Kern Fan Groundwater Storage Project

FEASIBILITY REPORT

Attachment 7: Storage Integration Study

October 21, 2019
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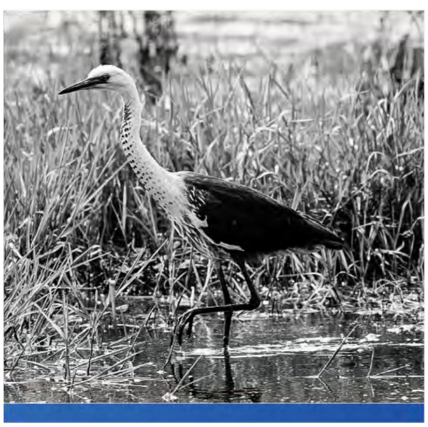

Irvine Ranch WATER DISTRICT

Rosedale-Rio Bravo WATER STORAGE DISTRICT

Storage Integration Study

June 2017

Prepared for

ACWA Association of California Water Agencies

Prepared by

MBK ENGINEERS

Contents

Executive Summary

To inform decision making related to water storage investments, the Association of California Water Agencies (ACWA) undertook this study to define and quantify the benefits of integrating the operation of new storage projects with the existing State Water Project (SWP) and Central Valley Project (CVP). In addition to these storage projects, the study analyzed how improved Delta conveyance capability could increase the benefits of integrated operations of proposed and existing storage facilities. The integration of the projects would significantly help fulfill statewide water supply needs and priorities.

This study describes new storage projects that are currently being proposed, how those projects may be integrated with existing water storage facilities and conveyance infrastructure (current and proposed), and analytical results quantifying the benefits of integrated operation of the proposed storage projects. The analytical results contained in this study were developed through the use of CalSim II and other spreadsheet modeling efforts. The study focused on assessing the benefits from both project-to-project integration and system-wide integration.

The potential new storage projects considered in this study are listed in order, from north to south, below:

1. Sites Reservoir
2. Centennial Reservoir
3. American River Conjunctive Management
4. Los Vaqueros Reservoir Expansion
5. San Luis Reservoir Enlargement
6. Temperance Flat Reservoir
7. Tulare Lake Storage and Floodwater Protection Project
8. Groundwater Storage in the Kern Fan Area

Findings

Significant Surplus Water Available

The study found that due to the nature of California's highly variable hydrology, there are surplus flows in the system that may be diverted to storage in almost every year. Figure 1 shows that average annual surplus in the Delta watershed is about 10 million acre feet (MAF). The annual surplus varies from over 22 MAF in wet years to over 1 MAF in critical years. These volumes of surplus water available within the Delta watershed are similar to amounts identified by the California Department of Water Resources (DWR) in its Draft Report on Water Available for Replenishment (WAFR). In that report, DWR developed its best estimate of WAFR and also a "maximum project estimate" that is similar to the total surplus illustrated in Figure 1.

SURPLUS WATER

Surplus water is defined in this report as flow above what is necessary to satisfy all current water demands, including existing environmental mitigation measures and compliance obligations. This water cannot be captured and stored with existing storage and conveyance infrastructure.

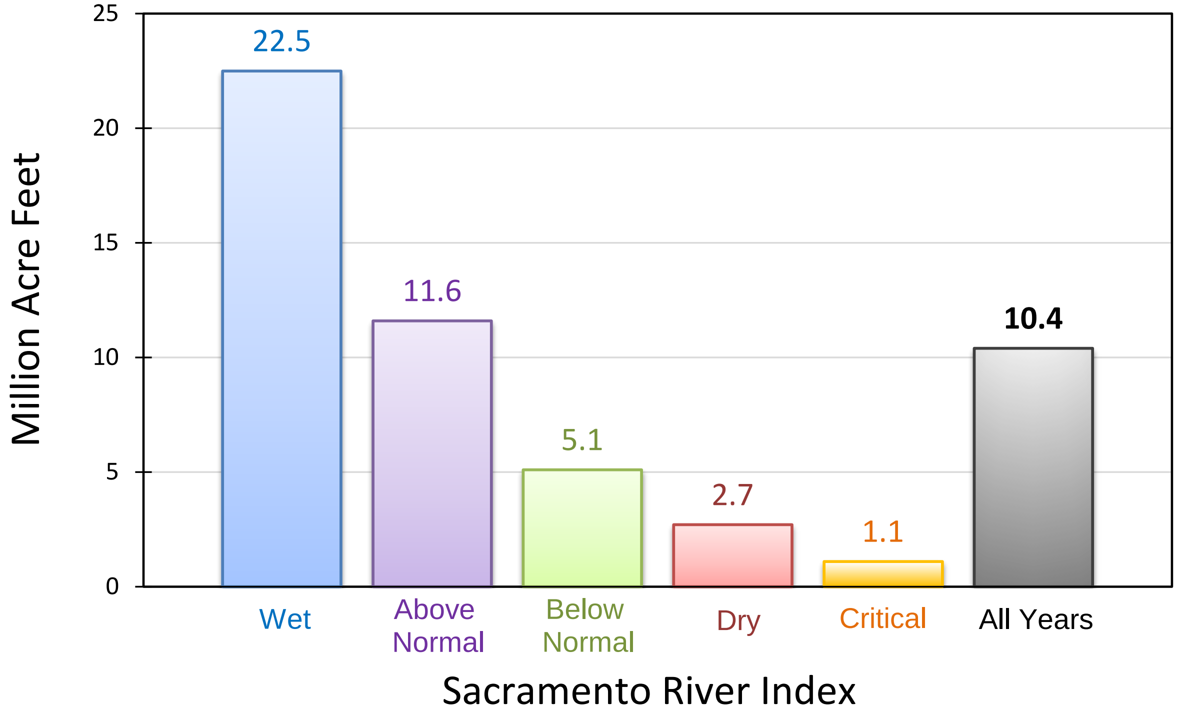

Figure 1. Average Annual Surplus

Integrating Operations Expands Benefits of Proposed and Existing Storage Facilities

Each proposed new storage project has its own unique geographic location, hydrology, connections to California's water system, and operational opportunities. Some projects are most effective at regulating the timing of water supply within each year, while others are most effective at regulating supplies from wetter years to drier years. Some projects may facilitate increased integration among upstream reservoirs, while others may improve south of the Delta integration. Some projects would help north and south of Delta reservoirs operate together in a more efficient manner. Each project, with its unique characteristics, may contribute to the overall integration of California's water system in a manner that expands benefits beyond the sum of the individual projects. This analysis also illustrates that improving Delta conveyance could further increase the system-wide benefits of integrating the operations of proposed new and existing storage projects.

The combined storage capacity of the proposed new storage projects included in this study is about 3.5 MAF. As shown in Figure 2, integrating operations of the existing and proposed projects would increase carryover storage by about 1.9 MAF in average years and by about 1.1 MAF in critical years.

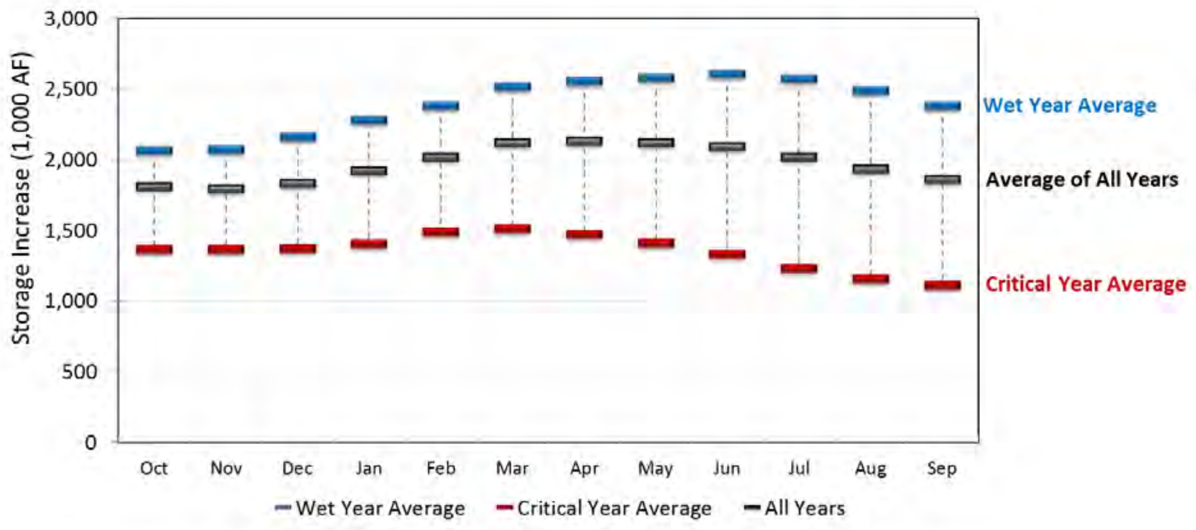

Figure 2. Average Monthly Change in Storage (Trinity, Shasta, Oroville, Folsom, San Luis, Sites, Los Vaqueros, Centennial, Millerton, Tulare Lakebed, and Temperance Flat)

When all of the proposed storage projects are operated together and integrated with the CVP and SWP, the average carryover storage in existing upstream project reservoirs (Trinity, Shasta, Oroville, and Folsom) increases by 250 thousand acre feet (TAF) and by more than 550 TAF in critical years (**Figure 3**). Such increased storage levels in existing storage facilities would provide multiple benefits to fishery habitat, recreation, water supply reliability, hydropower, groundwater sustainability, and more.

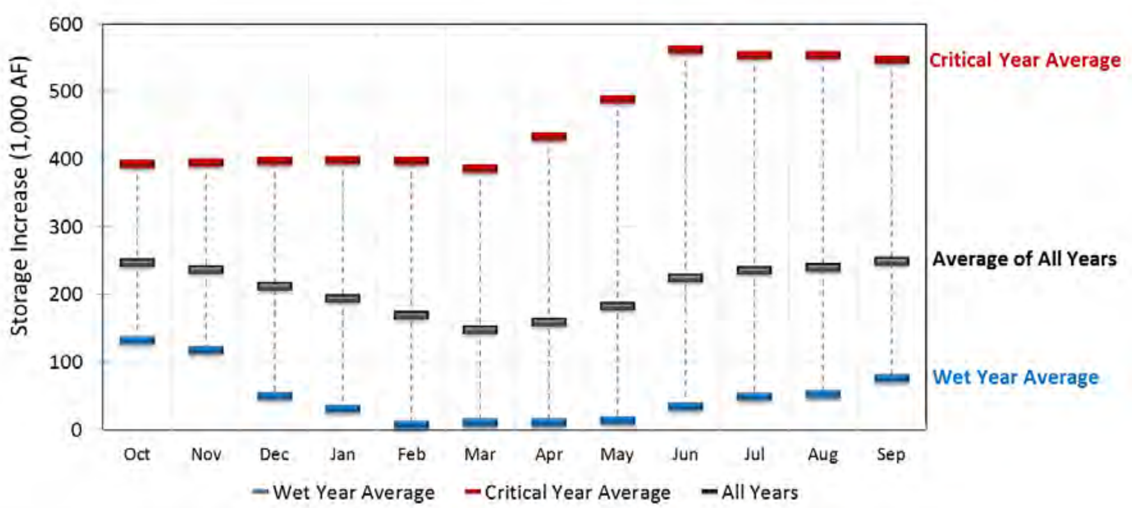

Figure 3. Average Monthly Change in Existing Upstream Project Storage (Trinity, Shasta, Oroville, Folsom)

New Storage Increases Water Supply and Reliability

Figure 4 shows that the proposed new storage projects would increase average annual water deliveries by 400 TAF if integrated into the operations of the SWP and CVP systems under current regulatory constraints. Annual water deliveries would increase by 720 TAF and 450 TAF in dry and critical years, respectively (Figure 4). By also improving north to south Delta conveyance capability, as proposed by the California WaterFix, average annual water deliveries increase by over 800 TAF, more than double the average benefit of integration without improved Delta conveyance. The benefits in wet and above normal years is almost three fold, and in below normal years almost five fold. These are the years when the most water could be made available to dramatically improve groundwater conditions from both in-lieu use of surface water as well as undertaking increased recharge. Improved Delta conveyance would also provide for substantially improved water supply reliability. The increased reliability from improved Delta conveyance is evident from the significant increase in deliveries across almost all hydrologic year types.

WATER DELIVERIES

Water deliveries in this study include deliveries to agricultural, municipal, and environmental water users such as wildlife refuges. Increases in water deliveries are a metric used to quantify the additional water that can be made available for a variety of purposes through integrated storage and improved conveyance.

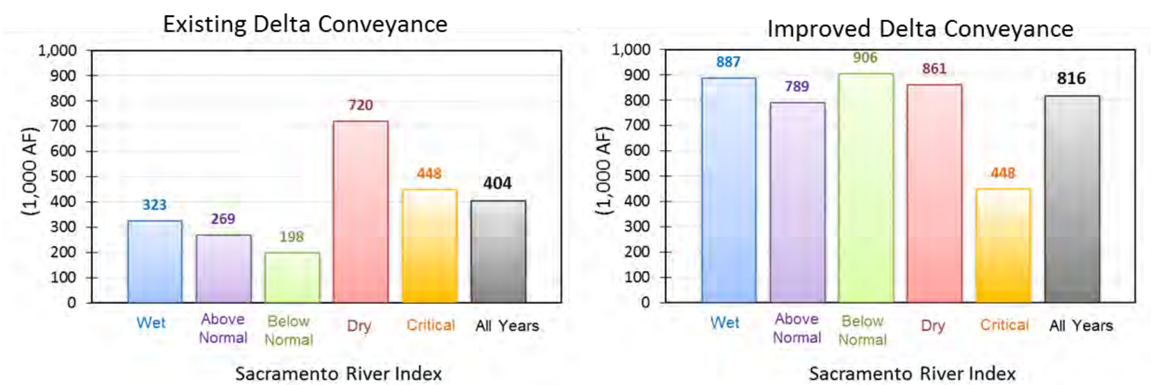

Figure 4. Average Annual Changes in Delivery with New Storage (Left) and New Storage and Improved Delta Conveyance (Right) by Water Year Type

Integrated Operation of New Storage Improves Groundwater Storage

Increases in surface water storage through the integration of the proposed new storage projects will increase surface water deliveries, which would result in reduced groundwater pumping through enhanced conjunctive use and increases in direct recharge. Such reductions in pumping and improved basin recharge would result in increased groundwater levels in many areas. Increased surface water deliveries resulting from expanded state-wide storage capacity and improved delivery reliability will contribute to groundwater sustainability, furthering the goals of the Sustainable Groundwater

Management Act. Surface water deliveries are the critical component to successful and expanded conjunctive management.

The average annual increase in groundwater storage throughout California, with all of the proposed storage projects, would be about 250 TAF. This storage amount increases to approximately 460 TAF with improved Delta conveyance. Figure 5 contains a chart showing annual increases in surface water deliveries that are made in-lieu of groundwater pumping with all proposed storage projects and improved Delta conveyance. The figure depicts that over the 82-year simulation period, 21 MAF would accumulate into groundwater storage through the integration of new proposed storage projects, without improved Delta conveyance. With both new storage projects and improved Delta conveyance, the figure shows approximately 38 MAF would accumulate into groundwater storage over the same period. Due to the variable nature of surface water availability, the integration of the use of groundwater storage projects (water banks) is necessary to manage wet and dry years by banking water in wetter years and extracting in dry years. Although surface storage is key to groundwater sustainability and conjunctive management throughout California, the primary benefits are in the San Joaquin and Tulare basins, which have historically experienced the greatest stress.

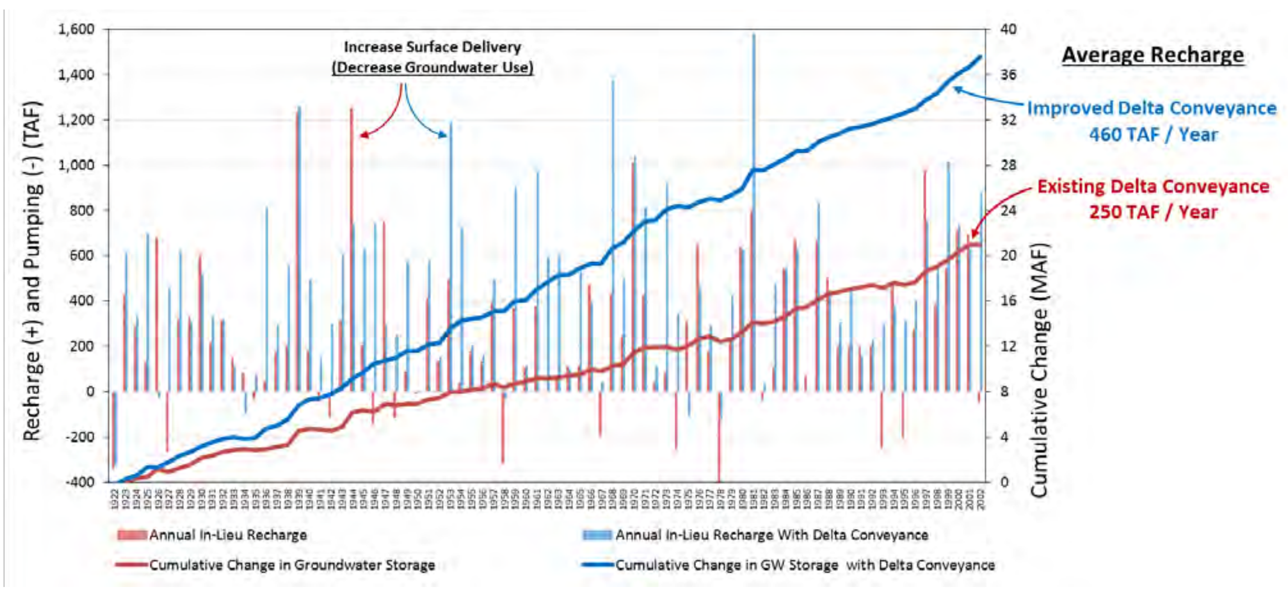

Figure 5. Annual and Cumulative Change in Groundwater Storage with All Storage Projects and Improved Delta Conveyance

Significant Surplus Remains with New Storage and Improved Delta Conveyance

A significant volume of surplus remains even after the addition and integration of 3.5 MAF of additional storage capacity and improved Delta conveyance. Figure 6 shows the portion of the existing surplus illustrated in Figure 1 that is stored or delivered with all storage projects and improved Delta conveyance. While a larger volume of water is captured in wet years, an average of approximately 21 MAF of surplus remains in these same years. Comparing Figure 6 and Figure 4 illustrates how water stored in wetter years is carried over to improve dry year water availability, while providing additional benefits of increased carryover storage to fisheries and other resource areas.

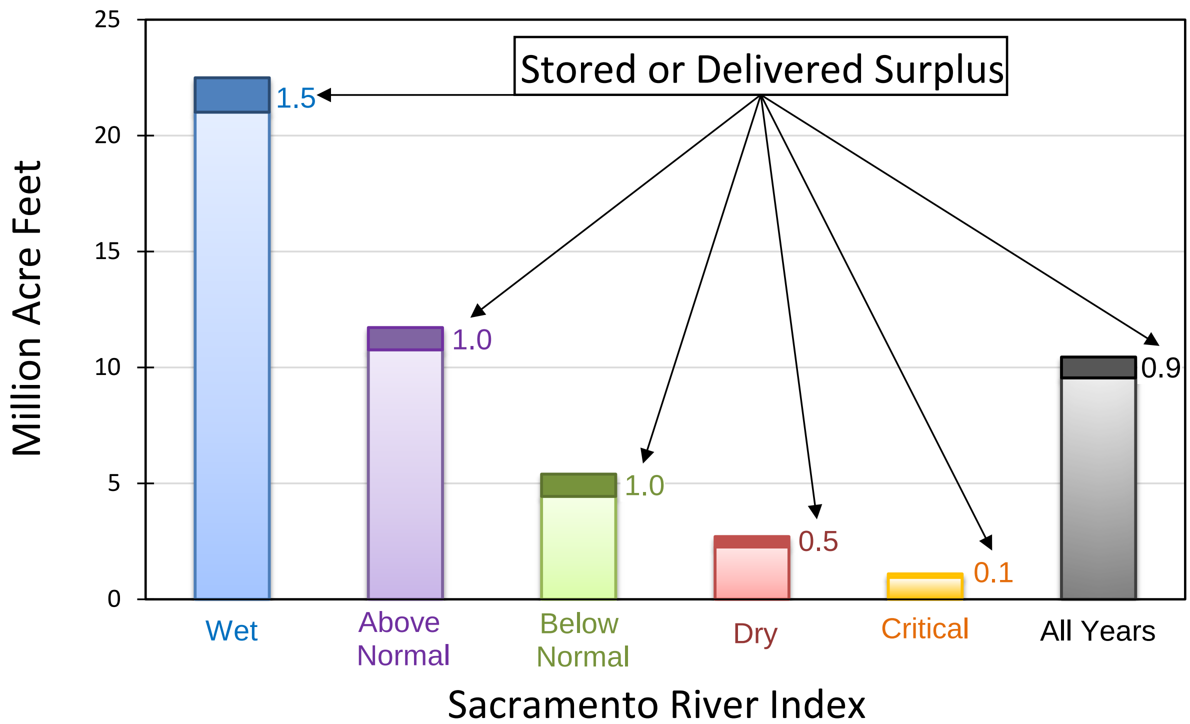

Figure 6. Average Annual Stored and Remaining Surplus with All Project and Improved Delta Conveyance

Introduction

Surface storage is essential to enable the development of more fully integrated statewide and regional water management systems. Surface storage assets contribute to the reliability of the state and federal water projects and local water supplies by allowing water to be captured and stored seasonally to meet both short- and long-term needs. Surface storage also uniquely provides other important benefits such as flood management capacity, holding space for supplies produced from local sources (including water recycling and desalination), hydropower production, ecosystem benefits (such as temperature management), in-stream flows and water quality for aquatic species, and recreational opportunities. Surface storage also is a prerequisite for enhanced groundwater recharge and storage opportunities, including conjunctive use. Surface storage provides multi-purpose operational benefits that can help enhance the SWP and the CVP's ability to contribute to groundwater replenishment activities, while on a local and regional basis, surface storage projects can improve in-lieu and direct recharge capabilities to enhance conjunctive use.

Infrastructure improvements that physically integrate and interconnect forms of storage can enhance operational flexibility, increase the reliability and efficiency of integrated statewide and regional water management systems, and allow for optimization of the multiple benefits served by storage. These infrastructure improvements include new projects and improvements to existing facilities. Delta conveyance improvements would provide expanded water system capacity particularly during wet periods, as well as overall reliability enhancements which would allow additional water to be placed in storage, both above and below ground. Required conveyance improvements include a Delta conveyance solution as well as other assets that interconnect, either physically or through operational integration, existing and future supply infrastructure.

ACWA undertook this study to inform decision making related to water storage investments, by defining and quantifying the benefits of integration, in terms of statewide water supply needs and priorities. This study describes proposed water storage projects, the integration of these projects with existing water storage facilities and conveyance infrastructure (current and proposed), and the analytical results quantifying benefits.

The potential projects considered in this study are listed below.

1. Centennial Reservoir
2. Sites Reservoir
3. American River Conjunctive Management
4. Los Vaqueros Reservoir Expansion
5. San Luis Reservoir Enlargement
6. Temperance Flat Reservoir
7. Groundwater Storage in the Kern Fan Area
8. Tulare Lake Storage and Floodwater Protection Project

In addition to these storage projects, improved Delta conveyance was analyzed to demonstrate how improved conveyance capability could increase integrated operations of proposed and existing storage facilities. The technical analysis focuses on assessing the benefits of water supply, conjunctive management, flood protection, ecosystem, water quality improvements, and other related benefits from both project-to-project integration and system-wide integration. Several of the storage projects also provide local recreation benefits.

First, this technical report describes the basics of the California water system and quantifies water available as surplus that may be stored in proposed facilities for multiple beneficial uses. Each proposed storage project is briefly described, along with its potential integrated operations and benefits. Each proposed storage project is presented and results of modeling of all proposed storage projects are presented with existing Delta conveyance. Improved Delta conveyance is then combined with all proposed storage projects and analyzed to better understand how it may further enhance the integrated operation of existing and proposed storage projects.

Information provided in this report focuses on how water that is currently available as surplus to current demands and existing environmental mitigation measures and compliance obligations can be managed with additional storage and conveyance infrastructure. One of the potential uses of water that is better managed with new infrastructure is to provide water available for replenishment to assist in sustainable management of groundwater resources. While some of the specific projects analyzed directly integrate surface storage and groundwater management, all of the projects have the potential to make water available for groundwater replenishment. In many instances, surface water storage projects can assist with groundwater management by temporarily storing large volumes of surplus surface water during what can be limited periods of availability, and by making that water available for replenishment either through direct or in-lieu recharge.

Water System Background

Many major SWP and CVP facilities in the Central Valley are first used to provide flood protection, and secondly to address issues of timing and distribution of water resources to provide water supplies for various beneficial uses. With cool wet winters and warm dry summers, California's Mediterranean climate creates the natural time management consideration regarding the availability and utilization of the water resources to capture water (when and where it is available) for delivery to locations during times when it is needed. Runoff, from both intense winter storm precipitation and spring snowmelt in the Sierra Nevada mountain range, can exceed the capacity of the Central Valley's river system. Numerous surface water reservoirs in Northern California were constructed to control, capture, and store water when it is available in the wet winter and spring for use elsewhere in the state during the dry summer and fall. In California, water is stored primarily in aquifers, mountain snowpack, and surface water reservoirs. These interdependencies amongst the meteorological, hydrological, and climatological systems; the water uses and demands in the state; and the water resource facilities and facility management; are important factors to consider when assessing how the system may be operated with new storage (and the potential effects of new storage) on other beneficial uses. Water storage in the State of California is the means of matching the timing and location of available water supplies with the timing and location of water demands. Without water storage California could not support its population or economy or the numerous environmental benefits provided by such storage.

Available Surplus

A key factor to the effectiveness of new storage is the availability of water to divert to that storage. Due to the nature of California's hydrology, there are often surplus flows in the system that may be diverted to storage. Surplus flows are defined as flow above what is necessary to satisfy all water demands, including environmental mitigation measures and compliance obligations, and that cannot be captured with existing infrastructure. Surplus flow conditions occur in most years and there are times when surplus flow may exceed 100,000 cubic feet per second (cfs). Figure 7 contains a picture of extreme surplus conditions from March 1940, and Figure 8 contains a picture of surplus flow from February 2004. During periods such as these, there is ample surplus to fill proposed storage facilities so this water could be available to meet multiple beneficial uses during dry periods.

Figure 7. Sacramento River and Sutter Basin in March 1940 (SR-173-CV B.D. Glaha, U.S.B.R March 1940)

Availability of surplus flow varies throughout the California water system. More surplus water can be found lower in the water system as the drainage area increases and more tributaries contribute to flow. Figure 9 contains average annual surplus flow for the proposed reservoirs analyzed as part of this effort. As expected, the Delta has the greatest amount of surplus flow, having an annual average of over 10 MAF. In wet years, there is an average of over 22 MAF of Delta surplus, while the average surplus in critical years is about 1 MAF. Although there is less surplus upstream of the Delta, there is still ample surplus to divert at the locations of proposed storage facilities, as can be seen in Figure 9.

Figure 8. Fremont Weir and Sacramento River Looking North on February 20, 2004

Figure 10, Figure 11, and Figure 12 contain average annual Delta surplus by water year type, average monthly Delta surplus by water year type, and annual Delta surplus for the 82-year CalSim II simulation period. Although there is surplus available in almost every year, the surplus is generally available during the winter months regardless of year types, and there are typically no surplus flows during the summer months when demands are highest. It is important to be aware that California relies on storage for time management of supplies by storing water each winter for use during each summer. Even in California's driest years, there are times when surplus water may be captured with proposed new storage. Figure 13 contains a chart showing the daily Delta inflow, outflow, and exports during water year 2015. Even though 2015 was the third year of a drought, several hundred thousand acre feet of surplus could have been captured with new storage, and that surplus utilized for multiple beneficial uses during a year when both the ecosystem and water users desperately needed additional supply.

In addition to the retiming of water supply each year, year-to-year management of supply is also important for satisfying California's water demands and protecting ecosystems. As can be seen in Figure 12, California has experienced extended periods of dry conditions, such as during the drought of the 1930's; the drought of the late 1980's, which lasted until the early 1990's; and during our most recent drought from 2013 through 2015. Storage is needed to capture water in wetter years for use in multi-year droughts.

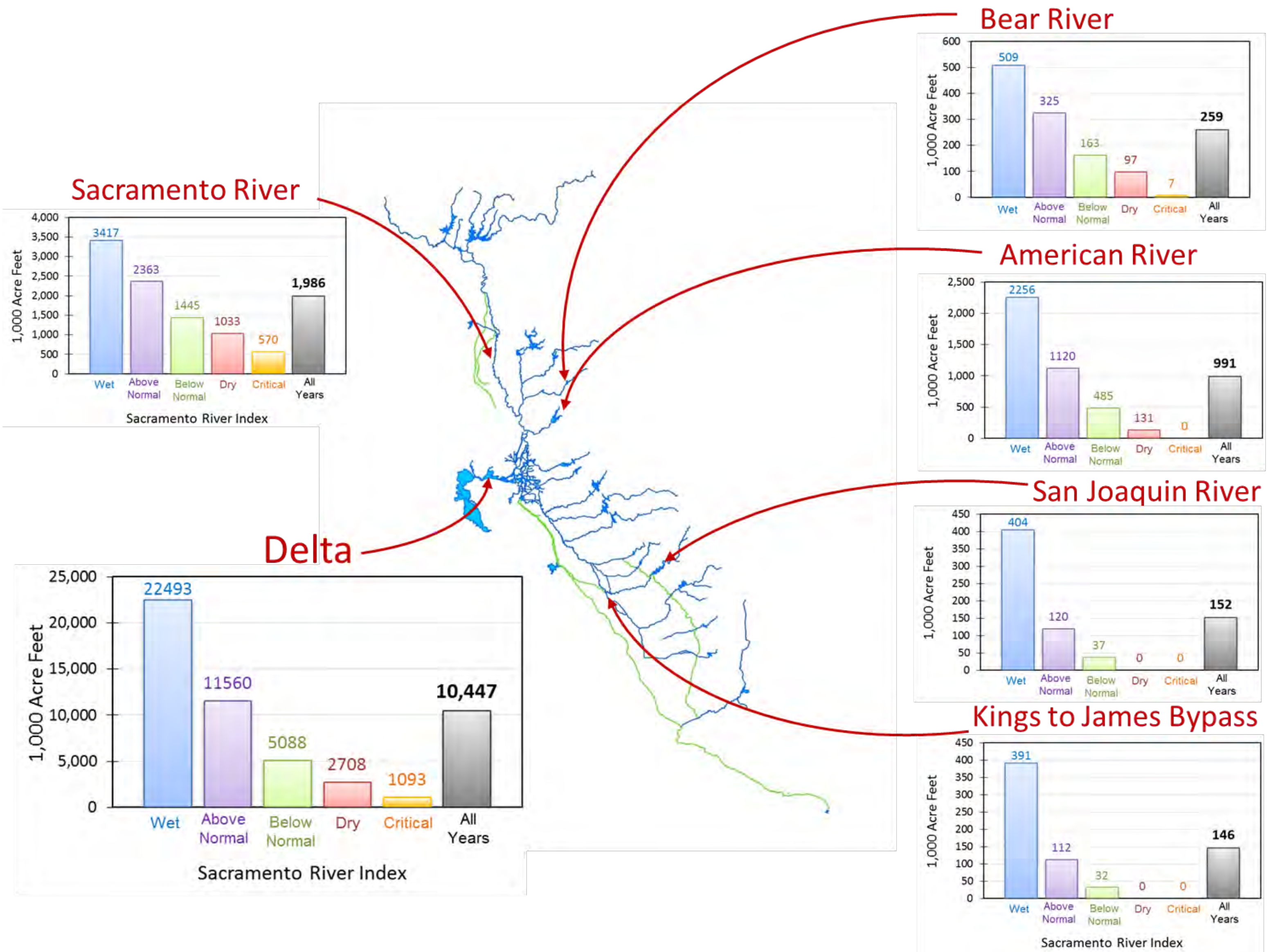

Figure 9. Surplus Available for Storage

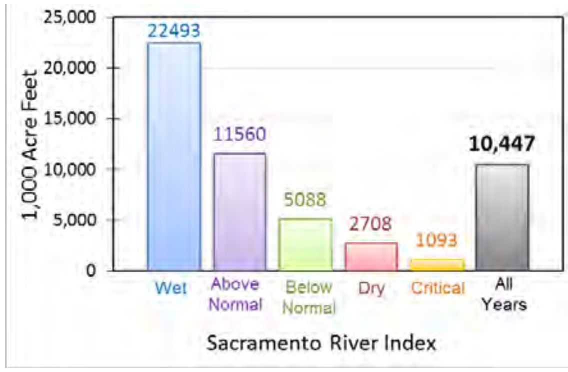

Figure 10. Annual Average Delta Surplus by Water Year Type

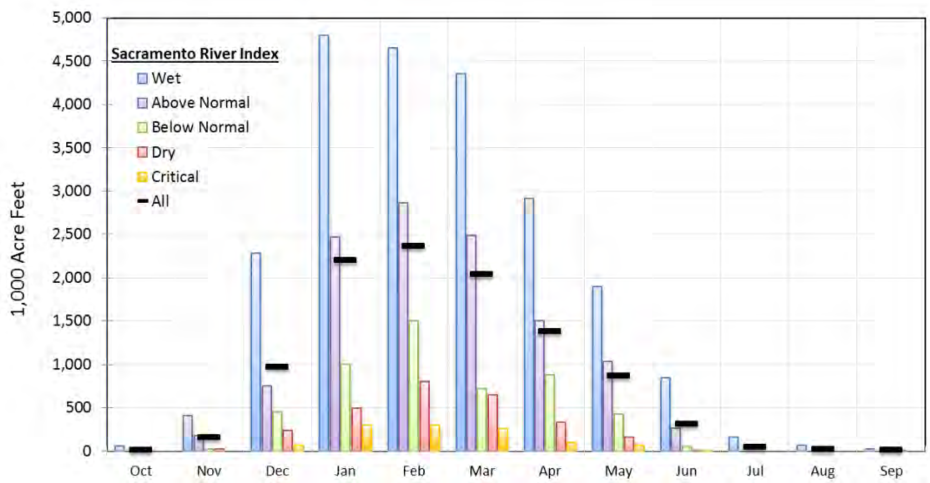

Figure 11. Monthly Average Delta Surplus by Water Year Type

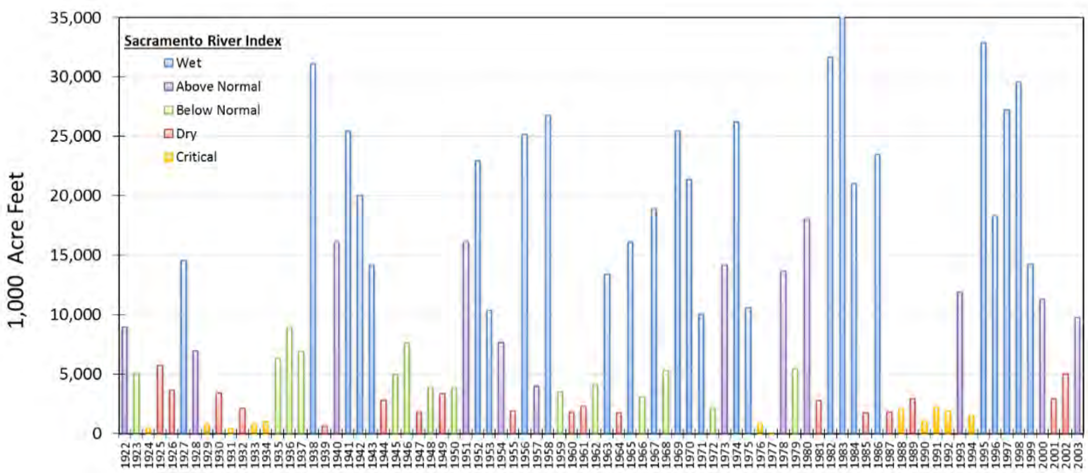

Figure 12. Annual Delta Surplus

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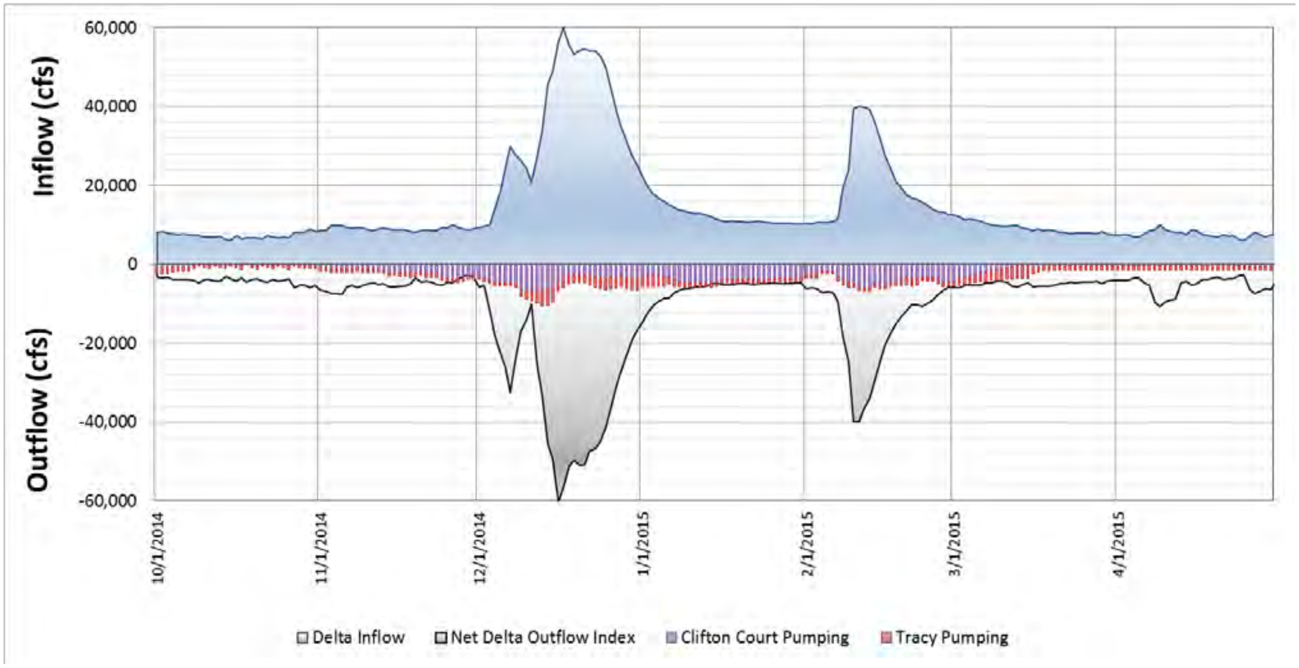

Figure 13. Surplus Delta Flow Conditions during a Critical Water Year

Conveyance

In order to be effective, almost every storage project also requires additional infrastructure to be fully integrated with the California water system. Some of the proposed reservoirs require local conveyance facilities to divert available surplus to storage, and then to deliver additional supply within their service area. Other proposed storage facilities require additional conveyance so they can be integrated with existing facilities and other proposed facilities. The most significant factor constraining system-wide integrated operations is Delta conveyance.

Figure 14 contains a chart showing the probability of exceedance by water year type of unused Delta export capacity during the primary months (July through September) when upstream stored water is released to support South-of-Delta water demands. The average July through September unused capacity, over the full 82-year period of simulation, is about 170,000 acre feet (AF). During the summer, the Delta is typically in balance; any increase in exports would require additional releases from upstream reservoirs such as Shasta, Folsom, Oroville, or from another proposed storage facility. During dry and critical years (when storage is low) additional releases from storage for export would not be a reasonable operation due to low water levels. Export facilities remain unused in these year types. However, in wet and above normal years (and occasionally in some below normal years) when carryover storage is expected to be above what would be needed to satisfy all upstream requirements, it is likely that additional stored water would be released to increase South-of-Delta water supplies resulting in maximum use of export facilities under existing regulations.

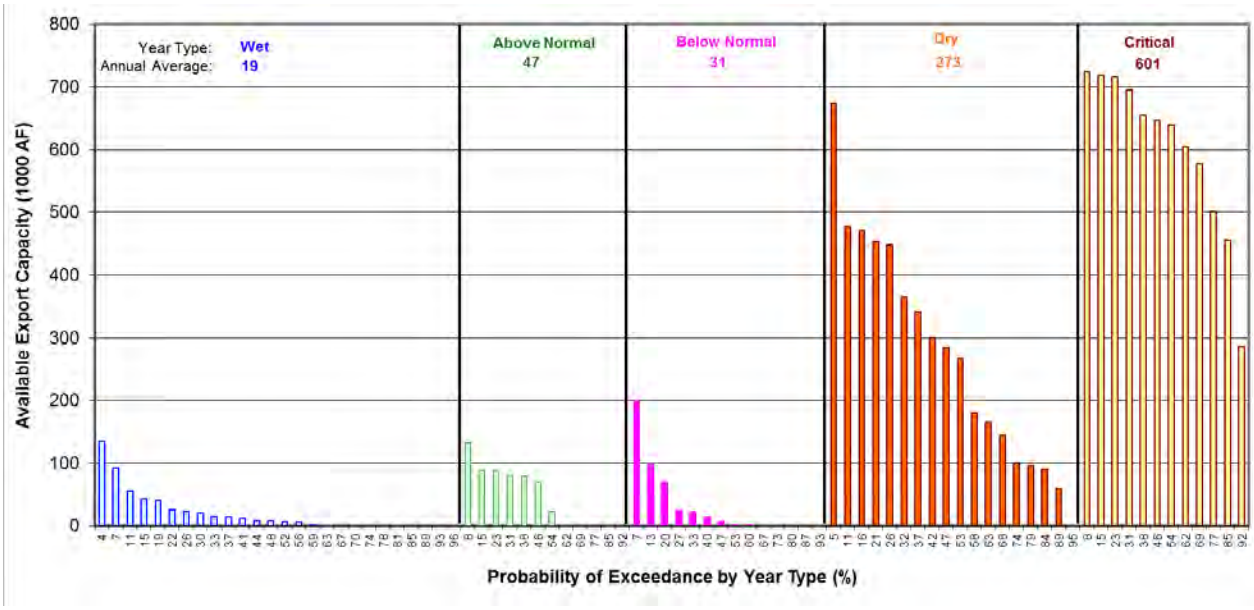

Figure 14. Annual Available Delta Export Capacity (July through September)

Given that July through September is the primary period when stored water is conveyed through the Delta, additional on-stream storage could only be exported during dry and critical years. One of the key reasons that release of stored water is limited to the July through September period is protection of upstream habitat during spawning months. Salmon typically begin spawning in rivers below CVP and SWP reservoirs during October, and once spawning has occurred, flow rates cannot be reduced until March of the following year or there may be dewatering of salmon eggs. If releases in October are set high to support exports, then there is a risk that reservoirs will be too low if there is below average inflow the following water year. There could also be resulting impacts to habitat and water users; thus, reservoir releases for the October through March period are typically set in October, commensurate with available stored water.

If proposed reservoirs are able to release water during fall months without affecting spawning habitat, there would be significantly greater opportunity to convey water through the Delta. The Sites Reservoir (Sites) is an example of a reservoir that could release water into the Sacramento River below the salmon spawning habitat. Figure 15 contains a chart showing probability of exceedance, by water year type, of unused Delta export capacity during the July through November period. The average unused capacity over the full 82-year period of simulation is about 420,000 AF. Under existing regulations, there is an average of about 250,000 AF of available Delta export capacity during October and November, releases from Sites could occur during these fall months to make use of this available export capacity.

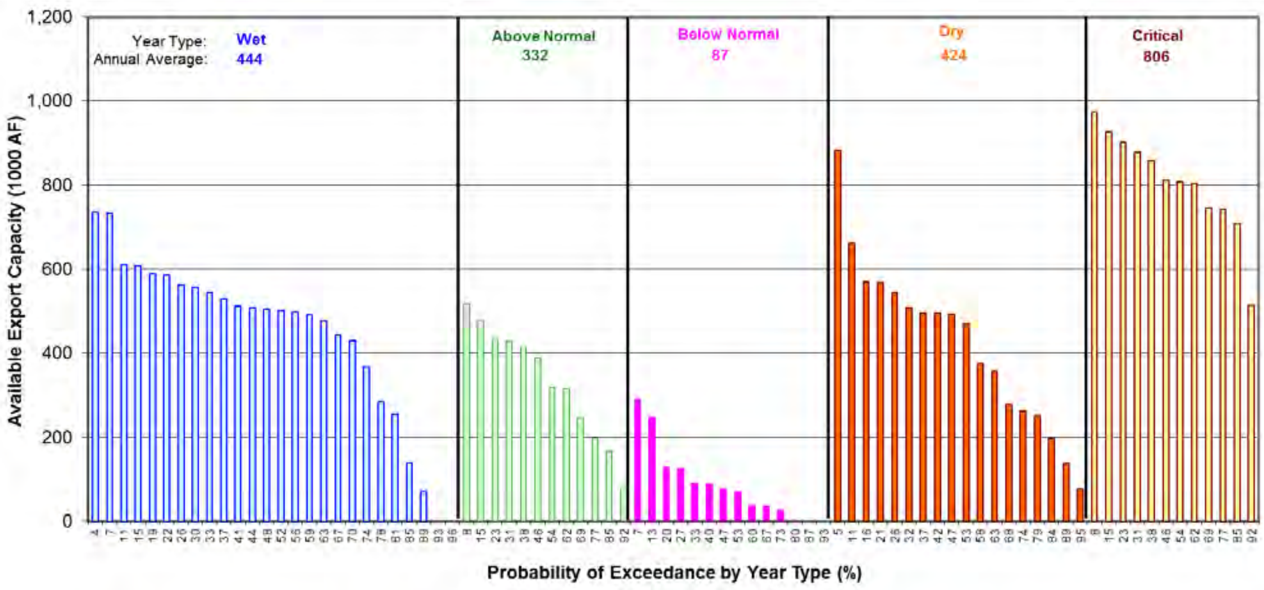

Figure 15. Annual Available Delta Export Capacity (July through November)

Analytical Approach

Technical analysis for the integrated storage investigation was performed by modeling each individual storage project as the only new facility in an integrated water system. The intent is to demonstrate how each project may operate when integrated with the existing storage and conveyance system. After modeling each individual storage project as an integrated component of the California water system, an operational scenario that includes all new storage projects was developed. A combination scenario with all proposed storage projects demonstrates how all the proposed projects may operate together in an integrated manner. Proposed Delta conveyance was added to the combination scenario to demonstrate how improved Delta conveyance may enhance the integration of all proposed projects.

CalSim II is the primary analytical tool used for evaluation of proposed storage projects. The CalSim II model is a computer program, jointly developed by DWR and the United States Bureau of Reclamation (Reclamation). CalSim II presents a comprehensive simulation of SWP and CVP operations, and it is used by DWR as a planning tool to predict future availability of SWP water. CalSim II is widely recognized as the best available water management model in California, and is generally accepted as a useful and appropriate tool for assessing the water delivery capability of the SWP and the CVP.

Additional models are used to simulate proposed storage facilities that are not represented in CalSim II. Operations in these spreadsheet models are integrated with CalSim II operations to evaluate how each project may operate in an integrated manner with existing facilities.

All modeling for this investigation assumes the same regulatory requirements, generally representing the existing regulatory environment, including the National Marine Fisheries Service (NMFS) Biological Opinion (BO) (June 2009) and the U.S. Fish and Wildlife Service (USF&WS) BO (December 2008). The modeling protocols for the recent USF&WS BO (2008) and NMFS BO (2009), have been cited as being developed in cooperation by Reclamation, NMFS, USF&WS, California Department of Fish and Wildlife (CDF&W), and DWR.

Integrated Operation

Overview

Modeling was performed to assess how all of the proposed storage projects evaluated for this effort could operate together as integrated components of California's water system. The modeling scenario described in this section includes the following storage projects:

1. Centennial Reservoir
2. Sites Reservoir
3. American River Conjunctive Management
4. Los Vaqueros Reservoir Enlargement
5. San Luis Reservoir Enlargement
6. Temperance Flat Reservoir
7. Integration with Groundwater Storage in the Kern Fan Area
8. Tulare Lake Storage and Floodwater Protection Project

Modeling for this scenario, like all others for this effort, was performed assuming existing regulatory requirements and historically based hydrology. No modeling was performed using predictions of climate-changed, future hydrology. This scenario assumes existing Delta conveyance, while the scenario in the next section assumes improved Delta conveyance is included with all of these storage facilities.

Each proposed storage project has its own unique geographic location, hydrology, connections to California's water system, and operations. Some projects are most effective at retiming water supply within each year, while others are most effective at retiming year-to-year supplies. Some projects may increase integration among upstream reservoirs and others improve south of the Delta integration, and some help North- and South-of-Delta reservoirs operate more efficiently together. With the unique characteristics of each proposed facility, each may contribute to the overall integration of California's water system in a manner that expands benefits beyond the sum of the individual projects.

Analytical Results

Figure 16 contains an exceedance probability plot of carryover storage for all the proposed storage projects with existing key CVP and SWP reservoirs; combined storage of Trinity, Shasta, Oroville, Folsom, San Luis, Sites, Los Vaqueros, Centennial, Millerton, Tulare Lake, and Temperance Flat reservoirs are included. The red line with markers represents the Baseline and the blue line represents storage in the integrated modeling scenario. Figure 17 contains average end of month change in storage by water year type for all of the same reservoirs. Annual average carryover (end of September) storage increase is about 1.8 MAF, and maximum average monthly increase during winter months is about 2.1 MAF. Figure 17 contains exceedance probability plots of carryover storage for existing CVP and SWP reservoirs in the Sacramento River basin, average annual increase in carryover is about 250 TAF. Although increases in carryover storage in most years provides benefits, increases in storage when these reservoirs are at their lowest levels is more than 500 TAF, which enhances habitat and provides multiple benefits. Figure

19 contains a plot of existing and combined storage for each month of the 82-year simulation, the red line with markers represents existing storage, while the blue line represents combined storage (as stated previously in this paragraph). The green bars in Figure 19 represent the monthly change in storage (secondary Y axis labeled on the right) due to all of these storage projects; during wetter years the storage may increase by 3 MAF, and this increase is reduced during dry periods as this storage is used to satisfy multiple beneficial uses.

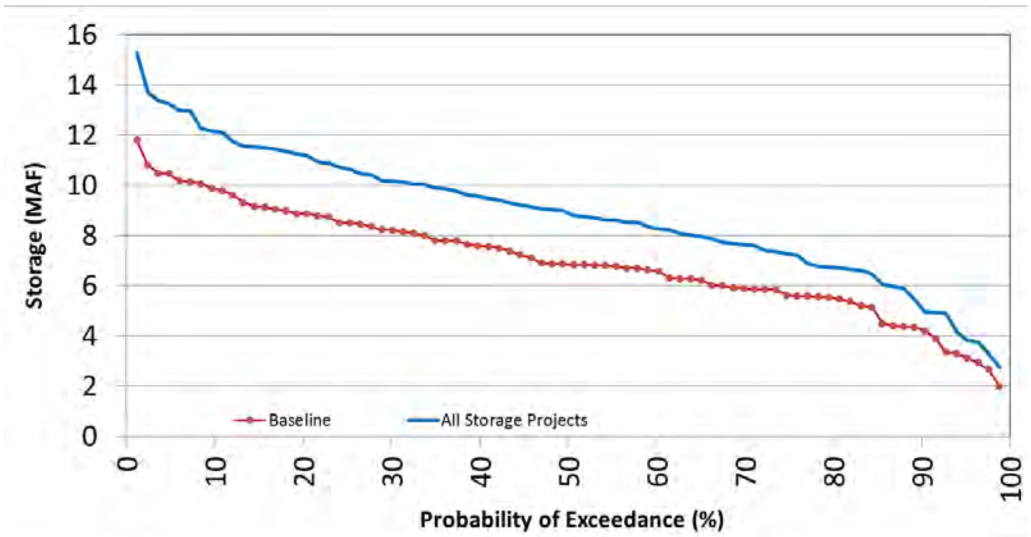

Figure 16. System Carryover (End of September) Surface Storage Exceedance Probability (Trinity, Shasta, Oroville, Folsom, San Luis, Sites, Los Vaqueros, Centennial, Millerton, Tulare Lakebed, and Temperance Flat)

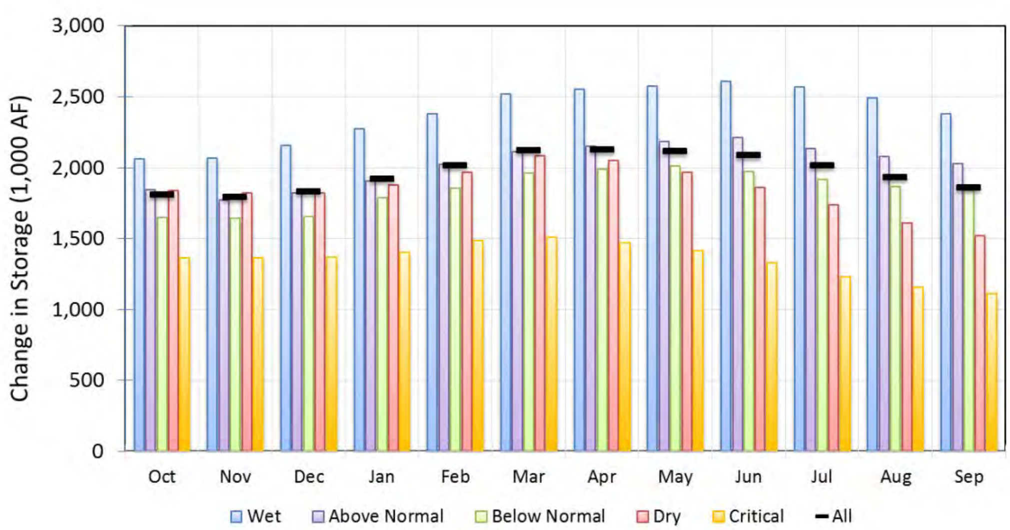

Figure 17. Average Monthly Change in Storage by Water Year Type (Trinity, Shasta, Oroville, Folsom, San Luis, Sites, Los Vaqueros, Centennial, Millerton, Tulare Lakebed, and Temperance Flat)

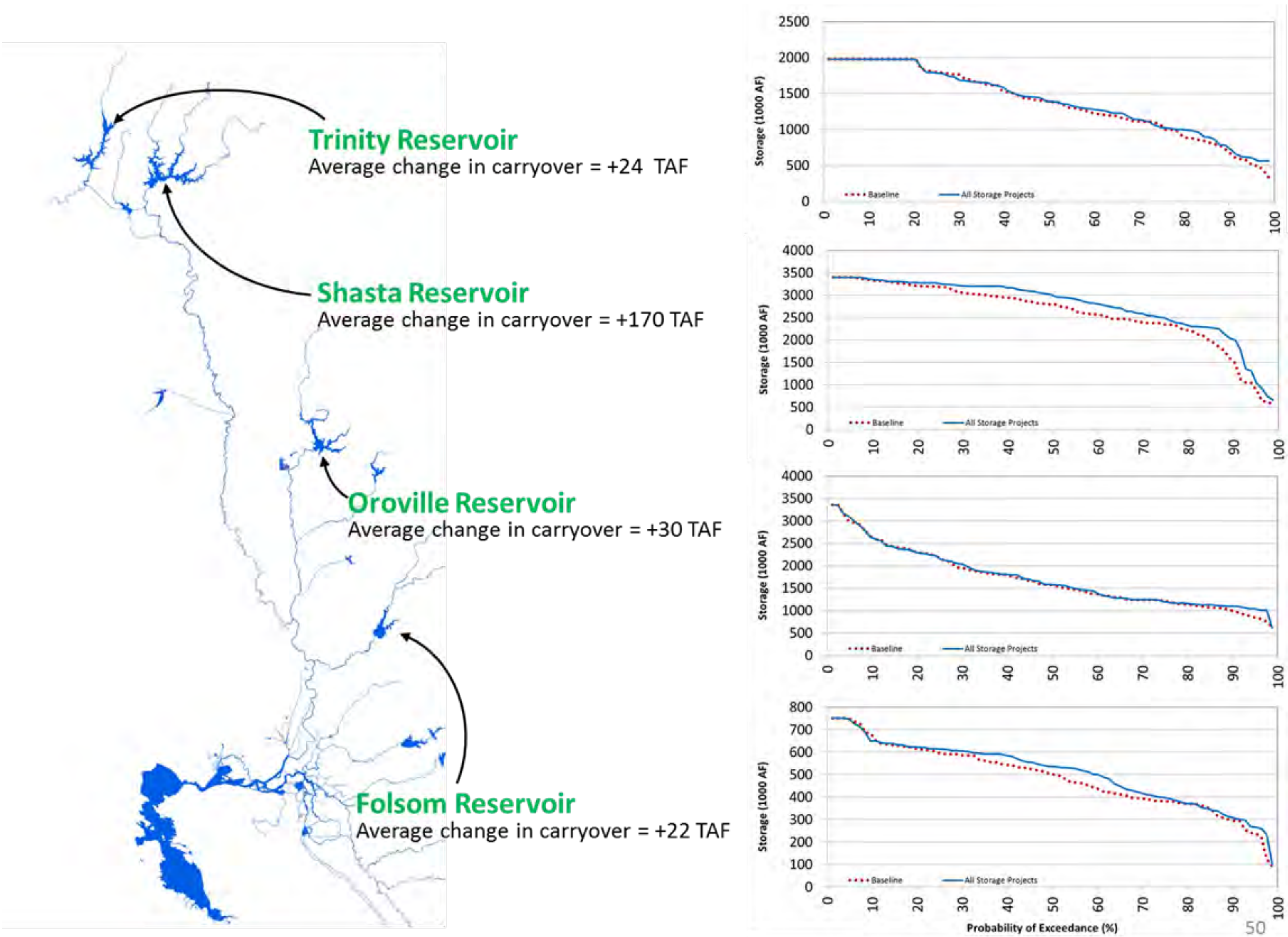

Figure 18. Carryover Storage of Existing CVP/SWP Reservoirs With and Without All Proposed Storage Projects

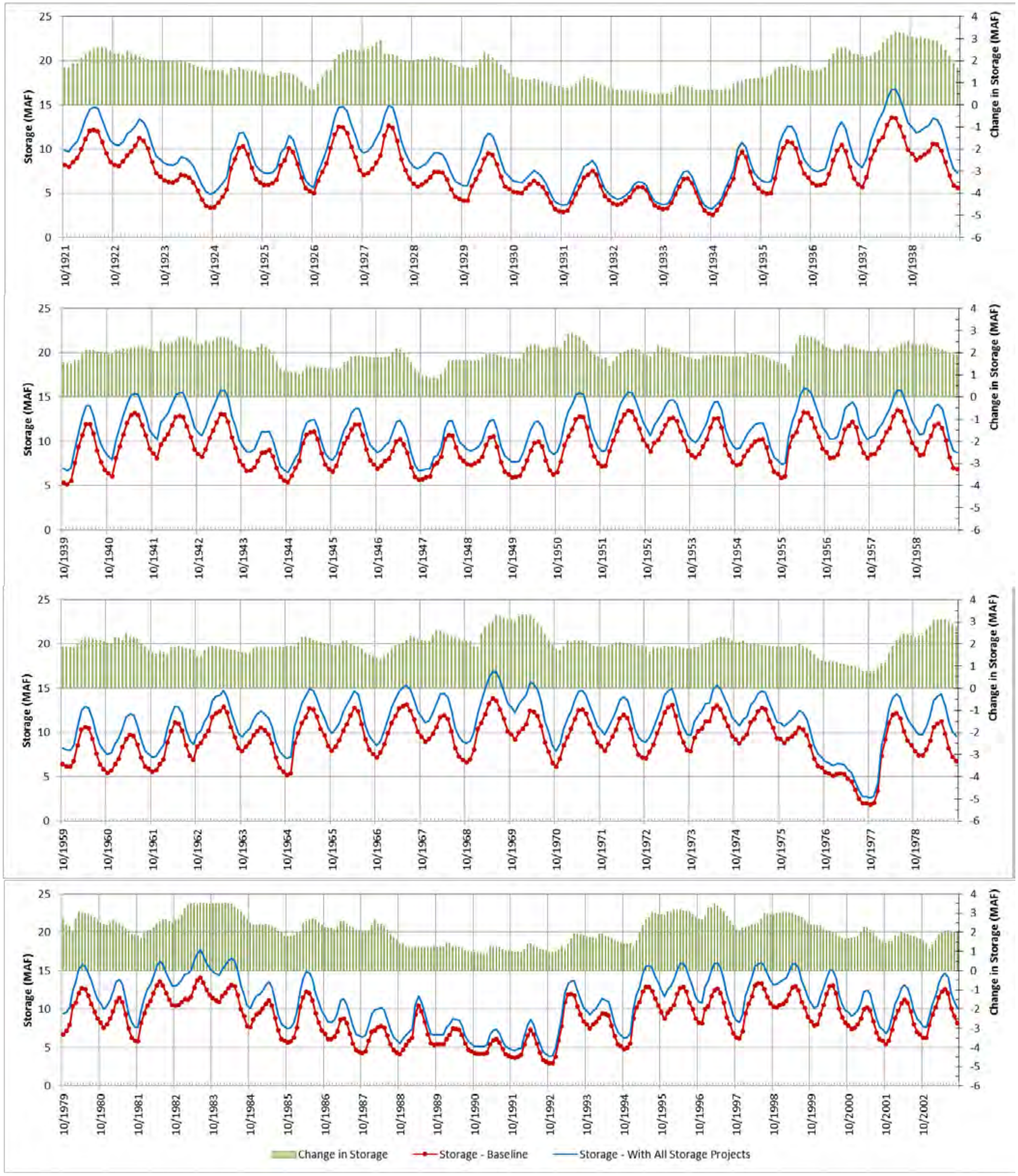

Figure 19. System Storage Monthly Operation
(Trinity, Shasta, Oroville, Folsom, San Luis, Sites, Los Vaqueros, Centennial, Millerton, Tulare Lakebed, and Temperance Flat)

Figure 20 summarized average annual water delivery increases by water year type due to the combined effect of all the storage projects. The average annual water supply increase is about 400 TAF while dry and critical year increases are approximately 720 TAF and 450 TAF, respectively.

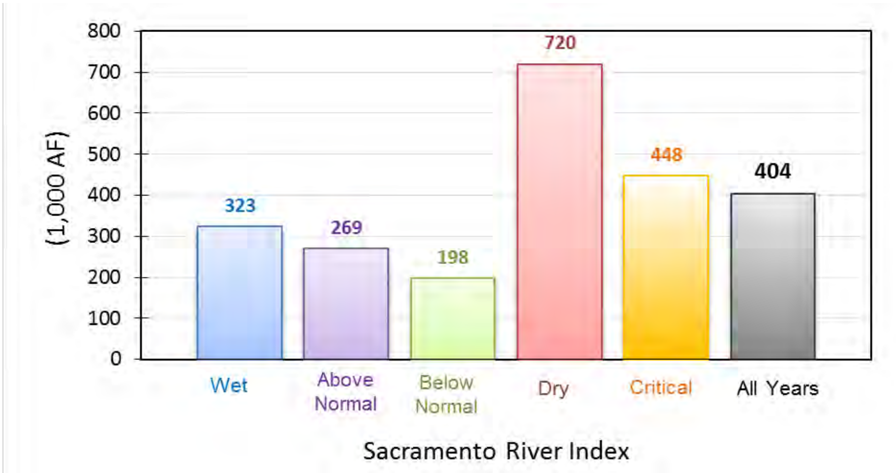

Figure 20. Average Annual Changes in Delivery with All Proposed Storage Projects

Many regions in California rely on conjunctive management to satisfy water demands for both urban and agricultural needs. In wetter years surface water use increases and groundwater pumping decreases. During dry years surface water use decreases and groundwater pumping increases. As regulatory requirements have constrained exports from the Delta over the last two decades, there has been an increase in reliance on groundwater for a large portion of California due to decreases in surface water supplies.

One of the key findings of this investigation is that increases in surface water storage will increase surface water deliveries, which would allow for reduced groundwater pumping as well as increase recharge opportunities, resulting in groundwater levels increasing. Surface water storage is needed to capture and manage surplus flows to increase beneficial uses and reduce reliance on groundwater. Figure 21 contains a chart showing annual increases in surface water deliveries, due to the combined benefits of all proposed storage projects, which are made in-lieu of groundwater pumping. This results in an average annual increase in groundwater storage of about 250 TAF. Due to the variable nature of surface water availability, groundwater banks are necessary to manage wet and dry years by banking water in wetter years and extracting water in dry years.

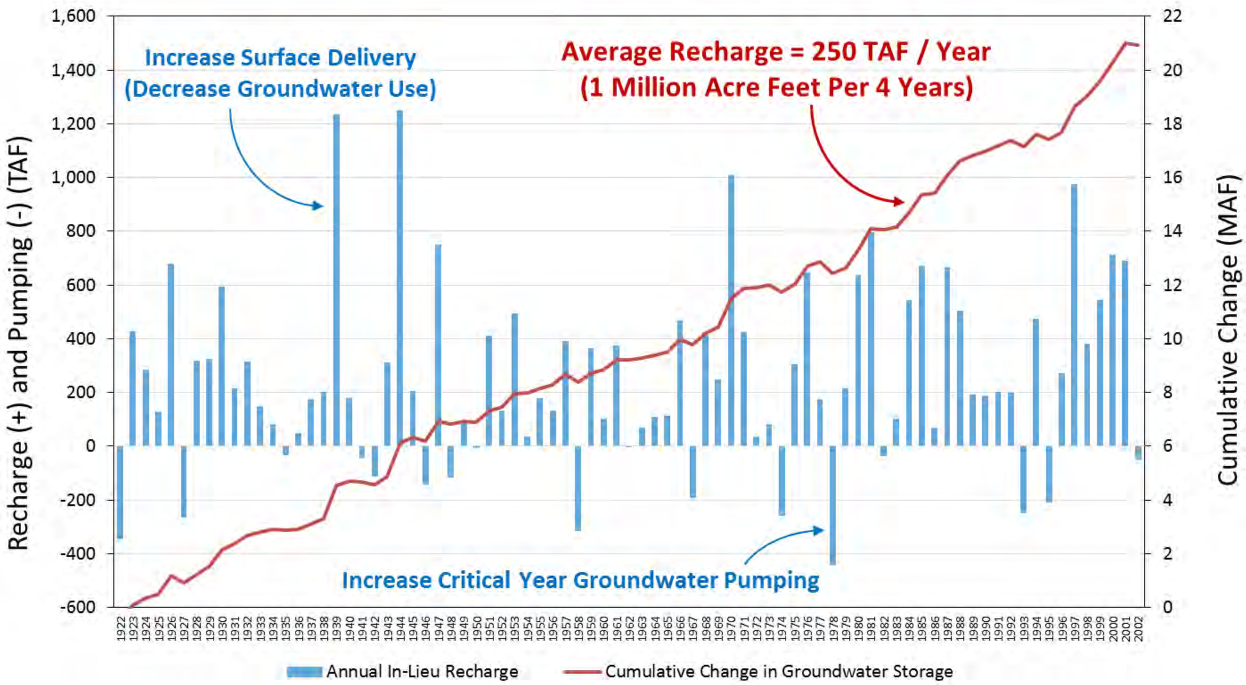

Figure 21. Annual and Cumulative Change in Groundwater Storage with All Storage Project

Delta Conveyance

Overview

Integrating North-of-Delta storage projects with storage projects south of the Delta is affected by the ability to convey water from north to south of the Delta. Although there are currently periods when unused Delta conveyance capacity could be used to transfer water developed from new storage, opportunities are constrained. In order to analyze the potential benefits of integrated storage operations with improved Delta conveyance, it has been incorporated into the modeling performed with all of the proposed storage projects as an additional analysis. New conveyance provides higher potential for physically integrating and interconnecting storage projects for operational flexibility, and for improved reliability and efficiency of integrated state-wide and regional water management systems. Assumptions for improved Delta conveyance capacity and operations are based on the Draft Biological Assessment for California WaterFix.

Analytical Results

Improved Delta conveyance increases the opportunity to use project and potential transfer water stored in upstream facilities to satisfy demands south of the Delta, which results in greater reservoir operational efficiency. Because improved conveyance provides greater opportunity to use project and potential transfer water stored north of the Delta, carryover storage levels in upstream reservoirs tend to be lower as the ability to convey water during the water year increases. Figure 22 contains an exceedance probability plot of carryover storage for all the proposed storage projects with existing key CVP and SWP reservoirs and combined storage, previously described. The red line with markers represents the Baseline, the blue line represents combined storage in the integrated modeling scenario, and the green dashed line represents combined storage with improved Delta conveyance. Figure 23 contains a plot of existing, combined storage, and combined storage with improved Delta conveyance for each month of the 82-year simulation, the red line with markers is existing storage, the blue line represents combined storage, and the green dashed line represents combined storage with improved Delta conveyance. Although carryover storage may generally be lower with improved conveyance, dry year carryover storage is less impacted than in other water year types.

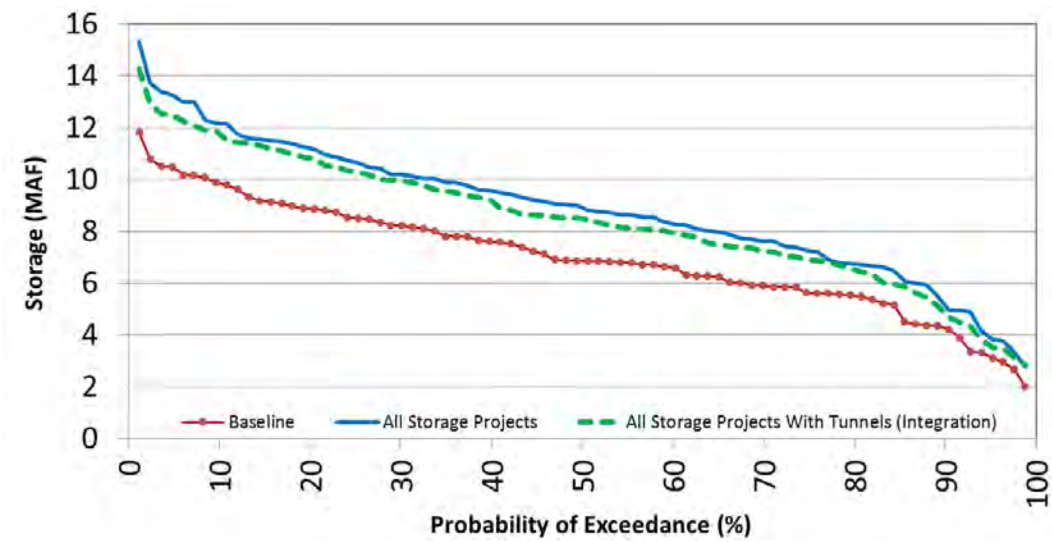

Figure 22. System Carryover (End of September) Storage with Tunnels Exceedance Probability (Trinity, Shasta, Oroville, Folsom, San Luis, Sites, Los Vaqueros, Centennial, Millerton, Tulare Lakebed, and Temperance Flat)

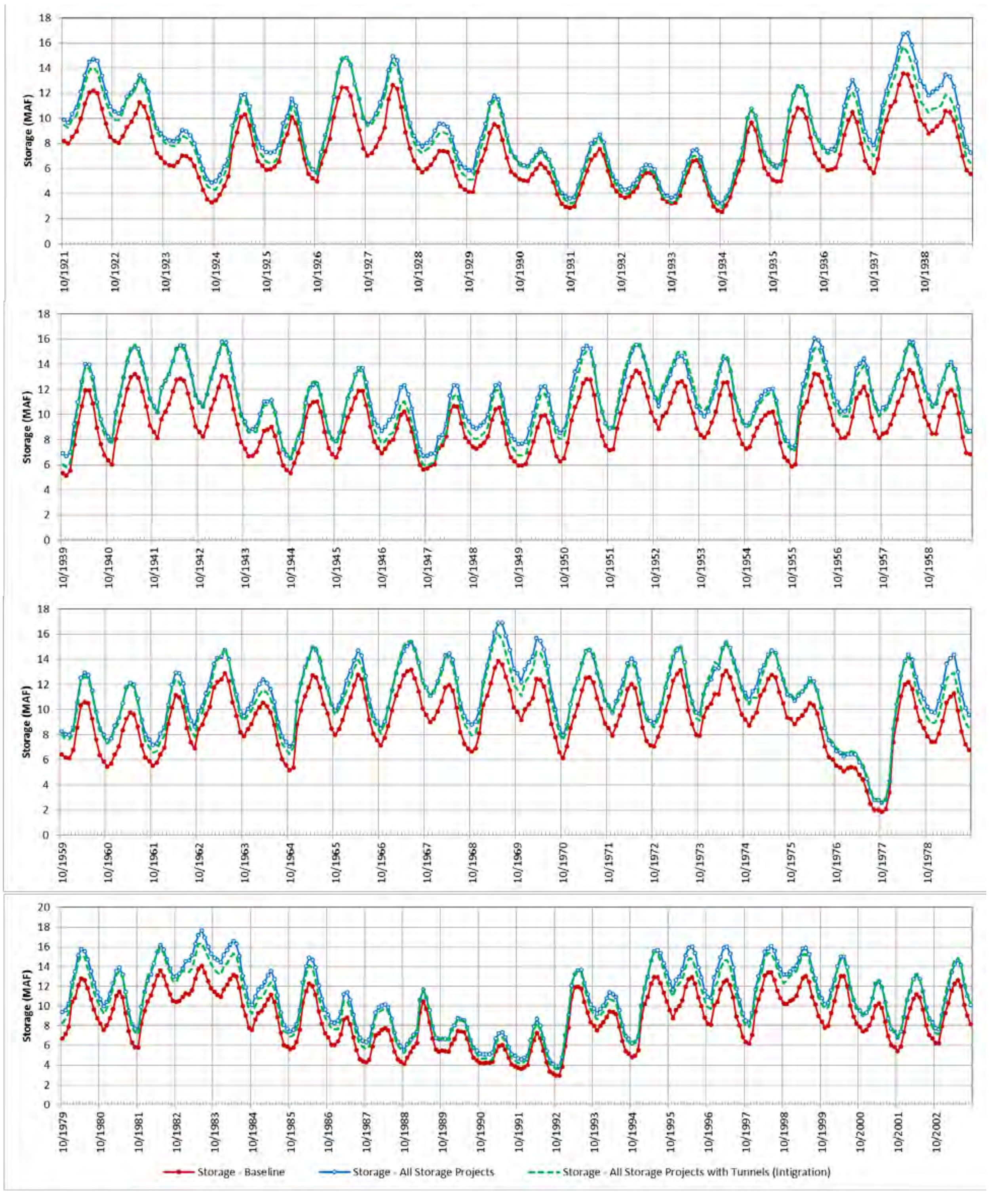

Figure 23. System Storage Monthly Operation with Improved Delta Conveyance (Trinity, Shasta, Oroville, Folsom, San Luis, Los Vaqueros, Centennial, Millerton, Tulare Lakebed, and Temperance Flat)

Figure 24 is a chart with summarized average annual water delivery increases by water year type due to the combined effect of all the storage projects with improved Delta conveyance. The average annual water supply increase is about 800 TAF. Thus, improved Delta conveyance increases yield by approximately 400 TAF.

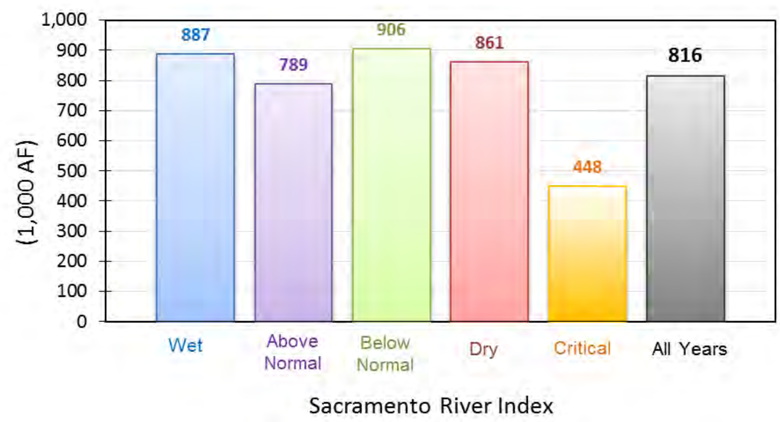

Figure 24. Average Annual Changes in Delivery with All Proposed Storage Projects and Improved Delta Conveyance

Figure 25 contains a chart, similar to Figure 21, showing annual increases in surface water deliveries resulting from the combination of all proposed storage projects and improved Delta conveyance. These supplies could be used to replace groundwater pumping, resulting in an average annual increase in groundwater storage of about 460 TAF. This is about a 200 TAF improvement attributable to improved Delta conveyance. Due to the variable nature of surface water availability, groundwater banks are becoming more important to manage wet and dry years by banking water in wetter years and extracting it in dry years.

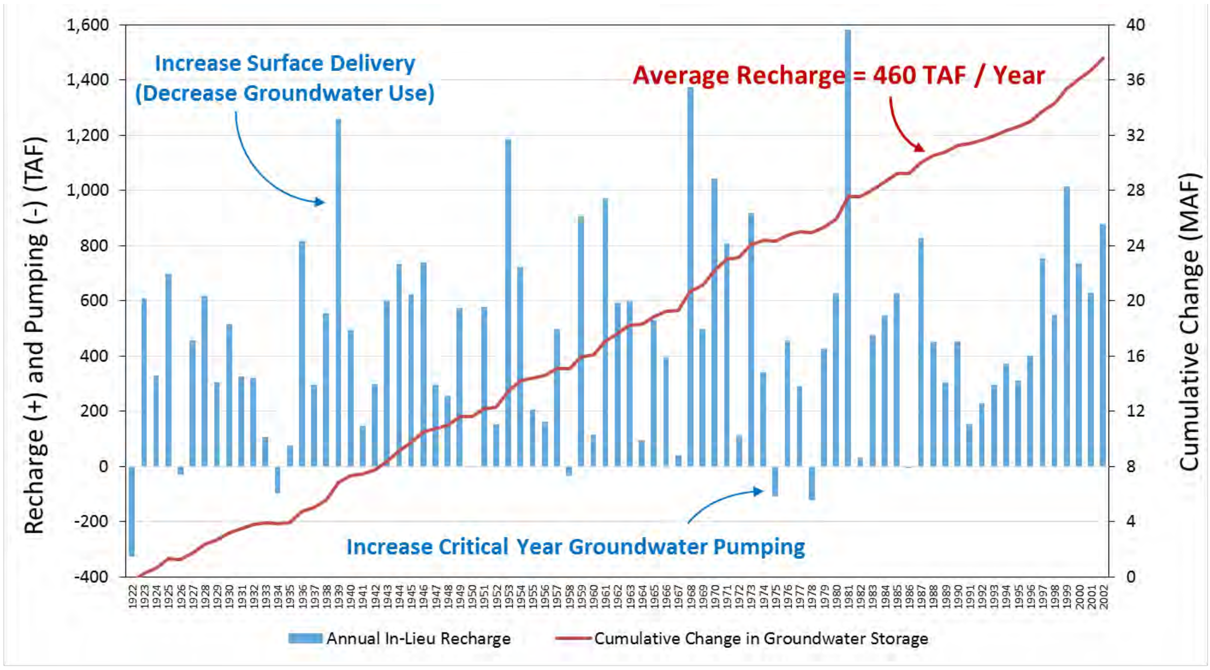

Figure 25. Annual and Cumulative Change in Groundwater Storage with All Storage Projects and Improved Delta Conveyance

Sites Reservoir

Overview

Located in the western foothills of the northern Central Valley (Figure 26), Sites Reservoir is a proposed, off-stream, storage project. The existing Tehama Colusa and Glen Colusa canals would be used to capture flood flows along the Sacramento River for storage in a 1.8 MAF reservoir. In addition to the two existing canals, a new intake/outlet will run from the Sacramento River (near the Moulton Weir) to the reservoir, providing a direct connection to the river, and to the rest of the CVP/SWP system. Capacity for fill or release from Sites are: Tehama-Colusa Canal of 2,100 cfs to fill, Glenn-Colusa Canal of 1,800 cfs to fill, and the Delevan Pipeline of 2,000 cfs to fill and 1,500 cfs release. Sites filling is regulated through bypass criteria at Red Bluff, Hamilton City, Wilkins Slough, and Freeport on the Sacramento River.

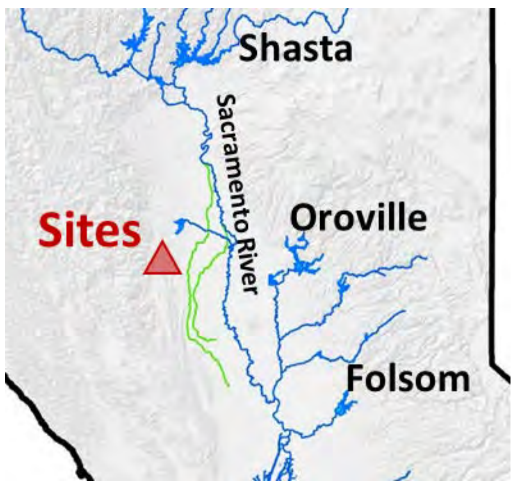

Figure 26. Proposed Sites Reservoir Location

Available Surplus

Figure 27, Figure 28, and Figure 29 contain average annual Sacramento River surplus by water year type, average monthly surplus by water year type, and annual surplus for the 82-year CalSim II simulation period. There are several large rain-fed creeks that enter the Sacramento River below Keswick Dam, with average annual flow of these creeks reaching approximately 2.7 MAF. When considering the timing of Sacramento River surplus, when the Delta is in surplus conditions, there is an average of about 2 MAF of surplus.

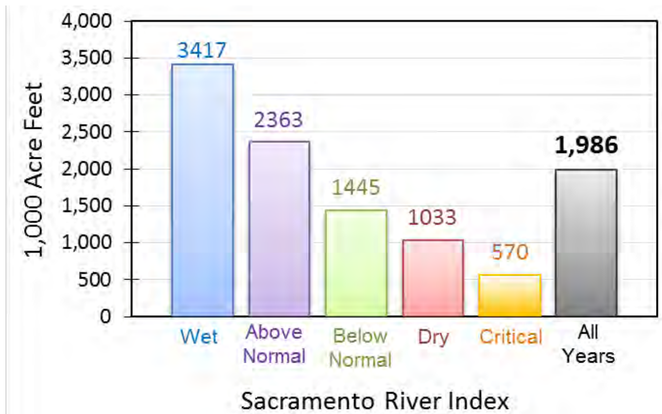

Figure 27. Annual Average Lower Sacramento River Surplus by Water Year Type

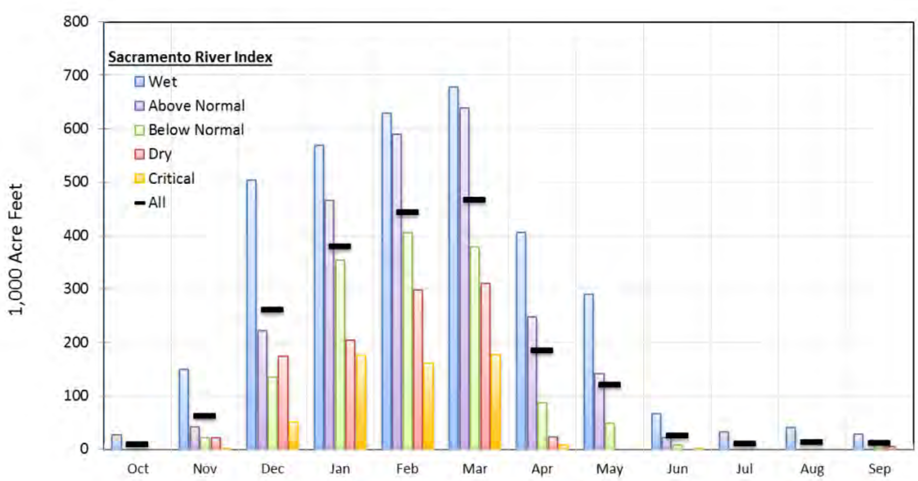

Figure 28. Monthly Average Lower Sacramento River Surplus by Water Year Type

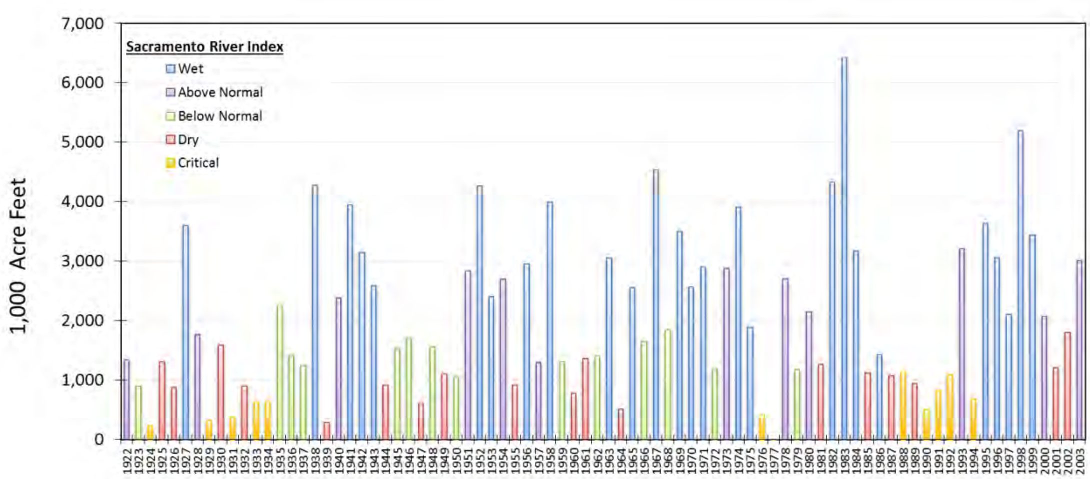

Figure 29. Annual Lower Sacramento River Surplus by Water Year Type

Even in critical years, there is often surplus water available for diversion into the proposed Sites Reservoir. Figure 30 contains a plot of daily Sacramento River flow at Bend Bridge during the recent California drought in Water Year 2015. Considering this flow and the Sacramento River bypass criteria for diversion to Sites, approximately 400 TAF could have been stored in Sites during the December through February period. During a critical drought situation this water could have significantly improved both ecosystem and water supply conditions. Conversely, in the current 2017 wet water year, if Sites began operating at the beginning of the water year, it could have gone from empty to full capacity of 1.8 MAF by May 1.

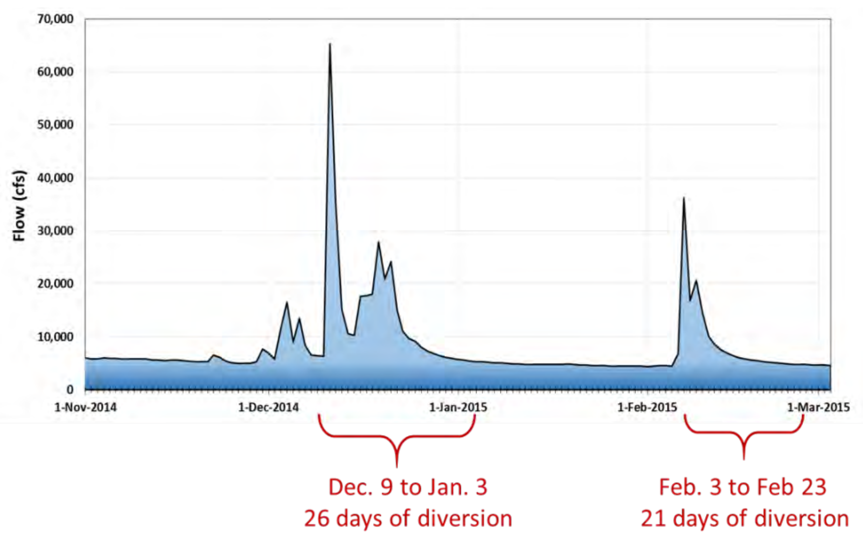

Figure 30. Sacramento River at Bend Bridge during Water Year 2015

Due to its size, location, and available surplus water, the potential for Sites Reservoir's integration with the larger CVP/SWP system to provide benefits on a state-wide basis is significant. Releases from Sites Reservoir may be made in lieu of releases from Shasta, Oroville, or Folsom Reservoirs when these reservoirs are lower in storage yet would normally be looked to satisfy regulatory requirements in the

Delta. Sites integration with Shasta may also be managed to improve cold water resources and for temperature benefit in the Sacramento River below Keswick by allowing more water to be retained in Shasta. Sites may also be operated as a backstop, keeping more water in Sites during wet years and lowering other project reservoirs to meet demands, resulting in increased flood reservations and the potential to capture high flows that might otherwise be spilled. Under the same principle, in dry years Sites could be operated to meet CVP/SWP demands first, allowing other reservoirs to retain a greater cold water pool and providing a temperature benefit, as well as local water supply reliability.

Reservoir releases that occur around mid-October from existing CVP/SWP reservoirs must be maintained through March to protect spawning habitat; therefore, Project reservoir releases are typically maintained at minimum required levels to avoid depleting storage if the winter rainfall is below normal. However, Sites Reservoir releases enter the Sacramento River below critical spawning habitat. As a result, releases from Sites during fall months may be conveyed through the Delta and provide South-of-Delta water supply, or potentially provide environmental flows as well.

Analytical Results

Figure 31 contains a plot of proposed Sites Reservoir operation for each month of the 82-year simulation. Although Sites is operated in an integrated manner, each year storage generally remains higher until dry and critical years. Sites carryover (end of September) storage exceeds 1 MAF in about 75 percent of years, and as such, in many years additional water supply and ecosystem benefits would be possible if additional demands were to be placed on the reservoir. In modeling performed for Sites Reservoir Draft environmental documentation, additional ecosystem and Delta water quality demands are placed on Sites Reservoir and its contributions to those needs are significantly greater.

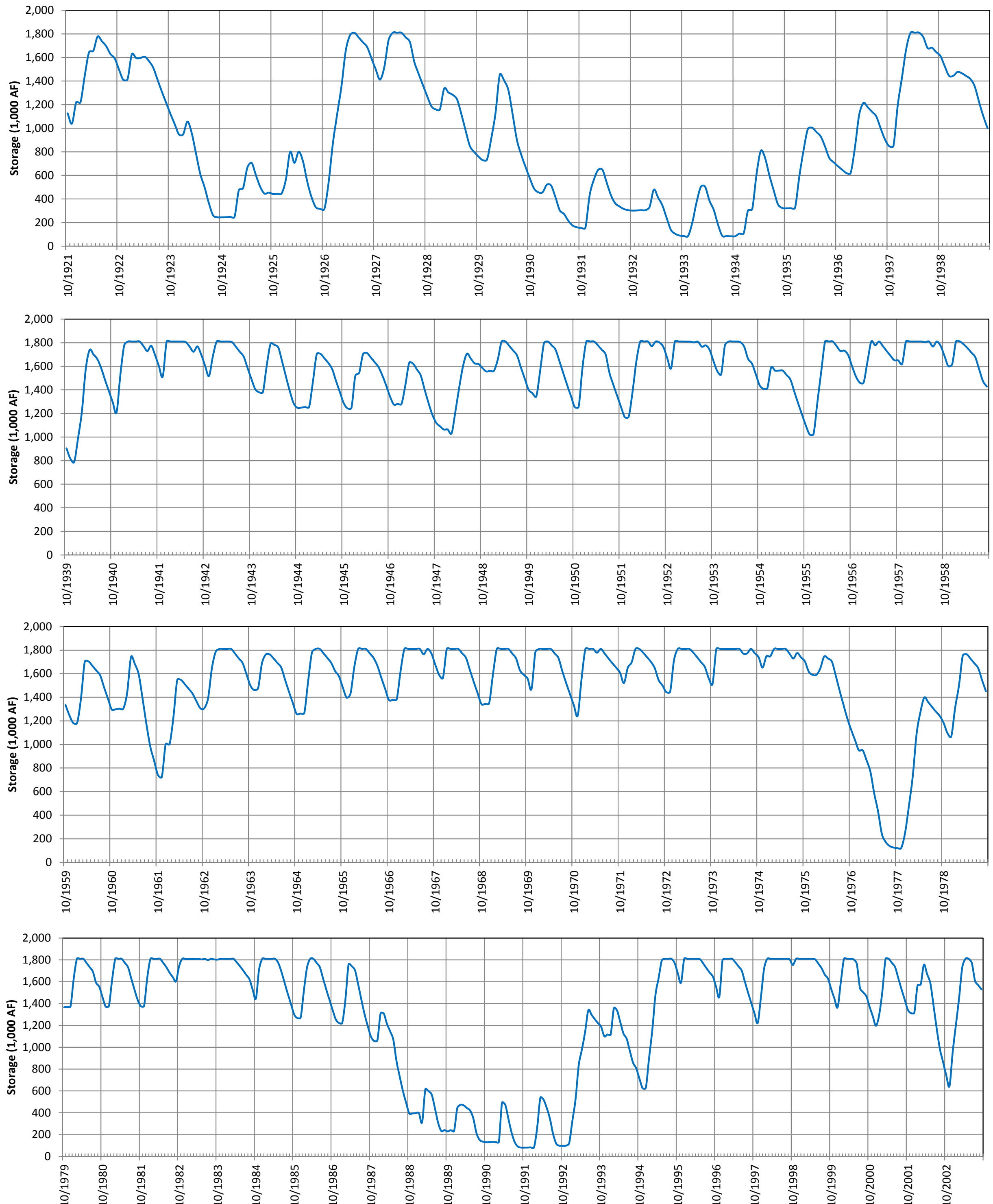

Figure 31. Sites Reservoir Monthly Storage

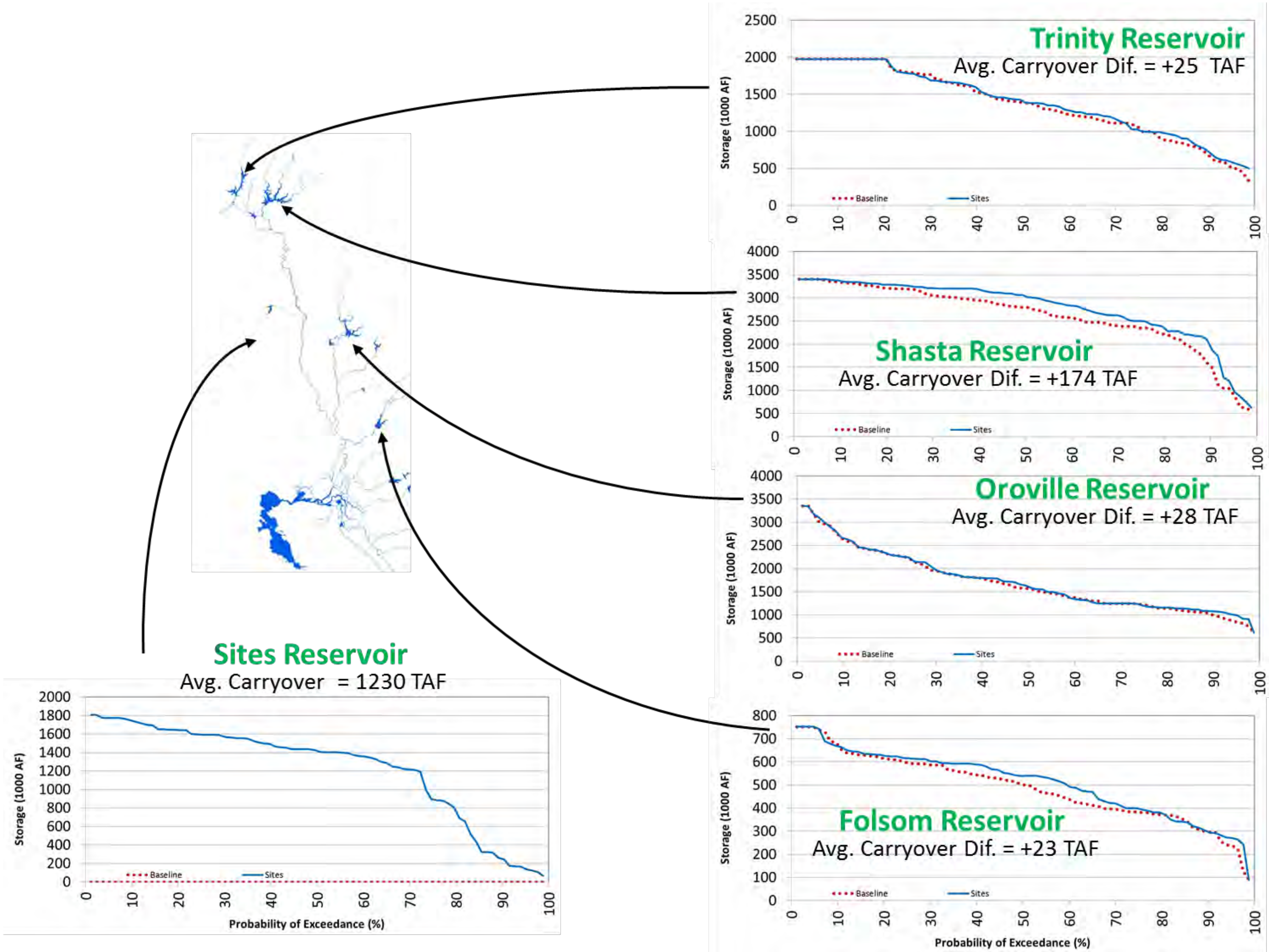

Figure 32. Sites Reservoir Integrated Operation Effect to Project Reservoir Storage

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Figure 32 illustrates exceedance probability plots for key CVP, SWP, and Sites reservoirs, showing both "baseline" and "with Sites" scenarios. Each reservoir remains higher with Sites reservoir included, with an average annual increase in Sacramento Basin carryover storage of approximately 1.5 MAF. This can contribute to improved ecosystem and water supply management, as well as other benefits.

Figure 33 contains average annual water supply increases, by water year type, for various CVP and SWP contract categories when utilizing Sites Reservoir. Average annual deliveries increase by about 260 TAF, while dry and critical year benefits exceed 400 TAF.

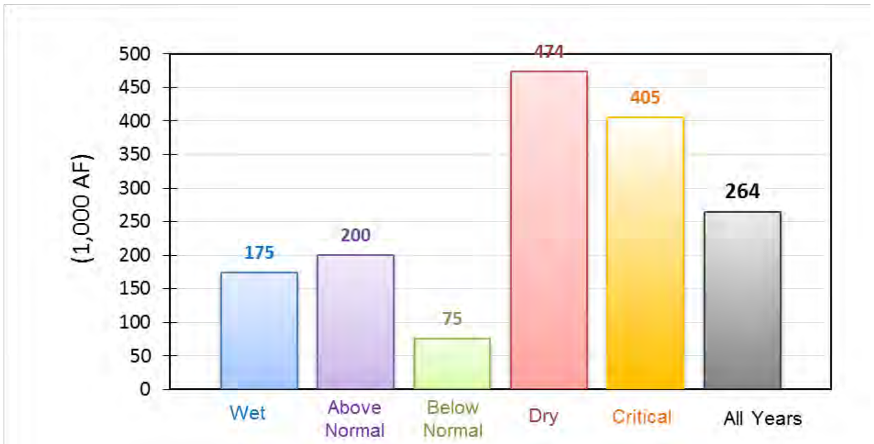

Figure 33. Sites Reservoir Delivery Summary

Centennial Reservoir

Overview

Nevada Irrigation District (NID) is proposing a new storage facility within the Bear River Watershed, called Centennial Reservoir, which is to be used as a part of the Yuba-Bear Project and would have a capacity of approximately 110 TAF. Centennial would be located immediately upstream of NID's Lake Combie and downstream of NID's Rollins Reservoir. Figure 34 shows the general location of the proposed Centennial Reservoir on the Bear River.

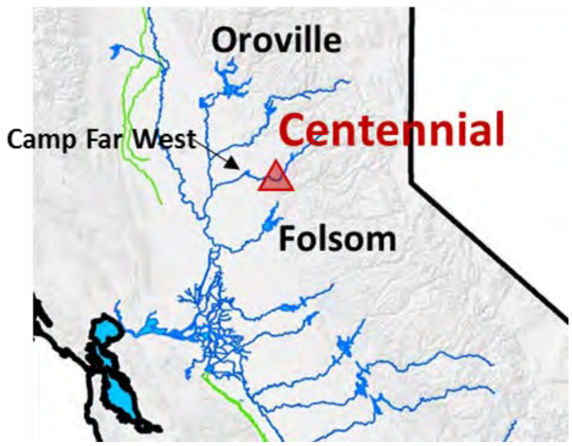

Figure 34. Location of Centennial Reservoir

The Bear River system, which is tributary to the Feather River, is "connected" to the upper American River system by canals that convey water between the two basins upstream of Folsom Lake. Supply from Centennial may be used to augment American River supplies when Folsom has low storage conditions, and provide water supply reliability to urban water users, while enhancing temperature conditions in the lower American River. Releases from Centennial to the American River may also help conserve storage in Shasta, and contribute water supply benefits to the CVP/SWP system, including in areas that rely on Delta exports. Releases from Centennial may also be used to augment flow in the lower Bear River, below Camp Far West Reservoir, and the lower Feather River. At times when Oroville releases are made to maintain adequate flows in the lower Feather River, Centennial releases may be integrated with Oroville releases to conserve storage levels in Oroville Reservoir.

Available Surplus

There is an annual average of 260 TAF of surplus in the Bear River. Figure 35 contains average annual Bear River surplus by water year type. There is an average surplus of 7 TAF in critical years, and approximately a half a million acre feet of surplus in wet years. In general, surplus is available in the Bear River system from December through May, with very little surplus available during the summer months (Figure 36). Although surplus is available in the Bear system in most years, there have been periods spanning 3-years when no surplus above what would be stored for local supply was available (Figure 37).

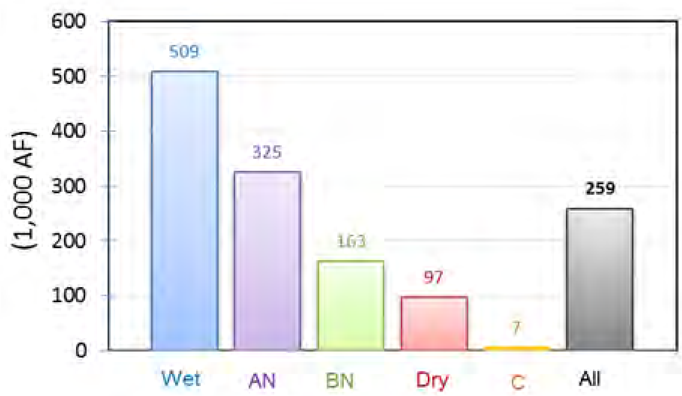

Figure 35. Annual Average Bear River Surplus by Water Year Type

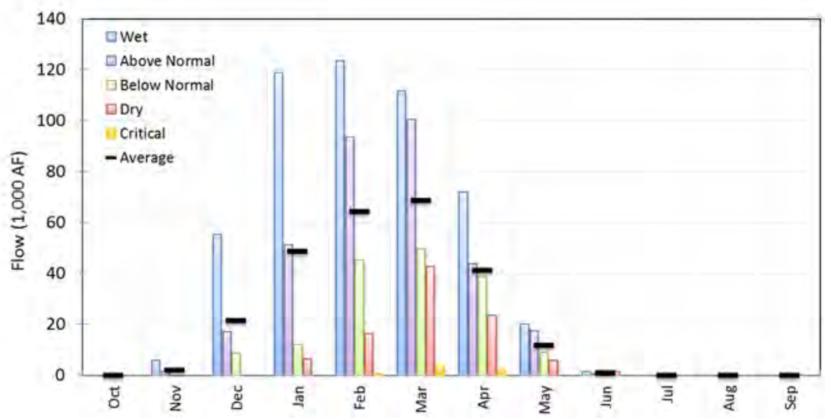

Figure 36. Monthly Average Bear River Surplus by Water Year Type

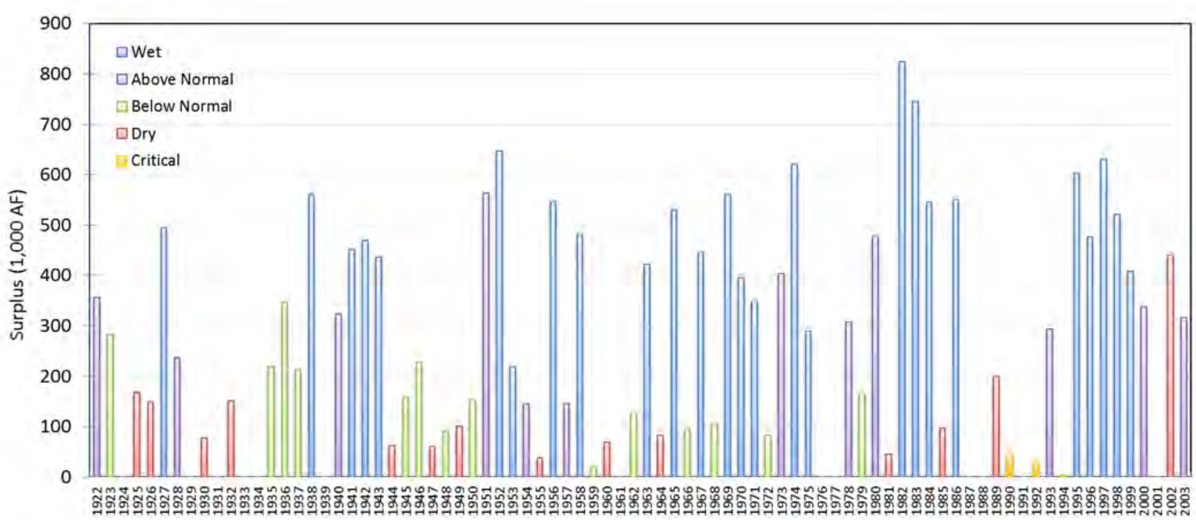

Figure 37. Annual Bear River Surplus by Water Year Type

Analytical Results

There are numerous possible ways Centennial Reservoir may be operated and integrated with operations of existing facilities. For the purpose of this analysis two operational scenarios are used to demonstrate how Centennial Reservoir may be operated with the CVP/SWP system. In both scenarios, Centennial Reservoir operates to augment American River supplies when Folsom carryover storage is forecasted to be below 350 TAF. Releases are made down the Bear River to augment system-wide supply when CVP South-of-Delta agricultural water service contract allocations are below 20 percent. In this analysis, CVP allocations are used as a simple indicator of system conditions, and releases down the Bear River are integrated with both the CVP and SWP and shared among the projects. Releases are only made from Centennial Reservoir when its carryover storage is forecasted to be above 40 TAF. Figure 38 contains a bar chart showing Centennial Reservoir carryover storage, when operated only for NID, with the orange portion of the bars indicating the volume of storage available for use outside NID. Figure 39 contains a bar chart showing Centennial Reservoir carryover storage with system integration; the black points are storage without integration and the blue bars are storage with integration. Figure 40 contains an annual bar chart showing how much water from Centennial is delivered to the American River and how much water is released down the Bear River and on to the Feather. While the average annual release to the Bear and American rivers is 3 TAF each, total annual releases can be as much as 50 TAF, which is significant during critical years.

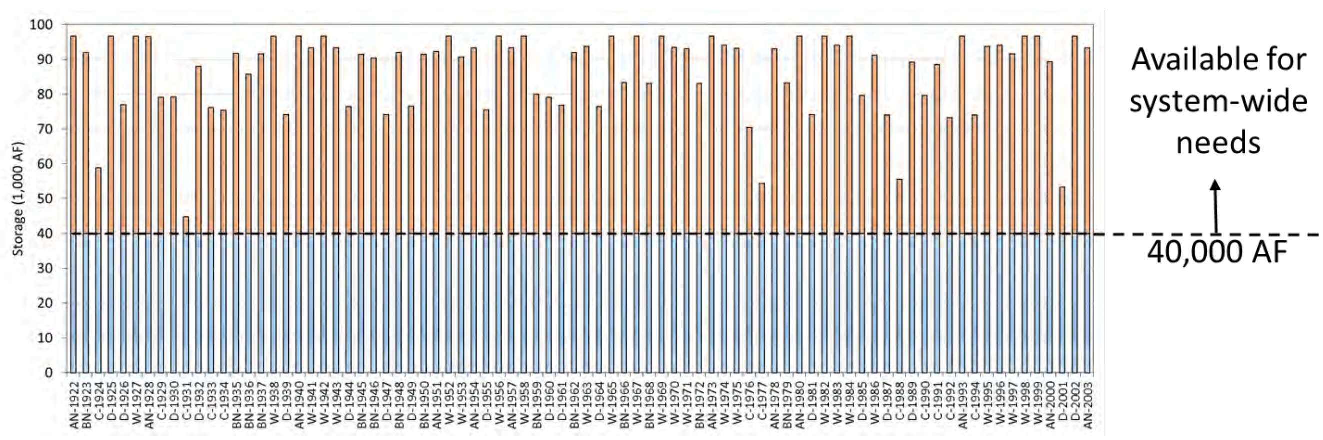

Figure 38. Centennial Reservoir End of September Storage when Operated for “Local” Needs

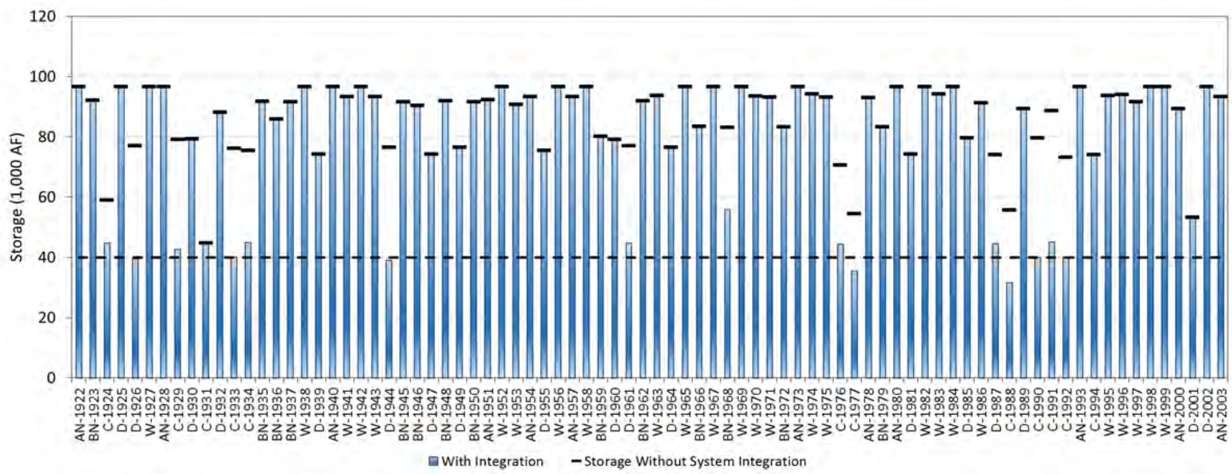

Figure 39. Centennial Reservoir End of September Storage with Integrated Operation

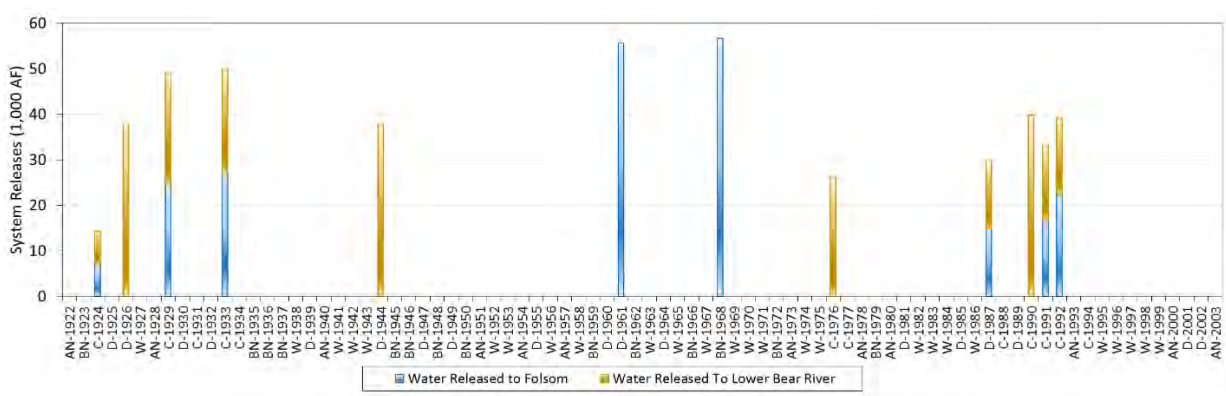

Figure 40. Centennial Releases for Integrated Operation

American River Conjunctive Management

Overview

Water purveyors diverting from the American River rely on a mix of groundwater and surface water for their supplies. These purveyors depend on diversions from Folsom Dam and the American River, gaining their supplies through CVP contracts, water rights, and water transfers. Some of the purveyors in the American River Basin rely solely upon surface water to meet demands, some use all or mostly groundwater, and others meet their demands from groundwater and surface water. Increasing connectivity between American River Basin diverters would expand conjunctive management capabilities. This could provide state-wide benefits by increasing capacity for dry-year transfers as local users could more readily shift to groundwater while allowing surface supplies to be temporarily transferred to other users.

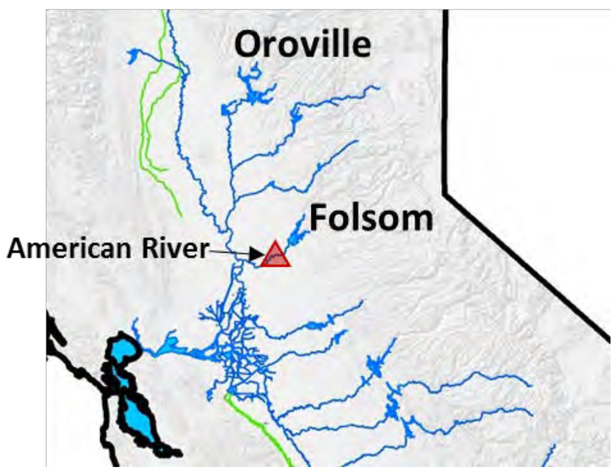

Figure 41. American River Conjunctive Management

Enhancing American River conjunctive management will provide multiple benefits, including contributing to long-term groundwater sustainability, improved regional water supply reliability and drought resiliency, as well as increased flexibility in managing flows in the lower American River for both ecosystem and water supply benefits. With the availability of surplus water in the American River, and the existing infrastructure, there is potential to improve groundwater storage conditions in the American River region. The opportunity to improve supply reliability for the American River region may come by increasing diversions from Folsom Reservoir in years when Folsom carryover storage is high, thereby decreasing the probability of spilling in the following year. Increases in surface water delivery during wet years, in lieu of groundwater pumping, would improve groundwater storage conditions and increase reliability for municipal and industrial (M&I) water users that depend on groundwater in dry years.

American River basin diverters are currently conducting a planning study, called the Regional Water Reliability Plan, to determine the potential additional water yield that could be generated by enhanced conjunctive use operations. Results of the Regional Water Reliability Plan will be available in early 2018.

Available Surplus

Because the enhanced conjunctive management assumptions of the Regional Water Reliability Plan are not yet available, this study relied on a conservative approach for identifying the availability of surface water for conjunctive management. This study assumed that additional use of surface water within the American River Basin would only be possible when surplus flows are present. For this study, available surplus in the American River is defined as flow above minimum required flow below Nimbus Dam and in the Lower American River at H Street. In addition to surplus on the American River, the Delta must also have surplus outflow to allow diversion of surplus American River flow without effects to other areas of the CVP/SWP. Figure 42, Figure 43, and Figure 44 contain average annual American River surplus by water year type, average monthly surplus by water year type, and annual surplus for the 82-year CalSim II simulation period. Although there is surplus available in almost every year, the surplus is generally available during the winter months in all year types, and there is typically no surplus flow during summer months when demands are the highest.

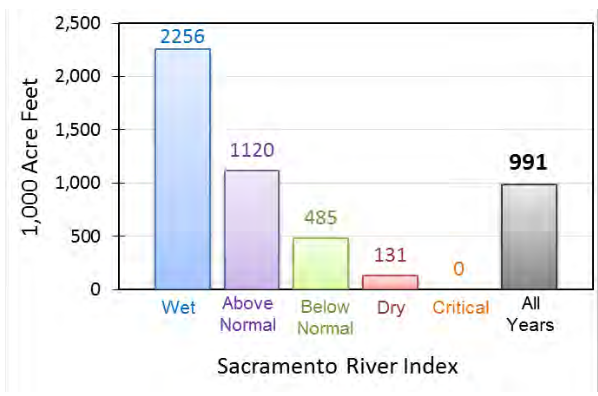

Figure 42. Annual Average Lower American River Surplus by Water Year Type

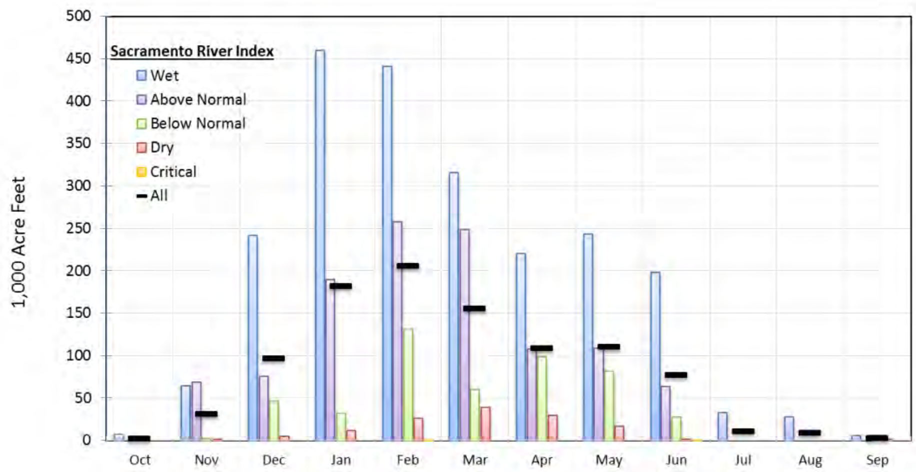

Figure 43. Monthly Average Lower American River Surplus by Water Year Type

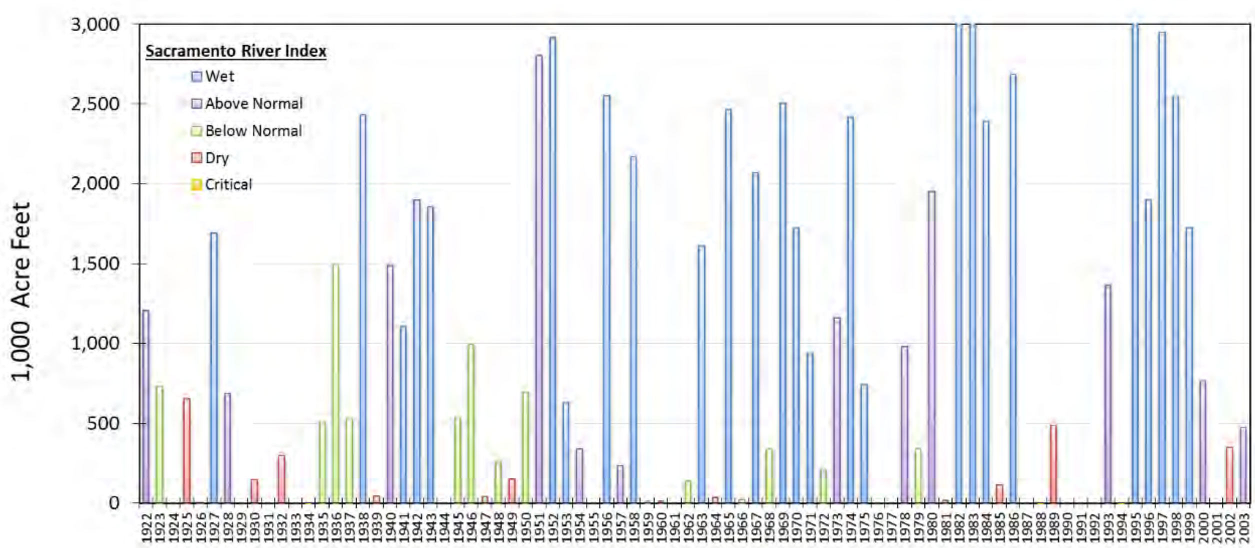

Figure 44. Annual Lower American River Surplus by Water Year Type

In order to divert additional water from Folsom Reservoir, storage levels must be above levels necessary to protect the lower American River, Delta, and CVP contractors south of the Delta. This analysis assumed that additional local delivery of water stored in Folsom Reservoir would only occur in years with Folsom Reservoir carryover above 450 TAF, and Jones pumping plant operating at full capacity for the entire summer season. Figure 45 illustrates a bar chart of Folsom Reservoir carryover storage with the black markers representing simulated carryover storage, the blue bars representing the amount of storage above 450 TAF, and the red bars representing years when additional groundwater pumping is desired to protect Folsom Reservoir storage.

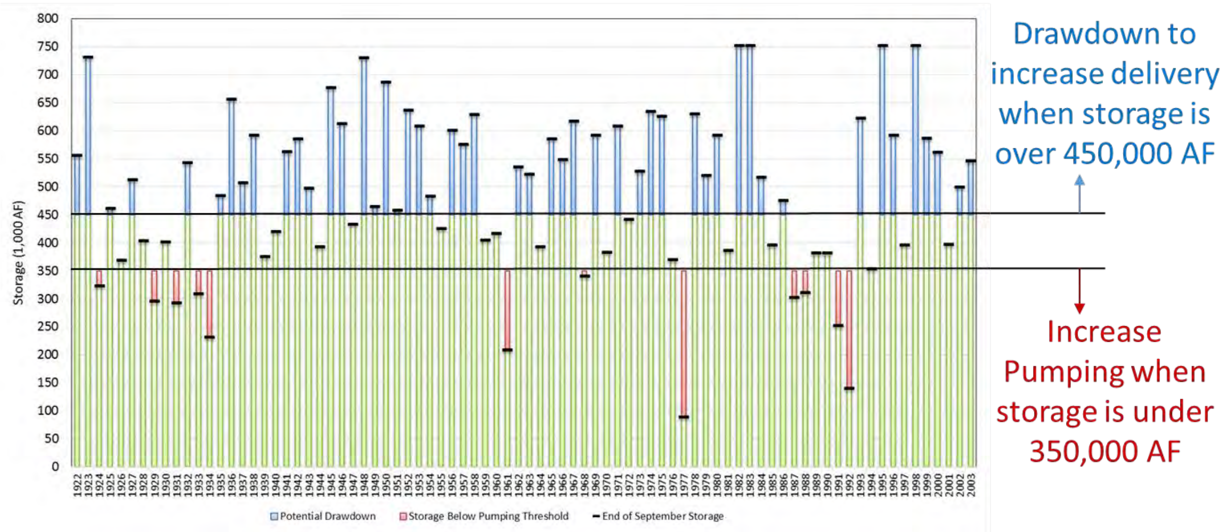

Figure 45. End of September Folsom Storage with Potential Drawdown and Groundwater Pumping Trigger

Analytical Results

Figure 46 contains a summary of the conjunctive management operation analyzed. The blue bars represent increased diversions when both the American River and Delta have surplus flows, the red bars represent increased diversion from Folsom storage, the green bars signify increases in groundwater pumping during low storage conditions, and the black dashed line shows cumulative changes in groundwater storage. On average, there is 9 TAF of increased diversion of surplus, 6 TAF increased diversion of water stored in Folsom, and a 3 TAF increase in dry year groundwater pumping. The net annual average increase to American River region groundwater is 12 TAF. Figure 47 contains a plot of Folsom storage, with and without conjunctive management, for each month of the 82-year simulation. The red line with markers denotes baseline storage, while the blue line denotes storage with conjunctive management. There are many dry years where Folsom Reservoir storage is improved; however, there are still some years when Folsom storage cannot be improved.

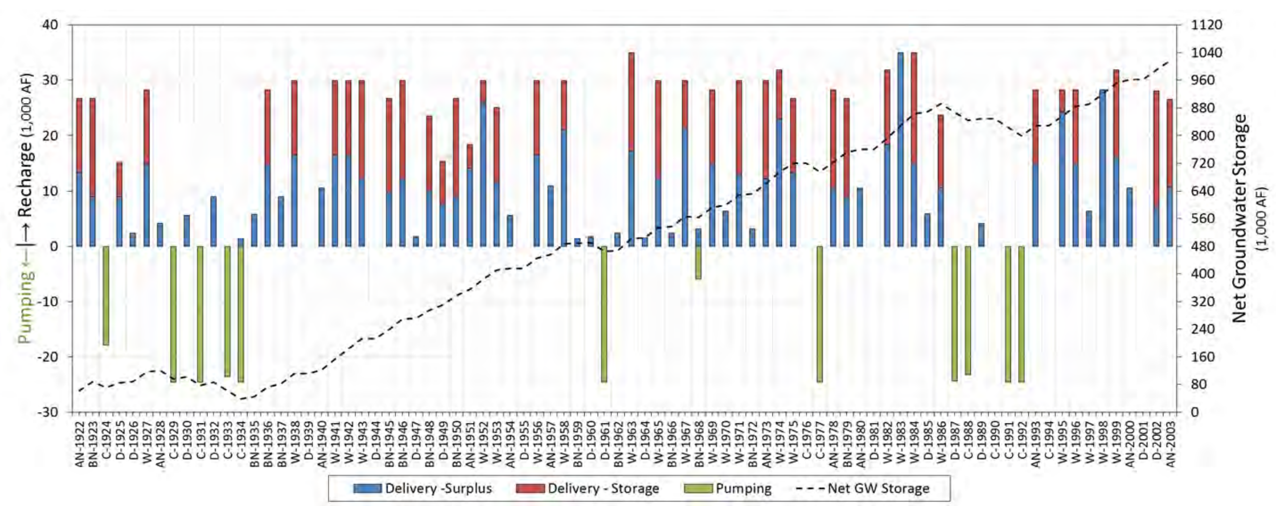

Figure 46. American River Conjunctive Management Operations

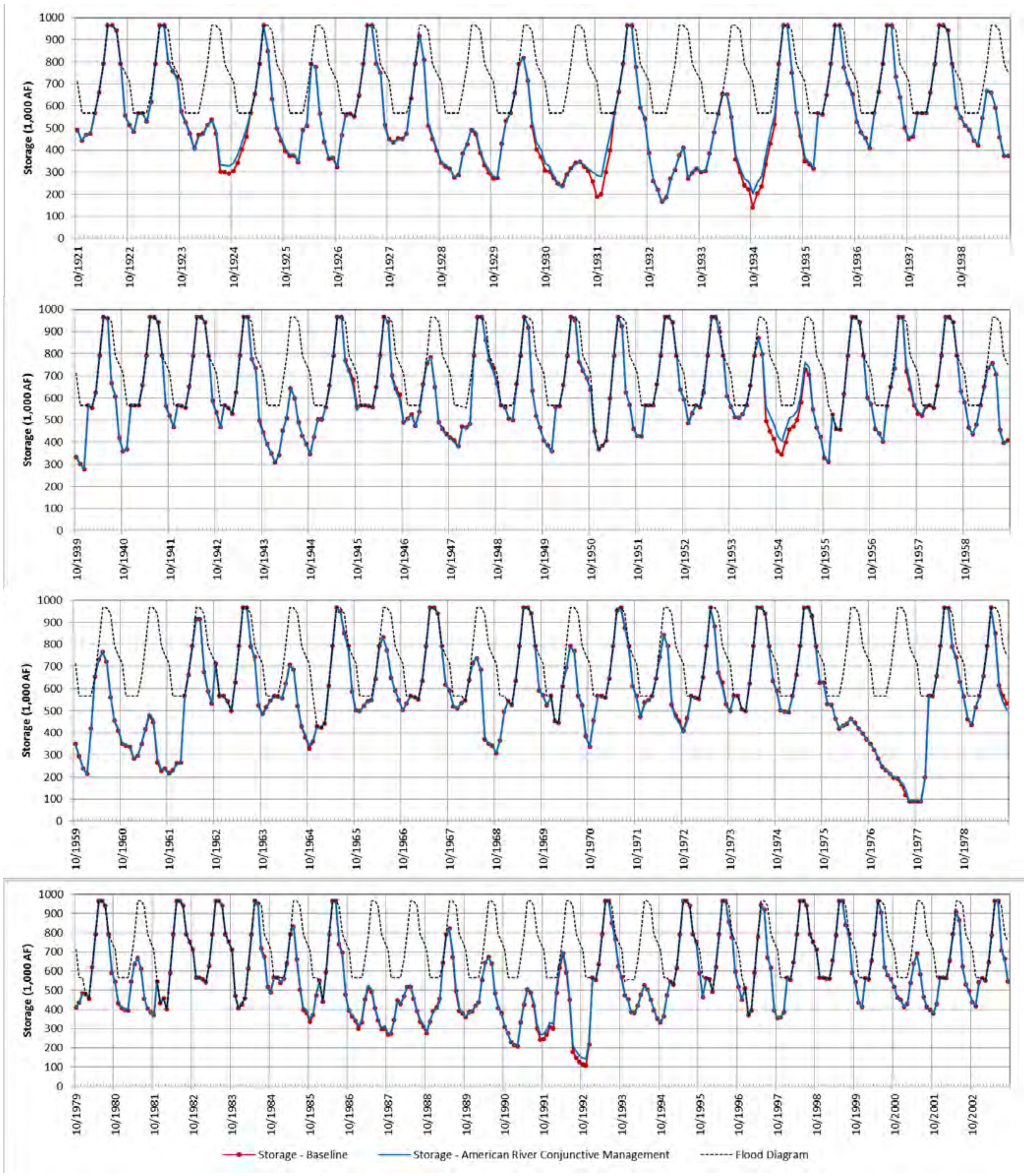

Figure 47. End of Month Folsom Storage with Baseline and American River Conjunctive Management

Los Vaqueros Reservoir Expansion

Overview

Contra Costa Water District's (CCWD) Los Vaqueros Reservoir (LV) is located in the foothills west of Clifton Court Forebay, which is situated near the southern limit of the Sacramento-San Joaquin Delta (Figure 48 contains a location map). LV is a 160 TAF capacity, off-stream reservoir, filled by Delta diversions. CCWD has Delta pump stations at Mallard Slough, Rock Slough, Old River, and Middle River (located on Victoria Canal). LV is filled with CVP water, allocated to CCWD under the authority of a long-term water supply contract and Delta surplus water, provided for under an existing Los Vaqueros water right held by CCWD. CCWD also has an agreement with the East Bay Municipal Utility District (EBMUD), the Sacramento County Water Agency (SCWA), and the Freeport Regional Water Authority to use the Freeport Regional Water Supply Project intake and pump station near Sacramento and associated conveyance facilities to convey up to 3.2 TAF per year to LV, by way of an intertie with EBMUD's Mokelumne Aqueduct No. 2. CCWD operates LV to help manage water quality, specifically salinity. The original purpose of LV was to reduce salinity of delivered water to CCWD's service area and provide emergency storage. The general plan of operation was to fill LV when low salinity water was available in the Delta, and to draw on LV storage for delivery to CCWD's service area when Delta salinity was high.

While the original purpose for LV was to lower salinity of CCWD deliveries, its location lends itself to integrated operations with other water districts for mutual benefit. Those benefits include improved water supply reliability and quality, increased emergency supplies and transfer capabilities, and enhanced ecosystem improvements and conjunctive use. The purpose of the Los Vaqueros Reservoir Expansion Project is to add the storage capacity and conveyance options necessary to maximize the benefits of integration. Potential components of the Los Vaqueros Reservoir Expansion Project are as follows:

1. Expansion of LV storage capacity by 115 TAF from 160 TAF to 275 TAF
    a. Emergency pool – 44 TAF to 70 TAF (depending on year type)
2. Delta Diversion Capacity
    a. Rock Slough – 350 cfs
    b. Old River – 250 cfs
    c. Middle River – 250 cfs
    d. Mokelumne Intertie – 155 cfs
3. Pipeline Capacity
    a. Old River Pipeline – 320 cfs to 500 cfs
    b. Transfer Pipeline – 200 cfs fill reservoir, 400 cfs deliver from reservoir
    c. Los Vaqueros Pipeline – 400 cfs
4. Construction of a 300 cfs Transfer-Bethany Pipeline connecting LV and the associated Delta intakes and conveyance facilities with the California Aqueduct at Bethany Reservoir.
5. Addition of 180 cfs of pipeline capacity from the Old River Pump Station to the Transfer Facility (Delta-Transfer Pipeline), thereby enabling the Old River and Middle River pump stations to operate at full capacity, simultaneously.

6. Addition of a 350 cfs Neroly High-lift Pump Station on the Contra Costa Canal to lift water from the canal to the Transfer Facility using the LV Pipeline.
7. Infrastructure improvements necessary to make greater use of the Freeport Regional Water Supply Project Intake and Pump Station and Intertie to EBMUD's Mokelumne Aqueduct No. 2.

Figure 48. Los Vaqueros Location

Given multiple points of diversion in the Delta and connections to the Mokelumne Aqueduct, California Aqueduct, and South Bay Aqueduct; the Los Vaqueros Reservoir Expansion Project is perfectly suited to integrate operations with the other proposed projects and potential partners. With screened intakes at Rock Slough, Old River, Middle River, and Freeport, water can be diverted to LV during biologically sensitive periods when pumping plants at Jones and Banks are restricted. This could be useful in capturing Delta surplus or conveying transfers. Expanded capacity at LV could also be used to simply store more water until needed. In addition, water could be delivered to other local water agency partners or San Joaquin Valley wildlife refuges using interconnected conveyance facilities.

Analytical Results

The Los Vaqueros Expansion Model (LVEM) was designed to connect with CalSim II and integrate with CVP and SWP operations. LVEM was used for the 2010 Final EIS/EIR analysis that preceded the first expansion of LV. It has since been modified to include Rock Slough filling, a new Delta-Transfer Pipeline, integration with EBMUD operations, and expanded Transfer-Bethany Pipeline partner operations.

Los Vaqueros Reservoir is primarily filled by diverting water from the Delta, Figure 10, Figure 11, and Figure 12 contain average annual Delta surplus by water year type, average monthly Delta surplus by water year type, and annual Delta surplus for the 82-year CalSim II simulation period. Because the Delta is the lowest point of the watershed, it is the location with the greatest amount of surplus.

Figure 49 contains a plot of existing and expanded Los Vaqueros Reservoir storage each month of the 82-year simulation, the red line with markers represents existing storage, while the blue line represents storage with the expansion.

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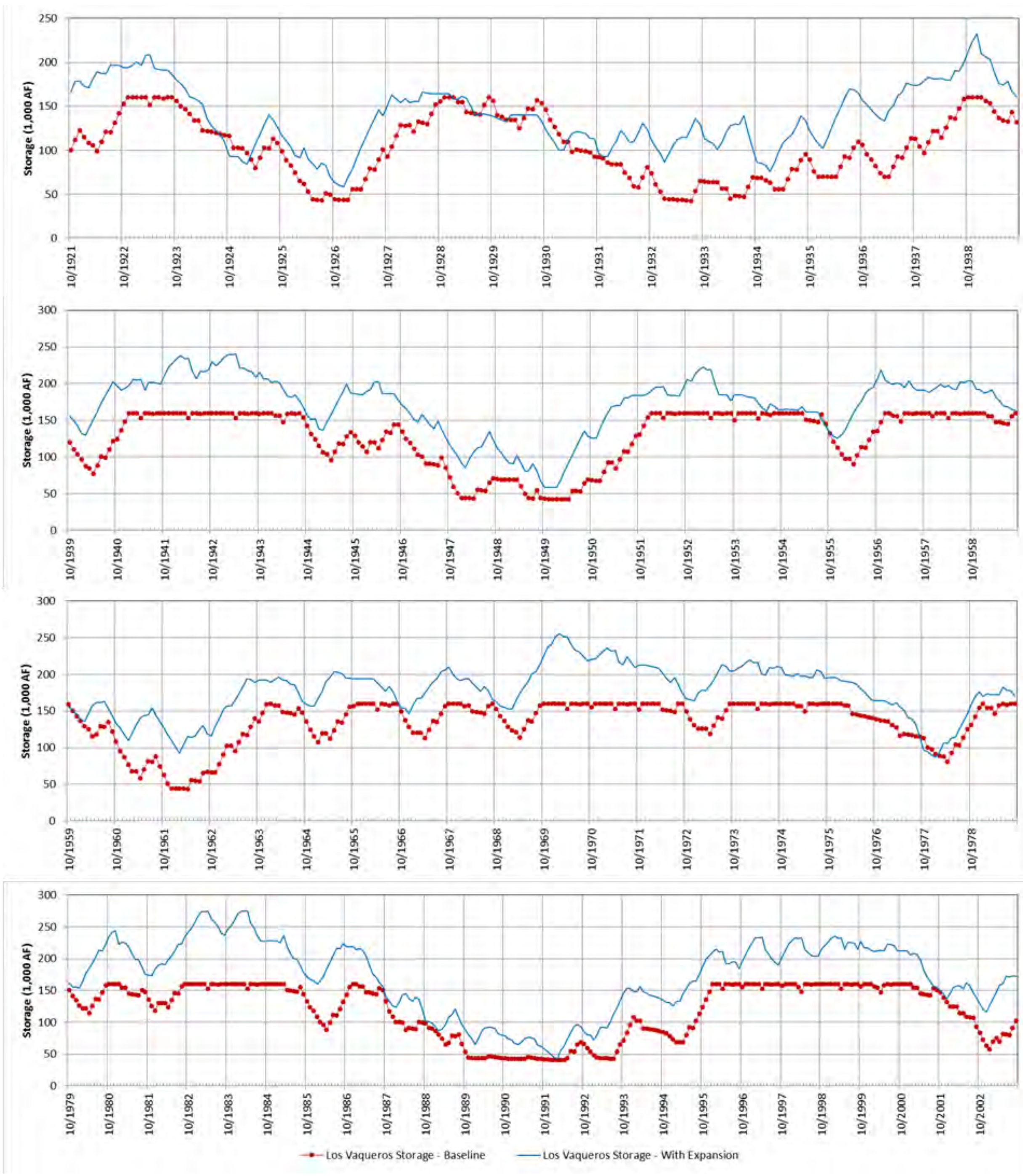

Figure 49. Los Vaqueros Monthly Storage with Baseline and Enlargement

Figure 50 shows the average annual water supply increase due to an expanded LVEM by water year type. Of the 69 TAF of annual average water supply benefits, 51 TAF is new supply (generated from capture of Delta surplus), and 18 TAF is a retiming of existing wet-year supply through storage in Los Vaqueros to dry and critical year supply.

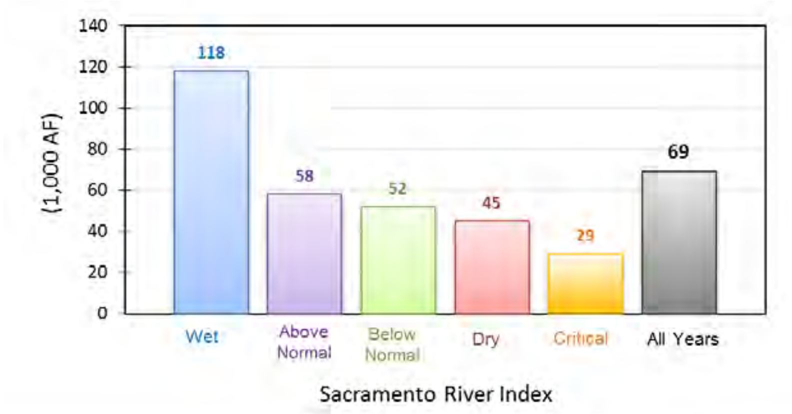

Figure 50. Annual Average Increase in Water Delivery to Local Partners and Wildlife Refuges with Los Vaqueros Reservoir Expansion

San Luis Reservoir Expansion

Overview

San Luis Reservoir (San Luis) is located 12 miles west of Los Banos (Figure 51) and is filled by pumping and conveying water from the Delta. In the coming years, Reclamation will be retrofitting the BF Sisk Dam (also known as the San Luis Dam) that impounds San Luis Reservoir to meet new seismic regulations. The feasibility of expanding the dam at the same time as the retrofit, as a single project, is being assessed. Combining these projects could potentially provide a means of augmenting South-of-Delta water supplies, while improving the seismic safety of the dam at the same time. A raise of 20 feet is being analyzed, with a net storage increase of 120 TAF. As San Luis is a shared CVP/SWP reservoir, the expanded storage can be reserved for either project; however, for the ACWA Storage Integration Study the additional capacity is assumed to be shared, with 57,000 AF designated for the CVP and 63,000 AF allocated for the SWP, based on the current sharing percentage.

Figure 51. San Luis Location

Due to San Luis Reservoir's location, south of the Delta and north of many major demand sites, benefits from this project could potentially span a significant portion of the state. San Luis is an off-stream reservoir filled with water drawn from the Delta by the CVP and SWP export pumps. Water is moved into San Luis Reservoir from the Delta through the Delta Mendota Canal and the California Aqueduct (SWP). An intertie with the two canals exists 70 miles south of the pumps, near the O'Neil Forebay. Some of this water is then pumped uphill into San Luis Reservoir as a storage reserve for South-of-Delta water users.

Over the years, the frequency of San Luis Reservoir filling has greatly diminished due to competing objectives contained in newer water quality control plans, and biological opinions issued by the NMFS and the USF&WS. Due to these same regulatory requirements, the ability to fill the increased storage will similarly be limited. However, Delta conveyance improvements would likely allow more surplus water to be captured and delivered to San Luis Reservoir with fewer regulatory constraints.

San Luis Reservoir is primarily filled by diverting water from the Delta, Figure 10, Figure 11, and Figure 12 contain average annual Delta surplus by water year type, average monthly Delta surplus by water year type, and annual Delta surplus for the 82-year CalSim II simulation period. Because the Delta is the lowest point of the watershed, it is the location with the greatest surplus.

Analytical Results

Figure 52 contains an exceedance probability plot of San Luis Reservoir maximum and minimum annual storage for baseline and enlargement scenarios. In both scenarios, San Luis Reservoir reaches maximum storage in approximately 14 percent of years; therefore, increased water supply occurs about this often. Figure 53 shows average annual changes in Delta exports due to San Luis enlargement, by water year type. Average annual increases in Delta exports are approximately 8 TAF. Figure 54 contains a plot of existing, and enlarged, San Luis storage each month of the 82-year simulation; the red line with markers represents existing storage, while the blue line represents storage with the enlargement.

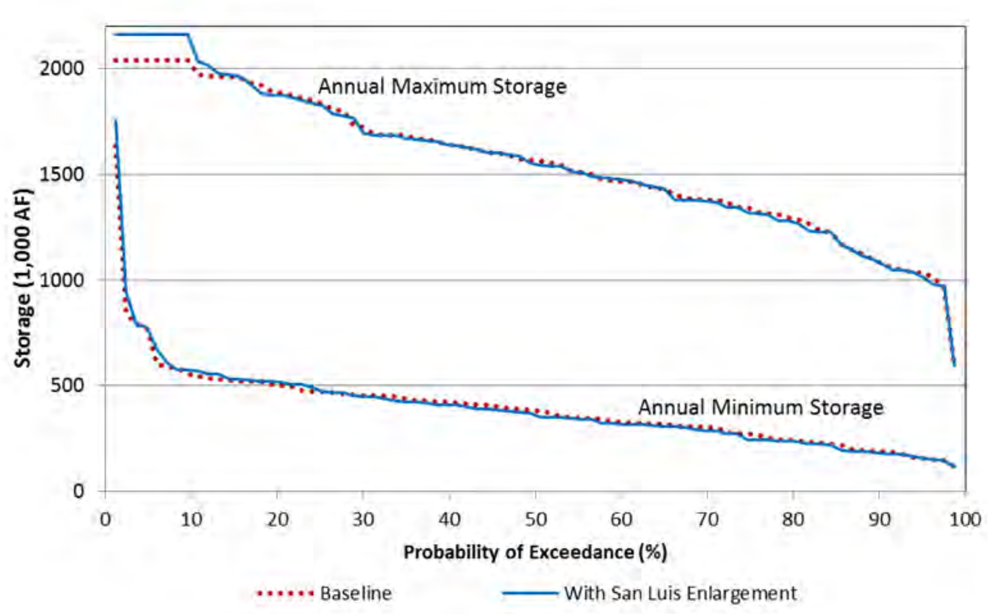

Figure 52. Total San Luis Reservoir Annual Maximum and Minimum Storage with Baseline and Enlargement

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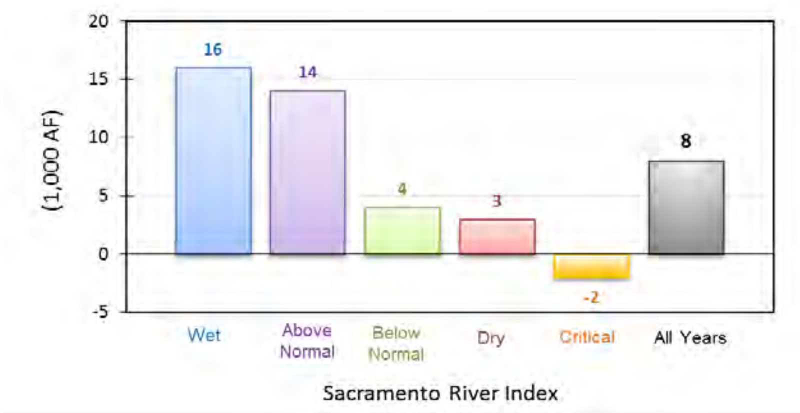

Figure 53. Change in Delta Exports Due to San Luis Reservoir Enlargement

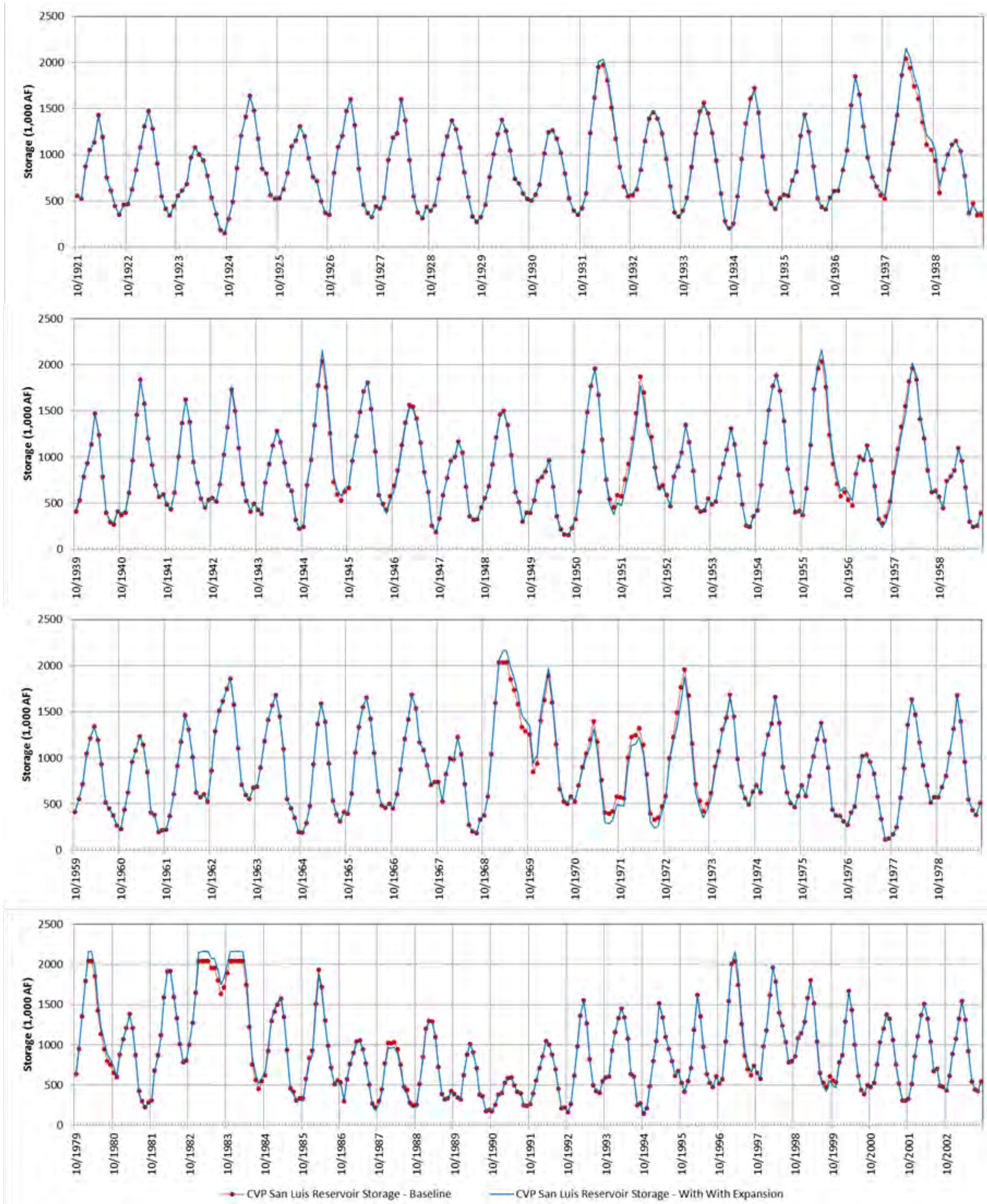

Figure 54. San Luis Reservoir Monthly Storage Operation with Baseline and Enlargement

Temperance Flat

Overview

Temperance Flat is a proposed dam and reservoir located in the upstream portion of Millerton Lake, at river mile (RM) 274 on the San Joaquin River. Figure 55 is a map of the Temperance Flat Reservoir location. Temperance Flat Reservoir would provide capacity for approximately 1.26 million AF of additional storage.

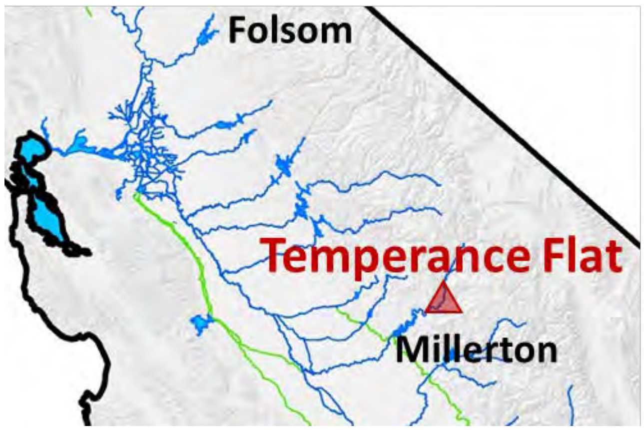

Figure 55. Temperance Flat Location

Temperance Flat Reservoir would provide opportunities for groundwater recharge/banking, development and management of other local water resources, flood flow management, watershed management actions, and integration with operations of facilities in nearby watersheds and South-of-Delta CVP/SWP facilities.

Water supply benefits from the proposed Temperance Flat Reservoir could be derived by capture of surplus water in the San Joaquin River and through integrating Temperance Flat operation with CVP/SWP South-of-Delta operations. Water supply benefits resulting from integrated operations occur when additional surplus Delta outflow may be captured and stored in Temperance Flat Reservoir for later delivery. Delta supplies are stored in Temperance Flat Reservoir by delivering water from San Luis Reservoir to the Friant contractors rather than from the San Joaquin River. In effect, water that was previously stored in San Luis Reservoir would then be stored in Temperance Flat. Additional room that is made available in San Luis Reservoir may then be refilled by diverting surplus Delta flows. If San Luis Reservoir is then filled during periods of Delta surplus then the combination of Delta supply in Temperance Flat and full San Luis Reservoir increased to develop water supply benefit. Similarly, this project could be operated in conjunction with groundwater recharge banks in the San Joaquin and Tulare basins. The benefits to integrating Temperance Flat Reservoir with CVP/SWP operations under existing conditions are limited; however, water supply benefits of Temperance Flat Reservoir increase approximately 50 TAF with improved Delta conveyance.

Available Surplus

Figure 56, Figure 57, and Figure 58 contain average annual San Joaquin River surplus by water year type, average monthly surplus by water year type, and annual surplus for the 82-year CalSim II simulation period. San Joaquin River surplus is estimated as Friant Dam release above flows required by the San Joaquin River Restoration Program. A majority of available surplus occurs in wet years, with no available surplus in dry and critical years. The upper San Joaquin River Basin is a high elevation watershed and a significant portion of its runoff is in the form of snowmelt, explaining why surplus flow in wet years lasts into June and July. Annual San Joaquin River surplus occurs infrequently, as can be seen in Figure 58.

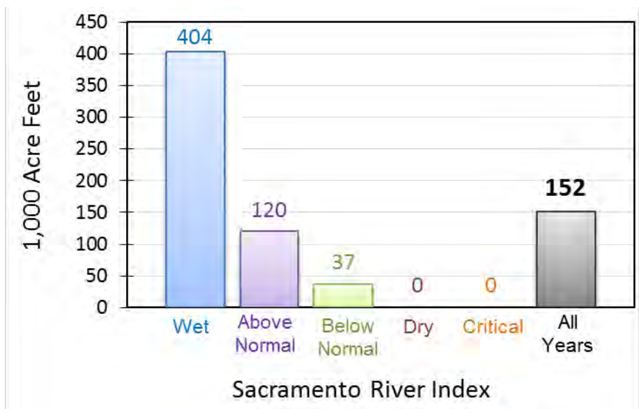

Figure 56. Annual Average San Joaquin River Surplus by Water Year Type

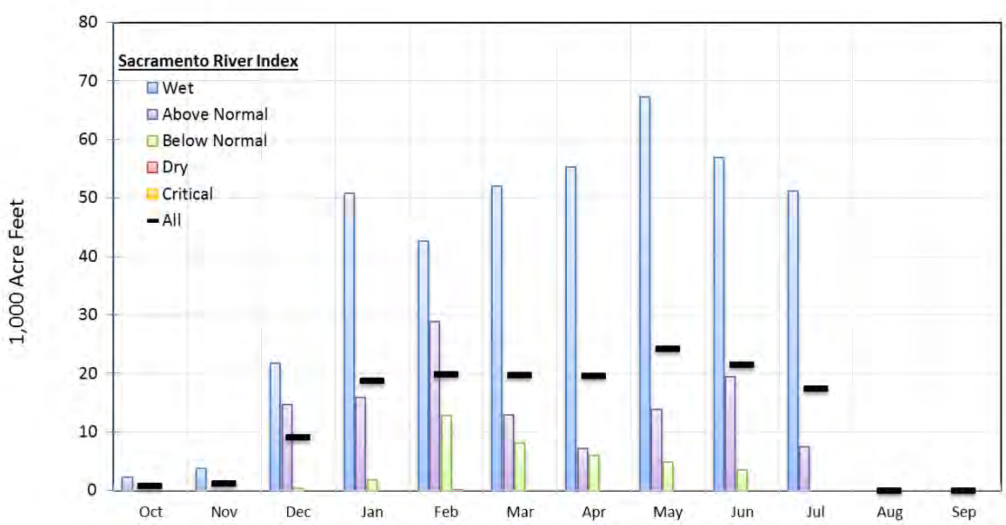

Figure 57. Monthly Average San Joaquin River Surplus by Water Year Type

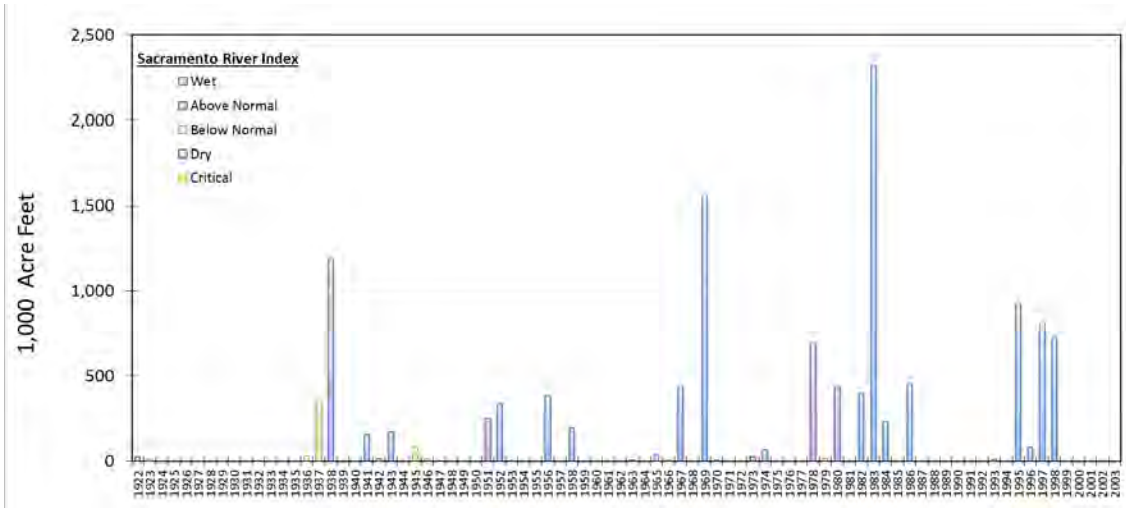

Figure 58. Annual San Joaquin River Surplus by Water Year Type

Analytical Results

Figure 59 contains a plot of combined Millerton and Temperance Flat Reservoir storage with and without Temperance Flat Reservoir for each month of the 82-year simulation. The red line with markers represents baseline Millerton storage, while the blue line represents combined Millerton and Temperance Flat Reservoir storage. Although Temperance Flat may fill infrequently, the average annual yield is about 110 TAF (Figure 60).

A significant benefit of Temperance Flat Reservoir is timing of water supply delivery within wetter years. In wetter years, high spring snowmelt is currently delivered within the Friant Division and banked in groundwater storage, then pumped during the latter parts of the irrigation season to satisfy demands. Temperance Flat allows high spring runoff to be controlled then delivered directly in months when demands are high, which reduces pumping costs and results in better groundwater management conditions.

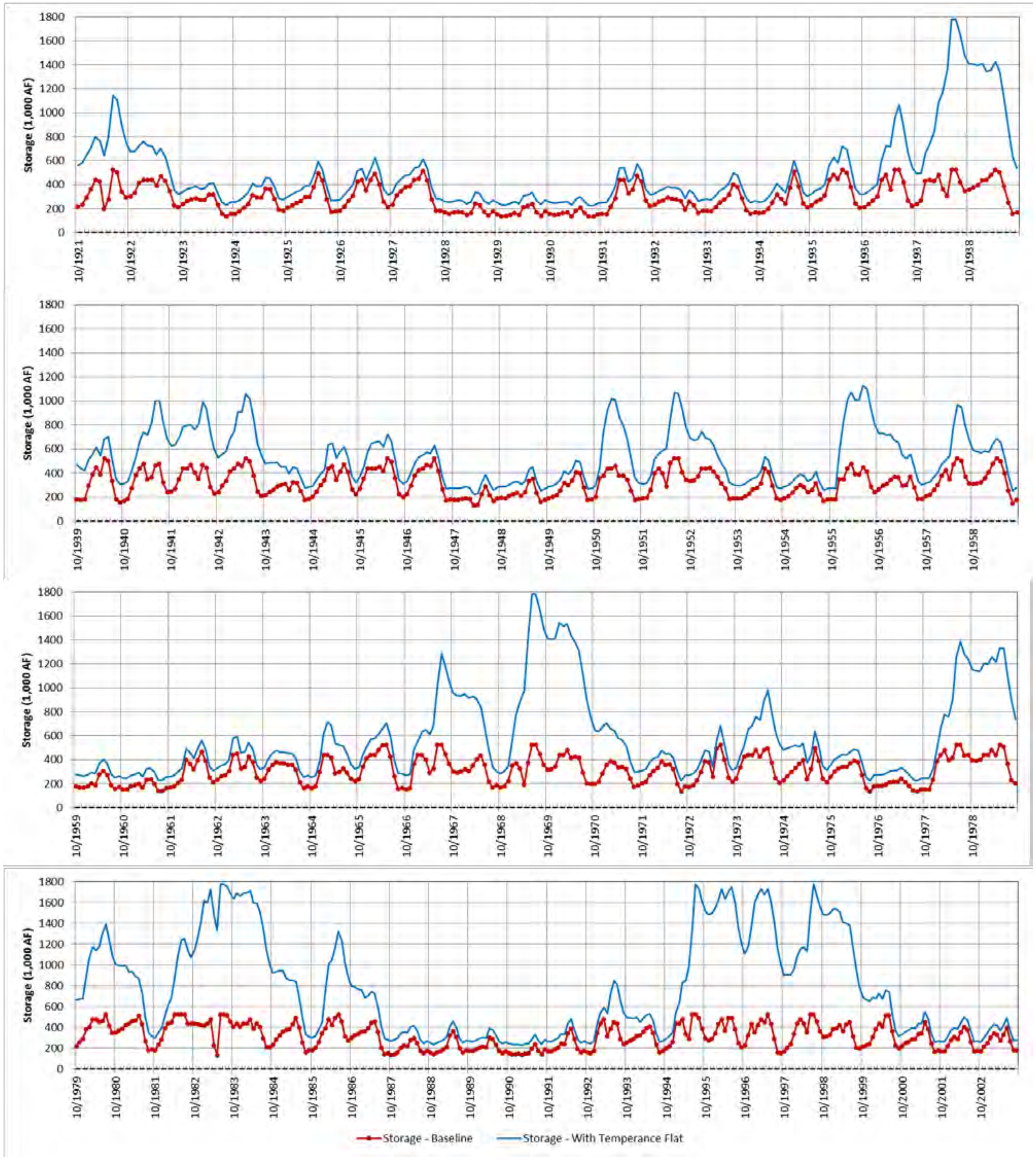

Figure 59. Temperance Flat and Millerton Monthly Operation

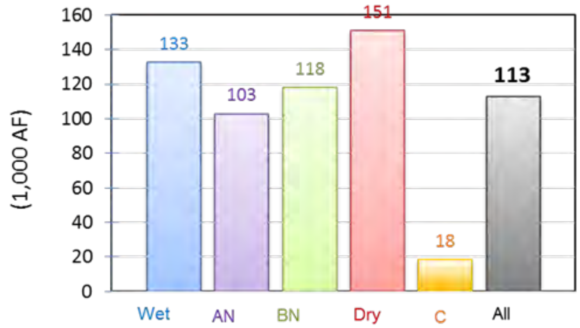

Figure 60. Annual Average Change in Friant Delivery by Water Year Type

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Tulare Lake Storage and Floodwater Protection Project

Overview

The Tulare Lake Storage and Floodwater Protection Project (TLP) is being proposed by Semitropic Water Storage District to provide local, regional, and state-wide public benefits to meet California's water storage and supply reliability challenges. TLP will include the construction of new South-of-Delta surface storage located along the western perimeter of Tulare Lake, with an intertie to the California Aqueduct and expansion of the existing Semitropic Groundwater Bank. This new storage project will rely upon surplus Kings River flows, Tulare Lake tributary floodwaters, and surplus flows from the Delta watershed for water supply. Key features of this proposed project are:

- Additional surface water storage of 120 TAF
- 1,200 cfs intertie from California Aqueduct
- Groundwater conjunctive use capacity
- In-lieu recharge (40 TAF annual)
- Groundwater extraction (20 TAF annual)

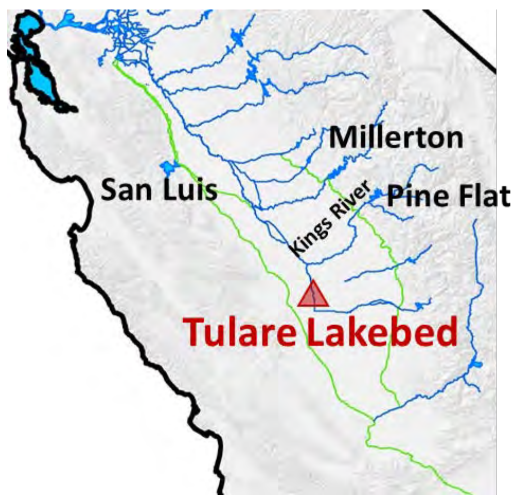

Figure 61. Tulare Lakebed Storage Location

Available Surplus

Figure 62, Figure 63, and Figure 64 contain average annual Kings River surplus by water year type, average monthly surplus by water year type, and annual surplus for the 82-year CalSim II simulation period. Kings River surplus is estimated as Kings River spills to Mendota Pool through the James Bypass. A majority of available surplus occurs in wet years with no available surplus in dry and critical years. The upper Kings River Basin is a high elevation watershed and a significant portion of its runoff is in the form of snowmelt, which results in surplus flow in wet years that can last into June and July. Annual Kings River surplus occurs infrequently, as can be seen in Figure 64.

SWP Article 21 water may also be available to store in the TLP. Article 21 water is available to State Water Contractors when San Luis Reservoir is full, there is available Delta surplus, and there is available conveyance capacity. Figure 65, Figure 66, and Figure 67 contain average annual Article 21 deliveries by water year type, average monthly Article 21 delivery by water year type, and annual Article 21 delivery for the 82-year CalSim II simulation period. Article 21 deliveries are shared among all SWP contractors; therefore, these charts show the upper bound of available supply for this storage project.

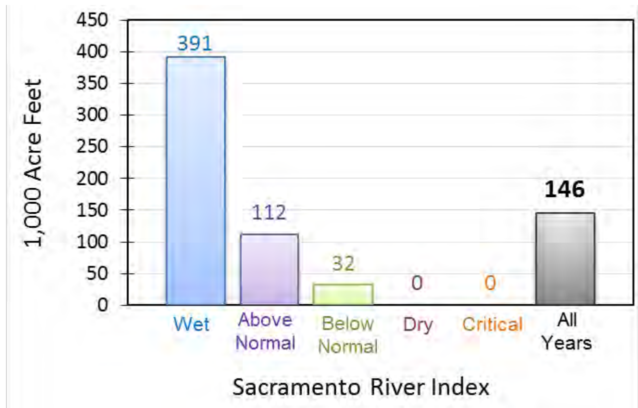

Figure 62. Annual Average Kings River Surplus by Water Year Type

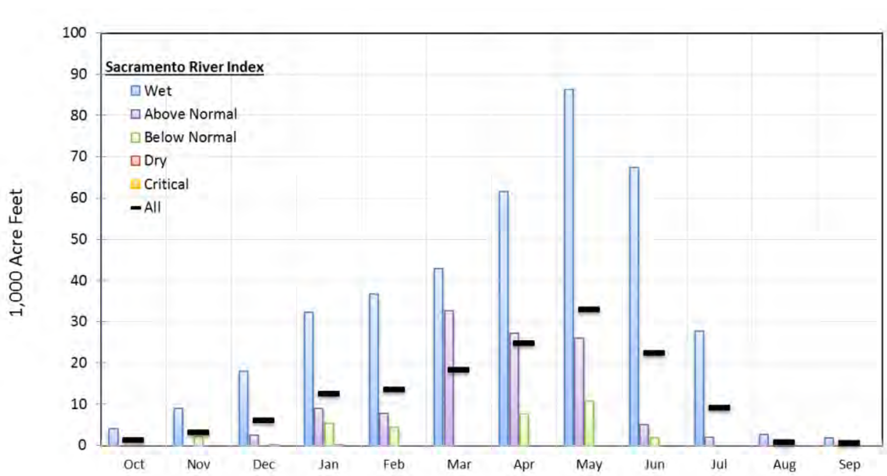

Figure 63. Monthly Average Kings River Surplus by Water Year Type

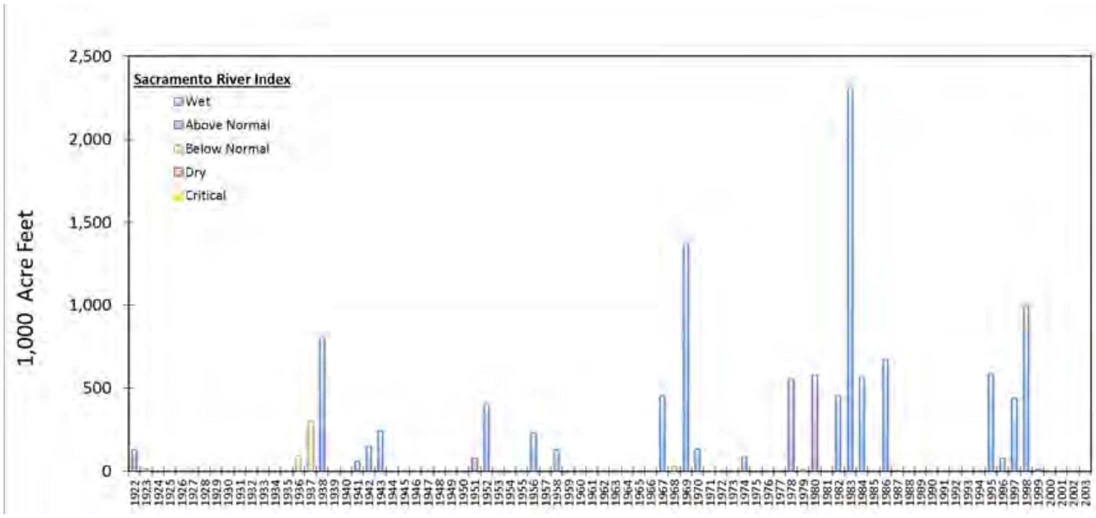

Figure 64. Annual Kings River Surplus by Water Year Type

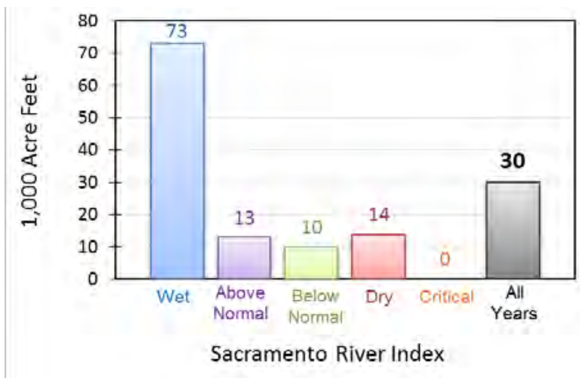

Figure 65. Annual Average SWP Article 21 delivery by Water Year Type

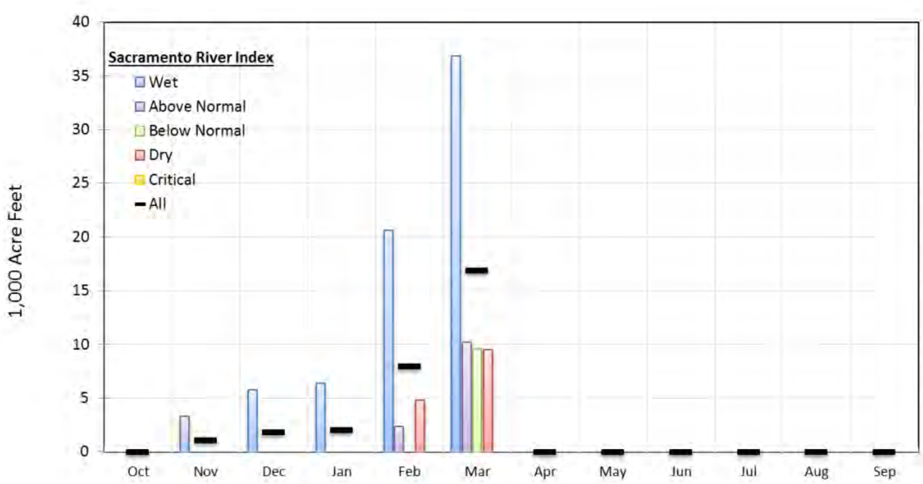

Figure 66. Monthly Average SWP Article 21 delivery by Water Year Type

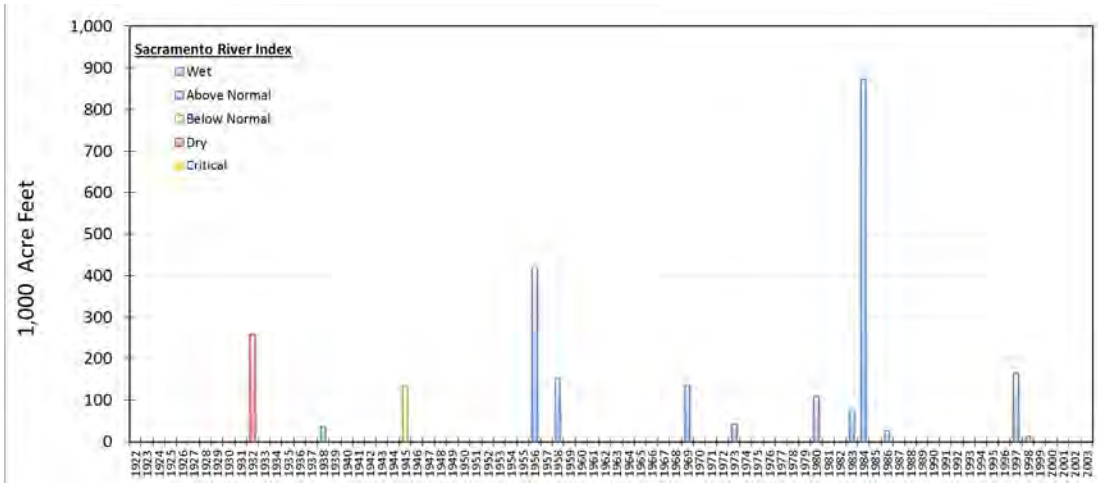

Figure 67. Annual SWP Article 21 delivery by Water Year Type

The TLP would provide additional surface storage and groundwater conjunctive use capacity, and can be integrated with the operations of other storage reservoirs such as San Luis Reservoir, Temperance Flat, and groundwater banks, to balance the spatial and temporal variabilities in supply and demand, as well as other capacity restrictions that would otherwise limit its performance.

Analytical Results

Figure 68 displays the annual operation of the proposed TLP. Diversion of Kings River surplus (represented by the blue bars) and Article 21 water (represented by the red bars) are inflow to storage. Reservoir outflow of Kings River supply (represented by the green bars), Article 21 water (represented by the pink bars), and evaporation (represented by the purple bars) are displayed as negative numbers, with carryover storage being represented by the black line. Figure 69 displays annual releases from proposed TLP storage. These releases would be used to satisfy demands in-lieu of groundwater pumping. The average annual increase in groundwater storage is approximately 15 TAF.

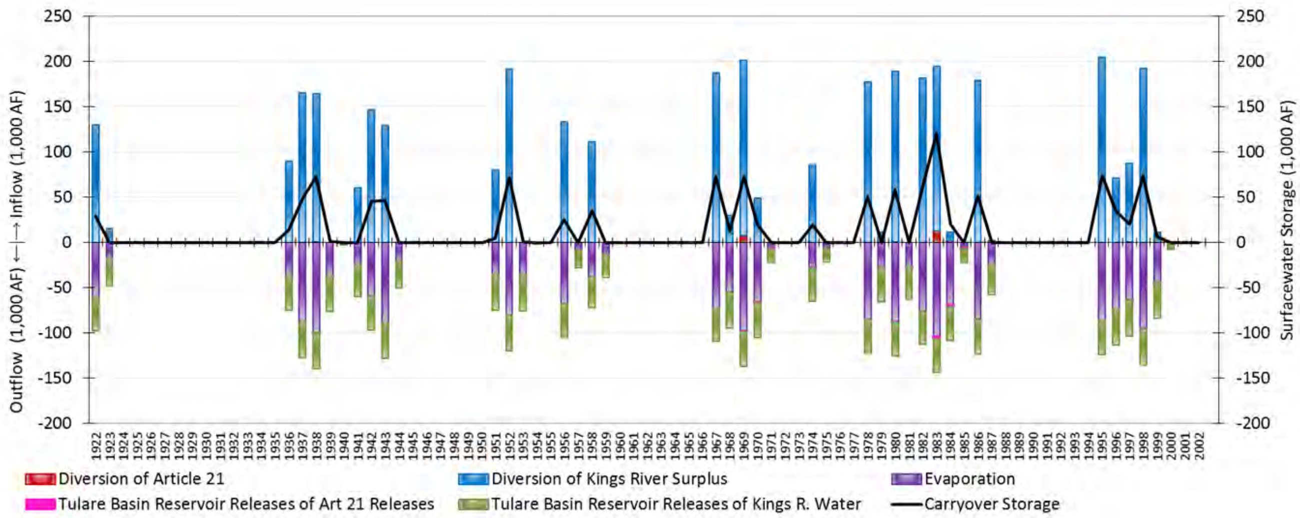

Figure 68. Annual Tulare Lakebed Operation

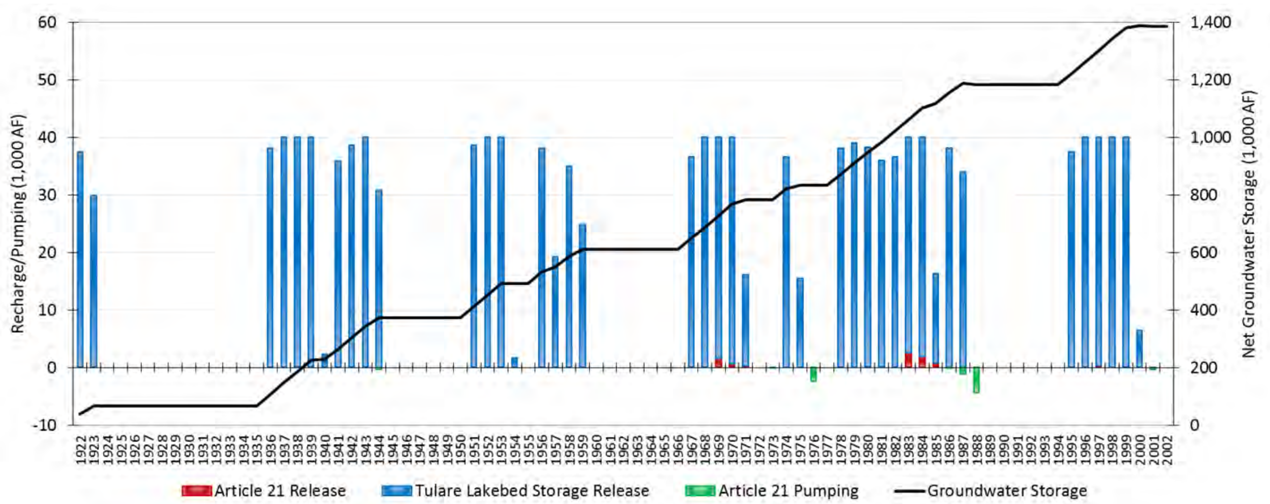

Figure 69. Tulare Lakebed Storage and Groundwater Operation

Groundwater Storage in the Kern Fan Area

Overview

Rosedale-Rio Bravo Water Storage District (RRBWSD) and Irvine Ranch Water District (IRWD) have recommended a groundwater storage project to integrate the operation of SWP/CVP surface reservoirs with groundwater banking projects in the Kern River Fan Area. This project would occur through the implementation of long-term exchange programs, which in turn, would provide wide ranging water supply, ecosystem, water quality, recreation and emergency supply benefits. The aim of this project is to utilize available groundwater storage capacity in Kern Fan Area water banks to capture surplus and/or regulated flows in the SWP/CVP systems. The project would increase SWP and CVP contractor yields, expand the conjunctive use of water, increase groundwater storage levels, improve aquatic resources, and facilitate the objectives of the Integrated Regional Water Management Plans.

The Kern Fan Area water banking projects are located in the Kern River alluvial fan at the southern end of the San Joaquin Valley. These projects are owned and operated by a wide range of agencies and districts that could offer opportunities to store water during wet and surplus conditions, when surface storage is limited, in exchange for water returned at a later date through groundwater recovery and the implementation of operational exchanges. The ability to recover stored water during dry periods would allow flexibility in responding to seasonal and inter-annual variability. Kern Fan Area groundwater banking projects can be integrated with the CVP/SWP systems through turnouts from the California Aqueduct, the Cross Valley Canal, the Friant Kern Canal, numerous small existing canals and potential new water conveyance facilities.

Figure 70. Location of Kern Fan Area Groundwater Banking Projects

Delta surplus is one of the key sources of water that can be captured at the Delta export pumps and stored in surface reservoirs and Kern Fan Area groundwater banking projects. Export of surplus water

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from the Delta is currently limited by export capacity, storage capacity, and regulatory constraints. This concept of integrating the operation of SWP/CVP surface reservoirs with groundwater banking projects in the Kern River Fan Area could improve water supply reliability at a minimum cost. For example, this project could be integrated with San Luis Reservoir to increase the capture of Delta surplus water by balancing the timing of storage and withdrawal from San Luis by providing additional storage space during wet periods. The integration and operation of the Kern Fan Area groundwater banking project with CVP and SWP storage projects in a coordinated manner would result in the ability to move additional surplus surface water from areas north of the Delta into groundwater storage in the Kern Fan when Delta conditions are favorable. The recovery and use of the stored water from the banking project could occur during dry periods when Delta conditions are less favorable. Portions of the recovered water could be used to meet local and downstream demands with releases of water to the Delta for aquatic and ecosystem purposes. The re-regulation of SWP/CVP supplies through implementation of creative groundwater water banking and exchange programs in partnership with agencies and districts in the Kern Fan Area would allow SWP and CVP contractors to increase dry year yields while providing local water supply benefits to the Kern Fan Area.