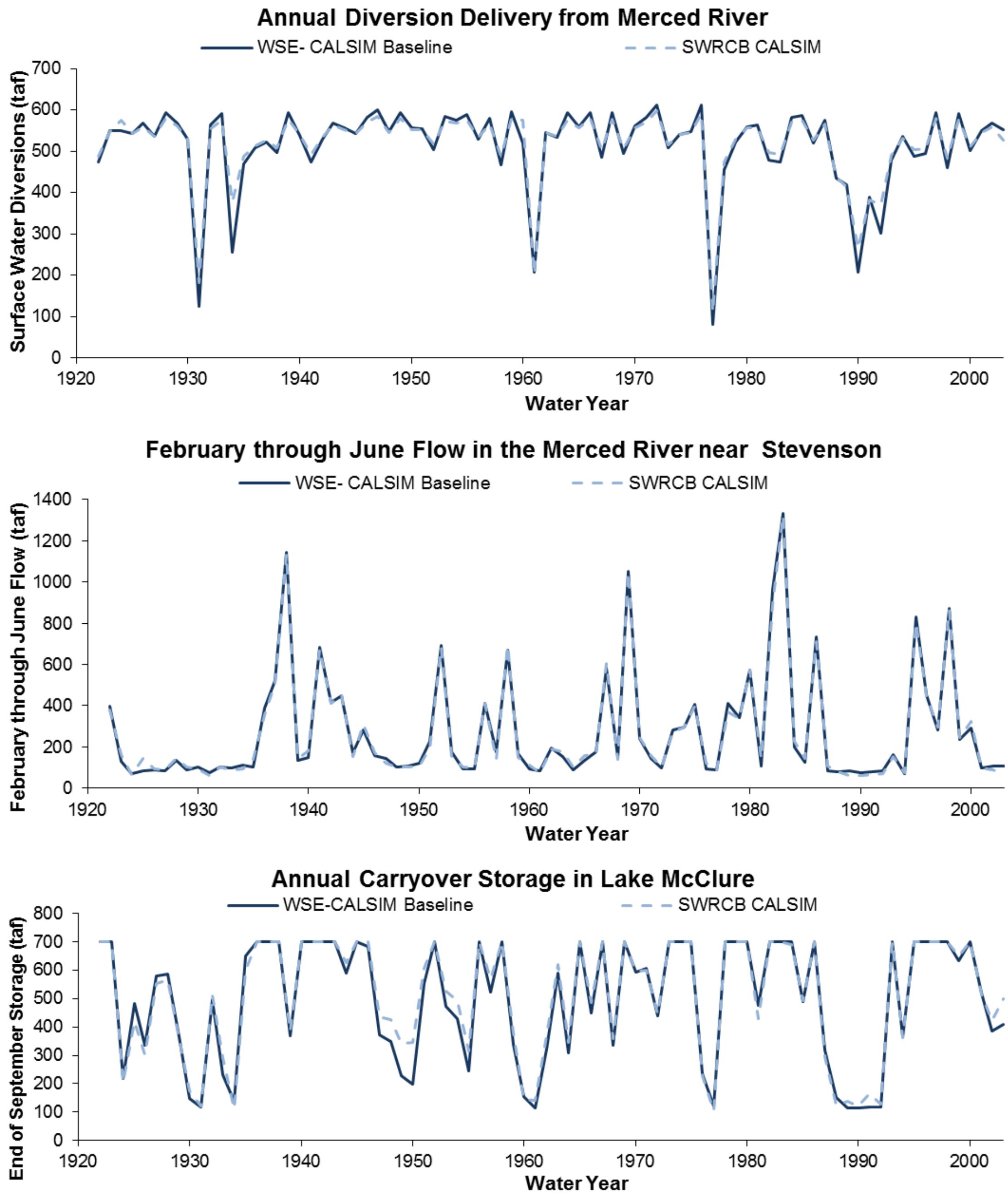


Figure F.1.2-15. Annual WSE CALSIM-Baseline Results for Merced River Diversions, Flow, and Reservoir Operations Compared to SWRCB CALSIM Results

F.1.3 Water Supply Effects Modeling—Results

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

In many cases, hydrologic conditions are described using cumulative distribution tables. The cumulative distribution of a particular variable (e.g., flow or storage) provides a basic summary of the distribution (range) of values. The percentile (percent cumulative distribution) associated with each value indicates the percent of time that the values were less than the specified value. For example, a 10th percentile value of 2 indicates that 10 percent of the time the values were less than 2. The 0th percentile is the minimum value, the 50th percentile is the median value, and the 100th percentile is the maximum value. In many cases, the 10th and 90th percentiles have been selected to represent relatively low and high values rather than the minimum and maximum because they are representative of multiple years rather than the one year with the highest value and the one year with the lowest value.

For additional detail, Attachment 1 of this appendix contains the monthly model outputs for reservoir storage and streamflow for the baseline conditions and LSJR Alternatives 2, 3, and 4 over the 1922–2003 period. Attachment 1 is presented by month for each water year.

F.1.3.1 Summary of Water Supply Effects Model Results

Summarized below are the resulting effects of monthly storage, carryover storage (end-of-September), annual water diversions, and river flows for LSJR Alternatives 2, 3, and 4 compared to baseline in the three eastside tributaries. Detailed results are discussed after this section for the baseline conditions and LSJR Alternatives 2, 3, and 4 (20, 40, and 60 percent unimpaired flow). Summary results also include the adaptive implementation approaches for the various LSJR alternatives (e.g., 30 and 50 percent unimpaired flow). Results on the tributaries were as calculated near the LSJR confluence, specifically at Ripon, Modesto, and Stevinson for the Stanislaus, Tuolumne, and Merced Rivers, respectively.

Reservoir Storage

Reservoir storage and release is used for calculation of hydropower generation effects, recreation, 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.1.3-1a for the entire 82-year modeling period and in Table F.1.3-1b for the critically dry years only.

Figures F.1.3-1a, F.1.3-1b, and F.1.3-1c display the baseline and WSE monthly storage results for the LSJR alternatives (20, 40, and 60 percent unimpaired flows) for the three tributary reservoirs for water years 1922–2003. The monthly flood control storage levels and the monthly unimpaired flows are shown for reference. The ranges of estimated storage for the LSJR alternatives were similar to the baseline storage values, although storage was allowed to be drained further in wetter years as the unimpaired flow requirement increased. The inclusion of carryover storage guidelines tended to raise storage in dryer years compared to baseline.

Table F.1.3-1a. Average Carryover Storage within the Three Major Reservoirs over the 82-Year Modeling Period (TAF)

Percent Unimpaired Flow	New Melones	New Don Pedro	Lake McClure
Baseline	1,125	1,348	453
20%	1,261	1,342	511
30%	1,211	1,291	498
40%	1,188	1,248	480
50%	1,131	1,216	476
60%	1,087	1,223	462

Table F.1.3-1b. Average Carryover Storage during Critically Dry Years within the Three Major Reservoirs over the 82-Year Modeling Period (TAF)

Percent Unimpaired Flow	New Melones	New Don Pedro	Lake McClure
Baseline	540	880	154
20%	793	945	315
30%	784	956	324
40%	830	939	329
50%	822	982	312
60%	846	968	267

Note:

Sixteen years were classified as critically dry from 1922–2003.

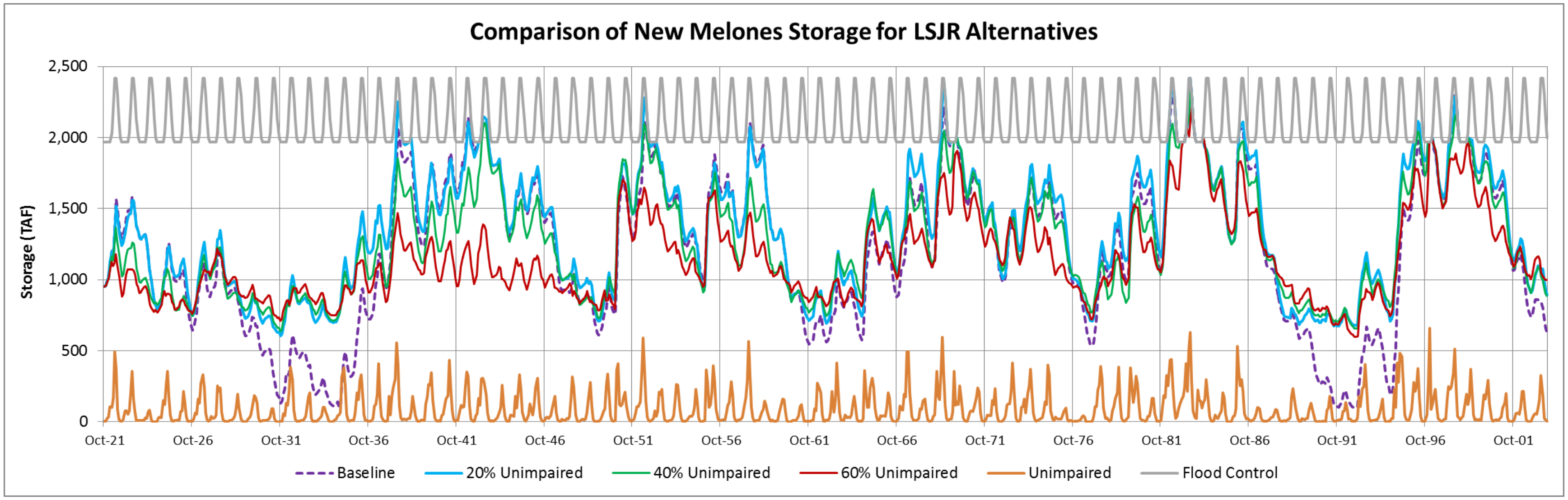


Figure F.1.3-1a. Comparison of Baseline Conditions and WSE Model Results for 20%, 40%, and 60% Unimpaired Flow (LSJR Alternatives 2–4): New Melones Reservoir Storage and Stanislaus River Unimpaired Flows for 1922–2003

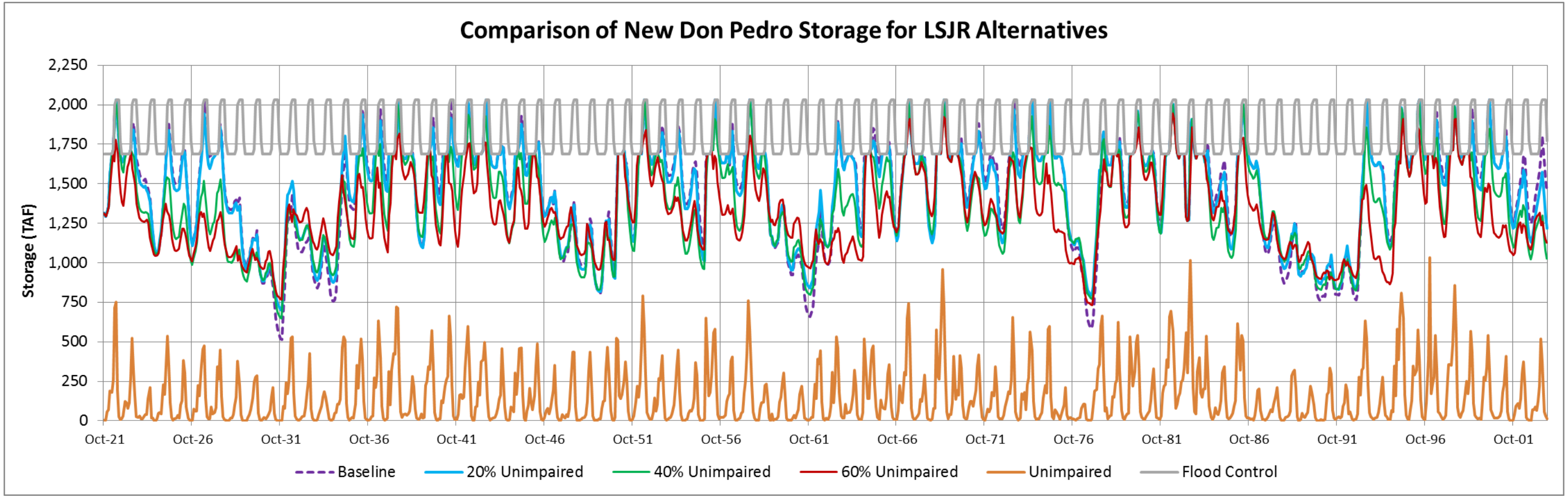


Figure F.1.3-1b. Comparison of Baseline Conditions and WSE Model Results for 20%, 40%, and 60% Unimpaired Flow (LSJR Alternatives 2–4): New Don Pedro Reservoir Storage and Tuolumne River Unimpaired Flows for 1922–2003

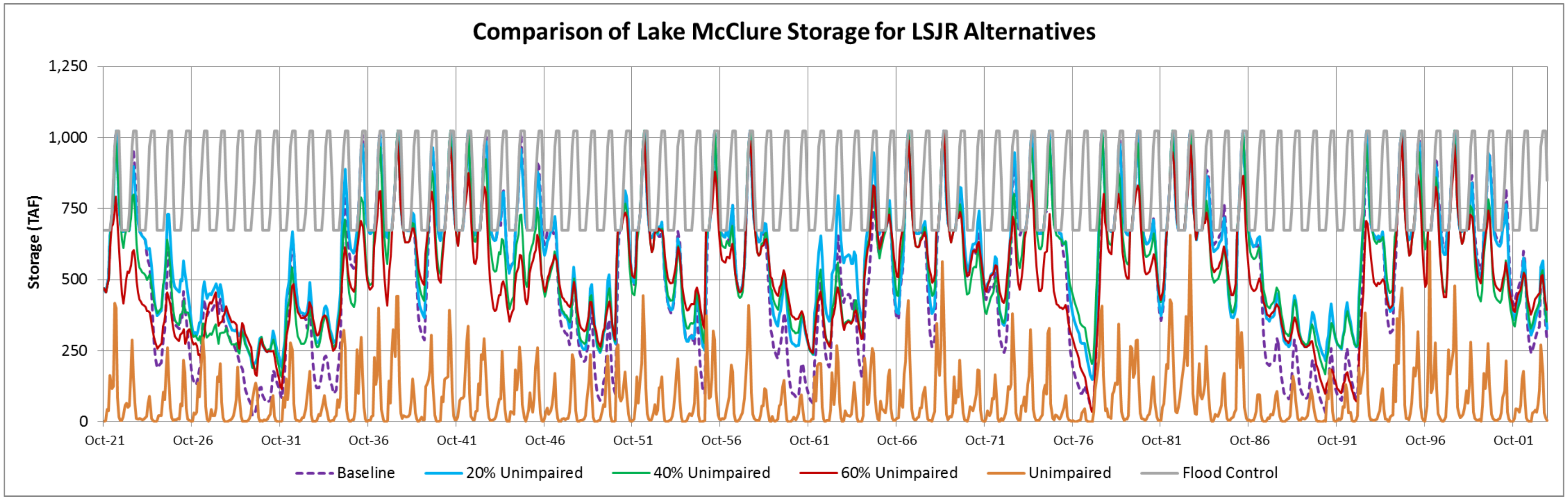


Figure F.1.3-1c. Comparison of Baseline Conditions and WSE Model Results for 20%, 40%, and 60% Unimpaired Flow (LSJR Alternatives 2–4): Lake McClure Storage and Merced River Unimpaired Flows for 1922–2003

River Flows

Table F.1.3-2a contains a summary of the average effects of the LSJR alternatives on river flows (flow volumes, TAF) from February–June and annually as compared to the baseline flows for each eastside tributary and near Vernalis on the SJR. Most of the change in flow volume associated with implementation of the unimpaired flow objectives (in terms of TAF) occurred during the unimpaired flow objective months (February–June). During the other months, the LSJR alternative flows were similar to the baseline flows. Table F.1.3-2b summarizes the mean annual February–June instream flow totals under Alternative 3 for each tributary in the plan area by water year type.

Figures F.1.3-2a, F.1.3-2b, F.1.3-2c, and F.1.3-2d show the simulated monthly flows in the Stanislaus, Tuolumne, and Merced Rivers near the confluence with the LSJR and the SJR at Vernalis for water years 1984–2003. The unimpaired flows are shown for comparison. The baseline flows were generally low in many months each year until runoff was high enough to increase reservoir storage and cause flood control releases (in wet years). From February–June, in general, as the percentage of unimpaired flow increases, the resulting river flow increased. The simulated river flows are described in more detail in Sections F.1.2.4 through F.1.2.7.

Table F.1.3-2a. Average Baseline Streamflow and Differences from Baseline Conditions on the Eastside Tributaries and near Vernalis

Percent Unimpaired Flow	Stanislaus River near Ripon (TAF)/(%)	Tuolumne River near Modesto (TAF)/(%)	Merced River near Stevinson (TAF)/(%)	Total three tributaries (TAF)/(%)	SJR near Vernalis (TAF)/(%)
February–June Average					
Baseline	312/100	562/100	245/100	1,116/100	1,742/100
20%	-3/-1	32/6	27/11	56/5	56/3
25%	11/4	53/10	42/17	106/10	106/6
30%	27/9	85/15	62/26	174/16	174/10
35%	30/9	98/17	70/29	197/18	197/11
40%	62/20	135/24	91/38	288/26	288/17
45%	91/29	171/30	111/46	373/33	373/21
50%	128/41	220/39	137/57	485/43	485/28
55%	164/53	271/48	163/67	598/54	598/34
60%	203/65	332/59	193/80	728/65	728/42
Annual Average					
Baseline	549/100	895/100	454/100	1,897/100	2,965/100
20%	5/1	23/3	31/7	59/3	59/2
25%	15/1	37/4	42/9	94/5	94/3
30%	28/5	63/7	58/13	149/8	149/5
35%	42/8	90/10	74/16	206/11	206/7
40%	74/13	127/14	93/21	294/15	294/10

Percent Unimpaired Flow	Stanislaus River near Ripon (TAF)/(%)	Tuolumne River near Modesto (TAF)/(%)	Merced River near Stevinson (TAF)/(%)	Total three tributaries (TAF)/(%)	SJR near Vernalis (TAF)/(%)
45%	94/17	159/18	110/24	363/19	363/12
50%	132/24	202/23	135/30	469/25	469/16
55%	163/30	249/28	158/35	571/30	571/19
60%	202/37	307/34	184/41	693/37	693/23

Notes:

Resulting flow effects on the tributaries were as calculated near the LSJR confluence, specifically at Ripon, Modesto, and Stevinson for the Stanislaus, Tuolumne, and Merced Rivers, respectively.

Table F.1.3-2b. Mean Annual February–June Instream Flow in the Plan Area by Water Year Type

		Year Type				
		Wet	Above Normal	Below Normal	Dry	Critically Dry
Stanislaus	Baseline (TAF)	455	380	261	232	134
	LSJR Alt 3 (30% UF)* (TAF)	519	382	288	231	155
	Change (TAF)	64	2	27	-1	21
	Change (%)	14%	1%	10%	-1%	15%
	LSJR Alt 3 (40% UF) (TAF)	555	440	343	234	175
	Change (TAF)	100	60	82	2	41
	Change (%)	22%	16%	31%	1%	31%
	LSJR Alt 3 (50% UF)* (TAF)	661	523	398	265	201
	Change (TAF)	206	143	137	33	67
	Change (%)	45%	38%	52%	14%	50%
Tuolumne	Baseline (TAF)	1165	575	297	231	132
	LSJR Alt 3 (30% UF)* (TAF)	1196	695	415	320	231
	Change (TAF)	31	120	118	89	99
	Change (%)	3%	21%	40%	39%	75%
	LSJR Alt 3 (40% UF) (TAF)	1177	780	514	387	296
	Change (TAF)	12	205	217	156	164
	Change (%)	1%	36%	73%	68%	124%
	LSJR Alt 3 (50% UF)* (TAF)	1226	903	637	473	365
	Change (TAF)	61	328	340	242	233
	Change (%)	5%	57%	115%	105%	176%
Merced	Baseline (TAF)	541	178	129	98	68
	LSJR Alt 3 (30% UF)* (TAF)	583	282	202	150	118
	Change (TAF)	42	104	73	52	50
	Change (%)	8%	58%	56%	53%	73%
	LSJR Alt 3 (40% UF) (TAF)	575	342	256	186	146
	Change (TAF)	34	164	127	88	78
	Change (%)	6%	92%	98%	90%	115%
	LSJR Alt 3 (50% UF)* (TAF)	606	421	315	226	176
	Change (TAF)	65	243	186	128	108
	Change (%)	12%	136%	144%	131%	158%
Total Three Tributaries	Baseline (TAF)	2161	1133	687	561	334
	LSJR Alt 3 (30% UF)* (TAF)	2298	1359	905	701	503
	Change (TAF)	137	226	218	140	169
	Change (%)	6%	20%	32%	25%	51%
	LSJR Alt 3 (40% UF) (TAF)	2307	1562	1113	807	617
	Change (TAF)	146	429	426	246	283
	Change (%)	7%	38%	62%	44%	85%
	LSJR Alt 3 (50% UF)* (TAF)	2493	1847	1350	965	741
	Change (TAF)	332	714	663	404	407
	Change (%)	15%	63%	97%	72%	122%

UF = unimpaired flow

TAF = thousand acre-feet

*LSJR Alt 3 (30% UF) and LSJR Alt 3 (50% UF) both refer to LSJR alternative 3 with adaptive implementation.

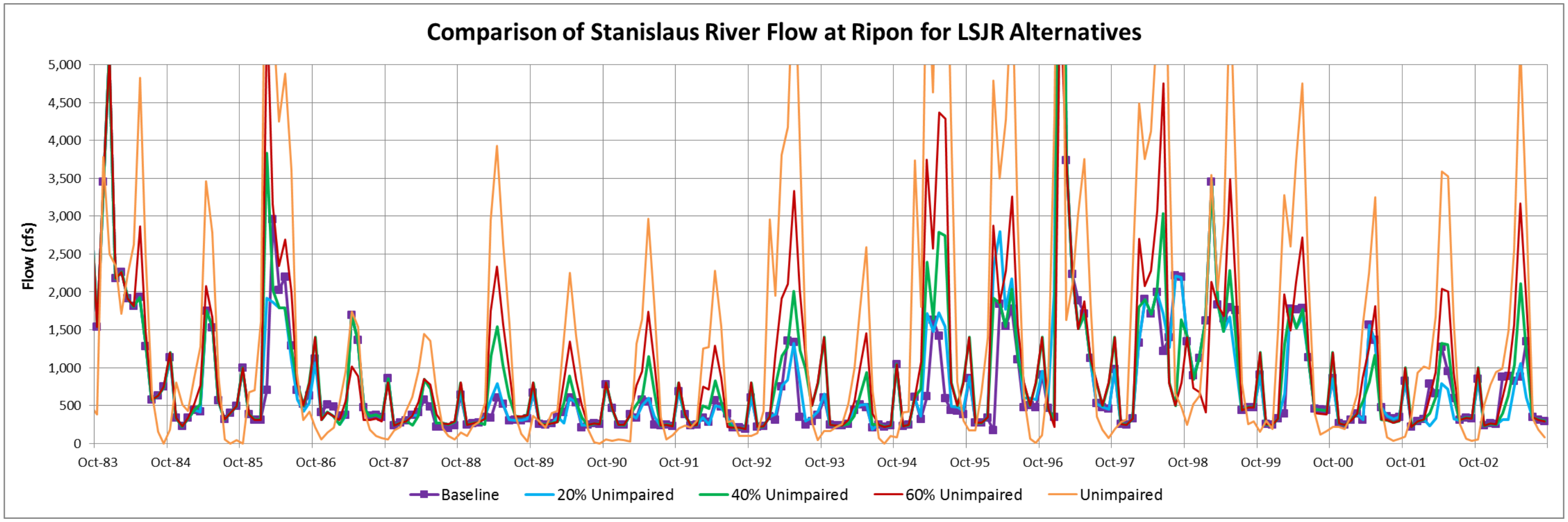


Figure F.1.3-2a. Comparison of Monthly Stanislaus River Flows for Baseline Conditions and 20%, 40%, and 60% Unimpaired Flow (LSJR Alternatives 2–4) for Water Years 1984–2003

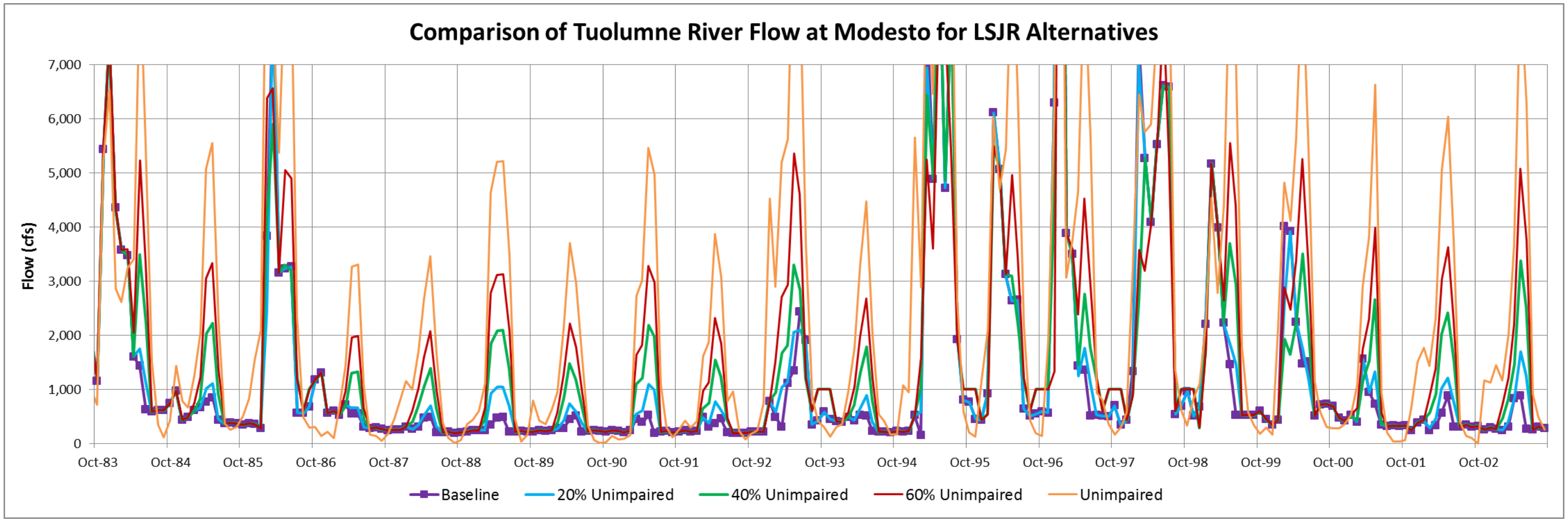


Figure F.1.3-2b. Comparison of Monthly Tuolumne River Flows for Baseline Conditions and 20%, 40%, and 60% Unimpaired Flow (LSJR Alternatives 2–4) for Water Years 1984–2003

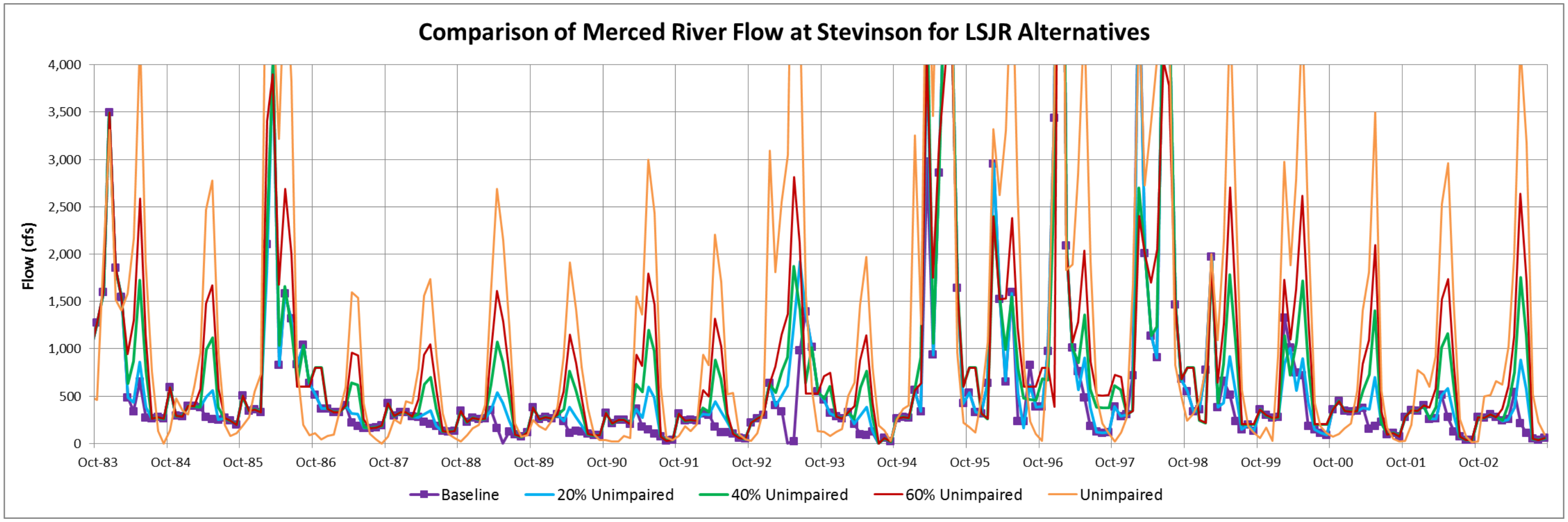


Figure F.1.3-2c. Comparison of Monthly Merced River Flows for Baseline Conditions and 20%, 40%, and 60% Unimpaired Flow (LSJR Alternatives 2–4) for Water Years 1984–2003

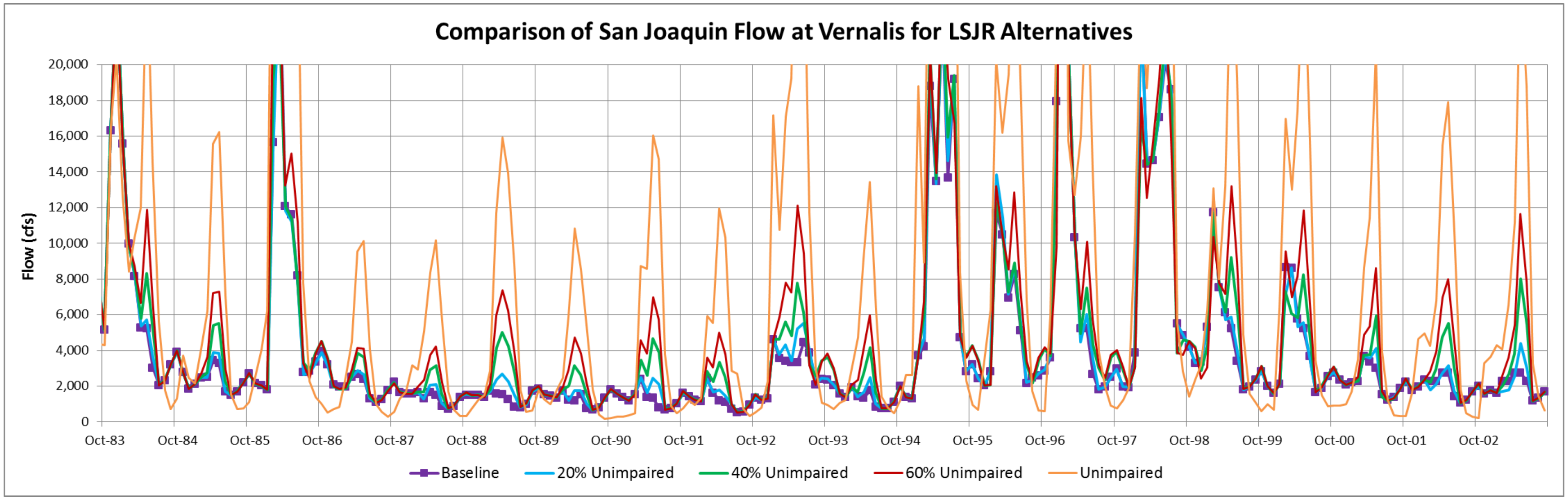


Figure F.1.3-2d. Comparison of Monthly SJR at Vernalis Flows for Baseline Conditions and 20%, 40%, and 60% Unimpaired Flow (LSJR Alternatives 2–4) for Water Years 1984–2003

Surface Water Diversions

Table F.1.3-3 contains a summary of the effects on diversions for each eastside tributary and for the plan area of the LSJR alternatives as compared to the baseline for the 82-year modeling period. Tables F.1.3-4a, F.1.3-4b, and F.1.3-4c show the annual cumulative distributions of water supply diversions under the LSJR alternatives as compared to the baseline water supply diversions and deficits indicators for each tributary. The deficit indicator was calculated as maximum demand minus delivery, where the maximum demand equals the maximum annual diversion under baseline conditions. It should be noted, however, that in some years (particularly wet years), the demand is lower than in other years, so the deficit indicator could be an overprediction of the actual deficit. The annual values are summarized with the minimum and maximum and average, as well as the 10 percent increments of the distribution of values. The range of annual unimpaired flow for each tributary is shown for comparison. Additional details are discussed in Sections F.1.2.4 through F.1.2.7 for baseline and LSJR Alternatives 2, 3, and 4.

Table F.1.3-3. Average Annual Baseline Water Supply and Difference from Baseline Conditions on the Eastside Tributaries and Plan Area Totals over the 82-year Modeling Period

Percent Unimpaired Flow Requirement	Stanislaus Diversion (TAF)/(% of Baseline)	Tuolumne Diversion (TAF)/(% of Baseline)	Merced Diversion (TAF)/(% of Baseline)	Total Three Tributaries (TAF)/(% of Baseline)
Baseline	637/100	851/100	580/100	2,068/100
20%	-12/-2	-20/-2	-33/-6	-65/-3
25%	-20/-3	-32/-4	-44/-8	-96/-5
30%	-33/-5	-56/-7	-60/-10	-149/-7
35%	-45/-7	-82/-10	-75/-13	-202/-10
40%	-79/-12	-119/-14	-95/-16	-293/-14
45%	-97/-15	-149/-18	-111/-19	-357/-17
50%	-136/-21	-193/-23	-136/-23	-465/-23
55%	-167/-26	-240/-28	-159/-27	-566/-27
60%	-206/-32	-298/-35	-185/-32	-689/-33

Annual Summary of Results

Baseline and the LSJR alternatives for each tributary are 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 and percentage of unimpaired flow). Tables F.1.3-4a, F.1.3-4b, and F.1.3-4c present the cumulative distributions for annual diversions and annual diversion deficits on the Stanislaus, Tuolumne, and Merced Rivers, respectively. Table F.1.3-4d illustrates the variation of diversion by water year type under LSJR Alternative 3.

Table F.1.3-4a. Annual Water Supply Diversions for Baseline Conditions and Percent of Unimpaired Flow on the Stanislaus

	Unimpaired Flow	Stanislaus Diversions (TAF)						Stanislaus Deficit Indicator (TAF)					
		Baseline	20%	30%	40%	50%	60%	Baseline	20%	30%	40%	50%	60%
Minimum	155	252	228	228	228	198	164	520	544	544	544	574	607
10%	456	538	452	320	265	222	201	234	320	452	507	550	571
20%	592	583	570	508	403	288	221	189	202	264	369	484	551
30%	680	605	624	616	464	333	260	167	148	156	307	439	511
40%	891	630	657	640	584	461	322	142	115	132	188	311	450
50%	1,095	661	673	664	640	575	399	111	99	108	132	196	373
60%	1,264	676	687	681	663	630	510	96	85	91	109	142	262
70%	1,368	694	701	697	679	663	601	78	71	75	93	109	171
80%	1,563	708	709	708	695	681	661	64	63	63	77	91	111
90%	1,910	723	724	724	712	705	690	49	48	48	60	67	82
Maximum	2,954	772	772	772	759	759	759	0	0	0	13	13	13
Average	1,118	637	624	604	558	500	431	135	147	168	214	271	341

Table F.1.3-4b. Annual Water Supply Diversions for Baseline Conditions and Percent of Unimpaired Flow on the Tuolumne

	Unimpaired Flow	Tuolumne Diversions (TAF)						Tuolumne Deficit Indicator (TAF)					
		Baseline	20%	30%	40%	50%	60%	Baseline	20%	30%	40%	50%	60%
Minimum	384	557	371	371	341	215	214	477	663	663	693	819	820
10%	836	685	652	543	408	322	229	349	382	491	625	712	805
20%	1,055	796	781	715	563	395	287	237	253	319	471	639	747
30%	1,166	828	822	777	641	511	378	205	211	257	393	523	656
40%	1,413	855	852	823	763	652	460	179	182	211	271	382	574
50%	1,783	878	869	851	802	751	538	156	165	183	232	283	496
60%	2,036	891	889	871	828	802	673	143	145	163	206	231	361
70%	2,198	915	910	890	859	828	763	119	124	144	175	206	271
80%	2,490	932	930	911	887	857	820	102	104	123	147	177	214
90%	3,090	960	957	938	908	890	853	74	77	96	126	144	181
Maximum	4,630	1,034	1,034	1,004	1,004	1,004	907	0	0	30	30	30	127
Average	1,851	851	831	795	732	657	553	183	203	239	302	376	481

Table F.1.3-4c. Annual Water Supply Diversions for Baseline Conditions and Percent of Unimpaired Flow on the Merced

	Unimpaired Flow	Merced Diversions (TAF)						Merced Deficit Indicator (TAF)					
		Baseline	20%	30%	40%	50%	60%	Baseline	20%	30%	40%	50%	60%
Minimum	151	136	203	203	203	202	202	543	476	476	476	478	478
10%	408	441	380	308	259	231	220	239	299	372	420	448	459
20%	489	558	472	407	353	300	243	122	208	273	326	380	437
30%	560	578	551	495	408	330	284	102	129	185	272	350	396
40%	669	602	565	537	467	387	323	78	114	143	212	293	357
50%	895	617	587	560	551	482	380	63	92	120	128	198	299
60%	1,086	630	603	582	564	522	442	50	77	98	116	158	238
70%	1,169	643	619	611	582	558	494	37	61	69	97	122	186
80%	1,399	653	632	627	607	579	557	26	48	53	73	100	122
90%	1,706	669	659	642	632	610	580	10	21	37	48	70	100
Maximum	2,790	680	673	673	673	668	648	0	7	7	7	12	32
Average	958	580	547	520	485	444	395	100	133	160	194	235	284

Table F.1.3-4d. Mean Annual Diversions Under 40 Percent Unimpaired Flow Proposal by Water Year Type

		Year Type				
		Wet	Above Normal	Below Normal	Dry	Critically Dry
Stanislaus	Baseline (TAF)	661	661	661	683	520
	LSJR Alt 3 (40% UF) (TAF)	662	630	613	536	303
	Change (TAF)	1	-31	-48	-147	-217
	Change (%)	0%	-5%	-7%	-22%	-42%
Tuolumne	Baseline (TAF)	848	882	931	938	689
	LSJR Alt 3 (40%UF) (TAF)	845	855	800	681	426
	Change (TAF)	-3	-27	-131	-257	-263
	Change (%)	0%	-3%	-14%	-27%	-38%
Merced	Baseline (TAF)	591	622	642	650	416
	LSJR Alt 3 (40% UF) (TAF)	591	607	508	381	272
	Change (TAF)	0	-15	-134	-268	-144
	Change (%)	0%	-2%	-21%	-41%	-35%
Total Three Tributaries	Baseline (TAF)	2,099	2,164	2,233	2,271	1,625
	LSJR Alt 3 (40% UF) (TAF)	2,097	2,091	1,921	1,598	1,001
	Change (TAF)	-2	-73	-313	-673	-624
	Change (%)	0%	-3%	-14%	-30%	-38%

UF = percent of unimpaired flow

TAF = thousand acre-feet

Figures F.1.3-3a, F.1.3-3b, F.1.3-3c, and, F.1.3-3d show the summary of annual results on the Stanislaus River. This compares the distribution of annual (a) February–June flow volume, (b) end-of-September storage, (c) diversion volume from the river, and (d) February–June flow as a percentage of unimpaired flow. The Stanislaus River February–June flow volumes were slightly reduced from baseline flows for LSJR Alternative 2 (20 percent unimpaired flow), were higher for LSJR Alternative 3 (40 percent unimpaired flow), and were much increased for LSJR Alternative 4 (60 percent unimpaired flow). As seen in Figure F.1.3-3d, the percentage of unimpaired flow does not always meet the percentage specified by the alternatives (LSJR Alternatives 3 and 4, specifically). This is because a portion of the flow from February–June in wet years was shifted to later in the year as part of adaptive implementation for controlling potential temperature effects during that time of year. End-of-September storage generally tended to be reduced slightly as a result of the LSJR alternatives, primarily during the wetter years (with the reduction increasing with the amount of unimpaired flow released), except in the driest years, when the carryover storage guidelines resulted in higher carryover storage for the LSJR alternatives compared with baseline conditions. The distribution of annual deliveries was decreased slightly for LSJR Alternative 2, reduced for LSJR Alternative 3, and reduced substantially for LSJR Alternative 4 in the majority of years compared with baseline conditions.

Figures F.1.3-4a, F.1.3-4b, F.1.3-4c, and F.1.3-4d show the summary of annual results on the Tuolumne River. This compares the distribution of (a) annual February–June flow, (b) end-of-September storage, (c) annual water supply diversions from the three tributaries, and (d) flow as a percentage of unimpaired flow. The Tuolumne River February–June flow volumes were generally slightly greater than the baseline flows for LSJR Alternative 2 (20 percent unimpaired flow), were increased for LSJR Alternative 3 (40 percent unimpaired flow), and were increased more for LSJR Alternative 4 (60 percent unimpaired flow). As can be seen in Figure F.1-20d, the percentage of unimpaired flow does not always meet the percentage specified by the alternatives (LSJR Alternatives 3 and 4 specifically). This is because there is a portion of the flow from February–June in wet years that shifts to later in the year as part of adaptive implementation for controlling potential temperature effects during that time of year. End-of-September storage generally tended to be reduced slightly as a result of the LSJR alternatives primarily during the wetter years (with the reduction increasing with the amount of unimpaired flow released), except in the driest years when the carryover storage guidelines resulted in higher carryover storage for the LSJR alternatives than baseline. The distribution of annual deliveries was decreased slightly for LSJR Alternative 2, was reduced for LSJR Alternative 3, and was reduced substantially for LSJR Alternative 4 in the majority of years compared to the baseline conditions.

Figures F.1.3-5a, F.1.3-5b, F.1.3-5c, and F.1.3-5d show the summary of annual results on the Merced River. This compares the distribution of (a) annual February–June flow, (b) end-of-September storage, (c) annual water supply diversions from the three tributaries, and (d) flow as a percentage of unimpaired flow. The Merced River February–June flow volumes were slightly increased from the baseline flows for LSJR Alternative 2 (20 percent unimpaired flow), were increased for LSJR Alternative 3 (40 percent unimpaired flow), and were increased more for LSJR Alternative 4 (60 percent unimpaired flow). As can be seen in Figure F.1-21d, the percentage of unimpaired flow does not always meet the percentage specified by the alternatives (LSJR Alternatives 3 and 4 specifically). This is because there is a portion of the flow from February–June in wet and above-normal years that shifts as part of adaptive implementation to later in the year for controlling potential temperature effects during that time of year. End-of-September storage generally tended to be reduced slightly as a result of the LSJR alternatives primarily during the wetter years (with the reduction increasing with the amount of unimpaired flow released), except in the driest years when the carryover storage guidelines resulted in higher carryover storage for the LSJR alternatives than baseline. The distribution of annual deliveries was decreased slightly for LSJR Alternative 2, was reduced for LSJR Alternative 3, and was reduced substantially for LSJR Alternative 4 in the majority of years compared to the baseline conditions.

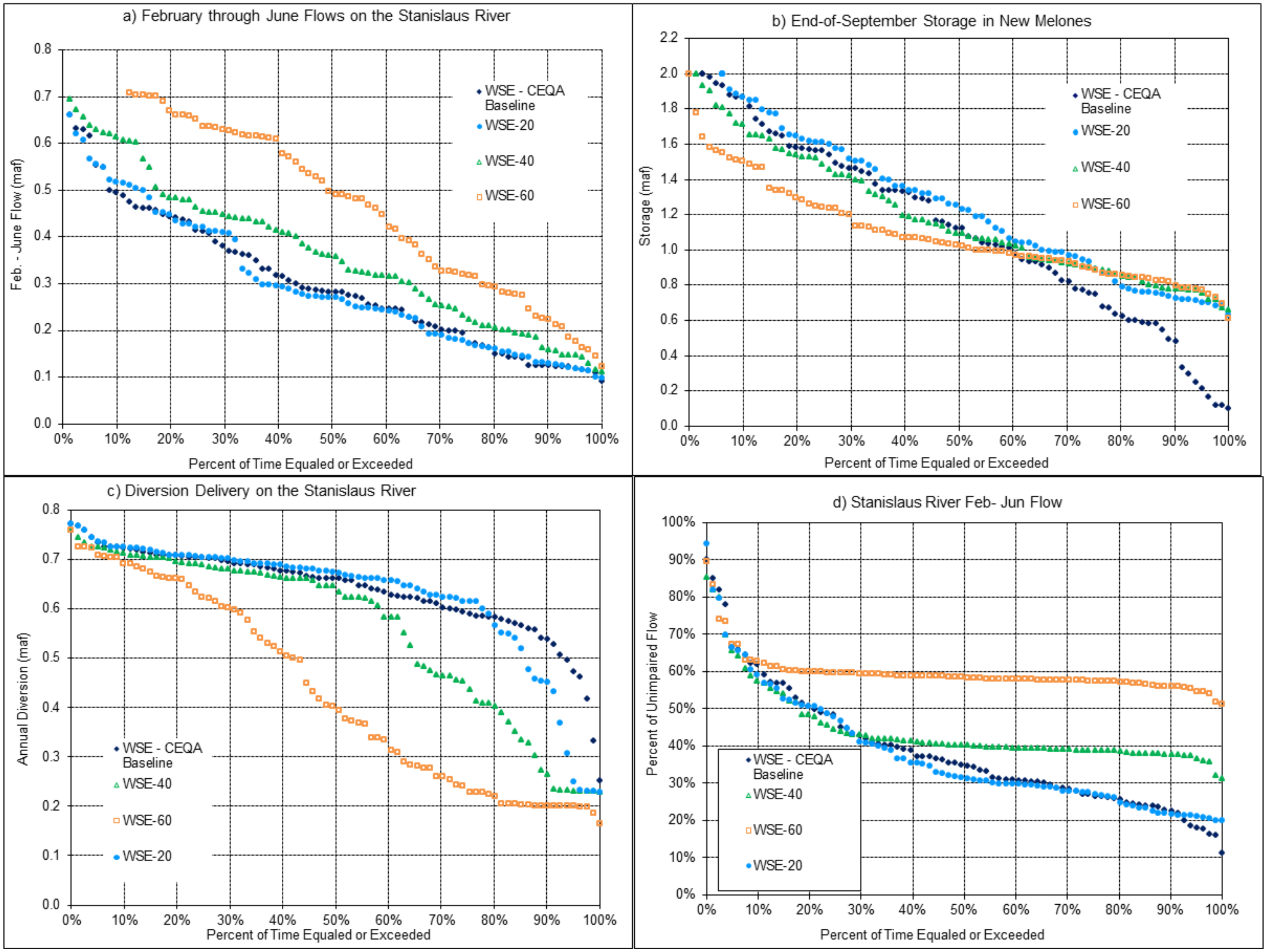


Figure F.1.3-3. Stanislaus River Annual Distributions from 1922–2003 of (a) February–June Flow Volume, (b) End-of-September Storage, (c) Annual Diversion Delivery, and (d) February–June Flow Volume as a Percentage of Unimpaired Flow

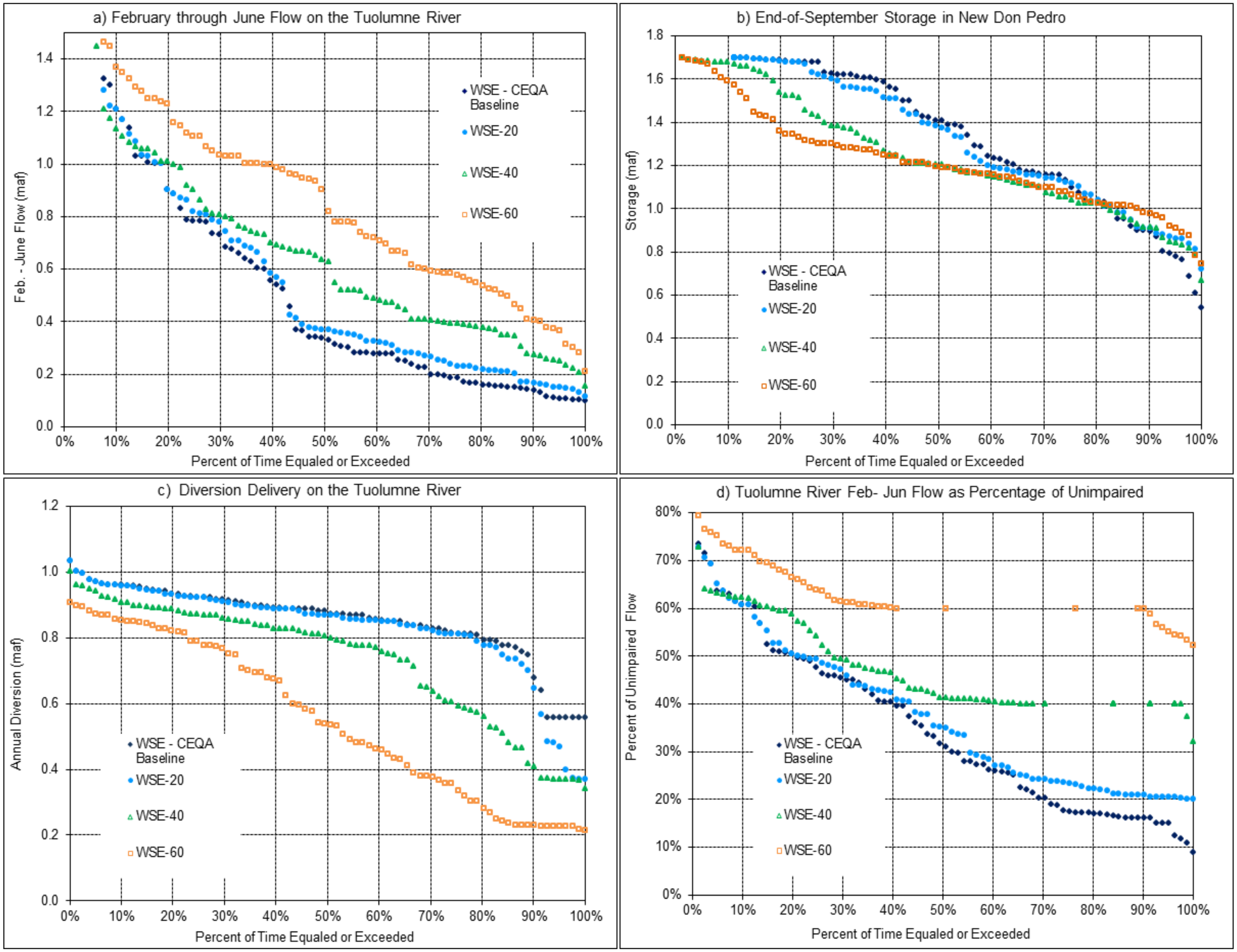


Figure F.1.3-4. Tuolumne River Annual Distributions from 1922–2003 of (a) February–June Flow Volume, (b) End-of-September Storage, (c) Annual Diversion Delivery, and (d) February–June Flow Volume as a Percentage of Unimpaired Flow

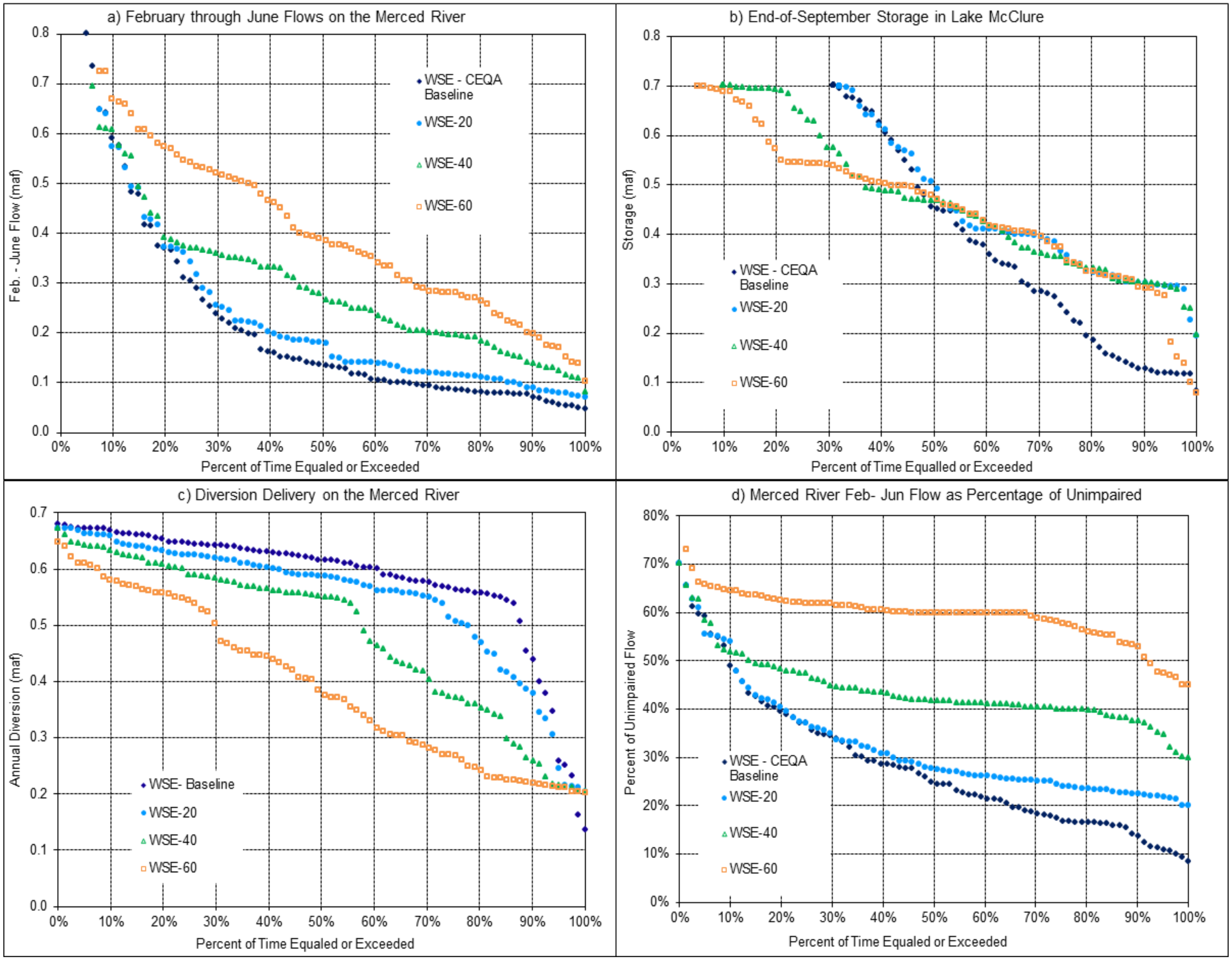


Figure F.1.3-5. Merced River Annual Distributions from 1922–2003 of (a) February–June Flow Volume, (b) End-of-September Storage, (c) Annual Diversion Delivery, and (d) February–June Flow Volume as a Percentage of Unimpaired Flow

Figures F.1.3-6a, F.1.3-6b, and F.1.3-6c show the summary of annual results on the SJR at Vernalis. This compares the distribution of (a) annual February–June Flow, (b) annual water supply diversions from the plan area, and (c) flow as a percentage of unimpaired flow. 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. Because the flow at Vernalis is also dependent on flow from the Upper SJR, the resulting flow at Vernalis did not reach the full percentage set out by LSJR Alternatives 3 and 4 as well as it was reached in the three tributaries.

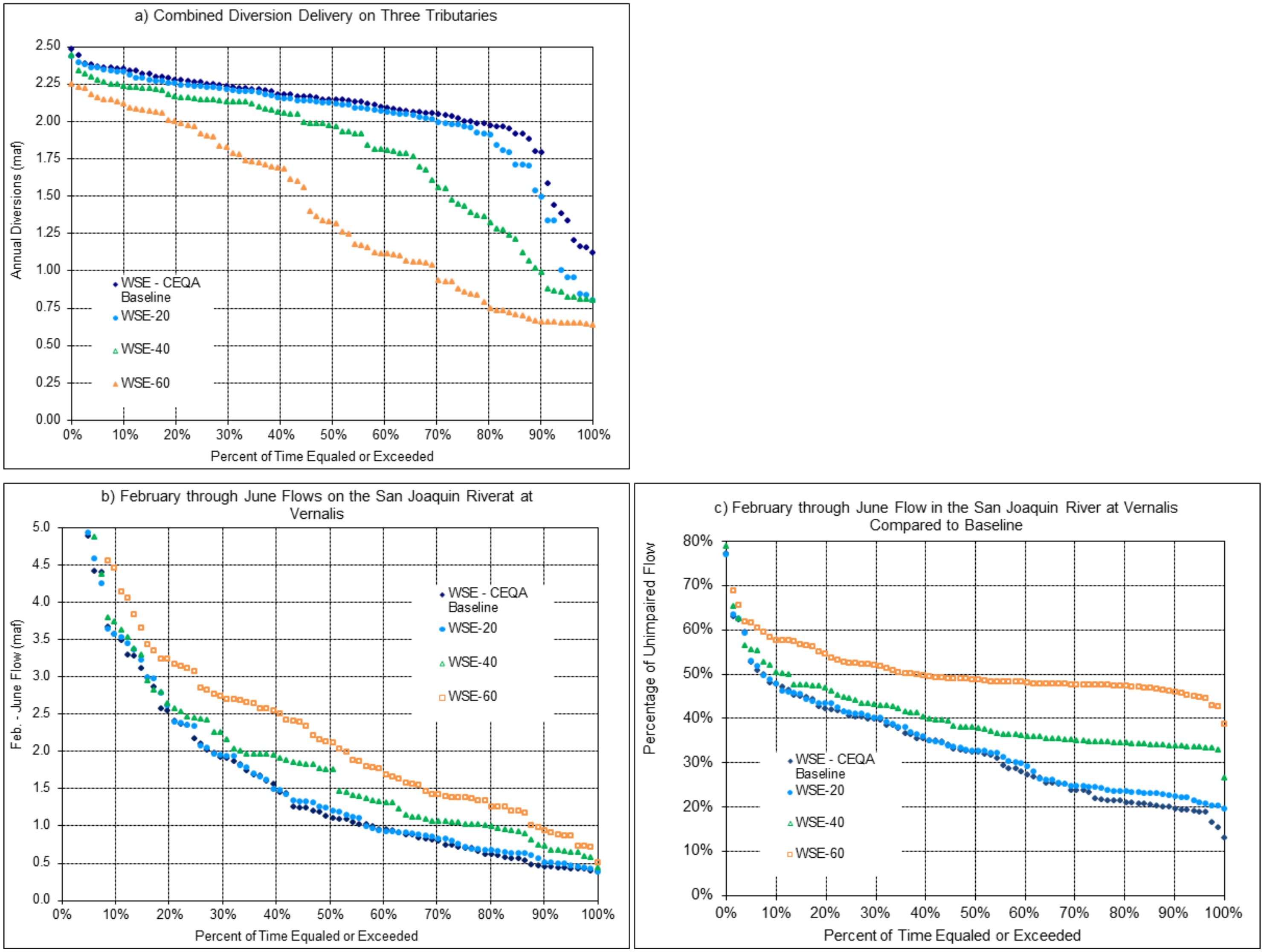


Figure F.1.3-6. SJR Annual Distributions from 1922–2003 of (a) Annual Three Tributary Diversion Delivery, (b) February–June Flow Volume near Vernalis, and (c) February–June Flow Volume near Vernalis as a Percentage of Unimpaired Flow

F.1.3.2 Characterization of Baseline Conditions

Baseline conditions were simulated with the WSE model, as previously described, using historical hydrology from 1922–2003 assuming regulatory conditions described in Section F.1.2.2, *Development of WSE Baseline and LSJR Alternative Conditions*. This section compares baseline to the three LSJR alternatives. The SJR upstream of the Merced River confluence was assumed to remain unchanged and equal to the baseline conditions for LSJR Alternatives 2, 3, and 4.

Upper and Middle SJR

For baseline conditions and all alternatives, flows in the SJR upstream of the Merced River were assumed to be equal to those simulated by the CALSIM case discussed in Section F.1.2.1, *Water Supply Effects Methods*. Table F.1.3-5a shows the monthly and annual cumulative distributions for the CALSIM simulated SJR flows upstream of the Merced River. This flow originates from upstream 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 Management Area refuges, and agricultural drainage from irrigated lands in this upstream portion of the SJR watershed. The CALSIM model estimated monthly flows that were nearly identical in more than 50 percent of the years (clearly assumed values) with median monthly flows that were less than 500 cubic feet per second (cfs) in most months and less than 1,000 cfs in all months.

Table F.1.3-5a. Baseline Monthly Cumulative Distributions of SJR above the Merced Flow (cfs) for 1922–2003

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	Annual (TAF)
						SJR above Merced Flow (cfs)							
Minimum	184	341	297	230	511	275	148	220	219	196	179	470	215
10%	193	396	378	285	565	447	247	284	296	248	198	485	259
20%	234	460	379	301	619	495	325	354	312	248	225	614	291
30%	234	460	396	334	655	528	369	443	329	264	225	614	304
40%	234	476	412	366	738	632	414	481	346	264	225	614	323
50%	237	477	428	423	864	702	555	510	380	264	225	614	367
60%	251	521	461	513	1,026	934	703	554	407	274	225	614	488
70%	251	595	516	800	1,477	1,213	843	633	452	296	241	614	552
80%	251	651	630	1,533	2,751	1,750	1,442	826	514	313	241	631	977
90%	266	765	1,096	2,353	6,149	4,604	4,696	4,660	1,889	360	256	631	1,583
Maximum	713	3,531	8,657	22,173	15,188	16,113	12,031	10,642	10,639	5,312	290	648	5,604
Average	246	612	885	1,355	2,136	1,759	1,511	1,356	948	472	228	604	726

Note:

This is the same for all LSJR alternatives as these alternatives are not modifying the flow above the confluence of the LSJR and the Merced River and this is outside the plan area. Please see Chapter 3, *Alternatives Description*, for more information.

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. The water delivery target was compared to the distribution of unimpaired flow values, which are shown as 10th, 30th, 50th, 70th, and 90th percentiles. 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 average monthly demands were less than or equal to the 10 percent cumulative monthly runoff from November through May. The average June demand was between 30 and 50 percent cumulative runoff, and the average monthly demands for July through October were greater than the 90 percent cumulative runoff. This indicates that reservoir storage is needed to satisfy the June demand in about 30 to 50 percent of the years, and reservoir storage is needed in more than 90 percent of the years to satisfy the July–October demands.

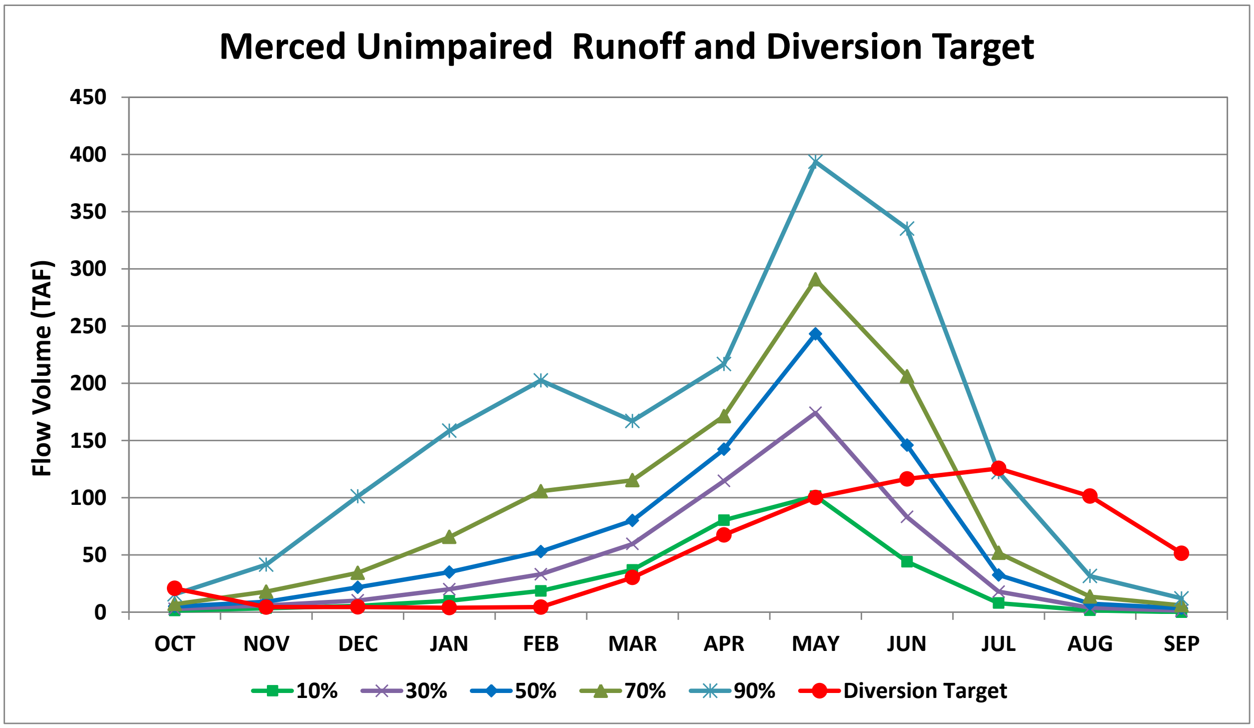


Figure F.1.3-7a. Monthly Merced River Unimpaired Runoff Compared to Average Monthly Water Supply Demands

Because there are no significant reservoirs or diversions in the Merced River watershed upstream of Lake McClure, the inflow to Lake McClure is the Merced unimpaired runoff. Table F.1.3-5b shows the monthly cumulative distributions for the baseline 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 30 percent of the years in June. Storage was limited for flood control in the other months. The maximum storage was 675 TAF from October–February. The median monthly storage levels were more than 400 TAF in all months and more than 600 TAF February–July. The minimum carryover storage (end-of-September) was 81 TAF (12 percent of capacity), the 10 percent cumulative carryover storage was 126 TAF (18 percent of capacity) and the 20 percent cumulative carryover storage was 186 TAF (27 percent of capacity). The 50 percent cumulative (or median) carryover storage was above 451 TAF (64 percent of capacity).

Table F.1.3-5b. Simulated Baseline Monthly Cumulative Distributions of Lake McClure Storage for 1922–2003

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
Lake McClure Storage (TAF)												
Minimum	56	39	56	46	31	24	23	39	67	94	97	81
10%	98	91	87	100	144	157	227	261	260	197	149	126
20%	155	163	193	208	276	273	329	401	412	319	235	186
30%	253	259	287	311	372	398	439	546	518	420	334	283
40%	350	348	389	440	484	506	584	650	617	516	407	365
50%	430	436	465	552	638	654	663	710	703	606	503	451
60%	573	588	611	635	674	680	721	831	854	755	667	616
70%	656	643	650	669	675	723	773	940	983	889	770	700
80%	666	662	665	675	675	735	818	970	1,024	910	770	700
90%	674	675	675	675	675	735	845	970	1,024	910	770	700
Maximum	675	675	675	675	675	735	845	970	1,024	910	770	700
Average	424	423	437	462	494	529	583	680	697	605	505	453

Figure F.1.3-7b shows the Lake McClure carryover storage for the baseline conditions compared to carryover storage for the simulated 20, 40, and 60 percent unimpaired flow. The baseline 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.

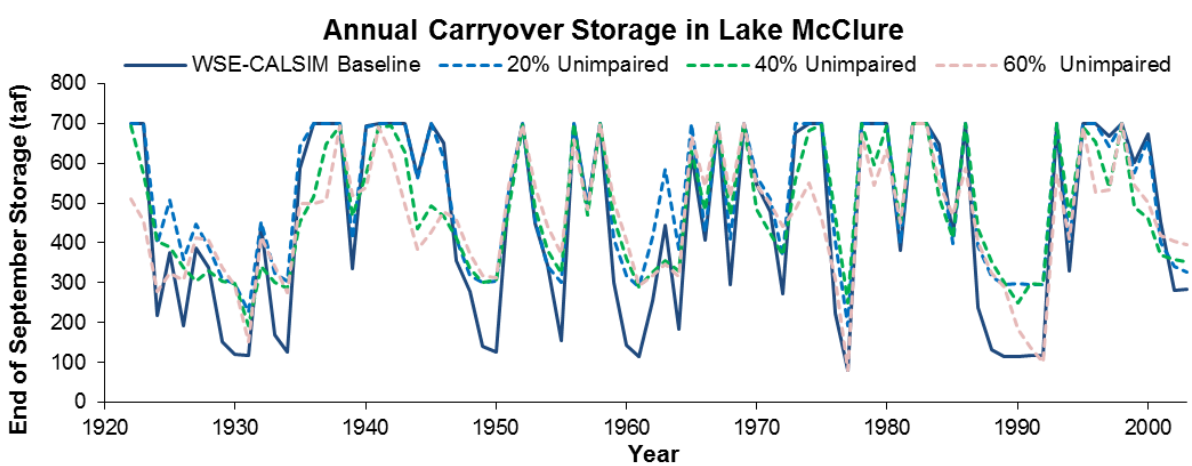


Figure F.1.3-7b. Lake McClure Carryover Storage (TAF) for Baseline Conditions and 20%, 40%, and 60% Unimpaired Flow (LSJR Alternatives 2–4) for 1922–2003

The Lake McClure storage values correspond to surface elevations that can be calculated with a simple stage-storage equation of the form:

Lake McClure Elevation = (Storage/Ks) ^ (1/b) (Eqn. F.1-11)

Where:

Elevation = feet above mean sea level (MSL)

Storage = reservoir storage in TAF

Ks = 1.665E-15 for storage ≥ 240 TAF and 3.068E-20 for storage < 240 TAF

b = 6.055 for storage ≥ 240 TAF and 7.709 for storage < 240 TAF

The equation coefficients Ks and b were based on the reservoir geometry (i.e., elevation, surface area, volume).

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 617 feet for a storage volume of 100 TAF (10 percent of maximum storage), 676 feet for a storage volume of 200 TAF (20 percent of maximum storage), and about 770 feet for a storage volume of 500 TAF (50 percent of maximum storage). The elevation is about 867 feet for a maximum storage of 1,024 TAF. Table F.1.3-5c shows the monthly cumulative distributions of Lake McClure water surface elevations (feet MSL) for the baseline.

Table F.1.3-5c. 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 mean sea level)												
Minimum	573	547	573	558	530	513	511	546	587	612	615	601
10%	616	610	606	617	647	654	686	692	692	674	650	636
20%	653	658	672	679	698	697	719	743	746	715	685	669
30%	688	691	703	712	733	742	754	782	775	748	720	701
40%	726	725	739	754	766	772	790	804	798	774	744	731
50%	751	753	761	783	802	805	807	816	815	795	771	757
60%	788	791	796	801	809	810	818	838	842	825	808	797
70%	806	803	804	808	809	819	828	855	861	847	827	814
80%	808	807	807	809	809	821	835	859	867	850	827	814
90%	809	809	809	809	809	821	840	859	867	850	827	814
Maximum	809	809	809	809	809	821	840	859	867	850	827	814
Average	735	734	739	747	756	765	778	799	802	782	759	745

Table F.1.3-5d shows the monthly cumulative distributions for the WSE-calculated Merced River target flows at Stevinson for baseline conditions. These target flows include all releases from Lake McClure to meet instream flow requirements, plus any inflows along the river below Lake McClure. Table F.1.3-5e shows the monthly and annual cumulative distributions for the baseline simulated Merced River flows at Stevinson. A need for flood control releases was indicated by values in the cumulative distributions of monthly flows that were higher than the values in the cumulative distribution of the targets flows (because target flows are specified at the downstream ends of the rivers in the absence of flood control releases). Under baseline conditions, flood control releases from Lake McClure were frequently necessary. Flood control releases were needed occasionally in all months but occurred primarily in late winter and spring. In February, for example, the average flow was more than 500 cfs greater than the average target flow. Based on month-by-month comparisons of the Merced River flows at Stevinson to the target flows, about 50 percent of the 82 years modeled required flood control releases under baseline conditions.

The median monthly flows were lowest (less than 250 cfs) June–September and were highest October–May. In some cases, average flows were much higher than median flows (e.g., average of 1,058 cfs in February). This phenomenon generally was caused by high flood control releases in a few years. The range of annual Merced River flows was 161 TAF (10 percent cumulative distribution) to 1,017 TAF (90 percent cumulative distribution), with a median flow of 261 TAF and an average flow of 454 TAF. Figure F.1.3-7c shows the annual sequence of February–June flows on the Merced River at Stevinson for baseline conditions and the LSJR alternatives.

The baseline Merced River annual diversions (water supply deliveries) ranged from 441 TAF (10 percent cumulative distribution) to 669 TAF (90 percent cumulative distribution), with a median annual diversion of 617 TAF and an average annual diversion of 580 TAF (Table F.1.3-4c). Figure F.1.3-7d shows the WSE simulated sequence of annual Merced River diversions for baseline conditions and the LSJR alternatives.

Table F.1.3-5d. Baseline Monthly Cumulative Distributions of Target Flows (cfs) for the Merced River at Stevinson for 1922–2003

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	Annual (TAF)
Merced at Stevinson Target Flow (cfs)													
Minimum	(0)	152	33	99	139	67	(0)	(0)	(0)	(0)	(0)	(0)	106
10%	300	255	263	260	283	275	121	55	57	47	19	36	157
20%	350	290	287	318	330	307	176	150	110	82	56	67	176
30%	372	312	309	332	340	343	271	184	126	101	84	87	196
40%	393	325	332	345	364	358	296	212	160	132	110	118	210
50%	414	336	338	360	388	378	353	277	211	147	122	131	227
60%	430	346	352	386	405	399	481	356	226	174	144	146	238
70%	450	353	363	424	452	480	563	474	251	223	171	167	250
80%	462	369	381	482	556	533	647	554	276	240	196	192	266
90%	502	396	409	560	730	658	757	706	387	276	220	222	299
Maximum	1,276	847	1,075	1,730	2,059	2,037	1,284	1,017	923	1,133	536	629	763
Average	415	338	344	416	465	441	428	341	214	175	128	135	231

Table F.1.3-5e. 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	219	152	33	144	207	204	(0)	(0)	(0)	(0)	(0)	(0)	130
10%	325	266	277	280	312	283	150	117	88	55	32	55	161
20%	356	296	304	327	337	328	220	196	121	92	76	90	181
30%	380	317	325	343	363	351	293	229	144	117	109	122	204
40%	399	330	336	360	393	363	354	312	181	139	124	140	232
50%	423	338	348	385	450	384	508	473	225	155	163	170	261
60%	440	348	358	431	671	475	592	548	250	226	205	193	326
70%	456	360	372	552	926	533	661	714	365	258	483	332	510
80%	470	374	395	837	1,661	969	756	929	1,251	993	964	420	699
90%	548	419	991	1,621	2,556	1,728	973	2,478	2,981	2,113	1,150	544	1,017
Maximum	1,276	1,910	3,495	9,859	5,151	5,959	4,845	5,379	7,273	5,863	2,392	1,275	2,398
Average	439	384	513	780	1,058	787	588	788	861	659	420	261	454

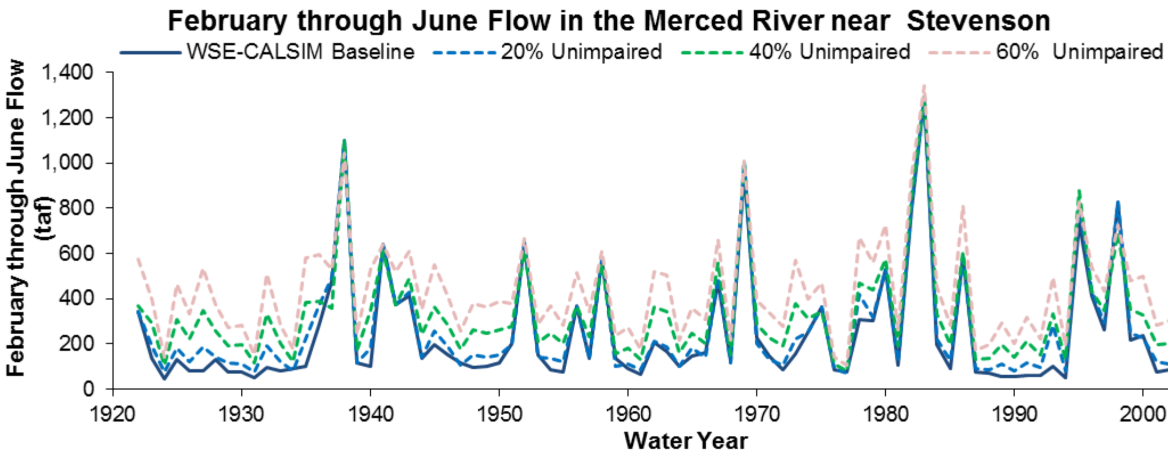


Figure F.1.3-7c. Merced River near Stevinson February–June Flow Volumes (TAF) Baseline Conditions and 20%, 40%, and 60% Unimpaired Flow (LSJR Alternatives 2–4) for 1922–2003

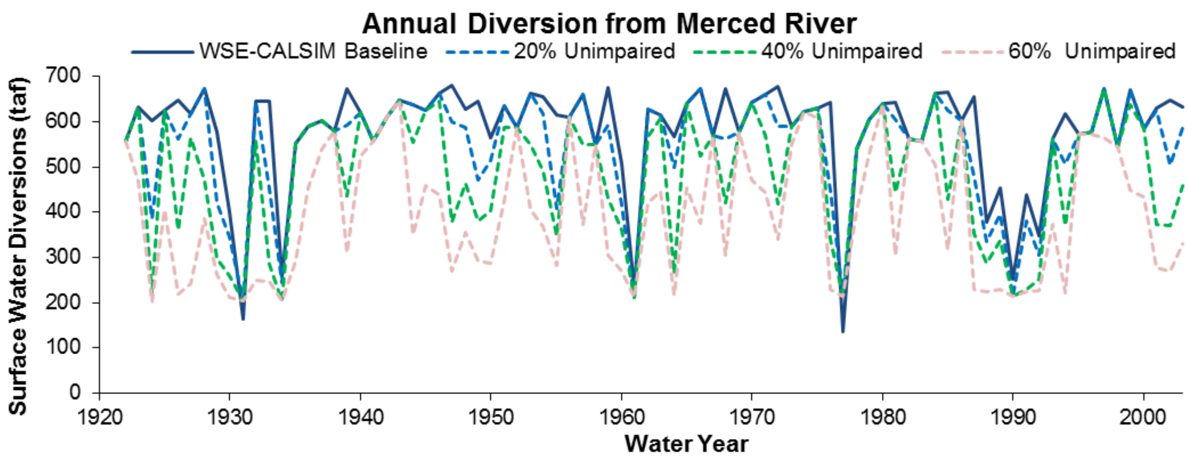


Figure F.1.3-7d. Merced River Annual Water Supply Diversions for Baseline Conditions and 20%, 40%, and 60% Unimpaired Flow (LSJR Alternatives 2–4) for 1922–2003

Tuolumne River

Figure F.1.3-8a 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. The water delivery target is compared to the distribution of unimpaired flow values, which are shown as 10th, 30th, 50th, 70th, and 90th percentiles. Because agricultural use requires a specified monthly pattern of water deliveries to satisfy crop needs (transpiration), storage is needed to extend the period when water can be diverted for irrigation. For the Tuolumne River, the average monthly demands were less than or equal to the 10 percent cumulative monthly runoff from November through May. The average June demand was between 10 and 30 percent cumulative runoff, while the demand for July was between 70 and 90 percent cumulative runoff. The average monthly demands for the remaining months, from August through October, were equal to or greater than the 90 percent cumulative monthly runoff. In other words, reservoir storage was needed to satisfy the July demand in about 70 to 90 percent of the years and the August–October demand in more than 90 percent of the years.

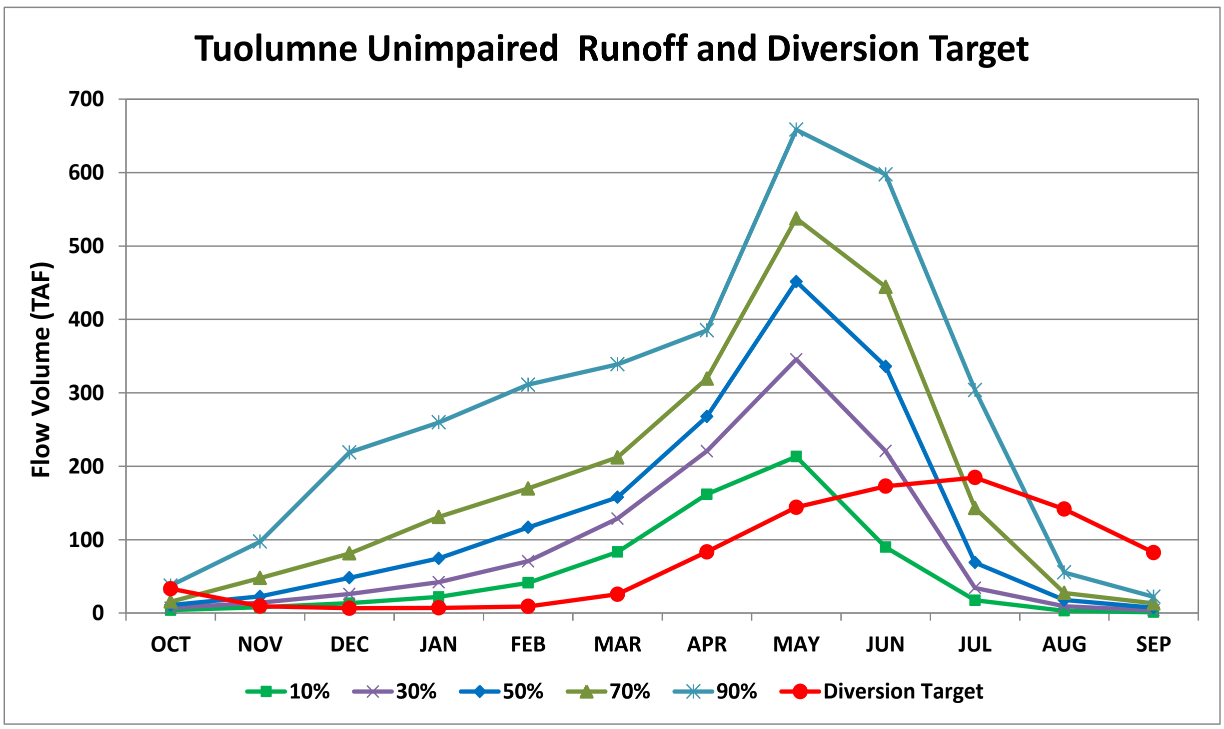


Figure F.1.3-8a. Monthly Tuolumne River Unimpaired Runoff Compared to Average Monthly Water Supply Demands

Under baseline conditions, the upstream operations of the CCSF seasonally shift and reduce the inflow to New Don Pedro Reservoir. Table F.1.3-5f gives the monthly and annual cumulative distributions 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.1.3-5g 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 CCSF diversions and reservoir filling (in 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 CCSF diversions were evenly distributed. The 10 percent annual diversion was 201 TAF, and the 90 percent annual diversion was 307 TAF.

Table F.1.3-5f. 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 Reservoir 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.1.3-5g. CALSIM-Simulated Baseline Monthly Cumulative Distributions of CCSF Upstream Diversions and Reservoir Operations (TAF) for 1922–2003

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	Annual
					CCSF 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.1.3-5h shows the monthly cumulative distributions for the baseline New Don Pedro Reservoir storage (TAF). The maximum storage was simulated in only about 10 percent of the years in June. Storage was limited for flood control in the other months. The maximum storage was 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 1,350 TAF August–December. The minimum carryover storage (September) was about 543 TAF (27 percent of capacity) and the 20 percent cumulative carryover storage values were above 1000 TAF (near 50 percent of capacity). Figure F.1.3-8b shows the New Don Pedro carryover storage for baseline conditions and the LSJR alternatives (simulated by the WSE model). The baseline 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.1.3-5h. Baseline Monthly Cumulative Distributions of New Don Pedro Reservoir Storage (TAF) for 1922–2003

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
	New Don Pedro Reservoir Storage (TAF)											
Minimum	520	514	644	705	787	870	892	854	759	651	575	543
10%	856	843	866	953	1,020	1,123	1,134	1,146	1,192	1,064	940	896
20%	1,002	1,018	1,053	1,067	1,139	1,257	1,292	1,338	1,350	1,210	1,104	1,031
30%	1,113	1,154	1,217	1,337	1,445	1,491	1,551	1,603	1,525	1,370	1,232	1,158
40%	1,216	1,269	1,338	1,445	1,590	1,638	1,627	1,656	1,621	1,443	1,309	1,239
50%	1,362	1,376	1,480	1,541	1,665	1,690	1,684	1,706	1,775	1,629	1,488	1,409
60%	1,527	1,522	1,553	1,630	1,690	1,690	1,694	1,737	1,873	1,787	1,650	1,578
70%	1,606	1,607	1,618	1,687	1,690	1,690	1,713	1,800	1,958	1,846	1,705	1,625
80%	1,635	1,626	1,665	1,690	1,690	1,690	1,713	1,857	2,019	1,910	1,767	1,687
90%	1,653	1,662	1,690	1,690	1,690	1,690	1,713	1,895	2,030	1,910	1,779	1,700
Maximum	1,662	1,690	1,690	1,690	1,690	1,690	1,718	2,002	2,030	1,910	1,790	1,700
Average	1,310	1,319	1,368	1,422	1,489	1,523	1,542	1,614	1,673	1,544	1,417	1,348

The New Don Pedro Reservoir storage values correspond to surface elevations that can be calculated with a simple equation of the form:

New Don Pedro Elevation = (Storage/Ks) ^ (1/b) (Eqn. F.1-12)

Where:

Elevation = feet above MSL

Storage = reservoir storage in TAF

Ks = 7.071E-12 for storage ≥ 700 TAF and 7.954E-19 for storage < 700 TAF

B = 4.950 for storage ≥ 700 TAF and 7.393 for storage < 700 TAF

The equation coefficients Ks and b were based on values from CALSIM, which were based on the reservoir geometry (i.e., elevation, surface area, volume).

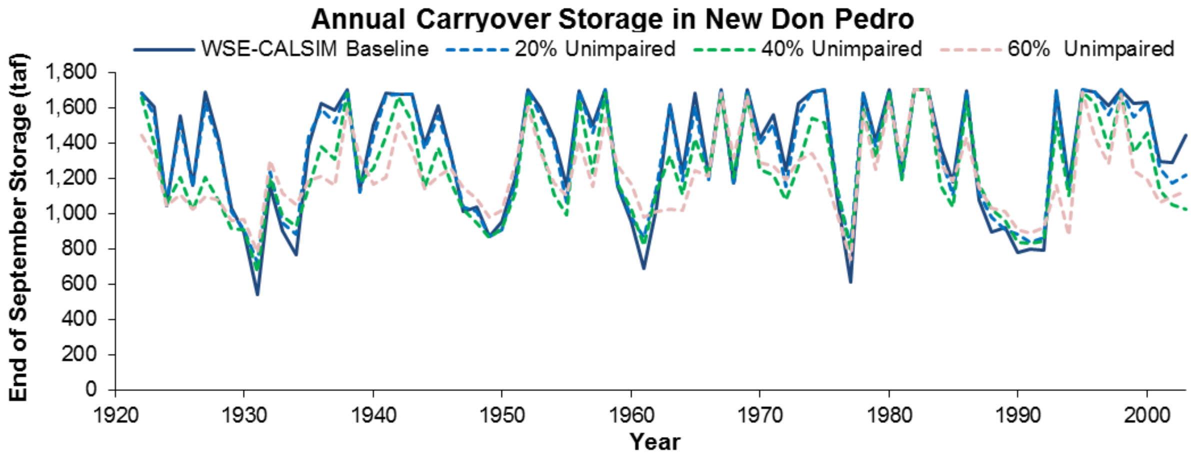


Figure F.1.3-8b. New Don Pedro Reservoir Carryover Storage (TAF) for Baseline Conditions and 20%, 40%, and 60% Unimpaired Flow (LSJR Alternatives 2–4) for 1922–2003

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 575 feet for a storage volume of 200 TAF (10 percent of maximum storage), 651 feet for a storage volume of 500 TAF (25 percent of maximum storage), and about 722 feet for a storage volume of 1,000 TAF (50 percent of maximum storage). The elevation is about 833 feet for a maximum storage of 2,030 TAF. Table F.1.3-5i shows the monthly cumulative distributions for the baseline New Don Pedro Reservoir water surface elevations (feet MSL).

Table F.1.3-5i. 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 Reservoir Elevation (feet mean sea level)												
Minimum	654	653	673	673	688	702	706	700	683	674	663	658
10%	700	698	702	715	725	739	741	742	748	731	713	706
20%	723	725	730	732	742	756	761	766	767	751	737	727
30%	738	743	752	766	778	783	789	795	787	770	753	744
40%	751	758	766	778	793	798	797	800	796	778	763	754
50%	769	770	782	788	801	803	802	805	811	797	783	774
60%	787	786	789	797	803	803	803	808	820	812	799	792
70%	795	795	796	803	803	803	805	813	827	817	804	797
80%	798	797	801	803	803	803	805	818	832	823	810	803
90%	799	800	803	803	803	803	805	822	833	823	811	804
Maximum	800	803	803	803	803	803	806	831	833	823	812	804
Average	759	760	766	772	780	785	786	793	798	785	771	763

Table F.1.3-5j shows the monthly cumulative distributions for the baseline Tuolumne River target flows at Modesto. Table F.1.3-5k shows the monthly and annual cumulative distributions for the baseline Tuolumne River Flows at Modesto. A need for flood control releases is indicated by values for the cumulative distributions of monthly flows that are higher than the values for the cumulative distributions of the target flows. Under baseline conditions, flood control releases from New Don Pedro Reservoir were required in many years, primarily during the late winter and spring. For example, in April, the average flow was more than 900 cfs greater than the average target flow. Based on month-by-month comparisons of the Tuolumne River flows at Modesto to the target flows, about 66 percent of the 82 years modeled required some flood control releases under baseline conditions.

The median monthly flows were between 422 and 647 cfs in all months, except for March through May, when median flows were well over 1,000 cfs. The range of annual Tuolumne River flows was 280 TAF (10 percent cumulative) to 1,799 TAF (90 percent cumulative), with a median annual flow of 572 TAF and an average annual flow of 895 TAF. Figure F.1.3-8c shows the annual sequence of February–June flows on the Tuolumne River for baseline conditions compared to values for the 20, 40, and 60 percent unimpaired flow simulations.

The baseline Tuolumne River annual diversions (water supply deliveries) ranged from 685 TAF (10 percent cumulative) to 960 TAF (90 percent cumulative) with a median annual diversion of 878 TAF and an average annual diversion of 851 TAF (Table F.1.3-4b). Figure F.1.3-8d shows the WSE-simulated sequence of annual Tuolumne River diversions for baseline conditions and the LSJR alternatives.

Table F.1.3-5j. Baseline Monthly Cumulative Distributions of Target Flows (cfs) for the Tuolumne River at Modesto for 1922–2003

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	Annual (TAF)
Tuolumne Target Flow at Modesto (cfs)													
Minimum	199	206	71	208	117	—	373	418	193	194	187	166	198
10%	290	246	251	316	276	328	546	540	270	262	277	256	280
20%	395	324	319	417	376	435	665	676	310	319	346	334	343
30%	447	382	399	434	466	476	800	798	368	364	365	366	383
40%	488	443	430	479	487	516	887	1,051	395	403	399	381	415
50%	550	454	445	524	514	573	1,203	1,133	455	448	426	421	431
60%	608	479	496	572	549	606	1,368	1,352	516	519	515	497	465
70%	689	525	581	602	610	652	1,449	1,422	592	568	581	544	518
80%	735	608	602	648	663	702	1,473	1,488	685	601	588	593	546
90%	757	756	655	757	795	782	1,531	1,590	766	681	638	611	594
Maximum	1,171	1,530	1,405	2,411	1,550	1,324	2,108	1,782	1,360	1,067	760	809	815
Average	556	502	479	560	547	573	1,106	1,106	504	471	458	447	441

Table F.1.3-5k. 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	199	206	217	208	152	248	373	418	193	194	187	166	198
10%	290	246	257	316	312	349	546	546	270	262	277	256	280
20%	395	324	327	427	458	458	737	699	323	319	346	334	351
30%	447	382	409	443	486	518	812	808	369	364	365	366	426
40%	488	449	434	518	519	647	1,111	1,088	410	403	399	381	482
50%	550	464	470	570	647	1,568	1,414	1,238	499	448	426	422	572
60%	632	498	523	610	992	2,220	1,633	1,427	606	559	515	522	870
70%	692	536	597	757	2,201	3,492	2,472	1,501	756	601	581	585	1,161
80%	737	608	675	1,483	3,597	4,058	3,462	1,771	2,407	915	588	599	1,425
90%	813	756	1,152	3,424	5,084	5,097	4,591	4,810	4,387	3,331	652	691	1,799
Maximum	3,090	5,440	7,479	17,925	7,440	16,297	9,332	9,474	8,159	8,190	2,996	2,296	4,129
Average	606	572	818	1,362	1,837	2,409	2,016	1,789	1,367	1,090	502	499	895

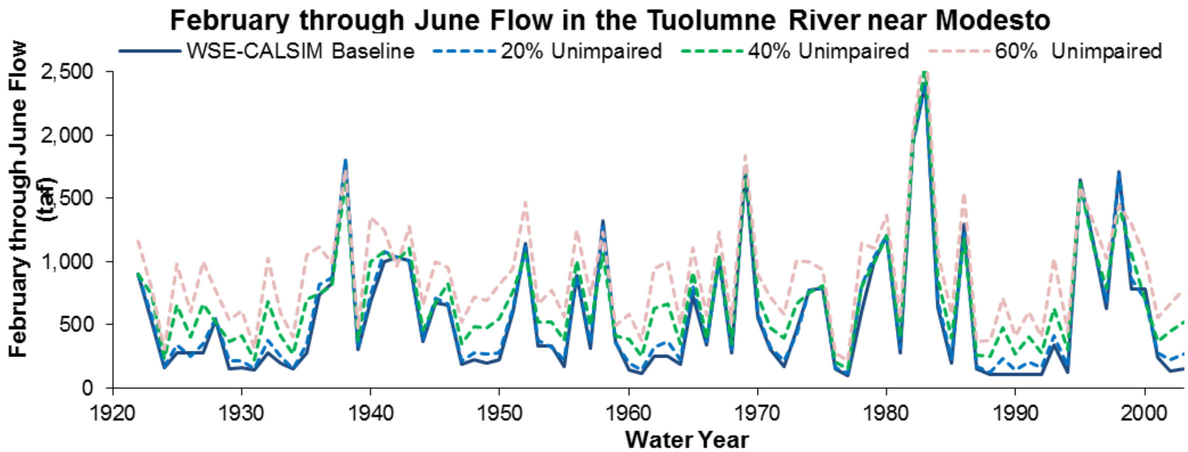


Figure F.1.3-8c. Tuolumne River February–June Flow Volumes (TAF) for Baseline Conditions and 20%, 40%, and 60% Unimpaired Flow (LSJR Alternatives 2–4) for 1922–2003

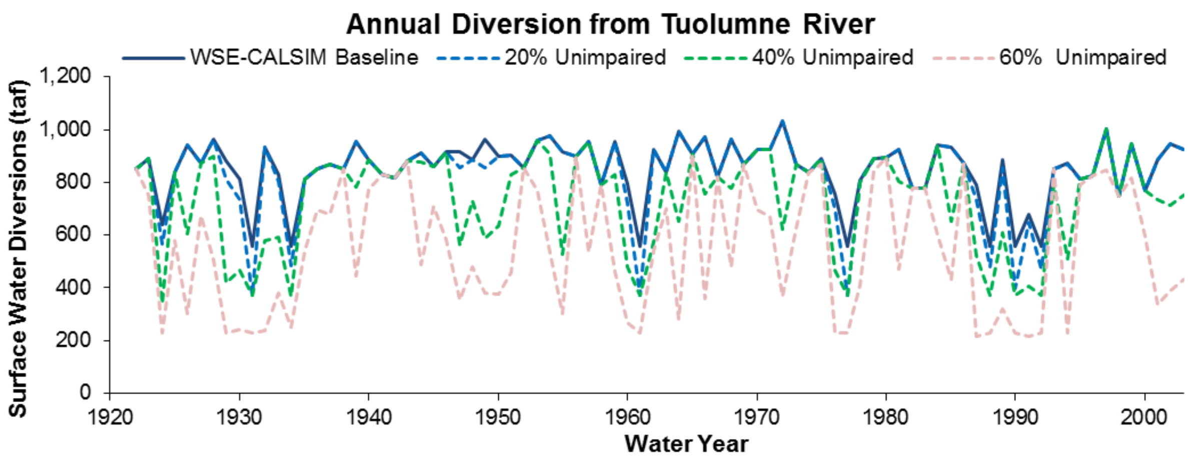


Figure F.1.3-8d. Tuolumne River Annual Water Supply Diversions for Baseline Conditions and 20%, 40%, and 60% Unimpaired Flow (LSJR Alternatives 2–4) for 1922–2003

Stanislaus River

Figure F.1.3-9a 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. Water delivery target was compared to the distribution of unimpaired flow values, which were shown as 10th, 30th, 50th, 70th, and 90th percentiles. 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 average monthly demands were less than or equal to the 10 percent cumulative monthly runoff from December through May. The average June demand was between 30 and 50 percent cumulative runoff, and the average monthly demands from July through October were greater than the 90 percent cumulative runoff. In other words, reservoir storage was needed to satisfy the June demand in about 30 to 50 percent of the years and was needed to satisfy the July–October demands in about 90 percent of the years.

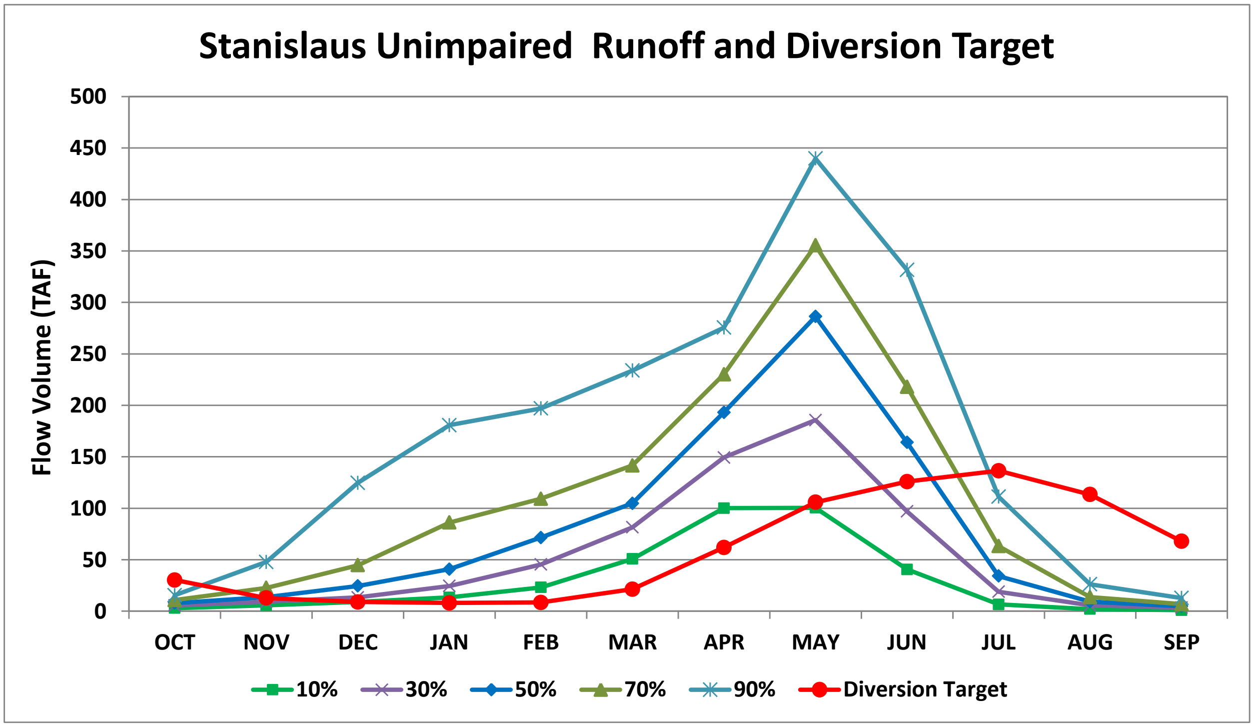


Figure F.1.3-9a. Monthly Stanislaus River Unimpaired Runoff Compared to Average Monthly Water Supply Demands

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.1.3-5l shows the monthly cumulative distributions for the baseline New Melones storage (TAF). The maximum storage of 2,420 TAF was simulated in just a few years in June. Storage was limited to less than 2,000 TAF October–February. The median monthly storage levels were all higher than 1,050 TAF (approximately 44 percent of capacity). The minimum carryover storage (end of September) was 100 TAF (4 percent of capacity), but the 10 percent cumulative carryover storage was 484 TAF (approximately 20 percent of capacity). The 50 percent cumulative carryover storage was 1,124 TAF (46 percent of capacity). Figure F.1.3-9b shows the New Melones carryover storage for baseline conditions and 20, 40, and 60 percent unimpaired flow. The baseline results reflect the historical periods of low runoff (reduced storage) and the periods of high runoff (with maximum carryover storage of 2,000 TAF).

Table F.1.3-5l. 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	97	99	101	130	102	111	216	175	144	122	105	100
10%	455	455	474	485	525	627	573	524	616	579	520	484
20%	611	612	651	676	737	831	850	854	807	727	662	630
30%	815	854	868	910	937	944	995	1,013	990	918	848	823
40%	961	984	1,004	1,081	1,130	1,186	1,175	1,227	1,193	1,101	1,030	989
50%	1,079	1,094	1,205	1,302	1,325	1,415	1,365	1,384	1,361	1,281	1,186	1,124
60%	1,287	1,284	1,314	1,429	1,524	1,607	1,586	1,580	1,555	1,470	1,372	1,329
70%	1,424	1,438	1,471	1,528	1,632	1,678	1,686	1,657	1,696	1,609	1,517	1,462
80%	1,553	1,568	1,611	1,650	1,736	1,809	1,745	1,844	1,814	1,720	1,623	1,580
90%	1,809	1,802	1,836	1,853	1,912	1,945	1,912	1,976	2,062	2,000	1,909	1,861
Maximum	1,970	1,970	1,970	1,970	1,970	2,030	2,151	2,250	2,420	2,300	2,130	2,000
Average	1,094	1,108	1,145	1,197	1,263	1,309	1,304	1,328	1,331	1,253	1,169	1,125

The New Melones storage values correspond to surface elevations that can be calculated with a simple equation of the form:

New Melones Elevation = (Storage/Ks) ^ (1/b) (Eqn. F.1-13)

Where:

Elevation = feet above MSL

Storage = reservoir storage in TAF

Ks = 6.237E-16 for storage ≥ 300 TAF and 3.393E-33 for storage < 300 TAF

B = 6.121 for storage ≥ 300 TAF and 12.026 for storage < 300 TAF

The equation coefficients Ks and b were based on values from CALSIM, which were based on the reservoir geometry (i.e., elevation, surface area, volume).

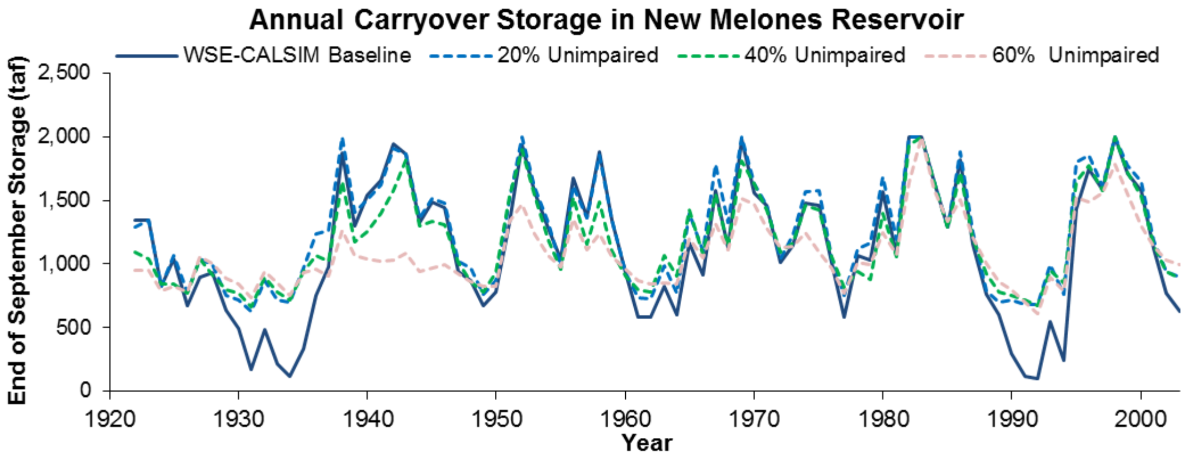


Figure F.1.3-9b. New Melones Reservoir Carryover Storage (TAF) for Baseline Conditions and 20%, 40%, and 60% Unimpaired Flow (LSJR Alternatives 2–4) for 1922–2003

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 was about 793 feet for a storage volume of 250 TAF (10 percent of maximum storage), 841 feet for a storage volume of 500 TAF (20 percent of maximum storage), and about 971 feet for a storage volume of 1,200 TAF (50 percent of maximum storage). The elevation is about 1,089 feet for a maximum storage of 2,420 TAF. Table F.1.3-5m shows the monthly cumulative distributions for the baseline New Melones Reservoir water surface elevations (feet).

Table F.1.3-5m. 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 mean sea level)												
Minimum	733	735	736	751	736	742	784	770	758	747	738	735
10%	828	828	834	837	848	873	860	848	870	862	847	837
20%	869	870	878	884	897	914	918	918	910	894	881	874
30%	911	918	921	928	932	934	941	944	941	929	917	913
40%	936	940	943	954	961	969	967	974	970	957	947	941
50%	954	956	971	984	987	997	991	994	991	981	969	961
60%	982	982	985	999	1,009	1,018	1,016	1,015	1,013	1,003	992	987
70%	998	1,000	1,004	1,010	1,021	1,025	1,026	1,023	1,027	1,018	1,009	1,003
80%	1,013	1,014	1,019	1,023	1,031	1,038	1,032	1,041	1,039	1,030	1,020	1,015
90%	1,038	1,037	1,041	1,042	1,048	1,051	1,048	1,053	1,061	1,055	1,047	1,043
Maximum	1,053	1,053	1,053	1,053	1,053	1,058	1,068	1,076	1,089	1,080	1,066	1,055
Average	941	943	949	957	965	971	971	974	974	963	952	946

Table F.1.3-5n shows the monthly and annual cumulative distributions for the baseline Stanislaus River target flows at Ripon, and Table F.1.3-5o shows the monthly and annual cumulative distributions for the baseline simulated Stanislaus River flows at Ripon. A need for flood control releases is indicated by values for the cumulative distributions of monthly flows that are higher than the values for the cumulative distributions of the target flows. Under baseline conditions, flood control releases from New Melones Reservoir were required less often than were needed on the Merced or Tuolumne Rivers. Flood control releases were needed more during January and February. Based on month-by-month comparisons of the Stanislaus River flows at Ripon to the target flows, about 12 percent of the 82 years modeled required some flood control releases under baseline conditions.

The median monthly flows were less than 500 cfs July–March, except for October, when required pulse flows increased the median flow to about 890 cfs. The high April and May flows were the result of the NMFS BO flow requirements that extend the VAMP flows to a 2-month pulse flow. The range of annual Stanislaus River flows was 271 TAF (10 percent cumulative) to 786 TAF (90 percent cumulative), with a median annual flow of 478 TAF and an average annual flow of 549 TAF. Figure F.1.3-9c shows the annual sequence of February–June flows on the Stanislaus River for baseline conditions and 20, 40, and 60 percent unimpaired flow.

The baseline Stanislaus River annual diversions (water supply deliveries) ranged from 538 TAF (10 percent cumulative) to 723 TAF (90 percent cumulative) with a median annual diversion of 661 TAF and an average annual diversion of 637 TAF (Table F.1.3-4a). Figure F.1.3-9d shows the WSE simulated sequence of annual Stanislaus River diversions for baseline conditions and the LSJR alternatives.

Table F.1.3-5n. Baseline Monthly Cumulative Distributions of Target Flows (cfs) for the Stanislaus River at Ripon for 1922–2003

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	Annual (TAF)
Stanislaus Target Flow at Ripon (cfs)													
Minimum	599	213	—	129	168	58	409	281	210	205	201	174	236
10%	729	248	223	261	230	308	573	525	292	293	302	311	271
20%	772	260	239	294	268	348	765	695	375	324	337	345	336
30%	806	267	262	309	326	372	918	828	444	358	365	369	380
40%	833	292	272	322	368	411	1,177	1,055	536	389	406	397	425
50%	889	319	287	335	384	486	1,556	1,422	629	437	416	419	478
60%	959	337	303	346	401	716	1,674	1,559	1,115	484	455	463	517
70%	979	348	311	366	464	1,265	1,754	1,707	1,276	523	478	490	584
80%	1,041	382	338	407	590	1,672	1,848	1,898	1,427	591	526	520	679
90%	1,110	449	403	506	741	1,842	1,997	2,107	1,625	688	624	666	706
Maximum	1,409	732	674	884	1,465	2,234	2,155	2,603	1,964	1,021	732	887	770
Average	905	328	299	361	453	869	1,347	1,328	872	466	435	448	490

Table F.1.3-5o. 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	599	213	—	198	168	58	409	281	210	205	201	174	236
10%	729	248	224	270	230	308	573	525	292	293	302	311	271
20%	772	260	241	295	268	348	765	695	375	324	337	345	336
30%	806	267	262	312	326	372	918	828	444	358	365	369	380
40%	833	292	280	324	368	411	1,177	1,055	536	389	406	397	425
50%	889	319	288	337	385	486	1,556	1,422	629	437	416	419	478
60%	959	337	304	349	415	716	1,674	1,559	1,115	484	463	463	517
70%	979	348	316	375	507	1,265	1,754	1,707	1,281	531	483	490	584
80%	1,042	382	348	449	654	1,717	1,848	1,898	1,456	616	529	528	681
90%	1,116	454	421	576	1,285	1,911	1,997	2,107	1,655	705	632	667	786
Maximum	1,810	3,453	5,126	10,555	5,177	6,223	2,155	2,603	4,653	4,340	2,664	3,050	2,520
Average	919	394	398	644	655	960	1,347	1,328	913	522	483	521	549

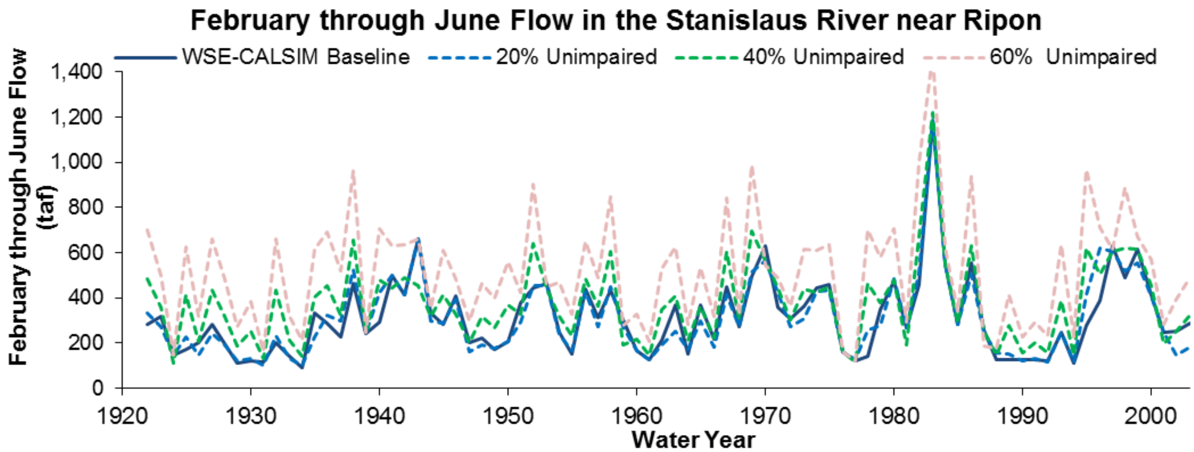


Figure F.1.3-9c. Stanislaus River February–June Flow Volumes (TAF) for Baseline Conditions and 20%, 40%, and 60% Unimpaired Flow (LSJR Alternatives 2–4) for 1922–2003

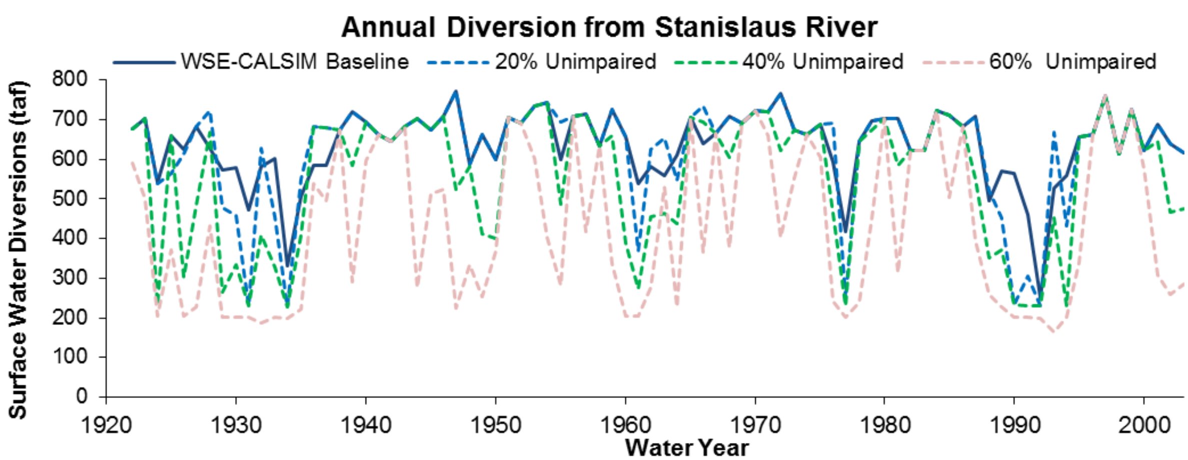


Figure F.1.3-9d. Stanislaus River Annual Water Supply Diversions for Baseline Conditions and 20%, 40%, and 60% Unimpaired Flow (LSJR Alternatives 2–4) for 1922–2003

SJR at Vernalis

Table F.1.3-5p shows the monthly and annual cumulative distributions for the baseline SJR flows at Vernalis, downstream of the Stanislaus River. The median monthly baseline flows were between 1,500 and 2,600 cfs from June to January and 3,400 and 4,700 cfs from February to May. The higher median flows in April and May were caused by the Vernalis pulse flows. High flows, greater than 10,000 cfs from January to June (i.e., reservoir flood control releases), were simulated in only about 10 percent of the years. The range of annual SJR flows was 1,077 TAF (10 percent cumulative) to 5,542 TAF (90 percent cumulative), with a median annual flow of 2,041 TAF and an average annual flow of 2,965 TAF. Figure F.1.3-10 shows the annual sequence of February to June flows on the SJR at Vernalis for baseline conditions and 20, 40, and 60 percent unimpaired flows.

Table F.1.3-5p. 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	1,343	1,233	1,238	1,146	1,526	1,124	1,171	1,096	710	525	579	955	875
10%	2,000	1,566	1,513	1,481	1,856	1,614	1,616	1,543	1,009	959	1,055	1,488	1,077
20%	2,132	1,696	1,657	1,699	2,029	2,280	2,347	2,310	1,420	1,134	1,249	1,685	1,386
30%	2,319	1,807	1,789	1,905	2,280	2,370	3,325	3,081	1,540	1,251	1,379	1,796	1,585
40%	2,385	1,918	1,884	2,121	2,707	3,405	3,925	3,443	1,843	1,418	1,437	1,894	1,778
50%	2,598	1,981	1,941	2,200	3,489	3,502	4,640	4,600	2,280	1,620	1,544	2,024	2,041
60%	2,727	2,132	2,044	2,479	4,456	5,570	5,239	5,210	3,097	1,831	1,703	2,165	2,690
70%	2,854	2,239	2,261	3,289	6,207	7,733	6,225	5,211	3,420	2,051	2,142	2,411	3,266
80%	2,971	2,512	2,679	4,785	9,314	8,562	7,901	7,075	6,229	3,284	2,665	2,610	4,197
90%	3,331	2,724	4,264	10,926	15,228	13,821	12,538	13,327	11,586	6,902	2,983	2,940	5,542
Maximum	6,753	16,297	24,021	62,587	34,271	48,485	26,465	25,624	27,086	23,865	9,143	7,677	15,907
Average	2,663	2,352	3,060	4,719	6,210	6,640	5,985	5,978	4,408	3,065	1,935	2,247	2,965

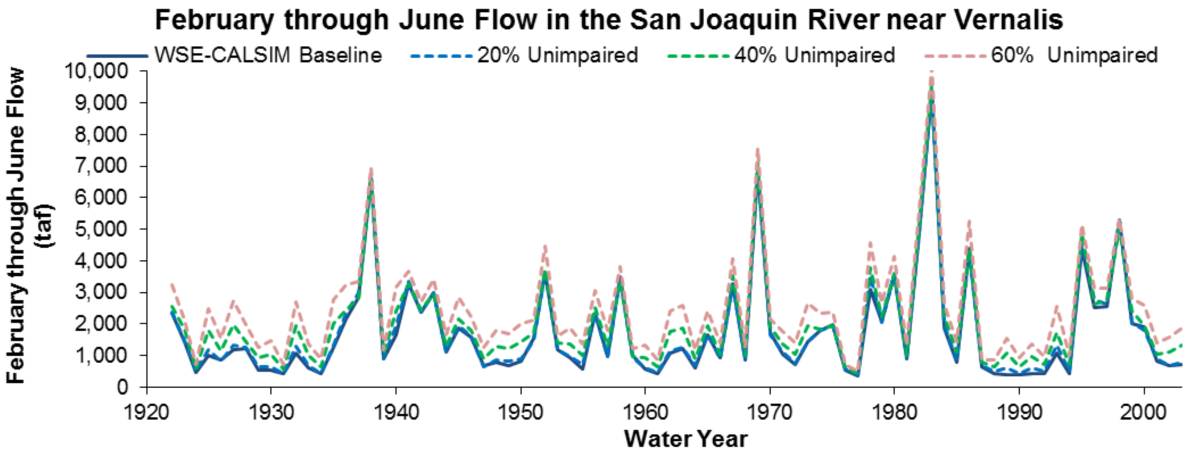


Figure F.1.3-10. SJR at Vernalis February–June Flow Volumes for Baseline Conditions and 20%, 40%, and 60% Unimpaired Flow (LSJR Alternatives 2–4) for 1922–2003

F.1.3.3 20 Percent Unimpaired Flow (LSJR Alternative 2)

The WSE model was used to simulate 20 percent unimpaired flow, which represents typical conditions for LSJR Alternative 2. For this simulation, LSJR tributary flows were greater than or equal to 20 percent of the unimpaired flow for February–June. In some years February–June flows were higher than the 20 percent unimpaired flow objective because of flood control releases or other flow requirements. The reservoir storage and water supply diversions were adjusted to satisfy these monthly flow objectives for each of the eastside tributaries. Flood control releases were reduced or eliminated in some years because more water was released to satisfy the flow objectives. Water supply diversions were reduced in some years to account for the 20 percent unimpaired flow requirement and maintain storage in the reservoirs.

Merced River

Table F.1.3-6a shows the monthly cumulative distributions for the WSE-calculated Lake McClure storage (TAF) for LSJR Alternative 2. These monthly storage patterns differ from baseline storage patterns because the timing and magnitude of releases for instream flow requirements and diversions are different. The median carryover storage was 499 TAF, slightly higher than the baseline median carryover storage of 451 TAF. Table F.1.3-6b shows the monthly cumulative distributions for the WSE-calculated Lake McClure water surface elevations (feet MSL) for LSJR Alternative 2. The median September reservoir elevation was 770 TAF, slightly higher than the baseline median September elevation of 757 TAF.

Table F.1.3-6a. WSE Results for Lake McClure Storage (TAF) for 20% Unimpaired Flow (LSJR Alternative 2)

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
Lake McClure Storage (TAF)												
Min	165	148	165	229	214	193	204	211	225	245	216	194
10%	274	264	261	265	302	319	351	413	416	367	326	302
20%	293	289	319	329	375	382	415	486	493	439	371	325
30%	366	361	367	392	445	488	558	599	577	494	429	395
40%	385	390	425	478	553	619	647	699	657	547	451	411
50%	471	465	519	587	637	659	686	729	737	652	554	499
60%	593	596	616	636	674	687	742	851	858	766	670	618
70%	657	644	650	669	675	723	774	922	963	883	770	700
80%	668	662	668	675	675	735	818	966	1,024	910	770	700
90%	675	675	675	675	675	735	845	970	1,024	910	770	700
Max	675	675	675	675	675	735	845	970	1,024	910	770	700
Avg	482	480	493	515	546	581	639	727	741	655	561	511

Table F.1.3-6b. WSE Results for Lake McClure Water Surface Elevations (feet MSL) for 20% Unimpaired Flow (20% Unimpaired Flow)

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
Lake McClure Elevation (feet mean sea level)												
Minimum	659	650	659	685	682	672	677	680	686	685	682	673
10%	698	693	692	694	709	715	727	746	747	732	718	709
20%	705	704	715	719	735	737	747	767	769	754	733	717
30%	732	730	732	740	756	767	784	794	789	769	751	741
40%	738	739	750	765	783	798	804	814	806	782	757	746
50%	763	761	775	791	802	806	812	820	821	805	784	770
60%	792	793	797	802	809	812	822	841	842	826	809	798
70%	806	803	804	808	809	819	828	852	858	846	827	814
80%	808	807	808	809	809	821	836	859	867	850	827	814
90%	809	809	809	809	809	821	840	859	867	850	827	814
Maximum	809	809	809	809	809	821	840	859	867	850	827	814
Average	759	759	762	768	776	784	796	813	815	799	779	767

Table F.1.3-6c shows the monthly cumulative distributions for the WSE-calculated Merced River target flows at Stevinson for 20 percent unimpaired flow. Target flows are the flows specified for the downstream ends of the river in the absence of flood control releases. Comparison to the baseline indicates that the average monthly target flows for LSJR Alternative 2 increased from February–June and remained unchanged from July–January. The greatest increase came in May when the average target flow increased from 341 cfs under baseline to 785 cfs under the alternative.

Table F.1.3-6c. Merced River Target Flows (cfs) for 20% Unimpaired Flow (LSJR Alternative 2)

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
Merced Target Flow (cfs)												
Minimum	(0)	152	33	99	207	205	186	182	44	(0)	(0)	(0)
10%	300	255	263	260	306	297	283	330	171	47	19	36
20%	350	290	287	318	336	335	317	435	229	82	56	67
30%	372	312	309	332	353	355	378	566	276	101	84	87
40%	393	325	332	345	385	372	432	658	383	132	110	118
50%	414	336	338	360	397	398	477	792	491	147	122	131
60%	430	346	352	386	449	475	533	876	562	174	144	146
70%	450	353	363	424	545	504	576	946	691	223	171	167
80%	462	369	381	482	660	575	647	1,045	881	240	196	192
90%	502	396	409	560	828	672	735	1,261	1,127	276	220	222
Maximum	1,276	847	1,075	1,730	2,059	2,037	1,442	1,838	2,205	1,133	536	629
Average	415	338	344	416	513	478	510	785	583	175	128	135

Table F.1.3-6d shows the monthly cumulative distributions for the WSE-calculated Merced River flows at Stevinson for LSJR Alternative 2. The Merced River flows were changed mostly in the February–June period. The monthly flows were higher than the target flows for the higher cumulative distribution values, indicating that flood control releases were required for LSJR Alternative 2 in many years, particularly during February. Based on month-by-month comparisons of the Merced River flows at Stevinson to the target flows, about 51 percent of the 82 years modeled required some flood control releases.

Table F.1.3-6d. Merced River Flows at Stevinson (cfs) for 20% Unimpaired Flow (LSJR Alternative 2)

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	Annual (TAF)
Merced at Stevinson Flow (cfs)													
Minimum	219	208	83	144	207	205	186	182	44	(0)	(0)	(0)	165
10%	325	271	281	280	312	297	283	330	171	55	30	53	187
20%	356	300	306	327	337	335	317	435	229	90	72	89	216
30%	380	318	325	342	372	355	378	566	276	113	104	120	241
40%	399	332	337	358	396	372	432	658	383	138	122	137	261
50%	423	340	349	378	470	399	477	792	491	153	155	166	293
60%	440	350	359	422	662	485	536	890	562	202	199	196	366
70%	457	361	374	528	843	550	578	946	698	232	401	332	536
80%	473	376	409	1,012	1,653	969	665	1,175	1,596	993	971	420	765
90%	563	437	1,037	1,725	2,874	1,728	914	2,445	2,658	2,113	1,159	545	1,016
Maximum	1,276	1,910	3,495	9,859	5,092	5,959	4,845	5,379	7,273	5,863	2,392	1,275	2,398
Average	440	395	540	835	1,074	813	603	1,020	1,011	644	414	260	485

Tuolumne River

Table F.1.3-6e shows the monthly cumulative distributions for the WSE-calculated New Don Pedro Reservoir storage (TAF) for LSJR Alternative 2. These monthly storage patterns differ from baseline storage patterns because the timing and magnitude of releases for instream flow requirements and diversions are different. The median carryover storage under the alternative was 1,381 TAF, slightly less than the baseline median carryover storage of 1,409 TAF. Table F.1.3-6f shows the monthly cumulative distributions for the WSE-calculated New Don Pedro Reservoir water surface elevations (feet MSL) for LSJR Alternative 2. The median September reservoir elevation was 771 TAF, about the same as the baseline median September elevation of 774 TAF.

Table F.1.3-6e. WSE Results for New Don Pedro Storage (TAF) for 20% Unimpaired Flow (LSJR Alternative 2)

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
New Don Pedro Reservoir Storage (TAF)												
Minimum	705	700	818	860	897	975	961	924	861	787	738	721
10%	885	887	924	1,015	1,080	1,161	1,187	1,220	1,183	1,052	936	910
20%	1,023	1,048	1,120	1,141	1,262	1,329	1,368	1,339	1,360	1,219	1,101	1,044
30%	1,112	1,123	1,183	1,303	1,408	1,466	1,539	1,574	1,495	1,326	1,201	1,145
40%	1,171	1,203	1,324	1,416	1,549	1,638	1,632	1,640	1,573	1,405	1,270	1,194
50%	1,341	1,347	1,444	1,506	1,636	1,690	1,680	1,712	1,761	1,600	1,459	1,381
60%	1,467	1,464	1,516	1,613	1,690	1,690	1,690	1,737	1,832	1,737	1,595	1,514
70%	1,550	1,605	1,615	1,669	1,690	1,690	1,713	1,768	1,899	1,815	1,675	1,599
80%	1,631	1,624	1,648	1,690	1,690	1,690	1,713	1,834	1,987	1,910	1,767	1,684
90%	1,649	1,643	1,690	1,690	1,690	1,690	1,713	1,895	2,030	1,910	1,779	1,700
Maximum	1,662	1,690	1,690	1,690	1,690	1,690	1,718	2,002	2,030	1,910	1,790	1,700
Average	1,307	1,317	1,370	1,428	1,497	1,534	1,553	1,613	1,657	1,533	1,409	1,342

Table F.1.3-6f. WSE Results for New Don Pedro Water Surface Elevations (feet MSL) for 20% Unimpaired Flow (LSJR Alternative 2)

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
New Don Pedro Reservoir Elevation (feet mean sea level)												
Minimum	673	672	694	701	707	719	716	711	701	688	679	676
10%	705	705	711	724	734	744	748	752	747	730	713	709
20%	726	729	739	742	757	765	770	766	769	752	736	729
30%	738	739	747	762	774	780	788	792	783	765	749	742
40%	746	750	764	775	789	798	797	798	792	774	758	749
50%	766	767	778	785	798	803	802	805	810	794	780	771
60%	780	780	786	796	803	803	803	807	816	807	794	785
70%	789	795	796	801	803	803	805	810	822	815	802	794
80%	797	797	799	803	803	803	805	816	830	823	810	802
90%	799	798	803	803	803	803	805	822	833	823	811	804
Maximum	800	803	803	803	803	803	806	831	833	823	812	804
Average	759	760	767	774	782	786	788	794	797	784	771	763

Table F.1.3-6g shows the monthly cumulative distributions for the WSE-calculated Tuolumne River target flows at Modesto for LSJR Alternative 2. Target flows are the flows specified for the downstream ends of the river in the absence of flood control releases. Comparison to the baseline indicates that the average monthly target flows for LSJR Alternative 2 increased from February–June and remain unchanged from July–January. The greatest increase came in June when the average target flow increased from 504 cfs under baseline to 1,203 cfs under the alternative.

Table F.1.3-6g. Tuolumne River Target Flows (cfs) for 20% Unimpaired Flow (LSJR Alternative 2)

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
Tuolumne Target Flow (cfs)												
Minimum	199	206	71	208	235	338	411	418	283	194	187	166
10%	290	246	251	316	348	434	633	695	374	262	277	256
20%	395	324	319	417	466	486	783	977	457	319	346	334
30%	447	382	399	434	487	538	852	1,124	742	364	365	366
40%	488	443	430	479	524	595	1,042	1,232	969	403	399	381
50%	550	454	445	524	580	628	1,207	1,469	1,129	448	426	421
60%	608	479	496	572	617	686	1,353	1,666	1,343	519	515	497
70%	689	525	581	602	795	738	1,417	1,752	1,495	568	581	544
80%	735	608	602	648	934	853	1,469	1,870	1,785	601	588	593
90%	757	756	655	757	1,158	1,115	1,525	2,142	2,009	681	638	611
Maximum	1,171	1,530	1,405	2,411	2,218	1,883	2,218	3,123	3,415	1,067	760	809
Average	556	502	479	560	680	711	1,158	1,460	1,203	471	458	447

Table F.1.3-6h shows the monthly cumulative distributions 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 distributions of monthly flows were often higher than the cumulative distributions of the target flows, indicating that flood control releases were required in many years, particularly in February through April. Based on month-by-month comparisons of the Tuolumne River flows at Modesto to the target flows, about 63 percent of the 82 years modeled required some flood control releases.

Table F.1.3-6h. Tuolumne River Flows at Modesto (cfs) for 20% Unimpaired Flow (LSJR Alternative 2)

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	Annual (TAF)
						Tuolumne at Modesto Flow(cfs)							
Minimum	199	206	217	208	235	338	411	418	283	194	187	166	222
10%	290	246	257	316	348	434	633	695	374	262	277	256	334
20%	395	324	327	427	466	488	795	977	457	319	346	334	396
30%	447	382	409	443	501	569	956	1,124	742	364	365	366	460
40%	488	447	434	518	609	815	1,075	1,232	969	403	399	381	525
50%	550	458	470	552	800	1,451	1,328	1,469	1,149	448	426	422	583
60%	632	489	523	599	1,044	1,945	1,633	1,700	1,379	559	515	522	940
70%	692	536	597	691	2,185	3,492	2,374	1,824	1,555	597	581	585	1,166
80%	737	608	624	1,483	3,377	4,058	3,462	2,117	2,174	864	588	599	1,403
90%	813	756	926	3,424	4,583	5,026	4,591	5,036	4,387	3,331	652	691	1,766
Maximum	3,090	5,440	7,479	17,925	7,280	16,297	9,332	9,474	7,396	8,190	2,996	2,296	4,129
Average	606	571	749	1,308	1,808	2,378	2,042	2,035	1,682	1,067	502	499	918

Stanislaus River

Table F.1.3-6i shows the monthly cumulative distributions for the WSE model calculated New Melones Reservoir storage (TAF) for LSJR Alternative 2. These monthly storage patterns differ from baseline storage patterns because the timing and magnitude of releases for instream flow requirements and diversions are different. The median carryover storage under the alternative was about 1,244 TAF, compared to the baseline median carryover storage of 1,124 TAF. Table F.1.3-6j shows the monthly cumulative distributions for the WSE model calculated New Melones Reservoir water surface elevations (feet MSL) for LSJR Alternative 2. The median September reservoir elevation was 977 TAF, slightly higher than the baseline median September elevation of 961 TAF.

Table F.1.3-6i. WSE Results for New Melones Storage (TAF) for 20% Unimpaired Flow (LSJR Alternative 2)

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
New Melones Reservoir												
Minimum	606	618	674	703	710	742	717	671	659	647	630	630
10%	710	710	732	759	806	866	865	856	843	794	756	727
20%	757	776	827	870	960	1,008	985	990	991	904	832	798
30%	947	960	1,002	1,032	1,063	1,105	1,120	1,168	1,174	1,096	1,015	974
40%	1,021	1,059	1,126	1,189	1,292	1,317	1,335	1,350	1,272	1,186	1,097	1,054
50%	1,199	1,221	1,294	1,364	1,439	1,485	1,437	1,515	1,485	1,378	1,289	1,244
60%	1,297	1,309	1,349	1,463	1,567	1,640	1,653	1,630	1,595	1,499	1,406	1,352
70%	1,478	1,502	1,557	1,597	1,720	1,749	1,727	1,723	1,777	1,663	1,564	1,513
80%	1,617	1,642	1,677	1,721	1,801	1,871	1,819	1,823	1,864	1,776	1,681	1,643
90%	1,836	1,850	1,867	1,897	1,967	1,992	1,948	2,054	2,106	2,010	1,917	1,865
Maximum	1,970	1,970	1,970	1,970	1,970	2,030	2,219	2,317	2,420	2,300	2,130	2,000
Average	1,226	1,239	1,275	1,327	1,390	1,437	1,437	1,463	1,469	1,391	1,307	1,261

Table F.1.3-6j. WSE Results for New Melones Water Surface Elevations (feet MSL) for 20% Unimpaired Flow (LSJR Alternative 2)

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
New Melones Elevation (feet mean sea level)												
Minimum	868	871	883	890	891	897	892	883	880	877	874	874
10%	891	891	895	901	910	920	920	919	916	908	900	894
20%	900	904	914	921	936	944	940	941	941	927	914	908
30%	934	936	943	947	952	958	960	966	967	957	945	938
40%	946	951	961	969	983	986	988	990	980	969	957	950
50%	971	974	983	991	1,000	1,005	1,000	1,008	1,005	993	982	977
60%	983	985	989	1,003	1,014	1,022	1,023	1,021	1,017	1,007	996	990
70%	1,004	1,007	1,013	1,017	1,030	1,032	1,030	1,030	1,035	1,024	1,014	1,008
80%	1,019	1,022	1,025	1,030	1,037	1,044	1,039	1,039	1,043	1,035	1,026	1,022
90%	1,041	1,042	1,043	1,046	1,052	1,055	1,051	1,060	1,064	1,056	1,048	1,043
Maximum	1,053	1,053	1,053	1,053	1,053	1,058	1,073	1,081	1,089	1,080	1,066	1,055
Average	967	968	973	980	988	994	994	996	996	987	977	971

Table F.1.3-6k shows the monthly cumulative distributions for the WSE-calculated Stanislaus River target flows at Ripon for LSJR Alternative 2. Target flows are the flows specified for the downstream ends of the river in the absence of flood control releases. The average monthly target flows under LSJR Alternative 2 were similar to the flows under baseline conditions, with slight differences because of changes in the NMI under the alternative. From March to June, the average monthly target flows were generally lower than the baseline targets. These target flows were reduced as a result of removing the Vernalis D1641 minimum flow requirements and the VAMP requirements.

Table F.1.3-6k. Stanislaus River Target Flows (cfs) for 20% Unimpaired Flow (LSJR Alternative 2)

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
					Stanislaus Target Flow (cfs)							
Minimum	599	213	94	129	216	238	393	299	188	205	208	174
10%	760	248	223	261	239	313	600	553	316	297	312	312
20%	774	260	241	294	308	340	798	726	363	325	352	358
30%	827	267	262	312	355	370	908	942	500	364	381	387
40%	850	292	273	325	373	384	1,122	1,263	587	395	413	419
50%	902	318	288	339	389	415	1,495	1,373	778	437	424	429
60%	970	336	304	349	422	497	1,650	1,478	836	500	463	469
70%	979	348	316	366	482	1,604	1,744	1,670	1,135	538	478	497
80%	1,041	382	347	407	600	1,719	1,775	1,743	1,281	618	538	537
90%	1,109	453	403	506	823	1,897	1,858	2,036	1,544	688	625	666
Maximum	1,409	732	674	884	1,916	2,234	2,088	2,425	2,124	1,021	732	887
Average	913	330	303	361	479	860	1,314	1,318	848	475	443	456

Table F.1.3-6l shows the monthly cumulative distributions for the Stanislaus River flows at Ripon for LSJR Alternative 2. The Stanislaus River flows were generally changed only in the February–June period. The cumulative distributions of the monthly flows were occasionally higher than the target flows, indicating that flood control releases were sometimes required. Based on month-by-month comparisons of the Stanislaus River flows at Ripon to the target flows, about 18 percent of the 82 years modeled required some flood control releases (less often than was needed on the Merced or Tuolumne Rivers).

Table F.1.3-6l. Stanislaus River Flows at Ripon (cfs) for 20% Unimpaired Flow (LSJR Alternative 2)

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	Annual (TAF)
							Stanislaus at Ripon Flow (cfs)						
Minimum	599	213	94	198	216	238	393	299	188	205	208	174	241
10%	760	248	225	270	239	313	600	553	316	297	312	312	284
20%	774	260	242	295	308	340	798	726	363	325	352	358	339
30%	827	267	262	317	355	370	908	942	500	364	381	387	369
40%	850	292	280	327	376	384	1,122	1,263	587	395	413	419	422
50%	902	318	291	343	389	415	1,495	1,373	778	437	424	429	474
60%	970	336	305	352	437	497	1,650	1,478	836	510	463	469	505
70%	979	348	320	375	546	1,639	1,744	1,670	1,135	540	483	501	624
80%	1,042	382	368	446	657	1,776	1,775	1,743	1,281	627	541	564	694
90%	1,128	456	423	606	1,315	1,911	1,858	2,036	1,544	726	632	689	929
Maximum	1,810	3,453	5,126	10,555	5,177	6,223	2,088	2,425	4,653	4,340	2,664	3,050	2,520
Average	928	395	426	645	696	949	1,314	1,318	878	537	521	564	554

SJR at Vernalis

Table F.1.3-6m shows the monthly cumulative distributions for the WSE-calculated SJR at Vernalis flows for LSJR Alternative 2. The SJR at Vernalis flows changed most during May and June. LSJR Alternative 2 provided a more natural distribution of flows from February–June. The average annual flow was about 59 TAF more (2 percent) than the average baseline flow.

Table F.1.3-6m. SJR Flows at Vernalis (cfs) for 20% Unimpaired Flow (LSJR Alternative 2)

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	Annual (TAF)
						SJR at Vernalis Flow (cfs)							
Minimum	1,343	1,233	1,238	1,146	1,526	1,124	1,349	1,267	1,000	525	579	955	915
10%	2,000	1,566	1,513	1,481	1,775	1,617	1,867	2,202	1,114	959	1,055	1,488	1,136
20%	2,147	1,696	1,657	1,699	1,937	1,810	2,499	2,930	1,540	1,139	1,249	1,685	1,451
30%	2,335	1,807	1,789	1,886	2,223	2,467	3,125	3,361	1,894	1,251	1,379	1,796	1,594
40%	2,395	1,918	1,884	2,121	2,445	2,979	3,603	4,203	2,583	1,447	1,449	1,913	1,825
50%	2,611	1,981	1,941	2,225	3,623	3,606	4,280	4,522	3,334	1,639	1,565	2,024	2,102
60%	2,755	2,132	2,035	2,373	4,575	5,295	5,074	5,522	3,719	1,819	1,682	2,173	2,740
70%	2,889	2,266	2,240	3,153	6,321	7,748	6,032	6,071	3,993	2,034	2,112	2,416	3,269
80%	2,992	2,525	2,622	4,849	9,115	9,231	8,229	8,106	6,093	3,284	2,718	2,616	4,507
90%	3,331	2,777	3,885	11,153	14,905	13,821	13,179	14,366	11,700	6,902	3,029	3,216	5,505
Maximum	6,753	16,297	24,021	62,587	34,271	48,485	26,465	25,624	27,086	23,865	9,143	7,677	15,907
Average	2,673	2,363	3,041	4,721	6,237	6,624	5,992	6,446	4,840	3,041	1,967	2,289	3,024

F.1.3.4 40 Percent Unimpaired Flow (LSJR Alternative 3)

The WSE model was used to simulate 40 percent unimpaired flow, which represents typical conditions for LSJR Alternative 3. For this simulation, LSJR tributary flows were generally greater than or equal to 40 percent of the unimpaired flow from February–June. Some of the February–June flow was reserved for controlling potential temperature effects later in the year; thus, resulting flows decreased to slightly below 40 percent of unimpaired flow during some years. In some years, February–June flows were higher than the 40 percent unimpaired flow objective because of flood control releases or other flow requirements. The reservoir storage and water supply diversions were managed to satisfy these monthly flow objectives for each tributary river. Flood releases in many years were reduced or eliminated because higher flows were released from February–June to satisfy the flow objectives. Water supply diversions were reduced in some years to account for the 40 percent unimpaired flow requirement and maintain storage in the reservoirs.

Merced River

Table F.1.3-7a shows the monthly cumulative distributions for the WSE-calculated Lake McClure storage (TAF) for LSJR Alternative 3. These monthly storage patterns differ from baseline storage patterns because the timing and magnitude of releases for instream flow requirements and diversions are different. The median carryover storage was 467 TAF, slightly higher than the baseline median carryover storage of 451 TAF. Table F.1.3-7b shows the monthly cumulative distributions for the WSE-calculated Lake McClure water surface elevations (feet MSL) for LSJR Alternative 3. The median September reservoir elevation was 762 TAF, slightly higher than the baseline median September elevation of 757 TAF.

Table F.1.3-7a. WSE Results for Lake McClure Storage (TAF) for 40% Unimpaired Flow (LSJR Alternative 3)

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
					Lake McClure Storage (TAF)							
Minimum	168	157	195	181	166	189	188	182	189	238	213	194
10%	276	266	265	272	303	313	341	348	358	338	314	301
20%	303	296	305	320	359	351	390	440	455	411	359	330
30%	334	343	366	393	413	429	469	522	527	458	394	360
40%	394	408	404	426	515	540	568	618	591	523	456	418
50%	442	437	460	502	569	624	644	671	648	572	503	467
60%	454	457	499	579	632	652	699	764	738	642	543	488
70%	543	536	584	618	667	707	744	841	832	741	633	573
80%	634	598	619	651	675	735	795	914	980	909	770	690
90%	645	627	653	675	675	735	837	968	1,024	910	770	700
Maximum	675	675	675	675	675	735	845	970	1,024	910	770	700
Average	448	442	460	487	522	556	601	669	681	609	526	480

Table F.1.3-7b. WSE Results for Lake McClure Water Surface Elevation (feet MSL) for 40% Unimpaired Flow (LSJR Alternative 3)

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
Lake McClure Elevation (feet mean sea level)												
Minimum	661	655	673	667	660	671	670	667	671	683	681	673
10%	698	694	693	696	709	713	723	725	729	722	713	708
20%	709	706	710	715	729	727	739	754	758	746	729	719
30%	721	724	731	740	746	751	762	776	777	759	741	730
40%	741	745	744	750	774	780	787	798	792	776	759	748
50%	755	753	760	771	787	799	803	809	804	788	771	762
60%	758	759	770	789	801	805	814	826	822	803	781	767
70%	781	779	790	798	808	816	822	839	838	822	801	788
80%	801	793	798	805	809	821	832	851	861	850	827	812
90%	803	800	805	809	809	821	839	859	867	850	827	814
Maximum	809	809	809	809	809	821	840	859	867	850	827	814
Average	751	750	755	761	771	778	788	801	803	789	771	760

Table F.1.3-7c shows the monthly cumulative distributions for the Merced River target flows at Stevinson for LSJR Alternative 3. Target flows are the flows specified for the downstream ends of the river in the absence of flood control releases. Comparison to the baseline indicates that the average monthly target flows for LSJR Alternative 3 increased from July–November (as a result of adaptive implementation flow shifting) and remained unchanged during December and January. From February through June, the average monthly target flows were higher under the alternative compared to baseline because of the unimpaired flow requirement, particularly from March to June. The greatest increase came in May when the average target flow increased from 341 cfs under baseline to 1,405 cfs under the alternative.

Table F.1.3-7c. Merced River Target Flows (cfs) for 40% Unimpaired Flow (LSJR Alternative 3)

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
Merced Target Flow (cfs)												
Minimum	219	166	33	99	207	260	208	254	87	(0)	(0)	(0)
10%	342	271	263	260	325	335	538	660	290	55	35	55
20%	358	304	287	318	340	363	620	870	348	94	84	101
30%	387	324	309	332	376	399	734	1,121	553	134	121	133
40%	405	336	332	345	392	475	814	1,263	758	163	163	172
50%	429	350	338	360	446	515	860	1,421	912	200	200	200
60%	457	368	352	386	537	603	946	1,552	1,029	223	200	200
70%	513	444	363	424	716	659	1,028	1,695	1,313	266	263	251
80%	727	709	381	482	900	782	1,128	1,841	1,486	521	506	503
90%	800	800	409	560	1,296	923	1,242	2,033	1,692	600	600	600
Maximum	1,276	847	1,075	1,730	2,103	2,364	2,614	2,882	4,330	1,133	600	629
Average	503	445	344	416	635	616	897	1,405	1,010	267	252	258

Table F.1.3-7d shows the monthly cumulative distributions for the Merced River flows at Stevinson for LSJR Alternative 3. The cumulative distributions of monthly flows were often higher than the target flows indicating that flood control releases were sometimes required. However, only about 37 percent of the years simulated required flood control releases, much less than under baseline conditions, during which flood control releases occurred in about 50 percent of the years.

Table F.1.3-7d. Merced River Flows at Stevinson (cfs) for 40% Unimpaired Flow (LSJR Alternative 3)

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	Annual (TAF)
							Merced at Stevinson Flow (cfs)						
Minimum	219	166	83	144	207	260	208	254	87	(0)	(0)	(0)	185
10%	342	271	268	266	325	335	538	660	290	55	35	55	247
20%	358	304	300	325	340	363	620	870	348	94	84	101	294
30%	387	324	317	338	380	399	734	1,121	553	134	121	133	323
40%	405	336	333	354	404	475	814	1,263	758	163	163	172	367
50%	429	350	342	376	453	515	860	1,421	912	200	200	200	417
60%	457	368	357	398	810	603	946	1,552	1,029	223	200	200	496
70%	513	444	368	433	1,089	760	1,034	1,695	1,313	266	263	251	548
80%	727	709	390	622	1,584	969	1,142	1,841	1,509	618	876	513	802
90%	800	800	434	1,726	2,158	1,728	1,328	2,519	2,625	1,844	1,150	600	982
Maximum	1,276	1,910	3,495	9,859	4,875	5,959	4,845	5,379	7,273	5,863	2,392	1,275	2,398
Average	507	468	448	762	995	884	945	1,522	1,233	636	396	282	547

Tuolumne River

Table F.1.3-7e shows the monthly cumulative distributions for the WSE-calculated New Don Pedro Reservoir storage (TAF) for 40 percent unimpaired flow (LSJR Alternative 3). These monthly storage patterns differ from baseline storage patterns because the timing and magnitude of releases for instream flow requirements and diversions are different. The median carryover storage was 1,207 TAF, 202 TAF less than the baseline median carryover storage of 1,409 TAF. Table F.1.3-7f shows the monthly cumulative distributions for the WSE-calculated New Don Pedro Reservoir water elevations (feet MSL) for LSJR Alternative 3. The median September reservoir elevation was 750 TAF, slightly less than the baseline median September elevation of 774 TAF.

Table F.1.3-7e. WSE Results for New Don Pedro Reservoir Storage (TAF) for 40% Unimpaired Flow (LSJR Alternative 3)

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
	New Don Pedro Storage (TAF)											
Minimum	653	648	827	846	859	906	913	871	808	735	686	669
10%	896	896	927	994	1,070	1,124	1,120	1,120	1,084	1,000	948	914
20%	1,007	1,018	1,075	1,122	1,178	1,269	1,268	1,248	1,214	1,123	1,051	1,024
30%	1,066	1,083	1,144	1,176	1,273	1,327	1,335	1,342	1,287	1,196	1,136	1,084
40%	1,126	1,143	1,194	1,257	1,363	1,411	1,463	1,514	1,458	1,317	1,202	1,148
50%	1,173	1,195	1,255	1,359	1,472	1,581	1,557	1,569	1,522	1,385	1,265	1,207
60%	1,245	1,282	1,339	1,424	1,547	1,672	1,663	1,628	1,634	1,492	1,349	1,264
70%	1,341	1,339	1,433	1,533	1,638	1,690	1,690	1,669	1,701	1,608	1,463	1,384
80%	1,496	1,486	1,534	1,639	1,690	1,690	1,713	1,716	1,865	1,787	1,641	1,537
90%	1,600	1,572	1,633	1,690	1,690	1,690	1,713	1,842	2,000	1,910	1,774	1,677
Maximum	1,660	1,690	1,690	1,690	1,690	1,690	1,718	1,974	2,030	1,910	1,790	1,700
Average	1,217	1,221	1,280	1,348	1,425	1,477	1,487	1,504	1,525	1,422	1,313	1,248

Table F.1.3-7f. WSE Results for New Don Pedro Reservoir Water Surface Elevation (feet MSL) for 40% Unimpaired Flow (LSJR Alternative 3)

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
	New Don Pedro Elevation (feet mean sea level)											
Minimum	674	674	695	698	700	708	709	702	692	679	679	677
10%	706	706	711	721	732	740	739	739	734	722	715	709
20%	723	725	733	739	747	758	758	755	751	739	730	726
30%	732	734	742	746	758	765	766	767	760	749	741	734
40%	740	742	749	756	769	774	780	785	779	764	750	743
50%	746	749	756	768	781	792	790	791	786	771	757	750
60%	755	759	766	776	789	801	800	797	798	783	767	757
70%	766	766	777	787	798	803	803	801	804	795	780	771
80%	783	782	787	798	803	803	805	806	819	812	798	788
90%	794	791	797	803	803	803	805	817	831	823	811	802
Maximum	800	803	803	803	803	803	806	829	833	823	812	804
Average	749	750	757	765	774	780	781	782	783	772	760	753

Table F.1.3-7g shows the monthly cumulative distributions for the WSE-calculated Tuolumne River target flows at Modesto for LSJR Alternative 3. Target flows are the flows specified for the downstream ends of the river in the absence of flood control releases. Comparison to the baseline indicates that the average monthly target flows for LSJR Alternative 3 increased slightly from July–November (as a result of adaptive implementation flow shifting) and remained unchanged during December and January. From February through June, the average monthly target flows were higher under the alternative compared to baseline because of the unimpaired flow requirement, particularly in May and June. The greatest increase came in June when the average target flow increased from 504 cfs under baseline to 2,231 cfs under the alternative.

Table F.1.3-7g. Tuolumne River Target Flows (cfs) for 40% Unimpaired Flow (LSJR Alternative 3)

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
	Tuolumne Target Flow (cfs)											
Minimum	199	206	71	208	235	338	531	690	283	194	187	166
10%	290	246	251	316	442	608	1,112	1,388	602	262	277	256
20%	395	324	319	417	505	738	1,293	1,894	913	319	346	334
30%	463	389	399	434	604	833	1,481	2,248	1,485	364	369	366
40%	499	452	430	479	647	925	1,632	2,439	1,846	403	403	381
50%	552	472	445	524	814	1,008	1,709	2,823	2,160	483	428	425
60%	681	562	496	572	940	1,116	1,804	3,013	2,583	582	586	574
70%	742	926	581	602	1,118	1,275	2,016	3,302	2,901	698	600	697
80%	1,000	1,000	602	648	1,662	1,545	2,183	3,497	3,232	1,200	600	1,000
90%	1,000	1,000	655	757	2,101	2,008	2,548	4,048	3,670	1,200	638	1,000
Maximum	1,171	1,530	1,405	2,411	4,164	3,484	4,063	5,693	6,531	1,200	760	1,000
Average	633	609	479	560	1,041	1,179	1,769	2,757	2,231	637	471	573

Table F.1.3-7h shows the monthly cumulative distributions for the WSE-calculated Tuolumne River flows at Modesto for LSJR Alternative 3. The cumulative distributions of monthly flows were higher than the target flows, indicating that flood control releases were sometimes required. However, only about 44 percent of the years simulated required flood control releases, much less than under baseline conditions, during which flood control releases occurred in about 66 percent of the years.

Table F.1.3-7h. Tuolumne River Flows at Modesto (cfs) for 40% Unimpaired Flow (LSJR Alternative 3)

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	Annual (TAF)
							Tuolumne at Modesto Flow(cfs)						
Minimum	199	206	217	208	235	338	531	690	283	194	187	166	261
10%	290	246	257	316	442	608	1,112	1,388	602	262	277	256	459
20%	395	324	322	427	511	801	1,293	1,894	913	319	346	334	560
30%	463	389	402	443	609	895	1,492	2,248	1,485	364	369	366	617
40%	499	452	431	518	722	1,014	1,659	2,439	1,846	403	403	381	678
50%	552	472	450	542	902	1,174	1,998	2,867	2,173	483	428	425	816
60%	681	562	518	593	1,188	1,661	2,236	3,117	2,583	582	586	574	918
70%	742	926	589	639	1,691	2,665	2,601	3,387	2,901	698	600	697	1,209
80%	1,000	1,000	611	836	2,583	3,463	3,183	3,538	3,334	1,200	600	1,000	1,425
90%	1,000	1,000	679	2,404	4,065	5,027	4,591	4,810	4,422	3,135	652	1,000	1,720
Maximum	3,090	5,440	7,479	17,925	6,927	16,297	9,332	9,474	7,110	8,047	2,996	2,296	4,129
Average	661	677	679	1,148	1,660	2,217	2,378	3,013	2,370	1,046	515	601	1,022

Stanislaus River

Table F.1.3-7i shows the monthly cumulative distributions for the WSE-calculated New Melones Reservoir storage (TAF) for LSJR Alternative 3. These monthly storage patterns differ from baseline storage patterns because the timing and magnitude of releases for instream flow requirements and diversions are different. The median carryover storage was 1,096 TAF, about 28 TAF less than the baseline median carryover storage of 1,124 TAF. Table F.1.3-7j shows the monthly cumulative distributions for the WSE-calculated New Melones Reservoir water surface elevations (feet MSL) for LSJR Alternative 3. The median September reservoir elevation was 957 TAF under the alternative, about the same as the baseline median September elevation of 961 TAF.

Table F.1.3-7i. WSE Results for New Melones Reservoir Storage (TAF) for 40% Unimpaired Flow (LSJR Alternative 3)

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
	New Melones Reservoir Storage (TAF)											
Minimum	636	648	661	737	748	784	767	704	691	679	662	662
10%	754	766	788	809	852	902	877	864	849	825	795	781
20%	824	830	858	872	906	968	949	929	964	949	891	854
30%	884	901	932	1,009	1,031	1,058	1,077	1,069	1,062	1,011	948	924
40%	988	1,001	1,045	1,094	1,128	1,208	1,214	1,211	1,178	1,123	1,067	1,028
50%	1,042	1,081	1,127	1,202	1,296	1,363	1,402	1,357	1,323	1,215	1,132	1,096
60%	1,141	1,178	1,235	1,361	1,418	1,476	1,477	1,493	1,447	1,332	1,235	1,193
70%	1,344	1,364	1,394	1,450	1,533	1,552	1,553	1,594	1,648	1,568	1,479	1,415
80%	1,489	1,494	1,546	1,607	1,649	1,734	1,717	1,705	1,753	1,690	1,596	1,539
90%	1,658	1,668	1,695	1,725	1,811	1,901	1,936	1,949	1,924	1,827	1,749	1,710
Maximum	1,970	1,970	1,970	1,970	1,970	2,030	2,090	2,137	2,385	2,300	2,130	2,000
Average	1,145	1,160	1,198	1,254	1,308	1,354	1,352	1,360	1,363	1,297	1,227	1,188

Table F.1.3-7j. WSE Results for New Melones Reservoir Water Surface Elevation (feet MSL) for 40% Unimpaired Flow (LSJR Alternative 3)

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
	New Melones Elevation (feet mean sea level)											
Minimum	875	878	881	896	899	906	902	890	887	884	881	881
10%	900	902	906	910	918	926	922	920	917	913	908	905
20%	913	914	919	922	927	937	934	931	937	934	925	918
30%	924	926	932	944	947	951	954	953	952	944	934	930
40%	940	942	949	956	961	972	973	972	968	960	952	947
50%	949	954	961	971	983	991	996	991	986	973	962	957
60%	963	968	975	991	998	1,004	1,004	1,006	1,001	987	975	970
70%	989	991	995	1,001	1,010	1,012	1,013	1,017	1,022	1,014	1,005	997
80%	1,006	1,006	1,012	1,018	1,022	1,031	1,029	1,028	1,033	1,027	1,017	1,011
90%	1,023	1,024	1,027	1,030	1,038	1,047	1,050	1,051	1,049	1,040	1,032	1,029
Maximum	1,053	1,053	1,053	1,053	1,053	1,058	1,063	1,067	1,086	1,080	1,066	1,055
Average	957	960	965	972	979	985	984	985	985	977	968	963

Table F.1.3-7k shows the monthly cumulative distributions for the WSE-calculated Stanislaus River target flows at Ripon for LSJR Alternative 3. Target flows are the flows specified for the downstream ends of the river in the absence of flood control releases. Comparison to the baseline indicates that the average monthly target flows under LSJR Alternative 3 remained mostly unchanged from July to February (except in October), with some differences because of changes in the NMI under the alternative. October targets were higher as a result of adaptive implementation flow shifting in order to control potential temperature effects during summer and fall. From February to June, the average monthly target flows were generally higher than under baseline. The greatest increase came in May when the average target flow increased from 1,328 cfs under baseline to 1,771 cfs under the alternative.

Table F.1.3-7k. Stanislaus River Target Flows (cfs) for 40% Unimpaired Flow (LSJR Alternative 3)

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
	Stanislaus Target Flow (cfs)											
Minimum	763	213	94	129	225	238	460	443	205	205	208	174
10%	800	248	225	267	268	371	693	756	315	307	312	299
20%	1,000	260	243	294	340	462	955	1,084	442	325	352	358
30%	1,000	267	263	310	389	516	1,230	1,346	608	357	370	377
40%	1,000	292	280	323	445	599	1,395	1,610	864	395	410	397
50%	1,122	318	288	335	519	692	1,539	1,782	1,114	437	425	421
60%	1,200	336	305	347	705	813	1,687	2,003	1,261	534	471	476
70%	1,204	348	320	360	778	1,162	1,744	2,109	1,365	682	500	700
80%	1,400	379	368	397	921	1,711	1,822	2,265	1,590	800	512	800
90%	1,400	445	423	502	1,409	1,897	1,928	2,711	2,050	800	554	800
Maximum	1,409	732	1,071	884	3,832	2,636	2,766	3,752	4,189	1,021	732	887
Average	1,121	326	323	358	730	967	1,440	1,771	1,139	524	439	515

Table F.1.3-7l shows the monthly cumulative distributions 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 sometimes required. However, only about 7 percent of the years required some flood control releases.

Table F.1.3-7l. Stanislaus River Flows at Ripon (cfs) for 40% Unimpaired Flow (LSJR Alternative 3)

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	Annual (TAF)
Stanislaus at Ripon Flow (cfs)													
Minimum	763	213	94	129	225	238	460	443	205	205	208	174	253
10%	800	248	225	267	268	371	693	756	315	307	312	299	325
20%	1,000	260	247	295	340	462	955	1,084	442	325	352	358	406
30%	1,000	267	267	312	389	516	1,230	1,346	608	357	370	377	457
40%	1,000	292	280	324	445	599	1,395	1,610	864	395	410	397	519
50%	1,122	318	291	336	519	692	1,539	1,782	1,114	437	425	421	591
60%	1,200	336	306	349	730	813	1,687	2,003	1,261	534	471	476	619
70%	1,204	348	320	362	788	1,162	1,744	2,109	1,365	682	500	700	686
80%	1,400	379	368	414	1,196	1,711	1,822	2,265	1,590	800	512	800	760
90%	1,400	445	423	541	1,799	1,897	1,928	2,711	2,050	800	554	800	930
Maximum	1,538	3,453	5,126	10,555	5,177	6,223	2,766	3,752	4,189	3,770	2,664	3,050	2,453
Average	1,123	382	417	582	878	1,011	1,440	1,771	1,139	560	462	551	622

SJR at Vernalis

Table F.1.3-7m shows the monthly cumulative distributions for the WSE-calculated SJR at Vernalis flows for LSJR Alternative 3. The average Vernalis flows were similar to the baseline flows in February and March but were 810–2,400 cfs higher from April–June. LSJR Alternative 3 provided a more natural distribution of flows from February–June, and the average annual flow volume was 294 TAF more than the average baseline flow volume at Vernalis (10 percent higher).

Table F.1.3-7m. SJR Flows at Vernalis (cfs) for 40% Unimpaired Flow (LSJR Alternative 3)

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	Annual (TAF)
							SJR at Vernalis Flow (cfs)						
Minimum	1,539	1,233	1,238	1,146	1,526	1,124	1,349	1,724	1,000	525	579	955	956
10%	2,000	1,566	1,513	1,480	1,852	1,742	2,788	3,220	1,537	955	1,054	1,459	1,465
20%	2,263	1,696	1,657	1,699	2,033	2,453	3,747	4,456	2,199	1,139	1,248	1,685	1,773
30%	2,451	1,795	1,789	1,886	2,316	2,775	4,219	5,349	3,083	1,226	1,341	1,796	1,924
40%	2,571	1,906	1,884	2,113	2,636	3,310	4,796	6,154	4,169	1,439	1,449	1,913	2,098
50%	2,832	1,998	1,941	2,167	3,073	3,949	5,394	7,330	5,061	1,633	1,568	2,030	2,504
60%	3,066	2,170	2,035	2,352	5,426	5,367	5,986	8,009	5,604	1,865	1,767	2,180	2,922
70%	3,473	2,706	2,157	3,024	6,679	6,733	6,926	9,125	6,197	2,289	2,081	2,971	3,412
80%	3,876	3,121	2,555	4,020	8,828	8,674	8,553	9,992	7,796	3,305	2,539	3,331	4,524
90%	3,987	3,344	3,029	9,349	12,232	13,701	13,460	15,878	11,927	6,345	2,984	3,543	5,492
Maximum	6,343	16,297	24,021	62,587	34,271	48,485	27,192	27,339	29,234	20,781	9,143	7,677	15,840
Average	2,990	2,528	2,869	4,425	6,194	6,596	6,795	8,378	6,011	3,036	1,904	2,401	3,259

F.1.3.5 60 Percent Unimpaired Flow (LSJR Alternative 4)

The WSE model was used to simulate 60 percent unimpaired flow, which represents typical conditions for LSJR Alternative 4. For this simulation, LSJR tributary flows were greater than or equal to 60 percent of the unimpaired reservoir inflow from February–June. Some of the February–June flow was reserved for controlling potential temperature effects later in the year; thus, resulting flows may decrease slightly below 60 percent of unimpaired flow during some years. In some years, February–June flows were higher than the 60 percent unimpaired flow objective because of flood control releases or other flow requirements. The reservoir storage and water supply diversions were adjusted to satisfy these monthly flow objectives for each of the eastside tributaries. Flood control releases in many years were reduced or eliminated because higher flows were released from February–June to satisfy the flow objectives. Water supply diversions were reduced in many years to account for the 60 percent unimpaired flow requirement and maintain storage in the reservoirs.

Merced River

Table F.1.3-8a shows the monthly cumulative distributions for the WSE-calculated Lake McClure storage (TAF) for LSJR Alternative 4. These monthly storage patterns differ from baseline storage patterns because the timing and magnitude of releases for instream flow requirements and diversions are different. The median carryover storage was 475 TAF, about 24 TAF more than the baseline median carryover storage of 451 TAF. Table F.1.3-8b shows the monthly cumulative distributions for the WSE-calculated Lake McClure water surface elevations (feet MSL) for LSJR Alternative 4. The median September reservoir elevation was 764 TAF, slightly higher than the baseline median September elevation of 757 TAF.

Table F.1.3-8a. WSE Results for Lake McClure Storage (TAF) for 60% Unimpaired Flow (LSJR Alternative 4)

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
Lake McClure Storage (TAF)												
Minimum	52	35	52	102	99	132	141	167	147	128	101	80
10%	269	264	264	264	288	318	339	291	303	321	305	292
20%	299	295	292	319	350	364	375	407	405	377	350	325
30%	376	374	389	394	402	394	420	461	482	456	410	397
40%	416	411	426	444	467	476	495	554	537	493	450	422
50%	446	442	460	483	534	550	571	611	615	575	515	475
60%	472	465	485	522	600	630	655	671	689	630	546	503
70%	501	495	522	587	637	681	698	737	728	677	588	541
80%	529	528	574	645	675	720	759	811	828	740	627	568
90%	631	597	637	675	675	735	797	875	964	910	770	689
Maximum	675	675	675	675	675	735	845	970	1,024	910	770	700
Average	431	424	444	473	503	530	559	602	612	568	502	462

Table F.1.3-8b. WSE Results for Lake McClure Water Surface Elevations (feet MSL) for 60% Unimpaired Flow (LSJR Alternative 4)

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
Lake McClure Elevation (feet mean sea level)												
Minimum	567	538	567	619	617	640	646	660	649	638	618	599
10%	695	693	693	693	703	715	722	704	709	716	710	705
20%	708	706	705	715	726	731	735	745	744	735	726	717
30%	735	734	739	741	743	741	748	760	766	759	745	742
40%	747	746	750	755	762	764	769	783	779	768	757	749
50%	756	755	760	766	779	783	787	796	797	788	774	764
60%	763	761	766	776	794	800	805	809	812	800	782	771
70%	771	769	776	791	802	811	814	821	820	810	791	780
80%	777	777	788	803	809	818	825	834	837	822	800	787
90%	800	793	802	809	809	821	832	845	858	850	827	812
Maximum	809	809	809	809	809	821	840	859	867	850	827	814
Average	746	743	749	757	765	772	778	787	788	779	765	755

Table F.1.3-8c shows the monthly cumulative distributions for the WSE-calculated Merced River target flows at Stevinson for LSJR Alternative 4. Target flows are the flows specified for the downstream ends of the river in the absence of flood control releases. Comparison to the baseline indicates that the average monthly target flows for LSJR Alternative 4 increased from July–November (as a result of adaptive implementation flow shifting) and remained unchanged during December and January. From February through June, the average monthly target flows were higher in the alternative compared to baseline because of the unimpaired flow requirement, particularly from April–June. The greatest increase came in May when the average target flow increased from 341 cfs under baseline to 2,164 cfs under the alternative.

Table F.1.3-8c. Merced River Target Flows (cfs) for 60% Unimpaired Flow (LSJR Alternative 4)

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
Merced Target Flow (cfs)												
Minimum	219	166	33	99	207	281	313	381	131	(0)	(0)	(0)
10%	342	271	263	260	332	391	807	989	435	55	35	55
20%	358	304	287	318	360	505	930	1,306	522	94	84	101
30%	387	324	309	332	397	576	1,101	1,681	829	134	121	133
40%	405	336	332	345	488	637	1,245	1,918	1,137	163	163	172
50%	429	350	338	360	557	769	1,308	2,192	1,377	200	200	200
60%	457	368	352	386	706	877	1,462	2,431	1,574	223	200	200
70%	569	444	363	424	903	1,002	1,589	2,604	2,016	266	263	251
80%	800	800	381	482	1,379	1,235	1,735	2,808	2,386	600	600	600
90%	800	800	409	560	1,961	1,442	1,961	3,191	2,703	600	600	600
Maximum	1,276	847	1,075	1,730	3,406	3,567	4,055	4,719	6,535	1,133	600	629
Average	517	461	344	416	873	911	1,379	2,164	1,563	281	267	274

Table F.1.3-8d shows the monthly cumulative distributions for the WSE-calculated Merced River flows at Stevinson for LSJR Alternative 4. The monthly flows were greater than the target flows for some of the higher cumulative distribution values, but this occurred less often than under baseline conditions. This indicates that flood control releases were required in fewer years than under baseline. Under LSJR Alternative 4, about 28 percent of years required flood control releases compared to about 50 percent of years under baseline.

Table F.1.3-8d. Merced River Flows at Stevinson (cfs) for 60% Unimpaired Flow (LSJR Alternative 4)

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	Annual (TAF)
Merced at Stevinson Flow (cfs)													
Minimum	219	166	196	144	207	281	313	381	131	(0)	(0)	(0)	209
10%	342	271	273	261	332	391	807	989	435	55	35	55	316
20%	358	304	301	323	360	505	930	1,306	522	94	84	101	379
30%	387	324	317	334	410	576	1,101	1,681	829	134	121	133	401
40%	405	336	333	352	497	637	1,245	1,918	1,137	163	163	172	474
50%	429	350	342	370	581	769	1,308	2,192	1,377	200	200	200	560
60%	457	368	357	395	881	913	1,462	2,431	1,574	223	200	200	640
70%	569	444	368	432	1,411	1,010	1,589	2,604	2,016	266	263	251	708
80%	800	800	389	521	1,844	1,350	1,735	2,808	2,386	600	600	600	860
90%	800	800	427	1,522	2,368	1,731	1,961	3,191	2,703	908	1,073	600	1,015
Maximum	1,276	1,910	3,495	9,859	4,474	5,959	4,845	5,120	6,535	5,048	2,392	1,073	2,398
Average	521	484	424	728	1,097	1,045	1,388	2,169	1,571	508	362	287	637

Tuolumne River

Table F.1.3-8e shows the monthly cumulative distributions for the WSE-calculated New Don Pedro Reservoir storage (TAF) for LSJR Alternative 4. These monthly storage patterns differ from baseline storage patterns because the timing and magnitude of releases for instream flow requirements and diversions are different. The median carryover storage was 1,192 TAF, lower than the baseline median carryover storage of 1,409 TAF. Table F.1.3-8f shows the monthly cumulative distributions for the WSE-calculated New Don Pedro Reservoir water surface elevations (feet MSL) for LSJR Alternative 4. The median September reservoir elevation was 748 TAF, slightly less than the baseline median September elevation of 774 TAF.

Table F.1.3-8e. WSE Results for New Don Pedro Reservoir Storage (TAF) for 60% Unimpaired Flow (LSJR Alternative 4)

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
New Don Pedro Reservoir Storage (TAF)												
Minimum	735	733	793	937	935	951	945	893	815	774	750	745
10%	962	964	997	1,027	1,087	1,130	1,110	1,082	1,043	1,009	986	979
20%	1,026	1,048	1,069	1,117	1,189	1,247	1,226	1,169	1,146	1,091	1,048	1,027
30%	1,081	1,076	1,144	1,198	1,256	1,304	1,287	1,277	1,233	1,185	1,124	1,098
40%	1,137	1,143	1,183	1,256	1,309	1,355	1,365	1,326	1,302	1,253	1,185	1,157
50%	1,175	1,176	1,247	1,297	1,379	1,453	1,410	1,435	1,434	1,344	1,247	1,192
60%	1,221	1,242	1,300	1,353	1,451	1,555	1,598	1,510	1,493	1,409	1,314	1,249
70%	1,282	1,297	1,366	1,457	1,571	1,638	1,646	1,556	1,532	1,444	1,343	1,297
80%	1,316	1,360	1,461	1,593	1,688	1,690	1,690	1,640	1,631	1,618	1,472	1,356
90%	1,524	1,482	1,565	1,690	1,690	1,690	1,705	1,729	1,792	1,814	1,683	1,590
Maximum	1,660	1,690	1,690	1,690	1,690	1,690	1,713	1,874	1,943	1,910	1,790	1,700
Average	1,196	1,202	1,263	1,333	1,395	1,439	1,440	1,408	1,402	1,352	1,271	1,223

Table F.1.3-8f. WSE Results for New Don Pedro Reservoir Water Surface Elevations (feet MSL) for 60% Unimpaired Flow (LSJR Alternative 4)

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
	New Don Pedro Reservoir Elevation (feet mean sea level)											
Minimum	679	678	689	713	712	715	714	706	693	686	681	680
10%	717	717	722	726	735	740	738	734	728	724	720	719
20%	726	729	732	739	748	755	753	745	742	735	729	726
30%	734	733	742	749	756	762	760	759	753	747	739	736
40%	741	742	747	756	763	768	769	765	762	756	747	744
50%	746	746	755	761	771	779	774	777	777	767	755	748
60%	752	755	762	768	779	790	794	785	783	774	763	755
70%	759	761	769	779	791	798	799	790	787	778	767	761
80%	763	769	780	793	803	803	803	798	797	796	781	768
90%	786	782	791	803	803	803	805	807	813	815	802	793
Maximum	800	803	803	803	803	803	805	820	826	823	812	804
Average	747	748	755	764	771	776	776	772	771	765	756	750

Table F.1.3-8g shows the monthly cumulative distributions for the Tuolumne River target flows at Modesto for LSJR Alternative 4. Target flows are the flows specified for the downstream ends of the river in the absence of flood control releases. Comparison to the baseline indicates that the average monthly target flows for LSJR Alternative 4 increased slightly from July–November (as a result of adaptive implementation flow shifting) and remained unchanged during December and January. From February through June, the average monthly target flows were higher under the alternative compared to baseline because of the unimpaired flow requirement. The greatest increase came in May when the average target flow increased from 1,106 cfs under baseline to 4,209 cfs under the alternative.

Table F.1.3-8g. Tuolumne River Target Flows (cfs) for 60% Unimpaired Flow (LSJR Alternative 4)

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
	Tuolumne Target Flow (cfs)											
Minimum	199	206	71	208	235	338	797	1,034	366	194	187	166
10%	290	246	251	316	525	826	1,605	2,081	903	262	277	256
20%	395	324	319	417	650	1,130	1,877	2,842	1,369	319	346	334
30%	463	389	399	434	756	1,249	2,221	3,371	2,227	364	369	366
40%	499	452	430	479	907	1,388	2,458	3,696	2,889	403	403	381
50%	552	472	445	524	1,247	1,542	2,617	4,332	3,287	483	428	425
60%	681	562	496	572	1,448	1,674	2,836	4,550	3,993	582	586	574
70%	742	926	581	602	1,623	1,968	3,042	5,091	4,390	698	600	697
80%	1,000	1,000	602	648	2,493	2,338	3,309	5,258	5,031	1,200	600	1,000
90%	1,000	1,000	655	757	3,269	3,106	3,827	6,095	5,673	1,200	638	1,000
Maximum	1,171	1,530	1,405	2,411	6,382	5,305	6,281	8,816	9,946	1,200	760	1,000
Average	633	609	479	560	1,535	1,791	2,677	4,209	3,410	637	471	573

Table F.1.3-8h shows the monthly cumulative distributions for the WSE-calculated Tuolumne River flows at Modesto for LSJR Alternative 4. The cumulative distributions of monthly flows were higher than the target flows in some months, indicating that flood control releases were sometimes required. However, only about 29 percent of years had flood control releases under LSJR Alternative 4 compared to 66 percent of years under baseline.

Table F.1.3-8h. Tuolumne River Flows at Modesto (cfs) for 60% Unimpaired Flow (LSJR Alternative 4)

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	Annual (TAF)
							Tuolumne at Modesto Flow (cfs)						
Minimum	199	206	217	208	235	338	797	1,034	366	194	187	166	319
10%	290	246	257	316	525	826	1,605	2,081	903	262	277	256	594
20%	395	324	322	427	650	1,130	1,877	2,842	1,369	319	346	334	739
30%	463	389	402	443	772	1,255	2,221	3,371	2,227	364	369	366	805
40%	499	452	431	518	971	1,413	2,458	3,696	2,889	403	403	381	913
50%	552	472	450	549	1,296	1,615	2,652	4,359	3,287	483	428	425	1,088
60%	681	562	518	595	1,712	1,928	2,937	4,684	3,993	582	586	574	1,256
70%	742	926	589	639	2,488	2,846	3,197	5,107	4,390	698	600	697	1,384
80%	1,000	1,000	611	748	3,291	3,544	3,545	5,338	5,031	1,200	600	1,000	1,588
90%	1,000	1,000	679	2,200	3,963	4,421	4,105	6,355	5,673	1,200	652	1,000	1,916
Maximum	3,090	5,440	7,479	17,925	6,917	16,297	9,332	8,816	9,946	5,424	2,123	2,296	4,131
Average	661	677	664	1,142	1,963	2,420	2,861	4,268	3,410	795	504	601	1,202

Stanislaus River

Table F.1.3-8i shows the monthly cumulative distributions for the WSE-calculated New Melones Reservoir storage (TAF) for LSJR Alternative 4. These monthly storage patterns differ from baseline storage patterns because the timing and magnitude of releases for instream flow requirements and diversions are different. The median carryover storage was 1,026 TAF, about 98 TAF lower than the baseline median carryover storage of 1,124 TAF. Table F.1.3-8j shows the monthly cumulative distributions for the WSE-calculated New Melones Reservoir water surface elevations (feet MSL) for LSJR Alternative 4. The median September reservoir elevation was 946 TAF under the alternative, slightly lower than the baseline median September elevation of 961 TAF.

Table F.1.3-8i. WSE Results for New Melones Reservoir Storage (TAF) for 60% Unimpaired Flow (LSJR Alternative 4)

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
New Melones Reservoir Storage (TAF)												
Minimum	599	601	603	719	744	757	714	656	642	627	615	613
10%	782	783	803	850	888	909	862	843	833	808	795	802
20%	834	853	872	916	940	951	919	880	898	883	858	857
30%	900	912	937	960	988	999	1,001	972	999	966	946	936
40%	944	962	997	1,037	1,087	1,121	1,097	1,062	1,065	1,031	996	974
50%	968	994	1,036	1,101	1,145	1,190	1,185	1,158	1,139	1,078	1,039	1,026
60%	1,034	1,064	1,109	1,202	1,241	1,265	1,242	1,250	1,232	1,181	1,098	1,072
70%	1,117	1,157	1,211	1,277	1,330	1,357	1,358	1,351	1,350	1,254	1,202	1,182
80%	1,250	1,263	1,299	1,444	1,509	1,526	1,524	1,512	1,486	1,415	1,328	1,294
90%	1,449	1,469	1,518	1,591	1,646	1,720	1,764	1,776	1,749	1,630	1,545	1,503
Maximum	1,970	1,970	1,970	1,970	1,970	2,030	2,065	2,011	2,133	2,232	2,130	2,000
Average	1,048	1,067	1,110	1,174	1,216	1,250	1,233	1,208	1,201	1,161	1,113	1,087

Table F.1.3-8j. WSE Results for New Melones Reservoir Water Surface Elevations (feet MSL) for 60% Unimpaired Flow (LSJR Alternative 4)

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
New Melones Reservoir Elevation (feet mean sea level)												
Minimum	867	867	867	893	898	900	892	880	877	873	870	870
10%	905	905	909	918	924	928	920	916	915	910	908	909
20%	915	918	921	929	933	935	929	923	926	923	919	919
30%	926	928	932	936	940	942	942	938	942	937	934	932
40%	933	936	942	948	955	960	957	952	952	947	942	938
50%	937	941	948	957	963	969	969	965	963	954	948	946
60%	947	952	958	971	976	979	976	977	975	968	957	953
70%	959	965	972	981	987	990	991	990	990	978	971	968
80%	977	979	983	1,001	1,008	1,010	1,009	1,008	1,005	997	987	983
90%	1,001	1,003	1,009	1,017	1,022	1,030	1,034	1,035	1,032	1,021	1,012	1,007
Maximum	1,053	1,053	1,053	1,053	1,053	1,058	1,061	1,056	1,066	1,074	1,066	1,055
Average	946	949	955	963	969	973	971	967	966	961	955	952

Table F.1.3-8k shows the monthly cumulative distributions for the WSE-calculated Stanislaus River target flows at Ripon for LSJR Alternative 4. Comparison to the baseline indicates that the average monthly target flows under LSJR Alternative 3 remained mostly unchanged from July to February (except in October), with some differences because of changes in the NMI under the alternative. October targets were higher as a result of adaptive implementation flow shifting in order to control potential temperature effects during summer and fall. From February to June, the average monthly target flows were generally higher than under baseline. The greatest increase came in May when the average target flow increased from 1,328 cfs under baseline to 2,617 cfs under the alternative.

Table F.1.3-8k. Stanislaus River Target Flows (cfs) for 60% Unimpaired Flow (LSJR Alternative 4)

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
Stanislaus Target Flow (cfs)												
Minimum	763	213	94	122	230	358	516	464	221	205	208	174
10%	800	248	225	267	325	463	1,001	922	389	298	279	293
20%	1,000	260	243	294	391	664	1,263	1,545	572	324	348	343
30%	1,000	267	263	312	479	770	1,540	1,764	931	356	365	372
40%	1,000	292	280	324	594	902	1,735	2,232	1,214	385	403	394
50%	1,113	318	288	336	767	1,000	1,902	2,631	1,548	423	413	419
60%	1,200	335	305	345	1,049	1,187	2,032	3,041	1,899	526	462	463
70%	1,200	347	320	362	1,167	1,492	2,130	3,295	2,103	657	500	700
80%	1,400	378	357	396	1,382	1,854	2,341	3,525	2,422	800	500	800
90%	1,400	442	411	503	2,113	2,215	2,659	4,141	3,139	827	578	800
Maximum	1,409	732	1,071	884	5,747	3,973	4,222	5,687	6,313	1,867	732	887
Average	1,121	325	321	359	1,047	1,249	1,880	2,617	1,690	547	430	507

Table F.1.3-8l shows the monthly cumulative distributions for the WSE-calculated Stanislaus River flows at Ripon for LSJR Alternative 4. Under LSJR Alternative 4, only about 4 percent of the years required flood control releases from New Melones Reservoir.

Table F.1.3-8l. Stanislaus River Flows at Ripon (cfs) for 60% Unimpaired Flow (LSJR Alternative 4)

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	Annual (TAF)
							Stanislaus at Ripon Flow (cfs)						
Minimum	763	213	94	122	230	358	516	464	221	205	208	174	258
10%	800	248	225	267	325	463	1,001	922	389	298	279	293	392
20%	1,000	260	243	295	391	664	1,263	1,545	572	324	348	343	496
30%	1,000	267	263	314	479	770	1,540	1,764	931	356	365	372	540
40%	1,000	292	280	325	594	902	1,735	2,232	1,214	385	403	394	652
50%	1,113	318	288	339	767	1,000	1,902	2,631	1,548	423	413	419	725
60%	1,200	335	305	347	1,096	1,187	2,032	3,041	1,899	526	462	463	806
70%	1,200	347	320	364	1,182	1,492	2,130	3,295	2,103	657	500	700	896
80%	1,400	378	357	405	1,731	1,854	2,341	3,525	2,422	800	500	800	947
90%	1,400	442	411	526	2,250	2,215	2,659	4,141	3,139	827	578	800	1,166
Maximum	1,538	3,453	5,126	6,009	5,747	6,223	4,222	5,687	6,313	1,867	1,560	3,050	2,162
Average	1,122	361	377	482	1,127	1,277	1,880	2,617	1,690	547	440	534	750

SJR at Vernalis

Table F.1.3-8m shows the monthly cumulative distributions for the WSE-calculated SJR at Vernalis flows for LSJR Alternative 4. The average Vernalis flows for LSJR Alternative 4 were much higher than the baseline flows from February–June. LSJR Alternative 4 provided a more natural distribution of flows from February–June. The average annual flow volume was 693 TAF more than the average annual baseline flow volume at Vernalis (19 percent higher).

Table F.1.3-8m. SJR Flows at Vernalis (cfs) for 60% Unimpaired Flow (LSJR Alternative 4)

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	Annual (TAF)
SJR at Vernalis Flow (cfs)													
Minimum	1,539	1,233	1,238	1,146	1,526	1,124	1,716	2,195	1,000	525	579	955	1,043
10%	2,000	1,566	1,513	1,480	1,941	2,284	3,838	4,338	2,057	955	1,054	1,459	1,659
20%	2,220	1,696	1,657	1,698	2,335	3,162	4,736	6,294	2,953	1,111	1,248	1,688	2,131
30%	2,451	1,795	1,789	1,886	2,714	3,570	5,468	7,424	4,389	1,235	1,335	1,796	2,263
40%	2,571	1,906	1,884	2,113	3,141	3,901	6,456	8,671	5,814	1,439	1,414	1,872	2,600
50%	2,832	1,998	1,941	2,163	3,725	4,824	7,174	10,188	7,036	1,615	1,537	2,013	3,153
60%	3,066	2,170	2,035	2,352	6,588	6,296	7,755	11,785	8,244	1,853	1,758	2,180	3,591
70%	3,543	2,706	2,140	2,985	8,203	7,804	8,633	12,841	9,134	2,274	2,040	2,969	3,999
80%	3,925	3,173	2,447	3,531	9,884	9,802	9,864	13,664	11,222	3,278	2,337	3,393	4,851
90%	4,020	3,434	3,024	7,772	14,782	13,521	13,926	19,299	14,257	4,450	2,958	3,543	6,312
Maximum	6,343	16,297	24,021	58,041	34,271	48,485	28,647	31,045	34,035	16,706	7,165	7,677	15,552
Average	3,003	2,523	2,791	4,285	6,847	7,225	8,162	11,127	7,940	2,644	1,837	2,388	3,658