BUREAU OF RECLAMATION

Long-Term Operation – Public Draft Alternatives

Appendix E – Exploratory Modeling

Central Valley Project, California

Interior Region 10 – California-Great Basin

U.S. Department of the Interior

November 2023

Mission Statements

The U.S. Department of the Interior protects and manages the Nation's natural resources and cultural heritage; provides scientific and other information about those resources; honors its trust responsibilities or special commitments to American Indians, Alaska Natives, and affiliated Island Communities.

The mission of the Bureau of Reclamation is to manage, develop, and protect water and related resources in an environmentally and economically sound manner in the interest of the American public.

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1. Introduction

This exploratory modeling appendix establishes an analytical foundation for the following.

1. Support a common understanding of the U.S. Department of the Interior, Bureau of Reclamation (Reclamation) and California Department of Water Resources (DWR) operational constraints and opportunities to inform potential alternatives and a Preferred Alternative/Proposed Action for consultation on the Long-Term Operation (LTO) of the Central Valley Project (CVP) and State Water Project (SWP),

2. Identify potential systemwide capabilities and impacts from related processes such as the update to the Bay-Delta Water Quality Control Plan and proposed infrastructure development.

The CVP and SWP facilities were designed and constructed in the 1940s through 1960s, primarily to meet flood protection and water supply needs to the extent those needs were understood at that time. Over the decades following construction of facilities, these needs have evolved and not only expanded in terms of increased water demands, but also expanded in the form of the needs. An understanding of environmental needs emerged and evolved. With each regulatory milestone, new operational rules have been layered on top of the existing set of rules. Current primary operational rules are State Water Resources Control Board (Water Board) Decision 1641 (D-1641), the 2019 National Marine Fisheries Service (NMFS) and U.S. Fish and Wildlife Service (USFWS) Biological Opinions (implemented through the 2020 Record of Decision [ROD]), and the 2020 Incidental Take Permit (ITP) (which only applies to the SWP). These requirements are complex and overlapping. Figure 1 provides a summary of the actions and timing of the D-1641 requirements. A summary of the actions in the 2019 Biological Opinions and their timing is included in Figure 2, and a summary of the SWP actions under the 2020 ITP and their timing is included in Figure 3.

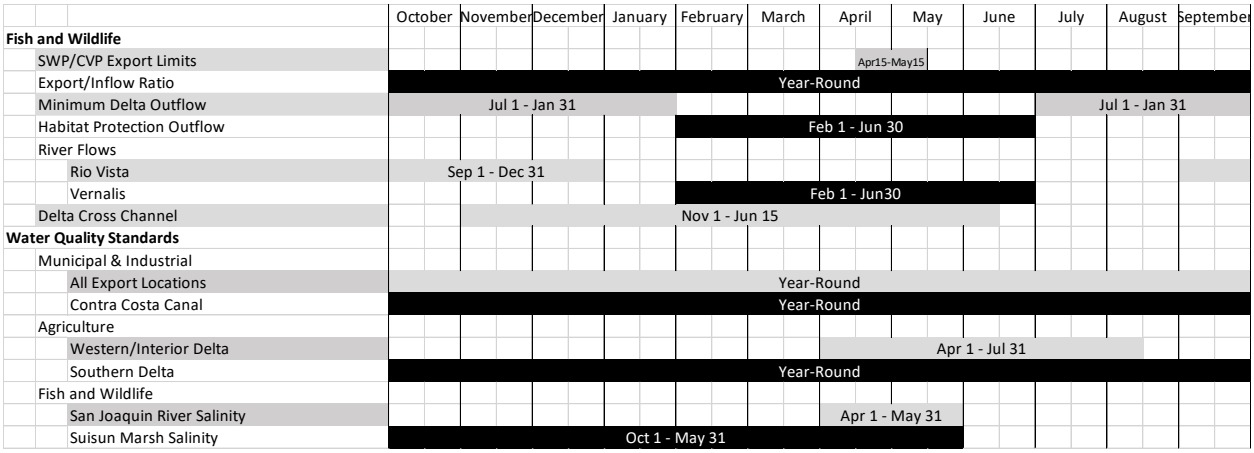
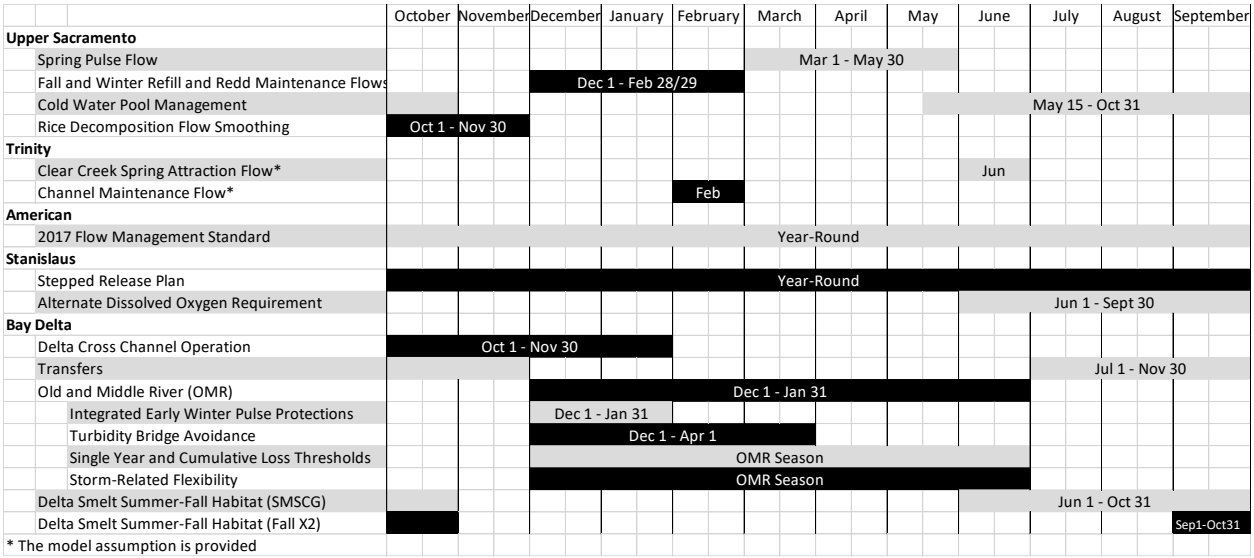


Figure 1. D-1641 Actions.



SMSCG = Suisun Marsh Salinity Control Gates

Figure 2. 2019 Biological Opinions Actions.

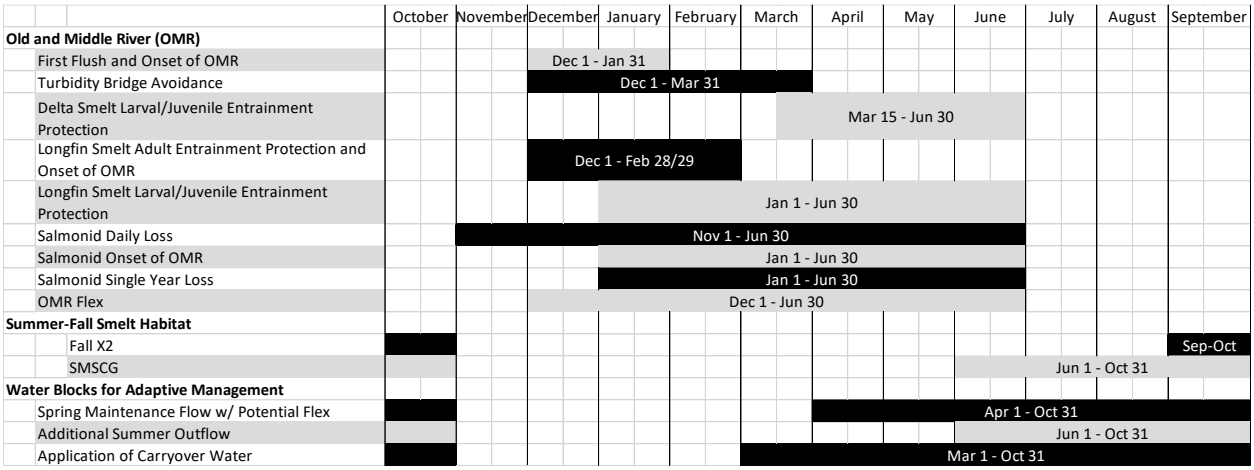


Figure 3. 2020 ITP Actions.

In addition to the evolving regulatory environment, the hydrology continued to change, with a prominent warming trend that affected the fills and releases from the reservoirs. Given these conditions, for the general audience, it has become increasingly more difficult to understand how the CVP and SWP are altering flow patterns and for what reason at any given time.

To facilitate discussions for the 2021 LTO, Reclamation developed an analytical framework to support common understanding of operational requirements and how Reclamation and DWR can operate project facilities to meet requirements. These models and their results were shared with interested parties in a series of recurring meetings, and Reclamation sought feedback on scenarios to consider. These models are also utilized to inform development of several

components of the initial alternatives. Analyses that helped inform initial alternatives are documented in the respective appendices of those components.

Reclamation operates the CVP and DWR operates the SWP under the 1986 Coordinated Operation Agreement (COA), as amended in 2018, authorized by Public Law 99-546. The CVP and SWP operate under overlapping statutory, regulatory, and contractual requirements. Reclamation and DWR must comply with the federal Endangered Species Act (ESA) by consulting with USFWS and NMFS on operations. Operations must comply with the terms of water rights issued for the CVP and SWP by the Water Board, including their water quality control plans. DWR must comply with the California Endangered Species Act (CESA) and has an ITP from the California Department of Fish and Wildlife (CDFW). The CVP and SWP deliver water for fish and wildlife, agriculture, and municipal and industrial uses under the terms of various contracts and agreements. Water operations modeling simulates the outcomes for how Reclamation and DWR may operate the CVP and SWP to meet these requirements.

These exploratory modeling efforts develop operational scenarios that may assist in discussions with USFWS, NMFS, CDFW, Water Board, and interested parties regarding how to meet operational requirements. The layering of permits and programs on hydrology results in tradeoffs on the availability of water within a year and with subsequent years. The information from these models and the tradeoffs they illustrate is to be used to facilitate alternatives development; the exploratory models do not reflect any proposed operation of the CVP and SWP, and the models are not intended to be alternatives.

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2. Background

Fish species native to the state of California evolved under California's hydrology in an unaltered landscape, but now face a different environment. Elements of natural flow regimes can provide a basis for the conditions that may best support species viability (State Water Resources Control Board 2017); however, achieving environmental objectives under an altered landscape and balancing multiple competing demands for water resources may require different operational actions. Reclamation and DWR can operate facilities to manage the water provided from each year's hydrology within the limitations of facilities and legal requirements.

The operational aspects of any LTO Proposed Action move water spatially from where water supplies are developed to where they are put to beneficial use, and consist of the following.

1. Storing water runoff from the impaired watersheds upstream of CVP and SWP dams.

2. Releasing stored water to augment flows in the system and moving flows in time:

    a. From the winter and spring to the summer and fall, or

    b. From wetter years to meet needs in drier years;

3. Diverting water for beneficial uses (e.g., public health and safety, Central Valley Project Improvements Act [CVPIA] wildlife refuges, water service contracts).

4. Routing of flows and fish through operating gates and barriers.

5. Blending withdrawals from reservoir levels to provide cold water for temperature-sensitive endangered/threatened species while generating and/or bypassing power plants.

Section 8 of the Reclamation Act of 1902 addresses the control, appropriation, use, and distribution of water by states and territories, provided those laws are not inconsistent with clear congressional directives. While some riparian rights exist in the state, California implements a priority system based on seniority; therefore, the CVP and SWP satisfy senior water rights before operating to meet CVP and SWP obligations. Some of these senior water rights are represented by Settlement, Exchange, and/or other types of agreements, such as the Sacramento River Settlement Contracts, Feather River Settlement Contracts (SWP), Friant Dam Riparian Holding Contracts, San Joaquin River Exchange Contract, and San Joaquin River Settlement Contracts. Reclamation and DWR satisfy these senior water rights in accordance with the specific agreements. Senior water right contracts are different than the contracts and agreements for water service and repayment (water service contracts). Water service contracts form the basis for the construction, operation, maintenance, and repayment of the CVP.

Reclamation also operates the CVP consistent with the hierarchy of purposes established by Section 2 of the 1937 Act, as amended and supplemented, specifically Section 3406 of the CVPIA. This hierarchy includes the following.

1. River regulation, improvement of navigation, and flood control.

2. Irrigation and domestic uses and fish and wildlife mitigation, protection, and restoration purposes.

3. Power and fish and wildlife enhancement.

Within that framework, Reclamation operates the CVP to meet senior water rights that predate the CVP's water rights, applicable federal law and regulations, applicable state law and regulations through Section 8 of the Reclamation Act, and other obligations, such as contracts and agreements. In general, Reclamation implements water operations in the following overall priority system.

- Senior Water Rights that Predate the CVP's Water Rights:
    - CVPIA(b)(23) flows, which reflect federal tribal trust responsibilities to protect fishery resources that predate the CVP and the state of California
    - CVPIA Level 1 Refuge Water supplies, binding obligations in Settlement Contract sand Agreements executed with the United States, including releases from Friant Dam for the Exchange Contractors, if required
    - Navigation and Flood Control:
    - Flood Control and Safety of Dams: Section 2 of 1937 Act implemented through U.S. Army Corps of Engineers flood control diagrams and regulations
    - Navigation: Section 2 of the 1937 Act
- Irrigation, Domestic, and Fish and Wildlife Mitigation, Protection and Restoration:
    - ESA under Biological Opinions issued under Section 7 of the ESA
    - CVPIA Level 2 Refuge Water Supply and Exchange Contractor deliveries from the Sacramento–San Joaquin Delta (Delta)
    - CVPIA Section 3406(b)(2), which dedicates up to 800,000 acre-feet of CVP yield for fish and wildlife purposes including measures under (b)(1)(B) and others
    - Municipal and Industrial water supply contracts
    - Irrigation water supply contracts
- Power and Fish and Wildlife Enhancement:
    - Power Marketing with Western Area Power Administration and their Power Contractors
    - CVPIA Level 4 Refuge Water supplies, which comes from acquired water
    - Flow Agreements

Reclamation and DWR must comply with applicable federal laws, and DWR must comply with applicable state laws. Both senior water right contracts and water service contracts have various provisions that impose binding obligations. A shortage of water supply under those contracts must be implemented in accordance with the terms of the contracts.

This effort focuses on water operations modeling. Water operations analyses may be later supplemented by hydraulic and temperature models to evaluate selective withdrawals from reservoirs for cold water pool management, and biological models for the routing flows and fish to determine growth and survival.

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3. Methodology

3.1 Tools

DWR and Reclamation developed the computer model CalSim to simulate operation of the water resources infrastructure in the Central Valley of California and the Delta region and coordinated operation of the CVP and SWP, over a range of hydrologic conditions, regulatory frameworks, and with existing and proposed infrastructure. Although CalSim is primarily intended for comparative analysis of water management alternatives analyzed in environmental compliance documents, Reclamation has expanded the model application to explore the boundaries or limits of the water resources and facilities managed by Reclamation and DWR.

For exploratory modeling purposes, Reclamation's CalSim II model with 2035_CT hydrology and operational rules that represent the 2020 ROD and 2020 ITP was used as the starting model to develop the exploratory layers. Additional information on the 2035_CT climate development and modeling approach and the 15-centimeter sea level rise can be found in Appendix F2, *Additional Climate Scenario Sensitivity Analysis*, Section F2.3, *Climate Changes Projections Development*, of Reclamation's 2019 *Reinitiation of Consultation on the Coordinated Long-Term Operation of the Central Valley Project and State Water Project* (Bureau of Reclamation 2019a).

3.1.1 Flow Tracker

The FlowTracker is a post processor tool that tracks "flow types" of water (such as pass-through inflow or stored water release from a particular reservoir) through the system, so that the user can track what flow type is contributing to meeting specific flow requirements or deliveries.

The FlowTracker takes as input the merged inputs and outputs of a CalSim II run. The FlowTracker determines what flow types are for each channel and delivery arc in the system by following just two principles: (1) that every channel or diversion arc is the sum of its flow types and (2) that mass balance of each flow type at each node must be maintained. Storage nodes need specific logic, depending on their characteristics, to assign flow types to evaporation, delivery, and release.

The user determines the disposition of flow types throughout the system through weights assigned to each flow type for each diversion. This enables the tool to be used for a wide variety of purposes in CVP/SWP system analysis.

For this application, a weight structure was used in the FlowTracker to prioritize the use of Shasta releases farther up in the system, minimizing the amount of Shasta releases traveling to the Delta so as to not overstate the role played by Shasta in meeting Delta requirements.

3.2 Layers

The approach for exploratory modeling layers high-level operational objectives on scenarios for different system requirements. Looking at each operational layer provides information on what drives different capabilities. Different scenarios explore different constraints. Chapter 6, *Title*, Section 6.1, *Attachment 1 – CalSim II Modeling Assumptions Callouts*, documents the assumptions in detail.

Initially, the exploratory modeling consisted of five layers, which were later refined to answer a broader range of questions.

- Layer 1 – Run of the River
- Layer 2 – Maximum Storage: The only releases are to pass-through inflow to meet senior water rights, minimum instream flows, and D-1641 requirements. Originally, Layer 2 met obligations upstream to downstream, often resulting in deliveries being met before downstream flows or Delta outflow. This was then expanded into two scenarios.
    - EXP2A prioritizes pass-through inflow for delivery to senior water rights
    - EXP2B prioritizes pass-through inflow for meeting minimum flow and D-1641 requirements

    In both scenarios, any inflow that was not needed to meet the priority can be released to meet the other objective; any inflow not used for senior water rights and minimum flow and D-1641 requirements is stored unless it evaporates or needs to be released to meet flood control.
- Layer 3 – Releases stored water to meet senior water rights and minimum flow and D-1641 requirements that were unmet through pass-through inflow. Finer resolution was requested, and a Layer 2.5 (between 2 and 3), was developed
    - Layer 2.5 uses pass-through inflow for senior water rights and minimum flow and D-1641 requirements, but then releases stored water to meet any minimum flow and D-1641 requirements that could not be met through pass-through inflow. Like Layer 2, Layer 2.5 has the following.
        - 2.5A that prioritizes pass-through inflow for delivery to senior water rights
        - 2.5B that prioritizes pass-through inflow for meeting minimum flow and D-1641 requirements
- Layer 4 – Allows for the delivery (including export) of water that would otherwise be excess Delta outflow to project water service contractors. Three versions of this layer explored different ways that delivery of exported water could be prioritized.
    - Only delivering to Exchange Contractors and Refuges
    - Delivering to all CVP contractors

- Delivering to all CVP contractors after reserving water for the Exchange Contractors and Refuges

These three versions were each run with and without Old and Middle River (OMR) requirements.

- Layer 5 – Implements most operations (Biological Opinions regulations and delivery of stored water). For finer resolution, the following were included.
    - Layer 4.95 was developed, which simulates current regulations, but limits exports and delivery to water service contractors to excess water except for deliveries for minimum public health and safety
    - Layer 5P was included to add some specialized programs that were not included in the exploratory modeling: the Lower Yuba River Accord transfers and delivery of Article 21 and Section 215 water

Layer 1 – Run of the River (EXP1): This layer identifies hydrologic conditions in the absence of the operation of the CVP and SWP and provides a basis of comparison to hydrologic impairment by factors other than the operation of the CVP and SWP. The following principles are included.

1. The CVP and SWP will not store water. Inflow to project reservoirs will be released at the earliest opportunity; however, the CVP and SWP will limit releases to downstream channel capacities (for flood control and dam safety purposes).

2. Senior water right holders, with or without contracts with the CVP and SWP, including wildlife refuges with Level 1 supplies, would continue to divert when water is available for their diversion.

3. No diversions or rerouting of flows would occur at CVP or SWP facilities, including no exports at Jones Pumping Plant and Banks Pumping Plant.

This layer is expected to show shortfalls, if they occur, to Settlement Contracts and other types of senior water right agreements, D-1641 requirements, minimum instream flow requirements, and anticipated water temperature requirements.

This layer informs agreement on hydrologic conditions and alterations not attributable to operation of the CVP and SWP.

Layer 2 – Maximum Storage (EXP2): This layer begins to incorporate aspects of project operations by allowing reservoirs to store water. Reclamation and DWR have an operational objective to store water in upstream reservoirs as it provides the greatest flexibility to meet the obligations of the CVP and SWP. The ability to store water is limited by releases required for the following.

1. Flood conservation and safety of dams

2. Bypassing inflow for downstream senior water rights (e.g., Sacramento River Settlement Contractors, Exchange Contract, Refuge Level 1)

3. Bypassing inflow for navigation and minimum instream flow agreements (e.g., CDFW, the Federal Energy Regulatory Commission) and/or required by CVPIA

4. Bypassing inflow for D-1641 Water Quality Control Plan

Reclamation and DWR would have some discretion, after meeting D-1641 to the extent possible by bypassing inflow, to select among storing water in Shasta, Oroville, or Folsom reservoirs (or a combination of the reservoirs). Under this layer, Friant and New Melones dams are not operated for D-1641 Delta requirements (New Melones can contribute bypassed inflow to the Vernalis flow and water quality standards). Under this layer, the ability to store water would be allocated based on minimizing the risk of spill (e.g., Reclamation would not make releases from Shasta Reservoir to store water in Folsom Reservoir if water in Folsom Reservoir is likely to later spill). Reclamation and DWR do not divert at project facilities under this layer. Reclamation and DWR only release stored water for flood control purposes. In this layer, Reclamation and DWR are exercising discretion to store water, but bypassing some inflow given the requirements of other parties, e.g., senior water right holders and the Water Board. Different scenarios may explore changes to those requirements.

This layer is expected to show shortfalls, if they occur, similar to the Run of the River layer.

This layer informs how much water Reclamation and DWR can potentially have available in storage to meet obligations. It may also inform how Settlement, Exchange, Refuge, and D-1641 requirements influence the availability of storage. It may inform potential unimpaired flow comparisons by showing when, for how long, and if, reservoirs refill. This information starts to demonstrate the sustainability of in-year and multi-year protections for species and health and safety.

Layer 2 was run in two ways.

- EXP2A: This version prioritizes the use of the bypassed inflow for downstream senior water rights
- EXP2B: This version prioritizes the use of the bypassed inflow to meet flow and D-1641 standards

Layer 2.5 – Maximize Storage – Release Stored Water for Unmet for Flow and D-1641 Standards (EXP2.5): The requirements in D-1641 and other (non-ESA) flow requirements commit Reclamation and DWR to use stored water in the absence of other intervening factors (e.g., Congressional Directive, Temporary Urgency Change Petitions, Voluntary Programs, Board Order, Shortage Provisions). In this layer, Reclamation and DWR will continue to bypass inflow to meet the releases as required in Layer 2 and will make releases from reservoir storage where the flows otherwise in the system are insufficient to meet navigation and minimum instream flow requirements and D-1641.

Facility capabilities and other limitations may still prevent meeting obligations (e.g., lake levels for hydropower generation, municipal and industrial intakes), and there continues to be no south of Delta exports.

Reclamation and DWR may have some discretion in how obligations are met, but the obligations in and of themselves are non-discretionary. Certain obligations are limited based on which facilities can provide water, e.g., releases on American River cannot meet demands on the Sacramento River that are upstream of the confluence. Where there is a possibility for either Shasta or Folsom to meet a downstream obligation, CalSim II determines the source of water through rules that attempt to match the reservoir balancing under historical operations. Reservoir balancing rules do not often control CalSim II operations.

This layer is expected to inform the demands on storage to meet instream flows and water quality standards.

Layer 2.5 was run in two ways.

- EXP2.5A: This version prioritizes the use of the bypassed inflow for downstream senior water rights
- EXP2.5B: This version prioritizes the use of the bypassed inflow to meet flow and D-1641 standards

Layer 3 – Minimum Releases from Storage (EXP3): The agreements and requirements in Settlement Contracts and Exchange Contracts also commit Reclamation and DWR to use stored water in the absence of other intervening factors (e.g., Congressional Directive, Temporary Urgency Change Petitions, Voluntary Programs, Board Order, Shortage Provisions). In this layer, Reclamation and DWR make releases from reservoir storage where the flows otherwise in the system are insufficient to meet the following.

1. Navigation and minimum instream flow requirements
2. Downstream senior water rights
3. Exchange Contract and Refuge Level 2
4. D-1641

Facility capabilities and other limitations may still prevent meeting obligations (e.g., lake levels for hydropower generation, municipal and industrial intakes) and there continues to be no south of Delta exports.

Reclamation and DWR may have some discretion in how obligations are met, but the obligations in and of themselves are non-discretionary. Certain obligations are limited based on which facilities can provide water, e.g., releases on American River cannot meet demands on the Sacramento River that are upstream of the confluence. Where there is a possibility for either Shasta or Folsom to meet a downstream obligation, CalSim II determines the source of water

through rules that attempt to match the reservoir balancing under historical operations. Reservoir balancing rules do not often control CalSim II operations.

This layer is expected to inform the demands on storage to meet instream flows, senior water right settlement diversions, and water quality standards.

Layer 4 – Excess Flow Diversions (EXP4): This layer begins to operate to meet project water supply functions. The model will divert water that cannot be stored and is not required for other purposes. Reclamation and DWR have an operational objective to divert excess flows to meet obligations without relying upon stored water. Preserving stored water preserves the flexibility to meet obligations of the CVP and SWP at other times. The model accomplishes the following.

1. Meets north of Delta (NOD) project deliveries as possible with water that otherwise would have gone to surplus Delta outflow

2. Enables export of remaining Delta surplus, sharing available water in the Delta between the CVP and SWP according to COA conditions for unstored water for export and suspended COA

3. For CVP, first meets CVP Refuge Level 2 and Exchange Contract requirements from Delta Exports

4. Delivers to Friant contracts if Exchange Contract and refuge demands are met

This layer reveals the potential for project operations without using stored water. It provides for deliveries based on diversion of water in the system and water previously stored in San Luis Reservoir. Meeting water service contract demands through use of excess flows reduces the demands for stored water described in the next layer.

Layer 4 was developed in experimental steps, as described below. Versions 3 and 6 were subsequently used and displayed as the most useful to the exploratory analysis.

- EXP4v1 – Does not include OMR restrictions on exports. Exports are delivered to Exchange Contractors and Refuge Level 2 and then stored in CVP San Luis. No deliveries are allowed to CVP service contracts. This version is the simplest way to meet senior CVP contractors with excess flow and full use of San Luis off-stream storage.

- EXP4v2 – Does not include OMR restrictions on exports. Exports are delivered to all water users and then stored in CVP San Luis. This version demonstrates the *maximum* amount of Delta excess that could be exported and delivered, but delivery patterns are unrealistic and water supply is depleted early.

- EXP4v3 – Does not include OMR restrictions on exports. Based on the results from EXP4v1, reserve exports and CVP San Luis storage to meet Exchange Contractors and Refuge Level 2; CVP agriculture (Ag) and municipal and industrial (M&I) can take exports and water stored in CVP San Luis that is not needed for Exchange Contractors and Refuge Level 2. This version attempted to strike a middle ground between versions 1

and 2 – senior water user demands are met first, but patterns of delivery to CVP service contractors reflect the "as available" basis.

- EXP4v4 – EXP4v1, but with OMR limits on exports.
- EXP4v5 – EXP4v2, but with OMR limits on exports.
- EXP4v6 – EXP4v3, but with OMR limits on exports.

Layer 4.95 (EXP4.95) – This layer fully operates the CVP and SWP to potentially make use of stored water for temperature benefits within a year, releases for fisheries such as pulse flows, or carryover for drought protection in a subsequent year by implementing the actions from the 2019 Biological Opinions and 2020 ITP. This is the first layer to include imports from the Trinity River. Deliveries to project contractors above a minimal health and safety level are limited to water that would have otherwise gone to excess Delta outflow.

Layer 5 – Storage Management (EXP5): This layer operates the CVP and SWP to make use of stored water for temperature benefits within a year, releases for fisheries such as pulse flows, carryover for drought protection in a subsequent year, and/or deliveries to project contractors. Differences in results relative to EXP4.95 may shed light on the use of stored water for project delivery and exports beyond public health and safety levels. Modeling assumptions for this layer assume stored water can be delivered to water service contracts after satisfying other operational criteria including those from the 2019 Biological Opinions and 2020 ITP.

Layer 5P – Placeholder for Additional Actions (EXP5P): Actions not considered in the above conditions that may be excluded from the models for the purpose of exploratory modeling, but provide an important component of operating the CVP and SWP. Examples include the following.

- Water Transfers and the Lower Yuba River Accord use of Banks Pumping in July and August
- Article 21/Section 215
- New Storage and Conveyance Projects

Exploratory modeling may provide a platform for analyzing these actions under alternative LTO operations.

3.3 Model Limitations

3.3.1 CalSim

CalSim II was used to develop the suite of scenarios for exploratory modeling, and the limitations of the exploratory modeling are either inherent in CalSim II or arise from the alterations or application of the exploratory modeling. CalSim II was designed to represent the full operations of the CVP and SWP system in a current or hypothetical regulatory environment and accommodate potential operational alternatives. The first layer of exploratory modeling

completely removes the CVP's and SWP's operational capabilities, and then, additional requirements and operational capabilities are added on for each progressive layer. CalSim II was not designed for scenarios with severely limited operational capabilities, and it cannot account for how water users or regulatory agencies would adjust to the CVP and SWP having severely limited to no operational capabilities.

CalSim II has a monthly time step, which does not capture daily variability in the system. While there are certain components in the model that are downscaled to a daily time step (simulated or approximated hydrology), such as an air-temperature–based trigger for a fisheries action, the results of those daily conditions are always averaged to a monthly time step. Any reporting or use of sub-monthly results from CalSim II should include disaggregation methods that are appropriate for the given application, report, or subsequent model.

In addition, the Artificial Neural Network (ANN) developed to determine the flows necessary to meet Delta water quality requirements was trained on full operations of the CVP and SWP. DSM2 simulations of the entire exploratory modeling suite were analyzed to examine whether the ANN was appropriate for use in the exploratory modeling. It was found that, for the layers where reservoirs were operated to meet D-1641 Delta water quality requirements, those reservoirs met those requirements as often or more than the full operations study, indicating that the ANN is appropriately depicting water quality in these scenarios.

Additional details on the limitations of CalSim II can be, Appendix F, Attachment 2-7, *Model Limitations*, of Reclamation's 2019 *Reinitiation of Consultation on the Coordinated Long-Term Operation of the Central Valley Project and State Water Project* (Bureau of Reclamation 2019b). Despite the limitations of the exploratory modeling, its narrow purpose of analyzing the limitations of the CVP and SWP to inform a consultation makes the analysis valuable.

Given the wide range of operations in the exploratory modeling, stream-groundwater interactions were fixed to EXP5 levels. Fixing the stream-groundwater allows the exploratory modeling to focus on the changing operations, without the additional complexity of varying stream-groundwater interactions.

The Water Balance Tool was used to review the results from the exploratory modeling suite. The Water Balance Tool aggregates inputs, outputs, and reservoir storage changes for different segments of the model (like Upper Sacramento River above Red Bluff, the American River). The output of the Water Balance Tool was used to ensure the model was operating correctly under the exploratory modeling scenarios and to investigate whether the models have used problematic methods to achieve mass balance. Mass balance was sustained in all regions in the Water Balance Tool for EXP1, EXP2, EXP3, EXP5, and EXP5P. The results also highlighted how changes in river flows, diversions, storage changes, etc., relate to each other between scenarios.

3.4 Appropriate Use of Model Results

3.4.1 CalSim

The exploratory modeling suites are meant to inform on water availability under different layers of regulatory conditions. The Run of the River scenario, specifically, is built to show a scenario

that is close to a more natural hydrograph, with the understanding that it will be different from a full natural flow or unimpaired flow. Reclamation did not try to depict what would have happened if the CVP and SWP were not in place as there might have been different outcomes and different facilities built to meet needs in any of the system sub-basins.

All of the exploratory models have their shortfalls and are merely offered to help understand water availability for actions of the CVP and SWP. Any specific action that may become a part of the Proposed Action or a National Environmental Policy Act (NEPA) alternative in the 2021 LTO process will be fully simulated and analyzed using CalSim 3.

3.4.2 Flow Tracker

As the name implies, the Flow Tracker keeps a running tally of where streamflow at any particular location originally came from. At diversion locations, the user must make decisions about what kind of water to divert for each category of demand. Different applications may use unique weight structures that produce different results for uses of storage release versus other kinds of flow. The use of the Flow Tracker for exploratory modeling was intended to help clarify the ultimate destination of storage releases, for Shasta in particular. Shasta releases were used as high up in the system as possible in an effort to not overstate the need for Shasta release to meet Delta criteria.

This perspective can lend an impression of explicit purpose for releases that enter the Delta that is not a factor in actual operations. If Shasta releases water for flood control, including normal ramp-down operations in wetter years, remaining release entering the Delta would be assigned by the Flow Tracker to go to exports while other flow types meet required Delta outflow. It would be equally reasonable in this context to assign the Shasta release to required Delta outflow. These perspectives are important to keep in mind when reviewing results.

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4. Exploratory Modeling Results

Each layer of the exploratory modeling suite changes the responsibilities and capabilities of the CVP and SWP, and therefore each layer is expected to alter elements of the Sacramento-San Joaquin Delta water system. These elements include but are not limited to reservoir storage, deliveries, river flows, exports, and Delta outflow. The following table lays out the study expectations for each model in the exploratory modeling suite in each of these elements.

Table 1. Exploratory Modeling Study Expectations within the Sacramento-San Joaquin Delta.

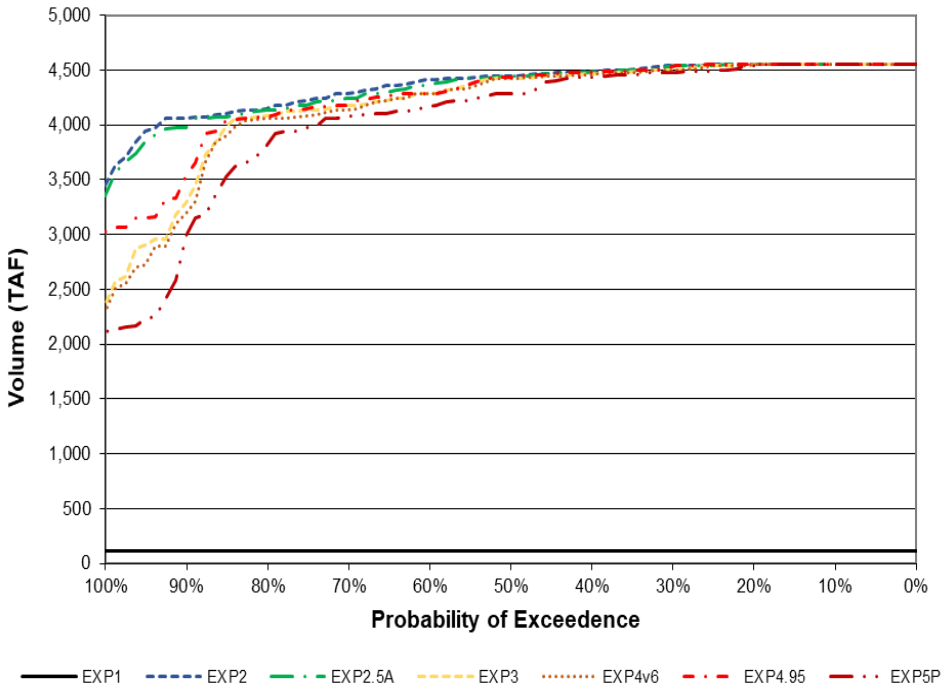
Runs	Storage	Deliveries	River Flows	Exports	Delta Outflow
EXP1	Dead pool	Senior water right deliveries limited by available flows	Reflect hydrologic mass balance	None	Reflects hydrologic mass balance
EXP2	Maximized up to flood limits	Similar to EXP1	Reduced flows aside from flood control releases and pass-through inflow	None	Reduced outflow aside from flood control releases
EXP2.5A	Storage affected by releases for D-1641 and minimum flows	Senior water right deliveries increase with stored water released for minimum flows	Increased river flows in summer due to stored water releases for D-1641 and minimum flows	None	Delta outflow reflects stored water releases for D-1641 and minimum flows
EXP3	Storage affected by releases for all non-discretionary uses	Senior water rights met by stored water releases	Increased river flows in summer due to stored water releases for non-discretionary uses	None	Delta outflow reflects stored water releases for non-discretionary uses
EXP4	Storage may reflect additional releases for Delta water quality due to use of excess water	Project deliveries from excess water enabled	Reflect delivery of excess water upstream to downstream	Export Excess water	Reduced due to delivery and export of excess water
EXP5P	Managed storage	Project deliveries increase with	Reflect full project operations	Exports	Delta outflow reflects full project operations

Runs	Storage	Deliveries	River Flows	Exports	Delta Outflow
		stored water releases and full exports			

The differences between layers had similar trends across all CVP and SWP reservoirs and the watersheds below those reservoirs. The results shown focus on Shasta Reservoir, the Sacramento River, the Delta, and exports to south of Delta (SOD). However, notable differences in other reservoirs and watersheds from that of Shasta and the Sacramento River are also described.

4.1 Reservoir Storage

Each subsequent layer adds responsibilities that the CVP and SWP attempt to meet, which affects reservoir storage, either by passing through inflow instead of storing it or by releasing previously stored water, when able and necessary. In general, the result is lower storage in the reservoirs as the layers progress. During the fill season (from October through the end of April), the differences between the layers are minimal in all but the driest years.



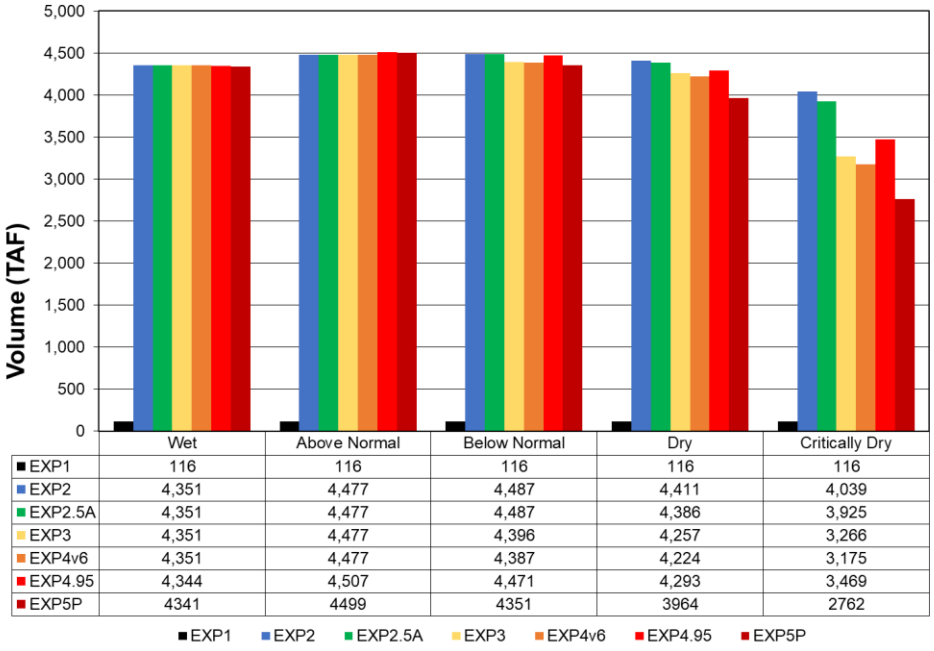
TAF = thousand acre-feet

Figure 4. End of April Exceedance for Shasta Storage.

Figure 4 shows an exceedance of Shasta storage at the end of April (EoApr) which is the end of the fill season. In EXP1, storage remains at dead pool because all inflow is passed, except when there are downstream capacity constraints. Reservoir storage in EXP2 represents the maximum possible storage. In this scenario, only inflow that passes through the reservoir is used to meet non-discretionary requirements, and previously stored water is only released for flood control. In EXP3, the reservoirs are operated to meet non-discretionary requirements by releasing previously stored water. Therefore, the difference between the EoApr Shasta storage in EXP2 versus EXP3 represents the volume of storage Shasta must release to meet non-discretionary requirements during the fill season. Note that even while meeting only non-discretionary regulations and limited senior water rights, EXP3 fill can be less than some commonly stated objectives. Fill is lower than 3.5 million acre-feet 11% of the time, and lower than 3.9 million acre-feet 15% of the time. (Dry and critical years comprise 35% of years in the period of record.)

In EXP4v6, excess water can be used for discretionary purposes such as project deliveries and exports. Despite only using excess water, there is an additional Delta water quality cost when excess water that could have helped decrease the salinity in the Delta is used for discretionary purposes instead (the change in Delta outflow can impact salinity for several subsequent months). The difference between the EoApr Shasta storage in EXP3 versus EXP4v6 represents the additional volume of storage Shasta must release to meet the additional Delta water quality cost. The introduction of Trinity imports in EXP4.95 takes some responsibility off of Shasta and results in higher Shasta storage, especially in the driest years.

In EXP5P, the reservoirs are operated to meet all non-discretionary requirements and previously stored water can be released for discretionary purposes. The difference between the EoApr Shasta storage in EXP3 and EXP5P represents the overall effect of discretionary purposes on Shasta fill, including the year-over-year effects of drought, carryover, and differences in non-discretionary costs incurred by project operations.



	Wet	Above Normal	Below Normal	Dry	Critically Dry
EXP1	116	116	116	116	116
EXP2	4,351	4,477	4,487	4,411	4,039
EXP2.5A	4,351	4,477	4,487	4,386	3,925
EXP3	4,351	4,477	4,396	4,257	3,266
EXP4v6	4,351	4,477	4,387	4,224	3,175
EXP4.95	4,344	4,507	4,471	4,293	3,469
EXP5P	4341	4499	4351	3964	2762

Figure 5. Average End of April Shasta Storage by Water Year Type.

Looking at Figure 4, the additional burden on Shasta storage from each subsequent layer of the exploratory modeling suite is most visible in the driest 15%-20% of years. Figure 5 shows Average EoApr Shasta storage by water year type. It reinforces that there is very little difference in fill between the scenarios in wet, above normal, and below normal years; some noticeable difference in dry years; and significant differences in critically dry years.

The need for releases, in all scenarios, is typically higher during the management season (from May through September) than during the filling season. Differences in end of September storage between the EXP scenarios are therefore more pronounced than end of April fill differences.

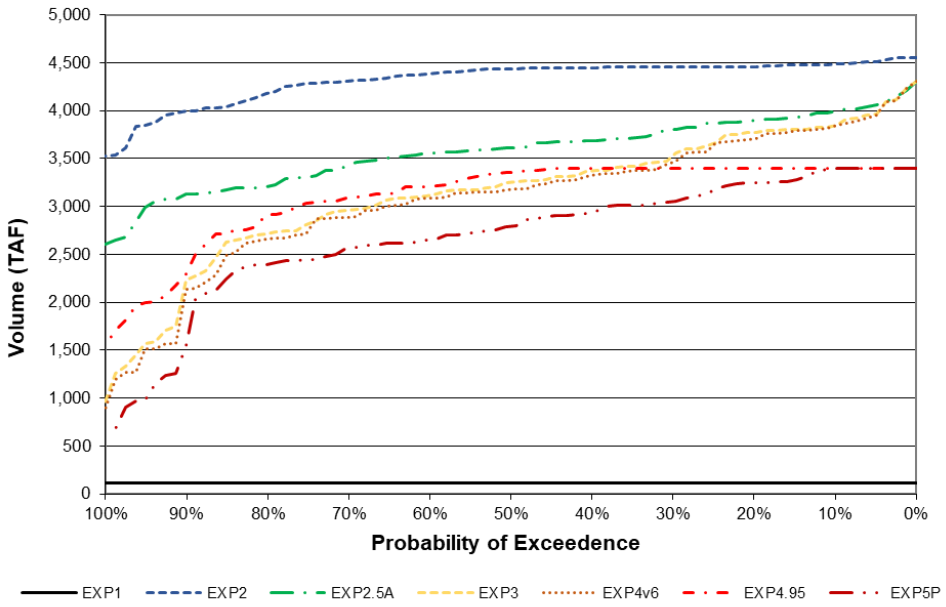
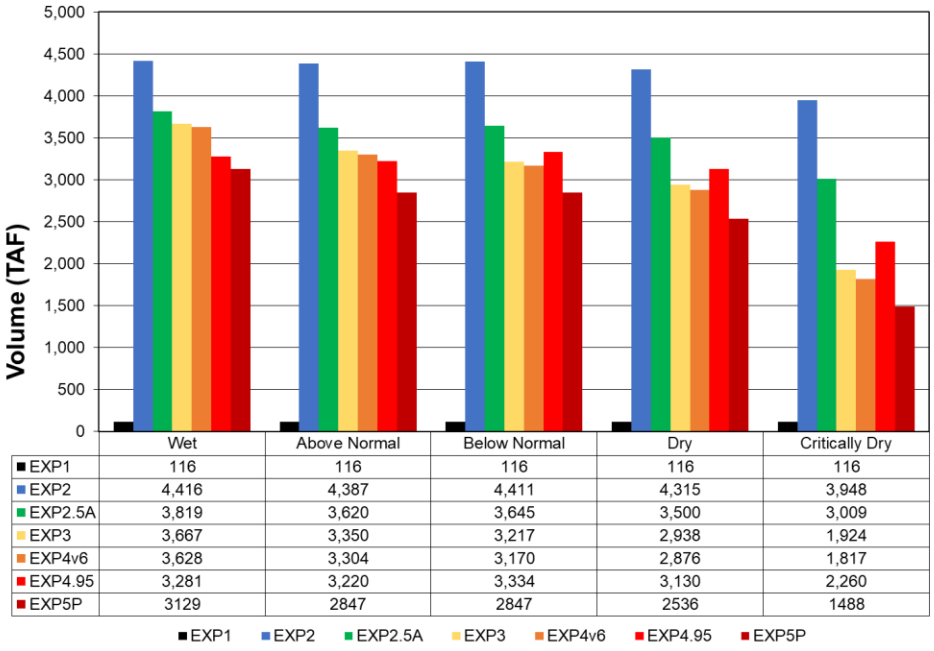


Figure 6. End of September Exceedance of Shasta Storage.

Figure 6 shows the exceedance of end of September (EoSep) Shasta storage. In EXP2.5A, previously stored water is released from Shasta to meet D-1641 requirements and minimum instream flows after pass-through inflow is prioritized for deliveries to senior water rights. The difference between EoSep Shasta storage in EXP2 and EXP2.5A represents the volume of storage that must be released to meet D-1641 and minimum instream flow requirements. The difference between EoSep Shasta storage in EXP2.5A versus EXP3 represents the additional storage that must be released to meet senior water right demands that were not met by pass-through inflow.

Looking at Figure 6, the difference in EoSep Shasta storage is much larger between EXP2 and EXP3 than it is between EXP3 and EXP5P, indicating that the burden of non-discretionary requirements on Shasta storage is larger than the costs of discretionary uses. While Trinity imports in EXP5P assume some of the burden of meeting the flow requirements, the bulk of the non-discretionary cost still falls to Shasta.



	Wet	Above Normal	Below Normal	Dry	Critically Dry
EXP1	116	116	116	116	116
EXP2	4,416	4,387	4,411	4,315	3,948
EXP2.5A	3,819	3,620	3,645	3,500	3,009
EXP3	3,667	3,350	3,217	2,938	1,924
EXP4v6	3,628	3,304	3,170	2,876	1,817
EXP4.95	3,281	3,220	3,334	3,130	2,260
EXP5P	3129	2847	2847	2536	1488

Figure 7. Average End of September Shasta Storage by Water Year Type.

This is especially true in the driest years. Looking at Figure 7 the difference in EoSep Shasta storage between EXP2 and EXP3 is 749 thousand acre-feet (TAF) in wet years while the difference is 2,024 TAF in critically dry years. On the other hand, the difference in EoSep Shasta storage between EXP3 and EXP5P is 538 TAF in wet years while the difference is 436 TAF in critically dry years. This shows that in the driest years, the increase of the cost on Shasta storage is primarily because of non-discretionary requirements, while additional Shasta storage that is used for discretionary purposes decreases in drier years.

The fill and carryover trends described for Shasta Reservoir are generally true for Folsom Lake and Lake Oroville. Shasta plays an outsized role in meeting non-discretionary actions due to the scale of releases for non-discretionary mainstem Sacramento River flow standards and deliveries, while full operations under EXP5P tend to have a larger impact on Folsom and Oroville. These facilities are discussed further in Section 6.2, *Attachment 2 – Model Results*.

4.2 River Flows

River flows downstream of the reservoirs are directly affected by hydrological inputs and reservoir operations, which cause changes across the exploratory modeling suite. Below Keswick Dam, on the Sacramento River, the flows are affected by both releases from Shasta Reservoir and water that is released from Trinity Reservoir and imported to the Sacramento River.

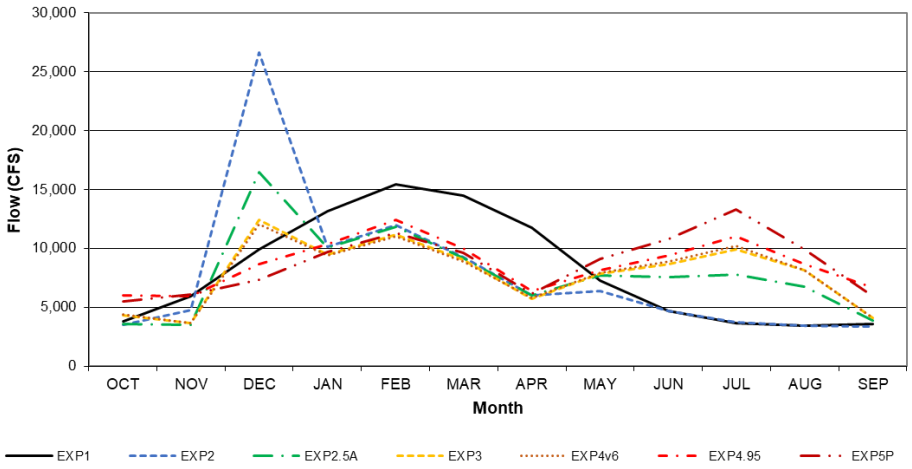
Table 2. Average Annual Total Keswick Releases by Source and Release Type[a]

WATER SOURCE	EXP1	EXP2	EXP2.5A	EXP3	EXP4V6	EXP4.95	EXP5P
SHASTA PASS-THROUGH INFLOW	5,796	4,575	4,432	4,295	4,275	4,387	4,133
SHASTA STORED WATER RELEASES FOR FLOOD CONTROL	0	1,092	282	313	297	328	100
SHASTA STORED WATER RELEASES	34	0	971	1,084	1,121	976	1,471
TRINITY PASS-THROUGH INFLOW	0	0	0	0	0	274	250
TRINITY STORED WATER RELEASES FOR FLOOD CONTROL	0	0	0	0	0	28	19
TRINITY STORED WATER RELEASES	0	0	0	0	0	255	342

[a] In thousands of acre-feet.

Table 1 shows the average annual total of different sources of water flowing below Keswick Dam. This includes pass-through inflow, releases for flood control, and releases of previously stored water from both Shasta and Trinity reservoirs. The operational capability to import Trinity water is not available until EXP4.95, and so, in all earlier models in the exploratory modeling suite, all the flow below Keswick Dam comes from Shasta releases.

In general, Shasta pass-through inflow and releases for flood control decrease and stored water releases increase for each subsequent layer of the exploratory modeling suite. In EXP1, water is not purposefully stored, but downstream channel capacities can back up water into the reservoirs which is later released as previously stored water. Flood control releases are higher in EXP3 and EXP4v6 than in EXP2.5A due to an oversight in a handful of years of input data for those two studies, which caused fall drawdown ahead of the December onset of formal flood control.



CFS = cubic feet per second

Figure 8. Monthly Pattern of Sacramento River Flow Below Keswick Dam.

Figure 8 shows the monthly pattern of average flows below Keswick Dam. Additional operational capabilities and responsibilities in each subsequent layer cause the CVP and SWP to store more water in the fill season (from October until the end of April) and release more of that water in the management season (from May until the end of September). Flows below Keswick in EXP1 reflect the inflows into Shasta Reservoir. In EXP2, previously stored water is only released for flood control, and this is what causes the high spike of flows below Keswick Dam. Subsequent exploratory modeling layers require less December release because stored water is used, particularly during summer months, to meet incremental levels of responsibilities. EXP4.95 and EXP5P further introduce summer and fall drawdown rules that ramp storage down to December flood control levels to avoid the sudden flow spike. After the December flood control releases, storing water during the fill season causes flow below Keswick in all scenarios to be lower than Run of the River. Upon the start of the management season in May, the progressively increased CVP responsibility in each subsequent layer causes progressively more releases for those responsibilities in the management season, which results in increased flows below Keswick Dam. In EXP3, Shasta releases water for non-discretionary requirements. Additional releases are needed to meet Delta water quality requirements due to the delivery and export of excess water in EXP4v6, and in EXP4.95 and EXP5P, there is full operations, including Trinity imports.

The trends described for Shasta Reservoir are generally true for flows below Folsom and Oroville; however, the large EXP2 releases for flood control at Folsom occur in November. Detailed results for these facilities are contained in Section 6.2, *Attachment 2 – Model Results*.

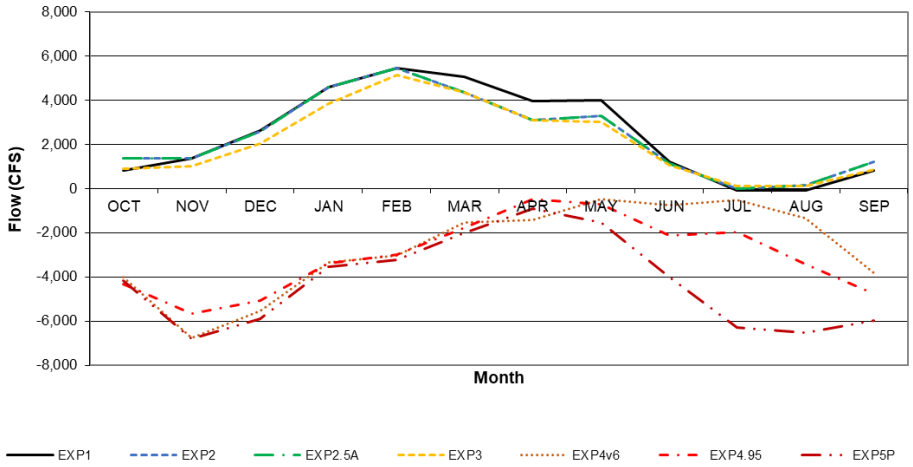


Figure 9. Monthly Pattern of Flow in the Old and Middle River.

As a result of exports starting in EXP4v6, flow in the OMR is affected by pumping at Jones and Banks pumping plants. Figure 9 clearly shows that operations of the pumps in EXP4v6 and EXP5P reverse the flow in the OMR, while flows are similar across all the other exploratory models that do not include operations of Jones and Banks pumping plants. It is important to note that even in scenarios when the pumps are not operational, negative flows still sometimes occur during June and August due to south Delta consumptive use.

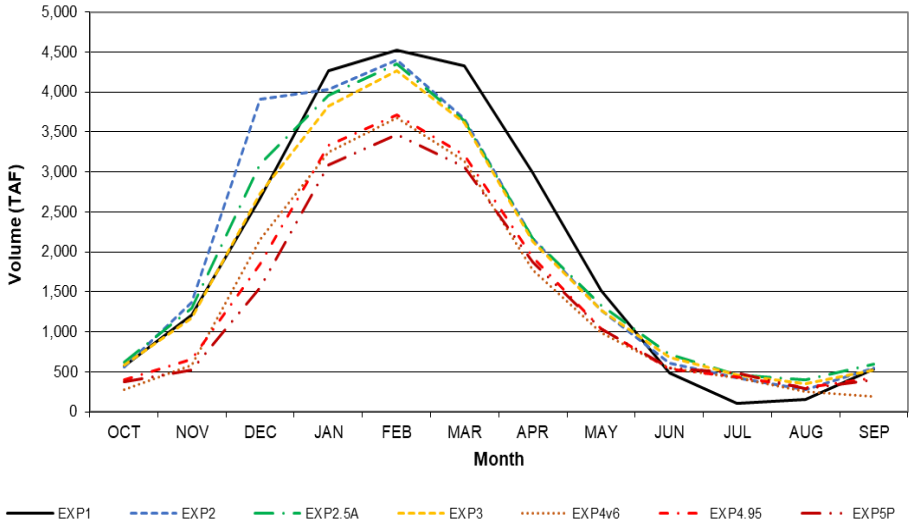


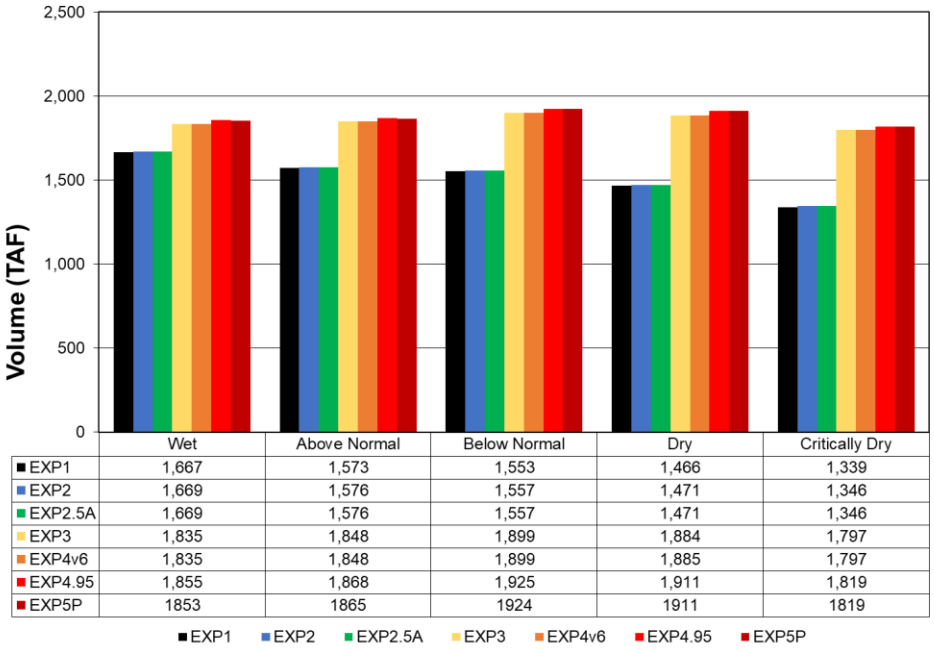
Figure 10. Monthly Pattern of Delta Outflow.

Figure 10 shows the average monthly pattern of Delta outflow. The trends described for flows below Keswick Dam are similar but muted for Delta outflow. EXP1 reflects the inflows into the system. The signal from December flood control releases is noticeable but decreased in EXP2 and EXP2.5A. When comparing EXP4v6 to EXP3, there is significantly less Delta outflow

during the fill season because water that would be excess Delta outflow in EXP3 is exported instead in EXP4v6.

4.3 Deliveries and Exports

The operational capability to deliver and export water is one of the primary differences between the layers of the exploratory modeling suite. In EXP1, EXP2, and both versions of EXP2.5, water can only be delivered to senior water rights as is hydrologically available. In EXP3, the reservoirs are operated to meet senior water right demands. In EXP4v6 and EXP4.95, excess water can be exported and delivered to project demands, and in EXP5 and EXP5P, the reservoirs are operated to meet all project demands and export.

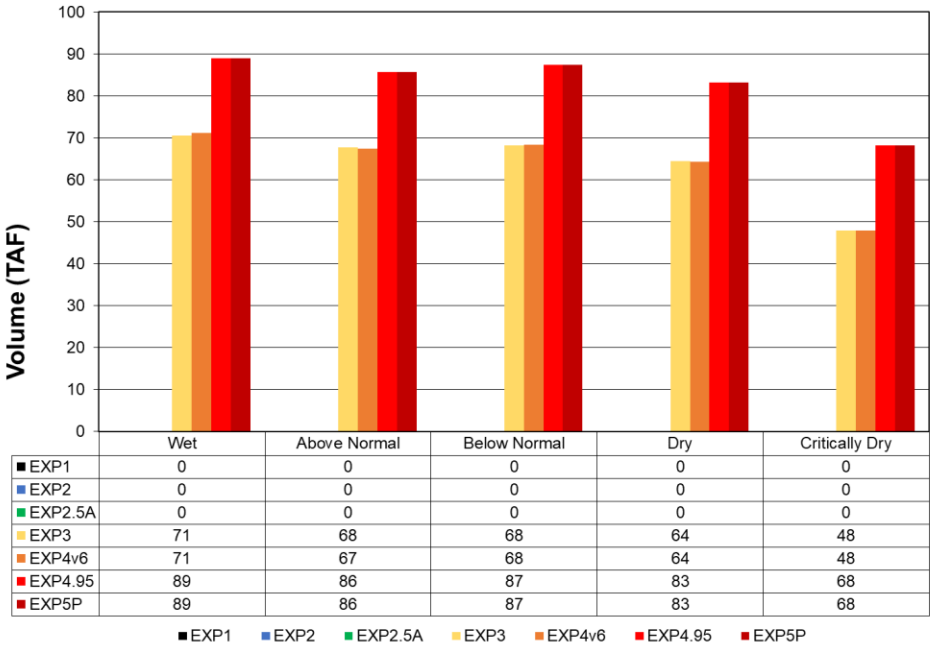


	Wet	Above Normal	Below Normal	Dry	Critically Dry
EXP1	1,667	1,573	1,553	1,466	1,339
EXP2	1,669	1,576	1,557	1,471	1,346
EXP2.5A	1,669	1,576	1,557	1,471	1,346
EXP3	1,835	1,848	1,899	1,884	1,797
EXP4v6	1,835	1,848	1,899	1,885	1,797
EXP4.95	1,855	1,868	1,925	1,911	1,819
EXP5P	1853	1865	1924	1911	1819

EXP1 EXP2 EXP2.5A EXP3 EXP4v6 EXP4.95 EXP5P

Figure 11. Average Annual Total Settlement Contract Deliveries by Water Year Type.

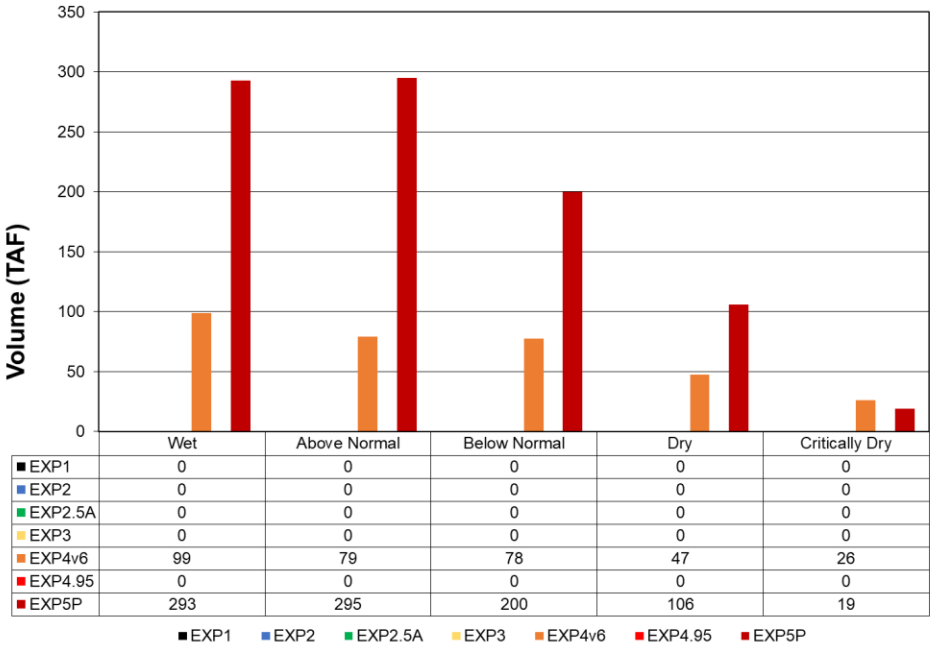
Figure 11 shows average annual deliveries to Settlement Contracts by water year type. EXP1, EXP2, and EXP2.5A deliver water as is hydrologically available, and, therefore, Settlement Contract demands are often not met in the management season when storage releases are needed to satisfy those demands. The CVP and SWP in EXP3, EXP4v6, EXP4.95, and EXP5P can operate the reservoirs to meet those demands and, therefore, rarely short those demands. The difference between these two groups of exploratory models increases in drier water year types because there is less water hydrologically available in drier years.



	Wet	Above Normal	Below Normal	Dry	Critically Dry
EXP1	0	0	0	0	0
EXP2	0	0	0	0	0
EXP2.5A	0	0	0	0	0
EXP3	71	68	68	64	48
EXP4v6	71	67	68	64	48
EXP4.95	89	86	87	83	68
EXP5P	89	86	87	83	68

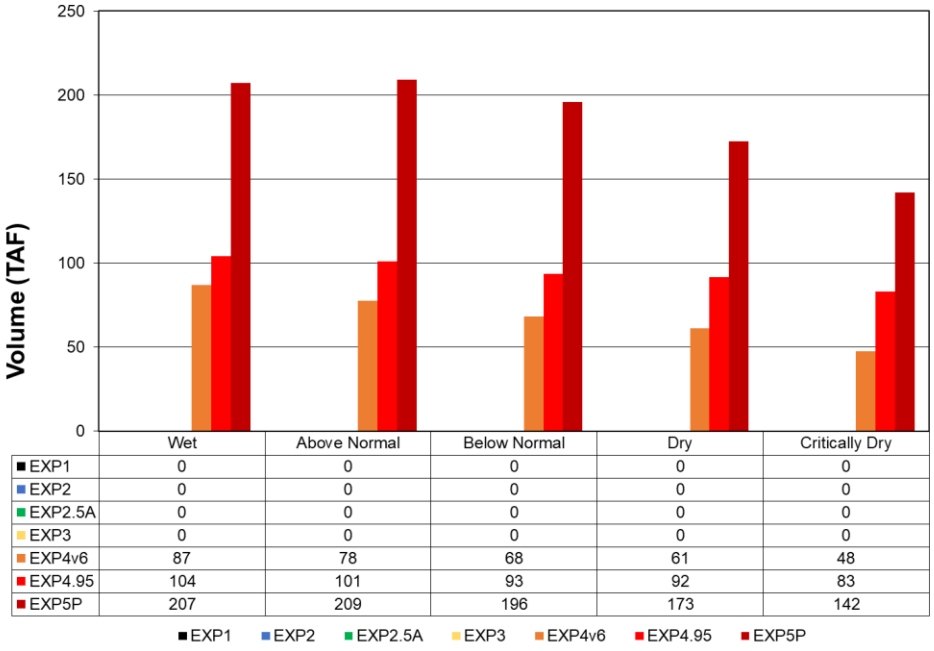
Figure 12. Average Annual Total NOD Refuge Deliveries by Water Year Type.

In EXP1, EXP2, and EXP2.5A, the CVP only makes deliveries to Level 1 refuge demands as is hydrologically possible, but north of the Delta, the Level 1 refuge demands are 0 TAF. As shown in Figure 12, refuge demands are increased to Level 2 in EXP3, and stored water releases are made to meet those demands. The discrepancies between EXP3/EXP4v6 and EXP4.95/EXP5P are due to weighting issues in the model and an unintended outcome of the exploratory modeling.



	Wet	Above Normal	Below Normal	Dry	Critically Dry
EXP1	0	0	0	0	0
EXP2	0	0	0	0	0
EXP2.5A	0	0	0	0	0
EXP3	0	0	0	0	0
EXP4v6	99	79	78	47	26
EXP4.95	0	0	0	0	0
EXP5P	293	295	200	106	19

Figure 13. Average Annual Total CVP NOD Ag Deliveries by Water Year Type.

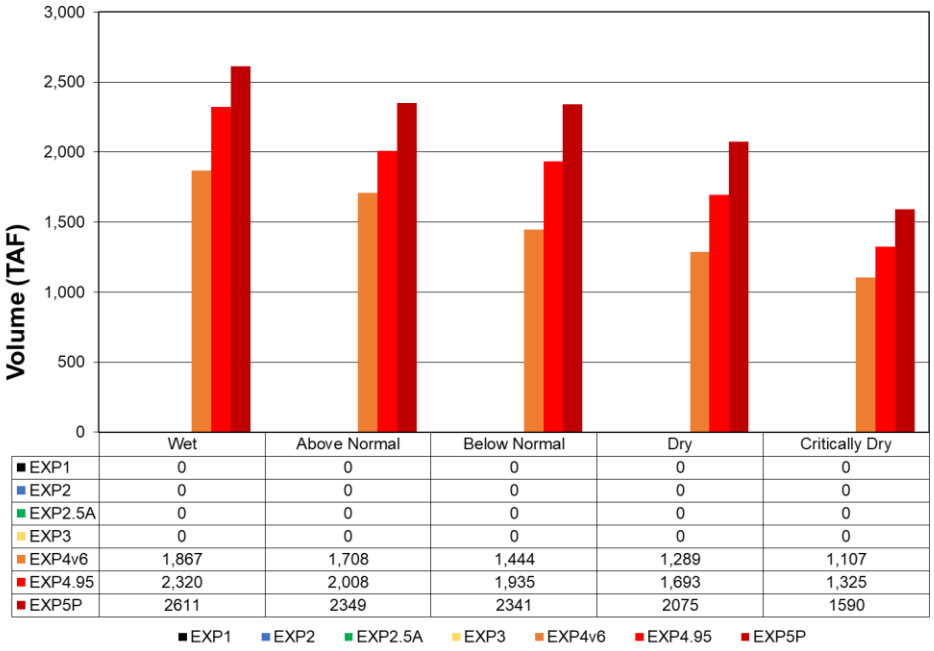


	Wet	Above Normal	Below Normal	Dry	Critically Dry
EXP1	0	0	0	0	0
EXP2	0	0	0	0	0
EXP2.5A	0	0	0	0	0
EXP3	0	0	0	0	0
EXP4v6	87	78	68	61	48
EXP4.95	104	101	93	92	83
EXP5P	207	209	196	173	142

Figure 14. Average Annual Total CVP NOD M&I Deliveries by Water Year Type.

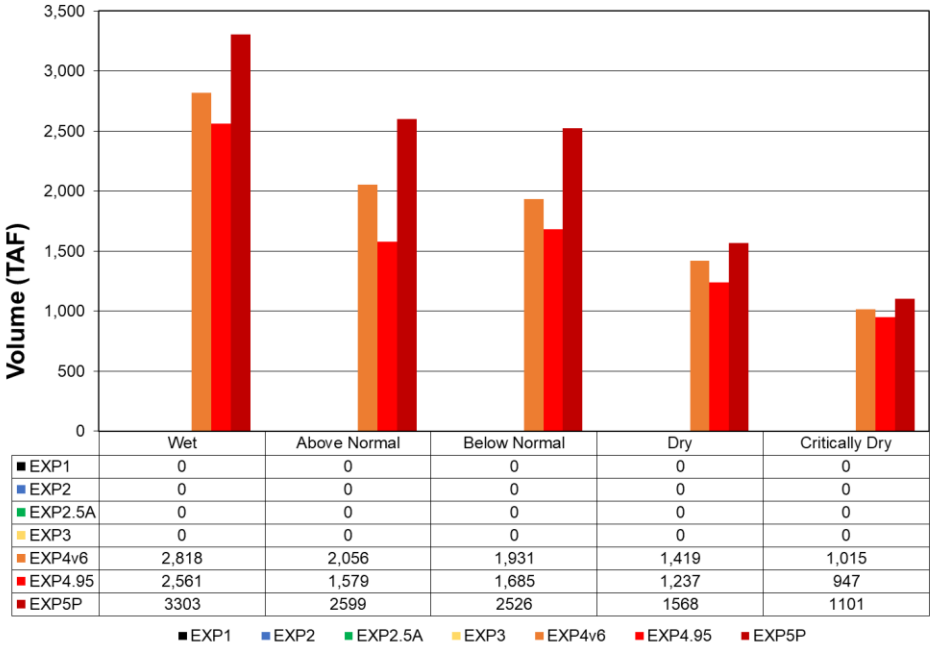
Project deliveries are only made in EXP4v6 and beyond, with access to varying levels of resources. EXP4 versions are able to deliver and export only Delta excess. EXP4.95 can export Delta surplus and meet health and safety requirements from storage releases, but does not deliver to CVP NOD Ag (due to model development schedule constraints). EXP5P operates to deliver

available water to all project users. Figure 13 and Figure 14 show average annual CVP NOD Ag and NOD M&I deliveries by water year type.



	Wet	Above Normal	Below Normal	Dry	Critically Dry
EXP1	0	0	0	0	0
EXP2	0	0	0	0	0
EXP2.5A	0	0	0	0	0
EXP3	0	0	0	0	0
EXP4v6	1,867	1,708	1,444	1,289	1,107
EXP4.95	2,320	2,008	1,935	1,693	1,325
EXP5P	2611	2349	2341	2075	1590

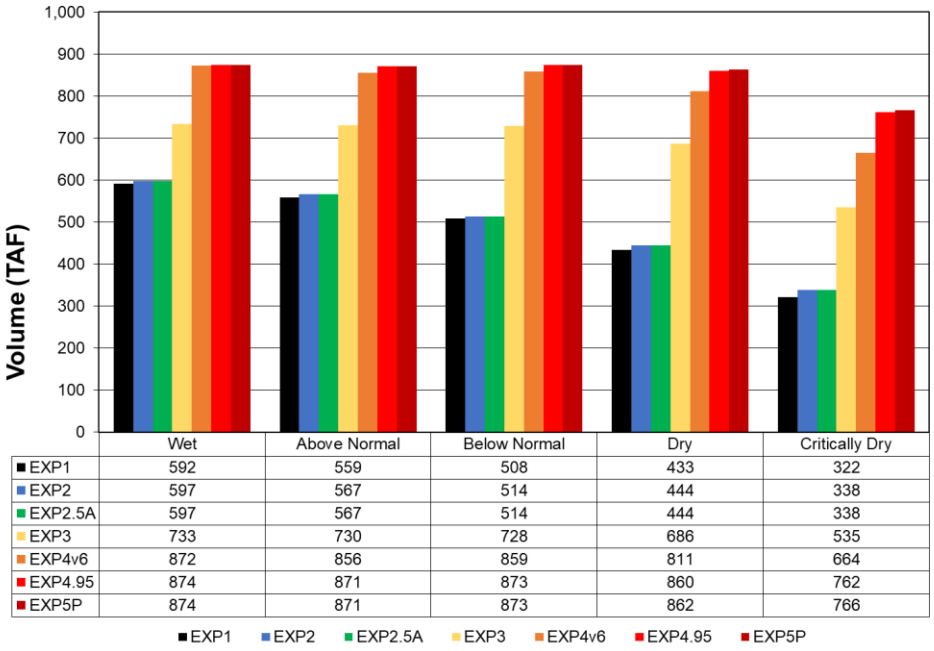
Figure 15. Average Annual Total Jones Pumping Plant by Water Year Type.



	Wet	Above Normal	Below Normal	Dry	Critically Dry
EXP1	0	0	0	0	0
EXP2	0	0	0	0	0
EXP2.5A	0	0	0	0	0
EXP3	0	0	0	0	0
EXP4v6	2,818	2,056	1,931	1,419	1,015
EXP4.95	2,561	1,579	1,685	1,237	947
EXP5P	3303	2599	2526	1568	1101

Figure 16. Average Annual Total Banks Pumping Plant by Water Year Type.

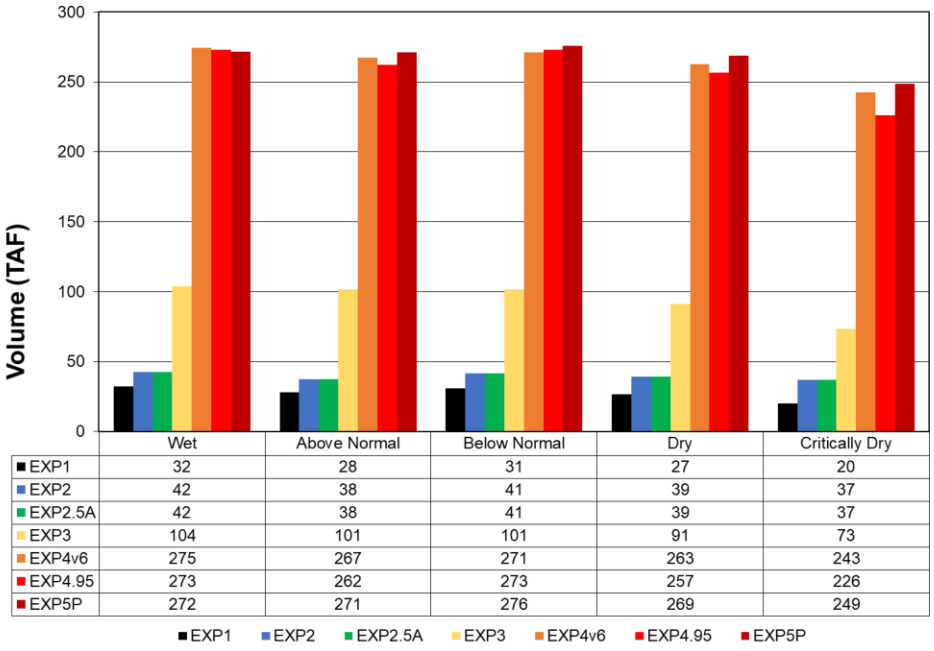
Figure 15 and Figure 16 show average annual Jones and Banks exports by water year type, respectively. Jones exports increase from EXP4v6 to EXP4.95 due to exports for M&I and availability of Trinity imports, which result in more water coming into the Delta. EXP5P allows export to the full extent that storage releases and regulatory criteria will support. The reduction in exports at Banks in EXP4.95 is due to the limit on delivery to health and safety levels, while EXP5P exports reflect full SWP operations under all regulatory criteria with storage releases for export.



	Wet	Above Normal	Below Normal	Dry	Critically Dry
EXP1	592	559	508	433	322
EXP2	597	567	514	444	338
EXP2.5A	597	567	514	444	338
EXP3	733	730	728	686	535
EXP4v6	872	856	859	811	664
EXP4.95	874	871	873	860	762
EXP5P	874	871	873	862	766

Figure 17. Average Annual Total SOD Exchange Contract Deliveries by Water Year Type.

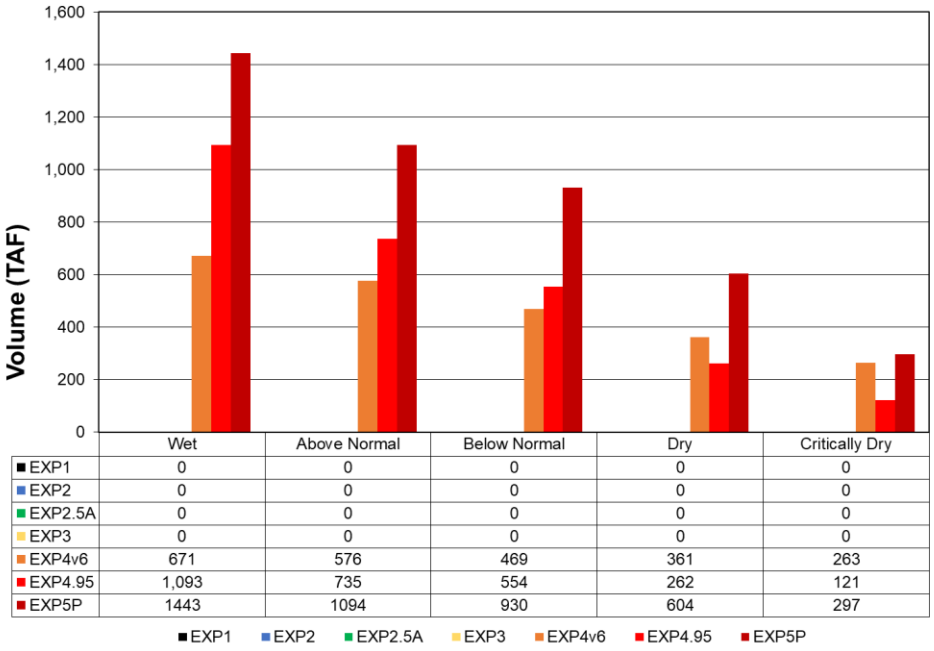
Figure 17 shows average annual Exchange Contract deliveries by water year type. In EXP1, EXP2, and EXP2.5A, deliveries are made as hydrologically available from the San Joaquin River, which results in shortages during the management season when there are less inflows. In EXP3, Friant is operated to meet Exchange Contractor demands. However, there are still some shortages during the management season. The CVP can export excess water in EXP4v6 and EXP4.95, decreasing shortages and reducing the reliance on inflows and SOD storage, and finally, in EXP5P full exports allow for full Exchange Contractor deliveries without the use of inflows and SOD storage.



	Wet	Above Normal	Below Normal	Dry	Critically Dry
EXP1	32	28	31	27	20
EXP2	42	38	41	39	37
EXP2.5A	42	38	41	39	37
EXP3	104	101	101	91	73
EXP4v6	275	267	271	263	243
EXP4.95	273	262	273	257	226
EXP5P	272	271	276	269	249

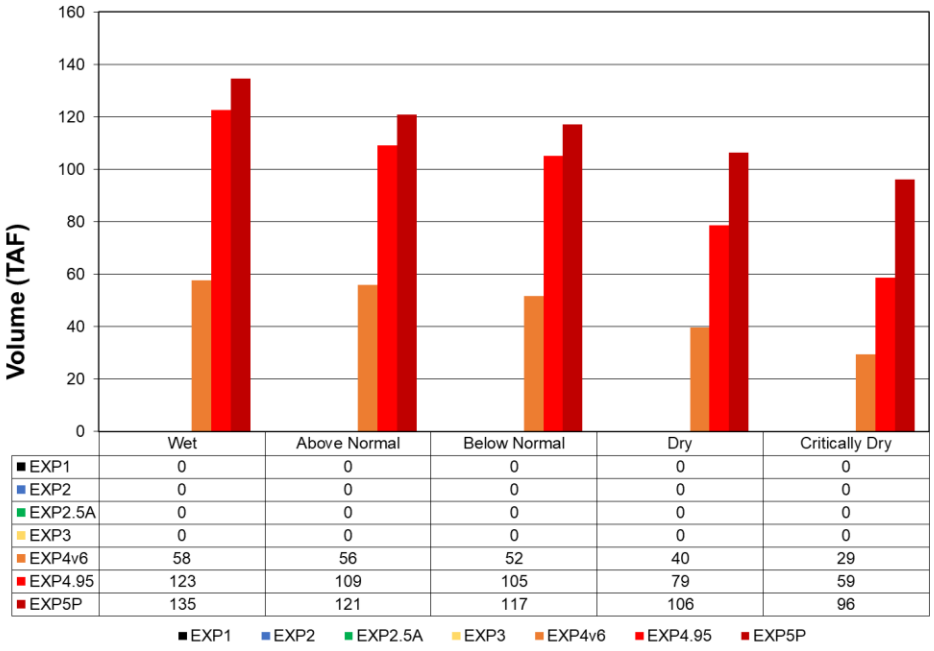
Figure 18. Average Annual Total SOD Refuge Deliveries by Water Year Type.

Figure 18 shows that SOD refuge deliveries are similar to Exchange Contract deliveries. Deliveries are made as hydrologically available in EXP1, EXP2, and EXP2.5A. In EXP3, Friant stored water releases are made to meet refuge demands, and starting in EXP4v6, the addition of exports minimize shortages to refuges.



	Wet	Above Normal	Below Normal	Dry	Critically Dry
EXP1	0	0	0	0	0
EXP2	0	0	0	0	0
EXP2.5A	0	0	0	0	0
EXP3	0	0	0	0	0
EXP4v6	671	576	469	361	263
EXP4.95	1,093	735	554	262	121
EXP5P	1443	1094	930	604	297

Figure 19. Average Annual Total CVP SOD Agriculture Deliveries by Water Year Type.



	Wet	Above Normal	Below Normal	Dry	Critically Dry
EXP1	0	0	0	0	0
EXP2	0	0	0	0	0
EXP2.5A	0	0	0	0	0
EXP3	0	0	0	0	0
EXP4v6	58	56	52	40	29
EXP4.95	123	109	105	79	59
EXP5P	135	121	117	106	96

Figure 20. Average Annual Total CVP SOD M&I Deliveries by Water Year Type.

Similar to NOD, SOD project deliveries are not made until EXP4v6. Figure 17 shows the effects of successive layers of operations. EXP4v6 opportunistically delivers exports of Delta surplus that are not reserved for senior SOD water users, limited only by OMR constraints. EXP4.95 exports are also limited to Delta surplus after minimal exports are made to meet Health and Safety deliveries, but are limited by allocation logic. The availability of Trinity imports in this scenario does affect water supply available for export. EXP5P meets all demands as possible under full operations and water supply conditions.

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5. Discussion

Project storage operations, deliveries, and exports will be key topics in the LTO 2021 Consultation. The exploratory modeling documented here provides insight to the capabilities and limits of project storage facilities to operate to successive layers of regulatory and contractual obligations. EXP2 captures the hydrologic feasibility of meeting core regulations and senior water rights and provides perspective on the maximum storage volumes that could be available for operations not covered by local inflow. EXP3 demonstrates the storage cost of legal and contractual obligations by making releases from storage reserves for these elements when local inflow is not sufficient. EXP4 added the storage responsibility for covering water quality costs of exporting Delta surplus, and illuminates remaining storage reserves available to enhance water supply delivery. EXP4.95 is the penultimate steppingstone, demonstrating the storage cost of full regulatory criteria and public health and safety deliveries while leaving out storage releases for additional discretionary delivery and export. EXP5P is the operation for all project obligations. Trinity imports in EXP4.95 and EXP5P add flexibility to meet both regulatory costs and deliveries.

This appendix, along with the Shasta Operations Analysis in Appendix L, *Shasta Coldwater Pool Management*, Attachment L.1, *Title*, provides background on feasible combinations of flow, storage, delivery, and export. Uncertainty in forecasted inflow, variability in regulatory cost, and facility limitations should illuminate potential tradeoffs among project purposes and inform action proposals. Exploratory model layers have the freedom to use systemwide flexibility in collectively managing CVP storage resources. Actions specific to any particular tributary would reduce this systemwide flexibility and should be carefully analyzed to avoid potential unintended consequences.

6. References

Bureau of Reclamation. 2019a. *Additional Climate Scenario Sensitivity Analysis*, Appendix F2 of *Reinitiation of Consultation on the Coordinated Long-Term Operation of 1 the Central Valley Project and State Water Project*. Available: https://www.usbr.gov/mp/nepa/includes/documentShow.php?Doc_ID=41745. Accessed: December 5, 2023.

Bureau of Reclamation. 2019b. *Model Limitations*, Appendix F Attachment 2-7 of *Reinitiation of Consultation on the Coordinated Long-Term Operation of 1 the Central Valley Project and State Water Project*. Available: https://www.usbr.gov/mp/nepa/includes/documentShow.php?Doc_ID=41744. Accessed: December 5, 2023.

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E.1 Attachment 1 – CalSim II Model Assumptions Callouts

Study Name	Exploratory 1	Exploratory 2A	Exploratory 2B	Exploratory 2.5A	Exploratory 2.5B	Exploratory 3	Exploratory 4v3	Exploratory 4v6	Exploratory 4.95*	Exploratory 5	Exploratory 5 Plus
Nickname	(EXP1)	(EXP2A)	(EXP2B)	(EXP2.5A)	(EXP2.5B)	(EXP3)	(EXP4v3)	(EXP4v6)	(EXP4.95)	(EXP5)	(EXP5P)
Description	Run of the River	Maximize Storage – Prioritize Senior Deliveries, No Stored Water Release Except for Flood Control	Maximize Storage – Prioritize Flow and D-1641 Standards, No Stored Water Release Except for Flood Control	Maximize Storage – Prioritize Pass-Through for Senior Deliveries, Release Stored Water for Unmet for Flow and D-1641 Standards	Maximize Storage – Prioritize Pass-Through for Flow and D-1641 Standards, Release Stored Water for Unmet Flow and D-1641 Standards	Obligated Releases	Project Delivery and Export from Excess Flows – No ESA or ITP Actions	Project Delivery and Export from Excess Flows – No ESA or ITP Action Except OMR	Manage Stored Water – Fully meet ESA/ITP – Project Delivery to Health and Safety, Otherwise Export Excess Flows Only	Managed Stored Water – Full Operations Without Article 21 or LYRA	Manage Stored Water – Full Operations
GENERAL											
Planning Horizon	Year 2030	Same as EXP1	Same as EXP1	Same as EXP1	Same as EXP1	Same as EXP1	Same as EXP1	Same as EXP1	Same as EXP1	Same as EXP1	Same as EXP1
Period of Simulation	82 years (1922–2003)	Same as EXP1	Same as EXP1	Same as EXP1	Same as EXP1	Same as EXP1	Same as EXP1	Same as EXP1	Same as EXP1	Same as EXP1	Same as EXP1
HYDROLOGY											
Climate Condition	2035_CT projected changes in temperature, and precipitation; sea level rise increased by 15 centimeters	Same as EXP1	Same as EXP1	Same as EXP1	Same as EXP1	Same as EXP1	Same as EXP1	Same as EXP1	Same as EXP1	Same as EXP1	Same as EXP1
Inflows/ Supplies	Modified inflows based on historical hydrology and projected climate condition	Same as EXP1	Same as EXP1	Same as EXP1	Same as EXP1	Same as EXP1	Same as EXP1	Same as EXP1	Same as EXP1	Same as EXP1	Same as EXP1
Level of Development	Projected 2030 level	Same as EXP1	Same as EXP1	Same as EXP1	Same as EXP1	Same as EXP1	Same as EXP1	Same as EXP1	Same as EXP1	Same as EXP1	Same as EXP1

Study Name	Exploratory 1	Exploratory 2A	Exploratory 2B	Exploratory 2.5A	Exploratory 2.5B	Exploratory 3	Exploratory 4v3	Exploratory 4v6	Exploratory 4.95*	Exploratory 5	Exploratory 5 Plus
DEMANDS, WATER RIGHTS,											
Sacramento River Region (Excluding American River)											
CVP	Demands reflect land-use basis. Settlement contractors may divert up to full contract amounts, given hydrologic conditions, without CVP facility operations or hydraulic conditions consideration. No deliveries to CVP M&I or Ag service contractors.	Same as EXP1	Same as EXP1	Same as EXP1	Same as EXP1	Demands reflect land-use basis. Deliveries to Settlement contractors are made, up to full contract amounts, with CVP facility operations. No deliveries to CVP M&I or Ag service contractors.	Demands reflect land-use basis. Deliveries to Settlement contractors are made, up to full contract amounts, with CVP facility operations. Deliveries to CVP M&I and Ag service contractors, up to allocated contract amounts given hydrologic conditions without delivery of stored water.	Same as EXP4v3	Same as EXP4v3	Demands reflect land-use basis. Deliveries to Settlement contractors are made, up to full contract amounts, with CVP facility operations. Deliveries to CVP M&I and Ag service contractors, up to allocated contract amounts with operating CVP facilities to deliver stored water.	Same as EXP5
SWP (FRSA)	Demands reflect land-use basis, limited by contract amounts. Deliveries to FRSA contractors are made as possible, up to full contract amounts, given hydrologic conditions,	Same as EXP1	Same as EXP1	Same as EXP1	Same as EXP1	Demands reflect land-use basis, limited by contract amounts. Deliveries to FRSA contractors are made, up to full contract amounts, with SWP facility operations.	Same as EXP3	Same as EXP3	Same as EXP3	Same as EXP3	Same as EXP3

Study Name	Exploratory 1	Exploratory 2A	Exploratory 2B	Exploratory 2.5A	Exploratory 2.5B	Exploratory 3	Exploratory 4v3	Exploratory 4v6	Exploratory 4.95*	Exploratory 5	Exploratory 5 Plus
	without SWP facility operations or hydraulic conditions consideration.										
Non-project	Land-use based, limited by water rights and Water Board Decisions for Existing Facilities. Deliveries to senior water rights are made as possible, given hydrologic conditions, without CVP facility operations or hydraulic conditions consideration.	Same as EXP1	Same as EXP1	Same as EXP1	Same as EXP1	Land-use based, limited by water rights and Water Board Decisions for Existing Facilities. Deliveries to senior water rights are made with CVP facility operations.	Same as EXP3	Same as EXP3	Same as EXP3	Same as EXP3	Same as EXP3
Antioch Water Works	Pre-1914 water right	Same as EXP1	Same as EXP1	Same as EXP1	Same as EXP1	Same as EXP1	Same as EXP1	Same as EXP1	Same as EXP1	Same as EXP1	Same as EXP1
Federal refuges	Deliveries to refuges are made as possible, up to Level 1 supply needs, given hydrologic conditions,	Same as EXP1	Same as EXP1	Same as EXP1	Same as EXP1	Deliveries to refuges are made up to firm Level 2 supply needs with CVP facility operations.	Same as EXP3	Same as EXP3	Same as EXP3	Same as EXP3	Same as EXP3

Study Name	Exploratory 1	Exploratory 2A	Exploratory 2B	Exploratory 2.5A	Exploratory 2.5B	Exploratory 3	Exploratory 4v3	Exploratory 4v6	Exploratory 4.95*	Exploratory 5	Exploratory 5 Plus
	without CVP facility operations or hydraulic conditions consideration.										
Sacramento River Region – American River											
Water rights	Year 2025, full water rights and Water Board Decisions for Existing Facilities. Deliveries to water rights are made as possible, given hydrologic conditions, without CVP facility operations or hydraulic conditions consideration.	Same as EXP1	Same as EXP1	Same as EXP1	Same as EXP1	Year 2025, full water rights and Water Board Decisions for Existing Facilities. Deliveries to water rights are made with CVP facility operations.	Same as EXP3	Same as EXP3	Same as EXP3	Same as EXP3	Same as EXP3
CVP	Year 2025, demands reflect full contracts. No deliveries to CVP M&I service contractors.	Same as EXP1	Same as EXP1	Same as EXP1	Same as EXP1	Year 2025, demands reflect full contracts. No deliveries to CVP M&I service contractors.	Year 2025, demands reflect full contracts. Deliveries to CVP M&I service contractors, up to allocated contract, including Freeport Regional Water Project,	Same as EXP4v3	Same as EXP4v3	Year 2025, demands reflect full contracts. Deliveries to CVP M&I service contractors, including Freeport Regional Water Project, up to allocated contract	Same as EXP5

Study Name	Exploratory 1	Exploratory 2A	Exploratory 2B	Exploratory 2.5A	Exploratory 2.5B	Exploratory 3	Exploratory 4v3	Exploratory 4v6	Exploratory 4.95*	Exploratory 5	Exploratory 5 Plus
							amounts given hydrologic conditions without operating CVP facilities to deliver stored water.			amounts with operating CVP facilities to deliver stored water.	
San Joaquin River Region											
San Joaquin River and tributaries (except Stanislaus River)	Land-use based, based on district-level operations and constraints. Deliveries to water rights, Exchange Contractors, and refuges (up to Level 1) are made as possible, up to full contract amount, through San Joaquin River diversions, given hydrologic conditions, without CVP facility operations or hydraulic conditions consideration.	Same as EXP1	Same as EXP1	Same as EXP1	Same as EXP1	Land-use based, based on district-level operations and constraints. Deliveries to water rights are made with CVP facility operations. Deliveries to CVP Exchange Contractors and refuges (firm Level 2) are made, up to full contract amounts, through San Joaquin River diversions, with CVP Friant facility operations but no hydraulic condition considerations.	Land-use based, based on district-level operations and constraints. Deliveries to water rights are made with CVP facility operations. Deliveries to Exchange contractors and refuges are first made through excess flow exports at Jones Pumping Plant as possible given hydrologic conditions, and second through San Joaquin River diversions, up to full contract amounts, with	Same as EXP4v3	Same as EXP4v3	Land-use based, based on district-level operations and constraints. Deliveries to water rights are made with CVP facility operations. Deliveries to Exchange contractors and refuges are first made through exports at Jones Pumping Plant up to full contract amounts, with CVP facility operations, and second through San Joaquin River diversions, up to full contract	Same as EXP5

Study Name	Exploratory 1	Exploratory 2A	Exploratory 2B	Exploratory 2.5A	Exploratory 2.5B	Exploratory 3	Exploratory 4v3	Exploratory 4v6	Exploratory 4.95*	Exploratory 5	Exploratory 5 Plus
							CVP Friant facility operations, as needed.			amounts, with CVP Friant facility operations, as needed.	
Friant Unit	No deliveries to Friant Unit CVP M&I or Ag service contractors.	Same as EXP1	Same as EXP1	Same as EXP1	Same as EXP1	Same as EXP1	Deliveries to Friant contractors are first made as possible given hydrologic conditions from the San Joaquin River after Exchange Contractors and refuges, up to full contract amounts, without CVP Friant facility operations.	Same as EXP4v3	Same as EXP4v3	Deliveries to Friant contractors are first made, up to allocated contract amounts, with CVP Friant facility operations (as available after Exchange Contractors, if needed).	Same as EXP5
Stanislaus River	Land-use based, based on district-level operations and constraints. Deliveries to water rights are made as	Same as EXP1	Same as EXP1	Same as EXP1	Same as EXP1	Land-use based, based on district-level operations and constraints. Deliveries to water rights are made with	Land-use based, based on district-level operations and constraints. Deliveries to water rights are made with	Same as EXP4v3	Same as EXP4v3	Land-use based, based on district-level operations and constraints. Deliveries to water rights are made with	Same as EXP5

Study Name	Exploratory 1	Exploratory 2A	Exploratory 2B	Exploratory 2.5A	Exploratory 2.5B	Exploratory 3	Exploratory 4v3	Exploratory 4v6	Exploratory 4.95*	Exploratory 5	Exploratory 5 Plus
	possible given hydrologic conditions, without CVP facility operations or hydraulic conditions consideration. No deliveries to Stanislaus Unit CVP M&I or Ag service contractors.					CVP facility operations. No deliveries to Stanislaus Unit CVP M&I or Ag service contractors.	CVP facility operations. Deliveries to CVP M&I and Ag service contractors up to allocated contract amounts, given hydrologic conditions, without CVP facility operations.			CVP facility operations. Deliveries to CVP M&I and Ag service contractors up to allocated contract amounts.	
San Francisco Bay, Central Coast, Tulare Lake and South Coast Regions (CVP/SWP Project Facilities)											
CVP	No project deliveries.	Same as EXP1	Same as EXP1	Same as EXP1	Same as EXP1	Same as EXP1	Deliveries to CVP M&I and Ag service contractors up to full contract amounts, through exports of Delta excess (i.e., w/o NOD storage releases), after Exchange and Refuge demands are fully met. CVP San Luis operated to facilitate export of Delta excess flows.	Same as EXP4v3	Same as EXP4v3	Deliveries to CVP M&I and Ag service contractors up to allocated contract amounts, with CVP facility operations.	Same as EXP5

Study Name	Exploratory 1	Exploratory 2A	Exploratory 2B	Exploratory 2.5A	Exploratory 2.5B	Exploratory 3	Exploratory 4v3	Exploratory 4v6	Exploratory 4.95*	Exploratory 5	Exploratory 5 Plus
CCWD	Deliveries to water rights are made as possible given Delta hydrologic conditions, without CVP facility operations. No deliveries to CCWD M&I service contracts.	Same as EXP1	Same as EXP1	Same as EXP1	Same as EXP1	Same as EXP1	195 TAF/year CVP contract supply and water rights; Deliveries to CVP M&I service contracts up to allocated contract amounts, given Delta hydrologic conditions, without CVP facility operations. Delivery operations now include in-Delta transfers.	Same as EXP4v3	Same as EXP4v3	195 TAF/year CVP contract supply and water rights; including in-Delta transfers. Deliveries to CVP M&I service contractors up to allocated contract amounts.	Same as EXP5
SWP	No project deliveries	Same as EXP1	Same as EXP1	Same as EXP1	Same as EXP1	Same as EXP1	Demand based on Table A amounts. Deliveries to SWP M&I and Ag service contractors up to allocated contract amounts, given Delta hydrologic conditions, without SWP facility operations. SWP San Luis operated to facilitate	Same as EXP4v3	Same as EXP4v3	Demand based on Table A amounts. Deliveries to SWP M&I and Ag service contractors up to allocated contract amounts.	Same as EXP5

Study Name	Exploratory 1	Exploratory 2A	Exploratory 2B	Exploratory 2.5A	Exploratory 2.5B	Exploratory 3	Exploratory 4v3	Exploratory 4v6	Exploratory 4.95*	Exploratory 5	Exploratory 5 Plus
							export of Delta excess flows.				
Article 56	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	Based on 2001–2008 contractor requests	Same as EXP4.95	Same as EXP4.95
Article 21	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	Metropolitan Water District demand up to 200 TAF/month from December to March subject to conveyance capacity, Kern County Water Agency demand up to 180 TAF/ month. and other contractor demands up to 34 TAF/month in all months, subject to conveyance capacity.

Study Name	Exploratory 1	Exploratory 2A	Exploratory 2B	Exploratory 2.5A	Exploratory 2.5B	Exploratory 3	Exploratory 4v3	Exploratory 4v6	Exploratory 4.95*	Exploratory 5	Exploratory 5 Plus
North Bay Aqueduct (NBA) SWP	No project deliveries	Same as EXP1	Same as EXP1	Same as EXP1	Same as EXP1	Same as EXP1	77 TAF/year demand under SWP contracts; deliveries to SWP M&I and Ag service contractors up to allocated contract amounts, given hydrologic conditions, without SWP facility operations.	Same as EXP4v3	Same as EXP4v3	77 TAF/year demand under SWP contracts; deliveries to SWP M&I and Ag service contractors up to allocated contract amounts.	Same as EXP5
North Bay Aqueduct (NBA) CVP Settlement	Not included	Same as EXP1	Same as EXP1	Same as EXP1	Same as EXP1	Up to 43.7 cfs of excess flow under Fairfield, Vacaville, and Benicia Settlement Agreement	Same as EXP3	Same as EXP3	Same as EXP3	Same as EXP3	Same as EXP3
Federal refuges	Deliveries to refuges are made as possible, up to Level 1 supply needs, through San Joaquin River diversions, given hydrologic conditions, without CVP facility operations or hydraulic conditions consideration.	Same as EXP1	Same as EXP1	Same as EXP1	Same as EXP1	Deliveries to refuges are made as possible, up to firm Level 2 supply needs, through San Joaquin River diversions, with CVP Friant facility operations but no hydraulic condition considerations	Deliveries to refuges are first made through excess flow exports at Jones Pumping Plant, as possible given hydrologic conditions, and second through San Joaquin River diversions, up to firm Level 2 supply needs, with CVP Friant facility	Same as EXP4v3	Deliveries to refuges are made through exports at Jones Pumping Plant, up to firm Level 2 supply needs, as exports allow, with CVP facility operations.	Same as EXP4.95	Same as EXP4.95

Study Name	Exploratory 1	Exploratory 2A	Exploratory 2B	Exploratory 2.5A	Exploratory 2.5B	Exploratory 3	Exploratory 4v3	Exploratory 4v6	Exploratory 4.95*	Exploratory 5	Exploratory 5 Plus
							operations, as needed.				
FACILITIES											
Trinity River Region											
Trinity Lake	Pass-through inflow, not limited to release capacity, subject to all other regulations and operation assumption callouts for this scenario. Release stored water as quickly as possible, limited by downstream channel capacity.	Store water to extent possible, subject to all other regulations and operation assumption callouts for this scenario.	Same as EXP2A, subject to all other regulations and operation assumption callouts for this scenario.	Store water and release stored water for non-discretionary flow and D-1641 standards, subject to all other regulations and operation assumption callouts for this scenario.	Store water and release stored water for non-discretionary flow and D-1641 standards, subject to all other regulations and operation assumption callouts for this scenario.	Store water and release stored water for non-discretionary obligations, subject to all other regulations and operation assumption callouts for this scenario.	Store water and release stored water subject to all other regulations and operation assumption callouts for this scenario.	Store water and release stored water subject to all other regulations and operation assumption callouts for this scenario.	Store water and release stored water subject to all other regulations and operation assumption callouts for this scenario.	Store water and release stored water subject to all other regulations and operation assumption callouts for this scenario.	Store water and release stored water subject to all other regulations and operation assumption callouts for this scenario.
Clear Creek Tunnel	Not Operated	Same as EXP1	Same as EXP1	Same as EXP1	Same as EXP1	Same as EXP1	Same as EXP1	Same as EXP1	Operated up to existing capacity of 3300 cfs	Same as EXP4.95	Same as EXP4.95
Whiskeytown Lake	Pass-through inflow, limited to release capacity, operated to	Operated up to existing capacity of 240 TAF.	Same as EXP2A	Same as EXP2A	Same as EXP2A	Same as EXP2A	Same as EXP2A	Same as EXP2A	Same as EXP2A	Same as EXP2A	Same as EXP2A

Study Name	Exploratory 1	Exploratory 2A	Exploratory 2B	Exploratory 2.5A	Exploratory 2.5B	Exploratory 3	Exploratory 4v3	Exploratory 4v6	Exploratory 4.95*	Exploratory 5	Exploratory 5 Plus
	dead pool capacity of 10 TAF.										
Spring Creek Tunnel	Not Operated	Same as EXP1	Same as EXP1	Same as EXP1	Same as EXP1	Same as EXP1	Same as EXP1	Same as EXP1	Operated up to existing capacity of 4200 cfs	Same as EXP4.95	Same as EXP4.95
Sacramento River Region											
Shasta Lake	Pass-through inflow, not limited to release capacity, subject to all other regulations and operation assumption callouts for this scenario. Release stored water as quickly as possible, limited by downstream channel capacity.	Store water to extent possible, subject to all other regulations and operation assumption callouts for this scenario. No summer draw down.	Same as EXP2A, subject to all other regulations and operation assumption callouts for this scenario.	Store water and release stored water for non-discretionary flow and D-1641 standards, subject to all other regulations and operation assumption callouts for this scenario. No summer draw down.	Store water and release stored water for non-discretionary flow and D-1641 standards, subject to all other regulations and operation assumption callouts for this scenario. No summer draw down.	Store water and release stored water for non-discretionary obligations, subject to all other regulations and operation assumption callouts for this scenario.	Store water and release stored water for non-discretionary obligations, subject to all other regulations and operation assumption callouts for this scenario.	Store water and release stored water for non-discretionary obligations, subject to all other regulations and operation assumption callouts for this scenario.	Store water and release stored water for non-discretionary obligations, subject to all other regulations and operation assumption callouts for this scenario.	Full operations under D-1641 and 2019 Biological Opinions, subject to all other regulations and operations assumptions callouts for this scenario.	Same as EXP5, subject to all other regulations and operations assumptions callouts for this scenario.
Keswick Reservoir	Pass-through inflow, limited to release capacity, operated to dead pool capacity of 0.014 TAF.	Same as EXP1	Same as EXP1	Same as EXP1	Same as EXP1	Operated up to existing capacity of 23.8 TAF.	Same as EXP3	Same as EXP3	Same as EXP3	Same as EXP3	Same as EXP3
Red Bluff Diversion Dam	No pumping	Same as EXP1	Same as EXP1	Same as EXP1	Same as EXP1	Same as EXP1	Pumping Plant operated	Same as EXP4v3	Same as EXP4v3	Same as EXP4v3	Same as EXP4v3

Study Name	Exploratory 1	Exploratory 2A	Exploratory 2B	Exploratory 2.5A	Exploratory 2.5B	Exploratory 3	Exploratory 4v3	Exploratory 4v6	Exploratory 4.95*	Exploratory 5	Exploratory 5 Plus
Stony Creek River Region											
East Park Reservoir	Existing Storage Operated	Same as EXP1	Same as EXP1	Same as EXP1	Same as EXP1	Same as EXP1	Same as EXP1	Same as EXP1	Same as EXP1	Same as EXP1	Same as EXP1
Stony Gorge Reservoir	Existing Storage Operated	Same as EXP1	Same as EXP1	Same as EXP1	Same as EXP1	Same as EXP1	Same as EXP1	Same as EXP1	Same as EXP1	Same as EXP1	Same as EXP1
Black Butte Lake	Existing Storage Operated	Same as EXP1	Same as EXP1	Same as EXP1	Same as EXP1	Same as EXP1	Same as EXP1	Same as EXP1	Same as EXP1	Same as EXP1	Same as EXP1
Fremont Weir	Notched Fremont Weir as represented in Yolo Bypass Salmonid Habitat Restoration and Fish Passage EIS/EIR Alternative 1 (preferred alternative).	Same as EXP1	Same as EXP1	Same as EXP1	Same as EXP1	Same as EXP1	Same as EXP1	Same as EXP1	Same as EXP1	Same as EXP1	Same as EXP1
Colusa Basin	Existing conveyance and storage facilities, water rights and Settlement Contractor and Refuge Level 1 diversions, given hydrologic conditions, without CVP facility operations or hydraulic	Same as EXP1	Same as EXP1	Same as EXP1	Same as EXP1	Existing conveyance and storage facilities, water rights and Settlement Contractor and refuge firm Level 2 diversions, with CVP facility operations.	Same as EXP3	Same as EXP3	Same as EXP3	Same as EXP3	Same as EXP3

Study Name	Exploratory 1	Exploratory 2A	Exploratory 2B	Exploratory 2.5A	Exploratory 2.5B	Exploratory 3	Exploratory 4v3	Exploratory 4v6	Exploratory 4.95*	Exploratory 5	Exploratory 5 Plus
	conditions consideration.										
Feather River											
Lake Oroville	Pass-through inflow, not limited to release capacity, subject to all other regulations and operation assumptions callouts for this scenario. Release stored water as quickly as possible, limited by downstream channel capacity.	Store water to extent possible, subject to all other regulations and operation assumption callouts for this scenario.	Same as EXP2A, subject to all other regulations and operation assumption callouts for this scenario.	Store water and release stored water for non-discretionary flow and D-1641 standards, subject to all other regulations and operation assumption callouts for this scenario.	Same as EXP2.5A, subject to all other regulations and operation assumption callouts for this scenario.	Store water and release stored water for non-discretionary obligations, subject to all other regulations and operation assumption callouts for this scenario.	Store water and release stored water for non-discretionary obligations, subject to all other regulations and operation assumption callouts for this scenario.	Store water and release stored water for non-discretionary obligations, subject to all other regulations and operation assumption callouts for this scenario.	Full operations under D-1641, 2019 Biological Opinions, and 2020 ITP, subject to all other regulations and operations assumptions callouts for this scenario.	Full operations under D-1641, 2019 Biological Opinions, and 2020 ITP, subject to all other regulations and operations assumptions callouts for this scenario.	Same as EXP5, subject to all other regulations and operations assumptions callouts for this scenario.
Thermalito Complex	Pass-through inflow not limited to outlet works release capacity, no storage capacity assumed.	Same as EXP1	Same as EXP1	Same as EXP1	Same as EXP1	Operated up to existing capacity of 55 TAF.	Same as EXP3	Same as EXP3	Same as EXP3	Same as EXP3	Same as EXP3

Study Name	Exploratory 1	Exploratory 2A	Exploratory 2B	Exploratory 2.5A	Exploratory 2.5B	Exploratory 3	Exploratory 4v3	Exploratory 4v6	Exploratory 4.95*	Exploratory 5	Exploratory 5 Plus
American River											
Upper American River	Placer County Water Agency American River Pump Station, water rights diversions only, given hydrologic conditions, and without hydraulic conditions consideration.	Same as EXP1	Same as EXP1	Same as EXP1	Same as EXP1	Same as EXP1	Placer County Water Agency American River Pump Station, full water rights diversions, diversions to CVP M&I and Ag service contractors, up to allocated contract amounts, given hydrologic conditions without CVP facility operations.	Same as EXP4v3	Same as EXP4v3	Placer County Water Agency American River Pump Station, water rights diversions and diversions to CVP M&I and Ag service contractors, up to allocated contract amounts.	Same as EXP5
Folsom Lake	Pass-through inflow, not limited to release capacity, subject to all other regulations and operation assumption callouts for this scenario. Release stored water as quickly as possible, limited by downstream channel capacity.	Store water to extent possible, subject to all other regulations and operation assumption callouts for this scenario.	Same as EXP2A, subject to all other regulations and operation assumption callouts for this scenario.	Store water and release stored water for non-discretionary flow and D-1641 standards, subject to all other regulations and operation assumption callouts for this scenario.	Same as EXP2.5A, subject to all other regulations and operation assumption callouts for this scenario.	Store water and release stored water for non-discretionary obligations, subject to all other regulations and operation assumption callouts for this scenario.	Store water and release stored water for non-discretionary obligations, subject to all other regulations and operation assumption callouts for this scenario.	Same as EXP4v3	Full operations under D-1641 and 2019 Biological Opinions, subject to all other regulations and operations assumptions callouts for this scenario.	Same as EXP4.95, subject to all other regulations and operations assumptions callouts for this scenario.	Same as EXP4.95, subject to all other regulations and operations assumptions callouts for this scenario.

Study Name	Exploratory 1	Exploratory 2A	Exploratory 2B	Exploratory 2.5A	Exploratory 2.5B	Exploratory 3	Exploratory 4v3	Exploratory 4v6	Exploratory 4.95*	Exploratory 5	Exploratory 5 Plus
Folsom South Canal	None	Same as EXP1	Same as EXP1	Same as EXP1	Same as EXP1	Same as EXP1	Operated up to existing capacity	Same as EXP4v3	Same as EXP4v3	Same as EXP4v3	Same as EXP4v3
Lake Natoma	Pass-through inflow, limited to release capacity, operated to dead pool capacity of 1.75 TAF.	Same as EXP1	Same as EXP1	Same as EXP1	Same as EXP1	Operated up to existing capacity of 8.8 TAF.	Same as EXP3	Same as EXP3	Same as EXP3	Same as EXP3	Same as EXP3
Lower Sacramento River	Water rights diversions only given hydrologic conditions, and without hydraulic conditions consideration. Freeport Regional Water Project not operated.	Same as EXP1	Same as EXP1	Same as EXP1	Same as EXP1	Same as EXP1	Freeport Regional Water Project, full water rights diversions, diversions to CVP M&I and Ag service contractors, up to allocated contract amounts, given hydrologic conditions without CVP facility operations.	Same as EXP4v3	Same as EXP4v3	Freeport Regional Water Project, diversions for water rights and CVP M&I and Ag service contractors up to allocated contract amounts.	Same as EXP5
San Joaquin River Region											
Millerton Lake (Friant Dam)	Pass-through inflow, not limited to release capacity, subject to all other regulations and operation assumption	Store water to extent possible, subject to all other regulations and operation assumption	Same as EXP2A, subject to all other regulations and operation assumption callouts for this scenario.	Store water and release stored water for non-discretionary flow and D-1641 standards, subject to all other regulations and operation	Same as EXP2.5A, subject to all other regulations and operation assumption callouts for this scenario.	Store water and release stored water for non-discretionary obligations, subject to all other regulations and operation	Store water and release stored water for non-discretionary obligations. Subject to all other regulations and operation	Same as EXP4v3	Full operations meet San Joaquin River Restoration flows and Friant Unit allocations.	Same as EXP4.95, subject to all other regulations and operations assumptions callouts for this scenario.	Same as EXP4.95, subject to all other regulations and operations assumptions callouts for this scenario.

Study Name	Exploratory 1	Exploratory 2A	Exploratory 2B	Exploratory 2.5A	Exploratory 2.5B	Exploratory 3	Exploratory 4v3	Exploratory 4v6	Exploratory 4.95*	Exploratory 5	Exploratory 5 Plus
	callouts for this scenario. Release stored water as quickly as possible, limited by downstream channel capacity.	callouts for this scenario.		assumption callouts for this scenario.		assumption callouts for this scenario.	assumption callouts for this scenario.				
Lower San Joaquin River	City of Stockton Delta Water Supply Project, 30 million gallon per day capacity	Same as EXP1	Same as EXP1	Same as EXP1	Same as EXP1	Same as EXP1	Same as EXP1	Same as EXP1	Same as EXP1	Same as EXP1	Same as EXP1
New Melones	Pass-through inflow, not limited to release capacity, subject to all other regulations and operation assumption callouts for this scenario. Release stored water as quickly as possible, limited by downstream channel capacity.	Store water to the extent possible, subject to all other regulations and operation assumption callouts for this scenario.	Same as EXP2A, subject to all other regulations and operation assumption callouts for this scenario.	Store water and release stored water for non-discretionary flow and D-1641 standards, subject to all other regulations and operation assumption callouts for this scenario.	Same as EXP2.5A, subject to all other regulations and operation assumption callouts for this scenario.	Store water and release stored water for non-discretionary obligations, subject to all other regulations and operation assumption callouts for this scenario.	Store water and release stored water for non-discretionary obligations, subject to all other regulations and operation assumptions callouts for this scenario.	Same as EXP4v3	Full operations under D-1641 and 2019 Biological Opinions, subject to all other regulations and operations assumptions callouts for this scenario.	Same as EXP4.95, subject to all other regulations and operations assumptions callouts for this scenario.	Same as EXP4.95, subject to all other regulations and operations assumptions callouts for this scenario.
CVP and SWP San Luis	No storage operation	Same as EXP1	Same as EXP1	Same as EXP1	Same as EXP1	Same as EXP1	San Luis operated to manage export	Same as EXP4v3	Same as EXP4v3	San Luis operated to	Same as EXP5

Study Name	Exploratory 1	Exploratory 2A	Exploratory 2B	Exploratory 2.5A	Exploratory 2.5B	Exploratory 3	Exploratory 4v3	Exploratory 4v6	Exploratory 4.95*	Exploratory 5	Exploratory 5 Plus
							of excess flows given Delta hydrologic conditions.			manage all exports.	
SWP Banks Pumping Plant (South Delta)	No pumping	Same as EXP1	Same as EXP1	Same as EXP1	Same as EXP1	Same as EXP1	Physical capacity is 10,300 cfs but 6,680 cfs permitted capacity in all months. Pumping can be up to 10,300 cfs during Dec 15–Mar 15 depending on Vernalis flow conditions. Only pumping of excess flows that cannot otherwise be stored, given hydrologic conditions. SWP San Luis operated.	Same as EXP4v3	Same as EXP4v3	Physical capacity is 10,300 cfs but 6,680 cfs permitted capacity in all months. Pumping can be up to 10,300 cfs during Dec 15–Mar 15 depending on Vernalis flow conditions; additional capacity of 500 cfs (up to 7,180 cfs) allowed Jul–Sep for reducing impact of OMR action on SWP exports.	Same as EXP5
CVP C.W. Bill Jones Pumping Plant (Tracy Pumping Plant)	No pumping	Same as EXP1	Same as EXP1	Same as EXP1	Same as EXP1	Same as EXP1	Permit capacity is 4,600 cfs in all months (allowed for by the Delta-Mendota Canal–California Aqueduct Intertie). Only pumping of	Same as EXP4v3	Same as EXP4v3	Permit capacity is 4,600 cfs in all months (allowed for by the Delta-Mendota Canal–California Aqueduct Intertie).	Same as EXP5

Study Name	Exploratory 1	Exploratory 2A	Exploratory 2B	Exploratory 2.5A	Exploratory 2.5B	Exploratory 3	Exploratory 4v3	Exploratory 4v6	Exploratory 4.95*	Exploratory 5	Exploratory 5 Plus
							excess flows that cannot otherwise be stored, given hydrologic conditions. CVP San Luis operated.				
Upper Delta-Mendota Canal Capacity	Not operated	Not operated	Not operated	Not operated	Not operated	Not operated	Existing plus 400 cfs Delta-Mendota Canal–California Aqueduct Intertie	Same as EXP4v3	Same as EXP4v3	Same as EXP4v3	Same as EXP4v3
CCWD Intakes	No pumping to store in Los Vaqueros Reservoir; only water right diversions for direct use by CCWD; no CVP M&I contract diversions.	Same as EXP1	Same as EXP1	Same as EXP1	Same as EXP1	Same as EXP1	Los Vaqueros Reservoir with existing storage capacity (160 TAF), and existing intakes except for Mallard Slough Intake; intake water quality conditions updated based on DSM2. For storage, only pumping of excess flows that cannot otherwise be stored, given hydrologic conditions.	Same as EXP4v3	Same as EXP4v3	Los Vaqueros Reservoir with existing storage capacity (160 TAF), and existing intakes except for Mallard Slough Intake; intake water quality conditions updated based on DSM2.	Same as EXP5

Study Name	Exploratory 1	Exploratory 2A	Exploratory 2B	Exploratory 2.5A	Exploratory 2.5B	Exploratory 3	Exploratory 4v3	Exploratory 4v6	Exploratory 4.95*	Exploratory 5	Exploratory 5 Plus
Montezuma Slough (Suisun Marsh) Salinity Control Gates	Not operated	Operate to meet Water Board D-1641 water quality standards in Montezuma Slough during salinity control season October through May, as possible, given hydrologic conditions.	Same as EXP2A	Same as EXP2A	Same as EXP2A	Operate to meet Water Board D-1641 water quality standards in Montezuma Slough during salinity control season October through May, as necessary with stored water release.	Same as EXP3	Same as EXP3	Same as EXP3	Same as EXP3	Same as EXP3
San Francisco Bay Region											
South Bay Aqueduct (SBA)	Not operated	Not operated	Not operated	Not operated	Not operated	Not operated	SBA rehabilitation, 430 cfs capacity from junction with California Aqueduct to Alameda County Flood Control & Water Conservation District Zone 7 diversion point.	Same as EXP4v3	Same as EXP4v3	Same as EXP4v3	Same as EXP4v3
South Coast Region											
California Aqueduct East Branch	Not operated	Not operated	Not operated	Not operated	Not operated	Not operated	Existing capacity	Same as EXP4v3	Same as EXP4v3	Same as EXP4v3	Same as EXP4v3
REGULATORY STANDARDS											
North Coast Region											
Trinity River											

Study Name	Exploratory 1	Exploratory 2A	Exploratory 2B	Exploratory 2.5A	Exploratory 2.5B	Exploratory 3	Exploratory 4v3	Exploratory 4v6	Exploratory 4.95*	Exploratory 5	Exploratory 5 Plus
Minimum flow below Lewiston Dam	None	Same as EXP1	Same as EXP1	Same as EXP1	Same as EXP1	Same as EXP1	Trinity EIS Preferred Alternative (369-815 TAF/year)	Same as EXP4v3	Same as EXP4v3	Same as EXP4v3	Same as EXP4v3
Trinity River Fall Augmentation Flows	None	Same as EXP1	Same as EXP1	Same as EXP1	Same as EXP1	Same as EXP1	420 cfs August 1 through September 30 in all but wet years	Same as EXP4v3	Same as EXP4v3	Same as EXP4v3	Same as EXP4v3
Trinity Reservoir end of September minimum storage	No target	Same as EXP1	Same as EXP1	Same as EXP1	Same as EXP1	Same as EXP1	Trinity EIS Preferred Alternative (600 TAF as able)	Same as EXP4v3	Same as EXP4v3	Same as EXP4v3	Same as EXP4v3
Sacramento River Region											
Clear Creek											
Minimum flow below Whiskeytown Dam	Downstream water rights	Downstream water rights 1960 MOA with the CDFG and 1963 USFWS Proposed flows, as possible.	Same as EXP2A	Downstream water rights, as possible. 1960 MOA with the CDFG and 1963 USFWS Proposed flows with stored water as necessary.	Same as EXP2.5A	Downstream water rights 1960 MOA with the CDFG and 1963 USFWS Proposed flows with stored water as necessary.	Downstream water rights 1960 MOA with the CDFG and 1963 USFWS Proposed flows with stored water as necessary.	Same as EXP4v3	Downstream water rights 1960 MOA with the CDFG and 1963 USFWS Proposed flows with stored water as necessary. 200 cfs October through May or 150 cfs in critical years and 150 cfs June through September with 10 TAF for channel maintenance in February of	Same as EXP4.95	Same as EXP4.95

Study Name	Exploratory 1	Exploratory 2A	Exploratory 2B	Exploratory 2.5A	Exploratory 2.5B	Exploratory 3	Exploratory 4v3	Exploratory 4v6	Exploratory 4.95*	Exploratory 5	Exploratory 5 Plus
									below normal, above normal, and wet years and 10 TAF for spring pulse flows in June of all years.		
Upper Sacramento River											
Minimum flow below Keswick Dam	None	Water Board WR 90-5, 3250 cfs, as possible	Same as EXP2A	Water Board WR 90-5, 3250 cfs with stored water as necessary	Same as EXP2.5A	Same as EXP2.5A	Same as EXP2.5A	Same as EXP2.5A	Same as EXP2.5A	Same as EXP2.5A	Same as EXP2.5A
Managed flow below Keswick Dam	None	None	None	None	None	None	None	None	Stabilize fall flows (if Sept Carryover > 2.2 million acre-feet) to reduce redd dewatering and rebuild cold water pool; and spring pulse flow up to 150 TAF if projected May 1 storage > 4.1 million acre-feet.	Same as EXP4.95	Same as EXP4.95

Study Name	Exploratory 1	Exploratory 2A	Exploratory 2B	Exploratory 2.5A	Exploratory 2.5B	Exploratory 3	Exploratory 4v3	Exploratory 4v6	Exploratory 4.95*	Exploratory 5	Exploratory 5 Plus
Feather River											
Minimum flow below Thermalito Diversion Dam (LFC)	None	2006 Settlement Agreement (700/800 cfs), as possible	Same as EXP2A	2006 Settlement Agreement (700/800 cfs) with stored water as necessary	Same as EXP2.5A	Same as EXP2.5A	Same as EXP2.5A	Same as EXP2.5A	Same as EXP2.5A	Same as EXP2.5A	Same as EXP2.5A
Minimum flow below Thermalito Afterbay outlet (HFC)	None	1983 DWR, DFG Agreement (750–1,700 cfs), as possible	Same as EXP2A	1983 DWR, DFG Agreement (750–1,700 cfs) with stored water as necessary	Same as EXP2.5A	Same as EXP2.5A	Same as EXP2.5A	Same as EXP2.5A	Same as EXP2.5A	Same as EXP2.5A	Same as EXP2.5A
Yuba River											
Minimum flow below Daguerre Point Dam	D-1644 Operations (Lower Yuba River Accord)	Same as EXP1	Same as EXP1	Same as EXP1	Same as EXP1	Same as EXP1	Same as EXP1	Same as EXP1	Same as EXP1	Same as EXP1	Same as EXP1
American River											
Minimum Flow at H Street Bridge	None	Water Board D-893, as possible	Same as EXP2A	Water Board D-893 with stored water as necessary	Same as EXP2.5A	Same as EXP2.5A	Same as EXP2.5A	Same as EXP2.5A	Same as EXP2.5A	Same as EXP2.5A	Same as EXP2.5A
Managed flow below Nimbus Dam	None	Same as EXP1	Same as EXP1	Same as EXP1	Same as EXP1	Same as EXP1	Same as EXP1	Same as EXP1	American River Flow Management Standard, per 2017 Water Forum Agreement with a planning minimum end of September storage target of 275 TAF.	Same as EXP4.95	Same as EXP4.95
Lower Sacramento River											

Study Name	Exploratory 1	Exploratory 2A	Exploratory 2B	Exploratory 2.5A	Exploratory 2.5B	Exploratory 3	Exploratory 4v3	Exploratory 4v6	Exploratory 4.95*	Exploratory 5	Exploratory 5 Plus
Minimum flow near Rio Vista	None	Water Board D-1641, as possible	Same as EXP2A	Water Board D-1641 with stored water as necessary	Same as EXP2.5A	Same as EXP2.5A	Same as EXP2.5A	Same as EXP2.5A	Same as EXP2.5A	Same as EXP2.5A	Same as EXP2.5A
Mokelumne River											
Minimum flow below Camanche Dam	FERC 2916-029, 1996 (Joint Settlement Agreement) (100–325 cfs)	Same as EXP1	Same as EXP1	Same as EXP1	Same as EXP1	Same as EXP1	Same as EXP1	Same as EXP1	Same as EXP1	Same as EXP1	Same as EXP1
Minimum flow below Woodbridge Diversion Dam	FERC 2916-029, 1996 (Joint Settlement Agreement) (25–300 cfs)	Same as EXP1	Same as EXP1	Same as EXP1	Same as EXP1	Same as EXP1	Same as EXP1	Same as EXP1	Same as EXP1	Same as EXP1	Same as EXP1
Stanislaus River											
Minimum flow below Goodwin Dam	None	1987 USBR, DFG agreement, as possible	Same as EXP2A	1987 USBR, CDFG agreement with stored water as necessary	Same as EXP2.5A	Flows according to SRP	Same as EXP2.5A	Same as EXP2.5A	Flows according to SRP	Same as EXP4.95	Same as EXP4.95
Minimum dissolved oxygen	None	Water Board D-1422, as possible	Same as EXP2A	Water Board D-1422 with stored water as necessary	Same as EXP2.5A	Same as EXP2.5A	Same as EXP2.5A	Same as EXP2.5A	Same as EXP2.5A	Same as EXP2.5A	Same as EXP2.5A
Merced River											
Minimum flow below Crocker-Huffman Diversion Dam	Cowell Agreement	Same as EXP1	Same as EXP1	Same as EXP1	Same as EXP1	Same as EXP1	Same as EXP1	Same as EXP1	Same as EXP1	Same as EXP1	Same as EXP1
Minimum flow at Shaffer Bridge	FERC 2179 (25–100 cfs) with 12.5 TAF in October based on 2002 Merced ID and	Same as EXP1	Same as EXP1	Same as EXP1	Same as EXP1	Same as EXP1	Same as EXP1	Same as EXP1	Same as EXP1	Same as EXP1	Same as EXP1

Study Name	Exploratory 1	Exploratory 2A	Exploratory 2B	Exploratory 2.5A	Exploratory 2.5B	Exploratory 3	Exploratory 4v3	Exploratory 4v6	Exploratory 4.95*	Exploratory 5	Exploratory 5 Plus
	CDFW Memorandum of Understanding										
Tuolumne River											
Minimum flow at Lagrange Bridge	FERC 2299-024, 1995 (Settlement Agreement) (94–301 TAF/year)	Same as EXP1	Same as EXP1	Same as EXP1	Same as EXP1	Same as EXP1	Same as EXP1	Same as EXP1	Same as EXP1	Same as EXP1	Same as EXP1
San Joaquin River											
San Joaquin River below Friant Dam/ Mendota Pool	None (flow capacity for San Joaquin River to Mendota pool changed to 2,600 cfs to accommodate deliveries to Exchange and Refuge contractors).	5 cfs Gravelly Ford (flow capacity for San Joaquin River to Mendota pool changed to 2,600 cfs to accommodate deliveries to Exchange and Refuge contractors).	Same as EXP2A	Same as EXP2A	Same as EXP2A	Same as EXP2A	Same as EXP2A	Same as EXP2A	San Joaquin River Restoration-full flows, not constrained by current river capacity, including recapture/ recirculation.	Same as EXP4.95	Same as EXP4.95
Maximum salinity near Vernalis	None	Water Board D-1641, as possible	Same as EXP2A	Water Board D-1641 with stored water as necessary	Same as EXP2.5A	Stanislaus contribution to Water Board D-1641 per New Melones SRP	Same as EXP2.5A	Same as EXP2.5A	Stanislaus contribution to Water Board D-1641 per New Melones SRP	Same as EXP4.95	Same as EXP4.95
Minimum flow near Vernalis	None	Feb–Jun Water Board D-1641 Bay Delta flows (non-pulse), as possible	Same as EXP2A	Feb–Jun Water Board D-1641 Bay-Delta flows (non-pulse), with stored water as necessary	Same as EXP2.5A	Stanislaus contribution to Water Board D-1641 per New Melones SRP	Same as EXP2.5A	Same as EXP2.5A	Stanislaus contribution to Water Board D-1641 per New Melones SRP	Same as EXP4.95	Same as EXP4.95

Study Name	Exploratory 1	Exploratory 2A	Exploratory 2B	Exploratory 2.5A	Exploratory 2.5B	Exploratory 3	Exploratory 4v3	Exploratory 4v6	Exploratory 4.95*	Exploratory 5	Exploratory 5 Plus
Sacramento River–San Joaquin Delta Region											
Delta Outflow (EC, NDOI, Spring X2)	None	Water Board D-1641 (SMSCG D-1641 Ops), as possible	Same as EXP2A	Water Board D-1641 (SMSCG D-1641 Ops) with stored water as necessary	Same as EXP2.5A	Same as EXP2.5A	Same as EXP2.5A	Same as EXP2.5A	Water Board D-1641 and SWP to allow up to 150 TAF of Delta outflow in April and May. Spring outflow block shall not exceed 150 TAF and is subject to a 44,500 cfs Delt Outflow off-ramp. SWP to release 100 TAF block of water in Jun through Sep of wet and above normal years.	Same as EXP4.95	Same as EXP4.95
Delta Outflow (Fall X2)	None	Same as EXP1	Same as EXP1	Same as EXP1	Same as EXP1	Same as EXP1	Same as EXP1	Same as EXP1	Summer/Fall Delta Smelt habitat-Projects operate to meet X2 of 80 kilometers for September and October of wet and above normal years with transitional flows in second half of August.	Same as EXP4.95	Same as EXP4.95

Study Name	Exploratory 1	Exploratory 2A	Exploratory 2B	Exploratory 2.5A	Exploratory 2.5B	Exploratory 3	Exploratory 4v3	Exploratory 4v6	Exploratory 4.95*	Exploratory 5	Exploratory 5 Plus
Delta Cross Channel gate operation	Gates closed	Same as EXP1	Same as EXP1	Same as EXP1	Same as EXP1	Same as EXP1	Water Board D-1641	Water Board D-1641	Water Board D-1641; Gate operations per 2019 Biological Opinions (modeled same as Multi-Year Study Program).	Same as EXP4.95	Same as EXP4.95
South Delta exports (Jones Pumping Plant and Banks Pumping Plant)	No exports	Same as EXP1	Same as EXP1	Same as EXP1	Same as EXP1	Same as EXP1	Water Board D-1641	Water Board D-1641	Water Board D-1641; and additional 500 cfs allowed for Jul–Sep for reducing impact on SWP.	Same as EXP4.95	Same as EXP4.95
Combined Flow in Old and Middle River (OMR)	No requirements	Same as EXP1	Same as EXP1	Same as EXP1	Same as EXP1	Same as EXP1	Same as EXP1	OMR target of -5,000 cfs January through June except for 5 days of -2,000 cfs when turbidity bridge occurs and 7 days of -6,000 cfs when increased pumping due to storm is possible, followed by "first flush" action only if it occurs in December (14 days of -2,000 cfs), OMR	Same as EXP4v6	Same as EXP4v6	Same as EXP4v6

Study Name	Exploratory 1	Exploratory 2A	Exploratory 2B	Exploratory 2.5A	Exploratory 2.5B	Exploratory 3	Exploratory 4v3	Exploratory 4v6	Exploratory 4.95*	Exploratory 5	Exploratory 5 Plus
								target of -3,500 cfs in March, April, and May of non-critical years.			
OPERATIONS CRITERIA: RIVER-SPECIFIC											
Sacramento River Region											
Upper Sacramento River: Flow objective for navigation (Wilkins Slough)	None	Assume 3,250 cfs, given hydrologic condition at priority over diversion to storage	Same as EXP2A	Assume 3250 cfs	Same as EXP2.5A	Same as EXP2.5A	Same as EXP2.5A	Same as EXP2.5A	Flow objective for Wilkins Slough based on month, CVP allocation, and Shasta storage condition to reflect CVP operations for local delivery.	Same as EXP4.95	Same as EXP4.95
American River: Folsom Dam flood control	Variable 400/600 flood control diagram	Same as EXP1	Same as EXP1	Same as EXP1	Same as EXP1	Same as EXP1	Same as EXP1	Same as EXP1	Same as EXP1	Same as EXP1	Same as EXP1
Feather River: Flow at Mouth of Feather River (above Verona)	None	Assume 2,800 cfs, given hydrologic condition at priority over diversion to storage	Same as EXP2A	Maintain CDFG/DWR flow target of 2,800 cfs for Apr–Sep dependent on Oroville inflow and FRSA allocation	Same as EXP2.5A	Same as EXP2.5A	Same as EXP2.5A	Same as EXP2.5A	Same as EXP2.5A	Same as EXP2.5A	Same as EXP2.5A

Study Name	Exploratory 1	Exploratory 2A	Exploratory 2B	Exploratory 2.5A	Exploratory 2.5B	Exploratory 3	Exploratory 4v3	Exploratory 4v6	Exploratory 4.95*	Exploratory 5	Exploratory 5 Plus
Sacramento River–San Joaquin Delta Region											
Suisun Marsh Salinity Control Gates	Not operated	Same as EXP1	Same as EXP1	Same as EXP1	Same as EXP1	Same as EXP1	Same as EXP1	Same as EXP1	Operate to meet Water Board D-1641 water quality standards in Montezuma Slough during salinity control season October through May, as necessary with stored water release. Operate for Summer/Fall Delta Smelt habitat up to 60 days June through October of below normal, above normal, and wet years (2019 Biological Opinion), and dry years (2020 ITP) as necessary with stored water release.	Same as EXP4.95	Same as EXP4.95
South Delta barriers	Head of Old River Barrier is not installed.	Same as EXP1	Same as EXP1	Same as EXP1	Same as EXP1	Same as EXP1	Same as EXP1	Same as EXP1	Same as EXP1	Same as EXP1	Same as EXP1
OPERATIONS CRITERIA: SYSTEMWIDE											
CVP Water Allocation											

Study Name	Exploratory 1	Exploratory 2A	Exploratory 2B	Exploratory 2.5A	Exploratory 2.5B	Exploratory 3	Exploratory 4v3	Exploratory 4v6	Exploratory 4.95*	Exploratory 5	Exploratory 5 Plus
Settlement / Exchange	Settlement and Exchange Contractors allocated at 100% (75%/77% in Shasta critical years). Deliveries without CVP facility operations.	Same as EXP1	Same as EXP1	Same as EXP1	Same as EXP1	Settlement and Exchange Contractors allocated at 100% (75%/77% in Shasta critical years).	Same as EXP3	Same as EXP3	Same as EXP3	Same as EXP3	Same as EXP3
Refuges	Delivery of water supply needs, up to Level 1, given hydrologic conditions, without CVP facility operations or hydraulic conditions consideration.	Same as EXP1	Same as EXP1	Same as EXP1	Same as EXP1	Water supply needs, up to firm Level 2 allocated at 100% (75% in Shasta critical years).	Same as EXP3	Same as EXP3	Same as EXP3	Same as EXP3	Same as EXP3
Agriculture Service	None	Same as EXP1	Same as EXP1	Same as EXP1	Same as EXP1	Same as EXP1	No allocations; pumping/ diversions limited to flows given hydrologic conditions. No preference for type.	Same as EXP4v3	No allocations.	100%–0% based on supply, south of Delta allocations are additionally limited due to D-1641 and OMR actions.	Same as EXP5
Municipal & Industrial Service	None	Same as EXP1	Same as EXP1	Same as EXP1	Same as EXP1	Same as EXP1	No allocations; pumping/ diversions limited to flows given hydrologic conditions. No	Same as EXP4v3	Health and Safety only (25% allocation)	100%–50% based on supply, south of Delta allocations are additionally limited due to	Same as EXP5

Study Name	Exploratory 1	Exploratory 2A	Exploratory 2B	Exploratory 2.5A	Exploratory 2.5B	Exploratory 3	Exploratory 4v3	Exploratory 4v6	Exploratory 4.95*	Exploratory 5	Exploratory 5 Plus
							preference for type.			D-1641 and OMR actions.	
Friant allocation	None	Same as EXP1	Same as EXP1	Same as EXP1	Same as EXP1	Same as EXP1	No allocations; diversions limited to available inflow after delivery to Exchange/ Refuge.	Same as EXP4v3	Class 1, Class 2, and 215 water deliveries as allocated given water supply.	Same as EXP4.95	Same as EXP4.95
SWP Water Allocation											
North of Delta (FRSA)	FRSA and water rights diversions off the river, contract specific conditions. Deliveries limited to given hydrologic conditions, without SWP facility operations and hydraulic conditions consideration.	Same as EXP1	Same as EXP1	Same as EXP1	Same as EXP1	FRSA and water rights diversions off the river, contract specific conditions.	Same as EXP3	Same as EXP3	Same as EXP3	Same as EXP3	Same as EXP3
South of Delta (including North Bay Aqueduct)	None	Same as EXP1	Same as EXP1	Same as EXP1	Same as EXP1	Same as EXP1	No allocations; pumping/ diversions limited to flows given hydrologic conditions. No	No allocations; pumping/ diversions limited to flows given hydrologic conditions. No	Allocations; pumping/ diversions limited to flows given hydrologic conditions. No	Based on supply; equal prioritization between Ag and M&I based on Monterey Agreement.	Same as EXP5

Study Name	Exploratory 1	Exploratory 2A	Exploratory 2B	Exploratory 2.5A	Exploratory 2.5B	Exploratory 3	Exploratory 4v3	Exploratory 4v6	Exploratory 4.95*	Exploratory 5	Exploratory 5 Plus
							preference for type.	preference for type.	preference for type.		
CVP-SWP Coordinated Operations											
Sharing of responsibility for in-basin-use	None	Revised Coordinated Operations Agreement (1986 COA w/ 2018 amendment)	Same as EXP2A	Same as EXP2A	Same as EXP2A	Same as EXP2A	Same as EXP2A	Same as EXP2A	Same as EXP2A	Same as EXP2A	Same as EXP2A
Sharing of UWFE flows	None	Same as EXP1	Same as EXP1	Same as EXP1	Same as EXP1	Same as EXP1	Revised Coordinated Operations Agreement (1986 COA w/ 2018 amendment)	Same as EXP4v3	Same as EXP4v3	Same as EXP4v3	Same as EXP4v3
Sharing of restricted export capacity for project-specific priority pumping	None	Same as EXP1	Same as EXP1	Same as EXP1	Same as EXP1	Same as EXP1	Revised Coordinated Operations Agreement (1986 COA w/ 2018 amendment)	Same as EXP4v3	Same as EXP4v3	Same as EXP4v3	Same as EXP4v3
Water transfers	None	Same as EXP1	Same as EXP1	Same as EXP1	Same as EXP1	Same as EXP1	Same as EXP1	Same as EXP1	Same as EXP1	Same as EXP1	Acquisitions by SWP contractors are wheeled at priority in Banks Pumping Plant over non-SWP users; LYRA included for SWP contractors.

Study Name	Exploratory 1	Exploratory 2A	Exploratory 2B	Exploratory 2.5A	Exploratory 2.5B	Exploratory 3	Exploratory 4v3	Exploratory 4v6	Exploratory 4.95*	Exploratory 5	Exploratory 5 Plus
Sharing of export capacity for lesser priority and wheeling-related pumping	None	Same as EXP1	Same as EXP1	Same as EXP1	Same as EXP1	Same as EXP1	Cross Valley Canal wheeling (max of 128 TAF/year), CALFED ROD defined JPOD; given hydrologic conditions.	Same as EXP4v3	Cross Valley Canal wheeling (max of 128 TAF/year), CALFED ROD JPOD.	Same as EXP4.95	Same as EXP4.95
San Luis Reservoir	Not operated	Same as EXP1	Same as EXP1	Same as EXP1	Same as EXP1	Same as EXP1	San Luis Reservoir is allowed to operate to a minimum storage of 100 TAF.	Same as EXP4v3	Same as EXP4v3	Same as EXP4v3	Same as EXP4v3
WATER MANAGEMENT ACTIONS											
Water Transfer Supplies (Long-Term Programs)											
Lower Yuba River Accord	None	Same as EXP1	Same as EXP1	Same as EXP1	Same as EXP1	Same as EXP1	Same as EXP1	Same as EXP1	Same as EXP1	Same as EXP1	Yuba River acquisitions for reducing impact of D-1641 and OMR Action export restrictions on SWP

Ag = agriculture; CCWD = Contra Costa Water District; CDFG = California Department of Fish and Game; CDFW = California Department of Fish and Wildlife; cfs = cubic feet per second; COA = Coordinated Operations Agreement; CVP = Central Valley Project; D-1641 = State Water Resources Control Board Water Right Decision 1641; DSM2 = Delta Simulation Model II; EC = electrical conductivity; EIR = environmental impact report; EIS = environmental impact statement; FERC = Federal Energy Regulatory Commission; FRSA = Feather River Service Area; HFC = High Flow Channel; ITP = incidental take permit; JPOD = Joint Point of Diversion; LFC = Low Flow Channel; LYRA = Lower Yuba River Accord; COA = Coordinated Operating Agreement; M&I = municipal and industrial; Merced ID = Merced Irrigation District; MOA = Memorandum of Agreement; NBA = North Bay Aqueduct; NDOI = Net Delta Outflow Index; OMR = Old and Middle River; Ops = operations; ROD = record of decision; SBA = South Bay Aqueduct; SMSCG = Suisun Marsh Salinity Control Gates; SRP = Stepped Release Plan; Water Board = State Water Resources Control Board; SWP = State Water Project; TAF = thousand acre-feet; USFWS = U.S. Fish and Wildlife Service.

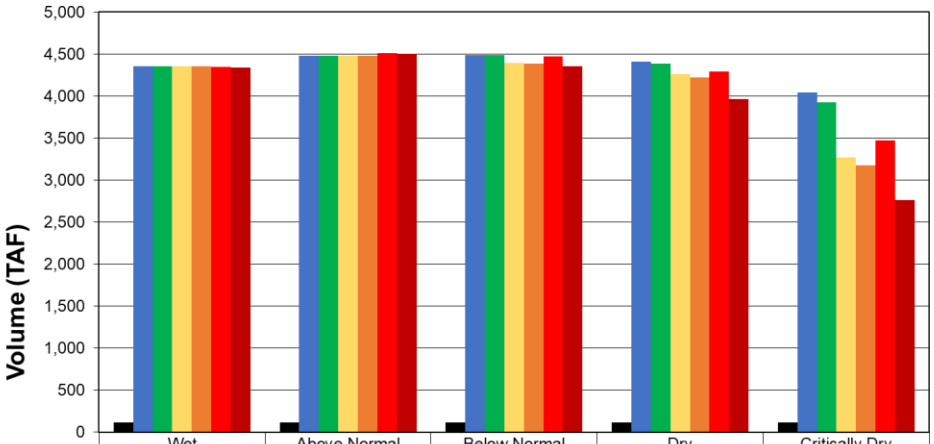
E.2 Attachment 2 – Model Results

E.2.1 Introduction

This attachment provides a summary of the results that were previously shared as outreach on the exploratory modeling. All water year types are Sacramento (40-30-30) Index, unless otherwise noted.

E.2.2 Storage

E.2.2.1 Sacramento River:



	Wet	Above Normal	Below Normal	Dry	Critically Dry
EXP1	116	116	116	116	116
EXP2	4,351	4,477	4,487	4,411	4,039
EXP2.5A	4,351	4,477	4,487	4,386	3,925
EXP3	4,351	4,477	4,396	4,257	3,266
EXP4v6	4,351	4,477	4,387	4,224	3,175
EXP4.95	4,344	4,507	4,471	4,293	3,469
EXP5P	4341	4499	4351	3964	2762

Figure E.2-1. End of April Shasta Storage by Water Year Type.

End of April Shasta storage shows little to no difference in wet, above normal (AN), and below normal (BN) years, slight differences in dry years, and substantial and progressively lower storage across the suite of models in critically dry years.

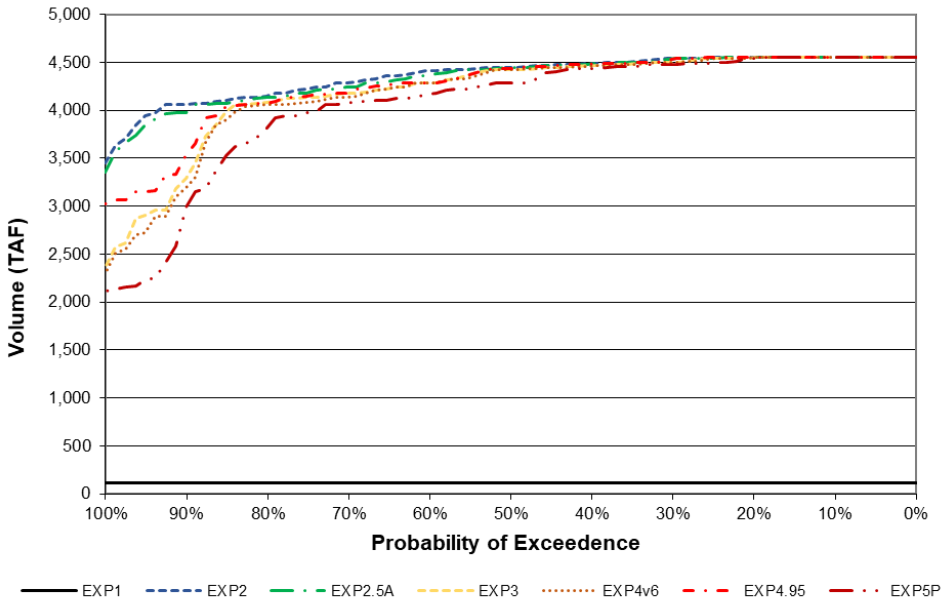
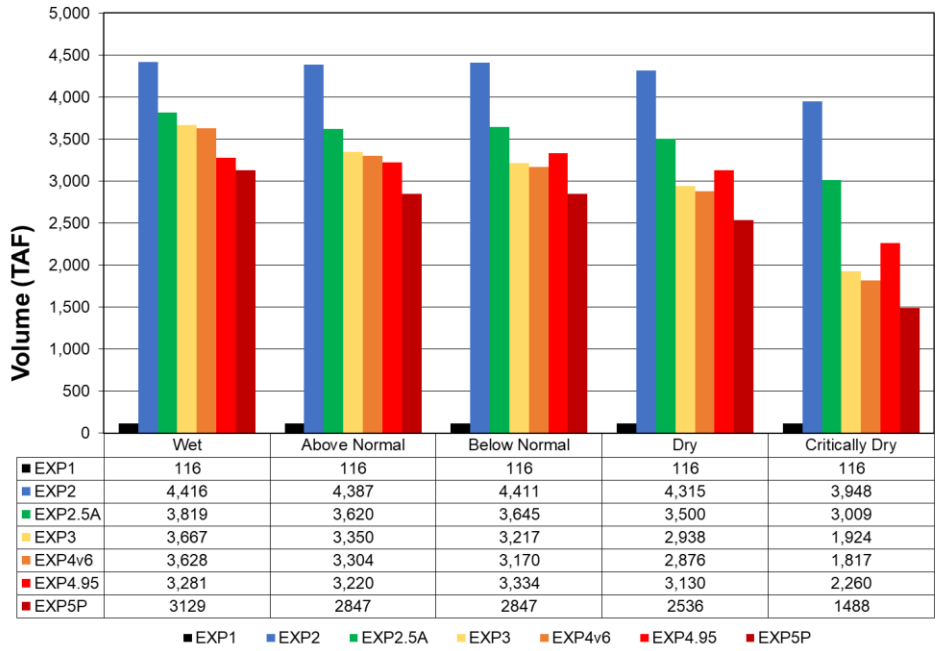


Figure E.2-2. End of April Exceedance for Shasta Storage.

The difference in end of April Shasta storage across the exploratory modeling suite significantly increases in the 20% of driest years.



	Wet	Above Normal	Below Normal	Dry	Critically Dry
EXP1	116	116	116	116	116
EXP2	4,416	4,387	4,411	4,315	3,948
EXP2.5A	3,819	3,620	3,645	3,500	3,009
EXP3	3,667	3,350	3,217	2,938	1,924
EXP4v6	3,628	3,304	3,170	2,876	1,817
EXP4.95	3,281	3,220	3,334	3,130	2,260
EXP5P	3129	2847	2847	2536	1488

Figure E.2-3. End of September Shasta Storage by Water Year Type.

The differences of end of September Shasta storage show the effects of increased use of storage across the exploratory modeling suite.

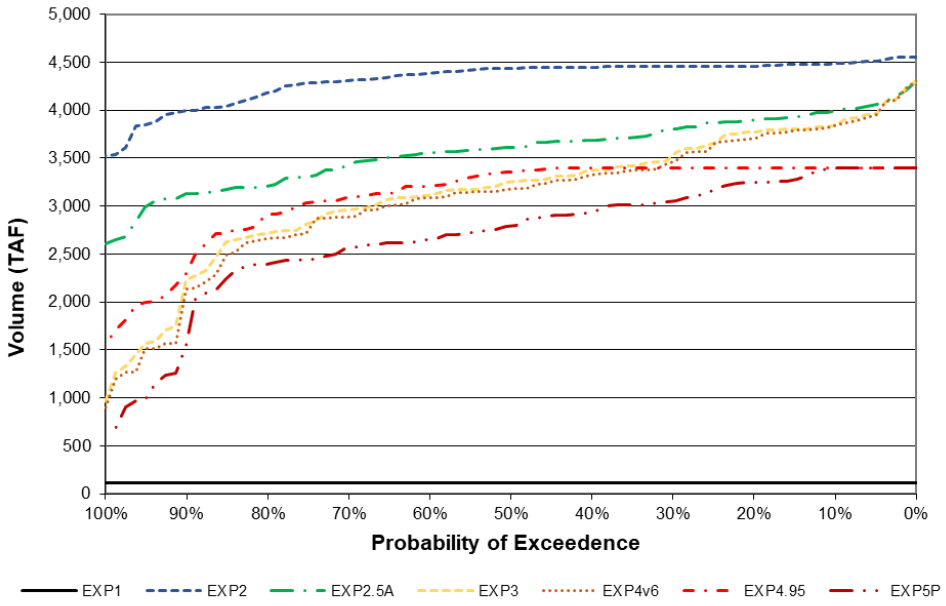


Figure E.2-4. End of September Exceedance for Shasta Storage.

The most pronounced difference in storage occurs between EXP2.5B and EXP3, which correlates with the introduction of stored water releases to meet senior water rights.

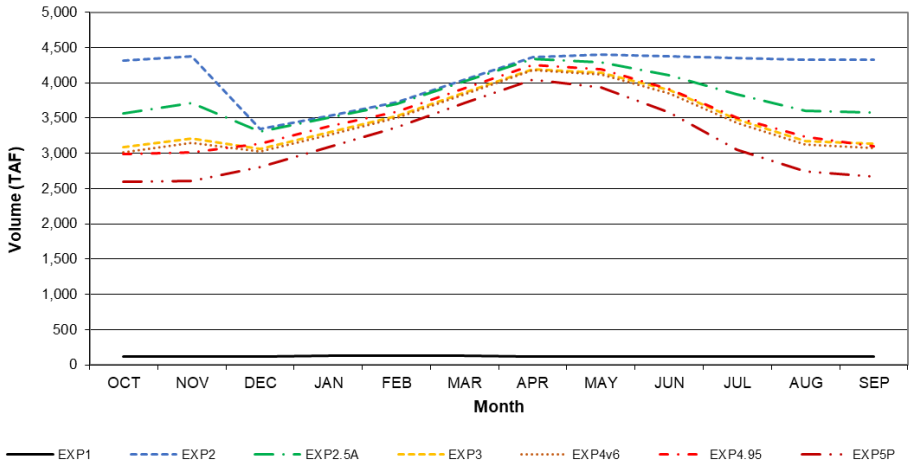


Figure E.2-5. Shasta Storage Monthly Pattern (Long-Term Average).

The monthly pattern of Shasta storage shows the gain in storage during the fill season and progressively larger use of storage across the exploratory modeling suite in the management season. EXP2A and EXP2.5B have pronounced decrease in storage in December due to flood control releases.

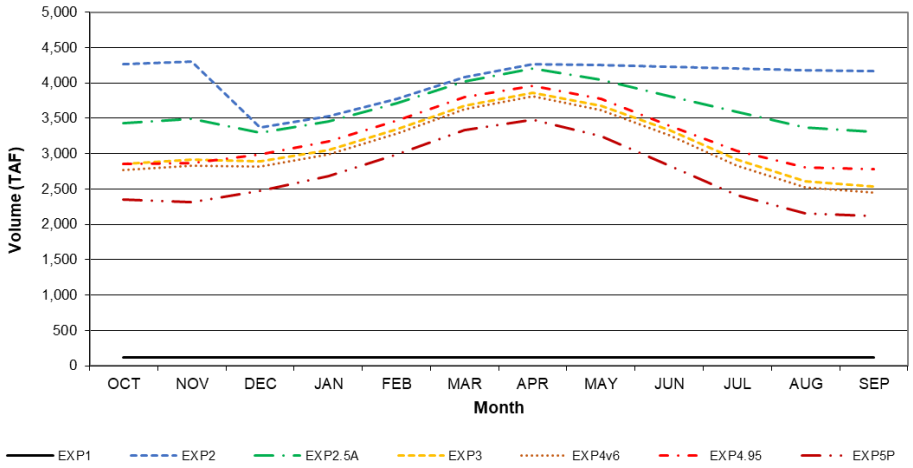
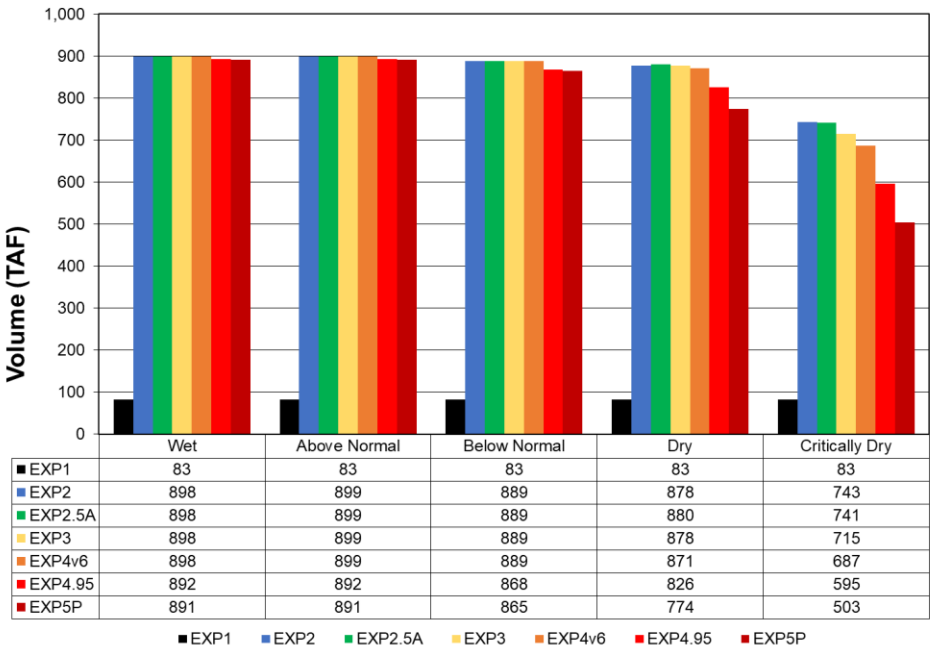


Figure E.2-6. Shasta Storage Monthly Pattern (Dry and Critically Dry Years).

Despite having lower storage levels, the monthly pattern for Shasta storage in dry and critically dry years is like the long-term averages.

E.2.2.2 American River:



	Wet	Above Normal	Below Normal	Dry	Critically Dry
EXP1	83	83	83	83	83
EXP2	898	899	889	878	743
EXP2.5A	898	899	889	880	741
EXP3	898	899	889	878	715
EXP4v6	898	899	889	871	687
EXP4.95	892	892	868	826	595
EXP5P	891	891	865	774	503

Figure E.2-7. End of April Folsom Storage by Water Year Type.

End of April Folsom storage shows little to no difference in wet, AN, and BN years, some difference in EXP5 for dry years, and substantial and progressively lower storage across the suite of models in critically dry years.

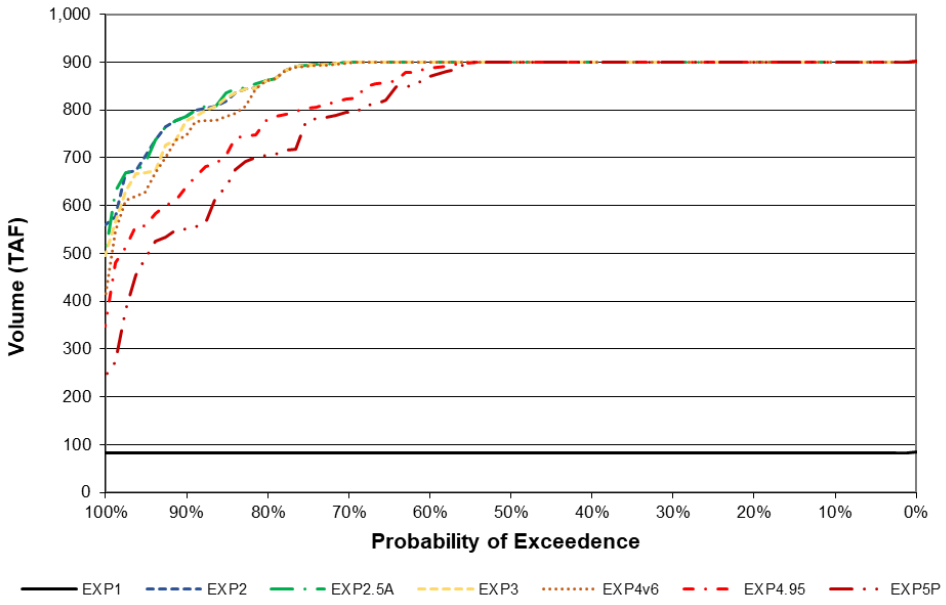
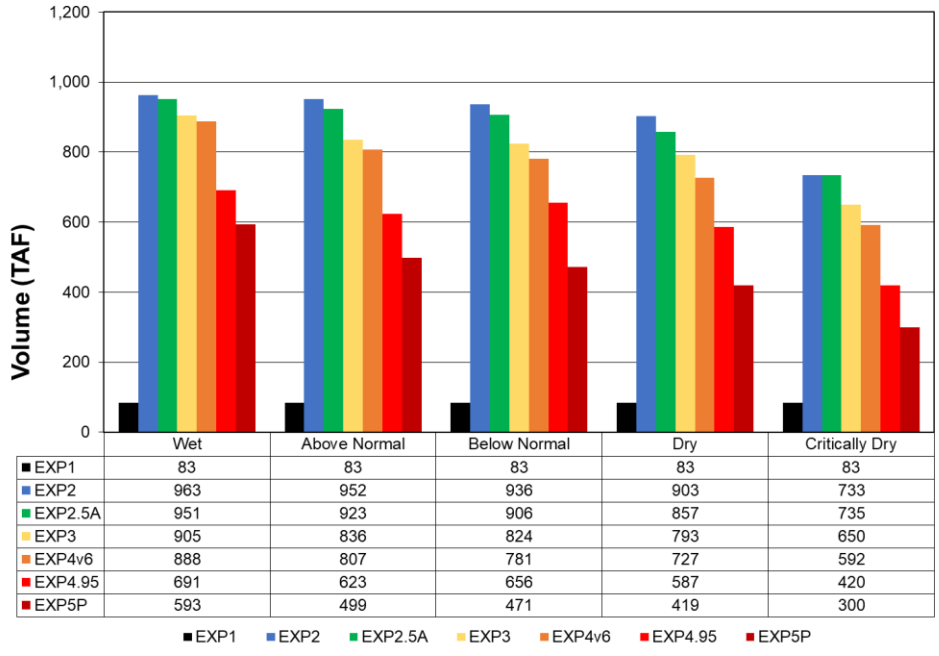


Figure E.2-8. End of April Exceedance for Folsom Storage.

The only significant differences between the models is due to introduction of storage releases for discretionary purposes in EXP5.



	Wet	Above Normal	Below Normal	Dry	Critically Dry
EXP1	83	83	83	83	83
EXP2	963	952	936	903	733
EXP2.5A	951	923	906	857	735
EXP3	905	836	824	793	650
EXP4v6	888	807	781	727	592
EXP4.95	691	623	656	587	420
EXP5P	593	499	471	419	300

Figure E.2-9. End of September Folsom Storage by Water Year Type.

The differences of end of September Folsom storage show the effects of increased use of storage across the exploratory modeling suite. The additional releases from EXP4v6 and EXP5 are

similar in all water year types, depicting the role that Folsom plays in meeting full project obligations.

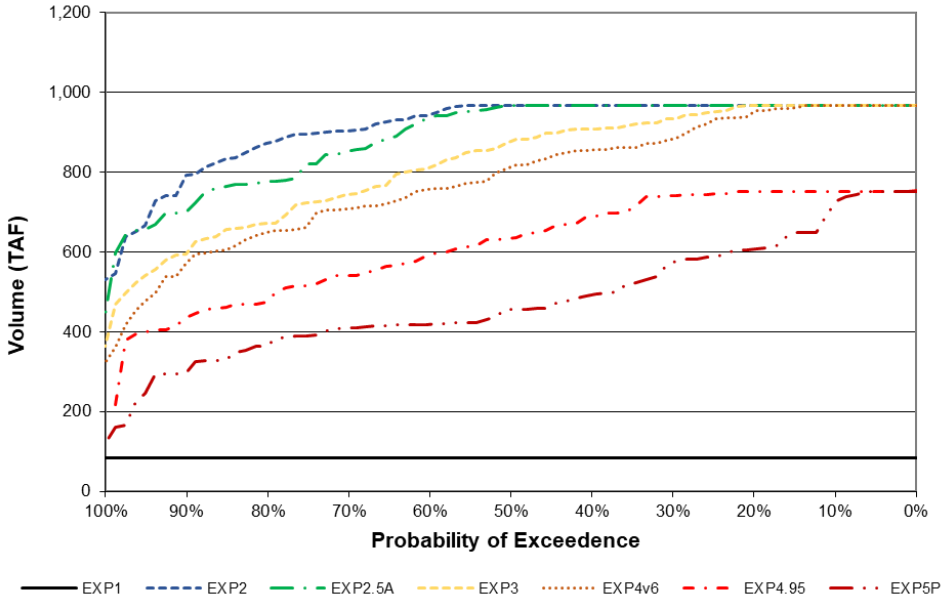


Figure E.2-10. End of September Exceedance for Folsom Storage.

The most pronounced and consistent difference in storage occurs between EXP4v6 and EXP5, which correlates with the introduction of stored water releases to meet discretionary purposes.

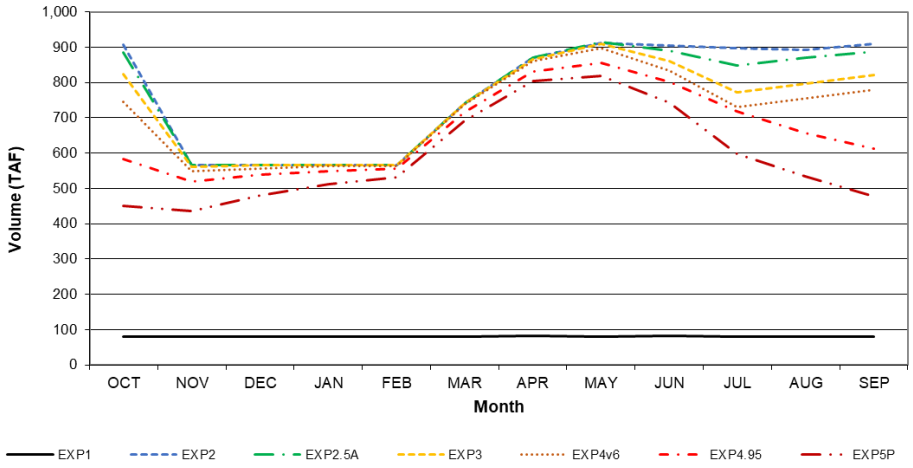


Figure E.2-11. Folsom Storage Monthly Pattern (Long-Term Average).

The monthly pattern of Folsom storage shows the gain in storage during the fill season and progressively larger use of storage across the exploratory modeling suite in the management season. All but EXP5 show a sharp decline in storage in November due to flood control releases.

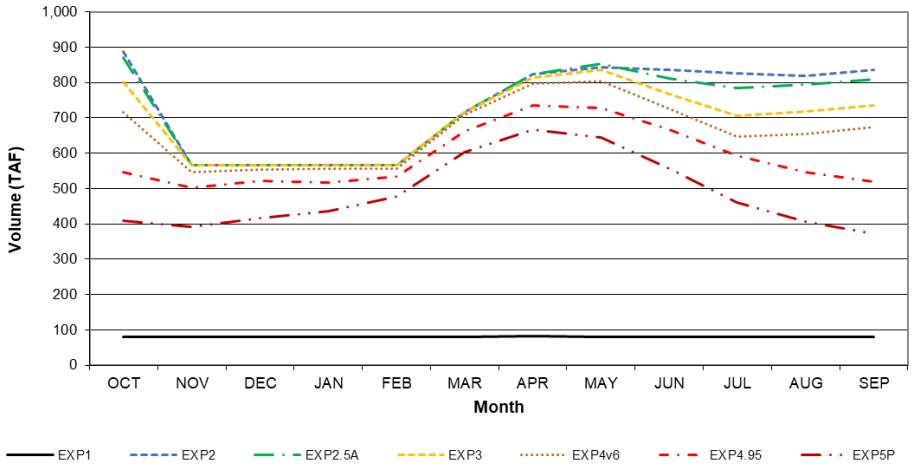
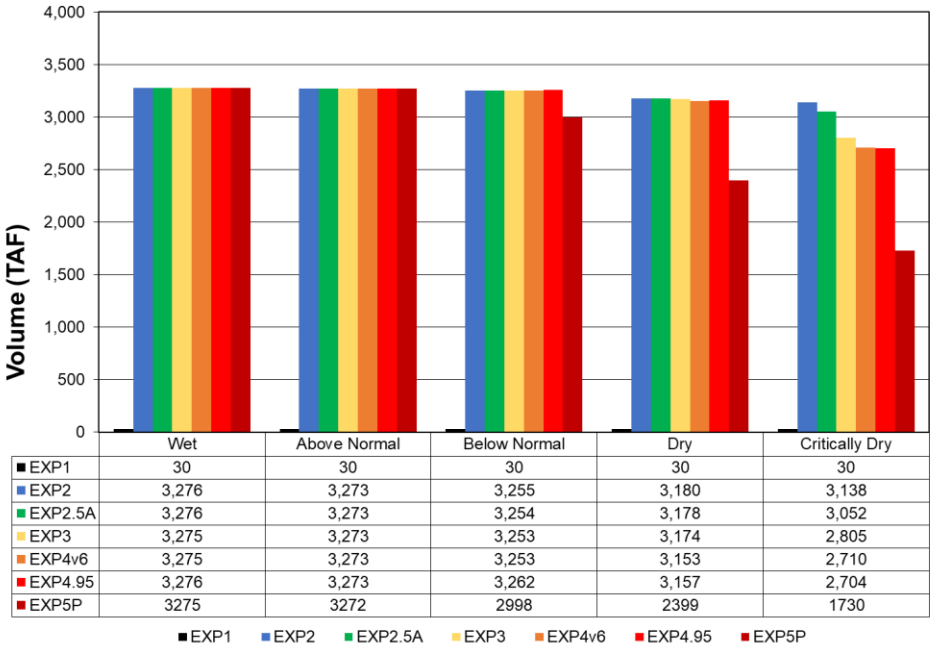


Figure E.2-12. Folsom Storage Monthly Pattern (Dry and Critically Dry Years).

Despite having lower storage levels while not at flood control, the monthly pattern for Folsom storage in dry and critically dry years is like the long-term averages.

E.2.2.3 Feather River:



	Wet	Above Normal	Below Normal	Dry	Critically Dry
EXP1	30	30	30	30	30
EXP2	3,276	3,273	3,255	3,180	3,138
EXP2.5A	3,276	3,273	3,254	3,178	3,052
EXP3	3,275	3,273	3,253	3,174	2,805
EXP4v6	3,275	3,273	3,253	3,153	2,710
EXP4.95	3,276	3,273	3,262	3,157	2,704
EXP5P	3275	3272	2998	2399	1730

Figure E.2-13. End of April Oroville Storage by Water Year Type.

End of April Oroville storage shows little to no difference in wet and AN years, significant lower storage in EXP5 for BN and dry years, and substantial and progressively lower storage across the suite of models in critically dry years.

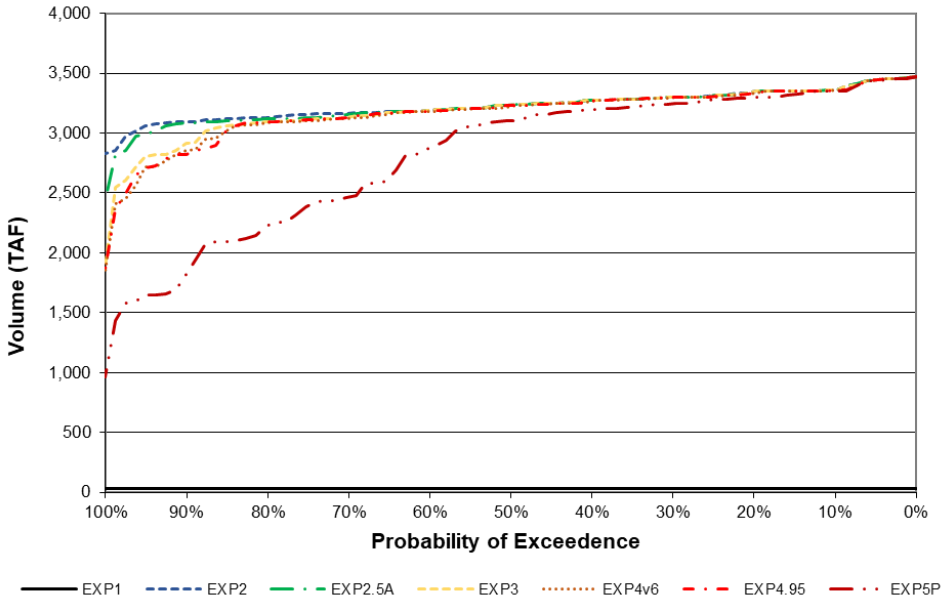
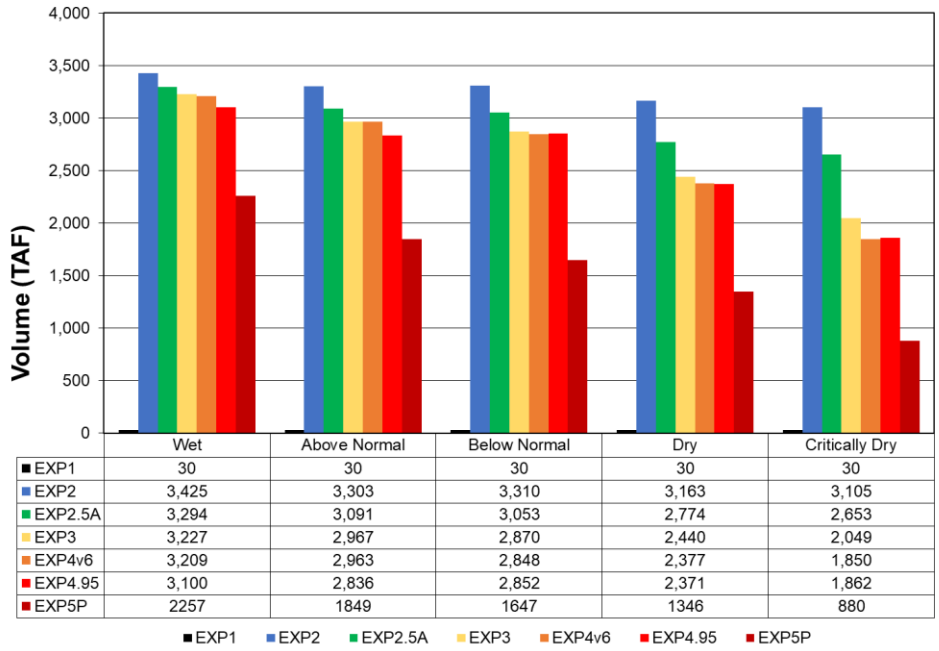


Figure E.2-14. End of April Exceedance for Oroville Storage.

The most significant change in end of April Oroville storage between the models is due to introduction of storage releases for discretionary purposes in EXP5. There are some additional differences in the models in the 15% of driest years.



	Wet	Above Normal	Below Normal	Dry	Critically Dry
EXP1	30	30	30	30	30
EXP2	3,425	3,303	3,310	3,163	3,105
EXP2.5A	3,294	3,091	3,053	2,774	2,653
EXP3	3,227	2,967	2,870	2,440	2,049
EXP4v6	3,209	2,963	2,848	2,377	1,850
EXP4.95	3,100	2,836	2,852	2,371	1,862
EXP5P	2257	1849	1647	1346	880

Figure E.2-15. End of September Oroville Storage by Water Year Type.

The differences of end of September Oroville storage show the effects of increased use of storage across the exploratory modeling suite.

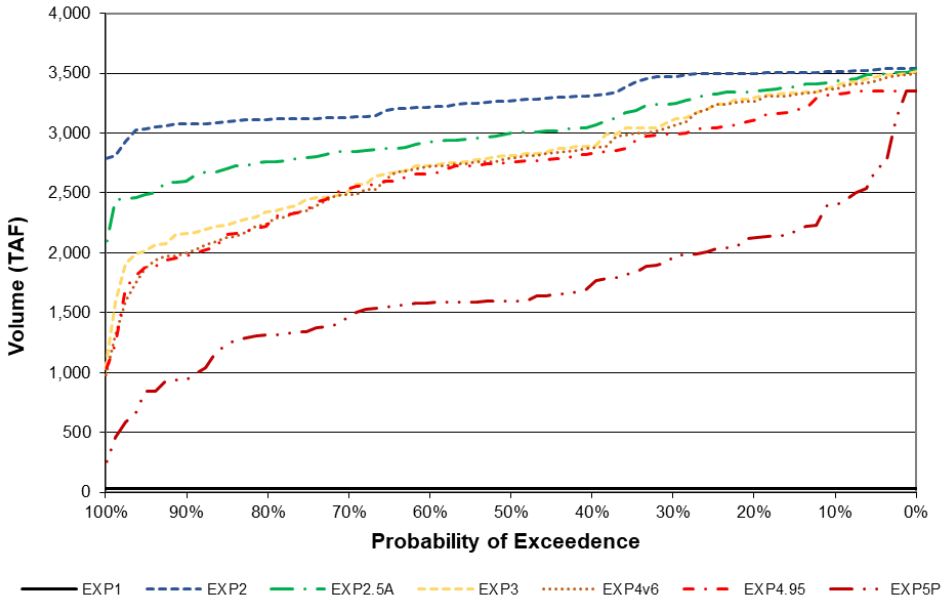


Figure E.2-16. End of September Exceedance for Oroville Storage.

The most pronounced and consistent difference in storage occurs between EXP4v6 and EXP5, which correlates with the introduction of stored water releases to meet discretionary purposes. Also, the drier the year, the larger the effect from the introduction of stored water releases for senior water rights introduced in EXP3.

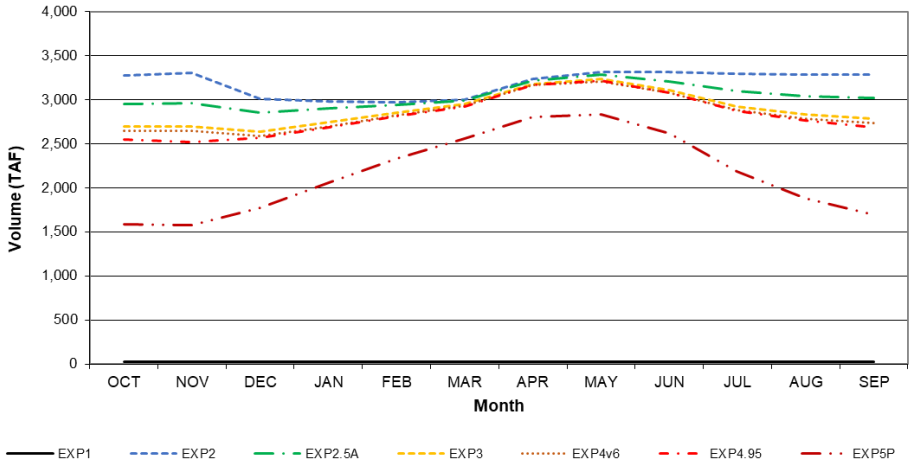


Figure E.2-17. Oroville Storage Monthly Pattern (Long-Term Average).

The monthly pattern of Oroville storage shows the gain in storage during the fill season and progressively larger use of storage across the exploratory modeling suite in the management season.

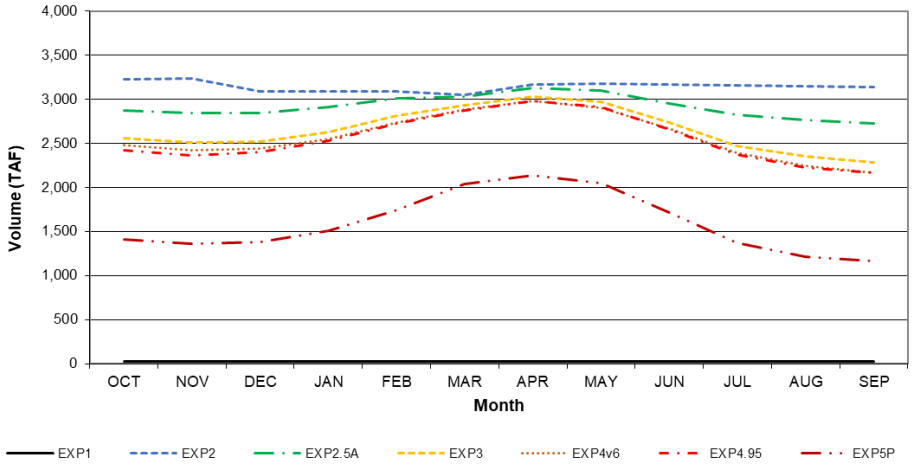


Figure E.2-18. Oroville Storage Monthly Pattern (Dry and Critically Dry Years).

Despite having lower storage levels, the monthly pattern for Oroville storage in dry and critically dry years is like the long-term averages.

E.2.3 Flow

E.2.3.1 Sacramento River:

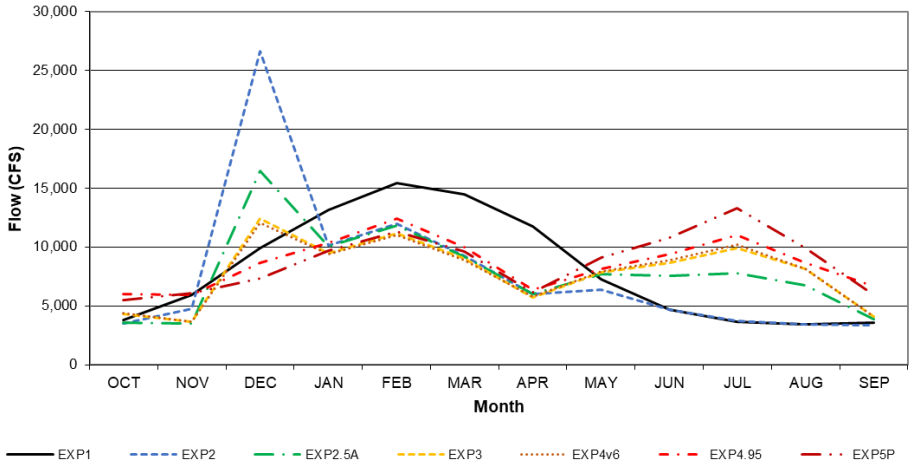


Figure E.2-19. Sacramento River Flow below Keswick Dam (Long-Term Average).

The monthly pattern for flow below Keswick Dam in EXP1 carries the same pattern as Shasta inflow. EXP2A and EXP2.5B have spikes in flow in December due to Shasta flood control releases, and the same, albeit smaller, flood control releases exist in EXP3 and EXP4v6. With increased operational capabilities in EXP3 and higher, there is greater flow in the management season due to releases for increased responsibilities.

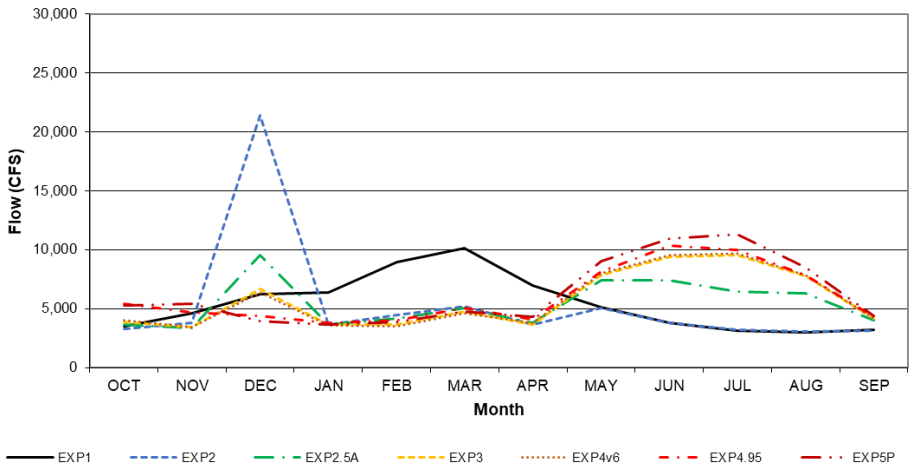


Figure E.2-20. Sacramento River Flow below Keswick Dam (Dry and Critically Dry Years).

Despite having significantly less flow in dry and critically dry years due to less inflow, the patterns for flow below Keswick Dam are the same as those for the long-term averages.

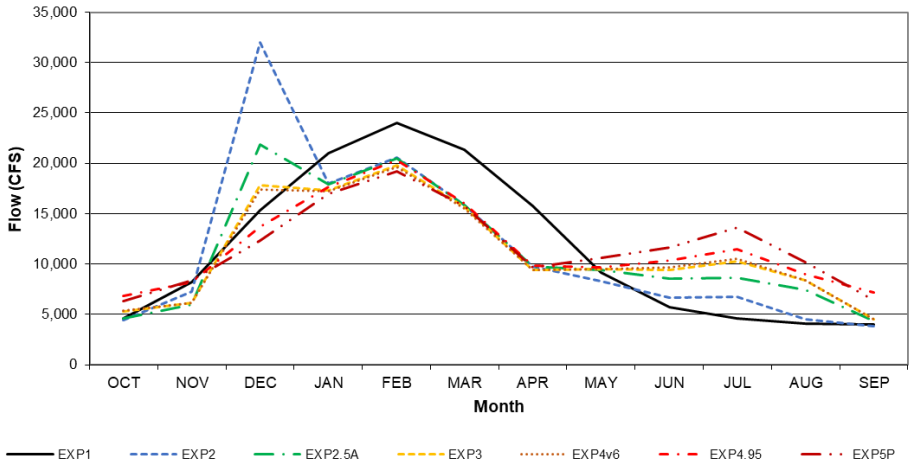


Figure E.2-21. Sacramento River Flow at Bend Bridge (Long-Term Average).

The monthly pattern of flow at Bend Bridge is like the one below Keswick Dam with the addition of local inflows.

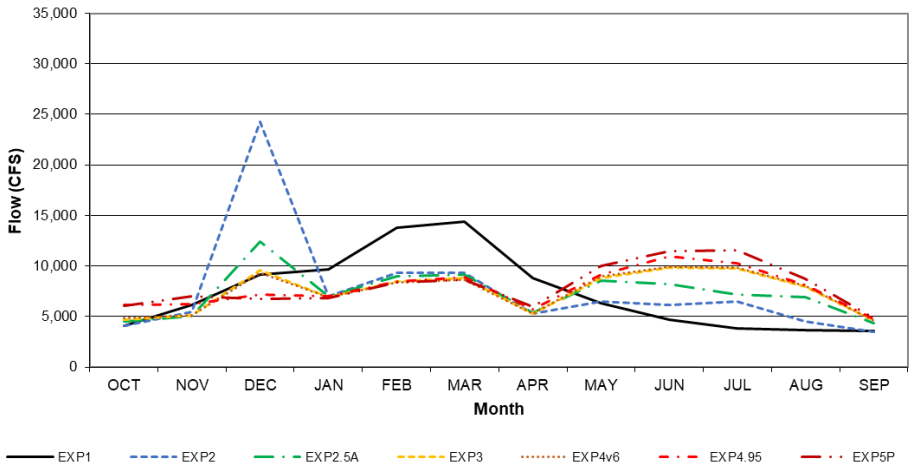


Figure E.2-22. Sacramento River Flow at Bend Bridge (Dry and Critically Dry Years).

Despite having significantly less flow in dry and critically dry years due to less inflow, the patterns for flow at Bend Bridge are the same as those for the long-term averages.

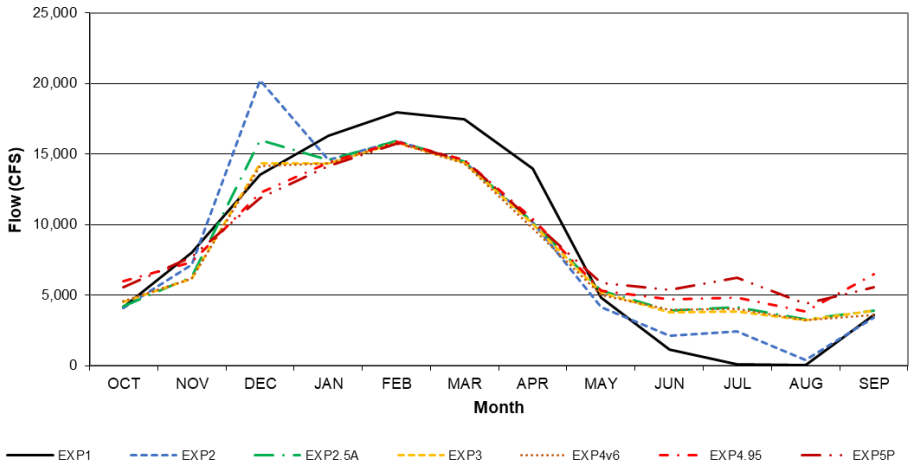


Figure E.2-23. Sacramento River Flow near Wilkins Slough (Long-Term Average).

The signal from Shasta flood control releases is muted by the time it gets to Wilkin's Slough. Flows at Wilkin's Slough sometimes zero out in EXP1 and EXP2, but water is released to meet Wilkin's Slough flow criteria in subsequent models.

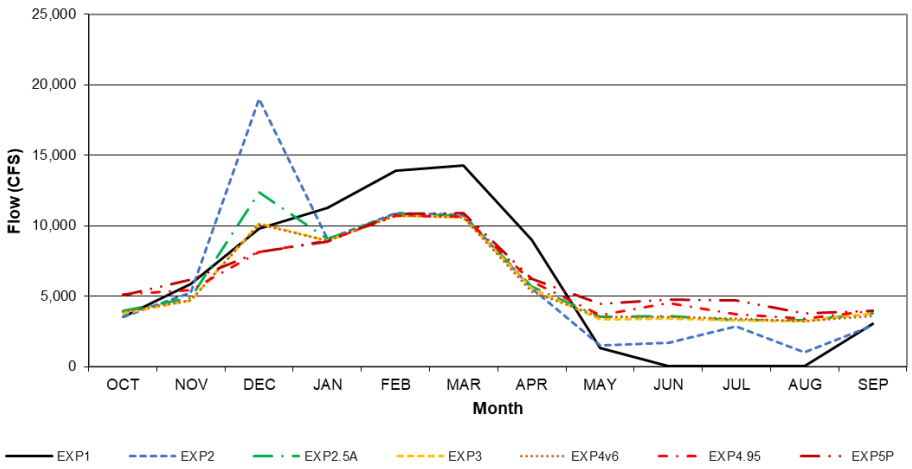


Figure E.2-24. Sacramento River Flow near Wilkins Slough (Dry and Critically Dry Years).

Despite having significantly less flow in dry and critically dry years due to less inflow, the patterns for flow at Wilkin's Slough are the same as those for the long-term averages.

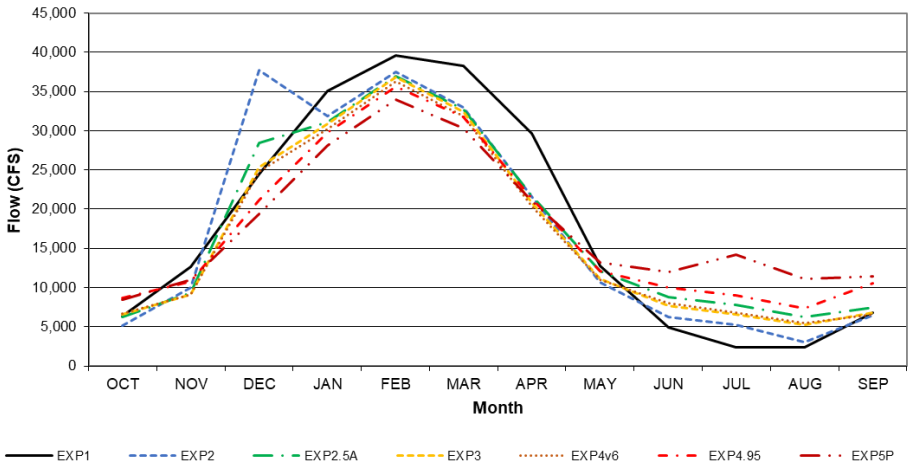


Figure E.2-25. Sacramento River Flow at Verona (Long-Term Average).

Flow at Verona continues to carry the same effects as at Wilkin's Slough, but now it is affected by inflow from the Feather River.

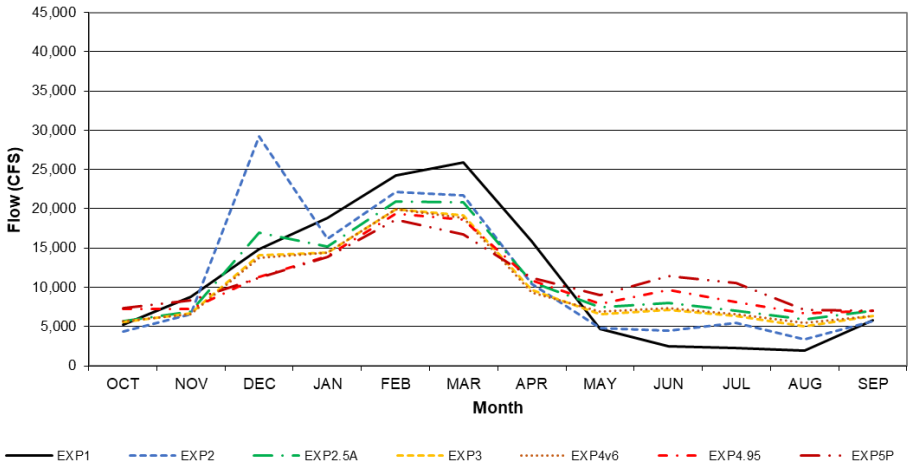


Figure E.2-26. Sacramento River Flow at Verona (Dry and Critically Dry Years).

Despite having significantly less flow in dry and critically dry years due to less inflow, the patterns for flow at Verona are the same as those for the long-term averages.

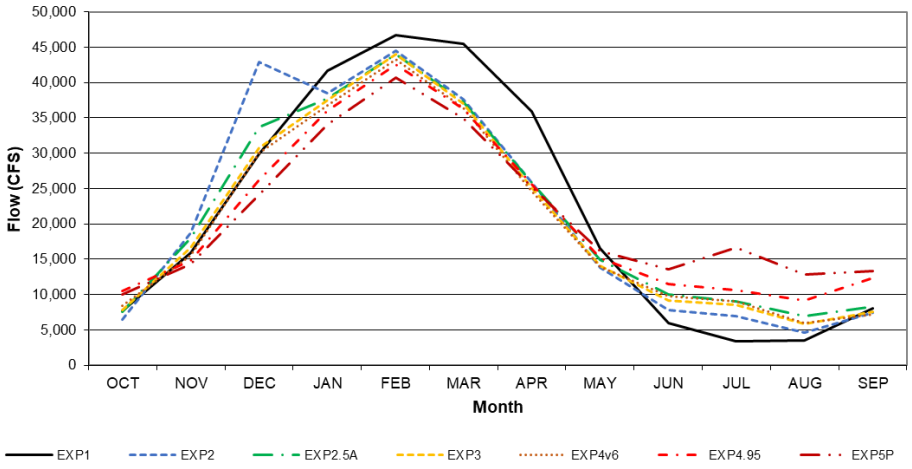


Figure E.2-27. Sacramento River Flow at Hood (Long-Term Average).

Flow at Hood continues to carry the same effects as at Verona, but now, it is affected by inflow from the American River.

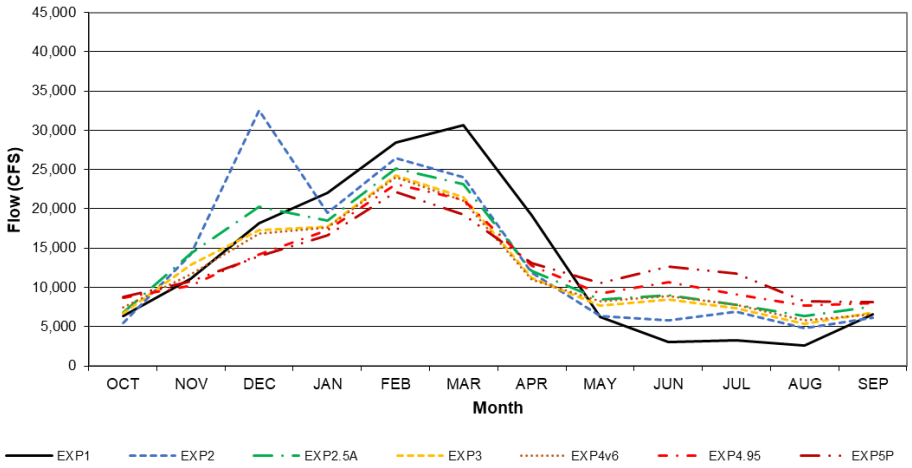


Figure E.2-28. Sacramento River Flow at Hood (Dry and Critically Dry Years).

Despite having significantly less flow in dry and critically dry years due to less inflow, the patterns for flow at Hood are the same as those for the long-term averages.

E.2.3.1.1 Sacramento River FlowTracker Flow Type

Table E.2-1. Summary of Flow Tracker Flow Type below Keswick.

Annual Total[a]	EXP1	EXP2	EXP2.5	EXP3	EXP4v6	EXP5
Shasta Pass-Through Inflow	5,796	4,575	4,596	4,295	4,275	4,133
Shasta Stored Water Releases for Flood Control	0	1,092	442	313	297	100
Shasta Stored Water Release	34	0	630	1,084	1,121	1,472
Trinity Pass-Through Inflow	0	0	0	0	0	250
Trinity Stored Water Releases	0	0	0	0	0	343

[a] In thousand acre-feet.

Shasta pass-through inflow and flood control releases generally decreases in subsequent models while releases of previously stored water increases. Trinity imports are not introduced until EXP5.

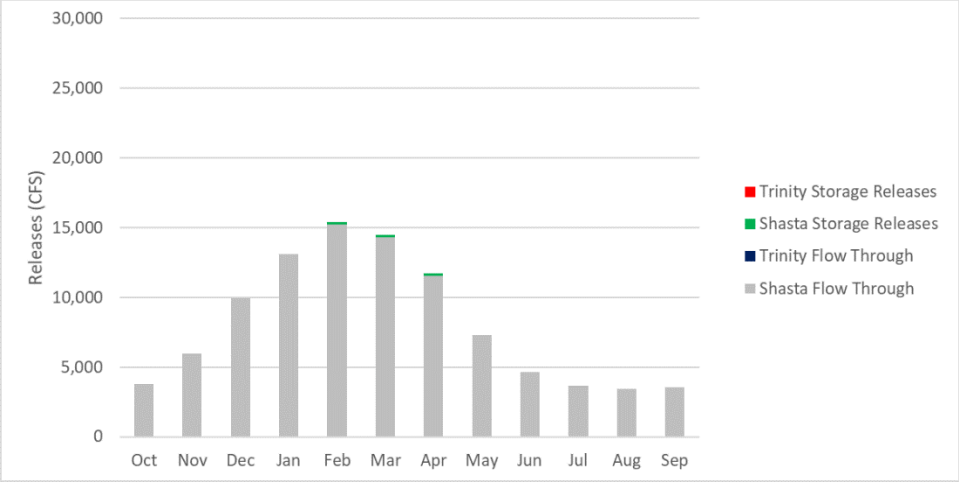


Figure E.2-29. FlowTracker Flow Type Below Keswick for EXP1.

In a handful of occasions, water is backed up into Shasta due to downstream channel capacities and released later as storage releases. Otherwise, the flow through releases mirror Shasta inflow.

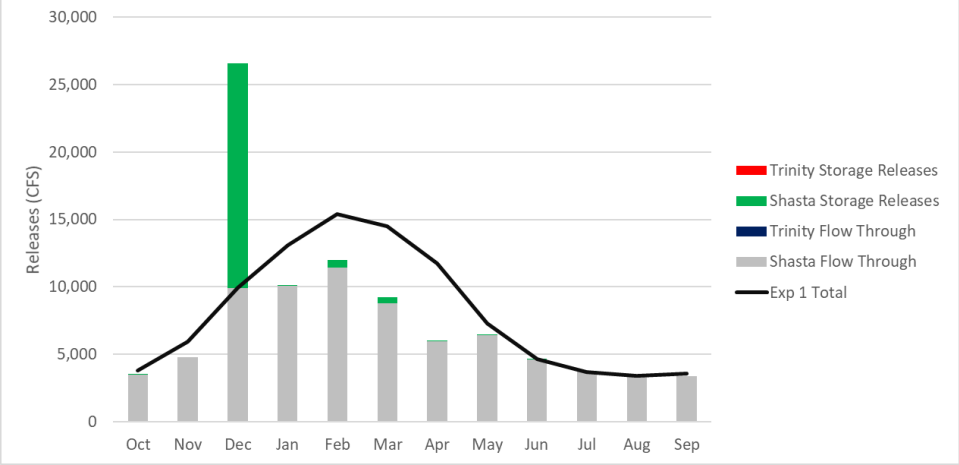


Figure E.2-30. FlowTracker Flow Type Below Keswick for EXP2.

A sharp reduction in the flood control level in December results in a large flood control release. Storage is regained through the fill season, resulting in less releases during the rest of the fill season.

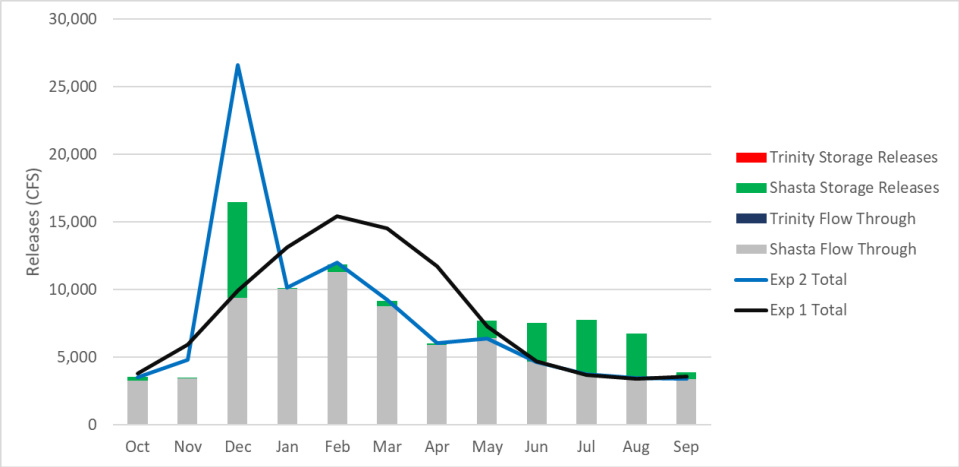


Figure E.2-31. FlowTracker Flow Type Below Keswick for EXP2.5.

In EXP2.5, additional storage releases are made in the fill season to meet D-1641 requirements.

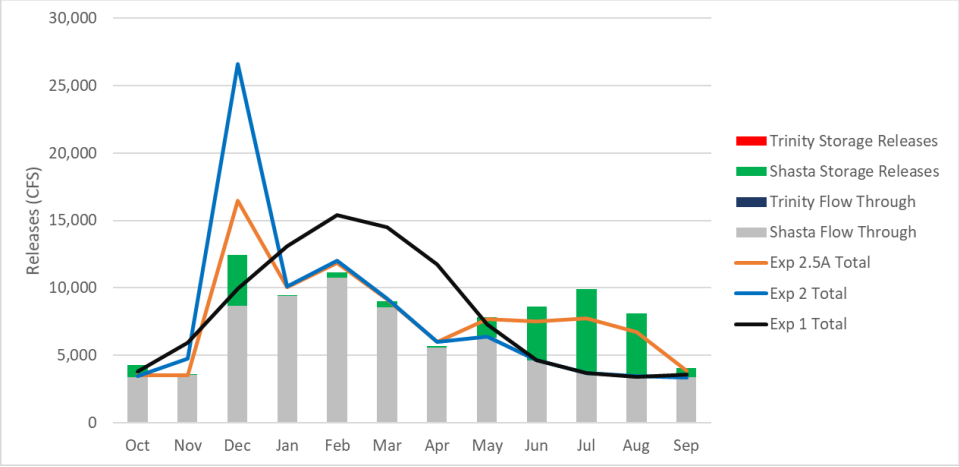


Figure E.2-32. FlowTracker Flow Type Below Keswick for EXP3.

In EXP3, storage releases in the management season increase flows and deplete storage, which greatly reduces flood control releases in December.

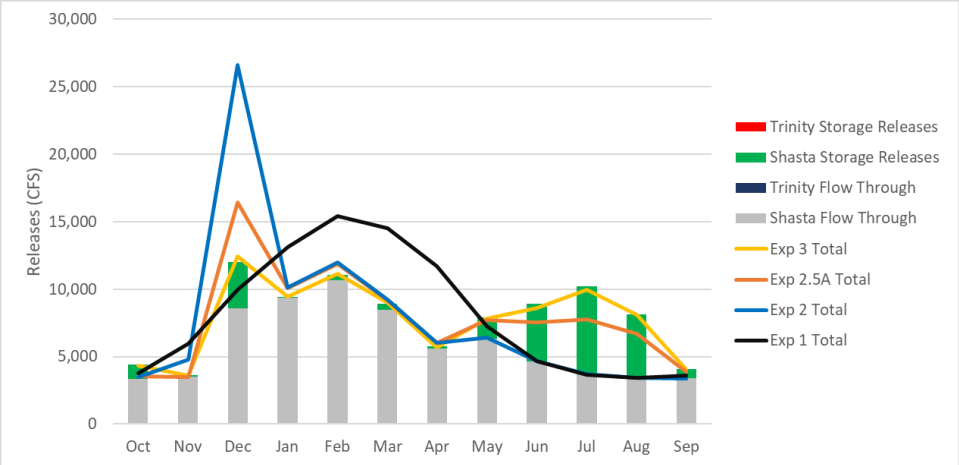


Figure E.2-33. FlowTracker Flow Type Below Keswick for EXP4v6.

In EXP4v6, there are only slight increases in flow because of storage releases for Delta water quality requirements, which are increased due to exports of excess water.

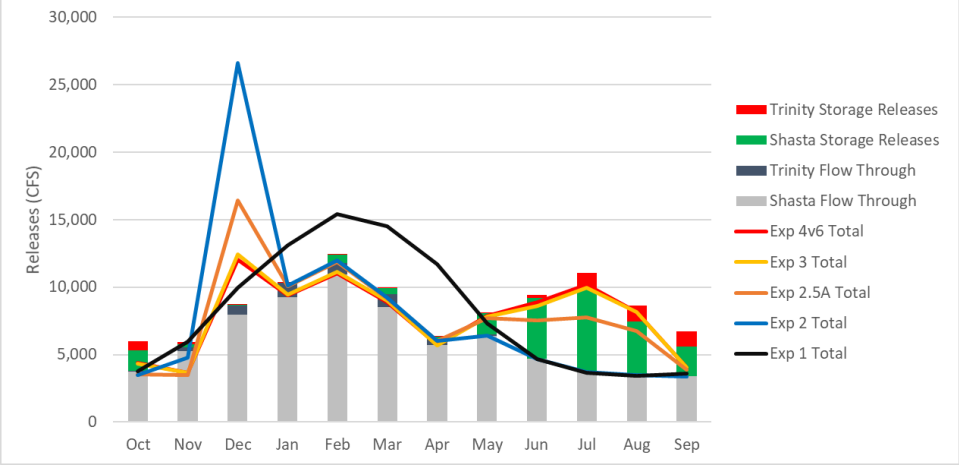


Figure E.2-34. FlowTracker Flow Type Below Keswick for EXP4.95.

EXP4.95 introduces supplemental flows from the Trinity basin to supplement releases from Shasta.

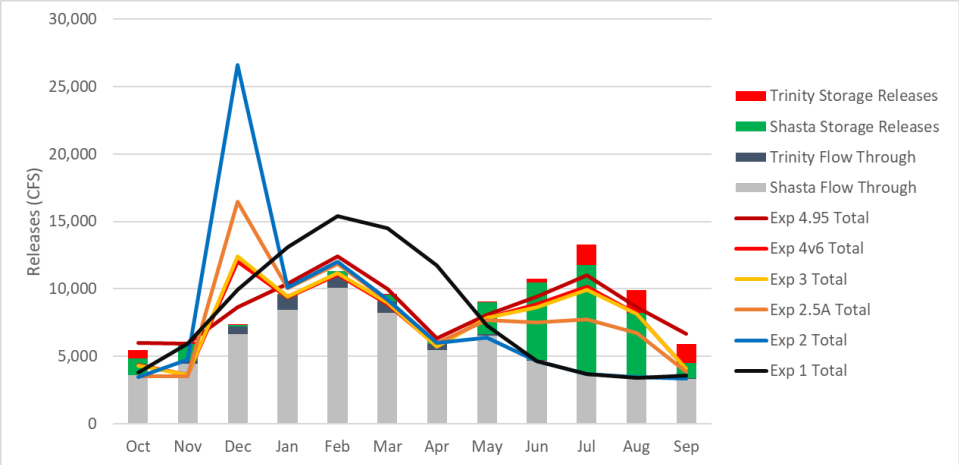


Figure E.2-35. FlowTracker Flow Type Below Keswick for EXP5.

Increased flows during the management season in EXP5 are due to storage releases for discretionary purposes.

E.2.3.1.2 American River:

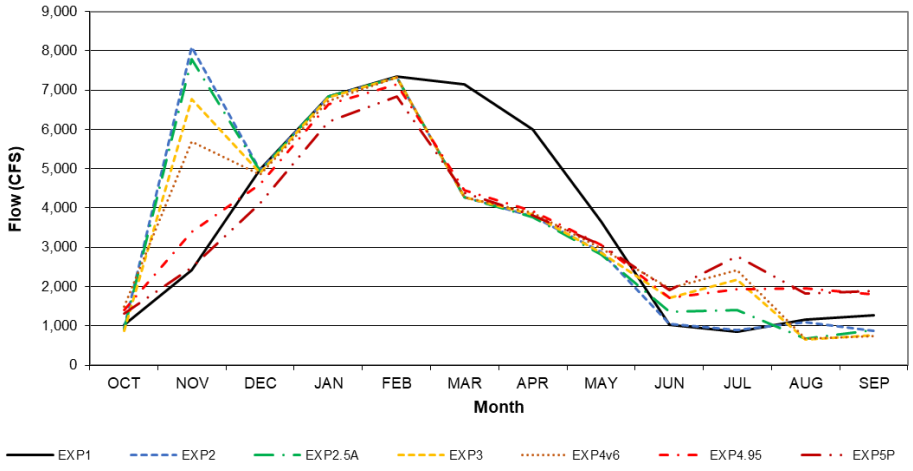


Figure E.2-36. American River Flow below Nimbus Dam (Long-Term Average).

The monthly pattern for flow below Nimbus Dam in EXP1 carries the same pattern as Folsom inflow. EXP2A, EXP2.5B, EXP3, and EXP4v6 have spikes in flow in November due to Folsom flood control releases. With increased operational capabilities in EXP3 and higher, there is greater flow in the management season due to releases for increased responsibilities, which results in lower flood control releases in November.

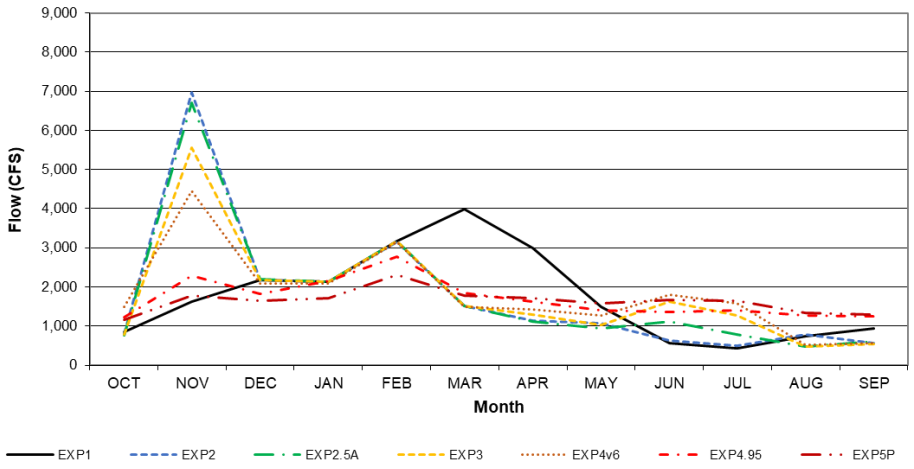


Figure E.2-37. American River Flow below Nimbus Dam (Dry and Critically Dry Years).

Despite having significantly less flow in dry and critically dry years due to less inflow, the patterns for flow below Nimbus Dam are the same as those for the long-term averages.

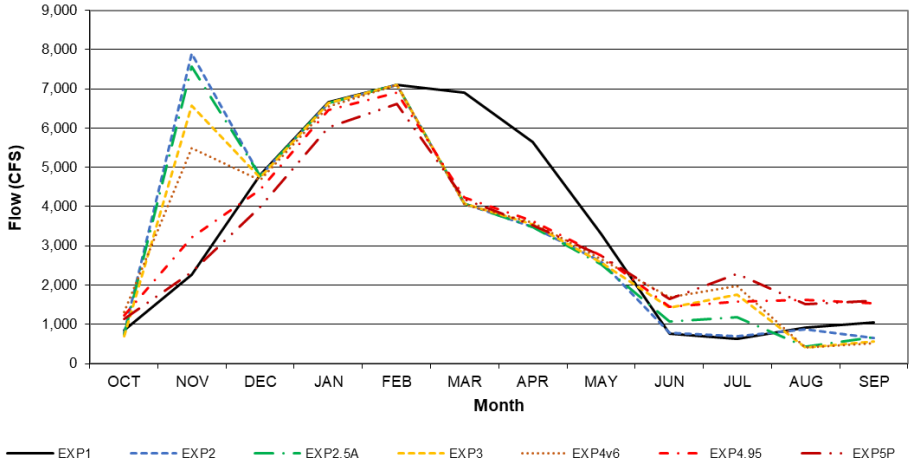


Figure E.2-38. American River Flow at H Street (Long-Term Average).

The same monthly flow patterns exist at H Street as below Nimbus Dam.

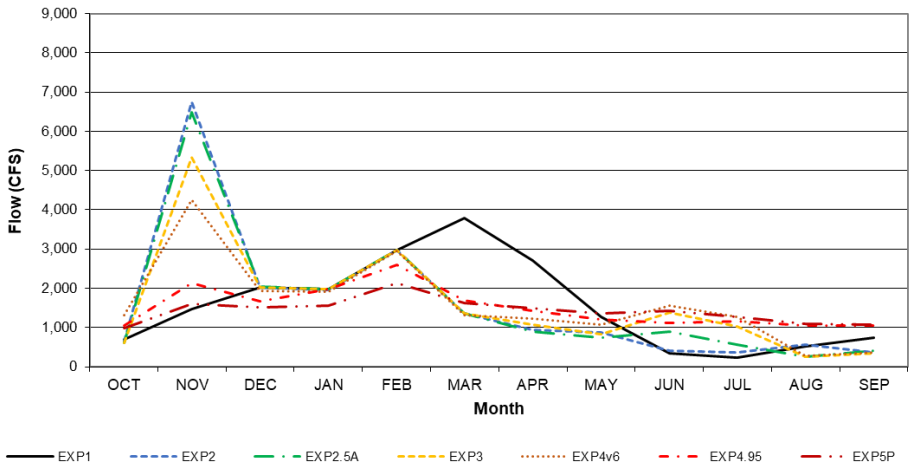


Figure E.2-39. American River Flow at H Street (Dry and Critically Dry Years).

Despite having significantly less flow in dry and critically dry years due to less inflow, the patterns for flow at H Street are the same as those for the long-term averages.

E.2.3.1.3 American River FlowTracker Flow Type:

Table E.2-2. Summary of Flow Tracker Flow Type below Folsom.

Annual Total[a]	EXP1	EXP2	EXP2.5	EXP3	EXP4v6	EXP5
Folsom Pass-Through Inflow	2,618	2,229	2,219	2,175	2,169	2,066
Folsom Stored Water Releases for Flood Control	0	340	329	264	196	196
Folsom Stored Water Release	0	0	22	132	207	222

[a] In thousands of acre-feet.

Folsom pass-through and flood control releases decrease in each subsequent model in the exploratory modeling suite while releases of previously stored water increases. This is due to increased use of storage in the management season to satisfy increased responsibilities.

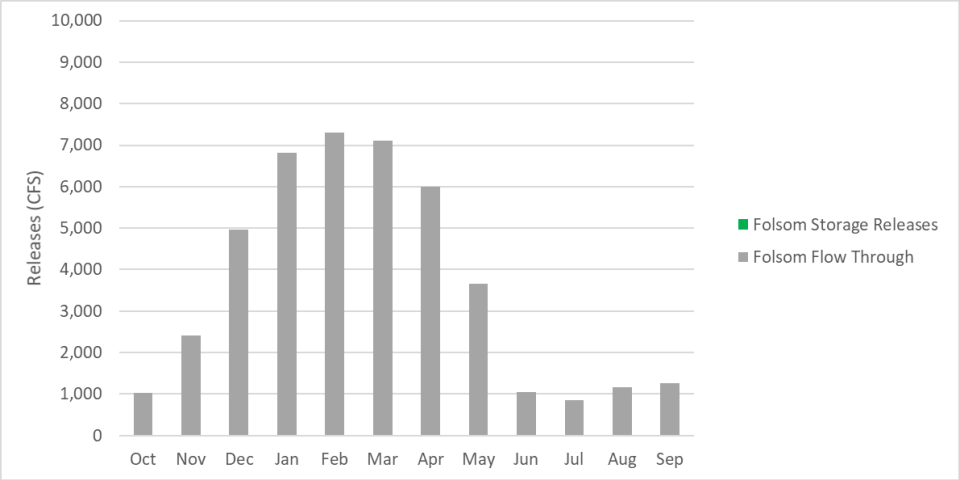


Figure E.2-40. FlowTracker Flow Type Below Nimbus for EXP1.

Flows below Nimbus Dam in EXP1 reflect inflows into Folsom.

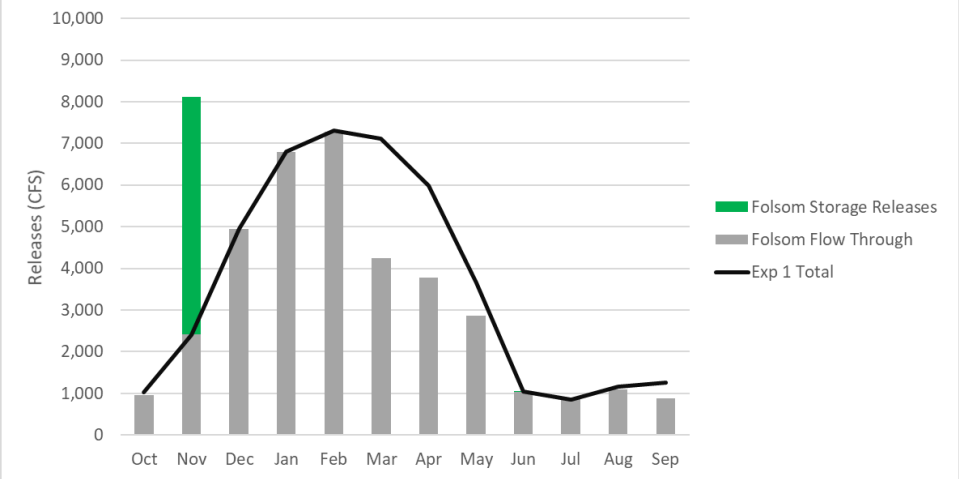


Figure E.2-41. FlowTracker Flow Type Below Nimbus for EXP2.

A sharp reduction in the flood control level in November results in a large flood control release. Storage is regained through the fill season, resulting in less releases during the rest of the fill season.

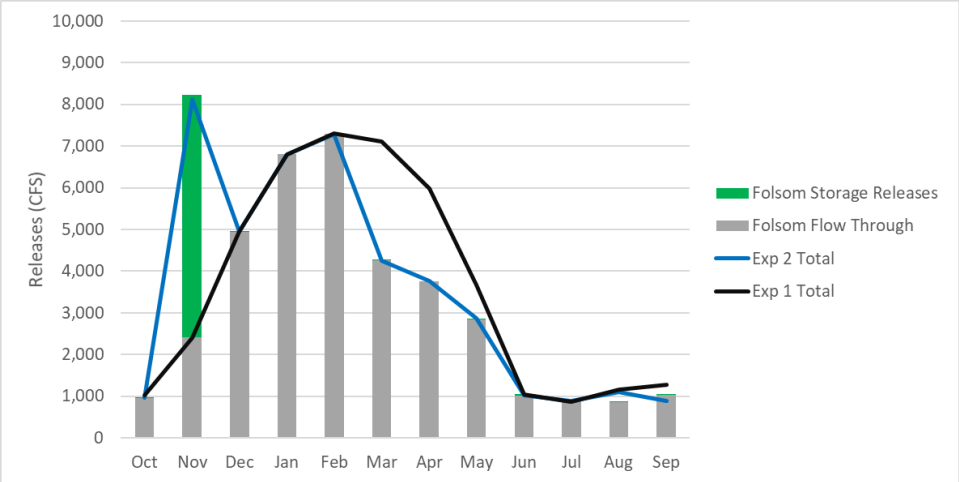


Figure E.2-42. FlowTracker Flow Type Below Nimbus for EXP2.5.

Flow below Nimbus Dam in EXP2.5 has little difference from EXP2.

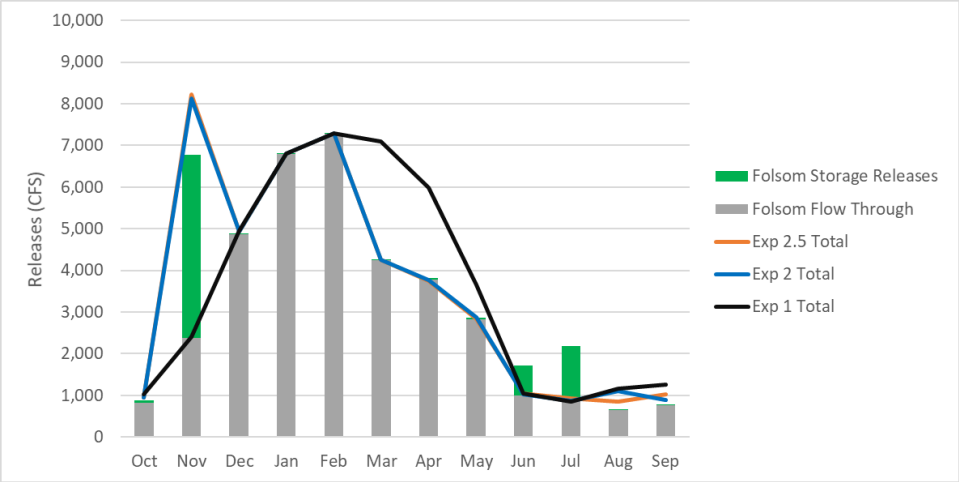


Figure E.2-43. FlowTracker Flow Type Below Nimbus for EXP3.

In EXP3, storage releases in the management season increase flows and deplete storage, which reduces flood control releases in December.

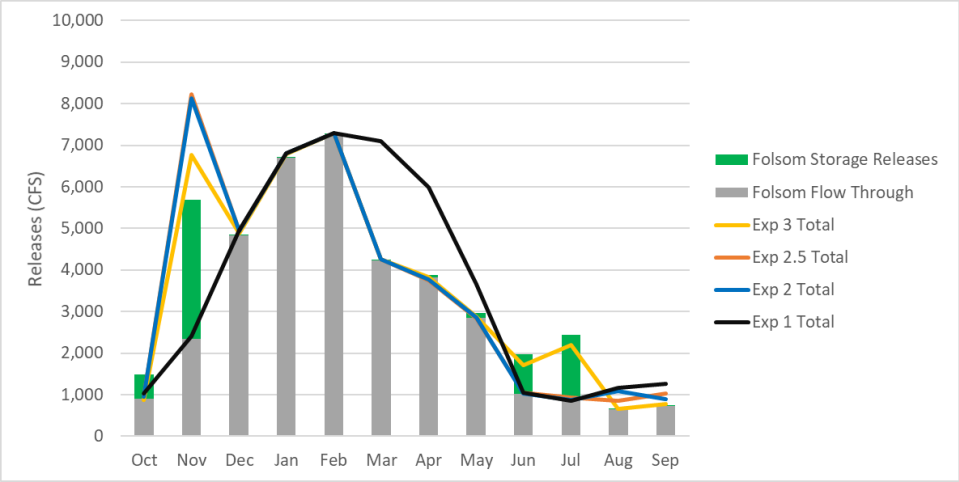


Figure E.2-44. FlowTracker Flow Type Below Nimbus for EXP4v6.

In EXP4v6, there are increases in flow because of storage releases for Delta water quality requirements, which are increased due to exports of excess water.

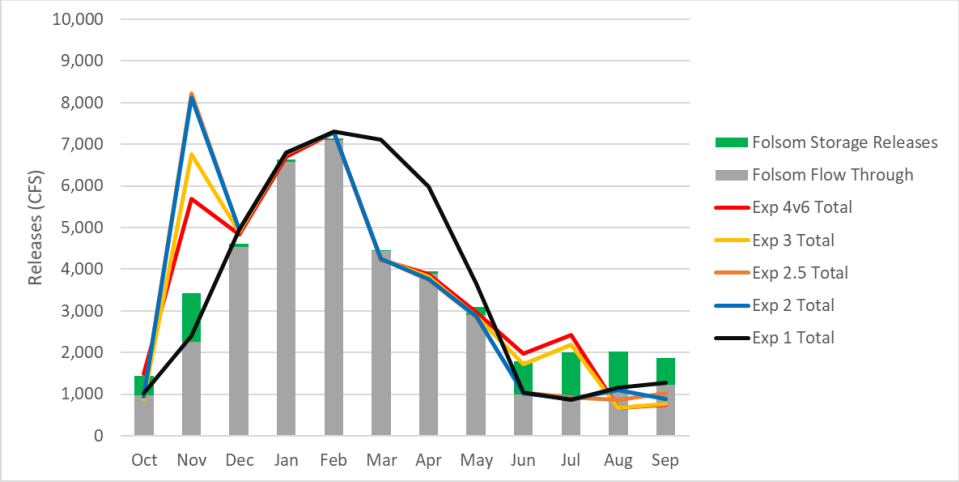


Figure E.2-45. FlowTracker Flow Type Below Nimbus for EXP4.95.

In EXP4.95, Fall X2 requirements cause more releases from Folsom in August than in September.

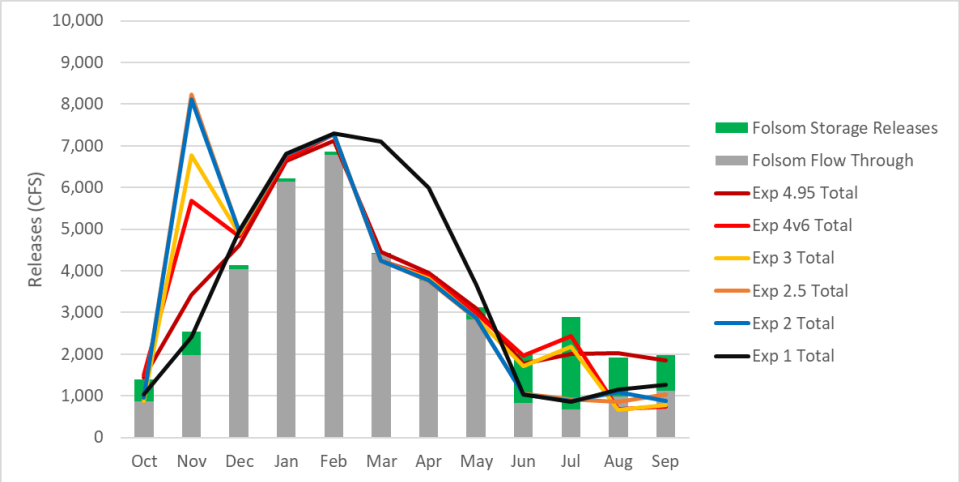


Figure E.2-46. FlowTracker Flow Type Below Nimbus for EXP5.

In EXP5, storage releases for discretionary purposes increases flows in July.

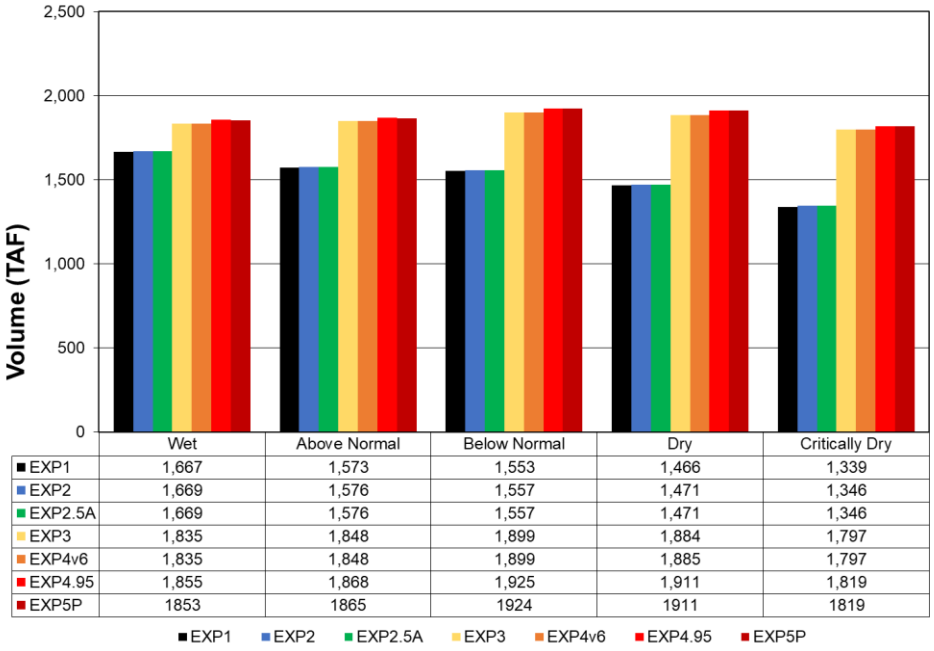
E.2.4 North of Delta CVP Deliveries

Table E.2-3. Total (Mar–Feb) NOD CVP Deliveries[a]

Runs	PMI	PAG	PSC	PRF
EXP1	0	0	1,542	0
EXP2	0	0	1,546	0
EXP2.5	0	0	905	0
EXP3	0	0	1,855	65
EXP4v6	71	71	1,855	65
EXP5	188	194	1,876	84

[a] In thousands of acre-feet.
PMI = Project Municipal and Industrial; PAG = Project Agricultural; PSC = Project Settlement Contractors; PRF = Project Refuge.

There are no CVP service deliveries until EXP4v6, which only uses excess water to make those deliveries. In EXP5, storage releases are made to satisfy those demands. Settlement Contract deliveries are made from pass-through inflow in EXP1, EXP2, and EXP2.5, but in EXP2.5, pass-through inflow is used to meet D-1641 requirements before being delivered to Settlement Contract demands. Storage releases are made for Settlement Contract demands in EXP3, EXP4v6, and EXP5. Level 2 refuge demands are introduced in EXP3.



	Wet	Above Normal	Below Normal	Dry	Critically Dry
EXP1	1,667	1,573	1,553	1,466	1,339
EXP2	1,669	1,576	1,557	1,471	1,346
EXP2.5A	1,669	1,576	1,557	1,471	1,346
EXP3	1,835	1,848	1,899	1,884	1,797
EXP4v6	1,835	1,848	1,899	1,885	1,797
EXP4.95	1,855	1,868	1,925	1,911	1,819
EXP5P	1853	1865	1924	1911	1819

Figure E.2-47. CVP NOD Deliveries to Settlement Contractors by Water Year Type.

For EXP1, EXP2, and EXP2.5, Settlement Contractors are delivered from pass-through inflow, so there is less water available in drier years. In EXP3, EXP4v6, and EXP5, storage releases are made to meet Settlement Contract demands, and so the deliveries are the same unless shortages occur.

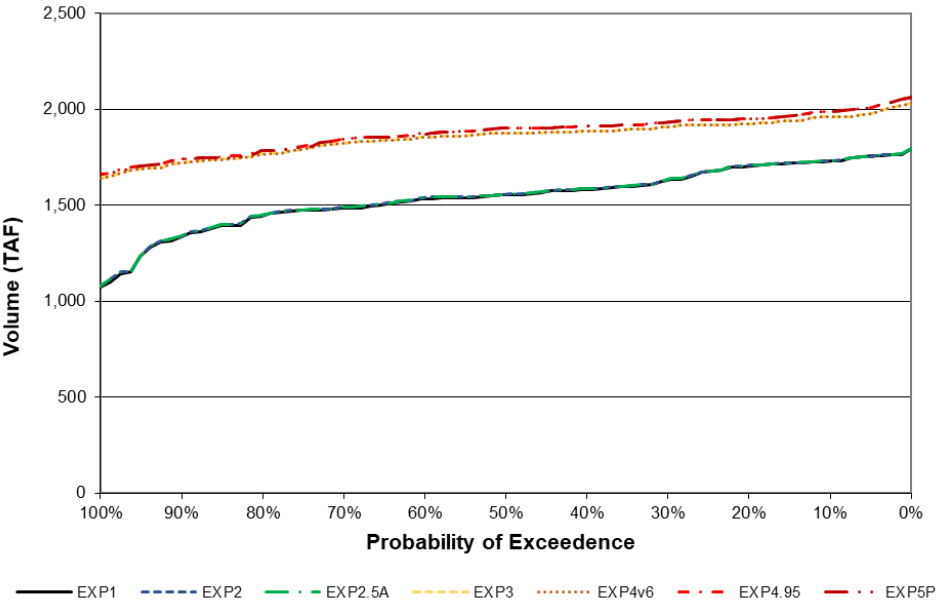


Figure E.2-48. Exceedance of CVP NOD Settlement Contractors Delivery.

Deliveries decrease in drier years due to shortages.

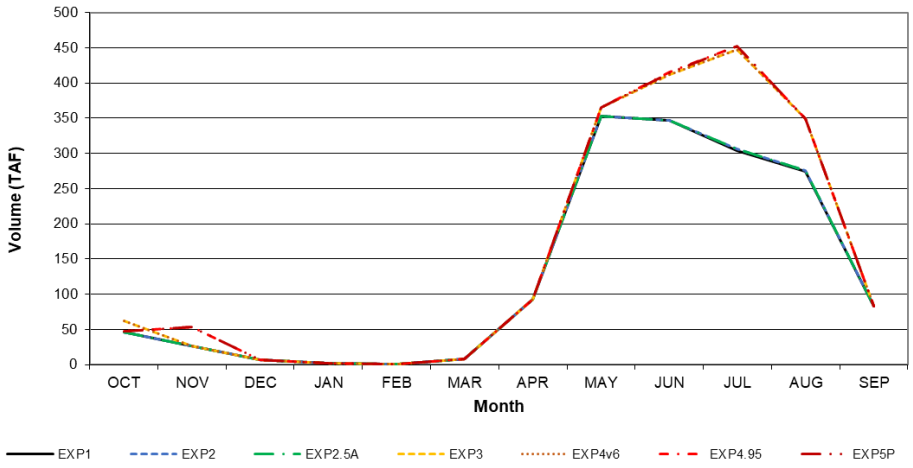
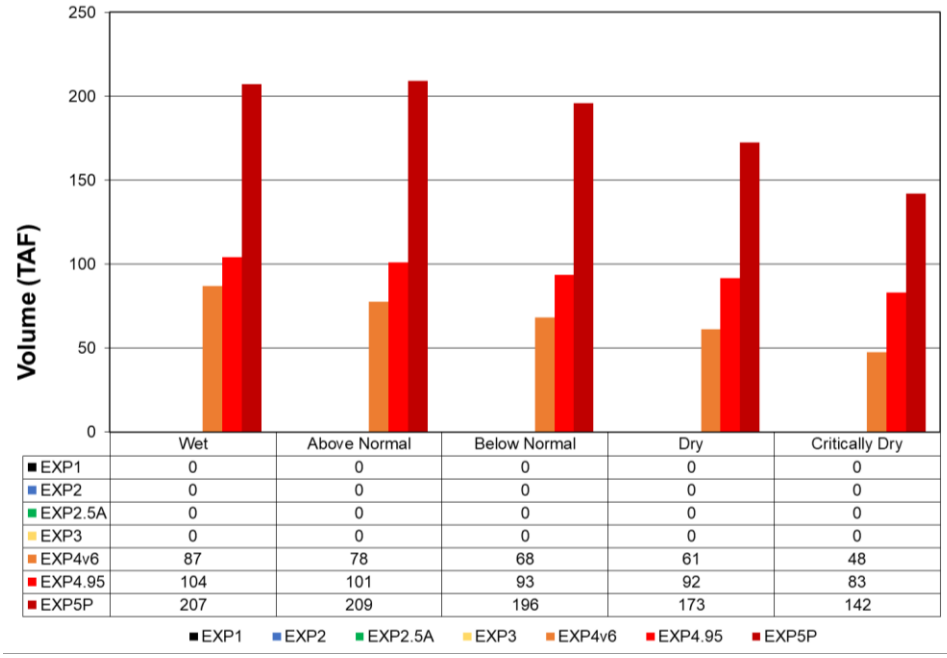


Figure E.2-49. CVP NOD Settlement Contractors Delivery Monthly Pattern.

Storage releases to meet Settlement Contract demands in EXP3, EXP4v6, and EXP5 increase deliveries from May through September.



	Wet	Above Normal	Below Normal	Dry	Critically Dry
EXP1	0	0	0	0	0
EXP2	0	0	0	0	0
EXP2.5A	0	0	0	0	0
EXP3	0	0	0	0	0
EXP4v6	87	78	68	61	48
EXP4.95	104	101	93	92	83
EXP5P	207	209	196	173	142

Figure E.2-50. CVP NOD Deliveries to M&I Contractors by Water Year Type.

There are no CVP M&I deliveries before EXP4v6, which makes deliveries from excess water. Storage releases to meet those demands increase deliveries in EXP5. Allocations decrease in drier years, decreasing deliveries, but there are always at least Health and Safety deliveries made.

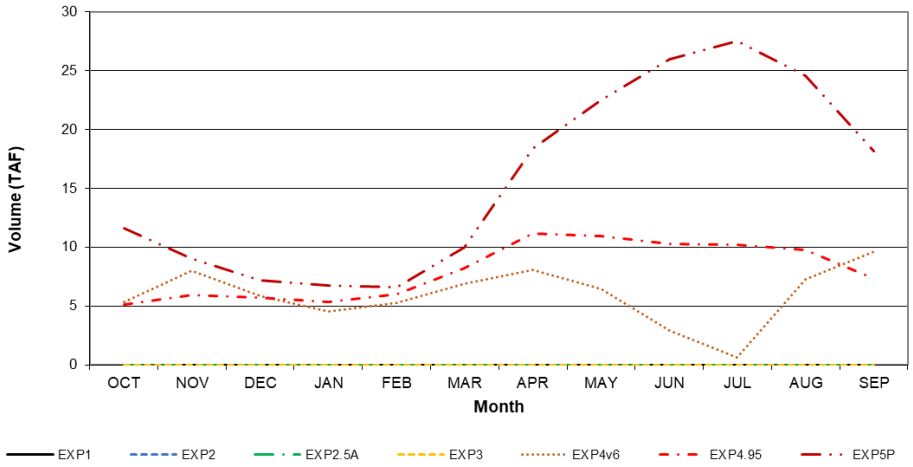
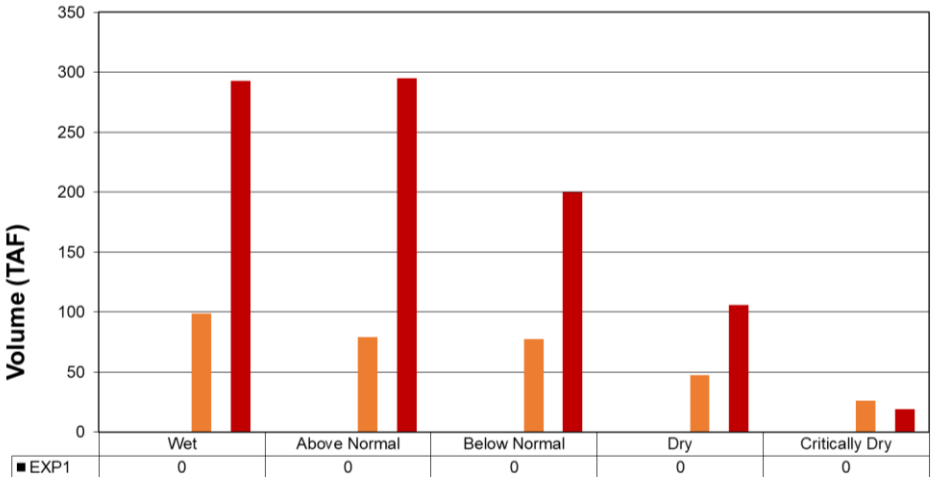


Figure E.2-51. CVP NOD M&I Contractors Delivery Monthly Pattern.

CVP M&I deliveries above and beyond Health and Safety in EXP4v6 and EXP4.95 are made as hydrologically available, so there is less water available in the summer months. Storage releases to meet those demands increase deliveries in the summer months when the demands are higher.



	Wet	Above Normal	Below Normal	Dry	Critically Dry
EXP1	0	0	0	0	0
EXP2	0	0	0	0	0
EXP2.5A	0	0	0	0	0
EXP3	0	0	0	0	0
EXP4v6	99	79	78	47	26
EXP4.95	0	0	0	0	0
EXP5P	293	295	200	106	19

Figure E.2-52. CVP NOD Deliveries to Ag Contractors by Water Year Type.

EXP4.95 does not make CVP NOD Ag deliveries while EXP4v6 uses excess water for those deliveries as available. EXP5P makes storage releases to meet those demands.

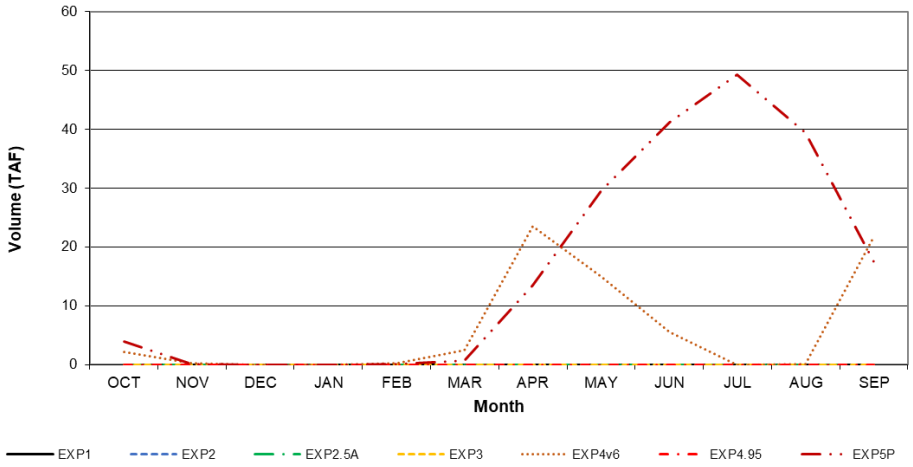


Figure E.2-53. CVP NOD Ag Contractors Delivery Monthly Pattern.

CVP NOD Ag deliveries resemble the same monthly patterns that are in CVP NOD M&I deliveries except that EXP4.95 does not make CVP NOD Ag deliveries.

E.2.5 Delta

Table E.2-4. Average Delta Flow (Oct–Sep)[a]

Runs	Sacramento River Flow at Freeport	Yolo Bypass Flow	San Joaquin River Flow at Vernalis	Old and Middle River Combined Flow	Delta Outflow
EXP1	15,683	3,615	4,088	1,784	23,321
EXP2	15,089	3,780	3,979	1,715	22,790
EXP2.5	16,014	3,698	4,137	1,788	23,790
EXP3	14,698	3,371	3,598	1,530	21,599
EXP4v6	14,509	3,317	3,140	-1,963	17,242
EXP5	15,415	3,033	3,216	-2,956	16,829

[a] In thousands of acre-feet

E.2.5.1 Inflow:

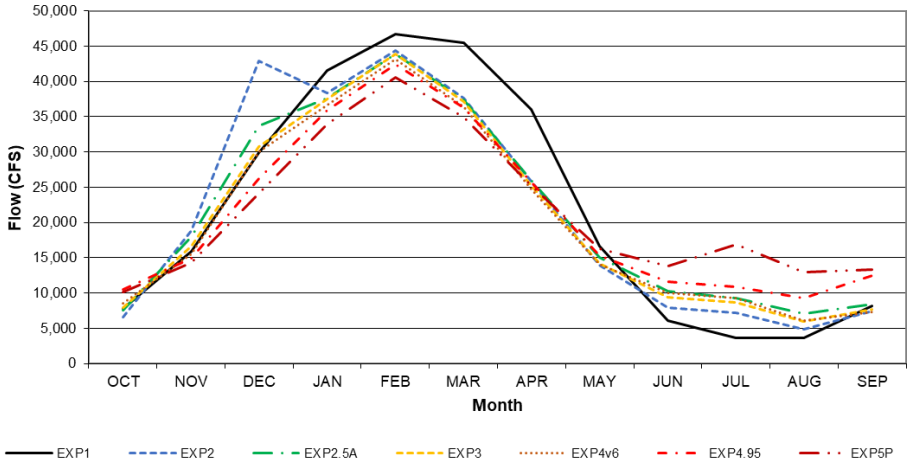


Figure E.2-54. Delta Inflow at Freeport Monthly Pattern (Long-Term Average).

Sacramento River flows at Freeport carry the same patterns as described at Hood.

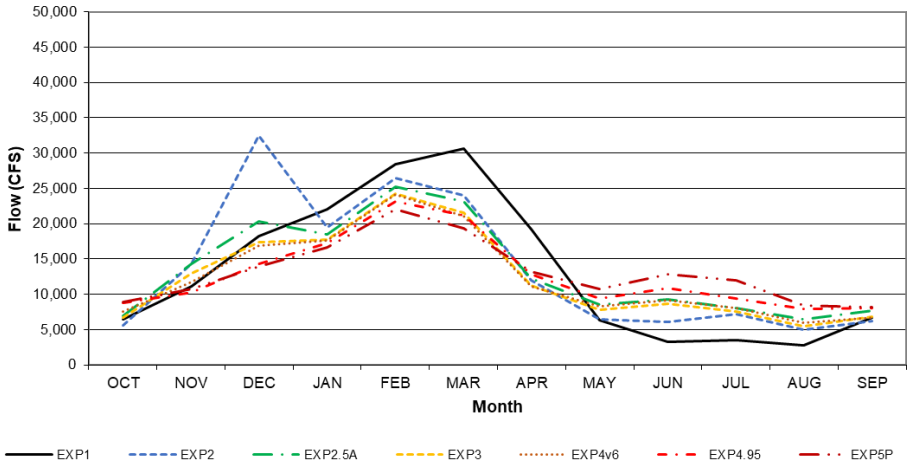


Figure E.2-55. Delta Inflow at Freeport Monthly Pattern (Dry and Critically Dry Years).

Despite having significantly less flow in dry and critically dry years due to less inflow, the patterns for flow at Freeport are the same as those for the long-term averages.

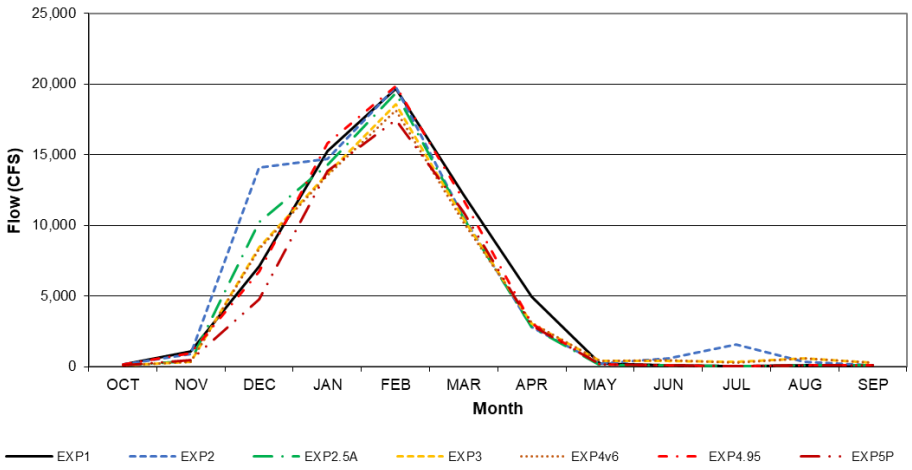


Figure E.2-56. Delta Inflow – Yolo Bypass Monthly Pattern (Long-Term Average).

Yolo Bypass flows reflect the layers of Shasta and Oroville operations, including spills and storage releases.

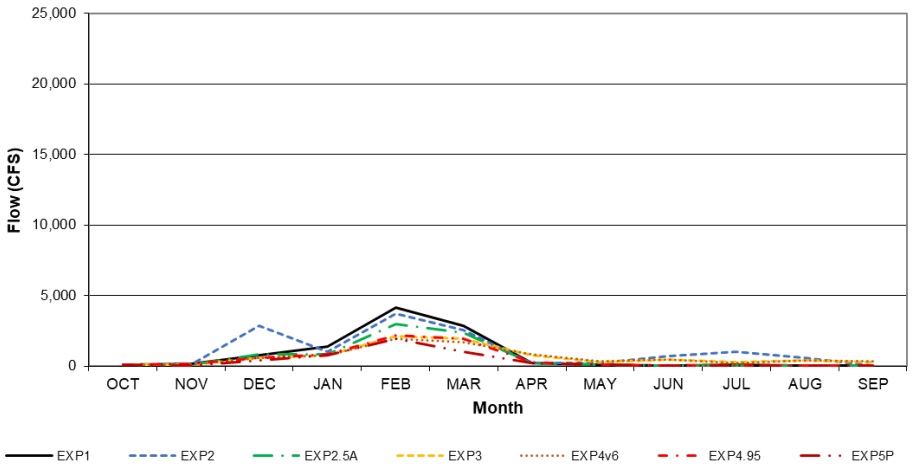


Figure E.2-57. Delta Inflow – Yolo Bypass Monthly Pattern (Dry and Critically Dry Years).

Despite having significantly less flow in dry and critically dry years due to less inflow, the patterns for Yolo Bypass flow are the same as those for the long-term averages.

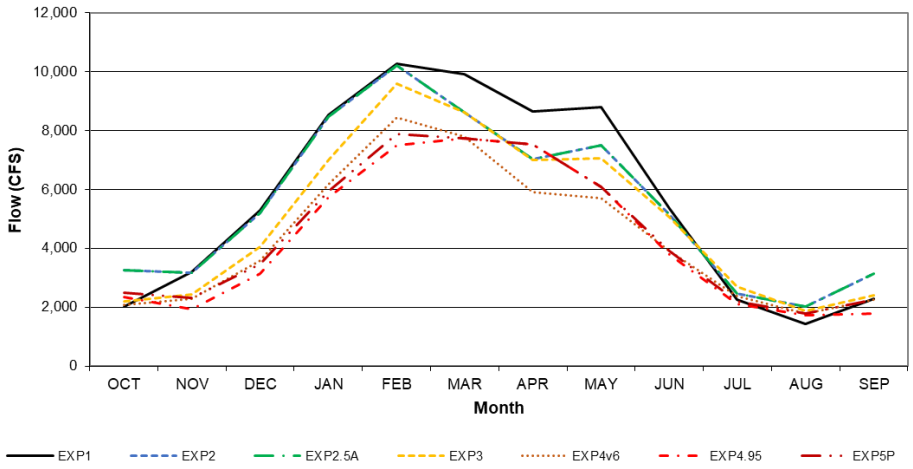


Figure E.2-58. Delta Inflow at Vernalis Monthly Pattern (Long-Term Average).

Flow at Vernalis in EXP1 reflects the hydrology and non-project operations upstream of inflows into the San Joaquin River. In EXP2 and EXP2.5, pass-through inflow is released for non-discretionary purposes. Vernalis flows decrease in EXP3 due to the use of Friant storage releases for delivery at Mendota Pool and Sack Dam, and flow is further reduced in EXP4v6 and EXP5 due to deliveries to the Friant Unit.

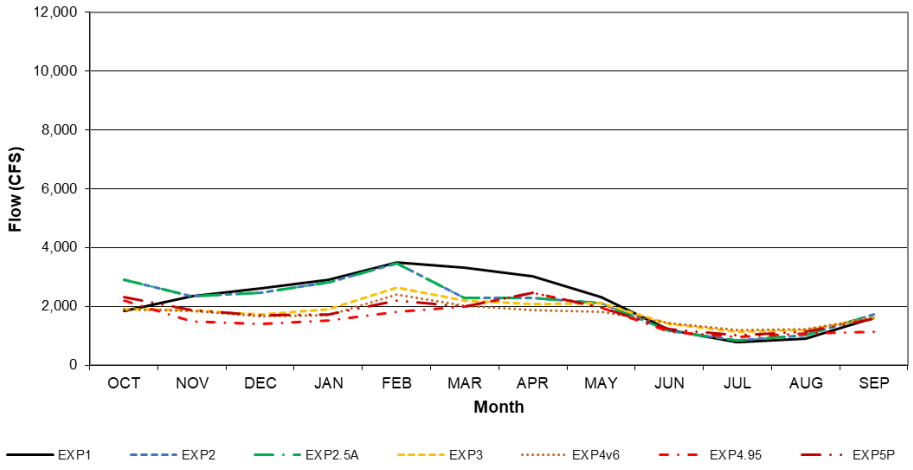


Figure E.2-59. Delta Inflow at Vernalis Monthly Pattern (Dry and Critically Dry Years).

Despite having significantly less flow in dry and critically dry years due to less inflow, the patterns for flow at Vernalis are the same as those for the long-term averages.

E.2.5.2 Flows:

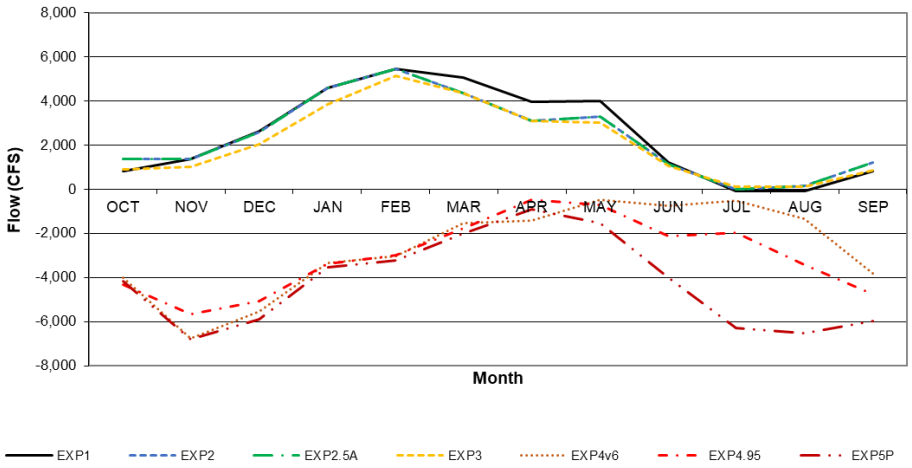


Figure E.2-60. Old and Middle River Combined Flow Monthly Pattern (Long-Term Average).

OMR combined flow is greatly affected by exports, which only exist in EXP4v6 and EXP5. More exports happen in the summer months in EXP5, causing more negative flows.

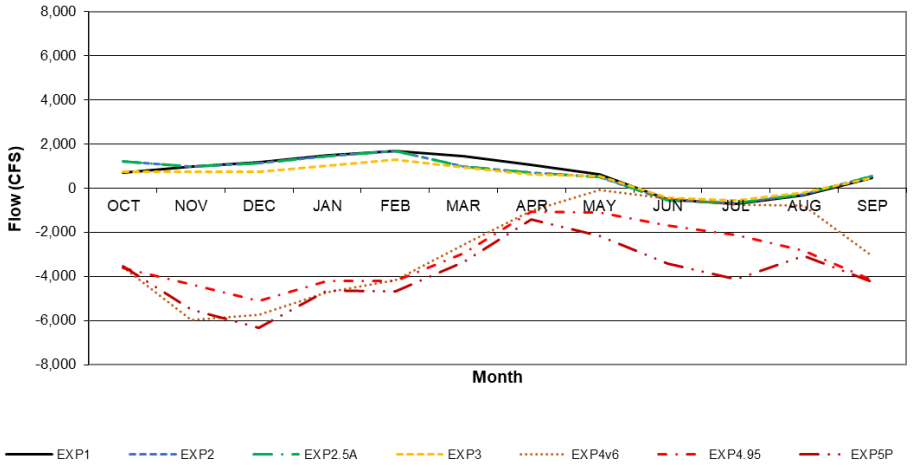


Figure E.2-61. Old and Middle River Combined Flow Monthly Pattern (Dry and Critically Dry Years).

In the driest years, OMR combined flow is negative, even in EXP1, which reflects the hydrology of the system with diverters taking water where they can.

E.2.5.3 Outflow:

Table E.2-5. Delta Outflow Annual (Oct–Sep) Volume[a] by Water Year Type.

Runs	Average	Wet Years	Above Normal Years	Below Normal Years	Dry Years	Critically Dry Years
EXP1	23,321	38,956	26,990	17,711	12,908	7,718
EXP2	22,790	37,809	26,163	17,455	12,596	8,147
EXP2.5	23,790	38,702	26,994	18,430	13,718	9,379
EXP3	21,599	36,832	24,158	16,047	11,361	7,490
EXP4v6	17,242	30,582	19,435	11,995	8,322	5,341
EXP5	16,829	30,580	19,179	10,896	7,604	5,186

[a] In thousands of acre-feet.

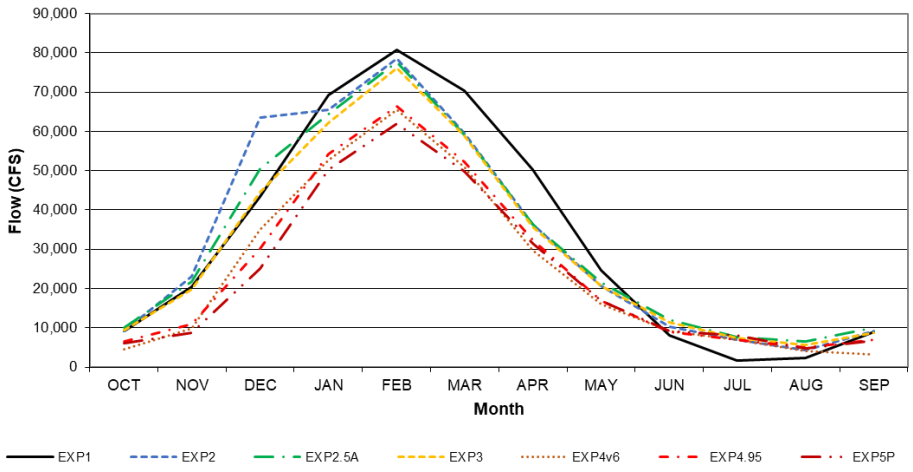


Figure E.2-62. Delta Outflow Monthly Pattern (Long-Term Average).

Delta outflow is mostly reflected by the layers of Shasta and Oroville operations, including spills and storage releases. The patterns resemble those at Hood on the Sacramento River.

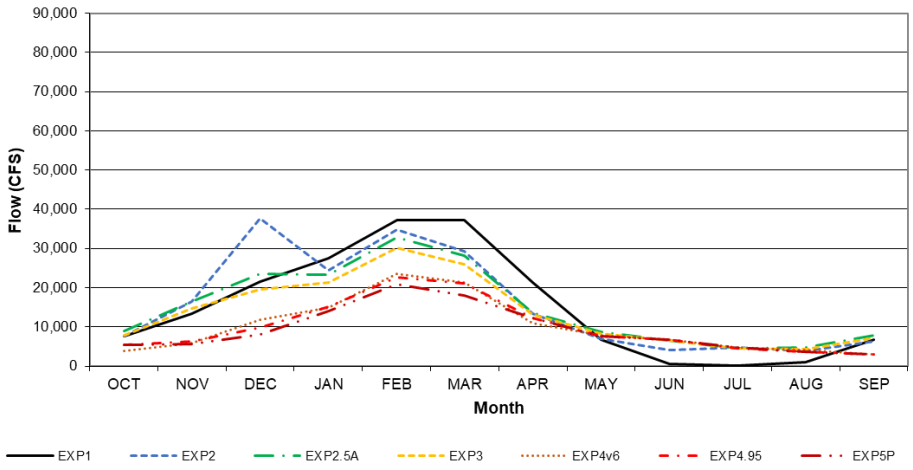
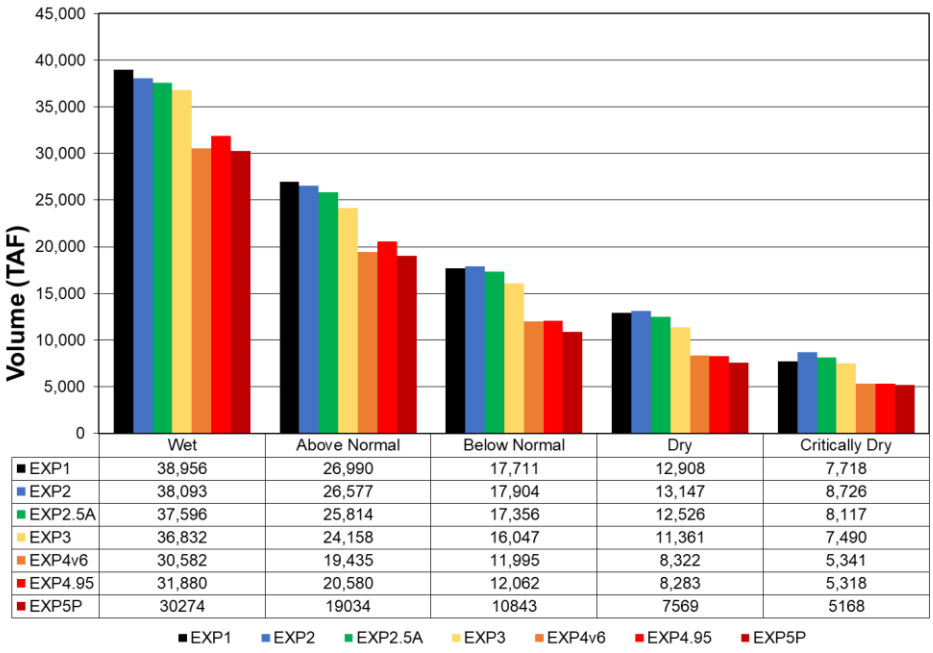


Figure E.2-63. Delta Outflow Monthly Pattern (Dry and Critically Dry Years).

Despite having significantly less flow in dry and critically dry years due to less inflow, the patterns for Delta outflow are the same as those for the long-term averages.



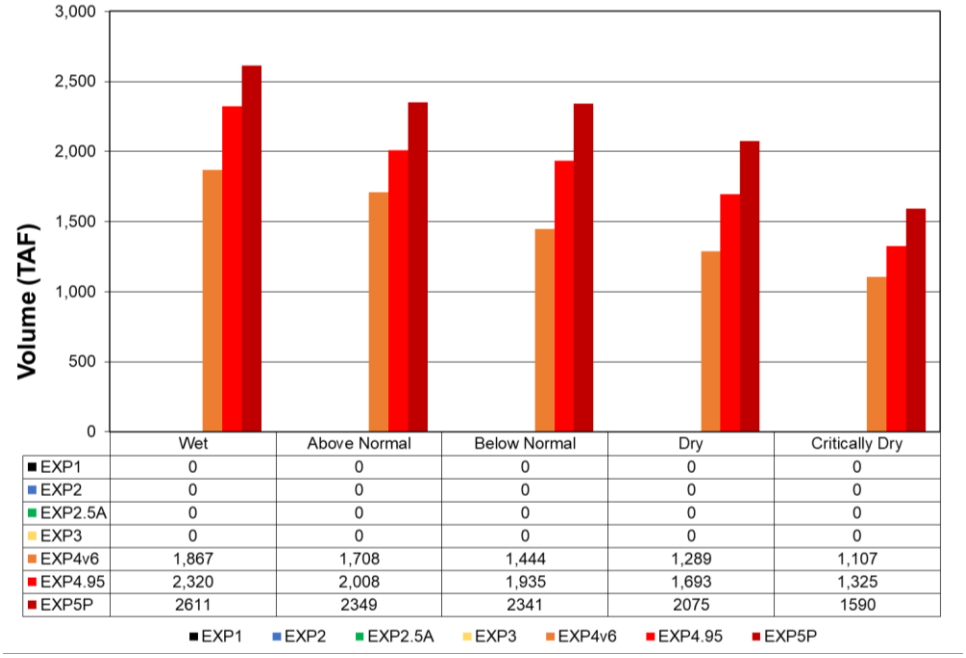
	Wet	Above Normal	Below Normal	Dry	Critically Dry
EXP1	38,956	26,990	17,711	12,908	7,718
EXP2	38,093	26,577	17,904	13,147	8,726
EXP2.5A	37,596	25,814	17,356	12,526	8,117
EXP3	36,832	24,158	16,047	11,361	7,490
EXP4v6	30,582	19,435	11,995	8,322	5,341
EXP4.95	31,880	20,580	12,062	8,283	5,318
EXP5P	30274	19034	10843	7569	5168

Figure E.2-64. Annual Delta Outflow by Water Year Type.

EXP1 and EXP2 reflect the hydrology of the system, with diverters only taking water as is available. There is increased Delta outflow in EXP2.5 because storage releases are made to meet D-1641 requirements, including minimum required Delta outflow (MRDO). Each subsequent layer after EXP2.5 has reduced Delta outflow due to increased project responsibilities causing less excess Delta outflow.

E.2.6 South of Delta

E.2.6.1 Exports



	Wet	Above Normal	Below Normal	Dry	Critically Dry
EXP1	0	0	0	0	0
EXP2	0	0	0	0	0
EXP2.5A	0	0	0	0	0
EXP3	0	0	0	0	0
EXP4v6	1,867	1,708	1,444	1,289	1,107
EXP4.95	2,320	2,008	1,935	1,693	1,325
EXP5P	2611	2349	2341	2075	1590

Figure E.2-65. Jones Export by Water Year Type.

Both versions of EXP4 only export excess water, while EXP5 releases stored water for exports. EXP4v3 does not limit negative flow on the OMR while EXP4v6 does.

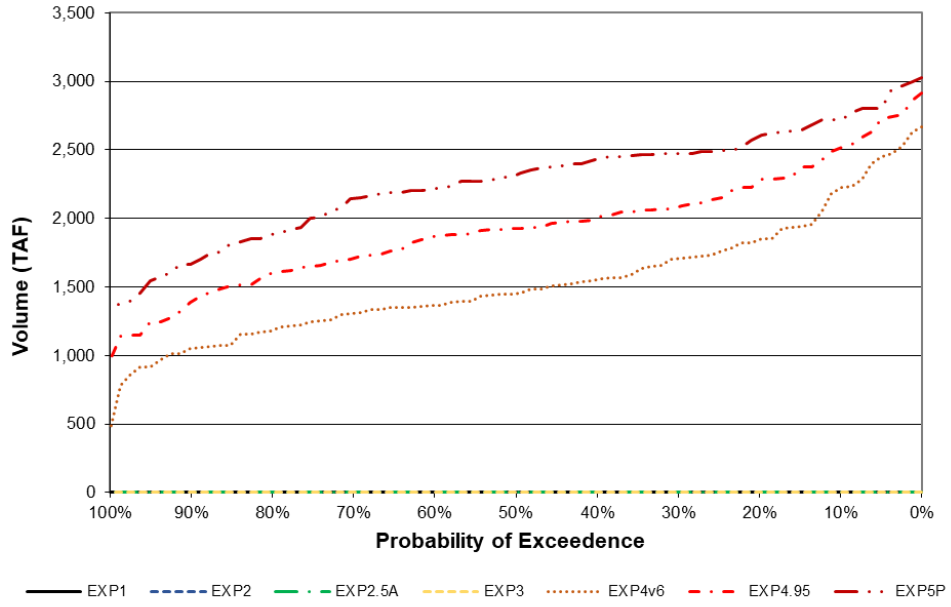


Figure E.2-66. Exceedance of Annual Jones Export (Oct–Sep).

The limits on OMR flows make little difference on the amount of water available for Jones export.

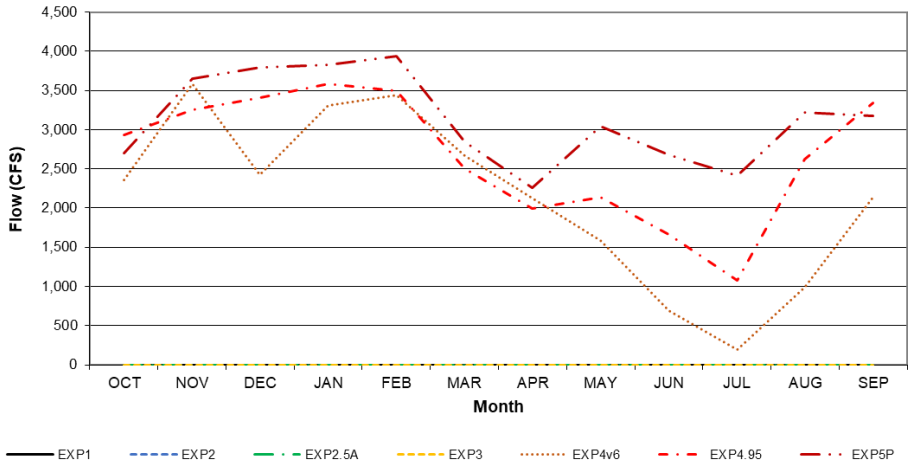
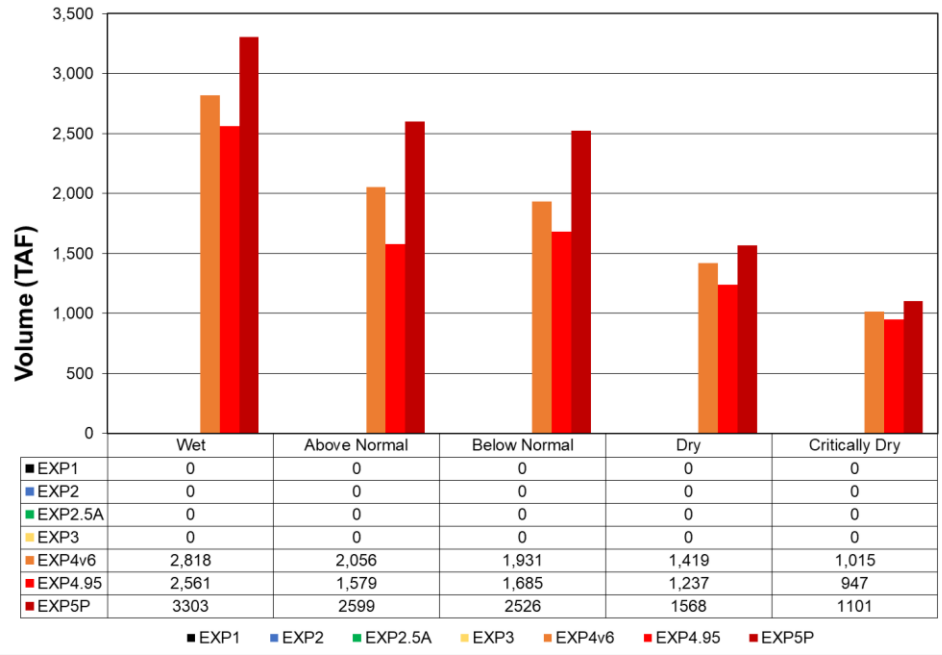


Figure E.2-67. Jones Export Monthly Pattern.

The storage releases for Jones exports make additional water available in the summer months.



	Wet	Above Normal	Below Normal	Dry	Critically Dry
EXP1	0	0	0	0	0
EXP2	0	0	0	0	0
EXP2.5A	0	0	0	0	0
EXP3	0	0	0	0	0
EXP4v6	2,818	2,056	1,931	1,419	1,015
EXP4.95	2,561	1,579	1,685	1,237	947
EXP5P	3303	2599	2526	1568	1101

Figure E.2-68. Banks Export by Water Year Type.

Greater EXP4v3 Banks export shows that limitations on negative flow in the OMR have a significant impact. Additional discretionary responsibilities in EXP5 decrease the amount of water available for Banks export.

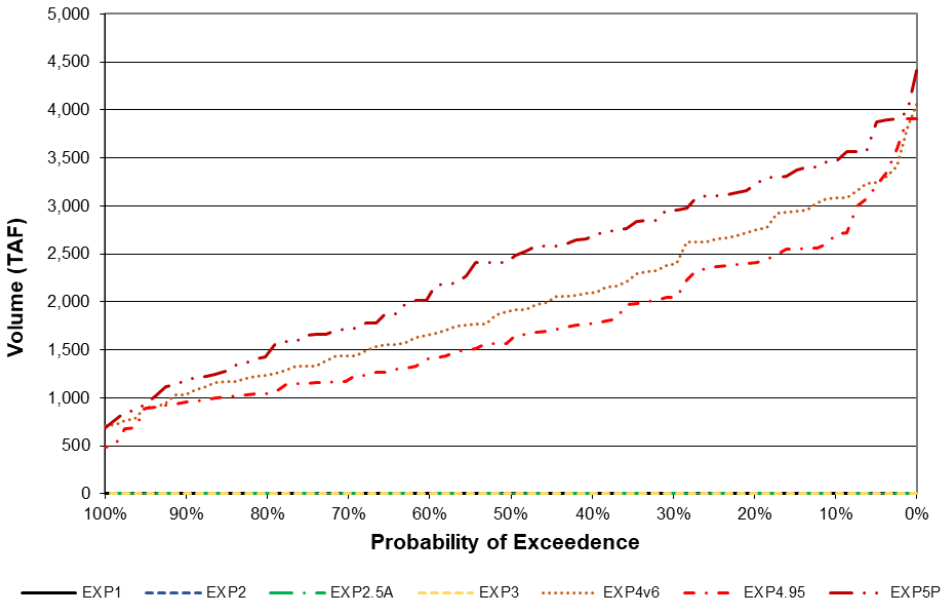


Figure E.2-69. Exceedance of Annual Banks Export (Oct–Sep).

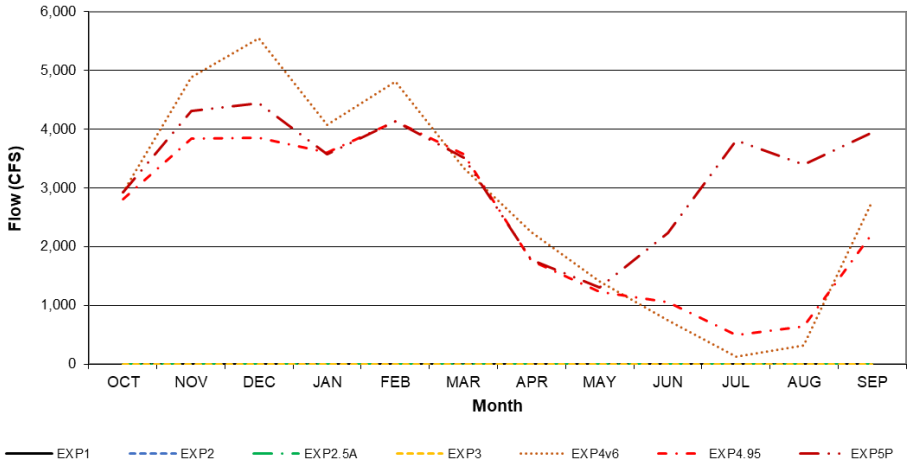


Figure E.2-70. Banks Export Monthly Pattern.

EXP5 stores more water in the fill season, reducing the amount of water available for export, but then releases stored water for export in the management season.

E.2.6.2 Deliveries

Table E.2-6. Total (Mar–Feb) SOD CVP Deliveries[a]

Runs	PAG	PMI	PEX	PRF
EXP1	0	0	497	28
EXP2/2.5	0	0	506	40

Runs	PAG	PMI	PEX	PRF
EXP3	0	0	692	96
EXP4v3	406	36	850	268
EXP4v6	496	48	824	266
EXP5	960	118	855	268

[a] In thousands of acre-feet.
PMI: Project Municipal and Industrial; PAG: Project Agricultural; PSC: Project Exchange Contractors; PRF: Project Refuge.

Deliveries to SOD Project Agriculture (PAG) and Project M&I (PMI) demands are not made until EXP4. Increased exports in EXP4v6 versus EXP4v3 allow for additional deliveries, and full exports in EXP5 further increase the water available for those deliveries. Exchange and refuge deliveries increase as operational capabilities increase across subsequent layers.

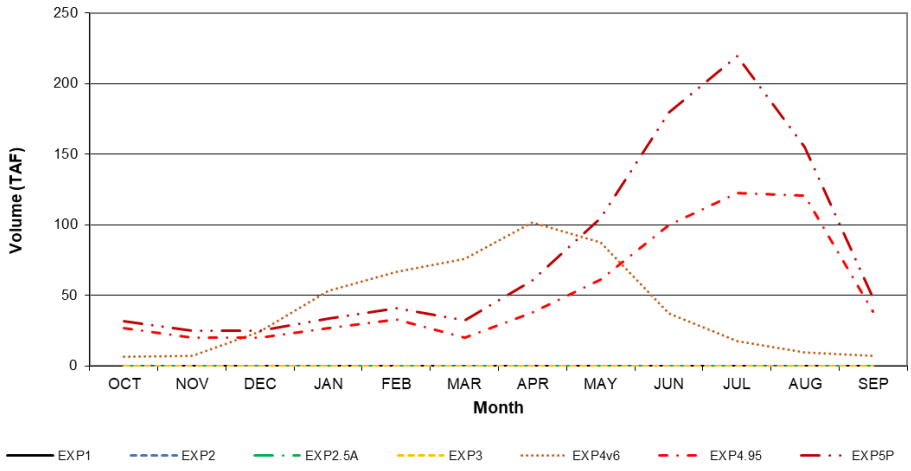


Figure E.2-71. CVP SOD Ag Contractors Delivery Monthly Pattern.

Full exports and storage releases in EXP5 increase CVP SOD Ag deliveries in the management season. Decreased flows in the fill season decrease those deliveries.

E.2.7 Exploratory 2 Perspectives

Originally, EXP2 was one step in the exploratory framework that met obligations with inflow and stored everything else, and specifically met delivery to senior water rights first and then meets minimum flow and D-1641 requirements. Based on requests the original EXP2 is now EXP2A; an EXP2B was developed with a reverse order of meeting non-discretionary obligations of minimum flow and D-1641 first, and then delivery to senior water rights holders can be met with any remaining inflow.

EXP2.5—or halfway between EXP2 and EXP3—was also developed as a result of requests. EXP3 meets both delivery to senior water rights and minimum flow requirements and D-1641 by releasing stored water as necessary. EXP2.5 allows for the full satisfaction of D-1641 with releases of stored water, but still does not release stored water for senior deliveries. As with EXP2A and EXP2B, there is also a EXP2.5A and an EXP2.5B, where A first uses inflow for senior water rights and B first uses inflow for minimum flow and D-1641 requirements.

E.2.7.1 Storage

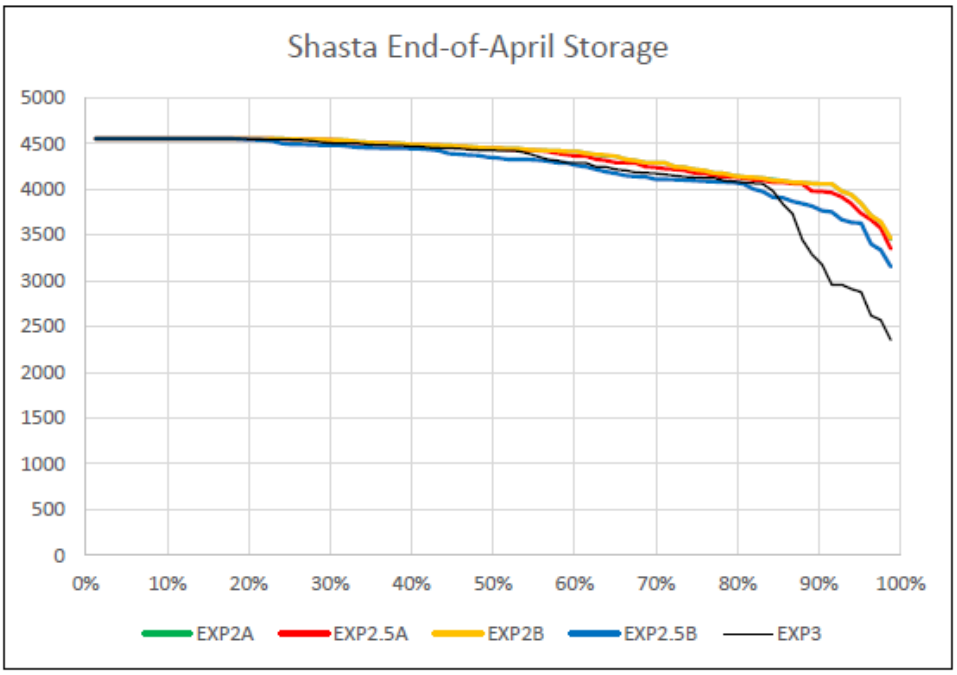


Figure E.2-72. End of April Exceedance for Shasta Storage.

In EXP2A and EXP2B, the lines are on top of each other as releases are limited to pass-through inflow; differences will show in deliveries. Because EXP2.5A uses pass-thorough inflow to meet minimum flows and D-1641 first, there is less deficit that would need to be met with stored water than in EXP2.5B where pass-through inflow first goes to meet senior water right deliveries. EXP3 shows further need for storage when deliveries to senior water rights and minimum flow and D-1641 requirements are met.

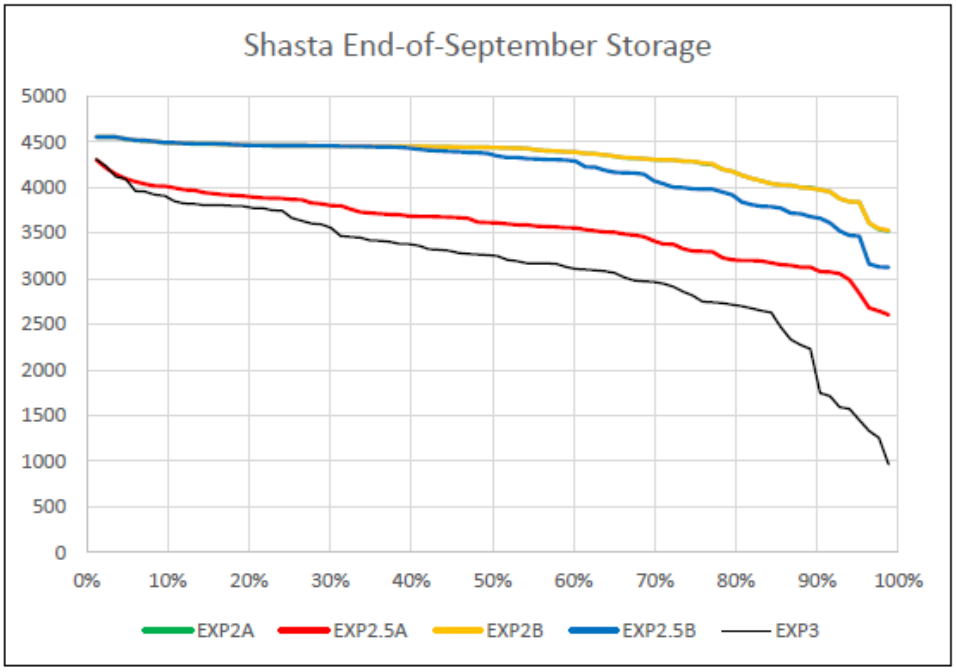


Figure E.2-73. End of September Exceedance for Shasta Storage.

By the end of September, the trends described for the end of April still apply but are more pronounced.

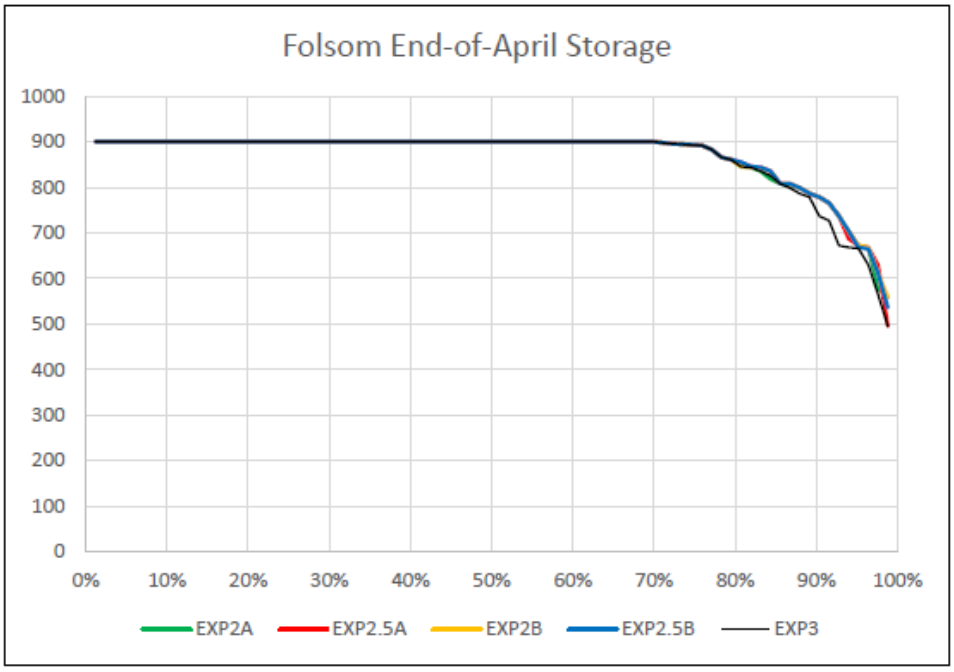


Figure E.2-74. End of April Exceedance for Folsom Storage.

Due to Folsom's small size relative to inflow and the low demands on Folsom in the exploratory modeling runs, Folsom fill is mostly consistent in the variations of EXP2 and EXP3.

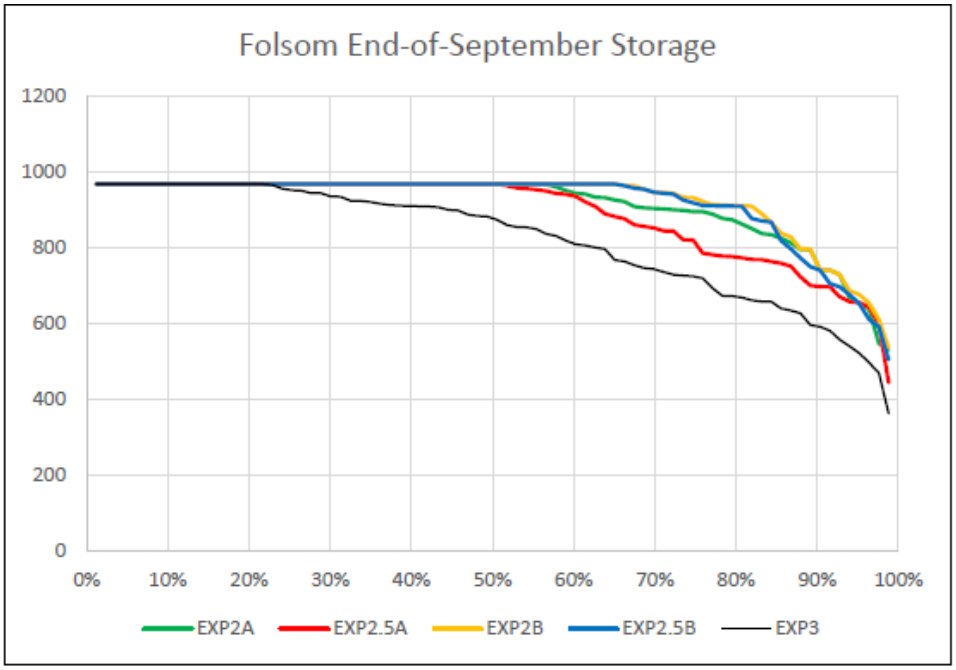


Figure E.2-75. End of September Exceedance for Folsom Storage.

When pass-through inflow goes to meet flow and D-1641 first (EXP2B and EXP2.5B), Shasta releases water for requirements on the Sacramento River that only it can meet; this water often continues through the system, reducing the demand on other reservoirs to contribute to the downstream flow requirements. This is why EXP2B and EXP2.5B are generally higher than EXP2A. In EXP2.5A, where pass-through inflow goes to senior water right delivery first, there is enough demand in the system to meet flow and D-1641 requirements that the model can balance between Shasta and Folsom, which shows some additional drawdown to Folsom compared to the other EXP2 runs. EXP3 shows further need for storage when deliveries to senior water rights and minimum flow and D-1641 requirements are met.

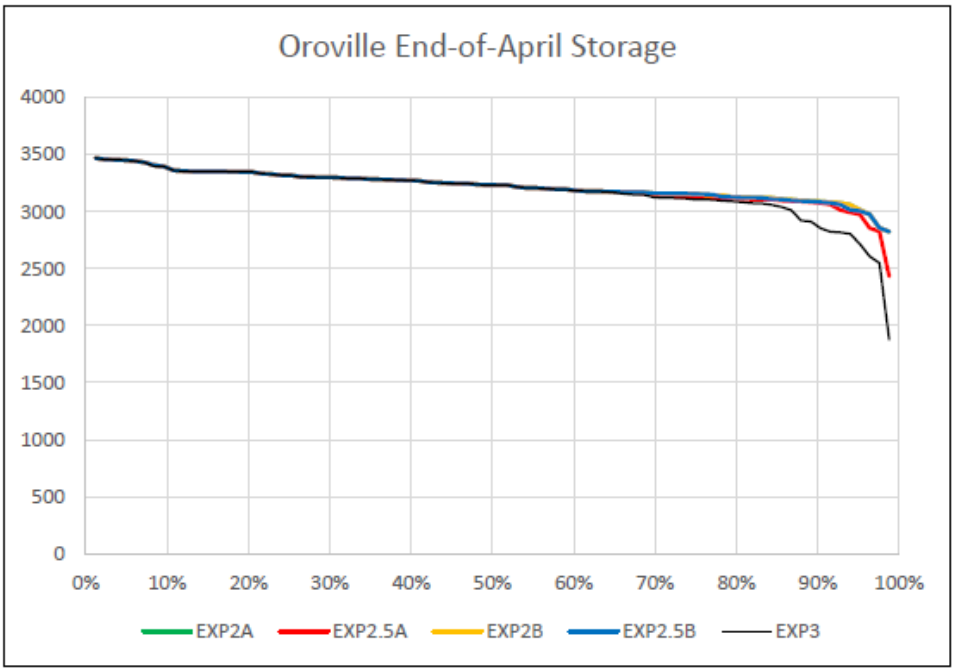


Figure E.2-76. End of April Exceedance for Oroville Storage.

Oroville fill is mostly consistent in the variations of EXP2.

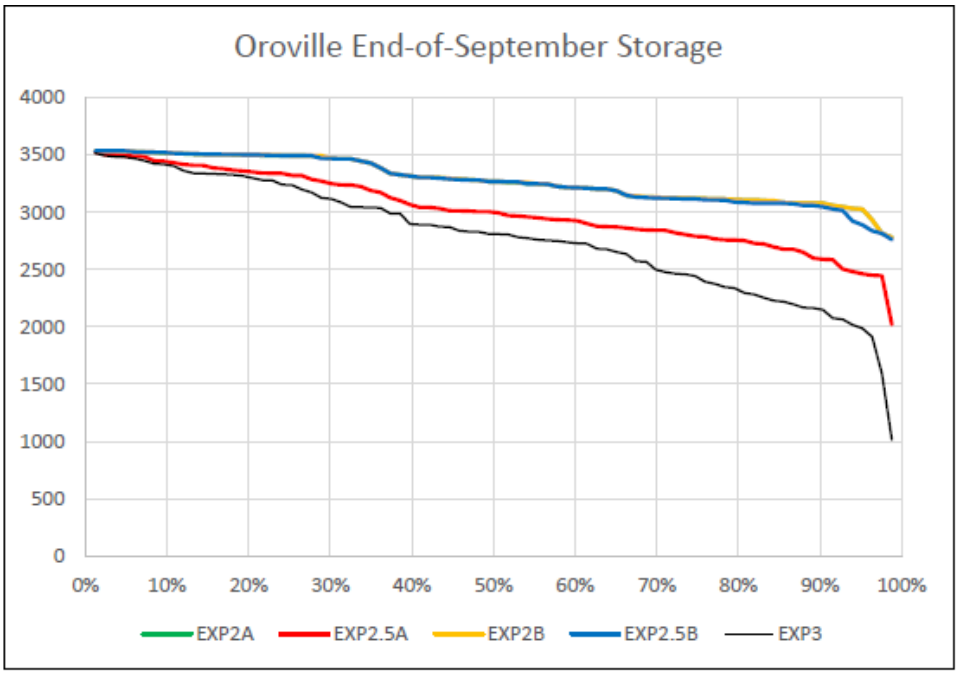


Figure E.2-77. End of September Exceedance for Oroville Storage.

When pass-through inflow goes to meet flow and D-1641 first (EXP2B and EXP2.5B), Shasta releases water for requirements on the Sacramento River that only it can meet; this water often continues through the system, reducing the demand on other reservoirs to contribute to the downstream flow requirements. This is why EXP2B and EXP2.5B are very similar to EXP2A. In EXP2.5A, where pass-through inflow goes to senior water right delivery first, there is enough demand in the system to meet flow and D-1641 requirements that the model can balance between reservoirs, which shows some additional drawdown to Oroville compared to the other EXP2 runs. EXP3 shows further need for storage when deliveries to senior water rights and minimum flow and D-1641 requirements are met.

E.2.7.2 Delivery

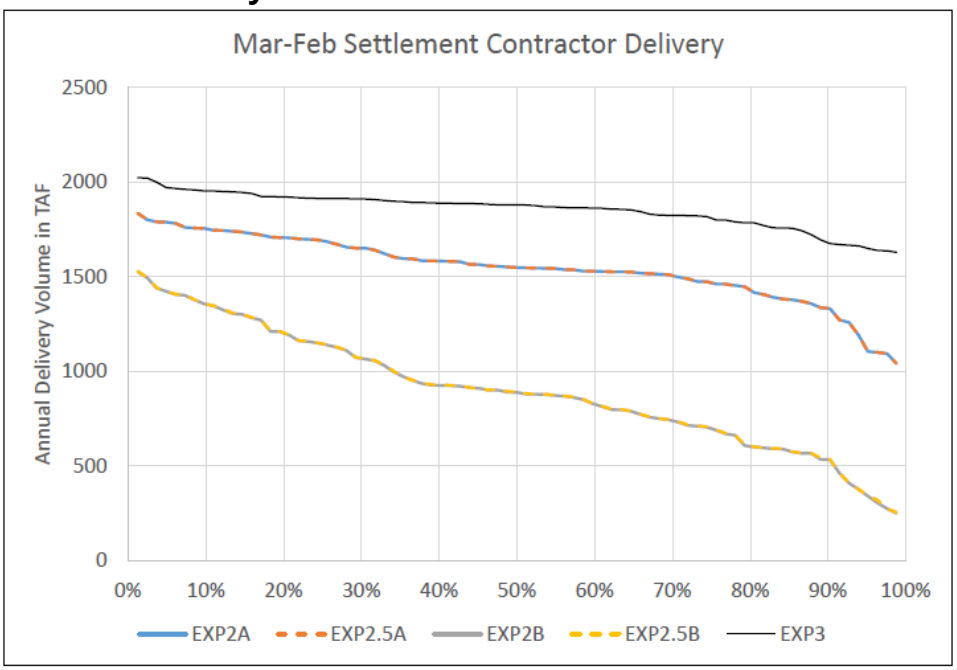


Figure E.2-78. Exceedance of CVP NOD Settlement Contractors Delivery.

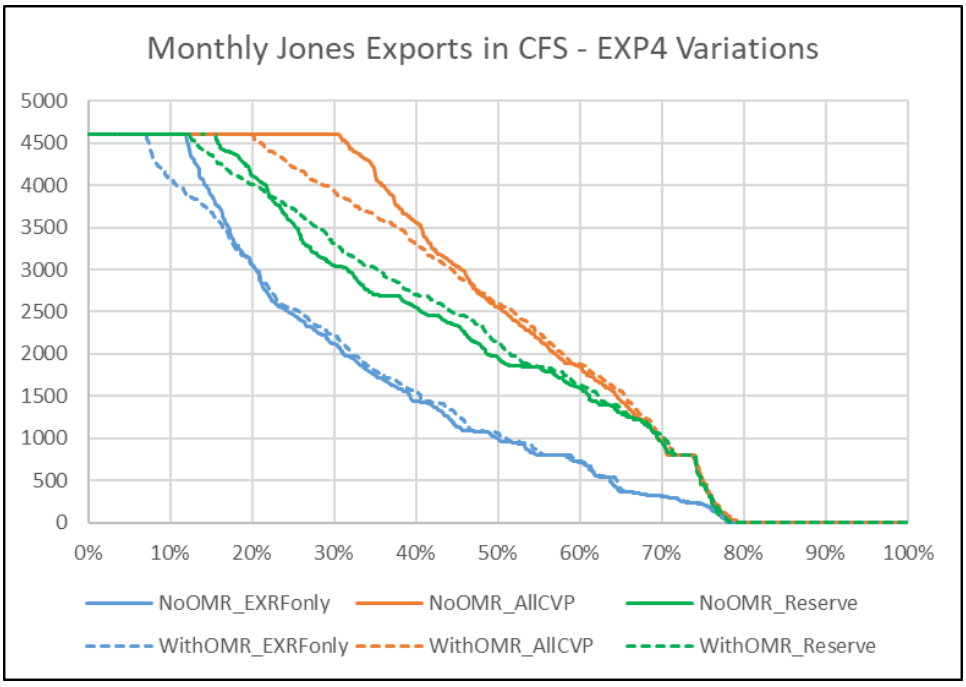
In EXP3, full CVP Settlement Contractor deliveries are made. In EXP2A and EXP2.5A, deliveries to CVP Settlement Contractors are limited to pass-through inflow, but these deliveries are given the highest priority, resulting in the middle line in the chart above. In EXP2B and EXP2.5B, deliveries to CVP Settlement Contractors are limited to pass-through inflow that is left over after inflow has gone to meet minimum flow and D-1641 requirements.

E.2.8 Exploratory 4 Perspectives

EXP4 informs project operations for water service contract delivery that do not rely upon using stored water. It provides for deliveries based on diversion of water in the system and water previously stored in San Luis Reservoir. Six sensitivities were run on EXP4 to examine different ways of considering how the water could be diverted and used:

- NoOMR_EXRFonly (EXP4v1) – Does not include OMR restrictions on exports. Exports delivered to Exchange Contractors and Refuge Level 2 and then stored in CVP San Luis.
- NoOMR_AllCVP (EXP4v2) – Does not include OMR restrictions on exports. Exports delivered to all water users and then stored in CVP San Luis.
- NoOMR_Reserve (EXP4v3) – Does not include OMR restrictions on exports. Based on the results from EXP4v1, reserve exports and CVP San Luis storage to meet Exchange Contractors and Refuge Level 2; CVP Ag and M&I can take exports and water stored in CVP San Luis that is not needed for Exchange Contractors and Refuge Level 2.
- WithOMR_EXRFonly (EXP4v4) – EXP4v1, but with OMR limits on exports.
- WithOMR_AllCVP (EXP4v5) – EXP4v2, but with OMR limits on exports.
- WithOMR_Reserve (EXP4v6) – EXP4v3, but with OMR limits on exports.

E.2.8.1 Exports



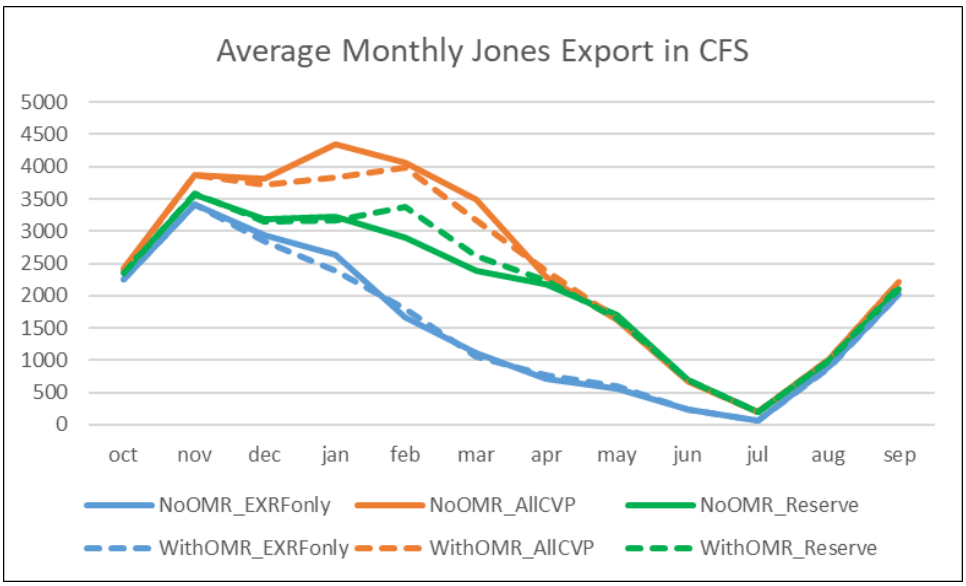


Figure E.2-79. Monthly Jones Exports Exceedance (top) and Jones Export Monthly Pattern (bottom).

The difference between the solid and striped lines is the impact of OMR. The _AllCVP runs have the highest export, because they have the most opportunities to use the water, the _Reserve runs are slightly lower because of the operation to reserve water to meet Exchange and Refuge, and the _EXRFonly runs have the lowest because there is less demand for the exported water.

E.2.8.2 Delivery

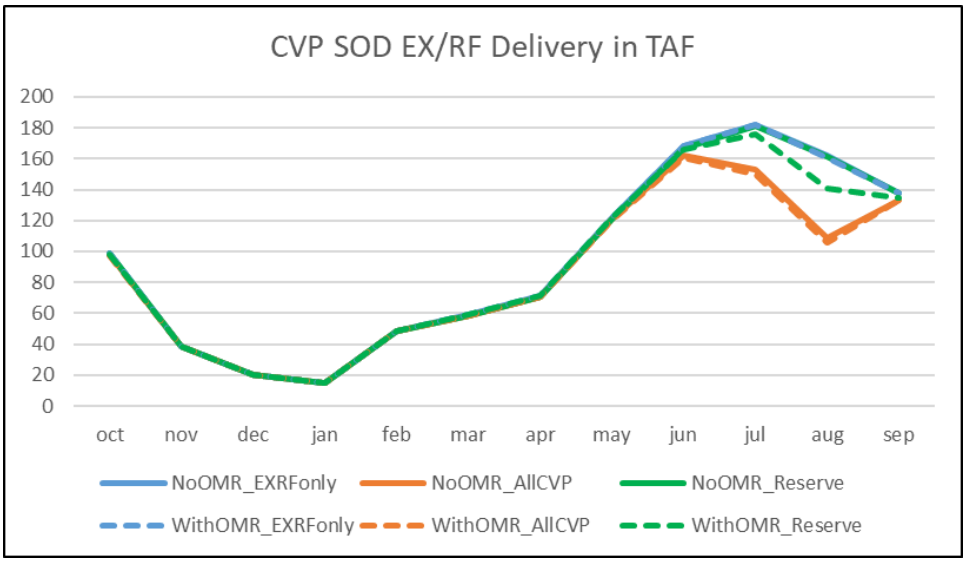


Figure E.2-80. CVP SOD Delivery to Exchange and Refuge Monthly Pattern.

Exchange and Refuge deliveries are the same in the _EXRFonly and Reserve runs, as the Reserve runs are set based on the _EXRFonly runs. Deliveries to Exchange and Refuge are lower in the _AllCVP runs as there is more competition for the water.

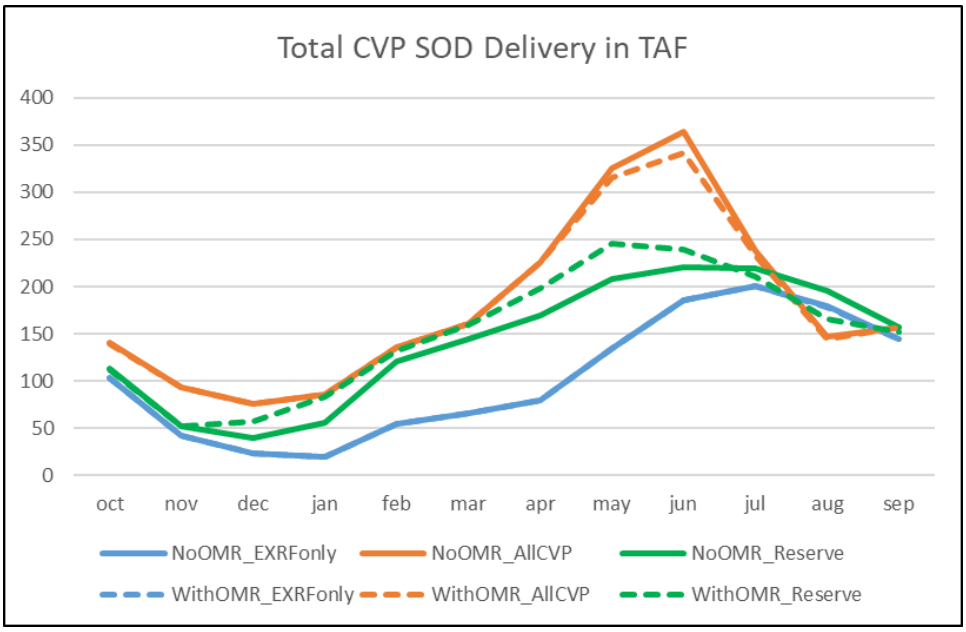
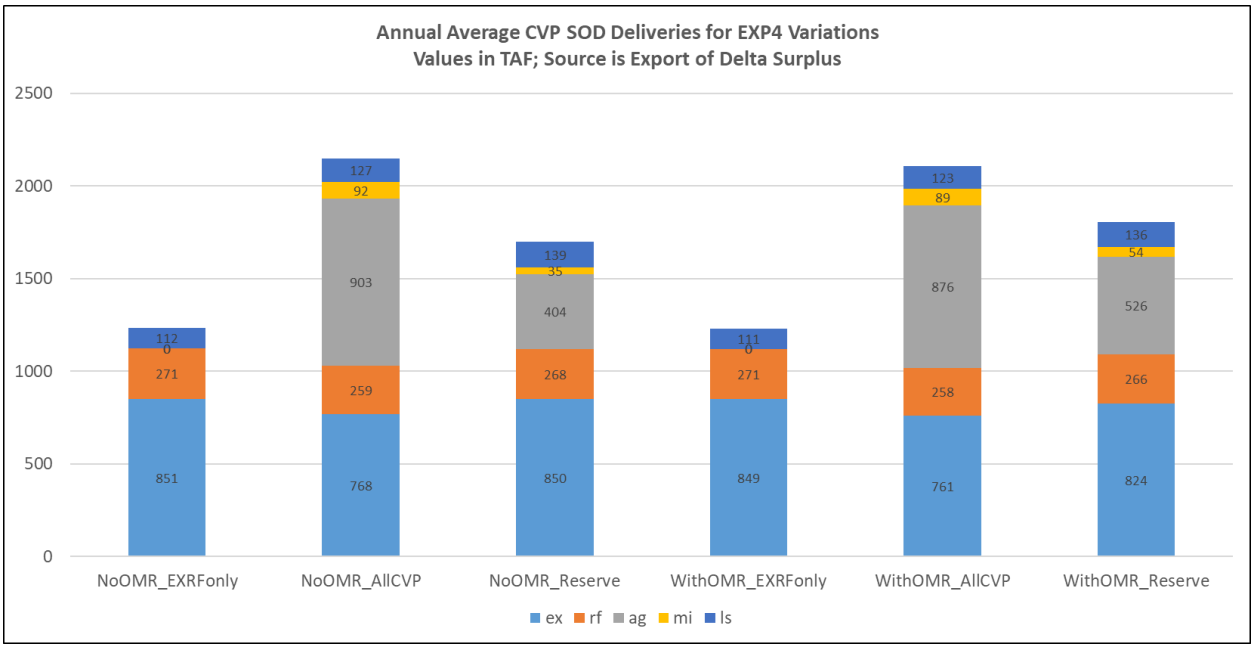


Figure E.2-81. CVP SOD Delivery Monthly Pattern.



ex = Project Exchange Contractors; rf = Project Refuge; ag = Project Agricultural; mi = Project Municipal and Industrial; ls= losses

Figure E.2-82. CVP SOD Delivery by Type.

The variations in EXP4 show the potential delivery SOD when just using water that would otherwise be Delta surplus. The model shows that Reclamation can mostly meet the SOD senior water rights to the Exchange Contractors and South of Delta Refuge demands with just surplus

water. The _All CVP alternative does result in further reductions to the senior water rights, as water is not reserved to meet their needs.

E.2.9 References

State Water Resources Control Board. 2017. *Scientific Basis Report in Support of New and Modified Requirements for Inflows from the Sacramento River and its Tributaries and Eastside Tributaries to the Delta, Delta Outflows, Cold Water Habitat, and Interior Delta Flows*. Final. Sacramento, CA.