San Luis Low Point Improvement Project Feasibility Report

Appendix A: Plan Formulation Appendix

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Chapter 1
Introduction

This appendix describes the iterative plan formulation and evaluation process for the San Luis Low Point Improvement Project (SLLPIP) by the U.S. Department of the Interior, Bureau of Reclamation (Reclamation) and the Santa Clara Valley Water District (SCVWD). The SLLPIP is proposed to maintain a reliable and cost-effective water supply for SCVWD and other contractors of the Bureau of Reclamation's San Felipe Division to ensure that these contractors receive their annual Central Valley Project (CVP) contract allocations at the time and at the level of quality needed to meet water supply commitments.

Progress and results of the SLLPIP were documented in a series of interim reports which culminate in the Feasibility Report and an Environmental Impact Statement/Environmental Impact Report (EIS/EIR) (see Figure 1-1).

The first interim planning document, the Final Appraisal Report, completed in May 2006 (Reclamation), identified problems and potential solutions related to low water levels and other water resources issues associated with San Luis Reservoir and its operation, and determined if Federal interest exists in participating in a feasibility study to resolve the identified problems.

The second interim planning document, the Initial Alternatives Information Report (IAIR), was completed in February 2008 (Reclamation). It evaluated identified management measures based on SCVWD's past work on the project, other water resources studies, and the team's technical understanding of the project's problems, opportunities, and objectives. The IAIR identified 87 management measures that were grouped into six categories: institutional agreements, source water quality control, water treatment, conveyance, local reservoir storage, and alternate water supplies. The management measures were screened based on technical viability, institutional viability, and the ability to meet the project objectives. The Study team developed 26 initial alternatives that were evaluated in a subsequent Plan Formulation Report (PFR) completed in 2011.

The PFR was the third interim planning report in the feasibility study process that built on the results and findings of the previous two interim planning documents. In the Plan Formulation Phase, alternatives carried forward from the IAIR were re-evaluated for their capacity to meet the four Federal planning criteria. The goal of this re-evaluation was to use updated information and data to identify and screen out alternatives that would not meet the planning Federal criteria prior to refining the alternatives in the PFR.

Finally, during development of the Feasibility Report, Reclamation and SCVWD reconsidered the alternatives recommended for consideration. At each stage of the feasibility study, the key features of the study were revisited, such as the need for the project and whether conditions have changed to allow any alternatives previously eliminated to be re-introduced. Several project changes occurred during the feasibility investigation.

Figure 1-1. Planning Process

1.1 Organization and Content of Plan Formulation Appendix

This Plan Formulation Appendix is organized as follows:

- Description of the plan formulation process, including water resources problems and needs in the study area warranting Federal consideration; planning objectives and opportunities; existing and likely future water resources and related conditions in the study area; and planning constraints, principles, and criteria used to help guide the feasibility study (Chapter 1).
- Description of management measures, and from these measures, the formulation and evaluation of a set of initial alternatives to address the planning objectives and opportunities, and screening of initial alternatives presented in the 2011 *Plan Formulation Report* (Chapter 2).
- Description of the further refinement and reformulation of alternatives recommended for consideration following the release of the 2011 report and the alternatives that are evaluated in the Draft EIS/EIR and Feasibility Report to investigate the potential technical, economic, environmental, and financial feasibility of SLLPIP (Chapter 3).

1.2 Plan Formulation Process

Consistent with the National Environmental Policy Act (NEPA), the plan formulation process for Federal water resources studies is identified in the *Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies*[1] (P&Gs) (U.S. Water Resources Council 1983) and consists of the following deliberate and iterative steps:

- Identifying water resources problems, needs, and opportunities, and developing planning objectives, constraints, and criteria
- Inventorying and forecasting conditions likely to occur in the study area
- Evaluating and comparing alternative plans
- Selecting a plan for recommendation to decision makers for implementation or no action

The main body of the Feasibility Report evaluates alternatives to avoid supply interruptions and increase reliability and quality to south-of-Delta contractors, including SCVWD, dependent on San Luis Reservoir. This appendix addresses the remaining steps listed above, beginning with identification of an array of management measures and progressing to the selection of a plan for recommended implementation.

1.3 Authorization and Appropriation

The SLLPIP began when the August 2000 CALFED Bay-Delta Program (CALFED) Programmatic Record of Decision (ROD) included the SLLPIP as a complementary conveyance action. The ROD referred to a bypass canal to the San Felipe Unit at the San Luis Reservoir as one complementary action. In May 2001, SCVWD accepted a $14 million Proposition 13 grant from the California Department of Water Resources (DWR) to fund a feasibility study to address the low point problem. SCVWD moved forward to identify potential alternatives. During this time, SCVWD initiated a stakeholder involvement effort to help identify and assess alternatives and conducted public scoping in 2002 for the development of an Environmental Assessment under the California Environmental Quality Act (CEQA).

The SLLPIP Study is authorized by Title I of Public Law 108-361, CALFED Bay-Delta Authorization Act (October 25, 2004, 118 Stat. 1694), also known as

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[1] The SLLPIP Feasibility Study was initiated by Reclamation in 2004 and as such, has been developed consistent with the guidelines presented in the P&Gs. In 2015, the Department of the Interior released the *Department of Interior Agency Specific Procedures for implementing the Council on Environmental Quality's Principles, Requirements, and Guidelines for Water and Land Related Resources Implementation Studies (PR&G)* (United States Department of the Interior 2015). These new PR&Gs are being used to provide input on the SLLPIP Feasibility process but are not required.

the Water Supply, Reliability, and Environmental Improvement Act (Act). Section 103(f)(1)(A) of the Act authorized the Secretary of the Interior to "expend funds for feasibility studies, evaluation, and implementation of the San Luis Low Point Improvement Project, except that Federal participation in any construction of the expanded Pacheco Reservoir shall be subject to future congressional authorization."

With Federal involvement, the feasibility investigation was conducted pursuant to the P&Gs. The P&Gs provide guidance to Federal agencies for planning and water resource-related projects. Reclamation and SCVWD worked to develop a joint feasibility investigation approach; identified Federal planning objectives, and formulated alternatives to address the low point problem. In 2008, Reclamation and SCVWD conducted public scoping meetings because the baseline conditions, project objectives, and alternatives had changed since the original scoping period completed by SCVWD in 2002. In 2016, the Water Infrastructure for Improvements to the Nation (WIIN) Act reaffirmed the feasibility study authority for SLLPIP.

In August 2017, SCVWD submitted an application to the State of California Water Commission (CWC) for funding an expansion of Pacheco Reservoir pursuant to the Water Storage Investment Program (WSIP). Proposition 1 of 2014 dedicated $2.7 billion for investments in water storage projects. The CWC is currently administering WSIP to fund the public benefits associated with eligible projects, including the Pacheco Reservoir Expansion Alternative included in this Report. In July 2018, SCVWD received a maximum conditional eligibility determination of $484.5 million from the CWC. Based on the public and non-public benefits identified in the evaluation conducted for the WSIP application and the stakeholder support for the project, SCVWD requested that Reclamation reevaluate the Pacheco Reservoir Expansion Alternative in the SLLPIP Feasibility Report.

1.4 Study Area Location and Project Background

The study area, shown in Figure 1-2, includes the Delta, San Luis Reservoir and its related infrastructure, SCVWD's service area in Santa Clara County, Pacheco Reservoir, Pacheco Creek downstream of the Pacheco Dam, and San Felipe Lake. The study area also includes service areas of south of Delta CVP and State Water Project (SWP) contractors and wildlife refuges.

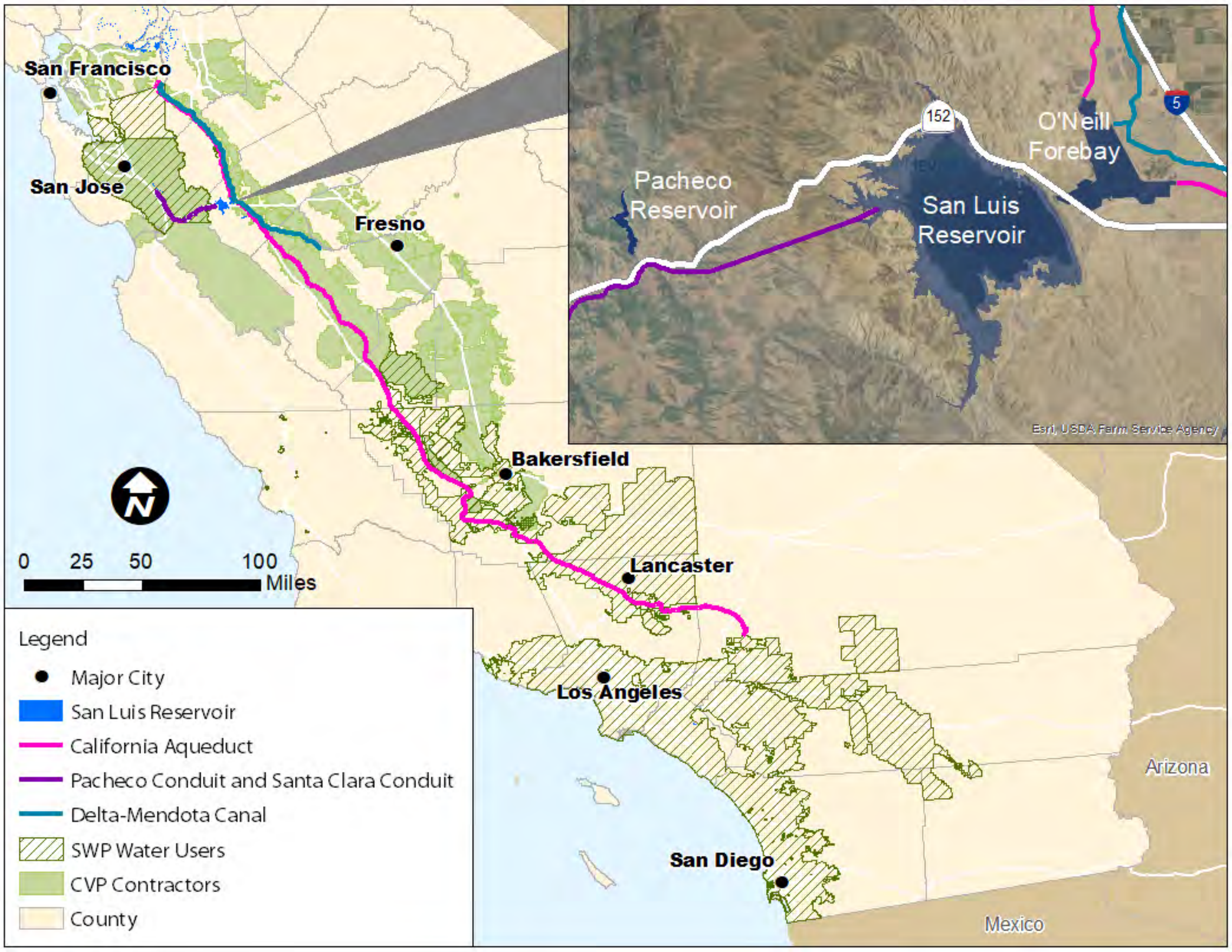

Figure 1-2. Study Area

Reclamation owns and jointly operates San Luis Reservoir with the California Department of Water Resources (DWR) to provide seasonal storage for the CVP and the SWP. San Luis Reservoir is capable of receiving water from both the Delta-Mendota Canal (DMC) and the California Aqueduct (see Figure 1-3), which enables the CVP and SWP to pump water into the reservoir during the wet season and release water into the conveyance facilities during the dry season when demands are higher. Deliveries from San Luis Reservoir also flow west through Pacheco Pumping Plant and Conduit to the San Felipe Division of the CVP, which includes SCVWD and the San Benito County Water District (SBCWD).

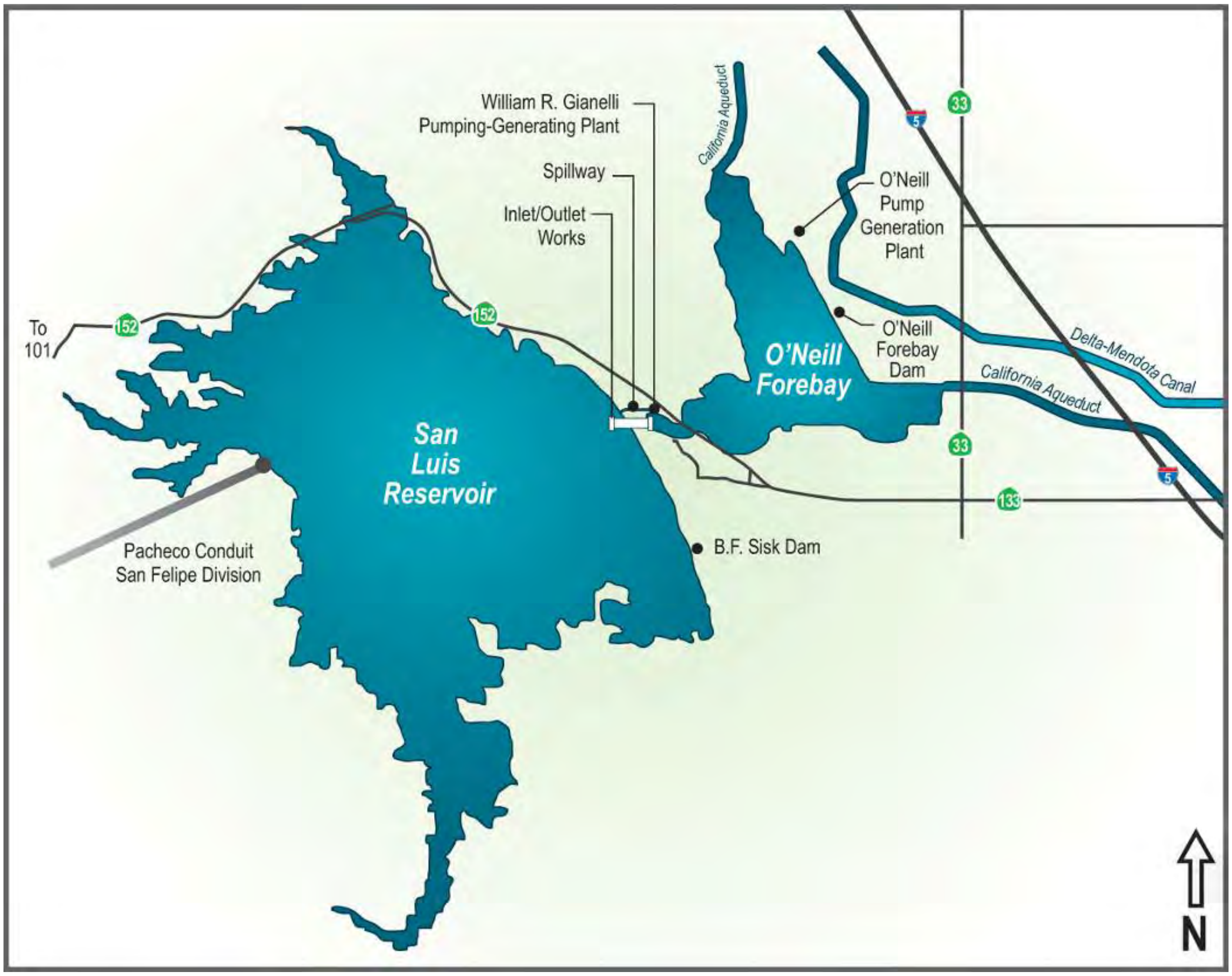

Figure 1-3. San Luis Reservoir and Associated Facilities

During the summer, high temperatures and declining water levels create conditions that foster algae growth. The thickness of the algae blooms vary, but typically average about 35 feet in depth. The water quality within the algal blooms is not suitable for municipal and industrial (M&I) water users relying on existing water treatment facilities in Santa Clara County.

Figure 1-4 shows the intake and outlet facilities associated with the reservoir. As water levels decline to the point that the algae is in the vicinity of the Upper Intake, that intake is no longer used. The low point problem occurs when the water levels decline to the point that the algae blooms are near the Lower Intake. Typically, this point occurs when water levels reach an elevation of 369 feet above mean sea level (MSL) or at 300 thousand acre-feet (TAF) capacity in the reservoir, when the water is approximately 35 feet above the top of the Lower Intake (334 feet above MSL or 110 TAF). The reservoir's minimum operating level is about 30 feet above the top of the Gianelli Intake; therefore, algae does not typically enter the DMC or California Aqueduct.

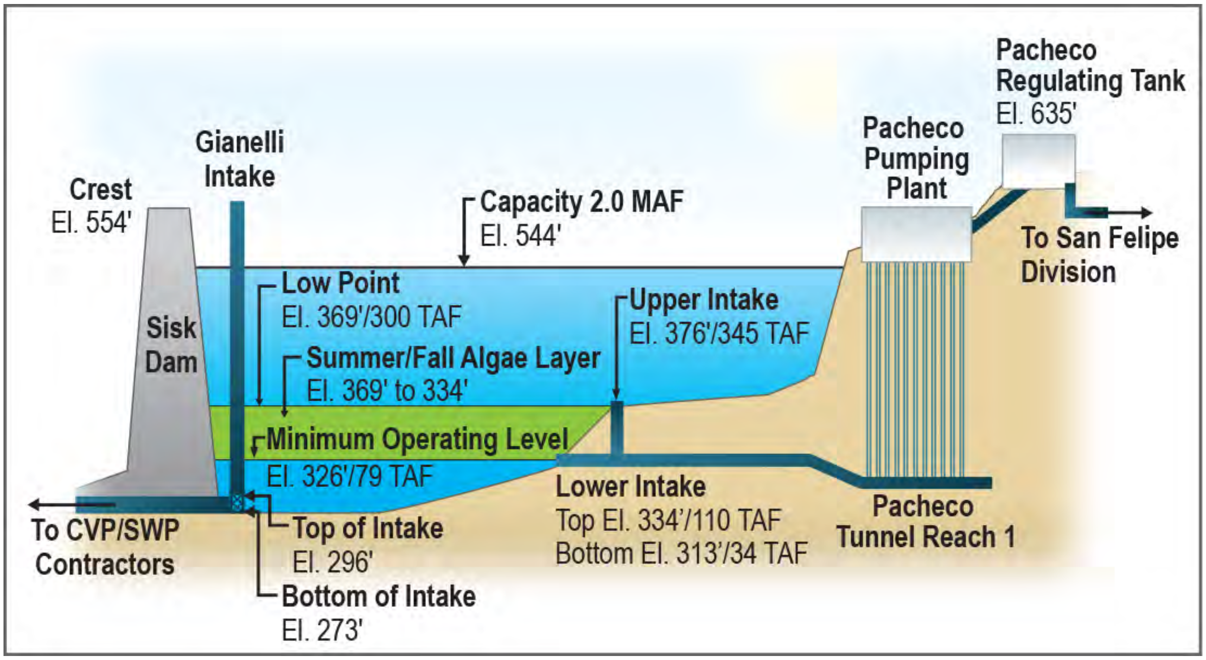

Figure 1-4. Reservoir Intake and Outlet Facilities

If water levels fall below 369 feet above MSL (300 TAF), SCVWD cannot receive water from San Luis Reservoir for M&I purposes because of water quality issues. San Luis Reservoir is the only delivery route for SCVWD's CVP supplies; therefore, SCVWD cannot access CVP supplies for M&I purposes during low-point events. The CVP operators allocate water based on the minimum operating level of 326 feet above MSL (79 TAF) and predict water levels below 369 feet above MSL (300 TAF) in most years. Even the prediction of a low point problem can cause water supply concerns for SCVWD because it must secure alternative water supplies in case disruptions occur, from sources including local groundwater supplies, District supplies stored in the Semitropic Water Storage District groundwater bank, and surface water transfers from willing sellers. In recent years, Reclamation has been implementing exchanges to deliver a portion of CVP supplies when there is a low point problem in San Luis Reservoir.

The CALFED Record of Decision (ROD) identifies the need for a "bypass canal to the San Felipe Unit at the San Luis Reservoir." The ROD recommended the allocation of California Proposition 13 funds administered by DWR to complete studies of the bypass canal and expanded local storage. Using these Proposition 13 funds, SCVWD initiated the SLLPIP in 2001 and completed the Draft Alternatives Screening Report in 2003. The report developed and screened alternatives to address the low point issue. In October 2004, the Project transitioned into a stronger partnership with Reclamation and the initiation of the federal feasibility study.

1.5 Water and Related Problems, Needs, and Opportunities

This section describes the problems associated with the San Luis Reservoir low point issue and potential opportunities resulting from implementation of the SLLPIP. This identification of problems and opportunities supports the analysis of comprehensive plans.

1.5.1 Problems

The San Luis Reservoir low point issue causes two main water resource problems that need to be addressed by the SLLPIP: reduced certainty of meeting south-of-Delta delivery schedules during the year and decreased water supply reliability for south-of-Delta contractors.

Multiple factors affect the predictability of delivery schedule and reliability of water supplies for south-of-Delta contractors, including growth in water demands, increasingly stringent regulatory requirements, and potential restricted operations because of the San Luis Reservoir low point constraints. These multiple factors, in addition to the uncertainty of hydrologic conditions, contribute to CVP and SWP water supply reliability issues. This section further describes the demonstrated need for the SLLPIP.

1.5.1.1 Factors Contributing to the Problems

Growth in Water Demand: Water demands exceed supplies in many areas of California, including the San Felipe Division. Because of growing statewide demands, both CVP and SWP facilities are expected to be severely stressed in the future. CVP contract amounts are not expected to increase; however, CVP M&I demands have increased and demand on the SWP is anticipated to increase to the full “Table A”2 amount. The effect of water supply shortages will become more severe as demands increase.

The California Department of Finance projects that California’s population will increase from 39.6 million in 2017 to 43.9 million in 2030 and 49.1 million in 2050, with some of the major growth occurring in south Central Valley and inland southern California counties (Department of Finance 2017). Water demands already exceed supplies throughout California, stressing the system severely during dry water years. Increasing water demands associated with this population growth will place additional pressure on CVP and SWP operations and facilities to meet contract allocations.

Water demand in the San Felipe Division is projected to grow with increases in population and expansion of the economy. SCVWD estimates that its future water demands will increase by 85 TAF, or about 25 percent, from 2015 to 2040 (SCVWD 2015). The SCVWD *Integrated Water Resources Planning Study*

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[2] Table A is a tool for apportioning available water supply and cost obligations under the SWP contract. When the SWP was being planned, the amount of water projected to be made available to the contractors was 4.2 million acre-feet (MAF) per year. Table A lists by year and acre-feet the portion of the 4.2 MAF deliverable to each contractor. DWR makes annual allocations as a percent of Table A amounts.

(SCVWD 2005) projects that dry year water shortages will grow over time within the SCVWD service area, from approximately 50 TAF in 2010 to 75 TAF by 2040, assuming that the San Luis Reservoir low point issue has been remedied. (If the low point issue is not addressed, this shortage would likely increase even more.)

SCVWD's water supply portfolio, which includes conjunctively managed groundwater basins recharged with both local and imported surface supplies, direct use of imported supplies, and storage in the Semitropic Water Storage District's groundwater bank in Kern County, is fully dedicated to meeting Santa Clara County's current and projected future demands. SCVWD's capacity to satisfy future demands is contingent upon the reliable delivery of imported surface supplies without supply interruptions caused by the low point issue.

In order to reduce the likelihood of supply interruptions when potential low point conditions are forecasted, SCVWD adjusts its water operations by securing transfers delivered through the SBA and using surface and groundwater resources from within the District that would otherwise be reserved for use in response to drought shortages and emergency outages. The adjustments may not necessarily be cost efficient and could be detrimental to the long-term sustainability of contractors' water supply with the potential to lead to larger water supply shortages. The adjustments in water operations occur whether or not the forecasted low point condition occurs.

Water demands in SBCWD are also projected to increase. SBCWD estimates that M&I demands will increase from 10.7 TAF in 2002 to 11.5 TAF in 2020 and agricultural demands will increase from 54.1 TAF in 2002 to 74.9 in 2020. One of the uses of CVP supplies in SBCWD is to protect local groundwater basins and reduced CVP deliveries would likely increase the SBCWD groundwater use and cause an overdraft. The SBCWD's CVP supply is its only imported water supply source.

Other CVP and SWP contractors' demands are also likely to increase in the future, primarily due to M&I demand increases associated with statewide population growth. In addition, the Metropolitan Water District of Southern California (MWD), which is an SWP contractor, projects that its M&I water demands will increase from 4.1 million acre-feet (MAF) in 2010 to 4.7 MAF by 2040 (MWD 2005). Increases in SWP demands could affect carryover storage quantities in San Luis Reservoir and change the frequency of low point conditions.

Regulatory Requirements: Operation of the CVP and SWP has been constrained by water quality and environmental protection regulations, and potential changes could result in further constraints. Provisions of the Federal Endangered Species Act (ESA), Water Rights Decisions, Coordinated Operations Agreement, the CVP Improvement Act (CVPIA), Water Quality Control Plan for the San Francisco Bay/Sacramento-San Joaquin Delta Estuary, Central Valley Regional Water Quality Control Board Basin Plan Amendments, the Bay Delta Conservation Plan, and new legislation based on recommendations made in the Delta Vision Strategic Plan could affect the water supply reliability for contractors that rely on water deliveries from the Delta. Some of these regulations and institutional changes have:

- Reduced the amount of water delivered to the Delta for later delivery to south-of-Delta users, in order to support threatened and endangered fish protection efforts;
- Reduced amounts of water that can be conveyed through the Delta during certain periods of the year in order to prevent negative impacts to water quality, water levels, and fish in the Delta; and
- Reserved a portion of the CVP yield for delivery to environmental uses.

These actions have affected the total supply of water available to CVP and SWP operators for delivery to contractors.

Project Operations: The Federal share (45%) of San Luis Reservoir is managed by Reclamation's Central Valley Operations Office and the State of California (State) share (55%) is managed by the SWP Operation Control Office. Water is pumped into San Luis Reservoir during the non-irrigation wet season (October through March), when supplies exceed demand for Delta water. The reservoir is typically drawn down during the dry season (April through September) when irrigation occurs.

Operational goals of both the CVP and SWP are to maximize annual water delivery under their respective contracts and to do so (to the extent possible) without drawing the reservoir down to the minimum level. The water elevation in San Luis Reservoir during the late summer and early fall periods varies from year to year depending on various conditions. These conditions include the amount of stored water carried over from the previous year (carryover water), the volume of water that can be delivered through the Delta (usually depending on hydrologic conditions and regulatory restrictions on Delta exports), demands of Federal and State contractors, and operational decisions made by Reclamation and DWR.

In most years, the storage level in San Luis Reservoir has remained above 300 TAF, which corresponds to the water surface elevation at which the low point conditions are likely to occur. The reservoir has not been drawn down to its minimum operating pool of 79 TAF since the San Felipe Division began receiving deliveries in 1987. During the drought events in 1977, 1989, 2008, and 2016 the reservoir was drawn down to below 500 TAF. San Luis Reservoir was drawn down to a storage level of 79 TAF to facilitate repairs in 1981 and 1982. While the reservoir has fallen below 300 TAF in very few years, Reclamation has forecasted low reservoir levels in other years that could affect water deliveries to the San Felipe Division. These forecasts have not been accurate because SWP contractor demands have been lower than estimated and some SWP water was left in the reservoir as carryover storage, but changing water supply conditions and increasing demands make continued long-term storage above 300 TAF unlikely. As discussed previously, even the prediction of low point conditions can cause SCVWD to take actions that may affect long-term water supplies.

San Luis Reservoir has a maximum drawdown rate of 2 feet per day as a dam safety measure. During periods of high demand, the maximum drawdown rate can limit the availability of water stored in San Luis Reservoir and require cooperation among contractors dependent on the reservoir, to share the constrained supply.

1.5.1.2 Problems to be Addressed by the SLLPIP

Delivery Schedule Certainty: Low levels in San Luis Reservoir in San Luis Reservoir cause supply interruptions to SCVWD because of algae problems at the San Felipe Division intakes. SCVWD provides water supplies to approximately two million residents and commuters in 15 cities in Santa Clara County (SCVWD 2011), and an interruption in water supply can have far-reaching effects on residents and businesses.

Water demands are typically at their peak during the summer months, which is also the time that low point problems have the potential to interrupt water supplies (SCVWD 2015). Decreased water deliveries during the peak demands pose the greatest risks of potential economic and environmental losses associated with a water shortage.

SCVWD is not only affected by the water supply interruptions, but also by the prediction of water supply interruptions. CVP and SWP water is stored in San Luis Reservoir in order to meet demands of south-of-Delta contractors. Reclamation requests an annual delivery schedule from each contractor and then approves the appropriate schedules based on CVP water availability. The actual demand schedules are, however, subject to uncertainty during the summer months because of operational constraints, varying temperature conditions, changing cropping patterns, and water transfers. The uncertainty associated with San Luis Reservoir water supply deliveries affects SCVWD’s overall water delivery operations to meet customer demands (SCVWD 2014). The frequency of low point forecasts and occurrences is projected to increase in the future and SCVWD’s ability to adjust operations to mitigate water supply impacts associated with the low point problem will diminish over time as local supplies, currently reserved for use during drought events, are relied on to replace interrupted imported CVP supplies during non-drought years.

Water Supply Reliability: Decreased water supply reliability affects CVP contractors’ ability to meet water demands. More stringent flow and water quality requirements in the Sacramento-San Joaquin River Delta (Delta) have restricted the amount of water that the CVP and SWP can pump. These limitations are causing water supply reliability concerns for SCVWD and other CVP and SWP contractors that receive Delta exports. Regulatory changes, project operations, and growth in water demand is expected to increase reliance on San Luis Reservoir supplies. Full exercise of the storage in San Luis Reservoir would cause reservoir levels to fall below 300 TAF more frequently than has occurred in the past, which interrupts deliveries to SCVWD and reduces water supply reliability.

1.5.2 Opportunities

1.5.2.1 Full Exercise of Storage in San Luis Reservoir

Implementation of the SLLPIP could allow the CVP and SWP to fully exercise San Luis Reservoir storage each year without the potential for supply interruption to the San Felipe Division during the summer months. Reclamation would be able to use the full storage capacity of the reservoir without any concerns about water levels falling below 300 TAF.

1.5.2.2 Improved Water Quality

During the late summer months, when San Luis Reservoir reaches low water levels that could trigger a low point issue, the San Felipe Division contractors might not be able to treat San Luis Reservoir water with their existing treatment facilities because of dense algae blooms. The algae could clog treatment plants' filters and could prevent clean water from passing through them. Algae-laden water also could clog irrigation systems for agricultural water users in the San Felipe Division. Implementing the SLLPIP could result in water quality improvements for M&I and agricultural customers beyond those possible in the future without the project.

1.5.2.3 Avoidance of Costs for Water Transfers and Other Alternative Supplies

Because of decreased imported water supplies, contractors must often find alternate sources of water to meet demands. Some contractors purchase water on a year-to-year basis through water transfers. Depending on the hydrologic year and location of source water, transfers can range in price from $175 to $200 per acre-foot (AF) for north-of-Delta supplies and $400 to $900 per acre-feet (AF) for south-of-Delta supplies. Average transfer prices are around $350 to $400 per AF, with higher prices during dry years (Mizuno 2008). Additional wheeling costs for deliveries through Project facilities could increase these transfer prices; for example, MWD charges $260 per AF for use of its conveyance facilities. DWR also charges a fee to convey supplies through the SWP system. The SLLPIP could reduce contractor need to identify additional water sources obtained through transfers or other sources.

1.5.2.4 Increased Cooperation

San Luis Reservoir is central to both CVP and SWP operations and requires coordination among Reclamation, DWR, and contractors. Implementing the

SLLPIP could further facilitate multi-agency cooperation by offering additional benefits for M&I, agricultural, and environmental water uses. SLLPIP could increase the ability of all agencies to work together to maximize potential benefits of San Luis Reservoir storage to all south-of-Delta contractors and water uses.

1.5.2.5 Avoidance of Interruption to SCVWD M&I Water Deliveries

Reclamation operates San Luis Reservoir to meet contract allocations and/or regulatory requirements. Reclamation operates the reservoir to reach the minimum operating pool of 79 TAF. In the past, water levels did not always decrease below 300 TAF because of historical SWP operations where contractors are storing carryover water in San Luis Reservoir, which prevented the low point problem. If Reclamation operated the reservoir down to 79 TAF, SCVWD would request that the reservoir be maintained above 300 TAF to avoid supply interruptions to SCVWD's M&I water users. Implementing the SLLPIP could improve SCVWD's utilization of CVP supplies.

1.5.2.6 Operational Flexibility

Operational flexibility allows water agencies to manage water supplies efficiently by increasing supply and storage options. Several SLLPIP measures would include new storage facilities or alternate water supplies within a local water agency. In years that the low point is not an issue, the local agency could use the additional storage for local water supplies, which would allow the agency to maximize use of surface and groundwater to meet both current and future water demands.

1.5.2.7 Ecosystem Enhancement

SCVWD is proposing to donate part of their CVP allocation to south-of-Delta National Wildlife Refuges as a part of Reclamation's obligation under the CVPIA Incremental Level 4 (IL4) refuge water supply. The 1992 CVPIA, Section 3406(d), includes provisions for refuge water supplies for 19 specified Central Valley refuges under the refuge water supply section of the Act. The CVPIA refuges are managed by United States Fish and Wildlife Service (USFWS), California Department of Fish and Wildlife (CDFW), and the landowners of privately owned/ managed wetlands in the Grasslands Conservation District. Each year, Reclamation strives to provide as much IL4 water as possible. However, full IL4 deliveries have only been achieved during wettest years, and only to refuges without conveyance constraints.

Developing a new water resource project outside of San Luis Reservoir could produce ecosystem enhancement benefits through improvements to refuge habitat quality and values.

1.6 Existing and Future Resources Conditions in Study Area

An important element of any water resources evaluation is defining existing resource conditions in the affected environment, and how these conditions may change in the future. The magnitude of change not only influences the scope of the problems, needs, and opportunities, but the extent of related resources that could be influenced by possible actions taken to address them. Defining the existing and likely future conditions is critical in establishing the basis for comparing potential alternative plans consistent with the P&Gs, NEPA, and CEQA guidance. The following section briefly discusses existing conditions in the study area, including existing infrastructure, the physical environment, biological environment, cultural resources, and socioeconomic resources.

1.6.1 Existing Condition Summary

This section describes existing conditions in the study area. These are described in more detail in the EIS/EIR.

1.6.1.1 Physical Infrastructure

Physical infrastructure in the study area includes facilities for San Luis Reservoir and its related water infrastructure. This consists of the San Felipe Division’s water intakes and associated infrastructure, associated recreational facilities a part of the San Luis Reservoir State Recreation Area (SRA), the California Aqueduct, and the South Bay Aqueduct (SBA). Additional physical infrastructure in the SCVWD service area includes Anderson Reservoir, the Santa Teresa Water Treatment Plant (WTP) in San Jose, the Campbell Well Field and San Tomas Injection well in Campbell, and the existing Pacheco Reservoir.

San Luis Reservoir

The San Luis Reservoir is a part of the San Luis Unit of the CVP and SWP. Reclamation and the State of California jointly maintain and operate this joint use facility including, the O’Neil Dam and Forebay, B.F. Sisk San Luis Dam, San Luis Reservoir, William R. Gianelli Pumping-Generating Plant, Dos Amigos Pumping Plant, Los Banos and Little Panoche reservoirs, the San Luis Canal, and associated switchyards. The primary purpose of the San Luis Unit is to provide approximately 1.25 MAF of supplemental irrigation water supply to western counties such as Fresno, Kings, and Merced.

San Luis Reservoir serves as a major storage reservoir for the CVP and SWP. The reservoir is an artificial lake on San Luis Creek in the eastern slopes of the Diablo Range of Merced County. The reservoir stores water taken from the San Joaquin-Sacramento River Delta that would otherwise discharge into the Pacific Ocean. Water is then pumped uphill into the reservoir from the O’Neil Forebay which is fed by the California Aqueduct and then released back into the forebay to continue downstream primarily for agricultural irrigation. The reservoir has an approximate depth of 270 feet, length of 9 miles, a surface area of 19.84 square miles, and a surface elevation of 544 feet (Reclamation 2013).

The San Luis Reservoir is also a part of the San Luis Reservoir SRA, owned and operated by the California Department of Parks and Recreation (CDPR). The SRA includes four campgrounds surrounding the reservoir including the Basalt, San Luis Creek, Medeiros, and Los Banos Creek, in addition to several day-use sites. The SRA affords for various recreation activities including boating, fishing, camping, hiking, equestrian, picnicking, swimming, wind surfing, and off-highway vehicles (CDPR 2016).

California Aqueduct

The California Aqueduct is a primary part of the SWP and carries water from the Delta to the San Joaquin Valley and Southern California. The concrete, open aqueduct has a width of 12 to 85 feet and an average depth of 30 feet. The aqueduct helps deliver SWP water to San Joaquin Valley farms and cities (Water Education Foundation [WEF] 2016a).

South Bay Aqueduct

The SBA was the first conveyance facility constructed as part of the SWP. The aqueduct conveys water from the Sacramento-San Joaquin Delta through over 40 miles of pipeline and canals to Alameda County Water District, Alameda County Flood Control and Water Conservation District, and the SCVWD. The aqueduct has a capacity of 300 cubic feet per second (cfs) (WEF 2016b).

Anderson Reservoir

Anderson Reservoir is the largest of 10 SCVWD reservoirs and provides a reliable supply of water to Santa Clara County. It has a total storage capacity of 89,073 AF. The reservoir is located three miles east of U.S. Highway 101 (US 101) in Morgan Hill. The SCVWD is currently conducting seismic retrofits to the dam and reservoir and have placed restrictions limiting maximum storage to approximately 52% of the reservoir's total capacity for public safety purposes (SCVWD 2018a). These storage restrictions challenge SCVWD's ability to meet instream flow requirements on Coyote Creek while maintaining adequate water storage for use later in the year for its primary purpose as an emergency supply reserved by SCVWD for use in response to system outages. The current schedule for completion of a seismic retrofit project at the dam has construction commencing in 2022 with an anticipated duration of 5 years (SCVWD 2018a)

A part of Anderson Lake County Park, Anderson Reservoir is a seven mile long lake with a 1,250 acre surface at full capacity and provides various recreation opportunities such as power and non-power boating, fishing, and picnicking (Santa Clara County Parks 2011).

Santa Teresa Water Treatment Plant

The Santa Teresa WTP is the largest of three WTPs in the SCVWD. The WTP produces safe drinking water to South San Jose – Almaden Valley, Blossom Valley, and Santa Teresa for residential and commercial users. Santa Teresa WTP treats and delivers up to 100 million gallons of water per day and primarily imports water from the San Luis Reservoir, in addition to the district's local supplies at Anderson and Calero reservoirs (SCVWD 2016a).

Existing Pacheco Reservoir

Pacheco Reservoir is located on North Fork Pacheco Creek, and it was established in 1939 through construction of the North Fork Dam. This existing earthen dam is owned and operated by Pacheco Pass Water District (PPWD), and operated for groundwater recharge via releases to Pacheco Creek in spring and early summer. The design capacity of Pacheco Reservoir is 6,000 AF with an operational capacity of 5,500 AF. The earthen dam is 100-feet tall and collects rainfall from a 75-square-mile watershed. The North Fork Dam is currently under restricted-operation criteria through an April 5, 2017 order of the DWR Division of Safety of Dams (DSOD), due to existing spillway deficiencies. PPWD is coordinating with the Federal Emergency Management Agency and DSOD on short-term and long-term repairs. The DSOD has stated that if satisfactory progress is not made to address spillway deficiencies, additional remedies would be invoked, a step that would reduce, among other things, existing fisheries habitat (SCVWD 2017a).

1.6.1.2 Physical Environment

Elements of the physical environment related to the Project study area are described in this section, and include geology and soils, water quality, groundwater resources, air quality, greenhouse gases and noise.

Geology, Seismicity and Soils

San Luis Reservoir The four geologic formations in the area around San Luis Reservoir include: (1) the Franciscan formation composed of a thick assemblage of sedimentary (sandstone, shale, chert and conglomerate), igneous, and metamorphic rock; (2) the Panoche formation composed of an arenaceous shale and thinly bedded sandstone, a sedimentary sequence of lenses of coarse-grained conglomerate of porphyritic and granite boulders, cobbles, and pebbles; (3) the Tulare formation composed of nonmarine gravel, sand, and silt derived from the Franciscan formation; and (4) the Tertiary Volcanic formation including small scattered deposits of volcanic rocks.

There are several soil associations that occur around the San Luis Reservoir, including Denverton, Kettleman, and Altamont clay associations which occupy 2,650 acres of the lands surrounding the reservoir (Reclamation and CDPR 2013). Rough stony land is the second most common soil type in the reservoir area, occupying approximately 2,000 acres mostly on the western side of the reservoir (Reclamation and CDPR 2013). The majority of developed lands in the vicinity of the reservoir, including most recreation areas, have slight or moderate erosion potential. Many of the undeveloped areas along the western, northern, and southern shorelines are categorized as having severe erosion hazard.

Soil types on the reservoir floor were characterized in geologic borings conducted by Reclamation in 1962. In the deeper areas of eastern San Luis Reservoir, reservoir bottom soils consist primarily of lean clay to sandy clay/clayey sand with trace peat/fat clay, overlying silty sand and gravel (Reclamation 1962 as cited in Reclamation and SCVWD 2013). In the western part of the reservoir, starting from approximately half way between the proposed new intake structure and the connection to the existing intake structure, the soil types transition from lean clay deposits to sandier sediments, sandy silt, silty sand beds, sandy clay beds, and gravels (Reclamation and SCVWD 2013).

San Luis Reservoir is in a seismically active area and is close to several faults and fault systems. The Ortigalita fault passes under the reservoir in two locations, one is along the western shore of the reservoir crossing over Lone Oak Bay to the east and the other runs from Cottonwood Bay close to the eastern shore of the reservoir on the eastern side of Basalt Hill (Reclamation and CDPR 2013 and United States Geological Survey [USGS] 2011). The O’Neill Fault System runs south and east of O’Neill Forebay and south of San Luis Reservoir (USGS 2011). The Calaveras and San Andreas faults are 23 and 28 miles away, respectively (Reclamation and CDPR 2013). These faults can cause earthquakes at or near San Luis Reservoir given that fault offsets can take place either along a single, or multiple fault planes. During a seismic event, secondary fault rupture and displacements can take place on neighboring faults, which had been considered to be less than active.

Landslides are common within the Coast Ranges, specifically, the west side of Merced County due to steep slopes, unstable terrain and proximity to earthquake faults (Merced County 1990). The eastern portion of San Luis Reservoir including O’Neill Forebay is in a low potential landslide zone while the western portion of the reservoir is in a medium potential landslide zone (Merced County 1990).

SCVWD Service Area: Sediments within the Santa Clara Subbasin include Holocene to Pliocene age continental deposits composed of unconsolidated to semi-consolidated gravels, sands, silts, and clays. These sediments have generally been classified as either alluvium, including unconsolidated gravels, sand, silts, and clays, or as the Santa Clara Formation, including poorly sorted deposits ranging from boulders to silt (Reclamation and SCVWD 2013).

The San Francisco Bay region is one of the most seismically active regions in the United States. There are three major faults that run across Santa Clara County: the San Andreas, Calaveras, and Hayward Faults.

The section of the San Andreas Fault directly west of San Luis Reservoir is the Santa Cruz Mountains section; this section is in Santa Clara and San Benito Counties. The San Andreas Fault has had historic earthquake activity within the past 150 years with recorded surface deformation taking place during the San

Francisco earthquake in 1906 (USGS, Department of Conservation [DOC], and California Geological Survey [CGS] 2011; Bryant and Lundberg 2002). The Calaveras Fault zone has four sections with the central Calaveras Fault section running west of the project area in the vicinity of Anderson Lake and Coyote Lake (USGS, DOC and CGS 2011 and Bryant and Cluett 1999a). Portions of the central section as well as the southern section of the fault are reported as having historic earthquake activity within the past 150 years, such as the Coyote Lake earthquake of August 1979 (Bryant and Cluett 1999b). The Hayward Fault Zone is located along the eastern side of San Francisco Bay and forms the western boundary of the East Bay Hills. The fault zone has three sections, two of which are near the area of analysis: the southern section and the southeast extension section (Bryant and Cluett 2000a and 2000b). Neither section has experienced historic surface rupturing; the most recent prehistoric surface rupture for both sections was less than 15,000 years ago (Bryant and Cluett 2000a and 2000b).

Areas most prone to landslides include areas in the mountainous regions surrounding Santa Clara Valley. There are a couple sites within the area of analysis that have been designated as prone to landslides; these include two areas south of the City of San Jose located between State Route (SR) 87 and US 101. The area of the county in the Santa Cruz Mountains, west of SR 85 is also classified as a high landslide hazard area (Santa Clara County 2006). These sites are outside of the area for proposed groundwater wells and the proposed groundwater recharge pond.

The Pacheco Reservoir site is located within the Diablo Range portion of the Coast Ranges Geomorphic Province. The Diablo Range is a broad anticlinorium with a core comprised largely of Franciscan Assemblage subduction sequence sedimentary rocks that have been folded, sheared and mildly metamorphosed. The overall fabric of the Coast Ranges is a reflection of the greater San Andreas fault system (SCVWD 2017a).

Water Quality

San Luis Reservoir: San Luis Reservoir stores runoff water from the Delta, with a storage capacity of over two million AF. The water arrives through the California Aqueduct and DMC, and is pumped from the O’Neill Forebay into the main reservoir during the winter and spring.

San Luis Reservoir and the surrounding area tend to be windy and are characterized by wet, cool winters and warm, dry summers. During the summer months, when water levels are low, water quality in the San Luis Reservoir deteriorates due to a combination of higher warmer temperatures, wind-induced nutrient mixing, and algal blooms near the reservoir surface. Presently, when San Luis Reservoir approaches its late summer/early fall low point, algal growth may begin to degrade water quality for contractors that utilize the water. If the algal layer is significantly thick, when the lake storage volume is reduced to approximately 300,000 AF, algae may begin to enter the Lower San Felipe

Intake. The water quality within the algal blooms is not suitable for agricultural water users with drip irrigation systems in San Benito County or for M&I water users relying on existing water treatment facilities in Santa Clara County.

San Luis Reservoir and O'Neill Forebay were designated in 2010 as impaired on the Central Valley Regional Water Quality Control Board 303(d) List. The reservoir and forebay were listed for mercury impairment. Potential sources of the impairment are listed as unknown.

Delta Region and South-of-Delta CVP and SWP Facilities: San Luis Reservoir provides off-stream storage, and the primary source of that water is Delta exports. The Delta Region forms the low-lying outlet of the Central Valley, between the bordering Sacramento River to the north and the San Joaquin River to the south. Water quality in the Delta Region is governed in part by Delta hydrodynamics, which are highly complex. The principal factors affecting Delta hydrodynamic conditions are: 1) river inflows from the San Joaquin and Sacramento River systems; 2) daily tidal inflows and outflows through the San Francisco Bay; and 3) export pumping from the south Delta through the Harvey O. Banks Pumping Plant and Jones Pumping Plant.

The existing water quality constituents of concern in the Delta can be categorized broadly as metals, pesticides, nutrient enrichment and associated eutrophication, constituents associated with suspended sediments and turbidity, salinity, bromide, and organic carbon.

Santa Clara County Region: The San Felipe Division provides supplemental water to 63,500 acres of land with up to 132,400 AF of water delivered annually for M&I use, subject to availability. Water is transported to the service area from the San Luis Reservoir via the Pacheco Tunnel to users in the SCVWD Service Area or stored in Anderson reservoir for later use (Reclamation 2011). Water is also imported from the SWP through the SBA.

Anderson Reservoir is the largest surface storage facility in SCVWD that was constructed in 1950. The reservoir is listed on California's 303(d) List for impairment due to mercury and polychlorinated biphenyl.

The SBA is a 44.7 mile SWP delivery system that conveys water to Zone 7 Water Agency of the Alameda County Water Conservation and Flood Control District, Alameda County Water District, and the SCVWD. The majority of SBA water originates from the Delta. Sanitary surveys and drinking water source assessments have identified water quality constituents as contaminants of concern. These contaminants include: bacteria and protozoa with possible sources being stormwater runoff, livestock grazing, and/or wastewater treatment facilities; bromide with a possible source of seawater contributions from Delta water; total organic carbon which may be derived from stormwater runoff, septic leaching, and/or wastewater treatment facilities; total solids introduced by stormwater runoff, agricultural activities, or by grazing; and nutrients with possible sources being sewage spills, stormwater flows, and/or agricultural activities (Alameda County Water District 2008).

Beneficial uses at Pacheco Reservoir include municipal and domestic supply, agricultural supply, groundwater recharge, water contact and non-contact water recreation, wildlife habitat, cold and warm freshwater habitat, fish spawning, preservation of rare and endangered species, freshwater replenishment, navigation and commercial and sport fishing. Beneficial Uses designated for Pacheco Creek include municipal and domestic supply, agricultural supply, groundwater recharge, water contact and non-contact water recreation, wildlife habitat, cold and warm freshwater habitat, fish migration, fish spawning, preservation of biological habitats, preservation of rare and endangered species, freshwater replenishment, and commercial and sport fishing. The Pacheco Reservoir releases are not known to contribute to the identified impairments to Beneficial Use. However, Beneficial Uses at Pacheco Creek are identified as impaired under the Clean Water Act (CWA) Section 303(d) due to high concentrations of fecal coliforms, low dissolved oxygen and turbidity sourced from agriculture, natural and grazing-related sources, as well as from storm drainage discharges, animal discharges, and sewer spills and leaks (SCVWD 2017a).

Groundwater Resources

San Joaquin Valley Groundwater Basin: The San Joaquin Valley Groundwater Basin, including the Tracy, Delta-Mendota, and Westside subbasins, extends over the southern two-thirds of the Central Valley regional aquifer system and has an area of approximately 13,500 square miles. The San Joaquin Valley Groundwater Basin, extends from just north of Stockton in San Joaquin County to Kern County. DWR has prioritized Tracy subbasins as medium priority based on degraded water quality throughout the subbasin (DWR 2014). The north western portion of the subbasin does not have designated groundwater sustainability agency at the time of writing this report. DWR has prioritized the Delta-Mendota subbasin as high priority based on overdraft concerns in the subbasin (DWR 2014). DWR has prioritized the Westside subbasin as high priority based on overdraft, land subsidence and water quality concerns in the subbasin (DWR 2014).

Santa Clara Valley Groundwater Basin and Gilroy- Hollister Groundwater Basin: Groundwater is an important water supply source for Santa Clara County and its preservation was the goal that spurred the formation of the SCVWD. SCVWD manages two groundwater subbasins: the Santa Clara Plain and Coyote Valley in the Santa Clara Valley Subbasin and the Llagas Subbasin in the Gilroy-Hollister Groundwater Basin. SCVWD's management of groundwater in these two subbasins includes replenishment with local and imported surface water, reductions in demand on groundwater through the use of treated surface water deliveries, water conservation, and water recycling, and ongoing monitoring of groundwater levels and quality across the subbasins (SCVWD 2018b).

DWR has prioritized the Santa Clara Valley subbasin as medium priority based on groundwater quality concerns in some wells across the subbasin (DWR 2014). Llagas Area subbasin was prioritized as high priority based on groundwater quality concerns over a significant number of wells across the subbasin (DWR 2014).

Pacheco Reservoir is currently operated for groundwater recharge through releases to Pacheco Creek. Pacheco Creek flows through the Gilroy-Hollister groundwater basin.

Air Quality

San Luis Reservoir: San Luis Reservoir is located within the San Joaquin Valley Air Basin (SJVAB). The region is highly susceptible to pollutant accumulation over time because of the mountains that surround the valley. Marine air flows towards the east through gaps in the Coast Range at the Golden Gate and Carquinez Strait.

Low wind speeds contribute to high concentrations of air pollutants in the winter time. During the summer, winds typically originate from the north end of the basin and flow in a south-southeast direction though the valley. These conditions contribute to persistent summer inversions that prevent the vertical dispersion of air pollutants. Summer time inversions occur when a layer of cool, marine air is trapped below a mass of warmer air above.

The SJVAB is currently designated by the U.S. Environmental Protection Agency (USEPA) as nonattainment for the ozone (O_3) and fine particulate matter ($PM_{2.5}$) national and California ambient air quality standards (NAAQS and CAAQS), nonattainment for the inhalable particulate matter (PM_{10}) CAAQS, and maintenance for the PM_{10} NAAQS (California Air Resources Board [CARB] 2015; USEPA 2016; 40 Code of Federal Regulations [CFR] 81.305).

Santa Clara Valley Water District Service Area and Pacheco Reservoir: Santa Clara County is in the San Francisco Bay Area Air Basin (SFBAAB). The basin is mostly covered on the east and south by the Diablo Range, on the west by the Pacific Ocean and on the north by the Coast Ranges. The basin is characterized by complex terrain consisting of inland valleys, coastal mountain ranges, and the San Francisco Bay.

The basin’s climate is mostly determined by a high-pressure system regularly present over the eastern Pacific Ocean off the West Coast of North America. This high-pressure system shifts to the south during the winter allowing storms to pass through the region. During the summer, abundant sunshine along with the region’s topography and subsidence inversion creates conditions that favor the formation of pollutants such as ozone.

The SFBAAB is currently designated by the USEPA as nonattainment for the O_3 and $PM_{2.5}$ NAAQS and CAAQS, nonattainment for the PM_{10} CAAQS, and maintenance for the carbon monoxide NAAQS. (CARB 2015; USEPA 2016; 40 CFR 81.305).

Noise
Noise sources currently existing in the area of analysis are of three general types: agricultural noise, general stationary noise, and general mobile noise. The counties in the area of analysis vary from rural to urban environments, and include farming, industrial, residential, and commercial noise sources. On the whole, no major long-term sources of vibration are known to exist in the area of analysis.

1.6.1.3 Biological Environment

Elements of the aquatic and terrestrial biological environment in the SLLPIP study area are described in this section. The discussion focuses on habitat and species, including special-status species.

Aquatic Resources
The following sections describe the existing aquatic resource conditions within the different regions of the area of analysis.

San Luis Reservoir: San Luis Reservoir contains warm water fish, and recreational fishing is an important use of the reservoir. The reservoir is an artificial environment and does not support a naturally evolved aquatic community. Although a few species native to San Luis Creek that the reservoir impounds may still be present, the vast majority of fish species in the reservoir have either been directly introduced or transported into the reservoir via the California Aqueduct and DMC. Although there are fish screens at the CVP and SWP pumps, fish eggs, larvae, small juveniles, and invertebrates can pass through the screens and be transported to San Luis Reservoir. Striped bass are the predominant species in the reservoir. Other species found in the reservoir include threadfin shad (*Dorosoma petenense*), Sacramento sucker, carp (*Cyprinus carpio*), Sacramento blackfish (*Orthodon microlepidotus*), hitch (*Lavinia exilicauda*), hardhead, white catfish, channel catfish, yellow bullhead (*Ictalurus natalis*), brown bullhead (*Ictalurus nebulosus*), black bullhead (*Ictalurus melas*), mosquitofish (*Gambusia affinis*), Sacramento perch (*Archoplites interruptus*), black crappie (*Pomoxis migromaculatus*), largemouth bass, warmouth (*Lepomis gulosus*), green sunfish (*Lepomis cyanellus*), bluegill (*Lepomis macrochirus*), and red-eared sunfish (*Lepomis microlophus*).

SCVWD Service Area: The SCVWD Service Area includes 10 dams and surface storage reservoirs, 3 water treatment plants, 400 acres of groundwater recharge ponds, and 275 miles of streams (SCVWD 2011). Waterbodies within the service area include, but are not limited to the Guadalupe River, Anderson Reservoir, Calero Reservoir, Almaden Reservoir, Coyote Creek, and Stevens Creek.

Fish-bearing watercourses in the SCVWD Service Area include the Guadalupe River and Coyote, Stevens, Calabasas, San Tomas Aquino creeks, all of which drain into the south San Francisco Bay. Chinook salmon and Central California Coast Distinct Population Segment (DPS) steelhead (*Oncorhynchus mykiss*) are the two fish species of primary management concern in this region. NMFS has designated critical habitat for steelhead in the SCVWD Service Area (NMFS 2007) in the Guadalupe River from its mouth upstream to its confluence with Los Gatos Creek, Coyote Creek, and Penitencia Creek.

Other native fish species known to occur in the SCVWD Service Area include Pacific lamprey (*Entosphenus tridentatus*), California roach (*Hesperoleucus symmetricus),* hitch, Sacramento blackfish, Sacramento pikeminnow, Sacramento sucker, threespine stickleback (*Gasterosteus aculeatus*), prickly sculpin (*Cottus asper*), riffle sculpin (*Cottus gulosus*), and tule perch (*Hysterocarpus traski*).

Pacheco Reservoir and Pacheco Creek The existing North Fork Pacheco Reservoir is operated by the Pacheco Water District to supply agricultural irrigation water through streambed percolation. Rearing and migratory habitat for South-Central California Coast (SCCC) steelhead in Pacheco Creek downstream of the dam is almost completely dependent upon releases from North Fork Pacheco Reservoir. Prior field studies have identified intermittent populations of SCCC steelhead in Pacheco Creek, with opportunistic migration to the creek when flows allow upstream movement. However, fish present in any life stages are at high-risk to death when flows decrease to a point of either resulting in warm water temperatures, or to the point of drying up the streambed. Therefore, having consistent and contiguous flow at a suitable temperature is vital to the survival of SCCC steelhead in Pacheco Creek.

Threatened, Endangered and Special-Status Species: Several native anadromous and resident species have been listed as threatened or endangered under the Federal ESA or California ESA or are candidates for listing. Seven fish species listed under Federal ESA or CESA have the potential to occur in the watercourses in the area of analysis including Central Valley Steelhead, Central California Coast and SCCC steelhead, Central Valley spring-run Chinook Salmon, Sacramento River winter-run Chinook salmon, Green sturgeon, Delta smelt, and longfin smelt. Additionally, Central Valley Chinook salmon (fall/late fall-run), California/San Joaquin Roach, and Sacramento perch have the potential to occur in the watercourses in the area of analysis that are listed as either federal or State species of concern (CDFW 2016; Moyle 2002).

SCCC steelhead were formally listed by NMFS as a threatened evolutionarily significant unit (ESU) on August 18, 1998 (62 FR 43937), with the ESU boundary from the Pajaro River south to (but not including) the Santa Maria River. NMFS subsequently adopted a DPS for steelhead, replacing the ESU designation (71 FR 834). Under the final listing, the SCCC steelhead DPS includes all naturally spawned steelhead that occur below impassible barriers, and which exhibit an anadromous life history. NMFS designated critical habitat for SCCC, which includes Pacheco Creek of the Pajaro River watershed, on September 2, 2005 (70 FR 52488).

Terrestrial Resources

The following section describes the existing terrestrial resource conditions within the area of analysis.

San Luis Reservoir: Dominant vegetation communities within the San Luis Reservoir Region include riparian woodland, woodland, coast live oak woodland, scrub/chaparral, grassland, mesic herbaceous (wetland), ruderal, and developed (Reclamation and CDPR 2013).

Riparian woodland support common wildlife species including: amphibians such as Sierran treefrog (*Pseudacris sierra*), California newt (*Taricha torosa*), and California slender salamander (*Batrachoseps attenuatus*); birds including Wilson's warbler (*Wilsonia pusilla*), Swainson's thrush (*Catharus ustulatus*), yellow warbler (*Dendroica petechia brewsteri*), green heron (*Butorides striatus*), and red-shouldered hawk (*Buteo lineatus*); and mammals including San Francisco dusky-footed woodrat (*Neotoma fuscipes annectens*), gray fox (*Urocyon cinereoargenteus*), and mountain lion (*Puma concolor*) (Santa Clara County 2012).

Scrub/chaparral provides cover for wildlife including desert cottontail (*Sylvilagus audubonii*), western rattlesnake (*Crotalus viridis*) and coyote.

Grassland habitats support many species of migratory birds and raptors including western meadowlark (*Sturnella neglecta*), savannah sparrow (*Passerculus sandwichensis*), and red-tailed hawk (*Buteo jamaicensis*). Reptiles including western fence lizard (*Sceloporus occidentalis*) and common garter snake (*Thamnophis sirtalis*) and mammals including California ground squirrel (*Otospermophilis beecheyi*), bobcat (*Felis rufus*), and coyote (*Canis latrans*) inhabit grassland.

Wetlands are important for foraging and breeding habitat for many species of water birds including: wading birds such as great egret (*Ardea alba*); waterfowl including green-winged teal (*Anas crecca*), mallard, and American coot; shorebirds including killdeer, black-necked stilt (Himanto*pus mexicanus*), greater yellowlegs (*Tringa melanoleuca*), and American avocet (*Recurvirostra americana);* and passerines including Brewer's blackbird (*Euphagus cyanocephalus*), red-winged blackbird, brown-headed cowbird (*Molothrus ater*), and American pipit (*Anthus rubescens*) (Santa Clara County 2012).

Developed areas provide limited habitat for wildlife because of their built environment. However, typical bird species that are found in developed areas include American robin (*Turdus migratorius*), mockingbird (*Mimus polyglottos*), American crow (*Corvus brachyrhynchos*), house sparrow (*Passer* *domesticus*), European starling (*Sturnus vulgaris*), and rock pigeon (*Columba livia*). Other wildlife adapted to living in developed areas include Norway rat (*Rattus norvegicus*), western gray squirrel (*Sciurus niger*), opossum (*Didelphis virginiana*), and raccoon.

Santa Clara Valley Water District Service Area: Major vegetation communities found in the SCVWD Service Area include grassland, chaparral and coastal scrub, oak woodland, riparian forest and scrub, and wetland and open water (Santa Clara County 2012). The Santa Teresa WTP is located within a developed area; hhowever, grassland, oak woodland, and riparian forest and scrub vegetation communities do occur nearby. These vegetation communities are described in more detail below.

Pacheco Reservoir and Pacheco Creek The area surrounding the Pacheco Reservoir is principally undeveloped. Oak woodland comprises the majority of land cover in the vicinity of the reservoir including: foothill-pine oak woodland, mixed oak woodland and forest, blue oak woodland, and valley oak woodland. Other habitat types in the area include northern riparian forest and woodland, annual grassland, and chaparral.

Given similarities in vegetation communities, many of the wildlife species that occur in the SCVWD Service Area are similar to those found in the San Luis Reservoir Region, such as grassland, riparian, and wetlands, as described above. Common wildlife associated with the vegetation communities not found in the San Luis Reservoir Region, including chaparral.

Chaparral communities in the SCVWD Service Area support many species of birds including Anna’s hummingbird (*Calypte anna*), western scrub-jay (*Aphelocoma californica*), Bewick’s wren (*Thryomanes bewickii*), California towhee (*Pipilo crissalis*), and California quail (*Callipepla californica*). Reptiles that utilize chaparral include gopher snake (*Pituophis melanoleucus*) and western rattlesnake (*Crotalus oreganus*). Mammals that utilize chaparral include California pocket mouse (*Perognathus californicus*), California ground squirrel, bobcat, and coyote.

Threatened, Endangered and Special-Status Species Special-status plant and wildlife species that have the potential to occur within the San Luis Reservoir region or in the SCVWD Service Area based on local sightings and/or the potential presence of suitable habitat are provided in Table 1-1.

Table 1-1. Federal and State Threatened, Endangered and Special-Status Species and Species of Note

Common Name	Scientific Name	Status
Bay checkerspot butterfly	*Euphydryas editha bayensis*	FT
Zayante band-winged grasshopper	*Trimerotropis infantilis*	FE
Valley elderberry longhorn beetle	*Desmocerus californicus dimorphus*	FT
California tiger salamander	*Ambystoma californiense*	FT, ST
Foothill yellow-legged frog	*Rana boylii*	CSC
California red-legged frog	*Rana draytonii*	FT, CSC
Western pond turtle	*Actinemys marmorata*	CSC
Blunt-nosed leopard lizard	*Gambelia sila*	FE, SE
Coast horned lizard	*Phrynosoma blainvillii*	CSC
Alameda whipsnake	*Masticophis lateralis euryxanthus*	FT, ST
San Joaquin whipsnake	*Masticophis flagellum ruddocki*	CSC
American peregrine falcon	*Falco peregrinus anatum*	CFP
Bald eagle	*Haliaeetus leucocephalus*	BGEPA, SE, CFP
Black swift	*Cypseloides niger*	CSC
Golden eagle	*Aquila chrysaetos*	BGEPA
Northern harrier	*Circus cyaneus*	CSC
Purple martin	*Progne subis*	CSC
Swainson's hawk	*Buteo swainsoni*	ST
Tricolored blackbird	*Agelaius tricolor*	SC
Western burrowing owl	*Athene cunicularia*	CSC
White-tailed kite	*Elanus leucurus*	CFP
American badger	*Taxidea taxus*	CSC
Greater western mastiff bat	*Eumops perotis californicus*	CSC
Pallid bat	*Antrozous pallidus*	CSC
Ringtail	*Bassariscus astutus*	CFP
San Joaquin kit fox	*Vulpes macrotis mutica*	FE, ST
Townsend's big-eared bat	*Corynorhinus townsendii*	CSC
Tule elk	*Cervus elaphus nannodes*	Managed as Big Game Mammal
Arburua Ranch jewelflower	*Streptanthus insignis* ssp. *lyonii*	CRPR 1B.2
Arcuate bush-mallow	*Malacothamnus arcuatus*	CRPR 1B.2
Big-scale balsamroot	*Balsamorhiza macrolepis* var. *macrolepis*	CRPR 1B.2
California alkali grass	*Puccinellia simplex*	CRPR 1B.2
Chaparral harebell	*Campanula exigua*	CRPR 1B.2
Congdon's tarplant	*Centromadia parryi ssp. congdonii*	CRPR 1B.2
Contra Costa goldfields	*Lasthenia conjugens*	FE, CRPR 1B.1
Coyote ceanothus	*Ceanothus ferrisiae*	FE, CRPR 1B.1
Fragrant fritillary	*Fritillaria liliacea*	CRPR 1B.2
Hairless popcorn-flower	*Plagiobothrys glaber*	CRPR 1A
Hall's bush-mallow	*Malacothamnus hallii*	CRPR1B.2
Hispid bird's-beak	*Chloropyron mollis* ssp. *hispidum*	CRPR 1B.1
Hospital Canyon larkspur	*Delphinium californicum ssp. interius*	CRPR 1B.2
Lemmon's jewel-flower	*Caulanthus lemmonii*	CRPR 1B.2
Lime Ridge navarretia	*Navarretia gowenii*	CRPR 1B.1
Loma Prieta hoita	*Hoita strobilina*	CRPR 1B.1
Maple-leaved checkerbloom	*Sidalcea malachroides*	CRPR 4.2
Most beautiful jewel-flower	*Streptanthus albidus* ssp. *peramoenus*	CRPR 1B.2
Mt. Hamilton fountain thistle	*Cirsium fontinale* var. *campylon*	CRPR 1B.2
Mt. Hamilton jewel-flower	*Streptanthus callistus*	CRPR 1B.3

Common Name	Scientific Name	Status
Pink creamsacs	*Castilleja rubicundula* ssp. *rubicundula*	CRPR 1B.2
Robust spineflower	*Chorizanthe robusta* var. *robusta*	FE, CRPR 1B.1
Round-leaved filaree	*California macrophyllum*	CRPR 1B.1
Saline clover	*Trifolium hydrophilum*	CRPR 1B.2
San Francisco collinsia	*Collinsia multicolor*	CRPR 1B.2
Santa Clara Valley dudleya	*Dudleya abramsii* ssp. *setchellii*	FE, CRPR 1B.1
Santa Cruz Mountains beardtongue	*Penstemon rattanii* var. *kleei*	CRPR 1B.2
Santa Cruz Mountains pussypaws	*Calyptridium parryi* var. *hesseae*	CRPR 1B.1
Shining navarretia	*Navarretia nigelliformis ssp. radians*	CRPR 1B.2
Smooth lessingia	*Lessingia micradenia var. glabrata*	CRPR 1B.2
Spiny-sepaled button-celery	*Eryngium spinosepalum*	CRPR 1B.2
Tiburon paintbrush	*Castilleja affinis* ssp. *neglecta*	FE, ST, CRPR 1B.2
Woodland woollythreads	*Monolopia gracilens*	CRPR 1B.2

Source: CDFW 2016, Reclamation and CDPR 2013.

Key:

Federal (USFWS):

BEPA = Bald Eagle Protection Act
FE = Listed as Endangered by the Federal Government
FT = Listed as Threatened by the Federal Government
FPE = Proposed for Listing as Endangered
FPT = Proposed for Listing as Threatened
FD = Federal Delisted Species
FC = Candidate for Federal listing

State (California Department of Fish and Wildlife):

SE = Listed as Endangered by the State of California
ST = Listed as Threatened by the State of California
SC = Candidate for State listing
SR = Listed as Rare by the State of California (plants only)
CSC = California species of special concern
CFP = California fully protected species

California Rare Plant Rank:

CRPR 1A – Species considered extinct in California
CRPR 1B – Rare and endangered in California and elsewhere
CRPR 2 – Species considered rare and endangered in California but more common elsewhere
0.1 – Seriously threatened
0.2 – Fairly threatened in California
0.3 – Not very threatened in California

1.6.1.4 Cultural Resources

The cultural resources area of analysis also includes a buffer surrounding the area of potential effects (APE) for each alternative. The APE for the four action alternative plans is as follows: (1) the Lower San Felipe Intake Alternative APE, which encompasses a proposed aeration facility, the Basalt Point use area, the Dinosaur Point area, Dinosaur Point Road, an intake or dredging area surrounding the proposed pipeline or tunnel, and Gate Shaft Island; (2) the Treatment Alternative APE, which includes the full extents of the existing Santa Teresa WTP; (3) the San Luis Reservoir Expansion Alternative APE, which spans B.F. Sisk Dam, the Basalt Hill borrow area and Borrow Area 6, the Cottonwood Bay levee modification and levee raise areas, the Dinosaur Point boat launch modification area, downstream fill impact areas, haul road and SR 152 impact areas, potential construction staging areas, and the San Luis Reservoir shoreline; and (4) the Pacheco Reservoir Expansion Alternative APE, which includes the existing North Fork Dam, a proposed dam and reservoir, new pipelines and tunnels, inlet/outlet facilities, a pump station, borrow areas, temporary haul roads, and a new transmission line. The alternatives plans span the Central Coast and Central Valley regions, which were inhabited by Native Americans beginning at least 10,000 years ago. The Ohlone and the Northern Valley Yokuts, the two major Native groups who would have been encountered by early Euro-Americans, left behind a rich material culture evident in archaeological sites throughout both regions. These groups were followed by Spanish, Mexican, and American explorers, missionaries, soldiers, and settlers who later altered the landscape in distinct ways. While much of what is known of Native Californian prehistory comes from archaeological evidence, Native Americans lifeways during the later prehistoric and historic periods also may be understood through the ethnographic record. That record includes written accounts and oral histories from European and American missionaries, soldiers, and settlers who made observations about the aboriginal cultures they encountered; it also includes observations from 18th and 19th century anthropologists who attempted to document the languages and practices of Native Americans even as they were being radically transformed. As documented through the ethnographic record, the study area is located in the western territorial boundary for the Northern Valley Yokuts (Wallace 1978; Kroeber 1925), and the traditional territory of the Coastanoan/Ohlone.

Archival and record searches of known cultural resource locations and prior cultural resource studies were carried out in 2009, 2012, 2016, and 2018 at the Central California Information Center (CCIC) and the Northwest Information Center (NWIC) of the California Historical Resources Information System (CHRIS) for the cultural resources area of analysis associated with each proposed action alternative. Pedestrian inventory surveys within the APE for alternatives were conducted, as access was available. The EIS/EIR provides information on resources discovered during record searches and pedestrian surveys.

1.6.1.5 Socioeconomic Resources

Population and Employment
San Joaquin Valley Region: The CVP and SWP water service contractors within the San Joaquin Valley have service areas within Fresno, Kern, Kings, Madera, Merced, San Joaquin, Stanislaus, and Tulare counties. In 2014, the total population in the 8-county region was 4.1 million (Minnesota IMPLAN Group (MIG), Inc. 2016). The region is largely rural with some large population centers in the cities of Stockton, Merced, Fresno, and Bakersfield. Much of the region's land is in agricultural production. CVP contractors in this region deliver both irrigation and M&I water supplies with the majority of the CVP water used in the region for agriculture.

Bay Area Region: CVP contractors in the Bay Area Region deliver both irrigation and M&I water supplies with Alameda, Contra Costa, and Santa Clara counties more reliant on M&I deliveries and San Benito County more reliant on irrigation deliveries. SWP contractors in this region deliver M&I water within Santa Clara County.

In 2014, the total population in the 4-county region was approximately 4.7 million (MIG 2016). Alameda, Contra Costa, and Santa Clara counties have the largest urban areas in the Bay Area Region, supporting the most employment and industry. These counties include residential suburbs of San Francisco, but are also home to important business services and retail businesses. California's Silicon Valley, the center of the region high-tech businesses, is in Santa Clara County.

Land Use

San Luis Reservoir The majority of land within Merced County is designated as Agricultural and Foothill Pasture Land and lies outside of existing cities, Rural Centers, Urban Communities, and Highway Interchange Centers (Merced County 2013).

Land surrounding the San Luis Reservoir and the SRA include a variety of uses. The unincorporated community of Santa Nella, located northeast of O'Neill Forebay, includes residential and commercial uses (Reclamation and CDPR 2013). Grazing land is the primary land use surrounding the reservoir. Lands to the southeast of the reservoir include privately owned ranchlands, agricultural lands, public utility uses, and other scattered nonresidential uses (Reclamation and CDPR 2013).

SCVWD Area Santa Clara County encompasses 1,300 square miles at the southern end of the San Francisco Bay (Santa Clara County 1994). The eastern and southern portions of the county are rural and designated as Ranchlands, Other Public Open Lands, and Regional Parks, with the exception of the lands immediately surrounding and in the cities of Morgan Hill and Gilroy (Santa Clara County 2013). San Jose is the largest city in Santa Clara County and Northern California. Residential development in the city tends to be low density, single-family detached housing (City of San Jose 2011). Pacheco Reservoir is located in the sphere of influence of unincorporated Santa Clara County. A majority of the area surrounding Pacheco Reservoir is rural, pastoral landscape of open space. Two single-family residences are located one mile south of the existing North Fork Dam. Several small ranching facilities are located along the North Fork of Pacheco Creek (SCVWD 2017a).

Traffic

San Luis Reservoir Regional access routes to the San Luis Reservoir SRA include Interstate 5 (I-5), US 101, SR 152, and SR 33. Local access routes in the vicinity of the San Luis SRA include Fifield Road, a two-land rural non-freeway road located west of the San Luis Reservoir running in the east/west direction connecting SR 152 with the San Luis Reservoir SRA; Dinosaur Point Road, a two-lane east-west rural non-freeway road that connects SR 152 with Fifield Road and the Dinosaur Point parking lot within the San Luis Reservoir SRA; and, Basalt Road, a two-lane rural road non-freeway road that runs along the edge of the San Luis Reservoir on the southeast side providing direct access from SR 152 to the Basal Recreation Area.

Public transit near San Luis Reservoir area includes the Merced Area Regional Transit System and Greyhound-Trailways bus lines. These two transit services do not stop at San Luis Reservoir.

The San Luis Reservoir SRA Resource Management Plan/General Plan identified parking shortages at the San Luis Creek and Los Banos Creek Use Areas during peak visitation periods (Reclamation and CDPR 2013).

SCVWD Service Area Regional and local access routes to the area where construction for the treatment technology upgrades at the Santa Teresa WTP would be involved include I-280, SR 87, and SR 85.

Throughout Santa Clara County and the incorporated cities and towns, public transportation is provided by Caltrain, light rail, rapid bus transit, Bay Area Rapid Transit, Santa Clara Valley Transit Authority (VTA) buses, and local shuttles. In addition to bus service, the VTA directly provides light rail, rail shuttles, and paratransit services to Santa Clara residents, workers, and visitors. The City of San Jose also provides bus and rail service throughout the region.

Vehicle access to Pacheco Reservoir site would occur from SR 152, also known as the Pacheco Pass Highway. Vehicles would access Pacheco Reservoir via the existing access road adjacent to SR 152.

Recreation

San Luis Reservoir: Recreation facilities potentially affected within the San Luis Reservoir study area include the San Luis Reservoir SRA and Pacheco State Park (SP).

San Luis Reservoir State Recreation Area: The San Luis Reservoir SRA was developed beginning with an agreement in 1969 and initiation of general plan development in 1971 (Reclamation and CDPR 2013). The San Luis Reservoir SRA is divided into five main use areas[3] (Basalt, Dinosaur Point, Los Banos Creek, Medeiros, and San Luis Creek), and one minor use area for off-highway vehicle use. There are two additional areas designated for wildlife; both allow for hunting and hiking in undeveloped areas, along with nature study activities. The primary activities at each main use area vary but, collectively, the San Luis Reservoir SRA provides opportunities for boating, swimming, windsurfing, camping, and fishing (Reclamation and CDPR 2013).

Pacheco Pass: The Pacheco SP lies directly west of the San Luis Reservoir SRA. Part of the park is open to the public for day use recreation. The remainder of the park is used as a horse and cattle ranch, in addition to a wind turbine farm that generates clean energy for 3,500 homes. The public park

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[3] Main use areas refer to the designated major public recreation facilities within the San Luis Reservoir SRA (Reclamation and CDPR 2013).

component is most notable for its rich historic heritage and public education opportunities (CDPR 2011).

SCVWD Service Area: Recreational facilities potentially affected in the SCVWD study area include Anderson Lake County Park. The Henry W. Coe State Park boundary is located 2,100 feet from the Pacheco Reservoir site (SCVWD 2017a). Land in the area of Pacheco Reservoir are primarily privately held and devoted to open space and ranchlands. Pacheco Reservoir itself does not support any recreational activities.

Anderson Lake County Park: Anderson Park encompasses Anderson Reservoir which has a storage capacity of 89,073 AF (SCVWD 2016b). In addition, the park includes portions of the Coyote Creek Parkway trail system, the Jackson Ranch historic site, the Moses L. Rosendin Park, and the Burnett Park area. The combination of recreation resources provides a variety of recreation opportunities to the public including boating, picnicking, fishing, hiking, bicycling, and equestrian use (Santa Clara County Parks 2011).

Visual Resources

San Luis Reservoir: Overall, the area around San Luis Reservoir offers open scenic vistas of undeveloped land and open water. These scenic qualities are enhanced by the surrounding undeveloped landscape consisting of “open grassland, expansive vistas of the rolling terrain and the adjacent Diablo range” (Reclamation and CDPR 2013). Most shoreline areas allow for uninterrupted views of the open water from the three nearby reservoirs (San Luis Reservoir, O’Neill Forebay, and Los Banos Reservoir). The views from the north and south plateaus at the Los Banos Reservoir provide a vista opportunity of the water and adjacent landscape. The San Luis SRA Regional Management Plan/General Plan notes that future plans for facilities and landscape features should consider the open, uninterrupted nature of the landscape (Reclamation and CDPR 2013). While there are developed areas around the reservoir, the overall layout and configuration of the built structures is “clustered in succinct areas, reducing the sense of sprawl and visual clutter” (Reclamation and CDPR 2013). Additionally, many of the engineered built structures contribute to the understanding of the site as a water storage and distribution facility in those areas.

SCVWD Service Area: The SCVWD Service Area extends across Santa Clara County. The Santa Clara Valley generally runs through the center of the county and is flanked by rolling hills leading to the Santa Cruz Mountains to the west and the Diablo Range to the east. Pacheco Reservoir is in this area of rolling hills and small valleys. The environment surrounding the Reservoir is relatively undeveloped, consisting of a few private ranches and residences, the North Fork Dam facilities, and telephone and electricity transmission lines. Santa Clara County encompasses 15 cities and most of the urban development is located within the incorporated cities (Santa Clara County 1994). Scenic characteristics of the area include largely undeveloped hillsides which are visible from the more developed valley floor. However, unobstructed views in urban areas are generally only possible from elevated viewpoints. Resource conservation areas such as public open lands, regional parks and ranch lands surround the urban areas to the west, south and east. Waterways are a contributing visual feature in the area and include Guadalupe River, Los Gatos Creek, Coyote Creek, and various tributaries.

Indian Trust Assets

Indian Trust Assets (ITAs) are defined as legal interests in property held in trust by the U.S. government for Indian tribes or individuals, or property protected under U.S. law for Indian tribes or individuals. There are no ITAs within or adjacent to Merced County and Santa Clara County, the area of analysis for ITAs. The ITAs in closest proximity to the area of analysis are northeast and slightly southeast of Merced County in Madera and Tuolumne counties.

Climate Variability

Historical Climate

The historical climate of the Central Valley is characterized by hot and dry summers and cool and damp winters. Average daytime temperatures are 95 degrees Fahrenheit (°F) in the summer and 55°F in the winter. Over the course of the 20th century, average mean-annual temperature has increased by approximately 2°F, although not steadily. The increases occurred primarily during the early part of the 20th century between 1915 and 1935 and began again in the mid-1970s through the present (Western Climate Mapping Initiative [WestMap] 2010).

Precipitation in the Central Valley falls primarily from mid-autumn to mid-spring. While snowfall is rare in the valley, temperatures below freezing may occur in the winter. The variability of annual precipitation has increased in the latter part of the 20th century. These extremes in wet and dry years have been especially frequent since the 1980s (WestMap 2010).

Historical Hydrology

Streamflow in the Sacramento River and San Joaquin River basins has historically varied considerably from year to year. Runoff can also vary geographically; during any particular year, some portions of the basin may experience relatively greater runoff than other areas. On a monthly to seasonal basis, runoff is generally greater during the winter to early summer months (December to June), with winter runoff generally originating from rainfall-runoff events and spring to early summer runoff generally supported by snowmelt from the Cascade Mountains and Sierra Nevada.

Runoff is also greater during the winter to early summer than the rest of the year. Winter runoff events are the consequence of rainfall while the spring and early summer events are more from snowmelt. Snowpack is measured as Snow Water Equivalent (SWE). Studies have shown a decreasing trend in the latter half of the 20th century, as measured by April 1st (Mote et al. 2005). The research by Knowles et al (2007) supported these findings using SWE measurements from 1948 through 2001 at 173 stations. Another study reported decreasing spring SWE trends as much as 50 percent (Regonda et al. 2005).

Despite a slight increase or unchanged annual precipitation in the area, annual runoff increases did not occur in the Sacramento and San Joaquin rivers (Dettinger and Cayan 1995). However, the seasonal timing of runoff has shifted in the Sacramento River Basin. Between April and July, a 10 percent decrease in total runoff has been observed throughout the course of the 20th century (Roos 1991). This is supported by similar results from Dettinger and Cayan (1995) for the combined Sacramento River and San Joaquin River runoff. This is a contrast to increases in winter runoff, such as the Peterson et al. (2008) study, which found earlier runoff trends for 18 Sierra Nevada river basins. Cayan et al. (2001) consider that the primary cause of the shift in runoff timing is due primarily from increasing spring temperatures and not increased winter precipitation.

1.6.2 Likely Future Without Project Conditions Summary

Identification of the magnitude of potential water resources and related problems, needs, and opportunities in the study area is based not only on the existing conditions highlighted above but also on an estimate of how these conditions may change in the future. Predicting future conditions is complicated by a variety of factors, including uncertainty regarding future regulatory requirements and ongoing programs and projects affecting the study area.

This section describes the changes in the environment expected in the study area assuming that no Federal (or State) actions are implemented to address the low point issues. The likely future condition includes actions reasonably expected to occur in the future. This includes projects and actions that are currently authorized, funded, and permitted[4].

1.6.2.1 Physical Environment

Physical conditions in the study area are expected to remain relatively unchanged in the future. No changes to area topography, geology, or soils are foreseen.

1.6.2.2 Biological Environment

Biological conditions at San Luis Reservoir are expected to remain relatively unchanged in the future. Without any action to improve the low point problem, there would be no related impacts on special-status fish species or their habitat and no foreseeable impacts on sensitive habitats such as watercourses and

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[4] A full listing of these currently authorized, funded, and permitted projects and actions are detailed in the SLLPIP EIS/EIR cumulative effects analysis.

riparian communities. There would be no impacts on fish migration corridors, and no conflicts with habitat conservation plans or other local plans or policies.

In addition, efforts are underway by numerous agencies and groups to restore various biological conditions in the SCVWD service area. Accordingly, major areas of wildlife habitat, including wetlands and riparian vegetation areas, are expected to be protected and restored. However, as population and urban growth continues and land uses are converted to urban centers, wildlife and plants dependent on native habitat types may be adversely affected.

1.6.2.3 Cultural Resources

At San Luis Reservoir, any paleontological, archaeological, historic, or ethnographic resources currently affected by erosion due to reservoir fluctuations or recreational use of the reservoir and shoreline would continue to be affected. Fossils and artifacts located around the perimeter of the existing reservoir will continue to be subject to potential inadvertent impacts from recreationalists. Similarly, existing conditions related to the cultural resources in the SCVWD service area unlikely to change significantly.

1.6.2.4 Socioeconomic Resources

The State’s population is estimated to increase from approximately 37 million in 2010 to about 44 million by 2030, and to approximately 49 million by 2050 (California Department of Finance 2017). Between 2018 and 2050, Merced and Santa Clara counties are expected to continue their historic growth trends. According to the California Department of Finance (2017), Merced County’s population is expected to increase by 46 percent by 2050 to a total of approximately 410,000 residents. Santa Clara County’s population is expected to increase by 33 percent by 2050 to a total of approximately 2,634,000 residents.

To support these expected increases in population, some conversion of agricultural and other rural land to urban uses, along with the densification of existing urbanized areas is anticipated. These trends are similar to the current trends under existing conditions.

Increases in population would increase demands for electric, natural gas, and wastewater utilities; public services such as fire, police protection, and emergency services; and water-related and communication infrastructure. Cities would continue to evaluate demands and respond to changing needs similar to existing conditions.

1.6.2.5 Climate Variability

Project changes in climate conditions with global climate variability are expected to result in a wide variety of impacts in the state of California, San Francisco Bay, and the Central Valley. Reclamation has actively pursued analysis and understanding of the potential effects of uncertainties related to climate variability and socioeconomic conditions through several recent studies, including the Sacramento and San Joaquin Basins Climate Impact Assessment (Reclamation 2014a), Central Valley Project Integrated Resource Plan (Reclamation 2014b), and the Sacramento and San Joaquin Rivers Basin Study (Reclamation 2016). These studies were used to develop the information summarized below.

The modeling approach and analysis tools for the Basins Study were developed as part of the CVP Integrated Resource Plan (Reclamation 2014b) and the Sacramento and San Joaquin Basin's Climate Risk Assessment Report (Reclamation 2014a) and further improved for the Basins Study. During these studies, Reclamation evaluated future uncertainties related to climate and socioeconomic changes. Uncertainties in future climates primarily surround changes in temperature and precipitation. Changes in both temperature and precipitation then drive changes in runoff, snowpack, and sea level rise assumptions that can affect water supplies and the operations of the CVP/SWP system. Additionally, changes in temperature and precipitation can also affect water needs for agriculture, urban, and the environment.

The Basins Study developed five representative climate futures using results from recent global climate model (GCM) simulations (Intergovernmental Panel on Climate Change [IPCC] 2013) that had been further refined for use in climate studies such as the Basins Study. Three of these climate futures were then evaluated in detail to capture a wide range of potential future climate conditions as they relate to water supply and the operations of the CVP and SWP. These three climate futures were Central Tendency, Warm-Wet, and Hot-Dry.

Under these climate variability futures average annual runoff from 2015 through 2019 in the Sacramento River basin was forecast to vary from nearly 18 million acre-feet (MAF) under the Hot-Dry scenario to 27 MAF under the Warm-Wet scenario. Average annual runoff in the Sacramento River system under the Hot-Dry scenario shows a decrease of approximately 4 MAF compared to the "No Climate Change" (No CC) scenario. Average annual runoff under the Warm-Wet scenario shows an increase of approximately 5 MAF from the No CC scenario. Average annual runoff in the San Joaquin basin are similar to those seen in the Sacramento basin. The Hot-Dry scenario has the lowest runoff at just less than 5 MAF, a reduction of approximately 1.2 MAF compared to the No CC scenario. The Warm-Wet scenario shows the highest runoff of over 8 MAF, an increase of approximately 2 MAF from the No CC scenario.

Under the Central Tendency scenario, Delta outflow is higher by approximately 1.2 MAF per year than under the No CC scenario. The majority of the increase in Delta outflow occurs from November through January, in part due to the shift in the timing of runoff in the Central Tendency scenario. During the months of March, April, May, and August, Delta outflow is reduced under the Central Tendency scenario. Total Delta exports decrease by nearly 150 TAF under the Central Tendency scenario as compared to the No CC scenario. In some months, the river flows are greater and in other months they are lower under Central Tendency as compared to the No CC scenario. River flows in the Sacramento basin show consistent average monthly increases from November through January. Average monthly flow of the San Joaquin River at Vernalis increases from November through March. Overall, on an average annual basis, Sacramento River flows and San Joaquin River flows increase by approximately 300 cfs under Central Tendency scenario as compared to the No CC scenario.

1.7 Related Studies, Projects, and Programs

Federal, State, and local agencies are participating throughout California in a wide range of other projects and programs that have the potential to influence water supply conditions for both San Luis Reservoir and SCVWD. The projects and programs listed below are in the study area and potentially relevant to the study.

1.7.1 Federal

Federal studies, projects, programs, and plans relevant to the Feasibility Report are described below.

1.7.1.1 San Luis Drainage Feature Re-evaluation Project

The purpose of the San Luis Drainage Feature Re-evaluation Project is to identify a plan to provide agricultural drainage service to the CVP’s San Luis Unit in accordance with the Ninth District Circuit Court decision that Reclamation must provide drainage service to the San Luis Unit. The San Luis Drainage Feature Re-evaluation Project could affect operations of the San Luis Reservoir by altering the schedule for water deliveries.

Drainage service has been defined as managing the regional shallow groundwater table by collecting and disposing shallow groundwater from the root zone of drainage-impaired lands and/or reducing contributions of water to the shallow groundwater table through land retirement. The related ROD, signed in March 2007, selected the In-Valley/Water Needs Alternative for implementation. This alternative includes collection systems, reuse areas, treatment, and disposal facilities, as well as the retirement of 184,000 acres of farmland in the Westlands Water District and 10,000 acres in the Broadview Water District. The In-Valley/Water Needs Alternative would retire enough lands to balance the internal water demand of the San Luis Unit with the expected available supply. Reclamation has finalized the estimate of project costs and determined that Congressional action is needed to implement the In-Valley/Water Needs Alternative.

1.7.1.2 B.F. Sisk Dam (San Luis Reservoir) Safety of Dams Corrective Action Study

Reclamation in coordination with DWR is completing a Corrective Action Study on the potential for liquefaction of the B.F. Sisk Dam foundation and resulting potential for dam slumping and overtopping. In addition to evaluating liquefaction potential, the Corrective Action Study is also identifying and evaluating potential dam modifications to reduce the potential for dam failure. A public scoping meeting in 2009 included a presentation on the project and the preliminary alternatives under consideration. Alternatives presented at that meeting and currently under consideration include a potential dam raise, construction of berms at locations along the dam toe requiring foundation support, and a reduction in maximum storage capacity. The Corrective Action Study is scheduled for completion in 2019. The dam embankment expansion and foundation modifications investigated in the ongoing Corrective Action Study have been incorporated into San Luis Reservoir Expansion alternative evaluated in this Feasibility Report.

1.7.1.3 Central Valley Project Improvement Act

Implementation of the CVPIA[5] changed the management of the CVP by making fish and wildlife protection a project purpose, equal to water supply for agricultural and urban uses. The CVPIA affects exports of water from the Delta to San Luis Reservoir and increases operational pressures on the reservoir to meet south-of-Delta water demands. CVPIA Section 3406 (b)(2) authorized and directed the Secretary of the Interior, among other actions, to dedicate and manage 800 TAF of CVP yield annually for the primary purpose of implementing the fish, wildlife, and habitat restoration purposes and measures authorized in CVPIA, to assist the State in its efforts to protect the waters of the San Francisco Bay-Delta Estuary, and to help meet obligations legally imposed on the CVP under State or Federal law following the date of enactment of the CVPIA.

CVPIA Section 3406(d)(1) required that the Secretary immediately provide specific quantities of water to the refuges referred to as “Level 2” supplies. The CVPIA requires delivery of the Level 2 water in all year types except critically dry water year conditions, when it can be reduced by 25 percent. Section 3406(d)(2) of the CVPIA refers to incremental “Level 4” refuge water supplies, which are the quantities required for optimum habitat management of the existing refuge lands. Incremental Level 4 water supplies amount to about 163 TAF above Level 2 water supplies. The availability of incremental Level 4 refuge water supplies are influenced by the availability of water for transfer from willing sellers.

1.7.1.4 California WaterFix

The Bay Delta Conservation Plan (BDCP), now referred to as California WaterFix, is being prepared by Reclamation and DWR, along with Kern County Water Agency, Metropolitan Water District of Southern California, San Luis and Delta-Mendota Water Authority, SCVWD, State and Federal Water

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[5] Title 34 of P.L. 102-575, the Reclamation Projects Authorization and Adjustment Act of 1992, signed October 30, 1992.

Contractors Agency, Westlands Water District, and Zone 7 Water Agency (referred to as Potential Authorized Entities).

California WaterFix is a comprehensive conservation strategy for the Delta designed to restore and protect ecosystem health, water supply, and water quality. The original Draft EIR/EIS for the BDCP, published in December 2013, included an ambitious and comprehensive plan under Section 10 of the Endangered Species Act (ESA) and California's Natural Community Conservation Planning Act, to include new water conveyance facilities and sought to secure water supplies and contribute to the recovery of listed species under a single regulatory package. The BDCP was anticipated to result in a permit decision concerning long-term regulatory authorizations under State and Federal ESA for the operations of the SWP and CVP. After receiving public comment on the Draft EIR/EIS, rather than pursuing the project as a Habitat Conservation Plan, under Section 10 of the ESA, and a Natural Community Conservation Plan, under the state's Natural Community Conservation Planning Act, DWR and Reclamation jointly decided to study additional alternatives to achieve the dual goals through implementation of new water conveyance facilities built in compliance with Section 7 of the ESA and Section 2018(b) of the California ESA. The State now proposes to restore more than 30,000 acres of Delta habitat separately through another venture called California EcoRestore.

In July 2015, DWR and Reclamation released the Partially Recirculated Draft EIR/Supplemental Draft EIS on the BDCP, proposing the California WaterFix as the preferred alternative. California WaterFix is proposed to fix California's aging water delivery system to help protect the state's economy and public safety. This project covers five main areas: water security; climate change adaptation; environmental protection; seismic safety; and affordability (DWR and Reclamation 2015). Primary goals of the alternative include the protection of the state's water supplies from climate change through water system upgrades, improvements of river flows for threatened fish species, and ecosystem restoration and protection.

The Final EIS/EIR that identified the California WaterFix for implementation was released in December 2016 (DWR and Reclamation 2016). Biological Opinions (BiOps) for the California WaterFix were release in June 2017 and a Notice of Determination was filed in July 2017. On July 17, 2018, DWR published the California WaterFix Draft Supplemental EIR/EIS evaluating the proposed changes to the conveyance facilities in compliance with CEQA. Reclamation issued the California WaterFix Draft Supplemental EIR/EIS in compliance with NEPA. Public review of Reclamation's California WaterFix Draft Supplemental EIR/EIS began on September 21, 2018 when the U.S. Environmental Protection Agency posted its notice of availability in the Federal Register. Public comment on the draft supplemental document closed on November 5, 2018 (DWR 2018).

1.7.1.5 CVPIA Contract Renewals

The CVP has more than 100 water service contracts. Reclamation has negotiated renewals of long-term water service contracts for all CVP contractors, including those within the SLLPIP study area, as required by CVPIA Section 3404(c). As mandated by Section 3404(c), irrigation contracts have a term not exceeding 25 years and M&I contracts have a term not exceeding 40 years. Most contracts have been renewed; those contracts not yet renewed will be executed upon completion of the re-initiated consultation on the Coordinated Long-term Operations of the CVP and SWP. All water service contracts contain terms and conditions for the delivery and use of CVP water, for the repayment of applicable capital construction costs, and for the reimbursement of annual operations and maintenance (O&M) expenditures. Contracts may be converted to permanent repayment contracts under the Water Infrastructure for Improvements to the Nation (WIIN) Act, regardless of the Biological Opinion completion date.

Reclamation recognizes that hydrologic, regulatory, and operational uncertainties constrain its ability to deliver CVP water and that such uncertainties may increase in importance as future water demands increase. Because of uncertainties, competing demands, variable supplies, and stated shortage provisions in service contracts, Reclamation and its contractors recognize that delivery of full contract quantities is not guaranteed and that deliveries may be equal to or less than historical deliveries. The SLLPIP may increase Reclamation’s ability to deliver greater quantities of water. Furthermore, improved operations of San Luis Reservoir may provide a more reliable water supply for CVP contractors.

1.7.2 Federal-State

Programs and plans relevant to the Study that were developed or are being developed as collaborations between Federal and State agencies are described below.

1.7.2.1 Los Vaqueros Expansion Phase 2

Contra Costa Water District (CCWD), Reclamation, and DWR have jointly undertaken a series of studies to analyze the feasibility of expanding Los Vaqueros Reservoir while adhering to reservoir expansion principles established by CCWD. The project had two primary objectives and one secondary objective.

Primary Objectives:

- Develop water supplies for environmental water management that supports fish protection, habitat management, and other environmental water needs.
- Increase water supply reliability for water providers within the San Francisco Bay Area, to help meet M&I water demands during drought

periods and emergencies, or to address shortages due to regulatory and environmental restrictions.

Secondary Objective:

- Improve the quality of water deliveries to M&I customers in the San Francisco Bay Area, without impairing the project's ability to meet the environmental and water supply reliability objectives stated above.

CCWD approved the Final EIR/EIS and an expansion of the reservoir from 100 TAF to 160 TAF in March 2010, and construction was completed in 2012 (CCWD undated). A further expansion of the reservoir to 275 TAF, as analyzed in the EIR/EIS is being investigated by Reclamation and CCWD. Reclamation and CCWD released a draft supplement to the Final EIR/EIR on July 3, 2017 and a Draft Feasibility Report on February 2, 2018. On July 24, 2018, the California Water Commission announced that $459 million of Proposition 1 funding will be slated for expanding Los Vaqueros Reservoir (CCWD 2018).

1.7.2.2. Biological Opinions on the Long-term Operations of the CVP and SWP

The Long-term Operation of the CVP and SWP is currently subject to the terms and conditions of BiOps issued by the USFWS (2008) and National Marine Fisheries Service (NMFS) (2009) pursuant to Section 7 of the Federal ESA. These BiOps control operation of the CVP and SWP Delta pumps and consequently storage levels in San Luis Reservoir and deliveries to CVP and SWP contractors. The BiOps requires maximum transfer volume to be limited to 600 TAF for critical and dry years and to 360 TAF for all other year types.

In 2011, these BiOps were remanded by court order to the Federal fish and wildlife agencies for revision, these decisions were appealed to the Ninth Circuit Court of Appeals and in 2014 the orders to rewrite the BiOps were reversed (Congressional Research Service 2014). The Ninth Circuit decision affirmed the requirement that Reclamation complete an EIS on implementing the BiOps by December 1, 2015 (Congressional Research Service 2014). The Final EIS was published on November 23, 2015 and the ROD was signed on January 11, 2016 (Reclamation 2016). On August 2, 2016, Reclamation requested reinitiation of ESA Section 7 consultation with USFWS and NMFS on the Long-Term Operations. Several factors resulted in Reclamation requesting reinitiation of consultation under the ESA, including the apparent decline in the status of several listed species, new information related to recent multiple years of drought, and the evolution of best available science. On December 29, 2017, Reclamation issued a Notice of Intent to prepare a programmatic EIS for analyzing potential modifications to the continued long-term operation of the CVP, for its authorized purposes, in a coordinated manner with SWP, for its authorized purposes.

1.7.2.3 Coordinated Operating Agreement Addendum

Reclamation and DWR developed and signed a detailed operations agreement, the “Agreement Between the United States of America and the State of California for Coordinated Operation of the Central Valley Project and the State Water Project” (Agreement) in 1986 (Reclamation and DWR 1986a). The United States Congress enacted Public Law 99-546, which authorized Reclamation to execute the Agreement. Under this Agreement, Reclamation and DWR established the terms by which they would use their respective water rights to ensure certain contractual and regulatory responsibilities were met, while maximizing Reclamation’s and DWR’s ability to operate the CVP and SWP to meet water right and contract obligations upstream of the Delta, Delta water quality and flow objectives, joint Delta water right requirements issued by the SWRCB, and CVP and SWP water right and contract obligations that depend upon diversions from the Delta. In 2018, Reclamation and DWR amended four key elements of the Agreement to reflect the evolved manner in which the Projects have been operated since the Agreement was originally authorized and signed: Article 6(c) in-basin uses; Article 10(b) CVP use of Harvey O. Banks (“Banks”) Pumping Plant; Article 10(i) export restrictions; and Article 14(a) the periodic review.

1.7.3 Regional and Local

Regional and local programs and plans relevant to the study are described below.

1.7.3.1 Rinconada Water Treatment Plant Reliability Improvements Project

SCVWD is also conducting the Rinconada Water Treatment Plant Reliability Improvements Project to address the WTP’s capacity to treat for taste-and-odor causing compounds common in the source water supply. The WTP upgrade also improves the disinfection capability and provides flexibility to treat contaminants of emerging concern, and provides reliable capacity to meet peak demands. As a part of these upgrades, SCVWD is constructing a new treatment train.

1.7.3.2 Water Supply and Infrastructure Master Plan

The SCVWD Water Supply and Infrastructure Master Plan identifies the District’s strategy to continue investments to meet the county’s future water supply needs through at least 2035. The plan outlines steps for developing indirect potable reuse and optimizing existing supplies in the form of additional groundwater recharge and increased local conveyance flexibility through a new pipeline connecting Lexington Reservoir to the SCVWD raw water distribution system. The Water Supply and Infrastructure Master Plan assumes that the low point problem at San Luis Reservoir will be resolved in the future and will not limit imported supplies.

1.7.3.3 Water Storage Investment Program Pacheco Reservoir Expansion Project

SCVWD received conditional funding from CWC’s WSIP under Proposition 1 for the Pacheco Reservoir Expansion Project. The project is a multi-agency effort led by SCVWD that is expected to provide local, regional and statewide environmental, water supply reliability, and water quality benefits. The objectives of the project are: (1) increase suitable habitat in Pacheco Creek for the federally threatened South-Central California Coast steelhead (i.e., provide ecosystem improvement benefits); (2) increase water supply reliability to help meet M&I water demands in the Santa Clara County during drought periods and emergencies, or to address shortages due to regulatory and environmental restrictions (i.e., provide emergency response and M&I benefits); (3) develop water supplies for environmental water needs at Incremental Level 4 wildlife refuges to support habitat management in the Delta watershed (i.e., provide ecosystem improvement benefits in the Delta watershed); (4) improve water quality and minimize supply interruptions, when water is needed, for Central Valley Project San Felipe Division contractors, and increase operational flexibility for south-of-Delta contractors dependent on San Luis Reservoir (i.e., provide M&I water quality benefits); (5) reduce flood risk along Pacheco Creek and downstream areas, including disadvantaged communities (i.e., provide flood control benefits) (SCVWD 2017a).

The WSIP application documents for the Expanded Pacheco Reservoir Plan provided technical details and analyses for the Pacheco Reservoir Expansion Alternative evaluated in this report (SCVWD 2017a).

1.8 Planning Objectives

SLLPIP objectives were developed based on the above-stated problems and opportunities. The planning objectives identified for the SLLPIP in the PFR were updated as the feasibility study progressed. The current planning objectives are structured to optimize the water supply benefit of San Luis Reservoir while reducing additional risks to water users by:

Primary Objectives

- Avoiding supply interruptions when water is needed by increasing the certainty of meeting the requested delivery schedule throughout the year to south-of-Delta contractors, including SCVWD, dependent on San Luis Reservoir.
- Increasing the reliability and quantity of yearly allocations to south-of-Delta contractors, including SCVWD, dependent on San Luis Reservoir.

Secondary Objective

- Provide opportunities for ecosystem enhancement.

The above objectives distinguish between certainty of meeting delivery schedules and the reliability of supplies. More specifically, the first objective is related to predictably meeting contractors' delivery schedules throughout the year as opposed to the second objective, which strives to increase yearly allocations to more closely match the contractual entitlements.

The objective for reliability and increased annual allocations could lead to conflicts regarding San Luis Reservoir operations. These issues are relevant to south-of-Delta contractors dependent on San Luis Reservoir. San Luis Reservoir serves as a storage facility to increase reliability for CVP contractors in the Central Valley. CVP contractors rely on both exports from the Jones Pumping Plant and San Luis Reservoir to meet summer demands. Full exercise of the reservoir helps to maximize CVP supplies, but any constraint in the release of water from San Luis Reservoir could limit supplies. The Jones Pumping Plant does not have enough pumping capacity to fully meet demands alone and CVP operators store additional water in San Luis Reservoir during the winter, when demands are low, to help meet summertime needs. If San Luis Reservoir dropped below the minimum conservation pool during times of high demands, the CVP would not be able to meet those demands and contractors would experience a supply interruption.

The San Felipe Division relies on San Luis Reservoir to receive its CVP allocation. Water supply interruptions are caused by water levels falling below approximately 300 TAF, which triggers water quality concerns in the San Felipe Division that render the water unusable with existing treatment facilities. If water quality in San Luis Reservoir becomes a problem, then the San Felipe Division will not have useable water supply from CVP with its existing facilities. SBCWD has no access to any other imported water without the CVP supply. In the future, maximizing CVP supplies and changing storage patterns for State contractors might increase the frequency of the low point issue and the risk of supply interruptions to the San Felipe Division.

Avoiding water supply interruptions for the San Felipe Division is a trade-off with increasing water supply reliability for other south-of-Delta contractors. San Felipe Division water supply interruptions are currently avoided because SWP contractors have left water in storage, thus maintaining water levels in San Luis Reservoir above approximately 300 TAF. However, increasing CVP and SWP water supply reliability requires the full use of the CVP and SWP water stored in San Luis Reservoir and a corresponding increase in the risk of supply interruptions for the San Felipe Division.

Similarly, allowing earlier confirmation of definitive allocations has some trade-offs with the other two objectives. Announcing higher allocations earlier in the year increases the risk that the CVP and SWP may not be able to supply the water that was forecasted—a decrease in water supply reliability. The SLLPIP will attempt to meet these three objectives without having to trade one for the other by developing safety nets to protect against supply interruptions.

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Chapter 2
Resources Management Measures and Initial Alternatives

The purpose of this chapter is to review the alternative formulation and screening process that was presented in the SLLPIP IAIR, and to describe additional alternative screening that was completed by the Study team in the Plan Formulation Phase of the SLLPIP Feasibility Study. The Study team is composed of representatives from Reclamation and SCVWD.

2.1 Management Measures

The first step in the development of the initial alternatives described in the IAIR was the identification of potential management measures, which could include programs, projects, or policies that would help achieve the objectives. These management measures were screened according to their technical and institutional viability and the degree to which their implementation would achieve the project objectives. This section describes the identification and screening of these management measures.

2.1.1 Management Measure Development

Management measures need not be complete alternatives capable of meeting all project objectives and may satisfy only some of the Study objectives. The team identified management measures based on SCVWD's past work on the project, other water resources studies, and the team's technical understanding of the project's problems, opportunities, and objectives. SCVWD's previous efforts included an extensive public outreach effort, which resulted in the inclusion of management measures suggested by the project stakeholders and the general public. The initial list of management measures in the IAIR was not constrained in any way.

The 87 management measures identified in the IAIR were grouped into six categories: institutional agreements, source water quality control, water treatment, conveyance, local reservoir storage, and alternate water supplies. The 87 management measures are presented in Figure 2-1.

Institutional Agreements

- Banking
- Exchanges
- Operating Agreements and Procedures
- Rescheduling

Source Water Quality Control

- Algae Harvesting
- Algaecides/Herbicides (for algae or macrophytes)
- Barley Straw (to absorb algae and nutrients)
- Coffer Dam Around Intake
- Dilution/Flushing (local runoff)
- Dredging
- Fish Grazers on Algae or Macrophytes
- Floating Covers
- Intermediate Intake for Pacheco Pumping Plant
- Isolate Portion (arm) of San Luis Reservoir
- Macrophyte (water weed harvesting)
- Managed Stratification (modify Gianelli inlet/outlet works)
- Mechanical Destratification and Lake Mixing
- Nutrient harvesting from Fish or Other Biota
- Oxygenation or Aeration
- Pathogens of Algae or Mycrophytes
- Sediment Sealing (fabric liners, chemical barriers)
- Shading (dyes) to Minimize light for Photosynthesis
- Use Calero as Wetland
- Water Level Fluctuation
- Wetlands Algae Filter

Water Treatment

- Dissolved Air Flotation (DAF) near San Felipe Intake
- DAF at Coyote Pumping Plant (plus San Benito and Pajaro)
- DAF at Santa Teresa and Rinconada (plus San Benito and Pajaro)
- Add Ozone to Raw Water as It Enters Water Treatment Facilities
- Add Potassium Permanganate to Raw Water along the Santa Clara Conduit

Conveyance

- Highway 152 Pipeline/ Tunnel
- Holladay Aqueduct
- Northerly Bypass Corridor
- Southerly Bypass Corridor
- Extend/Lower San Felipe Intake to Gianelli Inlet/ Outlet Level
- Ranney Collectors in San Luis Reservoir
- San Felipe Diversion Conveyance Modifications

Local Reservoir Storage: More Storage at Existing Dam and Reservoir Sites

- Almaden
- Anderson
- Calero
- Chesbro
- Coyote
- Guadalupe
- Lexington
- Lower Pacheco (Pacheco Lake Reservoir)
- Pacheco A
- Pacheco B
- Raise San Luis Reservoir
- Stevens Creek
- Upper Pacheco
- Uvas
- Vasona

Local Reservoir Storage: New Dams and Reservoir Sites

- Ausaymas
- Blue Ridge
- Cedar Creek
- Clarks Canyon
- Coe
- Harper
- Los Osos
- North Fork Pacheco
- Packwood
- San Benito Reservoir
- San Felipe
- Smith Creek
- Del Puerto Reservoir
- South Fork Pacheco
- Ingram Canyon Reservoir
- Quinto Creek Reservoir
- Garzas Reservoir
- Little Salado Creek Reservoir
- Los Banos Grandes Reservoir
- Orestimba Reservoir
- Romero Reservoir

Alternate Water Supplies

- Demand Side Management in SCVWD
- Desalination: Monterey Bay
- Desalination: San Benito Groundwater Basin
- Desalination: San Francisco Bay
- Desalination: San Benito Groundwater Basin, San Francisco Bay, and Monterey Bay
- Enlarged SBA/ Los Vaqueros Expansion
- Los Vaqueros Expansion
- More Storage in SCVWD Groundwater Basin
- Options from SBCWD Basin Management Plan
- Options from PVWMA Basin Management Plan
- Re-Operation of Anderson Reservoir
- Recycling in SCVWD
- SFPUC Expanded Calaveras Reservoir
- SFPUC Intertie

Figure 2-1. Management Measures

2.1.2 Management Measure Screening

2.1.2.1 Screening Resource Management Measures

The screening process (presented in the IAIR) evaluated management measures based on technical viability, institutional viability, and the ability to meet the project objectives. This screening did not evaluate management measures in detail, but rather looked for fatal flaws that would make a measure nonviable. Further analysis during the Study process could show that a particular management measure that was carried forward is actually nonviable. If management measures did not pass the technical and institutional viability criteria, they were dropped from the analysis immediately. Management measures that passed both technical and institutional viability criteria were then evaluated against the project objectives using defined rating scales.

The technical and institutional viability criteria take into account essential factors that the management measures were required to meet. Technical viability addresses the general engineering viability of the management measures. This criterion asks the question: can the measure be constructed or implemented to address the low point issue effectively? For example, some source water quality control management measures might not be viable because they could not be implemented at the scale required, given the large size of the reservoir. The institutional viability criterion considers the institutional aspects of a measure, including regulatory and environmental compliance and public acceptance. For example, some surface storage management measures that include expansion of existing reservoirs might not be viable given their projected inundation of existing communities adjacent to the reservoirs and the associated public opposition to the measure.

2.1.2.2 Management Measure Screening Results

Figure 2-2 presents the results of the management measure screening and indicates which management measures were carried forward into initial alternative screening. The Study team evaluated the potentially viable management measures according to the project objectives. Figure 2-2 depicts the evaluation results with circles. In general, a full circle in Figure 2-2 means the measure would perform “well” relative to the objective, a partially full circle means the measure would perform “moderately,” and an empty circle means the measure would not meet the objective at all. The study team presented definitions in the IAIR for the criteria used to rank the alternatives relative to the project objectives.

The Study team carried forward the management measures that were technically and institutionally viable and that received at least one "performs moderately" rating (a partially full circle in Figure 2-2) related to a project objective. These retained management measures could help to meet the objectives and could be combined with other viable management measures to form preliminary alternatives. Figure 2-2 also notes why the eliminated management measures were not carried forward.

2.2 Initial Alternatives

The Study team developed initial alternatives using the measures that were carried forward after management measure screening. In some cases, the initial alternatives were composed of multiple management measures, in combinations that performed better according to the project objectives than individual measures did. These initial alternatives were screened for how well they would meet the Federal criteria: completeness, effectiveness, acceptability, and efficiency. This section describes the identification and screening of these initial alternatives.

2.2.1 Initial Alternative Formulation

The Study team developed 26 initial alternatives using the retained management measures. Initial alternatives included either one measure or a combination of management measures, to achieve good performance relative to the project objectives: avoiding supply interruptions; increasing reliability and quantity of deliveries; and providing ecosystem enhancements. Each management measure was included in one or more initial alternatives. Figure 2-3 shows the 26 initial alternatives.

2.2.2 Alternative Screening

The Study team screened the initial alternatives based on how well they would meet the Federal criteria (completeness, effectiveness, acceptability, and efficiency) using rating scales to gauge each alternative. The Federal criteria are defined as:

- Completeness is the extent to which a given alternative plan provides and accounts for all necessary investments or other actions to ensure realization of the planned effects. This may require relating the plan to other types of public or private plans if the other plans are crucial to realization of the contributions to the objective.
- Effectiveness is the extent to which an alternative plan alleviates the specified problems and achieves the specified opportunities.
- Efficiency is the extent to which an alternative plan is the most cost effective means of alleviating the specified problems and realizing the

specified opportunities, consistent with protecting the Nation's environment.

- Acceptability is the workability and viability of the alternative plan with respect to acceptance by State and local entities and the public and compatibility with existing laws, regulations, and public policies.

The performance measures that the Study team applied to screen the initial alternatives according to the Federal criteria are presented in Figure 2-3 along with the ratings for each initial alternative.

The Study team selected at least one alternative from each category to carry forward for analysis, maintaining a reasonable range of alternative types. The Study team selected alternatives that appeared to be able to achieve the most benefits for the least cost relative to the other alternatives within a category. This comparison was qualitative because a full analysis of net benefits (benefits minus costs) had not been completed for the initial alternatives. If at least one alternative did not stand out within a category because of higher benefits or lower costs, then multiple alternatives from that category were retained. Much of the future Study work will center on refinement and quantitative measurement of benefits and costs, to enable selection of a preferred plan consistent with the P&Gs. Table 2-1 presents the 17 initial alternatives that were carried forward from the IAIR.

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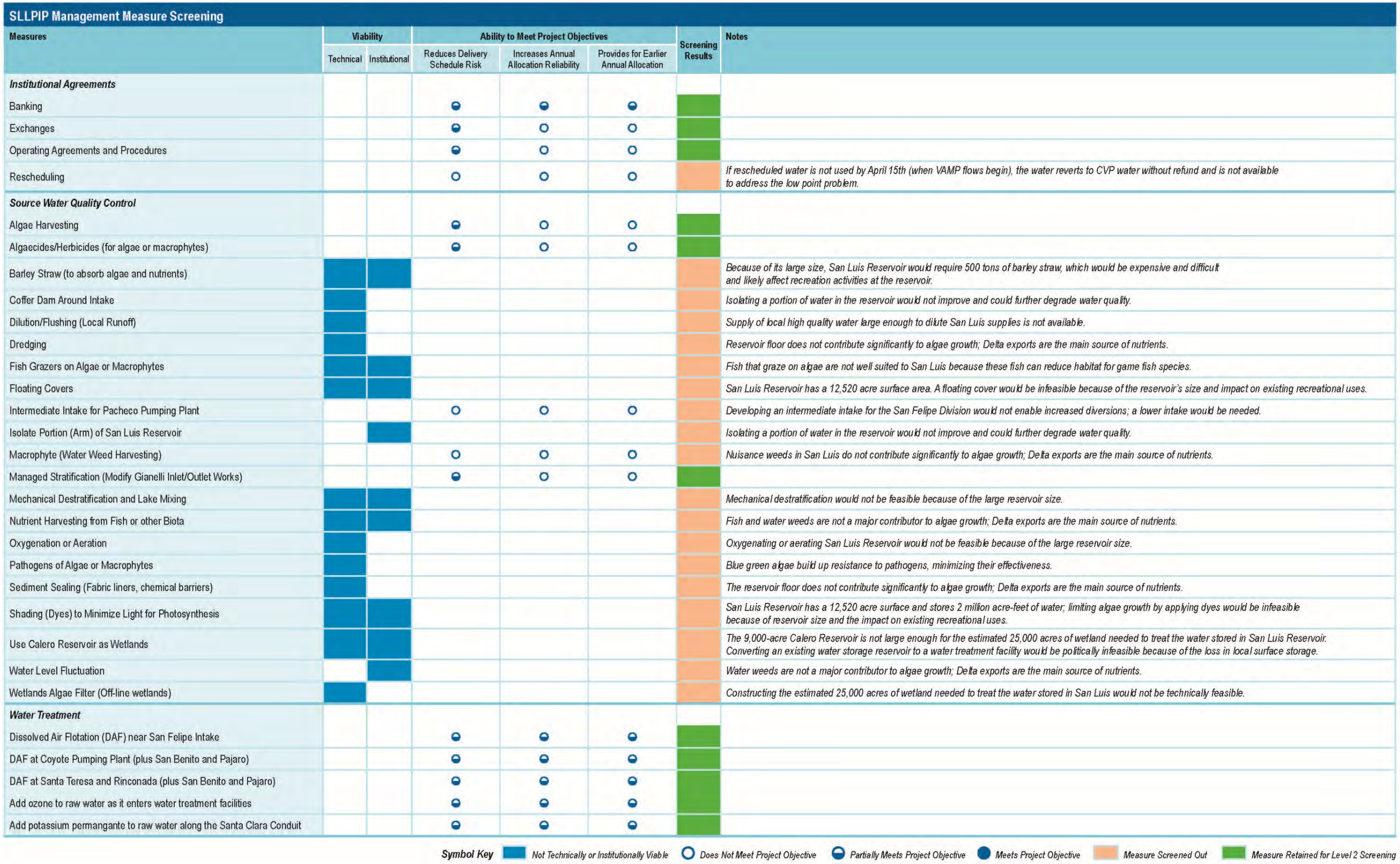

SLLPIP Management Measure Screening

Measures	Viability		Ability to Meet Project Objectives			Screening Results	Notes
	Technical	Institutional	Reduces Delivery Schedule Risk	Increases Annual Allocation Reliability	Provides for Earlier Annual Allocation		
Institutional Agreements							
Banking			◒	◒	◒	🟩	
Exchanges			◒	○	○	🟩	
Operating Agreements and Procedures			◒	○	○	🟩	
Rescheduling			○	○	○	🟧	*If rescheduled water is not used by April 15th (when VAMP flows begin), the water reverts to CVP water without refund and is not available to address the low point problem.*
Source Water Quality Control							
Algae Harvesting			◒	○	○	🟩	
Algaecides/Herbicides (for algae or macrophytes)			◒	○	○	🟩	
Barley Straw (to absorb algae and nutrients)	🟦	🟦				🟧	*Because of its large size, San Luis Reservoir would require 500 tons of barley straw, which would be expensive and difficult and likely affect recreation activities at the reservoir.*
Coffer Dam Around Intake	🟦					🟧	*Isolating a portion of water in the reservoir would not improve and could further degrade water quality.*
Dilution/Flushing (Local Runoff)	🟦					🟧	*Supply of local high quality water large enough to dilute San Luis supplies is not available.*
Dredging	🟦					🟧	*Reservoir floor does not contribute significantly to algae growth; Delta exports are the main source of nutrients.*
Fish Grazers on Algae or Macrophytes	🟦	🟦				🟧	*Fish that graze on algae are not well suited to San Luis because these fish can reduce habitat for game fish species.*
Floating Covers	🟦	🟦				🟧	*San Luis Reservoir has a 12,520 acre surface area. A floating cover would be infeasible because of the reservoir's size and impact on existing recreational uses.*
Intermediate Intake for Pacheco Pumping Plant			○	○	○	🟧	*Developing an intermediate intake for the San Felipe Division would not enable increased diversions; a lower intake would be needed.*
Isolate Portion (Arm) of San Luis Reservoir		🟦				🟧	*Isolating a portion of water in the reservoir would not improve and could further degrade water quality.*
Macrophyte (Water Weed Harvesting)			○	○	○	🟧	*Nuisance weeds in San Luis do not contribute significantly to algae growth; Delta exports are the main source of nutrients.*
Managed Stratification (Modify Gianelli Inlet/Outlet Works)			◒	○	○	🟩	
Mechanical Destratification and Lake Mixing	🟦	🟦				🟧	*Mechanical destratification would not be feasible because of the large reservoir size.*
Nutrient Harvesting from Fish or other Biota	🟦	🟦				🟧	*Fish and water weeds are not a major contributor to algae growth; Delta exports are the main source of nutrients.*
Oxygenation or Aeration	🟦					🟧	*Oxygenating or aerating San Luis Reservoir would not be feasible because of the large reservoir size.*
Pathogens of Algae or Macrophytes	🟦					🟧	*Blue green algae build up resistance to pathogens, minimizing their effectiveness.*
Sediment Sealing (Fabric liners, chemical barriers)	🟦					🟧	*The reservoir floor does not contribute significantly to algae growth; Delta exports are the main source of nutrients.*
Shading (Dyes) to Minimize Light for Photosynthesis	🟦	🟦				🟧	*San Luis Reservoir has a 12,520 acre surface and stores 2 million acre-feet of water; limiting algae growth by applying dyes would be infeasible because of reservoir size and the impact on existing recreational uses.*
Use Calero Reservoir as Wetlands	🟦	🟦				🟧	*The 9,000-acre Calero Reservoir is not large enough for the estimated 25,000 acres of wetland needed to treat the water stored in San Luis Reservoir. Converting an existing water storage reservoir to a water treatment facility would be politically infeasible because of the loss in local surface storage.*
Water Level Fluctuation		🟦				🟧	*Water weeds are not a major contributor to algae growth; Delta exports are the main source of nutrients.*
Wetlands Algae Filter (Off-line wetlands)	🟦					🟧	*Constructing the estimated 25,000 acres of wetland needed to treat the water stored in San Luis would not be technically feasible.*
Water Treatment							
Dissolved Air Flotation (DAF) near San Felipe Intake			◒	◒	◒	🟩	
DAF at Coyote Pumping Plant (plus San Benito and Pajaro)			◒	◒	◒	🟩	
DAF at Santa Teresa and Rinconada (plus San Benito and Pajaro)			◒	◒	◒	🟩	
Add ozone to raw water as it enters water treatment facilities			◒	◒	◒	🟩	
Add potassium permanganate to raw water along the Santa Clara Conduit			◒	◒	◒	🟩	

Symbol Key 🟦 *Not Technically or Institutionally Viable* ○ *Does Not Meet Project Objective* ◒ *Partially Meets Project Objective* ● *Meets Project Objective* 🟧 *Measure Screened Out* 🟩 *Measure Retained for Level 2 Screening*

Figure 2-2. SLLPIP Management Measure Screening

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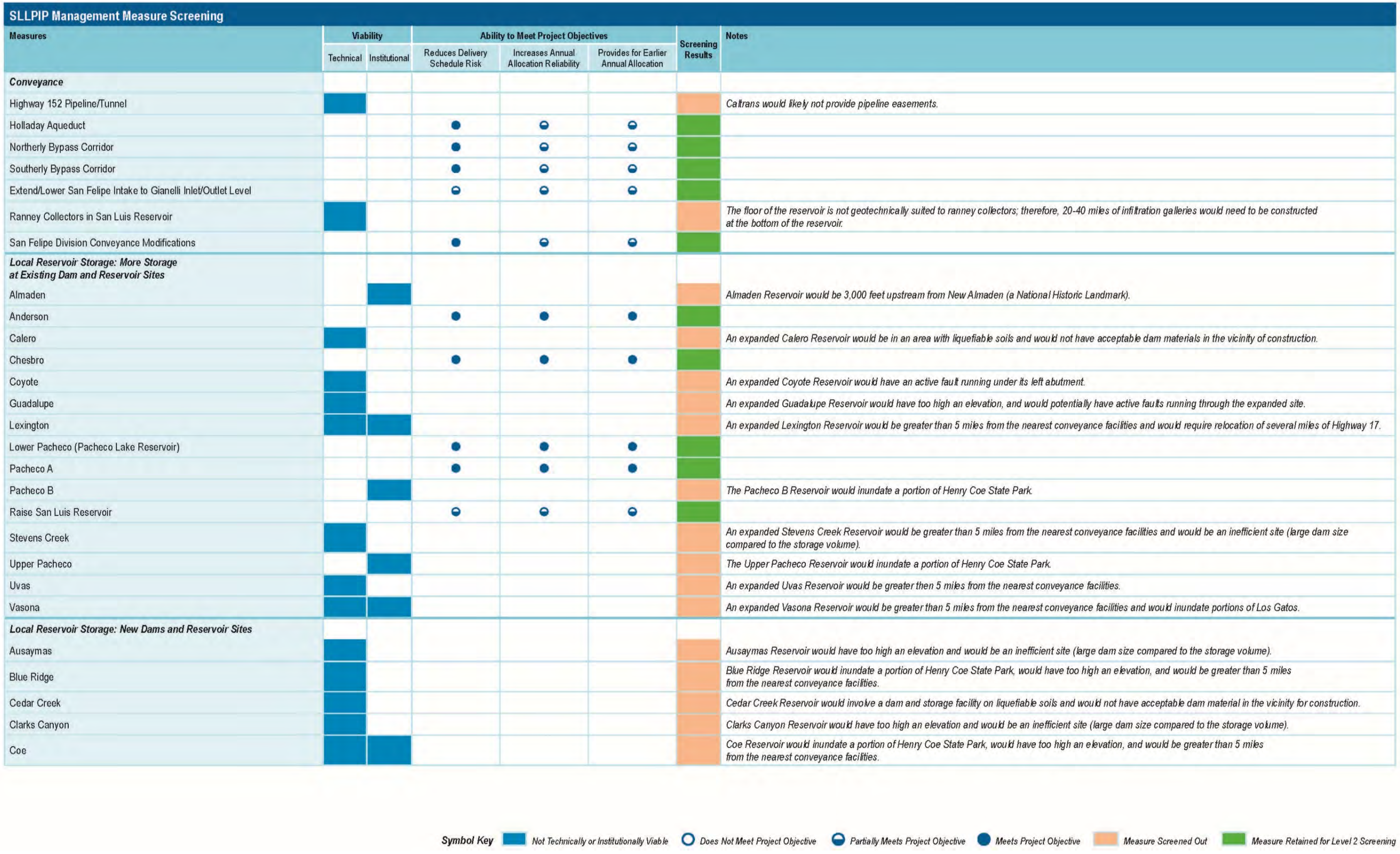

SLLPIP Management Measure Screening

Measures	Viability		Ability to Meet Project Objectives			Screening Results	Notes
	Technical	Institutional	Reduces Delivery Schedule Risk	Increases Annual Allocation Reliability	Provides for Earlier Annual Allocation		
Conveyance							
Highway 152 Pipeline/Tunnel	🟦					🟧	*Caltrans would likely not provide pipeline easements.*
Holladay Aqueduct			●	◒	◒	🟩	
Northerly Bypass Corridor			●	◒	◒	🟩	
Southerly Bypass Corridor			●	◒	◒	🟩	
Extend/Lower San Felipe Intake to Gianelli Inlet/Outlet Level			◒	◒	◒	🟩	
Ranney Collectors in San Luis Reservoir	🟦					🟧	*The floor of the reservoir is not geotechnically suited to ranney collectors; therefore, 20-40 miles of infiltration galleries would need to be constructed at the bottom of the reservoir.*
San Felipe Division Conveyance Modifications			●	◒	◒	🟩	
Local Reservoir Storage: More Storage at Existing Dam and Reservoir Sites							
Almaden		🟦				🟧	*Almaden Reservoir would be 3,000 feet upstream from New Almaden (a National Historic Landmark).*
Anderson			●	●	●	🟩	
Calero	🟦					🟧	*An expanded Calero Reservoir would be in an area with liquefiable soils and would not have acceptable dam materials in the vicinity of construction.*
Chesbro			●	●	●	🟩	
Coyote	🟦					🟧	*An expanded Coyote Reservoir would have an active fault running under its left abutment.*
Guadalupe	🟦					🟧	*An expanded Guadalupe Reservoir would have too high an elevation, and would potentially have active faults running through the expanded site.*
Lexington	🟦	🟦				🟧	*An expanded Lexington Reservoir would be greater than 5 miles from the nearest conveyance facilities and would require relocation of several miles of Highway 17.*
Lower Pacheco (Pacheco Lake Reservoir)			●	●	●	🟩	
Pacheco A			●	●	●	🟩	
Pacheco B		🟦				🟧	*The Pacheco B Reservoir would inundate a portion of Henry Coe State Park.*
Raise San Luis Reservoir			◒	◒	◒	🟩	
Stevens Creek	🟦					🟧	*An expanded Stevens Creek Reservoir would be greater than 5 miles from the nearest conveyance facilities and would be an inefficient site (large dam size compared to the storage volume).*
Upper Pacheco		🟦				🟧	*The Upper Pacheco Reservoir would inundate a portion of Henry Coe State Park.*
Uvas	🟦					🟧	*An expanded Uvas Reservoir would be greater then 5 miles from the nearest conveyance facilities.*
Vasona	🟦	🟦				🟧	*An expanded Vasona Reservoir would be greater than 5 miles from the nearest conveyance facilities and would inundate portions of Los Gatos.*
Local Reservoir Storage: New Dams and Reservoir Sites							
Ausaymas	🟦					🟧	*Ausaymas Reservoir would have too high an elevation and would be an inefficient site (large dam size compared to the storage volume).*
Blue Ridge	🟦					🟧	*Blue Ridge Reservoir would inundate a portion of Henry Coe State Park, would have too high an elevation, and would be greater than 5 miles from the nearest conveyance facilities.*
Cedar Creek	🟦					🟧	*Cedar Creek Reservoir would involve a dam and storage facility on liquefiable soils and would not have acceptable dam material in the vicinity for construction.*
Clarks Canyon	🟦					🟧	*Clarks Canyon Reservoir would have too high an elevation and would be an inefficient site (large dam size compared to the storage volume).*
Coe	🟦	🟦				🟧	*Coe Reservoir would inundate a portion of Henry Coe State Park, would have too high an elevation, and would be greater than 5 miles from the nearest conveyance facilities.*

Symbol Key 🟦 *Not Technically or Institutionally Viable* ○ *Does Not Meet Project Objective* ◒ *Partially Meets Project Objective* ● *Meets Project Objective* 🟧 *Measure Screened Out* 🟩 *Measure Retained for Level 2 Screening*

Figure 2-2. SLLPIP Management Measure Screening (continued)

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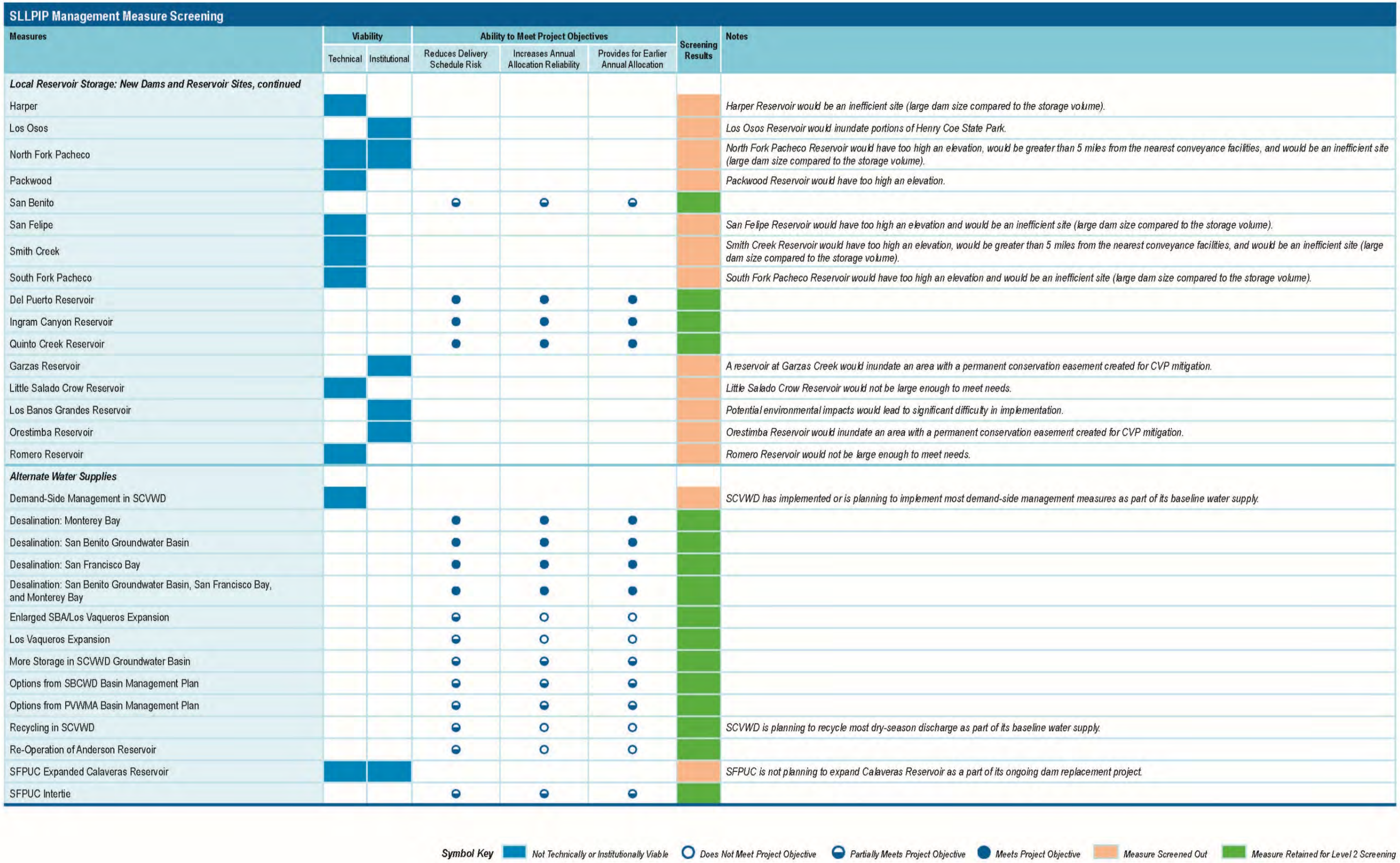

SLLPIP Management Measure Screening

Measures	Viability		Ability to Meet Project Objectives			Screening Results	Notes
	Technical	Institutional	Reduces Delivery Schedule Risk	Increases Annual Allocation Reliability	Provides for Earlier Annual Allocation		
Local Reservoir Storage: New Dams and Reservoir Sites, continued							
Harper	🟦					🟧	*Harper Reservoir would be an inefficient site (large dam size compared to the storage volume).*
Los Osos		🟦				🟧	*Los Osos Reservoir would inundate portions of Henry Coe State Park.*
North Fork Pacheco	🟦	🟦				🟧	*North Fork Pacheco Reservoir would have too high an elevation, would be greater than 5 miles from the nearest conveyance facilities, and would be an inefficient site (large dam size compared to the storage volume).*
Packwood	🟦					🟧	*Packwood Reservoir would have too high an elevation.*
San Benito			◒	◒	◒	🟩	
San Felipe	🟦					🟧	*San Felipe Reservoir would have too high an elevation and would be an inefficient site (large dam size compared to the storage volume).*
Smith Creek	🟦					🟧	*Smith Creek Reservoir would have too high an elevation, would be greater than 5 miles from the nearest conveyance facilities, and would be an inefficient site (large dam size compared to the storage volume).*
South Fork Pacheco	🟦					🟧	*South Fork Pacheco Reservoir would have too high an elevation and would be an inefficient site (large dam size compared to the storage volume).*
Del Puerto Reservoir			●	●	●	🟩	
Ingram Canyon Reservoir			●	●	●	🟩	
Quinto Creek Reservoir			●	●	●	🟩	
Garzas Reservoir		🟦				🟧	*A reservoir at Garzas Creek would inundate an area with a permanent conservation easement created for CVP mitigation.*
Little Salado Crow Reservoir	🟦					🟧	*Little Salado Crow Reservoir would not be large enough to meet needs.*
Los Banos Grandes Reservoir		🟦				🟧	*Potential environmental impacts would lead to significant difficulty in implementation.*
Orestimba Reservoir		🟦				🟧	*Orestimba Reservoir would inundate an area with a permanent conservation easement created for CVP mitigation.*
Romero Reservoir	🟦					🟧	*Romero Reservoir would not be large enough to meet needs.*
Alternate Water Supplies							
Demand-Side Management in SCVWD	🟦					🟧	*SCVWD has implemented or is planning to implement most demand-side management measures as part of its baseline water supply.*
Desalination: Monterey Bay			●	●	●	🟩	
Desalination: San Benito Groundwater Basin			●	●	●	🟩	
Desalination: San Francisco Bay			●	●	●	🟩	
Desalination: San Benito Groundwater Basin, San Francisco Bay, and Monterey Bay			●	●	●	🟩	
Enlarged SBA/Los Vaqueros Expansion			◒	○	○	🟩	
Los Vaqueros Expansion			◒	○	○	🟩	
More Storage in SCVWD Groundwater Basin			◒	◒	◒	🟩	
Options from SBCWD Basin Management Plan			◒	◒	◒	🟩	
Options from PVWMA Basin Management Plan			◒	◒	◒	🟩	
Recycling in SCVWD			◒	○	○	🟩	*SCVWD is planning to recycle most dry-season discharge as part of its baseline water supply.*
Re-Operation of Anderson Reservoir			◒	○	○	🟩	
SFPUC Expanded Calaveras Reservoir	🟦	🟦				🟧	*SFPUC is not planning to expand Calaveras Reservoir as a part of its ongoing dam replacement project.*
SFPUC Intertie			◒	◒	◒	🟩	

Symbol Key 🟦 *Not Technically or Institutionally Viable* ○ *Does Not Meet Project Objective* ◒ *Partially Meets Project Objective* ● *Meets Project Objective* 🟧 *Measure Screened Out* 🟩 *Measure Retained for Level 2 Screening*

Figure 2-2. SLLPIP Management Measure Screening (continued).

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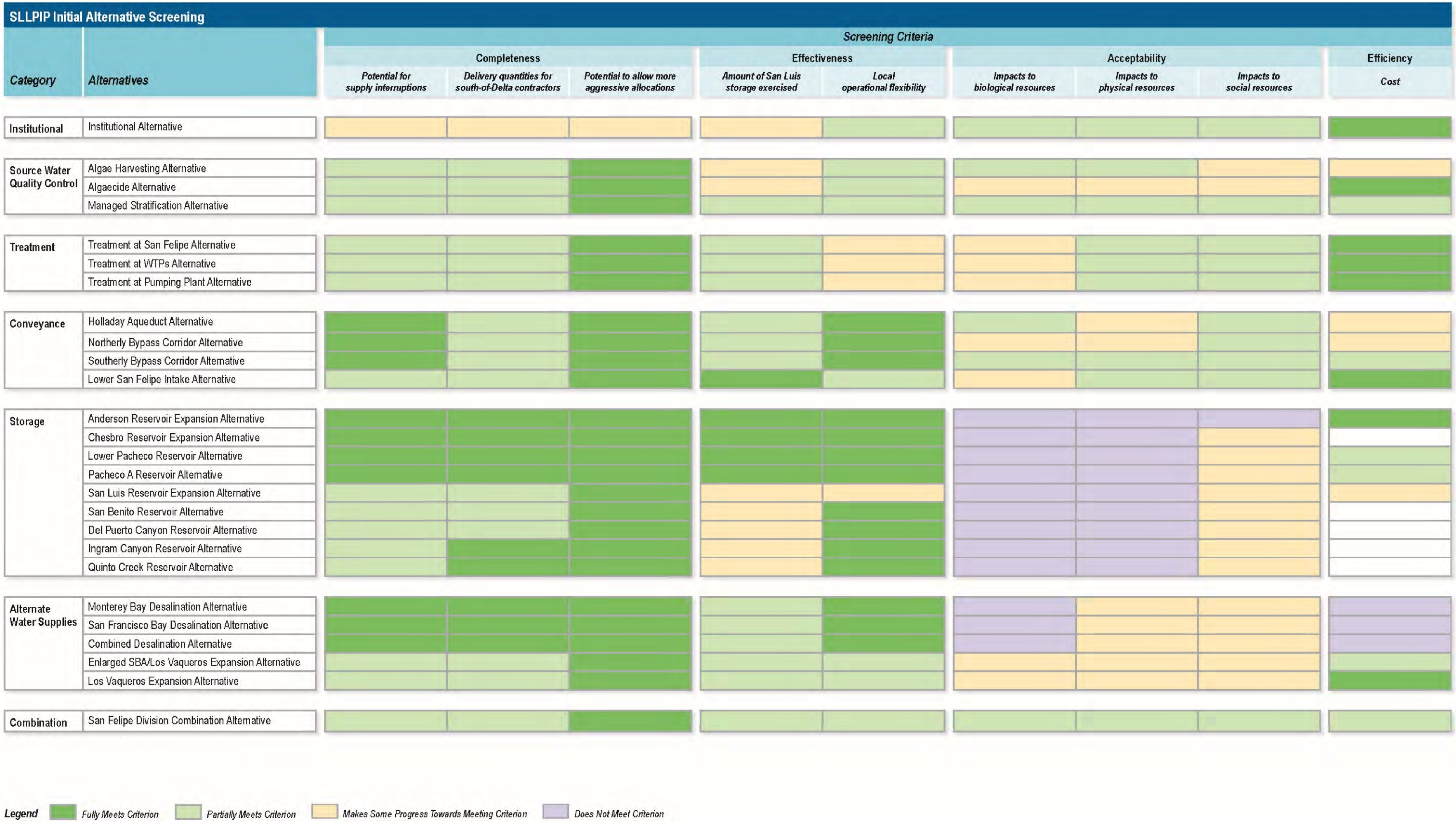

SLLPIP Initial Alternative Screening

Category	Alternatives	Screening Criteria								
		Completeness			Effectiveness		Acceptability			Efficiency
		Potential for supply interruptions	*Delivery quantities for south-of-Delta contractors*	*Potential to allow more aggressive allocations*	*Amount of San Luis storage exercised*	*Local operational flexibility*	*Impacts to biological resources*	*Impacts to physical resources*	*Impacts to social resources*	*Cost*
Institutional	Institutional Alternative	🟨	🟨	🟨	🟨	▨	▨	▨	▨	🟩
Source Water Quality Control	Algae Harvesting Alternative	▨	▨	🟩	🟨	▨	▨	▨	🟨	🟨
	Algaecide Alternative	▨	▨	🟩	🟨	▨	🟨	🟨	🟨	🟩
	Managed Stratification Alternative	▨	▨	🟩	🟨	▨	▨	▨	🟨	▨
Treatment	Treatment at San Felipe Alternative	▨	▨	🟩	▨	🟨	🟨	▨	▨	🟩
	Treatment at WTPs Alternative	▨	▨	🟩	▨	🟨	🟨	▨	▨	🟩
	Treatment at Pumping Plant Alternative	▨	▨	🟩	▨	🟨	🟨	▨	▨	🟩
Conveyance	Holladay Aqueduct Alternative	🟩	▨	🟩	▨	🟩	▨	🟨	▨	🟨
	Northerly Bypass Corridor Alternative	🟩	▨	🟩	▨	🟩	🟨	🟨	▨	🟨
	Southerly Bypass Corridor Alternative	🟩	▨	🟩	▨	🟩	▨	▨	▨	▨
	Lower San Felipe Intake Alternative	▨	▨	🟩	🟩	▨	🟨	▨	▨	🟩
Storage	Anderson Reservoir Expansion Alternative	🟩	🟩	🟩	🟩	🟩	🟪	🟪	🟪	🟩
	Chesbro Reservoir Expansion Alternative	🟩	🟩	🟩	🟩	🟩	🟪	🟪	🟨	
	Lower Pacheco Reservoir Alternative	🟩	🟩	🟩	🟩	🟩	🟪	🟪	🟨	▨
	Pacheco A Reservoir Alternative	🟩	🟩	🟩	🟩	🟩	🟪	🟪	🟨	▨
	San Luis Reservoir Expansion Alternative	▨	▨	🟩	🟨	🟨	🟪	🟪	🟨	🟨
	San Benito Reservoir Alternative	▨	▨	🟩	🟨	🟩	🟪	🟪	🟨	
	Del Puerto Canyon Reservoir Alternative	▨	▨	🟩	🟨	🟩	🟪	🟪	🟨	
	Ingram Canyon Reservoir Alternative	▨	🟩	🟩	🟨	🟩	🟪	🟪	🟨	
	Quinto Creek Reservoir Alternative	▨	🟩	🟩	🟨	🟩	🟪	🟪	🟨	
Alternate Water Supplies	Monterey Bay Desalination Alternative	🟩	🟩	🟩	▨	🟩	🟪	🟨	🟨	🟪
	San Francisco Bay Desalination Alternative	🟩	🟩	🟩	▨	🟩	🟪	🟨	🟨	🟪
	Combined Desalination Alternative	🟩	🟩	🟩	▨	🟩	🟪	🟨	🟨	🟪
	Enlarged SBA/Los Vaqueros Expansion Alternative	▨	▨	🟩	▨	▨	🟨	🟨	🟨	▨
	Los Vaqueros Expansion Alternative	▨	▨	🟩	▨	▨	🟨	🟨	🟨	🟩
Combination	San Felipe Division Combination Alternative	▨	▨	🟩	▨	▨	▨	▨	▨	▨

Legend 🟩 *Fully Meets Criterion* ▨ *Partially Meets Criterion* 🟨 *Makes Some Progress Towards Meeting Criterion* 🟪 *Does Not Meet Criterion*

Figure 2-3. SLLPIP Initial Alternative Screening

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Table 2-1. Initial Alternatives Retained after IAIR Evaluation

Category	Alternative	Included Management Measures
Institutional	Institutional Alternative	Banking, exchanges, and operating agreements and procedures.
Source Water Quality Control	Algaecide Alternative	Algaecides, banking, exchanges, and groundwater storage.
Treatment	Treatment at San Felipe Intake Alternative	DAF at San Felipe Intake, treatment at Rinconada, and exchanges.
	Treatment at Water Treatment Plants Alternative	DAF at Water Treatment Plants, treatment at Rinconada, and exchanges
	Treatment at Pumping Plant Alternative	DAF at Coyote PP, treatment at Rinconada, and exchanges.
Conveyance	Lower San Felipe Intake Alternative	Extend/Lower San Felipe Intake to Gianelli Inlet/Outlet Level and banking.
	Southerly Bypass Corridor Alternative	Southerly Bypass Corridor and exchanges.
Storage	Anderson Reservoir Expansion Alternative	Anderson expansion and exchanges.
	Chesbro Reservoir Expansion Alternative	Chesbro expansion and exchanges.
	Lower Pacheco Reservoir Alternative	Lower Pacheco (Pacheco Lake Reservoir) and exchanges.
	Pacheco A Reservoir Alternative	Pacheco A Reservoir and exchanges.
	San Benito Canyon Reservoir Alternative	San Benito Reservoir and exchanges.
	Del Puerto Canyon Reservoir Alternative	Del Puerto Canyon Reservoir, banking, groundwater storage, and exchanges.
	Ingram Canyon Reservoir Alternative	Ingram Canyon Reservoir.
	Quinto Creek Reservoir Alternative	Quinto Creek Reservoir.
Alternate Water Supplies	Los Vaqueros Expansion Alternative	Los Vaqueros Expansion, Anderson re-operation, SFPUC intertie, San Benito groundwater desalination, and exchanges.
Combination	San Felipe Division Combination Alternative	San Felipe Division conveyance modification, groundwater storage, recycling, and exchanges.

Key: DAF = Dissolved Air Flotation
WTPs = water treatment plants
PP = pumping plant
SBA = South Bay Aqueduct
SFPUC = San Francisco Public Utilities Commission

2.3 Additional Alternatives Screening in Plan Formulation Phase

In the Plan Formulation Phase, alternatives carried forward from the IAIR were re-evaluated for their capacity to meet the four Federal planning criteria: completeness, effectiveness, acceptability, and efficiency. The goal of this re-evaluation was to use updated information and data to identify and screen out alternatives that would not meet the planning criteria prior to development of comprehensive plans in the PFR. As a result of the re-evaluation, summarized in Table 2-2, the Study team screened out 14 alternatives, eliminating them from further consideration in the Study, as described following the figure and tables below.

Table 2-2. Alternatives Eliminated after Re-Evaluation during Plan Formulation

Category	Alternative	Included Management Measures
Institutional	Institutional Alternative	Banking, exchanges, and operating agreements and procedures.
Source Water Quality Control	Algaecide Alternative	Algaecides, banking, exchanges, and groundwater storage.
Treatment	Treatment at San Felipe Intake Alternative	DAF at San Felipe Intake, treatment at Rinconada, and exchanges.
	Treatment at Water Treatment Plants Alternative	DAF at Water Treatment Plants, treatment at Rinconada, and exchanges
	Treatment at Pumping Plant Alternative	DAF at Coyote PP, treatment at Rinconada, and exchanges.
Conveyance	Southerly Bypass Corridor Alternative	Southerly Bypass Corridor and exchanges.
Storage	Anderson Reservoir Expansion Alternative	Anderson expansion and exchanges.
	Chesbro Reservoir Expansion Alternative	Chesbro expansion and exchanges.
	Lower Pacheco Reservoir Alternative	Lower Pacheco (Pacheco Lake Reservoir) and exchanges.
	San Benito Canyon Reservoir Alternative	San Benito Reservoir and exchanges.
	Del Puerto Canyon Reservoir Alternative	Del Puerto Canyon Reservoir, banking, groundwater storage, and exchanges.
	Ingram Canyon Reservoir Alternative	Ingram Canyon Reservoir.
	Quinto Creek Reservoir Alternative	Quinto Creek Reservoir.
Alternate Water Supplies	Los Vaqueros Expansion Alternative	Los Vaqueros Expansion, Anderson re-operation, SFPUC intertie, San Benito groundwater desalination, and exchanges.

Key: DAF = Dissolved Air Filtration
WTPs = water treatment plants
PP = pumping plant
SBA = South Bay Aqueduct
SFPUC = San Francisco Public Utilities Commission

2.3.1 Institutional Alternative

The stand-alone Institutional Alternative was screened from further consideration by the Study team under the completeness criterion because it would not provide a reliable long term water supply to meet the SLLPIP project objective of avoiding supply interruptions. Although the Institutional Alternative was screened as a stand-alone alternative, institutional management measures are included as elements of other alternatives.

The Institutional Alternative developed in the IAIR included non-structural exchanges with CVP agricultural contractors that have access to groundwater supplies and with the Metropolitan Water District, north-of-Delta transfers, groundwater banking, and San Felipe Division re-operation management measures. The Institutional Alternative included reliance on end of month San Luis Reservoir storage levels as triggers for when the alternative would be implemented. The triggers were developed to counter the uncertainty associated with forecasting when a low point supply interruption would occur.

Preliminary estimates of Institutional Alternative operations indicate that exchanges with CVP agricultural contractors would be utilized in 46 of the 81 model years, exchanges with MWD would be utilized in 40 years, transfers from north-of-Delta contractors in 47 years, and withdrawals from a groundwater bank in 27 years. Estimates of north-of-Delta transfers were developed assuming constraints on through delta water deliveries including carriage water costs and the following regulatory requirements: State Water Resources Control Board Decision 1641; section b(2) of the CVPIA; and the Bay-Delta Hearings Phase 8 Settlement agreement. These estimates did not include consideration of potential changes in future Delta export limits to support Endangered Species Act (ESA) compliance.

Potential changes in regulatory limits on Delta exports to support ESA compliance related to salmon and delta smelt protection are expected to reduce the Institutional Alternative's ability to rely on north-of-Delta exchanges and transfers. Export limitations due to fishery protection actions are expected to affect spring export capacity, which would cause the CVP and SWP to increase exports later in the summer to meet contract allocations and likely limit the export capacity available to support this alternative's reliance on summer transfers. The uncertainty regarding future restrictions on south-of-Delta exports, and their potential to prevent the north-of-Delta transfers needed to hold San Luis Reservoir at the 300 TAF level in all years, limit the degree to which the Institutional Alternative is estimated to be able to achieve the SLLPIP project objectives.

The frequency with which the Institutional Alternative would call on each management measure further reduces the likelihood that the alternative would function as a complete alternative. Some measures, such as groundwater banking, have operational limitations in that water must be recharged before it is withdrawn. These limitations are considered when determining the frequency of use of this measure. In many years, only a few acre-feet would be withdrawn because adequate time has not passed since the last withdrawal to accumulate a substantial amount of water in storage. Other measures, such as exchanges and transfers, would require willing participants. Participants are less likely to be willing to engage in a program that requires them to change their actions (pumping groundwater or idling crops) in about half of the years; finding willing participants would therefore be difficult. These considerations contribute to the finding that this alternative would not function as a complete alternative.

The frequency of use of the measures within the Institutional Alternative creates an increased likelihood that they will not be available; however, using the measures on a less frequent basis as safety nets for allocations would be a better fit. When used as safety nets, these measures are necessary in approximately half as many years as in the Institutional Alternative, thereby increasing the likelihood of finding willing participants and the usefulness of a groundwater bank.

2.3.2 Source Water Quality Control Alternatives

The Algaecide Alternative described in the IAIR proposed the use of boats or helicopters to apply copper-based herbicides to San Luis Reservoir in the early stages of summer algae blooms to thin the algae density and lower the concentration of filter-clogging algae in water delivered from the reservoir. The total water quantity benefit that could be provided by the alternative was unknown when the IAIR was prepared, but was estimated to be approximately 50 TAF based on a previous investigation completed as a part of SCVWD’s work on the SLLPIP. The alternative has subsequently been screened from further consideration based on the effectiveness and acceptability criteria.

In the early stages of reservoir algae development, when algaecide application could control growth, the blooms in San Luis Reservoir are widely dispersed. This dispersion, coupled with summer winds at the reservoir, which can rapidly transport blooms to the area near the San Felipe Intakes, makes focused treatment infeasible. The entire reservoir would need to be treated with algaecide to control algae blooms.

Preliminary work completed by SCVWD and DWR in the summer of 2007 determined that the need for reservoir-wide algaecide application would necessitate the application of between 400,000 and 1,500,000 pounds of copper sulfate, depending on the concentration of copper sulfate needed and the depth of reservoir requiring treatment. At that time, preliminary cost estimates for this treatment ranged from between $500,000 and $1,700,000 per application. The highly productive water quality conditions found in San Luis Reservoir during the low point months could require multiple applications each year. Algaecide application at this scale would generate environmental and water quality concerns because San Luis Reservoir supplies drinking water and is used for recreational fishing. SCVWD and DWR did not pursue algaecide application because of the uncertain water supply benefits and the potential environmental concerns associated with applying between 400,000 and 1,500,000 pounds of copper sulfate (Janick 2008). These concerns make the alternative unacceptable.

Additional review of the Algaecide Alternative focused on reducing the uncertainty associated with the expected water supply benefit from algaecide application. The review investigated the algaecide application plan evaluated in the IAIR and determined that the proposed algaecide, Cutrine Plus, was not designed to treat algae blooms at depths greater than four feet. The application plan assumed reservoir-wide application at a depth of 30 feet. The proposed algaecide is also not designed for reservoir-wide application, because as the treated algae decays, it causes oxygen depletion that can have a harmful effect on fish in the reservoir. These limitations on application depth and scope directly affect the alternative's ability to meet the project objectives and the effectiveness criterion.

Uncertainty about the degree to which the Algaecide Alternative would meet the project objectives and the potential challenges associated with permitting the application of algaecide on a drinking water reservoir at this scale (Bolland 2008) led to the elimination of this alternative from further consideration in the Study based on the effectiveness and acceptability criteria.

2.3.3 Treatment Alternatives

The dissolved air flotation (DAF) treatment alternatives described in the IAIR included three potential layouts for using DAF treatment. DAF treatment would be used to reduce the amount of algae in water delivered from San Luis Reservoir and prevent clogging of filters at SCVWD drinking water treatment plants and in SBCWD and PVMWA irrigation infrastructure. Three DAF alternatives were carried forward from the IAIR based on water supply benefits and cost. Further investigation into the potential use of DAF technology for treatment of algae-laden water from San Luis Reservoir focused on previous investigations by SCVWD into adding DAF to its treatment plants as a part of recent treatment plant upgrades.

The addition of DAF facilities at the SCVWD treatment plants as a part of these recent treatment plant upgrades was investigated and, based on then-current information, abandoned in favor of a treatment process that consists of conventional treatment (chemical coagulation, flocculation, and sedimentation), ozonation, and granular media filtration using granular activated carbon (GAC) and sand. SCVWD determined that retrofitting the newly updated treatment plants with DAF was not a cost effective solution for the low point issue and would likely not be an acceptable project by its rate payers. The alternative has subsequently been screened from further consideration as a stand-alone alternative based on the acceptability criterion. Improvements to water treatment facilities, however, may have some utility when combined with other measures. Water treatment will remain as a potential measure within the Combination Alternative.

2.3.4 Conveyance Alternatives

The Lower San Felipe Intake and Southerly Bypass Corridor Alternatives were carried forward in the IAIR because their costs were similarly low relative to the other conveyance alternatives. The Study team's further review of these two conveyance alternatives under the efficiency criterion determined that construction costs for the Southerly Bypass Corridor would exceed the costs for the Lower San Felipe Intake Alternative because of the additional tunnel, pipeline, and pumping facility construction necessary to connect to the O'Neill Forebay. The potential water supply benefits generated by the alternatives were also determined to be the same. While the Southerly Bypass Corridor has greater costs for similar benefits, it should be retained if it has the potential to reduce environmental impacts compared to the Lower San Felipe Intake Alternative. However, the Southerly Bypass Corridor would require a larger pump station and longer tunneling effort (with more earth moving), and would not have the potential to reduce environmental effects. Because the Southerly Bypass Corridor Alternative would have higher costs than the Lower San Felipe Intake Alternative, which would offer similar benefits, the Southerly Bypass Corridor Alternative has been screened from the further consideration based on the efficiency criterion.

2.3.5 Storage Alternatives

Eight storage alternatives were carried forward from the IAIR because of an insufficient amount of data available to compare them effectively against other storage alternatives considered in the study. The Study team completed further analysis to provide sufficient background data to support a comparative analysis of each storage alternative's capacity to meet the project objectives.

The analysis focused on developing sufficient information on physical, geotechnical, geological, and hydraulic conditions as well as forecasting potential land development issues and social impacts associated with each storage alternative. This information was used to screen out alternatives with significant estimated earthwork costs and/or potentially greater impacts relative to the other storage alternatives. The storage alternative screening effort identified the Pacheco A and B Reservoir Alternatives as the most efficient storage alternatives to be carried forward for review in the PFR. The remaining storage alternatives, therefore, are eliminated from further consideration based on the efficiency criterion.

The screening effort carried forward the Pacheco B Reservoir Alternative, which had been screened out in the IAIR because of institutional viability concerns associated with its potential inundation of Henry Coe State Park. In 2003, the SCVWD board decided that any Pacheco Reservoir expansion project must avoid State Park lands. Further review determined that a slightly smaller footprint may be able to meet project needs while avoiding the State Park. In the next phase of this study, the Study team will delineate a reservoir footprint that would not inundate State Park lands.

Attachment A presents the details of the analysis.

2.3.6 Alternate Water Supplies

The Los Vaqueros Expansion Alternative would utilize additional storage capacity that would be created as a part of the Los Vaqueros Reservoir Expansion Project to store supplies for delivery in lieu of deliveries from San Luis Reservoir. For the IAIR, the Study team assumed that 100 TAF of Delta water supply would be available to store in an expanded Los Vaqueros Reservoir for later delivery during the summer low point months to replace supplies from San Luis Reservoir. The 100 TAF would be delivered via the SBA for use by SCVWD and via the California Aqueduct to San Luis Reservoir to maintain deliveries to the San Felipe Division and contractors east of San Luis Reservoir.

The Los Vaqueros Expansion Project Feasibility Study was under development during preparation of this PFR independent of this Study. The Los Vaqueros Expansion Project Feasibility Study Team has completed a Final EIS/EIR with alternatives designed to achieve the project objectives identified by Reclamation, DWR, and the local sponsor, CCWD. The degree to which the SLLPIP could rely on any changes made to the Los Vaqueros facility as a result of the Los Vaqueros Expansion Project Feasibility Study is uncertain and cannot be relied on as a tool to address the SLLPIP project objectives. This uncertainty has led to its elimination from the study based on the completeness criterion.

2.3.7 Alternatives Selected for Further Evaluation

The alternatives that remained after the initial PFR screening for further refinement and development included:

- Lower San Felipe Intake Alternative Plan;
- Pacheco Reservoir Alternative Plan; and
- Combination Alternative Plan.

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Chapter 3
Final Alternatives Evaluated in the Feasibility Report and EIS/EIR

This chapter describes key changes to the planning baseline following the release of the 2011 Plan Formulation Report, and the alternative plans evaluated in this Feasibility Report and EIS/EIR. The Final Alternatives include the No Action Alternative and four action alternatives.

3.1 Further Refinement and Reformulation

At each stage of the feasibility study, the key features of the study are revisited, such as the need for the project and whether conditions have changed to allow any alternatives previously eliminated to be re-introduced. Several project changes occurred during this feasibility investigation.

3.1.1 Project Modifications

3.1.1.1 Project Objectives

During the IAIR and the PFR, the objectives contained three key elements: avoiding supply interruptions; increasing reliability and quantity of deliveries; and announcing higher allocations earlier in the year. The third objective was eliminated after plan formulation due to the fact that solving the low point problem did not provide the opportunity for earlier CVP allocation announcements. As a result, the institutional measures related to earlier higher allocations were removed from all alternatives because they were not required to meet the remaining objectives.

3.1.1.2 New Alternatives

During the PFR development, SCVWD was concerned about Dissolved Air Flotation (DAF) as a method for drinking water treatment. The alternative to modify SCVWD's treatment plants with DAF was eliminated from further consideration based on the acceptability criterion. Subsequent analysis, however, found that other treatment methods (i.e., ballasted flocculation or raw water ozonation) may allow efficient treatment of algae-laden water without adversely affecting water treatment options during the non-low point periods. Additional studies on potential treatment options determined that water treatment should be reconsidered as an alternative.

The IAIR considered but eliminated the Expansion of San Luis Reservoir Alternative given its higher cost and similar benefits to the other storage alternatives that were identified in the IAIR. Potential dam safety issues at B.F. Sisk Dam have been under review in a Federal Corrective Action Study being prepared by Reclamation at the same time the SLLPIP Feasibility Investigation was underway. While geologic studies and engineering design of structural alternatives to raise the dam embankment and adding abutments were underway to support development of the Corrective Action Study, Reclamation completed the San Luis Reservoir Expansion Draft Appraisal Report (Reclamation 2013). The Report evaluated the potential water supply benefits generated by a reservoir expansion completed in coordination with the dam safety improvements. Results from the 2013 appraisal study indicated that inclusion of the Expansion of San Luis Reservoir Alternative in the SLLPIP Feasibility Report and EIS/EIR was warranted (Reclamation 2013).

The feasibility investigation considered multiple operational scenarios for an expanded San Luis Reservoir. These scenarios evaluated the potential water supply benefits of different dedications of the additional water stored in the reservoir – a CVP only storage configuration, a split CVP and SWP storage configuration, and a configuration that would allow CVP operators to carryover supply in this expanded space for delivery to CVP contractors in subsequent years. Table 3-1 presents the results of potential water supply benefit evaluations that were completed for these optional configurations.

Table 3-1. Changes in San Felipe Division and CVP/M&I Water Supply Benefits with San Luis Reservoir Expansion

Alternative[1]	Average Annual Change in San Felipe Division M&I Deliveries in years with Low Point Interruptions (AF)[2]	Average Annual Change in San Felipe Division M&I Deliveries in years without Low Point Interruptions (AF)	Average Annual Change in CVP Deliveries (AF)	Average Annual Change in SWP Deliveries (AF)[3]
CVP Reservoir Expansion	200	700	16,700	-5.600
Shared CVP and SWP Reservoir Expansion	100	370	8,400	1,200
Increased San Luis Reservoir Carryover Storage	700	>100	10,300	0

Notes:

[1] All reservoir expansion configurations considered 120 TAF of additional storage capacity in San Luis Reservoir consistent with the 10-foot embankment raise under consideration.

[2] CalSim II and post processing modeling analysis of the Future No Action condition identified 17 years out of the 82-year model record with the potential for low point generated water supply interruptions

[3] Includes changes in SWP Table, Article 21, and Article 56 deliveries

The results of this analysis determined that the CVP only dedication of the expanded 120 TAF would be the best option to improve water supply deliveries to SCVWD in low point and non-low point years.

3.1.1.3 Changes to Participating Parties

During the PFR, the key parties involved in the Study included Reclamation, SCVWD, San Luis and Delta-Mendota Water Authority (SLDMWA), and SBCWD. Currently, SLDMWA participation in the overall study shifted to an interested party and is no longer a regular member of the study team. The SBCWD shifted to an interested party due to lack of continued interest in the project.

3.1.2 Plan Reformulation

Reclamation and SCVWD were concerned about high costs of the alternatives and revisited them to determine if there was a more cost-effective way to achieve the objectives. Before moving forward, the team considered each alternative plan to determine if it should be reformulated.

After publication of the SLLPIP PFR, Reclamation and SCVWD reconsidered the alternatives recommended for consideration. The PFR considered but eliminated the Treatment Alternatives; however, new treatment methods suggested that this alternative should be re-considered in the Feasibility Report and EIS/EIR. In addition, actions taken by SCVWD resulted in completion of upgrades at the Rinconada WTP that improved its capacity to address the low point problem and has resulted in the narrowing of the Treatment Alternative to focus on upgrades to the Santa Teresa WTP only. Based on preliminary results of early drafts of the Feasibility Report, Reclamation completed a feasibility level of analysis, including design details, of the Treatment Alternative Plan. In the Feasibility Report, the design details of the Treatment Alternative Plan are shown at a feasibility level.

The PFR also recommended consideration of the Combination Alternative; however, detailed review of the alternative by SCVWD during development of the Draft Feasibility Report and the EIS/EIR identified issues with the feasibility of the alternative’s Anderson Reservoir reoperation component and its groundwater extraction and recharge components. These issues included concerns over the potential for future changes to operating rules for releases to Coyote Creek under the Fisheries and Aquatic Habitat Collaborative Effort Settlement Agreement between SCVWD, the Guadalupe Coyote Resource Conservation District, and the resource agencies—CDFW; USFWS; and NMFS (SCVWD 2017b). These changes in conditions are anticipated with implementation of the Anderson Dam Seismic Retrofit Project currently under design (SCVWD 2017b). SCVWD also determined that the operation of the groundwater extraction and recharge components of the Combination Alternative that were originally formulated by SCVWD during development of an Infrastructure Reliability Plan would be infeasible given issues identified with conflicts to operation of existing wells by SCVWD contractors during completion of the Infrastructure Reliability Plan (SCVWD 2017b). Without these major components, the Combination Alternative would be unable to adequately address the low point problem and water supply interruptions in Santa Clara County (SCVWD 2017b).

SCVWD continued evaluation of the feasibility of a Pacheco Reservoir expansion, refining some project features, and submitted the project for California Proposition 1 funding under WSIP. The California Water Commission awarded funding to SCVWD for this alternative. SCVWD requested that the refined Pacheco Reservoir expansion be included in this Federal feasibility report for reevaluation. Reclamation and SCVWD have added the Pacheco Reservoir expansion configuration into this investigation for further evaluation.

Table 3-2 displays the alternatives screened and refined in the IAIR and PFR processes, the reason that they were screened, and the alternatives to be considered in this Feasibility Report.

Table 3-2. Alternative Screening Results

Category	IAIR Screening		PFR Screening		Feasibility Report
	Alternative	**Screening Result**	**Alternative**	**Screening Result**	
Institutional	Institutional Alternative	Retained	Institutional Alternative	Screened out as a standalone plan under the completeness criterion	--
Source Water Quality Control	Algae Harvesting Alternative	Eliminated because it had similar benefits to algaecide and was economically infeasible when compared to algaecide	--	--	--
	Algaecide Alternative	Retained	Algaecide Alternative	Screened out under the effectiveness and acceptability criteria given concerns over potential capacity to treat SLR algae and the difficulty permitting the application of algaecide on a drinking water reservoir at this scale	--
	Managed Stratification Alternative	Eliminated because it had similar benefits to algaecide and was economically infeasible when compared to algaecide	--	--	--
Treatment	Treatment at San Felipe Intake Alternative	Retained	Treatment at San Felipe Intake Alternative	Screened out under the acceptability criterion given SCVWD's determination that DAF	--

Category	IAIR Screening		PFR Screening		Feasibility Report
	Alternative	**Screening Result**	**Alternative**	**Screening Result**	
	Treatment at WTPs Alternative	Retained	Treatment at WTPs Alternative	treatment is not an acceptable remedy to the low point issue because evaluation during previous WTP upgrades indicated DAF is less effective and more difficult to operate than current treatment methods	Treatment Alternative – carried forward following further analysis of ballasted flocculation at the Santa Teresa WTP
	Treatment at Pumping Plant Alternative	Retained	Treatment at Pumping Plant Alternative		--
Conveyance	Lower San Felipe Intake Alternative	Retained	Lower San Felipe Intake Alternative	Retained	Lower San Felipe Intake
	Holladay Aqueduct Alternative	Eliminated because it had similar benefits to the Lower San Felipe Intake and Southerly Bypass Alternatives and was economically infeasible when compared to those options	--	--	--
	Northerly Bypass Corridor Alternative	Eliminated because it had similar benefits to the Lower San Felipe Intake and Southerly Bypass Alternatives and was economically infeasible when compared to those options	--	--	--
	Southerly Bypass Corridor Alternative	Retained	Southerly Bypass Corridor Alternative	Screened out under the efficiency criterion given the alternative’s economic infeasibility when compared to the Lower San Felipe Intake Alternative	--
Storage	Anderson Reservoir Expansion Alternative	Retained	Anderson Reservoir Expansion Alternative	Screened out under the efficiency criterion given the alternative’s economic infeasibility when compared to the Pacheco B Alternative	--
	Chesbro Reservoir Expansion Alternative	Retained	Chesbro Reservoir Expansion Alternative	Screened out because of increased risk of landslides and inundation of existing residences.	--
	Lower Pacheco Reservoir Alternative	Retained	Lower Pacheco Reservoir Alternative	Screened out because additional engineering showed a weak foundation.	--
	Pacheco A Reservoir Alternative	Retained	Pacheco A Reservoir Alternative	Alternatives include partial demolition of existing dam. Screening	Pacheco Reservoir Expansion Alternative – construction and

Category	IAIR Screening		PFR Screening		Feasibility Report
	Alternative	Screening Result	Alternative	Screening Result	
	Pacheco B Reservoir Alternative	Retained	Pacheco B Reservoir Alternative	determined that an alternative with an alternative dam site would meet storage and geological needs better than Pacheco A and Pacheco B. Alternatives retained with the need for a site visit and further investigation.	operation of a new alternative dam site further downstream of A and B and an expanded reservoir, pump station, conveyance facilities, and miscellaneous infrastructure. Information is provided from the SCVWD WSIP application.
	San Benito Canyon Reservoir Alternative	Retained	San Benito Canyon Reservoir Alternative	Screened out because small size made reservoir less efficient than other options	--
	San Luis Reservoir Expansion Alternative	Eliminated because it had similar benefits to the other storage alternatives and was economically infeasible when compared to those options			San Luis Reservoir Expansion Alternative - multiple configurations of a reservoir expansion alternative considered by analysis of the potential combination with the connected Corrective Action Study action. Shared CVP and SWP reservoir expansion identified as best performing option.
	Del Puerto Canyon Reservoir Alternative	Retained	Del Puerto Canyon Reservoir Alternative	Screened out under the efficiency criterion given the alternative's economic infeasibility when compared to the Pacheco Alternative	--
	Ingram Canyon Reservoir Alternative	Retained	Ingram Canyon Reservoir Alternative		--
	Quinto Creek Reservoir Alternative	Retained	Quinto Creek Reservoir Alternative		--
Alternate Water Supplies	Monterey Bay Desalination Alternative	Eliminated because it was economically infeasible when compared to any of the other alternatives under consideration in the IAIR	--	--	--
	San Francisco Bay Desalination Alternative	Eliminated because it was economically infeasible when compared to any of the other alternatives under consideration in the IAIR	--	--	--
	Combined Desalination Alternative	Eliminated because it was economically infeasible when compared to any of the other alternatives under consideration in the IAIR	--	--	--

Category	IAIR Screening		PFR Screening		Feasibility Report
	Alternative	**Screening Result**	**Alternative**	**Screening Result**	
	Enlarged SBA/Los Vaqueros Expansion Alternative	Expansion of the SBA was screened out but enlarging Los Vaqueros Reservoir was retained	Los Vaqueros Expansion Alternative	Screened out under the completeness criterion given the ongoing development of the project in the Los Vaqueros Expansion Project Feasibility Study	--
	Los Vaqueros Expansion Alternative	Retained			--
Combination	Combination Alternative	Retained	Combination Alternative	Retained	Eliminated related to the acceptability criterion given the identification of issues with the feasibility of the Anderson Reservoir reoperation and groundwater components.

3.1.3 Alternative Refinement and Evaluation

The Feasibility Report refined the alternatives to the following:

- Lower San Felipe Intake Alternative Plan;
- Treatment Alternative Plan;
- San Luis Reservoir Expansion Alternative Plan; and
- Pacheco Reservoir Expansion Alternative Plan.

3.2 No Action/No Project Alternative

The No Action/No Project Alternative would leave the current operations at San Luis Reservoir unchanged. SCVWD would continue annual operations in anticipation of curtailment of CVP supply and would manage its uses and sources of imported and local water supplies. A low point supply interruption—and even the threat of an interruption—could result in the immediate reduction of the amount of treated water available for delivery, because it requires the re-operation of SCVWD’s surface and groundwater systems and requires the use of alternative water supplies that would otherwise be dedicated to other uses. The effects resulting from delivery reductions and/or curtailments due to a low point event pose a significant threat to SCVWD’s short- and long-term water supply reliability.

3.3 Lower San Felipe Intake Alternative Plan

The Lower San Felipe Intake Alternative Plan includes construction of a new, lower San Felipe Intake to allow reservoir drawdown to its minimum operating level without algae effects. Moving the San Felipe Intake to an elevation equal to that of the Gianelli Intake would allow operation of San Luis Reservoir below the 300 TAF level without creating the potential for a water supply interruption to SCVWD.

As part of this alternative plan, a new intake would be constructed and connected to the existing San Felipe Division Intake via approximately 20,000 feet of new pipeline or tunnel. Lowering the San Felipe Intake would require an extension of the intake for the Pacheco Pumping Plant because the reservoir is higher on the west side than at the site of the Gianelli Intake. The conveyance structure from the new intake to the existing intake would be either a submerged pipeline along the bottom of the reservoir or a tunnel beneath the bottom of the reservoir (see Figure 3-1).

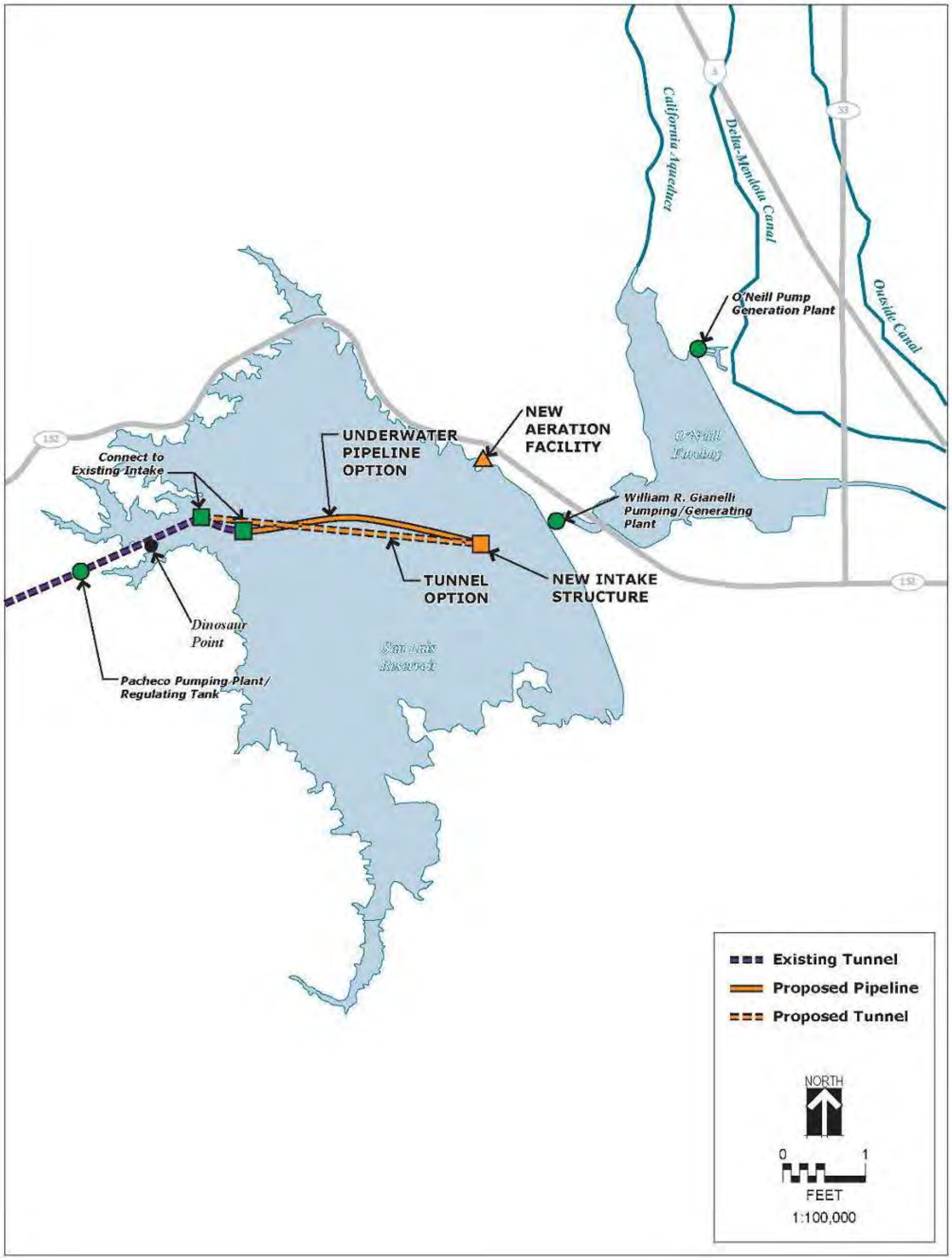

Figure 3-1. Pipeline and Tunnel Alignment for the Lower San Felipe Intake Alternative Plan

3.3.1 Tunnel Option

A tunnel would be constructed beneath the reservoir floor to convey water from the new intake to the existing intake. The tunnel option includes a new vertical shaft on Gate Shaft Island to tie into the existing intake and serve as a beginning point to launch the tunnel boring equipment. The tunnel would be about 20,000 feet long, 15 feet in diameter, and the liner would have an inner diameter of 13 feet. Figure 3-2 shows the tunnel profile.

3.3.2 Pipeline Option

For the pipeline option, a new 13-foot diameter, reinforced concrete cylinder pipe would be laid along the bottom of San Luis Reservoir. The pipeline would be approximately 20,000 feet long. The pipe would have a constant slope upward from the new intake and tie into the invert of the existing lower intake at elevation 313 feet. An existing intake channel is graded along the bottom of the reservoir. To reduce the amount of dredging required, the pipeline’s alignment would match the alignment of the existing intake channel. Construction would need to occur underwater because the water levels in San Luis Reservoir could not be affected by construction. Figure 3-3 shows the pipeline profile.

3.3.3 Hypolimnetic Aeration System

A hypolimnetic aeration facility would also be constructed to oxygenate the reservoir and prevent stratification that occurs during low water levels and warm weather. The aeration system (shown on Figure 3-1) would consist of a new facility near Romero Visitor Center. A liquid oxygen tank and vaporizers or a compressed air system would be used for the aeration facility. Either system would require a structure of approximately 1,200 square feet. A 3-inch air supply line would connect to approximately 6,000 feet of submerged high density polyethylene air diffuser piping within the reservoir.

3.3.4 Operation

The Lower San Felipe Intake Alternative Plan would provide an annual average of approximately 3,149 AF of additional water M&I supply to the San Felipe Division compared to the No Action/No Project Alternative. Figure 3-4 shows how the Lower San Felipe Intake Alternative Plan addresses the San Felipe Division supply interruptions and demand shortages in the No Action/No Project Alternative. Modeling results show that the Lower San Felipe Intake Alternative Plan would fully replace interrupted supplies in all 17 years with low point conditions (out of the 82 years modeled) low point years and fully address total demand shortages in 10 of those years.

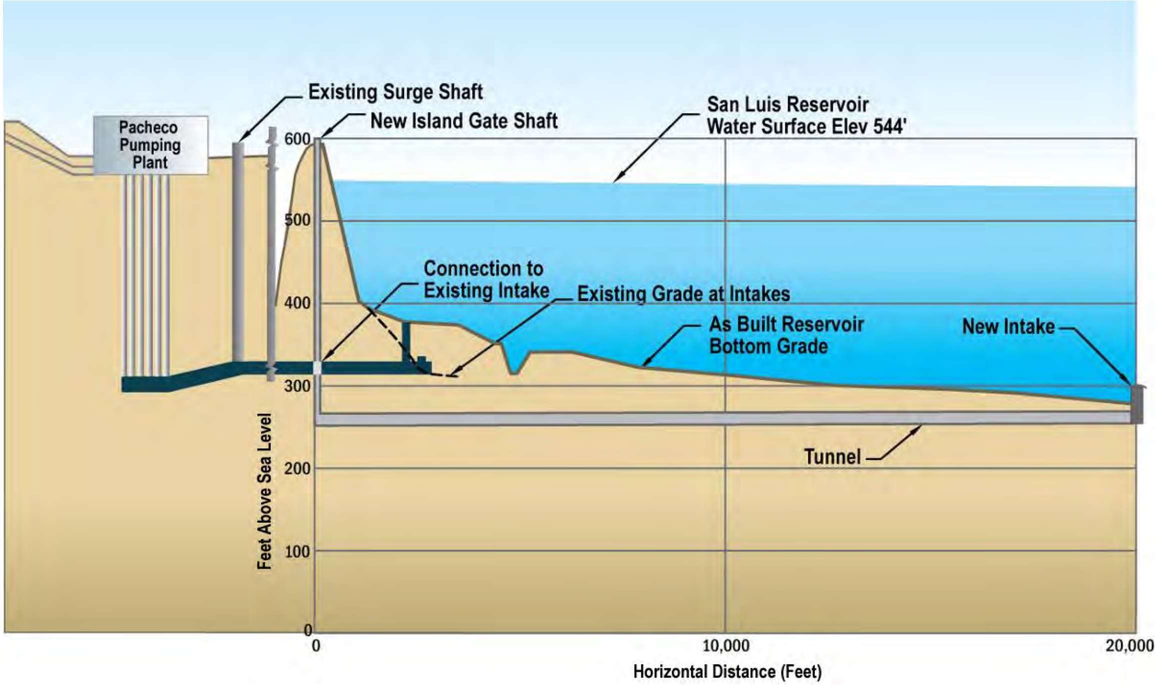

Figure 3-2. Lower San Felipe Intake Alternative Plan Tunnel Profile

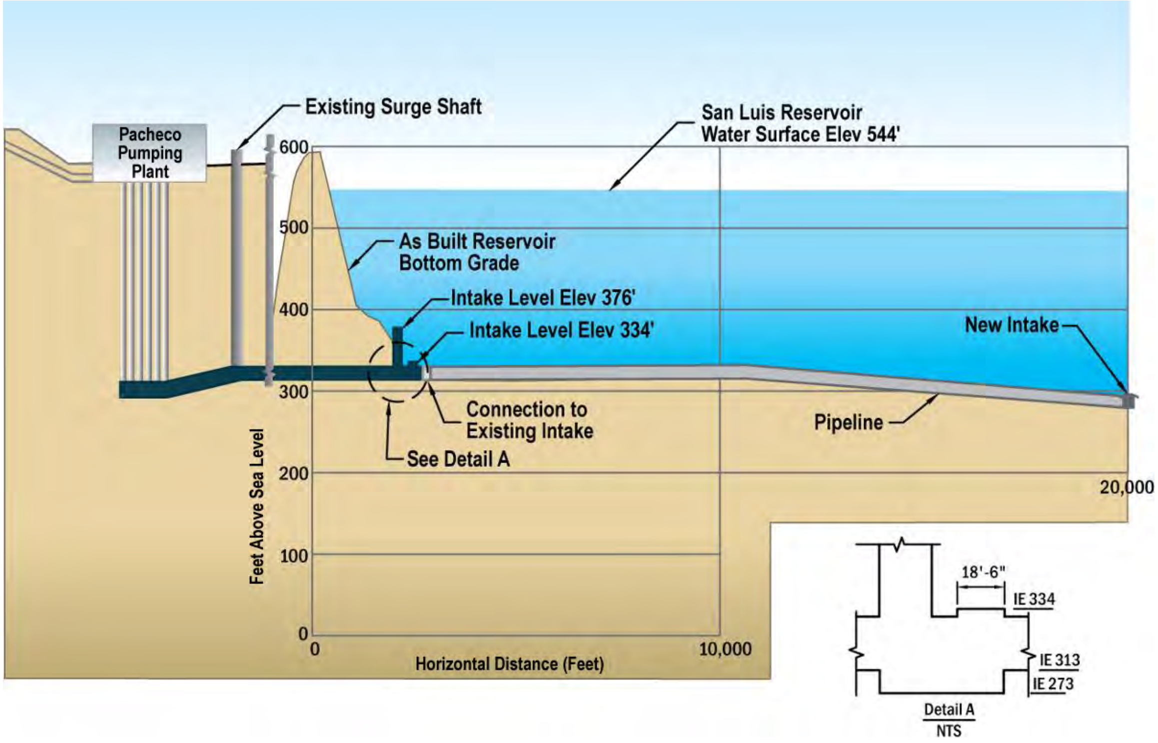

Figure 3-3. Lower San Felipe Intake Alternative Plan Pipeline Profile

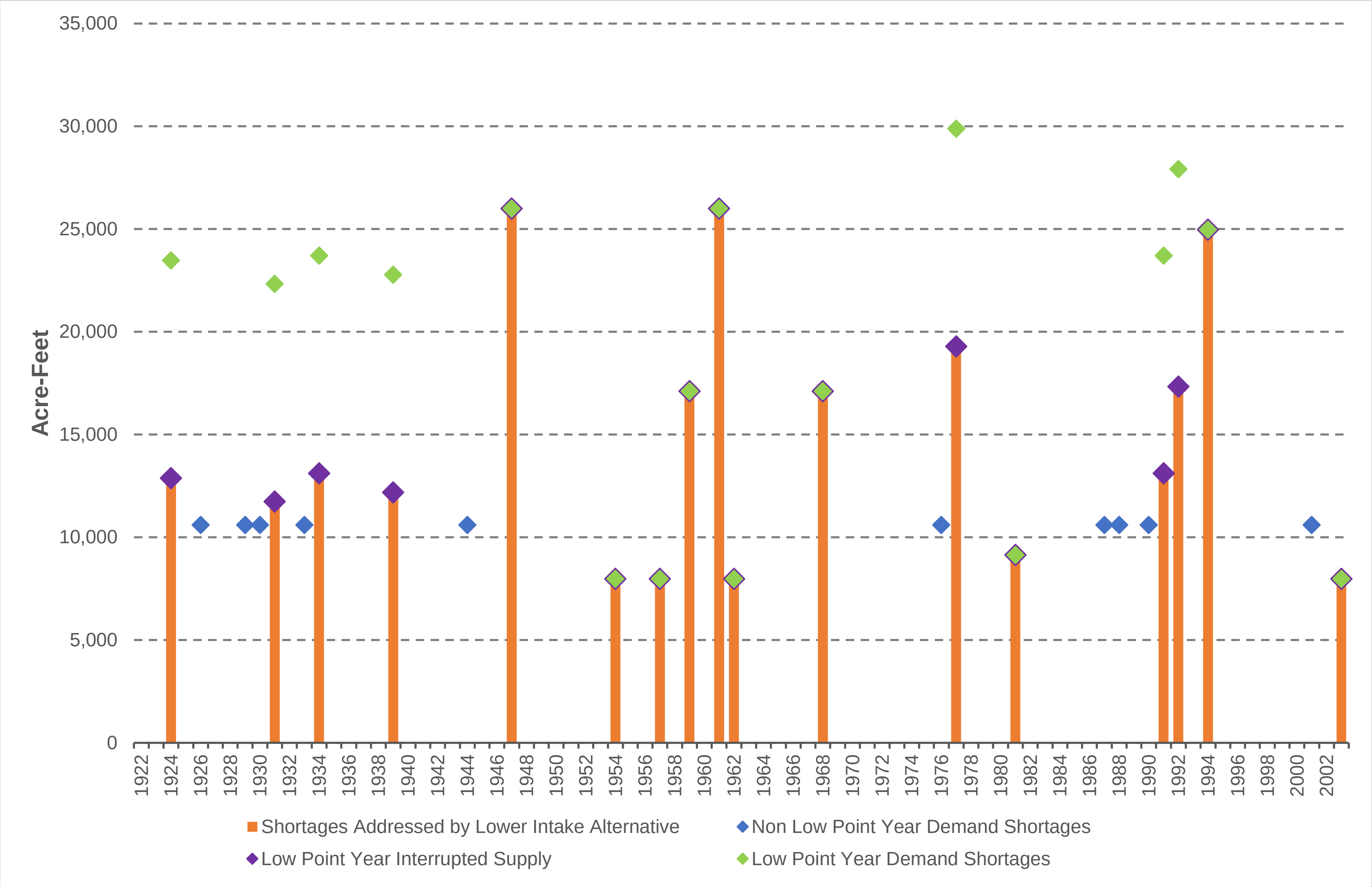

Figure 3-4. Annual San Felipe Division Shortages Addressed by the Lower San Felipe Intake Alternative Plan

3.3.5 Costs

The costs of the tunnel and pipeline options are similar. Table 3-3 shows appraisal-level cost estimates for the Lower San Felipe Intake Alternative Plan.

Table 3-3. Lower San Felipe Intake Alternative Plan Preliminary Costs

	Tunnel Option	Pipeline Option
Total Project Construction Costs	$968 million	$885 million
Annual Operation and Maintenance Costs	$2.5 million	$2.5 million

3.4 Treatment Alternative Plan

The Treatment Alternative Plan includes new technology retrofits at the SCVWD's Santa Teresa WTP. This WTP is supplied with water from San Luis Reservoir and cannot effectively treat the algae-laden water present during low point events.

3.4.1 Santa Teresa WTP

The existing Santa Teresa WTP process includes chemical coagulation, conventional clarification, settled water ozonation, granular media filtration, and disinfection. Solids handling facilities include washwater recovery basins and sludge drying beds. The recovered washwater is returned to the headworks of the plant. The recovered decant water from the sludge drying beds is returned to the washwater recovery basins, and the dried sludge is disposed of in a landfill.

The Treatment Alternative Plan would add a raw water ozonation process to the treatment train at the Santa Teresa WTP. A site plan of the Santa Teresa WTP with the raw water ozonation process is shown in Figure 3-5.

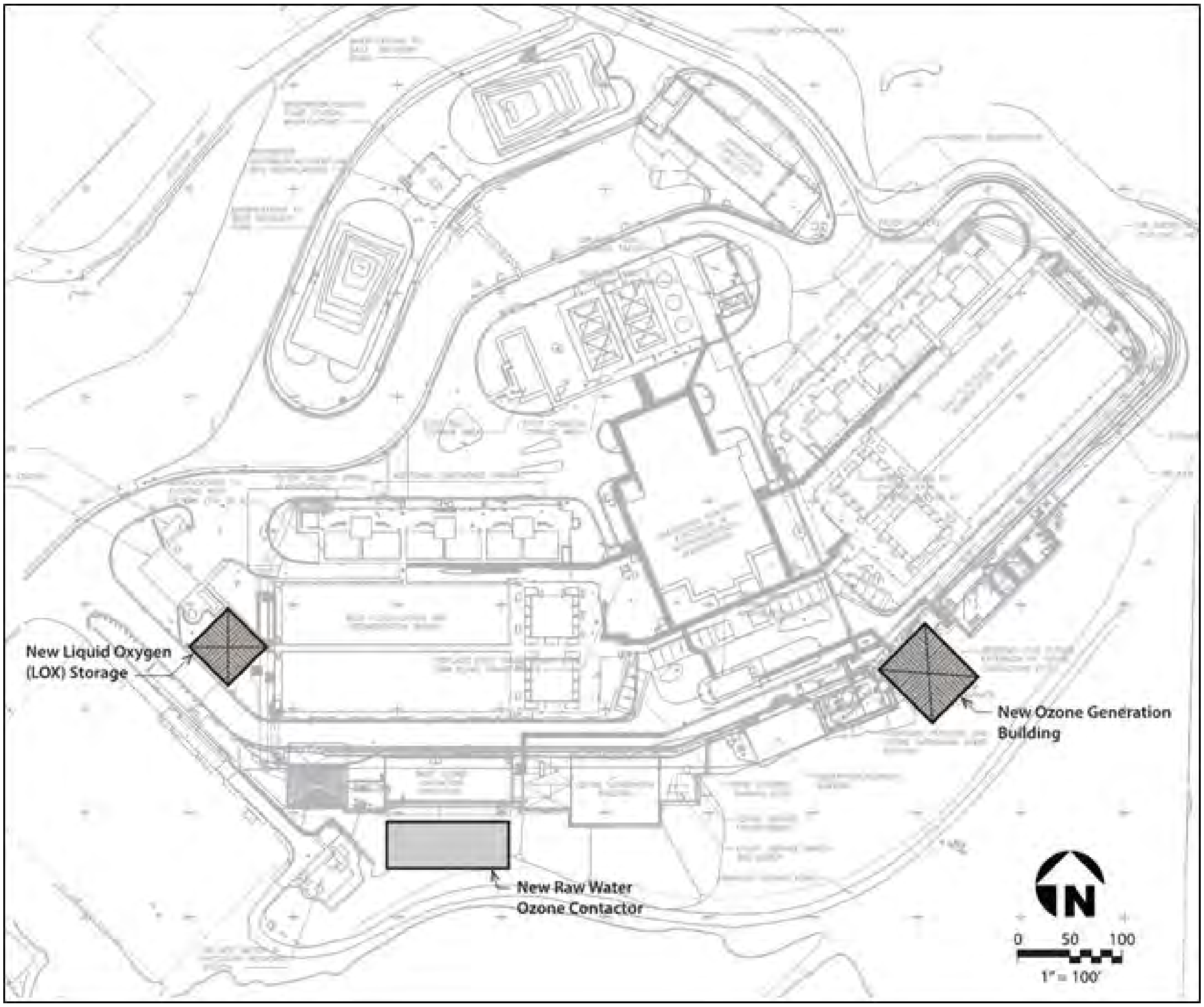

Figure 3-5. Santa Teresa WTP Conceptual Site Plan – Raw Water Ozonation

In a raw water ozonation process, ozone is added to the raw water entering the treatment plant before the water is treated by any other processes. Ozone oxidizes taste and odor causing compounds and other dissolved organic material released by algae. Ozone also improves clarification and filtration processes when used as a pre-oxidant. Implementation of a raw water ozonation process at the Santa Teresa WTP would require installation of a new ozone contactor, new ozone generation equipment housed in a new building, and new liquid oxygen storage facilities.

3.4.2 Operation

The Treatment Alternative Plan would provide additional water supply to meet SCVWD treated water demands. The additional water supply under the Treatment Alternative Plan would be the same as the Lower San Felipe Intake

Alternative Plan. The Treatment Alternative Plan would address the shortages in the No Action/No Project Alternative in the same manner as the Lower San Felipe Intake Alternative Plan, shown in Figure 3-4. Results show that the Treatment Alternative Plan would fully replace interrupted supplies in all 17 years with low point conditions (out of the 82 years modeled) low point years and fully address total demand shortages in 10 of those years.

3.4.3 Costs

Table 3-4 shows appraisal-level cost estimates for the Treatment Alternative Plan.

Table 3-4. Treatment Alternative Plan Preliminary Costs

	Santa Teresa Improvements
Total Project Construction Costs	$37 million
Annual Operation and Maintenance Costs	$0.25 million

3.5 San Luis Reservoir Expansion Alternative Plan

The San Luis Reservoir Expansion Alternative Plan would place additional fill material on the dam embankment to raise the dam crest to increase storage capacity. The alternative plan would build upon the dam embankment expansion and foundation modifications to address the seismic concerns that are currently in final design. The seismic modifications to B.F. Sisk Dam currently under Reclamation's Safety of Dams (SOD) Act, as amended, that the San Luis Reservoir Expansion Alternative Plan would build on are included in this alternative plan as connected actions as defined under NEPA. The San Luis Reservoir Expansion Alternative would allocate the increased capacity to the CVP only. This expanded capacity would be operated in the same way as the current CVP portion of San Luis Reservoir, with the reservoir used for seasonal storage.

Increasing storage capacity in San Luis Reservoir would potentially increase the yield of the CVP in years that surplus supplies in excess of the reservoir's existing storage capacity are available. This increased yield could increase SCVWD's capacity to access their CVP supply prior to the reservoir being drawn below the 300 TAF level and allow the District to avoid the potential for a water supply interruption from low point conditions.

As part of this alternative plan, the dam crest would be raised by adding additional embankment material (see Figure 3-6 for a schematic and Figure 3-7 for profile views). In addition, downstream stability berms and crack filters would be installed. Construction of foundation shear keys at slopewash sections in the abutments and the north valley section (NVS), and a filter around the downstream portion of the existing spillway conduit are also included in this alternative plan. The existing saddle dike located north of the main embankment would be modified by adding a downstream filter. In addition to these modifications, development of a foundation shear key at the south valley section (SVS) is under consideration as an optional additional feature of this alternative plan. With increased reservoir surface elevations, modifications would also be made at multiple locations along SR 152 to prevent inundation of the roadway when the enlarged reservoir is filled to capacity, and modifications to the Dinosaur Point Boat Launch and the Goosehead Point Boat Launch would be made to increase the ramps operating elevation by 10 feet. The existing berm developed during construction of the Pacheco Pumping Plant would be reconstructed with a higher crest elevation to protect the plant at high storage levels (see Figure 3-8). Key components are described below.

B.F. Sisk Dam. Studies completed during the Corrective Action Study (CAS) have identified the potential for significant deformation (crest settlement) of the dam in the sections built on the alluvium and clayey slopewash during a seismic event (Reclamation 2013). The SOD seismic modification will address this deformation potential with the placement of downstream stability berms anchored to bedrock and placement of additional embankment materials on the downstream slope of the dam to increase the crest elevation 10 feet, increasing the distance between the water surface and the dam crest (freeboard) to prevent reservoir overtopping and failure in the event of earthquake-induced deformations (Reclamation 2013).

In addition to dam crest deformation, seismic shaking can cause cracks in the dam embankment susceptible to erosion that can lead to dam failure. Downstream crack filters restrict the migration of soil materials through these cracks mitigating the potential for post seismic cracks to induce internal erosion within the dam embankment. The SOD modification will address this seismic crack induced erosion risk by installing downstream filters along the upper portion of the embankment across the entire length of the dam.

The San Luis Reservoir Expansion Alternative Plan would build on the physical SOD modifications currently under final design and raise the dam crest an additional 10 feet to a new crest elevation of 576 feet. This additional 10 feet in embankment height would support a new water surface elevation of 554 feet and an additional 120 TAF in storage capacity. In addition to the new embankment height added by the reservoir enlargement, the existing outlet works intake towers, access bridge, and spillway intake would need to be raised by 10 feet.

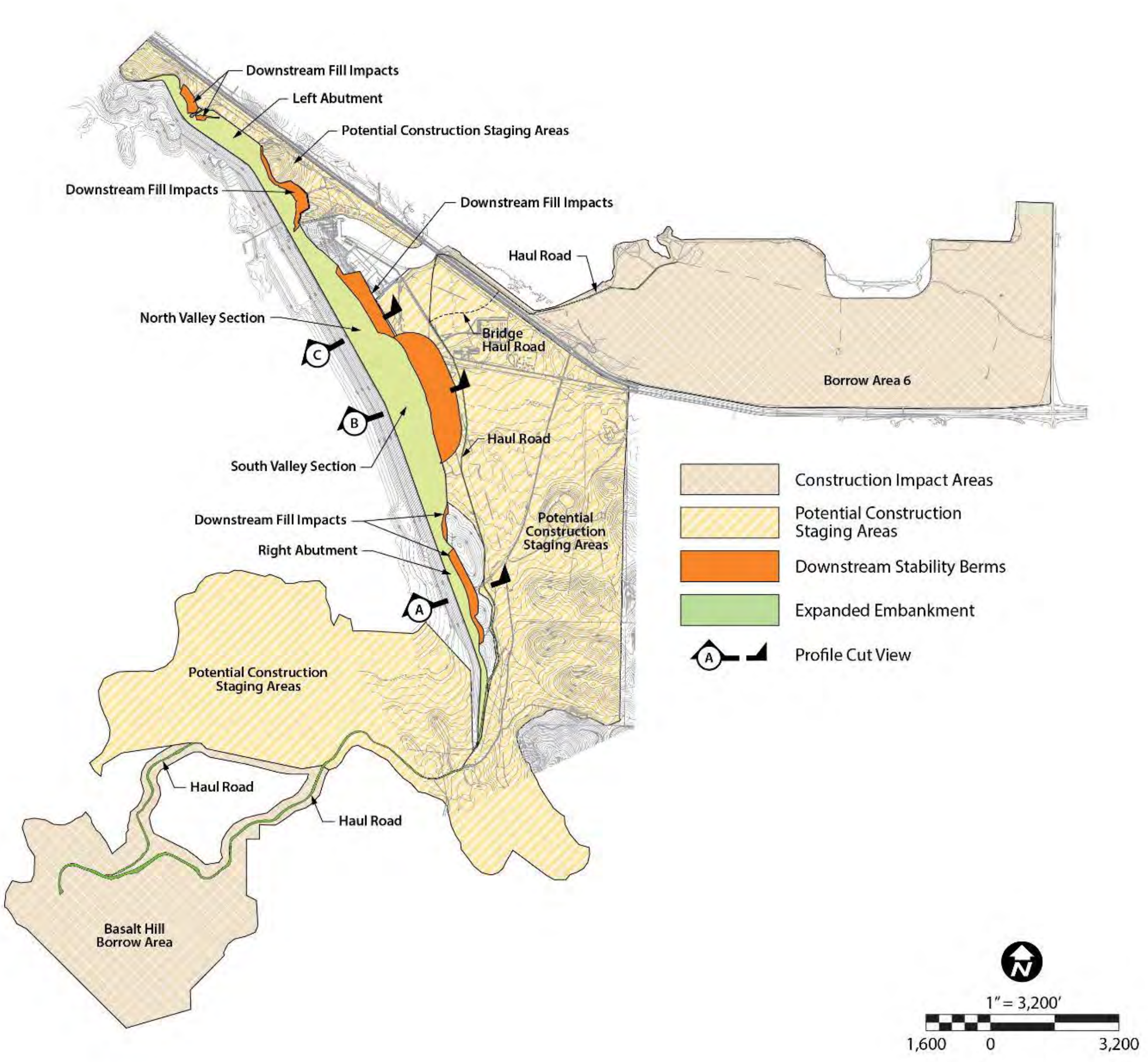

Figure 3-6. Reservoir Enlargement Construction and Staging Areas

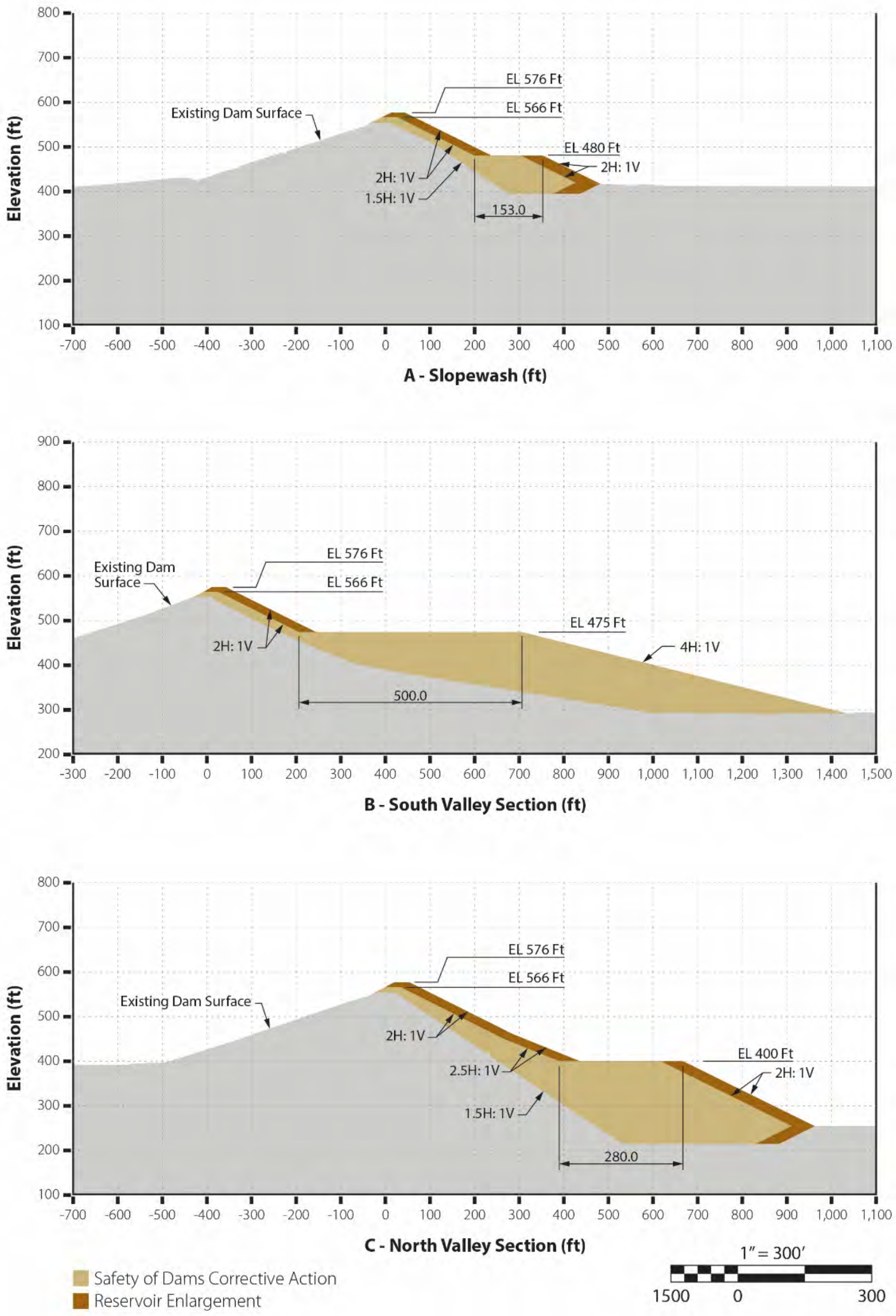

Figure 3-7. Reservoir Enlargement Profiles

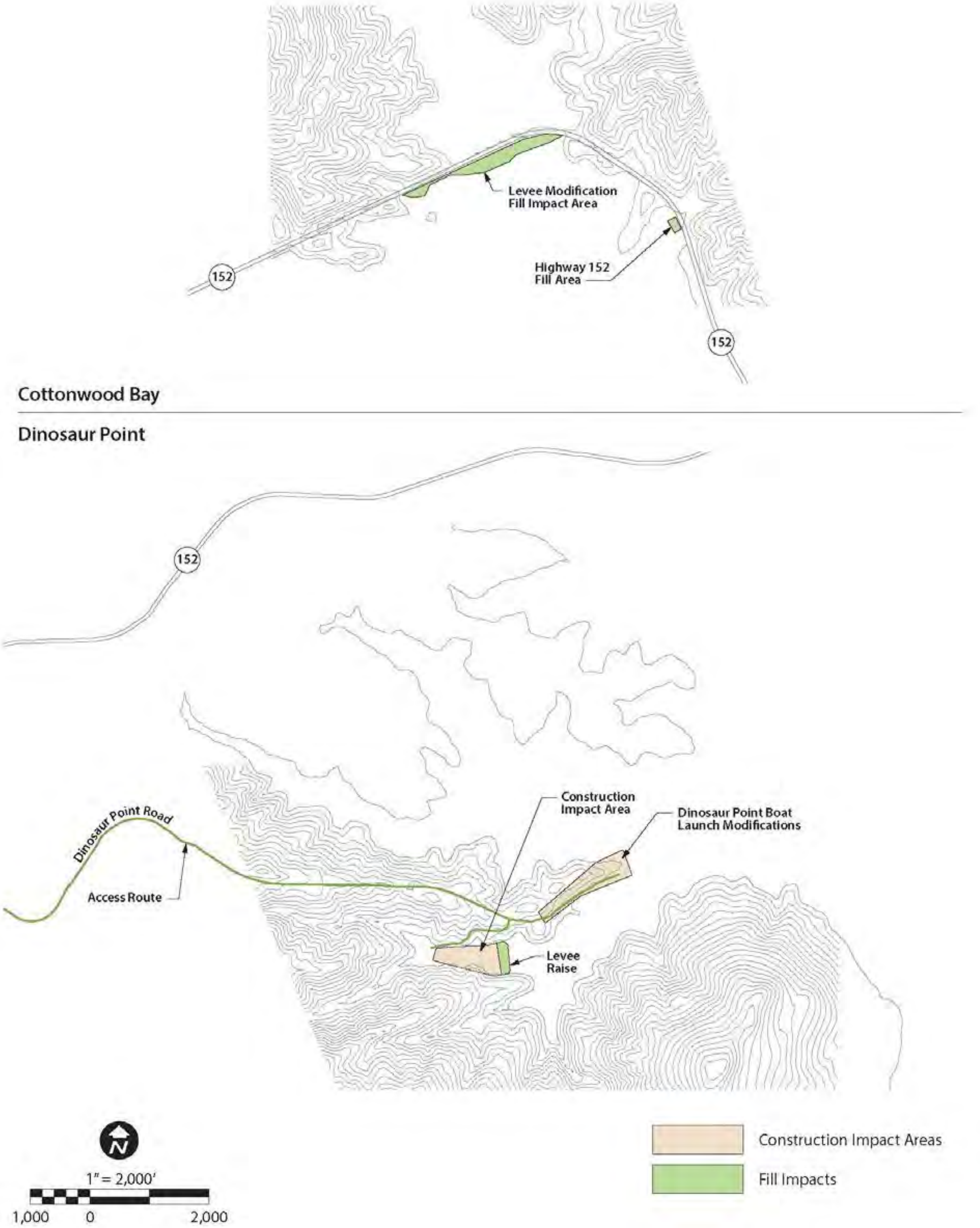

Figure 3-8. Reservoir Enlargement Actions along State Route 152 and at Pacheco Pumping Plant

Cottonwood Bay/State Route 152. Sections of SR 152 near and at Cottonwood Bay could potentially be affected by the 10-foot increase in water surface elevation, and will be protected by the development of berms separating the reservoir from the roadway in periods when storage in the enlarged reservoir is full (see Figure 3-8).

Pacheco Pumping Plant West Dike. The Pacheco Pumping Plant is located on the western side of San Luis Reservoir. The pumping plant is separated from San Luis Reservoir by an approximately 500-foot wide dike east of the pumping plant (see Figure 3-8). This dike will be replaced with a new dike 20 feet taller than the existing structure to protect the pumping plant from the enlarged reservoir.

Dinosaur Point Boat Launch. The Dinosaur Point Boat Launch is located on the western side of San Luis Reservoir close to the Pacheco Pumping Plant. The boat ramp and portions of the parking lot at Dinosaur Point would be inundated with the 10-foot increase in surface elevation requiring modifications to the facility to maintain launching functions during periods when the enlarged reservoir is at capacity (see Figure 3-8).

Goosehead Point Boat Launch. The Goosehead Point Boat Launch is located on the southern side of San Luis Reservoir close to Basalt Hill. The boat ramp and parking lot at Goosehead Point would be inundated with the 10-foot increase in reservoir surface elevation requiring modifications to the facility to maintain launching functions during periods when the enlarged reservoir is at capacity.

3.5.1 Operation

The San Luis Reservoir Expansion Alternative Plan would provide approximately 15,200 AF of additional south of Delta CVP M&I and agricultural water supply on an average annual basis as compared to the No Action/No Project Alternative. Figure 3-9 shows how the San Luis Reservoir Expansion Alternative Plan addresses SCVWD low point water supply interruptions in the No Action/No Project Alternative. Results show that the San Luis Reservoir Expansion Alternative Plan would deliver additional water supplies in 8 of the 17 low point years, but would not in any year fully address the low point generated water supply shortages.

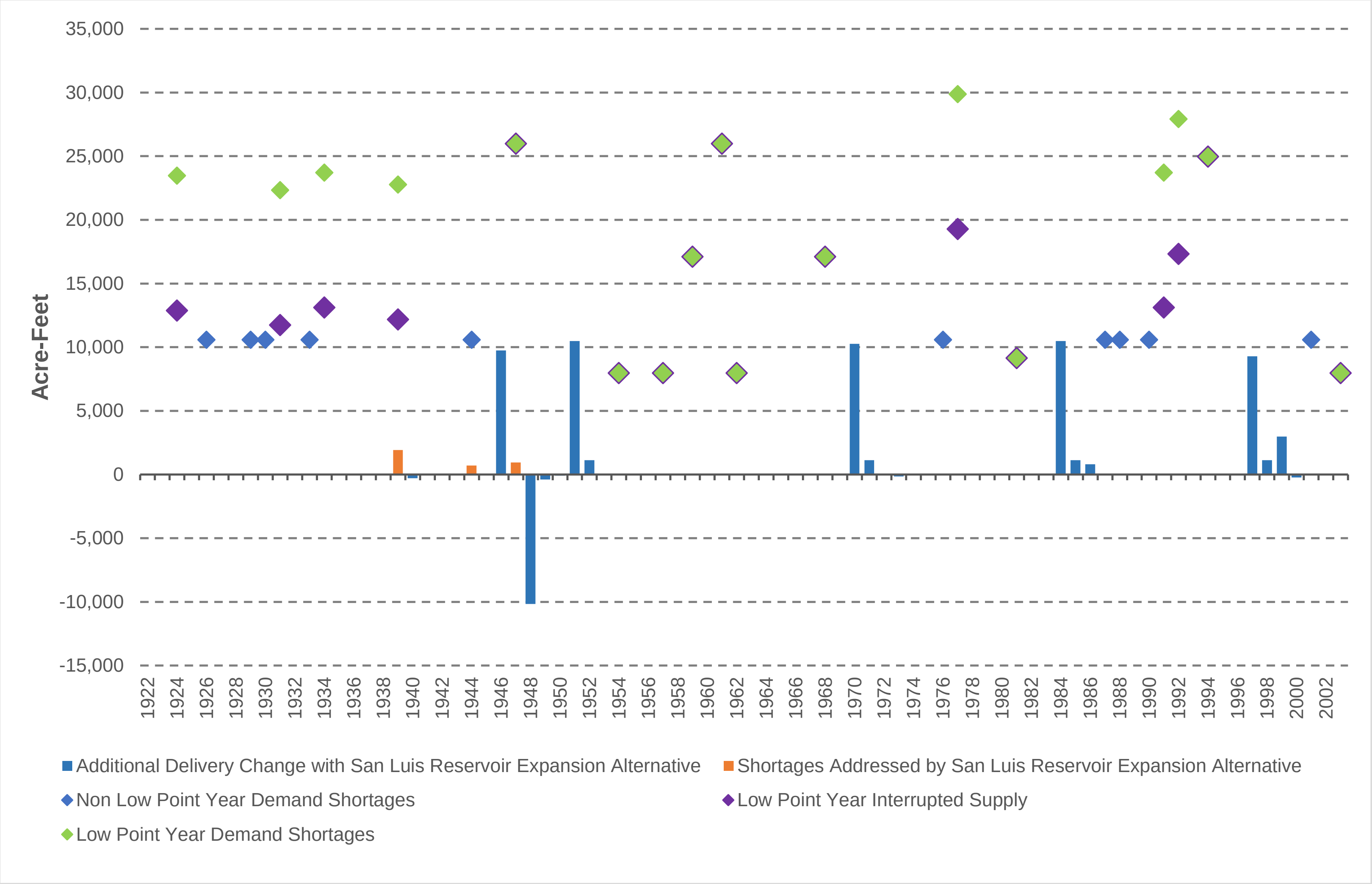

Figure 3-9. Annual San Felipe Division Shortages addressed by the San Luis Reservoir Expansion Alternative Plan

3.5.2 Costs

Table 3-5 shows appraisal-level cost estimates for the San Luis Reservoir Expansion Alternative Plan.

Table 3-5. Reservoir Expansion Alternative Plan Preliminary Costs

	Reservoir Expansion
Total Project Construction Costs	$490 million
Annual Operation and Maintenance Costs	$2.2 million[1]

Notes:

[1] O&M costs reflect increased pumping costs at the Gianelli Pumping Plant with increased capacity. This is an average annual estimate.

3.6 Pacheco Reservoir Expansion Alternative Plan

The Pacheco Reservoir Expansion Alternative Plan includes construction of new dam, removal of existing dam, and expansion of the reservoir. The new dam and reservoir would be constructed on Pacheco Creek 0.5 mile upstream from the existing North Fork Dam and would inundate most of the existing Pacheco Reservoir. Figure 3-10 and 3-11 shows the expanded Pacheco Reservoir footprint. The following are major components of the alternative plan.

Dam and Spillway
The new embankment dam would be a zoned earthfill structure consisting of an impervious core, flanked by an outer shell of compatible fill (see Exhibit 4 in Attachment A of Appendix C). A system of filters and drains would be provided to control seepage through the dam and foundation. A downstream sand chimney filter would protect the impervious core. A gravel chimney drain located downstream of the chimney filter would convey drainage to a gravel blanket beneath the downstream compatible fill zone. The gravel blanket drain would convey seepage from the impervious core and overlie form the foundation beneath the downstream compatible fill zone to the downstream toe of the dam. Sand filter zones would be placed above and beneath the gravel blanket drain to protect the gravel drain from contamination of the overlying compatible fill and underlying foundation materials. The upstream slope of dam would be protected from reservoir wave action by a 3-foot thick riprap layer.

An uncontrolled side channel spillway with a trapezoidal cross section would be located adjacent to the right (west) abutment of the proposed dam. Due to the relatively steep topography at the dam site, a side channel spillway would reduce the amount of excavation required in order to accommodate the spillway control weir. The spillway features include an approach channel, discharge chute and stilling basin, all of reinforced concrete and founded on bedrock. The side channel spillway entrance would include an ogee weir. A flip bucket located at the end of the stilling basin would dissipate the remaining energy in the basin during high discharge events. After leaving the deflector bucket, spillway discharges would be conveyed through a riprap lined outlet channel into the restored Pacheco Creek channel. Exhibit 5 in Attachment A of Appendix C shows the profile view of the spillway.

Inlet/Outlet Facilities

The inlet/outlet facilities would consist of a sloping intake/outlet structure and a low-level inlet/outlet designed to provide deliveries to the reservoir from Pacheco Conduit and withdrawals from the reservoir to the conduit and Pacheco Creek. However, these facilities would not be operated to facilitate these flows at the same time. For withdrawals from the reservoir, under normal operating conditions, this inlet/outlet facility would need to simultaneously convey up 490 cfs to Pacheco Conduit and release up to 35 cfs to Pacheco Creek. The inlet/outlet conveyance facilities have been sized to accommodate up to 1,350 cfs under emergency drawdown conditions. During emergency conditions, the outlet works would serve as an evacuation outlet for reservoir draw down.

A sloping intake structure would be located north of the left (east) abutment and would consist of a single 132-inch diameter reinforced-concrete structure, with approximately 10 ports located at various elevations for drawing from the reservoir. A low-level reservoir inlet would also be constructed, with an inlet elevation of 450 feet, for reservoir drainage. A hydraulically operated gate valve structure would be located upstream of the reinforced-concrete sloping intake to allow for switching between reservoir delivery (through the tunnel) and withdrawal operations (through the outlet structure).

A 2,300-foot long conveyance tunnel would be constructed under the dam abutment to connect the intake structures and the pump station. The conveyance tunnel would be excavated through the bedrock on the left abutment of the dam. A profile of the tunnel is shown on Exhibit 6 in Attachment A of Appendix C. The control gatehouse structure would be used to regulate outlet flows from the reservoir to the pump station, for normal releases, and the discharge channel for stream augmentation and emergency releases.

To connect the new outlet works to Pacheco Creek, the historical Pacheco Creek channel would be restored between the new dam and the existing dam through the existing Pacheco Reservoir. Restoration of the channel would include excavating a new 1,500-feet long, 1.7-feet deep, one-foot wide, low-flow channel, and a 6-feet deep, 20-feet wide overbank channel to facilitate riparian restoration. The channel would be designed to reduce streambank erosion (e.g., using bank stabilizing materials), and riparian vegetation would be planted to initiate growth of a new riparian forest along the restored channel.

Pacheco Reservoir Pump Station

The Pacheco Reservoir Pump Station would serve as a two-way pump station that both delivers water to and withdraws water from the Pacheco Reservoir. The water surface elevation of the new reservoir would have an operating range of 450 feet to 694 feet; however, at the connection point to the Pacheco Conduit the total hydraulic head would be 610 feet. This requires a "two-way" system operating both by gravity and through a booster pump station.

The conveyance system would contain 10 feet of dynamic head loss. Isolation valves would enable the pump station to deliver water to, or pump water from, the reservoir. Pressure-reducing sleeve valves are necessary to reduce excess pressure head under certain gravity-flow conditions. These valves would be used only when needed and bypassed at all other times. Additionally, a pressure relief air chamber and discharge structures would be required to prevent over-pressurization of the existing Pacheco Conduit.

The pump station would be below the new dam. To provide security and minimize noise levels in the surrounding area, the pumps would be housed in a building. Space has been identified for other facilities on site, including intake, access, parking, surge tanks, power substation, yard piping, and construction staging. The site footprint and conceptual layout for the pump station is shown in Exhibit 9 in Attachment A of Appendix C.

The new pump station would need to meet a wide range of lift (0 to 160 feet static plus 10 feet dynamic) and high flow (490 cfs). A single pump station with multiple pump ranges has been proposed to meet these requirements—while preventing pump station horsepower (hp) duplication—limiting the amount of head burned by pump control valves and minimizing cost. A total of 11 pumps (10 duty plus 1 standby) are planned, however the pump configuration may be refined during future design studies. The pump motors would be sized for the first operating range (higher lift) at 1,250 hp each (13,750 total hp).

The 14 megavolt amp (MVA) substation for the new reservoir pump station is located in the Pacific Gas and Electric Company (PG&E) service area, with no other nearby service sources. PG&E has a 70 kilovolt (kV) transmission line that cannot support the additional 14 MVA connected load, and it would need to be upgraded to support the increased load. The existing 70 kV transmission line would be upgraded to two circuits, for use by the double-ended substation arrangement for this alternative plan.

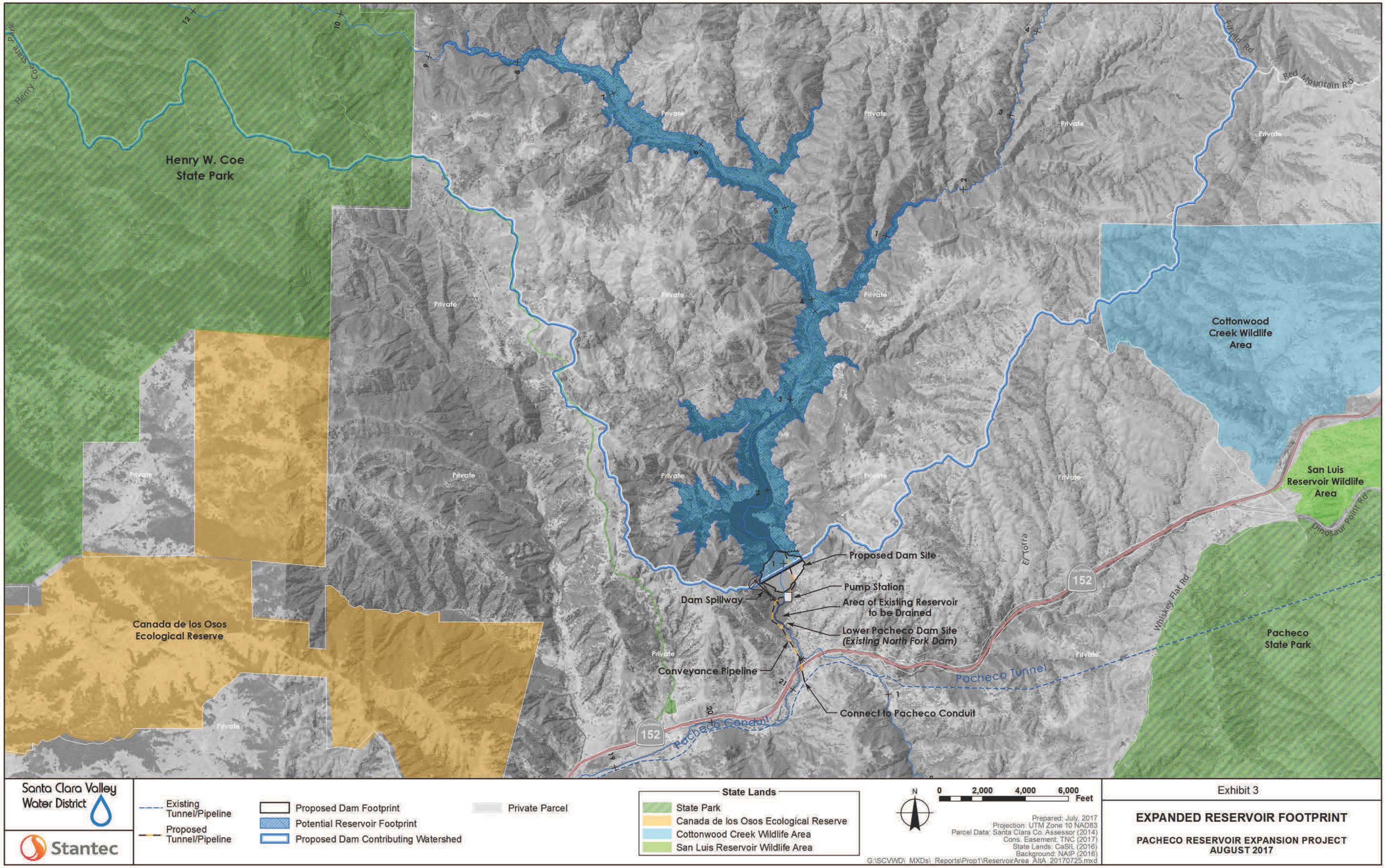

Figure 3-10. Pacheco Reservoir Expansion Footprint

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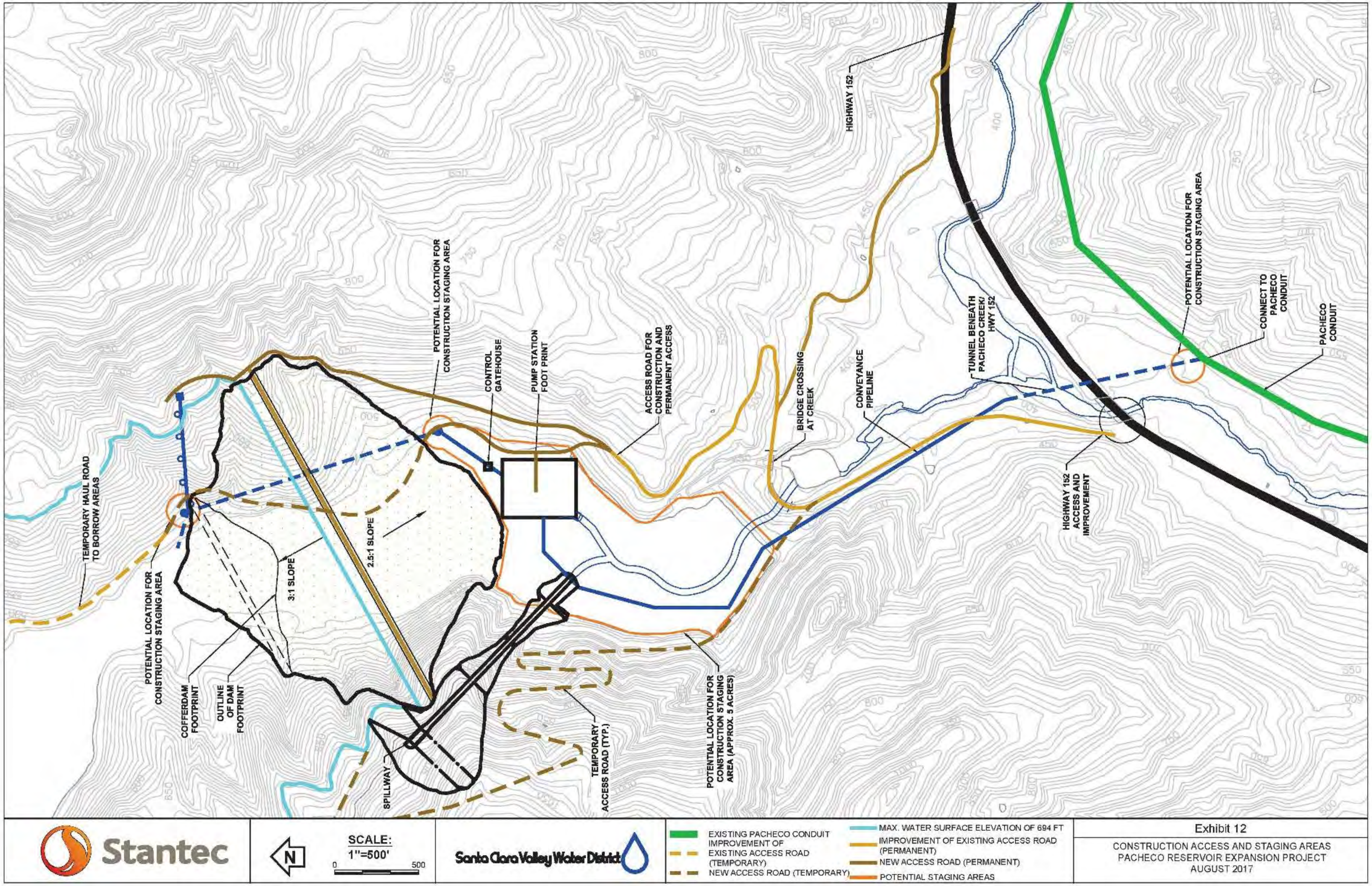

Figure 3-11. Pacheco Reservoir Construction Access and Staging Areas

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Conveyance from Pacheco Reservoir Pump Station to Pacheco Conduit

A pipeline would be constructed to connect the new pump station located immediately downstream of the new dam and the existing Pacheco Conduit. The proposed pipeline would be 9 feet in diameter and about 4,700 feet long, with a design capacity of 490 cfs. This pipeline would allow for delivery of imported water from the Pacheco Conduit to the proposed reservoir for future release and would also provide for reservoir releases to the Pacheco Conduit.

Construction would be by conventional excavation, open trench, and backfill—except for the length of pipe located under SR 152. The length of pipe that would be located under SR 152 and Pacheco Creek would be installed using bore and jack techniques (i.e., tunneling techniques), to minimize impacts during construction. Spoils would be hauled off and disposed of at a suitable location. The tunnel, when completed, would be a 132-inch casing containing a 108-inch carrier pipe. There would also be permanent structures for appurtenances, such as air/vacuum valves, vaults, drains and blowoffs for the conveyance line.

The connection of the pipeline to the existing Pacheco Conduit would be southeast of the existing North Fork Dam. The connection would be with a tee in the Pacheco Conduit, with an isolation valve for the turnout (inlet and outlet) for the new reservoir.

New Regulating Tank at Existing Pacheco Pumping Plant

Controls to turn pumps on or off remotely would be based on the water level within the expanded Pacheco Reservoir and regulating tanks at the existing Pacheco Pumping Plant site near San Luis Reservoir. A second regulating tank at the existing Pacheco Pumping Plant site would be added adjacent to the existing regulating tank to provide additional control buffer and surge control for the new Pacheco Reservoir Pump Station. The new regulating tank would match the elevation, diameter, and materials of the existing tank. This would add a second 3 million gallon, 150-feet diameter reservoir, as shown in Exhibit 10 in Attachment A of Appendix C. Additional piping, valving, and controls would be required.

3.6.1 Operation

The expanded Pacheco Reservoir would be primarily filled using natural inflows from the North and East Forks of Pacheco Creek. These inflows are typically realized from December through March. Supplemental flows to the expanded reservoir would arrive from SCVWD’s share of contracted CVP pumped water from San Luis Reservoir. This would include allocated CVP water supplies that otherwise could not be delivered to or stored by SCVWD. This CVP water supply would be pumped from the Pacheco Conduit up to the expanded Pacheco Reservoir earlier in the year prior to the summer months when the San Luis Reservoir is typically drawn down to the 300 TAF level. The rate at which these transfers are made between San Luis Reservoir and Pacheco

Reservoir would depend upon water rights, supply allocations, water demands, availability of other water supplies, and conveyance limitations of Pacheco Conduit. Conveyance and storage of these CVP supplies is anticipated to occur primarily in wet years. CVP water stored in Pacheco Reservoir could then be released through the summer while supplies from San Luis Reservoir would be inaccessible to SCVWD. The expanded Pacheco Reservoir could also limit the frequency of and impact from harmful cyanobacteria blooms that occur in the existing Pacheco Reservoir. Under existing conditions, cyanobacteria blooms can occur during low water levels during the fall that are toxic to fish downstream (Smith 2007). Increased reservoir storage capacity and water releases downstream in Pacheco Creek may limit the presence of cyanobacteria blooms or dilute their impact. The import of CVP supplies from San Luis Reservoir is not anticipated to further contribute to these algae conditions given small proportion of these supplies in comparison to the natural inflow to the reservoir.

The Pacheco Reservoir Expansion Alternative Plan would be operated to optimize the public and non-public benefits, including ecosystem enhancement and IL4 refuge water supply, emergency response, flood control, M&I water supply, and M&I water quality. Operations focus on (1) capturing and storing water during wetter periods from natural inflows for release during dry periods, both annually (i.e., capture winter flows for summer release and use), and across multiple years (i.e., capturing and storing water during wetter years for release and use during drier years and/or emergencies); and (2) integration with SCVWD’s water system operations to optimize use of all available supplies, including CVP/SWP Delta supplies, other imported supplies, other local surface supplies, and conjunctive use/groundwater recharge.

Pacheco Reservoir would be operated by SCVWD to both improve habitat conditions for steelhead in Pacheco Creek and improve SCVWD water supply reliability, including during drought periods and emergencies. Table 3-6 summarizes the average monthly release targets to Pacheco Creek from the expanded Pacheco Reservoir. Operation of the expanded Pacheco Reservoir would not change the existing operations of the CVP.

Table 3-6. Average Monthly Release Targets to Pacheco Creek from Expanded Pacheco Reservoir

Month	Average Monthly Release Targets to Pacheco Creek (cfs)[1,2]
January	10
February	10
March	20
April	20
May	12
June	13
July	14
August	14
September	14
October	14
November	10
December	10

Note: [1] Releases from Pacheco Reservoir may be adjusted based on high flows in the south fork of Pacheco Creek.

[2] SCVWD water through their water rights.

Key: cfs = cubic feet per second

The average monthly release targets shown in Table 3-6 incorporate the biological needs of the SCCC steelhead for higher flows in March and April for outmigration. The winter releases listed in Table 3-6 may be reduced depending on flows in the South Fork of Pacheco Creek. In addition, during heavy precipitation events, releases from the expanded reservoir would be reduced to minimize flooding risks along Pacheco Creek and the Pajaro River. Releases to Pacheco Conduit, to meet SCVWD water demands, may be reduced or discontinued when storage levels in the expanded Reservoir fall below 55 TAF. This would ensure that flow and water temperatures in Pacheco Creek (below the new dam) are maintained in consecutive dry years.

SCVWD would transfer 2,000 AF of its CVP water contract (in below normal water years), directly or through transfer and exchanges, in perpetuity to Reclamation's RWSP, for use in the IL4 refuge water supply. This long-term voluntary reallocation of CVP yield by SCVWD would be secured by an agreement between the USFWS and SCVWD detailing its operation, a contract between and DWR and SCVWD for the provision of grant funding through the WSIP that would require the provision of these supplies in perpetuity, and an integrated operations agreement between Reclamation and SCVWD for Pacheco Reservoir that would include the requirements for this transfer. While Reclamation sets priorities for Incremental Level 4 distribution, SCVWD has expressed its desire that the transferred water be designated to refuges supported by Grassland Resources Conservation District (GRCD). The water would be used to flood wetlands, directly benefiting wetland-dependent wildlife populations. The delivery schedule of this water would be flexible, but could be delivered as early as March or April. This water could be stored in San Luis Reservoir, providing Reclamation's RWSP greater flexibility in making late season deliveries to refuges. For deliveries to GRCD, deliveries would be made to Los Banos through the DMC.

SCVWD would use the reservoir for operational storage within their system as well as for emergency supply. SCVWD accesses its CVP contract water through the Pacheco Conduit. This alternative plan includes construction of an inlet/outlet facility connecting to the conduit that takes water from Pacheco Conduit to Pacheco Reservoir as well as from the reservoir to Pacheco Conduit. During years when SCVWD water supplies exceed the water demands in the SCVWD service areas and excess storage capacity is available in the expanded reservoir, SCVWD would convey CVP supplies from San Luis Reservoir through Pacheco Conduit and into the expanded Pacheco Reservoir. Conveyance and storage of these CVP supplies is anticipated to occur primarily in wet years. The rate at which these transfers are made between San Luis Reservoir and Pacheco Reservoir would depend on supply allocations, water demands, and availability of other water supplies.

Under this alternative plan, modeling results have predicted that there would be 17 years (out of the 82 modeled years) where San Luis Reservoir would be drawn below 300 TAF i.e. low point years. Under the Pacheco Reservoir Expansion Alternative Plan, San Felipe Division M&I and agricultural deliveries would increase on average by 2,800 AF annually. Figure 3-12 shows how the Pacheco Reservoir Expansion Alternative Plan addresses SCVWD low point water supply interruptions along with treated water demand shortages in the No Action Alternative. The alternative plan would fully replace interrupted supplies in 14 out of the 17 low point years when compared to the No Action/No Project Alternative.

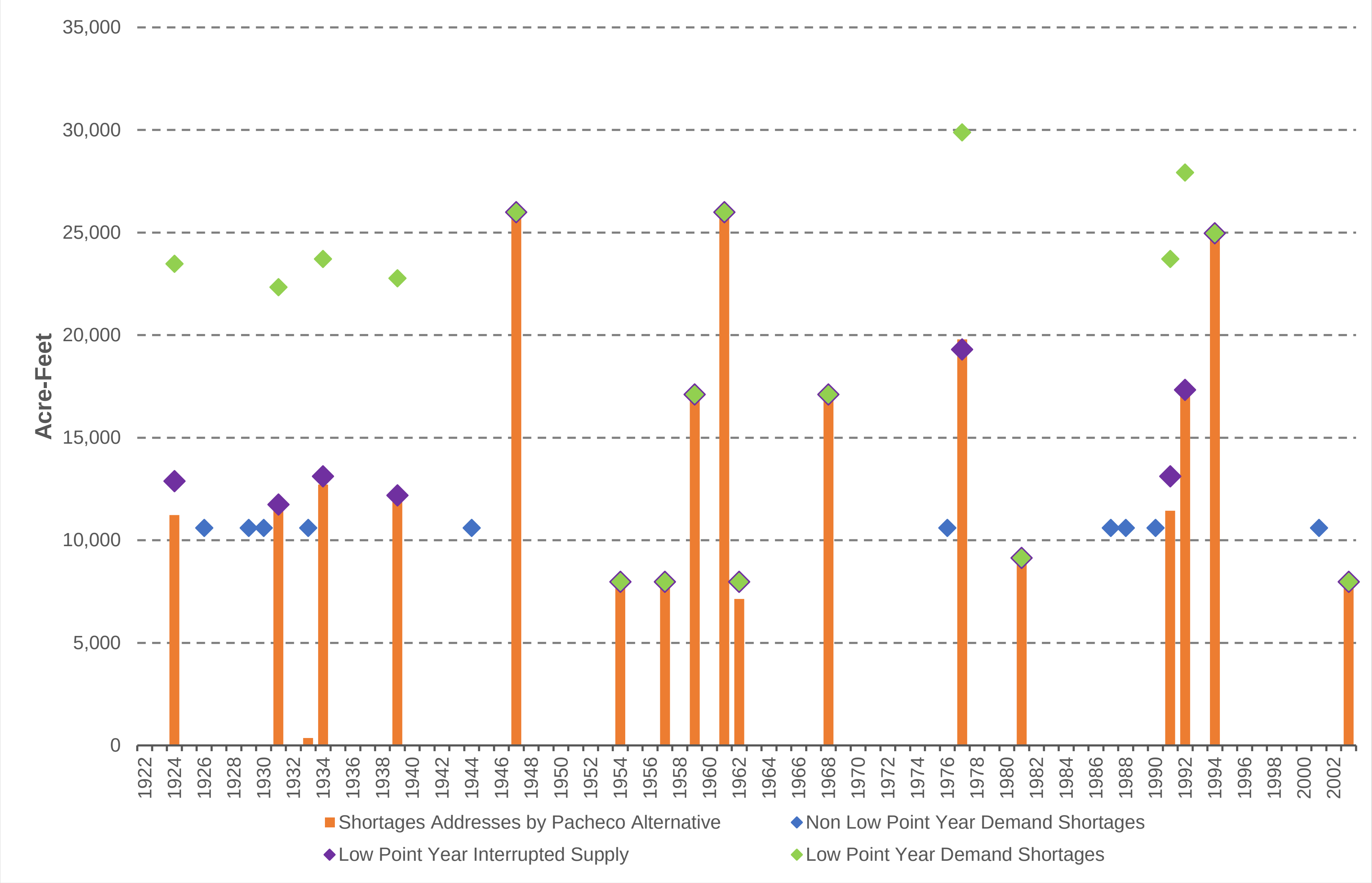

Figure 3-12. Annual San Felipe Division Shortages addressed by the Pacheco Reservoir Expansion Alternative Plan

3.6.2 Costs

Table 3-7 shows appraisal-level cost estimates for the Pacheco Reservoir Expansion Alternative Plan.

Table 3-7. Pacheco Reservoir Expansion Alternative Plan Preliminary Costs

	Pacheco Reservoir Expansion
Total Project Construction Costs	$1,127 million
Annual Operation and Maintenance Costs	$1.6 million

Chapter 4
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Attachment A
Storage Alternative Screening

A.1 Introduction

In May 2007, the Bureau of Reclamation (Reclamation), in cooperation with Santa Clara Valley Water District (SCVWD) and San Luis & Delta-Mendota Water Authority (SLDMWA), completed an Initial Alternatives Information Report (IAIR) for the San Luis Low Point Improvement Project (low point project). The IAIR identified eight potential alternatives for increasing surface storage capacity in the study area to address the low point project objectives (See Figure A-1 at the end of this report). The purpose of this storage alternative preliminary screening is to evaluate these storage alternatives based on a selected set of screening criteria and recommend storage alternatives that should be carried forward for further evaluation and engineering study in the Plan Formulation Phase of the low point project.

The eight storage alternatives identified in the IAIR for further review include:

- Anderson Reservoir Expansion;
- Chesbro Reservoir Expansion;
- Lower Pacheco Reservoir Expansion;
- Pacheco A Reservoir (new dam);
- San Benito Reservoir (new dam);
- Ingram Canyon Reservoir (new dam);
- Quinto Creek Reservoir (new dam); and
- Del Puerto Canyon Reservoir (new dam).

Preliminary review of the storage alternatives revealed significant challenges with respect to a weak foundation condition at the Lower Pacheco site that precluded the alternative's further consideration. The IAIR screened out the Pacheco B reservoir site because it would not be able to achieve the storage capacity goals without inundating a small portion of Henry Coe State Park; however, this site has been included in this preliminary screening report because of its superior foundation materials.

Appendix B (Surface Storage Level 1 Screening) of the IAIR presents the technical viability factors used to eliminate alternatives deemed the most difficult to design and construct relative to the benefits they would provide. The capacity factor in the IAIR established minimum sizes[1] needed for a reservoir to be carried forward for further consideration in the feasibility study process. The minimum sizes described in the IAIR are: 100 thousand acre-feet (TAF) of additional storage capacity for any reservoir west of San Luis Reservoir that would be expanded, 150 TAF for any new reservoir west of San Luis Reservoir, and 271 TAF for a reservoir east of San Luis Reservoir.

The San Benito Reservoir Alternative would develop a reservoir with a storage capacity of approximately 60 TAF or 90 TAF less than the technical viability factor. During review of the IAIR, San Benito Reservoir was identified by the Study Management Team as a potentially viable alternative in combination with other measures and was therefore carried forward into this preliminary screening to further investigate its viability.

The Chesbro Reservoir Alternative would expand an existing 8 TAF reservoir to create a new 150 TAF reservoir. This new reservoir would develop an additional 42 TAF of storage capacity beyond the 100 TAF required for a reservoir to be deemed technically feasible in the alternative screening completed for the IAIR. The potential for an expanded 150 TAF Chesbro Reservoir was identified in the 2003 San Luis Low Point Improvement Project Draft Alternatives Screening Report (SCVWD 2003). The 150 TAF Chesbro Reservoir is included in this preliminary screening to further investigate its viability.

A.1.2 Regional Setting and Geologic Conditions

Regional Setting

The proposed dam sites are all within the Coast Ranges Province of California. The Coast Ranges Province is a northwest-oriented grain of landscape that extends about 400 miles from the Transverse Ranges Province (to the south) to the Oregon border (Harden 1998). In an east-west direction, it extends approximately 50 miles from the Pacific Ocean to the Great Valley. The San Andreas Fault zone lies just west of the boundary between the southern Coast Ranges and the Central Valley of California. Because of interaction of the strike-slip San Andreas Fault system with the compressional tectonics of the Coast Ranges, the geologic conditions in the areas of the proposed dam construction are structurally complex.

Regionally, the geologic conditions are characterized by hilly terrain dominated by the Upper Jurassic (150 million years old) Franciscan complex and other younger rocks separated by a series of alluvial filled valleys.

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[1] Minimum reservoir sizes were developed based on the total amount of water the San Felipe Division would require during the low point months.

Seismicity and Faults

The geology of the region is dominated by tectonic activity associated with the active San Andreas and other active and potentially active fault systems. In accordance with Reclamation guidelines, this report considers faults younger than 100,000 years to be active for the purposes of dam siting. Figure A-2 shows the active or potentially active faults of most concern in the study area; these include the Calaveras, Greenville, Hayward, Ortigalita, Paicines, San Benito, San Andreas, and Sargent Faults. Other less well-defined faults may also affect the proposed sites.

The Calaveras Fault branches off the San Andreas Fault zone near Hollister, California, and extends north to Mt. Diablo for about 100 miles. The fault is considered a right-lateral strike slip. The Calaveras Fault has a creep rate of about 7.5 to 11.5 mm/yr near its southern end while almost no creep has been detected near its northern end (Galehouse 1990). The last earthquake to rupture the Calaveras measured 6.2 on the Richter scale and occurred in 1984 along the Morgan Hill section of the fault. The Maximum Credible Earthquake (MCE) for the Calaveras Fault is estimated to be 7.5 (Mualchin 1996).

The Greenville Fault is the easternmost of the faults that make up the San Andreas Fault system in the San Francisco Bay area. It consists of several strands and extends a distance of about 44 miles from the Diablo Range at the north to the Livermore Valley at the south. It is a right-lateral strike-slip fault. Based on offset stream terraces and paleosols, the Greenville Fault has an estimated slip rate ranging from 0.1 to 0.7 mm/yr (Wright et. al. 1982). The MCE for the Greenville Fault is estimated to be 7.25 (Mualchin 1996).

The Hayward Fault extends for a distance of approximately 100 miles from near San Jose at its southeastern end to San Pablo Bay at its northwestern end. Beneath San Pablo Bay the Hayward Fault steps over to the east and continues along the Rodgers Creek Fault. It is a northwest trending right-lateral strike-slip fault. The Hayward Fault creep rate, to a depth of about 3-miles along its entire length, is approximately 9 mm/yr, and it is considered capable of producing large earthquakes, as evidenced by the October 21, 1868 M6.8 earthquake. Its MCE is estimated to be 7.5 (Mualchin 1996). The Hayward Fault and its northern extension, the Rodgers Creek Fault, are regarded as one of the most hazardous fault systems in the San Francisco Bay Area with a future probability for a M6.7 earthquake of about 27% over the next thirty years (Working Group on California Earthquake Probabilities 1999, 2003).

The approximately 50-mile-long Ortigalita Fault extends between Crow Creek in western Stanislaus County southward to near Panoche in western Fresno County. It is a right-lateral strike-slip fault. The Ortigalita Fault is the tectonic contact between the Franciscan Complex core of the Diablo Range and the Great Valley Sequence at the eastern margin. It consists of two major segments separated at San Luis Reservoir by a 3-mile-wide, right-stepping, pull-apart basin (Anderson and O’Connell 2005). The right-slip movement is estimated to be 0.5 to 1.5 mm/yr (USGS 2006a). The Ortigalita Fault has an estimated MCE of 7.0 (Mualchin 1996).

The 15-mile-long Paicines and 14-mile-long San Benito Faults are immediately east of, and parallel to, the San Andreas Fault zone along the San Benito River Valley at Tres Pinos. These are right-lateral strike-slip faults. The slip rate on the Paicines Fault is high; on the order of 12-17 mm/yr. (Working Group on California Earthquake Probabilities 1999). The slip rate on the San Benito Fault is not known. Although the Paicines Fault shows evidence for movement in Holocene (last 10,000 years) and the San Benito Fault has been active during the Quaternary (last 2,000,000 years), their close proximity to the San Andreas Fault zone indicates that they are probably not independent sources. They are not considered capable of generating large earthquakes themselves, but considered capable of rupturing during large earthquakes on the neighboring San Andreas Fault zone.

The San Andreas Fault is approximately 745 miles long. It begins near the Salton Sea to the south and extends northwards to Point Delgada on the coast. It generally parallels the direction of plate motion between the Pacific and North American plates. It is a right-lateral strike-slip fault. Historic fault creep rates are as high as 34 mm/yr for an 82-mile-long creeping section in central California, with creep rates gradually tapering to zero at the northwestern and southeastern ends of the section (USGS 2006b). To the south, it is essentially a singular fault trace; however, in the site vicinity it branches into the Calaveras and Hayward Faults. Two major surface-rupturing earthquakes have occurred on the San Andreas Fault in historic time: the 1857 Fort Tejon and 1906 San Francisco earthquakes. Additional historic surface rupturing earthquakes include the unnamed 1812 earthquake along the Mojave section and the northern part of the San Bernardino Mountains section, and a large earthquake in the San Francisco Bay area that occurred in 1838. It has an estimated MCE of approximately 8.0.

The Sargent Fault is approximately 32-miles long. It branches from the San Andreas Fault and extends for about 34 miles near Lexington Reservoir in the north to just north of Hollister in the south. The Sargent fault is a reverse fault that dips steeply to the west and is seismically active (Wagner 1990). It has a slip rate of approximately 3 mm/yr (Prescott and Burford 1976 and Working Group on Northern California Earthquake Potential 1996). The Sargent Fault has an MCE of approximately 6.75 (Mualchin 1996).

A.1.3 Screening Criteria

Overview

This preliminary screening includes criteria to help determine which reservoir sites would best meet the project objectives while minimizing project costs. Each criterion is assigned a rating score to allow an overall score to be calculated. These scores are subjective measures. They have been used to provide a basis for elimination of some of the storage alternatives and select those that merit further investigation and engineering evaluation. The following sections and Table A-1 describe the criteria, which are grouped into four categories.

At this stage of the screening process, the evaluation does not include cost estimates. Several of the criteria reflect the difficulty and magnitude of the construction for each site; these criteria allow comparison of costs without completion of detailed cost estimates. In addition, this preliminary screening does not evaluate the impacts to the lands and populations downstream of each dam site from a dam break. The next phase of the Feasibility Study will include this analysis for the dam sites remaining after this preliminary screening.

Physical Conditions

The first set of criteria is related to the physical conditions at each dam site. The most efficient dam sites maximize the amount of storage created while minimizing reservoir footprint and dam embankment size. Three separate physical conditions criteria were considered as presented in Table A-1 and are explained below:

Ratio of Embankment Volume to Storage Capacity (CY per AF): This criterion is derived from the preliminary estimates of new or increased earth embankment volume in relation to new or increased storage capacity. The dams for which this ratio is a smaller number would be more efficient as less earth embankment needs to be constructed for the same amount of water being stored. Typically, values in the range of 30 to 50 are considered very efficient and have been assigned a higher rating score. Values of 100 or more are considered very inefficient and are assigned a lower rating score. Unit costs (i.e. construction cost per amount of water supplied) would be higher for inefficient dams. Embankment volumes are derived assuming a 2.5H:1V slope on both the upstream and downstream sides unless otherwise noted.

- **Ratio of Storage Capacity to Reservoir Area (AF/ Ac):** This criterion is derived from the preliminary estimates of new or increased storage capacity in relation to new or increased inundation area. Typically, values in the range of 100 or more are considered favorable and have been assigned a higher rating score. In comparing two dams that are otherwise similar, the dam for which this ratio is a larger number may have a lesser relative environmental impact, as a lesser inundation area would be needed to store the same amount of water.

Table B-1 - Screening Criteria and Ratings Scores

Rating Score	Physical Conditions				Geotechnical/Geological Conditions					Hydraulic Conditions			Social/Land Development Impacts			
	Embankment Volume CY/ Storage Capacity AF	Storage Capacity AF/ Reservoir Area AC	Dam Raise FT	Meet Capacity Goal	Liquefaction Potential	Nearest Fault Distance	Potential for Landslides	Foundation Treatment Required	On-Site Material Conditions	Conveyance Length MILES	Spillway Construction	Flood Protection Benefits	Inundated Roadways MILES	Additional Inundation Area AC	Developed Areas Impacted	Land Acquisition Issues
1	250 or >	50 or <	501 or >	No	very high	Site in A-P Zone	very high	extensive	materials on site are insufficient and unsuitable, site vicinity is mostly developed, will involve hauling substantial quantities for several miles	> 4.5 miles	extensive	none	> 9.0	< 2,500	extensive	extensive
2	200 - 249	51 - 60	401 - 500			< 1/2 mi				4.1 - 4.5		very little	8.1 - 9.0	< 2,250		
3	150 - 199	61 -70	351 - 400		high	< 1 mi	high	significant	materials on site are insufficient and/or unsuitable, considerable material will need to be hauled a few miles	3.6 - 4.0	significant		7.1 - 8.0	< 2,000	significant	significant
4	100 - 149	71 - 80	301 - 351			< 2.5 mi				3.1 - 3.5		some	6.1 - 7.0	< 1,750		
5	75 - 99	81 - 90	251 - 300	Reduced goal	moderate	< 5 mi	some	moderate	materials on site may be insufficient, what's available is suitable but some material will need to be hauled a few miles	2.6 - 3.0	moderate		5.1 - 6.0	< 1,500	moderate	moderate
6	60 - 74	91 - 100	201 - 250			<7.5 mi				2.1 - 2.5		adequate	4.1 - 5.0	< 1,250		
7	50 - 59	101 - 110	151 - 200		low	< 10 mi	low	some	adequate materials available but suitability is questionable, some material may need to be hauled a few miles	1.6 - 2.0	some		3.1 - 4.0	< 1,000	some	some
8	40 - 49	111 - 120	101 - 150			< 15 mi				1.1 - 1.5		significant	2.1 - 3.0	< 750		
9	30 - 39	121 - 130	51 - 100		very low	< 20 mi	very low	very little	ample material available on site but some may be unsuitable and may require selective grading	0.6 - 1.0	very little		1.1 - 2.0	< 500	very little	very little
10	30 or <	131 or >	50 or <	Yes	none	≥ 20 mi	none	none	ample suitable material is available on-site	≤ 0.5 mi	none	beyond required	< 1.0	< 250	none	none

- **Dam Height (ft)**: This physical condition criterion is included to reflect the potential engineering difficulties and safety concerns associated with taller dams. All other parameters being similar, if an excessive height is required to achieve the same capacity goal, it is considered to be less desirable. In some instances, heights of the order of over 500 feet were required and these have been assigned a lower rating score.

- **Meeting the Capacity Goal:** Meeting the desired capacity goal is a key factor in screening. Sites that meet the goal were assigned a high score. One site (Pacheco B) that could not meet the goal was assigned a low score. One site (San Benito) that was carried forward with the lesser available capacity goal was given an intermediate score. These scores by themselves do not have significance but introducing a score for this factor helps avoid a misleading high score for a site which does not meet the capacity goal but has otherwise favorable characteristics.

Evaluating how well each alternative met the physical conditions criteria required details of dam location, size, and layout. For several reservoir sites, exact dam locations were not available. An optimization of the largest reservoir storage capacity possible given the least amount of earthwork required to raise a dam determined the best location for each dam.

Table A-2 lists the longitude (easting) and latitude (northing) of the dam embankments used for this storage alternative preliminary screening.

Table A-2. Dam Locations

Name	Easting	Northing
Anderson Left	121 37' 46.21" W	37 10' 08.06" N
Anderson(1) Center	121 37' 50.07" W	37 10' 00.71" N
Anderson Right	121 37' 35.56" W	37 09' 47.95" N
Chesbro Left	121 41' 58.42" W	37 06' 50.36" N
Chesbro* Center	121 41' 49.58" W	37 06' 54.03" N
Chesbro* Center	121 41' 38.81" W	37 06' 59.09" N
Chesbro Right	121 41' 34.83" W	37 07' 11.76" N
Pacheco A Left	121 17' 40.90" W	37 03' 19.89" N
Pacheco A Right	121 17' 19.04" W	37 03' 31.79" N
Pacheco B Left	121 17' 52.96" W	37 04' 06.75" N
Pacheco B Right	121 17' 36.25" W	37 04' 15.83" N
San Benito Left	121 21' 14.35" W	36 46' 20.00" N
San Benito Right	121 20' 58.39" W	36 46' 38.03" N
Ingram Canyon Left	121 18' 01.71" W	37 31' 44.93" N
Ingram Canyon Right	121 17' 32.17" W	37 31' 28.09" N
Del Puerto Right	121 13' 26.55" W	37 28' 22.68" N
Del Puerto Right	121 13' 26.55" W	37 28' 22.68" N
Quinto Left	121 06' 53.54" W	37 09' 34.96" N
Quinto Right	121 05' 29.81" W	37 10' 39.99" N

(1) Anderson and Chesbro Dams have a curved configuration so additional points are provided for bearing purposes.

The source data used to develop topography for the physical condition evaluation included the USGS National Elevation Dataset (NED). This data set provided the most comprehensive and readily available source of information to proceed with the study. Prior to analyzing the locations, both 1 ft and 5 ft contours were generated in California State Plane NAD 83 Zone III. Water surface elevations were used to designate contour closure polygons to create the inundation areas for each location. The inundation polygon area was used with the NED dataset to arrive at volumetric capacity estimates. Analyses were performed in ArcGIS 9.2 with 3D Analyst. Calculations were substantiated using spreadsheet and hand calculations.

In all cases, a crest width of 40 feet was selected for the dam and the top of dam elevation included a 20-foot allowance for freeboard. While actual requirements would vary based on design, these values provide a reasonable basis for comparing alternative sites.

Geotechnical and Geological Conditions

Several geotechnical and geological criteria were selected for evaluation of the storage alternatives. Table A-1 lists these criteria and their rating scores, which can be summarized as follows:

- **Liquefaction Potential:** This criterion relates to the potential for soils beneath and near the dam embankment and abutments to liquefy during earthquake strong ground motion. Liquefiable soils will require removal or improvement during dam construction, increasing construction cost and impact.

- **Distance to Faults:** This criterion relates to the distance of the dam and reservoir from identified active faults. Closer faults increase the potential level of strong ground shaking and associated risk of embankment failure, liquefaction, landslides, lateral spreading, and seiches. Very close faults also imply some risk of fault displacement beneath the embankment or reservoir. The computer program EQFAULT Version 3.00 (Blake 2000) was used to help estimate the maximum earthquake site acceleration at each site. If a site was mapped within an Alquist Priolo Earthquake Fault Zone (A-P zone) that requires an in-depth field fault investigation, it was assigned the lowest rating.

- **Landslides:** This criterion relates to the potential for landslides to occur at the dam abutments and around the margins of the reservoir. Impacts were considered higher for two possible scenarios: Conditions at the dam abutment(s) that are likely to require significant landslide remediation and/or conditions at the shores of the new reservoir that have potential landslides that can be triggered by wetting. Of the second type of risk (reservoir shores), risks were considered higher and hence the assigned scores were lower, if the areas surrounding the reservoir were already developed and landslides had the potential to affect the neighboring uphill properties.

- **Foundation Treatment Required:** This criterion relates to identified requirements for overexcavation and replacement and/or grouting of weak or permeable soils beneath the dam embankment or weak, fractured rock in the dam abutments to control seepage and settlement.

- **On-Site Material Availability:** This criterion relates to the suitability and the availability of earth materials that can be used for the embankment construction. Specific borrow sources were not identified; rather; a subjective evaluation was made based on the quality of materials near the dam and development or topographic limitations on developing borrow sites near the dam. Sites that were estimated to require hauling due to lack of suitable materials on-site, were assigned lower scores. No site visits or field reconnaissance were conducted to make such assessments. Material source conditions were assessed from available geologic maps and are considered preliminary in nature.

Hydraulic Conditions

The hydraulic criteria selected for evaluation of the storage alternatives and their rating scores are shown in Table A-1 and can be summarized as follows:

- **Conveyance Length:** This criterion relates to the estimated distance between the outlet works of a proposed reservoir and the nearest connection of an existing conveyance pipeline.

- **Spillway Construction:** This criterion relates to the potential complexity of the spillway, hydraulic head, and energy dissipation requirements.

- **Flood Protection Benefits:** This criterion relates to anticipated flood protection benefit of the completed storage alternative. No specific evaluation was made; rather, the rating was assigned based on potential benefits previously reported in earlier evaluations and screening.

Land Development and Social Impacts

The land development and social impacts criteria selected for evaluation of the storage alternatives and their rating scores are shown in Table A-1 and can be summarized as follows:

- **Inundated Roadways:** This criterion relates to the length of streets, roads, and highways that would require relocation, as estimated from GIS mapping.

- **Additional Inundation Area:** This criterion relates to the new areas that would be inundated by the storage alternative, irrespective of the nature of the land inundated.

- **Affected Developed Areas:** This criterion relates to the amount of developed area affected by either embankment construction or inundation from the reservoir.

- **Land Acquisition Issues:** This criterion relates to relative social and economic impacts due to relocation of residences and structures from construction and/or newly inundated areas.

A.2 Evaluation of Alternatives

A.2.1 Anderson Reservoir Expansion

Physical Conditions

Anderson Reservoir - Physical Conditions Criteria

Embankment Efficiency *– 34 CY/AF*
Storage Utilization *– 88 AF/Ac*
Dam Raise *– 65 ft*

The Draft Conceptual Alternatives Screening Report (SCVWD 2003) initially conceptualized the expansion of Anderson Reservoir (see Figure A-3). This alternative addresses the San Luis Reservoir Low Point problem by raising the crest of the existing dam to increase storage by 100 TAF to allow for early delivery and storage of water from San Luis Reservoir prior to potential supply interruption caused by a low point issue. The reservoir expansion would be accomplished by extending and raising the downstream face of the earthen dam, which would allow construction without draining the existing reservoir. Extending and raising the downstream face would maintain the dam’s existing 2.5:1 side slope configuration. Table A-2 lists the east and north coordinates of the new crest at the intersections between the new dam axis and the abutments. Table A-3 provides the physical properties of the existing and the upgraded dams. The net increase values and other quantitative measures used in the screening are summarized in Table A-4.

Raising the dam height by 65 feet (reservoir raised by 60 feet) increases the reservoir capacity by 100 TAF to a total capacity of approximately 190 TAF. The additional earthwork required to expand Anderson Reservoir is approximately 3.4 million cubic yards, yielding a ratio of earthwork volume to reservoir capacity of 34 CY per AF (cubic yards per every acre-feet of additional storage gained).

Table A-3. Physical Properties of Alternative Storage Sites

Storage Alternative		Dam						Reservoir		
		Dam Height FT	**Dam Volume MCY**	**Crest Width FT**	**Crest Length FT**	**Crest Elevation FT**	**Freeboard FT**	**Water Surface Elevation FT**	**Inundation Area AC**	**Storage Capacity TAF**
Existing	Anderson	235	3.7	40	1,430	640	15	625	1,270	90
	Chesbro	95	0.4	22	690	535	10	525	285	8
Upgraded or New	Anderson	300	7.1	40	2,550	705	20	685	2,410	190
	Chesbro	275	9.8	40	3,400	715	20	695	1,910	150
	Pacheco A	255	8.0	40	2,140	730	20	710	1,475	150
	Pacheco B	285	7.0	40	1,650	760	20	740	1,290	130
	San Benito	160	1.8	40	2,250	575	20	555	1,040	60
	Ingram	540	26.6	40	2,750	1,005	20	985	1,995	271
	Del Puerto	505	67.9	40	6,750	780	20	760	1,900	271
	Quinto Dam	310	45.0	40	12,100	655	20	635	2,480	271

NOTES:

Dam heights rounded to nearest 5 ft.

Upgraded crest lengths rounded to nearest 50 ft.

Inundation areas rounded to nearest 5 Ac.

Existing Anderson and Chesbro values reflect recent survey results (SCVWD web page)

Pacheco A and Pacheco B values based on ground El. 475' (MWH report indicates ground El. 400')

San Benito height is approx. 145 ft except at a small local zone where it is 160 ft.

Table B-4 - Quantitative Screening Measures

Storage Alternative	Physical Condition Measures								Geotechnical Measures	Hydraulic Measures	Impact Measures
	Estimated Values						Derived Ratios				
	Additional Dam Height (ft)	Additional Water Height (ft)	Additional Storage Goal (TAF)	Additional Storage Available (TAF)	Additional Inundation Area (Ac)	Additional Dam Volume (MCY)	EMBANKMENT EFFICIENCY [Dam Vol.÷Storage Cap.] (CY/AF) (lower # is better)	STORAGE UTILIZATION [Storage Cap.÷Inund. Area] (AF/Ac) (higher # is better)	Nearest Fault Distance (Miles)	Additional Conveyance Length (Miles)	Inundated Roadways Length (Miles)
Anderson	65	60	100	100	1,140	3.4	34	88	1.8	0.7	3.9
Chesbro	180	170	142	142	1,625	3.4	24	87	7.0	2.7	9.8
Pacheco A	255	235	150	150	1,475	8.0	53	102	8.7	0.5	0.7
Pacheco B	285	265	150	130	1,290	7.0	54	101	8.5	1.7	4.0
San Benito	160	140	60	60	1,040	1.8	30	58	0.0	5.6	4.5
Ingram	540	520	271	271	1,995	26.6	98	136	0.0	2.4	6.6
Del Puerto	505	485	271	271	1,900	67.3	248	143	0.0	2.0	6.9
Quinto Dam	310	290	271	271	2,480	45.0	166	109	0.0	2.8	5.6

NOTES:

Physical condition values for existing dams reflect net increase only (see Table 2.1 for existing and total values)

Storage goals are as established in Appendix B of the SLLPIP (June 2007) and described in Section 1.1 of this report

Pacheco A vaues based on ground el. 475'. If ground El. 400 ft; Dam Ht = 330 ft, Earth Vol = 14.7 MCY, Embankment Efficiency = 98 CY/AF

Pacheco B vaues based on ground el. 475'. If ground El. 400 ft; Dam Ht = 360 ft, Earth Vol = 12.3 MCY, Embankment Efficiency = 95 CY/AF

Dam volumes do not include foundation or abutment overexcavation. Sites in alluvial basins (San Benito, Quinto) are likely to have higher earth volumes due to foundation overexcavation; sites with potential landslides at the abutments (Pacheco A, San Benito) are likely to have higher earth volumes due to abutment overexcavation

Fault distances reported as '0.0' are based on maps or EQFAULT program outputs, whichever is more conservative (maps and program outputs for the same site may differ)

All existing and new sites require new spillway and outlet construction

The additional amount of inundated land is approximately 1,140 acres (Ac), yielding a ratio of additional storage capacity to additional reservoir footprint of 88 AF per Ac (acre-feet of stored water capacity gained per every acre of additional land required).

Geotechnical and Geological Conditions

Anderson Reservoir- Geotechnical and Geological Conditions Criteria

Liquefaction *– Low*
Distance to Faults *– 1.8 mi*
Landslide Potential *– High*
Foundation Treatment *– Moderate (existing dam conditions uncertain)*
On-site Material *– Some hauling needed*

Geology Figure A-4 (Wagner 1991) depicts local geologic conditions near Anderson Dam. Generally, the dam site is characterized by Jurassic age ultramafic rocks in the abutment areas of the existing dam. These ultramafic rocks, which are gabbroic in part, include peridotite, hornblendite, and are locally serpentinized. According to the geologic map, the majority of the rocks surrounding the reservoir are unconsolidated Holocene age terrace deposits. These Plio-Pleistocene terrace deposits consist of sand, silt, clay, and gravel. The valley floor sediments consist of Quaternary alluvium of unknown thickness. These unconsolidated stream and basin deposits range in size from clay to boulder.

Seismicity As with most areas of California, the site is subject to ground shaking caused by earthquakes. Figure A-4 shows the Calaveras Fault and the Silver Creek Fault to be in close proximity. Available mapping suggests discontinuity of the Silver Creek Fault across the dam embankment area. Further research into the dam construction and its geotechnical studies may provide additional information. At this time, there does not appear to be any fault directly intercepting the dam embankment. The computer program EQFAULT lists the Calaveras Fault as the closest fault at 1.8 miles away. The San Andreas Fault is 12.7 miles away. The maximum earthquake site acceleration is estimated to be 0.39g.

Liquefaction The embankment area is comprised of serpentinized ultramafic rock; therefore, liquefaction susceptibility is low. Records of the original dam construction would need to be evaluated for further assessment.

Landsliding The area around Anderson Lake has had considerable landslide activity as shown in Figure A-5 (Weigers 2006; Delarette 2006). Many of the landslides appear to be deep seated. Of these landslides, some are active or historic slides, which are of more concern. Raising Anderson Dam would inundate the toes of these landslide areas (see Figure A-5). Fluctuations in water levels would make these landslide areas subject to wetting and drying cycles. Earthquake activity may also create increased landslide risk. Under such conditions, active and perhaps even dormant landslides may re-activate.

The southeasterly shore of the existing lake is a developed area. The Draft Conceptual Alternatives Screening Report (SCVWD 2003) estimated that an expanded Anderson Reservoir could inundate approximately 100 homes. This preliminary screening analysis suggests that additional homes upslope of the expanded reservoir could be subject to new landslide activity generated by the expanded reservoir footprint. Extending home acquisitions beyond the inundation footprint buffer could minimize such risks, but would potentially increase the alternative’s cost. Further geotechnical studies would be needed to assess landslide risks and to evaluate the added cost impacts. At this time, this alternative is considered to have a relatively high risk in terms of landslides around the inundation perimeter. Remediation of such risks is considered relatively difficult.

Dormant mature landslides are mapped near the existing right abutment and uphill from it. Even though these are mature landslides, at least one slide is directly in line with the proposed embankment expansion. The additional geotechnical studies described above would investigate its potential removal. Based on available mapping, this slide appears of a size that would permit its management through conventional earthwork activities. The additional cost impact is not known. This alternative is considered to have a moderate to high risk in terms of landslides at the dam embankment expansion area. Reduction of such risks is considered reasonable to moderately difficult depending on actual field conditions.

Material Availability Materials within approximately 3 miles of the dam embankment consist of terrace deposits, landslide debris, and serpentinized ultramafic rock. These materials are generally considered suitable for embankment construction, provided they are processed as engineered fill. Serpentinized rock may be harder to process depending on local conditions. Serpentinized rock can also contain naturally occurring asbestos and special health and safety measures may be needed during construction to avoid impacts associated with naturally occurring asbestos, if encountered.

Foundation Treatment Requirements Provided further investigation of the existing dam reveals suitable conditions for the expansion, the need for foundation treatment would not be anticipated. Raising the dam would typically involve keying in to the existing dam and widening on the downstream side. As mentioned earlier, landslide removal could be necessary at the right abutment. Further investigation of existing dam conditions is needed to assess if additional stabilization of the existing embankment will be needed prior to expansion.

In general, the foundation treatment rating for an existing dam would require an evaluation of the previously placed earth materials in addition to the natural site conditions. An existing dam can be considered to be more favorable than a new site with known problems (landslides, faults, etc.), however, less favorable than a new site expected to have stable foundation conditions. Raising a dam that has been previously designed for a certain height may or may not require treatment of the original dam, depending on several factors such as the potential for settlement under additional loads and the verifiable quality of as-built records. Remedial foundation treatment (i.e. stabilization of the existing dam embankment) may become necessary due to less stringent standards which may have been in effect at the time of its original construction (e.g. seismic loads). Also, investigations through existing dams are more complex than those in pristine sites. Increasing a dam height could pose various geotechnical engineering challenges depending on such aforementioned factors, which are not known at this time. At this level of study, an in-depth evaluation of existing dams has not been performed. A rating assignment in the range of moderate to significant is considered to be a reasonable value for existing dams.

Hydraulic Conditions

Anderson Reservoir - Hydraulic Conditions Criteria

Conveyance Length *– 3,900 ft*
Spillway *– Significant Upgrade*
Flood Protection *– Not Significant*

An expanded Anderson Reservoir would store early deliveries from San Luis Reservoir prior to the summer low point months. The San Felipe Division would receive deliveries of this San Luis supply from Anderson Reservoir when algae conditions prevent the pumping of supplies in San Luis Reservoir.

As mentioned in the IAIR, water stored at Anderson Reservoir would have to serve the San Benito and Pajaro Water Districts during a low point supply interruption. This would require a new 270 cfs pump station and a new 3,900-foot pipeline connecting Anderson Reservoir to the San Benito and Pajaro Water Districts. The existing spillway would need to be demolished and a new one excavated into the rock to the right abutment. A new stilling basin would be constructed to dissipate energy to allow releases to flow to Coyote Creek further downstream.

Increasing the storage capacity at this reservoir location has no significant flood control benefits. Further raising of the water surface at this location will increase the overall risk to the inhabitants and property downstream, should a dam break occur. Assessing the potential hazard at this location is not part of this current effort. A dam hazard reclassification would be conducted should this location be selected for full design.

Land Development and Social Impacts

Anderson Reservoir - Land Development and Social Criteria

***Inundated Roadway Miles** – 3.9 mi*
***Additional Inundation Area** –1,140 Ac*
***Affected Developed Areas** – Extensive*
***Land Acquisition** – > 100 Structures*

Anderson Reservoir is adjacent to a residential neighborhood in the City of Morgan Hill. Research competed on the Anderson Reservoir expansion alternative in the Draft Conceptual Alternatives Screening Report (SCVWD 2003) estimated that approximately 100 private residences in the Holiday Lake Estates neighborhood as well as other isolated private residences around the lake would be inundated by the footprint of an expanded Anderson Reservoir. The U.S. Census reports of median home values for the two Census Block Groups that overlay Anderson Reservoir indicate a price range between $609,300 and $750,000 (U.S. Census Bureau 2000). The Draft Conceptual Alternative Screening Report also described the potential inundation of portions of Anderson County Park.

Estimates for this preliminary screening indicate that an expanded Anderson Reservoir would create an estimated inundation area with a larger footprint area than the Draft Conceptual Alternatives Screening Report indicated. This revised footprint would result in the inundation of additional structures well beyond the 100 structures previously reported. The preliminary GIS work completed as a part of this reservoir screening effort also indicated that up to 3.9 miles of roadway could be inundated by the expanded Anderson Reservoir footprint.

Reservoir water level fluctuations to deliver flows to the San Felipe Division would also adversely affect potential redevelopment along the re-established shores of a new reservoir. This has important impacts to the land values of a newly created reservoir.

A.2.2 Chesbro Reservoir Expansion

Physical Conditions

Chesbro Reservoir - Physical Conditions Criteria

***Embankment Efficiency** – 24 CY/AF*
***Storage Utilization** – 87 AF/Ac*
***Dam Raise** –180 ft*

The Chesbro Reservoir Alternative (see Figure B-6) could increase storage capacity from the current 9 TAF to 150 TAF. The alternative would require a dam raise of approximately 180 feet. The reservoir's current storage capacity would be expanded by increasing the height and length of both the downstream and upstream slopes of the existing dam. Table A-3 shows the physical properties of the new dam and Table A-4 summarizes the quantitative parameters utilized in the screening. Table A-2 lists the north and east coordinates of the new crest at the intersections between the new dam axis and the abutments.

Raising the dam height by 180 feet would increase the reservoir capacity by about 142 TAF, which would meet the desired goal of 150 TAF. The additional earthwork required would be approximately 3.4 million cubic yards (MCY). This yields a ratio of additional earthwork to additional reservoir capacity gain of 24 CY per AF. The additional amount of inundated land is approximately 1,625 Ac (see Figure A-6), yielding a ratio of additional storage capacity to additional reservoir footprint of 87 AF per Ac.

Geotechnical and Geological Conditions

Chesbro Reservoir - Geotechnical and Geological Conditions Criteria

Liquefaction *– Low to Moderate*
Distance to Faults *– 7.0 mi*
Landslide Potential *– Moderate*
Foundation Treatment *– Moderate (existing dam conditions uncertain)*
On-site material *– Considerable hauling may be needed*

Geology Figure A-7 (McLaughlin et. al. 2001) depicts the local geologic conditions near Chesbro Dam. The left dam abutment is underlain by serpentinized ultramafic rocks of Jurassic age. The right dam abutment is underlain by similar rocks (serpentinized ultramafic rocks of Jurassic age) and by Jurassic age basaltic volcanic rocks. The majority of the reservoir area upstream from the dam is underlain by rocks of the Franciscan Complex (Cretaceous and Jurassic age) consisting primarily of melange that is in turn overlain by Jurassic age basaltic volcanic rocks that appear to be in fault (thrust fault) contact with the Franciscan Complex. The valley floor of Llagas Creek is predominantly underlain by unconsolidated stream channel deposits ranging in size from clay to boulder. The thickness of the valley floor deposits along Llagas Creek is unknown.

Seismicity The site lies approximately midway between the active Sargent Fault (a major splay of the San Andreas Fault) and the active Calaveras Fault. However, no known active faults transect the reservoir. Several other low to high angle reverse faults cross the reservoir although their specific age is not known. The computer program EQFAULT lists the Calaveras Fault as the closest fault at 7.0 miles away. The San Andreas Fault is 7.4 miles away. The maximum earthquake site acceleration is estimated to be 0.36g.

Liquefaction The embankment area is generally composed of serpentinized ultramafic rock but there are alluvial fan deposits near the downstream toe of the existing embankment. The liquefaction susceptibility in bedrock is considered very low and in alluvial deposits is considered moderate to high, with an estimated average of these two conditions for the overall site considered to be low to moderate liquefaction susceptibility. Any expansion would likely involve removal of alluvium deposits under the proposed toe depending on previous removal limits. Records of the original dam construction would need to be evaluated for further assessment.

Landsliding According to the geologic map (Figure A-7), there are three mapped landslides along the south/west embankment of Llagas Creek and one mapped landslide on the north/east embankment. These are upstream from the existing Chesbro Reservoir but within the new inundation area. Other smaller unmapped landslides likely exist that are not depicted on the geologic map.

Raising Chesbro Dam would inundate the toes of these landslide areas. Fluctuations in water levels would make these landslide areas subject to wetting and drying cycles. Earthquake activity may also create increased landslide risk. Under such conditions, these landslides may re-activate.

The implementation of this alternative would require inundation of the developed areas and the roads. There do not appear to be adjacent developed areas on the hillsides above the proposed inundation areas, as all existing development appears to be within the inundation area. Therefore, the above-mentioned landslides likely affect undeveloped areas.

There are no mapped landslides at the existing dam site. The proposed embankment expansion and its abutments are likely to encounter serpentinized ultramafic rocks, mélange of the Central belt, alluvial fan deposits, and artificial fill.

This alternative is considered to have some risk in terms of landslides. Sporadic areas along the uninhabited new shoreline would likely remain unremediated.

Material Availability Materials in the immediate vicinity of the dam embankment consist of serpentinized ultramafic rocks, mélange of the Central belt, alluvial fan deposits, and artificial fill. These materials are generally considered suitable provided they are processed as engineered fill. Serpentinized rock may be harder to process depending on local conditions. There may be localized areas of mélange, which can be difficult to excavate with conventional earthmoving equipment. In addition, serpentinized rocks can contain naturally occurring asbestos and special measures may be needed during construction. Material availability for this site may be relatively more difficult due to higher volume needed in the vicinity of a somewhat developed area.

Foundation Treatment Requirements Provided further investigation of the existing dam reveals suitable conditions for the expansion, the need for foundation treatment would not be anticipated. Raising the dam would typically involve keying in to the existing dam and widening on the downstream side. Further investigation of existing dam conditions is needed to assess if additional stabilization of the existing embankment is needed prior to expansion.

In general, the foundation treatment rating for an existing dam would require an evaluation of the previously placed earth materials in addition to the natural site conditions. An existing dam can be considered to be more favorable than a new site with known problems (landslides, faults, etc.), however, less favorable than a new site expected to have stable foundation conditions. Raising a dam that has been previously designed for a certain height may or may not require treatment of the original dam, depending on several factors such as the potential for settlement under additional loads and the verifiable quality of as-built records. Remedial foundation treatment (i.e. stabilization of the existing dam embankment) may become necessary due to less stringent standards which may have been in effect at the time of its original construction (e.g. seismic loads). Also, investigations through existing dams are more complex than those in pristine sites. Increasing a dam height could pose various geotechnical engineering challenges depending on such aforementioned factors, which are not known at this time. At this level of study, an in-depth evaluation of existing dams have not been performed. A rating assignment in the range of moderate to significant is considered to be a reasonable value for existing dams.

Hydraulic Conditions

Similar to the Anderson Reservoir Alternative, an expanded Chesbro Reservoir would store early deliveries from San Luis Reservoir prior to the summer low point months. Deliveries of this San Luis supply would be made from Chesbro Reservoir when algae conditions prevent the pumping of supplies in San Luis Reservoir.

Chesbro Reservoir - Hydraulic Conditions Criteria

Conveyance Length *– 14,150 ft*
Spillway *– Significant Upgrade*
Flood Protection *– Not Significant*

Water stored at Chesbro would need to serve the San Benito and Pajaro Water Districts during low point supply interruptions. This would require a new pump station and a 14,150-foot pipeline connecting Chesbro to the Santa Clara conduit. The existing spillway would need to be demolished and a new one excavated into the right abutment. A new stilling basin would be constructed to dissipate energy to allow releases to flow to the Llagas Creek further downstream.

Increasing the storage capacity at this reservoir location has no significant flood control benefits. Further raising of the water level at this location will increase the overall risk to the inhabitants and property downstream should a dam break occur. Assessing the potential hazard at this location is not part of this current effort. A dam hazard reclassification would be conducted should this location be selected for full design.

Land Development and Social Impacts

Chesbro Reservoir - Land Development and Social Criteria

Inundated Roadway Miles *– 9.8 mi*
Additional Inundation Area *– 1,625 Ac*
Affected Developed Areas *– Extensive*
Land Acquisition *– >40 Structures*

Chesbro Reservoir is adjacent to a residential neighborhood in the City of Morgan Hill. Research completed on the Chesbro Reservoir expansion alternative in the 2002 SLLPIP Conceptual Alternatives Screening Report estimated that the footprint of an expanded Chesbro Reservoir would inundate approximately 40 structures. The U.S. Census reports of median home values for the three Census Block Groups that overlay Chesbro Reservoir indicate a price range between $487,800 and $703,700 (U.S. Census Bureau 2000).

The estimated inundation area that would be created by an expanded Chesbro Reservoir that was developed as a part of preliminary GIS analysis for this reservoir screening effort indicates a larger footprint area than was estimated in the 2002 Alternatives Screening Report. This revised footprint is estimated to result in the inundation of additional structures well beyond the 40 structures described in the screening report. Preliminary GIS analysis completed as a part of this reservoir screening effort also indicated that up to 9.8 miles of roadway could be inundated by the expanded Chesbro Reservoir footprint and would require new access roads.

A.2.3 Pacheco A Reservoir

Physical Conditions

Pacheco A Reservoir - Physical Conditions Criteria

Embankment Efficiency *– 53 CY/AF*
Storage Utilization *– 102 AF/Ac*
Dam Raise *– 255 ft*

The Pacheco A Reservoir Alternative (see Figure A-8) would require the partial demolition of the existing dam on Pacheco Creek with provisions to maintain existing water deliveries during and after the construction of the new dam. The existing North Fork Dam is designed to impound water from the bottom of the original floodplain to elevation 472'. The elevation of the original floodplain at the proposed Pacheco A site has been reported at elevation 400' (SCVWD 2003a). More recent GIS information indicates an existing floodplain elevation of 475'. Also, the aerial photo image of the proposed dam site shows dry conditions. Uncertainties exist, but it is possible that the elevations on the aerial images are not accurate and the dry conditions in the photo may be from a time when the existing dam was drained. It is also possible that there has been excessive siltation which have created the higher ground elevation and the dry conditions. The level of siltation in the existing reservoir has not been evaluated, but the existing ground elevation at the proposed dam site has been taken as 475' for our screening. There may be additional foundation overexcavation involved to remove the silt deposits.

Tables B-3 and B-4 provide the physical properties of Pacheco A site, with alternate quantities and screening parameters for the lower ground elevation provided in the footnotes. Quantities with potential foundation overexcavation are not used in the comparison since other sites with potential overexcavation needs have not been evaluated for that variable as well. However, if this alternative is selected, refined estimates will be provided to account for both the foundation and the abutment overexcavations.

The new reservoir's water surface elevation of 710' would not encroach on Henry Coe National Park and would avoid any inundation of the parkland. However, there is conflicting published information regarding the contour levels along the tributary river as it approaches the property limits of the National Park. It is possible that the discrepancies may be related to the location of the boundary line for the park. Previous reports by SCVWD (2003a) state a normal water inundation contour of 680. This report is based on a normal inundation contour of 710 with a maximum inundation contour of 730 allowing for spillway surcharges. This elevation is still lower than the contour of 760 found at the boundary with the park (see Figure A-8). Based on this, this alternative would meet the desired goal of 150 TAF of storage capacity as stated in Table

A-3. This contour assumption would be verified should this alternative move further along the screening process.

Table A-2 lists the east and north coordinates of the new crest at the intersections between the new dam axis and the abutments. Table A-3 shows the physical properties of the new dam and Table A-4 summarizes the quantitative parameters utilized in the screening.

A new 255-foot high dam (based on elevation 475’) requires earthwork of approximately 8.0 million cubic yards with an embankment efficiency of 53 CY of earth volume per every AF of additional storage gained. The proposed dam uses 2.5:1 slopes on both sides of the crest. The aforementioned values do not include an allowance for overexcavation along the submerged floodplain. If overexcavation is carried to elevation 400’, the earth volume would increase to 14.7 MCY and the embankment efficiency would drop to 98 CY/AF. Any additional earthwork related to landslide remediation at the abutment(s), as will be discussed later, are not included in these figures.

The amount of inundated land is approximately 1,475 Ac , yielding a ratio of additional storage capacity to additional reservoir footprint of 105 AF of stored water capacity gained per every acre of new land required.

Geotechnical and Geological Conditions

Pacheco A Reservoir - Geotechnical and Geological Conditions Criteria

Liquefaction *– Moderate*
Distance to Faults *– 8.7 mi*
Landslide Potential *– Very High*
Foundation Treatment *– Moderate to Significant*
On-site Material *– Adequate*

Geology Figure A-10 (Wagner et. al. 1991) depicts the local geologic conditions near the proposed Pacheco A dam site. The proposed left dam abutment is underlain by deep-seated landslide material that overlie rocks of the Jurassic age Franciscan Formation. The proposed right abutment is underlain by the Franciscan Formation. The majority of the reservoir area upstream from the proposed abutments is also underlain by rocks of the Franciscan Complex (Cretaceous and Jurassic age melange), which largely consist of chaotic mixtures of fragmented rock masses in a sheared matrix. The valley floor upstream from the reservoir is predominantly underlain by unconsolidated stream channel deposits ranging in size from clay to boulder. The thickness of the valley floor deposits is unknown and is an important parameter in further evaluating the embankment volumes with more accuracy.

Seismicity The site is subject to ground shaking caused by earthquakes. There are no mapped active faults in the immediate vicinity. The site lies approximately midway between the active Calaveras Fault and the active Ortigalita Fault. No known active faults transect the abutments or the reservoir. The computer program EQFAULT lists the Ortigalita Fault, the Quien Sabe Fault, and the Calaveras Fault as the closest faults at 8.7, 9.8 and 10.6 miles away, respectively. The San Andreas Fault is 19.6 miles away. The maximum earthquake site acceleration is estimated to be 0.21g.

Liquefaction The embankment area is expected to consist of alluvium, landslide debris, and bedrock of the Franciscan Complex. Liquefaction susceptibility for these materials vary (high for alluvium to very low for bedrock). The current average liquefaction susceptibility is considered to be moderate. Conditions will likely be improved by removal and replacement of any alluvium under the dam foundation, to competent bedrock.

Landsliding As mentioned previously, the geologic map (Figure A-10) shows a large landslide at the left abutment of the Pacheco A site. There are other landslides in the area but not directly at the abutment location. Figure A-11 (Wentworth et. al. 1997) shows that many areas of the Pacheco Creek valley, especially near the upstream end of the inundation area, are susceptible to landsliding. This map shows areas defined by drawing envelopes around groups of mapped landslides and not each specific landslide.

Inundation of these landslide-prone areas and fluctuations in water levels in these areas may trigger landslides. Earthquake activity may also increase landslide risk. However, due to the relatively remote and uninhabited nature of the site, such risks are considered less critical and it is assumed that remediation to these landslides outside of the abutment area would be unnecessary.

It is assumed that the landslide at the abutment area would need to be removed. The potential cost of this remediation is not known and would need to be determined through additional geotechnical studies as a part of the low point project. The available information reviewed as a part of this screening exercise indicates a very high landslide risk at the dam embankment area. Remediation of such risks could add significant costs to construction of the alternative. However, since this site has several desirable attributes, costs associated with remediating landslides or performing further subsurface investigations to relocate the site to minimize landslide impacts, are considered worthwhile.

Material Availability Materials in the immediate vicinity of the dam embankment consist of Franciscan Complex bedrock and landslide debris. These materials are generally considered suitable provided they are processed as engineered fill. Landslide removal, foundation overexcavation, and related grading could provide suitable materials for the embankment. In general, adequate materials are expected to be available on-site. If needed, additional sources such as impermeable materials are expected to be available within a few miles.

Foundation Treatment Requirements Considerable quantities of foundation and landslide removals may be needed depending on site-specific conditions. Abutment removals may require ‘chasing’ the hillside well above the crest elevation. Construction within the existing reservoir area may also pose additional difficulties. Further investigations are needed for a more detailed assessment.

Hydraulic Conditions

Pacheco A reservoir would receive releases from San Luis Reservoir during wet periods and would later release this water to users during the low point supply interruptions. Because this reservoir is upstream from the Hollister conduit, there is no need to construct any reverse flow capacity. The existing conveyance pipeline would be extended 2,700 feet from the existing North Fork Dam upstream to the Pacheco A site and would be expanded along its full length to increase conveyance capacity.

Pacheco A Reservoir - Hydraulic Conditions Criteria

Conveyance Length *– 2,700 ft*
Spillway *– Significant*
Flood Protection *– Significant*

New auxiliary and service spillways would be required at this site. Impounding water at this location has been reported in the Draft Conceptual Alternatives Screening Report as having significant flood control benefits for the Lower Pajaro watershed.

Further raising the storage capacity at this reservoir location will increase the overall risk to the inhabitants and property downstream should a dam break occur. Assessing the potential hazard at this location is not part of this current effort. A dam hazard classification would be conducted should this location be selected for full design.

Land Development and Social Impacts

Pacheco A Reservoir- Land Development and Social Criteria

Inundated Roadway Miles *– 0.7 mi*
Additional Inundation Area *– 1,475 Ac*
Affected Developed Areas *– Minor*
Land Acquisition *– Minor*

The estimated inundation area that would be created by the Pacheco A Reservoir is shown on Figure A-8. Preliminary GIS analysis completed as a part of this reservoir screening effort also indicates approximately 0.7 miles of existing roadways would require relocation. The reservoir would not inundate any homes as the nature of the 1,475 acres to be inundated is not currently populated.

A.2.4 Pacheco B Reservoir

Physical Conditions

Pacheco B Reservoir - Physical Conditions Criteria

Embankment Efficiency *– 54 CY/AF*
Storage Utilization *– 101 AF/Ac*
Dam Raise *– 285 ft*

The Pacheco B Reservoir Alternative (see Figure B-9) would require the partial demolition of the existing dam on Pacheco Creek with provisions to assure existing water deliveries during and after construction of the new dam. The existing North Fork Dam is designed to impound water to elevation 472 from an assumed elevation at the bottom of the original floodplain of about 400. The elevation of the floodplain at the proposed Pacheco B site is 440. The new reservoir's water surface elevation of 740' would not encroach on Henry Coe National Park and would avoid any inundation of parkland. However, there is conflicting published information regarding the contour levels along the tributary river as it approaches the property limits of the National Park. It is possible that the discrepancies may be related to the location of the boundary line for the park. Previous reports by MWH state a normal water inundation contour of 680. This report is based on a normal inundation contour of 740 with a maximum inundation contour of 760 allowing for spillway surcharges. This elevation is at or lower than the contour found at the boundary with the park. Based on this, the Pacheco B alternative still does not meet the desired goal of 150 TAF of storage capacity. The maximum storage capacity achieved behind this dam location would be 130 TAF based on the 760 maximum contour.

Table A-2 lists the east and north coordinates of the new crest at the intersections between the new dam axis and the abutments. As discussed in Section A.1, the evaluation includes the Pacheco B Reservoir because the capacity is only slightly smaller than the storage goals and the Pacheco B site has fewer geotechnical constraints than other Pacheco sites. A site located downstream of Pacheco B and upstream of Pacheco A may satisfy the storage volume goal without impacting the park, while possibly reducing the impact of existing landslides at Pacheco A. Such potential site candidates as well as the aforementioned uncertainties regarding existing streambed elevations, the park boundary, and landslide limits would need to be further evaluated if a site on Pacheco Creek moves further along the screening process.

Table A-2 provides the physical properties of the proposed dam at Pacheco A. The quantitative measures for this site used in the screening are summarized in Table A-4.

A new 285-foot high dam requires earthwork of approximately 7.0 million cubic yards; the ratio of earthwork to reservoir capacity would be 54 CY per every AF of additional storage. The amount of inundated land would be approximately 1,290 Ac, as shown on Figure A-9, yielding a ratio of additional storage capacity to additional reservoir footprint of 101 AF of stored water capacity gained per every acre of new land required.

The streambed conditions at Pacheco B have similar uncertainties as described under Pacheco A. Alternate quantities for existing ground elevation of 400' (instead of 475') are: 360-foot high dam with an earth volume of 12.3 MCY and an embankment efficiency of 95 CY/AF.

Geotechnical and Geological Conditions

Pacheco B Reservoir - Geotechnical and Geological Conditions Criteria

Liquefaction *– Moderate*
Distance to Faults *– 8.5 mi*
Landslide Potential *– Some*
Foundation Treatment *– Moderate*
On-site Material *– Adequate*

Geology Figure A-10 (Wagner et. al. 1991) depicts the local geologic conditions near the proposed Pacheco B dam site. The proposed abutments are underlain rocks of Jurassic age Franciscan Formation. The reservoir area upstream from the proposed abutments is as described for the Pacheco A dam site.

Seismicity The site is subject to ground shaking caused by earthquakes similar to that described for the Pacheco A dam site. The computer program EQFAULT lists the Ortigalita Fault, the Great Valley Fault, the Quien Sabe Fault, and the Calaveras Fault as the closest faults at 8.5, 10.4, 10.6, and 10.9 miles away respectively. The San Andreas Fault is 20.1 miles away. The maximum earthquake site acceleration is estimated to be 0.22g.

Liquefaction The embankment area is expected to consist of alluvium and bedrock of the Franciscan Complex. Liquefaction susceptibility for these materials vary (high for alluvium to very low for bedrock). The current average liquefaction susceptibility is considered to be moderate. Conditions will likely be improved by removal and replacement of any alluvium under the dam foundation, to competent bedrock.

Landsliding Figure A-11 (Wentworth et. al. 1997) shows that many areas of the Pacheco Creek valley, especially near the upstream end of the inundation area, are susceptible to landsliding. Available reference resources reviewed as a part of this screening effort do not indicate the presence of any landslides at the proposed abutments; however, given the geologic setting and presence of sheared bedrock, it is likely that smaller unmapped landslides also occur near the proposed abutments.

Landslide risks in the reservoir area along the shores of the new inundation area are expected to be similar to those for the Pacheco A reservoir. Since this is an undeveloped area, such risks are not critical. Landslide risk at the abutment area (which is a more relevant screening factor) is expected to be more favorable than the conditions at Pacheco A. Based on the anticipated conditions, this site is considered to have some landslide risk.

Material Availability Materials in the immediate vicinity of the dam embankment consist of Franciscan Complex bedrock and landslide debris in the general vicinity. These materials are generally considered suitable provided they are processed as engineered fill. Remedial grading could provide some suitable materials for the embankment. In general, adequate materials are expected to be available on-site. If needed, additional sources such as impermeable materials are expected to be available within a few miles.

Foundation Treatment Requirements Foundation treatment needs depend on site-specific conditions such as the current level of siltation and will require further investigation. Construction within the existing reservoir area may also pose some difficulties.

Hydraulic Conditions

Pacheco B Reservoir - Hydraulic Conditions Criteria

Conveyance length *– 8,900 ft*
Spillway *– Significant*
Flood protection *– Significant*

Operation of this reservoir would be similar to that of Pacheco A. The reservoir is upstream from the Hollister conduit; there is no need to construct any reverse flow capacity. The existing conveyance pipeline would be extended 8,900 feet from the Lower Pacheco dam upstream to the Pacheco B site and would be expanded along its full length to increase conveyance capacity.

New auxiliary and service spillways would be required at this site. Impounding water at this location has reported in the Draft Conceptual Alternatives Screening Report as having significant flood control benefits for the Lower Pajaro watershed. Further raising the storage capacity at this reservoir location will increase the overall risk to the inhabitants and property downstream should a dam break occur. Assessing the potential hazard at this location is not part of this current effort. A dam hazard classification would be conducted should this location be selected for full design.

Land Development and Social Impacts

Pacheco B Reservoir - Land Development and Social Criteria

***Inundated Roadway Miles** – 4.0 mi*
***Additional Inundation Area** – 1,290 Ac*
***Affected Developed Areas** – Minor*
***Land Acquisition** – Minor*

The estimated inundation area that would be created by the Pacheco B Reservoir is shown on Figure A-9. The Henry Coe State Park which is upstream from Pacheco B and adjacent to the northwest side of the reservoir, restricts this alternative's storage goal.

Preliminary GIS analysis completed as a part of this reservoir screening effort indicates approximately 4.0 miles of existing roadways would require relocation. The reservoir would not inundate any homes as the nature of the 1,290 acres to be inundated is not currently populated

A.2.5 San Benito Reservoir

Physical Conditions

San Benito Reservoir - Physical Conditions Criteria

***Embankment Efficiency** – 30 CY/AF*
***Storage Utilization** – 58 AF/Ac*
***Dam Raise** – 160 ft*

The San Benito Reservoir Alternative (see Figure A-12) would create 60 TAF of water storage capacity. It would not be able to meet the storage goal of 150 TAF for new reservoirs on the west side of San Luis Reservoir; therefore, it would be combined with other measures to meet project objectives. The reservoir's water surface elevation would be at Elevation 555. Table A-2 lists the east and north coordinates of the new crest at the intersections between the new dam axis and the abutments.

Table A-3 provides the physical properties of the proposed dam. The quantitative measures used in the screening are summarized in Table A-4. A new 160-foot high dam requires approximately 1.8 million cubic yards of fill. The ratio of earthwork to reservoir capacity is estimated to be 30 CY per every AF of storage gained. The amount of inundated land would be approximately 1,040 Ac, yielding a somewhat low ratio of storage capacity to reservoir footprint of 58 AF of stored water capacity gained per every acre of new land required.

Geotechnical and Geological Conditions

San Benito Reservoir - Geotechnical and Geological Conditions Criteria

***Liquefaction** – Moderate*
***Distance to Faults** – >1 mile*
***Landslide Potential** – High to Very High*
***Foundation Treatment** –Extensive*
***On-site Material** – Substantial hauling*

Geology Figure A-13 (CDMG 1959) depicts local geologic conditions near San Benito Dam. Generally, the proposed site of the dam is characterized by moderately to steeply dipping non-marine sedimentary beds of the Tertiary age Etchegoin Formation on the right abutment and steeply dipping unconsolidated gravel, sand, and silt beds of the Quaternary age San Benito Formation on the left abutment (Majmundar 1994). Movement on faults has deformed the rock strata in the dam site area causing them to become steeply dipping to overturned. The Etchegoin Formation consists of moderately to poorly non-consolidated sandstone, siltstone, shale, mudstone, and pebbly sandstone and grit. The San Benito Formation is an unconsolidated, light-gray to variegated maroon, purple gravel, sand and silt commonly cross bedded and locally unconformable on the underlying Etchegoin Formation. Alluvial deposits occur within the bed of San Benito River. These Quaternary alluvial deposits are described as undifferentiated, unconsolidated sand, silt, gravel, and clay.

Seismicity As shown on Figure A-15, the active Calaveras Fault transects the proposed dam location and the active Paicines Fault is nearby. There are also several other active faults in the immediate vicinity. The proposed abutment location is within a State of California Special Studies Zone. While there have been dams built near active faults that have performed well, the presence of an active fault is considered to be a high risk. Also, the location of the abutment is in a zone requiring special studies according to the Alquist Priolo Earthquake Fault Zoning Act (A-P zone). This is considered to pose significant challenges in the design and permitting phase, if this alternative were to go forward.

Regardless of fault displacement, the site will be subject to strong ground shaking because of earthquakes. The computer program EQFAULT lists the San Andreas Fault as the closest fault at 2.6 miles away. The maximum earthquake site acceleration is estimated to be 0.36g.

Liquefaction Earth materials in vicinity of the dam are likely to consist of alluvium, Pliocene non-marine and marine deposits, and Quaternary lake deposits and non-marine terrace deposits. Some of these deposits are moderately prone to liquefaction depending on local site conditions.

Landsliding Figures B-14 and B-15 indicate landslides near the proposed dam. Areas labeled as ‘Massive Landslides’ are shown on Figure A-14 but specific slide zones are not mapped in that figure. The Etchegoin beds near the right abutment are associated with numerous bedrock landslides that appear to be deep seated. The San Benito formation is also prone to landsliding. The stream channel deposits within the bed of the San Benito River are generally incised and are subject to unstable banks that can slump into the channel because of undercutting. Landslide areas of varying severity ranging from ‘Least Susceptible’ to ‘Most Susceptible’ have been identified in Figure A-15 (Majmundar 1994). Areas close to the potential abutment site vary from ‘Marginally Susceptible’ to ‘Generally Susceptible’ (Majmundar 1994). The landslide risk for this site is considered to be high to very high.

Material Availability Materials in the immediate vicinity of the dam embankment consist of alluvium, Pliocene non-marine and marine deposits, and Quaternary lake deposits and non-marine terrace deposits. These materials can be processed and used for embankment construction but may not be suitable for an impervious core material. Landslide zones on nearby hillsides would limit mining for materials. A more detailed evaluation of material availability should be completed in subsequent phases if this alternative is carried forward to the Plan Formulation Phase of the low point project.

Foundation Treatment Requirements Alluvium is expected to be local and of limited extent. In general, removal of all alluvium is desirable for foundation stability and for liquefaction remediation. Depending on site-specific conditions in relation to existing landslides, removals would likely be needed for landslide remediation if they pose a threat at the abutment locations. The presence of the fault will also require further fault trenching studies and foundation stabilization measures. Maintaining this site under consideration would likely require additional siting studies and possible relocation of the dam up or downstream on San Benito Creek.

Hydraulic Conditions

The San Benito Reservoir would be close to the SCVWD and PVMWA water users thus providing local operational flexibility. However, this would require a conveyance pipeline 5.6 miles long to tie back to the Hollister pipeline. New auxiliary and service spillways would be required at this site.

San Benito Reservoir - Hydraulic Conditions Criteria

***Conveyance Length** – 5.6 mi*
***Spillway** – Moderate*
***Flood Protection** – Significant*

The 2007 IAIR reported that this location has significant flood control benefits for the San Benito River basin and well as the Lower Pajaro watershed; however the reservoir would require emptying ahead of large storm events to accomplish this benefit.

Land Development and Social Impacts

San Benito Reservoir - Land Development and Social Criteria

Inundated Roadway Miles *– 4.5 mi*
Additional Inundation Area *– 1,040 Ac*
Affected Developed Areas *– Some*
Land Acquisition *– Some (agricultural)*

Figure A-12 shows the estimated inundation area that the San Benito Reservoir would create. Preliminary GIS analysis completed as a part of this reservoir screening effort also indicates approximately 4.5 miles of existing roadways would require relocation. The reservoir would not inundate any homes; however, large tracks of agricultural land would need to be acquired.

A.2.6 Ingram Canyon Reservoir

Physical Conditions

Ingram Reservoir - Physical Conditions Criteria

Embankment Efficiency *– 98 Cy/AF*
Storage Utilization *– 136 AF/Ac*
Dam Raise *– 540 ft*

Figure A-16 shows the Ingram Canyon Reservoir Alternative, which would be east of San Luis Reservoir. Ingram Canyon Reservoir would be subject to larger storage goals to meet user needs as well as existing uses, flood control, and dead storage as described in Appendix B of the IAIR. This is a largely undeveloped site, which would impound water within the Ingram Canyon creek. The crest for this dam would be at Elevation 1,005 feet and the crest length would be approximately 2,750 feet. This alternative would meet the 271 TAF storage capacity goal. Table A-2 lists the east and north coordinates of the new crest at the intersections between the new dam axis and the abutments. Table A-3 provides the physical properties of the proposed dam. The quantitative measures used in the screening are summarized in Table A-4.

The new 540-foot high dam requires earthwork of approximately 26.6 million cubic yards; the ratio of earthwork to reservoir capacity would be 98 CY per every AF of storage gained. The amount of inundated land is approximately

1,995 Ac, yielding a ratio of storage capacity to reservoir footprint of 136 AF of stored water capacity gained per every acre of new land required.

Geotechnical and Geological Conditions

Ingram Reservoir - Geotechnical and Geological Conditions Criteria

Liquefaction *– Very Low*
Distance to Faults *– > 1.0 mi*
Landslide Potential *– Very Low*
Foundation Treatment *–Moderate*
On-site Material *– Available*

Geology Figure A-17 (Wagner et. al. 1991) depicts the local geologic conditions near the proposed Ingram Dam. The proposed dam abutments are underlain by Upper Cretaceous age sedimentary rocks along the west side of the San Joaquin Valley that strike northwest and dip moderately to steeply toward the northeast. Bedding dips are generally 50 to 65 degrees, but locally some beds are overturned to the west.

The western portion of the proposed reservoir is underlain by complexly folded Jurassic age ultramafic rock of the Franciscan Formation, which is in fault contact with the younger Cretaceous age rocks. These rocks are gabbroic in part, include peridotite and hornblendite, and are locally serpentinized. The eastern reservoir area would inundate younger Cretaceous age sedimentary rocks of the Panoche Formation (Bishop 1970). The Panoche Formation includes a variety of rock types including shale, siltstone, claystone, sandstone and conglomerate. Some of these lithologies represent turbidite (deep water mudflows) deposits and include sedimentary structures such as flute casts, load casts, and cross laminations.

The Ortigalita Fault is generally the boundary between the upthrown, sheared and complexly folded rocks of the Franciscan Formation in the western portion of the proposed reservoir and the younger Mesozoic sedimentary rocks in the east.

The valley floor sediments consist of Quaternary alluvium – unconsolidated stream and basin deposits ranging in size from clay to boulder. The thickness of the valley floor deposits is unknown.

Seismicity The site is subject to ground shaking caused by earthquakes. The geologic map (Figure A-17) does not show a fault crossing this potential reservoir site. However, the computer program EQFAULT lists the Great Valley 7 Fault as the closest fault at less than a mile away. Other close faults include the Great Valley 8 Fault at 8.8 miles, the Greenville Faults at 13.2 miles, and the Ortigalita Fault at 17.7 miles. The San Andreas Fault is 43.0 miles away. The maximum earthquake site acceleration is estimated to be 0.46g.

Liquefaction The site is generally comprised of sedimentary rocks; therefore, liquefaction susceptibility is considered very low.

Landsliding The geologic map (Figure A-17) does not depict the presence of any major landslides, although the 1:24,000 scale map presented may not depict all landslides. Relatively steep terrain may indicate that historical landslides are not very common in the area. Site-specific investigations and review of historic aerial photographs may reveal further information on landsliding.

Material Availability Materials in the immediate vicinity of the dam embankment consist of Moreno Formation and Panoche Formation. These materials can be processed and used for embankment construction. The area is not developed and material availability is not considered to be a concern. However, due to the relatively large embankment volume involved, a more detailed evaluation of materials will be needed in subsequent phases if this alternative is carried forward.

Foundation Treatment Requirements Foundation treatment would involve removal of localized unsuitable materials, weathered zones, and possibly some of the organic shale of the Moreno Formation, depending on site conditions. Due to the large embankment height, there may be a need for other specialized foundation treatment. Need for deep foundation overexcavation is not anticipated at this time.

Hydraulic Conditions

The Ingram Canyon Reservoir would drain toward the east of San Luis Reservoir within the San Joaquin River Valley. This would require construction of 2.41 miles of conveyance pipeline to deliver water to the California Aqueduct. Because US Highway 5 is west of the California Aqueduct, the pipeline would have to be tunneled under the highway.

Ingram Reservoir - Hydraulic Conditions Criteria

Conveyance Length *– 2.4 mi*
Spillway *– Extensive*
Flood Protection *– Not Significant*

New auxiliary and service spillways would be required at this site. Increasing the storage capacity at this reservoir location has no significant flood control benefits. Constructing a new dam at this location will increase the overall risk to the inhabitants and property downstream should a dam break occur. Assessing the potential hazard at this location is not part of this current effort. A dam hazard classification would be conducted should this location be selected for full design.

Land Development and Social Impacts

Ingram Reservoir - Land Development and Social Criteria

Inundated Roadway Miles *– 6.6 mi*
Additional Inundation Area *– 1,995 Ac*
Affected Developed Areas *– Minor*
Land Acquisition *– Minor*

Figure A-16 shows the estimated inundation area that Ingram Canyon Reservoir would create. Preliminary GIS analysis completed as a part of this reservoir screening effort also indicates about 6.6 miles of existing roadways would require relocation. The reservoir would inundate several rural residences and associated structures.

A.2.7 Del Puerto Canyon Reservoir

Physical Conditions

Del Puerto Reservoir - Physical Conditions Criteria

Embankment Efficiency *– 248 CY/AF*
Storage Utilization *– 143 AF/Ac*
Dam Raise *– 505 ft*

The Del Puerto Canyon Reservoir Alternative (see Figure A-18) would be east of San Luis Reservoir. The Del Puerto Canyon Reservoir would be subject to larger storage goals to meet user needs as well as existing uses, flood control, and dead storage as described in Appendix B of the IAIR. This is a largely undeveloped site, which would impound water within the Del Puerto Canyon. The crest for this dam would be at Elevation 780 feet and the crest length would be approximately 6,750 feet. This alternative meets the desired goal of 271 TAF of storage capacity; however, at the expense of a very large dam. Table A-2 lists the east and north coordinates of the new crest at the intersections between the new dam axis and the abutments. Table A-3 provides the physical properties of the proposed dam. The quantitative measures used in the screening are summarized in Table A-4.

This new 505-foot high dam would require earthwork of approximately 67.9 million cubic yards, which is the largest earth volume of all sites being considered. The ratio of earthwork to reservoir capacity for this site is 248 CY per every AF of storage gained, which indicates a very low efficiency for the dam embankment. The amount of inundated land would be approximately 1,900 Ac, yielding a storage capacity to reservoir footprint value of 142 AF per Ac. This indicates a favorable storage utilization condition.

Geotechnical and Geological Conditions

Del Puerto Reservoir - Geotechnical and Geological Conditions Criteria

Liquefaction – *Very Low*
Distance to Faults *– >1.0 miles*
Landslide Potential *– Very Low*
Foundation Treatment *– Moderate*
On-site Material *– Available*

Geology Figure A-19 depicts the local geologic conditions near the proposed Del Puerto Canyon Dam (Bishop 1970). Abutment rocks for the proposed Del Puerto Dam are Upper Cretaceous age sedimentary rocks along the west side of the San Joaquin Valley that strike northwest and dip moderately to steeply toward the northeast. Bedding dips are generally 50 to 65 degrees but locally some beds are overturned to the west.

The proposed reservoir is underlain by moderately to steeply dipping Cretaceous age rocks of the Panoche and Moreno formations (Bishop 1970). The Panoche Formation includes a variety of rock types including shale, siltstone, claystone, sandstone and conglomerate. Some of these lithologies represent turbidite (deep water mudflows) deposits and include sedimentary structures such as flute casts, load casts, and cross laminations. The Moreno Formation includes shale and thin sandstone beds.

The valley floor of Del Puerto Canyon is predominantly underlain by unconsolidated stream channel deposits ranging in size from clay to boulder. The thickness of the valley floor deposits is unknown.

Seismicity The site is subject to ground shaking caused by earthquakes. The geologic map (Figure A-19) does not show a fault crossing this potential reservoir site. However, the computer program EQFAULT lists the Great Valley 7 Fault as the closest fault at less than a mile away. Other close faults include the Great Valley 8 Fault at 4.5 miles and the Greenville Faults at 16.8 miles. The San Andreas Fault is 43.2 miles away. The maximum earthquake site acceleration is estimated to be 0.46g.

Liquefaction The site is generally comprised of sedimentary rocks and therefore liquefaction susceptibility is considered very low.

Landsliding The geologic map (Figure A-19) does not depict the presence of any major landslides at the abutments, although local areas of landslides are present just upstream of the abutments. Geologic map coverage of the same area in Figure A-17 does not indicate the presence of any landslides. Owing to the scale of the geologic maps and given the abutment lithologies, it is likely that smaller landslides exist near the proposed abutments but these are not considered significant threats. Site-specific investigations and review of historic aerial photographs may reveal further information. Based on the limited available information, this site is considered to have low to some landslide risk.

Material Availability Materials in the immediate vicinity of the dam embankment consist of Moreno Formation and Panoche Formation. These materials can be processed and used for embankment construction. Due to the large embankment volume involved, a more detailed evaluation of materials is needed in subsequent phases.

Foundation Treatment Requirements Foundation treatment would involve removal of localized unsuitable materials, weathered zones, and possibly some of the organic shale of the Moreno Formation, depending on site conditions. Due to the large embankment height, there may be a need for other specialized foundation treatment.

Hydraulic Conditions

The Del Puerto Canyon Reservoir would drain toward the east of San Luis Reservoir within the San Joaquin River Valley. This would require a conveyance pipeline 1.95 miles long to deliver water to the California Aqueduct. Because US Highway 5 is west of the California Aqueduct, the pipeline would have to be tunneled under the highway.

Del Puerto Reservoir - Hydraulic Conditions Criteria

Conveyance Length *– 2.0 mi*
Spillway *– Extensive*
Flood Protection *– Not Significant*

New auxiliary and service spillways would be required at this site. Increasing the storage capacity at this reservoir location has no significant flood control benefits. Constructing a new dam at this location will increase the overall risk to the inhabitants and property downstream should a dam break occur. Assessing the potential hazard at this location is not part of this current effort. A dam hazard classification would be conducted should this location be selected for full design.

Land Development and Social Impacts

Del Puerto Reservoir - Land Development and Social Criteria

Inundated Roadway Miles *– 6.9 mi*
Additional Inundation Area *–1,900 Ac*
Affected Developed Areas *– Minor*
Land Acquisition *– Minor*

Figure A-18 shows the estimated inundation area that the Del Puerto Canyon would create. Preliminary GIS analysis completed as a part of this reservoir screening effort also indicates approximately 6.9 miles of existing roadways would require relocation. The reservoir would inundate several houses and associated structures.

A.2.8 Quinto Creek Reservoir

Physical Conditions

Quinto Reservoir - Physical Conditions Criteria

Embankment Efficiency *– 166 CY/AF*
Storage Utilization *– 109 AF/Ac*
Dam Raise *– 310 ft*

Figure A-20 depicts the Quinto Creek Canyon Reservoir Alternative, which would be constructed east of San Luis Reservoir. The Quinto Creek Canyon Reservoir would be subject to larger storage goals to meet user needs as well as existing uses, flood control, and dead storage as described in Appendix B of the IAIR. This is a largely undeveloped site, which would impound water within the Quinto Creek subwatershed. The crest of this dam would be at Elevation 655 feet and the crest length would be 12,100 feet. This alternative meets the desired goal of 271 TAF of storage capacity; however, at the expense of a very large dam. Table A-2 lists the east and north coordinates of the new crest at the intersections between the new dam axis and the abutments

This new 315-foot high dam would require earthwork of approximately 45.0 million cubic yards; This value does not include potential foundation overexcavation. Considerable overexcavation may be needed since the dam spans over a very wide alluvial basin. The estimated ratio of earthwork volume to reservoir capacity is 166 CY per every AF of storage gained. The amount of inundated land would be approximately 2,480 Ac, yielding a ratio of storage capacity to reservoir footprint of 109 AF per Ac.

Geotechnical and Geological Conditions

Quinto Reservoir - Geotechnical and Geological Conditions Criteria

Liquefaction *– High*
Distance to Faults *– >1.0 mi*
Landslide Potential *– Very Low*
Foundation Treatment *–Significant*
On-site Material *– Substantial Hauling*

Geology Figure A-21 (Wagner and et. al. 1991) depicts the local geologic conditions near the proposed Quinto Creek Dam. The proposed dam abutments are underlain by Upper Cretaceous age sedimentary rocks along the west side of the San Joaquin Valley that strike northwest and dip moderately to steeply toward the northeast. Bedding dips are generally 50 to 65 degrees but locally some beds are overturned to the west.

The proposed reservoir is underlain by the same sedimentary rock type – Cretaceous age sedimentary rocks of the Panoche Formation described by Bishop (1970). The Panoche Formation includes a variety of rock types including shale, siltstone, claystone, sandstone, and conglomerate. Some of these lithologies represent turbidite (deep water mudflows) deposits and include sedimentary structures such as flute casts, load casts, and cross laminations. Local bedrock faults of unknown age, possibly related to movement of the Ortigalita Fault are within the proposed reservoir area.

The valley floor of the Quinto Creek Canyon is predominantly underlain by unconsolidated stream channel deposits ranging in size from clay to boulder. The thickness of the valley floor deposits along Quinto Creek is unknown.

Seismicity The site is subject to ground shaking caused by earthquakes. The geologic map (Figure A-21) does not show a fault crossing this potential reservoir site. The Ortigalita Fault is near the extreme western end of the proposed reservoir but would not underlie the reservoir.

The computer program EQFAULT lists the Great Valley 8 Fault as the closest fault at less than a mile away. Other close faults include the Ortigalita Fault at 2.9 miles and the Great Valley 9 Fault at 4.7 miles. The San Andreas Fault is 30.4 miles away. The maximum earthquake site acceleration is estimated to be 0.43g.

Liquefaction The dam site would be across a relatively wide alluvial valley (Figure A-21). Available published geologic information characterizes the basin as San Luis Ranch Alluvium, with some of the bordering areas consisting of Los Banos Alluvium. These deposits are locally susceptible to liquefaction depending on their in-place densities. The abutment areas would typically be comprised of Moreno or Panoche formations, which would not be susceptible to liquefaction.

Landsliding The geologic map (Figure A-21) does not depict the presence of any major landslides at the abutments, however, given the abutment lithology, and the potential out of slope bedding at the right abutment, it is likely that smaller landslides may be encountered. Site-specific investigations and review of historic aerial photographs may reveal further information. Based on available limited information, this site is considered to have low to very low landslide risk.

Material Availability Materials in the immediate vicinity of the dam embankment consist of alluvium, Moreno Formation, and Panoche Formation. These materials can be processed and used for embankment construction. A large embankment volume is involved. The dam is situated over a very wide alluvial basin and there may be limitations in the availability of hillside materials which are generally more competent. Mining of the nearby hillsides would require a more detailed evaluation of available materials, which should be done if this alternative is carried forward.

Foundation Treatment Requirements The depth of alluvium in the basin should be determined and the feasibility of removal down to bedrock should be verified. In general, removal of all alluvium is desirable for foundation stability and for liquefaction remediation. Depending on removal depths involved, this would further increase the volumes and decrease the efficiency of this site. The tabulated values for estimated embankment volumes do not include additional removal of alluvium, which may be required.

Hydraulic Conditions

Quinto Reservoir - Hydraulic Conditions Criteria

Conveyance Length *– 2.8 mi*
Spillway *– Extensive*
Flood Protection *– Not Significant*

The Quinto Creek Reservoir would drain toward the east of San Luis Reservoir within the San Joaquin River Valley. This would require construction of 2.82 miles of conveyance pipeline to deliver water to the California Aqueduct. New auxiliary and service spillways would be required at this site.

Increasing the storage capacity at this reservoir location has no significant flood control benefits. However, constructing a new dam at this location will increase the overall risk to the inhabitants and property downstream should a dam break occur. Assessing the potential hazard at this location is not part of this current effort. A dam hazard classification would be conducted should this location be selected for full design.

Land Development and Social Impacts

Quinto Reservoir - Land Development and Social Criteria

Inundated Roadway Miles *– 5.6 mi*
Additional Inundation Area *–2,480 Ac*
Affected Developed Areas *– Minor*
Land Acquisition *– Minor*

Figure A-20 shows the estimated inundation area that the Quinto Creek Reservoir would create. Preliminary GIS analysis completed as a part of this reservoir screening effort also indicates approximately 5.6 miles of existing roadways would require relocation. The Quinto Creek Reservoir would inundate several houses and associated structures.

A.3 Screening Results

A.3.1 Screening Scores

The screening criteria described in Section A.1 were used to assign scores to each storage alternative based on the evaluations presented in Section 2. The individual and total scores for each storage alternative are provided in Table A-5. Note that all criteria were considered to have equal weight, and potential overriding issues were not given additional emphasis. Table A-6 highlights the high scoring sites in each of the four screening dimensions (physical, geotechnical, hydraulic, and impact). The overall high scoring site based on total scores is also indicated in Table A-5. The scores for each site and screening dimension have been calculated as percentages and are presented in Table A-5.

A.3.2 Screening Evaluation

Low Screening Criteria Ratings

Both the Anderson and Chesbro Reservoir Expansion storage alternatives have multiple low social and land development impact ratings. The large number of private residences potentially inundated by expanding these reservoirs, as well as the estimated surface streets that would be flooded, present a much larger potential social impact relative to the majority of storage alternatives considered in this screening effort. In addition, there is an increased risk of landslide hazards for other residences that would remain around the expanded reservoir. Based on these findings, the Anderson and Chesbro Reservoir alternatives have been eliminated from further consideration.

The San Benito Reservoir storage alternative was given a storage goal equal to the available capacity at this location. Its abutment as proposed would cross the Calaveras Fault, and the Paicines Fault would be very close to the reservoir. The presence of these faults creates a high risk for dam stability during an earthquake event and would require extensive engineering work to minimize the chance of failure. Because of the high level of engineering work and relatively small potential storage capacity of 60 TAF comparative to other reservoirs being considered, this alternative has been eliminated from further consideration as an alternative.

Del Puerto Canyon Reservoir would require a very large dam embankment to create storage volumes that meet the capacity goals outlined in the IAIR. The Quinto Creek Reservoir would also require a very large dam embankment to develop storage volumes that meet the capacity goals outlined in the IAIR, and would be located near a potentially active fault. Because of the low storage

Table B-5 - Screening Scores

Storage Alternative Site	**Physical Condition Scores**				**Geotechnical/Geological Condition Scores**					**Hydraulic Condition Scores**			**Social/Land Development Impact Scores**				**Total Score**
	Embankment Volume CY/ Storage Capacity AF	Storage Capacity AF/ Reservoir Area AC	Dam Raise FT	Meet Capacity Goal	Liquefaction Potential	Distance to Faults	Potential for Landslides	Foundation Treatment Required	On-Site Material Conditions	Conveyance Length MILES	Spillway Construction	Flood Protection Benefits	Inundated Roadways MILES	Additional Inundation Area	Developed Areas Impacted	Land Acquisition Issues	
Anderson	9	5	9	10	8	4	3	4	5	9	3	2	7	6	1	1	86
Chesbro	6	5	7	10	6	6	4	4	3	5	4	2	1	5	1	1	70
Pacheco A	7	7	5	10	5	7	1	4	7	9	4	8	10	5	9	7	**105**
Pacheco B	7	7	5	1	5	7	5	5	7	7	4	8	7	5	9	7	96
San Benito	10	2	7	5	5	1	2	1	3	1	6	8	6	6	7	8	78
Ingram	5	10	1	10	9	2	9	6	9	6	1	2	4	3	8	9	94
Del Puerto	1	10	1	10	9	2	8	6	7	7	1	2	4	3	8	9	88
Quinto Dam	3	7	4	10	3	2	9	3	3	5	1	2	5	1	8	9	75

Color Key:

🟨	Site(s) with high subtotal score in a criteria category (physical, geotechnical, hydraulic, land impact)
⬜	Site with high total score in all criteria categories combined

Notes:

1. Higher scores are more favorable
2. See Table 2.1 for quantitative site parameters
2. See Table 1.1 for scoring criteria of qualitative and quantitative parameters

Same Scores as Percentages (100% = Perfect Score)

Storage Alternative Site	**Subtotals**				**Total**
	Physical	**Geotechnical**	**Hydraulic**	**Impact**	
Anderson	83%	48%	47%	38%	54%
Chesbro	70%	46%	37%	20%	43%
Pacheco A	73%	48%	70%	78%	**67%**
Pacheco B	50%	58%	63%	70%	60%
San Benito	60%	24%	50%	68%	50%
Ingram	65%	70%	30%	60%	56%
Del Puerto	55%	64%	33%	60%	53%
Quinto Dam	60%	40%	27%	58%	46%

efficiency of these sites relative to the other reservoir alternatives being considered, and in the case of the Quinto Creek Reservoir, its proximity to a potentially active fault, the Del Puerto Canyon Reservoir and Quinto Creek Reservoir alternatives have been eliminated from further consideration

Highest Scoring Alternatives

The Pacheco A Reservoir storage alternative received the highest total rating score for the selected screening criteria. Pacheco B received the second highest score and did not have any low criteria rating scores; however, it would not meet the total storage volume goal. Pacheco A would meet the goal, but has a single low rating score for landsliding. These alternatives (Pacheco A and Pacheco B) will be carried forward for consideration and refinement in the Plan Formulation Phase of the low point project as a single alternative concept.

A.3.3 Recommended Alternatives

Based on the screening scores and screening evaluation, three recommendation levels were established and assigned to each storage alternative, as follows:

1. Storage alternative should be eliminated from further consideration due to significant higher earthwork costs and/or greater impacts than other alternatives.

2. Storage alternative requires additional study to determine if the higher costs and/or greater impacts than other options might be lessened based on study results.

3. Storage alternative should be carried forward for additional evaluation.

Table A-6 lists the level of further consideration recommended for the storage alternatives along with a brief discussion of the justification for such recommendation. In summary, five of the original alternatives are recommended for elimination, one alternative is reserved for further study if the recommended alternative is found to be infeasible, and the Pacheco Reservoir Alternative concept is recommended for study in the Plan Formulation Phase of the San Luis Low Point Improvement Project Feasibility Study.

Table A-6. Recommended Storage Alternatives

Storage Alternative	Recommended Level	Discussion
Anderson Reservoir	1	Anderson Reservoir is surrounded by extensive potential landslide zones that with reservoir expansion would be subjected to annual wetting and drying cycles that could activate slides. These landslide zones include one slide area directly in line with the expanded dam embankment. The reservoir is also surrounded by over 100 high value homes that would be inundated by an expanded reservoir as well as others potentially affected by landslides activated by the expanded reservoir.
Chesbro Reservoir	1	Chesbro Reservoir is surrounded by multiple potential landslide zones that with reservoir expansion would be subjected to annual wetting and drying cycles that could activate slides. Developed areas surround the reservoir and enlargement of the existing dam would inundate over 40 residences, potentially activate landslides near or under residences not inundated, and inundate app. 9.8 miles of existing roadway.
Pacheco A Reservoir	3	The Pacheco A site has a large landslide area mapped near the potential dam abutment that could require the relocation of the dam site upstream in between the proposed Pacheco A and Pacheco B sites to avoid the landslide areas. Further engineering analysis will be needed to identify the optimal dam site.
Pacheco B Reservoir	2	The Pacheco B site is unable to support the development of the needed 150 TAF to address the objectives of this project. The potential dam site in between Pacheco A and Pacheco B could avoid landslides in the area and provide the needed storage capacity to serve the project objectives. Pacheco B has superior geotechnical qualities over Pacheco A, however it does not meet the storage goal requirements.
San Benito Reservoir	1	The San Benito Reservoir abutment as proposed would cross the Calaveras Fault with an estimated maximum earthquake acceleration of 0.36g. The presence of this fault creates a high risk for dam stability during an earthquake event and would require extensive engineering work to minimize the chance of failure. This high level of engineering work and relatively small potential storage capacity of 60 TAF comparative to other reservoirs being considered resulted in its elimination from further consideration.
Ingram Canyon Reservoir	2	Ingram Canyon Reservoir would create the needed storage capacity to meet the storage objectives but would require a substantially larger amount of embankment volume to achieve that storage target. A reservoir at Ingram Canyon would require 27 million yd^3. Ingram Canyon Reservoir is being tentatively retained in consideration if the landslide issues on Pacheco Creek cannot be avoided.
Del Puerto Canyon Reservoir	1	Del Puerto Canyon Reservoir would require a 505 foot tall earth embankment requiring 68 million yd^3 to store 271 TAF. This is much larger than other dam options and does not meet the project's financial objective.
Quinto Creek Reservoir	1	Quinto Creek Reservoir would be located near a potentially active fault and would require a 310 foot tall earth embankment requiring 45 million yd^3 store 271 TAF. This is much larger than other dam options and does not meet the project's financial objective.

[a] Recommended Level:

1 = Eliminate from further consideration

2= Do not eliminate from consideration pending further analysis of reservoir options

3 = Carry forward for additional review

A.3.4 Next Steps

Based on the findings of this report, storage alternative evaluation in the Plan Formulation Phase should consider the Pacheco Reservoir Alternative concept for further investigation regarding its feasibility as a project alternative. A site visit to the potential location of the dam will need to be performed to visually inspect landslides and other potential issues. Hydraulic modeling will need to be conducted for the proposed dam operations, and geometry that is more detailed will be developed. A conceptual cost estimate of the alternatives selected at this stage will be completed for the site deemed technically and institutionally feasible.

It is recommended that the Pacheco A and B alternatives be investigated as one alternative in order to identify the site that will provide the greatest benefit. If the landslide concerns can be remediated effectively, the Pacheco A site would be well suited relative to the screening criteria. If Pacheco A’s landslide concerns are significant after site visits, the Pacheco B alternative would provide similar project benefits with only a slightly smaller capacity. The storage goal for Pacheco B should be reviewed and a better definition of the embankment location and resulting reservoir capacity determined.

It is highly probable that a suitable location on Pacheco Creek would be to move upstream of the Pacheco A site until landslide conditions are more favorable and to move downstream of the Pacheco B site until capacity requirements are met. A desirable dam location can be found within this range, somewhere between the current Pacheco A and Pacheco B sites. Within this reach, detailed geotechnical evaluations can be performed and cost impacts of remediation of different locations can be compared, in order to establish the most suitable location.

Given the geological and geotechnical concerns of the region, it is not expected that a location would be entirely free of landslide concerns. Even with a worst-case scenario requiring a major landslide remediation, the Pacheco A site is considered feasible. If a location can be identified which requires potentially less landslide remediation volume, then that Pacheco alternative would be considered even more feasible than the current Pacheco A site.

Rather than proceeding with further study of the Ingram Canyon Reservoir, which requires a very tall dam, it is recommended that the study be put on hold until a more in-depth study of the Pacheco Reservoir Alternative concept is conducted. If that feasibility is exhausted, then the studies can move on to evaluating the Ingram Canyon alternative.

Detailed studies to address the landslide issues for the Pacheco Reservoir Alternative concept may be phased in progressively increasing steps. These should include: review of aerial photos, site reconnaissance, bucket auger boreholes with downhole logging for landslide evaluations, ground movement monitoring, landslide remediation alternative studies, and other activities, as appropriate and as needed.

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San Luis Low Point Improvement Project Planning Study Report

Appendix B Hydrologic Modeling Technical Report

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

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Contents

Tables

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Chapter 1
Background and Project Description

The purpose of the San Luis Low Point Improvement Project (SLLPIP) is to address the delivery schedule uncertainty and water supply reliability problems with San Luis Reservoir when reservoir storage drops below a certain threshold and low point issues may develop. Low point issues occur when conditions in San Luis Reservoir promote the growth of reservoir-wide algae. Algae blooms generally reach diversion facilities when reservoir storage is at or below 300,000 acre-feet (AF), corresponding to a lake elevation of approximately 370 feet. The first diversion facilities to be affected by algae blooms are intakes for the Pacheco Pumping Plant serving the San Felipe Division of the Central Valley Project (CVP). Water quality within algae blooms is not suitable for municipal and industrial water users and existing water treatment facilities in Santa Clara County, and may not be suitable for agricultural water users with drip irrigation systems in San Benito County. The SLLPIP investigated alternatives to remedy these potential issues and avoid supply interruptions to San Felipe Division contractors due to algae blooms in San Luis Reservoir.

This technical appendix to the Planning Study Report and environmental documentation describes modeling tools and assumptions used in analysis of SLLPIP alternatives. The Planning Study evaluated several alternatives for the ability to satisfy SLLPIP objectives. Each alternative was simulated in a model of the CVP and State Water Project (SWP) to determine effects on water supply for the San Felipe Division, Santa Clara Valley Water District (SCVWD), and effects in other areas of the CVP/SWP[1]. CalSim II model results for each alternative were compared to results of a No Action Alternative to quantify changes in water deliveries, reservoir storage levels, river flows, and CVP/SWP operations in the Sacramento-San Joaquin River Delta (Delta). Simulated water deliveries were used in the economic analysis of each alternative, conducted as part of the Planning Study. Simulated reservoir storage, river flow, Delta outflow and Delta exports were used to evaluate environmental effects during preparation of the Environmental Impact Statement/Environmental Impact Report (EIS/EIR). Key model results are summarized and presented in this report for each alternative. Model results for each alternative were subsequently input to the water supply model used by SCVWD to simulate the local effects of each alternative on the operation and performance of the SCVWD system. Water Evaluation and Planning (WEAP) model results for each alternative were compared to a No Action Alternative to quantify the effects of each alternative

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[1] The Treatment Alternative would provide SCVWD uninterrupted access to storage in San Luis Reservoir similar to the access that would be provided by implementation of the Lower San Felipe Intake. As a result, the modeling results presented in this appendix for the Lower San Felipe Intake are utilized in the EIS/EIR and Planning Study Report to evaluate anticipated water supply impacts and benefits for both alternatives.

to local water treatment plant (WTP) deliveries, and local surface and groundwater storage that contribute to SCVWD emergency water supply.

Chapter 2
Water Operations Modeling

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

2.1 Operations Models

Two models were used to analyze effects of SLLPIP alternatives. CalSim II was used to simulate CVP/SWP operations, including San Luis Reservoir and San Felipe Division deliveries. Subsequent analysis includes input of Calsim II CVP and SWP allocation and delivery results for each alternative to a WEAP model of the SCVWD system to simulate the local effects on the operation and performance of the SCVWD system.

2.1.1 CalSim II

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

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

CalSim II modeling conducted for the SLLPIP was developed from a baseline model provided by Reclamation to the project team. A baseline CalSim II simulation at a future level of development (LOD) was developed by Reclamation in January 2015. Baseline studies include actions in the reasonable and prudent alternatives from National Marine Fishery Service's (NMFS') 2009 Biological Opinion (BO) for Chinook salmon and United States Fish and Wildlife Service's (USFWS') 2008 BO for delta smelt. Additional key assumptions governing CVP/SWP operations in CalSim II are described in Attachment A to this Appendix.

2.1.2 CalSim II Representation of San Felipe Division

Water service contractors supplied through the Pacheco Pumping Plant make up the San Felipe Division of the CVP and include SCVWD, San Benito County Water District (SBCWD), and Pajaro Valley Water Management Agency. Table 2-1 summarizes agricultural and municipal and industrial (M&I) water service contracts, in thousands of AFAF per year, represented in CalSim II for each agency in the San Felipe Division.

Table 2-1. CVP San Felipe Division Annual Contract Quantities (1,000 AFAF)

Agency	Ag Contract	M&I Contract	Agency Total
Santa Clara Valley Water District	33.1	119.4	152.5
San Benito County Water District	35.6	8.3	43.9
Pajaro Valley Water Management Agency	6.3	0.0	6.3
Total by Contract Type	75	127.7	202.7

Calsim II simulates delivery of this contract water through the Pacheco Pumping Plant. CalSim II simulates Reclamation's annual allocation process for agricultural and M&I water service contracts in various divisions of the CVP. CalSim II uses a monthly demand pattern that varies from one month to the next but is the same each year to simulate delivery of CVP contract supplies. Monthly deliveries are subject to model allocations, annual contract amounts, and availability of water to meet contract demands.

2.1.3 Modifications to Reclamation CalSim II Baselines

Baseline models provided by Reclamation required modifications for use in evaluating operations under SLLPIP alternatives, including the Future No Action (FNA). The following sections describe key changes.

2.1.3.1 Refined Export Estimates and San Luis Reservoir Operations

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

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

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

The third improvement with implications to the operation of San Luis Reservoir and the SLLPIP were modifications to the San Luis target storage levels, or “rulecurve”, in CalSim II. The purpose of rulecurve is to prioritize balance between storage in north-of-Delta (NOD) reservoirs and San Luis Reservoir for both the CVP and SWP. Rulecurve controls release from NOD reservoirs for export when there is a choice between storing water in NOD reservoirs and releasing water for export and storing it in San Luis Reservoir. Rulecurve was improved to better simulate the scheduling of releases and Delta exports to balance storage in CVP and SWP reservoirs.

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

2.1.3.2 San Felipe Division M&I Delivery Interruptions

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

2.1.4 Level of Development

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

A FNA CalSim II simulation depicts how the Delta, its major tributaries, and the CVP/SWP may operate in the future without the Project. Areas tributary to the Delta have experienced numerous physical and institutional changes over the years, and are continuing to experience change. Projecting the availability of facilities, institutional, and regulatory requirements, and the practices that will affect the management of future water supplies and demands is a daunting task. Nevertheless, reasonable assumptions must be made regarding these items to estimate future conditions. These assumptions include actions in the reasonable and prudent alternatives from NMFS' 2009 BO for Chinook salmon and USFWS' 2008 BO for delta smelt.

2.1.5 CalSim II Limitations

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

One method for evaluating model adequacy is to compare model results with observed data. Unfortunately, this method is no longer appropriate for CalSim II and San Luis Reservoir storage. CalSim II assumptions for the Future No Action Alternative include actions in the reasonable and prudent alternatives from USFWS' 2008 BO for delta smelt and NMFS' 2009 BO for Chinook salmon. These two operational constraints were added to the system in 2008 and 2009, respectively. Requirements contained in the BOs result in significant operational changes including changes in upstream reservoir release, the ability to move water through the Delta, and the operation of both the CVP and SWP portions of San Luis Reservoir. CVP/SWP operators have operated to these requirements since 2009 providing only a few years of observed data under the BOs. The CalSim II simulation period does not include the historical hydrology for this period. Therefore, there is no common period between the model and observed data under a similar regulatory condition. A comparison of historical San Luis Reservoir storage and simulated storage under the BOs illustrates the change in regulatory requirements, but is not useful for understanding model limitations.

2.1.6 Santa Clara Valley Water District's WEAP Model

SCVWD uses the WEAP system model developed by the Stockholm Environment Institute's U.S. Center. WEAP is a software tool for water resources planning. WEAP uses a database to maintain water demand and supply information and drive the mass balance on a link-node architecture. In addition, the model evaluates a full range of water development and management options, and takes account of multiple and competing uses. The following model description was adapted from a document provided by SCVWD staff.

2.1.6.1 General Model Description

The SCVWD WEAP model is designed primarily to simulate SCVWD's local water system of facilities that recharge Santa Clara County's groundwater basins, operation of its reservoirs and creeks, existing and proposed treatment and distribution facilities, and raw water conveyance system of imported water. WEAP also accounts for non-District sources and distribution of water in Santa Clara County , including: imported water from the Hetch-Hetchy System, recycled water, and local water developed by other agencies. WEAP was formulated to simulate the total management of current and future water resources within Santa Clara County.

WEAP operates on a monthly time-step, and can simulate any defined set of hydrologic years with either fixed demands or any sequence of yearly demands. For this analysis, WEAP used an 82-year hydrologic record consistent with CalSim II.

WEAP is primarily a surface water supply simulation model. However, WEAP does track groundwater basin storage as a mass balance of inputs and outputs. The central focus of WEAP results is typically operation of the County's groundwater basins; the artificial recharge of sufficient water such that total natural and artificial recharge balances demands on the basins within the bounds of operational basin storage capacity. WEAP can also pass pumping demand data and recharge data to SCVWD's groundwater models to ensure basin storage results are in-line with groundwater model determinations.

2.1.6.2 Major Components of WEAP

WEAP has a data structure composed of five major systems: water demands, groundwater, local surface water, treated water, and raw water conveyance. Each major system is described in further detail below.

2.1.6.2.a Water Demands System

The water demands system is designed around a long-standing division of the County into water service areas that are closely associated with water retailer areas. Areas that are not served by a retail water agency are delineated using geographic and/or hydrologic boundaries. Water demand data have been developed using another model that uses census data and growth projections to generate annual service area water demands. These water demands are then reconciled with each retailer's Urban Water Management Plan for growth projections.

Water is delivered to meet demands according to availability, and priority. Commonly, the lowest priority source of supply (or last to be used to meet service area demands) is groundwater. Therefore, service area groundwater pumping is calculated as the supply necessary to meet service area water needs after taking into account conservation, treated water, and other available alternate supplies for a specific service area.

2.1.6.2.b Groundwater System

The groundwater system comprises the County's three groundwater subbasins and is currently depicted in WEAP with each basin having specific recharge, pumping, and subsurface inflows and outflows. Recharge occurs through streams and existing or planned recharge ponds that are located over the groundwater basins. Groundwater pumping is simulated to occur in water service areas associated with each basin.

The most northern basin is called the Santa Clara Valley basin. The central basin is called the Coyote basin. The southern basin is called the Llagas basin. One of the primary objectives of WEAP's Groundwater System is to determine if the basins all stay within their respective operational storage capacities and subsidence does not occur.

2.1.6.2.c Local Surface Water System

The local surface water system contains the major watersheds and their respective streams. The major streams, as used in WEAP, are those that are either: (1) controlled by a storage reservoir; (2) receive imported water; or (3) directly affect flow of a stream that is controlled by a reservoir or receives imported water. Each major stream that is processed by WEAP is defined as either regulated (controlled by reservoir releases) or unregulated (not controlled by a reservoir).

Regulated stream flow data are defined in WEAP as monthly unimpaired flows at the various reservoirs sites and downstream accretions between the reservoir and the basin boundary. Unregulated stream flows are defined in WEAP as monthly stream flows of the unregulated streams at the upstream basin boundary.

Recharge ponds are another part of the local surface water system. Recharge ponds can be connected to streams and/or raw water pipeline turnouts and can provide a source of recharge for associated groundwater basins.

Each major stream and recharge pond are defined within this system with a monthly recharge rate based on observed historical rates. Each stream has a variety of methods for connecting to other streams, reservoirs, ponds and raw water piping node recharge turnouts.

2.1.6.2.d Treated Water System

The treated water system, as depicted in WEAP, is comprised of a number of subsystems which simulate operation of SCVWD's distribution systems and three treatment plants: Rinconada, Penitencia, and Santa Teresa.

2.1.6.2.e Raw Water Conveyance System

The raw water conveyance system comprises the pipelines, canals, conduits, pumping plants, and other related facilities used to convey both imported and local raw water to recharge facilities, treatment plants, reservoirs, and other miscellaneous raw water turnouts.

Two imported water supplies are simulated in WEAP. One is from the South Bay Aqueduct (SBA) of the SWP and the other is from the San Felipe Division of the CVP. Raw water supplies available from the SWP/CVP are provided through contracts with the State and Federal governments. SCVWD's SWP contract is for 100,000 AF annually of Table A water. SCVWD's CVP contract is for 152,500 AF annually. WEAP relies on CalSim II's representation of CVP/SWP operations and deliveries through the SBA and Pacheco Pumping Plant, by using CalSim II output for CVP and SWP allocations and deliveries as input.

SCVWD participates in a water banking and exchange program with the Semitropic Water Storage District in Kern County. In wetter years, SCVWD is able to store excess Delta-conveyed water in the Semitropic groundwater bank for later use, particularly in dry years. This operation is defined in WEAP.

A banking arrangement with agencies from outside of Santa Clara County is also defined in WEAP to store excess imported supplies in wet years and draw upon these banked supplies in drought years.

2.1.6.2.f System Water Needs

WEAP's first major step in the analysis process is establishment of system water needs. Annual projected total water needs, expected water conservation savings, and expected sources of supply for each water service area are defined by the user. Sources of annual supplies are:

(1) Treated water from Rinconada, Penitencia, and Santa Teresa

(2) Other sources not managed by SCVWD (e.g. Hetch-Hetchy System)

(3) Raw surface water deliveries from SCVWD's raw water pipelines

(4) Recycled water from existing or proposed facilities

(5) Groundwater

(6) Water conservation

All or any combination of the above sources of water may be available to a service area. Groundwater pumping is computed by WEAP as the difference between a service area's total annual demands and its other annual sources of supplies.

2.1.6.2.g Operation of Local Facilities

WEAP then simulates reservoir operations using the defined storage rule curve for each reservoir. Rule curves define how much water can be released from the reservoir to meet remaining recharge capacity in ponds and streams connected to the regulated outlet stream. Reservoirs can also be connected to raw water pipelines and release water to meet these demands. When the reservoir is simulated to spill water, some of this excess can be moved to a pipeline if conveyance and demand allow. In times of excess imported CVP/SWP supply, reservoirs connected to a pipeline can store excess imported supply if conveyance and storage capacity allow. Monthly reservoir inflow is defined for each reservoir, and reservoir evaporation is calculated based on observed historical rates.

2.1.6.2.h Operation of Raw Water System

The raw water system serves as the nucleus of WEAP, determining how much and where imported water will be delivered through pipelines to WTPs and recharge turnouts. For the distribution of imported water, WEAP can draw its first priority supplies from either the SBA or the San Felipe Division. When needed, releases from any defined water banks and reservoirs connected to pipelines will be initiated.

Priorities are also defined by the user to determine the order of where the imported water is distributed. When there is not enough water to meet all facility needs, or conveyance of all water is not possible, reductions are made by WEAP according to the following priorities:

(1) Excess raw water to reservoirs connected to pipelines, and banking facilities outside of the County

(2) Raw water delivered to recharge facilities

(3) Raw water surface deliveries

(4) Raw water delivered to meet the needs of SCVWD's various treatment plants

WEAP was used to simulate SCVWD's water operations for each alternative, including the no action alternative, at a future LOD. CalSim II output for CVP and SWP allocations and deliveries were provided to SCVWD staff for each alternative to run WEAP and summarize results. WEAP results include local reservoir operations, flows at key locations, groundwater banking operations, and SCVWD's ability to meet service area demands. WEAP output for treated water deliveries was a key input to the economic evaluation.

2.2 Supplemental Support for Modeling Results

As discussed in the previous sections, CalSim II is the only tool available that includes the majority of the system components and inputs that affect storage conditions in San Luis Reservoir. An accurate simulation of San Luis Reservoir is extremely difficult to achieve because myriad factors and human decisions affect it. CalSim II's simulation of a future condition represents only one of many possible future conditions. Additional understanding of the potential range of future conditions may be gained from review of historical hydrology and system conditions.

An understanding of the historical hydrology and CVP SOD operations were combined to provide supplemental information to accompany CalSim II modeling results. A review of the hydrology identified conditions and factors that contribute to, or help prevent the occurrence of low point issues. The frequency of occurrence for those contributing and preventing factors can help identify years when low point issues are more and less likely. The frequency of occurrence of factors or combinations of factors can define a minimum and maximum number of years when low point issues are more likely to occur. This information provides a model-independent estimate of the range of potential low point occurrences and helps support CalSim II model results.

CVP operators currently target drawing down the CVP portion of San Luis Reservoir to minimum pool each year when making allocations. Reasons why CVP storage stays above or dips below minimum pool can be characterized as either supply or demand factors. Supply factors include reservoir inflows north and south of the Delta, the availability of local supplies or surplus flows south of the Delta, and unforeseen increases or reductions in Delta exports. Demand factors include meteorological conditions such as temperature, wind, and precipitation that drive evapotranspiration from crops and changes in cropping patterns that influence the timing of demand for water from San Luis Reservoir.

Reclamation currently uses conservative forecasts for both supply (90% exceedance for reservoir inflows) and demand. The use of conservative forecasts reduces the number of times actual inflow is less than forecasted inflow or actual demands exceed forecasts. Low point issues are more likely to occur when actual demands are at or above forecasted demands and/or supplies are at or below forecasted supplies. A review of the historical hydrology and data was made to estimate how frequently the actual factors that influence supply and demand are more likely to be significantly different from forecasted values. Supply factors include reservoir inflows, water year types, water supply forecasts, and spills into Mendota Pool. Demand factors include temperature, precipitation, and evapotranspiration data. Data for most of these factors was previously collected and analyzed to determine the feasibility of predicting potential low point issues. The same data were analyzed to determine the frequency of occurrence for factors that contribute to or help prevent low point issues. The frequency of occurrence for these factors can define a minimum and maximum number of years wherein low point issues are more likely to occur. This analysis attempts to determine the likely range or number of years when low point issues are more likely to occur. A worst case scenario would result in a low point condition occurring every year, whereas low point conditions would never occur in a best case scenario.

Sacramento and San Joaquin Valley Water Year indices can be used as one metric for evaluating factors that may tend to increase or decrease San Luis Reservoir storage conditions.

The Sacramento River is the largest river flowing into the Delta and carries water released from upstream CVP and SWP reservoirs. Water stored in San Luis Reservoir is exported from the Delta. The Sacramento Valley Index is one metric to define overall water supply conditions in the Sacramento Valley and is one supply factor for determining conditions that may increase or decrease the likelihood of low point conditions.

The San Joaquin Valley Water Year Index (SJR Index) is an indicator of hydrologic conditions in much of the area supplied by San Luis Reservoir. Conditions on the San Joaquin River can be an indicator of conditions on other rivers and creeks that serve as local supplies to areas also served from San Luis Reservoir. For example, the SJR Index can be an indicator of flow from the Kings River through James Bypass to Mendota Pool and spills from Friant Dam down the San Joaquin River to Mendota Pool. Spills into Mendota Pool during the April through September irrigation season reduce deliveries from San Luis Reservoir and decrease the likelihood of low point issues. Figure 2-1shows the frequency of such spills and the SJR Index in years when spills occur.

Figure 2-1 shows that historically there have been large volumes of water spilled into Mendota Pool from both the San Joaquin and Kings rivers when the SJR Index is wet. San Joaquin River spills are expected to decrease with implementation of San Joaquin River Restoration, but Kings River spills are likely to continue. While there can be differences between conditions in the northern and southern San Joaquin Valley, or the east and west sides of the San Joaquin River, the SJR Index generally indicates the availability of local water supplies. When the SJR Index is wet or above normal, there is typically more local supply available and less demand for water from San Luis Reservoir and vice versa. In this way, the SJR Index can be an indicator of demand for water from San Luis Reservoir.

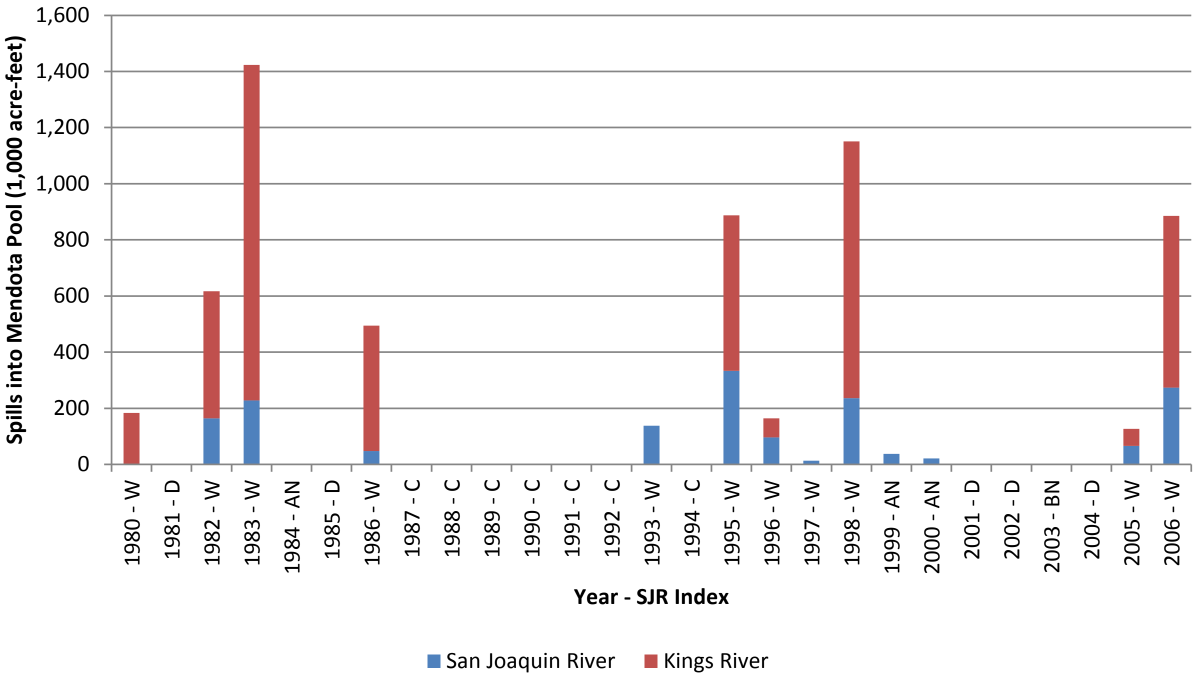

Figure 2-1. Total April through September Spills into Mendota Pool

Another indicator of demand may be obtained through analysis of historical temperature data. While numerous factors contribute to crop evapotranspiration and thereby water requirements, temperature is one of the main components and long-term data records of temperature are readily available. Daily temperature records for five locations throughout the San Joaquin Valley were reviewed and analyzed to determine years that were consistently above or below long-term average temperatures from April through September. The period of analysis was the 82-year period of historical hydrology simulated in CalSim II. Stations included in the analysis include Coalinga, Bakersfield, Hanford, Los Banos, and Visalia. Long-term average monthly temperatures were calculated for each station based on the available record. The difference between recorded daily temperature and average monthly temperature were summed for the April 1 through September 30 period each year. These degree-day differences for each station were analyzed to determine years when the stations were consistently above or below the average monthly temperature for the entire season. Data were not available for all years at all stations, but results reflect data for at least three stations for any year identified as consistently above or consistently below average. These results are summarized by SJR Index in the following figure.

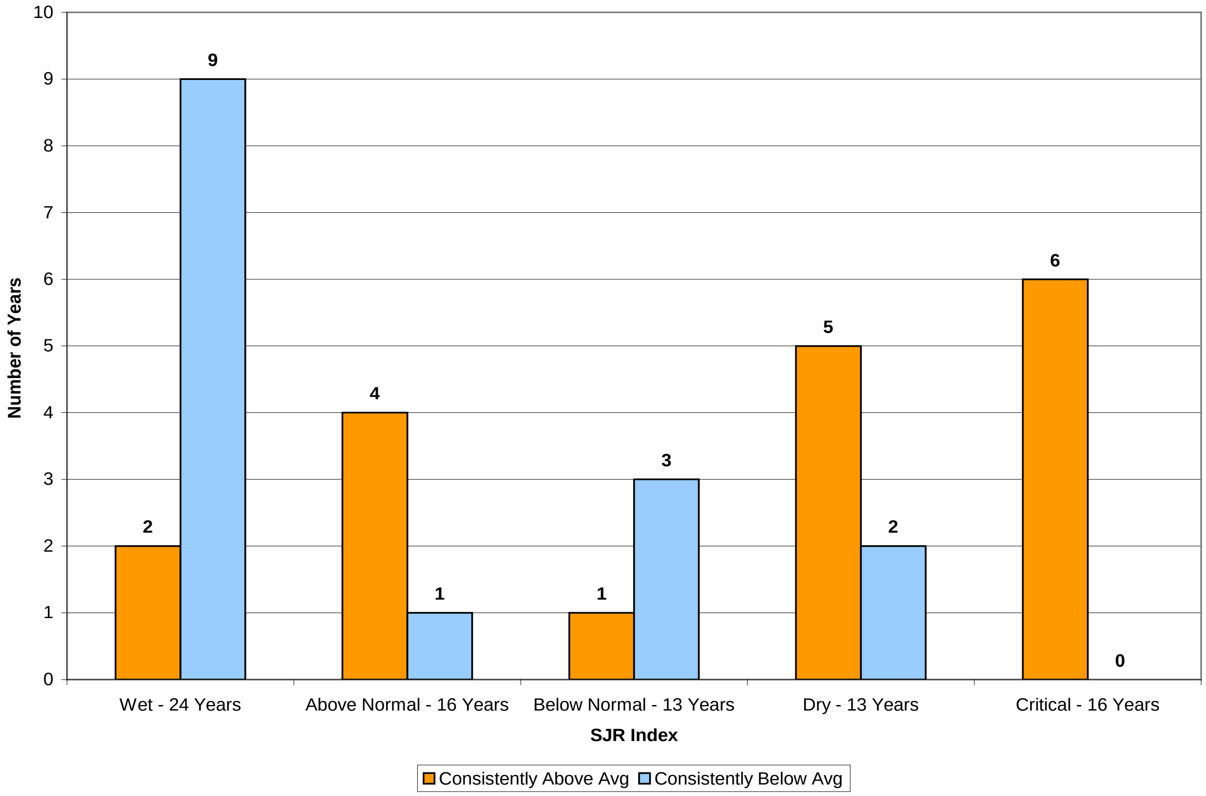

Figure 2-2. Years with Temperatures Consistently Different from Long-Term Averages throughout the CVP SOD Service Area

Figure 2-2 illustrates that out of the 82 years analyzed, in 18 years the majority of the stations analyzed show consistently above average temperatures with 11 of those years being classified as dry or critical (5 dry years and 6 critical years) according to the SJR Index on a calendar year basis. Conversely, 15 years show consistently below average temperatures with 10 of those years being classified as wet or above normal (9 wet years and 1 above normal year) according to the SJR Index. The combination of dry conditions and higher temperatures increase demand for water from San Luis Reservoir, and are more likely to result in low point conditions.

Storage levels at low point are also highly dependent on human decision-making including allocations made by CVP operators and water user’s response to storage conditions in San Luis Reservoir. Low point conditions will tend to occur when water supplies are less than runoff forecasts, and/or demands exceed forecasted demands used for seasonal operations plans and allocations. Low point conditions may occur outside of dry or critical years, and may not occur in every dry or critical year. However, the combination of dry and critical years with consistently higher temperatures, and therefore demands, are more likely to lead to low point conditions than wet years when demands are lower than forecasted.

Based on Figure 2-1 and Figure 2-2, it is possible to estimate the number of years when low point conditions are more and less likely. Table 2-2 is a summary of this analysis.

Table 2-2. Number of Calendar Years in Period of Analysis when Low Point Issues are More and Less Likely

Water Year Index	Sacramento Valley Index Years	SJR Index Years	Above Average Temperature	Below Average Temperature	Low Point More Likely[1]	Low Point Less Likely[2]
Wet	26	24	2	9	-	9
Above Normal	12	16	4	1	4	1
Below Normal	14	13	1	3	1	-
Dry	18	13	5	2	5	-
Critical	12	16	6	0	6	-
Total	82	82	18	15	16	10

[1] Assuming spills into Mendota Pool decrease the likelihood of low point issues in all wet years and above average temperatures in any other year increase the likelihood of low point issues.

[2] Assuming spills into Mendota Pool combined with below average temperatures in wet and above normal years decrease the likelihood of low point issues.

Table 2-2 shows that in the 82 (calendar) years analyzed, there are 16 years when low point conditions are more likely and 10 years when low point years are less likely to occur. These values, combined with the 82-year period of analysis, can be viewed as potential bookend values for how often low point issues may occur. The maximum number of years when low point issues may occur is 72, 82 minus 10 years when low point is less likely. The minimum number of years when low point may occur is 16, assuming low point issues occur in every year defined as more likely in Table 2-2. The FNA Alternative used for the economic analysis provides one scenario when low point issues occur in 17 years (on a calendar year basis). The distribution of low point years by Sacramento Valley and San Joaquin Valley Index are provided in Table 2-3.

Table 2-3. Number of Low Point Years by Sacramento Valley and San Joaquin Valley Index for FNA

Index Year Type for the Future No Action Alternative	Low Point Years: Sacramento Valley Index	Low Point Years: San Joaquin Valley Index
Wet	0	0
Above Normal	3	0
Below Normal	3	4
Dry	4	5
Critical	7	8
All Years	17	17

Based on the analysis of historical hydrology and temperature, these CalSim II results are within the range of a model independent analysis of potential low point occurrence.

Chapter 3
Future No Action Alternative

The following section describes the SLLPIP Future No Action Alternative and summarizes key model results for the alternative.

3.1 Future No Action Conditions: CalSim II

Results from the FNA Alternative simulation are used to depict operation of the CVP and SWP without SLLPIP alternatives at a future LOD. FNA results are used in a comparative sense with results from SLLPIP alternatives to quantify changes in CVP/SWP operations. Operation of San Luis Reservoir and any San Felipe Division M&I water service contract delivery interruptions are key results for the FNA simulation. These results are summarized in the following figures and tables.

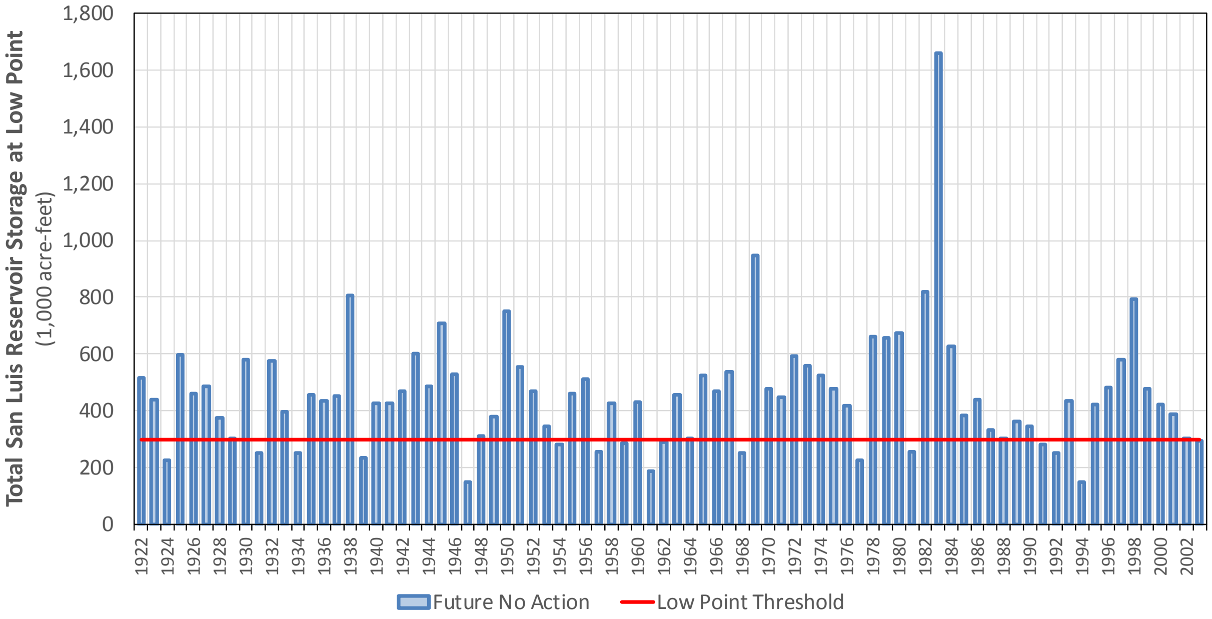

Figure 3-1. Annual Total San Luis Reservoir Storage at Low-Point

Figure 3-1 illustrates annual San Luis Reservoir storage at low-point for each year of the FNA simulation. A low point threshold of 300,000 AFAF is shown on the figure to illustrate years when low-point issues may develop. A low point of less than 300,000 AFAF occurs in 17 of the 82 years simulated.

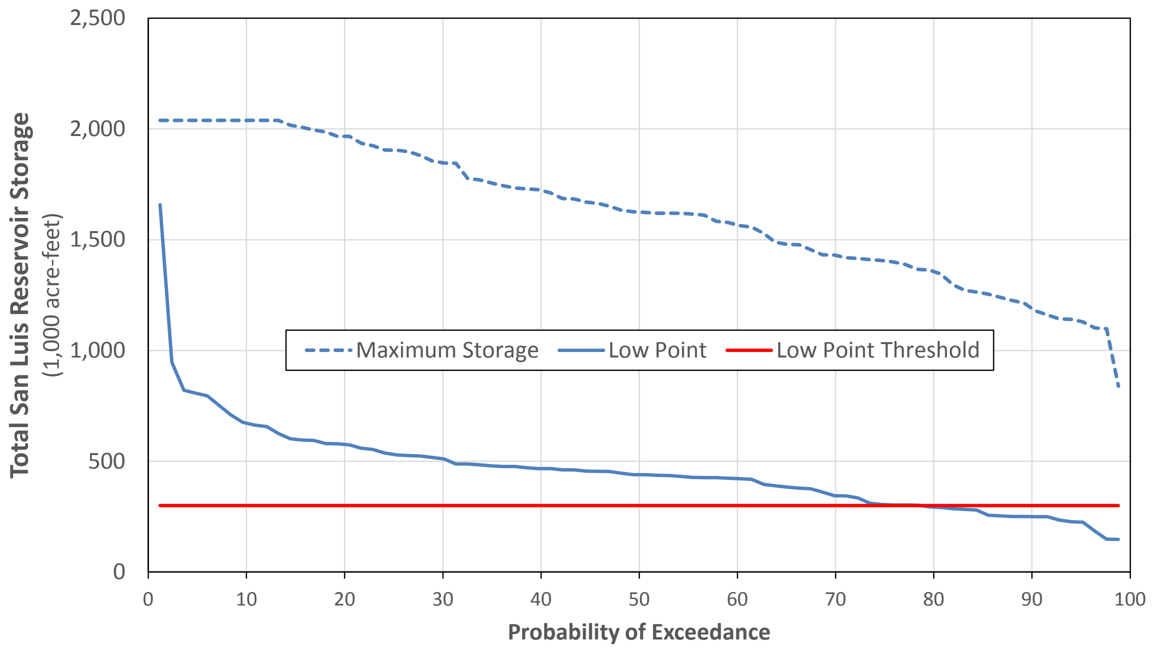

Figure 3-2. Probability of Total San Luis Reservoir Maximum and Low Point Storage

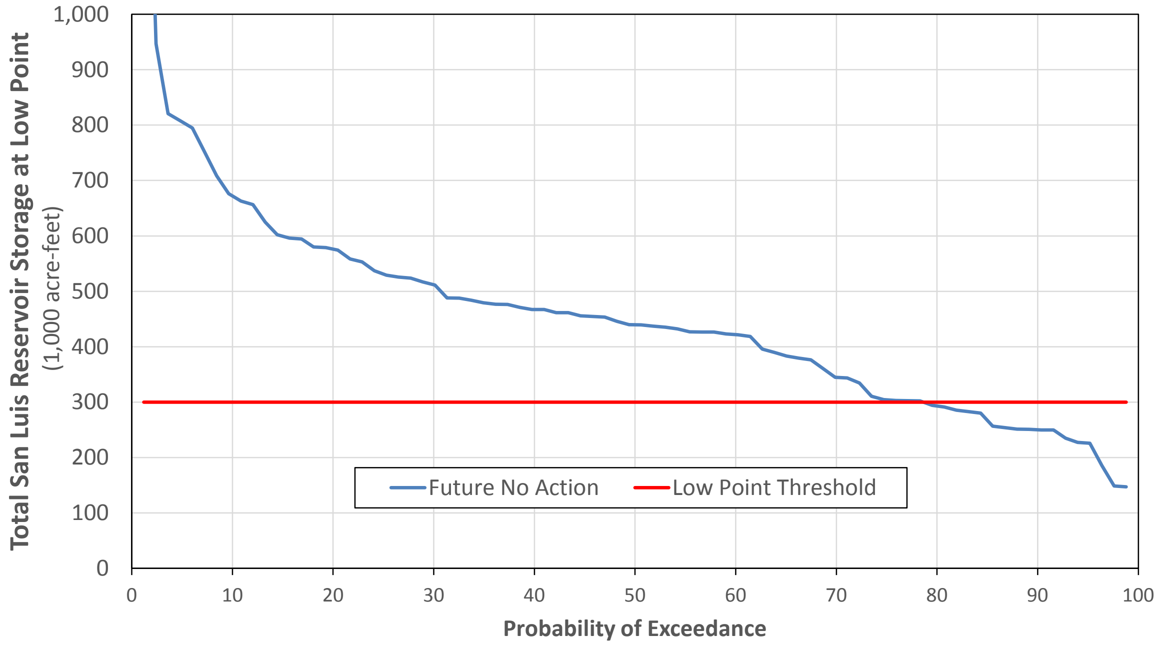

Figure 3-3. Probability of Total San Luis Reservoir Low Point Storage

Figure 3-3 illustrates annual San Luis Reservoir storage at low-point as a probability of exceedance. Results presented in Figure 3-3 indicate that storage may be below 300,000 AF in approximately 20 percent (17 out of 82) of all years at a future LOD.

Low point issues are assumed to occur when total San Luis Reservoir storage is less than 300,000 AF. When low point issues occur, San Felipe Division M&I contractors do not take delivery due to water quality concerns and deliveries are interrupted.

Table 3-1 is a summary of average annual interrupted San Felipe Division M&I deliveries for the FNA condition. Interrupted supplies reflect the volume of water that would not be delivered relative to the San Felipe M&I allocation for each water year type.

Table 3-1. Average Annual Interrupted San Felipe Division M&I Deliveries

Sacramento Valley Index	Future No Action (1,000 AFAF)
Wet	0.7
Above Normal	5.2
Below Normal	6.7
Dry	2.6
Critical	3.5
All Years	3.2

3.2 Future No Action Conditions: WEAP

SCVWD’s WEAP model was run to understand how interrupted San Felipe Division M&I deliveries affect SCVWD surface and groundwater storage conditions, as well as SCVWD’s ability to meet treated water demands. WEAP outputs have been summarized in the following figures and tables.

Imported water supplies entering the SCVWD system are either sent directly to one of the WTPs, or routed into storage, either in one of the local surface water reservoirs or recharged into one of the local groundwater basins. While local reservoir and groundwater basin storage levels are dependent on local hydrologic conditions, changes in storage between an alternative and the future no action model run will indicate changes to the volume of imported supply and/or operational changes triggered by the change in imported supplies. Accordingly, Table 3-2 includes relevant WEAP model output, including: annual average WTP delivery , annual average storage levels for total local surface water storage, total local groundwater storage, Semitropic storage, and the total SCVWD Emergency Supply. The total SCVWD Available Storage is a sum of the total local surface storage, total local groundwater storage, and Semitropic storage. Total SCVWD Emergency Supply is the average volume of water available to the system under a water supply emergency, such as a Delta outage. This value only includes the total local surface storage and the North County groundwater storage that would be accessible in an emergency.

Table 3-2. Annual Average WTP Delivery and Storage Conditions for the Future No Action model run

Annual Average Values (1,000 acre-feet)	Future No Action
Total WTP Delivery/M&I Water Supply	129
Unmet WTP Demand	2
Total Local Surface Storage	90
North County Groundwater Storage	316
Total Local Groundwater Storage	464
Total Semitropic Storage	150
Total SCVWD Available Storage	704
Total SCVWD Emergency Supply	406

The following figure illustrates annual WTP deliveries from the Future No Action WEAP results. Years when total San Luis Reservoir storage falls below 300,000 AF (low point years) are noted. Many of the years with reduced total WTP deliveries correspond to low point years. However, reduced water plant deliveries can also be caused by dry hydrologic conditions in Santa Clara County and in years with low imported water deliveries from the CVP and SWP.

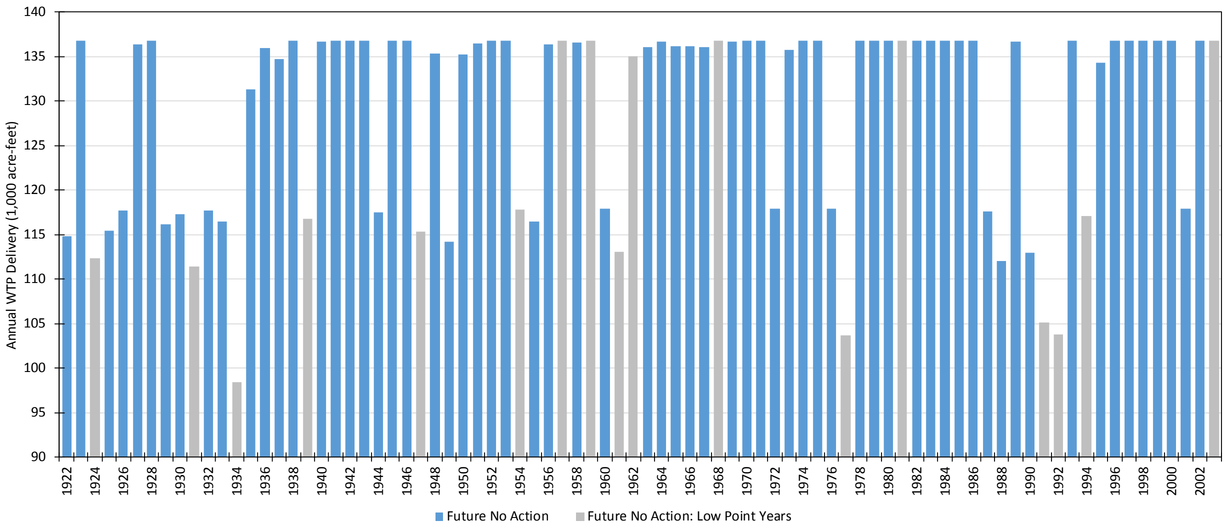

Figure 3-4. Simulated Annual WTP Deliveries, Future No Action

Chapter 4
Lower San Felipe Intake Alternative

This alternative includes construction of a new, lower San Felipe Intake to allow reservoir drawdown to its minimum operating level without algae reaching the San Felipe Intake. Moving the San Felipe Intake to an elevation equal to the Gianelli Intake would allow for continued San Felipe Division deliveries even when the total storage volume in San Luis Reservoir is below the 300,000 AF level.

A new intake would be constructed and connected to the existing San Felipe Division Intake via approximately 20,000 feet of new pipeline or tunnel. The San Felipe Intake is currently at elevation 334 feet, and algae-laden water can reach the intake when reservoir levels reach approximately 369 feet (approximately 300,000 AF in storage). Because the Gianelli Intake is at elevation of 296 feet (approximately 30 feet lower than the minimum operating pool), algae-laden water does not typically reach the Gianelli Intake. The new intake in this alternative would be at elevation 296 feet, the same elevation as the Gianelli Intake. The lower intake facility would allow the San Felipe Division to receive water from the lower reservoir levels that do not contain high concentrations of algae. A hypolimnetic aeration facility would also be constructed.

4.1 Modeling Approach and Assumptions

The Lower San Felipe Intake Alternative allows delivery to San Felipe Division M&I contractors if San Luis Reservoir storage is maintained above dead pool. This operation was simulated in CalSim II by removing the constraint requiring San Luis Reservoir storage to be greater than 300,000 AF for delivery to San Felipe Division M&I contractors.

4.2 Water Operations Modeling Results: CalSim II

The Lower San Felipe Intake Alternative was analyzed over an 82-year period to estimate the potential change in CVP deliveries due to the physical change to the intake. The following sections summarize the effects of the alternative on CVP SOD M&I and agricultural water service contract deliveries and the CVP/SWP system.

4.2.1 CVP Deliveries

The Lower San Felipe Intake Alternative allows for increases to San Felipe Division M&I water service contract deliveries by eliminating delivery interruptions due to low-point issues. San Felipe Division M&I deliveries increase because contractors can take delivery of water when San Luis Reservoir is below 300,000 AF.

Increased deliveries to San Felipe Division M&I contractors reduce CVP deliveries to SOD agricultural water service contractors. Agricultural deliveries decrease, as compared to the FNA Alternative, because interrupted M&I deliveries under the FNA Alternative remain in San Luis Reservoir and are included as supply available for allocation to CVP/SWP contractors in subsequent years. Under the Lower San Felipe Intake Alternative, that water is delivered and allocations in future years may be slightly less than under the no action alternative.

The following tables summarize changes in deliveries to San Felipe Division M&I contractors and CVP SOD agricultural water service contractors with the Lower San Felipe Intake Alternative.

Table 4-1. San Felipe Division M&I Deliveries under the Lower San Felipe Intake Alternative

Sacramento Valley Index	Future No Action (1,000 AF)	Lower San Felipe Intake (1,000 AF)	Change from FNA (1,000 AF)
Wet	114	115	1
Above Normal	98	103	5
Below Normal	95	102	7
Dry	90	92	2
Critical	73	76	3
All Years	97	100	3

Table 4-1 shows an average annual increase in San Felipe Division M&I deliveries of 3,000 AF under the Lower San Felipe Intake Alternative. Delivery increases occur only within the San Felipe Division. There is no meaningful change to CVP SOD M&I contractors outside the San Felipe Division because there is no meaningful change to M&I allocations. Increased deliveries match interrupted San Felipe Division M&I deliveries presented previously in Table 3-1.

Table 4-2. CVP SOD Agricultural Deliveries under the Lower San Felipe Intake Alternative

Sacramento Valley Index	Future No Action (1,000 AF)	Lower San Felipe Intake (1,000 AF)	Change from FNA (1,000 AF)
Wet	1,341	1,341	0
Above Normal	1,009	1,004	-5
Below Normal	878	876	-2
Dry	591	589	-2
Critical	176	176	0
All Years	878	876	-2

Table 4-2 shows an average annual decrease in CVP SOD agricultural service contract deliveries of 2,000 AF. Simulated deliveries decrease because under the FNA Alternative interrupted San Felipe Division M&I deliveries remain in San Luis Reservoir and are available to be allocated to agricultural water service contractors in subsequent years. Slightly lower SOD agricultural deliveries in the Lower San Felipe Intake Alternative result when this interrupted supply is instead delivered to San Felipe Division M&I contractors.

4.2.2 CVP/SWP Effects

The Lower San Felipe Intake Alternative has the potential to affect CVP/SWP operations beyond San Luis Reservoir and the contractors who take delivery of water from the reservoir. As described in the previous section, interrupted M&I deliveries under the FNA Alternative tend to increase allocations and deliveries to other CVP contractors relative to the Lower San Felipe Alternative. Changes in SOD allocations can affect other areas of the CVP and, in some instances, the SWP due to requirements in the Coordinated Operation Agreement. These changes have the potential to affect resources in other parts of the system. Therefore, changes in river flows, reservoir storage, Delta outflow, and Delta export operations were quantified and reviewed in support of the environmental documentation. The following table provides a high-level summary of changes throughout the CVP/SWP system. More detailed results were provided and reviewed by resource area specialists and are illustrated in figures located in Attachment B to this Appendix.

Table 4-3. Summary of CVP/SWP System Effects under the Lower San Felipe Intake Alternative

Future No Action	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Delta Outflow (cfs)	5,905	11,432	20,703	42,028	52,793	42,230	30,980	22,070	12,345	7,785	4,433	9,728
Jones Pumping Plant (cfs)	3,491	3,546	3,918	3,234	3,314	3,114	1,210	1,081	2,575	3,387	3,718	3,972
Banks Pumping Plant (cfs)	3,211	3,798	4,732	3,606	4,040	4,024	1,193	985	2,426	5,832	5,403	5,045
Sac. River into Delta (cfs)	10,870	15,725	21,534	29,935	36,387	30,746	22,316	19,041	15,950	18,013	14,204	17,822
Sac. River at Keswick (cfs)	6,211	6,913	6,488	8,357	10,648	8,336	7,035	8,114	10,768	12,754	10,088	8,125
Sac River at NCP (cfs)	6,012	9,018	11,278	13,679	15,379	14,107	8,840	7,088	5,647	6,248	5,280	7,841
Feather River blw. Thermalito (cfs)	2,538	1,999	2,457	4,043	4,291	5,284	3,033	3,629	3,660	7,061	4,838	5,376
Lower Feather River (cfs)	3,030	2,896	4,794	10,756	11,750	12,395	8,768	7,659	6,210	7,677	5,790	7,100
American River at Nimbus (cfs)	1,618	2,608	3,357	4,542	5,221	4,048	3,369	3,383	3,195	3,273	2,245	2,448
American River at H. St. (cfs)	1,442	2,444	3,219	4,385	5,033	3,855	3,088	3,044	2,805	2,722	1,852	2,135
SJ River at Vernalis (cfs)	2,710	2,605	3,248	4,821	6,203	7,165	7,473	5,747	4,609	3,188	2,032	2,312
Shasta Storage (TAF)	2,612	2,570	2,752	3,023	3,277	3,646	3,938	3,955	3,656	3,196	2,884	2,693
Folsom Storage (TAF)	457	431	456	473	493	592	719	838	803	671	591	505
Oroville Storage (TAF)	1,591	1,565	1,701	1,915	2,192	2,439	2,716	2,854	2,746	2,302	2,011	1,710
CVP San Luis Storage (TAF)	231	351	523	644	738	809	729	573	408	245	146	179
SWP San Luis Storage (TAF)	339	331	431	574	706	814	730	562	404	410	377	381
Lower San Felipe Intake Alt.	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**
Delta Outflow (cfs)	5,908	11,434	20,704	42,021	52,783	42,227	30,976	22,070	12,345	7,784	4,433	9,729
Jones Pumping Plant (cfs)	3,495	3,548	3,921	3,236	3,317	3,114	1,210	1,081	2,576	3,386	3,716	3,984
Banks Pumping Plant (cfs)	3,211	3,794	4,733	3,606	4,043	4,026	1,193	985	2,427	5,832	5,403	5,045
Sac. River into Delta (cfs)	10,876	15,727	21,538	29,933	36,386	30,744	22,313	19,041	15,951	18,011	14,202	17,836
Sac. River at Keswick (cfs)	6,219	6,913	6,490	8,352	10,642	8,335	7,031	8,114	10,768	12,752	10,086	8,137
Sac River at NCP (cfs)	6,020	9,019	11,279	13,678	15,381	14,106	8,836	7,088	5,647	6,247	5,278	7,854
Feather River blw. Thermalito (cfs)	2,538	1,999	2,457	4,044	4,291	5,283	3,033	3,628	3,659	7,059	4,835	5,374
Lower Feather River (cfs)	3,031	2,896	4,794	10,756	11,750	12,395	8,768	7,658	6,211	7,676	5,790	7,100
American River at Nimbus (cfs)	1,616	2,609	3,358	4,542	5,221	4,049	3,369	3,383	3,195	3,273	2,244	2,449
American River at H. St. (cfs)	1,441	2,446	3,219	4,385	5,033	3,855	3,088	3,044	2,805	2,722	1,852	2,136
SJ River at Vernalis (cfs)	2,710	2,605	3,248	4,821	6,203	7,165	7,473	5,747	4,609	3,188	2,032	2,312
Shasta Storage (TAF)	2,612	2,569	2,751	3,022	3,276	3,646	3,938	3,955	3,656	3,197	2,884	2,693
Folsom Storage (TAF)	457	431	456	473	493	592	719	838	803	671	591	504
Oroville Storage (TAF)	1,591	1,565	1,701	1,915	2,192	2,439	2,716	2,854	2,746	2,302	2,011	1,710
CVP San Luis Storage (TAF)	230	349	521	642	737	808	728	572	407	244	145	178
SWP San Luis Storage (TAF)	339	331	431	574	706	814	730	562	404	410	377	381
Change from Future No Action	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**
Delta Outflow (cfs)	3	2	1	-7	-11	-2	-4	0	0	0	0	1
Jones Pumping Plant (cfs)	4	3	2	2	3	-1	0	0	0	0	-2	12
Banks Pumping Plant (cfs)	0	-3	1	-1	3	1	0	0	0	0	-1	0
Sac. River into Delta (cfs)	6	2	3	-2	-1	-1	-3	0	1	-2	-2	14
Sac. River at Keswick (cfs)	8	0	2	-5	-5	-1	-4	0	0	-2	-2	12
Sac River at NCP (cfs)	7	1	1	-1	2	-1	-4	0	0	-1	-2	13
Feather River blw. Thermalito (cfs)	1	0	0	0	0	0	0	-1	-1	-3	-2	-2
Lower Feather River (cfs)	1	0	0	0	0	-1	0	0	0	0	0	0
American River at Nimbus (cfs)	-2	1	1	0	0	0	0	0	0	0	0	1
American River at H. St. (cfs)	-1	1	1	0	0	0	0	0	0	0	0	1
SJ River at Vernalis (cfs)	0	0	0	0	0	0	0	0	0	0	0	0
Shasta Storage (TAF)	-1	-1	-1	0	0	0	0	0	0	0	0	0
Folsom Storage (TAF)	0	0	0	0	0	0	0	0	0	0	0	0
Oroville Storage (TAF)	0	0	0	0	0	0	0	0	0	0	0	0
CVP San Luis Storage (TAF)	-2	-2	-2	-2	-2	-1	-1	-1	-1	-1	-1	-1
SWP San Luis Storage (TAF)	0	0	0	0	0	0	0	0	0	0	0	0

Results presented in Table 4-3 show only small changes in the CVP/SWP system.

4.3 Water Operations Modeling Results: WEAP

The additional San Felipe Division deliveries under the Lower San Felipe Intake Alternative provide additional imported supply for the SCVWD system. The results in Table 4-4 demonstrate how the additional supply helps to increase the total WTP deliveries, while also boosting average local surface, groundwater, and Semitropic storage levels. This allows the average annual emergency supply to increase by approximately 2,500 AF. ‘Change from FNA’ values are calculated and rounded from values with additional precision compared to those presented in the table. As a result, 'Change from FNA' values may reflect a different value than the difference between the Future No Action and Lower/Intake Treatment results shown in the table.

Table 4-4. Annual Average WTP Delivery and Storage Conditions for the Lower San Felipe Intake Alternative as compared to the FNA.

Annual Average Values (1,000 acre-feet)	Future No Action	Lower Intake/ Treatment	Change from FNA
Total WTP Delivery/M&I Water Supply	129	129	1
Unmet WTP Demand	2	1	-1
Total Local Surface Storage	90	90	0
North County Groundwater Storage	316	318	2
Total Local Groundwater Storage	464	467	2
Total Semitropic Storage	150	179	29
Total SCVWD Available Storage	704	736	32
Total SCVWD Emergency Supply	406	408	2

Compared to the FNA Alternative, annual WTP deliveries are typically higher in years when demand is not fully met, as shown in Figure 4-1. This is especially true in low point years, when additional CVP supply is able to be delivered to the SCVWD system.

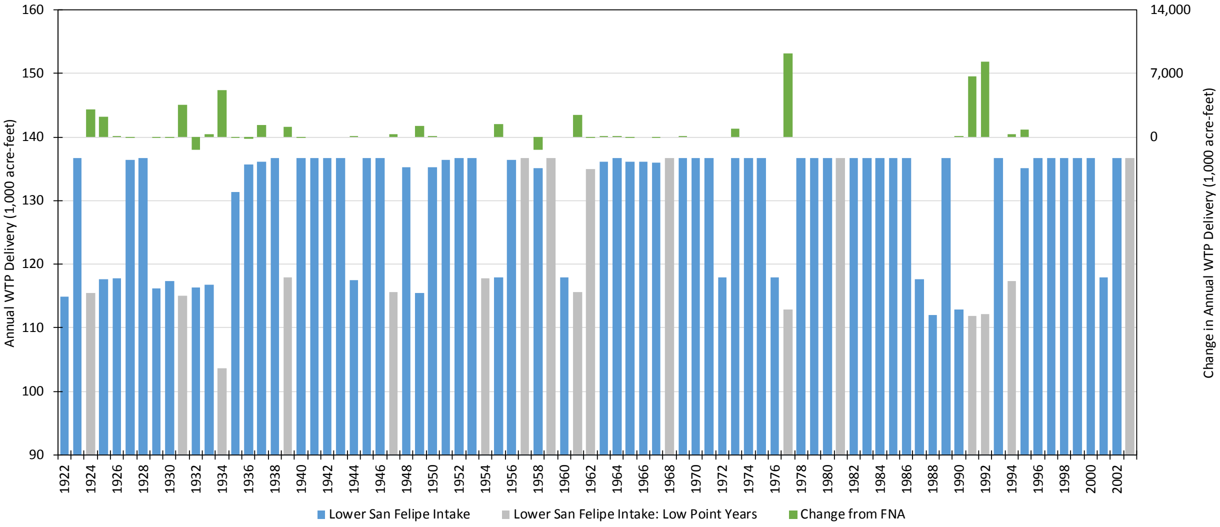

Figure 4-1. Annual Water Treatment Plant Delivery and Change from the FNA

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Chapter 5
San Luis Reservoir Expansion Alternative

The San Luis Reservoir Expansion Alternative would raise Sisk Dam by approximately ten feet above the dam safety raise currently being considered. The dam raise would allow water levels in the reservoir to also increase by ten feet, which results in a total storage increase of approximately 120,000 AF. This expansion would require additional construction at the dam (beyond what is required for the dam safety effort), including raising the impermeable layer to allow the water level increase.

The San Luis Reservoir Expansion Alternative would allocate the increased capacity to the CVP only. This expanded capacity would be operated in the same way as the current CVP portion of San Luis Reservoir, with the reservoir used for seasonal storage. The new capacity would fill after the existing capacity is filled, which would result in increased CVP yield during wetter years.

5.1 Modeling Approach and Assumptions

The San Luis Reservoir Expansion Alternative was simulated in CalSim II by increasing the storage capacity of both the CVP and SWP portion of San Luis Reservoir. The increased capacity of San Luis Reservoir could be filled during times when there is surplus Delta outflow in excess of required Delta outflow and Delta outflow needed to meet Delta water quality standards (Delta surplus). Delta surplus can only be exported when there also is available Delta export capacity. These periods typically overlap with periods when the existing CVP or SWP portion of San Luis Reservoir is full in the FNA.

This alternative may incidentally assist in maintaining storage in San Luis Reservoir above 300,000 AF and thus reducing the magnitude and/or magnitude of delivery interruptions to San Felipe Division M&I contractors.

5.2 Water Operations Modeling Results: CalSim II

The San Luis Reservoir Expansion Alternative was analyzed over an 82-year period to estimate the potential change in CVP deliveries due to the physical change in San Luis Reservoir. The following sections summarize the effects of the alternative on CVP SOD M&I and agricultural water service contract deliveries and the CVP/SWP system.

5.2.1 CVP Deliveries

By allowing for additional CVP SOD storage, the San Luis Reservoir Expansion Alternative increases CVP deliveries to SOD water service contractors. The following tables summarize changes in deliveries to San Felipe Division M&I contractors and CVP SOD agricultural water service contractors under the San Luis Reservoir Expansion Alternative.

Table 5-1. San Felipe Division M&I Deliveries under the San Luis Reservoir Expansion Alternative

Sacramento Valley Index	Future No Action (1,000 AF)	San Luis Reservoir Expansion (1,000 AF)	Change from FNA (1,000 AF)
Wet	114	115	1
Above Normal	98	99	1
Below Normal	95	95	0
Dry	90	91	1
Critical	73	73	0
All Years	97	98	1

Table 5-1 shows minimal changes in the average annual San Felipe Division M&I deliveries under the San Luis Reservoir Expansion Alternative.

Table 5-2. CVP SOD Agricultural Deliveries under the San Luis Reservoir Expansion Alternative

Sacramento Valley Index	Future No Action (1,000 AF)	San Luis Reservoir Expansion (1,000 AF)	Change from FNA (1,000 AF)
Wet	1,341	1,366	25
Above Normal	1,009	1,027	18
Below Normal	878	899	21
Dry	591	593	2
Critical	176	176	0
All Years	878	893	15

Table 5-2 shows an average annual increase in CVP SOD agricultural service contract deliveries of 15 TAF. ‘Change from FNA’ values are calculated and rounded from values with additional precision compared to those presented in the table. As a result, ‘Change from FNA’ values may reflect a different value than the difference between the Future No Action and San Luis Reservoir Expansion results shown in the table.

5.2.2 SWP Deliveries

The San Luis Reservoir Expansion Alternative has the potential to decrease SWP deliveries by reducing SWP exports from the Delta through Banks Pumping Plant. Banks Pumping Plant exports can be reduced as compared to the FNA because the additional CVP storage capacity under the alternative allows the CVP to export more of the water they are entitled to under the Coordinated Operations Agreement. Under the FNA, the SWP is able to export this water when the CVP portion of San Luis Reservoir fills and CVP SOD demands are being met.

The following tables summarize the average annual simulated SWP Table A and Article 21 deliveries for the FNA, CVP Reservoir Expansion Alternative, and the change from the FNA. Results summarized in these tables show relatively small changes compared to the volume of delivery in the FNA.

Table 5-3. SWP Table A Deliveries under the San Luis Reservoir Expansion Alternative

Sacramento Valley Index	Future No Action (1,000 AF)	San Luis Reservoir Expansion (1,000 AF)	Change from FNA (1,000 AF)
Wet	3,177	3,171	-6
Above Normal	2,659	2,656	-3
Below Normal	2,567	2,560	-7
Dry	2,009	2,011	2
Critical	1,242	1,242	0
All Years	2,458	2,455	-3

Table 5-4. SWP Article 21 Deliveries under the San Luis Reservoir Expansion Alternative

Sacramento Valley Index	Future No Action (1,000 AF)	San Luis Reservoir Expansion (1,000 AF)	Change from FNA (1,000 AF)
Wet	83	82	-1
Above Normal	107	107	0
Below Normal	71	57	-14
Dry	25	25	0
Critical	12	12	0
All Years	61	59	-2

5.2.3 CVP/SWP Effects

The Reservoir Expansion Alternative has the potential to affect CVP/SWP operations beyond San Luis Reservoir and the contractors who take delivery of water from the reservoir. Changes in SOD allocations can affect other areas of the CVP and SWP. These changes have the potential to affect resources in other parts of the system. Therefore, changes in river flows, reservoir storage, Delta outflow, and Delta export operations were quantified and reviewed in support of the environmental documentation. The following tables provide a high-level summary of changes throughout the CVP/SWP system. More detailed results were provided and reviewed by resource area specialists and are illustrated in figures located in Attachment B to this Appendix.

Table 5-5. Summary of CVP/SWP System Effects under the San Luis Reservoir Expansion Alternative

Future No Action	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**
Delta Outflow (cfs)	5,905	11,432	20,703	42,028	52,793	42,230	30,980	22,070	12,345	7,785	4,433	9,728
Jones Pumping Plant (cfs)	3,491	3,546	3,918	3,234	3,314	3,114	1,210	1,081	2,575	3,387	3,718	3,972
Banks Pumping Plant (cfs)	3,211	3,798	4,732	3,606	4,040	4,024	1,193	985	2,426	5,832	5,403	5,045
Sac. River into Delta (cfs)	10,870	15,725	21,534	29,935	36,387	30,746	22,316	19,041	15,950	18,013	14,204	17,822
Sac. River at Keswick (cfs)	6,211	6,913	6,488	8,357	10,648	8,336	7,035	8,114	10,768	12,754	10,088	8,125
Sac River at NCP (cfs)	6,012	9,018	11,278	13,679	15,379	14,107	8,840	7,088	5,647	6,248	5,280	7,841
Feather River blw. Thermalito (cfs)	2,538	1,999	2,457	4,043	4,291	5,284	3,033	3,629	3,660	7,061	4,838	5,376
Lower Feather River (cfs)	3,030	2,896	4,794	10,756	11,750	12,395	8,768	7,659	6,210	7,677	5,790	7,100
American River at Nimbus (cfs)	1,618	2,608	3,357	4,542	5,221	4,048	3,369	3,383	3,195	3,273	2,245	2,448
American River at H. St. (cfs)	1,442	2,444	3,219	4,385	5,033	3,855	3,088	3,044	2,805	2,722	1,852	2,135
SJ River at Vernalis (cfs)	2,710	2,605	3,248	4,821	6,203	7,165	7,473	5,747	4,609	3,188	2,032	2,312
Shasta Storage (TAF)	2,612	2,570	2,752	3,023	3,277	3,646	3,938	3,955	3,656	3,196	2,884	2,693
Folsom Storage (TAF)	457	431	456	473	493	592	719	838	803	671	591	505
Oroville Storage (TAF)	1,591	1,565	1,701	1,915	2,192	2,439	2,716	2,854	2,746	2,302	2,011	1,710
CVP San Luis Storage (TAF)	231	351	523	644	738	809	729	573	408	245	146	179
SWP San Luis Storage (TAF)	339	331	431	574	706	814	730	562	404	410	377	381
CVP Reservoir Expansion Alt.	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**
Delta Outflow (cfs)	5,906	11,422	20,697	42,001	52,730	42,156	30,978	22,070	12,344	7,788	4,432	9,724
Jones Pumping Plant (cfs)	3,511	3,511	3,922	3,291	3,347	3,221	1,218	1,081	2,602	3,390	3,716	3,971
Banks Pumping Plant (cfs)	3,230	3,800	4,725	3,573	4,055	3,996	1,193	985	2,400	5,840	5,403	5,048
Sac. River into Delta (cfs)	10,909	15,682	21,522	29,936	36,376	30,743	22,320	19,041	15,949	18,028	14,202	17,822
Sac. River at Keswick (cfs)	6,224	6,878	6,489	8,355	10,635	8,333	7,040	8,117	10,771	12,766	10,095	8,131
Sac River at NCP (cfs)	6,025	8,978	11,276	13,681	15,371	14,109	8,846	7,088	5,645	6,255	5,282	7,847
Feather River blw. Thermalito (cfs)	2,551	1,999	2,448	4,041	4,290	5,292	3,034	3,629	3,648	7,073	4,838	5,378
Lower Feather River (cfs)	3,044	2,896	4,785	10,753	11,749	12,403	8,769	7,658	6,198	7,689	5,791	7,104
American River at Nimbus (cfs)	1,630	2,603	3,356	4,544	5,222	4,047	3,369	3,383	3,207	3,269	2,240	2,438
American River at H. St. (cfs)	1,453	2,439	3,217	4,386	5,033	3,853	3,088	3,044	2,817	2,718	1,851	2,124
SJ River at Vernalis (cfs)	2,710	2,605	3,248	4,821	6,203	7,165	7,474	5,747	4,610	3,188	2,032	2,313
Shasta Storage (TAF)	2,611	2,570	2,752	3,023	3,277	3,647	3,939	3,955	3,656	3,196	2,884	2,693
Folsom Storage (TAF)	457	431	457	473	493	592	719	838	803	671	591	505
Oroville Storage (TAF)	1,591	1,566	1,702	1,916	2,194	2,440	2,717	2,855	2,748	2,303	2,012	1,711
CVP San Luis Storage (TAF)	238	356	527	651	748	825	745	587	421	254	153	186
SWP San Luis Storage (TAF)	338	331	431	571	705	812	728	561	401	408	376	380
Change from Future No Action	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**
Delta Outflow (cfs)	0	-10	-6	-27	-63	-74	-2	0	-1	3	0	-3
Jones Pumping Plant (cfs)	20	-35	4	57	32	107	8	0	27	4	-2	-1
Banks Pumping Plant (cfs)	19	2	-7	-33	14	-28	0	0	-26	8	0	3
Sac. River into Delta (cfs)	39	-43	-13	2	-11	-3	4	0	-1	15	-2	-1
Sac. River at Keswick (cfs)	13	-35	1	-2	-12	-3	6	3	4	12	7	6
Sac River at NCP (cfs)	13	-40	-2	3	-8	1	6	1	-1	7	2	6
Feather River blw. Thermalito (cfs)	14	0	-9	-3	-1	8	1	0	-13	11	0	2
Lower Feather River (cfs)	14	0	-9	-3	-1	8	1	0	-12	12	1	4
American River at Nimbus (cfs)	13	-5	-1	2	1	-1	-1	0	13	-4	-5	-10
American River at H. St. (cfs)	11	-5	-1	1	1	-1	-1	0	13	-5	-1	-10
SJ River at Vernalis (cfs)	0	0	0	0	0	0	0	0	0	0	0	0
Shasta Storage (TAF)	-2	1	0	0	1	1	0	0	0	0	0	-1
Folsom Storage (TAF)	0	0	0	0	0	0	0	0	-1	0	0	1
Oroville Storage (TAF)	0	1	1	1	2	1	1	1	2	1	1	1
CVP San Luis Storage (TAF)	7	5	4	8	10	16	15	14	13	10	7	7
SWP San Luis Storage (TAF)	0	0	0	-3	-1	-2	-2	-1	-3	-2	-2	-1

Average monthly results presented in Table 5-5 show relatively small changes in reservoir levels, river flow, Delta inflow and outflow, and Delta exports. The primary change in CVP and SWP operations with the San Luis Reservoir

Expansion Alternative is an increase in Delta exports at both Jones Pumping Plant to capture available Delta surplus and store it in the additional storage capacity provided by the alternative. This increase in Jones Pumping Plant exports results in a reduction in Delta outflow in these same months, and in some instances, a reduction in Banks Pumping Plant exports by the SWP. These changes tend to increase the average monthly storage in the CVP portion of San Luis Reservoir and decrease the average monthly storage in the SWP portion. Total San Luis Reservoir storage goes below 300,000 acre-feet in 18 of the 82-year simulation in the San Luis Reservoir Expansion Alternative.

5.3 Water Operations Modeling Results: WEAP

Local SCVWD results from the WEAP model indicate minimal to no change in local operations and supply under the San Luis Reservoir Expansion Alternative, as shown in Table 5-6. This is largely expected given the small changes in San Felipe Division deliveries shown in Table 5-1. ‘Change from FNA’ values are calculated and rounded from values with additional precision compared to those presented in the table. As a result, ‘Change from FNA’ values may reflect a different value than the difference between the Future No Action and the San Luis Reservoir Expansion results shown in the table.

Table 5-6. Annual Average WTP Delivery and Storage Conditions for the San Luis Reservoir Expansion Alternative as compared to the FNA.

Annual Average Values (1,000 acre-feet)	Future No Action	San Luis Res. Expansion	Change from FNA
Total WTP Delivery/M&I Water Supply	129	129	0
Unmet WTP Demand	2	2	0
Total Local Surface Storage	90	90	0
North County Groundwater Storage	316	316	0
Total Local Groundwater Storage	464	464	0
Total Semitropic Storage	150	151	1
Total SCVWD Available Storage	704	705	1
Total SCVWD Emergency Supply	406	406	0

Figure 5-1 shows annual SCVWD WTP deliveries under the San Luis Reservoir Expansion Alternative. There is little change in annual WTP deliveries under this alternative.

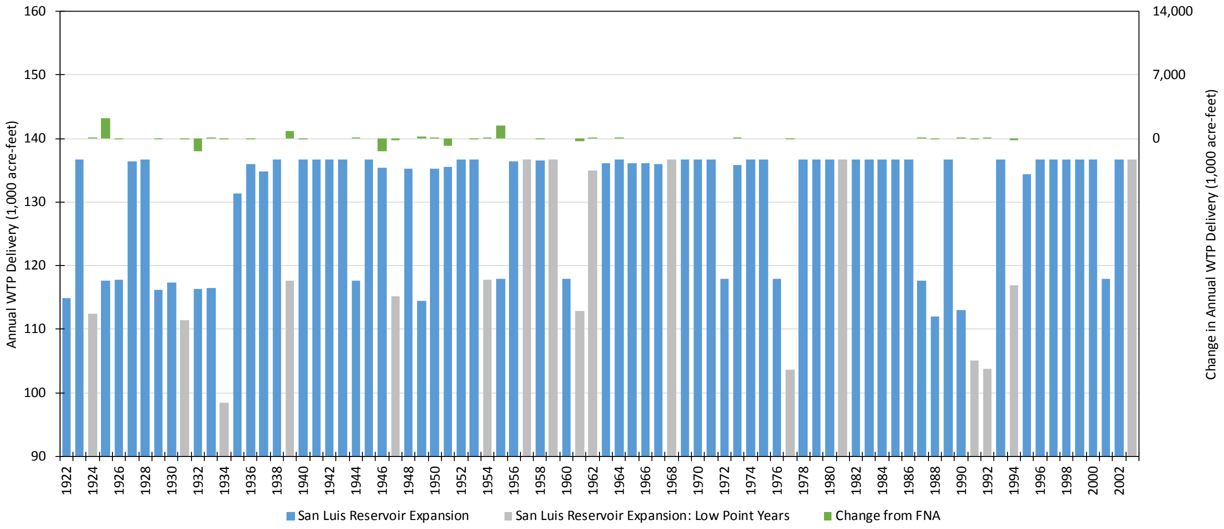

Figure 5-1. Annual Water Treatment Plant Delivery and Change from the FNA

Chapter 6
Treatment Alternative

The Treatment alternative includes infrastructure improvements to SCVWD water treatment facilities that would allow San Felipe Division diversions from San Luis Reservoir even when total storage in the reservoir is below 300,000 AF.

6.1 Modeling Approach and Assumptions

The Treatment Alternative would include the same assumptions as the Lower San Felipe Intake Alternative, with the addition of improvements to SCVWD water treatment facilities. San Luis Reservoir would continue to function as seasonal storage. This alternative allows delivery to San Felipe Division M&I contractors if San Luis Reservoir storage is maintained above dead pool. This operation was simulated in CalSim II by removing the constraint requiring San Luis Reservoir storage to be greater than 300,000 AF for delivery to San Felipe Division M&I contractors.

6.2 Water Operations Modeling Results

The Treatment Alternative was analyzed over an 82-year period to estimate the potential change in CVP deliveries due to the ability to continue deliveries to San Felipe M&I contractors during periods when San Luis Reservoir is below 300,000 AF. Overall results for both CalSim II and WEAP model runs are identical to those presented for the Lower San Felipe Intake Alternative. Please refer to results from Chapter 4 for effects to CVP deliveries, CVP/SWP system operations, and local SCVWD effects.

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Chapter 7
Pacheco Reservoir Expansion Alternative

The Pacheco Reservoir Expansion Alternative includes construction and operation of a new Pacheco dam and reservoir, pump station, conveyance facilities, and related miscellaneous infrastructure. The new dam and reservoir would be constructed on Pacheco Creek, 0.5 mile upstream from the existing North Fork Dam, and would inundate most of the existing Pacheco Reservoir. The proposed total storage for the new reservoir is 141,600 AF, with an active storage of 140,800 AF. The full pool elevation would be 694 feet and would inundate an additional 1,245 acres, for a total of 1,385 total acres inundated. Water would be collected in the new reservoir during the winter months from runoff from the local watershed area, and diversion of CVP supplies from the Pacheco Conduit, when needed.

7.1 Modeling Approach and Assumptions

The Pacheco Reservoir Expansion Alternative allows delivery to San Felipe Division CVP M&I contractors if San Luis Reservoir storage is maintained above dead pool. This operation was simulated in CalSim II by removing the constraint requiring San Luis Reservoir storage to be greater than 300,000 AF for delivery to San Felipe Division M&I contractors.

Operation of Pacheco Reservoir includes a transfer of 2,000 AF of San Felipe Division water supply to CVP SOD Refuge Supply in Below Normal years under the Accelerated Water Transfer Program. This operation is included in the CalSim II simulation.

7.2 Water Operations Modeling Results: CalSim II

The Pacheco Reservoir Expansion Alternative was analyzed over an 82-year period to estimate the potential change in CVP deliveries due to the ability to continue deliveries to San Felipe M&I contractors during periods when San Luis Reservoir is below 300,000 AF. The following sections summarize the effects of the alternative on CVP SOD M&I and agricultural water service contract deliveries and CVP/SWP system.

7.2.1 CVP Deliveries

The Pacheco Reservoir Expansion Alternative increases San Felipe Division CVP M&I water service contract deliveries by eliminating interruptions due to low-point issues. San Felipe Division CVP M&I deliveries increase because contractors can take delivery of water when San Luis Reservoir is below 300,000 AF.

The following tables summarize changes in deliveries to San Felipe Division CVP M&I contractors, CVP SOD agricultural water service contractors, and CVP SOD refuges under the Pacheco Reservoir Expansion Alternative.

Table 7-1. San Felipe Division CVP M&I Deliveries under the Pacheco Reservoir Expansion Alternative

Sacramento Valley Index	Future No Action (1,000 AF)	Pacheco Reservoir Expansion (1,000 AF)	Change from FNA (1,000 AF)
Wet	114	115	1
Above Normal	98	103	5
Below Normal	95	100	5
Dry	90	93	2
Critical	73	76	3
All Years	97	100	3

Table 7-1 shows an average annual increase in San Felipe Division CVP M&I deliveries of 3,000 AF under the Pacheco Reservoir Expansion Alternative. Delivery increases occur only within the San Felipe Division. There is no meaningful change to CVP SOD M&I contractors outside the San Felipe Division because there is no meaningful change to CVP M&I allocations. Increased deliveries match interrupted San Felipe Division M&I deliveries, as presented in Table 3-1, except for below normal years when 2,000 AF of San Felipe M&I supply is shifted to CVP SOD refuge supply. ‘Change from FNA’ values are calculated and rounded from values with additional precision compared to those presented in the table. As a result, ‘Change from FNA’ values may reflect a different value than the difference between the Future No Action and Pacheco Reservoir Expansion results shown in the table.

Table 7-2. CVP SOD Agricultural Deliveries under the Pacheco Reservoir Expansion Alternative

Sacramento Valley Index	Future No Action (1,000 AF)	Pacheco Reservoir Expansion (1,000 AF)	Change from FNA (1,000 AF)
Wet	1,341	1,341	0
Above Normal	1,009	1,004	-5
Below Normal	878	876	-2
Dry	591	589	-2
Critical	176	176	0
All Years	878	877	-2

Table 7-2 shows an average annual decrease in CVP SOD agricultural service contract deliveries of 2,000 AF. Simulated deliveries decrease because under the FNA Alternative interrupted San Felipe Division M&I deliveries remain in San Luis Reservoir and are available to be allocated to agricultural water service contractors in subsequent years. Under the Pacheco Reservoir Expansion Alternative, this interrupted supply is instead delivered to San Felipe Division M&I contractors, resulting in slightly lower CVP SOD agricultural deliveries. ‘Change from FNA’ values are calculated and rounded from values with additional precision compared to those presented in the table. As a result, ‘Change from FNA’ values may reflect a different value than the difference between the Future No Action and Pacheco Reservoir Expansion results shown in the table.

Table 7-3. CVP SOD Refuge Deliveries under the Pacheco Reservoir Expansion Alternative

Sacramento Valley Index	Future No Action (1,000 AF)	Pacheco Reservoir (1,000 AF)	Change from FNA (1,000 AF)
Wet	280	280	0
Above Normal	275	275	0
Below Normal	278	280	2
Dry	275	275	0
Critical	249	249	0
All Years	273	273	0

Table 7-3 shows an average annual increase in CVP SOD refuge deliveries of 2,000 AF in Below Normal years. This additional refuge delivery is part of the Pacheco Reservoir Expansion operations plan, which dedicates 2,000 AF of San Felipe Division CVP M&I supply in Below Normal years to CVP SOD refuges. This supply comes out of total SCVWD deliveries, as shown and discussed above in Table 7-1.

7.2.2 CVP/SWP Effects

The Pacheco Reservoir Expansion Alternative has the potential to affect CVP/SWP operations beyond San Luis Reservoir and the contractors who take delivery of water from the reservoir. As described in the previous section, interrupted M&I deliveries under the FNA tend to increase allocations and deliveries to other CVP contractors relative to the Pacheco Reservoir Expansion Alternative. Changes in SOD allocations can affect other areas of the CVP and, in some instances, the SWP due to requirements in the Coordinated Operation Agreement. These changes have the potential to affect resources in other parts of the system. Therefore, changes in river flows, reservoir storage, Delta outflow, and Delta export operations were quantified and reviewed in support of the environmental documentation. The following tables provide a high-level summary of changes throughout the CVP/SWP system. More detailed results were provided and reviewed by resource area specialists and are illustrated in figures located in Attachment B to this Appendix.

Table 7-4. Summary CVP/SWP System Effects under the Pacheco Reservoir Expansion Alternative

Future No Action	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**
Delta Outflow (cfs)	5,905	11,432	20,703	42,028	52,793	42,230	30,980	22,070	12,345	7,785	4,433	9,728
Jones Pumping Plant (cfs)	3,491	3,546	3,918	3,234	3,314	3,114	1,210	1,081	2,575	3,387	3,718	3,972
Banks Pumping Plant (cfs)	3,211	3,798	4,732	3,606	4,040	4,024	1,193	985	2,426	5,832	5,403	5,045
Sac. River into Delta (cfs)	10,870	15,725	21,534	29,935	36,387	30,746	22,316	19,041	15,950	18,013	14,204	17,822
Sac. River at Keswick (cfs)	6,211	6,913	6,488	8,357	10,648	8,336	7,035	8,114	10,768	12,754	10,088	8,125
Sac River at NCP (cfs)	6,012	9,018	11,278	13,679	15,379	14,107	8,840	7,088	5,647	6,248	5,280	7,841
Feather River blw. Thermalito (cfs)	2,538	1,999	2,457	4,043	4,291	5,284	3,033	3,629	3,660	7,061	4,838	5,376
Lower Feather River (cfs)	3,030	2,896	4,794	10,756	11,750	12,395	8,768	7,659	6,210	7,677	5,790	7,100
American River at Nimbus (cfs)	1,618	2,608	3,357	4,542	5,221	4,048	3,369	3,383	3,195	3,273	2,245	2,448
American River at H. St. (cfs)	1,442	2,444	3,219	4,385	5,033	3,855	3,088	3,044	2,805	2,722	1,852	2,135
SJ River at Vernalis (cfs)	2,710	2,605	3,248	4,821	6,203	7,165	7,473	5,747	4,609	3,188	2,032	2,312
Shasta Storage (TAF)	2,612	2,570	2,752	3,023	3,277	3,646	3,938	3,955	3,656	3,196	2,884	2,693
Folsom Storage (TAF)	457	431	456	473	493	592	719	838	803	671	591	505
Oroville Storage (TAF)	1,591	1,565	1,701	1,915	2,192	2,439	2,716	2,854	2,746	2,302	2,011	1,710
CVP San Luis Storage (TAF)	231	351	523	644	738	809	729	573	408	245	146	179
SWP San Luis Storage (TAF)	339	331	431	574	706	814	730	562	404	410	377	381
Pacheco Reservoir	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**
Delta Outflow (cfs)	5,908	11,434	20,703	42,021	52,783	42,227	30,976	22,070	12,345	7,784	4,433	9,729
Jones Pumping Plant (cfs)	3,496	3,548	3,920	3,236	3,317	3,114	1,210	1,081	2,576	3,386	3,716	3,984
Banks Pumping Plant (cfs)	3,211	3,794	4,733	3,606	4,043	4,025	1,193	985	2,427	5,832	5,403	5,044
Sac. River into Delta (cfs)	10,877	15,726	21,537	29,933	36,386	30,744	22,313	19,041	15,951	18,011	14,202	17,836
Sac. River at Keswick (cfs)	6,219	6,913	6,489	8,352	10,643	8,335	7,031	8,114	10,768	12,752	10,086	8,137
Sac River at NCP (cfs)	6,020	9,018	11,278	13,678	15,381	14,106	8,836	7,088	5,647	6,247	5,278	7,854
Feather River blw. Thermalito (cfs)	2,539	1,999	2,457	4,044	4,291	5,283	3,033	3,628	3,659	7,059	4,836	5,374
Lower Feather River (cfs)	3,031	2,896	4,794	10,756	11,750	12,395	8,768	7,658	6,211	7,676	5,790	7,100
American River at Nimbus (cfs)	1,616	2,609	3,358	4,542	5,221	4,049	3,369	3,383	3,195	3,273	2,244	2,449
American River at H. St. (cfs)	1,441	2,446	3,219	4,385	5,033	3,855	3,088	3,044	2,805	2,723	1,852	2,136
SJ River at Vernalis (cfs)	2,710	2,605	3,248	4,821	6,203	7,165	7,473	5,747	4,609	3,188	2,032	2,312
Shasta Storage (TAF)	2,611	2,569	2,751	3,022	3,276	3,646	3,938	3,955	3,656	3,197	2,884	2,693
Folsom Storage (TAF)	457	431	456	473	493	592	719	838	803	671	591	505
Oroville Storage (TAF)	1,591	1,565	1,701	1,915	2,192	2,439	2,716	2,854	2,746	2,302	2,011	1,710
CVP San Luis Storage (TAF)	230	349	521	642	736	808	728	572	407	244	145	178
SWP San Luis Storage (TAF)	339	331	431	574	706	814	730	562	404	410	377	381
Change from Future No Action	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**
Delta Outflow (cfs)	3	2	0	-7	-11	-3	-4	0	0	0	1	1
Jones Pumping Plant (cfs)	5	3	2	2	3	0	0	0	0	0	-2	12
Banks Pumping Plant (cfs)	-1	-4	1	-1	3	1	0	0	0	0	-1	0
Sac. River into Delta (cfs)	7	1	2	-2	-1	-2	-3	0	1	-2	-2	14
Sac. River at Keswick (cfs)	8	-1	1	-5	-5	-1	-4	0	0	-2	-2	13
Sac River at NCP (cfs)	8	0	1	-1	1	-1	-4	0	0	-1	-2	13
Feather River blw. Thermalito (cfs)	1	0	0	0	0	0	0	-1	-1	-3	-2	-1
Lower Feather River (cfs)	1	0	0	0	0	-1	0	0	0	0	0	0
American River at Nimbus (cfs)	-2	1	1	0	0	0	0	0	0	0	0	1
American River at H. St. (cfs)	-1	1	1	0	0	0	0	0	0	0	0	1
SJ River at Vernalis (cfs)	0	0	0	0	0	0	0	0	0	0	0	0
Shasta Storage (TAF)	-1	-1	-1	-1	0	0	0	0	0	0	0	0
Folsom Storage (TAF)	0	0	0	0	0	0	0	0	0	0	0	0
Oroville Storage (TAF)	0	0	0	0	0	0	0	0	0	0	0	0
CVP San Luis Storage (TAF)	-2	-2	-2	-2	-2	-1	-1	-1	-1	-1	-1	-1
SWP San Luis Storage (TAF)	0	0	0	0	0	0	0	0	0	0	0	0

Results presented in Table 7-4 show only small changes in the CVP/SWP system.

7.3 Water Operations Modeling Results: WEAP

The additional San Felipe deliveries under the Pacheco Reservoir Expansion Alternative provide additional imported supply into the SCVWD system as summarized by the WEAP results in Table 7-5. The additional supply helps to increase the total WTP deliveries, while also boosting local surface, groundwater, and Semitropic storage levels. Total local surface storage is much higher as a result of the expansion of the existing Pacheco Reservoir. This provides an important boost not only local surface water supply, but also to

SCVWD emergency supplies, which are approximately 102,000 AF higher compared to the FNA. 'Change from FNA' values are calculated and rounded from values with additional precision compared to those presented in the table. As a result, 'Change from FNA' values may reflect a different value than the difference between the Future No Action and Pacheco Reservoir Expansion results shown in the table.

Table 7-5. Annual Average WTP Delivery and Storage Conditions for the Pacheco Reservoir Expansion Alternative as compared to the FNA.

Annual Average Values (1,000 acre-feet)	Future No Action	New Pacheco Reservoir	Change from FNA
Total WTP Delivery/M&I Water Supply	129	129	0
Unmet WTP Demand	2	1	0
Total Local Surface Storage	90	187	97
North County Groundwater Storage	316	321	5
Total Local Groundwater Storage	464	471	7
Total Semitropic Storage	150	153	3
Total SCVWD Available Storage	704	811	107
Total SCVWD Emergency Supply	406	508	102

Annual WTP deliveries increase in most low point years, as shown in Figure 7-1. Results are similar to the changes in WTP deliveries under the Lower San Felipe Intake Alternative (Figure 4-1).

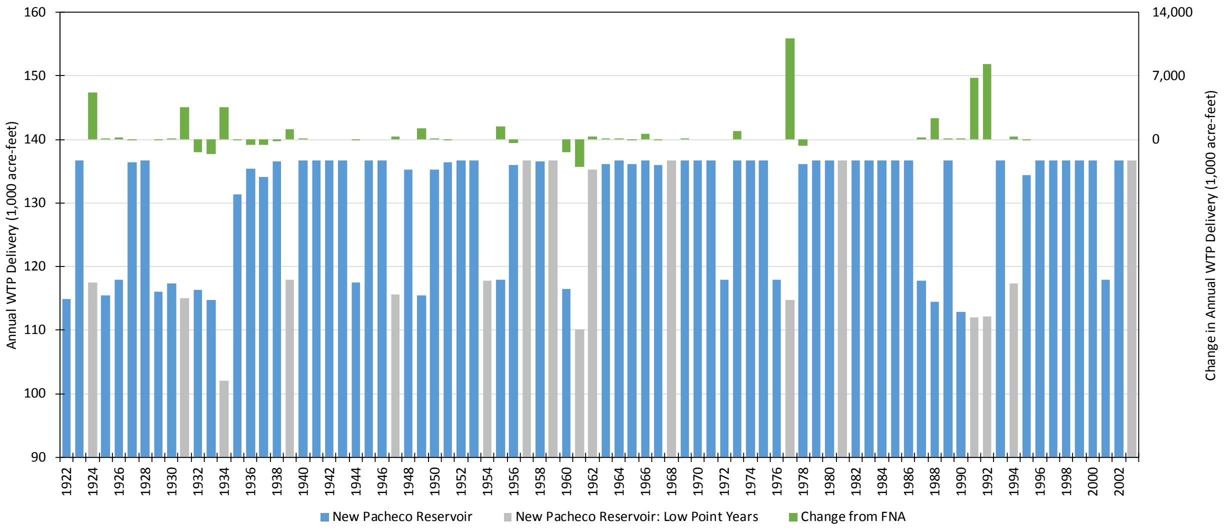

Figure 7-1. Annual Water Treatment Plant Delivery and Change from the FNA

Attachment A

CalSim II Assumptions for Future No Action Conditions

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

	Period of Simulation: 82 years (1922-2003)
	Future Level Study
Trinity Reservoir End-of-September Minimum Storage	Trinity EIS Preferred Alternative (600 taf as able)
Clear Creek	
Minimum Flow below Whiskeytown Dam	Downstream water rights, 1963 Reclamation Proposal to USFWS and NPS, predetermined Central Valley Project Improvement Act 3406(b)(2) flows and NMFS biological opinion (June 2009) Action I.1.1[5]
Upper Sacramento River	
Shasta Lake End-of-September Minimum Storage	NMFS 2004 Winter-run biological opinion (1900 taf), predetermined Central Valley Project Improvement Act 3406(b)(2) flows, and NMFS biological opinion (Jun 2009) Action I.2.1[5]
Minimum Flow below Keswick Dam	Flows for SWRCB Water Rights Order 90-5 and 1993 Winter-run biological opinion temperature control, predetermined Central Valley Project Improvement Act 3406(b)(2) flows, and NMFS biological opinion (Jun 2009), Action I.2.2[5]
Feather River	
Minimum Flow below Thermalito Diversion Dam	2006 Settlement Agreement (700/800 cfs)
Minimum Flow below Thermalito Afterbay outlet	1983 DWR, DFG Agreement (750-1700 cfs)
Yuba River	
Minimum flow below Daguerre Point Dam	D-1644 Operations (Lower Yuba River Accord)[4]
American River	
Minimum Flow below Nimbus Dam	American River Flow Management as required by NMFS biological opinion (Jun 2009), Action 2.1[5]
Minimum Flow at H Street Bridge	SWRCB D-893
Lower Sacramento River	
Minimum Flow near Rio Vista	SWRCB D-1641
Mokelumne River	
Minimum Flow below Camanche Dam	Federal Energy Regulatory Commission 2916-029, 1996 Joint Settlement Agreement (100 – 325 cfs)
Minimum Flow below Woodbridge Diversion Dam	Federal Energy Regulatory Commission 2916-029, 1996 Joint Settlement Agreement (25 – 300 cfs)
Stanislaus River	
Minimum Flow below Goodwin Dam	1987 Reclamation, DFG agreement, and flows required for NMFS biological opinion (Jun 2009) Actions III.1.2 and III.1.3[5]
Minimum Dissolved Oxygen	SWRCB D-1422
REGULATORY STANDARDS	
Merced River	
Minimum Flow below Crocker-Huffman Diversion Dam	Davis-Grunsky (180 – 220 cfs, Nov – Mar) and Cowell Agreement
Minimum Flow at Shaffer Bridge	Federal Energy Regulatory Commission 2179 (25-100 cfs)

	Period of Simulation: 82 years (1922-2003)
	Future Level Study
Tuolumne River	
Minimum Flow at Lagrange Bridge	Federal Energy Regulatory Commission 2299-024, 1995 Settlement Agreement (94-301 taf/yr)
San Joaquin River	
San Joaquin River Restoration	Full flows
Maximum Salinity near Vernalis	SWRCB D-1641
Minimum Flow near Vernalis	SWRCB D-1641, NMFS biological opinion (Jun 2009), Action 4.2.1[5]
Sacramento River-San Joaquin River Delta	
Delta Outflow Index (Flow and Salinity)	SWRCB D-1641, USFWS biological opinion (Dec 2008), Action 4[5]
Delta Cross Channel Gates	SWRCB D-1641, NMFS biological opinion (Jun 2009) Action 4.1.2[5]
Delta Exports	SWRCB D-1641, NMFS biological opinion (Jun 2009) Action 4.2.1[5]
Combined Flow in Old and Middle River	USFWS biological opinion (Dec 2008), Actions 1–3 and NMFS biological opinion (Jun 2009), Action 4.2.3[5]
OPERATIONS CRITERIA	
Subsystem	
Upper Sacramento River	
Flow Objective for Navigation (Wilkins Slough)	NMFS biological opinion (Jun 2009) Action I.4[5]; 3,250 – 5,000 cfs based on CVP water supply condition
American River	
Folsom Dam Flood Control	Variable 400/670 without outlet modifications
Feather River	
Flow at Mouth	Maintain DFG/DWR flow target above Verona or 2800 cfs Apr-Sep, dependent on Oroville inflow and FRSA allocation
System-wide	
CVP Water Allocation	
CVP Settlement and Exchange	100% (75% in Shasta Critical years)
CVP Refuges	100% (75% in Shasta Critical years)
CVP Agriculture	100% - 0% based on supply; additionally limited due to D-1641, USFWS biological opinion (Dec 2008) and NMFS biological opinion (Jun 2009) export restrictions[5]
CVP Municipal & Industrial	100% - 0% based on supply; additionally limited due to D-1641, USFWS biological opinion (Dec 2008) and NMFS biological opinion (Jun 2009) export restrictions[5]
OPERATIONS CRITERIA	
SWP Water Allocation	
North of Delta (FRSA)	Contract specific
South of Delta	Based on supply, Monterey Agreement; allocations limited due to D-1641, USFWS biological opinion (Dec2008) and NMFS biological opinion (Jun 2009) export restrictions[5]
CVP/SWP Coordinated Operations	
Sharing of Responsibility for In Basin Use	1986 Coordinated Operations Agreement
Sharing of Surplus Flows	1986 Coordinated Operations Agreement
Sharing of Restricted Export Capacity	Equal sharing of export capacity under SWRCB D-1641, USFWS biological opinion (Dec 2008) and NMFS biological opinion (Jun 2009) export restrictions[5]

	Period of Simulation: 82 years (1922-2003)
	Future Level Study
Transfers	
Lower Yuba River Accord[6]	Yuba River acquisitions for reducing impact of NMFS biological opinion export restrictions on SWP

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

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

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

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

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

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

Attachment B

Comparison of Future No Action Conditions and Project Alternatives at Future LOD

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Figure 1: Comparison of Trinity Storage for Lower San Felipe Intake Alternative

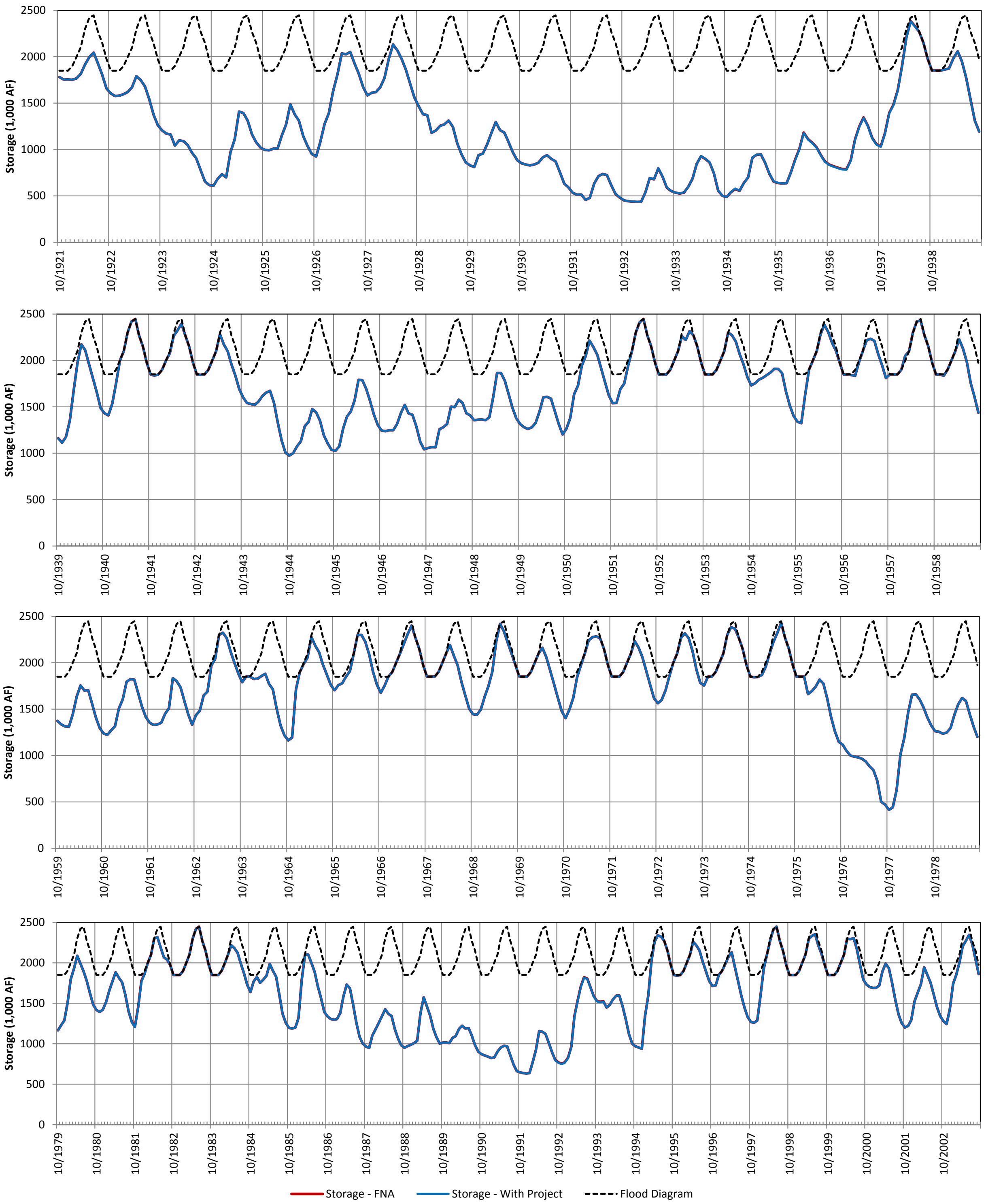


Figure 2: Comparison of Shasta Storage for Lower San Felipe Intake Alternative

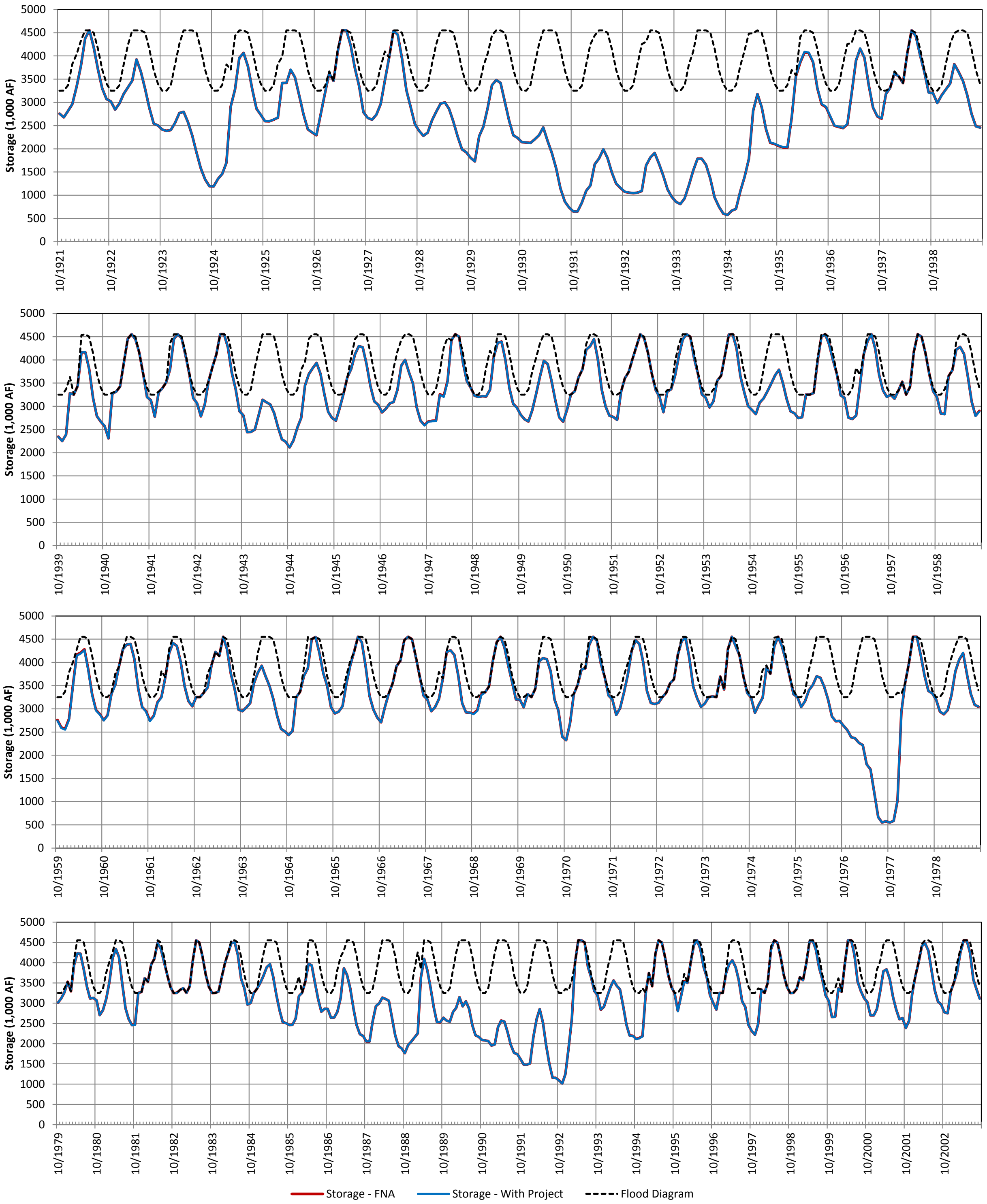


Figure 3: Comparison of Folsom Storage for Lower San Felipe Intake Alternative

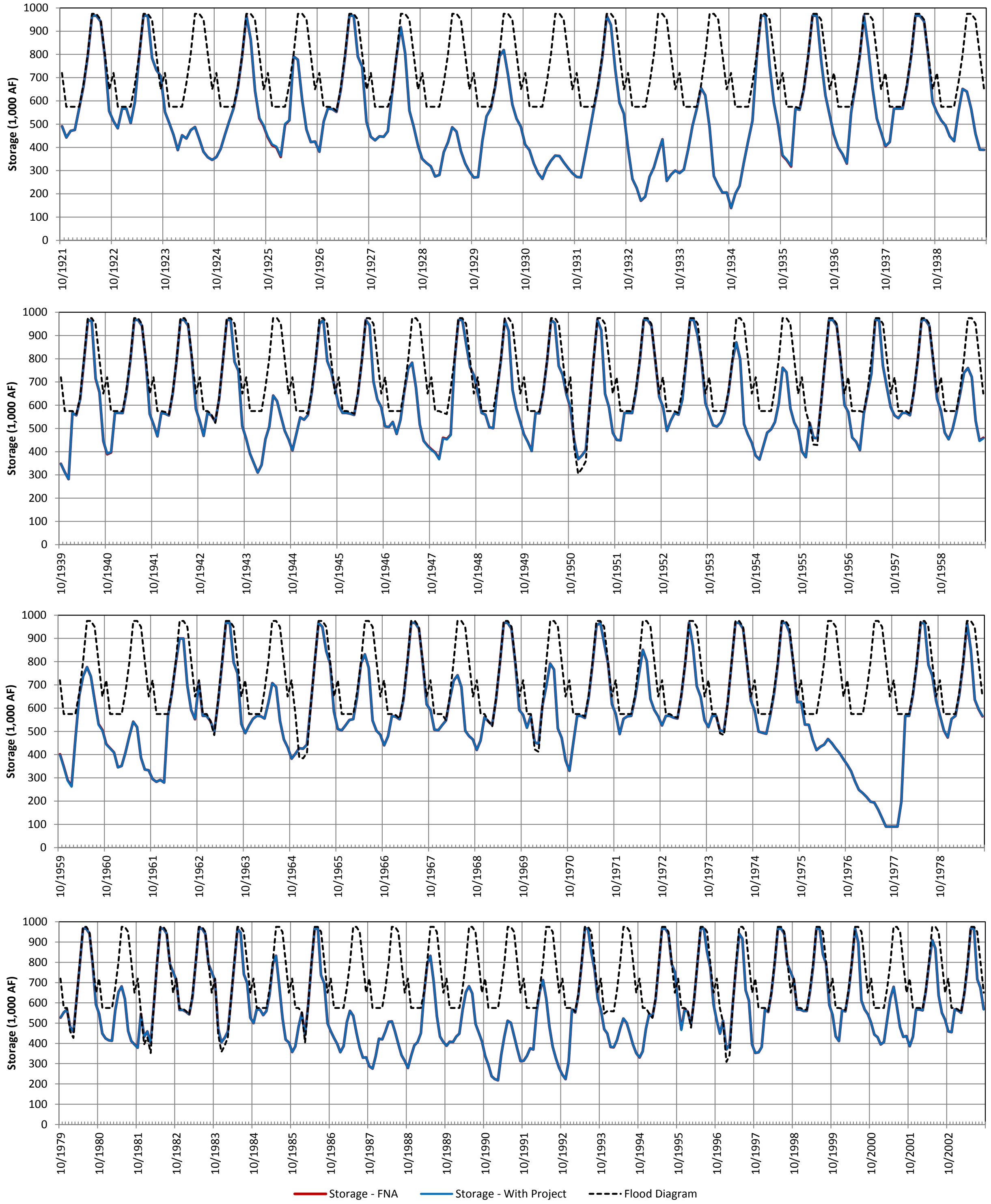


Figure 4: Comparison of Oroville Storage for Lower San Felipe Intake Alternative

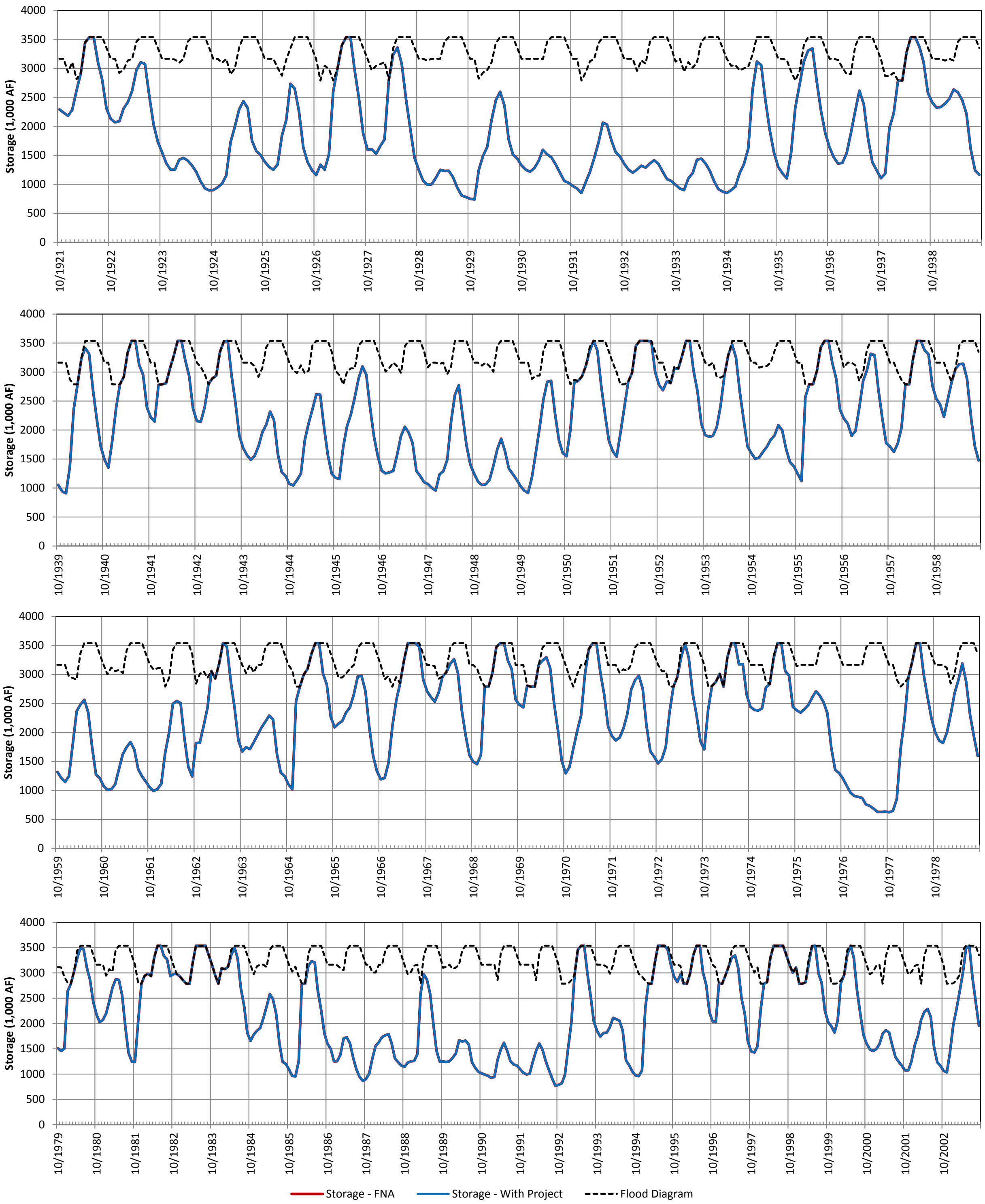


Figure 5: Comparison of Sacramento River below Keswick Flow for Lower San Felipe Intake Alternative

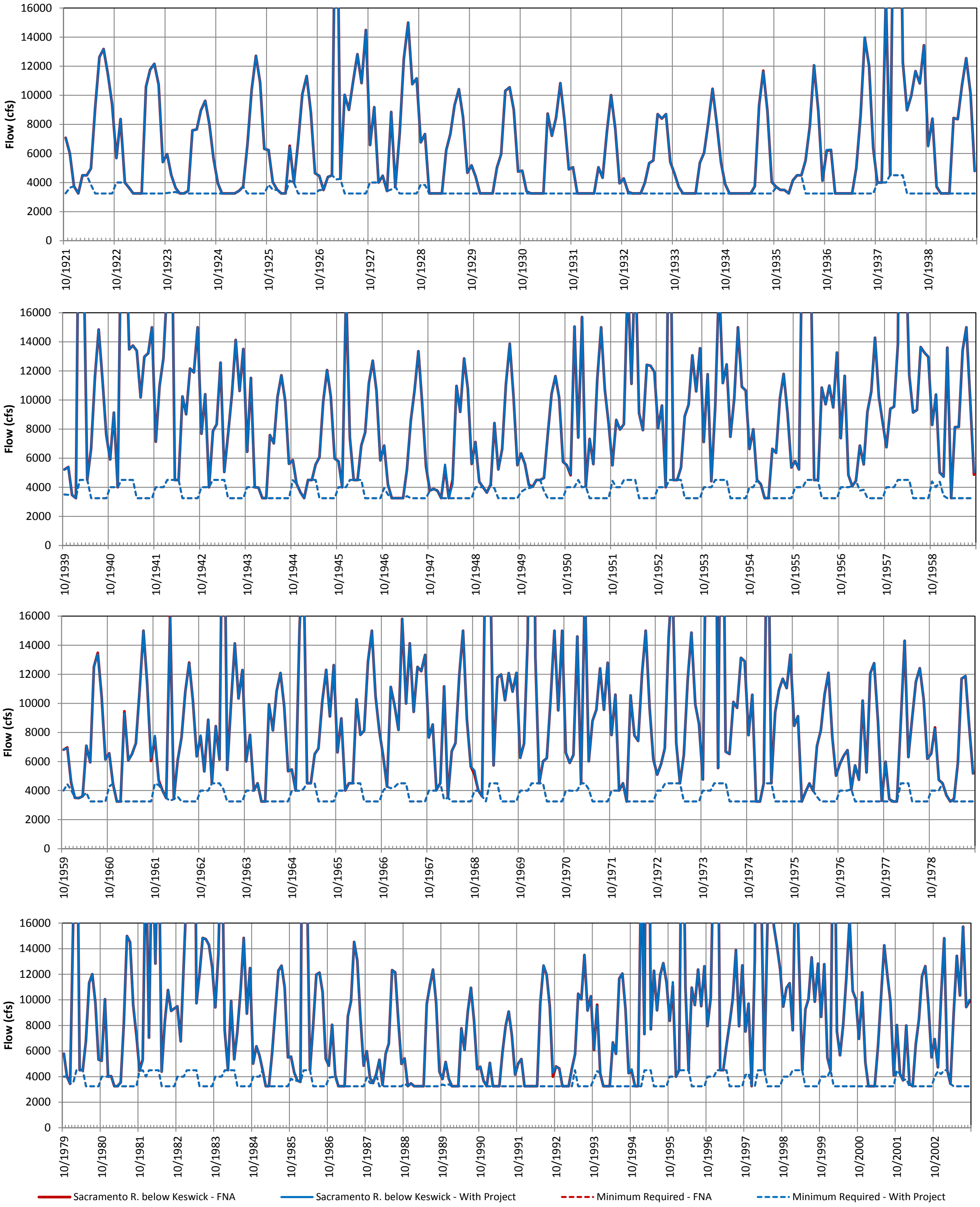


Figure 6: Comparison of Sacramento River at Wilkins Slough Flow for Lower San Felipe Intake Alternative

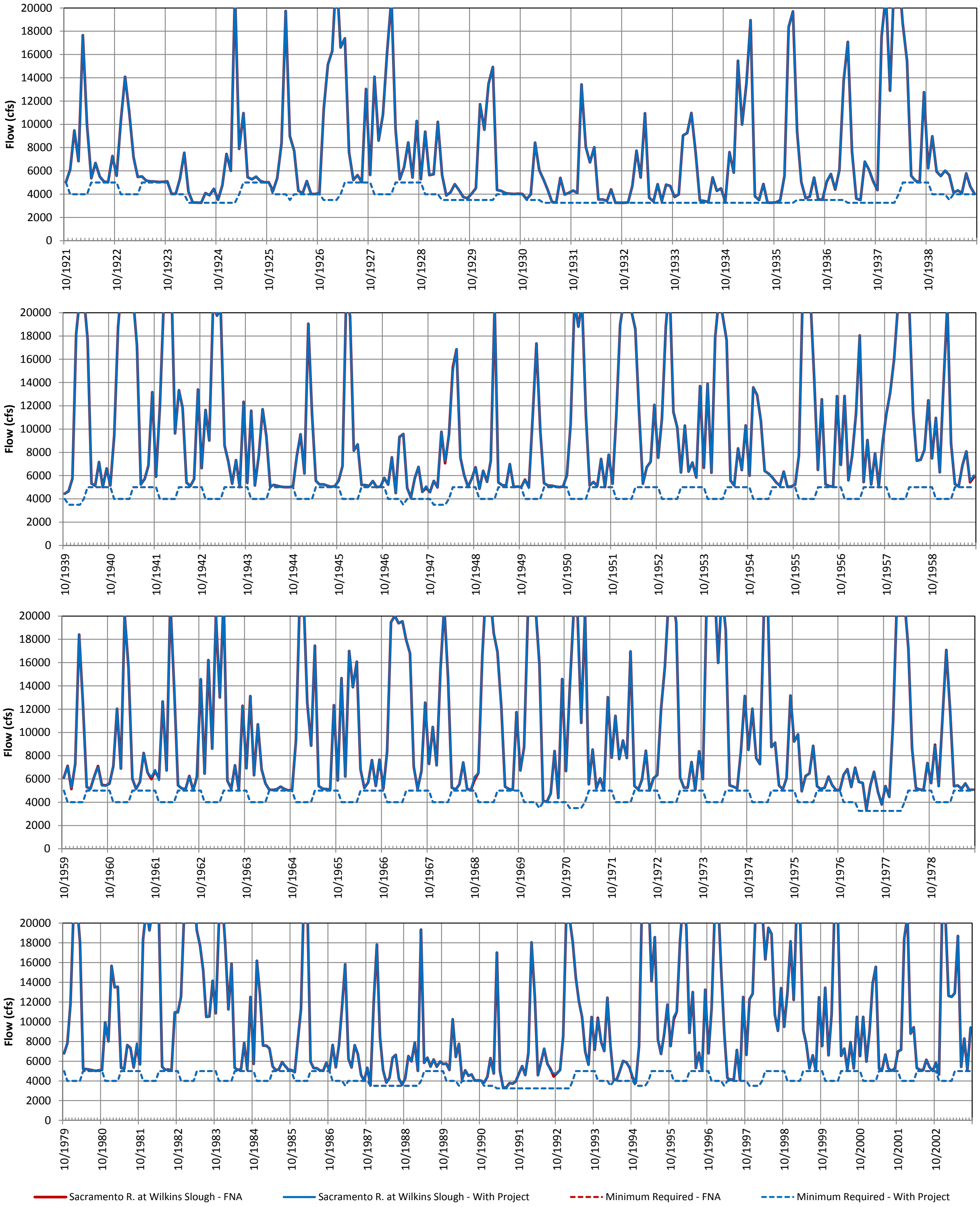


Figure 7: Comparison of American River below Nimbus Flow for Lower San Felipe Intake Alternative

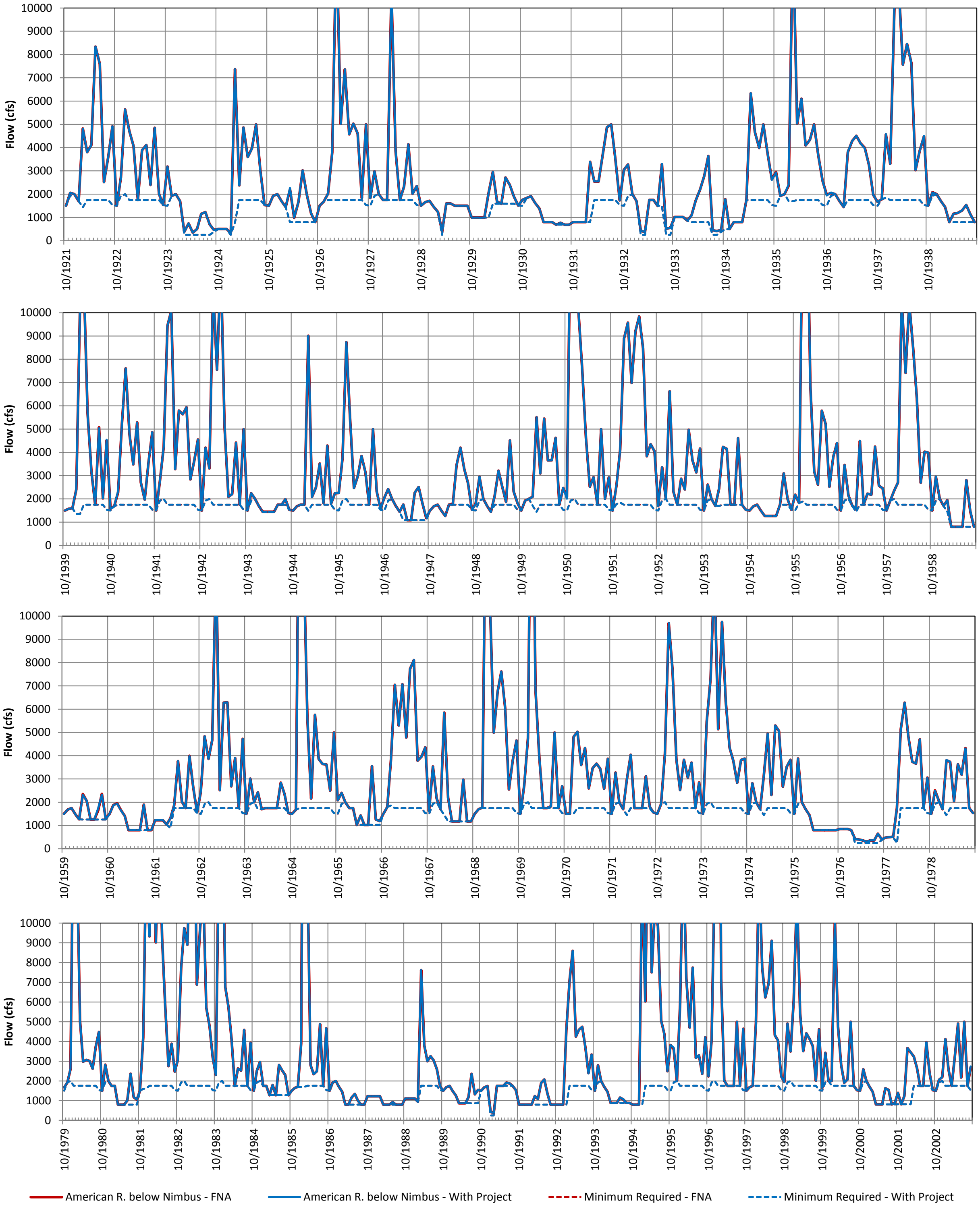


Figure 8: Comparison of Lower Feather River Flow for Lower San Felipe Intake Alternative

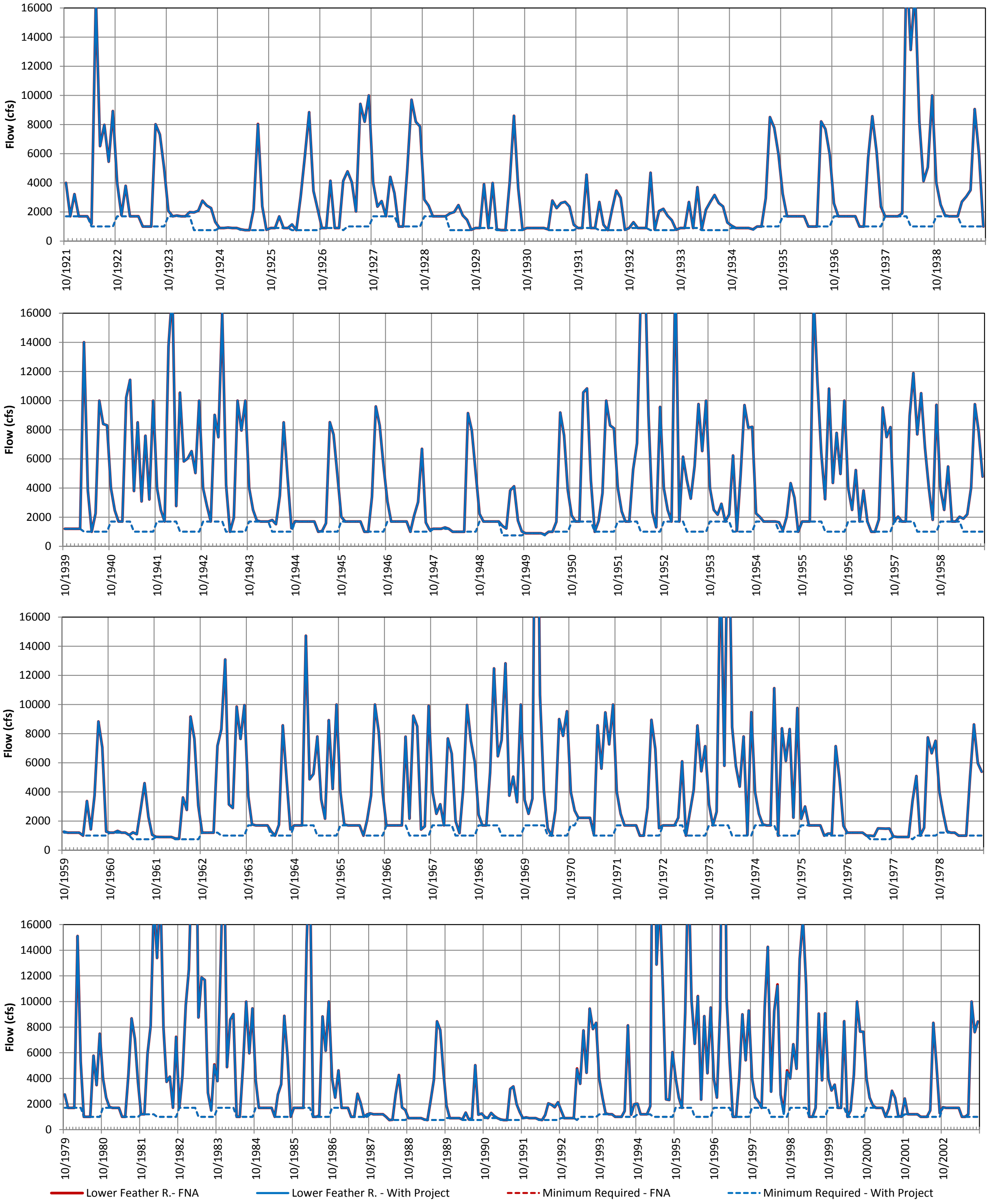


Figure 9: Comparison of Delta Inflow for Lower San Felipe Intake Alternative

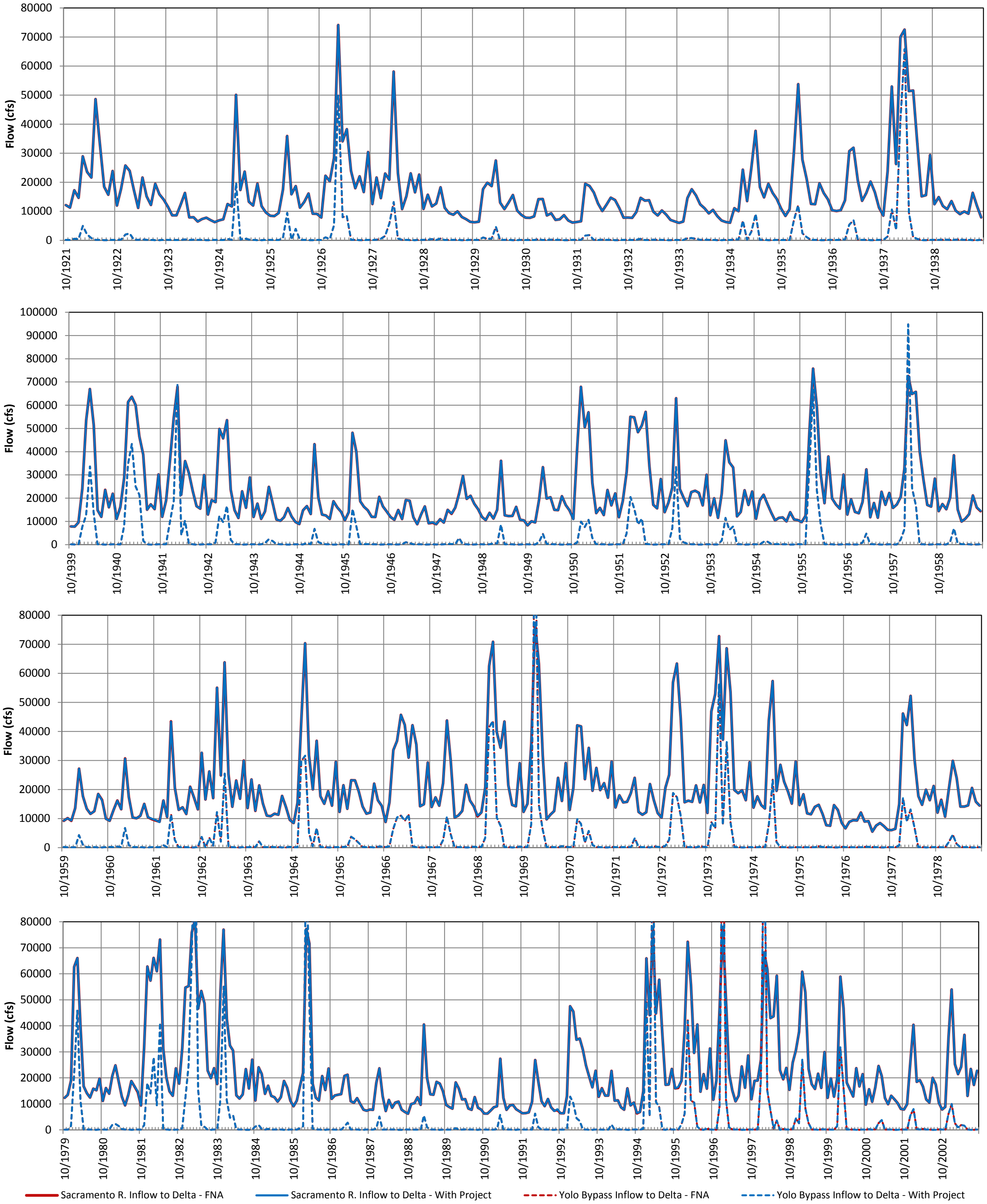


Figure 10: Comparison of Delta Outflow for Lower San Felipe Intake Alternative

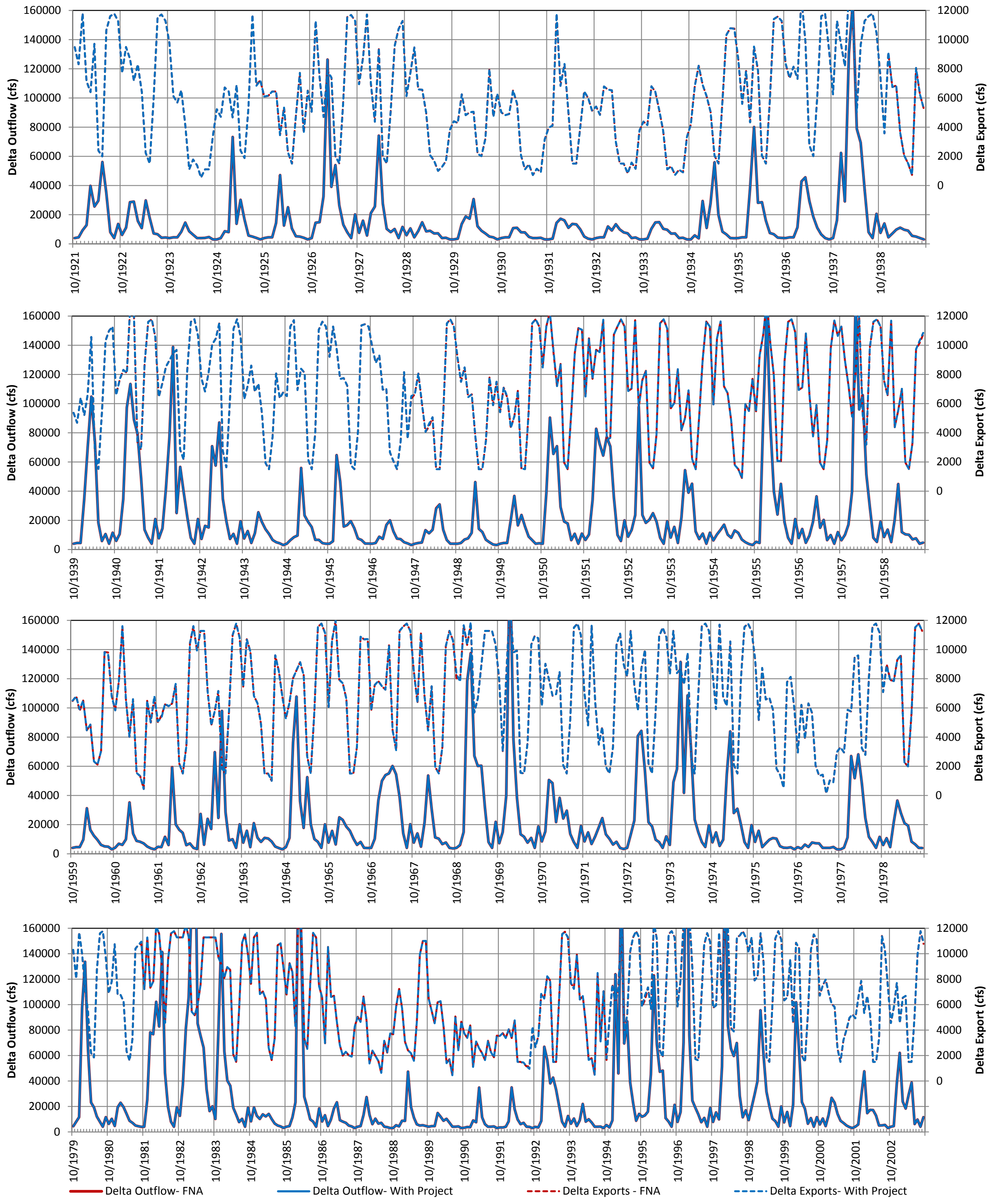


Figure 11: Comparison of San Luis Reservoir Storage for Lower San Felipe Intake Alternative

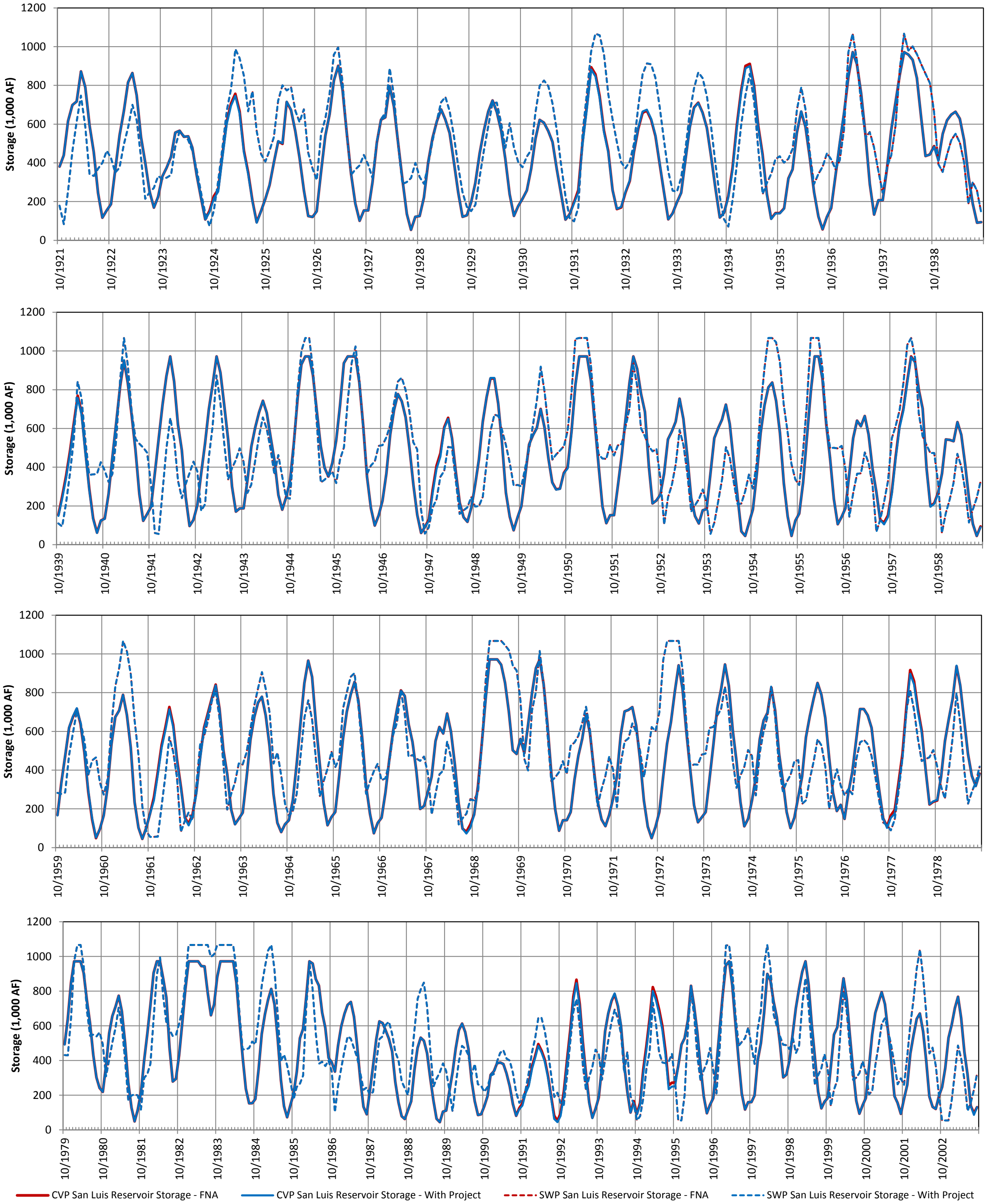


Figure 12: Comparison of Trinity Storage for San Luis Reservoir Expansion Alternative

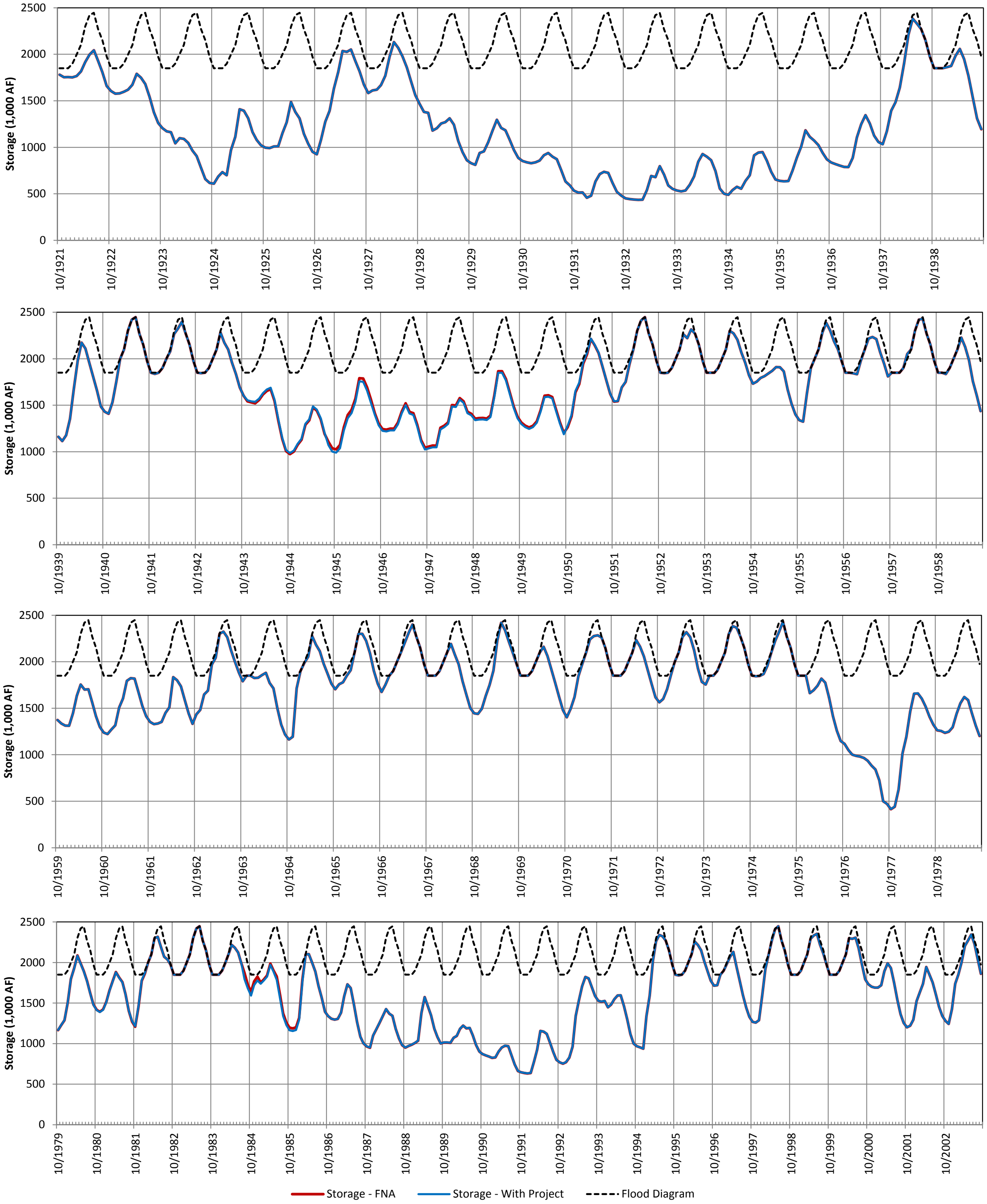


Figure 13: Comparison of Shasta Storage for San Luis Reservoir Expansion Alternative

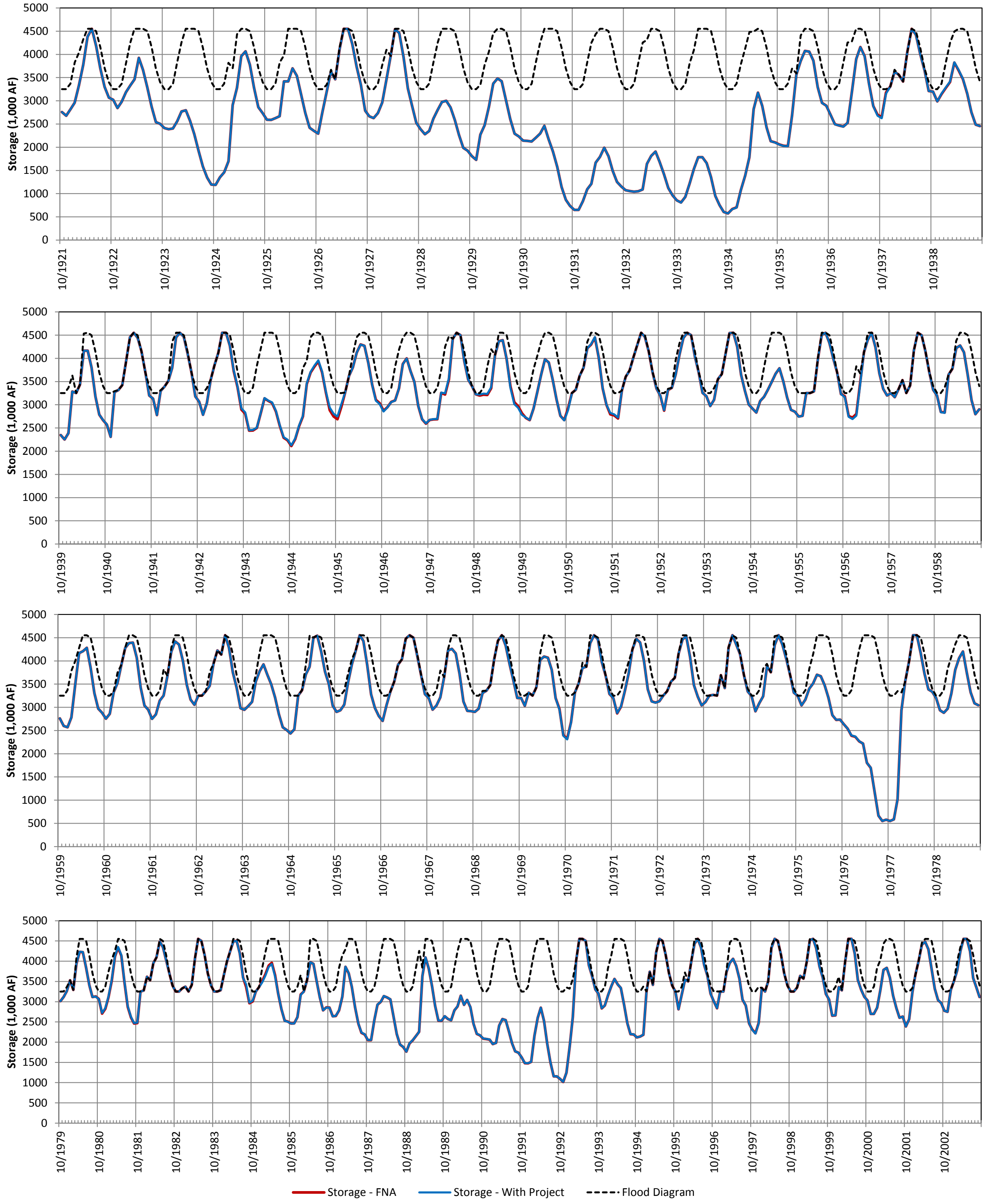


Figure 14: Comparison of Folsom Storage for San Luis Reservoir Expansion Alternative

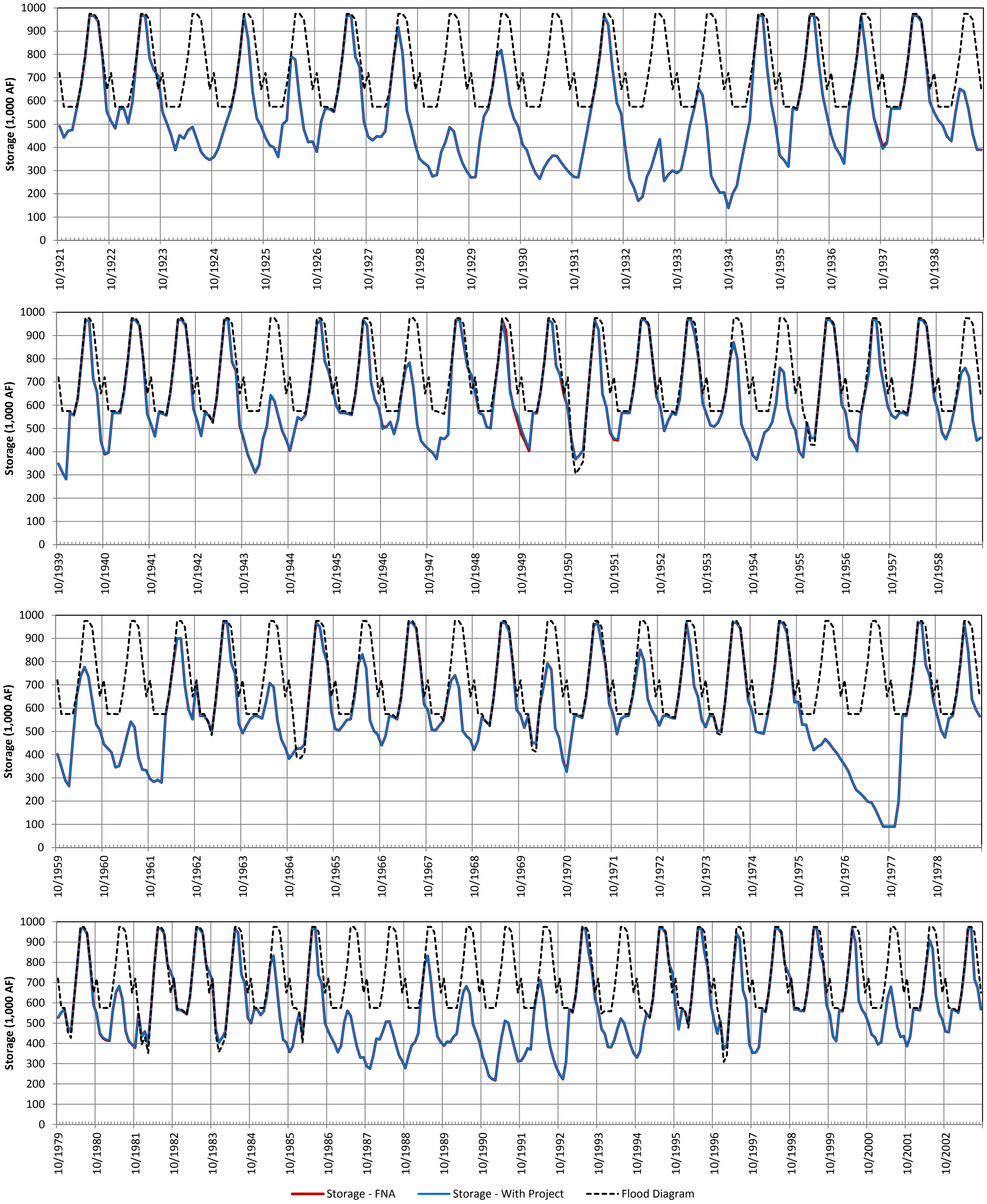


Figure 15: Comparison of Oroville Storage for San Luis Reservoir Expansion Alternative

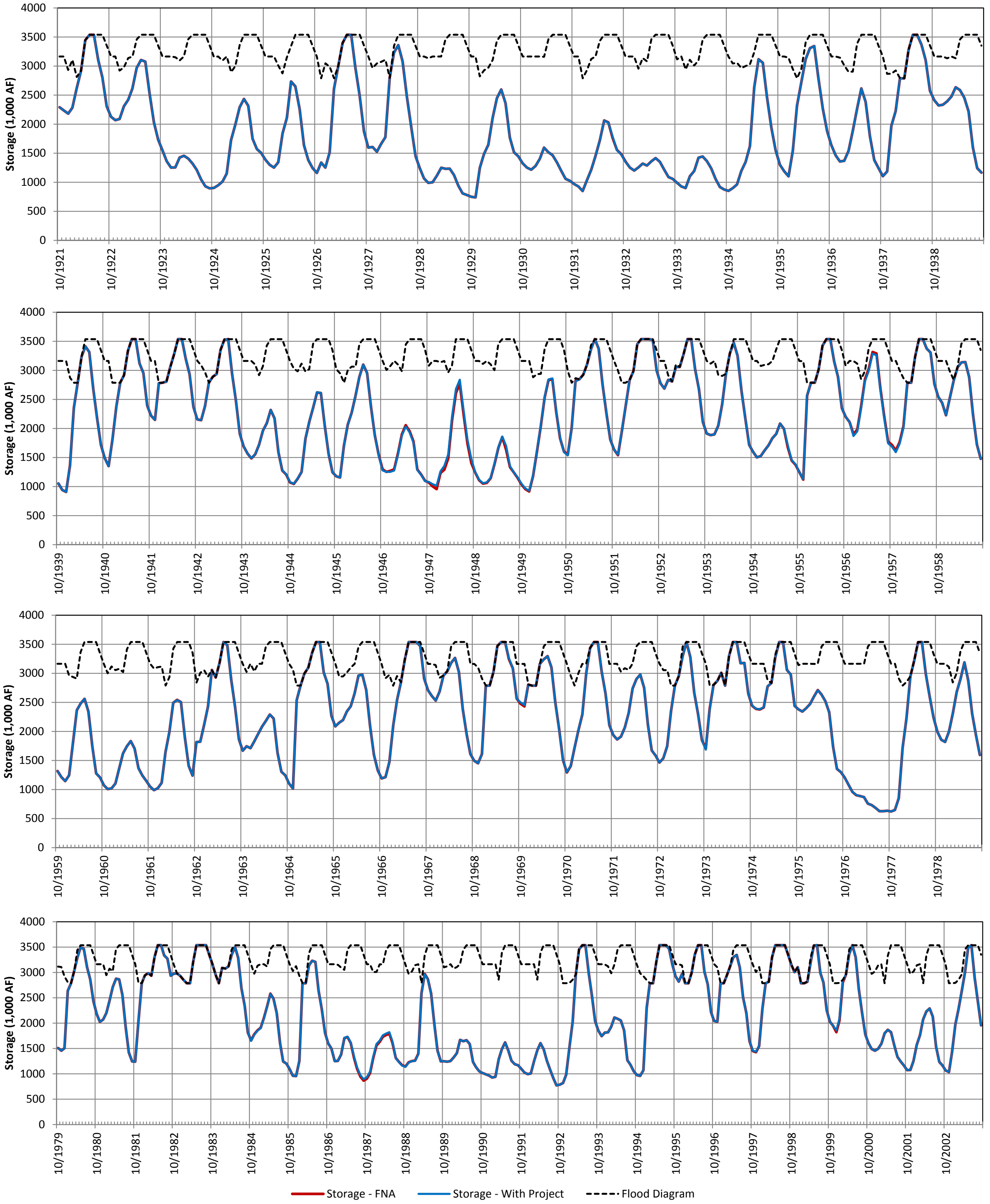


Figure 16: Comparison of Sacramento River below Keswick Flow for San Luis Reservoir Expansion Alternative

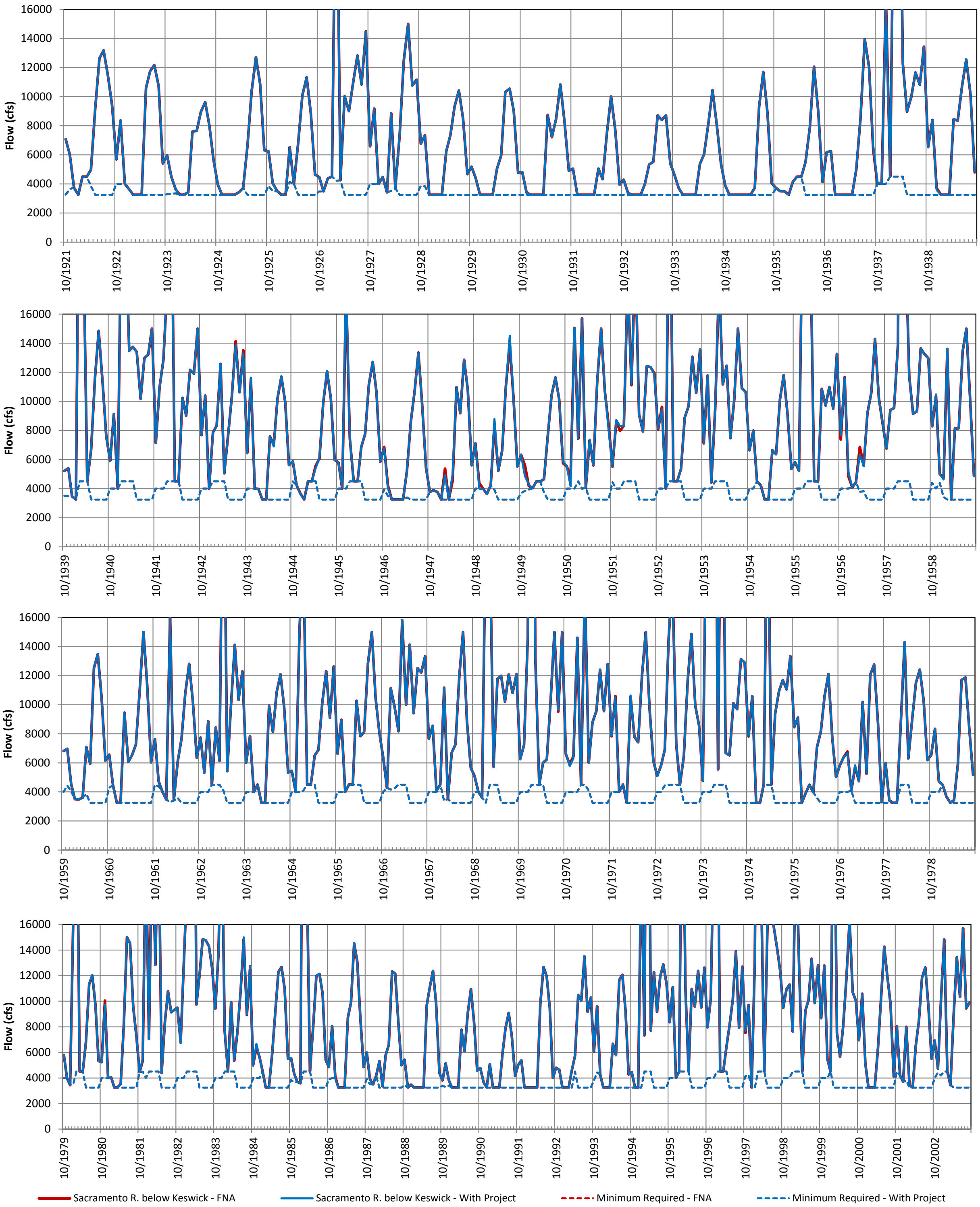


Figure 17: Comparison of Sacramento River at Wilkins Slough Flow for San Luis Reservoir Expansion Alternative

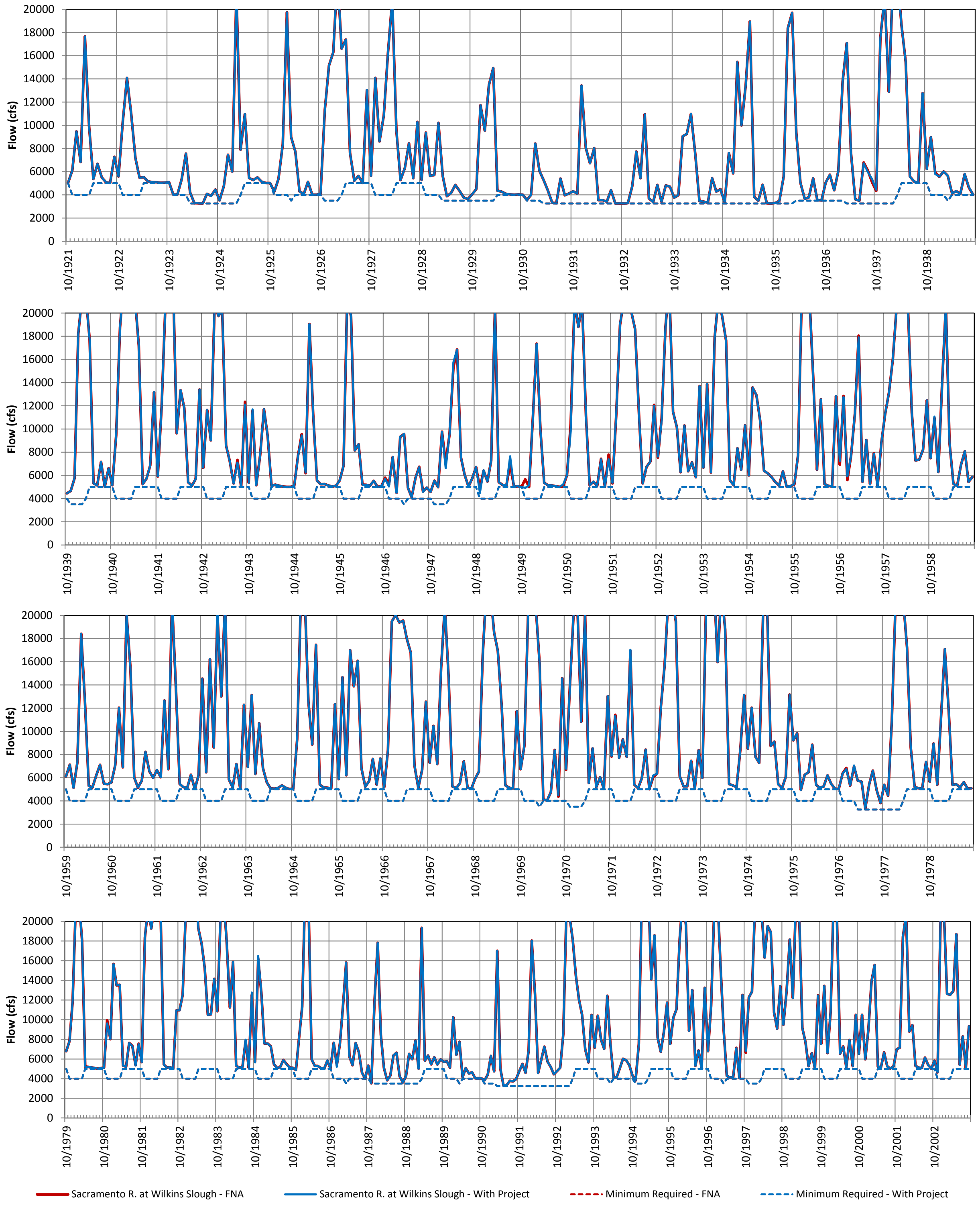


Figure 18: Comparison of American River below Nimbus Flow for San Luis Reservoir Expansion Alternative

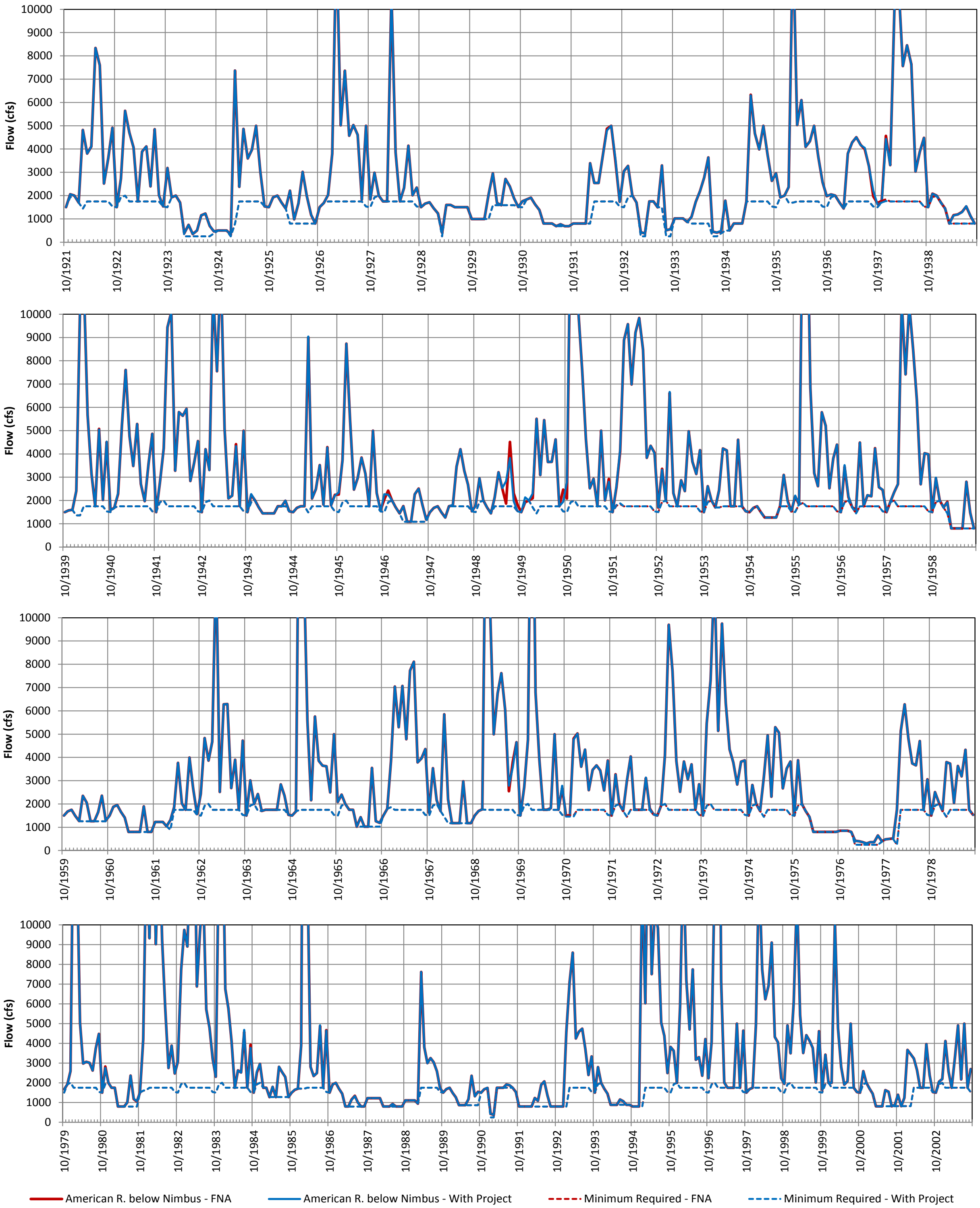


Figure 19: Comparison of Lower Feather River Flow for San Luis Reservoir Expansion Alternative

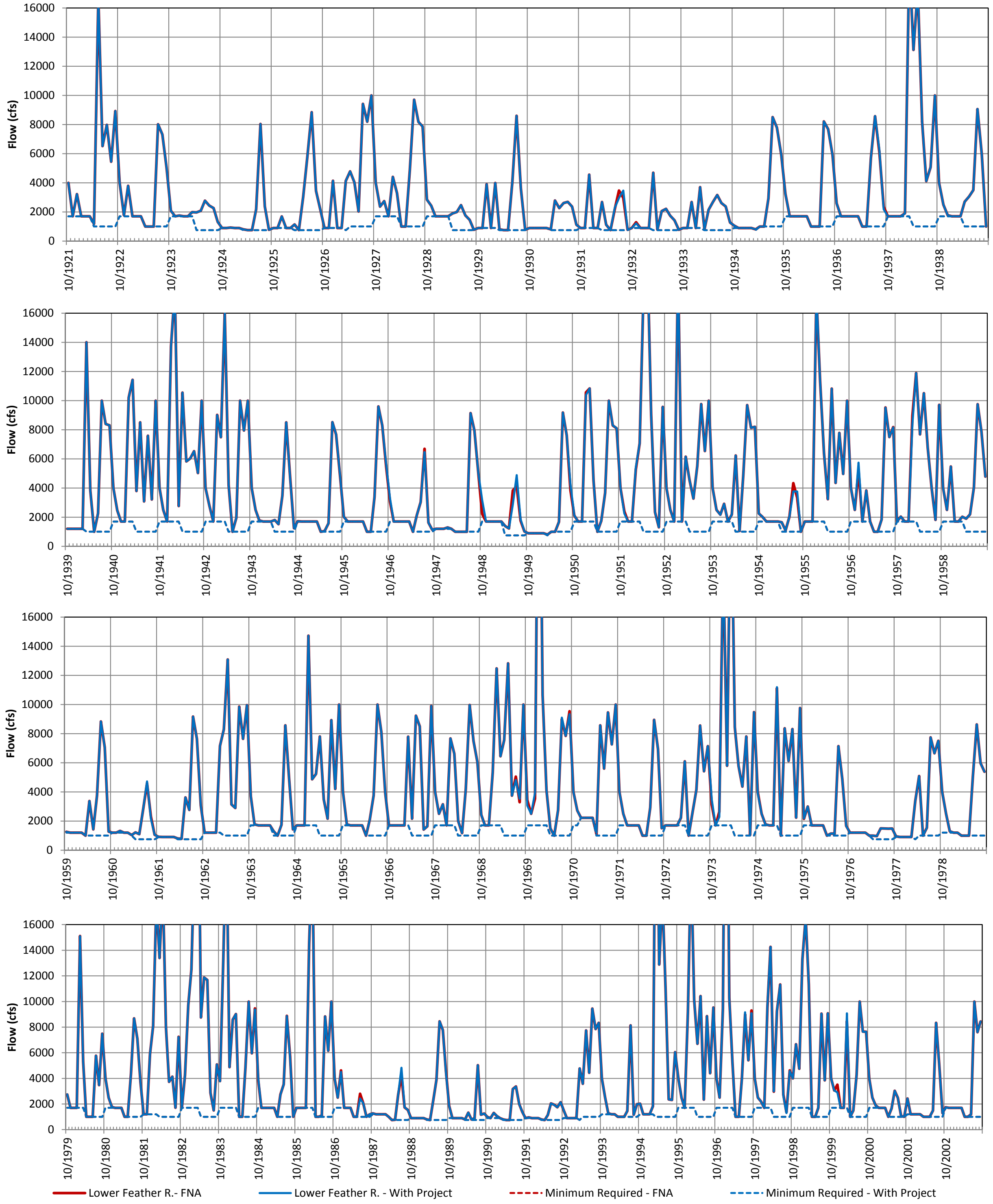


Figure 20: Comparison of Delta Inflow for San Luis Reservoir Expansion Alternative

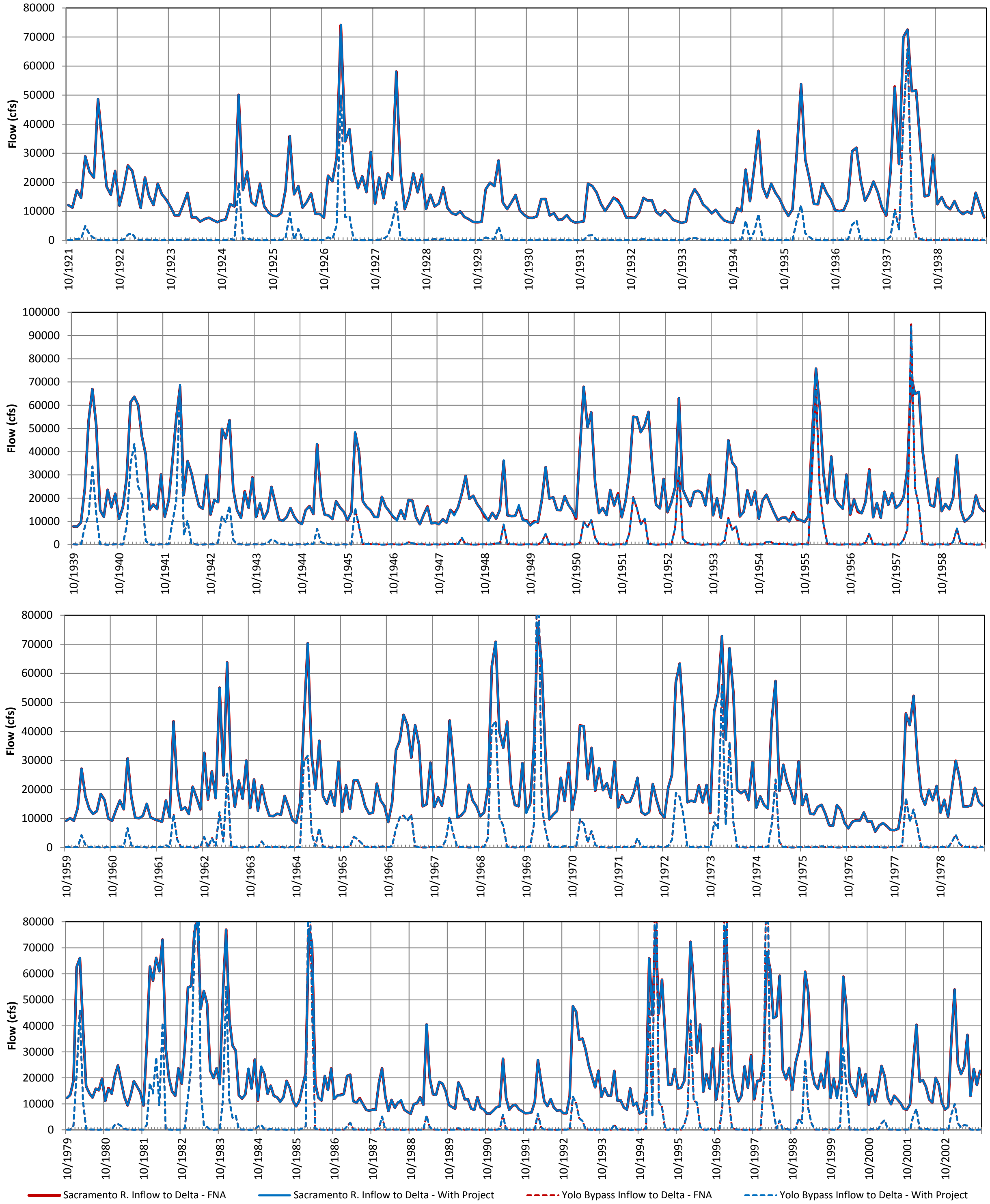


Figure 21: Comparison of Delta Outflow for San Luis Reservoir Expansion Alternative

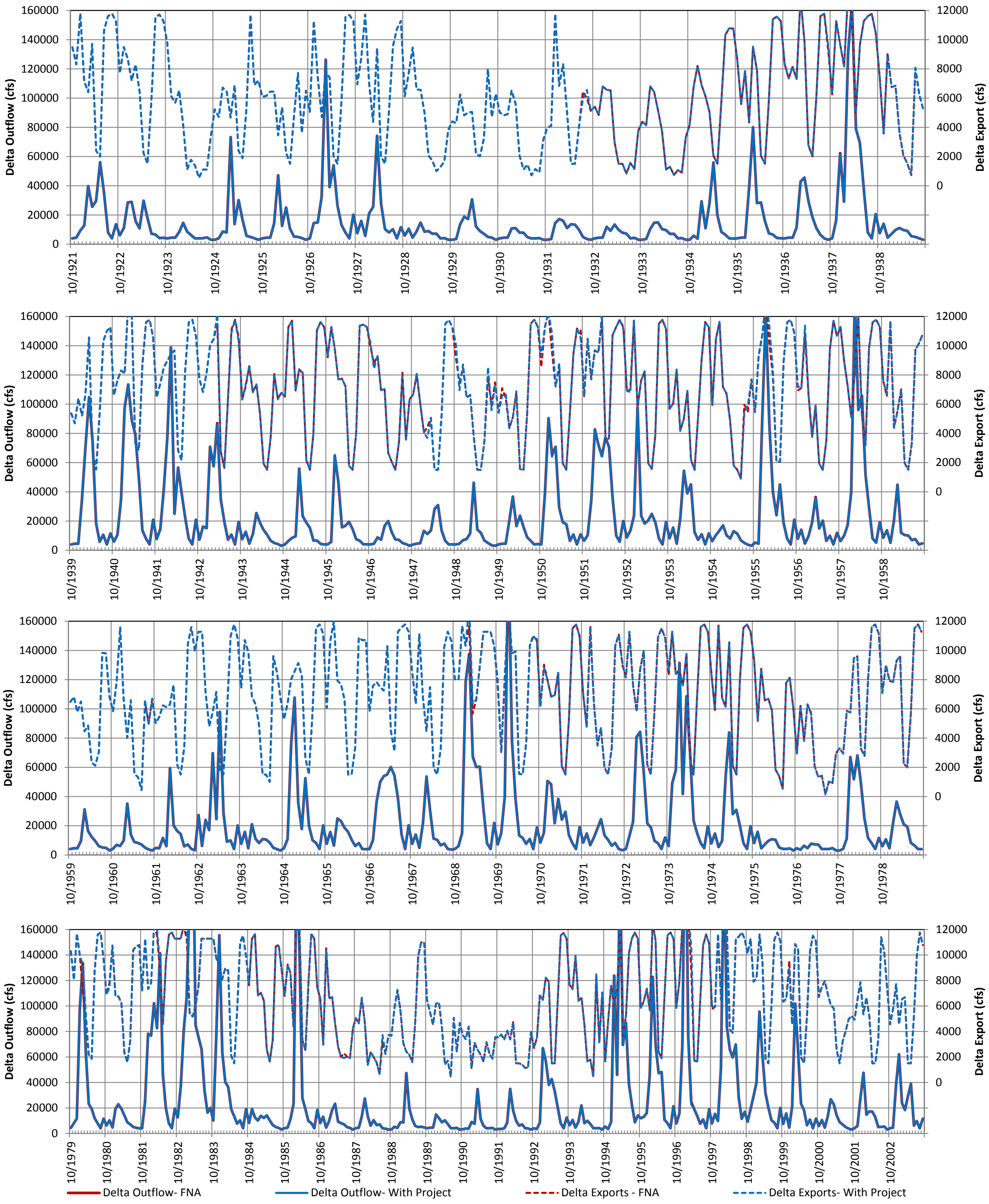


Figure 22: Comparison of San Luis Reservoir Storage for San Luis Reservoir Expansion Alternative

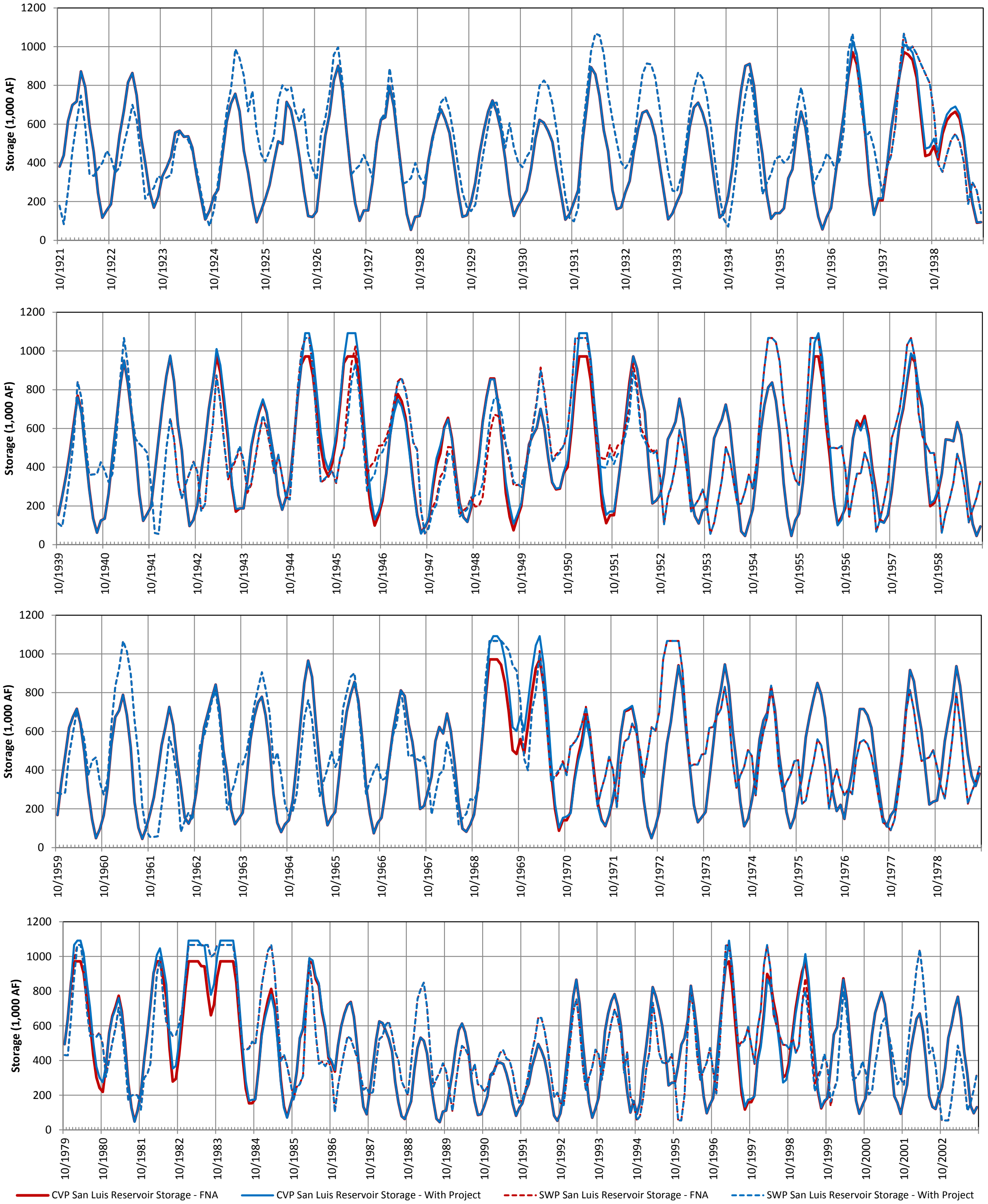


Figure 23: Comparison of Trinity Storage for Pacheco Reservoir Expansion Alternative

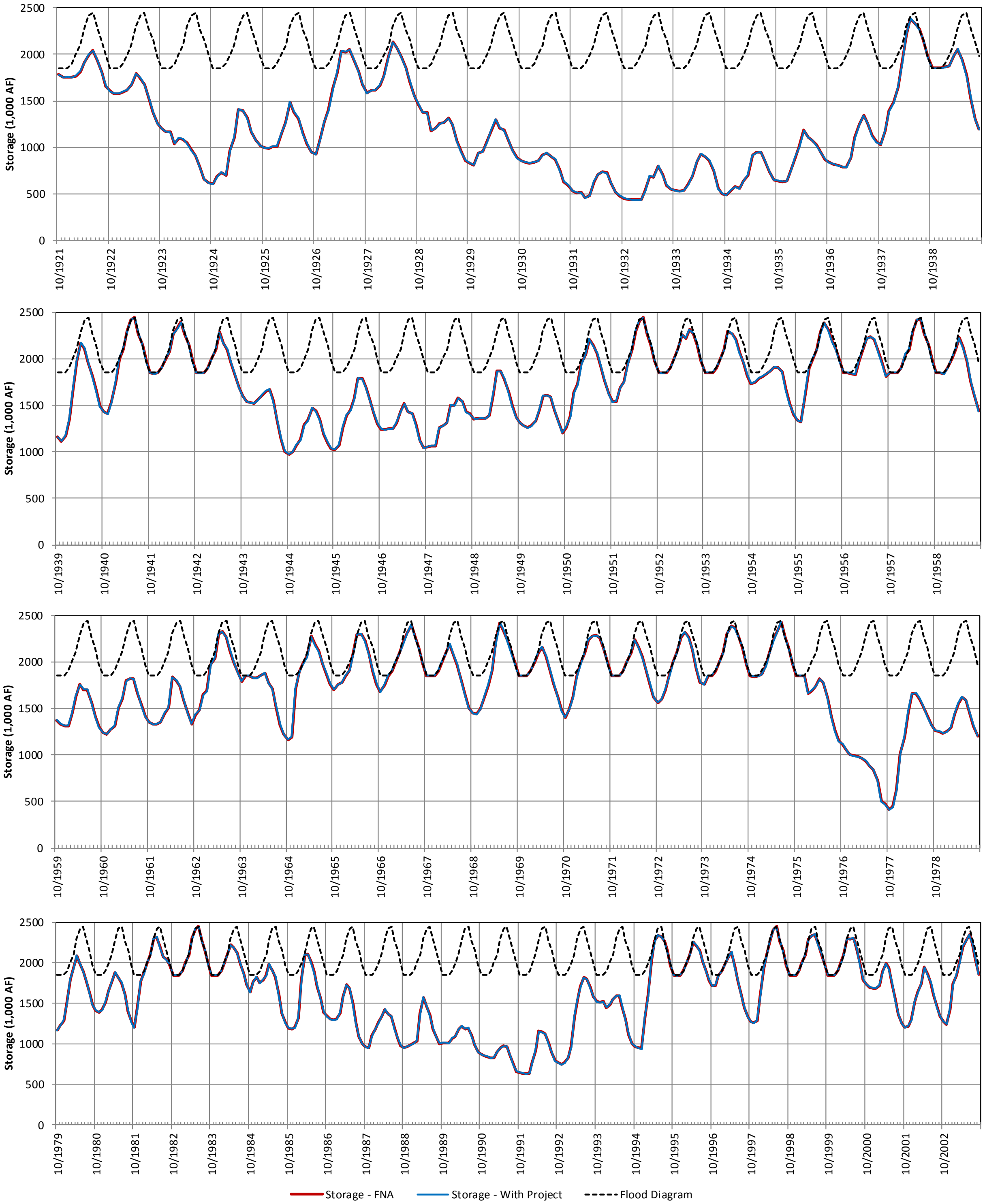


Figure 24: Comparison of Shasta Storage for Pacheco Reservoir Expansion Alternative

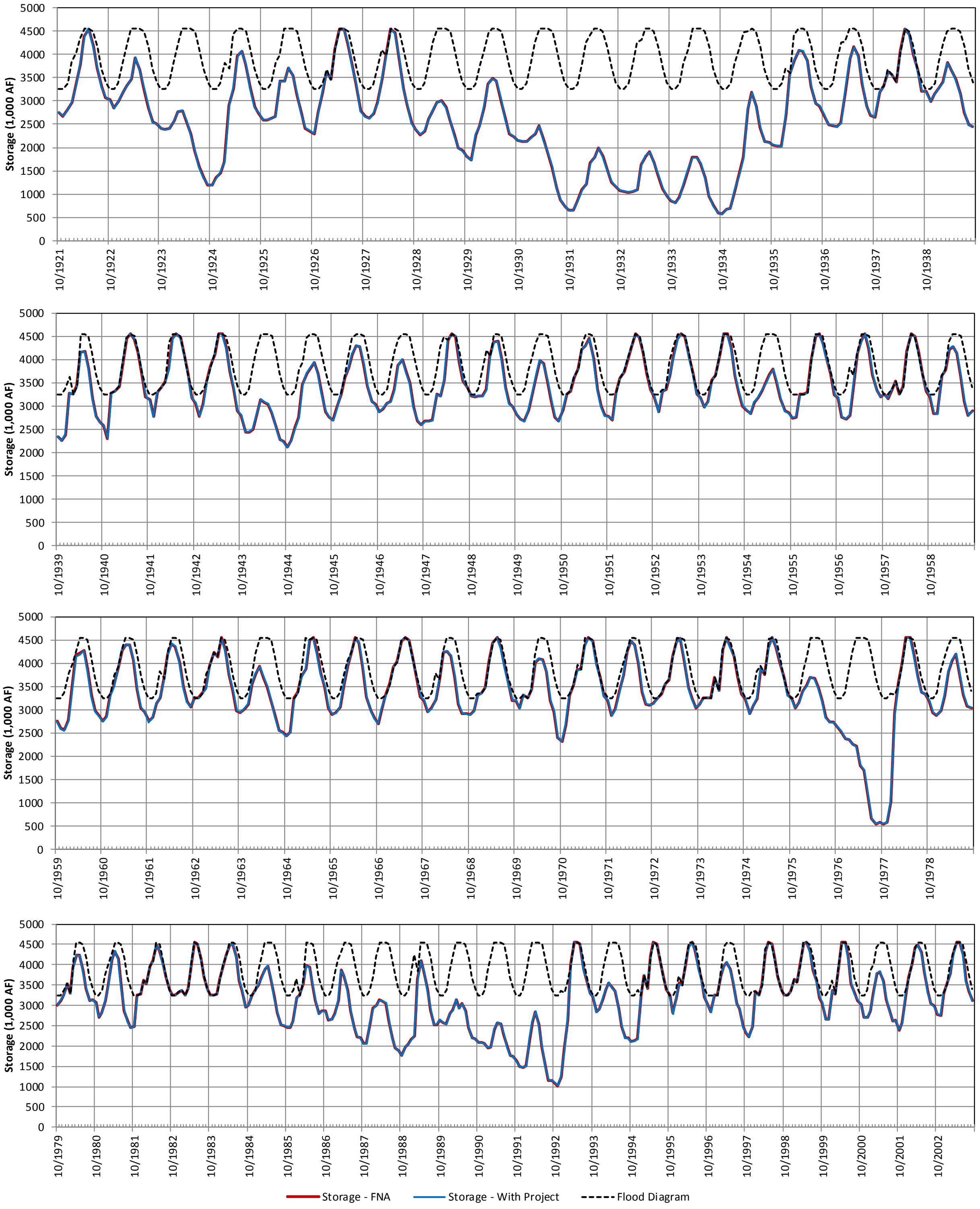


Figure 25: Comparison of Folsom Storage for Pacheco Reservoir Expansion Alternative

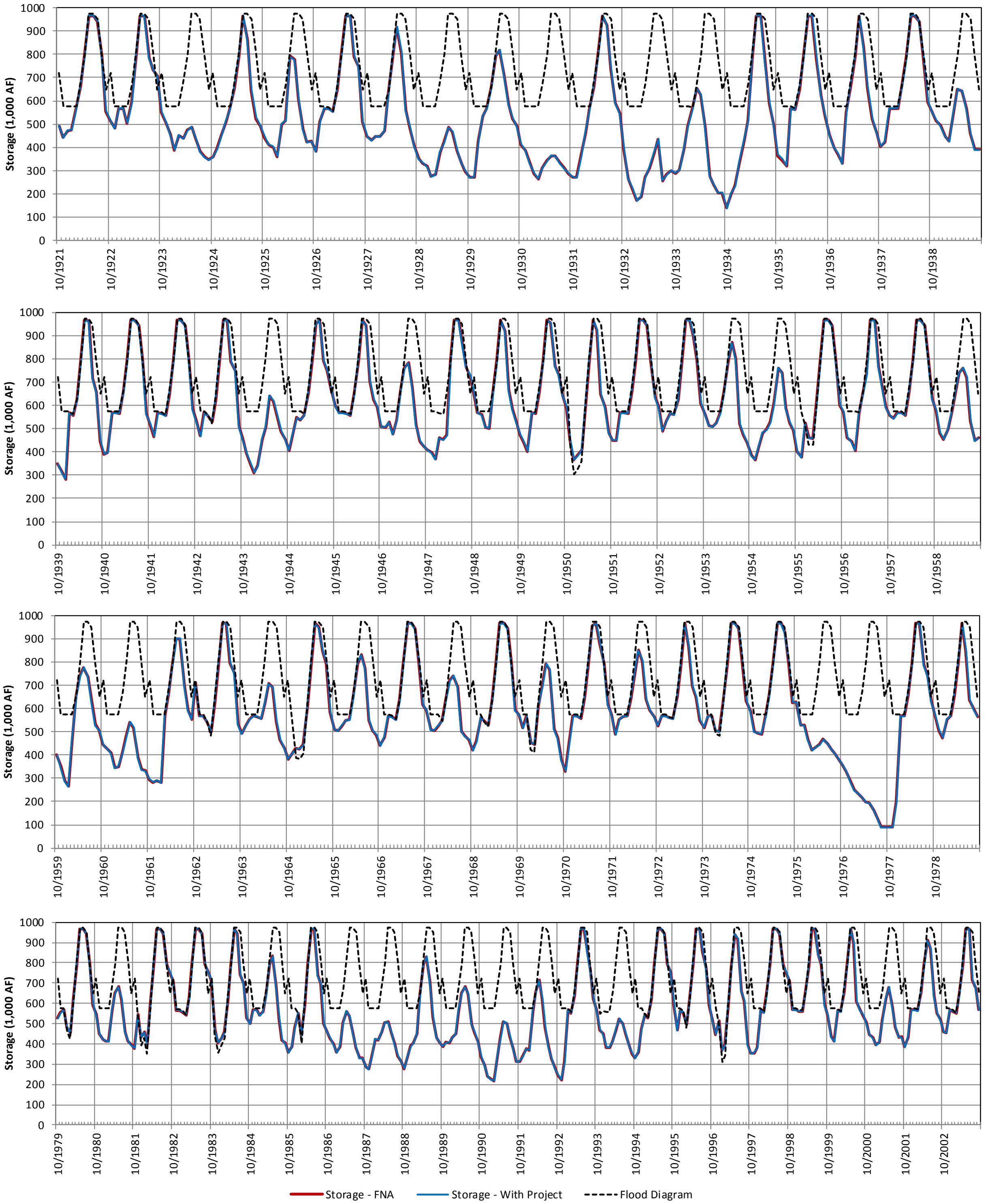


Figure 26: Comparison of Oroville Storage for Pacheco Reservoir Expansion Alternative

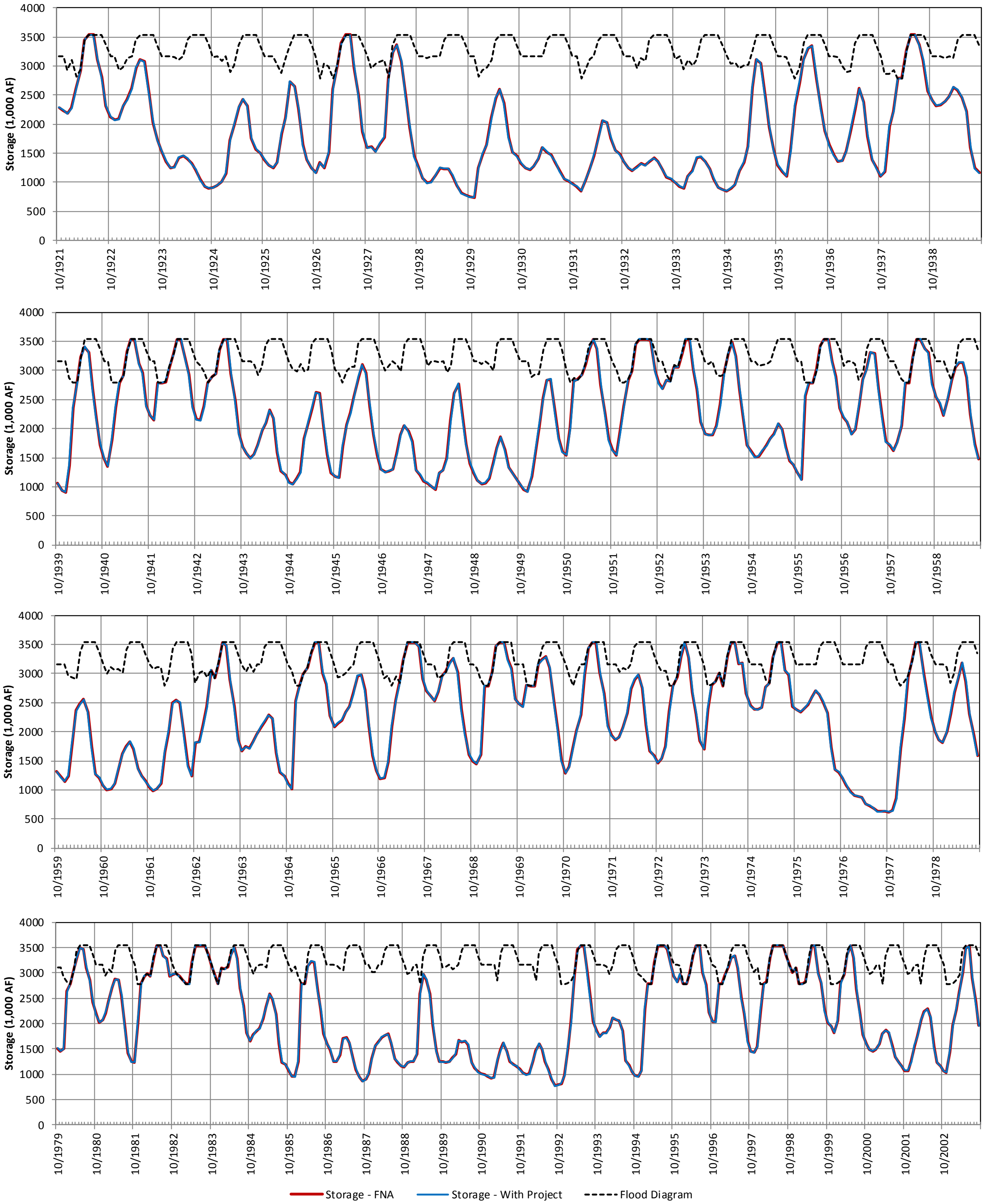


Figure 27: Comparison of Sacramento River below Keswick Flow for Pacheco Reservoir Expansion Alternative

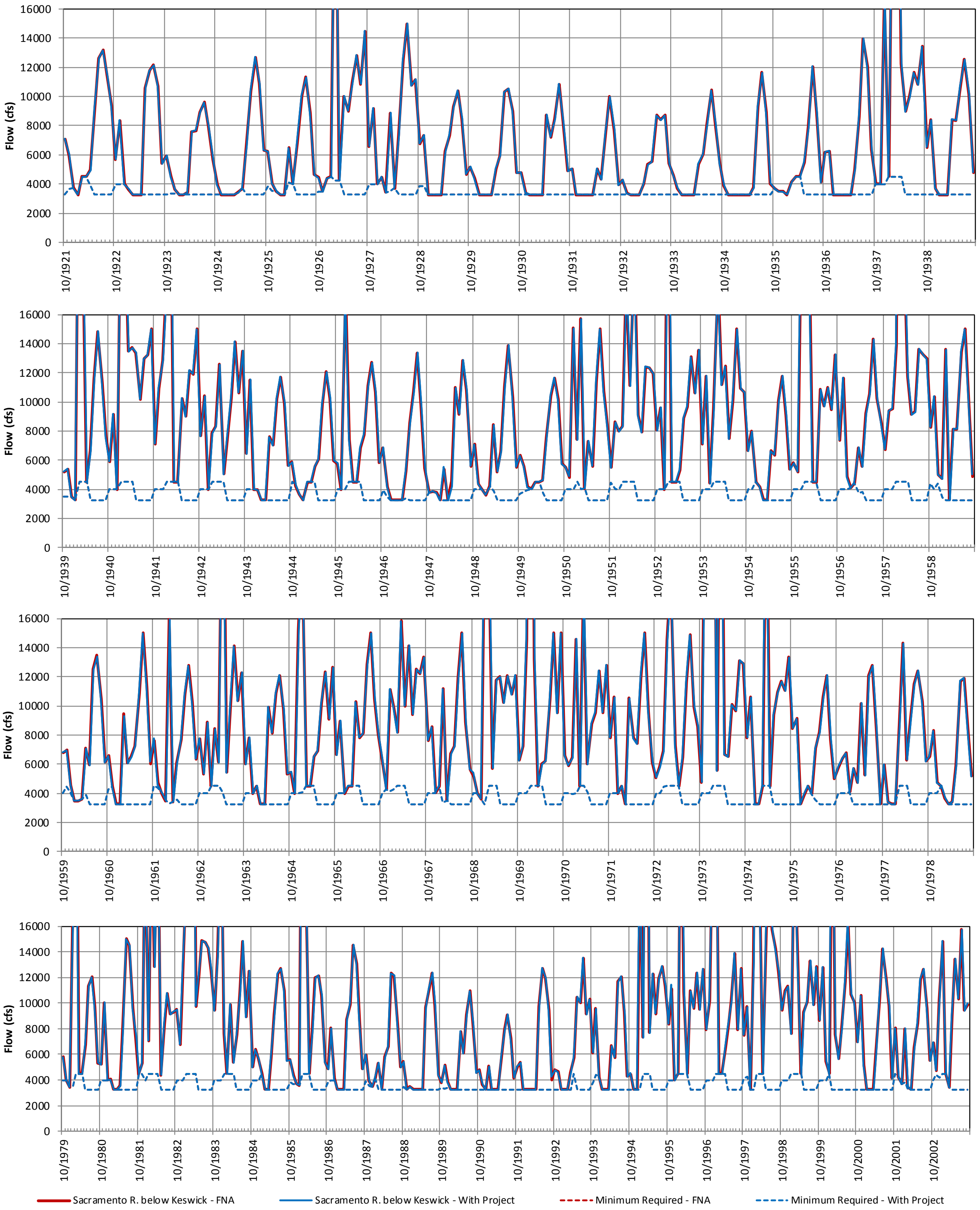


Figure 28: Comparison of Sacramento River at Wilkins Slough Flow for Pacheco Reservoir Expansion Alternative

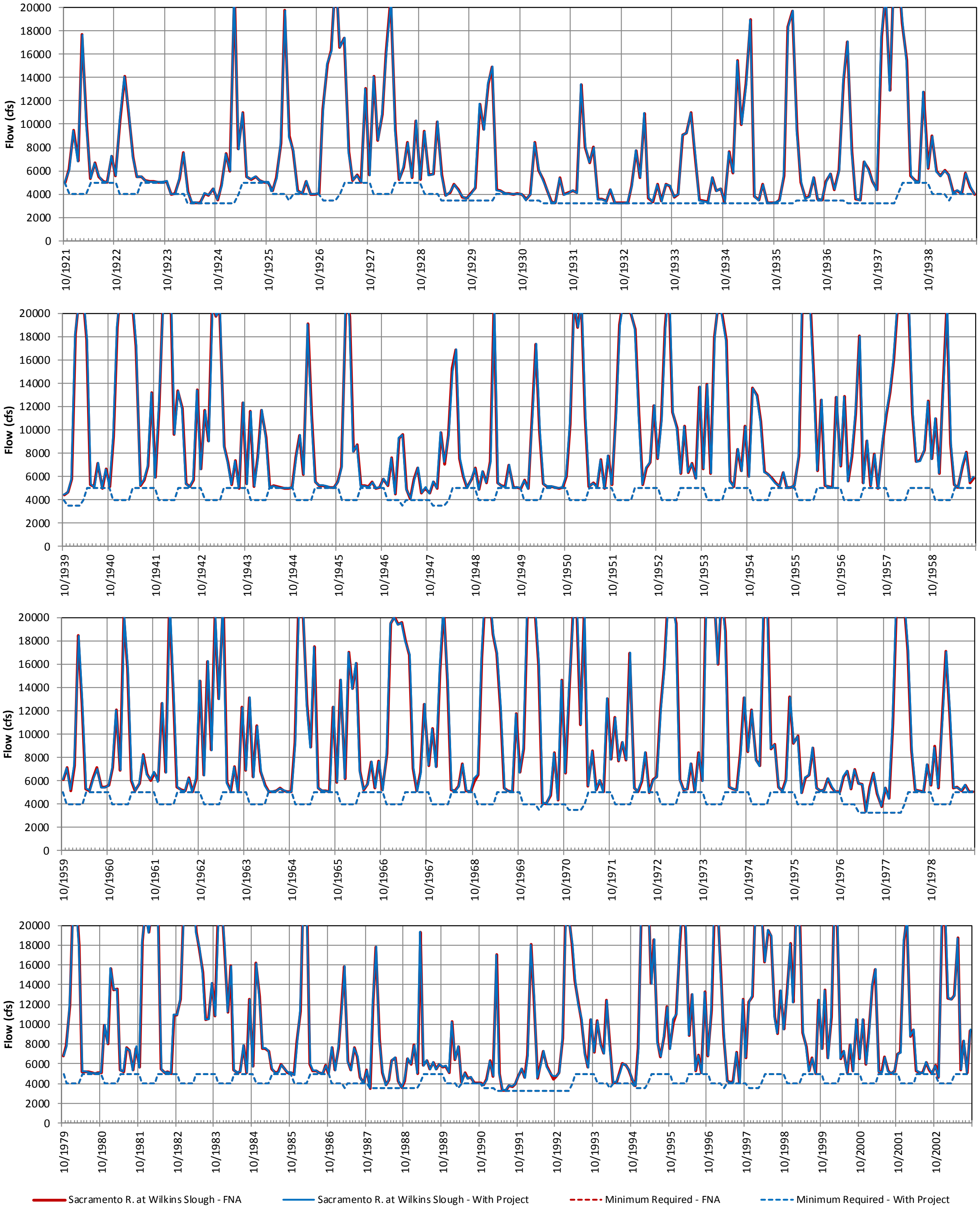


Figure 29: Comparison of American River below Nimbus Flow for Pacheco Reservoir Expansion Alternative

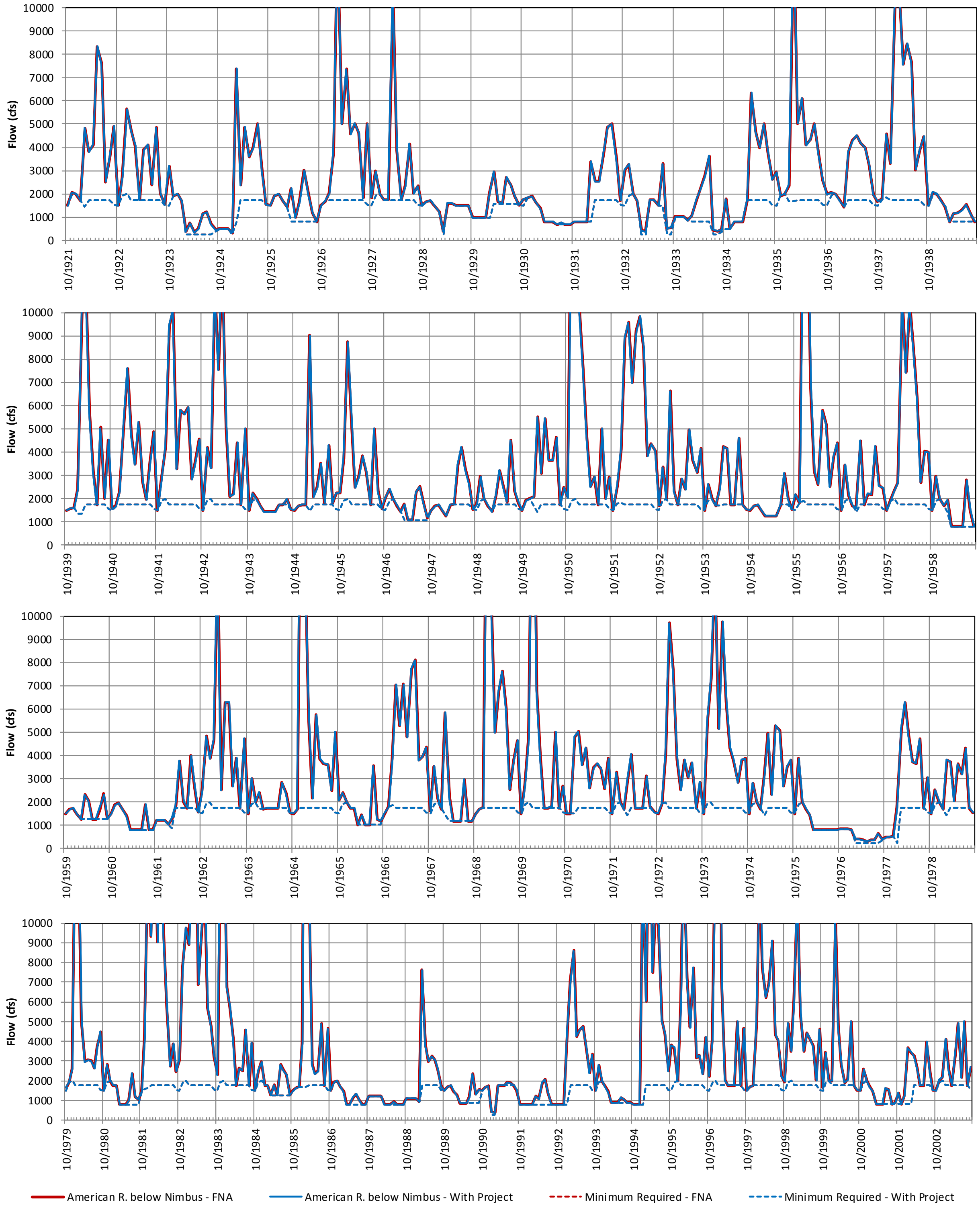


Figure 30: Comparison of Lower Feather River Flow for Pacheco Reservoir Expansion Alternative

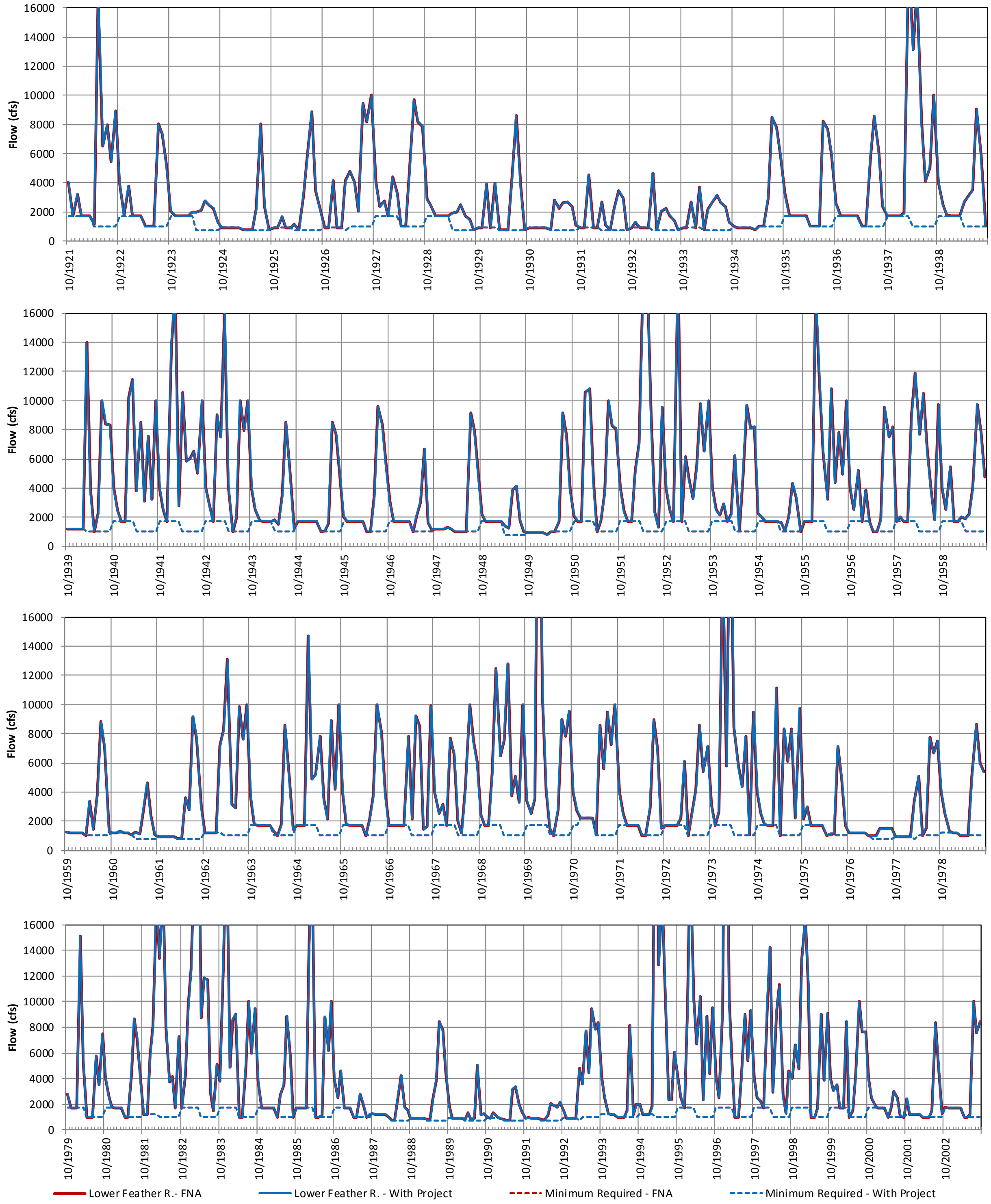


Figure 31: Comparison of Delta Inflow for Pacheco Reservoir Expansion Alternative

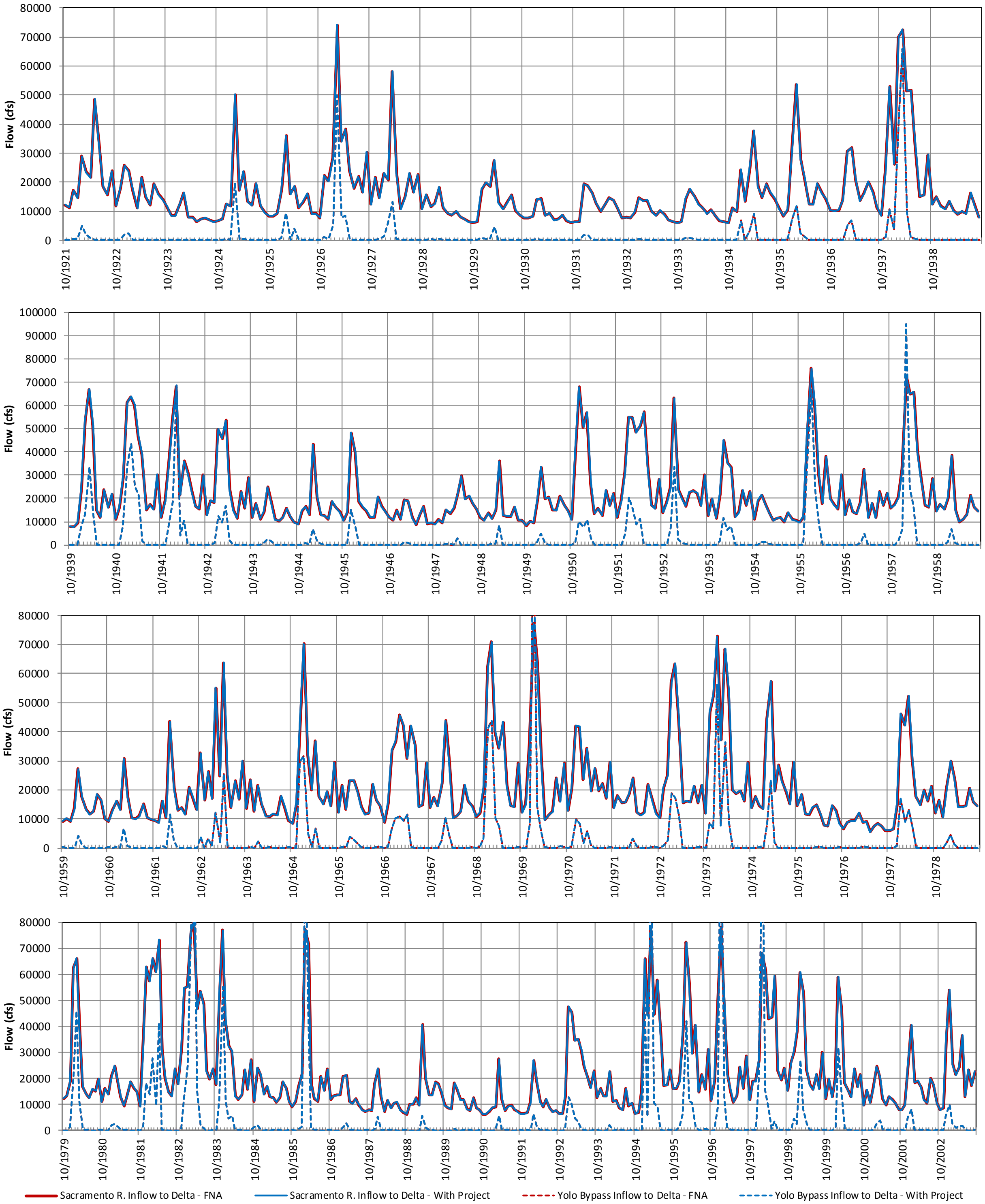


Figure 32: Comparison of Delta Outflow for Pacheco Reservoir Expansion Alternative

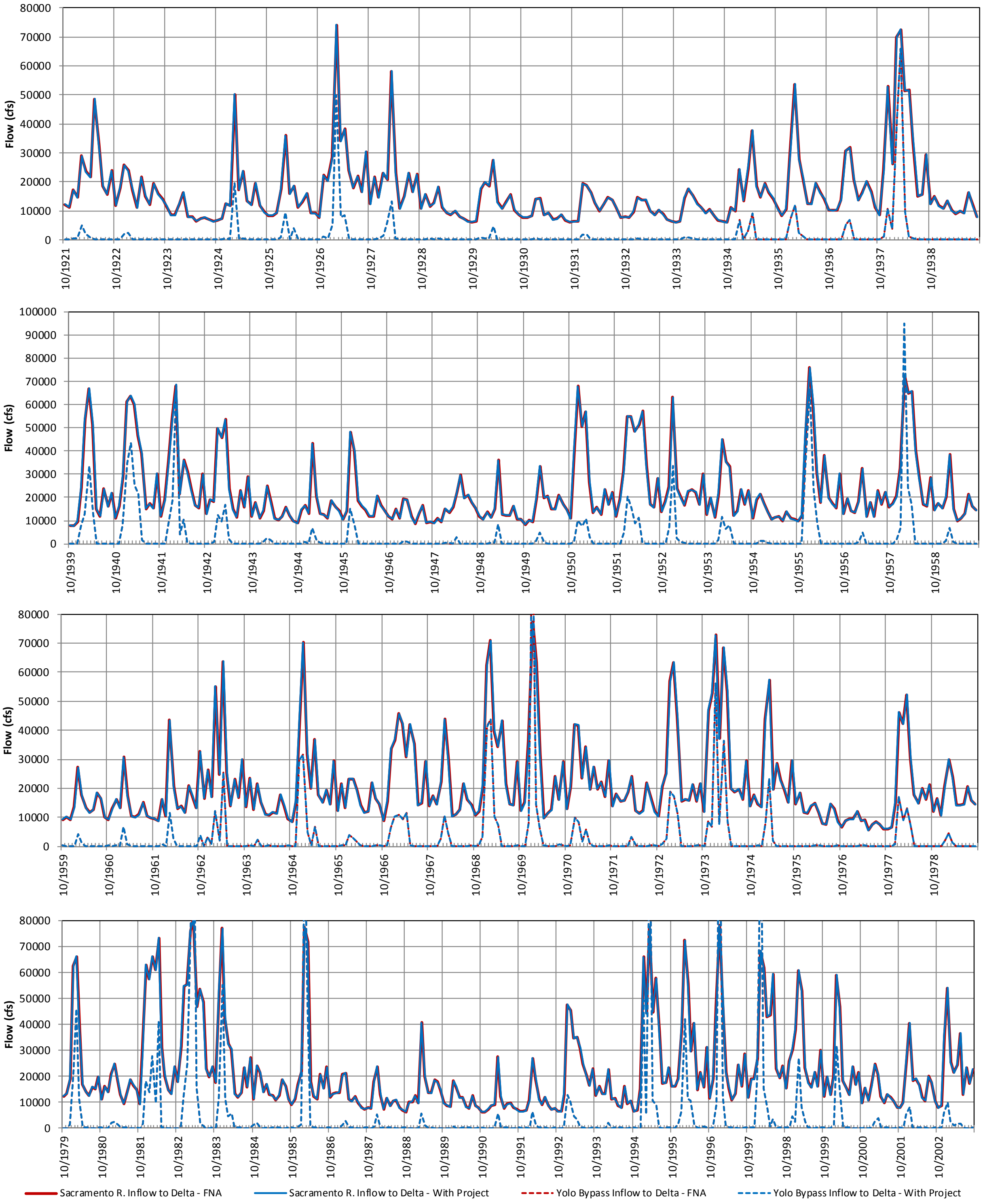
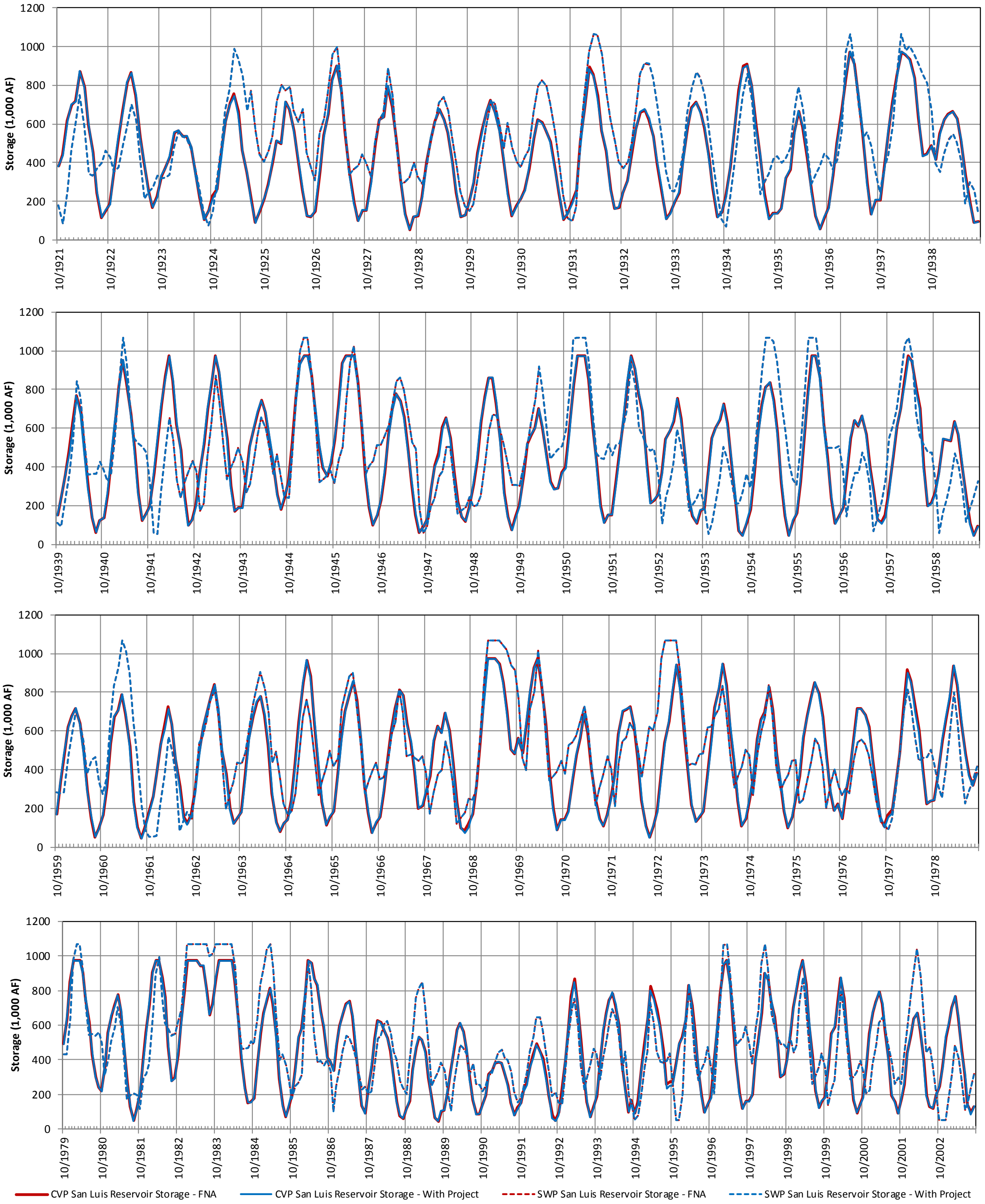


Figure 33: Comparison of San Luis Reservoir Storage for Pacheco Reservoir Expansion Alternative



Attachment C

Improvements to CalSim San Luis Operations Technical Memorandum

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MBK ENGINEERS
Water Resources ◆ Flood Control ◆ Water Rights

TECHNICAL MEMORANDUM

DATE: July 16, 2015

SUBJECT: Improvements to CalSim San Luis Operations

PREPARED BY: Dan Easton

REVIEWED BY: Walter Bourez and Jennifer Wilson

MBK Engineers was tasked with improving San Luis operations in CalSim. At the December 2014 scoping meeting with CalSim modelers and Central Valley Project (CVP) and State Water Project (SWP) operators, issues with CalSim San Luis operations were outlined, and it was decided that there was not sufficient budget to resolve all issues under this task order. As such, the three key items listed below were selected for MBK to address and determine whether significant improvements could be made.

1. Reduce frequency of drawing San Luis to dead pool and shorting South-of-Delta (SOD) contract deliveries by improving the export forecasts used in SWP and CVP allocations.
2. Reduce excessive carryover in CVP San Luis during the critical period (particularly the 1930’s) through reasonable increases in service contractor allocations.
3. Refine rulecurve formulations used to balance storage between North-of-Delta (NOD) project reservoirs and San Luis Reservoir.

While the problems outlined at the meeting have been present in CalSim for years, MBK used Reclamation’s latest CalSim baseline generated on January 27, 2015 as a starting point. For the rest of this document, this baseline will be referred to as CalSim_27JAN2015, and the model edited to address the above three issues will be referred to as CalSim_27JAN2015_Revised. Any reference to CalSim in general includes CalSim_27JAN2015 and preceding versions.

REFINEMENT OF CVP AND SWP EXPORT FORECASTS USED IN CALSIM ALLOCATION LOGIC TO REDUCE SOD CONTRACT DELIVERY SHORTAGES

Since implementation of the smelt and salmon biological opinions, CalSim tended to over-allocate water to SOD CVP and SWP contractors in many years of the simulation. Although this does not occur in every year, it happens enough to skew results in water supply planning analysis. Over-allocation can result in breaking San Luis (drawing San Luis down to dead pool) and shorting project contractors. Figure 1 and Figure 2 relate annual SOD contractor shortages and San Luis low point for both the CVP and SWP, respectively, as simulated by CalSim_27JAN2015. CVP San Luis storage is drawn to dead pool (dashed line) in 15 years of the 82-year simulation; SWP San Luis storage is drawn to dead pool in 21 years of the simulation. Annual shortages to CVP contractors range as

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high as 100 thousand acre-feet (TAF). Running debt to SWP contractors reaches higher than 400 TAF in year 1995 of the simulation and greater than 100 TAF in several other years.

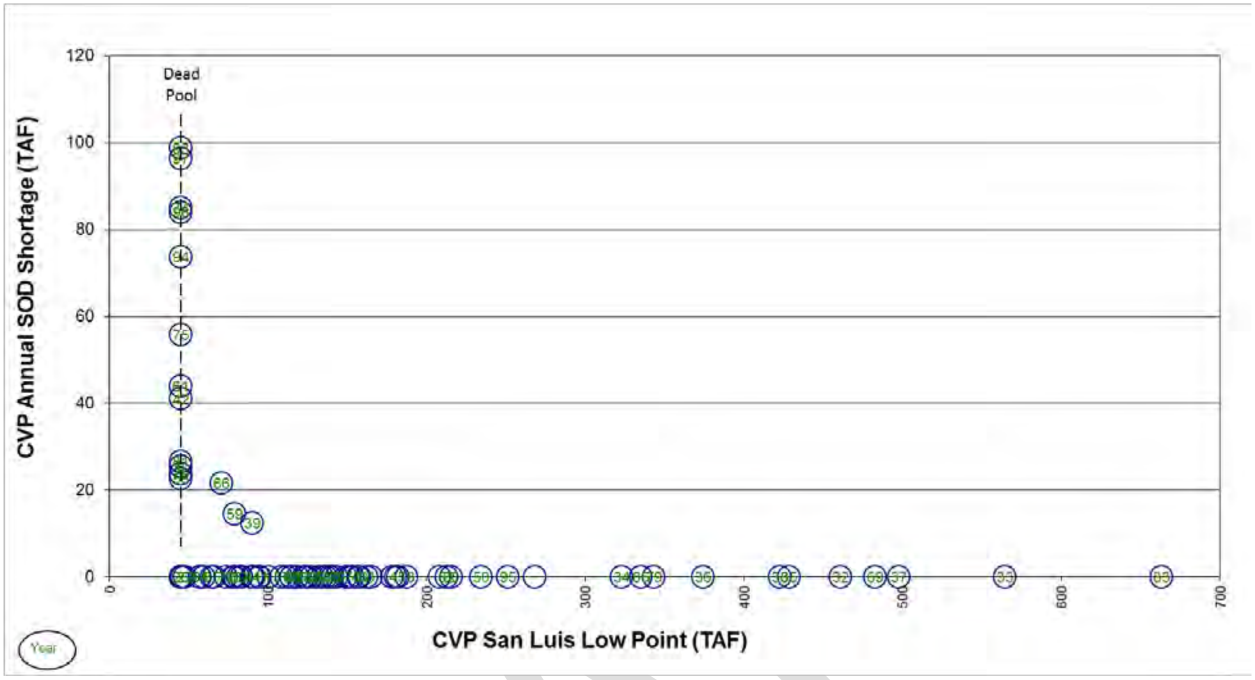

Figure 1. CVP annual SOD shortage versus CVP San Luis storage low point as simulated in CalSim_27JAN2015

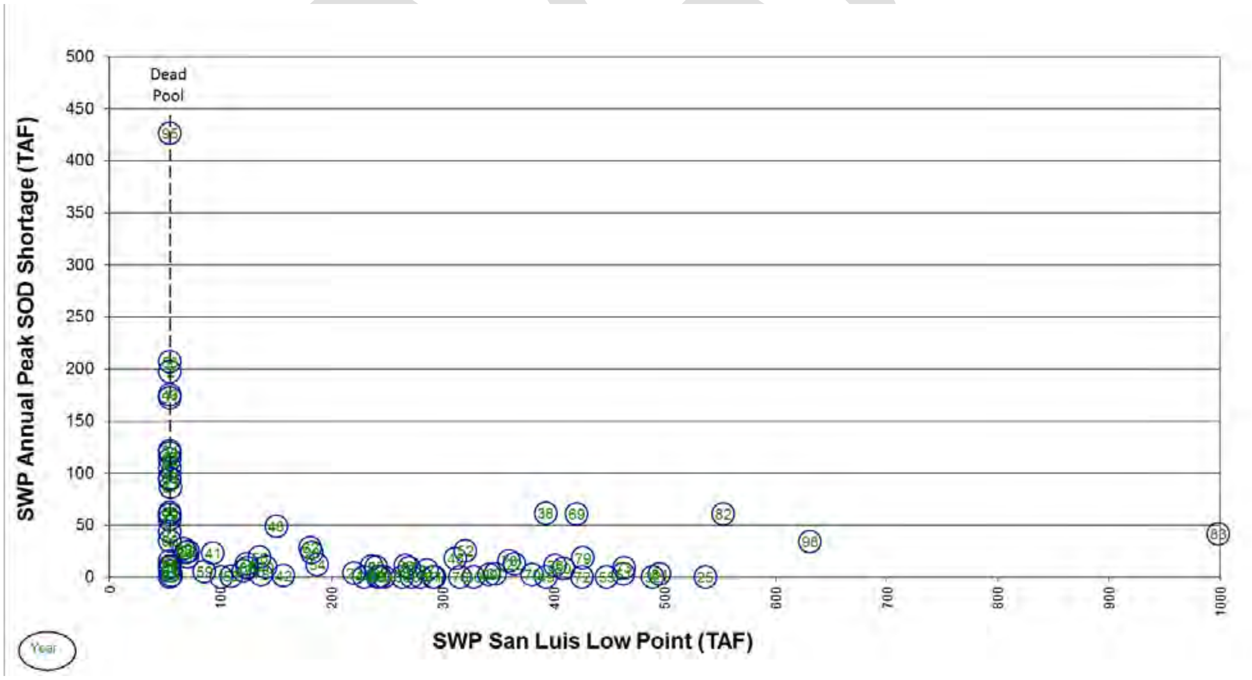

Figure 2. SWP annual maximum SOD shortage versus SWP San Luis storage low point as simulated in CalSim_27JAN2015

Over-allocation in CalSim can be traced back to the model methodology used for both the SWP Table A allocations and CVP SOD Agriculture (Ag) and Municipal and Industrial (M&I) allocations.

The CalSim allocation methodology (used for both the CVP and SWP) combines the Water Supply Index – Delivery Index (WSI-DI)–based allocation with an export forecast–based allocation. The minimum of the two is the final allocation for each project in each contract year. (Note that the CalSim model allocation methodology bears minimal resemblance to the methodology used in real-time allocations.)

The WSI-DI–based allocation assesses aggregate supply (forecasted inflow plus storage), but it does not adequately address limitations of available export capacity necessary to move the NOD supply to SOD contractors. Conversely, the export forecast–based allocation is intended to address export capacity limitations, but the current implementation has limited accuracy. Also, the export forecast–based allocation does not consider demand for export capacity. In other words, the export estimate does not consider whether or not the projects would release stored water from upstream reservoirs to make use of the available export capacity. If NOD storage is low, the projects will not want to release stored water to support exports. This should be explicitly incorporated into the allocation decisions, and it currently is not in CalSim.

The purpose of combining the WSI-DI allocation with an export forecast–based allocation was to have each allocation method cover the weaknesses of the other. However, as seen in current CalSim results (Figure 1 and Figure 2), this has not been accomplished. Ideally, the allocation methodology used in CalSim should better reflect real-time operations methodologies where consideration of supply, demand, conveyance capacity, and carryover in upstream reservoirs are physically integrated. This has been attempted by the Department of Water Resources (DWR) in the form of its Forecast Allocation Model (FAM), but it is beyond the scope of this contract.

The objective is to improve allocation decisions with the current methodology thereby preventing drawing San Luis to dead pool and shorting contractors. The most appropriate improvement is to create a more accurate export forecast—one that takes into account both the availability of and the demand for export capacity. However, before potential improvements are discussed, it is important to examine the CVP and SWP export forecast currently used in CalSim.

During the CVP allocation season (March–May), the current version of CalSim has only two possible export forecasts: one when it is a wet year as classified by the San Joaquin River (SJR) 60-20-20 index; and another when it is critical, dry, below normal, or above normal year classification. Table 1 shows the export estimates for each month from March to August. The export forecast–based allocation sums the export estimates from the current month through August.

In Table 1, only April, May, and June are conditioned on the SJR 60-20-20 index because those are the months where exports are most likely controlled by either the SJR inflow-export (IE) ratio or Old and Middle River (OMR) flow requirements. The sum total of the export estimates from April to June in a wet year is 516 TAF (2,000 cubic feet per second [cfs], 2,000 cfs, and 4,600 cfs); in a non-wet year the sum total is 240 TAF (1,000 cfs, 1,000 cfs, and 2,000 cfs). Such a coarse export estimate does not adequately account for the variability in SJR hydrology or in the conditionality of the SJR IE ratio or OMR flow regulations. It also does not reflect the information that operators have at hand to refine their forecasts, which include current SJR flows at Vernalis, forecasted operations on the SJR and its tributaries, and ongoing discussions with the U.S. Fish and Wildlife Service (FWS) about fish take, trawl data and expected OMR flow requirements.

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Table 1. Monthly CVP export estimates found in the CalSim_27JAN2015 lookup table ExportEstimate_CVP

CalSim Baseline CVP Export Forecast for SOD Ag and M&I Allocation			
Month	Export Estimate (cfs)	Wet SJR Export Estimate (cfs)	Delivery Pattern Fraction
MAR	2500	0	0.68
APR	1000	2000	0.622
MAY	1000	2000	0.553
JUN	2000	4600	0
JUL	4600	0	0
AUG	4600	0	0

The July and August export estimates for the CVP are listed in Table 1 at 4,600 cfs, which is Jones Pumping Plant's full capacity. Obviously this will never be an underestimate of simulated Jones pumping in July and August, but it is often an overestimate. Even though 4,600 cfs capacity is available, the CVP does not always want to release water from upstream reservoirs to fill that capacity. CalSim overestimates exports in these months with the expectation that the WSI-DI–based allocation will prevent an over-allocation. The WSI-DI does serve as a backstop in many years, but there are many years when it does not limit the export estimate based on available supply.

Figure 3 compares annual CVP SOD delivery shortage with the error in the CVP export forecast used in the export forecast–based allocation. The CVP export forecast error is calculated as the April–August CVP export forecast minus the modeled total April–August CVP Jones Pumping Plant exports. As shown in Figure 3, the error is both negative and positive but skews positive. There are no shortages when the export forecast is an underestimate of exports (negative error). There are 15 years with shortages when the forecast is an overestimate. However, the shortages in three of those years — 1939, 1959, and 1966, the three lowest shortages not equal to zero — have nothing to do with over-allocation but a quirk in the SJR model formulation. The remaining 12 are all due to over-allocation, both from the WSI-DI–based approach and the export forecast approach.

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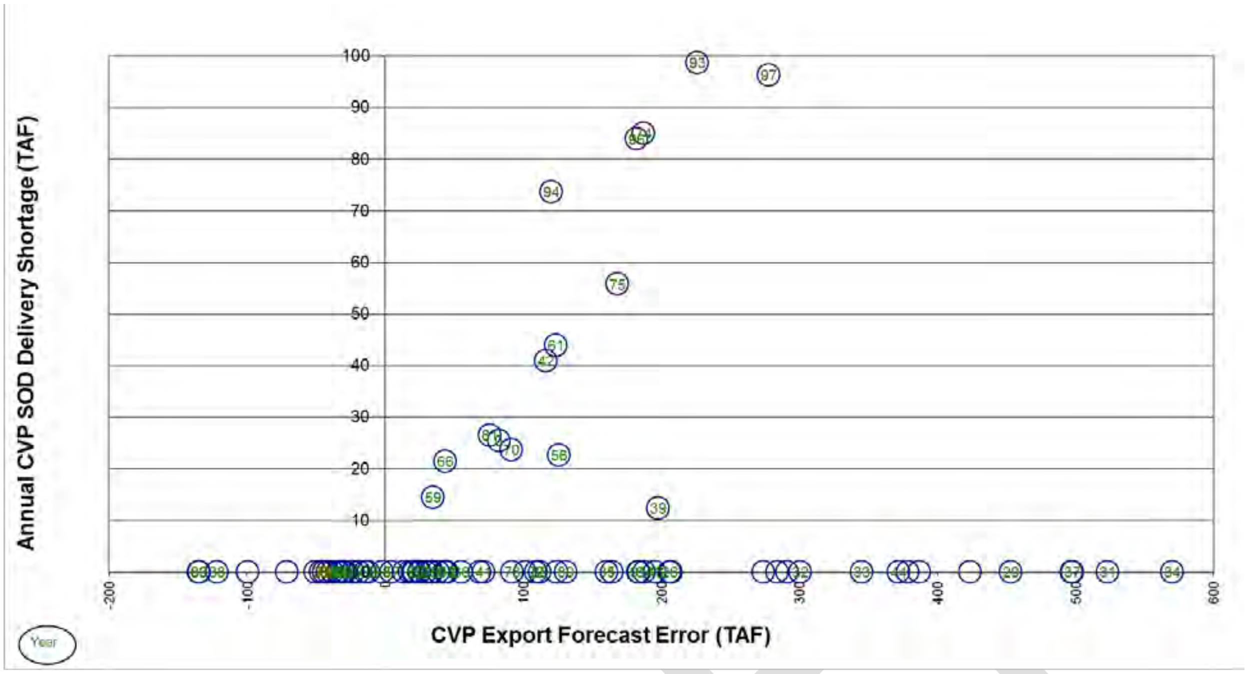

Figure 3. Annual CVP SOD delivery shortage versus CVP export forecast error in CalSim_27JAN2015

Problems with the SWP export forecast are similar to those explained above for the CVP. Table 2 lists the monthly SWP export estimates from January to August. Whereas the CVP contract year begins in March, the SWP contract year begins in January along with SWP allocations. Like the CVP, export estimates are conditioned on the SJR 60-20-20 index in April, May, and June. Unlike the CVP, the SWP export forecast logic adds a flood condition on the SJR in April and May. The flood condition is triggered when flow at Vernalis exceeds 16,000 cfs in March, April, or May. However, even with this added nuance, this is still a very coarse export forecast that does not capture the refinement inherent in real-time operations or what is needed in the model.

Table 2. Monthly SWP export estimates found in the CalSim_27JAN2015 lookup table ExportEstimate_SWP

CalSim Baseline SWP Export Forecast for Table A Allocation				
Month	Export Estimate (cfs)	Wet SJR Export Estimate (cfs)	Flood SJR Export Estimate (cfs)	Delivery Pattern Fraction
JAN	3750	0	0	0.737
FEB	4250	0	0	0.721
MAR	4250	0	0	0.695
APR	1000	2000	6000	0.657
MAY	1000	2000	6000	0.566
JUN	2500	6000	0	0
JUL	7000	0	0	0
AUG	7000	0	0	0

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The SWP export forecast for July and August is 7,000 cfs as listed in Table 2. This exceeds permitted capacity of 6,680 cfs in these months, and simulated SWP exports in CalSim_27JAN2015 never exceed permitted capacity in July and August. In fact, simulated July and August SWP exports are often significantly below permitted capacity. The explanation for this is the same as it was for the CVP: just because capacity is available does not mean the SWP wants to use it; that depends on the storage condition of Oroville, and the export forecast in Table 2 does not consider such details.

Figure 4 compares SWP SOD shortage with export forecast error. Export forecast error was again calculated by subtracting April–August total SWP exports from the forecasted exports. Only 1979 had an underestimate of forecasted exports, and that underestimate was slight. In all other years the SWP export forecasts were overestimates with some errors greater than 1 million acre-feet (MAF). The greatest delivery shortage occurred in a wet year, 1995 (Figure 4). The delivery shortage was approximately 425 TAF; it was the result of a 500 TAF overestimate of exports. (Many of the shortages shown that are below 70 TAF in Figure 4 are not due to over-allocation and breaking San Luis; they are due to insufficient California Aqueduct capacity to meet the assumed demand pattern. These are of less concern than the shortages caused by breaking San Luis.)

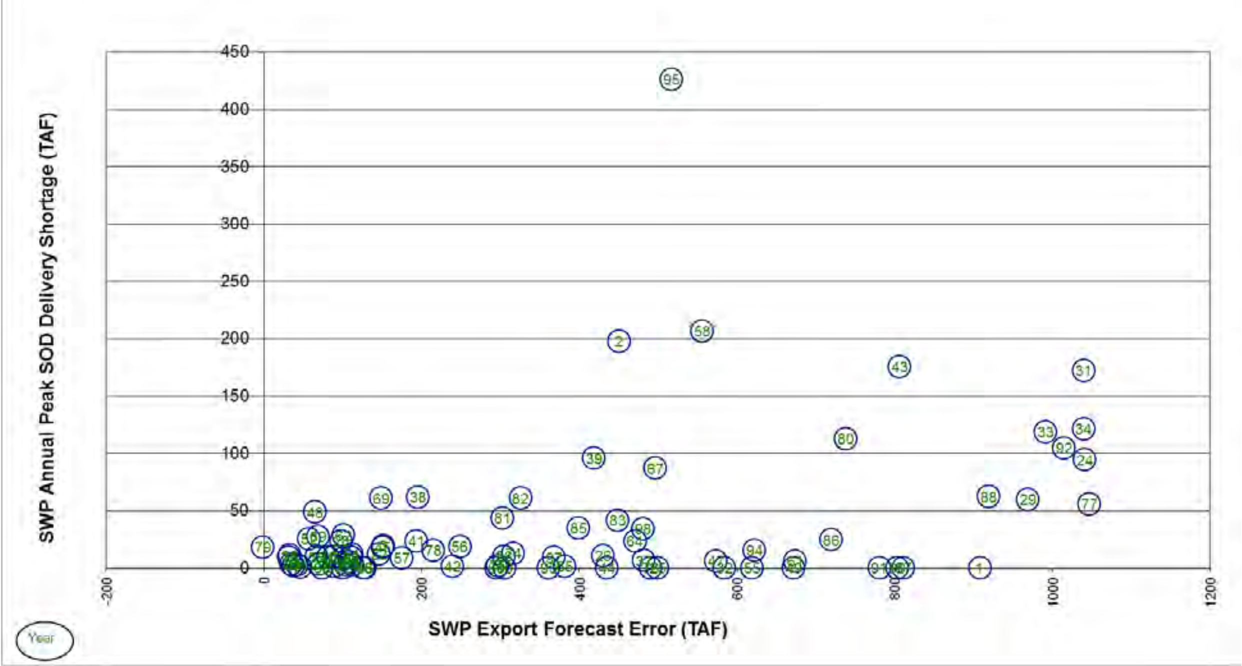

Figure 4. SWP annual peak SOD delivery shortage versus SWP export forecast error in CalSim_27JAN2015

To improve on the export forecasts, it is recognized that more detail is necessary. The two CVP and three SWP export forecast possibilities currently provided in CalSim do not adequately cover the different circumstances found from one year to the next. What follows is a proposal for deriving export forecasts that vary by year and month that will take into account hydrologic, regulatory, and operational variability. The methodology is similar to the WSI-DI procedure in that it requires infrequent iterations of CalSim, and it is best described as a series of steps.

STEP 1

Set the CVP and SWP export forecasts equivalent to Health and Safety (H&S) minimum export levels (800 cfs for the CVP and 300 cfs for the SWP). As such, the respective April to August export forecasts are approximately 240 TAF for the CVP and 90 TAF for the SWP. Run CalSim with this initial export forecast.

STEP 2

Use the CalSim CVP and SWP export results (D418 and D419_SWP, respectively) from Step 1 as new export estimates and re-run CalSim. Repeat until the maximum difference between aggregate export estimates and cumulative simulated exports is less than 100 TAF. Many previous trials indicate this will likely take three iterations. The first iteration (Step 1) uses the H&S export estimate, and the second and third use the CalSim-generated export estimates. A spreadsheet has been set up to process CalSim output into export forecast input for the purpose of expediting this process.

STEP 3

Refine export estimates as necessary to achieve desired balance of contract deliveries and storage carryover. This refinement of export forecasts can be done by an automated procedure or manually. A combination of both was employed in this analysis.

Ideally, the procedure would stop at Step 2. Understanding why the procedure progresses to Step 3 requires an understanding of the logic of the first two steps. Starting with the H&S export forecast in Step 1 ensures very low allocations for both projects in all years of that simulation. As such, export of available Delta supplies without supplemental reservoir release – or export of incidental Delta inflow – are sufficient in almost every year to meet allocated deliveries and San Luis carryover targets. So the final result of that first iteration and the iterations that follow in Step 2 is a lower bound on the SWP and CVP export forecasts. In any year that moving additional water from NOD reservoirs is not desired, the final export forecast derived in Step 2 also represents an upper bound. But in those years where NOD stored water and SOD export capacity are available, the export forecast must be increased to drive higher allocations and movement of that additional water through rulecurve. (Rulecurve will be discussed later in this memo.) There are also very wet years such as 1983, when a full San Luis prevented additional exports during the iterative process. A boost in the export forecast increases allocations and deliveries, which allows for higher exports when San Luis is full. Given the reasons for refinement, the only changes to the export forecasts going from Step 2 to Step 3 were increases.

The final CVP and SWP export forecasts derived from the three-step methodology are listed in Table 3 and Table 4. While these forecasts extend through the period of record (1922–2003), the tables show a small sample (1922–1931) for the sake of brevity. Each export forecast provided by year and month represents cumulative exports from the given month through August. As such, the export forecast can easily be retrieved from a lookup table or DSS timeseries (either data retrieval mechanism will work) and directly input into the current SWP and CVP export-based allocation logic (some minor edits were made for the new format of the export forecasts). Note the variability of

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the SWP and CVP export forecasts from a wet year like 1922, to a below-normal year like 1928, and to a critical year like 1931 (all SJR 60-20-20 index–based classifications). This is a significant change from the rough forecasts found in CalSim_27JAN2015.

Table 3. Sample CVP export forecast derived from the three-step process and used in CalSim_27JAN2015_Revised

Modified CVP Export Forecast
for SOD Ag and M&I Allocation
(cumulative from current simulation month to August)

	Cumulative Export Estimate (TAF)		
Year	MAR	APR	MAY
1922	1255	972	901
1923	1083	883	817
1924	388	269	180
1925	1039	856	784
1926	622	339	271
1927	1062	835	775
1928	935	652	592
1929	501	338	269
1930	551	395	329
1931	325	261	189

Table 4. Sample SWP export forecast derived from the three-step process and used in CalSim_27JAN2015_Revised

Modified SWP Export Forecast
for Table A Allocation
(cumulative from current simulation month to August)

	Cumulative Export Estimate (TAF)				
Year	JAN	FEB	MAR	APR	MAY
1922	2025	1805	1729	1409	1325
1923	1634	1413	1318	1117	1038
1924	412	232	111	93	75
1925	1227	1029	1049	800	709
1926	1179	981	1015	990	905
1927	1687	1542	1425	1192	1119
1928	1695	1482	1432	1132	1062
1929	684	482	299	136	67
1930	1209	1061	922	767	704
1931	508	308	152	88	71

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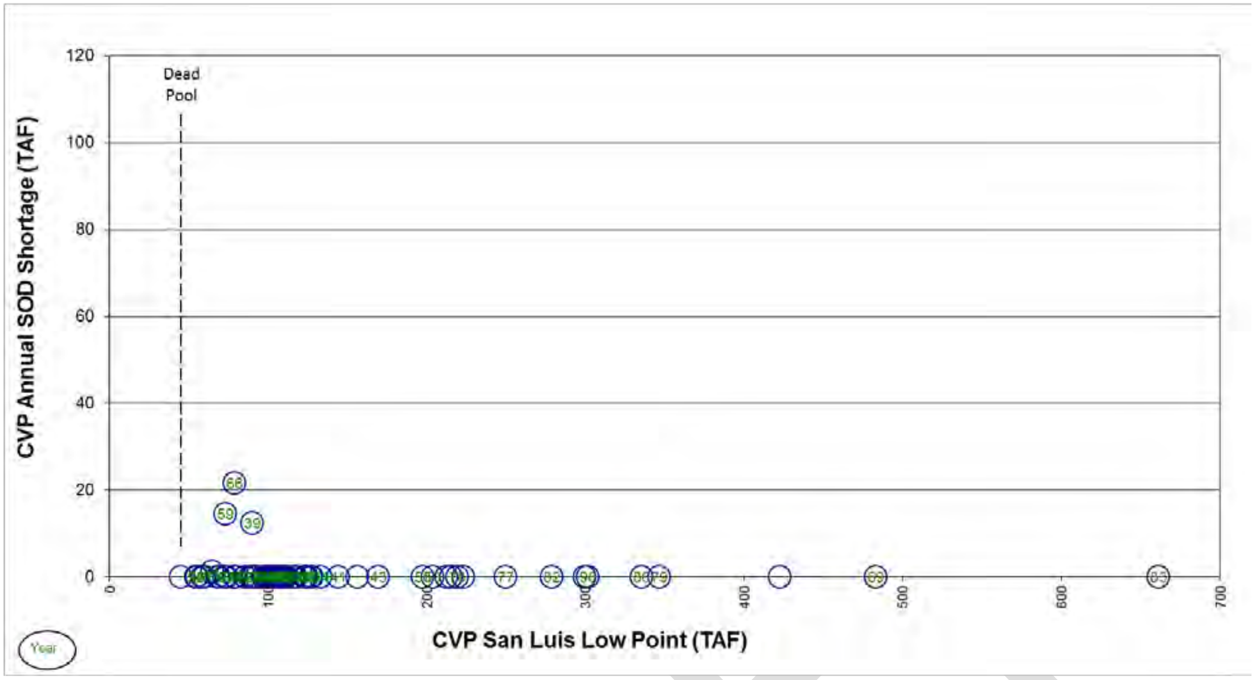

Figure 5. CVP annual SOD shortage versus CVP San Luis storage low point as simulated in CalSim_27JAN2015_Revised

Figure 5 and Figure 6 compare annual shortage and San Luis low point as simulated in CalSim_27JAN2015_Revised with the updated export forecasts listed above. CVP San Luis is drawn to dead pool only once and no shortage occurs in that year. The only years with CVP SOD shortages are 1939, 1959, and 1966; as discussed previously, the shortages are not caused by over-allocation but a quirk in the SJR model formulation. The SWP is drawn to dead pool in four years, but there are shortages in only two of them. (The two dead pool data points where the shortage is zero overlap.) All SWP shortages shown are reasonably small and are almost entirely caused by insufficient California Aqueduct capacity to meet the simulated delivery pattern. This type of shortage is of less concern than those caused by breaking San Luis. To gage the improvement in San Luis operations and reductions in project SOD delivery shortages due to the updated export forecasts, compare Figure 5 to Figure 1 and Figure 6 to Figure 2.

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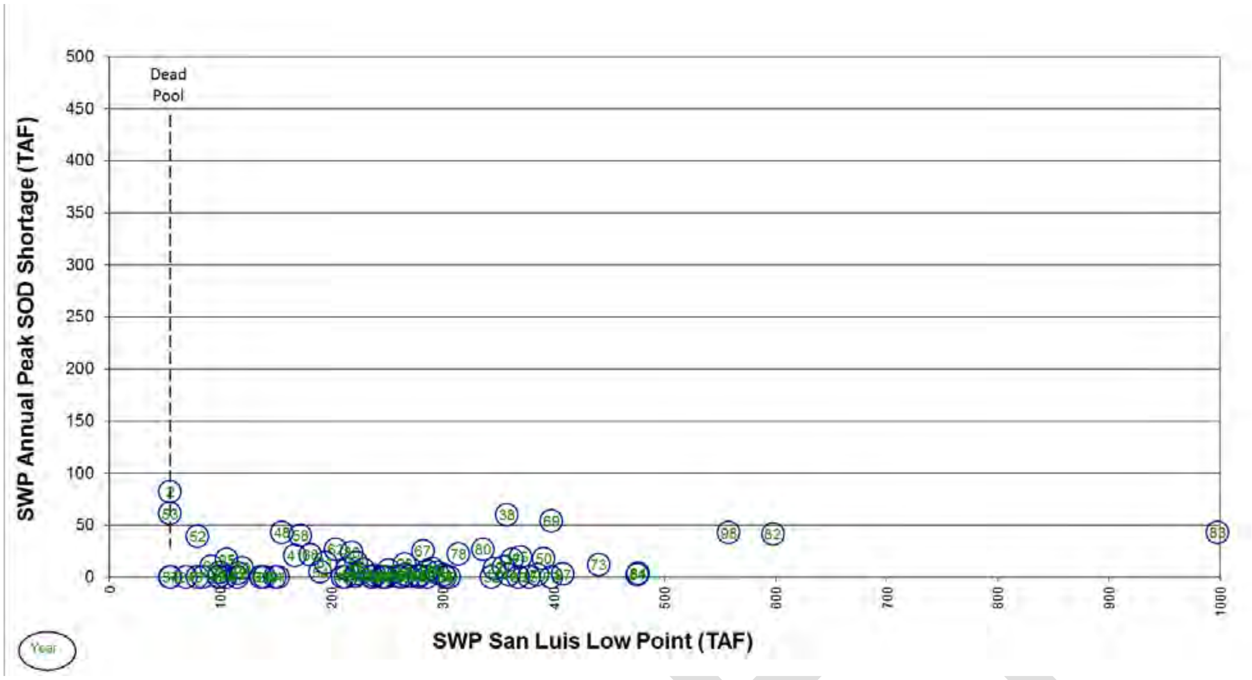

Figure 6. SWP annual maximum SOD shortage versus SWP San Luis storage low point as simulated in CalSim_27JAN2015_Revised

Export forecast error was shown to be large for both the CVP (Figure 3) and SWP (Figure 4) in CalSim_27JAN2015. Reducing export forecast error was essential to the prevention of breaking San Luis and shorting SOD contractors. Figure 7 relates CVP SOD delivery shortage to CVP export forecast error in CalSim_27JAN2015_Revised. As shown, most of the CVP export forecast errors fall under 100 TAF. Those errors above 100 TAF were edited in Step 3 of the proposed export forecast methodology to refine the balance between deliveries and carryover. Figure 8 relates SWP SOD delivery shortage to SWP export forecast error in CalSim_27JAN2015_Revised. The forecast error in three years is above 200 TAF: 1952, 1982, and 1983. It was recognized that in all three of these years there was sufficient water and export capacity to meet a 100% Table A allocation. The export forecast in each was set sufficiently high so that it would not prevent a full allocation. The rest of the SWP export forecast errors were less than 200 TAF. The refinements in Step 3 were responsible for pushing the errors above 100 TAF.

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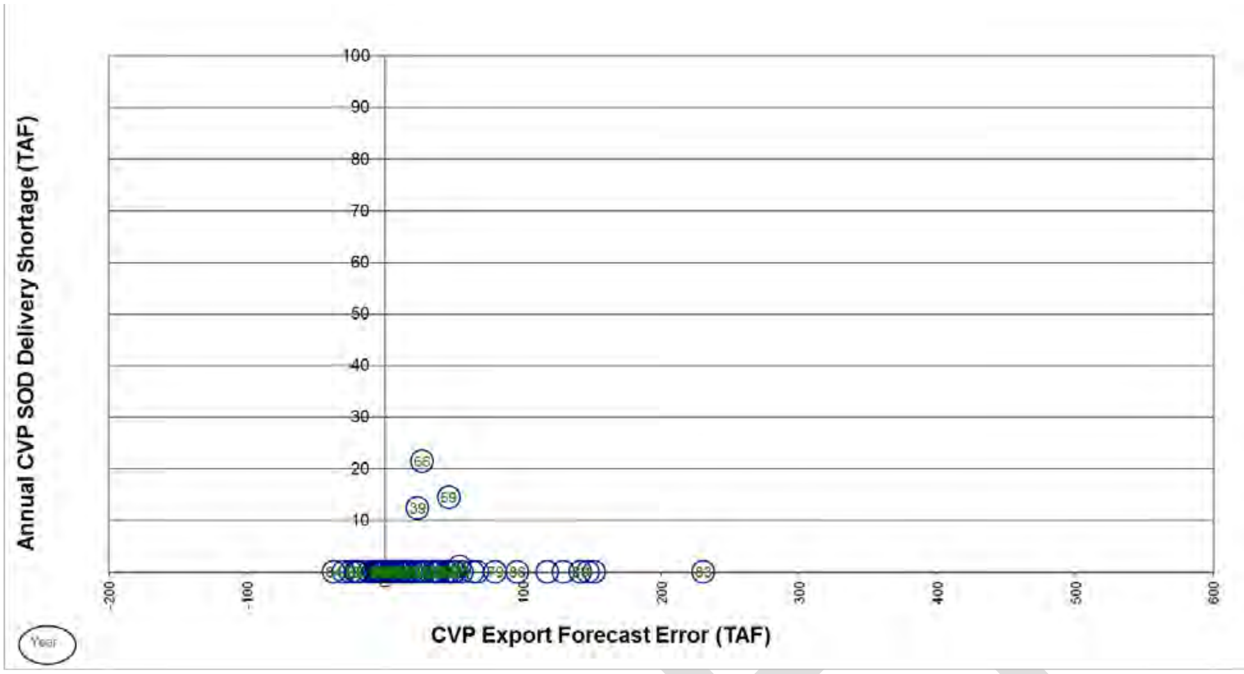

Figure 7. Annual CVP SOD delivery shortage versus CVP export forecast error in CalSim_27JAN2015_Revised

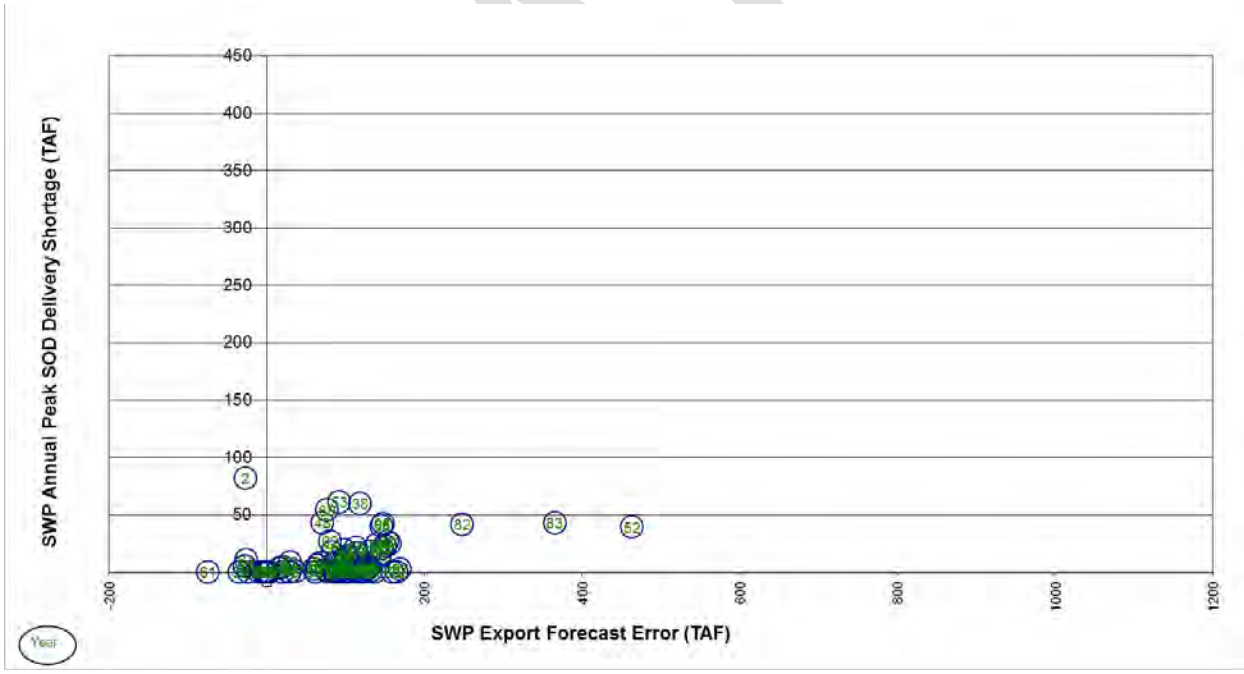

Figure 8. SWP annual peak SOD delivery shortage versus SWP export forecast error in CalSim_27JAN2015_Revised

CALSIM CVP ALLOCATION LOGIC REFINEMENT

Other adjustments were made to CalSim_27JAN2015_Revised in addition to the update of the export forecasts used in CVP and SWP allocations. One was a refinement to the CVP allocation procedure to reduce instances where there are low CVP SOD service contract allocations in years that end in excessively high San Luis carryover. Figure 9 links CVP San Luis low point with combined Shasta and Folsom carryover as simulated in CalSim_27JAN2015. Six of the annual data points are highlighted in red due the relatively high San Luis low point and low CVP SOD Ag Service allocation (see Figure 10 for the allocation associated with each data point). The highlighted years are 1932–1937, and the SOD Ag Service allocations in these years range from 4% in 1932 to 43% in 1936. The San Luis low point is above 300 TAF throughout this period and reaches almost 600 TAF in 1932. San Luis also fills during critical periods, thereby constraining CVP export of valuable winter surplus. Clearly, higher deliveries could be made SOD without impacting upstream storage; so it is advantageous to determine why the current model does not perform this operation, and what change can be made to more efficiently use available water.

The problem within the model is caused by dry conditions north of the American River and wetter conditions from the American River south. Such a hydrologic imbalance leaves Shasta and Trinity storage low but keeps San Luis storage high through export of surplus originating on the American and San Joaquin Rivers. Low Shasta and Trinity storage results in a low WSI-DI–based allocation. A low WSI-DI allocation supersedes a higher export-based allocation (recall that the model uses the minimum), and SOD service contractor allocations end up being governed by the dry conditions to the north even though there is sufficient water SOD to meet higher demand.

In the end, this is entirely the result of a modeling artifact. It is standard policy within the CVP that NOD service contractor allocations will be equal to or greater than SOD service contractor allocations. The issue lies with how this policy is applied in the model. NOD service contractor allocations are calculated using the WSI-DI method; SOD service contractor allocations are calculated as the minimum of the WSI-DI–based allocation and the export forecast–based allocation. This, at times, artificially constrains system-wide allocations based solely on low conditions at Shasta and Trinity.

In other words, the model ignores the details that operators would consider in developing a real-time service contractor allocation. Note that NOD Ag Service contracts along the Sacramento River total 377 TAF. As such, a NOD Ag Service allocation increase of 1 percent would expose Shasta and Trinity to a combined 4 TAF of additional drawdown. Also consider that SOD Ag Service contracts total 1,987 TAF. Therefore a 1 percent increase in SOD Ag Service allocations would require 20 TAF of combined drawdown in San Luis and/or increased exports. If in actual operations the CVP operators see the potential to boost SOD Ag Service allocations by 100 TAF due to high San Luis storage levels—an allocation increase of approximately 5 percentage points. There may be concern about boosting NOD Ag Service allocations by an equal percentage, but the operators would understand that such an increase would only result in an additional 20 TAF of load on Shasta and Trinity. There are certainly cases where such a tradeoff would be made, and years 1932–1937 as simulated in CalSim_27JAN2015 appear to be such cases.

The modification applied in CalSim_27JAN2015_Revised was to conditionally reformulate CVP Ag Service allocations in contract years 1932–1937. In these years, allocations for both NOD and SOD service contractors are allowed to be driven by the export-based methodology when appropriate. This does not circumvent the standard policy of maintaining NOD service contractor allocations at or above SOD allocations; this policy is maintained. The result of this change in allocation formulation is shown in Figure 11 and Figure 12. The data points highlighted in red correspond to

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the same annual data points highlighted in Figure 9 and Figure 10. The San Luis low point in these years has been significantly reduced in CalSim_27JAN2015_Revised as compared to CalSim_27JAN2015 and the impact to upstream carryover is acceptable.

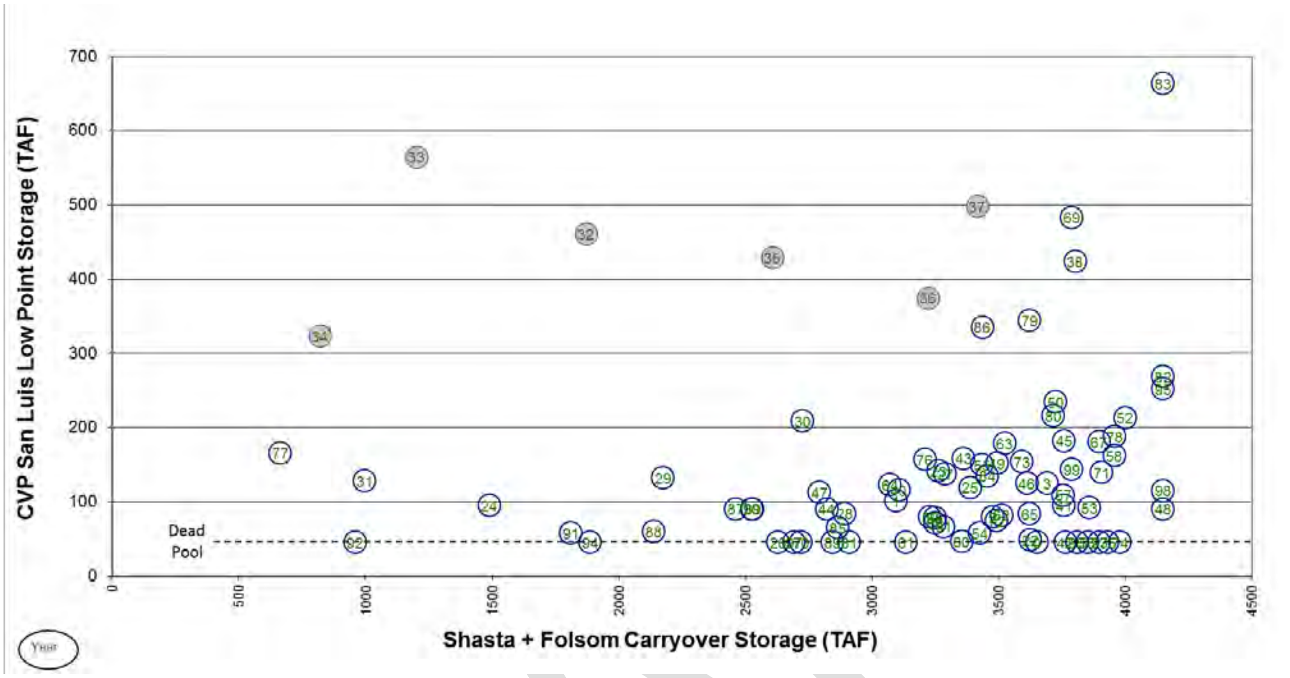

Figure 9. CVP San Luis low point storage versus combined Shasta and Folsom carryover in CalSim_27JAN2015 with contract year data label

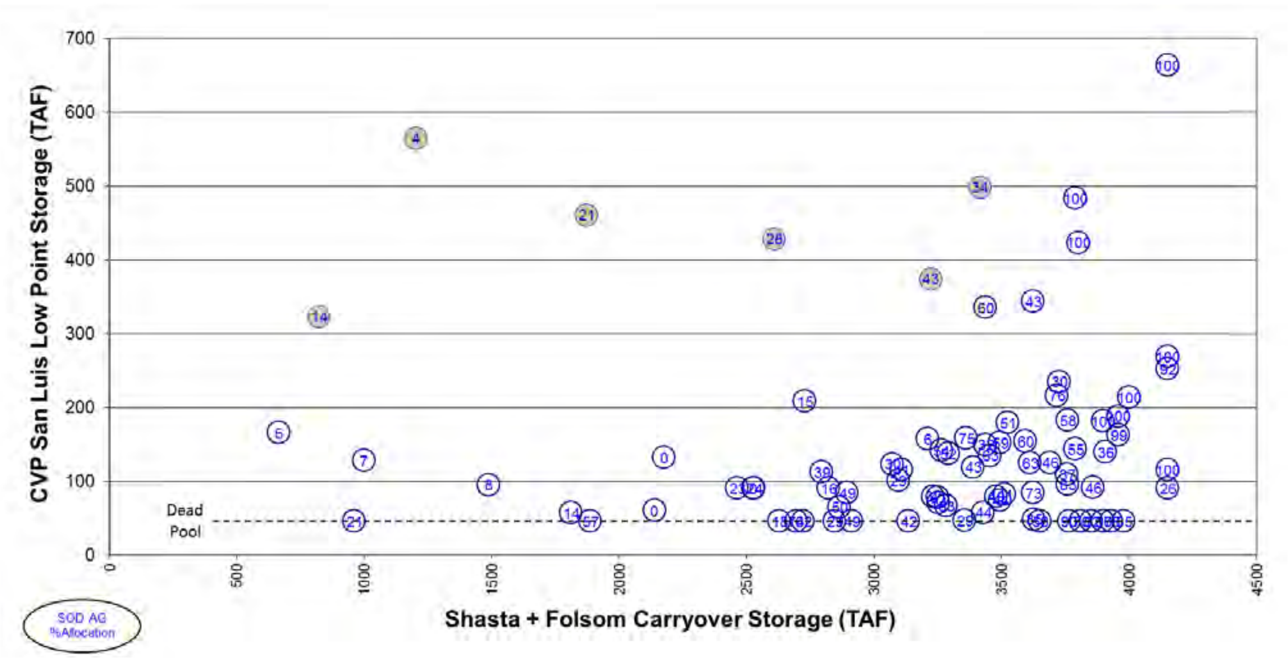

Figure 10. CVP San Luis low point storage versus combined Shasta and Folsom carryover in CalSim_27JAN2015 with SOD Ag Service allocation data label

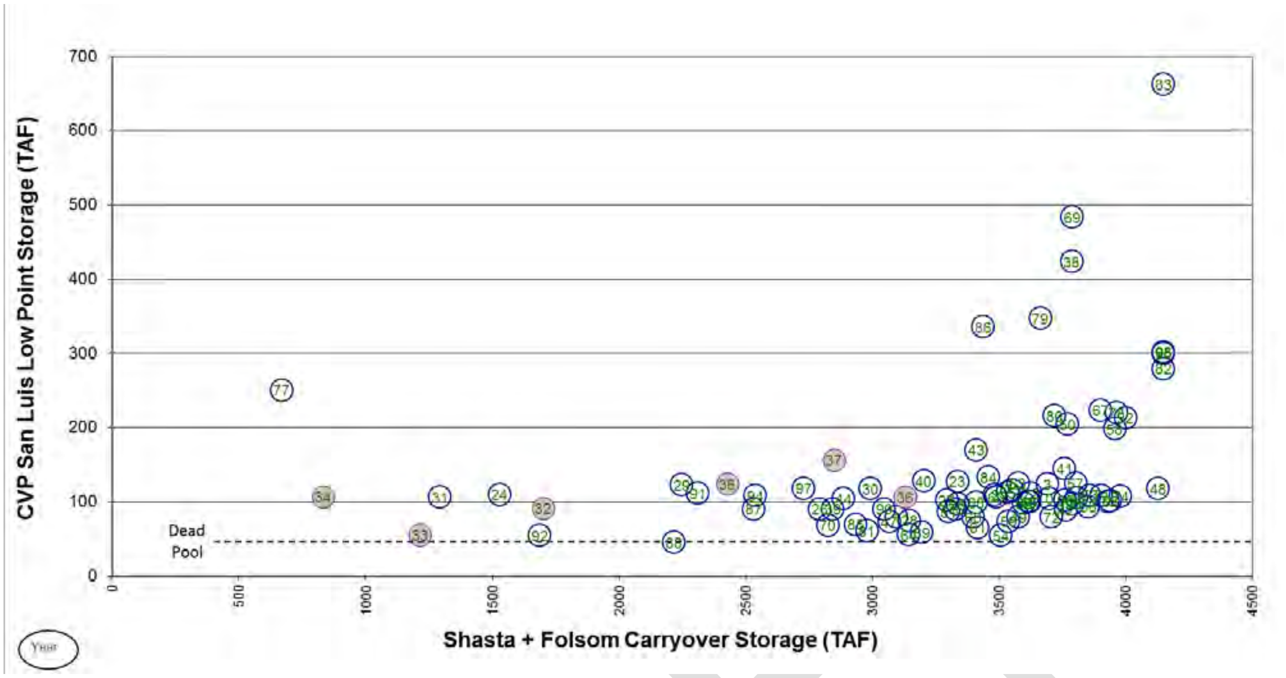

Figure 11. CVP San Luis low point storage versus combined Shasta and Folsom carryover in CalSim_27JAN2015_Revised with contract year data label

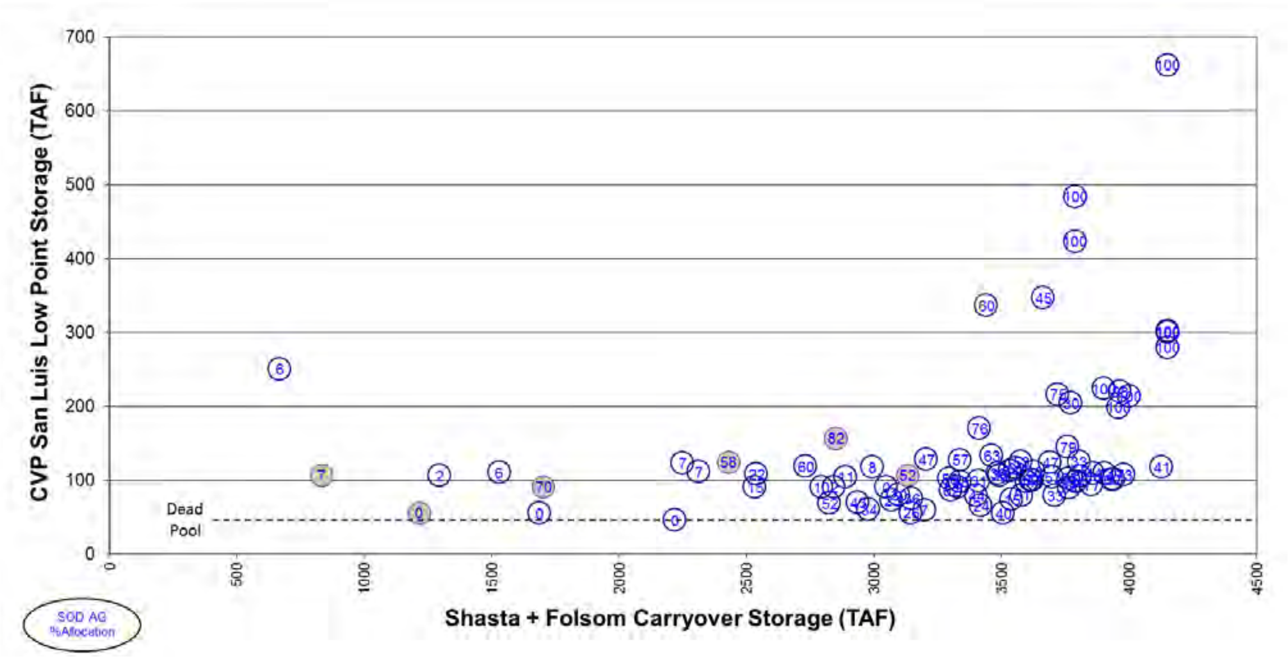

Figure 12. CVP San Luis low point storage versus combined Shasta and Folsom carryover in CalSim_27JAN2015_Revised with SOD Ag Service allocation data label

As discussed above, CalSim_27JAN2015_Revised results as plotted in Figure 5, Figure 6, Figure 7, Figure 8, Figure 11, and Figure 12 were significantly influenced by the revised export forecast used in CVP and SWP allocations and the reformulation of CVP allocation logic in 1932–1937. Two more changes were also made to CalSim_27JAN2015_Revised that affected results. However, while important to NOD-SOD storage balance, these changes are less significant than those already discussed. The first of these additional edits is refinement of San Luis rulecurve for the SWP and CVP, and the second is an adjustment to operational logic under an ANN negative carriage constraint; these edits are detailed below.

RULECURVE

The purpose of rulecurve is to prioritize balance between NOD storage and San Luis for both the CVP and SWP. Rulecurve controls upstream release for export when there is a choice between storing water in upstream reservoirs and releasing water for export and storing it in San Luis. Operational constraints such as flood pool, minimum instream flow requirements, export regulations, H&S pumping requirements, and physical pump capacity override rulecurve; and when any of these control operations, choices for balancing NOD storage are limited.

During the winter, rulecurve is set to encourage the filling of San Luis though it rarely controls. Incidental Delta inflow typically drives San Luis filling during the rainy season. Upstream reservoir releases are often controlled by flood pool or minimum flow requirements, and exports are controlled by OMR flow requirements or maximum pumping capacity. Since rulecurve does not play a significant role in driving winter San Luis operations, there was no need to modify wintertime rulecurve logic.

Where rulecurve does make a difference (or should make a difference) is during irrigation season when there are windows of opportunity to coordinate upstream reservoir releases with Delta exports. During the summer, SOD project demand typically exceeds Delta exports. As such, SOD project demand is met with a combination of Delta exports and San Luis releases, and if rulecurve is controlling, it influences the balance between Delta exports and San Luis reservoir releases. If rulecurve is set lower, exports decrease and San Luis releases increase. When set higher, the opposite occurs. Ideally the combination of San Luis releases and project exports over the irrigation season is sufficient to satisfy project allocations and San Luis targeted carryover storage, and rulecurve should be set to encourage the appropriate balance.

Therefore, formulation of rulecurve during the irrigation season should boil down to an export scheduling problem, to be solved by determining how much to export within a season to achieve delivery and carryover goals, how to distribute these exports from month to month, and where to set SWP and CVP rulecurve to encourage those Delta exports and the supporting upstream releases. The problem with the current irrigation season rulecurve formulations in CalSim is that they do not consider the amount of exports needed over the season. In fact, for both the SWP and CVP, the rulecurve formulation assumes exports of 60 TAF per month whether that is sufficient to meet operational objectives or not. Rulecurve levels are driven by this export assumption.

The implemented fix to the irrigation season rulecurve formulation is to incorporate export scheduling in CalSim_27JAN2015_Revised; SWP and CVP formulations vary slightly. With the CVP, exports need to be scheduled to ensure the project can meet peak summer demand and prevent San Luis low point issues through the end of September. The SWP has similar concerns, but must also consider Article 56 carryover into the next calendar year with the added complication of Feather River flow limitations for half of October and all of November that can interfere with the

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State's ability to make Oroville releases for export. So while the CVP's export scheduling formulation extends from May through September, the SWP's starts in April and extends through December. As an example, the SWP export schedule–based rulecurve formulation for the months of April–December is outlined below.

First, needed exports are calculated from the beginning of the current month of the simulation through the end of December (Required_Exports_NowtoDec (TAF)).

(1) Required_Exports_NowtoDec = max(0, remainDem_SOD + remain_evap + remain_loss + max(110, carryover_final + 55) – Beg_Month_SWP_San_Luis_Storage)

Where

- remainDem_SOD is the remaining Table A allocations to be delivered from now to the end of December (TAF)
- remain_evap is an estimate of total evaporation over the rest of the calendar year (TAF)
- remain_loss is an estimate of the total California Aqueduct losses over the rest of the calendar year (TAF)
- 110 is the SWP San Luis carryover target (TAF)
- carryover_final is the quantity of water needed in San Luis at the end of December to make Article 56 deliveries (TAF)
- 55 is SWP San Luis dead pool capacity (TAF)
- Beg_Month_SWP_San_Luis_Storage is SWP San Luis storage at the beginning of the current month of simulation (TAF)

Next, the amount that should be exported this month (Required_Exports (TAF)) in order to achieve the export goal for the remainder of the calendar year (Required_Exports_NowtoDec) is calculated. Assume exports will be scheduled uniformly over the remaining months of the calendar year, except for half of October and all of November due to Feather River flow restrictions. During the Feather River flow restrictions, we assume Banks pumping is held to the H&S level (300 cfs), which equals approximately 27 TAF over 1.5 months or 18 TAF over 1 month. So the formulation varies by month:

For the months April–September, the formulation is:

(2a) Required_Exports = (Required_Exports_NowtoDec - 27)/(remain_months - 1.5)

For the month of October, the formulation is:

(2b) Required_Exports = (Required_Exports_NowtoDec - 18)/(remain_months - 1)

And for the months of November–December the formulation is:

(2c) Required_Exports = Required_Exports_NowtoDec/remain_months

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Where

- remain_months is the number of months remaining in the calendar year starting from the beginning of this month of simulation to the end of December

At this point in the calculation, SWP exports could be prioritized up to Required_Exports such that Oroville releases would be made to support those exports. But that is not the modeling technique used in CalSim. As discussed, the balance of upstream storage and San Luis storage is guided with rulecurve; so to prioritize SWP exports up to Required_Exports, rulecurve must be appropriately set. Expected change in San Luis storage (Change_San_Luis_Storage (TAF)) if exports equal Required_Exports is now calculated. The formulation is:

(3) Change_San_Luis_Storage = Required_Exports – This_Month_Forecasted_Delivery – This_Month_Forecasted_Loss – This_Month_Forecasted_Evap

Where

- This_Month_Forecasted_Delivery is this month’s estimated Table A deliveries (TAF)
- This_Month_Forecasted_Loss is this month’s estimated California Aqueduct losses (TAF)
- This_Month_Forecasted_Evap is this month’s estimated SWP San Luis evaporation (TAF)

Given the calculated Change_San_Luis_Storage, the rulecurve (SWP_Rulecurve (TAF)) that will encourage sufficient Oroville releases to support SWP exports at Required_Exports is determined as follows:

(4) SWP_Rulecurve = Beg_Month_SWP_San_Luis_Storage + Change_San_Luis_Storage

NEGATIVE CARRIAGE OPERATIONS

Delta carriage is the additional Delta outflow above minimum required Delta outflow (MRDO) necessary to meet D-1641 salinity standards. When salinity is controlling, an increase in exports requires an increase in release from upstream reservoirs to the Delta that equals the export increase plus carriage. In other words, carriage is the water cost of Delta exports when salinity standards are controlling. While higher exports typically result in higher carriage, there are times of the year when Rock Slough and Emmaton salinity standards can be met with higher exports and negative carriage. Essentially, when a negative carriage salinity constraint is controlling, a unit increase in Delta exports is supplied partially by a decrease in carriage (decrease in Delta outflow) and the remainder by an increase in upstream reservoir release. While negative carriage might be counterintuitive, it is an actual phenomenon observed in Delta operations.

Negative carriage in CalSim presents problems of prioritization. In CalSim, Delta outflow above MRDO, whether the outflow is surplus or carriage, is given a highly negative weight (low priority). The intent is to discourage any Delta outflow in excess of MRDO. So when a negative carriage salinity constraint is controlling operations, CalSim will operate to minimize Delta outflow even though it might cause an imbalance between NOD and SOD storage. Delta outflow is reduced through increased exports, but some water still has to be released from upstream reservoirs to

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support part of the increased export. If NOD reservoirs are relatively full, this could be a desirable operation, but if NOD reservoirs are low and further exports are not needed to support this year's allocation, minimizing Delta outflow at the expense of upstream storage is an unwarranted operational decision. During the critical periods, CalSim makes several of these decisions that result in the transfer of NOD storage to San Luis when the water would be better kept NOD.

The implemented negative carriage operation fix in CalSim_27JAN2015_Revised is to remove the model flexibility to make an unwarranted decision. In CalSim, SWP and CVP export estimates are made to guide operations when salinity standards are controlling (C400_MIF logic). This is used to ensure that needed exports are made even if positive carriage must be paid. In CalSim_27JAN2015_Revised, similar export estimates are now used to limit how much carriage can be reduced through increases in exports under a negative carriage constraint. Essentially, under an Emmaton or Rock Slough negative carriage constraint, the carriage is held at the level to support the estimated export – no more and no less. CalSim does not get an objective function benefit of releasing more water from upstream storage for a fractional reduction in Delta outflow.

COMPARISON OF CALSIM_27JAN2015 AND CALSIM_27JAN2015_REVISED RESULTS

The revisions in CalSim_27JAN2015_Revised change the storage balance between Oroville and SWP San Luis. Figure 13 and Figure 14 relate SWP San Luis low point storage to Oroville carryover in each year of the CalSim_27JAN2015 simulation. The only difference between the two figures is that data in Figure 13 is labeled by year and data in Figure 14 is labeled by Table A allocation. Note the years that SWP San Luis low point is at dead pool. This occurs over a wide spectrum of Oroville carryover and Table A allocations. Also note the four data points highlighted in red—1925, 1932, 1949, and 1955 with Table A allocations of 37%, 28%, 29%, and 38%, respectively. Ideally, higher allocations would have been made in these years, reducing San Luis low point storage. Figure 15 and Figure 16 relate SWP San Luis low point storage to Oroville carryover storage in each year of the CalSim_27JAN2015_Revised simulation. Compare Figure 15 and Figure 16 to Figure 13 and Figure 14, respectively to see the effect of the model edits (export forecast, rulecurve, and negative carriage) on the overall San Luis-Oroville storage balance. Note that the San Luis low point has been largely lifted above dead pool in CalSim_27JAN2015_Revised. Also note the red highlighted data points in Figure 15 and Figure 16, which correspond to the same years highlighted in red in Figure 13 and Figure 14. The combined effect of the model edits creates a more ideal balance between Oroville storage, SWP San Luis storage, and Table A allocations.

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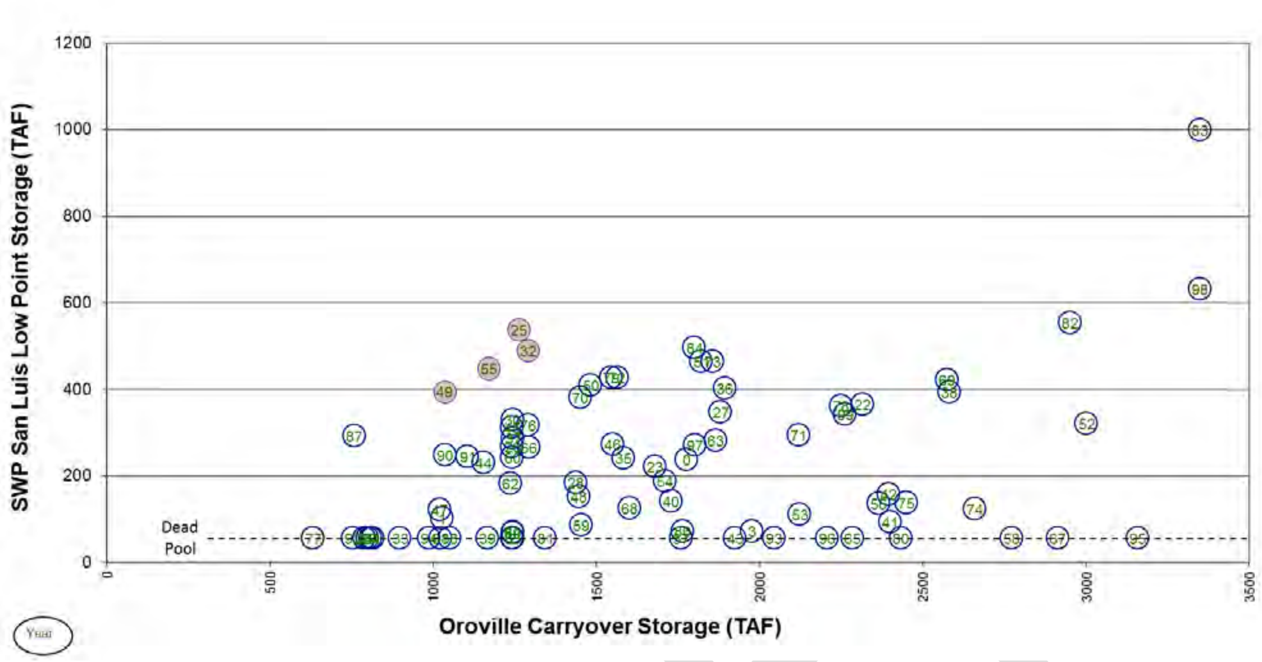

Figure 13. SWP San Luis low point storage versus Oroville carryover in CalSim_27JAN2015 with contract year data label

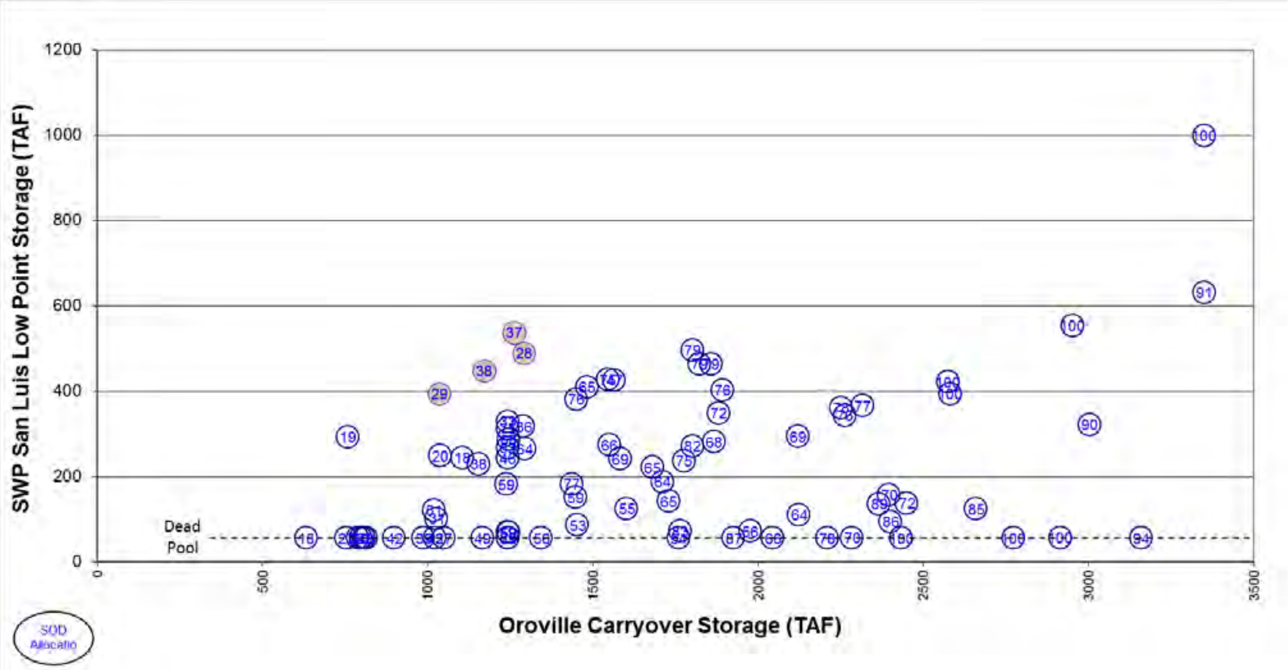

Figure 14. SWP San Luis low point storage versus Oroville carryover in CalSim_27JAN2015 with Table A allocation data label

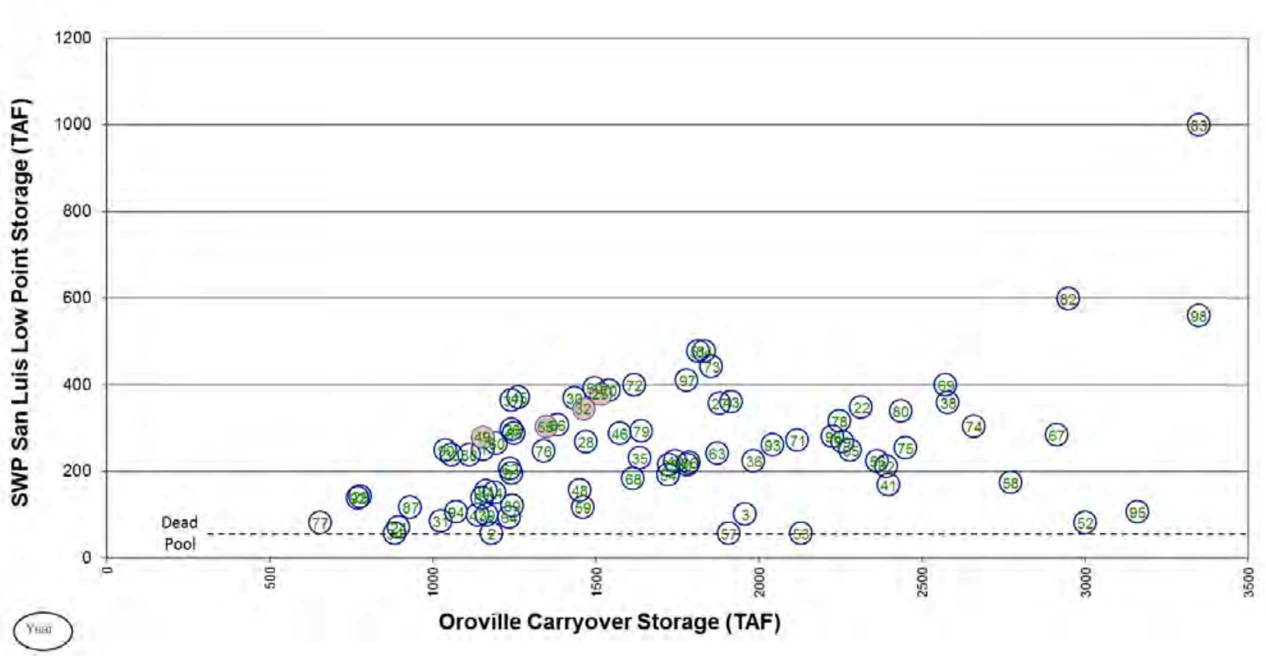

Figure 15. SWP San Luis low point storage versus Oroville carryover in CalSim_27JAN2015_Refined with contract year data label

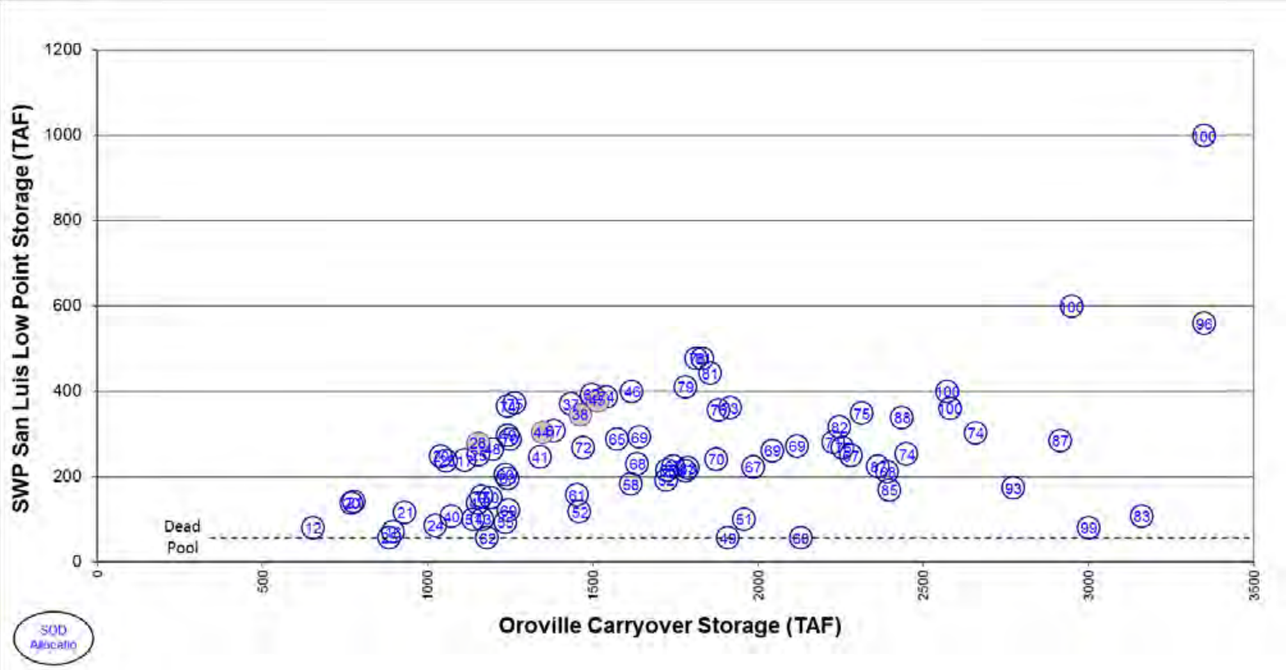

Figure 16. SWP San Luis low point storage versus Oroville carryover in CalSim_27JAN2015_Revised with Table A allocation data label

CVP San Luis storage often hits its annual low point in August. Figure 17 compares CVP San Luis end of August storage probability of exceedance curves for CalSim_27JAN2015 and CalSim_27JAN2015_Revised. In CalSim_27JAN2015, there is an almost 20% chance that end of August CVP San Luis storage is at dead pool; there is only slightly more than a 1% chance in

CalSim_27JAN2015_Revised. Also, in CalSim_27JAN2015_Revised, CVP San Luis is consistently drawn down to the 90 TAF low point target used in the CVP SOD export forecast allocation logic, whereas CalSim_27JAN2015 tends to diverge from this target.

SWP San Luis storage often hits its annual low point in October. Figure 18 compares SWP San Luis end-of-October storage probability of exceedance curves for CalSim_27JAN2015 and CalSim_27JAN2015_Revised. In CalSim_27JAN2015, there is a greater than 16% chance that end-of-October SWP San Luis storage is at dead pool; there is only a 3% chance in CalSim_27JAN2015_Revised. The low point target used in SWP export forecast allocation logic is 110 TAF. There is no obvious drawdown to this target in Figure 18 because of Article 56 carryover. CalSim_27JAN2015_Revised does a better job of preserving Article 56 requested by contractors. This is more evident when comparing CalSim_27JAN2015_Revised and CalSim_27JAN2015 Article 56 deliveries.

Model revisions also affect NOD carryover storage (end of September). Figure 19 through Figure 22 show the CalSim_27JAN2015 and CalSim_27JAN2015_Revised carryover storage probability exceedance curves for Trinity, Shasta, Folsom, and Oroville reservoirs, respectively. As shown, the model revisions had a largely positive effect on upstream carryover storage.

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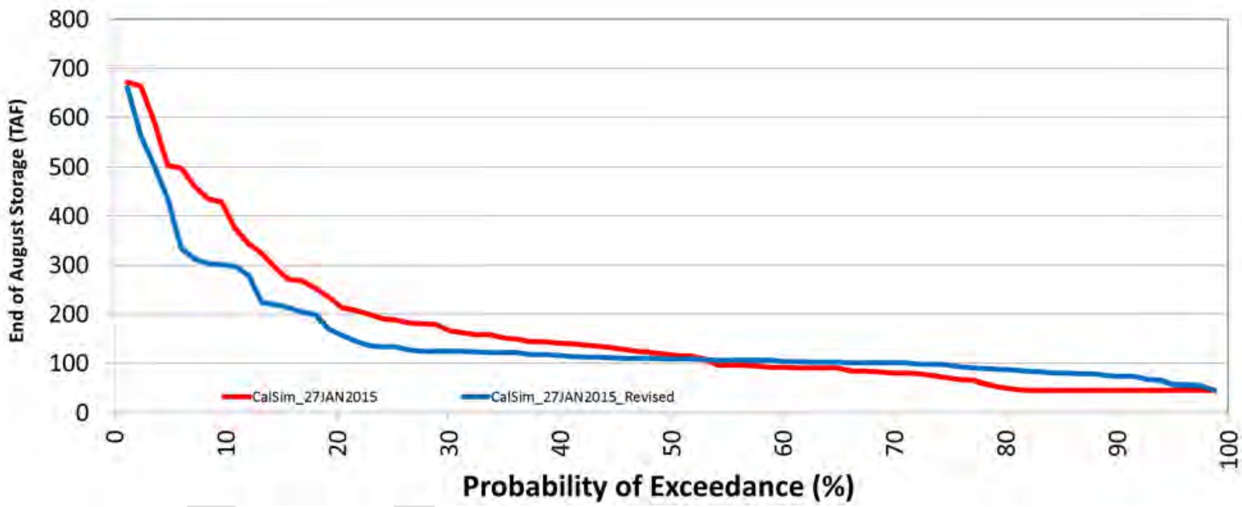

Figure 17. CVP San Luis end of August storage probability of exceedance for CalSim_27JAN2015 and CalSim_27JAN2015_Revised

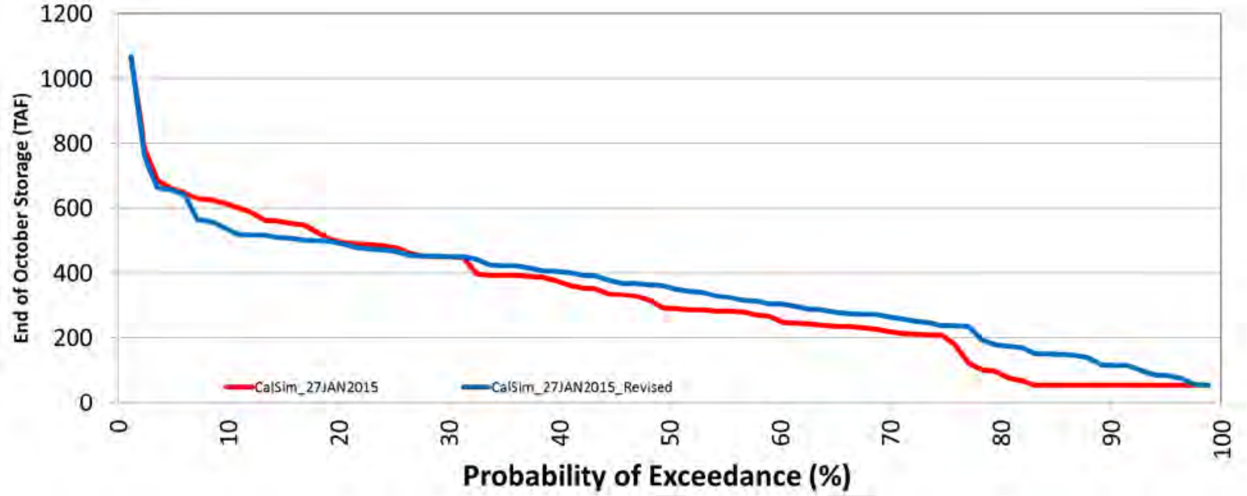

Figure 18. SWP San Luis end of October storage probability of exceedance for CalSim_27JAN2015 and CalSim_27JAN2015_Revised

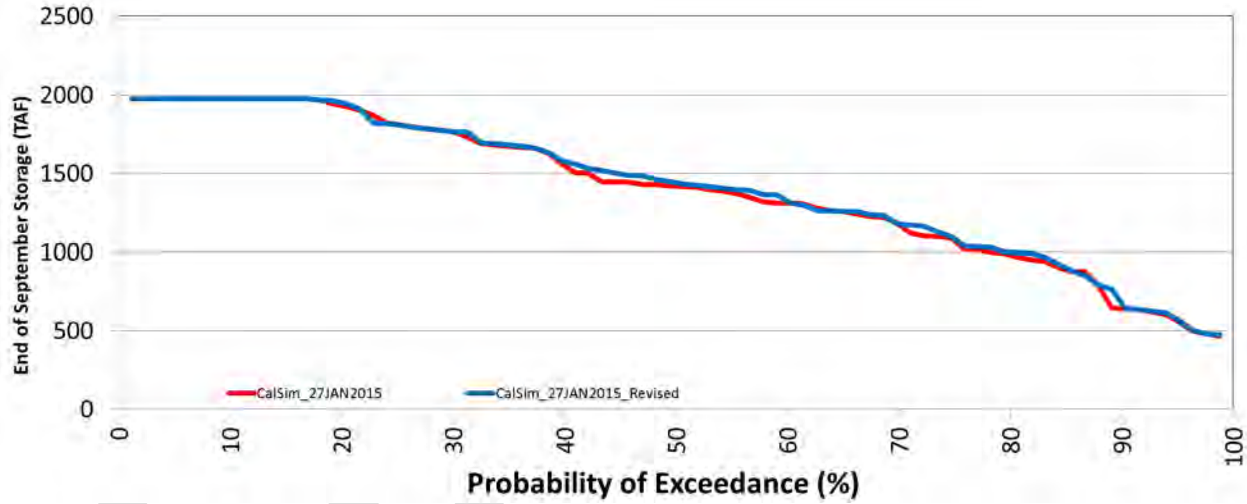

Figure 19. Trinity carryover storage probability of exceedance for CalSim_27JAN2015 and CalSim_27JAN2015_Revised

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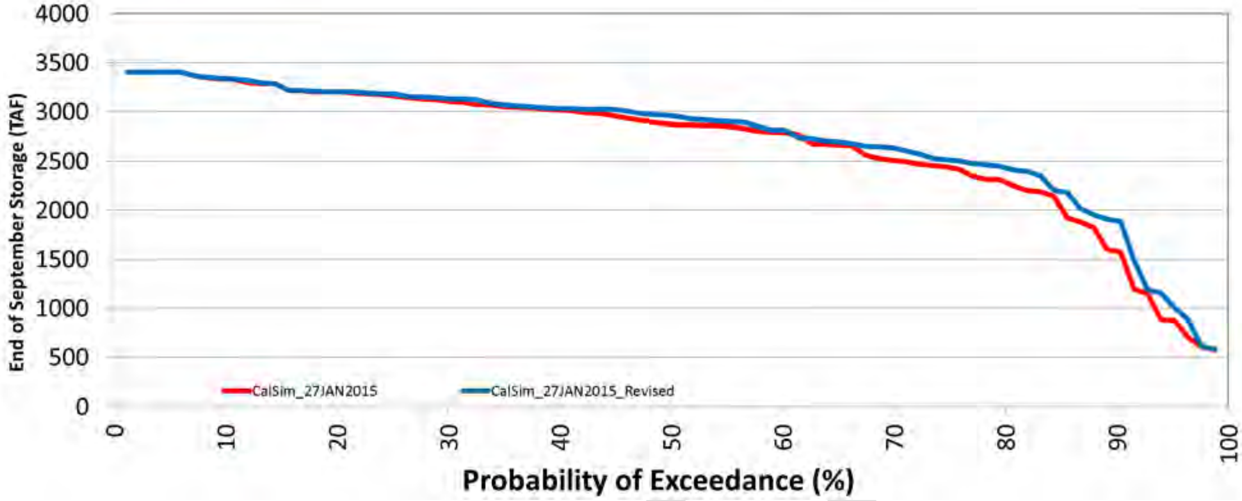

Figure 20. Shasta carryover storage probability of exceedance for CalSim_27JAN2015 and CalSim_27JAN2015_Revised

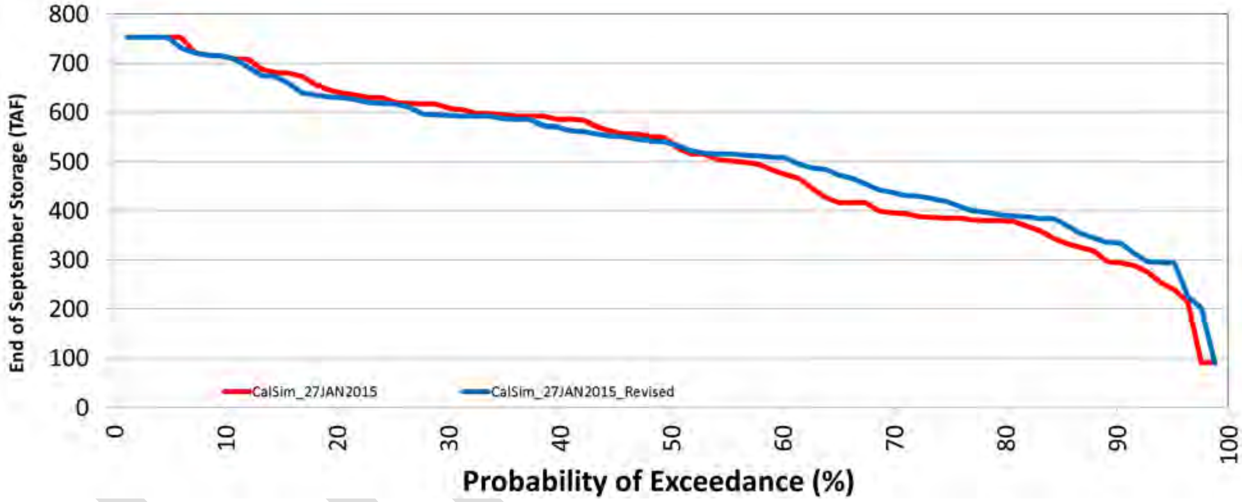

Figure 21. Folsom carryover storage probability of exceedance for CalSim_27JAN2015 and CalSim_27JAN2015_Revised

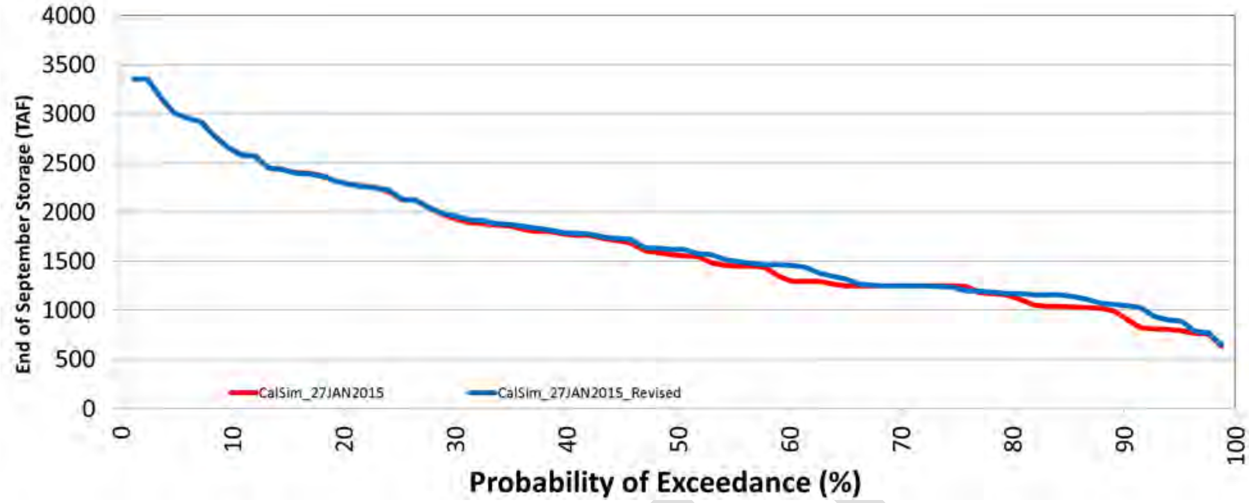

Figure 22. Oroville carryover storage probability of exceedance for CalSim_27JAN2015 and CalSim_27JAN2015_Revised

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Significant changes in project reservoir operations necessarily affect project deliveries. Table 5 and Table 6 quantify the difference in CVP NOD and SOD project deliveries by month and water year type. Overall, CVP NOD project deliveries increased by 13 TAF, whereas CVP SOD project deliveries decreased by 25 TAF.

Table 5. Change in total CVP NOD project deliveries between CalSim_27JAN2015_Revised and CalSim_27JAN2015 (TAF)

Indx	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
W	0	0	0	0	0	0	0	0	0	0	0	0	2
AN	0	0	0	0	0	0	1	1	2	2	2	1	8
BN	0	0	0	0	0	0	2	5	7	8	7	3	34
D	0	0	0	0	0	0	2	2	3	4	3	1	16
C	1	0	0	0	0	0	1	1	1	2	1	1	10
All	0	0	0	0	0	0	1	2	2	3	2	1	13

Table 6. Change in total CVP SOD project deliveries between CalSim_27JAN2015_Revised and CalSim_27JAN2015 (TAF)

Indx	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
W	-2	-1	-2	-3	-4	2	-3	-3	-5	-6	11	-2	-18
AN	-3	-2	-3	-5	-5	4	-4	-5	-8	-10	3	-2	-41
BN	0	0	0	-1	-1	9	8	9	14	18	13	4	73
D	0	0	0	0	0	1	-6	-8	-13	-16	-9	-4	-57
C	-1	-1	-1	-2	-2	-4	-7	-12	-17	-22	-13	-6	-89
All	-1	-1	-1	-2	-2	2	-2	-4	-6	-7	2	-2	-25

Table 7 through Table 9 quantify the difference in SWP Table A, Article 56, and Article 21 project deliveries by month and water year type. Overall, Table A deliveries decreased 44 TAF, Article 56 deliveries increased 7 TAF, and Article 21 deliveries decreased 11 TAF. It is expected that reduced Table A allocations would result in fewer Article 56 requests. The reason for higher Article 56 deliveries is that the improved San Luis operation results in fewer Article 56 shortages.

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Table 7. Change in SWP Table A deliveries between CalSim_27JAN2015_Revised and CalSim_27JAN2015 (TAF)

Indx	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
W	-2	6	-2	1	-3	11	-10	-11	-11	-8	-7	-6	-41
AN	21	-10	-25	1	0	1	-12	-13	-15	-16	-16	-12	-97
BN	0	-3	-14	8	-6	-6	-4	-3	-1	0	0	0	-30
D	-9	-6	-40	1	1	2	15	9	7	6	14	14	13
C	10	7	-6	0	0	-1	-1	-18	-30	-39	-38	17	-97
All	2	0	-16	2	-2	3	-3	-6	-9	-9	-7	2	-44

Table 8. Change in SWP Article 56 deliveries between CalSim_27JAN2015_Revised and CalSim_27JAN2015 (TAF)

Indx	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
W	0	0	0	6	4	2	0	0	0	0	0	0	11
AN	0	0	0	-4	-2	-1	0	0	0	0	0	0	-7
BN	0	0	0	3	2	2	0	0	0	0	0	0	7
D	0	0	0	3	3	2	0	0	0	0	0	0	9
C	0	0	0	4	4	1	0	0	0	0	0	0	9
All	0	0	0	3	2	1	0	0	0	0	0	0	7

Table 9. Change in SWP Article 21 deliveries between CalSim_27JAN2015_Revised and CalSim_27JAN2015 (TAF)

Indx	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
W	0	0	0	-7	-6	7	-2	0	0	0	1	0	-7
AN	0	0	-1	-2	-1	-1	0	0	0	0	1	0	-4
BN	0	0	0	0	-1	-25	0	0	0	0	0	0	-25
D	0	0	0	0	-4	-2	0	0	0	0	1	0	-6
C	0	0	0	0	-14	-7	0	0	0	0	0	0	-20
All	0	0	0	-2	-5	-4	-1	0	0	0	1	0	-11

Table 10 quantifies the difference in Feather River Settlement Contractor fall rice decomposition deliveries by month and water year type. The annual average difference between the CalSim_27JAN2015_Revised and CalSim_27JAN2015 is 8 TAF. CalSim meets less than the rice decomposition demand when Oroville storage drops below 1.2 MAF. Since CalSim_27JAN2015_Revised maintains higher Oroville storage than CalSim_27JAN2015, the revised study is able to meet more of the rice decomposition demand annually.

Table 10. Change in Feather River Settlement Contractor rice decomposition deliveries between CalSim_27JAN2015_Revised and CalSim_27JAN2015 (TAF)

Indx	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
W	2	2	1	0	0	0	0	0	0	0	0	0	5
AN	-2	-2	-1	-1	0	0	0	0	0	0	0	0	-6
BN	4	6	4	2	0	0	0	0	0	0	0	0	16
D	4	4	2	1	0	0	0	0	0	0	0	0	12
C	4	5	3	1	0	0	0	0	0	0	0	0	12
All	2	3	2	1	0	0	0	0	0	0	0	0	8

Appendix C Engineering Designs and Costs

This appendix documents the engineering and cost estimate analyses completed to support the federal plan formulation and evaluation presented in the San Luis Low Point Improvement Project Feasibility Report. The engineering designs and cost estimates presented in this appendix for the No Action/No Project and alternative plans are at an appraisal level of detail.

C.1 No Action/No Project Alternative

C.1.1 San Luis Reservoir Operations

The No Action/No Project Alternative would leave the current operations at San Luis Reservoir unchanged. Santa Clara Valley Water District (SCVWD) would continue annual operations planning to anticipate curtailment of Central Valley Project (CVP) supply and would manage its uses and sources of imported and local water supplies.

SCVWD seeks a stable supply of CVP surface water as a part of its larger water supply portfolio that includes imported surface water supplies from the CVP and State Water Project (SWP), local groundwater, and local surface water supplies. Low point supply interruptions reduce the reliability of SCVWD's CVP supply, which could jeopardize the short and long term reliability of other supplies intended for other uses. For instance, groundwater normally reserved for drought or emergency use may be relied upon during a low point event. A low point supply interruption—and even the threat of an interruption—can result in the immediate reduction of the amount of treated water available for delivery by SCVWD's customers, because it requires the re-operation of SCVWD's surface and groundwater systems and requires the use of alternative water supplies that would otherwise be dedicated to other uses. The effects resulting from delivery reductions and/or curtailments due to a low point would continue to pose a significant threat to the customer's short and long term water supply reliability.

Under this alternative, water supply modeling results have predicted that there would be 17 years (out of the 82 modeled years)[1] where the San Luis Reservoir would be drawn below 300 thousand acre-feet (TAF) of storage, i.e. low point years.

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[1] Appendix B presents in detail the assumptions and methods used by the CalSim II model to estimate effects from the No Action/No Project and action alternatives

C.1.2 Pacheco Reservoir Operations

The No Action/No Project Alternative would leave the current operations at Pacheco Reservoir unchanged. North Fork Dam is currently under restricted-operation criteria through an April 5, 2017 order of DWR’s Division of Safety of Dams (DSOD) due to existing spillway deficiencies. The Pacheco Pass Water District (PPWD) is coordinating with Federal Emergency Management Agency (FEMA) and DSOD on short-term and long-term repairs. The DSOD has stated that if satisfactory progress is not made to address spillway deficiencies, additional remedies would be invoked, inclusive of revocation of the PPWD’s Certificate of Approval to store water. If such certification is revoked, the lake would be drained and the Dam’s outlet structures would be left open, a step that would reduce, among other things, existing fisheries habitat. For the purpose of this EIS/EIR, in order to eliminate the risk of overestimating benefits, it is assumed that the existing reservoir is operated at full operational capacity and consistent with recommendations in the *2014 Report on Comprehensive Strategy and Instructions for Operation of Pacheco Reservoir* (i.e., optimized operations for steelhead habitat).

C.2 Lower San Felipe Intake Alternative Plan

C.2.1 Overview

The Lower San Felipe Intake Alternative Plan includes construction of a new, lower San Felipe Intake to allow reservoir drawdown to its minimum operating level without algae reaching the San Felipe Intake. Moving the San Felipe Intake to an elevation equal to that of the Gianelli Intake would allow operation of San Luis Reservoir below the 300 thousand acre-feet (TAF) level without creating the potential for a water supply interruption to SCVWD.

As part of this alternative, a new intake would be constructed and connected to the existing San Felipe Division Intake via approximately 20,000 feet of new pipeline or tunnel. The San Felipe Intake is currently at elevation 334 feet, and algae-laden water can reach the intake when reservoir levels reach approximately 369 feet (approximately 300 TAF in storage). Because the Gianelli Intake Facility is at elevation 296 feet (approximately 30 feet lower than the minimum operating pool), algae-laden water does not typically reach the Gianelli Intake. The new intake in this alternative would be at elevation 296 feet, the same elevation as the Gianelli Intake. The lower intake facility would allow the San Felipe Division to receive water from the lower reservoir levels that do not contain high concentrations of algae. A hypolimnetic aeration facility would also be constructed.

C.2.2 Project Facilities

The facilities for the Lower San Felipe Intake Alternative Plan include:

- New intake structure
- Extended intake conveyance, either a tunnel or underwater pipeline
- Connection to existing intake
- Aeration system
- Site access improvements
- Improved site utilities

Figure C-1 shows the locations of existing and proposed facilities at San Luis Reservoir under this alternative. Table C-1 summarizes key features of the project facilities. Modifications to the existing Pacheco Pumping plant are not expected.

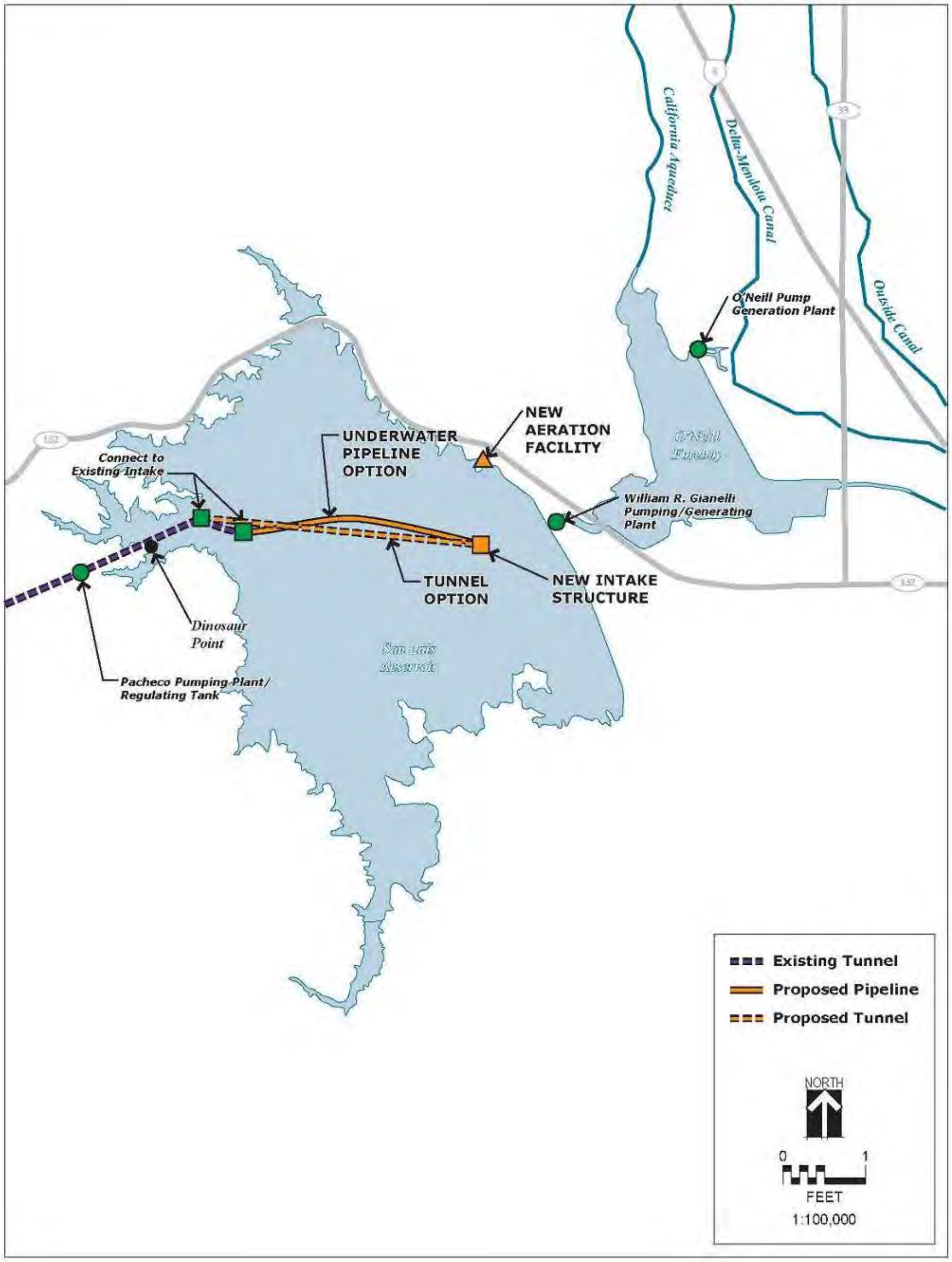

Figure C-1. Pipeline and Tunnel Alignment for the Lower San Felipe Intake Alternative Plan

Table C-1. Lower San Felipe Intake Alternative Plan – Key Design and Project Facilities Information

Parameter	Specification[1]
System Information	
Conveyance Capacity	490 cfs
Pacheco Pump Station Static Lift	80 to 310 feet [2,3]
San Luis Reservoir Minimum Operating Elevation	326 feet (79 TAF minimum pool elevation)
Connection to Existing Intake	
Tunnel option	
New vertical shaft	On Gate Shaft Island
Elevation	250 feet [3]
Diameter	35 to 40 feet
Pipeline Option	
Connection to Existing Intake	At existing lower intake at invert 313-feet
Intake Extension (Pipeline or Tunnel Option)	
Inner Diameter	13 feet
Length	20,000 feet
Head Loss	6 feet
New Intake Structure	
Elevation (top of structure)	296 feet [3]
Other Facilities	
Hypolimnetic Aeration	

Notes: [1] cfs = cubic feet per second
[2] Unchanged from existing conditions
[3] feet above mean sea level

C.2.2.1 New Intake Structure

The new intake structure would allow water to be drawn from an elevation of 296 feet to continue deliveries to the San Felipe Division during a low point event. The intake structure would consist of a vertical steel riser pipe, with a trash rack at the intake opening similar to the two existing intake structures. The conduit invert elevation at the new intake would be approximately 250 feet for the tunnel option and 280 feet for the pipeline option.

The existing upper and lower intakes would still be functional after the new conduit and lower intake are operational; however, valves or other means of isolation would be installed such that the existing intake structures could be isolated from service prior to low point events.

C.2.2.2 Intake Extension

Lowering the San Felipe Intake would require an extension of the intake for the Pacheco Pumping Plant because the reservoir is higher on the west side than at the site of the Gianelli Intake. The conveyance structure from the new intake to the existing intake would be either a submerged pipeline along the bottom of the reservoir or a tunnel beneath the bottom of the reservoir.

Tunnel Option

A tunnel would be constructed beneath the reservoir floor to convey water from the new intake to the existing intake. The tunnel option includes a new vertical shaft on Gate Shaft Island to tie into the existing intake and serve as a beginning point to launch the tunnel boring equipment. The tunnel would be about 20,000 feet long, 15 feet in diameter, and the liner would have an inner diameter of 13 feet. Figure C-2 shows the tunnel profile.

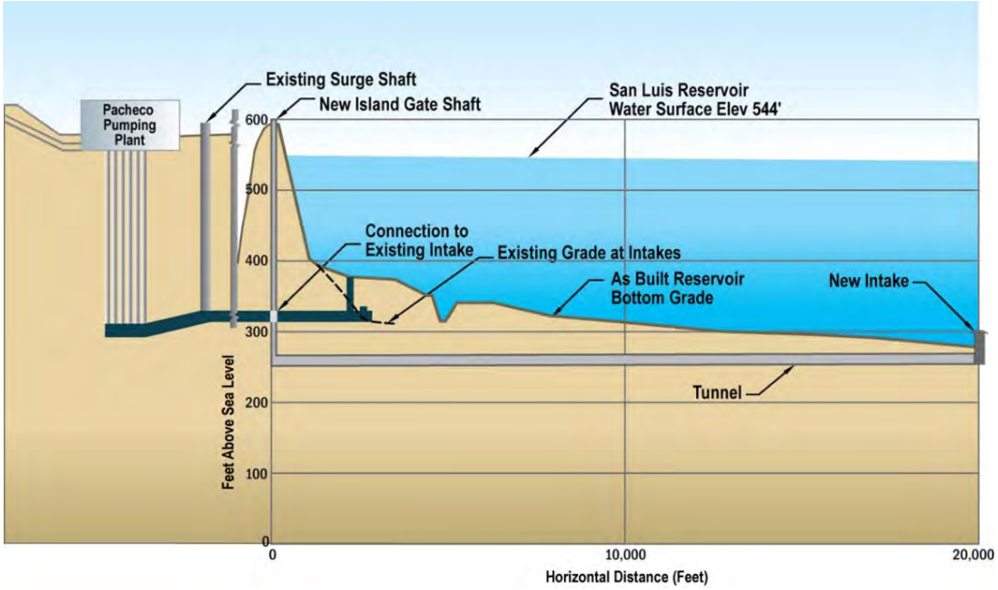

Figure C-2. Lower San Felipe Intake Alternative Plan Tunnel Profile

Pipeline Option

For the pipeline option, a new 13-foot diameter reinforced concrete cylinder pipe would be laid along the bottom of San Luis Reservoir. The pipeline would be about 20,000 feet long. The pipe would have a constant slope upward from the new intake and tie into the invert of the existing lower intake at elevation 313 feet. An existing intake channel is graded along the bottom of the reservoir. To reduce the amount of dredging required, the pipeline's alignment would match the alignment of the existing intake channel. Figure C-3 shows the pipeline profile.

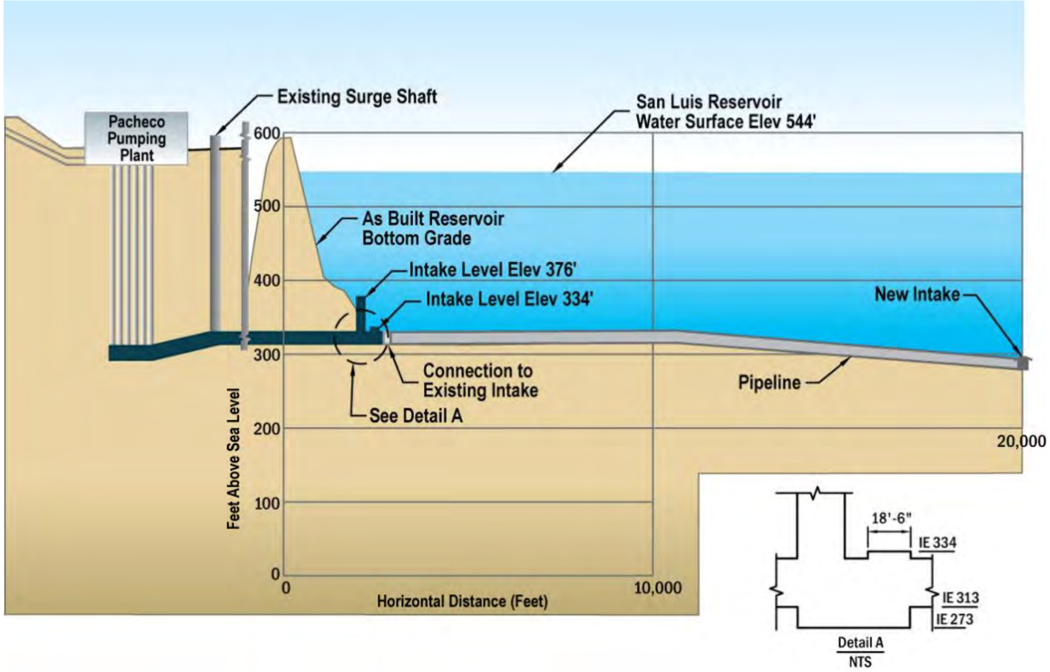

Figure C-3. Lower San Felipe Intake Alternative Plan Pipeline Profile

C.2.2.3 Connection to Existing Intake

The new intake pipeline or tunnel would connect to the existing intake, either at Gate Shaft Island for the tunnel option, or at the existing lower intake for the pipeline option. Gate Shaft Island is a 4-acre area approximately 2,050 feet from the existing lower intake. The San Felipe Division would likely experience a service interruption during the tie-in work.

Tunnel

The tunnel option would require a new vertical shaft on Gate Shaft Island for the tunneling equipment; this new shaft would connect to the existing intake shaft by a short connection structure constructed between the two shafts. The wall of the existing shaft would need to be penetrated in order to complete the connection. The new vertical shaft on the island would be 35-40 feet in diameter and approximately 330 feet deep.

Pipeline

The pipeline option would require a temporary coffer dam-style structure be constructed to allow for connection of the new pipeline to the existing intake. The coffer dam structure would be approximately 35 feet in diameter.

C.2.2.4 Hypolimnetic Aeration System

During periods of low water levels and warm weather, water within the reservoir can stratify, resulting in a hypolimnion layer at the elevation of the proposed new lower intake. The reduced level of dissolved oxygen in the hypolimnion could potentially lead to taste and odor issues in the water drawn from this layer. A new aeration system would be constructed to oxygenate the reservoir and prevent stratification. The aeration system (shown on Figure C-1) would consist of a new facility near Romero Visitor Center. A liquid oxygen tank and vaporizers or a compressed air system are being considered for the aeration facility. Either system would be placed in a structure with an approximate footprint of 1,200 square feet. A 3-inch air supply line would connect to approximately 6,000 feet of submerged high-density polyethylene air diffuser piping within the reservoir.

C.2.2.5 Site Access Improvements

Improved road access from Highway 152 to the Dinosaur Point and Basalt Area staging areas may be needed to accommodate the high volume of trucks and other heavy equipment anticipated during construction. Road reinforcement would be necessary at the intersections of Highway 152 and the access roads to Dinosaur Point and Basalt Area. Also, temporary paved roads would be constructed for truck transportation of materials between stockpiling areas and the launching area at the reservoir. Existing recreation boat launching ramps may be used for construction activities, however if the ramps are unsuitable, a temporary ramp would be constructed for moving equipment and materials into the reservoir.

C.2.2.6 Site Utilities

Temporary power facilities would be needed for construction equipment, welding and trailers at the Dinosaur Point boat launch area. Power would be provided by portable generators.

C.2.3 Construction Methods

C.2.3.1 Intake Structure

The new intake structure would be constructed on shore in 10-foot segments. The segments would be transported to the permanent intake location on a barge and then lowered into the reservoir using a crane. Intake segments would be stacked on top of each other to achieve the full intake height, and welded by divers to join and seal the segments.

Tunnel Option

For the tunnel option, the intake structure would be approximately 46 feet long, spanning from the intake elevation of 296 feet to the bottom of the tunnel at 250 feet.

The material volume generated by excavation for the intake structure under the tunnel option would be approximately 49,000 cubic yards. This material would be disposed of at Dinosaur Point if allowed.

Pipeline Option

The intake structure would be shorter for the underwater pipeline option than the tunnel option since it would only need to span between the intake elevation of 296 feet to the bottom of the reservoir at approximately 280 feet. The final connection to the underwater pipeline would be made by divers.

Dredges would be used to modify the existing intake channel which would serve as a trench for the underwater pipeline. Minimal dredging is expected, since the existing channel is at an approximate elevation of 313 feet. Approximately 9,000 cubic yards of spoils would be generated by the pipeline option. This material would be disposed of by distribution along the bottom of the reservoir.

C.2.3.2 Intake Extension

Tunnel Construction

Based on the anticipated alluvial and the potential for Pacheco formation soil materials, and the need to tunnel beneath the groundwater level, the tunnel would be constructed using an Earth Pressure Balance Tunnel Boring Machine (TBM). The TBM would be transported to Gate Shaft Island via a barge and lowered into the access shaft with a crane. Material would be excavated at the front of the TBM and a precast concrete lining would be installed behind the cutting head of the TBM. The lining would function as initial support as well as the permanent liner. This method is known as the one-pass system. No intermediate tunnel access shafts would be possible because work would be conducted below the bottom of the reservoir. Therefore, all TBM repairs and cutter replacement procedures would need to be performed from within the tunnel. Dewatering and blasting during construction would not be necessary. Hazardous materials are not expected to be encountered.

The tunnel option would require that the TBM be removed at the proposed lower intake location within the reservoir. A temporary coffer dam-style structure would be constructed within the reservoir for removing the TBM, and aiding in the tunnel connection to the new intake structure. The temporary coffer dam structure would be larger than the new intake structure, and would isolate the new intake while the tunnel connection is made. Alternatively, the TBM could be stripped of any fuels, oils, and salvageable components and abandoned in place, and the intake structure connection could be made by divers.

Pipeline Construction

Dredges would be used to modify the existing intake channel which would serve as a trench for the underwater pipeline. Minimal dredging is expected, since the existing channel is at an approximate elevation of 313 feet. Pipe segments of 50-foot lengths would be transported by tug boats from the staging area to a barge, then lowered into the reservoir with a crane. Connection of pipe segments would be made by divers. Pipeline installation would occur in water up to 265 feet deep in some areas, which would require professional divers with specialized technical deep dive certifications and deep water equipment. The availability of qualified divers in the project vicinity may be limited. The use of divers could be reduced if construction occurs during a period where the reservoir is low because of a drought cycle. However, construction would not cause any changes to the CVP or SWP operations in the reservoir. To prevent any pipeline shifting or buoyancy issues, it would be anchored with precast concrete saddles. Spacing and sizing would be determined during future design tasks.

C.2.3.3 Access Shaft and Coffer Dams

Construction of a new permanent access shaft on Gate Shaft Island would only be necessary for the tunnel option. Construction of temporary coffer dam structures is anticipated for both the tunnel and pipeline options in order to complete intake connections within the reservoir.

Tunnel Option

For the tunnel option, a permanent shaft would be assembled at Gate Shaft Island to function as a launch point for the TBM. To control groundwater conditions and improve subsurface working conditions during excavation of the shaft, ground freezing would be utilized during excavation. A temporary coffer dam-style structure would be constructed within the reservoir for removing the TBM, and aiding in the tunnel connection to the new intake structure.

Pipeline Option

For the pipeline option, a temporary coffer dam-style structure would be constructed around the existing lower intake structure to allow for connection of the new intake pipeline. Depending on the reservoir water level, either the upper intake or both intakes would need to be isolated. Steel segments would be used to create the coffer dam to isolate the work area around the existing intake structure. The coffer dam would be removed after the tie-in is complete.

C.2.4 Operation of the Lower San Felipe Intake Alternative Plan

The Lower San Felipe Intake Alternative Plan would allow the San Felipe Division to draw water from San Luis Reservoir at the same elevation as the Gianelli Intake, which serves other CVP south-of-Delta contractors.

Installation of the new lower intake structure at elevation 296 feet, and accounting for the same 35-foot deep algae growth layer at the surface of the reservoir, will allow a new low water elevation for the reservoir of 331 feet. This elevation coincides with the maximum potential drawdown elevation available by the Pacheco Pumping Plant. The minimum drawdown elevation allowed by the existing vertical pumps and intake shafts (325 feet) plus the anticipated head loss through the new 20,000-foot long intake tunnel or pipeline (anticipated to be approximately 6 feet) also allows a minimum low water elevation of 331 feet.

C.2.4.1 Water Deliveries

The Lower San Felipe Intake Alternative Plan would provide approximately 1,600 acre-feet (AF) of additional water supply on an average annual basis compared to the No Action/No Project Alternative. Figure C-4 shows how the Lower San Felipe Intake Alternative Plan addresses the shortages in the No Action/No Project Alternative. Results show that the Lower Intake Alternative Plan would fully replace interrupted supplies in all low point years. Appendix B includes more information about the hydrologic modeling methods and results.

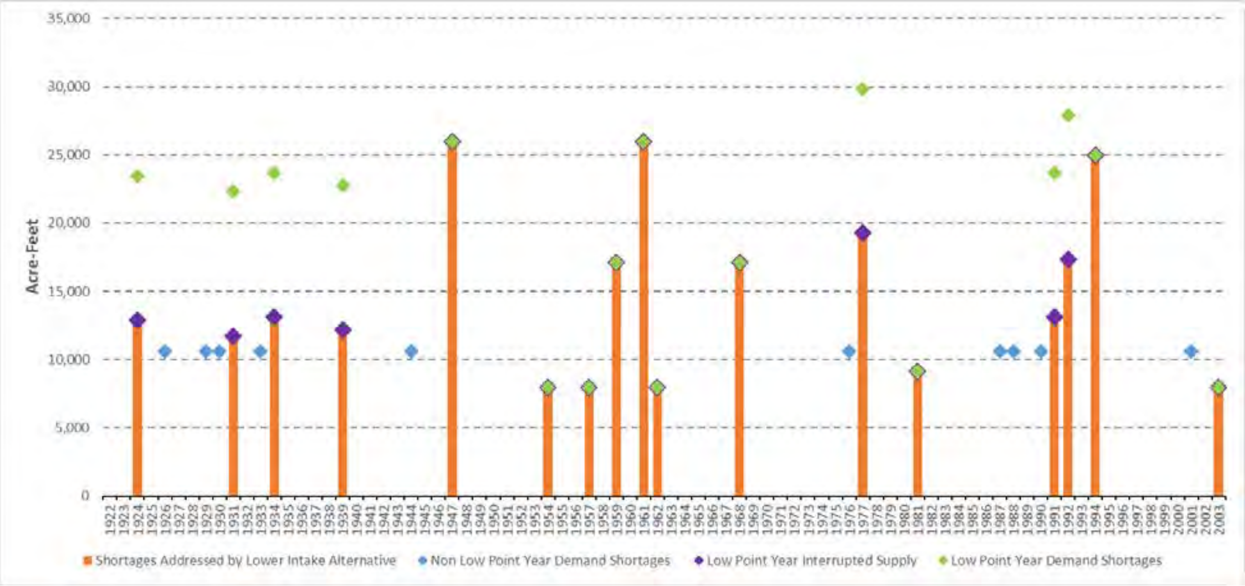

Figure C-4. Annual Shortages Addressed by the Lower San Felipe Intake Alternative Plan

C.3 Treatment Alternative Plan

The Treatment Alternative Plan would develop new technology retrofits at the SCVWD's Santa Teresa WTP. The Santa Teresa WTP is supplied with water from San Luis Reservoir, which during low point conditions can contain high concentrations of algae.

Challenges associated with high concentrations of algae in raw water include both treatment capacity limitations and water quality challenges. Treatment challenges include operational requirements to quickly optimize coagulation and clarification to reduce filter clogging and solids breakthrough into the treated water. These efforts to reduce filter clogging seek to avoid reductions in WTP filter run times. Water quality challenges include: 1) taste and odor control, 2) total organic carbon removal, and 3) algal toxin removal if toxin-producing species are present.

The Treatment Alternative Plan would develop new treatment technology at the SCVWD WTP to address some of the negative impacts associated with increased algae during low point events. The proposed improvements evaluated under this alternative would include: retrofitting the existing flocculation and sedimentation basins with DAF or ballasted clarification. This would result in the following treatment process (new processes are underlined): chemical coagulation, <u>ballasted clarification</u>, settled water ozonation, granular media filtration with a GAC/sand media configuration, and disinfection.

C.3.1 Project Facilities

As noted above the Treatment Alternative Plan would develop new treatment technology retrofits at the SCVWD WTP to improve the WTPs ability to treat water from San Luis Reservoir during low point conditions. This section outlines the existing treatment facilities at the WTP and the new facilities that would be developed under this alternative.

The existing Santa Teresa WTP treatment process includes chemical coagulation, conventional clarification, settled water ozonation, granular media filtration, and disinfection.

Chemical coagulation includes the addition of alum, a cationic polymer, and the ability to add chlorine or chloramines as a pre-oxidant. The conventional clarification process includes pump water injection for rapid mixing, 3-stage tapered mixing for flocculation, and rectangular basins for gravity sedimentation. The sedimentation basins utilize chain and flight mechanisms to remove settled solids. Ozonation includes liquid oxygen, ozone generators and 8-cell ozone contactor structures to provide a maximum ozone dose of 2 mg/L. Hydrogen peroxide can be dosed at concentrations up to 1.5 mg/L to improve oxidation of taste and odor causing compounds. Filtration includes 12 granular media filters with 48 inches of GAC over 10 inches of sand. The filters operate at loading rates of 6.0 to 7.2 gpm/square foot and are cleaned using both an air and water backwash. Disinfection includes free chlorine contact time and chloramine formation for disinfectant residual.

Solids handling facilities include washwater recovery basins and sludge drying beds. The recovered washwater is returned to the headworks of the plant. The recovered decant water from the sludge drying beds is returned to the washwater recovery basins, and the dried sludge is disposed of in a landfill. The use of ballasted clarification would increase the amount of solids for disposal.

The Treatment Alternative Plan would use ballasted clarification in place of the existing conventional clarification. The WTP site layout is shown in Figure C-5.

C.3.1.1 Ballasted Clarification

Ballasted clarification is a process designed to improve gravity settling of material that typically does not settle quickly by gravity alone. Ballasted clarification uses microsand particles to improve gravity settling of suspended solids and buoyant material. Coagulant chemicals and cationic polymers are added to bind the microsand to the material and is aided by the addition of pre-oxidants. Ballasted clarification has been shown to be efficient to remove both algae cells and suspended solids from algae-laden water at several existing facilities in the United States; however, there is a limited track record for State and Federal project water in California. Pilot testing of this treatment technology on SCVWD raw water is recommended as a future step under this alternative.

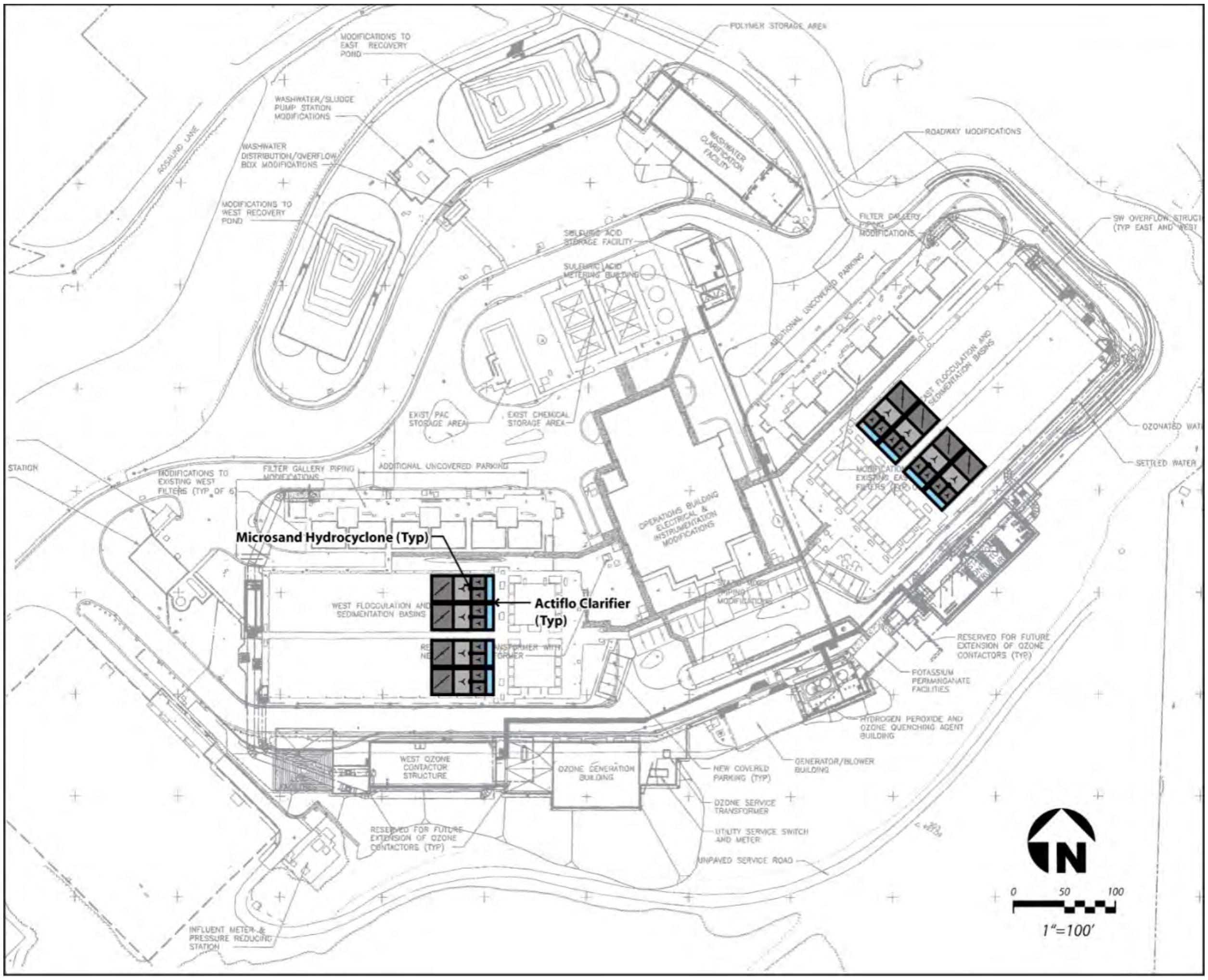

Figure C-5. Santa Teresa WTP Conceptual Site Plan – Ballasted Clarification Retrofit

C.3.1.2 Ozone

Ozone oxidizes taste and odor causing compounds and other dissolved organic material released by algae. The addition of hydrogen peroxide improves the oxidation of these constituents. Ozone also improves clarification and filtration processes when used as a pre-oxidant. For this analysis, settled water ozone (i.e., ozone following the clarification process) was assumed over raw water ozone (i.e., ozone before clarification) because: 1) settled water ozone is currently implemented at the SCVWD Santa Teresa and Penitencia WTPs; and 2) settled water ozone reduces the formation of bromate (a regulated disinfection byproduct) when compared to raw water ozone.

C.3.1.3 GAC/Sand Filtration

GAC filter media provides enhanced removal of taste and odor causing compounds, especially after oxidation with ozone. It also improves overall organics removal, which has additional benefits such as reducing the disinfection byproduct formation potential in the treated water.

C.3.2 Construction Methods

Construction of the Treatment Alternative Plan retrofits at the SCVWD WTP would be completed in compliance with existing SCVWD design standards.

Retrofitting the existing conventional clarification at the Santa Teresa WTP with ballasted clarification would require conversion of the existing sedimentation basins in phases to minimize the need for plant shutdowns. Conversion to ballasted clarification would require the construction of new concrete walls at the existing sedimentation basins to increase their height by eight feet and the installation of ballasted clarifier equipment. The existing ozone system at the WTP would not need to be modified to support this new treatment technology.

C.3.3 Operation of the Treatment Alternative Plan

The Treatment Alternative Plan would leave current SCVWD operations largely unchanged with the exception of periods with low point conditions in San Luis Reservoir (typically August and September) when SCVWD operators would be able to continue to take delivery of water supply from the reservoir while maintaining WTP performance.

C.3.3.1 Water Deliveries

The Treatment Alternative Plan would provide additional water supply to meet SCVWD treated water demands. Figure C-4 shows how the Lower San Felipe Intake Alternative Plan addresses shortages in the No Action Alternative. The additional water supply under the Treatment Alternative Plan would be the same as the Lower San Felipe Intake Alternative Plan. Results show that the Treatment Alternative Plan would fully replace interrupted supplies in all low point years.

C.4 San Luis Reservoir Expansion Alternative Plan

The San Luis Reservoir Expansion Alternative Plan would implement an expansion of San Luis Reservoir. This alternative would increase storage capacity in San Luis Reservoir which would which would be allocated would to the CVP only.

The expansion of San Luis Reservoir would be completed by placing additional fill material on the dam embankment to raise the dam crest to increase storage capacity. The alternative would build upon the dam embankment expansion and foundation modifications to address the seismic concerns. The seismic modifications to B.F. Sisk Dam under Reclamation’s Safety of Dams (SOD) Act, as amended, that the San Luis Reservoir Expansion Alternative would build on are included in this alternative as a connected action as defined under NEPA. The expanded capacity in San Luis Reservoir would be shared between the CVP and SWP consistent with the existing storage capacity allotment in San Luis Reservoir.

Increasing storage capacity in San Luis Reservoir would potentially increase the yield of the CVP, in years that surplus supplies in excess of the reservoir’s existing storage capacity are available. This increased yield could increase SCVWD’s capacity to access their CVP supply prior to the reservoir being drawn below the 300 TAF level and then with the addition of retrofits to the Santa Teresa WTP allow the District to avoid the potential for a water supply interruption from low point conditions.

As part of this alternative, the dam crest would be raised by adding additional embankment material (see Figure C-6 for a schematic), stability berms and downstream crack filters would be installed. Construction of foundation shear keys at slopewash sections in the abutments and the north valley section (NVS), and a filter around the downstream portion of the existing spillway conduit are also included in this alternative. The existing saddle dike located north of the main embankment would be modified by adding a downstream filter. In addition to these modifications, development of a foundation shear key at the south valley section (SVS) is under consideration as an optional additional feature of this alternative. With increased reservoir surface elevations, modifications would also be made at multiple locations along SR 152 to prevent inundation of the roadway when the enlarged reservoir is filled to capacity, and modifications to the Dinosaur Point Boat Launch and the Goosehead Point Boat Launch would be made to increase the ramps operating elevation by 10 feet. The existing berm developed during construction of the Pacheco Pumping Plant would be reconstructed with a higher crest elevation to protect the plant at high storage levels (see Figure C-7).

C.4.1 Project Facilities

As noted above the reservoir expansion alternative plan would expand storage in San Luis Reservoir to increase the yield of the CVP and the SWP, by supporting in some years when conditions permit, increases in south of Delta exports. This section outlines the physical modifications that would that would be developed under this alternative plan. Additional engineering and design details can be found in Attachment A, that presents the 2013 B.F. Sisk Dam – Increased Storage Alternatives, Appraisal-Level Study.

C.4.1.1 B.F. Sisk Dam

B.F. Sisk Dam is a zoned earthfill structure with a maximum structural height of 382 feet, a crest length of 18,600 feet, a crest width of 30 feet, and a crest elevation of 556 feet. The dam embankment was constructed of five materials in seven zones, with the central zone consisting primarily of low-plasticity clays. The downstream face of the dam is covered by a 2-foot-thick cobble blanket, and the upstream face is covered by a 3-foot-thick layer of riprap. Both thickness measurements are normal to the dam slope. A saddle dike is present along the north rim of the reservoir, approximately 1,300 feet from the dam.

The foundation that the dam is built on can be divided into sections: the right abutment, the left abutment, the north valley section, and the south valley section (See Figures C-6 and C-8). The north and south valley sections are the alluvial channel of Cottonwood Creek that B.F. Sisk Dam impounds and consist of deposits of sands and gravels with clayey or silty fines. The abutments are primarily founded on bedrock, which is covered by clayey slopewash in some locations.

Studies completed during the Corrective Action Study (CAS) have identified the potential for significant deformation (crest settlement) of the dam in the sections built on the alluvium and clayey slopewash during a seismic event (Reclamation 2013). The SOD seismic modification will address this deformation potential with the placement of downstream stability berms anchored to bedrock and placement of additional embankment materials on the downstream slope of the dam to increase the crest elevation 10 feet, increasing the distance between the water surface and the dam crest (freeboard) to prevent reservoir overtopping and failure in the event of earthquake-induced deformations (Reclamation 2013).

In addition to dam crest deformation, seismic shaking can cause cracks in the dam embankment susceptible to erosion that can lead to dam failure. Downstream crack filters restrict the migration of soil materials through these cracks mitigating the potential for post seismic cracks to induce internal erosion within the dam embankment. The SOD modification will address this seismic crack induced erosion risk by installing downstream filters along the upper portion of the embankment across the entire length of the dam.

Evaluation of the seismic shaking potential at B.F. Sisk Dam has identified the potential need for additional modification to the foundation soils beneath the SVS berm. The development of a foundation shear key is being evaluated as an optional modification in the San Luis Expansion Alternative Plan. A foundation shear key is developed by removing the weak overburden foundation soils found beneath the berm footprint and replacing them with material with a higher shear strength.

The San Luis Expansion Alternative Plan would build on the physical SOD modifications currently under final design and raise the dam crest an additional 10 feet to a new crest elevation of 576 feet. This additional 10 feet in embankment height would support a new water surface elevation of 554 feet and an additional 120 TAF in storage capacity. In addition to the new embankment height added by the reservoir enlargement the existing outlet works intake towers, access bridge, and spillway intake would need to be raised by 10 feet.

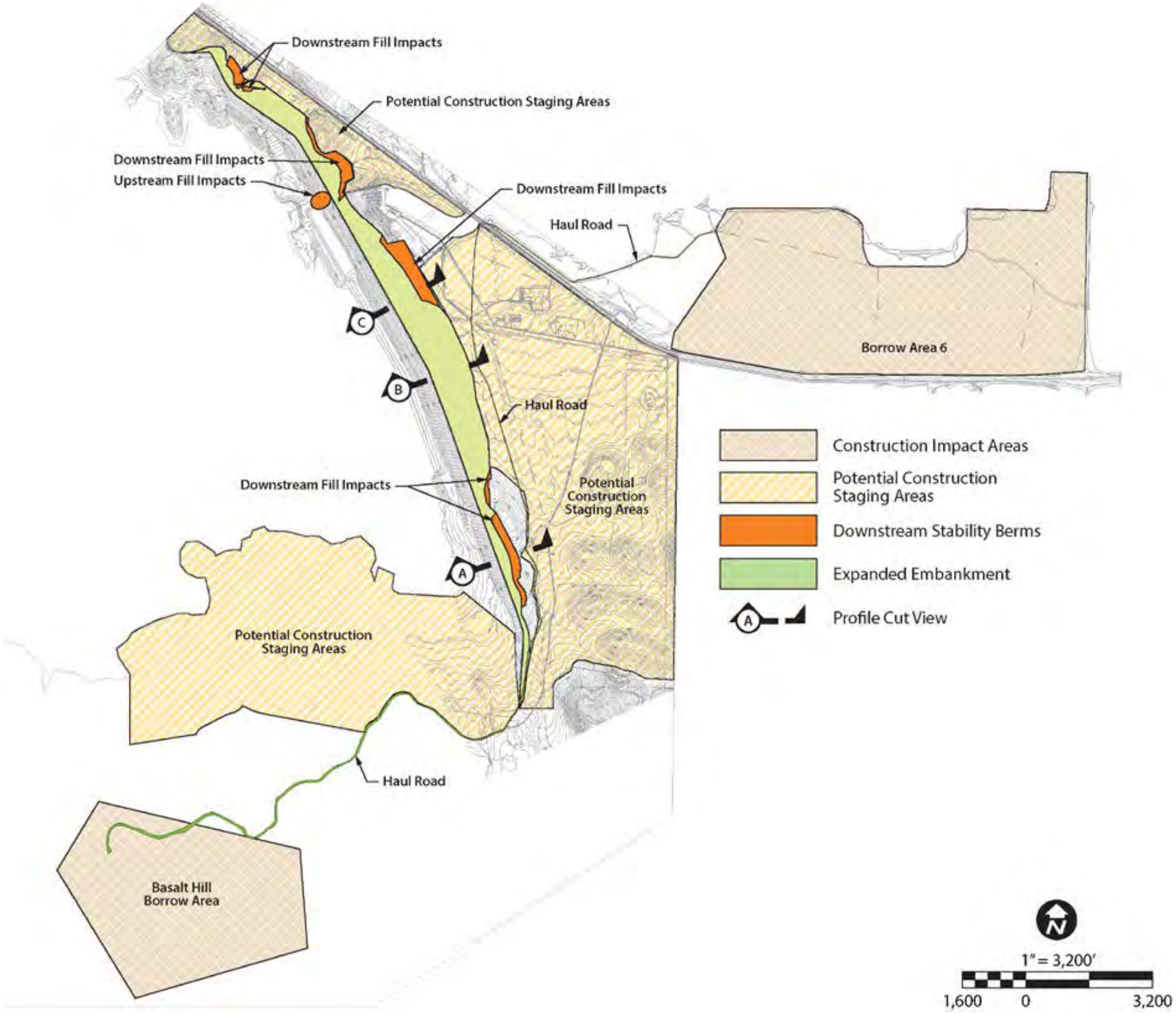

Figure C-6. Reservoir Enlargement Construction and Staging Areas

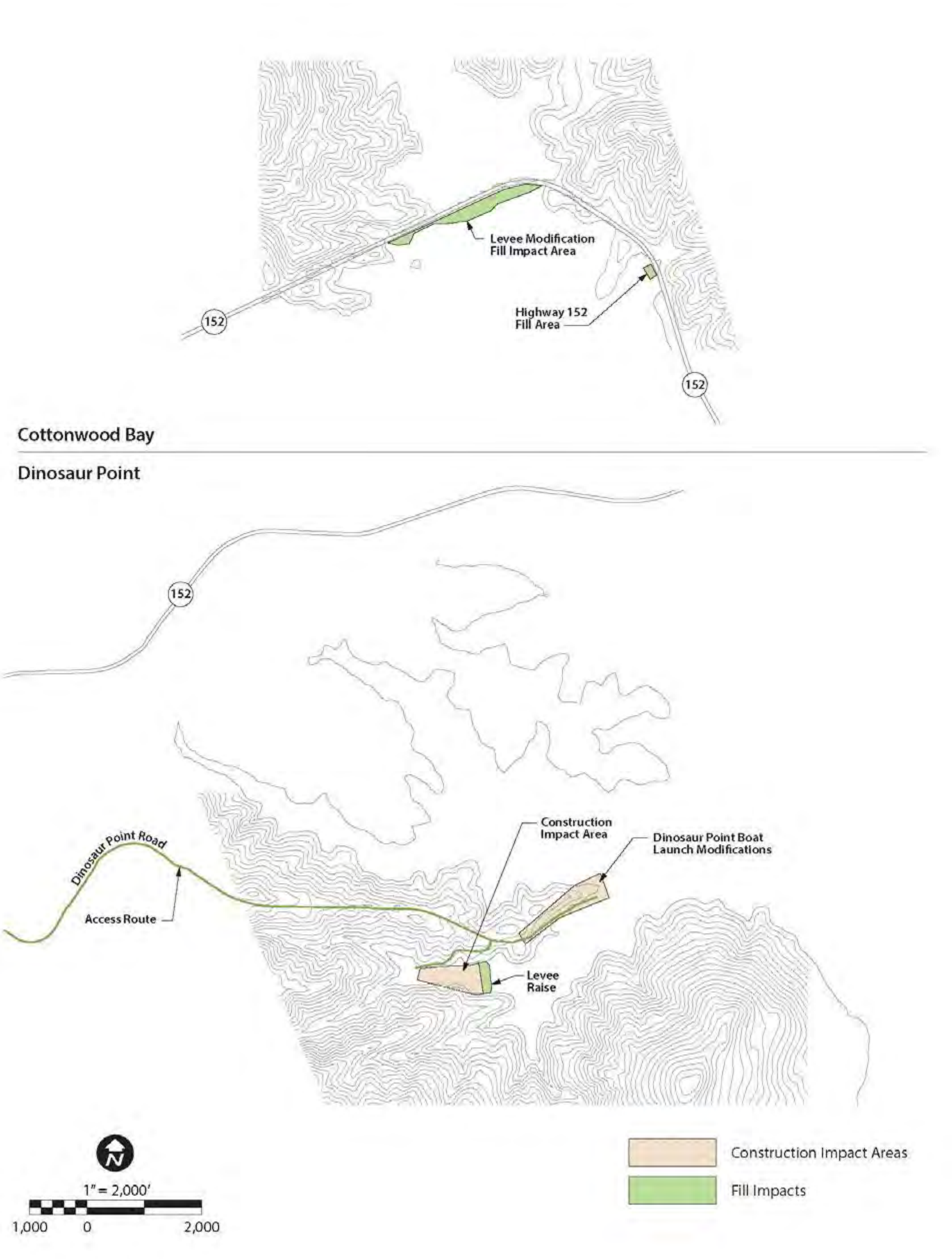

Figure C-7. Reservoir Enlargement Actions along Highway 152 and at Pacheco Pumping Plant

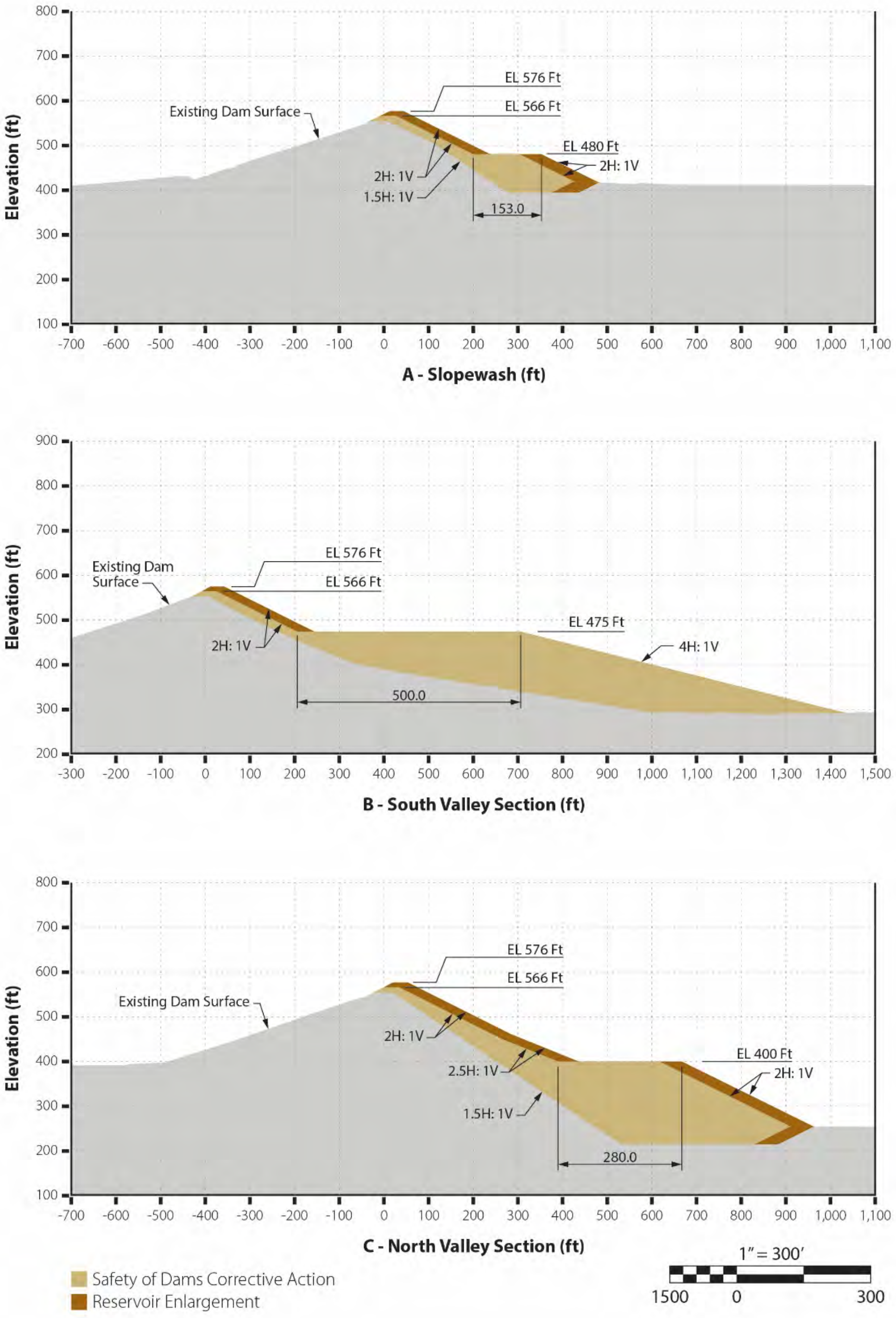

Figure C-8. Reservoir Enlargement Profiles

This work on the reservoir embankment would be timed seasonally to allow for any actions that would reduce embankment strength to occur during periods of the year when the reservoir is drawn down to lower elevations. This work would also be scheduled for completion each year prior to the refill of San Luis Reservoir back above safe levels to protect embankments strength. This could result in delays to refill if the construction schedule is delayed, but the division of specific modification actions scheduled to occur in one drawdown season would be structured to minimize this risk. Implementation of the optional SVS shear key action would require limits on the maximum surface elevation in San Luis Reservoir for two seasons, during the period that the berm foundation would be excavated. This reduction in surface elevation would reduce storage capacity in the reservoir and could limit CVP and SWP deliveries during this construction period.

C.4.1.2 Cottonwood Bay/Highway 152

Sections of Highway 152 near and at Cottonwood Bay could potentially be affected by the 10-foot increase in water surface elevation will be protected by the development of berms separating the reservoir from the roadway in periods when storage in the enlarged reservoir is full (see Figure C-7).

C.4.1.3 Pacheco Pumping Plant West Dike

The Pacheco Pumping Plant is located on the western side of San Luis Reservoir. The pumping plant separated from San Luis Reservoir by an approximately 500-foot wide dike east of the pumping plant (see Figure C-7). This dike will be replaced with a new dike 22 feet taller than the existing structure to protect the pumping plant from the enlarged reservoir

C.4.1.4 Dinosaur Point Boat Launch

The Dinosaur Point Boat Launch is located on the western side of San Luis Reservoir close to the Pacheco Pumping Plant. The boat ramp and portions of the parking lot at Dinosaur Point would be inundated with the 10-foot surface elevation increase requiring modifications to the facility to maintain launching functions during periods when the enlarged reservoir is at capacity (see Figure C-7).

C.4.1.5 Goosehead Point Boat Launch

The Goosehead Point Boat Launch is located on the southern side of San Luis Reservoir close to Basalt Hill. The boat ramp and parking lot at Goosehead Point would be inundated with the 10-foot increase in reservoir surface elevation requiring modifications to the facility to maintain launching functions during periods when the enlarged reservoir is at capacity.

C.4.2 Operation of the Reservoir Enlargement Alternative Plan

The San Luis Reservoir Expansion Alternative Plan would provide approximately 15,200 of additional south of Delta CVP M&I and agricultural water supply on an average annual basis compared to No Action. Figure C-9 shows how the San Luis Reservoir Expansion Alternative Plan addresses

SCVWD low point water supply interruptions in the No Action Alternative. Results show that the San Luis Reservoir Expansion Alternative Plan would deliver additional water supplies in 8 of the 17 low point years, but would not in any year fully address the low point generated water supply shortages.

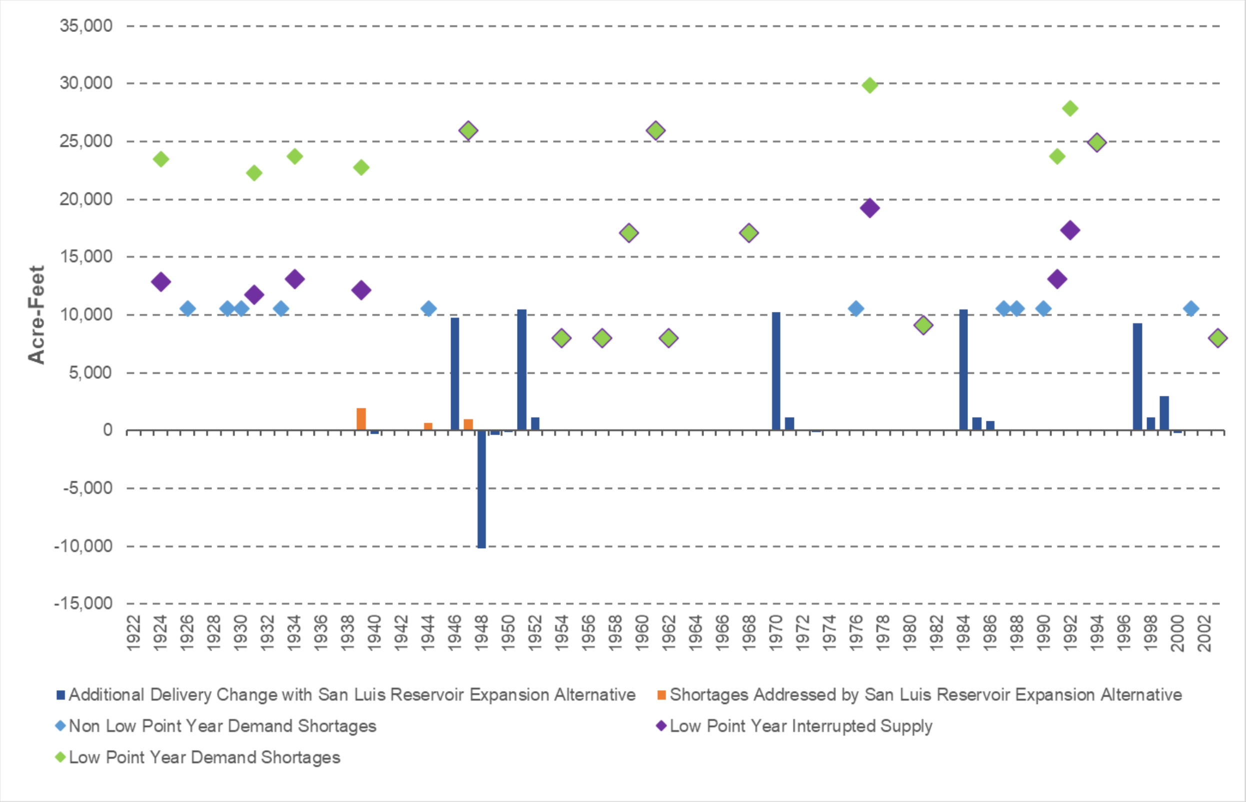

Figure C-9. Annual Shortages Addressed by the San Luis Reservoir Expansion Alternative Plan

C.4.3 Construction Methods

The shear keys and downstream stability berms would be constructed by first excavating the existing liquefiable and soft foundation soils. The rock blanket or slope protection would also be removed to the top elevation of the embankment and stockpiled downstream of the toe. Next, the existing toe drain would be removed by excavation. After completion of the excavations, the existing filters/drains located at the downstream toe would be re-established and a new toe drain seepage collection system would be installed, similar to the one currently in place. Stronger material would then be placed as backfill and compacted. At 480 feet, a two-stage downstream crack filter would be constructed. Above an elevation of 550 feet, the raised crest would be developed by simultaneously placing riprap and bedding, core, a two-stage chimney filter and the downstream shell. Materials used would be stockpiled downstream of the toe and in Borrow Area 6. After fill placement is completed, road base and paving of the dam crest complete the overlay raise.

Equipment in the staging areas would include trailers, equipment to be used, and stockpiled materials. Construction staging and stockpile areas would include area south of Gianelli Pumping Plant off of Basalt Road, area north of Gianelli Pumping Plant off of Gonzaga Road, and Dinosaur Point. The access route to the two main staging areas would be SR 152 to Basalt Road. Up to 240 large deliveries or waste material transports offsite per day could be expected, the transport and disposal of material to local landfills, along with the regular commuting of construction personnel.

Aside from areas dedicated to construction staging and transportation, all remaining available space at the areas next to B.F. Sisk Dam would be needed for stockpiling materials. These areas around the dam would be used as a staging area of the full duration of construction. These areas would be returned to pre-construction condition after the project is completed.

Recreational activities would be suspended for safety reasons during the entire construction schedule at Basalt Area and Medeiros Area, and during active construction at Dinosaur Point (approximately 1 year). Recreational use for boating would be suspended for the full year that both the Basalt and Dinosaur Point Areas are closed and would be limited to areas away from B.F. Sisk Dam for the full construction schedule. The closed Basalt Campground would be utilized as a temporary camping area for construction workers.

Final design of the dam raise will include the development of a construction schedule that times the completion work in the direct path of potential flood flows or on infrastructure specifically designed to direct flood flows to occur in periods of the year when rain is unlikely and reservoir levels are lower. In addition, the contractor would be required to develop a health and safety plan that includes a response plan to flood forecasts that would require the suspension of construction activities and the movement of construction equipment to higher ground.

Construction is expected to last approximately 8 to 10 years. With the addition of the SVS shear key option, construction is expected to last approximately 10 to 12 years. Both with and without the SVS shear key option, construction duration is based on 130 anticipated workers on site during the day shift and 87 workers on site during the night shift. Work would be performed 24 hours per day, seven days per week, 12 months per year. The 24 hour work day would consist of two 10 hour work shifts, with a half hour for lunch each shift, plus a 3 hour maintenance period. Blasting operations at Basalt Hill would be limited to the hours between 6:00 a.m. to 8:00 p.m.

This 8 to 12 year construction schedule is based on the assumption of no funding constraints and is used to analyze the impacts in this EIS/EIR. However, with potential funding constraints, the construction schedule could extend up to 20 years.

C.4.4 Equipment and Staging

Equipment in the staging areas would include trailers, equipment to be used, and stockpiled materials. Construction staging and stockpile areas would include:

- Area south of Gianelli Pumping Plant off of Basalt Road, for the staging of construction equipment, fill materials transported from the borrow sites, embankment materials excavated and stored for later use and materials transported form offsite. The area proposed for use consists of approximately 1,000 acres.
- Area north of Gianelli Pumping Plant off of Gonzaga Road for the staging of construction equipment, fill materials transported from the borrow sites, embankment materials excavated and stored for later use and materials transported form offsite. The area proposed for use consists of approximately 120 acres.
- Dinosaur Point for the staging of construction equipment for both the Pacheco Pumping Plant West Dike replacement and Dinosaur Point Boat Launch modifications. The area proposed for use consists of approximately 28 acres.

The access route to the two main staging areas would be SR 152 to Basalt Road. Most of the traffic to the site would come from the east. Construction related traffic would likely begin one to two months after Notice to Proceed. Up to 240 large deliveries or waste material transports offsite per day could be expected, the transport and disposal of material to local landfills, along with the regular commuting of construction personnel.

Aside from areas dedicated to construction staging and transportation, all remaining available space at the areas next to B.F. Sisk Dam would be needed for stockpiling materials. These areas around the dam would be used as a staging area of the full duration of construction. These areas would be returned to pre-construction condition after the project is completed.

Equipment used to construct the alternative would include:

- 2 Excavators
- 3 Bulldozers
- 1 Grader
- 13 Dump trucks
- 3 Water trucks

C.5 Pacheco Reservoir Expansion Alternative Plan

The Pacheco Reservoir Expansion Alternative includes construction and operation of a new dam and reservoir, pump station, conveyance facilities, and related miscellaneous infrastructure. The new dam and reservoir would be constructed on Pacheco Creek 0.5 mile upstream from the existing North Fork Dam and would inundate most of the existing Pacheco Reservoir. The proposed total storage for the expanded reservoir is 141,600 AF, with an active storage of 140,800 AF. The full pool elevation would be 694 feet and would inundate an additional 1,245 acres, for a total of 1,385 total acres inundated. Water would be collected in the expanded reservoir during the winter months from runoff from the local watershed area, and diversion of CVP supplies from Pacheco Pipeline, when needed.

C.5.1 Pacheco Reservoir Expansion Project Facilities

The Pacheco Reservoir Expansion Alternative Plan would include the removal of the existing dam, expansion of the reservoir, a new earthen dam and spillway, new pipelines and tunnels, a new pump station, and associated channel modifications, a new regulating tank at Pacheco Pumping Plant, and access improvements. Exhibits 1 through 12 in Attachment B show proposed project component layouts, borrow areas, and construction access and staging areas from SCVWD’s application for funding under the Proposition 1 Water Storage Investment Program.

C.5.1.1 Dam and Spillway

The new embankment dam would be a zoned earthfill structure consisting of an impervious core, flanked by an outer shell of compatible fill. A system of filters and drains would be provided to control seepage through the dam and foundation. A downstream sand chimney filter would protect the impervious core. A gravel chimney drain located downstream of the chimney filter would convey drainage to a gravel blanket beneath the downstream compatible fill zone. The gravel blanket drain would convey seepage from the impervious core and overlie form the foundation beneath the downstream compatible fill zone to the downstream toe of the dam. Sand filter zones would be placed above and beneath the gravel blanket drain to protect the gravel drain from contamination of the overlying compatible fill and underlying foundation materials. The upstream slope of dam would be protected from reservoir wave action by a 3-foot thick riprap layer.

An uncontrolled side channel spillway with a trapezoidal cross section would be located adjacent to the right (west) abutment of the proposed dam. Due to the relatively steep topography at the dam site, a side channel spillway would reduce the amount of excavation required in order to accommodate the spillway control weir. The spillway features include an approach channel, discharge chute and stilling basin, all of reinforced concrete and founded on bedrock. The side channel spillway entrance would include an ogee weir. A flip bucket located at the end of the stilling basin would dissipate the remaining energy in the basin during high discharge events. After leaving the deflector bucket, spillway discharges would be conveyed through a riprap lined outlet channel into the restored Pacheco Creek channel (see below description).

Current uncertainty related to the level of detail in the information available for use in the description of this alternative plan at an appraisal level of design could result in substantial changes to the configuration of this alternative design as additional geologic and geotechnical information is gathered in support of a future feasibility level design.

C.5.1.2 Inlet/Outlet Facilities

The inlet/outlet facilities would consist of a sloping intake/outlet structure and a low-level inlet/outlet designed to provide deliveries to the reservoir from Pacheco Conduit and withdrawals from the reservoir to the conduit and Pacheco Creek. However, these facilities would not be operated to facilitate these flows at the same time. For withdrawals from the reservoir, under normal operating conditions, this inlet/outlet facility would need to simultaneously convey up 490 cubic feet per second (cfs) to Pacheco Conduit and release up to 35 cfs to Pacheco Creek. The inlet/outlet conveyance facilities have been sized to accommodate up to 1,350 cfs under emergency drawdown conditions. During emergency conditions, the outlet works would serve as an evacuation outlet for reservoir draw down.

A sloping intake structure would be located north of the left (east) abutment and would consist of a single 132-inch diameter reinforced-concrete structure, with approximately 10 ports located at various elevations for drawing from the reservoir. A low-level reservoir inlet would also be constructed, with an inlet elevation of 450 feet, for reservoir drainage. A hydraulically operated gate valve structure would be located upstream of the reinforced-concrete sloping intake to allow for switching between reservoir delivery (through the tunnel) and withdrawal operations (through the outlet structure).

A 2,300-foot long conveyance tunnel would be constructed under the dam abutment to connect the intake structures and the pump station. The conveyance tunnel would be excavated through the bedrock on the left abutment of the dam. The control gatehouse structure would be used to regulate outlet flows from the reservoir to the pump station, for normal releases, and the discharge channel for stream augmentation and emergency releases.

To connect the new outlet works to Pacheco Creek, the historical Pacheco Creek channel would be restored between the new dam and the existing dam through the existing Pacheco Reservoir. Restoration of the channel would include excavating a new 1,500-feet long, 1.7-feet deep, one-foot wide, low-flow channel, and a 6-feet deep, 20-feet wide overbank channel to facilitate riparian restoration. The channel would be designed to reduce streambank erosion (e.g., using bank stabilizing materials), and riparian vegetation would be planted to initiate growth of a new riparian forest along the restored channel.

C.5.1.3 Pacheco Reservoir Pump Station

The Pacheco Reservoir Pump Station would serve as a two-way pump station that both delivers water to and withdraws water from the Pacheco Reservoir. The water surface elevation of the expanded reservoir would have an operating range of 450 feet to 694 feet; however, at the connection point to the Pacheco Conduit the total hydraulic head would be 610 feet. This requires a “two-way” system operating both by gravity and through a booster pump station.

The conveyance system would contain 10 feet of dynamic head loss that is included in the scenarios above. Isolation valves would enable the pump station to deliver water to, or pump water from, the reservoir. Pressure-reducing sleeve valves were identified as necessary to reduce excess pressure head under certain gravity-flow conditions. These valves would be used only when needed and bypassed at all other times. Additionally, pressure relief valves and discharge structures would be required to prevent over-pressurization of the existing Pacheco Conduit.

The pump station would be below the new dam. To provide security and minimize noise levels in the surrounding area, the pumps would be housed in a building. Space has been identified for other facilities on site, including intake, access, parking, surge tanks, power substation, yard piping, and construction staging.

The new pump station would need to meet a wide range of lift (0 to 160 feet static plus 10 feet dynamic) and high flow (490 cfs). A single pump station with multiple pump ranges has been proposed to meet these requirements—while preventing pump station horsepower (hp) duplication—limiting the amount of head burned by pump control valves and minimizing cost. A total of 11 pumps (10 duty plus 1 standby) are planned, however the pump configuration may be refined during future design studies. The pump motors would be sized for the first operating range (higher lift) at 1,250 hp each (13,750 total hp).

The 14 megavolt amp (MVA) substation for the new reservoir pump station is located in the Pacific Gas and Electric Company (PG&E) service area, with no other nearby service sources. PG&E has a 70 kilovolt (kV) transmission line that cannot support the additional 14 MVA connected load, and it would need to be upgraded to support the increased load. The existing 70 kV transmission line would be upgraded to two circuits, for use by the double-ended substation arrangement for this alternative.

C.5.1.4 Conveyance from Pacheco Reservoir Pump Station to Pacheco Conduit

A pipeline would be constructed to connect the new pump station located immediately downstream of the new dam and the existing Pacheco Conduit. The proposed pipeline would be 9 feet in diameter and about 4,700 feet long, with a design capacity of 490 cfs. This pipeline would allow for delivery of imported water from the Pacheco Conduit to the proposed reservoir for future release and would also provide for reservoir releases to the Pacheco Conduit.

Construction would be by conventional excavation, open trench, and backfill—except for the length of pipe located under SR 152. The length of pipe that would be located under SR 152 and Pacheco Creek would be installed using bore and jack techniques (i.e., tunneling techniques), to minimize impacts during construction. Spoils would be hauled off and disposed of at a suitable location. The tunnel, when completed, would be a 132-inch casing containing a 108-inch carrier pipe. There would also be permanent structures for appurtenances, such as air/vacuum valves, vaults, drains and blowoffs for the conveyance line.

The connection of the pipeline to the existing Pacheco Conduit would be southeast of the existing North Fork Dam. The connection would be with a tee in the Pacheco Conduit, with an isolation valve for the turnout (inlet and outlet) for the expanded reservoir.

C.5.1.5 New Regulating Tank at Existing Pacheco Pumping Plant

Controls to turn pumps on or off remotely would be based on the water level within the expanded Pacheco Reservoir and regulating tanks at the existing Pacheco Pumping Plant site near San Luis Reservoir. A second regulating tank at the existing Pacheco Pumping Plant site would be added adjacent to the existing regulating tank to provide additional control buffer and surge control for the new Pacheco Reservoir Pump Station. The new regulating tank would match the elevation, diameter, and materials of the existing tank. This would add a second 10 AF, 150-feet diameter reservoir. Additional piping, valving, and controls would be required.

C.5.2 Project Construction

The environmental compliance, design, permitting, land acquisition, and financial and institutional arrangements are anticipated to be completed in 2023. Major construction is anticipated to take approximately five years from 2024 to 2028 with commissioning of system completed in late 2028. Miscellaneous improvements, such as road repairs, would continue through 2029.

C.5.2.1 Borrow Areas

Preparation of borrow areas would include the reservoir borrow areas, the spillway area, and the existing dam site prior to its removal. Preparation would include logging, stripping and disposal of topsoil, and implementation of any associated work access or material processing areas. It is assumed that the material processing areas could include a crushing and screening plant at the filter and drain borrow area and a concrete batch plant near the spillway excavation.

The area for impervious borrow materials would be located upstream of Turkey Flat, with material in this area classified as low-plasticity silt or clay. The potential compatible fill borrow area is just above Turkey Flat, and the material consists of a mix of silt, sand, gravel, and boulders. The proposed rock borrow area is along Pacheco Creek, just above Turkey Flat.

Approximately 5.75 miles of 25 feet-wide haul road would be required to access the reservoir borrow areas upstream of the embankment location. The haul road would follow an existing access road along Pacheco Creek that would need to be improved. Construction access roads totaling 4 miles and 25 feet wide would need to be constructed across the stream, downstream of the embankment, to access the spillway area. One and a half miles of these construction roads would improve existing access roads, providing permanent access to the site post-construction. An existing bridge over the stream would need to be improved.

C.5.2.2 Inlet/Outlet Construction

Construction of the tunnel and pipe between the inlet/outlet structure and pump station area would be accomplished as a site preparation activity; either by open-cut excavation, tunneling, or a combination of excavation and tunneling. The low-level intake would also be completed to allow diversion of the stream through the outlet structure for the duration of the following embankment construction. Construction of the outlet tunnel could include excavation for, and construction of, the pump station lower level, that would act as the energy dissipation and discharge pipeline and channel to return flow to the stream below the dam.

Construction methods are anticipated to consist of clearing, grubbing, stripping, and disposal of topsoil; and grading consisting of excavation of soil and rock, filling, and compacting. Blasting of hard, fractured rock may be used to expedite excavation, but it is anticipated to be very limited during site preparation. Site preparation activities would include diversion of surface water, implementation of erosion and sediment controls, and establishment of a construction management area, including placement of temporary construction trailers. Site preparation activities may also include stabilization of potential or active landslide areas.

C.5.2.3 Dam Construction

Construction activities for the new dam and reservoir would include removing the existing North Fork Dam, and constructing a temporary cofferdam, new embankment dam, and spillway. Construction methods for dam removal and the cofferdam would consist of clearing, grubbing, stripping, and disposal of topsoil, and grading consisting of excavation of soil and rock, filling, and compacting. Construction methods for the new embankment and spillway include excavation and processing of borrow materials; hauling, placing and compacting fill and backfill; and forming and placing concrete.

Dam Removal

Demolition of the North Fork Dam of the existing Pacheco Reservoir would begin as the water level is drawn down through the outlet and would be completed once the reservoir is fully drained. This drawdown would be controlled to avoid any triggering of additional movement of the mapped landslides at the new dam site upstream. Removal of the existing dam would proceed from the top down to prevent steep slopes and to minimize the potential for slope failure. Material excavated from the dam, deemed suitable for earth fill, would need to be directly hauled to the temporary cofferdam site for placement and compaction. Unsuitable material would be stockpiled for disposal off-site. Sand, gravel, cobbles, and rock may be segregated from the excavated material and used for site restoration. Bank stabilization and channel reconfiguration would be performed once the dam is removed, and any planned riparian and aquatic habitat enhancements would be implemented, such as creating pools, adding boulders, installing logs, and enhancing irregular edges.

Cofferdam

The temporary cofferdam would be constructed at the upstream toe of the new dam footprint, following or concurrent with completion of the outlet construction, preferably during the dry season when flows in Pacheco Creek are low. The cofferdam crest elevation is 500 feet and was sized to ensure that flows in Pacheco Creek are maintained during construction while accommodating at least a 20-year flood event and would accommodate the 50-year flood event. Foundation preparation for the cofferdam would be similar to that for the main embankment, and would consist of over-excavation of alluvium from the valley bottom and surficial soils along the abutments. The foundation and embankment of the cofferdam would be incorporated into the dam. Material used to construct the cofferdam would be imported from the compatible fill borrow sources, spillway excavation, and removal of the North Fork Dam.

Embankment Construction

Initial preparation of the dam footprint would consist of clearing and grubbing of vegetation, removal of soft sediments and other deleterious materials, and shaping of the abutment side slopes. Excavation for slope protection may be needed to mitigate the for the mapped landslides at the proposed dam site and to protect against shallow-slope failures during construction. Dam foundation construction would include excavation of existing-channel alluvial materials to competent bedrock; loading and hauling excavated materials in the foundation footprint to stockpiles; cleaning of the foundation in the core and earth fill zones; surface treatment of the impervious-core foundation by excavating shear zones and backfilling with dental concrete/grout; and set-up, mix, and installation of a cutoff wall beneath the cores (grout curtain). Materials excavated from the foundation area could be stockpiled and reused in the earth fill areas of the embankment.

Embankment construction activities would include processing, excavating, loading, hauling, placing, and compacting of impervious core, adding earth fill, and draining and filtering of materials from borrow areas. Processing materials at the borrow sites would likely include, at a minimum, moisture conditioning.

Drain and filter materials are anticipated to be sourced from local commercial vendors or facilities. Additional moisture conditioning may be required at the dam site as the materials are placed and compacted. It is anticipated that up to four concurrent material placement and compaction operations could be occurring at the same time as the embankment elevation is raised.

A 2,300-foot long conveyance tunnel would be constructed under the dam abutment to connect the intake structures and the pump station. The conveyance tunnel would be excavated through the bedrock on the left abutment of the dam. 132-inch (inside diameter), concrete-lined tunnel would be located beneath the upstream portion of the dam and would connect the valve chamber vault to the sloping intake structure. The segment beneath the downstream portion of the dam would be a concrete-lined, 192-inch (inside diameter) walk-in tunnel with a 132-inch diameter steel carrier pipe.

To connect the new outlet works to Pacheco Creek, the historical Pacheco Creek channel would be restored between the new dam and the existing dam through the existing Pacheco Reservoir. Restoration of the channel would include excavating a new 1,500-feet long, 1.7-feet deep, one-foot wide, low-flow channel, and a 6-feet deep, 20-feet wide overbank channel to facilitate riparian restoration. The channel will be designed to reduce streambank erosion (e.g., using bank stabilizing materials), and riparian vegetation will be planted to initiate growth of a new riparian forest along the restored channel.

Spillway Construction

Spillway construction would consist of completing excavation to final grades; formwork and placement of concrete for the base and walls of the entrance channel; chute and energy dissipation and stilling basin; and backfilling of walls, and final grading and erosion protection for the excavation slopes.

C.5.2.4 Pump Station and Conveyance to Pacheco Conduit Construction Methods

Construction methods for the pump station, surge tanks, and electrical substation would consist of excavation for basements, foundations, and building pads; preparing formwork and pouring concrete; installation of pumps and equipment; and final finishing of the interior. Construction of the conveyance pipeline to the Pacheco Conduit would generally consist of conventional trench excavation and backfill. However, the section of the pipeline passing beneath SR 152 would be a tunnel constructed using jack and bore trenchless methods.

Excavations to competent bearing material would need to be performed to construct the proposed pump station and appurtenant structures. The pump station and surge tanks are anticipated to be reinforced-concrete structures, and the electrical substation an open-graveled area with concrete mat and pedestal foundations for the electrical gear and towers. Security fencing would be required around all above-grade facilities.

A temporary and permanent construction easement would be required for the conveyance pipeline to the existing Pacheco Conduit. A potential corridor for the high-capacity electric transmission lines to the pump station could be located adjacent to the permanent easement from the pipeline. The pipeline would be constructed in an open-trench excavation and backfilled with imported bedding material and native backfill to existing grade. A series of permanent structures for appurtenances (i.e., air/vacuum valves, vaults, drains, and blowoffs) would be placed along the pipeline right-of-way. These structures would generally be below-grade and positioned directly over, or adjacent to, the conveyance pipeline.

C.5.2.5 Access and Staging Areas

Site access for the tunnel would include constructing new haul and access roads in conjunction with making improvements to existing roadways. Wherever possible, the alignment of these roads would follow the existing unimproved roads or four-wheel-drive trails. The access road from SR 152 to the dam site would be about 2.74 miles long. It is anticipated that the road would eventually be completed as an approximately 40-feet wide, asphalt-paved, two-lane road. Preparing a temporary construction road with this width would allow two-way traffic during construction.

C.5.3 Operation of the Pacheco Reservoir Expansion Alternative Plan

The expanded Pacheco Reservoir would be primarily filled using natural inflows from the North and East Forks of Pacheco Creek. These inflows are typically realized from December through March. Supplemental flows to the expanded reservoir would arrive from SCVWD’s share of contracted CVP pumped water from San Luis Reservoir. This would include allocated CVP water supplies that otherwise could not be delivered to or stored by SCVWD. This CVP water supply would be pumped from the Pacheco Conduit up to the expanded Pacheco Reservoir earlier in the year prior to the summer months when the San Luis Reservoir is typically drawn down to the 300 TAF level. The rate at which these transfers are made between San Luis Reservoir and Pacheco Reservoir would depend upon water rights, supply allocations, water demands, availability of other water supplies, and conveyance limitations of Pacheco Conduit[2]. Conveyance and storage of these CVP supplies is anticipated to occur primarily in wet years. CVP water stored in Pacheco Reservoir could then be released through the summer while supplies from San Luis Reservoir would be inaccessible to SCVWD. The expanded Pacheco Reservoir’s configuration in a narrower canyon that would support a greater depth to surface width ratio than San Luis Reservoir is anticipated to limit the intensity of any algae blooms that could develop in the expanded reservoir and avoid the treatability issues associated with summer low point conditions in San Luis Reservoir. In addition, the development of the expanded reservoir’s outlet structure to divert water

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[2] Storage of water in Pacheco Reservoir previously diverted from the Delta and stored in San Luis Reservoir under the existing CVP water right would require the addition of a point of re-diversion to that permit.

stored at lower levels would help to avoid any surface algae that does develop in the summer months.

The Pacheco Reservoir Alternative Plan would be operated by SCVWD to improve habitat conditions for steelhead in Pacheco Creek, improve SCVWD water supply reliability, including during drought periods and emergencies, and meet the groundwater recharge objectives of PPWD. Average monthly target flows ranging from 10 to 30 cfs in Pacheco Creek would support the biological needs of South-Central California Coast (SCCC) steelhead for higher flows for outmigration. The average monthly release targets are shown in Table C-2[3]. During heavy precipitation events, releases from the expanded reservoir will be reduced to minimize flooding risks along Pacheco Creek and the Pajaro River. The winter releases indicated in Table C-2 could be reduced if South Fork Pacheco Creek flows fully meet steelhead habitat needs.

To ensure that flows and water temperatures in Pacheco Creek are maintained in consecutive dry years, releases to Pacheco Conduit—to meet SCVWD water demands—would be discontinued in the event that reservoir storage volumes fall below 55,000 AF. This flow regime may however be altered in the event of an emergency declaration by SCVWD for health and safety purposes. These habitat flows will be secured by operations requirements expected in the biological opinion(s) that will be developed for the expanded Pacheco Reservoir, as well as the contract between and DWR and SCVWD for the provision of grant funding through the WSIP, and in the integrated operations agreement between Reclamation and SCVWD for Pacheco Reservoir.

Table C-2. Average Monthly Release Targets to Pacheco Creek from Expanded Pacheco Reservoir

Month	Average Monthly Release Targets to Pacheco Creek (cfs)[1]	Inflow into Pacheco Reservoir Needed to Discontinue Releases under With-Project Operation (cfs)
January	10	11.2
February	10	11.2
March	20	22.4
April	20	22.4
May	12	13.4
June	13	NA
July	14	NA
August	14	NA
September	14	NA
October	14	NA
November	10	11.2
December	10	11.2

Notes: [1]Releases from Pacheco Reservoir are reduced during high flows in the south fork of Pacheco Creek.
Key: CFS = cubic feet per second

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[3] These average monthly release targets shown in Table A-2 incorporate the biological needs of the SCCC steelhead and include a 15-day pulse flow of 30 cubic feet per second (cfs), followed by a 15-day release schedule of 10 cfs. This pulse flow is anticipated to occur in March and April for outmigration.

In addition, SCVWD will transfer 2,000 AF of its CVP water contract allocation (in below normal water years), directly or through transfer and exchanges, in perpetuity to Reclamation and U.S. Fish and Wildlife Services' Refuge Water Supply Program (RWSP), for use in the Incremental Level 4 water supply pool for wildlife refuges. This long-term voluntary reallocation of CVP yield by SCVWD would be secured by an agreement between the USFWS and SCVWD detailing its operation, a contract between and DWR and SCVWD for the provision of grant funding through the WSIP that would require the provision of these supplies in perpetuity, and an integrated operations agreement between Reclamation and SCVWD for Pacheco Reservoir that would include the requirements for this transfer.

C.6 Costs

This section provides a summary description of the methods and general approach used in developing cost estimates for the alternative plans. Attachment C contains construction cost estimate worksheets for the four alternative plans. Designs and cost estimates of project features have been developed to an appraisal-level.

Different levels of cost estimates are required to plan and fund projects. As a project moves through its development, each subsequent estimate level reflects increasing detail and refinement of project features. Reclamation recognizes six different levels of construction cost estimates, as follows (Reclamation 2007):

- Preliminary
- Appraisal
- Feasibility
- Percent (%) Design (post-authorization)
- Prevalidation of Funds (Prevalidation)
- Independent Government Cost Estimate

Cost estimates are typically developed in the chronological order shown, and each supersedes the previous estimate. They differ in degree of detail, refinement, use, and confidence, depending on the amount of certainty regarding engineering and geological data, and other factors (e.g., environmental considerations, land acquisition costs, and procurement methods) known at the time the cost estimates are prepared (Reclamation 2007). For the Investigation alternatives, feasibility and appraisal-level cost estimates have been developed for project facilities.

Table C-3 summarizes the project costs and annual operations and maintenance costs of the four alternatives at the appraisal level of design. Attachment C includes more detail on the project costs.

Table C-3. Appraisal-Level Costs[1]

Alternative Plan	Layout	Project Costs	Average Annual Operations and Maintenance Costs
Lower Intake	Tunnel	$968,000,000	$2,500,000
	Pipeline	$885,000,000	$2,500,000
Treatment		$37,000,000	$250,000
San Luis Reservoir Expansion		$490,000,00	$2,200,000
Pacheco Reservoir Expansion		$1,127,000,000	$1,600,000

Notes:

[1] Based on April 2018 price levels, 2018 Federal discount rate of 2.875 percent, and 100-year period of analysis.

C.7 References

Bureau of Reclamation (Reclamation). 2007. Reclamation Manual, Directives and Standards FAC; 09-01, 09-02 and 09-03. Denver, Colorado. October 2007.

______. 2013. San Luis Reservoir Expansion Draft Appraisal Report. December 2013.

Attachment A

B.F. Sisk Dam - Increased Storage Alternatives, Appraisal-Level Study, Technical Memorandum

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Managing Water in the West

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Technical Memorandum No. VB-86-68313-25

B.F. Sisk Dam – Increased Storage Alternatives, Appraisal-Level Study

Central Valley Project, California
Mid-Pacific Region

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U.S. Department of the Interior
Bureau of Reclamation
Technical Service Center
Denver, Colorado

April 2013

Mission Statements

The mission of the Department of the Interior is to protect and provide access to our Nation's natural and cultural heritage and honor our trust responsibilities to Indian Tribes and our commitments to 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.

Cover Photo (courtesy of DWR) – Aerial photograph of B.F. Sisk Dam and San Luis Reservoir

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B.F. Sisk Dam – Increased Storage Alternatives, Appraisal-Level Study

Central Valley Project, California
Mid-Pacific Region

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Denver, Colorado

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Technical Memorandum No. VB-86-68313-23

B.F. Sisk Dam – Increased Storage Alternatives, Appraisal-Level Study

Central Valley Project, California
Mid-Pacific Region

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Acronyms and Abbreviations

AF	acre-feet
APS	allowance for procurement strategies
bcy	bank cubic yards
BOR	Bureau of Reclamation
CAS	Corrective Action Study
CFR	Comprehensive Facility Review
CMP	Corrugated Metal Pipe
CRB	Consultant Review Board
CY	cubic yards
DWR	California Department of Water Resources
FLAC	Fast Lagrangian Analysis of Continua
FS	factor of safety
ft^2	square foot (feet)
ft^3	cubic foot (feet)
GVS	Great Valley Sequence
IE	Issue Evaluation
km	kilometer(s)
MPRO	Mid-Pacific Regional Office
MSE	Mechanically Stabilized Earth
NVS	North Valley Section
PMP	Project Management Plan
RA	Risk Analysis
RRA	Risk Reduction Analysis
Reclamation	Bureau of Reclamation
RWS	reservoir water surface
SOD	Safety of Dams
SPT	standard penetration test
SVS	South Valley Section
TM	Technical Memorandum
TSC	Technical Service Center
URS	URS Group, Inc.

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Executive Summary

The California Department of Water Resources (DWR) and the Bureau of Reclamation's (Reclamation) Mid-Pacific Regional Office (MPRO) Planning Division are interested in increasing the storage capacity behind B.F. Sisk Dam (formerly San Luis Dam) in order to meet the increasing demands for water in the area. Reclamation's Technical Service Center (TSC) was requested to perform an appraisal-level analysis to provide the relative costs of the requirements to increase the storage capacity of the reservoir. The original thought was to construct an embankment raise to accomplish the objective. After discussion of various height increases with the project's team members, reservoir water surface (RWS) elevation increases of 6 feet and 10 feet were selected for static stability analysis. A centerline embankment raise with: 1) vertical upstream and downstream slopes utilizing a mechanically stabilized earth (MSE) wall section, and 2) steepened upstream and downstream slope faces (reinforced earth or soil cement) were also considered. These alternatives were eliminated during the appraisal-level Safety of Dams Corrective Action Study (CAS) due to the lack of erosion control measures in the event of a large earthquake.

The purpose of this Technical Memorandum (TM) is to document the background of the project, the preferred alternative that was selected to be pursued further, and the technical analyses associated with the appraisal-level designs and issues associated with the reservoir capacity of San Luis Reservoir. Reclamation standards were used as a basis for the analyses and designs, where applicable.

The MPRO Planning Division desired to maximize the storage capacity of San Luis Reservoir. The Project Management Plan (PMP) stated that this appraisal-level study would define a probable upper limit height increase, but that the reservoir raise would not likely exceed 24 feet. A CAS of B.F. Sisk Dam and its appurtenances is currently underway to address seismic potential failure modes. Because the CAS is occurring independently of this appraisal-level study, there are inherent limitations associated with a RWS raise and storage increase that were taken into account. In an attempt to reduce conflicts between the CAS design, which is currently at feasibility level design, and the storage capacity increase design, modified embankment configurations developed during the CAS were used as a starting point for the appraisal-level study analysis. The appraisal-level alternative (10-foot RWS raise and 20-foot embankment raise) provides a maximum increase in storage capacity of between approximately 127,000 acre-feet (AF) and 131,500 AF. Capacity increases above this range present significant challenges to raising the embankment to accommodate the additional volume, including significant modifications to the Gianelli Pumping-Generating Plant.

The final appraisal-level cost estimates are detailed in Appendix A (Option A) and Appendix B (Option B). The estimated costs are $310,000,000 and $360,000,000, respectively, for a 20-foot embankment and 10-foot RWS raise, including the cost to modify the spillway, intake towers, and access bridge. Appendix A presents costs associated with the embankment modification based on drained foundation strength static stability analyses. Appendix B costs are based on a modified embankment configuration determined using undrained foundation strength parameters in the static stability analyses. More discussion regarding these estimates is included in this report. The static stability analyses TM is included in Appendix C.

Risk analysis for the proposed raise was not performed because the appraisal-level analysis only considered static stability. A factor of safety (FS) of 1.5 was achieved for the proposed embankment configurations associated with the 20-foot embankment and the 6-foot and 10-foot RWS raises; this meets Reclamation’s requirements for static stability. Estimation of risks associated with seismic potential failure modes for the proposed embankment configurations was not within the scope of this appraisal-level study. The increased risks associated with the construction and post-construction conditions were not evaluated. These risks (seismic, construction and post-construction) should be evaluated during the next phase of design. It is likely that results of the risk analyses will necessitate changes to the embankment configurations and intake towers, and possibly to the spillway and bridge.

I. Scope of Work

The main focus of this appraisal-level study was to evaluate static stability of various reservoir/embankment raise scenarios to determine a probable upper limit for the reservoir raise. The scope of work for this project included an appraisal-level analysis of a 20-foot embankment raise and two different reservoir water surface elevation raises, 6 feet and 10 feet. In addition, appraisal-level designs for modifications to the spillway, outlet works intake towers, and access bridge were evaluated for a 10-foot RWS raise. Appraisal-level sketches and cost estimates were prepared for the 10-foot RWS raise and the 20-foot embankment raise. This work was requested by the Mid-Pacific Regional Office Division of Planning (MP-730) to be performed by the Denver Technical Service Center (TSC).

This study did not address or develop: 1) operational or maintenance costs, 2) seismic stability, or 3) qualitative or quantitative assessment of changes in risk.

II. Background

The following sections of the report discuss the general background information regarding the different aspects of B.F. Sisk Dam.

A. General

B.F. Sisk Dam and San Luis Reservoir are part of the Central Valley Project located on San Luis Creek approximately 12 miles west of Los Banos, California; the entire reservoir is within Merced County. San Luis Reservoir has 65 miles of shoreline and controls runoff from about 82 square miles. The dam is an offstream water storage facility used to store supplemental water for irrigation and domestic water. Water is lifted from the O’Neill Forebay into the reservoir for storage by the Gianelli Pumping-Generating Plant, and then water is released back through the pump-generating plant for use and to generate electricity. The dam impounds approximately 2,040,500 acre-feet at the maximum reservoir water surface elevation 544.0 (NGVD 1929). This is 10 feet below the crest elevation of 554.0.

The embankment was built under Bureau of Reclamation supervision beginning in February 1963 and completed in 1967. Releases from the reservoir serve many purposes ranging from domestic supply to power generation to irrigation. The Gianelli Pumping-Generating Plant was designed and constructed by Reclamation; construction was completed in 1967. Operations and maintenance of the facility is performed by DWR.

B. Dam Embankment

B.F. Sisk Dam is a zoned earthfill structure that includes a wide central core (Zone1) with downstream drainage zones (Zones 2 and 4), a drainage blanket (Zones 2 and 4), and a toe drain. The general plan and existing cross sections are included as Figures 2 through 5. Detailed description of the dam is provided in the 2009 CFR report [1] and summarized in the Appraisal-Level Study of Static Stability for Increased Storage Technical Memorandum (TM-86-68313-22) included as Appendix C. The Technical Record of Design and Construction [2] indicates the dam and structures were well-constructed.

The dam has a maximum structural height of 382 feet, hydraulic height of 303 feet, crest width of 30 feet, and total crest length of 18,600 feet at elevation 554.0. The maximum reservoir water surface elevation is 544.0. The upstream face of the dam is sloped at 3:1 horizontal to vertical (H:V) above elevation 400 and 8:1 H:V below elevation 400. The downstream face of the dam at the maximum section is sloped at 2:1 H:V above elevation 450, 2.5:1 H:V from elevation 450 to elevation 400, 6:1 H:V from elevation 400 to 290, and 2:1 H:V from elevation 290 to the downstream toe. The dam embankment has seven zones with the central zone consisting of low-plasticity clay. The downstream face of the dam is covered by a 2-foot-thick rock blanket and the upstream face is covered by a 3-foot-thick layer of riprap. There is a saddle dike located along the north rim of the reservoir approximately 1,300 feet from the dam.

In September of 1981, four stability berms (three upstream and one downstream) were added as a result of an upstream slope failure caused by rapid drawdown.

C. Features

The following paragraphs were taken from the 2009 Comprehensive Facility Review (CFR) report for B.F. Sisk Dam [1] and the Technical Record of Design and Construction [2].

Gianelli Pumping-Generating Plant: The Gianelli Pumping-Generating Plant located at the left end of the dam (Figure 6) also serves as the outlet works for the dam. The outlet capacity is approximately 16,000 ft3/s with the reservoir full. The intakes to the penstocks are located near the left abutment of the dam and consist of a 284-foot-high structure containing four trashrack structures and four parallel 17.5-foot-diameter concrete tunnels/penstocks. The inlet to each tunnel is controlled by a roller-mounted emergency closure gate located in each trashrack structure. The tunnels are approximately 2,230 feet long with the last 1,180 feet of each tunnel containing a steel liner. The concrete tunnels/penstocks bifurcate to eight 11.5-foot-diameter steel penstocks, with each steel penstock serving a pump-generator unit in the pump-generating plant. A 156-inch-diameter butterfly valve is located in each of the 11.5-foot-diameter steel penstocks just upstream from its respective pump-generator unit.

Each of the eight pump-generating units has a capacity of 63,000 horsepower as a motor, and 53,000 horsepower as a generator. Each unit features two-speed motor-generators by means of two rotors mounted on the same vertical shaft connected to Francis-type turbines. The lower motor operates at 150 revolutions per minute (rpm) and the upper motor operates at 120 rpm. The 150-rpm-motor is used for heads exceeding 190 feet while pumping and 227 feet while generating. In 1983, Units 1 and 5 were converted from 150 rpm to 156.5 rpm operation to increase efficiency at the higher head encountered when topping off the San Luis Reservoir

Refurbishment projects are underway to restore the reliability of the Gianelli Pumping-Generating Plant. These include speed conversions from 150 rpm to 156 rpm of two additional units, and refurbishing all pump/turbine casings and butterfly valves; these are scheduled for completion by 2026.

Outlet Works Intake Towers/Trashrack Structures: Four separate trashrack structures, constructed on a common base and controlled by roller-mounted emergency closure gates, are provided at the reservoir end of the outlet tunnels and are joined to the tunnels by sections of conduit. The trashrack structures also serve as intake, discharge, and gate structures. Figures 6 through 12 show plan and profiles of the outlet works and trashrack structures.

Each trashrack structure consists of a rectangular semi-bell mouth-shaped entrance joining a transition which changes from rectangular to a circular cross section. The entrance opening is a rectangle, 23.0 by 28.5 feet in size, and is vertical to permit seating of a 23.0- by 28.5-foot bulkhead gate. The centers of the entrance openings are at elevation 287.25 which is 38.75 feet below the minimum RWS elevation.

Each trashrack structure is provided with a 17.5- by 22.89-foot roller-mounted gate which operates in slots located 10 feet from the entrance opening. The roller-mounted gates provide emergency closure of the outlet works tunnels in the event of a failure of the penstocks or a malfunction of the butterfly valves installed near the pump turbine units. The emergency gate closure also permits unwatering of the tunnels for inspection, maintenance, and repair. The roller-mounted closure gates are actuated by hydraulic hoists whose pistons are sufficiently long to close the gates with a single thrust. Each hoist is mounted on the top of the trashrack structure in the open.

A single bulkhead gate is provided to be lowered over the entrance opening of any one of the trashrack structures to permit inspection, maintenance, and repair of the roller-mounted gate seats and guides. A gantry crane provides means of moving the bulkhead gate to a particular trashrack structure and in lowering and raising the gate.

Trashrack Structure Access Bridge: Vehicular and pedestrian access to the trashrack structures is provided by a 16-foot-wide bridge about 1,060 feet long which connects the crest of the dam with the left trashrack structure (see Figure 13). The trashrack structures are connected by bridges which support the gantry crane.

Spillway: An uncontrolled concrete morning-glory-type spillway is located at the left end of the dam near station 139+00 (see Figure 7). The full length of the spillway was excavated into bedrock. The upstream 350-foot section is a cut-and-cover conduit through the dam embankment and the left abutment. The remaining approximately 100 feet to the stilling basin is an open chute. The design discharge capacity for the spillway is 1,030 cubic feet per section (ft^3/s) at maximum water surface elevation 545.8.

III. Reservoir Area-Capacity

The Technical Record of Design and Construction [2] indicates San Luis Reservoir has a surface area of 12,700 acre-feet and a total capacity of 2,040,500 acre-feet at the current maximum reservoir elevation of 544.0. The original area-capacity curve prepared by the California DWR (Drawing 805-208-151 dated September 12, 1961) (Figure 14) indicates a reservoir volume of approximately 2,095,000 acre-feet at elevation 544.0. The DWR capacities were derived from their July 1960 1" = 400' aerial topography. The discrepancy in reservoir volume with the RWS at 544.0 is almost 54,500 acre-feet.

Reclamation's TSC is not aware of detailed topographic information for the reservoir rim. As a result, the increase in area capacity associated with a 10-foot reservoir raise is approximate and should be determined during the next phase of analysis. The DWR area-capacity curve indicates total capacity of the reservoir with a 10-foot RWS raise (to elevation 554.0) would be approximately 2,226,500 acre-feet, an increase of 131,500 AF. Extrapolating the surface area of 12,700 acre-feet vertically 10 feet yields a capacity increase of 127,000 acre-feet. For the purposes of this appraisal-level study, the increase in capacity associated with a 10-foot RWS raise is assumed to be approximately 130,000 acre-feet.

IV. Design Considerations

Certain assumptions and constraints were determined at the start of this appraisal study. The purpose was to focus on reasonable alternatives within the allotted budget and schedule. The assumptions and constraints simplified complex items for the evaluation of alternatives and provided direction in the study. The assumptions included:

- The appraisal-level study to increase reservoir capacity would consider the concurrent CAS and incorporate as many CAS design details into the embankment modification as practicable.
- Material for embankment fill and filter, drain and riprap is assumed to be available from borrow sites shown on Figure 15.
- Spoil areas will be available onsite for stockpiling and disposal of stripping.
- The existing spillway, intake towers, and bridge are not designed to current seismic code. The appraisal-level designs assume these structures will be modified only considering static loading to accommodate a reservoir raise. The designs do not include seismic loadings or address deficiencies.
- The reservoir raise cannot significantly impact the pumping-generating plant structure or pump-generating unit operations.
- Only field costs were considered. Additional costs for design, exploration, construction support, real estate, environmental costs, etc. would not be included.
- Contingencies and unlisted items were included and assumed to be 15 percent to cover costs for current “unlisted” items and 25 percent to reflect the uncertainty in the quantities, consistent with an appraisal-level study.

Alternatives discussed but not considered in this appraisal-level study included:

- Embankment raise from the upstream side, which would require reservoir evacuation.
- Dredging and excavation from within the reservoir, which would have negative impacts on the environmental and would likely be inefficient from a cost-benefit perspective (significant excavation depth to soil within the reservoir and blasting needed to remove shallow bedrock).

V. Other Crest Raise Alternatives Considered

Crest raise design options considered during the appraisal-level CAS, but not pursued, are described in this section. According to TM VB-8313-9 [3], these alternatives were not pursued because they are not appreciably different, have no bearing on the selection of a preferred alternative, or were ruled out for technical reasons. Three crest raise options were conceptualized during the CAS. The following two alternatives were eliminated from further consideration due to the lack of erosion control measures in the event of a large earthquake that causes significant cracking of the crest. The eliminated alternatives included:

- steepened upstream and downstream slopes utilizing either a reinforced earth section or soil cement for the upstream and downstream slope faces; and,
- vertical upstream and downstream slopes using a mechanically stabilized earth (MSE) wall section.

The third alternative was carried forward in the CAS and is similar to the preferred alternative for this appraisal-level study.

VI. Preferred Alternative

During the initial stages of this appraisal-level study, TSC's mechanical engineers indicated there is an upper limit to the increase in head (i.e. RWS raise) that the existing turbines can accommodate without significant reductions in efficiency or increases in operational risk. Complete replacement of the pump-generating units and/or constructing a new pump-generating plant at a new location were deemed cost-prohibitive for the purposes of this study and were not evaluated. As a result of these considerations, a maximum reservoir water surface elevation of 554.0 was identified.

This study evaluates design considerations for a 10-foot reservoir water surface raise and a 20-foot embankment raise of the dam and dike. In order to raise B.F. Sisk Dam, modifications to the dam embankment, dike, spillway, intake towers, and access bridge are needed. In this study, the raise height of 10 feet for which design alternatives were identified was based on balancing the need for additional water while minimizing impacts to existing facilities. In the static stability TM (Appendix C), a RWS raise height of 6 feet was also evaluated. However, the configurations of the downstream berms required to achieve a safety factor of 1.5 for static stability for the 6-foot raise were similar to those needed for a 10-foot RWS raise. As a result, the 10-foot RWS raise alternative in conjunction with a 20-foot embankment raise was selected to develop cost estimates.

The current study divided the dam into three main sections: the North Valley Section (NVS), the South Valley Section (SVS), and the Left and Right Abutment Sections. The dike is approximately 1,300 feet north of the dam. The locations are identified on Figure 2. The difference between the sections is the character of the foundation soils. The NVS is in the main San Luis Creek Valley between dam stations 100+00 and 111+00. The section analyzed was at station 107+00. This section is founded on a thin layer of unconsolidated alluvium deposits. The SVS is also in the main San Luis Creek Valley; it is generally located between dam stations 60+00 and 100+00. The section analyzed was at station 86+00. This section is founded on older alluvium (Los Banos) and a thick layer of the Tulare formation, which was deposited mainly by a lacustrine/fluvial process. The dam abutments are located between approximately dam stations 0+00 and 60+00 on the right and 111+00 to 185+00 on the left. The foundation is predominantly bedrock. However, there are areas where the slopewash material was not removed; the slopewash is moderately to highly plastic.

A. Downstream Stability Berms

In keeping with the CAS alternatives, this appraisal-level study to increase storage capacity focuses on an embankment crest raise and downstream berms to achieve the required 1.5 factor of safety for static stability. The proposed downstream modification extent (locations) and sizes (volumes) are provided in Table 1 on the following page. A downstream berm is not required in the SVS section to accommodate the RWS height raise.

The downstream modification sizes, and thus volumes, computed for this appraisal level of analysis are approximate only. The range of volumes reflects the uncertainty with the foundation conditions. The modification volumes in Table 1 also reflect the additional backfill required from the excavation of the foundation soils. Estimated quantities will be discussed in greater detail later in this report. For feasibility design, the modification sizes must be evaluated and adjusted as needed so the expected seismic deformations (as determined during the CAS) along the entire length of the dam will be similar. A typical section of the downstream modification is provided in the following sketch (Figure 1). Though not shown, a filter zone will be included at the berm/embankment contact as well as the berm/foundation contact to prevent internal erosion of materials. The foundation soils will be removed to bedrock under the berms where it was necessary to achieve a factor of safety of 1.5 for static stability. Backfill will consist of both the excavated soil and borrow area soil, both of which will be placed in a well-compacted state. The filter material will be processed from the Basalt Hill Quarry. Plan views of the dam showing the proposed berm locations are provided on Figures 16 and 17 and in Appendix C (Figures A-7 through A-10). Cross sections are provided in Appendix C (Figures A-11 through A-13).

TABLE 1. – PROPOSED MODIFICATION LOCATIONS AND VOLUMES

Right abutment	0+00 to 31+00	1,072,000
Right abutment (berm)	31+00 to 46+00	637,000 to 1,012,000
Right abutment	46+00 to 56+00	346,000
Right abutment (berm)	56+00 to 68+00	776,000 to 1,508,000
SVS	68+00 to 99+00	1,644,000
NVS (berm)	99+00 to 114+00	1,615,000
Left abutment	114+00 to 139+00	864,000
Left abutment (berm)	139+00 to 149+00	800,000 to 1,255,000
Left abutment	149+00 to 165+00	553,000
Left abutment (berm)	165+00 to 173+00	250,000
Left abutment	173+00 to 176+00	104,000
Left abutment (berm)	176+00 to 183+00	167,000
Left abutment	183+00 to 185+00	70,000
Dike	--	23,000

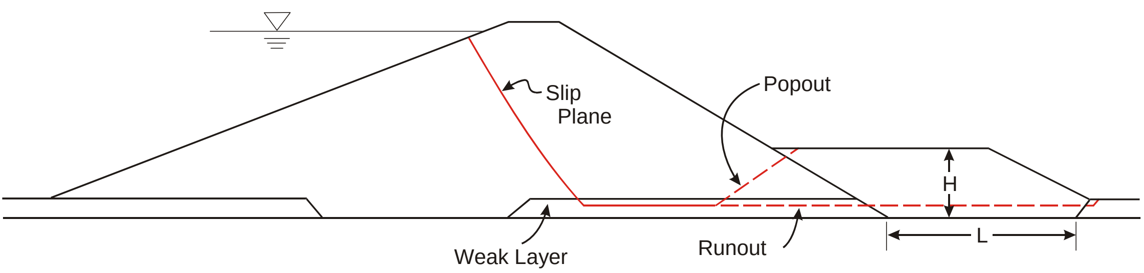

FIGURE 1. – TYPICAL PROPOSED MODIFICATION SECTION

B. Crest Raise

At the current crest elevation of 554.0, there is 10 feet of freeboard with the reservoir at the active conservation pool level (el. 544.0). The proposed crest raise will add 10 feet of freeboard to the current crest for a total static freeboard of 20 feet, so the modified crest will be at elevation 574.0. A section of the proposed crest raise is provided in Appendix C (Figure A-14). The raise includes removal of 10 feet of the existing crest for penetration into the existing Zone 1 core. Existing material that will be removed includes a 6-inch-thick gravel surfacing, Zone 4 minus-8-inch filter, Zone 5 riprap, and Zone 1 core. The excavated materials will be used in the downstream modification sections.

C. Structure Modifications

Outlet Works Intake Towers/Trashrack Structures: The intake towers would be raised 10 feet as described in TM BFS-8110-STY-2012-1 (Appendix D). To accomplish this, the top 16.25 feet of the existing towers would be demolished. The intake tower walls would be extended vertically using forms and cast-in-place concrete. The intake tower operating platform with support corbels would be reconstructed as originally designed. The operating platform deck elevation would be 564.0.

Prior to demolition of the top of the intake towers, removal of all existing equipment including the roller gate, hoist stem extension, gantry crane, and bulkhead gate would need to occur. Reconstruction of this equipment would be completed after extension of the intake towers is completed.

Trashrack Structure Access Bridge: The current access bridge deck elevation is 554.0, the same elevation as the crest of the dam and the top of the intake tower/trashrack structures. The bridge would be removed and replaced with a similar-type superstructure, as described in TM BFS-8140-STY-2013-1 (Appendix E). The new bridge deck elevation would vary from 564.0 at the intake towers to 574.0 at the abutment. The existing bridge piers would be extended vertically and the new bridge would be founded on the extended piers.

Spillway: The morning glory spillway is located approximately 100 feet upstream of the centerline of the dam near station 139+00, and the access bridge for the intake towers intersects the crest at approximately station 140+50, as shown on Figure 7. The upper 22 feet of the spillway would be demolished. The spillway would then be raised 10 feet from elevation 544.0 to 554.0, as discussed in TM BFS-8110-STY-2012-1 (Appendix D). Excavation of the upstream face of the dam would be necessary to expose the top 22 feet of the spillway. The embankment would be reconstructed after modifications to the spillway structure were completed. Modifications to the spillway may also involve covering part of the open chute to accommodate the fill.

VII. Material Zoning

The two key components to the proposed CAS modification at B.F. Sisk are the crest raise and downstream stability berms. These components are included in the appraisal-level modifications to maintain some consistency between the two studies. The following paragraphs discuss the materials appropriate for each.

A. Downstream Stability Berms

The sole purpose of the berms is to provide weight at the downstream toe of the existing embankment to achieve a static stability safety factor of 1.5 for the dam with the 10-foot reservoir raise and 20-foot embankment crest raise. The material used in the construction of the berm is not critical, but material with higher shear strength would reduce the overall berm size. Since rock sources are abundant in the area, the proposed plan is to construct the berms with well-graded rock fill obtained from on-site borrow sources and required excavation. The backfill will be placed and compacted in lifts.

B. Crest Raise

As part of the crest raise, the top 10 feet of the existing dam and dike will be removed. New construction will raise the dam 30 feet from the excavated limit and 20 feet overall. The Zone 1 impervious core will be raised, and a Zone 8 crack stopping layer and Zone 4 protection layer will be placed upstream. Along the downstream slope, there will be a three zone filter (Zones 6, 7, and 4) extended from the crest down the slope to where the steepened raise intersects the original slope. The downstream filter system is intended to protect the embankment from internal erosion if deformations during an earthquake cause cracking of the crest. The upstream “crack stopper” zone adjacent to the Zone 1 core is intended to reduce flow through any cracks that may develop.

VIII. Quantities and Field Cost Estimates

Appraisal-level field cost estimates were made for the 10-foot RWS raise in conjunction with the 20-foot embankment raise. Two estimates (Option A and Option B) were made in an attempt to bracket the uncertainty associated with the potential variability of the dam foundation. Only construction costs are presented here; that is, no contract, design, or remediation costs, or time escalation are included. The contingency includes 15 percent to cover costs for current “unlisted” items and 25 percent to reflect the uncertainty in the appraisal-level quantities. The estimate worksheets are included in Appendices A and B. The worksheets include costs for two different berm sizes for differing strength assumptions (middle estimate drained and undrained strength parameters from the CAS for the Slopewash and NVS-1 materials). Option A refers to quantities estimated based on static stability analyses using drained strength parameters, and Option B refers to quantities estimated using undrained strength parameters in the analyses.

Table 2 presents the quantities for the proposed 20-foot crest raise, Table 3 presents the quantities for the SVS berm, and Table 4 presents the quantities for the NVS berm. Quantities for the berms in the abutment sections are presented in Table 5. Table 6 presents the quantities for the dike. Excavation quantities are bank cubic yards (bcy), and fill quantities are compacted cubic yards.

Table 2. – Summary of Quantities for Crest Raise in Areas Not Analyzed for Static Stability

Common excavation	304,000
Zone 1 core	195,000
Sand and Gravel (Zones 4, 5, 6, 7 & 8)	646,000
Miscellaneous Fill	2,170,000

Table 3. – Summary of Quantities for Crest Raise in the SVS

68+00 to 99+00	Common excavation	131,000
	Filter	276,000
	Miscellaneous Fill	1,368,000

Table 4. – Summary of Quantities for Berms in the NVS

99+00 to 114+00	Common excavation	90,000
	Filter	530,000
	Miscellaneous Fill	1,085,000

TABLE 5. – SUMMARY OF QUANTITIES FOR BERMS IN THE ABUTMENTS

31+00 to 46+00	Common excavation	53,000	260,000
	Filter	210,000	274,000
	Miscellaneous Fill	427,000	738,000
56+00 to 68+00	Common excavation	147,000	466,000
	Filter	107,000	312,000
	Miscellaneous Fill	669,000	1,196,000
139+00 to 149+00	Common excavation	35,000	179,000
	Filter	239,000	319,000
	Miscellaneous Fill	561,000	936,000
165+00 to 173+00	Common excavation	14,000	
	Filter	20,000	
	Miscellaneous Fill	230,000	
176+00 to 183+00	Common excavation	37,000	
	Filter	32,000	
	Miscellaneous Fill	135,000	

TABLE 6. – SUMMARY OF QUANTITIES FOR THE DIKE

Dike	Common excavation	5,000
	Filter	8,000
	Miscellaneous Fill	15,000

Table 7 summarizes the field cost estimates for the embankment and structure modifications. The estimated cost for the crest raise, SVS and NVS sections, dike, and structures are the same for Options A and B. The difference in field costs between Option A and Option B is a result of the assumed soil strengths in the abutment sections. The estimated cost for the crest raise and dam/dike modifications, including the downstream berms where needed for static stability, is greater than 90 percent of the field costs. Modifications to the structures account for less than 10 percent of the field costs.

TABLE 7. – SUMMARY OF FIELD COSTS

Embankment Modifications:	
Crest Raise	$60,589,000
SVS Section	$28,491,900
NVS Section	$39,645,500
Abutment Sections	$53,531,600 to $87,022,500
Dike	$602,000
Structure Modifications:	
Intake Towers	$4,080,300
Spillway	$590,350
Bridge	$11,127,200
Roller Gate	$576,875
Gantry Crane	$557,200
Bulkhead Gate	$875,000
Subtotal:	$200,666,925 to $234,157,825
TOTAL ESTIMATED FIELD COSTS:	**$310,000,000 to $360,000,000**

NOTE: Total estimated field costs include mobilization (~5%), design contingencies (~15%), allowance for procurement strategies (~3%), and construction contingencies (~25%). See Appendices A and B for cost estimate worksheet details.

The values presented in Table 7 are field cost estimates made at the appraisal level and, as such, should not be used for authorization or as an indicator of total project costs. These values should also not be used in economic studies or as part of repayment negotiations with stakeholders. The estimates only include costs for construction and do NOT include associated costs for design, investigations, project coordination, contract administration, construction management, environmental studies, mitigation, operation and maintenance costs, etc.

Contingencies are considered funds to be used after construction starts and not for design changes during project planning. The purpose of contingencies is to identify funds to pay contractors for overruns on quantities, changed site conditions, change orders, etc. As per guidelines in Reclamation's Cost Estimating Handbook [4], appraisal-level estimates should have 25± percent added for contingencies. Based on the current level of design data, geologic information, and general knowledge of the conditions at the various sites, the contingency line item was set at 25± percent of the contract cost for all features. The contingency line item is a rounded value per Reclamation rounding criteria which may cause the dollar value to deviate from the actual percentage shown.

IX. Borrow Areas

The proposed modification will require significant quantity of fill for both the berms and the crest raise. To make the project as economical as possible, all of the required fill materials may be obtained from onsite sources. The following paragraphs are excerpted from the Appraisal-Level Construction Considerations report for B.F. Sisk Dam [3] and modified as needed for this appraisal-level study.

Proposed borrow locations are shown on Figure 15. Because of haul road constraints, environmental considerations, and other factors considered during the CAS, it is assumed that Zone 1 core material and miscellaneous fill will be excavated from Borrow Area 6 (O’Neill Forebay), and filter and slope protection material will be excavated from Borrow Area 1 (Basalt Hill). Information regarding environmental considerations can be found in the appraisal-level Borrow Site Environmental Evaluation Study completed for the CAS in the fall of 2009 by a collaboration of North State Resources, Inc. and ICF International [5]. Both Borrow Areas 1 and 6 are on Government-owned land and in locations previously borrowed for either the construction of the dam, the 1981 upstream slope failure repair, or the 1983 riprap overlay at O’Neill Dam.

A. Borrow Area 1 – Basalt Hill

Basalt Hill is located on the right side of the embankment about 2 miles upstream of the right abutment (see Figure 15 and Photo 1). Basalt Hill was extensively investigated for riprap during the planning phases of the original design. Two test quarries were developed in 1962. The first quarry was intended to develop production techniques, and the second was to provide grading characteristics and rock quality with depth. The top of the hill was quarried for riprap and filter materials in the 1960s, 1982, and 1983.

For the original dam construction and production of the Zone 4 filter and Zone 5 riprap, the rock was produced using 9-inch drill holes 40 to 50 feet in length. The holes were spaced on 22-foot centers and were loaded with ammonium nitrate and a 75-percent strength waterproof primer. Production averaged 0.6 to 0.75 pound of powder per yard of rock. The production rock was separated at 8 inches for the two materials.

Photo 1 – Borrow Area 1, BASALT HILL ROCK QUARRY

It is assumed this quarry will be brought back into production, and materials for the slope protection and filters required for the crest raise and berms will be obtained from this source. This includes all granular fill materials (Zones 4, 5, 6, 7 and 8). Fill material for the downstream stability berms could also be produced here. It is estimated that about 14.5 million bank cubic yards (bcy) would be available from this area. A 2006 email correspondence sited in [3] indicated there was difficulty finding acceptable riprap for the 1981 slide repair at B.F. Sisk. There was minimal detail in the correspondence, but it could be inferred that the problem was obtaining the large sizes required. This will only by an issue for the Zone 5 riprap, and the required quantity is not large.

The quarrying process for the required materials will most likely be drilling and blasting, with spacing of drill holes optimized for the appropriate gradation requirements. The filter materials will require additional processing by screening and washing.

B. Borrow Area 6 – O'Neill Forebay

The O'Neill Forebay borrow area is located about 2 miles downstream of B.F. Sisk Dam (see Figure 15 and Photo 2). This area is not specifically shown on Figure 15, but the general direction to the area and access route are. This site was used during original construction of B.F. Sisk Dam and the O'Neill Forebay in the 1960s. The existing extended face will be excavated southward and eastward. The available soil is fine grained, so this area will be used to obtain the Zone 1 impervious core for the crest raise. It is estimated that approximately 9.3 million bcy of common excavation would be available from this site. Normal soil excavation methods would be used at this site; however, there are high tension power lines through the site that will have to be avoided.

PHOTO 2 – EXCAVATED FACE OF BORROW AREA 6

C. Haul Roads

Haul roads that were identified during the CAS are shown on Figure 15. Most of the roads already exist and have been used in the past, but there will be significant rehabilitation required to make the roads usable for this construction project. The existing roads, at best, are capable of two-way traffic with passenger vehicles, and many of the dirt access roads are one-way traffic only. It is anticipated that most haul roads would be modified for two-way traffic. The most significant new haul road construction will be for access to the left abutment berms. A new hauls road up onto the downstream slope of the dam around the open spillway chute will have to be constructed. Access would be from the valley. In addition, the haul road to Borrow Area 6 (O'Neill Forebay site) requires the reconstruction of an access road under the State Highway 152 bridge adjacent to the Forebay channel for the Gianelli Pumping-Generating Plant. This haul road was originally constructed for riprap repair at the O'Neill Forebay Dam in 1983 by the DWR. The proposed approximate haul route alignment and location beneath the State Highway 152 bridge are shown on Photos 3 and 4, respectively.

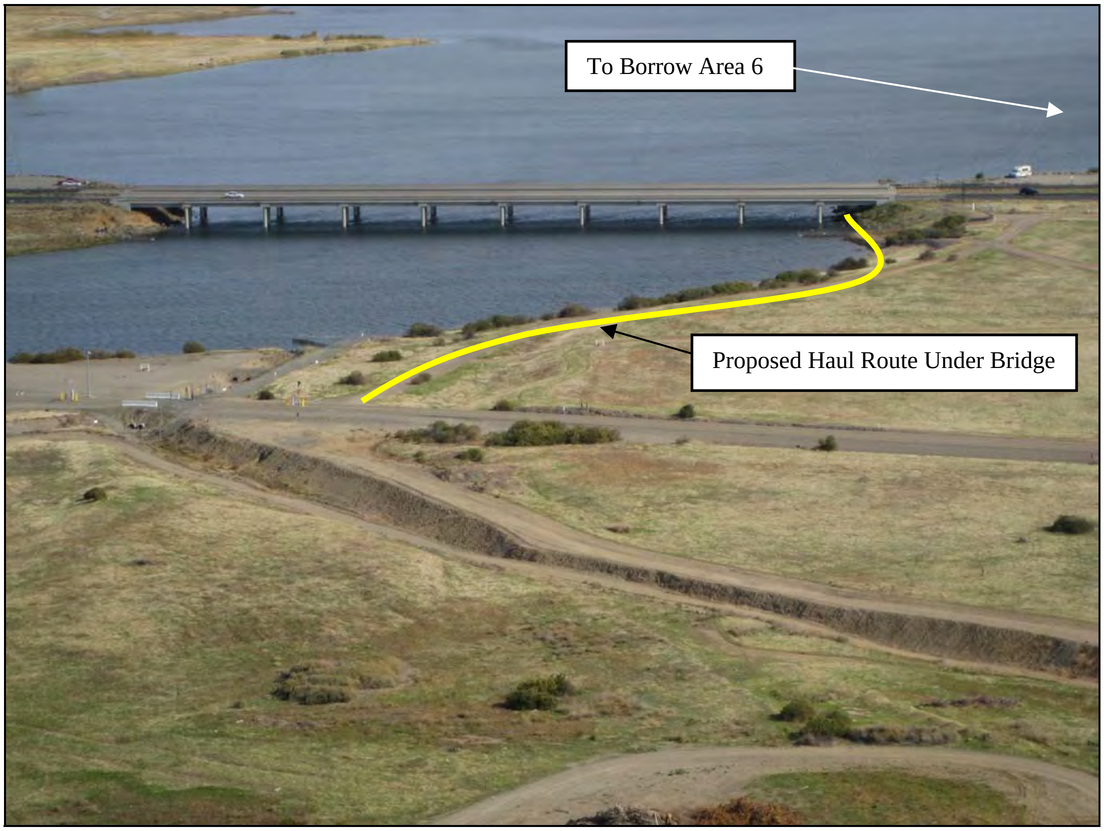

PHOTO 3 – PROPOSED HAUL ROUTE TO BORROW AREA 6 UNDER STATE HIGHWAY 152 BRIDGE

A proposed section of the revised alignment under the bridge is shown on Figure 18. The haul road would be one-way traffic under the bridge due to width restrictions. Depending on the recreational access remaining open during construction, traffic control would be required.

PHOTO 4 – PROPOSED LOCATION FOR ACCESS ROAD UNDER HWY 152 BRIDGE FOR BORROW AREA 6

1. Haul Road Constraints

The following bullets identify potential or real constraints that may affect the transportation of construction materials.

- Use of the crest road of the dam will not likely be allowed for use as a haul road. The crest will be either simultaneously under construction with the downstream berm additions, or the berm contractor will not be allowed to utilize the crest road to prevent damage from the large construction equipment.
- The spillway chute bisects the downstream area at approximately station 139+00. It would be preferred to have borrow sources on both sides of the spillway to simplify earthmoving operations for berm construction.
- There are several recreational areas on the upstream south side of the dam, the most significant of which is the Basalt Hill Campground. Construction haul roads for the Basalt Hill Quarry will likely impact access to at least some of these areas. It is probable that Basalt Hill Road will be closed beyond (upstream) of the campground. Access to the recreation areas should be considered during future planning for construction. It might be possible to

perform borrow operations mainly during the off-season to minimize impacts to recreation. If any of the recreation areas are open during the construction period, traffic control will be necessary.

X. Construction Methods

A. Borrow Area Excavation Methods

Borrow Area 6 will provide Zone 1 material for the crest raise and miscellaneous fill for the downstream berms. The haul route to the crest of the dam will be more than 3 miles, but off-road vehicles can be used. Common excavation methods will be sufficient – either large excavators and off-road dump trucks, or scrapers.

The Basalt Hill Quarry will be used to produce several types of materials. Material for Zones 4, 6, 7 and 8 will require processing to meet gradation requirements. Large excavators would likely be used to collect the shot rock for processing. Production of these materials would be accomplished using crushers and screens for material separation. Washing will be required for the filter materials. Materials will initially be stockpiled. Distribution of processed materials could be accomplished using either front-end loaders or conveyor systems. Quality control will be critical, so an on-site geotechnical testing laboratory and record control testing program will be required.

B. Crest Raise Excavation and Backfill Methods

1. Excavation

The existing crest consists of riprap and bedding upstream, the Zone 1 core, and a thin zone of rock fill on the downstream crest. The crest will be excavated down 10 feet before the raise section will be placed. Due to the limited work area, the zoned materials would be difficult to segregate, so they will likely be mixed during excavation and could be used for berm fill. Except for the riprap, these materials could be excavated using scrapers, though the dam materials are well compacted and may present some difficulty. Excavators and dump trucks may be the preferred method. The dam at the crest is only 30 feet wide, so both excavation and backfill operations will be difficult. Due to the limited area and the zoning of the backfill materials, it is anticipated that smaller and more maneuverable construction equipment will be used.

For the downstream filters, the rock blanket on the downstream slope will be removed. Excavation on the steep slope will probably be performed with excavators and trucks. Due to the length of the dam and the tight working conditions, progress of this work is expected to be slow.

2. Backfill

The backfill detail for the crest consists of several different zones of materials. Backfill operations would probably initiate by placing the downstream filter materials. The horizontal thickness of each of the three zones is only 8 feet, so care would be required when placing the zone lifts to avoid significant mixing. It is likely the placement would be by tractor and box dump, or a similar method. When the downstream work reaches the level of the crest excavation, three more zones of material are added, so placement will remain difficult. The wider zones are the Zone 1 core and upstream Zone 4 slope protection. The Zone 1 and Zone 4 materials could be placed using similar methods to the downstream slope filters. All materials for the crest raise will come from the right abutment access. Compaction of the Zone 1 core will be by tamping rollers, and compaction of all other zones will be with smooth drum vibratory rollers. Again, due to the length of the dam and the tight working conditions, progress of this work is expected to be slow.

C. Berm Excavation and Backfill Methods

1. Excavation

Excavation of the slopewash and NVS-1 foundation materials prior to berm construction will be performed to improve the stability of the dam. The excavation will extend to Panoche formation bedrock consisting of sandstone, shale, and conglomerate beds. Soft materials will be removed, and the bedrock contact will be cleaned using air or water methods prior to backfilling. The excavated slope adjacent to the dam will match the existing downstream slope of the dam, typically 2.5:1 horizontal to vertical (H:V). The excavation footprints for the berms are large, so excavation will likely be performed with scrapers. The excavated materials will be stockpiled for use during backfill operations. Groundwater may be encountered during the excavation depending upon the depth required, so unwatering will likely be required at some locations, especially in the valley. Groundwater will probably be controlled using sumps where needed.

2. Backfill

Backfill materials for the berms will be random materials and filter/drainage zones, both from the required excavation as well as from one of the two borrow areas. Material will likely be transported either by scraper or dump truck. Compaction of the berm fill will be required, so the backfill material should meet appropriate moisture requirements for the material being placed. A horizontal filter under the berm and a chimney filter between the berm and existing dam will also be constructed. The horizontal filter could be easily placed by dump trucks, but the chimney filter would again probably be placed by tractor and box dump, or a similar method. Compaction of the filter will be with vibratory rollers. The filter material would be processed from quarried rock originating at Basalt Hill.

XI. Summary

The following list summarizes the construction considerations that have been identified during this appraisal-level study for increased storage at B.F. Sisk Dam, as well as the concurrent CAS for B.F. Sisk Dam. This list identifies key considerations, but may not be all inclusive.

- The dam was divided into three sections for the purpose of this study: the NVS, the SVS, and the abutment sections.
- Downstream stability berms are necessary to maintain static stability of the dam for the proposed 10-foot RWS and 20-foot embankment raise. A downstream berm is not needed for the dike.
- Zoning of backfill materials will require use of at least two borrow sources. All materials will be obtained from on-site sources:
    - Basalt Hill Quarry for riprap and all filter materials.
    - O’Neill Forebay borrow area for Zone 1 impervious material to be used in the crest raise, as well as miscellaneous fill materials for placement in the downstream berms.
- The Basalt Hill Quarry will process several different filter materials and riprap. Production of these materials will have to occur early in the construction schedule because they are required for all backfill operations. Stockpiling of the processed materials will be necessary.
- An on-site geotechnical laboratory will be required for quality control purposes.
- Haul routes exist for access to the proposed borrow sources, though significant work will be required to prepare them for the construction operation.
- The haul road to the O’Neill Forebay borrow area will be constructed underneath the State Highway 152 bridge at the inlet channel for the Gianelli Pumping-Generating Plant. The road will be limited to one-way traffic due to space limitations.

- It is likely that a new haul road will have to be constructed on the downstream slope of the dam around the spillway chute for access to berm construction on the downstream left abutment area.
- The centerline alignment of the crest raise will be adjusted downstream so the fill does not decrease storage. This will require a significant amount of fill over the downstream slope and may require covering part of the open spillway chute to accommodate fill. This should be evaluated during the feasibility phase of study.
- Construction sequencing will be required to allow some of the outlet works intake towers to remain operational while other towers undergo demolition and reconstruction. Due to the location of the intake towers within the reservoir, the limited access, and the desire to maintain water storage during construction, use of a barge will likely be required for demolition and construction of the intake towers.
- Construction sequencing will be required for excavation, demolition, and reconstruction of the spillway to ensure the reservoir water surface is well below the level of the modifications.
- Due to the location of the bridge pier foundations within the reservoir, the limited access, and the desire to maintain water storage during construction, use of a barge may be required for all or a portion of the demolition and construction of the intake towers access bridge. This will be dependent on the RWS elevation.
- Construction may impact several recreation areas around the reservoir. Evaluation of whether these areas can remain open during construction should be considered during the feasibility phase of study.
- Further study of the environmental impacts of the borrow areas will be required.
- The scope of the proposed modifications will probably require phasing the work. Coordination between contractors will be required.

XII. Conclusions and Recommendations

An appraisal-level analysis was performed and documented in this TM pertaining to the alternatives that would increase the reservoir capacity of San Luis Reservoir. In order to raise B.F. Sisk Dam, increase storage capacity within San Luis Reservoir, and achieve a factor of safety of 1.5 for static slope stability, modifications to the embankment and dike are needed. Modifications to the spillway, intake towers, and access bridge are needed to accommodate an RWS raise and 20-foot embankment raise. Modifications to the existing concrete structures require attaching new concrete to existing structures. This will require adding structural concrete and careful preparation of the interface between old and new concrete.

Increases of the reservoir water surface elevation by 6 feet and 10 feet were considered in conjunction with a 20-foot embankment raise. Two additional alternatives: 1) steepened upstream and downstream slopes, and 2) vertical upstream and downstream slopes using an MSE wall, were eliminated from further consideration during the CAS due to the lack of erosion control measures these alternatives provide in the event of a large earthquake that causes significant cracking of the crest.

The preferred alternative to increase storage capacity in San Luis Reservoir is to raise the reservoir water surface by 10 feet to elevation 554.0 and raise the embankment 20 feet to elevation 574.0. This design alternative was identified based on balancing the need for additional water while minimizing impacts to existing facilities, namely the Gianelli Pumping-Generating Plant. The design details presented in this document are subject to change during the next phases of design.

Before a structural raise or other modifications to increase storage capacity could be considered, safety of dams (SOD) issues and deficiencies, as reported in the 2009 CFR report for B.F. Sisk Dam and the ongoing CAS, would have to be addressed. Specifically, the outcome of the concurrent CAS which was undertaken to evaluate seismic potential failure modes must be considered in the design of a raise.

Quantitative risks associated with a reservoir raise and construction have not been evaluated; both construction risks and long-term risks will need to be evaluated prior to final design. The alternative selected for increasing reservoir storage at B.F. Sisk Dam should not increase the risks to the downstream population when compared to the existing dam and reservoir. The safe performance of the proposed dam, dike, and structures during all expected loading conditions should equal or exceed that of the existing structure. This includes responses of the embankment, dike, and structures when exposed to seismic loading conditions. Results of the concurrent CAS to evaluate seismic potential failure modes must be considered and, to the extent appropriate, incorporated into the design of the raise.

The construction cost estimates provided for this study are based on available information. This document is based on the most probable estimate. However, further studies may result in a shift to alternative concepts not represented by the most probable estimate. Total field costs to raise the embankments by 20 feet and allow a 10-foot RWS raise, including modifications to the spillway, intake towers, and access bridge, are estimated between $310 and $360 million. The costs of design, design support, construction support and construction support activities are not included in the estimated field cost. The field cost estimates for this study do include estimates for mobilization, design and construction contingencies, and allowance for procurement strategies. Other project costs such as lost power revenues, environmental mitigation, and land acquisition are also not included in the construction cost estimate.

The results of this study indicate that future studies examining the opportunities for enlarging B.F. Sisk Dam and San Luis Reservoir can proceed. Through more advanced studies, engineering considerations and cost savings measures can be refined, operational opportunities can be further defined in the context of statewide water issues and programs, and benefits can be optimized in relation to meeting multiple demands. Development of a feasibility study program should be developed in coordination with Reclamation's Dam Safety Office, the State of California, DWR and other entities to ensure development of an acceptable plan for implementation, especially in light of the ongoing CAS to address seismic deficiencies at the dam.

XIII. Future Needs and Work

A. Final Design Data

The following is a partial list of data that will be needed for final design:

Borrow area delineation, explorations, laboratory testing
Concrete aggregate sources
Topography of reservoir road and State Highway
Determination of whether these roads will require relocation
Geologic data and material properties in relocated road areas
Design-level seismotectonic study
Determination of risk associated with a reservoir raise
Determination of construction risk
Limitations on construction seasons
Operational requirements during and after construction
Description of park maintenance and recreation facilities to be relocated
Identify fences/gates in area which need to be maintained
Security requirements
Location of utilities, overhead and underground
Location of Contractors use area
Delineation of wetlands and other areas that are not to be disturbed

Seeding and vegetation requirements
Water quality issues
Data required for permit process
Any special requirements/permits by county or state
New dam failure inundation mapping

B. Reservoir Rim Stability Issue

The reservoir rim currently has six areas which are unstable, where sliding has occurred in the past and may continue in the future [1]. The landslides are not considered a dam safety issue since they would not create a wave large enough to overtop the dam. The main concerns with the landslides are the damage it may do to the roads adjacent to the reservoir.

Raising the reservoir water surface has the potential to impact the stability of the reservoir rim. The slide areas are not considered large enough to impact the safety of the dam, but could cause increased damage to roads adjacent to the reservoir. If the additional water load will increase sliding, then remedial measures may need to be designed and included in the overall cost of raising the dam.

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References

[1] “Comprehensive Facility Review – B.F. Sisk Dam, Central Valley Project, Mid-Pacific Region”, U.S. Department of the Interior, Bureau of Reclamation, Technical Service Center, Denver, Colorado, June 2009.

[2] “Technical Record of Design and Construction, Volumes I, II, and III”, Central Valley Project, West San Joaquin Division, San Luis Unit, California, U.S. Department of the Interior, Bureau of Reclamation, Denver, Colorado, December 1974.

[3] “Appraisal-Level Construction Considerations”, TM No. VB-8313-9, B.F. Sisk Dam, Central Valley Project, Mid-Pacific Region, California, U.S. Department of the Interior, Bureau of Reclamation, Technical Service Center, Denver, Colorado, May 2010.

[4] “Cost Estimating Handbook”, U.S. Department of the Interior, Bureau of Reclamation, Denver Office, Construction Division, Engineering Support Branch, Revised March 1989.

[5] “Borrow Site Environmental Evaluation Report”, Technical Memorandum, North State Resources, Inc. and ICF International, Redding California, February 2010.

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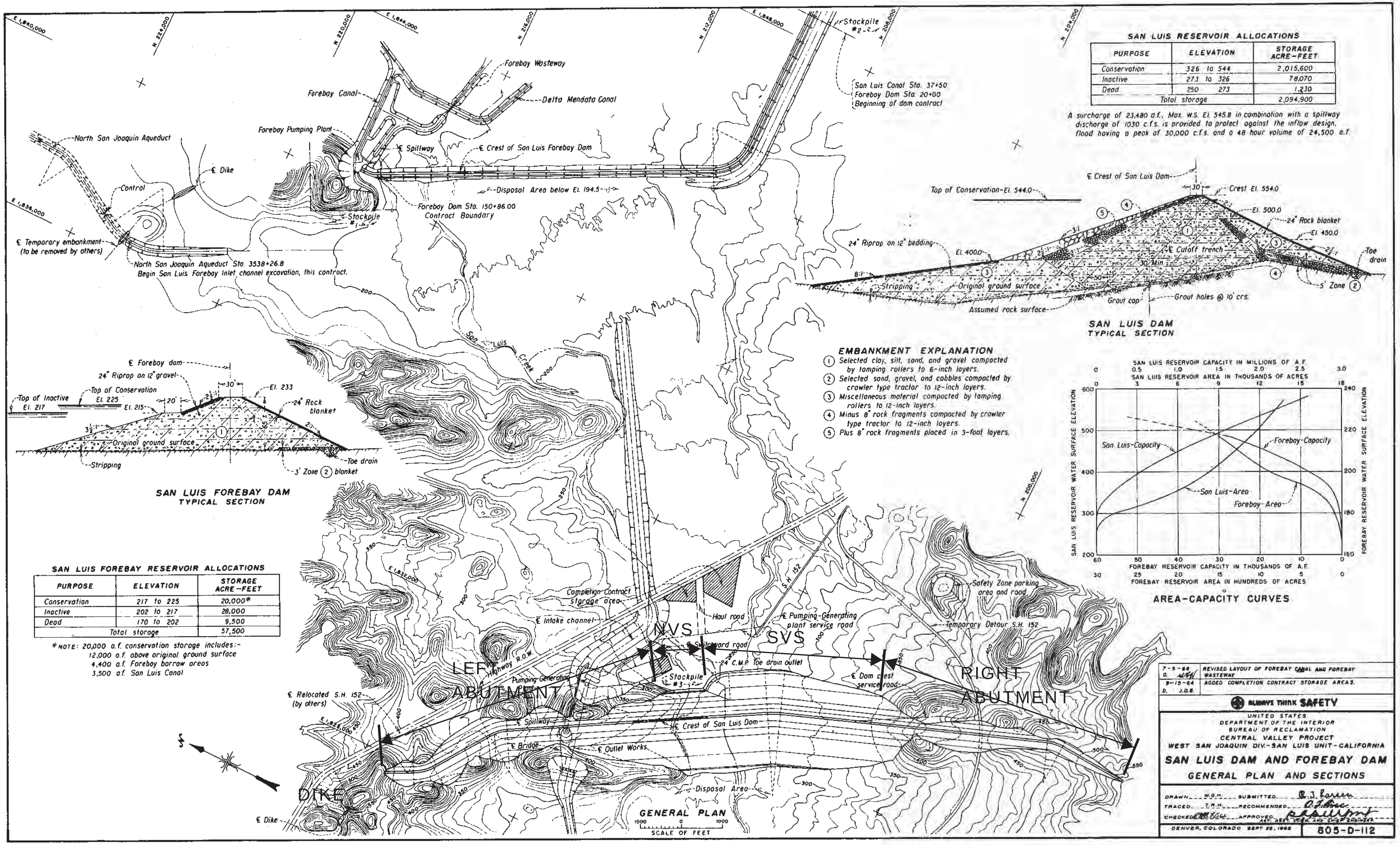
Figures

List of Figures



SAN LUIS RESERVOIR ALLOCATIONS

PURPOSE	ELEVATION	STORAGE ACRE-FEET
Conservation	326 to 544	2,015,600
Inactive	273 to 326	78,070
Dead	250 273	1,230
Total storage		2,094,900

A surcharge of 23,480 a.f., Max. W.S. El. 545.8 in combination with a spillway discharge of 1030 c.f.s. is provided to protect against the inflow design, flood having a peak of 30,000 c.f.s. and a 48 hour volume of 24,500 a.f.

EMBANKMENT EXPLANATION

① Selected clay, silt, sand, and gravel compacted by tamping rollers to 6-inch layers.
② Selected sand, gravel, and cobbles compacted by crawler type tractor to 12-inch layers.
③ Miscellaneous material compacted by tamping rollers to 12-inch layers.
④ Minus 8" rock fragments compacted by crawler type tractor to 12-inch layers.
⑤ Plus 8" rock fragments placed in 3-foot layers.

SAN LUIS FOREBAY RESERVOIR ALLOCATIONS

PURPOSE	ELEVATION	STORAGE ACRE-FEET
Conservation	217 to 225	20,000*
Inactive	202 to 217	28,000
Dead	170 to 202	9,500
Total storage		57,500

*NOTE: 20,000 a.f. conservation storage includes:-
12,000 a.f. above original ground surface
4,400 a.f. Forebay borrow areas
3,500 a.f. San Luis Canal

7-5-66 D.	REVISED LAYOUT OF FOREBAY CANAL AND FOREBAY WASTEWAY
9-15-64 D. J.O.B.	ADDED COMPLETION CONTRACT STORAGE AREAS.

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WEST SAN JOAQUIN DIV.-SAN LUIS UNIT-CALIFORNIA

SAN LUIS DAM AND FOREBAY DAM

GENERAL PLAN AND SECTIONS

DRAWN W.G.H. SUBMITTED R. J. Larsen
TRACED T.R.H. RECOMMENDED
CHECKED APPROVED
ACT. ASST. COMM. AND CHIEF ENGINEER
DENVER, COLORADO SEPT. 22, 1962
805-D-112

Figure 2

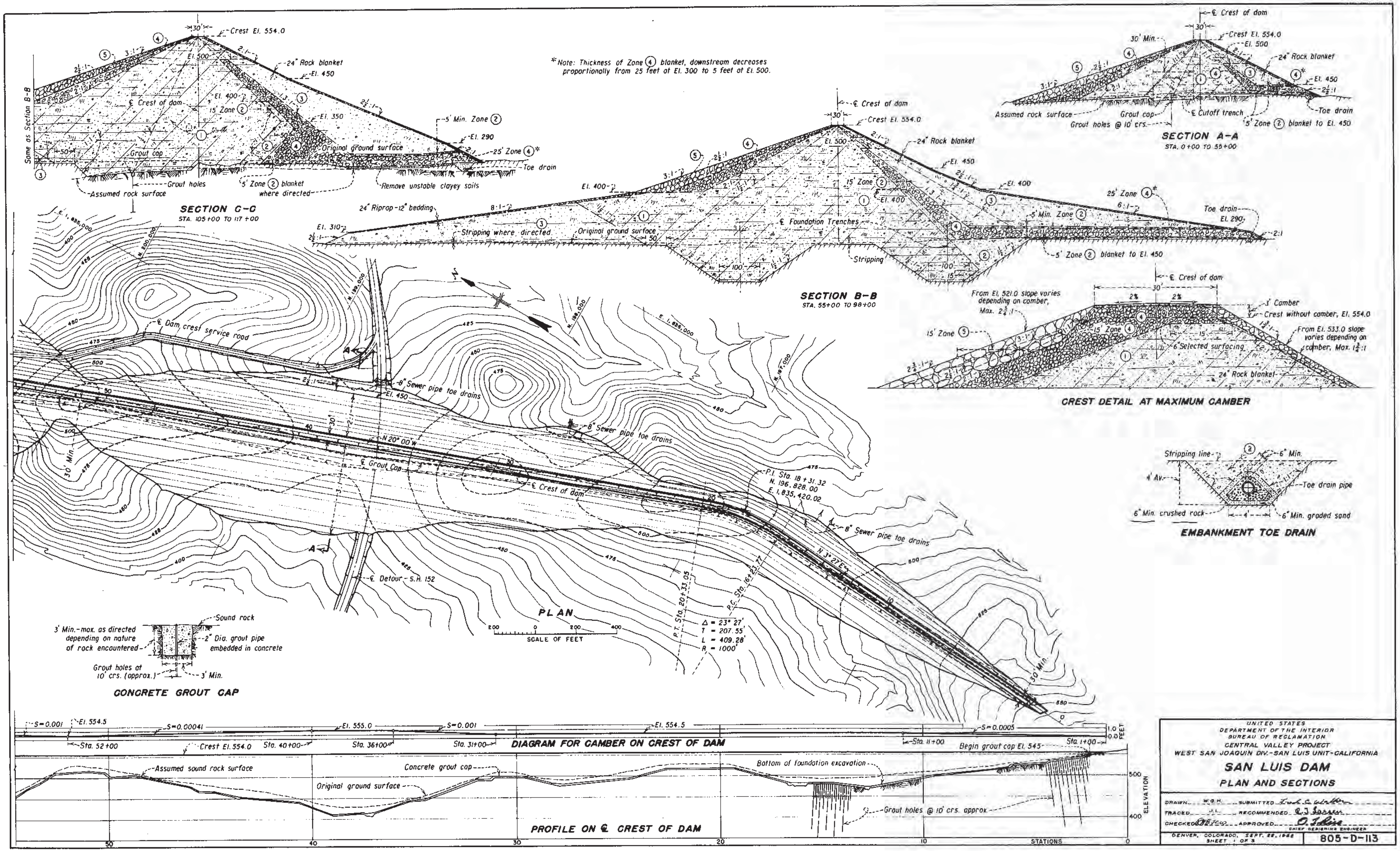

SECTION C-C
STA. 105+00 TO 117+00
*Note: Thickness of Zone ④ blanket, downstream decreases proportionally from 25 feet at El. 300 to 5 feet at El. 500.
Crest El. 554.0
24" Rock blanket
℄ Crest of dam
15' Zone ②
Original ground surface
5' Min. Zone ②
25' Zone ④*
Toe drain
Grout cap
Grout holes
Assumed rock surface
5' Zone ② blanket where directed
Remove unstable clayey soils
Same as Section B-B
SECTION B-B
STA. 55+00 TO 98+00
24" Riprap-12" bedding
Stripping where directed
℄ Foundation Trenches
Stripping
5' Zone ② blanket to El. 450
Toe drain- El. 290
SECTION A-A
STA. 0+00 TO 55+00
Assumed rock surface
Grout holes @ 10' crs.
℄ Cutoff trench
5' Zone ② blanket to El. 450
CREST DETAIL AT MAXIMUM CAMBER
From El. 521.0 slope varies depending on camber, Max. 2¾:1
3' Camber
Crest without camber, El. 554.0
From El. 533.0 slope varies depending on camber, Max. 1¾:1
15' Zone ⑤
15' Zone ④
6" Selected surfacing
EMBANKMENT TOE DRAIN
Stripping line
6" Min.
Toe drain pipe
6" Min. crushed rock
6" Min. graded sand
PLAN
℄ Dam crest service road
8" Sewer pipe toe drains
N 20° 00' W
℄ Grout Cap
℄ Crest of dam
℄ Detour - S.H. 152
P.I. Sta. 18+31.32
N. 196,828.00
E. 1,835,420.02
N 3° 27' E
P.T. Sta. 20+33.05
P.C. Sta. 16+23.77
Δ = 23° 27'
T = 207.55'
L = 409.28'
R = 1000'
SCALE OF FEET
CONCRETE GROUT CAP
3' Min.-max. as directed depending on nature of rock encountered
Sound rock
2" Dia. grout pipe embedded in concrete
Grout holes at 10' crs. (approx.)
3' Min.
DIAGRAM FOR CAMBER ON CREST OF DAM
PROFILE ON ℄ CREST OF DAM
Assumed sound rock surface
Original ground surface
Concrete grout cap
Bottom of foundation excavation
Begin grout cap El. 545
Grout holes @ 10' crs. approx.
ELEVATION
STATIONS
UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
CENTRAL VALLEY PROJECT
WEST SAN JOAQUIN DIV.-SAN LUIS UNIT-CALIFORNIA
SAN LUIS DAM
PLAN AND SECTIONS
DRAWN W.G.H. SUBMITTED
TRACED J.L. RECOMMENDED
CHECKED APPROVED O. T. Rise
CHIEF DESIGNING ENGINEER
DENVER, COLORADO, SEPT. 22, 1962
SHEET 1 OF 3
805-D-113

Figure 3

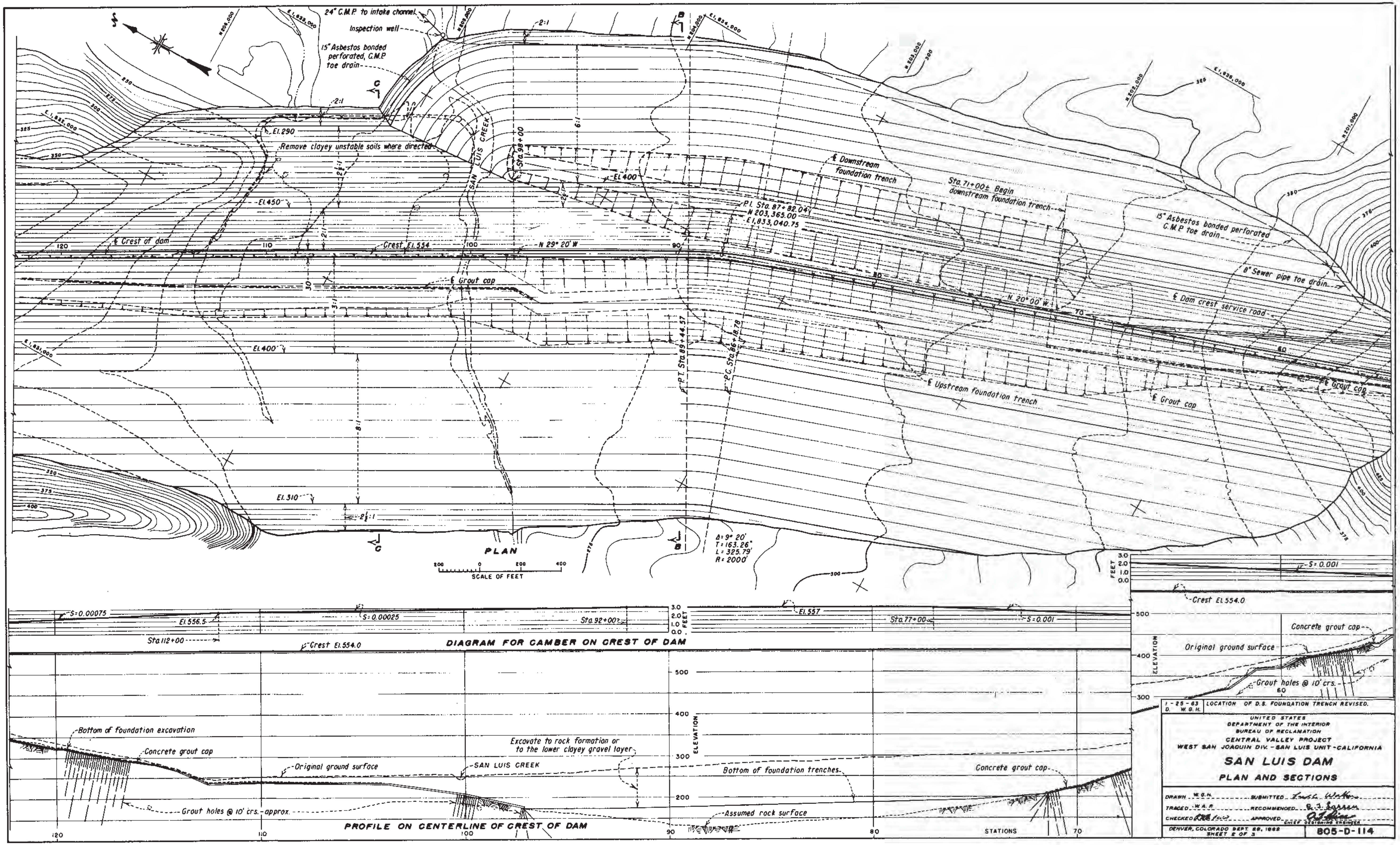
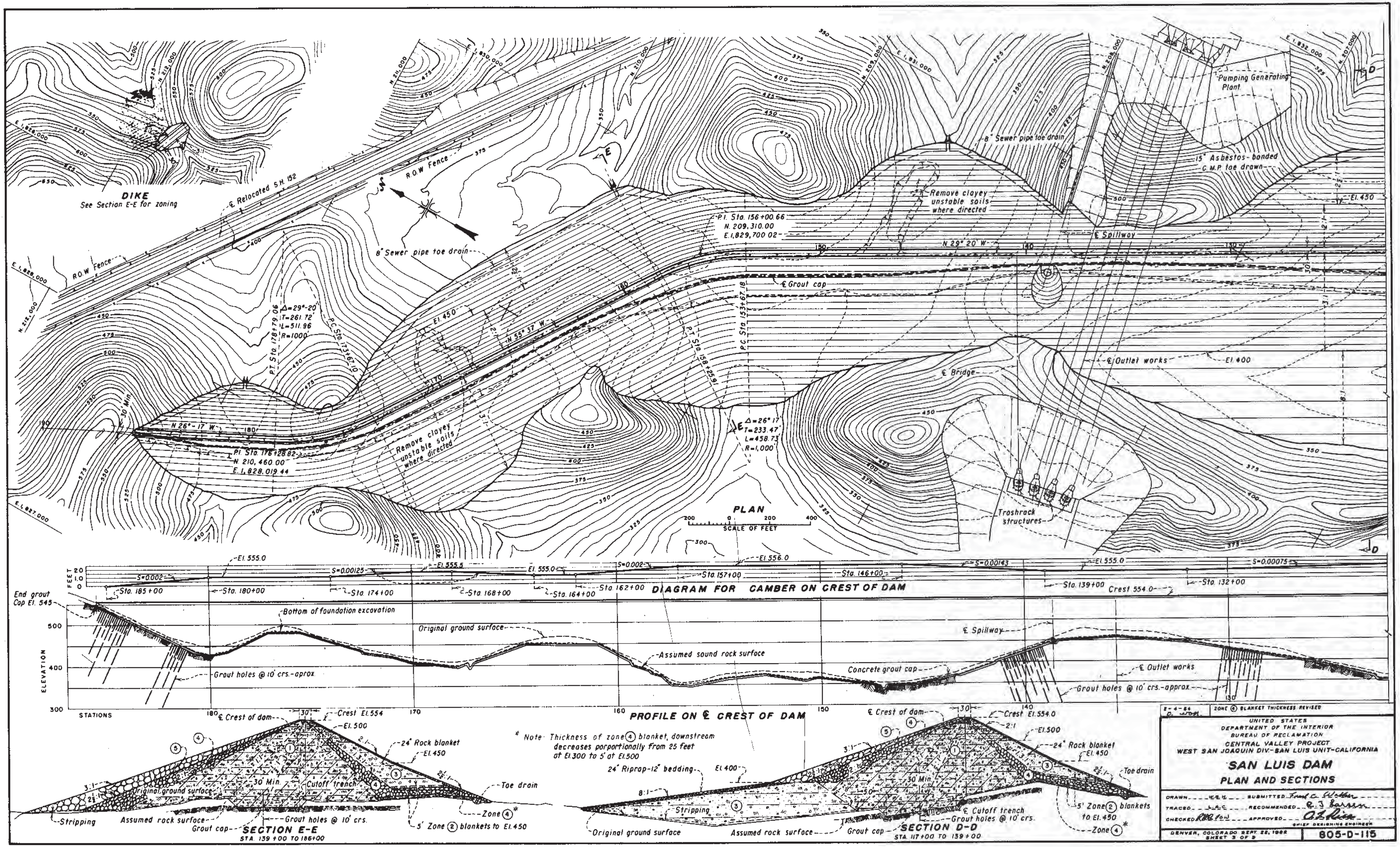

24" C.M.P. to intake channel
Inspection well
15" Asbestos bonded perforated, C.M.P. toe drain
2:1
6:1
El. 290
Remove clayey unstable soils where directed
El. 450
El. 400
SAN LUIS CREEK
Sta. 98+00
℄ Downstream foundation trench
Sta. 71+00± Begin downstream foundation trench
P.I. Sta. 87+82.04
N 203,365.00
E 1,833,040.75
15" Asbestos bonded perforated C.M.P. toe drain
8" Sewer pipe toe drain
℄ Dam crest service road
℄ Crest of dam
Crest El. 554
N 29° 20' W
N 20° 00' W
℄ Grout cap
P.T. Sta. 89+44.57
P.C. Sta. 86+18.78
℄ Upstream foundation trench
℄ Grout cap
8:1
3:1
2½:1
El. 310
Δ = 9° 20'
T = 163.26'
L = 325.79'
R = 2000'
PLAN
SCALE OF FEET
DIAGRAM FOR CAMBER ON CREST OF DAM
S = 0.00075
El. 556.5
S = 0.00025
Sta. 112+00
Sta. 92+00
El. 557
Sta. 77+00
S = 0.001
Crest El. 554.0
Bottom of foundation excavation
Concrete grout cap
Excavate to rock formation or to the lower clayey gravel layer
Original ground surface
SAN LUIS CREEK
Bottom of foundation trenches
Grout holes @ 10' crs. approx.
Assumed rock surface
PROFILE ON CENTERLINE OF CREST OF DAM
STATIONS
ELEVATION
Concrete grout cap
Original ground surface
Grout holes @ 10' crs.
1-25-63 D. W.G.H. LOCATION OF D.S. FOUNDATION TRENCH REVISED.
UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
CENTRAL VALLEY PROJECT
WEST SAN JOAQUIN DIV. - SAN LUIS UNIT - CALIFORNIA
SAN LUIS DAM
PLAN AND SECTIONS
DRAWN W.G.H. SUBMITTED
TRACED W.A.P. RECOMMENDED
CHECKED APPROVED CHIEF DESIGNING ENGINEER
DENVER, COLORADO SEPT. 26, 1962 SHEET 2 OF 3
805-D-114

Figure 4

DIKE
See Section E-E for zoning
℄ Relocated S.H. 152
R.O.W. Fence
R.O.W. Fence
8" Sewer pipe toe drain
Δ=29°-20'
T=261.72
L=511.96
R=1000
P.T. Sta. 178+79.06
P.C. Sta. 173+67.10
N 26°-17' W
P.I. Sta. 176+28.82
N. 210,460.00
E. 1,828,019.44
N 55°37' W
El. 450
Remove clayey unstable soils where directed
P.I. Sta. 156+00.66
N. 209,310.00
E. 1,829,700.02
℄ Grout cap
P.T. Sta. 158+25.91
P.C. Sta. 153+67.18
Δ=26°17'
T=233.47'
L=458.73
R=1,000
PLAN
200 0 200 400
SCALE OF FEET
Remove clayey unstable soils where directed
8" Sewer pipe toe drain
N 29° 20' W
℄ Spillway
Pumping Generating Plant
15" Asbestos-bonded C.M.P. toe drain
El. 450
El. 400
℄ Outlet works
℄ Bridge
Trashrack structures
D
D
E
E
DIAGRAM FOR CAMBER ON CREST OF DAM
El. 555.0
S=0.002
S=0.00125
El. 555.5
El. 555.0
S=0.002
El. 556.0
S=0.00143
El. 555.0
S=0.00075
Sta. 185+00
Sta. 180+00
Sta. 174+00
Sta. 168+00
Sta. 164+00
Sta. 162+00
Sta. 157+00
Sta. 146+00
Sta. 139+00
Crest 554.0
Sta. 132+00
FEET
End grout Cap El. 545
Bottom of foundation excavation
Original ground surface
Assumed sound rock surface
Grout holes @ 10' crs.-aprox.
Concrete grout cap
℄ Spillway
℄ Outlet works
Grout holes @ 10' crs.-approx.
ELEVATION
500
400
300
STATIONS
180
170
160
150
140
130
PROFILE ON ℄ CREST OF DAM
℄ Crest of dam
30'
Crest El. 554
El. 500
24" Rock blanket
El. 450
3:1
2½:1
Original ground surface
30' Min.
Cutoff trench
Toe drain
Stripping
Assumed rock surface
Grout cap
Grout holes @ 10' crs.
5' Zone ② blankets to El. 450
Zone ④*
SECTION E-E
STA. 139+00 TO 186+00
* Note: Thickness of zone ④ blanket, downstream decreases porportionally from 25 feet at El. 300 to 5' at El. 500
24" Riprap-12" bedding
El. 400
8:1
Stripping
Original ground surface
Assumed rock surface
Grout cap
℄ Crest of dam
30'
Crest El. 554.0
El. 500
24" Rock blanket
El. 450
30' Min.
Toe drain
℄ Cutoff trench
Grout holes @ 10' crs.
5' Zone ② blankets to El. 450
Zone ④*
SECTION D-D
STA. 117+00 TO 139+00
2-4-64 D. JOM
ZONE ④ BLANKET THICKNESS REVISED
UNITED STATES
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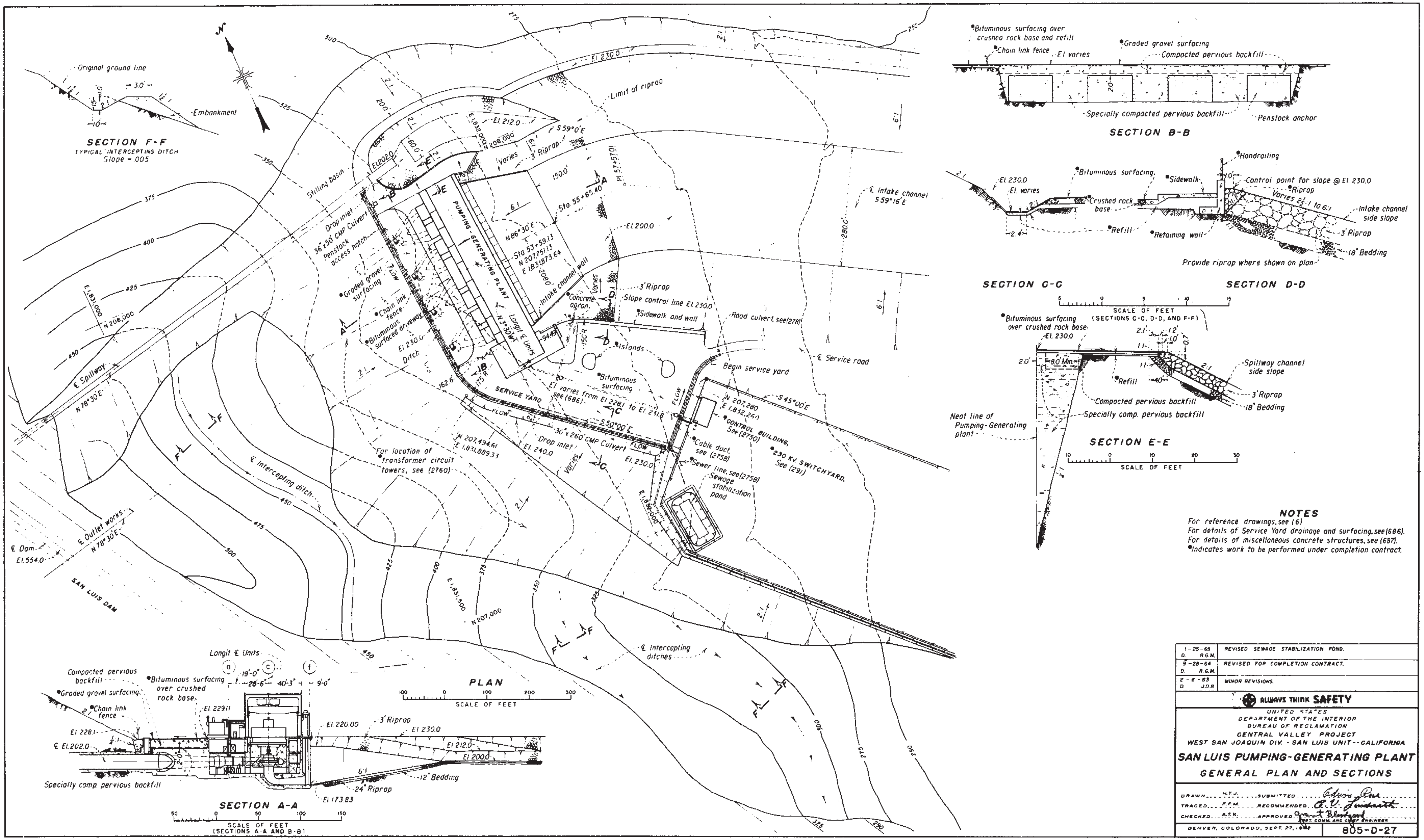
WEST SAN JOAQUIN DIV.-SAN LUIS UNIT-CALIFORNIA
SAN LUIS DAM
PLAN AND SECTIONS
DRAWN W.G.H. SUBMITTED Fred C. Walker
TRACED L.A.C. RECOMMENDED G. J. Larsen
CHECKED RWB for J APPROVED A. F. Rice
CHIEF DESIGNING ENGINEER
DENVER, COLORADO SEPT. 22, 1962
SHEET 3 OF 3
805-D-115

Figure 5


SECTION F-F
TYPICAL INTERCEPTING DITCH
Slope = .005
Original ground line
Embankment
SECTION B-B
Bituminous surfacing over crushed rock base and refill
Chain link fence
El varies
Graded gravel surfacing
Compacted pervious backfill
Specially compacted pervious backfill
Penstock anchor
SECTION C-C
SECTION D-D
Handrailing
Bituminous surfacing
Sidewalk
Control point for slope @ El. 230.0
Riprap
Intake channel side slope
Crushed rock base
Refill
Retaining wall
3" Riprap
18" Bedding
Provide riprap where shown on plan
SCALE OF FEET (SECTIONS C-C, D-D, AND F-F)
SECTION E-E
Spillway channel side slope
Neat line of Pumping-Generating plant
Compacted pervious backfill
Specially comp. pervious backfill
SCALE OF FEET
PUMPING-GENERATING PLANT
Stilling basin
Drop inlet
36"x50" CMP Culvert
Penstock access hatch
Graded gravel surfacing
Chain link fence
Bituminous surfaced driveway
Intake channel wall
Limit of riprap
℄ Intake channel S 59°16' E
℄ Spillway N 78°30' E
℄ Outlet works N 78°30' E
℄ Dam El. 554.0
SAN LUIS DAM
SERVICE YARD
Begin service yard
℄ Service road
Road culvert, see (278)
Islands
CONTROL BUILDING, See (2750)
230 KV SWITCHYARD, See (291)
Cable duct, see (2758)
Sewer line, see (2758)
Sewage stabilization pond
30"x260' CMP Culvert
For location of transformer circuit towers, see (2760)
℄ Intercepting ditch
℄ Intercepting ditches
PLAN
SCALE OF FEET
SECTION A-A
SCALE OF FEET (SECTIONS A-A AND B-B)
Longit ℄ Units
24" Riprap
12" Bedding
NOTES
For reference drawings, see (6)
For details of Service Yard drainage and surfacing, see (686).
For details of miscellaneous concrete structures, see (687).
•Indicates work to be performed under completion contract.
1-25-65 D. R.G.M. REVISED SEWAGE STABILIZATION POND.
9-28-64 D. R.G.M. REVISED FOR COMPLETION CONTRACT.
2-6-63 D. J.D.B. MINOR REVISIONS.
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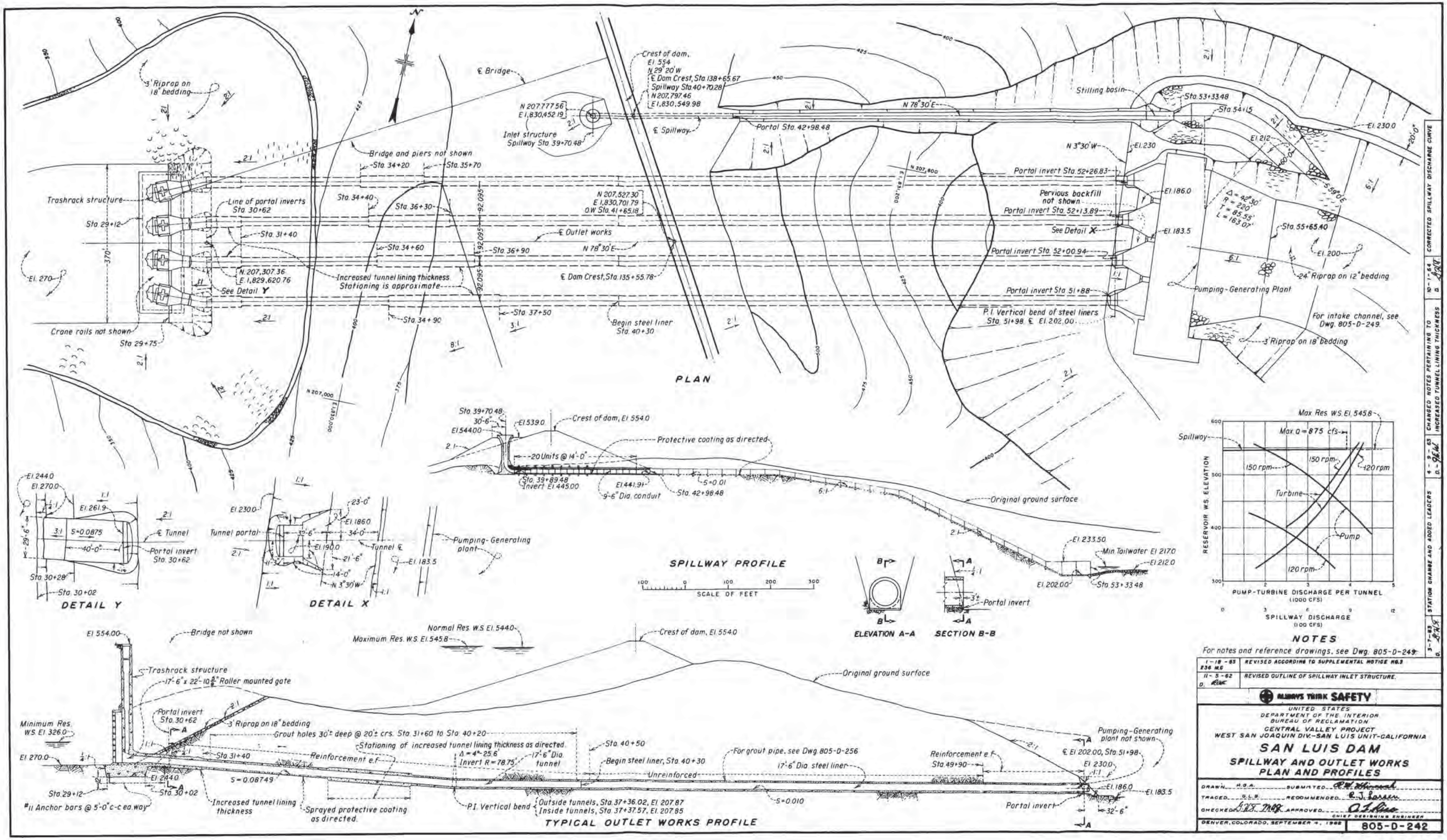
WEST SAN JOAQUIN DIV. - SAN LUIS UNIT--CALIFORNIA
SAN LUIS PUMPING-GENERATING PLANT
GENERAL PLAN AND SECTIONS
DRAWN H.T.J. SUBMITTED Edwin Rose
TRACED F.F.M. RECOMMENDED A.V. Lindsarth
CHECKED A.T.K. APPROVED Grant Bloodgood
ASST. COMM. AND CHIEF ENGINEER
DENVER, COLORADO, SEPT. 27, 19
805-D-27

Figure 6



NOTES

For notes and reference drawings, see Dwg. 805-D-249.

3-7-63 D. B.H.S.	STATION CHANGE AND ADDED LEADERS
4-9-63 D. 9E.W.	CHANGED NOTES PERTAINING TO INCREASED TUNNEL LINING THICKNESS
10-1-64 D. B.H.S.	CORRECTED SPILLWAY DISCHARGE CURVE
1-18-65 236 M.G	REVISED ACCORDING TO SUPPLEMENTAL NOTICE NO.3
11-5-62 D. R.W.C.	REVISED OUTLINE OF SPILLWAY INLET STRUCTURE.

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WEST SAN JOAQUIN DIV.–SAN LUIS UNIT–CALIFORNIA

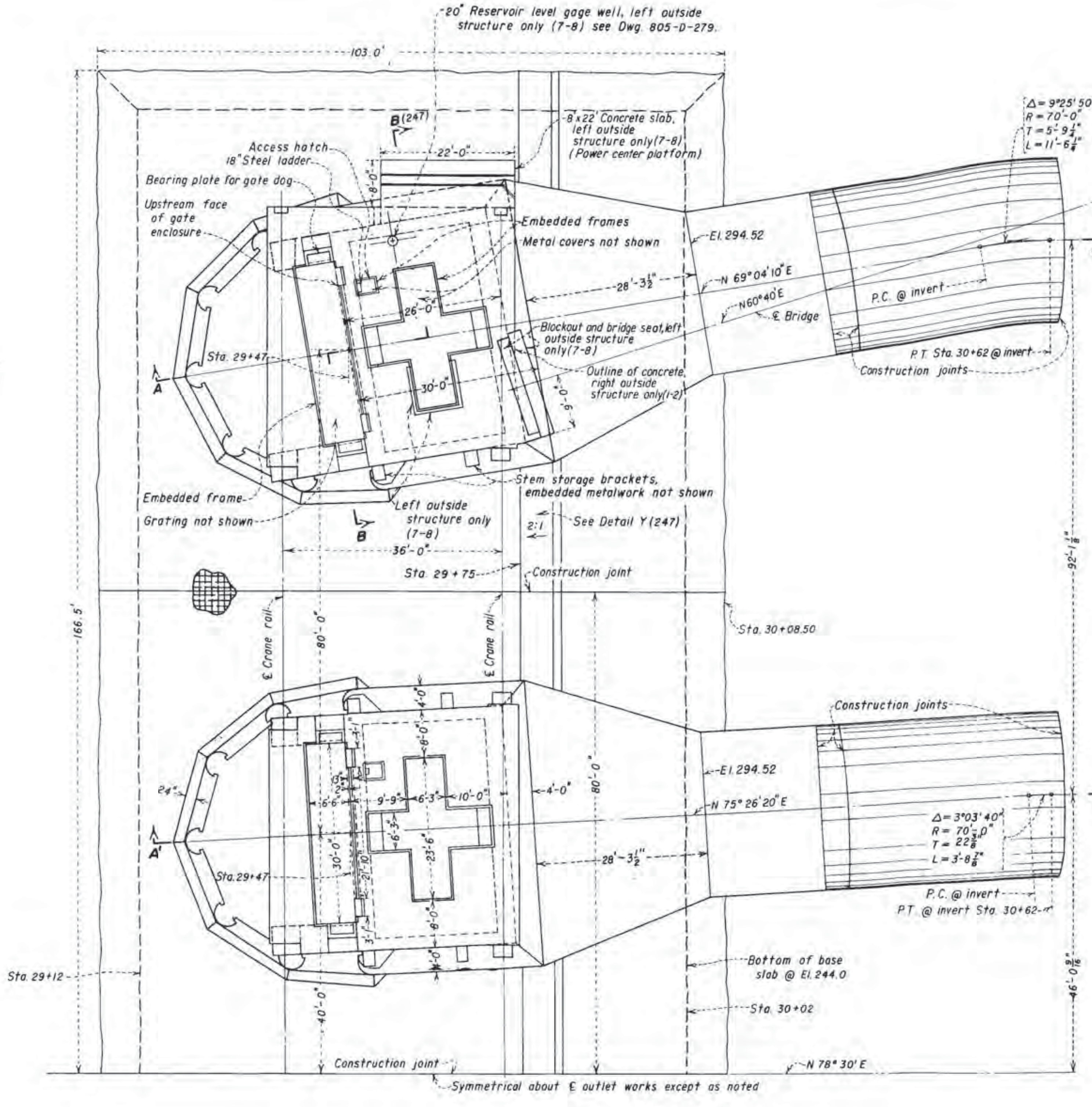
SAN LUIS DAM

SPILLWAY AND OUTLET WORKS
PLAN AND PROFILES

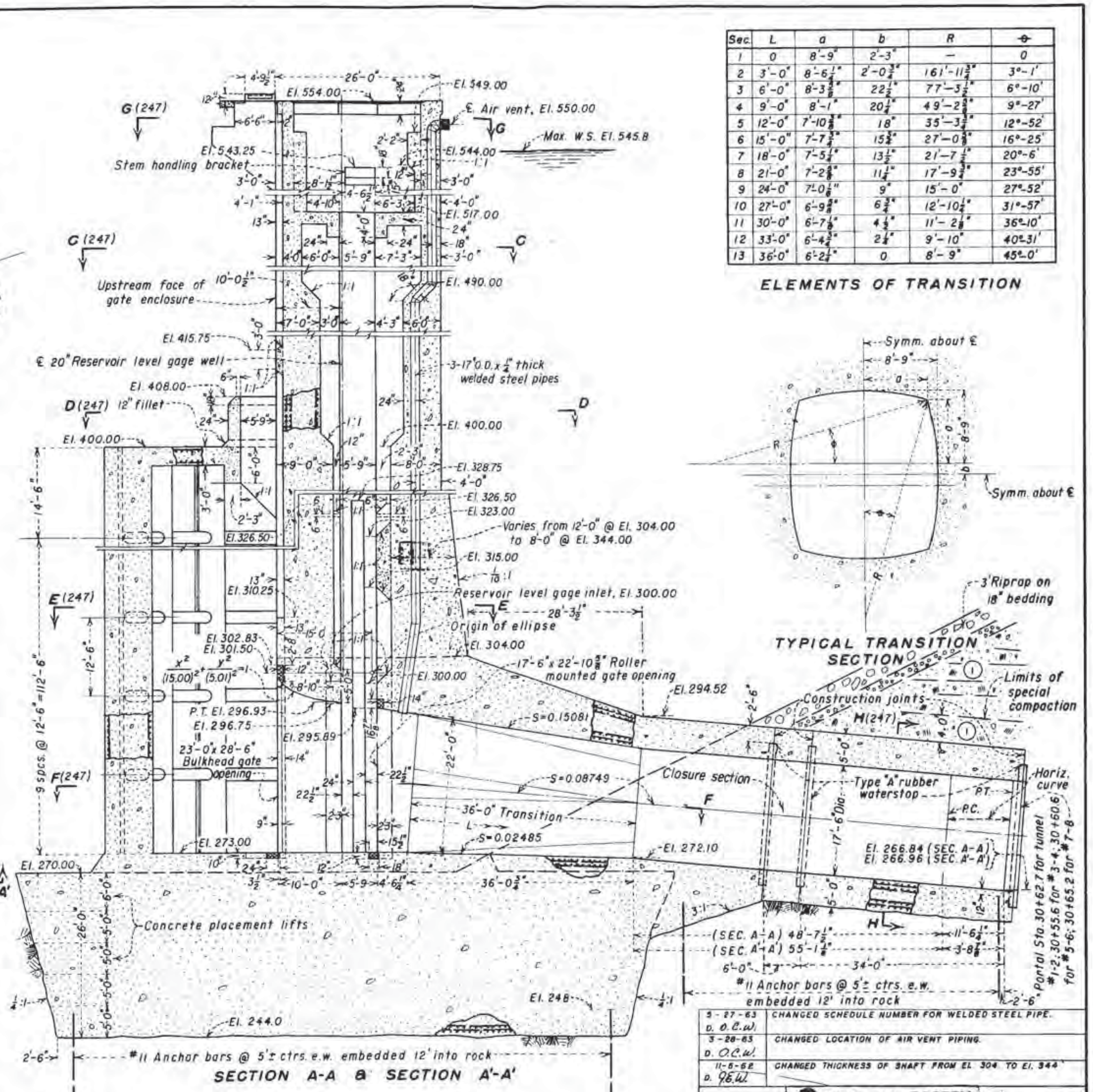
DRAWN H.G.A. SUBMITTED R.W. Hinnah
TRACED G.L.S. RECOMMENDED R.J. Larsen
CHECKED G.N.T. M.G. APPROVED O.F. Rice
CHIEF DESIGNING ENGINEER

DENVER, COLORADO, SEPTEMBER 4, 1962 805-D-242

Figure 7



HALF PLAN



Sec.	L	a	b	R	θ
1	0	8'-9"	2'-3"	—	0
2	3'-0"	8'-6¼"	2'-0¾"	161'-11¾"	3°-1'
3	6'-0"	8'-3⅜"	22½"	77'-3½"	6°-10'
4	9'-0"	8'-1"	20¼"	49'-2⅝"	9°-27'
5	12'-0"	7'-10⅝"	18"	35'-3¼"	12°-52'
6	15'-0"	7'-7¾"	15¾"	27'-0⅝"	16°-25'
7	18'-0"	7'-5¼"	13½"	21'-7½"	20°-6'
8	21'-0"	7'-2⅝"	11¼"	17'-9¾"	23°-55'
9	24'-0"	7'-0⅛"	9"	15'-0"	27°-52'
10	27'-0"	6'-9⅝"	6¾"	12'-10¼"	31°-57'
11	30'-0"	6'-7⅛"	4½"	11'-2⅛"	36°-10'
12	33'-0"	6'-4¾"	2¼"	9'-10"	40°-31'
13	36'-0"	6'-2¼"	0	8'-9"	45°-0'

ELEMENTS OF TRANSITION

TYPICAL TRANSITION SECTION

SECTION A-A & SECTION A'-A'

NOTE

For general notes and reference drawings see sheet 2 of 3, Dwg. 805-D-247

5-27-63 D. O.C.W.	CHANGED SCHEDULE NUMBER FOR WELDED STEEL PIPE.
3-28-63 D. O.C.W.	CHANGED LOCATION OF AIR VENT PIPING.
11-5-62 D. 9E.W.	CHANGED THICKNESS OF SHAFT FROM EL. 304 TO EL. 344

3-3-65 D. 9E.W.	REVISED RESERVOIR LEVEL GAGE, RELOCATED ACCESS HATCHES
8-25-64 D. 9E.W.	LENGTHENED CONDUIT CLOSURE SECTION AND CORRECTED TUNNEL PORTAL STATIONS
4-14-64 D. 9E.W.	REVISED CONCRETE DIMENSIONS AND AIR VENT PIPING.

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CENTRAL VALLEY PROJECT
WEST SAN JOAQUIN DIV.-SAN LUIS UNIT-CALIFORNIA

SAN LUIS DAM
OUTLET WORKS

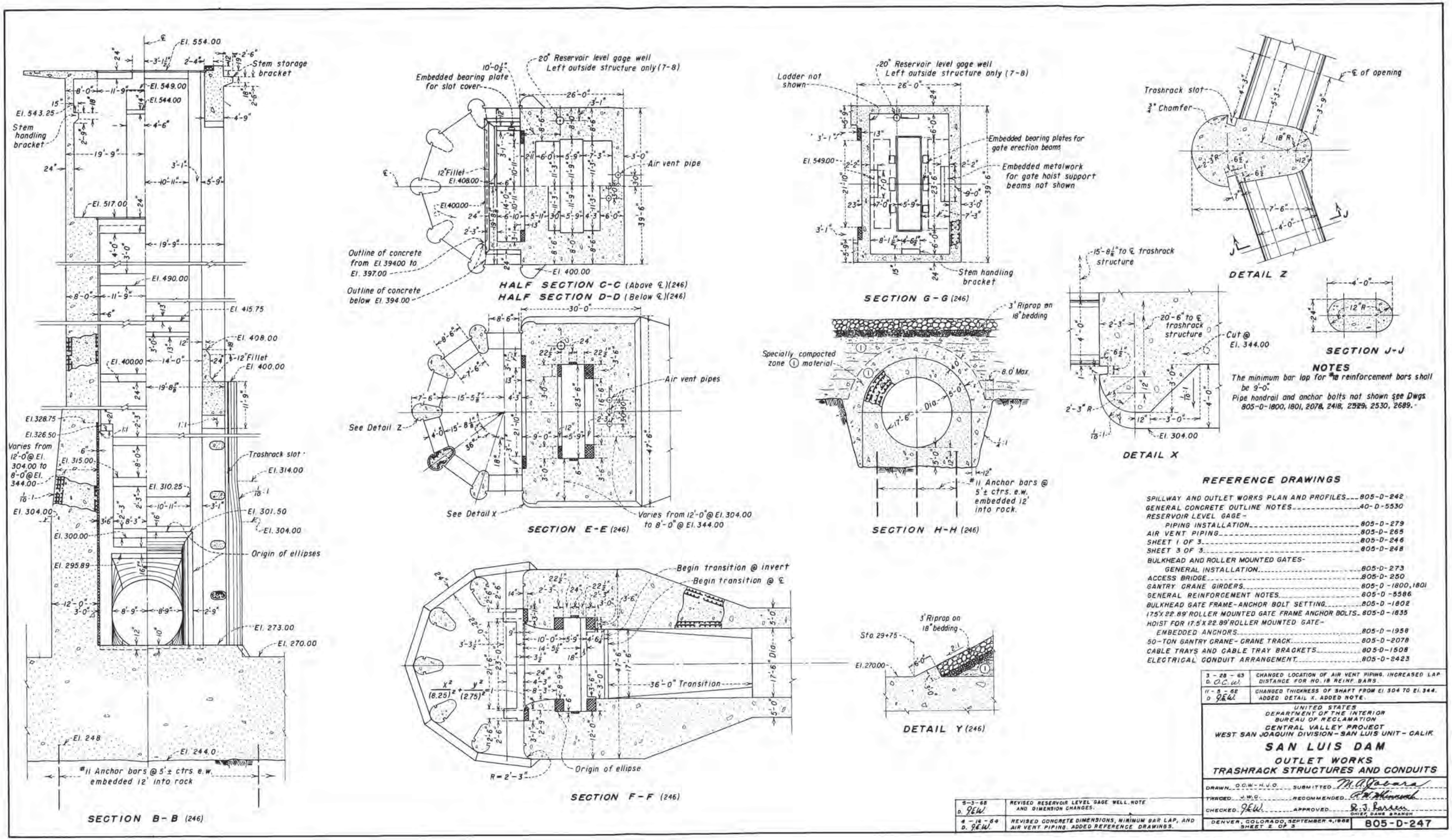
TRASHRACK STRUCTURES AND CONDUITS

DRAWN J.O.-O.C.W. SUBMITTED M.A. Jabara
TRACED R.T.H.-C.W.G. RECOMMENDED R.W. Almond
CHECKED 9E.W. APPROVED R.J. Larsen
CHIEF, DAMS BRANCH

DENVER, COLORADO SEPT. 4, 1962
SHEET 1 OF 3

805-D-246

Figure 8



NOTES

The minimum bar lap for #18 reinforcement bars shall be 9'-0".

Pipe handrail and anchor bolts not shown see Dwgs 805-D-1800, 1801, 2078, 2418, 2529, 2530, 2689.-

REFERENCE DRAWINGS

SPILLWAY AND OUTLET WORKS PLAN AND PROFILES	805-D-242
GENERAL CONCRETE OUTLINE NOTES	40-D-5530
RESERVOIR LEVEL GAGE- PIPING INSTALLATION	805-D-279
AIR VENT PIPING	805-D-265
SHEET 1 OF 3	805-D-246
SHEET 3 OF 3	805-D-248
BULKHEAD AND ROLLER MOUNTED GATES- GENERAL INSTALLATION	805-D-273
ACCESS BRIDGE	805-D-250
GANTRY CRANE GIRDERS	805-D-1800, 1801
GENERAL REINFORCEMENT NOTES	805-D-5586
BULKHEAD GATE FRAME-ANCHOR BOLT SETTING	805-D-1802
17.5'X 22.89' ROLLER MOUNTED GATE FRAME ANCHOR BOLTS	805-D-1835
HOIST FOR 17.5'X 22.89' ROLLER MOUNTED GATE- EMBEDDED ANCHORS	805-D-1958
50-TON GANTRY CRANE-CRANE TRACK	805-D-2078
CABLE TRAYS AND CABLE TRAY BRACKETS	805-D-1508
ELECTRICAL CONDUIT ARRANGEMENT	805-D-2423

3-28-63 D. O.C.W.	CHANGED LOCATION OF AIR VENT PIPING. INCREASED LAP DISTANCE FOR NO. 18 REINF. BARS.
11-5-62 D. 9EW	CHANGED THICKNESS OF SHAFT FROM El. 304 TO El. 344. ADDED DETAIL X. ADDED NOTE.
5-3-68 D. 9EW	REVISED RESERVOIR LEVEL GAGE WELL, NOTE AND DIMENSION CHANGES.
4-14-64 D. 9EW	REVISED CONCRETE DIMENSIONS, MINIMUM BAR LAP, AND AIR VENT PIPING. ADDED REFERENCE DRAWINGS.

UNITED STATES
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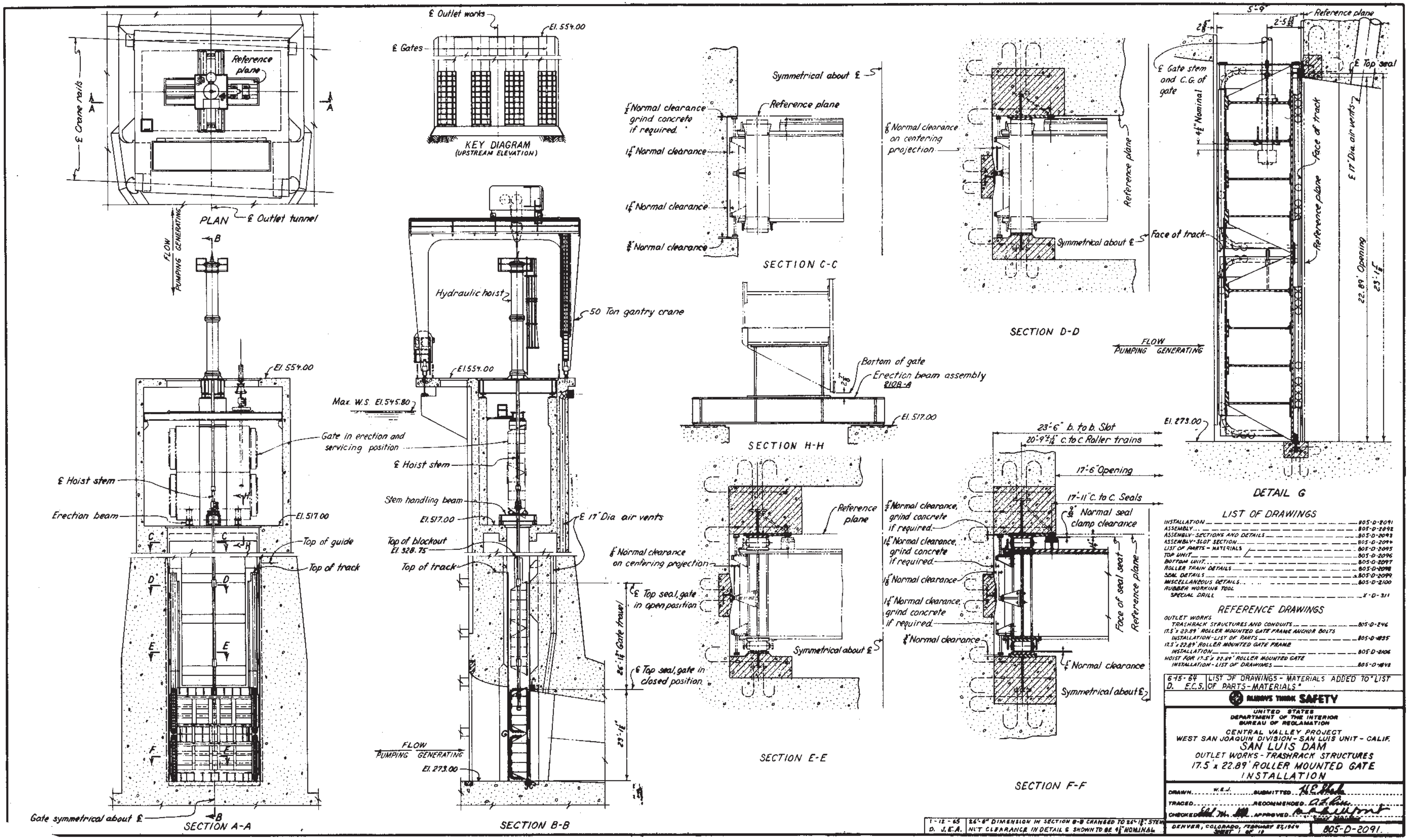
CENTRAL VALLEY PROJECT
WEST SAN JOAQUIN DIVISION - SAN LUIS UNIT - CALIF.

SAN LUIS DAM

OUTLET WORKS
TRASHRACK STRUCTURES AND CONDUITS

DRAWN O.C.W.-H.J.O. SUBMITTED M.A. Jabara
TRACED J.W.O. RECOMMENDED R.W. Kinnard
CHECKED 9EW APPROVED R.J. Larsen
CHIEF, DAMS BRANCH
DENVER, COLORADO, SEPTEMBER 4, 1962
SHEET 2 OF 3
805-D-247

Figure 9



LIST OF DRAWINGS

INSTALLATION	805-D-2091
ASSEMBLY	805-D-2092
ASSEMBLY-SECTIONS AND DETAILS	805-D-2093
ASSEMBLY-SLOT SECTION	805-D-2094
LIST OF PARTS - MATERIALS	805-D-2095
TOP UNIT	805-D-2096
BOTTOM UNIT	805-D-2097
ROLLER TRAIN DETAILS	805-D-2098
SEAL DETAILS	805-D-2099
MISCELLANEOUS DETAILS	805-D-2100
RUBBER WORKING TOOL SPECIAL DRILL	X-D-311

REFERENCE DRAWINGS

OUTLET WORKS TRASHRACK STRUCTURES AND CONDUITS	805-D-246
17.5'x 22.89' ROLLER MOUNTED GATE FRAME ANCHOR BOLTS INSTALLATION-LIST OF PARTS	805-D-1835
17.5'x 22.89' ROLLER MOUNTED GATE FRAME INSTALLATION	805-D-2106
HOIST FOR 17.5'x 22.89' ROLLER MOUNTED GATE INSTALLATION - LIST OF DRAWINGS	805-D-1848

6-15-64 D. E.C.S.	LIST OF DRAWINGS - MATERIALS ADDED TO "LIST OF PARTS-MATERIALS"
1-12-65 D. J.E.A.	26'-6" DIMENSION IN SECTION B-B CHANGED TO 26'-1⅛". STEM NUT CLEARANCE IN DETAIL G SHOWN TO BE 4½" NOMINAL

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UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
CENTRAL VALLEY PROJECT
WEST SAN JOAQUIN DIVISION - SAN LUIS UNIT - CALIF.
SAN LUIS DAM
OUTLET WORKS - TRASHRACK STRUCTURES
17.5' x 22.89' ROLLER MOUNTED GATE
INSTALLATION

DRAWN W.E.J. SUBMITTED H.E. Stark
TRACED RECOMMENDED A.L. Ru
CHECKED APPROVED
DENVER, COLORADO, FEBRUARY 27, 1964 SHEET 1 OF 10
805-D-2091.

Figure 10

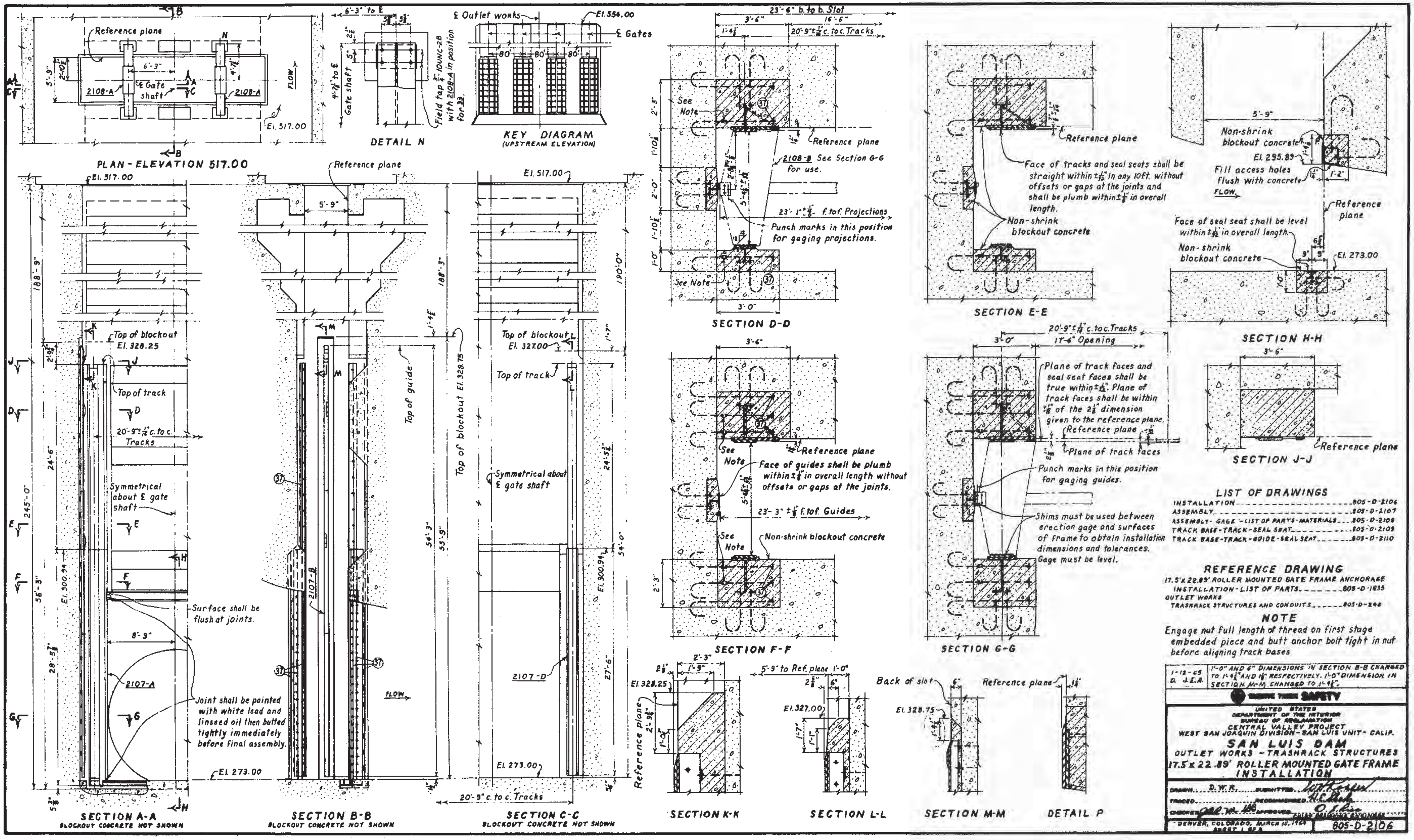

Figure 11

LIST OF DRAWINGS

INSTALLATION	805-D-2106
ASSEMBLY	805-D-2107
ASSEMBLY- GAGE - LIST OF PARTS-MATERIALS	805-D-2108
TRACK BASE-TRACK-SEAL SEAT	805-D-2109
TRACK BASE-TRACK-GUIDE-SEAL SEAT	805-D-2110

REFERENCE DRAWING

17.5'x 22.89' ROLLER MOUNTED GATE FRAME ANCHORAGE INSTALLATION - LIST OF PARTS	805-D-1835
OUTLET WORKS TRASHRACK STRUCTURES AND CONDUITS	805-D-246

NOTE

Engage nut full length of thread on first stage embedded piece and butt anchor bolt tight in nut before aligning track bases

1-12-65 D. J.E.A. 1'-0" AND 6" DIMENSIONS IN SECTION B-B CHANGED TO 1'-4½" AND 1½" RESPECTIVELY. 1'-0" DIMENSION IN SECTION M-M CHANGED TO 1'-4½".

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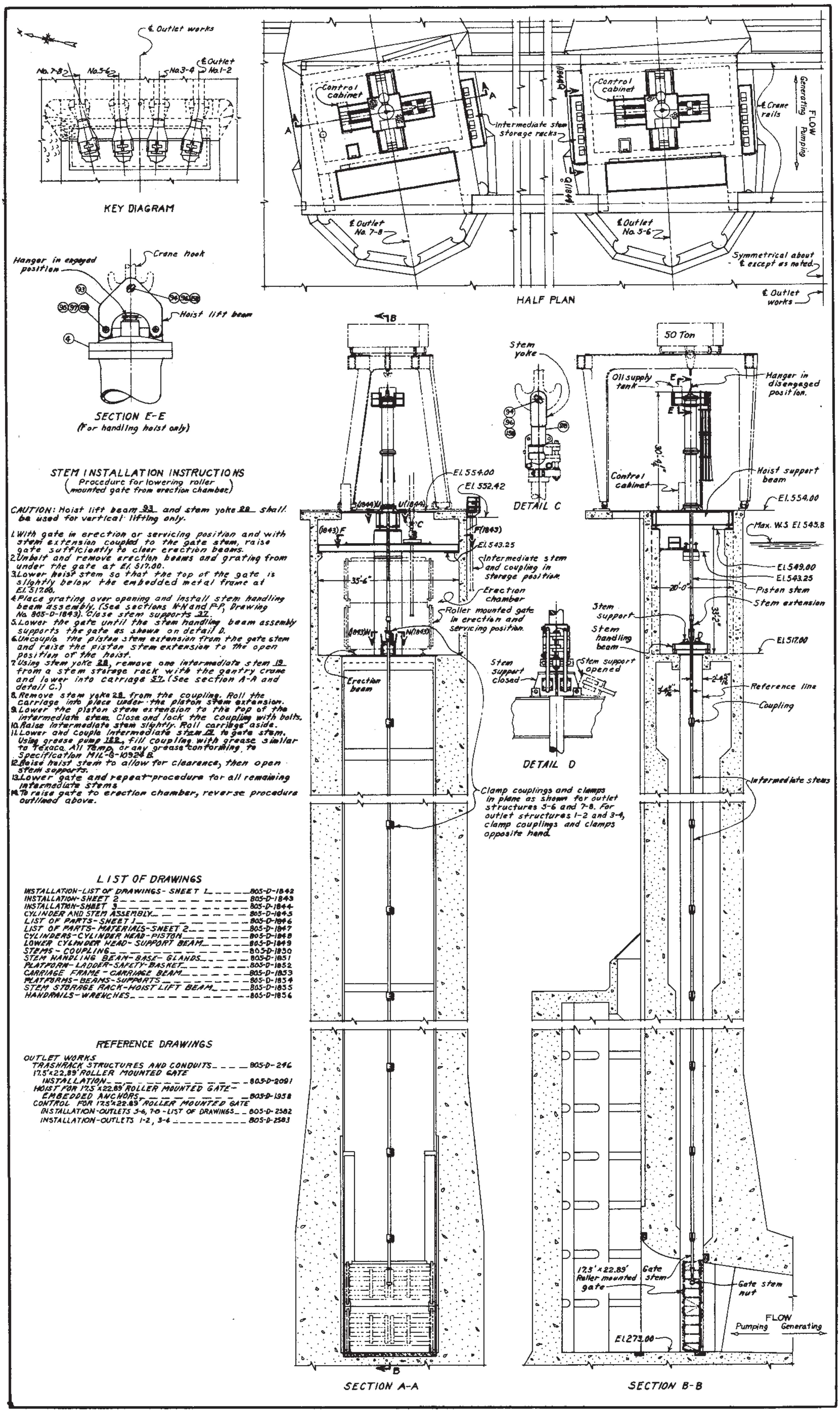
CENTRAL VALLEY PROJECT
WEST SAN JOAQUIN DIVISION - SAN LUIS UNIT - CALIF.
SAN LUIS DAM
OUTLET WORKS - TRASHRACK STRUCTURES
17.5'x 22.89' ROLLER MOUNTED GATE FRAME
INSTALLATION

DRAWN D.W.R. SUBMITTED
TRACED RECOMMENDED
CHECKED APPROVED
DENVER, COLORADO, MARCH 16, 1964
805-D-2106



STEM INSTALLATION INSTRUCTIONS

(Procedure for lowering roller mounted gate from erection chamber.)

CAUTION: Hoist lift beam 93 and stem yoke 28 shall be used for vertical lifting only.

1. With gate in erection or servicing position and with stem extension coupled to the gate stem, raise gate sufficiently to clear erection beams.
2. Unbolt and remove erection beams and grating from under the gate at El. 517.00.
3. Lower hoist stem so that the top of the gate is slightly below the embedded metal frame at El. 517.00.
4. Place grating over opening and install stem handling beam assembly. (See sections N-N and P-P, Drawing No. 805-D-1843). Close stem supports 37.
5. Lower the gate until the stem handling beam assembly supports the gate as shown on detail D.
6. Uncouple the piston stem extension from the gate stem and raise the piston stem extension to the open position of the hoist.
7. Using stem yoke 28, remove one intermediate stem 19 from a stem storage rack with the gantry crane and lower into carriage 57. (See section A-A and detail C.)
8. Remove stem yoke 28 from the coupling. Roll the carriage into place under the piston stem extension.
9. Lower the piston stem extension to the top of the intermediate stem. Close and lock the coupling with bolts.
10. Raise intermediate stem slightly. Roll carriage aside.
11. Lower and couple intermediate stem 19 to gate stem. Using grease pump 122, fill coupling with grease similar to Texaco All Temp, or any grease conforming to Specification MIL-G-10924 B.
12. Raise hoist stem to allow for clearance, then open stem supports.
13. Lower gate and repeat procedure for all remaining intermediate stems
14. To raise gate to erection chamber, reverse procedure outlined above.

LIST OF DRAWINGS

INSTALLATION-LIST OF DRAWINGS-SHEET 1	805-D-1842
INSTALLATION-SHEET 2	805-D-1843
INSTALLATION-SHEET 3	805-D-1844
CYLINDER AND STEM ASSEMBLY	805-D-1845
LIST OF PARTS-SHEET 1	805-D-1846
LIST OF PARTS-MATERIALS-SHEET 2	805-D-1847
CYLINDERS-CYLINDER HEAD-PISTON	805-D-1848
LOWER CYLINDER HEAD-SUPPORT BEAM	805-D-1849
STEMS-COUPLING	805-D-1850
STEM HANDLING BEAM-BASE-GLANDS	805-D-1851
PLATFORM-LADDER-SAFETY-BASKET	805-D-1852
CARRIAGE FRAME-CARRIAGE BEAM	805-D-1853
PLATFORMS-BEAMS-SUPPORTS	805-D-1854
STEM STORAGE RACK-HOIST LIFT BEAM	805-D-1855
HANDRAILS-WRENCHES	805-D-1856

REFERENCE DRAWINGS

OUTLET WORKS	
TRASHRACK STRUCTURES AND CONDUITS	805-D-246
17.5'x22.89' ROLLER MOUNTED GATE INSTALLATION	805-D-2091
HOIST FOR 17.5'x22.89' ROLLER MOUNTED GATE-EMBEDDED ANCHORS	805-D-1958
CONTROL FOR 17.5'x22.89' ROLLER MOUNTED GATE	
INSTALLATION-OUTLETS 5-6, 7-8-LIST OF DRAWINGS	805-D-2582
INSTALLATION-OUTLETS 1-2, 3-4	805-D-2583

Figure 12

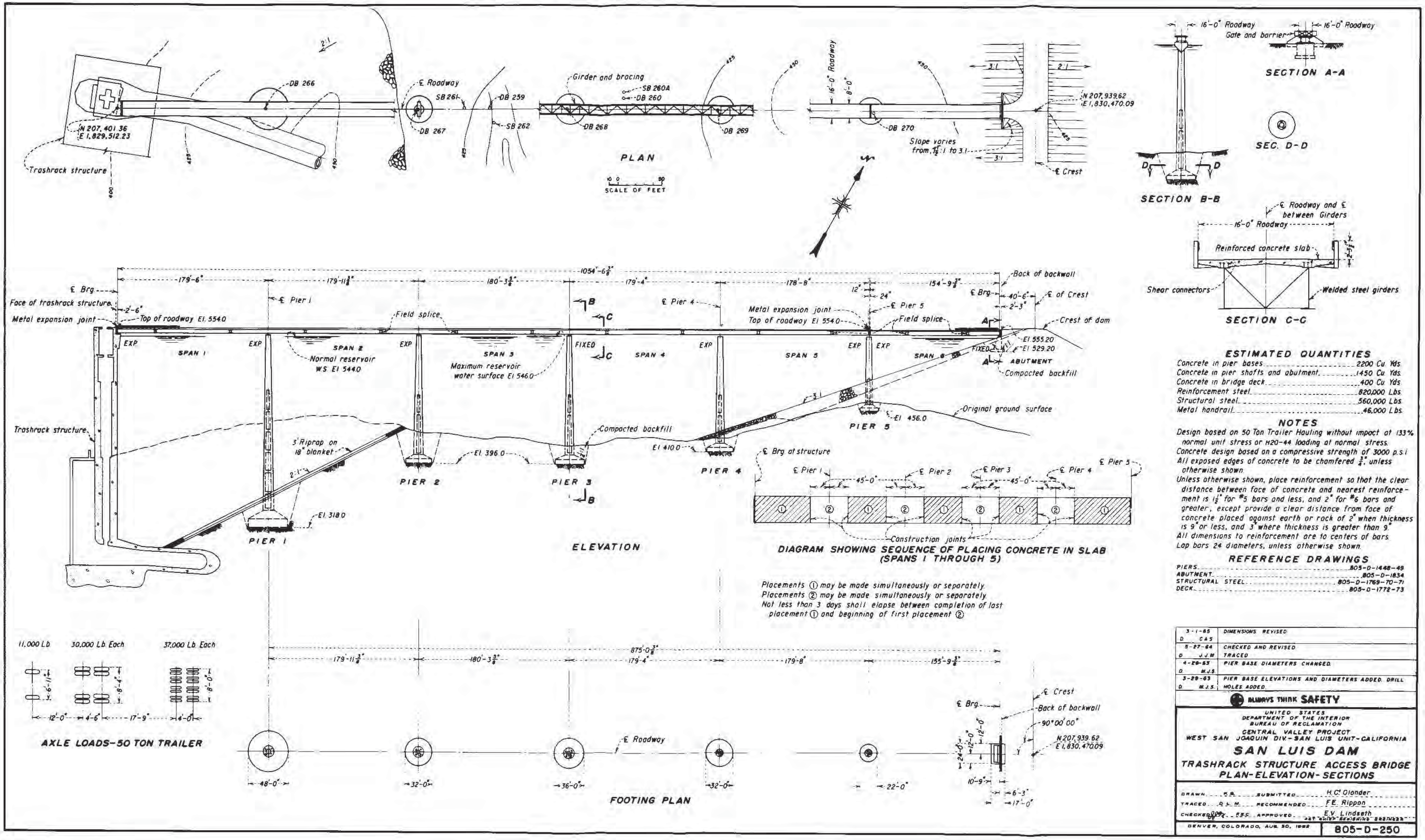


Figure 13

Placements ① may be made simultaneously or separately.
Placements ② may be made simultaneously or separately.
Not less than 3 days shall elapse between completion of last placement ① and beginning of first placement ②

ESTIMATED QUANTITIES

Concrete in pier bases	2200 Cu. Yds.
Concrete in pier shafts and abutment	1450 Cu. Yds.
Concrete in bridge deck	400 Cu. Yds.
Reinforcement steel	820,000 Lbs.
Structural steel	560,000 Lbs.
Metal handrail	46,000 Lbs.

NOTES

Design based on 50 Ton Trailer Hauling without impact at 133% normal unit stress or H20-44 loading at normal stress.

Concrete design based on a compressive strength of 3000 p.s.i.

All exposed edges of concrete to be chamfered ¾", unless otherwise shown.

Unless otherwise shown, place reinforcement so that the clear distance between face of concrete and nearest reinforcement is 1½" for #5 bars and less, and 2" for #6 bars and greater, except provide a clear distance from face of concrete placed against earth or rock of 2" when thickness is 9" or less, and 3" where thickness is greater than 9".

All dimensions to reinforcement are to centers of bars.

Lap bars 24 diameters, unless otherwise shown.

REFERENCE DRAWINGS

PIERS	805-D-1448-49
ABUTMENT	805-D-1834
STRUCTURAL STEEL	805-D-1769-70-71
DECK	805-D-1772-73

3-1-65 D CAS	DIMENSIONS REVISED
5-27-64 D J.J.M.	CHECKED AND REVISED TRACED
4-29-63 D M.J.S.	PIER BASE DIAMETERS CHANGED.
3-29-63 D M.J.S.	PIER BASE ELEVATIONS AND DIAMETERS ADDED. DRILL HOLES ADDED.

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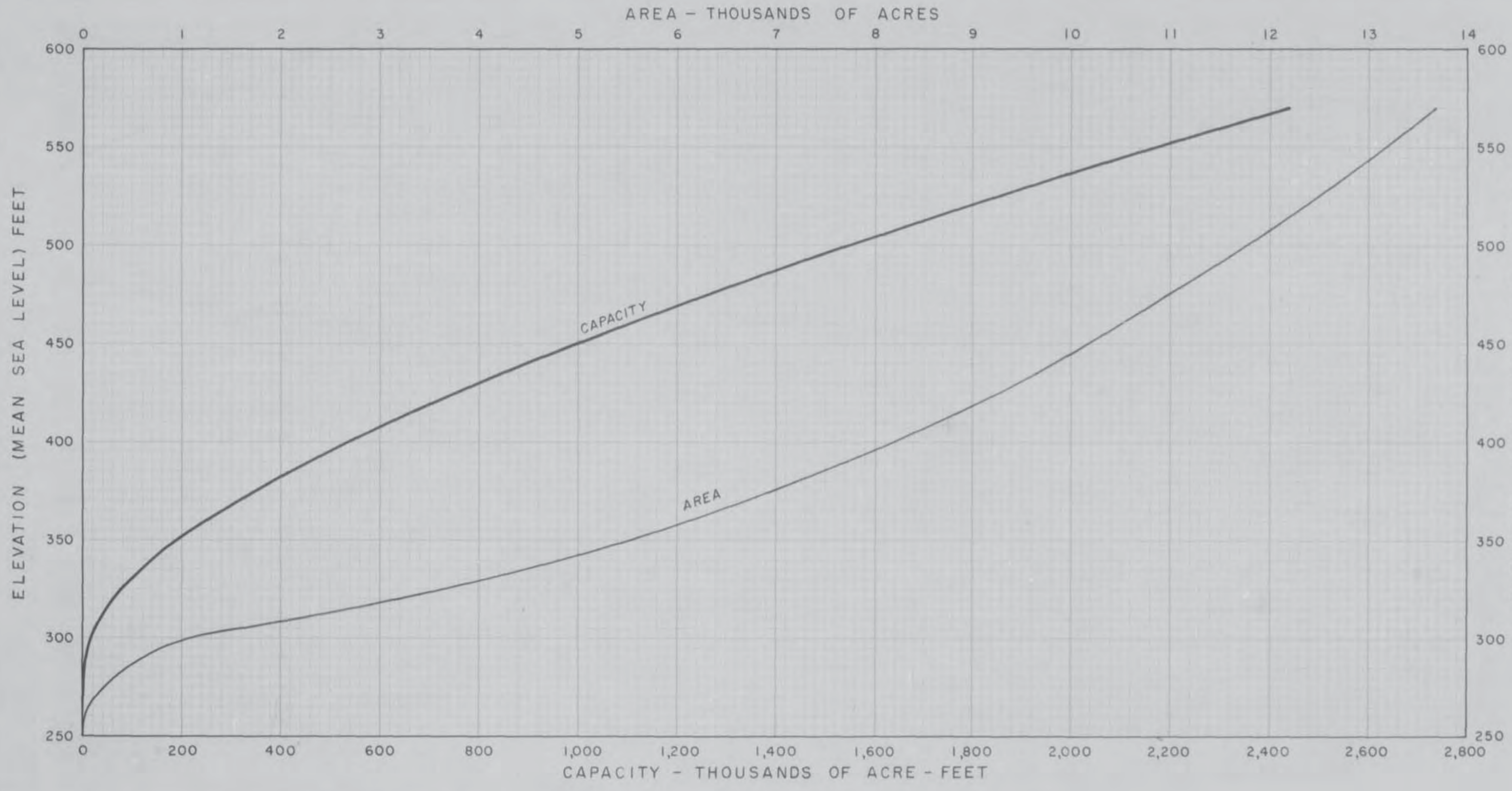
UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
CENTRAL VALLEY PROJECT
WEST SAN JOAQUIN DIV.-SAN LUIS UNIT-CALIFORNIA

SAN LUIS DAM
TRASHRACK STRUCTURE ACCESS BRIDGE
PLAN-ELEVATION-SECTIONS

DRAWN E.B. SUBMITTED H.C. Olander
TRACED D.J.M. RECOMMENDED F.E. Rippon
CHECKED F.E.S. APPROVED E.V. Lindseth
ACT. CHIEF DESIGNING ENGINEER
DENVER, COLORADO, AUG. 30, 1962
805-D-250



Note: Plotted from tabulation 805-0A-208-58
prepared by Calif. Dept of Water Resources
from their 1" = 400' aerial topography of
July 1960

AREA-CAPACITY TABLE

ELEV. FEET	AREA ACRES	CAPACITY ACRE-FEET	ELEV. FEET	AREA ACRES	CAPACITY ACRE-FEET
250	0	0	415	8,855	665,780
255	10	25	420	9,072	710,600
260	25	110	425	9,283	756,480
265	65	340	430	9,494	803,430
270	124	810	435	9,659	851,340
275	205	1,630	440	9,824	900,020
280	330	2,970	445	10,009	949,600
285	450	4,920	450	10,194	1,000,110
290	605	7,560	455	10,346	1,051,460
295	825	11,130	460	10,498	1,103,560
300	1,107	15,960	465	10,665	1,156,470
305	1,585	22,690	470	10,832	1,210,220
310	2,181	32,110	475	10,989	1,264,770
315	2,650	44,180	480	11,146	1,320,110
320	3,170	58,740	485	11,299	1,376,220
325	3,650	75,780	490	11,451	1,433,090
330	4,058	95,060	495	11,613	1,490,750
335	4,455	116,340	500	11,775	1,549,220
340	4,834	139,560	505	11,932	1,608,490
345	5,200	164,450	510	12,089	1,668,540
350	5,531	191,470	515	12,205	1,729,280
355	5,850	219,925	520	12,321	1,790,590
360	6,142	249,900	525	12,477	1,852,590
365	6,436	281,350	530	12,633	1,915,360
370	6,729	314,260	535	12,769	1,978,870
375	6,958	348,480	540	12,904	2,043,050
380	7,186	383,840	545	13,047	2,107,930
385	7,456	420,440	550	13,190	2,173,520
390	7,725	458,400	555	13,312	2,239,780
395	7,954	497,600	560	13,434	2,306,640
400	8,183	537,940	565	13,556	2,374,120
405	8,411	579,420	570	13,678	2,442,200
410	8,638	622,040			

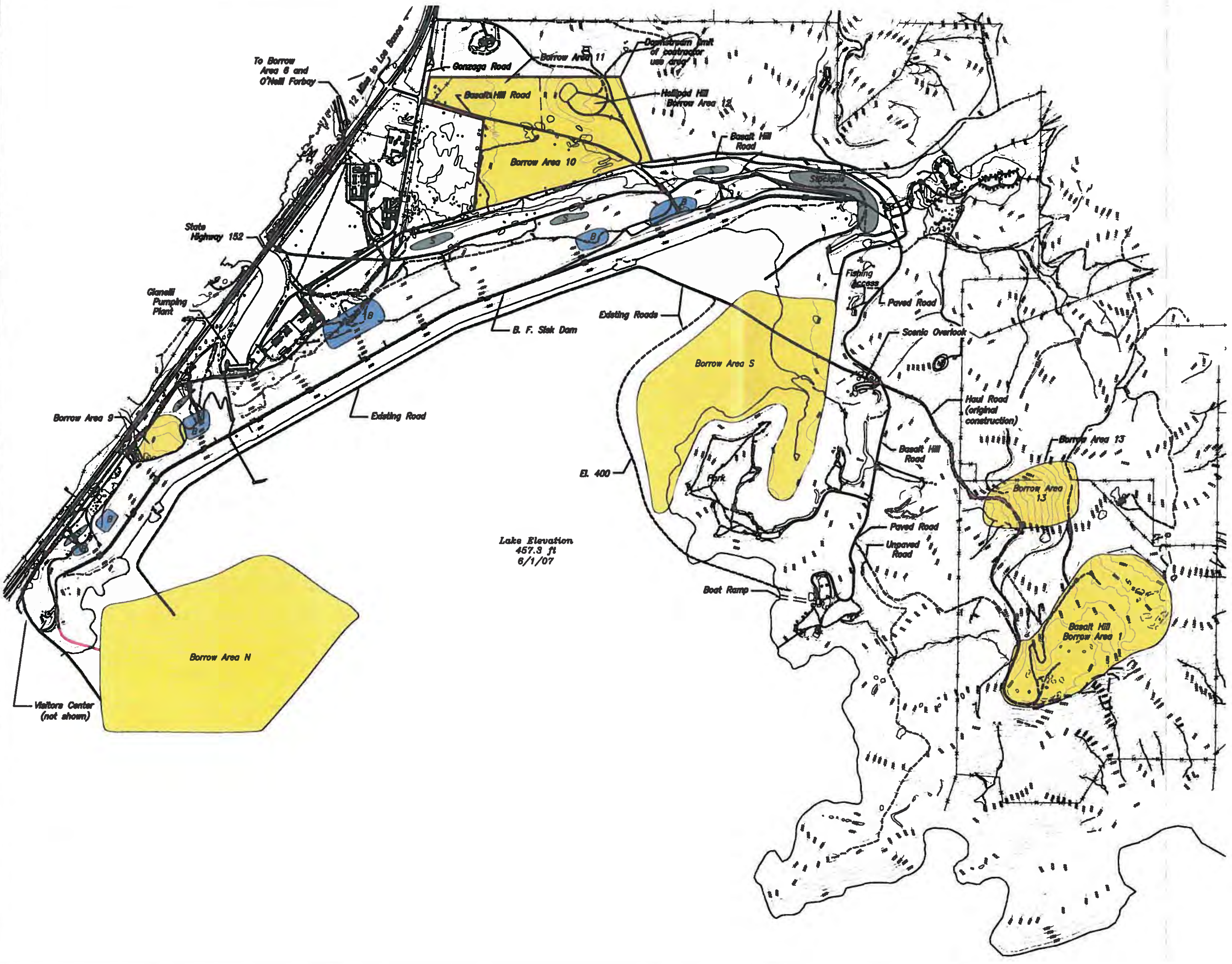
UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
CENTRAL VALLEY PROJECT
WEST SAN JOAQUIN DIV.-SAN LUIS UNIT-CALIF.
SAN LUIS RESERVOIR
AREA-CAPACITY CURVES

COMPUTED D of WR SUBMITTED
TRACED M.K. RECOMMENDED
CHECKED APPROVED

SACRAMENTO, CALIF SEPT. 12, 1961 805-208-151

Figure 14

RECLAMATION
Managing Water in the West



CALIFORNIA STATE PLANE COORDINATE SYSTEM
ZONE 3, U.S. SURVEY FEET
VERTICAL DATUM NAVD1988
ORIGINAL PROJECT DATUM NGVD29 = NAVD88–2.81 FEET

N

LEGEND

▬	Limit of contractor use area
▬	Haul Road
B	Berm
S	Stockpile Area
—×—×—	Fence

1000 0 1000 2000 3000
SCALE OF FEET

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BUREAU OF RECLAMATION

CENTRAL VALLEY PROJECT
WEST SAN JOAQUIN DIVISION–SAN LUIS UNIT–CALIFORNIA
B. F. SISK DAM
CORRECTIVE ACTION STUDY
SITE USE

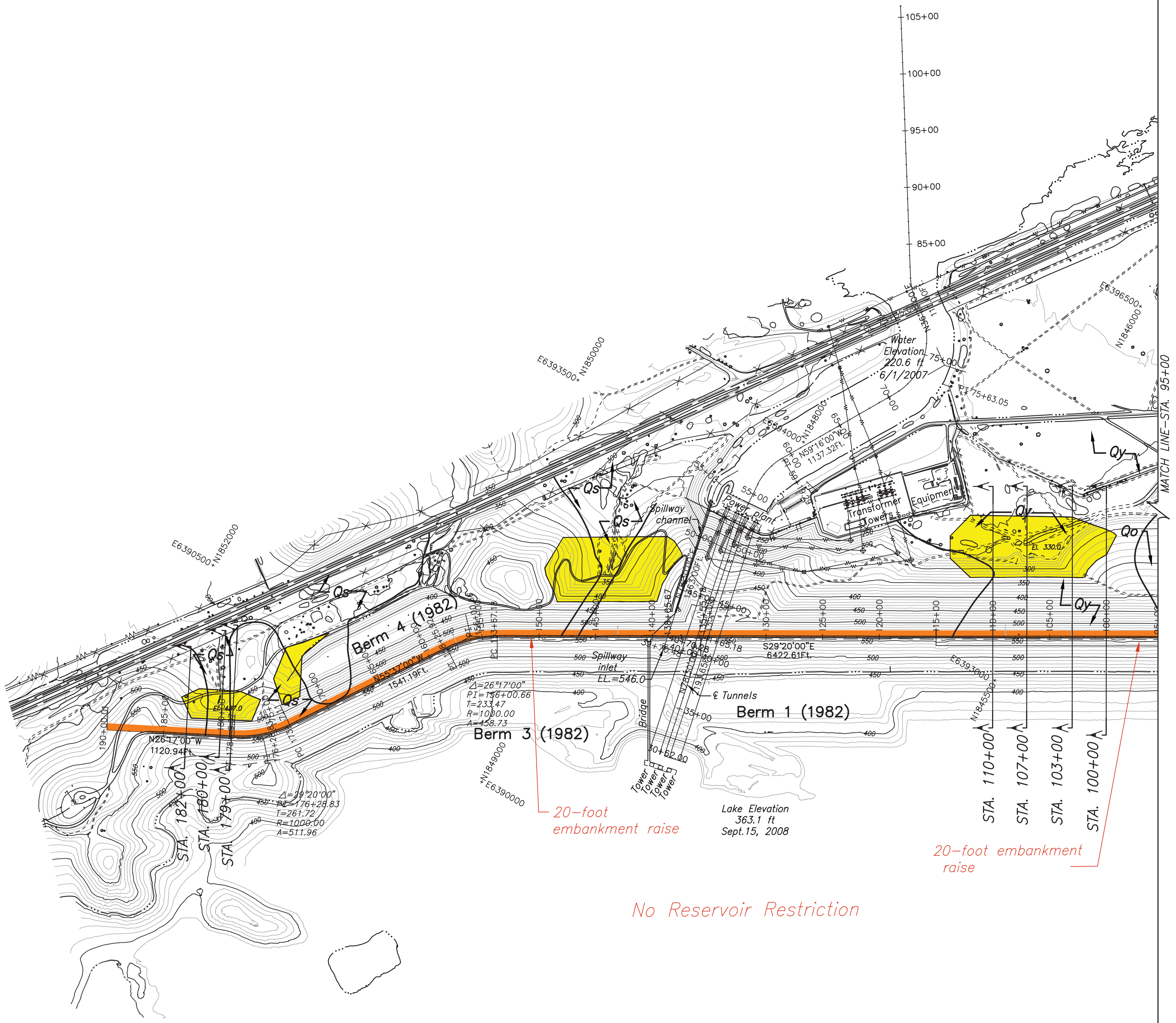
DESIGNED ______________________
DRAWN ______________________

DENVER, COLORADO 2009-01-08
SHEET 1 OF 1
CAS–ENV

DATE AND TIME PLOTTED
MAY 4, 2010 13:53
PLOTTED BY

CAD SYSTEM
AutoCAD Rel. 17.1s
CAD FILENAME

Figure 15



LEGEND

—w—w— *Transmission line*

☒ *Transmission tower*

CALIFORNIA STATE PLANE COORDINATE SYSTEM
ZONE 3 , U.S. SURVEY FEET
HORIZONTAL DATUM: NAV1983
VERTICAL DATUM: NAVD 1988
CONTOUR INTERVAL: 10 FT.

Topography by Surveys and Mapping Section,
Field Operations Branch, Division of Design
and Construction, Mid–Pacific Region.
Compiled from photography: BR–SLU–30
Date of photography: 9–15–08

500 0 500 1000 1500
SCALE OF FEET

RECLAMATION
Managing Water in the West

ALWAYS THINK SAFETY

U.S. DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION

CENTRAL VALLEY PROJECT–CALIFORNIA

B.F. SISK DAM

APPRAISAL LEVEL STUDY

SITE PLAN – FIGURE 16

DESIGNED ____________
DRAWN ____________
CHECKED ____________
TECH. APPR. ____________
APPROVED ____________
GEOTECHNICAL ENGINEERING GROUP 3

DENVER, COLORADO 2010–01–08

PLAN–FIGURE 16

SHEET 1 OF 2

DATE AND TIME PLOTTED
JANUARY 14, 2011 14:46
PLOTTED BY
JWHITFIELD

CAD SYSTEM
AutoCAD Rel. 18.1s
CAD FILENAME
PLAN ALT A ONE.DWG

Figure 16

LEGEND

—w—w— Transmission line
☒ Transmission tower

CALIFORNIA STATE PLANE COORDINATE SYSTEM
ZONE 3 , U.S. SURVEY FEET
HORIZONTAL DATUM: NAV1983
VERTICAL DATUM: NAVD 1988
CONTOUR INTERVAL: 10 FT.

Topography by Surveys and Mapping Section,
Field Operations Branch, Division of Design
and Construction, Mid–Pacific Region.
Compiled from photography: BR–SLU–30
Date of photography: 9–15–08

500 0 500 1000 1500
SCALE OF FEET

RECLAMATION
Managing Water in the West

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U.S. DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
CENTRAL VALLEY PROJECT–CALIFORNIA
B.F. SISK DAM
APPRAISAL LEVEL STUDY

SITE PLAN – FIGURE 17

DESIGNED
DRAWN
CHECKED
TECH. APPR.
APPROVED
GEOTECHNICAL ENGINEERING GROUP 3
DENVER, COLORADO 2010–01–08

PLAN–FIGURE 17
SHEET 2 OF 2

DATE AND TIME PLOTTED
JANUARY 14, 2011 14:46
PLOTTED BY
JWHITFIELD

CAD SYSTEM
AutoCAD Rel. 18.1s
CAD FILENAME
PLAN ALT A ONE.DWG

Figure 17

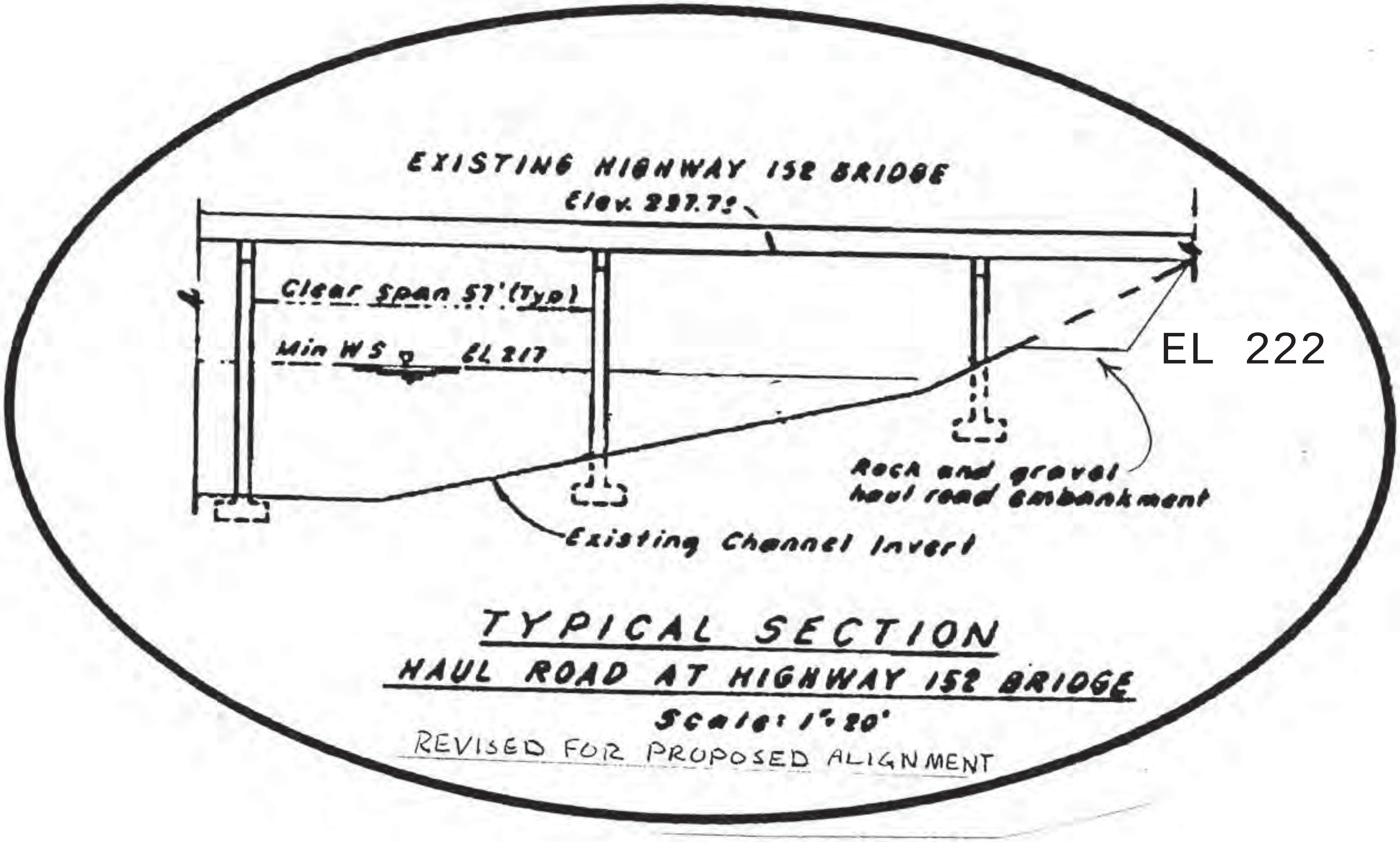

EXISTING HIGHWAY 152 BRIDGE
Elev. 237.7±
Clear Span 57' (Typ)
Min WS
EL 217
EL 222
Rock and gravel haul road embankment
Existing Channel Invert
TYPICAL SECTION
HAUL ROAD AT HIGHWAY 152 BRIDGE
Scale: 1"=20'
REVISED FOR PROPOSED ALIGNMENT

Figure 18

Appendix A

Cost Estimate Worksheets – Option A

BUREAU OF RECLAMATION

ESTIMATE WORKSHEET

SHEET 1 OF 16

FEATURE:

B.F. Sisk Dam Modification
Appraisal Level Study
20-foot Dam Raise
Middle Estimated Drained Strength Parameters

Option A
Geotechnical (86-68313)

PROJECT:
Central Valley Project, Madera County, California

WOID:	**A176F**	**ESTIMATE LEVEL:**	**Appraisal**
REGION:	**MP**	**UNIT PRICE LEVEL:**	**Oct-12**

FILE: U:\2012 Projects\BF Sisk\002 Completed Sheets\[Copy of 001 Summary BF Sisk - Drained.xlsx]Sht 1

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT

The cost estimate sheets from B.F. Sisk Dam Appraisal-Level Construction Considerations (TM VB-8313-9; May 2010) were used to establish quantities for preparing this cost estimate. The borrow areas, construction methods, and environmental considerations presented in TM VB-8313-9 are assumed to be the same for this Appraisal-Level study. Additionally, information presented in B.F. Sisk Dam Appraisal-Level Study of Static Stability for Increased Storage report (TM VB-86-68313-22; December 2012) should be reviewed.

NOTES:

1) Quantities were calculated at specific sections (e.g. stations 37+00, 65+00, 86+00, 107+00 and 147+20) and the dike during this Appraisal-Level study. Quantities at stations 169+00 and 180+00 were taken from VB-8313-9 and were not recalculated during this study. The quantities indicated at each station were assumed to be representative of the location (e.g. station 37+00 represents total quantities between stations 0+00 and 56+00).
2) Raise includes removal of 10 feet of the existing crest for penetration into existing Zone 1 core (6 inches of gravel surfacing plus Zone 4, Zone 5 (riprap), and Zone 1).
3) Costs associated with escalation to NTP, and non-contract costs are not included; mobilization and allowance for procurement strategies costs are included.
4) There is a Corrective Action Study (CAS) underway to address risks of dam failure during a major earthquake. This appraisal-level study evaluated increased storage in San Luis Reservoir based solely on static stability conditions using post-earthquake soil strength parameters. These estimates were prepared to provide a general order-of-magnitude-type cost. This study is not meant to be a stand-alone study, rather it should be reviewed during the CAS.

QUANTITIES		**PRICES**	
BY Tonya Hart, P.E.	**CHECKED** Tuti Tierney	**BY** Greg Akins	**CHECKED** 1/25/2013
DATE PREPARED 12/21/12	**PEER REVIEW / DATE** Randy Kuzniakowski	**DATE PREPARED** 01/25/13	**PEER REVIEW / DATE** 1/28/13

BUREAU OF RECLAMATION

ESTIMATE WORKSHEET

SHEET 2 OF 16

FEATURE:

B.F. Sisk Dam Modification
Appraisal Level Study
20-foot Dam Raise Only, No D/S Berm
Middle Estimated Drained Strength Parameters

Geotechnical (86-68313)

PROJECT:

Central Valley Project, Madera County, California

WOID: **A176F**

ESTIMATE LEVEL: **Appraisal**

REGION: **MP**

UNIT PRICE LEVEL: **Oct-12**

FILE: U:\2012 Projects\BF Sisk\002 Completed Sheets\[001 Summary BF Sisk - Drained.xlsx]Sht 4A

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
		The quantities on this sheet apply to the following locations. Sections for these locations were not analyzed in Slope/W for static stability. However, because the embankment is founded directly on bedrock (i.e. potentially liquefiable foundation materials were removed during construction), no downstream berm is needed.					
		Stations 0+00 to 31+00					
		Stations 46+00 to 56+00					
		Stations 114+00 to 139+00					
		Stations 149+00 to 165+00					
		Stations 173+00 to 176+00					
		Stations 183+00 to 185+00					
	1	**Excavation, Common**	**86-68313**	**304,000**	**yd3**	**$4.50**	**$1,368,000.00**
	2	**Zone 1: Selected clay, sand, and gravel**	**86-68313**	**195,000**	**yd3**	**$18.00**	**$3,510,000.00**
		compacted by tamping rollers to 6-inch lifts					
		(Assume Borrow Area 6 is sole borrow source for Zone 1 material and is rippable with dozer and processing is required)					
	3	**Processed sand & gravel**	**86-68313**	**646,000**	**yd3**	**$55.00**	**$35,530,000.00**
		compacted by vibratory smooth drum rollers in 12-inch to 24-inch lifts (for D/S filter zones & U/S riprap bedding and crack stopper zones) (Assume Basalt Hill is sole borrow source for sand & gravel which must be drilled/blasted and processed)					
	4	**Misc. Fill**	**86-68313**	**2,170,000**	**yd3**	**$9.30**	**$20,181,000.00**
		(Assume Borrow Area 6 is sole borrow source material which is rippable with dozer and minimal processing required)					
		SUBTOTAL THIS SHEET					**$60,589,000.00**

QUANTITIES		**PRICES**	
BY Tonya Hart, P.E.	**CHECKED** Tuti Tierney	**BY** Greg Akins	**CHECKED** 1/25/2013
DATE PREPARED 12/21/12	**PEER REVIEW / DATE** Randy Kuzniakowski	**DATE PREPARED** 01/25/13	**PEER REVIEW / DATE** 1/28/13

BUREAU OF RECLAMATION

ESTIMATE WORKSHEET

FEATURE:

B.F. Sisk Dam Modification
Appraisal Level Study
20-foot Dam Raise
Middle Estimated Drained Strength Parameters

Geotechnical (86-68313)

PROJECT:

Central Valley Project, Madera County, California

WOID: **A176F**
ESTIMATE LEVEL: **Appraisal**
REGION: **MP**
UNIT PRICE LEVEL: **Oct-12**
FILE: U:\2012 Projects\BF Sisk\002 Completed Sheets\[002 Summary BF Sisk - Undrained.xlsx]Summary 16

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
		Summary: Stations 37+00 thru 180+00 below					
	5	**Excavation, Common**		**507,000**	**yd3**	**$4.50**	**$2,281,500.00**
	6	**Filter**		**1,414,000**	**yd3**	**$55.00**	**$77,770,000.00**
		compacted by vibratory smooth drum rollers in 12-inch					
		to 24-inch lifts (for D/S filter zones & U/S riprap					
		bedding and crack stopper zones) (Assume Basalt Hill is					
		sole borrow source for sand & gravel which must be					
		drilled/blasted and processed)					
	7	**Misc. Fill**		**4,475,000**	**yd3**	**$9.30**	**$41,617,500.00**
		(Assume Borrow Area 6 is sole borrow source material which					
		is rippable with dozer and minimal processing required)					
Sta	37+00						
		Excavation, Common	86-68313	53,000	yd3		Included above
		Filter	86-68313	210,000	yd3		Included above
		Misc. Fill	86-68313	427,000	yd3		Included above
Sta	65+00						
		Excavation, Common	86-68313	147,000	yd3		Included above
		Filter	86-68313	107,000	yd3		Included above
		Misc. Fill	86-68313	669,000	yd3		Included above
Sta	86+00						
		Excavation, Common	86-68313	131,000	yd3		Included above
		Filter	86-68313	276,000	yd3		Included above
		Misc. Fill	86-68313	1,368,000	yd3		Included above
Sta	107+00						
		Excavation, Common	86-68313	90,000	yd3		Included above
		Filter	86-68313	530,000	yd3		Included above
		Misc. Fill	86-68313	1,085,000	yd3		Included above
Sta	147+20	Excavation, Common	86-68313	35,000	yd3		Included above
		Filter	86-68313	239,000	yd3		Included above
		Misc. Fill	86-68313	561,000	yd3		Included above
		SUBTOTAL THIS SHEET					**$121,669,000.00**

QUANTITIES		**PRICES**	
BY Tonya Hart, P.E.	**CHECKED** Tuti Tierney	**BY** Greg Akins	**CHECKED** 3/26/13
DATE PREPARED 12/21/12	**PEER REVIEW / DATE** Randy Kuzniakowski	**DATE PREPARED** 1/25/2013 - revised 3/20/13	**PEER REVIEW / DATE** 3/22/13

BUREAU OF RECLAMATION

ESTIMATE WORKSHEET

SHEET 4 OF 16

FEATURE:
B.F. Sisk Dam Modification
Appraisal Level Study
20-foot Dam Raise
"Best" Drained Strength Parameters

Geotechnical (86-68313)

PROJECT:
Central Valley Project, Madera County, California

WOID: A176F **ESTIMATE LEVEL:** Appraisal
REGION: MP **UNIT PRICE LEVEL:** Oct-12
FILE: U:\2012 Projects\BF Sisk\002 Completed Sheets\[001 Summary BF Sisk - Drained.xlsx]Sht 4A

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
Sta	169+00						
		Excavation, Common	86-68313	14,000	yd3		Included above
		Filter	86-68313	20,000	yd3		Included above
		Misc. Fill	86-68313	230,000	yd3		Included above
Sta	180+00						Included above
		Excavation, Common	86-68313	37,000	yd3		Included above
		Filter	86-68313	32,000	yd3		Included above
		Misc. Fill	86-68313	135,000	yd3		
		Dike					
	8	**Excavation, Common**	**86-68313**	**5,000**	**yd3**	**$4.50**	**$22,500.00**
	9	**Filter**	**86-68313**	**8,000**	**yd3**	**$55.00**	**$440,000.00**
		compacted by vibratory smooth drum rollers in 12-inch					
		to 24-inch lifts (for D/S filter zones & U/S riprap					
		bedding and crack stopper zones) (Assume Basalt Hill is					
		sole borrow source for sand & gravel which must be					
		drilled/blasted and processed)					
	10	**Misc. Fill**	**86-68313**	**15,000**	**yd3**	**$9.30**	**$139,500.00**
		(Assume Borrow Area 6 is sole borrow source material which					
		is rippable with dozer and minimal processing required)					
		SUBTOTAL THIS SHEET					**$602,000.00**

QUANTITIES		PRICES	
BY Tonya Hart, P.E.	**CHECKED** Tuti Tierney	**BY** Greg Akins	**CHECKED** 01/28/2013
DATE PREPARED 12/21/12	**PEER REVIEW / DATE** Randy Kuzniakowski	**DATE PREPARED** 01/25/13	**PEER REVIEW / DATE** 1/28/13

BUREAU OF RECLAMATION

ESTIMATE WORKSHEET

SHEET _5_ OF _16_

FEATURE:
B.F. Sisk Dam
Static Dam Raise Cost Estimate
Outlet Works
Intake Towers
Middle Estimated Drained Strength Parameters

PROJECT: **Central Valley Project, Madera County, California**

WOID: **AF743**

ESTIMATE LEVEL: Appraisal

REGION: MP

UNIT PRICE LEVEL: **Oct-12**

FILE: U:\2012 Projects\BF Sisk\002 Completed Sheets\[001 Summary BF Sisk - Drained.xlsx]Summary 16

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
		GENERAL SITEWORK					
		Assume the reservoir is low enough for					
		work to commence, and all equipment is					
		removed from the top of the intake towers					
		MOBILIZATION	86-68130	1	LS	Included on summary sheet	
		Assume a barge is mobilized for the work					
		INTAKE TOWERS					
	11	**Full depth saw cut**	**86-68130**	**520**	**LF**	**$240.00**	**$124,800.00**
		depth of cut varies from 2' to 3'					
	12	**Remove and dispose of top of intake towers**	**86-68130**	**1,200**	**yd3**	**$540.00**	**$648,000.00**
		quantity includes removal of the top 14 - 16					
		feet of 4 intake towers as well as gantry					
		crane slabs between towers					
	13	**Furnish, form, and place reinforced concrete**	**86-68130**	**1,700**	**yd3**	**$1,500.00**	**$2,550,000.00**
		4,500psi @ 28 days					
	14	**Cementitious Materials**	**86-68130**	**510**	**tons**	**$200.00**	**$102,000.00**
		assumed to be 600lbs/yd3					
	15	**Furnish and place concrete reinforcement**	**86-68130**	**255,000**	**lbs**	**$1.50**	**$382,500.00**
		assumes 150lbs/yd3					
	16	**Drill and grout anchor bars**	**86-68130**	**2,100**	**ea**	**$130.00**	**$273,000.00**
		assume #9 bars and 2" dia holes					
		5425 ft of linear drilling (31" per hole)					
		bars included in concrete reinforcement					
		line item					
		SUBTOTAL THIS SHEET					**$4,080,300.00**

QUANTITIES		PRICES	
BY Michael Shepherd	**CHECKED** Jason Schneider, P.E.	**BY** Greg Akins Greg Akins	**CHECKED** 01/28/2013
DATE PREPARED 11/15/12	**PEER REVIEW / DATE** Jason Schneider, P.E.	**DATE PREPARED** 01/25/13	**PEER REVIEW / DATE** 1/28/13

BUREAU OF RECLAMATION

ESTIMATE WORKSHEET

SHEET _6_ OF _16_

FEATURE:

B.F. Sisk Dam
Static Raise Cost Estimate
Morning Glory Spillway
Middle Estimated Drained Strength Parameters

PROJECT:

Central Valley Project, Madera County, California

WOID: AF743
ESTIMATE LEVEL: Appraisal
REGION: MP
UNIT PRICE LEVEL: Oct-12
FILE: U:\2012 Projects\BF Sisk\002 Completed Sheets\[001 Summary BF Sisk - Drained.xlsx]Summary 16

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
		GENERAL SITEWORK					
		Assume the reservoir is low enough for					
		work to commence					
		MOBILIZATION	86-68130	1	LS	Included on summary sheet	
		Assume the excavation and demolition					
		equipment is on site (from the intake tower					
		work)					
		SPILLWAY					
	17	**Full depth saw cut**	**86-68130**	**48**	**LF**	**$200.00**	**$9,600.00**
		depth of cut 2'-6"					
	18	**Excavation of upstream embankment**	**86-68130**	**1,950**	**yd3**	**$27.00**	**$52,650.00**
		Includes compacted embankment, rip rap					
		bedding, and rip rap					
	19	**Remove and dispose of top of Spillway**	**86-68130**	**180**	**yd3**	**$600.00**	**$108,000.00**
		quantity includes removal of the top 22ft					
	20	**Furnish, form, and place reinforced concrete**	**86-68130**	**220**	**yd3**	**$1,400.00**	**$308,000.00**
		4500psi @ 28 days					
	21	**Furnish and place concrete reinforcement**	**86-68130**	**33,000**	**lbs**	**$1.50**	**$49,500.00**
		assume 150lbs/yd3					
	22	**Cementitious Materials**	**86-68130**	**66**	**tons**	**$200.00**	**$13,200.00**
		600 lbs/yd3					
	23	**Drill and grout anchor bars**	**86-68130**	**80**	**ea**	**$130.00**	**$10,400.00**
		assume # 11 bars and 2.5" dia holes 255					
		feet of linear drilling (38" per hole) bars					
		included in concrete reinforcement line item					
		SUBTOTAL THIS SHEET					**$551,350.00**

QUANTITIES		**PRICES**	
BY Michael Shepherd	**CHECKED** Jason Schneider, P.E.	**BY** Greg Akins	**CHECKED** 1/28/2013
DATE PREPARED 11/15/12	**PEER REVIEW / DATE** Jason Schneider, P.E.	**DATE PREPARED** 01/25/13	**PEER REVIEW / DATE** TH 1/28/13

BUREAU OF RECLAMATION

ESTIMATE WORKSHEET

SHEET _7_ OF _16_

FEATURE:

B.F. Sisk Dam
Static Raise Cost Estimate
Morning Glory Spillway
Middle Estimated Drained Strength Parameters

PROJECT: **Central Valley Project, Madera County, California**

WOID: **AF743**

ESTIMATE LEVEL: **Appraisal**

REGION: **MP**

UNIT PRICE LEVEL: **Oct-12**

FILE: U:\2012 Projects\BF Sisk\002 Completed Sheets\[001 Summary BF Sisk - Drained.xlsx]Summary 16

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
		SPILLWAY					
	24	**Place compacted embankment**	**86-68130**	**1,950**	**yd3**	**$20.00**	**$39,000.00**
		Includes compacted embankment, rip rap					
		bedding, and rip rap					
		SUBTOTAL THIS SHEET					**$39,000.00**

QUANTITIES		**PRICES**	
BY Michael Shepherd	**CHECKED** Jason Schneider, P.E.	**BY** Greg Akins	**CHECKED** 01/28/2013
DATE PREPARED 11/15/12	**PEER REVIEW / DATE** Jason Schneider, P.E.	**DATE PREPARED** 01/25/13	**PEER REVIEW / DATE** 1/28/13

BUREAU OF RECLAMATION

ESTIMATE WORKSHEET

SHEET _8_ OF _16_

FEATURE:
BF Sisk (formerly San Luis) Dam
Appraisal Level Study
20 - foot dam raise
Intake Tower Access Bridge
Middle Estimated Drained Strength Parameters

PROJECT:
Central Valley Project, Madera County, California

WOID:	**A176F**	**ESTIMATE LEVEL:**	**Appraisal**
REGION:	**MP**	**UNIT PRICE LEVEL:**	**Oct-12**

FILE: U:\2012 Projects\BF Sisk\002 Completed Sheets\[001 Summary BF Sisk - Drained.xlsx]Summary 16

PLA NT ACC OU	PAY ITE M	DE SC	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
	25	**Removal & Disposal of Existing Bridge**	**86-68140**	**1**	**ls**	**$1,150,000.00**	**$1,150,000.00**
		The existing dam will be raised 20 feet. Since it would be very difficult to raise & reuse the existing bridge superstructure (six spans), it will be removed & replaced with a new bridge. The existing bridge superstructure consists of two steel plate girders (considered fracture critical) supporting a reinforced concrete deck Reservoir will not be dewatered, so demolition must consider barg access & handling / dispostal of structural steel coated with lead paint. To estimate the amount of materials to be removed, the existing bridge superstructure quantities are estimated to be:					
		Reinforced concrete = 400 cy					
		Structural steel = 640,000 lbs					
	26	**Concrete (4,500 psi @ 28 days)**	**86-68140**	**1,030**	**yd^3**	**$1,400.00**	**$1,442,000.00**
		Concrete volume is based on 3 quantities:					
		1. Pier caps extended vertically 12 ft.=170 cy					
		2. Superstructure deck = 700 cy					
		3. Abutment @ dam = 150 cy					
	27	**Cementatious Material (6 sacks/cy)**	**86-68140**	**290**	**tons**	**$200.00**	**$58,000.00**
	28	**Reinforcing Steel**	**86-68140**	**260,000**	**lbs**	**$1.50**	**$390,000.00**
		Specified minimum yield strength = 60 ksi					
	29	**Structural Steel (bridge superstructure)**	**86-68140**	**2,500,000**	**lbs**	**$3.00**	**$7,500,000.00**
		Structural steel girders conforming to ASTM A709 Grade 50W (Fy 50 ksi, weathering). See attached drawing for bridge cross sectio					
	30	**Bridge Guardrail (California ST-10)**	**86-68140**	**2,370**	**lf**	**$220.00**	**$521,400.00**
		See attached Caltrans Standard Plans B11-68, B11-69 & B11-70 f rail details					
	31	**Backfill behind/around abutment**	**86-68140**	**170.0**	**yd^3**	**$20.00**	**$3,400.00**
	32	**Compacted backfill behind/around abutment**	**86-68140**	**170.0**	**yd3**	**$20.00**	**$3,400.00**
		SUBTOTAL THIS SHEET					**$11,068,200.00**

ANTITIES		**3400**	
BY Jesus G. Romero, PE	**CHECKED** Joseph M. Gemperline, PE	**BY** Greg Akins	**CHECKED** 01/28/2013
DATE PREPARED 12/07/12	**PEER REVIEW / DATE** Roman M. Koltuniuk, PE	**DATE PREPARED** 01/25/13	**PEER REVIEW / DATE** 1/28/13

BUREAU OF RECLAMATION

ESTIMATE WORKSHEET

SHEET _9_ OF _16_

FEATURE:

BF Sisk (formerly San Luis) Dam
Appraisal Level Study
20 - foot dam raise
Intake Tower Access Bridge
Middle Estimated <u>Drained</u> Strength Parameters

PROJECT: **Central Valley Project, Madera County, California**

WOID: **A176F**

ESTIMATE LEVEL: **Appraisal**

REGION: **MP**

UNIT PRICE LEVEL: **Oct-12**

FILE: U:\2012 Projects\BF Sisk\002 Completed Sheets\[001 Summary BF Sisk - Drained.xlsx]Summary 16

PLA NT ACC OU	PAY ITE M	DE SC	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
	33	**Epoxy grouted anchors into existing caps**	**86-68140**	**400**	**ea**	**$50.00**	**$20,000.00**
		1in diameter Hilti Adhesive anchor: HIT_HY 150 MAX-SD+HAS. Grouted anchors are spaced at 1'-0" (16 x 5 grid), 80 per pier cap.					
	34	**Bearing Pads**	**86-68140**	**18**	**ea**	**$1,500.00**	**$27,000.00**
		Preformed fabric bearing pads at piers. Size of pads are estimate to be 5" thick x 2'-0" wide by 1'-9" long. Total number of pads = 18					
	35	**Bridge Joint Seals at Expansion Joints**	**86-68140**	**60**	**lf**	**$200.00**	**$12,000.00**
		Elastomeric expansion device equalt to General Tire Co. Transflex Model 1300 or to Watson Bowman & Associates Waboflex-SR Model SR 13 for full width of bridge.		20	lf		
		2 ½" by 2 ¾" Preformed Compression Joint Seals at tower & at abutment.		40	lf		
		SUBTOTAL THIS SHEET					**$59,000.00**

ANTITIES

BY Jesus G. Romero, PE

CHECKED Joseph M. Gemperline, PE

DATE PREPARED 12/07/12

PEER REVIEW / DATE Roman M. Koltuniuk, PE

PRICES

BY Greg Akins

CHECKED 01/28/2013

DATE PREPARED 01/25/13

PEER REVIEW / DATE 1/28/13

BUREAU OF RECLAMATION

ESTIMATE WORKSHEET

SHEET 10 OF 16

FEATURE: **B. F. Sisk Dam Modification** **Roller Gate re-location and Stem Extension** **Middle Estimated Drained Strength Parameters**	**PROJECT:** **Central Valley Project, Madera County, California**
	WOID:
	ESTIMATE LEVEL: **Appraisal**
	REGION: **MP**
	UNIT PRICE LEVEL: **Oct-12**
	FILE: U:\2012 Projects\BF Sisk\002 Completed Sheets\[001 Summary BF Sisk - Drained.xlsx]Summary 16

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
	36	**Site Survey (Pre-Rehab)**	**86-68420**	**1**	**LS**	**$12,000.00**	**$12,000.00**
		(assess general conditions and take					
		measurements as needed)					
		NOTE: The following quantities are for work on					
		one roller gate, hoist, & associated equipment					
		Total work is for four gates.					
	37	**Shut down and lock out unit associated with**	**86-68420**	**1**	**LS**	**$5,000.00**	**$5,000.00**
		gate to be removed					
	38	**Remove hydraulic piping to hoist**	**86-68420**	**1**	**EA**	**$9,500.00**	**$9,500.00**
		Crew: 1 supervisor, 1 mechanic					
		Shut valves to hoist					
		Drain oil from piping (15 gallons, 1 Crew HR)					
		Disconnect piping and plug ends (1 Crew HR)					
		Remove piping to hoist 150# (3 Crew HR)					
	39	**Remove Hydraulic Power Unit (8 Crew HR)**	**86-68420**	**1**	**EA**	**$14,500.00**	**$14,500.00**
		Disconnect electrical					
		Remove and store indorrs					
		Raise Roller Gate					
		Crew: 1 supervisor, 2 mechanics, 1 laborer					
	40	**Raise/lock gateby Gov't force (1 Crew HR)**	**86-68420**	**1**	**LS**	**$3,500.00**	**$3,500.00**
		Assume contractor assists gov't forces					
	41	**Remove hoist (18 Crew HR)**	**86-68420**	**1**	**LS**	**$21,000.00**	**$21,000.00**
	42	**Remove intermediate stems (12 Crew HR)**	**86-68420**	**1**	**LS**	**$26,000.00**	**$26,000.00**
	43	**Remove gate (10 Crew HR)**	**86-68420**	**1**	**LS**	**$31,000.00**	**$31,000.00**
		SUBTOTAL THIS SHEET	**1**				**$122,500.00**

QUANTITIES		**PRICES**	
BY D.L. Read	**CHECKED** D.M. Drake	**BY** Greg Akins	**CHECKED** 1/29/2013
DATE PREPARED 12/10//2012	**PEER REVIEW / DATE** DM Drake	**DATE PREPARED** 01/25/13	**PEER REVIEW / DATE** TA 1/28/13

BUREAU OF RECLAMATION

ESTIMATE WORKSHEET

SHEET 11 OF 16

FEATURE:

B. F. Sisk Dam Modification
Roller Gate re-location and Stem Extension
Middle Estimated Drained Strength Parameters

PROJECT: **Central Valley Project, Madera County, California**

WOID:

ESTIMATE LEVEL: **Appraisal**

REGION: **MP**

UNIT PRICE LEVEL: **Oct-12**

FILE: U:\2012 Projects\BF Sisk\002 Completed Sheets\[001 Summary BF Sisk - Drained.xlsx]Summary 16

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
		Install Embedded metalwork					
	44	**Furnish and install embedded gate guides**	**86-68420**	**1,875**	**LB**	**$13.00**	**$24,375.00**
		Install Roller Gate					
		Crew: 1 supervisor, 2 mechanics, 1 laborer					
	45	**Install gate (10 Crew HR)**	**86-68420**	**1**	**LS**	**$36,000.00**	**$36,000.00**
	46	**Install intermediate stems (12 Crew HR)**	**86-68420**	**1**	**LS**	**$30,000.00**	**$30,000.00**
	47	**Furnish and install one new intermediate stem**	**86-68420**	**1**	**LS**	**$140,000.00**	**$140,000.00**
		(steel - 1,475 # each, 12 Crew HR)					
	48	**Install hoist (18 Crew HR)**	**86-68420**	**1**	**LS**	**$50,000.00**	**$50,000.00**
	49	**Install hoist (18 Crew HR)**	**86-68420**	**1**	**LS**	**$42,000.00**	**$42,000.00**
		SUBTOTAL THIS SHEET	**2**				**$322,375.00**

QUANTITIES		PRICES	
BY D.L. Read	**CHECKED** D.M. Drake	**BY** Greg Akins	**CHECKED** 01/28/2013
DATE PREPARED 12/10//2012	**PEER REVIEW / DATE** D.M. Drake	**DATE PREPARED** 01/25/13	**PEER REVIEW / DATE** 1/28/13

BUREAU OF RECLAMATION

ESTIMATE WORKSHEET

SHEET 12 OF 16

FEATURE:
B. F. Sisk Dam Modification
Roller Gate re-location and Stem Extension
Middle Estimated Drained Strength Parameters

PROJECT:
Central Va Central Valley, California
California

WOID:

ESTIMATE LEVEL: **Appraisal**

REGION: **MP**

UNIT PRICE LEVEL: **Oct-12**

FILE: U:\2012 Projects\BF Sisk\002 Completed Sheets\[001 Summary BF Sisk - Drained.xlsx]Summary 16

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
		Install Hydraulic Controls					
		Crew: 1 supervisor, 1 mechanic, 1 laborer					
	50	**Install Hydraulic Power Unit (6 Crew HR)**	**86-68420**	**1**	**LS**	**$23,000.00**	**$23,000.00**
	51	**Connect piping (16 Crew HR)**	**86-68420**	**1**	**LS**	**$21,000.00**	**$21,000.00**
	52	**Electrically connect HPU, power, & control board**	**86-68420**	**1**	**LS**	**$18,000.00**	**$18,000.00**
		1 electician (10 HR)					
	53	**Fill and vent system (6 Crew HR)**	**86-68420**	**1**	**LS**	**$15,000.00**	**$15,000.00**
	54	**Test system:**		**1**	**LS**	**$19,000.00**	**$19,000.00**
	55	**Pressure test (6 Crew HR)**	**86-68420**	**1**	**LS**	**$12,000.00**	**$12,000.00**
	56	**Leak test Cylinder (6 Crew HR)**	**86-68420**	**1**	**LS**	**$12,000.00**	**$12,000.00**
	57	**Operational test (6 Crew HR)**	**86-68420**	**1**	**LS**	**$12,000.00**	**$12,000.00**
		SUBTOTAL THIS SHEET	**3**				**$132,000.00**

QUANTITIES		**PRICES**	
BY D.L. Read	**CHECKED** D.M. Drake	**BY** Greg Akins	**CHECKED** 1/28/2013
DATE PREPARED 12/10//2012	**PEER REVIEW / DATE** D.M. Drake	**DATE PREPARED** 01/25/13	**PEER REVIEW / DATE** 1/28/13

BUREAU OF RECLAMATION

ESTIMATE WORKSHEET

SHEET _13_ OF _16_

FEATURE: **B.F. Sisk Raise Appraisal Study** **Intake Tower Modifications** **Mechanical Equipment Group 86-68410** **Most Probable Estimate** **Middle Estimated Drained Strength Parameters**	**PROJECT:** **Central Valley Project, Madera County, California**
	WOID: **A176F** **ESTIMATE LEVEL:** **Appraisal**
	REGION: **MP** **UNIT PRICE LEVEL:** **Oct-12**
	FILE: U:\2012 Projects\BF Sisk\002 Completed Sheets\[001 Summary BF Sisk - Drained.xlsx]Summary 16

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
		GANTRY CRANE:					
	58	**Remove and dispose exist crane rails**	**86-68410**	**19,200**	**lbs.**	**$0.75**	**$14,400.00**
		All parts are structural steel					
		- 85# ASCE rails, 600 feet, 16,040 lbs.					
		- 585 Rail clips, 293 lbs.					
		- 290 Bearing plates, 1,600 lbs.					
		- 320 - ¾" Dia. x 12" machine bolts, 640 lbs.					
		- 300 - ¾" Dia. x 10" welded studs, 600 lbs.					
	59	**Furnish and install new crane rails**	**86-68410**	**19,200**	**lbs.**	**$9.00**	**$172,800.00**
		Structural steel, coated					
		- 85# ASCE rails, 600 feet, 16,040 lbs.					
		- 585 Rail clips, 293 lbs.					
		- 290 Bearing plates, 1,600 lbs.					
		- 320 - ¾" Dia. x 12" machine bolts, 640 lbs.					
		- 300 - ¾" Dia. x 10" welded studs, 600 lbs.					
	60	**Rerope the hoist and provide a new drums to**	**86-68410**	**1**	**LS**	**$120,000.00**	**$120,000.00**
		accommodate the additional 10"-0" of height					
		- 1-inch Dia. 6x37 IWRC, galvanized, extra		1,300	ft.		
		improved plow steel (XIP)					
		- Two new drums, cast steel, coated,		3,090	lbs.		
		9'-4" long, 24" dia., 1,545 lbs. ea.					
		Assume:					
		- Rope is 4 part					
		SUBTOTAL THIS SHEET					**$307,200.00**

QUANTITIES		**PRICES**	
BY **R. Stephen**	**CHECKED** **A. Ritt**	**BY** Greg Akins	**CHECKED** 01/28/2013
DATE PREPARED 12/17/12	**PEER REVIEW / DATE** D. Hulse	**DATE PREPARED** 01/25/13	**PEER REVIEW / DATE** 1/28/13

BUREAU OF RECLAMATION

ESTIMATE WORKSHEET

SHEET _14 _ OF _16 _

FEATURE:

B.F. Sisk Raise Appraisal Study
Intake Tower Modifications
Mechanical Equipment Group 86-68410
Most Probable Estimate
Middle Estimated Drained Strength Parameters

PROJECT: **Central Valley Project, Madera County, California**

WOID: **A176F**
ESTIMATE LEVEL: **Appraisal**
REGION: **MP**
UNIT PRICE LEVEL: **Oct-12**
FILE: U:\2012 Projects\BF Sisk\002 Completed Sheets\[001 Summary BF Sisk - Drained.xlsx]Summary 16

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
		GANTRY CRANE:					
	61	**Remove, store and reinstall gantry crane**	**86-68410**	**1**	**L.S.**	**$250,000.00**	**$250,000.00**
		after modifications to the intake towers are					
		completed					
		- Gantry crane will have to be disassembled					
		due to width of access bridge					
		- Crane dead weight is 176,000 lbs.					
		- Crane is approx. 40'-0" tall, 40'-0" wide,					
		and 38'-0" long.					
		Assume:					
		- Crane is stored onsite					
		- Crane is fully functional					
		- No modernization is required					
		- Removal and reinstallazation will require					
		the use of a mobile crane, ~20T					
		SUBTOTAL THIS SHEET					**$250,000.00**

QUANTITIES		**PRICES**	
BY **R. Stephen**	**CHECKED** **A. Ritt**	**BY** Greg Akins	**CHECKED** 01/28/2013
DATE PREPARED 12/17/12	**PEER REVIEW / DATE** D. Hulse	**DATE PREPARED** 01/25/13	**PEER REVIEW / DATE** 1/28/13

BUREAU OF RECLAMATION

ESTIMATE WORKSHEET

SHEET _15 _ OF _16 _

FEATURE:

B.F. Sisk Raise Appraisal Study
Intake Tower Modifications
Mechanical Equipment Group 86-68410
Most Probable Estimate
Middle Estimated Drained Strength Parameters

PROJECT: **Central Valley Project, Madera County, California**

WOID: **A176F**

ESTIMATE LEVEL: **Appraisal**

REGION: **MP**

UNIT PRICE LEVEL: **Oct-12**

FILE: U:\2012 Projects\BF Sisk\002 Completed Sheets\[001 Summary BF Sisk - Drained.xlsx]Summary 16

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
		BULKHEAD GATE:					
	62	**Remove and reinstall bulkhead gates,**	86-68410	1	L.S.	$500,000.00	$500,000.00
		lifting frame and storage arms.					
		- (2) Top bulkhead gates, 75,000 lbs. ea.,					
		approx. 24'-6" wide x 15'-0" tall					
		- (2) Bottom bulkhead gates, 73,000 lbs. ea.,					
		approx. 24'-6" wide x 14'-6" tall					
		- Bulkhead gates are stored in the top of the					
		guides of the intake towers.					
		- Lifting frame, 12,000 lbs., 26'-0" x 16'-6"					
		- (8) Storage arms, 1,200 lbs. ea., fastened					
		to concrete deck by anchor bolts, on top					
		of a grout pad.					
	63	**Remove and dispose existing bulkhead guides**	86-68410	20,000	lbs.	$0.75	$15,000.00
		- Embedded in concrete					
		- Eight at 2,500 lbs. ea., 10'-0" long					
	64	**Furnish and install new bulkhead guides**	86-68410	40,000	lbs.	$9.00	$360,000.00
		- Structural steel, coated, embedded					
		- Eight at 5,000 lbs. ea., 20'-0" long					
		SUBTOTAL THIS SHEET					**$875,000.00**

QUANTITIES		**PRICES**	
BY R. Stephen	**CHECKED** A. Ritt	**BY** Greg Akins	**CHECKED** 1/28/2013
DATE PREPARED 111/29/2012	**PEER REVIEW / DATE** D. Hulse	**DATE PREPARED** 01/25/13	**PEER REVIEW / DATE** tH 1/28/13

BUREAU OF RECLAMATION

ESTIMATE WORKSHEET

SHEET _16_ OF _16_

FEATURE: **B.F. Sisk Dam Modification** **Appraisal Level Study** **20-foot Dam Raise** **Middle Estimated Drained Strength Parameters** **Option A**	**PROJECT:** **Central Valley Project, Madera County, California**
	WOID: A176F — **ESTIMATE LEVEL:** Appraisal
	REGION: MP — **UNIT PRICE LEVEL:** Oct-12
	FILE: U:\2012 Projects\BF Sisk\002 Completed Sheets\[001 Summary BF Sisk - Drained.xlsx]Summary 16

PLANT ACCOUNT	PAY ITEM	DESCRIPTION				AMOUNT
		Subtotal Sheet 2 of 16				**$60,589,000.00**
		Subtotal Sheet 3 of 16				**$121,669,000.00**
		Subtotal Sheet 4 of 16				**$602,000.00**
		Subtotal Sheet 5 of 16				**$4,080,300.00**
		Subtotal Sheet 6 of 16				**$551,350.00**
		Subtotal Sheet 7 of 16				**$39,000.00**
		Subtotal Sheet 8 of 16				**$11,068,200.00**
		Subtotal Sheet 9 of 16				**$59,000.00**
		Subtotal Sheet 10 of 16				**$122,500.00**
		Subtotal Sheet 11 of 16				**$322,375.00**
		Subtotal Sheet 12 of 16				**$132,000.00**
		Subtotal Sheet 13 of 16				**$307,200.00**
		Subtotal Sheet 14 of 16				**$250,000.00**
		Subtotal Sheet 15 of 16				**$875,000.00**
		Subtotal				**$200,666,925.00**
		Mobilization	5%	+/-		$10,000,000.00
		Subtotal with Mobilization				**$210,666,925.00**
		Contract Cost Allowances (Sum of):	18%	+/-		$39,333,075.00
		Design Contingencies,15% (+/-)				
		APS, 3% (+/-). Type of procurement:Request for Proposal				
		CONTRACT COST				**$250,000,000.00**
		Construction Contingencies	25%	+/-		$60,000,000.00
		FIELD COST (Unit Price Level Oct 2012)				**$310,000,000.00**
		Non-Contract Costs		**To be determined by the appropriate responsible offic**		
		Escalation to Notice to Proceed (NTP)		**To be determined by the appropriate responsible offic**		
		CONSTRUCTION COST		**To be determined by the appropriate responsible offic**		
		Ref.: For appropriate use and terminology, see Reclamation Manual, Directives and Standards FAC; 09-01, 09-02 and 09-03.				

QUANTITIES		PRICES	
BY See Estimate Sheets	**CHECKED** See Estimate Sheets	**BY** Greg Akins	**CHECKED** 3/20/13
DATE PREPARED	**PEER REVIEW / DATE** See Estimate Sheets	**DATE PREPARED** 1/25/2013 - revised 3/20/13	**PEER REVIEW / DATE** 3/22/13

Appendix B

Cost Estimate Worksheets – Option B

BUREAU OF RECLAMATION

ESTIMATE WORKSHEET

FEATURE:

B.F. Sisk Dam Modification
Appraisal Level Study
20-foot Dam Raise
Middle Estimated Undrained Strength Parameters

Option B

Geotechnical (86-68313)

PROJECT: **Central Valley Project, Madera County, California**

WOID: **A176F**

ESTIMATE LEVEL: **Appraisal**

REGION: **MP**

UNIT PRICE LEVEL: **Oct-12**

FILE: U:\2012 Projects\BF Sisk\002 Completed Sheets\[002 Summary BF Sisk - Undrained.xlsx]Sht 1

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT

The cost estimate sheets from B.F. Sisk Dam Appraisal-Level Construction Considerations (TM VB-8313-9; May 2010) were used to establish quantities for preparing this cost estimate. The borrow areas, construction methods, and environmental considerations presented in TM VB-8313-9 are assumed to be the same for this Appraisal-Level study. Additionally, information presented in B.F. Sisk Dam Appraisal-Level Study of Static Stability for Increased Storage report (TM VB-86-68313-22; December 2012) should be reviewed.

NOTES:

1) Quantities were calculated at specific sections (e.g. stations 37+00, 65+00, 86+00, 107+00 and 147+20) and the dike during this Appraisal-Level study. Quantities at stations 169+00 and 180+00 were taken from VB-8313-9 and were not recalculated during this study. The quantities indicated at each station were assumed to be representative of the location (e.g. station 37+00 represents total quantities between stations 0+00 and 56+00).
2) Raise includes removal of 10 feet of the existing crest for penetration into existing Zone 1 core (6 inches of gravel surfacing plus Zone 4, Zone 5 (riprap), and Zone 1).
3) Costs associated with escalation to NTP, and non-contract costs are not included; mobilization and allowance for procurement strategies costs are included.
4) There is a Corrective Action Study (CAS) underway to address risks of dam failure during a major earthquake. This appraisal-level study evaluated increased storage in San Luis Reservoir based solely on static stability conditions using post-earthquake soil strength parameters. These estimates were prepared to provide a general order-of-magnitude-type cost. This study is not meant to be a stand-alone study, rather it should be reviewed during the CAS.

QUANTITIES		PRICES	
BY Tonya Hart, P.E.	**CHECKED** Tuti Tierney	**BY** Greg Akins	**CHECKED** 1/28/2013
DATE PREPARED 12/21/12	**PEER REVIEW / DATE** Randy Kuzniakowski	**DATE PREPARED** 01/25/13	**PEER REVIEW / DATE** 1/28/13

BUREAU OF RECLAMATION

ESTIMATE WORKSHEET

SHEET 2 OF 16

FEATURE: **B.F. Sisk Dam Modification** **Appraisal Level Study** **20-foot Dam Raise Only, No D/S Berm** **Middle Estimated Undrained Strength Parameters** **Geotechnical (86-68313)**	**PROJECT:** **Central Valley Project, Madera County, California**		
	WOID: A176F	**ESTIMATE LEVEL:** Appraisal	
	REGION: MP	**UNIT PRICE LEVEL:** Oct-12	
	FILE: U:\2012 Projects\BF Sisk\002 Completed Sheets\[002 Summary BF Sisk - Undrained.xlsx]Summary 16		

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
		The quantities on this sheet apply to the following locations. Sections for these locations were not					
		analyzed in Slope/W for static stability. However, because the embankment is founded directly					
		on bedrock (i.e. potentially liquefiable foundation materials were removed during construction),					
		no downstream berm is needed.					
		Stations 0+00 to 31+00					
		Stations 46+00 to 56+00					
		Stations 114+00 to 139+00					
		Stations 149+00 to 165+00					
		Stations 173+00 to 176+00					
		Stations 183+00 to 185+00					
	1	**Excavation, Common**	**86-68313**	**304,000**	**yd3**	**$4.50**	**$1,368,000.00**
	2	**Zone 1: Selected clay, sand, and gravel**	**86-68313**	**195,000**	**yd3**	**$18.00**	**$3,510,000.00**
		compacted by tamping rollers to 6-inch lifts					
		(Assume Borrow Area 6 is sole borrow					
		source for Zone 1 material which is rippable					
		with dozer and processing is required)					
	3	**Processed sand & gravel compacted by**	**86-68313**	**646,000**	**yd3**	**$55.00**	**$35,530,000.00**
		vibratory smooth drum rollers in 12-inch to					
		24-inch lifts (for D/S filter zones & U/S riprap					
		bedding and crack stopper zones)					
		(Assume Basalt Hill is sole borrow					
		source for sand & gravel which must be drilled/					
		blasted and processed)					
	4	**Misc. Fill**	**86-68313**	**2,170,000**	**yd3**	**$9.30**	**$20,181,000.00**
		(Assume Borrow Area 6 is sole borrow					
		source for Zone 1 material which is rippable					
		with dozer and minimal processing is required)					
		SUBTOTAL THIS SHEET					**$60,589,000.00**

QUANTITIES		**PRICES**	
BY Tonya Hart, P.E.	**CHECKED** Tuti Tierney	**BY** Greg Akins	**CHECKED** 1/28/2013
DATE PREPARED 12/21/12	**PEER REVIEW / DATE** Randy Kuzniakowski	**DATE PREPARED** 01/25/13	**PEER REVIEW / DATE** TH 1/28/13

BUREAU OF RECLAMATION

ESTIMATE WORKSHEET

SHEET 3 OF 16

FEATURE:
B.F. Sisk Dam Modification
Appraisal Level Study
20-foot Dam Raise
"Best" Undrained Strength Parameters

Geotechnical (86-68313)

PROJECT:
Central Valley Project, Madera County, California

WOID: A176F
ESTIMATE LEVEL: Appraisal
REGION: MP
UNIT PRICE LEVEL: Oct-12
FILE: U:\2012 Projects\BF Sisk\002 Completed Sheets\[002 Summary BF Sisk - Undrained.xlsx]Sht 3B

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
		Summary Station 37+00 to 180+00					
	5	**Excavation, Common**		**1,177,000**	**yd3**	**$4.50**	**$5,296,500.00**
	6	**Filter**		**1,763,000**	**yd3**	**$55.00**	**$96,965,000.00**
		compacted by vibratory smooth drum rollers in 12-inch					
		to 24-inch lifts (for D/S filter zones & U/S riprap					
		bedding and crack stopper zones) (Assume Basalt Hill is					
		sole borrow source for sand & gravel which must be					
		drilled/blasted and processed)					
	7	**Misc. Fill**		**5,688,000**	**yd3**	**$9.30**	**$52,898,400.00**
		(Assume Borrow Area 6 is sole borrow source material which					
		is rippable with dozer and minimal processing is required)					
Sta	37+00						
	10	Excavation, Common	86-68313	260,000	yd3		Included above
	20	Filter	86-68313	274,000	yd3		Included above
	30	Misc. Fill	86-68313	738,000	yd3		Included above
Sta	65+00						
	10	Excavation, Common	86-68313	466,000	yd3		Included above
	20	Filter	86-68313	312,000	yd3		Included above
	30	Misc. Fill	86-68313	1,196,000	yd3		Included above
Sta	86+00						
	10	Excavation, Common	86-68313	131,000	yd3		Included above
	20	Filter	86-68313	276,000	yd3		Included above
	30	Misc. Fill	86-68313	1,368,000	yd3		Included above
Sta	107+00						
	10	Excavation, Common	86-68313	90,000	yd3		Included above
	20	Filter	86-68313	530,000	yd3		Included above
	30	Misc. Fill	86-68313	1,085,000	yd3		Included above
Sta	147+20						
	10	Excavation, Common	86-68313	179,000	yd3		Included above
	20	Filter	86-68313	319,000	yd3		Included above
	30	Misc. Fill	**86-68313**	936,000	yd3		**Included above**
		SUBTOTAL THIS SHEET					**$155,159,900.00**

QUANTITIES		PRICES	
BY Tonya Hart, P.E.	**CHECKED** Tuti Tierney	**BY** Greg Akins	**CHECKED** 3/20/13
DATE PREPARED 12/21/12	**PEER REVIEW / DATE** Randy Kuzniakowski	**DATE PREPARED** 1/25/2013 - revised 3/20/13	**PEER REVIEW / DATE** MA 3/22/13

BUREAU OF RECLAMATION

ESTIMATE WORKSHEET

SHEET 4 OF 16

FEATURE:

B.F. Sisk Dam Modification
Appraisal Level Study
20-foot Dam Raise
"Best" Undrained Strength Parameters

Geotechnical (86-68313)

PROJECT:

Central Valley Project, Madera County, California

WOID:	**A176F**	**ESTIMATE LEVEL:**	**Appraisal**
REGION:	**MP**	**UNIT PRICE LEVEL:**	**Oct-12**

FILE: U:\2012 Projects\BF Sisk\002 Completed Sheets\[002 Summary BF Sisk - Undrained.xlsx]Summary 16

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
Sta	169+00						
	10	Excavation, Common	86-68313	14,000	yd3		Included above
	20	Filter	86-68313	20,000	yd3		Included above
	30	Misc. Fill	86-68313	230,000	yd3		Included above
Sta	180+00						
	10	Excavation, Common	86-68313	37,000	yd3		Included above
	20	Filter	86-68313	32,000	yd3		Included above
	30	Misc. Fill	86-68313	135,000	yd3		Included above
		Dike					
	8	**Excavation, Common**	**86-68313**	**5,000**	**yd3**	**$4.50**	**$22,500.00**
	9	**Filter**	**86-68313**	**8,000**	**yd3**	**$55.00**	**$440,000.00**
		compacted by vibratory smooth drum rollers in 12-inch					
		to 24-inch lifts (for D/S filter zones & U/S riprap					
		bedding and crack stopper zones) (Assume Basalt Hill is					
		sole borrow source for sand & gravel which must be					
		drilled/blasted and processed)					
	10	**Misc. Fill**	**86-68313**	**15,000**	**yd3**	**$9.30**	**$139,500.00**
		(Assume Borrow Area 6 is sole borrow source material which					
		is rippable with dozer and minimal processing is required)					
		SUBTOTAL THIS SHEET					**$602,000.00**

QUANTITIES		**PRICES**	
BY Tonya Hart, P.E.	**CHECKED** Tuti Tierney	**BY** Greg Akins	**CHECKED** 01/28/2013
DATE PREPARED 12/21/12	**PEER REVIEW / DATE** Randy Kuzniakowski	**DATE PREPARED** 01/25/13	**PEER REVIEW / DATE** 1/28/13

BUREAU OF RECLAMATION

ESTIMATE WORKSHEET

SHEET _5_ OF _16_

FEATURE: **B.F. Sisk Dam** **Static Dam Raise Cost Estimate** **Outlet Works** **Intake Towers** **Middle Estimated Undrained Strength Parameters**	**PROJECT:** **Central Valley Project, Madera County, California**
	WOID: **AF743** — **ESTIMATE LEVEL: Appraisal**
	REGION: MP — **UNIT PRICE LEVEL:** **Oct-12**
	FILE: U:\2012 Projects\BF Sisk\002 Completed Sheets\[002 Summary BF Sisk - Undrained.xlsx]Summary 16

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
		GENERAL SITEWORK					
		Assume the reservoir is low enough for					
		work to commence, and all equipment is					
		removed from the top of the intake towers					
		MOBILIZATION	86-68130	1	LS	Included on summary sheet	
		Assume a barge is mobilized for the work					
		INTAKE TOWERS					
	11	**Full depth saw cut**	**86-68130**	**520**	**LF**	**$240.00**	**$124,800.00**
		depth of cut varies from 2' to 3'					
	12	**Remove and dispose of top of intake towers**	**86-68130**	**1,200**	**yd3**	**$540.00**	**$648,000.00**
		quantity includes removal of the top 14 - 16					
		feet of 4 intake towers as well as gantry					
		crane slabs between towers					
	13	**Furnish, form, and place reinforced concrete**	**86-68130**	**1,700**	**yd3**	**$1,500.00**	**$2,550,000.00**
		4,500psi @ 28 days					
	14	**Cementitious Materials**	**86-68130**	**510**	**tons**	**$200.00**	**$102,000.00**
		assumed to be 600lbs/yd3					
	15	**Furnish and place concrete reinforcement**	**86-68130**	**255,000**	**lbs**	**$1.50**	**$382,500.00**
		assumes 150lbs/yd3					
	16	**Drill and grout anchor bars**	**86-68130**	**2,100**	**ea**	**$130.00**	**$273,000.00**
		assume #9 bars and 2" dia holes					
		5425 ft of linear drilling (31" per hole)					
		bars included in concrete reinforcement					
		line item					
		SUBTOTAL THIS SHEET					**$4,080,300.00**

QUANTITIES		**PRICES**	
BY Michael Shepherd	**CHECKED** Jason Schneider, P.E.	**BY** Greg Akins	**CHECKED** 01/28/2013
DATE PREPARED 11/15/12	**PEER REVIEW / DATE** Jason Schneider, P.E.	**DATE PREPARED** 01/25/13	**PEER REVIEW / DATE** 1/28/13

BUREAU OF RECLAMATION

ESTIMATE WORKSHEET

SHEET _6_ OF _16_

FEATURE: **B.F. Sisk Dam** **Static Raise Cost Estimate** **Morning Glory Spillway** **Middle Estimated Undrained Strength Parameters**	**PROJECT:** **Central Valley Project, Madera County, California**
	WOID: **AF743** **ESTIMATE LEVEL:** **Appraisal**
	REGION: **MP** **UNIT PRICE LEVEL:** **Oct-12**
	FILE: U:\2012 Projects\BF Sisk\002 Completed Sheets\[002 Summary BF Sisk - Undrained.xlsx]Summary 16

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
		GENERAL SITEWORK					
		Assume the reservoir is low enough for					
		work to commence					
		MOBILIZATION	86-68130	1	LS	Included on summary sheet	
		Assume the excavation and demolition					
		equipment is on site (from the intake tower					
		work)					
		SPILLWAY					
	17	**Full depth saw cut**	86-68130	48	LF	$200.00	$9,600.00
		depth of cut 2'-6"					
	18	**Excavation of upstream embankment**	86-68130	1,950	yd3	$27.00	$52,650.00
		Includes compacted embankment, rip rap					
		bedding, and rip rap					
	19	**Remove and dispose of top of Spillway**	86-68130	180	yd3	$600.00	$108,000.00
		quantity includes removal of the top 22ft					
	20	**Furnish, form, and place reinforced concrete**	86-68130	220	yd3	$1,400.00	$308,000.00
		4500psi @ 28 days					
	21	**Furnish and place concrete reinforcement**	86-68130	33,000	lbs	$1.50	$49,500.00
		assume 150lbs/yd3					
	22	**Cementitious Materials**	86-68130	66	tons	$200.00	$13,200.00
		600 lbs/yd3					
	23	**Drill and grout anchor bars**	86-68130	80	ea	$130.00	$10,400.00
		assume # 11 bars and 2.5" dia holes 255					
		feet of linear drilling (38" per hole) bars					
		included in concrete reinforcement line item					
		SUBTOTAL THIS SHEET					$551,350.00

QUANTITIES		**PRICES**	
BY Michael Shepherd	**CHECKED** Jason Schneider, P.E.	**BY** Greg Akins Greg Akins	**CHECKED** 01/28/2013
DATE PREPARED 11/15/12	**PEER REVIEW / DATE** Jason Schneider, P.E.	**DATE PREPARED** 01/25/13	**PEER REVIEW / DATE** 1/28/13

BUREAU OF RECLAMATION

ESTIMATE WORKSHEET

SHEET _7 _ OF _16 _

FEATURE:

B.F. Sisk Dam
Static Raise Cost Estimate
Morning Glory Spillway
Middle Estimated Undrained Strength Parameters

PROJECT:

Central Valley Project, Madera County, California

WOID:	**AF743**	**ESTIMATE LEVEL:**	**Appraisal**
REGION:	**MP**	**UNIT PRICE LEVEL:**	**Oct-12**

FILE: U:\2012 Projects\BF Sisk\002 Completed Sheets\[002 Summary BF Sisk - Undrained.xlsx]Summary 16

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
		SPILLWAY					
	24	**Place compacted embankment**	**86-68130**	**1,950**	**yd3**	**$20.00**	**$39,000.00**
		Includes compacted embankment, rip rap					
		bedding, and rip rap					
		SUBTOTAL THIS SHEET					**$39,000.00**

QUANTITIES		PRICES	
BY Michael Shepherd	**CHECKED** Jason Schneider, P.E.	**BY** Greg Akins	**CHECKED** 01/28/2013
DATE PREPARED 11/15/12	**PEER REVIEW / DATE** Jason Schneider, P.E.	**DATE PREPARED** 01/25/13	**PEER REVIEW / DATE** 1/28/13

BUREAU OF RECLAMATION

ESTIMATE WORKSHEET

SHEET _8_ OF _16_

FEATURE: **BF Sisk (formerly San Luis) Dam** **Appraisal Level Study** **20 - foot dam raise** **Intake Tower Access Bridge** **Middle Estimated Undrained Strength Parameters**	**PROJECT:** **Central Valley Project, Madera County, California**
	WOID: A176F — **ESTIMATE LEVEL:** Appraisal
	REGION: MP — **UNIT PRICE LEVEL:** Oct-12
	FILE: U:\2012 Projects\BF Sisk\002 Completed Sheets\[002 Summary BF Sisk - Undrained.xlsx]Summary 16

PLA NT ACC OU	PAY ITE M	DE SC	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
	25	**Removal & Disposal of Existing Bridge**	86-68140	1	ls	$1,150,000.00	$1,150,000.00
		The existing dam will be raised 20 feet. Since it would be very difficult to raise & reuse the existing bridge superstructure (six spans), it will be removed & replaced with a new bridge. The existing bridge superstructure consists of two steel plate girders (considered fracture critical) supporting a reinforced concrete deck Reservoir will not be dewatered, so demolition must consider barg access & handling / dispostal of structural steel coated with lead paint. To estimate the amount of materials to be removed, the existing bridge superstructure quantities are estimated to be:					
		Reinforced concrete = 400 cy					
		Structural steel = 640,000 lbs					
	26	**Concrete (4,500 psi @ 28 days)**	86-68140	1,030	yd^3	$1,400.00	$1,442,000.00
		Concrete volume is based on 3 quantities:					
		1. Pier caps extended vertically 12 ft.=170 cy					
		2. Superstructure deck = 700 cy					
		3. Abutment @ dam = 150 cy					
	27	**Cementatious Material (6 sacks/cy)**	86-68140	290	tons	$200.00	$58,000.00
	28	**Reinforcing Steel**	86-68140	260,000	lbs	$1.50	$390,000.00
		Specified minimum yield strength = 60 ksi					
	29	**Structural Steel (bridge superstructure)**	86-68140	2,500,000	lbs	$3.00	$7,500,000.00
		Structural steel girders conforming to ASTM A709 Grade 50W (Fy 50 ksi, weathering). See attached drawing for bridge cross sectio					
	30	**Bridge Guardrail (California ST-10)**	86-68140	2,370	lf	$220.00	$521,400.00
		See attached Caltrans Standard Plans B11-68, B11-69 & B11-70 f rail details					
	31	**Backfill behind/around abutment**	86-68140	170.0	yd^3	$20.00	$3,400.00
	32	**Compacted backfill behind/around abutment**	86-68140	170.0	yd3	$20.00	$3,400.00
		SUBTOTAL THIS SHEET					**$11,068,200.00**

ANTITIES		**3400**	
BY Jesus G. Romero, PE	**CHECKED** Joseph M. Gemperline, PE	**BY** Greg Akins	**CHECKED** 01/28/2013
DATE PREPARED 12/07/12	**PEER REVIEW / DATE** Roman M. Koltuniuk, PE	**DATE PREPARED** 01/25/13	**PEER REVIEW / DATE** 1/28/13

BUREAU OF RECLAMATION

ESTIMATE WORKSHEET

SHEET _9_ OF _16_

FEATURE:

BF Sisk (formerly San Luis) Dam
Appraisal Level Study
20 - foot dam raise
Intake Tower Access Bridge
Middle Estimated Undrained Strength Parameters

PROJECT: Central Valley Project, Madera County, California

WOID: A176F

ESTIMATE LEVEL: Appraisal

REGION: MP

UNIT PRICE LEVEL: Oct-12

FILE: U:\2012 Projects\BF Sisk\002 Completed Sheets\[002 Summary BF Sisk - Undrained.xlsx]Summary 16

PLA NT ACC OU	PAY ITE M	DE SC	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
	33	**Epoxy grouted anchors into existing caps**	**86-68140**	**400**	**ea**	**$50.00**	**$20,000.00**
		1in diameter Hilti Adhesive anchor: HIT_HY 150 MAX-SD+HAS.					
		Grouted anchors are spaced at 1'-0" (16 x 5 grid), 80 per pier cap.					
	34	**Bearing Pads**	**86-68140**	**18**	**ea**	**$1,500.00**	**$27,000.00**
		Preformed fabric bearing pads at piers. Size of pads are estimate					
		to be 5" thick x 2'-0" wide by 1'-9" long. Total number of pads = 18					
	35	**Bridge Joint Seals at Expansion Joints**	**86-68140**	**60**	**lf**	**$200.00**	**$12,000.00**
		Elastomeric expansion device equalt to General Tire Co. Transflex		20	lf		
		Model 1300 or to Watson Bowman & Associates Waboflex-SR					
		Model SR 13 for full width of bridge.					
		2 ½" by 2 ¾" Preformed Compression Joint Seals at tower & at		40	lf		
		abutment.					
		SUBTOTAL THIS SHEET					**$59,000.00**

ANTITIES

BY Jesus G. Romero, PE	**CHECKED** Joseph M. Gemperline, PE
DATE PREPARED 12/07/12	**PEER REVIEW / DATE** Roman M. Koltuniuk, PE

PRICES

BY Greg Akins	**CHECKED** 01/28/2013
DATE PREPARED 01/25/13	**PEER REVIEW / DATE** 1/28/13

BUREAU OF RECLAMATION

ESTIMATE WORKSHEET

SHEET 10 OF 16

FEATURE:

B. F. Sisk Dam Modification
Roller Gate re-location and Stem Extension
Middle Estimated <u>Undrained</u> Strength Parameters

PROJECT:
Central Valley Project, Madera County, California

WOID:

ESTIMATE LEVEL: **Appraisal**

REGION: **MP**

UNIT PRICE LEVEL: **Oct-12**

FILE: U:\2012 Projects\BF Sisk\002 Completed Sheets\[002 Summary BF Sisk - Undrained.xlsx]Summary 16

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
	36	**Site Survey (Pre-Rehab)**	**86-68420**	**1**	**LS**	**$12,000.00**	**$12,000.00**
		(assess general conditions and take					
		measurements as needed)					
		NOTE: The following quantities are for work on					
		one roller gate, hoist, & associated equipment					
		Total work is for four gates.					
	37	**Shut down and lock out unit associated with**	**86-68420**	**1**	**LS**	**$5,000.00**	**$5,000.00**
		gate to be removed					
	38	**Remove hydraulic piping to hoist**	**86-68420**	**1**	**EA**	**$9,500.00**	**$9,500.00**
		Crew: 1 supervisor, 1 mechanic					
		Shut valves to hoist					
		Drain oil from piping (15 gallons, 1 Crew HR)					
		Disconnect piping and plug ends (1 Crew HR)					
		Remove piping to hoist 150# (3 Crew HR)					
	39	**Remove Hydraulic Power Unit (8 Crew HR)**	**86-68420**	**1**	**EA**	**$14,500.00**	**$14,500.00**
		Disconnect electrical					
		Remove and store indorrs					
		Raise Roller Gate					
		Crew: 1 supervisor, 2 mechanics, 1 laborer					
	40	**Raise/lock gateby Gov't force (1 Crew HR)**	**86-68420**	**1**	**LS**	**$3,500.00**	**$3,500.00**
		Assume contractor assists gov't forces					
	41	**Remove hoist (18 Crew HR)**	**86-68420**	**1**	**LS**	**$21,000.00**	**$21,000.00**
	42	**Remove intermediate stems (12 Crew HR)**	**86-68420**	**1**	**LS**	**$26,000.00**	**$26,000.00**
	43	**Remove gate (10 Crew HR)**	**86-68420**	**1**	**LS**	**$31,000.00**	**$31,000.00**
		SUBTOTAL THIS SHEET	**1**				**$122,500.00**

QUANTITIES		PRICES	
BY D.L. Read	**CHECKED** D.M. Drake	**BY** Greg Akins	**CHECKED** 1/28/2013
DATE PREPARED 12/10//2012	**PEER REVIEW / DATE** P M Drake	**DATE PREPARED** 01/25/13	**PEER REVIEW / DATE** 1/28/13

BUREAU OF RECLAMATION

ESTIMATE WORKSHEET

SHEET 11 OF 16

FEATURE:

B. F. Sisk Dam Modification
Roller Gate re-location and Stem Extension
Middle Estimated Undrained Strength Parameters

PROJECT:
Central Valley Project, Madera County, California

WOID:

ESTIMATE LEVEL: **Appraisal**

REGION: **MP**

UNIT PRICE LEVEL: **Oct-12**

FILE: U:\2012 Projects\BF Sisk\002 Completed Sheets\[002 Summary BF Sisk - Undrained.xlsx]Summary 16

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
		Install Embedded metalwork					
	44	**Furnish and install embedded gate guides**	**86-68420**	**1,875**	**LB**	**$13.00**	**$24,375.00**
		Install Roller Gate					
		Crew: 1 supervisor, 2 mechanics, 1 laborer					
	45	**Install gate (10 Crew HR)**	**86-68420**	**1**	**LS**	**$36,000.00**	**$36,000.00**
	46	**Install intermediate stems (12 Crew HR)**	**86-68420**	**1**	**LS**	**$30,000.00**	**$30,000.00**
	47	**Furnish and install one new intermediate stem**	**86-68420**	**1**	**LS**	**$140,000.00**	**$140,000.00**
		(steel - 1,475 # each, 12 Crew HR)					
	48	**Install hoist (18 Crew HR)**	**86-68420**	**1**	**LS**	**$50,000.00**	**$50,000.00**
	49	**Install hoist (18 Crew HR)**	**86-68420**	**1**	**LS**	**$42,000.00**	**$42,000.00**
		SUBTOTAL THIS SHEET	**2**				**$322,375.00**

QUANTITIES		**PRICES**	
BY D.L. Read	**CHECKED** D.M. Drake	**BY** Greg Akins	**CHECKED** 1/28/2013
DATE PREPARED 12/10//2012	**PEER REVIEW / DATE** DM Drake	**DATE PREPARED** 01/25/13	**PEER REVIEW / DATE** 1/28/13

BUREAU OF RECLAMATION

ESTIMATE WORKSHEET

SHEET 12 OF 16

FEATURE:

B. F. Sisk Dam Modification
Roller Gate re-location and Stem Extension
Middle Estimated Undrained Strength Parameters

PROJECT:
Central Va Central Valley, California
California

WOID:
ESTIMATE LEVEL: Appraisal
REGION: MP
UNIT PRICE LEVEL: Oct-12
FILE: U:\2012 Projects\BF

NT ACC OU	PAY ITE M	DE SC	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
		Install Hydraulic Controls					
		Crew: 1 supervisor, 1 mechanic, 1 laborer					
	50	**Install Hydraulic Power Unit (6 Crew HR)**	86-68420	1	LS	$23,000.00	$23,000.00
	51	**Connect piping (16 Crew HR)**	86-68420	1	LS	$21,000.00	$21,000.00
	52	**Electrically connect HPU, power, & control board**	86-68420	1	LS	$18,000.00	$18,000.00
		1 electician (10 HR)					
	53	**Fill and vent system (6 Crew HR)**	86-68420	1	LS	$15,000.00	$15,000.00
	54	**Test system:**		1	LS	$19,000.00	$19,000.00
	55	**Pressure test (6 Crew HR)**	86-68420	1	LS	$12,000.00	$12,000.00
	56	**Leak test Cylinder (6 Crew HR)**	86-68420	1	LS	$12,000.00	$12,000.00
	57	**Operational test (6 Crew HR)**	86-68420	1	LS	$12,000.00	$12,000.00
		SUBTOTAL THIS SHEET	3				$132,000.00

ANTITIES		**PRICES**	
BY D.L. Read	**CHECKED** D.M. Drake	**BY** Greg Akins Greg Akin	**CHECKED** 1/28/2013
DATE PREPARED 12/10//2012	**PEER REVIEW / DATE** D M Drake	**DATE PREPARED** 01/25/13	**PEER REVIEW / DATE** TA 1/28/13

BUREAU OF RECLAMATION

ESTIMATE WORKSHEET

SHEET _13 _ OF _16 _

FEATURE:

B.F. Sisk Raise Appraisal Study
Intake Tower Modifications
Mechanical Equipment Group 86-68410
Most Probable Estimate
Middle Estimated Undrained Strength Parameters

PROJECT: **Central Valley Project, Madera County, California**

WOID: **A176F**

ESTIMATE LEVEL: **Appraisal**

REGION: **MP**

UNIT PRICE LEVEL: **Oct-12**

FILE: U:\2012 Projects\BF Sisk\002 Completed Sheets\[002 Summary BF Sisk - Undrained.xlsx]Summary 16

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
		GANTRY CRANE:					
	58	**Remove and dispose exist crane rails**	**86-68410**	**19,200**	**lbs.**	**$0.75**	**$14,400.00**
		All parts are structural steel					
		- 85# ASCE rails, 600 feet, 16,040 lbs.					
		- 585 Rail clips, 293 lbs.					
		- 290 Bearing plates, 1,600 lbs.					
		- 320 - ¾" Dia. x 12" machine bolts, 640 lbs.					
		- 300 - ¾" Dia. x 10" welded studs, 600 lbs.					
	59	**Furnish and install new crane rails**	**86-68410**	**19,200**	**lbs.**	**$9.00**	**$172,800.00**
		Structural steel, coated					
		- 85# ASCE rails, 600 feet, 16,040 lbs.					
		- 585 Rail clips, 293 lbs.					
		- 290 Bearing plates, 1,600 lbs.					
		- 320 - ¾" Dia. x 12" machine bolts, 640 lbs.					
		- 300 - ¾" Dia. x 10" welded studs, 600 lbs.					
	60	**Rerope the hoist and provide a new drums to**	**86-68410**	**1**	**LS**	**$120,000.00**	**$120,000.00**
		accommodate the additional 10"-0" of height					
		- 1-inch Dia. 6x37 IWRC, galvanized, extra		1,300	ft.		
		improved plow steel (XIP)					
		- Two new drums, cast steel, coated,		3,090	lbs.		
		9'-4" long, 24" dia., 1,545 lbs. ea.					
		Assume:					
		- Rope is 4 part					
		SUBTOTAL THIS SHEET					**$307,200.00**

QUANTITIES		**PRICES**	
BY R. Stephen	**CHECKED** A. Ritt	**BY** Greg Akins	**CHECKED** 01/28/2013
DATE PREPARED 12/17/12	**PEER REVIEW / DATE** D. Hulse	**DATE PREPARED** 01/25/13	**PEER REVIEW / DATE** 1/28/13

BUREAU OF RECLAMATION

ESTIMATE WORKSHEET

SHEET _14 _ OF _16 _

FEATURE:

B.F. Sisk Raise Appraisal Study
Intake Tower Modifications
Mechanical Equipment Group 86-68410
Most Probable Estimate
Middle Estimated Undrained Strength Parameters

PROJECT:
Central Valley Project, Madera County, California

WOID: **A176F**
ESTIMATE LEVEL: **Appraisal**
REGION: **MP**
UNIT PRICE LEVEL: **Oct-12**
FILE: U:\2012 Projects\BF Sisk\002 Completed Sheets\[002 Summary BF Sisk - Undrained.xlsx]Summary 16

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
		GANTRY CRANE:					
	61	**Remove, store and reinstall gantry crane**	**86-68410**	**1**	**L.S.**	**$250,000.00**	**$250,000.00**
		after modifications to the intake towers are					
		completed					
		- Gantry crane will have to be disassembled					
		due to width of access bridge					
		- Crane dead weight is 176,000 lbs.					
		- Crane is approx. 40'-0" tall, 40'-0" wide,					
		and 38'-0" long.					
		Assume:					
		- Crane is stored onsite					
		- Crane is fully functional					
		- No modernization is required					
		- Removal and reinstallazation will require					
		the use of a mobile crane, ~20T					
		SUBTOTAL THIS SHEET					**$250,000.00**

QUANTITIES

BY **R. Stephen**

CHECKED **A. Ritt**

DATE PREPARED
12/17/12

PEER REVIEW / DATE
D. Hulse

PRICES

BY
Greg Akins

CHECKED
01/28/2013

DATE PREPARED
01/25/13

PEER REVIEW / DATE
1/28/13

BUREAU OF RECLAMATION

ESTIMATE WORKSHEET

SHEET _15_ OF _16_

FEATURE: B.F. Sisk Raise Appraisal Study Intake Tower Modifications Mechanical Equipment Group 86-68410 Most Probable Estimate Middle Estimated Undrained Strength Parameters	**PROJECT:** Central Valley Project, Madera County, California
	WOID: A176F **ESTIMATE LEVEL:** Appraisal
	REGION: MP **UNIT PRICE LEVEL:** Oct-12
	FILE: U:\2012 Projects\BF Sisk\002 Completed Sheets\[002 Summary BF Sisk - Undrained.xlsx]Summary 16

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
		BULKHEAD GATE:					
	62	**Remove and reinstall bulkhead gates, lifting**	86-68410	1	L.S.	$500,000.00	$500,000.00
		frame and storage arms.					
		- (2) Top bulkhead gates, 75,000 lbs. ea.,					
		approx. 24'-6" wide x 15'-0" tall					
		- (2) Bottom bulkhead gates, 73,000 lbs. ea.,					
		approx. 24'-6" wide x 14'-6" tall					
		- Bulkhead gates are stored in the top of the					
		guides of the intake towers.					
		- Lifting frame, 12,000 lbs., 26'-0" x 16'-6"					
		- (8) Storage arms, 1,200 lbs. ea., fastened					
		to concrete deck by anchor bolts, on top					
		of a grout pad.					
	63	**Remove and dispose existing bulkhead guides**	86-68410	20,000	lbs.	$0.75	$15,000.00
		- Embedded in concrete					
		- Eight at 2,500 lbs. ea., 10'-0" long					
	64	**Furnish and install new bulkhead guides**	86-68410	40,000	lbs.	$9.00	$360,000.00
		- Structural steel, coated, embedded					
		- Eight at 5,000 lbs. ea., 20'-0" long					
		SUBTOTAL THIS SHEET					**$875,000.00**

QUANTITIES		PRICES	
BY R. Stephen	**CHECKED** A. Ritt	**BY** Greg Akins	**CHECKED** 1/28/2013
DATE PREPARED 111/29/2012	**PEER REVIEW / DATE** D. Hulse	**DATE PREPARED** 01/25/13	**PEER REVIEW / DATE** 1/28/13

BUREAU OF RECLAMATION

ESTIMATE WORKSHEET

SHEET _16 _ OF _16 _

FEATURE:

B.F. Sisk Dam Modification
Appraisal Level Study
20-foot Dam Raise
Middle Estimated Undrained Strength Parameters
Option B

PROJECT: **Central Valley Project, Madera County, California**

WOID: **A176F**
ESTIMATE LEVEL: **Appraisal**
REGION: **MP**
UNIT PRICE LEVEL: **Oct-12**
FILE: U:\2012 Projects\BF Sisk\002 Completed Sheets\[002 Summary BF Sisk - Undrained.xlsx]Sht 3B

PLANT ACCOUNT	PAY ITEM	DESCRIPTION					AMOUNT
		Subtotal Sheet 2 of 16					**$60,589,000.00**
		Subtotal Sheet 3 of 16					**$155,159,900.00**
		Subtotal Sheet 4 of 16					**$602,000.00**
		Subtotal Sheet 5 of 16					**$4,080,300.00**
		Subtotal Sheet 6 of 16					**$551,350.00**
		Subtotal Sheet 7 of 16					**$39,000.00**
		Subtotal Sheet 8 of 16					**$11,068,200.00**
		Subtotal Sheet 9 of 16					**$59,000.00**
		Subtotal Sheet 10 of 16					**$122,500.00**
		Subtotal Sheet 11 of 16					**$322,375.00**
		Subtotal Sheet 12 of 16					**$132,000.00**
		Subtotal Sheet 13 of 16					**$307,200.00**
		Subtotal Sheet 14 of 16					**$250,000.00**
		Subtotal Sheet 15 of 16					**$875,000.00**
		Subtotal					**$234,157,825.00**
		Mobilization	5%	+/-			$11,500,000.00
		Subtotal with Mobilization					**$245,657,825.00**
		Contract Cost Allowances (Sum of):	18%	+/-			$44,342,175.00
		Design Contingencies,15% (+/-)					
		APS, 3% (+/-). Type of procurement: Request for Proposal					
		CONTRACT COST					**$290,000,000.00**
		Construction Contingencies	25%	+/-			$70,000,000.00
		FIELD COST (Unit Price Level Oct 2012)					**$360,000,000.00**
		Non-Contract Costs		**To be determined by the appropriate responsible offic**			
		Escalation to Notice to Proceed (NTP)		**To be determined by the appropriate responsible offic**			
		CONSTRUCTION COST		**To be determined by the appropriate responsible offic**			
		Ref.: For appropriate use and terminology, see Reclamation Manual, Directives and Standards FAC; 09-01, 09-02 and 09-03.					

QUANTITIES		PRICES	
BY See Estimate Sheets	**CHECKED** See Estimate Sheets	**BY** Greg Akins	**CHECKED** 3/20/13
DATE PREPARED	**PEER REVIEW / DATE** See Estimate Sheets	**DATE PREPARED** 1/25/2013 - revised 3/20/13	**PEER REVIEW / DATE** 3/22/13

Appendix C

TM VB-86-68313-22

Appraisal-Level Study of Static Stability for Increased Storage

RECLAMATION
Managing Water in the West

FOR OFFICIAL USE ONLY

Technical Memorandum No. VB-86-68313-22

Appraisal-Level Study of Static Stability for Increased Storage

B.F. Sisk Dam
Central Valley Project, California
Mid-Pacific Region

FOR OFFICIAL USE ONLY

U.S. Department of the Interior
Bureau of Reclamation
Technical Service Center
Denver, Colorado

January 2013

Mission Statements

The mission of the Department of the Interior is to protect and provide access to our Nation's natural and cultural heritage and honor our trust responsibilities to Indian Tribes and our commitments to 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.

Cover Photo – Aerial photograph of B.F. Sisk Dam and San Luis Reservoir.

FOR OFFICIAL USE ONLY

Technical Memorandum No. VB-86-68313-22

Appraisal-Level Study of Static Stability for Increased Storage

B.F. Sisk Dam
Central Valley Project, California
Mid-Pacific Region

FOR OFFICIAL USE ONLY

U.S. Department of the Interior
Bureau of Reclamation
Technical Service Center
Denver, Colorado

Technical Memorandum No. VB-86-68313-22

Appraisal-Level Study of Static Stability for Increased Storage

B.F. Sisk Dam
Central Valley Project, California
Mid-Pacific Region

P.E.

Prepared: Tonya Hart, P.E.
Geotechnical Engineer, Geotechnical Engineering Group 3, 86-68313

Tuti H Tierney P.E.

Checked: Tuti Tierney, P.E.
Civil Engineer, Geotechnical Engineering Group 3, 86-68313

Randall Kuzniakowski

Peer Review: Randall Kuzniakowski, P.E.
Civil Engineer, Geotechnical Engineering Group 4, 86-68314

1/28/13
Date

REVISIONS					
Date	Description	Prepared	Checked	Technical approval	Peer review

Acronyms and Abbreviations

BOR	Bureau of Reclamation
CAS	Corrective Action Study
CFR	Comprehensive Facility Review
CRB	Consultant Review Board
DWR	Department of Water Resources
FLAC	Fast Lagrangian Analysis of Continua
FS	factor of safety
ft^2	square foot (feet)
ft^3	cubic foot (feet)
GVS	Great Valley Sequence
IE	Issue Evaluation
km	kilometer(s)
MPRO	Mid-Pacific Regional Office
MSE	Mechanically Stabilized Earth
NVS	North Valley Section
PMP	Project Management Plan
RA	Risk Analysis
Reclamation	Bureau of Reclamation
RWS	reservoir water surface
SOD	Safety of Dams
SPT	Standard Penetration Test
SVS	South Valley Section
TM	Technical Memorandum
URS	URS Group, Inc.

Contents

Page

Tables

Attachments

I. INTRODUCTION

The Bureau of Reclamation (BOR, Reclamation) Mid-Pacific Regional Office (MPRO) Division of Planning has requested an appraisal-level study of potentially feasible alternatives for raising B.F. Sisk Dam, dike, and appurtenant works to allow additional storage above the normal operating pool surface elevation in San Luis Reservoir. This Technical Memorandum (TM) studied one crest raise alternative and two reservoir water surface (RWS) raises to determine an upper-range embankment raise. The intent of assessing an upper-range dam raise is to determine if costs for increasing storage are justified by the associated potential benefits. This TM is intended to summarize the input parameters used in the analyses and present the results of the appraisal-level limit equilibrium for the two RWS raise scenarios.

The scope of work for this study was defined in the Project Management Plan (PMP) [1]. This portion of the appraisal-level study focused on: (1) modifying five previously developed cross sections of the existing dam and developing one cross section of the dike, to reflect the raise concept; (2) performing two-dimensional static stability analyses of the downstream slope of the embankment and dike at each of the sections to develop a probable upper RWS height increase associated with a 20-foot embankment/dike crest raise; and (3) preparing a TM report to explain the stability analyses and potential dam raise approach, as well as provide discussion regarding potential non-structural methods to increase storage capacity.

The information regarding the design and construction of B.F. Sisk Dam contained in this TM is primarily taken from the Technical Record of Design and Construction [2], unless otherwise noted.

II. BACKGROUND INFORMATION

A. Location and Features

B.F. Sisk Dam (formerly San Luis Dam) is located on San Luis Creek approximately 12 miles west of Los Banos, California. The dam was constructed between 1963 and 1967 to provide supplemental irrigation water storage for the Federal Central Valley Project and municipal and industrial water for the California State Water Project. B.F. Sisk Dam is owned by the BOR and operated by the California Department of Water Resources (DWR). Water is lifted into the reservoir for storage by the Gianelli Pumping-Generating Plant (via the O’Neill Forebay), and then water is released back through the pumping-generating plant for irrigation use and to generate electricity. San Luis Reservoir has a total capacity of 2,040,500 acre-feet and a surface area of 12,700 acres at normal operating pool (elevation 544.0). Elevations within this TM are NGVD 1929 unless otherwise noted. Reservoir storage space is allotted 55 percent State and 45 percent Federal.

B.F. Sisk Dam is a zoned earthfill structure with a maximum structural height of 382 feet, a hydraulic height of 303 feet, a crest length of 18,600 feet, a crest width of 30 feet, and a crest elevation of 554.0 feet. The dam embankment was constructed of five materials in seven zones, with the central zone consisting of low plasticity clays. The downstream face of the dam is covered by a 2-foot-thick rock blanket, and the upstream face is protected by a minimum 15-foot-thick layer of riprap. A plan view and cross sections are provided in Attachment A. There is a saddle dike located along the north rim of the reservoir approximately 1,300 feet from the dam. The dike has a crest width of 30 feet, a crest length of 300 feet, and a crest elevation of 554.0 feet.

The typical cross section of the dam in the main valley includes an upstream berm and a cutoff trench that extends either to a dense gravel zone or to bedrock. During construction of the dam, soft clays were discovered in the foundation between stations 55+00 and 98+00. Due to a concern for stability of the section, a second (downstream) cutoff trench and a downstream stability berm were added between these stations.

An uncontrolled concrete morning glory spillway is located at the left end of the dam (station 39+70.48). The spillway includes a 350-foot long cut-and-cover conduit through the dam embankment and the left abutment that transitions to a rectangular chute. The design capacity of the spillway is 1,030 ft^3/s at maximum water surface elevation 545.8.

The Gianelli Pumping-Generating Plant, located at the left end of the dam, also serves as the outlet works for the dam. The intakes to the penstocks are located near the left abutment of the dam and consist of a 284-foot-high structure containing four intake towers with trashrack structures, and four parallel 17.5-foot-diameter concrete tunnels/penstocks. A bridge provides pedestrian and vehicle access from the crest of the dam to the intake structures. The inlet to each tunnel is controlled by a roller-mounted emergency closure gate located in each tower. The total discharge of the outlet works is approximately 13,200 ft^3/s with all pumping units operating at a speed of 120 revolutions/min, the RWS at elevation 425, and the forebay water surface at elevation 225.

B. Previous and Concurrent Studies

Safety of Dams (SOD) evaluations for B.F. Sisk Dam began in the early 1980s, and a Corrective Action Study (CAS) initiated in 2008 is currently underway to address the risk posed by potential seismic loading of the dam and its foundation. A brief history of major evaluations performed to date is provided below; a detailed summary of these evaluations through 2009 is provided in TM No. VB-8313-5 [3].

In the fall of 1981, a slide initiated on the upstream slope, due to the rapid drawdown of the reservoir, approximately between station 122+00 and 139+00 where the embankment was founded on slopewash. An investigation was performed and the slide was repaired. Three stability berms were constructed on the upstream slope (Station 120+00 to 139+00 (slide area); Station 54+00 to 64+00; and Station 145+00 to 163+50). A fourth berm was constructed on the downstream slope from Station 155+00 to 172+00 to protect against future slope movements due to slopewash.

In 1983, static stability and dynamic displacement analyses were performed. Results of the field exploration program performed at the same time indicated that liquefiable soils may be present near the downstream toe.

Between 2000 and 2003, two Comprehensive Facility Reviews (CFRs) were performed and a Report of Findings on Seismic Dam Safety Issues was completed for B.F. Sisk Dam. The 2003 CFR produced recommendation **2003-SOD-C** to address the impacts of seismic loading on the stability of the dam.

In 2005 and 2006, dynamic deformation analyses and evaluation utilizing the computer program Fast Lagrangian Analysis of Continua (FLAC) were performed. The analyses showed that vertical crest deformations from seismic loading could be sufficient to allow overtopping of the dam at normal operating reservoir elevations. An Issue Evaluation (IE) Risk Analysis (RA) was completed in 2006 [14]. The Decision Document recommended action to reduce risk of dam failure. Recommendation 2005-SOD-A recommended a Corrective Action Study (CAS) be initiated.

In 2009, an appraisal-level parametric slope stability analysis of several sections of the dam was performed. The analyses attempted to bracket the possible responses of foundation soils subjected to dynamic loading. Berms at the downstream toe were sized to meet a limit equilibrium factor of safety of 1.5 [3], to be evaluated with a FLAC dynamic deformation analysis. Additionally, another CFR was performed in 2009 [4].

As part of the feasibility-level CAS, URS Group, Inc. (URS) reviewed applicable data and analyses associated with B.F. Sisk Dam. URS selected middle estimate and, as applicable, upper and lower bound material properties for various embankment zones and foundation materials and summarized their review in TM VB-R11PD80312-18 [5] and an addendum.

This study solely considered static loading conditions associated with 6-foot and 10-foot RWS raises in conjunction with a 20-foot embankment raise. Seismic loading or other dynamic loading conditions were not considered or evaluated during these analyses.

C. Site Geology

1. General

B.F. Sisk Dam and San Luis Reservoir occupy the San Luis Valley, a large 6-kilometer (km)-wide by 9-km long basin located near the eastern edge of the Diablo Range, approximately 15 km west of the city of Los Banos. B.F. Sisk Dam was constructed at the eastern edge of this valley, across the relatively narrow (~1 km wide) gap where the San Luis and Cottonwood Creeks exit the valley. Geologic studies indicate that San Luis Valley is a large pull-apart basin created by the Ortigalita fault, a northwest-striking, recurrently active, right-lateral strike-slip fault that extends through the reservoir. For most of its 100 km length, the Ortigalita fault is the tectonic contact between metamorphosed rocks of the Franciscan Complex on the west and the sedimentary rocks of the Great Valley Sequence (GVS) on the east. However, the 4.5-km-wide step-over between two sections or segments of the fault in the San Luis Valley has produced an extensional graben-like basin that contains over 400 meters of unconsolidated late Cenozoic fill. This compares to less than about 60 meters of unconsolidated fill beneath the dam at the eastern margin of the basin. Additional information is provided in TM 86-68330-2009-01 [6]. The bedrock under the dam and dike is the Panoche Group, which is a Cretaceous age formation steeply dipping downstream in the vicinity of the dam.

The alignment of the dam was designed to take advantage of existing bedrock ridges to minimize the fill volume required. The foundation can be divided into basically three sections. The abutment sections exist from approximately stations 0+00 to 67+00 and 113+00 to 185+00. The embankment bears upon the ridges of Panoche formation bedrock (Kp) with a thin cover of clayey slope wash (Qs). A valley section exists approximately between stations 67+00 and 113+00 where the embankment bears two distinct geologic units. The valley section can be divided into two parts, here called the North Valley Section (NVS) and the South Valley Section (SVS). The NVS, extending from approximately station 98+00 to 113+00, has a relatively thin alluvial deposit for the foundation comprised of the Patterson alluvium (Qp), and overlying the Tulare formation (QTt) near the upstream and downstream toes of the dam. The SVS, from approximately station 67+00 to 98+00, has a much thicker alluvial deposit comprised of either the Los Banos alluvium (Ql) or San Luis Ranch alluvium (Qsl) overlying the Tulare formation. Detailed descriptions of the formations are provided in [5] and [6]. Figure A-5, a geologic map, and Figure A-6, a geologic cross-section, are included in Attachment A.

2. Stratigraphy

a. Panoche Formation (Kp)

Steeply-dipping marine conglomerate with interbedded sandstone and shale of the Panoche formation serve as the bedrock foundation at B.F. Sisk Dam. The conglomerate typically occurs as thick beds or massive units and forms the most competent rock at the site. Locally the conglomerate matrix is shaly and varies from poorly- to well-cemented. The sandstone can be massive, but more typically has beds 5 to 10 feet thick, separated by thin shale layers. The unit is more than 900 feet thick. The Panoche formation exists directly beneath the upstream portions of the embankment in the abutment sections, so it underlies the cross sections at stations 37+00 and 147+20. Sandstone and interbedded sandstone and shale also underlie the dike.

b. Tulare Formation (QTt)

The Tulare formation is a deep soil deposit that exists in the SVS of the San Luis Creek valley, so it underlies the valley section at station 86+00. It also exists in the NVS (station 107+00), though in a much thinner zone. The Tulare formation consists of unconsolidated to moderately consolidated gravel, sand, silt and minor clay that is poorly- to well-bedded. The unit was deposited as coalescing alluvial fans along the Diablo Range front. The upper portion of the unit includes the Corcoran Clay Member (QTtc), a well-sorted, 5 to 25-feet thick silty clay and clayey silt lacustrine deposit. Basal gravel (Plbg) exists above the bedrock in the SVS of the San Luis Creek valley. It is a clayey gravel and is described as being very dense.

c. Los Banos Alluvium (Ql)

The Los Banos alluvium formation consists primarily of unconsolidated silty and clayey gravel and sand that is poorly- to well-bedded and is poorly- to well-sorted. The Los Banos alluvium exists primarily in the SVS of the San Luis Creek valley above the Tulare formation, so it underlies the cross section at station 86+00.

d. San Luis Ranch Alluvium (Qsl)

The San Luis Ranch alluvium formation consists primarily of unconsolidated gravel, sand, silt and clay that is poorly- to well-bedded and poorly- to well-sorted. The San Luis Ranch alluvium exists primarily in the NVS so it underlies the cross section at station 107+00.

e. Patterson Alluvium (Qp)

The Patterson alluvium formation consists of undifferentiated lenticular lenses of clay, silt, sand, and combinations thereof. It occurs only in the NVS of the San Luis Creek valley, so it underlies the cross section at station 107+00. It is believed to have been removed under the footprint of the dam during construction.

f. Slopewash (Qs)

Slopewash is a colluvial deposit that exists under much of the extensive abutment sections. The slopewash was derived from weathering of the Panoche formation bedrock and consists primarily of sandy lean and fat clays with some gravel ranging from 3- to 10-feet thick, but is locally up to 30 feet thick.

III. EMBANKMENT MATERIALS

A. General

The dam and dike embankments are zoned compacted earth and rockfill structures. The original embankments were designed and constructed with five zones. The impervious Zone 1 is composed of clay, silt, sand, and gravel. Zone 2 is a pervious filter zone consisting of sand, gravel, and cobbles. Zone 3 is composed of miscellaneous fill; it is similar in composition to Zone 1. Drainage material is designated as Zone 4. Zone 5 is an outer layer of cobble-rock fill on the upstream face. The embankment also includes riprap and riprap bedding materials placed on the flatter portion of the upstream face, and a rock blanket for slope protection on the downstream slope. The source material for the stability berms (Zones 6 and 7) constructed in 1982 was Panoche Formation from the reservoir area.

B. Zone 1

The impervious central core (Zone 1) consists primarily of sandy and gravelly clay with silt, sand, and gravel obtained from various borrow areas at and surrounding the site. Prior to August 1964, Zone 1 material was compacted by tamping rollers to 6-inch layers. Beginning in August 1964, the lift thickness was increased to 8 inches.

C. Zone 2

Zone 2 consists of a mixture of sand, gravel, and cobbles obtained from the reservoir borrow area and placed in lifts to produce a 12-inch layer after compaction. The 5-foot-thick zone is intended to provide an intermediate filter for part of the chimney drain and the horizontal blanket drain downstream of Zone 1. This zone provides a filter between Zones 1 and 4, Zones 3 and 4, as well as the foundation soils and Zone 4. Zone 2 does not extend above elevation 400 (which is 144 feet below the top of active conservation). This material is considered to be free draining.

D. Zone 3

Zone 3 includes a large upstream berm, the outer zone of the downstream slope, and the downstream stability berm between stations 55+00 and 98+00. Zone 3 consists of miscellaneous materials obtained from the abutments and foundation (below elevation 400) and the Zone 1 borrow excavation (above elevation 400). Occasionally, large fragments of shale, sandstone, or conglomerate were placed in the outer portion of the zone. Zone 3 was generally placed to achieve 12-inch-thick compacted lifts.

E. Zone 4

Zone 4 is a predominantly free-draining material comprised of 8-inch-minus rockfill from the Basalt Hill Quarry. This zone was used as a chimney drain and a horizontal blanket drain under the downstream slope, as well as bedding for the Zone 5 riprap on the upstream slope. Zone 4 material was placed in 12-inch compacted lifts.

F. Zone 5

Zone 5 material is described as plus 8-inch rock fragments placed in 3-foot layers. Predominantly 24-inch size Zone 5 material was placed on the upstream slope in the operating pool elevation (above elevation 400).

G. Rock Blanket, Riprap, and Bedding Material

Riprap was placed on the upstream face below elevation 400, where the slope is comparatively flat and there is no Zone 5, and as the 24-inch-thick rock blanket used to protect the downstream slope. The riprap came from the Basalt Hill Quarry. The bedding material was 3-1/2-inch-maximum-size crushed rock placed to about one-half the depth of the overlying riprap.

H. Stabilization Berms (Zones 6 and 7)

The source material for the stability berms constructed in 1982 was Panoche Formation from the reservoir area consisting of sandstone, shale, and conglomerate. Zone 6 materials were placed in the 7-foot-thick berm drainage blankets and were described in the specifications as “minus 12-inch material obtained from the Basalt Hill Quarry” [4].

Zone 7 refers to the downstream berm material placed above the drain blanket. The Zone 7 material was a mixture of sandstone, shale, and conglomerate excavated from the reservoir area.

Stability berm additions necessary to accommodate an increased storage capacity are unique to this analysis and were conservatively assumed to be sandy clay material obtained from local borrow areas.

IV. MODIFIED EMBANKMENT CONFIGURATION

Structural modification alternatives were developed in TM VB-8313-14 [7]. A mechanically-stabilized earth (MSE) crest raise was included as an alternative in the previous TM. The concurrent CAS has eliminated the MSE configuration, so this configuration was not considered during the analyses presented in this TM. A zoned embankment crest raise was selected as the preferable structural modification configuration for this stability analysis.

The sections analyzed include raising the embankment and dike from the existing elevation of 554.0 to approximate elevation 574.0. The dam and dike raise will key into the existing embankment and dike. The upstream Zone 4 and Zone 5 and the core (Zone 1) will be extended up to the raised crest elevation. The 24-inch rock blanket will be removed from the downstream face. A sand and gravel filter zone will be placed on the exposed downstream Zone 1 core and a gravel and cobble drainage zone will be placed downstream of the filter. Miscellaneous sand, gravel and cobble fill will be placed downstream of the drainage zone and as downstream berms (as needed to achieve static stability). A typical cross-section of the crest raise and embankment overlay is shown on Figure 1 below.

Reservoir water surface raises of 6 feet and 10 feet (to elevations 550 and 554, respectively) were analyzed. The existing dam and dike have 10 feet of freeboard when the RWS is at elevation 544.0. The minimum freeboard required at B.F. Sisk Dam was not calculated. Rather, because the static slope stability analysis requires an embankment crest raise, the freeboard was increased to 20 feet (approximately 6.5 percent of the hydraulic height).

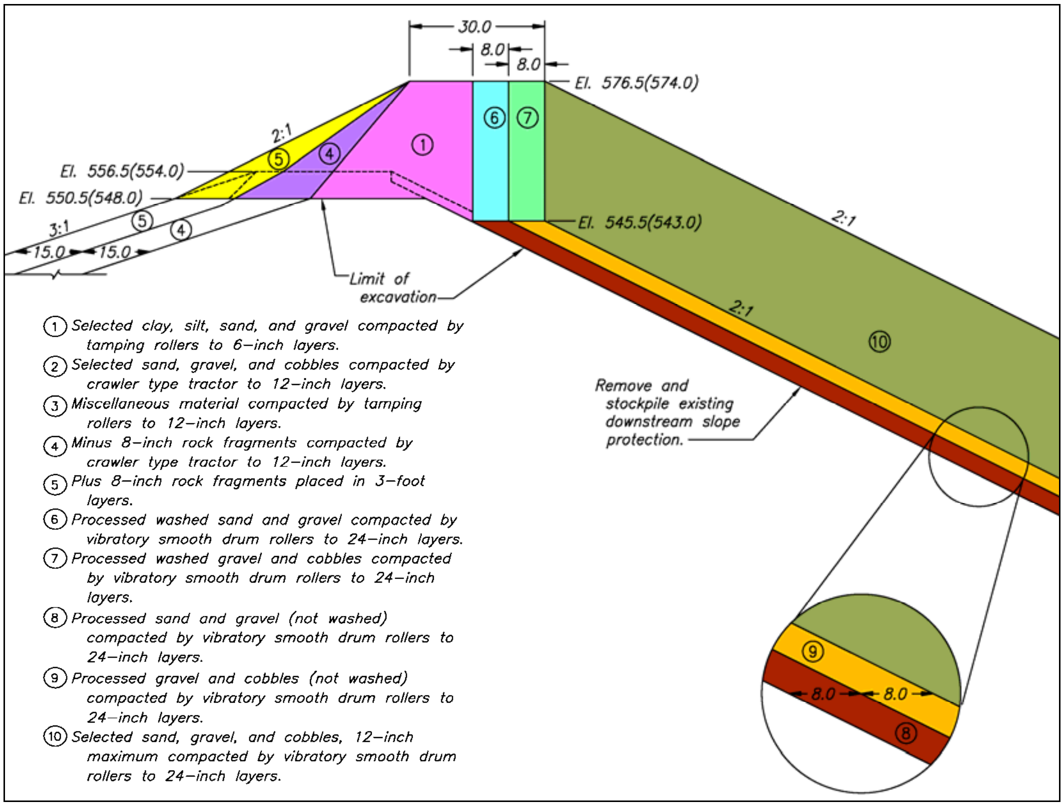


Figure 1: Typical 20-foot dam/dike overlay raise cross-section (abbreviated Figure A10 from [7]).

V. STABILITY ANALYSES

A. General

The analysis presented here is the first step in analyzing the viability of an increase in reservoir storage at B.F. Sisk Dam and is considered an appraisal-level study. The approach for this study was to define the range of potential alternatives of the dam in response to raising the RWS. The study included several cross sections along the dam and one through the dike. The first part of this study was to evaluate the static stability of each cross section with the range of material shear strengths presented in Table 1 of this TM. Additional field exploration as part of the CAS will commence during fiscal year 2013 to further evaluate the Zone 1 material. Depending on the field and laboratory data, the static stability analyses presented in this TM may require revision.

Where the modified cross-section (i.e. 20-foot crest raise and downstream embankment overlay) did not meet the minimum factor of safety of 1.50 with the RWS raise, a stability berm and drain extension were added to the toe of the downstream slope. The berms were sized for each section to meet the minimum 1.50 FS. The berm height was first established to prevent the slip surface from “popping out” through the berm. Then, the length of the berm was adjusted until the target factor of safety was obtained.

B. Method of Analysis

The static stability analyses were performed using the limit equilibrium analysis computer program Slope/W, part of the GeoStudio 2007 software package [8]. Spencer’s method of slices, which considers both force and moment equilibrium equations of planer statics, was utilized to calculate safety factors for downstream failure wedges. The phreatic surface, reservoir elevation, geometry, and sections are described in subsequent paragraphs. Both “Grid and Radius” and “Entry and Exit” slip surface input techniques were used to create the slip surfaces. Failure wedges that were considered “significant” were those that had a minimum thickness of at least 10 percent of the embankment height and whose slip surface encompassed the crest. Representative significant failure wedges are shown as related to the dam/dike crest in Figure 2 below. Downstream failure plane “A” would not be considered significant; failure planes “B” and “C” would.

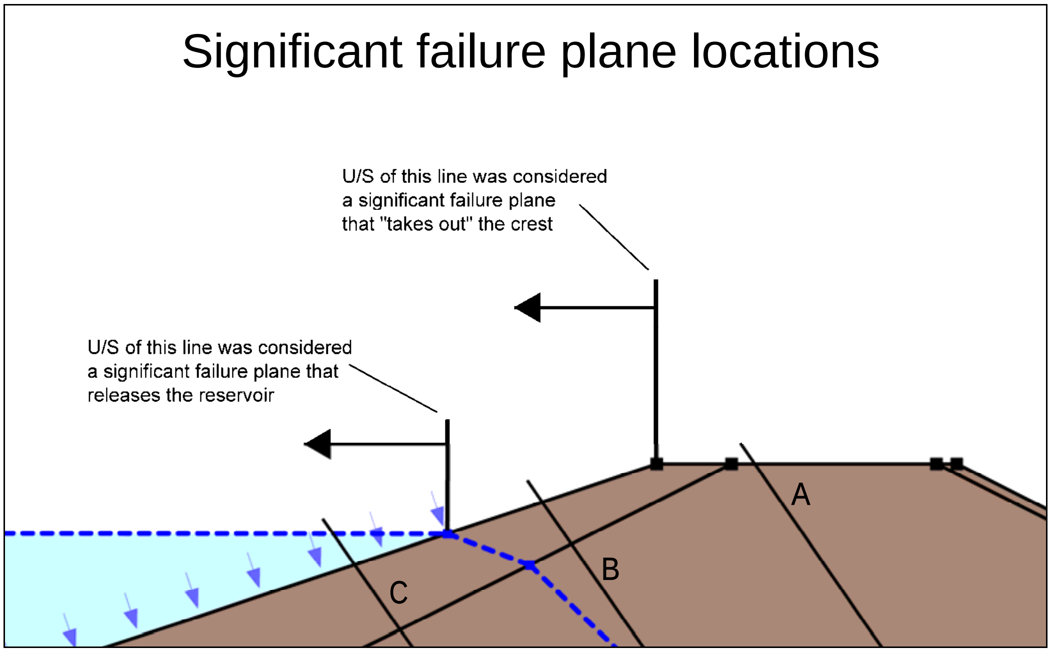


Figure 2: Examples of significant downstream failure wedges encompassing the crest.

C. Piezometric Data

The analyses of the as-built sections were performed with the reservoir at elevation 544, the normal operating pool. There is a significant amount of data available with the reservoir at this elevation. The piezometric surfaces used in the analyses of the as-built sections were taken either from actual piezometric data from the section being analyzed or from adjacent instruments and were applied to the sections where no piezometers are installed. The piezometric surface through the dike was estimated based on data from the main embankment dam and engineering judgment. In response to the increase of RWS elevation to 550 feet and 554 feet, the phreatic surface was raised. The slope of the phreatic surface through each embankment zone was assumed the same as for the 544-foot maximum RWS. Seepage analyses for the raised RWS were not within the scope of work of this study. Seepage analyses should be performed during feasibility-level studies; revisions to the modification geometry may be necessary.

D. Embankment Cross Sections and Locations

The dam foundation can be divided into three general sections: the abutments, the NVS, and the SVS. In [3], cross sections were developed near stations 37+00, 65+00, 86+00, 107+00, and 147+20 based on a combination of previous reports (Attachment C in [3]). These sections were modified slightly to incorporate the URS findings [TM VB-R11PD80312-18] and used in the current analyses. As discussed in [TM VB-R11PD80312-18], there are limited data of the foundation materials below the main axis of the dam.

1. Station 37+00

Station 37+00 is an abutment section located on the right abutment. The embankment at this location is approximately 150 feet tall with a 2H:1V downstream slope above elevation 450 and a 2.5H:1V slope between elevations 400 and 450. This section is located between two high surface features, and the downstream slope is founded on slopewash. The thickness of the slopewash layer is approximately 20 to 25 feet. The section was analyzed for three different drained strengths assigned to the slopewash. In some of the analyses, the slopewash beneath the embankment was also analyzed assuming undrained static conditions (see Table 1). Station 37+00 represents a reach from approximately station 35+00 to station 38+50.

2. Station 65+00

Station 65+00 is also an abutment section. It is located at the south edge of the SVS where the bedrock rises out of the valley. The section is approximately 225 feet tall with a downstream slope of 2H:1V above elevation 400, a 2.5H:1V slope between elevations 400 and 450, then a 6H:1V slope below elevation 400. The downstream slope is founded mainly on slopewash, with a section of Los Banos alluvium near the centerline of the dam. There is a cutoff trench to bedrock upstream of the embankment centerline. The thickness of the slopewash layer is approximately 15 to 20 feet. The Los Banos alluvium zone is insignificant in the results of the analysis for this section. Station 65+00 was analyzed for three different drained strengths assigned to the slopewash. In some of the analyses, the slopewash beneath the embankment was also analyzed assuming undrained static conditions (see Table 1). This section represents the reach from approximately station 60+00 to 67+00.

3. Station 86+00

Station 86+00 is located in the SVS. This section is approximately 300 feet tall with a downstream 2H:1V slope above elevation 400, a 2.5H:1V slope between elevations 400 and 450, a 6H:1V slope between elevations 290 and 400, then a 2H:1V slope to meet existing ground. There are two large cutoff trenches that were excavated to the basal gravel layer of the Tulare formation. One trench is upstream of the centerline, and the other is downstream of the centerline. The downstream slope is founded on the Tulare formation overlain by the Los Banos alluvium. The downstream cutoff trench was excavated and the 6H:1V berm added because of a soft clay layer discovered in the Tulare formation during construction. For some of the berm modification configurations, a portion of the existing downstream 1V on 6H berm will be removed. This section represents a reach from approximately station 67+00 to 98+00.

4. Station 107+00

Station 107+00 is located in the NVS and is intended to be representative of the entire reach from approximately station 98+00 to 113+00. This embankment section is over 300 feet tall with a downstream 2H:1V slope above elevation 450 and a 2.5H:1V slope between elevations 450 and 290, then another 2H:1V slope to meet existing ground. Bedrock is relatively shallow in this section, and there is one cutoff trench upstream of the embankment centerline. The downstream slope is founded on Patterson alluvium overlying bedrock. The alluvium is approximately 10 to 20 feet thick. This section was analyzed for three different drained strengths assigned to the Patterson formation (see Table 1).

5. Station 147+20

Station 147+20 is located on the left abutment and is in a valley between two high points in the natural ground. The valley is not perpendicular to the dam cross section, rather the section analyzed is at a 60 degree skew to the dam axis. The cross section is approximately 200 feet high, with a downstream 2H:1V slope normal to the dam axis above elevation 450 and a 2.5H:1V slope below that. The downstream slope is founded on slopewash, so this section was analyzed considering three different drained strengths assigned to the slopewash. In some of the analyses, the slopewash beneath the embankment was also analyzed assuming undrained static conditions (see Table 1). The slopewash ranges in thickness from approximately 10 to 15 feet. This section represents the reach from approximately station 145+00 to 150+00.

6. Dike

The dike is located about 1,300 feet northeast of the left abutment and is in a valley between two high points in the natural ground. The cross section is founded on the Panoche bedrock and is approximately 16 feet high, with a downstream 2H:1V slope normal to the dam axis and an upstream 3H:1V slope.

E. Material Properties

Several field explorations have been conducted previously at B.F. Sisk Dam. These investigations are summarized in detail by Reclamation’s Mid-Pacific Region Geology Branch in 2008 / 2010 Feasibility Level Geologic Investigation [9]. The characterization of the dam and foundation used in this analysis is based on the data developed during these prior investigations.

Table 1 below provides a summary of the material properties used in this static stability study. The unit weights and range of shear strengths used in this appraisal-level study are based upon existing laboratory and field tests as well as engineering judgment and typical values for similar soils [10]. Effective shear strength parameters for the slopewash and the NVS-2 material representing the upper bound, middle estimate, and lower bound ranges assuming drained conditions, as well as undrained conditions for the slopewash beneath the embankment, are presented in Table 1. URS TM No. VB-R11PD80312-18 [5] and several Reclamation TMs [3, 11, 12, 13, 14] provide additional detail on the selection of strength parameters.

Additionally, to better represent in-situ conditions, the Panoche formation bedrock and the dense gravel in the Tulare formation were represented as a hard layer in the model, meaning that the sliding surface was truncated at the surface of the Panoche and Tulare formations.

VI. RESULTS

Static stability analyses of the existing dam and dike subjected to normal water loads (e.g. RWS at elevation 544.0) were performed to establish a point of comparison with the two RWS raises. The results of the analyses for the target factor of safety of 1.5 including “order-of-magnitude” estimates regarding the cross-sectional area of the downstream embankment modification at each section are provided in Table 2 on the following pages and in Attachment B. The embankment modification configuration at the abutments (where the embankment height to width ratio is smaller) is more sensitive to variation in the slopewash strength parameters; larger downstream berms are needed to achieve a FS equal to 1.5 for cases where the slopewash is modeled using the lower bound values.

Table 1: Material properties used in the limit equilibrium stability analyses (adapted from Tables 3-1; 3-2a; 3-2b; 3-3; and 3-4 [5] and [11]).

Zone 1	Low plasticity clay (CL) with sand and gravel, average PI=14	125	135	400	28	NA
Zone 2 and 4 D/S	Rolled fill, non-saturated or free draining	125	135	200	35	NA
Zone 3 U/S	Clayey miscellaneous fill	125	135	400	28	NA
Zone 3 D/S	Rolled fill, non-saturated or free-draining	125	135	400	28	NA
Zone 4 U/S and 5	Rolled fill (free draining) and plus 8-inch riprap	130	140	0	40	NA
Los Banos alluvium (Ql)	Mostly low and high plasticity clays (CL-CH) with sand layers	125	135	0	32	NA
NVS fill	Spoils from foundation excavation	120	125	0	32	NA
NVS-1	“Cohesive” portion of Patterson alluvium (Qp)	120	125	0	32	NA
NVS-2	“Cohesionless” portion of Patterson alluvium (Qp)	120	130	Low: 0	30	NA
				Middle: 0	34	
				High: 0	36	
Slopewash (Qs)	Mostly low and high plasticity clays (CL-CH) with varying sand and gravel layers	120	125	Low: 250	20	$s_u/\sigma_v' = 0.3$; min s_u = 1,000 lb/ft^2
				Middle: 250	25	
				High: 600	25	
Tulare formation (QTt)	Mostly clay with sand and gravel layers	125	130	500	25	NA
Berm D/S	Assumed sandy clay borrow source	130	NA	0	35	NA

Notes: 1) “Satd.” indicates saturated and “deg” indicates degrees.
2) “Low” indicates the lowest conceivable value, “Middle” indicates the most likely average value, and “High” indicates the highest conceivable value [5].

Table 2: Results of the parametric study

37+00	As-built	Slopewash Drained	Low	NA	1.19	
			Middle	NA	1.35	
			High	NA	1.47	
	20-ft crest raise with 6-ft RWS raise	Slopewash Drained	Low	16,000	1.50	
			Middle	11,500	1.50	
			High	10,500	1.52	This is min. section to accommodate RWS raise
		Slopewash Undrained below Embankment	Low	18,500	1.50	
			Middle	17,500	1.50	
			High	17,000	1.50	
	20-ft crest raise with 10-ft RWS raise	Slopewash Drained	Low	16,000	1.50	
			Middle	11,500	1.50	
			High	10,500	1.52	This is min. section to accommodate RWS raise
		Slopewash Undrained below Embankment	Low	19,000	1.50	
			Middle	18,500	1.50	
			High	18,000	1.50	

65+00	As-built	Slopewash Drained	Low	NA	1.21	
			Middle	NA	1.56	
			High	NA	1.57	
	20-ft crest raise with 6-ft RWS raise	Slopewash Drained	Low	20,000	1.50	Inc. 1,000 ft^2 of existing D/S embankment removed
			Middle	17,500	1.50	Inc. 2,000 ft^2 of existing D/S embankment removed
			High	17,500	1.50	Inc. 2,000 ft^2 of existing D/S embankment removed
		Slopewash Undrained below Embankment	Low	34,000	1.50	
			Middle	34,000	1.50	
			High	34,000	1.50	
	20-ft crest raise with 10-ft RWS raise	Slopewash Drained	Low	20,000	1.50	Inc. 1,000 ft^2 of existing D/S embankment removed
			Middle	17,500	1.50	Inc. 2,000 ft^2 of existing D/S embankment removed
			High	17,500	1.50	Inc. 2,000 ft^2 of existing D/S embankment removed
		Slopewash Undrained below Embankment	Low	34,000	1.50	
			Middle	34,000	1.50	
			High	34,000	1.50	
86+00	As-built	Drained	NA	NA	1.66	
	20-ft crest raise with 6-ft RWS raise		NA	14,500	1.50	
	20-ft crest raise with 10-ft RWS raise		NA	14,500	1.50	

107+00	As-built	Drained	Low	NA	1.53	
			Middle	NA	1.53	
			High	NA	1.53	
	20-ft crest raise with 6-ft RWS raise		Low	38,000	1.50	
			Middle	29,000	1.50	
			High	29,000	1.50	
	20-ft crest raise with 10-ft RWS raise		Low	38,000	1.50	
			Middle	29,000	1.50	
			High	29,000	1.50	
147+20	As-built	Slopewash Drained	Low	NA	1.17	
			Middle	NA	1.35	
			High	NA	1.41	
	20-ft crest raise with 6-ft RWS raise	Slopewash Drained	Low	30,000	1.50	
			Middle	20,500	1.50	
			High	17,500	1.50	
		Slopewash Undrained below a portion of the Embankment	Low	35,500	1.50	
			Middle	32,500	1.50	
			High	29,500	1.50	

147+20	20-ft crest raise with 10-ft RWS raise	Slopewash Drained	Low	31,500	1.50	
			Middle	21,500	1.50	
			High	19,000	1.50	
		Slopewash Undrained below a portion of the Embankment	Low	38,000	1.50	
			Middle	34,000	1.50	
			High	31,500	1.50	
Dike	As-built	Drained	NA	NA	4.86	
	20-ft crest raise with 6-ft RWS raise		NA	3,000	2.13	
	20-ft crest raise with 10-ft RWS raise		NA	3,000	2.13	

Notes:
1) D/S modification area is approximate and rounded to nearest 500 ft^2. This area includes new material only. Removal of existing D/S embankment material is not included.
2) All factors of safety are calculated for D/S slope failures that threaten the dam crest.

VII. SUMMARY AND DISCUSSION

As a first step, due to uncertainties in the shear strength and other properties of the foundation materials, the factor of safety (FS) for static stability of the dam without the embankment crest raise and the RWS raise was calculated at each section. At the normal water surface elevation of 544.0, the FS ranged from 1.17 to 1.66 for the embankment. The calculated FS for the dike was 4.86 without the crest raise and 2.13 for a 10-foot RWS and 20-foot crest raise.

Downstream berms and flatter downstream slopes were needed to achieve a 1.5 FS at some of the modified dam sections, particularly where lower bound strength parameters were selected for the slopewash and NVS-2 materials.

The results of the static stability analyses indicate that the dam and dike embankments can be modified to accommodate a 10-foot raise of the normal RWS to elevation 554.0 provided the embankments are modified as shown. The modification configuration involves raising the crest 20 feet, from elevation 554.0 to 574.0, and constructing downstream filters, drains, embankment overlays, and berms. For most of the sections evaluated, there is little to no variation in the modification square footage between a 6-foot RWS raise and a 10-foot RWS raise (see Table 2).

The minimum freeboard will need to be evaluated during a later phase of the study using an in-depth analysis to ensure 20 feet of freeboard is adequate to protect against overtopping and will meet the dam safety requirements after modification. In addition, the impact of inundation on existing facilities (e.g. marina, boat ramps, access roads, campgrounds, day use areas, etc.) around the perimeter of the reservoir due to a raised RWS will need to be studied.

As an alternative to structurally modifying the dam and dike embankments, capacity can be increased by removing material from within the reservoir. At this time, there are two locations within the reservoir being considered for borrow areas for the SOD modifications. Excavation of material from the reservoir may be cost prohibitive because blasting or other rock excavation techniques and/or underwater excavation techniques will be needed. Consideration should be given to coordinating borrow areas with the CAS team.

Previous studies and deformation analyses indicate that during a major earthquake, crest settlement greater than existing freeboard, or cracking associated with embankment deformation, could occur and lead to dam failure. The Issue Evaluation (IE) Risk Analysis (RA) completed in 2006 [14] determined that the risk of failure due to overtopping or cracking resulting from seismic loading exceeds Reclamation Guidelines to reduce risk. The concurrent CAS for B.F. Sisk Dam was initiated to identify and evaluate risk reduction alternatives.

The static stability analyses presented in this TM utilized assumed drained soil strengths except for the slopewash and NVS-2 materials which also considered undrained soil strengths, as previously discussed. The analyses and conceptual modification sections included in this report did not consider seismically-induced settlements or other post-seismic deformations and subsequent loss of freeboard. Incorporation of the concurrent CAS data, analyses, findings, and recommendations into the feasibility level study for increased storage is paramount to the success of this project.

REFERENCES

[1] “B.F. Sisk Dam, Central Valley Project, California,” Project Management Plan, Bureau of Reclamation, Denver, Colorado, executed by Sharon McHale of Bureau of Reclamation’s Mid-Pacific Regional Office on August 18, 2011.

[2] “San Luis Dam and Pumping-Generating Plant, O’Neill Dam and Pumping Plant,” Technical Record of Design and Construction, Bureau of Reclamation, Denver, Colorado, December 1974.

[3] “Appraisal-Level Study of Static Stability Using Seismically Induced Shear Strengths, B.F. Sisk Dam, Central Valley Project, California,” Technical Memorandum No. VB-8313-5, Bureau of Reclamation, Denver, Colorado, October 2009.

[4] “B.F. Sisk Dam, Central Valley Project, California,” Comprehensive Facility Review, Bureau of Reclamation, Denver, Colorado, June 2009.

[5] “Material Properties Technical Memorandum – B.F. Sisk Dam – Corrective Action Study – Phase 2 Feasibility Level”, Technical Memorandum No. VB-R11PD80312-18, URS Group, Inc., Oakland, California, October 2011.

[6] “Evaluation of Quaternary Stratigraphy and Possible Quaternary Fault Displacement – B.F. Sisk Dam, Central Valley Project, California,” Technical Memorandum No. 86-68330-2009-01, Bureau of Reclamation, Denver, Colorado, January 20, 2009.

[7] “Structural and Non-structural Modification Alternatives, B.F. Sisk Dam, Central Valley Project, California,” Technical Memorandum No. VB-8313-14, Bureau of Reclamation, Denver, Colorado, Final Draft – September 2011.

[8] “GeoStudio 2007, version 7.13”, Slope/W, Users Guide, GEO-SLOPE International Ltd., Calgary, Alberta, Canada, 2004.

[9] “B.F. Sisk Dam 2008 / 2010 Feasibility Level Geologic Investigation, Central Valley Project, Merced County, California,” Bureau of Reclamation, Mid-Pacific Region, Geology Branch, MP-230, Sacramento, California, January 2012.

[10] "Chapter 4 Static Stability Analyses," Design Standards for Embankment Dams No. 13, Bureau of Reclamation, Denver, Colorado, August 3, 1987.

[11] "Slopewash Strength", Handwritten notes by R. Kuzniakowski, Bureau of Reclamation, Denver, Colorado, March XX, 2012.

[12] "NVS Foundation Material Properties, B.F. Sisk Dam, Central Valley Project, California," Technical Memorandum No. VB-8313-12, Bureau of Reclamation, Denver, Colorado, Final Draft – September 2011.

[13] "Slopewash Material Properties, B.F. Sisk Dam, Central Valley Project, California," Technical Memorandum No. VB-8313-11, Bureau of Reclamation, Denver, Colorado, Final Draft – September 2011.

[14] "B.F. Sisk Dam Seismic Deformation Analysis and Seismic Risk Analysis, Central Valley Project, California," Technical Memorandums No. VB-8313-3 and VB-8313-4, Bureau of Reclamation, Denver, Colorado, February 2006.

Attachments

A Drawings

B Results of Static Stability Analyses

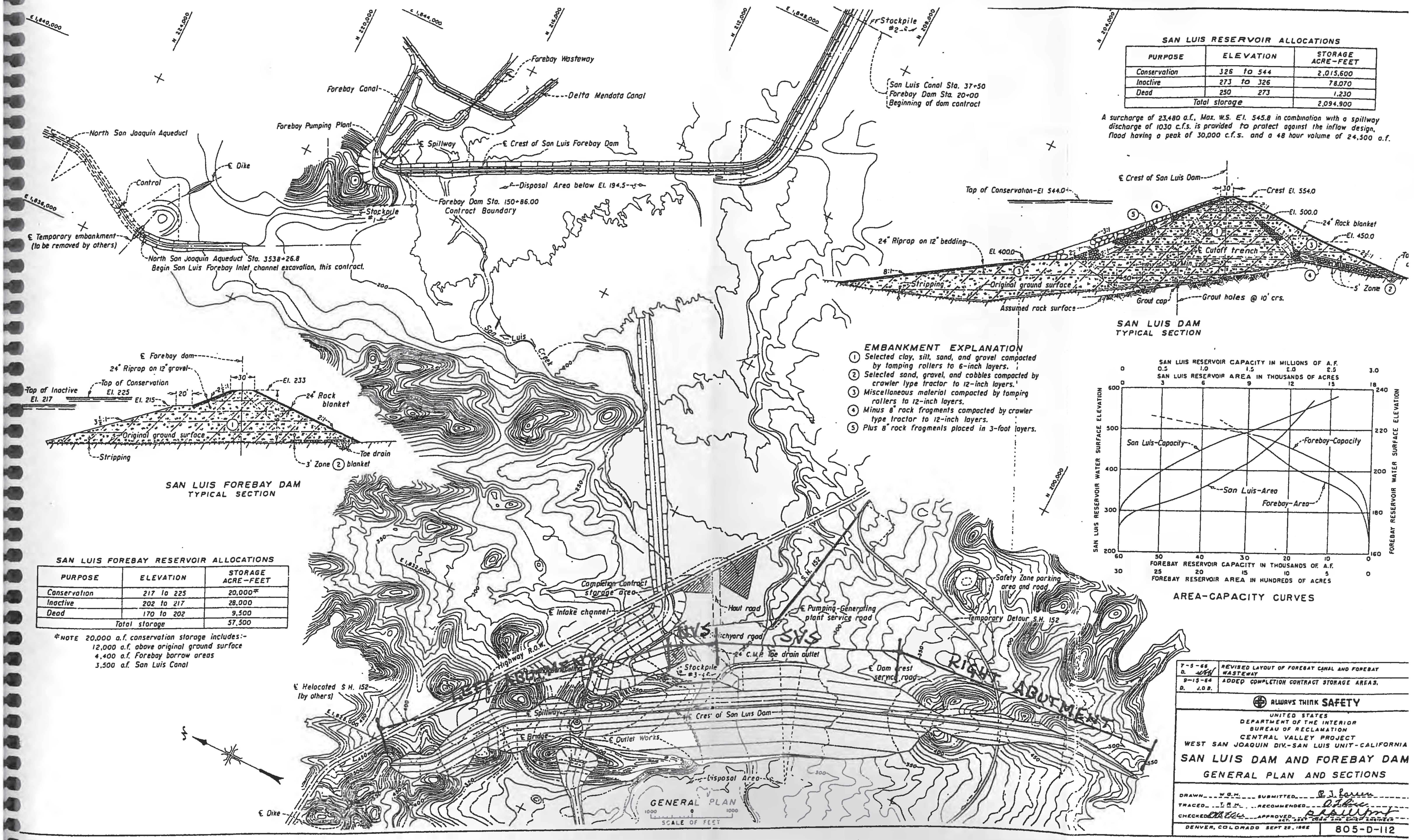
Attachment A

Drawings

List of Drawings

Title

Note: Attachments in this section are presented in 11 x 17 format.



SAN LUIS RESERVOIR ALLOCATIONS

PURPOSE	ELEVATION	STORAGE ACRE-FEET
Conservation	326 to 544	2,015,600
Inactive	273 to 326	78,070
Dead	250 273	1,230
Total storage		2,094,900

A surcharge of 23,480 a.f., Max. W.S. El. 545.8 in combination with a spillway discharge of 1030 c.f.s. is provided to protect against the inflow design, flood having a peak of 30,000 c.f.s. and a 48 hour volume of 24,500 a.f.

EMBANKMENT EXPLANATION

① Selected clay, silt, sand, and gravel compacted by tamping rollers to 6-inch layers.
② Selected sand, gravel, and cobbles compacted by crawler type tractor to 12-inch layers.
③ Miscellaneous material compacted by tamping rollers to 12-inch layers.
④ Minus 8" rock fragments compacted by crawler type tractor to 12-inch layers.
⑤ Plus 8" rock fragments placed in 3-foot layers.

SAN LUIS FOREBAY RESERVOIR ALLOCATIONS

PURPOSE	ELEVATION	STORAGE ACRE-FEET
Conservation	217 to 225	20,000*
Inactive	202 to 217	28,000
Dead	170 to 202	9,500
Total storage		57,500

*NOTE 20,000 a.f. conservation storage includes:-
12,000 a.f. above original ground surface
4,400 a.f. Forebay borrow areas
3,500 a.f. San Luis Canal

7-5-66 D.	REVISED LAYOUT OF FOREBAY CANAL AND FOREBAY WASTEWAY
9-15-64 D. J.D.B.	ADDED COMPLETION CONTRACT STORAGE AREAS.

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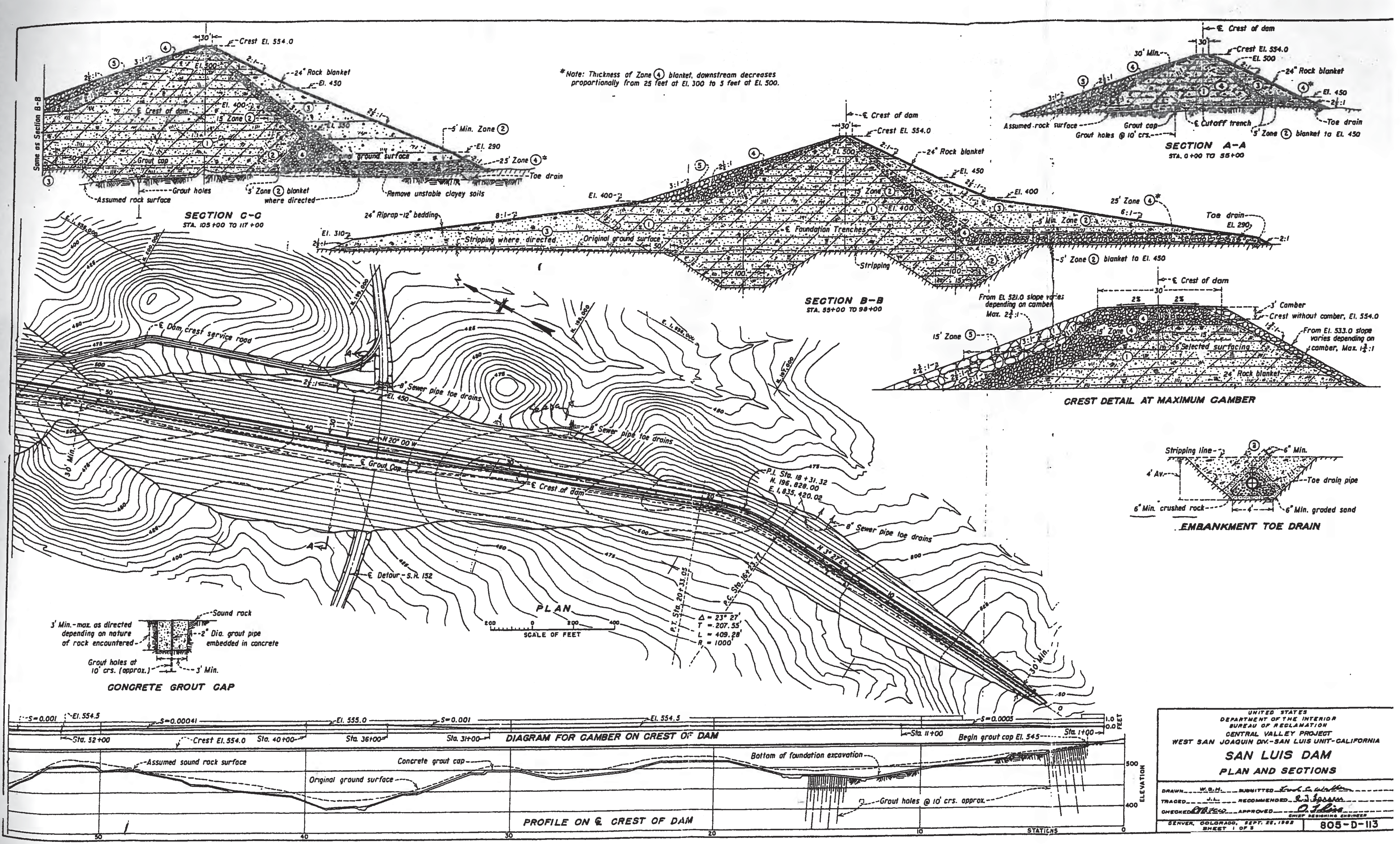
SAN LUIS DAM AND FOREBAY DAM
GENERAL PLAN AND SECTIONS

DRAWN W.G.H. SUBMITTED
TRACED T.R.M. RECOMMENDED
CHECKED APPROVED
ACT. ASST COMM AND CHIEF ENGINEER
DENVER, COLORADO SEPT 22, 1962
805-D-112

Figure A-1



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SAN LUIS DAM

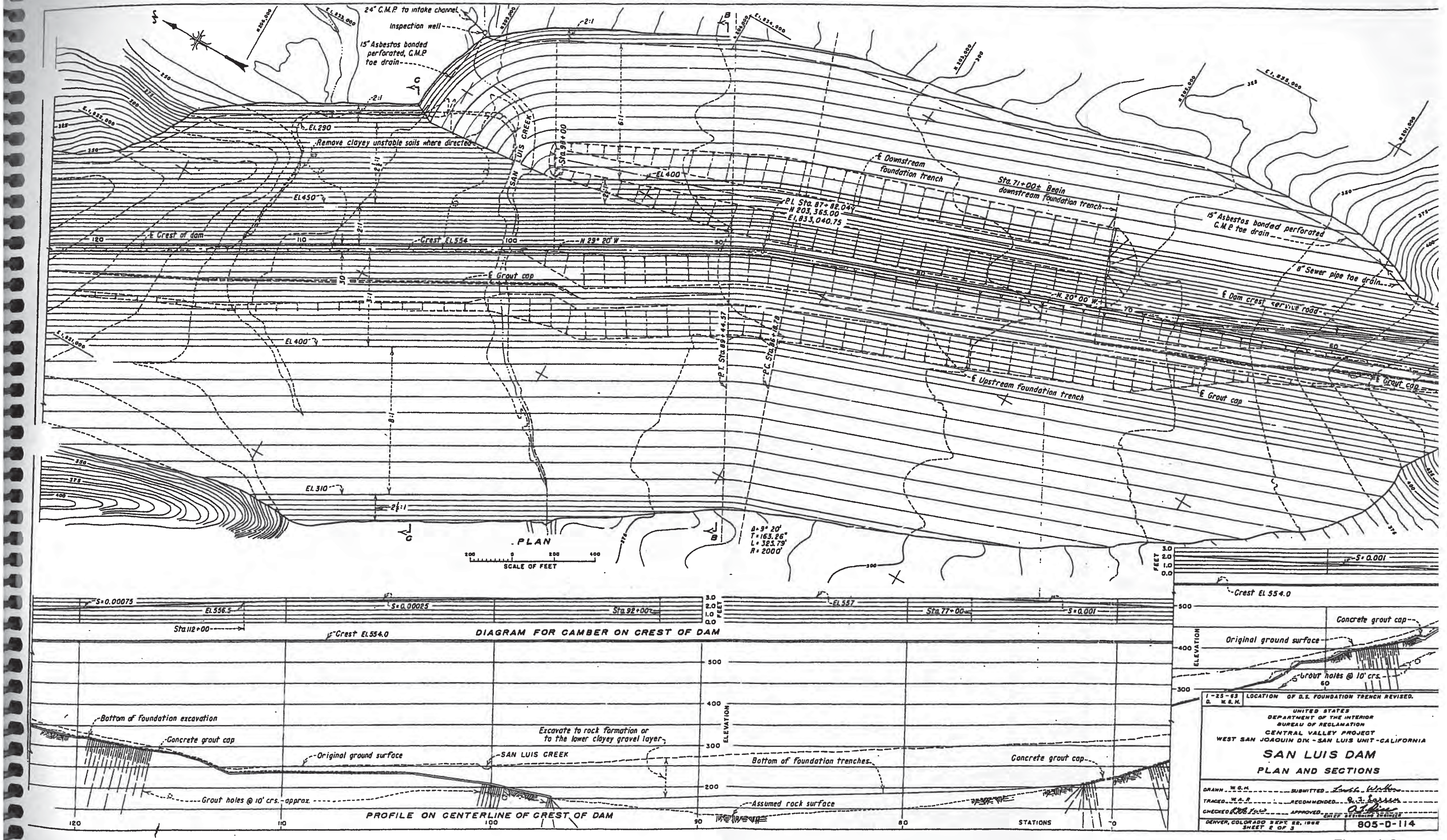
PLAN AND SECTIONS

DRAWN W.G.H. SUBMITTED
TRACED J.L. RECOMMENDED
CHECKED APPROVED
CHIEF DESIGNING ENGINEER

DENVER, COLORADO, SEPT. 25, 1962
SHEET 1 OF 3

805-D-113

Figure A-2



1-25-63 D. W.E.H. LOCATION OF D.S. FOUNDATION TRENCH REVISED.

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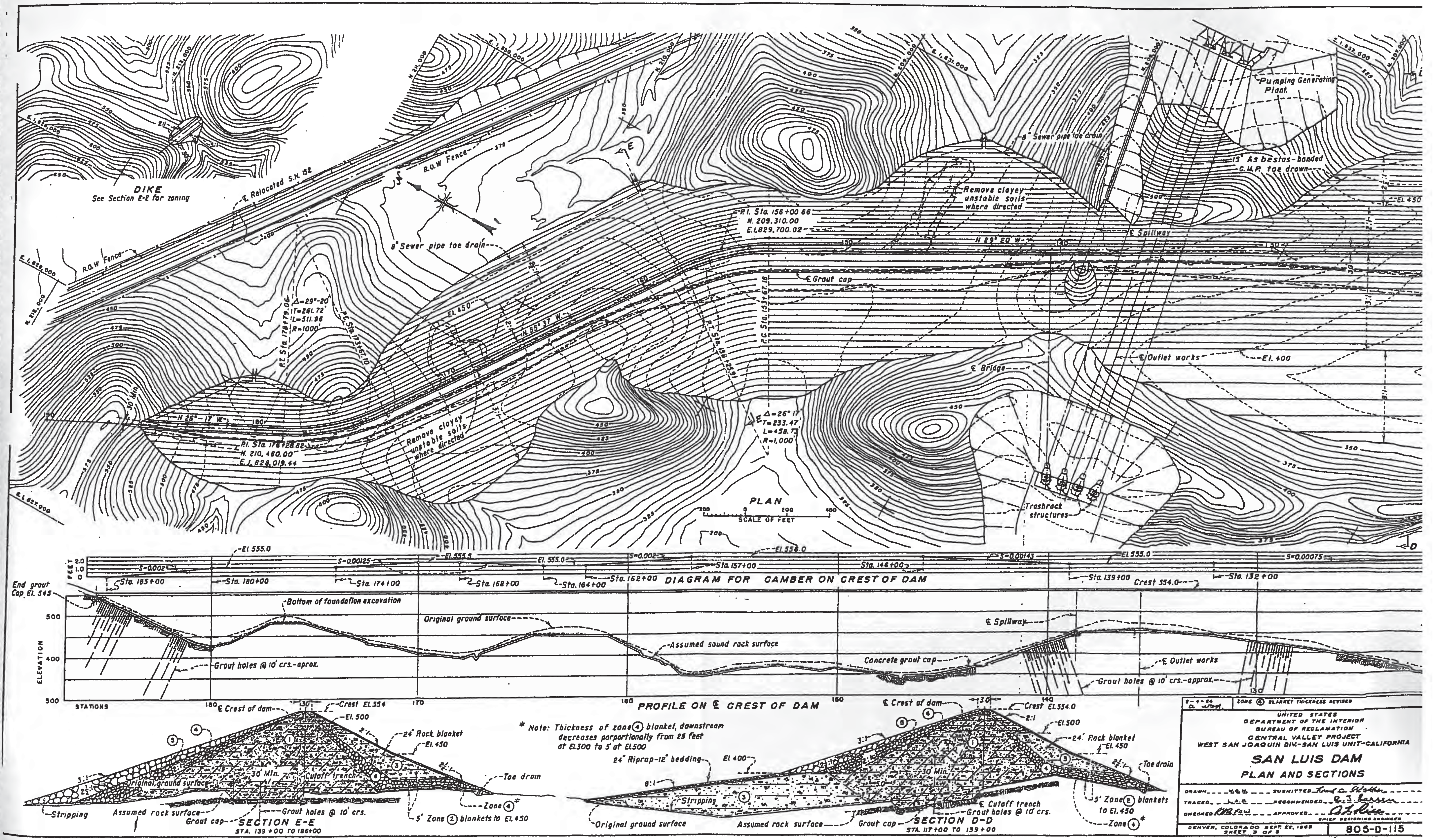
WEST SAN JOAQUIN DIV. - SAN LUIS UNIT - CALIFORNIA

SAN LUIS DAM
PLAN AND SECTIONS

DRAWN W.G.H. SUBMITTED Louis Walker
TRACED W.A.R. RECOMMENDED G. J. Larsen
CHECKED R.W.B. / c.o. APPROVED A. T. Rice
CHIEF DESIGNING ENGINEER
DENVER, COLORADO SEPT. 22, 1962
SHEET 2 OF 3
805-D-114

Figure A-3



* Note: Thickness of zone ④ blanket, downstream decreases porportionally from 25 feet at El.300 to 5' at El.500

2-4-64 ZONE ④ BLANKET THICKNESS REVISED

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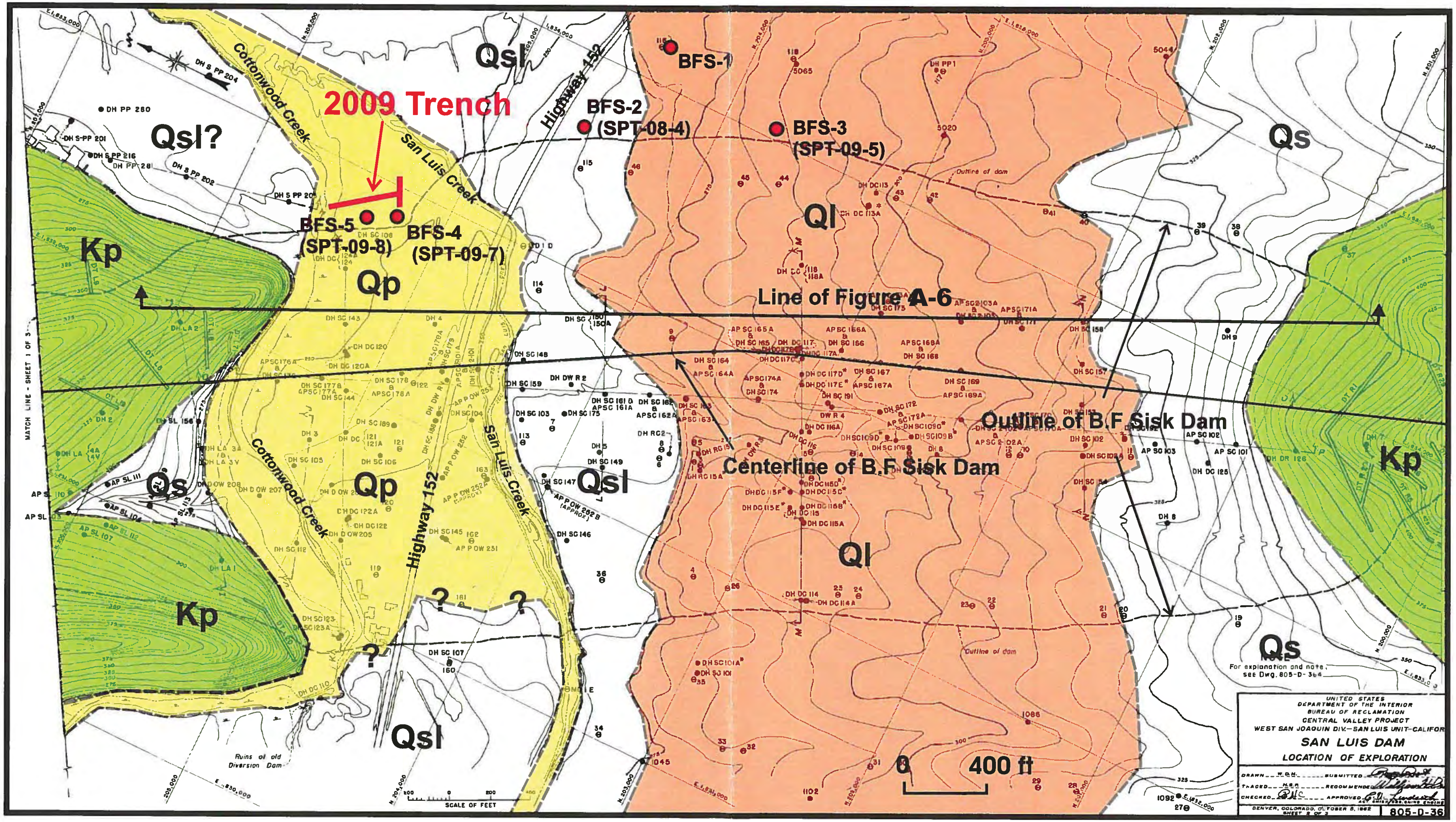
WEST SAN JOAQUIN DIV.-SAN LUIS UNIT-CALIFORNIA

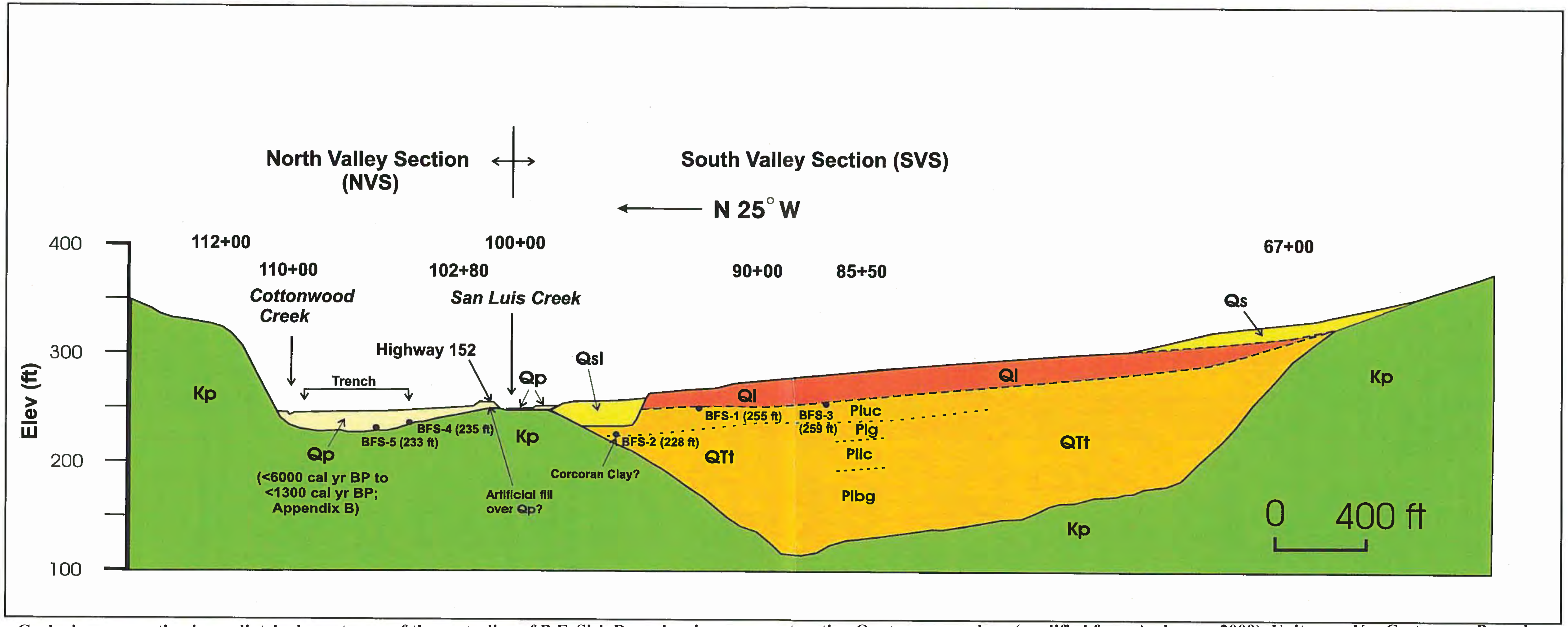
SAN LUIS DAM
PLAN AND SECTIONS

DRAWN ____ SUBMITTED Fred C. Walker
TRACED ____ RECOMMENDED C. J. Larsen
CHECKED ____ APPROVED A. F. Rice
CHIEF DESIGNING ENGINEER
DENVER, COLORADO SEPT. 22, 1962
SHEET 3 OF 3
805-D-115

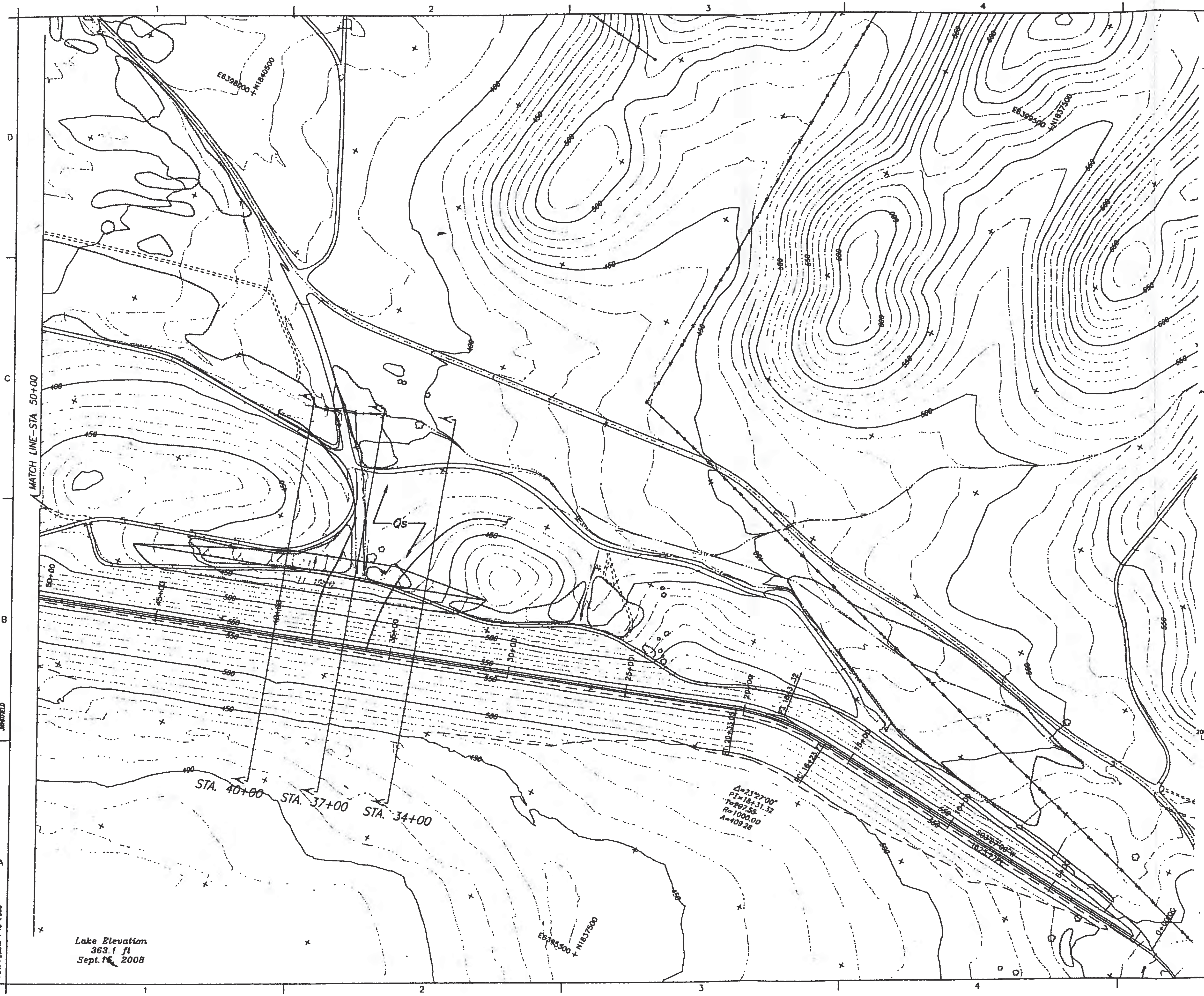
Figure A-4



Geologic map of the B.F. Sisk Dam site showing pre-construction surficial Quaternary geology (modified from Anderson, 2009). Units are Kp, Cretaceous Panoche Group sedimentary rocks; Ql, Los Banos alluvium (dark orange); Qs, slopewash/colluvium (white); Qsl, San Luis Ranch alluvium (white); Qp, Patterson alluvium (yellow). Base from Reclamation drawing 805-D-362, contour interval 5 ft; geology from pre-construction aerial photograph interpretation, photographs dated 1942 and 1960, and U.S. Department of Agriculture Soil Survey of the Los Banos, California area, 1952.



Geologic cross-section immediately downstream of the centerline of B.F. Sisk Dam showing pre-construction Quaternary geology (modified from Anderson, 2009). Units are: Kp, Cretaceous Panoche Group sedimentary rocks green); QTt, Quaternary-Tertiary Tulare Formation (orange; Pluc, upper clay [probably Corcoran Clay equivalent]; Plg, upper gravel; Pllc, lower clay, PPlbg, basal gravel); Ql, Los Banos alluvium (dark orange); Qs, slopewash/colluvium (dark yellow); Qsl, San Luis Ranch alluvium (yellow); Qp, Patterson alluvium (light yellow). Location of section shown on Figure A-5.



LEGEND

—×—	*Transmission line*
☒	*Transmission tower*

N

CALIFORNIA STATE PLANE COORDINATE SYSTEM
ZONE 3 , U.S. SURVEY FEET
HORIZONTAL DATUM: NAV1983
VERTICAL DATUM: NAVD 1988
CONTOUR INTERVAL: 10 FT.

Topography by Surveys and Mapping Section, Field Operations Branch, Division of Design and Construction, Mid-Pacific Region.
Compiled from photography: BR-SLU-30
Date of photography: 9-15-08

200 0 200 400 600
SCALE OF FEET

DATE AND TIME PLOTTED
MARCH 1, 2010 12:44
PLOTTED BY
JWHITFIELD

CAD SYSTEM
AutoCAD Rel. 17.1s
CAD FILENAME
PLAN P_BERM 1 TO 4.DWG

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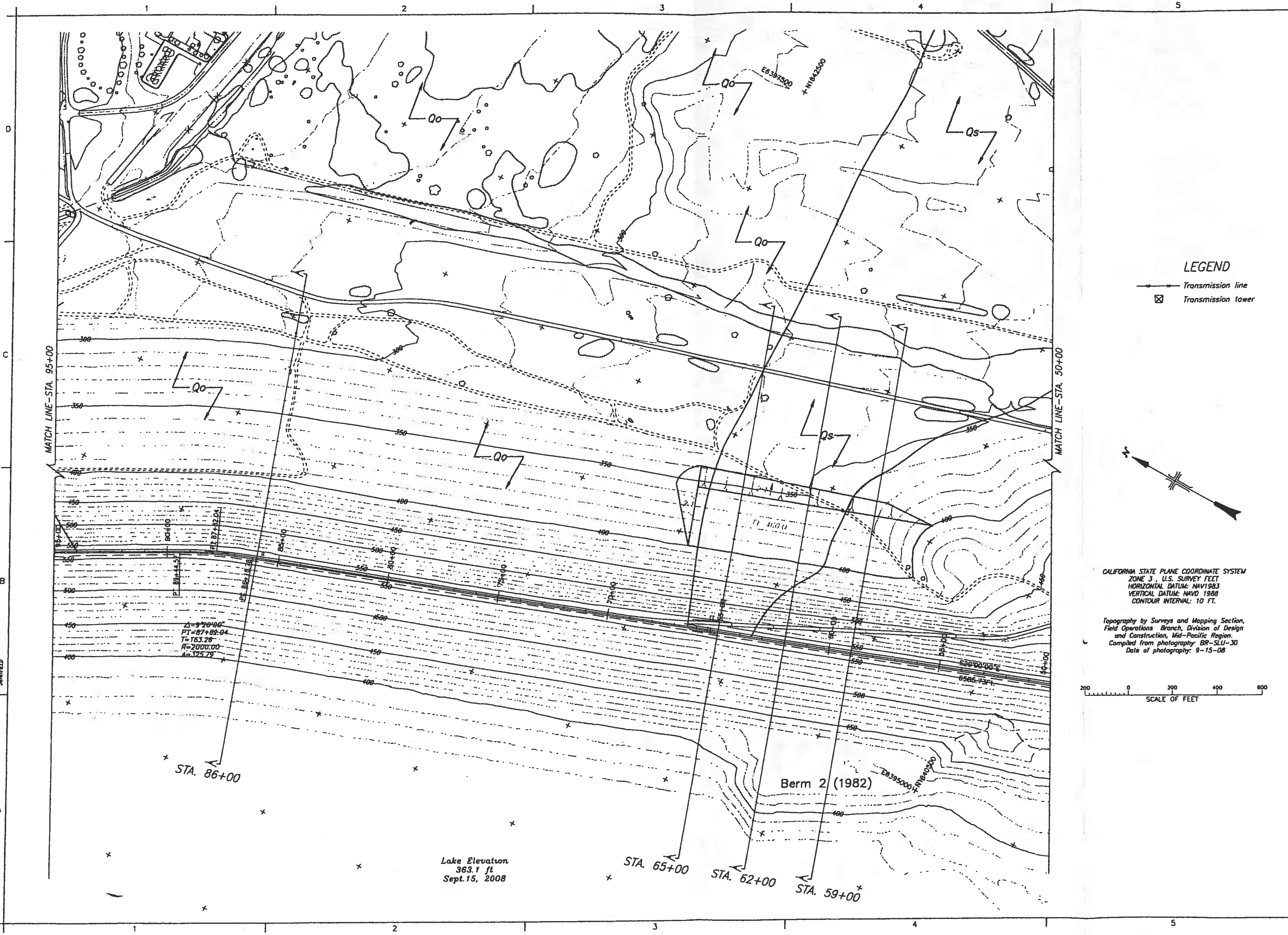
B.F. SISK DAM
CORRECTIVE ACTION STUDY
FEASIBILITY LEVEL
SITE PLAN - P-BERM

DESIGNED ____________
DRAWN ____________
CHECKED ____________
TECH. APPR. ____________
APPROVED ____________
GEOTECHNICAL ENGINEERING GROUP 3

DENVER, COLORADO 2010-01-08

PLAN-P-BERM 4
SHEET 4 OF 4

Figure A-7



CALIFORNIA STATE PLANE COORDINATE SYSTEM
ZONE 3 , U.S. SURVEY FEET
HORIZONTAL DATUM: NAV1983
VERTICAL DATUM: NAVD 1988
CONTOUR INTERVAL: 10 FT.

Topography by Surveys and Mapping Section, Field Operations Branch, Division of Design and Construction, Mid-Pacific Region. Compiled from photography: BR-5LU-30 Date of photography: 9-15-08

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B.F. SISK DAM
CORRECTIVE ACTION STUDY
FEASIBILITY LEVEL
SITE PLAN - P-BERM

DESIGNED
DRAWN
CHECKED
TECH. APPR.
APPROVED
GEOTECHNICAL ENGINEERING GROUP 3

DENVER, COLORADO 2010-01-08

PLAN P-BERM 3
SHEET 3 OF 4

DATE AND TIME PLOTTED
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JWHITFIELD

CAD SYSTEM
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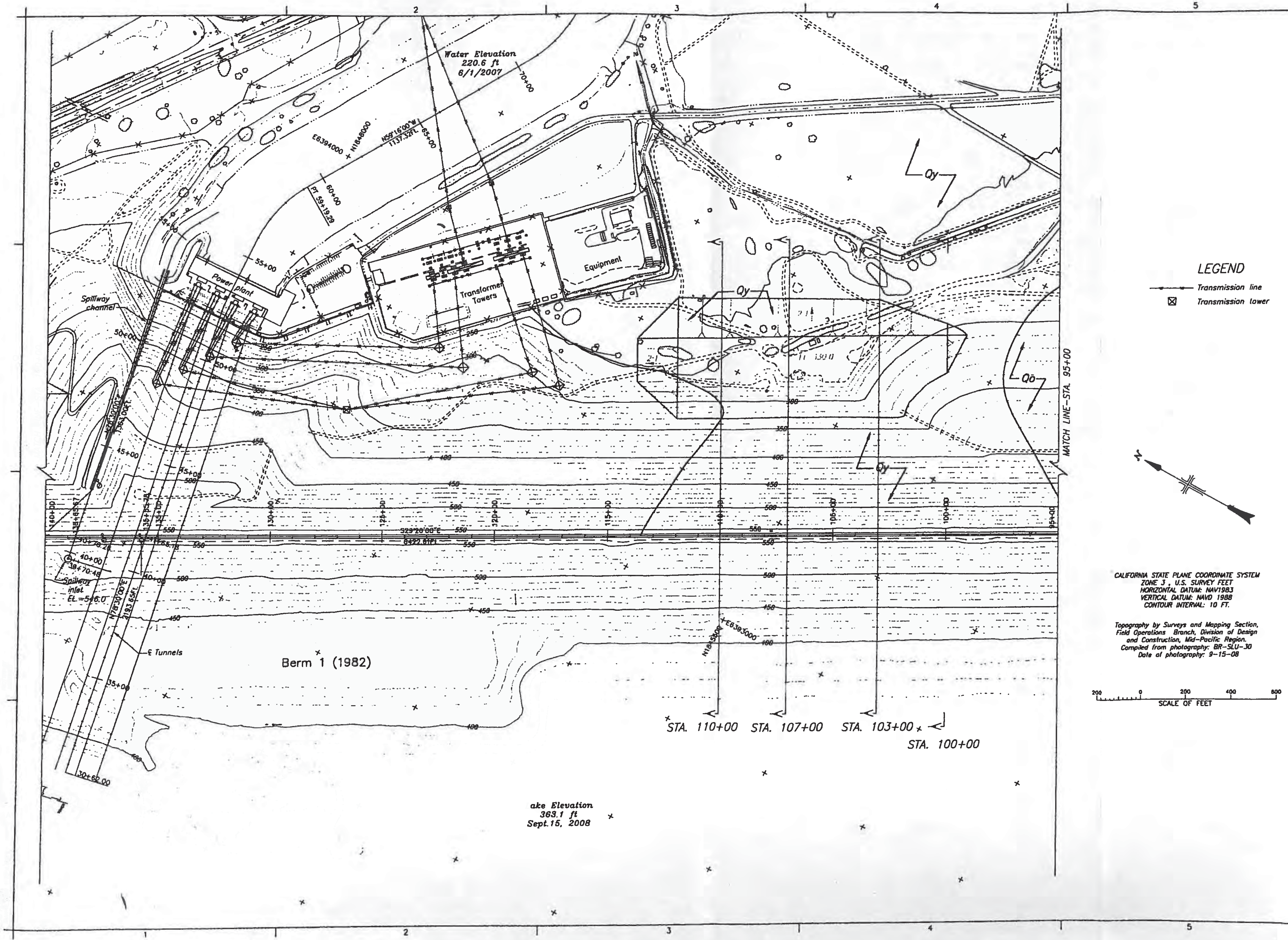
CAD FILENAME
PLAN P_BERM 1 TO 4.DWG

Figure A-8



CALIFORNIA STATE PLANE COORDINATE SYSTEM
ZONE 3 , U.S. SURVEY FEET
HORIZONTAL DATUM: NAV1983
VERTICAL DATUM: NAVD 1988
CONTOUR INTERVAL: 10 FT.

Topography by Surveys and Mapping Section,
Field Operations Branch, Division of Design
and Construction, Mid-Pacific Region.
Compiled from photography: BR-SLU-30
Date of photography: 9-15-08

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B.F. SISK DAM
CORRECTIVE ACTION STUDY
FEASIBILITY LEVEL
SITE PLAN – P-BERM

DESIGNED ____________
DRAWN ____________
CHECKED ____________
TECH. APPR. ____________
APPROVED ____________
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PLAN P-BERN 2

SHEET 2 OF 4

Figure A-9

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JWHITFIELD

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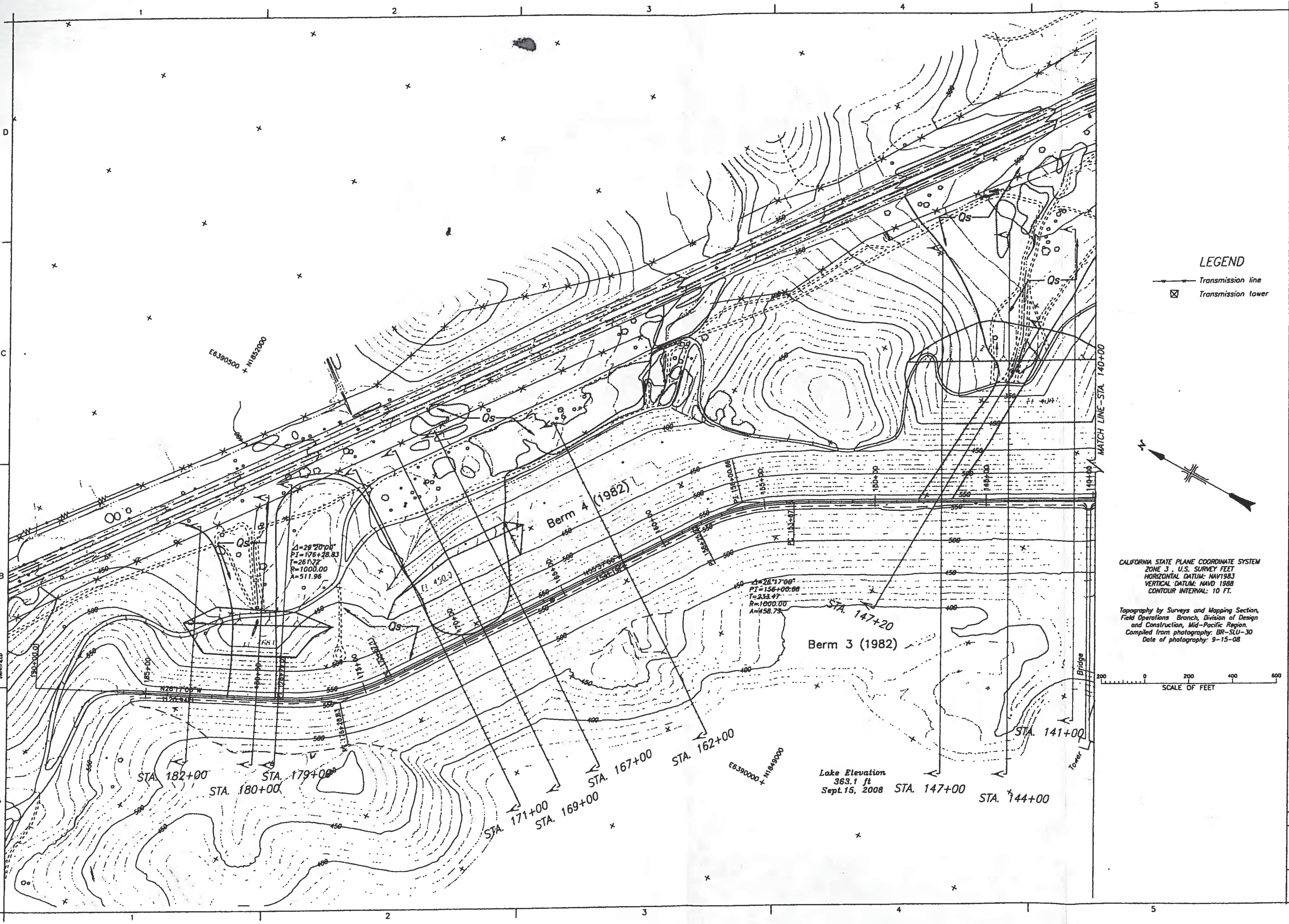
PLAN P_BERM 1 TO 4 DWG



LEGEND

—×—×—	Transmission line
☒	Transmission tower

CALIFORNIA STATE PLANE COORDINATE SYSTEM
ZONE 3 , U.S. SURVEY FEET
HORIZONTAL DATUM: NAV1983
VERTICAL DATUM: NAVD 1988
CONTOUR INTERVAL: 10 FT.

Topography by Surveys and Mapping Section, Field Operations Branch, Division of Design and Construction, Mid-Pacific Region.
Compiled from photography: BR-SLU-30
Date of photography: 9-15-08

200 0 200 400 600
SCALE OF FEET

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B.F. SISK DAM
CORRECTIVE ACTION STUDY
FEASIBILITY LEVEL
SITE PLAN - P-BERM

DESIGNED ____________
DRAWN ____________
CHECKED ____________
TECH. APPR. ____________
APPROVED ____________
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PLAN P-BERM 1
SHEET 1 OF 4

Figure A-10

CAS–BERM1

RECLAMATION
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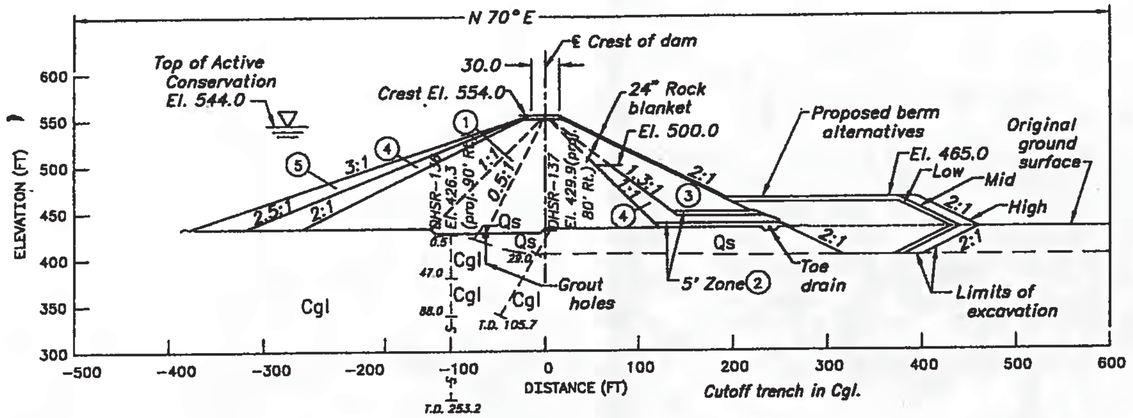
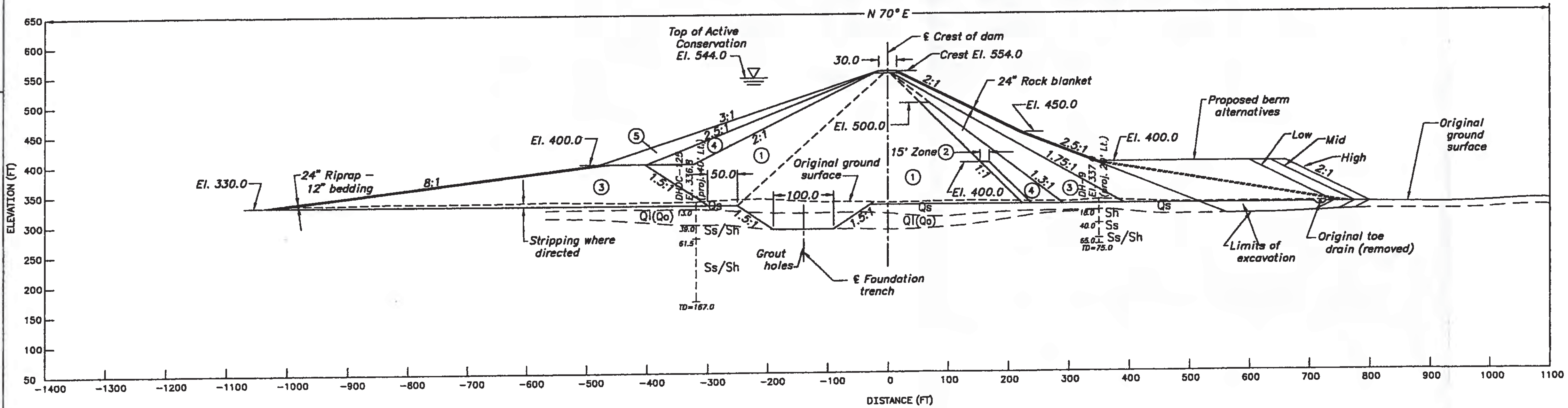
EMBANKMENT EXPLANATION

① Selected clay, silt, sand, and gravel compacted by tamping rollers to 6–inch layers.
② Selected sand, gravel, and cobbles compacted by crawler type tractor to 12–inch layers.
③ Miscellaneous material compacted by tamping rollers to 12–inch layers.
④ Minus 8–inch rock fragments compacted by crawler type tractor to 12–inch layrs.
⑤ Plus 8–inch rock fragments placed in 3–foot layers.



STATION 37+00



STATION 65+00

GEOLOGIC EXPLANATION

Ql = Los Banos alluvium, clay layer over gravel layer.
Also known as Qo = Older alluvium (upper alluvium)
Qsl = San Luis Ranch alluvium.
Also known as Qy = Young alluvium
Qs = Slope wash
QTtc = Corcoran clay
QTt = Tulare formation. Also known as
Pluc = Upper clay
Plg = Lower gravel (lower alluvium)
Pllc = Lower clay
Plbg = Basal clayey gravel (Basal gravel)
Ss = Sandstone
Sh = Shale
Slts = Siltstone
Cgl = Conglomerate

NOTES

1. All elevations are NGDV 29.

DATE AND TIME PLOTTED
MAY 6, 2010 13:25
PLOTTED BY
RKUZNIAKOWSKI

CAD SYSTEM
AutoCAD Rel. 17.1s
CAD FILENAME
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B.F. SISK DAM

CORRECTIVE ACTION STUDY
APPRAISAL LEVEL
CROSS SECTIONS

DESIGNED
REVIEWED BY
GEOTECHNICAL ENGINEERING GROUP 3

DENVER, COLORADO
SHEET 1 OF 3
2008–11–20
CAS–BERM 1

Figure A-11

CAS-BERM 2

RECLAMATION
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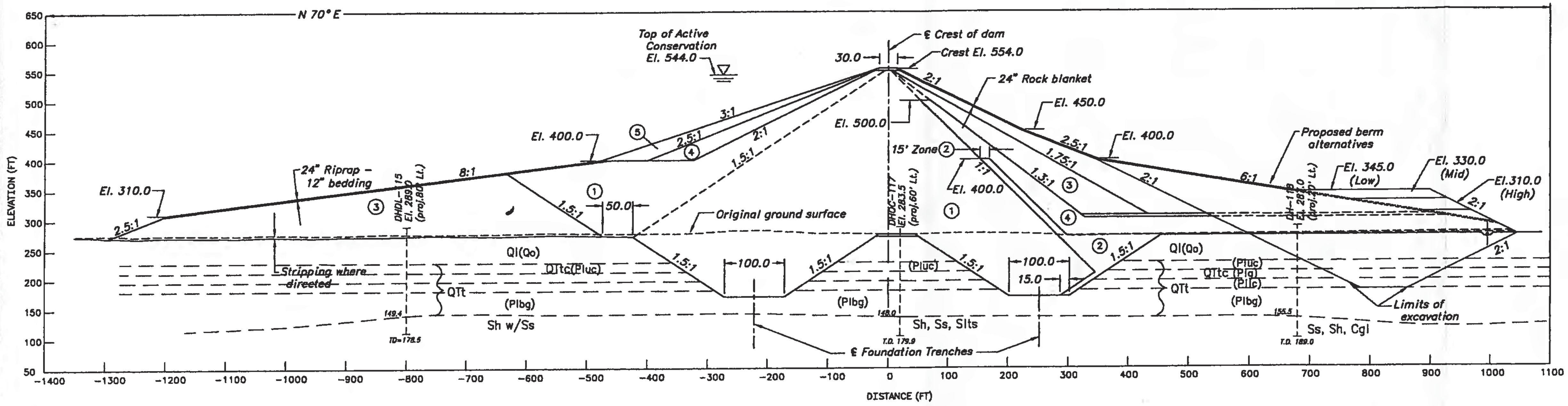
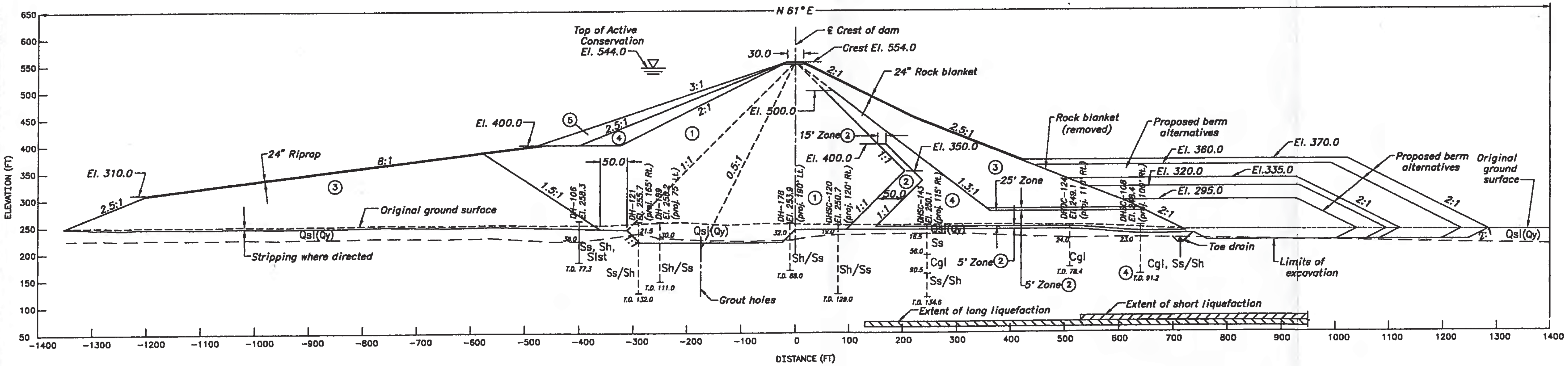


STATION 86+00



STATION 107+00

GEOLOGIC EXPLANATION

Ql = Los Banos alluvium, clay layer over gravel layer.
Also known as Qo = Older alluvium (upper alluvium)
Qsl = San Luis Ranch alluvium.
Also known as Qy = Young alluvium
Os = Slope wash
QTtc = Corcoran clay
QTt = Tulare formation. Also known as
Pluc = Upper clay
Plg = Lower gravel (lower alluvium)
Pllc = Lower clay
Plbg = Basal clayey gravel (Basal gravel)
Ss = Sandstone
Sh = Shale
Slts = Siltstone
Cgl = Conglomerate

NOTES

1. All elevations are NGDV 29.

EMBANKMENT EXPLANATION

① Selected clay, silt, sand, and gravel compacted by tamping rollers to 6-inch layers.
② Selected sand, gravel, and cobbles compacted by crawler type tractor to 12-inch layers.
③ Miscellaneous material compacted by tamping rollers to 12-inch layers.
④ Minus 8-inch rock fragments compacted by crawler type tractor to 12-inch layrs.
⑤ Plus 8-inch rock fragments placed in 3-foot layers.

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B.F. SISK DAM

CORRECTIVE ACTION STUDY
APPRAISAL LEVEL
CROSS SECTIONS

DESIGNED ______________________
REVIEWED BY ______________________
GEOTECHNICAL ENGINEERING GROUP 3

DENVER, COLORADO 2008-11-20
SHEET 2 OF 3
CAS-BERM 2

DATE AND TIME PLOTTED
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RRUDNIAKOWSKI

CAD SYSTEM
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Figure A-12

RECLAMATION
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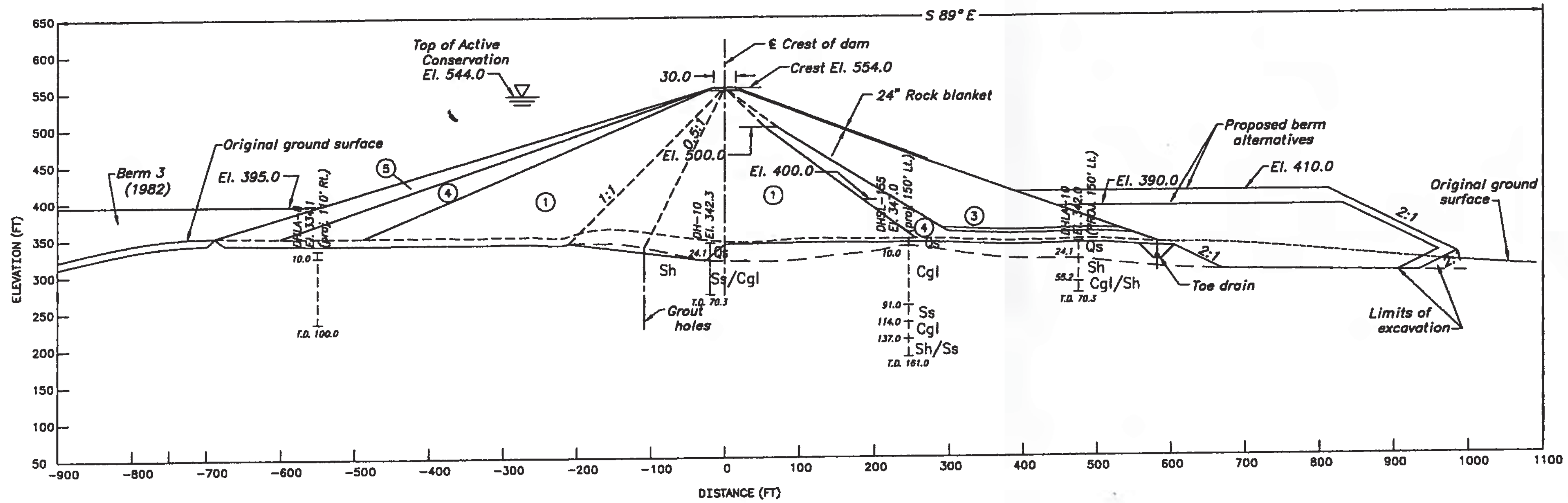

STATION 147+20
60° TO DAM AXIS

EMBANKMENT EXPLANATION

① Selected clay, silt, sand, and gravel compacted by tamping rollers to 6-inch layers.
② Selected sand, gravel, and cobbles compacted by crawler type tractor to 12-inch layers.
③ Miscellaneous material compacted by tamping rollers to 12-inch layers.
④ Minus 8-inch rock fragments compacted by crawler type tractor to 12-inch layrs.
⑤ Plus 8-inch rock fragments placed in 3-foot layers.

GEOLOGIC EXPLANATION

Ql = Los Banos alluvium, clay layer over gravel layer. Also known as Qo = Older alluvium (upper alluvium)
Qsl = San Luis Ranch alluvium. Also known as Qy = Young alluvium
Qs = Slope wash
QTtc = Corcoran clay
QTt = Tulare formation. Also known as
- Pluc = Upper clay
- Plg = Lower gravel (lower alluvium)
- Pllc = Lower clay
- Plbg = Basal clayey gravel (Basal gravel)

Ss = Sandstone
Sh = Shale
Slts = Siltstone
Cgl = Conglomerate

NOTES

1. All elevations are NGDV 29.

DATE AND TIME PLOTTED
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RRUDNIAKOWSKI

CAD SYSTEM
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CAS-BERM3.DWG

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B.F. SISK DAM

CORRECTIVE ACTION STUDY
APPRAISAL LEVEL
CROSS SECTIONS

DESIGNED____________________
REVIEWED BY____________________
GEOTECHNICAL ENGINEERING GROUP 3

DENVER, COLORADO
2008-11-20
SHEET 3 OF 3
CAS-BERM 3

Figure A-13

CAS-RAISE-1

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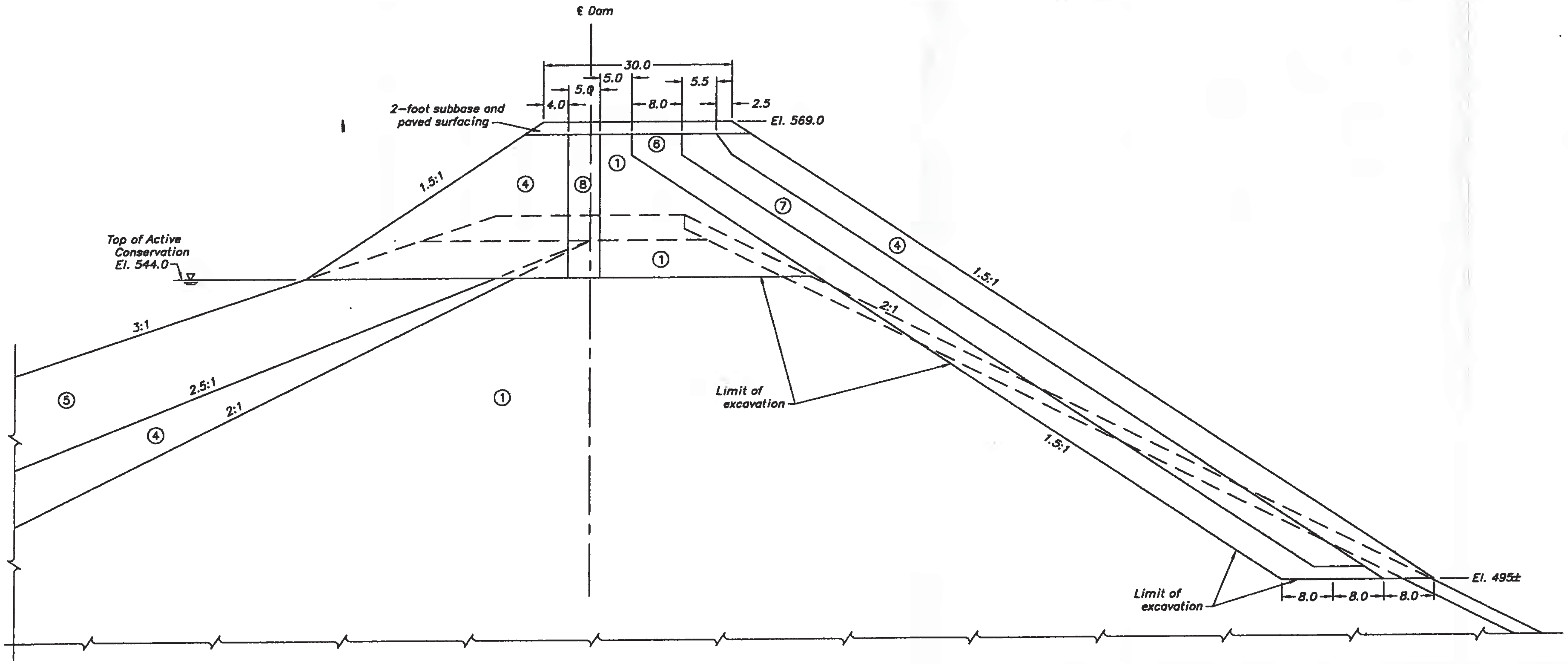
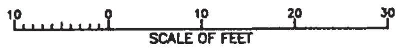


OVERLAY
EXAMPLE: 15' RAISE

EMBANKMENT EXPLANATION

① Selected clay, silt, sand, and gravel compacted by tamping rollers to 6-inch layers.
② Selected sand, gravel, and cobbles compacted by crawler type tractor to 12-inch layers.
③ Miscellaneous material compacted by tamping rollers to 12-inch layers.
④ Minus 8-inch rock fragments compacted by crawler type tractor to 12-inch layers.
⑤ Plus 8-inch rock fragments placed in 3-foot layers.
⑥ Processed sand and gravel compacted by vibratory smooth drum rollers to 24-inch layers.
⑦ Processed gravel compacted by vibratory smooth drum rollers to 24-inch layers.
⑧ Processed sand and gravel compacted by vibratory smooth drum rollers to 12-inch layers.

NOTES
1. All elevations are ~~NADV~~ 29.
NGVD



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B.F. SISK DAM

CORRECTIVE ACTION STUDY
APPRAISAL LEVEL
RAISE ALTERNATIVES

DESIGNED ______
REVIEWED BY ______
GEOTECHNICAL ENGINEERING GROUP 3
DENVER, COLORADO 2008-11-20
SHEET 1 OF 3
CAS-RAISE-1

DATE AND TIME PLOTTED
MAY 6, 2010 13:47
PLOTTED BY
RKUZNIAROWSKI

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Figure A-14

RECLAMATION
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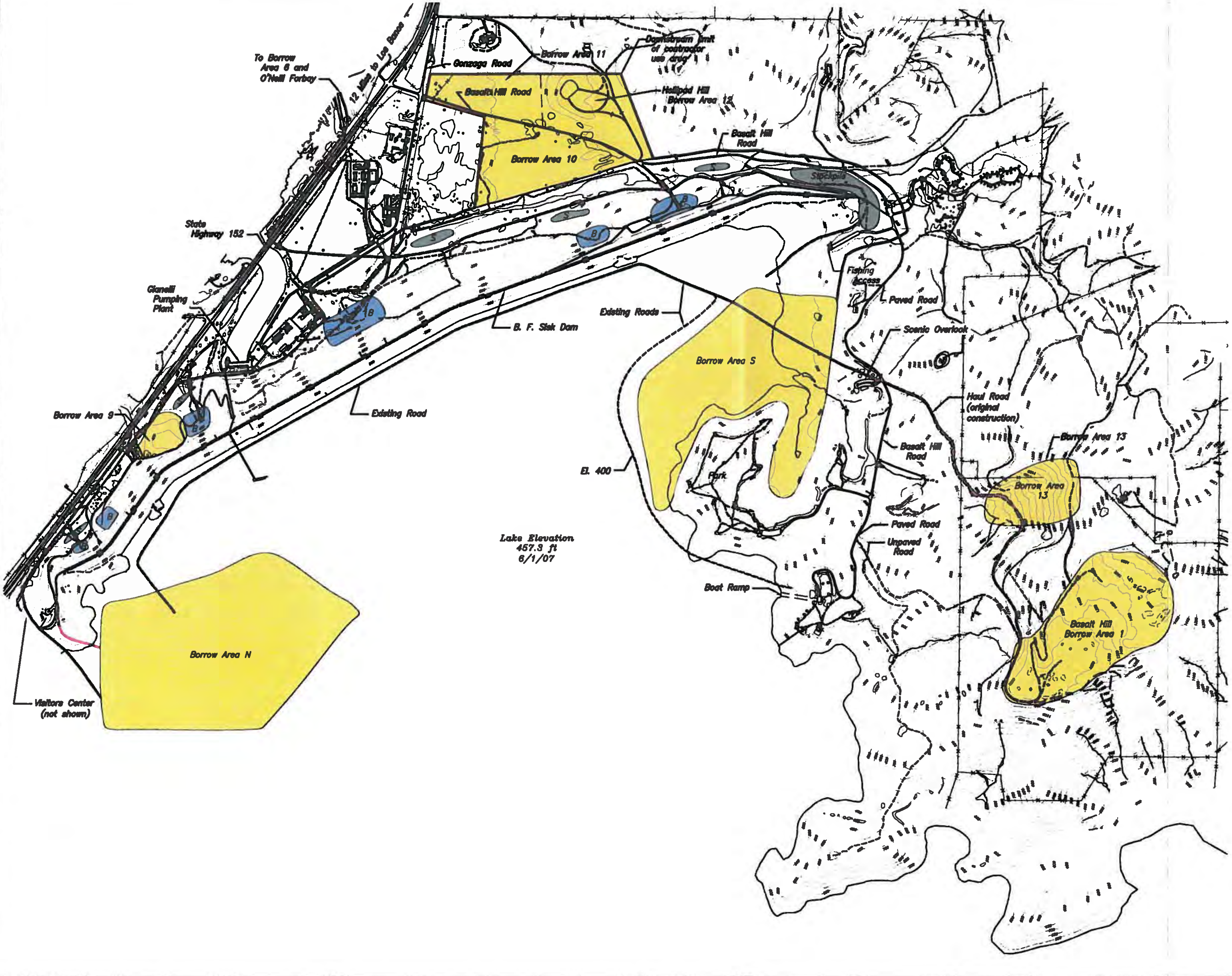

CALIFORNIA STATE PLANE COORDINATE SYSTEM
ZONE 3, U.S. SURVEY FEET
VERTICAL DATUM : NAVD1988
ORIGINAL PROJECT DATUM NGVD29 = NAVD88–2.81 FEET

N

LEGEND

- Limit of contractor use area
- Haul Road
- B Berm
- S Stockpile Area
- Fence

1000 0 1000 2000 3000
SCALE OF FEET

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CENTRAL VALLEY PROJECT
WEST SAN JOAQUIN DIVISION–SAN LUIS UNIT–CALIFORNIA
B. F. SISK DAM
CORRECTIVE ACTION STUDY
SITE USE

DESIGNED
DRAWN

DENVER, COLORADO
SHEET 1 OF 1
2009-01-08
CAS–ENV

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Figure A-15

Attachment B

Results of Static Stability Analyses

Results of Static Stability Analyses

Title

Appraisal-Level Embankment Modification Sections, 1 of 16 – Slope/W Output

Appraisal-Level Embankment Modification Sections, 2 of 16 – Slope/W Output

Appraisal-Level Embankment Modification Sections, 3 of 16 – Slope/W Output

Appraisal-Level Embankment Modification Sections, 4 of 16 – Slope/W Output

Appraisal-Level Embankment Modification Sections, 5 of 16 – Slope/W Output

Appraisal-Level Embankment Modification Sections, 6 of 16 – Slope/W Output

Appraisal-Level Embankment Modification Sections, 7 of 16 – Slope/W Output

Appraisal-Level Embankment Modification Sections, 8 of 16 – Slope/W Output

Appraisal-Level Embankment Modification Sections, 9 of 16 – Slope/W Output

Appraisal-Level Embankment Modification Sections, 10 of 16 – Slope/W Output

Appraisal-Level Embankment Modification Sections, 11 of 16 – Slope/W Output

Appraisal-Level Embankment Modification Sections, 12 of 16 – Slope/W Output

Appraisal-Level Embankment Modification Sections, 13 of 16 – Slope/W Output

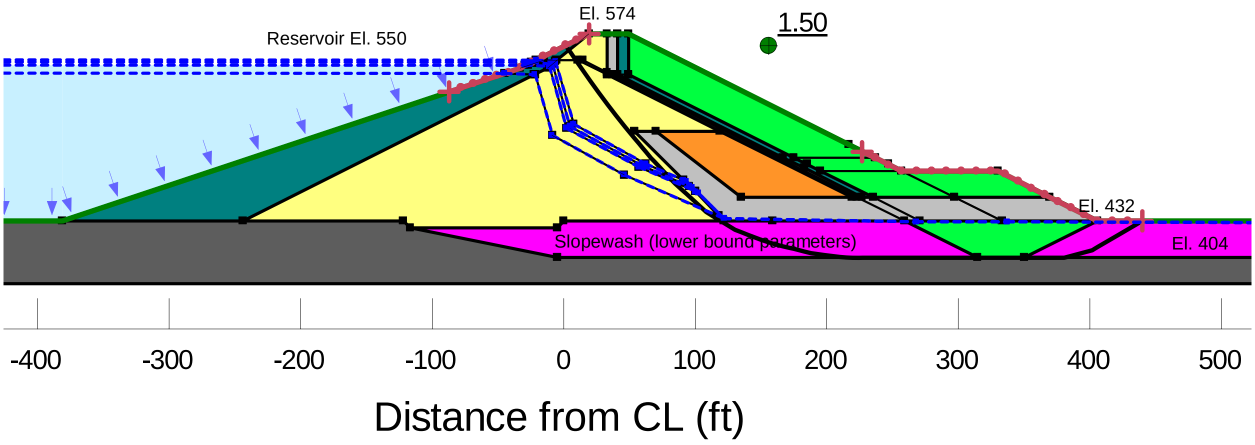
Appraisal-Level Embankment Modification Sections, 14 of 16 – Slope/W Output

Appraisal-Level Embankment Modification Sections, 15 of 16 – Slope/W Output

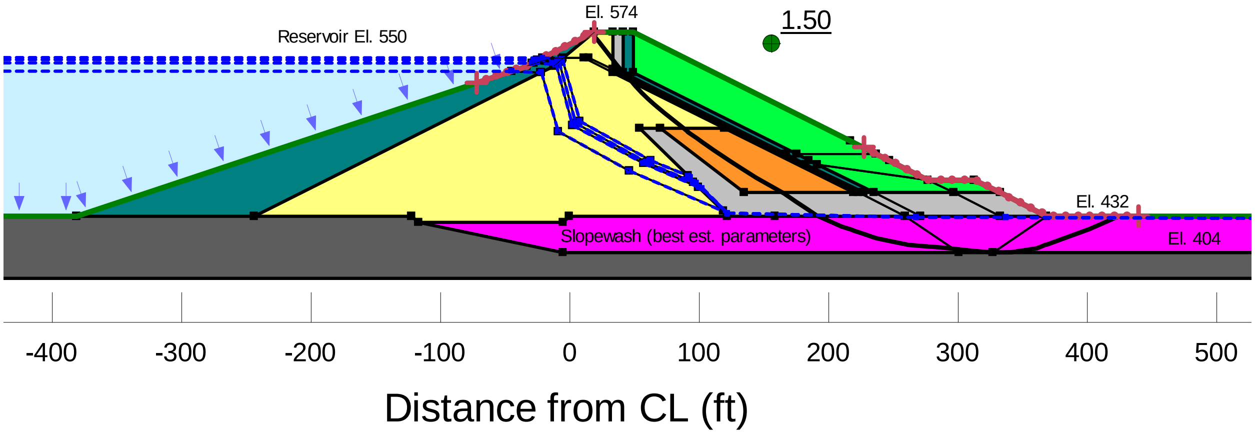
Appraisal-Level Embankment Modification Sections, 16 of 16 – Slope/W Output

Station 37+00 with 6-ft RWS Raise
Drained Slopewash Strength Parameters

Sta 37+00
Modified embankment
RWS raise = 6 ft
Lower bound parameters for Slopewash



Sta 37+00
Modified embankment
RWS raise = 6 ft
Middle est. parameters for Slopewash



Sta 37+00
Modified embankment
RWS raise = 6 ft
Upper bound parameters for Slopewash

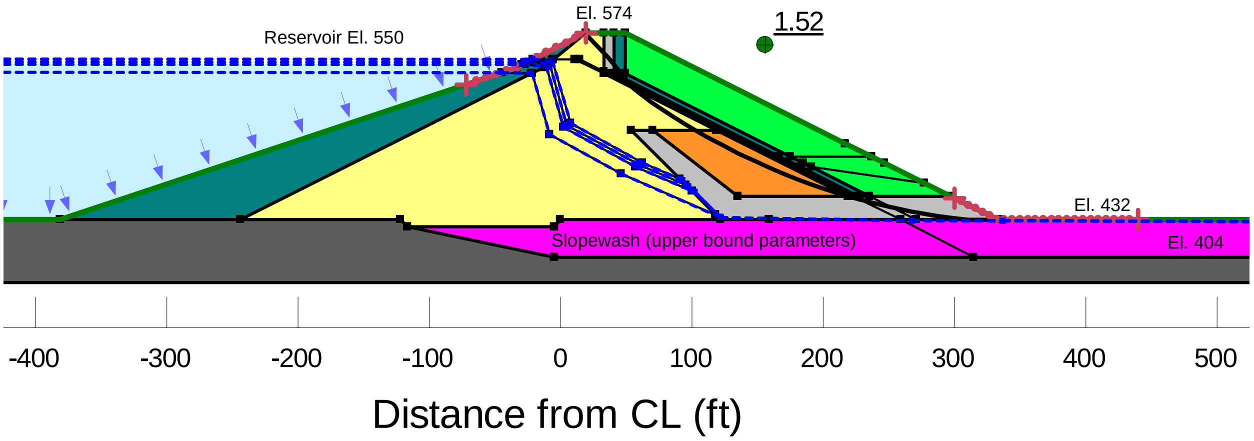
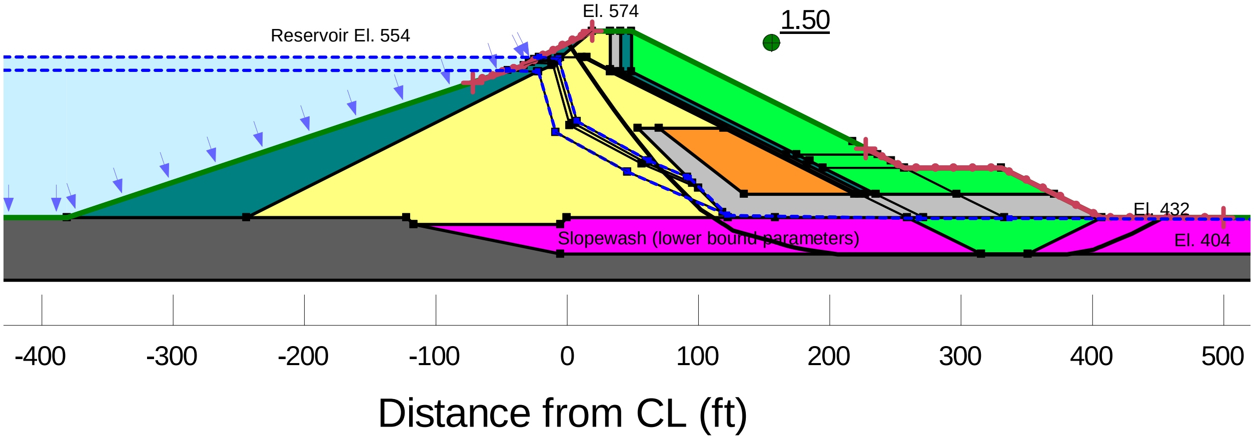
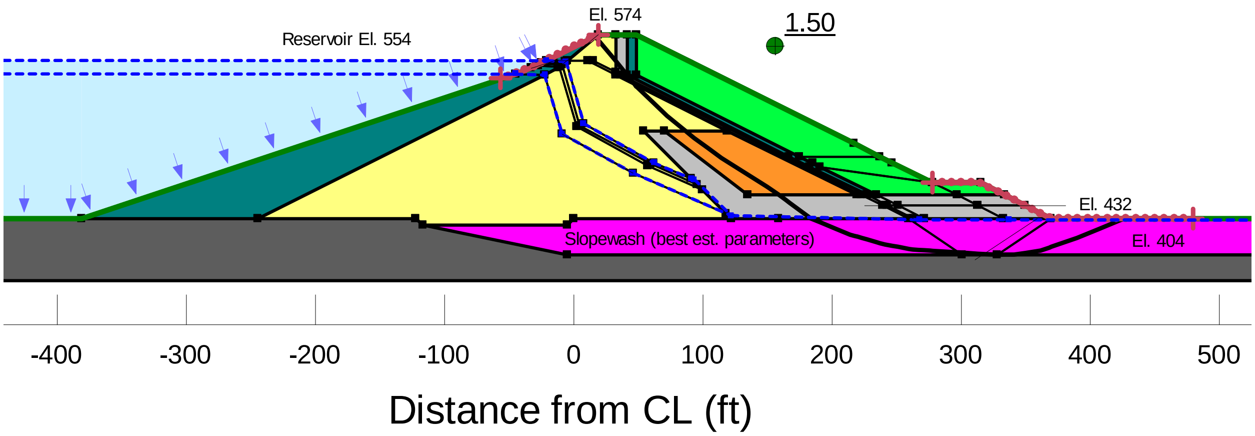


Figure B-1

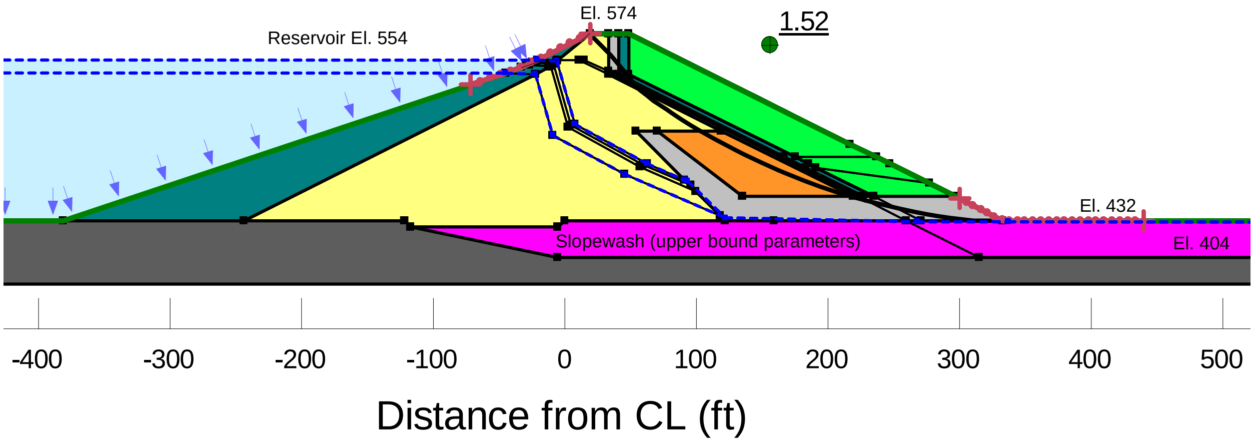
Station 37+00 with 10-ft RWS Raise
Drained Slopewash Strength Parameters



Sta 37+00
Modified embankment
RWS raise = 10 ft
Lower bound parameters for Slopewash



Sta 37+00
Modified embankment
RWS raise = 10 ft
Middle est. parameters for Slopewash



Sta 37+00
Modified embankment
RWS raise = 10 ft
Upper bound parameters for Slopewash

Figure B-2

Station 37+00 with 6-ft RWS Raise
Undrained Slopewash Strength Parameters

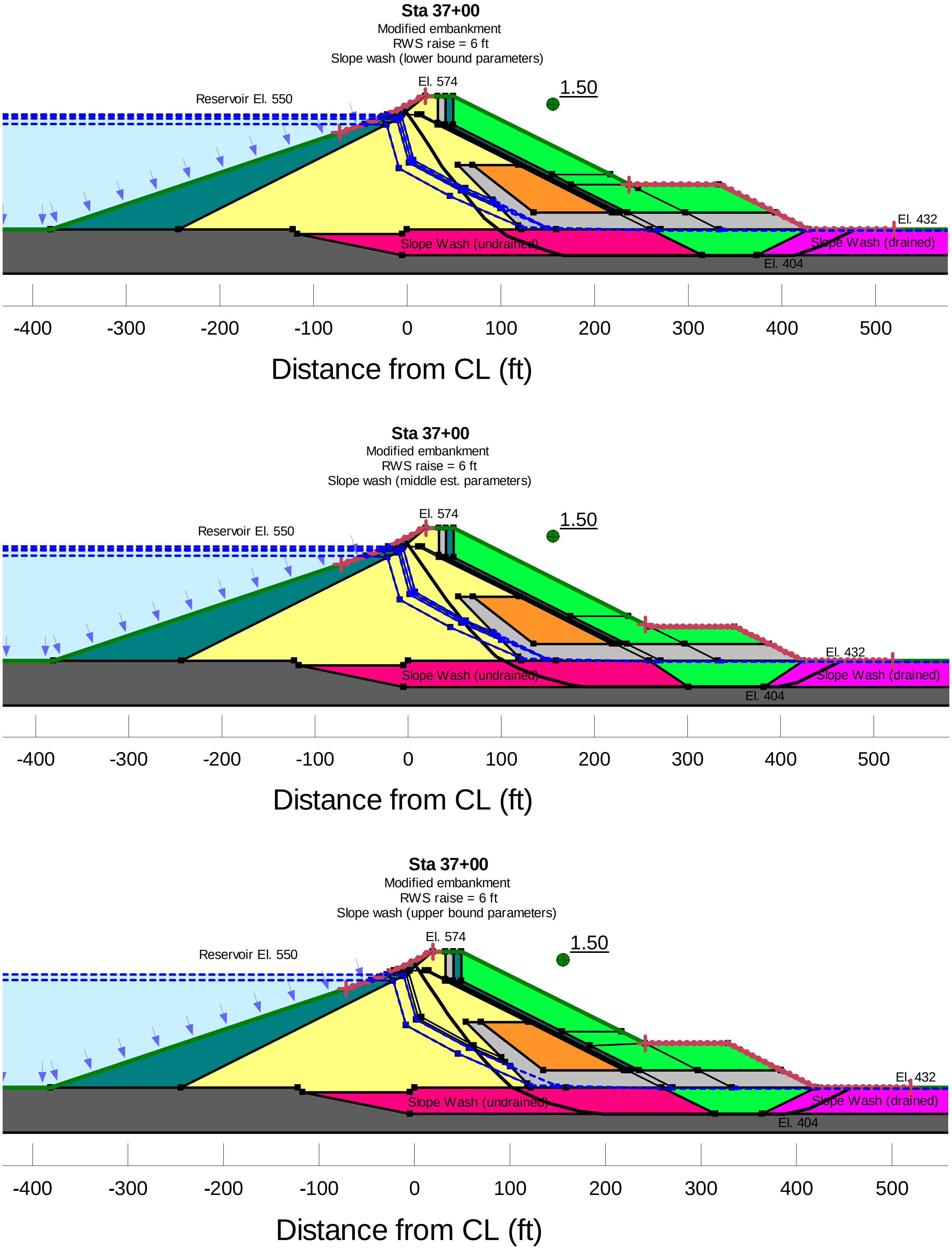
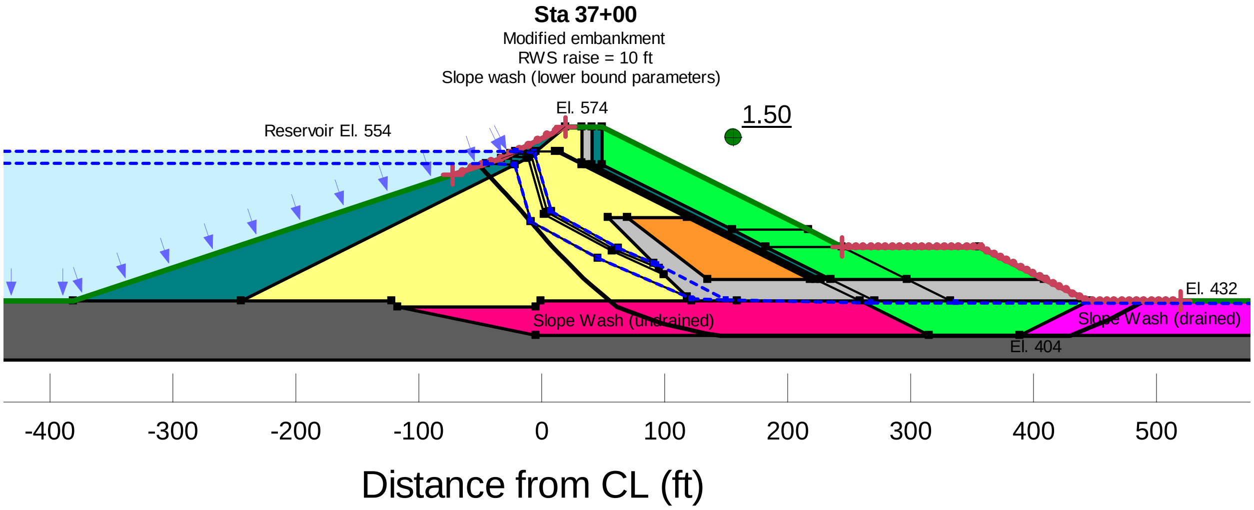
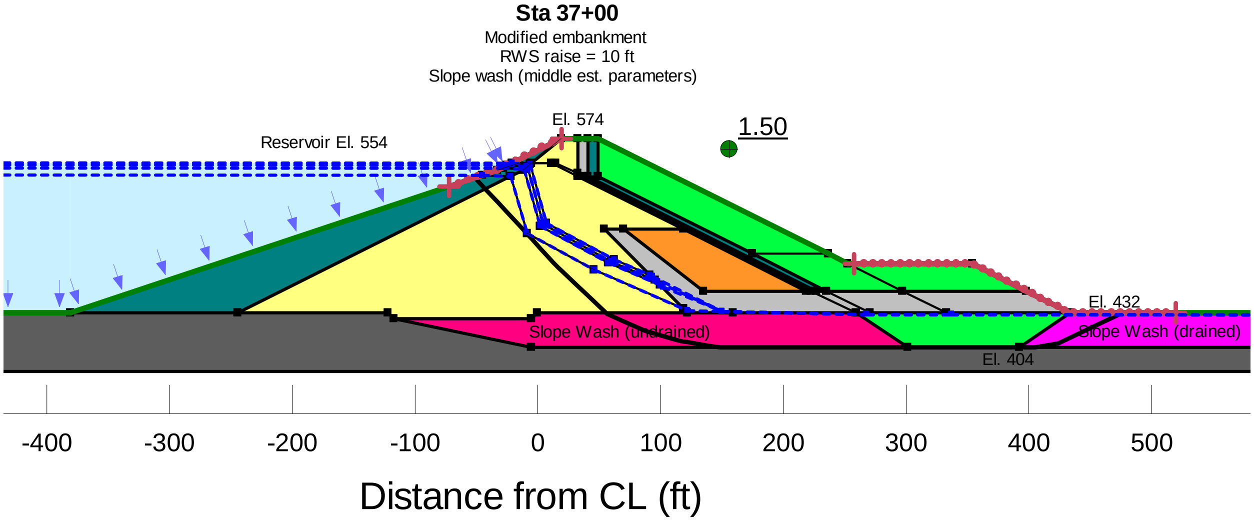


Figure B-3

Station 37+00 with 10-ft RWS Raise
Undrained Slopewash Strength Parameters


Sta 37+00
Modified embankment
RWS raise = 10 ft
Slope wash (lower bound parameters)


Sta 37+00
Modified embankment
RWS raise = 10 ft
Slope wash (middle est. parameters)

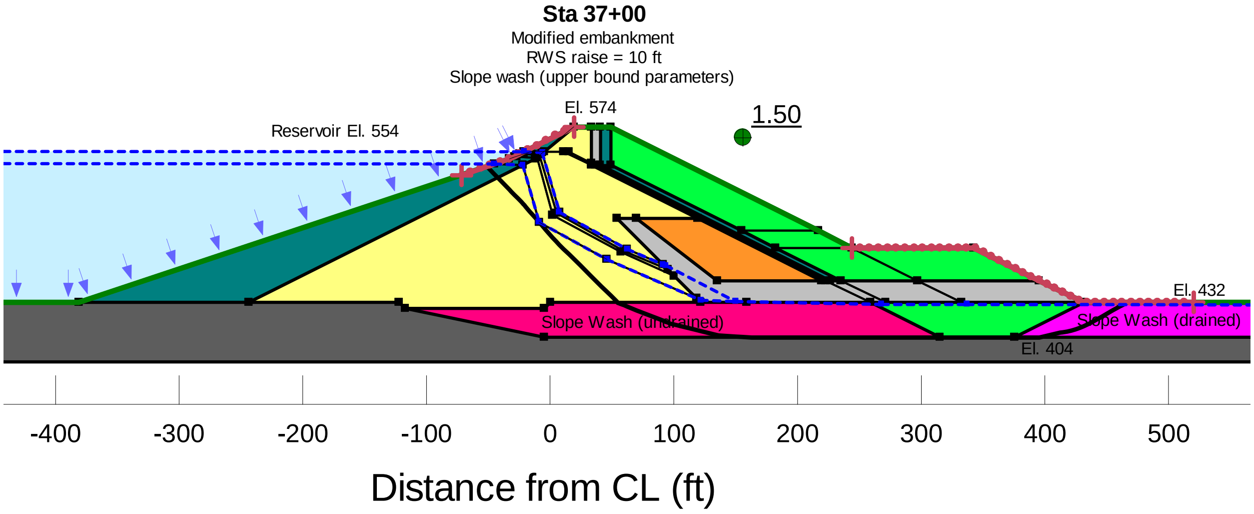
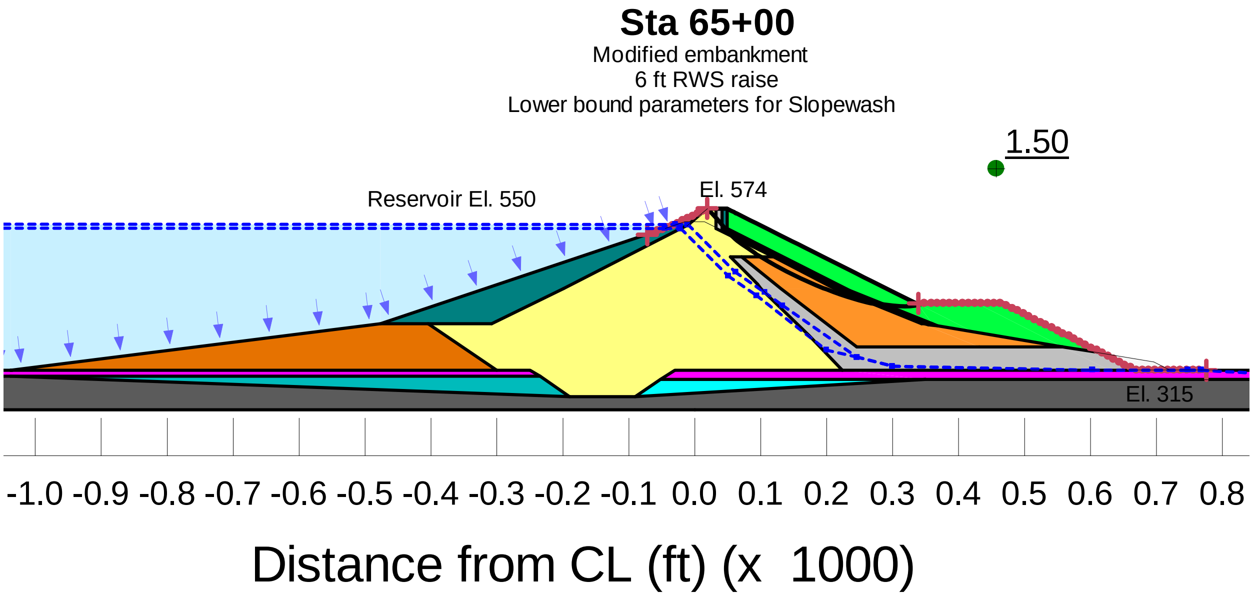
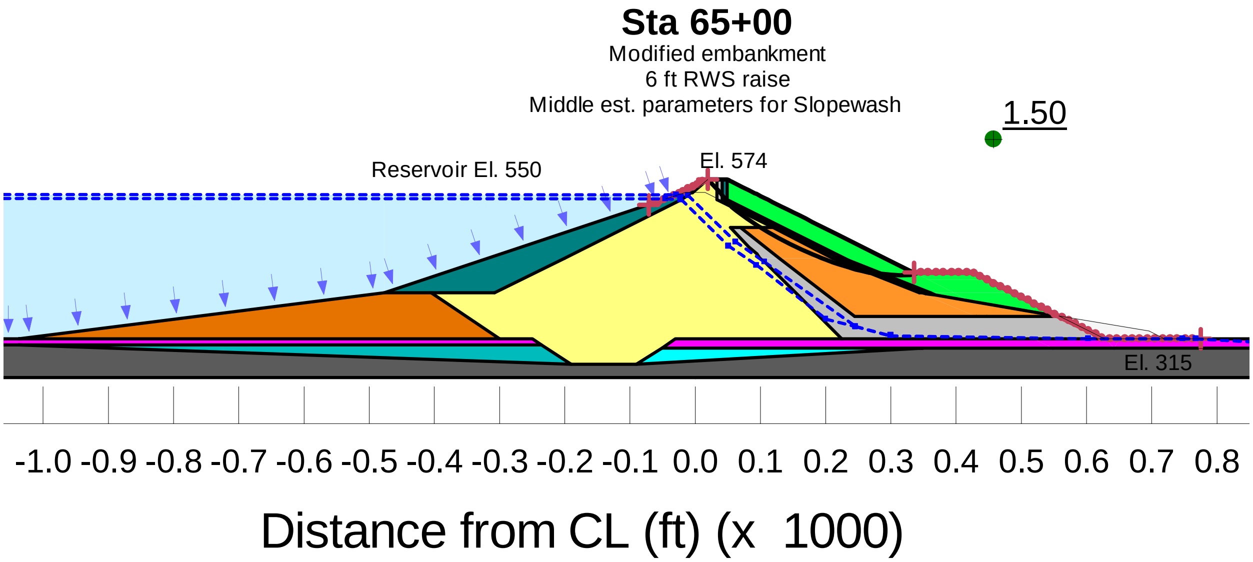

Sta 37+00
Modified embankment
RWS raise = 10 ft
Slope wash (upper bound parameters)

Figure B-4

Station 65+00 with 6-ft RWS Raise
Drained Slopewash Strength Parameters





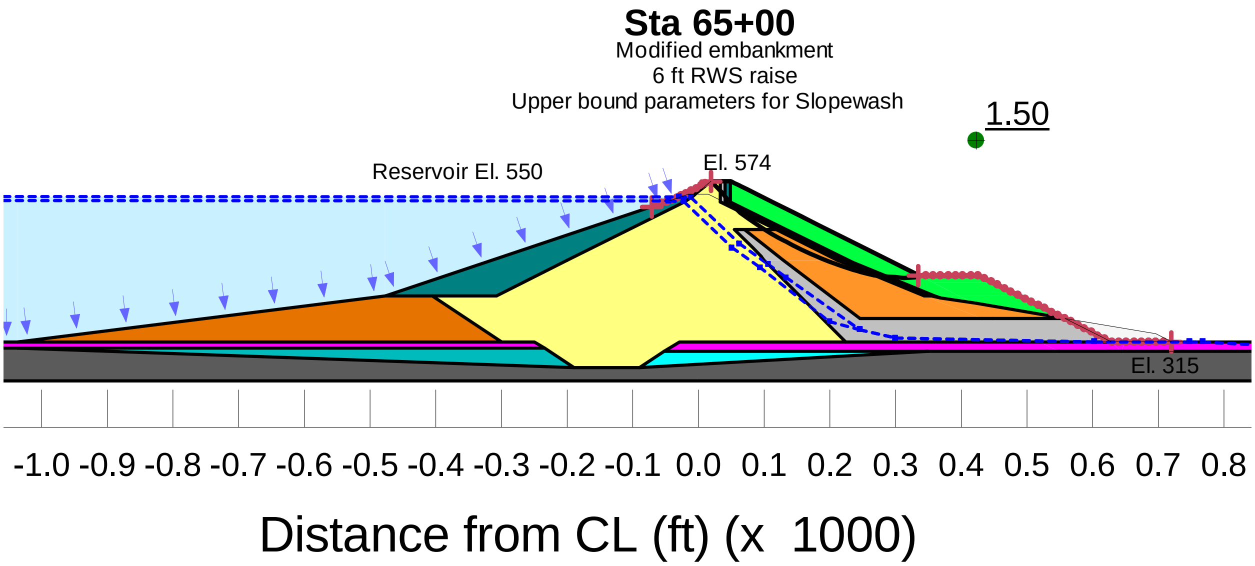
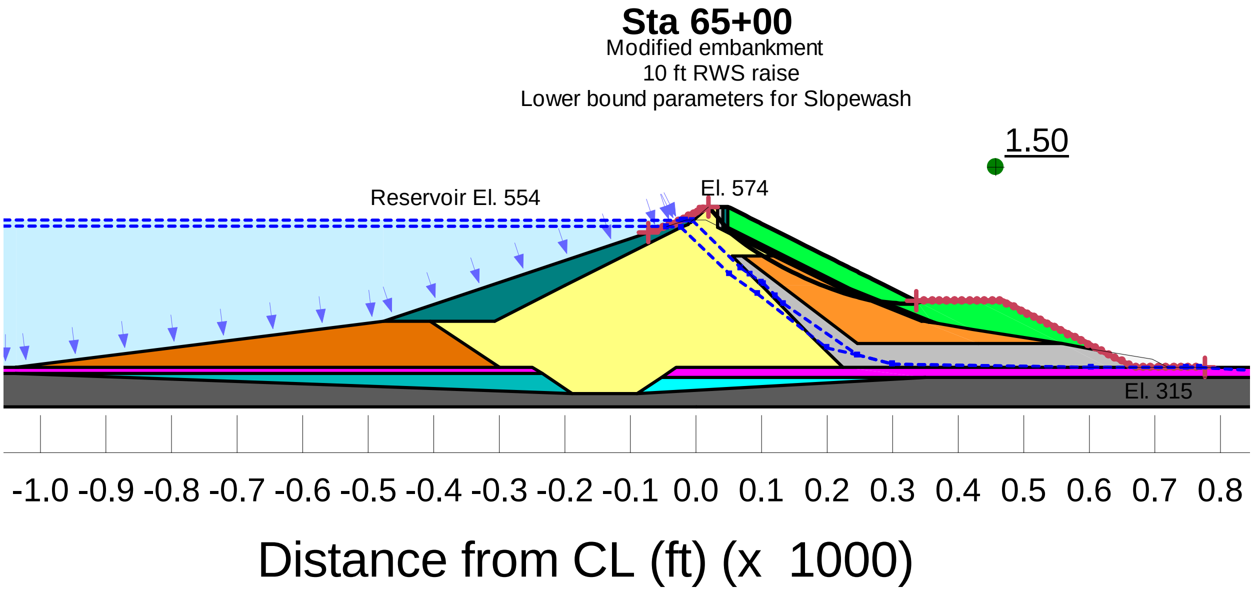
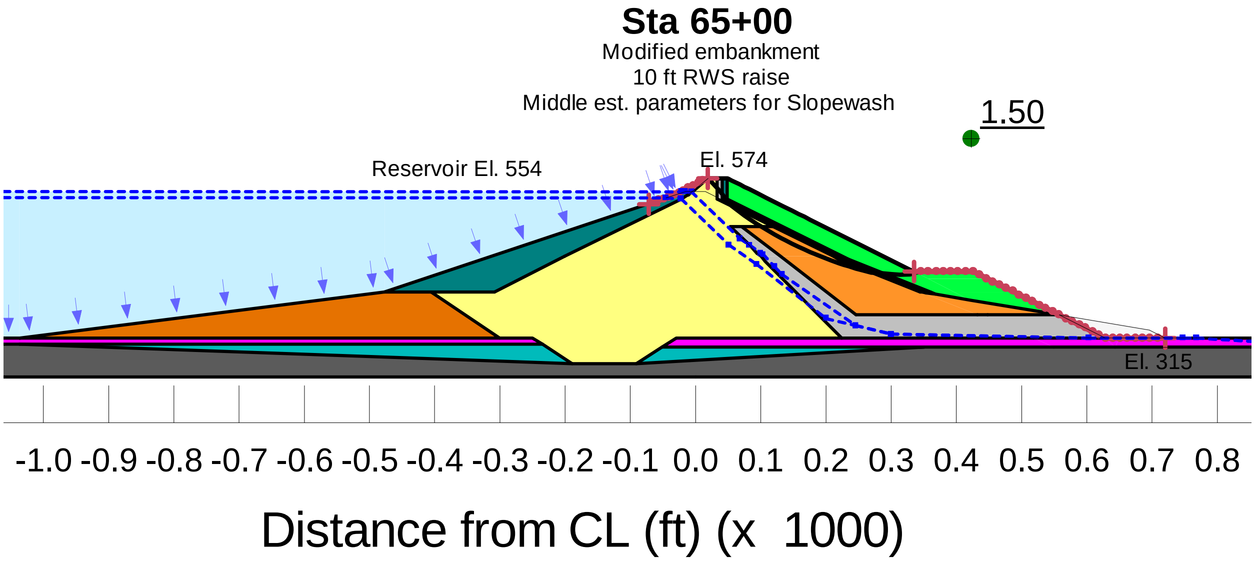


Figure B-5

Station 65+00 with 10-ft RWS Raise
Drained Slopewash Strength Parameters





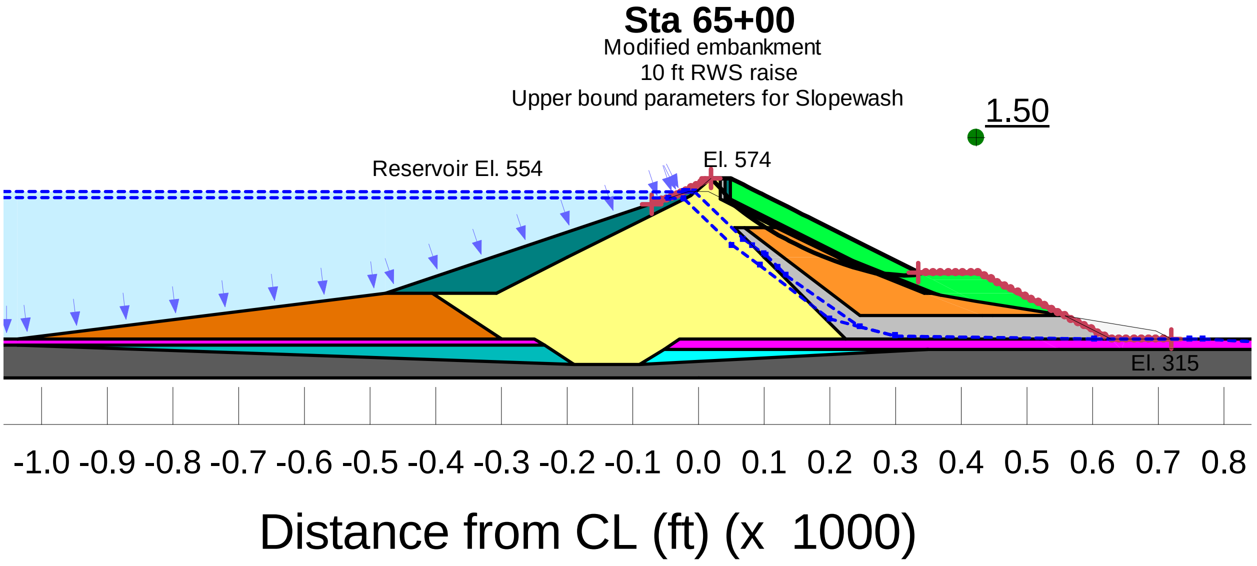
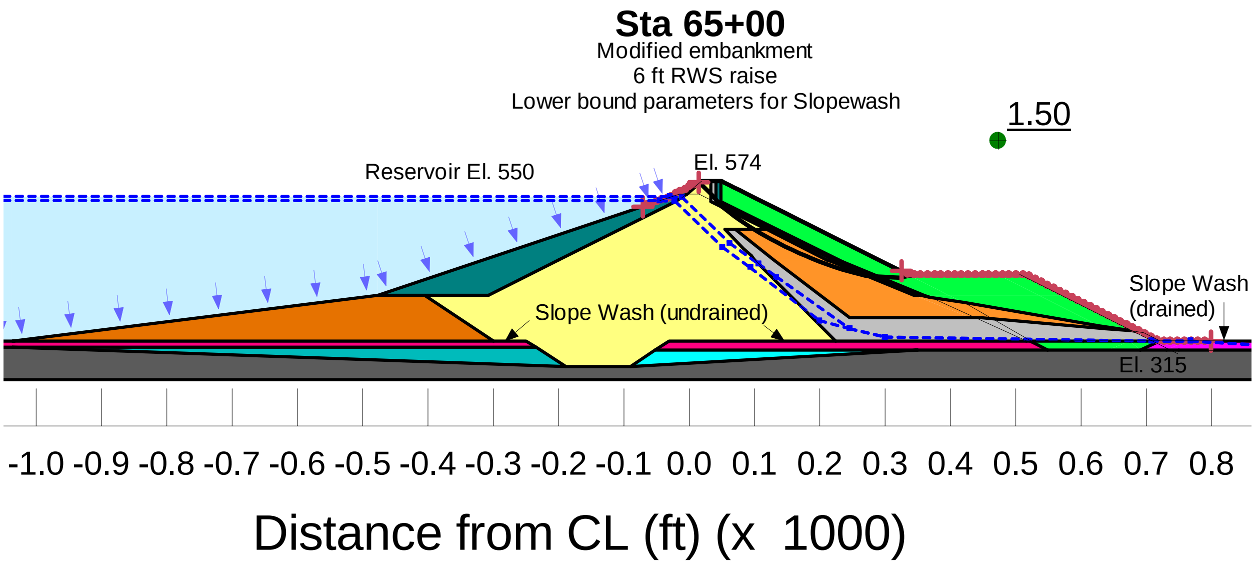
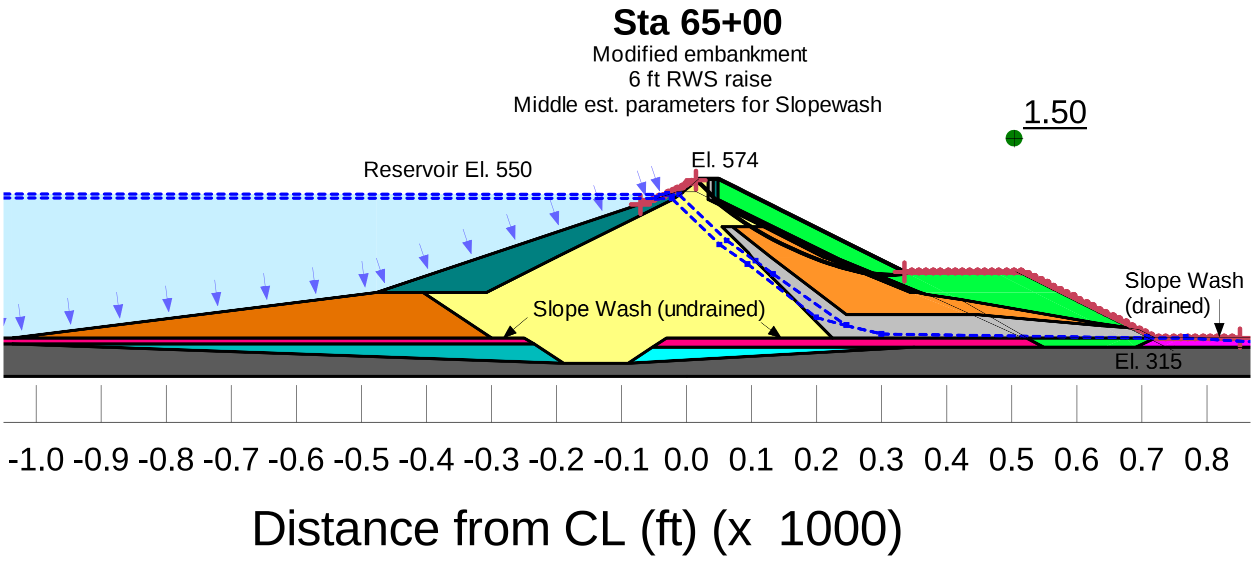


Figure B-6

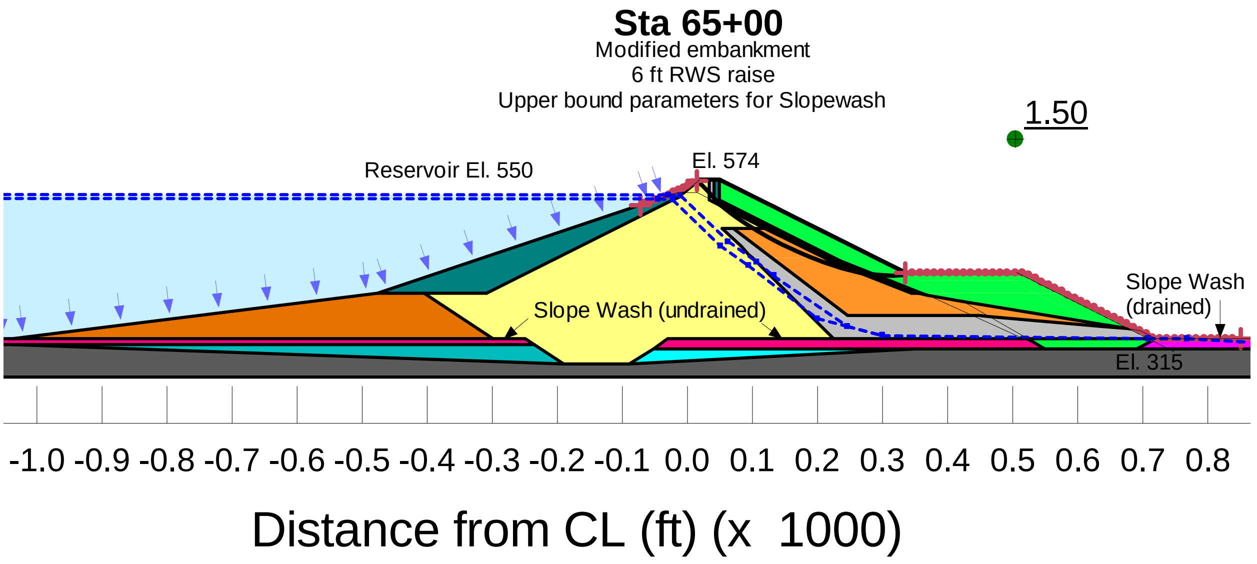
Station 65+00 with 6-ft RWS Raise
Undrained Slopewash Strength Parameters beneath Embankment



Sta 65+00
Modified embankment
6 ft RWS raise
Lower bound parameters for Slopewash



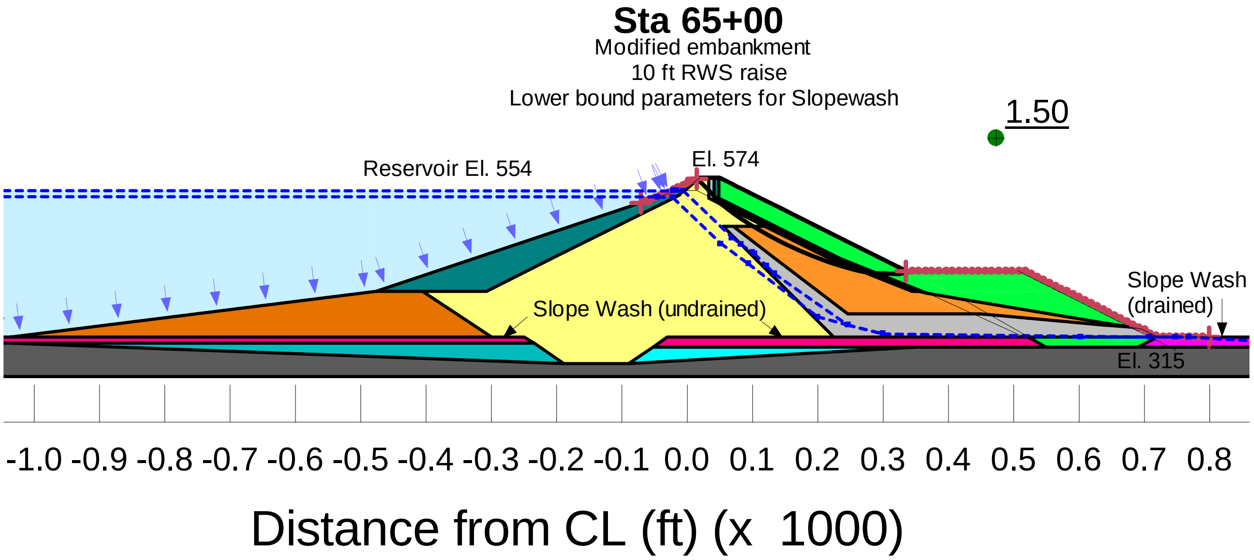
Sta 65+00
Modified embankment
6 ft RWS raise
Middle est. parameters for Slopewash

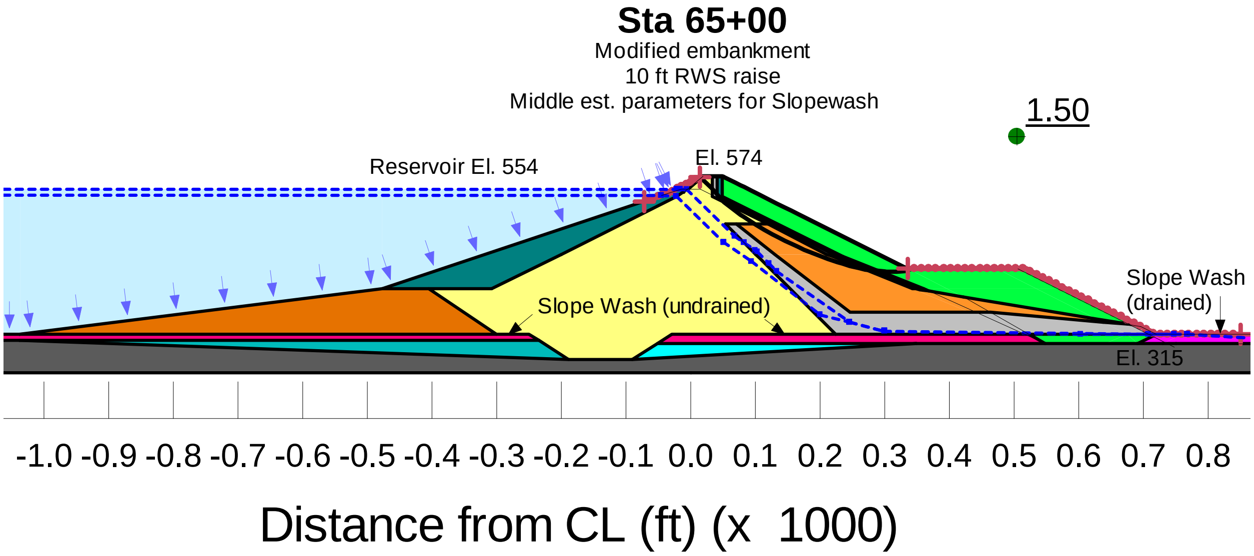


Sta 65+00
Modified embankment
6 ft RWS raise
Upper bound parameters for Slopewash

Figure B-7

Station 65+00 with 10-ft RWS Raise
Undrained Slopewash Strength Parameters beneath Embankment





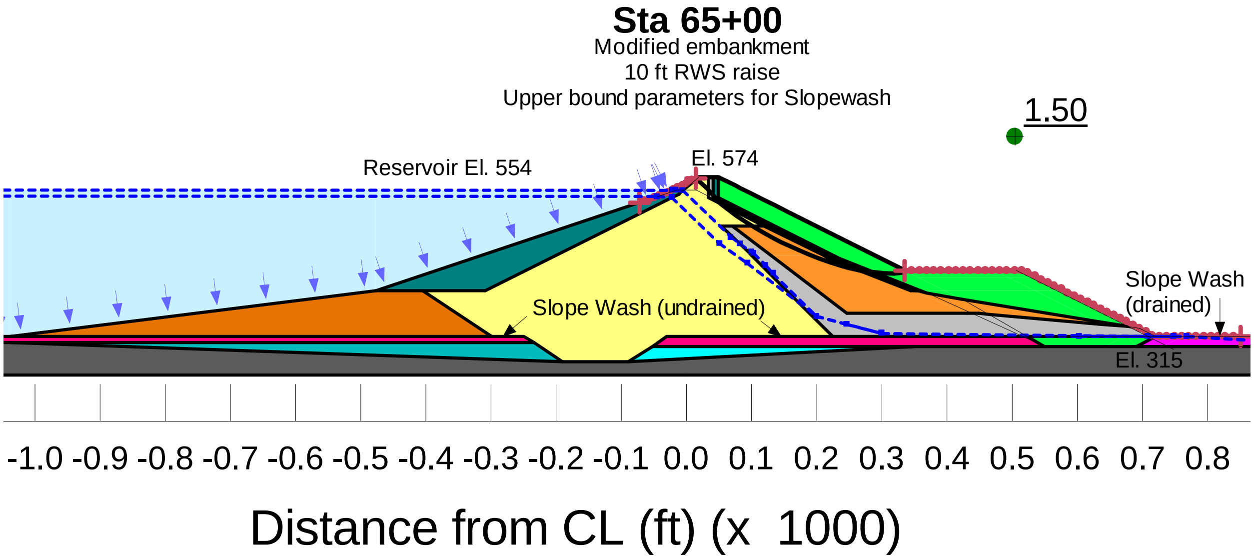
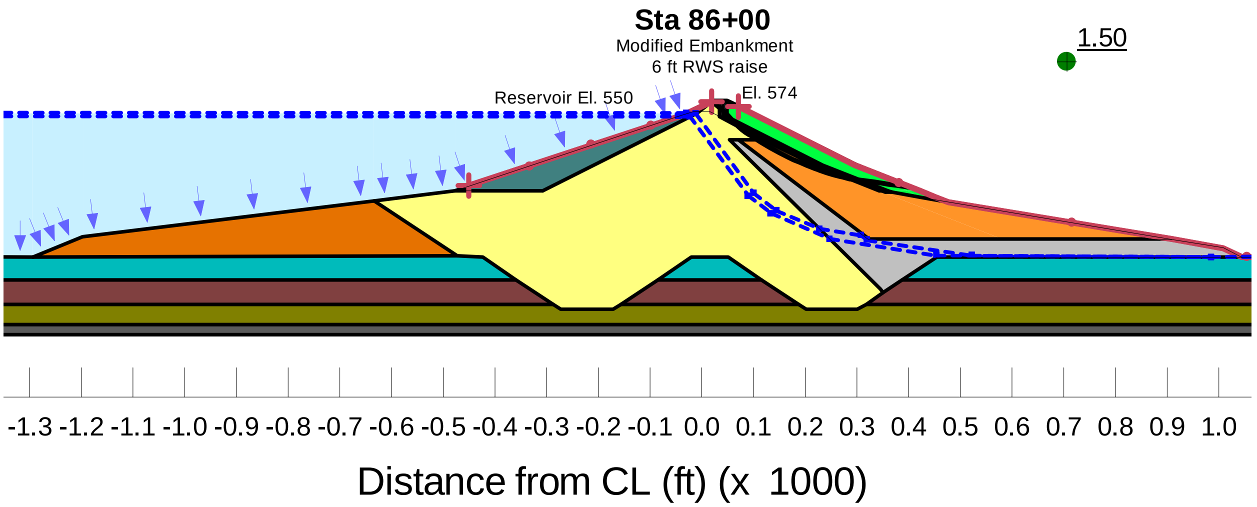


Figure B-8

Station 86+00 with 6- and 10-ft RWS Raises



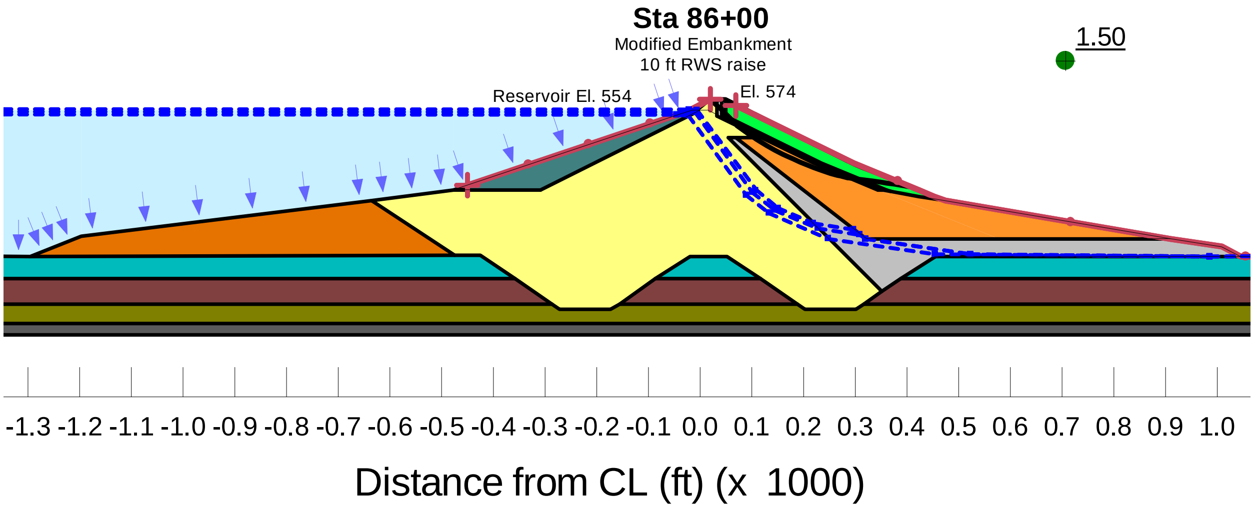
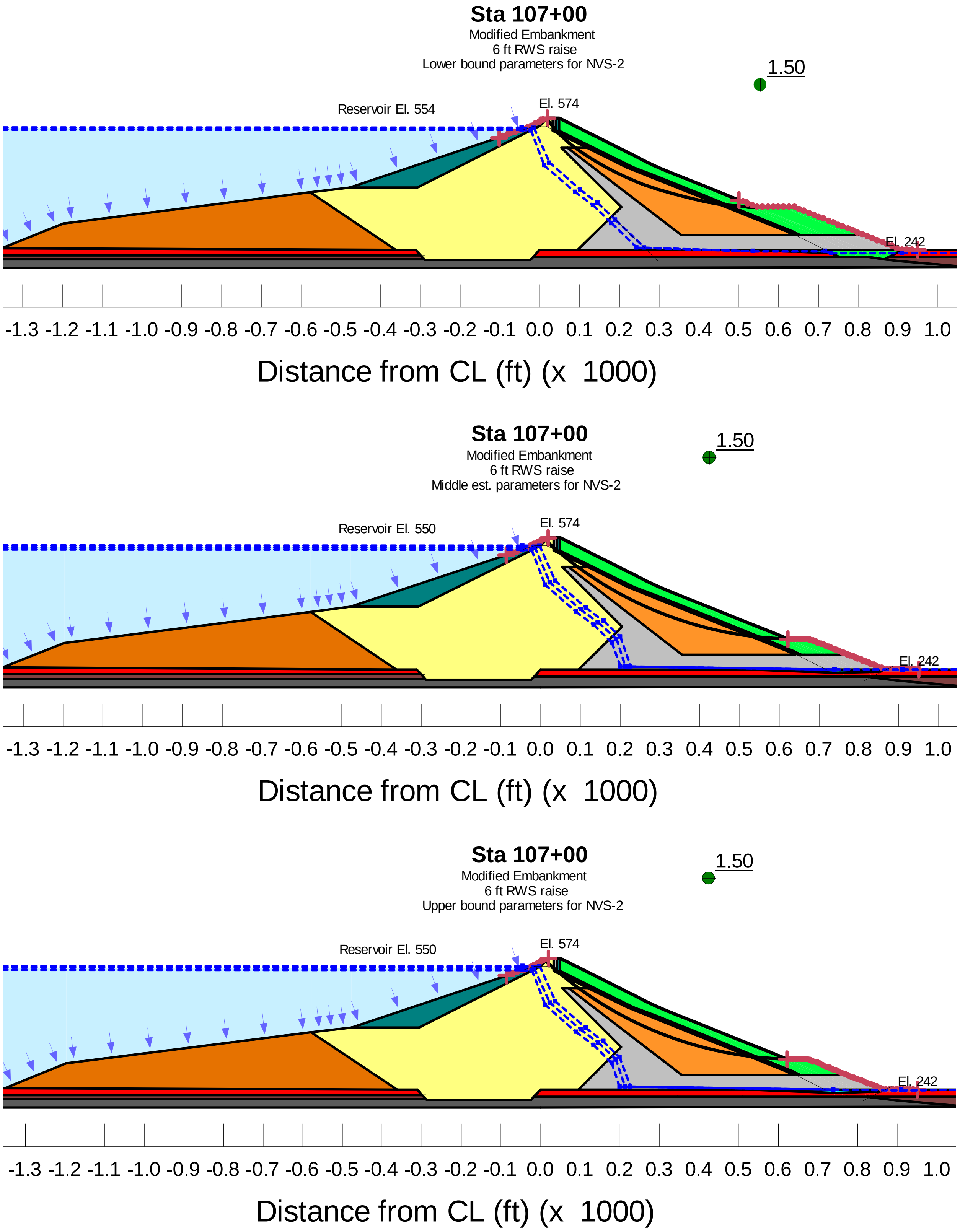


Figure B-9

Station 107+00 with 6-ft RWS Raise
Drained NVS-2 Strength Parameters



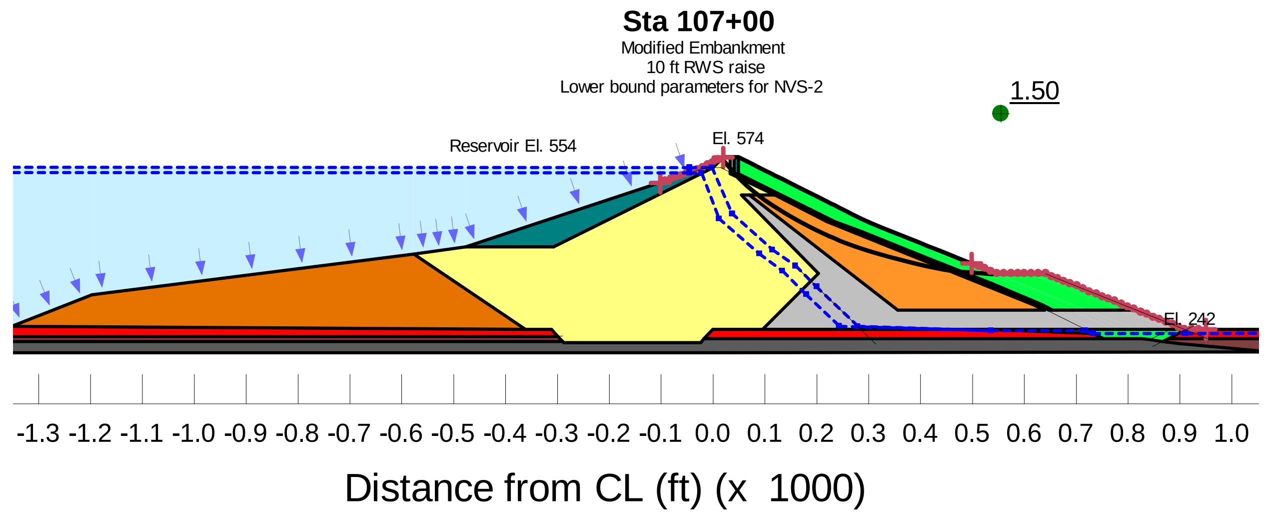
Sta 107+00
Modified Embankment
6 ft RWS raise
Lower bound parameters for NVS-2

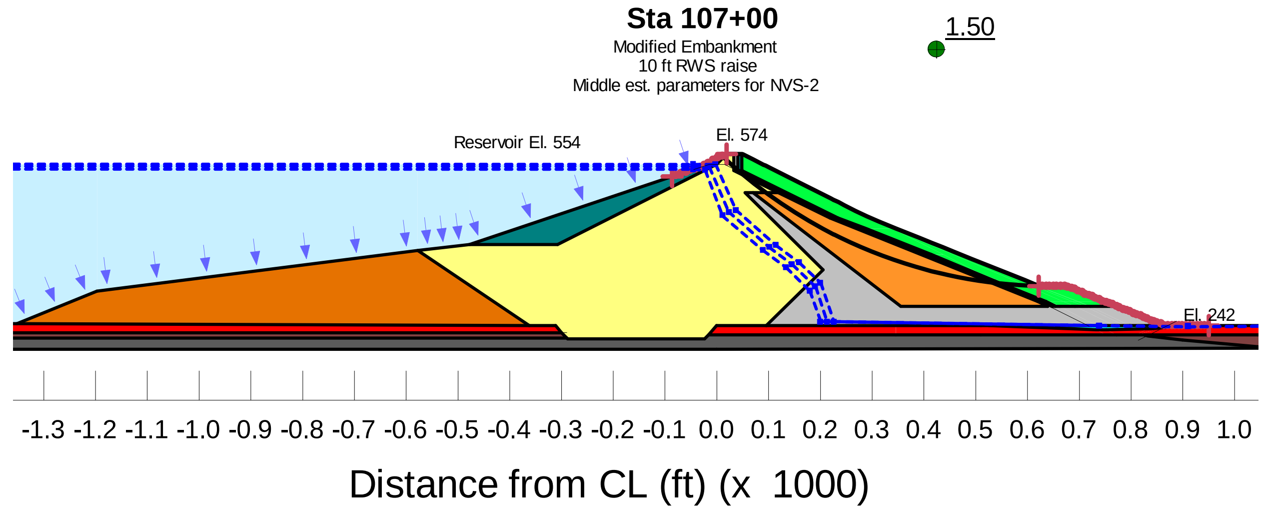
Sta 107+00
Modified Embankment
6 ft RWS raise
Middle est. parameters for NVS-2

Sta 107+00
Modified Embankment
6 ft RWS raise
Upper bound parameters for NVS-2

Figure B-10

Station 107+00 with 10-ft RWS Raise
Drained NVS-2 Strength Parameters





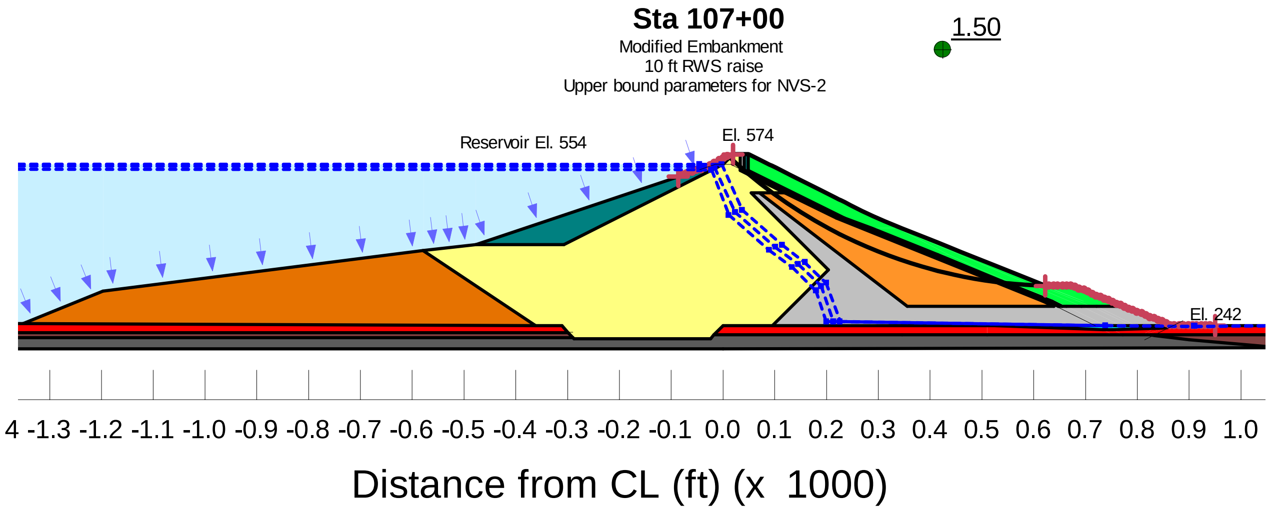
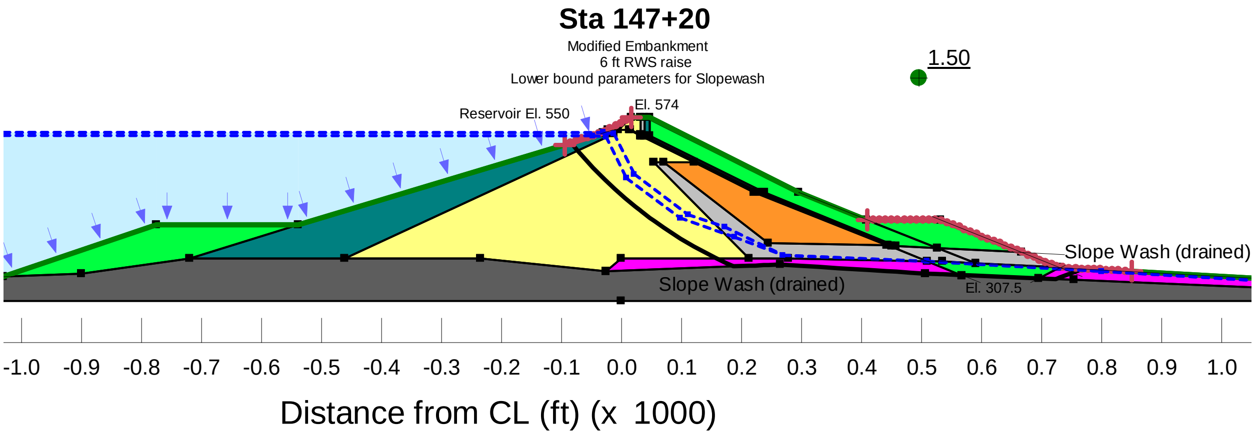
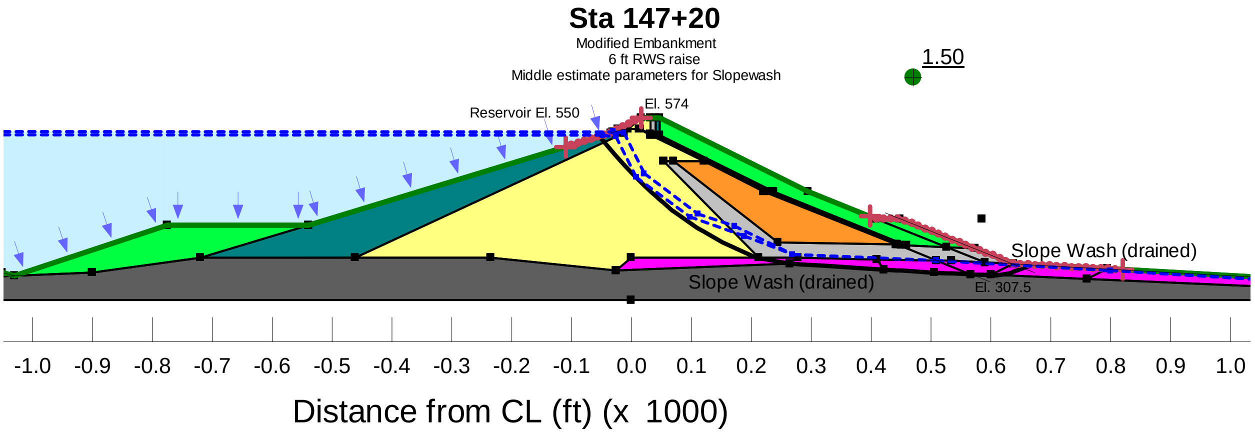


Figure B-11

Station 147+20 with 6-ft RWS Raise
Drained Slopewash Strength Parameters





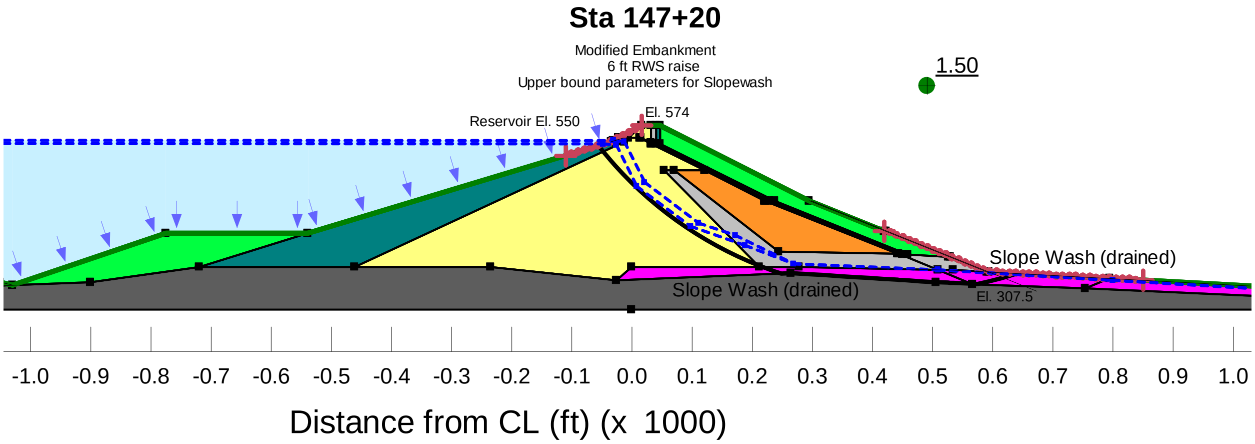
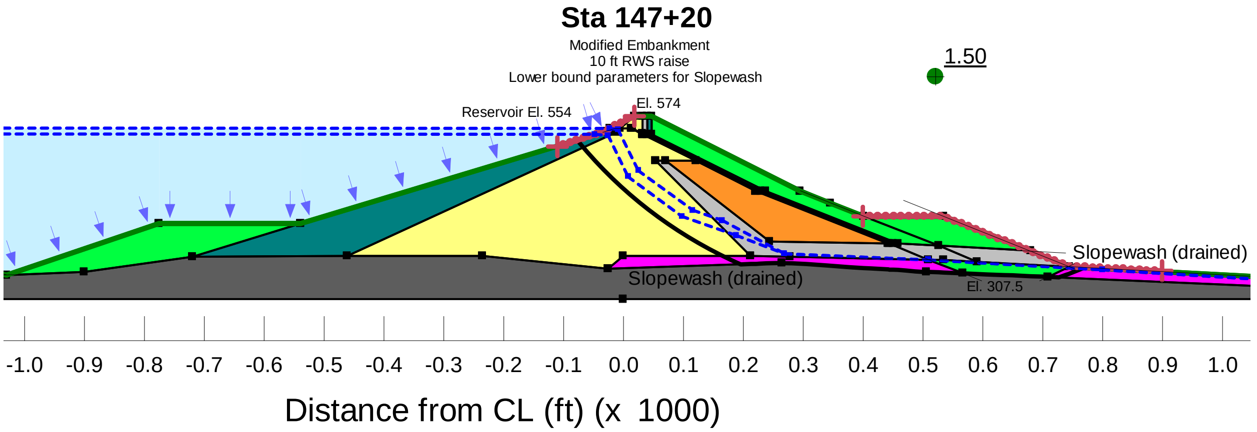
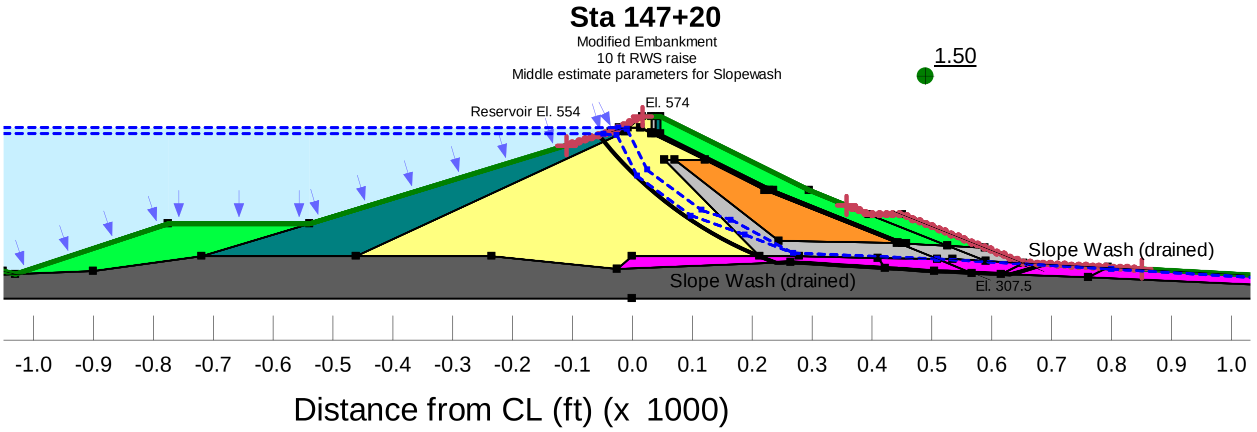


Figure B-12

Station 147+20 with 10-ft RWS Raise
Drained Slopewash Strength Parameters





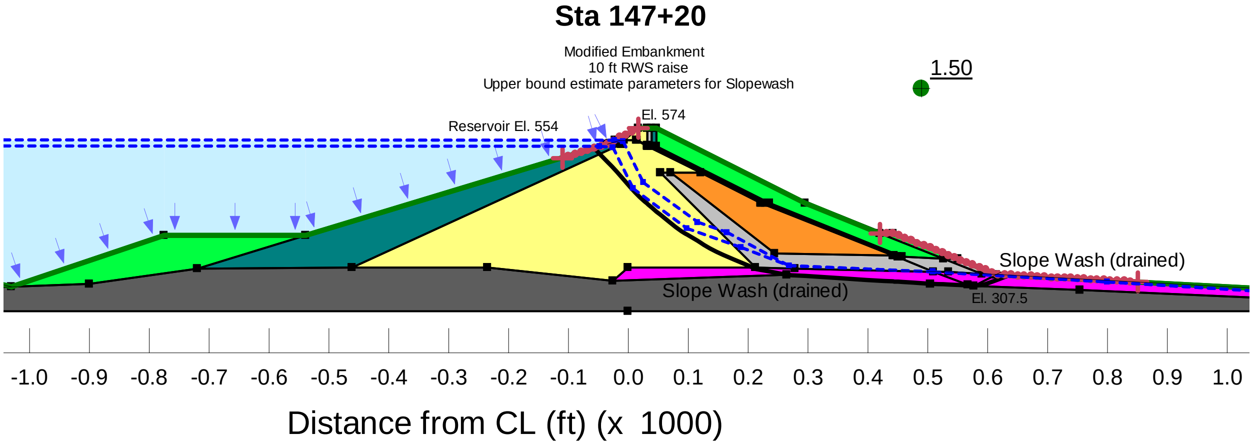
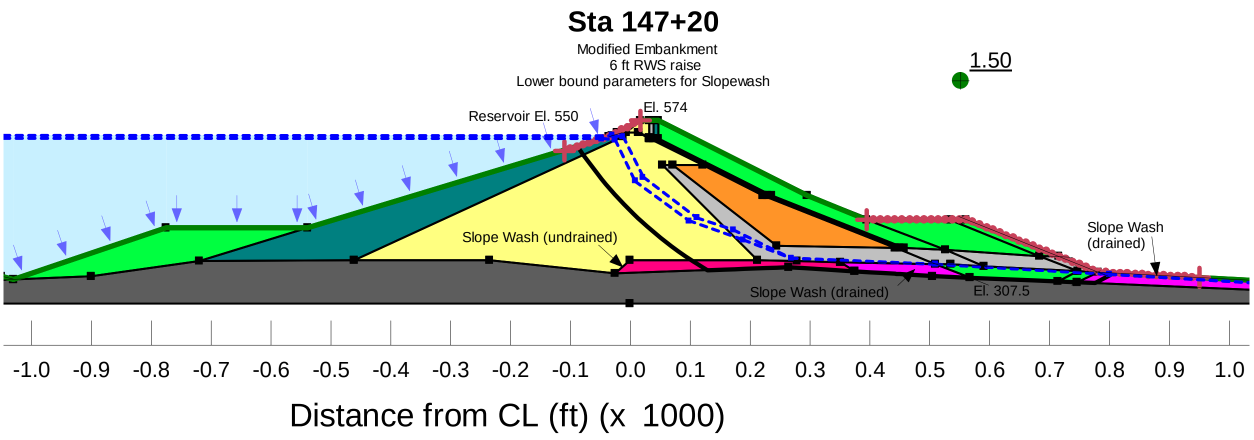
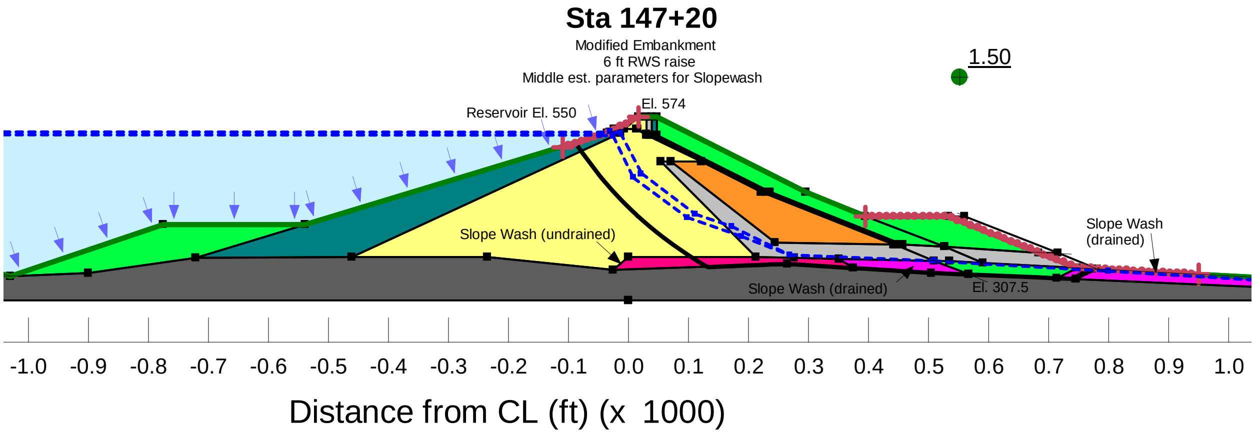


Figure B-13

Station 147+20 with 6-ft RWS Raise
Undrained Slopewash Strength Parameters beneath a Portion of the Embankment





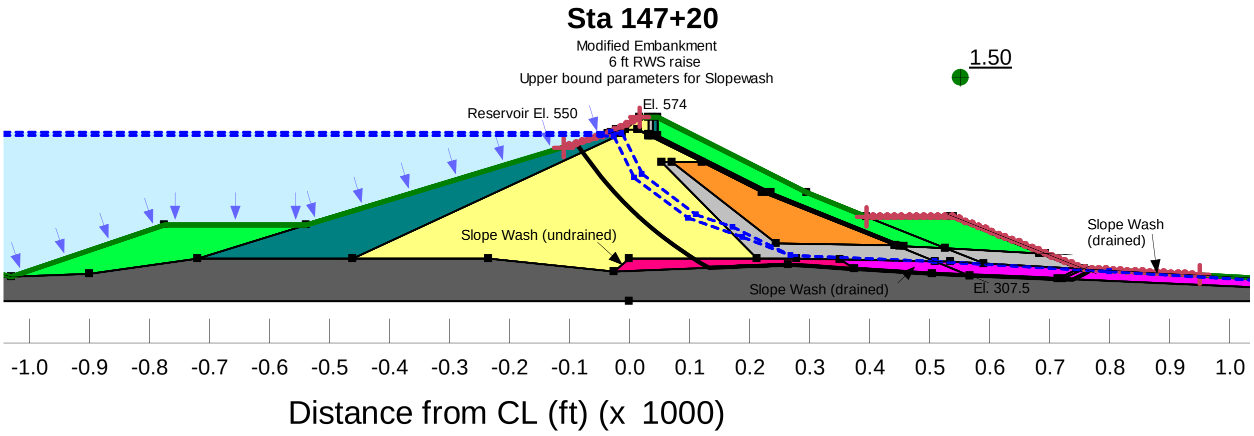
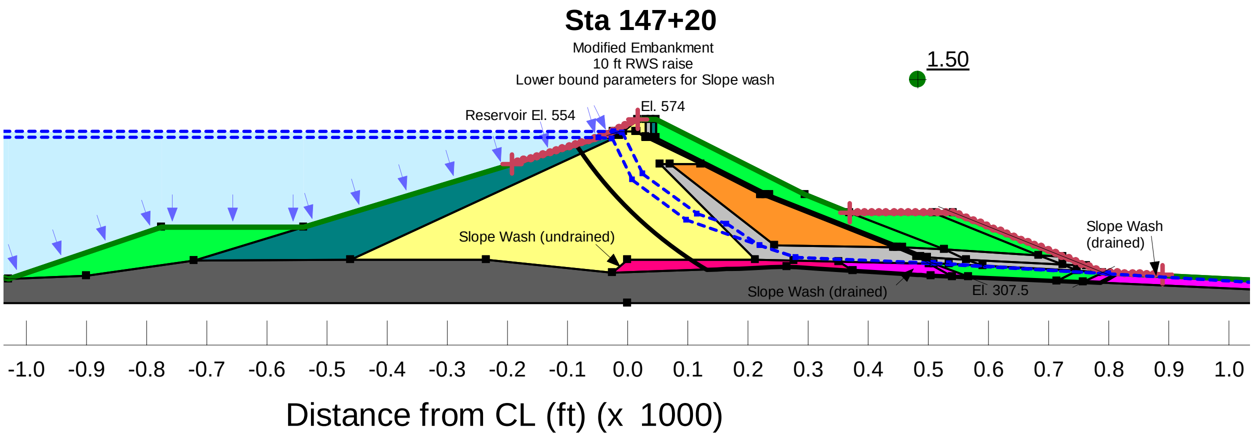
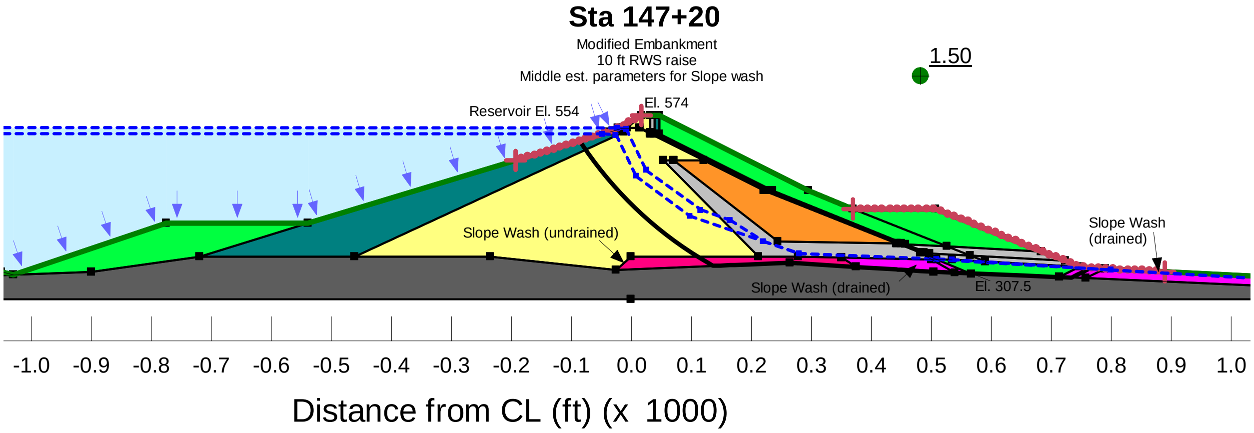


Figure B-14

Station 147+20 with 10-ft RWS Raise
Undrained Slopewash Strength Parameters beneath a Portion of the Embankment





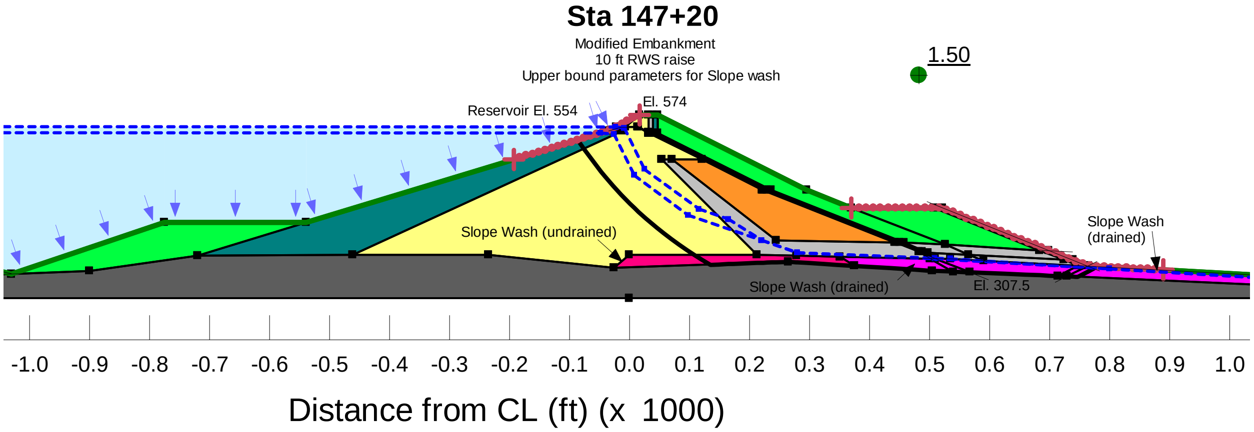
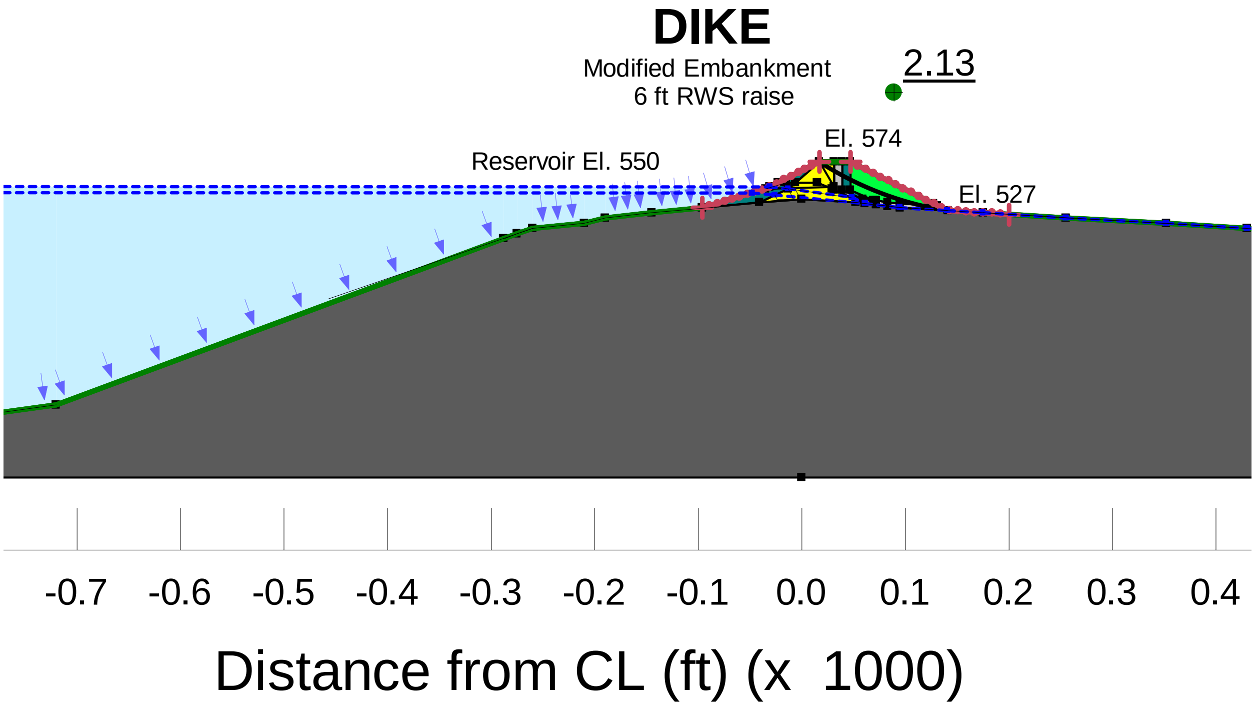


Figure B-15

Dike with 6- and 10-ft RWS Raises



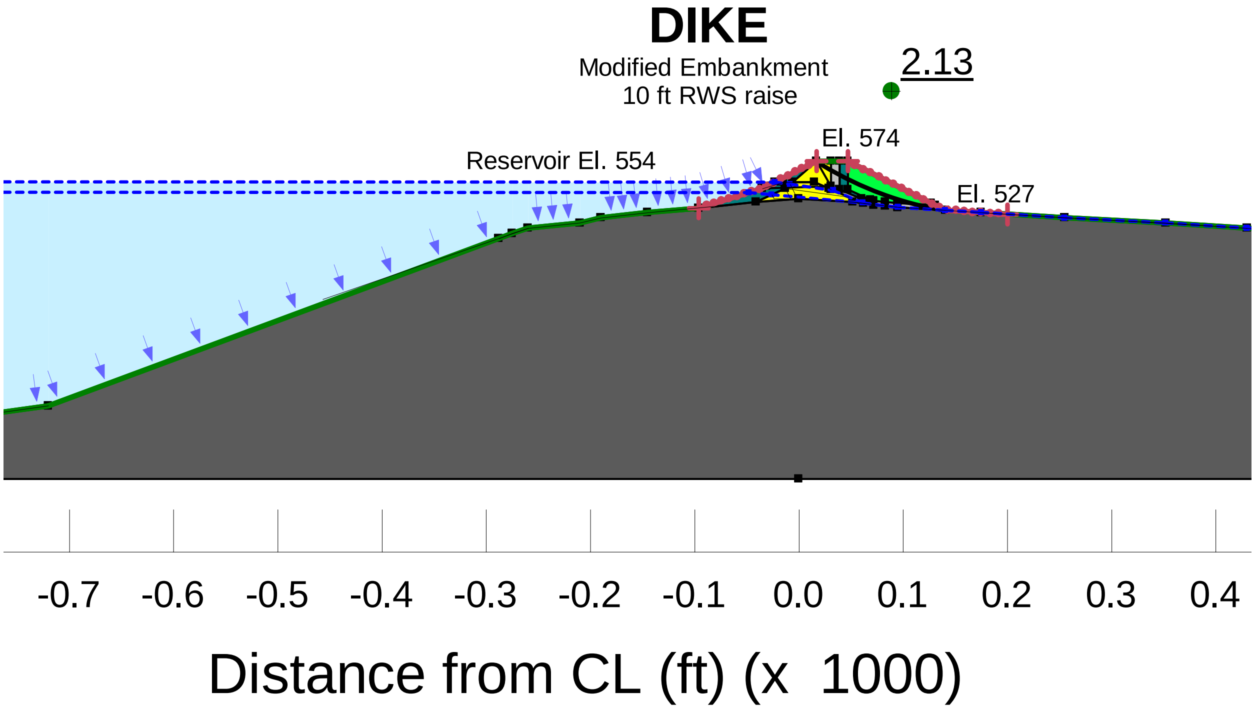


Figure B-16

Appendix D

TM BFS-8110-STY-2012-1

Analysis of Spillway, and Outlet Works Towers and Conduit, and Gianelli Pumping-Generating Plant

RECLAMATION

Managing Water in the West

Technical Memorandum No. BFS-8110-STY-2012-1

B.F. Sisk Dam Analysis of Spillway, and Outlet Works Towers and Conduit, and Gianelli Pumping –Generating Plant

Central Valley Project, California
Mid-Pacific Region

SENSATIVE – FOR OFFICIAL USE ONLY

U.S. Department of the Interior
Bureau of Reclamation
Technical Service Center
Denver, Colorado

December 2012

Mission Statements

The mission of the Department of the Interior is to protect and provide access to our Nation’s natural and cultural heritage and honor our trust responsibilities to Indian Tribes and our commitments to 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.

BUREAU OF RECLAMATION
Technical Service Center, Denver, Colorado
Structural Analysis Group, 86-68110

Technical Memorandum No. BFS-8110-STY-2012-1

B.F. Sisk Dam - Analysis of Spillway, and Outlet Works Towers and Conduit, and Gianelli Pumping – Generating Plant

B.F. Sisk Dam
Central Valley Project, California
Mid Pacific Region

Prepared: Michael A Shepherd
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Checked: Jason Schneider, P.E.
Civil Engineer, Waterways and Concrete Dams Group 86-68130

Jason Schneider P.E.
Technical Approval: Jason Schneider, P.E.
Civil Engineer, Waterways and Concrete Dams Group 86-68130

Walter Heyder P.E.
Peer Review: Walter Heyder P.E.
Civil Engineer, Waterways and Concrete Dams Group 86-68130

1/26/2013
Date

REVISIONS					
Date	Description	Prepared	Checked	Technical Approval	Peer Review

Table of Contents

I. Introduction

A. Purpose

The purpose of this Technical Memorandum (TM) is to summarize the appraisal level designs of a 10-foot raise of the outlet works intake towers and morning glory spillway at B.F. Sisk Dam to accommodate a maximum 10-foot raise of the reservoir water surface (RWS). This study is part of a larger dam raise study [1] to store additional water in the reservoir.

B. Description of Dam

The following was taken from the 2009 Comprehensive Facility Review (CFR) for B.F. Sisk [2].

B. F. Sisk Dam (formerly San Luis Dam) is located on San Luis Creek approximately 12 miles west of Los Banos, California. The dam was built from 1963 through 1967 to provide supplemental irrigation water storage for the Central Valley Project. Water is lifted into the reservoir for storage by the Gianelli Pumping-Generating Plant, and then water is released back through the pump-generating plant for irrigation use and to generate electricity. The San Luis Reservoir has a total capacity of 2,040,500 acre-feet and a surface area of 12,700 acres at elevation 544.0.

The dam is a zoned earthfill structure with a maximum structural height of 382 feet, hydraulic height of 303 feet, crest length of 18,600 feet, crest width of 30 feet, and crest elevation of 554.0 feet. The upstream face of the dam above elevation 400 is sloped at 3:1 H:V and 8:1 H:V below elevation 400. The downstream face of the dam at the maximum section is sloped at 2:1 H:V above elevation 450, 2.5:1 H:V from elevation 450 to elevation 400, 6:1 H:V from elevation 400 to 290, and 2:1 H:V from elevation 290 to the downstream toe. The dam embankment has seven zones with the central zone consisting of low plasticity clay. The downstream face of the dam is covered by a 2-foot-thick rock blanket and the upstream face is covered by a 3-foot-thick layer of riprap. There is a saddle dike located along the north rim of the reservoir approximately 1,300 feet from the dam.

The spillway is an uncontrolled morning-glory with a crest elevation at 543.84 feet, having settled slightly from its original elevation of 544.0 feet. The spillway consists of a 31-foot-diameter crest that transitions to a 9.5-foot-diameter shaft 22 feet below the crest, a 9.5-foot-diameter circular concrete elbow and a 350-foot long cut-and-cover conduit, an open rectangular chute for approximately 1000 feet, a concrete stilling basin structure, and a downstream discharge channel.

The spillway is located at the left end of the dam, which includes conduit through the dam embankment and the left abutment then an open chute, the full length excavated into bedrock. The capacity of the spillway is 875 ft^3/s at the design maximum RWS elevation 545.8.

The function of an outlet works is served by the intake and penstocks for the Gianelli pumping-generating plant located downstream of the embankment near the left abutment. The 284-foot-high trashracked intake structure is located upstream of the left abutment. It is equipped with four roller gates, each controlling one tunnel and measuring 17.5 feet wide by 22.89 feet high. There are also provisions for stoplogs for use when gate maintenance is required. The four 17.5-foot diameter penstock tunnels were excavated through bedrock. They are concrete-lined for approximately the first half their length, and have a steel plate liner in addition to the concrete in the downstream half. At the powerplant, each penstock bifurcates into two, each of which has a butterfly valve, then a pumping generating turbine. Control of the system is normally provided by the butterfly valves, and the roller gates are considered emergency gates. The outlet works discharge capacity is approximately 16,000 ft^3/s with the RWS at elevation 544.0. The discharge capacity of the outlet works allows the reservoir to be lowered at about 2.6 feet per day in the upper part of the storage. The drawdown rate is currently restricted to 2 feet per day for any large changes because of the concern about slope instability.

The outlet works tunnel is through bedrock, well below the dam embankment. There are no identified failure modes involving the outlet works. Concern has been raised about the seismic stability of the intake towers; however, failure of the intake towers is not considered a dam-safety issue because their failure would not result in a breach of the dam which would cause a catastrophic release of water.

II. Static Evaluation

A. Considerations

From a static load case scenario both the existing intake towers and the spillway could likely accommodate a 10 foot raise. Because of the age of the structure, changes in the state-of-the-art design practices, and changes to the applicable loading cases for the structures, if the structures were modified in the future, all applicable load conditions would need to be evaluated to ensure the modifications would meet the most recent design code requirements.

No structural analysis has been performed for the outlet works conduits or the spillway tunnel (statically or seismically). The additional fill for the embankment raise modification should not affect the structural stability of the outlet works conduits. The outlet works conduits were tunneled through bedrock, well below the dam embankment. Furthermore there have been no identified failure modes involving the outlet works conduits. The additional fill above the spillway tunnel will increase the vertical load on the conduit which could increase the stresses; however, at the same time the horizontal “confining” loads on the conduit will also increase which typically increase thrust within the conduit which resists increased tensile moments. Also, the spillway tunnel should have some level of reserve strength under increased static load conditions as it was designed with consideration of a 0.1g PHA. No significant cracking or damage has been reported within the outlet works or spillway conduits.

B. Outlet Works Intake Tower Modification

To accommodate the 10 foot raise of the intake towers, demolition of approximately the top 16.25 feet from elevation 554.0 to elevation 537.75 of the existing towers is considered necessary. While this represents a considerable amount of demolition, the top of the intake towers consist of several large projecting corbels which work in unison with large structural steel plate girders to support the gantry crane used to lift the intake gates. It was concluded that construction efforts would benefit from the demolition and removal of the corbels. Thus allowing a uniform geometry to begin construction of the 10-foot-high wall extension and re-construction of the intake towers operating platforms. The proposed demolition would render the bridge between the towers unusable. Figure 1 illustrates the approximate limits of the demolition required for the static raise.

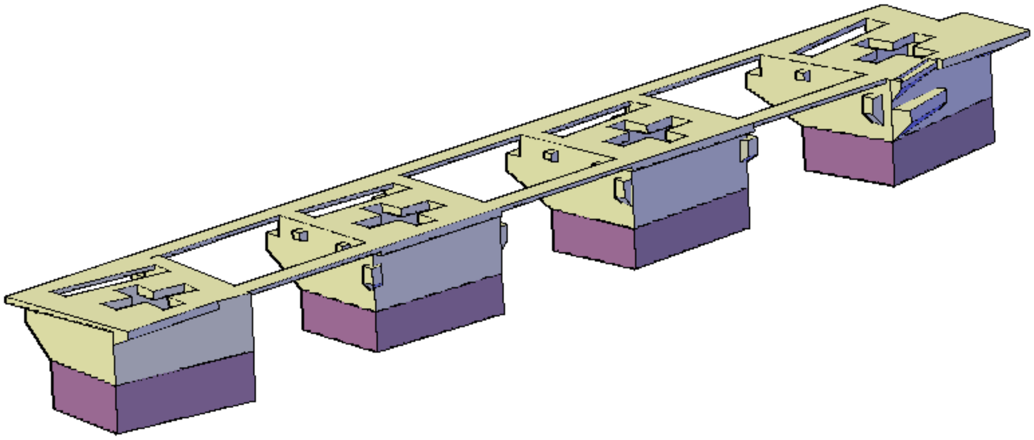

Figure 1. Approximate limits of concrete demolition (shown as tan) of the intake towers, (bridge, equipment, and structural steel not shown for clarity) purple section and below of towers to remain

Prior to demolition of the top of the intake towers, removal of all existing equipment including the gantry crane would need to occur. During this time, the ability to control the gates would be limited. If the static raise is adopted further study would be required to determine if construction sequencing would allow some towers to remain operational while other towers undergo demolition and re-construction. It should be noted, that due to the location of the intake towers within the reservoir, the limited access, and the desire to maintain water storage during construction, it was assumed a barge would be used for demolition and construction of the intake towers.

After the demolition is complete, the intake tower 10-foot wall extension would entail drilling into the existing structure's walls and grouting anchor bars in place. Reinforcement would be placed to match the existing reinforcement patterns for the walls at the demolition elevation of 537.75 feet. The wall extensions would then be formed and cast-in-place. The intake tower operating platform with support corbels would then be all reconstructed as originally designed ultimately placing the operating platform decks at elevation 564.0.

C. Outlet Works Conduit

The outlet works conduit is founded in bedrock and buried far below the embankment dam. The additional head from a ten foot RWS elevation raise and the additional soil load from the twenty foot dam raise would have a negligible impact on the integrity of the conduit.

D. Morning Glory Spillway Modification

Modifying the morning glory spillway would proceed in a similar method to that identified for the outlet works intake towers. For the spillway, demolition of approximately the top 22 feet (elevation 543.84 to elevation 522.0) is considered necessary to reach a geometrically uniform and structurally superior location for the 10 foot extension. Excavation of the upstream face of the embankment to facilitate the demolition of the spillway crest was assumed at a 2H:1V slope radially out from the spillway. The excavation boundaries would extend nearly to the existing dam crest. Because the dam crest would be undergoing modification for the dam raise as well, alternative access to the spillway during construction would have to be developed.

After the 10 foot extension and reconstruction of the morning glory spillway crest is complete, the spillway crest will be at elevation 554.0. The excavated embankment would be replaced around the modified structure and the embankment would be shaped as needed to accommodate the modifications to the embankment dam.

Because the San Luis Reservoir is an off stream reservoir, it was assumed that the spillway can be taken out of operation and the RWS elevation could be lowered to accommodate the required excavation and demolition, while at the same time lowered to an acceptable level to adequately contain any potential rainfall events that could occur during construction without impacting construction operations.

Under normal operating conditions the San Luis Reservoir tends to fill to capacity in the fall and winter and water is released in the spring and summer for irrigation. During periods of low pool, the spillway could be demolished and then rebuilt. Figure 2 shows the approximate boundaries of demolition for the spillway.

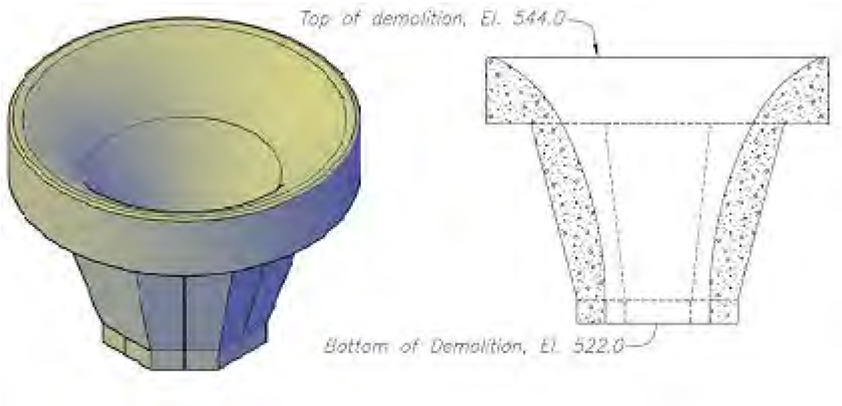

Figure 2 - Approximate limits of spillway demolition.

It should be noted that lengthening the vertical conduit section beneath the crest could change the water depths at which the crest would change from crest to throat control during operation. If this raise is pursued, the hydraulics of this modification should be evaluated and changes to the crest configuration pursued as needed.

E. Gianelli Pumping Generating Plant

Based on the appraisal level study, the 10-foot increase in the RWS elevation did not change the hydraulics of the existing penstocks. Also, the 20-foot embankment raise did not add additional loading to the Gianelli Pumping Generating Plant. Therefore, for this study, modifications to the pumping-generating plant's capacity and its associated switchyard will not be required.

III. Seismic Evaluation

While the spillway and outlet works intake towers could accommodate a raise under static loading conditions, the intake towers in particular would tend to be vulnerable during a seismic event. It should be noted that with changes in the understanding of seismic hazards since original design and construction these structures may presently be vulnerable during seismic events.

A. Outlet Works Intake Towers

The survivability of the intake towers during a seismic event is dependent on a large number of variables which include:

- The magnitude of the horizontal ground motions from the seismic event.
- The frequency of the ground motions; the structure has a fundamental period of over 1 second, higher frequency seismic events would be less damaging than seismic events with frequencies that are close to the towers fundamental period.
- The water level at the time of the event; in general the higher the water level the worse the load placed on the towers would be.
- The additional effects of the surrounding towers and submerged embankment that surrounds all four towers on three sides.

The intake towers were originally designed to accommodate peak horizontal accelerations (PHA) of 0.1g with a normal RWS elevation of 544.0. Since the original design and construction, the understanding of the potential seismic loads has increased greatly and is based on information gained from actual seismic events. Figure 3 presents the most recent PHA hazard curve for B.F. Sisk Dam taken from the 2004 Seismotectonic Report 2004-1 [3] "Probabilistic Ground Motion Evaluation for B.F. Sisk and O'Neill Forebay Dams"

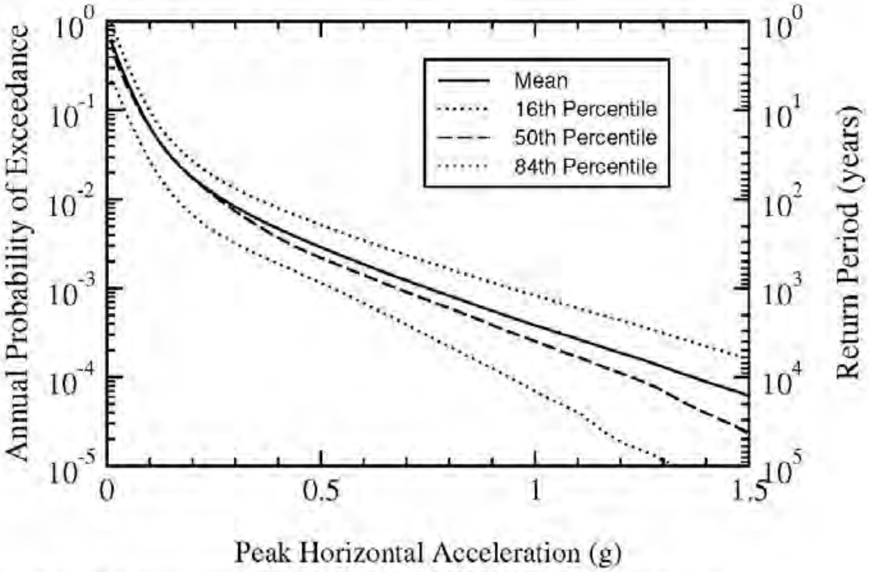

Figure 8-4: Peak horizontal acceleration (PHA) fractile results for B.F. Sisk Dam.

Figure 3. PHA fractile results for B.F. Sisk Dam

As it can be seen from Figure 3, the original design PHA of 0.1g corresponds to a return period of approximately 10 years. Because the original seismic design PHA represents such a frequent return period, a pseudo-static analysis of the outlet works towers was conducted to better understand the range of seismic events the existing towers would be capable of experiencing before significant structural damage occurs. This was done to better quantify what level earthquake the existing structures could be expected to withstand (from reserve strength due to conservatism in the original design) and what type of modification to the intake towers would be required if they were to be modified for a dam raise (given consideration of static and seismic load conditions).

To investigate the adequacy of the intake towers under seismic loads a finite element model was constructed using STAAD.Pro V8i, hereafter STAAD.Pro. STAAD.Pro is a general purpose finite element program that is best suited towards linear elastic solutions of beam, and shell elements, with some solid element capability.

A Model of the intake tower including the foundation was constructed, consisting of 18,396 solid elements and 896 shell elements. Parts of the actual towers were omitted from the model to simplify it and because their addition would not be significant enough to change the results for this level of study. These items include the trashrack structure, corbels, bridge, tower plate slabs, and gantry crane rails which connect all four towers together. Figure 4 shows the finite element model and a 3D representation of the model. To evaluate the intake towers the latest applicable reference adopted by the building code, American Concrete Institute, ACI-318-08 was used. The ACI code provides requirements to be met in design and evaluation that consider the linear elastic response of reinforced concrete. This code works in unison with the American Society of Civil Engineers, ASCE 7 series of references to develop loads to apply to the structure. Nonlinear behavior during seismic events is accounted for on the loads side by a reduction due to a Seismic Response Modification Factor, R [4]. This will be discussed in greater detail in the Dam Safety section of this report.

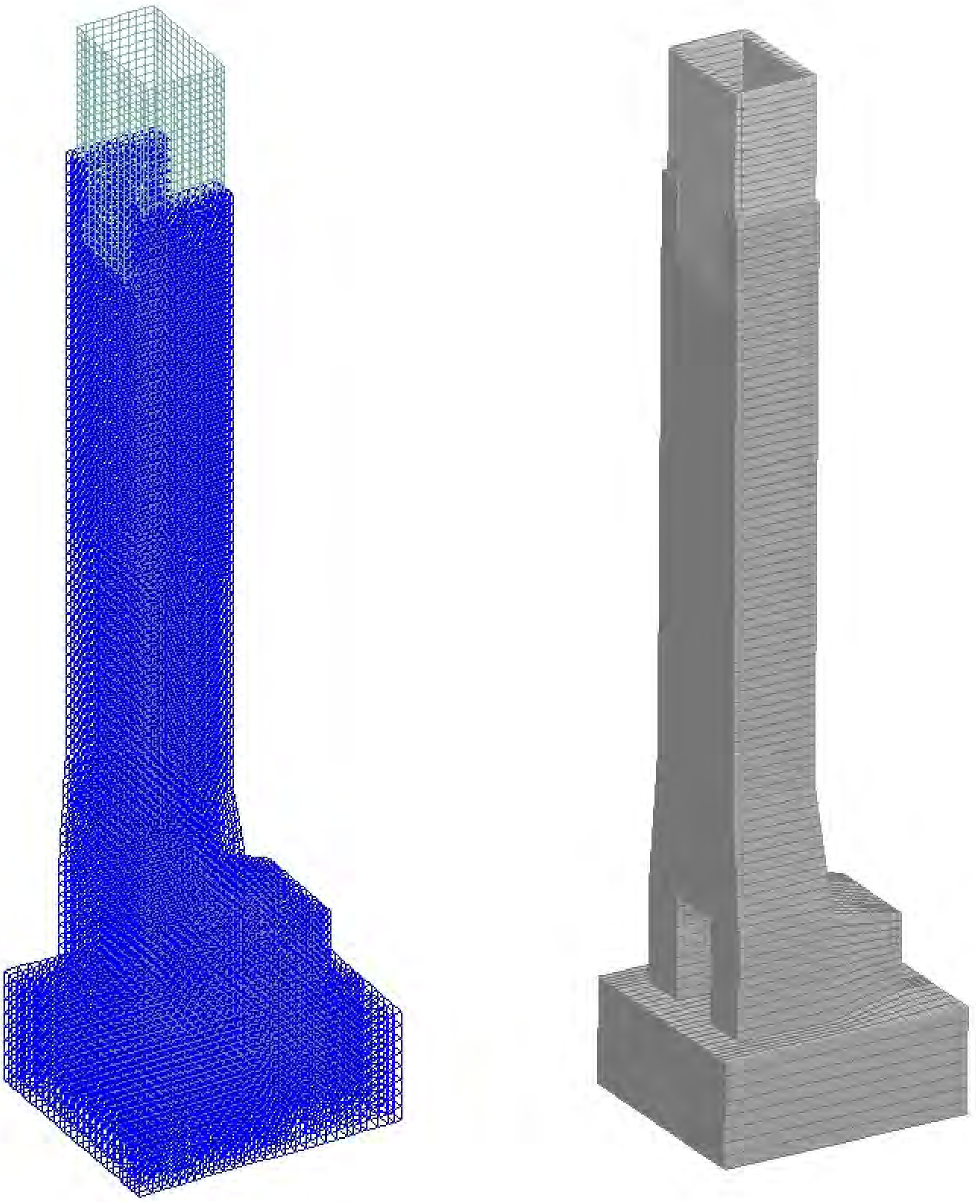

Figure 4. The finite element model on the left and 3D representation on the right.

Some overlying assumptions were made about the current state of the structure as well as application of the loads to the structure, these include:

- The earthquake occurs at the maximum normal pool level of 544.0
- Loads are applied pseudo statically to the structure
- Material strengths are unknown and therefore approximated
- All behavior is considered to be linear elastic

To adequately assess the strength of the towers, the hydrodynamic loads induced on the towers by the water outside and inside the tower had to be determined. To account for these loads, various “slices” of the tower representative of geometry near that section were taken and converted to equivalent circular sections. These circular cross sections were used to represent an idealized circular intake tower. This simplified approach is necessary to easily determine the mass of water outside and inside the tower that is excited during a seismic event. The equivalent mass of this excited water was added to the structure by calculating the ratio of the mass of reinforced concrete to mass of water and scaling up the self-weight of the structure accordingly. The US Army Corps of Engineers, Engineering Manual (EM) 1110-2-2400, Structural Design and Evaluation of Outlet Works [5], and the University of California at Berkeley, Report No. UCB/EERC-89/04, Earthquake Analysis and Response of Intake-Outlet Towers [6] were used as the primary references for this simplified evaluation of added hydrodynamic mass for the intake towers at B.F. Sisk.

B. Spillway

No seismic analysis of the spillway was performed. During the 2009 CFR [2], the potential failure mode for Earthquake-Induced Damage of the Spillway Crest Structure was considered. This failure mode was considered highly unlikely for several reasons which include:

- Past performance of structures surrounded by soil during seismic events has typically been good. Although not based on site-specific analysis, but rather on analysis and experiences with other structures at other dams it was estimated that PHA’s less than 0.75g would be likely to cause only minor damage which corresponds to approximately the 1,000-year event. For higher PHA’s, perhaps approaching or in excess of 1.0g (the 10,000-year event has PHA of approximately 1.4g), the spillway inlet may suffer greater damage including fairly large cracks and/or partial offset of the spillway structure.
- Because San Luis Reservoir is an off stream reservoir the likelihood of a large earthquake happening at the same time the spillway is required to operate or the reservoir is high enough to cause significant releases if damage occurs at a lower elevation of the inlet tower is unlikely. If a significant offset of the spillway inlet tower did occur the coarse to very coarse materials on the upstream side of the dam would be very likely to reduce flows through the spillway. With low flow rates entering the conduit, it is considered extremely unlikely that the well compacted, wide plastic core would be breached due to potentially erosive flows.
- In the event of an extremely large seismic event resulting in spillway failure, there is potential for damage or failure of the intake towers as well; however, given the outlet works gates are left open and reservoir control is left to the Gianelli Pumping-Generating Plant, it is likely that the reservoir

could be drawn down to a safe level before significant erosion of the embankment could occur through the spillway.

C. Finite Element Model Results

The finite element model results indicate that the outlet works intake tower is adequately designed to survive the design earthquake of 0.1g. For horizontal accelerations beyond 0.1g questions begin to arise about the survivability of the towers. It is unknown what method was used to the design the towers or what assumptions were made in the design process. However, the as built drawings indicate some sense that the towers were most vulnerable to seismic loads assuming the shaking would occur in the upstream to downstream direction. This design consideration resulted in a significant amount the reinforcement being provided in the faces of the longitudinal (upstream and downstream) faces. In the transverse direction there is much less flexure steel. There are limited areas with shear reinforcement, mainly at changes in geometry. Figure 5 illustrates the considerable reinforcement in the longitudinal faces versus the transverse faces of the intake tower.

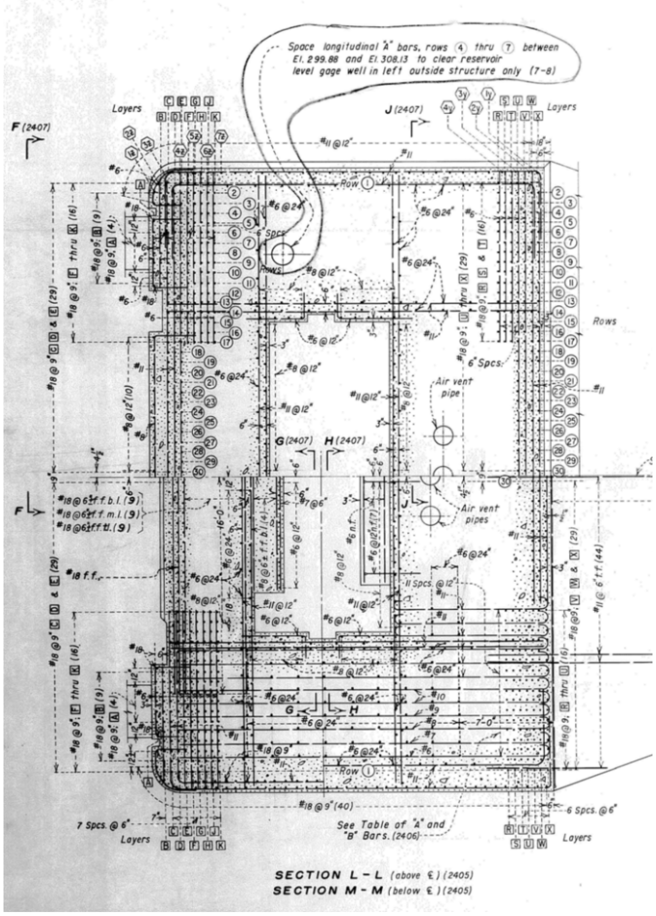

Figure 5. Section through outlet works tower to illustrate difference in longitudinal and transverse reinforcement

The worst areas of stress concentrations occur at the three major geometry changes; where the penstock tunnel leaves the tower; in the two legs on either side of the intake gate; and the tapered section between El. 304.0 and 344.0.

The biggest concern for the towers at lower horizontal accelerations is the presence of high concentrated shear stresses. Shear reinforcement is present where the tower connects to the penstock tunnel from El. 299.88 to El 308.13. While concentrations there are highest, they do not represent the area of greatest concern. At horizontal accelerations of 0.3g shear stresses in the legs of the tower where there is no reinforcement are more than double the allowable by ACI code. This concentration occurs when seismic forces are applied in the upstream and downstream direction as shown in Figure 6.

At horizontal accelerations of 0.4 g compression stresses due to bending begin to exceed the crushing strength of concrete in localized areas. The bending moment capacity of the legs in the weakly reinforced direction is exceeded in some areas by horizontal accelerations of 0.5g.

Results from horizontal accelerations above 0.5g indicate the probably of serious deficiencies occurring, and the stability of the towers in such an event may be in considerable jeopardy of survival.

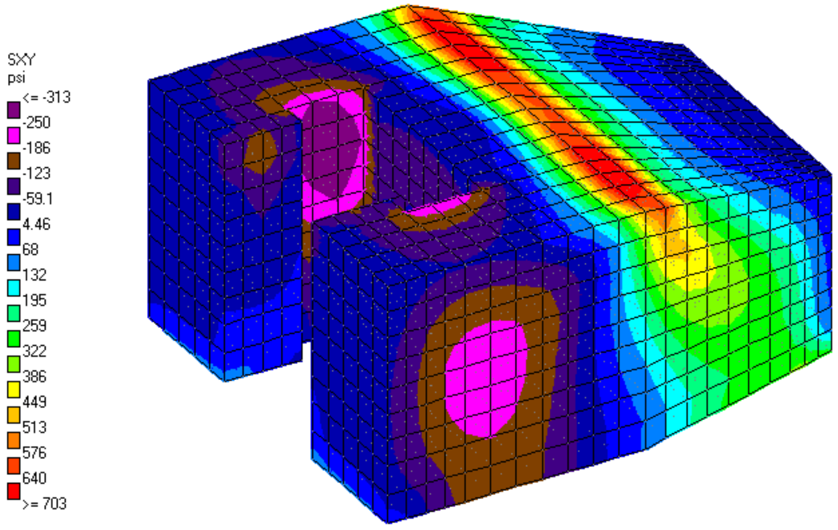

Figure 6. Collection of shear stresses in the tower legs with horizontal accelerations at 0.3g. Permissible stresses in concrete are capped at 126 psi for 4000 psi concrete.

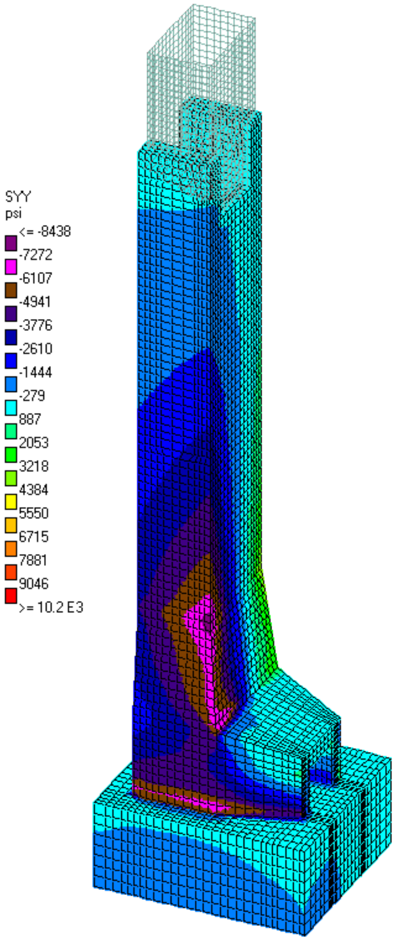

Figure 7. Concentration of stresses in the bottom of the tower for a 1.0g horizontal acceleration.

Issues related to strength and stability of the towers during seismic events are largely confined to the bottom half of each tower structure as shown in Figure 7. Results from the STAAD.Pro structural analysis indicate that there is little effect on the top of the structure during large horizontal accelerations. While adding 10 feet to the height of the dam will increase the risk to the towers due to the additional concrete mass and additional hydrodynamic load from the water around them, it will not increase the risk of failure substantially.

D. Dam Safety and Risk Analysis

In past risk analysis of B.F. Sisk dam, no failure modes were identified with the failure of the outlet works intake towers during seismic events. The reasons for this include that there are two gates (two points of control to prevent uncontrolled release of the reservoir) to limit flow, one at the intake tower and a second at the power house, the physical distance of the towers from the embankment (failure of the towers would not impact the embankment), and the fact that the outlet works conduits were tunneled through rock, are well below the embankment, and will retain their integrity during a seismic event.

Two failure modes exist for the morning glory spillway, one hydrologic, and one seismic, both of which are well below Reclamation's dam safety guidelines and therefore not of concern as documented in the 2011 CFR [2].

Because the past risk analysis has identified the towers as not being a dam safety concern, a decision about the design earthquake is necessary to properly evaluate the towers. Typically structures that fall under the umbrella of dam safety usually use low probability events with return periods in excess of 10,000 years (which corresponds to approximately a PHA of 1.4g at B.F. Sisk) in order to ensure the related potential failure modes for structures fall below Reclamation's dam safety guidelines. However, since the towers do not fall under a dam safety category it is necessary to determine what PHA would need to be used to seismically modify the outlet works intake towers and spillway under the today's current practice design codes. Based on ASCE 7-05 (hereafter ASCE 7) this category was estimated to be a 2,500-year event (approximate PHA of 0.714g). The ASCE7 provisions take into several proscriptive modifications to the peak horizontal accelerations to account for the foundation site conditions, the importance of the structure, and material non linearity. The design process is simplified to allow loads to be applied in a linear elastic method, while still accounting for nonlinear effects.

ASCE 7 permits the use of modification factors only if the detailing of reinforcement and connections is sufficient to meet the requirements to be classified as a certain type of structure type. As the layout of reinforcement becomes more detailed in a structure, its ability to endure damage without collapse increases. To reflect this fact, the Seismic Response Modification Factors, or "R" values are used to artificially reduce the horizontal acceleration, and permit designers to in essence account for nonlinear response while solving structures in a linear elastic method. The higher the R value the greater the load is reduced. For structures not permitted to perform nonlinearly, R is simply reduced to 1.0.

According to ASCE 7 the intake towers are permitted to be evaluated according to the provisions for Non building structures similar to buildings. Under the code provisions, the intake towers are permitted to use an R value of 3.0 to account for non-linearity, with the caveat that the structure meets these requirements. Considering the build up of shear stresses in the legs of the structure where there is no shear reinforcement is present, it is debatable if the existing structure indeed meets these requirements and if a lower value for R such as 1.25, which is used for unreinforced masonry structures is more appropriate. To underscore the importance of properly determining this modification factor, for the intake towers a horizontal acceleration could vary between 0.57 and 0.24 depending on the selection of the seismic response modification factors.

The results from examining the towers according to ASCE 7 point towards the necessity to perform a nonlinear finite element analysis of the towers and determine specifically what type of horizontal accelerations they are capable of surviving, and which they are not. After the completion of such an analysis a more proper assessment of the towers can be conducted, and specific questions such as if the towers fail to meet the provisions of the ASCE 7 and the ACI code is the owner willing to accept the risk of failure, well aware that the cost of a retrofit to repair or replace the intake towers after failure has occurred could be significantly more expensive (and impact water operations) than modifications made prior to a potentially damaging seismic event occurs.

IV. Conclusions

At this time, based on the current level of analysis a raise is feasible under static loading for the morning glory spillway and outlet works intake towers. However, further study is necessary particularly for the towers before any recommendation can be made when considering seismic load effects. The structural analysis should involve finite element modeling which can perform non-linear analysis and evaluate site specific earthquake time histories to achieve sufficient confidence of what type level of seismic loadings the existing structures can withstand.

Following thorough structural analysis a risk analysis should be conducted for the outlet works intake towers and spillway to determine how modifying the structures for a dam raise will affect potential failure modes for the dam. Depending on the outcome of this risk analysis several decisions would need to be made which might include:

- Determining the design earthquake for the outlet works intake towers and spillway modifications which include consideration for the use of the load reduction factors prescribed in ASCE 7 series if the structures do not represent a dam safety concern.
- The feasibility of retrofitting or demolishing and replacing the intake towers with a similar but more robust tower system or an entirely different structure to operate the intake tower gates.
- Identifying the costs of undertaking any retrofitting or replacement of the existing waterway structures. Dependent on the flexibility to lower the reservoir for construction, the cost of a cofferdam for retrofitting or replacing the outlet works towers could be significant given the depth of the reservoir.

Ultimately, considerable investigation into the seismic performance of the outlet works and spillway crest structures and tunnels would need to be conducted before reasonable evaluation of the potential for a dam raise at B.F. Sisk Dam could be determined.

References

[1] Technical Memorandum No. VB-86-68313-22, Appraisal –Level Study of Static Stability for Increased Storage, B.F. Sisk Dam, Central Valley Project, California, Mid Pacific Region, Bureau of Reclamation, Technical Service Center, Denver, Colorado, December 2012.

[2] Comprehensive Facility Review, B.F. Sisk Dam, Central Valley Project, California, Mid-Pacific Region, Bureau of Reclamation, Technical Service Center, Denver, Colorado, June 2009.

[3] Seismotectonic Report No. 2004-1, Probabilistic Ground Motion Evaluation for B.F. Sisk and O'Niell Forebay Dams, Central Valley Project, California, Bureau of Reclamation, Technical Service Center, Denver, Colorado, December 2004.

[4] Engineering and Design, EM1110-2-2400, Structural Design and Evaluation of Outlet Works, US Army Corps of Engineers, June 2, 2003.

[5] Earthquake Analysis and Response of Intake-Outlet Towers, Report No. UCB/EERC-89/04, Earthquake Engineering Research Center, College of Engineering, University of California at Berkeley, By Alok Goyal and Anil K. Chopra, July 1989.

Appendix E

TM BFS-8140-STY-2013-1

Analysis of Trashrack Structure Access Bridge

RECLAMATION

Managing Water in the West

Technical Memorandum No. BFS-8140-STY-2013-1

B.F. Sisk Dam - Analysis of Trashrack Structure Access Bridge

Central Valley Project, California
Mid-Pacific Region

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U.S. Department of the Interior
Bureau of Reclamation
Technical Service Center
Denver, Colorado

March 2013

Mission Statements

The mission of the Department of the Interior is to protect and provide access to our Nation's natural and cultural heritage and honor our trust responsibilities to Indian Tribes and our commitments to 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.

B.F. Sisk Dam - Analysis of Trashrack Structure Access Bridge

Central Valley Project, California
Mid-Pacific Region

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U.S. Department of the Interior
Bureau of Reclamation
Technical Service Center
Denver, Colorado

BUREAU OF RECLAMATION
Technical Service Center, Denver, Colorado
Water Conveyance Group, 86-68140

Technical Memorandum No. BFS-8140-STY-2013-1

B.F.Sisk Dam - Analysis of Trashrack Structure Access Bridge

Central Valley Project, California
Mid-Pacific Region

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Supervisory Civil Engineer, Structural Analysis Group, 86-68110

3/8/2013
Date

REVISIONS					
Date	Description	Prepared	Checked	Technical approval	Peer review

Contents

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Existing Access Bridge

The existing bridge provides access from the top of the dam embankment to the outlet works trashrack structure. The bridge consists of 6 spans for a total length of 1,059.25-feet. Spans 1 through 5 are continuous for live loads (there are no joints in the concrete deck), and Span 6 is simple supported. Span lengths for Spans 1 through 5 (continuous portion of the bridge) are 179’-6”, 179’-11⅜”, 180’-3⅝”, 179’-4” and 178’-8”, and Span 6 length is 154’-9⅜”. The bridge clear roadway width is 16-feet.

The bridge superstructure consists of two main steel girders supporting a reinforced concrete deck with w-beam guardrail system attached to both sides of the concrete deck. The estimated weight of the existing bridge superstructure is approximately 2.2 kips per lineal foot (k/lf). Since the bridge superstructure has only two main girders, it is a fracture critical structure. A fracture critical bridge is one that does not contain redundant supporting elements. This means that if one of those key supports fails, the bridge would be in danger of collapse. This does not mean the bridge is inherently unsafe, only that there is a lack of redundancy in its design.

The bridge was designed per the AASHO 1961 Code. The earthquake load applied to the existing bridge was approximated as 2 to 4 percent the structure dead load. Using Current AASHTO Seismic Design Guidelines, the base Peak Ground Acceleration at this site is estimated to be 0.594g. The bridge design live loading is given on drawing 805-D-250, which consists of a 50-ton tractor trailer combination and the HS20-44 AASHTO design vehicle.

Bridge Modification

The appraisal-level study is evaluating a 20-foot embankment raise to the existing dam (proposed crest elevation of 574.0 feet), with a potential 10-foot reservoir water surface raise to elevation 554.0 feet. The initial idea was to replace the existing bridge. If the bridge was replaced, it would be approximately 30 feet longer than the existing structure, and it would have the same number of spans. However, the spans would be different lengths than the existing spans. The first five spans would be continuous for live load, and the end span to be simply supported. This requires modification to piers, construction of new abutment and superstructure designed in accordance with the AASHTO LRFD Bridge Design Specifications, Customary U.S. Units/Fifth Edition/2010, including 2010 Interim Revisions. The replacement bridge would be designed for HL-93 live loading and also be evaluated for a vehicle similar to the 50-ton tractor trailer vehicle shown on the lower left of drawing 805-D-250.

The existing piers would be extended straight up approximately 12 feet At Pier 1 and 22 feet at Pier 2 (Figures 1 through 3). Since the continuous portion of the existing bridge superstructure is nearly 1003 feet, it would be difficult to raise and reuse. Also, Span 6 would also need replacement, since the new span is longer, approximately 177 feet, as compared to the current length of 154’-9⅜”. Therefore, a new bridge superstructure is required.

The new bridge superstructure will consist of three lines of steel plate girders (no longer be considered fracture critical) supporting a reinforced concrete deck with California ST-10 Bridge Rail on both sides.

All of the existing facilities were constructed in the early 1960's and therefore it is very likely that they will not survive a seismic event based on current design codes. Regardless, the current study only considers a static analysis in raising the existing trashrack structure tower, extending the existing bridge piers, constructing a new abutment at the dam crest, and installing a new bridge superstructure.

Bridge Analysis Preliminary

Even though a seismic analysis is not required, to get an idea of the strength of the existing bridge substructure, the capacity of the pier 1 column was evaluated for gravity loads as well as potential seismic loading. The existing bridge piers as shown on drawing 805-D-250 are supported by round spread footings founded on rock. The rock bearing capacity is not known at this time. The total loads applied to the pier 1 footing are estimated as follows:

1. Pier cap = 105 kips
2. Pier column = 2,080 kips
3. Pier footing = 4,375 kips
4. Superstructure dead load = 440 kips
5. Superstructure live load = 72 kips

The total dead load reaction at the pier 1 footing, which is supported by a 48-foot-diameter footing, is approximately 7,000 kips. The footing area is 1,810 square feet (ft^2), so the resulting bearing pressure is estimated to be 3.87 kips per square foot (k/ft^2).

The moment and axial capacity of the pier 1 column was evaluated using SAP2000. The column capacity is estimated to be 27,000 kips, however this is the pure axial capacity without any flexure. The column interaction diagram shows a flexural capacity of nearly 100,000 kip-feet, with a maximum axial load of nearly 7,500 kips.

To estimate the lateral loads applied to the bridge piers in their current condition, a preliminary seismic analysis was done. The AASHTO Guide Specifications for LRFD Seismic Bridge Design was used to estimate the Horizontal Peak Ground Acceleration (PGA) at the site. The PGA is approximately 0.6g with a seven percent probability of exceedance in 75 years (approximately 1000-year return period). The period of pier 1 was estimated to be 1.55 seconds based on a propped cantilever. Since the current normal reservoir water surface elevation is 544.0 feet, a seismic analysis requires the evaluation of the added hydrodynamic mass. The estimated hydrodynamic mass was applied using the procedure given in Chapter 8 of the "Earthquake Analysis and Response of Intake-Outlet Towers" by Alok Goyal and Anil K. Chopra, Report No. UCB/EERC-89/04, July 1989.

The total moment at the base of the existing bridge pier 1 column is estimated to be 150,000 kip-feet, which exceeds the estimated flexural capacity of the existing column. Because of the lack of seismic detailing, it is questionable that the bridge would survive a seismic event. However, it is understood that a seismic analysis is not required as part of this appraisal-level study. The purpose for this analysis was to evaluate whether it is likely the existing bridge will survive a seismic event in the current configuration (i.e. no modification or raise).

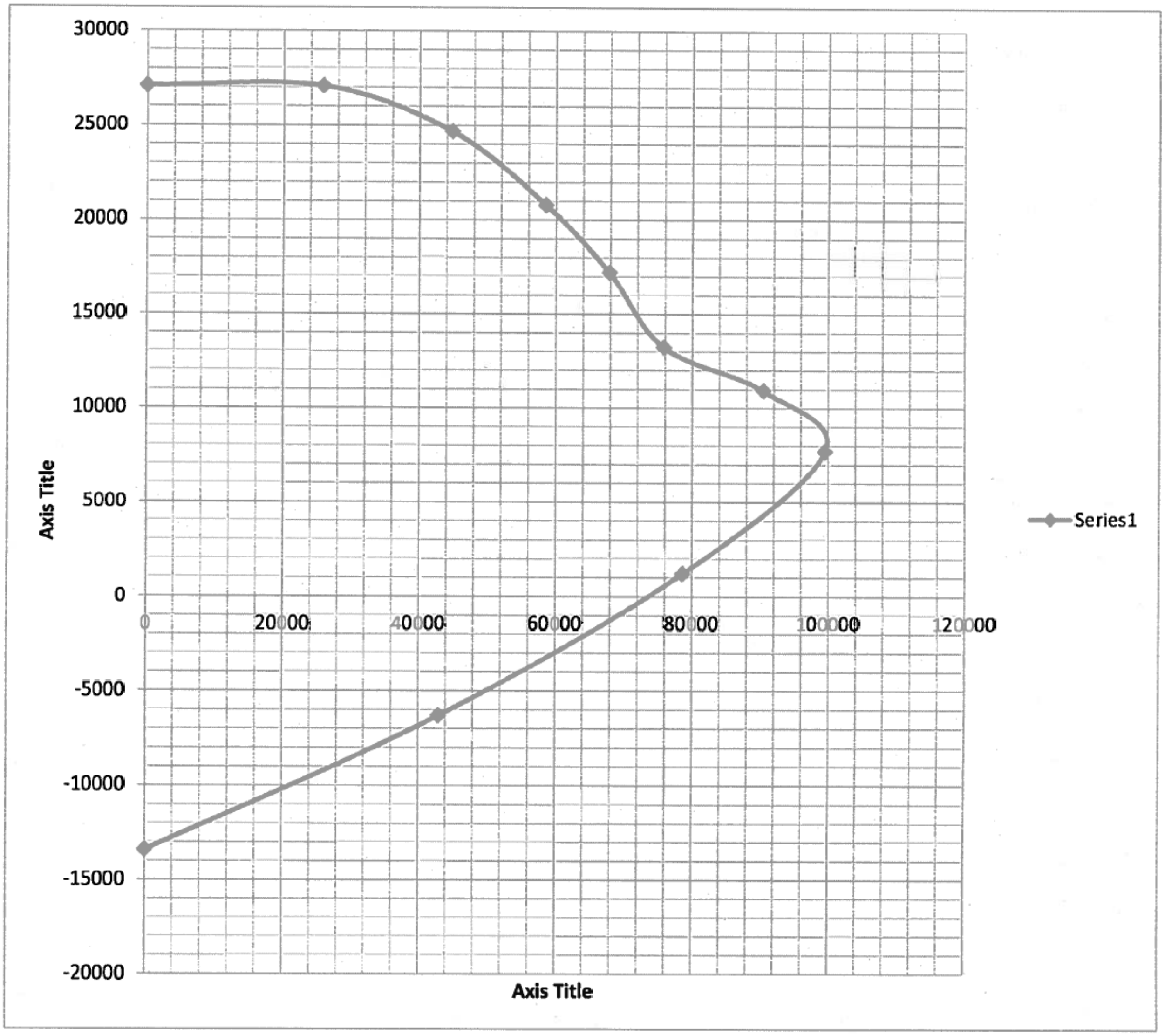
References

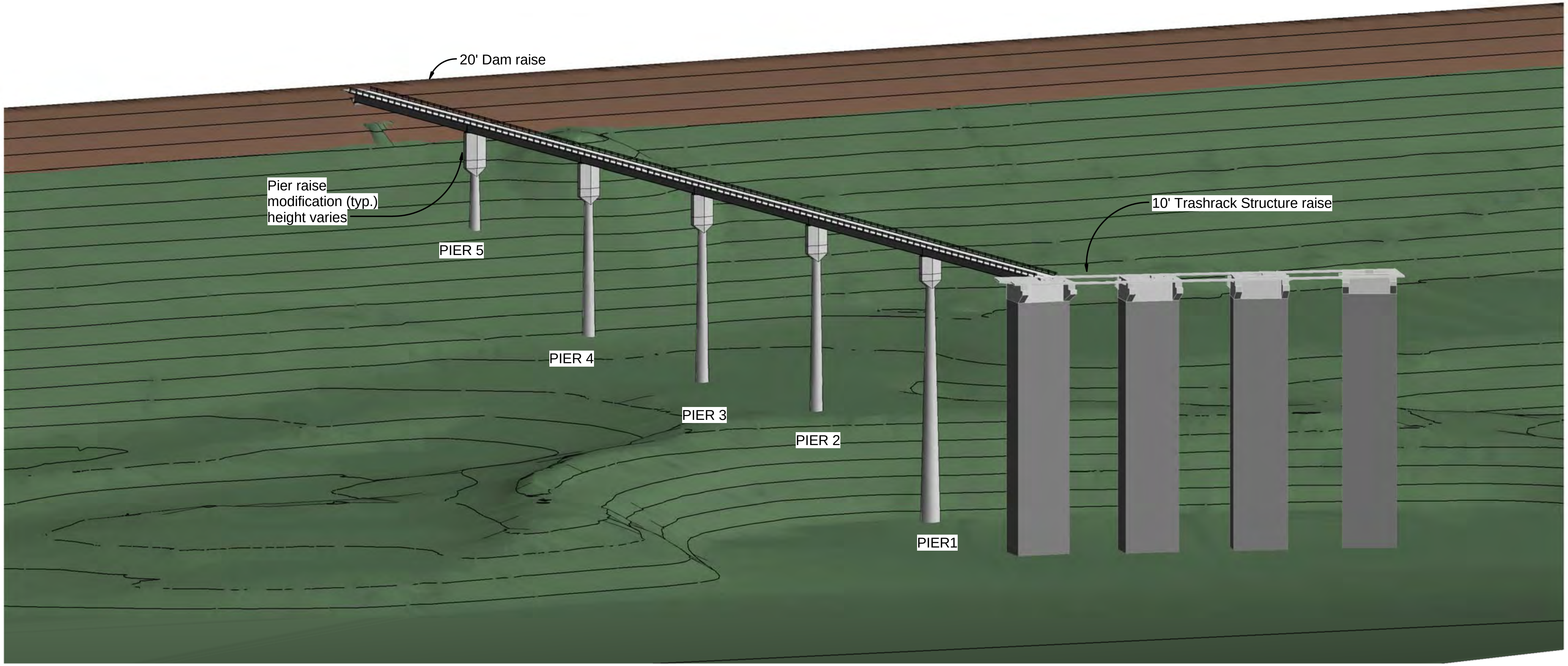
[1] AASHTO, 2010, *AASHTO LRFD Bridge Design Specifications, Fifth Edition,* American Association of State Highway and Transportation Officials, Washington, DC, 2010

[2] Earthquake Analysis and Response of Intake-Outlet Towers, Report No. UCB/EERC-89/04, Earthquake Engineering Research Center, College of Engineering, University of California at Berkeley by Alok Goyal and Anil K. Chopra, July 1989

Appendix

PIER 1 Interaction Diagram





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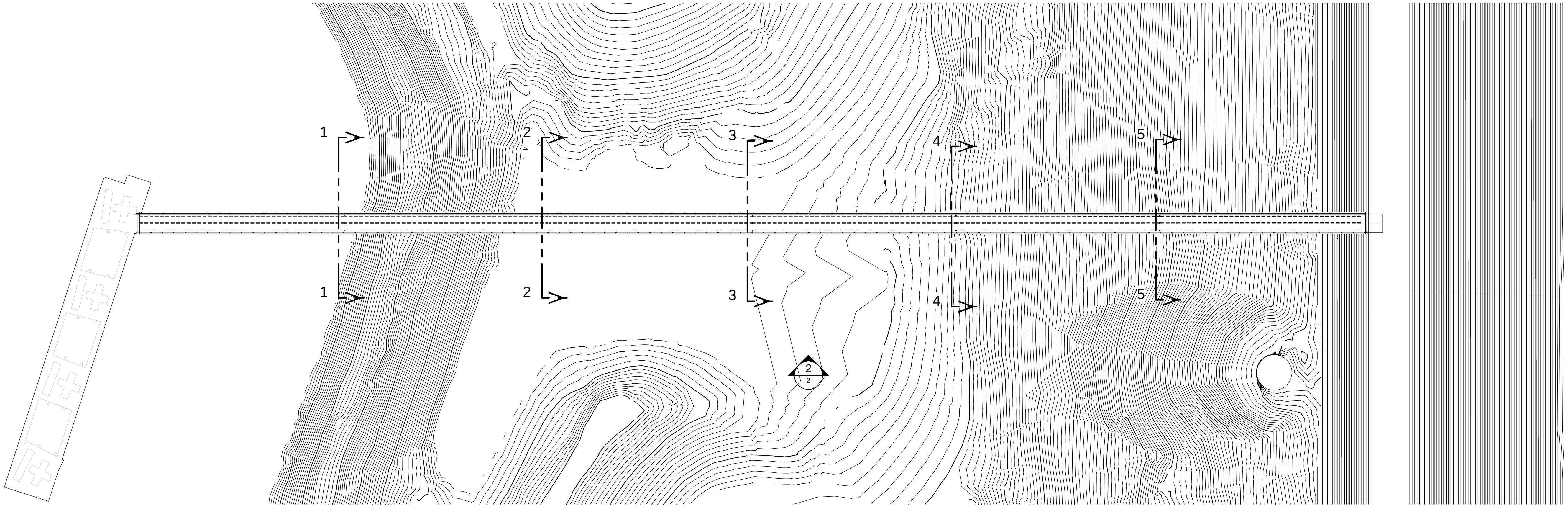

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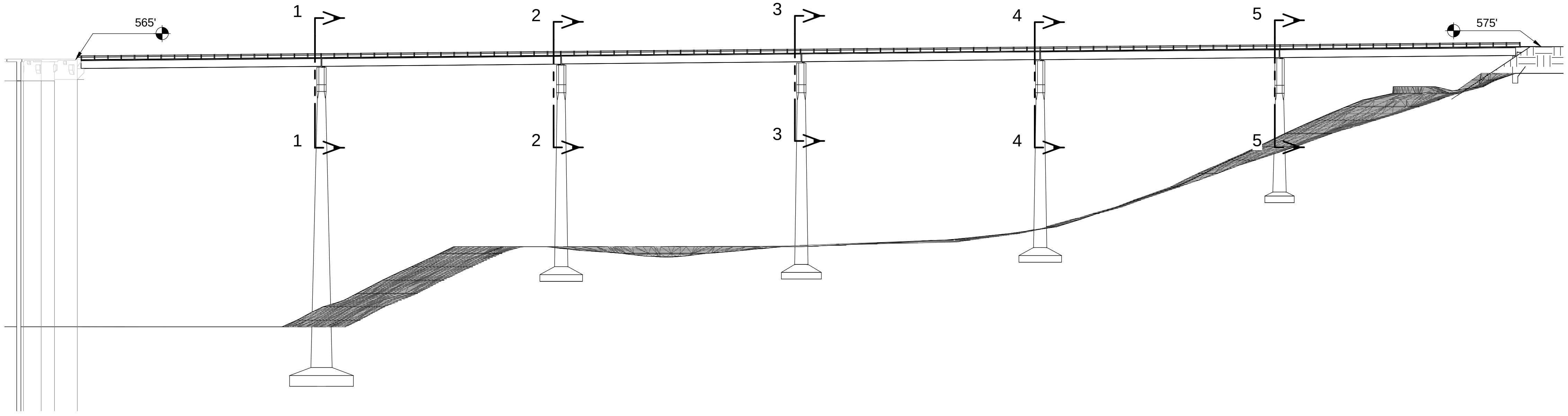

② Elevation
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RECLAMATION
Managing Water in the West

ALWAYS THINK **SAFETY**

U.S. DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
CENTRAL VALLEY PROJECT
WEST SAN JOAQUIN DIV.-SAN LUIS UNIT-CALIFORNIA
B.F. SISK DAM
TRASHRACK STRUCTURE ACCESS BRIDGE
PLAN AND ELEVATION

PRELIMINARY

NOT TO BE USED FOR CONSTRUCTION

JOE M. GEMPERLINE, P.E.
DESIGNED

JESUS ROMERO, P.E.
REVIEWED

DENVER, COLORADO *2013-03-7*

PLAN AND ELEVATION

FIGURE 2
2 OF 3

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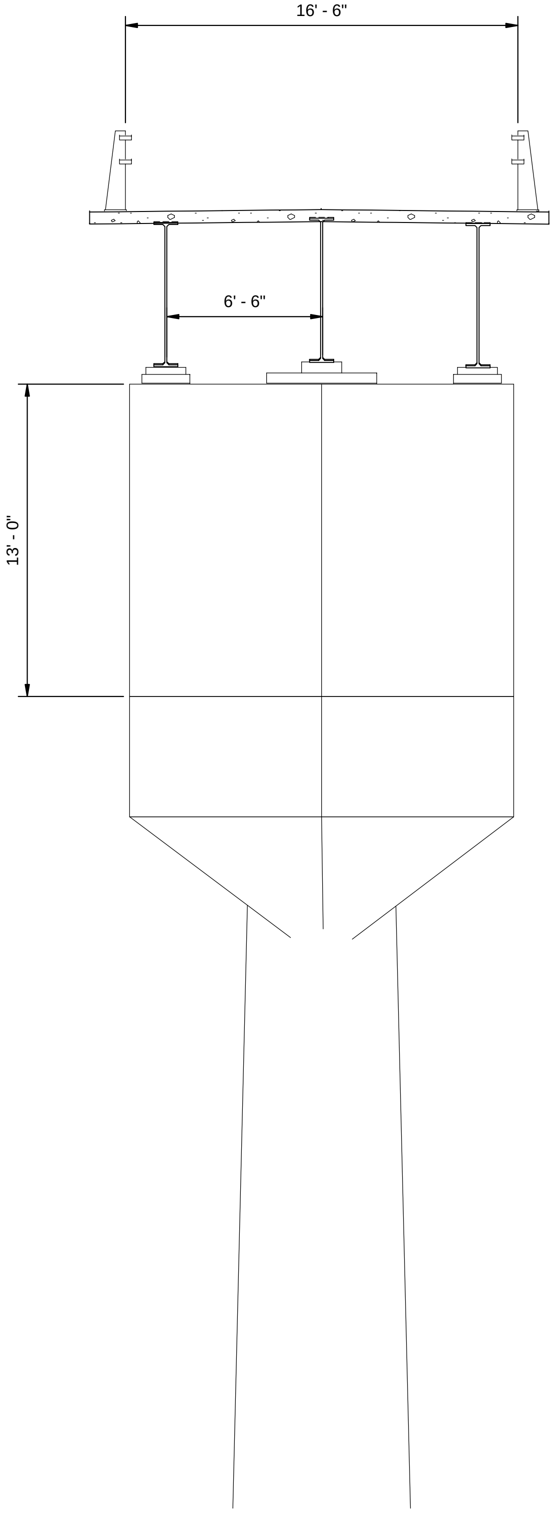
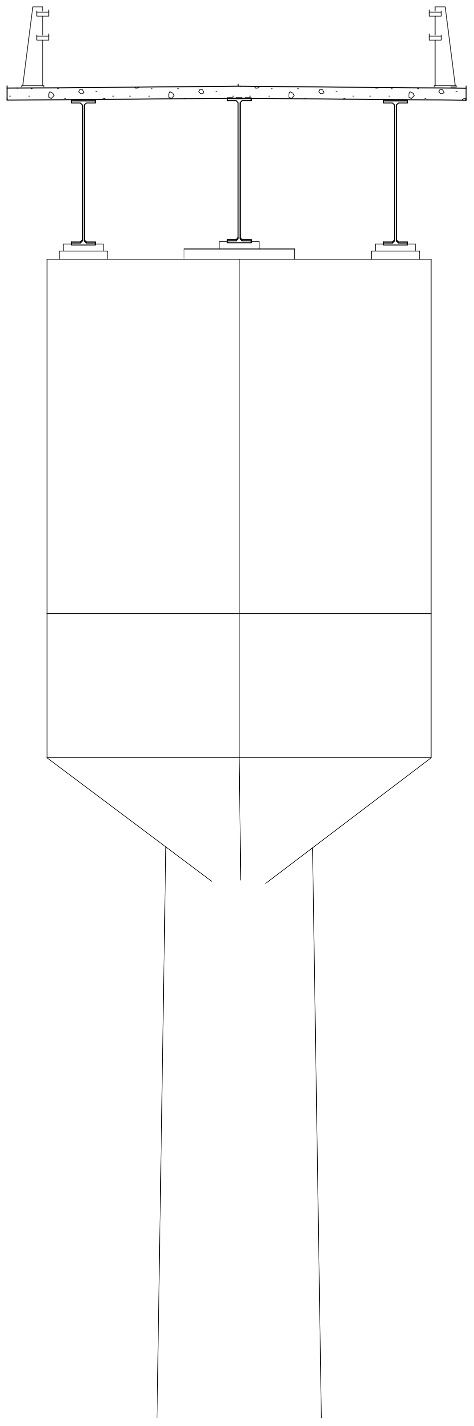
CAD FILENAME
Q:\CENTRAL VALLEY PROJECT\West San Joaquin Division\San Luis Unit\B.F. SISK\2011-2013
Appraisal Level Study\86-68140 Water Conveyance\Joe\Try a new.rvt

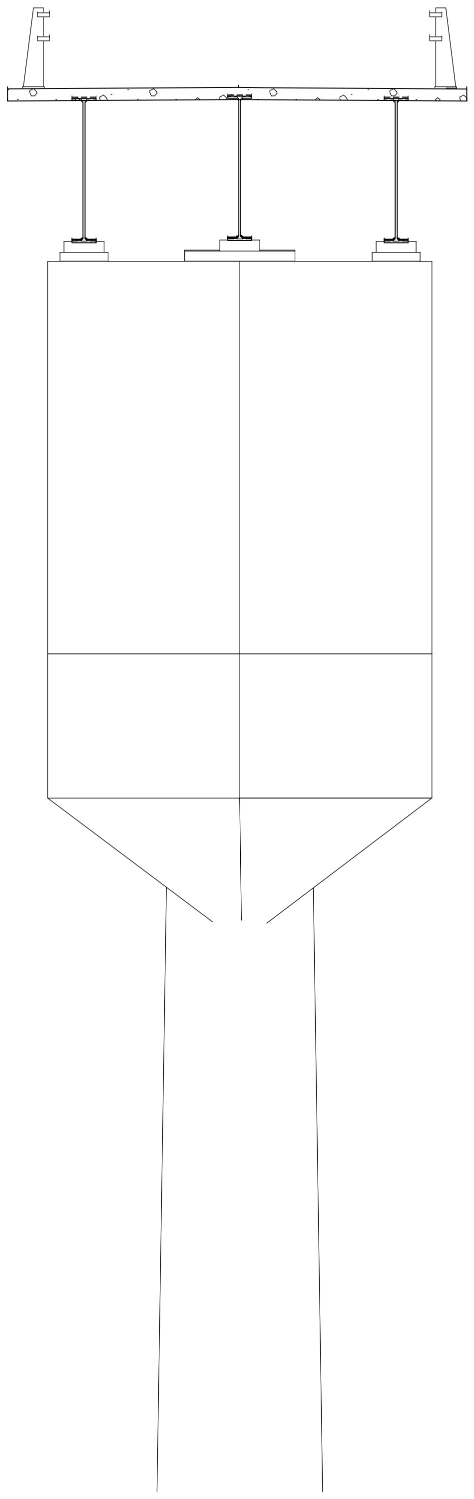
DATE AND TIME PLOTTED
3/8/2013 10:10:07 AM



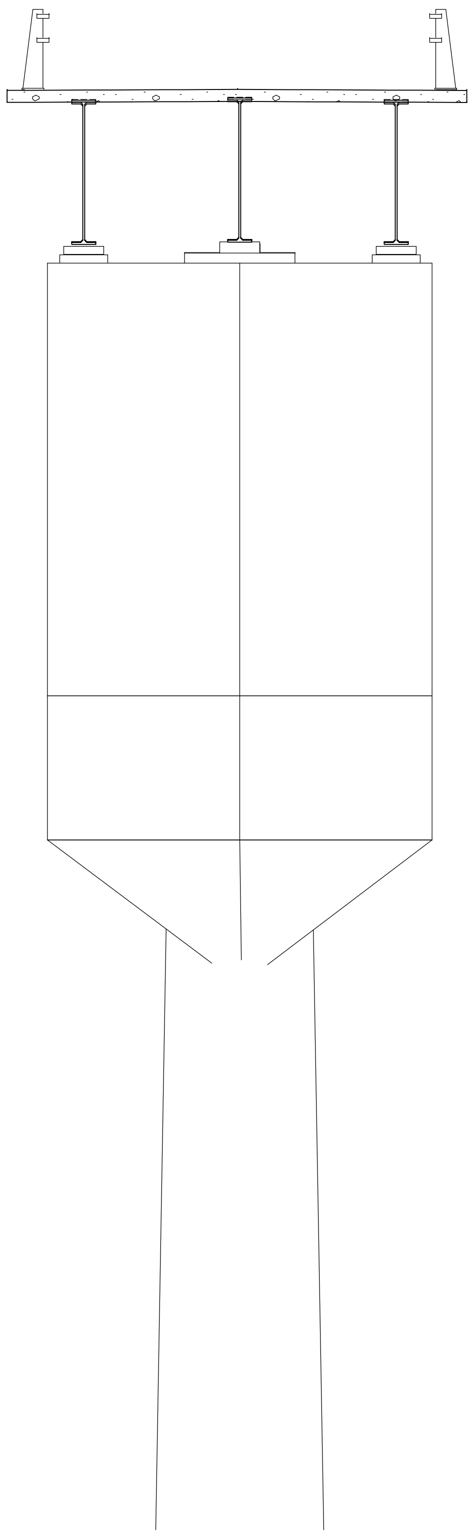
1 PIER 1
Scale: 1/4" = 1'-0"



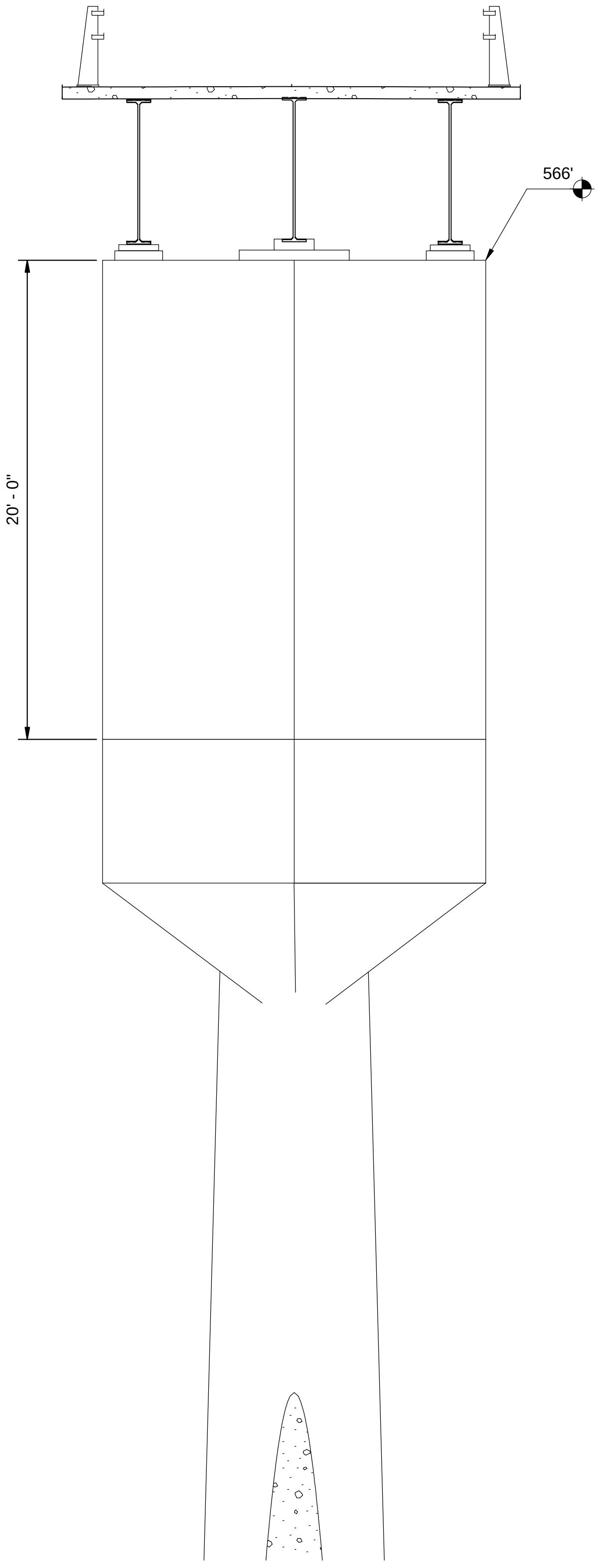
2 PIER 2
Scale: 1/4" = 1'-0"



3 PIER 3
Scale: 1/4" = 1'-0"



4 PIER 4
Scale: 1/4" = 1'-0"



5 PIER 5
Scale: 1/4" = 1'-0"

RECLAMATION
Managing Water in the West

ALWAYS THINK **SAFETY**

U.S. DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
CENTRAL VALLEY PROJECT
WEST SAN JOAQUIN DIV.-SAN LUIS UNIT-CALIFORNIA
B.F. SISK DAM
TRASHRACK STRUCTURE ACCESS BRIDGE
SECTIONS

PRELIMINARY

NOT TO BE USED FOR CONSTRUCTION

JOE M. GEMPERLINE, P.E.
DESIGNED
JESUS ROMERO, P.E.
REVIEWED

DENVER, COLORADO *2013-03-7*

SECTIONS

DATE AND TIME PLOTTED
3/8/2013 10:10:16 AM

CAD SYSTEM
Autodesk Revit 2013
CAD FILENAME
Q:\CENTRAL VALLEY PROJECT\West San Joaquin Division\San Luis Unit\B.F. SISK\2011-2013 Appraisal Level Study\86-68140 Water Conveyance\Joe\Try a new.rvt

Attachment B

Pacheco Reservoir Expansion Project Facilities

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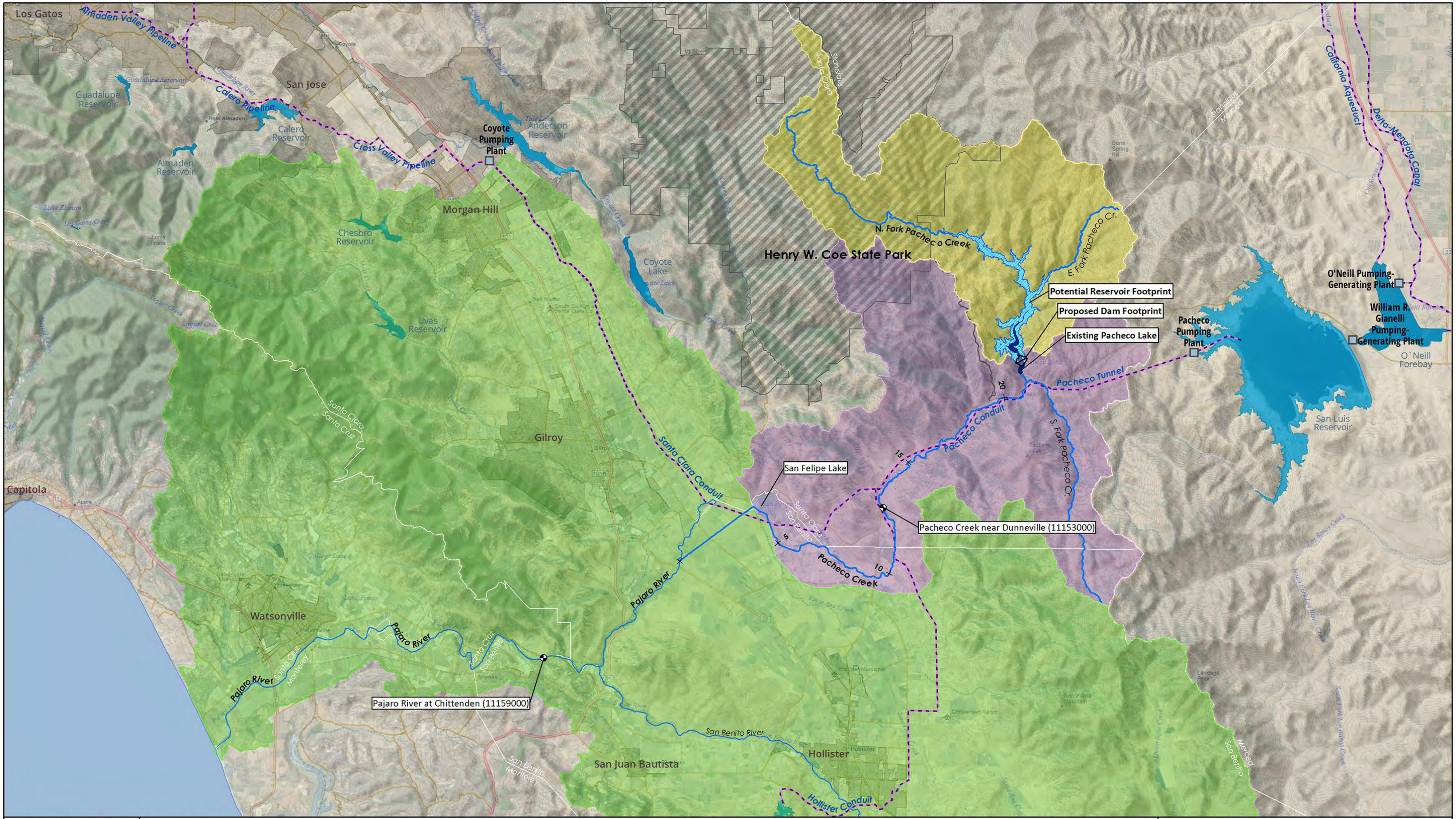


Santa Clara Valley Water District

Stantec

● Selected USGS Gage Station

☐ Existing Pump Station

Existing Tunnel/Pipeline

Affected Watersheds

🟩 Pajaro River below Pacheco Creek *(Includes San Benito River Shed - not shown in its entirety)*

🟪 Pacheco Creek below Proposed Dam

🟨 North Fork Pacheco Creek above Proposed Dam

N

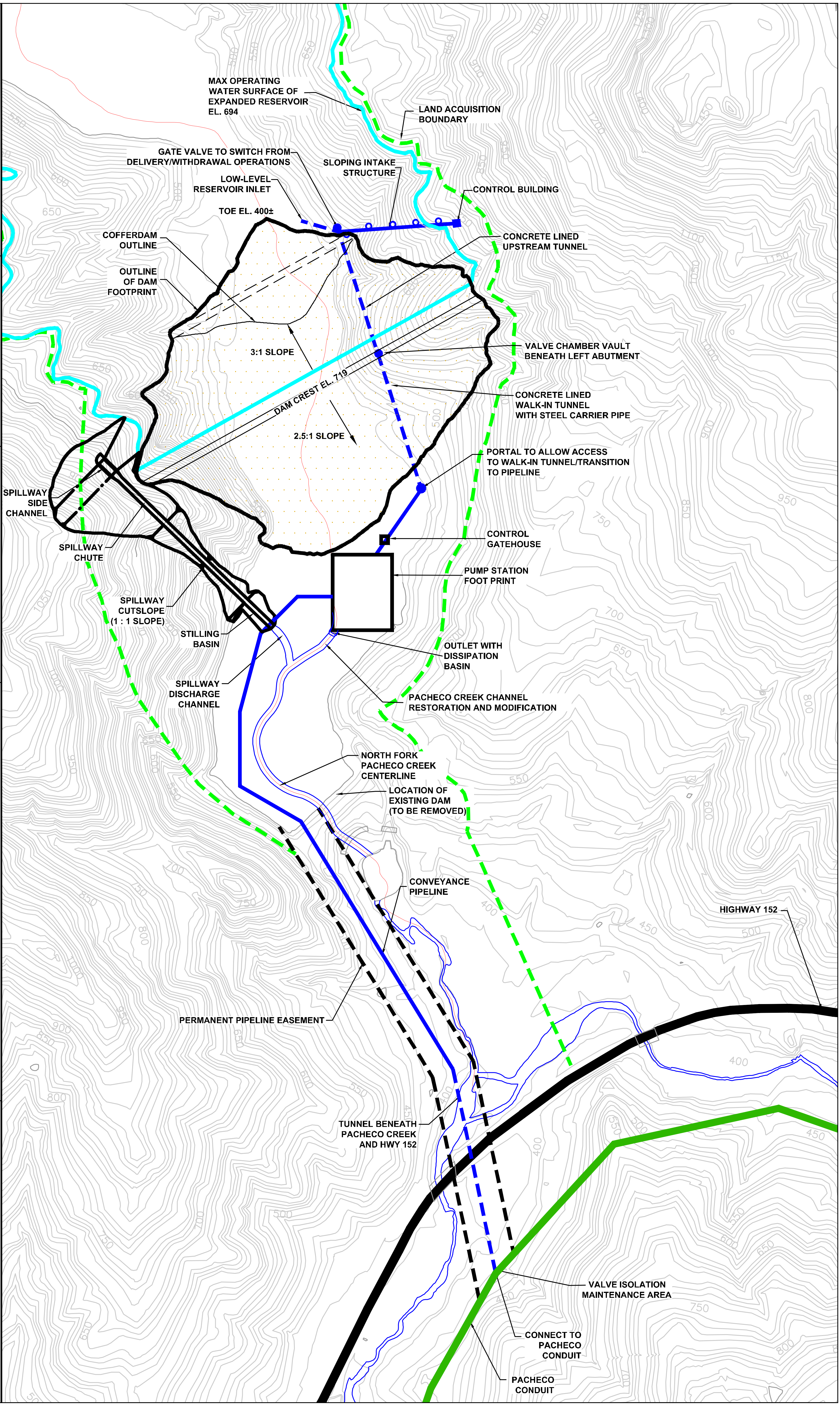
0 1.5 3 6 Miles

Prepared: July, 2017
Projection: CA SP III NAD83
Background: DeLorme (Copyright © 2015)
G:\SCVWD_MXDs_Reports\Prop1\Project_Overview_20170725.mxd

Exhibit 1

PROJECT LOCATION AND VICINITY

PACHECO RESERVOIR EXPANSION PROJECT
AUGUST 2017



Stantec

N

SCALE: 1"=500'

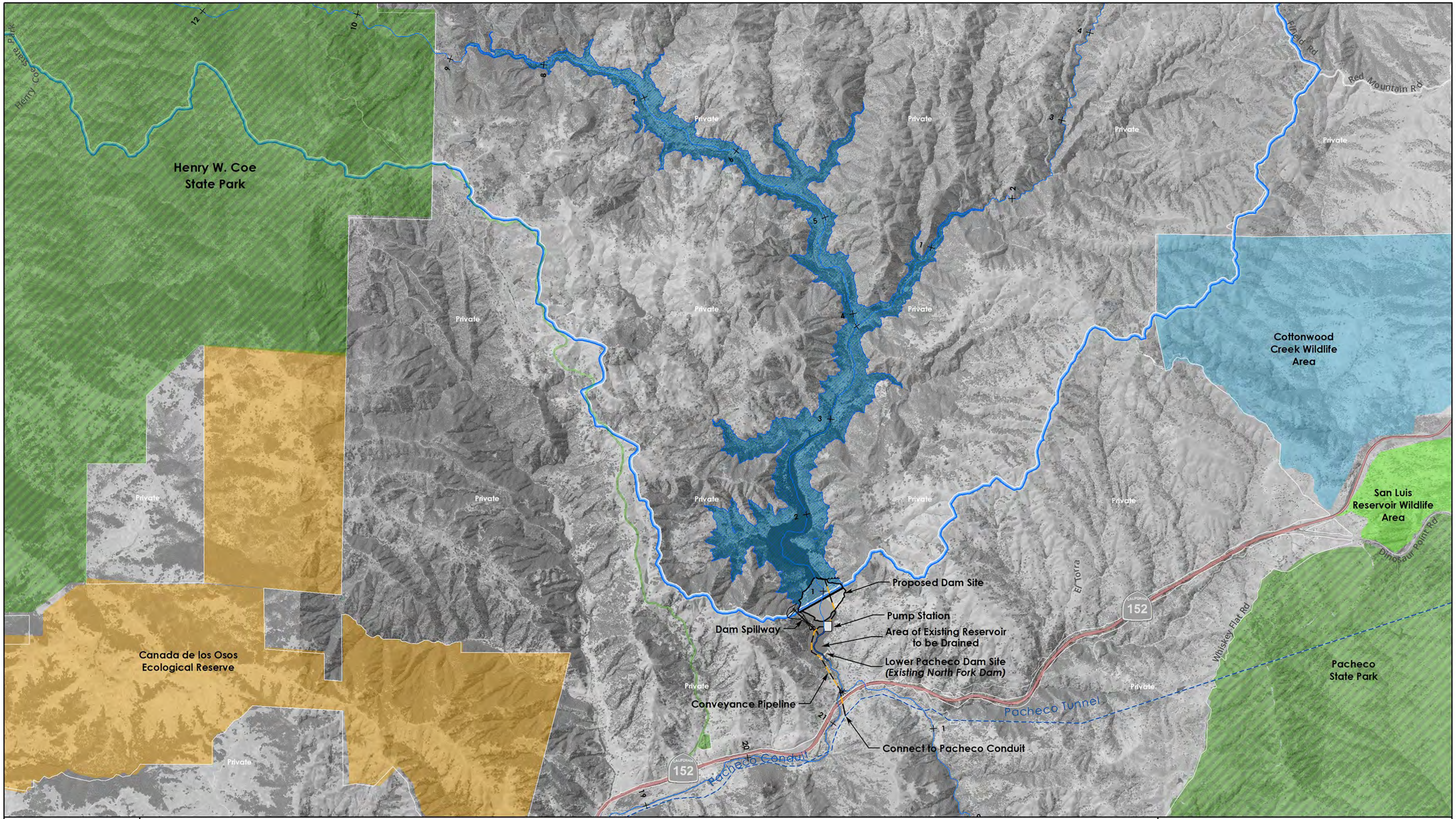
0 500

Santa Clara Valley Water District

- MAX. WATER SURFACE ELEVATION OF 694 FT
- LAND ACQUISITION BOUNDARY
- PERMANENT PIPELINE EASEMENT BOUNDARY
- EXISTING PACHECO CONDUIT
- PACHECO AND NORTH FORK PACHECO CREEK
- PACHECO AND NORTH FORK PACHECO CREEK

Exhibit 2

PROJECT SITE FEATURES
PACHECO RESERVOIR EXPANSION PROJECT
AUGUST 2017



Santa Clara Valley Water District

Stantec

- Existing Tunnel/Pipeline
- Proposed Tunnel/Pipeline
- ☐ Proposed Dam Footprint
- ▨ Potential Reservoir Footprint
- ☐ Proposed Dam Contributing Watershed
- ▨ Private Parcel

State Lands

- ▨ State Park
- ▨ Canada de los Osos Ecological Reserve
- ▨ Cottonwood Creek Wildlife Area
- ▨ San Luis Reservoir Wildlife Area

N

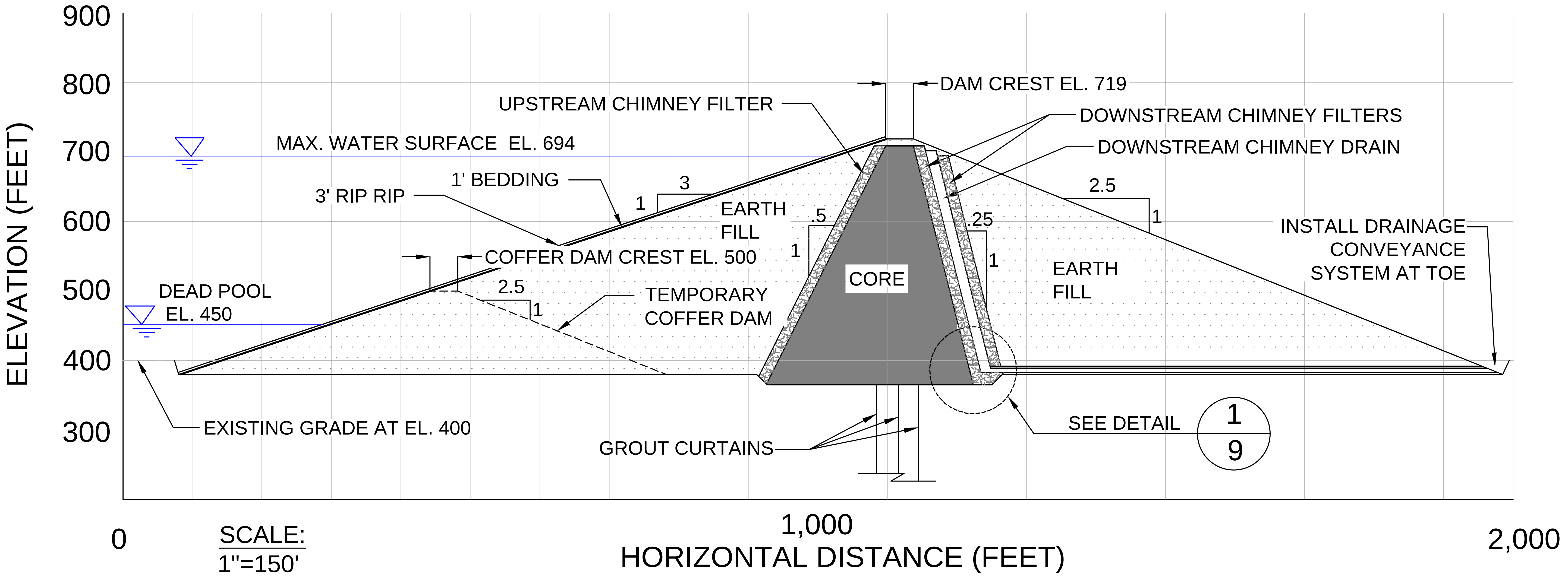
0 2,000 4,000 6,000 Feet

Prepared: July, 2017
Projection: UTM Zone 10 NAD83
Parcel Data: Santa Clara Co. Assessor (2014)
Cons. Easement: TNC (2017)
State Lands: CaSIL (2016)
Background: NAIP (2016)
G:\SCVWD_MXDs_Reports\Prop1\ReservoirArea_AltA_20170725.mxd

Exhibit 3

EXPANDED RESERVOIR FOOTPRINT

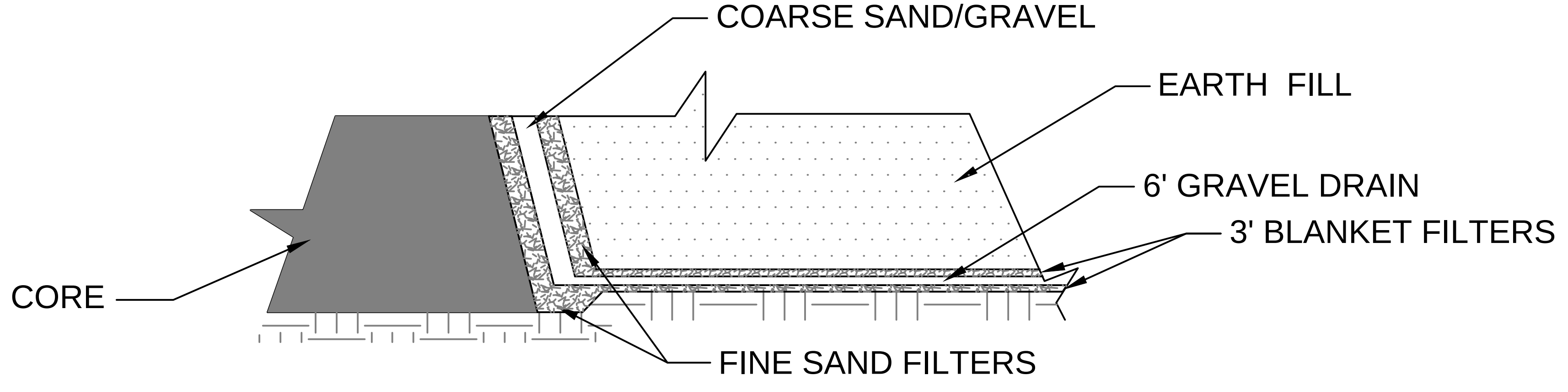
PACHECO RESERVOIR EXPANSION PROJECT
AUGUST 2017



SCALE:
1"=150'

0 75 150

CROSS SECTION OF ZONED DAM EMBANKMENT



DETAIL 1/9

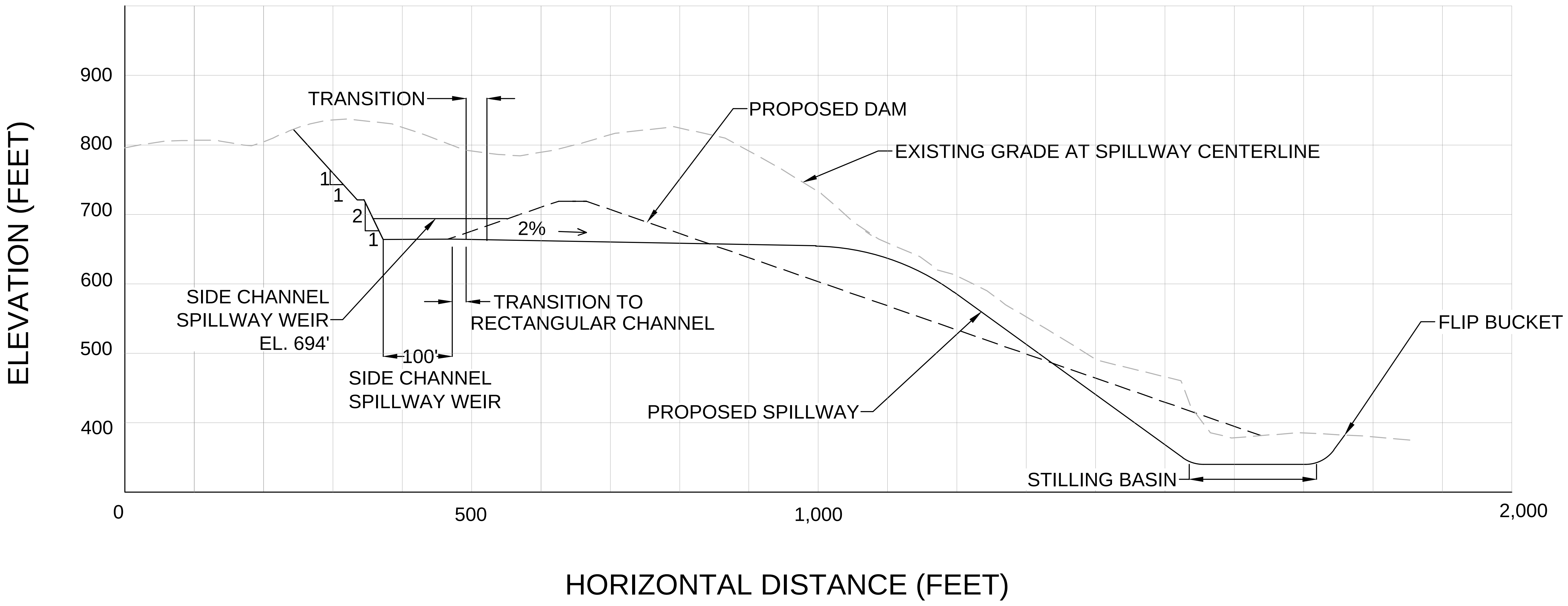
NTS

Stantec

Santa Clara Valley Water District

Exhibit 4

CROSS SECTION OF DAM EMBANKMENT
PACHECO RESERVOIR EXPANSION PROJECT
AUGUST 2017



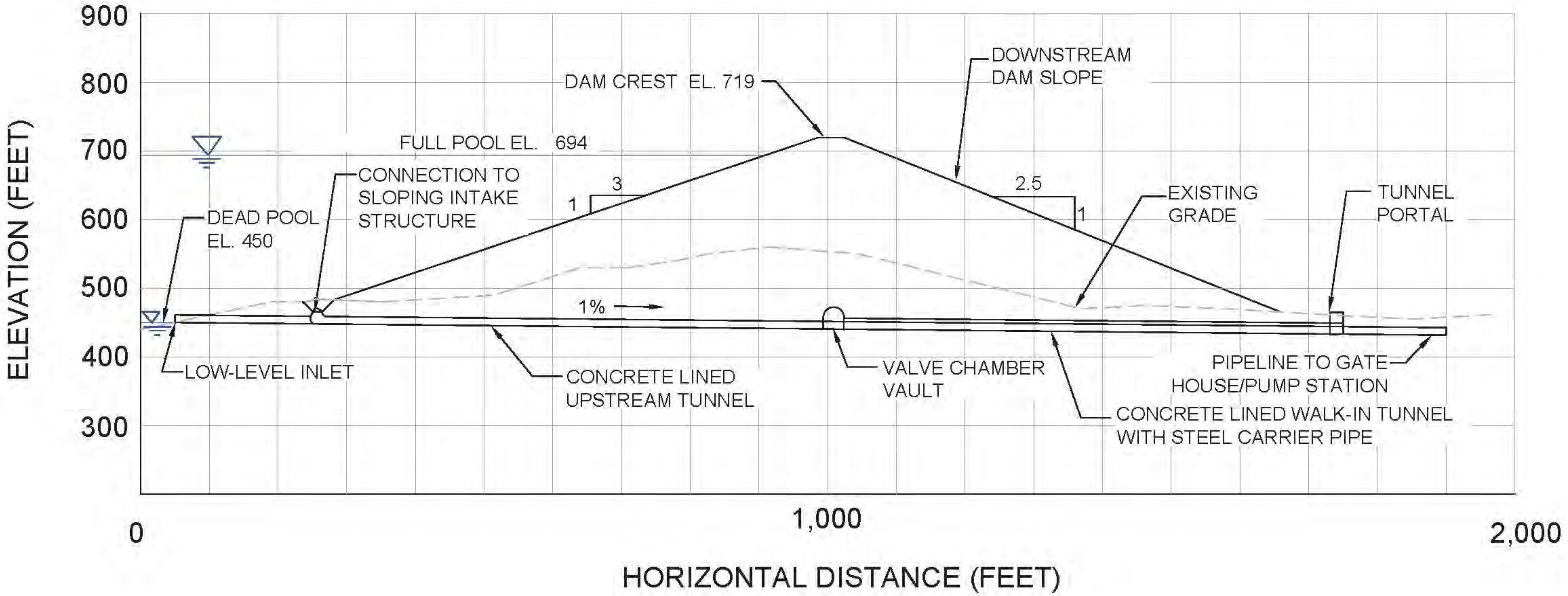
Stantec

SCALE:
1"=150'
0 75 150

Santa Clara Valley Water District

Exhibit 5

SPILLWAY PROFILE
PACHECO RESERVOIR EXPANSION PROJECT
AUGUST 2017



PROFILE - OUTLET TUNNEL

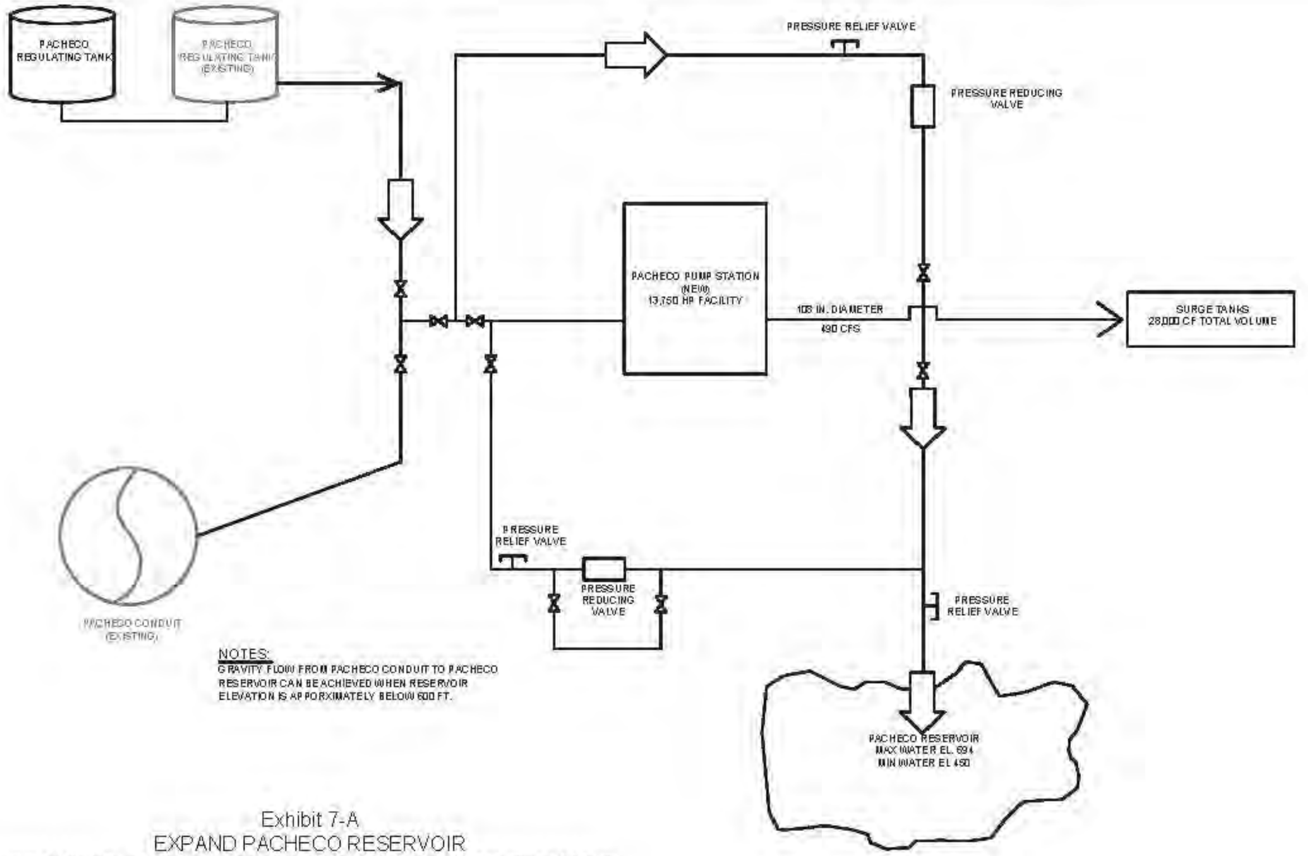
Stantec

SCALE:
1"=150'
0 75 150

Santa Clara Valley Water District

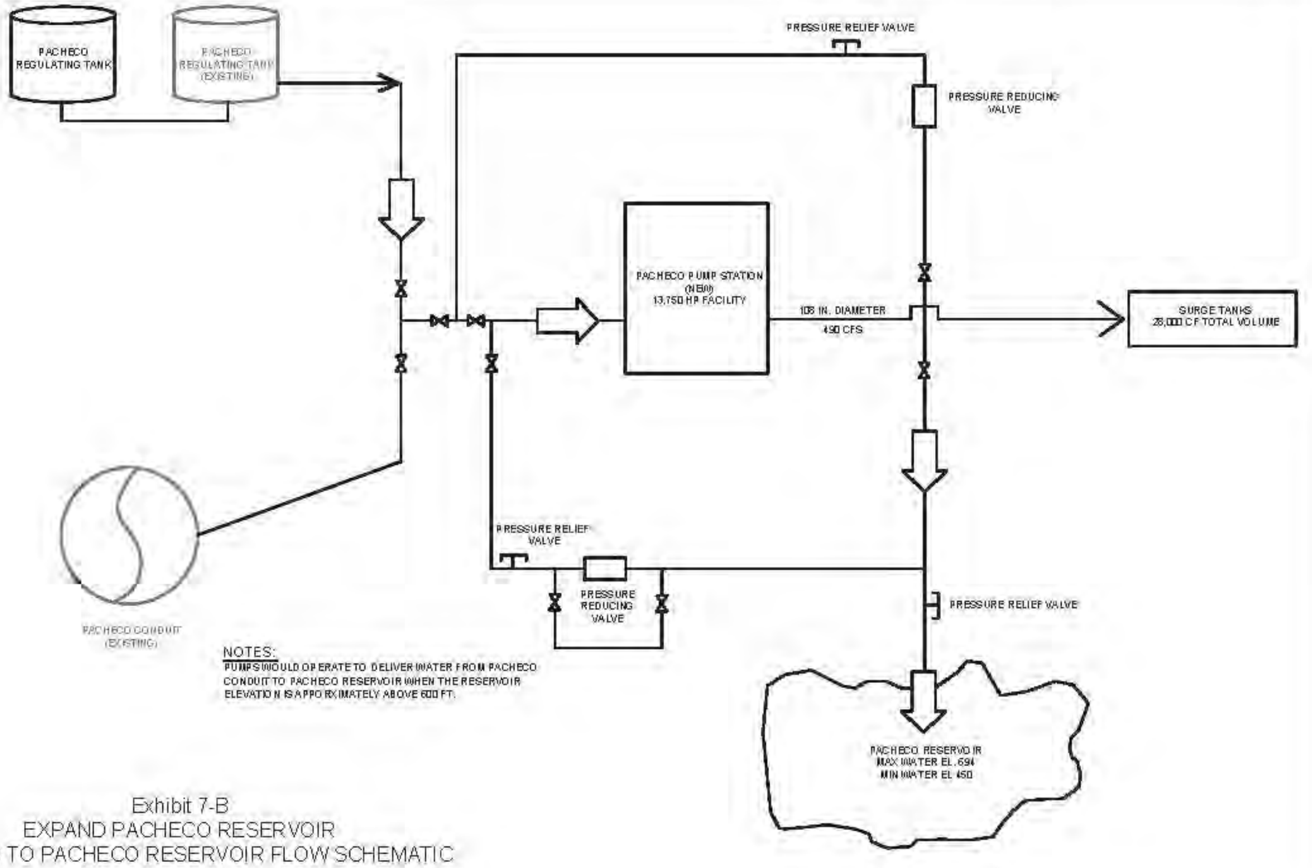
Exhibit 6

OUTLET TUNNEL PROFILE
PACHECO RESERVOIR EXPANSION PROJECT
AUGUST 2017



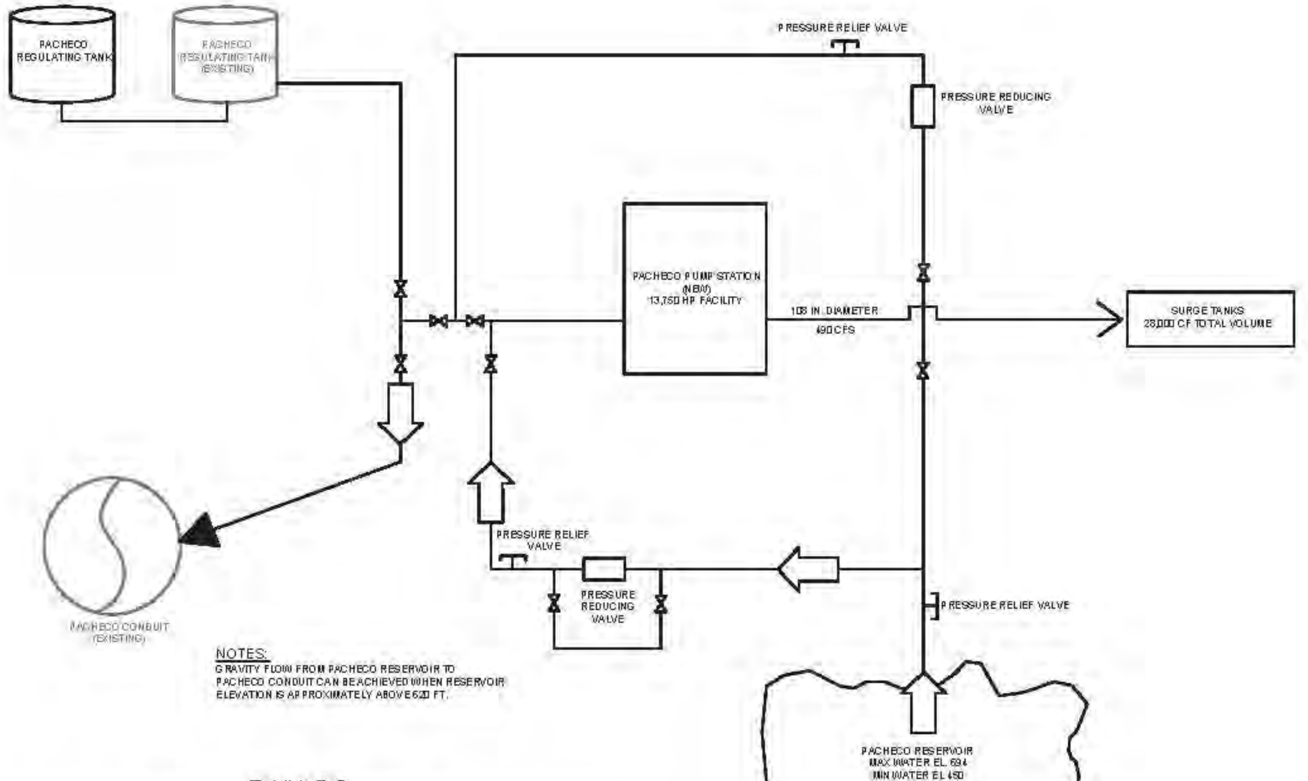
NOTES:
GRAVITY FLOW FROM PACHECO CONDUIT TO PACHECO RESERVOIR CAN BE ACHIEVED WHEN RESERVOIR ELEVATION IS APPORXIMATELY BELOW 600 FT.

Exhibit 7-A
EXPAND PACHECO RESERVOIR
GRAVITY FLOW TO PACHECO RESERVOIR FLOW SCHEMATIC



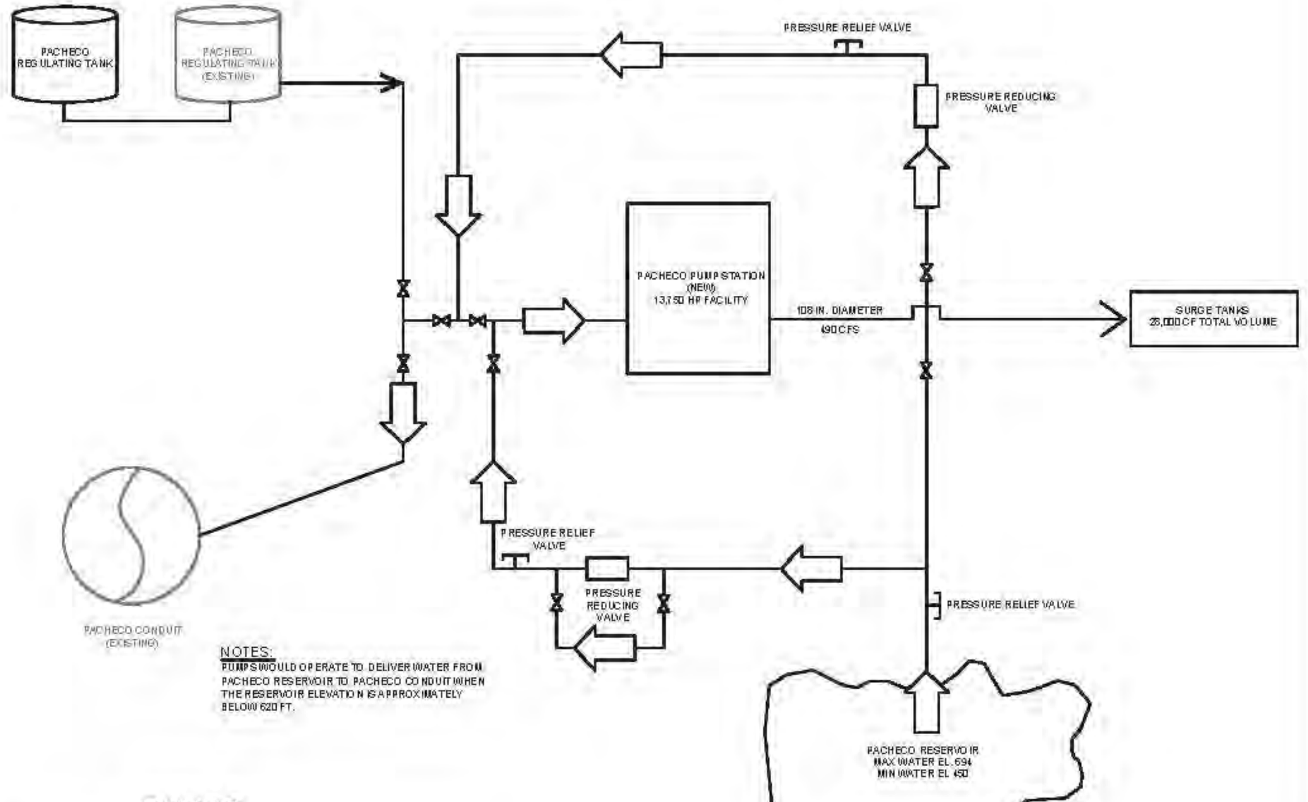
NOTES:
PUMPS WOULD OPERATE TO DELIVER WATER FROM PACHECO CONDUIT TO PACHECO RESERVOIR WHEN THE RESERVOIR ELEVATION IS APPORXIMATELY ABOVE 600 FT.

Exhibit 7-B
EXPAND PACHECO RESERVOIR
PUMPING TO PACHECO RESERVOIR FLOW SCHEMATIC



NOTES:
GRAVITY FLOW FROM PACHECO RESERVOIR TO PACHECO CONDUIT CAN BE ACHIEVED WHEN RESERVOIR ELEVATION IS APPROXIMATELY ABOVE 620 FT.

Exhibit 7-C
EXPAND PACHECO RESERVOIR
GRAVITY FLOW FROM PACHECO RESERVOIR FLOW SCHEMATIC



NOTES:
PUMPS WOULD OPERATE TO DELIVER WATER FROM PACHECO RESERVOIR TO PACHECO CONDUIT WHEN THE RESERVOIR ELEVATION IS APPROXIMATELY BELOW 620 FT.

Exhibit 7-D
EXPAND PACHECO RESERVOIR
PUMPING FROM PACHECO RESERVOIR FLOW SCHEMATIC

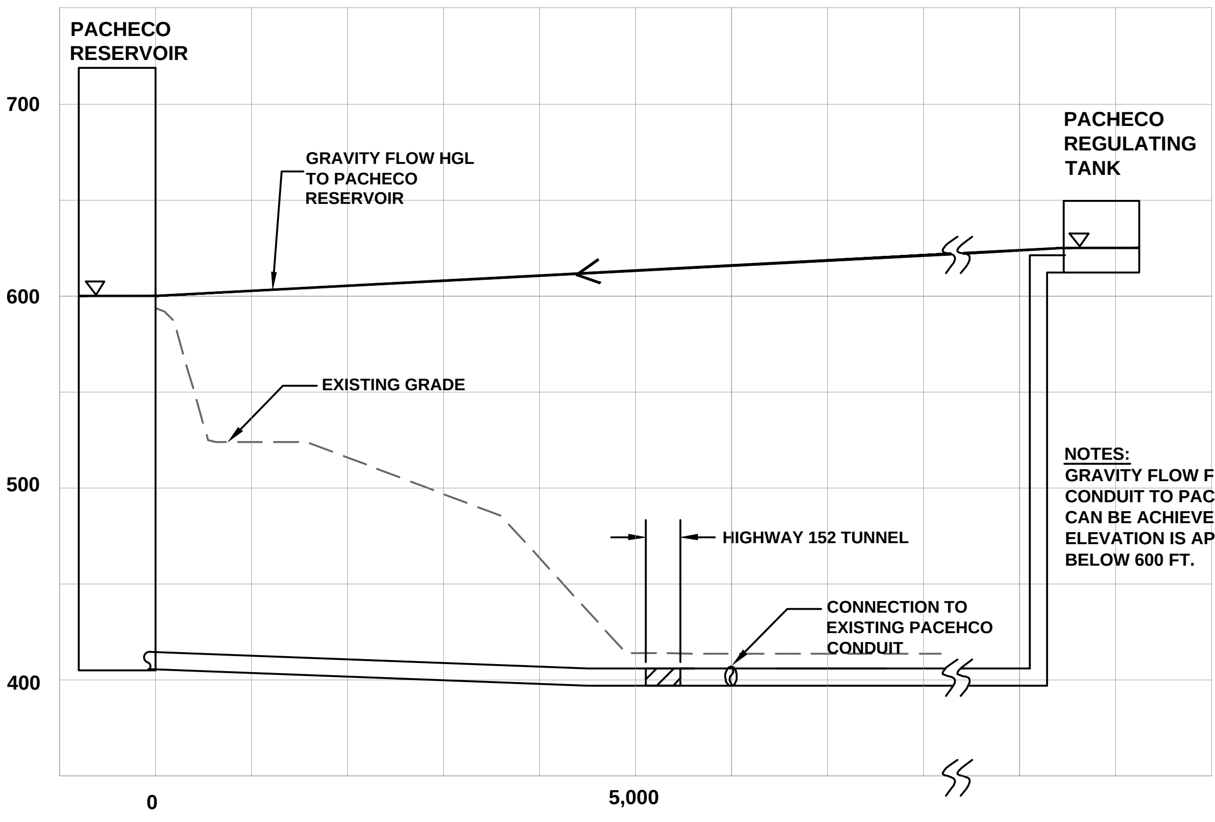
Stantec

NTS

Santa Clara Valley Water District

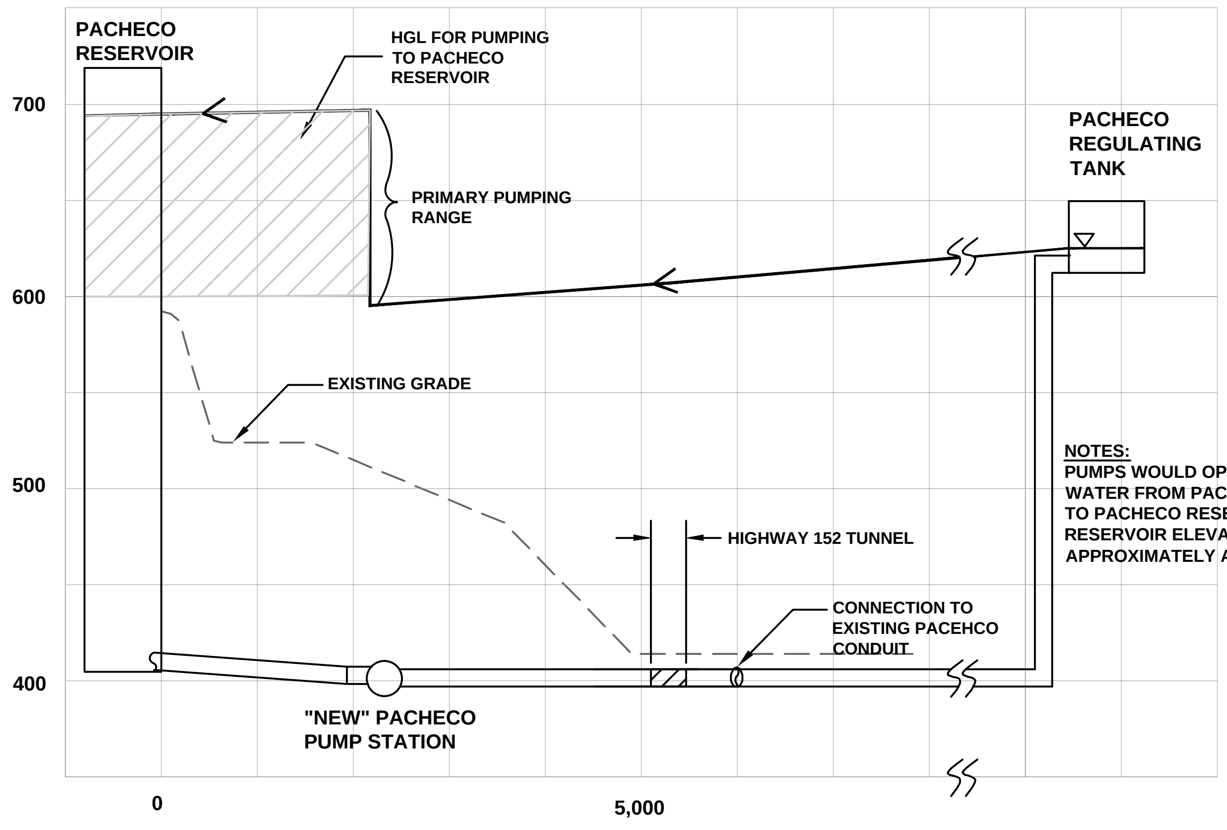
Exhibit 7

Pump/Gravity Flow Diagram
PACHECO RESERVOIR EXPANSION PROJECT
AUGUST 2017



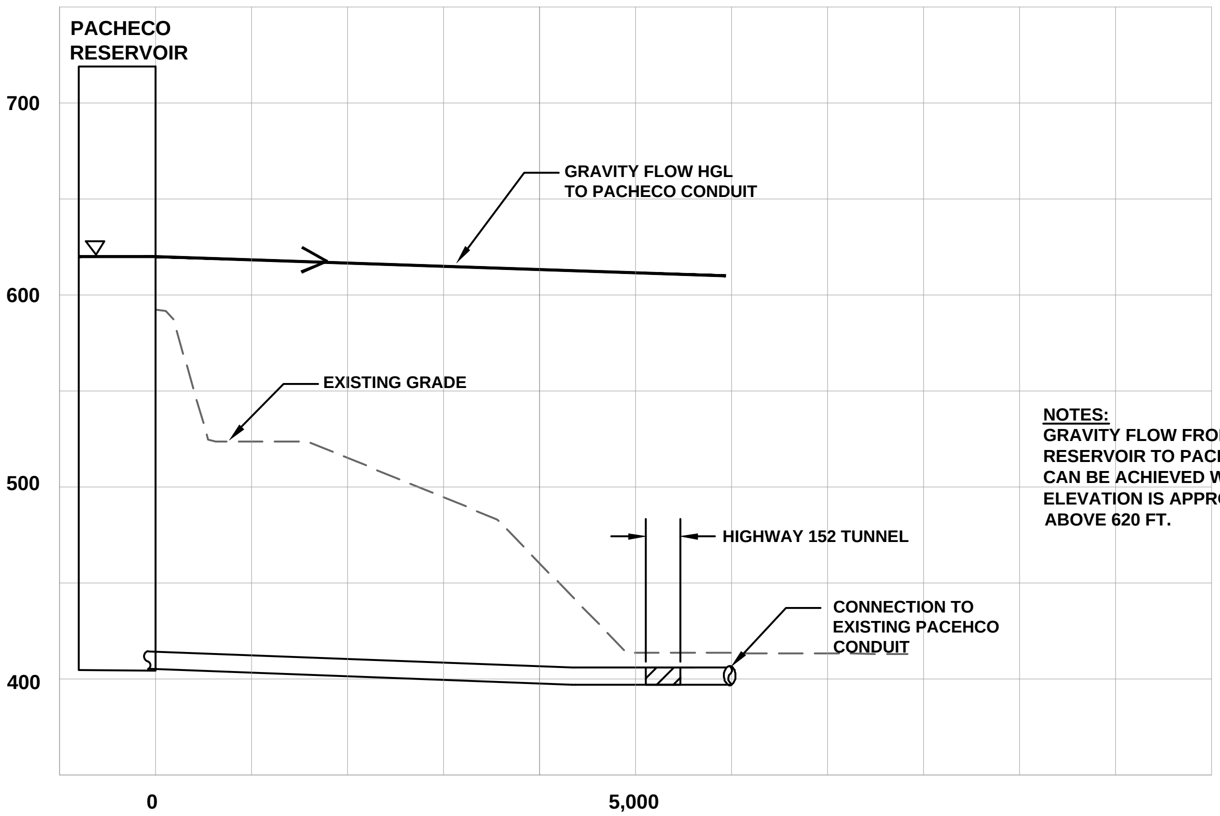
NOTES:
GRAVITY FLOW FROM PACHECO CONDUIT TO PACHECO RESERVOIR CAN BE ACHIEVED WHEN RESERVOIR ELEVATION IS APPORXIMATELY BELOW 600 FT.

GRAVITY FLOW TO PACHECO RESERVOIR



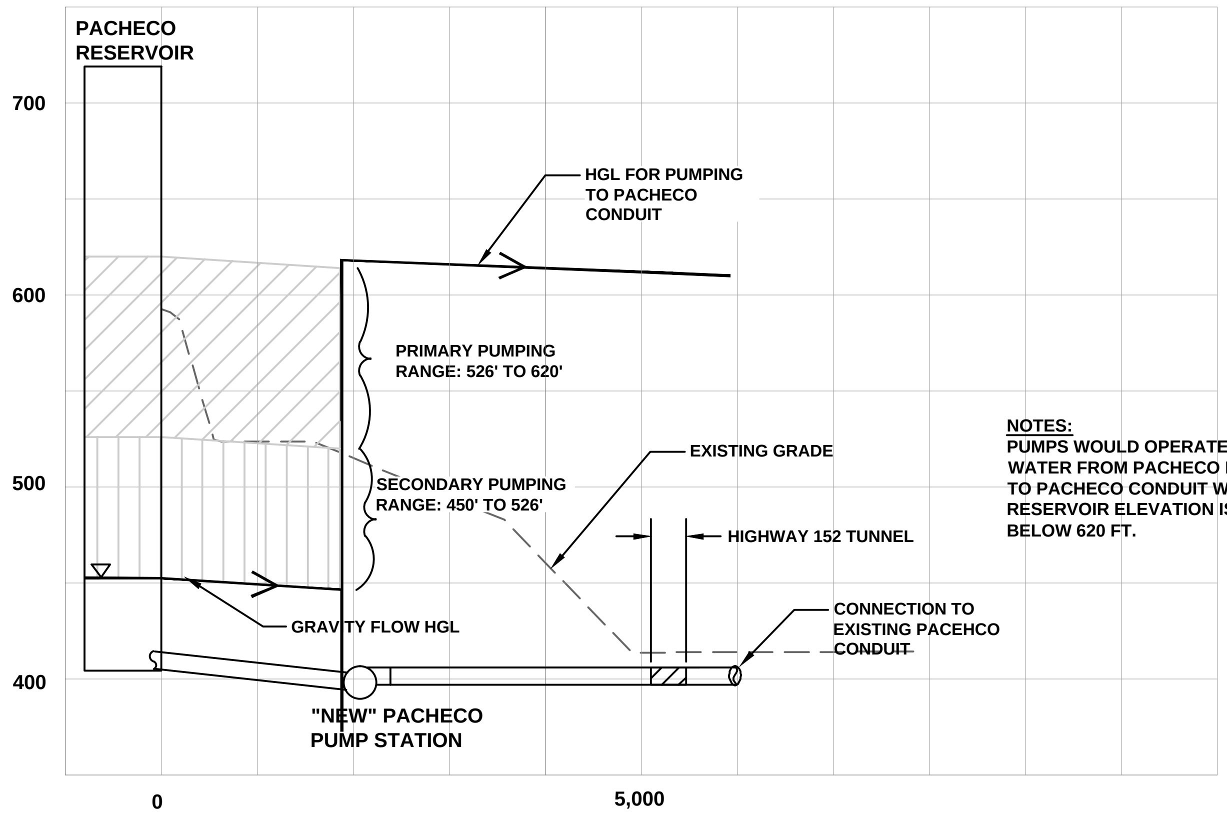
NOTES:
PUMPS WOULD OPERATE TO DELIVER WATER FROM PACHECO CONDUIT TO PACHECO RESERVOIR WHEN THE RESERVOIR ELEVATION IS APPROXIMATELY ABOVE 600 FT.

PUMP TO PACHECO RESERVOIR



NOTES:
GRAVITY FLOW FROM PACHECO RESERVOIR TO PACHECO CONDUIT CAN BE ACHIEVED WHEN RESERVOIR ELEVATION IS APPROXIMATELY ABOVE 620 FT.

GRAVITY FLOW TO PACHECO CONDUIT



NOTES:
PUMPS WOULD OPERATE TO DELIVER WATER FROM PACHECO RESERVOIR TO PACHECO CONDUIT WHEN THE RESERVOIR ELEVATION IS APPROXIMATELY BELOW 620 FT.

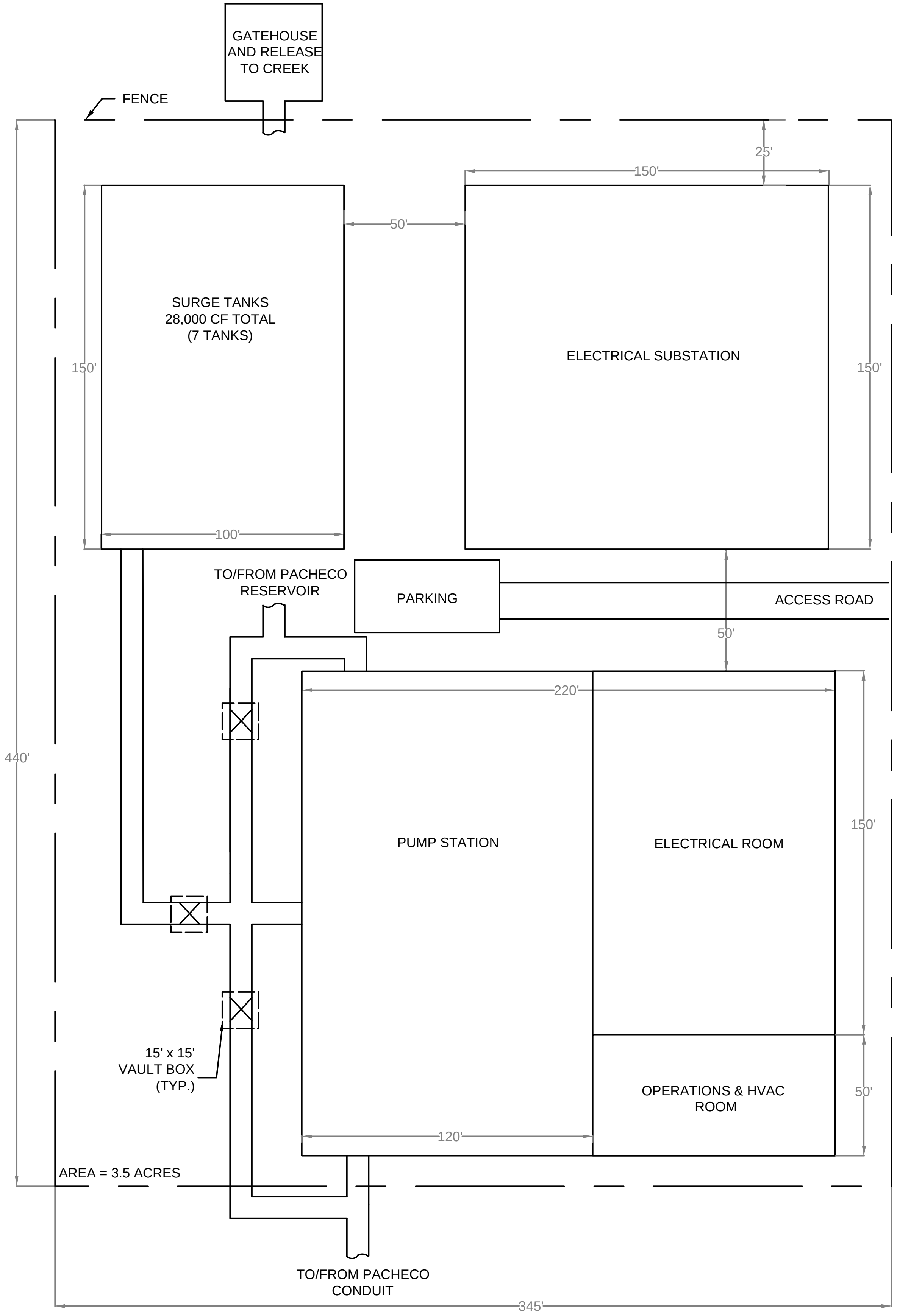
PUMP TO PACHECO CONDUIT

Stantec

SCALE
HOR: 1" = 2,000'
VERT: 1" = 100'

Santa Clara Valley Water District

Exhibit 8
PUMP/GRAVITY HYDRAULIC PROFILE
PACHECO RESERVOIR EXPANSION PROJECT
AUGUST 2017



NOTES:
1) SURGE ANALYSIS WILL BE PERFORMED TO DETERMINE THE SIZE AND NUMBER OF SURGE TANKS REQUIRED, DURING SUBSEQUENT STUDIES

Stantec

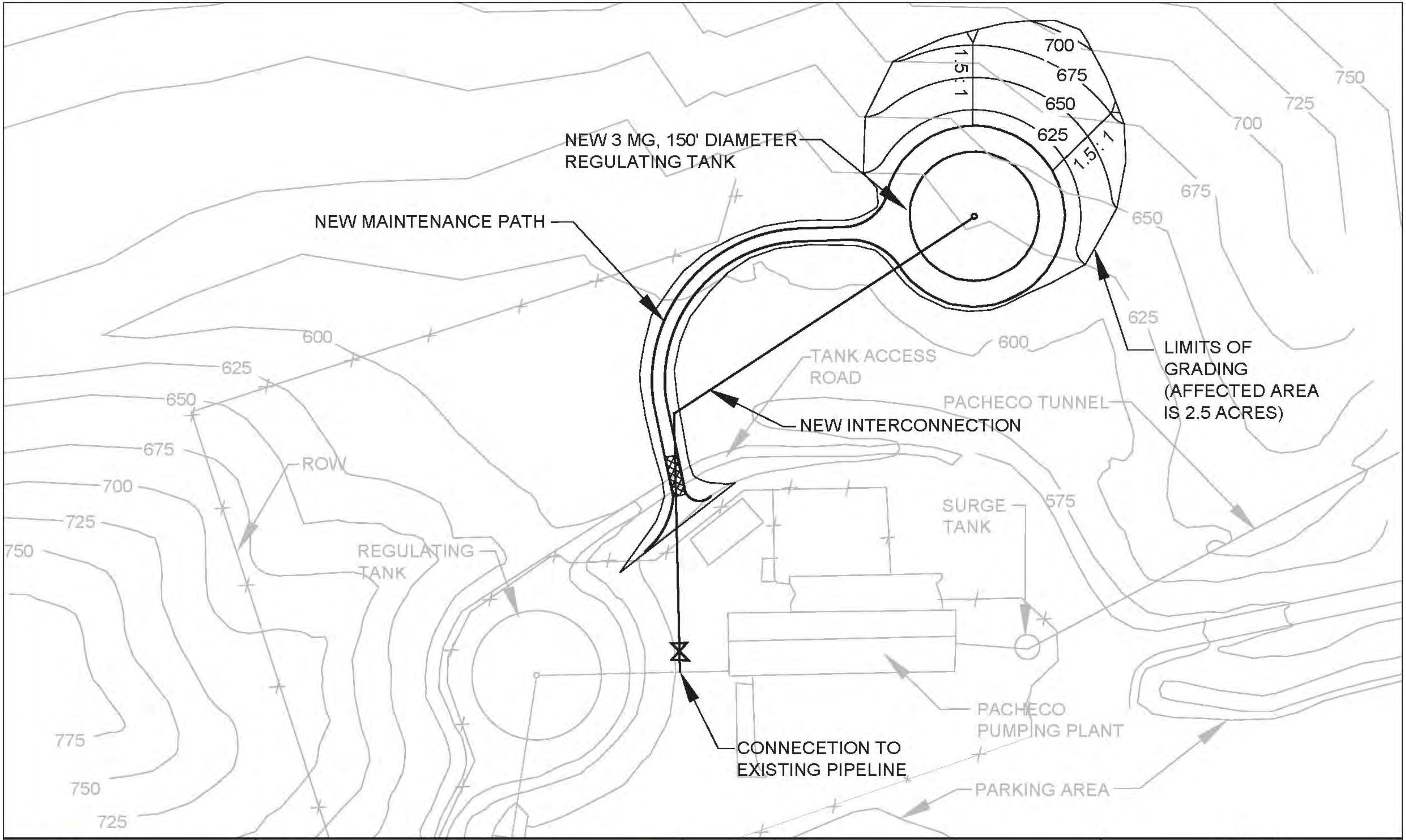
N

SCALE
1" = 60'
0 30 60

Santa Clara Valley Water District

Exhibit 9

PUMP STATION LAYOUT
PACHECO RESERVOIR EXPANSION PROJECT
AUGUST 2017



Stantec

N

SCALE 1" = 100'
0 100

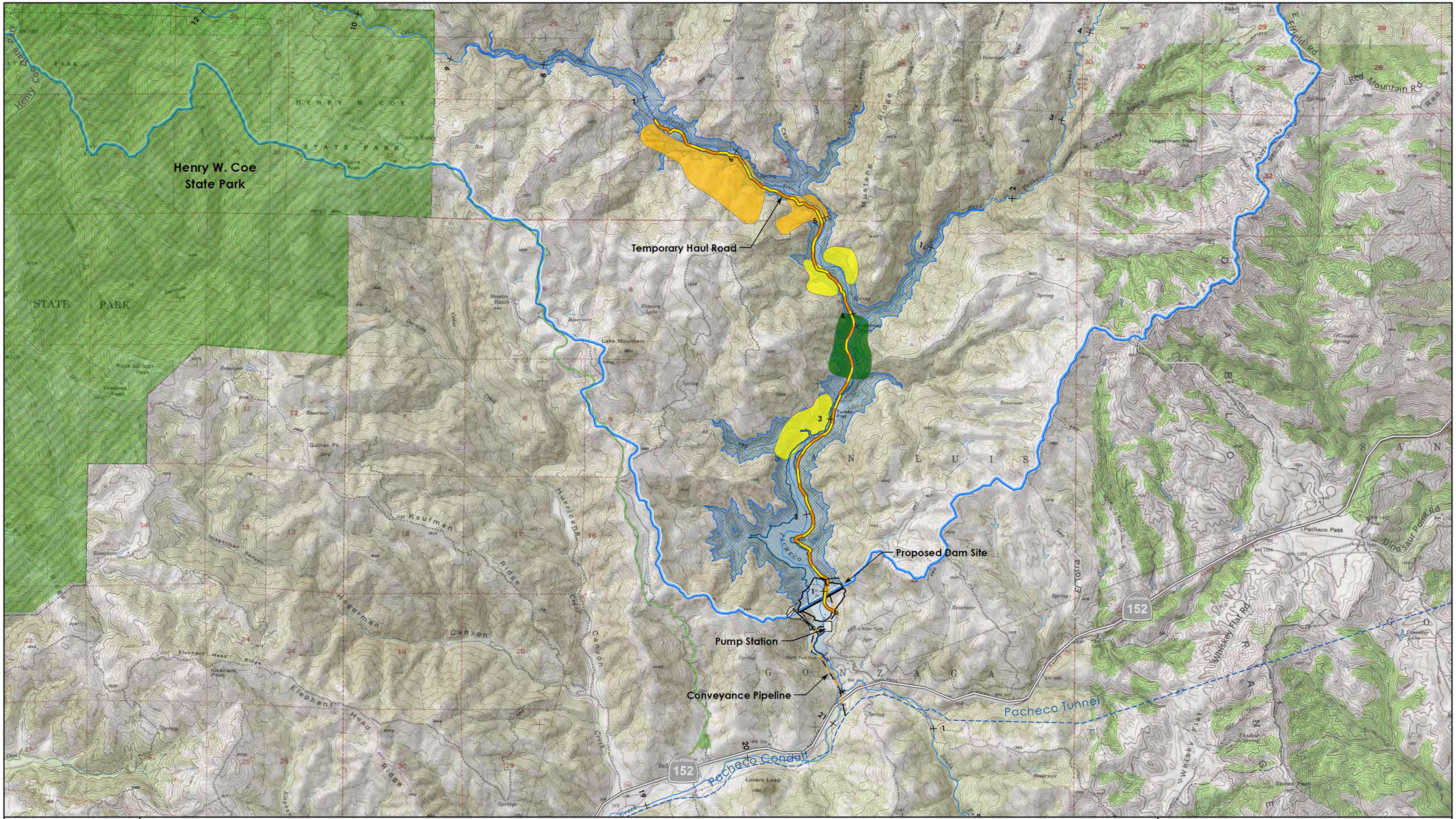
Santa Clara Valley Water District

LEGEND

EXISTING FEATURES
NEW REGULATING TANK & MAINTENANCE PATH
NEW CONTOURS

Exhibit 10

REGULATING TANK at Pacheco Pumping Plant
PACHECO RESERVOIR EXPANSION PROJECT
AUGUST 2017



Santa Clara Valley Water District

Stantec

- - - Existing Tunnel/Pipeline
- - - Proposed Tunnel/Pipeline
▬ Temporary Haul Road
☐ Proposed Dam Footprint
▨ Potential Reservoir Footprint
▨ Existing Pacheco Lake above Proposed Dam
☐ Contributing Watershed
▨ Henry W. Coe State Park

Borrow Areas

🟧	Potential Impervious Zone Source *(Landslides and Franciscan Melange)*
🟨	Potential Random Zone Source
🟩	Potential Rock Source

N

0 2,000 4,000 6,000 Feet

Prepared: July, 2017
Projection: CA SP III NAD83
Lanslide Data: Cotton (1972)
Borrow Areas: Wahler (1993)
Background: USGS 7.5' Topo
G:\SCVWD_MXDs_Reports\Prop1\ReservoirBorrowAreas_AltA_20170725.mxd

Exhibit 11

BORROW AREAS

PACHECO RESERVOIR EXPANSION PROJECT
AUGUST 2017

Exhibit 12

CONSTRUCTION ACCESS AND STAGING AREAS
PACHECO RESERVOIR EXPANSION PROJECT
AUGUST 2017

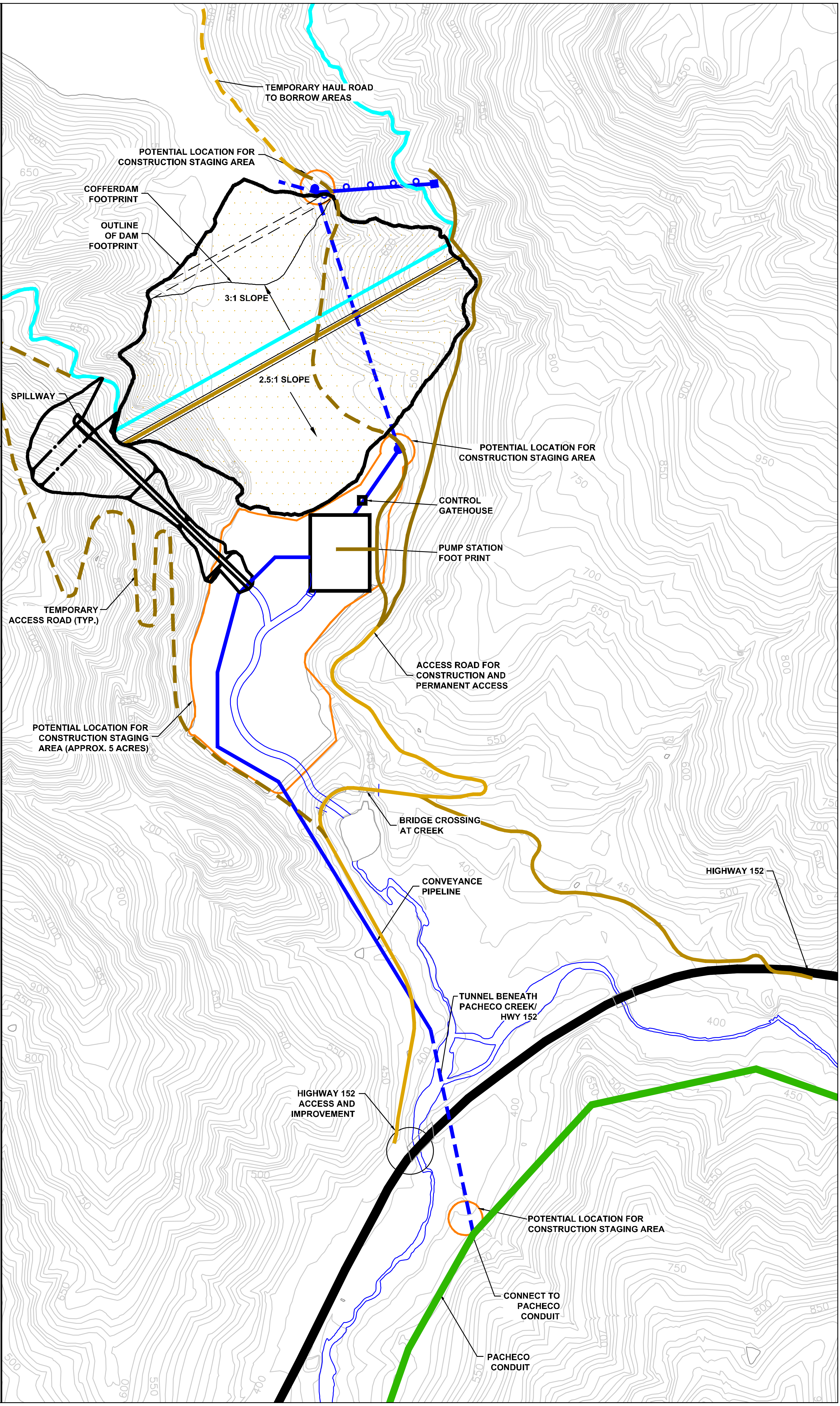
Santa Clara Valley Water District

Stantec

N

SCALE:
1"=500'
0 500

- 🟩 EXISTING PACHECO CONDUIT
- IMPROVEMENT OF EXISTING ACCESS ROAD (TEMPORARY)
- NEW ACCESS ROAD (TEMPORARY)
- MAX. WATER SURFACE ELEVATION OF 694 FT
- IMPROVEMENT OF EXISTING ACCESS ROAD (PERMANENT)
- NEW ACCESS ROAD (PERMANENT)
- POTENTIAL STAGING AREAS



Attachment C

Appraisal-Level Cost Estimates

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BUREAU OF RECLAMATION

ESTIMATE WORKSHEET

SHEET 1 OF 3

FEATURE: Lower Intake 4A (Tunnel)

PROJECT: San Luis Reservoir Low Point Improvements

WOID:

ESTIMATE LEVEL: Appraisal

REGION:

UNIT PRICE LEVEL: March 2011 (Base) Indexed to April 2018

FILE: #N/A

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	Contract Cost		Contingency Cost	Field Cost
Property Class 01 - Reservoirs and Dams							
Identified Property 01 - San Luis Reservoir							
140		Roads and Road Structures		$18,267,000		$4,567,000	$22,833,000
152		Waterways		$509,436,000		$127,359,000	$636,795,000
153		Waterway Structures		$85,244,000		$21,311,000	$106,555,000
199		Miscellaneous Installed Equipment		$6,089,000		$1,522,000	$7,611,000
		SUBTOTALS		$619,036,000		$154,759,000	
		TOTAL FIELD COST					$773,794,000
Indirect Costs							
		Program Cost (25%)					$193,449,000
		TOTAL INDIRECT COSTS					$193,449,000
		TOTAL PROJECT COST					$968,000,000

QUANTITIES		PRICES	
BY	**CHECKED**	**BY** J. Nghiem	**CHECKED** B. Brick
DATE PREPARED	**PEER REVIEW / DATE**	**DATE PREPARED** 03/15/19	**PEER REVIEW / DATE** 03/18/19

BUREAU OF RECLAMATION

ESTIMATE WORKSHEET

SHEET 2 OF 3

FEATURE: Lower Intake 4A (Tunnel)

PROJECT: San Luis Reservoir Low Point Improvements

WOID:

ESTIMATE LEVEL: Appraisal

REGION:

UNIT PRICE LEVEL: March 2011 (Base) Indexed to April 2018

FILE: #N/A

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE (4/2018)	AMOUNT
Property Class 01 - Reservoirs and Dams							
Identified Property 01 - San Luis Reservoir							
140		Roads and Road Structures					
	1	Site Access Improvements		1	ls	$14,137,984	$14,137,984
		Subtotal					$14,137,984
	2	Mobilization (7%)					$989,659
		Subtotal with Mobilization					$15,127,643
	3	Environmental Mitigation (5%)					$756,382
	4	Design Contingencies (15% of all above)					$2,382,604
		Contract Cost					$18,266,629
		Construction Contingencies (25%)					$4,566,657
		Field Cost					$22,833,286
152		Waterways					
	1	Tunnel - 156"		20,000	ft	$19,636	$392,721,786
	2	Tap to Existing Intake Structure		1	ls	$1,570,887	$1,570,887
		Subtotal					$394,292,673
	3	Mobilization (7%)					$27,600,487
		Subtotal with Mobilization					$421,893,160
	4	Environmental Mitigation (5%)					$21,094,658
	5	Design Contingencies (15% of all above)					$66,448,173
		Contract Cost					$509,435,991
		Construction Contingencies (25%)					$127,358,998
		Field Cost					$636,794,989

QUANTITIES		PRICES	
BY	**CHECKED**	**BY** J. Nghiem	**CHECKED** B. Brick
DATE PREPARED	**PEER REVIEW / DATE**	**DATE PREPARED** 03/15/19	**PEER REVIEW / DATE** 03/18/19

BUREAU OF RECLAMATION

ESTIMATE WORKSHEET

FEATURE: Lower Intake 4A (Tunnel)	**PROJECT:** San Luis Reservoir Low Point Improvements
	WOID:
	ESTIMATE LEVEL: Appraisal
	REGION:
	UNIT PRICE LEVEL: March 2011 (Base) Indexed to April 2018
	FILE: #N/A

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE (4/2018)	AMOUNT
Property Class 01 - Reservoirs and Dams							
Identified Property 01 - San Luis Reservoir							
153		Waterway Structures					
	1	TBM - Launch Shaft		300	ft	$94,253	$28,275,969
	2	Intake Structure		1	ls	$6,283,549	$6,283,549
	3	TBM - Temporary Retrieval Shaft		1	ls	$31,417,743	$31,417,743
		Subtotal					$65,977,260
	4	Mobilization (7%)					$4,618,408
		Subtotal with Mobilization					$70,595,668
	5	Environmental Mitigation (5%)					$3,529,783
	6	Design Contingencies (15% of all above)					$11,118,818
		Contract Cost					$85,244,269
		Construction Contingencies (25%)					$21,311,067
		Field Cost					$106,555,337
199		Miscellaneous Installed Equipment					
	1	Hypolimnetic Aeration System		1	ls	$4,712,661	$4,712,661
		Subtotal					$4,712,661
	2	Mobilization (7%)					$329,886
		Subtotal with Mobilization					$5,042,548
	3	Environmental Mitigation (5%)					$252,127
	4	Design Contingencies (15% of all above)					$794,201
		Contract Cost					$6,088,876
		Construction Contingencies (25%)					$1,522,219
		Field Cost					$7,611,095

QUANTITIES		PRICES	
BY	**CHECKED**	**BY** J. Nghiem	**CHECKED** B. Brick
DATE PREPARED	**PEER REVIEW / DATE**	**DATE PREPARED** 03/15/19	**PEER REVIEW / DATE** 03/18/19

BUREAU OF RECLAMATION

ESTIMATE WORKSHEET

SHEET 1 OF 3

FEATURE: **Lower Intake 4B (Pipeline)**	**PROJECT:** **San Luis Reservoir Low Point Improvements**
	WOID:
	ESTIMATE LEVEL: **Appraisal**
	REGION:
	UNIT PRICE LEVEL:March 2011 (Base) Indexed to April 2018
	FILE: #N/A

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	Contract Cost		Contingency Cost	Field Cost
Property Class 01 - Reservoirs and Dams							
Identified Property 01 - San Luis Reservoir							
140		Roads and Road Structures		$18,267,000		$4,567,000	$22,833,000
152		Waterways		$517,554,000		$129,389,000	$646,943,000
153		Waterway Structures		$24,356,000		$6,089,000	$30,444,000
199		Miscellaneous Installed Equipment		$6,089,000		$1,522,000	$7,611,000
		SUBTOTALS		$566,266,000		$141,567,000	
		TOTAL FIELD COST					$707,831,000
Indirect Costs							
		Program Cost (25%)					$176,958,000
		TOTAL INDIRECT COSTS					$176,958,000
		TOTAL PROJECT COST					$885,000,000

QUANTITIES		**PRICES**	
BY	**CHECKED**	**BY** J. Nghiem	**CHECKED** B. Brick
DATE PREPARED	**PEER REVIEW / DATE**	**DATE PREPARED** 03/15/19	**PEER REVIEW / DATE** 03/18/19

BUREAU OF RECLAMATION

ESTIMATE WORKSHEET

SHEET 2 OF 3

FEATURE: Lower Intake 4B (Pipeline)	**PROJECT:** San Luis Reservoir Low Point Improvements
	WOID:
	ESTIMATE LEVEL: Appraisal
	REGION:
	UNIT PRICE LEVEL: March 2011 (Base) Indexed to April 2018
	FILE: #N/A

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE (4/2018)	AMOUNT
Property Class 01 - Reservoirs and Dams							
Identified Property 01 - San Luis Reservoir							
140		Roads and Road Structures					
	1	Site Access Improvements		1	ls	$14,137,984	$14,137,984
		Subtotal					$14,137,984
	2	Mobilization (7%)					$989,659
		Subtotal with Mobilization					$15,127,643
	3	Environmental Mitigation (5%)					$756,382
	4	Design Contingencies (15% of all above)					$2,382,604
		Contract Cost					$18,266,629
		Construction Contingencies (25%)					$4,566,657
		Field Cost					$22,833,286
152		Waterways					
	1	Underwater Pipeline - 156" Diameter		20,000	ft	$11,782	$235,633,072
	2	Pipe Anchorage		1	ls	$141,379,843	$141,379,843
	3	Tap to Existing Intake Structure		1	ls	$23,563,307	$23,563,307
		Subtotal					$400,576,222
	4	Mobilization (7%)					$28,040,335.52
		Subtotal with Mobilization					$428,616,557
	5	Environmental Mitigation (5%)					$21,430,827.86
	6	Design Contingencies (15% of all above)					$67,507,108
		Contract Cost					$517,554,493
		Construction Contingencies (25%)					$129,388,623.19
		Field Cost					$646,943,116

QUANTITIES		PRICES	
BY	**CHECKED**	**BY** J. Nghiem	**CHECKED** B. Brick
DATE PREPARED	**PEER REVIEW / DATE**	**DATE PREPARED** 03/15/19	**PEER REVIEW / DATE** 03/18/19

BUREAU OF RECLAMATION

ESTIMATE WORKSHEET

SHEET 3 OF 3

FEATURE: Lower Intake 4B (Pipeline)	**PROJECT:** San Luis Reservoir Low Point Improvements
	WOID:
	ESTIMATE LEVEL: Appraisal
	REGION:
	UNIT PRICE LEVEL: March 2011 (Base) Indexed to April 2018
	FILE: #N/A

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE (4/2018)	AMOUNT
Property Class 01 - Reservoirs and Dams							
Identified Property 01 - San Luis Reservoir							
153		Waterway Structures					
	1	Intake Structure		1	ls	$18,850,646	$18,850,646
		Subtotal					$18,850,646
	2	Mobilization (7%)					$1,319,545
		Subtotal with Mobilization					$20,170,191
	3	Environmental Mitigation (5%)					$1,008,510
	4	Design Contingencies (15% of all above)					$3,176,805
		Contract Cost					$24,355,506
		Construction Contingencies (25%)					$6,088,876
		Field Cost					$30,444,382
199		Miscellaneous Installed Equipment					
	1	Hypolimnetic Aeration System		1	ls	$4,712,661	$4,712,661
		Subtotal					$4,712,661
	2	Mobilization (7%)					$329,886
		Subtotal with Mobilization					$5,042,548
	3	Environmental Mitigation (5%)					$252,127
	4	Design Contingencies (15% of all above)					$794,201
		Contract Cost					$6,088,876
		Construction Contingencies (25%)					$1,522,219
		Field Cost					$7,611,095

QUANTITIES		PRICES	
BY	**CHECKED**	**BY** J. Nghiem	**CHECKED** B. Brick
DATE PREPARED	**PEER REVIEW / DATE**	**DATE PREPARED** 03/15/19	**PEER REVIEW / DATE** 03/18/19

BUREAU OF RECLAMATION

ESTIMATE WORKSHEET

SHEET 1 OF 10

FEATURE: Treatment Alternative	**PROJECT:** San Luis Reservoir Low Point Improvements
	WOID:
	ESTIMATE LEVEL: Feasibility
	REGION: Mid Pacific
	UNIT PRICE LEVEL: June 2017 (Base) Indexed to April 2018
	FILE: #N/A

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	Contract Cost		Contingency Cost	Field Cost
Property Class 15 - General Property							
Identified Property 01 - Santa Teresa Water Treatment Plant							
120		Clearing Land and Right-of-Way		$1,092,000		$218,000	$1,311,000
130		Structures and Improvements		$5,086,000		$1,017,000	$6,103,000
140		Roads and Road Structures		$89,000		$18,000	$106,000
152		Waterways		$3,854,000		$771,000	$4,625,000
160		Pumps		$377,000		$75,000	$453,000
170		Electrical Equipment		$1,575,000		$315,000	$1,890,000
180		Supervisory Control & Comm. Equipment		$1,684,000		$337,000	$2,021,000
199		Miscellaneous Installed Equipment		$10,958,000		$2,192,000	$13,149,000
		TOTAL FIELD COST		$24,715,000		$4,943,000	$29,658,000
Indirect Costs							
		Program Cost (25%)					$7,415,000
		TOTAL PROJECT COST					$37,000,000

QUANTITIES		**PRICES**	
BY	**CHECKED**	**BY**	**CHECKED**
Riz Manas	Kirk Johnson	J. Nghiem	B. Brick
DATE PREPARED	**PEER REVIEW / DATE**	**DATE PREPARED**	**PEER REVIEW / DATE**
06/29/17	Bill Schilling / 06-30-17	03/15/19	03/18/19

BUREAU OF RECLAMATION

ESTIMATE WORKSHEET

SHEET 2 OF 10

FEATURE: Treatment Alternative	**PROJECT:** San Luis Reservoir Low Point Improvements	
	WOID:	**ESTIMATE LEVEL:** Feasibility
	REGION: Mid Pacific	**UNIT PRICE LEVEL:** June 2017 (Base) Indexed to April 2018
	FILE: #N/A	

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE (UPDATED 4/2018)	AMOUNT
Property Class 15 - General Property							
Identified Property 01 - Santa Teresa Water Treatment Plant							
120		Clearing Land and Right-of-Way					
	1	Quality Assurance/Quality Control		1	LS	$64,977	$64,977
	2	Scaffolding		1	LS	$83,701	$83,701
	3	Protect Existing Utilities		1	LS	$14,785	$14,785
	4	Traffic Control & SWPPP		1	LS	$101,125	$101,125
	5	Survey		1	LS	$25,482	$25,482
	6	Demolition		1	LS	$153,812	$153,812
	7	Trench Dewatering		1	LS	$14,377	$14,377
	8	Fencing		1	LS	$8,581	$8,581
	9	Drainage & Containment		1	LS	$7,392	$7,392
	10	Shutdown coordination		1	LS	$426,514	$426,514
		Subtotal					$900,747
	11	Mobilization (5%)					$45,037
	12	Environmental Mitigation (5% of all above)					$47,289
	13	Design Contingencies (10% of all above)					$99,307
		Contract Cost					$1,092,381
		Construction Contingencies (20%)					$218,476
		Field Cost					$1,310,857

QUANTITIES		PRICES	
BY	**CHECKED**	**BY**	**CHECKED**
Riz Manas	Kirk Johnson	J. Nghiem	B. Brick
DATE PREPARED	**PEER REVIEW / DATE**	**DATE PREPARED**	**PEER REVIEW / DATE**
06/29/17	Bill Schilling / 06-30-17	03/15/19	03/18/19

BUREAU OF RECLAMATION

ESTIMATE WORKSHEET

SHEET 3 OF 10

FEATURE: **Treatment Alternative**	**PROJECT:** **San Luis Reservoir Low Point Improvements**		
	WOID:	**ESTIMATE LEVEL:** **Feasibility**	
	REGION: Mid Pacific	**UNIT PRICE LEVEL: June 2017 (Base) Indexed to April 2018**	
	FILE: #N/A		

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE (UPDATED 4/2018)	AMOUNT
Property Class 15 - General Property							
Identified Property 01 - Santa Teresa Water Treatment Plant							
130		Structures and Improvements					
	1	Retaining Walls (Earthwork)		273	CY	$148	$40,383
	2	Retaining Walls (Concrete)		142	CY	$1,258	$178,637
	3	Valve Vault (Earthwork, including shoring)		347	CY	$275	$95,325
	4	Valve Vault (Concrete)		86	CY	$1,501	$129,125
	5	Flash Mix Facility & Ozone Contactor (Earthwork)		8,600	CY	$43	$370,854
	6	Flash Mix Facility (Structural)		95	CY	$3,379	$320,981
	7	Raw Water Ozone Contactor (Structural)		1,804	CY	$1,494	$2,694,460
	8	LOX Facility Expansion (Earthwork)		164	CY	$32	$5,315
	9	LOX Facility Expansion (Structural)		193	CY	$1,858	$358,597
		Subtotal					$4,193,677
	10	Mobilization (5%)					$209,684
	11	Environmental Mitigation (5% of all above)					$220,168
	12	Design Contingencies (10% of all above)					$462,353
		Contract Cost					$5,085,882
		Construction Contingencies (20%)					$1,017,176
		Field Cost					$6,103,058

QUANTITIES		PRICES	
BY Riz Manas	**CHECKED** Kirk Johnson	**BY** J. Nghiem	**CHECKED** B. Brick
DATE PREPARED 06/29/17	**PEER REVIEW / DATE** Bill Schilling / 06-30-17	**DATE PREPARED** 03/15/19	**PEER REVIEW / DATE** 03/18/19

BUREAU OF RECLAMATION

ESTIMATE WORKSHEET

SHEET 4 OF 10

FEATURE: Treatment Alternative

PROJECT: San Luis Reservoir Low Point Improvements

WOID:

ESTIMATE LEVEL: Feasibility

REGION: Mid Pacific

UNIT PRICE LEVEL: June 2017 (Base) Indexed to April 2018

FILE: #N/A

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE (UPDATED 4/2018)	AMOUNT
Property Class 15 - General Property							
Identified Property 01 - Santa Teresa Water Treatment Plant							
140		Roads and Road Structures					
	1	Pavement Restoration & New Roads		3,000	SF	$24	$73,029
		Subtotal					$73,029
	2	Mobilization (5%)					$3,651
	3	Environmental Mitigation (5% of all above)					$3,834
	4	Design Contingencies (10% of all above)					$8,051
		Contract Cost					$88,566
		Construction Contingencies (20%)					$17,713
		Field Cost					$106,279

QUANTITIES		PRICES	
BY Riz Manas	**CHECKED** Kirk Johnson	**BY** J. Nghiem	**CHECKED** B. Brick
DATE PREPARED 06/29/17	**PEER REVIEW / DATE** Bill Schilling / 06-30-17	**DATE PREPARED** 03/15/19	**PEER REVIEW / DATE** 03/18/19

BUREAU OF RECLAMATION

ESTIMATE WORKSHEET

SHEET 5 OF 10

FEATURE:
Treatment Alternative

PROJECT: **San Luis Reservoir Low Point Improvements**

WOID:

ESTIMATE LEVEL: **Feasibility**

REGION: **Mid Pacific**

UNIT PRICE LEVEL: **June 2017 (Base) Indexed to April 2018**

FILE: #N/A

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE (UPDATED 4/2018)	AMOUNT
Property Class 15 - General Property							
Identified Property 01 - Santa Teresa Water Treatment Plant							
152		Waterways					
	1	72-RW-SCLP		72	LF	$15,677	$1,128,745
	2	12-D-SCCP		96	LF	$712	$68,395
	3	66-OW-SCCP		112	LF	$4,556	$510,311
	4	1-1/2-OZ-SSP		296	LF	$122	$36,211
	5	4-OX-SSP		486	LF	$289	$140,233
	6	3-OZ-SSP		369	LF	$285	$105,317
	7	2-CA-CUP		132	LF	$226	$29,891
	8	20-RW-SCLP		82	LF	$2,183	$179,045
	9	48-OF-SCLP		55	LF	$2,755	$151,521
	10	3/4 (4)-SA, 3/4 (4)-AAM, & 3/4 (4)-OCL (all PVCP)		2,440	LF	$28	$68,350
	11	12-RW-SCLP		40	LF	$2,210	$88,408
	12	2-OX-SSP		70	LF	$193	$13,480
	13	1-LOX-CUP		61	LF	$102	$6,196
	14	2-1/2-CWS-SCLP		348	LF	$159	$55,317
	15	2-1/2-CWR-CUP		212	LF	$198	$41,967
	16	2-1/2-OZ-SSP		82	LF	$135	$11,077
	17	3/4-SN-SSP		143	LF	$45	$6,492
	18	10-V-SCLP		48	LF	$277	$13,290
	19	8-OG-SSP		115	LF	$803	$92,325
	20	10-OG-SSP		87	LF	$638	$55,479
	21	4-V-SSP		49	LF	$210	$10,266
	22	1-PW-CUP & 2-PW-CUP		223	LF	$42	$9,433
	23	6-D-SCLP		406	LF	$398	$161,655
	24	6-PW-SCCP		17	LF	$1,033	$17,557
	25	2-1/2-D-SSP		201	LF	$298	$59,812
	26	2-CA-SSP		121	LF	$69	$8,338
	27	1-1/2-OG-SSP		102	LF	$56	$5,750
	28	3/4-SAM-SSP		72	LF	$394	$28,367

QUANTITIES		PRICES	
BY Riz Manas	**CHECKED** Kirk Johnson	**BY** J. Nghiem	**CHECKED** B. Brick
DATE PREPARED 06/29/17	**PEER REVIEW / DATE** Bill Schilling / 06-30-17	**DATE PREPARED** 03/15/19	**PEER REVIEW / DATE** 03/18/19

BUREAU OF RECLAMATION **ESTIMATE WORKSHEET** SHEET 6 OF 10

FEATURE: **Treatment Alternative**	**PROJECT:** **San Luis Reservoir Low Point Improvements**		
	WOID:	**ESTIMATE LEVEL:**	**Feasibility**
	REGION: Mid Pacific	**UNIT PRICE LEVEL: June 2017 (Base) Indexed to April 2018**	
	FILE: #N/A		

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE (UPDATED 4/2018)	AMOUNT
Property Class 15 - General Property							
Identified Property 01 - Santa Teresa Water Treatment Plant							
152		Waterways (continued)					
	29	2-D-SSP		26	LF	$106	$2,746
	30	2-V-SSP		81	LF	$62	$5,039
	31	3/4-SAM-PVCP		41	LF	$207	$8,490
	32	1-1/2-PW-CUP		90	LF	$54	$4,895
	33	2-1/2-OW-SSP		96	LF	$249	$23,899
	34	2-OQA-PVCP		123	LF	$145	$17,777
	35	Other Process Piping		89	LF	$135	$12,035
		Subtotal					$3,178,107
	36	Mobilization (5%)					$158,905
	37	Environmental Mitigation (5% of all above)					$166,851
	38	Design Contingencies (10% of all above)					$350,386
		Contract Cost					$3,854,249
		Construction Contingencies (20%)					$770,850
		Field Cost					$4,625,099

QUANTITIES		PRICES	
BY Riz Manas	**CHECKED** Kirk Johnson	**BY** J. Nghiem	**CHECKED** B. Brick
DATE PREPARED 06/29/17	**PEER REVIEW / DATE** Bill Schilling / 06-30-17	**DATE PREPARED** 03/15/19	**PEER REVIEW / DATE** 03/18/19

BUREAU OF RECLAMATION

ESTIMATE WORKSHEET

SHEET 7 OF 10

FEATURE: **Treatment Alternative**	**PROJECT:** **San Luis Reservoir Low Point Improvements**
	WOID:
	ESTIMATE LEVEL: **Feasibility**
	REGION: Mid Pacific
	UNIT PRICE LEVEL: June 2017 (Base) Indexed to April 2018
	FILE: #N/A

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE (UPDATED 4/2018)	AMOUNT
Property Class 15 - General Property							
Identified Property 01 - Santa Teresa Water Treatment Plant							
160		Pumps					
	1	Raw Water Sample Pump		1	EA	$21,542	$21,542
	2	Raw Water Flash Mix Pumps		2	EA	$52,752	$105,505
	3	Plant Water Pumps		2	EA	$59,115	$118,231
	4	Sample Return Pumps		2	EA	$9,061	$18,121
	5	Sanitary Sump Pumps		2	EA	$10,122	$20,244
	6	Hypochlorite Metering Pump		1	EA	$14,397	$14,397
	7	Aqua Ammonia Metering Pump		1	EA	$12,929	$12,929
		Subtotal					$310,969
	8	Mobilization (5%)					$15,548
	9	Environmental Mitigation (5% of all above)					$16,326
	10	Design Contingencies (10% of all above)					$34,284
		Contract Cost					$377,128
		Construction Contingencies (20%)					$75,426
		Field Cost					$452,553

QUANTITIES		PRICES	
BY Riz Manas	**CHECKED** Kirk Johnson	**BY** J. Nghiem	**CHECKED** B. Brick
DATE PREPARED 06/29/17	**PEER REVIEW / DATE** Bill Schilling / 06-30-17	**DATE PREPARED** 03/15/19	**PEER REVIEW / DATE** 03/18/19

BUREAU OF RECLAMATION

ESTIMATE WORKSHEET

SHEET 8 OF 10

FEATURE: Treatment Alternative	**PROJECT:** San Luis Reservoir Low Point Improvements	
	WOID:	**ESTIMATE LEVEL:** Feasibility
	REGION: Mid Pacific	**UNIT PRICE LEVEL:** June 2017 (Base) Indexed to April 2018
	FILE: #N/A	

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE (UPDATED 4/2018)	AMOUNT
Property Class 15 - General Property							
Identified Property 01 - Santa Teresa Water Treatment Plant							
170		Electrical Equipment					
	1	Electrical Equipment		1	LS	$1,298,536	$1,298,536
		Subtotal					$1,298,536
	2	Mobilization (5%)					$64,927
	3	Environmental Mitigation (5% of all above)					$68,173
	4	Design Contingencies (10% of all above)					$143,164
		Contract Cost					$1,574,800
		Construction Contingencies (20%)					$314,960
		Field Cost					$1,889,760

QUANTITIES		PRICES	
BY	**CHECKED**	**BY**	**CHECKED**
Riz Manas	Kirk Johnson	J. Nghiem	B. Brick
DATE PREPARED	**PEER REVIEW / DATE**	**DATE PREPARED**	**PEER REVIEW / DATE**
06/29/17	Bill Schilling / 06-30-17	03/15/19	03/18/19

BUREAU OF RECLAMATION

ESTIMATE WORKSHEET

SHEET 9 OF 10

FEATURE: Treatment Alternative	**PROJECT:** San Luis Reservoir Low Point Improvements	
	WOID:	**ESTIMATE LEVEL:** Feasibility
	REGION: Mid Pacific	**UNIT PRICE LEVEL:** June 2017 (Base) Indexed to April 2018
	FILE: #N/A	

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE (UPDATED 4/2018)	AMOUNT
Property Class 15 - General Property							
Identified Property 01 - Santa Teresa Water Treatment Plant							
180		Supervisory Control & Comm. Equipment					
	1	Instrumentation		1	LS	$1,388,745	$1,388,745
		Subtotal					$1,388,745
	2	Mobilization (5%)					$69,437
	3	Environmental Mitigation (5% of all above)					$72,909
	4	Design Contingencies (10% of all above)					$153,109
		Contract Cost					$1,684,200
		Construction Contingencies (20%)					$336,840
		Field Cost					$2,021,041

QUANTITIES		PRICES	
BY Riz Manas	**CHECKED** Kirk Johnson	**BY** J. Nghiem	**CHECKED** B. Brick
DATE PREPARED 06/29/17	**PEER REVIEW / DATE** Bill Schilling / 06-30-17	**DATE PREPARED** 03/15/19	**PEER REVIEW / DATE** 03/18/19

BUREAU OF RECLAMATION

ESTIMATE WORKSHEET

SHEET 10 OF 10

FEATURE: Treatment Alternative

PROJECT: San Luis Reservoir Low Point Improvements

WOID:

ESTIMATE LEVEL: Feasibility

REGION: Mid Pacific

UNIT PRICE LEVEL: June 2017 (Base) Indexed to April 2018

FILE: #N/A

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE (UPDATED 4/2018)	AMOUNT
Property Class 15 - General Property							
Identified Property 01 - Santa Teresa Water Treatment Plant							
199		Miscellaneous Installed Equipment					
	1	LOX Storage Tank & Vaporizers		1	LS	$2,070,003	$2,070,003
	2	Supp N2 Equip, Diffusion Equip, & Destruct Units		1	LS	$6,663,168	$6,663,168
	3	Raw Water Ozone Contactor (HVAC & Plumbing)		1	LS	$250,506	$250,506
	4	Flash Mix Assembly		1	LS	$51,619	$51,619
		Subtotal					$9,035,295
	5	Mobilization (5%)					$451,765
	6	Environmental Mitigation (5% of all above)					$474,353
	7	Design Contingencies (10% of all above)					$996,141
		Contract Cost					$10,957,554
		Construction Contingencies (20%)					$2,191,511
		Field Cost					$13,149,065

QUANTITIES		PRICES	
BY	**CHECKED**	**BY**	**CHECKED**
Riz Manas	Kirk Johnson	J. Nghiem	B. Brick
DATE PREPARED	**PEER REVIEW / DATE**	**DATE PREPARED**	**PEER REVIEW / DATE**
06/29/17	Bill Schilling / 06-30-17	03/15/19	03/18/19

BUREAU OF RECLAMATION

ESTIMATE WORKSHEET

SHEET 1 OF 9

FEATURE: **BF Sisk Reservoir Expansion Alternative** **Summary**	**PROJECT:** **San Luis Reservoir Low Point Improvements**
	WOID:
	ESTIMATE LEVEL: **Appraisal**
	REGION: **MP**
	UNIT PRICE LEVEL: **Oct 2012 (Base)** **Indexed to Apr 2018**
	FILE: J:\ENGR Project Files\CVP\San Luis Unit\San Luis Low Point\Engineering Reports\[BF Sisk Reservoir Alternative Estimate 2019-03-27.xlsx]Project Cost Summary

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
Property Class 01 - Reservoirs and Dams							
Identified Property 01 - BF Sisk Reservoir							
140		Roads and Road Structures					$520,504
151		Dams					$273,444,152
		Subtotal					**$273,964,656**
		Mobilization		5%			$13,698,233
		Subtotal With Mobilization					**$287,662,889**
		Environmental Mitigation		5%			$14,383,144
		Design Contigencies		15%			$43,149,433
		APS		3%			$8,629,887
		CONTRACT COST					**$350,000,000**
		Construction Contingencies		25%			$90,000,000
		FIELD COST (Unit Price April 2018)					**$440,000,000**
		Non-Contract Costs*		12%			$50,000,000
		CONSTRUCTION COST					**$490,000,000**
		Note					
		* Environmental and APS (Alternative Procurement Strategies are covered above)					

QUANTITIES		**PRICES**	
BY	**CHECKED**	**BY** S Colburn	**CHECKED** D. Good
DATE PREPARED	**PEER REVIEW / DATE**	**DATE PREPARED** 03/27/19	**PEER REVIEW / DATE** 03/28/19

BUREAU OF RECLAMATION

ESTIMATE WORKSHEET

SHEET 2 OF 9

FEATURE:
BF Sisk Reservoir Expansion Alternative

Escalation to April 2018

PROJECT:
San Luis Reservoir Low Point Improvements

WOID:

ESTIMATE LEVEL: **Appraisal**

REGION: **MP**

UNIT PRICE LEVEL: **Oct 2012 (Base)**
Indexed to Apr 2018

FILE: J:\ENGR Project Files\CVP\San Luis Unit\San Luis Low Point\Engineering Reports\[BF Sisk Reservoir Alternative Estimate 2019-03-27.xlsx]Escalation

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	Oct 2012 AMOUNT	RATE	ESCALATION AMOUNT	APRIL 2018 AMOUNT
Property Class 01 - Reservoirs and Dams						
Identified Property 01 - BF Sisk Reservoir						
151		Subtotal Sheet 3	$216,350,900	1.17	$36,779,653	$253,130,553
151		Subtotal Sheet 4	$4,670,650	1.17	$794,011	$5,464,661
140		Subtotal Sheet 5	$11,127,200	1.17	$1,891,624	$13,018,824
151		Subtotal Sheet 6	$444,875	1.17	$75,629	$520,504
151		Subtotal Sheet 7	$132,000	1.17	$22,440	$154,440
151		Subtotal Sheet 8	$1,432,200	1.17	$243,474	$1,675,674
		Subtotal	$234,157,825			**$273,964,656**
140		Roads and Bridges Subtotal				$520,504.00
151		Dams Subtotal				$273,444,152.00

Notes

1) The escalation rate between October 2012 and April 2018 was determined from the published *CCI (Construction Cost Indices) found the ENR.*

QUANTITIES		**PRICES**	
BY	**CHECKED**	**BY** S Colburn	**CHECKED** D. Good
DATE PREPARED	**PEER REVIEW / DATE**	**DATE PREPARED** 03/27/19	**PEER REVIEW / DATE** 03/28/19

BUREAU OF RECLAMATION

ESTIMATE WORKSHEET

SHEET 3 OF 9

FEATURE: BF Sisk Reservoir Expansion Alternative

PROJECT: San Luis Reservoir Low Point Improvements

WOID:

ESTIMATE LEVEL: Appraisal

REGION: MP

UNIT PRICE LEVEL: Oct 2012 (Base)

FILE: J:\ENGR Project Files\CVP\San Luis Unit\San Luis Low Point\Engineering Reports\[BF Sisk Reservoir Alternative Estimate 2019-03-27.xlsx]Base Costs 3

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
151		**Dam Embankment**					
	1	Excavation, Common		304,000	yd3	$4.50	$1,368,000
	2	Zone 1: Selected clay, sand, and gravel		195,000	yd3	$18.00	$3,510,000
	3	Processed sand & gravel compacted		646,000	yd3	$55.00	$35,530,000
	4	Misc. Fill		2,170,000	yd3	$9.30	$20,181,000
	5	Excavation, Common		1,177,000	yd3	$4.50	$5,296,500
	6	Filter		1,763,000	yd3	$55.00	$96,965,000
	7	Misc. Fill		5,688,000	yd3	$9.30	$52,898,400
151		**Dike Embankment**					
	8	Excavation, Common		5,000	yd3	$4.50	$22,500
	9	Filter		8,000	yd3	$55.00	$440,000
	10	Misc. Fill		15,000	yd3	$9.30	$139,500
		SUBTOTAL THIS SHEET					**$216,350,900**

QUANTITIES

BY

CHECKED

DATE PREPARED

PEER REVIEW / DATE

PRICES

BY S Colburn

CHECKED D. Good

DATE PREPARED 03/27/19

PEER REVIEW / DATE 03/28/19

ESTIMATE WORKSHEET

FEATURE:
BF Sisk Reservoir Expansion Alternative

PROJECT:
San Luis Reservoir Low Point Improvements

WOID:

ESTIMATE LEVEL: Appraisal

REGION: MP

UNIT PRICE LEVEL: Oct 2012 (Base)

FILE: J:\ENGR Project Files\CVP\San Luis Unit\San Luis Low Point\Engineering Reports\[BF Sisk Reservoir Alternative Estimate 2019-03-27.xlsx]Base Costs 4

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
151		**INTAKE TOWERS**					
	11	Full depth saw cut		520	LF	$240.00	$124,800
	12	Remove and dispose of top of Intake towers		1,200	yd3	$540.00	$648,000
	13	Furnish, form, and place reinforced concrete		1,700	yd3	$1,500.00	$2,550,000
	14	Cementitious Materials		510	tons	$200.00	$102,000
	15	Furnish and place concrete reinforcement		255,000	lbs	$1.50	$382,500
	16	Drill and grout anchor bars		2,100	ea	$130.00	$273,000
150		**Spillway**					
	17	Full depth saw cut		48	LF	$200.00	$9,600
	18	Excavation of upstream embankment		1,950	yd3	$27.00	$52,650
	19	Remove and dispose of top of Spillway		180	yd3	$600.00	$108,000
	20	Furnish, form, and place reinforced concrete		220	yd3	$1,400.00	$308,000
	21	Furnish and place concrete reinforcement		33,000	lbs	$1.50	$49,500
	22	Cementitious Materials		66	tons	$200.00	$13,200
	23	Drill and grout anchor bars		80	ea	$130.00	$10,400
	24	Place compacted embankment		1,950	yd3	$20.00	$39,000
		SUBTOTAL THIS SHEET					**$4,670,650**

QUANTITIES		PRICES	
BY	**CHECKED**	**BY** S Colburn	**CHECKED** D. Good
DATE PREPARED	**PEER REVIEW / DATE**	**DATE PREPARED** 03/27/19	**PEER REVIEW / DATE** 03/28/19

BUREAU OF RECLAMATION

ESTIMATE WORKSHEET

SHEET 5 OF 9

FEATURE: BF Sisk Reservoir Expansion Alternative	**PROJECT:** San Luis Reservoir Low Point Improvements
	WOID:
	ESTIMATE LEVEL: Appraisal
	REGION: MP
	UNIT PRICE LEVEL: Oct 2012 (Base)
	FILE: J:\ENGR Project Files\CVP\San Luis Unit\San Luis Low Point\Engineering Reports\[BF Sisk Reservoir Alternative Estimate 2019-03-27.xlsx]Base Costs 5

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
140		**Bridge**					
	25	Removal & Disposal of Existing Bridge		1	ls	$1,150,000.00	$1,150,000
	26	Concrete (4,500 psi @ 28 days)		1,030	yd•	$1,400.00	$1,442,000
	27	Cementitious Material (6 sacks/cy)		290	tons	$200.00	$58,000
	28	Reinforcing Steel		260,000	lbs	$1.50	$390,000
	29	Structural Steel (bridge superstructure)		2,500,000	lbs	$3.00	$7,500,000
	30	Bridge Guardrail (California ST-10)		2,370	lf	$220.00	$521,400
	31	Backfill behind/around abutment		170	ydJ	$20.00	$3,400
	32	Compacted backfill behind/around abutment		170	yd3	$20.00	$3,400
	33	Epoxy grouted anchors Into existing caps		400	ea	$50.00	$20,000
	34	Bearing Pads		18	ea	$1,500.00	$27,000
	35	Bridge Joint Seals at Expansion Joints		60	lf	$200.00	$12,000
		SUBTOTAL THIS SHEET					**$11,127,200**

QUANTITIES		**PRICES**	
BY	**CHECKED**	**BY** S Colburn	**CHECKED** D. Good
DATE PREPARED	**PEER REVIEW / DATE**	**DATE PREPARED** 03/27/19	**PEER REVIEW / DATE** 03/28/19

BUREAU OF RECLAMATION

ESTIMATE WORKSHEET

SHEET 6 OF 9

FEATURE: BF Sisk Reservoir Expansion Alternative

PROJECT: San Luis Reservoir Low Point Improvements

WOID:

ESTIMATE LEVEL: Appraisal

REGION: MP

UNIT PRICE LEVEL: Oct 2012 (Base)

FILE: J:\ENGR Project Files\CVP\San Luis Unit\San Luis Low Point\Engineering Reports\[BF Sisk Reservoir Alternative Estimate 2019-03-27.xlsx]Base Costs 6

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
151		**Gates**					
	36	Site Survey (Pre-Rehab)		1	Ea	$12,000.00	$12,000
	37	Shut down and lock out units		1	Ea	$5,000.00	$5,000
	38	Remove hydraulic piping to hoist		1	Ea	$9,500.00	$9,500
	39	Remove Hydraulic Power Unit		1	Ea	$14,500.00	$14,500
	40	Raise/lock gate by Gov't force		1	Ea	$3,500.00	$3,500
	41	Remove hoist		1	Ea	$21,000.00	$21,000
	42	Remove Intermediate stems		1	Ea	$26,000.00	$26,000
	43	Remove gate		1	Ea	$31,000.00	$31,000
	44	Furnish and Install embedded gate guides		1,875	LB	$13.00	$24,375
	45	Install gate		1	LS	$36,000.00	$36,000
	46	Install intermediate stems		1	LS	$30,000.00	$30,000
	47	Furnish and install one new intermediate stem		1	LS	$140,000.00	$140,000
	48	Install hoist		1	LS	$50,000.00	$50,000
	49	Install hoist		1	LS	$42,000.00	$42,000
		SUBTOTAL THIS SHEET					**$444,875**

QUANTITIES		PRICES	
BY	**CHECKED**	**BY** S Colburn	**CHECKED** D. Good
DATE PREPARED	**PEER REVIEW / DATE**	**DATE PREPARED** 03/27/19	**PEER REVIEW / DATE** 03/28/19

BUREAU OF RECLAMATION

ESTIMATE WORKSHEET

SHEET 7 OF 9

FEATURE: BF Sisk Reservoir Expansion Alternative	**PROJECT:** San Luis Reservoir Low Point Improvements
	WOID:
	ESTIMATE LEVEL: Appraisal
	REGION: MP
	UNIT PRICE LEVEL: Oct 2012 (Base)
	FILE: J:\ENGR Project Files\CVP\San Luis Unit\San Luis Low Point\Engineering Reports\[BF Sisk Reservoir Alternative Estimate 2019-03-27.xlsx]Base Costs 7

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
151		**Gates (Cont)**					
	50	Install Hydraulic Power Unit		1	LS	$23,000.00	$23,000
	51	Connect piping		1	LS	$21,000.00	$21,000
	52	Electrically connect HPU, power, & control board		1	LS	$18,000.00	$18,000
	53	Flii and vent system		1	LS	$15,000.00	$15,000
	54	Test system:		1	LS	$19,000.00	$19,000
	55	Pressure test		1	LS	$12,000.00	$12,000
	56	Leak test Cylinder		1	LS	$12,000.00	$12,000
	57	Operational test		1	LS	$12,000.00	$12,000
		SUBTOTAL THIS SHEET					**$132,000**

QUANTITIES		PRICES	
BY	**CHECKED**	**BY** S Colburn	**CHECKED** D. Good
DATE PREPARED	**PEER REVIEW / DATE**	**DATE PREPARED** 03/27/19	**PEER REVIEW / DATE** 03/28/19

BUREAU OF RECLAMATION

ESTIMATE WORKSHEET

SHEET 8 OF 9

FEATURE: **BF Sisk Reservoir Expansion Alternative**	**PROJECT:** **San Luis Reservoir Low Point Improvements**
	WOID:
	ESTIMATE LEVEL: **Appraisal**
	REGION: **MP**
	UNIT PRICE LEVEL: **Oct 2012 (Base)**
	FILE: J:\ENGR Project Files\CVP\San Luis Unit\San Luis Low Point\Engineering Reports\[BF Sisk Reservoir Alternative Estimate 2019-03-27.xlsx]Base Costs 8

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
151		**GANTRY CRANE:**					
	58	Remove and dispose exist crane rails		19,200	lbs.	$0.75	$14,400
	59	Furnish and Install new crane rails		19,200	lbs.	$9.00	$172,800
	60	Rerope the hoist and provide a new drums		1	LS	$120,000.00	$120,000
	61	Remove, store and reinstall gantry crane		1	L.S.	$250,000.00	$250,000
151		**BULKHEAD GATE:**					
	62	Remove and reinstall bulkhead gates		1	L.S.	$500,000.00	$500,000
	63	Remove and dispose existing bulkhead guides		20,000	lbs.	$0.75	$15,000
	64	Furnish and Install new bulkhead guides		40,000	lbs.	$9.00	$360,000

Notes

1) The line item costs above are from the Option B Cost Estimate in the "*B.F. Sisk Dam – Increased Storage Alternatives, Appraisal-Level Study*", Technical Memorandum No. VB-86-68313-25, Dated April 2013

2) See the above study for additional background information and assumptions used for the above line items

SUBTOTAL THIS SHEET **$1,432,200**

QUANTITIES		**PRICES**	
BY	**CHECKED**	**BY** S Colburn	**CHECKED** D. Good
DATE PREPARED	**PEER REVIEW / DATE**	**DATE PREPARED** 03/27/19	**PEER REVIEW / DATE** 03/28/19

BUREAU OF RECLAMATION

ESTIMATE WORKSHEET

SHEET 9 OF 9

FEATURE:
BF Sisk Reservoir Expansion Alternative

PROJECT:
San Luis Reservoir Low Point Improvements

WOID:

ESTIMATE LEVEL: Appraisal

REGION: MP

UNIT PRICE LEVEL: Oct 2012 (Base)

FILE: J:\ENGR Project Files\CVP\San Luis Unit\San Luis Low Point\Engineering Reports\[BF Sisk Reservoir Alternative Estimate 2019-03-27.xlsx]Base Costs 9

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
151		Subtotal Sheet 3					$216,350,900
151		Subtotal Sheet 4					$4,670,650
140		Subtotal Sheet 5					$11,127,200
151		Subtotal Sheet 6					$444,875
151		Subtotal Sheet 7					$132,000
151		Subtotal Sheet 8					$1,432,200
		Subtotal					**$234,157,825**
		Mobilization		5%			$11,707,891
		Subtotal With Mobilization					**$245,865,716**
		Environmental Mitigation		5%			$12,293,286
		Design Contigencies		15%			$36,879,857
		APS		3%			$7,375,971
		CONTRACT COST					**$300,000,000**
		Construction Contingencies		25%			$80,000,000
		FIELD COST (Unit Price Oct 2012)					**$380,000,000**

QUANTITIES		PRICES	
BY	**CHECKED**	**BY** S Colburn	**CHECKED** D. Good
DATE PREPARED	**PEER REVIEW / DATE**	**DATE PREPARED** 03/27/19	**PEER REVIEW / DATE** 03/28/19

BUREAU OF RECLAMATION

ESTIMATE WORKSHEET

SHEET 1 OF 13

FEATURE: Pacheco Reservoir Expansion Project	**PROJECT:** San Luis Reservoir Low Point Improvements
	WOID:
	ESTIMATE LEVEL: Appraisal
	REGION:
	UNIT PRICE LEVEL: June 2015 (Base) Indexed to April 2018
	FILE: #N/A

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	Contract Cost		Contingency Cost	Field Cost
Property Class 01 - Reservoirs and Dams							
Identified Property 01 - Pacheco Reservoir							
100		Land and Rights		$1,685,000		$421,000	$2,106,000
120		Clearing Land and Right-of-Way		$47,523,000		$11,881,000	$59,404,000
140		Roads and Road Structures		$16,430,000		$4,108,000	$20,538,000
151		Dams		$390,647,000		$97,662,000	$488,309,000
152		Waterways		$92,120,000		$23,030,000	$115,150,000
153		Waterway Structures		$47,250,000		$11,813,000	$59,063,000
160		Pumps		$56,103,000		$14,026,000	$70,129,000
170		Accessory Electrical Equipment		$31,932,000		$7,983,000	$39,915,000
199		Miscellaneous Installed Equipment		$33,551,000		$8,388,000	$41,939,000
		SUBTOTALS		$717,241,000		$179,312,000	
		TOTAL FIELD COST					$896,553,000
Indirect Costs							
		Land (Purchase)					$5,655,000
		Land (Easements)					$539,000
		Program Cost (25%)					$224,138,000
		TOTAL INDIRECT COSTS					$230,332,000
		TOTAL PROJECT COST					$1,127,000,000

QUANTITIES		PRICES	
BY	**CHECKED**	**BY** J. Nghiem	**CHECKED** B. Brick
DATE PREPARED	**PEER REVIEW / DATE**	**DATE PREPARED** 11/06/18	**PEER REVIEW / DATE** 03/18/19

BUREAU OF RECLAMATION

ESTIMATE WORKSHEET

SHEET 2 OF 13

FEATURE: Pacheco Reservoir Expansion Project

PROJECT: San Luis Reservoir Low Point Improvements

WOID:

ESTIMATE LEVEL: Appraisal

REGION:

UNIT PRICE LEVEL: June 2015 (Base) Indexed to April 2018

FILE: #N/A

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE (4/2018)	AMOUNT
Property Class 01 - Reservoirs and Dams							
Identified Property 01 - Pacheco Reservoir							
100		Land and Rights					
	1	Submittals/Procurement/POs/Resource Coord		1	ls	$693,000	$693,000
	2	Drain Existing North Fork Reservoir (client task)		1	ls	$207,900	$207,900
	3	Equipment Mobilization		1	ls	$207,900	$207,900
	4	Labor Mobilization		1	ls	$138,600	$138,600
	5	Setup Roadheader (2)		2	ea	$34,650	$69,300
		Subtotal					$1,316,699
	6	Mobilization (6%)					$79,002
		Subtotal with Mobilization					$1,395,701
	7	Environmental Mitigation (5%)					$69,785
	8	Design Contingencies (15% of all above)					$219,823
		Contract Cost					$1,685,309
		Construction Contingencies (25%)					$421,327
		Field Cost					$2,106,636

QUANTITIES		PRICES	
BY	**CHECKED**	**BY** J. Nghiem	**CHECKED** B. Brick
DATE PREPARED	**PEER REVIEW / DATE**	**DATE PREPARED** 11/06/18	**PEER REVIEW / DATE** 03/18/19

BUREAU OF RECLAMATION

ESTIMATE WORKSHEET

SHEET 3 OF 13

FEATURE: Pacheco Reservoir Expansion Project

PROJECT: San Luis Reservoir Low Point Improvements

WOID:

ESTIMATE LEVEL: Appraisal

REGION:

UNIT PRICE LEVEL: June 2015 (Base) Indexed to April 2018

FILE: #N/A

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE (4/2018)	AMOUNT
Property Class 01 - Reservoirs and Dams (continued)							
Identified Property 01 - Pacheco Reservoir (continued)							
120		Clearing Land and Right-of-Way					
		Install/Implement					
	1	Contractor's Yard/Office Area		1	ls	$138,600	$138,600
	2	Develop Water Supply/Temporary Bypass Pumping		1	ls	$1,385,999	$1,385,999
	3	Best Management Practices		1	ls	$3,464,998	$3,464,998
	4	Environmental Compliance		1	ls	$3,464,998	$3,464,998
	5	Clearing of Borrow and Haul Road Areas		543	ac	$2,772	$1,505,195
	6	Strip/Stockpile Top Soils from Borrow Areas – 6"		440,000	cys	$6	$2,623,581
	7	Build Construction Haul Roads		30,254	lf	$166	$5,015,135
	8	Build Temporary Access Roads		6,230	lf	$166	$1,032,785
	9	Temporary Haul Road Bridge over the Pacheco River		1	ls	$693,000	$693,000
	10	Maintain Haul Roads/Dust Control		36,485	lf	$135	$4,928,923
	11	Wildlife or Livestock Exclusion Fencing		52,800	lf	$14	$731,807
		Remove/Restoration					
	12	Remove/Scarify Construction Haul Roads		84,040	sys	$7	$582,397
	13	Grade/Contour Borrow Areas		543	ac	$10,395	$5,644,481
	14	Replace Stockpiled Top Soils		440,000	cys	$8	$3,659,037
	15	Manual Seeding of Reclaimed Borrow Areas		543	ac	$4,158	$2,257,792
		Subtotal					$37,128,728
	16	Mobilization (6%)					$2,227,724
		Subtotal with Mobilization					$39,356,452
	17	Environmental Mitigation (5%)					$1,967,823
	18	Design Contingencies (15% of all above)					$6,198,641
		Contract Cost					$47,522,916
		Construction Contingencies (25%)					$11,880,729
		Field Cost					$59,403,645

QUANTITIES		PRICES	
BY	**CHECKED**	**BY** J. Nghiem	**CHECKED** B. Brick
DATE PREPARED	**PEER REVIEW / DATE**	**DATE PREPARED** 11/06/18	**PEER REVIEW / DATE** 03/18/19

BUREAU OF RECLAMATION

ESTIMATE WORKSHEET

SHEET 4 OF 13

FEATURE: Pacheco Reservoir Expansion Project

PROJECT: San Luis Reservoir Low Point Improvements

WOID:

ESTIMATE LEVEL: Appraisal

REGION:

UNIT PRICE LEVEL: June 2015 (Base) Indexed to April 2018

FILE: #N/A

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE (4/2018)	AMOUNT
Property Class 01 - Reservoirs and Dams (continued)							
Identified Property 01 - Pacheco Reservoir (continued)							
140		Roads and Road Structures					
	1	Construct New Access Roads		1	mi	$1,600,829	$1,969,020
	2	Improve Existing Access Roads		2	mi	$1,230,767	$1,858,458
	3	Highway 152 Access-Point Improvement		1	ls	$693,000	$693,000
	4	Bridge Crossing Improvements at Pacheco Creek		1	ls	$1,385,999	$1,385,999
	5	Other Miscellaneous Structures and Improvements		1	ls	$6,929,995	$6,929,995
		Subtotal					$12,836,472
	6	Mobilization (6%)					$770,188
		Subtotal with Mobilization					$13,606,660
	7	Environmental Mitigation (5%)					$680,333
	8	Design Contingencies (15% of all above)					$2,143,049
		Contract Cost					$16,430,042
		Construction Contingencies (25%)					$4,107,510
		Field Cost					$20,537,552

QUANTITIES		PRICES	
BY	**CHECKED**	**BY** J. Nghiem	**CHECKED** B. Brick
DATE PREPARED	**PEER REVIEW / DATE**	**DATE PREPARED** 11/06/18	**PEER REVIEW / DATE** 03/18/19

BUREAU OF RECLAMATION

ESTIMATE WORKSHEET

SHEET 5 OF 13

FEATURE: Pacheco Reservoir Expansion Project

PROJECT: San Luis Reservoir Low Point Improvements

WOID:

ESTIMATE LEVEL: Appraisal

REGION:

UNIT PRICE LEVEL: June 2015 (Base) Indexed to April 2018

FILE: #N/A

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE (4/2018)	AMOUNT
Property Class 01 - Reservoirs and Dams (continued)							
Identified Property 01 - Pacheco Reservoir (continued)							
151		Dams					
		U/S Cofferdam Dam					
	1	Clearing/Remove Vegetation/Trees/Debris – Minor		3	ac	$2,482	$7,446
	2	Excavate Overburden Below Dam Footprint		22,000	cys	$7	$162,996
	3	Foundation Preparation		13,000	sys	$32	$416,300
	4	Grouting of Dam Foundation		13,000	sys	$95	$1,231,119
	5	Excavate/Haul/Place and Compact N. Fork Dam Material		402,000	cys	$8	$3,297,645
	6	Excavate/Haul/Place and Compact Core/Filter Overburden		127,000	cys	$8	$968,120
		Embankment Dam (140 TAF)					
	7	Clearing/Remove Vegetation/Trees		558	ac	$4,157	$2,319,544
		Excavate Overburden Below Dam Footprint		1,555,000	cys		
	8	Drill and Shoot Allowance for Overburden Excavation		388,750	cys	$14	$5,388,071
	9	Exc/Haul/Place and Compact at U/S Earth Fill, <2,500' Haul		388,750	cys	$8	$2,963,439
	10	Exc/Haul/Stockpile Overburden at Nearest Borrow Area		1,166,250	cys	$8	$9,540,093
	11	Foundation Preparation		276,000	sys	$32	$8,838,383
	12	Grouting of Dam Foundation - Grout Curtains		276000	sys	$95	$26,137,606
	13	Dental Excavation and Concrete		5,000	cys	$693	$3,464,998
		Dam Earth Fill		8,539,338	cys		
	14	Exc/Haul/Place/Compact Stockpiled OB to U/S D/S Earth Fill		1,166,250	cys	$8	$9,566,861
	15	Excavate Spillway, Haul/Place/Compact to U/S D/S Earth Fill		1,054,784	cys	$7	$7,814,845
	16	Exc Stilling Basin, Haul/Place/Compact to U/S D/S Earth Fill		83,183	cys	$9	$739,558
	17	Drill and Shoot Allowance for Spillway/Stilling Basin Exc		376,000	cys	$14	$5,211,356
	18	Exc Borrow Pits, Haul/Place/Compact to U/S D/D Earth Fill		8,370,000	cys	$12	$97,437,911
		Process Impervious Core Materials					
	19	Setup Screening/Processing Equipment		1	ls	$69,300	$69,300
	20	Excavate/Sort/Classify/Process Clay Materials		4,920,000	tns	$2	$11,365,192
	21	Material Royalty		4,920,000	tns	$0	$1,704,779
	22	Load/Haul/Place/Compact Clay Materials at Core		2,665,000	cys	$13	$34,889,921

QUANTITIES

BY

CHECKED

DATE PREPARED

PEER REVIEW / DATE

PRICES

BY J. Nghiem

CHECKED B. Brick

DATE PREPARED 11/06/18

PEER REVIEW / DATE 03/18/19

BUREAU OF RECLAMATION

ESTIMATE WORKSHEET

SHEET 6 OF 13

FEATURE: Pacheco Reservoir Expansion Project

PROJECT: San Luis Reservoir Low Point Improvements

WOID:

ESTIMATE LEVEL: Appraisal

REGION:

UNIT PRICE LEVEL: June 2015 (Base) Indexed to April 2018

FILE: #N/A

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE (4/2018)	AMOUNT
Property Class 01 - Reservoirs and Dams (continued)							
Identified Property 01 - Pacheco Reservoir (continued)							
151		Dams (continued)					
		Dam Chimney Drain – Coarse Sand/Gravel – 6'					
	23	Purchase Sand/Gravel		1,053,000	tns	$14	$14,594,570
	24	Haul Gravel Materials to Dam		1,053,000	tns	$8	$8,624,064
	25	Stockpile/Re-handle Materials		1,053,000	tns	$1	$729,728
	26	Load/Haul/Place/Compact Sand Materials at Filter Zones		1,000,350	tns	$10	$10,383,740
	27	Dam Chimney Filters – Fine Sand/Gravels – 3'		314,000	cys	$54	$16,896,991
	28	Sand Bedding at Rip Rap Layer – 1'		52,000	cys	$62	$3,217,961
		Rip Rap at Dam U/S Face – 3'					
	29	Develop U/S Quarry		1	ls	$69,300	$69,300
	30	Mob/Setup Grizzly Screen or Sorting System		1	ls	$27,720	$27,720
	31	Drill/Shoot Quarry		200,000	cys	$6	$1,108,799
	32	Move/Classify/Sort Blasted Rip Rap Materials		200,000	cys	$14	$2,771,998
	33	Load/Haul/Dump Gravel Materials to Dam		180000	tns	$6	$1,156,679
	34	Stockpile/Re-handle Materials at Dam		180,000	tns	$1	$249,480
	35	Load/Haul/Place Rip Rap Materials at U/S Face		171,000	tns	$14	$2,370,058
	36	Material Royalty		180,000	tns	$1	$249,480
		Rip Rap at Outlet Return Channel					
	37	Grade/Contour Rip Rap Placement Areas		1,484	sys	$8	$12,345
	38	Purchase/Haul/Re-handle/Place Rip Rap at Channel		1,484	cys	$57	$84,314
		Rip Rap at Outlet Return Channel					
	39	Grade/Contour Rip Rap Placement Areas		7,693	sys	$7	$53,315
	40	Purchase/Haul/Re-handle/Place Rip Rap at Channel		7,693	cys	$57	$436,975
	41	Rechanneling of Reservoir		15,200	cys	$21	$316,008
		Reservoir Specialties					
	42	Dam Instrumentation		1	ls	$1,385,999	$1,385,999
	43	Hypolimentic Aeration System		1	ls	$6,929,995	$6,929,995
		Subtotal					$305,205,005

QUANTITIES		**PRICES**	
BY	**CHECKED**	**BY** J. Nghiem	**CHECKED** B. Brick
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BUREAU OF RECLAMATION **ESTIMATE WORKSHEET** SHEET 7 OF 13

FEATURE: Pacheco Reservoir Expansion Project	**PROJECT:** San Luis Reservoir Low Point Improvements
	WOID:
	ESTIMATE LEVEL: Appraisal
	REGION:
	UNIT PRICE LEVEL: June 2015 (Base) Indexed to April 2018
	FILE: #N/A

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE (4/2018)	AMOUNT
Property Class 01 - Reservoirs and Dams (continued)							
Identified Property 01 - Pacheco Reservoir (continued)							
151		Dams (continued)					
	44	Mobilization (6%)					$18,312,300.33
		Subtotal with Mobilization					$323,517,306
	45	Environmental Mitigation (5%)					$16,175,865
	46	Design Contingencies (15% of all above)					$50,953,976
		Contract Cost					$390,647,147
		Construction Contingencies (25%)					$97,661,787
		Field Cost					$488,308,933

QUANTITIES		PRICES	
BY	**CHECKED**	**BY** J. Nghiem	**CHECKED** B. Brick
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BUREAU OF RECLAMATION **ESTIMATE WORKSHEET** SHEET 8 OF 13

FEATURE: Pacheco Reservoir Expansion Project	**PROJECT:** San Luis Reservoir Low Point Improvements
	WOID:
	ESTIMATE LEVEL: Appraisal
	REGION:
	UNIT PRICE LEVEL: June 2015 (Base) Indexed to April 2018
	FILE: #N/A

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE (4/2018)	AMOUNT
Property Class 01 - Reservoirs and Dams (continued)							
Identified Property 01 - Pacheco Reservoir (continued)							
152		Waterways					
		Low Level Inlet					
	1	Excavation and Stripping at Dam Intake		2,000	cys	$21	$41,580
	2	Trash Rack Structure		1	ls	$2,771,998	$2,771,998
		13' Upstr Tunnel from Valve Chamber to Control Valve Struct					
	3	Tunnel Excavation (Rock)		3,700	cys	$346	$1,282,049
	4	Tunnel Contact Grouting		748	lf	$208	$155,509
	5	Tunnel Concrete Lining – 2'		2,300	cys	$901	$2,072,069
		Sloping Intake					
	6	Construct Sloping Intake (5 Levels /10 ports)		1	ls	$27,719,981	$27,719,981
	7	Connection to 13' Diameter Tunnel		1	ls	$2,078,999	$2,078,999
	8	Control House Structure and 132" Gate Valve		1	ea	$2,444,902	$2,444,902
		Valve Chamber					
	9	Vault Excavation		1,300	cys	$416	$540,540
	10	Vault Concrete Lining		240	cys	$1,039	$249,480
	11	132" Regulating Valve		1	ea	$365,904	$365,904
		18' Diameter Downstream Walk-in Tunnel		821	lf		
	12	Tunnel Excavation (Rock)		7,700	cys	$346	$2,668,048
	13	Tunnel Contact Grout		821	lf	$208	$170,686
	14	Tunnel Concrete Lining – 2'		3,400	cys	$901	$3,063,058
	15	Concrete for Tunnel Steel Pipe Supports		1	ls	$284,476	$284,476
	16	132" Steel Carrier Pipe		821	lf	$1,647	$1,351,831
	17	Tunnel Outlet Portal Structure		1	ls	$2,771,998	$2,771,998
	18	Outlet Cone Valves		2	ea	$346,500	$693,000
	19	Anchor Block at Tunnel Portal		75	cys	$554	$41,580
	20	Tunnel Plug		100	cys	$554	$55,440
		Low Level Inlet to Gate Valve Chamber					
	21	132" Open-Cut Pipeline		226	lf	$2,744	$620,207

QUANTITIES		PRICES	
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BUREAU OF RECLAMATION

ESTIMATE WORKSHEET

SHEET 9 OF 13

FEATURE: Pacheco Reservoir Expansion Project

PROJECT: San Luis Reservoir Low Point Improvements

WOID:

ESTIMATE LEVEL: Appraisal

REGION:

UNIT PRICE LEVEL: June 2015 (Base) Indexed to April 2018

FILE: #N/A

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE (4/2018)	AMOUNT
Property Class 01 - Reservoirs and Dams (continued)							
Identified Property 01 - Pacheco Reservoir (continued)							
152		Waterways (continued)					
		Tunnel Outlet Portal to Pump Station					
	22	132" Open-Cut Pipeline		462	lf	$2,744	$1,267,856
		Pump Station to Pacheco Conduit					
	23	108" Open-Cut Pipeline to Hwy 152		3503	lf	$2,245	$7,865,350
	24	132" Jack and Bore Under Hwy 132 with 108" Carrier Pipe		960	lf	$6,037	$5,795,915
	25	108" Open-Cut Pipeline to Hwy 152		250	lf	$2,994	$748,439
	26	Connection to (e) Pacheco Conduit		1	ls	$2,078,999	$2,078,999
	27	Pressure-Regulating Facilities		1	ls	$2,771,998	$2,771,998
		Subtotal					$71,971,892
	28	Mobilization (6%)					$4,318,314
		Subtotal with Mobilization					$76,290,205
	29	Environmental Mitigation (5%)					$3,814,510.26
	30	Design Contingencies (15% of all above)					$12,015,707
		Contract Cost					$92,120,423
		Construction Contingencies (25%)					$23,030,105.72
		Field Cost					$115,150,529

QUANTITIES		PRICES	
BY	**CHECKED**	**BY** J. Nghiem	**CHECKED** B. Brick
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BUREAU OF RECLAMATION **ESTIMATE WORKSHEET** SHEET 10 OF 13

FEATURE: Pacheco Reservoir Expansion Project

PROJECT: San Luis Reservoir Low Point Improvements

WOID:

ESTIMATE LEVEL: Appraisal

REGION:

UNIT PRICE LEVEL: June 2015 (Base) Indexed to April 2018

FILE: #N/A

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE (4/2018)	AMOUNT
Property Class 01 - Reservoirs and Dams (continued)							
Identified Property 01 - Pacheco Reservoir (continued)							
153		Waterway Structures					
	1	Clearing/Removal of Vegetation/Trees		6	ac	$6,364	$38,182
	2	Blasting Allowance for Spillway Excavation		421,914	cys	$8	$3,508,632
	3	Foundation Preparation for Spillway and Stilling Basin		31,000	sys	$28	$859,319
	4	Concrete for Spillway		11,500	cys	$901	$10,360,343
	5	Concrete for Stilling Basin		1,150	cys	$901	$1,036,034
	6	Reinforcing Steel at 175 lbs/cy		2,213,750	lbs	$1	$3,068,255
	7	Spillway Miscellaneous		1	ls	$3,464,998	$3,464,998
	8	Rip Rap Lined Spillway Discharge Channel		1,731	lf	$289	$500,953
	9	Clearing and Top Soil Stockpiling		1	ls	$10,395	$10,395
	10	Footprint/Up-Slope Excavation		8,000	cys	$14	$110,880
	11	Ring Foundation Excavation		2,800	cys	$28	$77,616
	12	Ring Foundation Granular Fill		2,500	cys	$69	$173,250
	13	Ring Foundation Concrete		280	cys	$624	$174,636
	14	Maintenance Gravel Path to Tank – 1'		500	lf	$73	$36,486
	15	3 MG, 150' Diameter A/G Pre-Stressed Concrete Tank		3,000,000	gal	$4	$12,473,991
	16	36" Interconnection Pipeline to Pacheco Pumping Plant		720	lf	$848	$610,727
	17	Valve Vault and 36" Valve		1	ls	$203,187	$203,187
	18	Connection to Pipeline		1	ls	$207,900	$207,900
		Subtotal					$36,915,784
	19	Mobilization (6%)					$2,214,947
		Subtotal with Mobilization					$39,130,731
	20	Environmental Mitigation (5%)					$1,956,536.53
	21	Design Contingencies (15% of all above)					$6,163,090
		Contract Cost					$47,250,357
		Construction Contingencies (25%)					$11,812,589.28
		Field Cost					$59,062,946

QUANTITIES

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PRICES

BY J. Nghiem

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DATE PREPARED 11/06/18

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ESTIMATE WORKSHEET

FEATURE: Pacheco Reservoir Expansion Project	**PROJECT:** San Luis Reservoir Low Point Improvements
	WOID:
	ESTIMATE LEVEL: Appraisal
	REGION:
	UNIT PRICE LEVEL: June 2015 (Base) Indexed to April 2018
	FILE: #N/A

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE (4/2018)	AMOUNT
Property Class 01 - Reservoirs and Dams (continued)							
Identified Property 01 - Pacheco Reservoir (continued)							
160		Pumps					
		Pacheco Reservoir Pump Station					
	1	Construct Pump Station		13,750	hp	$3,188	$43,832,219
		Subtotal					$43,832,219
	2	Mobilization (6%)					$2,629,933
		Subtotal with Mobilization					$46,462,153
	3	Environmental Mitigation (5%)					$2,323,108
	4	Design Contingencies (15% of all above)					$7,317,789
		Contract Cost					$56,103,049
		Construction Contingencies (25%)					$14,025,762
		Field Cost					$70,128,812

QUANTITIES		PRICES	
BY	**CHECKED**	**BY** J. Nghiem	**CHECKED** B. Brick
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BUREAU OF RECLAMATION

ESTIMATE WORKSHEET

SHEET 12 OF 13

FEATURE: **Pacheco Reservoir Expansion Project**

PROJECT: **San Luis Reservoir Low Point Improvements**

WOID:

ESTIMATE LEVEL: **Appraisal**

REGION:

UNIT PRICE LEVEL: **June 2015 (Base) Indexed to April 2018**

FILE: #N/A

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE (4/2018)	AMOUNT
Property Class 01 - Reservoirs and Dams (continued)							
Identified Property 01 - Pacheco Reservoir (continued)							
170		Accessory Electrical Equipment					
	1	Transmission Line Upgrade – 70 kV Line to 15 mVA		16	mi	$1,039,499	$16,631,988
	2	Substation at Pacheco Reservoir		1	ls	$8,315,994	$8,315,994
		Subtotal					$24,947,983
	3	Mobilization (6%)					$1,496,879
		Subtotal with Mobilization					$26,444,862
	4	Environmental Mitigation (5%)					$1,322,243
	5	Design Contingencies (15% of all above)					$4,165,066
		Contract Cost					$31,932,170
		Construction Contingencies (25%)					$7,983,043
		Field Cost					$39,915,213

QUANTITIES		PRICES	
BY	**CHECKED**	**BY** J. Nghiem	**CHECKED** B. Brick
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BUREAU OF RECLAMATION

ESTIMATE WORKSHEET

FEATURE: Pacheco Reservoir Expansion Project	**PROJECT:** San Luis Reservoir Low Point Improvements
	WOID:
	ESTIMATE LEVEL: Appraisal
	REGION:
	UNIT PRICE LEVEL: June 2015 (Base) Indexed to April 2018
	FILE: #N/A

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE (4/2018)	AMOUNT
Property Class 01 - Reservoirs and Dams (continued)							
Identified Property 01 - Pacheco Reservoir (continued)							
199		Miscellaneous Installed Equipment					
		Construction Allowances					
	1	Master Mech Crew for Equip Service/Repairs/Maintenance		60	mo	$223,146	$13,388,751
	2	Install/Run Active Water Treatment System		60	mo	$69,300	$4,157,997
	3	Contractor Quality Control		1.50%	ls	$8,315,994	$8,315,994
		Startup/Commission/Owner Training					
	4	Pre-commissioning		750	hrs	$208	$155,925
	5	Vendor Support		1	ls	$10,395	$10,395
	6	Commissioning		750	hrs	$208	$155,925
	7	Training		100	hrs	$139	$13,860
	8	Startup Expendables		1	ls	$13,860	$13,860
		Subtotal					$26,212,707
	9	Mobilization (6%)					$1,572,762
		Subtotal with Mobilization					$27,785,469
	10	Environmental Mitigation (5%)					$1,389,273
	11	Design Contingencies (15% of all above)					$4,376,211
		Contract Cost					$33,550,954
		Construction Contingencies (25%)					$8,387,739
		Field Cost					$41,938,693

QUANTITIES		PRICES	
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Appendix D
Climate Trends, Variability, and Future Uncertainties Technical Appendix

D.1 Introduction and Overview

This appendix provides a description of assumptions, methods, and modeling of the effects of future uncertainties in climate conditions on the San Luis Low Point Improvement Project (SLLPIP). In keeping with the U.S. Department of the Interior, Bureau of Reclamation's (Reclamation's) policy to use the best available science to inform decision making, quantitative methods and modeling tools were used whenever possible. Reclamation has actively pursued analysis and understanding of the potential effects of uncertainties related to climate trends and variability and socioeconomic conditions through several recent studies, including the Sacramento and San Joaquin Basins Climate Impact Assessment (Reclamation 2014a), Central Valley Project Integrated Resource Plan (Reclamation 2014b), and the Sacramento and San Joaquin Rivers Basin Study (Basins Study) (Reclamation 2016a). This appendix relies upon information and technical analyses developed under those studies, including modeling results that quantify the effects of future uncertainties in socioeconomic and climate conditions. Model results from the Basins Study were built upon to quantify the potential effects of future uncertainties related to climate trends and variability on the SLLPIP.

Analysis and results presented in this appendix represent a sensitivity analysis to the effects of future uncertainties. While this sensitivity analysis is in some regards less detailed than analyses conducted in the evaluation of project alternatives, it nonetheless presents a comprehensive evaluation of the potential impacts of future uncertainties on the project to inform decision makers.

This appendix is organized as follows:

- Section 2 presents a summary of global climate projections and relevant research on climate trends and variability implications for California water resources, particularly those for California's Central Valley.
- Section 3 provides an overview of the scenarios analyzed in the Basins Study.

- Section 4 summarizes changes in Central Valley (CVP)/State Water Project (SWP) operations under the range of future climate projections analyzed in the Basins Study. This section also summarizes the San Luis Reservoir low point conditions under the same range of future climate projections.
- Section 5 provides a quantitative and qualitative evaluation of how each SLLPIP alternative may perform under the potential range of future San Luis Reservoir low point conditions presented in Section 4.
- Section 6 lists the references used this appendix.

D.2 Climate Trends and Variability Research and Anticipated Effects on the Central Valley

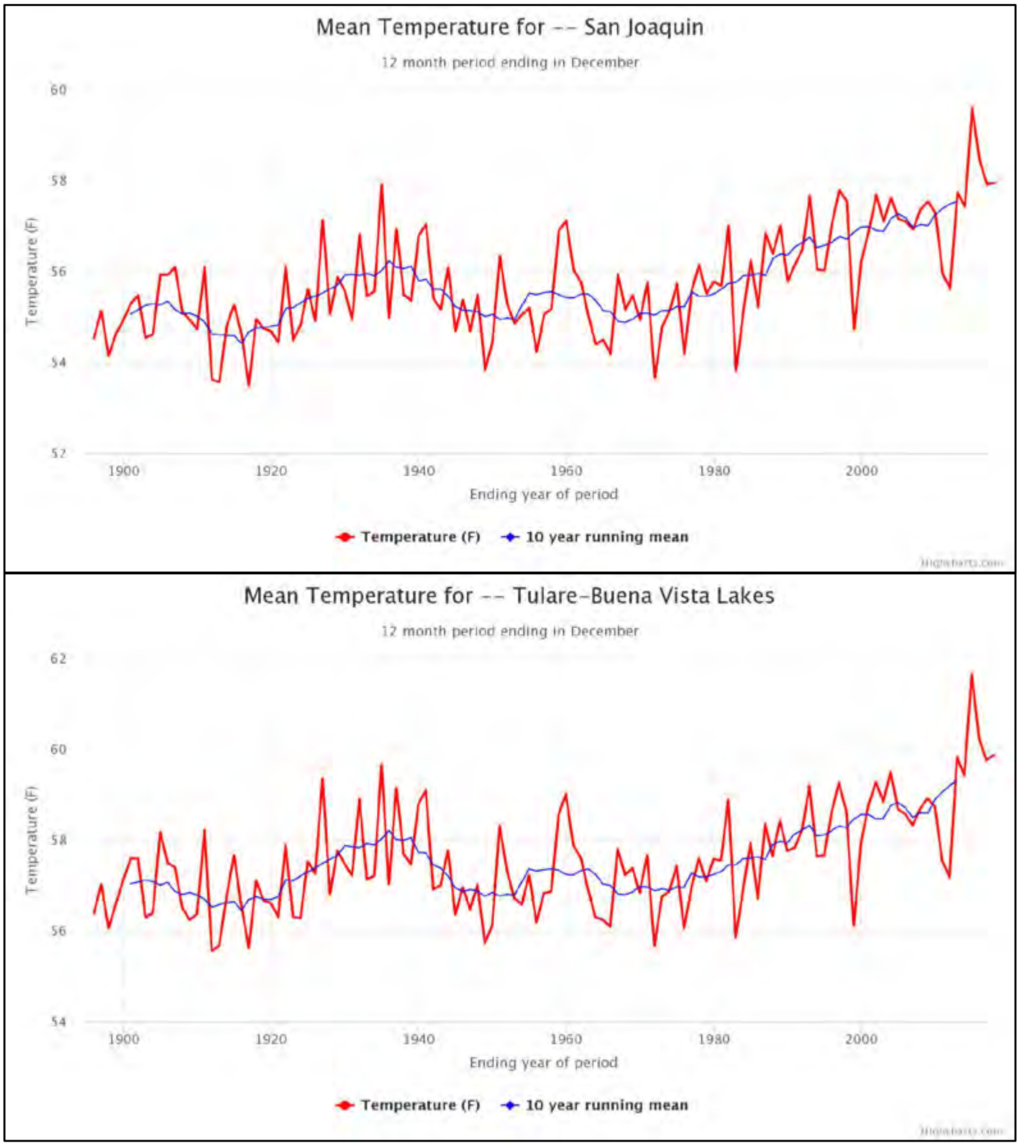
This section provides a summary of global climate projections and relevant research on climate trends and variability implications for California water resources, including a summary of key findings on the sensitivity of California water resources to climate variabilities, particularly those for the Central Valley. The location of San Luis Reservoir and its use as a shared resource of the CVP and SWP mean that conditions in San Luis Reservoir are potentially sensitive to climate and socioeconomic changes throughout, and potentially beyond, the Central Valley. Therefore, this chapter also includes a discussion of the potential influence of climate trends and variability over the larger Central Valley area represented by the Sacramento, San Joaquin, and Tulare Lake watersheds and the Sacramento-San Joaquin Delta (Delta) system to provide a comprehensive assessment of potential uncertainties.

D.2.1 Historical Climate

Temperature

The historical climate of the Central Valley is characterized by hot and dry summers and cool and damp winters. Average daytime temperatures are 95 degrees Fahrenheit (°F) in the summer and 55°F in the winter.

Over the course of the 20th century, average mean-annual temperature has increased by approximately 2°F, although not steadily. The increases occurred primarily during the early part of the 20th century between 1915 and 1935 and began again in the mid-1970s through the present (Western Climate Mapping Initiative [WestMap] 2010). Figure D-1 shows the mean temperature in the San Joaquin and Tulare-Buena Vista Lakes Hydrological Units from 1895 to 2017.

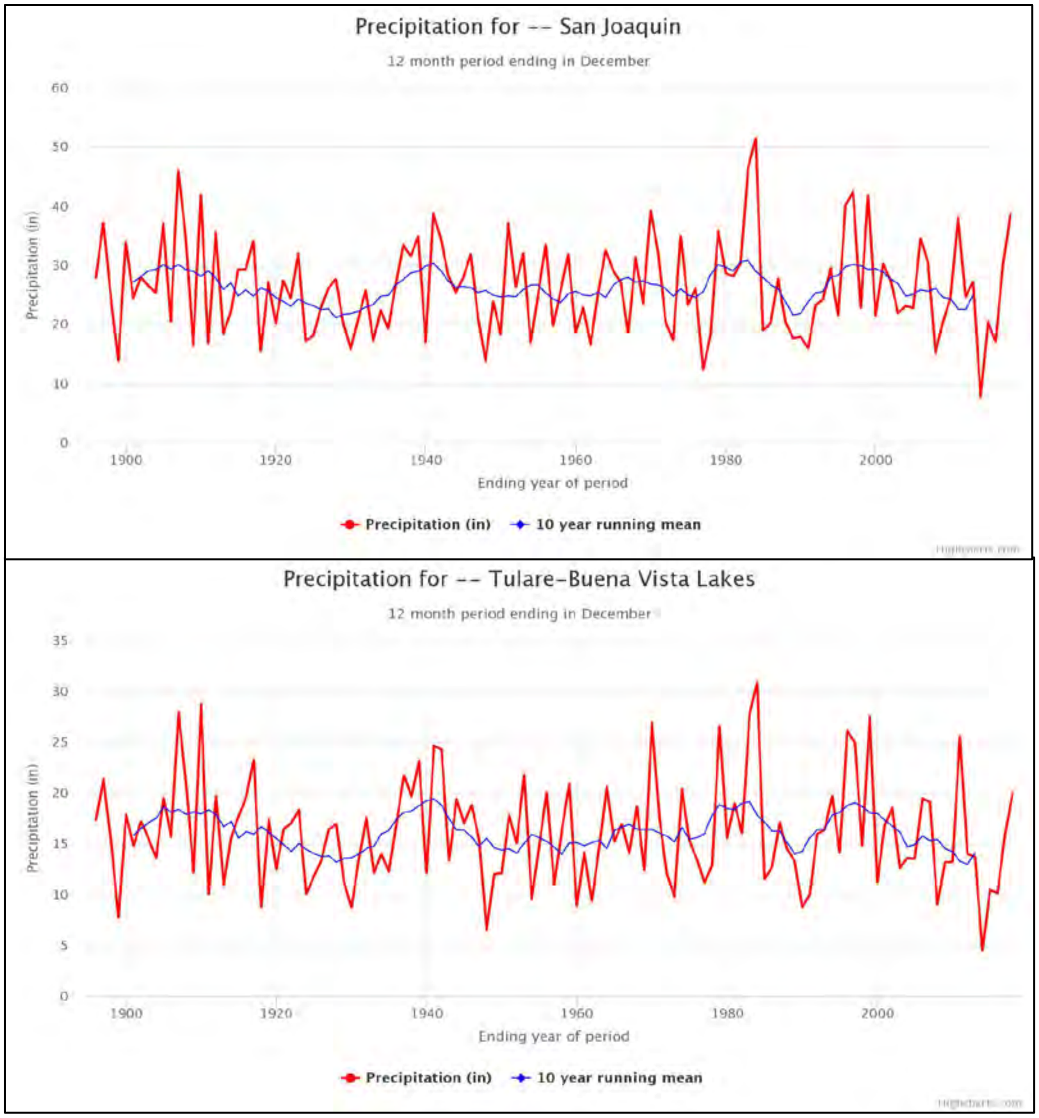


Source: WestMap 2010.
Notes: Red- Observed Annual; Blue- 10-Year Running Mean Annual

Figure D-1. Observed Annual and 10-Year Running Mean Annual Average Temperature in San Joaquin and Tulare-Buena Vista Lakes Hydrological Units from 1895 to 2017

Precipitation

Precipitation in the Central Valley falls primarily from mid-autumn to mid-spring. While snowfall is rare in the valley, temperatures below freezing may occur in the winter. The variability of annual precipitation has increased in the latter part of the 20th century. These extremes in wet and dry years have been especially frequent since the 1980s (WestMap 2010). Figure D-2 shows the amount of precipitation in San Joaquin and Tulare-Buena Vista Lakes Hydrological Units from 1895 to 2017.



Source: WestMap 2010.
Notes: Red- Observed Annual; Blue- 10-Year Running Mean Annual

Figure D-2. Observed Annual and 10-Year Running Mean Annual Average Precipitation in San Joaquin and Tulare-Buena Vista Lakes Hydrological Units from 1895 to 2017

D.2.2 Historical Hydrology

Historically, the streamflow in the Sacramento and San Joaquin River basins has varied from year to year. The runoff in the region varies by year and geography; with the northern Sacramento Valley experiencing more runoff than the drier southern San Joaquin Valley.

Paleoclimate information is useful in understanding longer time horizons of natural variability (droughts, floods, alternative sequences of wet-dry periods). Paleo-reconstructed streamflow data that contains reconstructions for

Sacramento, San Joaquin, and Klamath rivers' streamflows shows significant and prolonged drought periods during the following periods: 975-981, 1292-1301, 1395-1400, 1475-1483, 1578-1582, 1924-1931, 1975-1977, 1987-1992, and 2007-2010 (Reclamation 2016b).

Two important findings can be drawn from this analysis. First, paleo droughts have been identified that demonstrate greater short-term severity than those in the observed streamflow record. Second, multiple droughts extending beyond 8 years have been identified in the paleo record and indicate that droughts of this length are not unique to the 1930s. However, the observed short-term 1975-1977 drought and the long-term 1924-1931 drought are among the most severe in both the paleo and observed records (Reclamation 2016b).

Runoff is also greater during the winter to early summer than the rest of the year. Winter runoff events are the consequence of rainfall while the spring and early summer events are more from snowmelt. Snowpack is measured as Snow Water Equivalent (SWE). Studies have shown a decreasing trend in the latter half of the 20th century, as measured by April 1st (Mote et al. 2005). The research by Knowles et al (2007) supported these findings using SWE measurements from 1948 through 2001 at 173 stations. Another study reported decreasing spring SWE trends as much as 50 percent (Regonda et al. 2005).

Despite slightly increased or unchanged annual precipitation in the area, annual runoff increases did not occur in the Sacramento and San Joaquin rivers (Dettinger and Cayan 1995). However, the seasonal timing of runoff has shifted in the Sacramento River Basin. Between April and July, a 10 percent decrease in total runoff has been observed throughout the course of the 20th century (Roos 1991). This is supported by similar results from Dettinger and Cayan (1995) for the combined Sacramento River and San Joaquin River runoff. Corresponding increases in winter runoff have been observed, such as in the Peterson et al. (2008) study which found earlier runoff trends for 18 Sierra Nevada river basins.

Cayan et al. (2001) consider that the primary cause of the shift in runoff timing is due primarily from increasing spring temperatures and not increased winter precipitation.

D.3 Technical Approach and Modeling

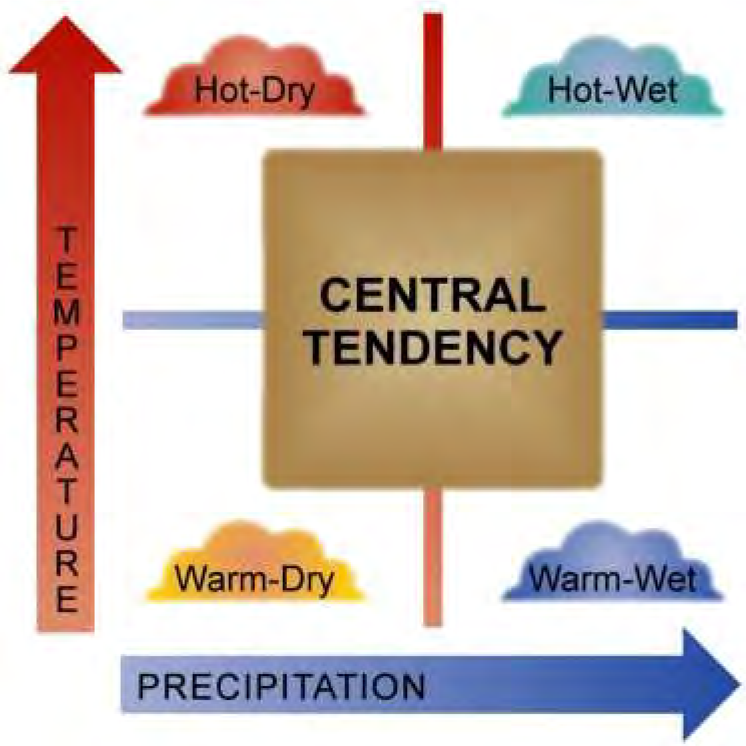
The modeling approach and analysis tools for the Basins Study were developed as part of the CVP Integrated Resource Plan (Reclamation 2014b) and the Sacramento and San Joaquin Basin's Climate Risk Assessment Report (Reclamation 2014a) and were further improved for the Basins Study. During these studies, Reclamation evaluated future uncertainties related to climate and socioeconomic changes. Uncertainties in future climates primarily surround changes in temperature and precipitation, which then drive changes in runoff, snowpack, and sea level rise assumptions that can affect water supplies and the operations of the CVP/SWP system. Additionally, changes in temperature and precipitation can also affect water needs for agricultural, municipal, and environmental uses.

This section provides a brief overview of the significant body of work performed in support of the CVP Integrated Resource Plan and the Basins Study to provide a high-level background on the assumptions included in the Basins Study modeling that was relied upon for the SLLPIP sensitivity analysis. Detailed information is available in those plans and their technical appendices.

D.3.1 Description of Ensemble Climate Scenarios

A total of five representative climate futures were developed for use in the Basins Study using results from recent global climate model (GCM) simulations (Intergovernmental Panel on Climate Change [IPCC] 2013) that had been further refined for use in climate studies such as the Basins Study. These are usually referred to as “ensemble” scenarios as they are assembled from an ensemble group of climate projections. By using only five representative future climates, it was possible to efficiently assess the impacts of a range of potential climate futures without having to perform an excessive number of simulations.

The representative climate futures were created by combining together multiple individual GCM projections that occur within defined representative climate categories. Future projections of temperature show a consistent trend of warming, but the magnitude of the warming can vary. Future projections of precipitation are less consistent with some GCMs showing future increases in precipitation while others show a decrease in precipitation. The combination of these two variables and the range of future projections create a range of future conditions that are grouped into five different climate categories. A representative scenario is then formed from the ensemble of climate projections included in each category. Figure D-3 presents the conceptual representative climate scenarios.



Source: Reclamation 2016a

Figure D-3. Conceptual Representation of Ensemble Climate Scenarios to Relate the Concept of Developing a Wide Range of Ensemble Projections

Representative scenarios illustrated in Figure D-3 are described as:

- Central Tendency (CEN) scenario is in the middle of the range of all the projected temperatures and precipitations. It consists of a large number of projections and can be viewed as a more representative, though not certain, estimate of what the future climate may be.
- Warm-Dry (WD) scenario consists of a small number of projections that are not as warm as the central tendency but are significantly drier.
- Warm-Wet (WW) scenario consists of a small number of projections that are not as warm as the central tendency but are significantly wetter
- Hot-Dry (HD) scenario consists of a small number of projections that are significantly warmer and drier than the central tendency.
- Hot-Wet (HW) scenario consists of a small number of projections that are significantly hotter and wetter than the central tendency projection.

Both the Basins Study and this analysis for SLLPIP focus effort on evaluation of three of the five scenarios. The Central Tendency, Warm-Wet, and Hot-Dry scenarios are used to evaluate a relatively wide range of potential future climate conditions, particularly future conditions related to water supply and the operations of the CVP and SWP.

D.3.2 Socioeconomic Scenarios and Future Demands for Water

As population increases, municipal, commercial, and industrial water demands tend to increase. These demands are dynamic and depend on a variety of factors, such as urban development and land use density. Agricultural demand is also influenced by socioeconomic trends but to a lesser degree. The Basins Study evaluated three different socioeconomic scenarios to describe how water demands might evolve with changing populations and land use. These scenarios vary based on the expected future population growth and urban density and include Expansive Growth, Current Trends, and Slow Growth scenarios. This analysis focuses only on the Current Trends scenario, in part because this analysis is primarily addressing uncertainty related to future climate conditions.

Future water demands depend upon changes in population and land use, as well as climate trends and variability. As urban population increases, adjacent agricultural land is often incorporated into urban areas, thus reducing the agricultural land area to varying degrees. Consequently, with fewer acres of future irrigated lands, projected agricultural water demands tend to decline over time. Correspondingly, future urban demands may be anticipated to increase with increasing populations. The agricultural and urban demands and growth vary by regions.

Additionally, modeling performed for the Basins Study includes changes in demand through time, as opposed to a fixed level of demand analyzed over a range of hydrologic conditions. Demands in the first decades of the analysis are similar to current levels of demand, while demands closer to the end of analysis period in 2099 are different due to both socioeconomic and climate driven changes expected by the end of the century.

Agricultural water demands are affected by climate, population, and land use as well as other factors such as the types of crops and agricultural water management practices. The crop types, acreages, and changes in irrigated land area are based on the scenarios developed from the California Department of Water Resources (DWR) analysis in the California Water Plan (DWR 2014). Under assumptions used in the Current Trends socioeconomic scenario for population growth and land changes, agricultural land in the Central Valley is projected to gradually decline from 6.5 million acres in 2012 to 5.8 million acres in 2040 and 5.4 million acres by 2099. Even though irrigated acreages were simulated as declining, the amount of contracted water supply available to the CVP/SWP contractors was not reduced. Details regarding the crop types, irrigated acreages, growing seasons, and other parameters used in the agricultural demands assessment are provided in technical appendices to the Basins Study.

If there were no climate trends and variability, then the projected average annual agricultural demands for water in the Central Valley would decline from estimates of current demands of approximately 21.7 million acre-feet (MAF) to 19.1 MAF by 2070 – 2099, as shown in Table D-1 under the “No CC” column, representing the “No Climate Change” scenario. Table D-1 also summarizes agricultural demands under each climate scenario. The declines seen for scenarios with climate trends and variability reflect both a decrease in irrigated crop acreage and changes in climate—especially increasing carbon dioxide levels and temperature increases that exceed crop water stress thresholds, resulting in reduced crop water use. These results occur because the hotter climate scenarios have higher temperatures as well as higher levels of carbon dioxide than the other climate scenarios. Subsequent sections of this appendix provide background on the development of projected demands. These changes do not become significant until the latter part of the 21st century. Table D-1 shows the average annual agricultural water demands for the Central Valley for the Current Trends socioeconomic scenario.

Urban demands are an important portion of Reclamation’s water deliveries. Understanding how these demands might change in the future and how they may be affected by changing population and climate is key to effective long-term planning. Urban demands now account for about one-twelfth of the water use in the Central Valley. Urban demands are driven largely by population and therefore tend to change steadily over time based on the assumed level of population, municipal, commercial, and industrial growth associated with each of the socioeconomic scenarios. Table D-1 shows the average annual urban water demands for the Central Valley for the Current Trends socioeconomic scenario.

Table D-1. Average Annual Water Demands under the No CC Scenario Compared with Ensemble Climate Scenarios in the Current Trends Socioeconomic Scenario in Thousand Acre-Feet per Year (TAF/Year)

Demand	Period	No CC	Hot-Dry	Warm-Wet	Central Tend.
Agricultural	2015-2039	21,722	22,456	21,416	21,946
	2040-2069	20,135	20,211	19,373	19,990
	2070-2099	19,081	15,864	17,905	17,695
	2015-2099	**20,230**	**19,337**	**19,456**	**19,756**
Urban	2015-2039	2,152	2,211	2,153	2,178
	2040-2069	2,920	3,036	2,933	2,986
	2070-2099	3,701	3,851	3,705	3,769
	2015-2099	**2,970**	**3,081**	**2,976**	**3,025**

D.3.3 Future Sea Level Rise

Transient sea level changes were also included in the analysis of climate scenarios. The amount of sea level rise was based on National Research Council (NRC) median projection for sea level rise which suggest that by 2100, sea levels could rise by about 90 centimeters (cm), with a projected range between 42 cm through 166 cm (NRC 2012). The representative scenarios each had different sea level rise assumptions, within the NRC projection range, which were functions of the anticipated effects of increasing temperature.

D.3.4 "No Climate Change" Scenario

In order to understand the uncertainties related to future climate and socioeconomic changes, it is necessary to compare results that include future projections with historical climate conditions. A "No Climate Change" (No CC) scenario was developed that "projected" historical climate conditions into the future climate period. In the No CC scenario, total Central Valley urban demand grows from 2 MAF in 2015 to almost 3 MAF in 2099. Short-term variability and longer-term trends both exist in urban water demands. Although there is much less variability in urban demands than agricultural demands, short-term urban demand is clearly correlated with variability in annual precipitation.

D.3.5 Modeling Tools

Several different modeling tools were used in the Basins Study to analyze uncertainties in future climate and socioeconomic trends. The Water Evaluation and Planning model of the Central Valley (WEAP-CV) hydrology model was used to simulate water supply and demands for multiple scenarios to address critical uncertainties related to climate and socioeconomic changes. Results from WEAP-CV were used as inputs to the CalLite-CV model to simulate how the CVP, SWP, and other water management systems operate to meet urban, agriculture, and environmental needs. Results from the CalLite-CV model were used to understand and quantify the potential changes in CVP and SWP operations as a result of climate trends and variability and assess how those changes may affect the SLLPIP. The following sections provide additional details on WEAP-CV and CalLite-CV. Additional details on these tools is available in technical appendices to the Basins Study.

WEAP-CV is a planning model of the Central Valley, developed on the WEAP modeling platform. Water supply is primarily driven by climatic variables such as precipitation and temperature. Precipitation directly affects water supplies whereas temperature influences soil and surface water supply through water evaporation and plant evapotranspiration. Demands are influenced by socioeconomic conditions such as population, commercial and industrial growth, and land-use changes. WEAP-CV is capable of simulating both water supply and demand changes under the different climate trends and variability scenarios and socioeconomic conditions.

WEAP-CV includes rainfall-runoff modules used to develop climate-based watershed runoff for the main watersheds of the Bay-Delta, the Sacramento River, San Joaquin River, and Tulare Lake hydrologic regions. One of the key components of the model is the dynamic calculation of crop water requirements under various climate scenarios. Each climate scenario is analyzed using a transient approach in which the climate and socioeconomic factors gradually change as the simulation progresses through time.

Results from WEAP-CV model are input to the CalLite-CV model. CalLite-CV simulates CVP and SWP operations, delivery allocation decisions, Delta salinity, river flows, and reservoir levels based on hydrologic inputs from WEAP-CV. CalLite-CV is developed on the GoldSim modeling platform and has the ability to rapidly simulate system operations and to incorporate changes with relative ease, making it suitable for analysis of multiple climatic and socioeconomic scenarios. Results from the CalLite-CV model were used in the Basins Study to understand water supply and demand, and as inputs to other tools for evaluating impacts on water temperature, hydropower, greenhouse gas emissions, and economics.

The purpose of modeling performed for the Basins Study was to address both the potential impacts of future climate and socioeconomic changes and explore how those challenges might be addressed. Model results from the Basins Study represent Reclamation’s best available information on the effects of climate trends and variability on CVP/SWP operations. However, Basins Study models are not exact predictions of how Reclamation and DWR may operate the CVP/SWP in the future, particularly a future where the effects of climate uncertainties may result in significant differences in the available water supply. Basin Study models have not been refined to include operational adaptation that may occur as a result of changes in demands, water supply, and the timing of runoff within different basins. Modeling conducted in support of the Basins Study was performed to understand more generalized effects of changes in demand and runoff and to evaluate options to address those changes.

Model results from the CalLite-CV model are not directly comparable with CalSim II results due to differences in the models. CalSim II is a more detailed model than CalLite-CV and includes fewer simplifying assumptions. CalSim II results presented in the other sections of this report have been closely reviewed and refined, particularly as they relate to the operation of San Luis Reservoir. Analyses in this appendix compare CalLite-CV results under the No CC scenario with CalLite-CV results under several projections of future climates. Results from these comparisons help understand how uncertainty in future climate conditions may affect CVP/SWP operations and SLLPIP alternatives.

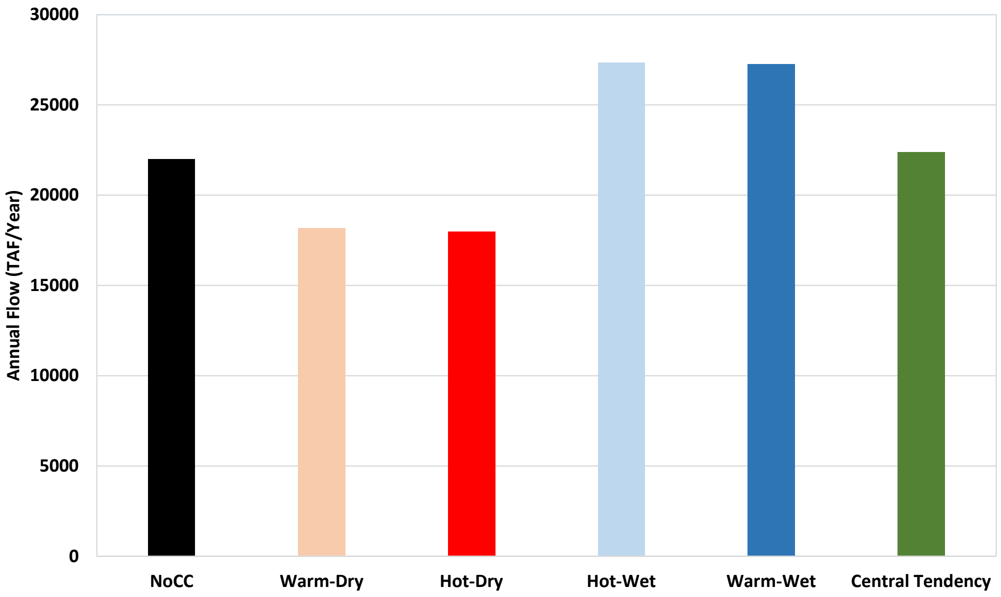
D.4 Effects of Climate Trends and Variability on CVP/SWP Operations

This analysis for the SLLPIP focuses on three climate scenarios: 1) Central Tendency; 2) Warm-Wet; and 3) Hot-Dry. These climate scenarios are based on the Current Trends scenario of socio-economic development. These three climate scenarios were selected out of the five scenarios for SLLPIP analysis as they represent a relatively wide range of potential future climate conditions, particularly future conditions related to water supply and the operations of the CVP and SWP.

While this analysis focuses on only three climate scenarios, Figure D-4 and Figure D-5 illustrate the range of runoff for all five ensemble climate scenarios to illustrate how the Central Tendency, Warm-Wet, and Hot-Dry scenarios compare with the Warm-Dry and Hot-Wet scenarios.

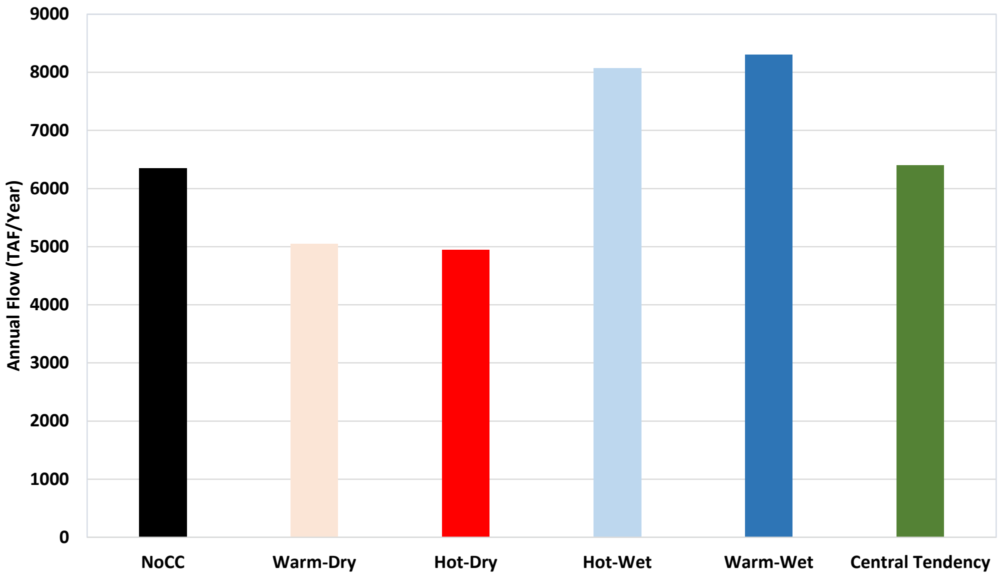
Figure D-4 compares the average annual runoff in the Sacramento River basin under the different climate scenarios with the No CC scenario for water year 2015 through 2099. Average annual runoff in the Sacramento River basin varies from nearly 18 MAF under the Hot-Dry scenario to 27 MAF under the Hot-Wet scenario. Average annual runoff in the Sacramento River system under both Warm-Dry and Hot-Dry scenarios is nearly the same and shows a decrease of approximately 4 MAF compared to the No CC scenario. Similarly, average annual runoff under both Hot-Wet and Warm-Wet scenarios is nearly the same and shows an increase of approximately 5 MAF from the No CC scenario. The average annual runoff in the Sacramento River system under the Central Tendency scenario is similar in volume to the No CC scenario, though there are changes in the monthly timing of runoff.

Figure D-5 presents average annual runoff in the San Joaquin River basin. Relative changes in runoff between scenarios in the San Joaquin basin are like those seen in the Sacramento basin. The Hot-Dry scenario has the lowest runoff at just less than 5 MAF, a reduction of approximately 1.2 MAF compared to the No CC scenario. The Warm-Wet scenario shows the highest runoff of over 8 MAF, an increase of approximately 2 MAF from the No CC scenario. Runoff under the Central Tendency scenario is again similar in volume to the No CC scenario with an average of approximately 6.2 MAF annually.



(Source: Reclamation 2016b)

Figure D-4. Average Annual Runoff in the Sacramento River System under Different Climate Projections and Current Trend Scenario



(Source: Reclamation 2016b)

Figure D-5. Average Annual Runoff in the San Joaquin River System under Different Climate Projections and Current Trend Scenario

Tables D-2, D-3, and D-4 summarize key results of CVP and SWP operations from the CalLite-CV model for the three climate scenarios as compared against the No CC scenario. Each table provides the average monthly results for one of the three climate projections, the No CC scenario, and the change from the No CC scenario.

Table D-2 compares average monthly results for the Central Tendency scenario as compared to the No CC scenario. Under the Central Tendency scenario, Delta outflow is higher by approximately 1.2 MAF per year than under the No CC scenario. The majority of the increase in Delta outflow occurs from November through January, in part due to the shift in the timing of runoff in the Central Tendency scenario. During the months of March, April, May, and August, Delta outflow is reduced under the Central Tendency scenario. Total Delta exports decrease by nearly 150 TAF under the Central Tendency scenario as compared to the No CC scenario. In some months, the river flows are greater and in other months they are lower under Central Tendency as compared to the No CC scenario. River flows in the Sacramento basin show consistent average monthly increases from November through January. Average monthly flow of the San Joaquin River at Vernalis increases from November through March. Overall, on an average annual basis, Sacramento River flows and San Joaquin River flows increase by approximately 300 cubic feet per second (cfs) under Central Tendency scenario as compared to the No CC scenario. Combined North-of-Delta (NOD) upstream reservoir carryover storage at the end of September under the Central Tendency scenario is lower by nearly 400 TAF as compared to the No CC scenario.

Table D-2. Comparison of Average Monthly Values of CVP/SWP Operations between Central Tendency and No CC Scenarios

No CC Scenario	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Delta Outflow (cfs)	11282	23296	45282	50666	48877	37851	22265	11413	7197	4443	4473	5812
Jones Pumping Plant (cfs)	3582	3961	3170	3047	2804	1516	1241	3004	3789	3445	3862	2728
Banks Pumping Plant (cfs)	6064	4340	4169	4509	4884	1641	1232	3149	4857	3410	3566	6187
Sac. River at Hood (cfs)	15957	24143	34614	37660	40112	29534	18696	16073	16592	10873	9414	11191
Sac. River at Keswick (cfs)	4253	5719	8609	11307	12962	9225	7731	13585	12971	9580	5520	5422
Sac. River at NCP (cfs)	6488	11903	19266	22307	21325	13407	7030	6650	6668	4799	4648	5299
Feather River blw. Thermalito (cfs)	2656	3267	5680	6810	8474	6024	4341	4416	6943	3903	1477	2864
American River at Nimbus (cfs)	2765	3226	5518	5315	5378	4708	3525	3696	2462	1838	1485	1480
American River at H.St (cfs)	2494	2970	5272	5082	5151	4469	3252	3375	2101	1470	1135	1167
SJ River at Vernalis (cfs)	2557	2724	5231	6569	7482	8957	6822	4440	2930	2692	2553	2720
Shasta Storage (TAF)	2269	2368	2604	2956	3227	3369	3427	3442	2994	2567	2326	2313
Folsom Storage (TAF)	426	407	440	469	495	589	675	749	642	536	471	449
Oroville Storage (TAF)	1461	1531	1700	1949	2114	2267	2379	2401	2127	1716	1498	1504
CVP San Luis Storage (TAF)	273	395	570	689	769	821	768	630	491	346	247	274
SWP San Luis Storage (TAF)	439	619	701	813	863	908	789	587	449	388	270	255
Central Tendency	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Delta Outflow (cfs)	11702	27528	55280	58777	50419	36170	19017	9811	8461	4869	4416	6906
Jones Pumping Plant (cfs)	3301	3910	3355	3011	2720	1508	1116	2928	3514	3078	3633	2418
Banks Pumping Plant (cfs)	5987	4578	4441	4874	5062	1754	1095	3018	4809	2829	3543	5159
Sac. River at Hood (cfs)	15944	26374	37505	39268	40111	27651	16605	15093	18073	10431	9297	10952
Sac. River at Keswick (cfs)	4080	6031	9585	11924	12581	8790	8726	14235	13896	9187	5462	5146
Sac. River at NCP (cfs)	6279	13124	21639	23885	20672	12758	7843	7455	7865	4697	4538	4961
Feather River blw. Thermalito (cfs)	3004	3717	7341	8097	8913	5616	3731	4254	7199	3707	1671	2999
American River at Nimbus (cfs)	2685	4119	7450	6171	5307	3692	2392	2913	2718	1708	1394	1457
American River at H.St (cfs)	2411	3860	7201	5934	5076	3448	2113	2587	2352	1336	1041	1146
SJ River at Vernalis (cfs)	2585	2912	7143	8983	9013	9698	5839	3345	2321	2394	2370	2688
Shasta Storage (TAF)	2068	2173	2478	2878	3164	3301	3366	3300	2805	2322	2108	2096
Folsom Storage (TAF)	376	383	439	476	501	592	645	647	542	440	395	388
Oroville Storage (TAF)	1340	1407	1633	1945	2165	2300	2382	2346	2039	1585	1386	1384
CVP San Luis Storage (TAF)	273	381	558	694	779	831	785	652	527	382	267	285
SWP San Luis Storage (TAF)	363	548	653	785	850	905	795	591	445	385	239	226
Change from No CC Scenario	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Delta Outflow (cfs)	420	4231	9997	8111	1543	-1681	-3247	-1601	1264	426	-58	1093
Jones Pumping Plant (cfs)	-281	-50	185	-36	-84	-8	-125	-76	-276	-367	-229	-311
Banks Pumping Plant (cfs)	-77	238	272	365	178	113	-136	-131	-48	-580	-23	-1027
Sac. River at Hood (cfs)	-13	2231	2891	1607	-1	-1883	-2092	-980	1481	-442	-117	-239
Sac. River at Keswick (cfs)	-173	312	976	617	-381	-435	995	650	925	-393	-57	-276
Sac. River at NCP (cfs)	-209	1221	2372	1578	-653	-649	814	805	1197	-103	-110	-338
Feather River blw. Thermalito (cfs)	348	450	1661	1287	439	-409	-610	-161	256	-196	194	134
American River at Nimbus (cfs)	-80	893	1932	856	-71	-1016	-1133	-784	256	-130	-92	-24
American River at H.St (cfs)	-82	890	1928	852	-75	-1021	-1139	-787	251	-133	-94	-21
SJ River at Vernalis (cfs)	28	188	1912	2414	1531	741	-983	-1096	-609	-298	-184	-32
Shasta Storage (TAF)	-200	-195	-126	-78	-63	-69	-61	-141	-189	-245	-218	-217
Folsom Storage (TAF)	-50	-24	0	8	6	2	-30	-102	-100	-96	-76	-61
Oroville Storage (TAF)	-121	-124	-68	-4	52	33	3	-54	-88	-131	-112	-120
CVP San Luis Storage (TAF)	0	-14	-13	5	10	10	18	22	37	36	20	11
SWP San Luis Storage (TAF)	-76	-71	-48	-29	-13	-3	6	4	-4	-2	-31	-28

Table D-3 summarizes similar results for the Hot-Dry scenario. This scenario is the driest scenario in terms of water supply with the greatest reduction in Delta exports and Delta outflows relative to the No CC scenario. Delta outflows decrease by nearly 3 MAF per year and Delta exports decrease by 1.2 MAF per year as compared to the No CC scenario. Reductions in average monthly Delta outflows occur from October through May, with the highest reduction in February. Under the Hot-Dry scenario, river flows and reservoir storages are consistently lower when compared to the No CC scenario. On an average annual basis, Sacramento River flows at Hood decrease by nearly 3,500 cfs as compared to the No CC scenario. Average annual flow in the San Joaquin River at Vernalis is reduced by nearly 1,100 cfs under the Hot-Dry scenario. Combined carryover storage (end of September) in Shasta, Folsom, and Oroville is reduced by nearly 1.6 MAF under the Hot-Dry scenario. San Luis reservoir carryover storage is reduced by approximately 70 TAF under the Hot-Dry scenario as compared to the No CC scenario, though the reduction occurs only in the SWP portion of San Luis Reservoir while the CVP portion has higher average carryover storage. The change in CVP San Luis storage for the Hot-Dry scenario is an example of how modeling completed for the Basins Study may not accurately reflect operations in all areas of the CVP. Basins Study modeling was performed for a different purpose that did not warrant focus on San Luis Reservoir operations. It is more likely that storage in both the CVP and SWP portions of San Luis Reservoir would be lower with the reduced water supply available in the Hot-Dry scenario. Higher storage in the CVP portion is likely the result of less water being allocated to south-of-Delta (SOD) CVP contractors due to lower storage in the spring.

Table D-3. Comparison of Average Monthly Values of CVP/SWP Operations between Hot-Dry and No CC Scenarios

No CC Scenario	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Delta Outflow (cfs)	11282	23296	45282	50666	48877	37851	22265	11413	7197	4443	4473	5812
Jones Pumping Plant (cfs)	3582	3961	3170	3047	2804	1516	1241	3004	3789	3445	3862	2728
Banks Pumping Plant (cfs)	6064	4340	4169	4509	4884	1641	1232	3149	4857	3410	3566	6187
Sac. River at Hood (cfs)	15957	24143	34614	37660	40112	29534	18696	16073	16592	10873	9414	11191
Sac. River at Keswick (cfs)	4253	5719	8609	11307	12962	9225	7731	13585	12971	9580	5520	5422
Sac. River at NCP (cfs)	6488	11903	19266	22307	21325	13407	7030	6650	6668	4799	4648	5299
Feather River blw. Thermalito (cfs)	2656	3267	5680	6810	8474	6024	4341	4416	6943	3903	1477	2864
American River at Nimbus (cfs)	2765	3226	5518	5315	5378	4708	3525	3696	2462	1838	1485	1480
American River at H.St (cfs)	2494	2970	5272	5082	5151	4469	3252	3375	2101	1470	1135	1167
SJ River at Vernalis (cfs)	2557	2724	5231	6569	7482	8957	6822	4440	2930	2692	2553	2720
Shasta Storage (TAF)	2269	2368	2604	2956	3227	3369	3427	3442	2994	2567	2326	2313
Folsom Storage (TAF)	426	407	440	469	495	589	675	749	642	536	471	449
Oroville Storage (TAF)	1461	1531	1700	1949	2114	2267	2379	2401	2127	1716	1498	1504
CVP San Luis Storage (TAF)	273	395	570	689	769	821	768	630	491	346	247	274
SWP San Luis Storage (TAF)	439	619	701	813	863	908	789	587	449	388	270	255
Hot-Dry Scenario	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Delta Outflow (cfs)	8991	18400	36288	39622	36099	27594	16321	9536	9414	4759	5129	7605
Jones Pumping Plant (cfs)	2328	3245	2936	2646	2409	1448	1136	2326	2510	2002	2446	1669
Banks Pumping Plant (cfs)	4513	4160	3846	4153	4172	1682	1132	2358	3570	1764	2270	3470
Sac. River at Hood (cfs)	12207	20437	29857	32318	31449	22504	15441	14537	17042	8591	8206	9810
Sac. River at Keswick (cfs)	3994	3871	5690	7582	9044	7246	9308	14108	13666	8222	5092	5225
Sac. River at NCP (cfs)	5010	8605	14533	16494	15174	10108	7867	7377	7967	4233	3950	4506
Feather River blw. Thermalito (cfs)	2617	3037	4190	5593	6576	4576	3479	4024	6363	2930	1749	3120
American River at Nimbus (cfs)	1769	3089	5436	4855	4275	3113	2322	3279	2798	1277	1109	1132
American River at H.St (cfs)	1498	2830	5187	4617	4041	2865	2041	2947	2437	933	779	835
SJ River at Vernalis (cfs)	2042	2082	4179	5352	5763	7125	4617	2624	2090	1991	1996	2322
Shasta Storage (TAF)	1310	1372	1634	2083	2439	2658	2719	2556	2022	1529	1355	1351
Folsom Storage (TAF)	235	258	346	415	466	552	592	560	404	273	244	244
Oroville Storage (TAF)	1011	1053	1226	1552	1764	1938	2006	1925	1625	1223	1076	1075
CVP San Luis Storage (TAF)	270	334	484	617	705	758	736	645	553	433	316	299
SWP San Luis Storage (TAF)	243	380	499	673	790	863	785	617	454	353	193	159
Change from No CC Scenario	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Delta Outflow (cfs)	-2291	-4897	-8994	-11044	-12778	-10258	-5944	-1877	2216	316	656	1792
Jones Pumping Plant (cfs)	-1254	-715	-234	-402	-395	-68	-105	-678	-1279	-1442	-1416	-1060
Banks Pumping Plant (cfs)	-1552	-180	-323	-356	-713	41	-99	-792	-1287	-1646	-1296	-2716
Sac. River at Hood (cfs)	-3749	-3706	-4758	-5342	-8662	-7029	-3255	-1536	449	-2282	-1208	-1382
Sac. River at Keswick (cfs)	-259	-1848	-2919	-3725	-3918	-1980	1578	523	695	-1358	-428	-197
Sac. River at NCP (cfs)	-1478	-3298	-4734	-5813	-6151	-3299	837	727	1299	-566	-698	-793
Feather River blw. Thermalito (cfs)	-40	-230	-1490	-1217	-1898	-1448	-862	-391	-580	-974	272	256
American River at Nimbus (cfs)	-996	-137	-81	-461	-1103	-1595	-1203	-418	336	-561	-376	-348
American River at H.St (cfs)	-996	-140	-86	-466	-1110	-1604	-1211	-428	336	-537	-356	-332
SJ River at Vernalis (cfs)	-515	-642	-1052	-1217	-1718	-1832	-2205	-1816	-840	-701	-557	-398
Shasta Storage (TAF)	-959	-996	-970	-874	-788	-711	-709	-886	-972	-1038	-971	-962
Folsom Storage (TAF)	-191	-149	-94	-53	-29	-37	-82	-189	-238	-263	-227	-204
Oroville Storage (TAF)	-450	-478	-474	-397	-349	-329	-373	-476	-502	-493	-422	-429
CVP San Luis Storage (TAF)	-3	-60	-86	-72	-64	-63	-32	15	62	87	69	24
SWP San Luis Storage (TAF)	-196	-239	-202	-140	-73	-45	-3	30	5	-35	-78	-95

Table D-4 presents results for the Warm-Wet scenario as compared against the No CC scenario. The Warm-Wet scenario is the wettest scenario with increased reservoir storage, river flows, and Delta exports. Delta outflow increases by an average of nearly 7.8 MAF per year and exports increase by nearly 660 TAF/Y. It is noted that Delta exports under the Warm-Wet scenario increase by only a fraction of the increase in Delta outflow indicating increases in Delta inflow occur primarily during periods when only a small fraction can be diverted under existing regulatory requirements and with existing infrastructure. River flows are higher in most months in the Sacramento basin. On an average annual basis, Sacramento River flow at Hood is nearly 4,500 cfs higher under Warm-Wet scenario as compare to the No CC scenario. San Joaquin River flow at Vernalis is higher in all months, with average annual flows higher by nearly 2,600 cfs under the Warm-Wet scenario. San Luis Reservoir storage does not change significantly under the Warm-Wet scenario, in part due to the relatively modest increase in Delta exports. Average end of September storage in combined CVP/SWP San Luis Reservoir increases under the Warm-Wet scenario by 11 TAF as compared to No CC scenario. Results for the CVP portion of San Luis storage show a decrease in storage while the SWP portion has higher storage. This is an example of how modeling completed for the Basins Study may not accurately reflect operations in all area of the CVP. It is more likely that storage in both the CVP and SWP portions of San Luis Reservoir would be higher, or at least similar to the No CC simulated storage with the increased water supply available in the Warm-Wet scenario. Lower storage in the CVP portion at the end of September may be the result of more water being allocated to SOD CVP contractors because of higher storage in the spring.

Table D-4. Comparison of Average Monthly Values of CVP/SWP Operations between Warm-Wet and No CC Scenarios

No CC Scenario	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Delta Outflow (cfs)	11282	23296	45282	50666	48877	37851	22265	11413	7197	4443	4473	5812
Jones Pumping Plant (cfs)	3582	3961	3170	3047	2804	1516	1241	3004	3789	3445	3862	2728
Banks Pumping Plant (cfs)	6064	4340	4169	4509	4884	1641	1232	3149	4857	3410	3566	6187
Sac. River at Hood (cfs)	15957	24143	34614	37660	40112	29534	18696	16073	16592	10873	9414	11191
Sac. River at Keswick (cfs)	4253	5719	8609	11307	12962	9225	7731	13585	12971	9580	5520	5422
Sac. River at NCP (cfs)	6488	11903	19266	22307	21325	13407	7030	6650	6668	4799	4648	5299
Feather River blw. Thermalito (cfs)	2656	3267	5680	6810	8474	6024	4341	4416	6943	3903	1477	2864
American River at Nimbus (cfs)	2765	3226	5518	5315	5378	4708	3525	3696	2462	1838	1485	1480
American River at H.St (cfs)	2494	2970	5272	5082	5151	4469	3252	3375	2101	1470	1135	1167
SJ River at Vernalis (cfs)	2557	2724	5231	6569	7482	8957	6822	4440	2930	2692	2553	2720
Shasta Storage (TAF)	2269	2368	2604	2956	3227	3369	3427	3442	2994	2567	2326	2313
Folsom Storage (TAF)	426	407	440	469	495	589	675	749	642	536	471	449
Oroville Storage (TAF)	1461	1531	1700	1949	2114	2267	2379	2401	2127	1716	1498	1504
CVP San Luis Storage (TAF)	273	395	570	689	769	821	768	630	491	346	247	274
SWP San Luis Storage (TAF)	439	619	701	813	863	908	789	587	449	388	270	255
Warm-Wet Scenario	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**
Delta Outflow (cfs)	17037	41762	81242	80532	70668	48340	25308	11774	8008	4474	5137	8256
Jones Pumping Plant (cfs)	4055	4205	3494	3557	3098	1699	1229	3348	4237	4014	4230	3443
Banks Pumping Plant (cfs)	6314	5045	4809	5701	6012	1908	1209	3492	5593	4306	4235	5850
Sac. River at Hood (cfs)	20761	34033	45503	45936	48517	34446	20009	16263	17953	11479	10526	13275
Sac. River at Keswick (cfs)	5544	9237	13852	15143	15381	10669	8139	13895	13516	9342	6005	5800
Sac. River at NCP (cfs)	8757	18115	29202	29751	26652	16313	8429	7521	7605	5055	5472	6269
Feather River blw. Thermalito (cfs)	3338	5289	11860	11671	11345	6924	4382	4273	6936	3873	1487	3315
American River at Nimbus (cfs)	3877	6419	9478	7589	6578	4671	3022	3146	2638	1955	1602	1823
American River at H.St (cfs)	3596	6154	9224	7348	6345	4426	2738	2812	2264	1573	1243	1501
SJ River at Vernalis (cfs)	3136	4787	11700	14652	14218	13212	8097	4782	3131	3026	2872	3169
Shasta Storage (TAF)	2636	2733	2952	3248	3479	3650	3735	3802	3373	2915	2694	2670
Folsom Storage (TAF)	492	465	490	509	519	612	691	729	646	574	526	514
Oroville Storage (TAF)	1741	1822	2037	2279	2423	2560	2680	2700	2430	2004	1797	1812
CVP San Luis Storage (TAF)	262	405	586	708	800	856	795	628	466	296	196	227
SWP San Luis Storage (TAF)	463	639	737	830	879	938	806	583	440	413	317	314
Change from No CC Scenario	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**
Delta Outflow (cfs)	5755	18465	35960	29866	21791	10488	3043	361	811	31	664	2444
Jones Pumping Plant (cfs)	473	244	324	510	294	183	-12	344	447	569	368	715
Banks Pumping Plant (cfs)	250	705	640	1192	1128	267	-23	342	736	897	669	-336
Sac. River at Hood (cfs)	4804	9891	10889	8275	8406	4912	1313	190	1360	606	1112	2084
Sac. River at Keswick (cfs)	1290	3518	5243	3836	2419	1444	408	310	546	-238	485	378
Sac. River at NCP (cfs)	2269	6212	9935	7444	5327	2907	1399	871	937	256	824	970
Feather River blw. Thermalito (cfs)	681	2023	6180	4860	2871	900	41	-142	-8	-31	10	451
American River at Nimbus (cfs)	1113	3193	3960	2273	1200	-37	-503	-550	177	117	117	343
American River at H.St (cfs)	1102	3184	3952	2266	1195	-43	-514	-562	163	103	108	334
SJ River at Vernalis (cfs)	579	2062	6469	8083	6736	4255	1275	341	201	335	319	449
Shasta Storage (TAF)	367	365	348	292	252	280	307	361	379	347	368	357
Folsom Storage (TAF)	65	57	50	40	24	23	16	-20	4	37	55	65
Oroville Storage (TAF)	280	291	337	330	309	293	300	299	304	288	299	308
CVP San Luis Storage (TAF)	-11	10	15	19	31	35	27	-2	-25	-49	-50	-48
SWP San Luis Storage (TAF)	24	20	36	17	15	30	17	-3	-9	26	47	59

In addition to information in the previous three tables, SOD deliveries within the CVP and SWP are important metrics for operations and potential benefits of SLLPIP alternatives. Table D-5 compares CVP SOD deliveries under different climate scenarios. The Hot-Dry scenario shows the greatest reduction in CVP SOD deliveries of 549 TAF as compared to the No CC scenario. The Warm-Wet scenario shows an increase in CVP SOD deliveries of 274 TAF, and the Central Tendency also shows a reduction of 102 TAF as compared to the No CC scenario.

Results presented in Table D-5 are summarized as average annual values by the Sacramento Valley Water Year Hydrologic Classification Index (Sacramento Valley Index or year type). For the purpose of calculating average annual results by year type, the Sacramento Valley Indices for the Central Tendency were used for all climate scenarios so that the same years and number of years of each year type were averaged for all scenarios. Sacramento Valley Indices for the Central Tendency scenario are like those in the No CC scenario and result in a similar distribution of year types as the historical record. The distribution of year types (i.e., the number of wet, above normal, below normal, etc. years) in the Hot-Dry and Warm-Wet scenarios can deviate from the historical distributions. This approach of using the Central Tendency year types was applied to calculate average annual results by Sacramento Valley Index for all results by year type reported in this technical appendix.

Table D-5. CVP South of Delta Deliveries

Sacramento Valley Index	No CC	Hot-Dry		Warm-Wet		Central Tendency	
	TAF	TAF	Change (TAF)	TAF	Change (TAF)	TAF	Change (TAF)
Wet	2716	2254	-461	2828	113	2602	-113
Above Normal	2360	1589	-771	2593	233	2220	-141
Below Normal	2265	1678	-587	2493	228	2169	-96
Dry	1919	1301	-618	2370	451	1815	-104
Critical	1441	1101	-340	1741	299	1386	-55
All Years	2134	1586	-549	2408	274	2032	-102

[1] Change calculated as difference from No CC scenario

Table D-6 presents a similar pattern for CVP SOD deliveries in the results for SWP Table A deliveries among the different scenarios.

Table D-6. SWP Table A Deliveries

Sacramento Valley Index	No CC	Hot-Dry		Warm-Wet		Central Tendency	
	TAF	TAF	Change (TAF)	TAF	Change (TAF)	TAF	Change (TAF)
Wet	3265	2895	-370	3365	100	3175	-90
Above Normal	2910	2306	-604	3233	322	2770	-141
Below Normal	2635	1912	-723	2894	259	2580	-56
Dry	2329	1607	-722	2753	424	2241	-89
Critical	1652	1268	-384	2036	384	1647	-5
All Years	2557	2006	-551	2857	300	2480	-77

[1] Change calculated as difference from No CC scenario

D.4.1 Effects on San Luis Reservoir Low Point

This section summarizes the operational results of San Luis Reservoir storage and San Felipe Division municipal and industrial (M&I) deliveries under different climate scenarios. Table D-7 presents average annual San Felipe Division M&I deliveries under the No CC scenario and the three climate scenarios by water year type based on the Sacramento Valley Index. Annual San Felipe Division M&I deliveries are most similar between the No CC and Central Tendency scenarios with a difference of approximately 4 TAF on an average annual basis. Deliveries under the Hot-Dry scenario are reduced by nearly 19 TAF as compared to the No CC scenario. Deliveries under the Warm-Wet scenario are increased by nearly 10 TAF as compared to the No CC scenario.

Table D-7. Average Annual San Felipe Division M&I Deliveries

Sacramento Valley Index	No CC	Hot-Dry		Warm-Wet		Central Tendency	
	TAF	TAF	Change (TAF)	TAF	Change (TAF)	TAF	Change (TAF)
Wet	120	102	-17	125	5	117	-3
Above Normal	106	82	-23	116	11	101	-5
Below Normal	110	86	-24	118	8	105	-5
Dry	98	78	-20	111	14	94	-3
Critical	82	70	-12	91	9	78	-3
All Years	103	84	-19	112	10	99	-4

[1] Change calculated as difference from No CC scenario

Table D-8 summarizes average annual interrupted San Felipe Division M&I deliveries under the different climate scenarios. Interrupted deliveries are calculated as the volume of water that would be delivered from San Luis Reservoir to San Felipe Division M&I contractors when the combined CVP and SWP San Luis storage is below 300 TAF. These deliveries are interrupted due to water quality concerns when San Luis storage is below the 300 TAF threshold. The volume of interrupted San Felipe Division M&I deliveries in any year is based on the duration of the low point event and the allocation to

SOD M&I water service contractors. Higher allocations and longer duration low point events result in a larger volume of interrupted delivery. Average annual interrupted San Felipe Division M&I deliveries range from 3 TAF under the Warm-Wet scenario to 8 TAF under the Hot-Dry scenario. Average annual interrupted deliveries under the No CC scenario and Central Tendency are nearly the same at 5 TAF.

Table D-8. Average Annual Interrupted San Felipe Division M&I Deliveries

Sacramento Valley Index	No CC	Hot-Dry		Warm-Wet		Central Tendency	
	TAF	TAF	Change (TAF)	TAF	Change (TAF)	TAF	Change (TAF)
Wet	4	5	1	5	1	3	-1
Above Normal	7	7	0	3	-5	6	-1
Below Normal	4	6	2	1	-3	6	2
Dry	7	11	5	4	-2	8	1
Critical	3	10	7	3	1	2	-1
All Years	5	8	3	3	-2	5	0

[1] Change calculated as difference from No CC scenario

Table D-9 summarizes the frequency of San Luis Low Point under the different climate scenarios. San Luis storage goes below the low point threshold of 300 TAF in 35 years out of 88 years simulated under the Hot-Dry scenario, nearly twice the number of years under the No CC scenario. The Warm-Wet scenario results in 14 years of storage below the 300 TAF threshold, and the Central Tendency scenario results in 18 years of San Luis storage below the threshold.

Table D-9. Frequency of San Luis Reservoir Low Point Conditions (Storage < 300 TAF) in Years

Sacramento Valley Index	No CC	Hot-Dry		Warm-Wet		Central Tendency	
	Years	Years	Change	Years	Change	Years	Change
Wet	3	2	-1	1	-2	2	-1
Above Normal	2	2	0	2	0	1	-1
Below Normal	4	7	3	1	-3	2	-2
Dry	3	12	9	4	1	8	5
Critical	6	12	6	6	0	8	2
All Years	18	35	17	14	-4	21	3

[1] Change calculated as difference from No CC scenario

Basins Study results are further expanded to show annual minimum storages as time-series plots for each scenario in Figures D-6 through D-9. Finally, exceedance curves comparing maximum and minimum San Luis storages under different climate scenarios are presented in Figure D-10. Overall, the Hot-Dry scenario shows the greatest impact on reservoir storage and water deliveries as compared to the No CC scenario. Alternatively, the Warm-Wet scenario could result in increased San Luis Reservoir storage and deliveries as compared to the No CC scenario.

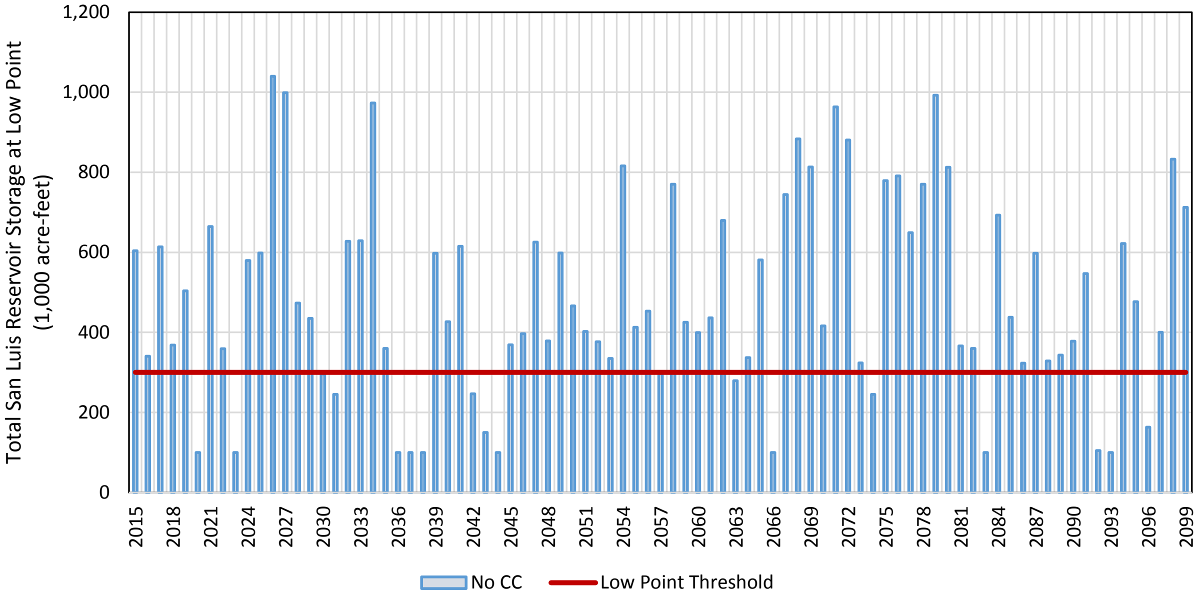


Figure D-6. Annual Total San Luis Reservoir Storage at Low Point under No CC Scenario

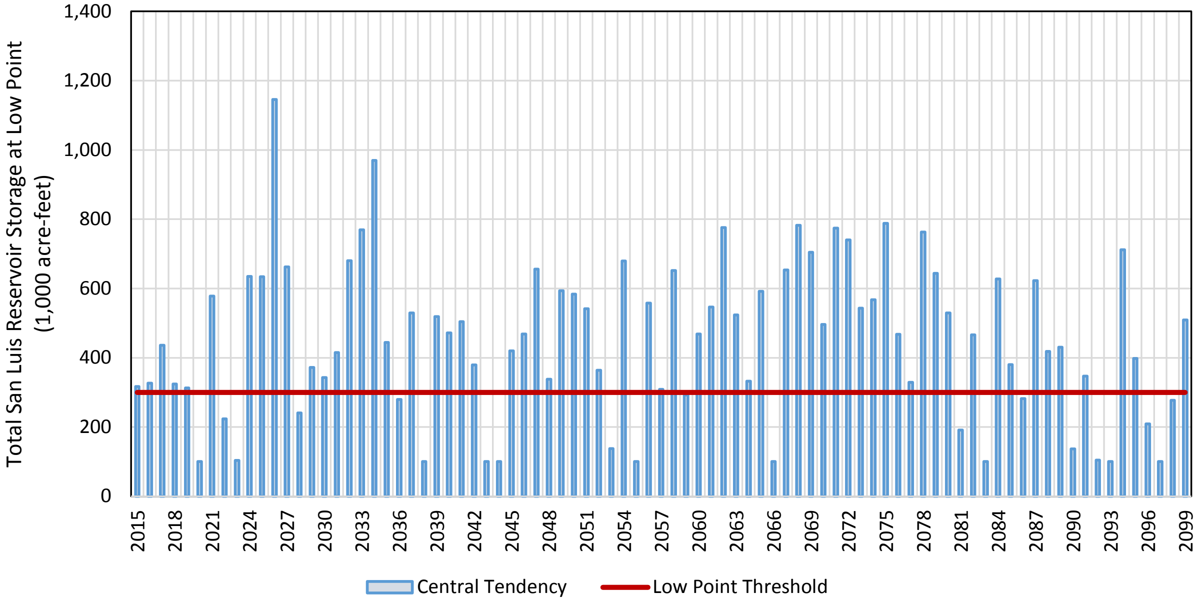


Figure D-7. Annual Total San Luis Reservoir Storage at Low Point under Central Tendency Scenario

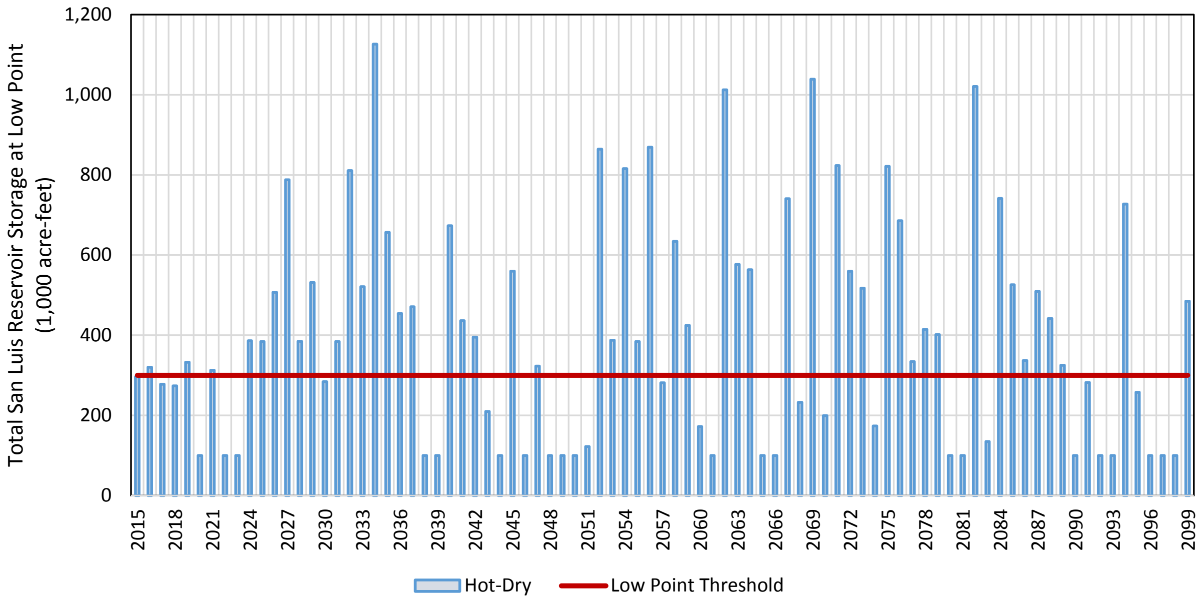


Figure D-8. Annual Total San Luis Reservoir Storage at Low Point under Hot-Dry Scenario

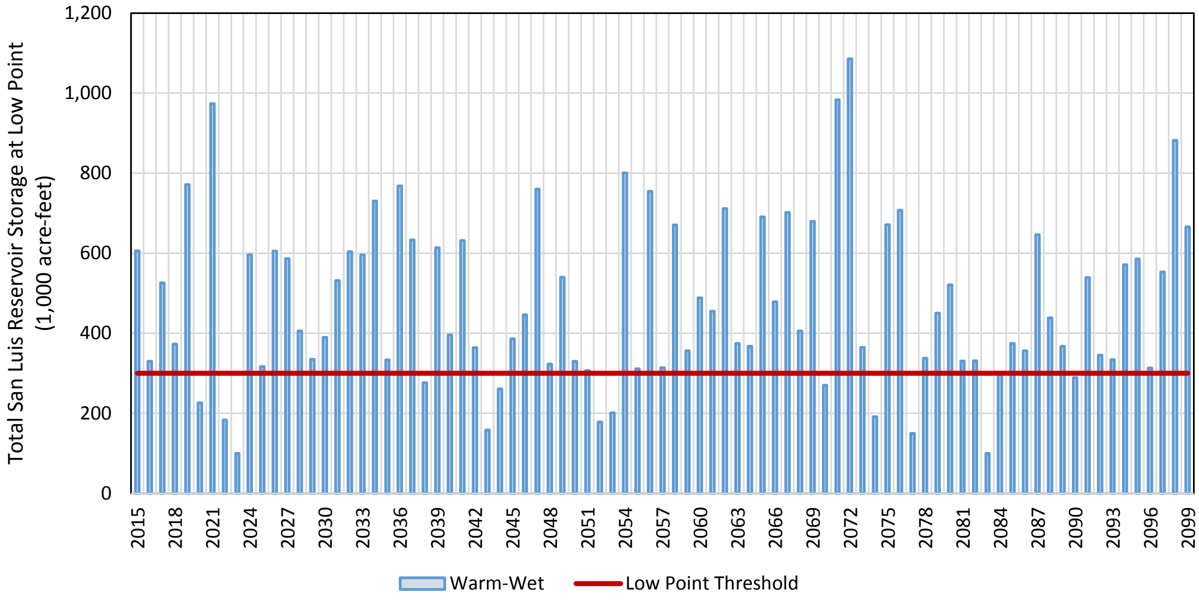


Figure D-9. Annual Total San Luis Reservoir Storage at Low Point under Warm-Wet Scenario

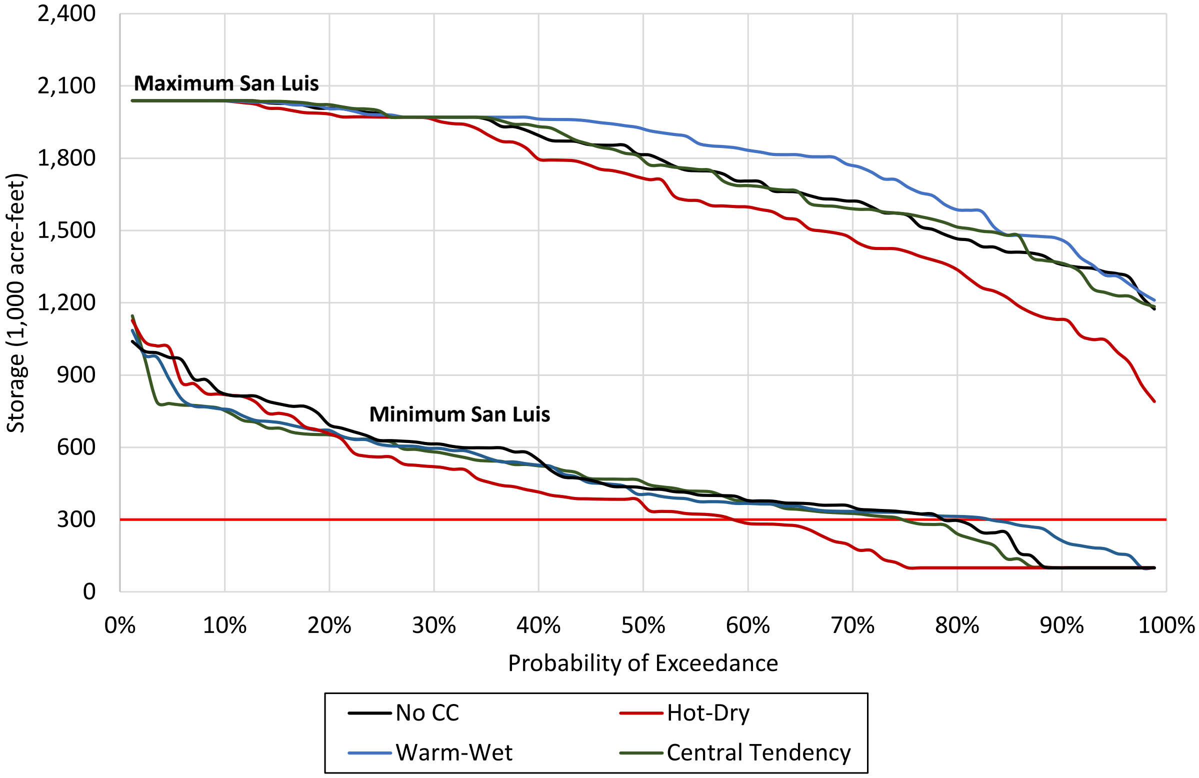


Figure D-10. Exceedance Plot of Maximum and Minimum San Luis Storage under Different Climate Scenarios

Figure D-10 presents exceedance plots of maximum and minimum San Luis storages under different climate scenarios. San Luis Reservoir fills approximately 12 percent of the time under all scenarios. The Warm-Wet scenario has the highest maximum San Luis Reservoir storage of all scenarios. The Hot-Dry scenario shows the lowest San Luis maximum and minimum storage. Results presented in Figure D-10 show San Luis maximum and minimum storages in the Central Tendency and No CC scenarios are similar. Under the Warm-Wet scenario, minimum San Luis storage falls below the low point threshold of 300 TAF in approximately 15 percent of the years. Minimum San Luis storage under the Hot-Dry scenario falls below the low point threshold in nearly 40 percent of the years.

As noted earlier, there are not any significant differences between Central Tendency scenario and No CC scenario in terms of low point frequency. Finally, San Luis Reservoir reaches dead pool at 90 TAF in approximately five to 25 percent of the years in the Warm-Wet and Hot-Dry scenarios, respectively. Simulated storage at dead pool in a significant number of years is another indication of the relatively coarse depiction of San Luis Reservoir operations in the model results.

D.5 Evaluation of Climate Trends and Variability on SLLPIP Alternatives

This section provides an assessment of how SLLPIP alternatives may perform under the range of future climate projections described in prior sections. The purpose of this evaluation is to understand whether an alternative is robust and capable of performing at a similar level as analyzed with the historical hydrology, under a range of future operational conditions that may occur due to climate trends and variability.

D.5.1 Lower San Felipe Intake Alternative

The Lower San Felipe Intake Alternative includes construction of a new, lower San Felipe Intake to allow reservoir drawdown to its minimum operating level without algae reaching the San Felipe Intake. The Lower San Felipe Intake Alternative allows delivery to San Felipe Division M&I contractors if San Luis Reservoir storage is maintained above dead pool. This alternative would be capable of maintaining deliveries to San Felipe Division M&I contractors under the range of CVP/SWP operations with climate trends and variability as analyzed in the Basins Study. Increases in the frequency or duration of future low point events as a result of climate trends and variability will not affect the performance of this alternative.

D.5.2 San Luis Reservoir Expansion Alternative

The San Luis Reservoir Expansion Alternative would raise Sisk Dam by approximately 10 feet above the dam safety raise currently being considered. The dam raise would increase the water storage capacity at San Luis Reservoir by about 120 TAF. The expansion capacity would be split in the same way as existing San Luis Reservoir capacity, with approximately 55 percent for the SWP and 45 percent for the CVP. San Luis Reservoir would continue to function as seasonal storage. This alternative would increase the yield of SWP Table A supply, but it would also affect the SWP contractors’ ability to capture and store wet season water after San Luis Reservoir is filled under Article 21 of the Monterey Agreement. This section focuses on evaluating the performance of this alternative under different climate scenarios.

The San Luis Reservoir Expansion Alternative was evaluated by post-processing results from the CalLite-CV model. The increased capacity of San Luis Reservoir could be filled during times when there is Delta outflow in excess of that required to meet Delta outflow and water quality standards (Delta surplus). Delta surplus can only be exported when there also is available Delta export capacity. These periods are times when the existing CVP or SWP portion of San Luis Reservoir is full in the CalLite-CV simulation.

A post-processing model was developed with the following logic to analyze the San Luis Reservoir Expansion Alternative for any of the CalLite-CV climate scenarios.

1. Estimate available Delta surplus.
2. Estimate available CVP and SWP export capacity as a function of:
    a. Available physical export capacity at Banks and Jones pumping plants.
    b. Available permitted capacity under regulatory constraints such as D-1641 and recent Biological Opinions.
    c. Available capacity in the expanded SWP and CVP San Luis Reservoir.

The post-processing model simulates filling the expanded capacity of San Luis Reservoir based on the above logic. Additional water stored in an expanded San Luis Reservoir under the alternative was simulated as delivered to CVP or SWP contractors in future years.

The post-processing model was configured to run any of the CalLite-CV model scenarios. CalLite-CV model results for a given climate scenario represent a Future No Action (FNA) condition and results from the post-processing model represent the San Luis Reservoir Expansion Alternative. Comparisons between the two simulations can be used to quantify the performance of the San Luis Reservoir Expansion Alternative.

Tables D-10 through D-12 summarize results of changes in frequency of low point conditions in San Luis Reservoir under the different climate scenarios with reservoir expansion. The San Luis Reservoir Expansion Alternative slightly decreases the frequency of low point conditions in the Hot-Dry and Warm-Wet scenarios and has no effect in the Central Tendency scenario.

Table D-10. Frequency of San Luis Reservoir Low Point Conditions (Storage < 300 TAF) in Years under the Hot-Dry Scenario

Sacramento Valley Index	Future No Action	San Luis Reservoir Expansion	Change from No Action
	Years	Years	Years
Wet	2	1	-1
Above Normal	2	2	0
Below Normal	7	6	-1
Dry	12	12	0
Critical	12	12	0
All Years	35	33	-2

Table D-11. Frequency of San Luis Reservoir Low Point Conditions (Storage < 300 TAF) in Years under the Warm-Wet Scenario

Sacramento Valley Index	Future No Action	San Luis Reservoir Expansion	Change from No Action
	Years	Years	Years
Wet	1	0	-1
Above Normal	2	2	0
Below Normal	1	1	0
Dry	4	4	0
Critical	6	6	0
All Years	14	13	-1

Table D-12. Frequency of San Luis Reservoir Low Point Conditions (Storage < 300 TAF) in Years under the Central Tendency Scenario

Sacramento Valley Index	Future No Action	San Luis Reservoir Expansion	Change from No Action
	Years	Years	Years
Wet	2	2	0
Above Normal	1	1	0
Below Normal	2	2	0
Dry	8	8	0
Critical	8	8	0
All Years	21	21	0

Results presented in Figure D-11 show the changes in combined CVP and SWP deliveries from San Luis Reservoir under this alternative as compared to FNA for each climate projection. On an average annual basis, changes in deliveries range from 10 TAF to 14 TAF. Delivery changes are for both the CVP and SWP and do not reflect the likely reduction in Article 21 deliveries to certain SWP contractors with the expansion of San Luis Reservoir.

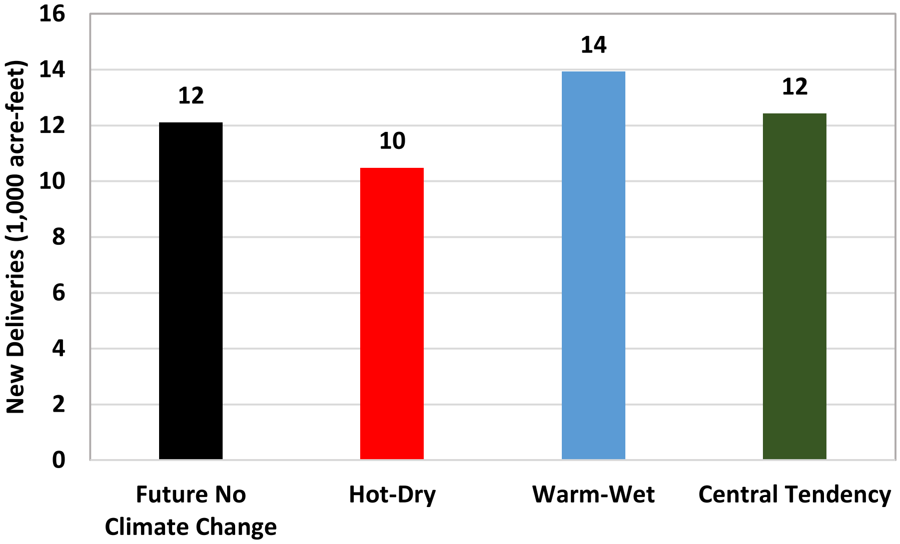


Figure D-11. Change in SWP and CVP Deliveries under San Luis Reservoir Expansion Alternative

D.5.3 Treatment Alternative

The Treatment Alternative includes improvements to Santa Clara Valley Water District water treatment facilities that would allow diversion from San Luis Reservoir even during low point conditions. The Treatment Alternative allows delivery to San Felipe Division M&I contractors if San Luis Reservoir storage is maintained above dead pool. This alternative would be capable of maintaining deliveries to San Felipe Division M&I contractors under the range of CVP/SWP operations with climate trends and variability as analyzed in the Basins Study. Increases in the frequency or duration of future low point events as a result of climate trends and variability will not significantly affect the performance of this alternative.

D.5.4 Pacheco Reservoir Alternative

The Pacheco Reservoir Alternative includes construction and operation of a new dam and expanded reservoir, pump station, conveyance facilities, and related miscellaneous infrastructure. The new dam and reservoir would be constructed on Pacheco Creek 0.5 mile upstream from the existing North Fork Dam and would inundate most of the existing Pacheco Reservoir. The proposed total storage for the expanded reservoir is 141,600 AF, with an active storage of 140,800 AF. The full pool elevation would be 694 feet and would inundate an additional 1,245 acres, for a total of 1,385 total acres inundated. Water would be collected in the expanded reservoir from runoff from the local watershed area during the winter months and from diversion of CVP supplies from the Pacheco Conduit, when needed.

Climate trends and variability may have a variety of potential effects on the operation of Pacheco Reservoir. Results presented in Figure D-5 show changes in annual average runoff for the San Joaquin River System, which could be similar to changes seen in the Pacheco Creek area. Results for the San Joaquin River System show changes in annual average runoff of -22 percent for the Hot-Dry scenario and +31 percent for the Warm-Wet scenario. There may be similar changes in the average annual runoff from Pacheco Creek for climate conditions analyzed in the Basins Study. These changes may reduce or increase the potential water supply available from Pacheco Reservoir.

Additionally, climate trends and variability can affect the frequency of low point conditions occurring in San Luis Reservoir (see Table D-9). Increased frequency of San Luis Reservoir low point conditions may require changes in the operation of Pacheco Reservoir to move more CVP contract supply into Pacheco Reservoir in advance of potential low point conditions to make the water available for use during low point conditions. The Pacheco Reservoir Alternative should be able to address more frequent or less frequent San Luis Reservoir low point conditions through changes in operations for the volume and timing of CVP contract supply moved into and out of Pacheco Reservoir.

Climate trends and variability are also expected to affect Santa Clara Valley Water District's (SCVWD's) imported supplies from the SWP and CVP (see Table D-6 and Table D-7, respectively). Basins Study results indicate reductions in the availability of CVP and SWP contract supplies under the Hot-Dry scenario and increases under the Warm-Wet scenario. The Pacheco Reservoir Alternative may improve SCVWD's ability to manage for changes in imported water supply by providing additional storage for water in years when imported supplies are higher, which can be carried over into years when imported supplies are lower.

D.6 References

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San Luis Low Point Improvement Project Feasibility Report

Appendix E: Economic Benefits Evaluation

U.S. Department of the Interior
Bureau of Reclamation
Sacramento, California

April 2019

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Contents

Tables

Figures

Chapter 1
Background and Project Description

This technical appendix to the Feasibility Report for the San Luis Low Point Improvement Project (SLLPIP) documents National Economic Development (NED) benefit analyses to support Federal plan formulation and evaluation. The benefit analysis herein also considers economic guidance by the California Water Commission (CWC) for the estimation of public benefits as part of the State of California's Water Quality, Supply, and Infrastructure Improvement Act of 2014.

The purpose of the SLLPIP is to address the delivery schedule uncertainty and water supply reliability problems with San Luis Reservoir when reservoir storage drops below a certain threshold and low point issues may develop. Low point issues occur when conditions in San Luis Reservoir promote the growth of reservoir-wide algae. Algae blooms generally reach diversion facilities when reservoir storage is at or below 300 thousand acre-feet (TAF), corresponding to a lake elevation of approximately 370 feet. The first diversion facilities to be affected by algae blooms are intakes for the Pacheco Pumping Plant serving the San Felipe Division of the Central Valley Project (CVP). Water quality within algae blooms is not suitable for municipal and industrial (M&I) water users and existing water treatment facilities of the Santa Clara Valley Water District (SCVWD). The SLLPIP investigated alternative plans to remedy these potential issues and avoid supply interruptions to San Felipe Division contractors due to algae blooms in San Luis Reservoir.

1.1 Background

Reclamation owns and jointly operates San Luis Reservoir with the California Department of Water Resources (DWR) to provide seasonal storage for the CVP and the SWP. San Luis Reservoir is capable of receiving water from both the Delta-Mendota Canal (DMC) and the California Aqueduct. This enables the CVP and SWP to pump water into the reservoir during the wet season (November through April) and release water into the conveyance facilities during the dry season (April through October) when demands are higher. Deliveries from San Luis Reservoir also flow west through Pacheco Pumping Plant and Conduit to the San Felipe Division of the CVP, which includes SCVWD.

During the summer, high temperatures and declining water levels in San Luis Reservoir create conditions that foster algae growth. The thickness of the algal blooms vary, but typically average approximately 35 feet. If water levels fall below 369 feet (300 TAF), SCVWD cannot withdraw water from San Luis

Reservoir because its existing water treatment plants (WTPs) cannot treat the algae-laden water to meet its existing water quality standards. San Luis Reservoir is the only delivery route for the San Felipe Division's CVP supplies; therefore, during a low point event, SCVWD cannot access its CVP supplies. In recent years, Reclamation has been implementing exchanges to supplement CVP supplies from San Luis Reservoir to SCVWD.

1.2 Study Location

The study location for the SLLPIP (Figure 1-1) includes San Luis Reservoir and its related water infrastructure (including the San Felipe Division's water intakes and associated infrastructure); Sacramento-San Joaquin River Delta (Delta); California Aqueduct; South Bay Aqueduct (SBA); South-of-Delta CVP and SWP contractors; SCVWD service area, including the Santa Teresa WTP in San Jose; and Pacheco Reservoir and the surrounding vicinity, Pacheco Creek, Pajaro River, San Felipe Lake and Miller Canal.

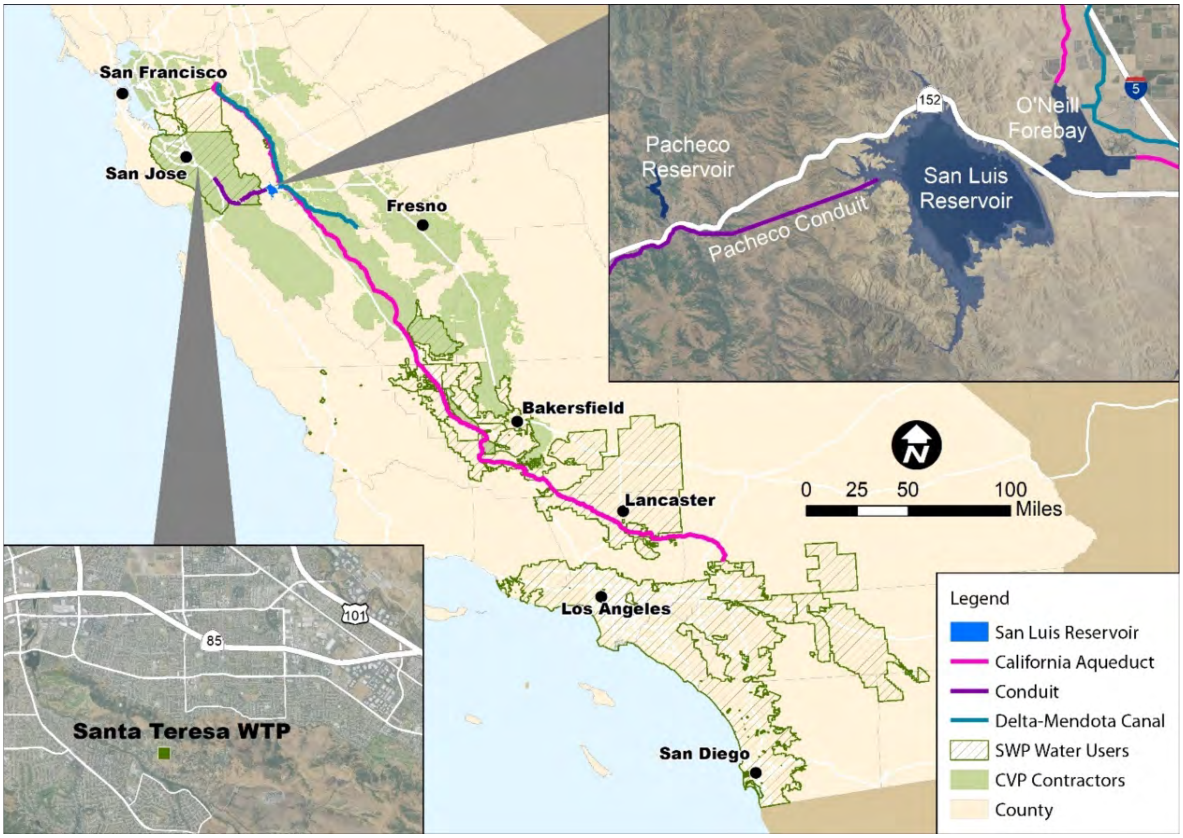

Figure 1-1. SLPPIP Study Location

1.3 Project Objectives

Reclamation and SCVWD are proposing the SLLPIP for the purpose of optimizing the water supply benefit of San Luis Reservoir while reducing additional risks to water users by:

- Avoiding supply interruptions when water is needed by increasing the certainty of meeting the requested delivery schedule throughout the year to South-of-Delta contractors, including SCVWD, dependent on San Luis Reservoir.
- Increasing the reliability and quantity of yearly allocations to South-of-Delta contractors, including SCVWD, dependent on San Luis Reservoir.

In addition to these primary objectives, the SLLPIP may also support a secondary objective to provide opportunities for ecosystem restoration. The primary objectives distinguish between certainty of meeting delivery schedules and the reliability of supplies. More specifically, the first objective is related to predictably meeting contractors' delivery schedules throughout the year as opposed to the second objective, which strives to increase yearly allocations to more closely match the contractual entitlements.

The objectives for predictably meeting delivery schedules and increased annual allocations could lead to conflicts regarding San Luis Reservoir operations. These issues are relevant to South-of-Delta contractors dependent on San Luis Reservoir, including SCVWD. San Luis Reservoir serves as a storage facility to increase the annual reliability of deliveries to CVP contractors in the Central Valley. CVP contractors rely on both direct diversions from the Jones Pumping Plant and stored water from San Luis Reservoir to meet summer demands. Full exercise of the reservoir helps to maximize CVP supplies, but any constraint in the release of water from San Luis Reservoir could limit supplies. The Jones Pumping Plant does not have enough pumping capacity to fully meet demands alone and CVP operators store additional water in San Luis Reservoir during the winter, when demands are low, to help meet summertime needs.

SCVWD is more impacted by conditions in San Luis Reservoir due to its position between the Delta and the San Felipe Unit. SCVWD is unable to adequately treat water with high algae/nitrates, and is therefore unable to adequately treat its CVP supply due to water quality conditions that can develop when San Luis Reservoir volume drops below 300 TAF. When SCVWD is unable to treat its CVP supply, then it must rely on other sources of water for M&I purposes which may be more expensive and/or not reliable each year. In the future, increased demand and the potential for further regulatory constraints on availability of CVP and SWP supplies may cause contractors to maximize use of their water stored in San Luis Reservoir, increasing the frequency of the low point issue and the risk of supply interruptions to SCVWD.

SCVWD water supply interruptions have historically been avoided because SWP contractors have left water in storage, thus maintaining water levels in San Luis Reservoir above approximately 300 TAF. However, in 2008, San Luis Reservoir was drawn down below 300 TAF which created treatment performance issues at SCVWD WTPs and resulted in an interruption of deliveries from San Luis Reservoir. Future CVP water supply reliability for SCVWD requires the full use of the CVP water from San Luis Reservoir, therefore, SCVWD desires a solution that resolves water quality issues in San Luis Reservoir that are impairing its ability to utilize these supplies.

1.4 Alternatives Evaluated

1.4.1 Alternative 1 - No Action/No Project Alternative

The No Action or No Project Alternative presents the reasonably foreseeable future conditions in the absence of the alternative plan. The purpose of the No Action or No Project Alternative is to allow decision makers to compare the impacts of approving the project to the impacts of not approving the project. The No Action/No Project Alternative would leave the current operations at San Luis Reservoir unchanged. SCVWD would continue annual operations planning to anticipate curtailment of CVP supply, and would cope with its uses and sources of imported and local water supplies. CVP agricultural contractors would continue to rely on the current water supply allocation process.

1.4.2 Alternative 2 - Lower San Felipe Intake Alternative

Alternative 2 includes construction of a new, lower San Felipe Intake to allow reservoir drawdown to its minimum operating level without algae reaching the San Felipe Intake. Moving the San Felipe Intake to an elevation equal to that of the Gianelli Intake would allow operation of San Luis Reservoir below the 300 TAF level without creating the potential for a water supply interruption to SCVWD. As part of this alternative, a new intake would be constructed and connected to the existing San Felipe Division Intake via approximately 20,000 feet of new pipeline or tunnel. The lower intake facility would allow the San Felipe Division to receive water from the lower reservoir levels that do not contain high concentrations of algae. A hypolimnetic aeration facility would also be constructed to increase dissolved oxygen levels in lower reservoir levels to prevent taste and odor issues.

1.4.3 Alternative 3 - Treatment Alternative

Alternative 3 would implement technology retrofits at SCVWD’s Santa Teresa WTP. The WTP is supplied with water from San Luis Reservoir, which during low point conditions can contain high concentrations of algae. Alternative 3 would develop new treatment technology at the WTP to address some of the negative impacts associated with increased algae during low point events. The proposed improvements evaluated under this alternative would add a raw water ozonation process to the Santa Teresa WTP. Implementation of a raw water ozonation process at the Santa Teresa WTP would require installation of a new ozone contactor, new ozone generation equipment housed in a new building, and new liquid oxygen storage facilities.

1.4.4 Alternative 4 - San Luis Reservoir Expansion Alternative

Alternative 4 would be completed by placing additional fill material on the dam embankment to raise the dam crest to increase storage capacity. The alternative would build upon the dam embankment expansion and foundation modifications to address the seismic concerns. The expanded capacity in San Luis Reservoir would be assigned to the CVP and not the SWP.

1.4.5 Alternative 5 - Pacheco Reservoir Expansion Alternative

Alternative 5 includes removal of existing dam, construction and operation of a new dam and reservoir, pump station, conveyance facilities, and related miscellaneous infrastructure. The new dam and reservoir would be constructed on Pacheco Creek 0.5 mile upstream from the existing North Fork Dam and would inundate most of the existing Pacheco Reservoir. The proposed total storage for the new reservoir is 141,600 acre-feet (AF), with an active storage of 140,800 AF. The full pool elevation would be 694 feet and would inundate an additional 1,245 acres, for a total of 1,385 total acres inundated. Water would be collected in the new reservoir during the winter months from runoff from the local watershed area, and diversion of CVP supplies from the Pacheco Conduit. Alternative 5 would be operated by SCVWD to both improve habitat conditions for steelhead in Pacheco Creek and improve SCVWD water supply reliability, including during drought periods and emergencies. In addition, SCVWD will transfer 2,000 AF of its CVP water contract (in below normal water years), directly or through transfer and exchanges, in perpetuity to Reclamation and U.S. Fish and Wildlife Services’ Refuge Water Supply Program (RWSP), for use in the Incremental Level 4 water supply pool for wildlife refuges.

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Chapter 2
Economic Principles and Methods

This chapter describes Federal economic principles and methods related to plan formulation, estimation of project benefits, and derivation of total annual equivalent benefits. This chapter also describes potential economic valuation methods, and the methods applied to the SLLPIP.

2.1 Guidelines

The economic valuation approach for Federal water resource projects and the SLLPIP is consistent with the *Federal Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies* (P&G) (WRC 1983). In 2015, the Council on Environmental Quality completed an interagency effort to update the 1983 P&G. This effort led to the development of the *Principles, Requirements and Guidelines for Water and Land Related Resources Implementation Studies* (PR&G). The PR&G apply only to plans or projects that are initiated after the PR&G take effect, therefore the P&G are the primary guidelines used for the SLLPIP. The approach to quantifying and monetizing benefits in the PR&G and the P&G are not significantly different (DOI 2015).

The P&G indicate the Federal objective of water and related land resources project planning is to contribute to national economic development consistent with protecting the Nation’s environment, pursuant to national environmental statutes, applicable executive orders, and other Federal planning requirements. Further, numerous Federal laws (e.g., the Endangered Species Act (ESA) (1973), Clean Water Act (1972)) establish policy and Federal interest in the protection, restoration, conservation, and management of protecting environmental quality.

The Federal Objective as updated and specified in the Water Resources Development Act of 2007 is that Federal water resources investments shall reflect national priorities, encourage economic development, and protect the environment by:

- seeking to maximize sustainable economic development;
- seeking to avoid the unwise use of floodplains and flood-prone areas and minimizing adverse impacts and vulnerabilities in any case in which a floodplain or flood-prone area must be used; and

- protecting and restoring the functions of natural systems and mitigating any unavoidable damage to natural systems.

In the Water Resources Development Act of 2007, Congress instructed the Secretary of the Army to develop a new P&G for the U.S. Army Corps of Engineers (USACE) to promote consistency and informed decision making among Federal agencies. In 2009 the Obama Administration began the process of updating the P&G for Federal agencies engaged in water resources planning, including USACE, Environmental Protection Agency, Department of Agriculture, Department of the Interior, National Oceanic and Atmospheric Administration, Tennessee Valley Authority, Federal Emergency Management Agency, and Office of Management and Budget.

In March 2013, the Administration released the Principles & Requirements that lay out broad principles to guide Federal investments in water management (Whitehouse 2013). In addition, Draft Interagency Guidelines for implementing the Principles & Requirements were also released. The modernized Principles & Requirements, together with agency specific Guidelines (PR&G), will allow agencies to better consider the full range of long-term economic, social, environmental, cultural, and other benefits of infrastructure projects.

In consideration of the many complex water management challenges and competing demands for limited Federal resources, it is intended that Federal investments in water resources should strive to maximize public benefits, particularly in comparison to costs. Public benefits encompass environmental, economic, and social goals, include monetary and non-monetary effects and allow for the inclusion of quantified and non-quantified measures. Stakeholders and decision makers expect the formulation and evaluation of a diverse range of alternative solutions. Such solutions may produce varying degrees of effects relative to the three goals specified above and as a result, tradeoffs among potential solutions will need to be assessed and properly communicated during the decision making process.

Thus, in addition to traditional, monetized economic development, projects that contribute to Federal ecosystem and species restoration goals, public health and safety, environmental justice, community benefits, and support recreation opportunities are relevant components of water project planning and development.

Economic evaluation provides a way to understand and evaluate trade-offs that can be quantified and monetized and that must be made between alternatives with respect to objectives, investments, and other social goals. It also provides a means to identify the plan that is acceptable, effective, efficient, and complete, and contributes the most favorably to national priorities. The Federal P&G

established four main accounts for organizing, displaying, and analyzing project alternatives:

- NED
- Regional Economic Development (RED)
- Environmental Quality (EQ)
- Other Social Effects (OSE)

The above accounts encompass all significant effects of a plan, consistent with NEPA of 1970 (42 United States Code 4321 et seq.) and other Federal guidance. The NED account is the only required account under the 1983 P&Gs, although information that could affect Federal decision-making should be presented in the other accounts. Only the NED benefits are quantified in this appendix.

2.1.1 National Economic Development Account

The NED account identifies the alternative providing the greatest net economic benefits to the Nation. The NED account considers and displays the potential changes and effects in the total value of the national output of goods and services from an alternative plan, expressed in monetary units. Contributions to NED are increases in the total value of the national output of goods and services, expressed in monetary units. NED benefits are the direct net benefits that would be expected to accrue in the primary study area and the rest of the Nation should a project or program be implemented. They include increases in the net value of those goods and services that are marketed, and also of those that may not be marketed.

The NED account describes the portion of the NEPA human environment, as defined in 40 Code of Federal Regulations 1508.14 that identifies beneficial and adverse effects on the economy which occur as a result of water resources planning and development. The NED account considers the estimated benefits and costs of the action alternatives. Beneficial effects could include (1) increases in the economic value of the national output of goods and services from a plan, (2) the value of output resulting from external economies caused by a plan, and (3) the value associated with the use of otherwise unemployed or under-employed labor resources. Adverse effects in the NED account would be the opportunity costs of resources used in implementing a plan. Such opportunity costs could include decreases in output in other sectors, or employment losses. These effects usually include (1) implementation outlays, (2) associated costs, and (3) other direct costs.

After displaying and comparing the estimated benefits and costs for the SLLPIP alternative actions, the NED analysis considers the monetary and non-monetary trade-offs and culminates in identifying the alternative that would reasonably provide the greatest net economic benefits to the Nation while protecting the environment. As required by the P&G, the plan with the greatest net NED benefits (NED benefits minus NED costs) is identified as the NED Plan and is usually selected for recommendation to Congress for approval, unless the Secretary of the Interior grants an exception based on overriding considerations and merits of another plan. If another plan is recommended instead of the NED Plan, such as a locally preferred plan, the NED Plan is still presented as a basis of comparison to define the extent of Federal financial interest in the plan recommended for implementation.

2.1.2 Regional Economic Development Account

The RED account examines and displays potential changes in the value of economic activity at the local or regional level for the alternative plans. RED analysis may reflect only a shift in economic productivity from one region to another, not the change in output at the national level required in Federal analysis. Because local and regional economic activity is of great interest to decision-makers and stakeholders, RED analysis may be included to assess changes in regional personal income and employment and can be part of an analysis of trade-offs as can the environmental quality account and other social effects account described below.

2.1.3 Environmental Quality Account

The EQ account examines and displays the effects of alternative plans on significant EQ resources and attributes of the NEPA human environment that is essential to a reasoned choice among alternative plans. Beneficial effects in the EQ account are favorable changes in the ecological, aesthetic, and cultural attributes of natural and cultural resources. Adverse effects in the EQ account are unfavorable changes in the ecological, aesthetic, and cultural attributes of natural and cultural resources.

2.1.4 Other Social Effects Account

The OSE examines and displays the potential changes of alternative plans on other social effects not covered under the NED, RED, and EQ accounts. The effects quantified by OSE include urban and community impacts, such as effects on income or population distribution, fiscal conditions of the State and local governments, the quality of community life, and similar impacts. OSE includes impacts to life, health, and safety, including the risk of flood, drought, or disaster; the potential loss of life, property, and essential services; and environmental effects not covered under the NED and EQ accounts.

2.2 Other Considerations

In addition to following Federal guidelines in development of economic analysis methods and procedures for the SLLPIP, consideration was given to economic guidance developed by the CWC (specifically the Draft Working Paper for Water Storage Investment Program Common Assumptions – Economics (July 29, 2015), available at: https://cwc.ca.gov/Pages/DocumentLibrary.aspx) related to the distribution of

Water Storage Investment Program funding available through the Water Quality, Supply, and Infrastructure Improvement Act of 2014 (Proposition 1). This bond initiative dedicated $2.7 billion for investments in water storage projects and designated the CWC as the agency responsible for allocating these funds based on specific criteria.

Projects that may receive State funding under Proposition 1 were selected by the CWC through a competitive public process based on a project's expected return on the public investment as measured by the magnitude of the public benefits provided. The public benefits categories defined by Proposition 1 include:

Ecosystem improvements, including changing the timing of water diversions, improvement in flow conditions, temperature, or other benefits that contribute to restoration of aquatic ecosystems and native fish and wildlife, including those ecosystems and fish and wildlife in the Delta.

Water quality improvements in the Delta, or in other river systems, that provide significant public trust resources, or that clean up and restore groundwater resources.

Flood control benefits, including, but not limited to, increases in flood reservation space in existing reservoirs by exchange for existing or increased water storage capacity in response to the effects of changing hydrology and decreasing snow pack on California's water and flood management system.

Emergency response, including, but not limited to, securing emergency water supplies and flows for dilution and salinity repulsion following a natural disaster or act of terrorism.

Recreational purposes, including, but not limited to, those recreational pursuits generally associated with the outdoors.

The CWC approved conditional funding of approximately $485 million for the Pacheco Reservoir Expansion Project in May of 2018. Final award of this funding is contingent upon SCVWD completing the remaining Proposition 1 requirements including final permits, environmental documents, contracts for the administration of public benefits, and commitments for non-Proposition 1 funding. Once SCVWD has obtained all the necessary permits, documents and contracts, CWC will hold a final award hearing. For the Pacheco Reservoir Expansion Project this final award hearing is scheduled to occur in 2024 before the scheduled start of construction.

In recognition that the preferred alternative for the SLLPIP i.e. Pacheco Reservoir Expansion Project has been conditionally approved to receive funding, economic guidance by the CWC related to the estimation of public benefits was considered as part of the project. CWC proposed methods for estimating benefits are generally consistent with Federal guideline in general.

The CWC guidelines were considered to ensure consistency in approach and methods.

2.3 NED Benefit Evaluation Procedures

In general, the objectives of Federally financed water resources projects are to enhance NED, the quality of the environment, the well-being of people in the United States, and regional economic development. NED costs and benefits are the decrease or increase in the value of the national output of goods and services, expressed in dollars. NED figures measure costs and benefits to the Nation, rather than to a particular region. This section generally describes the procedures used to identify the alternative that maximizes NED benefits.

As described in the P&G, water resources project plans shall be formulated to alleviate problems and take advantage of opportunities in ways that contribute to NED. The alternative plan with the greatest net NED economic benefit is identified as the NED plan and often has the greatest potential for Federal investment. The NED account includes the following categories of goods and services: (1) M&I water supply; (2) agricultural floodwater, erosion, and sediment reduction; (3) agricultural drainage; (4) agricultural irrigation; (5) urban flood damage reduction; (6) power (hydropower); (7) transportation (inland navigation); (8) transportation (deep draft navigation); (9) recreation; (10) commercial fishing; and, (11) other categories of benefits for which procedures are documented in the planning report and are consistent with the general measurement standard in the P&Gs. While multipurpose projects may provide additional types of benefits, these categories coincide with project purposes in which an established Federal financial interest exists. Other categories of benefits may be allowed or may be included in congressional authorization for a specific project.

Environmental benefits, including fisheries and ecosystem resources, are typically included in the EQ account if monetary units cannot be attributed to these benefits. However, in some cases, environmental benefits may be developed as monetary units, and be included in the NED account under “other categories of benefits.” For this analysis, refuge water supply benefits are based on the water transfer price and are quantified in the NED account.

NED costs are the opportunity costs of resource use and require consideration of the private and public uses that producers and consumers are making of available resources, now and in the future. For goods and services produced in a competitive market, price is often used to reflect opportunity cost. Consequently, market prices should be used to determine NED costs, provided market prices reflect the full economic value of a resource to society. The market price approach should reflect the interaction of supply and demand. If market prices do not reflect total resource values, surrogate values may be used that approximate opportunity costs based on an equivalent use or condition.

The two primary decision criteria used in a Federal economic analysis are net benefits and the benefit-cost ratio. The net benefit is the difference between the net present value of benefits and costs, and it measures the extent to which benefits to the Nation exceed project costs. The benefit-cost ratio is calculated by dividing annual project benefits by annual project costs. The net benefits and costs of alternative plans are compared to identify the plan that reasonably maximizes net benefits, or the NED plan. The NED Plan is not necessarily the plan with the greatest benefits, but rather the plan that maximizes benefits given the cost to the Nation. Section 1.10.2 of the P&G requires that the NED plan be selected unless the Secretary of the Interior grants an exception.

2.4 Economic Valuation Methods

Economic valuation methods generally fall into one of two categories: market valuation or nonmarket valuation. Market values refer to conditions for which a price can be observed, such as for human consumptive uses. Nonmarket valuation methods usually apply to a resource for which there is no established market to observe values, such as ecosystem restoration or wildlife conservation. As recommended in the P&G, economic benefits may be determined by one of four valuation approaches:

- Actual or simulated market prices
- Change in net income
- Cost of the most likely alternative
- Administratively established values

In general, the P&G indicate that the value of goods and services should be based on willingness to pay. Revealed and stated preferences are two approaches for measuring willingness to pay for goods and services. Revealed preferences are based on observed behavior that reflects preferences, while stated preferences are based on directly asking individuals to indicate preferences in a hypothetical setting. Demand functions cannot always be estimated for many goods and services due to a lack of observed market data or the ability to obtain survey data. In lieu of demand function estimation, the P&G recommend the use of actual or simulated market prices, where available, because they represent a close approximation of total willingness to pay value. Other generally acceptable approaches under the P&G include cost-based approaches. In addition, benefits transfer, which uses values from previous economic studies (developed with any of the four valuation approaches indicated by the P&G), may be used to estimate willingness to pay provided they are relevant to the study area and output being valued. Each of the valuation approaches indicated by the P&G to estimate NED economic benefits is briefly described below.

2.4.1 Actual or Simulated Market Prices Method

In cases when a demand curve cannot be directly estimated, market prices may be used to estimate society's willingness to pay for a good or service. The P&G provide some limited guidance on the use of market prices when the output of the plan is expected to have a significant effect on market price. Prices should be expressed in real terms (inflation adjusted). Real prices should be adjusted throughout the planning period to account for expected changes in demand and supply conditions. The methods include: revealed preferences, which relies on market-based data; contingent valuation, which uses surveys to directly elicit consumer benefits; and benefits transfer. A well-designed contingent valuation survey represents one possible method to measure willingness to pay in a developing market. However, conducting a primary revealed preference or contingent valuation study is often prohibitively time-consuming and expensive.

2.4.2 Change in Net Income Method

When willingness to pay and market price methods cannot be implemented, the P&G allow estimation of the change in net income to producers associated with a project to obtain an estimate of total value. This method is most frequently applied to circumstances when water supply from a project will be used as an input in a production process.

2.4.3 Cost of the Most Likely Alternative Method

In situations where water supply alternatives to a proposed project exist, the cost of the most likely alternative to obtain the same level of output can be used as a proxy measure of NED benefits. When applying this method, it is important to consider alternatives that would realistically be implemented in the absence of the proposed project. This method is generally considered for benefit categories that cannot be estimated through the market-based methods described above. This cost of the most likely alternative method identifies the cost of obtaining or developing the next unit of a resource to meet a particular objective. The net benefit is estimated by subtracting the cost of developing the project under consideration from the cost of the alternative unit. For water supply reliability benefits, for example, the cost of the most likely alternative represents the next unit of water supply the water user would purchase or develop if the project under consideration were not in place. The cost of the alternative that would be reasonably expected to be implemented in the absence of the NED plan would be the most likely alternative. If the NED Plan provides the same output as the most likely alternative at a lower cost, the net benefit of the NED Plan is equal to the difference in the project costs.

2.4.4 Administratively Established Values Methods

Administratively established values are representative values for specific goods and services that are cooperatively established by the water resources agencies. This method is the least preferred approach to estimating economic benefits identified in the P&G, and is only implemented when other options cannot be completed.

2.5 SLLPIP Alternatives Valuation Approaches

This section briefly describes economic analysis parameters. Valuation approaches are presented for M&I water supply reliability, agricultural water supply, emergency M&I water supply and ecosystem restoration benefits that include anadromous fish benefits and refuge water supply benefits in the following chapters.

2.5.1 Economic Analysis Parameters

Economic parameters and future without-project conditions that form the basis for the economic analysis presented in this section. Economic analysis assumptions outlined in the P&G include those related to full employment, risk neutrality, and others. Parameters specific to the SLLPIP alternative include period of analysis and discount rate, summarized below.

Period of analysis – The period of analysis is the anticipated period over which project effects are likely to accumulate. The P&G allow for a period of analysis for up to 100 years based on anticipated project life. A 100-year period of analysis is believed appropriate for the SLLPIP Alternatives because of the anticipated longevity of a dam and reservoir project. The economic benefits of the project would begin to accrue the year construction is completed. The projected construction period for each SLLPIP alternatives differs in this analysis. For consistency purpose, annual benefits are estimated for the year 2030 as an approximation of the benefits that would be obtained from completion of a planning horizon analysis. By many accounts, real water values are rising faster than the current Federal discount rate. As a result, applying the estimated 2030 benefits is a conservative approach.

Discount rate – The discount rate is the rate at which society as a whole is willing to trade off present for future benefits. NED impacts are compared at a common point in time in average annual equivalent terms. This is accomplished by discounting capital costs, deferred installation costs, and operation, maintenance, and replacement costs to the beginning of the period of analysis using an established Federal discount rate. The Federal discount rate for plan formulation and evaluation is established annually by the Secretary of the Treasury pursuant to 42 United States Code 1962d-1. The Federal discount rate of 2.875 percent (fiscal year 2018) is used in this economic analysis.

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Chapter 3
M&I Water Supply Benefits

3.1 Introduction

The SLLPIP alternatives affect water supplies to M&I water users in all water year types.

3.2 Physical Benefit Quantification

An analysis was performed to value the benefits of improved M&I water supply reliability from the SLLPIP alternative plans under 2030 future conditions for all water year types. The CalSim II model was used to estimate possible increases in water supply reliability for all the SLLPIP alternative plans. As currently formulated, each SLLPIP alternative plan increase water supply delivery. Estimated urban water deliveries associated with SLLPIP alternative plans are reported in Table 3-1. Refer to Appendix B of the Feasibility Report for details of the hydrologic model analysis and results.

Table 3-1. Estimated Change in Municipal and Industrial Water Supply Reliability Provided by SLLPIP Alternative Plans (TAF/year)

	Lower Intake/ Treatment	San Luis Reservoir Expansion	Pacheco Reservoir Expansion
Average Annual Additional Water Quantity	3.1	-2.6	2.8

3.3 NED Benefit Monetization

3.3.1 Economic Methods

In this analysis, the benefits to M&I water users are measured according to the cost of the most likely alternative water supply that would be pursued in the absence of development of the SLLPIP alternative plans. For water supply reliability benefits, the cost of the most likely alternative represents the next unit of water supply the water user would purchase, or develop, if the project under consideration were not in place. The cost of the most likely alternative assumes that if the preferred alternative is not implemented, the alternative action most likely to take place provides a relevant comparison. The valuation approach relies upon the costs associated with observed market transactions for water.

3.3.2 Economic Analysis

M&I water users rely on the water transfer market to augment existing supplies and avoid shortages. For example, Bay Area water providers, including SCVWD, purchased more than 40 TAF during 2015 at unit prices between $300 and $700 per acre-foot (AF) (not including conveyance costs). In addition, water market purchases are included as part of the long-term water supply portfolio for many water providers in the region. This analysis relies in part on market prices paid to purchase water on an annual basis from willing sellers. The market prices are reported according to the payments made directly to the sellers. The buyers incur additional costs to convey the water to their M&I service areas. These costs include both conveyance losses, which diminish the volume of water delivered to end users, as well as wheeling and power charges. The conveyance costs are estimated for M&I water users benefiting from the alternative plans and added to the estimated market prices to acquire the water to develop an estimate of the full cost associated with additional water supply obtained in the transfer market. Figure 3-1 illustrates the information used to estimate the value of M&I water supplies.

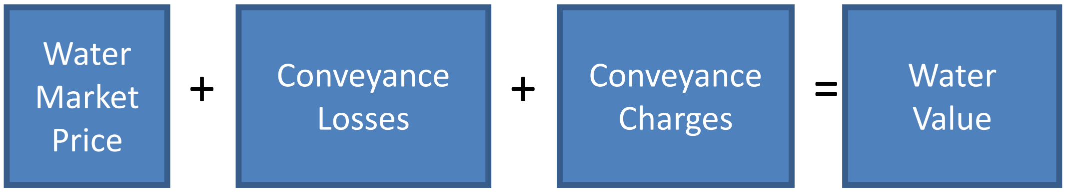

Figure 3-1. General M&I Water Value Estimation Procedures

3.3.2.1 Water Transfers Pricing Database

A database of California water market sales was developed for use in this analysis. Spot market (single year) transactions from 1990 through 2016 was developed using publicly available data from the following sources:

- Water Acquisition Program (WAP), Reclamation
- Resources Management Division, Environmental Water Account (EWA)
- State Water Bank, California Department of Water Resources (DWR)
- OnTap database, DWR
- State Water Board, California Environmental Protection Agency (Cal/EPA)
- Various irrigation districts and water agencies

Information for each transaction was researched and recorded to allow statistical analysis of a variety of factors influencing water trading activity and prices. During the research, transactions occurring from 1990 through 2016 were documented. The transactions were filtered for this analysis according to the following criteria:

- Water sales originating outside the operating region of the SWP facilities were excluded. These regions include the North Coast, North Lahontan, and South Lahontan regions.
- This analysis is intended to estimate spot market prices and trading activity. Thus, multi-year transfers and permanent water entitlement sales were excluded.
- “Within-project” transfers were removed from the analysis, because they do not reflect “arms-length” transactions.
- Transactions associated with SWP Turnback Pool supplies were excluded because they are associated with rules that limit market participation.
- Purchases of “flood” supplies were excluded.
- Reclaimed and desalination water sales were removed from the analysis.
- Water sales with incomplete or inadequate information were excluded.

Following application of the above criteria, 723 spot market transfers remained to support the statistical analysis. Transactions with verified terms were added since the previous analysis. These primarily consist of spot market transactions occurring in 2016 that were verified through more recent research. All prices were adjusted to July 2015 dollars using the Consumer Price Index[1]. Prices and volumes are presented from the seller’s perspective and do not include conveyance charges or losses incurred by the buyer.

The regression model theorizes that the price of water traded can be estimated through consideration of the following market factors: water supply, geographic location, municipal demand, buyer type, and State and Federal water supply acquisition programs.[2] These factors are described below.

Although Federal and State government agencies have recently been more active in recording some information related to water sales or leases, California has few sources that track water transfers between private individuals. Most of

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[1] The Consumer Price Index is considered to be the most appropriate index for adjusting water prices as it is commonly applied to adjust water prices in long-term agreements.

[2] Additional demand and supply factors were tested in the model but did not result in an improvement in overall explanatory power.

the recorded transfers involve a Federal or State government party either because an agency had to approve the transfer, as is the case when a transfer involves CVP or SWP water, or because the government agency was directly involved in the transfer as a purchaser or a seller. Transfers involving private parties are more difficult to track, because the State does not have any reporting requirements.

In California, single-year transfers of water entitlements issued before 1914 are allowed without review by the State Water Resources Control Board (State Water Board) as long as they do not adversely impact the water rights of a third party (CALFED 2000). For entitlements issued after 1914, the buyer and seller can petition the State Water Board for a 1-year temporary transfer. Nonetheless, prices for these transfers are not well documented. As a result, the data for this study were obtained from a mixture of public and private sources.

These sources provided information on the WAP, EWA, State Water Bank, and other public water transfers. State Water Bank observations included transfers to the State Water Bank to capture the price the seller receives.

Information on water transfers was also obtained from the January 1990 through December 2010 issues of the Water Strategist. The publication, previously called *Water Intelligence Monthly*, assembles information on public and private water transfers. Although not all transfers are recorded in the Water Strategist, the publication represents a primary source for water market research. Many of the transfers reported in the *Water Strategist* were independently researched to obtain more specific information and confirm transaction terms. The *Water Strategist* ceased to report on transactions in 2010. In addition, transactions not covered by the *Water Strategist* were researched and verified through direct communication with the transfer participants.

3.3.2.2 Spot Market Transaction Data Summary

This section provides a summary of the water transaction data applied in this analysis. As described above, the data include single-year transactions from 1990 through 2016 of surface water supplies originating in California's Central Valley. The dataset includes 204 transactions for municipal uses, 367 for agricultural uses, and 152 purchases by environmental users. Figure 3-2 shows the number of transactions by end use from 2000 through 2016. As shown, all three end uses are active buyers in most years. However, environmental buyers did not complete any spot market transactions in 2008, 2009, and 2015. For example, in 2015, spot market prices were high due to the extended drought and environmental buyers were unable or unwilling to purchase water during the year.

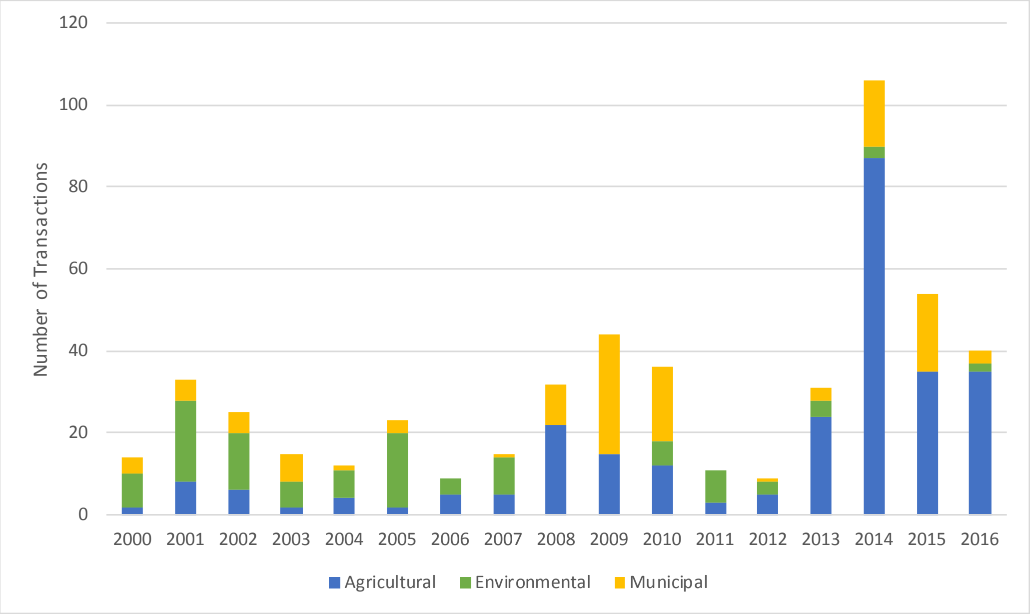

Figure 3-2. Spot Market Transactions by End Use, 2000-2016

Annual spot market trading varies widely according to annual CVP and SWP allocations, reservoir storage, and other factors. Figure 3-3 provides the volume of spot market purchases by end use. As shown, spot market purchases spiked in 2000 when nearly 800 TAF was purchased due to dry conditions. Since then, the volume of water traded in the spot market has been lower. In recent years, the total volume traded has been approximately 300 TAF. The decline may be due to a number of factors including conveyance constraints in the Delta, development of alternative water supplies such as long-term agreements, recycling and groundwater banking, and increased plantings of permanent crops both north and south of the Delta which have limited the potential supply to the spot market from crop fallowing.

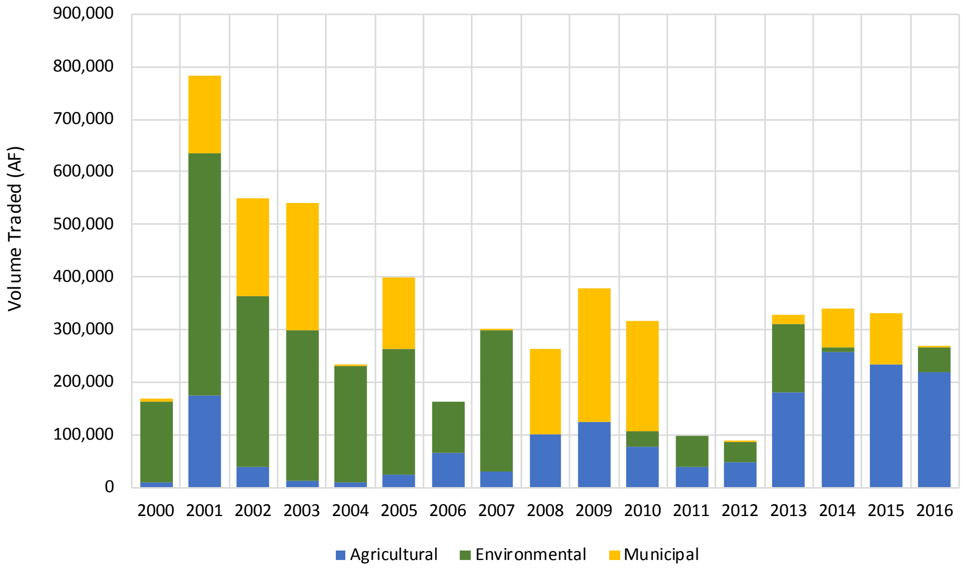

Figure 3-3. Spot Market Volume Purchased by End Use

Figure 3-4 provides average annual spot market prices by end use.[3] As shown, the average annual prices for each end use category have tended to move together. During the recent drought, the average prices show more variation among the end uses. However, this is largely due to the limited number of transactions completed by environmental buyers during 2014 and 2015 and the limited number of transactions completed by municipal buyers during 2016.

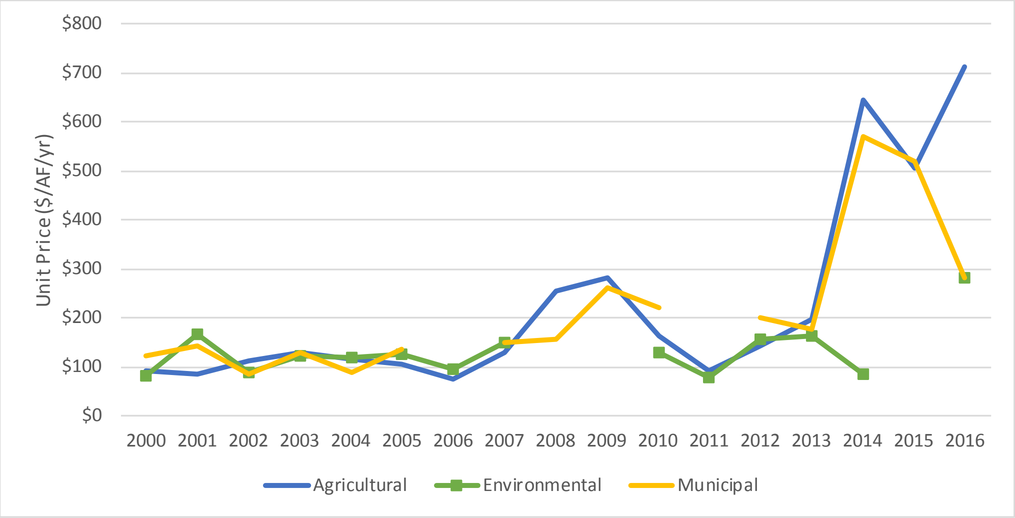

Figure 3-4. Spot Market Average Unit Price by End Use

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[3] All prices were adjusted to July 2015 dollars using the Consumer Price Index prior to estimating the annual averages.

3.3.2.3 Water Transfers Pricing Regression Model

This study applies a water transfer pricing regression model and builds on a previous analysis completed by Mann and Hatchett (2006) by applying an expanded data set and considering additional factors that influence water market trading prices. The water transfer pricing model developed in this study uses an Ordinary Least Squares technique equation to estimate unit price for spot market water transfers. The coefficients from the models may be used to forecast future water prices North of Delta (NOD) and South of Delta (SOD).

The regression model theorizes that prices and volume of water traded can be estimated through consideration of the following market factors: water supply, geographic location, real water price escalation, buyer type, and State and Federal water supply acquisition programs.[4] These factors are described below.

3.3.2.3.1 Water Supply

Hydrologic conditions are a primary driver of water transfer market activity and prices. Therefore, it is important to include variables that appropriately capture water supply conditions to describe water trading activity and prices. In this analysis, water supply conditions are measured using the final annual SWP allocation (DWR 2017) and the final CVP allocation (Reclamation 2017).

3.3.2.3.2 Geographic Location

Water prices and trading activity vary by location according to water year type. Consequently, the origin of the water source for each transaction is used to determine geographic differences in water prices. Water sales applied in the regression analysis were allocated among the hydrologic regions identified by DWR (DWR 2017). Binary variables are used to denote the different geographic regions of buyers and sellers including a variable identifying spot market transfers that involved through-Delta conveyance.

3.3.2.3.3 Urban Water Demand

Due to the growing urban water demand in the State, water transfer prices are anticipated to increase over time. The model includes population as an independent variable to capture the price impact of increased urban water demands (California Department of Finance, 2017). Future water market prices are estimated using forecast population.

3.3.2.3.4 Buyer Type

Previous economic analyses of water prices have concluded that the type of buyer (e.g., M&I, agricultural, and environmental) influences water prices. The water pricing equation tests the influence of buyer type on water price and trading. In this analysis, binary variables are used to estimate price differences among environmental, urban, and agricultural buyers.

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[4] Additional demand and supply factors were tested in the model but did not result in an improvement in overall explanatory power.

3.3.2.3.5 Seller Type

CVP and SWP agricultural contractors are the most common water sellers in the spot market. In order to test the influence of the two projects on water prices, a binary variable identifying sellers that are SWP contractors is included in the model.

3.3.2.3.6 Drought Water Bank and Environmental Water Account

The State has participated in the water market during drought years to facilitate trades. Under this program, DWR sets up a State Water Bank to facilitate water transfers, primarily from NOD agricultural users to SOD buyers.

The EWA acquired water supplies for environmental purposes annually between 2001 and 2007. The implementation of the EWA impacted spot market trading and prices by introducing a large, new demand for water supplies. A dummy variable separating acquisitions by the State Water Bank and the EWA from other buyers is included to test for the price impacts of the programs. A binary variable is included in the model to test the influence of the two programs on prices and trading activity.

3.3.3 Results

The regression model terms are described below. Table 3-2 presents the results of the regression analysis.

Lnadjprice = scbuyer + nodbuyer + nodsod + lnpopulation + twppercent + ag + env + dwbewa+ swpseller + e

where:

lnadjprice=Natural Logarithm of Price per Acre-Foot, Adjusted to July 2015 Dollars

scbuyer=1 if South Coast Region Water Buyer (binary)

nodbuyer=1 if the Buyer is North of the Delta (binary)

nodtosod=1 if North of Delta Water Supplier and South of the Delta Buyer (binary)

lnpopulation=Natural Log of the Population in the Year of the Transfer

twppercent=The Percentage of Project Water (SWP and CVP) that was Allocated in the Year the Transfer Occurred

ag=1 if Agricultural Water End Use (binary)

env=1 if Environmental Water End Use (binary)

dwbewa=1 if State Water Bank/Dry Year Water Acquisitions or the Environmental Water Account Acquisitions (binary)

swpseller=1 if the seller was a State Water Project Contractor (binary)

e=Error Term

Table 3-2. Regression Model Results

Independent Variables	Observations	Parameters	RMSE	R-Squared	F-Statistic	P-Value (P > F)
lnadjprice	723	9	0.56	0.61	126.04	0
Dependent Variable lnadjprice						
Independent Variables	**Coefficient**	**Standard Error**	**t-Statistic**	**P-Value (P > |t|)**	**95% Confidence Interval**	
scbuyer	0.23	0.08	2.97	0.00	0.08	0.38
nodbuyer	-0.30	0.06	-5.00	0.00	-0.42	-0.18
nodtosod	-0.05	0.06	-0.73	0.47	-0.17	0.08
lnpopulation	5.63	0.30	19.02	0.00	5.04	6.21
twppercent	-1.47	0.12	-12.22	0.00	-1.71	-1.24
ag	-0.05	0.06	-0.86	0.39	-0.17	0.07
env	-0.21	0.08	-2.72	0.01	-0.36	-0.06
dwbewa	0.21	0.07	2.82	0.01	0.06	0.35
swpseller	0.48	0.07	6.86	0.00	0.34	0.62
constant	-14.09	1.09	-12.96	0.00	-16.22	-11.95

Note:

[1] Equation and variables are defined in Equations 1 above.

Key:

RMSE = root-mean-square error

The variable twppercent is a measure of annual water availability. The amount of water available was calculated using the SWP and CVP maximum contract amounts, and the percentage of the maximum contract that was delivered each year to the different contractors. The SWP and CVP allocations decrease during drought conditions. Regulatory actions such as the Delta pumping constraints could further impact water deliveries. The statistical relationship between lnadjprice and twppercent is attributable to increased demand for additional water supplies under the hydrologic and regulatory scarcity conditions that drive reduced water allocations. As an example, the coefficient value of -1.47 on the twppercent variable indicates that water transfer prices increase by approximately 26 percent in response to a decrease in percentage of total project water allocation from 50 percent to 30 percent, all else held equal.

The coefficient value on the variable lnpopulation indicates that as population grew from 29.56 million in 1990, to 39.35 million in 2016, water transfer prices increased by a factor of four. The binary variables in the price equation describe conditions that influence prices but are qualitative in nature. The coefficients for env and ag represent the influence that end-water use has on price. When these variables are zero, the model estimates prices to urban water users. Environmental water users generally paid less for water than urban users, as indicated by the negative coefficients. Agricultural buyers were not found to be statistically different than urban buyers. The results show environmental buyers have paid 19 percent less per acre-foot than urban buyers in the market, with all else being equal.

The variable dwbewa is an indicator that the lease was either a State water lease through the Drought Water Bank of 1991, 1992, 1994, and 2009, or a lease through the EWA program. The binary variable is used to account for the price premium paid by the bank and the EWA program. The coefficient value indicates that water leased through the Drought Water Bank, and water that was purchased through the EWA program, was priced 23 percent higher than other transactions, with all else being equal.

The variable nodbuyer is a binary variable measuring the difference in spot market prices between water originating and remaining NOD and water that was purchased for use SOD. Sales from NOD suppliers to NOD buyers were 35 percent lower than sales where water was purchased for use SOD, suggesting there is a higher value for water SOD. According to the coefficient estimated for scbuyer, water transactions involving buyers in the South Coast region were priced 26 percent higher than acquisitions by buyers in other regions, with all else being equal. Premium prices paid by South Coast buyers result from strong competition for water supplies in the region, and the relatively high-value water uses in the area. The variable swpseller is a binary variable measuring the premium paid for purchasing SWP water. The coefficient on swpseller indicates SWP sellers receive a premium of approximately 61 percent over CVP and non-project sellers, on average.

3.3.3.1 Future Water Market Prices

In this section, regression results are used to project water prices to 2030 for M&I buyers. For Bay Area buyers, it is assumed that all water is purchased from buyers located south of the Delta. The regression model indicates that water prices are somewhat lower in the Sacramento Valley. However, conveyance constraints in the Delta limit the hydrologic conditions through which water from the Sacramento Valley can be transferred south. Further, the large through-Delta conveyance losses of approximately 25 percent increase the effective cost of water purchased from the Sacramento Valley above the cost of water purchased from the San Joaquin Valley.

Future water market prices are estimated using the average value for swpseller (0.116), the average value of twppercent for each water year type, and the estimated value for lnpopulation. Table 3-3 provides the applied values for twppercent for each water year type. The values are estimated using Project water allocations from 1990 through 2016. Calsim modeling indicates that future allocations will decline for each year type. To be conservative, this analysis holds future allocations constant.

Table 3-3. Value of TWPPERCENT by Water Year Type

Year Type[1]	All Years
Wet	88.83%
Above Normal	82.10%
Below Normal	63.28%
Dry	58.25%
Critical	35.20%

Note:

[1] Water year types based on the Sacramento Valley water year hydrologic classification. The values are estimated using Project water allocations from 1990 through 2016.

The population projection for the State of California was obtained from the California Department of Finance. Table 3-4 provides the estimated population for each year.

Table 3-4. Estimated California Population (millions)

	2016	2030	2045
Population	39.31	43.94	48.01

Source: California Department of Finance, January 2018.

Table 3-5 provides estimated 2030 water market prices for Bay Area M&I buyers.

Table 3-5. Estimated M&I Water Prices ($/AF/yr)

Year Type Type[1]	2016	2030
	SBA	SBA
Wet	$214	$400
Above Normal	$236	$442
Below Normal	$311	$583
Dry	$335	$627
Critical	$471	$881

Notes:

April 2018 price level.

[1] Sacramento Valley Water Year Hydrologic Classification Index used to define water year types.

Key:

AF/yr = acre feet per year

SBA = South Bay Aqueduct

3.3.3.2 Estimated Conveyance Losses and Charges

Water delivery results from the CalSim II model incorporate conveyance losses. Consequently, it is necessary to estimate conveyance losses to adjust estimated water market prices according to the geographic source of the supply. For example, an estimated delivery from CalSim II of 1,000 acre-feet to an M&I user may require the purchase of 1,111 acre-feet at the source, if 10 percent conveyance losses apply. Conveyance losses for water supplies to the South Bay Aqueduct originating SOD are assumed to be 10 percent.

The power costs associated with conveying the water purchase on the spot market to the end user is added to the estimated water purchase price described above. The cost to convey water to M&I users is estimated according to the cost to move water through SWP facilities. Conveyance cost varies by location and user type. This analysis applies the forecast market power price (Pinnacle 2012) to estimate variable water conveyance costs. Fixed water conveyance charges (e.g., Delta water charge, transportation charge capital cost component) incurred by water users are not included. This section summarizes the estimated water conveyance costs by buyer location.

The amount of power required to convey water is based on DWR's estimates of power use per acre-foot for SWP power facilities (DWR 2012). A pumping plant facility is selected as a reference delivery point for each region. For example, the South Bay Pumping Plant is chosen as the facility used for buyers moving water to the South Bay Aqueduct. Table 3-6 lists the cumulative power demand and the power costs to convey water using the forecast power price.

Table 3-6. Estimated Power Costs by Region

Contractor Region	Reach	Pumping Plant	Cumulative Power Demand (kWh/acre-foot)	Market Power Rate ($/kWh)	Estimated Power Cost ($/acre-foot)
South Bay Aqueduct	1, 2, 4-9	South Bay and Del Valle	1,165	$0.067	$77.83

Note: April 2018 price level.

Sources: California Department of Water Resources, Management of the California State Water Project: Bulletin 132-16. Appendix B Table 7. Kilowatt-Hour Per Acre-Foot Factors for Allocating Off-Aqueduct Power Facility Costs, 2016b.

Key:
kWh= kilowatt hour
SWP= State Water Project

3.3.3.3 Market Price for Water to Municipal and Industrial Purposes

Combined water market prices, carriage losses, and conveyance costs for SWP contractors are provided in Table 3-7. The values reflect the total cost of water (water price + conveyance losses + wheeling charges) by year type in 2030. These values are applied to water deliveries by year type to estimate total M&I water supply reliability benefits.

Table 3-7. Estimated 2030 Municipal and Industrial Water Cost by Year Type

Water Year Type[2]	2030 ($/acre-foot)[1]
Wet	$526
Above Normal	$572
Below Normal	$729
Dry	$779
Critical	$1,060

Note:

[1] April 2018 price levels.

[2] Sacramento Valley 40-30-30 Water Year Hydrologic Classification Index used to define water year types.

Key:
Above Normal = Total SWP and CVP deliveries are 83% of contracted volume.
Below Normal = Total SWP and CVP deliveries are 64% of contracted volume.
Critical = Total SWP and CVP deliveries are 45% of contracted volume.
Dry = Total SWP and CVP deliveries are 61% of contracted volume.
Wet = Total SWP and CVP deliveries is 89% of contracted volume.

3.3.4 M&I Water Supply Reliability Benefits

Table 3-8 presents the estimated annual M&I water supply reliability benefits for each alternative plan.

Table 3-8. Average Annual M&I Water Supply Economic Benefits

Alternative Plan	NED M&I Water Supply Reliability (TAF/year)	NED M&I Water Supply Annual Benefits (million $)[1]
Lower San Felipe Intake (Pipeline and Tunnel)	3.1	$2.3
Treatment	3.1	$2.3
San Luis Reservoir Expansion	-2.6	-$1.7
Pacheco Reservoir Expansion	2.8	$2.1

Note:

[1] April 2018 price levels.

3.4 Risk and Uncertainty

Population growth is a driving factor in a trend toward an increase in the value of water in the future. Because of increasing demands on a relatively fixed water supply existing water storage capacity is likely to grow increasingly valuable as water shortages become more frequent and severe. In addition, shifts in cropping patterns from field crops to fruits, nuts, and vegetables may contribute to future increases in the value of water supply reliability as more irrigation water is applied to high-valued commodities. Among the specialized commodities are permanent crops, such as almonds, walnuts, and grapes, which require reliable water supplies and will result in a “hardening” of water demand in the agricultural sector. As this trend continues, it is likely that agriculture will have less flexibility during dry years to transfer water supplies to other users. This demand hardening, in combination with increases in M&I water demand will result in increases in the value of reliable water supplies. Compounding these trends is the uncertainty associated with climate change. As California, the U.S., and others prepare for the contingencies of global warming, the demand for and value of water supply reliability will rise.

Available information on the potential strategies and costs to improve water supply reliability within the Bay Area are described below to address risk and uncertainty associated with the M&I benefit estimates. Comparison of the projected costs associated with alternative water supply development strategies in the Bay Area allows a more complete understanding of the effects value of water supply reliability in the Bay Area and provides a useful comparison to the estimates developed using the water transfer pricing model described above.

The Bay Area Water Supply and Conservation Agency (BAWSCA) recently completed an assessment of available strategies to meet long-term water supply reliability (2015). The strategy report identified and evaluated a number of potential water supply development opportunities to meet dry year needs including water transfers, desalination, recycled water, rainwater harvest, and aquifer storage and recovery. According to the analysis, water transfers ranked the highest due to lower costs. However, desalination, recycled water, and groundwater development were also identified as options for filling the projected supply shortage. Estimated costs ranged from approximately $1,300/AF to nearly $5,000/AF. It is important to note that the analysis focused on dry year supplies which impacted the unit cost estimates and makes them somewhat difficult to directly compare to the SLLPIP alternatives which would provide water supply during all hydrologic conditions.

Chapter 4
Agricultural Water Supply Benefits

4.1 Introduction

The SLLPIP alternatives affect water supplies to agricultural water users in all water year types.

4.2 Physical Benefit Quantification

The incremental change in annual agricultural water supply under the alternatives relative to the No Action Alternative is the basis for agricultural water supply benefits. The hydrologic model results provide the quantity of water available under the No Action and action alternatives. Table 4-1 shows the average annual incremental differences in water quantity delivered to agricultural contractors under the No Action and action alternatives. Only the San Luis Reservoir Expansion Alternative Plan would increase agricultural water supplies. Appendix B of this Feasibility Report presents the hydrologic model analysis and results.

Table 4-1. Estimated Change in Annual Average Agricultural Water Supply Provided by SLLPIP Alternative Plans (TAF/year)

	Lower Intake/ Treatment	San Luis Reservoir Expansion	Pacheco Reservoir Expansion
Average Annual Additional Water Quantity	-1.6	16.1	-1.6

4.3 NED Benefit Monetization

4.3.1 Economic Method

Similar to economic valuation method used to estimate M&I water supply benefits in Chapter 3, agricultural water supply benefits are also measured according to the cost of the most likely alternative water supply that would be pursued in the absence of development of the SLLPIP alternative plans. The cost of the most likely alternative assumes that if the preferred alternative is not implemented, the alternative action most likely to take place provides a relevant comparison. The valuation approach relies upon the costs associated with observed market transactions for water estimated using the water transfer pricing model.

4.3.2 Economic Analysis

The water transfer pricing model described in Chapter 3 is applied here to estimate the benefits of improved agricultural water supply. As previously described, the economic model consists of a statistical analysis of documented spot market water transactions in California. The model seeks to explain the factors that influence California water market prices and is used to forecast 2030 prices under a variety of conditions including seller and buyer location, buyer type, and hydrologic conditions.

Table 4-2 provides the estimated 2030 water market prices assuming:

- The water is being leased for agricultural purposes. As shown by the coefficient value for model variable *ag* (presented in Table 3-2, above), agricultural buyers are typically able to acquire water for a lower price than urban buyers.
- Water is leased from SOD sources during all water year types.
- A 10 percent to water leased from SOD sources.

Table 4-2. Estimated 2030 Agricultural Water Prices Paid to Seller by Year Type

Water Year Type[1]	Water Transfer Price [2] ($/acre-feet/year)
Wet	$380
Above Normal	$420
Below Normal	$554
Dry	$596
Critical	$837

Note:
[1] Sacramento Valley 40-30-30 Water Year Hydrologic Classification Index used to define water year types.
[2] Losses and conveyance losses not included in the price.

In addition to the market price for water, agricultural buyers incur conveyance costs that vary with location and infrastructure. This analysis assumes that the purchased water is conveyed to CVP south of Delta agricultural users at a cost of approximately $20/AF. Combined water market prices, carriage losses, and conveyance costs for agricultural water supplies are provided in Table 4-3. The values reflect the total cost of water (water price + conveyance losses + power charges) to agricultural water users by location and year type in 2030.

Table 4-3. Estimated 2030 Agricultural Water Supply Costs by Year Type

Water Year Type[1]	Water Cost [2] ($/acre-feet/year)
Wet	$422
Above Normal	$464
Below Normal	$606
Dry	$651
Critical	$905

Note:

[1] Sacramento Valley 40-30-30 Water Year Hydrologic Classification Index used to define water year types.

[2] Losses and conveyance losses not included in the price.

These values are applied to water deliveries by location and year type to estimate total agricultural water supply reliability benefits. Table 5-4 provides a summary of the estimated benefits for the alternatives.

Table 5-4. Estimated Agricultural Water Supply NED Benefits by Final Alternative

Alternative Plan	NED Ag Water Supply Reliability (TAF/year)	NED Ag Water Supply Annual Benefits (million $)[1]
Lower San Felipe Intake (Pipeline and Tunnel)	-1.6	-$0.9
Treatment	-1.6	-$0.9
San Luis Reservoir Expansion	16.1	$7.8
Pacheco Reservoir Expansion	-1.6	-$0.9

Notes:

[1] NED agricultural water supply reliability benefits are based on average water year type hydrologic conditions and calculated as the weighted average of five water year types and values in Table 4-3, above. Sacramento Valley 40-30-30 Water Year Hydrologic Classification Index used to define water year types.

[2] April 2018 price level.

Key:

NED = National Economic Development

TAF = thousand acre-feet

4.4 Risk and Uncertainty

As discussed in Section 3.4, shifts in cropping patterns in the future could increase the value of water supply reliability as more irrigation water is applied to high-valued commodities. Risk and uncertainty associated with the valuation of agricultural benefits using the water transfer pricing model is discussed in Section 3.4.

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Chapter 5
Emergency Water Supply Benefits

5.1 Introduction

The SLLPIP alternative plans provide emergency water supply benefits from increased storage. This evaluation incorporates analysis methods identified in SCVWD's WSIP application (SCVWD 2018).

5.2 Physical Benefit Quantification

Water supply could be reduced or interrupted after an emergency such as a flood or earthquake. Conveyance of water supply through the Delta could be interrupted or reduced in the event of Delta levee failures if seawater intruded into the Delta to an extent that would make it too saline for human consumption. In such cases, the additional water available in surface and groundwater storage, the physical interconnections between groundwater and surface water system, and the operational would help to mitigate the impacts of the emergency.

Emergency storage benefits are increased supplies stored surface reservoirs and underlying groundwater basins that can be delivered in the event of a major levee failure in the Delta that would significantly degrade water quality, or a major earthquake that would disrupt the ability of SCVWD to import water into their service area. An analysis was performed to quantify and value emergency water supplies, and those available to SCVWD M&I water users in the event of a Delta water-supply outage. These disruptions depend upon a variety of factors, including the risk of a seismic, flood or other catastrophic event, vulnerability of non-Delta water supplies, and the timing and duration of the supply disruption. Supply disruptions in an emergency that occur during prolonged periods of drought may result in significantly higher economic costs than those that coincide with wetter conditions. In addition, supply disruptions that are shorter in duration will result in lower economic costs for water users.

SCVWD's existing water system includes nine surface reservoirs with a combined total storage capacity of 157 TAF. In addition, SCVWD's water system incorporates underlying groundwater basins which are recharged through natural infiltration and use of groundwater recharge ponds. Both imported water supplies (i.e., CVP, SWP, and San Francisco Public Utilities Commission (SFPUC) Hetch Hetchy) and developed local surface supplies are used to recharge underlying groundwater basins.

An expanded Pacheco Reservoir would be integrated into SCVWD's existing water system, including coordinated operations of SCVWD surface water reservoirs and underlying groundwater aquifers (see Figure 5-1). Emergency supplies developed at the expanded Pacheco Reservoir would be available for direct delivery to drinking water plants in northern Santa Clara County (See Figure 5-1). The service areas of these drinking water plants overlie the North County Santa Clara Subbasin (see Figures 5-2 and 5-3). To reflect the physical limitations of the SCVWD system, this emergency response monetization analysis is focused on the northern portion of Santa Clara County.

The Lower Intake, and Treatment alternatives would change storage in San Luis Reservoir that could be used for emergency response during a Delta outage by south of Delta CVP and SWP contractors. The Lower Intake, Treatment, and Pacheco Reservoir Expansion Alternative Plans would decrease emergency response storage in San Luis Reservoir for south of Delta CVP and SWP contractors because the reservoir could be drawn down further by increased San Felipe Division deliveries relative to the No Action Alternative, which would decrease available storage in the reservoir for south of Delta contractors. For the San Luis Reservoir emergency response benefits or losses, CalSim II was used to estimate changes in storage to south of Delta M&I CVP and SWP contractors.

The San Luis Reservoir Expansion alternative would provide a minimal increase to SCVWD water supply and would not have the supply availability to provide emergency water supply. Therefore, there would be no emergency water supply benefits to SCVWD under the San Luis Reservoir Expansion alternative.

Figure 5-1. SCVWD Existing Water System Facilities

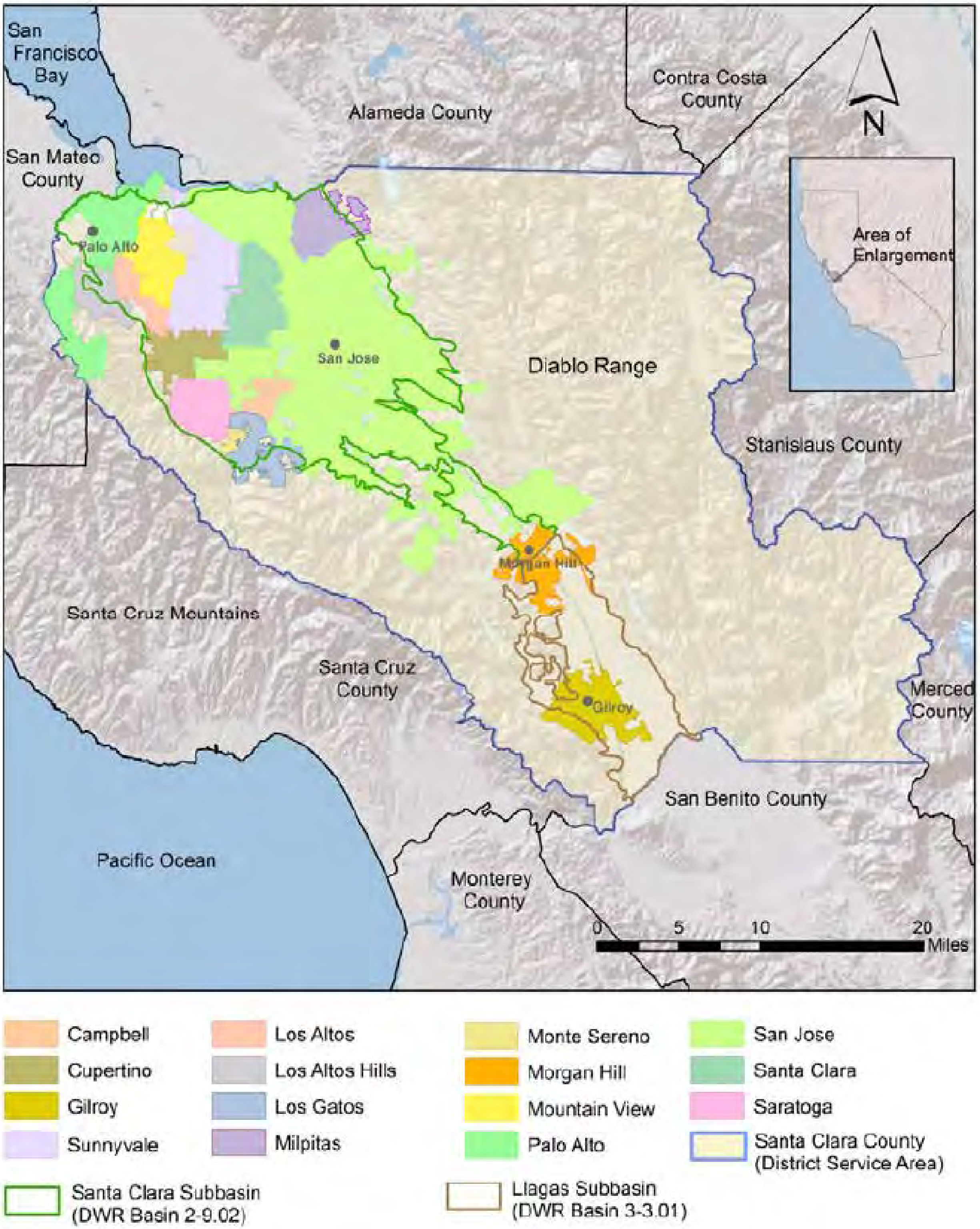
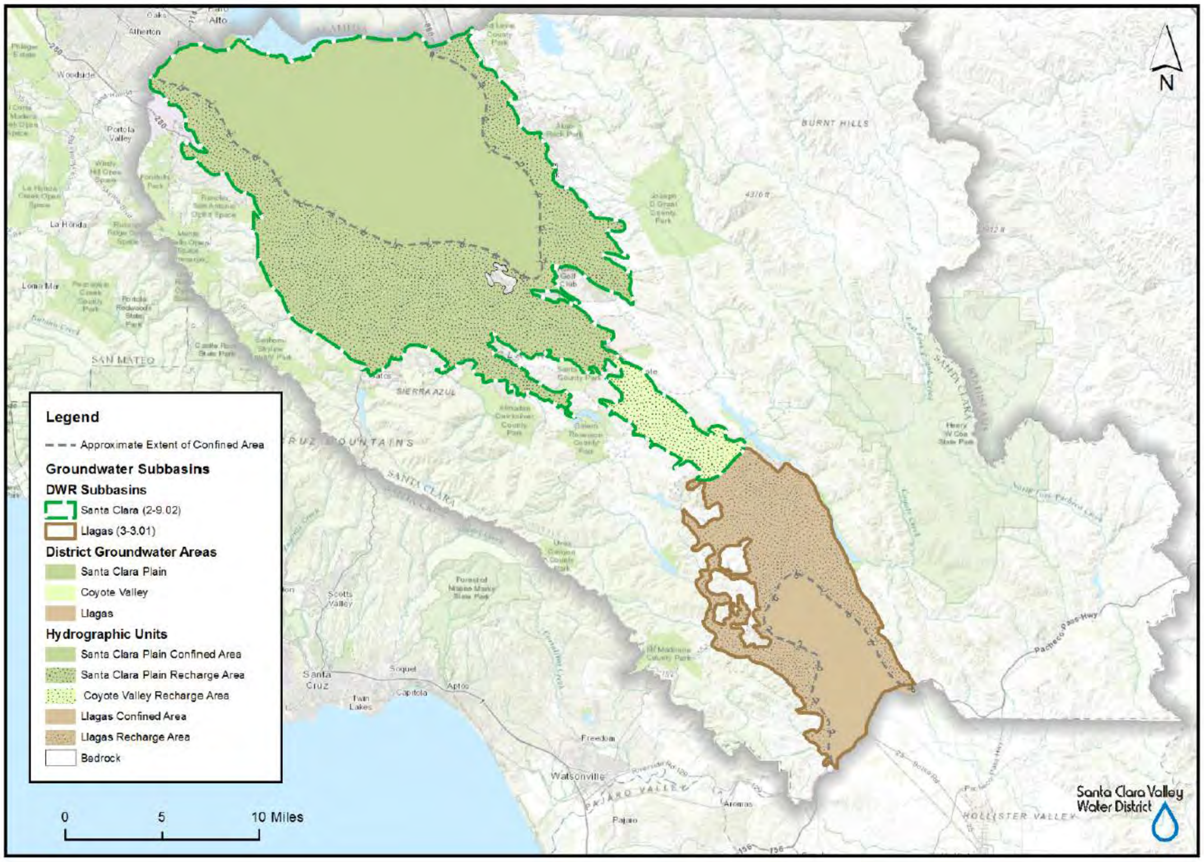


Figure 5-2. Santa Clara County Groundwater Subbasins and Urban Areas



Note: Santa Clara Plain reflected as North County Santa Clara Subbasin in WEAP modeling.

Figure 5-3. Santa Clara Valley Water District Groundwater Areas

To quantify this benefit, the SCVWD WEAP model was used to estimate with- and without-Project storage conditions (both surface storage and groundwater storage) in the SCVWD system under 2030 future conditions. CalSim II CVP and SWP allocations were used as inputs into the WEAP model. With- and without-Project M&I emergency response water supplies available in SCVWD surface water reservoirs and underlying groundwater basins under 2030 future conditions are summarized in Table 5-1.

Table 5-1. Increased Groundwater and Surface Water Storage Available for Emergency Response for 2030 Future Conditions

Annual Average Values	No Action (acre-feet)	Lower Intake/ Treatment	San Luis Reservoir Expansion	Pacheco Reservoir Expansion
Total Local Surface Storage[1]	89,552	89,962	--	186,505
North County Groundwater Storage[1]	316,042	318,086	--	321,090
San Luis Reservoir Storage[2]	969,566	968,150	--	968,137

Note:

M&I Emergency Water Supply Benefits include change in North County Groundwater Storage, change in SCVWD local surface water storage and change in San Luis Reservoir Storage

Source:

[1] SCVWD WEAP Model

[2] CalSimII Modeling

5.3 NED Physical Benefit Monetization

5.3.1 Economic Methods

A water supply disruption associated with flood or seismic events affecting the Delta has the potential to persist for many months. As a result, such an event is likely to lead to water shortages in Santa Clara County as a large component of the water supply to the region consists of Delta exports. Under some circumstances it may be possible to value foregone water supplies to Santa Clara County according to the costs required to purchase water supplies from willing sellers. However, a lengthy Delta disruption is likely to result in extensive shortages to many water users that rely upon Delta exports. Under these conditions, it is unlikely that there will be adequate water supplies to purchase from potential sellers. In addition, the level and duration of water supply shortage will surpass the water supplies that can be obtained from local sources within the region. Due to these circumstances, this analysis applies a willingness to pay approach to estimate the benefits associated with emergency water supplies.

5.3.2 Economic Analysis

5.3.2.1 Previous Studies Considered

Several studies have estimated the economic impacts associated with Delta levee failures and water supply disruptions. The Delta Risk Management Strategy (DRMS) (DWR, USACE, and DFG, 2009) considered seismic, high water conditions, sea level rise and land subsidence as risks to Delta levee integrity and related Delta water exports. The study determined a seismic event as the greatest risk to levee integrity in the Delta, and Delta water exports, and estimated statewide economic costs and impacts of $15 billion (70 percent from urban user loss due to water supply disruption and about 30 percent from damaged major infrastructure) or more if a major earthquake occurs and simultaneously floods as many as 30 Delta islands. While earthquakes pose the greatest consequences to Delta levees and water exports, winter storms and related high water conditions are the most common cause of levee failures in the

Delta region. Multiple island failures caused by high water would likely lead to less severe export disruptions than failures from a major earthquake, but could still be extensive.

In a study by Hanneman et al. (2006), the partial economic impacts of Delta levee failure due to climate change-induced sea-level rise and storm events were considered for three scenarios occurring during different months and hydrologic conditions. Estimated economic impacts to urban users in the South Coast region ranged from $10 to $14 billion. However, the study found that future development of water supplies for Southern California independent of the Delta would reduce the economic costs to urban users to between $1.8 and $4.0 billion. The analysis relied upon a short-run price elasticity of -0.05 and assumed a linear demand function to estimate the change in consumer surplus associated with the projected shortages (Hanneman et al. 2006). The analysis did not consider economic impacts of water shortages on commercial and industrial water users.

Brozovic et al. (2007) provided another estimate of the economic losses associated with water supply disruption to the San Francisco Bay Area (Bay Area) resulting from two potential earthquake scenarios affecting water supplies from the Hetch Hetchy system. Residential losses were estimated through measurement of changes in consumer surplus by applying a constant elasticity demand function to an estimate of price elasticity from empirical studies. The price elasticity used in the study (-0.41) was considerably larger than the elasticity applied in Hanneman et al. (2006) and is more representative of long-run elasticity estimates from empirical studies. The authors note that the estimates of economic losses are highly sensitive to the choice of price elasticity of demand and that the estimates should be considered a lower bound. Business losses are estimated through the use of loss functions with increasing marginal costs as shortages increase, as well as a minimum threshold water supply below which business output would cease. Study results indicated that a 60-day disruption of the Hetch Hetchy water supply would produce between $9.3 and $14.4 billion in business interruption losses, and between $37 and $279 million in residential welfare losses.

Reclamation’s Upper San Joaquin River Basin Storage Investigation employed the valuation approach used by Brozovic et al. (2007) to estimate economic losses from water shortages to M&I water users in California caused by seismic events and Delta levee failures. Information regarding the probabilities of Delta levee failures, potential levee failure scenarios, and associated projected shortages SOD were based on information developed for the Draft DRMS (DWR, USACE, and DFG 2009). This analysis is limited to disruptions as characterized by scenarios under which 1, 3, 10, 20, and 30 Delta islands would become inundated due to a seismic event. The economic value of emergency water supplies potentially provided by a Temperance Flat River Mile 274 Reservoir to southern California residential users was estimated by applying a short-run price elasticity (-0.22) to a constant elasticity demand function calibrated to observed price and quantity information from southern California water providers.

In addition, the Bay Delta Conservation Plan estimated the economic value of reduced seismic risk with the Brozovic et al. (2007) approach (DWR 2013). The analysis assumed a level of water supply availability potentially experienced due to a seismic event, and assumes a two percent probability of a seismic event occurring in any forecasted year. The Brozovic et al. (2007) approach was applied to residential, agricultural, commercial, and industrial sectors. An urban water price and consumption data set was constructed and used to estimate individual water agency price elasticities. The economic value of water supplies after a seismic event was estimated by applying each agency's estimated elasticity to constant elasticity demand functions calibrated to observed price and quantity information from each water provider.

Both sea level rise and Delta Island subsidence will significantly increase the risk of levee failures and flooding during the next 50 years, due to higher static pressure. Delta Subventions Program funds have increased stability of levees, but more funding has been directed in some areas of the Delta than others. Historically, funding has provided about $6 million for the program annually, where typically local levee districts cost share 25% of the total for improvements. With funds from Proposition 84 (2006) and Proposition 1E (2007), the subventions program has expended approximately $200 million in bond funding on Delta levees in the last decade. However, with 1,100 miles of levees and worsening conditions due to sea-level rise and subsidence, investments would need to increase significantly over the historic levels and land owners would have to increase their own contributions to keep pace with declining conditions. Under the right circumstances, any levee failure could usher in significant bay salinity which higher in bromides and severely detrimental to drinking water quality. Chain reactions of levee failures can also happen because of wave erosion and tidal pumping, thus leading to extended periods of time when Delta water at the export facilities is unsuitable for drinking water use.

5.3.2.2 Benefits Estimation Method

This section describes the method applied to estimate the benefits of emergency water supplies resulting from project alternatives, beginning with key considerations and followed by the estimation procedures.

5.3.2.2.1 Key Considerations

Key considerations in estimating the economic cost of water supply disruptions include the probability that a supply disruption would occur, level of water supply shortage, and duration and timing of the supply disruption to urban water agencies.

Probability of a Supply Disruption

Supply disruptions could arise from a variety of human and natural conditions. This analysis relies on estimates of Delta levee failures due to seismic, flood, and sunny-day hazard events. No attempt was made in this analysis to estimate the probability or potential water supply effects associated with additional environmental constraints on Delta pumping.

Information regarding the probabilities of Delta levee failures, potential levee failure scenarios, and associated projected Bay Area shortages was based on information developed for the DRMS (DWR, USACE, and DFG 2009). The annual probabilities associated with seismic, flood, and all hazard events for Delta island inundation scenarios considered in this analysis are listed in Table 5-2. Because sunny-day hazard events are only considered to occur one island at a time, the annual probability of occurrence for all hazards only includes the probability of a sunny-day occurrence in the 1-island breach scenario. This analysis assumes that seismic and flood events that result in a small number of levee breaches do not result in significant water shortages to M&I water suppliers. This analysis is limited to longer disruptions as characterized by the 20 and 30 Delta island inundation scenarios. The annual probabilities associated with the 20 and 30 Delta island inundation scenarios for all hazards applied in this analysis are 0.055 and 0.029, respectively. Annual emergency water supply benefits were estimated using an annual probability of occurrence of 0.042, which was derived by averaging the 20-island probability (0.055) and the 30-island probability (0.029) listed under the “All Hazards” column in Table 5-2. A sensitivity analysis was developed using the 20-island probability and the 30-island probability.

Table 5-2. Probabilities of Delta Island Breach Scenarios

Delta Island Breach Scenario	Annual Probability of Occurrence[1]		
	Seismic	Flood	All Hazards[2]
1-island	0.107	0.205	0.420
3-island	0.082	0.138	0.220
10-island	0.051	0.051	0.102
20-island	0.032	0.023	0.055
30-island	0.019	0.010	0.029

Notes:

[1] Probabilities of occurrence were developed by the Delta Risk Management Strategy (DWR, USACE, and DFG 2009).

[2] All hazards includes the probability of seismic, flood, and sunny-day Delta island breach scenarios. Because sunny-day failures are considered to occur one island at a time, the all hazards probability of occurrence only includes the probability of a sunny-day occurrence in the 1-island breach scenario.

Level of Water Supply Shortage

Bay Area water providers rely on a variety of water sources to satisfy M&I water demand, including local surface water and groundwater, stored water, recycled water, desalination, and imported supplies. The diversity in potential water sources is indicative of the need to address the potential for an individual source to be affected by drought, poor water quality, or damages to conveyance infrastructure. Despite this, water providers in the Bay Area are particularly susceptible to a hazard event that would restrict water supplies from the Delta due to heavy reliance on water supplies upstream from the Delta. Imported water supplies susceptible to Delta disruptions comprise an estimated 45 percent of total water supplies to emergency water supply beneficiary (SCVWD) during an average water year (2030 future conditions), and 31 percent during dry and critical years (DWR 2015). Groundwater banking agreements that may be exercised in dry and critical years are also susceptible to Delta disruptions because they generally involve in-lieu deliveries of SWP water. This analysis assumes longer water export disruptions (0.9 to 1.9 years) characterized by 20- and 30-island breach scenarios (DWR, USACE, and DFG 2007) would result in a shortage level of 45 percent of the forecast 2030 water demand without additional groundwater pumping and 28 percent of the forecast 2030 water demand with additional groundwater pumping.

Duration and Timing of Supply Disruption
The economic effects of a water supply disruption would vary according to the length of time that water supplies from the Delta are shut down or curtailed, the season during which the disruption occurs, and the hydrologic conditions that exist at the time. For example, a Delta water supply disruption that occurs during or immediately following drought conditions would result in larger economic losses than a disruption that occurs during or immediately following a wetter period. Similarly, a disruption that occurs during the winter may have different effects than one occurring in the spring or summer, depending upon the duration of the water supply disruption. In this analysis, it was assumed that the disruption occurs during hydrologic conditions that would have resulted in water deliveries that meet demand in Santa Clara County. As a result, the water supply shortage and associated economic value can be fully attributed to the reduction in Delta water supplies.

Analyses summarized in the DRMS phase 1 Risk Analysis Summary Report (2007) determined that pumping from the Delta would be disrupted for extended periods as a result of the breach scenarios considered. According to the seismic hazard analysis, partial export pumping could resume in 0.9 to 1.8 years under the “20-island breach” scenario and 1.3 to 1.9 years under the “30-island breach” scenario. Depending on the number of flooded islands, timing and size of flood, and Delta salinity conditions, export disruptions under flood hazard conditions could be less significant than under seismic hazard conditions. It is assumed that under larger Delta island breach scenarios (i.e., 20- and 30-island breach scenarios) export disruptions could extend greater than one year. Based on these findings, this analysis assumed a Delta water supply disruption of 12 months.

5.3.2.2.2 Estimation Methodology

Economic benefits from emergency water supplies are measured according to water users’ WTP to avoid interruptions in water deliveries. The value of emergency supplies to M&I users was estimated by applying an estimated short-run price elasticity to a constant elasticity demand function calibrated to observed price and quantity information from Santa Clara County water providers. This valuation approach was used by Jenkins, et al. (2003) and Brozovic, et al. (2007) to estimate economic losses from water shortages to M&I water users in California. Estimated benefits were weighted according to the probability of a Delta water supply disruption (DWR, USACE, and DFG 2009). Demand, price, price elasticity, and the demand function used in the analysis are discussed below.

Demand

The alternatives would provide emergency water supply benefits to water providers within Santa Clara County. Table 5-3 shows the estimated future population and water demands for the SCVWD North County Santa Clara Subbasin.

Table 5-3. Estimated North County Santa Clara Subbasin Population and Water Demands 2030 Conditions

Population/Demands	2017[3]	2030[2]
Population[1]	1,895,211	2,115,128
Water Demands (acre-feet)		
Water Retailer Potable Demands	291,335	295,442
Treatment Plant Losses	2,993	2,940
Other Demands	-	1,652
Total Demands	***294,328***	***298,382***

Notes:

[1] Population estimates are based on estimated population for North County Santa Clara Subbasin, based on population estimates from the California Department of Finance Demographic Research Unit (February 2017).

[2]Based upon SLLPIP WEAP input data.

[3] Based on projections in SCVWD's WSIP Application for Pacheco Reservoir Expansion, Attachment G1: Economics for Emergency Response- Delta Outage (SCVWD 2018)Numbers have been rounded for display purposes and may not sum to totals.

Price

The water price used in this analysis is based on reported charges for Santa Clara County water providers (M. Cubed 2016). The price used in this analysis is the volume weighted average price charged by water providers in 2015 ($1,694/AF), adjusted to 2017 price levels ($1,796/AF).

Price Elasticity

M&I demand for water has been shown by most studies to be inelastic. A survey of previous economic literature by Dalhuisen et al. (2003) found a mean price elasticity of demand of -0.41 and a median of -0.35 for 268 individual estimates. Previous studies have shown that the price elasticity of demand varies throughout the year. In general, price elasticity is higher in the summer when water use is at its peak and lowest during the winter when water use is lower. Similarly, price elasticity is lower in the short-term than the long-term because water users are less able to alter water demand through conservation. However, most of the previous studies estimated long-term price elasticities of demand. Economic losses from an unexpected water supply outage are most appropriately measured through application of a short-term price elasticity. Estimates of economic losses increase with application of lower price elasticities. Table 5-4 provides price elasticity estimates from water demand studies in California.

Seasonal variation in price elasticity was not considered in this analysis because of the uncertainty regarding potential timing of a Delta water supply disruption. In addition, as described above, the duration of the event is expected to last nearly a year, thereby limiting the usefulness of considering seasonal demand patterns. This analysis applies elasticities estimated from a recently completed California urban water demand study (DWR 2013). The study used panel data from 127 California water retailers and estimated an elasticity -0.189 which is applied in this analysis.

Table 5-4. Estimated Price Elasticities of Water Demand in California

Study	Location	Sector	Season	Elasticity	
				Low	High
Howe 1982	Western U.S.	Residential, single family	summer	-0.43	
Weber 1989	Bay Area	Residential	winter	-0.08	-0.2
			annual	-0.1	-0.2
CCWD 1989	Bay Area	Residential	annual	-0.2	-0.4
			summer	-0.35	
DWR 1991	California	Residential	annual	-0.2	-0.5
Dziegielewski & Optiz 1991	Southern California	Residential, single family	winter	-0.24	
			summer	-0.39	
		Residential, multiple family	winter	-0.13	
			summer	-0.15	
		Urban	annual	-0.22	
Renwick, 1996	California	Residential	annual	-0.33	
Renwick and Archibald 1998	Bay Area and Southern California	Residential, single family	average	-0.16	
			summer	-0.2	
Metzner 1989[1]	San Francisco	Residential	annual	-0.25	
Metropolitan Water District of Southern California 1990[1]	South Coast	Residential, single family	summer	-0.29	-0.36
			winter	-0.03	-0.16
DWR 1998	California	Residential, single family	annual	-0.16	
Espey et al. 1997	U.S.	Residential	annual	-0.64	
			annual	-0.38	
			annual	-0.51	
Dalhuisen et al. 2003	U.S.	Residential	annual	-0.41	
Olmstead and Stavins 2006	U.S. and Canada	Residential, uniform marginal prices	annual	-0.33	
		Residential, increasing block rates	annual	-0.064	
California Climate Change Center 2009	El Dorado County, California	Residential, increasing block rate structure	annual	-0.2198	

Study	Location	Sector	Season	Elasticity	
				Low	High
Gleick et al. 2005	U.S.	Residential, single family	annual	-0.16	
		Residential, multiple family	annual	-0.05	
Upper San Gabriel Valley Municipal Water District, 2012	Upper San Gabriel Valley	Residential, single family	annual	-0.13	
		Residential, multiple family	annual	-0.11	
Metropolitan Water District of Southern California, 2010	Southern California	Residential, single family	annual	-0.1947	
		Residential, multiple family	annual	-0.1626	
Jenkins et al. 2003	Santa Clara Valley	Residential	(average of summer and winter)	-0.25	
Bay Delta Conservation Plan (DWR 2013)	California	Residential	Annual	-0.146	-0.324

Note:
[1] Cited in California Water Plan Update (DWR 1998)
Key:
CA = California
CCWD = Contra Costa Water District
DWR = California Department of Water Resources

Demand Function

This analysis assumes a constant price elasticity of demand over the changes in water delivery considered. The demand function is calibrated to 2030 water demand levels by adjusting 2017 prices and quantities according to water demand projections. The demand function applied in this analysis is as follows:

$$P = e^{\frac{\ln(D)}{\eta}+C}, \qquad \text{or} \qquad P = D^{\frac{1}{\eta}}\, e^{C} \qquad (1)$$

Where

- P is the observed price ($/AF) of water to residential users in Santa Clara County (M. Cubed, 2016)
- D is the estimated volume of M&I water use for Santa Clara County under 2030 conditions
- e is a mathematical constant approximately equal to 2.71828
- η is the short-run price elasticity of demand
- k is the integration constant, where $k = \mathrm{e}^{C}$

The integration constant is calculated according to Equation 2 using the observed water price (P2017) and level of water use (D2017). The integration constant is then scaled to 2030 according to the ratio of population in 2030 to population in 2015 (N2017 / N2030) as shown in Equation 3.

$$\mathrm{k}_{2017} = \mathrm{P}_{2017} * \mathrm{D}_{2017}{}^{\frac{-1}{\eta}} \qquad (2)$$

$$\mathrm{P}_{2030} = \mathrm{k}_{2017} * \left(\mathrm{D}_{2030} * \frac{N_{2017}}{N_{2030}}\right)^{\frac{1}{\eta}} \qquad (3)$$

The economic benefits of emergency water supplies are calculated according to Equation 4.

$$Benefits\ (Q_E) = \ \mathrm{k}_{2030} \frac{\eta}{1+\eta}\left[(\mathrm{D}_{2030} - \mathrm{Q}_R + \mathrm{Q}_E)^{\left\{\frac{1+\eta}{\eta}\right\}} - (\mathrm{D}_{2030} - \mathrm{Q}_R)^{\left\{\frac{1+\eta}{\eta}\right\}}\right] (4)$$

Where,

- Q_E is the Project emergency water supply yield
- Q_R is the level of disrupted through-Delta water deliveries
- c is the avoided marginal cost of water delivery and treatment during a shortage

The estimation method described above was used to generate an estimate of the economic losses associated with a 12-month Delta outage to develop a dollar per acre-foot benefit for emergency water supplies. The average value was then multiplied by the volume of emergency supplies available from the Alternatives, and the expected annual benefit is calculated by multiplying by the probability of a Delta water export disruption. The estimation method described above was used to generate an estimate of the economic losses associated with a 28 percent shortage level in 2030 to develop a dollar per acre-foot benefit for emergency water supplies. The average value was then multiplied by the volume of emergency supplies available from the alternatives, and the expected annual benefit is calculated by multiplying by the probability of a Delta water export disruption. The expected annual emergency water supply benefit is then reduced by the avoided marginal cost of emergency water delivery and treatment to M&I customers (c). This analysis applies a fixed per unit cost of $270/AF/year (DWR 2013). Table 5-5 summarizes the parameters applied in this analysis.

Table 5-5. Summary of Key Assumptions and Parameters

Variable	Value	Description	Source
P_{2017}	$1,796/ acre-foot	Weighted average service rate (2017 dollars)[1] for water providers in Santa Clara County	M. Cubed (2016)
D_{2017}	294,328 acre-feet	Estimated 2017 annual M&I water demand for North County Santa Clara Subbasin	SCVWD WEAP model
D_{2030}	298,382 acre-feet	Forecast 2030 annual M&I water demand in North County Santa Clara Subbasin	SCVWD WEAP model
Q_E	2,354 acre-feet (Intake/Treatment) 102,016 acre-feet (Pacheco Expansion)	Average emergency water supply yield in 2030 under each alternative plan	SCVWD WEAP model
η	-0.189	Short-term price elasticity of demand	Bay Delta Conservation Plan (DWR 2013)
Shortage Level	28%	Level of shortage to M&I users as a percent of 2030 water demand	SCVWD WEAP model
Shortage Duration	12 months	Duration of the Delta water supply disruption	DRMS Phase 1 Summary Report (2007)
Probability	0.042	Annual probability of a Delta water supply export disruption during the planning period[1]	DRMS (DWR, USACE, and DFG 2009)
c	$270/ acre-foot	Marginal cost of delivery	Bay Delta Conservation Plan (DWR 2013)

Notes:

[1] The annual probability of a Delta water supply export disruption applied in this analysis is the average annual all hazards probabilities for the 20 and 30 “island-breach” scenarios identified for the Delta Risk Management Strategy (DWR, USACE, and DFG, 2009).

Key:

Delta = Sacramento-San Joaquin Delta
DRMS = Delta Risk Management Strategy
M&I = municipal & industrial
SCVWD = Santa Clara Valley Water District
WEAP = Water Evaluation and Planning

Supplies

The available supplies accessible to areas overlying the North Area Santa Clara Subbasin during a Delta outage for 2030 future conditions include:

- Natural groundwater recharge
- Local surface water supplies
- Recycled water
- San Francisco Public Utilities Commission (SFPUC) Hetch Hetchy
- Groundwater extraction in excess of natural groundwater recharge

Delta conveyed supplies (i.e., Central Valley Project and State Water Project deliveries) were not included due to the assumed Delta outage. Estimated quantities of available supplies, including natural groundwater recharge, local surface water supplies, recycled water, and SFPUC Hetch Hetchy, were based on long-term averages (i.e., 1922 to 2003) for the without-Project conditions from SCVWD's WEAP model and are shown in Table 5-6.

Table 5-6. Summary of SCVWD North Basin 2030 Demands and Available Water Supplies During Delta Outage

Demand	Value
Demand (acre-feet)[1]	298,382
Available Supplies During Outage Prior to Additional Groundwater Pumping	
Natural Groundwater Recharge/Sustainable Groundwater Use (acre-feet) [1]	36,586
Surface Water (acre-feet) [1]	42,269
Recycled Water (acre-feet) [1]	26,665
SFPUC Hetch Hetchy (acre-feet) [1]	58,525
Total Available Supplies (acre-feet) [1]	164,046
Shortage (acre-feet)	134,336
Water Availability (%)	55%
Shortage (%)	45%
Available Supplies During Outage with Additional Groundwater Pumping	
Shortage Quantity prior to Groundwater Pumping (acre-feet)	134,336
Additional Groundwater Pumping during Outage (acre-feet) [2]	50,458
Shortage with Additional Groundwater Pumping (acre-feet)	83,878
Total Available Supplies with Additional Groundwater Pumping (acre-feet)	214,504
Water Availability (%)	72%
Shortage (%)	28%

Notes:

[1] Based upon WEAP output for No Action Alternative.

[2] Assumed additional groundwater pumping above natural groundwater recharge rates/sustainable groundwater yield of the basin. The North County Santa Clara Subbasin reaches the "severe" stage, as defined in the Water Shortage Contingency Plan, at 232,000 acre-feet. The long-term average storage in the North County Santa Clara Subbasin, based on the WEAP output for the No Action Alternative, is 316,000 acre-feet. The difference between the long-term average storage and the Water Shortage Contingency Plan "severe" stage is 84,000 acre-feet. For the purposes of this analysis, it is assumed that 50,458 acre-feet of additional groundwater pumping would occur during the initial 12 months of an outage, allowing for a limited of groundwater (approximately 33,500 acre-feet) to be available to help meet shortages in the event that a Delta outage lasted beyond 12 months.

The ability to pump groundwater in response to shortages is limited by SCVWD thresholds established to ensure sustainable groundwater conditions. Santa Clara County has historically experienced land subsidence caused by groundwater pumping and overdraft. It is assumed that additional groundwater pumping from North County Santa Clara Subbasin, beyond natural groundwater recharge rates and sustainable groundwater yield of the basin, would be used to help meet demands during the outage. For this analysis, limitations on additional groundwater pumping was limited by the severe stage of the Water Shortage Consistency Plan (WSCP) and considerations for maintaining minimal quantities of groundwater supplies above the severe stage in the event that a Delta outage lasted beyond twelve months. SCVWD's WSCP is included in SCVWD's 2015 Urban Water Management Plan as Chapter 8. The WSCP stages represent countywide values; in the North County Santa Clara Subbasin, the severe stage of the WSCP corresponds to 232,000 acre-feet of storage.

Table 5-7 shows the values for groundwater and surface water outage supplies for the SCVWD. The total was then multiplied by the annual probability of occurrence to obtain the expected annual benefit for each alternative.

Table 5-7. Average Annual NED Benefits for Emergency Response: Delta Outage for 2030 Future Conditions

Alternative	Outage Supply	Volume (acre-feet)	Value[1] ($)	Benefit[1] ($ million)	Total NED Benefit[1] ($ million)
Lower San Felipe Intake (Pipeline and Tunnel)	Groundwater	0	$1,019[2]	$0.0	$38.4
	Surface Water	2,354	$16, 329	$38.4	
San Luis Reservoir Expansion	Groundwater	0	$1,019[2]	$0.0	$0.0
	Surface Water	0	$16,794	$0.0	
Treatment	Groundwater	0	$1,019[2]	$0.0	$38.4
	Surface Water	2,354	$16, 329	$38.4	
Pacheco Reservoir Expansion	Groundwater	18,137	$1,019[2]	$18.5	$565.4
	Surface Water	83,878	$6,526	$546.8	

Notes:

[1] Based on 2018 price levels.

[2] Reflects 2018 groundwater charges for SCVWD Zone 5 of $1,289 (https://www.valleywater.org/your-water/current-water-charges) less $270/acre-foot.

5.3.3 South-of-Delta Contractors

The alternative plans would change storage in San Luis Reservoir that could be used for emergency response by south of Delta CVP and SWP contractors. The San Luis Reservoir Expansion Alternative Plan would increase storage by expanding capacity in the reservoir. The Lower Intake, Treatment, and Pacheco Reservoir Expansion Alternative Plans would decrease emergency response storage in San Luis Reservoir for south of Delta CVP and SWP contractors because the reservoir could be drawn down further for San Felipe Division deliveries relative to the No Action Plan, which would decrease available storage in the reservoir. For the San Luis Reservoir emergency response benefits or losses, CalSim II was used to estimate changes in storage to south of Delta M&I CVP and SWP contractors.

For the San Luis Reservoir emergency response benefits or losses, CalSim II was used to estimate changes in storage to south of Delta M&I CVP and SWP contractors. Table 5-8 summarizes the estimated change in San Luis Reservoir storage to south of Delta CVP and SWP contractors. These emergency response benefits to south of Delta contractors was monetized using the least cost alternative approach. It is assumed that local groundwater supplies would be used to meet demands during a Delta outage. Therefore, the emergency response benefit to south of Delta contractors was monetized using

Metropolitan Water District of Southern California’s (MWDSC) forecasted Tier 2 water rates (MWDSC 2016). These forecasted rates took into consideration willingness to pay for water during Delta outages. Fixed water conveyance charges (e.g., Delta water charge, transportation charge capital cost component) are not included. Table 5-9 shows the key parameters used to estimate south of Delta emergency water rates.

Table 5-8. Average Annual Emergency Response to South-of-Delta Contractors Relative to No Action Alternative (TAF)

Alternative Plan	Expected Emergency Response Deliveries to South of Delta Contractors (TAF)
Lower San Felipe Intake (Pipeline and Tunnel)	-1.4
Treatment	-1.4
San Luis Reservoir Expansion	0.0
Pacheco Reservoir Expansion	-1.4

Table 5-9. Summary of Key Assumptions and Parameters for South-of-Delta Emergency Response Benefits

Variable	Value	Description	Source
P_{2026}	$1,066/ acre-foot	MWDSC forecasted Tier 2 water rates	MWDSC (2016)
Probability	0.042	Annual probability of a Delta water supply export disruption during the planning period[1]	DRMS (DWR, USACE, and DFG 2009)
C	$270/ acre-foot	Marginal cost of delivery	Bay Delta Conservation Plan (DWR 2013)

Notes:

[1] The annual probability of a Delta water supply export disruption applied in this analysis is the average annual all hazards probabilities for the 20 and 30 “island-breach” scenarios identified for the Delta Risk Management Strategy (DWR, USACE, and DFG, 2009).

Key:
Delta = Sacramento-San Joaquin Delta
DRMS = Delta Risk Management Strategy
MWDSC = Metropolitan Water District of Southern California

5.3.4 Results

Table 5-10 shows the estimated NED benefits for emergency response under 2030 future conditions. The total groundwater and surface water volumes were multiplied by the annual probability of occurrence (0.042) and value (Table 5-7) to obtain the expected total and annual benefit for each alternative plan.

Table 5-10. Estimated NED Benefits for Emergency Response

Alternative Plan	Total Monetized change to SCVWD Water Storage (million $)	Total Monetized Emergency Response to South-of-Delta Contractors (million $)	Total NED Emergency Response Benefit (million $)[1]	NED Emergency Response Annual Benefits (million $)[2]
Lower San Felipe Intake (Pipeline and Tunnel)	$38.4	-$1.1	$37.3	$1.6
Treatment	$38.4	-$1.1	$37.3	$1.6
San Luis Reservoir Expansion	$0.0	$0.0	$0.0	$0.0
Pacheco Reservoir Expansion	$565.4	-$1.1	$564.3	$23.7

Total might not add up due to rounding.

[1] Total NED Emergency Response Benefit= Total Emergency Response Benefit to SCVWD (Includes change to local surface water storage and change to north county groundwater storage)+ Total Emergency Response Benefit to South-of-Delta Contractors

[2] Total economic losses were multiplied by the annual probability of occurrence of 0.042 to obtain the emergency response annual benefits.

5.4 Risk and Uncertainty

The forecasted 2030 level and duration of water supply shortages to the emergency water supply beneficiaries was estimated from information developed from the DRMS study (DWR, USACE, and DFG, 2009) and 2010 urban water management plans. Improvements to Delta levee conditions, continued water agency conservation activities, and unforeseen population changes could affect the probability of a Delta export disruption, shortage percentage, and duration assumptions employed in this analysis.

5.4.1 Emergency Response Sensitivity Analysis for the Pacheco Reservoir Expansion Alternative

As the Pacheco Reservoir Expansion Alternative provides substantial emergency response benefits, additional sensitivity analyses were conducted for that alternative only. It is important to note that various factors affect the economic value attributed to emergency water supplies provided by the Pacheco Reservoir Expansion Alternative beyond the quantity of water available in storage at the time of a Delta water export emergency. Several of these factors are discussed below:

- The forecasted 2030 level and duration of water supply shortages to the emergency water supply beneficiaries was estimated from information developed from the DRMS study (DWR, USACE, and DFG, 2009) and 2010 urban water management plans. Improvements to Delta levee conditions, continued water agency conservation activities, and unforeseen population changes could affect the probability of a Delta export disruption, shortage percentage, and duration assumptions employed in this analysis.

- The economic value of emergency water supply provided by the Pacheco Reservoir Expansion Alternative was estimated through application of a short-term demand function. The price elasticity of demand was obtained from previous studies of residential water demand in California, and there was a wide range of estimated elasticities. The results of the analysis are highly sensitive to the selection of price elasticity of demand. As a result, relatively small changes in the assumed elasticity can lead to large changes in estimated benefits.

The NED emergency water supply benefit estimate described above is based on Delta outage probability of .049, estimated 28-percent water shortage, and -0.189 elasticity assumptions. To address risk and uncertainty related to water supply shortage and price elasticity, various approaches are applied and are described briefly below:

- **Sensitivity Approach 1 –** The average Delta outage probability of 0.049 was presented in the above analysis. A sensitivity was conducted based on the probability of a Delta outage based on the 20- and 30-island breach scenarios, or 0.055 and 0.029 probability, respectively.

- **Sensitivity Approach 2 –** 17 percent shortage based on additional groundwater pumping of all available groundwater supplies within the North County Santa Clara Subbasin above the severe stage (per Water Storage Contingency Plan) and 45 percent storage based on no additional pumping of groundwater supplies from the North County Santa Clara Subbasin (i.e., pumping of natural groundwater recharge quantities only).

- **Sensitivity Approach 3 –** Lowerbound (-0.146) and upperbound (-0.324) California water agency price elasticities estimated by the Bay Delta Conservation Plan (DWR 2013) are applied.

- **Sensitivity Approach 4 –** No additional groundwater pumping with upperbound elasticity (-0.324) applied and additional groundwater pumping of all available supplies with lowerbound elasticity (-0.146).

Table 5-11 presents results of the sensitivity analyses. These values can be compared to annual emergency water supply benefits of $23.7 million used in the above analysis. For the lower bounds of the sensitivity analyses 2,3, and 4, there would be net costs of the Pacheco Reservoir Expansion Alternative. For the lower bounds of the sensitivity analysis 1, there would be net benefits of approximately $1.9 million.

Table 5-11. Sensitivity Analysis Comparison for Estimated Average Annual Emergency Water Supply Benefits for Pacheco Reservoir Expansion Alternative ($ million)

	Annual Emergency Water Supply Benefits (million $)	Net Benefits (million $)	Benefit Cost Ratio
Sensitivity Approach 1			
20-island breach scenario (probability of 0.055)	$31.1	$16.5	1.42
30-island breach scenario (probability of 0.029)	$16.4	$1.9	1.05
Sensitivity Approach 2			
No Additional Groundwater Pumping (45% Shortage)	$98.20	$83.72	3.10
Pumping of Groundwater to Severe Stage (17% Shortage)	$9.00	($5.48)	0.86
Sensitivity Approach 3[1]			
Lower Elast	$37.50	$23.02	1.58
Upper Elast	$13.00	($1.48)	0.96
Sensitivity Approach 4			
No Additional Groundwater Pumping w/ Upper Elast	$31.00	$16.52	1.41
Pumping of Groundwater to Severe Stage w/ Lower Elast	$11.00	($3.48)	0.91

Notes:

General: April 2018 price level.

[1] To address uncertainty in consumers' willingness to pay to avoid a water supply shortage lowerbound (-0.146) and upperbound (-0.324) California water agency price elasticities estimated by the Bay Delta Conservation Plan (DWR 2013) are applied to the constant elasticity of demand function to estimate emergency water supply benefits with sensitivity approach 2.

Key:

Lower Elast = lowerbound elasticity
NED = National Economic Development
SCVWD = Santa Clara Valley Water District
Upper Elast = upperbound elasticity

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Chapter 6
Ecosystem Improvement – Pacheco Creek Anadromous Fish

6.1 Introduction

The Pacheco Reservoir Expansion Alternative Plan would be the only alternative plan evaluated with ecosystem benefits to anadromous fish population in the Pajaro River watershed. This evaluation incorporates analysis methods identified in SCVWD's WSIP application (SCVWD 2018).

6.2 Physical Benefit Quantification

Enlarging Pacheco Reservoir would contribute to improved anadromous fish (South-Central California Coast (SCCC) steelhead) habitat by altering seasonal water flows and temperatures in the Pacheco Creek downstream from new Pacheco Dam. SCCC steelhead (*Oncorhynchus mykiss*) were listed by National Marine Fisheries Service (NMFS) as a threatened in 1998. In 2013, the NMFS *South-Central California Steelhead Recovery Plan* (NMFS 2013) identifies that a critical recovery action for SCCC steelhead is to ensure that the pattern and magnitude of water releases to Pacheco Creek from Pacheco Reservoir provides the essential habitat functions to support the life history and habitat requirements of both adult and juvenile life stages. The Pacheco Reservoir Expansion Alternative Plan has the potential to provide substantive beneficial improvements to SCCC steelhead habitat conditions in Pacheco Creek through improved flow and temperature conditions.

Monetization of ecosystem improvement benefits for SCCC steelhead in Pacheco Creek considers the availability of suitable habitat for all steelhead life stages. Improvements in habitat conditions for SCCC steelhead in Pacheco Creek were directly evaluated using the Pacheco Creek Steelhead Habitat Suitability Model. The Pacheco Creek Steelhead Habitat takes into consideration change in flow and temperature among other parameters to determine suitable habitat for steelhead in Pacheco Creek. The Pacheco Creek Steelhead Habitat Suitability Model was developed through grant funding provided by the Fisheries Restoration Grant Program, including contributing partner CDFW. The model was used to simulate with- and without-Project conditions for 2030 future conditions. Pacheco Reservoir storage levels, and releases to Pacheco Creek from the SCVWD's WEAP model, were used as inputs into the Pacheco Creek Steelhead Habitat Suitability Model.

An output of the Pacheco Creek Steelhead Habitat Suitability Model is a Steelhead Cohort Score. This Score provides an index of Pacheco Creek's ability to support SCCC steelhead through all life stages, based on the 14-month period in which a cohort is expected to remain in the creek (i.e., from adult migration through juvenile outmigration), and considers a range of environmental factors that improve or degrade habitats including water operations, water flow and temperature, surface and groundwater interaction, and ratings of pools, runs, and riffles from field surveys. The Steelhead Cohort Score reflects habitat suitability in Pacheco Creek over the entire cohort lifecycle. For example, if habitat conditions for early life stages during winter/spring months are good, but Pacheco Creek has no flow during summer months, the resultant Steelhead Cohort Score for that cohort would be poor.

Table 6-1 present with- and without-Project steelhead cohort scores under 2030 future condition summarized by water year type. Table 5-2 presents the with- and without-Project steelhead cohort scores under 2030 future condition for the 1922 to 2003 simulation period.

As shown in Table 6-1 and 6-2, the Pacheco Reservoir Expansion Alternative Plan could significantly improve the viability of steelhead populations through improved habitat conditions in Pacheco Creek in all year types under 2030 future conditions. The Pacheco Reservoir Expansion Alternative Plan provides the most significant improvement in steelhead cohort scores in dry and critical years, where steelhead cohort scores are increased by substantially under 2030 future conditions.

Table 6-1. Summary of Pacheco Creek Steelhead Cohort Scores by Water Year Type Under 2030 Conditions for the Pacheco Reservoir Expansion Alternative

Water Year Type[1]	2030 Future Conditions			
	With-Project[2] (Steelhead Cohort Score)	**Without-Project[2] (Steelhead Cohort Score)**	**Difference (Steelhead Cohort Score)**	**Percent Change (%)**
Wet	28.9	13.2	15.7	119%
Above Normal	22.9	8.2	14.8	181%
Below Normal	25.6	13.1	12.5	95%
Dry	24.6	7.5	17.1	227%
Critical	20.6	0.8	19.9	2628%
Average All Years	25.3	9.4	15.9	170%

Notes:
[1] Water year types based on the Sacramento Valley water year hydrologic classification.
[2] Values were derived from Pacheco Creek Steelhead Habitat Suitability Model.

Table 6-2. Pacheco Creek Steelhead Cohort Scores for 1922 to 2003 Simulation Period Under 2030 Conditions for the Pacheco Reservoir Expansion Alternative

Year	Year Type[1]	Without-Project[2] (Steelhead Cohort Score)	With-Project[2] (Steelhead Cohort Score)	Difference[2] (Steelhead Cohort Score)
1922	Above Normal	NA	NA	NA
1923	Below Normal	17.6	24.3	6.7
1924	Critical	0.0	23.8	23.8
1925	Dry	0.0	18.4	18.4
1926	Dry	0.8	22.8	22.0
1927	Wet	13.3	28.1	14.9
1928	Above Normal	17.6	23.4	5.8
1929	Critical	0.0	23.2	23.2
1930	Dry	0.0	17.2	17.2
1931	Critical	0.0	17.6	17.6
1932	Dry	0.0	17.4	17.4
1933	Critical	0.0	26.6	26.6
1934	Critical	0.0	22.2	22.2
1935	Below Normal	0.0	22.2	22.2
1936	Below Normal	11.2	21.8	10.6
1937	Below Normal	19.4	32.0	12.5
1938	Wet	24.2	36.7	12.5
1939	Dry	14.8	29.7	14.9
1940	Above Normal	4.9	17.4	12.4
1941	Wet	12.6	22.6	10.0
1942	Wet	16.5	26.7	10.2
1943	Wet	20.5	35.8	15.3
1944	Dry	20.2	28.1	7.9
1945	Below Normal	19.3	34.1	14.8
1946	Below Normal	16.3	27.1	10.8
1947	Dry	21.7	31.4	9.7
1948	Below Normal	16.2	18.5	2.3
1949	Dry	13.4	18.1	4.8
1950	Below Normal	15.0	26.7	11.7
1951	Above Normal	7.8	34.4	26.5
1952	Wet	18.4	36.1	17.7
1953	Wet	14.4	28.3	13.9
1954	Above Normal	11.4	26.5	15.0
1955	Dry	0.0	26.5	26.5
1956	Wet	4.4	28.6	24.2
1957	Above Normal	15.5	27.4	11.9
1958	Wet	3.6	22.8	19.3
1959	Below Normal	20.6	26.7	6.1
1960	Dry	0.0	24.4	24.4
1961	Dry	0.0	22.5	22.5
1962	Below Normal	0.0	18.0	18.0
1963	Wet	10.8	25.0	14.2
1964	Dry	16.4	30.5	14.1
1965	Wet	0.5	23.3	22.8
1966	Below Normal	12.8	30.2	17.4

Year	Year Type[1]	Without-Project[2] (Steelhead Cohort Score)	With-Project[2] (Steelhead Cohort Score)	Difference[2] (Steelhead Cohort Score)
1967	Wet	0.0	18.5	18.5
1968	Below Normal	15.9	27.8	11.9
1969	Wet	0.1	21.0	20.9
1970	Wet	19.6	26.7	7.0
1971	Wet	19.3	35.1	15.8
1972	Below Normal	0.0	22.6	22.6
1973	Above Normal	0.0	22.4	22.4
1974	Wet	19.1	35.2	16.1
1975	Wet	19.5	26.7	7.1
1976	Critical	0.0	19.8	19.8
1977	Critical	0.0	16.1	16.1
1978	Above Normal	0.0	17.2	17.2
1979	Below Normal	19.5	26.7	7.1
1980	Above Normal	0.9	26.6	25.7
1981	Dry	19.9	26.7	6.8
1982	Wet	14.8	34.1	19.3
1983	Wet	20.6	35.8	15.2
1984	Wet	14.3	30.2	15.9
1985	Dry	0.0	34.3	34.3
1986	Wet	2.4	29.1	26.7
1987	Dry	12.7	27.8	15.2
1988	Critical	0.0	18.2	18.2
1989	Dry	0.0	17.5	17.5
1990	Critical	0.0	18.2	18.2
1991	Critical	0.0	16.0	16.0
1992	Critical	9.1	17.8	8.8
1993	Above Normal	12.3	15.0	2.7
1994	Critical	0.0	27.9	27.9
1995	Wet	0.0	24.1	24.1
1996	Wet	17.1	28.7	11.6
1997	Wet	20.3	35.8	15.5
1998	Wet	17.2	27.7	10.5
1999	Wet	19.3	29.5	10.2
2000	Above Normal	20.3	35.8	15.5
2001	Dry	9.6	25.5	15.9
2002	Dry	5.9	23.7	17.8
2003	Above Normal	7.3	29.1	21.8

Notes:

[1] Water year types based on the Sacramento Valley water year hydrologic classification.

[2] Values were derived from Pacheco Creek Steelhead Habitat Suitability Model.

6.3 NED Benefit Monetization

6.3.1 Economic Methods

There are a variety of economic approaches that can be applied to estimate the benefits associated with flow improvements that will lead to improvements in anadromous fish populations. Under some circumstances, the societal willingness-to-pay (WTP) for improvements in fish populations can be directly estimated through survey-based approaches. However, survey based methods are time and resource intensive and could not be completed as part of this evaluation. In the absence of an economic study directly applicable to the expected fish benefits in Pacheco Creek, it is sometimes possible to apply the results from similar studies in other regions. However, such benefit transfer approaches require that conditions in the study region are similar to conditions in Pacheco Creek. There are no known applicable economic studies that estimate the WTP associated with improvements to threatened steelhead populations on the California coast. Further, there is not a model available to support estimation of steelhead numbers in Pacheco Creek with and without the project. In the absence of relevant economic studies, it is possible to estimate the benefits associated with fish population improvements according to the least-cost method of achieving similar benefits through alternative means. Within Pacheco Creek, the alternative methods of providing streamflow improvements are limited. For example, it is not possible to consider the costs of purchasing water from existing diverters from Pacheco Creek for flow restoration as there are no surface diverters within or above the stream reaches that require increased flow to benefit steelhead. Given these circumstances, this analysis estimates the benefits associated with improvements in steelhead populations according to the costs associated with developing a single-purpose reservoir project.

6.3.2 Economic Analysis

6.3.2.1 Importance of Anadromous Fish

The number of programs and amount of money dedicated to anadromous fish conservation suggest that society places a high value on salmon restoration. According to the General Accounting Office (GAO), at least 11 federal agencies and numerous other entities are involved in anadromous fish restoration in the Pacific Northwest. In the Columbia River Basin alone, Federal government agencies spent at least $1.8 billion (unadjusted for inflation) between fiscal year (FY) 1982 and FY 1996, according to GAO estimates. Between FY 1997 and FY 2001, these agencies spent $1.5 billion (or nearly $2.0 billion in current dollars) to rebuild the Columbia River Basin’s salmon and steelhead stocks (GAO 2002). The Bonneville Power Administration continues to spend about $60 million annually on Fish and Wildlife programs in the Columbia River Basin (BPA 2014).

The Pacific Coastal Salmon Recovery Fund (NMFS 2011), a fishery restoration program established by Congress, contributed $884.8 million to states and tribes from FY 2000 to FY 2010 for restoring salmon stocks in California, Oregon, Washington, Idaho, and Alaska. State matching funds for this program totaled more than $451 million during this period (through FY 2009).

Because steelhead salmon are migratory, open-access biotic resources, their full value is not reflected in typical market transactions. Economic practitioners, recognizing that market prices do not reveal the total economic value of ecological resources, have developed a variety of nonmarket valuation techniques that may be used in estimating the value of these resources. Assigning a benefit value to anadromous fish based on sports fishing significantly underestimates the value society assigns to a viable anadromous fish stock. This is because only use values are represented and not nonuse values, which are the values people place on the resource independent of their desires or intentions to directly experience it.

An extensive literature exists defining efforts at valuing fisheries, including salmon. Much of the literature has focused on valuing recreational harvests, and attributing value to increased salmon levels or harvest success (Olson et al. 1991, Berrens et al. 1993, and Layman et al. 1996). Recent efforts have also attempted to address the total economic value of ecosystems, freshwater salmon habitat, and restored riverine systems. Holmlund and Hammer (1999) identified the ecosystem services generated by fish populations. Knowler et al. (2003) estimated the value of Coho salmon habitat (in Canada) to be worth $1,322 to $7,010 (1994 dollars) per kilometer. Loomis et al. (2000) developed a framework and survey for determining the WTP of residents for the restoration of a river in Colorado.

In addition, there have been some efforts to estimate the WTP of individuals (or households) for the preservation or recovery of Endangered Species Act (ESA)-listed species, including “Pacific salmon and steelhead.” Loomis and White (1996) estimated the annual WTP by households for preserving Pacific salmon and steelhead as $63 (1996 dollars), as the average of multiple studies. Hanneman, Loomis, and Kanninen (1991) attempted to estimate the WTP of California residents to restore flows to the Upper San Joaquin River for use in Chinook salmon restoration. They estimated a value of $181 (1989 dollars) per household. Layton, Brown, and Plummer (2001) attempted to value an increase (doubling) in the population of migratory salmon in Washington, including ESA-listed species. Richardson and Loomis (2009) conducted a meta-analysis of economic value of ESA-listed species, updating the earlier Loomis and White (1996) compendium; they determined that overall WTP values have actually increased on a per-capita basis with the passage of time.

6.3.2.2 Benefit Estimation Methodology

The process used in this evaluation to estimate economic benefits for increasing the populations of steelhead along the Pacheco Creek is based on a “least-cost” most likely alternative approach. Under this process, it is assumed that increasing the steelhead population in Pacheco Creek is a socially desirable goal, as indicated by the listing of the species as threatened, and the demonstrated expenditures on anadromous fish restoration in other regions. Given that increasing anadromous fish populations is a socially desirable goal, the least costly method of attaining increases in steelhead populations is sought. Because the increased potential of additional surface water storage to improve flows and reduce water temperatures during critical periods is essential to increasing steelhead survival and the limited potential means of achieving the flow improvements, the least-cost and most likely alternative is based on the cost of various reservoir enlargements operated solely for the purpose of increasing the number of steelhead in Pacheco Creek.

6.3.2.2.1 Least Cost/Most Likely Alternatives

This section describes additional alternatives than were evaluated against the Pacheco Reservoir Expansion Alternative to provide ecosystem restoration benefits in the Pajaro River watershed. The Pajaro River watershed currently has four tributaries, Corralitos Creek, Uvas Creek, Llagas Creek, and Pacheco Creek, that either regularly or intermittently support SCCC steelhead. In order to improve the stability of the SCCC steelhead in the Interior Coast Range Biogeographic Population Group, improvements to the Pajaro River and one or more of its tributaries would be required. Establishing another self-sustaining population in the Pajaro River watershed is important in order to provide added protection to the population as a whole.

Currently in the Pajaro River watershed, Uvas Creek has a fully self-sustaining population and coastal Corralitos Creek has a smaller self-sustaining population. According to the Recovery Plan, SCCC steelhead in the Interior Coast Range are identified as Core 1 populations (highest priority for recovery) because they have a low redundancy, and that steps to restore flows are necessary to achieve viability. Increasing redundancy protects the genetic and ecological diversity to ensure the long-term viability under changing environmental conditions, including droughts. In the 2016 Final Coastal Multispecies Recovery Plan, NMFS states that redundancy is critical to prevent extirpation and to support recovery of the SCCC steelhead.

For consideration under the least cost alternative/alternative cost economic analysis, other alternatives must be able to provide the following physical benefits:

- Substantial improvements to SCCC steelhead habitat
- High likelihood of establishing an additional self-sustaining and functionally independent population in the Pajaro River watershed
- Other alternatives must also be technically feasible (i.e., constructible, implementable) and consistent with applicable laws and regulations.

Table 6-3 summarizes the other alternatives that were screened out of this analysis.

Table 6-3. Screened "Least-Cost" Alternatives

Alternative	Reason for screening alternative
Improve Steelhead Habitat through direct discharge of imported supplies to Pacheco Creek	This alternative is not feasible due to a lack of dedicated capacity in Pacheco Conduit to convey imported water, and flow conditions that would impact steelhead imprinting and water temperatures that would not provide equivalent benefits as the Project
Improve Steelhead Habitat through delivery of imported supplies to Pacheco Reservoir and subsequent release to Pacheco Creek	This alternative is not feasible due the exceedance of imported water ratio requirements impacting steelhead imprinting and would not provide equivalent benefits at the Project due to high summer temperatures of San Luis Reservoir supplies.
Improve Steelhead Habitat in Pacheco Creek through In-Basin Groundwater Augmentation	This alternative is not feasible due to conflicts San Benito County water policy and the Sustainable Groundwater Management Act (SGMA).
Improve Steelhead Habitat in Pacheco Creek through Out-of-Basin Groundwater Augmentation	This alternative is not feasible due to conflicts with SCVWD's Groundwater Management Plan and SGMA.
Improve Steelhead Habitat in Pacheco Creek by Implementing NMFS Recovery Actions	This alternative would not provide equivalent year-round habitat for SCCC steelhead and, therefore, would not provide the same amount of physical benefits.
Improve Steelhead Habitat in Corralitos Creek through Restored Groundwater Levels, Habitat Modification, and Improved Passage	This alternative was screened out due to the uncertainty in the ability to provide equivalent benefits. While the alternative would allow for expanded migration through the Salispuedes Creek system and the lower portions of Corralitos Creek, the alternative would not increase water supplies where fish spawn and migrate in the upper Corralitos Creek watershed.
Improve Steelhead Habitat in Llagas Creek through Stream Habitat Restoration and Improved Passage	This alternative would not address the significant smolt outmigration in the long lower channel of Llagas Creek, which severely constrains any potential steelhead population. While the SCVWD Groundwater Management Plan indicates that groundwater pumping in the Llagas Area is not interconnected with surface water sources, it is unlikely this alternative would create suitable steelhead habitat below Chesbro Dam to the same quality as provided by the Pacheco Reservoir Expansion Alternative. Moreover, a trap-and-haul for both adult and juvenile steelhead in the flashy upper Llagas Creek may not be reliable due, in part, to channel debris during storm events. Further, high development along much of the lower creek corridor limits habitat restoration activities.
Improve Steelhead Habitat in Uvas Creek through Stream Habitat Restoration and Improved Passage	The Uvas Creek watershed currently has a functionally independent population of SCCC steelhead this alternative would not achieve the objective of the NMFS Recovery Plan to establish additional functionally independent populations in the Pajaro River watershed. The existing MOU also demonstrates efforts are underway to guard against extirpation of this Pajaro River watershed population.

Based on the information provided above, a series of single purpose reservoir enlargement scenarios were evaluated to represent most likely alternatives to achieve improved steelhead Cohort viability in the Pajaro River watershed. Table 6-4 summarizes a series of single purpose reservoir enlargements that were simulated through the Pacheco Creek Salmon Habitat Suitability Model under both 2030 future conditions. These scenarios include single purpose operations focused only on improving steelhead viability and do not include water supply and other objectives. Each scenario was optimized to maximize the steelhead cohort score given the hydrologic and climatic conditions. Table 6-4 presents the steelhead cohort scores for the single purpose reservoir enlargement scenarios under 2030 future conditions, respectively. Table 6-4 includes the estimated increase in steelhead cohort score for each scenario representing reservoir enlargement scenarios operated solely for increased cohort viability, where all of the increased volume would be dedicated to improving flows and temperatures.

Table 6-4. Average Steelhead Cohort Score for Various Single-Purpose Reservoir Sizes at 2030 Future Conditions

Sole-Purpose Reservoir Size (acre-feet)	Steelhead Cohort Score[1]
100,000	20.7
80,000	23.4
60,000	25.8

Notes:
[1] Values were derived from Pacheco Creek Steelhead Habitat Suitability Model.

For 2030 future conditions, Figures 6-1 and 6-2 show the plots and “best fit” lines/curves using quadratic and linear-log equations, respectively, for various reservoir enlargements versus their steelhead cohort scores. To determine the reservoir size to provide at least the same level benefit (i.e., equivalent steelhead cohort score), the quadratic and linear-log equations were solved for 2030 future conditions, as shown in Table 6-5. For the purposes of benefit monetization, a conservative estimated single purpose reservoir size was selected, an 96,000 acre-foot reservoir for 2030 future conditions.

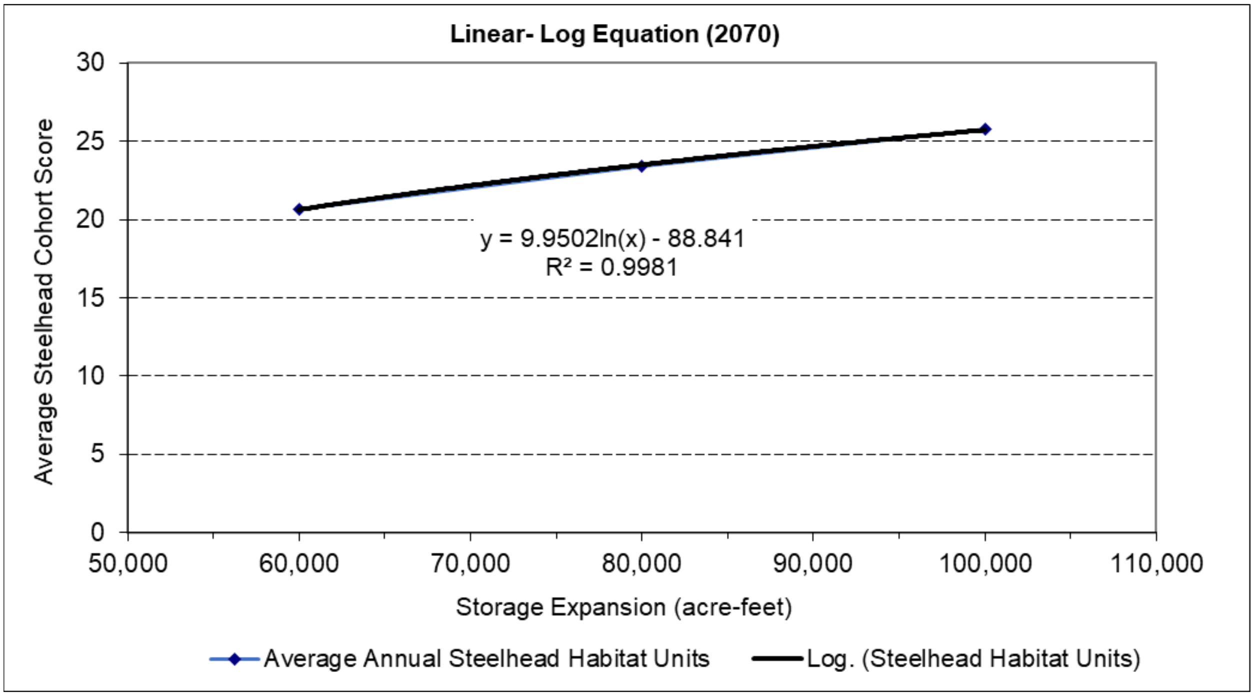

Figure 6-1. Relationship (Using Quadratic Equation) Between Estimated Habitat Unit Increases Relative to Dam Raises for 2030 Future Conditions

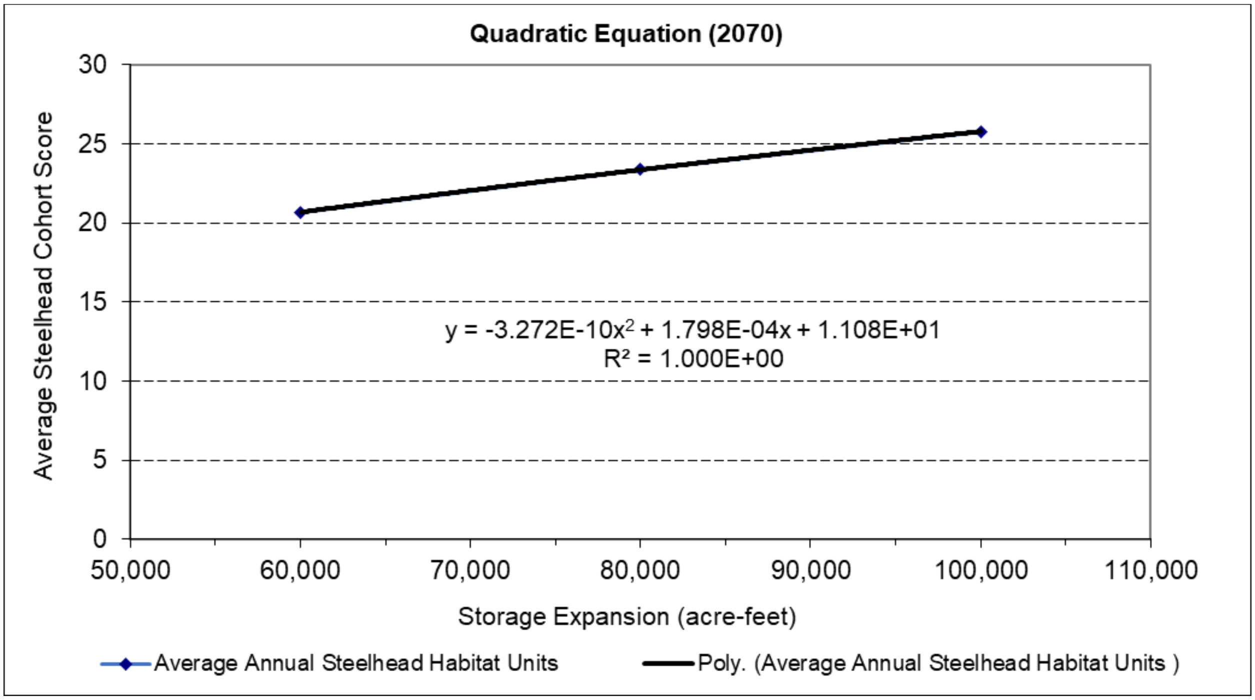

Figure 6-2. Relationship (Using Linear Log) Between Estimated Habitat Unit Increases Relative to Dam Raises for 2030 Future Conditions

Table 6-5. Identification of Single Purpose Reservoir Size for 2030 through Use of Quadratic and Linear-Log Equations

Equation Type	Resultant Single Purpose Reservoir Size – Active Storage (acre-feet)	Dead Pool	Total Required Storage
2030 Future Conditions			
Linear-log equation y = 9.9502ln(x) - 88.841	96,080	800	96,880
Quadratic Equation y = -3.272E-10x2 + 1.798E-04x + 1.108E+01	95,950	800	96,750
Selected Single Purpose Reservoir Size for 2030 Future Conditions			96,000[1]

Notes:
[1] For the purposes of benefit monetization, conservative single purpose reservoir sizes were selected.

To quantify the monetary benefits, capital cost estimates were developed for the 96,000 acre-foot reservoir, as shown in Table 6-6 (key physical features of the single purpose reservoir are summarized in table 6-7). An annualized cost estimate was developed for the single purpose reservoir, as shown in 6-7. The annualized costs for the 96,000 acre-foot reservoirs represent the alternative cost for 2030 future conditions, respectively. Table 6-8 summarizes average annual net monetary benefits for ecosystem improvement on Pacheco Creek under 2030 future conditions.

Table 6-6. Details of Capital Costs for 96,000 Acre-Foot Single-Purpose Reservoir on Pacheco Creek Used to Estimate Alternative Costs for 2030 Future Conditions for Ecosystem Restoration Monetary Benefit Quantification

Item	Cost[1] ($ Million)
Construction Costs	
Field Costs	
Contract Costs	
Pay Items, Quantities, and Unit Prices	
Land and Rights	$2.1
Clearing Land and Right-of-Way	$50.7
Roads and Road Structures	$20.5
Dams	$376.6
Waterways	$79.0
Waterway Structures	$36.5
Miscellaneous Installed Equipment	$31.5
Total Field Cost	**$569.9**
Land (Purchase)	$5.7
Land (Easements)	$0.5
Program Cost (25%)	$149.2
Total Indirect Costs	**$155.4**
Total Project Costs	**$752.1**

Notes: [1] Dollar values are expressed in 2018 price levels.

Table 6-7. Alternative Costs Based on Single-Purpose Reservoirs for Ecosystem Restoration Monetary Benefits on Pacheco Creek Under 2030 Future Conditions

Item	2030 Future Conditions
Physical Attributes of Single-Purpose Reservoir	
Active storage (acre-feet)	96,000
Dam Height (feet)	670
Full Pool Elevation (feet)	655
Costs	
Capital cost ($ millions)[1]	$752.1
Interest during construction ($ millions)[1]	$39.1
Annualized Costs	
Amortization of capital costs ($ millions)[1]	$22.2
Amortization of interest during construction ($ millions)[1]	$1.2
Annual OM&R ($ millions)[1]	$0.5
Annual replacement ($ millions)[1]	$0.1
Annual future monitoring/Adaptive management ($ millions)[1]	$0.1
Total Annualized Costs ($ millions)[1,2]	$24.0

Notes:
[1] Dollar values are expressed in 2nd Quarter 2018 price levels.
[2] All numbers are rounded for display purposes, and therefore line items may not sum to totals.
Key:
cy = cubic yards
msl = mean sea level
OM&R = Operations, Maintenance, and Repair

Table 6-8. Average Annual Net NED Benefits for Ecosystem Restoration - Anadromous Fish Under 2030 Future Conditions

Monetary Benefit	2030
Ecosystem Improvement - Anadromous Fish ($ millions)[1]	$24.0

Notes:
[1] Dollar values are expressed in 2018 price levels.
Key:
NED = National Economic Development.

6.4 Risk and Uncertainty

The expanded Pacheco Reservoir is used to store inflow and imported supplies and to provide water for deliveries to meet demands. Releases for deliveries to Pacheco Conduit (for SCVWD) are conditional, based on storage being above 95 TAF, which is the level sufficient to maintain suitable flows and temperatures for steelhead habitat in Pacheco Creek. Multiple factors could affect runoff and storage in Pacheco Reservoir, including climate variability, changes in water management operations within SCVWD due to demand or changes in water supply portfolios, and extended droughts.

Chapter 7
Ecosystem Improvement – San Joaquin Valley Wildlife Refuge Water Supplies

7.1 Introduction

The Pacheco Reservoir Expansion Alternative Plan would be the only alternative plan evaluated that would provide ecosystem benefits to San Joaquin Valley wildlife refuges. This evaluation incorporates analysis methods identified in SCVWD’s WSIP application (SCVWD 2018).

7.2 Physical Benefit Quantification

Through the passage of the CVPIA in 1992, fish and wildlife were given equal priority as other water uses in the Central Valley Project (CVP) service area. As a result, the federal government was required to provide a clean and reliable supply of water to wetland habitats in these refuges in support of fish and wildlife species. This is being accomplished through the Refuge Water Supply Program (Reclamation and USFWS 2009). Reclamation delivers water to wildlife refuges in the Central Valley as a requirement of the CVPIA, as Level 2 supply (firm supply) and Incremental Level 4 supply (purchased from willing sellers). Currently, Incremental Level 4 refuge demands are not being fully met.

An ecosystem improvement benefit of the Pacheco Reservoir Expansion Alternative Plan would be the increased deliveries of Incremental Level 4 water supplies to the Refuge Water Supply Program. The Pacheco Reservoir Expansion Alternative would transfer 2,000 AF of SCVWD’s CVP water supply, during below normal water years, to the Incremental Level 4 Refuge Water Supply Pool—which is managed by Reclamation and USFWS. SCVWD has requested that Reclamation dedicate this supply to the Grasslands Resource Conservation District (GRCD) which provides water to the largest contiguous block of wetlands remaining in California’s Central Valley. The increased supply would provide habitat and food for migratory birds of the Pacific Flyway, resident bird species, and many wildlife species. Additionally, purchases on the spot market by Reclamation to meet Level 4 refuge demands may be avoided.

An analysis was performed to estimate the benefit of improved environmental water-supply reliability under 2030 future conditions. The CalSim II model was used to estimate increases in environmental water supplies available to the

Incremental Level 4 Refuge Water Supply Pool, between with- and without-Project for 2030 future conditions over an 82 year simulation period (1922 to 2003). These CalSim II simulations specifically targeted improving deliveries for GRCD. Increased environmental water supplies for San Joaquin River watershed wildlife refuges are summarized in Table 7-1.

Table 7-1. Increased Environmental Water Supplies for San Joaquin Valley Wildlife Refuges for 2030 Future Conditions

Water Year Type[1]	2030 Future Conditions		
	With-Project[2] (acre-feet)	**Without- Project[2] (acre-feet)**	**Difference (acre-feet)**
Below Normal	279,688	277,688	2,000

Notes:

[1] Water year types based on the Sacramento Valley water year hydrologic classification.

[2] Values were derived from CalSim II and reflect south-of-Delta refuge deliveries.

7.3 NED Benefit Monetization

7.3.1 Economic Methods

The economic value of improvements in water deliveries to refuges and the associated improvements in wetland functions and wildlife habitat can be measured in a variety of ways. Applicable valuation methods generally include revealed preferences, surveys, and alternative costs. As described above, Reclamation has an ongoing program to purchase water supplies to benefit refuges in the Central Valley from willing sellers. Given the existence of the program, the costs associated with purchasing water supplies from willing sellers is considered to be the most applicable for valuing the improved water supplies for refuges.

7.3.2 Economic Analysis

This section addresses the refuge water supply benefits that may be realized by providing additional refuge water supplies to help meet Incremental Level 4 refuge water needs. The quantification of refuge water supply benefits considers the estimated short-term water market purchase price as the most likely alternative in the absence of firm water supply from the Pacheco Reservoir Expansion.

7.3.2.1 Market Price for Water to Refuges

Historically, Incremental Level 4 water supplies have been primarily obtained through single-year water purchase agreements. In this analysis, the benefits of refuge water supply are measured according to the estimated cost of obtaining the water supply through continued spot market leases. The water transfer pricing model is applied here to estimate the benefits of improved refuge water supply. The economic model consists of a statistical analysis of documented spot market water transactions in California. The model seeks to explain the factors that influence California water market prices and is used to forecast 2030 prices under a variety of conditions including seller and buyer location, buyer type, and hydrologic conditions.

Table 7-2 provides the estimated 2030 water market prices assuming:

- The water is being leased for environmental purposes. As shown by the coefficient value for model variable *env* (presented in Table 5-4 in Chapter 5 of this document) environmental buyers are typically able to acquire water for a lower price than urban buyers.
- Water is leased from lower priced north-of-Delta (NOD) sources during below normal, dry, and critical years when Sacramento-San Joaquin River Delta (Delta) conveyance capacity is available. During above normal and wet year types water is leased from SOD sources.
- A 25 percent conveyance loss factor is applied to water leased from NOD sources and 10 percent to water leased from SOD sources.

Table 7-2. Estimated 2030 Refuge Water Prices

Year Type	Water Transfer Price[1] ($/AF/yr)
Wet	$325
Above Normal	$359
Below Normal	$473
Dry	$509
Critical	$715

Key:
AF/yr = acre-feet per year
Notes:
[1] Dollar values are expressed in 2018 price levels.

In addition to the market price for water, buyers incur conveyance costs that vary with location and infrastructure. This analysis assumes that the refuge water delivered to the Delta Mendota Canal is estimated at the Banks Pumping Plant and is approximately $20/ AF.[5] Combined water market prices, carriage losses, and conveyance costs for refuge water supplies are provided in Table 7-3. The values reflect the total cost of water (water price + conveyance losses + conveyance charges) to environmental water users by location and year type in 2030. These values are applied to the Pacheco Reservoir water deliveries year type to estimate total refuge water supply reliability benefits displayed in Table 7-4. While water transfer costs are expected to continue to increase in the future, the estimated values are not increased beyond the 2030 levels in this

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[5] Sources: California Department of Water Resources, Management of the California State Water Project: Bulletin 132-16. Appendix B Table 7. Kilowatt-Hour Per Acre-Foot Factors for Allocating Off-Aqueduct Power Facility Costs, 2016b.

analysis due to the limit set of WTP based estimates that can be applied as a constraint on future water values.

Table 7-3. Estimated 2030 Refuge Water Supply Costs

Year Type[1]	Total Water Cost ($/AF/yr)
Wet	$381
Above Normal	$418
Below Normal	$545
Dry	$586
Critical	$814

Notes:

[1] Sacramento Valley Water Year Hydrologic Classification Index used to define water year types.

[2] Dollar values are expressed in 2018 price levels.

Table 7-4 provides a summary of the estimated benefits for Pacheco Reservoir. As shown, the estimated annual benefits are approximately $0.2 million in 2030. Table 7-4 presents monetary benefits for the simulation period (1922-2003) for environmental water supplies to San Joaquin River Valley wildlife refuges under 2030 future conditions.

Table 7-4. Average Annual NED Benefits for Increased Environmental Water Supplies to San Joaquin Valley Wildlife Refuges

Alternative	Increase in water supply for San Joaquin River Valley wildlife refuges (AF)[1]	2030 environmental water supply for San Joaquin River Valley wildlife refuges ($ millions)[1]
Pacheco Reservoir Expansion Alternative	2,000	$0.2

Notes:

[1] Pacheco Reservoir Expansion Alternative would transfer 2,000 AF of SCVWD's CVP water supply, during below normal water years, to the Incremental Level 4 Refuge Water Supply Pool—which is managed by Reclamation and USFWS.

[2] Dollar values are expressed in 2018 price levels.

7.4 Risk and Uncertainty

In general terms, total economic value is measured as the combination of market and non-market components. For many common resource uses, such as agriculture or hydroelectric power generation, well established markets with considerable and publicly available price information provides a ready measure of "value." For other resource uses, such as recreation, there is both market (e.g., admittance or user fee) and non-market components. However, for the largely non-market basis for value associated with ecosystem services, ecosystem improvements, or enhancement and/or protection of ESA-listed species, the information base is far more limited. There is normally a high reliance on site-specific biological, physical, and hydrologic information that is often not available. Although there is consensus among economists that non-market values exist and are positive, there is also recognition that methods for measuring these values are difficult. The lack of consensus about appropriate methods and varying levels of resource data and information contributes to uncertainty in the estimation of improved habitat condition, or ecosystem benefits.

The refuge ecosystem benefit estimates, discussed above, are based on short-term, spot-market pricing and represent some portion of the total value or willingness to pay for increased Refuge water supply. Although, the water transfer price, or spot-market price, is potentially a good approximation of NED benefit value, it may underestimate the total public willingness to pay for market and non-market components of value.

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Chapter 8
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Appendix G
Preliminary Cost Allocation

This appendix documents cost allocation terminology and methods, and an initial cost allocation and apportionment for Pacheco Reservoir Expansion Alternative Plan. Chapters 1 and 4 of the Feasibility Report present the project background, objectives, and alternatives evaluated. The cost allocation is applied to the Pacheco Reservoir Expansion Alternative Plan, which was determined to be the preliminary National Economic Development (NED) plan, as described in Chapter 5 of the Feasibility Report.

G.1 Process Overview, Terms, and Potential Methods

G.1.1 Process Overview and Terms

Allocation of Federal water resources project costs is conducted to derive an equitable distribution of costs among the authorized project purposes, or those purposes proposed for authorization, in accordance with existing law. This initial analysis provides an indication of the cost implications of constructing the NED Plan for each authorized purpose.

Three basic steps are associated with cost allocation and apportionment:

- Identify costs to be allocated
- Allocate costs to project purposes
- Apportion costs to beneficiaries

The cost allocation process provides an important intermediary step towards evaluating the financial feasibility of potential alternatives, as illustrated in Figure 1.

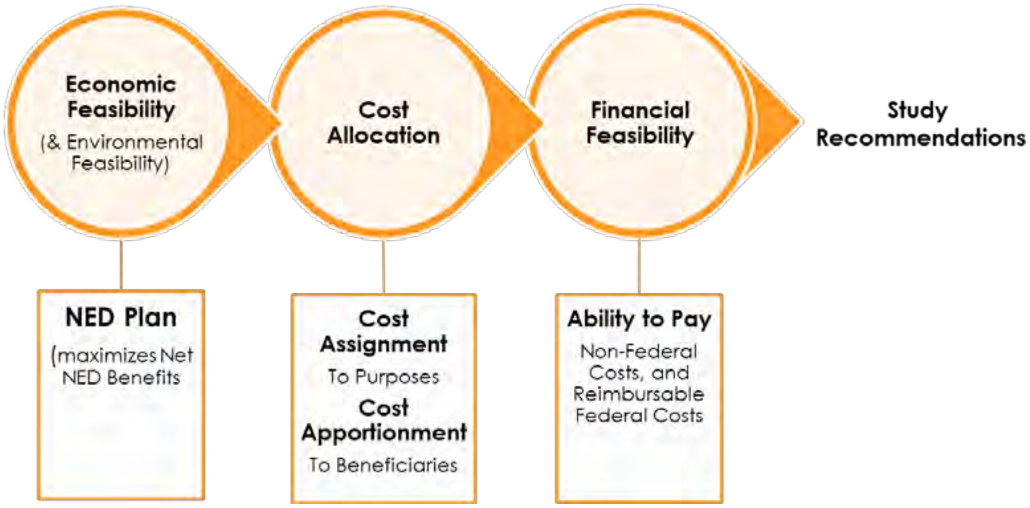


Figure G-1. Process for Evaluating Financial Feasibility

G.1.2 Costs Allocated

Total project costs allocated include construction costs, interest during construction (IDC), and annual operations, maintenance and replacement (OM&R) costs. These costs are summarized below:

- Construction costs – Construction costs include field costs and non-contract costs to implement all elements of the project necessary to achieve the associated benefits.

- Interest during construction – IDC accounts for the financial cost of project expenditures during the period between when construction begins and benefits are derived.

- Annual operation, maintenance, and replacement costs – OM&R costs are the costs required to assure continued benefits over the life of the project.

It should be noted that cost allocation is a financial exercise rather than an economic evaluation; consequently, project costs may be presented differently in a cost allocation than in an economic analysis.

G.1.3 Allocating Costs to Project Purposes

Once all project costs have been identified, they are allocated to the project purposes. Specific costs are for project components that contribute to a single purpose. For each purpose, separable costs are the costs of the portion of multi-purpose facilities due to the inclusion of the purpose in question. Separable costs include specific costs and may include a portion of joint costs. They are estimated as the reduction in financial costs that would result if a purpose were excluded from an alternative. Joint costs are the costs remaining after specific and separable costs have been removed.

Methods for allocating joint costs generally fall into two categories, depending on how benefits are considered. Benefits are derived in the economic analysis. Methods that do not consider benefits may divide joint costs between beneficiaries equally or based on beneficiaries' share of separable costs. Methods that are based on benefits divide joint costs among beneficiaries proportional to the benefits each receives. Among these, the separable costs-remaining benefits (SCRB) method has historically been used to allocate CVP facility costs. Other methods for allocating joint costs based on benefits include the Alternative Justifiable Expenditure method and the share of Total Benefits Method.

G.1.4 Apportioning Costs to Beneficiaries

The cost allocation process is designed so that costs associated with project purposes can be apportioned to beneficiaries for repayment. Once costs are allocated to the appropriate purpose, costs can be assigned to Federal and/or State taxpayers (nonreimbursable) and project beneficiaries (reimbursable) based on specific project authorization, existing Federal law, existing cost sharing requirements, and laws and objectives of non-Federal entities, including states, counties, and non-profit organizations.

Reimbursable costs are those that, through some form of upfront cost sharing, repayment, or other financial agreement, are repaid to the government. Non-reimbursable costs are those borne entirely by the government.

G.1.5 Potential Cost Allocation Methods

This section discusses two potential cost allocation methods for multipurpose projects.

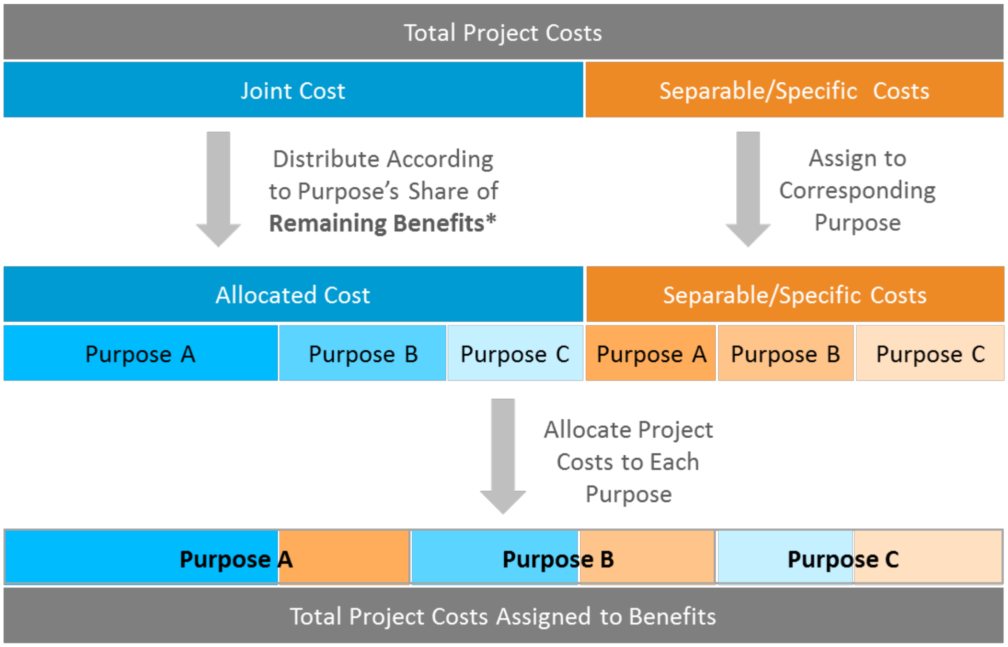
G.1.5.1 Separable Costs-Remaining Benefits Method

Distribution of project cost considers both the elements of the project that are directly tied to a project purpose, as well as the elements tied to multiple project purposes. A widely used method for cost allocation in Federal water resources projects is the SCRB method, which distributes costs among the project purposes by identifying separable costs and allocating joint costs in proportion to each purpose's remaining benefits. Project costs (i.e., construction cost, IDC, operations and maintenance costs, and indirect costs) can be grouped, with respect to project purposes, into separable and joint costs. Separable costs are the incremental costs of adding a purpose to a multipurpose project. Separable costs for a project purpose are estimated as the reduction in project costs that would result if that purpose is excluded. Joint costs are the remaining project costs after all separable costs are subtracted.

The SCRB method starts by identifying the separable costs for each project purpose. Separable costs are subtracted from the lesser of benefits or single-purpose alternative project costs to derive remaining benefits. Next, joint costs are allocated in proportion to the distribution of remaining benefits. Joint project costs are then assigned to a project purpose based on the proportion of their remaining benefits (i.e., total benefits less the separable costs of each project purpose). Total cost allocated to a project purpose is the sum of its separable and apportioned joint costs. This is illustrated in Figure 2.

G.1.5.2 Alternative Justifiable Expenditure

The Alternative Justifiable Expenditure method is a modified SCRB method used in situations when derivation of the separable costs is not feasible. Cost allocation under the Alternative Justifiable Expenditure method is the same as under the SCRB method, except that specific costs (i.e., costs for project components that contribute to a single purpose and exclude the costs of a change in project design due to inclusion) replace separable costs. The remaining (joint) costs are apportioned among project purposes based on their total benefits. However, if no specific or separable costs can be identified, cost allocation can be directly carried out based on the distribution of benefits between project purposes.



* **Remaining Benefit** for each Purpose = Justifiable Expenditure - Separable Costs

Justifiable Expenditure = Minimum of: (1) Estimated Benefit, or (2) Single Purpose Alternative Cost

Figure G-2. Separable Cost-Remaining Benefit Method

G.2 Authorization for Financial Participation

This section discusses existing Federal and State of California authorities for financial participation for benefits for the proposed project alternatives.

The NED Plan is formulated to provide a range of Federal benefits that include:

1. Municipal and industrial (M&I) water supply reliability, including emergency water storage, to SCVWD.

2. Refuge water supply, through increased reliability and deliveries of Incremental Level 4 water.

3. Ecosystem improvement for Federal ESA listed fish species, Southcoast Steelhead, in Pacheco Creek.

G.2.1 Federal Authority

Authorization for Federal financial participation in implementing Pacheco Reservoir Expansion is established by the *Water Infrastructure Improvements for the Nation Act*, 2015- 2016 (Public Law 114-322). Public Law 114-322, Section 4007 (a)(2) establishes Pacheco Reservoir Expansion as a qualified State-Led storage project:

(2) State-led storage project.--The term ‘‘State-led storage project’’ means any project in a Reclamation State that —

> *(A) involves a groundwater or surface water storage facility constructed, operated, and maintained by any State, department of a State, subdivision of a State, or public agency organized pursuant to State law; and*
>
> *(B) provides a benefit in meeting any obligation under Federal law (including regulations).*

Further guidance is provided in Public Law 114-322, Section 4007(c)(2)(B)(i):

Participation by the Secretary of the Interior in a State-led storage project under this subsection shall not occur unless—

> *(B) the State or local sponsor determines, and the Secretary of the Interior concurs, that--*
>
> > *(i) the State-led storage project is technically and financially feasible and provides a Federal benefit in accordance with the reclamation laws;*

Taking together, Section 4007(a)(2)(B) and Section 4007(c)(2)(B)(i) define the scope for Federal interest in State-led storage projects as: (1) providing Federal benefits in accordance with the Reclamation laws, and/or (2) providing a benefit in meeting obligations under Federal law.

G.1.2.1 Authorities for Ecosystem Improvement on Pacheco Creek

The reimbursability of separable and joint recreation and fish and wildlife costs is addressed in Section 2.(a)(3) of Pub. L. 89-72 where it states that "*not more than 50 percent of the separable costs and all the joint costs of the project allocated to recreation and exactly 75 percent allocated to fish and wildlife enhancement (both separable and joint) shall be borne by the United States and be non-reimbursable.*"

G.1.2.2 Authorities for Refuge Water Supply

According to Public Law 114-322, Section 4007(c)(2)(C), Refuge water supply is singled out as an example of an authorized Federal benefit:

(C) the Secretary of the Interior determines that, in return for the Federal cost-share investment in the State-led storage project, at least a proportional share of the project benefits are the Federal benefits, including water supplies dedicated to specific purposes such as environmental enhancement and wildlife refuges;

CVPIA (Public Law 102-575), Section 3406(d), establishes Federal requirements for providing Level 2 and full Level 4 water supplies to Central Valley refuges and wildlife habitat areas. Both Level 2 and Incremental Level 4 (the gap between Level 2 and full Level 4) are considered obligations under CVPIA. However, they have different requirements. Level 2 water is acquired by reallocating the CVP yield. Incremental Level 4 is water acquired through voluntary measures that do not include involuntary reallocation of project yield. Public Law 102-575, Section 3406 (d) states:

..., the Secretary shall provide, either directly or through contractual agreements with other appropriate parties, firm water supplies of suitable quality to maintain and improve wetland habitat areas on units of the National Wildlife Refuge System in the Central Valley of California;

(1)..., the quantity and delivery schedules of water measured at the boundaries of each wetland habitat area described in this paragraph shall be in accordance with Level 2 of the "Dependable Water Supply Needs" table for those habitat areas....

(2) Not later than ten years after enactment of this title, the quantity and delivery schedules of water measured at the boundaries of each wetland habitat area described in this paragraph shall be in accordance with Level 4 of the "Dependable Water Supply Needs" table for those habitat area… The quantities of water required to supplement the quantities provided under paragraph (1) of

this subsection shall be acquired by the Secretary through voluntary measures which include water conservation, conjunctive use, purchase, lease, donations, or similar activities, or a combination of such activities which do not require involuntary reallocations of project yield.

(3) All costs associated with implementation of paragraph (1) of this subsection shall be reimbursable pursuant to existing law. Incremental costs associated with implementation of paragraph (2) of this subsection shall be fully allocated in accordance with the following formula: 75 percent shall be deemed a nonreimbursable Federal expenditure; and 25 percent shall be allocated to the State of California for recovery through direct reimbursements or through equivalent in-kind contributions.

Taken together, Public Law 114-322, Section 4007(c)(2)(C) and Public Law 102-575, Section 3406 (d) provide a clear basis for Federal interest in Refuge water supply benefits.

G.1.2.3 Applicable Authorities for Cost Assignment

Costs allocated to each purpose are assigned to Federal taxpayers (nonreimbursable) and project beneficiaries (reimbursable) based on the specific project authorization, existing Federal law, existing cost sharing requirements, and laws and objectives of non-Federal entities, including states, counties, and non-profit organizations. Applicable Federal authorities are summarized in Table G-1. Note that non-Federal partners are not seeking Federal upfront financing in the form of reimbursable Federal funding for the implementation of this project.

Table G-1. Existing Authorities for Federal Financial Participation for Monetized Benefit Categories

Purpose	Pertinent Federal Legislation	Description
Federal Cost Share for a State-Led Project (Fish Habitat Enhancement and Incremental Level 4 Refuge)	Water Infrastructure Improvements for the Nation Act, 2015-2016 (Public Law 114-322)	Provides authorization for Federal funding in surface storage projects led by public agencies organized pursuant to State law and limits Federal participation to not more than 25% of the total cost of a State-led storage project.[2]
M&I Water Supply (Including Emergency Water Supply)[1]	Reclamation Act of 1939, as amended	Provides for up-front Federal financing of M&I water supply purposes, with 100% repayment of capital costs (including interest during construction and interest over the repayment period); 100% of OM&R costs are non-Federal.
Refuge Water Supply[2]	Central Valley Project Improvement Act (Public Law 102-575)	Provides Federal non-reimbursable share of up to 75% and 25% non-Federal share (State of California) for voluntary acquisition of Incremental Level 4 supplies to meet full Level 4 obligations.

Purpose	Pertinent Federal Legislation	Description
Pacheco Creek Ecosystem Improvement[3]	Federal Water Project Recreation Act of 1965 (Public Law 89-72), as amended	Public Law 89-72 provides Federal non-reimbursable share of up to 75% and non-Federal share of at least 25% for fish and wildlife enhancements, including planning, design, and IDC. In addition, 50% of the annual OM&R costs would be a non-Federal responsibility.

Notes:

[1] The Investigation is not pursuing Federal funding for M&I Water Supply and M&I Emergency Water Supply project benefit categories. The authorities listed for these project benefit categories were considered during initial determinations of Federal interest in the Investigation. Construction under these authorities would need to be authorized by a specific act of Congress.

[2] Applies to annual O&M costs for Incremental Level 4 Refuge Water Supply

[3] The Investigation is not pursuing Federal funding for Pacheco Creek Fish Habitat Enhancement under this authority. The authority listed for this project benefit category was considered during initial determinations of Federal interest in the Investigation. Construction under this authority would need to be authorized by a specific act of Congress.

G.2.2 State Authority

In November 2014, California voters passed funding for the Water Quality, Supply, and Infrastructure Improvement Act of 2014 (Proposition 1), a $7.5 billion water bond that will make needed investments in California's water management systems. Proposition 1 dedicates $2.7 billion for investments in water storage projects and designated the California Water Commission as the agency responsible for appropriately allocating these funds. The California Water Commission, through the Water Storage Investment Program, will fund the public benefits of eligible projects. Eligible projects must also provide measurable benefits to the Delta ecosystem or its tributaries.

Projects that may be funded by the State under Proposition 1 will be selected by the California Water Commission through a competitive public process based on a project's expected return on the public investment as measured by the magnitude of the public benefits provided. The public benefits categories defined by Proposition 1 include the following:

1. Ecosystem improvements, including changing the timing of water diversions, improvement in flow conditions, temperature, or other benefits that contribute to restoration of aquatic ecosystems and native fish and wildlife, including those ecosystems and fish and wildlife in the Delta.

2. Water quality improvements in the Delta, or in other river systems, that provide significant public trust resources, or that clean up and restore groundwater resources.

3. Flood control benefits, including, but not limited to, increases in flood reservation space in existing reservoirs by exchange for existing or increased water storage capacity in response to the effects of changing hydrology and decreasing snow pack on California's water and flood management system.

4. Emergency response, including, but not limited to, securing emergency water supplies and flows for dilution and salinity repulsion following a natural disaster or act of terrorism.

5. Recreational purposes, including, but not limited to, those recreational pursuits generally associated with the outdoors.

Article 4 of Chapter 8 of Proposition 1 identifies limitations regarding funding of public benefits. Proposition 1 limits funding in relation to quantified public benefits as follows:

1. Ecosystem improvement benefits must be at least 50 percent of total public benefits requested for funding. If non-ecosystem public benefits are more than ecosystem public benefits, then the difference is not eligible for funding.

2. The public benefit cost share of a project, other than conjunctive use and reservoir reoperation projects, may not exceed 50 percent of the total costs of the project.

3. The entire package of public benefits provided by the project must be provided in a cost- effective manner.

SCVWD is pursuing funding for $485 million towards the Pacheco Reservoir Expansion project from the State of California under the Water Storage Investment Program component of Proposition 1. The project was conditionally funded in May 2018. State funds would be used for the non-Federal costs presented in subsequent sections. They are unlikely to impact Federal funding. No funding from the California Water Commission is assumed in this initial cost allocation.

G.3 Initial Cost Allocation

This section presents the cost allocation by purpose for the Pacheco Reservoir Expansion Alternative Plan. This initial cost allocation uses the Justifiable Expenditure method.

G.3.1 Single Purpose Alternative Costs

Single purpose alternatives have not been developed for this initial cost allocation. The evaluation assumes that benefits would be less than the single purpose alternative costs; therefore, the proportion of benefits are used to determine cost allocations among project purposes.

G.3.2 Specific Costs

There are no specific costs that have been allocated to individual project purposes.

G.3.3 Joint Costs

The initial cost allocation assumes that all costs would be joint costs.

G.3.4 Initial Cost Allocation

Table G-2 displays a step-by-step process for determining the construction cost to be allocated to each project purpose. The initial allocation assumes that the estimated benefits would be less than the single purpose alternative costs; therefore, the benefits would be the justifiable expenditure. At this time, the single purpose alternative costs have not been estimated for this preliminary cost allocation. Further, the allocation assumes that all costs are joint costs and there are not specific costs. This will be revisited in subsequent drafts, but at this time, specific costs for each purpose are not estimated.

Table G-2. Initial Total Cost Allocation Summary for the Pacheco Reservoir Expansion Alternative Plan ($ millions)

	Emergency Water Storage	**M&I Water Supply**	**Ecosystem Improvement on Pacheco Creek**	**Refuge Water Supply**	**Total**
Item					
Annual Costs to be allocated	**$0.0**	**$0.0**	**$0.0**	**$0.0**	**$39.9**
Total Construction Costs	$0.0	$0.0	$0.0	$0.0	$1,127.0
Total IDC	$0.0	$0.0	$0.0	$0.0	$84.8
Amortization of Construction and IDC (annual)	$0.0	$0.0	$0.0	$0.0	$34.4
Annual OM&R	$0.0	$0.0	$0.0	$0.0	$5.4
Average Annual Benefits[1]	$23.7	$2.1	$24.0	$0.2	$50.0
Justifiable Expenditure	**$23.7**	**$2.1**	**$24.0**	**$0.2**	**$50.0**
Specific Costs[2]	$0.0	$0.0	$0.0	$0.0	$0.0
Construction Costs	$0.0	$0.0	$0.0	$0.0	$0.0
IDC	$0.0	$0.0	$0.0	$0.0	$0.0
Average Annual OM&R	$0.0	$0.0	$0.0	$0.0	$0.0
Remaining Justifiable Expenditure[3]	$23.7	$2.1	$24.0	$0.2	$50.0
Percent Distribution[4]	47.4%	4.2%	48.0%	0.4%	100.0%
Remaining Joint Costs (annual)	**$18.9**	**$1.7**	**$19.1**	**$0.2**	**$39.9**
Construction Costs	$534.5	$47.2	$540.8	$4.5	$1,127.0
IDC	$40.2	$3.6	$40.7	$0.3	$84.8
Average Annual OM&R	$2.6	$0.2	$2.6	$0.0	$5.4
Total Allocation (annual)	**$18.9**	**$1.7**	**$19.1**	**$0.2**	**$39.9**
Construction Costs	$534.5	$47.2	$540.8	$4.5	$1,127.0
IDC	$40.2	$3.6	$40.7	$0.3	$84.8
Average Annual OM&R	$2.6	$0.2	$2.6	$0.0	$5.4

[1] The cost allocation assumes that benefits are less than single purpose alternative costs and that benefits are used as the justifiable expenditure.

[2] Specific costs have not been identified for this preliminary cost allocation.

[3] Remaining justifiable expenditure is justifiable expenditure less specific costs. See note 2, specific costs are assumed to be zero for this initial cost allocation.

[4] Percent distribution is based on proportion of benefits for each project purpose.

G.3.5 Initial Cost Assignment

G.3.5.1 Methodology

The assignment of costs includes all costs required to accomplish all purposes consistent with the planning objectives. Cost assignment was conducted on a purpose by purpose basis, based off relevant authorities. The assignment percentages used as the basis for assigning costs are based on existing Federal authorities (see Table G-1) and are summarized below in Table G-3.

Table G-3. Initial Cost Assignment Percentages

Cost Type	Cost Category	Emergency Water Storage	M&I Water Supply	Ecosystem Improvement on Pacheco Creek	Refuge Water Supply
Construction	Federal Non-Reimbursable Costs	0%	0%	50%	0%
	Non-Federal Costs	100%	100%	50%	100%
Interest During Construction	Federal Non-Reimbursable Costs	0%	0%	50%	0%
	Non-Federal Costs	100%	100%	50%	100%
OM&R	Federal Non-Reimbursable Costs	0%	0%	0%	75%
	Non-Federal Costs	100%	100%	100%	25%

G.3.5.2 Initial Cost Assignment

Table G-4 shows an estimate of costs assigned to beneficiaries for each project purpose for the Pacheco Reservoir Expansion Alternative Plan.

Table G-4. Initial Cost Assignment for the Pacheco Reservoir Expansion Alternative Plan by Project Purpose

Cost		Emergency Water Storage	M&I Water Supply	Ecosystem Improvement on Pacheco Creek	Refuge Water Supply
Construction	Non-Reimbursable Federal Costs	$0	$0	$270.40	$0
	Non-Federal Costs	$534.46	$47.24	$270.40	$4.51
IDC	Non-Reimbursable Federal Costs	$0	$0	$20.35	$0
	Non-Federal Costs	$40.23	$3.56	$20.35	$0.34
OM&R	Non-Reimbursable Federal Costs	$0	$0	$0	$0.02
	Non-Federal Costs	$2.58	$0.23	$2.61	$0.01

G.3.5.3 Potential Impact of State Funding

In addition to Federal funding, non-Federal funding for a majority of the construction costs of a recommended plan would need to be identified and secured for the Secretary of the Interior to recommend funding for construction. Financing arrangements are being actively explored by SCVWD for the remainder of non-Federal costs. At this time, WSIP funding has conditionally identified $485 million for the Pacheco Reservoir expansion.

G.3.6 Payment Capacity and Ability to Pay

The financial feasibility analysis for M&I water supply benefits assesses how much water users can afford to pay for water supply improvements (i.e., payment capacity) and provides the basis to determine if their payment capacity is sufficient to pay for the allocated project costs.

For municipal water supply beneficiaries, ability to pay and payment capacity of potential beneficiaries is estimated with an “affordability threshold” represented as a percent of median household income. This analysis applies the affordability threshold established by the USEPA. In 1980, the USEPA Office of Drinking Water completed a study to assess the costs of complying with new drinking water regulations. The study determined that costs of water service exceeding 2.5 percent of household income were not affordable (Reclamation 2014d). For this analysis, the USEPA affordability threshold of 2.5 percent of median income is applied to estimate payment capacity. The NED Plan could provide water supply reliability and emergency benefits to Santa Clara County, which is the SCVWD service area.

In this analysis, the number of households (U.S. Census Bureau 2017) within Santa Clara County is used to estimate payment capacity. Table 6-5 provides the average payment capacity analysis results for SCVWD. As described above, payment capacity is estimated as 2.5 percent of median household income. To account for existing water payments, an average annual water charge for Santa Clara County residential customers of $656, (obtained from Raftelis Financial Consultants, Inc. and American Water Works Association 2013) is subtracted from the estimate to arrive at the estimated additional payments that are available to support new water projects. As shown in Table G-5, the estimated annual unused payment capacity in the SCVWD service area is approximately $1.3 billion.

Table G-5. Santa Clara Valley Water District Payment Capacity Results

Households, 2013-2017[1]	Median Household Income, 2013-2017[1]	Estimated Current Water Rates, 2013[2] ($1/hhld/yr)	Household Payment Capacity ($1/hhld/yr)	Estimated Total Payment Capacity ($/yr)
630,451	$106,761	$656	$2,013	$1.3 billion

Key: hhld = household; yr = year

Source: [1]U.S. Census Bureau 2017; [2] Raftelis Financial Consultants, Inc. and American Water Works Association 2013