B.F. Sisk Dam Corrective Action Study Planning Study Report

Appendix B Modeling Technical Report

Prepared for Reclamation by MBK Engineers and CDM Smith under Contract No. R10PC20537

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Bureau of Reclamation
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Chapter 1
Background and Project Description

The purpose of the B.F. Sisk Dam Corrective Action Study Economic Analysis is to address potential restrictions on the operation of San Luis Reservoir resulting from safety of dam concerns. The Reservoir Restriction alternatives identified reduce the usable capacity of San Luis Reservoir for both the Central Valley Project (CVP) and State Water Project (SWP), while the Breach Alternative effectively eliminates San Luis Reservoir as part of CVP and SWP operations. Restrictions on the operation of San Luis Reservoir affect system-wide operations of both the CVP and SWP, including water supplies delivered to contractors in the export service area. Restricting the volume of San Luis Reservoir limits the ability of the CVP and SWP to store available surplus flows from the Sacramento-San Joaquin River Delta (Delta) and to re-store water released from CVP and SWP reservoirs upstream of the Delta. A smaller San Luis Reservoir restricts the volume and alters the timing of water supply deliveries, impacting both irrigation and M&I water supply benefits. Changes to San Luis also impact operations of upstream reservoirs and conditions in the Delta. The Corrective Action Study investigated the lost economic benefits by quantifying the changes to available water supply through hydrologic modeling, and then calculating the economic impacts of those changes.

This technical appendix to the Planning Study Report and environmental documentation describes the modeling tools and assumptions made through analysis of the Corrective Action alternatives. The Planning Study evaluated three alternatives (55-feet Restriction, 47-feet Restriction, and Dam Breach) to determine the economic effects of each potential corrective action relative to a No Action/No Project Alternative (NAA). For the B.F. Sisk Dam Safety of Dams (SOD) Modification Project (Project) Environmental Impact Statement/Environmental Impact Report (EIS/EIR), the Reservoir Restriction Alternative analyzes the impacts of the 55-feet Restriction as the worst-case restriction. Figure 1-1 shows total San Luis Reservoir storage vs. elevation, with the two Reservoir Restriction alternatives.

Each of the three alternatives was simulated in a model of the CVP and SWP to determine the water supply effects to contractors served by the CVP/SWP throughout the State of California. For the Breach Alternative, results from the CVP/SWP system model, CalSim II, were used as input to a spreadsheet model which reallocated water from the CVP's Friant Division to meet delivery shortages to the San Joaquin River Exchange Contractors. Model results for each alternative were compared to the NAA to quantify the changes in water supply deliveries (including low-point interruptions to M&I contractors in the San Felipe Division), reservoir storage levels, river flows, and CVP/SWP operations in the Delta. The simulated water deliveries from this study were

then input to M&I and agricultural economic models to evaluate the lost economic benefits resulting from each alternative. Changes to simulated reservoir storage, river flow, Delta outflow, and Delta exports were used to evaluate environmental impacts as part of the EIS/EIR preparation. Key model results for each alternative are summarized and presented in this report.

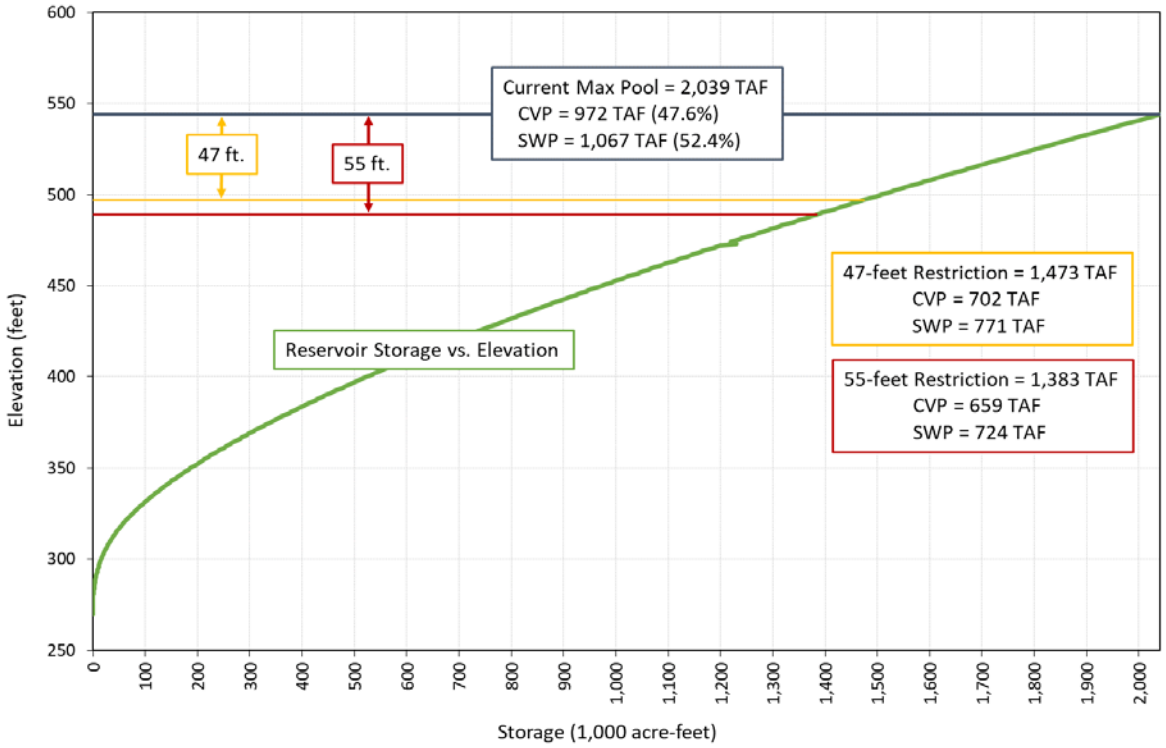

Figure 1-1. San Luis Reservoir Storage vs. Elevation with Restriction Alternatives

Chapter 2
Water Operations Modeling

Water operations modeling is a key step in the analysis of the Corrective Action alternatives, as model results frequently serve as the basis of subsequent economic and environmental analyses. This section provides brief descriptions of the models used to analyze the Corrective Action alternatives. Descriptions include model assumptions and modifications made to baseline model files provided by the Bureau of Reclamation (Reclamation), as well as model limitations for analysis of the Corrective Action alternatives.

2.1 Operations Models

Two models were used to analyze the effects of the three Corrective Action alternatives. CalSim II was used to simulate CVP/SWP operations, including San Luis Reservoir. Subsequent analysis for the Breach Alternative utilized CalSim II results to reallocate water from the CVP's Friant Division to meet delivery shortages to the San Joaquin River Exchange Contractors. The assumptions made for the Friant Division analysis are discussed in Chapter 5.

2.1.1 CalSim II

Water operations modeling of the CVP/SWP system was performed using CalSim II. CalSim II is a planning model designed to simulate operations of CVP and SWP reservoirs and water delivery systems. CalSim II simulates flood control criteria, water delivery policies, in-stream flow, and Delta outflow requirements. CalSim II is the best available tool for modeling CVP and SWP operations and is the primary system-wide hydrologic model used by Reclamation and the California Department of Water Resources (DWR) to conduct planning and impact analyses of potential projects.

CalSim II is a simulation by optimization model. The model simulates operations by solving a mixed-integer linear program to maximize an objective function for each month of the simulation. CalSim II was developed by Reclamation and DWR to simulate operation of the CVP and SWP for a set of defined physical conditions and regulatory requirements. The model simulates these conditions using 82 years of historical hydrology from water year 1922 through 2003.

This study uses CalSim II modeling previously produced for the San Luis Low Point Improvement Project (SLLPIP), which was developed from a baseline model provided by Reclamation to the project team. Reclamation developed the baseline CalSim II simulation at a future level of development in January 2015.

The baseline study includes actions in the reasonable and prudent alternatives from National Marine Fishery Service's 2009 Biological Opinion (BO) for Chinook salmon and U.S. Fish and Wildlife Service's 2008 BO for delta smelt. Additional key assumptions governing CVP/SWP operations in CalSim II are described in Attachment A.

2.1.2 CalSim II Representation of San Luis Reservoir

San Luis Reservoir is a shared facility between the CVP and SWP, located west of Los Banos in California's Central Valley. The reservoir can hold 2.039 million acre-feet (MAF) of water, with the SWP having a 52% share of storage and the CVP having a 48% share. The storage split was determined based on cost sharing at the time of construction, and is set in a 1961 agreement between the United State of America and the State of California. San Luis Reservoir stores water conveyed south of the Delta through the California Aqueduct and the Delta-Mendota Canal. San Luis creates additional flexibility for upstream and Delta project operations, and also acts as an important source of water supply during periods of reduced surface water availability and when regulatory requirements limit Delta exports.

CalSim II simulates San Luis Reservoir as two separate but connected reservoirs, with maximum and deadpool storage levels relative to each project's share of total reservoir storage. The CVP's share of San Luis (CVP San Luis) has a maximum storage volume of 972 thousand acre-feet (TAF), and a deadpool level of 45 TAF. The SWP's share of San Luis (SWP San Luis) has a maximum storage volume of 1,067 TAF, and a deadpool level of 55 TAF. Water can be stored in CVP San Luis from the Delta-Mendota Canal via O'Neill Forebay, and can be released to downstream demands on the California Aqueduct and Delta-Mendota Canal. The Pacheco Pumping Plant delivers water from CVP San Luis to the San Felipe Division of the CVP on the westside of the reservoir. Water can be stored in SWP San Luis from the California Aqueduct via O'Neill Forebay, and can be released to meet downstream demands on the California Aqueduct.

To simulate actual operations, operation of each San Luis reservoir in CalSim II is governed by "rulecurve". Rulecurve prioritizes the balance between North-of-Delta (NOD) reservoirs and San Luis Reservoir, by releasing water from NOD reservoirs for export when there is a choice between storing water in NOD reservoirs or releasing water for export and re-storing it in San Luis Reservoir. The rulecurve value for each San Luis reservoir is updated monthly to provide a target storage in CVP/SWP San Luis. Annual maximum storage (high-point) is typically reached at the beginning of April, while minimum storage (low-point) occurs in August. As the growing season comes to an end and agricultural deliveries decrease, exports become greater than deliveries, and San Luis will begin to fill. San Luis will continue to fill with Delta surplus through the winter months. Project allocations become more certain at the beginning of April, and are based on available storage in San Luis and NOD reservoirs, forecasted inflow to NOD reservoirs, and the ability of the projects to export. When

exports are constrained in April through June, San Luis is relied on to be the main source of South-of-Delta (SOD) deliveries. Figure 2-1 shows typical monthly San Luis Reservoir storage and operations.

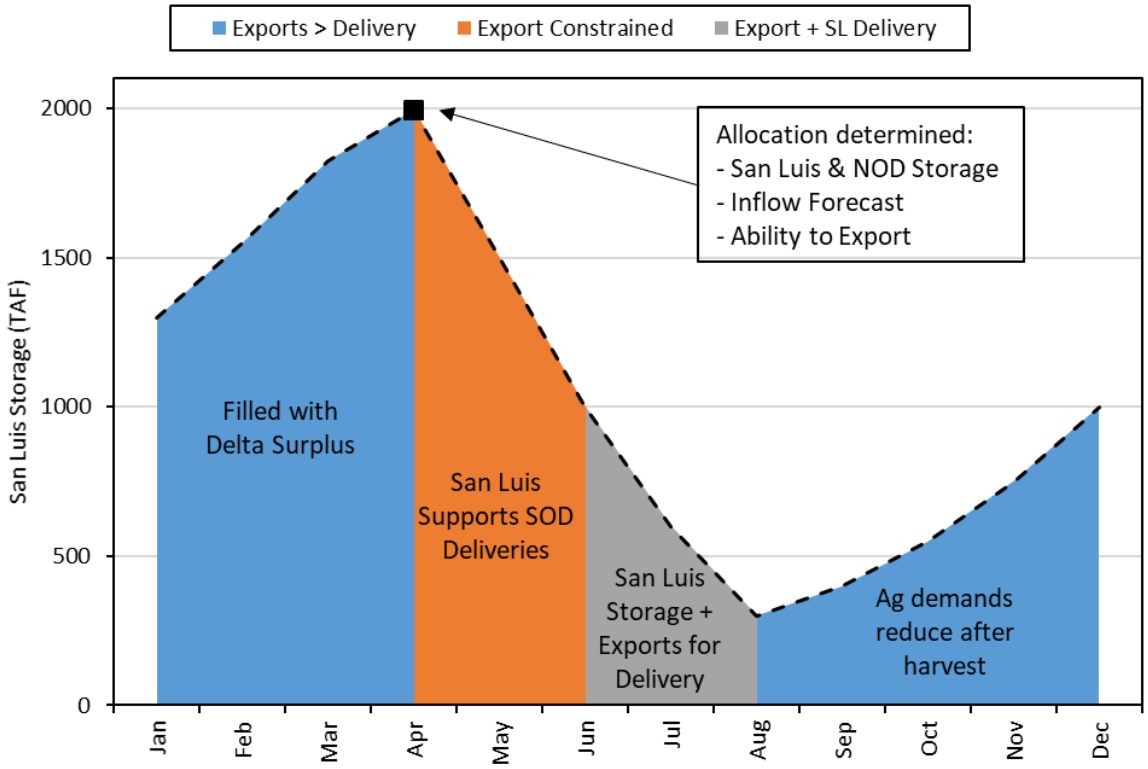

Figure 2-1. Typical San Luis Reservoir Storage and Operations

2.1.3 CalSim II Representation of SWP Article 21 Interruptible Deliveries

Article 21 is an interruptible water supply available to SWP contractors when the following conditions exist simultaneously:

1. SWP San Luis is full.

2. The Delta is in excess.

3. Sufficient capacity exists at Banks Pumping Plant and in the California Aqueduct to deliver additional water and not affect Table A allocations or deliveries.

These three conditions are typically only present during January – March and most frequently occur in years with above-average runoff. In CalSim II, 13 SWP contractors have a listed demand for Article 21 deliveries, which was estimated to be the maximum amount of additional delivery beyond Table A allocations that each contractor would be able to accept. If the size of San Luis Reservoir is reduced or San Luis is removed from the system, the conditions

which allow for Article 21 deliveries will occur more frequently. Accordingly, the frequency and volume of Article 21 deliveries will also increase.

Total annual Article 21 demand in CalSim II is up to 2.5 million acre-feet (MAF). The majority of the demand is from Kern County Water Agency and Metropolitan Water District (MWD), which account for 1.4 and 0.8 MAF of the total annual demand, respectively. In years of Kern River surplus, CalSim II assumes that KCWA demands are met with surplus water from the Kern River. In years of Kern River surplus, total annual Article 21 demand is reduced to 824 thousand acre-feet (TAF) with all demands except MWD and North Bay Aqueduct (NBA) reduced to zero. Figure 2-2 displays the monthly SWP Article 21 demand pattern for Kern River non-surplus and surplus years.

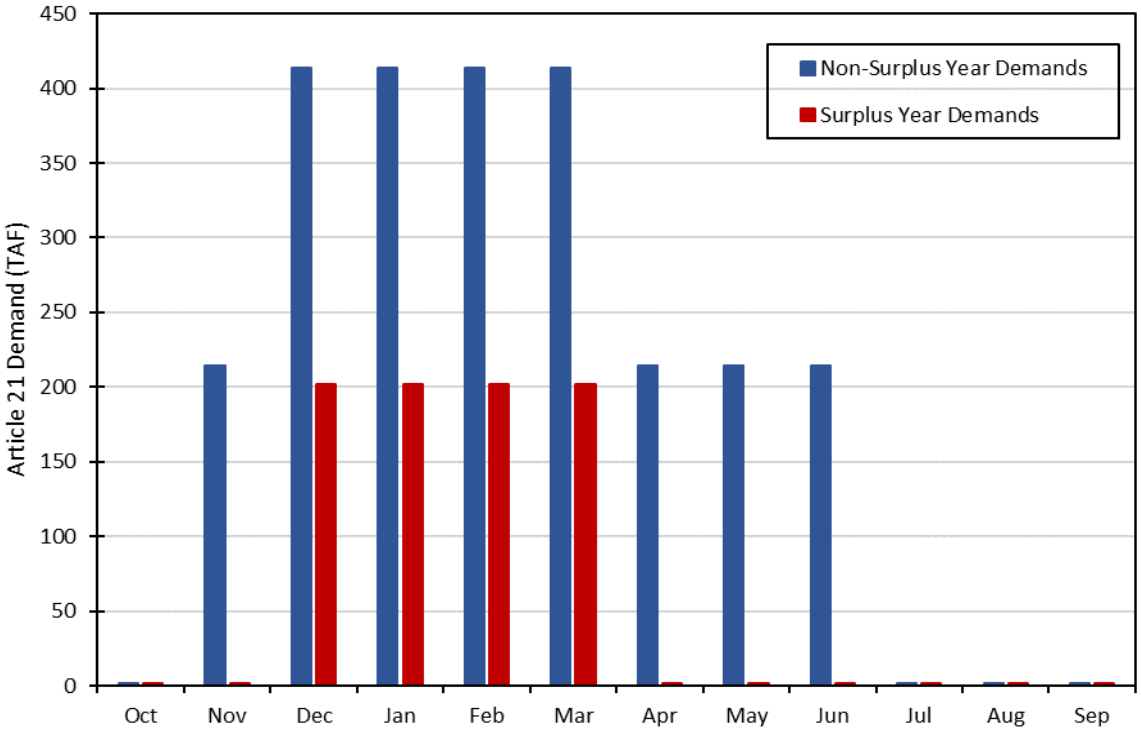

Figure 2-2. Monthly Article 21 Demand Pattern for Kern River Surplus and Non-Surplus Years

There is some question whether SWP contractors, particularly KCWA and MWD, would be able to accept the larger volumes of Article 21 deliveries, and deliveries in consecutive years likely to be present under a reduced or removed San Luis Reservoir. Historical operations of the Kern Water Bank suggest that KCWA would be able to accept and store larger Article 21 deliveries in groundwater banks. MWD would also likely be able to accept larger volumes of Article 21 deliveries given the storage capacity at Diamond Valley Reservoir, and MWD's ability to store water on the Colorado River System. MWD (and several other South Coast contractors) can also borrow water from Lake Perris

and Castaic Lake using Article 54 of their SWP contracts. Article 54 would allow these contractors additional flexibility to manage lower Table A allocations and make up any storage reductions at Lake Perris and Castaic Lake with additional Article 21 supplies. However, these Article 21 assumptions may be overly optimistic, and additional capacity and/or operational changes beyond the scope of this study may be necessary for most contractors to fully take advantage of additional Article 21 supplies.

2.1.4 Modifications to Reclamation CalSim II Baselines

Baseline models provided by Reclamation required modifications for use in evaluating operations under the Corrective Action alternatives, including the NAA. The following sections describe key changes.

Representation of CVP Section 215 Deliveries

The most significant modification to the baseline model provided by Reclamation was the inclusion of logic to simulate Section 215 deliveries to SOD CVP contractors. Section 215 (for Ag contractors) and M&I spill water is defined as unstorable water to be released due to flood control criteria or un-managed flood flows. Section 215[1] is available when the following conditions exist simultaneously:

1. CVP San Luis is full.

2. The Delta is in excess.

3. Sufficient capacity must exist at Jones Pumping Plant and in the Upper Delta Mendota Canal to not affect delivery of any CVP contract allocations or deliveries. Contractors cannot accept Section 215 deliveries in lieu of their contract delivery (e.g. for the purpose of "Carrying Over" Contract supply).

CalSim II does not currently simulate Section 215 deliveries because of the infrequent and small volumes of available Section 215 supply. However, in the Corrective Action alternatives, San Luis fills more frequently and Section 215 would be available more frequently, in larger volumes, and for longer periods of time. Additionally, the Corrective Action alternatives reduce total CVP SOD deliveries to areas that are already frequently water supply limited. As such, it was appropriate to assume CVP SOD contractors would have a demand for and take Section 215 deliveries when available. For the Corrective Action alternatives to be comparable to the NAA, Section 215 was added into the NAA CalSim II model.

To meet the requirement that Section 215 deliveries do not affect contract delivery, demand for Section 215 was simulated to be located on the Lower

[1] For simplicity, all Section 215 and M&I spill water are collectively referred to as Section 215 throughout the rest of this report.

Delta-Mendota Canal. To meet the requirement that CVP San Luis is full and that the Delta is in excess, Section 215 demands were given a lower weight (priority) than filling San Luis or delivering contract supplies. Section 215 demands were weighted equally with Article 21 demands. For each month of the simulation, demand for Section 215 water was set to equal the difference between total CVP SOD contract demand and delivery. This assumption limits Section 215 delivery to meet a 100% contract delivery in each month. In some months, this might be a relatively modest estimate. However, it limits the need to make assumptions related to contractors' ability to accept or require new projects or infrastructure to handle additional water supply. Figure 2-3 provides an example of the Section 215 demand calculation.

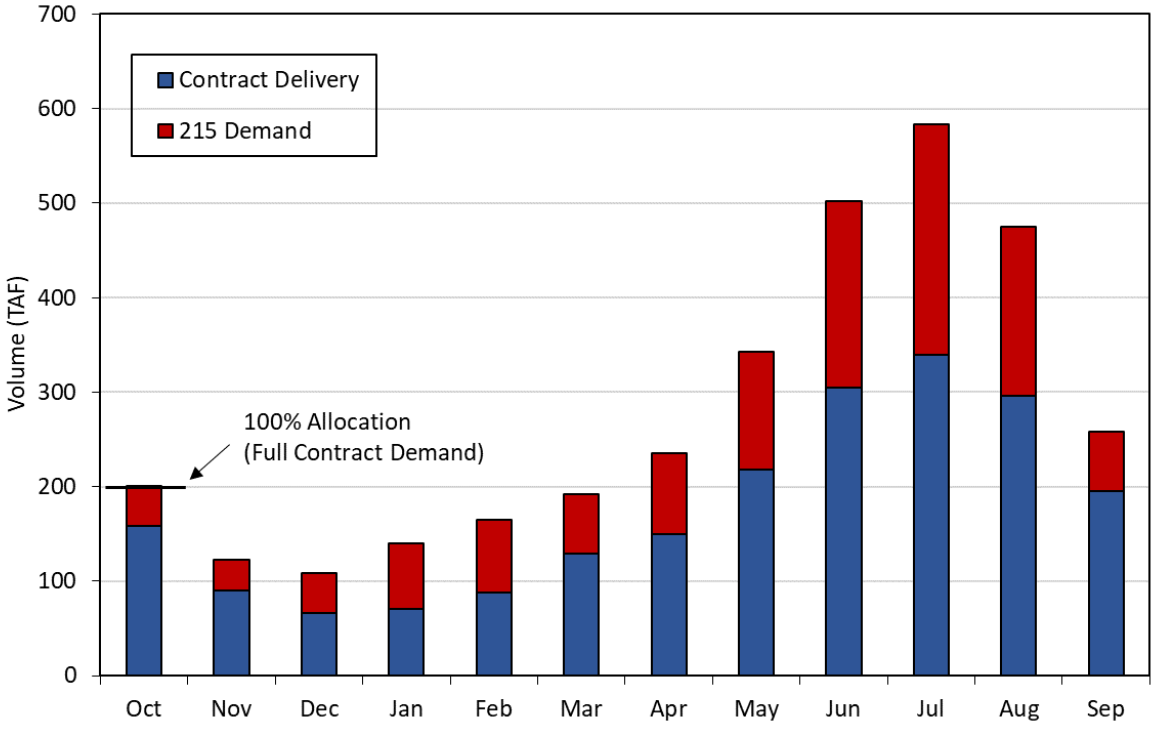

Figure 2-3. Example Calculation of Monthly Section 215 Demand

The demand estimation may be overly optimistic for the ability of CVP SOD contractors to accept this volume of Section 215 deliveries, particularly given the resulting shift in delivery pattern in the Corrective Action alternatives. There is considerable uncertainty regarding how the CVP and SWP would operate and share available surplus, especially in a scenario with San Luis removed from the system. The approach taken in this study is one of many potential operational approaches, but one that attempts to meet the reasonable and realistic expectation that CVP SOD users would have a demand for and take delivery of Section 215 water when it is available at a greater frequency and in much greater volumes.

Refined Export Estimates and San Luis Reservoir Operations

Identical to the SLLPIP study, modifications were made to Delta export estimates, simulated CVP and SWP allocations, and the operations of San Luis Reservoir. These modifications to CalSim II were made by MBK Engineers in 2015 under a separate contract with Reclamation intended to improve simulated operations of San Luis Reservoir. Additional detail on the specific model changes and the associated effects to CalSim II simulated operations are provided in a technical memorandum from July 2015 (Easton, 2015).

Model improvements addressed three long-standing issues in CalSim II simulated operations, and resulted in a significantly improved operation of San Luis Reservoir. The first improvement involved replacing static input tables of estimated Delta export capacity used in the allocation logic. These tables were replaced with an iterative process that uses prior simulations to develop more reliable, and more realistic Delta export estimate forecasts.

The second improvement was to address instances where simulated CVP allocations to SOD water service contractors were low, yet a significant volume of water remained in the CVP portion of San Luis Reservoir. Under these conditions, Reclamation is likely to increase SOD allocations to deliver the water that is already in storage. This model improvement tends to increase allocations and draw down storage in the CVP portion of San Luis Reservoir more during drier periods, particularly during water years 1932 through 1934.

The third improvement with implications to the operation of San Luis Reservoir and the SLLPIP were modifications to the San Luis target storage levels, or rulecurve, in CalSim II. Rulecurve logic was improved to better simulate the scheduling of releases and Delta exports to balance storage in CVP and SWP reservoirs.

Each of these three model improvements affect the simulated operation of San Luis Reservoir in CalSim II, and improve a previous deficiency in model operations for the SLLPIP and Corrective Action studies.

San Felipe Division M&I Delivery Interruptions

CalSim II was modified to simulate San Felipe Division M&I water service delivery interruptions that may occur due to low point issues. Simulated deliveries to M&I water service contractors were interrupted when previous end-of-month combined CVP and SWP storage in San Luis Reservoir was less than 300,000 acre-feet. Interrupted San Felipe Division M&I water service contract deliveries were not rescheduled or delivered in later months. This water was simulated as remaining in San Luis Reservoir and available for allocation in future years. San Felipe Division agricultural water service deliveries were simulated to occur as long as storage in CVP San Luis was above dead pool.

2.1.5 Level of Development

CalSim II simulations at a projected Level of Development (LOD) are used to depict how the modeled water system might operate with an assumed physical and institutional configuration imposed on a long-term hydrologic sequence. A future LOD study is needed to explore how the system may perform under an assumed set of physical and institutional conditions. This future setting is developed by assuming year 2030 land use, facilities, and operational objectives. The NAA uses this future setting for National Environmental Policy Act (NEPA) analysis.

A NAA CalSim II simulation depicts how the Delta, its major tributaries, and the CVP/SWP system may operate in the future without the Project. Over the last 150 years, areas tributary to the Delta have and continue to experience numerous physical and institutional changes. Projecting the availability of facilities, institutional and regulatory requirements, and the practices that will affect the management of future water supplies and demands is a daunting task. Nevertheless, reasonable assumptions must be made to estimate future conditions.

2.1.6 CalSim II Limitations

There are limitations to the use of CalSim II for most projects. CalSim II is a monthly model and does not capture daily fluctuations in flow, reservoir storage, or Delta exports.

CalSim II is a simulation by optimization model of a very complex system. This complexity, combined with mathematical optimization techniques, can create relatively large differences in model results in some months or years for comparatively small differences in simulated conditions in the CVP/SWP system. These differences are more model nuance than effects of a project alternative. Interpretation of these differences is important when reviewing results to avoid drawing erroneous conclusions.

A key limitation for the Corrective Action study analyses is the ability to adequately simulate San Luis Reservoir operations. CalSim II is the only available model that adequately simulates the integrated operations of the CVP and SWP, both north and south of the Delta; therefore, it must be relied upon as the foundation of most studies that affect CVP/SWP operations. However, CalSim II was developed primarily to simulate reservoir operations upstream of the Delta, Delta conditions, and export operations. CalSim II does not consider several variables that affect San Luis Reservoir storage. An understanding of the limitations of CalSim II for the analysis of the Corrective Action alternatives is necessary to properly characterize results.

One method for evaluating model adequacy is to compare model results with observed data. Unfortunately, this method is no longer appropriate for CalSim II and San Luis Reservoir storage. CalSim II assumptions for the NAA include actions in the reasonable and prudent alternatives from National Marine Fishery

Service's 2009 BO for Chinook salmon and U.S. Fish and Wildlife Service's 2008 BO for delta smelt. Requirements contained in the BOs result in significant operational changes, including changes in upstream reservoir release, the ability to move water through the Delta, and the operation of both CVP and SWP portions of San Luis Reservoir. CVP/SWP operators have operated to these requirements since 2009, thus providing a limited range of observed data under the BOs. Additionally, CalSim II's simulation period does not include the historical hydrology for the period since implementation of the BOs. As such, no common period between the model and observed operations exists under similar regulatory conditions.

2.1.7 Coordinated Operations Agreement Assumptions

The Coordinated Operations Agreement (COA) is an agreement between the United States of American and the State of California to operate the CVP and SWP in a manner that meets Sacramento Valley and Delta needs, while maintaining their respective annual water supplies. COA outlines the percent of responsibility to be borne by each project to meet Sacramento Valley and Delta requirements, as well as how unstored water is shared and allocated to each project.

For the alternatives in this study, no changes to COA responsibilities, accounting, allocations, operational framework, or non-COA defined agreements (e.g. sharing of regulatory reductions to export capacity) were made. For the Restriction alternatives, each project's share of the reduction in reservoir storage was set to be consistent with the current 52% (SWP) / 48% (CVP) split of San Luis Reservoir storage. Many different arguments could be made for potential changes to COA and to each project's share of reservoir storage that would occur under the Restriction and Breach alternatives. However, given the complex legal and institutional questions surrounding COA, at this time it is difficult to suggest a potential change that would be more likely than another.

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Chapter 3
No Action/No Project Alternative

The following section describes the No Action/No Project Alternative and summarizes key model results for the alternative. The NAA is the same baseline model used in the SLLPIP studies, except for the addition of Section 215 deliveries to CVP SOD contractors.

3.1 No Action/No Project Alternative

Results from the NAA simulation are used to depict operation of the CVP and SWP at a future level of development. NAA results are used in a comparative sense with results from the Corrective Action alternatives to quantify changes in CVP/SWP operations. SOD CVP and SWP water supply deliveries and operation of San Luis Reservoir are key results for the NAA simulation. These results are summarized in the following figures and tables.

3.1.1 South-of-Delta CVP and SWP Deliveries

Table 3-3 displays annual average delivery volumes for CVP SOD contractors by water year type. Water year type is defined by the Sacramento Valley 40-30-30 Index, which indicates whether the current water year is Wet, Above Normal, Below Normal, Dry, or Critical. Section 215 was included in the model to provide a direct comparison to results of the Corrective Action alternatives. Section 215 deliveries in the NAA are typically small and only occur in wetter years. Total SOD delivery volumes also include canal and aqueduct losses within the export service area.

Table 3-1. Annual Average CVP SOD Deliveries by Water Year Type

CVP South-of-Delta Deliveries (TAF)	Exchange Contractors	Refuge	Ag Service	M&I	Section 215	Total SOD	Total SOD w/ 215
Wet	874	280	1,341	132	16	2,810	2,826
Above Normal	870	275	990	113	28	2,433	2,461
Below Normal	872	278	852	112	23	2,297	2,320
Dry	862	275	584	106	0	2,010	2,010
Critical	752	249	171	84	0	1,440	1,440
All Years	853	273	869	113	13	2,291	2,305

Table 3-2 displays annual average delivery volumes for CVP NOD contractors. Deliveries to Settlement Contractors and refuges are 100% in all years except Shasta Critical Years.

Table 3-2. Annual Average CVP NOD Deliveries by Water Year Type

CVP North-of-Delta Deliveries (TAF)	Settlement Contractors	Refuge	Ag Service	M&I	Total NOD
Wet	1,855	88	321	227	2,476
Above Normal	1,871	88	311	221	2,481
Below Normal	1,902	89	218	203	2,421
Dry	1,900	85	146	189	2,324
Critical	1,770	58	47	154	2,047
All Years	1,863	83	224	203	2,371

Table 3-3 displays annual average deliveries for the SWP. Article 21 deliveries are significant in wetter years, and less in drier years.

Table 3-3. Annual Average SWP Deliveries by Water Year Type

SWP Deliveries (TAF)	Ag SOD	M&I	Table A	Article 56	Article 21	Total SWP
Wet	799	2,317	3,116	112	98	3,326
Above Normal	670	1,976	2,647	66	103	2,816
Below Normal	643	1,908	2,552	108	52	2,713
Dry	501	1,518	2,019	80	19	2,118
Critical	292	959	1,251	54	12	1,317
All Years	614	1,823	2,437	89	61	2,587

3.1.2 Article 56 Sensitivity Analysis

SWP contractors have the option to delay delivery of Table A water to a future contract year, by "carrying over" their water in San Luis Reservoir per the terms of Article 56 in their contract. Carryover water allows contractors to augment their delivery in a year where additional water might be needed, particularly Below Normal and Dry years. However, the ability to carryover supply comes with some risk, because if San Luis fills, carryover supplies are converted to SWP supply and are no longer available only to the original contractor.

There was some concern that CalSim II's Article 56 logic would not function properly with a smaller San Luis Reservoir. In CalSim II, five SWP contractors have a listed demand for Article 56 deliveries. Each contractor's Article 56 demand is a function of their maximum Article 56 demand, current Table A allocation, and current Article 56 supply in storage. An additional model run with Article 56 demands set to zero was completed to test the sensitivity of the model's logic. Results of this model run are displayed in Table 3-4. The removal of Article 56 increases Table A deliveries even more than the reduction of Article 56 deliveries in Wet, Above Normal, and Below Normal years. However, in Dry and Critical years, Table A deliveries are much less than the

reduction of Article 56 delivery. Additionally, 5.7 TAF of Article 56 water is "spilled" annually in the NAA. Spilled water is a result of an imperfect simulation of an imperfect operation, and represents a lost opportunity to store and deliver additional Table A supplies. Nonetheless, the results demonstrate that the Article 56 logic functions properly, by augmenting Table A supplies, particularly in Dry and Critical years.

Table 3-4. Change in SWP Deliveries from NAA without Article 56

SWP Deliveries (TAF)	Table A Change from NAA	Art. 56 Change from NAA	Art. 21 Change from NAA	Total SWP Change from NAA
Wet	136	-112	5	29
Above Normal	118	-66	1	53
Below Normal	124	-108	2	18
Dry	43	-80	0	-37
Critical	7	-54	0	-47
All Years	92	-89	2	5

3.1.3 San Luis Reservoir Operations and Interrupted San Felipe M&I Deliveries

Figure 3-1 illustrates the annual maximum and minimum San Luis Reservoir storage as a probability of exceedance. Results indicate that storage is below 300 TAF in approximately 20 percent (17 out of 82) of all years at a future level of development. Low point issues are assumed to occur when total San Luis Reservoir storage is less than 300 TAF. When low point issues occur, San Felipe Division M&I contractors do not take delivery of project water due to water quality concerns, and deliveries are interrupted.

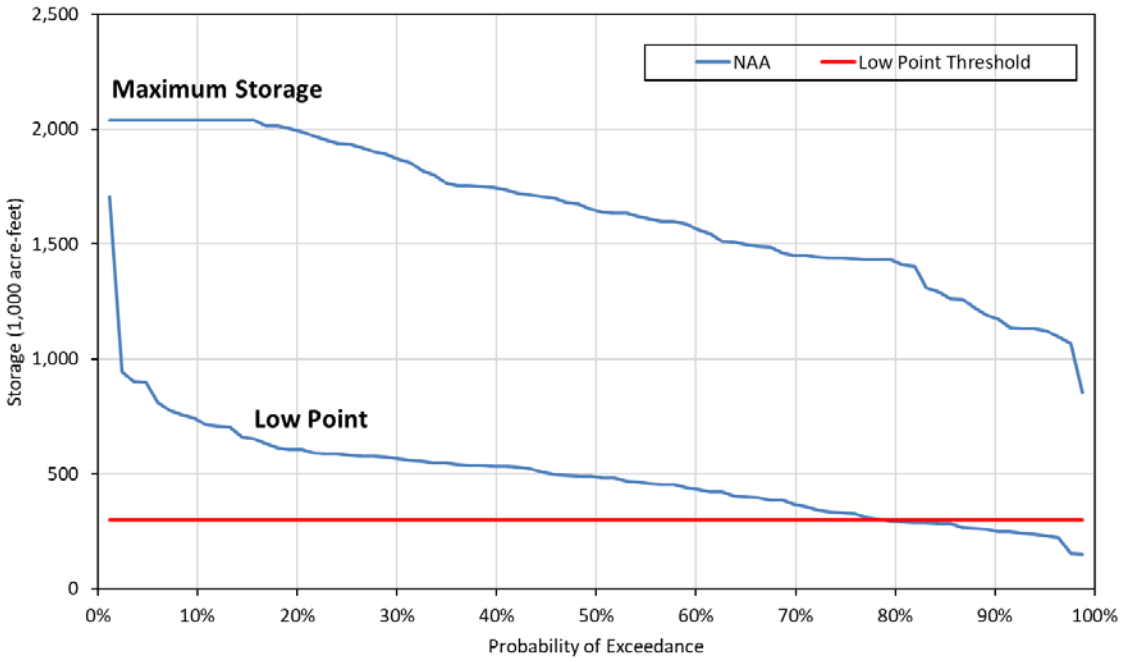

Figure 3-1. Probability of Annual Maximum and Minimum San Luis Reservoir Storage

The annual maximum storage levels for CVP and SWP San Luis are plotted as a probability of exceedance in Figure 3-2. Results indicate that CVP San Luis is full (972 TAF) in approximately 23% of years, while SWP San Luis is full (1,067 TAF) in approximately 22% of years. One of the requirements to deliver Section 215 and Article 21 is for San Luis storage to be full. As such, the frequency of a full San Luis affects the frequency and potential volume of Section 215 and Article 21 supplies.

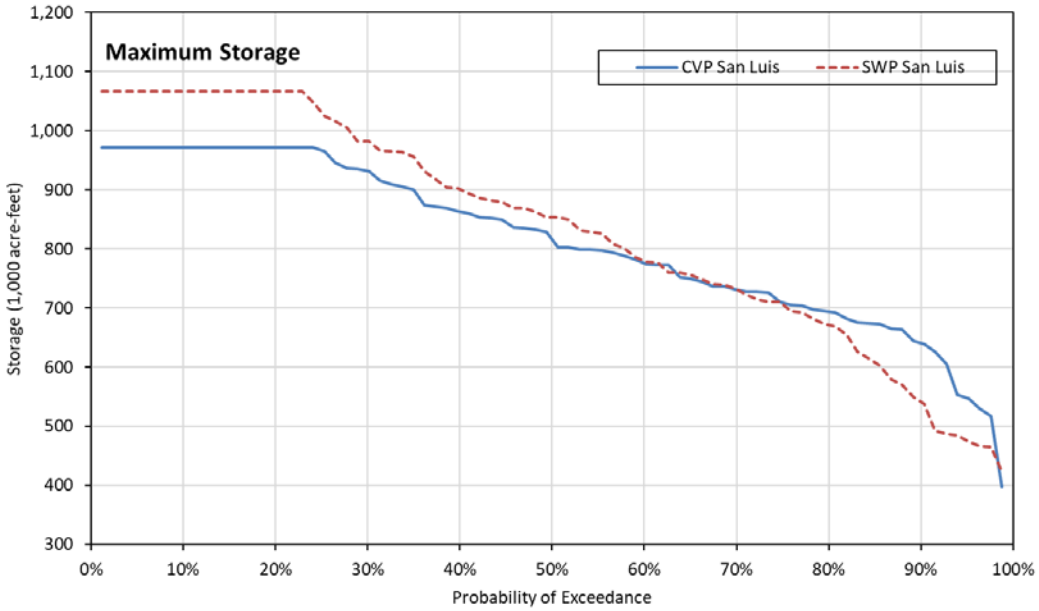

Figure 3-2. Probability of Annual Maximum Storage for CVP and SWP San Luis

Table 3-5 is a summary of average annual interrupted San Felipe Division M&I deliveries for the NAA.

Table 3-5. Average Annual Interrupted San Felipe Division M&I Deliveries

Sacramento Valley Index	NAA (TAF)
Wet	1.1
Above Normal	6.3
Below Normal	4.6
Dry	1.4
Critical	3.4
All Years	2.9

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Chapter 4
Reservoir Restriction Alternative (55 feet)

The Reservoir Restriction Alternative (55 feet) includes a 55-feet reduction in the maximum operational elevation of San Luis Reservoir, allowing for a maximum elevation of 489 feet. The lower maximum elevation reduces allowable storage in the reservoir to 1,383 thousand acre-feet (TAF), a reduction of 656 TAF. The SWP/CVP share of San Luis is kept at 52% / 48%, with SWP San Luis having a maximum storage of 724 TAF and CVP San Luis having a maximum storage of 659 TAF.

To implement this change, adjustments to reservoir sizes and some allocation logic that relied on reservoir size were made to the CalSim II baseline code. The updated Delta export estimate logic developed by MBK was also applied to the model to improve export operations and operation of San Luis Reservoir.

The B.F. Sisk Dam SOD Project EIS/EIR analyzes the 55-feet Restriction as the worst-case restriction.

Fixed CVP North of Delta Ag Service Contractor Allocations

For the Restriction and Breach alternatives, delivery allocations to CVP NOD Ag Service contractors were fixed to equal allocations made in the NAA. While there are years when NOD CVP Ag allocations may be higher without San Luis, that is also true in the NAA. Attempts to refine NOD CVP Ag allocations were not made because NOD deliveries are not the focus of this study. Additionally, it is difficult to predict whether Reclamation's current policy of equal NOD and SOD allocations (unless export constrained) would hold in the future. "Export constrained" for SOD Ag service deliveries will nearly always occur in April and May in the Breach Alternative because all available export capacity is needed to meet SOD Exchange Contractor and Refuge demands. There is an argument that NOD CVP Ag allocations would be higher with a smaller San Luis Reservoir or without San Luis Reservoir. However, that argument relies on past practice and policy that may not hold true in a system with a smaller San Luis or in a system without San Luis Reservoir.

4.1 Reservoir Restriction Alternative (55 feet) Results

Results from the 55-feet Reservoir Restriction Alternative are summarized and compared to the NAA. The primary difference between the NAA and the 55-feet Restriction Alternative is the size of CVP and SWP San Luis. The reduction in reservoir size impacts all parts of the CVP/SWP system, including reductions in SOD exports and deliveries, availability of Section 215 and Article 21

supplies, changes to Delta outflow, and changes to upstream reservoir storage. Accordingly, key outputs from the model are simulated deliveries to all SOD contractors, San Luis Reservoir storage, as well as the values of important system parameters. The following figures and tables summarize these results for the 55-feet Reservoir Restriction Alternative as compared to the NAA.

4.1.1 Summary of South-of-Delta Deliveries

San Luis Reservoir provides an important source of water supply during periods affected by reduced surface water availability and regulatory restrictions on Delta exports. As such, reducing the size of the reservoir limits the benefits the reservoir is able to provide by reducing the volume of water able to be delivered within the export service area. Table 4-1 provides a summary of the average annual CVP SOD delivery by water year type for the 55-feet Restriction Alternative and the change from the NAA. Tables 4-2 through 4-4 provide a detailed summary of average monthly CVP SOD deliveries with Section 215 and the change from the NAA. Exchange Contractors and refuges did not incur a reduction in delivery during any water year and thus are not included in the table. Results indicate a significant reduction of deliveries to Ag service contractors occurs in all year types. A large portion of this reduction is made up with Section 215 pumping, some of which reflects water that was available in the system, but was unable to be allocated because of an inability to export and deliver the water on a typical delivery pattern.

Table 4-1. Annual Average CVP SOD Deliveries and Change from the NAA

CVP South-of-Delta Deliveries (TAF)	Ag Service	M&I	Section 215	Total SOD	Total SOD w/ 215
Wet	1,066	122	126	2,525	2,652
Above Normal	757	104	124	2,190	2,314
Below Normal	650	109	132	2,092	2,223
Dry	455	100	98	1,875	1,972
Critical	123	78	44	1,386	1,430
All Years	678	106	108	2,093	2,201
Change from No Action Alternative					
Wet	-275	-10	110	-285	-175
Above Normal	-233	-10	95	-243	-147
Below Normal	-202	-3	108	-205	-97
Dry	-129	-6	98	-135	-38
Critical	-47	-6	44	-54	-10
All Years	-191	-7	95	-198	-103

Table 4-2. CVP SOD Agricultural Deliveries Under the 55-feet Reservoir Restriction Alternative and Change from the NAA

No Action/No Project Alternative													
	Oct	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Total**
W	35	26	37	64	78	72	96	145	233	290	209	66	1,351
AN	24	17	25	52	59	52	73	108	175	218	157	50	1,010
BN	30	22	32	60	72	41	57	85	137	170	122	39	867
D	24	18	25	44	51	22	37	56	90	111	80	25	584
C	16	12	17	29	33	5	6	8	13	17	12	4	171
All	27	20	29	52	62	43	60	90	145	180	130	41	877
55-feet Reservoir Restriction Alternative													
	Oct	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Total**
W	27	20	29	72	99	75	77	115	186	231	166	53	1,149
AN	19	14	24	48	75	67	55	81	132	163	118	37	834
BN	23	17	27	69	78	56	43	64	104	129	93	29	733
D	19	14	21	52	72	35	29	42	68	85	61	19	518
C	12	9	12	27	38	13	4	5	9	11	8	3	151
All	21	16	24	57	77	53	47	69	112	139	100	32	747
Change from No Action Alternative													
	Oct	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Total**
W	-7.7	-5.7	-7.9	7.7	21.6	2.4	-18.2	-29.6	-47.8	-59.4	-42.8	-13.6	-201
AN	-4.6	-3.4	-0.8	-4.6	16.2	15.0	-17.9	-27.0	-43.6	-54.2	-39.0	-12.4	-176
BN	-7.3	-5.4	-5.1	9.0	6.5	14.3	-13.3	-20.4	-32.9	-40.9	-29.4	-9.3	-134
D	-4.6	-3.4	-4.8	7.8	21.1	13.2	-8.2	-13.4	-21.6	-26.8	-19.3	-6.1	-66
C	-4.0	-3.0	-4.2	-1.8	4.4	8.4	-1.9	-2.8	-4.5	-5.6	-4.0	-1.3	-20
All	-6.0	-4.4	-5.2	4.7	15.6	9.5	-12.8	-20.2	-32.6	-40.5	-29.1	-9.3	-130

Key: AN – Above Normal; BN – Below Normal; C – Critical; D – Dry; W – Wet

Table 4-3. CVP SOD M&I Deliveries Under the 55-feet Reservoir Restriction Alternative and Change from the NAA

No Action/No Project Alternative													
	Oct	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Total**
W	9	11	12	8	4	15	11	10	10	12	14	15	133
AN	7	9	11	8	4	13	10	10	10	11	10	13	115
BN	8	10	12	8	4	12	9	9	9	10	11	12	114
D	8	10	11	7	3	10	9	8	8	9	11	11	106
C	7	10	10	7	3	8	7	6	6	7	8	6	84
All	8	10	11	8	4	12	10	9	9	10	11	12	114
55-feet Reservoir Restriction Alternative													
	Oct	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Total**
W	9	11	11	10	5	16	10	10	10	11	12	14	129
AN	7	8	11	8	4	16	10	9	9	10	9	10	111
BN	7	10	12	10	5	15	9	8	8	10	11	11	118
D	7	10	10	8	4	13	8	8	8	9	10	10	105
C	6	8	9	7	3	10	7	6	6	7	8	4	80
All	7	10	11	9	5	14	9	8	8	10	11	10	112

Change from No Action Alternative													
	Oct	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Total**
W	-0.6	-0.4	-0.7	1.5	1.2	1.1	-0.9	-0.9	-0.9	-1.1	-1.2	-1.3	-4
AN	-0.4	-1.1	0.4	-0.1	0.8	2.8	-0.7	-0.6	-0.6	-0.7	-0.8	-2.6	-4
BN	-0.4	0.7	-0.1	1.6	0.6	3.0	-0.3	-0.3	-0.3	-0.3	0.3	-0.4	4
D	-1.0	-0.9	-0.6	1.1	1.0	2.4	-0.4	-0.4	-0.4	-0.5	-0.5	-0.9	-1
C	-0.7	-1.7	-0.6	0.1	0.3	1.4	-0.2	-0.2	-0.2	-0.2	-0.2	-1.8	-4
All	-0.7	-0.6	-0.4	1.0	0.8	2.0	-0.5	-0.5	-0.5	-0.6	-0.6	-1.3	-2

Key: AN – Above Normal; BN – Below Normal; C – Critical; D – Dry; W – Wet

Table 4-4. CVP SOD Deliveries Under the 55-feet Reservoir Restriction Alternative and Change from the NAA

No Action/No Project Alternative													
	Oct	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Total**
W	176	103	82	97	124	176	203	297	429	493	409	237	2,826
AN	159	90	69	86	105	152	179	260	370	420	354	218	2,461
BN	169	97	77	93	118	142	159	235	331	371	320	206	2,320
D	161	93	69	76	94	117	140	204	281	310	276	190	2,010
C	148	84	58	59	75	86	96	137	181	191	182	143	1,440
All	165	95	73	85	106	141	162	237	335	377	323	205	2,305
55-feet Reservoir Restriction Alternative													
	Oct	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Total**
W	168	96	74	112	159	192	184	267	380	433	365	222	2,652
AN	154	85	70	83	131	191	161	232	326	365	314	203	2,314
BN	161	92	74	109	133	179	146	215	297	330	291	196	2,223
D	156	88	64	89	126	147	131	190	259	283	256	183	1,972
C	143	79	54	59	84	104	94	134	176	185	178	140	1,430
All	158	90	68	94	132	167	149	217	302	336	294	194	2,201
Change from No Action Alternative													
	Oct	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Total**
W	-8.3	-6.1	-8.5	14.4	35.6	15.6	-18.7	-30.5	-48.7	-60.5	-44.0	-14.9	-175
AN	-5.1	-4.5	1.8	-3.8	25.7	38.7	-18.6	-27.6	-44.2	-54.9	-39.8	-15.0	-147
BN	-7.8	-4.7	-3.7	15.9	14.5	36.5	-13.6	-20.6	-33.2	-41.2	-29.2	-9.7	-97
D	-5.5	-4.3	-5.4	12.7	32.5	30.6	-8.6	-13.8	-21.9	-27.3	-19.8	-7.1	-38
C	-4.7	-4.7	-4.8	-0.3	9.0	18.0	-2.0	-2.9	-4.7	-5.8	-4.2	-3.1	-10
All	-6.6	-5.0	-5.0	9.5	26.0	26.2	-13.2	-20.7	-33.1	-41.1	-29.7	-10.6	-103

Key: AN – Above Normal; BN – Below Normal; C – Critical; D – Dry; W – Wet

Table 4-5 provides a summary of the average annual SWP SOD delivery by water year type for the 55-feet Restriction Alternative and the change from the NAA. Tables 4-6 through 4-8 provide a detailed summary of average monthly SWP SOD deliveries and the change from the NAA. Reductions in Table A deliveries are largely made up through additional Article 21 deliveries, which in turn suggest a minimal impact to total SWP deliveries. Article 56 supplies are also reduced, and the annual average conversion (spill) of Article 56 supply increases to 12.5 TAF. While this represents a lost opportunity to deliver additional Table A supply, it is largely a function of the model's simulation of an imperfect system. The relatively small increase in Article 56 spill also demonstrates the model's sensitivity to the Article 56 logic and that contractors are still utilizing Article 56 despite the increased frequency of SWP San Luis filling.

Table 4-5. Annual Average SWP SOD Deliveries and Change from the NAA

SWP SOD Deliveries (TAF)	Ag SOD	M&I	Table A	Article 56	Article 21	Total SWP
Wet	716	2,121	2,837	70	345	3,251
Above Normal	637	1,882	2,519	44	263	2,826
Below Normal	619	1,847	2,466	81	233	2,780
Dry	459	1,403	1,863	61	184	2,108
Critical	280	925	1,205	45	48	1,298
All Years	568	1,707	2,274	62	235	2,572
Change from No Action Alternative						
Wet	-83	-196	-279	-42	247	-75
Above Normal	-33	-94	-128	-21	160	10
Below Normal	-24	-62	-86	-27	181	67
Dry	-42	-114	-156	-19	165	-10
Critical	-12	-34	-46	-9	36	-19
All Years	-46	-117	-163	-27	174	-16

Table 4-6. SWP SOD Table A Deliveries Under the 55-feet Reservoir Restriction Alternative and Change from the NAA

No Action/No Project Alternative													
	Oct	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Total**
W	287	247	237	65	85	160	206	302	373	397	419	338	3,116
AN	239	198	197	21	43	106	169	253	331	374	395	321	2,647
BN	261	221	212	19	23	51	149	225	314	369	389	319	2,552
D	226	187	182	8	10	19	89	155	248	314	320	262	2,019
C	194	158	152	5	7	11	26	82	136	176	167	137	1,251
All	248	209	202	29	41	81	139	217	295	338	352	286	2,437

55-feet Reservoir Restriction Alternative													
	Oct	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Total**
W	262	219	209	68	84	150	170	266	337	367	392	314	2,837
AN	219	183	175	20	42	109	145	233	318	368	391	317	2,519
BN	242	200	193	24	26	52	127	205	305	375	393	323	2,466
D	213	174	168	8	10	16	66	139	231	298	297	243	1,863
C	186	151	146	5	7	11	26	78	131	169	161	133	1,205
All	230	191	183	31	40	78	115	195	275	324	337	274	2,274
Change from No Action Alternative													
	Oct	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Total**
W	-25	-28	-28	2	-1	-10	-35	-36	-36	-30	-27	-24	-279
AN	-20	-15	-22	-1	-2	3	-24	-20	-13	-6	-4	-5	-128
BN	-19	-20	-19	5	3	2	-22	-20	-9	5	4	4	-86
D	-13	-13	-13	0	0	-3	-23	-16	-17	-16	-23	-19	-156
C	-8	-7	-6	0	0	0	0	-4	-5	-7	-5	-4	-46
All	-18	-18	-19	2	0	-3	-23	-22	-19	-14	-14	-12	-163

Key: AN – Above Normal; BN – Below Normal; C – Critical; D – Dry; Sac Yr Type – Sacramento River Water Year Type; W – Wet

Table 4-7. CVP SOD M&I Deliveries Under the 55-feet Reservoir Restriction Alternative and Change from the NAA

No Action/No Project Alternative													
	Oct	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Total**
W	0	5	9	9	27	45	3	0	0	1	1	0	98
AN	0	1	1	24	34	38	2	0	0	2	1	0	103
BN	0	0	1	2	4	40	2	1	1	1	0	0	52
D	0	1	1	2	2	7	2	2	1	0	2	0	19
C	1	0	1	2	2	1	1	1	1	0	2	0	12
All	0	2	4	7	15	28	2	1	0	1	1	0	61
55-feet Reservoir Restriction Alternative													
	Oct	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Total**
W	0	8	15	41	109	161	8	0	0	1	1	0	345
AN	0	2	25	47	57	127	2	0	0	1	1	0	263
BN	0	1	2	27	69	130	2	1	1	1	0	0	233
D	0	1	5	15	73	79	7	2	1	0	2	0	184
C	1	0	1	2	16	18	7	1	0	0	2	0	48
All	0	3	10	28	73	112	6	1	0	1	1	0	235
Change from No Action Alternative													
	Oct	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Total**
W	0	3	6	32	83	117	5	0	0	0	0	0	247
AN	0	1	23	23	23	89	0	0	0	0	0	0	160
BN	0	0	1	25	65	90	0	0	0	0	0	0	181
D	0	0	4	13	71	71	6	0	0	0	0	0	165
C	0	0	0	0	15	17	5	0	0	0	0	0	36
All	0	1	6	21	59	83	4	0	0	0	0	0	174

Key: AN – Above Normal; BN – Below Normal; C – Critical; D – Dry; Sac Yr Type – Sacramento River Water Year Type; W – Wet

Table 4-8. CVP SOD Deliveries Under the 55-feet Reservoir Restriction Alternative and Change from the NAA

No Action/No Project Alternative													
	Oct	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Total**
W	0	0	0	55	43	13	0	0	0	0	0	0	112
AN	0	0	0	32	26	7	0	0	0	0	0	0	66
BN	0	0	0	50	44	15	0	0	0	0	0	0	108
D	0	0	0	37	32	11	0	0	0	0	0	0	80
C	0	0	0	25	22	7	0	0	0	0	0	0	54
All	0	0	0	43	35	11	0	0	0	0	0	0	89
55-feet Reservoir Restriction Alternative													
	Oct	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Total**
W	0	0	0	41	26	3	0	0	0	0	0	0	70
AN	0	0	0	25	14	5	0	0	0	0	0	0	44
BN	0	0	0	42	32	7	0	0	0	0	0	0	81
D	0	0	0	32	23	6	0	0	0	0	0	0	61
C	0	0	0	21	18	6	0	0	0	0	0	0	45
All	0	0	0	34	23	5	0	0	0	0	0	0	62
Change from No Action Alternative													
	Oct	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Total**
W	0	0	0	-15	-17	-11	0	0	0	0	0	0	-42
AN	0	0	0	-7	-12	-2	0	0	0	0	0	0	-21
BN	0	0	0	-8	-12	-8	0	0	0	0	0	0	-27
D	0	0	0	-5	-9	-5	0	0	0	0	0	0	-19
C	0	0	0	-4	-4	-1	0	0	0	0	0	0	-9
All	0	0	0	-9	-12	-6	0	0	0	0	0	0	-27

Key: AN – Above Normal; BN – Below Normal; C – Critical; D – Dry; Sac Yr Type – Sacramento River Water Year Type; W – Wet

Figure 4-1 and Figure 4-2 further illustrate the shift from project contract supplies to interruptible Section 215 and Article 21 supplies, respectively. On average, both projects deliver less contract water in all months for the 55-feet Restriction Alternative. However, for January through March, more water is delivered in total because of increased Section 215 and Article 21 deliveries.

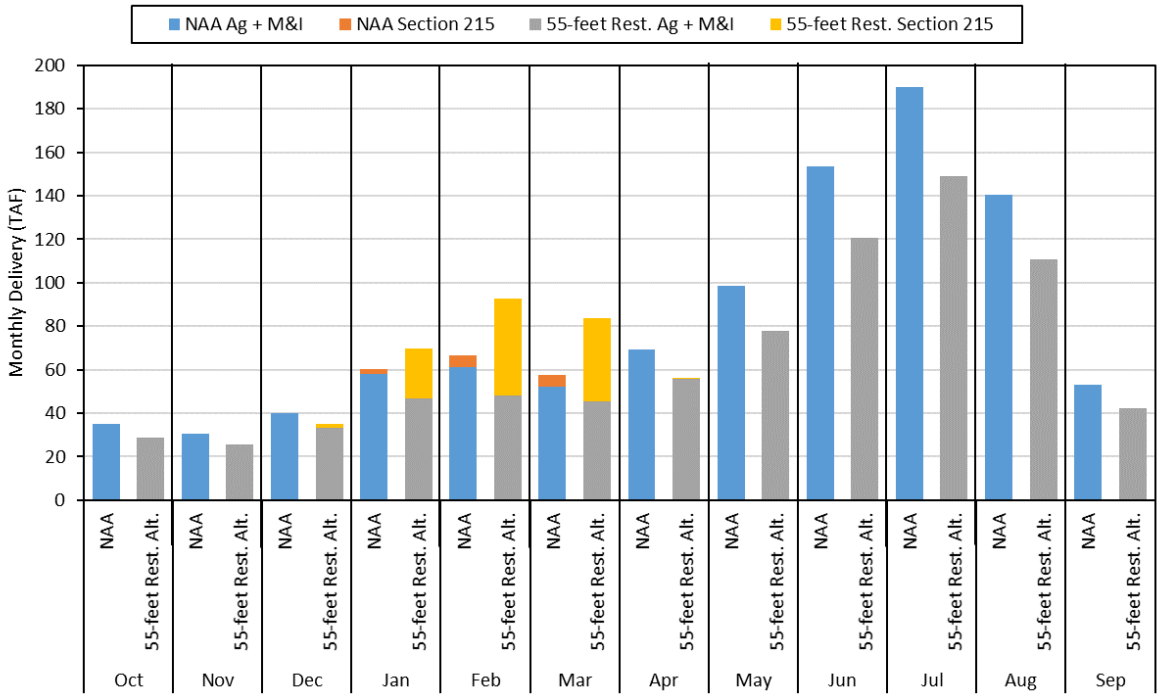

Figure 4-1. Average Monthly CVP Water Service Contract (Ag + M&I) and Section 215 Deliveries for the NAA and 55-feet Restriction Alternative

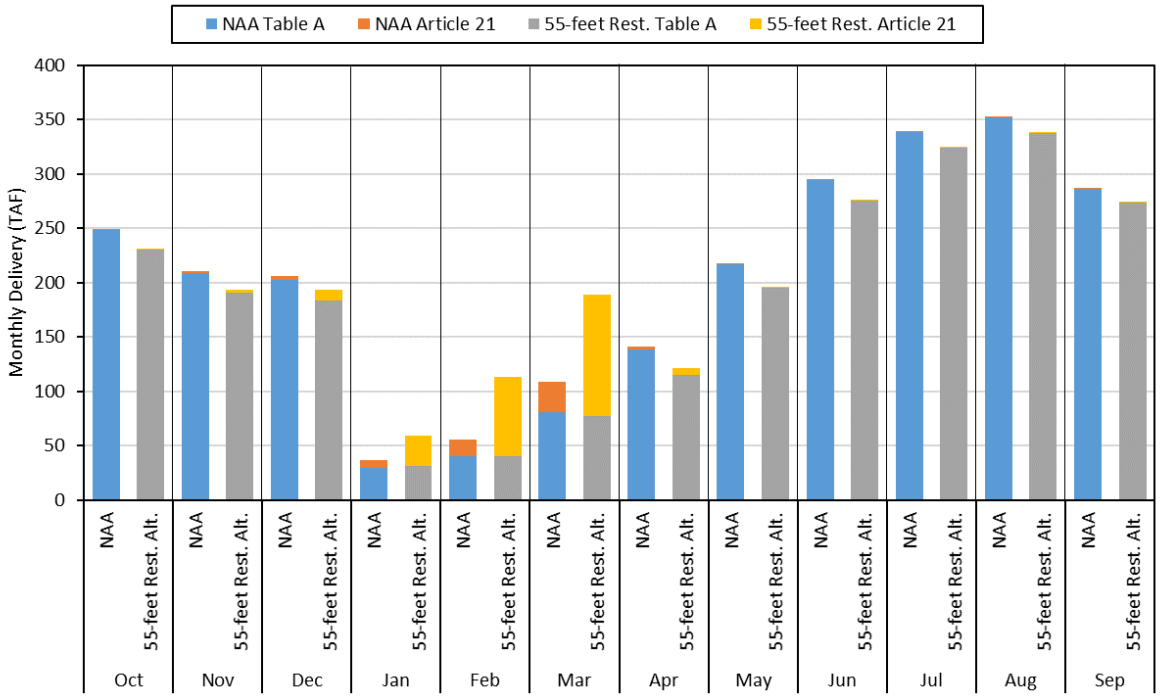

Figure 4-2. Average Monthly SWP Contract (Table A) and Article 21 Deliveries for the NAA and 55-feet Restriction Alternative

As shown above, Section 215 and Article 21 supplies are largely delivered in the winter months when demand is low, and would likely require additional costs for Ag contractors to accept and use, as compared to typical contract deliveries. Although total SOD deliveries for each project show minimal impacts when accounting for Section 215 and Article 21 deliveries, it is inappropriate for the cost of using interruptible supplies to equal contract supply. Therefore, the cost of using Section 215 and Article 21 deliveries is different than contract supplies in the Ag economic model.

4.1.2 Summary of Impacts to System Parameters

A comparison of key system parameters for reservoir storage, river flows, and the Delta is provided in Table 4-9. Average monthly results for the NAA and the 55-feet Restriction Alternative are presented and compared to one another.

Average monthly changes in upstream reservoir storage are typically small. Changes to Sacramento and Feather River flows are also typically small, except for July through August, when river flows are consistently lower in the Restriction Alternative. Delta outflow is higher most of the year (especially December through March), reflecting reduced exports, and lower during July through September, reflecting a reduction in carriage water to support exports. A smaller San Luis limits the projects' ability to support higher SOD allocations, leaving NOD reservoir storage higher and summer exports lower. Delta exports (Jones and Banks pumping) are often lower, however there are months when each project pumps a similar or even greater amount of water. Increases in pumping reflect both a shift in delivery timing (the SWP can make up previous months' delivery shortage) but also the increased volume of Section 215 and Article 21 supplies. December through March pumping at Jones is significantly lower, despite increased Section 215 pumping. Even with the availability of Section 215, demands are low during this period and the reduction of CVP San Luis is greater than the demand for Section 215. As such, Section 215 deliveries cannot make up for the loss in contract delivery. Banks pumping is less in October through December, reflecting lower Table A allocations, but more from January through March. Increased Banks pumping in these months occurs in part because Article 21 demands as a whole are greater than the reduction in SWP San Luis, which allows the SWP to make up delivery losses in some months.

CVP and SWP San Luis are also consistently lower, with the largest changes occurring during the February through May period, when both projects typically achieve their annual maximum storage. Lower storage levels are a function of both the reduced reservoir size and more aggressive operations. There is an expectation that with a smaller San Luis and SOD delivery cuts, the system would be operated more aggressively. While this is true, in many years, allocations are capacity constrained because less water is available SOD at the beginning of each contract year.

Table 4-9. Comparison of Key System Parameters Under the 55-feet Reservoir Restriction Alternative and Change from the NAA

NAA	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Delta Outflow (cfs)	5,891	11,479	20,756	42,066	52,870	42,241	30,993	22,068	12,346	7,758	4,435	9,704
Jones Pumping Plant (cfs)	3,496	3,512	3,927	3,277	3,410	3,192	1,213	1,087	2,591	3,341	3,654	3,914
Banks Pumping Plant (cfs)	3,148	3,785	4,662	3,570	4,011	3,982	1,190	987	2,411	5,841	5,414	5,011
Sac. River into Delta (cfs)	10,800	15,719	21,512	29,958	36,427	30,779	22,325	19,048	15,951	17,953	14,154	17,708
Yolo Bypass (cfs)	196	475	3,725	10,901	14,319	9,589	3,607	363	224	48	88	171
Sac. River below Keswick (cfs)	6,196	6,894	6,530	8,373	10,690	8,329	7,038	8,122	10,772	12,777	10,058	8,044
Sac. River at NCP (cfs)	6,000	8,987	11,286	13,669	15,383	14,092	8,846	7,094	5,648	6,269	5,247	7,763
Feather R. blw Thermalito (cfs)	2,485	1,983	2,377	4,047	4,390	5,321	3,051	3,633	3,646	7,060	4,852	5,324
Lower Feather River (cfs)	2,977	2,881	4,714	10,761	11,851	12,433	8,786	7,663	6,198	7,678	5,806	7,051
American R blw Nimbus (cfs)	1,614	2,641	3,381	4,567	5,222	4,065	3,360	3,379	3,207	3,195	2,213	2,461
American R at H St (cfs)	1,438	2,478	3,241	4,409	5,033	3,872	3,078	3,040	2,817	2,653	1,829	2,151
SJ River at Vernalis (cfs)	2,710	2,605	3,248	4,821	6,203	7,165	7,474	5,746	4,609	3,187	2,032	2,312
Shasta Storage (TAF)	2,621	2,579	2,758	3,030	3,281	3,651	3,944	3,960	3,660	3,202	2,887	2,702
Oroville Storage (TAF)	1,602	1,577	1,717	1,931	2,203	2,447	2,723	2,861	2,753	2,309	2,016	1,719
Folsom Storage (TAF)	463	434	458	473	493	591	719	838	803	675	597	510
CVP San Luis Storage (TAF)	232	351	523	645	741	811	731	577	415	251	149	179
SWP San Luis Storage (TAF)	367	361	460	598	726	831	749	585	428	436	407	411
55-feet Restriction Alt.	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**
Delta Outflow (cfs)	5,955	11,535	20,984	42,379	53,543	42,968	31,066	22,103	12,373	7,715	4,413	9,683
Jones Pumping Plant (cfs)	3,528	3,574	3,862	3,059	2,800	2,579	1,212	1,082	2,525	3,226	3,642	3,797
Banks Pumping Plant (cfs)	2,991	3,649	4,531	3,594	4,163	3,985	1,153	954	2,432	5,754	5,332	4,976
Sac. River into Delta (cfs)	10,736	15,700	21,542	30,031	36,482	30,857	22,357	19,043	15,936	17,713	14,043	17,540
Yolo Bypass (cfs)	200	476	3,728	10,947	14,480	9,629	3,611	363	224	48	88	171
Sac. River below Keswick (cfs)	6,248	6,917	6,538	8,440	10,704	8,370	7,042	8,118	10,791	12,687	9,999	7,952
Sac. River at NCP (cfs)	6,055	8,987	11,271	13,706	15,377	14,100	8,848	7,089	5,668	6,180	5,191	7,672
Feather R. blw Thermalito (cfs)	2,404	1,969	2,375	4,076	4,566	5,403	3,056	3,636	3,625	6,974	4,782	5,243
Lower Feather River (cfs)	2,895	2,865	4,711	10,787	12,023	12,512	8,791	7,666	6,177	7,593	5,737	6,969
American R blw Nimbus (cfs)	1,588	2,624	3,410	4,592	5,226	4,066	3,390	3,378	3,193	3,136	2,226	2,466
American R at H St (cfs)	1,414	2,461	3,270	4,433	5,036	3,873	3,108	3,039	2,807	2,594	1,835	2,154
SJ River at Vernalis (cfs)	2,709	2,605	3,248	4,821	6,204	7,165	7,472	5,745	4,607	3,183	2,027	2,310
Shasta Storage (TAF)	2,641	2,598	2,776	3,042	3,293	3,661	3,952	3,969	3,668	3,215	2,904	2,726
Oroville Storage (TAF)	1,638	1,611	1,750	1,960	2,224	2,463	2,739	2,877	2,770	2,330	2,042	1,749
Folsom Storage (TAF)	467	440	462	475	495	593	719	838	803	680	600	513
CVP San Luis Storage (TAF)	211	338	511	610	644	649	582	449	317	188	116	149
SWP San Luis Storage (TAF)	339	349	449	570	653	692	638	494	359	376	358	370
Change from NAA	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**
Delta Outflow (cfs)	64	56	228	312	673	727	73	35	28	-43	-23	-21
Jones Pumping Plant (cfs)	32	62	-65	-218	-610	-614	-1	-5	-66	-115	-12	-117
Banks Pumping Plant (cfs)	-156	-136	-131	25	151	3	-37	-33	21	-87	-81	-36
Sac. River into Delta (cfs)	-64	-19	30	73	54	77	32	-4	-15	-240	-111	-168
Yolo Bypass (cfs)	4	1	3	46	160	40	4	0	0	0	0	0
Sac. River below Keswick (cfs)	53	23	8	66	14	41	4	-5	19	-90	-59	-92
Sac. River at NCP (cfs)	55	-1	-15	37	-6	8	2	-6	19	-89	-55	-90
Feather R. blw Thermalito (cfs)	-82	-14	-2	29	176	82	6	3	-21	-86	-70	-81
Lower Feather River (cfs)	-82	-16	-3	26	172	78	5	3	-21	-85	-69	-83
American R blw Nimbus (cfs)	-26	-17	30	25	3	1	30	-1	-14	-59	13	5
American R at H St (cfs)	-24	-17	29	24	2	1	30	-2	-10	-59	6	3
SJ River at Vernalis (cfs)	-1	0	0	0	1	0	-1	-1	-2	-5	-4	-2
Shasta Storage (TAF)	20	19	17	13	12	9	9	9	8	13	17	24
Oroville Storage (TAF)	35	34	33	29	22	16	16	16	17	21	26	31
Folsom Storage (TAF)	5	6	4	2	2	2	0	0	1	4	4	3
CVP San Luis Storage (TAF)	-21	-13	-12	-35	-97	-162	-149	-128	-98	-63	-34	-29
SWP San Luis Storage (TAF)	-28	-13	-11	-28	-73	-140	-111	-90	-70	-60	-49	-40

4.1.3 San Luis Reservoir Operations and Interrupted San Felipe M&I Deliveries

In the 55-feet Restriction Alternative, San Luis Reservoir is operated in a similar manner as the NAA, albeit slightly more aggressively. Low Point occurs as often (20% of years) as in the NAA, but the reservoir is also consistently lower and reaches capacity in 71% of years. Figure 4-3 illustrates the probability of annual maximum and minimum San Luis Reservoir storage.

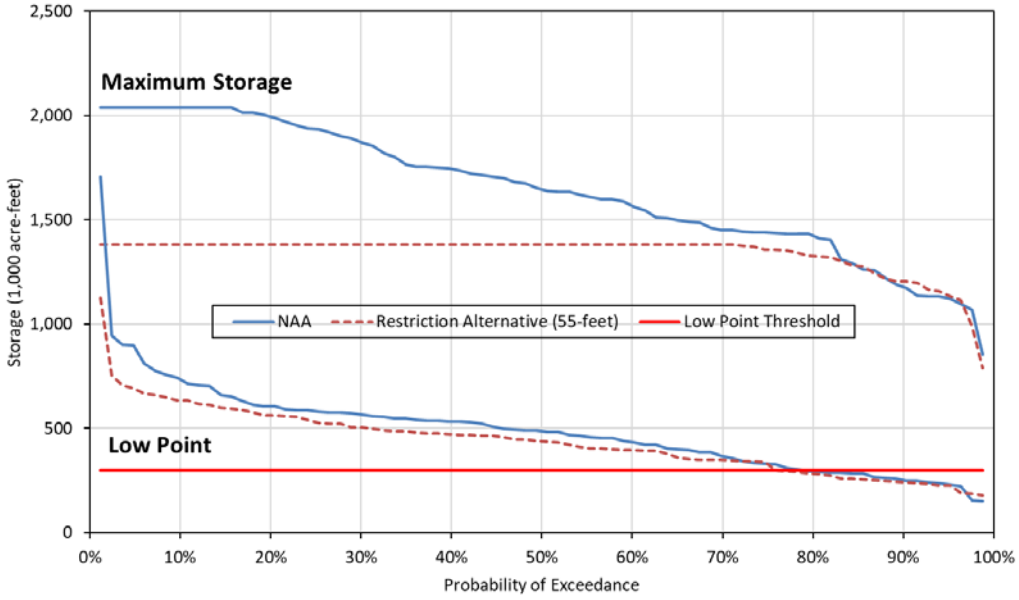

Figure 4-3. Probability of Annual Maximum and Minimum San Luis Reservoir Storage

The reduced size of CVP and SWP San Luis allows for both project's share of San Luis Reservoir reach capacity more frequently. As seen in Figure 4-4, CVP San Luis reaches capacity in 89% of years, while Figure 4-5 shows SWP San Luis reaching capacity in 75% of years. Increases in the probability of filling each project's share of the reservoir greatly increases the availability of Section 215 and Article 21 supplies, respectively, but also reduces the ability of each project to export excess flow and store it for periods of reduced surface water availability and regulatory restrictions. Both reservoirs are operated slightly more aggressively, as a greater percentage of reservoir volume is needed to meet higher SOD allocations in wetter years.

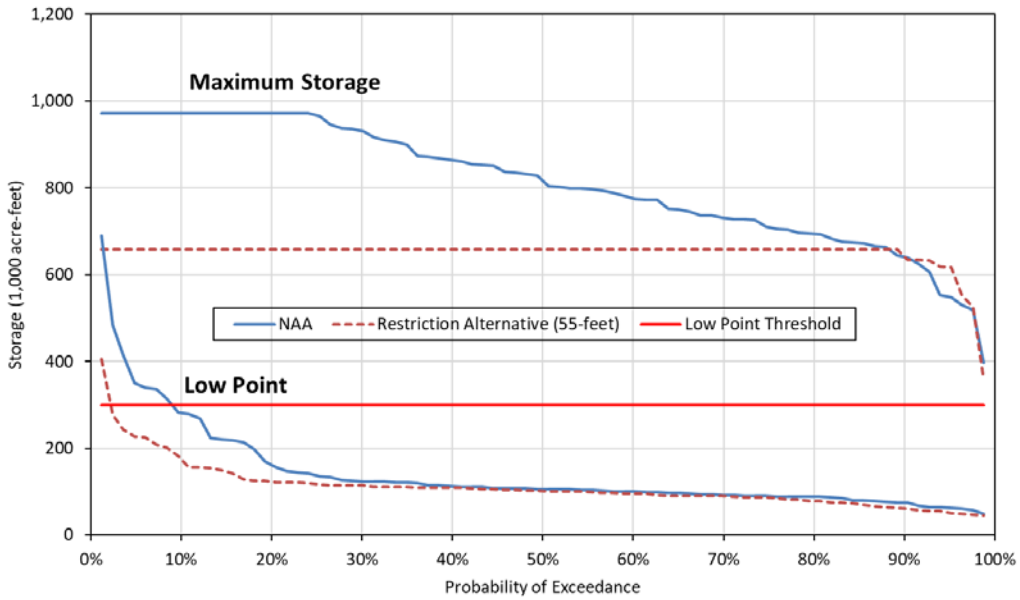

Figure 4-4. Probability of Annual Maximum and Minimum CVP San Luis Storage

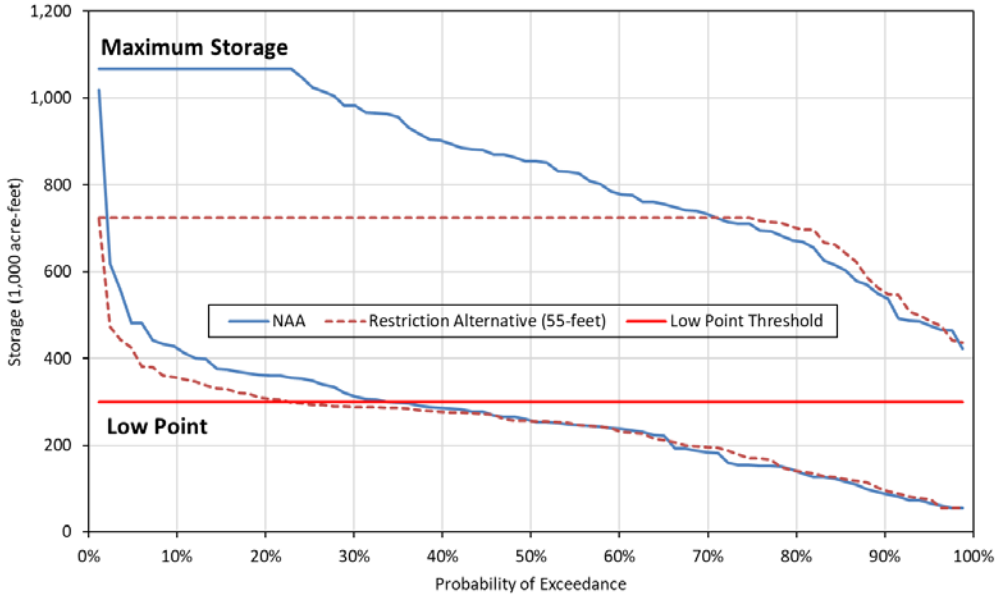

Figure 4-5. Probability of Annual Maximum and Minimum SWP San Luis Storage

Table 4-10 shows the volume of interrupted San Felipe M&I deliveries and the change from the NAA. The annual average volume of interrupted deliveries increases by 0.5 TAF.

Table 4-10. Annual Average Interrupted San Felipe M&I Deliveries and Change from the NAA

Sacramento Valley Index	Restriction Alt. (55-feet) (TAF)	Change from NAA (TAF)
Wet	0.6	-0.5
Above Normal	8.5	2.2
Below Normal	2.4	-2.2
Dry	2.7	1.2
Critical	6.5	3.1
All Years	3.4	0.5

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Chapter 5
Reservoir Restriction Alternative (47 feet)

The Reservoir Restriction Alternative (47 feet) includes a 47-feet reduction in the maximum operational elevation of San Luis Reservoir, allowing for a maximum elevation of 497 feet. The lower maximum elevation reduces allowable storage in the reservoir to 1,473 thousand acre-feet (TAF), a reduction of 566 TAF. The SWP/CVP share of San Luis is kept at 52% / 48%, with SWP San Luis having a maximum storage of 771 TAF and CVP San Luis having a maximum storage of 702 TAF.

To implement this change, adjustments to reservoir sizes and to some allocation logic that relied on reservoir size were made to the CalSim II baseline code. The updated Delta export estimate logic developed by MBK was also applied to the model to improve export operations and operation of San Luis Reservoir. Additionally, CVP NOD Ag allocations were fixed to equal allocations made in the NAA.

The B.F. Sisk Dam SOD Project EIS/EIR analyzes the 55-feet Restriction as the worst-case restriction alternative. Impacts generated by this worst-case scenario that are presented in the EIS/EIR would capture all the potential impacts potentially generated by a 47-feet Restriction Alternative.

5.1 Reservoir Restriction Alternative (47-feet) Results

Results from the 47-feet Reservoir Restriction Alternative are summarized and compared to the NAA. The primary difference between the NAA and the 47-feet Restriction Alternative is the size of CVP and SWP San Luis. The reduction in reservoir size impacts all parts of the CVP/SWP system, including reductions in SOD exports and deliveries, availability of Section 215 and Article 21 supplies, changes to Delta outflow, and changes to upstream reservoir storage. Accordingly, key outputs from the model are simulated deliveries to all SOD contractors, San Luis Reservoir storage, as well as the values of important system parameters. The following figures and tables summarize these results for the 47-feet Reservoir Restriction Alternative as compared to the NAA.

Overall, results of the 47-feet Reservoir Restriction Alternative are comparable to results from the 55-feet Reservoir Restriction Alternative. As would be expected, the smaller reduction in the size of San Luis lessens the negative impacts to SOD deliveries.

5.1.1 Summary of South-of Delta Deliveries

Table 5-1 provides a summary of the average annual CVP SOD delivery by water year type for the 47-feet Restriction Alternative and the change from the NAA. Exchange Contractors and refuges did not incur a reduction in delivery and thus are not included in the table. Results are similar to the 55-feet Restriction Alternative, although reductions in deliveries are not as severe. The volume of Section 215 deliveries is less than the 55-feet Restriction Alternative, reflecting a reduced demand for Section 215 and the reduced frequency of CVP San Luis reaching capacity.

Table 5-1. Annual Average CVP SOD Deliveries and Change from the NAA

CVP South-of-Delta Deliveries (TAF)	Ag Service	M&I	Section 215	Total SOD	Total SOD w/ 215
Wet	1,121	123	104	2,581	2,685
Above Normal	813	106	98	2,248	2,346
Below Normal	707	111	93	2,150	2,243
Dry	499	101	65	1,920	1,985
Critical	140	79	26	1,404	1,430
All Years	725	107	81	2,141	2,223
Change from No Action Alternative					
Wet	-220	-9	88	-229	-142
Above Normal	-178	-7	70	-185	-115
Below Normal	-145	-1	69	-147	-77
Dry	-85	-5	65	-90	-25
Critical	-31	-6	26	-36	-11
All Years	-144	-6	68	-150	-82

Table 5-2 provides a summary of the average annual SWP SOD delivery by water year type for the 47-feet Restriction Alternative and the change from the NAA. Reductions in deliveries are again less than compared to the 55-feet Reservoir Restriction Alternative, including less Article 21 delivery. Article 56 deliveries are greater than the 55-feet Restriction Alternative, but still see a reduction from the NAA. Annual average Article 56 spill is 11.2 TAF, which is comparable to the spill that occurs in both the NAA and the 55-feet Restriction Alternative.

Table 5-2. Annual Average SWP SOD Deliveries and Change from the NAA

SWP SOD Deliveries (TAF)	Ag SOD	M&I	Table A	Article 56	Article 21	Total SWP
Wet	734	2,158	2,892	87	273	3,252
Above Normal	646	1,901	2,548	52	226	2,825
Below Normal	627	1,867	2,494	92	183	2,769
Dry	471	1,431	1,902	67	142	2,111
Critical	283	935	1,218	49	37	1,304
All Years	579	1,732	2,311	73	187	2,572

Change from No Action Alternative						
Wet	-65	-159	-224	-25	175	-75
Above Normal	-24	-75	-99	-14	123	10
Below Normal	-16	-41	-58	-16	130	57
Dry	-30	-87	-117	-13	123	-7
Critical	-9	-24	-33	-4	25	-12
All Years	-35	-91	-126	-16	126	-16

Figure 5-1 and Figure 5-2 further illustrate the shift from project contract supplies to interruptible Section 215 and Article 21 supplies, respectively. On average, both projects deliver less contract water in all months for the 47-feet Restriction Alternative. However, for January through March, more water is delivered in total because of increased Section 215 and Article 21 deliveries.

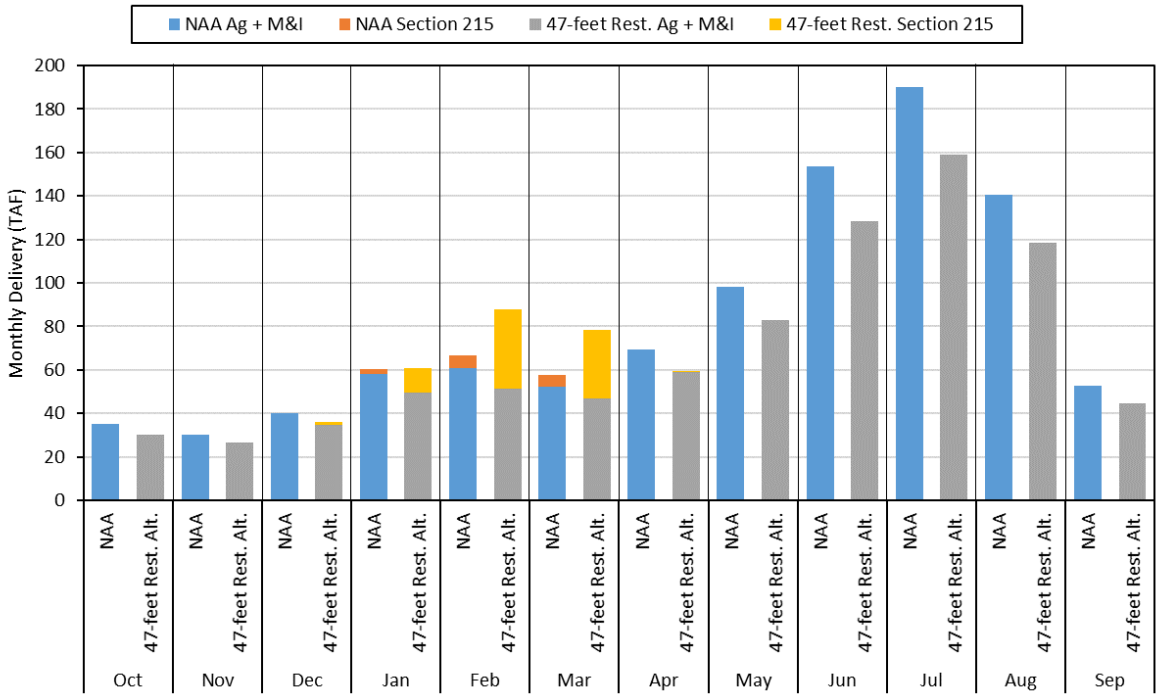

Figure 5-1. Average Monthly CVP Water Service Contract (Ag + M&I) and Section 215 Deliveries for the NAA and 47-feet Restriction Alternative

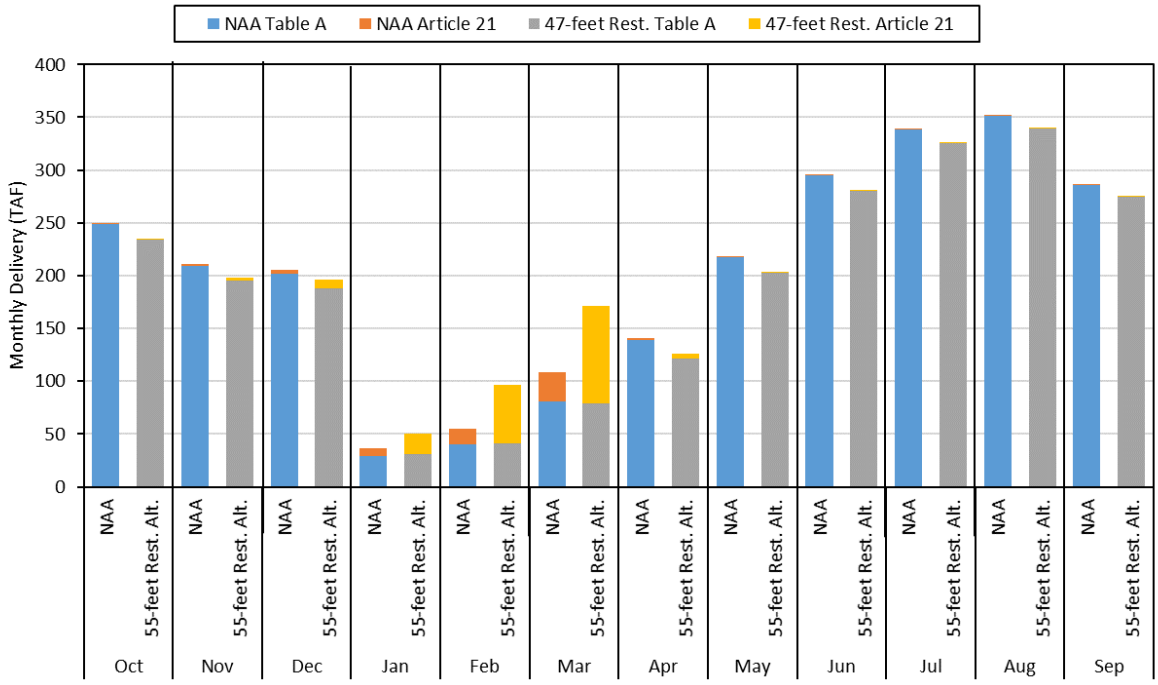

Figure 5-2. Average Monthly SWP Contract (Table A) and Article 21 Deliveries for the NAA and 47-feet Restriction Alternative

5.1.2 Summary of Impacts to System Parameters

A comparison of key system parameters for reservoir storage, river flows, and the Delta is provided in Table 5-3. Average monthly results for the NAA and the 47-feet Restriction Alternative are presented and compared to one another.

Results are again comparable to the 55-feet Restriction Alternative results, although differences between the 47-feet Restriction Alternative and the NAA are not as severe. Average monthly change to upstream reservoir storage is small, as are changes to Sacramento and Feather River flows. Delta outflow is again higher in most months, reflecting reduced exports, but lower in July through September, reflecting a reduction in carriage water to support exports. Exports are lower overall, as the projects do not need to export as much to fill San Luis, nor are the projects able to support higher SOD allocations given the smaller size of San Luis Reservoir.

CVP and SWP San Luis are also consistently lower, with the largest changes in the February through May period, when both projects typically achieve their annual maximum storage. Lower storage levels are a function of both the reduced reservoir size and more aggressive operations.

Table 5-3. Comparison of Key System Parameters Under the 47-feet Reservoir Restriction Alternative and Change from the NAA

NAA	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Delta Outflow (cfs)	5,891	11,479	20,756	42,066	52,870	42,241	30,993	22,068	12,346	7,758	4,435	9,704
Jones Pumping Plant (cfs)	3,496	3,512	3,927	3,277	3,410	3,192	1,213	1,087	2,591	3,341	3,654	3,914
Banks Pumping Plant (cfs)	3,148	3,785	4,662	3,570	4,011	3,982	1,190	987	2,411	5,841	5,414	5,011
Sac. River into Delta (cfs)	10,800	15,719	21,512	29,958	36,427	30,779	22,325	19,048	15,951	17,953	14,154	17,708
Yolo Bypass (cfs)	196	475	3,725	10,901	14,319	9,589	3,607	363	224	48	88	171
Sac. River below Keswick (cfs)	6,196	6,894	6,530	8,373	10,690	8,329	7,038	8,122	10,772	12,777	10,058	8,044
Sac. River at NCP (cfs)	6,000	8,987	11,286	13,669	15,383	14,092	8,846	7,094	5,648	6,269	5,247	7,763
Feather R. blw Thermalito (cfs)	2,485	1,983	2,377	4,047	4,390	5,321	3,051	3,633	3,646	7,060	4,852	5,324
Lower Feather River (cfs)	2,977	2,881	4,714	10,761	11,851	12,433	8,786	7,663	6,198	7,678	5,806	7,051
American R blw Nimbus (cfs)	1,614	2,641	3,381	4,567	5,222	4,065	3,360	3,379	3,207	3,195	2,213	2,461
American R at H St (cfs)	1,438	2,478	3,241	4,409	5,033	3,872	3,078	3,040	2,817	2,653	1,829	2,151
SJ River at Vernalis (cfs)	2,710	2,605	3,248	4,821	6,203	7,165	7,474	5,746	4,609	3,187	2,032	2,312
Shasta Storage (TAF)	2,621	2,579	2,758	3,030	3,281	3,651	3,944	3,960	3,660	3,202	2,887	2,702
Oroville Storage (TAF)	1,602	1,577	1,717	1,931	2,203	2,447	2,723	2,861	2,753	2,309	2,016	1,719
Folsom Storage (TAF)	463	434	458	473	493	591	719	838	803	675	597	510
CVP San Luis Storage (TAF)	232	351	523	645	741	811	731	577	415	251	149	179
SWP San Luis Storage (TAF)	367	361	460	598	726	831	749	585	428	436	407	411
47-feet Restriction Alt.	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**
Delta Outflow (cfs)	5,966	11,525	20,919	42,301	53,395	42,914	31,044	22,086	12,370	7,727	4,420	9,683
Jones Pumping Plant (cfs)	3,493	3,586	3,880	3,155	2,937	2,637	1,208	1,083	2,539	3,257	3,641	3,813
Banks Pumping Plant (cfs)	3,032	3,692	4,565	3,533	4,122	3,976	1,164	971	2,422	5,787	5,333	4,987
Sac. River into Delta (cfs)	10,754	15,745	21,538	30,006	36,457	30,856	22,345	19,046	15,937	17,786	14,048	17,564
Yolo Bypass (cfs)	198	475	3,720	10,931	14,452	9,625	3,608	363	224	48	88	171
Sac. River below Keswick (cfs)	6,223	6,954	6,529	8,425	10,697	8,371	7,036	8,118	10,784	12,717	10,012	7,957
Sac. River at NCP (cfs)	6,030	9,023	11,273	13,705	15,386	14,107	8,841	7,091	5,661	6,210	5,203	7,680
Feather R. blw Thermalito (cfs)	2,428	1,974	2,381	4,058	4,539	5,400	3,054	3,636	3,626	7,006	4,777	5,266
Lower Feather River (cfs)	2,920	2,871	4,718	10,767	11,995	12,507	8,789	7,665	6,177	7,625	5,731	6,996
American R blw Nimbus (cfs)	1,603	2,623	3,402	4,584	5,222	4,066	3,384	3,378	3,200	3,149	2,226	2,459
American R at H St (cfs)	1,428	2,459	3,261	4,425	5,033	3,872	3,103	3,040	2,814	2,607	1,839	2,149
SJ River at Vernalis (cfs)	2,709	2,605	3,248	4,821	6,204	7,165	7,473	5,745	4,608	3,184	2,028	2,311
Shasta Storage (TAF)	2,633	2,589	2,767	3,035	3,286	3,653	3,945	3,962	3,661	3,208	2,895	2,717
Oroville Storage (TAF)	1,631	1,605	1,744	1,956	2,221	2,461	2,736	2,874	2,768	2,326	2,038	1,744
Folsom Storage (TAF)	466	438	461	475	495	592	719	837	803	678	599	512
CVP San Luis Storage (TAF)	212	338	512	625	672	686	616	477	338	200	121	154
SWP San Luis Storage (TAF)	347	354	453	577	672	722	663	513	372	389	369	381
Change from NAA	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**
Delta Outflow (cfs)	74	45	164	235	524	673	50	17	24	-31	-16	-21
Jones Pumping Plant (cfs)	-3	75	-47	-122	-472	-556	-4	-4	-52	-84	-13	-101
Banks Pumping Plant (cfs)	-116	-93	-97	-36	110	-6	-26	-16	11	-54	-81	-24
Sac. River into Delta (cfs)	-46	26	25	47	30	77	19	-2	-15	-167	-106	-144
Yolo Bypass (cfs)	3	1	-5	29	133	35	1	0	0	0	0	0
Sac. River below Keswick (cfs)	28	60	0	52	7	41	-3	-4	12	-61	-46	-87
Sac. River at NCP (cfs)	29	36	-13	36	3	15	-5	-3	13	-59	-44	-83
Feather R. blw Thermalito (cfs)	-57	-8	4	10	149	79	4	3	-20	-54	-75	-58
Lower Feather River (cfs)	-58	-10	4	6	144	74	3	2	-21	-54	-75	-55
American R blw Nimbus (cfs)	-11	-18	21	17	0	0	24	-1	-7	-46	13	-2
American R at H St (cfs)	-10	-18	20	16	0	0	24	-1	-3	-46	10	-2
SJ River at Vernalis (cfs)	-1	0	0	0	1	0	-1	-1	-1	-4	-3	-1
Shasta Storage (TAF)	12	9	9	5	4	2	2	2	1	6	8	15
Oroville Storage (TAF)	29	28	27	25	18	14	13	13	14	17	22	25
Folsom Storage (TAF)	3	4	3	2	2	1	0	0	0	3	2	2
CVP San Luis Storage (TAF)	-20	-12	-11	-19	-69	-125	-115	-100	-77	-50	-28	-25
SWP San Luis Storage (TAF)	-20	-8	-7	-21	-55	-109	-86	-72	-56	-47	-39	-30

5.1.3 San Luis Reservoir Operations and Interrupted San Felipe M&I Delivery

In the 47-feet Restriction Alternative, San Luis Reservoir is operated in a similar manner as the NAA, albeit slightly more aggressively. Low Point occurs as often (20% of years) as in the NAA, but the reservoir is also consistently lower and reaches capacity in 65% of years. Figure 5-3 illustrates the probability of annual maximum and minimum San Luis Reservoir storage.

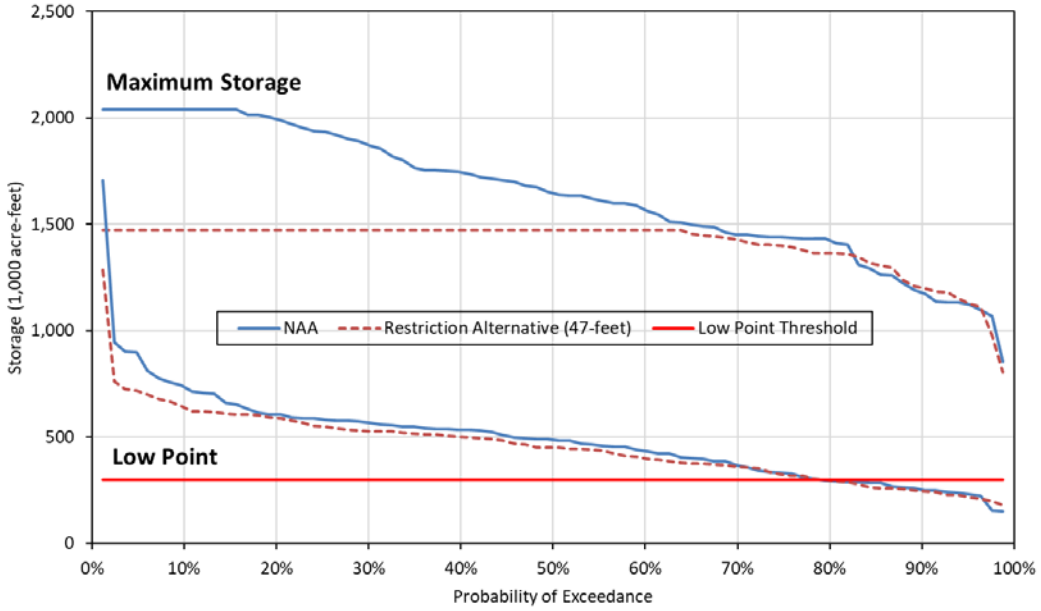

Figure 5-3. Probability of Annual Maximum and Minimum San Luis Reservoir Storage

The reduced size of CVP and SWP San Luis allows for both project's share of San Luis Reservoir to reach capacity more frequently than the NAA, but not as often as in the 55-feet Restriction Alternative. As seen in Figure 5-4, CVP San Luis reaches capacity in 84% of years, while Figure 5-5 shows SWP San Luis reaching capacity in 69% of years. Increases in the probability of filling each project's share of the reservoir greatly increases the availability of Section 215 and Article 21 supplies, respectively, but also reduces the ability of each project to export excess flow and store it for periods of reduced surface water availability and regulatory restrictions. Both reservoirs are again operated slightly more aggressively, as a greater percentage of reservoir volume is needed to meet higher SOD allocations in wetter years.

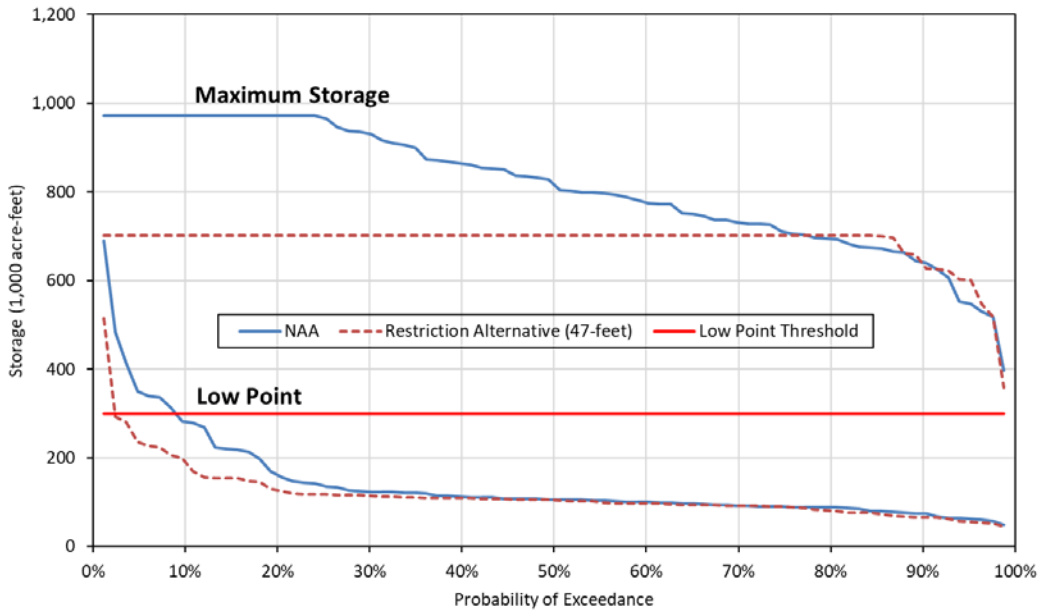

Figure 5-4. Probability of Annual Maximum and Minimum CVP San Luis Storage

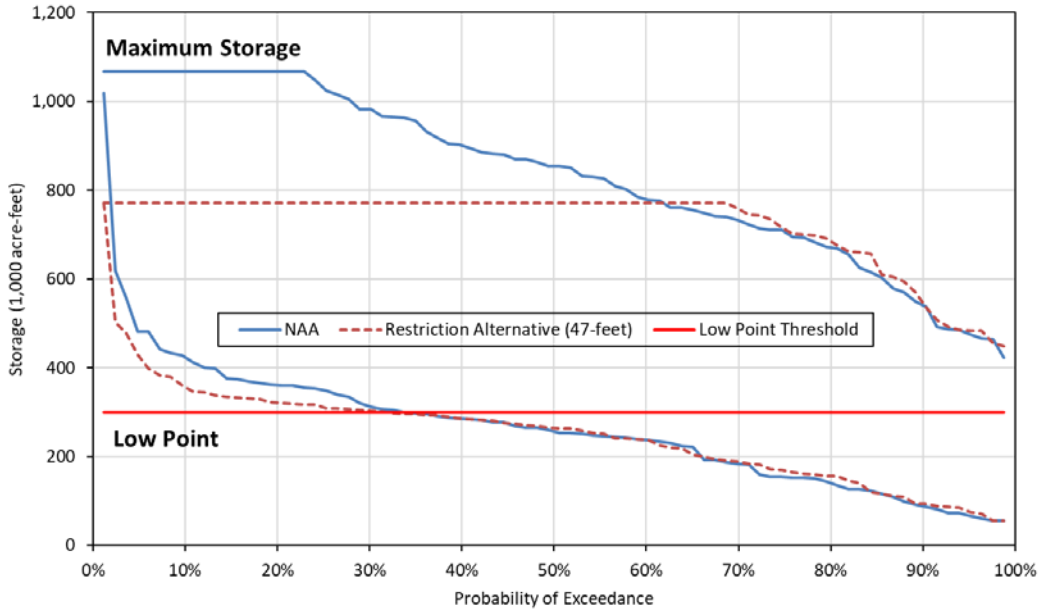

Figure 5-5. Probability of Annual Maximum and Minimum SWP San Luis Storage

Table 5-4 shows the volume of interrupted San Felipe M&I deliveries and the change from the NAA. The annual average volume of interrupted deliveries

increases by 0.3 TAF, but overall is less than the volume of interrupted deliveries in the 55-feet Restriction Alternative.

Table 5-4. Annual Average Interrupted San Felipe M&I Deliveries and Change from the NAA

Sacramento Valley Index	Restriction Alt. (47-feet) (TAF)	Change from NAA (TAF)
Wet	0.8	-0.3
Above Normal	6.9	0.6
Below Normal	1.9	-2.7
Dry	2.8	1.4
Critical	6.6	3.1
All Years	3.2	0.3

Chapter 6
Breach Alternative

The Breach Alternative effectively eliminates San Luis Reservoir from the CVP/SWP system. Removing San Luis from the system produces severe impacts to the entire system, but especially to SOD deliveries. Modeling the Breach Alternative required changes to CalSim II, but also required additional post-processing to simulate changes to deliveries expected in the Friant Division of the CVP.

The B.F. Sisk Dam SOD Project EIS/EIR analyzes the 55-feet Restriction as the worst-case restriction alternative. The Breach Alternative was eliminated from further consideration in the EIS/EIR during development of the B.F. Sisk Dam SOD Project Description Technical Memorandum (Reclamation 2017) given its high cost, substantial potential environmental impacts including substantial water supply impacts. The CalSim modeling of the Breach Alternative presented below was completed in part to support development of that technical memorandum.

6.1 Breach Alternative Modeling Methodology

6.1.1 CalSim II Modeling

To implement the Breach Alternative in CalSim II, changes were made to reservoir elevations, along with some adjustments to water supply index and allocation logic that relied on San Luis Reservoir size. Without San Luis Reservoir, deliveries to the CVP's San Felipe Division cannot be made. Accordingly, model logic was added to preclude any deliveries to San Felipe. The updated Delta export estimate logic developed by MBK was also applied to the model to improve export operations. Without San Luis, it was necessary to increase the aggressiveness of the export estimate by including surplus export capacity in the export estimate calculation, as well as making some manual adjustments to years with unrealistically low SOD allocations. As in the Reservoir Restriction alternatives, CVP NOD Ag allocations were fixed to equal allocations made in the NAA.

After reviewing the initial CalSim II results, it was determined that Shasta Reservoir was being operated unrealistically in some Shasta Critical years. This operation brought Shasta to near deadpool, as additional summertime releases were being made to support exports for Exchange Contractor and Refuge demands. To limit this unrealistic operation, Exchange Contractor and SOD refuge allocations were reduced to 50% in Shasta Critical Years when the end of September Shasta storage was forecast to be below 1.8 MAF. Although this ultimately reduced SOD refuge delivery in these years, Exchange Contractors

were able to call on the Friant Division to fulfill their 77% Shasta Critical year allocation.

6.1.2 CVP SOD Deliveries and Friant Division Post-Processing

The initial CalSim II results contained significant delivery shortages to Exchange Contractors, SOD refuges, SOD minimum public health and safety (PH&S) requirements, and SOD canal losses. Under a realistic scenario, operations would be adjusted to avoid such shortages. As such, a post-processor was created that sought to meet these shortages by reallocating the available SOD water supply, and calling on the CVP's Friant Division to make up Exchange Contractor shortages.

The post-processor first determined the monthly shortage to each set of CVP SOD demands (Ag, M&I, Exchange Contractors, refuges, canal losses) and the total SOD delivery (including Section 215) in each month. Water available for delivery was first allocated to meet canal losses and then unmet minimum PH&S demands. Deliveries to Exchange Contractors and refuges were equally reduced to satisfy any remaining canal loss or minimum PH&S shortages. The post-processor then determined the delivery shortage to Exchange Contractors given their allocation (77% in Shasta Critical Years, 100% in all others), and attempted to meet these shortages by calling on deliveries from the Friant Division via the San Joaquin River. Friant Section 215, Friant Class 2, and Friant Class 1 deliveries were reduced sequentially and released from Millerton Reservoir for delivery to the Exchange Contractors. Reductions to Friant supplies were included in the Friant allocation logic to account for reductions in total supply and potential changes to delivery patterns.

CVP SOD Minimum Public Health and Safety Deliveries

The initial CalSim II results for the Breach Alternative had significant shortages to CVP SOD M&I contractors. These shortages meant that M&I contractors frequently did not receive a delivery that satisfied their minimum PH&S demand. CalSim II models CVP SOD M&I demands at two nodes: contractors served by the joint-use branch of the California Aqueduct (D844 - Cities of Coalinga, Huron, and Avenal) and M&I users in the San Felipe Division (D711). Additionally, one-third of the water delivered at demand node (D700) on the upper Delta-Mendota Canal is for the City of Tracy. Minimum PH&S requirements were defined for each of these demands, and are shown in Figure 6-1. Demands were estimated by examining historical CVP deliveries to these contractors in 2015, when CVP SOD M&I allocations were 25% and deliveries were often made to satisfy only PH&S demands.

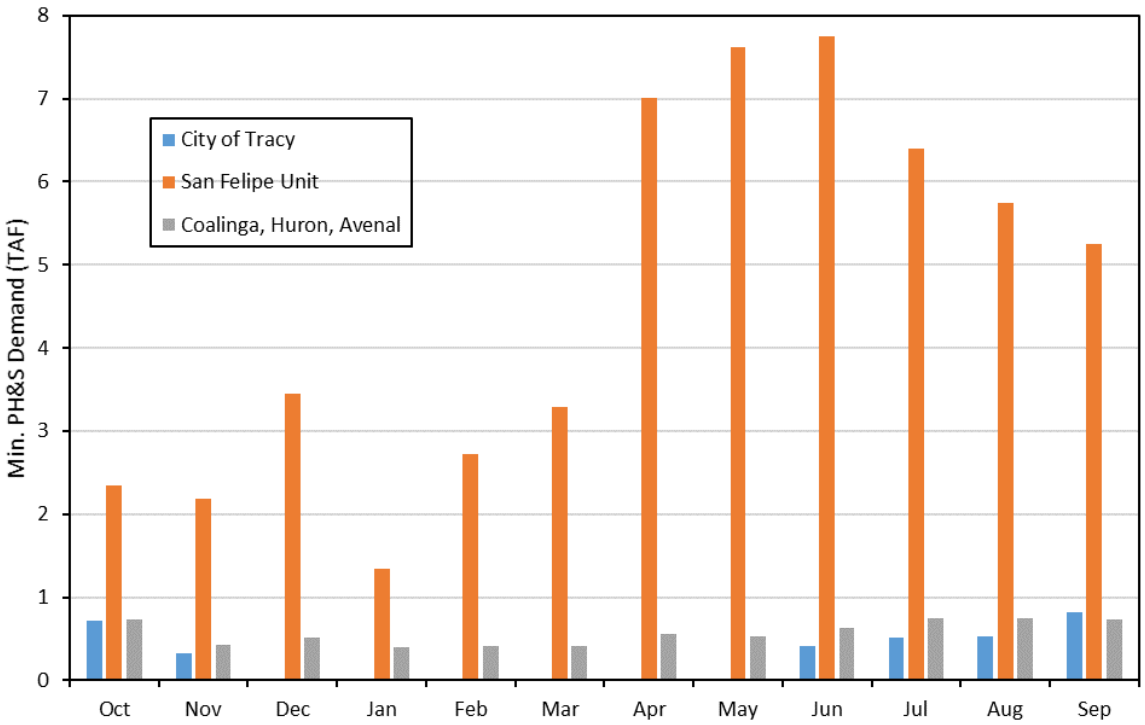

Figure 6-1. Monthly Minimum PH&S Demands for CVP SOD M&I Contractors

In a situation with no San Luis Reservoir, CVP deliveries to the San Felipe Division through the Pacheco Tunnel are not possible. Accordingly, for this analysis it was assumed that CVP deliveries to the Santa Clara Valley Water District could be made through additional pumping at Banks Pumping Plant and conveyance through the South Bay Aqueduct. Such deliveries were only allowed when sufficient capacity was available at Banks and in the South Bay Aqueduct, and only deliveries to meet minimum PH&S were made. These constraints meant that all San Felipe Division Ag and San Benito County Water Conservation and Flood Control District M&I contract deliveries were unable to be met.

CVP SOD April and May Export Constraints

In the initial CalSim II results, Exchange Contractor, refuge, and canal loss shortages typically occurred only in April and May, largely a result of regulatory export restrictions. Without San Luis, there is simply not enough available export capacity in April and May to meet these senior CVP SOD demands.

CalSim II model results were adjusted in these months to first meet all canal loss and minimum PH&S demands, even if that included reducing Exchange Contractor and refuge supplies. Any remaining CalSim II simulated delivery was split evenly between the Exchange Contractors and refuges, and the revised

Exchange Contractor shortage (including delivery needed to meet a 77% allocation) volume was met with deliveries from the Friant Division.

Friant Division Water Supply Allocation

Since most Exchange Contractor shortage occurs in April and May, it was assumed that "perfect-foresight" could be used to reduce Friant Division allocations by the expected Millerton release for Exchange Contractor deliveries plus additional San Joaquin River losses. Any water spilled from Friant that did not go down the Chowchilla Bypass was available for diversion by the Exchange Contractors. Any remaining Exchange Contractor shortage was met by sequentially reducing Friant Section 215, Friant Class 2, and Friant Class 1 supplies.

The post-processor then reallocated available Friant supply using the same allocation logic as CalSim II to determine Class 1, Class 2, and Section 215 deliveries to the Friant-Kern and Madera canals. In some cases, the reduction in Friant allocations caused a change in the annual delivery pattern. This, along with the additional dam releases, occasionally caused Millerton Lake to spill and to reach deadpool storage. However, these occurrences were rare and resulted in small changes to deliveries and reservoir operations over the period of study.

6.2 Breach Alternative Results

Results from the Breach Alternative are summarized and compared to the NAA. The primary difference between the NAA and the Breach Alternative is the removal of San Luis Reservoir from the system. The removal of San Luis impacts all parts of the CVP/SWP system, including reductions in SOD exports and deliveries, reductions in Friant Division deliveries, availability and volume of Section 215 and Article 21 supplies, changes to Delta outflow, and changes to upstream reservoir storage. Accordingly, key outputs from the model are simulated deliveries to all SOD and Friant Division contractors, along with key system parameters. The following figures and tables summarize these results for the Breach Alternative as compared to the NAA.

Overall, results of the Breach Alternative suggest substantial impacts to SOD deliveries. Without San Luis Reservoir, Section 215 and Article 21 supplies are available much more frequently, as one of the conditions (full San Luis Reservoir) for their availability is eliminated. Although a significant portion of the contract delivery reductions can be made up with Section 215 and Article 21 supplies, these deliveries occur most frequently in the winter months, out of season with demands. Although it's still possible to export significant volumes of water SOD, it is difficult to support high allocations because of regulatory restrictions in April through June.

6.2.1 Summary of South-of Delta Deliveries

Table 6-1 provides a summary of the average annual CVP SOD delivery by water year type for the Breach Alternative and the change from the NAA. Exchange Contractors and refuges face delivery reductions in this alternative, and thus are included. Water supply impacts are more extreme than either of the Restriction alternatives, and indicate that it would be difficult for many SOD Ag contractors to expect CVP supplies in all but the wettest years. The volume of Section 215 deliveries is significantly greater than the Restriction alternatives, however it is still an interruptible supply, and is typically delivered in the winter months.

Table 6-1. Annual Average CVP SOD Deliveries and Change from the NAA

CVP South-of-Delta Deliveries (TAF)	Exchange Contractors	Refuges	Ag Service	M&I	Section 215	Total SOD	Total SOD w/ 215
Wet	874	265	320	53	578	1,695	2,273
Above Normal	869	251	199	55	486	1,558	2,045
Below Normal	873	250	162	57	508	1,526	2,034
Dry	861	241	109	59	435	1,454	1,889
Critical	739	209	17	63	377	1,211	1,588
All Years	850	247	185	57	492	1,522	2,014
Change from No Action Alternative							
Wet	0	-15	-1,021	-79	561	-1,115	-554
Above Normal	-1	-24	-791	-58	458	-874	-417
Below Normal	1	-28	-690	-55	484	-771	-287
Dry	-1	-34	-475	-47	435	-556	-121
Critical	-14	-40	-154	-22	377	-229	148
All Years	-2	-26	-684	-57	478	-769	-291

Table 6-2 provides a summary of the average annual SWP SOD delivery by water year type for the Breach Alternative and the change from the NAA. Impacts to the SWP are less given the State's greater export capacity and larger demand for Article 21 supply. However, significant reductions still exist and Article 21 supplies mostly benefit only two SWP contractors (KCWA and MWD). Without San Luis, Article 56 supplies are unavailable.

Table 6-2. Annual Average SWP SOD Deliveries and Change from the NAA

SWP SOD Deliveries (TAF)	Ag SOD	M&I	Table A	Article 56	Article 21	Total SWP
Wet	543	1,670	2,213	0	1,047	3,260
Above Normal	464	1,460	1,924	0	934	2,858
Below Normal	423	1,321	1,744	0	988	2,732
Dry	313	972	1,285	0	915	2,200
Critical	143	578	721	0	640	1,361
All Years	402	1,267	1,669	0	932	2,601
Change from No Action Alternative						
Wet	-256	-647	-903	-112	949	-66
Above Normal	-206	-516	-723	-66	831	43
Below Normal	-220	-587	-808	-108	936	20
Dry	-188	-546	-734	-80	896	82
Critical	-149	-381	-530	-54	628	44
All Years	-212	-556	-769	-89	871	13

Figure 6-2 illustrates the shift from CVP contract supplies to interruptible Section 215 supplies. On average, contract deliveries are less in all months for the Breach Alternative, especially during the April through September irrigation season. However, for October through March, more water is delivered in total because of increased Section 215 deliveries. Ag contractors would likely need to change cropping patterns or develop additional projects or infrastructure to make use of the Section 215 supplies delivered in the winter months.

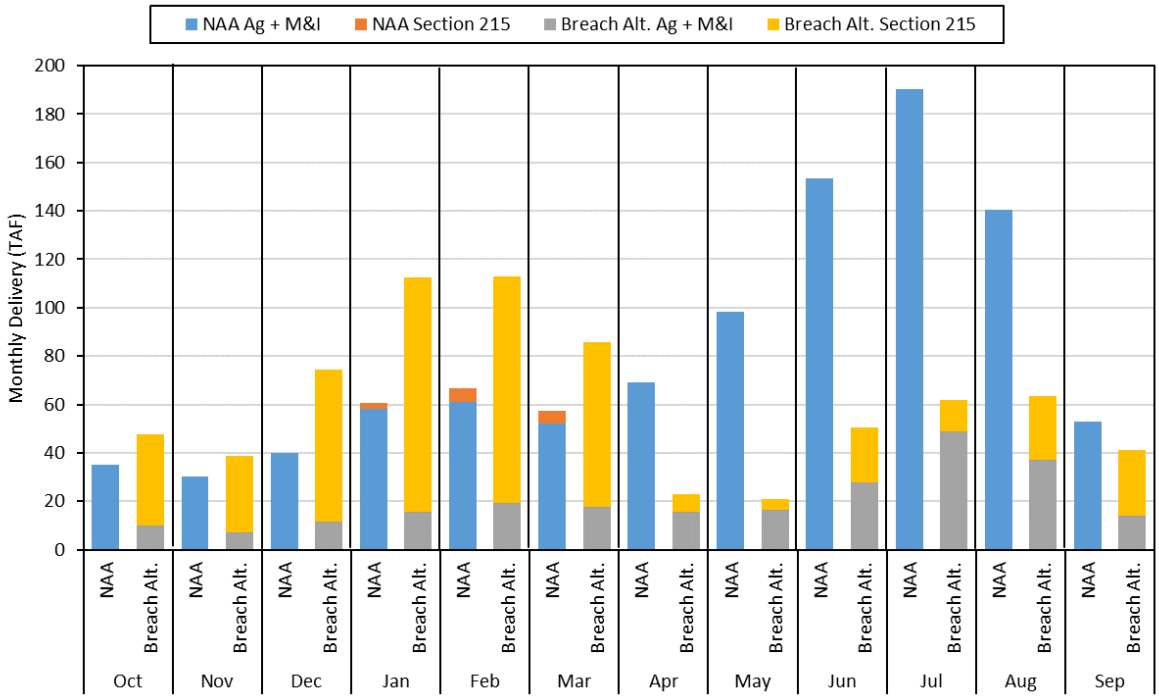

Figure 6-2. Average Monthly CVP Water Service Contract (Ag + M&I) and Section 215 Deliveries for the Breach Alternative and the NAA

Figure 6-3 illustrates the shift from SWP contract supplies to interruptible Article 21 supplies. On average, contract deliveries are less in all months for the Breach Alternative, especially in the April through June period. Impacts to deliveries in other months are less because in CalSim II, SWP delivery shortages can be made up in later months. This means that higher SWP allocations can be supported because the deliveries can be made up later in the year. While this might not impact M&I contractors significantly, Ag contractors would need to adjust their irrigation supply schedule (e.g. using groundwater at the beginning of the season) or switch crop types or cropping patterns. The SWP's greater export capacity and large demand for Article 21 supplies mean that in December through March, more water is delivered in total because of the significantly increased Article 21 deliveries.

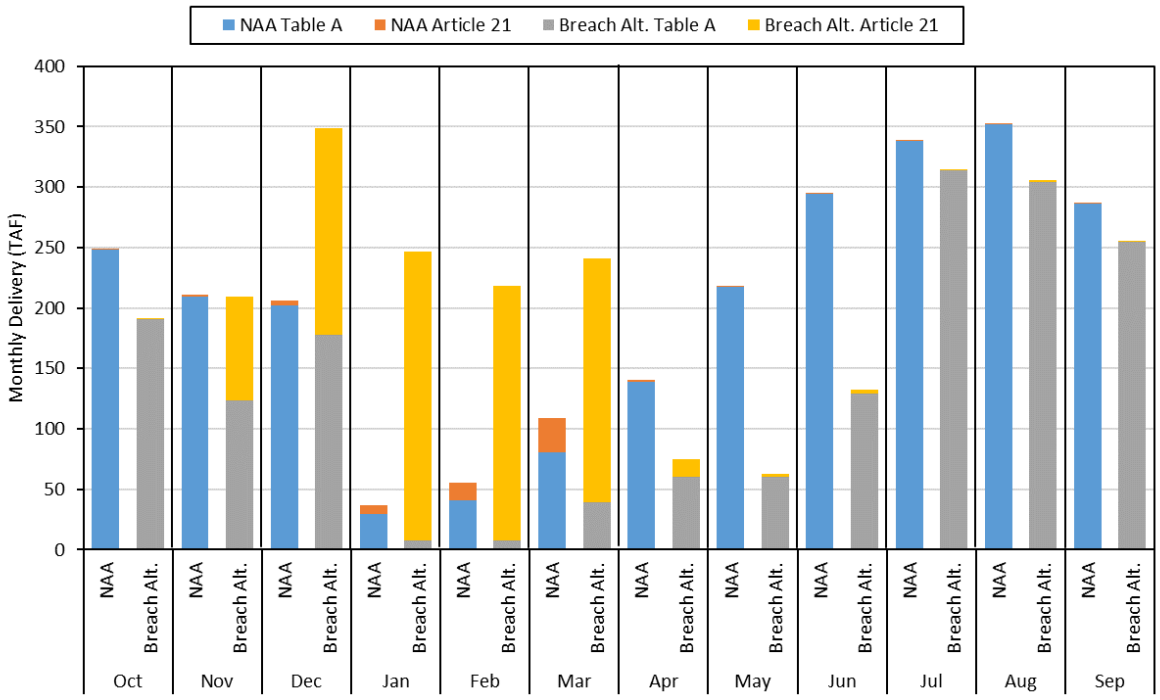

Figure 6-3. Average Monthly SWP Contract (Table A) and Article 21 Deliveries for the Breach Alternative and the NAA

6.2.2 Summary of Impacts to System Parameters

A comparison of key system parameters for reservoir storage, river flows, and the Delta is provided in Table 6-3. Average monthly results for the NAA and the Breach Alternative are presented and compared to one another.

Delta outflow is higher in all months (particularly winter months), except for July through September. The lower summer outflow reflects the reduced need for carriage water to support SWP exports. Pumping at Jones is less in October through March, as exports are no longer made to support filling of San Luis

Reservoir. Pumping in the summer months is higher at Jones, because without San Luis, exports are the only supply for minimum PH&S, Exchange Contractor, and refuge demands. Pumping at Banks is less in most months, reflecting lower Table A allocations, but higher in December and January, largely a result of increased pumping for Article 21 supplies. Upstream river flows are higher in the winter because of additional spills and flood releases from higher reservoir storage levels, but lower in the fall because releases are not made to support exports to fill San Luis. Sacramento River flows are higher in the summer, largely to support SOD exports. San Joaquin River flows are somewhat lower, a result of reduced return flows from Ag users in the San Joaquin basin. Shasta storage is higher in the fall and winter, but lower in July and August, reflecting the change in release pattern. Releases are shifted from supporting exports to fill San Luis in the fall and winter, to supporting exports for delivery in the summer months. Oroville is significantly higher, particularly in the fall and winter. As shown in Figure 6-4, Oroville carryover storage is often higher to avoid August through December delivery shortages. Even when allocations are more aggressive (higher) it is often difficult to export that water, leading to large volumes of August through December shortage.

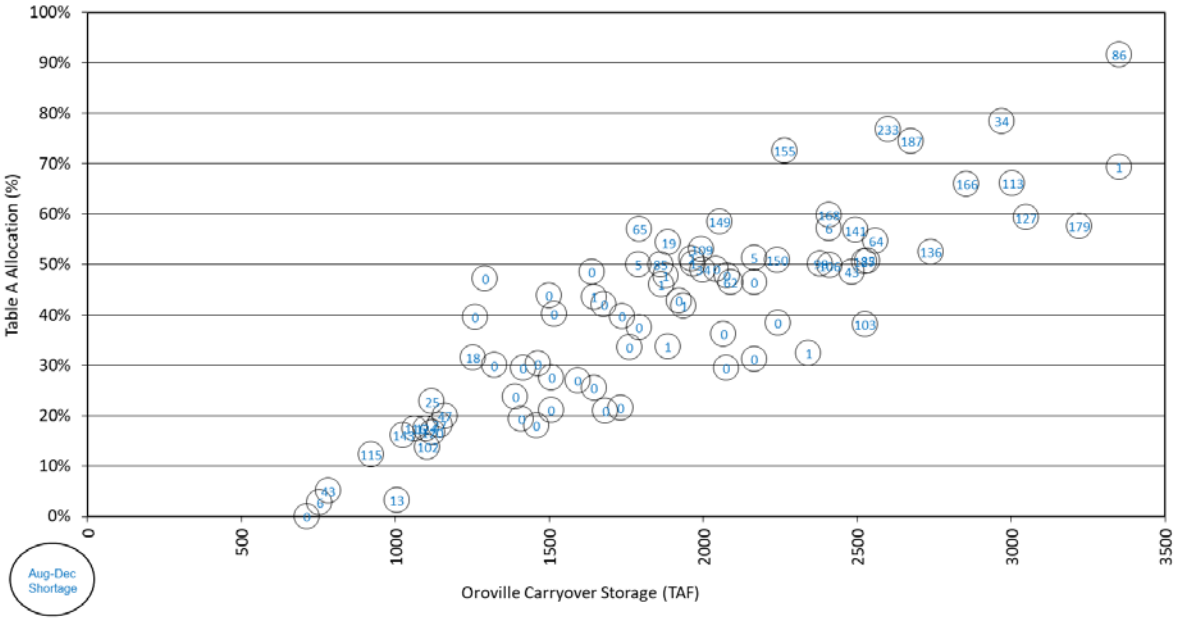

Figure 6-4. Annual Oroville Carryover Storage vs. Table A Allocation with August – December Shortage

Table 6-3. Comparison of Key System Parameters Under the Breach Alternative and Change from the NAA

NAA	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Delta Outflow (cfs)	5,891	11,479	20,756	42,066	52,870	42,241	30,993	22,068	12,346	7,758	4,435	9,704
Jones Pumping Plant (cfs)	3,496	3,512	3,927	3,277	3,410	3,192	1,213	1,087	2,591	3,341	3,654	3,914
Banks Pumping Plant (cfs)	3,148	3,785	4,662	3,570	4,011	3,982	1,190	987	2,411	5,841	5,414	5,011
Sac. River into Delta (cfs)	10,800	15,719	21,512	29,958	36,427	30,779	22,325	19,048	15,951	17,953	14,154	17,708
Yolo Bypass (cfs)	196	475	3,725	10,901	14,319	9,589	3,607	363	224	48	88	171
Sac. River below Keswick (cfs)	6,196	6,894	6,530	8,373	10,690	8,329	7,038	8,122	10,772	12,777	10,058	8,044
Sac. River at NCP (cfs)	6,000	8,987	11,286	13,669	15,383	14,092	8,846	7,094	5,648	6,269	5,247	7,763
Feather R. blw Thermalito (cfs)	2,485	1,983	2,377	4,047	4,390	5,321	3,051	3,633	3,646	7,060	4,852	5,324
Lower Feather River (cfs)	2,977	2,881	4,714	10,761	11,851	12,433	8,786	7,663	6,198	7,678	5,806	7,051
American R blw Nimbus (cfs)	1,614	2,641	3,381	4,567	5,222	4,065	3,360	3,379	3,207	3,195	2,213	2,461
American R at H St (cfs)	1,438	2,478	3,241	4,409	5,033	3,872	3,078	3,040	2,817	2,653	1,829	2,151
SJ River at Vernalis (cfs)	2,710	2,605	3,248	4,821	6,203	7,165	7,474	5,746	4,609	3,187	2,032	2,312
Shasta Storage (TAF)	2,621	2,579	2,758	3,030	3,281	3,651	3,944	3,960	3,660	3,202	2,887	2,702
Oroville Storage (TAF)	1,602	1,577	1,717	1,931	2,203	2,447	2,723	2,861	2,753	2,309	2,016	1,719
Folsom Storage (TAF)	463	434	458	473	493	591	719	838	803	675	597	510
CVP San Luis Storage (TAF)	232	351	523	645	741	811	731	577	415	251	149	179
SWP San Luis Storage (TAF)	367	361	460	598	726	831	749	585	428	436	407	411
Breach Alternative	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**
Delta Outflow (cfs)	6,329	12,357	22,783	43,318	54,727	43,646	31,066	22,069	12,395	7,743	4,321	9,629
Jones Pumping Plant (cfs)	2,845	1,679	1,688	2,152	2,550	2,509	1,222	1,067	2,987	3,750	3,908	3,163
Banks Pumping Plant (cfs)	2,937	3,564	5,684	4,083	3,855	3,864	1,159	998	2,203	5,289	4,982	4,298
Sac. River into Delta (cfs)	10,402	14,535	22,027	30,275	36,716	31,143	22,379	19,049	16,037	17,815	13,886	16,205
Yolo Bypass (cfs)	197	513	4,056	11,230	14,877	9,839	3,614	363	224	48	88	171
Sac. River below Keswick (cfs)	6,005	5,702	6,962	8,743	10,845	8,535	7,052	8,112	10,987	13,020	10,232	7,439
Sac. River at NCP (cfs)	5,843	7,713	11,358	13,794	15,372	14,156	8,851	7,083	5,861	6,492	5,401	7,158
Feather R. blw Thermalito (cfs)	2,426	2,184	2,641	4,326	5,020	5,747	3,067	3,659	3,456	6,528	4,527	4,672
Lower Feather River (cfs)	2,918	3,074	4,970	11,033	12,464	12,849	8,797	7,686	5,997	7,152	5,470	6,394
American R blw Nimbus (cfs)	1,498	2,518	3,507	4,605	5,294	4,066	3,406	3,372	3,283	3,364	2,138	2,246
American R at H St (cfs)	1,332	2,362	3,365	4,445	5,101	3,872	3,123	3,033	2,884	2,794	1,767	1,945
SJ River at Vernalis (cfs)	2,702	2,595	3,238	4,818	6,204	7,157	7,462	5,735	4,602	3,170	2,008	2,293
Shasta Storage (TAF)	2,665	2,692	2,840	3,082	3,324	3,683	3,975	3,991	3,674	3,199	2,881	2,735
Oroville Storage (TAF)	1,781	1,743	1,868	2,065	2,305	2,524	2,799	2,936	2,839	2,429	2,155	1,897
Folsom Storage (TAF)	476	455	471	484	499	597	722	841	802	664	591	516
CVP San Luis Storage (TAF)	0	0	0	0	0	0	0	0	0	0	0	0
SWP San Luis Storage (TAF)	0	0	0	0	0	0	0	0	0	0	0	0
Change from NAA	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**
Delta Outflow (cfs)	438	878	2,028	1,252	1,857	1,405	73	0	50	-15	-114	-75
Jones Pumping Plant (cfs)	-651	-1,833	-2,239	-1,125	-859	-683	9	-20	396	409	254	-751
Banks Pumping Plant (cfs)	-211	-221	1,022	514	-156	-118	-32	11	-208	-552	-432	-713
Sac. River into Delta (cfs)	-398	-1,184	515	317	288	363	54	1	85	-138	-268	-1,503
Yolo Bypass (cfs)	1	38	332	328	557	250	7	0	0	0	0	0
Sac. River below Keswick (cfs)	-191	-1,193	432	370	155	206	14	-11	216	242	174	-605
Sac. River at NCP (cfs)	-158	-1,275	72	124	-10	64	5	-11	213	223	154	-605
Feather R. blw Thermalito (cfs)	-59	201	264	279	630	426	17	26	-190	-531	-325	-652
Lower Feather River (cfs)	-59	192	256	272	613	416	11	22	-201	-526	-336	-657
American R blw Nimbus (cfs)	-116	-123	127	39	72	1	46	-7	77	169	-75	-215
American R at H St (cfs)	-106	-116	123	36	68	0	45	-8	67	140	-62	-206
SJ River at Vernalis (cfs)	-8	-10	-10	-3	1	-8	-12	-11	-7	-18	-23	-20
Shasta Storage (TAF)	44	113	82	52	43	32	32	31	14	-3	-6	34
Oroville Storage (TAF)	179	166	151	134	102	77	76	75	86	119	139	178
Folsom Storage (TAF)	14	21	13	11	7	6	3	4	-1	-11	-6	7
CVP San Luis Storage (TAF)	-232	-351	-523	-645	-741	-811	-731	-577	-415	-251	-149	-179
SWP San Luis Storage (TAF)	-367	-361	-460	-598	-726	-831	-749	-585	-428	-436	-407	-411

6.2.3 Summary of Friant Division Delivery Results

Friant Division deliveries were identical between the Reservoir Restriction alternatives and the NAA. In the Breach Alternative, Friant Division deliveries are reduced in most years to meet Exchange Contractor shortages. Table 6-4 shows delivery volumes of Friant Class 1, Class 2, and Section 215 supplies by water year type and the change from the NAA.

Table 6-4. Annual Average Friant Division Deliveries and Change from the NAA

Friant Division Deliveries (TAF)	Class 1	Class 2	Section 215	Total Friant Delivery
Wet	787	456	132	1,375
Above Normal	749	269	74	1,092
Below Normal	727	199	37	963
Dry	565	26	5	596
Critical	273	7	0	280
All Years	647	224	60	931
Change from No Action Alternative				
Wet	-1	-56	-6	-63
Above Normal	-28	-59	-17	-104
Below Normal	-53	-55	-14	-122
Dry	-133	-31	0	-164
Critical	-188	-2	0	-190
All Years	-70	-43	-7	-120

Class 2 supplies are largely available only in wetter years, which are years when it is more likely that Exchange Contractor demands can be met with Delta exports. Accordingly, reductions in total Friant deliveries are greater in drier years and average reductions in Class 1 supplies are greater than reductions in Class 2 supplies.

Friant supplies are sufficient to meet Exchange Contractor shortage in all but two years, 1931 and 1977. However, in these years, a small amount of Friant Class 1 supply is still delivered. This is a function of the Friant allocation logic that is based on forecasted inflow to Millerton Lake. Each month the inflow forecast is updated, which can affect the allocation. In some months of these years, not all Exchange Contractor shortage can be met, but shortage is not made up in subsequent months. As such, inflow later in the season can be used to meet Friant Division demands, but occurs too late to meet Exchange Contractor demands.

Occasionally Millerton Lake hits deadpool under the revised operations of the post-processor. In these months, the post-processor cuts deliveries to the Friant-Kern and Madera canals to prevent the reservoir from going below deadpool. Although rare and small in volume, these cuts further reduce Friant Division deliveries.

6.2.4 Annual Average San Felipe M&I Delivery

Table 6-5 shows deliveries to San Felipe M&I contractors in the Breach Alternative and the change from the NAA. Given the inability to make CVP deliveries to the San Felipe Division through the Pacheco Tunnel in the Breach Alternative, M&I deliveries to San Benito County Water Conservation and Flood Control District are unable to be met, while deliveries to Santa Clara Valley Water District are capped at their minimum PH&S demand and available capacity at Banks Pumping Plant and in the South Bay Aqueduct. Deliveries are increasingly less in wetter years because of the reduced capacity available at Jones Pumping Plant and in the South Bay Aqueduct.

Table 6-5. Annual Average San Felipe M&I Deliveries and Change from the NAA

Sacramento Valley Index	Breach Alternative (TAF)	Change from NAA (TAF)
Wet	40	-73
Above Normal	44	-53
Below Normal	46	-51
Dry	48	-43
Critical	53	-20
All Years	45	-52

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Appendix B:
Attachment A

CalSim II Assumptions for
No Action/No Project Conditions

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	Period of Simulation: 82 years (1922-2003)
	Future Level Study
HYDROLOGY	
Level of Development	2020 Level, *DWR Bulletin 160-98*[1]
Sacramento River Region Demands	
CVP	Land use based, limited by full contract
SWP (FRSA)	Land use based, limited by full contract
Non-Project	Land use based
Woodland-Davis Clean Water Agency	Included
Antioch	Pre-1914 water right
CVP Refuges	Firm Level 2 water needs
American River Basin Demands	
Water rights	2020 Level
CVP	2020 Level, full contracts including Freeport Regional Water Project and Sacramento River Water Reliability Project
San Joaquin River Basin Demands	
Friant Unit	Limited by contract amounts, based on current allocation policy
Lower Basin	Land use based with district level operations and constraints
Stanislaus River Basin[2]	Land use based, with New Melones Interim Operations Plan and NMFS biological opinion (June 2009), Actions 3.1.2 and 3.1.3[5]
South of Delta Demands	
CVP	Full contract
Contra Costa Water District	195 taf/yr
SWP (with North Bay Aqueduct)	4.1 maf/yr
SWP Article 21 Demand	Metropolitan Water District of Southern California up to 200 taf/month (Dec-Mar), KCWA demand up to 180 taf/month and others up to 34 taf/month
FACILITIES	
Red Bluff Diversion Dam	Fish Passage Improvement Project in place with 2,500 cfs capacity
Freeport Regional Water Project	Included with diversions to EBMUD
Banks Pumping Capacity	Physical capacity is 10,300 cfs, 6,680 cfs permitted capacity up to 8,500 cfs (Dec 15th–Mar 15th) depending on Vernalis flow conditions[3] additional capacity of 500 cfs (up to 7,180 cfs) allowed for Jul–Sep for reducing impact of NMFS biological opinion on SWP (Jun 2009), Action 4.2.1[5]
Jones Pumping Capacity	Exports up to 4,600 cfs permit capacity in all months
Delta-Mendota Canal-California Aqueduct Intertie	Included with 400 cfs capacity
Los Vaqueros Reservoir Capacity	160 taf
South Bay Aqueduct	South Bay Aqueduct Enlargement to 430 cfs
REGULATORY STANDARDS	
Trinity River	
Minimum Flow below Lewiston Dam	Trinity EIS Preferred Alternative (369-815 taf/yr)
Trinity Reservoir End-of-September Minimum Storage	Trinity EIS Preferred Alternative (600 taf as able)

	Period of Simulation: 82 years (1922-2003)
	Future Level Study
Clear Creek	
Minimum Flow below Whiskeytown Dam	Downstream water rights, 1963 Reclamation Proposal to USFWS and NPS, predetermined Central Valley Project Improvement Act 3406(b)(2) flows and NMFS biological opinion (June 2009) Action I.1.1[5]
Upper Sacramento River	
Shasta Lake End-of-September Minimum Storage	NMFS 2004 Winter-run biological opinion (1900 taf), predetermined Central Valley Project Improvement Act 3406(b)(2) flows, and NMFS biological opinion (Jun 2009) Action I.2.1[5]
Minimum Flow below Keswick Dam	Flows for SWRCB Water Rights Order 90-5 and 1993 Winter-run biological opinion temperature control, predetermined Central Valley Project Improvement Act 3406(b)(2) flows, and NMFS biological opinion (Jun 2009), Action I.2.2[5]
Feather River	
Minimum Flow below Thermalito Diversion Dam	2006 Settlement Agreement (700/800 cfs)
Minimum Flow below Thermalito Afterbay outlet	1983 DWR, DFG Agreement (750-1700 cfs)
Yuba River	
Minimum flow below Daguerre Point Dam	D-1644 Operations (Lower Yuba River Accord)[4]
American River	
Minimum Flow below Nimbus Dam	American River Flow Management as required by NMFS biological opinion (Jun 2009), Action 2.1[5]
Minimum Flow at H Street Bridge	SWRCB D-893
Lower Sacramento River	
Minimum Flow near Rio Vista	SWRCB D-1641
Mokelumne River	
Minimum Flow below Camanche Dam	Federal Energy Regulatory Commission 2916-029, 1996 Joint Settlement Agreement (100 – 325 cfs)
Minimum Flow below Woodbridge Diversion Dam	Federal Energy Regulatory Commission 2916-029, 1996 Joint Settlement Agreement (25 – 300 cfs)
Stanislaus River	
Minimum Flow below Goodwin Dam	1987 Reclamation, DFG agreement, and flows required for NMFS biological opinion (Jun 2009) Actions III.1.2 and III.1.3[5]
Minimum Dissolved Oxygen	SWRCB D-1422
REGULATORY STANDARDS	
Merced River	
Minimum Flow below Crocker-Huffman Diversion Dam	Davis-Grunsky (180 – 220 cfs, Nov – Mar) and Cowell Agreement
Minimum Flow at Shaffer Bridge	Federal Energy Regulatory Commission 2179 (25-100 cfs)
Tuolumne River	
Minimum Flow at Lagrange Bridge	Federal Energy Regulatory Commission 2299-024, 1995 Settlement Agreement (94-301 taf/yr)
San Joaquin River	
San Joaquin River Restoration	Full flows
Maximum Salinity near Vernalis	SWRCB D-1641
Minimum Flow near Vernalis	SWRCB D-1641, NMFS biological opinion (Jun 2009), Action 4.2.1[5]

	Period of Simulation: 82 years (1922-2003)
	Future Level Study
Sacramento River-San Joaquin River Delta	
Delta Outflow Index (Flow and Salinity)	SWRCB D-1641, USFWS biological opinion (Dec 2008), Action 4[5]
Delta Cross Channel Gates	SWRCB D-1641, NMFS biological opinion (Jun 2009) Action 4.1.2[5]
Delta Exports	SWRCB D-1641, NMFS biological opinion (Jun 2009) Action 4.2.1[5]
Combined Flow in Old and Middle River	USFWS biological opinion (Dec 2008), Actions 1–3 and NMFS biological opinion (Jun 2009), Action 4.2.3[5]
OPERATIONS CRITERIA	
Subsystem	
Upper Sacramento River	
Flow Objective for Navigation (Wilkins Slough)	NMFS biological opinion (Jun 2009) Action I.4[5]; 3,250 – 5,000 cfs based on CVP water supply condition
American River	
Folsom Dam Flood Control	Variable 400/670 without outlet modifications
Feather River	
Flow at Mouth	Maintain DFG/DWR flow target above Verona or 2800 cfs Apr-Sep, dependent on Oroville inflow and FRSA allocation
System-wide	
CVP Water Allocation	
CVP Settlement and Exchange	100% (75% in Shasta Critical years)
CVP Refuges	100% (75% in Shasta Critical years)
CVP Agriculture	100% - 0% based on supply; additionally limited due to D-1641, USFWS biological opinion (Dec 2008) and NMFS biological opinion (Jun 2009) export restrictions[5]
CVP Municipal & Industrial	100% - 0% based on supply; additionally limited due to D-1641, USFWS biological opinion (Dec 2008) and NMFS biological opinion (Jun 2009) export restrictions[5]
OPERATIONS CRITERIA	
SWP Water Allocation	
North of Delta (FRSA)	Contract specific
South of Delta	Based on supply, Monterey Agreement; allocations limited due to D-1641, USFWS biological opinion (Dec2008) and NMFS biological opinion (Jun 2009) export restrictions[5]
CVP/SWP Coordinated Operations	
Sharing of Responsibility for In Basin Use	1986 Coordinated Operations Agreement
Sharing of Surplus Flows	1986 Coordinated Operations Agreement
Sharing of Restricted Export Capacity	Equal sharing of export capacity under SWRCB D-1641, USFWS biological opinion (Dec 2008) and NMFS biological opinion (Jun 2009) export restrictions[5]
Transfers	
Lower Yuba River Accord[6]	Yuba River acquisitions for reducing impact of NMFS biological opinion export restrictions on SWP

[1] The Sacramento Valley hydrology used in the Future Conditions CalSim II model reflects 2020 land-use assumptions associated with Bulletin 160-98. The San Joaquin Valley hydrology reflects draft 2030 land-use assumptions developed by Reclamation. Development of future-level projected land-use assumptions are being coordinated with the California Water Plan Update for future models.

[2] The CalSim II model representation for the Stanislaus River does not necessarily represent Reclamation's current or future operational policies. A suitable plan for supporting flows has not been developed for NMFS biological opinion (Jun 2009), Action 3.1.3.

[3] Current US Army Corps of Engineers permit for Harvey O. Banks Pumping Plant allows for an average diversion rate of 6,680 cfs in all months. Diversion rate can increase up to 1/3 of the rate of San Joaquin River flow at Vernalis during Dec 15th–Mar 15th up to a maximum diversion of 8,500 cfs, if Vernalis flow exceeds 1,000 cfs.

[4] D-1644 and the Lower Yuba River Accord are assumed to be implemented for Future Conditions. The Yuba River is not dynamically modeled in CalSim II. Yuba River hydrology and availability of water acquisitions under the Lower Yuba River Accord are based on modeling performed and provided by the Lower Yuba River Accord EIS/EIR study team.

[5] In cooperation with USBR, NMFS, USFWS, and DGF, the DWR has developed assumptions for implementation of the USFWS biological opinion (December 15, 2008) and NMFS biological opinion (June 4, 2009) in CalSim II.

[6] Acquisitions of Component 1 water under the Lower Yuba River Accord, and use of 500 cfs dedicated capacity at Banks Pumping Plant during Jul–Sep, are assumed to be used to reduce as much of the effect of the April–May Delta export actions on SWP contractors as possible.