From: Jerry Brown [jbrown@sitesproject.org]
Sent: 6/2/2020 6:35:46 AM
To: Alicia Forsythe [aforsythe@sitesproject.org]
CC: Kevin Spesert [kspesert@sitesproject.org]
Subject: Shasta Carryover
Attachments: 2020 SAC TMP response letter.pdf

Ali – You're probably aware of this current battle between the SWRCB and USBR over the 2020 temperature management plan. I would expect that statements in this letter could be useful to our claims about Sites assisting with cold water pool management. It appears Reclamation is claiming water temperature is more important than volume but the State Board is arguing for more volume because they want more carryover storage as a hedge in case next year is dry. Both positions would support our claims that the additional colder water Sites is able to back-up in Shasta is valuable to temperature management in dry and critical years.

Kevin – making you aware of this for the purpose of making edits to our message platform relative to environmental benefits to temperature management for salmon.

CALIFORNIA
Water Boards

GAVIN NEWSOM
GOVERNOR

JARED BLUMENFELD
SECRETARY FOR
ENVIRONMENTAL PROTECTION

State Water Resources Control Board

June 1, 2020

Ernest A. Conant
Mid-Pacific Regional Director
U.S. Bureau of Reclamation
econant@usbr.gov

ORDER 90-5 SACRAMENTO RIVER TEMPERATURE MANAGEMENT

Dear Mr. Conant:

This letter responds to the U.S. Bureau of Reclamation's (Reclamation) May 20, 2020 submittal of a final 2020 Sacramento River Temperature Management Plan (TMP) pursuant to State Water Resources Control Board (State Water Board or Board) Water Right Order 90-5. Additionally, the attached appendix addresses certain issues raised in Reclamation's May 11, 2020 comment letter to the State Water Board related to the draft TMP.

Order 90-5 requires Reclamation to take actions reasonably within its control to protect winter-run Chinook salmon and other native species from elevated temperatures and other adverse conditions created by Reclamation's operations on the Sacramento River. State Water Board staff repeatedly requested that Reclamation provide information on operational scenarios other than those proposed in Reclamation's TMP that could allow for better temperature control. Unfortunately, Reclamation has failed to provide the requested information. This information is needed to inform adequate temperature management. Since Reclamation has declined to provide the information, the State Water Board does not have sufficient information to make a well-informed decision on Reclamation's final TMP. We are therefore unable to approve the TMP, and object to the plan.[1]

In the spirit of cooperative federalism, we expect that Reclamation will provide the information we requested. In order to be in a position to potentially improve temperature conditions this year, the State Water Board needs the requested analyses within 20 days from the date of this letter. If this information is provided timely, we will reevaluate the TMP and consider approval at that time.

---

[1] The decision on Reclamation's TMP is made pursuant to authority delegated to the Executive Director of the State Water Board, and does not necessarily reflect the views of all of the State Water Board Members.

E. JOAQUIN ESQUIVEL, CHAIR | EILEEN SOBECK, EXECUTIVE DIRECTOR

1001 I Street, Sacramento, CA 95814 | Mailing Address: P.O. Box 100, Sacramento, CA 95812-0100 | www.waterboards.ca.gov

Background

Operations of Shasta Reservoir and associated facilities are not only critically important to California's water supply but also to the protection of winter-run Chinook salmon, which is one of the state's most endangered salmon species. Prior to construction of Shasta Dam, winter-run Chinook salmon spawning and early rearing habitat encompassed approximately 200 miles of snow-fed cold water streams in the upper reaches of the Sacramento River and its tributaries. These stream systems remained cold throughout the year, which protected salmon eggs and emergent fry from heat-induced mortality. With the construction and operation of Shasta and Keswick Dams, winter-run Chinook salmon no longer have access to this historic cold water habitat and are instead limited to a small stretch of the Sacramento River below Keswick Dam, where cooler temperatures are dependent on reservoir releases.

A number of controllable and uncontrollable factors contribute to temperatures below Keswick Dam, including the volumes of cold water that are affected by runoff and the timing and volume of releases from Shasta Reservoir, imports of water from the Trinity River system, temperature control device and side gate operations, power supply operations, air temperatures, and tributary inflow volumes and temperature in downstream reaches.

For the last several decades, winter-run Chinook salmon have teetered on the verge of extinction, due in large part to elevated temperature conditions in their sole remaining habitat, which is below Keswick Dam. The winter-run Chinook salmon population declined from over 100,000 fish in the late 1960s to fewer than 200 in the early 1990s (Yoshiyama et al. 1998).[2] These dramatic population declines led to the State Water Board's adoption of Order 90-5 that requires Reclamation to take actions reasonably within its control to protect winter-run and other native species from elevated temperatures and other adverse conditions created by Reclamation's operations on the Sacramento River.

In 2014 and 2015, temperatures were not maintained at protective levels below Shasta and Keswick Reservoirs, resulting in near total mortality of winter-run in those years and the near extinction of the species. Extinction of the winter-run was likely only avoided by maintaining high levels of hatchery production. In those years, adequate reservoir storage and cold water pool levels in Shasta Reservoir needed for temperature control were not maintained. Reclamation's modeling and monitoring was also inadequate to inform regulatory agency decision making and adjustments to operations that could have allowed for adequate temperature management.

This year's hydrology is very similar to the hydrology the region faced in 2013, the year before temperature control was lost. Over the last 21 years, every year with similar

---

[2] Yoshiyama, R. M., Fisher, F. W., & Moyle, P. B. (1998). Historical abundance and decline of chinook salmon in the Central Valley region of California. *North American Journal of Fisheries Management*, *18*(3), 487-521.

hydrology to this year was followed by another dry year. This observed pattern supports the importance of planning for and maintaining carryover storage levels this year. The operations proposed by Reclamation in its TMP are very similar to Reclamation's 2013 operations. And in fact, Reclamation's cold water pool estimates are already diverging from Reclamation's modeling. The volumes of coldest water in Shasta Reservoir are more than 10 percent lower than what was modeled less than two weeks ago. In addition, the current volumes of coldest water less than 48 degrees F in Shasta Reservoir are similar to the low levels experienced in 2014. This raises concerns that temperature conditions could already be deteriorating relative to Reclamation's TMP and could continue to do so. Recent science from the National Marine Fisheries Service (NMFS) (Daniels and Danner, 2020)[3] shows that dam discharge temperature from Shasta Reservoir has a greater effect on Sacramento River temperature than discharge volume, which suggests that reduced releases may be an effective tool in extending cold water pool resources, particularly if accurate information regarding cold water pool volumes and supporting modeling are available to inform regulatory decisions.

Given the conditions this year, the State Water Board asked Reclamation to evaluate scenarios that may improve temperature control and carryover storage going into next year, including reduced water deliveries under Reclamation's water rights, allowing Reclamation to retain more water in storage for the protection of cold water pool. Modifications to the volume and timing of imports from the Trinity River, and adjustments to power operations could also be considered.

Since this information is needed to inform adequate temperature management, and Reclamation failed to provide it, the State Water Board cannot approve the TMP. In the interim, although the State Water Board objects to the current plan, we do not expect, recommend, or require that Reclamation meet 56 degrees Fahrenheit (F) at the Red Bluff Diversion Dam (RBDD), as that would not be the best use of the limited Shasta Reservoir cold water pool. Instead, Reclamation should take every action in its reasonable control to protect native fish in the Sacramento River with an emphasis on actions that optimize protection of the winter-run Chinook salmon fishery downstream of Keswick Dam and provide for improved storage conditions going into next year. We also encourage Reclamation to work with the Sacramento River Settlement Contractors and other watershed stakeholders to implement voluntary measures that could improve fishery conditions, such as adjusting the timing of fall diversions.

Regulatory Background

Order WR 90-5 requires Reclamation to operate Keswick Dam, Shasta Dam, and the Spring Creek Power Plant to meet a daily average water temperature of 56 degrees F on the Sacramento River at RBDD during periods when higher temperatures will be detrimental to fish. If there are factors beyond Reclamation's reasonable control that

---

[3] Daniels, M. E., & Danner, E. M. (2020). The Drivers of River Temperatures Below a Large Dam. *Water Resources Research*, *56*(5), e2019WR026751.

prevent Reclamation from meeting 56 degrees F at RBDD, Reclamation, in consultation with staff from the State Water Board, fisheries agencies, and the Western Area Power Administration, may develop a plan and propose that the compliance point be moved upstream. The State Water Board has 10 days to consider the TMP (which is June 1 this year due to the 10 day period ending on the weekend).

Under the 2019 Reclamation Biological Assessment and associated 2019 NMFS Biological Opinion, Reclamation proposes to operate to meet a temperature between 53.5 degrees F and 56 degrees F or higher at a compliance point 41 miles upstream of RBDD at Clear Creek (CCR). In the TMP, Reclamation is identifying a compliance location in addition to CCR for meeting 56 degrees F at times that 56 degrees F is not proposed at CCR as the compliance location for Order 90-5. Water temperatures generally increase incrementally downstream of Keswick Dam until an equilibrium temperature is reached. Accordingly, providing a temperature of 56 degrees F at a downstream location like RBDD provides cooler temperatures upstream. Meeting a temperature of 56 degrees F at RBDD would generally provide cooler temperatures than 53.5 at CCR.

Reclamation's 2020 TMP

This year, Reclamation is proposing to meet the following temperature compliance points:

- End of May through end of June, 2020: 53.5 degrees F at CCR and 56 degrees F at Balls Ferry
- End of June through middle of September, 2020: 54 degrees F at CCR and 56 degrees F at Balls Ferry
- Middle of September to the end of October, 2020: 56 degrees F at CCR

Reclamation submitted estimates of temperature dependent mortality indicating that these operations would be expected to result in stage independent temperature dependent mortality of 28 percent (with stage dependent temperature dependent mortality of 15 to 16 percent).[4] Estimates of temperature dependent mortality provided

---

[4] While State Water Board staff recognizes the efforts of Anderson (2018) in adapting the temperature dependent model from Martin et al. (2017) to develop stage dependent mortality estimates for optimizing use of cold water during the temperature management season, this model may underestimate temperature dependent mortality. Martin et al. (2017) shows that temperature related mortality of eggs can occur earlier than the critical age used in Anderson (2018), and that lower temperatures for only a portion of the incubation period may not be sufficiently protective. Together with a historical reduction in the length of the temperature management reach and a lack of protection for fish that emerge after October 31 through mid-November, underestimating temperature mortality during the early stages of egg development could lead to management actions that further impact wild winter-run Chinook salmon stock and its genetic diversity. (Martin, B. T., Pike, A., John, S. N., Hamda, N., Roberts, J., Lindley, S. T., & Danner, E. M. (2017). Phenomenological vs. biophysical models of thermal stress in aquatic eggs. *Ecology letters*, *20*(1), 50-59; Anderson, J. J. (2018). Using river temperature to optimize fish incubation metabolism and survival: a case for mechanistic models. *bioRxiv*, 257154).

by Reclamation on May 27, 2020 (Table 1), show similar results for mean/median stage independent mortality with a possible lower and upper range of less than 1 percent to nearly 70 percent.

Table 1: Estimated temperature-dependent egg mortality under different scenarios assuming a 2012-2019 spatial and temporal redd distribution using output from RAFT and interpolated HEC-5Q water temperature models.

Scenario	MODEL	Mean (%)	Median (%)	Lower (%)	Upper (%)
MAY_26_2020_INPUT_90_OUTPUT_90_25L3MTO	RAFT	30.63	27.57	0.08	69.6
MAY_26_2020_INPUT_90_OUTPUT_90_25L3MTO	HEC-5Q	26.46	22.16	0.11	67.22

While the mortality levels expected from the TMP are generally consistent with that expected for a Tier 3 year described in the 2019 Biological Opinion (median mortality of 24 percent)[5], the projected temperature dependent mortality rate of approximately 28 percent is concerning to State Water Board staff considering the poor condition of winter-run Chinook salmon and other natural and anthropogenic causes of mortality that will affect these fish. Uncertainties concerning mortality rates and operations could also result in higher levels of mortality. Accordingly, approaches that could lower mortality and improve carryover storage conditions for next year merit consideration.

Evaluation of Alternative Operational Scenarios

Reclamation evaluated many scenarios in developing the initial draft TMP; however, Reclamation only evaluated possible modifications to temperature shutter operations that all included similar levels of mortality, or scenarios that would not be recommended due to uncertainties with the ability to provide temperature control throughout the temperature control season. Reclamation did not evaluate any other actions that could improve temperature conditions, including possible changes to the timing or volume of releases, modifications to Trinity River imports, or power production operations to evaluate the possibility for more protective temperature conditions.

In response to an earlier draft of the TMP, State Water Board staff requested that Reclamation evaluate scenarios in which volumes of water equivalent to reductions in deliveries to exchange contractors and refuges that occur under the current Shasta Critical year conditions are backed up in to storage in Shasta Reservoir. The purpose of Board staff's request was multi-fold: to evaluate whether conservation of water in Shasta Reservoir would improve temperature management this year; to avoid the higher end of possible temperature dependent mortality estimates; to evaluate whether the additional stored water would benefit carryover storage conditions going into next year; and to better understand the supply side and system management tradeoffs that would result from additional Shasta storage. Recognizing the interconnected nature of

---

[5] The 2017 NMFS proposed Biological Opinion amendments, although never finalized, recommended that temperature dependent mortality not exceed 8 percent in this type of year.

the water supply system and the potential for unintended consequences of modifying project operations, State Water Board staff also asked Reclamation to include information regarding the tradeoffs associated with lower releases and information regarding why Reclamation does not recommend such operations.

Reclamation has declined to evaluate additional operational scenarios. Reclamation's position is that scenarios with different operational assumptions would be inconsistent with its contractual obligations, and are therefore beyond Reclamation's reasonable control. The State Water Board disagrees. To the extent that Reclamation delivers water under its own water rights, Reclamation's obligation to deliver water to its contractors does not take precedence over its permit obligations. Order WR 90-5 requires Reclamation to reduce releases to the extent reasonable and necessary to control water temperature. This permit condition is not and cannot be nullified by a contractual obligation. Reclamation's water supply contractors are not entitled to more water under their contracts than Reclamation is authorized to deliver consistent with the terms and conditions of its water right permits and licenses. (See *United States v. State Water Resources Control Bd.* (1986) 182 Cal.App.3d 82, 145-148; *State Water Resources Control Board Cases* (2006) 136 Cal.App.4th 674, 806, fn. 54; see also Order WR 92-02, p. 9, fn. 3 [compliance with Order WR 90-5 may require adjustments to water deliveries, which are controllable factors, and water should not be considered available for delivery if it is needed as carryover to maintain an adequate cold water pool].)

Reclamation's May 11 letter also suggested that the Board intends "to evaluate or take action on water rights held by parties other than Reclamation, in particular the Sacramento River Settlement Contractors, the San Joaquin River Exchange Contractors, and wildlife refuges . . . ." That is not the case. The Board's April 29, 2020 letter was intended to clarify that none of the operational scenarios the Board seeks to evaluate would impact the natural or abandoned flows to which senior riparian or appropriative water right holders may be entitled, including the settlement and exchange contractors.

The Board appreciates the willingness of Reclamation and the Sacramento River Settlement Contractors to continue to discuss this and other legal issues pertaining to compliance with Order WR 90-5. For purposes of compliance this year, however, it may not be necessary to resolve this issue because, due to the improvements in hydrology that occurred in early April, the Board is not seeking to evaluate any operational scenarios that may be inconsistent with Reclamation's contractual obligations to settlement or exchange contractors. Specifically, the Board's April 29, 2020 letter asked Reclamation to evaluate a scenario that stores water that is not delivered to settlement and exchange contractors due to the Shasta Critical year determination. There is reason to believe that this action may improve both temperature conditions in the fall and carryover storage. If the Shasta Critical year determination changes, evaluation of a scenario that reduces exports for service contractor deliveries is also requested.

These operations would be consistent with the settlement and exchange contracts, which provide for 75 percent allocations in a Shasta Critical year. These operational scenarios are also consistent with the shortage provisions contained in Central Valley Project (CVP) service contracts, which generally provide for reduced annual deliveries to service contractors when CVP water is unavailable due to hydrology or other legal requirements, which would include obligations under Order WR 90-5. (See *State Water Resources Control Board Cases*, *supra*, 136 Cal.App.4th at pp. 805-806 [discussing shortage provision in CVP service contract].) The State Water Board recognizes that such a scenario would have significant tradeoffs, however, and would therefore also like information on those tradeoffs.

Drought and Carryover Storage

Storage conditions this year are very similar to conditions in 2013. That year was the beginning of California's most recent drought, when low storage at the end of water year 2013 contributed to reduced storage in 2014 and 2015. The low storage levels in 2014 and 2015 led to the loss of temperature control and near extinction of winter-run Chinook salmon. Given the parallels this year to hydrologic conditions in 2013, the State Water Board continues to be concerned with preventing temperature dependent mortality and providing for carryover storage in the event that this is the first year in a series of drought years. One of the significant lessons learned from the recent drought was the need to plan for such contingencies. As such, Reclamation's proposal to operate this year similar to 2013 needs to be carefully considered. Recent information from Reclamation provided on May 27 indicates that the volume of coldest water in Shasta Reservoir (water less than 48 degrees F) is tracking very close to cold water volumes observed in 2014, and that the volumes of water less than 49 degrees F is more than 10 percent lower than what was modeled less than 2 weeks prior. The fact that cold water pool estimates are already diverging from Reclamation's model raises concerns that temperature conditions could already be deteriorating relative to the May 20th TMP. Further, it is possible that this year's Shasta Critical year determination (in which water supply allocations are reduced to various contractors) could change resulting in changes in operations that could affect temperatures. Reclamation, however, has not provided information regarding how such a change would affect operations this year.

State Water Board Renewed Request for Information

As stated above, the State Water Board currently does not have sufficient information to make a well-informed decision on Reclamation's final TMP. If the following information is provided within 20 days of the date of this letter, we will consider approval of the TMP at that time:

- Evaluation of operational scenarios that improve temperature protection this year, including extending temperature protection beyond October 31 if eggs are still in the redds at that time, and carryover storage going into next year. Assuming this remains a Shasta Critical year, this should include evaluation of improving temperature management and carryover storage with water not allocated to settlement and exchange contractors and refuges under the contractual shortage provisions of the associated contracts. In the event it is not a Shasta Critical year following the recent storm event, a scenario in which exports for service contractors are reduced to provide 100 thousand acre-feet (TAF) of additional storage in Shasta Reservoir and up to 250 TAF if feasible should be evaluated.

- An evaluation of other possible adjustments to other operations to improve temperature conditions, including adjustments to power operations and Trinity River imports.

- The State Water Board recognizes that at this point in the water year, such scenarios could have significant water supply and economic impacts so also requests an evaluation of the tradeoffs associated with the above scenarios.

In addition to providing this information, Reclamation should notify the State Water Board immediately if any conditions (monitoring, modeling, operations, etc.) or projections indicate that conditions will be any less protective than identified in the May 20th TMP. This includes, but is not limited to, lower than projected reservoir storage levels or cold water pool volumes, higher than projected reservoir releases, higher than projected water temperatures at CCR or Balls Ferry, increases to estimated winter-run Chinook salmon mortality levels, or other indications that conditions for protection of winter-run and other native species are degrading this year.

Transparency and Collaboration Moving Forward

The State Water Board wants to work cooperatively with Reclamation and watershed stakeholders on collaborative science and planning to further improve our shared understanding of temperature management actions that can best achieve water supply and fish protection goals. Climate change, increased population growth, increased water demand will continue to put additional stressors on an already overburdened system, and could lead to endangered species going extinct when coupled with other stressors on these fish. At the same time, the State Water Board recognizes that curtailments in water supply and deliveries may cause real economic effects. Decisions that deplete the cold water pool too early, or that require releases at the wrong time, could have disastrous effects for water users and species alike. The State Water Board is tasked with balancing competing demands, and relies on the best available science and data when making related decisions and recommendations. The Board relies on the expertise of our federal partners to help us make the best decisions. We cannot do this alone.

While Reclamation evaluated over 300 management scenarios in developing the TMP for this year, each scenario relied on the same basic set of assumptions related to releases and supplies. The result was each scenario forecasted similar mortality levels of salmon. The alternative operational scenarios the Board has requested are needed to make the most informed temperature management decisions – not only for the Board, but for the numerous stakeholders who are directly involved in management and stewardship of California's water resources. Most critically, voluntary efforts to develop a long-lasting and meaningful balance between water supply and ecosystem needs will ultimately rely on timely and accurate information. The information developed from the requested scenario evaluations, combined with a better understanding of how water supply changes propagate throughout the water supply system, is a necessary part of an ongoing collaborative process.

One of the most difficult elements in temperature management planning is the short decision-making window inherent to the current process. With a highly fluid hydrology, changes in temperature and supply can occur on a near weekly basis, particularly during the winter and spring. In 2018, State Water Board staff requested that Reclamation develop a temperature management and planning protocol, in part to help address the ongoing challenges associated with the short timelines of the existing process. Reclamation worked towards this effort in 2018, but ultimately requested to pause the development of the protocol as a new biological opinion was being developed. A revised biological opinion was adopted in 2019.

Given that the 2019 biological opinion is now complete, Board staff requested in our April 3, 2020 letter that Reclamation develop a draft protocol for submittal to the State Water Board and fisheries agencies for comment by September 15, 2020. In public comments on the TMP, the State Water Board received helpful recommendations from Reclamation's contractors, fisheries agencies, and non-governmental organizations (NGOs) on possible improvements to the temperature management process that should be considered related to early planning, voluntary measures, and collaboration. The protocol should consider these recommendations, as the recommended improvements could help all stakeholders involved. The State Water Board also recognizes that Reclamation plans to develop a drought tool kit of actions that can be taken during drought conditions to improve temperature management. The State Water Board is very supportive of those efforts and encourages Reclamation to include information regarding the drought tool kit in the draft protocol. Prior to development of the protocol, State Water Board staff will be sending a letter outlining additional issues it believes are important to consider, and we would like to meet with Reclamation to share ideas that would meet our collective needs and objectives.

The draft protocol requested above will be a good first step in establishing an earlier and ongoing collaborative process. Looking forward, efforts already underway may provide additional opportunities for temperature management collaboration. A science partnership with agencies, water users, and NGOs like that being proposed by the Northern California Water Association, could be a promising opportunity for identifying key temperature management questions and solutions in a collaborative forum. We look forward to seeing additional information and outcomes from that process, and are available for discussions as helpful.

If you have any questions regarding this letter, please contact Diane Riddle at diane.riddle@waterboards.ca.gov. Please be aware that due to the public health concerns regarding the COVID-19 virus and the resulting pandemic, many State Water Board staff are telecommuting; therefore, the best avenue of communication at this time is via email.
Sincerely,

ORIGINAL SIGNED BY

Eileen Sobeck
Executive Director
State Water Resources Control Board

Appendix: Clarifications and Corrections to Issues Raised in Reclamation's May 11, 2020 Letter to the State Water Resources Control Board.

1. Prior Drought

Reclamation raises a number of comments in their May 11, 2020 letter to the State Water Board regarding conditions during the prior drought and technical issues related to temperature management that require clarification. The description provided in the May 11th letter offers an incomplete analysis of the complicated temperature management issues that developed during the drought. We wish to provide additional context to statements made in the May 11th letter related to loss of temperature control and modeling efforts.

Reclamation attributes the loss of temperature control during the drought years of 2014 and 2015 entirely to decisions by the regulatory agencies, including the State Water Board. As Reclamation has acknowledged, depleted storage conditions in 2013 contributed to low storage in 2014 and associated temperature concerns. Regulatory agencies relied on temperature modeling provided by Reclamation in 2014 as part of the temperature planning process, and based regulatory decisions on that modeling information. Unfortunately, as described in the *Sacramento River Temperature Task Group Annual Report and Activities*, water temperatures from October 1, 2013 through September 30, 2014 were about 4 degrees F higher than modeled. These high temperature levels resulted in the loss of nearly all of the 2014 cohort of winter-run Chinook salmon due to temperature dependent mortality.

In 2015, delayed reporting by Reclamation on limited cold water storage conditions left limited options for improving temperature conditions, particularly without significant loss of already dedicated economic resources, and little time to analyze what options remained. By the time state and federal regulatory agencies were aware of the limited cold water volumes there were few actions that could be taken.

Reclamation seems to attribute 2014-2015 winter-run Chinook salmon mortality to the actions of regulatory actions, but clearly there are numerous factors that affected poor outcomes in those years. A collaborative multi-agency and stakeholder approach will help future temperature planning efforts – although without timely and accurate information such collaborative efforts will be constrained. The experience of the 2014-2015 drought years, and the resulting loss of nearly all the 2014 and 2015 cohorts of winter-run Chinook salmon, have informed the Board's subsequent temperature management planning efforts. Likewise, Reclamation has also taken the lessons learned during the most recent drought as an opportunity to evaluate drought responses and improve its temperature planning and management processes. Continuing (and potentially expanding) this working relationship will provide for better outcomes during dry conditions in the future.

2. Releases from Shasta, Allocations, and Decision Making

Reclamation's May 11th comment letter states that there is little difference in March through April releases from Shasta Reservoir between a zero allocation to water service contractors and a 100 percent allocation to water service contractors in a dry year. Reclamation further indicates that requirements for early water supply planning would only impact planting decisions without benefiting the available cold water pool, since the majority of deliveries to water service contractors begin in May when the hydrology and stratification of the available cold water-pool is better known. The Board acknowledges that changes in hydrology can be rapid and have significant effects on temperature management planning, as evidenced by this water year in particular. But the challenges associated with hydrologic uncertainty make early planning efforts more critical, not less. Reclamation may begin the majority of its deliveries to water service contractors in May; however, water supply allocation and associated planting decisions related to deliveries are made earlier in the season making it important to start planning processes early when conditions are dry. Early discussions on hydrology could facilitate voluntary efforts to identify reasonable options for improving cold water pool volumes and related temperature induced mortality.

3. Temperature Relationship to Shasta Releases and Fall Carryover

Reclamation indicates that lower releases from Shasta Reservoir during the spring through fall would not benefit temperature operations. Reclamation cites Daniels and Danner (2020), who evaluated the relationship of river temperatures to discharge over a wide range of flows and geographic scales. Daniels and Danner (2020) found that "discharge temperature often had a larger effect compared to discharge volume," particularly in the upper reach of the Sacramento River near CCR where Reclamation intends to manage temperatures. According to Daniels and Danner (2020), the river temperature in the upper Sacramento River (between Keswick Dam and upstream of Bend Bridge) responded primarily to changes in discharge temperature, with the exception of flows below 5,300 cfs. (Reclamation's forecasted releases during June and July are about 12,000 cfs.) Thus, when releases are above 5,300 cfs, greater discharge volumes may not be necessary to control river temperatures in the locations where temperature management currently occurs, and higher releases may deplete stored cold water resources.

Reclamation's May 11 comment letter also indicates that there is not a significant correlation between end of September storage levels and the next year's cold-water pool. Yet at the same time, Reclamation's analysis of historical prior storage, inflow, and releases for May 1 cold water capabilities states that "lower release in the fall of 2013 could have improved conditions for 2014." As discussed above, this year is very similar to 2013. Accordingly, improvements to carryover storage levels this year merit further consideration to address the types of challenges encountered during 2014 and 2015.

4. Releases to Maintain Delta Water Quality

Reclamation indicates that State Water Board Decision 1641 (D-1641) required high releases from Shasta storage this winter to meet Delta outflow requirements, despite low precipitation. The D-1641 Delta outflow requirements are based on the prior month's hydrologic conditions to provide more operational certainty. The outflow requirements include significant flexibility to reduce water supply impacts, including three different methods of compliance and the ability to carry over excess compliance days from one month to the next. Although daily outflow from Shasta Reservoir exceeded inflow intermittently during the period from December through mid-March, approximately twenty percent of inflow to the reservoir was stored on a net basis during February and March. Although it is more typical to store upwards of fifty percent of inflow during these months, outflow from Shasta is well within the range observed during the prior twenty years of implementation of D-1641, on the basis of both absolute volume and fraction of inflow to the reservoir.

Talking Points Regarding Expansion Capabilities of Rightsized Sites Reservoir Project

June 1, 2020

In communicating the results of the April 2020 Value Planning Report to various stakeholders and interested parties, questions have been raised about the capabilities of the "rightsized" project to be expanded for future purposes. These talking points are a summary of the areas covered in these conversations and the responses that have been provided.

Reservoir and Dams

- Inundation Area - In sizing to 1.5MAF it was possible to minimize inundating an Oak woodlands habitat including mature oak trees. If the reservoir was enlarged to 1.8MAF these areas would be inundated and may require mitigation.
- Dam Height - The height of the dams was reduced about 20-ft as a result of the 1.5MAF versus 1.8 MAF. To accomplish the additional height in the future, it is possible to establish an adequate dam base originally to support the additional height which can be raised in the future following a "haircut" to tie in to the clay core and increase the height of the dam without complete demolition. This construction could temporarily reduce the operating surface elevation until the raise is complete.
- Outlet Works – The number and size of gates and tunnels to release water from the reservoir would likely be undersized for to evacuate the volumes required for the larger reservoir size because of DSOD release criteria and would require modifications. A cost analysis could be performed in the preliminary design for including the larger facilities upfront.

Crossing and Bridge

- Road and Bridge Height – The configuration of the lowest cost alternative for the road and bridge for the 1.5MAF does not lend itself to a phase-able solution should the reservoir be enlarged in the future. This issue is being discussed with the County since it is necessary to not impact this road in the future.

Conveyance

- Delevan Pipeline and Pumping Station – These features were eliminated as part of the value planning project. It could be added as a standalone element in the future to either fill additional reservoir capacity or fill existing capacity over a shorter period of time. Alternative sources for diversions could also be evaluated (including the Colusa Basin Drain and Stony Creek). The addition would also make additional capacity available for greater amounts of release from the reservoir to meet demands. Interconnecting these features would require some modification of pumping plants at the Funks Reservoir.

Energy Generation

- Pump-back Generation – This capability was eliminated due to a lack of cost effectiveness. A Forebay/Afterbay (Fletcher/Holthouse) and a Pumping/Generating Plant totaling more than $600M was eliminated. Adding this feature at a later date would require major rework of facilities plus adding back what was eliminated in Value Planning.
- In-Line Hydro – The Value Planning report for VP7 incorporates in line hydro generation as part of pressure control on releases from the reservoir.

Sites Reservoir

Sites

Rightsized to Meet Our Current and Future Water Supply Needs

Sites Reservoir has been designed and optimized to meet our water supply needs for today and in the future

The Sites Project Authority conducted a **rigorous Value Planning effort** to review the project's proposed operations and facilities **to develop a project that is "right sized" for our investors and participants** while still providing water supply reliability and enhancing the environment

Rightsizing the reservoir was **responsive to input** from **state and federal agencies, NGOs, elected officials, landowners and local communities**

The **feedback we received** through a robust outreach effort was **critical** to developing a reservoir that is the **right size for both people and the environment**

Sites

Rightsized to Meet Our Current and Future Water Supply Needs

Member	Reservoir Participation(AFY)
Public Water Agencies	
North of Delta	52,142
South of Delta	140,750
Subtotal Public Water Agencies	192,892
State of CA	~ 40,000
Total Requirement	~230,000

Participant Demand

Participant water subscriptions allocated in the **current participation agreement**

Allocation of State of California water subscription is based on the **Proposition 1 water investment**

- Water for Delta Smelt
- Water for Refuges

Release Capacity from Sites

The "rightsized" project can deliver water to meet the demands of our participants and California's investment of water for the environment

Long term average ~240,000 AFY

Year Type	1,000 cfs Release Capacity (AFY) to the Colusa Basin Drain
Wet	90 - 120
Above Normal	260 - 290
Below Normal	245 - 275
Dry	355 - 385
Critically Dry	210 - 240

Sites

Rightsized to Meet Our Current and Future Water Supply Needs

Reservoir Size (MAF)	1.5
Project Cost (2019$, billions)	$2.4 - $2.7
Contingency Cost (2019$, billions)	$0.6
Total Project Cost (2019$, billions)	$3.0 - $3.3
Annualized AFY release	240,000
Range of Annual Costs During Repayment Without WIFIA Loans (2020$, $/AF)	$650 - $710
Range of Annual Costs During Repayment With WIFIA Loans (2020$, $/AF)	$600 - $660

The rightsized project is **roughly $2 Billion less** then the 2017 preferred alternative

Cost savings primarily from the **removal** of the **Delevan Diversion** facility on the Sacramento River and the **Delevan Pipeline**

Lowered the Annual Cost during repayment ($/AF)

Significant savings to participants with finance through a **WIFIA** government backed loan

Sites

Provides Statewide Benefits for Generations to Come

Sites Reservoir provides many multi-layered benefits

Off-stream Storage

Does not create a barrier to native fish migration

Federal and State Agencies Manage Environmental Water

Adaptable to current and future conditions and priorities

Local Leadership and Cooperation

Aligns with Sacramento Valley's values and fosters regional and statewide collaboration

Cooperative Operation

Increases effectiveness and efficiency of existing water storage infrastructure

Adaptable to Climate Change

Contributes to system reliability and performance with climate change

Dry Year Water Supply

Reliable dry year water supply for California communities, farms and businesses

Recreational Opportunities

Provides northern Sacramento Valley with additional opportunities for recreation

Environmental Support

Provides environmental water in drier periods for native fish, and habitat for native species and birds

Sites

We are On-Track to Deliver This Vital Project for the People of California

Key Milestones Through 2021

Meet **eligibility requirements under Prop 1 (WSIP)** in order to access the remainder of the $816 Million in funding

Recirculate Draft EIR for public comment, proactively engage stakeholders, develop responses to comments to support environmental feasibility determination

Complete Feasibility Report

Secure environmental permit certainty and **draft permit applications**

Update and **refine cost estimate** and **affordability analysis**

Develop Plan of Finance

Improve definition of **SWP/CVP** exchange, including **Operations Plan**

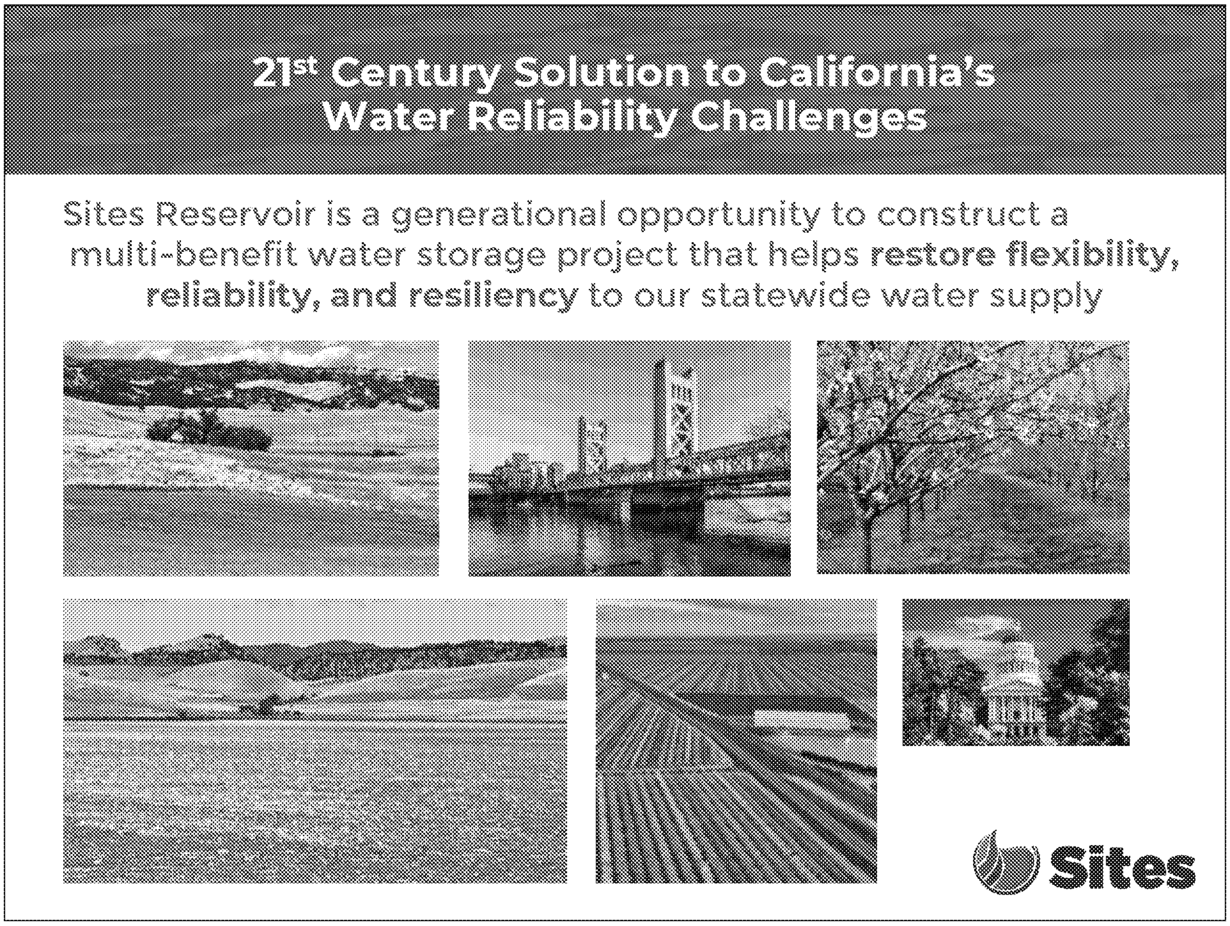
Enhance landowner, stakeholder & NGO engagement

Develop Operating Agreement Term Sheets with: DWR, USBR, TCCA, GCID, CBD Authority

Sites

Questions

Sites

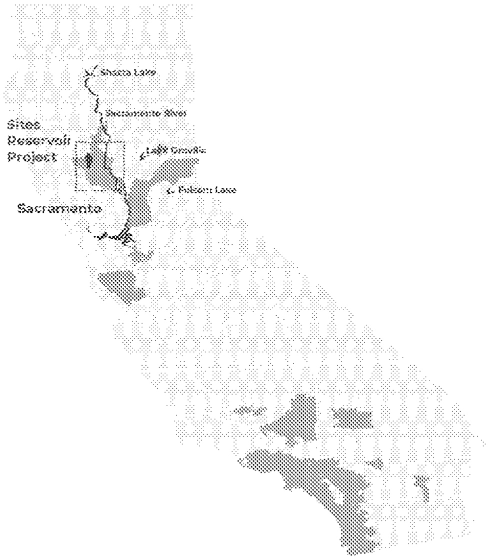


21st Century Solution to California's Water Reliability Challenges

Sites Reservoir is a generational opportunity to construct a multi-benefit water storage project that helps **restore flexibility, reliability, and resiliency** to our statewide water supply

Our Strength is in Our Broad Statewide Participation

Diverse statewide representation of public agencies advancing Sites Reservoir



Participants include **counties, cities, water and irrigation districts**

Urban and Rural

Sacramento Valley

San Joaquin Valley

Bay Area

Southern California

Sites

Our Strength is in Our Broad Statewide Participation

Sacramento Valley

- Carter Mutual Water Company
- City of American Canyon
- Colusa County
- Colusa County Water Agency
- Cortina Water District
- Davis Water District
- Dunnigan Water District
- Glenn County
- Glenn-Colusa Irrigation District
- LaGrande Water District
- Placer County Water Agency
- Reclamation District 108
- City of Roseville
- Sacramento County Water Agency
- City of Sacramento
- Tehama-Colusa Canal Authority
- Westside Water District
- Western Canal Water District

Bay Area

- Santa Clara Valley Water District
- Zone 7 Water Agency

San Joaquin Valley

- Wheeler Ridge-Maricopa Water Storage District

Southern California

- Antelope Valley - East Kern Water Agency
- Coachella Valley Water District
- Desert Water Agency
- Metropolitan Water District
- San Bernardino Valley Municipal Water District
- San Gorgonio Pass Water Agency
- Santa Clarita Valley Water Agency

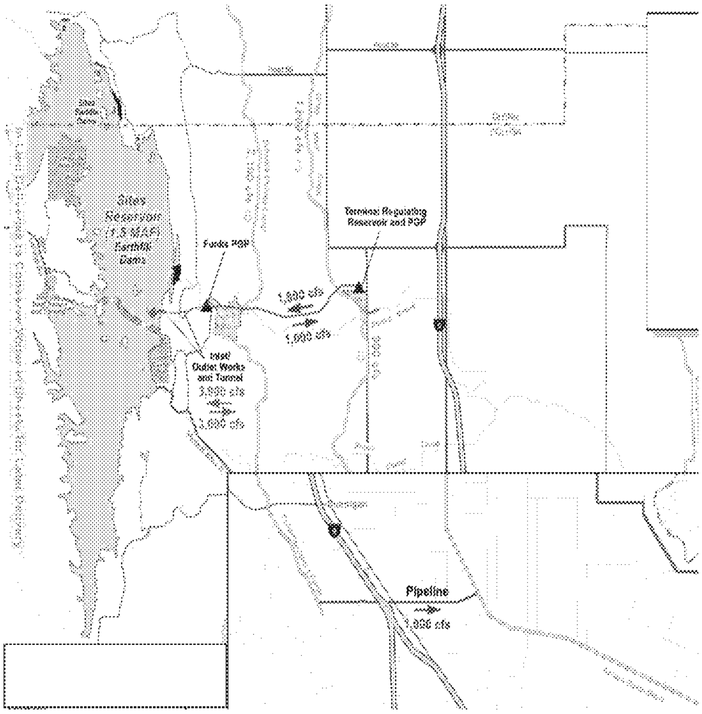
Sites

Rightsized to Meet Our Current and Future Water Supply Needs

1.5 million acre-feet

Utilizes the existing **Glenn-Colusa Irrigation District** and **Tehama-Colusa Canal Authority** canals to convey water to Sites Reservoir from the Sacramento River

Delivers water back to the Sacramento River through the **Tehama-Colusa Canal** and through the **Colusa Basin Drain** for participant deliveries and for the environment



Assumed Diversion and Operations Criteria

Location	Criteria
Wilkins Slough Bypass Flow	8,000 cfs April/May 5,000 cfs all other times
Fremont Weir Notch	Prioritize the Fremont Weir Notch, Yolo Bypass preferred alternative, flow over weir within 5%
Flows into the Sutter Bypass System	No restriction due to flow over Moulton, Colusa, and Tisdale Weirs
Freeport Bypass Flow	Modeled WaterFix Criteria (applied on a daily basis) Post-Pulse Protection (applied on a moving 7-day average) Post-Pulse (3 levels) = January–March Level 2 starts January 1 Level 1 is initiated by the pulse trigger
Net Delta Outflow Index (NDOI) Prior to Project Diversions	44,500 cfs between March 1 and May 31

Sites

Assumed Release Criteria

Most releases occur in dry years for water supply and environmental benefits

Priority of releases assume the following:

- Provide water to project participants north and south of the delta
- Provide water to Cache Slough area via Yolo bypass
- Provide water for incremental Level 4 refuge deliveries
- Support Reclamation goals through exchanges

Deliveries to SWP contractors supplement Table A (start @ 85% allocation and more aggressive releases starting @ 65%)

Sites

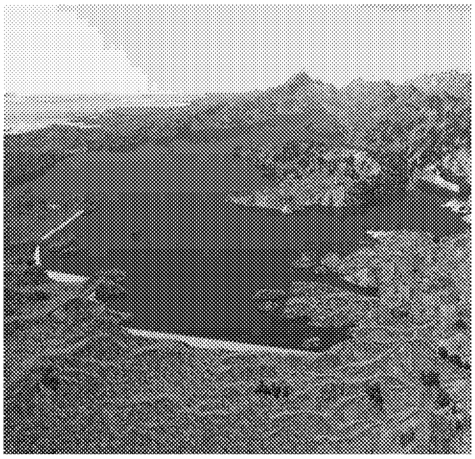
Rightsized to Meet Our Current and Future Water Supply Needs

The Value Planning process has **resulted** in a project that has a **smaller footprint** and **operated in a different manner** then originally designed

Due to these changes the Authority will **revise and recirculate its Draft EIR**

Work with **landowners, tribes, stakeholders, NGOs, and local communities** to develop a **collaborative environmental review process**

It is essential that we **build a project now that makes sense for all our participants** – local, state, and federal



Sites

Provides Statewide Benefits for Generations to Come

Sites Reservoir provides water dedicated to environmental use

A significant portion of the **Sites Reservoir Project's annual water supplies will be dedicated to environment uses:**

- **Preserve cold-water** pool in **Lake Shasta** later into the summer months to support **salmon development, spawning and rearing**
- Provide a **reliable supply of refuge water** to improve **Pacific Flyway** habitat for **migratory birds** and other **native species**
- Provide **water dedicated** to help improve conditions for the **Delta Smelt**

Water dedicated for the environment provided by Sites Reservoir will be **managed by state resources agency managers** who will decide how, and when, this water would be used – creating a water asset for the state that **does not currently exist**

Sites

Possibilities of Environmental Water Uses

Member	Reservoir Participation(AFY)
Public Water Agencies	
North of Delta	52,142
South of Delta	140,750
Subtotal Public Water Agencies	192,892
State of CA	~ 40,000
Total Requirement	~230,000

⟷

Potential Beneficiary
Level 4 refuge water
Enhanced Delta Ecosystem
Improve Survival of Anadromous Fish

Sites **creates a resource that can be managed for the benefit of the species.**

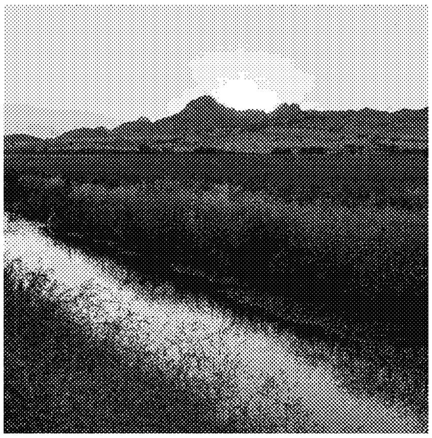
Water for the environment is **managed by state resource agencies.**

There is **flexibility** to manage these benefits each year.

The range of possibilities will be covered in the recirculated Draft EIR.

Provides Statewide Benefits for Generations to Come

Sites Reservoir will benefit the local and regional economy



Create hundreds of construction-related jobs during each year of the construction period, and **long-term jobs related to operations**

Creates **new recreation opportunities** in the Sacramento Valley which adds to the **region's economy**

Adding **resiliency** to the water supply will **strengthen the statewide economy** and **business** that rely on a reliable source of water for their operations – particularly agriculture

Sites

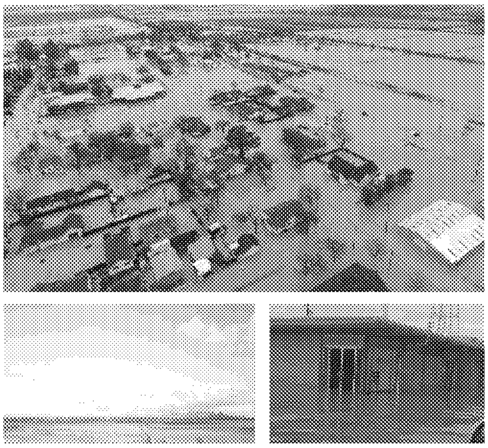
Provides Statewide Benefits for Generations to Come

Sites Reservoir provides regional flood protection benefits

Provides significant **regional flood protection benefits** for the Sacramento Valley

Will capture and store **flood flows** that would normally impact the community of **Maxwell** - protecting homes, business and farms

Will help to **limit "down stream" flooding issues** by capturing storm flows that sometimes overwhelm the regions flood control facilities



Sites

From: Laurie Warner Herson [laurie.warner.herson@phenixenv.com]
Sent: 6/3/2020 10:51:26 AM
To: Williams, Nicole [Nicole.Williams@icf.com]; Briard, Monique [Monique.Briard@icf.com]
CC: Luu, Henry [Henry.Luu@hdrinc.com]; Alicia Forsythe [aforsythe@sitesproject.org]; Linda Fisher (linda.fisher@hdrinc.com) [linda.fisher@hdrinc.com]
Subject: Engineering Coordination Update

Hi Nicole,

I had a call with Henry late yesterday to follow up on items we talked about during our EIR/EIS call on Monday morning as well as some other topics related to the EIR/EIS. The following is a brief overview of our discussion:

- We had a general discussion of the data and assumptions needed for the EIR/EIS analysis. I brought up the forthcoming AQ spreadsheets and we agreed that it would be best to hold off submitting those to the engineers while they are focused on the near-term priorities.
- Henry and I will be having a call with Jeff and Pete to go through the comments Jeff had on Alternatives 1 and 2; I'm in the process of updating the table to incorporate Jeff's comments and will walk through it during that call, also confirming whether there are other components that should be included.
- We talked about how to address the Intertie Project. Henry has talked with Kevin and there is a meeting scheduled this week with the engineers to discuss the Intertie Project. For now, I will be adding a footnote to the table, assuming that accommodation of the Intertie Project in project design would occur under both Alternatives 1 and 2.
- Regarding the comments from Colusa County and the term 'incremental' flood damage reduction included in the project objectives, I will be sending a follow-up email to let Mike to let him know that Henry and the engineering team will be updating the CWC flood benefit analysis and will coordinate with the County at that time; we will need to confirm with Ali whether we keep 'incremental' as part of that objective or not.
- Henry and I discussed the road to Ladoga and conceptual level of analysis that can be done. There is a meeting with the County tentatively scheduled for next week to discuss roads. I will attend and confirm approach to including the Ladoga Road under Alternative 2.
- Henry is going to be working with the engineers to develop preliminary figures for Alternatives 1 and 2 so we have them by 6/15.

More discussion to come during our call this afternoon as well as after the other meetings mentioned above.

Thanks,

Laurie

Laurie Warner Herson
Principal/Owner
Phenix
Environmental Planning

916.201.3935
laurie.warner.herson@phenixenv.com
State of California Small Business (#1796182)
Supplier Clearinghouse Women Business Enterprise (#16000323)

http://phenixenv.com/

From: Heather Dyer [heatherd@sbvmwd.com]
Sent: 6/3/2020 12:35:14 PM
To: Jerry Brown [jbrown@sitesproject.org]
CC: Marcia Kivett [MKivett@sitesproject.org]; Kevin Spesert [kspesert@sitesproject.org]
Subject: RE: Board Workshop Thursday

Perfect. I just gave them a presentation two weeks ago – a detailed primer on climate change and megadrought. So they are familiar with the issues and excited to be in "preparation and resiliency" mode.

Heather

From: Jerry Brown <jbrown@sitesproject.org>
Sent: Tuesday, June 2, 2020 3:38 PM
To: Heather Dyer <heatherd@sbvmwd.com>
Cc: Melissa Zoba <melissaz@sbvmwd.com>; Marcia Kivett <MKivett@sitesproject.org>; Kevin Spesert <kspesert@sitesproject.org>
Subject: Re: Board Workshop Thursday

Heather – Thanks for the guidance. Everything after "questions" is hip pocket – six slides total.

Melissa – Here are my slides for my presentation to the Board on Thursday afternoon. I appreciate your help and let me know any questions or concerns.

Jerry

From: Heather Dyer <heatherd@sbvmwd.com>
Date: Tuesday, June 2, 2020 at 1:39 PM
To: Jerry Brown <jbrown@sitesproject.org>
Cc: Melissa Zoba <melissaz@sbvmwd.com>
Subject: RE: Board Workshop Thursday

I think a few key slides from our recent Advocacy virtual meetings with legislators would be good. I think just concentrating on the high points about the right-sizing and the cost savings, new leadership, momentum, etc.. My Board is very into win-win solutions, collaboration with many partners for multi-benefit projects, and they understand that reducing impacts or making things better with the fisheries situation helps all of us down the road.

Thanks! You're first up on the schedule tomorrow. Here's the agenda with a link to Zoom. If you have a few slides to show we can put them in our powerpoint and have Melissa run the presentation for you. I've cc:d our IT manager, Melissa Zoba so you can send her the slides.

Heather

From: Jerry Brown <jbrown@sitesproject.org>
Sent: Tuesday, June 2, 2020 11:52 AM
To: Heather Dyer <heatherd@sbvmwd.com>
Subject: Board Workshop Thursday

Hi Heather – would you prefer I come to the meeting with a slide deck or should I go without powerpoint? I assume I have 5-10 minutes of comments followed by any questions from your board members. Is this correct? Thanks. Jerry

Agenda

Meeting name
Sites Reservoir Roadway/
Bridge Feasibility Design
Kick Off Meeting

Subject
Roadway Design Methodology
and Criteria
(Task Order 1)

Attendees
Colusa County: Michael Azevedo; Gary Evans,

Sites: Kevin Spesert

AECOM: Vanessa Doctolero; Howard Michael;
Jeff Herrin (Optional)

Meeting date
June 10, 2020

Time
10:00 AM

Location
Colusa County Public Works

Project name
Sites Reservoir Project

AECOM Project number
60476765.31000

Prepared by
Howard Michael/
Vanessa Doctolero

Meeting Goal: Establish roadway design criteria for feasibility level studies.

Our current Scope of Work involves feasibility level design for roads in support of environmental impact assessments through August 31, 2020. This task will not include cost estimating beyond that previously performed. The following table lists the roads, road type, and road location. The following pages include related agenda for this kick off meeting.

ROAD	COLUSA COUNTY	GLENN COUNTY
Eastside Road	Local Access	Local Access
Road to Southern Residents (Sulfur Gap Road)	Local Access	
North Road (Access Road - Construction Bypass)		Local Access
Saddle Dam Road – North (5 - 9)		Maintenance
Saddle Dam Road – South (1 - 5)	Maintenance	Maintenance
Road to Stone Corral Recreation Area / Sites Dam (Exist. – no plans)	Local Access	
Comm Road (Existing – no plans)	Local Access	
Sites Lodoga Road (Alt 1 – with South Bridge)	Local Access	
Sites Lodoga Road (Alt 2 – with South Side Road)	Local Access	
Road to Peninsula Hills Recreation Area (Existing – no plans)	Local Access	
Road to west side Day Use Boat Ramp (Existing – no plans)	Local Access	
County Road 68 (no plans yet, only estimate)		Local Access
County Road D (no plans yet, only estimate)		Local Access
County Road 69 (no plans yet, only estimate)		Local Access
Potential Access Road A1 (no plans yet, only estimate)	Maintenance	
Potential Access Road B1 (no plans yet, only estimate)	Maintenance	
Potential Access Road C1 (no plans yet, only estimate)	Maintenance	

1) **Feasibility Study (general alignment and roadway/bridge definition)**

   a) Roadway alignment methodology

      - United States Geological Survey (USGS) publicly available LiDAR and aerial imagery
        - 1-foot contour intervals
        - 1-foot to 2-foot tolerance
        - 200 scale, not 50 scale feasibility design

        > From USGS website site, "There is no guarantee or warranty concerning the accuracy of these data. Users should be aware that temporal changes may have occurred since these data were collected and that some parts of these data may no longer represent actual surface conditions. Users should not use these data for critical applications without a full awareness of its limitations".

      - Planning level design
      - Corridor width for flexibility in redesigning final alignment/bridge layout
      - Design just to support environmental studies
      - Right of way/parcel impacts

   b) County coordination

      - Colusa County
        - Staff
        - BOS
      - Glenn County
        - Staff
        - BOS

2) **Roadway functional classification (Design Type)**

   a) Access control

   b) Rural collector

      - Glenn County:
        - Road 68 (I-5 to Road D) – minor collector, travel speed 35 to 45 mph
      - Colusa County, Sites Lodoga Road – major collector, Class 3 bike route

   c) Rural local

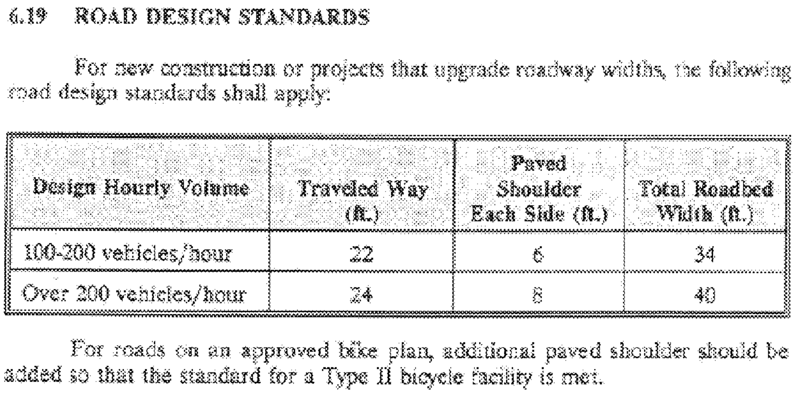
      - Glenn County (not mapped)
        - Road D (south of Road 68), travel speed 25 to 30 mph

        - Road 68, travel speed 25 to 30 mph

3) Alignment alternative criterion

a) AASHTO or Caltrans Design Criteria

- County unique design criteria
    - Glenn County



6.19 ROAD DESIGN STANDARDS

For new construction or projects that upgrade roadway widths, the following road design standards shall apply:

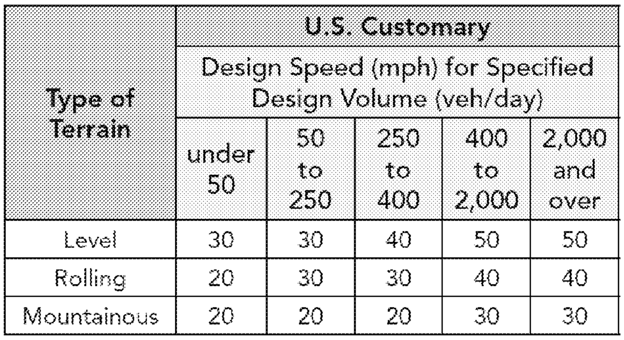
Design Hourly Volume	Traveled Way (ft.)	Paved Shoulder Each Side (ft.)	Total Roadbed Width (ft.)
100-200 vehicles/hour	22	6	34
Over 200 vehicles/hour	24	8	40

For roads on an approved bike plan, additional paved shoulder should be added so that the standard for a Type II bicycle facility is met.

-
    - Colusa County – Caltrans Highway Design Manual (HDM) per General Plan
        - HDM references AASHTO for Local Agency Projects

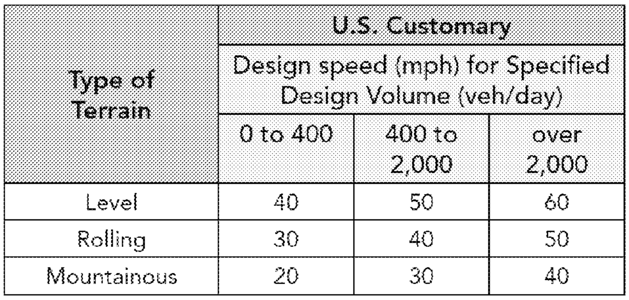
b) AASHTO design speed

- Rural Local



Type of Terrain	U.S. Customary				
	Design Speed (mph) for Specified Design Volume (veh/day)				
	under 50	50 to 250	250 to 400	400 to 2,000	2,000 and over
Level	30	30	40	50	50
Rolling	20	30	30	40	40
Mountainous	20	20	20	30	30

- Rural Collector



Type of Terrain	U.S. Customary		
	Design speed (mph) for Specified Design Volume (veh/day)		
	0 to 400	400 to 2,000	over 2,000
Level	40	50	60
Rolling	30	40	50
Mountainous	20	30	40

c) ADT

d) Cross sections

e) Design vehicle – California Legal Truck or STAA

f) Travel time

g) Standard geometry

h) Safety
  - Longer trips encourage faster driving

i) Long term maintenance

j) Constructability

k) Right of way
  - Property impacts
  - No. of properties

l) Emergency response

m) Evacuation route

n) Cost

4) Roadway features

a) Grade limitations

b) Passing/climbing lanes

c) Turn outs

d) Bike lanes (5' or 6' shoulders) – County standard is 4'

e) Overlook on fill prism in reservoir

f) One or two navigational passageways?

g) Upgrading non-standard features (e.g. Striping, MGS, flared end terminal systems, etc.)

h) Drainage features (e.g. box culverts, irrigation canals, roadside ditches, etc.)

5) Roadway feasibility (10%) design

a) Bridge and roadway (causeway) elevation over reservoir
  - 1.5 MAF (WSE = 498 ft) + 10 ft = Max. flood + wave
  - Dam crest elev. ~498 ft + 20 ft freeboard (may reduce to 15 ft – TBD) = 518 ft

b) Flexible alignments for redefining during final design (35% to 100%)

c) Service Area coordination
  - Preliminary geotechnical report
    - "Caltrans" Structures Preliminary Geotechnical Report
    - "Caltrans" Roadway Preliminary Geotechnical Report
    - Preliminary Pavement Evaluations for Cost Scoping in later phases
    - Preliminary Geologic Hazards Evaluations/Study for risk determination and risk assessment for cost and schedule development

- Preliminary Environmental Constraints Analysis
    - Wide study corridor for flexible alignment during preliminary design
- Preliminary Right of Way Evaluation
    - Property/owner constraints
    - Property/owner requirements/needs

d) Cut slopes

- Per geotechnical investigations
- General criteria
    - 1.5:1 (H:V)

e) Fill slopes

- General criteria
    - 1.5:1 (H:V) with soil reinforcement
    - 2:1 (H:V)

6) Bridge features

a) Cross section equal to approach roadway

- Reduced shoulder width to save cost

> AASHTO – 7.2.5: Long bridges, defined as bridges having an overall length in excess of 200 ft, may have a lesser width if current or projected bicycle use is very infrequent and no pedestrian facility is needed *(4' min.)*.

b) High winds

c) Jump prevention fencing?

d) Suicide prevention/emergency phone

e) Upgrading existing bridges

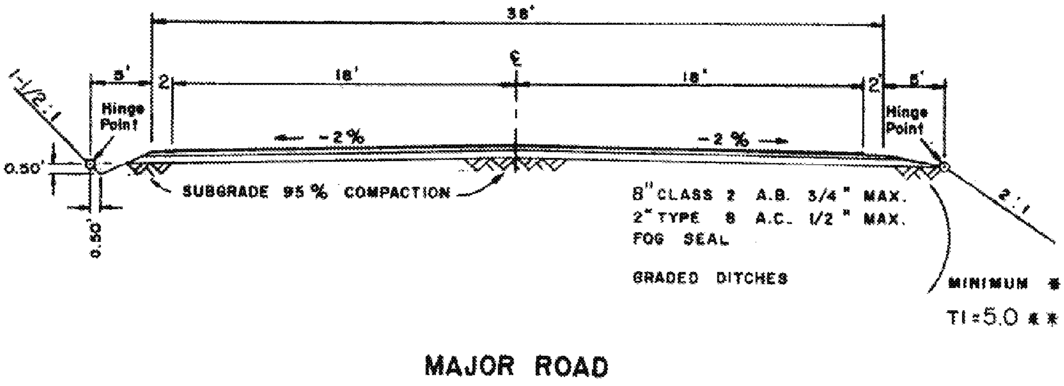


Figure 1 - Glenn County Standard Roadway Cross Section

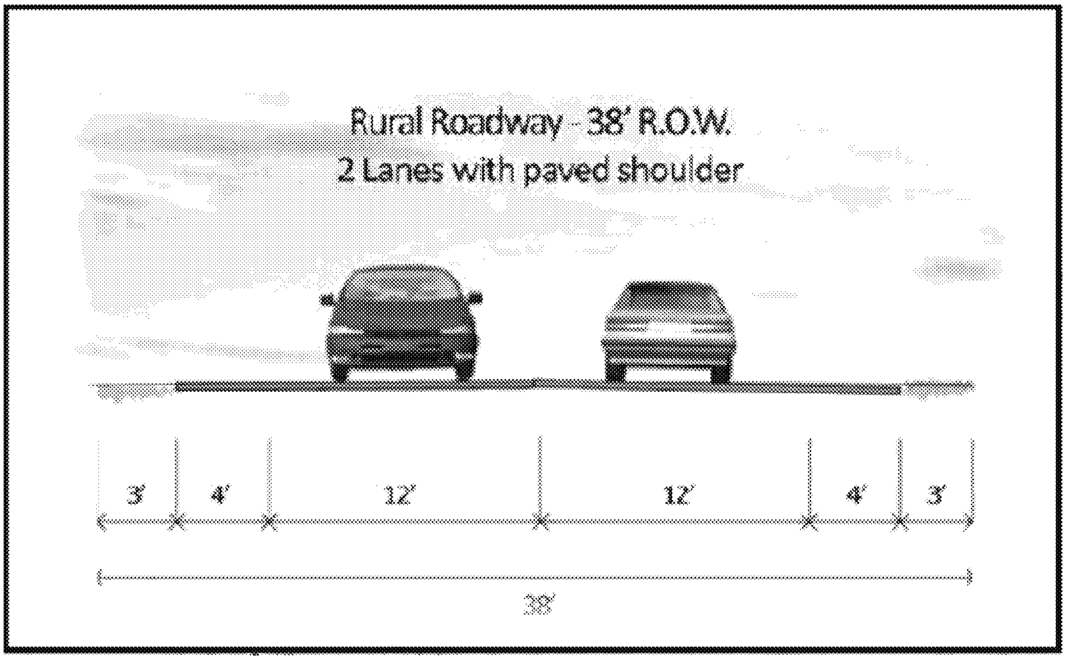


Figure 2 - Roadway Cross Section Considered to Date – Colusa County Rural Roadway

Ad Hoc Operations and Engineering Workgroup Agenda

Sites
Program Management Team

Date: June 10, 2020 **Location:** Webex meeting

Time: 2:30 PM to 5:00 PM

Leader: Robert Kunde **Recorder:** HDR – Sites Integration

Purpose: Ongoing update for the Ad Hoc for the Operations and Engineering Workgroup for 2020

Attendees:

Mike Azevedo, Colusa County
Thad Bettner, GCID
Robert Cheng, CVWD
Rob Cooke, DWR
Amparo Flores, Zone 7
Katrina Jessop, Valley Water
Rick Kaufman (A), American Canyon
Robert Kunde, WRMWSD
Eric Leitterman, Valley Water
Wes Mercado, Zone 7
Dirk Marks (A), SCVWD
Randall Neudeck, MWD
Dan Ruiz, WWD
Jeff Sutton (A), TCCA
Bob Tincher, SBVMWD
Bill Vanderwaal, RD 108
Jerry Brown, Sites Authority
Ali Forsythe, Sites Authority
Erin Heydinger, Sites Integration
Rob Leaf, CH2M
Henry Luu, Sites Integration
John Spranza, Sites Integration
Rob Tull, CH2M

(A) Indicates alternate

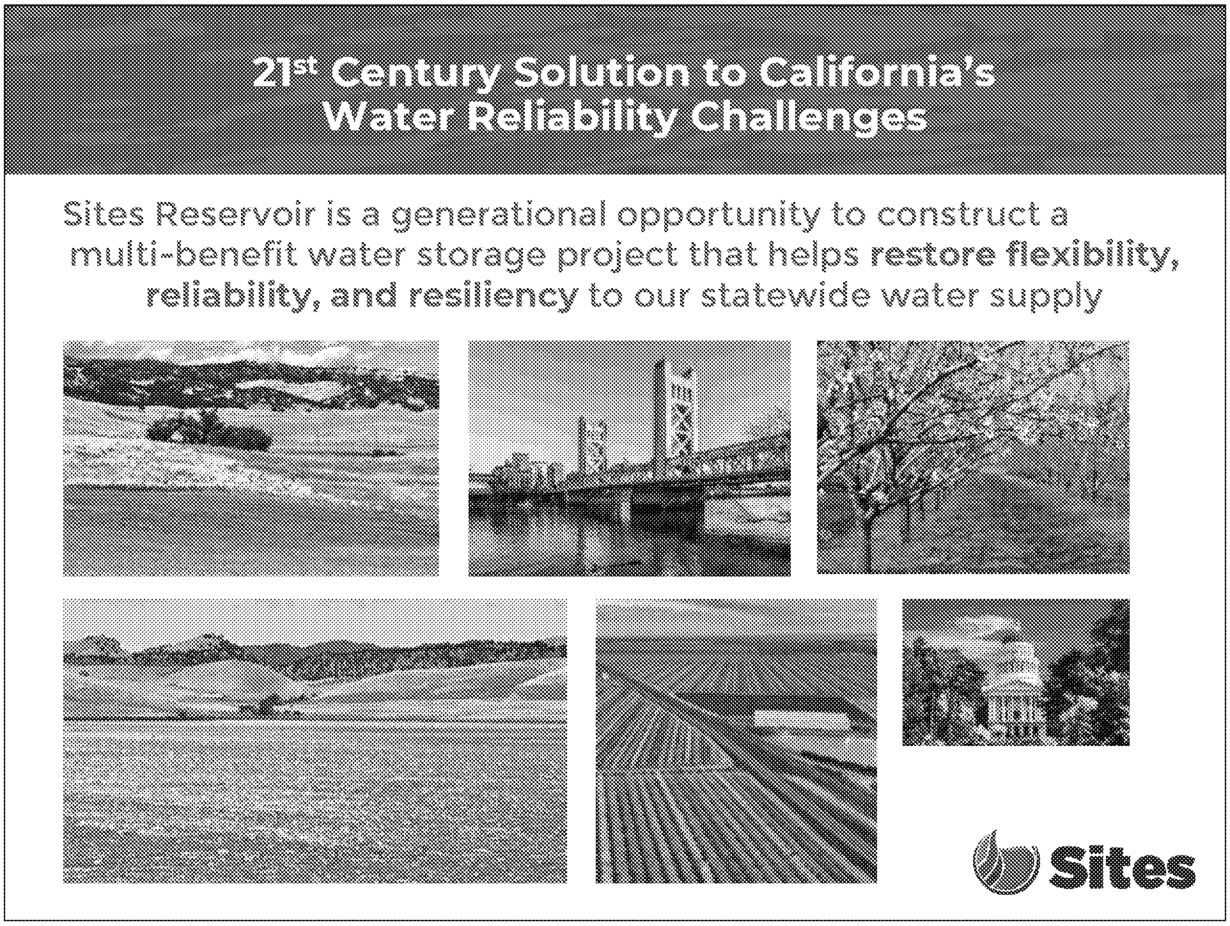
Agenda:

Discussion Topic	Topic Leader	Time Allotted
1. Introductory Remarks	Kunde/Azevedo	5 min
2. Agenda Overview	Forsythe	5 min
3. Engineering Update	Luu	10 min
4. Modeling Baseline	Tull	45 min
5. Shasta Exchanges		
a. Principles of Agreement	Forsythe	10 min
b. Operational Parameters	Tull	20 min
6. Diversion Scenarios Results	Tull	30 min
7. Demand Patterns	Tull	10 min
8. Organizational Asssessment – Negotiations Approach	Forsythe	10 min
9. Recap and Schedule Next Call	Forsythe	5 min

File Provided Natively

Sites Reservoir

Sites

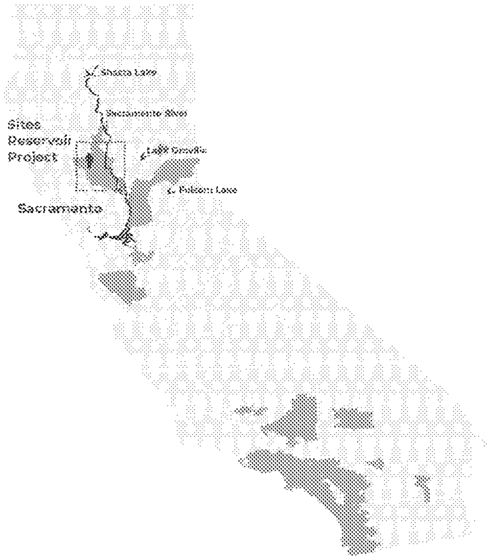


21st Century Solution to California's Water Reliability Challenges

Sites Reservoir is a generational opportunity to construct a multi-benefit water storage project that helps **restore flexibility, reliability, and resiliency** to our statewide water supply

Our Strength is in Our Broad Statewide Participation

Diverse statewide representation of public agencies advancing Sites Reservoir



Participants include **counties, cities, water and irrigation districts**

Urban and Rural

Sacramento Valley

San Joaquin Valley

Bay Area

Southern California

Sites

Our Strength is in Our Broad Statewide Participation

Sacramento Valley

- Carter Mutual Water Company
- City of American Canyon
- Colusa County
- Colusa County Water Agency
- Cortina Water District
- Davis Water District
- Dunnigan Water District
- Glenn County
- Glenn-Colusa Irrigation District
- LaGrande Water District
- Placer County Water Agency
- Reclamation District 108
- City of Roseville
- Sacramento County Water Agency
- City of Sacramento
- Tehama-Colusa Canal Authority
- Westside Water District
- Western Canal Water District

Bay Area

- Santa Clara Valley Water District
- Zone 7 Water Agency

San Joaquin Valley

- Wheeler Ridge-Maricopa Water Storage District

Southern California

- Antelope Valley - East Kern Water Agency
- Coachella Valley Water District
- Desert Water Agency
- Metropolitan Water District
- San Bernardino Valley Municipal Water District
- San Gorgonio Pass Water Agency
- Santa Clarita Valley Water Agency

Sites

Rightsized to Meet Our Current and Future Water Supply Needs

Sites Reservoir has been designed and optimized to meet our water supply needs for today and in the future

The Sites Project Authority conducted a **rigorous Value Planning effort** to review the project's proposed operations and facilities **to develop a project that is "right sized" for our investors and participants** while still providing water supply reliability and enhancing the environment

Rightsizing the reservoir was **responsive to input** from **state and federal agencies, NGOs, elected officials, landowners and local communities**

The **feedback we received** through a robust outreach effort was **critical** to developing a reservoir that is the **right size for both people and the environment**

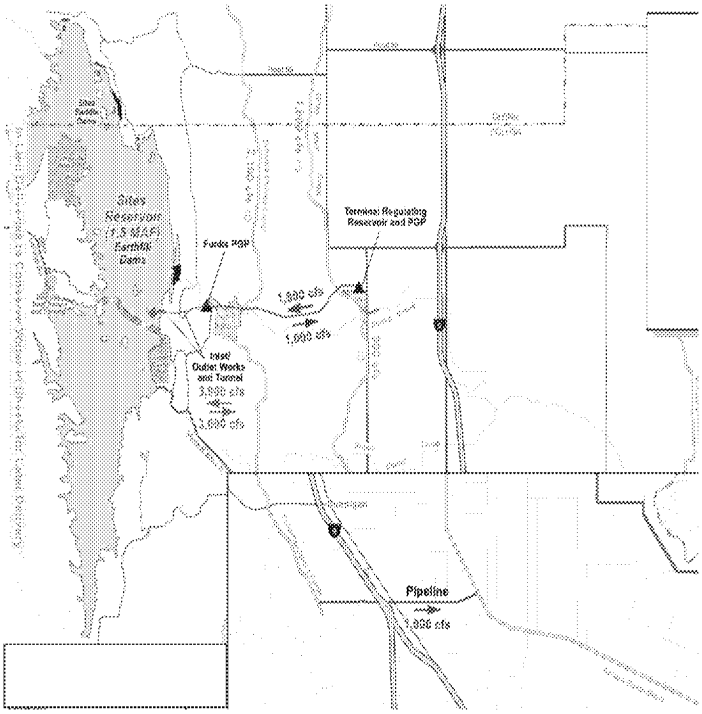
Sites

Rightsized to Meet Our Current and Future Water Supply Needs

1.5 million acre-feet

Utilizes the existing **Glenn-Colusa Irrigation District** and **Tehama-Colusa Canal Authority** canals to convey water to Sites Reservoir from the Sacramento River

Delivers water back to the Sacramento River through the **Tehama-Colusa Canal** and through the **Colusa Basin Drain** for participant deliveries and for the environment



Rightsized to Meet Our Current and Future Water Supply Needs

Member	Reservoir Participation(AFY)
Public Water Agencies	
North of Delta	52,142
South of Delta	140,750
Subtotal Public Water Agencies	192,892
State of CA	~ 40,000
Total Requirement	~230,000

Participant Demand

Participant water subscriptions allocated in the **current participation agreement**

Allocation of State of California water subscription is based on the **Proposition 1 water investment**

- Water for Delta Smelt
- Water for Refuges

Release Capacity from Sites

The "rightsized" project can deliver water to meet the demands of our participants and California's investment of water for the environment

Long term average ~240,000 AFY

Year Type	1,000 cfs Release Capacity (AFY) to the Colusa Basin Drain
Wet	90 - 120
Above Normal	260 - 290
Below Normal	245 - 275
Dry	355 - 385
Critically Dry	210 - 240

Sites

Assumed Diversion and Operations Criteria

Location	Criteria
Wilkins Slough Bypass Flow	8,000 cfs April/May 5,000 cfs all other times
Fremont Weir Notch	Prioritize the Fremont Weir Notch, Yolo Bypass preferred alternative, flow over weir within 5%
Flows into the Sutter Bypass System	No restriction due to flow over Moulton, Colusa, and Tisdale Weirs
Freeport Bypass Flow	Modeled WaterFix Criteria (applied on a daily basis) Post-Pulse Protection (applied on a moving 7-day average) Post-Pulse (3 levels) = January–March Level 2 starts January 1 Level 1 is initiated by the pulse trigger
Net Delta Outflow Index (NDOI) Prior to Project Diversions	44,500 cfs between March 1 and May 31

Sites

Assumed Release Criteria

Most releases occur in dry years for water supply and environmental benefits

Priority of releases assume the following:

- Provide water to project participants north and south of the delta
- Provide water to Cache Slough area via Yolo bypass
- Provide water for incremental Level 4 refuge deliveries
- Support Reclamation goals through exchanges

Deliveries to SWP contractors supplement Table A (start @ 85% allocation and more aggressive releases starting @ 65%)

Sites

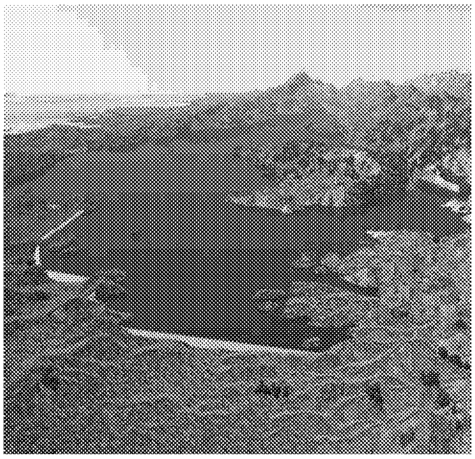
Rightsized to Meet Our Current and Future Water Supply Needs

The Value Planning process has **resulted** in a project that has a **smaller footprint** and **operated in a different manner** then originally designed

Due to these changes the Authority will **revise and recirculate its Draft EIR**

Work with **landowners, tribes, stakeholders, NGOs, and local communities** to develop a **collaborative environmental review process**

It is essential that we **build a project now that makes sense for all our participants** – local, state, and federal



Sites

Rightsized to Meet Our Current and Future Water Supply Needs

Reservoir Size (MAF)	1.5
Project Cost (2019$, billions)	$2.4 - $2.7
Contingency Cost (2019$, billions)	$0.6
Total Project Cost (2019$, billions)	$3.0 - $3.3
Annualized AFY release	240,000
Range of Annual Costs During Repayment Without WIFIA Loans (2020$, $/AF)	$650 - $710
Range of Annual Costs During Repayment With WIFIA Loans (2020$, $/AF)	$600 - $660

The rightsized project is **roughly $2 Billion less** then the 2017 preferred alternative

Cost savings primarily from the **removal** of the **Delevan Diversion** facility on the Sacramento River and the **Delevan Pipeline**

Lowered the Annual Cost during repayment ($/AF)

Significant savings to participants with finance through a **WIFIA** government backed loan

Sites

Provides Statewide Benefits for Generations to Come

Sites Reservoir provides many multi-layered benefits

Off-stream Storage

Does not create a barrier to native fish migration

Federal and State Agencies Manage Environmental Water

Adaptable to current and future conditions and priorities

Local Leadership and Cooperation

Aligns with Sacramento Valley's values and fosters regional and statewide collaboration

Cooperative Operation

Increases effectiveness and efficiency of existing water storage infrastructure

Adaptable to Climate Change

Contributes to system reliability and performance with climate change

Dry Year Water Supply

Reliable dry year water supply for California communities, farms and businesses

Recreational Opportunities

Provides northern Sacramento Valley with additional opportunities for recreation

Environmental Support

Provides environmental water in drier periods for native fish, and habitat for native species and birds

Sites

Provides Statewide Benefits for Generations to Come

Sites Reservoir provides water dedicated to environmental use

A significant portion of the **Sites Reservoir Project's annual water supplies will be dedicated to environment uses:**

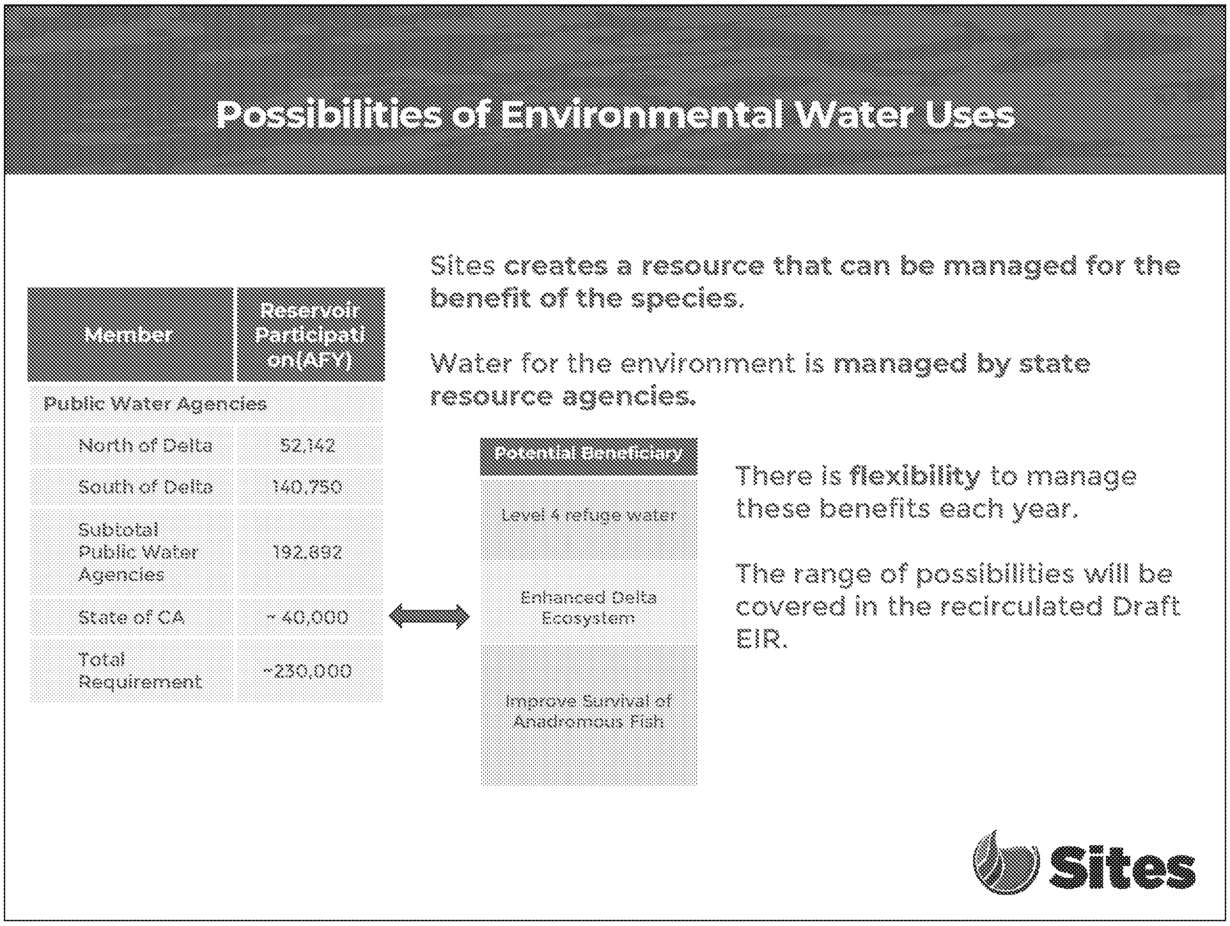
Preserve cold-water pool in **Lake Shasta** later into the summer months to support **salmon development, spawning and rearing**

Provide a **reliable supply of refuge water** to improve **Pacific Flyway** habitat for **migratory birds** and other **native species**

Provide **water dedicated** to help improve conditions for the **Delta Smelt**

Water dedicated for the environment provided by Sites Reservoir will be **managed by state resources agency managers** who will decide how, and when, this water would be used ~ creating a water asset for the state that **does not currently exist**

Sites



Possibilities of Environmental Water Uses

Member	Reservoir Participati on(AFY)
Public Water Agencies	
North of Delta	52,142
South of Delta	140,750
Subtotal Public Water Agencies	192,892
State of CA	~ 40,000
Total Requirement	~230,000

↔

Potential Beneficiary
Level 4 refuge water
Enhanced Delta Ecosystem
Improve Survival of Anadromous Fish

Sites **creates a resource that can be managed for the benefit of the species.**

Water for the environment is **managed by state resource agencies.**

There is **flexibility** to manage these benefits each year.

The range of possibilities will be covered in the recirculated Draft EIR.

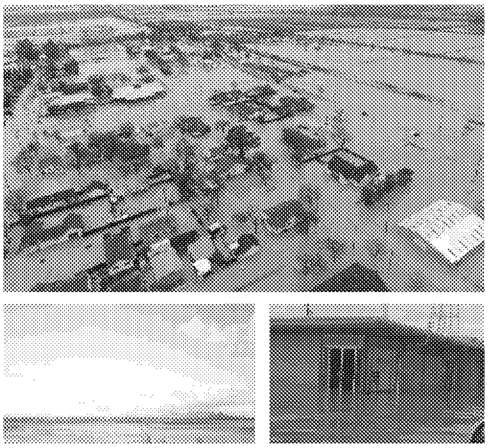
Provides Statewide Benefits for Generations to Come

Sites Reservoir provides regional flood protection benefits

Provides significant **regional flood protection benefits** for the Sacramento Valley

Will capture and store **flood flows** that would normally impact the community of **Maxwell** - protecting homes, business and farms

Will help to **limit "down stream" flooding issues** by capturing storm flows that sometimes overwhelm the regions flood control facilities



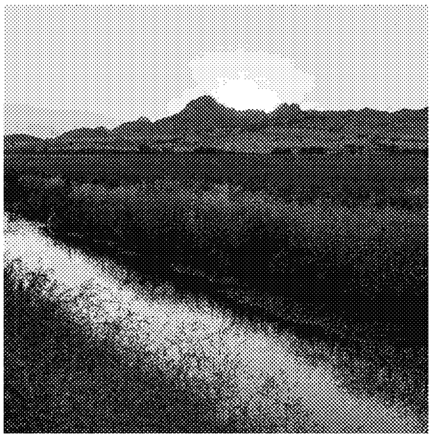
Provides Statewide Benefits for Generations to Come

Sites Reservoir will benefit the local and regional economy

Create hundreds of construction-related jobs during each year of the construction period, and **long-term jobs related to operations**

Creates **new recreation opportunities** in the Sacramento Valley which adds to the **region's economy**

Adding **resiliency** to the water supply will **strengthen the statewide economy** and **business** that rely on a reliable source of water for their operations – particularly agriculture



Sites

We are On-Track to Deliver This Vital Project for the People of California

Key Milestones Through 2021

Meet **eligibility requirements under Prop 1 (WSIP)** in order to access the remainder of the $816 Million in funding

Recirculate Draft EIR for public comment, proactively engage stakeholders, develop responses to comments to support environmental feasibility determination

Complete Feasibility Report

Secure environmental permit certainty and **draft permit applications**

Update and **refine cost estimate** and **affordability analysis**

Develop Plan of Finance

Improve definition of **SWP/CVP** exchange, including **Operations Plan**

Enhance landowner, stakeholder & NGO engagement

Develop Operating Agreement Term Sheets with: DWR, USBR, TCCA, GCID, CBD Authority

Sites

Questions

Sites

From: Heydinger, Erin [Erin.Heydinger@hdrinc.com]
Sent: 6/8/2020 9:37:45 AM
To: Alicia Forsythe [aforsythe@sitesproject.org]; Jerry Brown [jbrown@sitesproject.org]
Subject: RE: Workgroup Draft Agenda

Sounds good, I just added it.

Ali – I also added a placeholder in the PowerPoint for that item.

Erin

Erin Heydinger PE, PMP
D 916.679.8863 M 651.307.9758

hdrinc.com/follow-us

From: Alicia Forsythe <aforsythe@sitesproject.org>
Sent: Monday, June 8, 2020 8:50 AM
To: Heydinger, Erin <Erin.Heydinger@hdrinc.com>; Jerry Brown <jbrown@sitesproject.org>
Subject: RE: Workgroup Draft Agenda

CAUTION: [EXTERNAL] This email originated from outside of the organization. Do not click links or open attachments unless you recognize the sender and know the content is safe.

It would be separate from the Shasta Exchanges. Its more of a Sites "procedure" on how we would approach negotiations.

Thanks Erin!

Ali

Alicia Forsythe | Environmental Planning and Permitting Manager | Sites Reservoir Project | 916.880.0676 | aforsythe@sitesproject.org | www.SitesProject.org

CONFIDENTIALITY NOTICE: This communication with its contents may contain confidential and/or legally privileged information. It is solely for the use of the intended recipient(s). Unauthorized interception, review, use or disclosure is prohibited and may violate applicable laws including the Electronic Communications Privacy Act. If you are not the intended recipient, please contact the sender and destroy all copies of the communication.

From: Heydinger, Erin <Erin.Heydinger@hdrinc.com>
Sent: Monday, June 8, 2020 7:37 AM
To: Alicia Forsythe <aforsythe@sitesproject.org>; Jerry Brown <jbrown@sitesproject.org>
Subject: RE: Workgroup Draft Agenda

Sounds good, I'll add it. Is that separate from the Shasta Exchanges agreement item or would those slides move in to the Negotiations Approach part of the agenda?

Thanks,
Erin

Erin Heydinger PE, PMP
D 916.679.8863 M 651.307.9758

hdrinc.com/follow-us

From: Alicia Forsythe <aforsythe@sitesproject.org>
Sent: Monday, June 8, 2020 6:50 AM
To: Jerry Brown <jbrown@sitesproject.org>; Heydinger, Erin <Erin.Heydinger@hdrinc.com>
Subject: RE: Workgroup Draft Agenda

CAUTION: [EXTERNAL] This email originated from outside of the organization. Do not click links or open attachments unless you recognize the sender and know the content is safe.

Yes. We should. Good catch. We have it on the environmental work group agenda but completely forgot it here.

Erin, can you insert "Organization Assessment Item – Negotiations Approach" as #8 and allocate it 10 mins? Lets take Demand Patterns down to 10 mins and Modeling Baseline down to 45 mins to make up the time. I can keep the recap and next call super short if we are running low on time to fit all of this in.

Ali

Alicia Forsythe | Environmental Planning and Permitting Manager | Sites Reservoir Project | 916.880.0676 | aforsythe@sitesproject.org | www.SitesProject.org

CONFIDENTIALITY NOTICE: This communication with its contents may contain confidential and/or legally privileged information. It is solely for the use of the intended recipient(s). Unauthorized interception, review, use or disclosure is prohibited and may violate applicable laws including the Electronic Communications Privacy Act. If you are not the intended recipient, please contact the sender and destroy all copies of the communication.

From: Jerry Brown <jbrown@sitesproject.org>
Sent: Sunday, June 7, 2020 12:36 PM
To: Heydinger, Erin <Erin.Heydinger@hdrinc.com>; Alicia Forsythe <aforsythe@sitesproject.org>
Subject: Re: Workgroup Draft Agenda

Shouldn't we review the proposed negotiations approach at this meeting and the environmental planning and permitting workgroup meeting?

From: "Heydinger, Erin" <Erin.Heydinger@hdrinc.com>
Date: Friday, June 5, 2020 at 11:38 AM
To: Michael Azevedo <mjazevedo@countyofcolusa.com>, Rob Kunde <rkunde@wrmwsd.com>
Cc: Alicia Forsythe <aforsythe@sitesproject.org>, "Robert.Tull (Robert.Tull@jacobs.com)" <Robert.Tull@jacobs.com>, Jerry Brown <jbrown@sitesproject.org>
Subject: Workgroup Draft Agenda

Hi Rob and Mike,

Attached for your review is a draft agenda for next week's Workgroup meeting. Please get back to me if you have any changes or other topics we need to cover. I hope to send this out midday Monday and will also include a draft memo on the modeling baseline that CH put together.

Thanks, and have a great weekend!
Erin

Erin Heydinger, PE, PMP
Asst. Project Manager

Water/Wastewater

HDR
2379 Gateway Oaks Dr, #200
Sacramento, CA 95833
D 916.679.8863 M 651.307.9756

hdrinc.com/follow-us

TECHNICAL MEMORANDUM

Sites Project Authority – Sacramento River Intake Fish Screen Operations

PREPARED FOR:	Rob Tull/SAC
PREPARED BY:	James Kapla/SEA Aaron George/SEA
DATE:	25 March 2020
PROJECT NUMBER:	D3205400.A.CS.OE.D1.D1-03-03

Introduction and Purpose

The Sites Reservoir Project is a proposed 1.8 million acre-foot off-stream reservoir intended to divert and store excess Sacramento River streamflows, providing approximately 500,000 acre-feet per year of additional water supply on average. The Project would provide multiple beneficial uses including a reliable water supply for cities and agriculture; dedicated water for fisheries and environmental purposes; increased habitat for migratory birds; and improved flexibility and drought resiliency for the Central Valley Project and the State Water Project.

The purpose of this technical memorandum (TM) is to summarize key operational parameters of three Sacramento River intakes intended to supply water to the proposed Project. This includes estimates of available diversion capacity at various streamflows, given instream flow requirements and pumping capability. The intake facilities under consideration include the following:

1. Tehama-Colusa Canal Authority (TCCA) Red Bluff
2. Glenn-Colusa Irrigation District (GCID) Hamilton City
3. Delevan (Proposed)

The location of each facility is shown in Figure 1. This TM includes the following sections:

- Introduction and Purpose
- Intake Facilities Overview
- Methodology, Assumptions and Limitations
- Red Bluff Facility Operations
- Hamilton City Facility Operations
- Delevan Facility Operations
- References
- Attachments

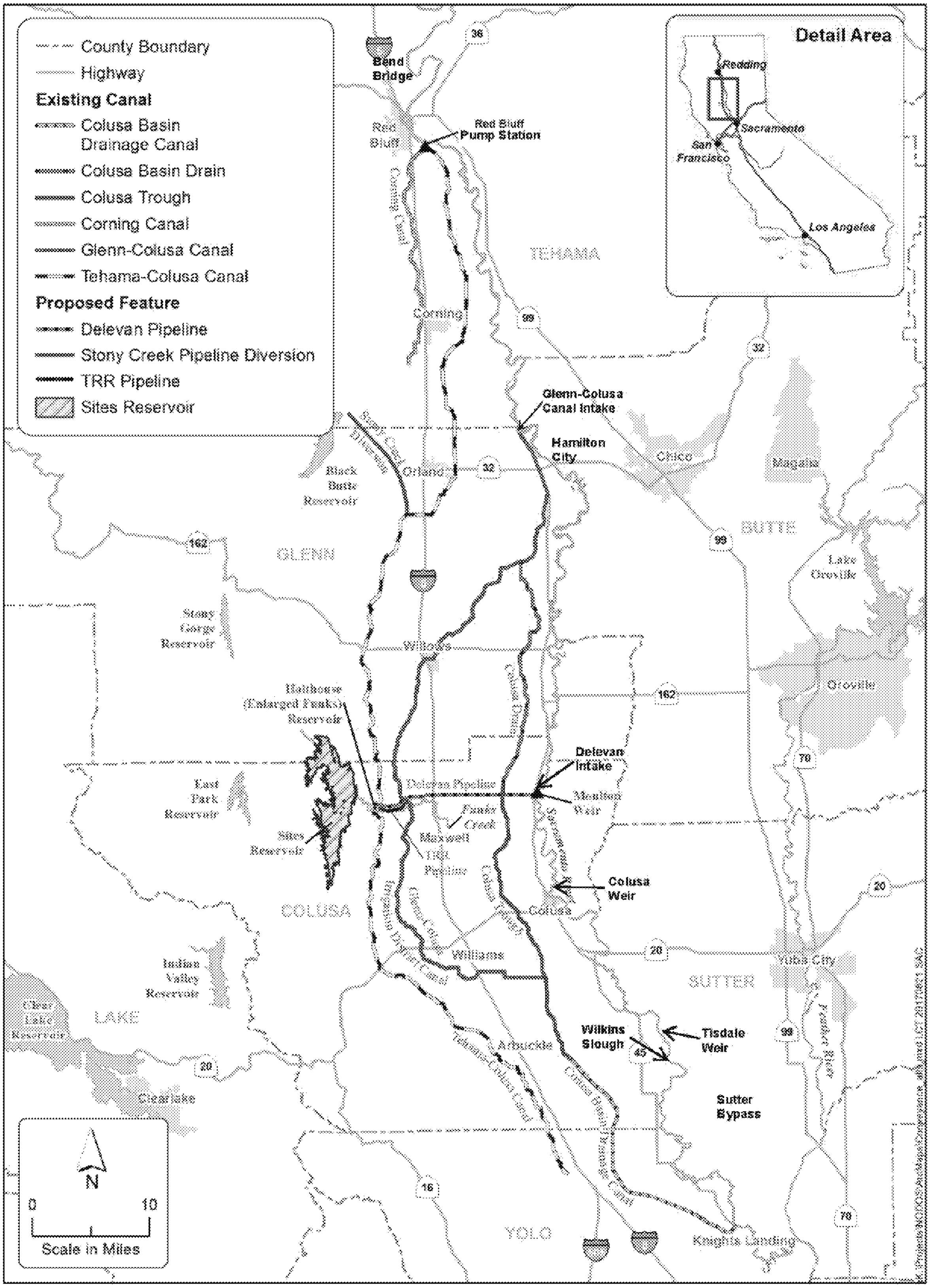


Figure 1. Sites Reservoir Project Facilities

Sites Project Authority – Sacramento River Intake Fish Screen Operations

Intake Facilities Overview

Table 1. Intake Facilities Overview

Sites Project Authority – Sacramento River Intake Fish Screen Operations

Intake Facility	Location	Screen Configuration	Fish Protection Screen Criteria	Screen Cleaning	Provisions for Fish Protection and Monitoring	Pumping Capability	Diversion Capacity	Operations
TCCA Red Bluff	River mile 244 near Red Bluff, CA.	• Flat plate screens in vertical configuration. • 60 screen bays with a total structure length of approximately 1,118 feet. • Effective screen height of 9.8 feet, from EL 235.83 to EL 245.67 (NAVD88).	• 1.75 mm slot size. • 0.33 fps approach velocity. • Sweeping velocity minimum 2x approach velocity.	• Four mechanical brush cleaners. • Sediment jetting system with one duty and one standby pump: 100 Hp rated at 3,500 gpm.	• Seven fish refuge bays, of which three are located at blowout panel openings. • Refuge bays include ¾-inch round bars with 1-inch clear openings. • Anchorages for fyke net frames located downstream of screen panels.	• Installed capacity of 2,000 cfs. – Pump Nos. 1 and 11: 300 Hp rated at 125 cfs. – Pump Nos. 3 through 9: 600 Hp rated at 250 cfs. • Future capacity of 2,500 cfs. – Future Pump Nos. 2 and 10: 600 Hp rated at 250 cfs. • All pumps are controllable with VFDs.	• Minimum is 80 cfs with all screen bays except 59 and 60 blocked off with solid panels, and maximum VFD turn-down on Pump Nos. 1 or 11. • Sites Reservoir maximum requirement is 2,100 cfs. • Maximum capacity of 2,500 cfs.	• Streamflows per USGS Gage 11377100 Sacramento River above Bend Bridge near Red Bluff, CA. • Existing minimum instream flow requirement of 3,250 cfs below intake for summer operations. • Red Bluff Diversion Dam located immediately downstream is operated with gates out.
GCID Hamilton City	River mile 206 near Hamilton City, CA.	• Flat plate screens in vertical configuration with 5 degree batter. • 87 screen bays with a total structure length of approximately 1,090 feet. • Original structure effective screen height of 11.5 feet, from EL 127.52 to EL 138.99 (NAVD88). • Extended structure effective screen height of 11.5 feet, from EL 126.72 to EL 138.19 (NAVD88).	• 1.75 mm slot size. • 0.33 fps approach velocity. • Sweeping velocity minimum 2x approach velocity.	• Eight mechanical brush cleaners.	• Three bypass bays with internal fish return system (not currently operated).	• Existing capacity of 3,000 cfs. - Pump Nos. 1 and 2: 206 Hp rated at 150 cfs and 10.3 feet TDH. - Pump Nos. 3 through 8: 550 Hp rated at 400 cfs and 10.3 feet TDH. - Pump No. 9: 270 Hp rated at 200 cfs and 10.3 feet TDH. - Pump No. 10: 135 Hp rated at 100 cfs and 10.3 feet TDH. • Diversion by gravity is available starting at an approximate intake afterbay WSEL of 136.0. Maximum gravity diversion rate is approximately 1,000 cfs with an intake afterbay WSEL > 145.0. • Deck at EL 154.8 is overtopped at streamflows greater than approximately 100,000 cfs.	• Minimum is 150 cfs. • Sites Reservoir maximum requirement is 1,800 cfs. • Maximum capacity is 3,000 cfs.	• Streamflows per USGS Gage 11383800 Sacramento River near Hamilton City, CA. • Existing minimum instream flow requirement of 4,000 cfs below intake for summer operations. • Average daily irrigation withdrawals from November 2012 through April 2018 were approximately 293 cfs. Monthly averages for this period were as follows: • November - 671 cfs • December - 336 cfs • January - 90 cfs • February - 51 cfs • March - 103 cfs • April - 513 cfs • Operated with Water Control Structure weir blocks removed.

Intake Facility	Location	Screen Configuration	Fish Protection Screen Criteria	Screen Cleaning	Provisions for Fish Protection and Monitoring	Pumping Capability	Diversion Capacity	Operations
Delevan (Proposed)	River mile 158.5 near Maxwell, CA.	• Flat plate screens in vertical configuration. • 32 screen bays with a total structure length of approximately 560 feet. • Effective screen height of 12.3 feet, from EL 38.33 to EL 50.67 (NGVD29).	• 1.75 mm slot size. • 0.33 fps approach velocity • Sweeping velocity minimum 2x approach velocity.	• Two mechanical brush cleaners. • Sediment jetting system.	• To be determined (TBD)	• Design capacity of 2,000 cfs. - Pump Nos. 1 through 4: rated at 500 cfs. - No VFDs are currently considered.	• Sites Reservoir maximum requirement is 2,000 cfs. • Minimum is 200 cfs (per AECOM). • Adjacent Maxwell ID intake and PS is 200 cfs.	• Streamflows per CA DWR Station BTC, Sacramento River at Butte City, CA. • Proposed minimum instream flow requirement of 5,000 cfs. • Proposed return flow requirement of 1,500 cfs; separate or combined facility TBD.

Methodology, Assumptions and Limitations

The following provides an overview of the methodology, assumptions and limitations associated with the estimates of available diversion capacity. Some information is common to all three intakes while other information is specific to TCCA Red Bluff, GCID Hamilton City or Delevan.

Common Attributes

Methodology

The analysis utilized the following general methodology at each intake facility location:

1. Identify appropriate Sacramento River streamflow data set, typically a U.S. Geological Survey (USGS) or California Department of Water Resources (CA DWR) stream gage.
2. Develop rating curve for correlating streamflow with water surface elevations (River stage) at the intake location.
3. Evaluate facility configuration and geometry to compare effective screen area with River stage.
4. Consider instream flow requirements, pump capability and other constraints.
5. Develop estimates of available diversion capacity versus streamflow, while maintaining approach velocities in accordance with fisheries design criteria (NMFS, 2018).

Assumptions

- Where river stage water surface elevation information is available at both the upstream and downstream ends of the intake facility, the water surface profile is averaged linearly across the face of the screeens.
- The intake screens are in a clean condition without significant accumulation of sediment and/or debris.
- Porosity controls provide balanced and uniform approach velocities through the intake screens.

Limitations

This memorandum provides high-level estimates of water availability at Project facilities and is intended to support water supply and operations modeling efforts. The estimates are based on recent historical streamflows, rating curves and pumping data. Actual withdrawal rates may be affected by a variety of factors including the following:

- Changing River morphology
- Ground subsidence
- Sediment and debris accumulation
- Non-uniform approach velocities
- Future winter irrigation demands
- Other proposed diversions not quantified herein
- Differing instream flow requirements
- Modifications to existing fisheries design guidelines and criteria

TCCA Red Bluff

Methodology

Historical streamflows for TCCA Red Bluff were obtained from USGS Gage 11377100 Sacramento River above Bend Bridge near Red Bluff, CA. The gage is located approximately 17 miles upstream of the site.

A composite rating curve was developed using data from the November 2009 Design Development Report (CH2M, 2009), including Appendix A, Table A-1 for the low end of rating curve (streamflow 0 cfs to 24,999 cfs), and Table A-2 for the high end of rating curve (streamflow 25,000 cfs and greater). This curve was used for the purposes of generating stage-frequency data based on the USGS data set.

Existing estimates of diversion capacity are available in the table "Project Diversion as a Function of River Stage" located in the conformed construction drawings (CH2M, 2009a), as well as another table (Table 2) located in the Design Development Report. The values in the drawing set utilized a slightly lower, more conservative diversion capacity for a given streamflow and were therefore used for the purposes of evaluating diversion capacity.

River stage values interior to the existing rating curve were interpolated at 0.1-foot WSEL intervals, and extended at the upstream and downstream work points as necessary. Diversion rates for the additional data points were then calculated assuming an approach velocity equal to the average approach velocity from existing data. This results in approach velocities that are approximately 3 percent lower than the criteria velocity of 0.33 fps. This was deemed reasonable and appropriately conservative for this type of analysis.

Assumptions

- Instream flow requirement of 3,250 cfs.
- The Red Bluff Diversion Dam located immediately downstream of the Intake is operated with the gates removed.
- The additional water demand associated with the sediment jetting system is intermittent and has negligible impact.
- The minimum diversion of 80 cfs occurs with all screen bays except 59 and 60 blocked off with solid panels, and maximum VFD turn-down on Pump Nos. 1 or 11.
- Future Pump Nos. 2 and 10 are installed.

Limitations

- Additional pumping capacity is required to meet Project objectives (future Pump Nos. 2 and 10).
- Several tributaries including Red Bank Creek and Elder Creek are located between the Bend Bridge gage and the Red Bluff Intake. The tributaries are understood to have substantial streamflows in winter, but such flows were not quantified as part of this analysis. This is assumed to conservatively under-estimate diversion capacity at the intake location.

GCID Hamilton City

Methodology

Historical streamflows for GCID Hamilton City were obtained from USGS Gage 11383800 Sacramento River near Hamilton City, CA. The gage is located approximately 5 miles downstream of the site. The streamflows were adjusted to a location just upstream of the oxbow by adding historical pumping rates from the GCID Main Pump Station. Daily shift records of pump discharge (typically three shifts per day) were averaged to develop average daily pump discharge rates. This information was then correlated and added to the average daily streamflow data.

Water surface elevations were obtained from historical data collected by GCID from 2011 through 2018 at the upstream end of the intake structure, "Screen 85;" the downstream end of the screen structure, "Bypass Channel;" and the intake structure afterbay/pump station forebay, "Forebay." The water surface profile at the face of the screens was linearly averaged between "Screen 85" and "Bypass Channel." Where data was missing, the average differential was assumed in order to facilitate calculation of the profile.

A large data gap in water surface elevation data exists between April 2015 and December 2017. The average differential was 0.63 feet before that time, and 1.01 feet after that time. The cause of the change is unknown, but could potentially be attributed to re-calibration of instruments, an increase in the headwater at the Gradient Structure, removal of a hydraulic constriction downstream, and/or some other contributing event. The removal of the weir blocks in the Water Control Structure were ruled out as a cause since this occurred circa 2006. The most recent average water differential value of 1.01 feet was assumed to be representative of current operations and was therefore utilized where necessary for the purposes of this diversion capacity analysis.

Operation of the GCID Main Pump Station impacts the water surface elevations (WSELs) at the screens, and the water surface profile along the screens for a given streamflow in the Sacramento River can vary with pump discharge. A higher pumped flowrate will result in a lower water surface profile through the oxbow as compared to the profile for a lower pumped flowrate – for the same streamflow. Therefore, a series of rating curves were developed for a range of pump station discharges and streamflows to account for the impact of drawdown on the water surface profile in the oxbow.

Table 2. GCID Hamilton City Rating Curves

Sites Project Authority – Sacramento River Intake Fish Screen Operations

Streamflow Above Oxbow (cfs)	Rating Curve Utilized
< 20,000	Low flow curve developed from data where Main Pump Station discharge is >2,500 cfs
20,000 to 30,000	Linear transition assumed between low and high flow curves (0.25 feet per 1,000 cfs)
> 30,000	High flow curve developed from data where Main Pump Station discharge is zero

The curves are based on empirical data and are intended to conservatively estimate water surface elevations in the oxbow over the range of operational conditions, particularly for low streamflows.

The rating curve was tabulated at 0.1-foot intervals (using the average WSEL at the screens) and estimates of available screen area were calculated. Separate calculations were made for the original intake screen structure and the fish screen extension (circa 2001), since the structures are not identical and have different geometry.

Existing estimates of diversion capacity are available in Table 1 of the Designer's Operating Criteria (USBR, 2010) and this information is plotted on the diversion capacity figure for reference. Diversion rates utilizing the developed rating curves were then calculated for both portions of the intake structure assuming an approach velocity of 0.33 fps.

Assumptions

- No other significant diversions or inflows are assumed to occur between the intake facility and the gage location. Therefore, the summation of the Main Pump Station discharge and gage streamflow is assumed to be representative of the Sacramento River streamflow immediately upstream of the oxbow.
- Instream flow requirement of 4,000 cfs.
- Minimum diversion of 150 cfs in accordance with pump capability.
- The bypass bays and internal fish return system are not operated.
- The Water Control Structure weir blocks were removed circa 2006 and are no longer utilized.
- November through April irrigation withdrawals are typically less than approximately 1,200 cfs.

Limitations

- A significant change in average water surface differential across the screens is evident in data before and after the April 2015 to December 2017 time period. This discontinuity is unexplained and associated impacts to diversion capacity are currently unknown.

- It is understood that gravity flow is possible starting at an afterbay WSEL of approximately 136.0 (streamflow of approximately 5,500 cfs). A review of the available data set indicates that there may be periods when gravity flow is possible (and probable), but the pumped flow is reported as zero. These periods typically occur at streamflows greater than approximately 20,000 cfs. Therefore, the rating curve for streamflows above approximately 20,000 cfs may slightly under-estimate available diversion capacity for certain conditions.

Delevan

Methodology

Historical streamflows were obtained from CA DWR Station BTC, Sacramento River at Butte City, CA. The gage is approximately 10 miles upstream of the site.

The rating curve (Figure 6) from the North of Delta Offstream Storage (NODOS) Sacramento River Fish Screen Facility Feasibility Study (CH2M, 2008) was utilized to inform this analysis. This curve was developed via analysis of existing ratings at the Butte City gage and USGS gage 11389500 Sacramento River at Colusa. The curve includes a River stage of 52.0 feet (NGVD29) at a streamflow of 6,000 cfs. A supporting field measurement of 53.5 feet at 6,212 cfs suggests that the actual stage may be even higher. However, a subsequent analysis by the California Department of Water Resources (CA DWR) recommended that a conservative value of 51.0 feet be used at 6,000 cfs for the purposes of the Feasibility Study.

For the diversion capacity analysis, the curve was adjusted in accordance with the 51.0-foot constraint, and linear interpolation was used to complete interior portions of the curve. River stage values for diversion capacities ranging from 0 cfs to 2,000 cfs were interpolated at 1-foot WSEL intervals.

Assumptions

- Streamflows were not adjusted to account for reach gains or losses (likely negligible) between the gage and intake facility.
- Instream flow requirement of 5,000 cfs.
- Minimum diversion of 200 cfs in accordance with proposed pump capability.

Limitations

- The design low WSEL for the fish screens of 51.0 feet at 6,000 cfs streamflow identified by CA DWR varies from the Figure 6 rating curve (AECOM, 2018 and CH2M, 2008) and measurements taken in the field. It appears that this elevation is conservatively low, and could be refined (raised) during future design. This may result in a slightly shorter intake structure with a reduced footprint.

- Additional water surface elevation measurements were identified in as a potential method to be taken to develop a more detailed rating curve for final design (CH2M, 2008).

- The proposed intake facility may also be required to operate as a flow release / discharge structure under certain scenarios. This analysis does not include consideration of specific fisheries criteria (i.e., exclusion barrier criteria) that would be required to accommodate this mode of operation.

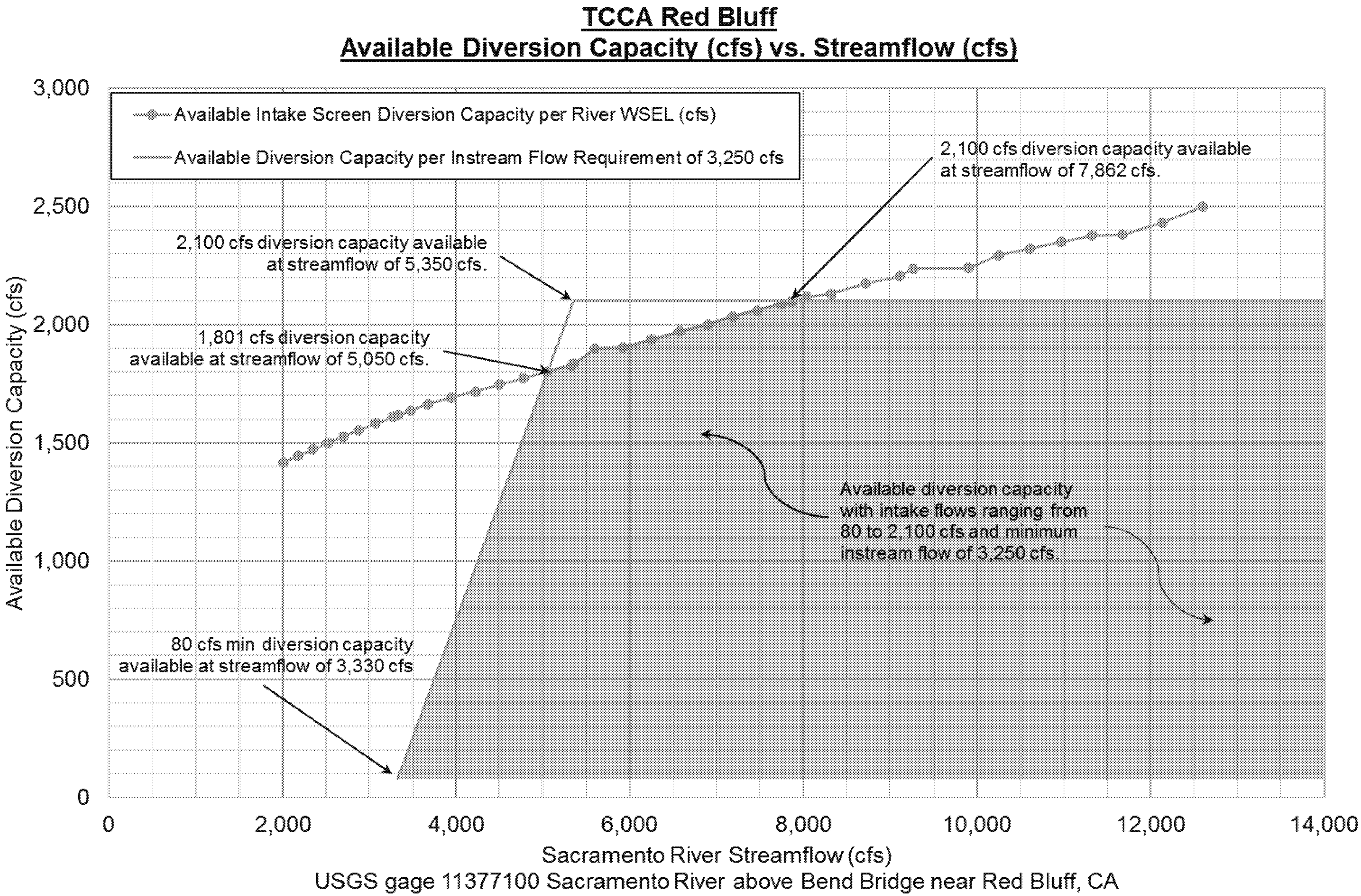
TCCA Red Bluff Facility Operations

Table 3. TCCA Red Bluff Available Diversion Capacity by Streamflow
Sites Project Authority – Sacramento River Intake Fish Screen Operations

Streamflow at Gage (cfs)	River WSEL at U/S Work Point (feet, NAVD88)	Available Facility Diversion Capacity (cfs)
2,010	241.2	1,417
2,175	241.3	1,445
2,350	241.4	1,472
2,525	241.5	1,500
2,700	241.6	1,527
2,875	241.7	1,554
3,075	241.8	1,582
3,275	241.9	1,609
3,330	241.9	1,617
3,475	242.0	1,637
3,675	242.1	1,664
3,950	242.2	1,692
4,225	242.3	1,719
4,500	242.4	1,746
4,775	242.5	1,774
5,050	242.6	1,801
5,325	242.7	1,829
5,350	242.7	1,835
5,600	242.9	1,900
5,925	243.1	1,904
6,250	243.2	1,938
6,575	243.4	1,973
6,900	243.5	2,000
7,184	243.6	2,034
7,468	243.7	2,062
7,751	243.8	2,089
7,862	243.8	2,100
8,035	243.9	2,117
8,319	244.0	2,130

8,714	244.1	2,175
9,109	244.3	2,206
9,266	244.4	2,237
9,898	244.5	2,240
10,254	244.6	2,295
10,610	244.7	2,322
10,965	244.8	2,350
11,321	244.9	2,377
11,677	245.0	2,380
12,139	245.1	2,432
12,600	245.2	2,500

░	Diversions limited by instream flow requirement of 3,250 cfs
▒	Diversions limited by River WSEL and submerged screen area
▓	No restrictions (assumes use of future Pump Nos. 2 and 10)


TCCA Red Bluff
Available Diversion Capacity (cfs) vs. Streamflow (cfs)
Available Intake Screen Diversion Capacity per River WSEL (cfs)
Available Diversion Capacity per Instream Flow Requirement of 3,250 cfs
2,100 cfs diversion capacity available at streamflow of 7,862 cfs.
2,100 cfs diversion capacity available at streamflow of 5,350 cfs.
1,801 cfs diversion capacity available at streamflow of 5,050 cfs.
Available diversion capacity with intake flows ranging from 80 to 2,100 cfs and minimum instream flow of 3,250 cfs.
80 cfs min diversion capacity available at streamflow of 3,330 cfs
Available Diversion Capacity (cfs)
3,000
2,500
2,000
1,500
1,000
500
0
0
2,000
4,000
6,000
8,000
10,000
12,000
14,000
Sacramento River Streamflow (cfs)
USGS gage 11377100 Sacramento River above Bend Bridge near Red Bluff, CA

GCID Hamilton City Facility Operations

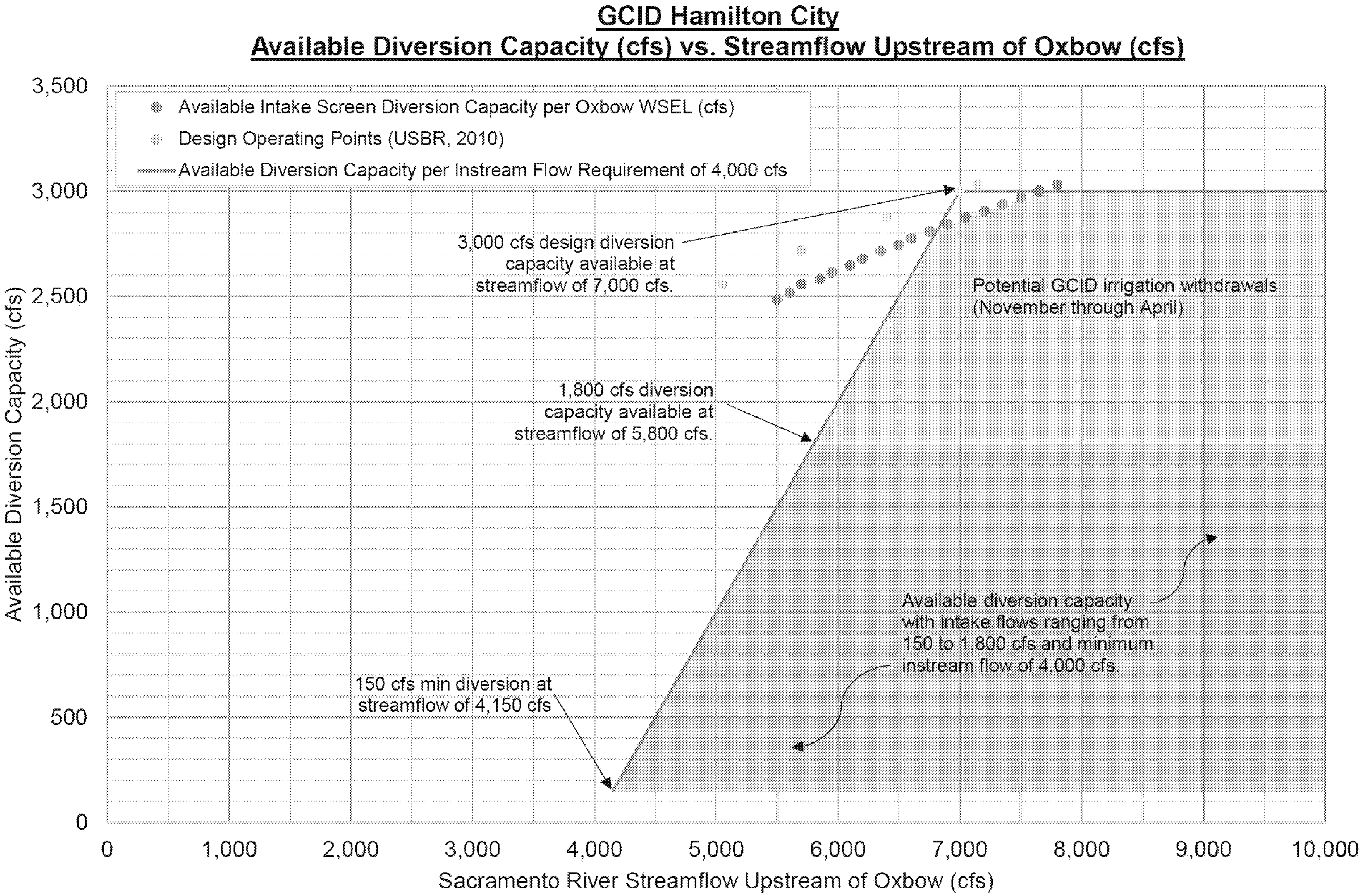
Table 4. GCID Hamilton City Available Diversion Capacity by Streamflow

Sites Project Authority – Sacramento River Intake Fish Screen Operations

Streamflow Upstream of Oxbow (cfs)	River WSEL at U/S Oxbow (feet, NGVD29)	Available Facility Diversion Capacity (cfs)
900	132.5	1,744
938	132.6	1,777
977	132.7	1,809
1,018	132.8	1,841
1,061	132.9	1,873
1,105	133.0	1,906
1,151	133.1	1,938
1,200	133.2	1,970
1,250	133.3	2,002
2,690	133.4	2,035
2,765	133.5	2,067
2,842	133.6	2,099
2,921	133.7	2,131
3,002	133.8	2,164
3,086	133.9	2,196
3,172	134.0	2,228
3,260	134.1	2,260
3,351	134.2	2,292
3,445	134.3	2,325
3,541	134.4	2,357
3,639	134.5	2,389
3,741	134.6	2,421
3,845	134.7	2,454
3,952	134.8	2,486
4,062	134.9	2,518
4,176	135.0	2,559
4,292	135.1	2,583
4,412	135.2	2,615
4,534	135.3	2,647
4,661	135.4	2,679

4,791	135.5	2,717
4,924	135.6	2,744
5,061	135.7	2,776
5,203	135.8	2,808
5,348	135.9	2,841
5,497	136.0 (begin possible gravity diversion)	2,874
5,650	136.1	2,905
5,807	136.2	2,937
5,969	136.3	2,969
6,135	136.4	3,002
6,306	136.5	3,031

░	Diversions limited by instream flow requirement of 4,000 cfs
▓	No restrictions, assuming GCID irrigation withdrawals are less than approximately 1,000 cfs


GCID Hamilton City
Available Diversion Capacity (cfs) vs. Streamflow Upstream of Oxbow (cfs)
Available Intake Screen Diversion Capacity per Oxbow WSEL (cfs)
Design Operating Points (USBR, 2010)
Available Diversion Capacity per Instream Flow Requirement of 4,000 cfs
3,000 cfs design diversion capacity available at streamflow of 7,000 cfs.
Potential GCID irrigation withdrawals (November through April)
1,800 cfs diversion capacity available at streamflow of 5,800 cfs.
Available diversion capacity with intake flows ranging from 150 to 1,800 cfs and minimum instream flow of 4,000 cfs.
150 cfs min diversion at streamflow of 4,150 cfs
Available Diversion Capacity (cfs)
3,500
3,000
2,500
2,000
1,500
1,000
500
0
0
1,000
2,000
3,000
4,000
5,000
6,000
7,000
8,000
9,000
10,000
Sacramento River Streamflow Upstream of Oxbow (cfs)

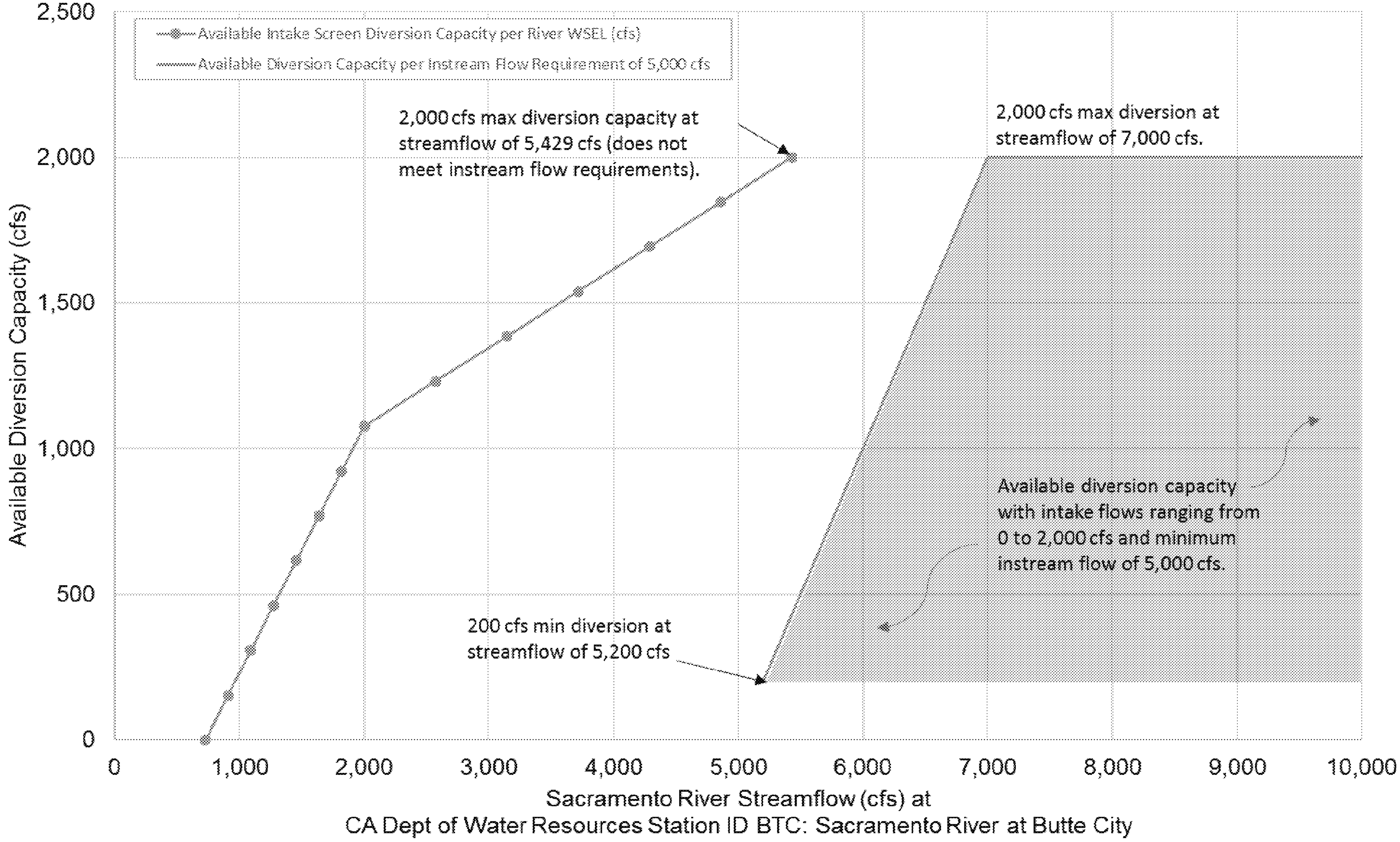
Delevan Facility Operations

Table 5. Delevan Available Diversion Capacity by Streamflow

Sites Project Authority – Sacramento River Intake Fish Screen Operations

Streamflow at Gage (cfs)	River WSEL at Fish Screens (feet, NGVD29)	Available Facility Diversion Capacity (cfs)
727	38.0	0
909	39.0	154
1,091	40.0	308
1,273	41.0	462
1,455	42.0	615
1,636	43.0	769
1,818	44.0	923
2,000	45.0	1,077
2,571	46.0	1,231
3,143	47.0	1,385
3,714	48.0	1,538
4,286	49.0	1,692
4,857	50.0	1,846
5,429	51.0	2,000

Delevan
Streamflow (cfs) vs. Available Diversion Capacity (cfs)



References

Table 6. References.
Sites Project Authority – Sacramento River Intake Fish Screen Operations

Intake Site	Document Number	Document Title	Description and Use
Common to All Three Intakes	1	CH2M. 2017. *Sites Reservoir Project Preliminary Operations Plan Under a Range of Hydrologic Conditions.* August.	Project operations.
	2	NMFS. 2018. National Oceanic and Atmospheric Administration (NOAA) Fisheries *West Coast Region Anadromous Salmonid Passage Design Guidelines, Peer Review Draft*. 16 August.	Fisheries design guidelines and criteria.
	3	URS Group, Inc. 2018. *North-of-the-Delta Offstream Storage Investigation Final Feasibility Study.* Prepared for the U.S. Bureau of Reclamation (USBR), Mid-Pacific Region. 18 October.	Project configuration and operations.
	4	USBR. 2009. Water Resources Technical Publication. *Guidelines for Performing Hydraulic Field Evaluations at Fish Screening Facilities.* Denver, Colorado. April.	Fish screen hydraulics.
Red Bluff	5	USGS Gage 11377100 Sacramento River above Bend Bridge near Red Bluff, CA.	Streamflow data. https://waterdata.usgs.gov/nwis/uv?site_no=11377100

Red Bluff	6	CH2M. 2009. *Design Development Report, Fish Passage Improvement Project at the Red Bluff Diversion Dam.* Prepared for the Tehama-Colusa Canal Authority and the USBR. November.	Rating Curve: • Appendix A, Table A-1 used to generate low end of rating curve, up to 24,999 cfs • Appendix A, Table A-2 used to generate high end of rating curve, 25,000 cfs and greater Diversion Capacity: • Table 2 provides design capacity at low River streamflow/stage conditions to maintain the maximum 0.33 fps approach velocity; however, this information was not used for purposes of this analysis. Capacity values from a similar table on the construction drawings were used instead since they were deemed to be more conservative (see below).
	7	CH2M. 2009a. *Conformed Construction Drawings for the Red Bluff Pumping Plant and Fish Screen.* Four volumes. Prepared for the Tehama-Colusa Canal Authority and the USBR. 29 October.	Diversion Capacity: • Volume 1, Drawing 602-D-4308, Table “Project Diversion as a Function of River Stage.” Provides design capacity at low River streamflow/stage conditions to maintain the maximum 0.33 fps approach velocity (used for this analysis). • Volume 2, various drawings including Drawing 602-D-4390, “Typical Bay Section.” Section of fish screen used to confirm design capacity for diversion at various water levels.
	8	USBR. 2018. *Tehama-Colusa Canal Authority Red Bluff Pumping Plant Post-Construction Fish Screen Hydraulic Evaluation.* March.	Post-construction hydraulic monitoring and evaluation.

GCID Hamilton City	9	Ayres Associates. 1995. *Riverbed Gradient Restoration Structures for the Sacramento River at the Glenn-Colusa Irrigation District Intake, California.* Prepared for the U.S. Army Corps of Engineers (USACE) Sacramento District. 10 July.	Hydraulic analysis of riverbed gradient structure alternatives.
	10	Ayres Associates. 1999. *Gradient Facility Project Report.* Prepared for USACE Sacramento District. June.	Design development of riverbed gradient structure.
	11	Ayres Associates. 2002. *Sacramento River Gradient Facility Post-Construction Evaluation Draft Report.* Prepared for USACE Sacramento District. July	Post construction monitoring and evaluation of riverbed gradient structure.
	12	CA DWR Station ID: HMC, Sacramento River at Hamilton City, CA	Streamflow data. http://cdec.water.ca.gov/dynamicapp/staMeta?station_id=hmc
	13	CH2M. 1985. *Plans for the Construction of Main Pump Station.* Prepared for Glenn-Colusa Irrigation District (GCID).	Record drawings of GCID Main Pump Station.
	14	CH2M. 1993. *Modifications to the CDF&G Fish Screens at the GCID Diversion.* Prepared for GCID. February.	Drawings for installation of screen cleaners and fish bypass. Used in conjunction with original drawings (USBR, 2007) to confirm design capacity for diversion at various water levels while maintaining maximum approach velocity of 0.33 fps.
	15	CH2M. 2008. *Glenn-Colusa Irrigation District Fish Protection Evaluation and Monitoring Program.* Prepared for GCID. January.	Hydraulic monitoring and evaluation.
	16	GCID operational flows and WSEL data.	Historical operations data collected by GCID from January 2011 through December 2018. Provided in numerous Excel files, compiled and processed by Jacobs for this evaluation. Includes Main Pump Station discharge and WSELs for the River, Oxbow (Screen 85), Bypass and Afterbay.
	17	GCID Main Pump Station Data	Pump specifications and pump curves.

GCID Hamilton City	18	McMillen, LLC. 2013. *Glenn-Colusa Irrigation District Gradient Facility, Sacramento River, CA, Water Data Collection Technical Memorandum.* Prepared for USACE Sacramento District. 21 June.	Water surface elevation data.
	19	USBR. 2010. *Designer's Operating Criteria for Hamilton City Pumping Plant Fish Screen Structure and Downstream Channel Structures.* Prepared for GGCID, California. Technical Service Center, Denver, Colorado. 26 January.	Diversion Capacity: • Table 1 summarizes design capacity for diversion at low river flow conditions to maintain maximum 0.33 fps approach velocity. Note that this table does not contain associated stage information, which was based on the low flow rating curve. • Provides minimum WSEL for full pumped flow of 3,000 cfs (El. 136.5 upstream of the weir)
	20	USBR. 1997. *Drawings for Specification No. 20-C0476.* Fish Screen Structure Extension, Fish Screen Structure Improvement Project, Glenn-Colusa Irrigation District, Central Valley Project Improvement Act. 21 October.	Volume III, various drawings including Drawing 602-D-4095 "Fish Screen Structure Sections." Sections used to confirm design capacity for diversion at various water levels while maintaining maximum approach velocity of 0.33 fps.
Delevan	21	AECOM. Delevan Intake Pumping-Generating Plant and Fish Screen Structure, Site Plan, Authority Project Alternative - D. Prepared for Sites Project Authority. 2018.	Intake and fish screen general arrangement drawing.
	22	CA DWR Station ID: BTC, Sacramento River at Butte City, CA	Streamflow data. http://cdec.water.ca.gov/dynamicapp/staMeta?station_id=btc
	23	CH2M. 2008. *North-of-Delta Offstream Storage – Sacramento River Fish Screen Facility Feasibility Study.* Prepared for California Department of Water Resources. June.	Rating Curve: • Figure 6 rating curve used to generate stage data at the intake based on streamflow. Diversion Capacity: • Fish screen drawings used to confirm design capacity for diversion at various water levels while maintaining maximum approach velocity of 0.33 fps.

Attachments

1 – TCCA Red Bluff

- November through April flow-duration curve
- Monthly flow-duration curves
- Annual stage-frequency curve
- November through April stage-frequency curve
- Monthly stage-frequency curves

2 – GCID Hamilton City

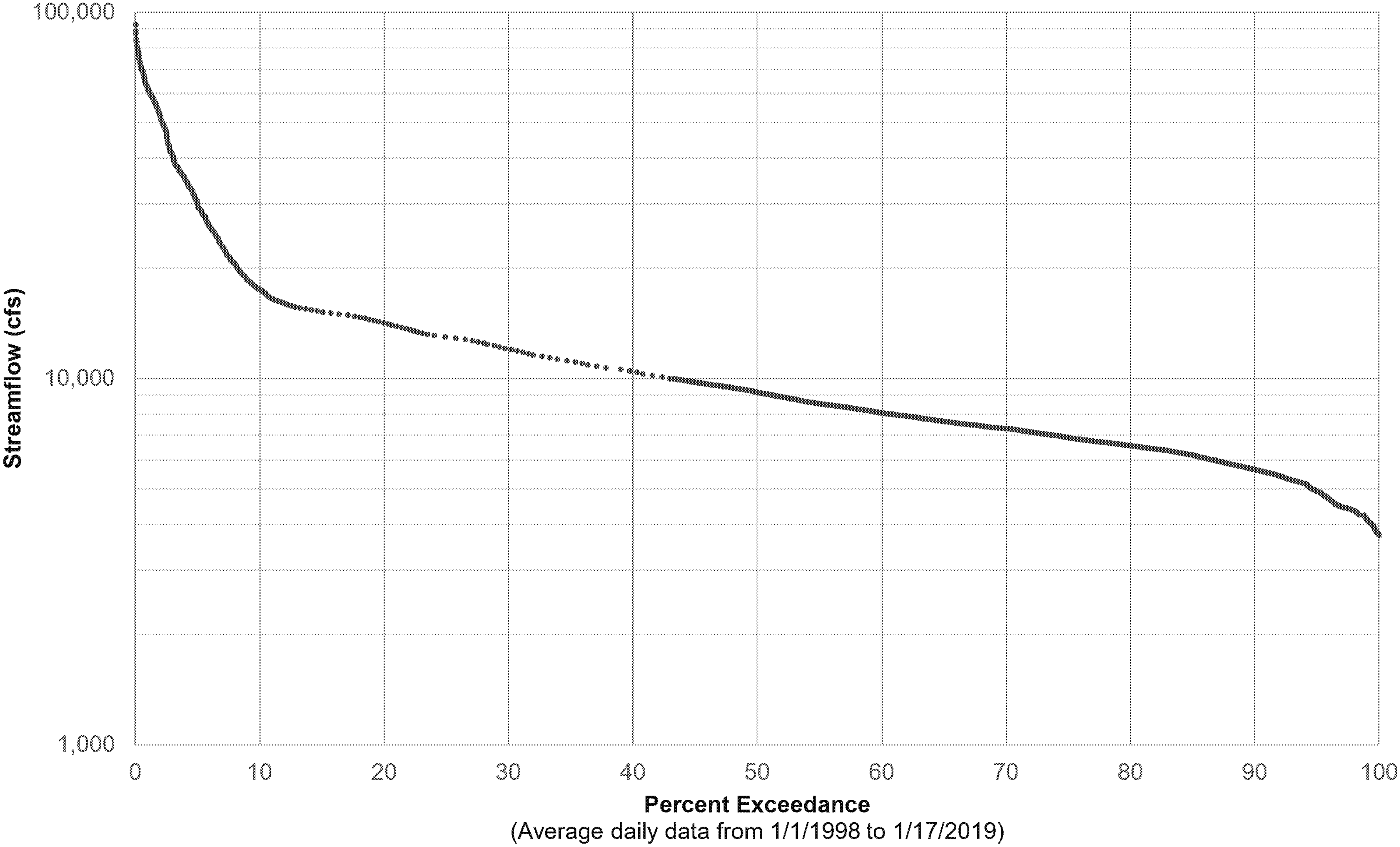
- Annual flow-duration curve
- November through April flow-duration curve
- Monthly flow-duration curves
- Annual stage-frequency curve
- November through April stage-frequency curve
- Monthly stage-frequency curves

3 – Delevan

- Annual flow-duration curve
- November through April flow-duration curve
- Monthly flow-duration curves
- Annual stage-frequency curve
- November through April stage-frequency curve
- Monthly stage-frequency curves

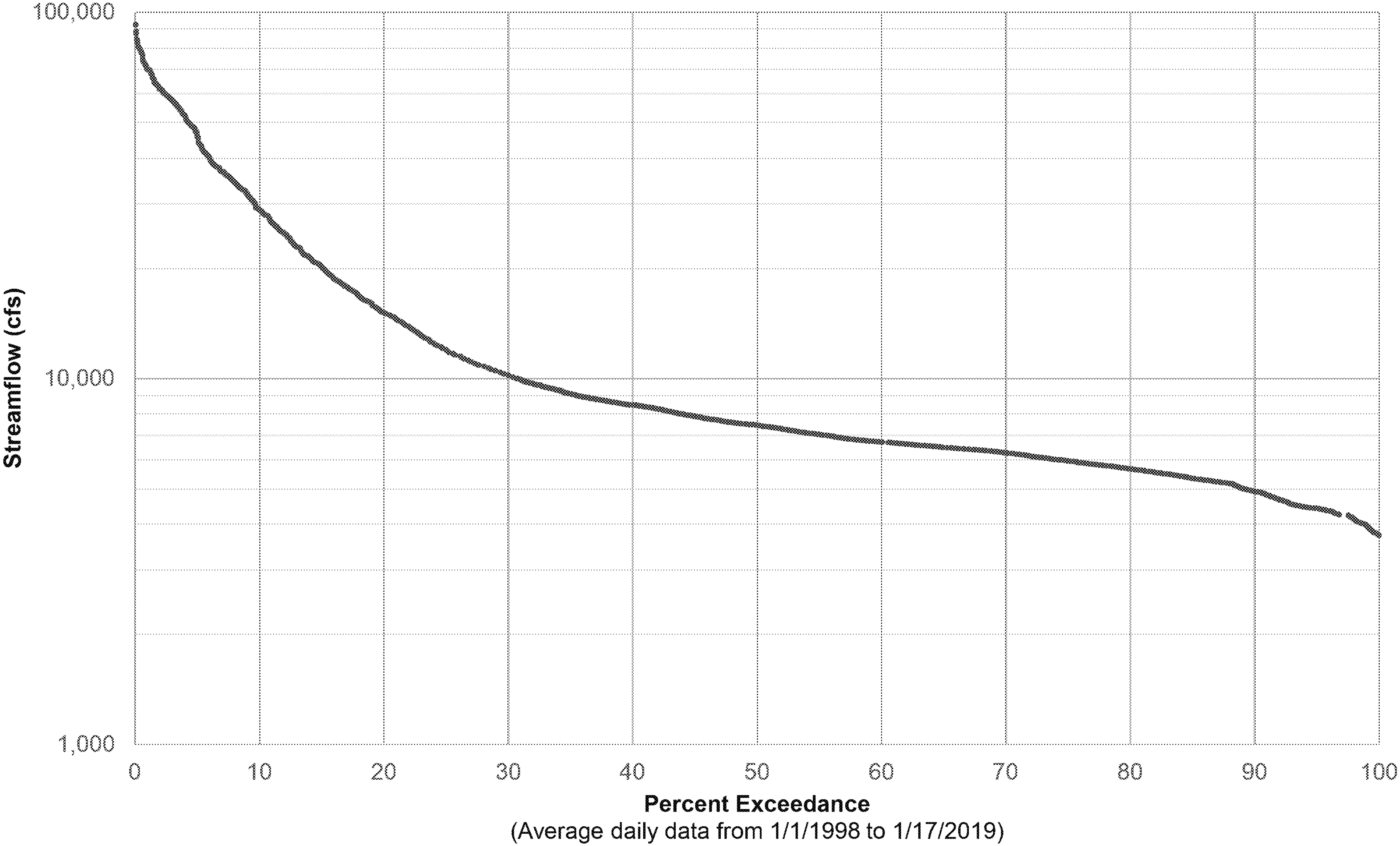
Attachment 1 – TCCA Red Bluff

Flow-Duration Curve - Annual
USGS 11377100 Sacramento River above Bend Bridge near Red Bluff, CA



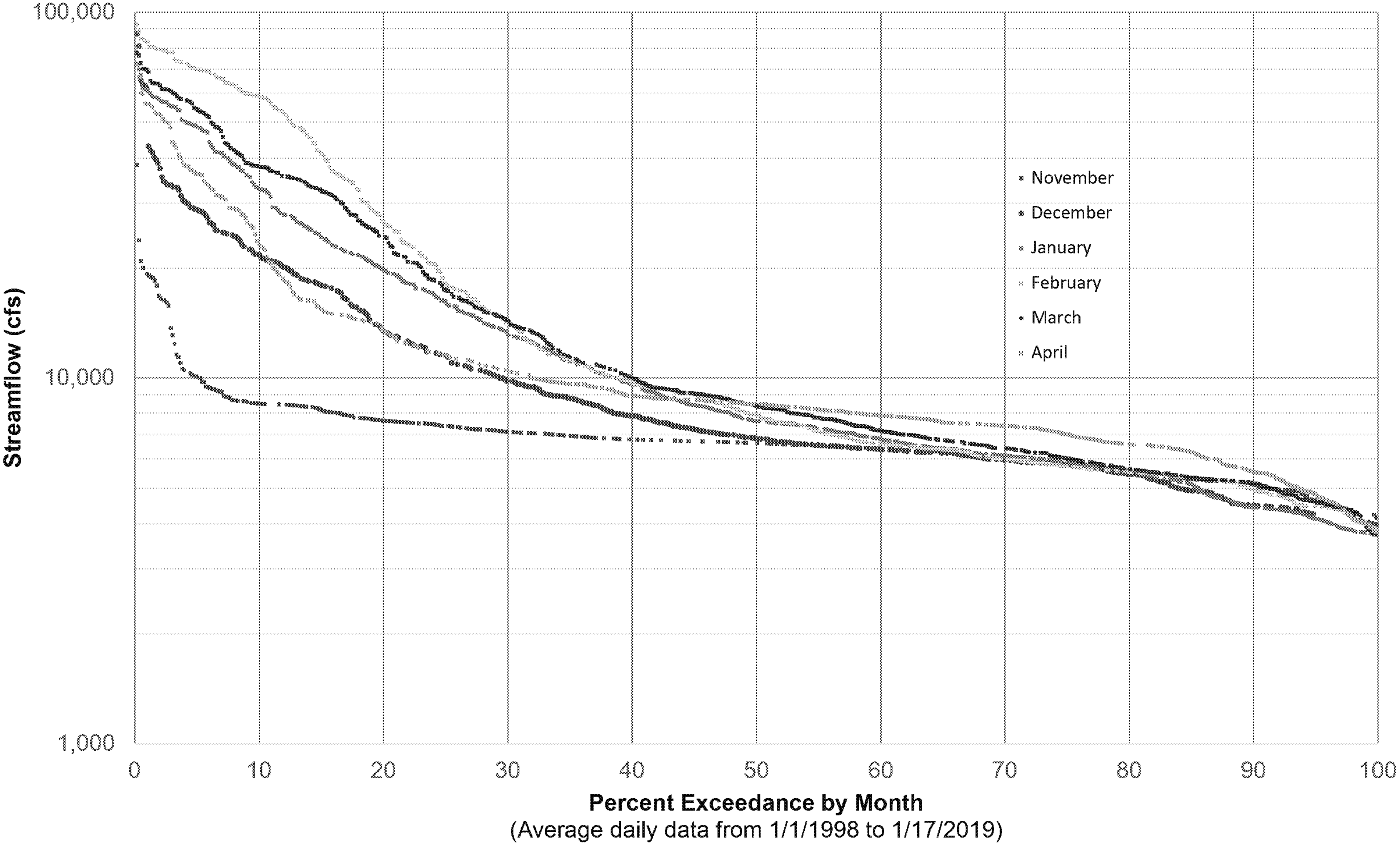
3/25/2020

Flow-Duration Curve - November-April
USGS 11377100 Sacramento River above Bend Bridge near Red Bluff, CA



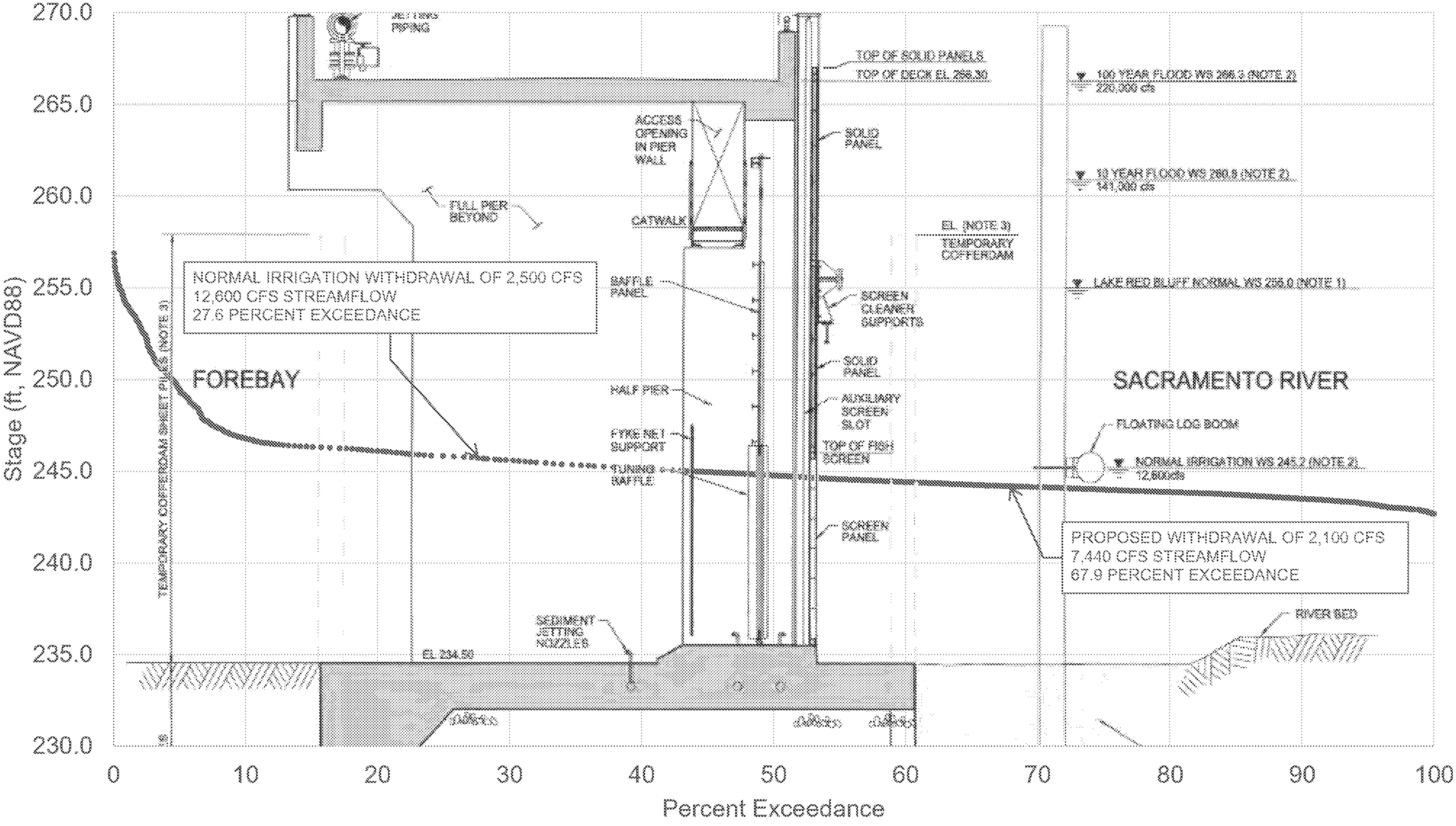
11/14/2019

Monthly Flow-Duration Curves - November-April
USGS 11377100 Sacramento River above Bend Bridge near Red Bluff, CA



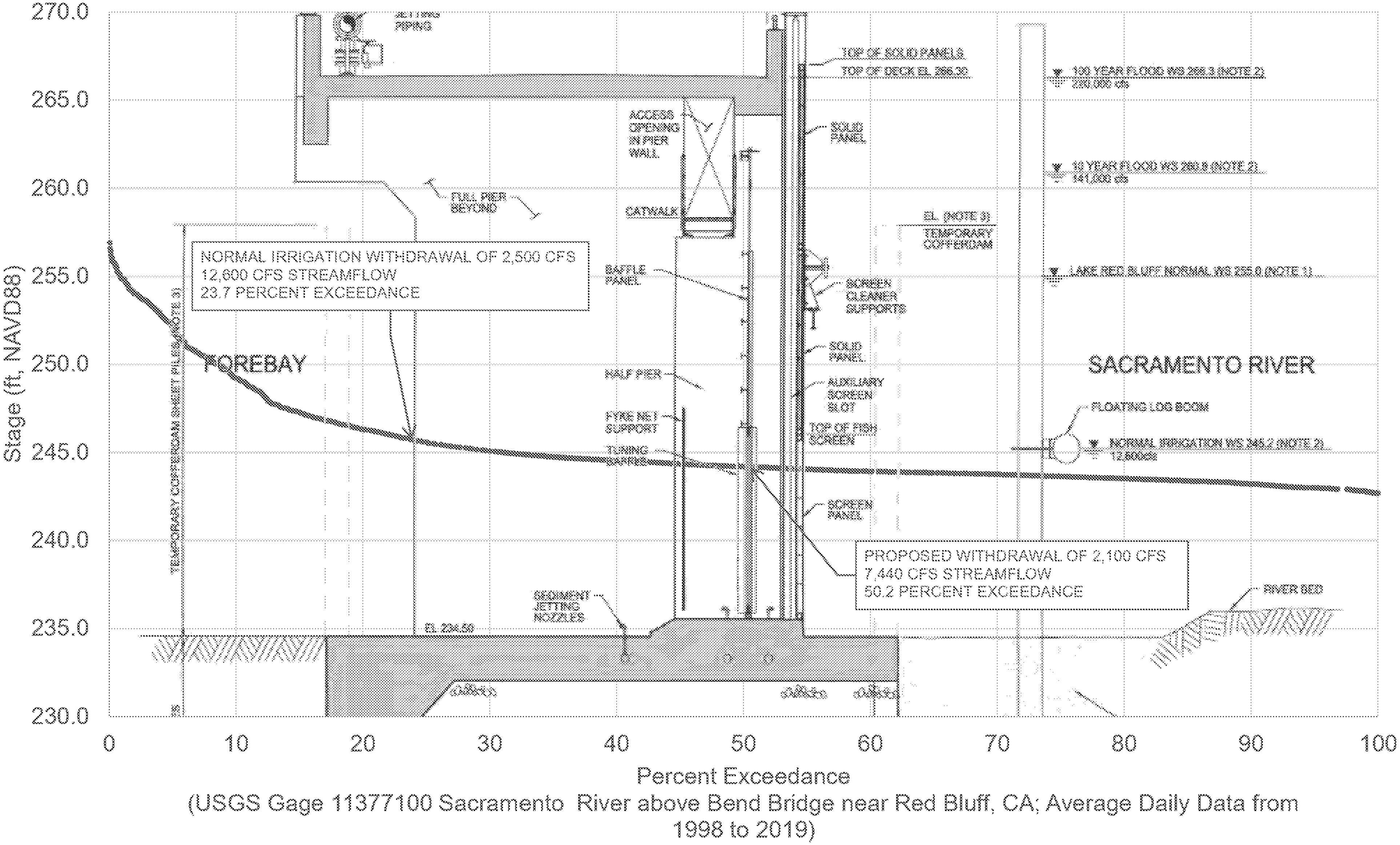
11/14/2019

Stage Frequency Curve - Annual
Sacramento River at Red Bluff Diversion Dam (U/S Work Point)

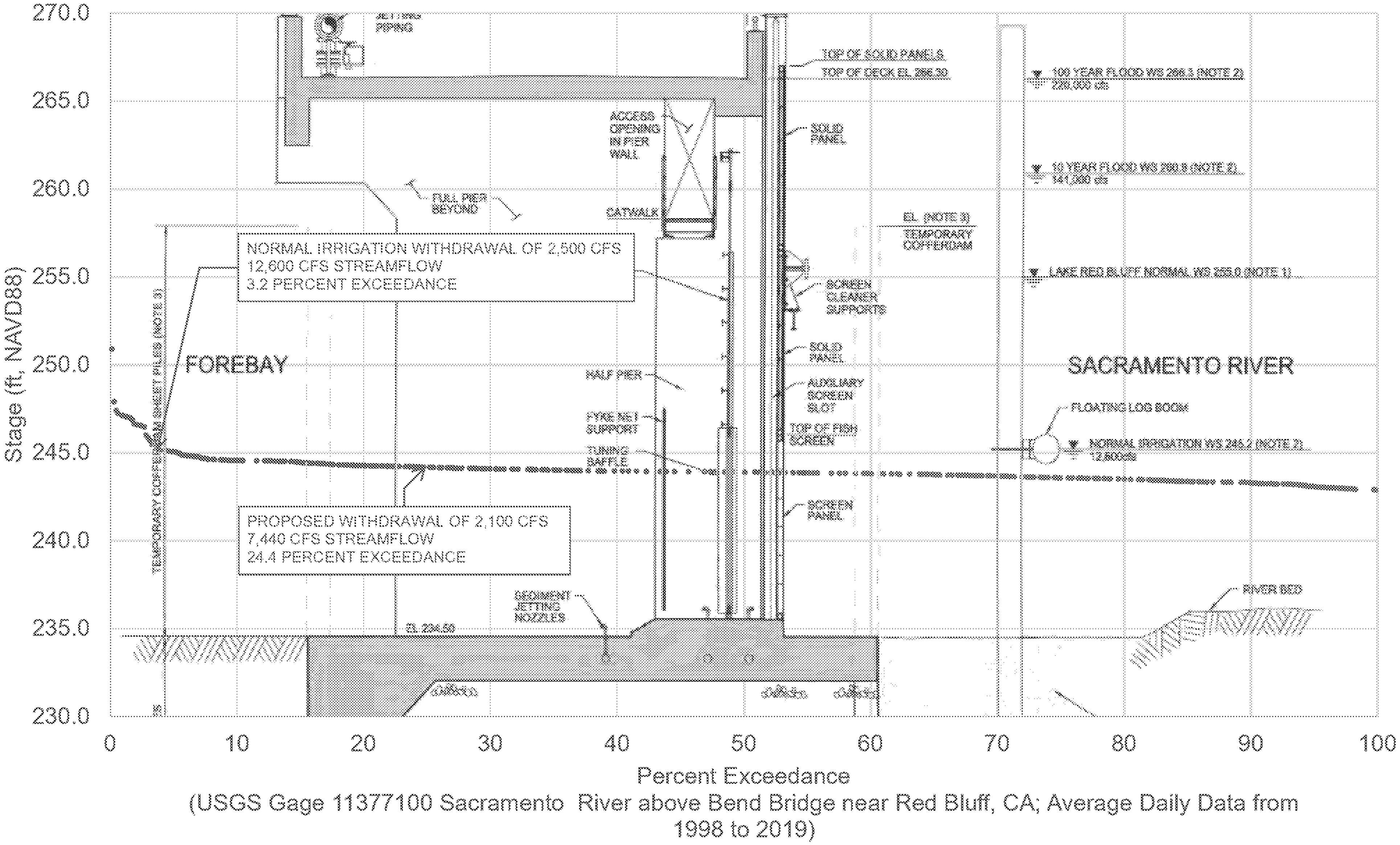


(USGS Gage 11377100 Sacramento River above Bend Bridge near Red Bluff, CA; Average Daily Data from 1998 to January 2019)

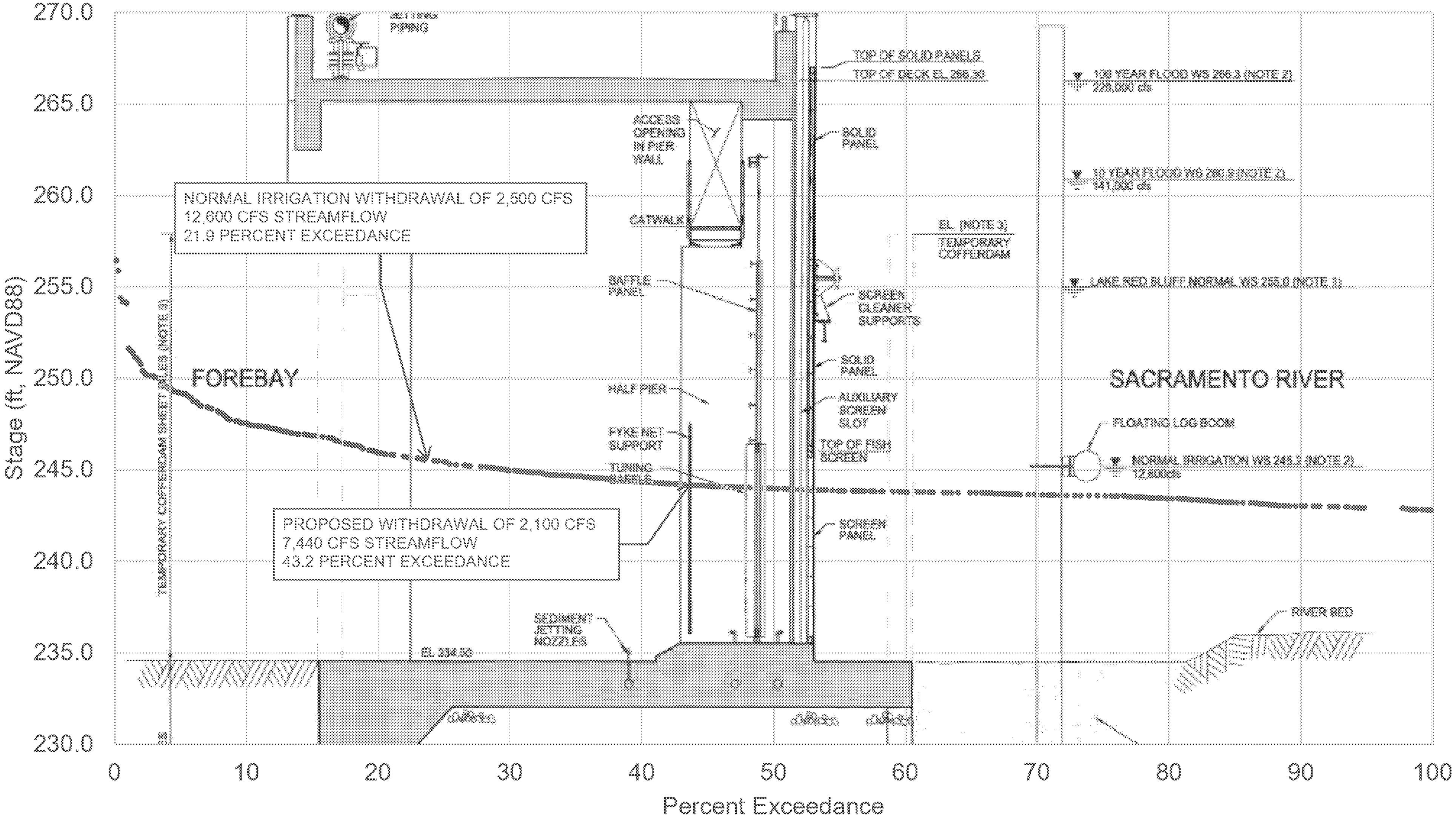
Stage Frequency Curve - November-April
Sacramento River at Red Bluff Diversion Dam (U/S Work Point)



Stage Frequency Curve - November
Sacramento River at Red Bluff Diversion Dam (U/S Work Point)

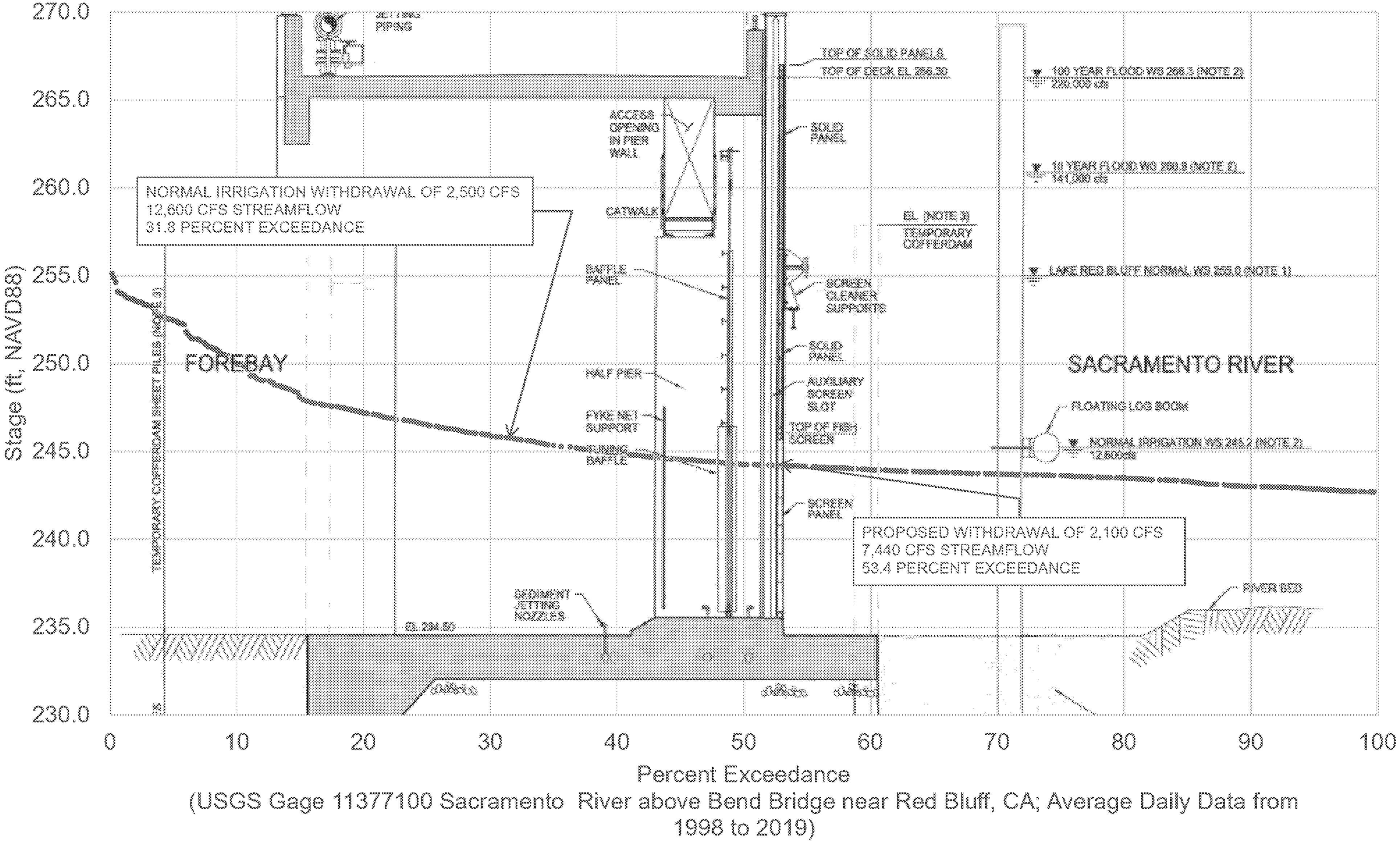


Stage Frequency Curve - December
Sacramento River at Red Bluff Diversion Dam (U/S Work Point)

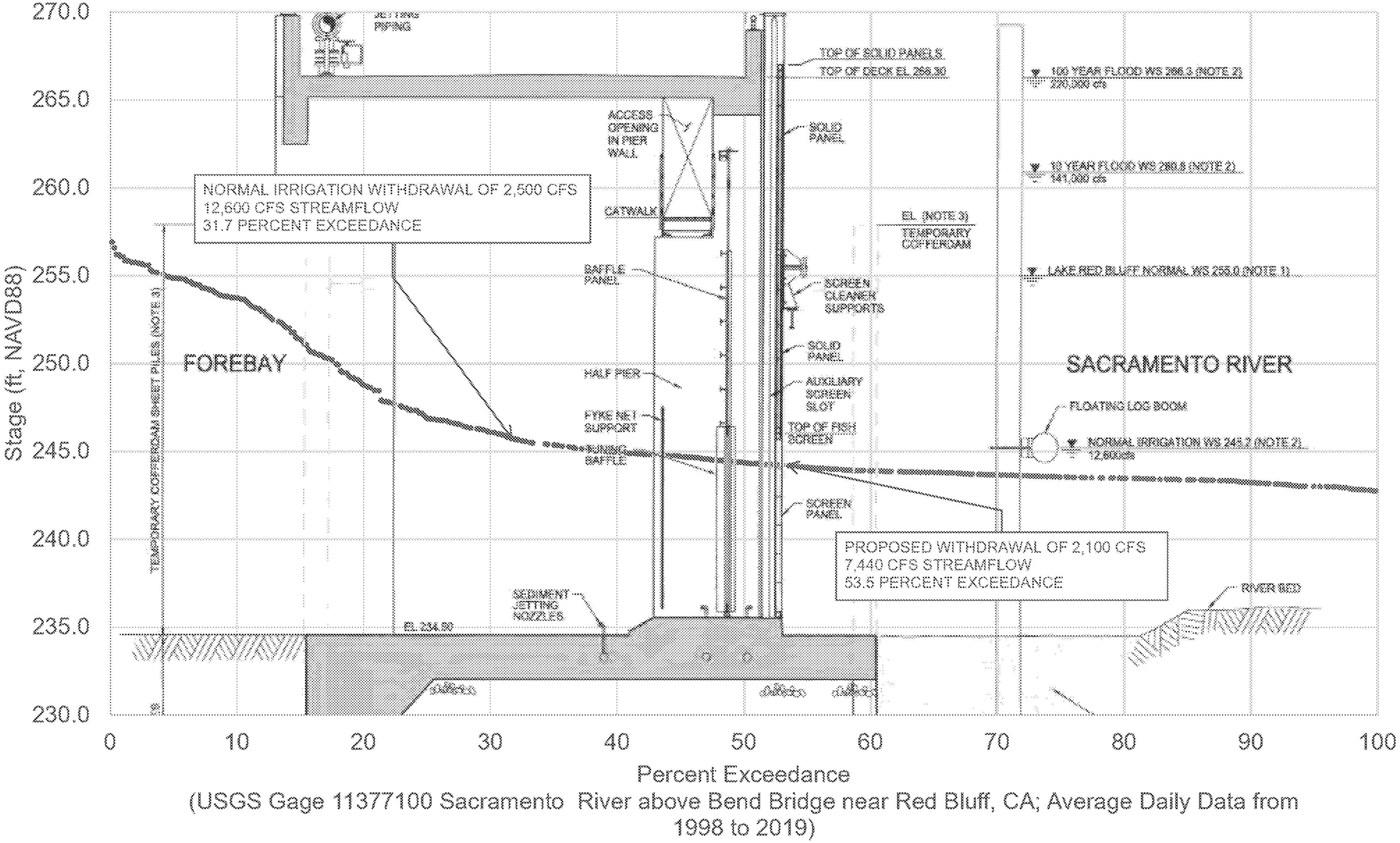


(USGS Gage 11377100 Sacramento River above Bend Bridge near Red Bluff, CA; Average Daily Data from 1998 to 2019)

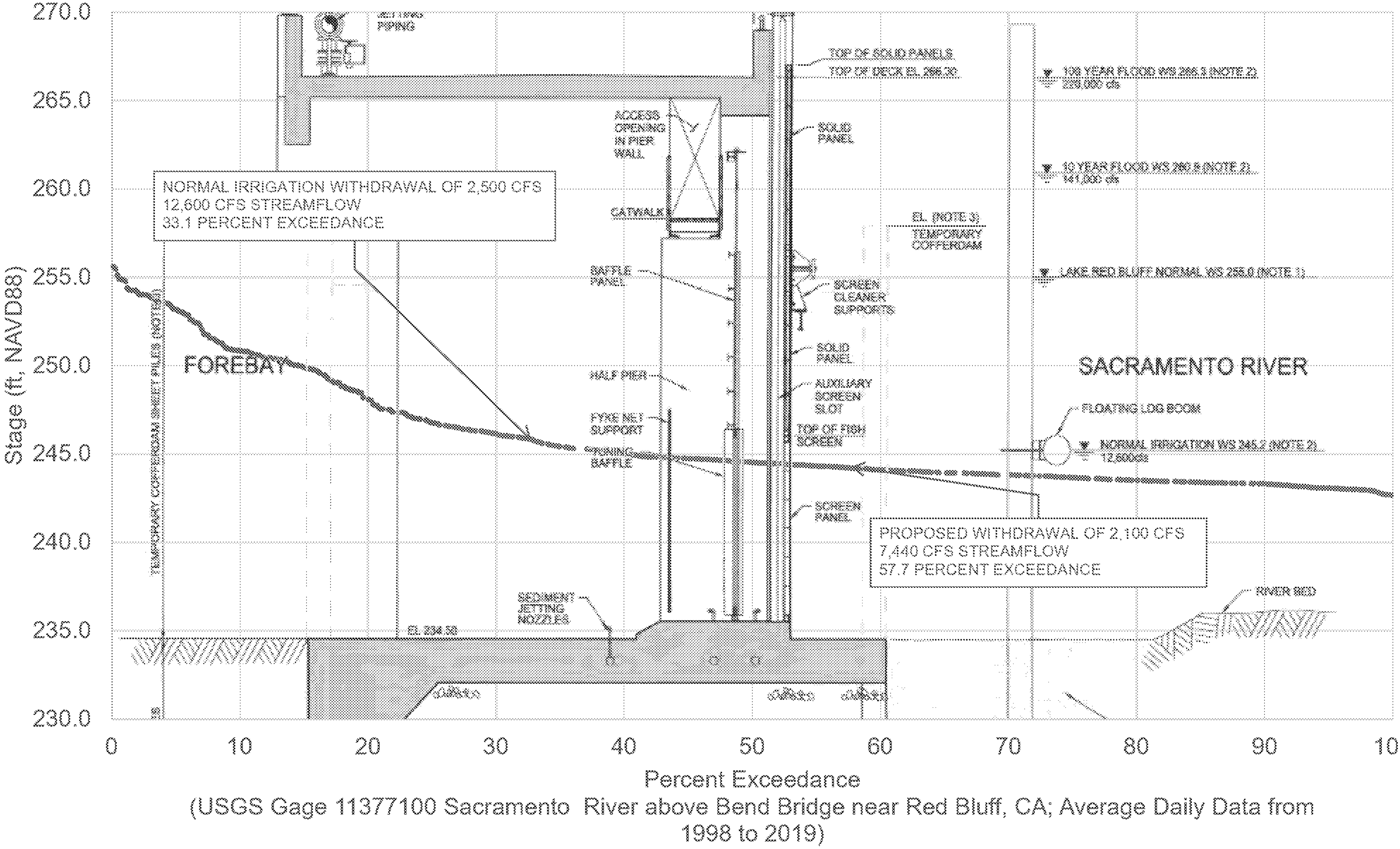
Stage Frequency Curve - January
Sacramento River at Red Bluff Diversion Dam (U/S Work Point)



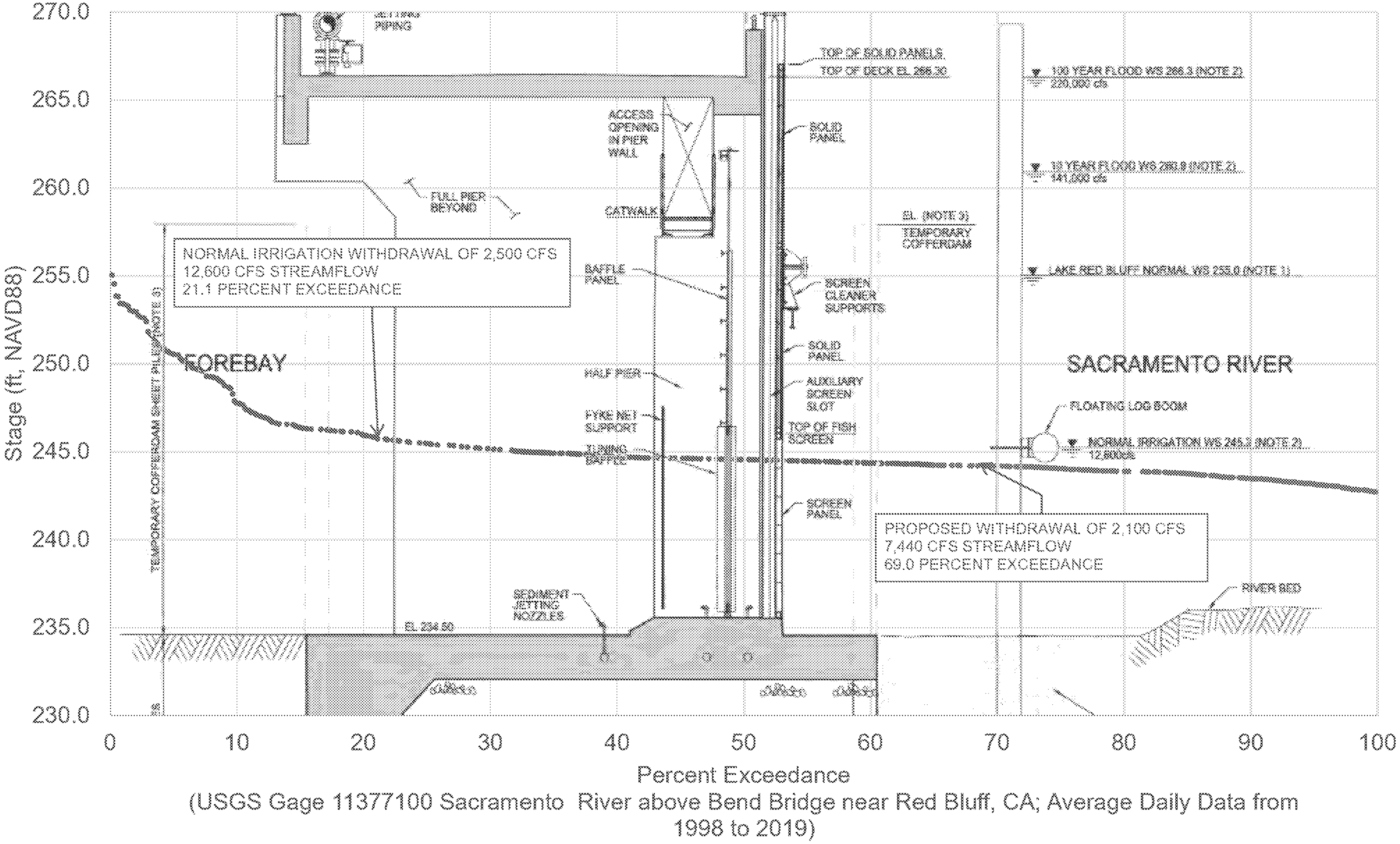
Stage Frequency Curve - February
Sacramento River at Red Bluff Diversion Dam (U/S Work Point)



Stage Frequency Curve - March
Sacramento River at Red Bluff Diversion Dam (U/S Work Point)

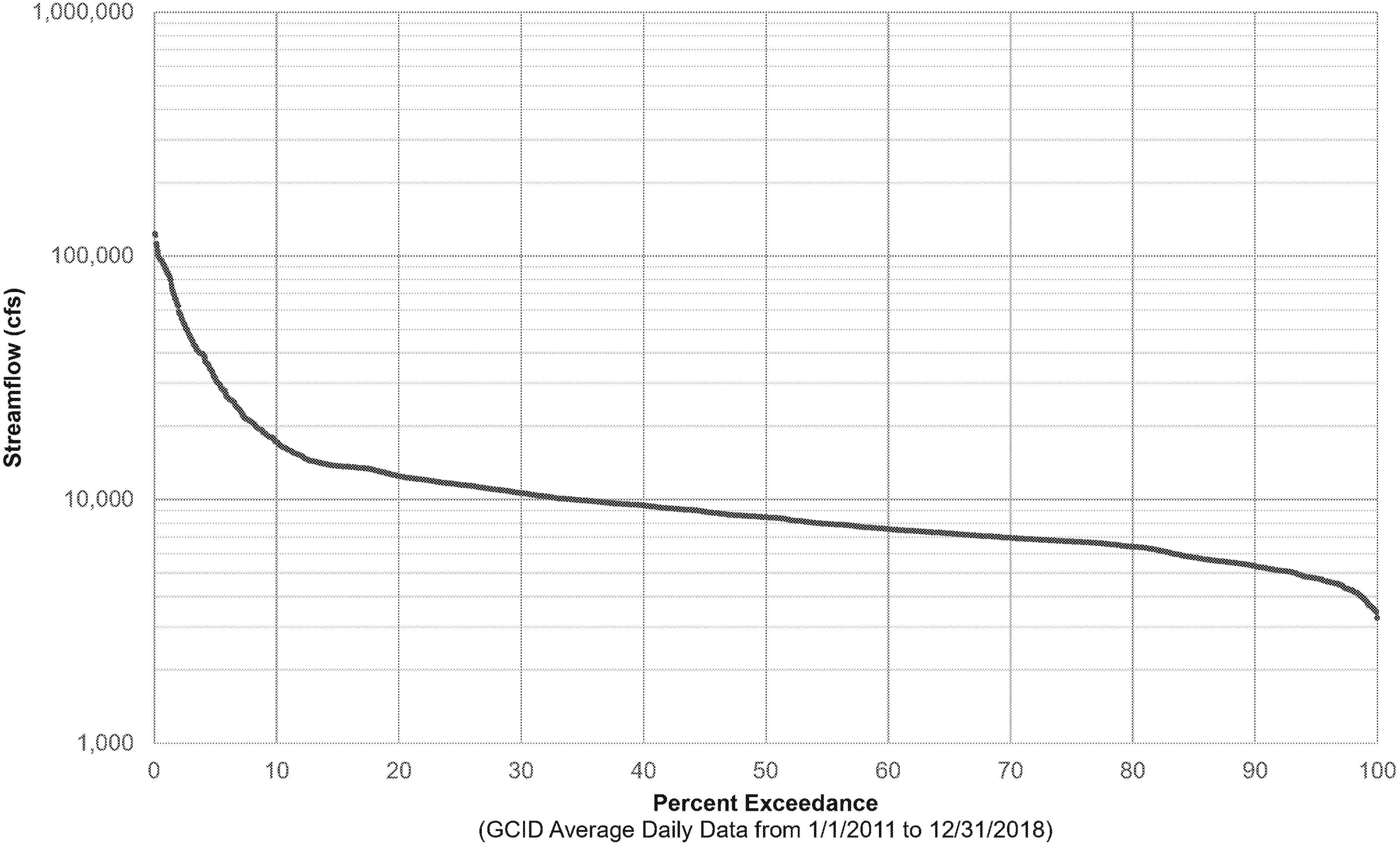


Stage Frequency Curve - April
Sacramento River at Red Bluff Diversion Dam (U/S Work Point)



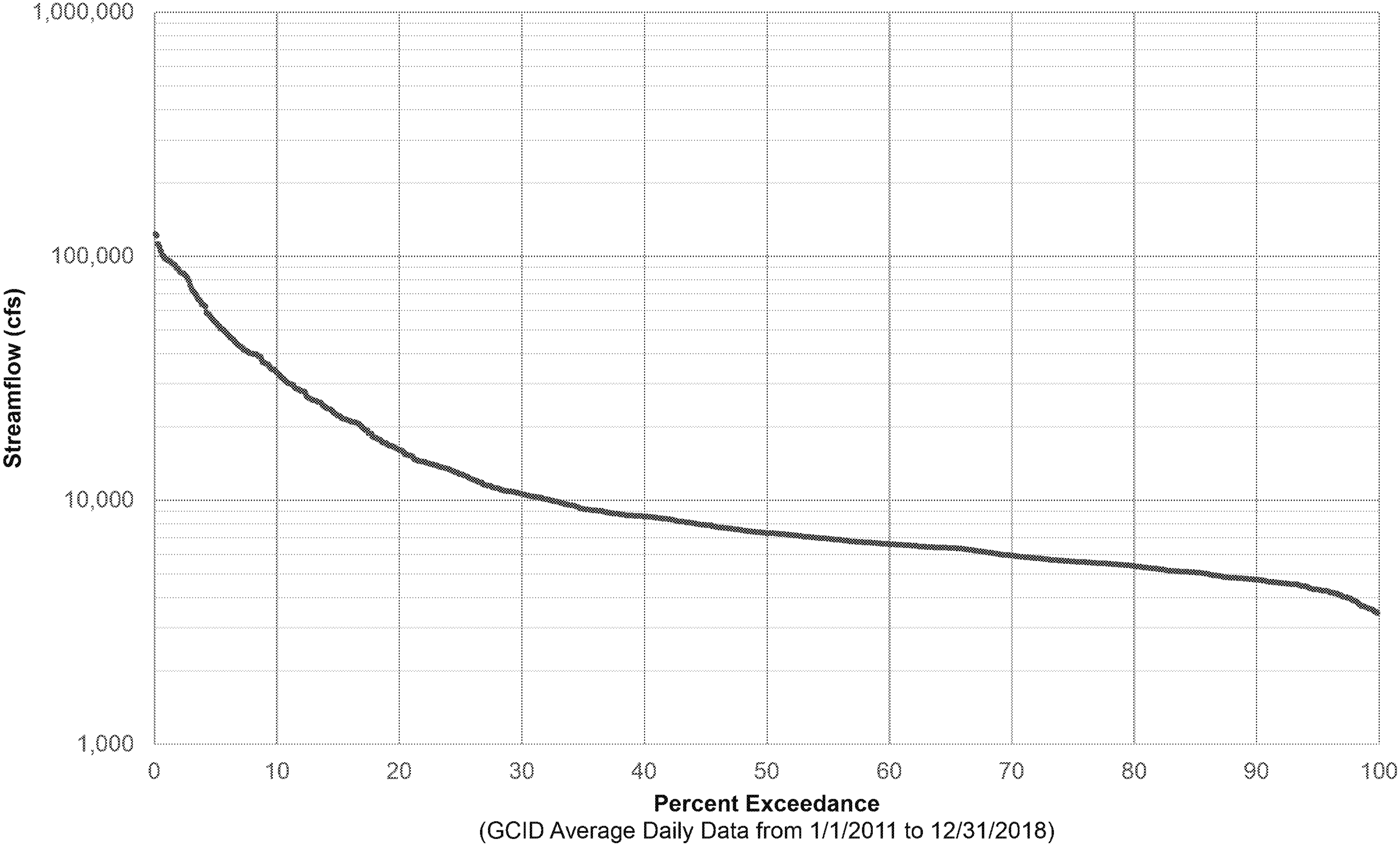
Attachment 2 – GCID Hamilton City

Flow-Duration Curve - Annual
Sacramento River Upstream from Oxbow



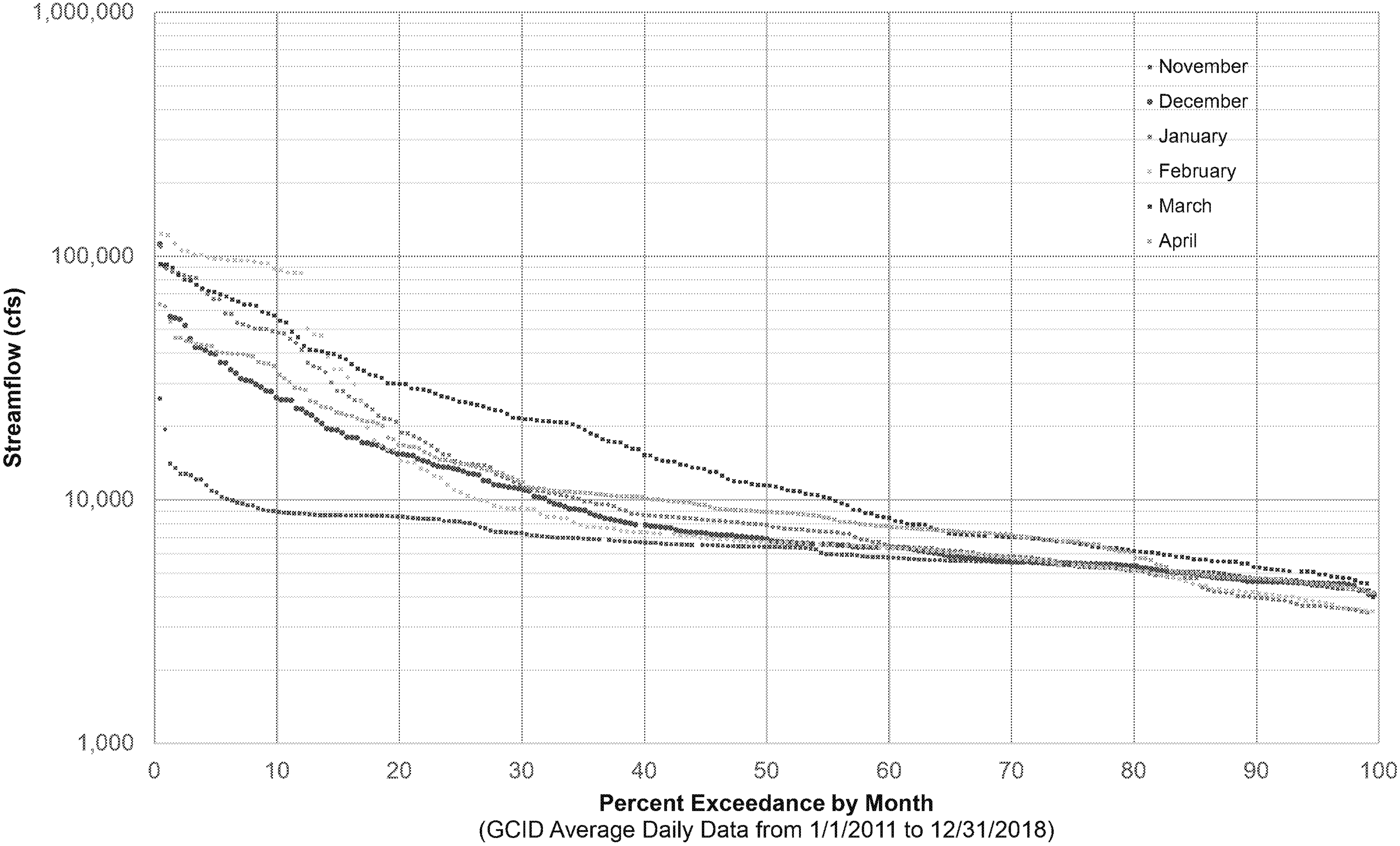
8/2/2019

Flow-Duration Curve - November-April
Sacramento River Upstream from GCID Diversion



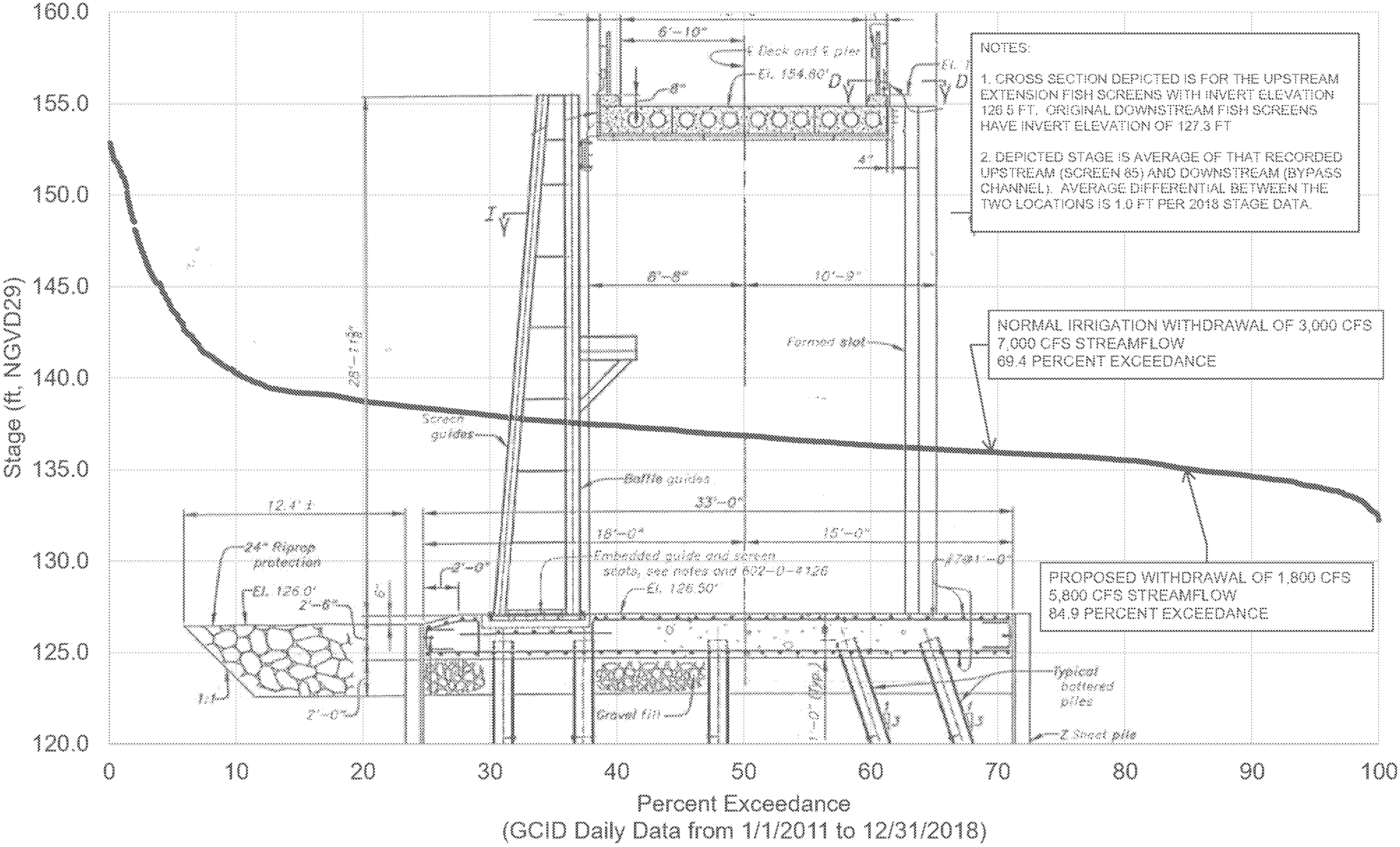
11/14/2019

Monthly Flow-Duration Curves - November-April
Sacramento River Upstream from GCID Diversion



11/14/2019

Stage Frequency Curve - Annual
Sacramento River at GCID Diversion Fish Screens



NOTES:

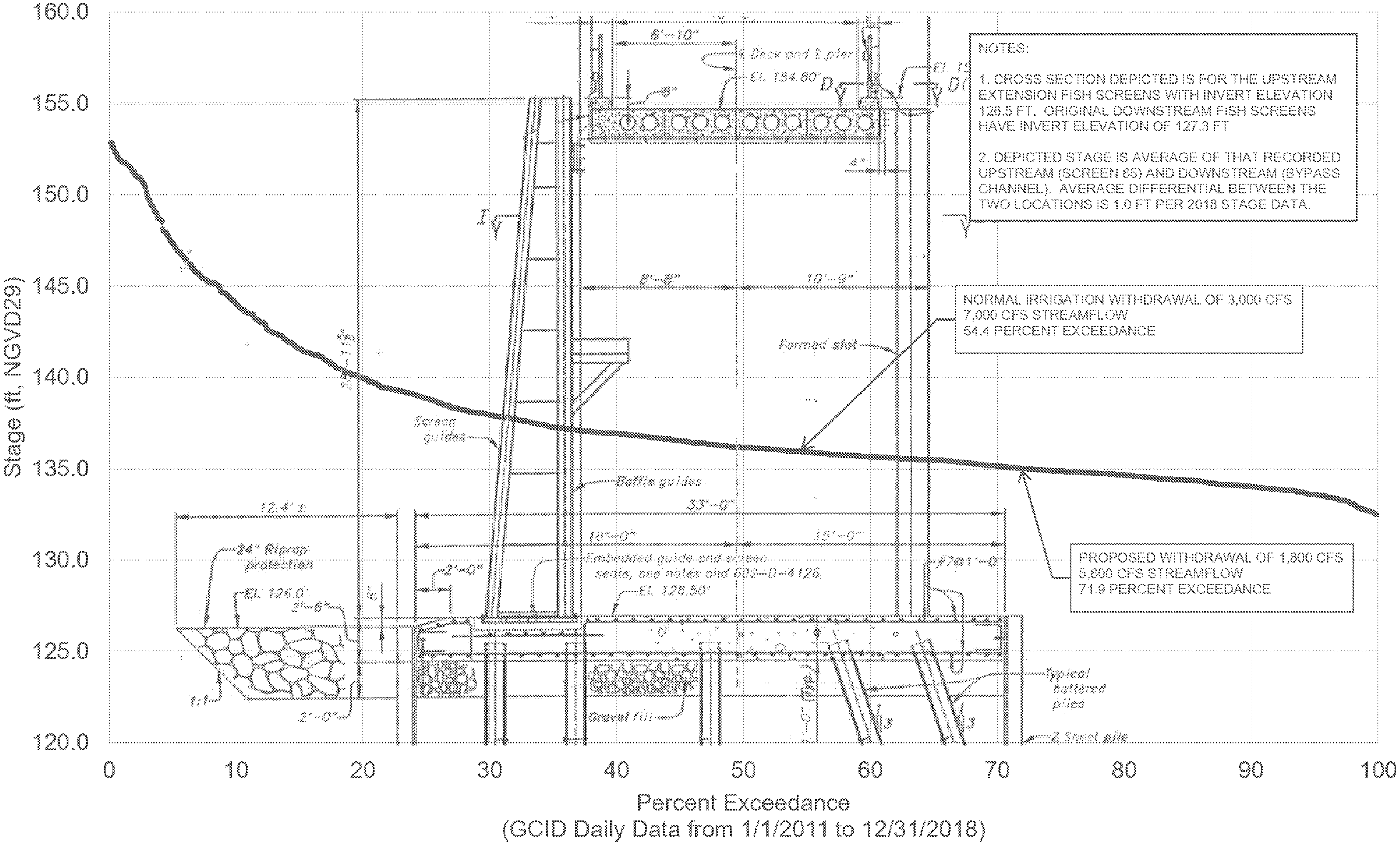
1. CROSS SECTION DEPICTED IS FOR THE UPSTREAM EXTENSION FISH SCREENS WITH INVERT ELEVATION 126.5 FT. ORIGINAL DOWNSTREAM FISH SCREENS HAVE INVERT ELEVATION OF 127.3 FT

2. DEPICTED STAGE IS AVERAGE OF THAT RECORDED UPSTREAM (SCREEN 85) AND DOWNSTREAM (BYPASS CHANNEL). AVERAGE DIFFERENTIAL BETWEEN THE TWO LOCATIONS IS 1.0 FT PER 2018 STAGE DATA.

NORMAL IRRIGATION WITHDRAWAL OF 3,000 CFS
7,000 CFS STREAMFLOW
69.4 PERCENT EXCEEDANCE

PROPOSED WITHDRAWAL OF 1,800 CFS
5,800 CFS STREAMFLOW
84.9 PERCENT EXCEEDANCE

Stage Frequency Curve - November-April
Sacramento River at GCID Diversion Fish Screens



NOTES:

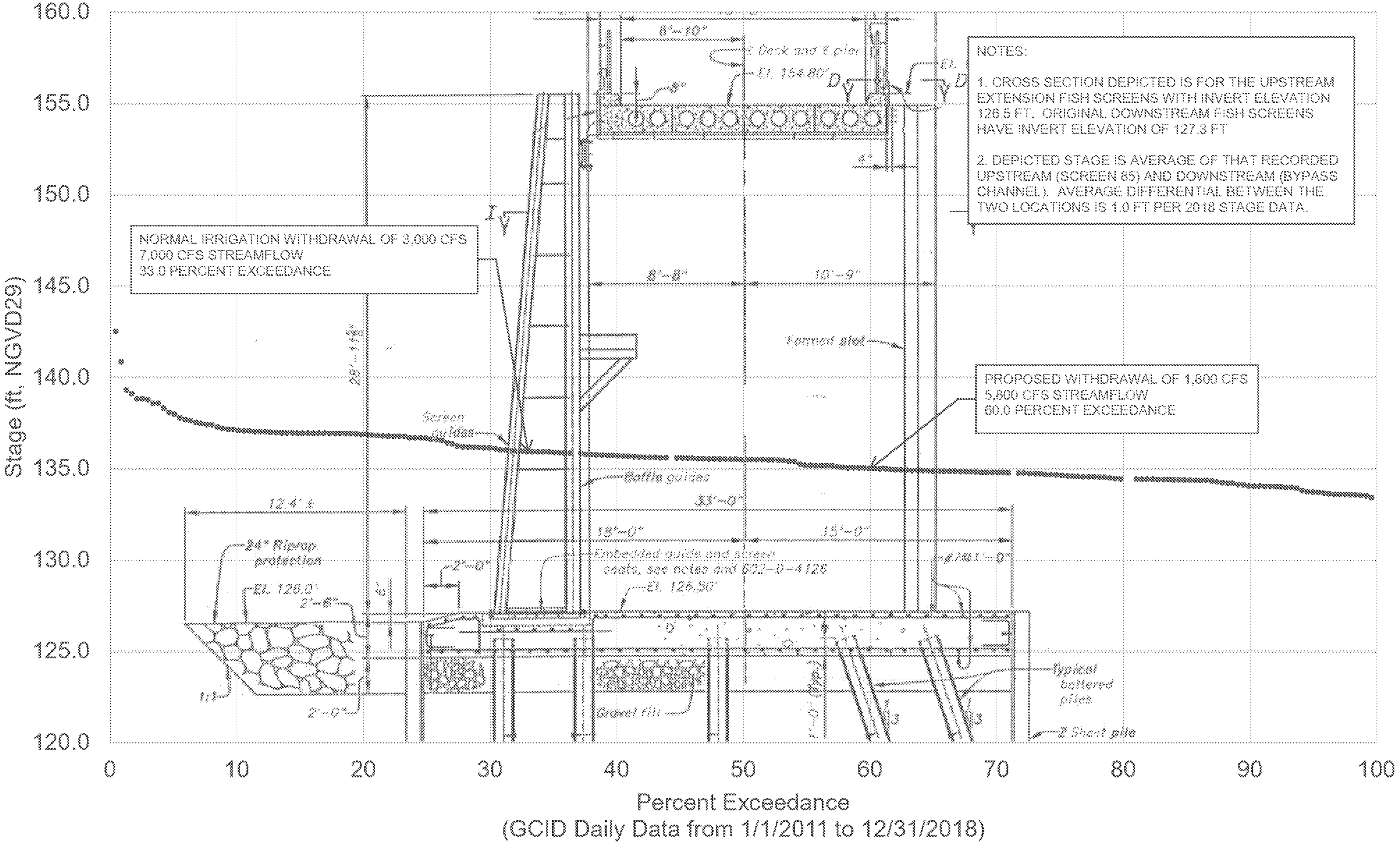
1. CROSS SECTION DEPICTED IS FOR THE UPSTREAM EXTENSION FISH SCREENS WITH INVERT ELEVATION 126.5 FT. ORIGINAL DOWNSTREAM FISH SCREENS HAVE INVERT ELEVATION OF 127.3 FT

2. DEPICTED STAGE IS AVERAGE OF THAT RECORDED UPSTREAM (SCREEN 85) AND DOWNSTREAM (BYPASS CHANNEL). AVERAGE DIFFERENTIAL BETWEEN THE TWO LOCATIONS IS 1.0 FT PER 2018 STAGE DATA.

NORMAL IRRIGATION WITHDRAWAL OF 3,000 CFS
7,000 CFS STREAMFLOW
54.4 PERCENT EXCEEDANCE

PROPOSED WITHDRAWAL OF 1,800 CFS
5,800 CFS STREAMFLOW
71.9 PERCENT EXCEEDANCE

Stage Frequency Curve - November
Sacramento River at GCID Diversion Fish Screens



NORMAL IRRIGATION WITHDRAWAL OF 3,000 CFS
7,000 CFS STREAMFLOW
33.0 PERCENT EXCEEDANCE

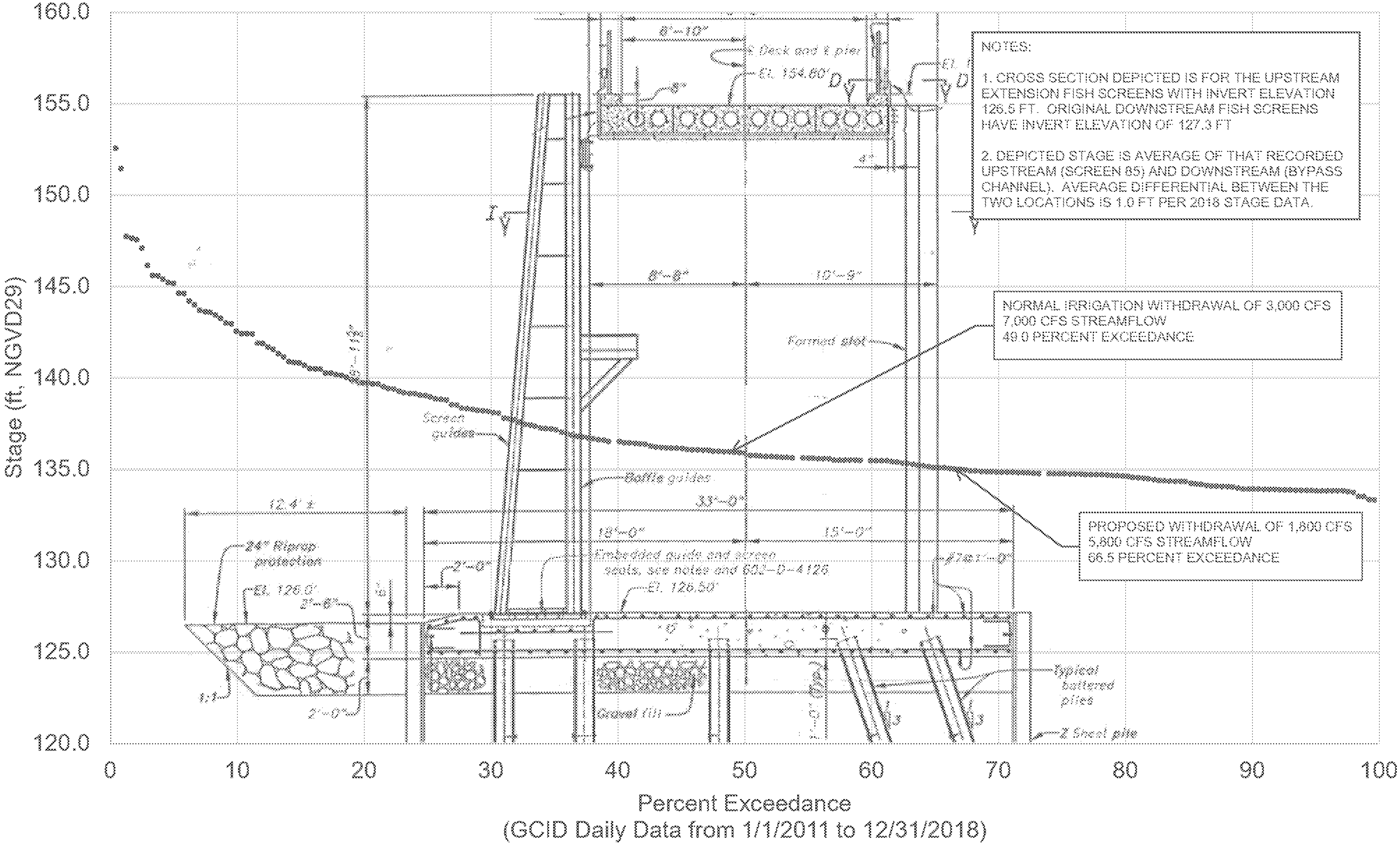
PROPOSED WITHDRAWAL OF 1,800 CFS
5,800 CFS STREAMFLOW
60.0 PERCENT EXCEEDANCE

NOTES:

1. CROSS SECTION DEPICTED IS FOR THE UPSTREAM EXTENSION FISH SCREENS WITH INVERT ELEVATION 126.5 FT. ORIGINAL DOWNSTREAM FISH SCREENS HAVE INVERT ELEVATION OF 127.3 FT

2. DEPICTED STAGE IS AVERAGE OF THAT RECORDED UPSTREAM (SCREEN 85) AND DOWNSTREAM (BYPASS CHANNEL). AVERAGE DIFFERENTIAL BETWEEN THE TWO LOCATIONS IS 1.0 FT PER 2018 STAGE DATA.

Stage Frequency Curve - December
Sacramento River at GCID Diversion Fish Screens



NOTES:

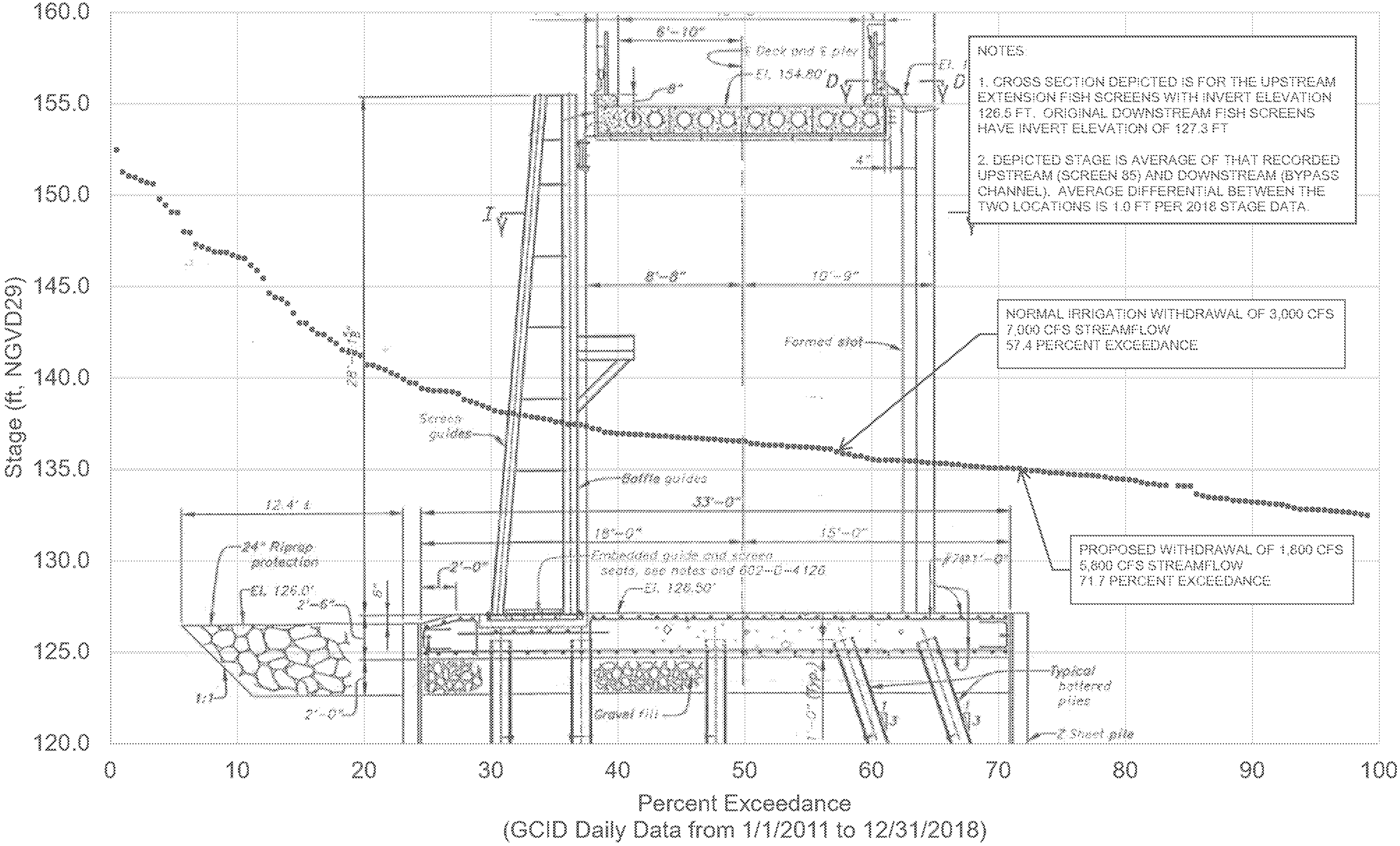
1. CROSS SECTION DEPICTED IS FOR THE UPSTREAM EXTENSION FISH SCREENS WITH INVERT ELEVATION 126.5 FT. ORIGINAL DOWNSTREAM FISH SCREENS HAVE INVERT ELEVATION OF 127.3 FT

2. DEPICTED STAGE IS AVERAGE OF THAT RECORDED UPSTREAM (SCREEN 85) AND DOWNSTREAM (BYPASS CHANNEL). AVERAGE DIFFERENTIAL BETWEEN THE TWO LOCATIONS IS 1.0 FT PER 2018 STAGE DATA.

NORMAL IRRIGATION WITHDRAWAL OF 3,000 CFS
7,000 CFS STREAMFLOW
49.0 PERCENT EXCEEDANCE

PROPOSED WITHDRAWAL OF 1,800 CFS
5,800 CFS STREAMFLOW
66.5 PERCENT EXCEEDANCE

Stage Frequency Curve - January
Sacramento River at GCID Diversion Fish Screens



NOTES:

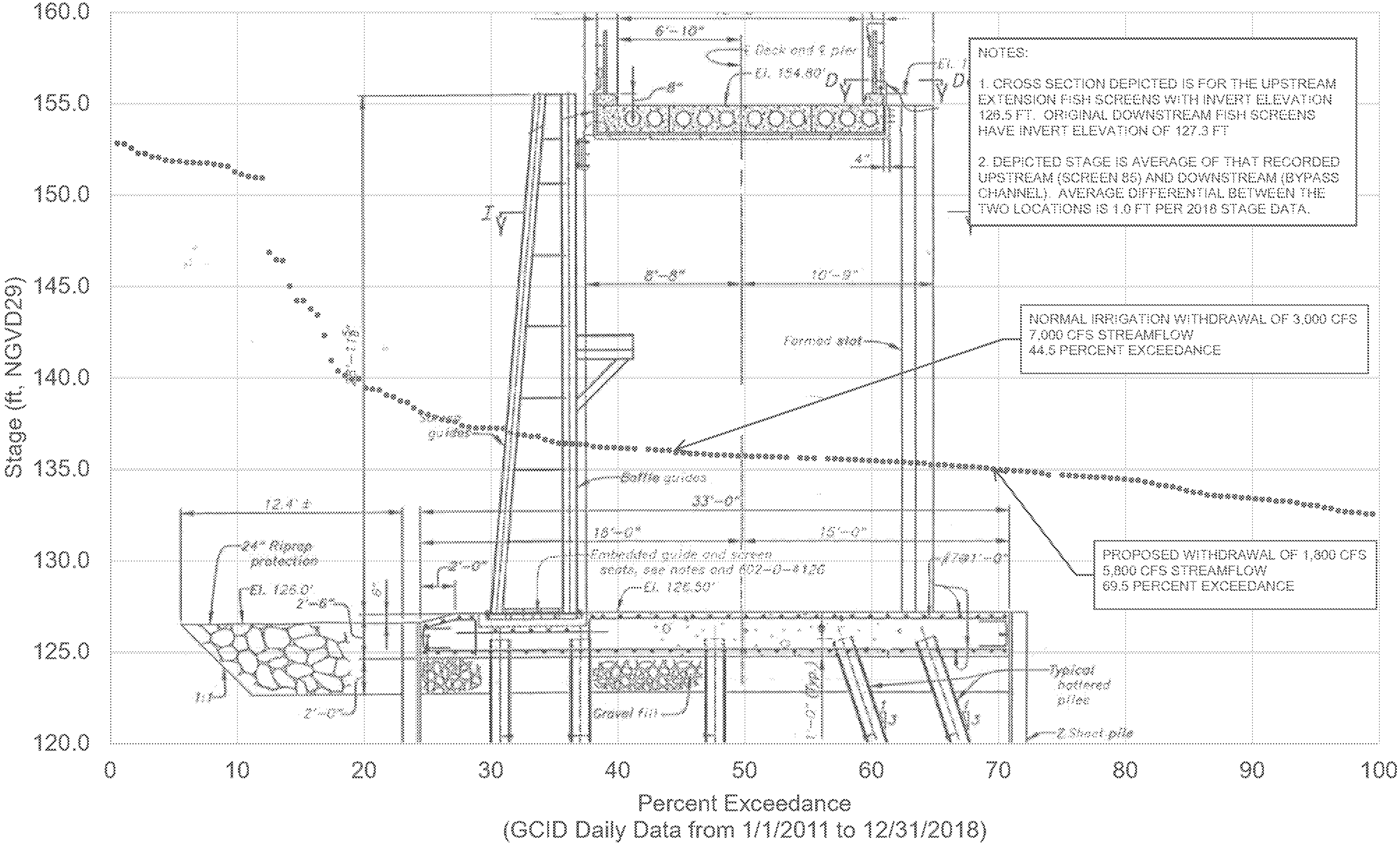
1. CROSS SECTION DEPICTED IS FOR THE UPSTREAM EXTENSION FISH SCREENS WITH INVERT ELEVATION 126.5 FT. ORIGINAL DOWNSTREAM FISH SCREENS HAVE INVERT ELEVATION OF 127.3 FT

2. DEPICTED STAGE IS AVERAGE OF THAT RECORDED UPSTREAM (SCREEN 85) AND DOWNSTREAM (BYPASS CHANNEL). AVERAGE DIFFERENTIAL BETWEEN THE TWO LOCATIONS IS 1.0 FT PER 2018 STAGE DATA.

NORMAL IRRIGATION WITHDRAWAL OF 3,000 CFS
7,000 CFS STREAMFLOW
57.4 PERCENT EXCEEDANCE

PROPOSED WITHDRAWAL OF 1,800 CFS
5,800 CFS STREAMFLOW
71.7 PERCENT EXCEEDANCE

Stage Frequency Curve - February
Sacramento River at GCID Diversion Fish Screens



NOTES:

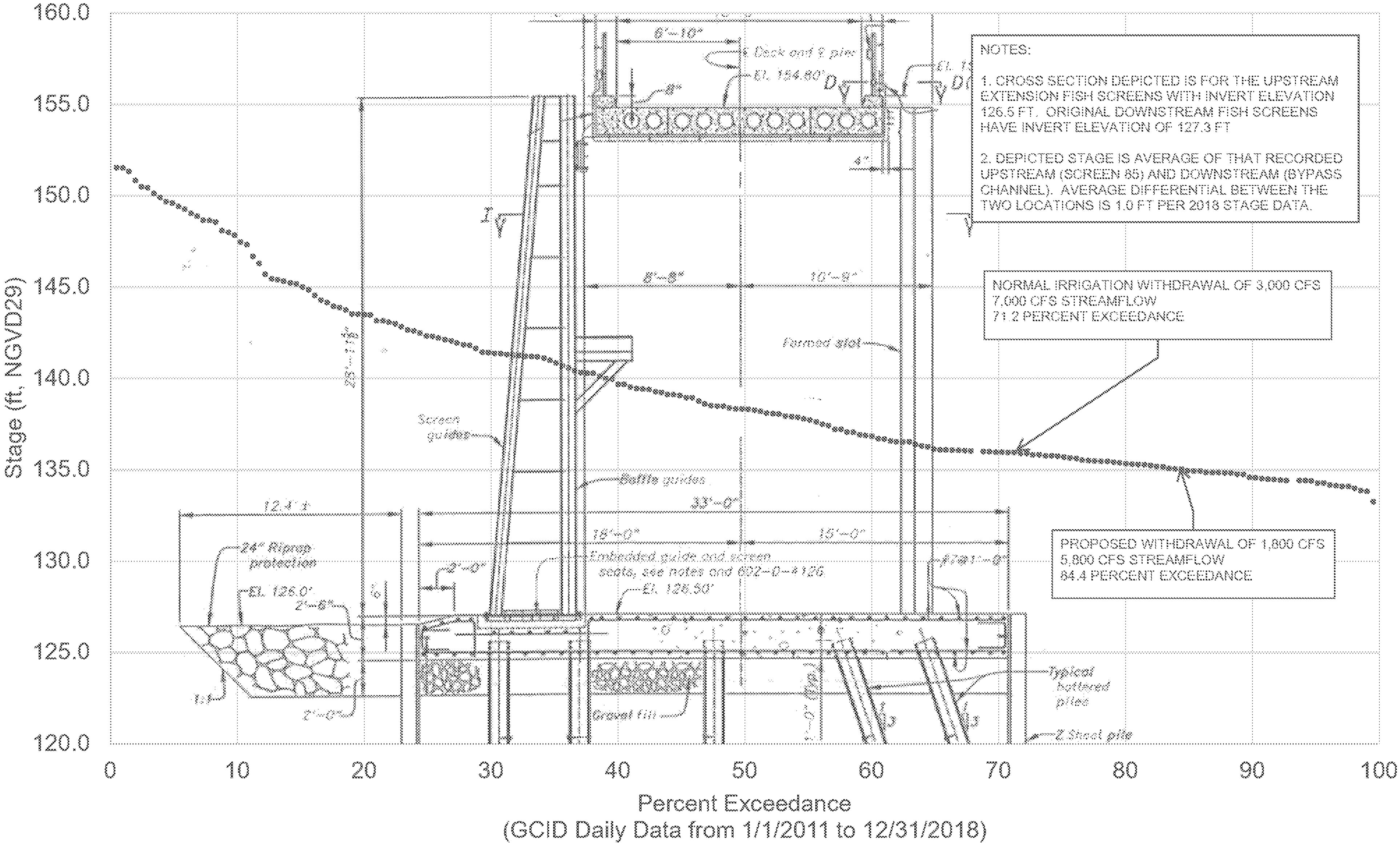
1. CROSS SECTION DEPICTED IS FOR THE UPSTREAM EXTENSION FISH SCREENS WITH INVERT ELEVATION 126.5 FT. ORIGINAL DOWNSTREAM FISH SCREENS HAVE INVERT ELEVATION OF 127.3 FT

2. DEPICTED STAGE IS AVERAGE OF THAT RECORDED UPSTREAM (SCREEN 85) AND DOWNSTREAM (BYPASS CHANNEL). AVERAGE DIFFERENTIAL BETWEEN THE TWO LOCATIONS IS 1.0 FT PER 2018 STAGE DATA.

NORMAL IRRIGATION WITHDRAWAL OF 3,000 CFS
7,000 CFS STREAMFLOW
44.5 PERCENT EXCEEDANCE

PROPOSED WITHDRAWAL OF 1,800 CFS
5,800 CFS STREAMFLOW
69.5 PERCENT EXCEEDANCE

Stage Frequency Curve - March
Sacramento River at GCID Diversion Fish Screens



NOTES:

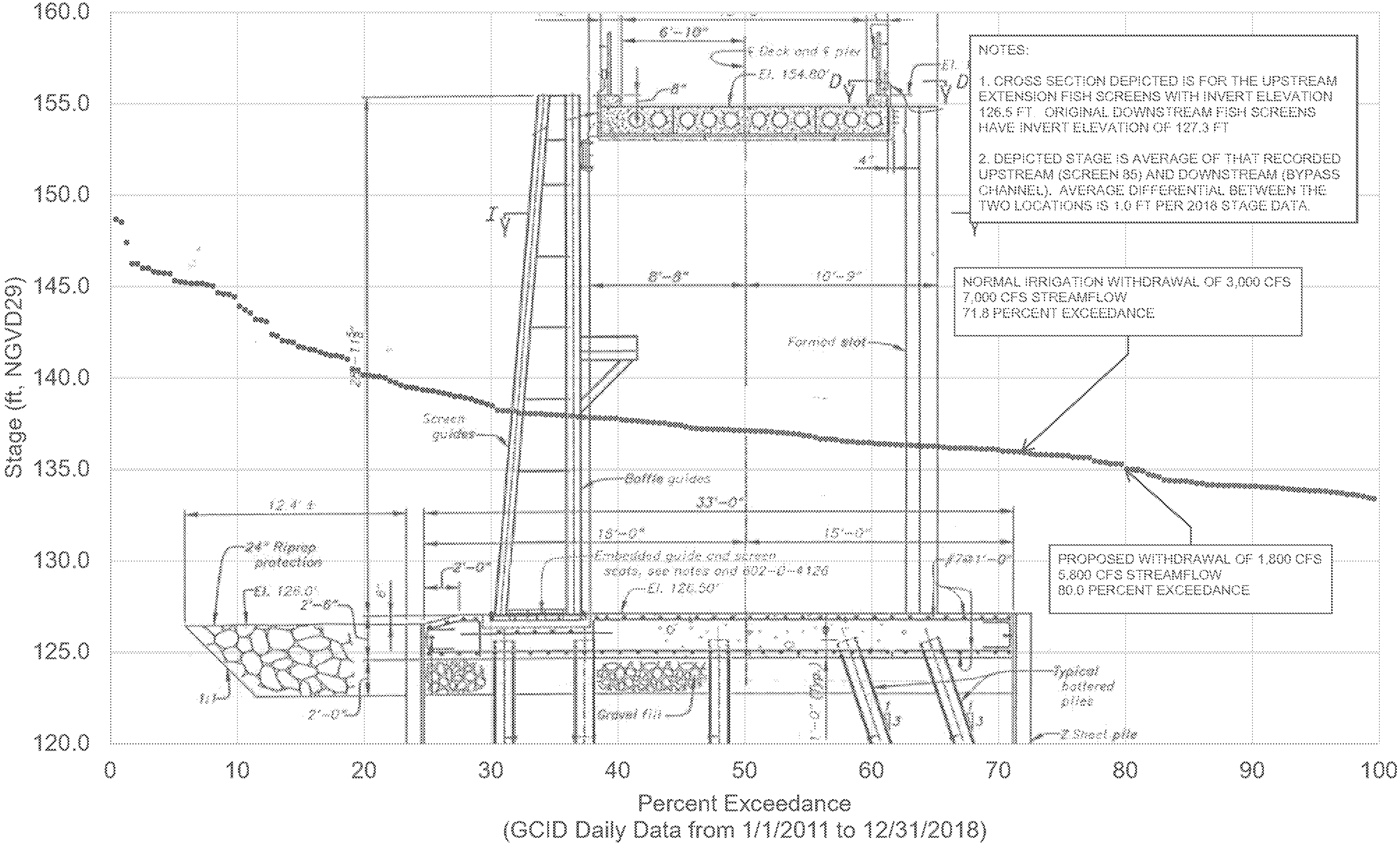
1. CROSS SECTION DEPICTED IS FOR THE UPSTREAM EXTENSION FISH SCREENS WITH INVERT ELEVATION 126.5 FT. ORIGINAL DOWNSTREAM FISH SCREENS HAVE INVERT ELEVATION OF 127.3 FT

2. DEPICTED STAGE IS AVERAGE OF THAT RECORDED UPSTREAM (SCREEN 85) AND DOWNSTREAM (BYPASS CHANNEL). AVERAGE DIFFERENTIAL BETWEEN THE TWO LOCATIONS IS 1.0 FT PER 2018 STAGE DATA.

NORMAL IRRIGATION WITHDRAWAL OF 3,000 CFS
7,000 CFS STREAMFLOW
71.2 PERCENT EXCEEDANCE

PROPOSED WITHDRAWAL OF 1,800 CFS
5,800 CFS STREAMFLOW
84.4 PERCENT EXCEEDANCE

Stage Frequency Curve - April
Sacramento River at GCID Diversion Fish Screens



NOTES:

1. CROSS SECTION DEPICTED IS FOR THE UPSTREAM EXTENSION FISH SCREENS WITH INVERT ELEVATION 126.5 FT. ORIGINAL DOWNSTREAM FISH SCREENS HAVE INVERT ELEVATION OF 127.3 FT

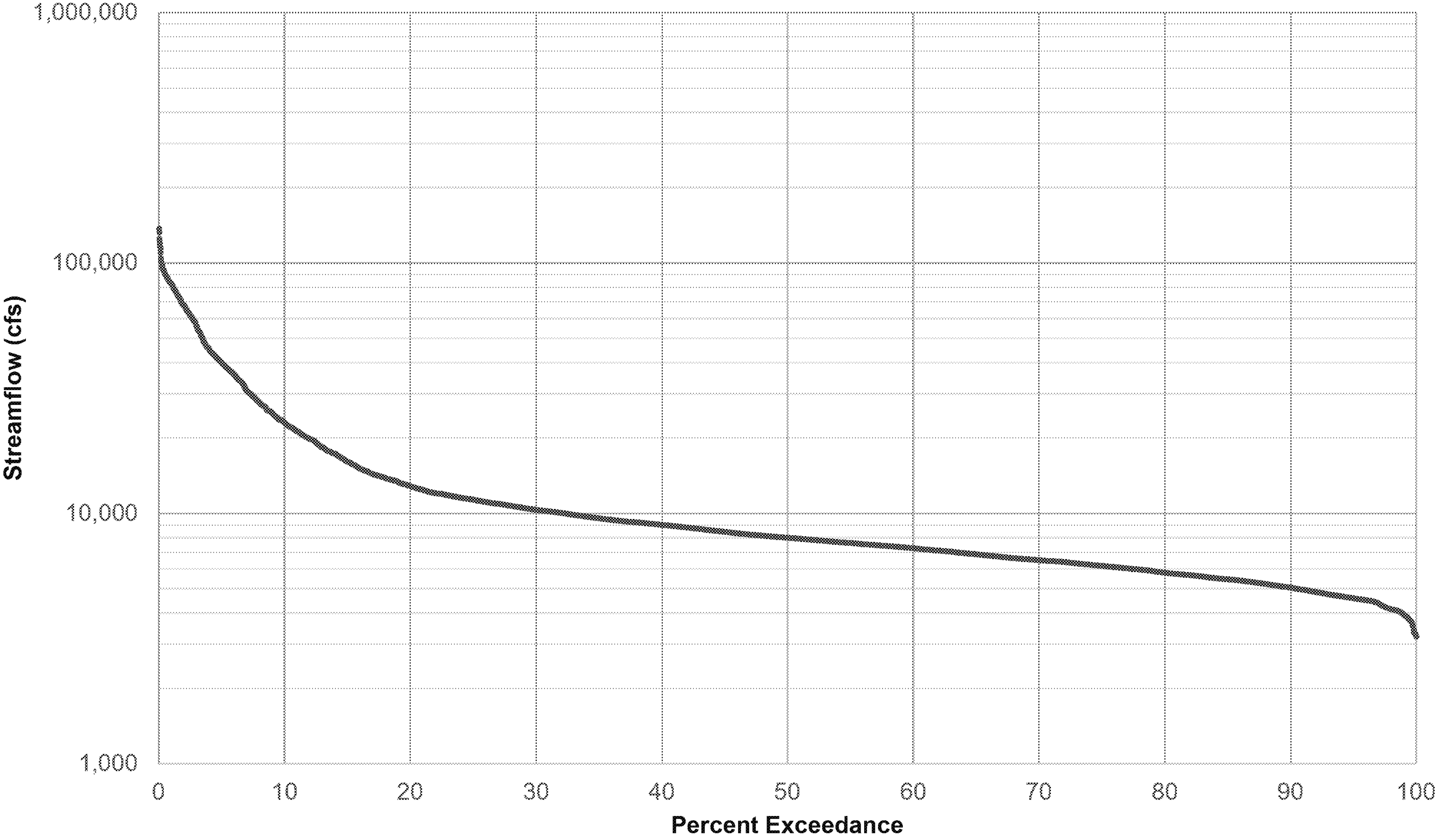
2. DEPICTED STAGE IS AVERAGE OF THAT RECORDED UPSTREAM (SCREEN 85) AND DOWNSTREAM (BYPASS CHANNEL). AVERAGE DIFFERENTIAL BETWEEN THE TWO LOCATIONS IS 1.0 FT PER 2018 STAGE DATA.

NORMAL IRRIGATION WITHDRAWAL OF 3,000 CFS
7,000 CFS STREAMFLOW
71.8 PERCENT EXCEEDANCE

PROPOSED WITHDRAWAL OF 1,800 CFS
5,800 CFS STREAMFLOW
80.0 PERCENT EXCEEDANCE

Attachment 3 – Delevan

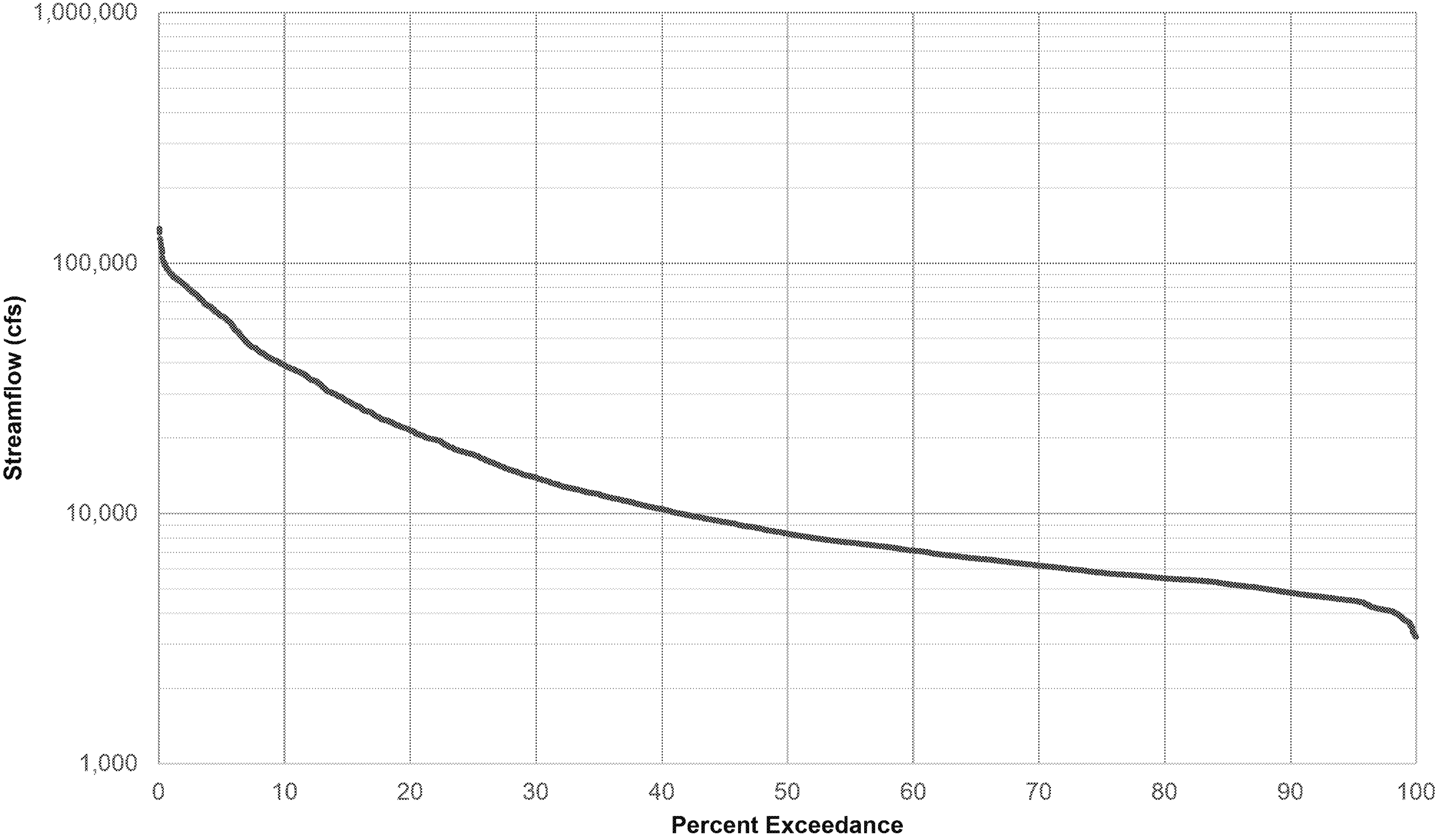
Flow-Duration Curve - Annual
CA DWR Station ID: BTC; Sacramento River at Butte City



(Average daily data from 1/28/1998 to 4/10/2019)

3/25/2020

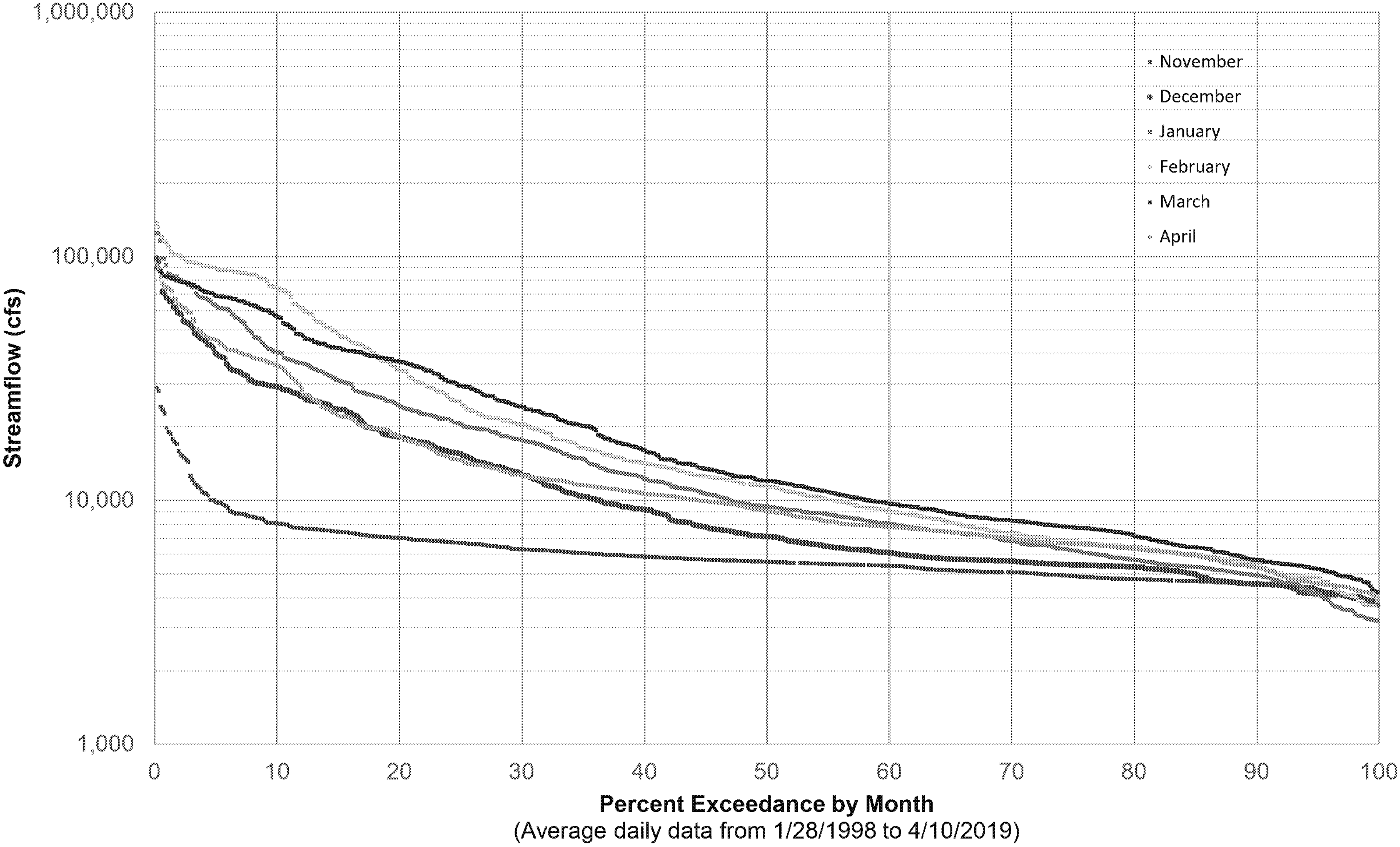
Flow-Duration Curve - November-April
CA DWR Station ID: BTC; Sacramento River at Butte City



(Average daily data from 1/28/1998 to 4/10/2019)

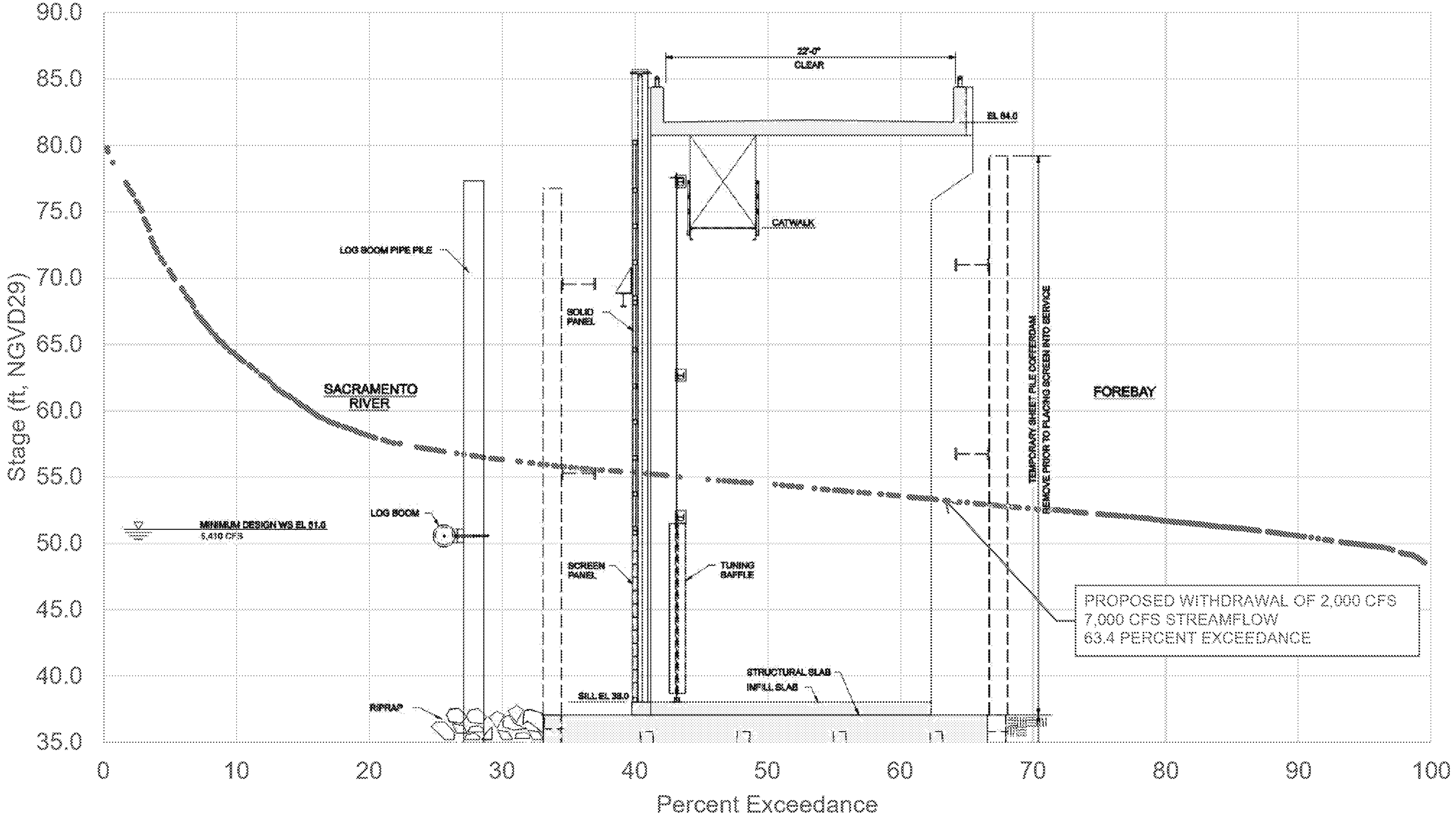
11/14/2019

Monthly Flow-Duration Curves - November-April
CA DWR Station ID: BTC; Sacramento River at Butte City



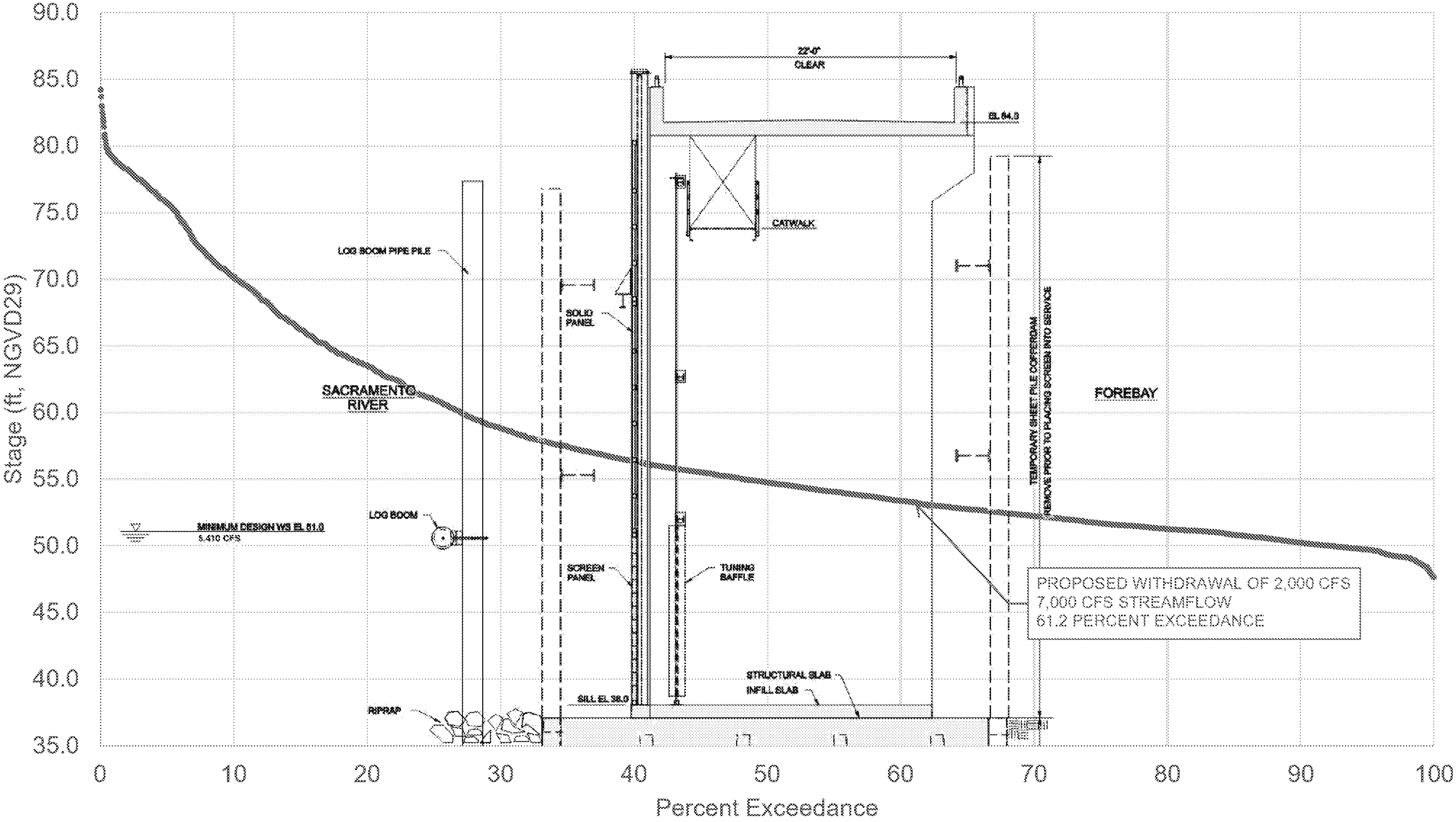
11/14/2019

Stage Frequency Curve - Annual
Sacramento River at Butte City, CA



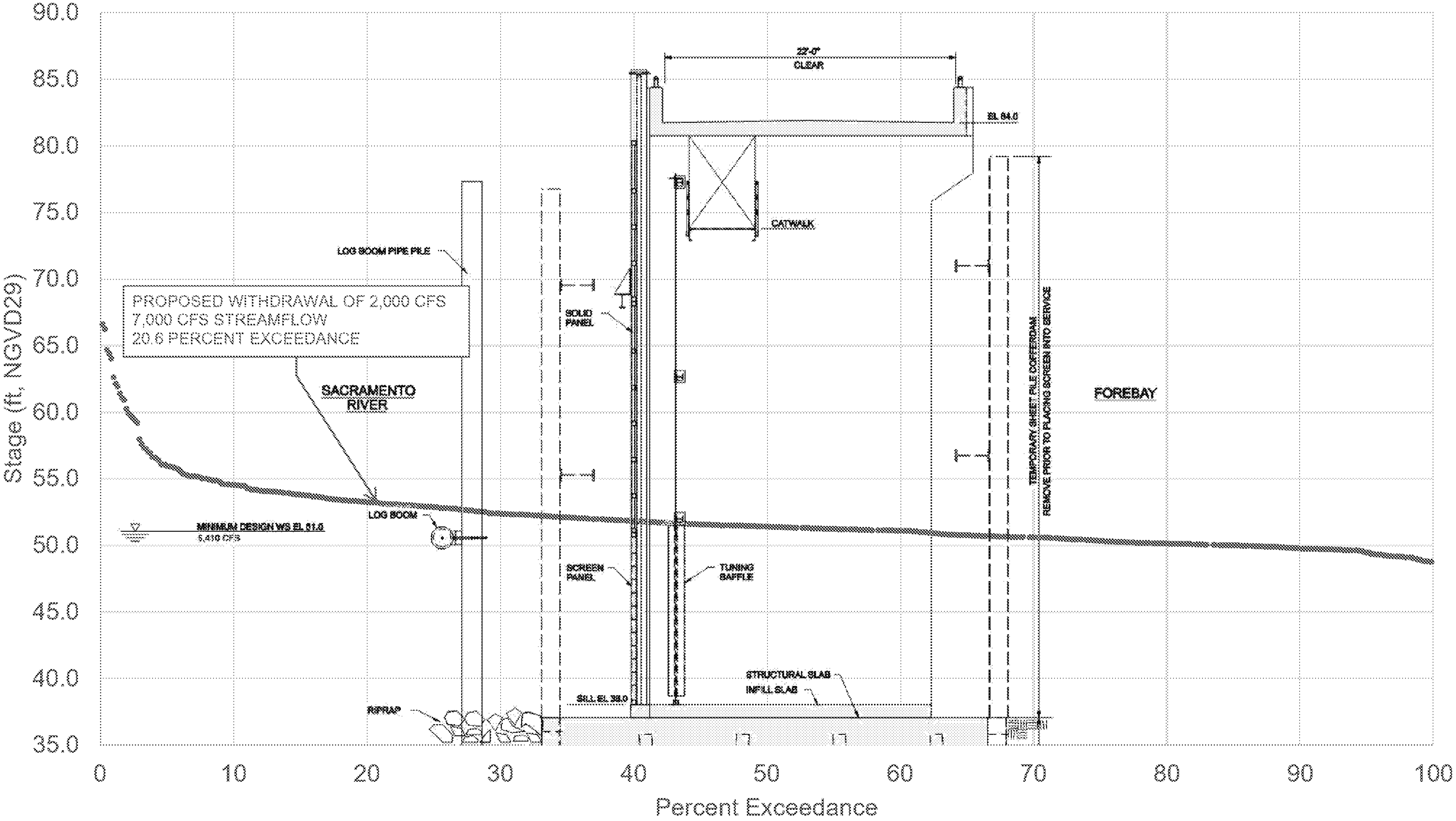
(CA Dept of Water Resources Station ID BTC: SACRAMENTO RIVER AT BUTTE CITY; Average Daily Data from January 1998 - April 2019)

Stage Frequency Curve - November-April
Sacramento River at Butte City, CA



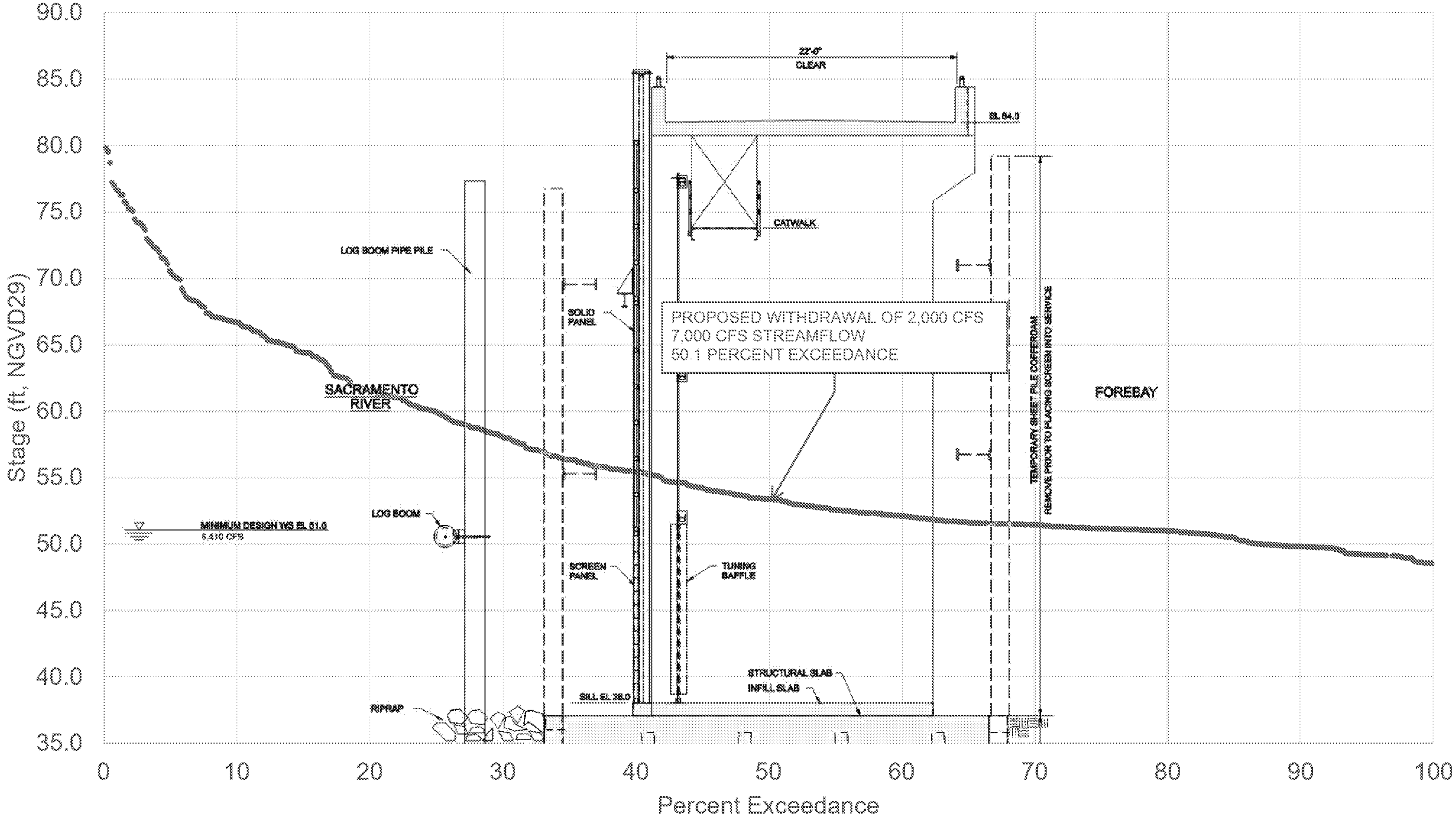
(CA Dept of Water Resources Station ID BTC: SACRAMENTO RIVER AT BUTTE CITY;
Average Daily Data from January 1998 - April 2019)

Stage Frequency Curve - November
Sacramento River at Butte City, CA



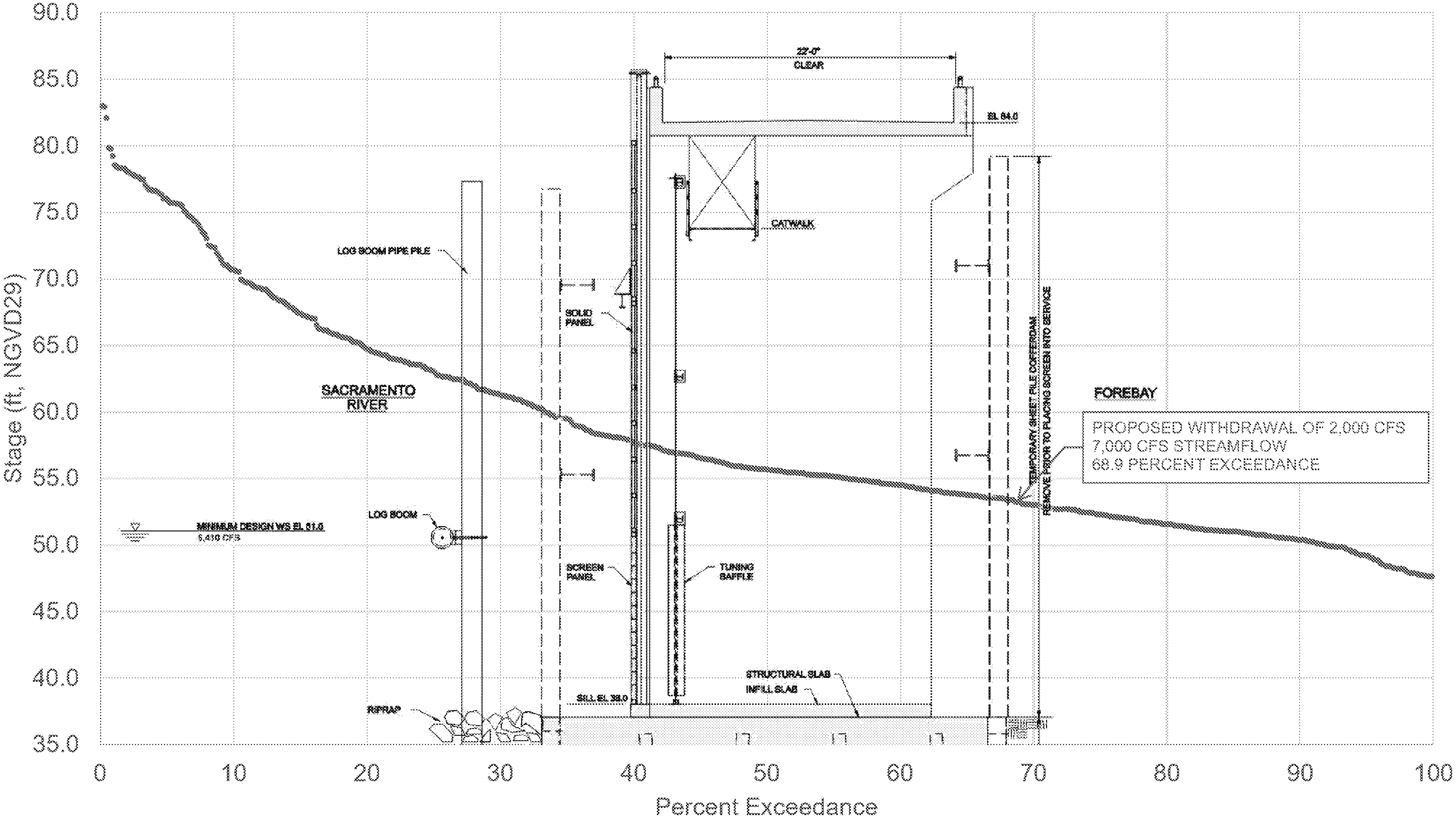
(CA Dept of Water Resources Station ID BTC: SACRAMENTO RIVER AT BUTTE CITY;
Average Daily Data from January 1998 - April 2019)

Stage Frequency Curve - December
Sacramento River at Butte City, CA



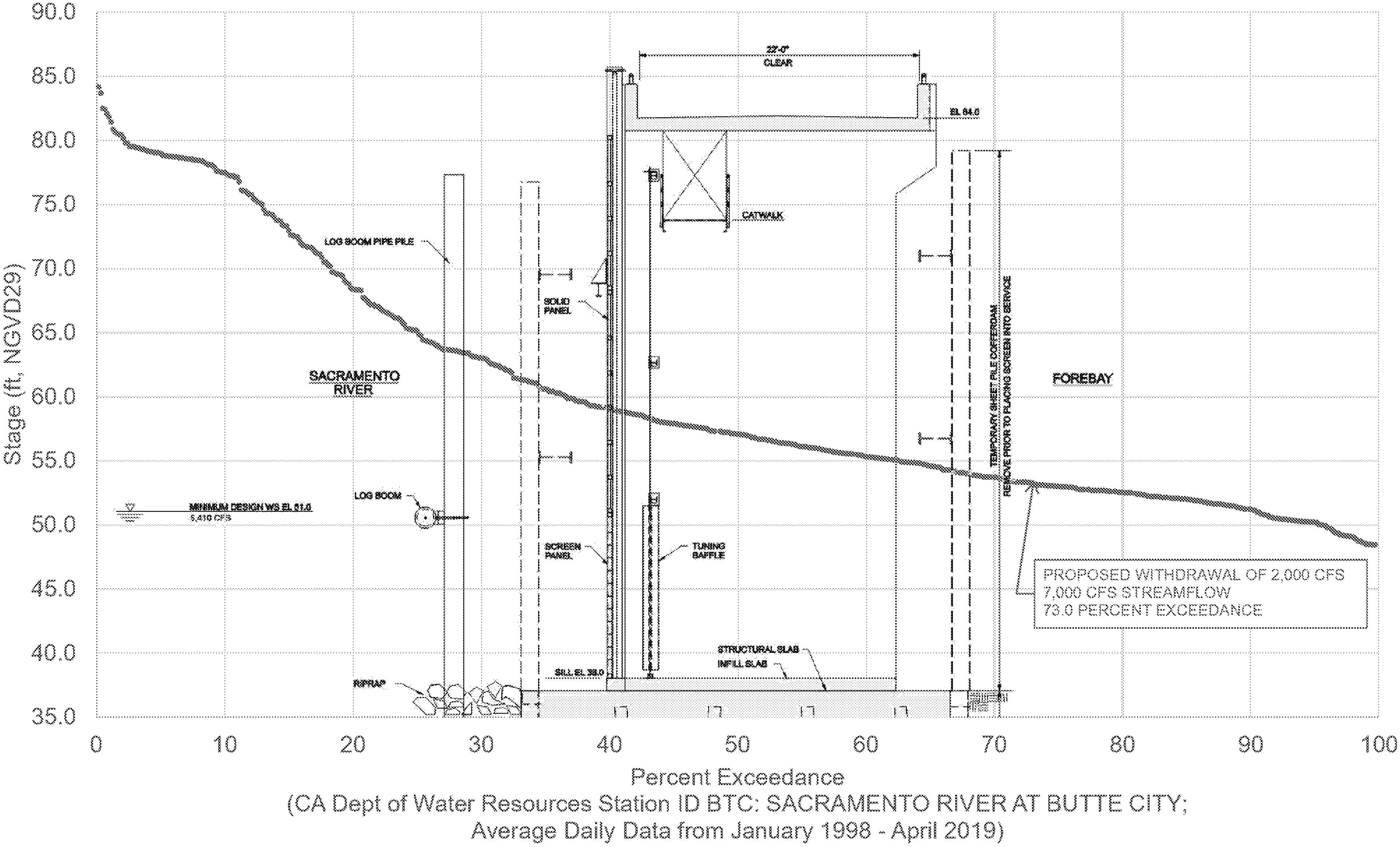
(CA Dept of Water Resources Station ID BTC: SACRAMENTO RIVER AT BUTTE CITY;
Average Daily Data from January 1998 - April 2019)

Stage Frequency Curve - January
Sacramento River at Butte City, CA

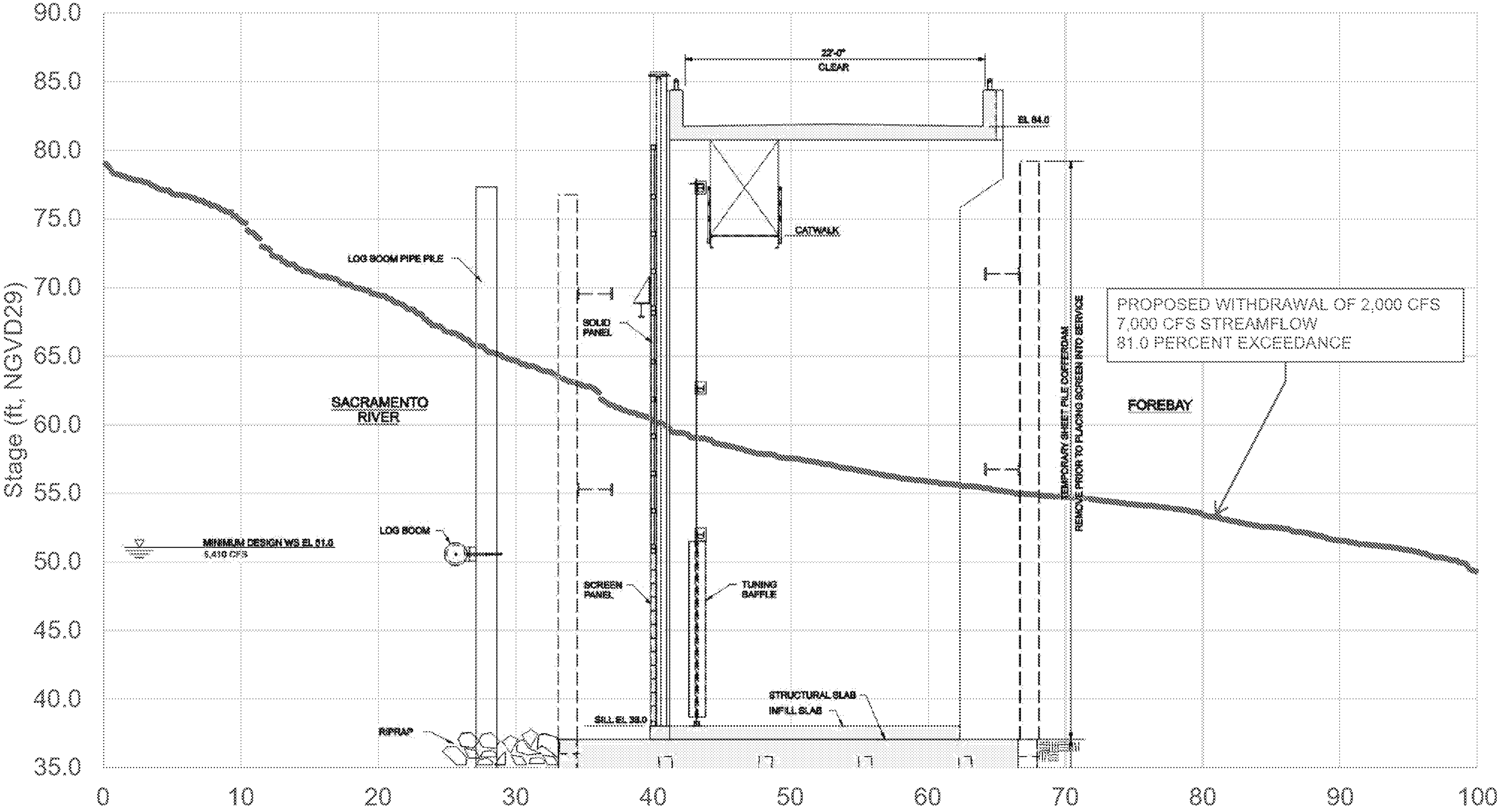


(CA Dept of Water Resources Station ID BTC: SACRAMENTO RIVER AT BUTTE CITY;
Average Daily Data from January 1998 - April 2019)

Stage Frequency Curve - February
Sacramento River at Butte City, CA

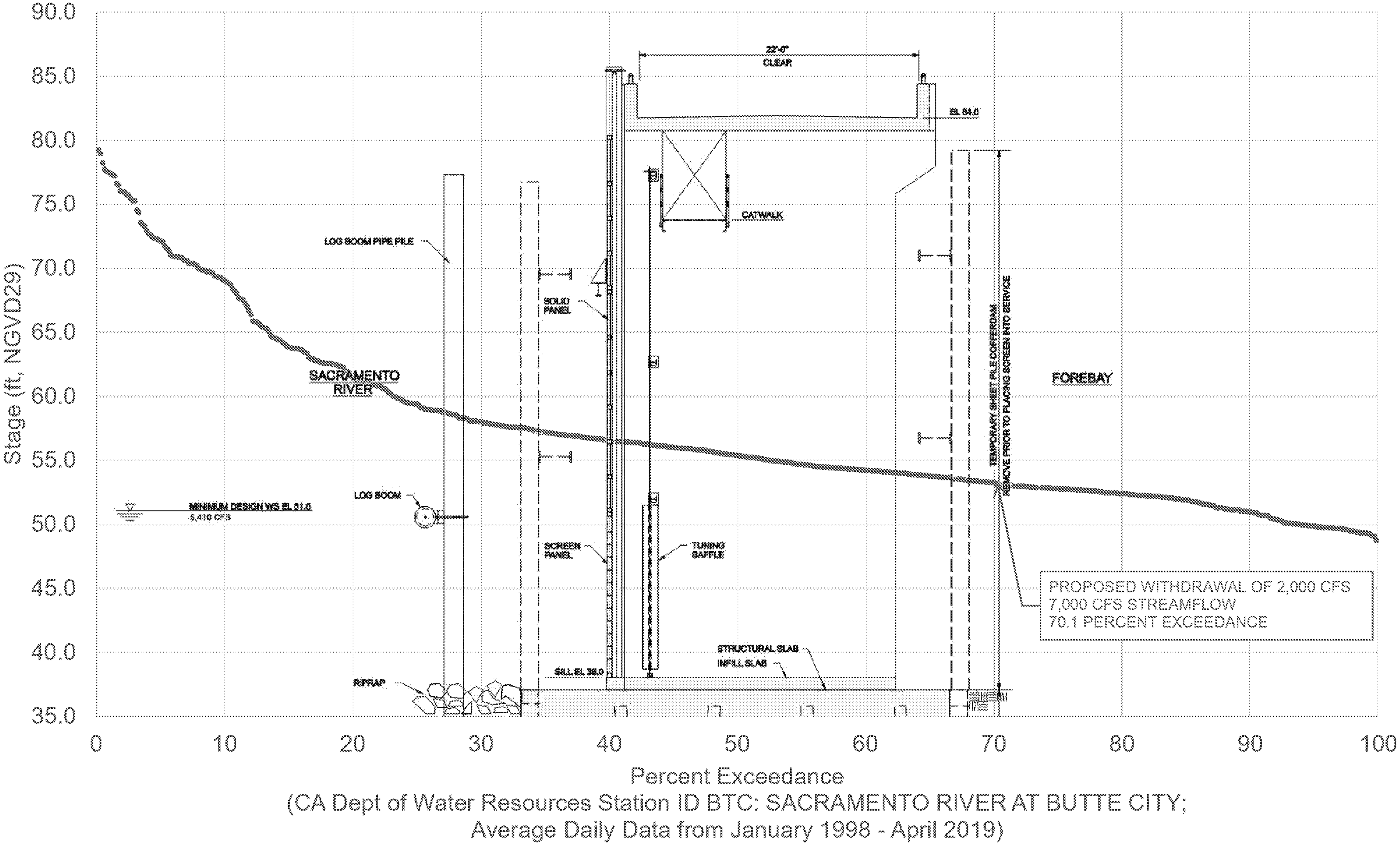


Stage Frequency Curve - March
Sacramento River at Butte City, CA



Percent Exceedance
(CA Dept of Water Resources Station ID BTC: SACRAMENTO RIVER AT BUTTE CITY;
Average Daily Data from January 1998 - April 2019)

Stage Frequency Curve - April
Sacramento River at Butte City, CA



STORAGE POLICY
BY
THE SITES PROJECT AUTHORITY

(1) This Storage Policy was adopted by the Sites Authority on 26th day of August 2019, to assist in the development and operation of the Sites Reservoir Project (Project) by the Sites Project Authority and the Sites Storage Partners listed in Attachment 1.

INTRODUCTION

(2) The Sites Project Authority (Authority) will apply for and expects to hold the water rights and be responsible for the operation of the Sites Reservoir Project with the Reservoir Committee being responsible for the planning, permitting and real-time operations implementation. There are numerous financial participants in the Sites Reservoir Project. These participants will receive water supply benefits, water supply related environmental benefits and other benefits from Sites Reservoir operation. These participants include the (1) State of California, (2) United States Bureau of Reclamation, (3) Northern California agencies and organizations, and (4) water agencies both west and south of the Sacramento-San Joaquin Delta. The participants in the Sites Reservoir Project who receive (a) water supply related benefits or (b) water supply related environmental benefits are considered Sites Storage Partners. The Sites Storage Partners will enter into agreements with the Authority for the funding of the Project and the benefits derived from the Project and may specify each Sites Storage Partner's storage space in Sites Reservoir. To the extent allowed by natural conditions, permit requirements and physical capabilities of the Project, each of these Sites Storage Partners will have control over the use of their storage allocation space based on the conditions set forth in this policy. The water supply related benefits derived from these storage allocation spaces will depend in large part on how the each Sites Storage Partner manages the water stored and released from their allocated storage space. The Reservoir Committee is responsible for accounting for all the water placed into each Sites Storage Partner's allocated storage space, water released from that storage space and any losses on a daily basis.

DEFINITIONS

(3) Sites Participants – Government Agencies, Water Organizations and others who financially contribute to the planning and construction of the Sites Reservoir Project.

(4) Sites Storage Partners – The Sites Participants who have funded and receive water supply or water supply related environmental benefits from the Sites Reservoir Project (see Attachment 1 for the list of Sites Storage Partners).

(5) Active Storage – That portion of Sites Reservoir above dead pool that can be exercised to create water supply related benefits. The total maximum storage in Sites Reservoir is expected to be 1.81 MAF. Firm dead pool storage is expected to be about 60 TAF. However, operationally another 60 TAF will likely be needed to prevent water quality issues in the storage releases. Therefore, the operational dead pool is considered to be 120 TAF. For this Policy the Active Storage for Sites Reservoir is considered to be about 1.69 MAF. These values are approximate and subject to change in the future.

(6) Water Year - The California Water Year is from October 1 through September 30.

(7) Operation and Maintenance and Replacement- (O&M) or (O&M&R). Those costs associated with the operations of the Sites Reservoir Project. These can be broken down into:

(a) Fixed operations and maintenance and replacement costs that are more stable year-to-year and that are not significantly influenced by varying diversions or releases of water, and

(b) variable operations and maintenance costs that reflect annual operations and maintenance costs that vary based on actual operations each year.

ROLES

(8) Sites Project Authority (Authority) - The Authority will apply for and expects to hold the water rights for the Sites Reservoir Project and be responsible for its operation.

(9) Reservoir Committee - The Reservoir Committee is a standing committee of the Authority and oversees the planning, permitting, and day-to-day operations and accounting of Sites Reservoir storage, releases and losses and related activities including coordination with each of the Sites Storage Partners. This will be done in a way that is open and transparent to all the Sites Storage Partners.

(10) State and Federal Agencies:

(a) The State of California - As described in Proposition 1 (2014) and associated regulations, the Sites Authority expects that the State of California will work though the California Water Commission and the Resources Agency to manage, at their request, the water held in the Sites storage allocation space obtained by the Water Commission for environmental purposes. In addition, the State of California will cooperate with the Reservoir Committee's operation of Sites Reservoir and that of the State Water Project (and if appropriate the Central Valley Project) to maximize the water supply and water supply related benefits of Sites Reservoir.

(b) The United States – To be provided.

STORAGE OF WATER

(11) Water Storage by the Appropriation of Water: The Authority will be responsible for compliance with water right provisions and other conditions that control the appropriation of water into storage in Sites Reservoir. The Authority through the Reservoir Committee will take all actions necessary to maximize the appropriation of water into storage consistent with regulatory requirements, physical constraints and hydrologic conditions. Water appropriated will be placed into Sites Reservoir and then allocated into each Sites Storage Partners contractual storage space proportional to their acquired storage space amount.[1]

Based on the water accounting system approved by the Reservoir Committee, if a Sites Storage Partner's storage volume is not available (whether due to being completely filled, filled up to the requested amount by a Storage Partner, or any other reason, the available water will be allocated to the remaining Sites Storage Partners who still have available storage allocation space and the water will be used to fill the other Sites Storage Partner's storage allocation spaces (based on their storage space allocation) until all Sites Storage Partners storage allocation spaces are filled up to each Partner's requested amount of fill within that Partner's space. Each Sites Storage Partner will be responsible for the Operation and Maintenance (O&M) costs associated with the

---

[1] *For example, if only 340 TAF of water is able to be appropriated into Sites Reservoir in any one year, this represents 20% of the total allocated storage of Sites Reservoir (340/1.69 MAF) = 20%). In that year each Sites Storage Partner will receive an amount of water equal to 20% of their allocated storage space amount.*

use of their storage allocation space as set forth below. However, a Sites Storage Partner may opt out of having water appropriated into their storage space and avoid the variable O&M costs if they so inform the Reservoir Committee at the beginning of the Water Year or as otherwise established by the Reservoir Committee. The appropriation of water into storage will take priority over the release of stored water. If needed, a dispute resolution process will be developed.

(12) Water Storage from Other Sources: There are opportunities for the Sites Storage Partners to request that the Reservoir Committee place water from sources other than that by appropriation by the Project into their storage allocation space. These other sources could include among other things: the re-diversion of previously stored water, water transfers, exchanges between Sites Storage Partners, exchanges with other entities, etc. The Reservoir Committee will take all reasonable steps to help facilitate these requests. The Sites Storage Partners will be responsible for the costs of obtaining/storing these other sources of water including any costs associated with water right changes, environmental compliance, and Reservoir Committee costs associated with reviews. Also, the Sites Storage Partner is responsible for all O&M costs of placing this water into their storage allocation space as set forth below. Placing water into storage from other sources shall not impact the ability of the Reservoir Committee to appropriate water or release water from Sites Reservoir.

(13) Storage/Release Conflict Resolution: If there is a conflict between placing water into storage in Sites Reservoir from other sources of water and the release of water from Sites Reservoir at the same time, an "in lieu storage" option may be used by the parties involved provided the water rights issues are addressed on a case-by-case basis.

ACCOUNTING FOR LOSSES

(14) Allocation of Losses: Losses of water held in Sites Reservoir storage including evaporation and seepage will be accounted for on a daily basis. These losses will be allocated to each Sites Storage Partner based proportionally on the amount of their water in storage that day.

SHARING OR LEASING OF STORAGE SPACE

(15) Sharing or Leasing of Storage Allocation Space: The Sites Storage Partners are allowed to share or lease their storage allocation space with other Sites Storage Partners or other entities. This sharing or leasing could span multiple years and will be subject to several conditions set forth below.

- Any sharing or leasing of storage allocation space shall be coordinated with the Reservoir Committee so that proper water accounting can be maintained.
- If the Sites Storage Partner's allocated storage space fills, then any shared or leased water held in that storage space that day will stay in the shared or leased space unless the Reservoir Committee receives written instructions otherwise from the Sites Storage Partner.
- The responsibility for collecting payment for the use of a Sites Storage Partners shared storage space will be the responsibility of the Sites Storage Partner and not that of the Reservoir Committee.
- The Sites Storage Partner maintains the responsibility to the Reservoir Committee for all the O&M costs of placing water of any source into its storage allocation space. However, the Sites Storage Partner will likely collect costs of placing water into any shared storage space from the party making use of that shared space.

RELEASES OF WATER FROM STORAGE

(16) Water Released From Storage: The Sites Storage Partners have total discretion on the amount of water held in their storage allocation space that they wish to be scheduled for release in any calendar year for their use. These requested stored water releases and their schedule for release shall be coordinated with the Reservoir Committee so the Reservoir Committee can coordinate this request with the other Sites Storage Partners, State Water Project, Central Valley Project and any regulations related to the release of water from Sites Reservoir.

The Reservoir Committee will work with the Department of Water Resources and the U. S. Bureau of Reclamation to manage these releases with those of the State Water Project and Central Valley Project to maximize the benefits to the above parties when possible.

It is anticipated water will be released from storage for environmental/public benefits (e.g. on behalf of the State of California per their WSIP funding investment; e.g. on behalf of the United States per WIIN Act funding investment). The Authority's intent is that the non-consumptive use of water for environmental/ public benefits will remain under the control of the Sites Authority and its Storage Partners for further allocation to another in-basin or out-of-basin uses.

(17) Scheduling Stored Water Releases: No later than February 20th of each water year, the Reservoir Committee will make a water storage forecast for each Sites Storage Partner for that water year based on each Sites Storage Partner physical storage to date and several examples of projected hydrologic conditions ranging from critically dry to far above normal. These forecasts will be updated each month by the 20th of every month until April 20th. Each Sites Storage Partner will provide the Reservoir Committee the monthly schedule and amounts of the water they wish to be released that calendar year based upon each of these forecasts 15 days after the receipt of these forecasts. These schedules will be updated monthly as needed until June and changes after that will be accommodated to the extent it does not conflict with those of other Sites Storage Partners. Any water held in a shared/leased allocation space will be the responsibility of the Sites Storage Partner to communicate the requested release of that water to the Reservoir Committee unless other arrangements are provided to the Reservoir Committee in writing.

The Reservoir Committee will work with each Sites Storage Partner, the State Water Project, Central Valley Project and regulatory agencies and make all reasonable efforts to satisfy the water release schedules requested by each Sites Storage Partner. If there is a Sites Reservoir release constraint affecting the ability of meeting the requested water release schedules from Sites Reservoir, the Reservoir Committee will first work with those conflicted Sites Storage Partners to see if accommodations can be made. If the conflict cannot be resolved, the priority for the releases will be in proportion to the Storage Allocation space as divided among the conflicted Sites Storage Partners.

OPERATION, MAINTENANCE AND REPLACEMENT

(18) Operation and Maintenance Cost Allocations: Operation and Maintenance (O&M) costs will be divided into fixed O&M&R and variable O&M. Fixed O&M&R will cover those O&M&R costs that are generally stable from year to year like monitoring costs, routine maintenance, Reservoir Committee staff costs, repair funds, replacement of equipment funds etc. These costs will be calculated by the Reservoir Committee and paid by the Sites Storage Partners for the coming Water Year in advance. They will be allocated to all the Sites Storage Partners in the same manner as the capital costs.

Annual variable O&M costs include pumping costs to appropriate water into storage, pumping water from other sources into storage, other costs related to the placement of water into storage and the costs, if any, of releasing water from storage. These costs will be assessed to each Sites Storage Partner based on the amount of water placed into their storage allocation that year. An estimate of these costs will be made by the Reservoir Committee. These costs will be assessed to each Sites Storage Partner and paid for the coming Water Year in advance. However, a Sites Storage Partner may opt out of having water appropriated into their storage space and avoid the variable O&M costs if they so inform the Reservoir Committee at the beginning of the Water Year. At the end of each Water Year any revenue received in excess of costs will be returned to the Sites Storage Partners or applied as a credit to the next year's variable O&M costs. However, the Reservoir Committee will retain a reasonable reserve fund to cover any unforeseen variable O&M costs that may come up in any year. =

(19) Power Revenue. It is recognized that the Sites Reservoir Project could generate power revenues. The use of these revenues is not part of this Storage Policy at this time.

FUTURE STORAGE POLICY CHANGES

(20) Future Storage Policy Changes - This policy is intended, at this time, for use in the Sites Participation Agreements that will be developed in the near future. This policy will likely evolve and change as the Sites Reservoir Project develops. This policy may be modified in the future by the Authority with approval by the Reservoir Committee. Under the current Bylaws, such Reservoir Committee approval requires a 75% affirmative vote.

DATE

August 26, 2019________________________________

ATTACHMENT 1

SITES STORAGE PARTNERS

ENVIRONMENTAL

WSIP - California Water Commission

WIIN- United States Bureau of Reclamation

WATER USERS

America Canyon, City of
Antelope Valley-East Kern WA
Carter Mutual Water Company
Coachella Valley Water District
Colusa County
Colusa County Water District
Desert Water Agency
Glenn-Colusa Irrigation District
MWD of So. California
Reclamation District 108
San Bernardino Valley MWD
San Gorgonio Pass WA
Santa Clara Valley WD
Santa Clarita Valley WA
TC-4 Cortina Water District
TC-4 Davis Water District
TC-4 Dunnigan Water District
TC-4 LaGrange Water District
Westside Water District
Wheeler Ridge-Maricopa WSD
Zone 7 Water Agency

Excerpt Jerry Boles, retired Chief of the Water Quality and Biology Section of the Northern District of the Department of Water Resources in Red Bluff, submitted comments on the proposed Sites Reservoir Draft Environmental Impact Report. I have pulled a few of his comments for you to read but I encourage you to view his full report for details.

"The draft fails to discuss the high concentrations of a number of metals in the source waters to the proposed project, and, even more important, does not discuss water quality in the proposed reservoir. Water quality in the proposed reservoir will mimic that of the source waters, and hence the reservoir will have concentrations of a large number of metals that exceed many water quality criteria and standards. The high concentrations of metals likely to occur in the proposed reservoir will impact most, if not all, beneficial uses of the proposed project, including agricultural supply, wildlife and fisheries, and drinking water supplies for communities that divert water from the Sacramento River, making the project potentially infeasible."

Mr. Boles has compiled source water data to illustrate his analysis and explains, "It is apparent that the preparers of the EIR failed to examine or simply ignored the available data that would show potential significant adverse impacts from the proposed project."

Boles explains that during his tenure with DWR he collected data that showed elevated levels of aluminum, arsenic, cadmium, iron, chromium, copper, lead, manganese, mercury, nickel, selenium, and zinc in the Sacramento River with the highest levels coming from tributary flows. The highest concentrations were found during the higher flow months (December through March). Many of these metals exceed a large number of criteria and standards, including those developed to protect drinking water, public health, freshwater aquatic life, and agricultural uses. Funding for water quality monitoring by DWR was curtailed in 1998 after the project manager in the Red Bluff office was informed of potential adverse impacts from metals by Boles when he was Chief of the Water Quality and Biology Section.

The Sites project plans to pull water out of the river during high water runoff events when tributaries provide 95% of the flow below Keswick Dam. Boles explains that Cottonwood Creek contributes the most significant input into the Sacramento River during high runoff events and that toxic concentrations increase during high runoff events.

The poor quality of the source water will certainly be further degraded if the water is impounded in the proposed off-stream reservoir. Boles explains, ""Extremely high concentrations of metals are present in the small streams in the reservoir footprint, which occur due to the nature of the soils in the area of the proposed reservoir. Sites Reservoir would inundate these soils resulting in leaching of metals and further incremental loading of metals to the proposed reservoir. There is no discussion in the EIR about the potential impacts of metals leaching from the soils that would be inundated by the proposed reservoir."

Releases from the proposed reservoir would occur during the summer when metals concentrations in the Sacramento River are much lower due to the majority of flow being from Shasta Reservoir, with much better water quality, though still carrying a metals load. High metals concentrations in the proposed reservoir releases could adversely affect water quality in the Sacramento River during the summer months by increasing metals loads beyond acceptable limits and adversely impact beneficial uses.

"Though high concentrations of metals that exceed water quality criteria exist in source waters to the proposed project, they cannot be regulated by governmental entities since they are natural occurrences. However, once contained artificially in a reservoir, they are subject to jurisdictional control by regulatory agencies. Any releases of water from the proposed reservoir will likely be subject to review by water quality regulatory agencies to ensure that such releases do not adversely affect downstream resources due to the heavy metals loads in the releases. The SWRCB has an antidegradation policy that prohibits discharges that would degrade water quality to a level below water quality objectives .. The contribution of additional metal loads from releases from the proposed Sites Reservoir during the summer could cause concentrations of metals in the Sacramento River to exceed criteria and standards or at least be subject to the antidegradation policy due to an incremental increase in metals in the Sacramento River from the proposed project. Thus, the proposed project may face prohibition of releases if stored water does not meet water quality criteria or standards or if releases can cause criteria or standards to be exceeded by downstream inputs (i.e., antidegradation policy)."

A factual evaluation of the available data is presented by Boles in his comments which includes detailed data sheets showing significant potential adverse impacts associated with the proposed project.

The Storage Policy was adopted by the Reservoir Project Committee on August 22, 2019 and by the Sites Project Authority on August 26, 2019. The attached Policy reflects the revisions 'as amended' referenced in the Reservoir Project Committee Minutes of August 22, 2019, to wit:

"Consider approval of a recommendation the Reservoir Committee approve the Water Storage policy and then recommend the Sites Project Authority consider adoption of the Water Storage Policy in conjunction with the development of future participation agreements. (Attachment 7-1A)

Action: It was moved by Ruiz, seconded by Davis to adopt the Water Storage Policy <u>as amended</u> and pending home board legal review. Further, recommend the Sites Project Authority also consider adoption of the Water Storage Policy in conjunction with the development of future participation agreement and further legal review of the Policy by Counsel. The motion carried unanimously."

Please also note the findings described in the August 22, 2019 memorandum to the Reservoir Project Committee "Topic: Reservoir Committee Agenda Item 7-1, Subject: Operations Workgroup - Draft Water Storage Policy", to wit:

"It is noted such approval of this policy does not result in the implementation of any Project operation or action resulting in a significant effect on the environment nor does it preclude future changes to the Water Storage Policy which are likely to be necessary as the Project proceeds."

Storage policy

BY
THE SITES PROJECT AUTHORITY

(1) This Storage Policy was adopted by the Sites Authority on 26th day of August 2019, to assist in the development and operation of the Sites Reservoir Project (Project) by the Sites Project Authority and the Sites Storage Partners listed in Attachment 1.

INTRODUCTION

(2) The Sites Project Authority (Authority) will apply for and expects to hold the water rights and be responsible for the operation of the Sites Reservoir Project with the Reservoir Committee being responsible for the planning, permitting and real-time operations implementation. There are numerous financial participants in the Sites Reservoir Project. These participants will receive water supply benefits, water supply related environmental benefits and other benefits from Sites Reservoir operation. These participants include the (1) State of California, (2) United States Bureau of Reclamation, (3) Northern California agencies and organizations, and (4) water agencies both west and south of the Sacramento-San Joaquin Delta. The participants in the Sites Reservoir Project who receive (a) water supply related benefits or (b) water supply related environmental benefits are considered Sites Storage Partners. The Sites Storage Partners will enter into agreements with the Authority for the funding of the Project and the benefits derived from the Project and may specify each Sites Storage Partner's storage space in Sites Reservoir. To the extent allowed by natural conditions, permit requirements and physical capabilities of the Project, each of these Sites Storage Partners will have control over the use of their storage allocation space based on the conditions set forth in this policy. The water supply related benefits derived from these storage allocation spaces will depend in large part on how the each Sites Storage Partner manages the water stored and released from their allocated storage space. The Reservoir Committee is responsible for accounting for all the water placed into each Sites Storage Partner's allocated storage space, water released from that storage space and any losses on a daily basis.

DEFINITIONS

(3) Sites Participants – Government Agencies, Water Organizations and others who financially contribute to the planning and construction of the Sites Reservoir Project.

(4) Sites Storage Partners – The Sites Participants who have funded and receive water supply or water supply related environmental benefits from the Sites Reservoir Project (see Attachment 1 for the list of Sites Storage Partners).

(5) Active Storage – That portion of Sites Reservoir above dead pool that can be exercised to create water supply related benefits. The total maximum storage in Sites Reservoir is expected to be 1.81 MAF. Firm dead pool storage is expected to be about 60 TAF. However, operationally another 60 TAF will likely be needed to prevent water quality issues in the storage releases. Therefore, the operational dead pool is considered to be 120 TAF. For this Policy the Active Storage for Sites Reservoir is considered to be about 1.69 MAF. These values are approximate and subject to change in the future.

(6) Water Year - The California Water Year is from October 1 through September 30.

(7) Operation and Maintenance and Replacement- (O&M) or (O&M&R). Those costs associated with the operations of the Sites Reservoir Project. These can be broken down into:

(a) Fixed operations and maintenance and replacement costs that are more stable year-to-year and that are not significantly influenced by varying diversions or releases of water, and

(b) variable operations and maintenance costs that reflect annual operations and maintenance costs that vary based on actual operations each year.

ROLES

(8) Sites Project Authority (Authority) - The Authority will apply for and expects to hold the water rights for the Sites Reservoir Project and be responsible for its operation.

(9) Reservoir Committee - The Reservoir Committee is a standing committee of the Authority and oversees the planning, permitting, and day-to-day operations and accounting of Sites Reservoir storage, releases and losses and related activities including coordination with each of the Sites Storage Partners. This will be done in a way that is open and transparent to all the Sites Storage Partners.

(10) State and Federal Agencies:

(a) The State of California - As described in Proposition 1 (2014) and associated regulations, the Sites Authority expects that the State of California will work though the California Water Commission and the Resources Agency to manage, at their request, the water held in the Sites storage allocation space obtained by the Water Commission for environmental purposes. In addition, the State of California will cooperate with the Reservoir Committee's operation of Sites Reservoir and that of the State Water Project (and if appropriate the Central Valley Project) to maximize the water supply and water supply related benefits of Sites Reservoir.

(b) The United States – To be provided.

STORAGE OF WATER

(11) Water Storage by the Appropriation of Water: The Authority will be responsible for compliance with water right provisions and other conditions that control the appropriation of water into storage in Sites Reservoir. The Authority through the Reservoir Committee will take all actions necessary to maximize the appropriation of water into storage consistent with regulatory requirements, physical constraints and hydrologic conditions. Water appropriated will be placed into Sites Reservoir and then allocated into each Sites Storage Partners contractual storage space proportional to their acquired storage space amount.[1]

Based on the water accounting system approved by the Reservoir Committee, if a Sites Storage Partner's storage volume is not available (whether due to being completely filled, filled up to the requested amount by a Storage Partner, or any other reason), the available water will be allocated to the remaining Sites Storage Partners who still have available storage allocation space and the water will be used to fill the other Sites Storage Partner's storage allocation spaces (based on their storage space allocation) until all Sites Storage Partners storage allocation spaces are filled up to each Partner's requested amount of fill within that Partner's space. Each Sites Storage Partner will be responsible for the Operation and Maintenance (O&M) costs associated with the

---

[1] *For example, if only 340 TAF of water is able to be appropriated into Sites Reservoir in any one year, this represents 20% of the total allocated storage of Sites Reservoir (340/1.69 MAF) = 20%). In that year each Sites Storage Partner will receive an amount of water equal to 20% of their allocated storage space amount.*

use of their storage allocation space as set forth below. However, a Sites Storage Partner may opt out of having water appropriated into their storage space and avoid the variable O&M costs if they so inform the Reservoir Committee at the beginning of the Water Year or as otherwise established by the Reservoir Committee. The appropriation of water into storage will take priority over the release of stored water. If needed, a dispute resolution process will be developed.

(12) Water Storage from Other Sources: There are opportunities for the Sites Storage Partners to request that the Reservoir Committee place water from sources other than that by appropriation by the Project into their storage allocation space. These other sources could include among other things: the re-diversion of previously stored water, water transfers, exchanges between Sites Storage Partners, exchanges with other entities, etc. The Reservoir Committee will take all reasonable steps to help facilitate these requests. The Sites Storage Partners will be responsible for the costs of obtaining/storing these other sources of water including any costs associated with water right changes, environmental compliance, and Reservoir Committee costs associated with reviews. Also, the Sites Storage Partner is responsible for all O&M costs of placing this water into their storage allocation space as set forth below. Placing water into storage from other sources shall not impact the ability of the Reservoir Committee to appropriate water or release water from Sites Reservoir.

(13) Storage/Release Conflict Resolution: If there is a conflict between placing water into storage in Sites Reservoir from other sources of water and the release of water from Sites Reservoir at the same time, an "in lieu storage" option may be used by the parties involved provided the water rights issues are addressed on a case-by-case basis.

ACCOUNTING FOR LOSSES

(14) Allocation of Losses: Losses of water held in Sites Reservoir storage including evaporation and seepage will be accounted for on a daily basis. These losses will be allocated to each Sites Storage Partner based proportionally on the amount of their water in storage that day.

SHARING OR LEASING OF STORAGE SPACE

(15) Sharing or Leasing of Storage Allocation Space: The Sites Storage Partners are allowed to share or lease their storage allocation space with other Sites Storage Partners or other entities. This sharing or leasing could span multiple years and will be subject to several conditions set forth below.

- Any sharing or leasing of storage allocation space shall be coordinated with the Reservoir Committee so that proper water accounting can be maintained.
- If the Sites Storage Partner's allocated storage space fills, then any shared or leased water held in that storage space that day will stay in the shared or leased space unless the Reservoir Committee receives written instructions otherwise from the Sites Storage Partner.
- The responsibility for collecting payment for the use of a Sites Storage Partners shared storage space will be the responsibility of the Sites Storage Partner and not that of the Reservoir Committee.
- The Sites Storage Partner maintains the responsibility to the Reservoir Committee for all the O&M costs of placing water of any source into its storage allocation space. However, the Sites Storage Partner will likely collect costs of placing water into any shared storage space from the party making use of that shared space.

RELEASES OF WATER FROM STORAGE

(16) Water Released From Storage: The Sites Storage Partners have total discretion on the amount of water held in their storage allocation space that they wish to be scheduled for release in any calendar year for their use. These requested stored water releases and their schedule for release shall be coordinated with the Reservoir Committee so the Reservoir Committee can coordinate this request with the other Sites Storage Partners, State Water Project, Central Valley Project and any regulations related to the release of water from Sites Reservoir.

The Reservoir Committee will work with the Department of Water Resources and the U. S. Bureau of Reclamation to manage these releases with those of the State Water Project and Central Valley Project to maximize the benefits to the above parties when possible.

It is anticipated water will be released from storage for environmental/public benefits (e.g. on behalf of the State of California per their WSIP funding investment; e.g. on behalf of the United States per WIIN Act funding investment). The Authority's intent is that the non-consumptive use of water for environmental/ public benefits will remain under the control of the Sites Authority and its Storage Partners for further allocation to another in-basin or out-of-basin uses.

(17) Scheduling Stored Water Releases: No later than February 20th of each water year, the Reservoir Committee will make a water storage forecast for each Sites Storage Partner for that water year based on each Sites Storage Partner physical storage to date and several examples of projected hydrologic conditions ranging from critically dry to far above normal. These forecasts will be updated each month by the 20th of every month until April 20th. Each Sites Storage Partner will provide the Reservoir Committee the monthly schedule and amounts of the water they wish to be released that calendar year based upon each of these forecasts 15 days after the receipt of these forecasts. These schedules will be updated monthly as needed until June and changes after that will be accommodated to the extent it does not conflict with those of other Sites Storage Partners. Any water held in a shared/leased allocation space will be the responsibility of the Sites Storage Partner to communicate the requested release of that water to the Reservoir Committee unless other arrangements are provided to the Reservoir Committee in writing.

The Reservoir Committee will work with each Sites Storage Partner, the State Water Project, Central Valley Project and regulatory agencies and make all reasonable efforts to satisfy the water release schedules requested by each Sites Storage Partner. If there is a Sites Reservoir release constraint affecting the ability of meeting the requested water release schedules from Sites Reservoir, the Reservoir Committee will first work with those conflicted Sites Storage Partners to see if accommodations can be made. If the conflict cannot be resolved, the priority for the releases will be in proportion to the Storage Allocation space as divided among the conflicted Sites Storage Partners.

OPERATION, MAINTENANCE AND REPLACEMENT

(18) Operation and Maintenance Cost Allocations: Operation and Maintenance (O&M) costs will be divided into fixed O&M&R and variable O&M. Fixed O&M&R will cover those O&M&R costs that are generally stable from year to year like monitoring costs, routine maintenance, Reservoir Committee staff costs, repair funds, replacement of equipment funds etc. These costs will be calculated by the Reservoir Committee and paid by the Sites Storage Partners for the coming Water Year in advance. They will be allocated to all the Sites Storage Partners in the same manner as the capital costs.

Annual variable O&M costs include pumping costs to appropriate water into storage, pumping water from other sources into storage, other costs related to the placement of water into storage and the costs, if any, of releasing water from storage. These costs will be assessed to each Sites Storage Partner based on the amount of water placed into their storage allocation that year. An estimate of these costs will be made by the Reservoir Committee. These costs will be assessed to each Sites Storage Partner and paid for the coming Water Year in advance. However, a Sites Storage Partner may opt out of having water appropriated into their storage space and avoid the variable O&M costs if they so inform the Reservoir Committee at the beginning of the Water Year. At the end of each Water Year any revenue received in excess of costs will be returned to the Sites Storage Partners or applied as a credit to the next year's variable O&M costs. However, the Reservoir Committee will retain a reasonable reserve fund to cover any unforeseen variable O&M costs that may come up in any year.

(19) Power Revenue. It is recognized that the Sites Reservoir Project could generate power revenues. The use of these revenues is not part of this Storage Policy at this time.

FUTURE STORAGE POLICY CHANGES

(20) Future Storage Policy Changes - This policy is intended, at this time, for use in the Sites Participation Agreements that will be developed in the near future. This policy will likely evolve and change as the Sites Reservoir Project develops. This policy may be modified in the future by the Authority with approval by the Reservoir Committee. Under the current Bylaws, such Reservoir Committee approval requires a 75% affirmative vote.

DATE

August 26, 2019______________________________

ATTACHMENT 1

SITES STORAGE PARTNERS

ENVIRONMENTAL

WSIP - California Water Commission

WIIN- United States Bureau of Reclamation

WATER USERS

America Canyon, City of
Antelope Valley-East Kern WA
Carter Mutual Water Company
Coachella Valley Water District
Colusa County
Colusa County Water District
Desert Water Agency
Glenn-Colusa Irrigation District
MWD of So. California
Reclamation District 108
San Bernardino Valley MWD
San Gorgonio Pass WA
Santa Clara Valley WD
Santa Clarita Valley WA
TC-4 Cortina Water District
TC-4 Davis Water District
TC-4 Dunnigan Water District
TC-4 LaGrange Water District
Westside Water District
Wheeler Ridge-Maricopa WSD
Zone 7 Water Agency

Ad Hoc Operations and Engineering Workgroup Agenda

Date: June 10, 2020 **Location:** Webex meeting

Time: 10:00 AM to 11:30 AM

Leader: Robert Kunde **Recorder:** HDR – Sites Integration

Purpose: Ongoing update for the Ad Hoc for the Operations and Engineering Workgroup for 2020

Attendees:

Mike Azevedo, Colusa County
Thad Bettner, GCID
Robert Cheng, CVWD
Rob Cooke, DWR
Amparo Flores, Zone 7
Katrina Jessop, Valley Water
Rick Kaufman (A), American Canyon
Robert Kunde, WRMWSD
Eric Leitterman, Valley Water

Wes Mercado, Zone 7
Dirk Marks (A), SCVWD
Randall Neudeck, MWD
Dan Ruiz, WWD
Jeff Sutton (A), TCCA
Bob Tincher, SBVMWD
Bill Vanderwaal, RD 108
Jerry Brown, Sites Authority
Ali Forsythe, Sites Authority

Erin Heydinger, Sites Integration
Rob Leaf, CH2M
Henry Luu, Sites Integration
John Spranza, Sites Integration
Rob Tull, CH2M

(A) Indicates alternate

Agenda:

Discussion Topic	Topic Leader	Time Allotted
1. Introductory Remarks	Kunde/Azevedo	5 min
2. Agenda Overview	Forsythe	5 min
3. Engineering Update	Luu	10 min
4. Modeling Baseline	Tull	45 min
5. Shasta Exchanges		
a. Principles of Agreement	Forsythe	10 min
b. Operational Parameters	Tull	20 min
6. Diversion Scenarios Results	Tull	30 min
7. Demand Patterns	Tull	10 min
8. Organizational Asssessment – Negotiations Approach	Forsythe	10 min
9. Recap and Schedule Next Call	Forsythe	5 min

From: Jerry Brown [jbrown@sitesproject.org]
Sent: 6/9/2020 7:06:19 AM
To: Robert Cheng [RCheng@cvwd.org]
CC: Mark Krause (mkrause@dwa.org) [mkrause@dwa.org]; Marcia Kivett [MKivett@sitesproject.org]; Sylvia Bermudez [SBermudez@cvwd.org]
Subject: Re: Reduced reliance language, CCR Title 23, Division 6, Section 5003
Attachments: 138_DeltaStewardship_DEIR_Comments_050218[1].pdf; 34_Delta-Council_DEIR_Comments_011618[1].pdf

For our call this afternoon. The May letter clarifies that Sites would not be considered a covered action under the Delta Plan and would not need a consistency determination from the DSC.

From: Robert Cheng <RCheng@cvwd.org>
Date: Friday, June 5, 2020 at 1:50 PM
To: Jerry Brown <jbrown@sitesproject.org>
Cc: "Mark Krause (mkrause@dwa.org)" <mkrause@dwa.org>, Marcia Kivett <MKivett@sitesproject.org>, Sylvia Bermudez <SBermudez@cvwd.org>
Subject: RE: Reduced reliance language, CCR Title 23, Division 6, Section 5003

Thanks Jerry.

Marcia, please feel free to work directly with Sylvia Bermudez, CVWD's Board Clerk, on my availability.

Thanks,
Robert

From: Jerry Brown <jbrown@sitesproject.org>
Sent: Friday, June 5, 2020 1:48 PM
To: Robert Cheng <RCheng@cvwd.org>
Cc: Mark Krause (mkrause@dwa.org) <mkrause@dwa.org>; Marcia Kivett <MKivett@sitesproject.org>
Subject: Re: Reduced reliance language, CCR Title 23, Division 6, Section 5003

Hi Robert and Mark - yes let's discuss on a phone call next week. We have discussed Sites with DSC staff and can report on that conversation.

Marcia can schedule this for us when she returns on Monday.

Sent from my iPhone

On Jun 5, 2020, at 1:17 PM, Robert Cheng <rcheng@cvwd.org> wrote:

Jerry,

As we're gearing up towards having discussions with our home boards, many of us are also preparing the 2020 urban water management plan. As you are probably aware, there has been more discussions surrounding the Delta Stewardship Council's influence in the water rights process. One of the issues that the State Water Contractors have been discussing is topic of reduced reliance from water sources from the Delta. A link to the CCR language is provide in this link.

https://govt.westlaw.com/calregs/Document/I201CA5F007AA11E39A73EBDA152904D8?viewType=FullText&originationContext=documenttoc&transitionType=CategoryPageItem&contextData=(sc.Default)

I'm trying to remember whether if we've had discussions regarding this topic during our reservoir committee meetings, and don't believe this has taken place. I have several questions surrounding this topic as related to the Sites water (i.e. is it considered a Delta water source, covered action under the DSC). The outcome of these discussions could have a significant impact on our agencies' continued participation in the project. I wanted to reach out and see if you were aware of this issue, and to strategize on the best path forward recognizing this is potentially yet another bridge that we have to cross.

Let me know if a phone call to discuss is warranted?

Thanks,
Robert

Robert C. Cheng, Ph.D., P.E.
Assistant General Manager
Coachella Valley Water District

From: Heydinger, Erin [Erin.Heydinger@hdrinc.com]
Sent: 6/9/2020 8:15:33 AM
To: Alicia Forsythe [aforsythe@sitesproject.org]
Subject: RE: Workgroup Draft Agenda

Rob Cooke will be on the call tomorrow. Is it okay if he hears the Negotiations Approach item?

Erin Heydinger PE, PMP
D 916.679.8863 M 651.307.9758

hdrinc.com/follow-us

From: Alicia Forsythe <aforsythe@sitesproject.org>
Sent: Monday, June 8, 2020 8:50 AM
To: Heydinger, Erin <Erin.Heydinger@hdrinc.com>; Jerry Brown <jbrown@sitesproject.org>
Subject: RE: Workgroup Draft Agenda

CAUTION: [EXTERNAL] This email originated from outside of the organization. Do not click links or open attachments unless you recognize the sender and know the content is safe.

It would be separate from the Shasta Exchanges. Its more of a Sites "procedure" on how we would approach negotiations.

Thanks Erin!

Ali

Alicia Forsythe | Environmental Planning and Permitting Manager | Sites Reservoir Project | 916.880.0676 | aforsythe@sitesproject.org | www.SitesProject.org

CONFIDENTIALITY NOTICE: This communication with its contents may contain confidential and/or legally privileged information. It is solely for the use of the intended recipient(s). Unauthorized interception, review, use or disclosure is prohibited and may violate applicable laws including the Electronic Communications Privacy Act. If you are not the intended recipient, please contact the sender and destroy all copies of the communication.

From: Heydinger, Erin <Erin.Heydinger@hdrinc.com>
Sent: Monday, June 8, 2020 7:37 AM
To: Alicia Forsythe <aforsythe@sitesproject.org>; Jerry Brown <jbrown@sitesproject.org>
Subject: RE: Workgroup Draft Agenda

Sounds good, I'll add it. Is that separate from the Shasta Exchanges agreement item or would those slides move in to the Negotiations Approach part of the agenda?

Thanks,
Erin

Erin Heydinger PE, PMP
D 916.679.8863 M 651.307.9758

hdrinc.com/follow-us

From: Alicia Forsythe <aforsythe@sitesproject.org>
Sent: Monday, June 8, 2020 6:50 AM
To: Jerry Brown <jbrown@sitesproject.org>; Heydinger, Erin <Erin.Heydinger@hdrinc.com>
Subject: RE: Workgroup Draft Agenda

CAUTION: [EXTERNAL] This email originated from outside of the organization. Do not click links or open attachments unless you recognize the sender and know the content is safe.

Yes. We should. Good catch. We have it on the environmental work group agenda but completely forgot it here.

Erin, can you insert "Organization Assessment Item – Negotiations Approach" as #8 and allocate it 10 mins? Lets take Demand Patterns down to 10 mins and Modeling Baseline down to 45 mins to make up the time. I can keep the recap and next call super short if we are running low on time to fit all of this in.

Ali

Alicia Forsythe | Environmental Planning and Permitting Manager | Sites Reservoir Project | 916.880.0676 | aforsythe@sitesproject.org | www.SitesProject.org

CONFIDENTIALITY NOTICE: This communication with its contents may contain confidential and/or legally privileged information. It is solely for the use of the intended recipient(s). Unauthorized interception, review, use or disclosure is prohibited and may violate applicable laws including the Electronic Communications Privacy Act. If you are not the intended recipient, please contact the sender and destroy all copies of the communication.

From: Jerry Brown <jbrown@sitesproject.org>
Sent: Sunday, June 7, 2020 12:36 PM
To: Heydinger, Erin <Erin.Heydinger@hdrinc.com>; Alicia Forsythe <aforsythe@sitesproject.org>
Subject: Re: Workgroup Draft Agenda

Shouldn't we review the proposed negotiations approach at this meeting and the environmental planning and permitting workgroup meeting?

From: "Heydinger, Erin" <Erin.Heydinger@hdrinc.com>
Date: Friday, June 5, 2020 at 11:38 AM
To: Michael Azevedo <mjazevedo@countyofcolusa.com>, Rob Kunde <rkunde@wrmwsd.com>
Cc: Alicia Forsythe <aforsythe@sitesproject.org>, "Robert.Tull (Robert.Tull@jacobs.com)" <Robert.Tull@jacobs.com>, Jerry Brown <jbrown@sitesproject.org>
Subject: Workgroup Draft Agenda

Hi Rob and Mike,

Attached for your review is a draft agenda for next week's Workgroup meeting. Please get back to me if you have any changes or other topics we need to cover. I hope to send this out midday Monday and will also include a draft memo on the modeling baseline that CH put together.

Thanks, and have a great weekend!
Erin

Erin Heydinger, PE, PMP
Asst. Project Manager
Water/Wastewater

HDR

2379 Gateway Oaks Dr, #200
Sacramento, CA 95833
D 916.679.8863 M 651.307.9758

hdrinc.com/follow-us

Ad Hoc Operations and Engineering Workgroup Agenda

Sites
Program Management Team

Date: June 10, 2020 **Location:** Webex meeting

Time: 10:00 AM to 11:30 AM

Leader: Robert Kunde **Recorder:** HDR – Sites Integration

Purpose: Ongoing update for the Ad Hoc for the Operations and Engineering Workgroup for 2020

Attendees:

Mike Azevedo, Colusa County
Thad Bettner, GCID
Robert Cheng, CVWD
Rob Cooke, DWR
Amparo Flores, Zone 7
Katrina Jessop, Valley Water
Rick Kaufman (A), American Canyon
Robert Kunde, WRMWSD
Eric Leitterman, Valley Water
Wes Mercado, Zone 7
Dirk Marks (A), SCVWD
Randall Neudeck, MWD
Dan Ruiz, WWD
Jeff Sutton (A), TCCA
Bob Tincher, SBVMWD
Bill Vanderwaal, RD 108
Jerry Brown, Sites Authority
Ali Forsythe, Sites Authority
Erin Heydinger, Sites Integration
Rob Leaf, CH2M
Henry Luu, Sites Integration
John Spranza, Sites Integration
Rob Tull, CH2M

(A) Indicates alternate

Agenda:

Discussion Topic	**Topic Leader**	**Time Allotted**
1. Introductory Remarks	Kunde/Azevedo	5 min
2. Agenda Overview	Forsythe	5 min
3. Engineering Update	Luu	10 min
4. Modeling Baseline	Tull	45 min
5. Shasta Exchanges		
a. Principles of Agreement	Forsythe	10 min
b. Operational Parameters	Tull	20 min
6. Diversion Scenarios Results	Tull	30 min
7. Demand Patterns	Tull	10 min
8. Organizational Asssessment – Negotiations Approach	Forsythe	10 min
9. Recap and Schedule Next Call	Forsythe	5 min

Ad Hoc Operations and Engineering Workgroup Agenda

Sites
Program Management Team

Date: June 10, 2020 **Location:** Webex meeting

Time: 2:30 PM to 5:00 PM

Leader: Robert Kunde **Recorder:** HDR – Sites Integration

Purpose: Ongoing update for the Ad Hoc for the Operations and Engineering Workgroup for 2020

Attendees:

Mike Azevedo, Colusa County
Thad Bettner, GCID
Robert Cheng, CVWD
Rob Cooke, DWR
Amparo Flores, Zone 7
Katrina Jessop, Valley Water
Rick Kaufman (A), American Canyon
Robert Kunde, WRMWSD
Eric Leitterman, Valley Water
Wes Mercado, Zone 7
Dirk Marks (A), SCVWD
Randall Neudeck, MWD
Dan Ruiz, WWD
Jeff Sutton (A), TCCA
Bob Tincher, SBVMWD
Bill Vanderwaal, RD 108
Jerry Brown, Sites Authority
Ali Forsythe, Sites Authority
Erin Heydinger, Sites Integration
Rob Leaf, CH2M
Henry Luu, Sites Integration
John Spranza, Sites Integration
Rob Tull, CH2M

(A) Indicates alternate

Agenda:

Discussion Topic	**Topic Leader**	**Time Allotted**
1. Introductory Remarks	Kunde/Azevedo	5 min
2. Agenda Overview	Forsythe	5 min
3. Engineering Update	Luu	10 min
4. Modeling Baseline	Tull	45 min
5. Shasta Exchanges		
a. Principles of Agreement	Forsythe	10 min
b. Operational Parameters	Tull	20 min
6. Diversion Scenarios Results	Tull	30 min
7. Demand Patterns	Tull	10 min
8. Organizational Asssessment – Negotiations Approach	Forsythe	10 min
9. Recap and Schedule Next Call	Forsythe	5 min

~~Permitting~~ Regulatory Agency Technical Working Groups Approach

The following two technical working groups will be established to facilitate regular communication and coordination with state, federal and local agencies ~~assist in communication and coordination~~ during the permitting efforts for the Sites Reservoir Project. These groups are expected to be in place thru~~u~~ Amendment 2 efforts (~~thru~~ e.g., the end of 2021) and likely into Phase 3 efforts (post 2021). Additional technical working groups may be added as permitting activities progress depending on need. It is important to note that these groups are not intended to ~~supplant~~ replace or supersede focused discussions and meetings with specific agencies, but rather facilitate a common understanding and basis of Project-wide and Fisheries/Operations ~~issues~~knowledge and dialogue.

Group 1: Interagency General Update and Coordination Meetings

- **Purpose**: Quarterly meetings to efficiently update and coordinate with all and state, ~~and~~ federal and local regulatory and/or partnering agencies. Items to be include in the meeting agenda would include general updates on project status, design efforts, status of permit development, status of working thru any key considerations that may affect all permits, and upcoming items. Attendees would also be asked to update on permit processing status (if a permit application has been submitted and permit development is in process), update on any changes in their organizations, law or regulation that may affect Sites, and identify any information needs or concerns they may have. Specific items, information requests, or concerns would be identified and a process developed for resolution with the relevant agencies and the Sites team.

- **Potential Attendees**: This meeting would be open to any agency that had an interest. Potential attendees would be broad and could include the following:
    - United States Fish and Wildlife Service (USFWS)
    - Bureau of Reclamation (Reclamation)
    - Bureau of Indian Affairs (BIA)
    - National Marine Fisheries Service (NMFS)
    - Natural Resources Conservation Service (NRCS)
    - United States Army Corps of Engineers (USACE)
    - United States Environmental Protection Agency (USEPA)
    - Western Area Power Administration (WAPA)
    - California Department of Fish and Wildlife (CDFW)
    - California Department of Transportation (Caltrans)
    - California Department of Water Resources (DWR)
    - California Office of Historic Preservation - State Historic Preservation Officer (SHPO)
    - ~~California State Lands Commission~~
    - California State Water Resources Control Board
    - Central Valley Regional Water Quality Control Board
    - Central Valley Flood Protection Board
    - County of Colusa, Planning
    - County of Yolo, Planning
    - ~~California Northern Railroad~~

Group 2: Fishery and Operations Technical Meetings

- **Purpose**: Focused, as needed, fishery and operations meetings to review and discuss the modeling approach, analysis approach, operational criteria and the resulting effects to species of the Project. These meetings are intended to stimulate collaboration and early input into the fisheries and operational components and analysis and are anticipated to include technical, detailed discussion of topics.

- **Potential Attendees**: Potential attendees could include the following:
    - United States Fish and Wildlife Service (USFWS)
    - Bureau of Reclamation (Reclamation)
    - National Marine Fisheries Service (NMFS)
    - California Department of Fish and Wildlife (CDFW)
    - Additional agencies, depending on topics and authority

HOW

Water Management Investments

IMPROVE THE ENVIRONMENT
IN NORTHERN CALIFORNIA

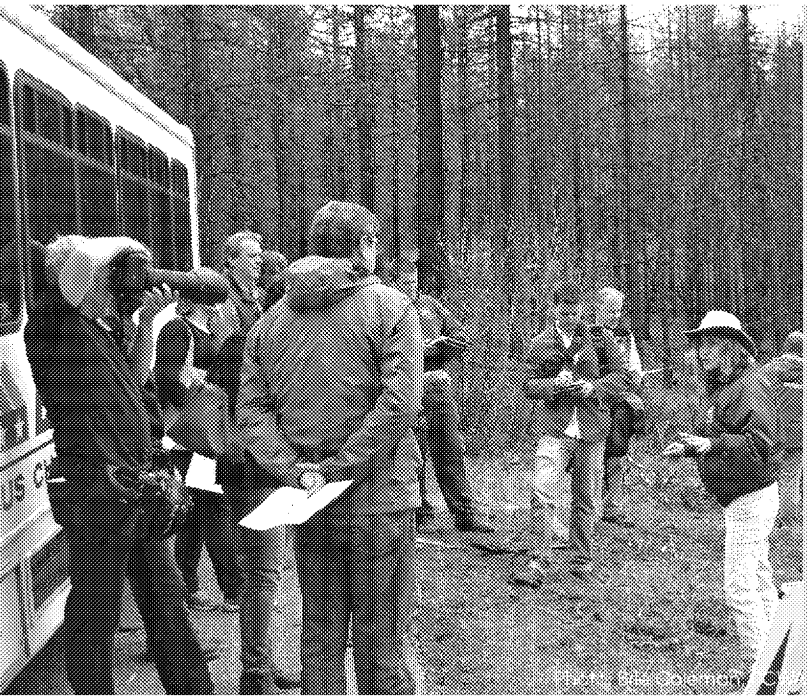
Water suppliers in the Sacramento River basin are working closely with federal and state agencies and conservation and community organizations to improve their operations and modernize infrastructure. Rural and urban organizations have joined together as the North State Water Alliance (Alliance) to manage water resources for future generations. The north state region is home to over three million people and California's state Capitol.

The American, Feather, Yuba and Sacramento rivers provide water for cities and urban areas, rural communities, farms and ranches, fish and wildlife and recreation benefits. It is critically important to guarantee reliable and high-quality water for a strong business climate, ready workforce, high quality of life, healthy environment and vibrant communities.

NORTH STATE
WATER ALLIANCE
UNIFIED FUTURE

NATURAL INFRASTRUCTURE

North State Water Alliance members have unique opportunities to use natural infrastructure to better manage our aquifers, forests and floodplains.



◀ Healthy Forests Have Multiple Benefits

Forests and meadows in the Sierra Nevada, Coastal Range and Cascade Mountains are primary water sources for the mountain and foothill communities, most of the Sacramento River basin and throughout California. Healthy headwaters:

- increase water supply reliability.
- improve water quality.
- reduce impacts from catastrophic wildfires.
- increase renewable energy supplies.
- enhance habitat.
- improve response to climate change and extreme weather.

Responsible and active forest management is a foundational element for watershed uses. Examples include:

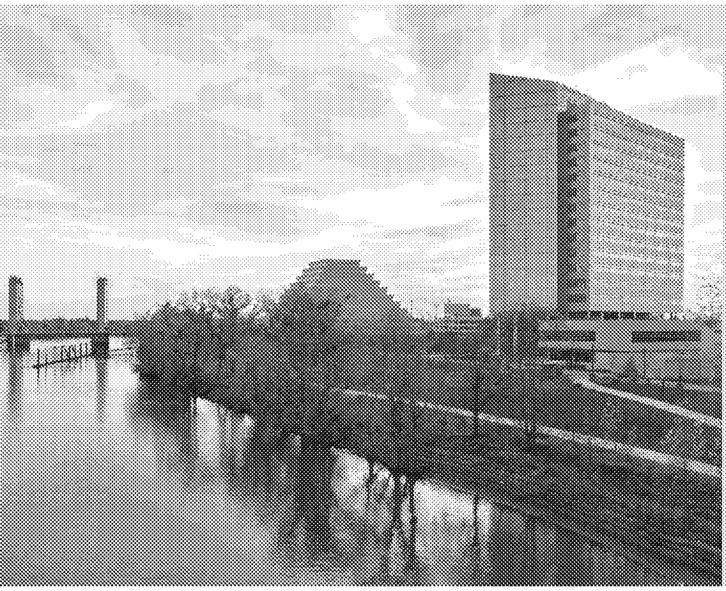
- Upper Mokelumne River Watershed Authority Master Stewardship Agreement
- Placer County Water Agency's French Meadows Forest Restoration Program
- Yuba Water Agency's watershed restoration activities through Forest Resilience Bonds

▶ Reactivating Floodplains Protects Public Safety and Ecosystems

The Sacramento River basin is fertile ground to reactivate our floodplains, which can enhance river ecosystems and public safety during flood events. Through practical experience, flood and water resources managers, working with conservation partners, have developed the best available science to re-activate floodplains.

Through dynamic conservation strategies, partners collaborate to improve California's ecosystems and water systems to:

- sustain the return of migratory birds along the Pacific Flyway.
- revitalize river food webs to support recovery of salmon and other fish populations.
- recharge groundwater aquifers.
- improve flood protection from increasing storm severity and a changing climate.



◀ Groundwater Recharge Improves Dry-Year Benefits

Alliance members are developing natural infrastructure for active groundwater management and additional aquifer recharge. The Sacramento Regional Water Bank is an innovative groundwater storage program to store water in the underlying basin during wet periods for use during dry periods now and in the future.

The Sacramento region's unique, natural infrastructure is ideal for the Water Bank. We are situated at the confluence of the Sacramento and American rivers near Folsom Reservoir and the North American and South American river sub-basins.

The Water Bank and other programs actively recharge aquifers throughout the basin. Using a multi-benefit approach helps enhance climate resiliency, support environmental needs, provide improved water management flexibility and other benefits.

21ST CENTURY INFRASTRUCTURE

Alliance members support new and improved 21st Century infrastructure to ensure climate resiliency and better prepare our region for floods, fires and droughts.

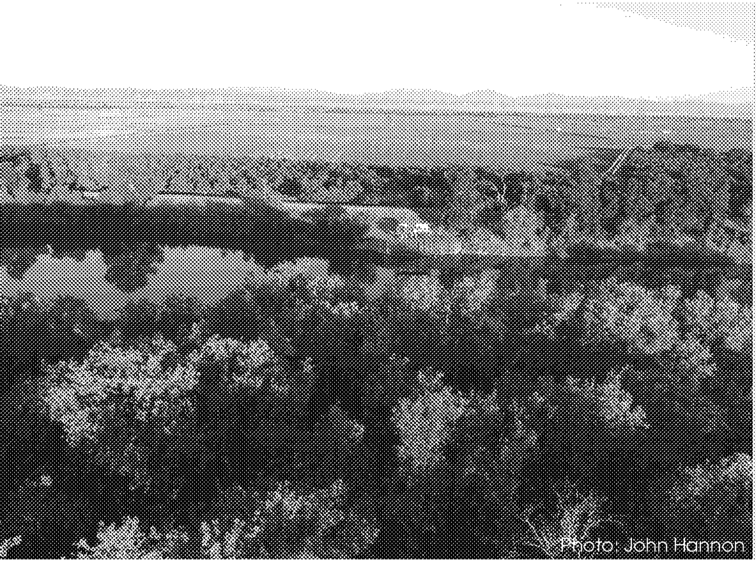


Photo: John Hannon

◀ Sites Reservoir Will Enhance Dry-Year Supply

Climate change is forecasted to drastically reduce snowpack and alter precipitation patterns. Water managers see a strong need for 21st century investments like Sites Reservoir to enhance:

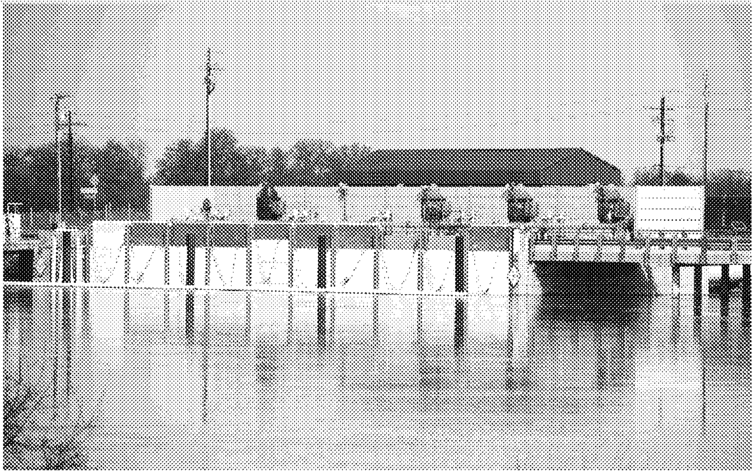
- water management flexibility
- the ecosystem
- climate resiliency
- future dry-year supply

Sites new style of infrastructure as an off-stream, regulating reservoir will store water by capturing it during high runoff periods and releasing it when needed. With its location upstream of the Delta and near the Sacramento River, water from Sites will support multiple benefits in the Sacramento River basin, the Delta and the rest of California. This includes helping California's farms, businesses and cities have a reliable water supply.

▶ RiverArc Will Support Healthy Riverine Habitat

Residents in the Sacramento area receive most their water from the American River. Water purveyors in the region are looking "into other water supply sources to protect fish habitat in the scenic American River and provide alternate supply.

RiverArc will help Sacramento water providers follow through on water supply agreements, meet current and future drinking water demands, protect fish species and provide climate change resiliency. Using existing, modern fish screens with excess capacity, RiverArc will require two new facilities: a water treatment plant and pipelines to move water through the system.



A FOCUS ON FIXING, NOT FIGHTING


Photo: Brie Coleman, PCWA

◀ Advancing Voluntary Agreements

The Alliance supports voluntary agreements as a better alternative to regulatory processes such as the State Water Board's Water Quality Control Plan Update. Alliance water providers are coordinating 15-year agreements with:

- California Natural Resources Agency
- U.S. Bureau of Reclamation
- State and Federal water contractors

Natural infrastructure and Sites Reservoir are important elements of voluntary agreements.

The comprehensive proposal helps meet water quality objectives in the State Board's Bay-Delta Plan. This is a more collaborative alternative to the traditional adversarial State Water Board hearing process. The agreements include a portfolio of instream flows, reactivated floodplains and habitat restoration measures to benefit fish and wildlife.

Northern California Plans for Their Water Future

CALIFORNIA'S NORTH STATE is a unique place to live, work and raise a family. Our region is on the leading edge of ecological and economical sustainability. The Sacramento River basin is world-renowned for its natural abundance of productive farmlands, wildlife refuges and managed wetlands, and rivers that support and feed fisheries and natural habitats.

The basin nourishes and sustains agriculture fields, fish and wildlife habitats, recreation and a high quality of life. Through planning and multi-use projects, North State Water Alliance members will provide water for California's future success and prosperity.

NORTH STATE WATER ALLIANCE
UNIFIED FUTURE

NCWA
Northern California Water Association

David J. Guy
President
dguy@norcalwater.org
916-442-8333

Mountain Counties
Water Resources Association

John Kingsbury
Executive Director
executivedirector.
mcwra11@gmail.com
530-957-7879

RWA
Regional Water Authority

Jim Peifer
Executive Director
jpeifer@rwah2o.org
916-967-7692

Photo: Bob D'Elia, PCWA

Sites Water Quality Meeting

Sites Reservoir Project

Date: *June 15, 2020* **Location:** *Webex*

Time: 10:00 am – 11:00 am

Purpose: Re-initiate discussions and approach for addressing the water quality comments made on the Draft EIR/S and identify and discus new items associated with the revised Project.

Invitees:

Ali Forsythe, Sites Authority	Monique Briard, ICF	Erin Heydinger, Integration
Steve Micko, Jacobs	Anne Huber, ICF	John Spranza, Integration
Jeff Herrin, AECOM	Nicole Williams, ICF	Laurie Warner Herson, Integration
Pete Rude, Jacobs	Jim Lecky, ICF	

Action Item		Owner	Deadline	Notes
1				
2				
3				
5				
6				
7				
8				

Agenda:

Discussion Topic **Topic Leader** **Est Time**

1. Overview and Purpose John Spranza 20 min
    a. Introductions and Overview
    b. Previous Water Quality Topics
        i. EIR/EIS Comments
        ii. Trinity River
        iii. Others?
    c. New Water Quality Topics
        i. Colusa Basin Drain
        ii. Discharge Temperature
        iii. VA Conflicts
        iv. Others?

2. Addressing Water Quality Topics a. Previous Efforts b. Current Efforts c. Additional Efforts Needed	John Spranza	30 min
3. Next Steps	Group discussion	10 min

Meeting Notes

SITES RESERVOIR MESSAGE PLATFORM

Updated ~~April 28, 2020~~June 10, 2020

KEY MESSAGE 1 *SITES RESERVOIR IS A 21st CENTURY MULTI-BENEFIT SOLUTION TO CALIFORNIA'S WATER RELIABILITY CHALLENGES*

- The Sites Project Authority is **working in collaboration** with a **broad coalition** of project participants and stakeholders - **throughout California** – to address our **statewide water supply challenges and create a resilient water future**.

- Sites Reservoir is a generational opportunity to construct a multi-benefit water storage project that helps **restore flexibility, reliability, and resiliency** to our **statewide** water supply.

- No other storage project currently under consideration in California can **positively influence the operational efficiencies of our existing statewide water system** like Sites Reservoir.

- Sites is **not a "traditional" reservoir project**. It is an **off-stream facility** that **does not dam a major river system** and would **not block fish migration or spawning.**

- Sites **captures and stores stormwater flows** from the **Sacramento River**—after all other water rights and regulatory requirements are met—**for release primarily in dry and critical years** for **environmental use** and for California **communities, farms, and businesses** when it is so desperately **needed**.

- ~~Sites is designed to be **adaptable to a changing climate**. As snowpack declines due to **climate change** and more of our water comes in the form of **atmospheric rivers** – Sites Reservoir will **become even more vital to the future resiliency of our statewide water supply.**~~

Commented [KS1]: Rewording and moving to key message 3

- Sites will be cooperatively managed in conjunction with both the State Water Project and Central Valley Project and **will greatly increase the flexibility, reliability and resiliency of statewide water supplies in drier years for environmental, agricultural, and urban uses.**

KEY MESSAGE 2 *OUR STRENGTH IS IN OUR DIVERSE STATEWIDE PARTICIPATION*

- The agencies participating in Sites Reservoir are diverse, representing **major urban centers** and **rural agricultural regions** across California.

- **Broad statewide representation** including the **local counties** where the project is located, along with **cities**, and **water** and **irrigation districts** throughout the **Sacramento Valley, San Joaquin Valley, Bay Area, and Southern California**.

- Sites participants provide water for over **24 million Californians** and over **500,000 acres of farmland** throughout California.

Formatted: List Paragraph, No bullets or numbering

Formatted: Font: Bold

Formatted: Font: Bold

- Working in **close collaboration** with **California Department of Water Resources** and **Bureau of Reclamation** to add **operational flexibility** to the **State Water Project** and **Central Valley Project.**

- **Spirit of teamwork and regional collaboration** to advance a practical solution for our statewide water management challenges.

KEY MESSAGE 3 *SITES RESERVOIR IS A "RIGHT SIZED" PROJECT THAT WILL MEET OUR WATER SUPPLY NEEDS FOR TODAY AND IN THE FUTURE*

The Sites Project Authority conducted a **rigorous Value Planning effort** to review the project's proposed operations and facilities **to develop a project that is "right sized" for our investors and participants while still providing water supply reliability and enhancing the environment.**

Formatted: Font: Not Bold

Formatted: Indent: Left: 0.5", No bullets or

The recommended project is a 1.5 million acre-foot reservoir – with a **smaller footprint** that **costs less** than the original proposal, **reduces impacts to the environment** and identifies **new opportunities to benefit key natural resources**, while providing a tremendous amount of **flexibility** to manage the project for the greatest overall benefit to the State.

Formatted: Font: Bold

Formatted: Font: Bold

Formatted: Font: Bold

Formatted: Font: Bold

Formatted: Font: Bold

Formatted: Indent: Left: 0.5", No bullets or

- The rightsized project is roughly $2 Billion less than the 2017 preferred alternative

Rightsizing the reservoir was **responsive to input** from **state and federal agencies, NGOs, elected officials, landowners and local communities**. The feedback we received through this~~a~~ robust outreach effort was critical to developing a reservoir that is the right size for both people and the environment.

Formatted: Indent: Left: 0.5", No bullets or

Right-sizing has resulted in a project that includes **facilities and operations that are different than originally proposed** – as such, the Authority as the California Environmental Quality Act lead agency will **revise and recirculate its Draft EIR** and work with landowners, tribes, stakeholders, NGOs, and local communities to conduct a **collaborative environmental review process.**

Formatted: Font: Bold

Formatted: Font: Bold

Formatted: Font: Bold

Formatted: Bulleted + Level: 1 + Aligned at: 0.25" + Indent at: 0.5"

Formatted: Indent: Left: 0.5", Add space between paragraphs of the same style, No bullets or numbering

~~The rightsizing has **resulted** in a project that has **a smaller footprint** and **operated in a different manner** then originally designed – due to these changes the Authority will **recirculate its Draft EIR/EIS** – and work with **landowners, tribes, stakeholders, NGOs, and local communities** to develop a **collaborative environmental review process.**~~

- ~~The rightsized project is **roughly $2 Billion less** than the 2017 preferred alternative~~

- ~~**It is essential that we build a project now that makes sense for all our participants** – local, state, and federal. This means **rightsizing** and **optimizing the project for current conditions**, while **maintaining flexibility** to expand and adapt the project to address future conditions.~~

KEY MESSAGE 4 *SITES RESERVOIR PROVIDES ENVIRONMENTAL, WATER SUPPLY, FLOOD PROTECTION AND RECREATION BENEFITS FOR THE STATE OF CALIFORNIA FOR GENERATIONS TO COME*

Environmental Benefits

- A significant portion of the **Sites Reservoir Project's annual water supplies will be dedicated to environment uses** to help improve conditions for **Delta smelt**; help **preserve cold-water pools in Shasta Lake** later into the summer months **to support salmon development, spawning, and rearing**; and **improve Pacific Flyway habitat** for migratory birds and other native species.

- **Water dedicated for the environment** provided by Sites Reservoir will be **managed by state resources agency managers** who will decide how, and when, this water would be used - creating a **water asset** for the state that **does not currently exist**.

Water Supply Benefits

- Sites Reservoir will **significantly improve** the state's water management system in **drier periods** and **restore much-needed flexibility and reliability** that has been lost in the statewide system.

- Will **increase California's existing water supply** by providing 1.5 million acre-feet of additional storage capacity to the state – providing a **vital supply of water** to our farms, communities, and the environment **during times of drought**.

- As **snowpack declines due to the effects of climate change** and more of our water comes in the form of atmospheric rivers – Sites Reservoir will become even more vital to the future resiliency of our statewide water supply.

- Extensive modeling has indicated that Sites Reservoir **performs better and provides the most benefit to the people and environment of California, under the most challenging climate change scenarios.**

Commented [KS2]: Ali – Are there any additional specific environmental benefit statements that we can add

Formatted: Font: Bold

Formatted: Font: Bold

Formatted: Font: Bold

Formatted: Indent: Left: 0.5", No bullets or

Formatted: Font: Bold

Formatted: Font: Bold

Formatted: Font: Bold

Formatted: Indent: Left: 0.5", Space After: 0 pt, No bullets or numbering

Formatted: Font: Bold

Formatted: Indent: Left: 0.5", Space After: 12 pt, No bullets or numbering

Formatted: Font: Bold

Formatted: Font: Bold

Formatted: Font: Bold

Formatted: Indent: Left: 0.5", Space After: 0 pt, No bullets or numbering

- Sites can deliver a **significant amount water to meet the needs of our participants and provide a dedicated and reliable supply of water for the environment – 230,000 AFY long-term average**

Formatted: Font: Bold

Flood Protection Benefits

- Sites Reservoir will provide **significant regional flood protection benefits** for the Sacramento Valley by **storing flood flows** that would normally impact the community of **Maxwell** - protecting homes, business and farms.

Formatted: Indent: Left: 0.5", No bullets or

- Will help to **limit "down-stream" flood impacts** by capturing storm flows in the Sacramento River that sometimes overwhelm the regions flood control facilities during major storm events.

Formatted: Font: Bold

Economic & Recreation Benefits

- Sites Reservoir will benefit the **local and regional economy** by **creating hundreds of construction-related jobs** during each year of the construction period, and **long-term jobs related to operations and recreation.**

- Sites Reservoir will provide **additional recreational opportunities** and **contribute to the overall economy** of the **Sacramento Valley**.

Formatted: Indent: Left: 0.5", Space After: 0 pt, No bullets or numbering

- Agriculture is a critical component of the Sacramento Valley's economy - a more reliable water supply creates a stronger agricultural economy - which creates a ripple of benefits for our rural communities

KEY MESSAGE 5 *WE ARE ON-TRACK TO DELIVER THIS VITAL PROJECT FOR THE PEOPLE OF CALIFORNIA*

- Sites Reservoir is **one of only two statewide projects specifically named as a priority project in Governor Newsom's Water Resilience Portfolio.**

- Sites **participants** have **invested over $27 million** to advance the project over the last 3 years.

- Sites Reservoir was **awarded $816 million** in state investment under **Proposition 1** to advance the project, the **largest award given to any project requesting funding**.

- Sites Reservoir has received **significant Federal investment** - including over **$10 million in Water Infrastructure Improvements for the Nation (WIIN) Act** funding and a **$449 million loan** from the **US Department of Agriculture's Rural Development** program.

- The Authority is working to **further refine** the **reservoir's operations and integration with the State Water Project and Central Valley Project** and **improve certainty** related to the project's **permittability** and prepare applications for key **federal and state permits** and the **state's water rights.**

- The Authority will continue to **strengthen partnerships** with **local landowners, communities, and key stakeholders** that represent **environmental, business, labor, and other interests** and continue to **pursue funding** to move the project forward through the **planning and feasibility stage** and into **implementation** beginning in **2022**.

####

From: Jerry Brown [jbrown@sitesproject.org]
Sent: 6/11/2020 12:53:33 PM
To: Tull, Robert/SAC [Robert.Tull@jacobs.com]
CC: Alicia Forsythe [aforsythe@sitesproject.org]; Heydinger, Erin [Erin.Heydinger@hdrinc.com]; Leaf, Rob/SAC [Rob.Leaf@jacobs.com]
Subject: Re: Follow-up Engr/Ops Work

Thanks Rob, this is helpful. I'll talk to Ali but I think it would be useful to have the five of us sit down after you have the capability to analyze varying levels of Shasta exchange and decide what makes sense. Exploring these interdependencies (w/CVP and SWP) might be a good topic potentially to discuss at July RC and AB mtgs in association with storage policy review.

Your statement that we do not have a project with DWR re-regulating makes me nervous. We can talk more at that time too about what is causing this to be the case in your mind.

From: "Tull, Robert/SAC" <Robert.Tull@jacobs.com>
Date: Thursday, June 11, 2020 at 12:03 PM
To: Jerry Brown <jbrown@sitesproject.org>
Cc: Alicia Forsythe <aforsythe@sitesproject.org>, "Heydinger, Erin" <Erin.Heydinger@hdrinc.com>, "Leaf, Rob/SAC" <Rob.Leaf@jacobs.com>
Subject: RE: Follow-up Engr/Ops Work

Jerry,

I included the text below from the Release Capacity and Reservoir Size TM. We didn't have the capability to simulate an annual (no carry over) exchange when we conducted the sensitivity analysis for the VP effort. As noted in the text below, the modeling included an average annual exchange of about 60 TAF. We have not conducted any analysis to date without Shasta Exchange/Oroville re-regulating.

We have always tried to maximize the Shasta exchange volume as that is a priority for the Sac valley members looking for a Shasta cold water pool management benefits and American River members looking to take pressure off of Folsom for Delta releases. Increasing Shasta storage was also the corner stone of the net benefit concept for salmonids and to reduce mitigation needs/costs.

I agree it would be beneficial to conduct some analyses without Shasta Exchange/Oroville re-regulating. I think we could have a viable project without Shasta exchange as long as we can implement the "real time exchange" we discussed yesterday. We don't have a viable project without the ability to re-regulate water with SWP for Delta export. As our SOD membership increases the ability to re-regulate water with the SWP will become more critical to the project. We are currently developing capability in the model to operate with varying levels of Shasta exchange or no exchange and should have this ready in a few weeks.

As I noted previously, we need to re-evaluate everything and are essentially developing a new project with the changes in facility sizing, baseline operations, CVP coordination and Shasta exchange, shift in membership, and greater need for SWP coordination for re-regulation and exports.

I am available to discuss.
Let me know if you have any further questions

Thanks,
Rob

These sensitivity analyses include a surrogate approximation of the potential to exchange water between Sites Reservoir and Shasta Lake. This exchange would be implemented through the release of Sites water to meet Sacramento Valley Central Valley Project (CVP) contract demands and Delta regulatory obligations. There would be a corresponding reduction in Shasta Lake releases that preserves storage in the lake and contributes to water temperature management and Sacramento River flow stability benefits. Based on previous analyses it is assumed that about 60 thousand acre-feet (TAF) could be exchanged on an average annual basis with the majority of these exchanges occurring in dry and critical water year types. This also assumes integration with the State Water Project (SWP) to facilitate operations and deliveries to South-of-Delta members. Work is on-going to develop the capability to simulate the Reclamation no investment exchange and integration of operations with the SWP.

From: Jerry Brown <jbrown@sitesproject.org>
Sent: Thursday, June 11, 2020 6:45 AM
To: Tull, Robert/SAC <Robert.Tull@jacobs.com>
Cc: Alicia Forsythe <aforsythe@sitesproject.org>; Heydinger, Erin <Erin.Heydinger@hdrinc.com>
Subject: [EXTERNAL] Follow-up Engr/Ops Workg

Rob – You did nice job yesterday explaining some of the operations modeling challenges and how we are addressing them. There was one question from Cindy K which I don't think we answered which is the reason for my follow-up.

Does the modeling results in the value planning include shasta exchanges? The value planning report Appendix B-2 indicates exchanges ARE NOT included but that there is a potential for it. If we did include shasta exchanges, I don't understand why we would need to do so. Using the release criteria you've described (CVP/SWP shortage levels and Yolo bypass pilot/refuge demands) it would seem that we don't need any exchanges with Shasta because all of the water we're releasing is new water and is consumed upon release. Our releases have nothing to do with operations of Shasta or the river flow.

What am I missing?

I think we need to see with and without Shasta Exchange/Oroville re-regulating so the criticality of each circumstance is quantified and the reason for the with/without differences can be better explained. Right now its muddled and confusing. We can't negotiate with DWR and USBR without knowing our BATNA and right now I don't know what that is. We need your help with this.

Jerry

NOTICE - This communication may contain confidential and privileged information that is for the sole use of the intended recipient. Any viewing, copying or distribution of, or reliance on this message by unintended recipients is strictly prohibited. If you have received this message in error, please notify us immediately by replying to the message and deleting it from your computer.

Ad Hoc Operations and Engineering Workgroup Agenda

Date: June 10, 2020 **Location:** Webex meeting

Time: 2:30 PM to 5:00 PM

Leader: Robert Kunde **Recorder:** HDR – Sites Integration

Purpose: Ongoing update for the Ad Hoc for the Operations and Engineering Workgroup for 2020

Attendees:

Mike Azevedo, Colusa County
Thad Bettner, GCID
Robert Cheng, CVWD
Rob Cooke, DWR
Amparo Flores, Zone 7
Katrina Jessop, Valley Water
Rick Kaufman (A), American Canyon
Robert Kunde, WRMWSD
Eric Leitterman, Valley Water
Wes Mercado, Zone 7
Dirk Marks (A), SCVWD
Randall Neudeck, MWD
Dan Ruiz, WWD
Jeff Sutton (A), TCCA
Bob Tincher, SBVMWD
Bill Vanderwaal, RD 108
Jerry Brown, Sites Authority
Ali Forsythe, Sites Authority
Erin Heydinger, Sites Integration
Rob Leaf, CH2M
Henry Luu, Sites Integration
John Spranza, Sites Integration
Rob Tull, CH2M

(A) Indicates alternate

Agenda:

Discussion Topic	Topic Leader	Time Allotted
1. Introductory Remarks	Kunde/Azevedo	5 min
2. Agenda Overview	Forsythe	5 min
3. Engineering Update	Luu	10 min
4. Modeling Baseline	Tull	45 min
5. Shasta Exchanges		
a. Principles of Agreement	Forsythe	10 min
b. Operational Parameters	Tull	20 min
6. Diversion Scenarios Results	Tull	30 min
7. Demand Patterns	Tull	10 min
8. Organizational Assessment – Negotiations Approach	Forsythe	10 min
9. Recap and Schedule Next Call	Forsythe	5 min

DEFENDERS OF WILDLIFE

The Bay Institute

NRDC

The Nature Conservancy
Protecting nature. Preserving life.

Audubon | CALIFORNIA

SITES RESERVOIR:
CRITERIA FOR AN ENVIRONMENTALLY RESPONSIBLE PROJECT

- Upper Sacramento River bypass flows: Flows of at least 15,000 cfs past all Sacramento River points of diversion for Sites Reservoir are required prior to the diversion of water into the reservoir during the months of October to June to protect out-migrating juvenile salmonids. (*See* Table A)

- Lower Sacramento River flows: Diversions of water into the reservoir should not occur from October to June unless flows at Freeport are greater than 35,000 cfs. Lower Sacramento River bypass flows in October and June shall be based on real time monitoring for salmonids. (*See* Table A)

- Flows for the San Francisco Bay-Delta Estuary: Per Table B, diversions of water into the reservoir should occur only when sufficient Delta inflows and outflows are available to meet the needs of Delta smelt, longfin smelt, migrating Chinook salmon, and other flow-dependent species.

- Floodplain inundation: Diversions must not reduce the frequency or duration of inundation of the Yolo Bypass and the Sutter Bypass, as floodplain inundation is beneficial for rearing salmon, migratory birds, and other wildlife.

- Overhead powerlines: Any new overhead powerlines associated with the project should be sited along exiting transmission corridors and not run along the Delevan National Wildlife Refuge. The power lines should also conform to current Avian Power Line Interaction Committee guidelines.

- Refuge water supplies: Water supply availability for federal, state, and private wildlife refuges must not be negatively affected, and a detailed description of conveyance methods should be provided for any publicly funded Level 4 refuges water supplies.

- Mitigation for construction impacts: Detailed plans must be developed showing how all temporary and permanent impacts of the project on golden eagles, giant garter snakes, vernal pools, and other species and habitats will be mitigated according to law, including appropriate assurances and performance standards.

- Releases of water from Sites Reservoir to the Sacramento River: Additional analysis of the water quality impacts of reservoir releases is necessary, given concerns regarding water temperature, algal blooms, and other water quality parameters.

Table A: Sites Reservoir bypass flows triggered by Sacramento River fish and wildlife protections

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Notes
Sacramento River at Freeport	real time	35,000 cfs	35,000 cfs	35,000 cfs	35,000 cfs	35,000 cfs	35,000 cfs	35,000 cfs	real time				Based on NGO proposed WaterFix minimum bypass flow of 35,000 cfs at Freeport Nov-May. The 35,000 cfs bypass flow is also in effect in Oct and Jun if real time observations show salmon are present.
Sacramento River at all Points of Diversion for	15000 cfs	15000 cfs	15000 cfs	15000 cfs	15000 cfs	15000 cfs	15000 cfs	15000 cfs	15000 cfs				Minimum bypass flow. Based on CDFW 2016 recommendation.
Max diversion rate	2% / 5%	2% / 5%	2% / 5%	2% / 5%	2% / 5%	2% / 5%	2% / 5%	2% / 5%	2% / 5%				When Net Delta Outflow Index (NDOI) is above minimum flows identified in Table A and Table B but below 60,000 cfs, diversions to Sites limited to a maximum of 2% of the river flow. When NDOI exceeds 60,000 cfs, diversions to Sites limited to 5% of Sacramento River flow.

Table B: Sites Reservoir bypass flows triggered by downstream water quality protections

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Notes
Delta Outflow				42,800 cfs		44,500 cfs			42,800 cfs				Bypass flow, based on longfin smelt flow need but will benefit salmon and other species as well (SWRCB 2017)
	11,400 cfs in W and AN years, 7,400 cfs all other yr types	11,400 cfs in W and AN years, 7,400 cfs all other yr types								7,100 cfs	7,100 cfs	11,400 cfs in W and AN years, 7,400 cfs all other yr types	Bypass flow, consistent with proposed NGO terms and conditions for California Water Fix regarding Delta Smelt
X2	74 km (W) or 81 km (AN)	No diversions in AN or W years	No diversions of X2-related releases in AN or W years									74 km (W) or 81 km (AN)	No diversions when diversions would result in noncompliance with current Delta smelt RPA requirements to maintain Fall X2 position in Sept-Dec period following a W or AN year
OMR, E:I, etc.	Water supply releases, water transfers, and refuge releases for SOD delivery are subject to all water quality and endangered species protections in the Delta.												

From: Jerry Brown [jbrown@sitesproject.org]
Sent: 6/13/2020 3:18:51 PM
To: Alicia Forsythe [aforsythe@sitesproject.org]
Subject: Friends of the River

FYI - Ron Storks May blog following our briefing to him and Jonas last month. It's interesting that he emphasizes the affordability for participants but avoids any mention that the bypass conditions affect the availability of environmental benefits too. He also expresses concerns about temperature effects from releases.

Sites Dam and Reservoir gets a facelift

There's two big dam proposed projects in the Sacramento Valley spawned by the prospect of taxpayer cash from California's Proposition 1 and the federal Water Infrastructure Improvements for the Nation Act (WIIN): the Shasta Dam raise (the WIIN) and the Sites Reservoir Project (Prop 1 and maybe the WIIN).

Credit Sue Graue

The Sites project is a proposed offstream reservoir
in the inner coast ranges to be filled by water pumped from the Sacramento River. But at five or six billion dollars, it's been looking a bit dodgy in recent years. Most spending than income can do that to you.

Enter, the new slimmed-down, 1.5 million acre-foot, three-billion-dollar remake: this project skips the pumped-storage energy plant, a canal directly from the Sacramento River, and some of the more elegant ways to make deliveries from the reservoir. Estimated project deliveries are also slimmed down considerably from earlier estimates. The price of water at the reservoir is hoped to be in the $600 to $650 per acre-foot range, a price that is likely to find only urban buyers with lots of cash to bring the water to them.

The project would be owned and operated by local water districts, but three quarters of its customers would be south-of-delta State Water Project customers. Some of those customers are likely going to be some state wildlife refuges, something that the California Water Commission allocated $818 million from Proposition 1, with $40 million for project studies and permitting.

Of course that $40 million gift helped to finance the remake and will finance a recirculated environmental impact report (EIR), a process that will take a couple of years. The Sites Project's major target will be the California Department of Fish & Wildlife's proposed conditions on diversions to protect Sacramento River resources. Sites is unfinanceable under those conditions. There are also likely going to be some thermal issues associated with outflows from the reservoir that use the Sacramento River as a delivery canal. So the Department will be

under huge pressure from the State Water Project Contractors to relent — and these contractors are powerful political players who know how to reach the Governor's office and legislators.

From: Jerry Brown [jbrown@sitesproject.org]
Sent: 6/16/2020 7:46:13 AM
To: Alicia Forsythe [aforsythe@sitesproject.org]
Subject: Fwd: Range of Alternatives for Sites Reservoir RDEIR/RDEIS

I know you have already got a response to this question. Please CC me when you reply to Doug. Thanks

Sent from my iPhone

Begin forwarded message:

From: "Obegi, Doug" <dobegi@nrdc.org>
Date: June 15, 2020 at 2:22:57 PM PDT
To: Alicia Forsythe <aforsythe@sitesproject.org>, Jerry Brown <jbrown@sitesproject.org>
Subject: Range of Alternatives for Sites Reservoir RDEIR/RDEIS

Hi Jerry and Ali,

I hope you're both doing ok these days. I wanted to check in briefly because I was reviewing the meeting material for the upcoming Reservoir Committee meeting, and the attachments seem to suggest that the revised/recirculated draft EIR/EIS would only consider one operational criteria for the action alternatives in the document. Are y'all seriously planning to only review one operational criteria in the revised EIR/EIS?

https://3hm5en24txyp2e4cxyxaklbs-wpengine.netdna-ssl.com/wp-content/uploads/2019/11/03-03-Proposed-Objectives-and-Alternatives-for-the-Revised-EIR_EIS.pdf

That's certainly not the approach that I took away from our prior conversation, where we discussed how the revised recirculated DEIR/DEIS would consider a range of operational criteria that included at least one set of operational criteria that were more protective than what you proposed (and potentially similar to what we've proposed). It also seems to run afoul of CEQA's requirement to consider a reasonable range of alternatives.

Hopefully I'm misunderstanding the Board materials. In any event I would strongly urge you to ensure that the CEQA/NEPA documents analyze more than 1 operational scenario for the action alternatives that are considered, including an alternative that proposes operations that are significantly more protective than what you shared with me in our last conversation.

Thanks,
Doug

____
DOUG OBEGI
*Senior Attorney**
Water Program

NATURAL RESOURCES DEFENSE COUNCIL
111 SUTTER ST., 21ST FLOOR
SAN FRANCISCO, CA 94104
T 415.875.6100
DOBEGI@NRDC.ORG
NRDC.ORG

Please save paper.
Think before printing.

* *Admitted to practice in California*

From: Luu, Henry [Henry.Luu@hdrinc.com]
Sent: 6/16/2020 10:09:28 AM
To: Spranza, John [John.Spranza@hdrinc.com]; Alicia Forsythe [aforsythe@sitesproject.org]; Laurie Warner Herson [laurie.warner.herson@phenixenv.com]; Arsenijevic, Jelica [Jelica.Arsenijevic@hdrinc.com]; Fisher, Linda [Linda.Fisher@hdrinc.com]; Heydinger, Erin [Erin.Heydinger@hdrinc.com]; Kevin Spesert [kspesert@sitesproject.org]; conner@cmdwest.com
Subject: RE: Sites - Project Description Team

Thanks John.

Ali – Erin and I are currently tracking engineering needs for Amendment 2. We have a scoping meeting with the engineering team tomorrow, and these are some of the topics we will be discussing. I can provide an update during next Monday's Project Description meeting.

Henry H. Luu, PE
D 916.679.8857 M 916.754.7566

hdrinc.com/follow-us

From: Spranza, John
Sent: Tuesday, June 16, 2020 9:31 AM
To: Alicia Forsythe <aforsythe@sitesproject.org>; Luu, Henry <Henry.Luu@hdrinc.com>; Laurie Warner Herson <laurie.warner.herson@phenixenv.com>; Arsenijevic, Jelica <Jelica.Arsenijevic@hdrinc.com>; Fisher, Linda <Linda.Fisher@hdrinc.com>; Heydinger, Erin <Erin.Heydinger@hdrinc.com>; Kevin Spesert <kspesert@sitesproject.org>; conner@cmdwest.com
Subject: RE: Sites - Project Description Team

This is super helpful, I will put it in a table so we can track it.

John Spranza

D 916.679.8858 M 818.640.2487

From: Alicia Forsythe [mailto:aforsythe@sitesproject.org]
Sent: Tuesday, June 16, 2020 9:12 AM
To: Luu, Henry <Henry.Luu@hdrinc.com>; Laurie Warner Herson <laurie.warner.herson@phenixenv.com>; Spranza, John <John.Spranza@hdrinc.com>; Arsenijevic, Jelica <Jelica.Arsenijevic@hdrinc.com>; Fisher, Linda <Linda.Fisher@hdrinc.com>; Heydinger, Erin <Erin.Heydinger@hdrinc.com>; Kevin Spesert <kspesert@sitesproject.org>; conner@cmdwest.com
Subject: FW: Sites - Project Description Team

CAUTION: [EXTERNAL] This email originated from outside of the organization. Do not click links or open attachments unless you recognize the sender and know the content is safe.

Jeff is always so great at jumping in on things. See his thoughts below. I will add these to the agenda. We aren't looking for "solutions" tomorrow – more how best to tee up the discussion on these items.

Henry – I do wonder if HR/HC should put together a list of "needs" from others for the Feasibility Report. We've been so focused on what environmental needs but haven't discussed much of what we need to complete Feasibility from environmental or operations. Maybe its just what is below, but we need to get this on the radar screen so we can make sure to account for this in Amendment 2 effort and schedule / costs.

Ali

Alicia Forsythe | Environmental Planning and Permitting Manager | Sites Reservoir Project | 916.880.0676 | aforsythe@sitesproject.org | www.SitesProject.org

CONFIDENTIALITY NOTICE: This communication with its contents may contain confidential and/or legally privileged information. It is solely for the use of the intended recipient(s). Unauthorized interception, review, use or disclosure is prohibited and may violate applicable laws including the Electronic Communications Privacy Act. If you are not the intended recipient, please contact the sender and destroy all copies of the communication.

From: Herrin, Jeff <jeff.herrin@aecom.com>
Sent: Monday, June 15, 2020 2:48 PM
To: Alicia Forsythe <aforsythe@sitesproject.org>
Cc: Forrest, Michael <michael.forrest@aecom.com>
Subject: RE: Sites - Project Description Team

Ali,

I don't know that any of these are urgent enough to require discussion this week, but they may belong on the agenda at some point.

- Flood Damage Reduction – There will be a flood benefits section in the WSIP Feasibility Report and I anticipate there will be a chapter on flooding in the EIR/EIS. We have recently developed a draft memo regarding handling water from emergency drawdown. I think Colusa County would like an updated evaluation of long-term flood benefits. This probably belongs in the WSIP Feasibility Report as well. This doesn't fall neatly into any of our service areas, but probably needs some attention in the next phase of work.
- Operations Plan – This may fall outside the Project Description Group, but the California Water Commission Technical Reference requires the following for Technical Feasibility: the applicant must demonstrate that the project is technically feasible consistent with the operations plan, including a description of data and analytical methods, the hydrologic period, development conditions, hydrologic time step, and water balance analysis showing, for the with- and without-project condition, all flows and water supplies relevant to the benefits analysis. This is the longest lead item to complete the Feasibility Report. We will need this from the operations team in time to allow for economics analysis (I would like to have a minimum of 6 weeks).
- Environmental Feasibility – The CWC Technical Reference requires the following: the applicant must demonstrate that the project is environmentally feasible. The applicant must describe how significant environmental issues will be mitigated or indicate if the Lead Agency has or will file a Statement of Overriding Considerations. The Engineering Team is tasked with compiling the report, but we will need this determination from the Environmental Team.
- The Engineering Team will need criteria for streamflows in Funks Creek and Stone Corral Creek. We are including the capability to provide flows, but don't know what range of flows are needed for aquatic species in the creeks.
- Salt Pond – I've never seen the salt pond and data is pretty scant. We threw some money at it in the previous report, but we don't know exactly what problem we are trying to solve, exactly where the source of the problem is, or what can be done to solve the problem. We need some science to base an engineering solution on. I think this could be deferred to preliminary engineering from an engineering/construction schedule perspective. I suspect you will need to at least define the problem to resolve comments on water quality in the EIR/S. The current mitigation proposal is a cap and it was proposed by DWR. I don't have enough data to have an opinion one way or the other regarding whether this is an appropriate mitigation measure. I feel like everybody is generally hoping a cap will work – but we need some science to base the engineering on.
- Corridors – Laurie was a little shocked when we talked about a 300 to 500 foot wide corridor for roads. We are not suggesting that the right of way needs to be that wide, but that our current topography is so poor that we cannot place the road with better accuracy. I don't think the same issue applies to pipelines (the ground is more level), but I think it may surprise the environmental team. Without surveys, this is the best we can do.

You may want to take some of these offline.

Jeff Herrin
Water Resources Planner, Water Business Unit, Sacramento, CA
D +1-916-679-2084 IPT 264-679-2084
M +1-916-432-0956
Jeff.Herrin@aecom.com

AECOM
2020 L Street
Suite 400
Sacramento, CA 95811, United States
T +1-916-414-5800
aecom.com

Built to deliver a better world

LinkedIn Twitter Facebook Instagram

From: Alicia Forsythe <aforsythe@sitesproject.org>
Sent: Monday, June 15, 2020 2:18 PM
To: Forrest, Michael <michael.forrest@aecom.com>; john.spranza@hdrinc.com; laurie.warner.herson@phenixenv.com; 'Heydinger, Erin' <Erin.Heydinger@hdrinc.com>; Arsenijevic, Jelica <Jelica.Arsenijevic@hdrinc.com>; Fisher, Linda <Linda.Fisher@hdrinc.com>; Henry.Luu@hdrinc.com; Monique Briard (Monique.Briard@icf.com) <Monique.Briard@icf.com>; Lecky, Jim <Jim.Lecky@icf.com>; Williams, Nicole <Nicole.Williams@icf.com>; robert.tull@jacobs.com; Rude, Pete/RDD <Pete.Rude@jacobs.com>; Jim Watson <jwatson@sitesproject.org>; Boling, Robert M. <Robert.Boling@hdrinc.com>; Herrin, Jeff <jeff.herrin@aecom.com>; Berryman, Ellen <Ellen.Berryman@icf.com>; Unsworth, Ellen <Ellen.Unsworth@icf.com>; Jerry Brown <jbrown@sitesproject.org>; Kevin Spesert <kspesert@sitesproject.org>; conner@cmdwest.com; Smith, Jeff/SAC <Jeff.Smith1@jacobs.com>; Alexander, Jeriann <jalexander@fugro.com>; connermcdonald@gmail.com
Cc: Marcia Kivett <MKivett@sitesproject.org>
Subject: [EXTERNAL] RE: Sites - Project Description Team

Hi all – We're getting ready for Wednesday's Bi-Weekly Team meeting. A preliminary draft agenda is located here: https://sitesreservoirproject.sharepoint.com/:w:/r/ProjectDescription/Meetings/20200617_Project%20Description%20Team_Meeting-AGN.docx?d=wdd52e0176bcd45e7b7f335ebd2b8e28f&csf=1&web=1&e=28u2uV

Please let me know if there are additional topics you'd like us to discuss on Wednesday. This is your meeting and we want to make these useful for you. Don't hesitate to give feedback, suggest topics and speakers, or let us know what we can do better. It wont hurt our feelings – we actually appreciate it.

Please provide any thoughts by noon tomorrow. I'll finalize the agenda and send a final around 1 PM tomorrow.

Ali

Alicia Forsythe | Environmental Planning and Permitting Manager | Sites Reservoir Project | 916.880.0676 | aforsythe@sitesproject.org | www.SitesProject.org

CONFIDENTIALITY NOTICE: This communication with its contents may contain confidential and/or legally privileged information. It is solely for the use of the intended recipient(s). Unauthorized interception, review, use or disclosure is prohibited and may violate applicable laws including the Electronic Communications Privacy Act. If you are not the intended recipient, please contact the sender and destroy all copies of the communication.

-----Original Appointment-----
From: Marcia Kivett **On Behalf Of** Alicia Forsythe
Sent: Monday, May 11, 2020 6:41 AM
To: Forrest, Michael; Alicia Forsythe; Ali Forsythe; john.spranza@hdrinc.com; laurie.warner.herson@phenixenv.com; 'Heydinger, Erin'; Arsenijevic, Jelica; Fisher, Linda; Henry.Luu@hdrinc.com; Monique Briard (Monique.Briard@icf.com); Lecky, Jim; Williams, Nicole; robert.tull@jacobs.com; Rude, Pete/RDD; Jim Watson, General Manager; Boling, Robert M.; Jeff.Herrin@aecom.com; Berryman, Ellen; Unsworth, Ellen; Jerry Brown; Kevin Spesert (kspesert@sitesproject.org); conner@cmdwest.com; Smith, Jeff/SAC
Cc: Marcia Kivett; Alexander, Jeriann; connermcdonald@gmail.com
Subject: Sites - Project Description Team
When: Wednesday, June 17, 2020 1:00 PM-2:30 PM (UTC-08:00) Pacific Time (US & Canada).
Where: +1 213-379-5743 Conference ID: 576 656 37#

This is a recurring, bi-weekly meeting.

Join Microsoft Teams Meeting
+1 213-379-5743 United States, Los Angeles (Toll)
(888) 404-2493 United States (Toll-free)
Conference ID: 576 656 37#
Local numbers | Reset PIN | Learn more about Teams | Meeting options

Brown and Caldwell

A Brown and Caldwell Teams meeting has been created for this event.
Help

Sites

Topic: **Reservoir Committee Agenda Item 3.6** **2020 June 18**

Subject: **Regulatory Agency Technical Working Group**

Requested Action:

Receive status update on the approach for Regulatory Agency Technical Working Group.

Detailed Description/Background:

Staff have reinitiated efforts on the development and submittal of key permits for the Sites Project as reflected in the Amendment 1B Work Plan. As part of this effort, the team has developed an approach to facilitate regular communication and coordination with state, federal and local agencies with jurisdiction over all or portions of the Project. The attached, *Regulatory Agency Technical Working Groups Approach* document, details this effort. This approach is also in response to Action 2.4 in the November 2019 Organizational Assessment. The activities of the regulatory coordination will be reported to the Environmental Planning and Permitting Workgroup.

Prior Action:

None.

Fiscal Impact/Funding Source:

Conducting regulatory coordination is within the scope of work for the Amendment 1B and 2 work plans.

Staff Contact:

Ali Forsythe

Attachments:

Attachment A - Regulatory Agency Technical Working Groups Approach.

Status:	Final	Preparer:	Luu	Phase:	2	Version:	A
Purpose:	Staff Report	QA/QC:		Date:	2020 June 18		
Caveat:	Informational	Authority Agent:	Brown	Ref/File #:	10.700		
Notes:				Page:	1	of	1

Regulatory Agency Technical Working Groups Approach

The following two technical working groups will be established to facilitate regular communication and coordination with state, federal and local agencies during the permitting efforts for the Sites Reservoir Project. These groups are expected to be in place thru Amendment 2 efforts (e.g., the end of 2021) and likely into Phase 3 efforts (post 2021). Additional technical working groups may be added as permitting activities progress depending on need. It is important to note that these groups are not intended to replace or supersede focused discussions and meetings with specific agencies, but rather facilitate a common understanding and basis of Project-wide and Fisheries/Operations knowledge and dialogue. These would be staff and consultant run meetings. Reservoir Committee and Authority Board members could attend to observe if desired. Results of the meetings will be reported out to the appropriate Reservoir Committee and Authority Board workgroups.

Group 1: Interagency General Update and Coordination Meetings

- **Purpose**: Quarterly meetings to efficiently update and coordinate with all and state, federal and local regulatory and/or partnering agencies. Items to be include in the meeting agenda would include general updates on project status, design efforts, status of permit development, status of working thru any key considerations that may affect all permits and upcoming items. Attendees would also be asked to update on permit processing status (if a permit application has been submitted and permit development is in process), update on any changes in their organizations, law or regulation that may affect Sites and identify any information needs or concerns they may have. Specific items, information requests or concerns would be identified, and a process developed for resolution with the relevant agencies and the Sites team.

- **Potential Attendees**: This meeting would be open to any agency that had an interest. Potential attendees would be broad and could include the following:
    - United States Fish and Wildlife Service (USFWS)
    - Bureau of Reclamation (Reclamation)
    - Bureau of Indian Affairs (BIA)
    - National Marine Fisheries Service (NMFS)
    - Natural Resources Conservation Service (NRCS)
    - United States Army Corps of Engineers (USACE)
    - United States Environmental Protection Agency (USEPA)
    - Western Area Power Administration (WAPA)
    - California Department of Fish and Wildlife (CDFW)
    - California Department of Transportation (Caltrans)

    - California Department of Water Resources (DWR)
    - California Office of Historic Preservation - State Historic Preservation Officer (SHPO)
    - California State Water Resources Control Board
    - Central Valley Regional Water Quality Control Board
    - Central Valley Flood Protection Board
    - County of Colusa, Planning
    - County of Yolo, Planning

Group 2: Fishery and Operations Technical Meetings

- **Purpose**: Focused, as needed, fishery and operations meetings to review and discuss the modeling approach, analysis approach, operational criteria and the resulting effects to species of the Project. These meetings are intended to stimulate collaboration and early input into the fisheries and operational components and analysis and are anticipated to include technical, detailed discussion of topics.

- **Potential Attendees**: Potential attendees could include the following:
    - United States Fish and Wildlife Service (USFWS)
    - Bureau of Reclamation (Reclamation)
    - National Marine Fisheries Service (NMFS)
    - California Department of Fish and Wildlife (CDFW)
    - Additional agencies, depending on topics and authority

Topic: **Sites Reservoir Project, Phase 1 (2019)** **2020 June 17**

Subject: **Reservoir Committee's Environmental and Permitting Work Group**

Work Group Chartering Document

Status: **Ad Hoc**

- Leaders:
  - Chair: Thad Bettner, GCID
  - Vice Chair: Heather Dyer (SBVMWD)
- Members (9):
  - Mike Azevedo (Colusa Co.)
  - Robert Cheng (CVWD)
  - Jeff Davis (SGPWA)
  - Rob Kunde (WR-M WSD)
  - Eric Leitterman (Valley Water)
  - Randall Neudeck (MWD)
  - Bill Vanderwaal (DWD)
- Expertise: PCWA/Roseville for Lower American River

  Staff from participating agencies who have specific expertise that is relevant to the matter being addressed by this work group.
- Staff Support:
  1. Environmental Planning and Permitting Manager.
  2. Legal counsel on an as needed basis.
  3. Other specialty advisors or experts, including consultant team members on an as needed basis.
- Re-Adoption of Charter: June 17, 2020
- Expires: End of the Phase 2 Reservoir Project Agreement

Related Documents:

- Attachment A: Work Group Chartering Process, General Requirements

Purpose: To advise the Reservoir Committee on all environmental planning and permitting aspects of the development and implementation of pre-construction, construction, and mitigation actions for the Sites Reservoir Project.

Meeting Frequency: When either the Leader determines or the Reservoir Committee Chairperson requests that a potential issue exists to warrant convening the work group to develop a recommended resolution or response for the Reservoir Committee to then consider and act upon.

Work Group's Roles and Responsibilities:

- The primary focus of this work group is to review and provide input to:

    1. The Authority's adoption of CEQA Guidelines, revisions to those Guidelines, if any, and proposed environmental policies.

    2. The Authority's development, completion, and implementation of all environmental planning and permitting aspects of pre-construction, construction, environmental commitments, and mitigation actions for the Sites Reservoir Project.

       NOTE: The review of operations and engineering permits and approvals has been assigned to the Reservoir Operations and Engineering Work Group (e.g., Dam Safety, Traffic).

From: Spranza, John [John.Spranza@hdrinc.com]
Sent: 6/16/2020 3:45:26 PM
To: Alicia Forsythe [aforsythe@sitesproject.org]; Jim Lecky (jim.Lecky@icf.com) [jim.Lecky@icf.com]
Subject: RE: Range of Alternatives for Sites Reservoir RDEIR/RDEIS
Attachments: Nobriga &. Rosenfield (2016).pdf

Attached is the Nobriga paper. So we don't get cross-wise I'll let Jim send what he thinks should be on Jerry's reading list.

Great exchange with Doug.

John Spranza

D 916.679.8858 M 818.640.2487

From: Alicia Forsythe [mailto:aforsythe@sitesproject.org]
Sent: Tuesday, June 16, 2020 3:27 PM
To: Jim Lecky (jim.Lecky@icf.com) <jim.Lecky@icf.com>; Spranza, John <John.Spranza@hdrinc.com>
Subject: FW: Range of Alternatives for Sites Reservoir RDEIR/RDEIS

CAUTION: [EXTERNAL] This email originated from outside of the organization. Do not click links or open attachments unless you recognize the sender and know the content is safe.

Hi Jim and John – See the email exchange below. I will also forward on one more email that I sent to Doug.

Jim – I thought you did a longer write up on the pros and cons with the studies that folks continue to reference. I recall like a 5 page document. But I couldn't find it just now. Is this something you recall and can find? Also, do you have the Nobriga and Rosenfield 2016 paper? Anything else to send to Jerry to help him on all of this?

Ali

Alicia Forsythe | Environmental Planning and Permitting Manager | Sites Reservoir Project | 916.880.0676 |
aforsythe@sitesproject.org | www.SitesProject.org

CONFIDENTIALITY NOTICE: This communication with its contents may contain confidential and/or legally privileged information. It is solely for the use of the intended recipient(s). Unauthorized interception, review, use or disclosure is prohibited and may violate applicable laws including the Electronic Communications Privacy Act. If you are not the intended recipient, please contact the sender and destroy all copies of the communication.

From: Alicia Forsythe
Sent: Tuesday, June 16, 2020 3:22 PM
To: Jerry Brown <jbrown@sitesproject.org>
Subject: RE: Range of Alternatives for Sites Reservoir RDEIR/RDEIS

Jerry – See the paper that Gary Bobker sent to us over the weekend for the NRDC, TBI's proposed criteria.

Attached are the following:

- 20191011_Topics for Oct Exec Team Meeting – This was prepare by Jim Lecky and is "unfiltered" – See the references to specific studies with regard to locations

- 20191014_Talking Points for Oct Exec Team Meeting – This was my shortening of Jim's document, trying to get at the heart of some of these issues for our members
- Perry et al – Relates to Freeport Flows and salmonid survival
- Michel and Henderson – Related to Wilkins Slough flows and salmonid survival

I cant find the Nobriga paper (NDOI) but will see if Jim Lecky has that. I thought Jim also did a longer write-up on the pros and cons with these studies, but I cant seem to locate that right now. I'll ask him for this.

Happy to set up a briefing on all of this if you think it would be helpful.

Ali

Alicia Forsythe | Environmental Planning and Permitting Manager | Sites Reservoir Project | 916.880.0676 | aforsythe@sitesproject.org | www.SitesProject.org

CONFIDENTIALITY NOTICE: This communication with its contents may contain confidential and/or legally privileged information. It is solely for the use of the intended recipient(s). Unauthorized interception, review, use or disclosure is prohibited and may violate applicable laws including the Electronic Communications Privacy Act. If you are not the intended recipient, please contact the sender and destroy all copies of the communication.

From: Jerry Brown <jbrown@sitesproject.org>
Sent: Tuesday, June 16, 2020 2:54 PM
To: Alicia Forsythe <aforsythe@sitesproject.org>
Subject: Re: Range of Alternatives for Sites Reservoir RDEIR/RDEIS

Can you provide me with a copy of the technical paper Doug is referring to when he says "scientifically sound" operational criteria? I assume there must be some in depth studies that we need to be aware of.

From: "Obegi, Doug" <dobegi@nrdc.org>
Date: Tuesday, June 16, 2020 at 1:08 PM
To: Alicia Forsythe <aforsythe@sitesproject.org>
Cc: Jerry Brown <jbrown@sitesproject.org>
Subject: RE: Range of Alternatives for Sites Reservoir RDEIR/RDEIS

Thanks Ali.

I suspect the project is going to have some serious challenges, if scientifically sound operational criteria make the project infeasible from the proponents' perspective.

From: Alicia Forsythe <aforsythe@sitesproject.org>
Sent: Tuesday, June 16, 2020 11:30 AM
To: Obegi, Doug <dobegi@nrdc.org>
Cc: Jerry Brown <jbrown@sitesproject.org>
Subject: RE: Range of Alternatives for Sites Reservoir RDEIR/RDEIS

Doug – The initial alternatives in the June packet are very preliminary. We're really just beginning the development of alternatives but want to make sure we update the Board on some of our initial thoughts and ideas. We expect to come back to the Board in September with a more complete project description, including possible changes to what we are proposing this week. The door isn't even close to being shut and we have a ways to go.

We will have Jacobs conduct an analysis of at least one set of operational criteria that are similar to (or the same as) what you have proposed. We will work with you, TBI, and others to confirm these criteria before we model them. This analysis will be in the Revised Draft EIR/EIS. However, based on analyses we completed last summer / fall, we expect these criteria to result in a project that's not affordable and provides very little water to accomplish the project objectives. Thus, we don't anticipate that this will result in an alternative that we would carry forward for detailed analysis in the Revised EIR as we don't anticipate it to result in a feasible project.

We have yet to "finalize" operational criteria for the project and continue to work on these and refinements to the model. So we may have more than one operational criteria, but we haven't yet made it far enough along to determine that. We will also complete the analysis described above early in the process – once we get the model refinements completed – so if my assumption is wrong here, we will have time to include it as a full alternative in the document.

The door isn't closed to adding in an alternative with different operational criteria – and we will complete the analysis you've requested. From the work we did last summer / fall, we just expect that the operational criteria proposed by NRDC won't result in a feasible project.

Ali

Alicia Forsythe | Environmental Planning and Permitting Manager | Sites Reservoir Project | 916.880.0676 | aforsythe@sitesproject.org | www.SitesProject.org

CONFIDENTIALITY NOTICE: This communication with its contents may contain confidential and/or legally privileged information. It is solely for the use of the intended recipient(s). Unauthorized interception, review, use or disclosure is prohibited and may violate applicable laws including the Electronic Communications Privacy Act. If you are not the intended recipient, please contact the sender and destroy all copies of the communication.

From: Obegi, Doug <dobegi@nrdc.org>
Sent: Monday, June 15, 2020 2:23 PM
To: Alicia Forsythe <aforsythe@sitesproject.org>; Jerry Brown <jbrown@sitesproject.org>
Subject: Range of Alternatives for Sites Reservoir RDEIR/RDEIS

Hi Jerry and Ali,

I hope you're both doing ok these days. I wanted to check in briefly because I was reviewing the meeting material for the upcoming Reservoir Committee meeting, and the attachments seem to suggest that the revised/recirculated draft EIR/EIS would only consider one operational criteria for the action alternatives in the document. Are y'all seriously planning to only review one operational criteria in the revised EIR/EIS?

https://3hm5en24txyp2e4cxyxaklbs-wpengine.netdna-ssl.com/wp-content/uploads/2019/11/03-03-Proposed-Objectives-and-Alternatives-for-the-Revised-EIR_EIS.pdf

That's certainly not the approach that I took away from our prior conversation, where we discussed how the revised recirculated DEIR/DEIS would consider a range of operational criteria that included at least one set of operational criteria that were more protective than what you proposed (and potentially similar to what we've proposed). It also seems to run afoul of CEQA's requirement to consider a reasonable range of alternatives.

Hopefully I'm misunderstanding the Board materials. In any event I would strongly urge you to ensure that the CEQA/NEPA documents analyze more than 1 operational scenario for the action alternatives that are considered, including an alternative that proposes operations that are significantly more protective than what you shared with me in our last conversation.

Thanks,
Doug

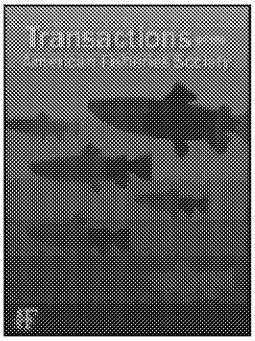
DOUG OBEGI
*Senior Attorney**
Water Program

NATURAL RESOURCES
DEFENSE COUNCIL

111 SUTTER ST., 21ST FLOOR
SAN FRANCISCO, CA 94104
T 415.875.6100
DOBEGI@NRDC.ORG
NRDC.ORG

Please save paper.
Think before printing.

** Admitted to practice in California*



Transactions of the American Fisheries Society

ISSN: 0002-8487 (Print) 1548-8659 (Online) Journal homepage: http://www.tandfonline.com/loi/utaf20

Population Dynamics of an Estuarine Forage Fish: Disaggregating Forces Driving Long-Term Decline of Longfin Smelt in California's San Francisco Estuary

Matthew L. Nobriga & Jonathan A. Rosenfield

To cite this article: Matthew L. Nobriga & Jonathan A. Rosenfield (2016) Population Dynamics of an Estuarine Forage Fish: Disaggregating Forces Driving Long-Term Decline of Longfin Smelt in California's San Francisco Estuary, Transactions of the American Fisheries Society, 145:1, 44-58, DOI: 10.1080/00028487.2015.1100136

To link to this article: http://dx.doi.org/10.1080/00028487.2015.1100136

Published online: 18 Dec 2015.

Submit your article to this journal

Article views: 65

View related articles

View Crossmark data

Full Terms & Conditions of access and use can be found at
http://www.tandfonline.com/action/journalInformation?journalCode=utaf20

Download by: [24.6.237.115] **Date:** 27 January 2016, At: 14:12

Transactions of the American Fisheries Society 145:44–58, 2016
© American Fisheries Society 2016
ISSN: 0002-8487 print / 1548-8659 online
DOI: 10.1080/00028487.2015.1100136

ARTICLE

Population Dynamics of an Estuarine Forage Fish: Disaggregating Forces Driving Long-Term Decline of Longfin Smelt in California's San Francisco Estuary

Matthew L. Nobriga*
U.S. Fish and Wildlife Service, Bay Delta Fish and Wildlife Office, 650 Capitol Mall, Suite 8-300, Sacramento, California 95831, USA

Jonathan A. Rosenfield
The Bay Institute, Pier 39, Box Number 200, San Francisco, California 94133, USA

Downloaded by [24.6.237.115] at 14:12 27 January 2016

Abstract

Forage fish production has become a central concern of fisheries and ecosystem managers because populations of small fish are a critical energetic pathway between primary producers and predator populations. Management of forage fish often focuses on controlling exploitation rates, but it is also possible to manage productivity of these species in coastal ecosystems, particularly estuaries. Like several forage fish species that are native to the San Francisco Estuary (SFE) in California, the Longfin Smelt *Spirinchus thaleichthys* has experienced dramatic population declines over the past few decades. This population is not fished commercially or recreationally; trends in its relative abundance have been described statistically, but the mechanisms that drive population dynamics are still poorly understood. Our objective was to evaluate alternative conceptual models of Longfin Smelt population dynamics to better understand the forces that may constrain the species' productivity during different phases of its life cycle. We created contrasting variants of a generalizable population model (the Ricker model) and parameterized those variants using empirical data from a long-term sampling program in the SFE. Predictions from alternative models were compared with empirical results from a second (independent) data series of relative abundance to identify the model variants that best captured the empirical trend. The results indicated that (1) freshwater flow had a positive association with recruits per spawner and (2) both recruits per spawner and spawners per recruit appeared to be density-dependent life stage transitions. Juvenile survival may have declined to some extent, but we could not conclusively demonstrate this. By constraining the possible timing and location of mechanisms that modulate productivity at different life stages, the present results improve our understanding of production for a key native forage fish in the SFE.

Forage fishes serve as energy conduits between zooplankton and higher-trophic-level predators (Pikitch et al. 2014). The central role of forage fishes in aquatic food webs means that forage fish production is critical to sustainable fisheries management (Alder et al. 2008), desired ecosystem functions (Hall et al. 2012), and, in some cases, the maintenance of biodiversity (Trathan et al. 2015). For instance, seabirds around the world display reduced and more variable productivity when forage fish biomass drops below one-third of the maximum levels observed in long-term studies (Cury et al. 2011). Thus, marine fisheries and ecosystem management is increasingly focused on protecting forage fishes from overexploitation. Management may also be directed toward maintaining or restoring the habitats and processes that support the production of forage fish, especially in estuarine ecosystems (Kennish 2002; Hughes et al. 2014).

---

*Corresponding author: matt_nobriga@fws.gov
Received August 13, 2015; September 17, 2015

Downloaded by [24.6.237.115] at 14:12 27 January 2016

A general conceptual model of forage fish productivity in coastal ecosystems, including estuaries, is that recruitment is strongly influenced by the interplay of zooplankton production and piscivore predation on forage fishes (Walters and Juanes 1993; Essington and Hansson 2004). The matches and mismatches between forage fishes and their prey can be affected by physical conditions, such as ocean currents (Genin 2004) and upwelling (Reum et al. 2011). For species that rely on low-salinity environments to complete their life cycle, variation in freshwater flow rates can also play an important role in aligning young fish with their prey and protecting them from predators (Turner and Chadwick 1972; North and Houde 2003). Fish behavior and physiological capacities can influence the details of this conceptual model, particularly for euryhaline fishes (Kimmerer 2006; Peebles et al. 2007).

The protection of forage fish habitats in developed rivers and their receiving estuaries can be very difficult, as human economic systems' strong reliance on freshwater results in competition for limited freshwater resources (Vörösmarty et al. 2010; Cloern and Jassby 2012). Many estuarine forage fishes (and their supporting food webs) that are tolerant of or dependent upon low-salinity and freshwater habitats are influenced by the timing, duration, and magnitude of freshwater flow and its effects on estuarine hydrodynamics (Jassby et al. 1995; North and Houde 2003; Gillson 2011). The biological productivity and accessibility of freshwater that were historically provided by river–estuary systems have attracted considerable human settlement and exploitation, which have in turn led to intensive changes that include large-scale reclamation of estuarine landscapes, water pollution, nonnative species introductions, modification of estuarine hydrodynamics, and declines in native biota (Kennish 2002; Lotze et al. 2006; Shan et al. 2013). California's San Francisco Estuary (SFE; Figure 1) is a well-known example of an estuary that has undergone tremendous physical, chemical, and biological transformation (Kimmerer 2002a; Cloern and Jassby 2012). The declines of once-productive fisheries and the potential ongoing loss of native fish biodiversity are key aquatic resource concerns for the SFE and its watershed (Moyle 2002; Sommer et al. 2007; Katz et al. 2013).

One formerly abundant forage fish that has undergone a substantial decline within the SFE is the Longfin Smelt

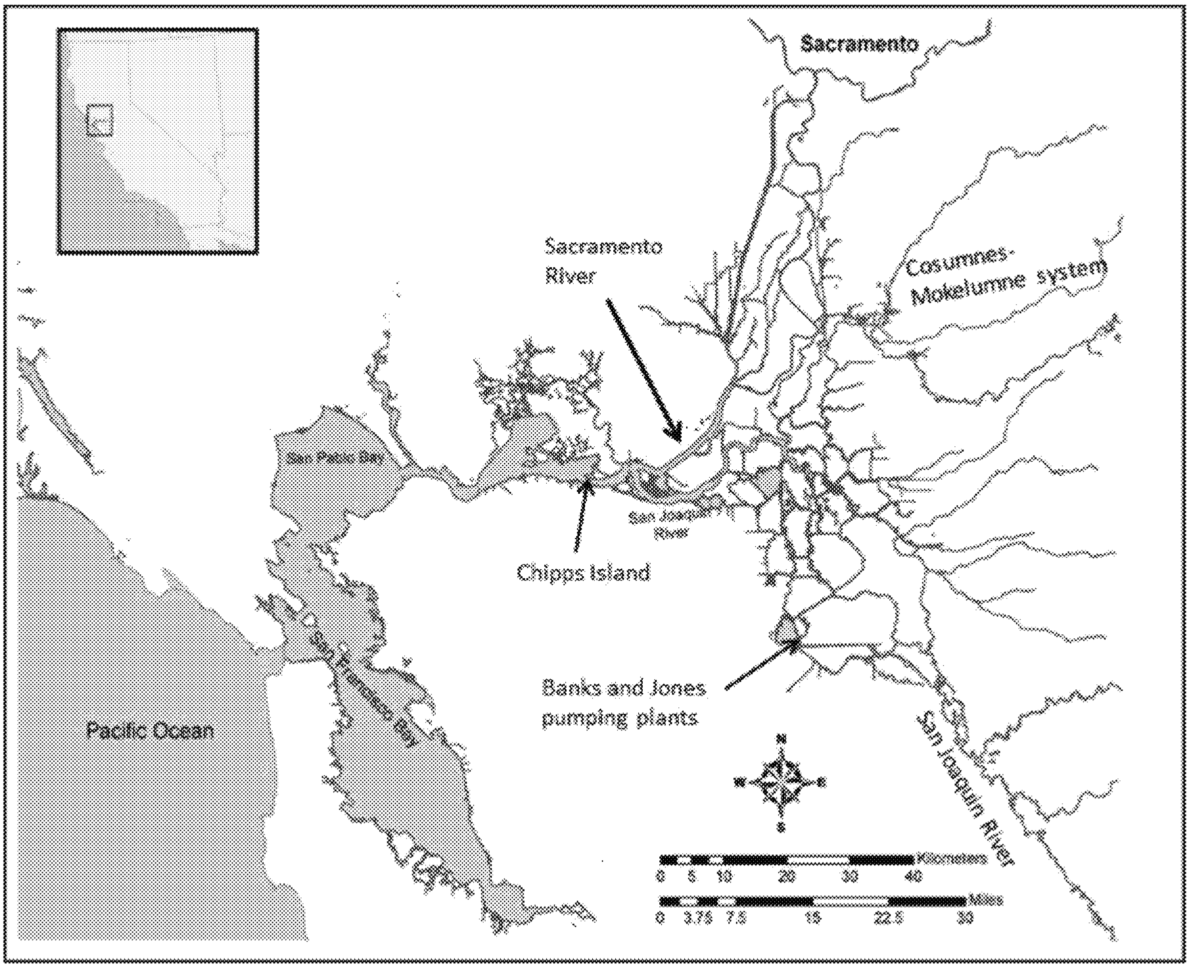


FIGURE 1. Map of the San Francisco Estuary. The Pacific Ocean enters the estuary under the Golden Gate Bridge; the Sacramento–San Joaquin Delta encompasses the waterways to the east of Chipps Island (sampling locations for California Department of Fish and Wildlife monitoring stations are available at www.wildlife.ca.gov/Regions/3).

Spirinchus thaleichthys (Rosenfield and Baxter 2007). This species is a small, facultatively anadromous, pelagic fish that typically reaches adult sizes of 80–150 mm FL (Moyle 2002). Longfin Smelt inhabit lakes, coastal river estuaries, and nearshore marine environments from Alaska to central California; the SFE is the southern limit of the species' inland distribution along the Pacific coast of North America. Most Longfin Smelt live for 2 years and are semelparous. In the SFE, Longfin Smelt spawn in tidally influenced freshwater habitats, but low-salinity habitats may also provide suitable spawning areas (microhabitat requirements for Longfin Smelt spawning are unknown). Spawning typically peaks in the winter (December–February), when water temperatures range from about 7.0°C to 14.5°C (Moyle 2002). Larvae and small juveniles aggregate in low-salinity waters during the late winter through spring (Dege and Brown 2004) and then move seaward into mesohaline to marine waters of central San Francisco Bay and the coastal ocean during the summer (Rosenfield and Baxter 2007). Juveniles and adults begin to move landward again during the fall (September–December).

The Longfin Smelt was once among the most abundant and widespread fishes in the SFE (Moyle 2002; Sommer et al. 2007). The species' former abundance and broad distribution strongly suggest that it once played an important role in the SFE food web; however, given an abundance decline of approximately 99.9%, Longfin Smelt are currently too rare to serve as an important prey species for piscine, avian, or mammalian predators foraging in the estuary. The Longfin Smelt is one of several fish populations that play a central role in California water management because in 2009, it was listed as threatened under the California Endangered Species Act (CESA), and regulations that were developed as part of the CESA listing can limit diversions of freshwater from the SFE. The U.S. Fish and Wildlife Service also recently determined that protection of the SFE Longfin Smelt population under the U.S. Endangered Species Act (ESA) is warranted (USOFR 2012).

Many details of Longfin Smelt ecology in the SFE are virtually unknown, as the species has not been targeted by a sport fishery or commercial fishery for many decades (Moyle 2002). Longfin Smelt are caught as bycatch in a limited bait fishery for bay shrimp *Crangon franciscorum*; although the California Department of Fish and Wildlife (CDFW 2009) considered this a factor limiting Longfin Smelt recovery, we know of no evidence that bycatch rates have increased substantially in recent times. Furthermore, until the species' recent listing under the CESA, the status of Longfin Smelt did not factor directly into decisions about water diversions. As a result, current scientific understanding of the SFE population is largely derived from correlation-based analyses of abundance indices (Stevens and Miller 1983; Jassby et al. 1995; Kimmerer 2002b), evaluations of the catch data that underlie those indices (Rosenfield and Baxter 2007; Kimmerer et al. 2009; Latour, in press), and the presumption (e.g., Moyle 2002) that the SFE population is fundamentally similar to the better-researched (but landlocked) population of Longfin Smelt in Lake Washington, Washington (Chigbu 2000).

The Longfin Smelt is also one of several SFE fishes that have shown a strong and persistent association between juvenile production and the freshwater flow variation experienced early in the life cycle (Stevens and Miller 1983; Jassby et al. 1995; Kimmerer 2002b; Rosenfield and Baxter 2007; Thomson et al. 2010; Maunder et al. 2015). However, little attention has been given to whether and how freshwater flow rates might affect production of Longfin Smelt beyond the first year of life. It is well established that Longfin Smelt production per unit of flow has declined (Kimmerer 2002b; Rosenfield and Baxter 2007; Thomson et al. 2010), but with only one very recent exception (Maunder et al. 2015), researchers have not attempted to evaluate the population dynamics of SFE Longfin Smelt in a classical spawner–recruit framework.

Food web alteration has been considered a primary factor contributing to the decline of Longfin Smelt in the SFE; however, the details of when and where prey production may limit Longfin Smelt recruitment have not been determined. Furthermore, predation on SFE Longfin Smelt has not been studied, so the role of predators in driving the population can only be speculated upon. The zooplankton assemblages that Longfin Smelt likely prey upon began changing dramatically after the overbite clam *Potamocorbula amurensis* invaded the SFE in 1986. Changes included abrupt declines in chlorophyll (Alpine and Cloern 1992) and several crustaceans, including mysid shrimps (Kimmerer 2002b); changes in the distribution (Kimmerer 2006; Sommer et al. 2011) and diet composition (Feyrer et al. 2003; Nobriga and Feyrer 2008) of several fishes were also observed. In addition, wastewater ammonium limits the growth rate of diatoms in the SFE (Wilkerson et al. 2006), and this may be another, more gradually changing factor that acts to suppress production of the Longfin Smelt's zooplankton prey.

We explored the population ecology of SFE Longfin Smelt in an attempt to identify when during the life cycle (and, by extension, where) productivity has changed and how temporal changes in these productivity parameters may explain the long-term decline of the population. To do this, we employed conceptually different variants of a standard population modeling framework (the Ricker model) to determine which formulations of the model best explained the empirical trends. We did not attempt to develop a model that would precisely recreate Longfin Smelt population dynamics; rather, our objective was to evaluate alternative conceptual models of the species' population dynamics to better understand the forces potentially constraining Longfin Smelt productivity during different phases of the life cycle. Specifically, we sought to identify factors that were correlated with productivity parameters for different life stages in order to disaggregate the effects of changes in productivity at those life stages. This information would allow future research and management actions to focus on (1) the Longfin Smelt life stages that have experienced

Downloaded by [24.6.237.115] at 14:12 27 January 2016

declines in productivity and (2) the environmental variables that can be manipulated to increase the production of those life stages.

STUDY AREA

The SFE is formed by the confluence of two major California river systems: the Sacramento and San Joaquin rivers (Figure 1). These rivers meet in the Sacramento–San Joaquin Delta (hereafter, Delta) and begin to mix with Pacific Ocean waters. This estuarine mixing intensifies in a westward direction in the several embayments that comprise San Francisco Bay (Figure 1; Jassby et al. 1995; Kimmerer et al. 2013). Some portion of central San Francisco Bay, nearest to the bay's outlet to the Pacific Ocean, usually approaches marine salinity (≥30 psu). In the northern reach of the SFE (from San Pablo Bay through the Delta), average salinity decreases from west to east due to the influence of freshwater that flows from Central Valley rivers into the Delta. The Delta comprises a network of tidal freshwater channels from which large quantities of water are exported to more arid parts of California for agricultural and municipal use. The U.S. Central Valley Project has been exporting water to the San Joaquin Valley since 1951, and the State Water Project has been exporting water to the San Joaquin Valley and southern California municipalities since 1968. The historical changes associated with the development of California's surface water supplies and the diversion of water from the Delta have been reviewed extensively (Arthur et al. 1996; Enright and Culberson 2010; Cloern and Jassby 2012).

METHODS

Overview.—Fisheries stock assessments have long relied on spawner–recruit models (e.g., Ricker 1954). These mathematical tools link the production of new cohorts of fish (recruits) to the available spawning stock and often also attempt to explain residual variation in recruitment by using environmental covariates (Myers 1998). Stock assessments are usually applied to harvested fishes, particularly those in marine ecosystems. Although the Longfin Smelt is not targeted for harvest in the SFE, it is nonetheless useful to construct explicit spawner–recruit relationships so as to evaluate different conceptual models of Longfin Smelt recruitment (see also Maunder et al. 2015).

Our analysis was based on alternative formulations of the Ricker (1954) model,

$$R = aSe^{-BS}. \tag{1}$$

In this general formulation, R is the number (or biomass) of fish recruiting to a population and S is the number (or biomass) of spawners. The parameters to be solved for are a and B, where a is the recruits per spawner (in essence, the slope of the spawner–recruit relationship near the origin) and B interacts with a to adjust the intensity of density dependence between generations. Using the Ricker model, we developed alternative conceptual models to identify the best strategy for modeling SFE Longfin Smelt recruitment. A long-term, age-specific data series of Longfin Smelt relative abundance in the SFE was used to parameterize the alternative Ricker models by (1) screening variables to predict a; (2) screening variables for predicting survival from age 0 to age 2 in order to predict S; and (3) finding values of B that constrained predictions of R, thereby creating a contrast with model variants that lacked this constraint. We then simulated a time series of Longfin Smelt relative abundance using each alternative Ricker model and compared each simulation to an empirical time series that was measured independently of the data series used to parameterize the models.

Alternative conceptual models of recruitment.—Five alternative conceptual models of Longfin Smelt recruitment were evaluated (Table 1). All models had a recruits-per-spawner

TABLE 1. Summary of five alternative Ricker models of Longfin Smelt recruitment in the San Francisco Estuary. The alphanumeric model codes are shorthand for the embedded hypotheses: the number represents whether one life stage or two life stages were explicitly modeled; "a" denotes the inclusion of a recruits-per-spawner term (i.e., applicable to all five models); "b" indicates that a model has an explicit density-dependent exponent term (e^{-BS}; see Methods); and "c" indicates that a model employs a time-dependent change in one or more parameters.

Model	Embedded hypotheses
1abc	The trend in age-0 relative abundance is sufficient to model long-term population dynamics; the production of age-0 fish is density dependent; and survival has changed through time (e.g., due to changes in the estuary's food web).
2a	Understanding the trend in age-0 relative abundance requires explicit modeling of spawner and recruit relative abundances; the production of age-0 fish is density independent; and survival has not changed through time.
2ab	Understanding the trend in age-0 relative abundance requires explicit modeling of spawner and recruit relative abundances; the production of age-0 fish is density dependent; and survival has not changed through time.
2ac	Understanding the trend in age-0 relative abundance requires explicit modeling of spawner and recruit relative abundances; the production of age-0 fish is density independent; and survival has changed through time.
2abc	Understanding the trend in age-0 relative abundance requires explicit modeling of spawner and recruit relative abundances; the production of age-0 fish is density dependent; and survival has changed through time.

Downloaded by [24.6.237.115] at 14:12 27 January 2016

Downloaded by [24.6.237.115] at 14:12 27 January 2016

term (*a*; indicated by an "a" in the alphanumeric codes that differentiate the models described in Table 1). One model (1abc) compared age-0 abundance from one generation to the next (i.e., *a* estimated the recruits per recruit) to evaluate whether age-0 indices were sufficient to model long-term population dynamics—a hypothesis that could be inferred from the numerous published analyses of Longfin Smelt age-0 abundance indices (e.g., Stevens and Miller 1983; Jassby et al. 1995; Kimmerer 2002b; Thomson et al. 2010). If the one-life-stage model performed as well as the four models with two life stages (i.e., models with "2" in their alphanumeric codes; Table 1), this would indicate that Longfin Smelt age-2 abundance is more or less determined by age-0 production (i.e., that survival from age 0 to age 2 is relatively invariant through the data series) and that the use of a traditional, two-life-stage spawner–recruit model is not necessary for modeling Longfin Smelt population dynamics in the SFE.

The four model variants that used two life stages incorporated a term to estimate survival between age 0 and age 2, thereby estimating *S* from predictions of *R*. These models differed in (1) their combination of an explicit density-dependent term for the spawner-to-recruit life history transition (indicated by a "b" in the model alphanumeric codes) and (2) whether their parameters were allowed to change through time (indicated by a "c" in the model alphanumeric codes; Table 1). The relative importance of these terms in describing empirical patterns in Longfin Smelt population abundance has ecological and management implications, as the terms suggest different mechanisms for constraining population dynamics.

Data sources.—The CDFW conducts several trawl-based surveys of fisheries resources in the SFE (www.wildlife.ca.gov/Regions/3). Longfin Smelt have been commonly collected in most of these surveys, and CDFW has generated indices of Longfin Smelt relative abundance from some of the surveys (Stevens and Miller 1983; Rosenfield and Baxter 2007). We obtained spawner–recruit parameters by using data from the San Francisco Bay Study (SFBS), which has been conducted by CDFW since 1980. Predictions made with the SFBS data were then compared to an estimate of Longfin Smelt relative abundance based on an independent data series originating from the CDFW's Fall Midwater Trawl Survey (FMWT). The CDFW has generated unitless indices of Longfin Smelt abundance from the FMWT data since 1967 (except in 1974 and 1979). The methodologies of the SFBS and FMWT sampling programs have been reported elsewhere (e.g., Stevens and Miller 1983; Rosenfield and Baxter 2007) and are not repeated here. The key differences that are pertinent to this study are as follows: (1) the SFBS and FMWT sampling grids overlap, but the former program samples further seaward and the latter program samples further landward; (2) SFBS sampling occurs during all months of the year, whereas FMWT sampling takes place only during September–December; (3) the number of stations sampled in a month is considerably higher for the FMWT (~100) than for the SFBS (~35); (4) the SFBS deploys both a bottom-oriented otter trawl and a midwater trawl at each sampling station, whereas the FMWT uses only a midwater trawl; and (5) CDFW calculates age-specific indices of Longfin Smelt relative abundance from the SFBS data but calculates only one index (essentially an age-0 index) from the FMWT data (Table 2).

The CDFW uses February–May catch data to generate an index of age-2 Longfin Smelt relative abundance for each sampling gear employed by the SFBS; May–October catch data are used to generate abundance indices for age-0 Longfin Smelt. We averaged the midwater trawl and otter trawl indices generated by the SFBS to produce unitless annual indices for each age-class of Longfin Smelt (hereafter, Bay Age-0 index and Bay Age-2 index; Table 2). We combined indices from the two sampling gears because the SFBS midwater trawl was not deployed during some years (Rosenfield and Baxter 2007), so the Bay Age-0 and Bay Age-2 indices provided continuous time series of relative abundance for 1980–2013. We did not attempt to estimate missing data (missing values were replaced with a zero before taking the average) because it was possible that estimation of missing values would be no more accurate than simply treating the missing data as zeroes. These choices reflect a trade-off between long-term data availability and the timing of peak Longfin Smelt catches (Rosenfield and Baxter 2007).

Selection of environmental covariates.—We developed one freshwater flow variable and three water quality variables to use as candidate predictors of Longfin Smelt life stage transitions. Following the work of Rosenfield and Baxter (2007), we used monthly means of the net Delta outflow index (hereafter, Delta outflow; www.water.ca.gov/dayflow/) to represent the commonly reported influence of freshwater flow on Longfin Smelt. Delta outflow is the estimated net tidally filtered river flow passing Chipps Island (Figure 1); it is the freshwater flow variable that most directly influences salinity distribution in SFE river channels and embayments (Jassby et al. 1995; Kimmerer et al. 2013). These open-water habitats comprise the major larval rearing areas for Longfin Smelt (Dege and Brown 2004; Hobbs et al. 2006). We calculated the monthly mean Delta outflow for December–May because (1) these months fully overlap with the Longfin Smelt spawning and larval rearing phases in the SFE (CDFW, unpublished data); and (2) outflow during these months is typically greater and more variable than outflow in other months. As a result, December–May outflow is most likely to influence the fate of Longfin Smelt (Jassby et al. 1995; Kimmerer et al. 2013). Estuarine hydrodynamics are also influenced greatly during droughts, which affect the fate of Longfin Smelt (Rosenfield and Baxter 2007). Delta outflow data were available for the period 1956–2013, and we converted monthly means into metric units (m^3/s).

We also used monthly means of water temperature (°C) and water transparency (Secchi depth, cm) from all available data

NRDC-36

TABLE 2. Time series of the first principal component (PC1) from principal components analyses (PCA) of available water quantity and water quality variables, presented with time series of the Longfin Smelt relative abundance indices used in this study. The PCA on the net Delta outflow index (Delta outflow PC1; Sacramento–San Joaquin River Delta) was conducted on data for December–May; the PCAs for water temperature (water temp PC1) and water transparency were conducted on data for February–May. All abundance indices are unitless metrics of the Longfin Smelt's relative abundance in the San Francisco Estuary. The Fall Midwater Trawl Survey (FMWT) index is based on data collected during September–December. Bay indices are average results from the San Francisco Bay Study's (SFBS) two sampling gears (midwater trawl and otter trawl); the Bay Age-0 index is based on data collected during May–October, and the Bay Age-2 index is based on data collected during February–May.

Water year	Delta outflow PC1	Water temp PC1	Water transparency PC1	FMWT index	Bay Age-0 index	Bay Age-2 index
1956	2.77					
1957	−0.627					
1958	3.74					
1959	−1.14					
1960	−1.19					
1961	−1.29					
1962	−0.575					
1963	1.21					
1964	−1.5					
1965	1.3					
1966	−1.02					
1967	1.91			81,737		
1968	−1.12			3,279		
1969	2.68			59,350		
1970	0.928			6,515		
1971	0.152			15,903		
1972	−1.6			760		
1973	0.442			5,896		
1974	1.97			No data		
1975	−0.123			2,819		
1976	−1.93			658		
1977	−2.23			210		
1978	0.722			6,619		
1979	−1.05			No data		
1980	1.08	−1.22	−0.142	31,184	159,555	1,339
1981	−1.5	−0.651	−0.029	2,202	3,049	383
1982	3.04	−0.257	1.19	62,905	278,517	1,656
1983	5.91	−1.88	1.8	11,864	28,755	1,891
1984	0.492	−1.63	−1.56	7,408	36,774	4,924
1985	−1.67	0.222	−3.3	992	7,341	1,939
1986	1.71	−1.06	1.21	6,160	18,489	1,384
1987	−1.81	1.5	−0.68	1,520	2,428	1,785
1988	−1.97	0.335	−0.24	791	1,409	3,571
1989	−1.7	3.01	1.15	456	1,054	941
1990	−2.06	2.12	1.09	243	713	687
1991	−1.98	−1.43	2.33	134	188	351
1992	−1.88	2.18	−1.05	76	495	152
1993	0.006	−0.649	1.76	798	6,046	11
1994	−1.79	−0.06	0.379	545	1,424[a]	414
1995	3.59	−1.57	0.885	8,205	354,186	252[a]
1996	1.2	−0.451	−0.464	1,346	5,856	124[a]
1997	1.6	0.627	1.25	690	7,638	1,432

Downloaded by [24.6.237.115] at 14:12 27 January 2016

Downloaded by [24.6.237.115] at 14:12 27 January 2016

TABLE 2. Continued.

Water year	Delta outflow PC1	Water temp PC1	Water transparency PC1	FMWT index	Bay Age-0 index	Bay Age-2 index
1998	3.11	−2.06	3.0	6,654	41,729	605
1999	0.414	0.989	0.529	5,243	58,510	748
2000	0.036	−0.511	0.322	3,437	14,202	704
2001	−1.61	0.659	−0.329	247	1,460	1,158
2002	−1.35	1.37	−0.271	707	9,652	1,752
2003	−0.468	0.81	−0.229	467	2,119	739
2004	−0.514	0.852	0.268	191	2,418	686
2005	−0.235	−0.956	0.048	129	4,538	569
2006	3.79	0.371	−0.411	1,949	12,148	188
2007	−1.73	0.799	−1.56	13	2,039	447
2008	−1.67	−0.361	0.341	139	3,681	204
2009	−1.57	0.149	−0.857	65	647	272
2010	−1.17	−0.247	−0.529	191	748	197
2011	1.21	−0.996	−3.51	477	7,833	305
2012	−1.53		0.365	61	1,284	733
2013	−1.38		−2.76	164	8,495	300

[a] The SFBS midwater trawl data were not collected in this year, but a value of zero was assumed in order to calculate the index.

collected by the SFBS. Water temperature data provided by CDFW were available for the years 1980–2011, and water transparency data were available for the period 1980–2013. We calculated monthly means of these two water quality variables for February–May (the indexing period for age-2 Longfin Smelt); during those months, age-0 Longfin Smelt are primarily in larval stages and have a center of distribution near the estuary's 2-psu isohaline (Dege and Brown 2004).

We summarized the Delta outflow, water temperature, and water transparency data separately by using principal components analysis (PCA) on the z-scored monthly means. We used PCA because sequential monthly means of flow and water quality variables can be closely correlated due to California's seasonal climate and high year-to-year variation in precipitation. This covariation makes it difficult to determine the averaging periods that best reflect the mechanistic linkages between environmental conditions and Longfin Smelt production. The first principal component (PC1) scores from each PCA (Table 2) were used as candidate predictors of Longfin Smelt recruits per spawner (a) in the regression analyses described below.

Derivation of recruits per spawner.—We represented a by using one of the following $\log_e$ transformed ratios: (Bay Age $0_{t=0}$)/(Bay Age $0_{t\text{-}2}$) for model 1abc; or (Bay Age $0_{t=0}$)/(Bay Age $2_{t=0}$) for the two-life-stage models. Multiple linear regression analyses were performed to screen candidate predictors of a in an information-theoretic framework; to develop a smaller set of statistically defensible covariates, we evaluated predictors by using Akaike's information criterion corrected for small sample sizes (AIC_c). Regression analyses were conducted separately for each version of the response variable; separate regression analyses were also conducted for tests involving water temperature variables (i.e., due to the smaller data set mentioned above). The candidate predictors and their assumed mechanistic meanings are described in Table 3.

During our analyses, we discovered that the relationship between Delta outflow and the two-life-stage version of $\log_e(a)$ was not linear. We used locally weighted scatter plot smoothing (LOESS) regression to depict the empirical shape of the relationship between these variables, and we found that the LOESS prediction was very similar to a second-order polynomial fit. We used AIC_c to confirm whether a polynomial fit was better supported than a linear fit; the polynomial regression was then used to predict a in our model variants with two life stages, as that equation was far simpler to implement than the LOESS equation.

Derivation of spawners per recruit.—In the two-life-stage models (2a, 2ab, 2ac, and 2abc), we estimated the relative abundance of age-2 Longfin Smelt to predict the relative abundance of the next generation of age-0 fish. We did this by deriving an estimator of survival from age 0 to age 2 ($S_{0\rightarrow 2}$) and multiplying estimates of R by this survival term to estimate the next generation of spawners (i.e., S). We estimated $S_{0\rightarrow 2}$ as the $\log_e$ transformed ratio, (Bay Age $2_{t=0}$)/(Bay Age 0_{t-2}) (i.e., the two SFBS indices for the same cohort of fish). We then tested a set of candidate predictor variables for this ratio by following the same analytical approach used to predict a. For this analysis, we also included the birth-year FMWT index as a candidate predictor (Table 3) to evaluate whether juvenile survival might be density dependent, given similar findings for other SFE fishes (Kimmerer et al. 2000; Bennett 2005).

Derivation of the exponent term.—To evaluate whether density dependence also affected R, we imposed a carrying

TABLE 3. Variables used as candidate covariates for predicting Longfin Smelt recruits per spawner and survival from age 0 to age 2, presented with implied or explicit hypotheses associated with the use of each variable (PC1 = first principal component; Delta outflow = net Delta outflow index, Sacramento–San Joaquin River Delta; SFBS = San Francisco Bay Study, California Department of Fish and Wildlife [CDFW]; FMWT = Fall Midwater Trawl Survey, CDFW).

Explanatory variable	Data source	Hypothesis for relationship to recruits per spawner	Hypothesis for relationship to survival from age 0 to age 2
PC1 for Delta outflow (m^3/s)	Dayflow[a]	Freshwater flow has a positive influence on survival of developing eggs, larvae, or early age-0 fish.	Freshwater flow has a positive influence on catchability of age-2 fish or survival from age 0 to age 2.[b]
PC1 for water transparency (Secchi depth, cm)	SFBS	Water transparency has a negative influence on survival of developing eggs, larvae, or early age-0 fish.	Water transparency has a negative influence on spatial distribution, catchability, or survival of age-2 fish.
PC1 for water temperature (°C)	SFBS	Intra-annual temperature change between winter and spring has a negative influence on survival of developing eggs, larvae, or early age-0 fish.	Intra-annual temperature change between winter and spring has a negative influence on spatial distribution, catchability, or survival of age-2 fish.
Mean water temperature (°C)	SFBS	Temperature has a negative influence on survival of developing eggs, larvae, or early age-0 fish.	Temperature has a negative influence on spatial distribution, catchability, or survival of age-2 fish.
Year		Dummy variable to indicate that an important variable with a continuous time trend had been missed (e.g., regional trends in Secchi depth; ammonium inhibition of phytoplankton growth rates)	Dummy variable to indicate that an important variable with a continuous time trend had been missed
Step-decline		Binary variable reflecting that the discontinuous time trend associated with some food web impacts (e.g., linked to the overbite clam invasion) had affected the survival of age-0 fish	Binary variable reflecting that the discontinuous time trend associated with some food web impacts had affected the survival of fish older than age 0
FMWT index	FMWT	Not applicable	The abundance of age-0 fish affects subsequent survival.

[a] California Department of Water Resources (www.water.ca.gov/dayflow/).

[b] This hypothesis was tested by determining whether survival from age 0 to age 2 could be better predicted by including flows that occurred during spawning (e.g., the ratio of [Bay Age-2 index in 1982]/[Bay Age-0 index in 1980] tested for an influence of the flow during 1982). The influence of freshwater flow on the year in between birth and spawning was also tested but was not statistically significant and therefore is not reported in this paper.

Downloaded by [24.6.237.115] at 14:12 27 January 2016

capacity on the models identified with a “b” in their alphanumeric codes (Table 1). Inclusion or exclusion of the exponent term e^{-BS} allowed us to investigate whether interannual variation in environmental conditions was sufficient to produce a natural limit on the production of age-0 Longfin Smelt (models 2a and 2ac) or, conversely, whether an explicit carrying capacity provides for better-fitting models (models 1abc, 2ab, and 2abc). To do this, we found values for B that reflected empirical relative abundance maxima given our estimates of a. The maximum FMWT index for Longfin Smelt was 81,737 in 1967. The maximum a, indexed as (Bay Age $0_{t=0}$)/(Bay Age 0_{t-2}), was 59 in 1995. We rounded these values up slightly and found a B-value that, when multiplied by hypothetically increasing numbers of spawners, would limit the ability of model 1abc to predict FMWT indices greater than 82,000 when a was equal to 60. Similarly, for the two-life-stage models, the maximum observed a (indexed as [Bay Age $0_{t=0}$]/[Bay Age $2_{t=0}$]) for the 10 years with the highest age-2 abundance was 168 in 1982. We rounded these values up slightly to calculate a B-value that would limit the ability of simulations from the two-life-stage models to predict FMWT indices greater than 82,000 when a was equal to 170.

Evaluating changes in model parameters assumed to result from changes in the San Francisco Estuary food web.—The feeding habits of juvenile Longfin Smelt in the SFE are basically undescribed, particularly for individuals foraging in mesohaline to marine waters (but see Hobbs et al. [2006] for data on larvae inhabiting the low-salinity zone). Hypothesized

Downloaded by [24.6.237.115] at 14:12 27 January 2016

changes in Longfin Smelt foraging success are either abrupt (e.g., due to the invasion of the overbite clam) or gradual and continuous (e.g., due to altered nutrient concentrations or changes in water transparency). We explored the predictive power of several temporal variables as surrogates for food web changes in the regression analyses (Table 3). Specifically, Kimmerer (2002b) used 1987 as a change point associated with invasion of the overbite clam; thus, we used a step-decline in that year as a predictor variable for a in model 1abc because fish that were spawned in 1987 would have been the first to be impacted by the high density of overbite clams detected in that year and thereafter. However, Thomson et al. (2010) found that evidence for a step-decline in Longfin Smelt relative abundance was strongest between 1989 and 1991. In our two-life-stage models, we tested step-declines in survival for 1989 and 1991; fish that were spawned in 1987 would have reached adulthood in 1989, so we would expect to see the overbite clam's first effects on $S_{0\rightarrow 2}$ during that year. We also screened "year" as a predictor variable to test for the possibility that trends in survival were not well represented as step-declines (Table 3).

Spawner–recruit simulations.—Using each of the five alternative spawner–recruit models, we generated 58-year time series of predicted Longfin Smelt FMWT indices (1958–2013). We started each simulation by seeding 1956 and 1957 with the median observed FMWT index (798). The simulations then predicted all Longfin Smelt abundance indices from 1958 through water year 2013. The simulations were stochastic; each year of each simulation was iterated 1,000 times by using randomly drawn values of every regression parameter; the parameter estimate was assumed to be the mean, and the SE was used to scale the random variability. We restricted the simulations such that juvenile survival had to remain less than or equal to 1.0 (i.e., $\leq$100%). This is an extremely high upper limit on survival, but it is not greatly beyond the observed data: the index ratio we used to represent survival had a maximum empirical value of 0.98 in 2012.

Model variants were evaluated based on their ability to predict the empirical FMWT time series and based on the frequency with which they produced results that were clearly spurious. Each of the resulting 5,000 simulations was compared to the empirical FMWT indices by calculating the mean square error (MSE). Because FMWT data were available for 1967–1973, 1975–1978, and 1980–2013, those years were extracted from our simulations for use in this comparison. The central 95% of MSE estimates (i.e., 950 of the 1,000 iterations) were summarized by using box plots. We also evaluated the relative performance of model variants with the lowest MSEs by summarizing how frequently they predicted Longfin Smelt quasi-extinction, defined here as a FMWT index value less than 1 (the lowest empirical FMWT index value was 13 in 2007). Lastly, the time series predictions from the best-performing models were summarized graphically to more explicitly illustrate their performance relative to the observed FMWT index time series.

RESULTS

The PC1s for Delta outflow, water transparency, and water temperature had eigenvalues of 3.5, 2.0, and 1.5, respectively, and explained 58, 50, and 37% of the variance in the time trends for these variables. The PC1 for Delta outflow and the PC1 for water transparency were highly concordant with multiple-month means of each year (Delta outflow: Pearson's product-moment correlation coefficient $r = 0.99$; water transparency: Pearson's $r = 0.98$). In contrast, the PC1 for water temperature was not correlated with mean water temperature (Pearson's $r = 0.17$) and instead reflected variation within years; the PC1 for temperature segregated the years with relatively large temperature changes between winter and spring (i.e., cool February–March and warm April–May) from the years with less seasonal variation. Therefore, we tested both the PC1 and the mean of water temperature as candidate predictor variables for a and $S_{0\rightarrow 2}$.

Recruits per Spawner

The linear regression analyses that were used to screen candidate predictor variables indicated positive effects of Delta outflow PC1 and the binary step-change at 1987 as predictors of a for use in model 1abc (Table 4). The step-change variable was not significant ($P = 0.07$), and its sign was opposite our expectation (i.e., a was predicted to increase after 1987), but its inclusion was supported by the change in ACI_c. The final model selected was $\log_e(a) = [0.596 \pm 0.146(\text{Delta outflow PC1})] + [1.54 \pm 0.829(\text{step-decline in 1987})] - (1.39 \pm 0.748)$. The similar analyses for models 2a, 2ab, 2ac, and 2abc supported only the use of Delta outflow PC1 as a predictor of a; in that case, a nonlinear fit was better supported than a linear fit (Table 4). The final model selected was $\log_e(a) = [-0.148 \pm 0.049(\text{Delta outflow PC1})^2] + [0.954 \pm 0.152(\text{Delta outflow PC1})] + [2.94 \pm 0.303]$; neither the linear fit nor the nonlinear fit showed evidence of a monotonic residual time trend (Figure 2).

Juvenile Survival

The linear regression analyses that were used to screen candidate predictor variables of $S_{0\rightarrow 2}$ strongly supported the use of the birth-year FMWT index (Table 5), suggesting that juvenile survival is density dependent. All of the temporal variables we tested had P-values ≤ 0.052. Interestingly, the 1989 step-decline performed poorly ($\text{AIC}_c = 103$) relative to "year" ($\text{AIC}_c = 99.6$) and the 1991 step-decline ($\text{AIC}_c = 95.4$). The final model selected was $\log_e(S_{0\rightarrow 2}) = [-0.630 \pm 0.114 \cdot \log_e(\text{FMWT index})] - [1.68 \pm 0.474(\text{step-decline in 1991})] + [3.19 \pm 1.03]$.

TABLE 4. Results of linear regression analyses exploring candidate predictors of two versions of the recruits-per-spawner parameter for Longfin Smelt in the San Francisco Estuary. In model 1abc, the response variable was the natural logarithm of (Bay Age $0_{t=0}$)/(Bay Age 0_{t-2}). In the other models, the response variable was the natural logarithm of (Bay Age $0_{t=0}$)/(Bay Age $2_{t=0}$). The cells for each candidate predictor variable report whether the variable was tested in each model step, its P-value when tested, and whether it was dropped in subsequent steps due to a nonsignificant P-value. Akaike's information criterion corrected for small sample sizes (AIC$_c$) is shown; AIC$_c$ values from steps 1 and 2 cannot be compared with those from steps 3–5 due to the increase in sample size for the latter three steps. Step 5 in the two-life-stage models tested the quadratic flow relationship against the linear version tested in step 4. See Table 3 for descriptions of the predictor variables.

Statistic or predictor variable	Step 1	Step 2	Step 3	Step 4	Step 5
		One-life-stage model (1abc)			
Adjusted R^2	0.26	0.26	0.31	0.32	Not applicable
Sample size	30	30	32	32	
AIC$_c$	124	122	127	125	
Flow PC1	0.001	0.01	0.0005	0.0003	
Temperature PC1	Not tested	0.81	Dropped	Dropped	
Water transparency PC1	Not tested	Not tested	0.56	Dropped	
Mean temperature	0.68	Dropped	Dropped	Dropped	
Year	0.41	Dropped	Dropped	Dropped	
Step-decline in 1987	Not tested	Not tested	0.06	0.07	
		Two-life-stage models (2a, 2ab, 2ac, and 2abc)			
Adjusted R^2	0.43	0.46	0.41	0.44	0.55
Sample size	32	32	34	34	34
AIC$_c$	123	120	130	126	119
Flow PC1	0.00003	0.0007	0.00004	0.00001	6×10^{-7}
Temperature PC1	Not tested	0.33	Dropped	Dropped	Dropped
Water transparency PC1	Not tested	Not tested	0.46	Dropped	Dropped
Mean temperature	0.66	Dropped	Dropped	Dropped	Dropped
Year	0.70	Dropped	Dropped	Dropped	Dropped
Step-decline in 1987	Not tested	Not tested	0.62	Dropped	Dropped

Model Evaluation

The MSEs of most models overlapped at least somewhat, but two of the models (2a and 2ac) had notably poorer fits to the FMWT data and thus produced higher MSEs 63–100% of the time (Figure 3). It therefore appears that an explicit carrying capacity on R is a useful model construct. The MSEs of models 1abc, 2ab, and 2abc overlapped strongly (Figure 4), suggesting that the models provided a similar fit to the FMWT data. Compared with models 2ab and 2abc, model 1abc showed low variation in MSE among model iterations (Figure 4), but that low variability reflected model 1abc's rapid predictions of quasi-extirpation in 100% of the iterations (Figure 5). Thus, although model 1abc appeared to have a relatively good fit to the FMWT data, this model was clearly unreliable. By design, models 2ab and 2abc were equivalent until the 1991 step-decline was implemented in the latter model. Thus, FMWT predictions based on these models were nearly equivalent from 1967 to 1990 (Figure 6). Median FMWT predictions using model 2ab were closer to the empirical data from 1991 to 1994; thereafter, the median predictions from model 2ab systematically overestimated the observed FMWT time series, whereas the median predictions from model 2abc more closely matched the empirical data (Figure 6). As a result, the median predictions of model 2abc provided a better overall representation of the empirical FMWT indices (compare panels D and B in Figure 6).

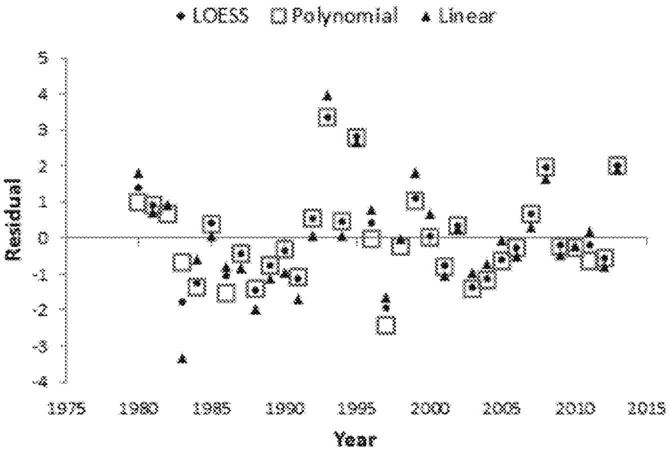


FIGURE 2. Time series of residuals from three regression analyses of the first principal component for the net Delta outflow index (December–May; Sacramento–San Joaquin Delta) in relation to the natural logarithm of Longfin Smelt recruits (age 0) per spawner (age 2) in the San Francisco Estuary (LOESS = locally weighted scatter plot smoothing).

Downloaded by [24.6.237.115] at 14:12 27 January 2016

Downloaded by [24.6.237.115] at 14:12 27 January 2016

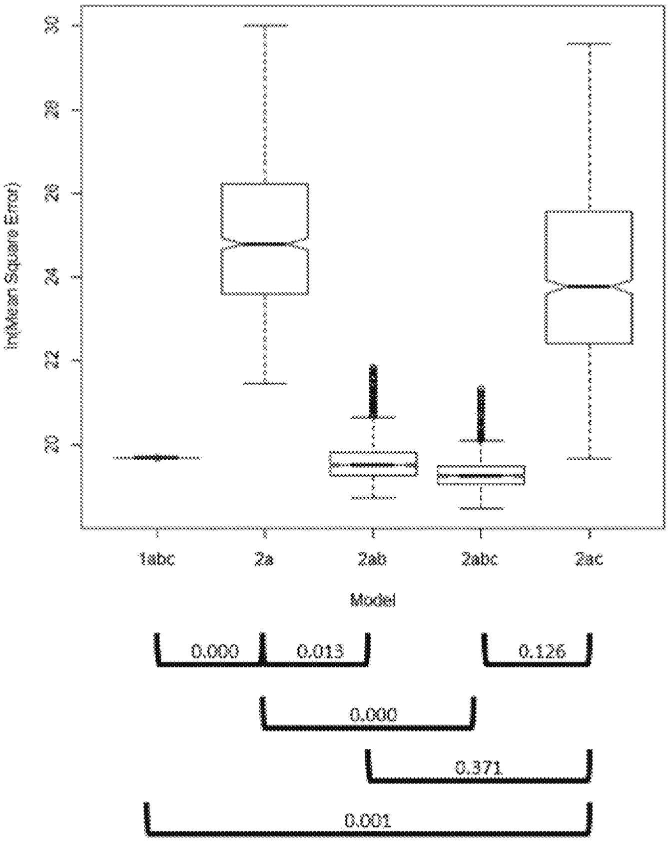


FIGURE 3. Notched box plot summarizing the mean square error (MSE; $\log_e$ transformed) from the central 95% of predictions of the Longfin Smelt Fall Midwater Trawl Survey index using five alternative spawner–recruit models (see Table 1 for model descriptions). The ends of the box represent the first and third quartiles; the line inside the box represents the median; the ends of the whiskers represent a 95% confidence interval; outliers (open circles) are also shown. Where notches associated with MSEs from different models do not overlap, there is "strong evidence" that their medians differ (Quick R; www.statmethods.net/graphs/boxplot.html). The pairwise proportions of overlapping MSE predictions from 950 model iterations are provided below the box plot.

However, the propagated prediction error was high even for models 2ab and 2abc (Figure 6A, C), making it impossible to conclude that one outperformed the other. In addition, both model 2ab and model 2abc considerably underpredicted and were nonlinearly related to the FMWT indices (Figure 6B, D), suggesting that our e^{-BS} term was too strongly density dependent.

DISCUSSION

Relying on a few well-supported assumptions about Longfin Smelt life history and ecology in the SFE, our two best-supported Ricker models each incorporated two life stages in which productivity was density dependent during each life stage transition. In both models, recruits per spawner were related to freshwater flow rates. Apparently, despite differences in geographic extent, timing, and sampling gears, the SFBS and FMWT sampling programs detected the same general patterns in Longfin Smelt population dynamics, and our Ricker-model-based analyses indicated that there are at least two important—but temporally distinct—population dynamic effects: (1) an influence of freshwater flow on the production of age-0 fish; and (2) density-dependent and possibly declining juvenile survival.

Implications of Spawner–Recruit Dynamics

The influence of freshwater flow on the production of age-0 Longfin Smelt has been recognized for several decades (Stevens and Miller 1983; Jassby et al. 1995; Rosenfield and Baxter 2007), although we found evidence for nonlinearities that had not been identified before (Table 4; Figure 2). Depending on its timing and magnitude, freshwater flow was observed to have both positive and negative effects on the recruitment of age-0 Longfin Smelt in Lake Washington (Chigbu 2000). There was no evidence that the ratio we used to depict recruits per spawner

TABLE 5. Results of linear regression analyses exploring candidate predictors of survival from age 0 to age 2 for Longfin Smelt in the San Francisco Estuary. The response variable was the natural logarithm of (Bay Age $2_{t=0}$)/(Bay Age 0_{t-2}). The cells for each candidate predictor variable report whether the variable was tested in each model step, its P-value when tested, and whether it was dropped in subsequent steps due to a nonsignificant P-value. Akaike's information criterion corrected for small sample sizes (AIC_c) is shown; the AIC_c values from steps 1 and 2 cannot be compared with those from steps 3–6 due to the increase in sample size for the latter four steps. See Table 3 for descriptions of the predictor variables.

Statistic or predictor variable	Step 1	Step 2	Step 3	Step 4	Step 5	Step 6
Adjusted R^2	0.44	0.46	0.39	0.41	0.35	0.48
Sample size	30	30	32	32	32	32
AIC_c	94.1	91.5	102	99.6	103	95.4
$\log_e$(birth-year FMWT index)	0.00009	0.00003	0.00005	0.00004	0.0002	0.000006
Flow PC1	0.38	Dropped	Dropped	Dropped	Dropped	Dropped
Temperature PC1	Not tested	0.44	Dropped	Dropped	Dropped	Dropped
Water transparency PC1	Not tested	Not tested	0.78	Dropped	Dropped	Dropped
Mean temperature	0.99	Dropped	Dropped	Dropped	Dropped	Dropped
Year	0.005	0.004	0.01	0.01	Not tested	Not tested
Step-decline in 1989	Not tested	Not tested	Not tested	Not tested	0.052	Not tested
Step-decline in 1991	Not tested	Not tested	Not tested	Not tested	Not tested	0.001

Downloaded by [24.6.237.115] at 14:12 27 January 2016

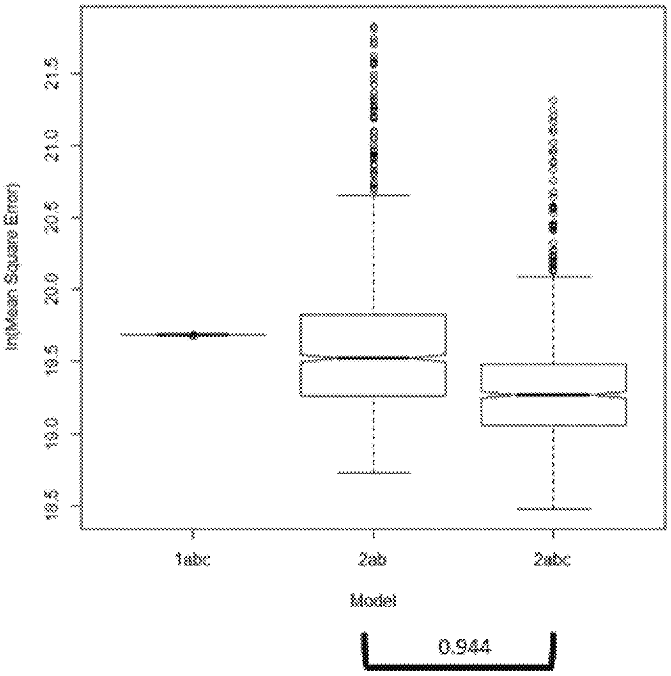


FIGURE 4. Notched box plot summarizing the mean square error (MSE; $\log_e$ transformed) from the central 95% of predictions of the Longfin Smelt Fall Midwater Trawl Survey index based on the two best-supported spawner–recruit models as well as model 1abc (see Table 1 for model descriptions). The ends of the box represent the first and third quartiles; the line inside the box represents the median; the ends of the whiskers represent a 95% confidence interval; outliers (open circles) are also shown. Where notches associated with MSEs from different models do not overlap, there is "strong evidence" that their medians differ (Quick R; www.statmethods.net/graphs/boxplot.html). The pairwise proportion of overlapping MSE predictions from 950 iterations of models 2ab and 2abc is provided below the box plot.

has declined over time; thus, food web changes apparently have not impacted this life stage transition. However, there is some suggestion of a cyclical pattern among the residuals (Figure 2), which implies a potential ocean influence on Longfin Smelt recruitment in the SFE (sensu Feyrer et al. 2015). This possibility warrants further research. Improvements in the scientific understanding of when freshwater flow modulates Longfin Smelt production may help to reveal the flow-related mechanisms at work and the area where those mechanisms function. Focusing on the time and place where freshwater flow is likely to affect recruitment may assist Central Valley water project managers in optimizing freshwater flow rates so as to benefit Longfin Smelt production.

Implications for Juvenile Survival

We found no indication that freshwater flow moderated the survival of Longfin Smelt between age 0 and age 2, but we did detect evidence that survival during this life stage transition is density dependent (Table 5). In contrast to the production of age-0 fish, there was evidence for continuous declines or step-declines (Table 5) in the survival of juvenile Longfin Smelt, which may reflect food-web-related impacts on this older life stage. Several other studies have detected one or more step-declines in the FMWT time series for Longfin Smelt (Kimmerer 2002b; Thomson et al. 2010). Rosenfield and Baxter (2007) noted an age-specific decline in production between age 0 and the age of spawning in Longfin Smelt; this decline may have occurred sometime during the severe drought of 1987–1994. Due to the propagation of variance, our spawner–recruit simulations were unable to robustly distinguish between the model that allowed survival rates to change (model 2abc) and the model in which survival did not change directionally (model 2ab; Figures 4, 6).

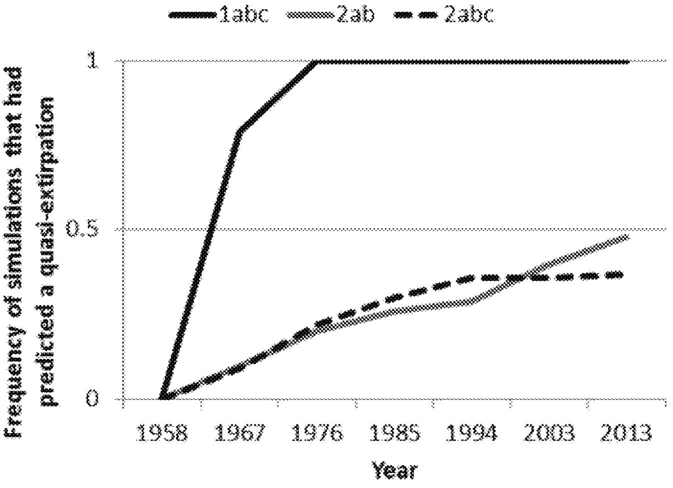


FIGURE 5. Time series showing the proportion of stochastic simulations of Longfin Smelt recruitment that predicted quasi-extirpation (defined as a predicted Fall Midwater Trawl Survey index < 1.0) from three alternative spawner–recruit models (see Table 1 for model descriptions).

Constraining the timing and location of the density dependence and declining survival of Longfin Smelt may help to identify mechanisms that control these vital rates. The forces creating density-dependent survival and possible declines in that survival are most likely to operate during the period between (1) sampling that produces the age-0 abundance index (May–October in year 0) and (2) sampling that produces the age-2 abundance index (February–May). For most of the SFE Longfin Smelt, this part of the life cycle is primarily spent in mesohaline or marine waters (Rosenfield and Baxter 2007); therefore, the mechanisms affecting juvenile survival are more likely to operate in mesohaline or marine environments than in freshwater or low-salinity-zone waters.

Implications for Forage Fish Management in the San Francisco Estuary

Our results support some emerging generalizations about fish recruitment in the SFE. The results suggest that the general life cycle model for Longfin Smelt is very similar to

Downloaded by [24.6.237.115] at 14:12 27 January 2016

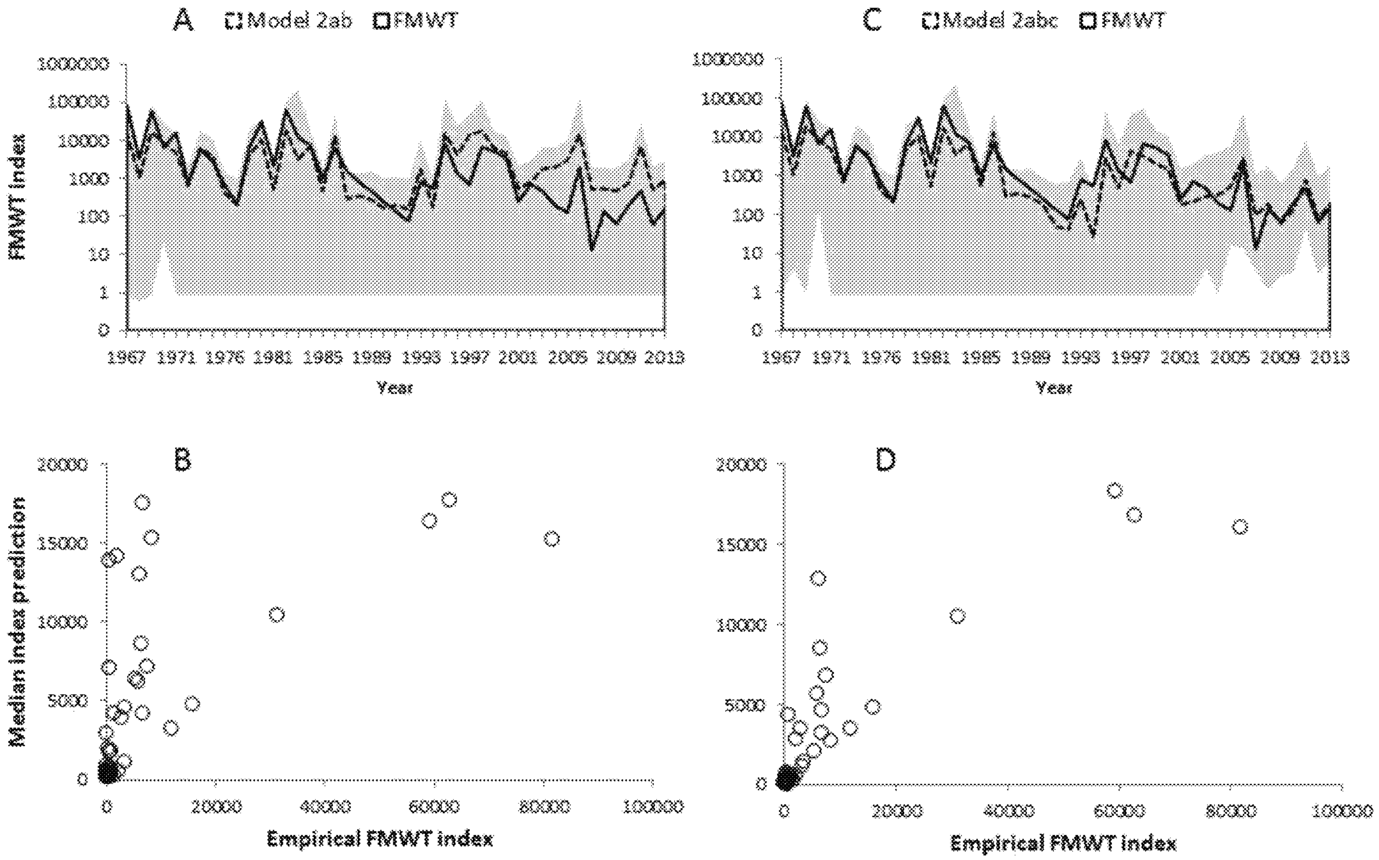


FIGURE 6. The Fall Midwater Trawl Survey (FMWT) index for Longfin Smelt, presented relative to predictions from the two best-supported spawner–recruit models: (**A**) the time series for the FMWT index (solid line), the median prediction (dashed line) from model 2ab (950 model iterations/year), and the range of the central 95% of predictions (gray shading); (**B**) scatter plot of the median FMWT index prediction from model 2ab in relation to the empirical FMWT index; (**C**) the time series for the FMWT index, the median prediction from model 2abc (950 model iterations/year), and the range of the central 95% of predictions; and (**D**) scatter plot of the median FMWT index prediction from model 2abc in relation to the empirical FMWT index.

Striped Bass *Morone saxatilis* (Kimmerer et al. 2000). For each of these species, freshwater flow variation has been linked to productivity early in the life cycle—an effect that is subsequently tempered by density-dependent survival during the juvenile life stage. Density-dependent survival may seem paradoxical in a declining fish species like the Longfin Smelt, but fisheries recruitment theory has demonstrated how a spawner–recruit relationship that appears to reflect density dependence can arise from food-web-related mechanisms that are unrelated to a population's limitation of its own resource base (Walters and Juanes 1993).

The SFE population of Longfin Smelt is in the queue for potential listing under the ESA (USOFR 2012). By disaggregating the life-stage-specific constraints on population dynamics, our results can help to inform a future ESA listing decision for Longfin Smelt and can assist in development of the accompanying recovery plan if the population is listed. Perhaps more importantly, the present study helps to identify the portion of the Longfin Smelt's life cycle during which productivity is limited and may be changing over time, thus potentially informing efforts to research and monitor recruitment limitation in this species. The persistence of Longfin Smelt and several other native forage fish species in the SFE (and potentially the predators that historically relied on these populations; e.g., Striped Bass and California Halibut *Paralichthys californicus*) depends on taking steps to improve the productivity of these fishes.

ACKNOWLEDGMENTS

This study emerged from our work for the Bay–Delta Conservation Plan. The viewpoints expressed are those of the authors and do not necessarily reflect the opinions of the U.S. Department of the Interior or the U.S. Fish and Wildlife Service. We thank A. Weber-Stover for help in assembling and reviewing an early draft of the manuscript; K. Sun for generating Figure 3; and R. Baxter for providing the SFBS data. The comments of three anonymous reviewers are greatly appreciated.

REFERENCES

Alder, J., B. Campbell, V. Karpouzi, K. Kaschner, and D. Pauly. 2008. Forage fish: from ecosystems to markets. Annual Review of Environment and Resources 33:153–166.

Alpine, A. E., and J. E. Cloern. 1992. Trophic interactions and direct physical effects control phytoplankton biomass and production in an estuary. Limnology and Oceanography 37:946–955.

Arthur, J. F., M. D. Ball, and S. Y. Baughman. 1996. Summary of federal and state water project environmental impacts in the San Francisco Bay–Delta estuary, California. San Francisco State University, San Francisco, California.

Bennett, W. A. 2005. Critical assessment of the Delta Smelta population in the San Francisco Estuary, California. San Francisco Estuary and Watershed Science [online serial] 3(2).

CDFW (California Department of Fish and Wildlife). 2009. Report to the Fish and Game Commission: a status review of the Longfin Smelt (*Spirinchus thaleichthys*) in California. CDFW, Napa.

Chigbu, P. 2000. Population biology of Longfin Smelt and aspects of the ecology of other major planktivorous fishes in Lake Washington. Journal of Freshwater Ecology 15:543–557.

Cloern, J. E., and A. D. Jassby. 2012. Drivers of change in estuarine-coastal ecosystems: discoveries from four decades of study in San Francisco Bay. Reviews of Geophysics [online serial] 50(4):RG4001.

Cury, P. M., I. L. Boyd, S. Bonhommeau, T. Anker-Nilssen, R. J. M. Crawford, R. W. Furness, J. A. Mills, E. J. Murphy, H. Österblom, M. Paleczny, J. F. Piatt, J.-P. Roux, L. Shannon, and W. J. Sydeman. 2011. Global seabird response to forage fish depletion–one-third for the birds. Science 334:1703–1706.

Dege, M., and L. R. Brown. 2004. Effect of outflow on spring and summertime distribution and abundance of larval and juvenile fishes in the upper San Francisco Estuary. Pages 49–66 *in* F. Feyrer, L. R. Brown, R. L. Brown, and J. J. Orsi, editors. Early life history of fishes in the San Francisco Estuary and watershed. American Fisheries Society, Symposium 39, Bethesda, Maryland.

Enright, C., and S. Culberson. 2010. Salinity trends, variability, and control in the northern reach of the San Francisco Estuary. San Francisco Estuary and Watershed Science[online serial] 7(2).

Essington, T. E., and S. Hansson. 2004. Predator-dependent functional responses and interaction strengths in a natural food web. Canadian Journal of Fisheries and Aquatic Sciences 61:2215–2226.

Feyrer, F., J. E. Cloern, L. R. Brown, M. A. Fish, K. A. Hieb, and R. D. Baxter. 2015. Estuarine fish communities respond to climate variability over both river and ocean basins. Global Change Biology 21:3608–3619.

Feyrer, F., B. Herbold, S. A. Matern, and P. B. Moyle. 2003. Dietary shifts in a stressed fish assemblage: consequences of a bivalve invasion in the San Francisco Estuary. Environmental Biology of Fishes 67:277–288.

Genin, A. 2004. Bio-physical coupling in the formation of zooplankton and fish aggregations over abrupt topographies. Journal of Marine Systems 50:3–20.

Gillson, J. 2011. Freshwater flow and fisheries production in estuarine and coastal systems: where a drop of rain is not lost. Reviews in Fisheries Science 19:168–186.

Hall, C. J., A. Jordaan, and M. G. Frisk. 2012. Centuries of anadromous forage fish loss: consequences for ecosystem connectivity and productivity. BioScience 62:723–731.

Hobbs, J. A., W. A. Bennett, and J. E. Burton. 2006. Assessing nursery habitat quality for native smelts (Osmeridae) in the low-salinity zone of the San Francisco Estuary. Journal of Fish Biology 69:907–922.

Hughes, B. B., M. D. Levey, J. A. Brown, M. C. Fountain, A. B. Carlisle, S. Y. Litvin, C. M. Greene, W. N. Heady, and M. G. Gleason. 2014. Nursery functions of U.S. West Coast estuaries: the state of knowledge for juveniles of focal invertebrate and fish species. Nature Conservancy, Arlington, Virginia.

Jassby, A. D., W. J. Kimmerer, S. G. Monismith, C. Armor, J. E. Cloern, T. M. Powell, J. R. Schubel, and T. J. Vendlinski. 1995. Isohaline position as a habitat indicator for estuarine populations. Ecological Applications 5:272–289.

Katz, J., P. B. Moyle, R. M. Quiñones, J. Israel, and S. Purdy. 2013. Impending extinction of salmon, steelhead, and trout (Salmonidae) in California. Environmental Biology of Fishes 96:1169–1186.

Kennish, M. J. 2002. Environmental threats and environmental future of estuaries. Environmental Conservation 29:78–107.

Kimmerer, W. J. 2002a. Physical, biological, and management responses to variable freshwater flow into the San Francisco Estuary. Estuaries 25:1275–1290.

Kimmerer, W. J. 2002b. Effects of freshwater flow on abundance of estuarine organisms: physical effects or trophic linkages? Marine Ecology Progress Series 243:39–55.

Kimmerer, W. J. 2006. Response of anchovies dampens effects of the invasive bivalve *Corbula amurensis* on the San Francisco Estuary food web. Marine Ecology Progress Series 324:207–218.

Kimmerer, W. J., J. H. Cowan Jr., L. W. Miller, and K. A. Rose. 2000. Analysis of an estuarine Striped Bass population: influence of density-dependent mortality between metamorphosis and recruitment. Canadian Journal of Fisheries and Aquatic Sciences 57:478–486.

Kimmerer, W. J., E. S. Gross, and M. L. MacWilliams. 2009. Is the response of estuarine nekton to freshwater flow in the San Francisco Estuary explained by variation in habitat volume? Estuaries and Coasts 32:375–389.

Kimmerer, W. J., M. L. MacWilliams, and E. S. Gross. 2013. Variation of fish habitat and extent of the low-salinity zone with freshwater flow in the San Francisco Estuary. San Francisco Estuary and Watershed Science [online serial] 11(4).

Latour, R. J. In press. Explaining patterns of pelagic fish abundance in the Sacramento–San Joaquin delta. Estuaries and Coasts. DOI : 10.1007/s12237-015-9968-9.

Lotze, H. K., H. S. Lenihan, B. J. Bourque, R. H. Bradbury, R. G. Cooke, M. C. Kay, S. M. Kidwell, M. X. Kirby, C. H. Peterson, and J. B. C. Jackson. 2006. Depletion, degradation, and recovery potential of estuaries and coastal seas. Science 312:1806–1809.

Maunder, M. N., R. B. Deriso, and C. H. Hanson. 2015. Use of state-space population dynamics models in hypothesis testing: advantages over simple log-linear regressions for modeling survival, illustrated with application to Longfin Smelt (*Spirinchus thaleichthys*). Fisheries Research 164:102–111.

Moyle, P. B. 2002. Inland fishes of California, revised and expanded. University of California Press, Berkeley.

Myers, R. A. 1998. When do environment–recruitment correlations work? Reviews in Fish Biology and Fisheries 8:285–305.

Nobriga, M. L., and F. Feyrer. 2008. Diet composition in San Francisco Estuary Striped Bass: does trophic adaptability have its limits? Environmental Biology of Fishes 83:509–517.

North, E. W., and E. D. Houde. 2003. Linking ETM physics, zooplankton prey, and fish early life histories to Striped Bass *Morone saxatilis* and White Perch *M. americana* recruitment. Marine Ecology Progress Series 260:219–236.

Peebles, E. B., S. E. Burghart, and D. J. Hollander. 2007. Causes of interestuarine variability in Bay Anchovy (*Anchoa mitchelli*) salinity at capture. Estuaries and Coasts 30:1060–1074.

Pikitch, E. K., K. J. Rountos, T. E. Essington, C. Santora, D. Pauly, R. Watson, U. R. Sumaila, P. D. Boersma, I. L. Boyd, D. O. Conover, P. Cury, S. S. Heppell, E. D. Houde, M. Mangel, É. Plagányi, K. Sainsbury, R. S. Steneck, T. M. Geers, N. Gownaris, and S. B. Munch. 2014. The global contribution of forage fish to marine fisheries and ecosystems. Fish and Fisheries 15:43–64.

Reum, J. C. P., T. E. Essington, C. M. Greene, C. A. Rice, and K. L. Fresh. 2011. Multiscale influence of climate on estuarine populations of forage fish: the role of coastal upwelling, freshwater flow and temperature. Marine Ecology Progress Series 425:203–215.

Ricker, W. E. 1954. Stock and recruitment. Journal of the Fisheries Research Board of Canada 115:559–623.

Rosenfield, J. A., and R. D. Baxter. 2007. Population dynamics and distribution patterns of Longfin Smelt in the San Francisco Estuary. Transactions of the American Fisheries Society 136:1577–1592.

Downloaded by [24.6.237.115] at 14:12 27 January 2016

Shan, X., P. Sun, X. Jin, X. Li, and F. Dai. 2013. Long-term changes in fish assemblage structure in the Yellow River estuary ecosystem, China. Marine and Coastal Fisheries: Dynamics, Management, and Ecosystem Science [online serial] 5:65–78.

Sommer, T., F. Mejia, K. Hieb, R. Baxter, E. Loboschefsky, and F. Loge. 2011. Long-term shifts in the lateral distribution of age-0 Striped Bass in the San Francisco Estuary. Transactions of the American Fisheries Society 140:1451–1459.

Sommer, T., C. Armor, R. Baxter, R. Breuer, L. Brown, M. Chotkowski, S. Culberson, F. Feyrer, M. Gingras, B. Herbold, W. Kimmerer, A. Mueller-Solger, M. Nobriga, and K. Souza. 2007. The collapse of pelagic fishes in the upper San Francisco Estuary. Fisheries 32:270–277.

Stevens, D. E., and L. W. Miller. 1983. Effects of river flow on abundance of young Chinook Salmon, American Shad, Longfin Smelt, and Delta Smelt in the Sacramento–San Joaquin River system. North American Journal of Fisheries Management 3:425–437.

Thomson, J. R., W. J. Kimmerer, L. R. Brown, K. B. Newman, R. Mac Nally, W. A. Bennett, F. Feyrer, and E. Fleishman. 2010. Bayesian change point analysis of abundance trends for pelagic fishes in the upper San Francisco Estuary. Ecological Applications 20:1431–1448.

Trathan, P. N., P. García-Borboroglu, D. Boersma, C.-A. Bost, R. J. M. Crawford, G. T. Crossin, R. J. Cuthbert, P. Dann, L. S. Davis, S. De La Puente, U. Ellenberg, H. J. Lynch, T. Mattern, K. Pütz, P. J. Seddon, W. Trivelpiece, and B. Wienecke. 2015. Pollution, habitat loss, fishing, and climate change as critical threats to penguins. Conservation Biology 29:31–41.

Turner, J. L., and H. K. Chadwick. 1972. Distribution and abundance of young-of-the-year Striped Bass, *Morone saxatilis*, in relation to river flow in the Sacramento–San Joaquin estuary. Transactions of the American Fisheries Society 101:442–452.

USOFR (U.S. Office of the Federal Register). 2012. Endangered and threatened wildlife and plants; 12-month finding on petition to list the San Francisco Bay–delta population of Longfin Smelt as endangered or threatened. Federal Register 77:63(2 April 2012):19755–19797.

Vörösmarty, C. J., P. B. McIntyre, M. O. Gessner, D. Dudgeon, A. Prusevich, P. Green, S. Glidden, S. E. Bunn, C. A. Sullivan, C. R. Liermann, and P. M. Davies. 2010. Global threats to human water security and river biodiversity. Nature 467:555–561.

Walters, C. J., and F. Juanes. 1993. Recruitment limitation as a consequence of natural selection for use of restricted feeding habitats and predation risk taking by juvenile fishes. Canadian Journal of Fisheries and Aquatic Sciences 50:2058–2070.

Wilkerson, F. P., R. C. Dugdale, V. E. Hogue, and A. Marchi. 2006. Phytoplankton blooms and nitrogen productivity in San Francisco Bay. Estuaries and Coasts 29:401–416.

Downloaded by [24.6.237.115] at 14:12 27 January 2016

From: Laurie Warner Herson [laurie.warner.herson@phenixenv.com]
Sent: 6/16/2020 3:51:36 PM
To: Alicia Forsythe [aforsythe@sitesproject.org]
CC: Spranza, John [John.Spranza@hdrinc.com]; Arsenijevic, Jelica [Jelica.Arsenijevic@hdrinc.com]; Linda Fisher (linda.fisher@hdrinc.com) [linda.fisher@hdrinc.com]
Subject: FW: Updated Dunnigan Pipeline Map for Meeting Presentation
Attachments: INTERNAL_Sites_Alternative1_Pipeline.pdf; INTERNAL_Sites_Alternative2_Pipeline.pdf

Hi Ali,

These are the figures that Kim prepared today. Just to clarify - we have not included roads on these figures due to scale and because they are updating alignments per the meeting with Colusa and Glenn County staff last week. Also, saddle dams have not been defined yet but will be generally in the same locations. So, conceptual at this time.

Laurie

From: Tran, Kim Loan [mailto:KimLoan.Tran@hdrinc.com]
Sent: Tuesday, June 16, 2020 1:53 PM
To: Laurie Warner Herson <laurie.warner.herson@phenixenv.com>
Cc: Luu, Henry <Henry.Luu@hdrinc.com>; Heydinger, Erin <Erin.Heydinger@hdrinc.com>
Subject: RE: Updated Dunnigan Pipeline Map for Meeting Presentation

Hi Laurie,

Per your request for the maps, here are the two alternatives from Dunnigan to CBD and from Dunnigan to the Sacramento River.

Kim Loan Tran
GIS Analyst

"Carpe Diem"

HDR
2379 Gateway Oaks Dr. #200
Sacramento, CA 95829
D: 916-679-8804
Kimloan.tran@hdrinc.com

hdrinc.com/follow-us

From: Laurie Warner Herson [mailto:laurie.warner.herson@phenixenv.com]
Sent: Tuesday, June 16, 2020 11:58 AM
To: Tran, Kim Loan <KimLoan.Tran@hdrinc.com>
Cc: Luu, Henry <Henry.Luu@hdrinc.com>
Subject: RE: Updated Dunnigan Pipeline Map for Meeting Presentation

CAUTION: [EXTERNAL] This email originated from outside of the organization. Do not click links or open attachments unless you recognize the sender and know the content is safe.

Awesome – thank you !!

From: Tran, Kim Loan [mailto:KimLoan.Tran@hdrinc.com]
Sent: Tuesday, June 16, 2020 11:52 AM

To: Laurie Warner Herson <laurie.warner.herson@phenixenv.com>
Cc: Luu, Henry <Henry.Luu@hdrinc.com>
Subject: RE: Updated Dunnigan Pipeline Map for Meeting Presentation

Hi Laurie,

Henry is reviewing them after his conference call before I send the final PDFs over to you.

Sent from Workspace ONE Boxer

On Jun 16, 2020 11:51 AM, Laurie Warner Herson <laurie.warner.herson@phenixenv.com> wrote:

CAUTION: [EXTERNAL] This email originated from outside of the organization. Do not click links or open attachments unless you recognize the sender and know the content is safe.

I forgot to mention – we don't need the parcel lines for this iteration. Will you be able to provide these today?

From: Laurie Warner Herson
Sent: Tuesday, June 16, 2020 9:51 AM
To: Tran, Kim Loan <KimLoan.Tran@hdrinc.com>
Cc: Luu, Henry <Henry.Luu@hdrinc.com>
Subject: RE: Updated Dunnigan Pipeline Map for Meeting Presentation

Hi Kim -

What we need are figures for each of the project alternatives. Alternative 1 includes a 1.5 MAF reservoir and pipeline to the Colusa Basin Drain (shown in blue). Alternative 2 includes a 1.3 MAF reservoir and a pipeline to the Sacramento River (shown in red). I don't think we have the 1.3 MAF footprint in GIS– Henry will have to confirm – but given the resolution, it doesn't matter with the current figures. So label this figure Alternative 1 (not VP7)and eliminate the Sacramento River (red) alignment; create a copy, label it Alternative 2 and change the reservoir label to 1.3 MAF, delete the Colusa Basin Drain (blue) and add the Sacramento River (red) alignment.

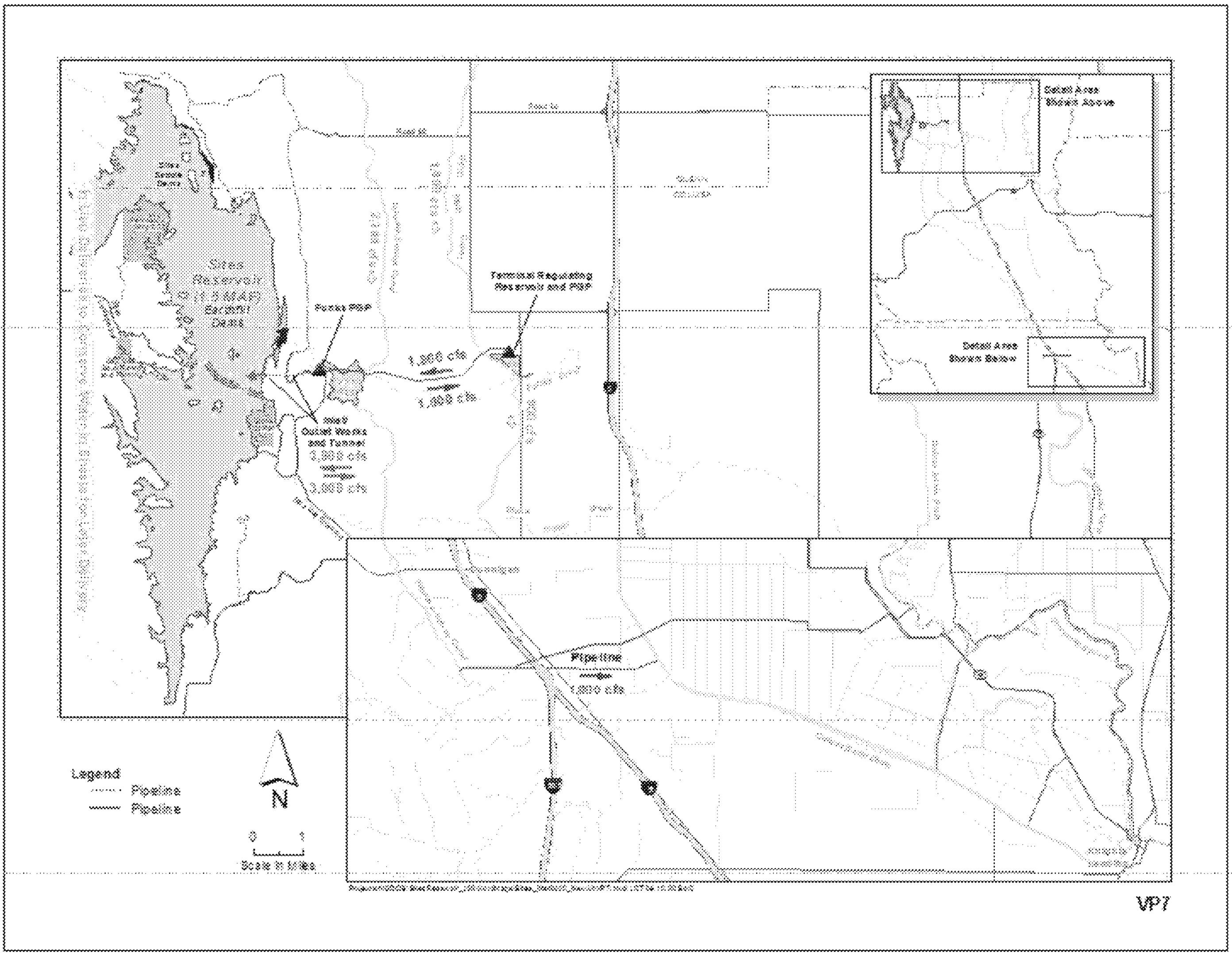
Alternative 1 – 1.5 MAF Reservoir; Dunnigan Pipeline to Colusa Basin Drain (blue)
Alternative 2 – 1.3 MAF Reservoir; Dunnigan Pipeline to Sacramento River (red)

Thank you !!

From: Tran, Kim Loan [mailto:KimLoan.Tran@hdrinc.com]
Sent: Tuesday, June 16, 2020 9:14 AM
To: Laurie Warner Herson <laurie.warner.herson@phenixenv.com>
Cc: Luu, Henry <Henry.Luu@hdrinc.com>
Subject: Updated Dunnigan Pipeline Map for Meeting Presentation

Hi Laurie,

I have the updated Dunnigan pipeline ready to go for the map. However, can you let me know what kind of map you're thinking? For example, do you want me to update the VP7 map (screenshot below) with the Dunnigan pipeline, more zoomed in, or do you want the "Real Estate" view with the parcels?

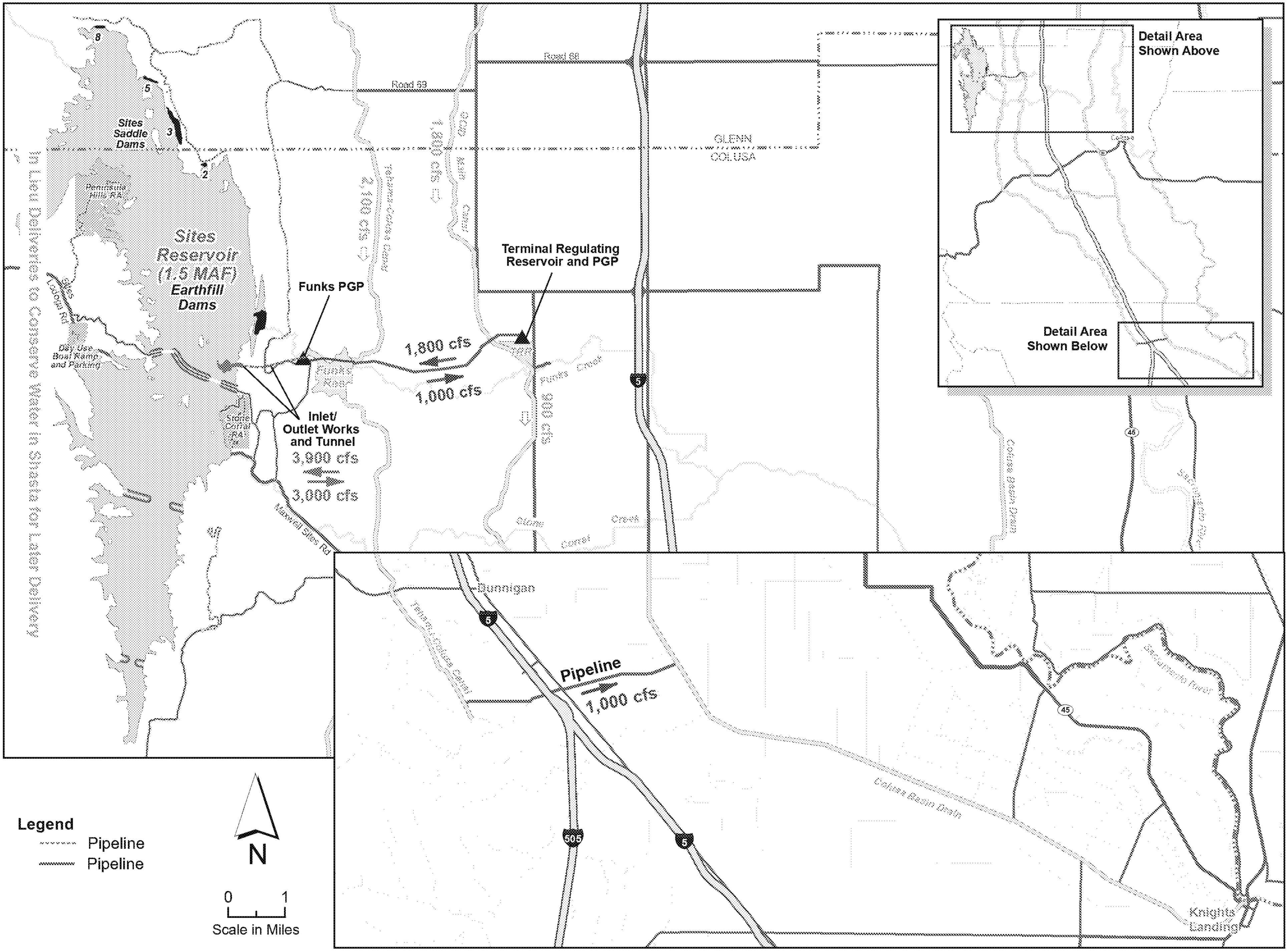


Kim Loan Tran
GIS Analyst

"Carpe Diem"

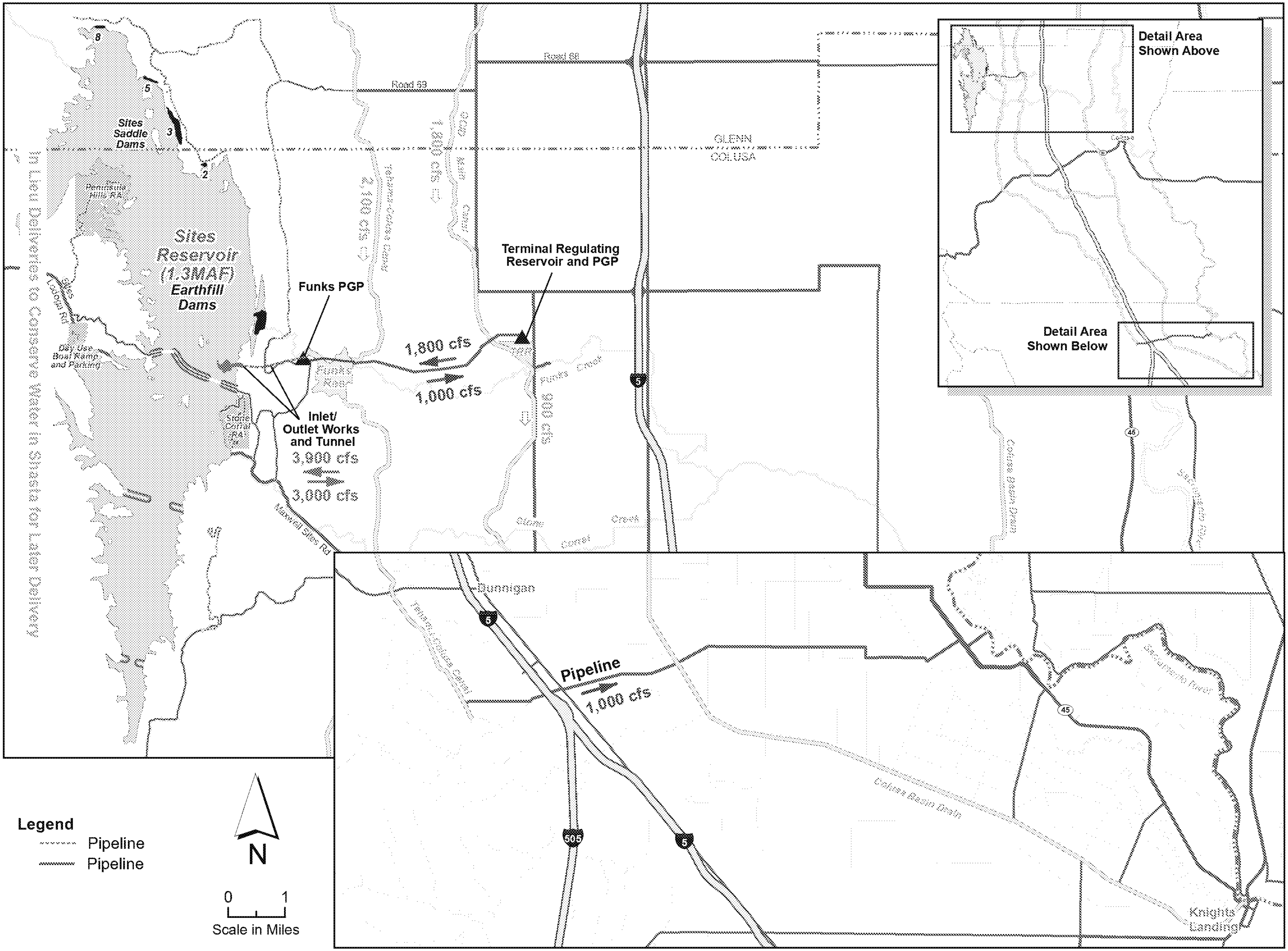
HDR
2379 Gateway Oaks Dr. #200
Sacramento, CA 95829
D: 916-679-8804
Kimloan.tran@hdrinc.com

hdrinc.com/follow-us



Projects\NODOS\SitesReservoir_2020\ArcMaps\Sites_Mar2020_NewAltVP7.mxd LCT 06.16.20 SAC

ALTERNATIVE 1



\\sac-srv01\GIS\Projects\Sites_Reservoir\ProgramManagement\7.2_Working\map_docs\Engineering\INTERNAL_Sites_Alternative2_Pipeline.mxd 06.16.20

ALTERNATIVE 2

From: Lecky, Jim [Jim.Lecky@icf.com]
Sent: 6/16/2020 6:54:51 PM
To: Alicia Forsythe [aforsythe@sitesproject.org]
Subject: RE: Range of Alternatives for Sites Reservoir RDEIR/RDEIS
Attachments: Nobriga and Rosenfield 2016.pdf

Hi Ali, I have been focused on another project for the last two days – big deadline. So just getting to my e-mail. I haven't had time to recall of locate a summary document I may have prepared. I'll focus on that tomorrow. In the mean time here is the Nobriga and Rosenfield 2016 paper.

From: Alicia Forsythe <aforsythe@sitesproject.org>
Sent: Tuesday, June 16, 2020 3:27 PM
To: Lecky, Jim <Jim.Lecky@icf.com>; John Spranza (john.spranza@hdrinc.com) <john.spranza@hdrinc.com>
Subject: FW: Range of Alternatives for Sites Reservoir RDEIR/RDEIS

Hi Jim and John – See the email exchange below. I will also forward on one more email that I sent to Doug.

Jim – I thought you did a longer write up on the pros and cons with the studies that folks continue to reference. I recall like a 5 page document. But I couldn't find it just now. Is this something you recall and can find? Also, do you have the Nobriga and Rosenfield 2016 paper? Anything else to send to Jerry to help him on all of this?

Ali

Alicia Forsythe | Environmental Planning and Permitting Manager | Sites Reservoir Project | 916.880.0676 |
aforsythe@sitesproject.org | www.SitesProject.org

CONFIDENTIALITY NOTICE: This communication with its contents may contain confidential and/or legally privileged information. It is solely for the use of the intended recipient(s). Unauthorized interception, review, use or disclosure is prohibited and may violate applicable laws including the Electronic Communications Privacy Act. If you are not the intended recipient, please contact the sender and destroy all copies of the communication.

From: Alicia Forsythe
Sent: Tuesday, June 16, 2020 3:22 PM
To: Jerry Brown <jbrown@sitesproject.org>
Subject: RE: Range of Alternatives for Sites Reservoir RDEIR/RDEIS

Jerry – See the paper that Gary Bobker sent to us over the weekend for the NRDC, TBI's proposed criteria.

Attached are the following:

- 20191011_Topics for Oct Exec Team Meeting – This was prepare by Jim Lecky and is "unfiltered" – See the references to specific studies with regard to locations
- 20191014_Talking Points for Oct Exec Team Meeting – This was my shortening of Jim's document, trying to get at the heart of some of these issues for our members
- Perry et al – Relates to Freeport Flows and salmonid survival
- Michel and Henderson – Related to Wilkins Slough flows and salmonid survival

I cant find the Nobriga paper (NDOI) but will see if Jim Lecky has that. I thought Jim also did a longer write-up on the pros and cons with these studies, but I cant seem to locate that right now. I'll ask him for this.

Happy to set up a briefing on all of this if you think it would be helpful.

Ali

Alicia Forsythe | Environmental Planning and Permitting Manager | Sites Reservoir Project | 916.880.0676 | aforsythe@sitesproject.org | www.SitesProject.org

CONFIDENTIALITY NOTICE: This communication with its contents may contain confidential and/or legally privileged information. It is solely for the use of the intended recipient(s). Unauthorized interception, review, use or disclosure is prohibited and may violate applicable laws including the Electronic Communications Privacy Act. If you are not the intended recipient, please contact the sender and destroy all copies of the communication.

From: Jerry Brown <jbrown@sitesproject.org>
Sent: Tuesday, June 16, 2020 2:54 PM
To: Alicia Forsythe <aforsythe@sitesproject.org>
Subject: Re: Range of Alternatives for Sites Reservoir RDEIR/RDEIS

Can you provide me with a copy of the technical paper Doug is referring to when he says "scientifically sound" operational criteria? I assume there must be some in depth studies that we need to be aware of.

From: "Obegi, Doug" <dobegi@nrdc.org>
Date: Tuesday, June 16, 2020 at 1:08 PM
To: Alicia Forsythe <aforsythe@sitesproject.org>
Cc: Jerry Brown <jbrown@sitesproject.org>
Subject: RE: Range of Alternatives for Sites Reservoir RDEIR/RDEIS

Thanks Ali.

I suspect the project is going to have some serious challenges, if scientifically sound operational criteria make the project infeasible from the proponents' perspective.

From: Alicia Forsythe <aforsythe@sitesproject.org>
Sent: Tuesday, June 16, 2020 11:30 AM
To: Obegi, Doug <dobegi@nrdc.org>
Cc: Jerry Brown <jbrown@sitesproject.org>
Subject: RE: Range of Alternatives for Sites Reservoir RDEIR/RDEIS

Doug – The initial alternatives in the June packet are very preliminary. We're really just beginning the development of alternatives but want to make sure we update the Board on some of our initial thoughts and ideas. We expect to come back to the Board in September with a more complete project description, including possible changes to what we are proposing this week. The door isn't even close to being shut and we have a ways to go.

We will have Jacobs conduct an analysis of at least one set of operational criteria that are similar to (or the same as) what you have proposed. We will work with you, TBI, and others to confirm these criteria before we model them. This analysis will be in the Revised Draft EIR/EIS. However, based on analyses we completed last summer / fall, we expect these criteria to result in a project that's not affordable and provides very little water to accomplish the project objectives. Thus, we don't anticipate that this will result in an alternative that we would carry forward for detailed analysis in the Revised EIR as we don't anticipate it to result in a feasible project.

We have yet to "finalize" operational criteria for the project and continue to work on these and refinements to the model. So we may have more than one operational criteria, but we haven't yet made it far enough along to determine that. We will also complete the analysis described above early in the process – once we get the model refinements completed – so if my assumption is wrong here, we will have time to include it as a full alternative in the document.

The door isn't closed to adding in an alternative with different operational criteria – and we will complete the analysis you've requested. From the work we did last summer / fall, we just expect that the operational criteria proposed by NRDC won't result in a feasible project.

Ali

Alicia Forsythe | Environmental Planning and Permitting Manager | Sites Reservoir Project | 916.880.0676 | aforsythe@sitesproject.org | www.SitesProject.org

CONFIDENTIALITY NOTICE: This communication with its contents may contain confidential and/or legally privileged information. It is solely for the use of the intended recipient(s). Unauthorized interception, review, use or disclosure is prohibited and may violate applicable laws including the Electronic Communications Privacy Act. If you are not the intended recipient, please contact the sender and destroy all copies of the communication.

From: Obegi, Doug <dobegi@nrdc.org>
Sent: Monday, June 15, 2020 2:23 PM
To: Alicia Forsythe <aforsythe@sitesproject.org>; Jerry Brown <jbrown@sitesproject.org>
Subject: Range of Alternatives for Sites Reservoir RDEIR/RDEIS

Hi Jerry and Ali,

I hope you're both doing ok these days. I wanted to check in briefly because I was reviewing the meeting material for the upcoming Reservoir Committee meeting, and the attachments seem to suggest that the revised/recirculated draft EIR/EIS would only consider one operational criteria for the action alternatives in the document. Are y'all seriously planning to only review one operational criteria in the revised EIR/EIS?

https://3hm5en24txyp2e4cxyxaklbs-wpengine.netdna-ssl.com/wp-content/uploads/2019/11/03-03-Proposed-Objectives-and-Alternatives-for-the-Revised-EIR_EIS.pdf

That's certainly not the approach that I took away from our prior conversation, where we discussed how the revised recirculated DEIR/DEIS would consider a range of operational criteria that included at least one set of operational criteria that were more protective than what you proposed (and potentially similar to what we've proposed). It also seems to run afoul of CEQA's requirement to consider a reasonable range of alternatives.

Hopefully I'm misunderstanding the Board materials. In any event I would strongly urge you to ensure that the CEQA/NEPA documents analyze more than 1 operational scenario for the action alternatives that are considered, including an alternative that proposes operations that are significantly more protective than what you shared with me in our last conversation.

Thanks,
Doug

____

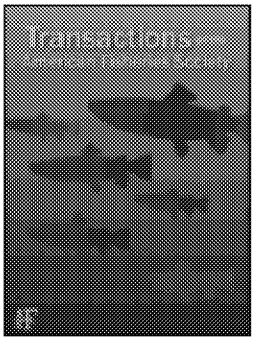
DOUG OBEGI
*Senior Attorney**
Water Program

NATURAL RESOURCES
DEFENSE COUNCIL
111 SUTTER ST., 21ST FLOOR
SAN FRANCISCO, CA 94104
T 415.875.6100
DOBEGI@NRDC.ORG
NRDC.ORG

Please save paper.
Think before printing.

** Admitted to practice in California*

NRDC-86



Taylor & Francis

Transactions of the American Fisheries Society

ISSN: 0002-8487 (Print) 1548-8659 (Online) Journal homepage: http://www.tandfonline.com/loi/utaf20

Population Dynamics of an Estuarine Forage Fish: Disaggregating Forces Driving Long-Term Decline of Longfin Smelt in California's San Francisco Estuary

Matthew L. Nobriga & Jonathan A. Rosenfield

To cite this article: Matthew L. Nobriga & Jonathan A. Rosenfield (2016) Population Dynamics of an Estuarine Forage Fish: Disaggregating Forces Driving Long-Term Decline of Longfin Smelt in California's San Francisco Estuary, Transactions of the American Fisheries Society, 145:1, 44-58, DOI: 10.1080/00028487.2015.1100136

To link to this article: http://dx.doi.org/10.1080/00028487.2015.1100136

Published online: 18 Dec 2015.

Submit your article to this journal

Article views: 65

View related articles

View Crossmark data

Full Terms & Conditions of access and use can be found at
http://www.tandfonline.com/action/journalInformation?journalCode=utaf20

Download by: [24.6.237.115] **Date:** 27 January 2016, At: 14:12

Transactions of the American Fisheries Society 145:44–58, 2016
© American Fisheries Society 2016
ISSN: 0002-8487 print / 1548-8659 online
DOI: 10.1080/00028487.2015.1100136

ARTICLE

Population Dynamics of an Estuarine Forage Fish: Disaggregating Forces Driving Long-Term Decline of Longfin Smelt in California's San Francisco Estuary

Matthew L. Nobriga*
U.S. Fish and Wildlife Service, Bay Delta Fish and Wildlife Office, 650 Capitol Mall, Suite 8-300, Sacramento, California 95831, USA

Jonathan A. Rosenfield
The Bay Institute, Pier 39, Box Number 200, San Francisco, California 94133, USA

Downloaded by [24.6.237.115] at 14:12 27 January 2016

Abstract

Forage fish production has become a central concern of fisheries and ecosystem managers because populations of small fish are a critical energetic pathway between primary producers and predator populations. Management of forage fish often focuses on controlling exploitation rates, but it is also possible to manage productivity of these species in coastal ecosystems, particularly estuaries. Like several forage fish species that are native to the San Francisco Estuary (SFE) in California, the Longfin Smelt *Spirinchus thaleichthys* has experienced dramatic population declines over the past few decades. This population is not fished commercially or recreationally; trends in its relative abundance have been described statistically, but the mechanisms that drive population dynamics are still poorly understood. Our objective was to evaluate alternative conceptual models of Longfin Smelt population dynamics to better understand the forces that may constrain the species' productivity during different phases of its life cycle. We created contrasting variants of a generalizable population model (the Ricker model) and parameterized those variants using empirical data from a long-term sampling program in the SFE. Predictions from alternative models were compared with empirical results from a second (independent) data series of relative abundance to identify the model variants that best captured the empirical trend. The results indicated that (1) freshwater flow had a positive association with recruits per spawner and (2) both recruits per spawner and spawners per recruit appeared to be density-dependent life stage transitions. Juvenile survival may have declined to some extent, but we could not conclusively demonstrate this. By constraining the possible timing and location of mechanisms that modulate productivity at different life stages, the present results improve our understanding of production for a key native forage fish in the SFE.

Forage fishes serve as energy conduits between zooplankton and higher-trophic-level predators (Pikitch et al. 2014). The central role of forage fishes in aquatic food webs means that forage fish production is critical to sustainable fisheries management (Alder et al. 2008), desired ecosystem functions (Hall et al. 2012), and, in some cases, the maintenance of biodiversity (Trathan et al. 2015). For instance, seabirds around the world display reduced and more variable productivity when forage fish biomass drops below one-third of the maximum levels observed in long-term studies (Cury et al. 2011). Thus, marine fisheries and ecosystem management is increasingly focused on protecting forage fishes from overexploitation. Management may also be directed toward maintaining or restoring the habitats and processes that support the production of forage fish, especially in estuarine ecosystems (Kennish 2002; Hughes et al. 2014).

---

*Corresponding author: matt_nobriga@fws.gov
Received August 13, 2015; September 17, 2015

Downloaded by [24.6.237.115] at 14:12 27 January 2016

A general conceptual model of forage fish productivity in coastal ecosystems, including estuaries, is that recruitment is strongly influenced by the interplay of zooplankton production and piscivore predation on forage fishes (Walters and Juanes 1993; Essington and Hansson 2004). The matches and mismatches between forage fishes and their prey can be affected by physical conditions, such as ocean currents (Genin 2004) and upwelling (Reum et al. 2011). For species that rely on low-salinity environments to complete their life cycle, variation in freshwater flow rates can also play an important role in aligning young fish with their prey and protecting them from predators (Turner and Chadwick 1972; North and Houde 2003). Fish behavior and physiological capacities can influence the details of this conceptual model, particularly for euryhaline fishes (Kimmerer 2006; Peebles et al. 2007).

The protection of forage fish habitats in developed rivers and their receiving estuaries can be very difficult, as human economic systems' strong reliance on freshwater results in competition for limited freshwater resources (Vörösmarty et al. 2010; Cloern and Jassby 2012). Many estuarine forage fishes (and their supporting food webs) that are tolerant of or dependent upon low-salinity and freshwater habitats are influenced by the timing, duration, and magnitude of freshwater flow and its effects on estuarine hydrodynamics (Jassby et al. 1995; North and Houde 2003; Gillson 2011). The biological productivity and accessibility of freshwater that were historically provided by river–estuary systems have attracted considerable human settlement and exploitation, which have in turn led to intensive changes that include large-scale reclamation of estuarine landscapes, water pollution, nonnative species introductions, modification of estuarine hydrodynamics, and declines in native biota (Kennish 2002; Lotze et al. 2006; Shan et al. 2013). California's San Francisco Estuary (SFE; Figure 1) is a well-known example of an estuary that has undergone tremendous physical, chemical, and biological transformation (Kimmerer 2002a; Cloern and Jassby 2012). The declines of once-productive fisheries and the potential ongoing loss of native fish biodiversity are key aquatic resource concerns for the SFE and its watershed (Moyle 2002; Sommer et al. 2007; Katz et al. 2013).

One formerly abundant forage fish that has undergone a substantial decline within the SFE is the Longfin Smelt

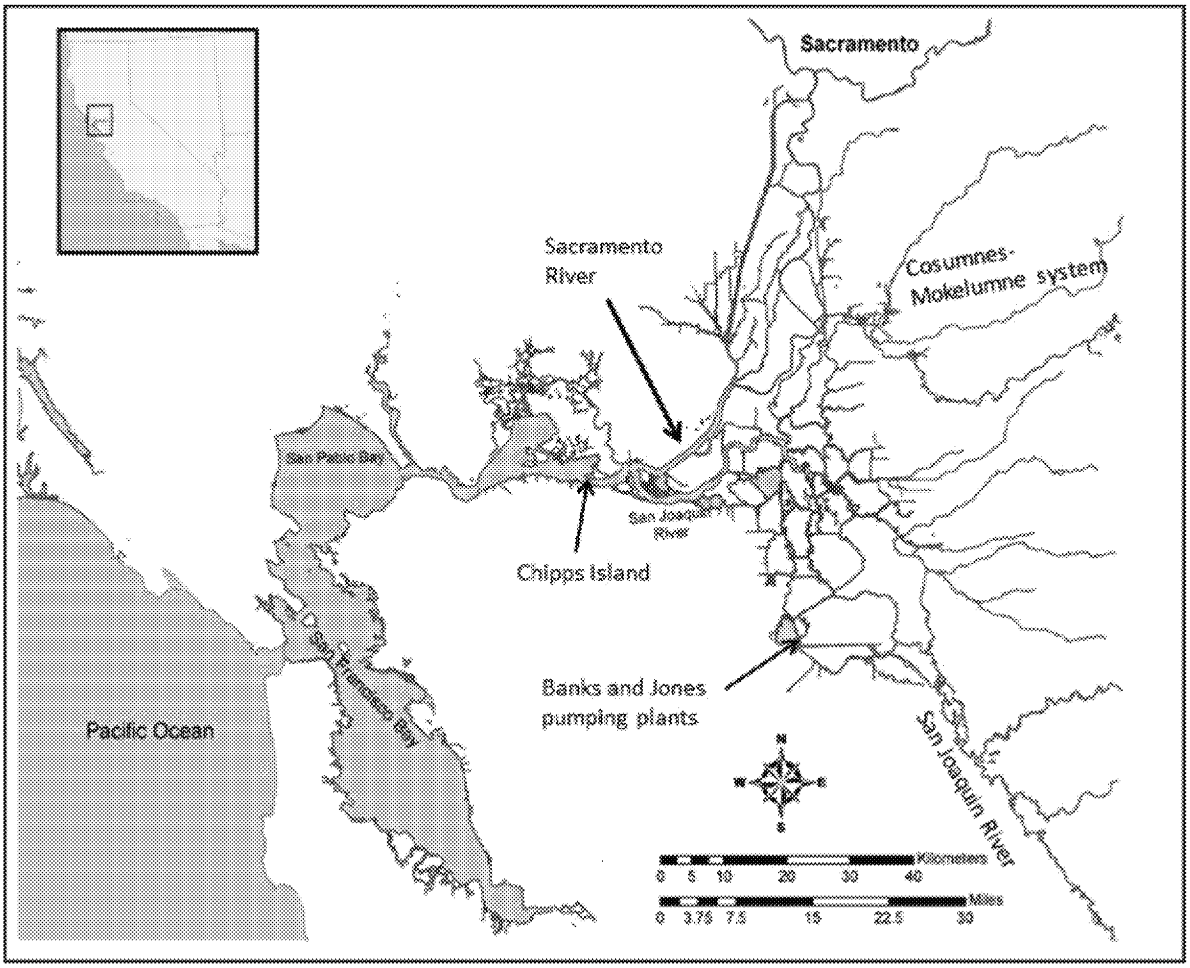


FIGURE 1. Map of the San Francisco Estuary. The Pacific Ocean enters the estuary under the Golden Gate Bridge; the Sacramento–San Joaquin Delta encompasses the waterways to the east of Chipps Island (sampling locations for California Department of Fish and Wildlife monitoring stations are available at www.wildlife.ca.gov/Regions/3).

Spirinchus thaleichthys (Rosenfield and Baxter 2007). This species is a small, facultatively anadromous, pelagic fish that typically reaches adult sizes of 80–150 mm FL (Moyle 2002). Longfin Smelt inhabit lakes, coastal river estuaries, and nearshore marine environments from Alaska to central California; the SFE is the southern limit of the species' inland distribution along the Pacific coast of North America. Most Longfin Smelt live for 2 years and are semelparous. In the SFE, Longfin Smelt spawn in tidally influenced freshwater habitats, but low-salinity habitats may also provide suitable spawning areas (microhabitat requirements for Longfin Smelt spawning are unknown). Spawning typically peaks in the winter (December–February), when water temperatures range from about 7.0°C to 14.5°C (Moyle 2002). Larvae and small juveniles aggregate in low-salinity waters during the late winter through spring (Dege and Brown 2004) and then move seaward into mesohaline to marine waters of central San Francisco Bay and the coastal ocean during the summer (Rosenfield and Baxter 2007). Juveniles and adults begin to move landward again during the fall (September–December).

The Longfin Smelt was once among the most abundant and widespread fishes in the SFE (Moyle 2002; Sommer et al. 2007). The species' former abundance and broad distribution strongly suggest that it once played an important role in the SFE food web; however, given an abundance decline of approximately 99.9%, Longfin Smelt are currently too rare to serve as an important prey species for piscine, avian, or mammalian predators foraging in the estuary. The Longfin Smelt is one of several fish populations that play a central role in California water management because in 2009, it was listed as threatened under the California Endangered Species Act (CESA), and regulations that were developed as part of the CESA listing can limit diversions of freshwater from the SFE. The U.S. Fish and Wildlife Service also recently determined that protection of the SFE Longfin Smelt population under the U.S. Endangered Species Act (ESA) is warranted (USOFR 2012).

Many details of Longfin Smelt ecology in the SFE are virtually unknown, as the species has not been targeted by a sport fishery or commercial fishery for many decades (Moyle 2002). Longfin Smelt are caught as bycatch in a limited bait fishery for bay shrimp *Crangon franciscorum*; although the California Department of Fish and Wildlife (CDFW 2009) considered this a factor limiting Longfin Smelt recovery, we know of no evidence that bycatch rates have increased substantially in recent times. Furthermore, until the species' recent listing under the CESA, the status of Longfin Smelt did not factor directly into decisions about water diversions. As a result, current scientific understanding of the SFE population is largely derived from correlation-based analyses of abundance indices (Stevens and Miller 1983; Jassby et al. 1995; Kimmerer 2002b), evaluations of the catch data that underlie those indices (Rosenfield and Baxter 2007; Kimmerer et al. 2009; Latour, in press), and the presumption (e.g., Moyle 2002) that the SFE population is fundamentally similar to the better-researched (but landlocked) population of Longfin Smelt in Lake Washington, Washington (Chigbu 2000).

The Longfin Smelt is also one of several SFE fishes that have shown a strong and persistent association between juvenile production and the freshwater flow variation experienced early in the life cycle (Stevens and Miller 1983; Jassby et al. 1995; Kimmerer 2002b; Rosenfield and Baxter 2007; Thomson et al. 2010; Maunder et al. 2015). However, little attention has been given to whether and how freshwater flow rates might affect production of Longfin Smelt beyond the first year of life. It is well established that Longfin Smelt production per unit of flow has declined (Kimmerer 2002b; Rosenfield and Baxter 2007; Thomson et al. 2010), but with only one very recent exception (Maunder et al. 2015), researchers have not attempted to evaluate the population dynamics of SFE Longfin Smelt in a classical spawner–recruit framework.

Food web alteration has been considered a primary factor contributing to the decline of Longfin Smelt in the SFE; however, the details of when and where prey production may limit Longfin Smelt recruitment have not been determined. Furthermore, predation on SFE Longfin Smelt has not been studied, so the role of predators in driving the population can only be speculated upon. The zooplankton assemblages that Longfin Smelt likely prey upon began changing dramatically after the overbite clam *Potamocorbula amurensis* invaded the SFE in 1986. Changes included abrupt declines in chlorophyll (Alpine and Cloern 1992) and several crustaceans, including mysid shrimps (Kimmerer 2002b); changes in the distribution (Kimmerer 2006; Sommer et al. 2011) and diet composition (Feyrer et al. 2003; Nobriga and Feyrer 2008) of several fishes were also observed. In addition, wastewater ammonium limits the growth rate of diatoms in the SFE (Wilkerson et al. 2006), and this may be another, more gradually changing factor that acts to suppress production of the Longfin Smelt's zooplankton prey.

We explored the population ecology of SFE Longfin Smelt in an attempt to identify when during the life cycle (and, by extension, where) productivity has changed and how temporal changes in these productivity parameters may explain the long-term decline of the population. To do this, we employed conceptually different variants of a standard population modeling framework (the Ricker model) to determine which formulations of the model best explained the empirical trends. We did not attempt to develop a model that would precisely recreate Longfin Smelt population dynamics; rather, our objective was to evaluate alternative conceptual models of the species' population dynamics to better understand the forces potentially constraining Longfin Smelt productivity during different phases of the life cycle. Specifically, we sought to identify factors that were correlated with productivity parameters for different life stages in order to disaggregate the effects of changes in productivity at those life stages. This information would allow future research and management actions to focus on (1) the Longfin Smelt life stages that have experienced

Downloaded by [24.6.237.115] at 14:12 27 January 2016

declines in productivity and (2) the environmental variables that can be manipulated to increase the production of those life stages.

STUDY AREA

The SFE is formed by the confluence of two major California river systems: the Sacramento and San Joaquin rivers (Figure 1). These rivers meet in the Sacramento–San Joaquin Delta (hereafter, Delta) and begin to mix with Pacific Ocean waters. This estuarine mixing intensifies in a westward direction in the several embayments that comprise San Francisco Bay (Figure 1; Jassby et al. 1995; Kimmerer et al. 2013). Some portion of central San Francisco Bay, nearest to the bay's outlet to the Pacific Ocean, usually approaches marine salinity (≥30 psu). In the northern reach of the SFE (from San Pablo Bay through the Delta), average salinity decreases from west to east due to the influence of freshwater that flows from Central Valley rivers into the Delta. The Delta comprises a network of tidal freshwater channels from which large quantities of water are exported to more arid parts of California for agricultural and municipal use. The U.S. Central Valley Project has been exporting water to the San Joaquin Valley since 1951, and the State Water Project has been exporting water to the San Joaquin Valley and southern California municipalities since 1968. The historical changes associated with the development of California's surface water supplies and the diversion of water from the Delta have been reviewed extensively (Arthur et al. 1996; Enright and Culberson 2010; Cloern and Jassby 2012).

METHODS

Overview.—Fisheries stock assessments have long relied on spawner–recruit models (e.g., Ricker 1954). These mathematical tools link the production of new cohorts of fish (recruits) to the available spawning stock and often also attempt to explain residual variation in recruitment by using environmental covariates (Myers 1998). Stock assessments are usually applied to harvested fishes, particularly those in marine ecosystems. Although the Longfin Smelt is not targeted for harvest in the SFE, it is nonetheless useful to construct explicit spawner–recruit relationships so as to evaluate different conceptual models of Longfin Smelt recruitment (see also Maunder et al. 2015).

Our analysis was based on alternative formulations of the Ricker (1954) model,

$$R = aSe^{-BS}. \quad (1)$$

In this general formulation, R is the number (or biomass) of fish recruiting to a population and S is the number (or biomass) of spawners. The parameters to be solved for are a and B, where a is the recruits per spawner (in essence, the slope of the spawner–recruit relationship near the origin) and B interacts with a to adjust the intensity of density dependence between generations. Using the Ricker model, we developed alternative conceptual models to identify the best strategy for modeling SFE Longfin Smelt recruitment. A long-term, age-specific data series of Longfin Smelt relative abundance in the SFE was used to parameterize the alternative Ricker models by (1) screening variables to predict a; (2) screening variables for predicting survival from age 0 to age 2 in order to predict S; and (3) finding values of B that constrained predictions of R, thereby creating a contrast with model variants that lacked this constraint. We then simulated a time series of Longfin Smelt relative abundance using each alternative Ricker model and compared each simulation to an empirical time series that was measured independently of the data series used to parameterize the models.

Alternative conceptual models of recruitment.—Five alternative conceptual models of Longfin Smelt recruitment were evaluated (Table 1). All models had a recruits-per-spawner

TABLE 1. Summary of five alternative Ricker models of Longfin Smelt recruitment in the San Francisco Estuary. The alphanumeric model codes are shorthand for the embedded hypotheses: the number represents whether one life stage or two life stages were explicitly modeled; "a" denotes the inclusion of a recruits-per-spawner term (i.e., applicable to all five models); "b" indicates that a model has an explicit density-dependent exponent term (e^{-BS}; see Methods); and "c" indicates that a model employs a time-dependent change in one or more parameters.

Model	Embedded hypotheses
1abc	The trend in age-0 relative abundance is sufficient to model long-term population dynamics; the production of age-0 fish is density dependent; and survival has changed through time (e.g., due to changes in the estuary's food web).
2a	Understanding the trend in age-0 relative abundance requires explicit modeling of spawner and recruit relative abundances; the production of age-0 fish is density independent; and survival has not changed through time.
2ab	Understanding the trend in age-0 relative abundance requires explicit modeling of spawner and recruit relative abundances; the production of age-0 fish is density dependent; and survival has not changed through time.
2ac	Understanding the trend in age-0 relative abundance requires explicit modeling of spawner and recruit relative abundances; the production of age-0 fish is density independent; and survival has changed through time.
2abc	Understanding the trend in age-0 relative abundance requires explicit modeling of spawner and recruit relative abundances; the production of age-0 fish is density dependent; and survival has changed through time.

Downloaded by [24.6.237.115] at 14:12 27 January 2016

term (*a*; indicated by an "a" in the alphanumeric codes that differentiate the models described in Table 1). One model (1abc) compared age-0 abundance from one generation to the next (i.e., *a* estimated the recruits per recruit) to evaluate whether age-0 indices were sufficient to model long-term population dynamics—a hypothesis that could be inferred from the numerous published analyses of Longfin Smelt age-0 abundance indices (e.g., Stevens and Miller 1983; Jassby et al. 1995; Kimmerer 2002b; Thomson et al. 2010). If the one-life-stage model performed as well as the four models with two life stages (i.e., models with "2" in their alphanumeric codes; Table 1), this would indicate that Longfin Smelt age-2 abundance is more or less determined by age-0 production (i.e., that survival from age 0 to age 2 is relatively invariant through the data series) and that the use of a traditional, two-life-stage spawner–recruit model is not necessary for modeling Longfin Smelt population dynamics in the SFE.

The four model variants that used two life stages incorporated a term to estimate survival between age 0 and age 2, thereby estimating *S* from predictions of *R*. These models differed in (1) their combination of an explicit density-dependent term for the spawner-to-recruit life history transition (indicated by a "b" in the model alphanumeric codes) and (2) whether their parameters were allowed to change through time (indicated by a "c" in the model alphanumeric codes; Table 1). The relative importance of these terms in describing empirical patterns in Longfin Smelt population abundance has ecological and management implications, as the terms suggest different mechanisms for constraining population dynamics.

Data sources.—The CDFW conducts several trawl-based surveys of fisheries resources in the SFE (www.wildlife.ca.gov/Regions/3). Longfin Smelt have been commonly collected in most of these surveys, and CDFW has generated indices of Longfin Smelt relative abundance from some of the surveys (Stevens and Miller 1983; Rosenfield and Baxter 2007). We obtained spawner–recruit parameters by using data from the San Francisco Bay Study (SFBS), which has been conducted by CDFW since 1980. Predictions made with the SFBS data were then compared to an estimate of Longfin Smelt relative abundance based on an independent data series originating from the CDFW's Fall Midwater Trawl Survey (FMWT). The CDFW has generated unitless indices of Longfin Smelt abundance from the FMWT data since 1967 (except in 1974 and 1979). The methodologies of the SFBS and FMWT sampling programs have been reported elsewhere (e.g., Stevens and Miller 1983; Rosenfield and Baxter 2007) and are not repeated here. The key differences that are pertinent to this study are as follows: (1) the SFBS and FMWT sampling grids overlap, but the former program samples further seaward and the latter program samples further landward; (2) SFBS sampling occurs during all months of the year, whereas FMWT sampling takes place only during September–December; (3) the number of stations sampled in a month is considerably higher for the FMWT (~100) than for the SFBS (~35); (4) the SFBS deploys both a bottom-oriented otter trawl and a midwater trawl at each sampling station, whereas the FMWT uses only a midwater trawl; and (5) CDFW calculates age-specific indices of Longfin Smelt relative abundance from the SFBS data but calculates only one index (essentially an age-0 index) from the FMWT data (Table 2).

The CDFW uses February–May catch data to generate an index of age-2 Longfin Smelt relative abundance for each sampling gear employed by the SFBS; May–October catch data are used to generate abundance indices for age-0 Longfin Smelt. We averaged the midwater trawl and otter trawl indices generated by the SFBS to produce unitless annual indices for each age-class of Longfin Smelt (hereafter, Bay Age-0 index and Bay Age-2 index; Table 2). We combined indices from the two sampling gears because the SFBS midwater trawl was not deployed during some years (Rosenfield and Baxter 2007), so the Bay Age-0 and Bay Age-2 indices provided continuous time series of relative abundance for 1980–2013. We did not attempt to estimate missing data (missing values were replaced with a zero before taking the average) because it was possible that estimation of missing values would be no more accurate than simply treating the missing data as zeroes. These choices reflect a trade-off between long-term data availability and the timing of peak Longfin Smelt catches (Rosenfield and Baxter 2007).

Selection of environmental covariates.—We developed one freshwater flow variable and three water quality variables to use as candidate predictors of Longfin Smelt life stage transitions. Following the work of Rosenfield and Baxter (2007), we used monthly means of the net Delta outflow index (hereafter, Delta outflow; www.water.ca.gov/dayflow/) to represent the commonly reported influence of freshwater flow on Longfin Smelt. Delta outflow is the estimated net tidally filtered river flow passing Chipps Island (Figure 1); it is the freshwater flow variable that most directly influences salinity distribution in SFE river channels and embayments (Jassby et al. 1995; Kimmerer et al. 2013). These open-water habitats comprise the major larval rearing areas for Longfin Smelt (Dege and Brown 2004; Hobbs et al. 2006). We calculated the monthly mean Delta outflow for December–May because (1) these months fully overlap with the Longfin Smelt spawning and larval rearing phases in the SFE (CDFW, unpublished data); and (2) outflow during these months is typically greater and more variable than outflow in other months. As a result, December–May outflow is most likely to influence the fate of Longfin Smelt (Jassby et al. 1995; Kimmerer et al. 2013). Estuarine hydrodynamics are also influenced greatly during droughts, which affect the fate of Longfin Smelt (Rosenfield and Baxter 2007). Delta outflow data were available for the period 1956–2013, and we converted monthly means into metric units (m^3/s).

We also used monthly means of water temperature (°C) and water transparency (Secchi depth, cm) from all available data

Downloaded by [24.6.237.115] at 14:12 27 January 2016

TABLE 2. Time series of the first principal component (PC1) from principal components analyses (PCA) of available water quantity and water quality variables, presented with time series of the Longfin Smelt relative abundance indices used in this study. The PCA on the net Delta outflow index (Delta outflow PC1; Sacramento–San Joaquin River Delta) was conducted on data for December–May; the PCAs for water temperature (water temp PC1) and water transparency were conducted on data for February–May. All abundance indices are unitless metrics of the Longfin Smelt's relative abundance in the San Francisco Estuary. The Fall Midwater Trawl Survey (FMWT) index is based on data collected during September–December. Bay indices are average results from the San Francisco Bay Study's (SFBS) two sampling gears (midwater trawl and otter trawl); the Bay Age-0 index is based on data collected during May–October, and the Bay Age-2 index is based on data collected during February–May.

Water year	Delta outflow PC1	Water temp PC1	Water transparency PC1	FMWT index	Bay Age-0 index	Bay Age-2 index
1956	2.77					
1957	−0.627					
1958	3.74					
1959	−1.14					
1960	−1.19					
1961	−1.29					
1962	−0.575					
1963	1.21					
1964	−1.5					
1965	1.3					
1966	−1.02					
1967	1.91			81,737		
1968	−1.12			3,279		
1969	2.68			59,350		
1970	0.928			6,515		
1971	0.152			15,903		
1972	−1.6			760		
1973	0.442			5,896		
1974	1.97			No data		
1975	−0.123			2,819		
1976	−1.93			658		
1977	−2.23			210		
1978	0.722			6,619		
1979	−1.05			No data		
1980	1.08	−1.22	−0.142	31,184	159,555	1,339
1981	−1.5	−0.651	−0.029	2,202	3,049	383
1982	3.04	−0.257	1.19	62,905	278,517	1,656
1983	5.91	−1.88	1.8	11,864	28,755	1,891
1984	0.492	−1.63	−1.56	7,408	36,774	4,924
1985	−1.67	0.222	−3.3	992	7,341	1,939
1986	1.71	−1.06	1.21	6,160	18,489	1,384
1987	−1.81	1.5	−0.68	1,520	2,428	1,785
1988	−1.97	0.335	−0.24	791	1,409	3,571
1989	−1.7	3.01	1.15	456	1,054	941
1990	−2.06	2.12	1.09	243	713	687
1991	−1.98	−1.43	2.33	134	188	351
1992	−1.88	2.18	−1.05	76	495	152
1993	0.006	−0.649	1.76	798	6,046	11
1994	−1.79	−0.06	0.379	545	1,424[a]	414
1995	3.59	−1.57	0.885	8,205	354,186	252[a]
1996	1.2	−0.451	−0.464	1,346	5,856	124[a]
1997	1.6	0.627	1.25	690	7,638	1,432

Downloaded by [24.6.237.115] at 14:12 27 January 2016

NRDC-36

TABLE 2. Continued.

Water year	Delta outflow PC1	Water temp PC1	Water transparency PC1	FMWT index	Bay Age-0 index	Bay Age-2 index
1998	3.11	−2.06	3.0	6,654	41,729	605
1999	0.414	0.989	0.529	5,243	58,510	748
2000	0.036	−0.511	0.322	3,437	14,202	704
2001	−1.61	0.659	−0.329	247	1,460	1,158
2002	−1.35	1.37	−0.271	707	9,652	1,752
2003	−0.468	0.81	−0.229	467	2,119	739
2004	−0.514	0.852	0.268	191	2,418	686
2005	−0.235	−0.956	0.048	129	4,538	569
2006	3.79	0.371	−0.411	1,949	12,148	188
2007	−1.73	0.799	−1.56	13	2,039	447
2008	−1.67	−0.361	0.341	139	3,681	204
2009	−1.57	0.149	−0.857	65	647	272
2010	−1.17	−0.247	−0.529	191	748	197
2011	1.21	−0.996	−3.51	477	7,833	305
2012	−1.53		0.365	61	1,284	733
2013	−1.38		−2.76	164	8,495	300

[a] The SFBS midwater trawl data were not collected in this year, but a value of zero was assumed in order to calculate the index.

collected by the SFBS. Water temperature data provided by CDFW were available for the years 1980–2011, and water transparency data were available for the period 1980–2013. We calculated monthly means of these two water quality variables for February–May (the indexing period for age-2 Longfin Smelt); during those months, age-0 Longfin Smelt are primarily in larval stages and have a center of distribution near the estuary's 2-psu isohaline (Dege and Brown 2004).

We summarized the Delta outflow, water temperature, and water transparency data separately by using principal components analysis (PCA) on the z-scored monthly means. We used PCA because sequential monthly means of flow and water quality variables can be closely correlated due to California's seasonal climate and high year-to-year variation in precipitation. This covariation makes it difficult to determine the averaging periods that best reflect the mechanistic linkages between environmental conditions and Longfin Smelt production. The first principal component (PC1) scores from each PCA (Table 2) were used as candidate predictors of Longfin Smelt recruits per spawner (a) in the regression analyses described below.

Derivation of recruits per spawner.—We represented a by using one of the following $\log_e$ transformed ratios: (Bay Age $0_{t=0}$)/(Bay Age $0_{t\text{-}2}$) for model 1abc; or (Bay Age $0_{t=0}$)/(Bay Age $2_{t=0}$) for the two-life-stage models. Multiple linear regression analyses were performed to screen candidate predictors of a in an information-theoretic framework; to develop a smaller set of statistically defensible covariates, we evaluated predictors by using Akaike's information criterion corrected for small sample sizes (AIC_c). Regression analyses were conducted separately for each version of the response variable; separate regression analyses were also conducted for tests involving water temperature variables (i.e., due to the smaller data set mentioned above). The candidate predictors and their assumed mechanistic meanings are described in Table 3.

During our analyses, we discovered that the relationship between Delta outflow and the two-life-stage version of $\log_e(a)$ was not linear. We used locally weighted scatter plot smoothing (LOESS) regression to depict the empirical shape of the relationship between these variables, and we found that the LOESS prediction was very similar to a second-order polynomial fit. We used AIC_c to confirm whether a polynomial fit was better supported than a linear fit; the polynomial regression was then used to predict a in our model variants with two life stages, as that equation was far simpler to implement than the LOESS equation.

Derivation of spawners per recruit.—In the two-life-stage models (2a, 2ab, 2ac, and 2abc), we estimated the relative abundance of age-2 Longfin Smelt to predict the relative abundance of the next generation of age-0 fish. We did this by deriving an estimator of survival from age 0 to age 2 ($S_{0\rightarrow 2}$) and multiplying estimates of R by this survival term to estimate the next generation of spawners (i.e., S). We estimated $S_{0\rightarrow 2}$ as the $\log_e$ transformed ratio, (Bay Age $2_{t=0}$)/(Bay Age 0_{t-2}) (i.e., the two SFBS indices for the same cohort of fish). We then tested a set of candidate predictor variables for this ratio by following the same analytical approach used to predict a. For this analysis, we also included the birth-year FMWT index as a candidate predictor (Table 3) to evaluate whether juvenile survival might be density dependent, given similar findings for other SFE fishes (Kimmerer et al. 2000; Bennett 2005).

Derivation of the exponent term.—To evaluate whether density dependence also affected R, we imposed a carrying

Downloaded by [24.6.237.115] at 14:12 27 January 2016

TABLE 3. Variables used as candidate covariates for predicting Longfin Smelt recruits per spawner and survival from age 0 to age 2, presented with implied or explicit hypotheses associated with the use of each variable (PC1 = first principal component; Delta outflow = net Delta outflow index, Sacramento–San Joaquin River Delta; SFBS = San Francisco Bay Study, California Department of Fish and Wildlife [CDFW]; FMWT = Fall Midwater Trawl Survey, CDFW).

Explanatory variable	Data source	Hypothesis for relationship to recruits per spawner	Hypothesis for relationship to survival from age 0 to age 2
PC1 for Delta outflow (m^3/s)	Dayflow[a]	Freshwater flow has a positive influence on survival of developing eggs, larvae, or early age-0 fish.	Freshwater flow has a positive influence on catchability of age-2 fish or survival from age 0 to age 2.[b]
PC1 for water transparency (Secchi depth, cm)	SFBS	Water transparency has a negative influence on survival of developing eggs, larvae, or early age-0 fish.	Water transparency has a negative influence on spatial distribution, catchability, or survival of age-2 fish.
PC1 for water temperature (°C)	SFBS	Intra-annual temperature change between winter and spring has a negative influence on survival of developing eggs, larvae, or early age-0 fish.	Intra-annual temperature change between winter and spring has a negative influence on spatial distribution, catchability, or survival of age-2 fish.
Mean water temperature (°C)	SFBS	Temperature has a negative influence on survival of developing eggs, larvae, or early age-0 fish.	Temperature has a negative influence on spatial distribution, catchability, or survival of age-2 fish.
Year		Dummy variable to indicate that an important variable with a continuous time trend had been missed (e.g., regional trends in Secchi depth; ammonium inhibition of phytoplankton growth rates)	Dummy variable to indicate that an important variable with a continuous time trend had been missed
Step-decline		Binary variable reflecting that the discontinuous time trend associated with some food web impacts (e.g., linked to the overbite clam invasion) had affected the survival of age-0 fish	Binary variable reflecting that the discontinuous time trend associated with some food web impacts had affected the survival of fish older than age 0
FMWT index	FMWT	Not applicable	The abundance of age-0 fish affects subsequent survival.

[a] California Department of Water Resources (www.water.ca.gov/dayflow/).

[b] This hypothesis was tested by determining whether survival from age 0 to age 2 could be better predicted by including flows that occurred during spawning (e.g., the ratio of [Bay Age-2 index in 1982]/[Bay Age-0 index in 1980] tested for an influence of the flow during 1982). The influence of freshwater flow on the year in between birth and spawning was also tested but was not statistically significant and therefore is not reported in this paper.

Downloaded by [24.6.237.115] at 14:12 27 January 2016

capacity on the models identified with a “b” in their alphanumeric codes (Table 1). Inclusion or exclusion of the exponent term e^{-BS} allowed us to investigate whether interannual variation in environmental conditions was sufficient to produce a natural limit on the production of age-0 Longfin Smelt (models 2a and 2ac) or, conversely, whether an explicit carrying capacity provides for better-fitting models (models 1abc, 2ab, and 2abc). To do this, we found values for B that reflected empirical relative abundance maxima given our estimates of a. The maximum FMWT index for Longfin Smelt was 81,737 in 1967. The maximum a, indexed as (Bay Age $0_{t=0}$)/(Bay Age 0_{t-2}), was 59 in 1995. We rounded these values up slightly and found a B-value that, when multiplied by hypothetically increasing numbers of spawners, would limit the ability of model 1abc to predict FMWT indices greater than 82,000 when a was equal to 60. Similarly, for the two-life-stage models, the maximum observed a (indexed as [Bay Age $0_{t=0}$]/[Bay Age $2_{t=0}$]) for the 10 years with the highest age-2 abundance was 168 in 1982. We rounded these values up slightly to calculate a B-value that would limit the ability of simulations from the two-life-stage models to predict FMWT indices greater than 82,000 when a was equal to 170.

Evaluating changes in model parameters assumed to result from changes in the San Francisco Estuary food web.—The feeding habits of juvenile Longfin Smelt in the SFE are basically undescribed, particularly for individuals foraging in mesohaline to marine waters (but see Hobbs et al. [2006] for data on larvae inhabiting the low-salinity zone). Hypothesized

Downloaded by [24.6.237.115] at 14:12 27 January 2016

changes in Longfin Smelt foraging success are either abrupt (e.g., due to the invasion of the overbite clam) or gradual and continuous (e.g., due to altered nutrient concentrations or changes in water transparency). We explored the predictive power of several temporal variables as surrogates for food web changes in the regression analyses (Table 3). Specifically, Kimmerer (2002b) used 1987 as a change point associated with invasion of the overbite clam; thus, we used a step-decline in that year as a predictor variable for *a* in model 1abc because fish that were spawned in 1987 would have been the first to be impacted by the high density of overbite clams detected in that year and thereafter. However, Thomson et al. (2010) found that evidence for a step-decline in Longfin Smelt relative abundance was strongest between 1989 and 1991. In our two-life-stage models, we tested step-declines in survival for 1989 and 1991; fish that were spawned in 1987 would have reached adulthood in 1989, so we would expect to see the overbite clam's first effects on $S_{0\rightarrow 2}$ during that year. We also screened "year" as a predictor variable to test for the possibility that trends in survival were not well represented as step-declines (Table 3).

Spawner–recruit simulations.—Using each of the five alternative spawner–recruit models, we generated 58-year time series of predicted Longfin Smelt FMWT indices (1958–2013). We started each simulation by seeding 1956 and 1957 with the median observed FMWT index (798). The simulations then predicted all Longfin Smelt abundance indices from 1958 through water year 2013. The simulations were stochastic; each year of each simulation was iterated 1,000 times by using randomly drawn values of every regression parameter; the parameter estimate was assumed to be the mean, and the SE was used to scale the random variability. We restricted the simulations such that juvenile survival had to remain less than or equal to 1.0 (i.e., $\leq$100%). This is an extremely high upper limit on survival, but it is not greatly beyond the observed data: the index ratio we used to represent survival had a maximum empirical value of 0.98 in 2012.

Model variants were evaluated based on their ability to predict the empirical FMWT time series and based on the frequency with which they produced results that were clearly spurious. Each of the resulting 5,000 simulations was compared to the empirical FMWT indices by calculating the mean square error (MSE). Because FMWT data were available for 1967–1973, 1975–1978, and 1980–2013, those years were extracted from our simulations for use in this comparison. The central 95% of MSE estimates (i.e., 950 of the 1,000 iterations) were summarized by using box plots. We also evaluated the relative performance of model variants with the lowest MSEs by summarizing how frequently they predicted Longfin Smelt quasi-extinction, defined here as a FMWT index value less than 1 (the lowest empirical FMWT index value was 13 in 2007). Lastly, the time series predictions from the best-performing models were summarized graphically to more explicitly illustrate their performance relative to the observed FMWT index time series.

RESULTS

The PC1s for Delta outflow, water transparency, and water temperature had eigenvalues of 3.5, 2.0, and 1.5, respectively, and explained 58, 50, and 37% of the variance in the time trends for these variables. The PC1 for Delta outflow and the PC1 for water transparency were highly concordant with multiple-month means of each year (Delta outflow: Pearson's product-moment correlation coefficient $r = 0.99$; water transparency: Pearson's $r = 0.98$). In contrast, the PC1 for water temperature was not correlated with mean water temperature (Pearson's $r = 0.17$) and instead reflected variation within years; the PC1 for temperature segregated the years with relatively large temperature changes between winter and spring (i.e., cool February–March and warm April–May) from the years with less seasonal variation. Therefore, we tested both the PC1 and the mean of water temperature as candidate predictor variables for *a* and $S_{0\rightarrow 2}$.

Recruits per Spawner

The linear regression analyses that were used to screen candidate predictor variables indicated positive effects of Delta outflow PC1 and the binary step-change at 1987 as predictors of *a* for use in model 1abc (Table 4). The step-change variable was not significant ($P = 0.07$), and its sign was opposite our expectation (i.e., *a* was predicted to increase after 1987), but its inclusion was supported by the change in ACI_c. The final model selected was $\log_e(a) = [0.596 \pm 0.146(\text{Delta outflow PC1})] + [1.54 \pm 0.829(\text{step-decline in 1987})] - (1.39 \pm 0.748)$. The similar analyses for models 2a, 2ab, 2ac, and 2abc supported only the use of Delta outflow PC1 as a predictor of *a*; in that case, a nonlinear fit was better supported than a linear fit (Table 4). The final model selected was $\log_e(a) = [-0.148 \pm 0.049(\text{Delta outflow PC1})^2] + [0.954 \pm 0.152(\text{Delta outflow PC1})] + [2.94 \pm 0.303]$; neither the linear fit nor the nonlinear fit showed evidence of a monotonic residual time trend (Figure 2).

Juvenile Survival

The linear regression analyses that were used to screen candidate predictor variables of $S_{0\rightarrow 2}$ strongly supported the use of the birth-year FMWT index (Table 5), suggesting that juvenile survival is density dependent. All of the temporal variables we tested had *P*-values ≤ 0.052. Interestingly, the 1989 step-decline performed poorly ($\mathrm{AIC}_c = 103$) relative to "year" ($\mathrm{AIC}_c = 99.6$) and the 1991 step-decline ($\mathrm{AIC}_c = 95.4$). The final model selected was $\log_e(S_{0\rightarrow 2}) = [-0.630 \pm 0.114{\cdot}\log_e(\text{FMWT index})] - [1.68 \pm 0.474(\text{step-decline in 1991})] + [3.19 \pm 1.03]$.

Downloaded by [24.6.237.115] at 14:12 27 January 2016

TABLE 4. Results of linear regression analyses exploring candidate predictors of two versions of the recruits-per-spawner parameter for Longfin Smelt in the San Francisco Estuary. In model 1abc, the response variable was the natural logarithm of (Bay Age $0_{t=0}$)/(Bay Age 0_{t-2}). In the other models, the response variable was the natural logarithm of (Bay Age $0_{t=0}$)/(Bay Age $2_{t=0}$). The cells for each candidate predictor variable report whether the variable was tested in each model step, its P-value when tested, and whether it was dropped in subsequent steps due to a nonsignificant P-value. Akaike's information criterion corrected for small sample sizes (AIC_c) is shown; AIC_c values from steps 1 and 2 cannot be compared with those from steps 3–5 due to the increase in sample size for the latter three steps. Step 5 in the two-life-stage models tested the quadratic flow relationship against the linear version tested in step 4. See Table 3 for descriptions of the predictor variables.

Statistic or predictor variable	Step 1	Step 2	Step 3	Step 4	Step 5
One-life-stage model (1abc)					
Adjusted R^2	0.26	0.26	0.31	0.32	Not applicable
Sample size	30	30	32	32	
AIC_c	124	122	127	125	
Flow PC1	0.001	0.01	0.0005	0.0003	
Temperature PC1	Not tested	0.81	Dropped	Dropped	
Water transparency PC1	Not tested	Not tested	0.56	Dropped	
Mean temperature	0.68	Dropped	Dropped	Dropped	
Year	0.41	Dropped	Dropped	Dropped	
Step-decline in 1987	Not tested	Not tested	0.06	0.07	
Two-life-stage models (2a, 2ab, 2ac, and 2abc)					
Adjusted R^2	0.43	0.46	0.41	0.44	0.55
Sample size	32	32	34	34	34
AIC_c	123	120	130	126	119
Flow PC1	0.00003	0.0007	0.00004	0.00001	6×10^{-7}
Temperature PC1	Not tested	0.33	Dropped	Dropped	Dropped
Water transparency PC1	Not tested	Not tested	0.46	Dropped	Dropped
Mean temperature	0.66	Dropped	Dropped	Dropped	Dropped
Year	0.70	Dropped	Dropped	Dropped	Dropped
Step-decline in 1987	Not tested	Not tested	0.62	Dropped	Dropped

Model Evaluation

The MSEs of most models overlapped at least somewhat, but two of the models (2a and 2ac) had notably poorer fits to the FMWT data and thus produced higher MSEs 63–100% of the time (Figure 3). It therefore appears that an explicit carrying capacity on R is a useful model construct. The MSEs of models 1abc, 2ab, and 2abc overlapped strongly (Figure 4), suggesting that the models provided a similar fit to the FMWT data. Compared with models 2ab and 2abc, model 1abc showed low variation in MSE among model iterations (Figure 4), but that low variability reflected model 1abc's rapid predictions of quasi-extirpation in 100% of the iterations (Figure 5). Thus, although model 1abc appeared to have a relatively good fit to the FMWT data, this model was clearly unreliable. By design, models 2ab and 2abc were equivalent until the 1991 step-decline was implemented in the latter model. Thus, FMWT predictions based on these models were nearly equivalent from 1967 to 1990 (Figure 6). Median FMWT predictions using model 2ab were closer to the empirical data from 1991 to 1994; thereafter, the median predictions from model 2ab systematically overestimated the observed FMWT time series, whereas the median predictions from model 2abc more closely matched the empirical data (Figure 6). As a result, the median predictions of model 2abc provided a better overall representation of the empirical FMWT indices (compare panels D and B in Figure 6).

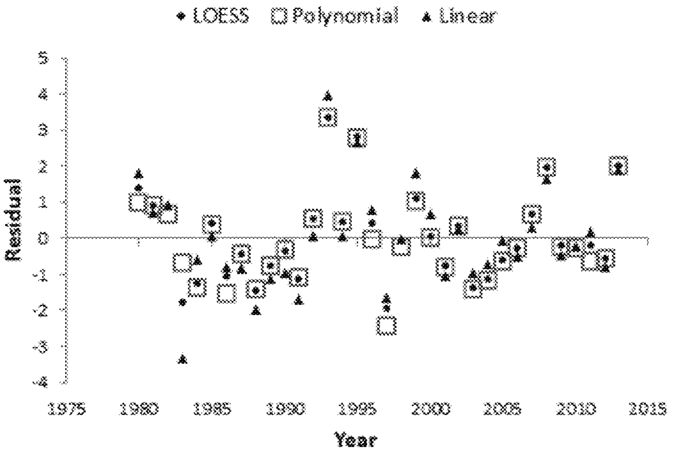


FIGURE 2. Time series of residuals from three regression analyses of the first principal component for the net Delta outflow index (December–May; Sacramento–San Joaquin Delta) in relation to the natural logarithm of Longfin Smelt recruits (age 0) per spawner (age 2) in the San Francisco Estuary (LOESS = locally weighted scatter plot smoothing).

Downloaded by [24.6.237.115] at 14:12 27 January 2016

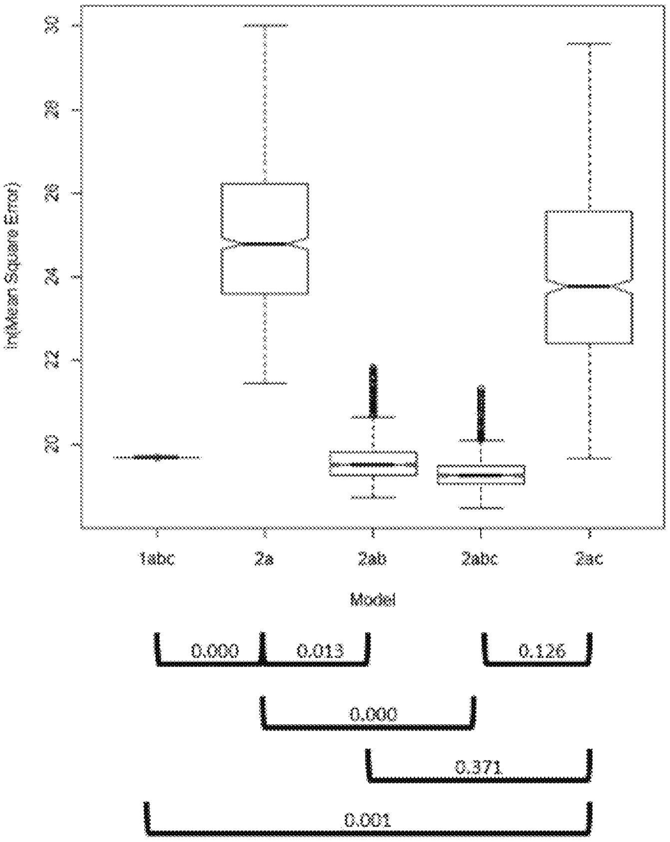


FIGURE 3. Notched box plot summarizing the mean square error (MSE; $\log_e$ transformed) from the central 95% of predictions of the Longfin Smelt Fall Midwater Trawl Survey index using five alternative spawner–recruit models (see Table 1 for model descriptions). The ends of the box represent the first and third quartiles; the line inside the box represents the median; the ends of the whiskers represent a 95% confidence interval; outliers (open circles) are also shown. Where notches associated with MSEs from different models do not overlap, there is "strong evidence" that their medians differ (Quick R; www.statmethods.net/graphs/boxplot.html). The pairwise proportions of overlapping MSE predictions from 950 model iterations are provided below the box plot.

However, the propagated prediction error was high even for models 2ab and 2abc (Figure 6A, C), making it impossible to conclude that one outperformed the other. In addition, both model 2ab and model 2abc considerably underpredicted and were nonlinearly related to the FMWT indices (Figure 6B, D), suggesting that our e^{-BS} term was too strongly density dependent.

DISCUSSION

Relying on a few well-supported assumptions about Longfin Smelt life history and ecology in the SFE, our two best-supported Ricker models each incorporated two life stages in which productivity was density dependent during each life stage transition. In both models, recruits per spawner were related to freshwater flow rates. Apparently, despite differences in geographic extent, timing, and sampling gears, the SFBS and FMWT sampling programs detected the same general patterns in Longfin Smelt population dynamics, and our Ricker-model-based analyses indicated that there are at least two important—but temporally distinct—population dynamic effects: (1) an influence of freshwater flow on the production of age-0 fish; and (2) density-dependent and possibly declining juvenile survival.

Implications of Spawner–Recruit Dynamics

The influence of freshwater flow on the production of age-0 Longfin Smelt has been recognized for several decades (Stevens and Miller 1983; Jassby et al. 1995; Rosenfield and Baxter 2007), although we found evidence for nonlinearities that had not been identified before (Table 4; Figure 2). Depending on its timing and magnitude, freshwater flow was observed to have both positive and negative effects on the recruitment of age-0 Longfin Smelt in Lake Washington (Chigbu 2000). There was no evidence that the ratio we used to depict recruits per spawner

TABLE 5. Results of linear regression analyses exploring candidate predictors of survival from age 0 to age 2 for Longfin Smelt in the San Francisco Estuary. The response variable was the natural logarithm of (Bay Age $2_{t=0}$)/(Bay Age 0_{t-2}). The cells for each candidate predictor variable report whether the variable was tested in each model step, its P-value when tested, and whether it was dropped in subsequent steps due to a nonsignificant P-value. Akaike's information criterion corrected for small sample sizes (AIC_c) is shown; the AIC_c values from steps 1 and 2 cannot be compared with those from steps 3–6 due to the increase in sample size for the latter four steps. See Table 3 for descriptions of the predictor variables.

Statistic or predictor variable	Step 1	Step 2	Step 3	Step 4	Step 5	Step 6
Adjusted R^2	0.44	0.46	0.39	0.41	0.35	0.48
Sample size	30	30	32	32	32	32
AIC_c	94.1	91.5	102	99.6	103	95.4
$\log_e$(birth-year FMWT index)	0.00009	0.00003	0.00005	0.00004	0.0002	0.000006
Flow PC1	0.38	Dropped	Dropped	Dropped	Dropped	Dropped
Temperature PC1	Not tested	0.44	Dropped	Dropped	Dropped	Dropped
Water transparency PC1	Not tested	Not tested	0.78	Dropped	Dropped	Dropped
Mean temperature	0.99	Dropped	Dropped	Dropped	Dropped	Dropped
Year	0.005	0.004	0.01	0.01	Not tested	Not tested
Step-decline in 1989	Not tested	Not tested	Not tested	Not tested	0.052	Not tested
Step-decline in 1991	Not tested	Not tested	Not tested	Not tested	Not tested	0.001

Downloaded by [24.6.237.115] at 14:12 27 January 2016

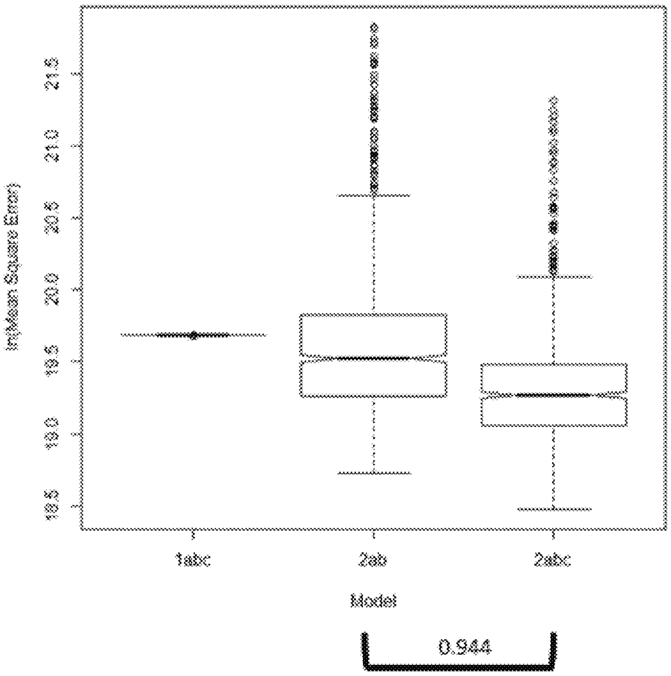


FIGURE 4. Notched box plot summarizing the mean square error (MSE; $\log_e$ transformed) from the central 95% of predictions of the Longfin Smelt Fall Midwater Trawl Survey index based on the two best-supported spawner–recruit models as well as model 1abc (see Table 1 for model descriptions). The ends of the box represent the first and third quartiles; the line inside the box represents the median; the ends of the whiskers represent a 95% confidence interval; outliers (open circles) are also shown. Where notches associated with MSEs from different models do not overlap, there is "strong evidence" that their medians differ (Quick R; www.statmethods.net/graphs/boxplot.html). The pairwise proportion of overlapping MSE predictions from 950 iterations of models 2ab and 2abc is provided below the box plot.

has declined over time; thus, food web changes apparently have not impacted this life stage transition. However, there is some suggestion of a cyclical pattern among the residuals (Figure 2), which implies a potential ocean influence on Longfin Smelt recruitment in the SFE (sensu Feyrer et al. 2015). This possibility warrants further research. Improvements in the scientific understanding of when freshwater flow modulates Longfin Smelt production may help to reveal the flow-related mechanisms at work and the area where those mechanisms function. Focusing on the time and place where freshwater flow is likely to affect recruitment may assist Central Valley water project managers in optimizing freshwater flow rates so as to benefit Longfin Smelt production.

Implications for Juvenile Survival

We found no indication that freshwater flow moderated the survival of Longfin Smelt between age 0 and age 2, but we did detect evidence that survival during this life stage transition is density dependent (Table 5). In contrast to the production of age-0 fish, there was evidence for continuous declines or step-declines (Table 5) in the survival of juvenile Longfin Smelt, which may reflect food-web-related impacts on this older life stage. Several other studies have detected one or more step-declines in the FMWT time series for Longfin Smelt (Kimmerer 2002b; Thomson et al. 2010). Rosenfield and Baxter (2007) noted an age-specific decline in production between age 0 and the age of spawning in Longfin Smelt; this decline may have occurred sometime during the severe drought of 1987–1994. Due to the propagation of variance, our spawner–recruit simulations were unable to robustly distinguish between the model that allowed survival rates to change (model 2abc) and the model in which survival did not change directionally (model 2ab; Figures 4, 6).

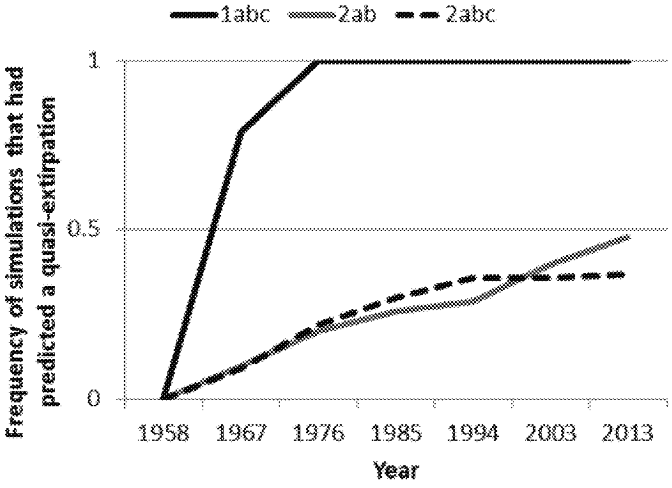


FIGURE 5. Time series showing the proportion of stochastic simulations of Longfin Smelt recruitment that predicted quasi-extirpation (defined as a predicted Fall Midwater Trawl Survey index < 1.0) from three alternative spawner–recruit models (see Table 1 for model descriptions).

Constraining the timing and location of the density dependence and declining survival of Longfin Smelt may help to identify mechanisms that control these vital rates. The forces creating density-dependent survival and possible declines in that survival are most likely to operate during the period between (1) sampling that produces the age-0 abundance index (May–October in year 0) and (2) sampling that produces the age-2 abundance index (February–May). For most of the SFE Longfin Smelt, this part of the life cycle is primarily spent in mesohaline or marine waters (Rosenfield and Baxter 2007); therefore, the mechanisms affecting juvenile survival are more likely to operate in mesohaline or marine environments than in freshwater or low-salinity-zone waters.

Implications for Forage Fish Management in the San Francisco Estuary

Our results support some emerging generalizations about fish recruitment in the SFE. The results suggest that the general life cycle model for Longfin Smelt is very similar to

Downloaded by [24.6.237.115] at 14:12 27 January 2016

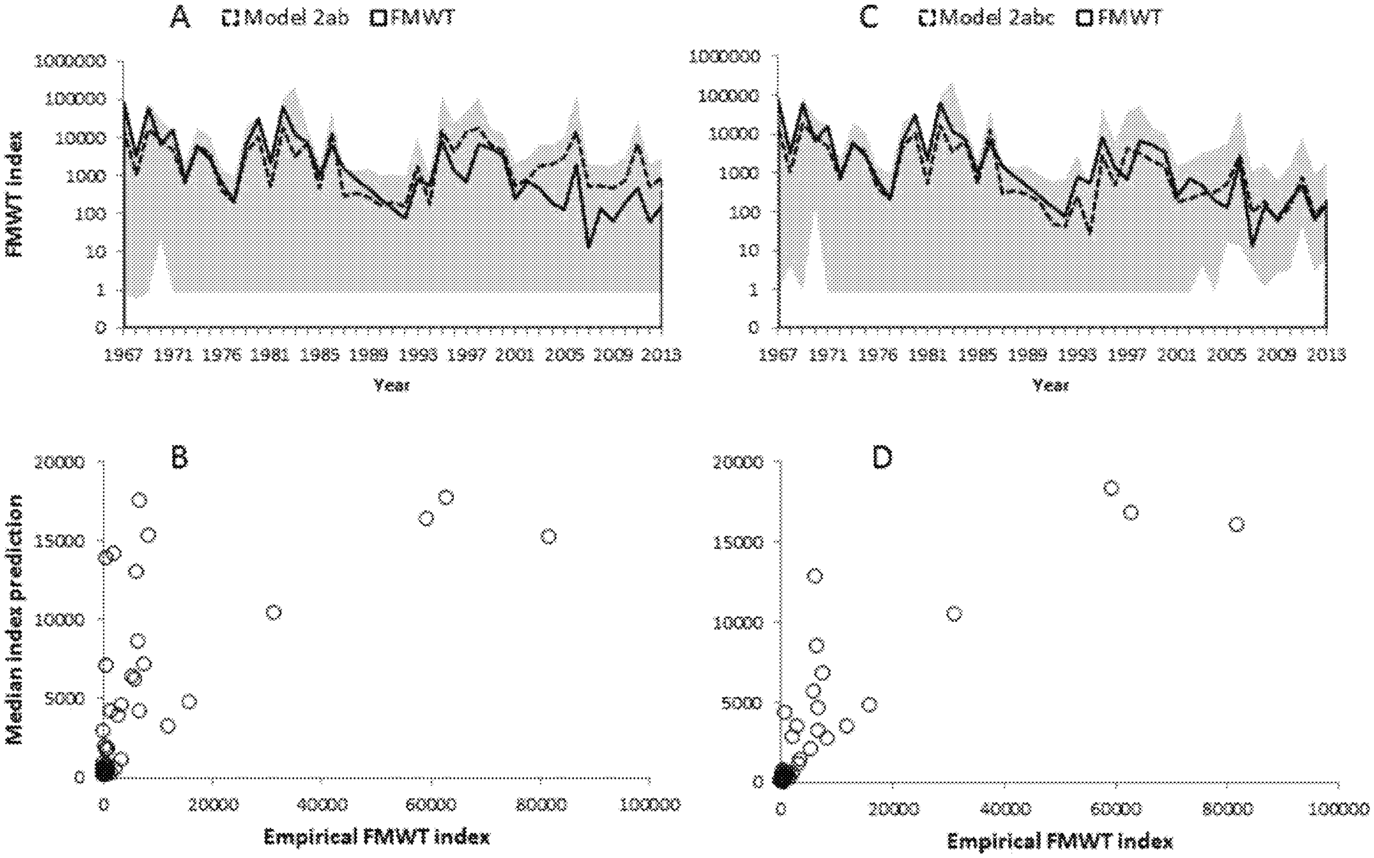


FIGURE 6. The Fall Midwater Trawl Survey (FMWT) index for Longfin Smelt, presented relative to predictions from the two best-supported spawner–recruit models: (**A**) the time series for the FMWT index (solid line), the median prediction (dashed line) from model 2ab (950 model iterations/year), and the range of the central 95% of predictions (gray shading); (**B**) scatter plot of the median FMWT index prediction from model 2ab in relation to the empirical FMWT index; (**C**) the time series for the FMWT index, the median prediction from model 2abc (950 model iterations/year), and the range of the central 95% of predictions; and (**D**) scatter plot of the median FMWT index prediction from model 2abc in relation to the empirical FMWT index.

Striped Bass *Morone saxatilis* (Kimmerer et al. 2000). For each of these species, freshwater flow variation has been linked to productivity early in the life cycle—an effect that is subsequently tempered by density-dependent survival during the juvenile life stage. Density-dependent survival may seem paradoxical in a declining fish species like the Longfin Smelt, but fisheries recruitment theory has demonstrated how a spawner–recruit relationship that appears to reflect density dependence can arise from food-web-related mechanisms that are unrelated to a population's limitation of its own resource base (Walters and Juanes 1993).

The SFE population of Longfin Smelt is in the queue for potential listing under the ESA (USOFR 2012). By disaggregating the life-stage-specific constraints on population dynamics, our results can help to inform a future ESA listing decision for Longfin Smelt and can assist in development of the accompanying recovery plan if the population is listed. Perhaps more importantly, the present study helps to identify the portion of the Longfin Smelt's life cycle during which productivity is limited and may be changing over time, thus potentially informing efforts to research and monitor recruitment limitation in this species. The persistence of Longfin Smelt and several other native forage fish species in the SFE (and potentially the predators that historically relied on these populations; e.g., Striped Bass and California Halibut *Paralichthys californicus*) depends on taking steps to improve the productivity of these fishes.

ACKNOWLEDGMENTS

This study emerged from our work for the Bay–Delta Conservation Plan. The viewpoints expressed are those of the authors and do not necessarily reflect the opinions of the U.S. Department of the Interior or the U.S. Fish and Wildlife Service. We thank A. Weber-Stover for help in assembling and reviewing an early draft of the manuscript; K. Sun for generating Figure 3; and R. Baxter for providing the SFBS data. The comments of three anonymous reviewers are greatly appreciated.

Downloaded by [24.6.237.115] at 14:12 27 January 2016

REFERENCES

Alder, J., B. Campbell, V. Karpouzi, K. Kaschner, and D. Pauly. 2008. Forage fish: from ecosystems to markets. Annual Review of Environment and Resources 33:153–166.

Alpine, A. E., and J. E. Cloern. 1992. Trophic interactions and direct physical effects control phytoplankton biomass and production in an estuary. Limnology and Oceanography 37:946–955.

Arthur, J. F., M. D. Ball, and S. Y. Baughman. 1996. Summary of federal and state water project environmental impacts in the San Francisco Bay–Delta estuary, California. San Francisco State University, San Francisco, California.

Bennett, W. A. 2005. Critical assessment of the Delta Smelta population in the San Francisco Estuary, California. San Francisco Estuary and Watershed Science [online serial] 3(2).

CDFW (California Department of Fish and Wildlife). 2009. Report to the Fish and Game Commission: a status review of the Longfin Smelt (*Spirinchus thaleichthys*) in California. CDFW, Napa.

Chigbu, P. 2000. Population biology of Longfin Smelt and aspects of the ecology of other major planktivorous fishes in Lake Washington. Journal of Freshwater Ecology 15:543–557.

Cloern, J. E., and A. D. Jassby. 2012. Drivers of change in estuarine-coastal ecosystems: discoveries from four decades of study in San Francisco Bay. Reviews of Geophysics [online serial] 50(4):RG4001.

Cury, P. M., I. L. Boyd, S. Bonhommeau, T. Anker-Nilssen, R. J. M. Crawford, R. W. Furness, J. A. Mills, E. J. Murphy, H. Österblom, M. Paleczny, J. F. Piatt, J.-P. Roux, L. Shannon, and W. J. Sydeman. 2011. Global seabird response to forage fish depletion–one-third for the birds. Science 334:1703–1706.

Dege, M., and L. R. Brown. 2004. Effect of outflow on spring and summertime distribution and abundance of larval and juvenile fishes in the upper San Francisco Estuary. Pages 49–66 *in* F. Feyrer, L. R. Brown, R. L. Brown, and J. J. Orsi, editors. Early life history of fishes in the San Francisco Estuary and watershed. American Fisheries Society, Symposium 39, Bethesda, Maryland.

Enright, C., and S. Culberson. 2010. Salinity trends, variability, and control in the northern reach of the San Francisco Estuary. San Francisco Estuary and Watershed Science[online serial] 7(2).

Essington, T. E., and S. Hansson. 2004. Predator-dependent functional responses and interaction strengths in a natural food web. Canadian Journal of Fisheries and Aquatic Sciences 61:2215–2226.

Feyrer, F., J. E. Cloern, L. R. Brown, M. A. Fish, K. A. Hieb, and R. D. Baxter. 2015. Estuarine fish communities respond to climate variability over both river and ocean basins. Global Change Biology 21:3608–3619.

Feyrer, F., B. Herbold, S. A. Matern, and P. B. Moyle. 2003. Dietary shifts in a stressed fish assemblage: consequences of a bivalve invasion in the San Francisco Estuary. Environmental Biology of Fishes 67:277–288.

Genin, A. 2004. Bio-physical coupling in the formation of zooplankton and fish aggregations over abrupt topographies. Journal of Marine Systems 50:3–20.

Gillson, J. 2011. Freshwater flow and fisheries production in estuarine and coastal systems: where a drop of rain is not lost. Reviews in Fisheries Science 19:168–186.

Hall, C. J., A. Jordaan, and M. G. Frisk. 2012. Centuries of anadromous forage fish loss: consequences for ecosystem connectivity and productivity. BioScience 62:723–731.

Hobbs, J. A., W. A. Bennett, and J. E. Burton. 2006. Assessing nursery habitat quality for native smelts (Osmeridae) in the low-salinity zone of the San Francisco Estuary. Journal of Fish Biology 69:907–922.

Hughes, B. B., M. D. Levey, J. A. Brown, M. C. Fountain, A. B. Carlisle, S. Y. Litvin, C. M. Greene, W. N. Heady, and M. G. Gleason. 2014. Nursery functions of U.S. West Coast estuaries: the state of knowledge for juveniles of focal invertebrate and fish species. Nature Conservancy, Arlington, Virginia.

Jassby, A. D., W. J. Kimmerer, S. G. Monismith, C. Armor, J. E. Cloern, T. M. Powell, J. R. Schubel, and T. J. Vendlinski. 1995. Isohaline position as a habitat indicator for estuarine populations. Ecological Applications 5:272–289.

Katz, J., P. B. Moyle, R. M. Quiñones, J. Israel, and S. Purdy. 2013. Impending extinction of salmon, steelhead, and trout (Salmonidae) in California. Environmental Biology of Fishes 96:1169–1186.

Kennish, M. J. 2002. Environmental threats and environmental future of estuaries. Environmental Conservation 29:78–107.

Kimmerer, W. J. 2002a. Physical, biological, and management responses to variable freshwater flow into the San Francisco Estuary. Estuaries 25:1275–1290.

Kimmerer, W. J. 2002b. Effects of freshwater flow on abundance of estuarine organisms: physical effects or trophic linkages? Marine Ecology Progress Series 243:39–55.

Kimmerer, W. J. 2006. Response of anchovies dampens effects of the invasive bivalve *Corbula amurensis* on the San Francisco Estuary food web. Marine Ecology Progress Series 324:207–218.

Kimmerer, W. J., J. H. Cowan Jr., L. W. Miller, and K. A. Rose. 2000. Analysis of an estuarine Striped Bass population: influence of density-dependent mortality between metamorphosis and recruitment. Canadian Journal of Fisheries and Aquatic Sciences 57:478–486.

Kimmerer, W. J., E. S. Gross, and M. L. MacWilliams. 2009. Is the response of estuarine nekton to freshwater flow in the San Francisco Estuary explained by variation in habitat volume? Estuaries and Coasts 32:375–389.

Kimmerer, W. J., M. L. MacWilliams, and E. S. Gross. 2013. Variation of fish habitat and extent of the low-salinity zone with freshwater flow in the San Francisco Estuary. San Francisco Estuary and Watershed Science [online serial] 11(4).

Latour, R. J. In press. Explaining patterns of pelagic fish abundance in the Sacramento–San Joaquin delta. Estuaries and Coasts. DOI : 10.1007/s12237-015-9968-9.

Lotze, H. K., H. S. Lenihan, B. J. Bourque, R. H. Bradbury, R. G. Cooke, M. C. Kay, S. M. Kidwell, M. X. Kirby, C. H. Peterson, and J. B. C. Jackson. 2006. Depletion, degradation, and recovery potential of estuaries and coastal seas. Science 312:1806–1809.

Maunder, M. N., R. B. Deriso, and C. H. Hanson. 2015. Use of state-space population dynamics models in hypothesis testing: advantages over simple log-linear regressions for modeling survival, illustrated with application to Longfin Smelt (*Spirinchus thaleichthys*). Fisheries Research 164:102–111.

Moyle, P. B. 2002. Inland fishes of California, revised and expanded. University of California Press, Berkeley.

Myers, R. A. 1998. When do environment–recruitment correlations work? Reviews in Fish Biology and Fisheries 8:285–305.

Nobriga, M. L., and F. Feyrer. 2008. Diet composition in San Francisco Estuary Striped Bass: does trophic adaptability have its limits? Environmental Biology of Fishes 83:509–517.

North, E. W., and E. D. Houde. 2003. Linking ETM physics, zooplankton prey, and fish early life histories to Striped Bass *Morone saxatilis* and White Perch *M. americana* recruitment. Marine Ecology Progress Series 260:219–236.

Peebles, E. B., S. E. Burghart, and D. J. Hollander. 2007. Causes of interestuarine variability in Bay Anchovy (*Anchoa mitchelli*) salinity at capture. Estuaries and Coasts 30:1060–1074.

Pikitch, E. K., K. J. Rountos, T. E. Essington, C. Santora, D. Pauly, R. Watson, U. R. Sumaila, P. D. Boersma, I. L. Boyd, D. O. Conover, P. Cury, S. S. Heppell, E. D. Houde, M. Mangel, É. Plagányi, K. Sainsbury, R. S. Steneck, T. M. Geers, N. Gownaris, and S. B. Munch. 2014. The global contribution of forage fish to marine fisheries and ecosystems. Fish and Fisheries 15:43–64.

Reum, J. C. P., T. E. Essington, C. M. Greene, C. A. Rice, and K. L. Fresh. 2011. Multiscale influence of climate on estuarine populations of forage fish: the role of coastal upwelling, freshwater flow and temperature. Marine Ecology Progress Series 425:203–215.

Ricker, W. E. 1954. Stock and recruitment. Journal of the Fisheries Research Board of Canada 115:559–623.

Rosenfield, J. A., and R. D. Baxter. 2007. Population dynamics and distribution patterns of Longfin Smelt in the San Francisco Estuary. Transactions of the American Fisheries Society 136:1577–1592.

Shan, X., P. Sun, X. Jin, X. Li, and F. Dai. 2013. Long-term changes in fish assemblage structure in the Yellow River estuary ecosystem, China. Marine and Coastal Fisheries: Dynamics, Management, and Ecosystem Science [online serial] 5:65–78.

Sommer, T., F. Mejia, K. Hieb, R. Baxter, E. Loboschefsky, and F. Loge. 2011. Long-term shifts in the lateral distribution of age-0 Striped Bass in the San Francisco Estuary. Transactions of the American Fisheries Society 140:1451–1459.

Sommer, T., C. Armor, R. Baxter, R. Breuer, L. Brown, M. Chotkowski, S. Culberson, F. Feyrer, M. Gingras, B. Herbold, W. Kimmerer, A. Mueller-Solger, M. Nobriga, and K. Souza. 2007. The collapse of pelagic fishes in the upper San Francisco Estuary. Fisheries 32:270–277.

Stevens, D. E., and L. W. Miller. 1983. Effects of river flow on abundance of young Chinook Salmon, American Shad, Longfin Smelt, and Delta Smelt in the Sacramento–San Joaquin River system. North American Journal of Fisheries Management 3:425–437.

Thomson, J. R., W. J. Kimmerer, L. R. Brown, K. B. Newman, R. Mac Nally, W. A. Bennett, F. Feyrer, and E. Fleishman. 2010. Bayesian change point analysis of abundance trends for pelagic fishes in the upper San Francisco Estuary. Ecological Applications 20:1431–1448.

Trathan, P. N., P. García-Borboroglu, D. Boersma, C.-A. Bost, R. J. M. Crawford, G. T. Crossin, R. J. Cuthbert, P. Dann, L. S. Davis, S. De La Puente, U. Ellenberg, H. J. Lynch, T. Mattern, K. Pütz, P. J. Seddon, W. Trivelpiece, and B. Wienecke. 2015. Pollution, habitat loss, fishing, and climate change as critical threats to penguins. Conservation Biology 29:31–41.

Turner, J. L., and H. K. Chadwick. 1972. Distribution and abundance of young-of-the-year Striped Bass, *Morone saxatilis*, in relation to river flow in the Sacramento–San Joaquin estuary. Transactions of the American Fisheries Society 101:442–452.

USOFR (U.S. Office of the Federal Register). 2012. Endangered and threatened wildlife and plants; 12-month finding on petition to list the San Francisco Bay–delta population of Longfin Smelt as endangered or threatened. Federal Register 77:63(2 April 2012):19755–19797.

Vörösmarty, C. J., P. B. McIntyre, M. O. Gessner, D. Dudgeon, A. Prusevich, P. Green, S. Glidden, S. E. Bunn, C. A. Sullivan, C. R. Liermann, and P. M. Davies. 2010. Global threats to human water security and river biodiversity. Nature 467:555–561.

Walters, C. J., and F. Juanes. 1993. Recruitment limitation as a consequence of natural selection for use of restricted feeding habitats and predation risk taking by juvenile fishes. Canadian Journal of Fisheries and Aquatic Sciences 50:2058–2070.

Wilkerson, F. P., R. C. Dugdale, V. E. Hogue, and A. Marchi. 2006. Phytoplankton blooms and nitrogen productivity in San Francisco Bay. Estuaries and Coasts 29:401–416.

Downloaded by [24.6.237.115] at 14:12 27 January 2016

From: Lecky, Jim [Jim.Lecky@icf.com]
Sent: 6/16/2020 7:58:35 PM
To: Alicia Forsythe [aforsythe@sitesproject.org]; John Spranza (john.spranza@hdrinc.com) [john.spranza@hdrinc.com]
Subject: RE: Range of Alternatives for Sites Reservoir RDEIR/RDEIS
Attachments: Flow Considerations_Technical Memo draft final.docx; ISSUES AND SUPPORT FOR SITES RESERVOIR ECOSYSTEM ENHANCEMENT STORAGE ACCOUNT ACTIONS AND OPERATIONS.docx

Ali, not sure if these are what you are looing for since they are from 2017, but they seem relevant.

From: Alicia Forsythe <aforsythe@sitesproject.org>
Sent: Tuesday, June 16, 2020 3:27 PM
To: Lecky, Jim <Jim.Lecky@icf.com>; John Spranza (john.spranza@hdrinc.com) <john.spranza@hdrinc.com>
Subject: FW: Range of Alternatives for Sites Reservoir RDEIR/RDEIS

Hi Jim and John – See the email exchange below. I will also forward on one more email that I sent to Doug.

Jim – I thought you did a longer write up on the pros and cons with the studies that folks continue to reference. I recall like a 5 page document. But I couldn't find it just now. Is this something you recall and can find? Also, do you have the Nobriga and Rosenfield 2016 paper? Anything else to send to Jerry to help him on all of this?

Ali

Alicia Forsythe | Environmental Planning and Permitting Manager | Sites Reservoir Project | 916.880.0676 | aforsythe@sitesproject.org | www.SitesProject.org

CONFIDENTIALITY NOTICE: This communication with its contents may contain confidential and/or legally privileged information. It is solely for the use of the intended recipient(s). Unauthorized interception, review, use or disclosure is prohibited and may violate applicable laws including the Electronic Communications Privacy Act. If you are not the intended recipient, please contact the sender and destroy all copies of the communication.

From: Alicia Forsythe
Sent: Tuesday, June 16, 2020 3:22 PM
To: Jerry Brown <jbrown@sitesproject.org>
Subject: RE: Range of Alternatives for Sites Reservoir RDEIR/RDEIS

Jerry – See the paper that Gary Bobker sent to us over the weekend for the NRDC, TBI's proposed criteria.

Attached are the following:

- 20191011_Topics for Oct Exec Team Meeting – This was prepare by Jim Lecky and is "unfiltered" – See the references to specific studies with regard to locations
- 20191014_Talking Points for Oct Exec Team Meeting – This was my shortening of Jim's document, trying to get at the heart of some of these issues for our members
- Perry et al – Relates to Freeport Flows and salmonid survival
- Michel and Henderson – Related to Wilkins Slough flows and salmonid survival

I cant find the Nobriga paper (NDOI) but will see if Jim Lecky has that. I thought Jim also did a longer write-up on the pros and cons with these studies, but I cant seem to locate that right now. I'll ask him for this.

Happy to set up a briefing on all of this if you think it would be helpful.

Ali

Alicia Forsythe | Environmental Planning and Permitting Manager | Sites Reservoir Project | 916.880.0676 | aforsythe@sitesproject.org | www.SitesProject.org

CONFIDENTIALITY NOTICE: This communication with its contents may contain confidential and/or legally privileged information. It is solely for the use of the intended recipient(s). Unauthorized interception, review, use or disclosure is prohibited and may violate applicable laws including the Electronic Communications Privacy Act. If you are not the intended recipient, please contact the sender and destroy all copies of the communication.

From: Jerry Brown <jbrown@sitesproject.org>
Sent: Tuesday, June 16, 2020 2:54 PM
To: Alicia Forsythe <aforsythe@sitesproject.org>
Subject: Re: Range of Alternatives for Sites Reservoir RDEIR/RDEIS

Can you provide me with a copy of the technical paper Doug is referring to when he says “scientifically sound” operational criteria? I assume there must be some in depth studies that we need to be aware of.

From: "Obegi, Doug" <dobegi@nrdc.org>
Date: Tuesday, June 16, 2020 at 1:08 PM
To: Alicia Forsythe <aforsythe@sitesproject.org>
Cc: Jerry Brown <jbrown@sitesproject.org>
Subject: RE: Range of Alternatives for Sites Reservoir RDEIR/RDEIS

Thanks Ali.

I suspect the project is going to have some serious challenges, if scientifically sound operational criteria make the project infeasible from the proponents’ perspective.

From: Alicia Forsythe <aforsythe@sitesproject.org>
Sent: Tuesday, June 16, 2020 11:30 AM
To: Obegi, Doug <dobegi@nrdc.org>
Cc: Jerry Brown <jbrown@sitesproject.org>
Subject: RE: Range of Alternatives for Sites Reservoir RDEIR/RDEIS

Doug – The initial alternatives in the June packet are very preliminary. We’re really just beginning the development of alternatives but want to make sure we update the Board on some of our initial thoughts and ideas. We expect to come back to the Board in September with a more complete project description, including possible changes to what we are proposing this week. The door isn’t even close to being shut and we have a ways to go.

We will have Jacobs conduct an analysis of at least one set of operational criteria that are similar to (or the same as) what you have proposed. We will work with you, TBI, and others to confirm these criteria before we model them. This analysis will be in the Revised Draft EIR/EIS. However, based on analyses we completed last summer / fall, we expect these criteria to result in a project that’s not affordable and provides very little water to accomplish the project objectives. Thus, we don’t anticipate that this will result in an alternative that we would carry forward for detailed analysis in the Revised EIR as we don’t anticipate it to result in a feasible project.

We have yet to “finalize” operational criteria for the project and continue to work on these and refinements to the model. So we may have more than one operational criteria, but we haven’t yet made it far enough along to determine that. We will also complete the analysis described above early in the process – once we get the model refinements completed – so if my assumption is wrong here, we will have time to include it as a full alternative in the document.

The door isn't closed to adding in an alternative with different operational criteria – and we will complete the analysis you've requested. From the work we did last summer / fall, we just expect that the operational criteria proposed by NRDC won't result in a feasible project.

Ali

Alicia Forsythe | Environmental Planning and Permitting Manager | Sites Reservoir Project | 916.880.0676 | aforsythe@sitesproject.org | www.SitesProject.org

CONFIDENTIALITY NOTICE: This communication with its contents may contain confidential and/or legally privileged information. It is solely for the use of the intended recipient(s). Unauthorized interception, review, use or disclosure is prohibited and may violate applicable laws including the Electronic Communications Privacy Act. If you are not the intended recipient, please contact the sender and destroy all copies of the communication.

From: Obegi, Doug <dobegi@nrdc.org>
Sent: Monday, June 15, 2020 2:23 PM
To: Alicia Forsythe <aforsythe@sitesproject.org>; Jerry Brown <jbrown@sitesproject.org>
Subject: Range of Alternatives for Sites Reservoir RDEIR/RDEIS

Hi Jerry and Ali,

I hope you're both doing ok these days. I wanted to check in briefly because I was reviewing the meeting material for the upcoming Reservoir Committee meeting, and the attachments seem to suggest that the revised/recirculated draft EIR/EIS would only consider one operational criteria for the action alternatives in the document. Are y'all seriously planning to only review one operational criteria in the revised EIR/EIS?

https://3hm5en24txyp2e4cxyxaklbs-wpengine.netdna-ssl.com/wp-content/uploads/2019/11/03-03-Proposed-Objectives-and-Alternatives-for-the-Revised-EIR_EIS.pdf

That's certainly not the approach that I took away from our prior conversation, where we discussed how the revised recirculated DEIR/DEIS would consider a range of operational criteria that included at least one set of operational criteria that were more protective than what you proposed (and potentially similar to what we've proposed). It also seems to run afoul of CEQA's requirement to consider a reasonable range of alternatives.

Hopefully I'm misunderstanding the Board materials. In any event I would strongly urge you to ensure that the CEQA/NEPA documents analyze more than 1 operational scenario for the action alternatives that are considered, including an alternative that proposes operations that are significantly more protective than what you shared with me in our last conversation.

Thanks,
Doug

____

DOUG OBEGI
*Senior Attorney**
Water Program

NATURAL RESOURCES
DEFENSE COUNCIL

111 SUTTER ST., 21ST FLOOR
SAN FRANCISCO, CA 94104
T 415.875.6100
DOBEGI@NRDC.ORG
NRDC.ORG

Please save paper.
Think before printing

** Admitted to practice in California*

Memorandum

To:	Sites Project Authority
From:	Jim Lecky, Technical Director Marin Greenwood, Senior Technical Specialist Lenny Grimaldo, Senior Fisheries Biologist Rick Wilder, Senior Fisheries Biologist
Date:	November 3, 2017
Re:	**Supplemental Consideration of Flows for Anadromous Fish**

Background

The Sites Reservoir Project is a proposed off-stream water storage project north of the Sacramento-San Joaquin Delta (Delta). It is designed to increase water supply reliability and water system flexibility to address both water supply and ecosystem benefits. The project includes a new reservoir of either 1.2 million acre feet or 1.8 million acre feet of storage capacity that would be filled by pumping unappropriated water from two existing pumping plants (Tehama-Colusa Canal Authority Plant at Red Bluff and the Glenn-Colusa Irrigation District Plant at Hamilton City) and a new pumping plant at Delevan. This new off-stream storage reservoir would, among other things, increase water supply for agricultural and urban uses and enhance operational flexibility for environmental benefits. For example, the additional storage could be used to improve cold water pool management in upstream reservoirs (e.g., Shasta, Oroville, Folsom) to maintain suitable temperatures for spawning and rearing salmon; to supplement flows in flood bypasses to enhance rearing habitat for juvenile salmon or increase food production for Delta fish; to improve water quality; and to improve wildlife refuge water supply.

The Sites Project Authority and the U.S. Bureau of Reclamation (Reclamation) released the *Draft Environmental Impact Report/Environmental Impact Statement and Draft Feasibility report for Sites Reservoir Project, Sites, California* (DEIR/S) in August 2017 (Sites Reservoir Authority and U.S. Bureau of Reclamation 2017). While that document presents a thorough review of the effects of the project, concern has been expressed by California Department of Fish and Wildlife (CDFW) that recent literature regarding the relationship between river flow and emigrating juvenile salmon survival is not adequately addressed in the document. The purpose of this memorandum is to address that issue in the context of existing flow standards and potential needs for additional measures. In this memorandum we review the following topics:

- Existing flow standards and bypass criteria.
- Recent scientific information regarding the relationship between flow and survival of juvenile Chinook salmon emigrating from the Sacramento River.
- Potential effects of the flow depletions by the Sites Reservoir Project on emigrating juvenile Chinook salmon.
- Measures to minimize adverse effects on emigrating Chinook salmon.

Recent scientific publications (e.g., Iglesias et al. 2017, del Rosario et al. 2013, Michel et al. 2013) have explored movement and survival rates for juvenile salmonids during emigration in the Sacramento River. This new science is beginning to define the value of flows in the Sacramento River for juvenile salmon emigration, particularly in late fall and winter months, when unappropriated flows may be available in the Sacramento River for diversion.

Existing Flow Standards and Proposed Bypass Criteria

Existing flow standards in the Sacramento River were developed against a backdrop of spring and summer reservoir releases and diversions for agricultural and municipal uses. The standards protect fall-run and late fall–run Chinook salmon spawning locations and rearing habitat above Red Bluff Diversion Dam, ensuring flow over redds and functional operation of fish screens. Existing flow standards generally do not address the effect of depletions in flows in the mainstem Sacramento River on anadromous fish.

Flow Standards

Water Right Order 90-5 (WR 90-5) was adopted by the California State Water Resources Control Board in 1990 as a mechanism to enforce the water quality criteria contained in the Water Quality Control Plan for the upper Sacramento River. Among other standards, WR 90-5 requires Reclamation to meet a daily average water temperature of 56°F in the Sacramento River at Red Bluff Diversion Dam during periods when higher temperatures would be detrimental to the fishery or at an upstream location when conditions beyond Reclamation's control preclude achieving 56°F at Red Bluff Diversion Dam. WR 90-5 also establishes a flow standard of 3,200 cubic feet per second (cfs) at Red Bluff Diversion Dam from September through February and ramping rates to prevent dewatering of redds and stranding of juvenile salmon when reservoir operations require flows to be reduced from a higher flow to a lower flow. The timing of this standard addresses protection of spawning areas for fall-run and late fall–run Chinook salmon redds and a portion of spring-run Chinook salmon redds (based on the spawning and rearing seasons described in Vogel and Marine [1991]). The winter-run spawning season (mid-April to mid-August) is not addressed by this standard, but flows at that time are usually elevated by reservoir releases for contract deliveries,[1] as well as the requirement to maintain suitable temperatures between May and October for winter-run, spring-run, steelhead, and green sturgeon.[2]

---

[1] U.S. Geological Survey river gage data, USGS 11270500 Sacramento River at Keswick CA

[2] As required by Action 1.2.4 from the NMFS (2009) State Water Project/Central Valley Project Biological Opinion

Diversion Criteria

Diversions at the Hamilton City intake for Glenn Colusa Irrigation District (GCID) currently require a minimum bypass flow of 4,000 cfs in the Sacramento River downstream of the intake to meet state and federal velocity criteria at the fish screen. The proposed operating criteria for filling Sites Reservoir would only allow diversions at Red Bluff Pumping Plant and GCID intake such that the 4,000-cfs downstream flow standard would be achieved. This requirement derives from a design flow condition of the project in which a river flow of 7,000 cfs upstream of the oxbow on which the pumping plant is located would be needed to ensure sweeping velocity and screen approach velocity compliant with state and federal standards at the maximum pumping rate of 3,000 cfs (Glenn Colusa Irrigation District 1997, Vogel 2008).

Diversions for filling Sites Reservoir would only be allowed when the Wilkins Slough flow criterion of 5,000 cfs is met. The Wilkins Slough flow criterion derives from the original Central Valley Project authorization, which incorporated by reference a 1934 report from the U.S. Army Corps of Engineers (Corps) that established navigation improvements between Sacramento and Chico Landing[3] (Northern California Water Agency 2014). Historically, a minimum flow of 5,000 cfs was required to support commercial boat traffic; however, the Corps has not dredged this reach to maintain channel depth since 1972. Nevertheless, the standard remains established in law and Reclamation continues to manage Sacramento River flows to this Wilkins Slough navigation requirement in all but the most critical water supply conditions. The flow requirement is now used to support long-time water diversions that have intake pumps set just below the 5,000-cfs water level. Diverters are able to operate for extended periods at flows as low as 4,000 cfs and for short periods at 3,500 cfs (National Marine Fisheries Service 2009). In addition, the fish screens at RD 108 were designed to this standard and this flow standard ensures functioning of the fish screens in compliance with state and federal criteria for approach and sweeping velocity.

Operating Criteria

Proposed operating criteria for filling Sites Reservoir would allow diversions resulting in minimum Sacramento River flows of 15,000 cfs at Freeport in January, 13,000 cfs in December and February through June, and 11,000 cfs in all other months. These flow thresholds are proposed to protect and maintain existing downstream water uses and water quality in the Delta (Sites Project Authority and U.S. Bureau of Reclamation 2017). In common with the standards previously noted, these proposed criteria do not explicitly address the effect of flow depletions on anadromous fish.

Diversions to Sites Reservoir would be restricted to protect fish migration during naturally occurring, storm-induced, pulse flows in the Sacramento River. Pulse flows would be protected because recent studies have documented major pulses of fish movement in association with naturally occurring pulse flows (del Rosario et al. 2013). The proposed pulse protection period would extend from October through May to address outmigration of juvenile winter-, spring-, fall- and late fall–run Chinook salmon as well as steelhead. Pulse flows during this period would provide flow continuity between the upper and lower Sacramento River to support fish migration. The details of this proposal are not yet fully defined but will likely be adaptively managed based on real-

---

[3] 74 Congressional Record 5344 Statement of Congressman Frank Buck

time monitoring of flows and fish movements (Sites Project Authority and U.S. Bureau of Reclamation 2017).

CDFW has incorporated bypass flow and pulse flow protection measures in the incidental take permit[4] it recently issued under the California Endangered Species Act for the Construction and Operation of Dual Conveyance Facilities of the State Water Project in the north Delta (California WaterFix). In addition to ensuring proper function of the fish screens installed at the proposed north Delta diversions, the permit includes a bypass flow requirement to support salmonid and pelagic fish movements past the diversions to regions of suitable habitat, reduce losses to predation downstream of the diversions, and maintain or improve rearing habitat conditions in the north Delta. To ensure these objectives are met, the permit restricts diversions at certain times of the year that bracket the main juvenile salmon migration periods. The following restrictions are specified:

- Minimum flow of 7,000 cfs below the north Delta diversion from October 1 through November 30.
- Pulse protection and post-pulse operating criteria from December 1 through June 30.
- Pulse protection for winter-run and spring-run Chinook salmon from October 1 through June 30.
- Real-time monitoring of juvenile fish movement to trigger restrictions on diversions.
- Post-pulse bypass flow operations at levels to be determined through initial operating studies evaluating the level of protection provided at various levels of diversion.

The Sites Reservoir Project would be operated such that its diversions allow compliance with CDFW's California WaterFix incidental take permit restrictions.

Recent Literature on Flow and Juvenile Salmon Survival in the Sacramento River

Much of the effort to investigate juvenile salmon survival in Sacramento River has focused on migration through the Delta (Cavallo et al. 2015, Holbrook et al. 2009, Perry et al. 2010, Baker and Morhardt 2001, Brandes and McLain 2001), while information on smolt outmigration survival in the river upstream of the Delta is lacking (Michel et al. 2015). More recently, investigators have been looking at juvenile fish migration patterns and survival rates in the migration from the spawning and rearing grounds in the upper Sacramento River through the Delta (Iglesias et al. 2017, Michel et al. 2015, del Rosario 2013, Michel et al. 2013).

Del Rosario et al. 2013

This study examined patterns of juvenile migration into and through the Delta in terms of geographic distribution, timing, numbers, and residence time. It analyzed the role of flow, turbidity, temperature, and adult escapement on the downstream movement (migration) of winter-run-sized Chinook salmon. A significant relationship was found between winter-run Chinook salmon passing Knights Landing (river kilometer [rkm] 144 or 51 rkm upstream of the Delta) and high flows (equal

---

[4] Incidental Take Permit No. 2081-2016-055-03

to or greater than 400 cubic meters per second [$m^3s^{-1]}$ or 14,126 cfs) at Wilkins Slough associated with the onset of winter storms. Although peak migrations varied between October and April, the first 5% of the annual catch usually arrived within a day of the pulse flow and the median (50%) catch occurred several days to a week later in 7 of the 9 years studied, demonstrating that winter-run Chinook salmon tend to migrate *en masse* following the first large storm event. This flow threshold, in response to the first large rain event of the season, was correlated with the timing of migration, regardless of when during the season the first large rain event occurred.

This study analyzed other variables but found no significant relationships between total seasonal catch of winter-run at Knights Landing (number of fish/day/season) and mean flow during the emigration season ($p = 0.93$), mean turbidity ($p = 0.40$), mean water temperature ($p = 0.27$), and adult escapement ($p = 0.31$). Although flow increase was found to be a consistent precursor to the onset of migration, the authors cautioned that several factors change simultaneously with flow, including turbidity, velocity, olfactory cues, and food supply. The specific cues responsible for downstream movement of winter-run remain unclear.

Michel et al. 2013

This study investigated migration rates of juvenile late fall–run Chinook salmon from 2007 through 2009 using acoustically tagged yearlings from Coleman National Fish Hatchery. It estimated smolt outmigration rates, investigated reach-specific movements, and tested the influence of environmental factors on outmigration success. While reported migration rates through the entire system were similar to rates published for yearling Chinook salmon smolt emigrations in other West Coast rivers (14.3 kilometers [km]$\cdot$day^{-1} (± 1.3 S.E.) to 23.5 km day^{-1} (± 3.6 S.E.)), differences were found in reach-specific movement rates. The authors modeled the potential influence of multiple environmental variables, chosen *a priori*, based on salmon migration literature and data availability for the watershed. Variables included water temperature (°C), river flow ($m^3 \cdot s^{-1}$), water turbidity (nephelometric turbidity units [ntu]), channel water velocity (meters per second [$m \cdot s^{-1}$]), a ratio of river surface width (meters) to maximum river depth (meters) (WDR), and a ratio of daily river flow to mean river flow over the migration season of the year in question (FMFR). The study also found that WDR provided the strongest, albeit negative, contribution to migration rates (i.e., the wider and shallower the river, the slower the migration rate). The next best supported smolt travel time model was the river flow model, with a positive relationship between flow rate and movement rate. Turbidity and FMFR also correlated with smolt movement rates. The temperature model was the only environmental model that was not found to be better supported than the null model, likely because smolts were released all at once, during two releases each season, and therefore experienced a narrow range of temperatures. Also, Shasta Dam releases tend to moderate temperatures in the upper reaches of the river.

One interesting postulation of this study is that the influence of flow on movement of smolts may be temporal rather than spatial. This was the motivation for creating the model including FMFR as a linear predictor. This relationship was found to be positive, thus supporting the hypothesis and the observed increased watershed-wide smolt movements during particularly strong storm events. The authors concluded that the relationship between flow and movement rate may be strong above a certain flow threshold and a more complex model should be explored to capture the occurrence of those flow levels. This is consistent with migration events reported in del Rosario et al. (2013) for winter-run Chinook salmon.

Michel et al. 2015

This study investigated environmental factors affecting outmigration survival of acoustically tagged hatchery-origin late fall–run Chinook salmon in the Sacramento River in wet and dry years from 2007 through 2011 (expanding on the analysis by Michel et al. 2013 by including 2 more years of data). Overall survival of late fall-run Chinook salmon through the entire migration corridor (rkm 518–2) per year ranged from 2.8% to 15.7%, with the highest flow and survival occurring in 2011 and much lower flow and survival from 2007 to 2010. Survival rates on a reach-by-reach basis were quite variable (Figure 1). During the first 4 years of the study, the upper river reaches (reaches 1 to 8; rkm 518 to 325) had some of the lowest survival per 10 kilometers, and the lower reaches of the river (reaches 9 through 12; rkm 325 to 169) had the highest. The Delta (reach 13) was comparable to the upper river, and the San Francisco and Suisun Bays (reaches 14 to 17; rkm 169–2) had the lowest survival rates. High flows during 2011 resulted in poor detection probabilities at most receiver locations, which precluded estimating reach-specific survival rates for that year. However, the receivers at the downstream end of the major divisions could be used. The authors reported higher survival rates in the river above Knights Landing in 2011 compared to the four previous years, which were all drier than the wet 2011 (water year type for 2007 and 2009 was dry, 2008 was critically dry, and 2010 was below normal) . The authors also reported generally comparable survival rates among all 5 years in the Delta and bays.

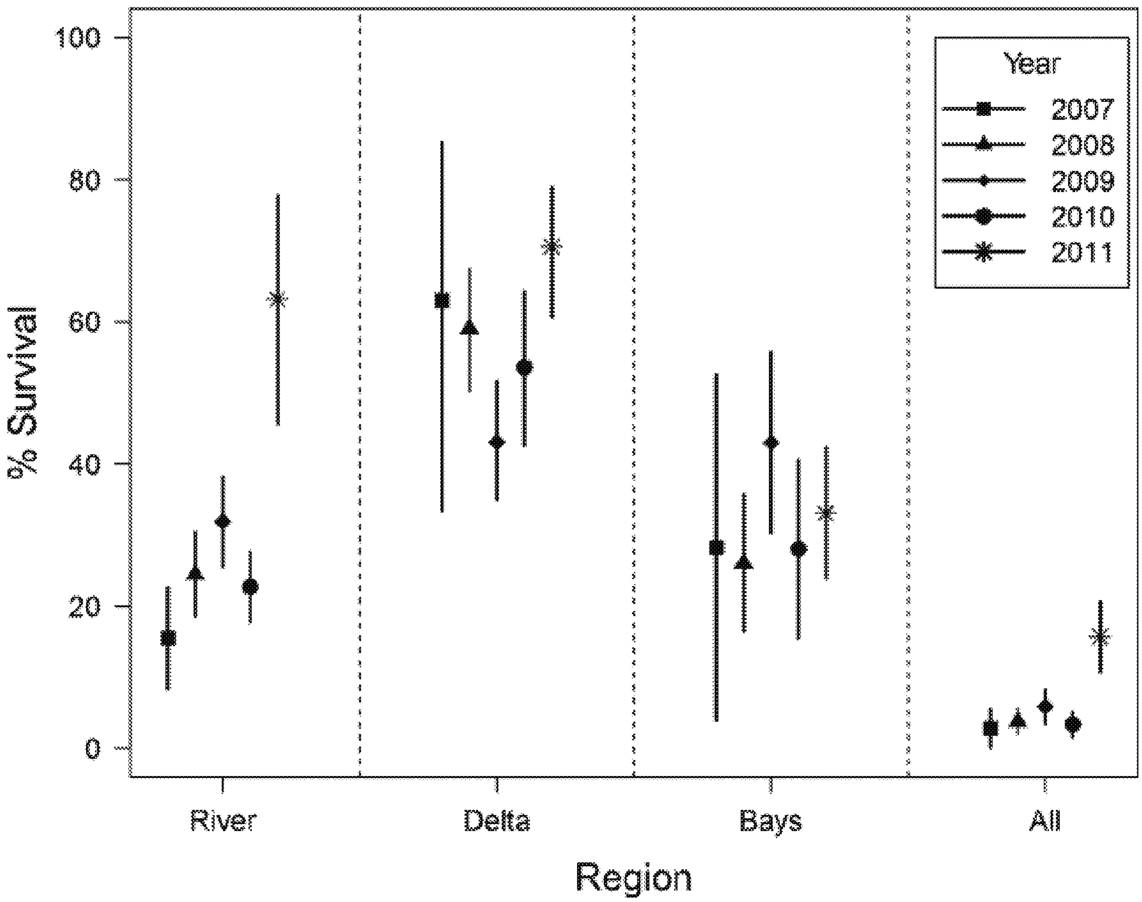


Fig. 1. Percent survival of tagged juvenile late fall-run Chinook Salmon per major region for all 5 study years. Regions include river, delta, bays, and the percent survival for the entire watershed (All). Error bars represent 95% confidence intervals. Source: Michel et al. (2015).

Notch 2017

In this thesis, the author studied out-migration survival of wild Chinook salmon smolts for Mill Creek through the Sacramento River using acoustically tagged, naturally produced smolts longer than 80 millimeters. Similar to Michel et al. (2013), survival rates were determined based on sequential detections of fish as they moved downstream. Notch found the lowest survival rates were in Mill Creek, followed by increased survival in the first upper Sacramento River reach, and then variable but declining survival rates in downstream reaches of the Sacramento River. He attributed the low survival rate in Mill Creek to slower movement rates and longer residence times in Mill Creek compared to Sacramento River (8 to 14 kilometers per day in Mill Creek compared to 40 to 80 kilometers per day in the Sacramento River). Notch used a similar modeling approach to Michel et al. (2015) to investigate relationships between survival and biotic or abiotic factors. He found flow at release in Mill Creek in addition to tagged fish size and year best explained the variation in survival at both the reach-specific and regional scale. The second-best supported model for both analyses included flow and temperature in Mill Creek in addition to tagged fish length and release year. Similar to Michel et al. (2015) and Iglesias et al. (2017, described in the following section), flow-survival curves developed by Notch (2017) were based on 3 dry years (2014 through 2016) and a wetter year (2013). The wetter year has a mean April through June flow corresponding to the 15 to 50% exceedance level based on the Sites FEIR/S CalSim modeling (Sites Project Authority and U.S. Bureau of Reclamation 2017) for flow below the Delevan diversion. The flow-survival curves thus have relatively broad confidence intervals at the higher flows as a result of relatively few observations (Figure 2).

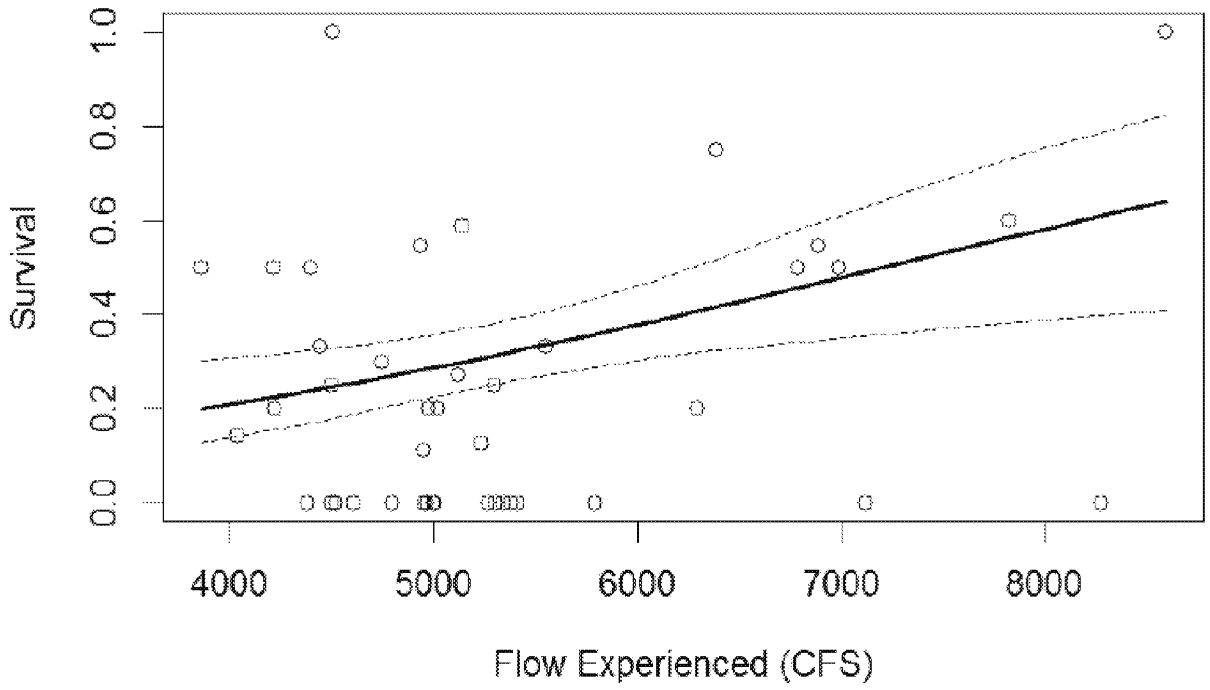


Figure 2. Cumulative wild Mill and Deer Creek Juvenile spring-run Chinook salmon survival predicted through the Upper Sacramento River during 2013-2016 as a function of flow at Butte City bridge (rkm 344), including upper and lower 95% confidence intervals (dashed lines). Dots represent the cumulative survival rates for groups of fish through the upper Sacramento River at the specific flow values. Source: Notch (2017)

Iglesias et al. 2017

This study re-evaluated the acoustically tagged, hatchery-origin late fall–run Chinook salmon 2007 to 2011 data from Michel et al. (2015) and found that flow was the strongest environmental correlate with survival, and had a positive relationship (Figure 3). As previously discussed in the summary of the Michel et al. (2015) study, 2007 to 2011 comprised four relatively low-flow years (2007 to 2010) and one very high flow year (2011). Using the number of acoustic-tagged fish detected by day during each year of these studies (Michel pers. comm.), we illustrated relative difference in flows between years by weighting the mean daily flow at three CDEC stations (Butte City, Ord Ferry, and Colusa) in each year of the study by the number of fish detected on each day. This showed that the mean flow in 2011 (approximately 18,200 cfs) was considerably greater than in the other years (2007: approximately 7,400 cfs; 2008: approximately 8,000 cfs; 2009:

approximately 5,000 cfs; 2010: approximately 6,200 cfs). This suggests that the flow-survival relationship shown in Figure 3 is driven by the difference between a single very high flow value and four low flow values, with little information on intermediate flows (between approximately 8,000 and 18,200 cfs).

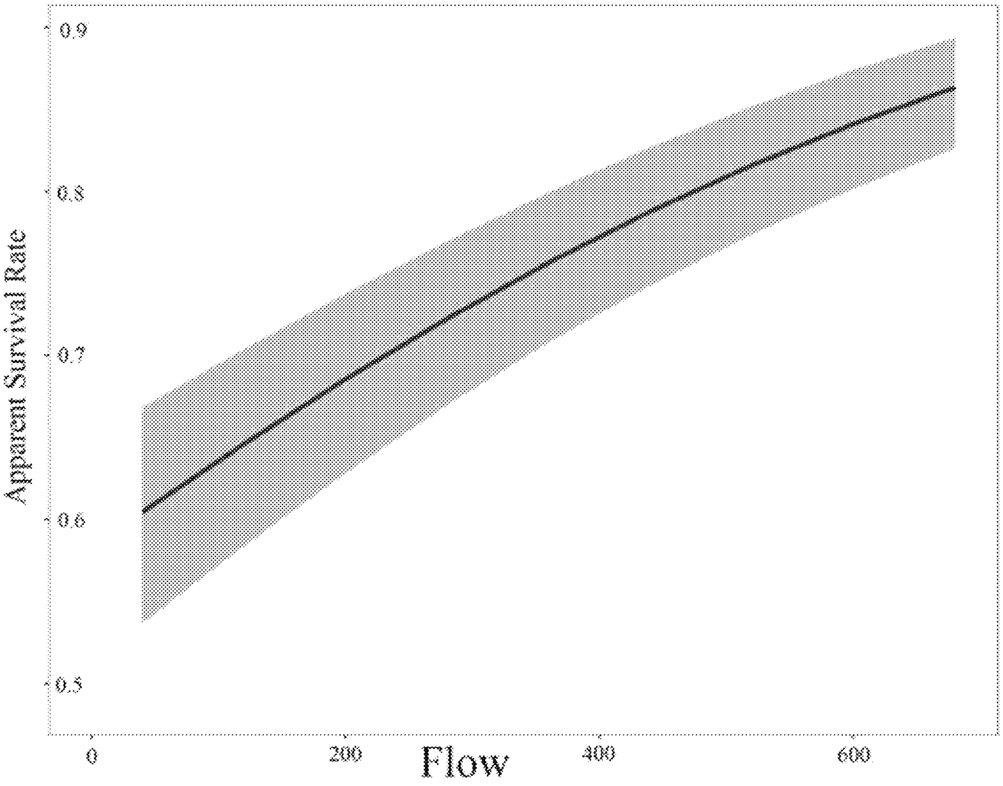


Figure 3. Simulated survival as a function of flow (cubic meters per second) in the Sacramento River. As flow increases, apparent survival increases. Dark line indicates survival estimate, and grey area represents 95% confidence intervals (from figure 5 in Iglesias et al. 2017)

Examining release-specific survival results for four releases in 2008 and 2009 also leads to concern about the generality of flow-survival relationships. Fish detection-weighted mean flows in December 2007 (approximately 6,700 cfs) were considerably less than those in January 2008 (approximately 9,600 cfs), yet survival from the upper Sacramento River to the lower river and Delta was not significantly different between the releases (Figure 4a). In contrast, flows in December 2008 (approximately 5,200 cfs) were quite similar to flows in January 2009 (approximately 4,900 cfs), yet survival in December was significantly greater (Figure 4b).

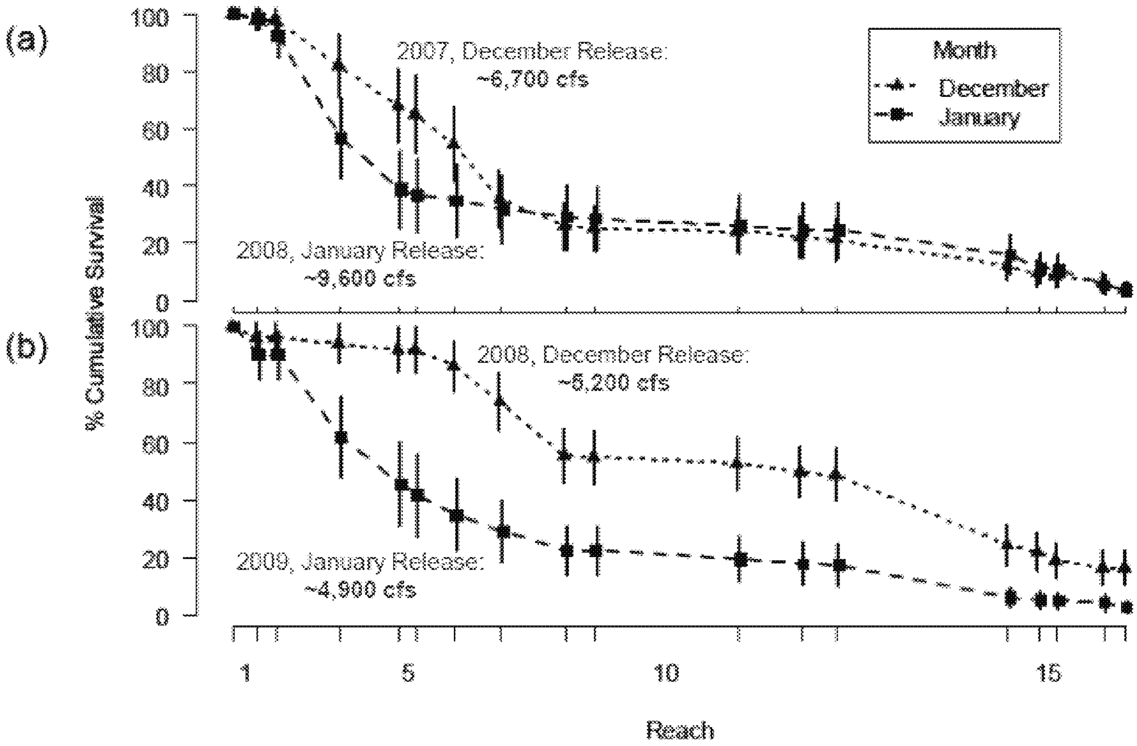


Figure 4. Cumulative survival of outmigrating acoustic tagged, hatchery-origin late fall–run Chinook salmon smolts by month of release in (a) December 2007 and January 2008, (b) December 2008 and January 2009. Reach 1 represents the upper-most reach, and reach 17 represents the lowest reach, in the San Francisco Bay Estuary. Error bars represent 95% confidence intervals. Adapted from Figure 5 of Michel 2010.

Also, the temporal and spatial variability in the distribution of low-survival reaches in the upper and middle reaches of the Sacramento River suggest there are likely to be a number of factors (perhaps habitat-related) that interact with flow to produce reach-specific survival rates (Figure 5).

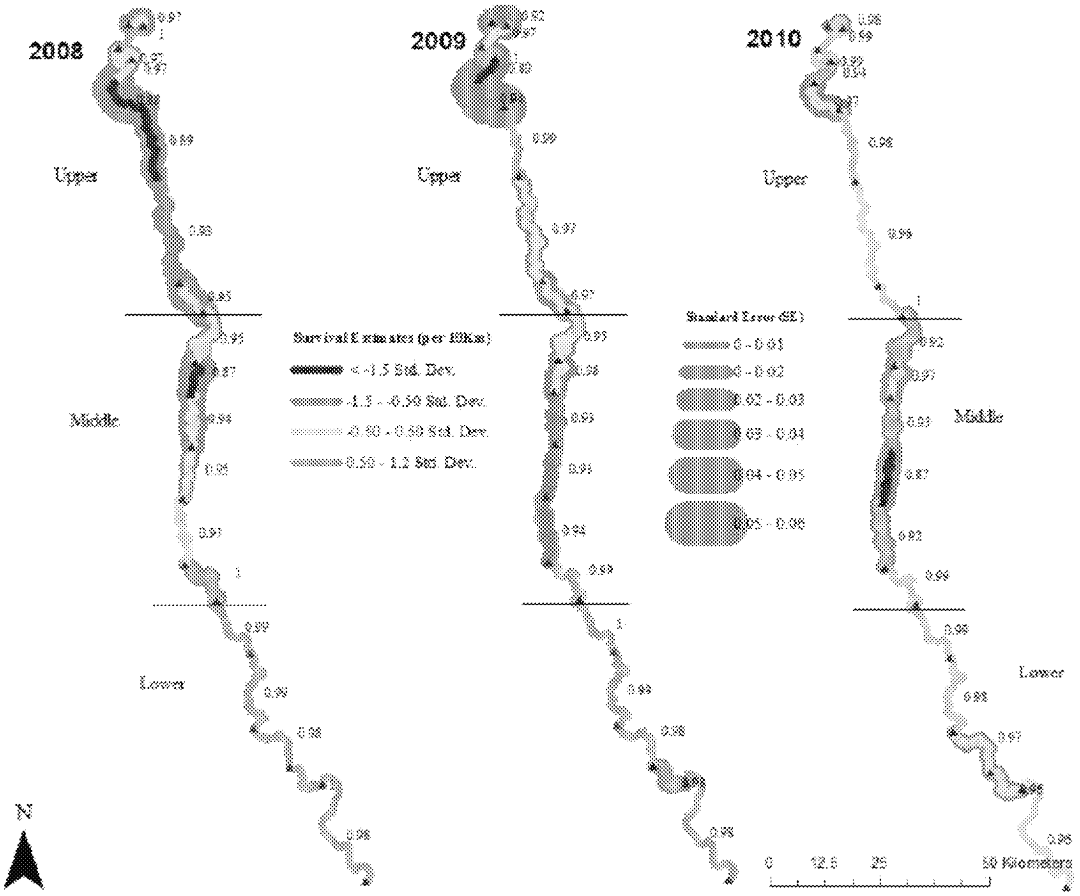


Figure 5. Reach-specific survival estimates (per 10 kilometers) for each study years colored to represent per reach survival risk. Standard error is represented as the grey buffer surrounding each reach. The values adjacent to each reach represent the survival estimate for a given reach (per 10 kilometers) from our full survival model. Note that the spatial distribution of mortality zones (those areas with lower estimated survival compared to mean survival for that year) varied between reaches and years, with mortality zones occurring in the upper and middle reaches of the river. In 2010, the reach with the greatest amount of mortality (near Butte) was greater than 2 standard deviations from the mean survival of that year. Reproduced from figure 4 in Iglesias et al. 2017.

National Marine Fisheries Service Winter-Run Chinook Salmon Life Cycle Model

The National Marine Fisheries Service (NMFS) Winter-Run Chinook Salmon Life Cycle Model (WRLCM) includes a flow-survival relationship for winter-run Chinook salmon smolts migrating downstream from rearing in the upper and lower mainstem Sacramento River to the Delta (Hendrix et al. 2017). The relationship is based on mean flow at Bend Bridge, is applied on a monthly basis, and is derived from statistical fitting of indices of abundance rather than specific survival studies such as that of Iglesias et al. (2017). In comparison to the relationship found by Iglesias et al. (2017), the WRLCM flow-survival relationship is steeper, so that survival changes at a greater rate with changing river flow (Figure 6).

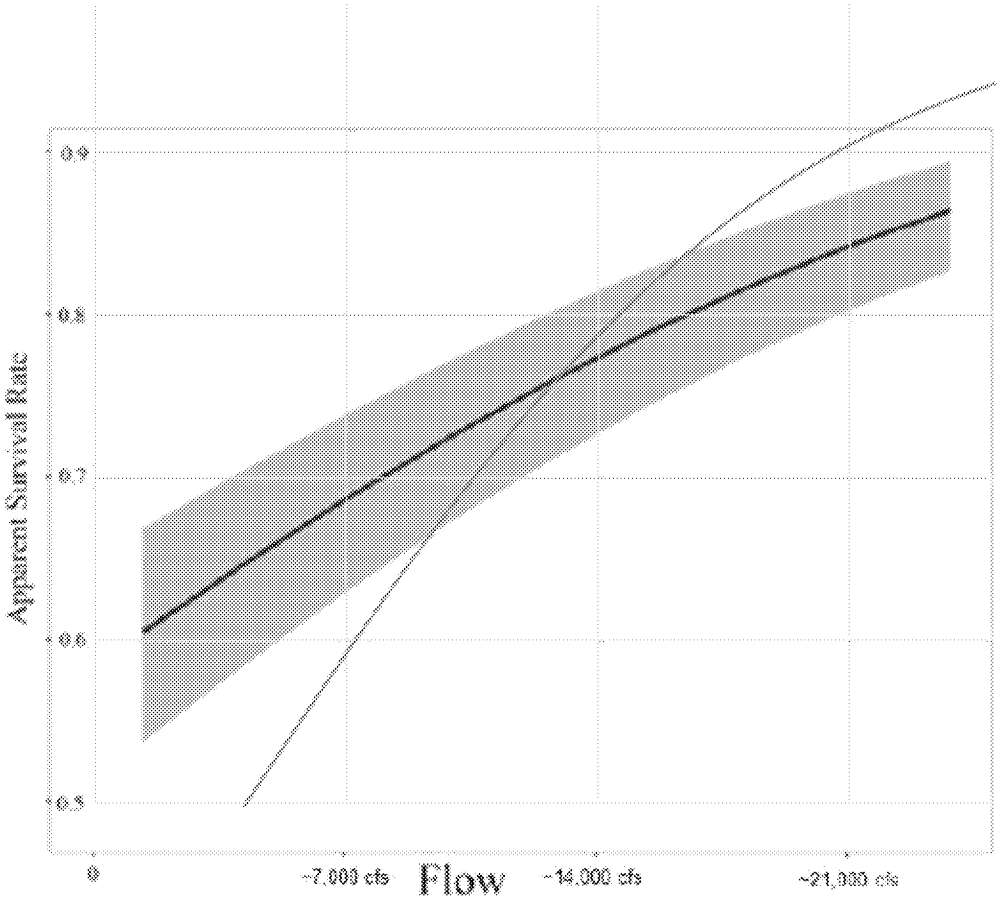


Figure 6. Comparison of the NMFS Winter-Run Chinook Salmon Life Cycle Model flow survival relationship (blue line) to the Iglesias et al. (2017) flow-survival relationship. Figure adapted from Iglesias et al. 2017.

Relevance to Sites Reservoir Project

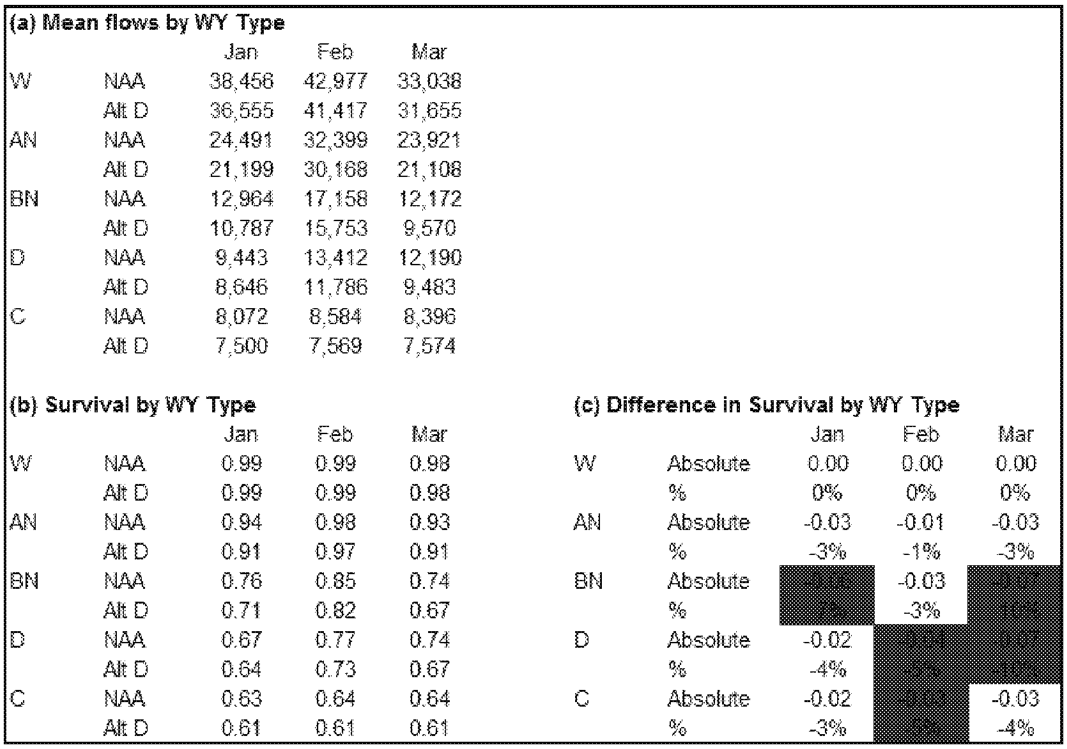
The flow-survival relationships developed by Iglesias et al. (2017) and included in the WRLCM (Hendrix et al. 2017) suggest that greater Sacramento River flow results in greater survival of juvenile Chinook salmon. This finding is relevant to the Sites Reservoir Project, which at times would change river flow because of diversions or releases. In the case of the WRLCM, nearly all smolt migration from the river to the Delta occurs in January (approximately 27%), February (approximately 37%), or March (approximately 35%). In these months, the Sites Reservoir Project would likely be diverting water, resulting in less flow in the Sacramento River than would occur under the no action alternative. Application of the WRLCM flow-survival relationship to the mean monthly river flows below Delevan suggests that there would be the potential for reduced survival of winter-run Chinook salmon, with the relative difference being 5% or greater in drier years (Table 1).

Because the WRLCM operates on a monthly time step, it is challenging for the model to capture the real-time management effects of restricting diversions (pulse protection) during increasing flow periods when fish are expected to migrate downstream. The Sites DEIR/S (Sites Project Authority and U.S. Bureau of Reclamation 2017) includes, for analytical purposes, pulse flow protections to restrict diversions (see DEIR/S Section 5.9.1 for discussion) once per month. Diversions to Sites Reservoir would not be allowed when the 3-day running-average flow below Bend Bridge exceeds 15,000 cfs and the storm event lasts at least 7 days. The pulse is considered terminated under any of the following conditions:

- The 3-day running average discharge flow remains greater than 15,000 cfs for 7 days after initiation.
- The 3-day running average discharge flow drops below 15,000 cfs before reaching the 7-day duration.
- The 3-day running average discharge flow exceeds 25,000 cfs before reaching the 7-day duration (25,000 cfs is an upper flow threshold wherein additional flow does not appreciably increase survival, as borne out by the flow-survival curves shown in Figure 6).

Incorporation of these rules—or other rules that aim to account for pulsed movements of fish—into the WRLCM or other tools may require weighting of flow by the percentage of the population assumed to be migrating on a daily basis, as informed by patterns observed from monitoring data, such as Knights Landing rotary screw traps (del Rosario et al. 2013, Roberts et al. 2013, Acierto et al. 2014). Thus, for example, from 1997 to 2011, an average of 40% (from less than 5% to approximately 60%) of the annual juvenile winter-run Chinook salmon population migrated downstream within 7 days of Sacramento River flow near Wilkins Slough exceeding 14,000 cfs for the first time (Roberts et al. 2013: Appendix A).

Table 1. Application of the NMFS Winter-Run Chinook Salmon Life Cycle Model flow-survival relationship to mean Sacramento river flows below the Delevan Intake: (a) mean flows by water year-type from CalSim modeling for the Sites Reservoir Project (Alternative D) and the No Action Alternative (Source: Sites Draft EIR/S (Sites Project Authority, U.S. Bureau of Reclamation. 2017), Appendix 6B), (b) survival by water-year type (c) difference in survival between Sites Reservoir Project and No Action Alternative. Note: The WRLCM applies the flow-survival relationship at Bend Bridge, but this location is upstream of the proposed Sites diversions, so was applied here below the lowermost diversion (Delevan) to be conservative. Red highlights indicate differences of 5% or greater.



(a) Mean flows by WY Type

		Jan	Feb	Mar
W	NAA	38,456	42,977	33,038
	Alt D	36,555	41,417	31,655
AN	NAA	24,491	32,399	23,921
	Alt D	21,199	30,168	21,108
BN	NAA	12,964	17,158	12,172
	Alt D	10,787	15,753	9,570
D	NAA	9,443	13,412	12,190
	Alt D	8,646	11,786	9,483
C	NAA	8,072	8,584	8,396
	Alt D	7,500	7,569	7,574

(b) Survival by WY Type

		Jan	Feb	Mar
W	NAA	0.99	0.99	0.98
	Alt D	0.99	0.99	0.98
AN	NAA	0.94	0.98	0.93
	Alt D	0.91	0.97	0.91
BN	NAA	0.76	0.85	0.74
	Alt D	0.71	0.82	0.67
D	NAA	0.67	0.77	0.74
	Alt D	0.64	0.73	0.67
C	NAA	0.63	0.64	0.64
	Alt D	0.61	0.61	0.61

(c) Difference in Survival by WY Type

		Jan	Feb	Mar
W	Absolute	0.00	0.00	0.00
	%	0%	0%	0%
AN	Absolute	-0.03	-0.01	-0.03
	%	-3%	-1%	-3%
BN	Absolute	-0.05	-0.03	-0.07
	%	-7%	-3%	-10%
D	Absolute	-0.02	-0.04	-0.07
	%	-4%	-5%	-10%
C	Absolute	-0.02	-0.03	-0.03
	%	-3%	-5%	-4%

As an example of the potential importance of daily weighting of fish migration patterns in association with pulse protection operations, the NMFS WRLCM flow-survival function used to create the values in Table 1 was applied to daily flows for December 2002 from the Sites DEIR/S model USRDOM (Sites DEIR/S: Appendix 6C (Sites Project Authority and U.S. Bureau of Reclamation 2017). During most of this month, combined Sites Reservoir diversions under Alternative D[5], were modeled to be high (around 5,400 to 5,700 cfs), except for a 3-day pulse protection period with 200-cfs diversions from December 18 to 20 (Figure 7), which was triggered by the previously stated rules. Diversions under the No Action Alternative were minimal (around 100 to 240 cfs), with the result that early in the month (December 1 to 13), flows downstream of Delevan were around 7,000

---

[5] Alternative D, the proposed project, includes the 1.8-million-acre-foot Sites Reservoir with conveyance from the Sacramento River to the reservoir provided by the existing Tehama-Colusa and GCID Main Canals, and conveyance from the reservoir to the Sacramento River through the new Delevan pipeline (2,000-cfs diversion/1,500-cfs release)(Sites Project Authority and U.S. Bureau of Reclamation 2017).

to 10,000 cfs under the No Action Alternative, compared to 2,000 to 5,000 cfs under Alternative D. The percentage of the migrating juvenile winter-run Chinook salmon population for that year, as observed at Knights Landing (Roberts et al. 2013: Appendix A), was zero early in the month when river flow was relatively low, whereas there was a considerable increase in migration as river flow rapidly increased (Figure 7). Applying the WRLCM flow-survival function to each day's flow without considering the daily percentage of fish migrating gives estimated survival for December 2002 of 0.83 for the No Action Alternative and 0.73 for Alternative D, a relative difference of 11% less under Alternative D. In contrast, weighting the estimated daily survival by the percentage of fish migrating gives estimated survival for December 2002 of 0.98 for the No Action Alternative and 0.96 for Alternative D, a small relative difference of 2% less under Alternative D. In this example month, the pulse protection reduction in diversions is of relatively minor importance in reducing the survival difference between the No Action Alternative and Alternative D for the weighted mean calculation. More important is the relatively high diversion early in the month when river flow is low (7,000 to 10,000 cfs), which gives relatively large differences in daily survival based on the steep slope in the flow-survival relationship (Figure 6). Based on the rules for diversions, relatively high diversions are permissible at higher river flows (equal to or greater than 25,000 cfs), as is justified by the flow-survival curve leveling off at higher flows (Figure 6). Thus, although diversions recommence at high levels after the short, 3-day pulse protection period, the diversions occur during a relatively high-flow period at which they have little effect on survival based on the flow-survival curve.

Limitations of these studies for the purposes of regulating additional depletions from the river include the difficulty in generalizing results from a specific study to the diversity of juvenile life history patterns exhibited by Chinook salmon in the basin.

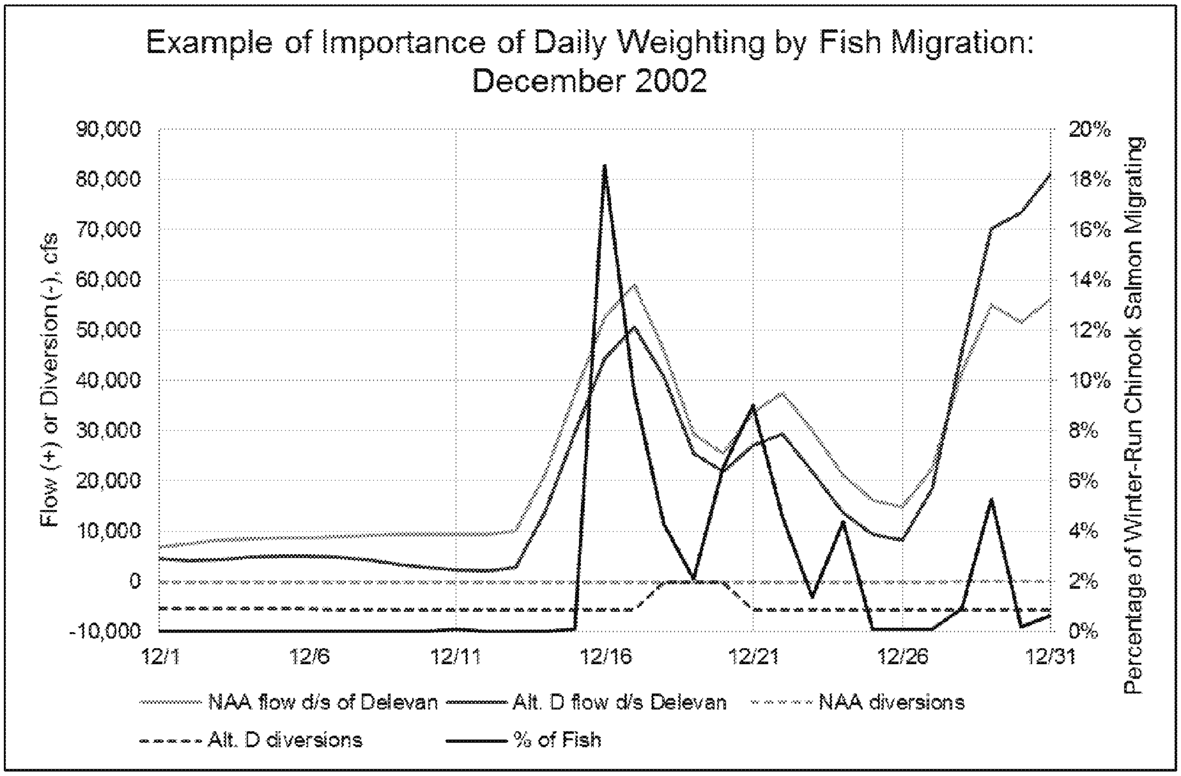


Figure 7. Example of importance of daily weighting by percentage of fish migrating: Sites Reservoir Project DEIR/S USRDOM-modeled river flow downstream of Delevan, diversions (Tehama Colusa Canal at Red Bluff + Glen Colusa Irrigation District at Hamilton City + Sites Reservoir Project at Delevan), and percentage of winter-run Chinook Salmon juveniles migrating (Knights Landing Rotary Screw Traps; Roberts et al. 2013), December 2002

Poytress et al. (2014) summarized juvenile anadromous fish production above Red Bluff Diversion Dam based on screw trap data collected at the dam. Table 2 summarizes the size and passage dates of each of the four runs of Chinook salmon that spawn above Red Bluff Diversion Dam. It demonstrates the considerable overlap in maturation and migration timing among the runs as well as movement patterns among the different stages of development.

Table 2. Size and date of juvenile Chinook Salmon passage at Red Bluff Diversion Dam

Red Bluff Diversion Dam Passage				
	Size		Date	
Run	Fry	Smolt/ Presmolt	Range	Peak
Fall	75.5%	24.5%	Jan - July	Jan - Mar
Late fall	24.9%	75.1%	April - Dec	April - Aug
Winter	77.9%	22.1%	Aug - Mar	Aug - mid Oct
Spring	58.6%	41.4%	Oct -May	Oct -Nov

Based on Poytress et al. 2014

Williams (2012) distinguishes six different life history patterns for juvenile Chinook in the Central Valley, ranked in terms of increasing amounts of time spent in fresh water and the habitats in which juveniles mainly rear (Figure 8).

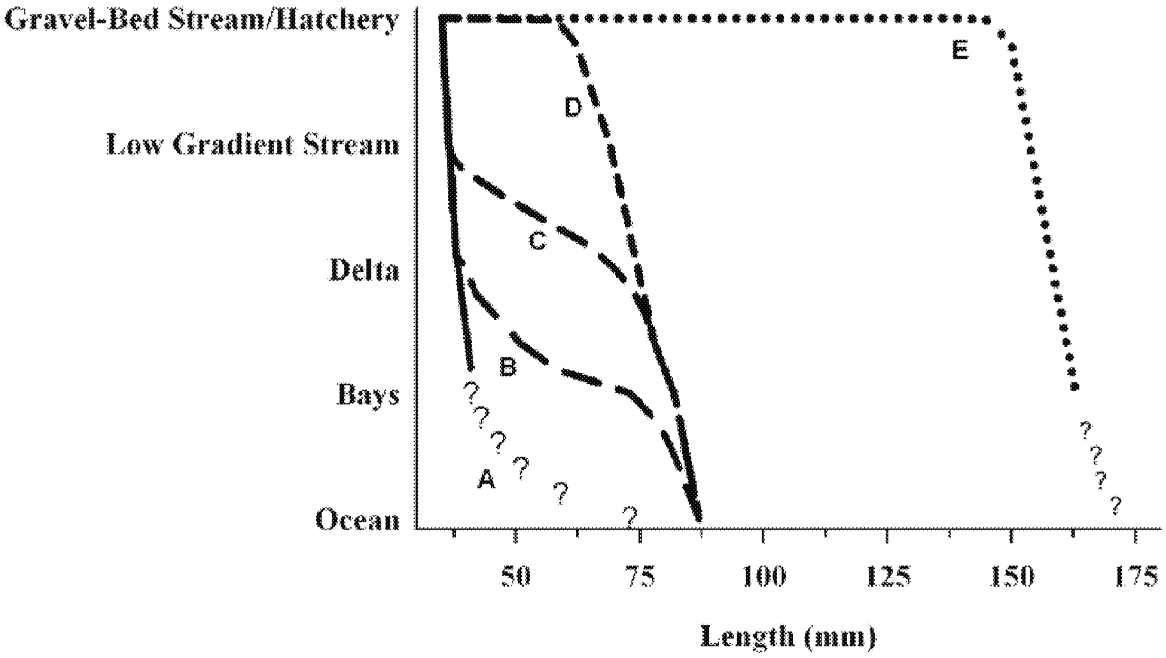


Figure 8. **Conceptual juvenile life-history space. Lines show representative trajectories of growth and migration for naturally produced juvenile Chinook. (A) Fry emerge at ~35 mm, and may migrate directly to the bays; what they do when they get there is poorly understood. (B) Many fish migrate directly to the Delta and rear there (long dashed line); if they survive, they migrate through the bays to the ocean. (C) Some fry migrate to the lower rivers and rear there before migrating through the Delta and bays (medium dashed line). (D) Other fry emerge and remain in the gravel-bed reaches of the stream until they migrate, generally in spring, as fingerlings (short dashed line), (E)[6] while others remain in the gravel-bed reaches through the summer and migrate as larger juveniles in the fall, winter, or spring. How long they remain in the bays is unknown. Except for fry, lengths are actually highly variable, so properly the figure should show broad smears rather than discrete lines. Reproduced from Figure 3 in Williams 2012.**

Given the information from recent investigations on the influence of flow on juvenile Chinook salmon emigrant survival and the diversity of life history patterns for juvenile Chinook salmon, it is evident that new diversions for the Sites Reservoir Project have the potential to affect both emigrating juvenile salmonids as well as rearing in the reach affected by the diversions. In the case of rearing, analyses in the DEIR/S (Sites Project Authority and U.S. Bureau of Reclamation 2017) based on tools such as SALMOD generally suggest limited potential for negative effect (and some potential for positive effect). This appears consistent with Vogel's (2011) view that that the mainstem Sacramento River is not flow-limited for fish rearing habitats and that existing flows in the mainstem Sacramento River at important times of the year may actually be too high to maximize the quantity and quality of rearing habitats for fry and juvenile life stages of salmonids. Although

---

[6] Williams (2012) divides the E strategy into a) a general description of fish that rear near the spawning grounds and migrate out as smolts in fall or winter and b) those that exhibit a "classical stream type" which hatch in the spring, remain in the gravel-bed reaches of the stream through the winter, and migrate the following spring as smolts.

proposed pulse flow protections would be expected to safeguard migration flows for much of the migrating juvenile salmonid populations, potential survival effects may remain that could require mitigation with other actions. Expansion of rearing habitat offers one means for consideration to achieve such mitigation.

Vogel (2011) notes, in a comprehensive review of Sacramento River basin native anadromous fish restoration, that damming the mainstem Sacramento River may have resulted in not only less habitat for juvenile salmonid rearing, but also reduced habitat quality because of the larger channel environment associated with conveyance of reservoir releases and protected river banks not being suited for smaller juveniles. He describes indications that optimal habitat is limited and that the lack of structural complexity means that small fish can be displaced downstream during high flow events (e.g., from reservoir releases). His report concludes with a recommended high priority action for projects to replenish coarse substrates (i.e., gravel and boulders) and woody debris in the upper portion of the mainstem Sacramento River in key locations to improve and expand juvenile salmonid rearing habitat.

The NMFS WRLCM represents Sacramento River rearing habitat in terms of velocity and water depth (Hendrix et al. 2017): high quality habitat is greater than 0.2 but less than or equal to 1 meter deep, with velocity less than or equal to 0.15 meter per second; depth and velocity outside these bounds is low-quality habitat. This emphasizes the importance of a low- velocity, shallow habitat for rearing. A greater extent of these habitat characteristics increases the capacity of the river (i.e., the space available for rearing salmonids), which reduces migration downstream because of crowding (density dependence). Providing a larger extent of rearing habitat is an important consideration for mitigating potential reduced survival of migrating life stages because of the Sites Reservoir Project water diversions.

Vogel (2011) also presents a case for more research into the effects of flow on fish survival using new technology (e.g., acoustic transmitters and detection arrays) that will allow fine-scale investigation of the mechanisms operating to affect fish survival. He notes, "most fish tagging studies over the past several decades have appeared to simply conclude 'more flow is better' without determining numerical thresholds or examination of site-specific causal mechanistic effects of flow on survival." He also acknowledges more flow is not necessarily better, particularly if it comes at the cost of consuming water that is needed for known environmental benefits such as temperature control.

Conclusions and Recommendations

In summary, we make the following conclusions and recommendations about the relationship of flow to juvenile salmon migration and survival relative to the Sites Reservoir Project.

- There is evidence that juvenile salmonid survival increases asymptotically with increasing mainstem Sacramento River flow.
  - Some uncertainty exists because of the generally limited number of years and flow conditions for which relationships have been developed.
  - Additional study of mechanisms, over a greater range of flows, and with the goal of establishing thresholds is recommended.

  - The available information suggests the effect of flow on survival begins to level off above 20,000 cfs, which justifies the Sites Reservoir Project's modeling assumption that diversions need less restriction at higher flows (i.e., there is good potential to divert more water at higher flow).
- Juvenile salmonids move downstream in pulses in response to flow increases.
  - The Sites Reservoir Project appropriately recognizes the protection of fish pulses by curtailing diversions during expected flow pulses.
  - Further refinement of pulse flow protection criteria is recommended, to examine whether the existing modeling assumptions are borne out by empirical observations of fish movement and flow triggers at further upstream locations than have been examined in the existing literature (e.g., determining if a 15,000-cfs threshold at Bend Bridge is a good surrogate for 14,000 cfs at Wilkins Slough).
  - Quantitative modeling of Sites Reservoir Project effects (e.g., with the NMFS WRLCM) must appropriately account for daily movements of fish, otherwise effects on survival could be overestimated.
- Increased rearing habitat has the potential to mitigate residual potential negative effects on migrating juvenile salmonid survival caused by Sites Reservoir Project diversions.
  - Priority should be given to increasing structural complexity, in addition to providing more shallow-water, low-velocity habitat.
  - Explore necessary restoration quantities to mitigate survival effects, by conducting sensitivity analyses over a range of potential restoration configurations, acreages, and locations.

References

Written References

Acierto, K. R., J. Israel, J. Ferreira, and J. Roberts. 2014. Estimating juvenile winter-run and spring-run Chinook salmon entrainment onto the Yolo Bypass over a notched Fremont Weir. *California Fish and Game* 100(4):630-639.

Baker, P. F., and J. E. Morhardt. 2001. Survival of Chinook salmon smolts in the Sacrament San Joaquin Delta and Pacific Ocean. Pages 163 – 182 in R.L. Brown, Editor. *Contributions to the Biology of Central Valley Salmonids*, Volume 2, Fish Bulletin 179. California Department of Fish and Game, Sacramento, CA.

Brandes, P. L., and J. S. McLain. 2001. Juvenile Chinook salmon abundance, distribution, and survival in the Sacramento-San Joaquin Estuary. Pages 39 – 138 in R.L. Brown, Editor. *Contributions to the Biology of Central Valley Salmonids*, Volume 2, Fish Bulletin 179. California Department of Fish and Game, Sacramento, CA.

Cavallo, B., P. Gaskill, J. Melgo, and S. C. Zeug. 2015. Predicting juvenile Chinook salmon routing in riverine and tidal channels of a freshwater estuary. *Environmental Biology of Fishes* 98:1571-1582.

del Rosario, R. B., Y. J. Redler, K. Newman, P. L. Brandes, T. Sommer, K. Reece, and R. Vincik. 2013. Migration patterns of juvenile winter-run-sized Chinook Salmon (*Oncorhynchus tshawytscha*) through the Sacramento–San Joaquin Delta. *San Francisco Estuary and Watershed Science* 11(1).

Glenn-Colusa Irrigation District. 1997. *Hamilton City Pumping Plant Fish Screen Improvement Project Draft EIR/EIS.* State Clearing House Number: 93062042

Hendrix, N., E. Jennings, A. Criss, E. Danner, V. Sridharan, C.M. Greene, H. Imaki, and S.T. Lindley. 2017. *Model Description for the Sacramento River Winter-Run Chinook Salmon Life Cycle Model.* March 8. Appendix H, Biological Opinion for the California WaterFix Project in Central Valley, California. Portland, OR: National Marine Fisheries Service, West Coast Region. Available: http://www.westcoast.fisheries.noaa.gov/publications/Central_Valley/CAWaterFix/WaterFix%20Biological%20Opinion/cwf_appendix_h.pdf.

Holbrook, C. M., R. W. Perry, and N. S. Adams. 2009. *Distribution and Joint Fish-Tag Survival of Juvenile Chinook Salmon Migrating through the Sacramento-San Joaquin River Delta, California, 2008.* U.S. Geological Survey Open-File Report 2009-1204. U.S. Geological Survey, Reston, VA.

Iglesias, I. S., M. J. Henderson, C. J. Michel, A. J. Ammann, and D. D. Huff. 2017. *Chinook Salmon Smolt Mortality Zones and the Influence Of Environmental Factors on Out-Migration Success in the Sacramento River Basin.* Prepared for U.S. Fish and Wildlife Service, Pacific Southwest Region, Central Valley Project Improvement Act, Sacramento, CA. Agreement Number F15PG00146. April. National Marine Fisheries Service, Southwest Fisheries Science Center, Santa Cruz, CA.

Michel, C. J. 2010. River and Estuarine Survival and Migration of Yearling Sacramento River Chinook Salmon (*Oncorhynchus tshawytscha*) Smolts and the Influence of Environment. Master's Thesis. University of California, Santa Cruz.

Michel, C. J., A. J. Ammann, E. D. Chapman, P. T. Sandstrom, H. E. Fish, M. J. Thomas, G. P. Singer, S. T. Lindley, A. P. Klimley, and R. B. MacFarlane. 2013. The effects of environmental factors on the migratory movement patterns of Sacramento River yearling late-fall run Chinook salmon (*Oncorhynchus tshawytscha*). *Environmental Biology of Fishes* 96(2-3):257-271.

Michel, C. J., A. J. Ammann, S. T. Lindley, P. T. Sandstrom, E. D. Chapman, M. J. Thomas, G. P. Singer, A. P. Klimley, and R. B. MacFarlane. 2015. Chinook salmon outmigration survival in wet and dry years in California's Sacramento River. *Canadian Journal of Fisheries and Aquatic Sciences* 72(11):1749-1759.

National Marine Fisheries Service. 2009. *Biological Opinion and Conference Opinion on the Long-Term Operations of the Central Valley Project and State Water Project.* 844pp.

Northern California Water Agency. 2014. *Instream Flow Requirements in the Sacramento River Hydrologic Region.* Updated November 2014. Briefing paper. 15pp.

Notch, J. 2017. Out-Migration Survival of Wild Chinook Salmon (*Oncorhynchus tshawytscha*) Smolts from Mill Creek through the Sacramento River during Drought Conditions. Master's Thesis. University of California, Santa Cruz.

Perry, R. W., J. R. Skalski, P. L. Brandes, P. T. Sandstrom, A. P. Klimley, A. Ammann, and B. MacFarlane. 2010. Estimating survival and migration route probabilities of juvenile Chinook salmon in the Sacramento-San Joaquin River Delta. *North American Journal of Fisheries Management* 30(1):142-156.

Poytress, W. R., J. J. Gruber, F. D. Carrillo, and S. D. Voss. 2014. *Compendium Report of Red Bluff Diversion Dam Rotary Trap Juvenile Anadromous Fish Production Indices for Years 2002–2012.* U.S. Fish and Wildlife Service. Red Bluff Fish and Wildlife Office, CA. 151 pp.

Roberts, J., J. Israel, and K. Acierto. 2013. *An Empirical Approach to Estimate Juvenile Salmon Entrainment over Fremont Weir.* Fisheries Branch Administrative Report 2013-01. California Department of Fish and Wildlife, Sacramento.

Sites Project Authority and U.S. Bureau of Reclamation. 2017. *Draft Environmental Impact Report/Environmental Impact Statement and Draft Feasibility report for Sites Reservoir Project, Sites, California*. August. State Clearinghouse #2001112009

Vogel, D. A. 2008. *Biological Evaluation of the Fish Screens at the Glen-Colusa Irrigation District's Sacramento River Pump Station 2002-2007.*

Vogel, D. A. 2011. *Insights into the Problems, Progress, and, Potential Solutions for Sacramento River Basin Native Anadromous Fish Restorations.* Prepared for Northern California Water Association and Sacramento Valley Water Users.

Vogel, D. A., and K. R. Marine. 1991. *Guide to Upper Sacramento River Chinook Salmon Life History.* Prepared for the U.S. Bureau of Reclamation, Central Valley Project. CH2M Hill. July. 55 pp. with appendices.

Williams, J. G. 2012. Juvenile Chinook Salmon (Oncorhynchus tshawytscha) in and Around the San Francisco Estuary. San Francisco Estuary and Watershed Science 10(3).

Personal Communications

Michel, Cyril J. Assistant Project Scientist, Salmon Ecology Team, NOAA Fisheries, Santa Cruz, CA. September 28, 2017—Email to Marin Greenwood, Aquatic Ecologist, ICF, Sacramento, CA, containing a csv file with late fall-run Chinook salmon acoustic tag detections per day from 2007 to 2011.

ISSUES AND SUPPORT FOR SITES RESERVOIR ECOSYSTEM ENHANCEMENT STORAGE ACCOUNT ACTIONS AND OPERATIONS

Based on review of information presented in the Briefing meeting on February 23 and discussions on February 28, 2017 there are a number of issues that need refinement in order to assess the effects of the project on listed fishes and other resources. Primary among these issues is that the project adds new facilities and removes water from the system. These actions are typically associated with changes in habitat that may adversely affect fish. For example, there will be increased diversions at Tehama Colusa Canal and Glenn Colusa Canal to take advantage of surplus capacity for filling Sites. While both of these facilities have state of the art fish screens designed to meet NMFS fish passage criteria, they are expected to incur up 5% mortality of fish that encounter them (NMFS 2009). Additional diversions would likely result in proportionate increases in mortality. There is also a new diversion facility at Delevan, which will create a new source of mortality from loss at its fish screen. There is also potential for increased predation, which is often associated with facilities that provide ambush habitat for predators (e.g. Vogel 2008). How the proposed ecosystem enhancements offset sources of mortality to achieve the expected ecosystem benefit needs clarification.

The project proposal purports a number of ecosystem enhancements, but without a better-defined discussion of operating criteria and priorities, determining whether the benefits offset the impacts is difficult. Presumably not all the purported benefits can be achieved with the amount of water anticipated to be available for the ecosystem enhancement storage account. For example, what are the criteria for choosing between storing water in Shasta versus Oroville or Folsom. What are the criteria for capturing releases for temperature control, diverting them to Yolo bypass, or using them for Delta water quality?

Below is a preliminary discussion of the currently proposed ecosystem enhancements with a view on relative benefits and priorities for salmon and steelhead. None of these measures address green sturgeon or other aquatic species of concern. How these measures affect those species should be discussed.

Action

> EESA-1 Shasta Coldwater Pool. Improve the reliability of cold-water pool storage in Shasta Lake to increase Reclamation's operational flexibility to provide suitable water temperature in the Sacramento River. This Action would operationally translate into the increase May Storage levels, and increased coldwater pool in storage, with particular emphasis on below normal, dry, and critical water year types.
>
> EESA-2 Provide release from Shasta Dam of appropriate water temperature, and subsequently from Keswick Dam, to maintain water temperatures year-round at levels suitable for all species and life stages of anadromous salmonids in the Sacramento River between Keswick Dam and Red Bluff Diversion Dam, with particular emphasis on the months of highest potential water temperature related impacts (that is, July through November) during below normal, dry, and critical water year types.

Issues

EESA-1 and 2 are essentially components of the same issue. They should be combined. While EESA-1 increases reliability of the cold pool its benefit is determined by how it is allocated via EESA-2. The California Water Resources Control Board Water Right Order 90-5 requires Reclamation to meet a daily average water temperature of 56°F in the Sacramento River at Red

Bluff Diversion Dam during periods when higher temperatures will be detrimental to the fishery. Circumstances are rare when Reclamation can achieve this standard for the duration of spring and summer months when winter-run and spring-run chinook salmon are spawning. The order allows flexibility in the location of the compliance point based on consultation with the California Department of Fish and Wildlife (CDFW), National Marine Fisheries Service (NMFS), and U.S. Fish and Wildlife Service (FWS). In addition, NMFS 2009 biological opinion on the long-term operations of the Central Valley Project and State Water Project includes end of September and end of April storage targets to facilitate Reclamation's ability to provide suitable spawning and rearing habitat for winter-run Chinook. NMFS biological opinion also acknowledges a need for real time management of the coldwater pool to maximize its benefit for spawning, incubating eggs, and emergent fry, and requires Reclamation to develop an annual temperature management plan in consultation with the Sacramento River Temperature Task Group (SRTTG). Given the poor performance of this process in 2014 and 2015, NMFS is considering higher end of September (EOS) and end of April (EOA) targets and revised temperature targets to provide suitable temperatures for winter-run Chinook spawning and redds through the period of incubation.

Using Sites Reservoir to increase storage in Shasta Reservoir would enhance Reclamations ability to meet the expectations in NMFS biological opinion and perhaps to extend temperature control to expand available spawning habit beyond its recent confines above Clear Creek (reference needed). Given this is currently the only available spawning habitat for winter-run these actions should be considered high priority. It should also be considered for use in above normal and wet years to ensure EOS and EOA storage levels are met and temperature compliance points cover the entirety of the year's winter-run redd distribution. Between 1996 and 2015 there were nine above normal or wet years in the Sacramento Valley (http://cdec.water.ca.gov/cgi-progs/iodir/WSIHIST). During each of those years the temperature compliance point was managed and moved from Bend Bridge to Jellys Ferry or Balls Ferry (https://www.usbr.gov/mp/cvo/temp.html).

These measures also provide temperatures and flows for spring-run Chinook spawning below Keswick and for rearing juvenile spring-run Chinook and steelhead emigrating from Butte, Deer, Mill, and Clear Creeks to rearing habitat in the upper Sacramento River.

There should be consideration of opportunities for augmenting the cold-water pool in Trinity. NMFS 2009 biological opinion includes temperature requirements for spring-run Chinook and steelhead which are managed through Whiskeytown Reservoir releases.

There should be a discussion of how temperature control water is used once it is moved past the temperature control point. Is it available for diversion at the Sites diversion point, for use south of the Delta, or can it contribute to Delta water quality standards and outflow?

Action

EESA-3 Folsom Lake Coldwater Pool: Increase the availability of coldwater pool storage in Folsom Lake, by increasing May storage and coldwater pool storage, to allow Reclamation additional operational flexibility to provide suitable water temperatures in the lower American River. This action would use additional cold water pool storage by provide releases from Folsom Dam (and subsequently from Nimbus Dam) to maintain water temperatures at levels suitable for juvenile steelhead over-summer rearing and fall-run Chinook spawning in the lower American River from May through November during all water year types.

EESA-4: Stabilize American River Flows: Stabilize flows in the lower American River to minimize dewatering of fall-run Chinook salmon redds (October through March) and steelhead redds (January through May), and reduce juvenile anadromous salmonid isolation events (specifically, flow increases to 4,000 cfs with subsequent reduction to less than 4,000 cfs) particularly from October through June. Reduce the reliance upon Folsom Lake as a "real time first response facility" to meet Delta objectives and demands, particularly for January through August, to reduce flow fluctuations and water temperature-related impacts on fall-fun Chinook salmon and steelhead in the lower American River.

Issue

Like EESA-1 and 2, EESA-3 and 4 are closely relate and could be combined to address steelhead life history comprehensively. Steelhead likely spawned above Folsom historicaly where oversummering juveniles had access to cold water refugia and stable flows. Now they are confined to the American River below Nimbus Dam where suitable oversummering habitat for juveniles is limited. NMFS 2009 biological opinon requires Reclamation to manage the Folsom/Nimbus Dam complex and the water temperature control shutters at Folsom Dam to maintain a daily average water temperature of 65°F or lower at Watt Avenue Bridge from May 15 through October 31, to provide suitable conditions for juvenile steelhead rearing in the lower EESA-3 provides water to manage temperatures and provide oversummering habitat for juvenile steelhead, thereby benefiting American River steelhead from spawning through rearing. While EESA-4 provides water to stabilze flows and prevent dewatering redds. The difference is water for implementing EESA-4 could come from sources upstream of the American River, includinging Sites Reservoir. While a base flow necssary to prevent stranding of juvenile fish and to ensure implementation of ramping rates could be stored in Flosom Lake. Water to meet demands for Delta water quality criteria that would otherwise cause a spike in American River flows could come from upstraem. EESA-3 would allow Reclamation in cooperation with Sites Reservoir operations to store water in Folsom to enhance its ability to meet the summertime temperature targets. Emegrating fall-run Chinook juveniles would likely receive a benefit during warm springs as well. How Reclamtion and Sites could cooperate to implement EESA-3 and 4 should be explained. ESSA-3 and 4 are appropriately set as a priority 2, how and whether these actions can be achieved without compromising or limiting the effectiveness of EESA-1 and 2 should be explained.

Action

EESA-5: Delta Outflow for Delta Smelt Habitat Improvement (Summer/Fall): Provide supplemental Delta outflow during summer and fall months (that is, May through December) to improve X2 (if possible, west of Collinsville 50 miles) and increase estuarine habitat, reduce entrainment, and improve food availability for anadromous fishes and other estuarine-dependent species (for example, delta smelt, longfin smelt, Sacramento splittail, starry flounder, and California bay shrimp). Shading highlights the period in which Delta outflow would be augmented (operation coordinated with Delta water quality action).

Issue

A discussion of how this measuer could be integrated with EESA-1, 2, and 8 to take advantage of the same volume of water to meet multiple purposes would be helpful. May through October is the critical period of temperature control in the upper Sacarmento River for winter-run and spring-run Chinook. Allowing this water to flow through the Sacramento River (EESA-8) to the Delta would provide enhance survival of spawned egg, emergent fry, and migrating fish from their natal site to the Delta. Where it could contribute to improving habitat in the delta for rearing juvenile salmon, delta smelt, and other resident fish. The mechanism for coopertion between Reclamtion and Sites operators to ccoperate to optimze the ecosystem enhancement measures should be explored and explained.

Action

> EESA-6: Lake Oroville Coldwater Pool
> Improve the reliability of coldwater pool storage in Lake Oroville to improve water temperature suitability for juvenile steelhead and spring-run Chinook salmon over-summer rearing and fall-run Chinook salmon spawning in the lower Feather River from May through November during all water year types. Provide releases from Oroville Dam to maintain water temperatures at levels suitable for juvenile steelhead and spring-run Chinook salmon over-summer rearing and fall-run Chinook salmon spawning in the lower Feather River. Stabilize flows in the lower Feather River to minimize redd dewatering, juvenile stranding, and isolation of anadromous salmonids.

Issue

The current unanswered question on the Feather River is what is the current state of the habitat following the large input of sediment resulting from erosion or the spillways at Oroville Dam. This measure is structured to supplement cold water pool storage and to relase that water to povide temperature control in the River and stabilize flows to prevent dewatering of redds and stranding of salmon. Assuming fish use of this habiat will recover and temperature compliance points remain relevant, this action should benefit spring-run and steelhead trout below Oroville Dam. As with the American River, this action is lower priority than the upper Sacramento River. An explanation of how water could be stored in the cold water pool in Lake Oroville without depleting higher priority uses of cold water in Shasta Reservoir is needed.

Action

> EESA-7: Stabilize Sacramento River Fall Flows: Stabilize flows in the Sacramento River between Keswick Dam and Red Bluff Diversion Dam to minimize dewatering of fall-run Chinook salmon redds (for the spawning and embryo incubation lifestage periods extending from October through March), particularly during fall months. Avoid abrupt changes. Operations would be limited to not adversely affect coldwater pool operations in dry and critical years.

Issue

WRO 90-5 also establishes a requirement for a minimum flow of 3,250 cfs from September through February for the maintenance of fish and wildlife resources, except during critical dry years. The timeing of this requirement address protection of fall-run Chinook, which spawn in the upper Sacramento from October through September and much of the late fall-run spawning season, which extends from December through March with a peak in late February (Vogel and Marine 1991). It establishes a stable flow mesure to prevent fluctuations in flow that could dewater redds. While this is identified as and Average year priority 1 action, it could compromise Reclamations ability to achieve the EOA storage target for winter-run Chinook cold water pool and Reclamation's ability to protect winter-run Chinook redds and emerging fry. A decision to enhance Reclamations ability to meet or exceed the WR) 90-5 flow criteria should not be made withut considertions of its effect on the Bureau's ability to meet NMFS biological opinion storage targets.

Action

EESA-8: Sacramento River Diversion Reduction at Red Bluff and Hamilton City:
Provide increased flows from spring through fall in the lower Sacramento River by reducing diversions at Red Bluff Diversion Dam (into TCC) and at Hamilton City (into GCC), and by providing supplemental flows at the proposed Delevan Pipeline intake and discharge facilities. This action would provide multiple benefits to riverine and estuarine habitats, and to anadromous fishes and estuarine-dependent species (for example, delta smelt, splittail, longfin smelt, Sacramento splittail, starry flounder, and California bay shrimp) by reducing entrainment, providing or augmenting transport flows, increasing habitat availability, increasing productivity, and improving nutrient transport and food availability.

Issue

While some studies sugges winter-run move quickly through the middle reach of the Sacramento River to the Delta (del Rosario et al. 2014) other studies indicate a protracted rearing and migration period (Vogel and Marine 1991). Both may be true such that peaks may move in response to major strom events, younger fish or smaller fish may wait for subsequent flow signals or different signals before starting to emigrate. Consequently, juvenile fish, in particular winter-run Chinook could be migrating past these diversion facilities from late summer until the following spring. Reducing diversion below what would have occurred in the absence of Sites Reservoir project could provide a survival benefit in theis middle reach and deliver more fish and water to the Delta. Again how this measue would be integrated into operations should be explained. For example, would it result in modification of any of the bypass flow criteria identified as prerequisites for diversion.

Action

Bypass flows: Diversions to storage are restricted until the following bypass requirements are achieved
- •Below Hamilton City: 4,000 cfs (3 day average)
- •At Wilkins Slough: 5,000 cfs (3 day average)
- •At Freeport/Hood (average monthly) to protect Delta water quality and prevent any CVP/SWP releases in the subsequent months compared to No Action Alternative:
    - •15,000 cfs in January
    - •13,000 cfs in December or February through June
    - •Otherwise 11,000 cfs

- Diversions to storage restricted to protect fish migration pulse events
    - •Up to one pulse event per month (October –May)
    - •Pulse range 15,000 cfs –25,000 cfs (based on Bend Bridge as indicator)
    - •Pulse event qualified if duration of seven days

Issue

The rationale for each of these criteria needs to be provided. For example, the below Hamliton City, Wilkins Slough, and Freeport criteria appear to associated with ensuring senior water wrights are met before diversions to Sikes are initiated. However, these in some cases exceed Sacramento flows proposed by Reclamation in its 2008 biological assessment on operation of the CVP. The Hamilton City criterion appers to exceed WRO 90-5 requirements for flows at RBDD, and the Wilkins Slough criterion is based on an obsolete navigation standard. That flow requirement is now used to support long-time water diversions that have set their intake pumps just below this level. Diverters are able to operate for extended periods at flows as low as 4,000 cfs and for short periods at 3,500 cfs. Releases are made to meet the Wilkins Slough requirement in the spring and fall that impact the carryover storage and cold water pool in Shasta (NMFS

2009). Is there flexibity in meeting senior water rights? If not, how do these criteria affect operators ability to use Sites as a mechanism to enhance temperature control below Shasta.

The rationale and benefits of the fish pulse flow also need addition explanation. For example, a number of studies have documented fish movement in association with pulses. A recent study by del Rosario et al. (2013) report a spike in fish arrivals at Knights Landing in association with the first strom event producing a flow of 400 m^3/sec (14126 CFS) and passage of 50 percentile of cumulate migration shortly there after. But other studies report suggest wild fish exhibit a more-protracted migration timing and do not migrate *en masse* (Vogel 2008, Williams 2006). Allowing the first pulse to pass would protect the pulse, but subsequent to the first pulse fish that were not ready to migrate are likely to remian in the rearing reach below RBDD and could move on subsequent pulses. Capturing the entirety of subsequent pulsed each month would expose those fish to operating diversion facilities. Also recent studies of the flow/survival relations ships for emigrating late fall-fun juvenile Chinnok indicate the Wilkins Slough standards is insufficient to provide safe passage of juvenile salmonids through the rearing reaches of the Sacramento River (Michel et al. 2015). The effect of addition diversions on flow the consequent effect on juvenile survival should be estimated and compared to the expected benefits form enhanced temperature control and stabilized flow over spawning grounds. This would allow an assessment of the net benefit of the project.

Topic: **Reservoir Committee Agenda Item 3.3** **2020 June 18**

Subject: **Proposed Objectives and Alternatives for the Revised EIR/EIS**

Requested Action:

Review and comment on the objectives and alternatives for the Revised Environmental Impact Report / Environmental Impact Statement (EIR/EIS) to focus efforts in developing a more complete project description on schedule.

Detailed Description/Background:

Staff has begun work on preparation of the revised and recirculated Draft EIR (Revised EIR). As part of this effort, the project objectives and action alternatives are being revised based on the Value Planning Report for the Revised EIR/EIS as described in more detail below and attached.

It is important that the Reservoir Committee and Authority Board review and comment on these recommended revisions at this early stage so staff and the consultant team can focus our efforts on development of more complete descriptions of these alternatives for the Revised EIR/EIS, permitting effort, and feasibility design currently underway. Staff anticipates returning to the Reservoir Committee and Authority Board in September with the Revised EIR/EIS project description, including any changes to the objectives based on initial analysis, a more complete description of the action alternatives, along with a recommendation for a Preferred Project. Staff will be seeking Reservoir Committee and Authority Board approval of this Revised EIR/EIS project description and the recommended Preferred Project in September.

Section 15124(b) of the California Environmental Quality Act (CEQA) Guidelines requires that a project description contain a clear statement of the project objectives including the underlying purpose of the project. Revisions to the Project objectives are needed from those contained in the 2017 Draft EIR/EIS to: (1) better reflect the goals of the Reservoir Committee and Authority Board as reflected in the Value Planning Report along with Sites Project messaging and informational materials adopted by the Authority Board in April 2020; and (2) add additional clarity and specificity on what the Project is focused on achieving to improve understanding of the foundational components that lead to formulation of Project alternatives. The revised objectives are being reviewed by the Ad Hoc Environmental Planning and Permitting Work Group at their June 18 meeting and the outcome of this review, including any changes will be reported at the Reservoir Committee meeting.

The CEQA Guidelines require that an EIR analyze a reasonable range of alternatives to the project which would feasibly attain most of the basic objectives of the project but would avoid or substantially lessen any of the significant effects of the project. Staff is recommending revisions to the Project action alternatives from those contained in the 2017 Draft EIR/EIS to better align with the Value Planning Report and the alternatives contained therein. Two action alternatives are being recommended that combine components of VP5, VP6, and VP7 from the Value Planning Report to simplify the EIR and streamline its preparation and review by the public. The recommended revised action alternatives are being reviewed by the Ad Hoc Environmental Planning and Permitting Work Group at their June 18 meeting and the outcome of this review, including any changes will be reported at the Reservoir Committee meeting.

The recommended revisions to the project objectives and the action alternatives are within the scope allowed by CEQA to complete a Revised EIR and do not trigger any new process. Staff is working with Legal Counsel on the recommended revisions and Legal Counsel will continue to be involved in the development of the project description and Revised EIR.

Staff is coordinating the Revised EIR with similar changes Reclamation is or will be making to the EIS document.

Prior Action:

April 2020 Board Meeting - The Authority Board approved the Sites Project Value Planning Alternatives Appraisal Report (Value Planning Report) and the recommendations contained in that Report. The Value Planning Report included substantial changes in the recommended Project, VP7, as compared to Alternative D in the 2017 Draft EIR/EIS. At the same meeting, the Authority Board directed staff to begin preparation of a Revised EIR to analyze the environmental effects of the options identified in the Value Planning Report.

Fiscal Impact/Funding Source:

Development of the recommended project objectives and action alternatives is within the Amendment 1B work plan currently and sufficient funds are available to complete the project description. Completing the Revised EIR is part of the Amendment 2 work plan

Staff Contact:

Ali Forsythe

Attachments:

Attachment A - Recommended Revised EIR Objectives.
Attachment B - Recommended Revised EIR/EIS Alternatives.

Sites Reservoir Project
Preliminary Revised CEQA Objectives
June 12, 2020

- Improve agricultural, municipal, and environmental water supply reliability in a cost-effective manner for Project Participants;
- Improve cold water pool management in Shasta Reservoir through coordination and exchanges with Reclamation to benefit anadromous fish;
- Enhance the Delta ecosystem by providing water to convey food resources from the floodplain to the Delta thereby improving the food chain and quality of the Delta's estuarine habitat for the benefit of pelagic fishes[1] in the north Delta (e.g. Cache Slough);
- Provide improvements in state-wide water supply reliability to enhance opportunities for fish protection, habitat management, and other environmental needs; and
- Provide local and regional amenities, including developing recreational facilities, reducing local flood damage, and maintaining community connectivity through roadway modifications.

---

[1] Pelagic fish are species that spend most of their life swimming in the water column, having little contact or dependency with the bottom.

Sites Reservoir Project
Preliminary Revised Draft EIR/EIS Alternatives
June 12, 2020

Facilities/Operations	Action Alternative 1 (Derived from VP7)	Action Alternative 2 (Includes Parts of VP5 and VP6)
Diversion/Reservoir Infrastructure Details		
Reservoir Size	1.5 MAF	1.3 MAF
Dams [Scaled to the size of the reservoir]	Two main dams (Golden Gate and Sites) and 8 or 9 saddle dams (to be determined in design)	Two main dams and 7 saddle dams
Spillway	One spillway, design and location to be determined	Similar to Alternative 1*
Funks Reservoir and Funks Pumping Generating Plant	Pumping from the existing Funks Reservoir to Sites Reservoir through new Funks Pumping and Generating Plant and new Funks pipeline; operation will be modified and Funks Reservoir may be dredged. Footprint as described in Value Planning Report.	Similar to Alternative 1
Terminal Regulating Reservoir (TRR); TRR Pumping Generating Plant; TRR Pipeline	Pumping from the GCID Main Canal to Sites Reservoir requires construction of the TRR facilities; footprint as described in Value Planning Report	Same as Alternative 1
Holthouse Reservoir/Fletcher	Eliminated facilities from 2017 Draft EIR/EIS and pumpback generation	Same as Alternative 1
Hydropower	Power generation incidental upon release	Same as Alternative 1
Diversion(s)	Diversion from Sacramento River into exiting Tehama-Colusa Canal at Red Bluff and the existing GCID Main Canal at Hamilton City Adding 2 pumps in existing bays at the plant at Red Bluff	Same as Alternative 1
Emergency Release Flow [Function of the size of the reservoir]	1. Releases into Funks and Stone Corral creeks; and 2. Emergency outflow works pipeline and structure to release north to Hunters Creek Watershed	Similar to Alternative 1*

Sites Reservoir Project
Preliminary Revised Draft EIR/EIS Alternatives
June 12, 2020

Facilities/Operations	Action Alternative 1 (Derived from VP7)	Action Alternative 2 (Includes Parts of VP5 and VP6)
Flood Control	Flood damage reduction benefit for local watersheds from reservoir storage	Same as Alternative 1
Reservoir Management	Reservoir Management Plan (To be developed)	Same as Alternative 1
Electrical Facilities	Transmission Lines, Substations, Switchyards; Interconnection with WAPA or PG&E	Same as Alternative 1
Operations		
One Operational Criteria	Option based on Value Planning Report Table 3.1 Scenario B but anticipated to be modified by future modeling efforts	Same as Alternative 1
Reclamation Involvement	Two Options: 1. Funding Partner 2. Operational Exchanges a. Within Year Exchanges b. Real-time Exchanges	Same as Alternative 1
Bypass Releases		
Bypass Releases into Funks Creek and Stone Corral Creek	Develop specific bypass criteria to protect downstream water right holders and ecological function	Same as Alternative 1
Conveyance Release		
Dunnigan Release	Release 1,000 cfs into new pipeline to Colusa Basin Drain	Release into new pipeline to Sacramento River, partial release into the Colusa Basin Drain to fulfill the Proposition 1 needs
Recreation		
Facilities Consistent with WISP Application	Two primary areas with infrastructure: 1. Peninsula Hills Area 2. Stone Corral Creek One day-use boat ramp w/parking located on the west side of the reservoir and south of the bridge	Same as Alternative 1

Sites Reservoir Project
Preliminary Revised Draft EIR/EIS Alternatives
June 12, 2020

Facilities/Operations	Action Alternative 1 (Derived from VP7)	Action Alternative 2 (Includes Parts of VP5 and VP6)
Transportation/Circulation		
Provide Route to West Side of Reservoir	Bridge and road to residents at the south end of reservoir (does not go to Lodoga)	Road to south residents continues to Lodoga; no bridge
Other Maintenance and Access Roads	Sites Reservoir Road Modifications Plan – In development	Similar to Alternative 1*

* May have minor differences due to reservoir size

Topic: **Reservoir Committee Agenda Item 3.6** **2020 June 18**

Subject: **Regulatory Agency Technical Working Group**

Requested Action:

Receive status update on the approach for Regulatory Agency Technical Working Group.

Detailed Description/Background:

Staff have reinitiated efforts on the development and submittal of key permits for the Sites Project as reflected in the Amendment 1B Work Plan. As part of this effort, the team has developed an approach to facilitate regular communication and coordination with state, federal and local agencies with jurisdiction over all or portions of the Project. The attached, *Regulatory Agency Technical Working Groups Approach* document, details this effort. This approach is also in response to Action 2.4 in the November 2019 Organizational Assessment. The activities of the regulatory coordination will be reported to the Environmental Planning and Permitting Workgroup.

Prior Action:

None.

Fiscal Impact/Funding Source:

Conducting regulatory coordination is within the scope of work for the Amendment 1B and 2 work plans.

Staff Contact:

Ali Forsythe

Attachments:

Attachment A - Regulatory Agency Technical Working Groups Approach.

Status:	Final	Preparer:	Luu	Phase:	2 Version: A
Purpose:	Staff Report	QA/QC:		Date:	2020 June 18
Caveat:	Informational	Authority Agent:	Brown	Ref/File #:	10.700
Notes:				Page:	1 of 1

Regulatory Agency Technical Working Groups Approach

The following two technical working groups will be established to facilitate regular communication and coordination with state, federal and local agencies during the permitting efforts for the Sites Reservoir Project. These groups are expected to be in place thru Amendment 2 efforts (e.g., the end of 2021) and likely into Phase 3 efforts (post 2021). Additional technical working groups may be added as permitting activities progress depending on need. It is important to note that these groups are not intended to replace or supersede focused discussions and meetings with specific agencies, but rather facilitate a common understanding and basis of Project-wide and Fisheries/Operations knowledge and dialogue. These would be staff and consultant run meetings. Reservoir Committee and Authority Board members could attend to observe if desired. Results of the meetings will be reported out to the appropriate Reservoir Committee and Authority Board workgroups.

Group 1: Interagency General Update and Coordination Meetings

- **Purpose**: Quarterly meetings to efficiently update and coordinate with all and state, federal and local regulatory and/or partnering agencies. Items to be include in the meeting agenda would include general updates on project status, design efforts, status of permit development, status of working thru any key considerations that may affect all permits and upcoming items. Attendees would also be asked to update on permit processing status (if a permit application has been submitted and permit development is in process), update on any changes in their organizations, law or regulation that may affect Sites and identify any information needs or concerns they may have. Specific items, information requests or concerns would be identified, and a process developed for resolution with the relevant agencies and the Sites team.

- **Potential Attendees**: This meeting would be open to any agency that had an interest. Potential attendees would be broad and could include the following:
    - United States Fish and Wildlife Service (USFWS)
    - Bureau of Reclamation (Reclamation)
    - Bureau of Indian Affairs (BIA)
    - National Marine Fisheries Service (NMFS)
    - Natural Resources Conservation Service (NRCS)
    - United States Army Corps of Engineers (USACE)
    - United States Environmental Protection Agency (USEPA)
    - Western Area Power Administration (WAPA)
    - California Department of Fish and Wildlife (CDFW)
    - California Department of Transportation (Caltrans)

  - California Department of Water Resources (DWR)
  - California Office of Historic Preservation - State Historic Preservation Officer (SHPO)
  - California State Water Resources Control Board
  - Central Valley Regional Water Quality Control Board
  - Central Valley Flood Protection Board
  - County of Colusa, Planning
  - County of Yolo, Planning

Group 2: Fishery and Operations Technical Meetings

- **Purpose**: Focused, as needed, fishery and operations meetings to review and discuss the modeling approach, analysis approach, operational criteria and the resulting effects to species of the Project. These meetings are intended to stimulate collaboration and early input into the fisheries and operational components and analysis and are anticipated to include technical, detailed discussion of topics.

- **Potential Attendees**: Potential attendees could include the following:
  - United States Fish and Wildlife Service (USFWS)
  - Bureau of Reclamation (Reclamation)
  - National Marine Fisheries Service (NMFS)
  - California Department of Fish and Wildlife (CDFW)
  - Additional agencies, depending on topics and authority

Work Group Chartering Document

Status: **Ad Hoc**

- Leaders: Chair Vice Chair
  Thad Bettner, GCID — Heather Dyer (SBVMWD)
- Members (9):
  Mike Azevedo (Colusa Co.)
  Robert Cheng (CVWD)
  Jeff Davis (SGPWA)
  Rob Kunde (WR-M WSD)
  Eric Leitterman (Valley Water)
  Randall Neudeck (MWD)
  Bill Vanderwaal (DWD)
- Expertise: PCWA/Roseville for Lower American River
  Staff from participating agencies who have specific expertise that is relevant to the matter being addressed by this work group.
- Staff Support:
  1. Environmental Planning and Permitting Manager.
  2. Legal counsel on an as needed basis.
  3. Other specialty advisors or experts, including consultant team members on an as needed basis.
- Re-Adoption of Charter: June 17, 2020
- Expires: End of the Phase 2 Reservoir Project Agreement

Related Documents:

- Attachment A: Work Group Chartering Process, General Requirements

Purpose: To advise the Reservoir Committee on all environmental planning and permitting aspects of the development and implementation of pre-construction, construction, and mitigation actions for the Sites Reservoir Project.

Meeting Frequency: When either the Leader determines or the Reservoir Committee Chairperson requests that a potential issue exists to warrant convening the work group to develop a recommended resolution or response for the Reservoir Committee to then consider and act upon.

Work Group's Roles and Responsibilities:

- The primary focus of this work group is to review and provide input to:

    1. The Authority's adoption of CEQA Guidelines, revisions to those Guidelines, if any, and proposed environmental policies.

    2. The Authority's development, completion, and implementation of all environmental planning and permitting aspects of pre-construction, construction, environmental commitments, and mitigation actions for the Sites Reservoir Project.

       NOTE: The review of operations and engineering permits and approvals has been assigned to the Reservoir Operations and Engineering Work Group (e.g., Dam Safety, Traffic).

From: Jerry Brown [jbrown@sitesproject.org]
Sent: 6/17/2020 11:55:52 AM
To: Alicia Forsythe [aforsythe@sitesproject.org]
Subject: Re: Range of Alternatives for Sites Reservoir RDEIR/RDEIS

Thanks for this. I would like to see Jim's pros and cons on these studies (when you get them) and possibly talk to Jim. As I expected, these studies illustrate that flow in the river is important to fish, but they DO NOT establish specific flow amounts.

So Doug's "puffing" when he says we'll be challenged by scientifically sound operational criteria that have been defined by him. I get that Doug is pushing his interest which I respect. But in a truly collaborative world (as opposed to a warrior world, using Tim Quinn's terms) we would work as partners, as opposed to adversaries. I'd like us to make sure we are staying on the collaborative level which is what I see in your responses to date. Keep it up!

From: Alicia Forsythe <aforsythe@sitesproject.org>
Date: Tuesday, June 16, 2020 at 3:22 PM
To: Jerry Brown <jbrown@sitesproject.org>
Subject: RE: Range of Alternatives for Sites Reservoir RDEIR/RDEIS

Jerry – See the paper that Gary Bobker sent to us over the weekend for the NRDC, TBI's proposed criteria.

Attached are the following:

- 20191011_Topics for Oct Exec Team Meeting – This was prepare by Jim Lecky and is "unfiltered" – See the references to specific studies with regard to locations
- 20191014_Talking Points for Oct Exec Team Meeting – This was my shortening of Jim's document, trying to get at the heart of some of these issues for our members
- Perry et al – Relates to Freeport Flows and salmonid survival
- Michel and Henderson – Related to Wilkins Slough flows and salmonid survival

I cant find the Nobriga paper (NDOI) but will see if Jim Lecky has that. I thought Jim also did a longer write-up on the pros and cons with these studies, but I cant seem to locate that right now. I'll ask him for this.

Happy to set up a briefing on all of this if you think it would be helpful.

Ali

Alicia Forsythe | Environmental Planning and Permitting Manager | Sites Reservoir Project | 916.880.0676 |
aforsythe@sitesproject.org | www.SitesProject.org

CONFIDENTIALITY NOTICE: This communication with its contents may contain confidential and/or legally privileged information. It is solely for the use of the intended recipient(s). Unauthorized interception, review, use or disclosure is prohibited and may violate applicable laws including the Electronic Communications Privacy Act. If you are not the intended recipient, please contact the sender and destroy all copies of the communication.

From: Jerry Brown <jbrown@sitesproject.org>
Sent: Tuesday, June 16, 2020 2:54 PM
To: Alicia Forsythe <aforsythe@sitesproject.org>
Subject: Re: Range of Alternatives for Sites Reservoir RDEIR/RDEIS

Can you provide me with a copy of the technical paper Doug is referring to when he says "scientifically sound" operational criteria? I assume there must be some in depth studies that we need to be aware of.

From: "Obegi, Doug" <dobegi@nrdc.org>
Date: Tuesday, June 16, 2020 at 1:08 PM
To: Alicia Forsythe <aforsythe@sitesproject.org>
Cc: Jerry Brown <jbrown@sitesproject.org>
Subject: RE: Range of Alternatives for Sites Reservoir RDEIR/RDEIS

Thanks Ali.

I suspect the project is going to have some serious challenges, if scientifically sound operational criteria make the project infeasible from the proponents' perspective.

From: Alicia Forsythe <aforsythe@sitesproject.org>
Sent: Tuesday, June 16, 2020 11:30 AM
To: Obegi, Doug <dobegi@nrdc.org>
Cc: Jerry Brown <jbrown@sitesproject.org>
Subject: RE: Range of Alternatives for Sites Reservoir RDEIR/RDEIS

Doug – The initial alternatives in the June packet are very preliminary. We're really just beginning the development of alternatives but want to make sure we update the Board on some of our initial thoughts and ideas. We expect to come back to the Board in September with a more complete project description, including possible changes to what we are proposing this week. The door isn't even close to being shut and we have a ways to go.

We will have Jacobs conduct an analysis of at least one set of operational criteria that are similar to (or the same as) what you have proposed. We will work with you, TBI, and others to confirm these criteria before we model them. This analysis will be in the Revised Draft EIR/EIS. However, based on analyses we completed last summer / fall, we expect these criteria to result in a project that's not affordable and provides very little water to accomplish the project objectives. Thus, we don't anticipate that this will result in an alternative that we would carry forward for detailed analysis in the Revised EIR as we don't anticipate it to result in a feasible project.

We have yet to "finalize" operational criteria for the project and continue to work on these and refinements to the model. So we may have more than one operational criteria, but we haven't yet made it far enough along to determine that. We will also complete the analysis described above early in the process – once we get the model refinements completed – so if my assumption is wrong here, we will have time to include it as a full alternative in the document.

The door isn't closed to adding in an alternative with different operational criteria – and we will complete the analysis you've requested. From the work we did last summer / fall, we just expect that the operational criteria proposed by NRDC won't result in a feasible project.

Ali

Alicia Forsythe | Environmental Planning and Permitting Manager | Sites Reservoir Project | 916.880.0676 | aforsythe@sitesproject.org | www.SitesProject.org

CONFIDENTIALITY NOTICE: This communication with its contents may contain confidential and/or legally privileged information. It is solely for the use of the intended recipient(s). Unauthorized interception, review, use or disclosure is prohibited and may violate applicable laws including the Electronic Communications Privacy Act. If you are not the intended recipient, please contact the sender and destroy all copies of the communication.

From: Obegi, Doug <dobegi@nrdc.org>
Sent: Monday, June 15, 2020 2:23 PM
To: Alicia Forsythe <aforsythe@sitesproject.org>; Jerry Brown <jbrown@sitesproject.org>
Subject: Range of Alternatives for Sites Reservoir RDEIR/RDEIS

Hi Jerry and Ali,

I hope you're both doing ok these days. I wanted to check in briefly because I was reviewing the meeting material for the upcoming Reservoir Committee meeting, and the attachments seem to suggest that the revised/recirculated draft EIR/EIS would only consider one operational criteria for the action alternatives in the document. Are y'all seriously planning to only review one operational criteria in the revised EIR/EIS?

https://3hm5en24txyp2e4cxyxaklbs-wpengine.netdna-ssl.com/wp-content/uploads/2019/11/03-03-Proposed-Objectives-and-Alternatives-for-the-Revised-EIR_EIS.pdf

That's certainly not the approach that I took away from our prior conversation, where we discussed how the revised recirculated DEIR/DEIS would consider a range of operational criteria that included at least one set of operational criteria that were more protective than what you proposed (and potentially similar to what we've proposed). It also seems to run afoul of CEQA's requirement to consider a reasonable range of alternatives.

Hopefully I'm misunderstanding the Board materials. In any event I would strongly urge you to ensure that the CEQA/NEPA documents analyze more than 1 operational scenario for the action alternatives that are considered, including an alternative that proposes operations that are significantly more protective than what you shared with me in our last conversation.

Thanks,
Doug

DOUG OBEGI
*Senior Attorney**
Water Program

**NATURAL RESOURCES
DEFENSE COUNCIL**
111 SUTTER ST., 21ST FLOOR
SAN FRANCISCO, CA 94104
T 415.875.6100
DOBEGI@NRDC.ORG
NRDC.ORG

Please save paper.
Think before printing.

** Admitted to practice in California*

From: Spranza, John [John.Spranza@hdrinc.com]
Sent: 6/17/2020 1:23:21 PM
To: Alicia Forsythe [aforsythe@sitesproject.org]
Subject: FW: CDFW Sites Debrief/Planning Discussion
Attachments: Pages from DRAFT_Sites_DFW_Delta_06252019.pdf; Maunder_et_al_2015_Use of state-space population dynamics models in hypo....pdf; Maunder_et_al_2015_Use of state-space population dynamics models in hypothesis testing_longfin smelt_Fish_Res_suppl_mat.docx

Jerry may find this interesting as well.

John Spranza

D 916.679.8858 M 818.640.2487

From: Greenwood, Marin [mailto:Marin.Greenwood@icf.com]
Sent: Wednesday, July 17, 2019 2:27 PM
To: Briard, Monique <Monique.Briard@icf.com>; rthomson@sitesproject.org; Spranza, John <John.Spranza@hdrinc.com>; Grimaldo, Lenny <Lenny.Grimaldo@icf.com>; Lecky, Jim <Jim.Lecky@icf.com>; Tull, Robert/SAC <Robert.Tull@jacobs.com>; Chris Fitzer (cfitzer@esassoc.com) <cfitzer@esassoc.com>; Aforsythe@sitesproject.org
Subject: RE: CDFW Sites Debrief/Planning Discussion

Hello all: in advance of tomorrow's debrief call, I wanted to just let you know of a couple of thoughts related to the exploratory modeling exercise that DFW requested at yesterday's meetings. I think such explorations are very important to give perspective on the potential for the project to accommodate flow criteria. I'd like to summarize a couple of issues regarding the rationale for a couple of aspects, with italics below from the document provided by DFW (<Sites 7-16-2019 Workshop - CDFW Operational Scenario.docx>):

- *Bypass flow > 10,000 cfs at Wilkins Slough prior to Sites diversions – functional fish flow (Matt Johnson CDFW in conjunction with NMFS SW Science Center pers. comm.)*
- Matt Johnson provided no specific supporting materials for this at yesterday's meeting—we would like to see such materials to inform considerations
- *35,000 cfs inflow at Freeport prior to Sites diversions – functional fish flow (NMFS CWF BO 2017 Appendix E, CDFW CWF ITP 2017, Flow-mediated effects on travel time, routing, and survival of juvenile Chinook salmon in a spatially complex, tidally forced river delta, Perry et al 2018)*
- Recall that we used the Perry et al (2018) model for the Delta effects portion of the admin draft BA, and that it showed only a small potential negative under DCR 2015 With vs. Without Project scenarios (see attached excerpt from my ppt presented to DFW on 6/26/2019)
- Be aware that the 35,000-cfs criterion cited in the DFW ITP for California WaterFix is not an on-off ability to divert, it is the ability to divert more than just low-level diversions (where low-level diversions = 300 cfs per each of 3 intakes, or 900 cfs total) during a pulse protection period; see https://www.waterboards.ca.gov/waterrights/water_issues/programs/bay_delta/california_waterfix/exhibits/exhibit107/docs/CWF_ITP_final#page=191.pdf
- *NDOI outflow index > 44,500 cfs – functional fish flow longfin smelt (CDFW CWF ITP 2017, Population Dynamics of an Estuarine Forage Fish: Disaggregating Forces Driving Long-Term Decline of Longfin Smelt in California's San Francisco Estuary, Nobriga and Rosenfield 2016)*
- The DFW ITP for California WaterFix had sliding scale Delta outflow requirements depending on 8-river runoff index; see p.185-187

https://www.waterboards.ca.gov/waterrights/water_issues/programs/bay_delta/california_waterfix/exhibits/exhibit107/docs/CWF_ITP_final#page=185.pdf

- Nobriga and Rosenfield (2016) does not provide a rationale for 44,500 cfs; that threshold arose from an unpublished analysis, as I testified in the California WaterFix hearings in response to questions from Mr Obegi of NRDC: https://www.waterboards.ca.gov/waterrights/water_issues/programs/bay_delta/california_waterfix/docs/transcripts/20180228_cwfpethearing#page=216.pdf
- DFW indicated at yesterday's meeting that consideration of criteria related to Delta outflow is based partly on the Kimmerer et al. papers showing linear correlations between Longfin Smelt abundance indices and X2; these papers do not provide a threshold value of Delta outflow
- Maunder et al. (2015), as documented in their Supplemental Table 1, did not find support for a 44,500-cfs flow threshold in their Longfin Smelt life cycle analysis relative to other flow-based covariates (see attached paper and Supplemental Table 1)

Please let me know if you have questions.

MARIN GREENWOOD | marin.greenwood@icf.com | **ICF** | +1.530.400.8081 mobile

-----Original Appointment-----
From: Briard, Monique
Sent: Tuesday, June 4, 2019 12:59 PM
To: Briard, Monique; rthomson@sitesproject.org; John Spranza (Jo hn.Spranza@hdrinc.com); Grimaldo, Lenny; Greenwood, Marin; Lecky, Jim; Tull, Robert/SAC; Chris Fitzer (cfitzer@esassoc.com); Aforsythe@sitesproject.org
Subject: CDFW Sites Debrief/Planning Discussion
When: Thursday, July 18, 2019 11:00 AM-11:30 AM (UTC-08:00) Pacific Time (US & Canada).
Where: Skype Meeting

Juvenile Chinook Salmon Through-Delta Survival: Summary

	Winter-Run			Late Fall-Run		
WYT	**Without**	**With**	**With vs. Without**	**Without**	**With**	**With vs. Without**
W	0.60	0.59	0.00 (-1%)	0.44	0.44	0.00 (0%)
AN	0.55	0.54	-0.01 (-1%)	0.38	0.38	0.00 (1%)
BN	0.49	0.48	-0.01 (-2%)	0.37	0.37	0.00 (1%)
D	0.46	0.45	-0.01 (-2%)	0.35	0.35	0.00 (1%)
C	0.41	0.41	0.00 (-1%)	0.31	0.32	0.01 (2%)

	Fall-Run			Spring-Run		
WYT	**Without**	**With**	**With vs. Without**	**Without**	**With**	**With vs. Without**
W	0.54	0.54	0.00 (0%)	0.57	0.57	0.00 (0%)
AN	0.48	0.48	0.00 (0%)	0.53	0.52	-0.01 (-1%)
BN	0.43	0.43	0.00 (-1%)	0.46	0.46	-0.01 (-1%)
D	0.40	0.40	0.00 (0%)	0.43	0.42	0.00 (-1%)
C	0.37	0.37	0.00 (0%)	0.39	0.39	0.00 (0%)

Fisheries Research 164 (2015) 102–111

Contents lists available at ScienceDirect

Fisheries Research

journal homepage: www.elsevier.com/locate/fishres

Use of state-space population dynamics models in hypothesis testing: advantages over simple log-linear regressions for modeling survival, illustrated with application to longfin smelt (*Spirinchus thaleichthys*)

Mark N. Maunder[a,b,*], Richard B. Deriso[b], Charles H. Hanson[c]

[a] *Quantitative Resource Assessment LLC, San Diego, CA 92129, USA*
[b] *Inter-American Tropical Tuna Commission, 8901 La Jolla Shores Drive, La Jolla, CA 92037-1508, USA*
[c] *Hanson Environmental, Inc., 446 Green View Court, Walnut Creek, CA 94596, USA*

ARTICLE INFO

Article history:
Received 28 April 2014
Received in revised form 22 October 2014
Accepted 27 October 2014
Handling Editor A.E. Punt

Keywords:
Data assimilation
Longfin smelt
Population dynamics
Random effects
State-space model
Survival

ABSTRACT

Factors impacting the survival of individuals between two life stages have traditionally been evaluated using log-linear regression of the ratio of abundance estimates for the two stages. These analyses require simplifying assumptions that may impact the results of hypothesis tests and subsequent conclusions about the factors impacting survival. Modern statistical methods can reduce the dependence of analyses on these simplifying assumptions. State-space models and the related concept of random effects allow the modeling of both process and observation error. Nonlinear models and associated estimation techniques allow for flexibility in the system model, including density dependence, and in error structure. Population dynamics models link information from one stage to the next and over multiple time periods and automatically accommodate missing observations. We investigate the impact of observation error, density dependence, population dynamics, and data for multiple stages on hypothesis testing using data for longfin smelt in the San Francisco Bay-Delta.

© 2014 The Authors. Published by Elsevier B.V. This is an open access article under the CC BY-NC-SA license (http://creativecommons.org/licenses/by-nc-sa/3.0/).

1. Introduction

Estimation of survival, and the factors influencing survival, are vital in the research, and to the management, of natural resources. Survival is a critical component of methods used to determine sustainable yields of harvested resources (Quinn and Deriso, 1999). Managers need to know the most influential factors affecting the survival of endangered species to focus limited financial resources on research and management actions that obtain the most benefit. Anthropogenic effects have to be separated from natural impacts to determine the relative importance of restricting human activities (e.g. Deriso et al., 2008).

Survival can be estimated using a number of approaches ranging from field studies such as following individuals using radio tracking and determining their fate (White and Garrott, 1990; Skalski et al., 2010) to sophisticated statistical state-space population dynamics models that integrate multiple data types (Besbeas et al., 2003; Maunder, 2004; Schaub and Abadi, 2010). Facilitated by the availability of time series of relative abundance, log-linear modeling of the ratio of relative abundance in two life stages is a common approach to estimate relative survival and evaluate the support for different hypotheses about the factors influencing survival (e.g. Miller et al., 2012). Log-linear modeling is used because it is conveniently implemented in traditional software packages as a linear equation. However, it restricts the analysis to a subset of models that are not necessarily the most appropriate for the particular application. Log-linear modeling also aggregates process and observation error into a single term, limiting the ability to fully characterize uncertainty. Modern nonlinear modeling software such as BUGS (Lunn et al., 2009) and AD Model Builder (Fournier et al., 2012) expand the modeling options outside those covered by "fixed effects" log-linear models, allowing flexibility in model and error structure (Bolker et al., 2013).

Correctly dealing with both observation and process error is important for hypothesis testing and evaluating the data-based support for alternative hypotheses (Maunder and Watters, 2003; Deriso et al., 2008). Process error (also known as process noise or

---

[*] Corresponding author at: Inter-American Tropical Tuna Commission, 8901 La JollaShores Drive, La Jolla, CA 92037-1508, USA. Tel.: +1 858 546 7027..
E-mail addresses: mmaunder@iattc.org (M.N. Maunder), rderiso@iattc.org (R.B. Deriso), chanson@hansonenv.com (C.H. Hanson).

http://dx.doi.org/10.1016/j.fishres.2014.10.017
0165-7836/© 2014 The Authors. Published by Elsevier B.V. This is an open access article under the CC BY-NC-SA license (http://creativecommons.org/licenses/by-nc-sa/3.0/).

process variability) generally refers to stochasticity in population dynamics (but can also relate to model structure misspecification) and is hence parameterized as "random effects", and observation error refers to inaccuracy in observations (de Valpine, 2003).

One approach for dealing with both observation and process error is to ignore one or the other entirely. Polacheck et al. (1993) found that ignoring process error (an observation error estimator) was superior to ignoring observation error (a process error estimator) when estimating the parameters of a simple population dynamics model, but they did not evaluate which choice was best for hypothesis testing. Ignoring process error biases likelihood ratio and Akaike information criterion (AIC; Akaike, 1973) based tests towards incorrectly accepting covariates (Maunder and Watters, 2003). Other tests such as analysis of deviance (Skalski, 1996) or randomization tests (Edgington, 1987; Deriso et al., 2008) can be used, but they are less elegant and impractical in some situations. An alternative approach is to include both process and observation error, but assume the ratio of the variances between these two sources of variation is known (e.g. Walters and Ludwig, 1981) or that one of the variances is known (e.g. Maunder and Watters, 2003). Incorrectly specifying the variance terms can bias hypothesis tests (Deriso et al., 2007).

The preferred approach is to use state-space models (e.g. Schnute, 1994; Newman, 1998; de Valpine, 2002; Buckland et al., 2004, 2007; Maunder and Deriso, 2011) that allow the estimation of the both observation and process error variances. It should be noted that state-space models are often described as random effect, hierarchical, or Bayesian models. de Valpine and Hastings (2002) found that state-space models led to lower bias and often lower variance estimates than least squares estimators that ignore either process noise or observation error. Traditionally, state-space models have been used to model demographic variability such as the binomial probability of individuals surviving given an average survival rate (Dupont, 1983; Besbeas et al., 2002). However, demographic variability is typically overwhelmed by environmental variability (Buckland et al., 2007), so environmental variability is often modeled instead of demographic variability or in addition to demographic variability (e.g. Rivot et al., 2004; Newman and Lindley, 2006). Nonlinear, non-Gaussian state-space models generally require computationally intensive high dimensional integrals that have no closed form solution (de Valpine, 2003). The implementation of state-space models in a Bayesian framework has been facilitated by the development of Markov chain Monte Carlo (MCMC) methods (Punt and Hilborn, 1997; Newman et al., 2009; Lunn et al., 2009). MCMC methods have also been adapted to implement state-space models in a classical framework (Lele et al., 2007). Alternatively, the Laplace approximation (Skaug, 2002; Skaug and Fournier, 2006) or importance sampling (Maunder and Deriso, 2003) can be used to implement the integration in a classical framework. Modern nonlinear modeling software packages such as BUGS and AD Model Builder have made state-space models practical for many applications (Bolker et al., 2013).

Log-linear models, such as generalized linear models, analysis of variance (ANOVA), and related statistical methods, do not incorporate demographic relationships between abundances through time (de Valpine, 2003). In contrast, lifecycle models link life-stages and time periods using population dynamics propagating information and uncertainty (Buckland et al., 2007; Maunder and Deriso, 2011). This link allows information related to one life-stage to inform processes influencing other life-stages and is particularly important when data are not available for all life stages for all time periods. Hypotheses that are difficult to consider with ANOVA and related methods can be simple to express using a population dynamics model (de Valpine, 2003). de Valpine (2003) found that a population dynamics model had much higher statistical power than ANOVA, and provided greater biological insight. Even approximately correct population dynamics models had higher power than omitting demographic structure, but the rate at which Type I error occurs may increase, or the power might be reduced as the model structure becomes more incorrect (de Valpine, 2003).

Hypothesis testing is an essential part of statistical analysis and is particularly important when evaluating factors that are impacting survival. When we refer to hypothesis testing, we are more generally referring to the evaluation of the data based support for alternative configurations of a model, where each configuration could represent an alternative hypothesis. This approach is often termed model selection to differentiate it from traditional hypothesis testing that involves the rejection of a null hypothesis (Johnson and Omland, 2004). Hypothesis testing can easily become complex when analysing population dynamics because of the many factors operating on different stages under the presence of density dependence. Deriso et al. (2008) present a framework for evaluating alternative factors influencing survival, and Maunder and Deriso (2011) extended the framework to include density dependence in survival. The first step is to identify the factors to be considered, including the life stages that are impacted by each factor and where density dependence occurs. Next, a model should be developed to include these factors. Then hypothesis tests should be conducted to determine which factors are important. Finally, impact analysis (Wang et al., 2009; Maunder and Deriso, 2011) should be conducted to determine the impact of the factors on quantities useful for management.

Density dependence is an important factor in the dynamics of many populations (Brook and Bradshaw, 2006) and can occur in multiple life stages (e.g. Ciannelli et al., 2004). It is important to consider density dependence when carrying out model selection because it can modify the impact of factors (Rose et al., 2001; Maunder and Deriso, 2011). Environmental conditions can also have a large impact on population dynamics. Environmental factors can directly affect survival through processes such as temperature tolerance or can interact with density dependence through affecting density limiting processes such as habitat or prey availability. Environmental factors and density dependence have been identified as impacting population dynamics in numerous studies either independently or in combination (e.g. Sæther, 1997; Brook and Bradshaw, 2006; Ciannelli et al., 2004; Deriso et al., 2008; Maunder and Deriso, 2011). Density dependence can easily be integrated into state-space models (e.g. de Valpine and Hastings, 2002; Maunder and Deriso, 2011).

Data from longfin smelt (*Spirinchus thaleichthys*) in the San Francisco Bay-Delta are used to illustrate the development and advantages of using state-space population dynamics models over simple log-linear regressions for modeling survival. The models are implemented in AD Model Builder using the Laplace approximation for random effects (Skaug and Fournier, 2006) under a classical (frequentist) framework. Longfin smelt is of conservation concern because it is exposed to a variety of anthropogenic factors (e.g. habitat modification, sewage outflow, farm runoff, and water diversions) and survey data have shown a decline in abundance. Longfin smelt was listed as threatened under the California Endangered Species Act in 2009. The U.S. Fish and Wildlife Service also evaluated the status of the Bay-Delta longfin smelt population and concluded in 2012 that although the species warranted protection under the federal Endangered Species Act, staff limitations precluded listing the species as of that time. Several other species in the San Francisco Estuary have also experienced declines (e.g., Bennett, 2005; Sommer et al., 2007; Mac Nally et al., 2010; Thomson et al., 2010; Maunder and Deriso, 2011), but the declines have yet to be fully explained.

2. Theory

State-space models appropriately accommodate both observation and process error. de Valpine (2002, 2003) provides a useful description of state-space models in the context of population dynamics models. Here we illustrate state-space models using a simple population dynamics model where the abundance in the next time period is simply those that survive from the previous time period:

$$E[X_{t+1}|X_t] = \mu_s X_t \tag{1}$$

where X_t is the number of individuals at time t, which are the states; and μ_s is the mean survival rate. The observations of the population are estimates of absolute abundance and the sampling variation in these estimates is assumed to be normally distributed:

$$Y_t \sim N(X_t, \sigma^2) \tag{2}$$

where Y_t is the estimate of absolute abundance at time t and σ^2 is the sampling variance.

State-space population dynamics models have three main components: (1) states ($\boldsymbol{X}$), (2) parameters ($\boldsymbol{\theta}$), and (3) observations ($\boldsymbol{Y}$). The states represent the population such as the abundance in a life stage at a given time. The parameters describe the average (or sometimes the exact) relationship (transition) between the states (e.g. the average survival rate), but also include the initial state (e.g. X_1) and the variance parameters (e.g. σ). The observations are measurements of the states, or some function of the states. The states and parameters are unknown and they, or a function of them, are the quantities of interest. The observations, which are known, are used to provide information about the states and parameters. Observations are generally not a census of the population, but a sample of the population and therefore contain sampling error (e.g. if a line transect or trawl survey is used to estimate the abundance of a population). This sampling error is the observation error and is generally represented by the likelihood function. In other words, the observation is known, but there is uncertainty in how the observation relates to the true abundance. There may also be additional observation error over and above the sampling variability, but for illustrative purposes we ignore this.

In traditional maximum likelihood estimation, the parameters of the model are estimated by finding the parameter values that, conditional on these values, give the highest probability (likelihood) that the observations came from the model. Since the states ($\boldsymbol{X}$) are a direct function of the parameters ($\boldsymbol{\theta}$), for known observations and given parameter values, the probability function described in Eq. (2) can be evaluated and maximized. To better illustrate state-space models, let

$$f(\boldsymbol{\theta}, \boldsymbol{Y}) = f(\boldsymbol{X}, \boldsymbol{Y}) \tag{3}$$

be the joint distribution of the data and parameters, since the parameters determine the states, and

$$f_{\theta}(\boldsymbol{Y}), \tag{4}$$

be the likelihood function evaluated at the parameter values $\boldsymbol{\theta}$. Traditional maximum likelihood assumes that there is a single true value for each parameter. State-space population dynamics models implicitly assume that the values of the parameters representing some population processes may change over time. This is the process error. Before describing state-space models, consider the survival in each time period as a separate model parameter s_t:

$$E[X_{t+1}|X_t] = s_t X_t \tag{5}$$

In this case, the likelihood function can be denoted $f_{\theta,s}(\boldsymbol{Y})$, and traditional maximum likelihood assumes that there is a single true value for survival probability in each time period and for the other model parameters (note that the average survival parameter is replaced with a set of survival parameters, one for each time period) and the survival parameters are estimated along with the other model parameters by maximizing the likelihood function. However, there is now one survival parameter for each observation and each survival will be estimated to exactly match the observation. No other parameters can be estimated (e.g. the observation error variance), and the process error cannot be separated from the observation error.

Intuitively, the estimation procedure could be improved by adding information based on the form of the process error probability distribution (e.g. if the temporal variability in survival is known to be low, a survival parameter in one time period that is very different from the survival in the other time periods is unlikely) and can be conceptualized as placing an informative prior, in the Bayesian sense, on the process error (except that the mean and variance of the prior are unknown) (e.g. $s_t = \mu_s \exp(\varepsilon_t)$, where $\varepsilon_t \sim N(0, \nu^2)$, which parallels the random effects approach in generalized linear mixed models (GLMMs), or in alternative notation $\ln(X_{t+1}) \sim N(\ln(\mu_s X_t), \nu^2)$). In this case, $f_{\boldsymbol{\theta},\boldsymbol{s}}(\boldsymbol{Y}) = f(\boldsymbol{Y}|\boldsymbol{s}, \boldsymbol{\theta}) f(\boldsymbol{s}|\boldsymbol{\theta}) = f(\boldsymbol{Y}|\boldsymbol{\varepsilon}, \boldsymbol{\theta}) f(\boldsymbol{\varepsilon}|\boldsymbol{\theta})$, where $f(\boldsymbol{\varepsilon}|\boldsymbol{\theta})$ is the process error probability distribution, and the resulting likelihood is often referred to as a penalized likelihood. The penalized likelihood combines the sampling probability distribution of the observations with the probability distribution of the states (recall that the parameters determine the state and similarly the process error probability distribution also defines the state probability distribution). These methods estimate the process errors (or states) along with the other model parameters while maximizing the joint probability distribution of the process error and the observations. However, the MLE of the process error variance is not statistically consistent (Seber and Wild, 1989) and the likelihood function is degenerative towards zero variance (Maunder and Deriso, 2003). There is often a negatively biased local maximum that has been used for inference, but the global maximum is at zero process error variance (Maunder and Deriso, 2003).

The process error variance will decrease as covariates are added and therefore the process variance should be reduced, which can only be practically achieved if the process variance is estimated. In contrast to penalized maximum likelihood, state-space models treat the process error (or states) as random variables rather than as parameters and when the process error is integrated out they produce a marginal likelihood or "true likelihood" function that is used for inference (e.g. Eq. (4) becomes $\int f_{\boldsymbol{\theta}}(\boldsymbol{Y}, \boldsymbol{\varepsilon}) d\boldsymbol{\varepsilon}$ or equivalently $\int f_{\boldsymbol{\theta}}(\boldsymbol{Y}, \boldsymbol{X}) d\boldsymbol{X}$). Intuitively, this can be thought of as summing up the likelihood of the observations for each possible state weighted by the probability of that state (conditioned on the parameter values). Each possible survival will lead to different population abundance (state). Hence, the derivation of "state-space", which refers to the whole range of possible trajectories through time of the population states (de Valpine, 2002). Integrating out the process error takes advantage of properties of random variables (e.g. the marginal distribution), which has the advantage that it provides a consistent non-degenerative MLE for the process error variance.

Pawitan (2003) appropriately summarizes state-space models/random effects as a convenient way to deal with many parameters. In a Bayesian framework (Punt and Hilborn, 1997), parameters are also treated as random variables and integrated out (e.g. Eq. (4) becomes $\int\int f(\boldsymbol{Y}, \boldsymbol{\theta}, \boldsymbol{\varepsilon}) d\boldsymbol{\varepsilon} d\boldsymbol{\varphi}$ or equivalently $\int\int f(\boldsymbol{Y}, \boldsymbol{\theta}, \boldsymbol{X}) d\boldsymbol{X} d\boldsymbol{\varphi}$, where $\boldsymbol{\varphi}$ are the parameters that are not of interest) and the probability distribution is used for inference rather than the likelihood function. One advantage of the state-space modeling approach over penalized maximum likelihood is that the marginal likelihood is consistent with AIC theory, which can be used for hypothesis testing and model selection.

3. Methods

3.1. Models

3.1.1. Log-linear regression

A common approach to model survival from one life-stage to the next as a function of explanatory variables is a log-linear regression (Christensen, 1997) of the numbers in the second stage as a ratio of those in the first stage (e.g. Miller et al., 2012). A typical analysis models the reproductive output from adults (A_t) to the surviving juveniles in the next year (J_{t+1}) as:

$$\ln(J_{t+1}/A_t) \sim N(\alpha + \boldsymbol{\beta} I_t, \sigma^2) \tag{6}$$

or equivalently in a different notation (the former notation is commonly used to describe state-space models and the latter notation commonly used to describe random effect models and can be a more useful description (de Valpine, 2003)).

$$\ln(J_{t+1}/A_t) = \alpha + \boldsymbol{\beta I_t} + \varepsilon_t \tag{7}$$

where $\varepsilon_t \sim N(0, \sigma^2)$, N represents a normal distribution, α and $\boldsymbol{\beta}$ are parameters of the linear model, $\boldsymbol{I}_t$ is a matrix of covariates (forcing functions), and σ^2 is the variance of the error. The observations are often only an index of relative abundance related to the absolute abundance by a constant q, often called catchability in the fisheries literature, such that

$$\ln(q_J J_{t+1}/q_A A_t) = \alpha + \boldsymbol{\beta I_t} + \varepsilon_t \tag{8}$$

so unless $q_J = q_A$, α no longer relates to survival (it also includes reproductive output in our example), but a combination of survival and differences in catchability. However, this does not influence hypothesis tests related to the covariates as long as the q's are constant through time or their temporal variation is random and independent of the covariates.

The parameters can be estimated by maximizing the likelihood based on the assumed error distribution (Eq. (8)). The likelihood function is typically used to represent observation error. However, ε in Eq. (8) includes both process and observation error and ε describes the unexplained variation (process error) in the modeled relationship if J and A are known without error. If J and A are known with error (multiplicative and log-normal):

$$\ln\left(\left(J_{t+1}\exp(\varepsilon_{J,t+1})\right) / \left(A_t \exp(\varepsilon_{A,t})\right)\right) = \alpha + \boldsymbol{\beta I_t} + \varepsilon_t \tag{9}$$

where $\varepsilon_{A,t} \sim N(0, \sigma^2_{A,t})$, $\varepsilon_{J,t+1} \sim N\left(0, \sigma^2_{J,t+1}\right)$,
such that

$$\ln(J_{t+1}/A_t) = \alpha + \boldsymbol{\beta I_t} + \varepsilon_t - \varepsilon_{J,t+1} + \varepsilon_{A,t} \tag{10}$$

illustrating that Eqs. (6) and (7) combine process error and observation error from both measures of abundance into a single error term $\varepsilon_t \sim N(0, \sigma^2_{J,t} + \sigma^2_{A,t+1} + \sigma^2_\varepsilon)$.

Often an estimate of the sampling precision of each observation is available (hence the time subscript on the variance terms), which eliminates the need to estimate the observation error variance, but this is generally not the case for the process error. Ignoring observation error may bias the results if the observation error variance differs substantially among observations.

3.1.2. Alternative formulation

The log-linear regression is deterministically equivalent and, depending on assumptions, stochastically equivalent to an exponential growth model. The log-linear model assumes that the unexplained variation in the log of the abundance ratios is normally distributed while the exponential growth model assumes that the unexplained variation in the abundance in the second stage is log-normally distributed

$$J_{t+1} = \acute{\alpha} A_t \exp(\boldsymbol{\beta I_t} + \varepsilon_t) \tag{11}$$

where $\acute{\alpha} = \exp(\alpha)$

3.1.3. State-space model

State-space models can be used to include both observation and process error. Non-linear state-space models are flexible in representing process and observation error. Eq. (6) assumes log-normal multiplicative error for both the observation and process error with constant variance. The log-normal assumption as implemented in Eq. (6) will provide an unbiased estimate of α, but the quantity of interest $\acute{\alpha} = \exp(\alpha)$ will be biased such that the expected value of $E[\acute{\alpha}] = \exp(\alpha + 0.5\sigma^2)$ (Maunder and Deriso, 2011). Eq. (11) could be modified to account for the bias

$$J_{t+1} = \acute{\alpha} A_t \exp(\boldsymbol{\beta I_t} + \varepsilon_t - 0.5\sigma^2) \tag{12}$$

Similarly, the likelihood and random effects can be modified to deal with the log-normal bias correction. This may be particularly important when the observations have different variances, resulting in different bias correction factors for each time period. The distribution for the process and observation error need not be normal. For example, the process error may be log-normal, while the observation error might be normal.

3.1.4. Density dependence

Population regulation is controlled by both density-independent and density-dependent factors. The log-linear regression typically includes covariates representing density-independent factors (e.g. the environment). Density dependence can be included in the log-linear regression by adding additional terms related to abundance into the regression. The Ricker model (Ricker, 1954)

$$J_{t+1} = \acute{\alpha} A_t \exp(-bA_t + \boldsymbol{\beta I_t} + \varepsilon_t) \tag{13}$$

is often used because it can be linearized by taking the natural logarithm and implemented using multiple linear regression.

$$\ln(J_{t+1}) = \alpha + \ln(A_t) - bA_t + \boldsymbol{\beta I_t} + \varepsilon_t \tag{14}$$

where $\alpha = \ln(\acute{\alpha})$. However, the Beverton–Holt model (Beverton and Holt, 1957) may be applicable for some populations, but is non-linear:

$$J_{t+1} = \frac{\acute{\alpha} A_t}{1 + bA_t} \exp(\boldsymbol{\beta I_t} + \varepsilon_t) \tag{15}$$

The models are derived based on solving the differential equation for abundance where mortality is a linear function of the cohort abundance and initial abundance for the Beverton–Holt and Ricker models, respectively. The Beverton–Holt model has asymptotic properties, which represent processes such intra-cohort competition, while the Ricker model produces lower abundance from high initial abundance, which represents processes such as cannibalism when used in a stock-recruitment context.

3.1.5. State-space population dynamics (life cycle) model

The log-linear regression only models survival from one stage to the next. A sequence of separate log-linear regressions can be used to model the survival between each stage. However this does not link information among stages, which can be useful particularly if there is substantial error in the estimates of abundance or if there are missing abundance estimates. In the case where adults are a

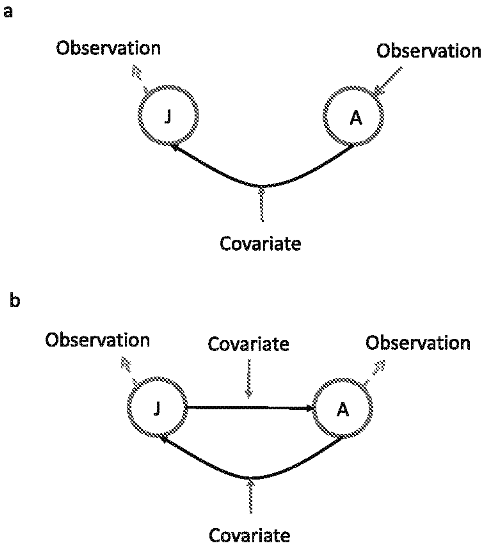


Fig. 1. Conceptual diagram illustrating the differences between (a) the exponential model representation of the log-linear regression and (b) the full state-space population dynamics model. The shaded (red) solid arrows represent forcing functions and the dashed arrows represent predictions of the observations used in the likelihood functions. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

year older than juveniles and the juveniles are measured the year after spawning:

$$J_{t+1} = \frac{\alpha'_J A_t}{1 + b_J A_t}\exp(\boldsymbol{\beta_J I_t} + \varepsilon_{J,t}) \tag{16}$$

$$A_{t+1} = \frac{\alpha'_A J_t}{1 + b_A J_t}\exp(\boldsymbol{\beta_A I_t} + \varepsilon_{A,t}) \tag{17}$$

where the process errors $\varepsilon_A \sim N(0, \sigma^2_{\in,A})$ and $\varepsilon_J \sim N(0, \sigma^2_{\in,J})$ are treated as random effects and the observation errors $N(\ln(J), \sigma^2_J)$ and $N(\ln(A), \sigma^2_A)$ are implemented using likelihoods.

The initial condition for the population dynamics model, which are the abundances in the first time period for juveniles, J_1, and adults, A_1, have to be estimated as parameters in addition to the parameters of the two Beverton–Holt models, the covariate coefficients, and the standard deviations of the random effects. Fig. 1 illustrates the difference between the exponential model representation of the log-linear regression and the state-space population dynamics model.

3.2. Hypothesis testing and model selection

Various methods can be used for hypothesis testing and evaluating the data-based evidence of support for alternative hypotheses, or, perhaps more accurately, evaluating the measure of evidence from data about alternative models (Hilborn and Mangel, 1997; Hobbs and Hilborn, 2006). The influence of a covariate can be eliminated from the model by fixing its value at zero. This produces a nested model, and model selection can be conducted using likelihood ratio tests. The likelihood ratio test is not appropriate for non-nested models. For example, when comparing between two models that include different covariates or two different density dependence assumptions. In this case, information theory-based methods such as the Akaike information criterion (AIC; Akaike, 1973) are appropriate. They are also appropriate for nested models. We use the AIC adjusted for small sample size (AIC$_C$) (Burnham and Anderson, 2002)

$$AIC_c = -2\ln L + 2K + \frac{2K(K+1)}{n-K-1} \tag{18}$$

where L is the likelihood function evaluated at its maximum, K is the number of estimated parameters, and n is the number of observations. The difference between a given model and the model with the lowest AIC$_C$ value, Δ, is used for comparing models. For model comparison, Burnham and Anderson (1998) recommend: "For any model with $\Delta \le 2$ there is no credible evidence that the model should be ruled out ... For a model with $2 \le \Delta \le 4$ there is weak evidence that the model is not the K–L [Kullback–Leibler] best model. If a model has $4 \le \Delta \le 7$ there is definite evidence that the model is not the K–L best model, and if $7 \le \Delta \le 10$, there is strong evidence that the model is not the K–L best model. Finally, if $\Delta > 10$, there is very strong evidence that the model is not the K–L best model."

3.3. Application

Data from longfin smelt in the San Francisco Bay-Delta from 1980 to 2009 are used to show the development and advantages of using state-space population dynamics models over simple log-linear regressions for modeling survival. We implement a range of models to determine the difference between the modeling approaches (Table 1). A conceptual model of the San Francisco Bay longfin smelt population (e.g., Rosenfield and Baxter, 2007; Baxter et al., 2008) [1] was used as a basis for identifying potential environmental covariates considered in the models. The covariates reflected various geographic regions of the estuary and seasonal periods based on the life history and seasonality of each lifestage of longfin smelt. A total of 36 potential covariates were identified in the initial selection process (Supplemental Table 1). The covariates included various flow variables (e.g., spring X2 location (a measure of the spatial extent of salinity: position of the 2% isohaline), winter-spring Delta outflow, winter-spring Napa River flow, spring outflow thresholds of 34,500 cfs and 44,500 cfs, spring Sacramento River inflow in addition to various variations of Sacramento and San Joaquin River runoff), zooplankton (prey) densities (e.g., mysid, *Eurytemora*, and *Pseudodiaptomus* densities over various seasonal time periods), predators and competitors (e.g., juvenile Chinook salmon densities in the spring, predators in various regions, and the Asian overbite clam *Potamocorbula*), and a variety of abiotic environmental variables (e.g., Secchi depth as an index of turbidity, water temperature, ammonium loading to various regions of the estuary, and the ratio of ammonium loading to Delta inflow). Based on the conceptual model, the expected sign (positive or negative) in the relationship between each covariate and an expected longfin smelt population response was also assigned to each covariate. All of the environmental covariates were then entered into two formulations of the longfin smelt lifecycle model (a model in which spawners are the adult lifestage (November–March) ages 1 and 2 and an alternative model in which pre-adults (October–March) ages 0 and 1 and adults (November–March) ages 1 and 2 were equally weighted in the model as spawners) and a series of statistical analyses were performed to identify the best model. The models were fit to indices of juvenile and adult longfin smelt abundance created using Bay study otter and mid-water trawl surveys[2]. The covariates that explained the most variation from

---

[1] Rosenfield, J.A. 2010. Life History Conceptual Model and Sub-Models for Longfin Smelt, San Francisco Estuary Population. Unpublished Report. Available at: http://www.dfg.ca.gov/erp/cm_list.asp. Hanson, C. H. 2014. Covariates for Consideration in Developing a Lifecycle Model for the San Francisco Bay-Delta Population of Longfin Smelt. Hanson Environmental, Inc. Unpublished contract report. 93pp. http://new.baydeltalive.com/projects/7012

[2] Maunder, M.N. and Deriso, R.B. 2013. Empirical estimates of abundance indices and standard deviation for longfin smelt from the bay study otter and mid-water trawl surveys. Unpublished QRA contract report. 13pp. http://new.baydeltalive.com/projects/7012

Table 1
Description of modeling scenarios. The symbol under the "Analysis type" column is based on the entries in the other columns with symbols: juvenile = "J", adult = "A", juvenile divided by adult = "J/A", both juvenile and adult = "J+A" None = "-", likelihood = "L", random effects = "re", Beverton–Holt = "BH", Ricker = "R".

Name	Analysis type	Dependent variable	Adult observation error	Juvenile observation error	Process error	Density dependence	Equation
Log-linear	J/A- -L-	Juvenile divided by Adult	None	None	Likelihood	None	7
Exponential	J- -L-	Juvenile	None	None	Likelihood	None	11
Log-linear with observation error	J/AreреL-	Juvenile divided by Adult	Random effect	Random effect	Likelihood	None	7
Exponential with juvenile observation error only	J-L- -	Juvenile	None	Likelihood	None	None	11
Exponential with juvenile observation error and process error	J-Lre-	Juvenile	None	Likelihood	Random effect	None	11
Exponential with observation an process error	JreLre-	Juvenile	Random effect	Likelihood	Random effect	None	11
Ricker	JreLreR	Juvenile	Random effect	Likelihood	Random effect	Ricker	13
Beverton–Holt	JreLreBH	Juvenile	Random effect	Likelihood	Random effect	Beverton–Holt	15
Population dynamics (Life cycle)	J+ALLreBH	Juvenile and Adult	Likelihood	Likelihood	Random effect for both A and J	Beverton–Holt	16 and 17

each category of covariate[3] (e.g. flow, prey, predators, environmental conditions) were then used in the application below that illustrates the benefits of state-space models.

AIC_C was used to conduct forward stepwise covariate selection. The covariates were normalized (mean subtracted and divided by the standard deviation) to improve model performance. Several covariates were chosen as candidates for the model selection procedure (Table 2 and Supplemental 2). These covariates were chosen based on initial analysis of the wider range of factors in supplemental Table 1. Many of the factors in the larger set were highly correlated and so were eliminated. We kept two flow variables that were highly correlated to illustrate some of the difficulties in hypothesis testing. The model is fit to relative abundance indices for each stage (Supplemental Table 3), as appropriate. The models were implemented using AD Model builder and the Laplace approximation was used for random effects. The observation error in Eq. (10) was implemented by treating the true population abundance as a random effect and using the sampling distribution as the likelihood for abundance. The true abundance was then used in the calculation of the regression model and the likelihoods for the observations were combined with the likelihood for the regression equation. The lognormal bias correction is not used since α is not of interest and the temporal variation in the observation error is low.

4. Results

In general, all scenarios support the two flow-related covariates (Sacramento and Napa river runoff) when a single covariate is tested (Fig. 2) followed closely by the prey species *Eurytemora*. However, after including a flow covariate, support for *Eurytemora* is lost and it is not selected in any of the final models. In all models, ammonia is the second covariate selected and temperature is the third covariate selected (Table 3). Adding density dependence (models JreLreR and JreLreBH) results in more support for Sacramento River runoff over Napa River runoff, and over the other covariates in general, when comparing single covariate models. Using observation error only for juveniles and no process error (model J-L- -; Table 1) creates greater differences in the likelihood between covariates and gives increased relative support to temperature and ammonia.

The likelihood values from the log-linear model (model J/A- -L-) and the exponential model (model J- -L-) are identical as expected (Table 3). The results from the log-linear model with observation error (model J/ArereL-), which implies both observation and process error, and the exponential model with both observation and process error (model JreLre-) are identical despite the likelihood and random effects representing different error components.

Adding observation error (e.g. compare model J- -L- with model JreLre-) makes little difference in relative likelihoods (Table 3), but changes the variables selected (Table 3). Sacramento River runoff is selected in the first stage of the stepwise regression in place of Napa River runoff when allowance is made for observation error. This is in part because Napa River runoff and Sacramento River runoff are highly correlated. The stepwise procedure also selects Napa River runoff as a fourth covariate. However, if Sacramento River runoff is dropped from the final model (that is the model chosen by the stepwise procedure that includes both flow variables) the AICc drops by 2.58 units. The AIC_C for the model which only includes Napa River runoff as the flow variable is 5.39 units lower than the model which only includes Sacramento River run off as the flow variable (Fig. 3) providing "definite" evidence of Napa River runoff over Sacramento River runoff in models that do not include density-dependence; evidence favors Napa River runoff over Sacramento River runoff in all the various model configurations, but not as definitive as the ones above (Table 3).

Ignoring process error and including observation error only for the juvenile abundance (model J-L- -) leads to much greater changes in the likelihood causing all covariates to be selected except for those that are rejected because the coefficient has the wrong sign.

The Ricker (model JreLreR) and Beverton–Holt (model JreLreBH) forms of density dependence lead to different results, with the Beverton–Holt model including Napa River runoff as a fourth covariate resulting in a better AIC_C, but it is only 1.65 units lower than the Ricker model providing "no credible" evidence to differentiate between the two forms of density dependence. The AIC_C for the Beverton–Holt model is 4.19 units less than the exponential model with observation error providing "definite" evidence for density dependence. If the Sacramento outflow is discarded from the Beverton–Holt model, the AIC_C is only 0.25 units less than the final model, and is only 1.21 units lower than if Napa River runoff is not included and Sacramento runoff is

---

[3] Maunder, M.N. and Deriso, R.B. 2013. Evaluation of factors impacting longfin smelt – summary analysis. Unpublished QRA contract report. 9 pp. http://new.baydeltalive.com/projects/7012

Table 2
Covariates used in the longfin smelt application (Hanson, C.H. 2014. Selection of Environmental Covariates for Consideration in Developing a Lifecycle Model for the San Francisco Bay-Delta Population of Longfin Smelt. Hanson Environmental, Inc. Unpublished contract report. 93pp. http://new.baydeltalive.com/projects/7012).

Factor	Time	Stage	Sign of coefficient
Mysid	May–June	Adult to Juveniles	+
Secchi depth	April–June	Adult to Juveniles	–
Eurytemera	April–May	Adult to Juveniles	+
Napa River flow	January–March	Adult to Juveniles	+
Predators central + San Pablo	Annual	Adult to Juveniles	–
Average temperature	April–June	Adult to Juveniles	–
San Pablo ammonium	April–June	Adult to Juveniles	–
Sacramento River runoff	Previous October–July	Adult to Juveniles	+
Overbite clam presence	Year round	Adult to Juveniles	–
Mysid	July–September	Juveniles to pre-adult	+

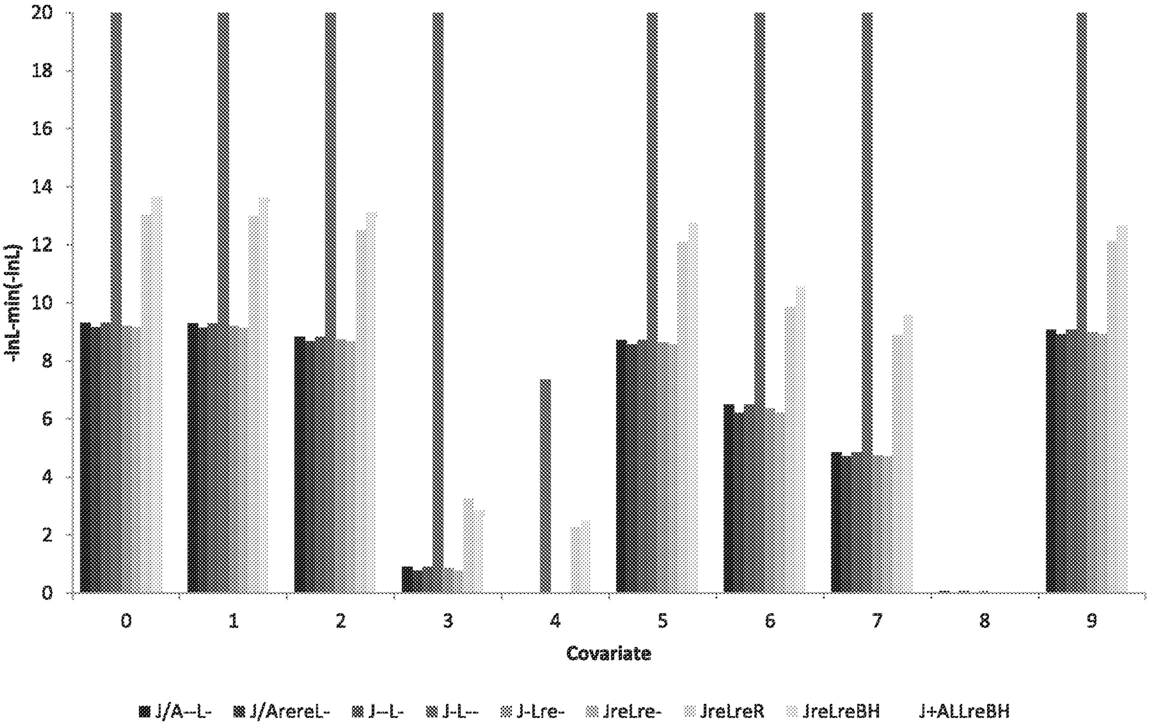


Fig. 2. Difference in negative log-likelihood from the model with the covariate minus the lowest negative log-likelihood for a scenario with any covariate [$-\ln L - \min(-\ln L)$]. A smaller value represents more support for that covariate compared to the other covariates in that scenario. The value for Model J-L-- is truncated. The covariates are presented in the same order as they are defined in Table 2, with the exception that "0" represents no covariates.

Table 3
AIC$_C$ values for the steps (step order given in parenthesis) in the forward stepwise selection procedure and for models with no covariates and with different combinations of flow variables (temperature and ammonia included). AICc scores cannot be compared among some models because the data used to fit the model differs. Models with observation error in both abundance time series fit to both abundance time series are comparable (indicated by "b") but cannot be compared to models that fit to only the juvenile abundance time series (indicated by "a"). The two stage model (J+ALLreBH) includes two random effects and due to the method used to model random effects cannot be compared to the other models. The row labeled "Delta AICc" is the absolute difference in AICc from the selected model compared to the model without covariates for each scenario.

Covariates	Analysis type								
	J/A-L- (a)	J/ArereL- (b)	J-L- (a)	J-L-- (a)	J-Lre- (a)	JreLre- (b)	JreLreR (b)	JreLreBH (b)	J+ALLreBH (c)
Mysid May–June									
Secchi depth									
Eurytemera									
Napa River flow	105.14 (1)	–19.46 (4)	105.14 (1)	359.95 (4)	50.32 (1)	–19.46 (4)		–23.64 (4)	41.33 (5)
Predators central +San Pablo				351.12 (5)					
Average temperature	88.53 (3)	–16.65 (3)	88.53 (3)	405.73 (3)	33.44 (3)	–16.65 (3)	–21.99 (3)	–22.68 (3)	44.52 (3)
San Pablo ammonium	95.23 (2)	–13.10 (2)	95.23 (2)	650.94 (2)	40.28 (2)	–13.10 (2)	–17.39 (2)	–18.98 (2)	47.62 (2)
Sacramento River runoff		–4.72 (1)		1006.95 (1)		–4.72 (1)	–10.84 (1)	–12.17 (1)	55.11 (1)
Overbite clam presence									
Mysid July–Sept									42.16 (4)
Delta AICc	32.76	30.57	32.76	1222.22	32.83	27.77	34.48	36.09	38.02
No covariates	121.29	11.11	121.29	1573.34	66.27	11.11	12.49	12.45	79.35
Napa River runoff	88.53	–22.04	88.53	365.05	33.44	–22.04	–23.59	–23.89	43.76
Sacramento River runoff	94.07	–16.65	94.07	405.73	38.89	–16.65	–21.99	–22.68	44.52
Both flow variables	91.23	–19.46	91.23	359.95	36.10	–19.46	–23.01	–23.64	43.55
Best forward stepwise	88.53	–19.46	88.53	351.12	33.44	–19.46	–21.99	–23.64	41.33

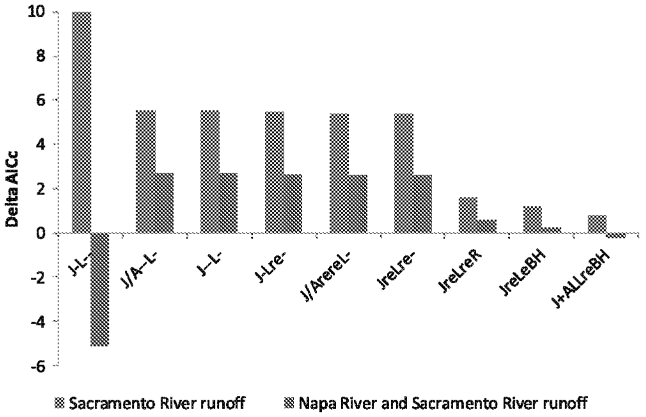


Fig. 3. Difference in AICC between the models with different flow variables. The blue histogram includes only Sacramento River runoff and the red histogram includes both Napa River and Sacramento River runoff. The ΔAICc values are the AICc values for these models minus the AICc values for the model with only Napa River runoff. The Sacramento River runoff value for model J-L-- is truncated. The models are ordered by ΔAIC_C. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

included (Fig. 3). Consequently, there is "no credible" evidence supporting one runoff covariate over the other in the presence of density dependence. This differs from the result without density dependence, which shows "definite" evidence of Napa River runoff over Sacramento River runoff.

Using a population dynamics model by linking both stages using a Beverton–Holt relationship (model J+ALLreBH) produces nearly identical support for the covariates compared to the Beverton–Holt model when evaluating single covariate models. The final selected model adds the additional prey covariate for survival from juveniles to adults.

5. Discussion

We have illustrated the progression from traditional log-linear models for estimating the factors influencing survival to state-space population dynamics life-cycle models. State-space models accommodate both observation and process error, which can be vital to avoid bias in parameter estimates, confidence intervals, and hypothesis tests (de Valpine and Hastings, 2002; Maunder and Watters, 2003; Deriso et al., 2007). Our model that ignored process error selected prey as an additional covariate, which was not selected by any other model, and would have selected additional covariates if they had not been discarded because the coefficient was the wrong sign. In our application, ignoring observation error did not have a large impact on the relative support for the various covariates. However, it did change which covariates were selected because the two flow covariates were highly correlated. In other applications, the influence of including observation error is likely to be greater where observation error is larger and particularly if it varies among data points. Explicitly modeling process error and separating it from observation error is also important in estimating the probability of future events such as extinction (Maunder, 2004) and evaluating the uncertainty in the relationships between survival and covariates so this uncertainty can be included in management advice (Maunder and Deriso, 2011).

5.1. Observation error

The observation error standard deviations used in our application, calculated from bootstrap analysis of the survey data, were assumed known and were used to represent the random sampling error. They do not include variation due to other factors such as annual changes in survey catchability. This additional observation error may influence hypothesis testing. The standard deviation representing additional variation in the observation process could be estimated analytically (Maunder and Starr, 2003; Deriso et al., 2007) or covariates could be added to the observation model, perhaps using finer scale data (e.g. Maunder, 2001; Besbeas and Freeman, 2006). Estimating the additional observation error variance adds one more parameter, which will increase the variance of parameter estimates and will probably reduce the statistical significance of covariates.

5.2. Process error

The estimated observation (sampling) error variance often incorporates the process error in models such as the log-linear and simple exponential models. They do not explicitly model the process error, but accommodate it by ignoring the observation error variances in the likelihood and estimating the variance of the likelihood function. However, it is important to understand that the variance estimates from these models represent a combination of process error and observation error. In more complex population dynamics models, such as those used in fisheries stock assessment (Maunder and Punt, 2013; Punt et al., 2013, Methot and Wetzel, 2013), which model many processes, only one type of process error is typically modeled (e.g. annual recruitment variability) and estimation of the observation error variance for a variety of data types or the modeled process error is implicitly assumed to accommodate the unmodeled process error.

Contemporary fisheries stock assessment models are often too complicated to model in a state-space framework, although some success has been achieved (McAllister and Ianelli, 1997; Maunder and Deriso, 2003; Nielsen and Berg, 2014), particularly in a Bayesian context (Punt and Hilborn, 1997). The standard approach is to use penalized likelihood, with the variance of the process error for annual recruitment fixed at a pre-determined value (Maunder and Deriso, 2003). Misspecified process error variance will bias confidence intervals and hypothesis tests. Adding covariates to explain process error will reduce the process error variance, and the variance needs to be adjusted for this. Hopefully, fisheries stock assessment models can be implemented in the state-space framework as computers and estimation algorithms get more efficient, so the process error variance can be estimated. In the meantime, it might be prudent to estimate the parameters and conduct hypothesis tests under different assumptions about the process error variance to ensure that results are consistent.

We found that modeling either process error or observation error as random effects or likelihood functions gave the same results. This was an interesting result and it is not clear if this is a general phenomenon or if it is a consequence of comparing linear Gaussian models. Further research is needed.

5.3. Model selection

Our results corroborate other studies that have found that evaluating factors in isolation can lead to different results than evaluating them in combination (e.g. Deriso et al., 2008; Maunder and Deriso, 2011). Similarly, our results parallel those of Maunder and Deriso (2011) who found that some final models had a coefficient with confidence intervals that cover zero, and removing that covariate improved the AIC_C. As with Maunder and Deriso's (2011) study, the covariate in question (Sacramento River flow) was highly correlated with another covariate (Napa River flow) included in the model.

Maunder and Deriso (2011) recommend that all possible combinations of covariates and density dependent factors should be evaluated because some factors may only be detected in combination with other factors or in the presence of density dependence. However, conducting analyses of all possible combinations can be computationally demanding. To reduce the computational time, Maunder and Deriso (2011) applied a strategy that evaluates two covariates at a time and uses AIC_c summed over all possible one and two covariate combinations to select a covariate that has general support. In contrast, Anderson et al. (2000) warn against testing all possible combinations unless model averaging is used. Practical advice is to ensure that covariates included in the model have *a priori* support and that the framework of Maunder and Deriso (2011) is followed to identify the life stage and the relationship to density dependence before conducting an all combinations analysis. Results should be used to rank models and provide an idea of the data based evidence for alternative hypotheses rather than strict acceptance–rejection hypothesis testing (Maunder and Deriso, 2011).

5.4. Integrated analysis

We illustrated how multiple life stages of a species, each with their own data sets, can be integrated into a population dynamics model. This is an elementary form of the contemporary integrated analysis (also known as data assimilation), which attempts to include all relevant data into a single analysis (e.g. Maunder, 2003; Buckland et al., 2007; Schaub and Abadi, 2010; Maunder and Punt, 2013). Integrated analysis facilitates the propagation of information and uncertainty, particularly when states are linked from one time period to the next in a population dynamics model. For example, one life stage in the analysis of Maunder and Deriso (2011) did not have an abundance index until partway through the modeling time frame and the processes related to this stage were informed by the indices of abundance for other stages. However, the years that the index was available for were enough to help determine which stages the covariates influenced. Similarly, Tenan et al. (2012) showed how integrating different types of data allowed for the estimation of population processes not directly measured in the field. We found that adding data and a covariate for survival from juveniles to adults did not influence the support for the covariates of survival from adults to juveniles. This is somewhat reassuring since the application had good data for all time periods and therefore it would not be desirable for the results of one stage to influence those of another. If process error was not modeled, the added data may have inadvertently influenced the covariate selection. If the data were poor or missing for some time periods, then it would be reasonable and desirable for data for one stage to influence the other stages.

5.5. Model structure

The models we used to illustrate state-space models were simple compared to those used in many real applications. Alternative functions could be used to model the transition among stages. For example, Maunder and Deriso (2011) used the three-parameter Deriso–Schnute stock-recruitment model (Deriso, 1980; Schnute, 1985) and also allowed the flexibility to implement covariates before or after density dependence. The covariates were included as simple log linear terms and there may be more appropriate relationships between survival and covariates. For example there may be a dome shaped relationship between survival and temperature, with lower survival at lower and higher temperature or temperature may interact with prey availability.

5.6. Longfin smelt application

We found that multiple factors and density dependence influenced the survival of longfin smelt. The AIC_c was over four units higher for the Beverton–Holt model compared to the exponential model suggesting there is "definite" evidence for density dependence. The level of evidence is less if the models with Napa River flow are used. We also found that flow, ammonia, and temperature were consistently supported by the data for longfin smelt. Thomson et al. (2010) found that X2, which is related to flow, and water clarity explained longfin abundance. Mac Nally et al. (2010) also found that X2 explained longfin abundance, but in addition found a correlation with prey species. Among candidate flow variables, we did not find X2, OMR flow, or the two outflow threshold variables in supplemental Table 1 to be important covariates in our initial screening after the inclusion of flow variables that had higher support in the data.

Acknowledgements

Richard Deriso and Charles Hanson were funded by the State Water Contractors. Mark Maunder was funded by San Luis & Delta-Mendota Water Authority. Ken Burnham provided useful comments on the manuscript. Comments from André Punt and two anonymous reviewers improved the manuscript. Survey data was from California Department of Fish and Wildlife's San Francisco Bay Study and the Interagency Ecological Program for the San Francisco Estuary.

Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at http://dx.doi.org/10.1016/j.fishres.2014.10.017.

References

Akaike, H., 1973. Information theory and an extension of the maximum likelihood principle. In: Petrov, B.N., Csaki, F. (Eds.), Proceedings of the 2nd International Symposium on Information Theory. Publishing house of the Hungarian Academy of Sciences, Budapest, pp. 268–281.

Anderson, D.R., Burnham, K.P., Thompson, W.L., 2000. Null hypothesis testing: problems, prevalence, and an alternative. J. Wildl. Manag. 64 (4), 912–923, http://dx.doi.org/10.2307/3803199.

Baxter, R., Breuer, R., Brown, L., Chotkowski, M., Feyrer, F., Gingras, M., Herbold, B., Mueller-Solger, A., Nobriga, M., Sommer, T., Souza, K., 2008. Pelagic Organism Decline Progress Report: 2007 Synthesis of Results. California Department of Water Resources, Sacramento, USA (Interagency Ecological Program Technical Report 227).

Bennett, W.A., 2005. Critical assessment of the delta smelt population in the San Francisco estuary, California. San Franc. Estuary Watershed Sci. 3 (2), 1–71.

Besbeas, P., Freeman, S.N., Morgan, B.J.T., Catchpole, E.A., 2002. Integrating mark–recapture–recovery and census data to estimate animal abundance and demographic parameters. Biometrics 58 (3), 540–547.

Besbeas, P., Lebreton, J.D., Morgan, B.J.T., 2003. The efficient integration of abundance and demographic data. Appl. Stat. 52, 95–102.

Besbeas, P., Freeman, S.N., 2006. Methods for joint inference from panel survey and demographic data. Ecology 87, 1138–1145.

Beverton, R.J.H., Holt, S.J., 1957. On the Dynamics of Exploited Fish Populations, Fisheries Investigations Series 2, 19. Ministry of Agriculture, London, U.K.

Bolker, B.M., Gardner, B., Maunder, M., Berg, C.W., Brooks, M., Comita, L., Crone, E., Cubaynes, S., Davies, T., deValpine, P., Ford, J., Gimenez, O., Kery, M., Kim, E.J., Lennert-Cody, C., Magnusson, A., Martell, S., Nash, J., Nielsen, A., Regetz, J., Skaug, H., Zipkin, E., 2013. Strategies for fitting nonlinear ecological models in R, AD Model Builder, and BUGS. Methods Ecol. Evol. 4, 501–512.

Brook, B.W., Bradshaw, C.J.A., 2006. Strength of evidence for density dependence in abundance time series of 1198 species. Ecology 87 (6), 1445–1451.

Buckland, S.T., Newman, K.B., Thomas, L., Koesters, N.B., 2004. State-space models for the dynamics of wild animal populations. Ecol. Model. 171 (1–2), 157–175.

Buckland, S.T., Newman, K.B., Fernandez, C., Thomas, L., Harwood, J., 2007. Embedding population dynamics models in inference. Stat. Sci. 22 (1), 44–58.

Burnham, K.P., Anderson, D.R., 1998. Model Selection and Inference: A Practical Information-theoretical Approach. Springer Verlag, New York.

Burnham, K.P., Anderson, D.R., 2002. Model selection and multimodel inference: a practical information-theoretic approach, 2nd ed. Springer, New York.

Christensen, R., 1997. Log-Linear Models and Logistic Regression, 2nd ed. Springer.

Ciannelli, L., Chan, K.-S., Bailey, K.M., Stenseth, N.C., 2004. Nonadditive effects of the environment on the survival of a large marine fish population. Ecology 85 (12), 3418–3427.

Deriso, R.B., 1980. Harvesting strategies and parameter estimation for an age-structured model. Can. J. Fish. Aquat. Sci. 37 (2), 268–282.

Deriso, R.B., Maunder, M.N., Skalski, J.R., 2007. Variance estimation in integrated assessment models and its importance for hypothesis testing. Can. J. Fish. Aquat. Sci. 64, 187–197.

Deriso, R.B., Maunder, M.N., Pearson, W.H., 2008. Incorporating covariates into fisheries stock assessment models with application to Pacific herring. Ecol. Appl. 18 (5), 1270–1286.

de Valpine, P., 2002. Review of methods for fitting time-series models with process and observation error and likelihood calculations for nonlinear, non-Gaussian state-space models. Bull. Mar. Sci. 70, 455–471.

de Valpine, P., 2003. Better inferences from population dynamics experiments using Monte Carlo state-space likelihood methods. Ecology 84, 3064–3077.

de Valpine, P., Hastings, A., 2002. Fitting population models with process noise and observation error. Ecol. Monogr. 72, 57–76.

Dupont, W.D., 1983. A stochastic catch-effort method for estimating animal abundance. Biometrics 39 (4), 1021–1033.

Edgington, E.S., 1987. Randomization Tests. Marcel Dekker, New York, New York, USA.

Fournier, D.A., Skaug, H.J., Ancheta, J., Ianelli, J., Magnusson, A., Maunder, M.N., Nielsen, A., Sibert, J., 2012. AD Model Builder: using automatic differentiation for statistical inference of highly parameterized complex nonlinear models. Opt. Met. SOFT 27, 233–249.

Hilborn, R., Mangel, M., 1997. The Ecological Detective: Confronting Models with Data. Princeton University Press, Princeton, N.J.

Hobbs, N.T., Hilborn, R., 2006. Alternatives to statistical hypothesis testing in ecology: a guide to self teaching. Ecol. Appl. 16 (1), 5–19.

Johnson, J.B., Omland, K.S., 2004. Model selection in ecology and evolution. Trends Ecol. Evolut. 19 (2), 101–108.

Lele, S.R., Dennis, B., Lutscher, F., 2007. Data cloning: easy maximum likelihood estimation for complex ecological models using Bayesian Markov chain Monte Carlo methods. Ecol. Lett. 10, 551–563.

Lunn, D., Spiegelhalter, D., Thomas, A., Best, N., 2009. The BUGS project: evolution, critique and future directions. Stat. Med. 28 (25), 3049–3067.

Mac Nally, R., Thomson, J.R., Kimmerer, W., Feyrer, F., Newman, K.B., Sih, A., Bennett, W., Brown, L., Fleishman, E., Culberson, S.D., Castillo, G., 2010. Analysis of pelagic species decline in the upper San Francisco Estuary using multivariate autoregressive modeling (MAR). Ecol. Appl. 20 (5), 1417–1430.

Maunder, M.N., 2001. A general framework for integrating the standardization of catch-per-unit-of-effort into stock assessment models. Can. J. Fish. Aquat. Sci. 58, 795–803.

Maunder, M.N., 2003. Paradigm shifts in fisheries stock assessment: from integrated analysis to Bayesian analysis and back again. Nat. Resour. Model. 16 (4), 465–475.

Maunder, M.N., 2004. Population viability analysis, based on combining integrated, Bayesian, and hierarchical analyses. Acta Oecol. 26, 85–94.

Maunder, M.N., Deriso, R.B., 2003. Estimation of recruitment in catch-at-age models. Can. J. Fish. Aquat. Sci. 60, 1204–1216.

Maunder, M.N., Deriso, R.B., 2011. A state-space multistage life cycle model to evaluate population impacts in the presence of density dependence: illustrated with application to delta smelt (*Hyposmesus transpacificus*). Can. J. Fish. Aquat. Sci. 68, 1285–1306.

Maunder, M.N., Punt, A.E., 2013. A review of integrated analysis in fisheries stock assessment. Fish. Res. 142, 61–74.

Maunder, M.N., Starr, P.J., 2003. Fitting fisheries models to standardised CPUE abundance indices. Fish. Res. 63, 43–50.

Maunder, M.N., Watters, G.M., 2003. A general framework for integrating environmental time series into stock assessment models: model description, simulation testing, and examples. Fish. Bull. 101, 89–99.

McAllister, M.K., Ianelli, J.N., 1997. Bayesian stock assessment using catch-age data and the sampling/importance resampling algorithm. Can. J. Fish. Aquat. Sci. 54, 284–300.

Methot, R.D., Wetzel, C.R., 2013. Stock synthesis: a biological and statistical framework for fish stock assessment and fishery management. Fish. Res. 142, 86–99.

Miller, W.J., Manly, B.F.J., Murphy, D.D., Fullerton, D., Ramey, R.R., 2012. An investigation of factors affecting the decline of delta smelt (*Hypomesus transpacificus*) in the Sacraento-San Joaquin Estuary. Rev. Fish. Sci. 20, 1–19.

Nielsen, A., Berg, C.W., 2014. Estimation of time-varying selectivity in stock assessments using state-space models. Fish. Res. 158, 96–101.

Newman, K.B., 1998. State-space modeling of animal movement and mortality with application to salmon. Biometrics 54 (4), 1290–1314.

Newman, K.B., Lindley, S.T., 2006. Accounting for demographic and environmental stochasticity, observation error and parameter uncertainty in fish population dynamics models. N. Am. J. Fish. Manag. 26 (3), 685–701.

Newman, K.B., Fernandez, C., Thomas, L., Buckland, S.T., 2009. Monte Carlo inference for state-space models of wild animal populations. Biometrics 65 (2), 572–583.

Pawitan, Y., 2003. In All Likelihood: Statistical Modeling and Inference using Likelihood. Oxford University Press, Oxford, UK.

Polacheck, T., Hilborn, R., Punt, A.E., 1993. Fitting surplus production models: comparing methods and measuring uncertainty. Can. J. Fish. Aquat. Sci. 50, 2597–2607.

Punt, A.E., Hilborn, R., 1997. Fisheries stock assessment and decision analysis: the Bayesian approach. Rev. Fish. Biol. Fish. 7, 35–63.

Punt, A.E., Huang, T.-C., Maunder, M.N., 2013. Review of integrated size-structured models for stock assessment of hard-to-age crustacean and mollusc species. ICES J. Mar. Sci. 70 (1), 16–33.

Quinn II, T.J., Deriso, R.B., 1999. Quantitative Fish Dynamics. Oxford University Press, New York.

Ricker, W.E., 1954. Stock and recuitment. J. Fish. Res. Board Can. 11, 559–623.

Rivot, E., Prevost, E., Parent, E., Bagliniere, J.L., 2004. A Bayesian state-space modelling framework for fitting a salmon stage-structured population dynamic model to multiple time series of field data. Ecol. Model. 179 (4), 463–485.

Rose, K.A., Cowan Jr., J.H., Winemiller, K.O., Myers, R.A., Hilborn, R., 2001. Compensatory density dependence in fish populations: importance, controversy, understanding and prognosis. Fish Fish. 2, 293–327.

Rosenfield, J.A., Baxter, R.D., 2007. Population dynamics and distribution patterns of longfin smelt in the San Francisco Estuary. Trans Am. Fish. Soc. 136, 1577–1592.

Sæther, B.E., 1997. Environmental stochasticity and population dynamics of large herbivores: a search for mechanisms. Trends Ecol. Evol. 12 (4), 143–149.

Schaub, M., Abadi, F., 2010. Integrated population models: a novel analysis framework for deeper insights into population dynamics. J. Ornithol. 152, 227–237.

Schnute, J., 1985. A general theory for the analysis of catch and effort data. Can. J. Fish. Aquat. Sci. 42 (3), 414–429.

Schnute, J.T., 1994. A general framework for developing sequential fisheries models. Can. J. Fish. Aquat. Sci. 51, 1676–1688.

Seber, G.A., Wild, C.J., 1989. Nonlinear Regression. John Wiley and Sons, New York.

Skalski, J.R., 1996. Regression of abundance estimates from mark—recapture surveys against environmental covariates. Can. J. Fish. Aquat. Sci. 53, 196–204.

Skalski, J.R., Townsend, R.L., Steig, T.W., Hemstrom, S., 2010. Comparison of two alternative approaches for estimating dam passage survival using acoustic-tagged sockeye salmon smolts. N. Am. J. Fish. Manag. 30, 831–839.

Skaug, H.J., 2002. Automatic differentiation to facilitate maximum likelihood estimation in nonlinear random effects models. J. Comput. Graph. Stat. 11 (2), 458–470.

Skaug, H., Fournier, D., 2006. Automatic approximation of the marginal likelihood in non-Gaussian hierarchical models. Comput. Stat. Data Anal. 51 (2), 699–709.

Sommer, T., Armor, C., Baxter, R., Breuer, R., Brown, L., Chotkowski, M., Culberson, S., Feyrer, F., Gingras, M., Herbold, B., Kimmerer, W., Mueller-Solger, A., Nobriga, M., Souz, K., 2007. The collapse of pelagic fishes in the upper San Francisco Estuary: El colapso de los peces pelagicos en la cabecera del Estuario San Francisco. Fisheries 32, 270–277.

Tenan, S., Adrover, J., Navarro, A.M., Sergio, F., Tavecchia, G., 2012. Demographic consequences of poison-related mortality in a threatened bird of prey. PLOS One 7 (11), 1–11.

Thomson, J.R., Kimmerer, W.J., Brown, L.R., Newman, K.B., Mac Nally, R., Bennett, W.A., Feyrer, F., Fleishman, E., 2010. Bayesian change point analysis of abundance trends for pelagic fishes in the upper San Francisco Estuary. Ecol. Appl. 20 (5), 1431–1448.

Walters, C.J., Ludwig, D., 1981. Effect of measurement errors on the assessment of stock-recruitment relationships. Can. J. Fish. Aquat. Sci. 38, 704–710.

Wang, S.-P., Maunder, M.N., Aires-da-Silva, A., Bayliff, W.H., 2009. Evaluating fishery impacts: application to bigeye tuna (*Thunnus obesus*) in the eastern Pacific Ocean. Fish. Res. 99 (2), 106–111.

White, G.C., Garrott, R.A., 1990. Analysis of Wildlife Radio-Tracking Data. Academic Press, San Diego.

Supplemental Table 1. Covariates evaluated for inclusion in the life cycle model for longfin smelt (Hanson, C.H. 2014. Selection of Environmental Covariates for Consideration in Developing a Lifecycle Model for the San Francisco Bay-Delta Population of Longfin Smelt. Hanson Environmental, Inc. contract report. 93pp. http://new.baydeltalive.com/projects/7012).

Factor	Time	Stage	sign of coefficient
Mysid	July to September	Juveniles to pre-adult	+
Mysid	May to June	Adult to Juveniles	+
OMR	January to March	Adult to Juveniles	+
X2	April to June	Adult to Juveniles	-
Secchi	April to June	Adult to Juveniles	-
Secchi	August to September	Juveniles to pre-adult	-
Outflow	January to March	Adult to Juveniles	+
Eury	April to May	Adult to Juveniles	+
Napa R	Jan-Mar	Adult to Juveniles	+
outflow threshold indicator at 34500 cfs	Mar-May	Adult to Juveniles	+
outflow threshold indicator at 44500 cfs	Mar-May	Adult to Juveniles	+
chinook salmon Chipps Island trawl	Apr-May	Adult to Juveniles	-
predators central +San pablo	Annual	all stages	-
predators suisun Bay	Jan-Mar	Adult to Juveniles	-
predators suisun	Mar-Jul	Adult to Juveniles	-
avg MWT temperature	January to March	Adult to Juveniles	-
avg MWT temperature	April to June	Adult to Juveniles	-
avg MWT temperature	July	Adult to Juveniles	-
area weighted ammonium	April to June	Adult to Juveniles	-
Central Bay ammonium	April to June	Adult to Juveniles	-
San Pablo ammonium	April to June	Adult to Juveniles	-
Suisun Bay ammonium	April to June	Adult to Juveniles	-
Pseudodiaptomus	April to July	Adult to Juveniles	+
Water Temperature where smelt occur	spring	Adult to Juveniles	-
Secchi Depth where smelt occur	spring	Adult to Juveniles	-
predators where smelt occur total 12 months	year round	all stages	-
Metric Tons of Ammonium discharged Sacramento	April to June	Adult to Juveniles	-
Sacramento River Inflow	April to June	Adult to Juveniles	+
Ammonium/inflow	April to June	Adult to Juveniles	-
Sacramento River Runoff	previous Oct to March	Adult to Juveniles	+
Sacramento Runoff	April to June	Adult to Juveniles	+

Sacramento Runoff	previous Oct to July	Adult to Juveniles	+
Sacramento + San Joaquin Runoff	previous Oct to March	Adult to Juveniles	+
Sacramento + San Joaquin Runoff	April to July	Adult to Juveniles	+
Sacramento + San Joaquin Runoff	year round	all stages	+
overbite clam presence	year round	all stages	-

Supplemental Table 2. Normalized covariates used in the models

Year	Mysid	Secchi depth	Eurytemera	Napa River Flow	Predators central + San Pablo	Average temperature	San Pablo ammonium	Sacramento River runoff
1980	0.853718	1.132715	1.080842	-0.53318	-1.00832	1.000508	-0.49261	-0.81876
1981	0.008556	-0.38085	1.563369	0.942767	-0.73836	-1.07541	-1.07396	1.717238
1982	-0.57054	-0.47351	1.13467	1.605906	-0.81277	-0.70393	1.154556	2.202613
1983	1.294227	0.876522	0.081392	-0.13147	-0.75301	-0.5933	-1.17085	0.460037
1984	2.456133	2.069006	-0.55701	-0.59147	-0.76796	-0.35928	0.185635	-0.82558
1985	3.304004	-0.91878	1.685837	0.907025	-0.47223	0.672727	-0.27897	0.855612
1986	0.818859	1.863066	-0.53119	-1.25034	-0.7215	1.877846	-1.26775	-1.02678
1987	-0.22898	-1.13284	-0.69825	-0.76187	-0.83145	-0.14351	1.057664	-1.03133
1988	-0.39433	-1.65546	-0.60016	-1.1355	-0.31977	0.618684	0.214993	-0.39591
1989	-0.51841	-0.93892	-0.69613	-1.118	-0.75124	1.215098	1.352603	-1.02792
1990	-0.58082	-1.44758	-0.5917	-2.28245	-0.10439	-1.39273	0.240282	-1.12113
1991	-0.53252	1.137815	-0.68111	-0.92498	-0.46803	2.259919	-0.84297	-1.07225
1992	-0.48866	0.330416	-0.07055	1.075703	-0.21676	0.012591	-1.11001	0.444124
1993	-0.69768	-0.5702	-0.70014	-1.16338	-0.39592	-0.60919	1.248929	-1.19274
1994	-0.73336	1.35507	2.518919	1.348697	-0.52902	-0.7761	-1.11059	1.846823
1995	-0.68224	-0.07661	-0.7433	0.658241	-0.42458	0.682527	0.869306	0.453217
1996	-0.28661	-0.5692	-0.719	0.509216	-0.14333	0.855629	3.141715	0.809007
1997	0.23437	-0.62056	0.617156	1.339571	-0.69596	-1.44204	-0.56712	1.48876
1998	-0.60568	-0.67723	0.041468	0.409611	0.004222	-1.22387	-0.4494	0.328179
1999	0.488225	1.119202	0.313572	0.039809	0.330112	0.014348	0.246096	0.067873
2000	-0.41639	1.365879	-0.7372	-0.60789	1.841149	0.795584	-0.59938	-0.9654
2001	-0.4009	0.208726	-0.73971	0.198123	2.578221	0.086682	0.454607	-0.42091
2002	-0.57373	0.301604	-0.7808	0.474233	1.235607	1.471128	-0.33894	0.114478
2003	-0.27168	-0.10606	-0.81838	0.533286	0.43951	0.276905	1.033635	-0.25723
2004	-0.70805	-0.11766	-0.77685	0.808158	-0.71743	0.072677	-0.6497	0.028088
2005	-0.50008	0.386148	1.257426	1.246163	-0.29197	0.327947	-0.77243	1.567193

2006	-0.76575	-1.13876	-0.7933	-1.05727	0.62834	-0.16466	0.719187	-0.91197
2007	0.147108	-0.91678	-0.57735	-0.00905	1.433459	-1.91036	0.346218	-0.91197
2008	-0.74928	-1.09509	-0.73349	-1.52307	0.770768	-0.83802	-0.42892	-0.60051
2009	-0.63695	-0.00317	-4.72E-17	0.13014	2.654387	-0.09821	0.142357	-0.26064

Supplemental Table 3. Relative abundance indices and their standard deviations.

	Juveniles		Adults	
Year	Index	sd	Index	sd
1980	5.147645	1.540905	0.671315	0.147691
1981	0.054695	0.011506	2.028516	0.500702
1982	6.811693	1.338478	1.789226	0.375208
1983	0.762013	0.223661	4.703123	0.83494
1984	0.903832	0.288505	1.00861	0.214744
1985	0.112521	0.031633	1.54415	0.293123
1986	0.306562	0.027569	0.850549	0.107033
1987	0.056342	0.013876	3.128023	0.350311
1988	0.039315	0.010529	0.999951	0.130288
1989	0.032967	0.006855	0.522527	0.122224
1990	0.015897	0.004812	0.246579	0.062757
1991	0.00576	0.001925	0.147667	0.082057
1992	0.025127	0.00702	0.051506	0.023044
1993	0.138967	0.03988	0.377306	0.089155
1994	0.043509	0.011538	0.75603	0.2145
1995	10.73554	2.403421	0.158759	0.045147
1996	0.029749	0.007081	3.440189	0.42718
1997	0.073301	0.013608	0.567071	0.101007
1998	1.387879	0.420226	0.61144	0.098984
1999	2.561377	0.471928	0.917655	0.122052
2000	0.344826	0.072434	1.297423	0.180564
2001	0.033508	0.009184	1.427239	0.203511
2002	0.114351	0.027719	0.695358	0.177047
2003	0.095383	0.0378	0.719237	0.120373
2004	0.054189	0.012327	0.586214	0.096707
2005	0.1773	0.048076	0.498012	0.111741
2006	0.270357	0.083662	0.457178	0.102388
2007	0.074141	0.026098	0.185869	0.042095
2008	0.06446	0.014879	0.479959	0.108918
2009	0.023163	0.00668	0.292118	0.082641

From: Spranza, John [John.Spranza@hdrinc.com]
Sent: 6/18/2020 9:14:44 AM
To: Lecky, Jim [Jim.Lecky@icf.com]; Alicia Forsythe [aforsythe@sitesproject.org]
Subject: RE: Range of Alternatives for Sites Reservoir RDEIR/RDEIS
Attachments: Lecky Letter-The CA Committee on Salmon and Steelhead Letter to Carlton ....docx

Flag: Follow up

One more.

John Spranza

D 916.679.8858 M 818.640.2487

From: Lecky, Jim [mailto:Jim.Lecky@icf.com]
Sent: Tuesday, June 16, 2020 7:59 PM
To: Alicia Forsythe <aforsythe@sitesproject.org>; Spranza, John <John.Spranza@hdrinc.com>
Subject: RE: Range of Alternatives for Sites Reservoir RDEIR/RDEIS

CAUTION: [EXTERNAL] This email originated from outside of the organization. Do not click links or open attachments unless you recognize the sender and know the content is safe.

Ali, not sure if these are what you are looing for since they are from 2017, but they seem relevant.

From: Alicia Forsythe <aforsythe@sitesproject.org>
Sent: Tuesday, June 16, 2020 3:27 PM
To: Lecky, Jim <Jim.Lecky@icf.com>; John Spranza (john.spranza@hdrinc.com) <john.spranza@hdrinc.com>
Subject: FW: Range of Alternatives for Sites Reservoir RDEIR/RDEIS

Hi Jim and John – See the email exchange below. I will also forward on one more email that I sent to Doug.

Jim – I thought you did a longer write up on the pros and cons with the studies that folks continue to reference. I recall like a 5 page document. But I couldn't find it just now. Is this something you recall and can find? Also, do you have the Nobriga and Rosenfield 2016 paper? Anything else to send to Jerry to help him on all of this?

Ali

Alicia Forsythe | Environmental Planning and Permitting Manager | Sites Reservoir Project | 916.880.0676 | aforsythe@sitesproject.org | www.SitesProject.org

CONFIDENTIALITY NOTICE: This communication with its contents may contain confidential and/or legally privileged information. It is solely for the use of the intended recipient(s). Unauthorized interception, review, use or disclosure is prohibited and may violate applicable laws including the Electronic Communications Privacy Act. If you are not the intended recipient, please contact the sender and destroy all copies of the communication.

From: Alicia Forsythe
Sent: Tuesday, June 16, 2020 3:22 PM
To: Jerry Brown <jbrown@sitesproject.org>
Subject: RE: Range of Alternatives for Sites Reservoir RDEIR/RDEIS

Jerry – See the paper that Gary Bobker sent to us over the weekend for the NRDC, TBI's proposed criteria.

Attached are the following:

- 20191011_Topics for Oct Exec Team Meeting – This was prepare by Jim Lecky and is "unfiltered" – See the references to specific studies with regard to locations
- 20191014_Talking Points for Oct Exec Team Meeting – This was my shortening of Jim's document, trying to get at the heart of some of these issues for our members
- Perry et al – Relates to Freeport Flows and salmonid survival
- Michel and Henderson – Related to Wilkins Slough flows and salmonid survival

I cant find the Nobriga paper (NDOI) but will see if Jim Lecky has that. I thought Jim also did a longer write-up on the pros and cons with these studies, but I cant seem to locate that right now. I'll ask him for this.

Happy to set up a briefing on all of this if you think it would be helpful.

Ali

Alicia Forsythe | Environmental Planning and Permitting Manager | Sites Reservoir Project | 916.880.0676 |
aforsythe@sitesproject.org | www.SitesProject.org

CONFIDENTIALITY NOTICE: This communication with its contents may contain confidential and/or legally privileged information. It is solely for the use of the intended recipient(s). Unauthorized interception, review, use or disclosure is prohibited and may violate applicable laws including the Electronic Communications Privacy Act. If you are not the intended recipient, please contact the sender and destroy all copies of the communication.

From: Jerry Brown <jbrown@sitesproject.org>
Sent: Tuesday, June 16, 2020 2:54 PM
To: Alicia Forsythe <aforsythe@sitesproject.org>
Subject: Re: Range of Alternatives for Sites Reservoir RDEIR/RDEIS

Can you provide me with a copy of the technical paper Doug is referring to when he says "scientifically sound" operational criteria? I assume there must be some in depth studies that we need to be aware of.

From: "Obegi, Doug" <dobegi@nrdc.org>
Date: Tuesday, June 16, 2020 at 1:08 PM
To: Alicia Forsythe <aforsythe@sitesproject.org>
Cc: Jerry Brown <jbrown@sitesproject.org>
Subject: RE: Range of Alternatives for Sites Reservoir RDEIR/RDEIS

Thanks Ali.

I suspect the project is going to have some serious challenges, if scientifically sound operational criteria make the project infeasible from the proponents' perspective.

From: Alicia Forsythe <aforsythe@sitesproject.org>
Sent: Tuesday, June 16, 2020 11:30 AM
To: Obegi, Doug <dobegi@nrdc.org>
Cc: Jerry Brown <jbrown@sitesproject.org>
Subject: RE: Range of Alternatives for Sites Reservoir RDEIR/RDEIS

Doug – The initial alternatives in the June packet are very preliminary. We're really just beginning the development of alternatives but want to make sure we update the Board on some of our initial thoughts and ideas. We expect to come back to the Board in September with a more complete project description, including possible changes to what we are proposing this week. The door isn't even close to being shut and we have a ways to go.

We will have Jacobs conduct an analysis of at least one set of operational criteria that are similar to (or the same as) what you have proposed. We will work with you, TBI, and others to confirm these criteria before we model them. This analysis will be in the Revised Draft EIR/EIS. However, based on analyses we completed last summer / fall, we expect these criteria to result in a project that's not affordable and provides very little water to accomplish the project objectives. Thus, we don't anticipate that this will result in an alternative that we would carry forward for detailed analysis in the Revised EIR as we don't anticipate it to result in a feasible project.

We have yet to "finalize" operational criteria for the project and continue to work on these and refinements to the model. So we may have more than one operational criteria, but we haven't yet made it far enough along to determine that. We will also complete the analysis described above early in the process – once we get the model refinements completed – so if my assumption is wrong here, we will have time to include it as a full alternative in the document.

The door isn't closed to adding in an alternative with different operational criteria – and we will complete the analysis you've requested. From the work we did last summer / fall, we just expect that the operational criteria proposed by NRDC won't result in a feasible project.

Ali

Alicia Forsythe | Environmental Planning and Permitting Manager | Sites Reservoir Project | 916.880.0676 | aforsythe@sitesproject.org | www.SitesProject.org

CONFIDENTIALITY NOTICE: This communication with its contents may contain confidential and/or legally privileged information. It is solely for the use of the intended recipient(s). Unauthorized interception, review, use or disclosure is prohibited and may violate applicable laws including the Electronic Communications Privacy Act. If you are not the intended recipient, please contact the sender and destroy all copies of the communication.

From: Obegi, Doug <dobegi@nrdc.org>
Sent: Monday, June 15, 2020 2:23 PM
To: Alicia Forsythe <aforsythe@sitesproject.org>; Jerry Brown <jbrown@sitesproject.org>
Subject: Range of Alternatives for Sites Reservoir RDEIR/RDEIS

Hi Jerry and Ali,

I hope you're both doing ok these days. I wanted to check in briefly because I was reviewing the meeting material for the upcoming Reservoir Committee meeting, and the attachments seem to suggest that the revised/recirculated draft EIR/EIS would only consider one operational criteria for the action alternatives in the document. Are y'all seriously planning to only review one operational criteria in the revised EIR/EIS?

https://3hm5en24txyp2e4cxyxaklbs-wpengine.netdna-ssl.com/wp-content/uploads/2019/11/03-03-Proposed-Objectives-and-Alternatives-for-the-Revised-EIR_EIS.pdf

That's certainly not the approach that I took away from our prior conversation, where we discussed how the revised recirculated DEIR/DEIS would consider a range of operational criteria that included at least one set of operational criteria that were more protective than what you proposed (and potentially similar to what we've proposed). It also seems to run afoul of CEQA's requirement to consider a reasonable range of alternatives.

Hopefully I'm misunderstanding the Board materials. In any event I would strongly urge you to ensure that the CEQA/NEPA documents analyze more than 1 operational scenario for the action alternatives that are considered, including an alternative that proposes operations that are significantly more protective than what you shared with me in our last conversation.

Thanks,
Doug

DOUG OBEGI
*Senior Attorney**
Water Program

NATURAL RESOURCES
DEFENSE COUNCIL

111 SUTTER ST., 21ST FLOOR
SAN FRANCISCO, CA 94104
T 415.875.6100
DOBEGI@NRDC.ORG
NRDC.ORG

Please save paper.
Think before printing.

** Admitted to practice in California*

The California Advisor Committee on Salmon and Steelhead (CAC) Letter to Carlton Bonham dated Jan 9, 2020 regarding the Sites Reservoir Project (Project) presents three recommendations:

1. The Sites Project Authority and Bureau of Reclamation should prepare a supplemental/recirculated DEIS/EIR for Sites Reservoir
2. Oppose language in the draft Water Resiliency Portfolio to accelerate permitting and approvals for Sites
3. Stand firm with your agency staff recommendation to oppose Sacramento River minimum instream bypass flows of less than 15,000 cfs per CDFWs 2016 recommendations

The first recommendation is supported by a list of 38 issues to be addressed in the supplemental/recirculated DEIR/S. The rationale for these issues draws heavily on letters from CDFW in response to the Sites Notice of Preparation (March 01, 2017) and commenting on the DEIR/S (Jan 12, 2018), and the comment letter from a coalition of non-governmental organizations (Jan 15, 2018). Those documents raise concerns regarding compliance with CEQA and NEPA requirements (procedural claims), inadequacy of analysis, and failure or lack of disclosure of social issues. Their procedural claims include the breath of alternatives considered is too narrow (specifically there is a lack of operational alternatives), there is an inadequate cumulative effects analysis, and the baseline is flawed. The claims of inadequate analysis address the analysis of effects on salmonids and delta fishes, criticism of effects analysis on native fishes in Funks and Stone Corral Creeks, inadequate analysis of water quality impacts, and inadequate development or description of monitoring and mitigation measures for aquatic and terrestrial resources, and the effects on the Trinity River. Concerns regarding social issues include failure or lack of disclosure regarding coordination with tribes and inadequate consideration of effects on commercial and recreational fisheries.

The Second Recommendation apparently stems from concern that the Governor's proposed direction in the Water Resiliency Portfolio means short cutting the permit process. The State should assure the Committee that the Governor's policy is about priorities and not exceptions to legal requirement. The State must still comply with its laws and procedures in addressing the Governor's Priorities. Doing otherwise would likely result in litigation that would frustrate achieving to goals of the Water Resiliency Portfolio.

The third recommendation is an affirmation of the CDFW comment on the DEIR/S. Of note thought, it erroneously increases CDFW's recommendation for an instream flow requirement from13,000 cfs to 15,000 cfs.

Below is overview of the fish issues, in the overview CAC and CDFW are used interchangeably because the CAC letter incorporates CDFW comments by reference.

Criticism of Salmonid effects analysis

In general terms the salmon analysis in the DEIR/S concludes the Project will have "less than significant impact" on salmon species based on a consideration of adverse effects, benefits, and mitigation measures. The analysis acknowledges adverse effect from increased diversion, associated habitat reduction, and exposure to fish screens. It suggests benefits of increased temperature and flow management in spawning and rearing habitat in the upper Sacramento River would increase production of juvenile salmonids, in particular winter- and fall-run Chinook salmon. And It includes a suite of mitigation measures, e.g. habitat restoration and pulse flow protections. The CAC, and comment letters they reference criticize almost every element of the effects analysis.

Temperature and flow benefits above Red Bluff Diversion Dam

The CAC suggest the claimed temperature benefit is flawed because it relies on an outdated version of the CALSIM II model (DCR 2015) not calibrated to current data. The monthly time step of CALSIM II is inadequate for assessing temperature effects which may manifest at daily time steps or less. The model does not incorporate the recent drought conditions and changes made in Shasta operations to improve water temperature operations. The CAC suggest the temperature benefit is overestimated because in compares effects with project to conditions prior to the improvements made in the water temperature management program. These criticisms appear valid in that the period of record in the CALSIM II runs do not include the 2012-2016 drought period. In addition, the NMFS 2009 biological opinion and it 2011 amendment have been replaced by a new biological opinion with new temperature control measures designed to address the shortcomings of the temperature control strategy revealed during the drought.

If the role of the USBR changes and the ability to store Sites Reservoir Project water in Shasta Reservoir is limited, the ability to achieve a temperature benefit may be diminished. Likewise, the ability to provide stabilization of flows for protection of redds may be diminished. Any new analyses should take into consideration the criticisms of the CAC, CDFW, and NGO community to ensure updated CALSIM II runs (e.g. DCR 2019, and post processing of daily effects) present the best representation of temperature effects/benefits and flow stabilization benefits possible.

Flows in the Sacramento River

The CAC criticizes the analysis of the effects of diversions on salmonids in the river because it is compared to an inappropriate baseline based on existing regulatory requirements some of which were promulgated for purposed other the fish protection (e.g. Wilkins Slough). The effects presented are the effects of the diversion with a pulse flow protection mitigation measure in place. The appropriate CEQA analysis would disclose the effect of the diversions without mitigation, and then present the mitigation measure and an analysis of how well the measure mitigates the effects. The CAC is also critical that the analysis does reflect the “best available science” regarding the flow survival relationships for salmonids.

The DEIR/S does recognize that the new diversions during late fall and winter may have impacts on migrating salmonids and proposes to mitigate those effects with a pulse protection mitigation measure. The rationale for the pulse protection measure is based in part on the analysis of migration behavior of winter-run Chinook salmon presented in Del Rosario et al. 2013. Del Rosario et al. analyzed rotary screw trap data for Knights Landing and demonstrated that 50 percent out-migrant juvenile winter-run chinook salmon arrive at Knights landing following the first Autumn pulse exceeding 15,000 cfs. CDFW does not consider the short-term and limited pulse flow protections to adequately reduce impacts to migrating juvenile fish because it only addresses the migrating portion of the population. CDFW recommends instead a base flow requirement of 13,000 cfs (the CAC erroneously reports the CDFW recommendation as 15,000 cfs) based on studies by Michele et al. 2015 and Michele et al. 2016.

CDFW views the pulse flow protection measure as insufficient because not all fish move on pulses. Williams (2006) describes 6 emigration strategies for juvenile fish leaving the spawning grounds in the upper Sacramento River. After larval fish emerge from their redds and begin dispersing to rearing habitat some move down the river to the delta, some move into bypasses if accessible, some move into tributaries, others stay at various locations in the Sacramento River to rear. Of those remining in the River following the first pulse, some emigrate on subsequent pulses and some emigrate independent of pulses. Those that emigrate on small pulses or independent of pulses are also important to the population and they are vulnerable to the proposed diversions and base flow conditions.

CDFW's recommendation for a higher base flow requirement is based on Chinook salmon survival studies in the River above the Delta (Michel et al. 2015, Michel 2016). These studies demonstrate a correlation between juvenile hatchery origin late-fall run Chinook salmon survival and flows at Bend Bridge. Survival begins to decline at flows around 13,000 cfs. These studies all rely on a data set created by monitoring acoustically tagged emigrating hatchery produced late-fall run Chinook salmon through their emigration from the upper River to and beyond the Delta. The data set, was produced in water years 2007 to 2011. It is limited in that it includes only on wet year, 2011, and 4 dry years. It does not include any intermediate below normal or above normal years. So, the steepness of the flow survival curve is influenced by a single data point. In addition, several of the monitoring stations in the River were not functional during the single high flow year. Of note, the statistical correlation between flow and survival in NMFS life cycle model supports the flow survival relationship and need for base flow requirement higher that the existing standards. Despite the weakness in these studies, they reflect the "best available science" standard required by the relevant environmental statutes and the regulatory agencies must consider them.

Delta survival of juvenile salmon

The DEIR/S incorporates delta flow measures to ensure diversions to Sites Reservoir are consistent with meeting Delta water quality standards. CDFW view these measures as inadequate as well. Del Rosario et al. (2013) demonstrate the importance of the delta to rearing juvenile winter-run Chinook salmon. The juvenile winter-run move past Knights Landing in response to the first Autumn pulse they reside in the Delta until Spring. The first emigration to Chipps Island occurs on average 9 days following Sacramento River flow events exceeding 20,000 cfs, measured at Freeport and 50% of the smolts leave the delta by March. During this month, smolts migrating through the North Delta experience Sacramento River flow ranging from median flows of 18,240 cfs to 50,050 cfs, measured at Freeport. The Del Rosario (2013) study shows residence time of winter-run juvenile population is inversely correlated with time of Delta entry. In addition, studies by Perry et al. (2018) demonstrate flow related mechanisms that affect survival of migrating juvenile salmon. Specifically, fish that migrate through the Sacramento River and Cache Slough have higher survival rates that fish that migrate through Georgiana Slough. Perry et al. (2018) demonstrate that when flood tides cause negative Sacramento River flow in the vicinity of Georgiana Slough more fish enter Georgian Slough than when flow in the Sacramento River remains positive. They also demonstrate that when Freeport flow is between 20,000 and 35,000 cfs the Sacramento River flows tend to be positive at Georgiana Slough throughout the tidal cycle. Therefore, more fish are likely to use migration routes with higher survival rates. CDFW relied on these studies to develop preliminary criteria for diversion by California Water-Fix, but elements of those criteria are vague or undefined and are expected to be refined by additional studies.

These studies were not available for consideration in the development of the DEIR/S, so the issue of migration routes through the delta will need to be addressed in the revitalized environmental review process. There are fish guidance measures and habitat restoration measures required by the NMFS biological opinion that could influence conditions in the vicinity of Georgiana Slough. These could be explored in the environmental review process, but the agencies will want to ensure diversions to Sites do not erode benefits from requirements on other projects.

Additional hydraulic modeling of delta flows should be conducted to demonstrate the expected effect of diversions to Sites Reservoir on the flow split at Georgiana Slough. If that analysis demonstrates that diversions to Sites Reservoir do not affect the flow split there would be little basis to support CDFW recommendation for a Freeport flow requirement.

Mitigation Measures

The CAC and CDFW are critical of the mitigation measures in the DEIR/S. They view them as poorly defined in the case of habitat restoration measures and inadequate in other respects. These criticisms rise in part from their view that the impacts are insufficiently quantified and accounted for. For example, if the estimated effect on survival is underestimated then the mitigation obligation to offset that effect is undervalued. There also affects that are not mitigated. The exposure of fish to new diversion is proposed to be mitigated by use of fish screen. While fish screen prevent entrainment, there still is likely to be residual injury and mortality of a small proportion of fish exposed to the fish screens. There is not a mitigation measure proposed to address that residual injury and mortality.

The criticism is not entirely valid because the proposed habitat restoration is intended to offset that residual mortality, but the habitat restoration obligation and how it will be met is poorly defined in the document. Habitat restoration opportunities in the upper river that are not already accounted for in mitigation strategies of other projects should be identified and addressed programmatically.

Delta outflow for delta species

The NGO letter referenced by CAC suggest the effects of the Sites Reservoir Project will adversely affect delta smelt and longfin smelt by reducing outflow, increasing reverse flow in Old and Middle Rivers, and increasing entrainment. Comparison of the DCR 2015 CALSIM II runs with and without project shows minor differences in these values. These relatively small differences between proposed action and no action are likely to be even smaller because the WSIP DCR 2015 modeling did not include the more restrictive diversion criteria that likely would be applied but were not modeled and revisions to the project design (e.g. reduced diversion capacity) will likely also reduce this effect.

Revised CALSIM II analysis for the revised project is needed to estimate effects of the resized project on theses parameters, and a detailed easily understood explanation of the results should be developed to explain how best to interpret the results, levels of precisions and uncertainty, and how they should be interpreted. There should also be a detailed (as possible) discussion of likely population level effects of any differences. For example, what is the population level effect of an estimated migration of X2 by a kilometer or less?

Trinity River Effects

The NGO community commissioned Kamman Hydrology & Engineering, Inc. to review the CALSIM II runs for effect on Trinity River operations. That report suggests there are changes in timing and magnitude of diversions for the Trinity to the Sacramento, which would have adverse effects on Trinity River temperatures and salmon populations in the Trinity. The DEIR/S is dismissive of differences in the CALSIM II runs for with and without project as incremental flow and storage changes of 5 percent or less are generally considered within the standard range of uncertainty associated with model processing and are considered to be similar to Existing Conditions/No Project/No Action flow levels. The Kamman Report demonstrates differences that appear to be greater the 5 percent level discussed in the DEIR/S and that could adversely affect temperatures and production of salmon in Trinity River.

While the Sites Authority and USBR have assured the NGOs and county governments that the Sites Reservoir Project will not result in additional demands for diversions of Trinity Water to the Sacramento Basin, these assurances also need to address timing of diversions, as changes in timing of transfers between basins can also affect temperatures in the Trinity. A detailed review and critique of the Kamman Report should be done and where the identified effects appear valid mechanisms to address them should be developed and incorporated into the project operations. Also, development of an enforceable mechanism to ensure commitments to the Trinity River are met.

Fishes in Funks and Stone Corral Creeks

While there are no ESA protected species in Funks and Stone Corral Creeks, there is a community of native fishes, same of which may be used recreationally. CDFW is critical of the analysis of effects of the project on these fish. In particular the mechanism for providing flow to Funks and Stone Corral Creeks are not capable of passing high intermittent flows, which may exceed 1,000 cfs, there is inadequate discussion of the effect of the loss of instream habitat created by the dams, and there is inadequate discussion of the effect of the pump storage proposal of reservoir populations of recreational species. Revisions to the project may address some these issues, others will remain and should be addressed.

Lifecycle modeling

The DEIR/S did not employ a lifecycle model in its analysis of effects, but it did rely on Salmod to define the expected benefit to juvenile production from improved temperature control to offset effect of the diversions. CDFW criticizes this analysis because Salmod is not a life cycle model. The Sites Authority did conduct some preliminary life cycle modeling using OBAN as part the Water Storage Investment Program process, but CDFW has not acknowledged the validity of that analysis.

To date as part of the CDFW 60-day process relevant to the development of the Governor's draft water resiliency policy, the Sites Authority has been negotiations against CDFW view that there needs be and instream flow requirement higher than the existing 5,000 cfs flow standard and a Freeport flow requirement of 30,000 cfs without the ability to look at population level effects.

Lifecycle modeling would be beneficial because it would allow assessment of tradeoffs among the various life stages, specifically higher fry production versus reduced juvenile and smolt survival to determine the likelihood of achieving a net benefit for salmon. It also would allow comparison of the project effects to the appropriate regulatory standard, at least with respect to endangered species statutes. The appropriate regulatory standard under the endangered species statutes is avoidance of jeopardy which is evaluated at the species level. This suggests a comparison of future population condition with the project to the future population condition without the project is needed. Lifecycle models when they are available are a good tool for making this comparison. There are several models available or in various stages of development, the renewed environmental review process should incorporate time and tools to conduct a life cycle analysis.

From: Heydinger, Erin [Erin.Heydinger@hdrinc.com]
Sent: 6/18/2020 10:01:38 AM
To: Alicia Forsythe [aforsythe@sitesproject.org]
CC: Spranza, John [John.Spranza@hdrinc.com]; Laurie Warner Herson (laurie.warner.herson@phenixenv.com) [laurie.warner.herson@phenixenv.com]
Subject: FW: Operations Support for Feasibility Report

FYI. I think this is generally in line with what we have been discussing with Rob related to his Amendment 2 SOW, but there is some good info here.

I'm asking Jeff for a copy of the WSIP technical reference so we have it on file.

Erin Heydinger PE, PMP
D 916.679.8863 M 651.307.9758

hdrinc.com/follow-us

From: Herrin, Jeff <jeff.herrin@aecom.com>
Sent: Thursday, June 18, 2020 9:54 AM
To: Luu, Henry <Henry.Luu@hdrinc.com>; Heydinger, Erin <Erin.Heydinger@hdrinc.com>
Cc: Tull, Robert/SAC <Robert.Tull@jacobs.com>
Subject: Operations Support for Feasibility Report

CAUTION: [EXTERNAL] This email originated from outside of the organization. Do not click links or open attachments unless you recognize the sender and know the content is safe.

Henry and Erin,

Rob and I discussed the operations support needed for the Feasibility Report (note the Commission requires a Feasibility Report, not an Engineering Feasibility Report). In my opinion, the upcoming Feasibility Report will need to true up the Authority's preferred alternative to document what has changed since the application. We are diverting a lot less water than was anticipated in the application and the facilities have changed significantly. Rob is going to include the supporting information in his budget, but it is a considerable expense and we don't know exactly what the Commission will require. The text in the WSIP Technical Reference regarding operations is as follows:

"The applicant must demonstrate that the project is technically feasible consistent with the operations plan, including a description of data and analytical methods, the hydrologic period, development conditions, hydrologic time step, and water balance analysis showing, for the with- and without-project condition, all flows and water supplies relevant to the benefits analysis."

We recommend someone contact the Commission to confirm the modeling baseline. If Rob can use the EIR/EIS baseline, that will significantly reduce the expense. Previously, we had to use DWR's 2030 and 2070 hydrology with climate change for the application. We do not know if remodeling the preferred alternative using this hydrology is a requirement for the Feasibility Report.

For financial feasibility, we should show the full cost assignment. The Commission previously rejected Anadromous Fish as a public benefit. I am assuming they will still want it included in the cost assignment if there is a Federal investment in the Anadromous Fish purpose. I don't know what kind of (if any) modeling is required to support this assignment. We may need life-cycle or SALMOD results to demonstrate the cost assignment to Reclamation. If we only have to model for State benefits funded through WSIP, it will simplify the analysis and reduce cost.

Jeff Herrin
Water Resources Planner, Water Business Unit, Sacramento, CA
D +1-916-679-2084   IPT 264-679-2084
M +1-916-432-0956
Jeff.Herrin@aecom.com

AECOM
2020 L Street
Suite 400
Sacramento, CA 95811, United States
T +1-916-414-5800
aecom.com

Built to deliver a better world

LinkedIn Twitter Facebook Instagram

From: Heydinger, Erin [Erin.Heydinger@hdrinc.com]
Sent: 6/18/2020 10:03:58 AM
To: Herrin, Jeff [jeff.herrin@aecom.com]; Luu, Henry [Henry.Luu@hdrinc.com]
CC: Tull, Robert/SAC [Robert.Tull@jacobs.com]; Alicia Forsythe [aforsythe@sitesproject.org]
Subject: RE: Operations Support for Feasibility Report

Hi Jeff,

Thank you for this – very helpful. I think this is in line with what we had in mind and what Rob, Ali, and I discussed yesterday as we reviewed the tasks for Amendment 2. You raise some good points about what we did for the original application versus what the CWC actually requires, and I hadn't thought of the baseline issue specifically. Ali and I can talk about this and loop in Jerry too, since he has been in discussions with the Water Commission.

Could you send me a copy of the WSIP Technical Reference? I looked online but was only able to find the executive summary.

Thanks,
Erin

Erin Heydinger PE, PMP
D 916.679.8863 M 651.307.9758

hdrinc.com/follow-us

From: Herrin, Jeff <jeff.herrin@aecom.com>
Sent: Thursday, June 18, 2020 9:54 AM
To: Luu, Henry <Henry.Luu@hdrinc.com>; Heydinger, Erin <Erin.Heydinger@hdrinc.com>
Cc: Tull, Robert/SAC <Robert.Tull@jacobs.com>
Subject: Operations Support for Feasibility Report

CAUTION: [EXTERNAL] This email originated from outside of the organization. Do not click links or open attachments unless you recognize the sender and know the content is safe.

Henry and Erin,

Rob and I discussed the operations support needed for the Feasibility Report (note the Commission requires a Feasibility Report, not an Engineering Feasibility Report). In my opinion, the upcoming Feasibility Report will need to true up the Authority's preferred alternative to document what has changed since the application. We are diverting a lot less water than was anticipated in the application and the facilities have changed significantly. Rob is going to include the supporting information in his budget, but it is a considerable expense and we don't know exactly what the Commission will require. The text in the WSIP Technical Reference regarding operations is as follows:

"The applicant must demonstrate that the project is technically feasible consistent with the operations plan, including a description of data and analytical methods, the hydrologic period, development conditions, hydrologic time step, and water balance analysis showing, for the with- and without-project condition, all flows and water supplies relevant to the benefits analysis."

We recommend someone contact the Commission to confirm the modeling baseline. If Rob can use the EIR/EIS baseline, that will significantly reduce the expense. Previously, we had to use DWR's 2030 and 2070 hydrology with climate change for the application. We do not know if remodeling the preferred alternative using this hydrology is a requirement for the Feasibility Report.

For financial feasibility, we should show the full cost assignment. The Commission previously rejected Anadromous Fish as a public benefit. I am assuming they will still want it included in the cost assignment if there is a Federal investment in the Anadromous Fish purpose. I don't know what kind of (if any) modeling is required to support this assignment. We may need life-cycle or SALMOD results to demonstrate the cost assignment to Reclamation. If we only have to model for State benefits funded through WSIP, it will simplify the analysis and reduce cost.

Jeff Herrin
Water Resources Planner, Water Business Unit, Sacramento, CA
D +1-916-679-2084   IPT 264-679-2084
M +1-916-432-0956
Jeff.Herrin@aecom.com

AECOM
2020 L Street
Suite 400
Sacramento, CA 95811, United States
T +1-916-414-5800
aecom.com

Built to deliver a better world

LinkedIn Twitter Facebook Instagram

From: Heydinger, Erin [Erin.Heydinger@hdrinc.com]
Sent: 6/18/2020 10:35:55 AM
To: Kevin Spesert [kspesert@sitesproject.org]; Jerry Brown [jbrown@sitesproject.org]; Alicia Forsythe [aforsythe@sitesproject.org]; Luu, Henry [Henry.Luu@hdrinc.com]
CC: JP Robinette (JRobinette@BrwnCald.com) [JRobinette@BrwnCald.com]
Subject: Reservoir Committee Presentations

Hi all,

I have presentations for the following agenda items:

- 2-1 Legislative Priorities
- 2-2 Negotiations Approach
- 3-2 Federal Feasibility
- 3-3 Revised EIR/EIS Objectives & Alternatives
- 3-4 DWR Discussions
- 3-5 CBD and Dunnigan Pipeline Alignment

They are all located on SharePoint in the PowerPoint folder. I assume at this point they are all final and will download them to my desktop for presenting. Please let me know if I'm missing anything.

Thanks!
Erin

Erin Heydinger, PE, PMP
Asst. Project Manager
Water/Wastewater

HDR
2379 Gateway Oaks Dr, #200
Sacramento, CA 95833
D 916.679.8863 M 651.307.9758

hdrinc.com/follow-us

Authorization/Permit	Regulatory Agency	Trigger	Needed for	Target Approval Date	Status/Notes	Permitting Timelines
CEQA: Final EIR NOD	Sites JPA	Discretionary authority to approve and implement a project	Construction, CF&GC 1602, CF&GC 2081, CWA 401, CVFPB encroachment permit, CSLC lease, water right, property acquisition, state funding	3/30/2020	Currently working on responses to comments on Draft EIS/EIR	Schedule driven by lead agency
NEPA: Final EIS ROD	USBR	Discretionary authority to approve and fund a project	Funding approval	6/7/2021	Currently working on responses to comments on Draft EIS/EIR	Schedule driven by lead agency; assumes signature required by Assistant Secretary of Water and Science
CEQA: Supplemental /Subsequent/ Addendum EIR	Sites JPA	Discretionary authority to approve and implement a project, specifically for project changes/refinements	Construction, CF&GC 1602, CF&GC 2081, CWA 401, CVFPB encroachment permit, CSLC lease, water right	3/29/2021	The type of document required will be dependent on the level of changes needed.	Schedule driven by lead agency
NEPA: Supplemental or standalone EIS	USACE Operations	Discretionary approvals under CWA (Section 10 and 404) and RHA (Section 408)	Construction, CWA 404/10 permit, RHA Section 408 permission	~7/2021	Supplemental or standalone document will be adopted post USBR EIS ROD. EIS for 408 action needed for levee modifications at Delevan intake and 404 individual permit requirement of 404(b)(1) Alternative Analysis	Schedule driven by USACE and applicant
CCR: Title 23 encroachment permit	CVFPB	Work in a designated floodway; reviewed in conjunction with USC 408 permission	Construction	11/19/2021	CVFPB will initiate the 408 consultation with USACE	CVFPB has 10 days to determine completeness of application, but total timeline is dependent on USC Section 408 review. Total process typically takes 6 to 9 months.
RHA: Section 14 (USC Section 408) permission	USACE Operations	Alteration and/or occupation of a Civil Works project (Delevan intake)	Construction, CWA 404, NEPA ROD (USACE), CVFPB encroachment permit	12/27/2021	Will want to meet criteria to stay at the USACE Division level for approval. 65% drawings and USACE NEPA document required. USBR led Section 106 and Section 7 consultation will be used for the 408 permission.	USACE has 30 days to determine completeness of submittal and 90 days to review and issue decision (total of 120 days). If a multi-phased review is requested, this timeline applies to each phase.
CWA Section 404/RHA Section 10 permit (CWA 404)	USACE Regulatory	Discharge to Waters of the U.S. and Navigable Waters	Construction, Section 408 permission, NEPA ROD (USACE)	12/27/2021	Individual Permit will require public notice, public interest review, individual NEPA analysis and a 404(b)(1) Alternative Analysis	USACE decision dependent on the timing of additional permits and reviews (e.g., Water Quality Certification, an approved Compensatory Mitigation Plan, or other federal Processes [CZMA, NHPA, or ESA Section 7).
ESA: Section 7 biological opinion (includes MBTA)	USFWS	Construction and Operations potential effects ESA terrestrial species	Construction, CWA 404, NEPA ROD (USBR and USACE)	3/25/2020	Admin Draft submitted to Sites and Reclamation 7/28. Updating to include project description details, operations criteria and additional analysis. Consultation with FWS anticipated to resume in September 2019.	Presidential Memo timeline. Standard consultation is supposed to last 135 days after submittal of Biological Assessment (90 days for Corps/USFWS/NMFS consultation, 45 days to prepare the Biological Opinion).
ESA: Section 7 biological opinion (includes MSFCMA)	NMFS	Construction and Operations potential effects on ESA fish species	Construction, CWA 404, NEPA ROD (USBR and USACE)	3/25/2020	Admin Draft submitted to Sites and Reclamation 7/28. Updating to include project description details, operations criteria and additional analysis. Consultation with NMFS and CDFW to develop the Proposed Action anticipated to begin in September 2019.	Presidential Memo timeline. Standard consultation is supposed to last 135 days after submittal of Biological Assessment (90 days for Corps/USFWS/NMFS consultation, 45 days to prepare the Biological Opinion).
NHPA: Section 106 Programmatic Agreement (PA)	SHPO	Potential effects on listed or eligible cultural resources	Construction, CWA 404, Section 408, NEPA ROD (USBR and USACE)	6/3/2020	Draft PA scheduled to be submitted for review September 2019. Will need to engage USACE to be a signatory party. Outreach with Tribes, treatment and relocation plans, effects analysis and field work/surveys will be phased to be completed prior to start of construction.	Consultation for a Section 106 PA can take up to a year, depending on the complexity of the project.
CF&GC: Section 2081 incidental take permit	CDFW	Potential effect on State-listed fish and wildlife	Construction	3/26/2021	Final EIR ROD is needed, and mitigation purchased or bonds posted for permit to be valid.	30 days to determine application for a take permit is complete, then 90 days to issue the permit.
CF&GC: Section 2081 incidental take permit	CDFW	Potential effect on State-listed fish and wildlife	Operations	3/26/2021	Final EIR ROD is needed, and mitigation purchased or bonds posted for permit to be valid.	30 days to determine application for a take permit is complete, then 90 days to issue the permit.
CF&GC: Section 1602 streambed alteration agreement	CDFW	Modification of a lake, river, or stream	Construction	12/22/2021	Anticipate phasing of construction and obtaining up to 6 agreements prior to start of construction in 2021. CDFW's general practice is to issue 2081 permit first and then base 1602 conservation measures and mitigation on the 2081 requirements.	Submit application, 30 days to determine completeness, then 60 days to issue draft agreement. If the applicant submits comments to draft agreement, CDFW must respond within 30 days.
CWA: Section 401/ Porter-Cologne Act water quality certification	SWRCB	Discharge to Waters of the State	Construction, CWA 404	10/21/2021	Will need to analyze and mitigate for both dredging and fill activities.	Submit application, 30 days to determine completeness, 60 days after determined complete to issue or deny certification.
Land Use Lease	CSLC	Work on sovereign land; specifically, below OHWM of Sacramento River	Construction	~9/2021	Will require approval at a Board meeting (infrequently scheduled). Will require copy of FEIR NOD.	30 days to determine if application is complete. Approval timelines depend on CEQA/NEPA authorizations and may take over a year to complete.
Water Right	SWRCB	Diversion of water from a specified source and put to a beneficial, nonwasteful use	Water diversions	1/3/2022		Currently, the water rights permitting process is estimated to require five to seven years for regular priority projects from the time an application is received to the time that a decision is rendered. Applications may be considered as higher priority depending on their consistency with these prioritization criteria.
SMARA mining permit	Colusa County, Glenn County	Borrow pitting exceeding 1 acre or removal of more than 1,000 cubic yards of material	Onsite borrow activities	???	EnviroMINE will be a subconsultant in Phase II to lead this effort.	Dependent on lead agency review.
Eagle Nest Take Permit	USFWS	Removal of eagle nests	Construction	3/2021	Surveys to start in January 2020.	90 days for a standard permit application once they are deemed complete.

Commented [AH1]: Schedule has Supplemental EIR being complete before ROD is issued by USBR for the Final EIS, which means ROD will not include current information.

Commented [AH2]: The 408 permission needs to be complete before CVFPB issues the encroachment permit, but the schedule has them flipped.

Commented [AH3]: Will need Supplemental EIR done prior to issuance of permit. Suggest revising target date.

Commented [AH4]: Will need Supplemental EIR done prior to issuance of permit. Suggest revising target date.

Commented [AH5]: This text is from SWRCB's website. Has there been any discussion with SWRCB regarding priority or the process in general that informed the target date of 1/3/2022?

Commented [AH6]: Need target date (permit not included in project schedule)

Commented [AH7]: Could not find any language on how long it takes to process/review SMARA permits

---

From: Spranza, John [John.Spranza@hdrinc.com]
Sent: 6/18/2020 1:44:59 PM
To: Micko, Steve/SAC [Steve.Micko@jacobs.com]; Heydinger, Erin [Erin.Heydinger@hdrinc.com]; Rude, Pete/RDD [Pete.Rude@jacobs.com]; Lecky, Jim [Jim.Lecky@icf.com]; Alicia Forsythe [aforsythe@sitesproject.org]; Monique Briard (monique.briard@icf.com) [monique.briard@icf.com]; Williams, Nicole (Nicole.Williams@icf.com) [Nicole.Williams@icf.com]; Laurie Warner Herson [laurie.warner.herson@phenixenv.com]; anne.huber@icf.com; Herrin, Jeff (jeff.herrin@aecom.com) [jeff.herrin@aecom.com]
CC: Alexander, Jeriann [jalexander@fugro.com]
Subject: Sites water quality working group
Attachments: 2020-0615_Water Quality_Agenda-and AI.docx; Salt Pond Memo-Working Draft-2020-0617.docx

Good Afternoon,
Attached are the notes and Action Items identified in Monday's meeting, please let me know if you have any questions or edits. Folks with AI's are Erin, Steve, Jim, Anne and I. I am thinking that the next meeting with be the week we return from the July 4th holiday but am open to other suggestions.

I have also attached the information I put together for the Salt Lake, that document has a list of next steps to address the Salt lake. If you could please review the document and send me any thoughts you might have on the next steps I would appreciate it.

Thank you.
John

John Spranza, MS, CCN
Senior Ecologist / Regulatory Specialist

HDR
2379 Gateway Oaks Drive, Suite 200
Sacramento, CA 95833
D 916.679.8858 M 818.640.2487
john.spranza@hdrinc.com

hdrinc.com/follow-us
hdrinc.com/follow-us

Sites Water Quality Meeting

Sites Reservoir Project

Date: *June 15, 2020* **Location:** *Webex*

Time: 10:00 am – 11:00 am

Purpose: Re-initiate discussions and approach for addressing the water quality comments made on the Draft EIR/S and identify and discus new items associated with the revised Project.

Invitees:

Ali Forsythe, Sites Authority
Steve Micko, Jacobs
Jeff Herrin, AECOM
Pete Rude, Jacobs
Monique Briard, ICF
Anne Huber, ICF
Nicole Williams, ICF
Jim Lecky, ICF
Erin Heydinger, Integration
John Spranza, Integration
Laurie Warner Herson, Integration

Action Item		Owner	Deadline	Notes
1	Environmental to discuss valve for flow into SC and Funks Creeks also for temperature control gate design.	Spranza/Herrin	TBD	Will call to discuss when appropriate time for this level o input will be needed
2	Identify gaps in water quality modeling needed.	Erin/Steve	7-1-20	
3	Schedule meeting for temperature model needs-CBD	Erin	7-1-20	
5	Review potential constituents of concern for CBD and Yolo	Anne	7-1-20	2017 EIR/S has these listed in chapter 7
6	Consult with RD 108 and North Delta Flow Group from DWR on food for fish programs	Jim	7-1-20	
7	Funks and SC Creek temp future assessment approach	Erin	TBD	Pending outcome of #2 and #3
8	Circulate Salt lake document and follow up on next steps identified therein	Spranza	6-19-20	
9	Coordinate with MBK on existing data and proposed CBD work	Spranza	7-1-20	
10	Schedule meeting; focused is modeling and temperature	Spranza	6-30-20	

Agenda:

Discussion Topic	Topic Leader	Est Time
1. Overview and Purpose a. Introductions and Overview b. Previous Water Quality Topics i. EIR/EIS Comments ii. Trinity River iii. Others? c. New Water Quality Topics i. Colusa Basin Drain ii. Discharge Temperature iii. VA Conflicts iv. Others?	John Spranza	20 min
2. Addressing Water Quality Topics a. Previous Efforts b. Current Efforts c. Additional Efforts Needed	John Spranza	30 min
3. Next Steps	Group discussion	10 min

Meeting Notes

1) Mercury issues from Jerry Bowles need to be further addressed
2) Baseflow requirements for Funks and SC Creeks need to be developed
3) Design team needs input from environmental for design of valves for channel forming flows and fish flows
4) Design team needs input from environmental for design of temperature control gates
5) Reservoir water quality model has been deferred to Phase II workplan
   - Future flows through Funks and SC Creeks will include:
   - Existing allocated water rights
   - Channel forming flows
   - Fish flows (Fish and Game Code 5937 to ensure that fish below reservoirs are in “good condition)
   - Emergency releases
6) Temperature modeling for the reservoir releases will likely be needed to determine:
   - Release temperature for SC and Funks creeks
   - In lake water temperature assessment for temperature modeling through discharge facilities, including Colusa Basin Drain and Sacramento River.
7) Need to loop in MBK to assess what data/model they are aware of that could be used for temp in CBD and have them collaborate with this group as appropriate
8) Consult with RD 108 and North Delta Flow Group from DWR on food for fish program and any existing WQ data that may be available.

Salt Lake Existing Information

Sites Reservoir Project

Purpose: This document summarizes the existing information of the salt pond within the inundation zone for Sites Reservoir to provide the detail needed to identify what if any further action is needed to address the concerns associated with water quality within the reservoir.

Background

Saline water has been observed to seep from underground salt springs in the vicinity of the Salt Lake fault along the slopes above the valley and along the valley floor within the proposed inundation area of Sites Reservoir. These areas are generally located in the Funks Creek watershed. The water from the underground springs accumulates along the trough of the valley and forms Salt Lake (USGS, 1915 DWR 2000). The California Department of Water Resources (DWR) began monthly sampling of streams and lakes in the region around Sites Reservoir in 1997, including physical parameters, nutrients, minerals, and metals in the water column (DWR, 2012 and 2013).

Salt Lake was only sampled on a few occasions from 1997 to 1998. The size of Salt Lake and adjacent seasonal brackish wetlands varies with time. The wetted area appears to vary from 0 to 30 acres. The deeper water appears to be approximately 15 acres based on observations in 2017. The depth of the water has not been monitored. In August 1997, the Salt Lake was dry. In September 1997, the springs were bubbling and the EC was 194,100 micromhos per centimeter (µmhos/cm) as compared to 3,490 µmhos/cm for the nearby Stone Corral Creek. In January 1998, there was less than 1 cfs of flow from the springs, and the EC was 7,200 µmhos/cm as compared to 540 µmhos/cm for the nearby Stone Corral Creek. From these samples, it was found that waters from this location are extremely high in minerals. The EC value on one occasion reached 194,100 micromhos per centimeter. The Total dissolved Solids (TDS) measurement at this time was 258,000 mg/L. EC, TDS, sodium, and boron exceeded all Central Valley Basin Plan criteria. A few metals also were noted at very high concentrations (aluminum, iron, and manganese) and exceeded all criteria, and a few others exceeded some criteria (arsenic, copper, lead, and nickel). Levels of ammonia and orthophosphate also were noted at high levels and exceeded criteria. Temperatures from this site were variable, and probably depend on seasonal conditions. Concentrations present in water from this site likely depend on the season and flow.

Discussion and Analysis in 2017 Draft EIR/EIS

As described in Chapter 3 of the 2017 Draft EIR/EIS, the springs that provide water to the Salt Lake would be grouted to reduce the amount of highly saline water from entering Sites Reservoir. However, the effectiveness of the grouting measures is not known at this time. Therefore, the water quality impact analysis for Sites Reservoir includes the following worst-case evaluation, assuming that salt water continues to enter the reservoir in a similar manner as historical seepage.

Based upon observations of the Salt Lake in 2017, it appears that the main body of Salt Lake is approximately 15 acres and could be 5 to 10 feet deep. These dimensions would result in a volume of 150 acre-feet. Evaporation rates for fresh water near Sites is approximately 5 feet/year, and saline water evaporates more slowly than fresh water. However, for this evaluation, the more conservative evaporation rate was assumed. To maintain the main body of the Salt Lake, approximately 75 acre-feet/year would need to seep from the springs into the Salt Lake (at a long-term average rate of 0.1 cfs).

As described in Section 7.2, Salt Lake becomes very small, especially in drier years. Therefore, it was assumed that seepage from the springs was very low in Dry and Critical water years.

[redacted]

The average monthly storage in Sites Reservoir under Alternative A in Wet, Above Normal, and Below Normal water years ranges from 800,000 to 1,050,000 acre-feet. The annual volume of saline water that currently seeps into Salt Lake would represent 0.008 to 0.009 percent of the total annual volume in Sites Reservoir under Alternative A. Assuming that the salinity of the water was an average of 7,200 µmhos/cm and the salinity of the Sacramento River water near Colusa was 170 µmhos/cm, the addition of the saline water that historically has formed Salt Lake would increase the overall salinity of Sites Reservoir by less than 1 µmhos/cm (0.4 percent).

Commented [SJ1]: I think this is way low based on the background information above.

2017 P6/18/2020roposed mitigation

The springs at the Salt Lake within the Sites Reservoir would be grouted to reduce the seepage of saline water into Sites Reservoir

Under Alternative D, the potential for changes in salinity in Sites Reservoir related to potential seepage from the springs near Salt Lake (if the grout seal does not reduce seepage) would result in an increase in EC of less than 0.5 µmhos/cm (0.2 percent). The high salinity water from the Salt Lake area would represent less than 0.005 to 0.75 percent of the total water in Sites Reservoir under Alternative D.

Next Steps:

1. Determine more realistic average salinity of Salt Lake than identified in the EIR/EIS analysis
2. Identify average depth of water column Salt Lake would be inundated by.
3. Assess change in pressure at Salt Lake due once inundated and compare to Salt Lake's known discharge rate to determine potential for seepage once inundated.
4. Reassess 2017 analysis using more realistic average salinity of Salt Lake and change in pressure due to inundation
5. Determine if cap mitigation is needed based on results from #4
6. Confirm ability to adequately cap Salt Lake if needed

References

California Department of Water Resources (DWR). 2000. North of Delta Offstream Storage Investigation. Progress Report. February

U.S. Geological Survey (USGS). 1915. Springs of California. Water Supply Paper 338

California Department of Water Resources (DWR). 2012. *The State Water Project, Final Delivery Reliability Report, 2011*. June.

California Department of Water Resources (DWR). 2013. Water Data Library. http://www.water.ca.gov/waterdatalibrary/docs/Hydstra/index.cfm?site=A02976&source=map.

From: Alexander, Jeriann [jalexander@fugro.com]
Sent: 6/22/2020 8:59:13 AM
To: Spranza, John [John.Spranza@hdrinc.com]; Micko, Steve/SAC [Steve.Micko@jacobs.com]; Heydinger, Erin [Erin.Heydinger@hdrinc.com]; Rude, Pete/RDD [Pete.Rude@jacobs.com]; Lecky, Jim [Jim.Lecky@icf.com]; Alicia Forsythe [aforsythe@sitesproject.org]; Monique Briard (monique.briard@icf.com) [monique.briard@icf.com]; Williams, Nicole (Nicole.Williams@icf.com) [Nicole.Williams@icf.com]; Laurie Warner Herson [laurie.warner.herson@phenixenv.com]; anne.huber@icf.com; Herrin, Jeff (jeff.herrin@aecom.com) [jeff.herrin@aecom.com]
Subject: RE: Sites water quality working group

John
Are the DWR water quality studies added to the Project Description reference folder?

Since 1997 numerous improvements in sampling and testing methodologies have been made. Very high TDS values indicates significant influence by sediments in the water quality sample data, including if salt crystals were captured in the water sample. Data skewing is very possible.

Historic data regarding the Salt Lake area I reviewed suggested that the salt is present in the native soils and parent rock materials. Salt Lake also exists along the Salt Lake fault. Geothermal and geochemical changes may influence the presence of the springs and the quality and temperature of the water.

Thus when we are able, obtaining additional sediment, soil and water samples from the Salt Lake area would provide better data to correlate where the salt is coming from and what the range in concentrations may be.

In the absence of the new data, we should consider that the weight of the water filling the reservoir may overcome any spring flow and thus any significant release of low quality salt from the subsurface springs. Thus the % increase may be de minimis.

Best Regards,

Jeriann N. Alexander, PE, REPA
Principal Engineer
Fugro

T +1 916 559 6873 or +1 925 949 7103 | **M** +1 510 610 8052
E jalexander@fugro.com | **W** www.fugro.com

A 2420 Del Paso Road, Suite 250, Sacramento, California 95834, USA
A 1777 Botelho Drive, Suite 262, Walnut Creek, California 94596, USA
A 469 Roland Way, Oakland, California 94621, USA

Together we create a safe and liveable world.

From: Spranza, John <John.Spranza@hdrinc.com>
Sent: Thursday, June 18, 2020 1:45 PM
To: Micko, Steve/SAC <Steve.Micko@jacobs.com>; Heydinger, Erin <Erin.Heydinger@hdrinc.com>; Rude, Pete/RDD <Pete.Rude@jacobs.com>; Lecky, Jim <Jim.Lecky@icf.com>; aforsythe (aforsythe@sitesproject.org) <aforsythe@sitesproject.org>; Monique Briard (monique.briard@icf.com) <monique.briard@icf.com>; Williams, Nicole (Nicole.Williams@icf.com) <Nicole.Williams@icf.com>; Laurie Warner Herson <laurie.warner.herson@phenixenv.com>; anne.huber@icf.com; Herrin, Jeff (jeff.herrin@aecom.com) <jeff.herrin@aecom.com>
Cc: Alexander, Jeriann <jalexander@fugro.com>
Subject: Sites water quality working group

Good Afternoon,
Attached are the notes and Action Items identified in Monday's meeting, please let me know if you have any questions or edits. Folks with AI's are Erin, Steve, Jim, Anne and I. I am thinking that the next meeting with be the week we return from the July 4th holiday but am open to other suggestions.

I have also attached the information I put together for the Salt Lake, that document has a list of next steps to address the Salt lake. If you could please review the document and send me any thoughts you might have on the next steps I would appreciate it.

Thank you.
John

John Spranza, MS, CCN
Senior Ecologist / Regulatory Specialist

HDR
2379 Gateway Oaks Drive, Suite 200
Sacramento, CA 95833
D 916.679.8858 M 818.640.2487
john.spranza@hdrinc.com

hdrinc.com/follow-us
hdrinc.com/follow-us

From: Herrin, Jeff [jeff.herrin@aecom.com]
Sent: 6/22/2020 10:43:05 AM
To: Alexander, Jeriann [jalexander@fugro.com]; Spranza, John [John.Spranza@hdrinc.com]; Micko, Steve/SAC [Steve.Micko@jacobs.com]; Heydinger, Erin [Erin.Heydinger@hdrinc.com]; Rude, Pete/RDD [Pete.Rude@jacobs.com]; Lecky, Jim [Jim.Lecky@icf.com]; Alicia Forsythe [aforsythe@sitesproject.org]; Monique Briard (monique.briard@icf.com) [monique.briard@icf.com]; Williams, Nicole (Nicole.Williams@icf.com) [Nicole.Williams@icf.com]; Laurie Warner Herson [laurie.warner.herson@phenixenv.com]; anne.huber@icf.com
Subject: RE: Sites water quality working group

It seems like it may eventually be necessary to develop a mixing model to estimate the concentrations that would occur in the reservoir, but I doubt you have adequate information to develop something like that at this time.

From: Alexander, Jeriann <jalexander@fugro.com>
Sent: Monday, June 22, 2020 8:59 AM
To: Spranza, John <John.Spranza@hdrinc.com>; Micko, Steve/SAC <Steve.Micko@jacobs.com>; Heydinger, Erin <Erin.Heydinger@hdrinc.com>; Rude, Pete/RDD <Pete.Rude@jacobs.com>; Lecky, Jim <Jim.Lecky@icf.com>; aforsythe (aforsythe@sitesproject.org) <aforsythe@sitesproject.org>; Monique Briard (monique.briard@icf.com) <monique.briard@icf.com>; Williams, Nicole (Nicole.Williams@icf.com) <Nicole.Williams@icf.com>; Laurie Warner Herson <laurie.warner.herson@phenixenv.com>; anne.huber@icf.com; Herrin, Jeff <jeff.herrin@aecom.com>
Subject: [EXTERNAL] RE: Sites water quality working group

John
Are the DWR water quality studies added to the Project Description reference folder?

Since 1997 numerous improvements in sampling and testing methodologies have been made. Very high TDS values indicates significant influence by sediments in the water quality sample data, including if salt crystals were captured in the water sample. Data skewing is very possible.

Historic data regarding the Salt Lake area I reviewed suggested that the salt is present in the native soils and parent rock materials. Salt Lake also exists along the Salt Lake fault. Geothermal and geochemical changes may influence the presence of the springs and the quality and temperature of the water.

Thus when we are able, obtaining additional sediment, soil and water samples from the Salt Lake area would provide better data to correlate where the salt is coming from and what the range in concentrations may be.

In the absence of the new data, we should consider that the weight of the water filling the reservoir may overcome any spring flow and thus any significant release of low quality salt from the subsurface springs. Thus the % increase may be de minimis.

Best Regards,

Jeriann N. Alexander, PE, REPA
Principal Engineer
Fugro

T +1 916 559 6873 or +1 925 949 7103 | **M** +1 510 610 8052
E jalexander@fugro.com | **W** www.fugro.com

A 2420 Del Paso Road, Suite 250, Sacramento, California 95834, USA
A 1777 Botelho Drive, Suite 262, Walnut Creek, California 94596, USA
A 469 Roland Way, Oakland, California 94621, USA

Together we create a safe and liveable world.

From: Spranza, John <John.Spranza@hdrinc.com>
Sent: Thursday, June 18, 2020 1:45 PM
To: Micko, Steve/SAC <Steve.Micko@jacobs.com>; Heydinger, Erin <Erin.Heydinger@hdrinc.com>; Rude, Pete/RDD <Pete.Rude@jacobs.com>; Lecky, Jim <Jim.Lecky@icf.com>; aforsythe (aforsythe@sitesproject.org) <aforsythe@sitesproject.org>; Monique Briard (monique.briard@icf.com) <monique.briard@icf.com>; Williams, Nicole (Nicole.Williams@icf.com) <Nicole.Williams@icf.com>; Laurie Warner Herson <laurie.warner.herson@phenixenv.com>; anne.huber@icf.com; Herrin, Jeff (jeff.herrin@aecom.com) <jeff.herrin@aecom.com>
Cc: Alexander, Jeriann <jalexander@fugro.com>
Subject: Sites water quality working group

Good Afternoon,
Attached are the notes and Action Items identified in Monday's meeting, please let me know if you have any questions or edits. Folks with AI's are Erin, Steve, Jim, Anne and I. I am thinking that the next meeting with be the week we return from the July 4th holiday but am open to other suggestions.

I have also attached the information I put together for the Salt Lake, that document has a list of next steps to address the Salt lake. If you could please review the document and send me any thoughts you might have on the next steps I would appreciate it.

Thank you.
John

John Spranza, MS, CCN
Senior Ecologist / Regulatory Specialist

HDR
2379 Gateway Oaks Drive, Suite 200
Sacramento, CA 95833
D 916.679.8858 M 818.640.2487
john.spranza@hdrinc.com

hdrinc.com/follow-us
hdrinc.com/follow-us

From: Spranza, John [John.Spranza@hdrinc.com]
Sent: 6/22/2020 10:48:41 AM
To: Herrin, Jeff [jeff.herrin@aecom.com]; Alexander, Jeriann [jalexander@fugro.com]; Micko, Steve/SAC [Steve.Micko@jacobs.com]; Heydinger, Erin [Erin.Heydinger@hdrinc.com]; Rude, Pete/RDD [Pete.Rude@jacobs.com]; Lecky, Jim [Jim.Lecky@icf.com]; Alicia Forsythe [aforsythe@sitesproject.org]; Monique Briard (monique.briard@icf.com) [monique.briard@icf.com]; Williams, Nicole (Nicole.Williams@icf.com) [Nicole.Williams@icf.com]; Laurie Warner Herson [laurie.warner.herson@phenixenv.com]; anne.huber@icf.com
Subject: RE: Sites water quality working group

Erin, Laurie and I were just talking about that this morning. Erin is going to follow up with Rob Tull on water quality-related modeling in and downstream of the reservoir. It will be a Phase 2 item at the earliest.

John Spranza

D 916.679.8858 M 818.640.2487

From: Herrin, Jeff [mailto:jeff.herrin@aecom.com]
Sent: Monday, June 22, 2020 10:43 AM
To: Alexander, Jeriann <jalexander@fugro.com>; Spranza, John <John.Spranza@hdrinc.com>; Micko, Steve/SAC <Steve.Micko@jacobs.com>; Heydinger, Erin <Erin.Heydinger@hdrinc.com>; Rude, Pete/RDD <Pete.Rude@jacobs.com>; Lecky, Jim <Jim.Lecky@icf.com>; aforsythe (aforsythe@sitesproject.org) <aforsythe@sitesproject.org>; Monique Briard (monique.briard@icf.com) <monique.briard@icf.com>; Williams, Nicole (Nicole.Williams@icf.com) <Nicole.Williams@icf.com>; Laurie Warner Herson <laurie.warner.herson@phenixenv.com>; anne.huber@icf.com
Subject: RE: Sites water quality working group

CAUTION: [EXTERNAL] This email originated from outside of the organization. Do not click links or open attachments unless you recognize the sender and know the content is safe.

It seems like it may eventually be necessary to develop a mixing model to estimate the concentrations that would occur in the reservoir, but I doubt you have adequate information to develop something like that at this time.

From: Alexander, Jeriann <jalexander@fugro.com>
Sent: Monday, June 22, 2020 8:59 AM
To: Spranza, John <John.Spranza@hdrinc.com>; Micko, Steve/SAC <Steve.Micko@jacobs.com>; Heydinger, Erin <Erin.Heydinger@hdrinc.com>; Rude, Pete/RDD <Pete.Rude@jacobs.com>; Lecky, Jim <Jim.Lecky@icf.com>; aforsythe (aforsythe@sitesproject.org) <aforsythe@sitesproject.org>; Monique Briard (monique.briard@icf.com) <monique.briard@icf.com>; Williams, Nicole (Nicole.Williams@icf.com) <Nicole.Williams@icf.com>; Laurie Warner Herson <laurie.warner.herson@phenixenv.com>; anne.huber@icf.com; Herrin, Jeff <jeff.herrin@aecom.com>
Subject: [EXTERNAL] RE: Sites water quality working group

John
Are the DWR water quality studies added to the Project Description reference folder?

Since 1997 numerous improvements in sampling and testing methodologies have been made. Very high TDS values indicates significant influence by sediments in the water quality sample data, including if salt crystals were captured in the water sample. Data skewing is very possible.

Historic data regarding the Salt Lake area I reviewed suggested that the salt is present in the native soils and parent rock materials. Salt Lake also exists along the Salt Lake fault. Geothermal and geochemical changes may influence the presence of the springs and the quality and temperature of the water.

Thus when we are able, obtaining additional sediment, soil and water samples from the Salt Lake area would provide better data to correlate where the salt is coming from and what the range in concentrations may be.

In the absence of the new data, we should consider that the weight of the water filling the reservoir may overcome any spring flow and thus any significant release of low quality salt from the subsurface springs. Thus the % increase may be de minimis.

Best Regards,

Jeriann N. Alexander, PE, REPA
Principal Engineer
Fugro

T +1 916 559 6873 or +1 925 949 7103 | **M** +1 510 610 8052
E jalexander@fugro.com | **W** www.fugro.com

A 2420 Del Paso Road, Suite 250, Sacramento, California 95834, USA
A 1777 Botelho Drive, Suite 262, Walnut Creek, California 94596, USA
A 469 Roland Way, Oakland, California 94621, USA

Together we create a safe and liveable world.

From: Spranza, John <John.Spranza@hdrinc.com>
Sent: Thursday, June 18, 2020 1:45 PM
To: Micko, Steve/SAC <Steve.Micko@jacobs.com>; Heydinger, Erin <Erin.Heydinger@hdrinc.com>; Rude, Pete/RDD <Pete.Rude@jacobs.com>; Lecky, Jim <Jim.Lecky@icf.com>; aforsythe (aforsythe@sitesproject.org) <aforsythe@sitesproject.org>; Monique Briard (monique.briard@icf.com) <monique.briard@icf.com>; Williams, Nicole (Nicole.Williams@icf.com) <Nicole.Williams@icf.com>; Laurie Warner Herson <laurie.warner.herson@phenixenv.com>; anne.huber@icf.com; Herrin, Jeff (jeff.herrin@aecom.com) <jeff.herrin@aecom.com>
Cc: Alexander, Jeriann <jalexander@fugro.com>
Subject: Sites water quality working group

Good Afternoon,
Attached are the notes and Action Items identified in Monday's meeting, please let me know if you have any questions or edits. Folks with AI's are Erin, Steve, Jim, Anne and I. I am thinking that the next meeting with be the week we return from the July 4th holiday but am open to other suggestions.

I have also attached the information I put together for the Salt Lake, that document has a list of next steps to address the Salt lake. If you could please review the document and send me any thoughts you might have on the next steps I would appreciate it.

Thank you.
John

John Spranza, MS, CCN
Senior Ecologist / Regulatory Specialist

HDR
2379 Gateway Oaks Drive, Suite 200
Sacramento, CA 95833
D 916.679.8858 M 818.640.2487
john.spranza@hdrinc.com

hdrinc.com/follow-us

hdrinc.com/follow-us

Scene Setter for Environmental Water Management Discussion
Manager's Group of the Northern California Water Association
June 23, 2020

Purpose of the Discussion: Consider tasking a group of Sac Valley water managers to create a concept framework of a governance system that could most effectively manage a portfolio of environmental assets in the watershed with the goal of achieving an outcome from the whole that is greater than the sum of the parts.

Why is this important to water users?

- This is an opportunity to provide leadership on a critical water issue facing the state. The State currently is not equipped to manage these assets for optimized benefit.
- Effective water management in a watershed relies on collaborative structures among the various uses of water.
- Future voter support for water related efforts is improved with prior successes – a failure in one area of water management reflects poorly on all of the areas.

Structure of the Discussion: The following questions are provided as a means to get the conversation started and provide some structure of topic areas to be covered.

1. What projects/programs would be covered? Is this a Sites only structure or should it be the entire watershed encompassing many projects? If at a watershed level, would there be sub-governance units or committees for each element, e.g. Sites, floodplain restoration, water transfers, etc?
2. Who are the parties at the table, i.e who is in the tent and who is out?
3. Can there by voting members and non-voting members, perhaps dependent on project funding participation, or a structure of an advisory committee (which could include NGOs) subordinate to a voting body (comprised of project funders)?
4. What are the voting rules for those that get to vote? Is unanimous consent or supermajority required?
5. What are the powers of the group (i.e., what is their scope of authority? when does it begin? does the group have voice in project design)?
6. Is legislation needed (i.e., the closest analogy I can think of is a legislatively established state conservancy)?
7. What keeps all the parties at the table?
8. How do you measure the tools in the toolkit (i.e., what are the assets/variables that the body governs: Is it solely "environmental" water? Is it land? Is it credits of habitat types? Is it based on ecosystem or species functions and values?)?
9. What are the measures of success?
10. How does an ecosystem budget respect water rights seniority?
11. How does the structure evolve over time and what triggers changes?
12. Can the powers of the State be limited within contracts?
13. Is there a regular, secured funding mechanism (i.e., a proportion of expected yield)?
14. Should plans be drawn up for management actions to be taken for different water year types so crisis management can be avoided?
15. Can we identify ecosystem priorities and impact trade-offs so decisions can be well thought out.
16. Do we need systems for data and water accounting?
17. Can we measure environmental changes resulting from the water use to quantify benefits in all asset classes?
18. Is a sufficient science program necessary to support the activities and to advise the regulatory agencies?
19. Do we have a manageable set of problems?

VOLUNTEERS?

From: Jerry Brown [jbrown@sitesproject.org]
Sent: 6/22/2020 5:05:15 PM
To: Rob Kunde [rkunde@wrmwsd.com]
CC: Alicia Forsythe [aforsythe@sitesproject.org]; Heydinger, Erin [Erin.Heydinger@hdrinc.com]; Marcia Kivett [MKivett@sitesproject.org]
Subject: Follow-up

Hi Rob – You made a comment at the RC meeting last week to review the environmental benefits of the CBD. I'm getting back to you that we will be doing what you requested as part of the environmental review process leading up to the Revised and Recirculated Draft EIR July 2021. Our work will involve analyzing all of the environmental effects of our possible use of the CBD. The environmental planning and permitting workgroup will be kept abreast of any significant findings. Don't hesitate to let me know any other questions or concerns in this regard.

Thanks
Jerry

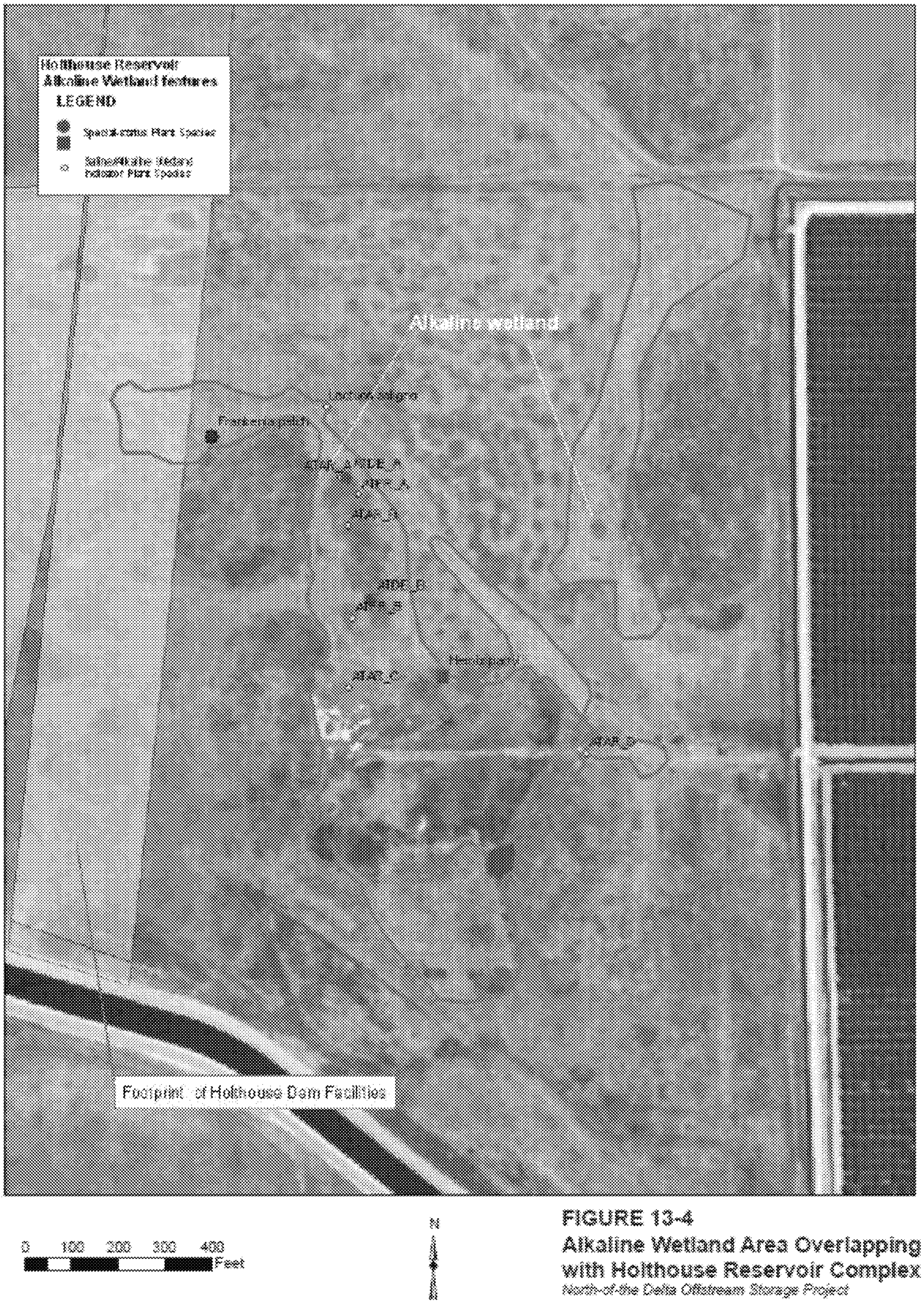


FIGURE 13-4
Alkaline Wetland Area Overlapping with Holthouse Reservoir Complex
North-of-the Delta Offstream Storage Project

FIGURE 13-2
Vegetation Types Near Project Facility Locations
North-of-the-Delta Offstream Storage Project

From: Lyons, Amy@DWR [Amy.Lyons@water.ca.gov]
Sent: 6/23/2020 10:49:06 AM
To: Spranza, John [John.Spranza@hdrinc.com]
CC: Arsenijevic, Jelica [Jelica.Arsenijevic@hdrinc.com]; Monique Briard (monique.briard@icf.com) [monique.briard@icf.com]; Alicia Forsythe [aforsythe@sitesproject.org]; Heydinger, Erin [erin.heydinger@hdrinc.com]; Heydinger, Erin [erin.heydinger@hdrinc.com]
Subject: Sites Project/NODOS Biological data - avian report
Attachments: Avian.cmstyle.body.10.02.03.doc

Hi John –

The avian report is attached. Please note that these reports are in draft form and were never finaled. - Amy

---

From: Spranza, John <John.Spranza@hdrinc.com>
Sent: Tuesday, June 23, 2020 9:49 AM
To: Lyons, Amy@DWR <Amy.Lyons@water.ca.gov>
Cc: Arsenijevic, Jelica <Jelica.Arsenijevic@hdrinc.com>; Monique Briard (monique.briard@icf.com) <monique.briard@icf.com>; aforsythe (aforsythe@sitesproject.org) <aforsythe@sitesproject.org>; Heydinger, Erin <erin.heydinger@hdrinc.com>; Heydinger, Erin <erin.heydinger@hdrinc.com>
Subject: Sites Project/NODOS Biological data

Good Morning Amy,
I am following up on a voicemail I just left you regarding the biological data that DWR collected for the Sites Project area in the early and mid 2000's. The data was from surveys that were performed by DWR in collaboration with CDFW for the North of Delta Off-Stream Storage (NODOS) project and the Sites Reservoir Project. We have been trying to locate these data so that we can include them in the revised EIR/EIS that is being prepared but have not been able to. Jeff Heron from AECOM thought that you might be able to locate the dataset for us, or maybe help with some additional information. I have provide a few of the references we are looking for below, and have attached a word document that has a few graphics from the Prelim EIR/EIS from 2013.

Any help would be much appreciated and feel free to call or email me at the cointact information below. I would be more than happy to come up to Red Bluff if need be.

Reference Text
"Initial field surveys were conducted within the Primary Study Area from 1998 to 2004 at all Project facility locations, then again in 2010 to 2011 at newly proposed Project facility locations." From Page 14-17 DWR's of North-Of-The-Delta Offstream Storage Project EIR/EIS prelim Admin Draft 2013

California Department of Fish and Game (DFG). 2003a. Amphibian and Reptile Studies at Sites and Newville Projects. Draft Progress Report, May 2003, 80 p. Prepared under interagency agreement
between the CA Department of Water Resources and the CA Department of Fish and Game. Pages cited: 12-27.

California Department of Water Resources (DWR). 2005. NODOS Botanical Resources Report. Progress report prepared by Barbara Castro. Northern District, Red Bluff, California. References 2000
Progress Report prepared for 1998-1999 surveys by Jenny Marr, Northern District, Red Bluff, CA.

California Department of Fish and Game (CDFG) (now known as California Department of Fish and Wildlife [CDFW]). 2003b. Offstream Storage Investigations: Mammal Surveys. Draft Progress Report. Prepared under interagency agreement between the CA Department of Water Resources and the CA Department of Fish and Game. July. pp. 14-21 and 84-100.

California Department of Water Resources (DWR). 2003. Survey for State and Federal Special Status Avian Species at North-of-the-Delta Offstream Storage Reservoir Alternatives. Draft Progress
Report, October 2003, 42 p. Pages cited: 11-33.

Thanks much,
John

John Spranza, MS, CCN
Senior Ecologist / Regulatory Specialist

HDR
2379 Gateway Oaks Drive, Suite 200
Sacramento, CA 95833
D 916.679.8858 M 818.640.2487
john.spranza@hdrinc.com

hdrinc.com/follow-us
hdrinc.com/follow-us

From: Lyons, Amy@DWR [Amy.Lyons@water.ca.gov]
Sent: 6/23/2020 10:50:51 AM
To: Spranza, John [John.Spranza@hdrinc.com]
CC: Arsenijevic, Jelica [Jelica.Arsenijevic@hdrinc.com]; Monique Briard (monique.briard@icf.com) [monique.briard@icf.com]; Alicia Forsythe [aforsythe@sitesproject.org]; Heydinger, Erin [erin.heydinger@hdrinc.com]; Heydinger, Erin [erin.heydinger@hdrinc.com]
Subject: Sites Project/NODOS Biological data - mammal report
Attachments: OSI0703report.doc

Hi John –

The draft mammal report is attached. - Amy

From: Spranza, John <John.Spranza@hdrinc.com>
Sent: Tuesday, June 23, 2020 9:49 AM
To: Lyons, Amy@DWR <Amy.Lyons@water.ca.gov>
Cc: Arsenijevic, Jelica <Jelica.Arsenijevic@hdrinc.com>; Monique Briard (monique.briard@icf.com) <monique.briard@icf.com>; aforsythe (aforsythe@sitesproject.org) <aforsythe@sitesproject.org>; Heydinger, Erin <erin.heydinger@hdrinc.com>; Heydinger, Erin <erin.heydinger@hdrinc.com>
Subject: Sites Project/NODOS Biological data

Good Morning Amy,
I am following up on a voicemail I just left you regarding the biological data that DWR collected for the Sites Project area in the early and mid 2000's. The data was from surveys that were performed by DWR in collaboration with CDFW for the North of Delta Off-Stream Storage (NODOS) project and the Sites Reservoir Project. We have been trying to locate these data so that we can include them in the revised EIR/EIS that is being prepared but have not been able to. Jeff Heron from AECOM thought that you might be able to locate the dataset for us, or maybe help with some additional information. I have provide a few of the references we are looking for below, and have attached a word document that has a few graphics from the Prelim EIR/EIS from 2013.

Any help would be much appreciated and feel free to call or email me at the cointact information below. I would be more than happy to come up to Red Bluff if need be.

Reference Text
"Initial field surveys were conducted within the Primary Study Area from 1998 to 2004 at all Project facility locations, then again in 2010 to 2011 at newly proposed Project facility locations." From Page 14-17 DWR's of North-Of-The-Delta Offstream Storage Project EIR/EIS prelim Admin Draft 2013

California Department of Fish and Game (DFG). 2003a. Amphibian and Reptile Studies at Sites and Newville Projects. Draft Progress Report, May 2003, 80 p. Prepared under interagency agreement
between the CA Department of Water Resources and the CA Department of Fish and Game. Pages cited: 12-27.

California Department of Water Resources (DWR). 2005. NODOS Botanical Resources Report. Progress report prepared by Barbara Castro. Northern District, Red Bluff, California. References 2000
Progress Report prepared for 1998-1999 surveys by Jenny Marr, Northern District, Red Bluff, CA.

California Department of Fish and Game (CDFG) (now known as California Department of Fish and Wildlife [CDFW]). 2003b. Offstream Storage Investigations: Mammal Surveys. Draft Progress Report. Prepared under interagency agreement between the CA Department of Water Resources and the CA Department of Fish and Game. July. pp. 14-21 and 84-100.

California Department of Water Resources (DWR). 2003. Survey for State and Federal Special Status Avian Species at North-of-the-Delta Offstream Storage Reservoir Alternatives. Draft Progress
Report, October 2003, 42 p. Pages cited: 11-33.

Thanks much,
John

John Spranza, MS, CCN
Senior Ecologist / Regulatory Specialist

HDR
2379 Gateway Oaks Drive, Suite 200
Sacramento, CA 95833
D 916.679.8858 M 818.640.2487
john.spranza@hdrinc.com

hdrinc.com/follow-us
hdrinc.com/follow-us

From: Spranza, John [John.Spranza@hdrinc.com]
Sent: 6/23/2020 2:58:51 PM
To: Alicia Forsythe [aforsythe@sitesproject.org]
Subject: RE: CDFW-Sites Coordination Documents

Ali,
So this does appear to be based off of the schedule we sent DWR but it is not too far off from what I have as the current schedule that incorporated HC and HR start-up changes (including CEQA/NEPA schedule).
We had originally sent you the table below for the ITP, which goes into more detail than the DWR one; it might come in handy for reference and discussion with Krystal.

I reviewed the budget they had provided and here are my comments:

1. They have 3 FTE in 2021, 5 FTE in 2022, and 1.75 FTE in 2023, I think the total hours are okay. If we expect more consultation with them during the ITP drafting then maybe move some hours from 2022 to 2021.
2. There are no hours in 2020. We are counting on having them start work in 2020 on the terrestrial components (species models, programmatic discussions for CRLF, etc.) and some of the aquatics components, will they still be able to do that?
3. They have included hours in 2022 for the 1600 permit so that is right on schedule.
4. They have also included time for ITP amendments and post ITP issuance implementation so that is also good.
5. Do they anticipate any time needed for the Water Rights? It would be ideal if we had some time with them so we do not receive any surprises in the protest that they will file. It would be good to include at least some discussions with CDFW staff to see if we can get issues worked out before the April 2022 WR submittal.
6. I am assuming this budget does not include funding for CDFW staff to implement Prop 1 as that is paid for by the state.
7. The base rates are equivalent to what I set up for High Speed Train so no issues there. We did however keep having issues with getting that time from our FTE at CDFW so I would confirm that this schedule and workload is booked hard into the Staff's schedule as who knows what other project will pop up (i.e., the next Delta Conveyance)

Milestone	Scheduled Date
Share new project footprint and features from Value Planning effort	June 2020
Terrestrial species – agreement on species list (ENG-200/220)	September 2020
Terrestrial species – agreement on species models and analytical approach (CES-020)	February 2021
Terrestrial species - Agreement on mitigation strategies (CES-025 & 200)	April 2021
Define Operations for modeling purposes (OP-220)	June 2020
Final Operations Analysis Output (OP-450)	November 2020
Operations Mitigation and Adaptive Management Plans (BA-025, BA-010, BA-015, CES 200)	April 2021
Agreement on effects analysis and mitigation strategy (CES 210 & 030)	August 2021
Submit ITP application (CES-090 & 260)	December 2021
CDFW issues ITP	2022

Other than that, I think it looks okay.

John Spranza

D 916.679.8858 M 818.640.2487

From: Alicia Forsythe [mailto:aforsythe@sitesproject.org]
Sent: Tuesday, June 23, 2020 12:45 PM
To: Spranza, John <John.Spranza@hdrinc.com>
Subject: FW: CDFW-Sites Coordination Documents

CAUTION: [EXTERNAL] This email originated from outside of the organization. Do not click links or open attachments unless you recognize the sender and know the content is safe.

Alicia Forsythe | Environmental Planning and Permitting Manager | Sites Reservoir Project | 916.880.0676 | aforsythe@sitesproject.org | www.SitesProject.org

CONFIDENTIALITY NOTICE: This communication with its contents may contain confidential and/or legally privileged information. It is solely for the use of the intended recipient(s). Unauthorized interception, review, use or disclosure is prohibited and may violate applicable laws including the Electronic Communications Privacy Act. If you are not the intended recipient, please contact the sender and destroy all copies of the communication.

From: Davis-Fadtke, Kristal@Wildlife <Kristal.Davis-Fadtke@wildlife.ca.gov>
Sent: Thursday, June 4, 2020 11:54 AM
To: Jerry Brown <jbrown@sitesproject.org>; Alicia Forsythe <aforsythe@sitesproject.org>
Subject: CDFW-Sites Coordination Documents

Jerry and Ali,

It was good to talk to you today and hear about the progress that is being made. Attached is the milestone schedule we viewed in our meeting and the draft budget we developed to work with your team through the permitting and CEQA process. Please let me know when you would like to meet to flush out more specifics for the milestone schedule.

Best,

Kristal

Kristal Davis Fadtke
Environmental Program Manager
Water Branch, Ecosystem Conservation Division
California Department of Fish and Wildlife
P.O. Box 944209
Sacramento, CA 94244-2090
Office: (916) 376-1987
Cell: (916) 701-3226

From: Marcia Kivett [MKivett@sitesproject.org]
Sent: 6/24/2020 8:22:17 AM
To: Marcia Kivett [MKivett@sitesproject.org]
Subject: FW: Sites Reservoir Discussion

From: Marcia Kivett
Sent: Wednesday, June 24, 2020 8:21 AM
To: Tom Stokely <tgstoked@gmail.com>; Regina Chichizola <regina@californiasalmon.org>; Mike Conroy <mike@ifrfish.org>
Subject: Sites Reservoir Discussion

Good Morning,

Would your schedules allow for a 30-minute call during any of the below days/times?

July 7 – any time at/after 10:00
July 8 – 9:00, 10:30 2:00, 4:30
July 10 – any time at/after 10:00

I will set up a Microsoft Teams call, and you may forward it to additional staff. Thank you for your consideration.

Marcia Kivett
Sites Project Admin
Phone: 561.843.9740
Email: mkivett@sitesproject.org
Web: www.SitesProject.org
P.O. Box 517
122 Old Hwy 99W
Maxwell, CA 95955

From: Jerry Brown <jbrown@sitesproject.org>
Sent: Wednesday, June 17, 2020 7:01 AM
To: Tom Stokely <tgstoked@gmail.com>
Cc: Regina Chichizola <regina@californiasalmon.org>; Mike Conroy <mike@ifrfish.org>; Marcia Kivett <MKivett@sitesproject.org>
Subject: Re: Reaching Out

Hi Tom – thanks for the reply. I'll have my assistant Marcia work with you all next week when she returns to the office to set up a meeting for us to review the current status of the project. Ali will join us too.

Jerry

From: Tom Stokely <tgstoked@gmail.com>
Date: Tuesday, June 16, 2020 at 4:13 PM
To: Jerry Brown <jbrown@sitesproject.org>
Cc: Regina Chichizola <regina@californiasalmon.org>, Mike Conroy <mike@ifrfish.org>
Subject: Re: Reaching Out

Jerry,

Thanks for reaching out! You have a big job!

Happy to talk with you sometime. I'm cc'ing my associates Regina Chichizola with Save California Salmon and Mike Conroy who is the new Executive Director of PCFFA and IFR who may also be interested.

I'm attaching our coalition letter from 3/17/19 and Humboldt County's most recent letters, if you haven't already reviewed them.

The coalition letter is quite specific with 38 issues that we feel have not been adequately addressed.

Is Ali Forsythe still heading up your EIS/EIR team?

Thank you.

Tom Stokely
Salmon and Water Policy Analyst
530-524-0315

On Tue, Jun 16, 2020 at 12:45 PM Jerry Brown <jbrown@sitesproject.org> wrote:

> Hi Tom - As you have most likely heard, as of March 30 I started in the position of Executive Director for the Sites Reservoir Project. I'm reaching out to express my commitment going forward to work collaboratively with you on this project. I don't know what your history has been with this project, but I want to make sure 1) you are kept well informed and 2) there is always an open line of communication.
>
> In this vein, a new and improved rightsized project has been accepted by the JPA Board as the direction for the next stage of development and I would like to give you a briefing via video chat if you're interested.
>
> If agreeable to you, let me know who my assistant can work with to get on your schedules.
>
> Looking forward to speaking with you soon.
>
> Jerry
>
> Jerry Brown | Executive Director | Sites Reservoir Project | 925.260.7417
> | jbrown@sitesproject.org | www.SitesProject.org
>
> CONFIDENTIALITY NOTICE: This communication with its contents may contain confidential and/or legally privileged information. It is solely for the use of the intended recipient(s). Unauthorized interception, review, use or disclosure is prohibited and may violate applicable laws including the Electronic Communications Privacy Act. If you are not the intended recipient, please contact the sender and destroy all copies of the communication.

Sent: 6/24/2020 8:40:21 AM
To: 'Tom Stokely' [tgstoked@gmail.com]; 'Regina Chichizola' [regina@californiasalmon.org]; 'Mike Conroy' [mike@ifrfish.org]
Subject: RE: Sites Reservoir Discussion

Sorry for resending. I'm in
Good Morning,

Would your schedules allow for a 30-minute call during any of the below days/times?

July 7 – any time at/after 10:00
July 8 – 9:00, 10:30 2:00, 4:30
July 10 – any time at/after 10:00

I will set up a Microsoft Teams call, and you may forward it to additional staff. Thank you for your consideration.

Marcia Kivett
Sites Project Admin
Phone: 561.843.9740
Email: mkivett@sitesproject.org
Web: www.SitesProject.org
P.O. Box 517
122 Old Hwy 99W
Maxwell, CA 95955

From: Jerry Brown <jbrown@sitesproject.org>
Sent: Wednesday, June 17, 2020 7:01 AM
To: Tom Stokely <tgstoked@gmail.com>
Cc: Regina Chichizola <regina@californiasalmon.org>; Mike Conroy <mike@ifrfish.org>; Marcia Kivett <MKivett@sitesproject.org>
Subject: Re: Reaching Out

Hi Tom – thanks for the reply. I'll have my assistant Marcia work with you all next week when she returns to the office to set up a meeting for us to review the current status of the project. Ali will join us too.

Jerry

From: Tom Stokely <tgstoked@gmail.com>
Date: Tuesday, June 16, 2020 at 4:13 PM
To: Jerry Brown <jbrown@sitesproject.org>
Cc: Regina Chichizola <regina@californiasalmon.org>, Mike Conroy <mike@ifrfish.org>
Subject: Re: Reaching Out

Jerry,

Thanks for reaching out! You have a big job!

Happy to talk with you sometime. I'm cc'ing my associates Regina Chichizola with Save California Salmon and Mike Conroy who is the new Executive Director of PCFFA and IFR who may also be interested.

I'm attaching our coalition letter from 3/17/19 and Humboldt County's most recent letters, if you haven't already reviewed them.

The coalition letter is quite specific with 38 issues that we feel have not been adequately addressed.

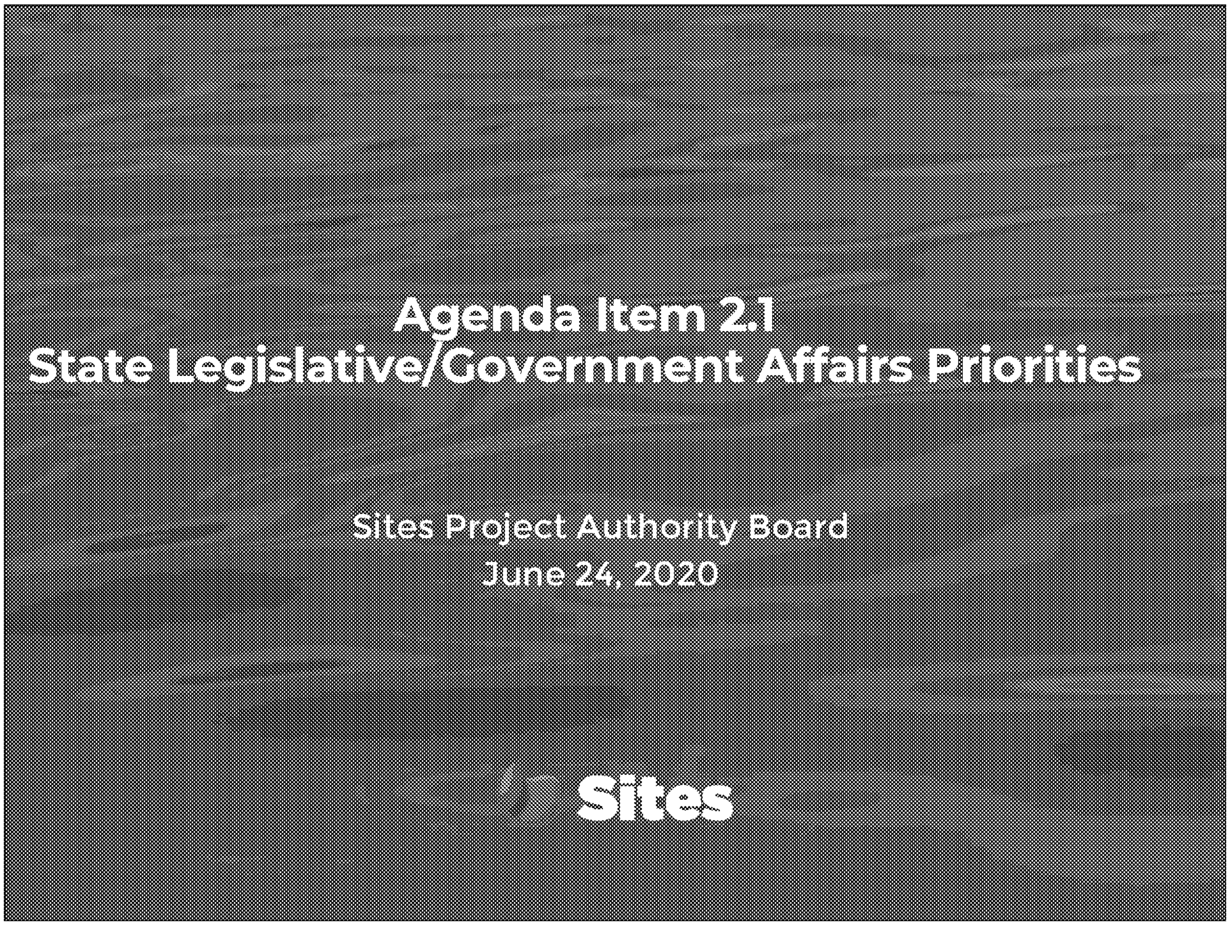
Is Ali Forsythe still heading up your EIS/EIR team?

Thank you.

Tom Stokely
Salmon and Water Policy Analyst
530-524-0315

On Tue, Jun 16, 2020 at 12:45 PM Jerry Brown <jbrown@sitesproject.org> wrote:

> Hi Tom - As you have most likely heard, as of March 30 I started in the position of Executive Director for the Sites Reservoir Project. I'm reaching out to express my commitment going forward to work collaboratively with you on this project. I don't know what your history has been with this project, but I want to make sure 1) you are kept well informed and 2) there is always an open line of communication.
>
> In this vein, a new and improved rightsized project has been accepted by the JPA Board as the direction for the next stage of development and I would like to give you a briefing via video chat if you're interested.
>
> If agreeable to you, let me know who my assistant can work with to get on your schedules.
>
> Looking forward to speaking with you soon.
>
> Jerry
>
> Jerry Brown | Executive Director | Sites Reservoir Project | 925.260.7417
> | jbrown@sitesproject.org | www.SitesProject.org
>
> CONFIDENTIALITY NOTICE: This communication with its contents may contain confidential and/or legally privileged information. It is solely for the use of the intended recipient(s). Unauthorized interception, review, use or disclosure is prohibited and may violate applicable laws including the Electronic Communications Privacy Act. If you are not the intended recipient, please contact the sender and destroy all copies of the communication.



Agenda Item 2.1
State Legislative/Government Affairs Priorities

Sites Project Authority Board
June 24, 2020

Sites

Agenda Item 2.1 - State Legislative/Government Affairs Priorities

Staff has been working with the Authority Ad Hoc Legislative & Outreach Committee to identify near-term (2020-21) State legislative and government affairs priorities

- Ensure that legislative/government affairs activities better align with key project milestones, overall project schedule and available resources
- Coordinated with our Federal legislative/government affairs activities

Effort focused on identifying near-team priorities associated with State Funding and State Agency coordination activities

Any adjustment to the priorities would be brought back to the Reservoir Committee and Authority Board before being incorporated and updates will be project on significant progress

Sites

Agenda Item 2.1 - State Legislative/Government Affairs Priorities

STATE FUNDING

- California Water Commission – Proposition 1
  - Continue to advance activities to meet the statutory requirements of WSIP to secure the $816 million awarded to the project – must be completed by **January 1, 2022**
  - Continue to secure WSIP Early Funding that was awarded to the project – approximately **$32 million** in early funding is available
  - Advance discussion with CWC to address requests outlined in Prop 1 Coalition letter to address the impact of COVID-19
  - Advance Discussions with CWC to reconcile WSIP public benefits regarding the VP7 recommend project
- Other State Appropriations/Bonds/Grants
  - California Infrastructure and Economic Development Bank (IBank) - Identify opportunities for loan funding for appropriate/eligible project components
  - Track opportunities for state appropriations, grants or other bond funds for eligible project components

Sites

Agenda Item 2.1 - State Legislative/Government Affairs Priorities

STATE AGENCY COORDINATION

- Pursue development of a **DWR/SWP Coordination Operations Plan** – including a term-sheet whereby the parties agree on key provisions by **July 2021**
- Completion of the recirculated Draft Environmental Impact Report (EIR) by **July 2021**
- Develop strategy to advance the Authority's water rights application by **September 2020** with a planned submittal of the application by **June 2022**
- Secure permits and approvals of CDFW for ITP & LSA and execute a contract with CDFW for WSIP benefits
- Secure permits and approvals from the Division of Safety of Dams (DSOD) to initiate preliminary design by **January 2022**
- Work towards completion of approvals and permits to achieve the Final Funding Conditions for Prop 1 by **June 2023**

Sites

Agenda Item 2.1 - State Legislative/Government Affairs Priorities

Other Administrative Priorities

- Permitting
  - Ongoing consultation with state agencies to secure required state permits to advance the project
  - Ongoing consultation with local government/agencies to secure required approvals and permits to advance the project.

- Public Outreach & Communications
  - Coordination with local and state agencies on any public outreach/involvement activities associated with a recirculated EIR
  - Reestablish AB 52 engagement with tribes and reengage in consultation to support the development of the recirculated EIR
  - Continued engagement with landowners, local governments and project stakeholders in support of the development of the recirculated EIR

Sites

Questions

Sites

From: Luu, Henry [Henry.Luu@hdrinc.com]
Sent: 6/25/2020 11:55:47 AM
To: Spranza, John [John.Spranza@hdrinc.com]
CC: Alicia Forsythe [aforsythe@sitesproject.org]; Heydinger, Erin [Erin.Heydinger@hdrinc.com]; Laurie Warner Herson [laurie.warner.herson@phenixenv.com]
Subject: RE: ICF EIR/EIS Work Plan Assumptions - Engineering

Will do. Thanks, John.

Henry H. Luu, PE
D 916.679.8857 M 916.754.7566

hdrinc.com/follow-us

From: Spranza, John
Sent: Thursday, June 25, 2020 11:49 AM
To: Luu, Henry <Henry.Luu@hdrinc.com>
Cc: aforsythe (aforsythe@sitesproject.org) <aforsythe@sitesproject.org>; Heydinger, Erin <Erin.Heydinger@hdrinc.com>; Laurie Warner Herson <laurie.warner.herson@phenixenv.com>
Subject: FW: ICF EIR/EIS Work Plan Assumptions - Engineering

Henry,
Below is a list of the assumptions that ICF provided for their Phase 2. I need to talk with Monique and Ali about some of these such as the 408 and the encroachment permit but folks are super busy and I am not sure that will happen by the COB so I figured I would send these over.

For the 408 the 10% design seems like we can work with it given the lack of Delevan and the overall schedule of the 408 and the NEPA requirements for that document (i.e., we can push it out). However, for the CVFCB Encroachment Permit, we will need approximately a 20-30% design for those features as our current CEQA document will need to cover that permit. I need to run this by Ali for approval but please pass this along to HC. We will have a second chance to review this and discuss internally once the service areas submit their draft scopes tomorrow.

John Spranza

D 916.679.8858 M 818.640.2487

From: Briard, Monique [mailto:Monique.Briard@icf.com]
Sent: Wednesday, June 24, 2020 4:32 PM
To: Spranza, John <John.Spranza@hdrinc.com>
Subject: RE: ICF EIR/EIS Work Plan Assumptions - Engineering

CAUTION: [EXTERNAL] This email originated from outside of the organization. Do not click links or open attachments unless you recognize the sender and know the content is safe.

The TMs/Appendices that have been identified for the EIR/EIS will also be used for the BA, 404/401, and ITP. The following are the list of items/assumptions identified in our Amd 2 SOW:

BA/ITP:

- Engineers will provide sufficient project description information prior to September 15, 2020, including coordination on development of assumptions for components not yet designed, for ICF to analyze effects on the listed species.

- The project description will not substantially change (to the extent that it warrants additional analysis) after September 15, 2020.
- Jacobs and the integration team will provide all model outputs necessary to inform analysis of effect by November 10, 2020.

404/401:

- Project footprint and preliminary design (30%) prior to Pre-Application Meeting.
- 60% design and addresses of adjacent property owners prior to CWA 404 Permit Application
- The project engineers will provide the means for ICF to quantify the types and materials to be discharged to waters of the United States (shape files or CAD files of project plans and pdf files of design drawings and construction specifications).

408:

- Set up and attend (in person or virtually) a pre-application meeting with the Authority, CVFPB and USACE to discuss the proposed project and permitting issues including impacts to sensitive habitats, including riparian, public use, applicability of the categorical permission for Section 408 requests, and any special reports required CVFPB or USACE.
- Coordinate with the Authority and engineer team to establish project design goals for the Section 408 Permission and CVFPB Encroachment Permit that will keep Section 408 review at the USACE local district.
- The project engineers will provide the means for ICF to quantify the areas, materials, and quantities of materials excavated and placed within CVFPB and USACE jurisdiction (shape files or CAD files of project plans and pdf files of design drawings and construction specifications).
- The project engineers will provide the plan elevation views of the proposed project showing proximity in relation to the CVFPB and USACE existing facilities, property lines, levees, and floodways.
- The project engineers will provide Drawings of levee cross sections or profiles indicating the elevations of levee crowns, toes, low-water surface, and design flood plain. These drawings should include horizontal and vertical scales and must be referenced to a known vertical datum.
- The project engineers will provide any hydraulic modelling and geotechnical reports, if requested by CVFPB or USACE.
- Project footprint and preliminary design (30%) prior to Pre-Application Meeting
- 60% design prior to Encroachment Permit Application

Mitigation Planning:

- Engineering and Operations teams to provide project construction and operations information to support evaluation of project effects and development of adaptive management approaches

---

From: Spranza, John <John.Spranza@hdrinc.com>
Sent: Tuesday, June 23, 2020 3:26 PM
To: Briard, Monique <Monique.Briard@icf.com>
Subject: Fwd: ICF EIR/EIS Work Plan Assumptions - Engineering

Laurie's question is a good one. Can you provide any additional information needs that engineering needs to include in their phase 2 scope to support your permitting efforts?

Sent from my iPhone

Begin forwarded message:

From: Laurie Warner Herson <laurie.warner.herson@phenixenv.com>
Date: June 23, 2020 at 3:15:08 PM PDT
To: "Spranza, John" <John.Spranza@hdrinc.com>, "Arsenijevic, Jelica" <Jelica.Arsenijevic@hdrinc.com>, "Heydinger, Erin" <Erin.Heydinger@hdrinc.com>
Subject: FW: ICF EIR/EIS Work Plan Assumptions - Engineering

CAUTION: [EXTERNAL] This email originated from outside of the organization. Do not click links or open attachments unless you recognize the sender and know the content is safe.

I assume Pete knows what support is needed for the CBD analysis – are there other support needs (other than what I sent to Henry yesterday) for permitting?

From: Rude, Pete/RDD [mailto:Pete.Rude@jacobs.com]
Sent: Tuesday, June 23, 2020 2:00 PM
To: Herrin, Jeff <jeff.herrin@aecom.com>; Laurie Warner Herson <laurie.warner.herson@phenixenv.com>; Luu, Henry <Henry.Luu@hdrinc.com>; Smith, Jeff/SAC <Jeff.Smith1@jacobs.com>; Forrest, Michael <michael.forrest@aecom.com>
Cc: Alexander, Jeriann <jalexander@fugro.com>; Heydinger, Erin <Erin.Heydinger@hdrinc.com>
Subject: RE: ICF EIR/EIS Work Plan Assumptions - Engineering

Henry et al.

The ICF example you sent out last night was for the Reservoir (HR). Do they have something for Conveyance (HC)? Also I assume they want to include a section on Colusa Basin Drain – our modeling results etc.

Peter H. Rude, PE (*CA, HI, CO*) /Jacobs/ Civil Engineer & Principal Project Manager
1-530-229-3396 (office)/ 1-530-917-4164 (mobile)/ 2525 Airpark Drive, Redding, CA 96001
pete.rude@jacobs.com / www.jacobs.com

From: Herrin, Jeff <jeff.herrin@aecom.com>
Sent: Tuesday, June 23, 2020 9:26 AM
To: Laurie Warner Herson <laurie.warner.herson@phenixenv.com>; Luu, Henry <Henry.Luu@hdrinc.com>; Rude, Pete/RDD <Pete.Rude@jacobs.com>; Smith, Jeff/SAC <Jeff.Smith1@jacobs.com>; Forrest, Michael <michael.forrest@aecom.com>
Cc: Alexander, Jeriann <jalexander@fugro.com>; Heydinger, Erin <Erin.Heydinger@hdrinc.com>
Subject: [EXTERNAL] RE: ICF EIR/EIS Work Plan Assumptions - Engineering

An example of a construction appendix from another project would help us develop the level of effort for Task Order 2, even if there is some variance an example would help.

Suggest you send the equipment spreadsheet format. We have a similar spreadsheet, but it may not meet their needs.

Also, do we need a Maintenance Appendix similar to the Construction Appendix, but describing maintenance activities?

From: Laurie Warner Herson <laurie.warner.herson@phenixenv.com>
Sent: Tuesday, June 23, 2020 7:58 AM
To: Herrin, Jeff <jeff.herrin@aecom.com>; Luu, Henry <Henry.Luu@hdrinc.com>; Rude, Pete/RDD <Pete.Rude@jacobs.com>; Smith, Jeff/SAC <Jeff.Smith1@jacobs.com>; Forrest, Michael <michael.forrest@aecom.com>

Cc: Alexander, Jeriann <jalexander@fugro.com>; Heydinger, Erin <Erin.Heydinger@hdrinc.com>
Subject: [EXTERNAL] RE: ICF EIR/EIS Work Plan Assumptions - Engineering

Hi Jeff,

You are correct – engineering would not be the lead on the Reservoir Management Plan but would need to support; the Resident Relocation Plan is the responsibility of others; and all operations support would be from CH/Jacobs.

ICF will develop the outline/template for the construction appendix. We can also get an example, if needed. They have also assumed in their draft Amendment 2 scope of work that all GIS files would be available to them by mid-September so they can prepare EIR/EIS figures. I will confirm with Nicole whether there is additional support needed for Geology/Seismicity (other than dam safety info they listed) and socioeconomics.

Just a reminder that they also have a construction equipment/durations spreadsheet that will need to be populated for the purposes of the AQ analysis. If you would like to see the spreadsheet now for the purposes of defining your TO scope, we can send it along – we were hesitant to send it too soon given other data requests. I will discuss with Henry today.

Thanks,

Laurie

From: Herrin, Jeff [mailto:jeff.herrin@aecom.com]
Sent: Tuesday, June 23, 2020 7:20 AM
To: Luu, Henry <Henry.Luu@hdrinc.com>; Rude, Pete/RDD <Pete.Rude@jacobs.com>; Smith, Jeff/SAC <Jeff.Smith1@jacobs.com>; Forrest, Michael <michael.forrest@aecom.com>
Cc: Alexander, Jeriann <jalexander@fugro.com>; Heydinger, Erin <Erin.Heydinger@hdrinc.com>; Laurie Warner Herson <laurie.warner.herson@phenixenv.com>
Subject: RE: ICF EIR/EIS Work Plan Assumptions - Engineering

Thanks Henry. This is very helpful.

The Construction Appendix is a good idea. Can ICF or HDR provide an example of a good template from another project for the Construction Appendix?

There are some items in the text that may or may not be our responsibility.

- Operation plan – this should come from Rob Tull
- Reservoir Management Plan – We can support this, but I'm not sure we should be leading it. Topics on the 2nd page include water quality, fisheries management, and land use management. Some of these are environmental topics with regulatory drivers and some are policy decisions. It would be helpful to have an outline and clarify who is responsible for which parts of the plan. I think there should also be an early kickoff meeting with Mike Azevedo to make sure the County concurs with the direction of the plan (they will likely take over management of recreation).
- Resident relocation program – Assume this is being developed by others (maybe Connor and Kevin).

Missing Items?
- For the 2017 EIR/S version, Jacobs needed input from us on Geology and Seismicity. Is this still needed?
- For the 2017 EIR/S version, Jacobs needed input from us on Socioeconomics. Is this still needed?
- What about figures? We are planning to provide footprints in GIS and assume that ICF will generate figures with the plan view of facilities. Are there other figures that are needed from the engineering team?

Jeff Herrin
Water Resources Planner, Water Business Unit, Sacramento, CA

D +1-916-679-2084 IPT 264-679-2084
M +1-916-432-0956
Jeff.Herrin@aecom.com

AECOM
2020 L Street
Suite 400
Sacramento, CA 95811, United States
T +1-916-414-5800
aecom.com

Built to deliver a better world

LinkedIn Twitter Facebook Instagram

From: Luu, Henry <Henry.Luu@hdrinc.com>
Sent: Monday, June 22, 2020 6:17 PM
To: Rude, Pete/RDD <Pete.Rude@jacobs.com>; Smith, Jeff/SAC <Jeff.Smith1@jacobs.com>; Forrest, Michael <michael.forrest@aecom.com>; Herrin, Jeff <jeff.herrin@aecom.com>
Cc: Alexander, Jeriann <jalexander@fugro.com>; Heydinger, Erin <Erin.Heydinger@hdrinc.com>
Subject: [EXTERNAL] FW: ICF EIR/EIS Work Plan Assumptions - Engineering

All,

Please consider the attached environmental data needs from engineering as we pull together the Amendment 2 scope. I will be discussing with Laurie, but wanted to give everyone a heads-up. We can discuss as part of the Focused Feasibility Meeting this Wednesday (6/24/2020).

Thanks,

Henry H. Luu, PE
D 916.679.8857 M 916.754.7566

hdrinc.com/follow-us

From: Laurie Warner Herson [mailto:laurie.warner.herson@phenixenv.com]
Sent: Monday, June 22, 2020 5:13 PM
To: Luu, Henry <Henry.Luu@hdrinc.com>
Subject: ICF EIR/EIS Work Plan Assumptions - Engineering

CAUTION: [EXTERNAL] This email originated from outside of the organization. Do not click links or open attachments unless you recognize the sender and know the content is safe.

Hi Henry,

Per our internal PD team call this morning, I am attaching the sections of the ICF EIR/EIS Work Plan that pertain to engineering. Please take a look at this and let me know when we can have a call tomorrow. If needed, the full work plan can be found here:

https://sitesreservoirproject.sharepoint.com/:w:/r/EnvPlanning/Shared%20Documents/RDEIR_EIS-%20Work%20Plan/ENV-MEM-WorkPlanDraft_20200612_revisedhighlight.docx?d=wf4d5e576231f4850b07220ee0dc58612&csf=1&web=1&e=hb9a0Q

Thank you,

Laurie

Laurie Warner Herson
Principal/Owner

Phenix
Environmental Planning

916.201.3935
laurie.warner.herson@phenixenv.com
State of California Small Business (#1796182)
Supplier Clearinghouse Women Business Enterprise (#16000323)

http://phenixenv.com/

NOTICE - This communication may contain confidential and privileged information that is for the sole use of the intended recipient. Any viewing, copying or distribution of, or reliance on this message by unintended recipients is strictly prohibited. If you have received this message in error, please notify us immediately by replying to the message and deleting it from your computer.

From: Chris Fitzer [CFitzer@esassoc.com]
Sent: 6/25/2020 12:25:20 PM
To: Alicia Forsythe [aforsythe@sitesproject.org]; Tull, Robert/SAC [Robert.Tull@jacobs.com]; Jim Lecky (jim.Lecky@icf.com) [jim.Lecky@icf.com]; John Spranza (john.spranza@hdrinc.com) [john.spranza@hdrinc.com]; Heydinger, Erin [Erin.Heydinger@hdrinc.com]
Subject: RE: Sites - Member Statements on Reduced Reliance on Delta
Attachments: 2013-appendix-g-reduced-reliance.pdf

FYI - Delta Plan doc focused on reduced reliance with examples.

Chris Fitzer
Fisheries Program Manager

Working from Home - Reachable via email or text/ph 916.806.7834

ESA | Environmental Science Associates
Celebrating 50 Years of Work that Matters!

-----Original Appointment-----
From: Alicia Forsythe <aforsythe@sitesproject.org>
Sent: Wednesday, June 24, 2020 10:08 AM
To: Alicia Forsythe; Tull, Robert/SAC; Jim Lecky (jim.Lecky@icf.com); Chris Fitzer; John Spranza (john.spranza@hdrinc.com); Heydinger, Erin
Subject: Sites - Member Statements on Reduced Reliance on Delta
When: Thursday, June 25, 2020 12:00 PM-12:30 PM (UTC-08:00) Pacific Time (US & Canada).
Where: Microsoft Teams Meeting

The Sites M&I districts need to complete their 2020 Urban Water Management Plans this year. We believe that there is a requirement for them to describe how their UWMP seeks to reduce reliance on the Delta.

For consistency in messaging, we thought we would draft a few talking points for them on how Sites helps them reduce their reliance on the Delta.

I'd like to get your thoughts on this and brainstorm a few options / talking points. Please let me know your availability for an hour call this week.

Join Microsoft Teams Meeting

+1 916-538-7066 United States, Sacramento (Toll)

Conference ID: 724 990 795#

Local numbers | Reset PIN | Learn more about Teams | Meeting options

---

From: Heydinger, Erin [Erin.Heydinger@hdrinc.com]
Sent: 6/25/2020 12:38:15 PM
To: Robert.Tull (Robert.Tull@jacobs.com) [Robert.Tull@jacobs.com]
CC: Alicia Forsythe [aforsythe@sitesproject.org]
Subject: Ops Meeting Follow Up

Hi Rob,

A couple of items I wanted to discuss yesterday but didn't get the opportunity.

1. Following up on the email chain related to exchange modeling and getting Reclamation's buy-off. When do you think you can develop the modeling assumptions so we can get them over to Reclamation? If you are thinking this isn't the way to move forward, we need to discuss ASAP what you propose instead.
2. We are operating under the assumption the modeling will be completed by November 10th. Your original estimate said four months of modeling is needed and we are still five months out, so I feel this deadline is reasonable. If you have any concerns about meeting this date, we need to know and figure out what needs to be done so we can meet the schedule.
3. What's the latest on the 'colorful' table and getting some operations info over to the engineering team?
4. What items do you think need to go to the workgroup on July 1? We have 20 minutes scheduled for ops and a placeholder in the PowerPoint. Please give a general outline of the topics needed. Here are the items from your priority list that we haven't yet covered with the Workgroup:

a. SWP integration and coordination
b. Accounting logic
c. Sacramento River criteria
d. Delta criteria

As a reminder, we are ultimately looking for a writeup on all ops criteria and why the various criteria were selected similar to what you produced for the baseline.

I will also bring these items up on tomorrow's call with Rob Leaf but wanted to get your take on them too.

Thanks,
Erin

Erin Heydinger, PE, PMP
Asst. Project Manager
Water/Wastewater

HDR
2379 Gateway Oaks Dr, #200
Sacramento, CA 95833
D 916.679.8863 M 651.307.9758

hdrinc.com/follow-us

From: Luu, Henry [Henry.Luu@hdrinc.com]
Sent: 6/25/2020 3:23:02 PM
To: Luu, Henry [Henry.Luu@hdrinc.com]; Kevin Spesert [kspesert@sitesproject.org]; Conner McDonald [conner@cmdwest.com]; Rude, Pete/RDD [Pete.Rude@jacobs.com]; Jeff.Smith1@jacobs.com; Derek Morley [dmorley@geosyntec.com]; Brian Martinez [bmartinez@geosyntec.com]; JOLeary@Geosyntec.com; jalexander@fugro.com
CC: jeff.herrin@aecom.com; michael.forrest@aecom.com; Barnes, Joseph [joseph.barnes@aecom.com]

Subject: Sites HC: Alternatives to existing TRR location
Attachments: INT-TEM-TM-Alternatives to TRR-20200624_r3.pdf
Location: Webex

Start: 6/30/2020 9:00:00 AM
End: 6/30/2020 10:00:00 AM
Show Time As: Busy

Recurrence: (none)

All – I sincerely apologize for the inconvenience, but we will need to reschedule to Tuesday (6/30/2020) from 9am-10am due to schedule conflicts with team members.

Hi everyone, please note this is a sensitive topic so please do not share beyond our internal team. The intent of this meeting is to discuss with Kevin and gather input regarding the HC team findings for TRR:

As we mentioned on the June 22 engineering coordination call, attached is a draft Technical Memorandum about the TRR and the urgent need to consider alternative locations for this regulating reservoir.

Subsurface explorations now completed at the TRR show severely adverse soil conditions, across the site and to-depth, which would necessitate expensive ground improvement work (likely >$100M) in order to develop the TRR at this location. A possible alternative to incurring this cost is to re-locate this regulating reservoir to an area of better geotechnical conditions. Such conditions exist northwest of the current TRR location, on the western side of the GCID Canal. The attached TM identifies three candidate locations in this area for possible re-siting of the reservoir.

To either confirm the current location of the TRR or to select a more economical location is a schedule-critical need for the project, significantly affecting the project footprint, impacts, and risk profile. Evaluation of alternatives is urgently needed to enable this decision; postponing initiation of this evaluation may have significant adverse impacts to the project. We recommend that the three general candidate alternative locations identified in the attached TM be evaluated to enable this key decision, and we recommend that this evaluation be started immediately.

Jeff Herrin and Mike Forrest – your participation is optional.
-- Do not delete or change any of the following text. --

When it's time, join your Webex meeting here.

Meeting number (access code): 146 054 7152

Meeting password: MAt7PS9Ux8N

Join meeting

Join by phone

Tap to call in from a mobile device (attendees only)

+1-408-418-9388 United States Toll

Global call-in numbers

Join from a video system or application

Dial 1460547152@meethdr.webex.com

You can also dial 173.243.2.68 and enter your meeting number.

Join using Microsoft Lync or Microsoft Skype for Business

Dial 1460547152.meethdr@lync.webex.com

If you are a host, click here to view host information.

Need help? Go to http://help.webex.com

Alternatives to the Terminal Regulating Reservoir (TRR) DRAFT Technical Memorandum

Sites
Program Management Team

To:	Pete Rude, PE, Jacobs Jeff Smith, PE, Jacobs
CC:	Henry Luu, PE, HDR
Date:	June 24, 2020
From:	Brian Martinez, PhD, PE
Quality Review by:	Derek Morley, PE
Authority Agent Review by:	Reviewer
Subject:	Alternatives to the Terminal Regulating Reservoir (TRR)

DRAFT

1.0 Background and Purpose

Sites Reservoir is a 1.5-million-acre-foot reservoir project undergoing feasibility evaluations led by the Sites Joint Powers Authority (Authority). The project will be designed to support California's water infrastructure and includes the main reservoir and conveyance features. Conveyance features will include two pumping/generating plants, two regulating reservoirs, and pipelines, which hydraulically connect the new Sites Reservoir to the existing Funks reservoir, the existing Tehama-Colusa (TC) Canal, the existing Glenn-Colusa Irrigation District (GCID) Canal, and the new Terminal Regulating Reservoir (TRR).

The TRR is planned to be located on the east side of the GCID Canal roughly due east of Funks Reservoir within a flatland area currently used for agriculture. Attachment A provides a map (prepared by others) showing the location of TRR relative to the GCID Canal, the TC Canal, and the previously proposed Holthouse Reservoir (a previously proposed eastward expansion of Funks Reservoir). In 2019, geotechnical explorations were performed in two locations around the TRR, adding to historical borings from 1975, to inform the feasibility of design and construction of the TRR. No other subsurface exploration data relevant to the TRR is known to exist at this time.

The purpose of this technical memorandum is to provide interpretation of the recent and historic borings, discuss the implications of those findings, and recommend considerations for TRR based on the implications.

2.0 Summary of Geotechnical Data

The soils underlying the TRR are predominantly soft clay with thick layers of loose sand. This characterization is based on the four soil borings surrounding the facility. Attachment A provides the data relied upon for this evaluation, including draft locations and recorded logs of borings performed as part of (i) recently collected data by the United States Bureau of Reclamation (USBR) from 2019 feasibility-level explorations; and (ii) excerpt drawings from a historic plan set (1975) for structural improvement of the Funks Siphon and Check at the GCID Canal near the planned TRR with plan and log of test borings for two locations on the west side of the canal.

The boring identified as Delevan Pipeline 1 (DH-19-DP1-A) is located on the northeast corner of the planned TRR in the flatlands of an adjacent agriculture area, approximately 2000 ft northeast from the nearest point of the GCID Canal. The boring was situated on the shoulder of McDermott Road. The boring log indicates that groundwater was encountered at a depth of approximately 6 feet (approximately 3 feet below the top of native soils), and the following general stratigraphic layering was observed from top to bottom:

- ~3 feet of silty fill;
- ~12 feet of soft to very soft, lean to fat clays with a very loose 3-ft silty sand layer;
- ~11 feet of loose to very loose poorly graded sands with low fines content (<15%);
- ~11 feet of soft to very soft lean clay to elastic silt;
- ~9 feet of loose to medium dense silty sands with higher fines content (>15%) and trace gravel;
- ~12 feet of medium stiff lean clays with sand and sandy clays; and
- ~42 feet of stiff to very stiff lean clays with trace sands and gravels intermixed.

The boring identified as TRR-PGP (DH-19-TRRPGP-A) is located near the northwest corner of the planned TRR on the northeast embankment of the GCID Canal. The boring log indicates that groundwater was encountered at a depth of approximately 12 feet (approximately 5 feet below the top of native soils), and the following general stratigraphic layering was observed from top to bottom:

- ~7 feet of canal embankment fill, consisting mostly of very soft to soft sandy lean clay;
- ~10 feet of a mixture of soft to medium stiff lean clays and silts with thin layers of silty sand;
- ~4 feet of loose to medium dense poorly graded sand with silt and low fines content (<15%);
- ~26 feet of stiff lean clays with trace gravels and sands; and
- ~52 feet of stiff to very stiff lean clays with a few 1-3 ft seams of dense silty or clayey sands.

In addition to the two recent borings, there are logs of test borings available from the plan set for a structural improvement to the Funks Siphon and Check located near the southern tip of the planned TRR. These borings are shown as B-1 and B-2 on the General Plan for the Funks Slough Siphon in Attachment A. The boring log of B-1 extends to a depth of approximately 34 feet and indicates that groundwater was encountered at a depth of approximately 9 feet, with stiff silty clay above the water table, underlain by ~15 feet of soft to very soft silty clays, underlain by stiff clay with sand layers. The boring log of B-2 extends to a depth of approximately 40 feet and indicates a groundwater depth of approximately 9 feet, with stiff silty clay above the water table, underlain by ~10 feet of soft to very soft silty clay, underlain by ~7 feet of stiff clay with sand layers, underlain by ~11 feet of loose poorly graded sand, underlain by stiff sandy clay and clayey sand.

3.0 Implications of Findings

The subsurface conditions encountered in the borings indicate the presence of adverse foundation conditions for the TRR. The soils present that are of greatest concern (from a geotechnical design standpoint) are the soft clays and the loose poorly graded sands below the water table.

The soft clays are compressible and prone to substantial settlement under the weight of the new embankment. These settlements would impact the TRR embankment, other TRR hydraulics infrastructure, the existing GCID Canal embankment, and other new and existing infrastructure adjacent to the TRR. These settlements may occur non-uniformly across the site given the various thickness of clay deposits encountered.

The loose sands are prone to liquefaction, considering the anticipated seismic hazard of the area[1], the shallow depth to groundwater, and the relatively shallow depth of the sand layers. The consequences of liquefaction of these layers during an earthquake may include seismically-induced settlements and differential settlements of overlying embankments and other TRR hydraulics infrastructure. Additionally, liquefaction of these layers may cause embankment instability and lateral deformations of the embankments, including embankment instability and lateral deformations adjacent to and toward the GCID Canal.

---

[1] DWR DOE. 2003a. Sites Reservoir Engineering Feasibility Study – Golden Gate, Sites, and Saddle Dams. February.

DRAFT

Note that the adverse soils conditions were observed in all four borings – situated near all three corners of the TRR – including either soft clay, loose sands, or both in each boring. The depths of layers varied from boring to boring, including between the two borings situated relatively close to each other at the southern end of the TRR site. At both the southern end of the site (close to Funks Creek) and northern end of the site (distant from Funks Creek), adverse soil conditions were encountered to depths of about 40 feet. Considering these observations, and that the entire TRR site is located within the same geologic context, it is likely that adverse soil conditions are present underneath most (if not all) of the length of the TRR perimeter. The adverse conditions have been observed down to about 40 feet deep in 2 of 3 locations explored along the TRR perimeter, including liquefiable sands at this depth. Commonly, liquefaction is considered of concern for liquefaction-prone soils down to a depth of 50 feet. Given the variation in depth of liquefiable sands encountered in borings recorded to date, the observation of such sands as deep as about 40 feet, and that there is not a geologic constraint limiting such sands to this depth, it is reasonable to expect that liquefiable sands also exist at depths between 40 and 50 feet at various locations at the site.

These adverse soil conditions – both the soft clays and loose sands – will need to be mitigated in order to develop the TRR at this site. Given the mixed nature of the soils, the most likely viable method of ground improvement is cement deep soil mixing (CDSM).

For feasibility-level planning, it is prudent to estimate that the entire depth of adverse soil conditions will need to be mitigated, under the width of the footprint of the embankment and widened embankment/infrastructure areas. However, ground improvement using CDSM may be performed in a way that doesn't modify 100% of the foundation area - a tight grid pattern of treatment can be performed to mitigate the soils while limiting the amount of materials/work needed to accomplish the mitigation (this is referred to as the replacement ratio). Based on the need to improve the entire perimeter of TRR (approximately 2.2 miles) to approximately 50 feet below surface over the footprint (varies 50-120 feet wide) of the embankment, with a replacement ratio of approximately 30-40%, **an initial rough estimate for ground improvement is in the range of $150M** (-50% to +100%) considering local unit costs[2]. The overall cost could be optimized with appropriate geologic and geomorphic mapping in conjunction with design-level exploration, but the optimized cost is likely to fall with this range. This accounts for only the ground improvement and would be an additional cost beyond already-planned costs for grading to construct the TRR or any of the various facilities and improvements. This cost also does not account for ground improvement staging as required or appropriate disposal/handling of spoils generated during CDSM (up to 20% of volume treated).

This need for ground improvement at TRR represents a significant cost and introduces additional risk to the project cost and schedule. Also, it seems unlikely that additional subsurface exploration will result in a finding that ground improvement is not needed at the TRR site (i.e., additional exploration will refine the estimate of ground improvement cost, but not preclude the need for ground improvement).

4.0 Alternative Locations for a Reservoir

An alternative to incurring this significant additional cost may be to relocate this reservoir, to a location that does not necessitate ground improvement in order to develop the site. Three preliminary alternative locations for the reservoir have been identified to avoid the adverse soil conditions found at the TRR site. These alternative locations are in the topographically higher area between the GCID Canal and TC Canal, to the northwest of the TRR site, and were sized to provide the same storage capacity within the same operational range as TRR. Figure 1 shows the layout of these alternatives, where there is anticipated to be more advantageous geology/soil conditions (i.e., avoiding the flatland basin deposits, which include the soft clays and loose sands). Two historic borings on the southern edge of this region near the proposed TRR pipeline (see excerpt boring logs in Attachment A) were performed in 2001 by the Department of Water Resources (DWR). These borings indicate much more favorable soils for reservoir construction, including medium stiff to stiff lean clays with some silts and sands intermixed. These stiff soils likely comprise the majority of the topographic high between the two canals, but should be confirmed with geologic/geomorphic mapping, followed by further subsurface explorations.

---

[2] Unit cost of CDSM in West Coast U.S. can range from $100 - $200 per cubic yard.

Draft

To avoid confusion with TRR, we have chosen to use a distinctly different name for a potential reservoir in this area. Considering the location of the reservoir, we have developed a working title as the Between-Canals Management Reservoir, or BCM. The three preliminary alternative locations for this reservoir are referred to as BCM-1, BCM-2, and BCM-3 and are shown on the attached Figure 1.

BCM-1 is situated along the southeastern portion of the topographic high. BCM-1 is the closest location to the current TRR and pipeline alignment. BCM-1 shortens the length of pipeline needed, since the pumping/generating plant (PGP) can be located at the southwestern corner of the reservoir. BCM-1 is expected to involve the greatest amount of earthwork of the three alternatives (its western margin is controlled by increasing elevation of the topography).

BCM-2 is situated along the northern portion of the topographic high, just south of the Colusa Substation. This alternative is situated intentionally within the lowest/flattest area (of assumed good geology and avoiding basin deposits) and is expected to involve significantly less earthwork than BCM-1. The northern location of BCM-2 would likely increase the length of the pipeline, however.

BCM-3 is situated in the central portion of the topographic high, sited to work a balance of earthwork and pipeline length. Additionally, BCM-3 provides an alternative location if there is some significant problem with the viability of BCM-1 or BCM-3, such as real estate, environmental, or other constraints not known at this time.

5.0 Stockpiling and Staging

Stockpiling and staging areas for earthwork activities would need to be considered also for the BCM reservoir alternatives, optimized for proximity to earthmoving activities and ease of access/haul road use, within the constraints identified for environmental concerns, real estate, and more.

For the planned TRR, an area roughly equal to the size of the TRR is likely needed for stockpiling fill materials for processing and staging (e.g., moisture control of excavated materials prior to placement as embankment fill). Candidate locations include north or east of the proposed TRR, or on the other side of the GCID Canal.

For the BCM alternatives to TRR, depending on which alternative is selected, areas west and adjacent to the reservoir locations are candidates for stockpiling and staging. As for TRR, these stockpile and staging areas are anticipated to be large areas, likely requiring and area approximately equal to the planned reservoir area.

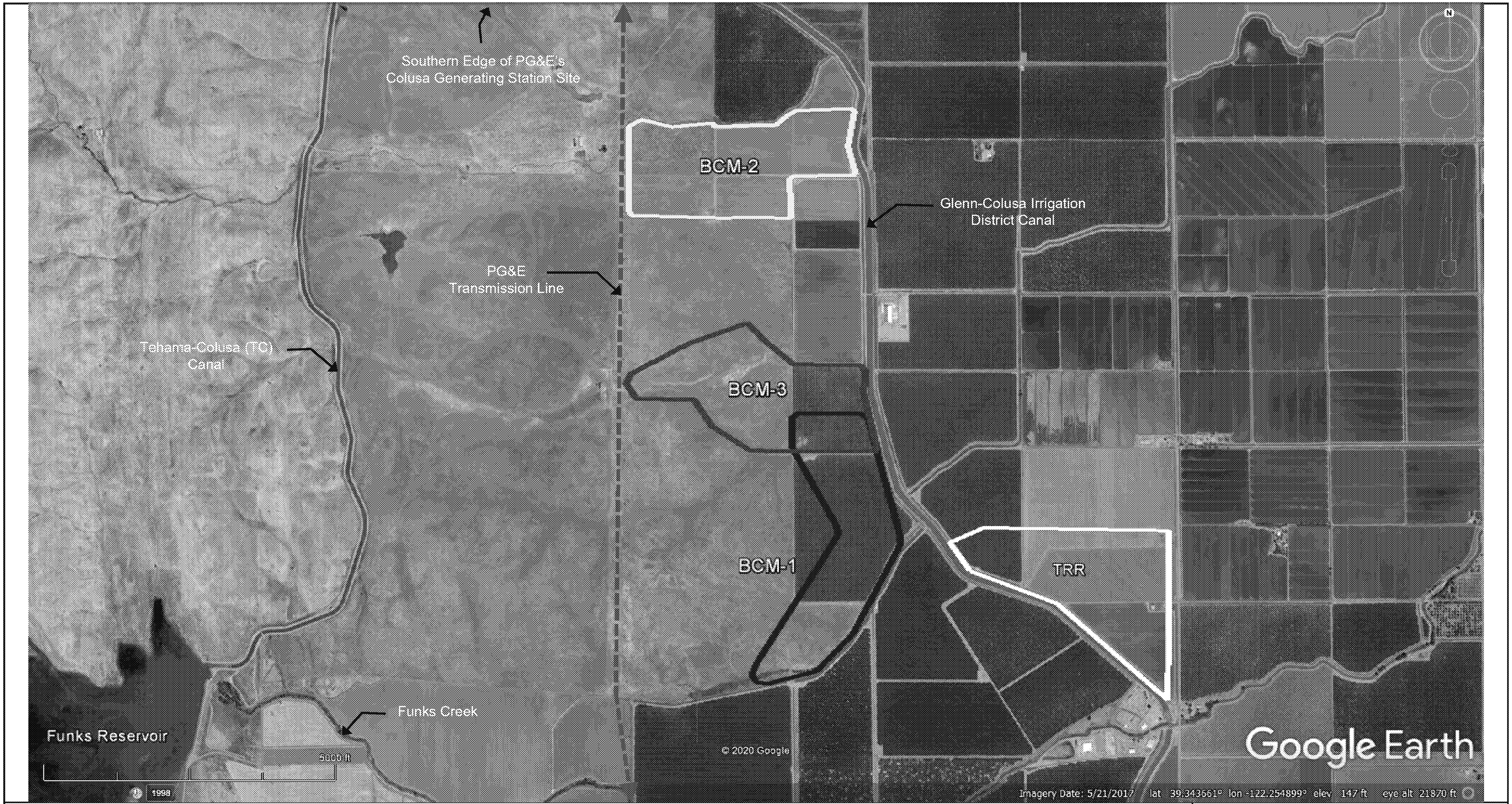
6.0 Other Considerations and Recommendation

One or more of the preliminary alternative locations identified as BCM-1, BCM-2, and BCM-3 may result in significantly lower project cost than the currently planned TRR location. Principally, the expensive ground improvement that is needed at TRR would be avoided. There may also be additional cost savings at some of these locations, associated with pipeline length, real estate, etc.

Additionally, it is likely that one or more of these locations is much more resilient (i.e., less prone to risk) with respect to project changes than the TRR location. The TRR is tightly constrained by real estate requirements; changes to hydraulic design needs could result in significant real estate conflicts. One or more of the BCM alternatives are likely much more flexible in configuration and constraints and could accommodate changes to hydraulic requirements or other changes that might alter the capacity requirements.

A range of hydraulic considerations and infrastructure interface considerations (especially with the GCID Canal) are controlled in large part by the location and configuration of this reservoir. Additionally, the project environmental footprint is determined in part by the location of this reservoir, as well as the pipeline alignments and other features controlled by the reservoir location. This potential change from TRR to one of the BCM locations is a critical path decision. To maintain overall project schedule, evaluation of the BCM alternatives would need to be started as soon as possible, to either confirm that the project will proceed with TRR as currently planned or modify the project configuration to one of the BCM locations and layouts.

DRAFT



Notes:

Alternatives shown in blue, yellow, and red represent potentially more advantageous options in comparison to the high likelihood of ground improvement needs for the planned Terminal Regulating Reservoir (TRR). Alternatives use an evaluation of topographic contours, parcel boundaries, potentially more suitable ground conditions pending further exploratory mapping and investigations.

Base Map Source : Google Earth Pro, © 2016

DRAFT

ALTERNATIVES TO TRR

Sites Reservoir Project
Sites, California

Geosyntec
consultants

Davis, CA

June 2020

Figure

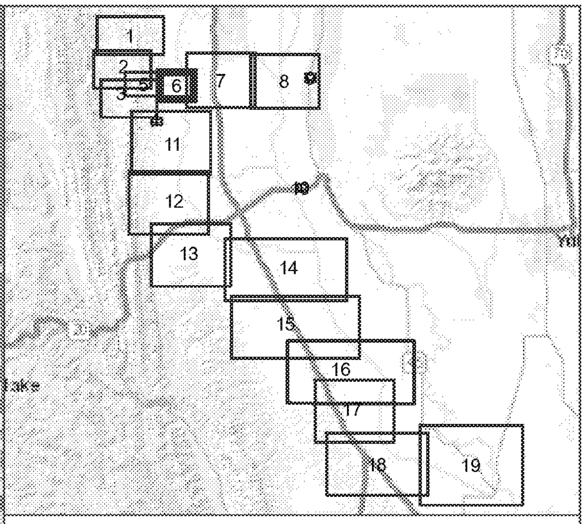
1

P:\PRJ2003Geo\Jacobs\WG2877 - Sites Reservoir\06. Deliverables\Working Versions-Delete when finalized\20200619 TRR Alternatives

ATTACHMENT A

Geotechnical Boring Locations and Logs

Note: Pipelines are offset for clarity



LEGEND

- ● NODOS Explorations Surveyed
- ▲ Historic Boring Locations
- Historic Geophysic Survey Lines
- ● Water Wells
- Overhead T-Line
- Delevan Pipeline
- Fletcher Pipeline North
- Fletcher Pipeline South
- Funks Creek Pipeline
- TRR Pipeline
- ▨ Dam
- ☐ Intake Outlet
- Reservoir
- Holthouse
- Terminal Regulating

DRAFT

DATA SOURCES: Historic Borings/Geophysic Survey Lines -DWR (1969-2010), Proposed Borings/Geophysic Survey Lines - ICF (2019), Fugro (2019), Faults - WLA (2002), Water Wells - DWR (2019), Gas Wells - CDC (2019), Substations, Transmission Lines - CEC (2019), Flowlines - NHD (2019), Other Data - HDR (2019).

DISCLAIMER: This exhibit is preliminary and is subject to change. All locations are approximate.

MAP DATE: 4.05.2020

GEOTECHNICAL BORINGS AND ASSOCIATED DATA - OPTION 1

SITES RESERVOIR

N

1,240
Feet

Sites

PATH: E:\PROJECTS\LOCATION-72\2019\04.72190035_SITES_RESERVOIR\08_GIS\04_OUTPUTS\WORKING\MXD\INTERNAL_GEOTECHNICAL_BORINGS_ASSOCIATEDDATA_FUG_OPT1.MXD - USER: E.ISLEYEN - DATE: 4.05.2020

GEOLOGIC LOG OF DRILL HOLE NO. DH-19-DP1-A

PROJECT: Sites - NODOS
FEATURE: Pipeline
STATE: California
LOCATION: Approx. 0.25 mile north of intersection between McDermott Rd and Lenahan Road. On east shoulder of of McDermott Road
START DATE, END DATE: 11/3/2019, 11/14/2019

COORDINATES: N 2,249,169.31 E 6,496,885.06
DATUM: CA State Plane, Zone 2, NAD83
GROUND ELEVATION: 112.2 ft. NAVD88
FIRST ENCOUNTERED WATER DEPTH, DATE: 6.3 ft. (el. 105.9 ft.), 11/3/2019
POTENTIOMETRIC (STATIC) WATER DEPTH, DATE: NA

DEPTH TO BEDROCK: Not Encountered
TOTAL DEPTH: 100.2 ft. (el. 12.0 ft.)
ANGLE FROM HORIZONTAL: 90° (vertical)
LOGGED BY: B. Holmes; S. Dalton
REVIEWED BY:

Laboratory Data

% Fines	% Sand	% Gravel	% Cobble (3- to 5-inch)	Liquid Limit	Plasticity Index	Moisture Content %	Lab Classification
74.5	25.5	0.0	0.0	36	21	13.4	(CL)s
94.2	5.8	0.0	0.0	31	14	30.1	CL
69.2	30.7	0.1	0.0	31	17	26.1	s(CL)
32.6	67.4	0.0	0.0	0	0	22.1	SM
17.9	81.0	1.1	0.0	0	0	21.2	SM
75.5	24.5	0.0	0.0	36	21	25.4	(CL)s

Visual Classification

s(ML)
s(CL)
SM
(CH)s
s(CL)
SM
SP
s(CL)

FADC % Recovery

100
100
100
100
100
100
100
100
96
76
52
100
100

SPT Data

SPT Blows / 0.5 ft.*	SPT Blows / ft.*	SPT % Recovery
0 0 0	0	87
0 0 0	0	100
0 5 7	12	87
0 1 4	5	100
0 1 2	3	100
1 3 7	10	100
2 3 8	11	87
2 4 6	10	47
2 2 2	4	87
3 3 3	6	80

Geologic Unit

Fill
▼
Qb

Visual Classification and Physical Condition

0.0 to 2.9 ft.
Fill

0.0 to 2.0 ft.: FAPB. Logged auger flight drill cuttings.

0.0 to 2.9 ft.: SANDY SILT, s(ML):
About 70% fines with low plasticity, high to very high dry strength, low toughness, slow dilatancy; about 30% predominantly fine with medium and coarse, hard, angular to subangular sand; maximum size, coarse sand; soft consistency; dry; brown; no reaction with HCl.

2.9 to 100.2 ft.
Quaternary: Basin Deposits, Qb

2.9 to 7.0 ft.: SANDY LEAN CLAY, s(CL):
About 60% fines with medium plasticity, very high dry strength, medium toughness, no dilatancy; about 40% predominantly fine with medium sand; maximum size, medium sand; firm consistency; moist; brown; no reaction with HCl.

7.0 to 10.4 ft.: SILTY SAND, SM:
About 60% fine sand; about 40% non-plastic fines with very high dry strength, slow dilatancy; maximum size, fine sand; wet; brown; no reaction with HCl.

10.4 to 12.5 ft.: FAT CLAY WITH SAND, (CH)s:
About 80% fines with high plasticity, very high dry strength, high toughness, no dilatancy; about 20% predominantly fine with trace medium sand; maximum size, medium sand; firm to hard consistency; moist; brown; upper contact difficult to discern due to swelling of material in sampler; no reaction with HCl.

12.5 to 14.8 ft.: SANDY LEAN CLAY, s(CL):
About 55% fines with medium to high plasticity, high to very high dry strength, medium toughness, no to slow dilatancy; about 45% predominantly fine with medium sand; maximum size, medium sand; soft to firm consistency; moist to wet; brown; grades coarser with depth from 14.0 to 14.8 ft.; no reaction with HCl.

14.8 to 21.2 ft.: SILTY SAND, SM:
About 85% predominantly fine to medium with trace coarse, hard, subangular to subrounded sand; about 15% non-plastic fines with no dry strength, rapid dilatancy; trace fine, hard, subrounded gravel; maximum size, 3/4 inch; wet; brown; no reaction with HCl.

21.2 to 25.8 ft.: POORLY GRADED SAND, SP:
About 95% predominantly fine to medium with trace coarse, hard, angular to subangular sand; about 5% fines; maximum size, coarse sand; wet; brown; no reaction with HCl.

25.8 to 30.2 ft.: SANDY LEAN CLAY, s(CL):
About 70% fines with medium plasticity, very high dry strength, medium toughness, no dilatancy; about 30% predominantly fine with medium sand; maximum size, medium sand; firm consistency; moist; brown; grades finer with depth; no reaction with HCl.

30.2 to 36.8 ft.: SANDY ELASTIC SILT, s(MH):
About 65% fines with medium plasticity, very high dry strength, low toughness, no dilatancy; about 35% fine sand; maximum size, fine sand; soft consistency; moist to wet; light brown ; sticky; sand is fine to very fine; grades coarser with depth; no reaction with HCl.

36.8 to 41.1 ft.: SILTY SAND, SM:
About 65% predominantly fine to medium with trace coarse, hard, angular to subangular sand; about 35% non-plastic fines with high dry strength, slow dilatancy; maximum size, coarse sand; wet; brown; grades coarser with depth; no reaction with HCl.

41.1 to 45.2 ft.: SILTY SAND WITH GRAVEL, (SM)g:
About 40% fine, hard, subrounded gravel; 40% fine to coarse, hard, subangular to subrounded sand; about 20% non-plastic fines; maximum size, 1/2 inch; moist to wet; brown; gravels are concentrated in thin layers (about 0.1 to 0.3 inches thick); no reaction with HCl.

45.2 to 45.5 ft.: POORLY GRADED GRAVEL WITH SILT AND SAND, (GP-GM)s:
About 60% fine, hard, subrounded gravel; about 30% fine to coarse, hard, subangular to subrounded sand; about 10% fines; maximum size, 1/2 inch; moist to wet; brown; no reaction with HCl.

45.5 to 51.5 ft.: SANDY LEAN CLAY, s(CL):
About 65% fines with medium plasticity, high dry strength, low toughness, slow

Geologic Units

Roadbase	
▨ Fill	
Qb	Quaternary: Basin Deposits

Symbols

▽ First Encountered Water Depth ▼ Potentiometric (static) Water Level Depth

Abbreviations

FAPB:	Flight Auger Pilot Bit
FADC:	Flight Auger Dry Core
SPT:	Standard Penetration Test
HCl:	Hydrochloric acid
NR:	No Recovery

*Blow counts are uncorrected ("N"-Values)

RECLAMATION
Managing Water in the West

DRAFT

GEOLOGIC LOG OF DRILL HOLE NO. DH-19-DP1-A

SHEET 2 OF 6

PROJECT: Sites - NODOS
FEATURE: Pipeline
STATE: California
LOCATION: Approx. 0.25 mile north of intersection between McDermott Rd and Lenahan Road. On east shoulder of of McDermott Road
START DATE, END DATE: 11/3/2019, 11/14/2019

COORDINATES: N 2,249,169.31 E 6,496,885.06
DATUM: CA State Plane, Zone 2, NAD83
GROUND ELEVATION: 112.2 ft. NAVD88
FIRST ENCOUNTERED WATER DEPTH, DATE: 6.3 ft. (el. 105.9 ft.), 11/3/2019
POTENTIOMETRIC (STATIC) WATER DEPTH, DATE: NA

DEPTH TO BEDROCK: Not Encountered
TOTAL DEPTH: 100.2 ft. (el. 12.0 ft.)
ANGLE FROM HORIZONTAL: 90° (vertical)
LOGGED BY: B. Holmes; S. Dalton
REVIEWED BY:

Depth (feet)	Elevation (feet)
	82
31	81
32	80
33	79
34	78
35	77
36	76
37	75
38	74
39	73
40	72
41	71
42	70
43	69
44	68
45	67
46	66
47	65
48	64
49	63
50	62
51	61
52	60
53	59
54	58
55	57
56	56
57	55
58	54
59	53

Laboratory Data

% By Weight							
% Fines	% Sand	% Gravel	% Cobble (3- to 5-inch)	Liquid Limit	Plasticity Index	Moisture Content %	Lab Classification
88.8	11.2	0.0	0.0	31	15	29.9	CL
20.3	48.6	31.1	0.0	46	26	18.2	(SC)g
79.8	17.5	2.7	0.0	28	8	25.3	(CL)s
67.0	31.3	1.7	0.0	27	11	23.1	s(CL)

Visual Classification: s(MH); SM; (SM)g; (GP-GM)s; s(CL); SC; (SC)g

FADC % Recovery: 100; 100; 100; 100; 72; 48; 96; 100; 80; 96; 100; 100; 100

SPT Data

SPT Blows / 0.5 ft.*	SPT Blows / ft.*	SPT % Recovery
0 0 0	0	100
0 0 3	3	100
0 2 4	6	100
0 3 4	7	100
2 7 9	16	100
3 4 9	13	73
4 4 4	8	60
3 4 5	9	93
4 4 6	10	100
2 4 5	9	100
2 4 6	10	100
7 13 21	34	100

Geologic Unit: Qb

Visual Classification and Physical Condition

dilatancy; about 35% predominantly fine with medium and trace coarse, hard, angular to subangular sand; maximum size, coarse sand; soft to firm consistency; moist; mottled light brown with gray; grades coarser with depth; no reaction with HCl.

51.5 to 58.2 ft.: CLAYEY SAND, SC:
About 55% fine to coarse, hard, angular to subangular sand; about 45% fines with medium plasticity, high dry strength, medium toughness, no to slow dilatancy; maximum size, coarse sand; moist; mottled brown with gray; no reaction with HCl.

58.2 to 60.9 ft.: CLAYEY SAND WITH GRAVEL, (SC)g:
About 50% fine to coarse, hard, angular to subangular sand; about 35% fines with medium plasticity, high dry strength, medium toughness, no to slow dilatancy; about 15% fine, hard, subangular to subrounded gravel; moist; brown with gray, orange, and black; no reaction with HCl.

60.9 to 63.0 ft. NO RECOVERY

63.0 to 64.1 ft.: SILTY SAND, SM:
About 80% fine sand; about 20% fines with no to low plasticity, rapid dilatancy; trace fine, hard, subrounded gravel; maximum size, 3/8 inch; wet; mottled predominantly brown with minor pale green-gray and red-brown; no reaction with HCl.

64.1 to 64.8 ft.: CLAYEY SAND WITH GRAVEL, (SC)g:
About 50% fine to coarse, hard, angular to subangular sand; about 35% fines with medium plasticity, high dry strength, medium toughness, no to slow dilatancy; about 15% fine, hard, subangular to subrounded gravel; maximum size, 3/8 inch; moist; brown with gray, orange, and black; no reaction with HCl.

64.8 to 66.5 ft.: SANDY LEAN CLAY, s(CL):
About 65 to 70% fines with low to medium plasticity, medium to high dry strength, low toughness, no to slow dilatancy; about 30 to 35% fine sand; trace fine, hard, angular to subangular gravel; maximum size, 5/8 inch; soft to firm consistency; moist; mottled brown, green-gray, red-brown (FeOx), and minor black (MnO2); gravels have strong reaction with HCl; no reaction with HCl.

66.5 to 67.1 ft.: LEAN CLAY WITH SAND, (CL)s:
About 80 to 85% fines with low to medium plasticity, medium to high dry strength, low toughness, no to slow dilatancy; about 15 to 20% fine sand; trace fine, hard, angular to subangular gravel; maximum size, 5/8 inch; soft to firm consistency; moist; mottled brown, green-gray, red-brown (FeOx), and minor black (MnO2); no reaction with HCl.

67.1 to 70.2 ft.: LEAN CLAY WITH SAND TO SANDY LEAN CLAY, (CL)s / s(CL):
About 65 to 85% fines with low to medium plasticity, medium to high dry strength, low toughness, no to slow dilatancy; about 15 to 35% fine sand; trace fine, hard, angular to subangular gravel; maximum size, 5/8 inch; soft to firm consistency; moist; mottled brown, green-gray, red-brown (FeOx), and minor black (MnO2); alternating layers of (CL)s and s(CL); difficult to discern layer contacts; interbed from 68.1 to 68.3 feet consisting of calcareous cemented, fine to coarse gravel size, moderately hard, angular fragments (strong reaction with HCl; maximum size, 1-inch) ; no reaction with HCl.

70.2 to 70.7 ft.: SANDY SILT TO SILTY SAND, s(ML) / SM:
About 50% fine sand; about 50% non-plastic fines with rapid dilatancy; maximum size, fine sand; soft consistency; wet; mottled brown, red-brown, and green-gray; no reaction with HCl.

> 70.7 to 70.8 ft.: Interbed of calcareous cemented, fine to coarse gravel, moderately hard, angular, strong reaction with HCl.

70.8 to 74.7 ft.: LEAN CLAY TO LEAN CLAY WITH SAND, CL / (CL)s:
About 85 to 90% fines with medium to high plasticity, very high dry strength, medium toughness, no dilatancy; about 10 to 15% fine with trace coarse, moderately hard, subangular sand; maximum size, coarse sand; hard consistency; moist; mottled brown and green-gray with off-white stringers; no reaction with HCl in body of soil, strong reaction with HCl in off-white stringers.

74.7 to 75.2 ft. NO RECOVERY

75.2 to 75.5 ft.: SILTY SAND, SM:
About 80% fine sand; about 20% fines with no to low plasticity, rapid dilatancy; maximum size, fine sand; wet; brown; no reaction with HCl.

> **75.5 to 76.5 ft.:** Gradational contact with next layer.

Geologic Units

Roadbase	
▨ Fill	
Qb	Quaternary: Basin Deposits

Symbols

▽ First Encountered Water Depth ▼ Potentiometric (static) Water Level Depth

Abbreviations

FAPB:	Flight Auger Pilot Bit
FADC:	Flight Auger Dry Core
SPT:	Standard Penetration Test
HCl:	Hydrochloric acid
NR:	No Recovery

*Blow counts are uncorrected ("N"-Values)

DRAFT

RECLAMATION
Managing Water in the West

GEOLOGIC LOG OF DRILL HOLE NO. DH-19-DP1-A

SHEET 3 OF 6

PROJECT: Sites - NODOS
FEATURE: Pipeline
STATE: California
LOCATION: Approx. 0.25 mile north of intersection between McDermott Rd and Lenahan Road. On east shoulder of of McDermott Road
START DATE, END DATE: 11/3/2019, 11/14/2019

COORDINATES: N 2,249,169.31 E 6,496,885.06
DATUM: CA State Plane, Zone 2, NAD83
GROUND ELEVATION: 112.2 ft. NAVD88
FIRST ENCOUNTERED WATER DEPTH, DATE: 6.3 ft. (el. 105.9 ft.), 11/3/2019
POTENTIOMETRIC (STATIC) WATER DEPTH, DATE: NA

DEPTH TO BEDROCK: Not Encountered
TOTAL DEPTH: 100.2 ft. (el. 12.0 ft.)
ANGLE FROM HORIZONTAL: 90° (vertical)
LOGGED BY: B. Holmes; S. Dalton
REVIEWED BY:

DRAFT

Depth (feet): 61, 62, 63, 64, 65, 66, 67, 68, 69, 70, 71, 72, 73, 74, 75, 76, 77, 78, 79, 80, 81, 82, 83, 84, 85, 86, 87, 88, 89

Elevation (feet): 52, 51, 50, 49, 48, 47, 46, 45, 44, 43, 42, 41, 40, 39, 38, 37, 36, 35, 34, 33, 32, 31, 30, 29, 28, 27, 26, 25, 24, 23

Laboratory Data

% By Weight							
% Fines	% Sand	% Gravel	% Cobble (3- to 5-inch)	Liquid Limit	Plasticity Index	Moisture Content %	Lab Classification
29.8	69.5	0.7	0.0	0	0	21.1	SM
89.1	10.1	0.8	0.0	31	16	19.9	CL
50.5	20.7	28.8	0.0	39	23	19.8	g(CL)s

Visual Classification

- (SC)g
- NR
- SM
- (SC)g
- s(CL)
- (CL)s
- (CL)s / s(CL)
- s(ML) / SM
- CL / (CL)s
- NR
- SM
- (CL)s
- s(ML) / SM
- (CL)s
- NR
- s(CL) / SC
- CL
- g(CL)s
- CL
- (CL)s
- CL
- s(CL)
- (CL)s

FADC % Recovery	SPT Data: SPT Blows / 0.5 ft.*	SPT Blows / ft.*	SPT % Recovery
43	23 37 40	77	100
95	5 7 16	23	80
100	8 11 13	24	100
92	14 13 15	28	100
100	3 6 14	20	100
80	7 12 16	28	100
100	3 6 10	16	100
80	5 14 15	29	100
100	9 21 39	60	100
100	11 13 17	30	100
100	10 15 22	37	100
100	8 11 13	24	100

Geologic Unit: Qb

Visual Classification and Physical Condition

76.5 to 77.7 ft.: LEAN CLAY WITH SAND, (CL)s:
About 75 to 85% fines with medium to high plasticity, high to very high dry strength, medium toughness, no dilatancy; about 15 to 25% predominantly fine with trace coarse, moderately hard, subangular sand; maximum size, coarse sand; hard consistency; moist; mottled brown and green-gray with off-white stringers; no reaction with HCl in body of soil, strong reaction with HCl in off-white stringers.

77.7 to 78.1 ft.: SANDY SILT TO SILTY SAND, s(ML) / SM:
About 50% fine sand; about 50% non-plastic fines with rapid dilatancy; maximum size, fine sand; soft consistency; wet; mottled brown, red-brown, and green-gray; no reaction with HCl.

78.1 to 79.7 ft.: LEAN CLAY WITH SAND, (CL)s:
About 75 to 80% fines with medium to high plasticity, high to very high dry strength, medium toughness, no dilatancy; about 20 to 25% predominantly fine with trace coarse, hard, subangular sand; maximum size, coarse sand; hard consistency; moist; mottled brown and green-gray with off-white stringers; no reaction with HCl in body of soil, strong reaction with HCl in off-white stringers.

79.7 to 80.2 ft. NO RECOVERY

80.2 to 80.6 ft.: SANDY LEAN CLAY TO CLAYEY SAND, s(CL) / SC:
About 50% fine with trace coarse, subangular, moderately hard sand (strong reaction with HCl); about 50% fines with medium plasticity, high dry strength, low to medium toughness, no to slow dilatancy; maximum size, fine sand; soft to firm consistency; moist to wet; mottled brown, green-gray, and red-brown (FeOx); no reaction with HCl in body of soil.

80.6 to 81.0 ft.: LEAN CLAY, CL:
About 90% fines with medium to high plasticity, very high dry strength, medium toughness, no dilatancy; about 10% fine sand; maximum size, fine sand; hard consistency; moist; mottled brown and green-gray with off-white stringers; no reaction with HCl in body of soil.

81.0 to 83.4 ft.: GRAVELLY LEAN CLAY WITH SAND, g(CL)s:
About 65% fines with medium plasticity, high dry strength, medium toughness, no dilatancy; about 20% fine to coarse, moderately hard, subangular gravel; about 15% fine to coarse, moderately hard, subangular sand; maximum size, 2.5 inches; firm to hard consistency; moist to wet; mottled brown with minor green-gray and red-brown (FeOx); no reaction with HCl in body of soil, strong reaction with HCL in gravels.

83.4 to 84.6 ft.: LEAN CLAY, CL:
About 90 to 95% fines with medium to high plasticity, very high dry strength, medium toughness, no dilatancy; about 5 to 10% coarse, hard, subangular sand; maximum size, coarse sand; hard consistency; moist; mottled brown and green-gray with off-white stringers; no reaction with HCl in body of soil, strong reaction with HCl in coarse sand.

84.6 to 85.4 ft.: LEAN CLAY WITH SAND, (CL)s:
About 75 to 80% fines with medium to high plasticity, high to very high dry strength, medium toughness, no dilatancy; about 20 to 25% predominantly fine with trace coarse, hard, subangular sand; maximum size, coarse sand; hard consistency; moist; mottled brown and green-gray with off-white stringers; no reaction with HCl in body of soil, strong reaction with HCl in off-white stringers.

85.4 to 87.7 ft.: LEAN CLAY, CL:
About 90 to 95% fines with medium to high plasticity, very high dry strength, medium toughness, no dilatancy; about 5 to 10% coarse, hard, subangular sand; maximum size, coarse sand; hard consistency; moist; mottled brown and green-gray with off-white stringers; no reaction with HCl in body of soil, strong reaction with HCl in coarse sand.

87.7 to 89.7 ft.: SANDY LEAN CLAY, s(CL):
About 70% fines with medium plasticity, high dry strength, low to medium toughness, no dilatancy; about 30% fine with trace coarse, hard, subangular sand; maximum size, coarse sand; firm consistency; moist; mottled brown with minor gray-green; no reaction with HCl in body of soil, strong reaction with HCl in coarse sand.

89.7 to 92.7 ft.: LEAN CLAY WITH SAND, (CL)s:
About 85% fines with medium to high plasticity, high to very high dry strength, medium toughness, no dilatancy; about 15% fine with trace coarse, moderately hard, subangular sand; trace fine, moderately hard, subangular gravel (strong reaction with HCl); maximum size, 1/2 inch; firm to hard consistency; moist; mottled brown with minor gray-green; no reaction with HCl in body of soil.

92.7 to 93.6 ft.: SANDY LEAN CLAY, s(CL):

Geologic Units

Roadbase	
▨ Fill	
Qb	Quaternary: Basin Deposits

Symbols

▽ First Encountered Water Depth ▼ Potentiometric (static) Water Level Depth

Abbreviations

FAPB:	Flight Auger Pilot Bit
FADC:	Flight Auger Dry Core
SPT:	Standard Penetration Test
HCl:	Hydrochloric acid
NR:	No Recovery

*Blow counts are uncorrected ("N"-Values)

RECLAMATION
Managing Water in the West

LIBRARY: SITES - NODOS.GLB REPORT: SITES_SPT DATE PRINTED: 3/10/2020

GEOLOGIC LOG OF DRILL HOLE NO. DH-19-DP1-A

PROJECT: Sites - NODOS
FEATURE: Pipeline
STATE: California
LOCATION: Approx. 0.25 mile north of intersection between McDermott Rd and Lenahan Road. On east shoulder of of McDermott Road
START DATE, END DATE: 11/3/2019, 11/14/2019

COORDINATES: N 2,249,169.31 E 6,496,885.06
DATUM: CA State Plane, Zone 2, NAD83
GROUND ELEVATION: 112.2 ft. NAVD88
FIRST ENCOUNTERED WATER DEPTH, DATE: 6.3 ft. (el. 105.9 ft.), 11/3/2019
POTENTIOMETRIC (STATIC) WATER DEPTH, DATE: NA

DEPTH TO BEDROCK: Not Encountered
TOTAL DEPTH: 100.2 ft. (el. 12.0 ft.)
ANGLE FROM HORIZONTAL: 90° (vertical)
LOGGED BY: B. Holmes; S. Dalton
REVIEWED BY:

Depth (feet)	Elevation (feet)	Laboratory Data								Visual Classification	FADC % Recovery	SPT Data			Geologic Unit
		% By Weight													
		% Fines	% Sand	% Gravel	% Cobble (3- to 5-inch)	Liquid Limit	Plasticity Index	Moisture Content %	Lab Classification			SPT Blows / 0.5 ft.*	SPT Blows / ft.*	SPT % Recovery	
	22														
91	21	88.7	10.0	1.3	0.0	46	28	19.1	CL	(CL)s	100	10 15 20	35	100	Qb
92	20														
93	19									s(CL) SC (CL)s	100	9 11 13	24	100	
94	18									SC-SM					
95	17														
96	16										100	5 8 11	19	100	
97	15	97.1	2.9	0.0	0.0	49	30	27.6	CL	CL / (CL)s					
98	14										100	4 9 11	20	100	
99	13														
100															

BOTTOM OF HOLE: T.D. 100.2 ft. (el. 12.0)

Visual Classification and Physical Condition

About 70% fines with medium plasticity, high dry strength, low to medium toughness, no dilatancy; about 30% fine with trace coarse, hard, subangular sand; maximum size, coarse sand; firm consistency; moist; mottled brown with minor gray-green; no reaction with HCl in body of soil, strong reaction with HCl in coarse sand.

93.6 to 93.8 ft.: CLAYEY SAND, SC:
About 55% fine sand; about 45% fines with low to medium plasticity, medium to high dry strength, low toughness, slow dilatancy; maximum size, fine sand; moist to wet; brown ; no reaction with HCl.

93.8 to 94.4 ft.: LEAN CLAY WITH SAND, (CL)s:
About 85% fines with medium to high plasticity, high to very high dry strength, medium toughness, no dilatancy; about 15% fine sand; maximum size, 1/2 inch; firm to hard consistency; moist; mottled brown with minor gray-green; no reaction with HCl.

94.4 to 94.9 ft.: CLAYEY TO SILTY SAND, SC-SM:
About 70 to 80% predominantly fine to medium with trace coarse, hard, subangular to subrounded sand; about 20 to 30% fines with no to low plasticity, slow to rapid dilatancy; maximum size, coarse sand; moist to wet; brown; no reaction with HCl.

94.9 to 100.2 ft.: LEAN CLAY TO LEAN CLAY WITH SAND, CL / (CL)s:
About 85 to 95% fines with medium to high plasticity, high to very high dry strength, medium toughness, no dilatancy; about 5 to 15% fine sand; firm to hard consistency; moist; mottled brown with minor gray-green; no reaction with HCl.

DRAFT

Geologic Units

Roadbase
Fill
Qb Quaternary: Basin Deposits

Symbols

▽ First Encountered Water Depth
▼ Potentiometric (static) Water Level Depth

Abbreviations

FAPB:	Flight Auger Pilot Bit
FADC:	Flight Auger Dry Core
SPT:	Standard Penetration Test
HCl:	Hydrochloric acid
NR:	No Recovery

*Blow counts are uncorrected ("N"-Values)

RECLAMATION
Managing Water in the West

GEOLOGIC LOG OF DRILL HOLE NO. DH-19-DP1-A

PROJECT: Sites - NODOS
FEATURE: Pipeline
STATE: California
LOCATION: Approx. 0.25 mile north of intersection between McDermott Rd and Lenahan Road. On east shoulder of of McDermott Road
START DATE, END DATE: 11/3/2019, 11/14/2019

COORDINATES: N 2,249,169.31 E 6,496,885.06
DATUM: CA State Plane, Zone 2, NAD83
GROUND ELEVATION: 112.2 ft. NAVD88
FIRST ENCOUNTERED WATER DEPTH, DATE: 6.3 ft. (el. 105.9 ft.), 11/3/2019
POTENTIOMETRIC (STATIC) WATER DEPTH, DATE: NA

DEPTH TO BEDROCK: Not Encountered
TOTAL DEPTH: 100.2 ft. (el. 12.0 ft.)
ANGLE FROM HORIZONTAL: 90° (vertical)
LOGGED BY: B. Holmes; S. Dalton
REVIEWED BY:

NOTES

PURPOSE OF HOLE:
To determine geotechnical properties of soil and depth to groundwater bearing soils (foundation conditions) for the proposed Delevan Pipeline. Data will be used to prepare feasibility level design of excavation slopes, a dewatering system, and structural support.

LOCATION:
About 0.25 miles north of the intersection between McDermott Road and Lenahan Road. Drill hole is located on the east shoulder of McDermott Road, about 16 feet from the edge of the road and about 8 feet from an unlined irrigation canal to the east (parallel to McDermott Road).

DRILLED BY:
Bureau of Reclamation: Pacific Northwest (PN) Region drill crew:
Rick Knott, driller
Austin Anderson, helper

DRILL RIG:
Central Mining Equipment (CME) 850 track mounted rig

DRILLING AND SAMPLING METHODS :
Drill hole was advanced using flight auger pilot bit (FAPB) and flight auger dry core (FADC) systems.

FAPB was to advance the lead auger between depths of 0.0 to 2.0 feet, which then allowed for FADC advancement. FAPB consisted of 4-1/4 inch i.d. by 8 inch o.d. hollow flight augers equipped with an 8.5-inch o.d. lead drill bit containing six carbide bullet bit teeth around the rim, and a 4-1/4 inch o.d. pilot bit with six carbide bullet teeth attached to NWJ rods and set inside the lead drill bit using. FAPB is a closed system and does not allow for collection of core.

FADC was used to advance the drill hole and collect soil core from 2.0 to 100.2 feet. FADC utilizes the same augers as FAPB. Instead of using a pilot bit, FADC uses a 3-3/8 inch i.d. by 4 inch o.d. by 5-foot-long split barrel dry coring system. NWJ rods were attached to a free spinning bearing assembly, which is attached to the FADC barrel. The bearing assembly allows for the FADC barrel to remain stationary while the augers rotate and advance the hole. The barrel's cutting shoe was 0.1 foot beyond the lead drill bit between 2.0 and 100.2 feet. A metal "basket" was used in the cutting shoe to assist with retention of core.

SPT was performed at 2.5 foot intervals (1-foot spacing between SPT intervals), unless otherwise noted. SPT consisted of a 1-3/8 inch i.d. by 2 inch o.d. by 2.0 foot long split spoon sampler driven 1.5 feet. Sampler was attached to NWJ rods that weigh about 57.5 lbs/10 ft. The sampler was advanced with an auto-hammer (140 pound weight with a 30 inch drop) at a rate of about 54 blows per minute (drill rig engine at about 1550 rpm). The auto-hammer energy was measured in companion hole DH-19-TRRPGP-B on November 1, 2019, resulting in a 87.4% energy correction. Blow count data presented in this log is uncorrected "N"-values.

DRILLING CONDITIONS:
0.0 to 5.2 ft.: FADC. Smooth and easy auger advancement.

5.2 to 6.7 ft.: SPT. No blow counts; sampler advanced under weight of the rods and hammer.

5.2 to 7.7 ft.: FADC. Very soft drilling. Wet zone observed from 6.3 to 6.6 feet. Driller noted lots of heave prior to drilling this interval.

7.7 to 9.2 ft.: SPT. No blow counts; sampler advanced under weight of the rods and hammer.

7.7 to 10.2 ft.: FADC. Smooth and easy auger advancement. Driller noted some heave.

10.2 to 11.7 ft.: SPT. Sampler sank about 0.4 feet before test. Driller noted about 0.2 ft. of heave.

10.2 to 12.7 ft.: FADC. Smooth and easy auger advancement. Driller noted heave.

12.7 to 14.2 ft.: SPT. Sampler sank about 0.7 feet before test. Driller noted about 0.3 ft. of heave.

12.7 to 16.0 ft.: FADC. Smooth and easy auger advancement. Ended the day with a short run (15.2 to 16.0 ft.) to set the augers flush with the ground surface (in accordance with the county encroachment permit).

16.0 to 17.7 ft.: FADC. Driller noted about 0.4 ft. of heave.

17.7 to 19.2 ft.: SPT was not performed due to about 1.5 ft. of heave. More water was added to the augers.

16.2 to 17.7 ft.: Pilot bit was used to cleanout heave down to 17.7 feet.

17.7 to 22.7 ft.: Smooth and easy auger advancement.

22.2 to 22.7 ft.: Pilot bit was used to clean out about 0.5 ft. of heave.

22.7 to 25.2 ft.: Smooth and easy auger advancement.

25.2 to 26.7 ft.: SPT. Driller noted 0.2 ft. of heave. Sampler sank through the 0.2 ft. of heave.

25.2 to 30.8 ft.: Smooth and easy auger advancement. Ended the day with a short run (30.2 to 30.8 ft.) to set the augers flush with the ground surface.

30.8 to 40.2 ft.: Smooth and easy auger advancement.

40.2 to 42.7 ft.: Driller notes "scratchy" drilling (slightly rough).

42.7 to 45.2 ft.: Smooth drilling with slightly rough spots.

45.2 to 57.7 ft.: Smooth and easy auger advancement.

57.7 to 60.2 ft.: Driller notes drilling became very hard at about 59.7 feet and had to switch to manual down pressure.

60.2 to 60.9 ft.: Hit refusal with augers at 60.9 feet.

60.9 to 63.0 ft.: Pilot bit interval.

DRAFT

Geologic Units

Roadbase
▨ Fill
Qb **Quaternary: Basin Deposits**

Symbols

▽ **First Encountered Water Depth** ▼ **Potentiometric (static) Water Level Depth**

Abbreviations

FAPB:	Flight Auger Pilot Bit
FADC:	Flight Auger Dry Core
SPT:	Standard Penetration Test
HCl:	Hydrochloric acid
NR:	No Recovery

*Blow counts are uncorrected ("N"-Values)

GEOLOGIC LOG OF DRILL HOLE NO. DH-19-DP1-A

SHEET 6 OF 6

PROJECT: Sites - NODOS
FEATURE: Pipeline
STATE: California
LOCATION: Approx. 0.25 mile north of intersection between McDermott Rd and Lenahan Road. On east shoulder of of McDermott Road
START DATE, END DATE: 11/3/2019, 11/14/2019

COORDINATES: N 2,249,169.31 E 6,496,885.06
DATUM: CA State Plane, Zone 2, NAD83
GROUND ELEVATION: 112.2 ft. NAVD88
FIRST ENCOUNTERED WATER DEPTH, DATE: 6.3 ft. (el. 105.9 ft.), 11/3/2019
POTENTIOMETRIC (STATIC) WATER DEPTH, DATE: NA

DEPTH TO BEDROCK: Not Encountered
TOTAL DEPTH: 100.2 ft. (el. 12.0 ft.)
ANGLE FROM HORIZONTAL: 90° (vertical)
LOGGED BY: B. Holmes; S. Dalton
REVIEWED BY:

NOTES

63.0 to 65.2 ft.: Smooth and easy auger advancement. Minor cuttings return.

65.2 to 67.7 ft.: Alternating hard and soft drilling.

74.7 to 75.2 ft.: No recovery.

79.7 to 80.2 ft.: No recovery.

80.2 to 82.7 ft.: Slow auger advancement due to clay/gravel.

85.2 to 100.2 ft.: Smooth and easy auger advancement.

DRILLING FLUID, RETURN AND COLOR:
Drilling fluid was not used to advance the hole.

REASON FOR HOLE TERMINATION:
Drill hole terminated at target depth.

HOLE COMPLETION:
The hole was backfilled with bentonite from total depth to ground surface.

GROUNDWATER LEVELS:
The following water levels were measured at the start of each day, prior to drilling:

11/3/2019: Groundwater initially encountered at 6.3 feet.
11/4/2019: 5.0 feet with lead auger at 16.0 feet.
11/5/2019: 4.1 feet with lead auger at 30.8 feet.
11/6/2019: 4.6 feet with lead auger at 50.2 feet.
11/13/2019: 4.8 feet with lead auger at 60.9 feet.
11/14/2019: 4.8 feet with lead auger at 77.7 feet.

NEARBY SURFACE WATER LEVELS:
11/03-14/2019: About 2.0 feet below ground surface elevation at the drill hole in an unlined canal located approximately 15 feet to the east.

GENERAL NOTE:
Lab and visual classifications are described according to the Unified Soil Classification System (USCS) as presented in Bureau of Reclamation (Reclamation) standards USBR 5000 and 5005. Reclamation's standards are consistent with the American Society for Testing Materials (ASTM) D2487 and D2488.

SURVEY NOTE:
Geologic explorations were surveyed February 19, 2020 by Surveys and Mapping Branch, Division of Design and Construction California-Great Basin Region. Horizontal datum is NAD 1983 (2007) State Plane Coordinates, CA State Plane Zone 2, US Survey Feet. Vertical datum is NAVD 1988 (Based on NGS Benchmark DL92228 "CANAL 1").

DRAFT

Geologic Units

Roadbase
▨ Fill
Qb **Quaternary: Basin Deposits**

Symbols

▽ **First Encountered Water Depth** ▼ **Potentiometric (static) Water Level Depth**

Abbreviations

FAPB:	Flight Auger Pilot Bit
FADC:	Flight Auger Dry Core
SPT:	Standard Penetration Test
HCl:	Hydrochloric acid
NR:	No Recovery

*Blow counts are uncorrected ("N"-Values)

GEOLOGIC LOG OF DRILL HOLE NO. DH-19-TRRPGP-A

PROJECT: Sites - NODOS
FEATURE: Pipeline
STATE: California
LOCATION: Approx. 0.65 mile northwest of McDermott Rd. on GCID's canal embankment
START DATE, END DATE: 10/17/2019, 10/23/2019

COORDINATES: N 2,248,042.59 E 6,494,158.64
DATUM: CA State Plane, Zone 2, NAD83
GROUND ELEVATION: 128.2 ft. NAVD88
FIRST ENCOUNTERED WATER DEPTH, DATE: 12.0 ft. (el. 116.2 ft.), 10/18/2019
POTENTIOMETRIC (STATIC) WATER DEPTH, DATE: NA

DEPTH TO BEDROCK: Not Encountered
TOTAL DEPTH: 100.9 ft. (el. 27.3 ft.)
ANGLE FROM HORIZONTAL: 90° (vertical)
LOGGED BY: S. Dalton
REVIEWED BY:

Depth (feet)	Elevation (feet)	Laboratory Data: % By Weight: % Fines	% Sand	% Gravel	% Cobble (3- to 5-inch)	Liquid Limit	Plasticity Index	Moisture Content %	Lab Classification	Visual Classification	FADC % Recovery	SPT Data: SPT Blows / 0.5 ft.*	SPT Blows / ft.*	SPT % Recovery	Geologic Unit
0.0–1.0	128–127									Roadbase					Fill
1.0–4.4	127–124									s(CL)	92				Fill
4.4–5.9	124–122	70.2	29.8	0.0	0.0	28	17	15.9	(CL)s	s(CL)	100	0 0 0	0	80	Fill
5.9–6.4	122									SC					Fill
6.4–7.3	122–121									s(CL)		0			Fill
7.3–8.4	121–120									(CL)s	100	3 5	8	93	Qb
9.4–10.9	119–117	74.3	25.7	0.0	0.0	38	24	16.8	(CL)s	(CL)s	92	1 5 7	12	100	Qb
10.9–12.0	117–116									s(CL)					Qb
12.0–12.2	116									s(ML) / SM	100	0 3 4	7	100	Qb
12.2–16.9	116–111	65.0	34.9	0.1	0.0	27	13	23.6	s(CL)	s(CL-ML)	100	2 2 4	6	100	Qb
16.9–17.5	111									SM	84	3	8	73	Qb
17.5–18.1	111–110									SP-SM		5			Qb
18.1–18.6	110									s(CL-ML)		3			Qb
18.6–21.9	110–106	15.4	70.6	14.0	0.0	0	0	17.9	SM	SP-SM	92	4 13 25	38	100	Qb
21.9–25.0	106–103									(CL)s	100	5 13 16	29	100	Qb
24.5–	104–									(CL)s	100	6		100	Qb

First encountered water depth ▼ at 12.0 ft.

Visual Classification and Physical Condition

0.0 to 1.9 ft.: FAPB. Logged auger flight drill cuttings.

0.0 to 7.3 ft.
Embankment Fill

0.0 to 1.0 ft.: **Aggregate Roadbase:** Lower contact is estimated. SILTY GRAVEL WITH SAND, (GM)s.

1.0 to 5.9 ft.: **SANDY LEAN CLAY, s(CL):** Upper contact is estimated. About 70% fines with medium plasticity, high dry strength, low to medium toughness, no dilatancy; about 30% fine sand; trace fine, hard, subrounded gravel; maximum size, 1/4 inch; firm consistency; moist; brown to dark brown; no reaction with HCl.

5.9 to 6.4 ft.: **CLAYEY SAND, SC:** About 55% predominantly fine with medium sand; about 45% fines with low to medium plasticity, medium dry strength, low toughness, slow to rapid dilatancy; moist to wet; brown; no reaction with HCl.

6.4 to 7.3 ft.: **SANDY LEAN CLAY, s(CL):** Upper contact is estimated. About 70% fines with medium plasticity, high dry strength, low to medium toughness, no dilatancy; about 30% fine sand; trace fine, hard, subrounded gravel; maximum size, 1/4 inch; firm consistency; moist; brown to dark brown; no reaction with HCl.

7.3 to 100.9 ft. Upper contact is approximated, based on drill cuttings.
Quaternary: Basin Deposits, Qb

7.3 to 10.9 ft.: **LEAN CLAY WITH SAND, (CL)s:** About 85% fines with medium plasticity, high to very high dry strength, medium toughness, no dilatancy; about 15% fine sand; maximum size, fine sand; firm to hard consistency; moist; brown; no reaction with HCl.

10.1 to 10.4 ft.: Trace off-white, medium sand size fragments; strong reaction with HCl.

10.9 to 12.0 ft.: **SANDY LEAN CLAY, s(CL):** About 65% fines with low to medium plasticity, medium dry strength, low toughness, slow dilatancy; about 35% fine sand; maximum size, fine sand; firm consistency; moist; brown; no reaction with HCl.

12.0 to 12.2 ft.: **SANDY SILT TO SILTY SAND, s(ML) / SM:** About 50% fine sand; about 50% fines with no to low plasticity, rapid dilatancy; maximum size, fine sand; very soft consistency; wet; dark gray; no reaction with HCl.

12.2 to 16.9 ft.: **SANDY LEAN CLAY TO SILT, s(CL-ML):** About 55 to 65% fines with no to low plasticity, low dry strength, no to low toughness, slow to rapid dilatancy; about 35 to 45% fine sand; maximum size, fine sand; soft consistency; wet; brown; minor silty sand (SM) interbeds (<0.1-ft. thick) with about 75% fine sand and about 25% non-plastic fines; no reaction with HCl.

16.9 to 17.5 ft.: **SILTY SAND, SM:** About 60 to 70% fine sand; about 30 to 40% fines with no to low plasticity, rapid dilatancy; maximum size, fine sand; wet; brown; no reaction with HCl.

17.5 to 18.1 ft.: **POORLY GRADED SAND WITH SILT, SP-SM:** About 90% predominantly fine to medium with coarse, hard, subangular to subrounded sand; about 10% non-plastic fines; trace fine, hard, subangular to subrounded gravel; maximum size, 3/8 inch; wet; dark brown to olive brown; no reaction with HCl.

18.1 to 18.6 ft.: **SANDY LEAN CLAY TO SILT, s(CL-ML):** About 55 to 65% fines with no to low plasticity, low dry strength, no to low toughness, slow to rapid dilatancy; about 35 to 45% fine sand; maximum size, fine sand; soft consistency; wet; brown; minor silty sand (SM) interbeds (<0.1-ft. thick) with about 75% fine sand and about 25% non-plastic fines; no reaction with HCl.

18.6 to 21.9 ft.: **POORLY GRADED SAND WITH SILT, SP-SM:** About 90% predominantly fine to medium with coarse, hard, subangular to subrounded sand; about 10% non-plastic fines; trace fine, hard, subangular to subrounded gravel; maximum size, 1/2 inch; wet; dark brown to olive brown; some interbeds of silty sand (SM) up to 0.4-ft. thick, about 85% predominantly fine with medium sand and about 15% non-plastic fines; no reaction with HCl.

21.9 to 25.0 ft.: **LEAN CLAY WITH SAND, (CL)s:** About 85% fines with medium plasticity, high dry strength, medium toughness, no dilatancy; about 15% fine sand; maximum size, fine sand; firm to hard consistency;

DRAFT

Geologic Units

Roadbase
▨ Fill
Qb Quaternary: Basin Deposits

Symbols

▽ First Encountered Water Depth ▼ Potentiometric (static) Water Level Depth

Abbreviations

FAPB:	Flight Auger Pilot Bit
FADC:	Flight Auger Dry Core
SPT:	Standard Penetration Test
HCl:	Hydrochloric acid
NR:	No Recovery

*Blow counts are uncorrected ("N"-Values)

RECLAMATION
Managing Water in the West

GEOLOGIC LOG OF DRILL HOLE NO. DH-19-TRRPGP-A

PROJECT: Sites - NODOS
FEATURE: Pipeline
STATE: California
LOCATION: Approx. 0.65 mile northwest of McDermott Rd. on GCID's canal embankment
START DATE, END DATE: 10/17/2019, 10/23/2019

COORDINATES: N 2,248,042.59 E 6,494,158.64
DATUM: CA State Plane, Zone 2, NAD83
GROUND ELEVATION: 128.2 ft. NAVD88
FIRST ENCOUNTERED WATER DEPTH, DATE: 12.0 ft. (el. 116.2 ft.), 10/18/2019
POTENTIOMETRIC (STATIC) WATER DEPTH, DATE: NA

DEPTH TO BEDROCK: Not Encountered
TOTAL DEPTH: 100.9 ft. (el. 27.3 ft.)
ANGLE FROM HORIZONTAL: 90° (vertical)
LOGGED BY: S. Dalton
REVIEWED BY:

Depth (feet): 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49

Elevation (feet): 103, 102, 101, 100, 99, 98, 97, 96, 95, 94, 93, 92, 91, 90, 89, 88, 87, 86, 85, 84, 83, 82, 81, 80, 79

Laboratory Data								Visual Classification	FADC % Recovery	SPT Data			Geologic Unit
% By Weight													
% Fines	% Sand	% Gravel	% Cobble (3- to 5-inch)	Liquid Limit	Plasticity Index	Moisture Content %	Lab Classification			SPT Blows / 0.5 ft.*	SPT Blows / ft.*	SPT % Recovery	
									100	10 10 14	24 24	100	
									100	5 11 13	24	100	
									100	5 15 17	32	87	
86.8	13.2	0.0	0.0	39	21	21.6	CL	(CL)s	100	6 12 16	28	100	
									100	6 14 16	30	100	
									100	6 14 16	30	100	Qb
71.9	15.0	13.1	0.0	42	24	22.1	(CL)s	g(CL)s	100	4 13 15	28	100	
								(CL)s	100	5 12 16	28	100	
									100	8 16 16	32	100	
									100	8 15 18	33	100	
								s(CL) / SC					
								(CL)s	100	10		100	

Visual Classification and Physical Condition

moist; brown with localized minor green-gray; trace off-white fine to coarse sand and fine gravel size fragments throughout (strong reaction with HCl); trace black MnO2 specks throughout (medium sand size); no reaction with HCl.

25.0 to 25.6 ft.: LEAN CLAY WITH SAND, (CL)s:
About 75% fines with medium plasticity, high dry strength, medium toughness, no dilatancy; about 25% fine sand; maximum size, fine sand; firm consistency; moist; brown with localized minor green-gray; no reaction with HCl.

25.6 to 38.8 ft.: LEAN CLAY WITH SAND, (CL)s:
About 85% fines with medium plasticity, high dry strength, medium toughness, no dilatancy; about 15% fine sand; maximum size, fine sand; firm to hard consistency; moist; brown with localized minor green-gray; fairly consistent gradation, slight (5%) variation in sand percentage; no reaction with HCl.

29.4 to 30.0 ft.: slight decrease in plasticity (approaching ML, but still rolls a thread), soft consistency.

29.4 to 38.8 ft.: brown to red-brown with minor green-gray

38.8 to 41.0 ft.: GRAVELLY LEAN CLAY WITH SAND, g(CL)s:
About 60% fines with medium plasticity, high dry strength, medium toughness, no dilatancy; about 30% CaCO3 cemented nodules/fragments consisting of fine to coarse sand and fine to coarse gravel, hard, angular to subangular (surfaces coated with black MnO2, strong reaction with HCl); about 10% fine sand; moist; light brown; presence of CaCO3 fragments caused soil to break apart (crumbly); no reaction with HCl in body of soil.

41.0 to 42.1 ft.: LEAN CLAY WITH SAND, (CL)s:
About 80% fines with low to medium plasticity, high dry strength, low to medium toughness, no to slow dilatancy; about 20% fine sand; maximum size, fine sand; firm consistency; moist; brown to red-brown with minor green-gray; black MnO2 specks throughout (medium sand size); trace off-white, fine to coarse sand size fragments (strong reaction with HCl); no reaction with HCl.

42.1 to 43.5 ft.: LEAN CLAY WITH SAND, (CL)s:
About 85% fines with medium plasticity, high dry strength, medium toughness, no dilatancy; about 15% fine sand; maximum size, fine sand; firm to hard consistency; moist; brown with localized minor green-gray; fairly consistent gradation, slight (5%) variation in sand percentage; no reaction with HCl.

43.5 to 48.6 ft.: LEAN CLAY WITH SAND, (CL)s:
About 75 to 85% fines with low to medium plasticity, high dry strength, low to medium toughness, no to slow dilatancy; about 15 to 25% fine sand; maximum size, fine sand; firm consistency; moist; brown to red-brown with minor green-gray; no reaction with HCl.

48.6 to 49.4 ft.: SANDY LEAN CLAY TO CLAYEY SAND, s(CL) / SC:
About 50% predominantly fine to medium with trace coarse, hard, subangular to subrounded sand; about 50% fines with low to medium plasticity, medium dry strength, low toughness, slow dilatancy; maximum size, coarse sand; moist to wet; brown; weakly consolidated (breaks apart with light manual pressure); no reaction with HCl.

49.4 to 52.0 ft.: LEAN CLAY WITH SAND, (CL)s:
About 75% fines with medium plasticity, high dry strength, medium toughness, no dilatancy; about 25% fine sand; maximum size, fine sand; firm consistency; moist; brown; no reaction with HCl.

52.0 to 52.5 ft.: SANDY LEAN CLAY TO CLAYEY SAND, s(CL) / SC:
About 50% predominantly fine to medium with coarse, hard, subangular to subrounded sand; about 50% fines with low to medium plasticity, medium dry strength, low toughness, slow dilatancy; maximum size, coarse sand; moist to wet; brown; weakly consolidated (breaks apart with light manual pressure); no reaction with HCl.

52.5 to 57.6 ft.: LEAN CLAY WITH SAND, (CL)s:
About 75% fines with medium plasticity, high dry strength, medium toughness, no dilatancy; about 25% fine sand; maximum size, fine sand; firm consistency; moist; brown; no reaction with HCl.

57.6 to 61.2 ft.: LEAN CLAY WITH SAND TO SANDY LEAN CLAY, (CL)s / s(CL):
About 70 to 80% fines with medium plasticity, high dry strength, medium toughness, no dilatancy; about 20 to 30% fine sand; maximum size, fine sand; firm consistency; moist; brown; no reaction with HCl.

61.2 to 63.1 ft.: SILTY SAND, SM:

Geologic Units

Roadbase
▨ Fill
Qb Quaternary: Basin Deposits

Symbols

▽ First Encountered Water Depth ▼ Potentiometric (static) Water Level Depth

Abbreviations

FAPB:	Flight Auger Pilot Bit
FADC:	Flight Auger Dry Core
SPT:	Standard Penetration Test
HCl:	Hydrochloric acid
NR:	No Recovery

*Blow counts are uncorrected ("N"-Values)

RECLAMATION
Managing Water in the West

DRAFT

GEOLOGIC LOG OF DRILL HOLE NO. DH-19-TRRPGP-A

PROJECT: Sites - NODOS
FEATURE: Pipeline
STATE: California
LOCATION: Approx. 0.65 mile northwest of McDermott Rd. on GCID's canal embankment
START DATE, END DATE: 10/17/2019, 10/23/2019

COORDINATES: N 2,248,042.59 E 6,494,158.64
DATUM: CA State Plane, Zone 2, NAD83
GROUND ELEVATION: 128.2 ft. NAVD88
FIRST ENCOUNTERED WATER DEPTH, DATE: 12.0 ft. (el. 116.2 ft.), 10/18/2019
POTENTIOMETRIC (STATIC) WATER DEPTH, DATE: NA

DEPTH TO BEDROCK: Not Encountered
TOTAL DEPTH: 100.9 ft. (el. 27.3 ft.)
ANGLE FROM HORIZONTAL: 90° (vertical)
LOGGED BY: S. Dalton
REVIEWED BY:

		Laboratory Data										SPT Data			
		% By Weight													
Depth (feet)	Elevation (feet)	% Fines	% Sand	% Gravel	% Cobble (3- to 5-inch)	Liquid Limit	Plasticity Index	Moisture Content %	Lab Classification	Visual Classification	FADC % Recovery	SPT Blows / 0.5 ft.*	SPT Blows / ft.*	SPT % Recovery	Geologic Unit
	78											22	45		
												22	45	100	
												23			
51	77									(CL)s	100				
52	76									s(CL) / SC		9			
												13		100	
53	75	92.4	7.0	0.6	0.0	41	22	23.0	CL		100	14	27		
54	74														
												9			
55	73									(CL)s		16	34	100	
											100	18			
56	72														
57	71											4			
												12	27	100	
58	70										100	15			
59	69														
										(CL)s / s(CL)		4			
60	68											7	17	100	
											100	10			
61	67														
62	66											5			
		50.1	49.9	0.0	0.0	24	8	15.2	s(CL)	SM		14	32	100	Qb
63	65										84	18			
64	64	34.3	65.4	0.3	0.0	31	17	15.1	SC						
												7			
65	63											18	39	100	
											100	21			
66	62														
										CL / (CL)s					
67	61											5			
												12	26	100	
68	60										100	14			
69	59														
										s(CL)		6			
70	58									SC		13	34	100	
											100	21			
71	57														
		80.2	19.8	0.0	0.0	42	32	14.2	(CL)s						
72	56									CL / (CL)s		11			
												25	57	100	
73	55										100	32			
74	54														
										s(CL)	100	9		100	

Visual Classification and Physical Condition

About 60% fine sand; about 40% fines with no to low plasticity, rapid dilatancy; maximum size, fine sand; moist; brown; black MnO2 throughout; trace off-white, fine to coarse sand size, CaCO3 fragments (strong reaction with HCl); no reaction with HCl in body of soil.

63.1 to 64.4 ft.: SILTY SAND, SM:
About 85% predominantly fine with trace medium sand; about 15% non-plastic fines; maximum size, medium sand; moist to wet; brown; no reaction with HCl.

64.4 to 69.2 ft.: LEAN CLAY TO LEAN CLAY WITH SAND, CL / (CL)s:
About 75 to 90% fines with medium plasticity, high dry strength, medium toughness, no dilatancy; about 10 to 25% fine sand; maximum size, fine sand; hard consistency; moist; brown with minor green-gray; trace off-white, fine to coarse sand size fragments with strong reaction with HCl; minor black MnO2 specks throughout; no reaction with HCl in body of soil.

69.2 to 70.0 ft.: SANDY LEAN CLAY, s(CL):
About 65 to 70% fines with medium plasticity, high dry strength, medium toughness, no dilatancy; about 30 to 35% fine sand; maximum size, fine sand; hard consistency; moist; brown with minor green-gray; no reaction with HCl.

70.0 to 70.5 ft.: CLAYEY SAND, SC:
About 70% fine sand; about 30% fines with low to medium plasticity, medium dry strength, low toughness, slow to rapid dilatancy; maximum size, fine sand; moist to wet; brown; minor black MnO2 specks; no reaction with HCl.

70.5 to 74.1 ft.: LEAN CLAY TO LEAN CLAY WITH SAND, CL / (CL)s:
About 85 to 90% fines with medium plasticity, high dry strength, medium toughness, no dilatancy; about 10 to 15% fine sand; maximum size, fine sand; hard consistency; moist; brown with minor green-gray; trace off-white, fine to coarse sand size fragments with strong reaction with HCl; minor black MnO2 specks throughout; no reaction with HCl in body of soil.

74.1 to 74.4 ft.: SANDY LEAN CLAY, s(CL):
About 65 to 70% fines with medium plasticity, high dry strength, medium toughness, no dilatancy; about 30 to 35% fine sand; maximum size, fine sand; firm to hard consistency; moist to wet; brown with minor green-gray; no reaction with HCl.

74.4 to 75.2 ft.: SANDY LEAN CLAY, s(CL):
About 85% fines with medium plasticity, high dry strength, medium toughness, no dilatancy; about 15% fine sand; maximum size, fine sand; firm to hard consistency; moist to wet; brown with minor green-gray; no reaction with HCl.

75.2 to 76.5 ft.: SANDY LEAN CLAY, s(CL):
About 65 to 70% fines with medium plasticity, high dry strength, medium toughness, no dilatancy; about 30 to 35% fine sand; maximum size, fine sand; firm to hard consistency; moist to wet; brown with minor green-gray; no reaction with HCl.

76.5 to 76.9 ft.: SANDY LEAN CLAY, s(CL):
About 50% fine sand; about 50% fines with low plasticity, medium to high dry strength, no to low toughness, slow dilatancy; maximum size, fine sand; firm consistency; moist; brown with minor red-brown and dark brown (spotty); no reaction with HCl.

76.9 to 77.2 ft.: SILTY SAND, SM:
About 85% fine sand; about 15% non-plastic fines; maximum size, fine sand; wet; brown to red-brown; no reaction with HCl.

77.2 to 77.9 ft.: CLAYEY SAND, SC:
About 65% predominantly fine with trace medium sand; about 35% fines with low plasticity, medium dry strength, low toughness, slow dilatancy; maximum size, medium sand; moist to wet; brown with minor red-brown and dark brown in patches; no reaction with HCl.

77.9 to 80.8 ft.: SANDY LEAN CLAY, s(CL):
About 65 to 70% fines with medium to high plasticity, high to very high dry strength, medium to high toughness, no dilatancy; about 30 to 35% predominantly fine to medium with coarse, hard, subrounded sand; maximum size, coarse sand; hard consistency; moist; green-gray; trace off-white, fine to coarse sand size fragments (strong reaction with HCl); no reaction with HCl.

80.8 to 81.4 ft.: CLAYEY SAND, SC:
About 75% predominantly fine to medium with coarse, hard, subangular to subrounded sand; about 25% fines with low to medium plasticity, medium dry strength, low toughness, slow dilatancy; maximum size, coarse sand; moist to wet; olive-brown; minor spotty FeOx; no reaction with HCl.

Geologic Units

Roadbase
▨ Fill
Qb **Quaternary: Basin Deposits**

Symbols

∇ **First Encountered Water Depth** ▼ **Potentiometric (static) Water Level Depth**

Abbreviations

FAPB:	Flight Auger Pilot Bit
FADC:	Flight Auger Dry Core
SPT:	Standard Penetration Test
HCl:	Hydrochloric acid
NR:	No Recovery

*Blow counts are uncorrected ("N"-Values)

RECLAMATION
Managing Water in the West

DRAFT

GEOLOGIC LOG OF DRILL HOLE NO. DH-19-TRRPGP-A

PROJECT: Sites - NODOS
FEATURE: Pipeline
STATE: California
LOCATION: Approx. 0.65 mile northwest of McDermott Rd. on GCID's canal embankment
START DATE, END DATE: 10/17/2019, 10/23/2019

COORDINATES: N 2,248,042.59 E 6,494,158.64
DATUM: CA State Plane, Zone 2, NAD83
GROUND ELEVATION: 128.2 ft. NAVD88
FIRST ENCOUNTERED WATER DEPTH, DATE: 12.0 ft. (el. 116.2 ft.), 10/18/2019
POTENTIOMETRIC (STATIC) WATER DEPTH, DATE: NA

DEPTH TO BEDROCK: Not Encountered
TOTAL DEPTH: 100.9 ft. (el. 27.3 ft.)
ANGLE FROM HORIZONTAL: 90° (vertical)
LOGGED BY: S. Dalton
REVIEWED BY:

		Laboratory Data										SPT Data			
		% By Weight													
Depth (feet)	Elevation (feet)	% Fines	% Sand	% Gravel	% Cobble (3- to 5-inch)	Liquid Limit	Plasticity Index	Moisture Content %	Lab Classification	Visual Classification	FADC % Recovery	SPT Blows / 0.5 ft.*	SPT Blows / ft.*	SPT % Recovery	Geologic Unit
	53									s(CL)	100	16 16 18	34 34	100	
76	52														
77	51									SM SC		6 15	31	100	
78	50										93	16			
79	49									s(CL)					
80	48											11 22	49	100	
81	47	70.3	20.7	9.0	0.0	59	29	32.5	(CH)s	SC	100	27			
82	46									(CL)s		10			
83	45									s(CL)	84	11 17	28	100	
84	44									s(ML)					
85	43									s(CL)		12 16	37	100	
86	42										100	21			
87	41									CL		7			Qb
88	40										96	14 20	34	100	
89	39														
90	38									(CL)s		9 15	33	100	
91	37										100	18			
92	36									s(CL)		11			
93	35										100	26 38	64	100	
94	34									(CL)s					
95	33									s(CL)	100	9 15	36	100	
96	32	80.1	19.3	0.6	0.0	41	20	27.0	(CL)s	(CL)s		21			
97	31									s(CL) (CL)s	100	14 23	67	100	
98	30									NR		44			
99	29									(CL)s		14		100	

Visual Classification and Physical Condition

81.4 to 83.0 ft.: LEAN CLAY WITH SAND, (CL)s:
About 85% fines with medium to high plasticity, high to very high dry strength, medium toughness, no dilatancy; about 15% predominantly fine with medium sand; maximum size, medium sand; hard to very hard consistency; moist; light green-gray; weakly cemented with CaCO3; strong reaction with HCl in off-white, fine to coarse sand and fine gravel (up to 3/8-inch) size fragments; displays claystone-like appearance and properties, breaks apart with light to moderate manual pressure, crumbly; clay is somewhat dispersive and air slakes/dessication cracks; weak reaction with HCl.

83.0 to 84.2 ft.: SANDY LEAN CLAY, s(CL):
About 65% fines with medium plasticity, medium to high dry strength, low toughness, no to slow dilatancy; about 35% fine sand; maximum size, fine sand; firm to hard consistency; moist; light green-gray; trace clay nodules (CaCO3 cemented, strong reaction with HCl); no reaction with HCl.

84.2 to 84.9 ft.: SANDY SILT, s(ML):
About 60% fines with no to low plasticity, slow dilatancy; about 40% fine sand; maximum size, fine sand; hard to very hard consistency; moist to wet; dark brown; weakly to moderately cemented with non-calcareous material, break apart with manual pressure and with some effort between fingernails; no reaction with HCl.

84.9 to 86.4 ft.: SANDY LEAN CLAY, s(CL):
About 65% fines with medium plasticity, medium to high dry strength, low toughness, no to slow dilatancy; about 35% fine sand; maximum size, fine sand; firm to hard consistency; moist; light green-gray; about 5% clay nodules (CaCO3 cemented, strong reaction with HCl), fine to coarse sand and fine to coarse gravel size; no reaction with HCl.

86.4 to 88.5 ft.: LEAN CLAY, CL:
About 90 to 95% fines with high plasticity, very high dry strength, medium to high toughness, no dilatancy; about 5 to 10% fine sand; maximum size, fine sand; very hard consistency; moist; light green-gray; trace FeOx thread-like rootlets; no reaction with HCl.

88.5 to 91.4 ft.: LEAN CLAY WITH SAND, (CL)s:
About 85% fines with medium plasticity, high dry strength, medium toughness, no dilatancy; about 15% fine sand; maximum size, fine sand; firm to hard consistency; moist; light green-gray; trace off-white fragments (strong reaction with HCl); band of FeOx (about 3/8-inch thick) at the upper contact ; no reaction with HCl in body of soil.

91.4 to 93.5 ft.: SANDY LEAN CLAY, s(CL):
About 70% fines with medium plasticity, high dry strength, medium toughness, no dilatancy; about 30% fine sand; maximum size, fine sand; firm to hard consistency; moist; light green-gray; no reaction with HCl.

93.5 to 94.9 ft.: LEAN CLAY WITH SAND, (CL)s:
About 85% fines with medium plasticity, high dry strength, medium toughness, no dilatancy; about 15% fine sand; maximum size, fine sand; firm to hard consistency; moist; light green-gray; no reaction with HCl.

94.9 to 95.8 ft.: SANDY LEAN CLAY, s(CL):
About 70% fines with medium plasticity, high dry strength, medium toughness, no dilatancy; about 30% fine sand; maximum size, fine sand; firm to hard consistency; moist; light green-gray; no reaction with HCl.

95.8 to 96.9 ft.: LEAN CLAY WITH SAND, (CL)s:
About 75 to 85% fines with medium plasticity, high dry strength, medium toughness, no dilatancy; about 15 to 25% fine sand; maximum size, fine sand; firm to hard consistency; moist; light green-gray; no reaction with HCl.

96.6 to 96.9 ft.: contains weakly to moderately cemented s(CL) and SM, appears like claystone/siltstone/sandstone

96.9 to 97.5 ft.: SANDY LEAN CLAY, s(CL):
About 70% fines with medium plasticity, high dry strength, medium toughness, no dilatancy; about 30% fine sand; maximum size, fine sand; firm to hard consistency; moist; light green-gray; contains weakly to moderately cemented s(CL) and SM; no reaction with HCl.

97.5 to 98.2 ft.: LEAN CLAY WITH SAND, (CL)s:
About 75 to 85% fines with medium plasticity, high dry strength, medium toughness, no dilatancy; about 15 to 25% fine sand; maximum size, fine sand; firm to hard consistency; moist; light green-gray; contains weakly to moderately cemented s(CL) and SM at 98.2 ft.; no reaction with HCl.

98.2 to 99.4 ft. NO RECOVERY

Geologic Units

▨ Roadbase
▨ Fill
Qb Quaternary: Basin Deposits

Symbols

▽ First Encountered Water Depth ▼ Potentiometric (static) Water Level Depth

Abbreviations

FAPB:	Flight Auger Pilot Bit
FADC:	Flight Auger Dry Core
SPT:	Standard Penetration Test
HCl:	Hydrochloric acid
NR:	No Recovery

*Blow counts are uncorrected ("N"-Values)

RECLAMATION
Managing Water in the West

DRAFT

GEOLOGIC LOG OF DRILL HOLE NO. DH-19-TRRPGP-A

SHEET 5 OF 7

PROJECT: Sites - NODOS
FEATURE: Pipeline
STATE: California
LOCATION: Approx. 0.65 mile northwest of McDermott Rd. on GCID's canal embankment
START DATE, END DATE: 10/17/2019, 10/23/2019

COORDINATES: N 2,248,042.59 E 6,494,158.64
DATUM: CA State Plane, Zone 2, NAD83
GROUND ELEVATION: 128.2 ft. NAVD88
FIRST ENCOUNTERED WATER DEPTH, DATE: 12.0 ft. (el. 116.2 ft.), 10/18/2019
POTENTIOMETRIC (STATIC) WATER DEPTH, DATE: NA

DEPTH TO BEDROCK: Not Encountered
TOTAL DEPTH: 100.9 ft. (el. 27.3 ft.)
ANGLE FROM HORIZONTAL: 90° (vertical)
LOGGED BY: S. Dalton
REVIEWED BY:

Depth (feet)	Elevation (feet)	Laboratory Data: % By Weight: % Fines	% Sand	% Gravel	% Cobble (3- to 5-inch)	Liquid Limit	Plasticity Index	Moisture Content %	Lab Classification	Visual Classification	FADC % Recovery	SPT Data: SPT Blows / 0.5 ft.*	SPT Blows / ft.*	SPT % Recovery	Geologic Unit	Visual Classification and Physical Condition
	28									(CL)s		21 21 29	50 50	100	Qb	**99.4 to 100.9 ft.:** **LEAN CLAY WITH SAND, (CL)s:** About 75 to 85% fines with medium plasticity, high dry strength, medium toughness, no dilatancy; about 15 to 25% fine sand; maximum size, fine sand; firm to hard consistency; moist; light green-gray; no reaction with HCl.

BOTTOM OF HOLE: T.D. 100.9 ft. (el. 27.3)

DRAFT

Geologic Units

- Roadbase
- ▨ Fill
- Qb **Quaternary: Basin Deposits**

Symbols

▽ **First Encountered Water Depth** ▼ **Potentiometric (static) Water Level Depth**

Abbreviations

FAPB:	Flight Auger Pilot Bit
FADC:	Flight Auger Dry Core
SPT:	Standard Penetration Test
HCl:	Hydrochloric acid
NR:	No Recovery

*Blow counts are uncorrected ("N"-Values)

RECLAMATION
Managing Water in the West

GEOLOGIC LOG OF DRILL HOLE NO. DH-19-TRRPGP-A

SHEET 6 OF 7

PROJECT: Sites - NODOS
FEATURE: Pipeline
STATE: California
LOCATION: Approx. 0.65 mile northwest of McDermott Rd. on GCID's canal embankment
START DATE, END DATE: 10/17/2019, 10/23/2019

COORDINATES: N 2,248,042.59 E 6,494,158.64
DATUM: CA State Plane, Zone 2, NAD83
GROUND ELEVATION: 128.2 ft. NAVD88
FIRST ENCOUNTERED WATER DEPTH, DATE: 12.0 ft. (el. 116.2 ft.), 10/18/2019
POTENTIOMETRIC (STATIC) WATER DEPTH, DATE: NA

DEPTH TO BEDROCK: Not Encountered
TOTAL DEPTH: 100.9 ft. (el. 27.3 ft.)
ANGLE FROM HORIZONTAL: 90° (vertical)
LOGGED BY: S. Dalton
REVIEWED BY:

NOTES

PURPOSE OF HOLE:
To perform Standard Penetration Test (SPT), visually classify, and collect/test samples in order to determine geotechnical properties of soil and depth to groundwater bearing soils (foundation conditions) for a proposed pumping plant associated with proposed Terminal Regulating Reservoir (TRR). Data will be used to prepare feasibility level design of excavation slopes, a dewatering system, and structural support.

LOCATION:
About 0.7 mile northwest where McDermott Road crosses Funks Creek. Drill hole is located on the north (left side) embankment of GCID's unlined canal, about 12 feet north-northeast (perpendicular) from the top edge of the canal's water-side slope.

Approximately 5 feet northwest of companion undisturbed/intact sample hole, DH-19-TRRPGP-B.

DRILLED BY:
Bureau of Reclamation: Pacific Northwest (PN) Region drill crew:
Rick Knott, driller
Austin Anderson, helper

DRILL RIG:
Central Mining Equipment (CME) 850 track mounted rig

DRILLING AND SAMPLING METHODS :
Drill hole was advanced using flight auger pilot bit (FAPB) and flight auger dry core (FADC) systems.

FAPB was to advance the lead auger between depths of 0.0 to 1.9 feet, which then allowed for FADC advancement. FADC refusal was encountered at a depth of 98.2 feet, so FAPB was advanced from 98.2 to 99.4 feet. FAPB consisted of 4-1/4 inch i.d. by 8 inch o.d. hollow flight augers equipped with an 8.5-inch o.d. lead drill bit containing six carbide bullet bit teeth around the rim, and a 4-1/4 inch o.d. pilot bit with six carbide bullet teeth attached to NWJ rods and set inside the lead drill bit using. FAPB is a closed system and does not allow for collection of core.

FADC was used to advance the drill hole and collect soil core from 1.9 to 98.2 feet. FADC utilizes the same augers as FAPB. Instead of using a pilot bit, FADC uses a 3-3/8 inch i.d. by 4 inch o.d. by 5-foot-long split barrel dry coring system. NWJ rods were attached to a free spinning bearing assembly, which is attached to the FADC barrel. The bearing assembly allows for the FADC barrel to remain stationary while the augers rotate and advance the hole. The barrel's cutting shoe was 0.1 foot beyond the lead drill bit between 1.9 and 96.9 feet. The cutting shoe was retracted even with the lead drill bit between 96.9 and 98.2 feet, where FADC refusal was encountered in hard consistency clay that lifted the rig off its supports. A metal "basket" was used in the cutting shoe to assist with retention of core.

SPT was performed at 2.5 foot intervals (1-foot spacing between SPT intervals), unless otherwise noted. SPT consisted of a 1-3/8 inch i.d. by 2 inch o.d. by 2.0 foot long split spoon sampler driven 1.5 feet. Sampler was attached to NWJ rods that weigh about 57.5 lbs/10 ft. The sampler was advanced with an auto-hammer (140 pound weight with a 30 inch drop) at a rate of about 54 blows per minute (drill rig engine at about 1550 rpm). The auto-hammer energy was measured in companion hole DH-19-TRRPGP-B on November 1, 2019, resulting in a 87.4% energy correction. Blow count data presented in this log is uncorrected "N"-values.

DRILLING CONDITIONS:
0.0 to 16.9 ft.: Smooth and easy auger advancement.

16.9 to 18.4 ft.: SPT. Wet SM and SP-SM in sampler. Appears to have potential to be flowing sand (potential for heaving).

16.9 to 19.4 ft.: FADC. Filled augers with water prior to pulling sampler. Heaving did not occur.

19.4 to 20.9 ft.: SPT. Filled augers with water prior to pulling sampler. Wet, flowing sand heaved 2 ft. into augers after pulling sampler.

19.4 to 21.9 ft.: FADC. Lifted augers a few feet to flush sand out bottom of augers and to allow FADC sampler to seat in lead auger. Advanced auger/sampler. Filled augers with water prior to pulling sampler. Heaving did not occur (measured hole depth to confirm). Upper 0.5 ft. in sampler is SP-SM and appears to be flowing/heaved sand.

21.9 to 24.4 ft.: FADC. Firm to hard clay, which sealed off heaving sand with augers socketed into it.

21.9 to 100.9 ft.: Minor drill cuttings generated, which slowed auger advancement. Smooth, but slow drilling.

29.4 to 36.9 ft.: FADC. Abundant water displaced to surface. Driller rate significantly reduced so drillers could shovel water into Bobcat bucket (permit disallows water discharge to surface and adjacent canal).

61.9 to 64.4 ft.: FADC. No material in sampler cutting shoe (fell downhole). Auger refusal (drill rig lifted off ground). Due to minimal drill cuttings, auger flights are believed to be plugged with compacted soil. Pulled back augers 5 ft., backspun augers to remove material from auger flights (downhole), and drilled out material with FAPB. Minimal success in generating drill cuttings.

64.4 to 74.4 ft. and 79.9 to 98.2 ft.: FADC. 0.2 to 1 ft. of slough (wet, loose sand) in top and on outside of FADC sample tube. Sand originating from 16.9 to 21.9 ft. Slight wobble of augers created a small annular space between the borehole sidewall and augers, allowing sand to move down the outside of the augers and then in through bottom of augers.

74.4 to 76.9 ft.: FADC. No material in sampler cutting shoe (fell downhole).

76.9 to 79.9 ft.: FADC. No material in sampler cutting shoe (fell downhole).

79.9 to 82.4 ft.: FADC. Auger refusal (drill rig lifted off ground and shifted over). Refusal encountered on a thin layer of very hard compacted clay (claystone-like appearance). Driller was able to slowly advance through clay layer.

82.4 to 84.9 ft.: FADC. No material in sampler cutting shoe (fell downhole).
87.4 to 89.9 ft.: FADC. No material in sampler cutting shoe (fell downhole).

89.9 to 92.4 ft.: FADC. No material in sampler cutting shoe (fell downhole).

94.9 to 96.9 ft.: FADC. Auger refusal. Driller was able to slowly advance augers.

96.9 to 98.2 ft.: FADC. Driller was able to slowly advance augers after retracting FADC sampler cutting shoe even with lead auger drill bit. Auger refusal at 98.2 ft.

98.2 to 99.4 ft.: FAPB. Pilot bit required to advance hole to final SPT interval (99.4 to 100.9 ft.)

DRAFT

Geologic Units

Roadbase
▨ Fill
Qb **Quaternary: Basin Deposits**

Symbols

▽ **First Encountered Water Depth** ▼ **Potentiometric (static) Water Level Depth**

Abbreviations

FAPB:	Flight Auger Pilot Bit
FADC:	Flight Auger Dry Core
SPT:	Standard Penetration Test
HCl:	Hydrochloric acid
NR:	No Recovery

*Blow counts are uncorrected ("N"-Values)

RECLAMATION
Managing Water in the West

GEOLOGIC LOG OF DRILL HOLE NO. DH-19-TRRPGP-A

SHEET 7 OF 7

PROJECT: Sites - NODOS
FEATURE: Pipeline
STATE: California
LOCATION: Approx. 0.65 mile northwest of McDermott Rd. on GCID's canal embankment
START DATE, END DATE: 10/17/2019, 10/23/2019

COORDINATES: N 2,248,042.59 E 6,494,158.64
DATUM: CA State Plane, Zone 2, NAD83
GROUND ELEVATION: 128.2 ft. NAVD88
FIRST ENCOUNTERED WATER DEPTH, DATE: 12.0 ft. (el. 116.2 ft.), 10/18/2019
POTENTIOMETRIC (STATIC) WATER DEPTH, DATE: NA

DEPTH TO BEDROCK: Not Encountered
TOTAL DEPTH: 100.9 ft. (el. 27.3 ft.)
ANGLE FROM HORIZONTAL: 90° (vertical)
LOGGED BY: S. Dalton
REVIEWED BY:

NOTES

DRILLING FLUID, RETURN AND COLOR:
Drilling fluid was not used to advance the hole.

REASON FOR HOLE TERMINATION:
Drill hole terminated at target depth.

HOLE COMPLETION:
The hole was backfilled with bentonite from total depth to 1 ft. bgs, and with gravel road base from 1 to ground surface.

GROUNDWATER LEVELS:
The following water levels were measured at the start of each day, prior to drilling:

10/18/2019: Groundwater initially encountered at 12.0 feet in SPT interval 11.9 to 13.4 ft.
10/19/2019: 15.6 feet with lead auger at 29.4 feet.
10/20/2019: 20.4 feet with lead auger at 59.4 feet.
10/21/2019: 30.2 feet with lead auger at 79.9 feet.
10/22/2019: 23.4 feet with lead auger at 94.9 feet.

NEARBY SURFACE WATER LEVELS:
10/18-22/2019: About 2.5 feet below ground surface elevation at the drill hole in GCID's canal located approximately 14 feet to the south-southwest. Surface water is also present in a ditch located about 45 feet north. Water in the ditch is about 9.5 feet below ground surface elevation at the drill hole.

GENERAL NOTE:
Lab and visual classifications are described according to the Unified Soil Classification System (USCS) as presented in Bureau of Reclamation (Reclamation) standards USBR 5000 and 5005. Reclamation's standards are consistent with the American Society for Testing Materials (ASTM) D2487 and D2488.

SURVEY NOTE:
Geologic explorations were surveyed February 19, 2020 by Surveys and Mapping Branch, Division of Design and Construction California-Great Basin Region. Horizontal datum is NAD 1983 (2007) State Plane Coordinates, CA State Plane Zone 2, US Survey Feet. Vertical datum is NAVD 1988 (Based on NGS Benchmark DL92228 "CANAL 1").

DRAFT

Geologic Units

Roadbase
▨ Fill
Qb **Quaternary: Basin Deposits**

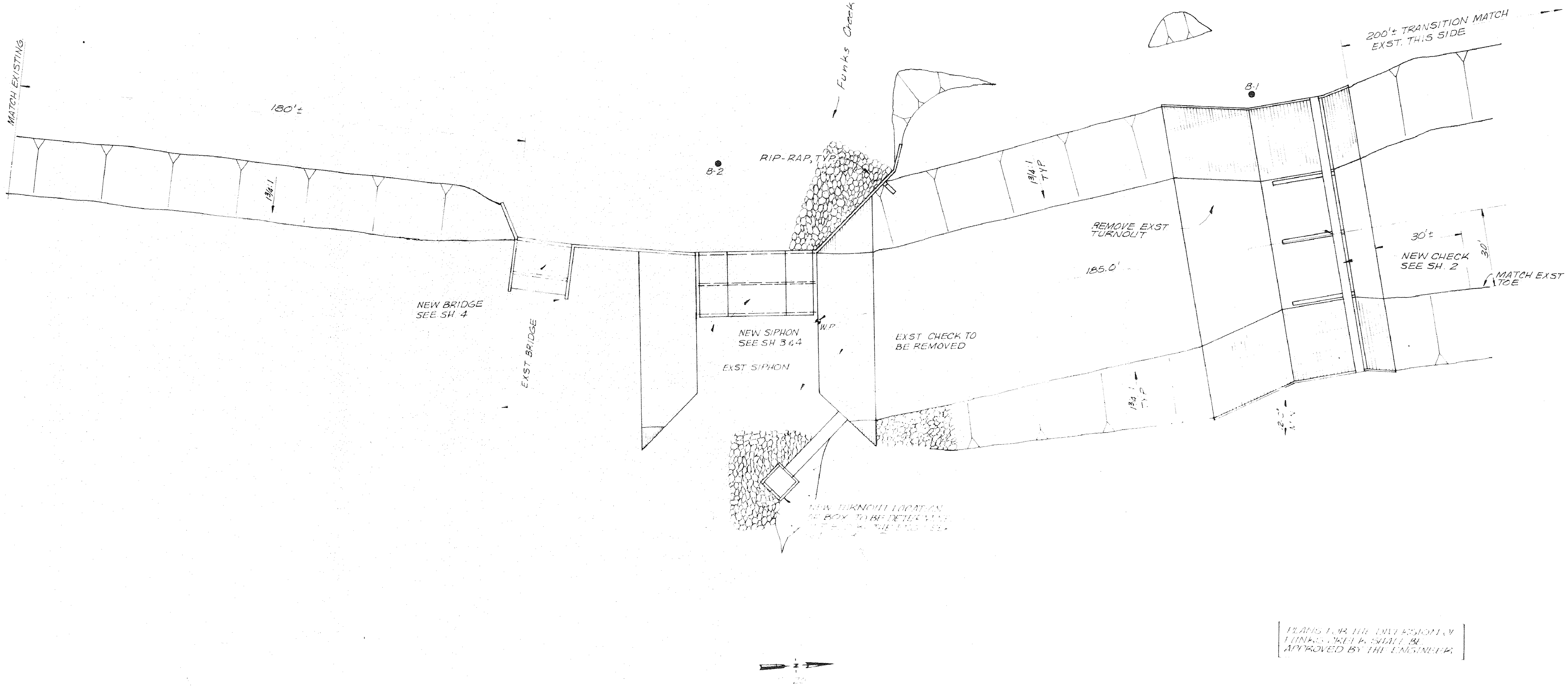
Symbols

▽ **First Encountered Water Depth** ▼ **Potentiometric (static) Water Level Depth**

Abbreviations

FAPB:	Flight Auger Pilot Bit
FADC:	Flight Auger Dry Core
SPT:	Standard Penetration Test
HCl:	Hydrochloric acid
NR:	No Recovery

*Blow counts are uncorrected ("N"-Values)



PLANS FOR THE DIVERSION OF
FUNKS CREEK SHALL BE
APPROVED BY THE ENGINEER.

JACK E. CALL
RSE 1542

CH2M HILL

DES. JEC
DR. ELM
CHK. GRK
APPD.

NO.	DATE	REVISION	BY	APPD.

GLENN - COLUSA
IRRIGATION DISTRICT
WILLOWS CALIFORNIA

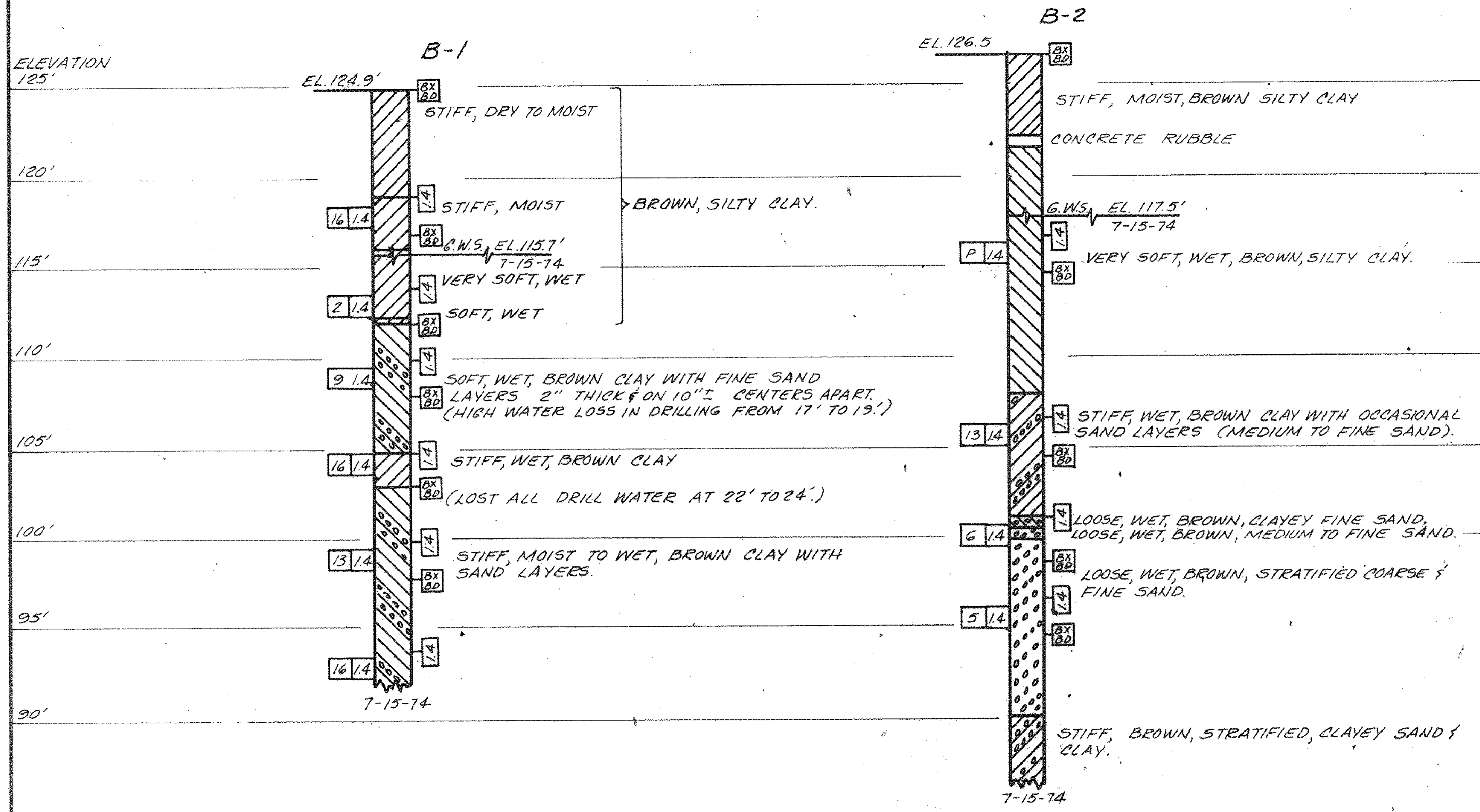
SIPHON AND CHECK

GENERAL PLAN

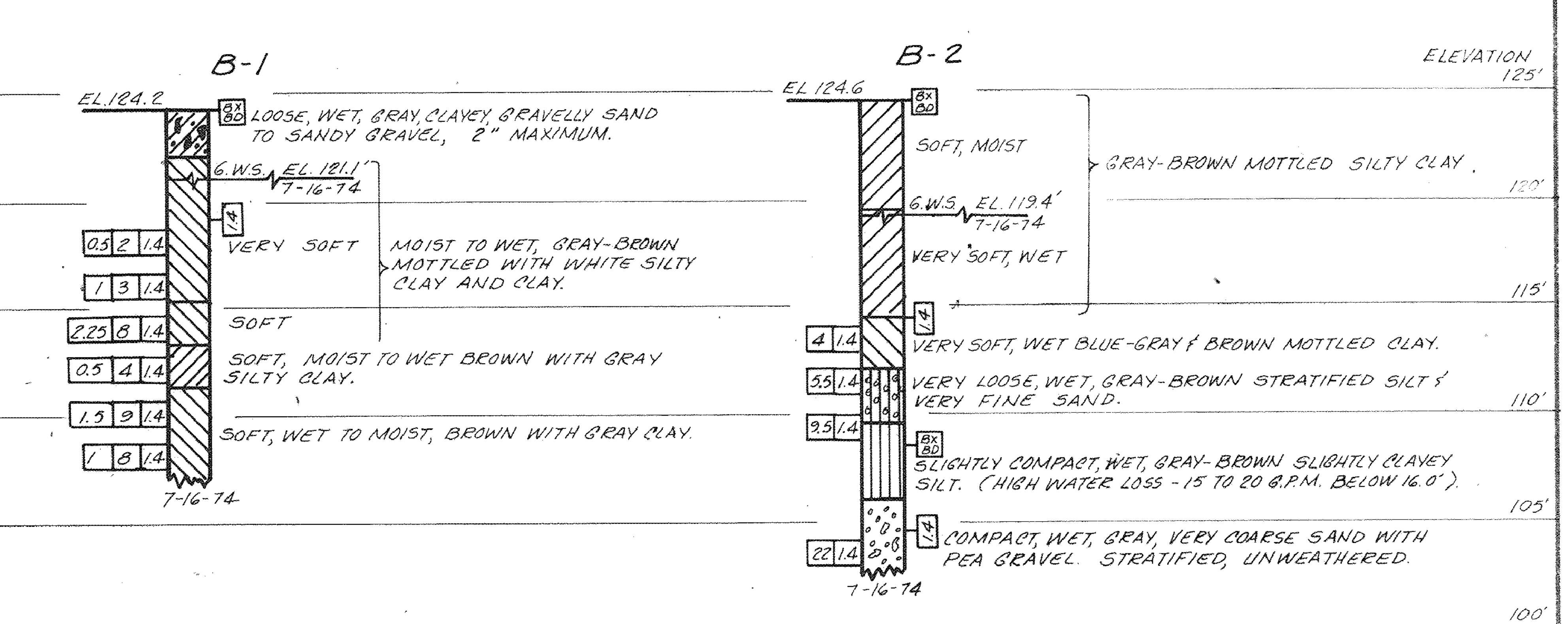
SHEET 1
OF 8
DATE
DWG. NO. R-3013.24

23-A

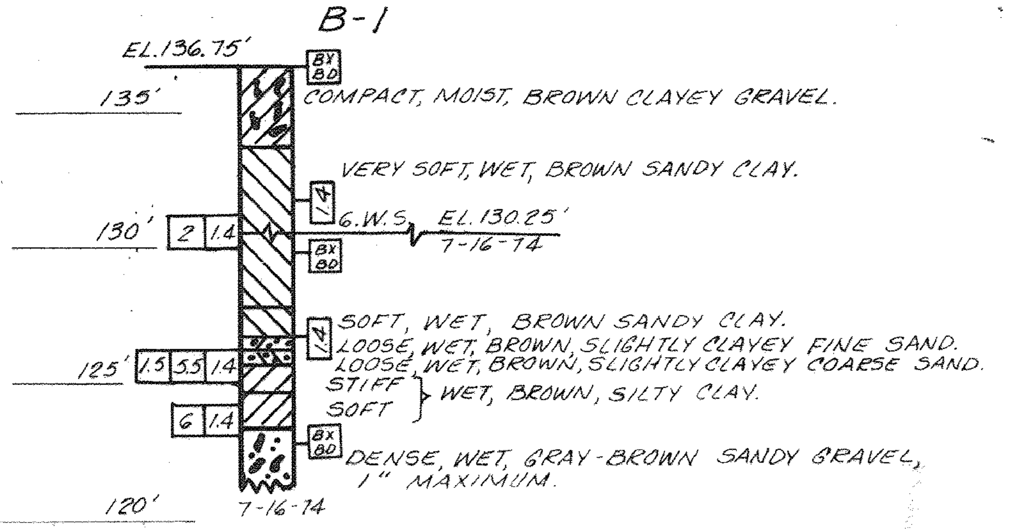
FUNKS SLOUGH SIPHON



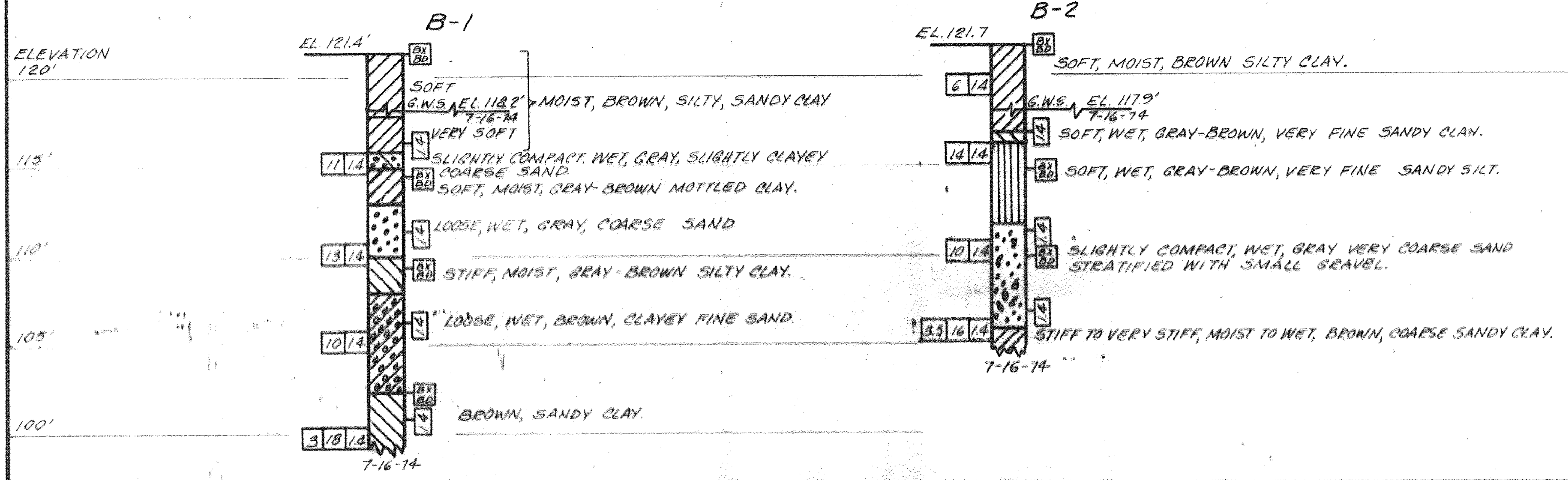
WILLOW CREEK SIPHON



WALKER CREEK CHECK



WALKER CREEK SIPHON

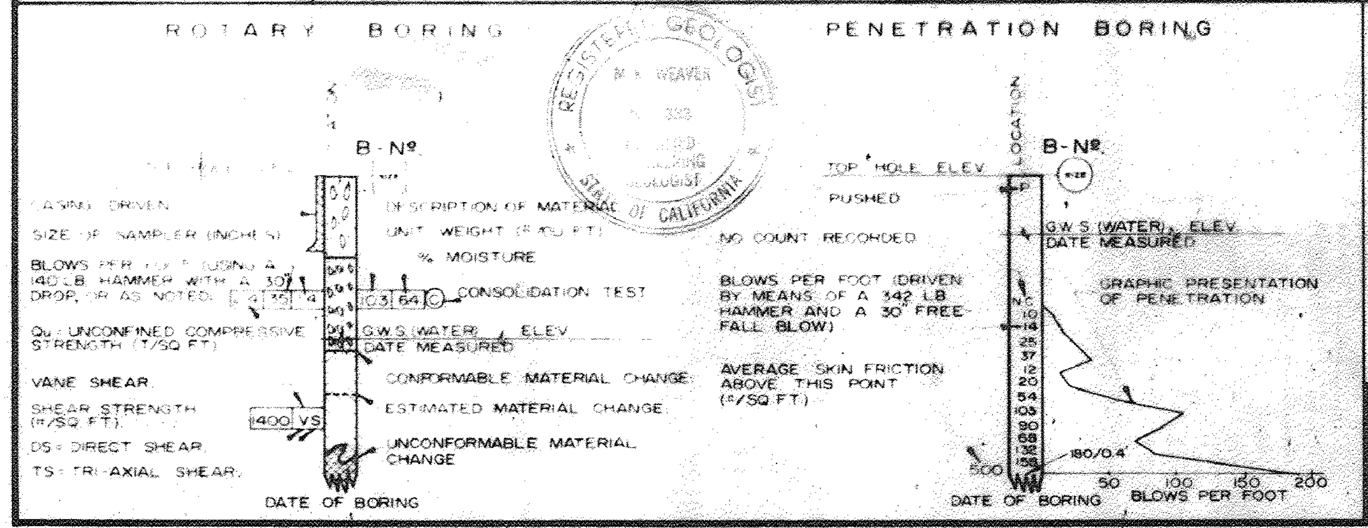


BORING PROFILES

Scale: 1"=5' vertical

Note: For plan of borings see Sheet 1 & 2

LEGEND OF DRILLING, SAMPLING & TESTING OPERATIONS



REGISTERED GEOLOGIST M. K. WEAVER 333 STATE OF CALIFORNIA

● PLAN OF ANY BORING

PENETROMETER (FLUSH-COUPLED)

● 2 ¼" CONE PENETROMETER

SAMPLER BORING (DRY)

ROTARY BORING (WET)

AUGER BORING (DRY)

JET BORING

DIAMOND CORE BORING

TEST PIT

BIT SIZES; (O.D.) "AX" = 1 13/16", "BX" = 2 9/32", "NX" = 2 29/32"

CASING SIZES, (O.D.) "BX" = 2 7/8", "NX" = 3 ½"

THE UNIFIED SOIL CLASSIFICATION SYSTEM

MAJ. DIV.		LETTER	SYMBOL	NAME
COARSE GRAINED MATERIAL	GRAVEL AND GRAVELLY SOIL	GW		WELL-GRADED GRAVEL OR GRAVEL-SAND MIXTURES, LITTLE OR NO FINES
		GP		POORLY-GRADED GRAVEL OR GRAVEL-SAND MIXTURES, LITTLE OR NO FINES
		GM		SILTY GRAVEL, GRAVEL-SAND SILT MIXTURES
		GC		CLAYEY GRAVEL, GRAVEL-SAND-CLAY MIXTURES
	SAND AND SANDY SOIL	SW		WELL-GRADED SAND OR GRAVELLY SAND, LITTLE OR NO FINES
		SP		POORLY-GRADED SAND OR GRAVELLY SAND, LITTLE OR NO FINES
		SM		SILTY SAND, SAND SILT MIXTURES
		SC		CLAYEY SAND, SAND-SILT MIXTURES
FINE GRAINED SOIL	SILTS AND CLAYS LL<50	ML		INORGANIC SILT AND VERY FINE SAND, ROCK FLOUR, SILTY OR CLAYEY FINE SAND OR CLAYEY SILT WITH SLIGHT PLASTICITY
		CL		INORGANIC CLAY OF LOW TO MEDIUM PLASTICITY, GRAVELLY CLAY, SANDY CLAY, SILTY CLAY, LEAN CLAY
		OL		ORGANIC SILT AND ORGANIC SILTY CLAY OF LOW PLASTICITY
	SILTS AND CLAYS LL>50	MH		INORGANIC SILT, MICACEOUS OR DIATOMACEOUS FINE SANDY OR SILTY SOILS, ELASTIC SILT
		CH		INORGANIC CLAY OF HIGH PLASTICITY, FAT CLAY
		OH		ORGANIC CLAY OF MEDIUM TO HIGH PLASTICITY, ORGANIC SILT
HIGHLY ORGANIC SOILS		PT		PEAT AND OTHER HIGHLY ORGANIC SOILS

ROCK CLASSIFICATION

SYMBOL	NAME
	[illegible]
	SEDIMENTARY ROCK
	METAMORPHIC ROCK

NOTE:
CLASSIFICATION OF EARTH MATERIAL SHOWN ON THIS SHEET IS BASED UPON FIELD INSPECTION UNLESS NOTED OTHERWISE

SOIL CONSISTENCY CLASSIFICATION

CONSISTENCY		* BLOWS PER FT.
GRANULAR	COHESIVE	
VERY LOOSE	VERY SOFT	[illegible] 5
LOOSE	SOFT	5 TO 10
SLIGHTLY COMPACT	STIFF	[illegible] TO 20
COMPACT	VERY STIFF	20 TO 35
DENSE	HARD	35 TO 70
VERY DENSE	VERY HARD	70

* (STANDARD PENETRATION TEST) BLOWS PER FT (140 LB HAMMER, 30" FREE-FALL BLOW USING A 2" O.D. x 1 3/8" I.D. SAMPLER)

DWN. BB
CHK
DATE

Mont D Weaver
ENGINEERING GEOLOGIST
333
REGISTRATION NUMBER

CH2M HILL
1525 COURT STREET
REDDING, CALIFORNIA

LOG OF TEST BORINGS

GLEN - COLUSA IRRIGATION DISTRICT

DWG. NO. 8

JOB NO. R-3013.26 H

State of California
The Resources Agency
DEPARTMENT OF WATER RESOURCES

DRILL HOLE LOG

SHEET 1 of 3
HOLE NO. NC-AUG-1
ELEV. 200* FEET
DEPTH 51.5 FEET

PROJECT SITES RESERVOIR PROJECT
FEATURE NEW CANAL ALIGNMENT
LOCATION CAL COORDS: N- 2247683; E- 6482710
CONTR. LAYNE-CHRISTENSEN DRILL RIG CME-850
DATE DRILLED 05/05/01
ATTITUDE VERTICAL
LOGGED BY D. FOREWALTER, G. GORDON
DEPTH TO WATER NOT DETERMINED

*As measured off of contour maps prepared by DWR (contour interval=10 feet).

DEPTH (ELEV.)	LOG	FIELD CLASSIFICATION AND DESCRIPTION	SAMPLE NO.	MODE	REMARKS
0.0 (200)		<u>PLIOCENE TEHAMA FORMATION</u> 0.0 to ~16.0'		AD	8" hollow stem auger used for drilling.
2.0 4.0		2.0 to 4.5' <u>Clay (CL)</u>; silty; light yellowish-brown (10YR 6/4); dry, high plasticity; medium toughness; very high dry strength.	1	PS	Shelby Tube 800 psi Shear Strength = N/A Unconfined Strength = >4.5 tons/ft^2
				AD	
6.0	CL	5.0 to 7.5' <u>Clay (CL)</u>; silty; olive brown (2.5Y 6/6); dry, high plasticity; very high dry strength.	2	PS	Shelby Tube 1000 psi Shear Strength = 4.25 kg/cm^2 Unconfined Strength = >4.5 tons/ft^2
8.0 (192)				AD	
10.0		10.0 to 11.5' <u>Clay (CL)</u>; silty; yellowish-brown (10YR 5/6); dry; very stiff to hard; low to medium plasticity; very high dry strength.	3	DR	California Modified Blow Count- 16,42,50 for 5" Shear Strength = 6.0 kg/cm^2 Unconfined Strength = >4.5 tons/ft^2
12.0 14.0				AD	
		15.0 to 16.5' <u>Clay (CL)</u>; silty; yellowish-brown (10YR5/6); dry, very stiff to hard; medium plasticity; very high dry strength; severely weathered bedrock; remaining bedrock, mudstone; light olive brown (2.5Y5/3).	4	DR	California Modified Blow Count- 18,50,50+ cont. next page.

State of California
The Resources Agency
DEPARTMENT OF WATER RESOURCES

DRILL HOLE LOG

SHEET 2 of 3
HOLE NO. NC-AUG-1

PROJECT & FEATURE SITES RESERVOIR PROJECT; New Canal Alignment

DEPTH (ELEV.)	LOG	FIELD CLASSIFICATION AND DESCRIPTION	SAMPLE NO.	MODE	REMARKS
15.0 (184)					Shear Strength = 5.25 kg/cm^2 Unconfined Strength = >4.5 tons/ft^2
18.0		<u>GREAT VALLEY SEQUENCE</u> <u>CRETACEOUS CORTINA FORMATION</u> ~16.0 to 51.5'		AD	
20.0		20.0 to 51.5' Weathered mudstone.	5	DR	California Modified Blow Count- 12,29,45 Shear Strength = 8.125 kg/cm^2 Unconfined Strength = >4.5 tons/ft^2
22.0 24.0 (176)				AD	
26.0			6	DR	California Modified Blow Count- 27,50 for 5" Shear Strength = N/A Unconfined Strength = >4.5 tons/ft^2
28.0				AD	
30.0			7	DR	California Modified Blow Count- 46,50 for 3" Shear Strength = N/A Unconfined Strength = >4.5 tons/ft^2
32.0 34.0				AD	
			8	DR	California Modified Blow Count- 48,50 for 3"

State of California
The Resources Agency
DEPARTMENT OF WATER RESOURCES

SHEET 3 of 3
HOLE NO. NC-AUG-1

DRILL HOLE LOG

PROJECT & FEATURE SITES RESERVOIR PROJECT; New Canal Alignment

DEPTH (ELEV.)	LOG	FIELD CLASSIFICATION AND DESCRIPTION	SAMPLE NO.	MODE	REMARKS
36.0 (164)					Shear Strength = N/A Unconfined Strength = >4.5 tons/ft^2
38.0				AD	
40.0			9	DR	California Modified Blow Count- 30,50 for 3" Shear Strength = N/A Unconfined Strength = >4.5 tons/ft^2
42.0 44.0 (156)				AD	
46.0			10	DR	California Modified Blow Count- 50,50 for 3" Shear Strength = N/A Unconfined Strength = >4.5 ton/ft^2
48.0				AD	
50.0		BOH = 51.5'	11	DR	California Modified Blow Count- 100 for 5" Shear Strength = N/A Unconfined Strength = >4.5 tons/ft^2
52.0 54.0					Hole completed by back filling with cuttings.

State of California
The Resources Agency
DEPARTMENT OF WATER RESOURCES

SHEET 1 of 3
HOLE NO. NC-AUG-2
ELEV. 170* FEET
DEPTH 51.5 FEET

DRILL HOLE LOG

PROJECT SITES RESERVOIR PROJECT
FEATURE NEW CANAL ALIGNMENT
LOCATION CAL COORDS: N- 2246895; E- 6486288
CONTR. LAYNE-CHRISTENSEN DRILL RIG CME-850
DATE DRILLED 05/05/01
ATTITUDE VERTICAL
LOGGED BY D. FOREWALTER, G. GORDON
DEPTH TO WATER 6.0'

*As measured off of contour maps prepared by DWR (contour interval=10 feet).

DEPTH (ELEV.)	LOG	FIELD CLASSIFICATION AND DESCRIPTION	SAMPLE NO.	MODE	REMARKS
0.0 (170)	CL	<u>PLIOCENE TEHAMA FORMATION</u> 0.0 to 51.5'		AD	8" hollow stem auger used for drilling.
2.0 4.0		2.0' <u>Clay (CL)</u>; silty; dark brown (10YR 3/3); hard, dry; meduim to high plasticity; high dry strength; few grass rootlets.	1	PS	Shelby Tube 500 psi Shear Strength = N/A Unconfined Strength = N/A
	SC	4.5' <u>Sand (SC)</u>, very fine sand, clayey, silty; yellowish brown (10YR 5/4); dry, very dense; low to medium plasticity, low toughness; high dry strength; some calcareous blebs (white 2.5 Y 8/2).		AD	
6.0	CL	5.0' <u>Clay (CL)</u>; sandy, silty; yellowish brown (10YR 5/4); dry, hard; high plasticity; high toughness; high dry strength.	2	PS	Shelby Tube 1200 psi Shear Strength = 13.76 kg/cm^2 Unconfined Strength = 4.6 tons/ft^2
8.0 (162)		7.5' <u>Clay (CL)</u>; sandy, silty; yellow (2.5YR 7/6); dry, hard; medium plasticity; medium toughness; high dry strength.		AD	
10.0		10.0 to 11.5' <u>Sand (SM)</u>; silty; light yellowish-brown (10YR 6/4); fine sand, sub-angular to sub-rounded; medium dense to dense, dry; nonplastic; low toughness.	3	DR	California Modified Blow Count- 10,19,42 Shear Strength = 2.5 kg/cm^2 Unconfined Strength = >4.5 tons/ft^2
12.0 14.0				AD	
	CL	15.0 to 16.5' <u>Clay (CL)</u>; silty; yellowish brown (10YR 5/4), stiff to hard, dry; high plasticity; medium toughness; high dry strength.	4	DR	California Modified Blow Count- 13,20,33 cont. next page.

State of California
The Resources Agency
DEPARTMENT OF WATER RESOURCES

SHEET 2 of 3
HOLE NO. NC-AUG-2

DRILL HOLE LOG

PROJECT & FEATURE SITES RESERVOIR PROJECT; New Canal Alignment

DEPTH (ELEV.)	LOG	FIELD CLASSIFICATION AND DESCRIPTION	SAMPLE NO.	MODE	REMARKS
16.0 (154)					Shear Strength = 2.5 kg/cm^2 Unconfined Strength = >4.5 tons/ft^2
18.0				AD	
20.0		20.0 to 21.5' Clay (CL); silty; light olive brown (2.5 Y 5/4); stiff to very stiff, slightly moist; high plasticity; low dry strength.	5	DR	California Modified Blow Count- 9,13,28 Shear Strength = 1.25 kg/cm^2 Unconfined Strength = >4.5 tons/ft^2
22.0				AD	
24.0 (146)					
26.0	CL	25.0 to 26.5' Clay (CL); sandy, silty; brownish-yellow (10YR 6/6); minor fine sand, moist.	6	DR	California Modified Blow Count- 11,18,24 Shear Strength = 11.25 kg/cm^2 Unconfined Strength = >4.5 tons/ft^2
28.0				AD	
30.0		30.0 to 31.5' Clay (CL); silty, sandy; yellowish-brown (10 YR 5/4); fine sand; stiff, slightly moist; low plasticity; low toughness; minor iron staining.	7	DR	California Modified Blow Count- 8,15,19 Shear Strength = 10.625 kg/cm^2 Unconfined Strength = >4.5 tons/ft^2
32.0				AD	
34.0		35.0 to 36.5' Clay (CL); sandy, silty; brownish-yellow (10YR 6/6); fine to medium sand; stiff to hard, slightly moist; low plasticity; low toughness; abundant iron staining.	8	DR	California Modified Blow Count- 6,9,43

State of California
The Resources Agency
DEPARTMENT OF WATER RESOURCES

SHEET 3 of 3
HOLE NO. NC-AUG-2

DRILL HOLE LOG

PROJECT & FEATURE SITES RESERVOIR PROJECT; New Canal Alignment

DEPTH (ELEV.)	LOG	FIELD CLASSIFICATION AND DESCRIPTION	SAMPLE NO.	MODE	REMARKS
36.0 (134)					Shear Strength = 1.25 kg/cm^2 Unconfined Strength = >4.5 tons/ft^2
38.0				AD	
40.0		40.0 to 41.5' Clay (CL); gravelly, silty; olive brown (2.5Y4/3); fine gravel; firm to very stiff, slightly moist; high plasticity; medium toughness; nodules of greenish-brown clay.	9	DR	California Modified Blow Count- 8,17,22 Shear Strength = 9.375 kg/cm^2 Unconfined Strength = 3.0 tons/ft^2
42.0				AD	
44.0 (126)	CL				
46.0		45.0 to 46.5' Clay (CL); silty; light olive brown (2.5Y 5/4); stiff to hard, slightly moist; high plasticity; low to medium toughness.	10	DR	California Modified Blow Count- 11,17,31 Shear Strength = 8.75 kg/cm^2 Unconfined Strength = >4.5 ton/ft^2
48.0				AD	
50.0		50.0 to 51.5' Clay (CL); silty; olive brown (2.5Y 4/3); firm to very stiff, slightly moist; high plasticity; medium to high toughness; iron staining and mottling. BOH = 51.5'	11	DR	California Modified Blow Count- 8,15,28 Shear Strength = 11.25 kg/cm^2 Unconfined Strength = >4.5 tons/ft^2
52.0					Hole completed by back filling with cuttings.
54.0					

From: Heydinger, Erin [Erin.Heydinger@hdrinc.com]
Sent: 6/26/2020 1:37:33 PM
To: Jerry Brown [jbrown@sitesproject.org]
CC: Alicia Forsythe [aforsythe@sitesproject.org]
Subject: Reclamation Side-by-Side Schedule
Attachments: Reclamation Ops Agreement Dev Schedule_20200626.docx

Hi Jerry,

See attached for a draft side-by-side schedule for Reclamation. Ali and I discussed this morning and believe that the overall timeline can be similar to that with DWR. I did want to point out one item (highlighted in the document). The line item that says "Complete Plan of Finance and Allocation of Benefits and Costs" – I think we will need to allocate the benefits and costs prior to August 2021 to meet the CWC schedule as it's currently identified. I think the same thing is true for "Receive Confirmation of Local Agency Participation in Prop 1." Based on the current schedule, I think we may need to have something pulled together before October, even if it is in draft form, at least based on our existing schedule.

I am also going to call you right now to discuss.

Thanks!
Erin

Erin Heydinger, PE, PMP
Asst. Project Manager
Water/Wastewater

HDR
2379 Gateway Oaks Dr, #200
Sacramento, CA 95833
D 916.679.8863 M 651.307.9758

hdrinc.com/follow-us

Milestone	Date
Perform Operations Analysis for EIR/EIS, BA, CWC Feasibility	July 2020 – November 2020
Re-Analyze Public Benefits	November 2020 – April 2021
Provide Support for Post-Authorization Report	May 2021 – September 2021
Submit State Prop 1 Feasibility Report	July 2021
Complete Plan of Finance and Allocation of Benefits and Costs	August 2021
Receive Confirmation of Local Agency Participation in Prop 1	October 2021
CWC Determination of Prop 1 Construction Funds Eligibility	December 2021
Submit Water Rights Application to SWRCB	January 2022
Issue Final EIR	March 2022

Milestone	Date
Meet with Sites/CVO to Outline Approach	June 19, 2020
Meet to Review Operations Options with Reclamation • Project water • Assumed level of federal participation • Operational exchange outline	August 2020
Conduct Operations Analysis to show: • Amount of water available • CVP flexibility	July 2020 – November 2020
Initial Meeting on Post-Authorization Report	January 2021
Establish initial term sheet reflecting final model results and initiate negotiation of commercial terms	January 2021
Final coordinated operations term sheet complete	June 2021
Bi-weekly check-ins throughout (may shift to monthly depending on need)	

Environmental Feasibility Mtg Agenda

Date: June 29, 2020 **Location:** WebEx Link included in Outlook Invitation

Time: 9:00 AM to 10:00 AM

Leader: Sites Integration **Recorder:** Sites Integration

Purpose: Discuss CWC Feasibility Study Requirements and Authority Approach

Attendees:

Ali Forsythe	John Spranza
Erin Heydinger	Laurie Warner Herson

Agenda:

Discussion Topic	Topic Leader	Time Allotted
1. Purpose of the Meeting	Ali	5 min
2. CWC Feasibility Study Requirements – see below	Laurie	10 min
3. Authority Approach/Schedule (per P6) a. Feasibility Study • Prepare Feasibility Report - April 1, 2021 – July 9, 2021 • Work Group Review May 2021 • Release for CWC Review Pkg 1: Engineering – 7/9/21 • Release for CWC Review Pkg 2: Economic and Finance – 3/31/21 • Release for CWC Review Pkg 3: Environmental with Res Ops - 12/3/21 • State Determination of Feasibility – December 15, 2021 b. Provide CWC with Revised Public Benefits – October 2020 c. Prepare Environmental Summary Report – August 2021-December 2021 (submit December 3, 2021)	Ali/Erin?	15 min
4. Feasibility Study – Environmental Topics/Authors a. CEQA/NEPA Status (including background, alternatives selection process, public meetings/outreach, summary of impacts and mitigation measures b. Permitting – permit requirements and status, baseline? c. Ecological Benefits d. Other?	All	10 min
5. Environmental Feasibility Summary Report a. Update and provide detailed Information based on public review of Revised Draft EIR/EIS and Permitting b. ICF summary of comments received and approach to responses to comments c. Update on any permits and/or consultations d. Other?	Laurie	10 min
6. Next Steps/Action Items	All	5 min

3.5 Feasibility Study (WISP Draft Technical Reference, CWC August 2016)

A completed project feasibility study is required as part of project eligibility (Water Code Section 79757) requirement of the WSIP. In addition, the Commission must make a determination that the project is feasible (Water Code Section 79755 (a)(5)(B)). The feasibility study is also a primary information source for the detailed project description and project analyses.

For the WSIP, the feasibility study must contain sufficient information to demonstrate the project's viability and to help the Commission make its feasibility determination. A feasibility study for proposed water storage projects must include the following elements:

- **Project objectives** – the applicant must identify the project objectives, including all public and non-public benefits the proposed project is designed to provide.
- **Project description** – the applicant must fully describe the proposed project, including facilities, operations, and relationships with existing facilities and operations.
- **Project costs** – the applicant must identify and describe all project costs, including construction costs, interest during construction, replacement costs, operations and maintenance costs consistent with the operations plan, and costs of mitigation for adverse environmental consequences identified in the draft environmental documentation.
- **Project benefits** – the applicant must describe and quantify all proposed project benefits, consistent with the operations plan. Public benefits and non-public benefits shall be quantified using physical measures and, where possible, monetary measures. Proposed project benefits must be displayed as expected average annual values for each year of the planning horizon. For benefits that vary according to hydrologic condition, applicants must display that variability using, for example specific water year types (such as dry and critical), or exceedance probabilities. Appropriate ways to display variability depend on the benefit category and how the physical benefit is to be monetized, as discussed in later sections of this document.
- **Cost allocation** – the applicant must conduct a benefits-based cost allocation to determine the costs to be assigned to the project beneficiaries. The cost allocation must be sufficient to demonstrate that the project and the request for funding of public benefits comply with Water Code Sections 79756 and 79757. The federal government's Separable Costs-Remaining Benefits method is a commonly acceptable method to do a cost allocation.
- **Technical feasibility** – the applicant must demonstrate that the project is technically feasible consistent with the operations plan, including a description of data and analytical methods, the hydrologic period, development conditions, hydrologic time step, and water balance analysis showing, for the with- and without-project condition, all flows and water supplies relevant to the benefits analysis.
- **Environmental feasibility** – the applicant must demonstrate that the project is environmentally feasible. The applicant must describe how significant environmental issues will be mitigated or indicate if the Lead Agency has or will file a Statement of Overriding Considerations.
- **Economic feasibility** – the applicant must demonstrate that the expected benefits of the project equal or exceed the expected costs, considering all benefits and costs to the State and its residents.
- **Financial feasibility** – the applicant must demonstrate that sufficient funds will be available from public (including the funds requested in the application) and non- public sources to cover the construction and operation and maintenance of the project over the planning horizon. It must also show that beneficiaries of non-public benefits are allocated costs that are consistent with and do not exceed the benefits they receive.
- **Constructability** – the applicant must demonstrate that the project can be constructed with existing technology and availability of construction materials, work force, and equipment.

ICF – Amendment 2 EIR/EIS Technical Appendices - Assumptions to confirm with Engineering and Operations/Modeling teams:

- ICF will receive GIS shapefiles of all alternative components/footprints as soon as each footprint is ready and no later than the middle of September 2020; adjustments to the shapefiles after the middle of September 2020 will result in schedule delay.
- The Authority/Integration will provide the following appendices with analysis and results prepared by other consultants through different contract vehicles for review and inclusion in the Administrative Draft Revised EIR/EIS Batch Deliverables (note: numbers/letters are those used in the 2017 Public Draft EIR/EIS and will likely change) and ICF will coordinate with others on desired output formats for various appendices
    - New Construction Appendix documenting construction methods, means, and timing/duration/phasing for constructing all components of each alternative prepared by Sites Integration/HC and HR Engineering by October 12, 2020; this appendix will provide assumptions related to construction activities for use in various resource impacts (e.g., air quality, greenhouse gases, transportation and traffic); the contents of the construction appendix based on an outline prepared by ICF/Integration.
    - Updated Appendix (former 6A), Surface Water Resources Modeling of Alternatives (include reservoir elevations compared to existing reservoir boat ramps), prepared by Jacobs
    - Updated Appendix (former 6B), Water Resources System Modeling, prepared by Jacobs
    - Updated Appendix (former 6B1), Project Operations, prepared by Jacobs
    - Updated Appendix (former 6B2), River Operations, prepared by Jacobs
    - Updated Appendix (former 6B3), Delta Operations, prepared by Jacobs
    - Updated Appendix (former 6B4), Regional Deliveries (including analysis of CBD modeling), prepared by Jacobs
    - Updated Appendix [redacted]), Upper Sacramento River Daily River Flow and Operations Model, prepared by Jacobs
    - Updated Appendix ([redacted]), Sensitivity Analysis to include sensitivity between CalSIM II and CalSIM III (could also be included in Surface Water Resources Modeling of Alternatives ([redacted]), prepared by Jacobs
    - Updated Appendix ([redacted]), Sedimentation and River Hydraulics Model, prepared by Jacobs
    - Updated Appendix ([redacted]), Sacramento-San Joaquin Delta Modeling, prepared by Jacobs
    - Updated Appendix ([redacted]), River Temperature Modeling, prepared by Jacobs
    - Updated Appendix (former 7F), Sites Reservoir Discharge Temperature Modeling, prepared by Jacobs
    - New appendix for discharge into Colusa Basin Drain showing hydrology, flooding, and sedimentation (unless to be included in update of existing Sedimentation and River Hydraulics Model appendix), prepared by Jacobs
    - New Appendix discussing water temperature of reservoir and downstream conveyance facilities, incorporating potential temperature model and results, or data/equations, prepared by Jacobs; the Authority will determine by August 31, 2020 if release temperature will be modeled.
    - The Water Quality Working Subgroup will not ask for work that would substantially increase ICFs level of effort to analyze impacts to water quality; if no modeling is provided, ICF anticipates

Commented [WN1]: Laurie to provide information: operations output 'agreed upon format'- is format specified in Jacobs scope? Do they need to?

Commented [WN2]: Laurie – the color coding below corresponds to email Nicole sent to Integration team on Friday 6/19.

Green indicates the appendices that Erin and I had on both our lists.

Red indicate appendices that I identified in that email that didn't appear on Erin's list and need to be resolved.

In addition, if we can have Jacobs add some hours in their scope/cost for Dave Vogal (a sub to them) to do QA/QC on appendices related to fish, that would be helpful.

    needing to gather data, make assumptions about reservoir release temperatures, and perform warming calculations, which is not included in this cost estimate.
  - Updated Appendix (former 10A), Groundwater Modeling Results, prepared by Jacobs
  - Updated Appendix (former 11A), Groundwater Study Results, prepared by Jacobs
  - Update Appendix (former 12B), Fisheries Impact Assessment Methodology, for those methods/analysis, including information supplied by Cramer and QEDA
  - Update Appendix (former 12G), Smelt Analysis, Jacobs to run DSM2-PTM
  - Update Appendix (formerly 12H), Early Life-Stage Salmonid Mortality Modeling, model run(s), background description, methods, results, and technical support provided by Jacobs Update Appendix (former 12I), Salmonid Population Modeling (SALMOD), model run(s), background description, methods, results, and technical support provided by Jacobs
  - Update Appendix (former 12J), Winter Run Chinook Salmon Life Cycle Modeling, IOS to be run by Cramer; OBAN to be run by QEDA, results and technical support to be provided by Cramer and QEDA.
  - Update Appendix (former 12K), Through-Delta Survival of Juvenile Salmonids, Delta Passage Model run(s), results, and technical support provided by Cramer
  - Updated Appendix (former 12N), Yolo and Sutter Bypass Flow and Weir Spill Analysis, results and technical support provided by Jacobs
  - New Fisheries Appendix, Riverine Flow Survival, Henderson et al. (2019) model run(s), results, and technical support provided by QEDA
  - Updated Appendix (former 25A) Climate Change and Sea Level Rises Sensitivity Analysis, prepared by Jacobs, assumed appendix will follow state guidance (e.g., the California 4th Climate Assessment and Ocean Protection Council)

    Commented [WN3]: Laurie to confirm with Erin
  - Updated Appendix (former 31B) CVP-SWP Power Modeling (for air quality/greenhouse gas analysis, and energy analysis), prepared by Jacobs
  - Updated Appendix [redacted] Growth-Inducing Considerations for Municipal and Industrial Water Users, prepared by Jacobs
  - [redacted]
- Technical support will be provided by Integration/HR-HC Engineering and operations subconsultants from September 1, 2020 through March 23, 2020 to provide the information needed for the analysis described in the June 2020 EIR/EIS Work Plan to meet CEQA/NEPA requirements.
- Technical support (e.g., communications, existing documentation, technical memos) will be provided by Integration/other subconsultants between September 1, 2020 and October 16, 2020 to support impact analysis, including, but not limited to the following:
  - Reservoir-triggered seismicity from the geotechnical engineers/engineering geologists (AECOM/Fugro)
  - Reservoir slope-stability from the geotechnical engineers/engineering geologists (AECOM/Fugro)
  - Circumstances (e.g., locations, volumes, rates) regarding emergency release flows (AECOM)
  - Technical memorandum summarizing assumptions, methods, and results related to hydrologic modeling using the HEC-RAS 1-dimentional (1D) Sacramento River Routing Model for the Colusa Basin Drain (Jacobs)

From: Heydinger, Erin [Erin.Heydinger@hdrinc.com]
Sent: 6/29/2020 1:07:35 PM
To: Spranza, John [John.Spranza@hdrinc.com]; Micko, Steve/SAC [Steve.Micko@jacobs.com]; Rude, Pete/RDD [Pete.Rude@jacobs.com]; Lecky, Jim [Jim.Lecky@icf.com]; Alicia Forsythe [aforsythe@sitesproject.org]; Monique Briard (monique.briard@icf.com) [monique.briard@icf.com]; Williams, Nicole (Nicole.Williams@icf.com) [Nicole.Williams@icf.com]; Laurie Warner Herson [laurie.warner.herson@phenixenv.com]; anne.huber@icf.com; Herrin, Jeff (jeff.herrin@aecom.com) [jeff.herrin@aecom.com]
Subject: RE: Sites water quality working group

Hi John,

Rob, Ali, and I spoke about this at our ops meeting last week. CH, under the ops contract, will be doing reservoir temperature modeling and will also provide an analysis on water temperature in the CBD to the river. I need to follow up with Rob on other potential constituents of concern/water quality parameters beyond temperature. We still need to determine exactly how the temperature impacts Funks and Stone Corral will be evaluated, but for now we do plan to have some modeling data on water released from the reservoir.

Erin

Erin Heydinger PE, PMP
D 916.679.8863 M 651.307.9758

hdrinc.com/follow-us

From: Spranza, John <John.Spranza@hdrinc.com>
Sent: Monday, June 29, 2020 12:56 PM
To: Micko, Steve/SAC <Steve.Micko@jacobs.com>; Heydinger, Erin <Erin.Heydinger@hdrinc.com>; Rude, Pete/RDD <Pete.Rude@jacobs.com>; Lecky, Jim <Jim.Lecky@icf.com>; aforsythe (aforsythe@sitesproject.org) <aforsythe@sitesproject.org>; Monique Briard (monique.briard@icf.com) <monique.briard@icf.com>; Williams, Nicole (Nicole.Williams@icf.com) <Nicole.Williams@icf.com>; Laurie Warner Herson <laurie.warner.herson@phenixenv.com>; anne.huber@icf.com; Herrin, Jeff (jeff.herrin@aecom.com) <jeff.herrin@aecom.com>
Subject: RE: Sites water quality working group

Hey Folks,

Time is moving quick and there are a few action items that I still need input on from Erin, Steve, Jim, Anne. Can you give this a look and let me know the status. I would like to get the temperature modeling meeting scheduled in the next 2 weeks.
Thanks.

John Spranza

D 916.679.8858 M 818.640.2487

From: Spranza, John
Sent: Thursday, June 18, 2020 1:45 PM
To: Micko, Steve/SAC <Steve.Micko@jacobs.com>; Erin Heydinger (Erin.Heydinger@hdrinc.com) <Erin.Heydinger@hdrinc.com>; Rude, Pete/RDD <Pete.Rude@jacobs.com>; 'Lecky, Jim' <Jim.Lecky@icf.com>; aforsythe (aforsythe@sitesproject.org) <aforsythe@sitesproject.org>; Monique Briard (monique.briard@icf.com) <monique.briard@icf.com>; Williams, Nicole (Nicole.Williams@icf.com) <Nicole.Williams@icf.com>; Laurie Warner Herson <laurie.warner.herson@phenixenv.com>; 'anne.huber@icf.com' <anne.huber@icf.com>; Herrin, Jeff (jeff.herrin@aecom.com) <jeff.herrin@aecom.com>

Cc: Jeriann Alexander (jalexander@fugro.com) <jalexander@fugro.com>
Subject: Sites water quality working group

Good Afternoon,
Attached are the notes and Action Items identified in Monday's meeting, please let me know if you have any questions or edits. Folks with AI's are Erin, Steve, Jim, Anne and I. I am thinking that the next meeting with be the week we return from the July 4th holiday but am open to other suggestions.

I have also attached the information I put together for the Salt Lake, that document has a list of next steps to address the Salt lake. If you could please review the document and send me any thoughts you might have on the next steps I would appreciate it.

Thank you.
John

John Spranza, MS, CCN
Senior Ecologist / Regulatory Specialist

HDR
2379 Gateway Oaks Drive, Suite 200
Sacramento, CA 95833
D 916.679.8858 M 818.640.2487
john.spranza@hdrinc.com

hdrinc.com/follow-us
hdrinc.com/follow-us

From: Janis Offermann [janis@horizonh2o.com]
Sent: 6/30/2020 9:10:56 AM
To: Laverne Bill [LBill@yochadehe-nsn.gov]; Isaac Bojorquez [IBojorquez@yochadehe-nsn.gov]
CC: Alicia Forsythe [aforsythe@sitesproject.org]; Laurie Warner Herson [laurie.warner.herson@phenixenv.com]; Kevin Spesert [kspesert@sitesproject.org]
Subject: sites reservoir meeting today
Attachments: 20200630_Sites-Yocha Dehe Mtg-AGN.docx; INT-REP-Value Planning Appraisal Report-FinalCompressed.pdf

Good morning, Laverne and Isaac
Attached please find the agenda for our 2pm meeting this afternoon and the Value Planning Appraisal Report that describes the revised project.

We look forward to talking with you this afternoon and re-establishing AB 52 consultation on this project.

Thanks
Janis

Janis Offermann
Cultural Resources Practice Leader
Horizon Water and Environment
400 Capitol Mall, Suite 2500
Sacramento, CA 95814
916.465.8076 – office
530.220.4918 – mobile

Sites Reservoir Project - Yocha Dehe Meeting Agenda

Date: June 30, 2020 **Location:** WebEx Link included in Outlook Invitation

Time: 2:00 PM to 3:00 PM

Leader:	Sites Integration	**Recorder:**	Sites Integration

Purpose: Provide Representatives of the Yocha Dehe Wintun Nation with an Update of the Project

Attendees:

Laverne Bill, Yocha Dehe	Kevin Spesert, Sites Authority	Ali Forsythe, Sites Authority
Isaac Bojorquez, Yocha Dehe	Janis Offermann, Horizon	Laurie Warner Herson, Sites Integration

Agenda:

Discussion Topic	**Topic Leader**	**Time Allotted**
1. Introductions/Purpose of the Meeting	Kevin	10 min
2. Changes to the Project a. Value Planning Process and Report b. New Alternatives	Kevin/Laurie	10 min
3. CEQA Schedule a. Re-initiation of AB 52	Ali/Laurie	10 min
4. Reclamation Involvement	Laurie	5 min
5. Yocha Dehe Questions and Concerns	Laverne/Isaac	20 min
6. Next Steps	All	5 min

Sites Project Value Planning Alternatives Appraisal Report

April 2020

Status:	For Use	Phase:	2	Revision:		
Filename:	INT-REP-Value Planning Appraisal Report-Final	Date:	April 13, 2020			
Notes:		Page:	1	of		32

This page is intentionally blank.

Contents

Appendices

- Appendix A – Value Planning Alternatives and Costs
    - A-1: Value Planning TM
    - A-2: Road and Bridge Analysis
    - A-3: Conveyance Systems
    - A-4: Cost Estimate
    - Attachment A-4-1: Value Planning Alternatives
- Appendix B – Operations
    - B-1: Release Capacity and Reservoir Size
    - Attachment B-1-1: Sites Operations Scenario B
    - B-2: Shasta Exchanges with No Reclamation Investment
    - B-3: Colusa Basin Drain Value Planning Evaluation
- Appendix C – Environmental Permitting and Planning
    - C-1: Permitting and Environmental Planning Impacts Assessment
    - Attachment C-1-1: Mitigation Cost Estimate Update
- Appendix D – Repayment
    - D-1: Financial Analysis in Support of March 2020 Value Planning
    - D-2: Annual Cash Flow Tool (available digitally)

Executive Summary

Ongoing planning efforts to develop the Sites Reservoir Project (Project) continue to inform expectations on diversion permits and water rights, as well as shape investor participation. In October 2019, representatives from the Authority Board and Reservoir Committee began undertaking a "value planning" process: an effort to identify and evaluate additional alternatives that could make the Project more affordable for the Project's participants. This decision was based on ongoing discussions with permitting agencies, expected project cost and cost per acre foot, and existing participation levels. An Ad Hoc Value Planning Workgroup was formed in late 2019 and continued to meet through early 2020. The Workgroup directed the efforts of Authority staff and the consultant team to formulate and evaluate Project alternatives that would be more affordable, and to identify a recommended Project.

For the purpose of this value planning effort, project objectives were limited to the interests of the Authority's participants and the anticipated benefits to be funded through the Water Storage Investment Program (WSIP) by the State of California. The primary and secondary Project objectives are provided in Table E-1.

TABLE E-1. PROJECT OBJECTIVES.

Primary Objectives	Secondary Objectives
Improve Water Supply and Water Supply Reliability	Provide Opportunities for Recreation
Provide Incremental Level 4 Water Supply for Refuges	Provide Opportunities for Flood Damage Reduction
Improve the Survival of Anadromous Fish	
Enhance the Delta Ecosystem	

Overview of Project Components

The Project includes many facilities. Most of the Project costs are associated with four primary functions: diversions for filling, conveyance for releases, storage, and roads and bridges.

- Diversion Facilities for Filling – Diversion facilities include pipelines, canals, and pumping plants required to fill Sites Reservoir. To reduce costs, the value planning alternatives focused on using existing facilities for filling Sites Reservoir rather than constructing new facilities.
- Conveyance for Releases – The value planning alternatives focused on using the existing Tehama-Colusa Canal (T-C Canal) to deliver water to the southern terminus of the canal. Releases could then be conveyed from the southern end of the T-C Canal to either the Colusa Basin Drain (CBD) or the Sacramento River.
- Storage – Smaller reservoir sizes, focusing on reservoir sizes of 1.5, 1.3, and 1.0 million acre-feet (MAF) were evaluated to reduce the number and size of the dams and saddle dams along with related gates, towers, tunnels, and pumping facilities needed to fill Sites Reservoir.
- Roads and Bridges – The value planning effort considered a number of road and bridge combinations, ultimately focusing on lower costs options for a new bridge to maintain emergency and public access from Maxwell to Lodoga along with roads (paved and unpaved) to maintain access for residents and provide for construction traffic.

Value Planning Alternatives

Value planning alternatives that combine different types and sizes of diversion, release, reservoir, and road and bridge facilities were developed. Initial alternatives were developed following the October 2, 2019 kickoff meeting. These initial alternatives were then refined in the following months and additional alternatives were also added. Over this time period, analyses were completed to assess the operational, environmental, and permitting considerations for different alternatives. Staff also performed a repayment analyses for the alternatives. These analyses are summarized below.

Operational Assessment

The value planning alternatives evaluated the ability of several reservoir sizes and conveyance capacities to meet current participant subscriptions of approximately 230,000 acre-feet (AF), comprised of 192,892 AF of public water agency participation and approximately 40,000 AF of participation by the State of California through the Water Storage Investment Program (WSIP). A sensitivity analysis for a range of reservoir sizes and release capacities for Sites Reservoir was conducted to evaluate the quantity of water that could be released under different conveyance capacities assuming diversion criteria based on current discussions with regulatory agencies. Table 5-2 shows the estimated average annual releases under different combinations of potential Sites storage and release capacities.

TABLE E-2. SITES RESERVOIR RELEASES UNDER VARYING STORAGE AND RELEASE CAPACITIES

	Long-term Average		
Storage Capacity (MAF)	**1,500 cfs Release Capacity (TAF)**	**1,000 cfs Release Capacity (TAF)**	**750 cfs Release Capacity (TAF)**
1.5	253	243	236
1.3	243	234	230
1.0	207	195	191

Based on the preliminary analysis performed, the value planning alternatives with reservoir sizes of 1.3 to 1.5 MAF including assumed diversion criteria would be able to provide enough water to meet current participant demands. In addition, the use of the T-C Canal and the CBD as the conveyance systems appears possible based on preliminary analysis. Additional hydraulic analyses will be needed to confirm downstream conveyance conditions in the CBD, and the available capacity of the T-C Canal downstream of Funks Reservoir should be confirmed. Discussions with Reclamation on non-investment exchanges with Shasta Lake are ongoing. Annual Shasta Lake exchanges including assumed diversion criteria are estimated to be about 60 TAF. While field verification and additional analysis are required, the value planning alternatives with reservoir sizes of 1.3 to 1.5 MAF appear feasible from an operations standpoint.

Environmental and Permitting

The analysis of the value planning alternatives determined that obtaining permits from regulatory resource agencies for some of the alternatives would be relatively easier because of the (1) reduced inundation areas (within reservoir footprint), (2) lack of a pipeline easement to the Sacramento River, (3) removal of the northern regulating reservoir facilities, and (4) shorter conveyance off the T-C Canal (to CBD).

Repayment Analyses

A repayment analysis was conducted to estimate the annual repayment costs per AF of release from Sites Reservoir for both with and without a Water Infrastructure Finance and Innovation Act (WIFIA) loan. The analysis was based upon the estimated construction, operation and maintenance costs, and the estimated releases. Key assumptions included using 2019 as the base year, the U.S. Department of Agriculture loan for the Maxwell Intertie at 3.85%, a revenue bond interest rate of 5%, and a 30-year repayment. Including the USDA loan reduces the overall project cost by approximately $20 per acre-foot. The range in repayment costs are summarized in Table E-3.

TABLE E-3. ANNUAL REPAYMENT COSTS PER ACRE-FOOT OF RELEASE

	VP1			VP2			VP3		VP4		VP5	VP6	VP7
Reservoir Size (MAF)	1.0	1.3	1.5	1.0	1.3	1.5	1.3	1.5	1.3	1.5	1.3	1.3	1.5
Release Capacity (cfs)	750			750			1,500		1,000		1,000	1,000	1,000
Project Cost (2019 $, billions)	3.2	3.4	3.6	2.7	2.9	3.1	3.4	3.6	2.9	3.1	2.9	3.0	3.0
Annualized acre-feet/year Release (TAF)	191	230	236	191	230	236	243	253	234	243	234	234	243
PWA Annual Costs During Repayment Without WIFIA[a] Loan (2020 $, $/acre-feet)	862	776	805	730	667	693	738	754	660	678	644	674	661
PWA Annual Costs During Repayment With WIFIA Loan (2020 $, $/acre-feet)	799	724	755	665	614	641	689	708	608	628	592	621	611

[a] Water Infrastructure Finance and Innovation Act

Recommended Project

The recommended Project was developed by the Ad Hoc Value Planning Workgroup through a sequential process that included initial and refined alternatives. Important considerations included total project cost, impacts on landowners, impacts on traffic and public safety, ability to meet participant demands, ability to provide public benefits to the State, relative magnitude of environmental impacts, and the estimated cost per acre-foot of water delivered. The recommended Project and two options for consideration are shown in Table E-4.

TABLE E-4. VALUE PLANNING GROUP RECOMMENDED PROJECTS

	VP5	VP6	VP7
	Option 1	Option 2	Recommended
Reservoir Size	1.3 MAF	1.3 MAF	1.5 MAF
Dunnigan Release Capacity (cfs)	1,000	1,000	1,000
Estimated Cost (2019 dollars)	$2,855,000,000	$2,988,000,000	$3,037,000,000
Estimated Cost per Acre-Foot with WIFIA[a] (2020)	$592	$621	$611
Estimated Deliveries (Long-Term Average in TAF)	234	234	243

[a] Water Infrastructure Finance and Innovation Act

The recommended project (Alternative VP7) includes a 1.5 MAF reservoir to provide additional storage for dry and critical years. All options include a bridge to minimize travel times and provide emergency access for communities on the west side of the reservoir. The bridge for all options was sized based on the maximum water surface elevation for a 1.5 MAF facility to avoid future traffic impacts that could arise if climate change or other factors necessitated expanding a smaller reservoir. All alternatives also include a new unpaved road to maintain access for residents along the southern portion of the reservoir.

All options for consideration, including the recommended alternative, would release water through the T-C Canal. A 1,000 cfs release near the end of the canal would deliver water to either the CBD (Alternatives VP5 and VP7) or to the Sacramento River (Alternative VP6).

The Value Planning Workgroup recommends the Project proceed as Alternative VP7. Although Alternative VP5 had the lowest overall cost and lower cost per acre-foot, the Value Planning Workgroup recommends VP7 based on higher deliveries at a comparable cost and improved operational flexibility with a 1.5 MAF reservoir. The proposed facility locations associated with VP7 are shown in Figure E-1.

The Value Planning Workgroup also recommends the subsequent analyses of the Project include a 1.3 MAF reservoir (per VP5) and a Dunnigan to Sacramento River 1000 cfs release pipeline (per VP6) in order to provide flexibility to respond to any future condition changes that might result in such facilities becoming preferable.

The Recommended Project results in the following significant changes to the Draft Environmental Impact Report/Environmental Impact Statement (EIR/EIS) Alternative D 1.8 MAF Project:

- Reduced project size and footprint
- Reduced Sacramento River diversions
- Elimination of Delevan Sacramento River diversion and release facility
- Elimination of Delevan Pipeline and associated impacts to landowners and wildlife refuges along that alignment
- Reduced costs and improved affordability to the Project's funding participants

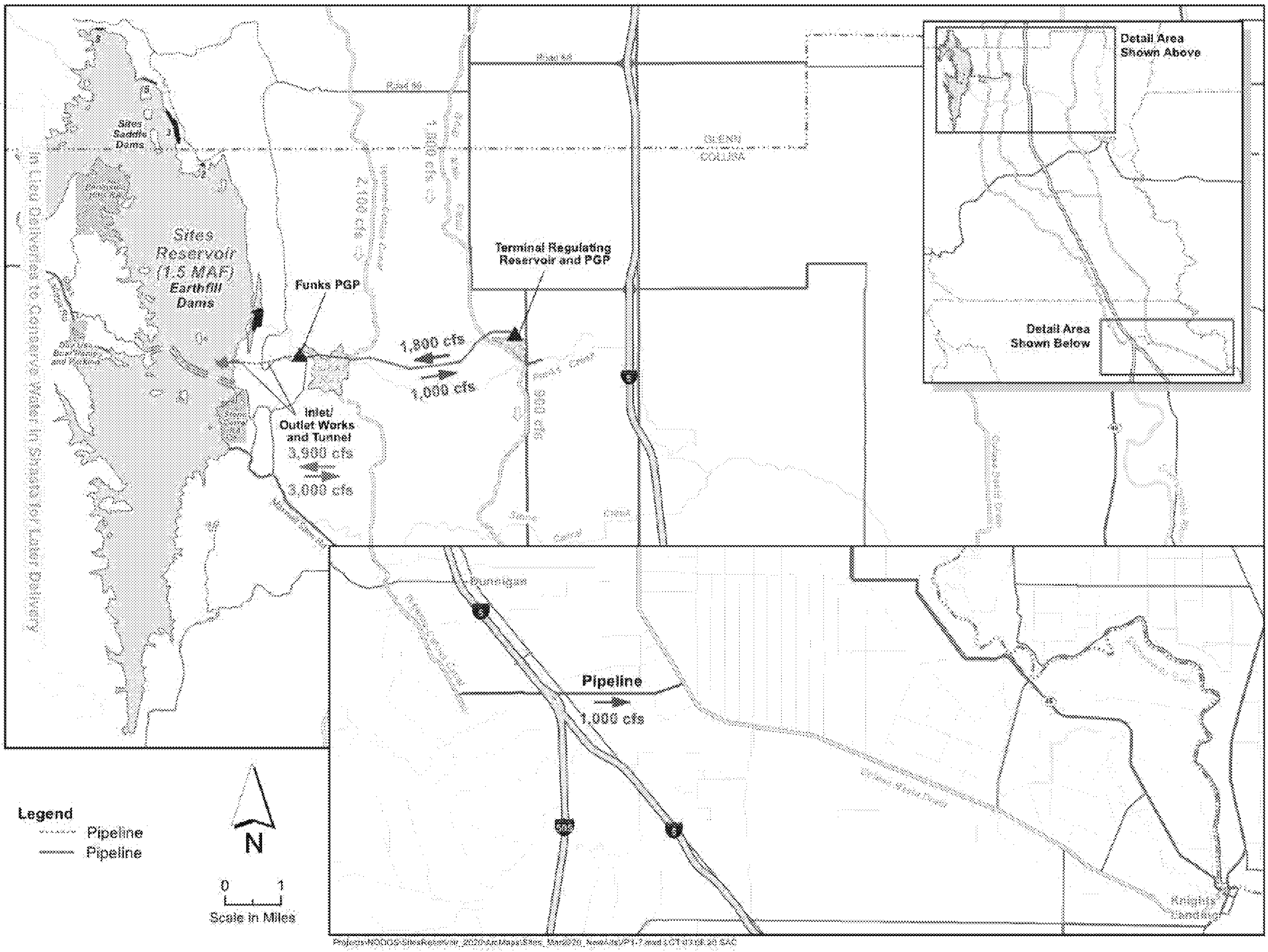


FIGURE E-1. RECOMMENDED VALUE PLANNING ALTERNATIVE (VP7)

This page is intentionally blank.

1. Introduction

1.1 Background

Ongoing planning efforts to develop the Sites Reservoir Project (Project) continue to inform expectations on diversion permits and water rights, as well as shape investor participation. In October 2019, representatives from the Authority Board and Reservoir Committee began undertaking a “value planning” process: an effort to identify and evaluate additional alternatives that could make the Project more affordable for the Project’s participants. This decision was based on ongoing discussions with permitting agencies, expected project cost and cost per acre foot, and existing participation levels. An Ad Hoc Value Planning Workgroup was formed in late 2019 and continued to meet through early 2020. The Workgroup directed the efforts of Authority staff and the consultant team to formulate and evaluate Project alternatives that would be more affordable, and to identify a recommended Project.

1.2 Purpose

The purpose of this report is to present the methodology and findings of the value planning process and to summarize the overall Project status from a permitting, operations, and repayment perspective. The intent is that the Participants will find this information useful in assessing their level of ongoing Project participation.

2. Project Objectives and Participants

2.1 Objectives

A wide variety of Project objectives have been proposed in previous planning efforts by the Authority, the California Department of Water Resources (DWR), the Bureau of Reclamation (Reclamation), and others. For the purpose of this value planning effort, project objectives were limited to the interests of the Authority’s participants and the anticipated benefits to be funded through the Water Storage Investment Program (WSIP) by the State of California.

Prior to the initiation of the value planning effort, the estimated Project cost for participants for a presumed 1.8 million acre-feet (MAF) reservoir exceeded the average annual cost per acre-foot subscription that was acceptable (i.e. affordable for the agricultural participants) for their continued participation. The primary purpose of value planning was to provide enough water for current Project subscription while reducing the overall cost and the cost per acre-foot to an affordable level, which varies by participants. It was also essential that the alternatives selected meet the overall Project objectives:

- **Improve Water Supply and Water Supply Reliability.** The assumed total Project demand is approximately 230 thousand acre-feet per year (TAFY) in releases from Sites Reservoir, including a water agency demand of approximately 193 TAFY (see Table 5.1 for additional details).
- **Provide Incremental Level 4 Water Supply for Refuges.** Through the WSIP, the State committed to invest in Incremental Level 4 water supply for refuges at an undetermined level. The estimated level of commitment is an average delivery of 26 TAFY. Level 4 refuge demand is located primarily south of the Sacramento-San Joaquin Delta (Delta).
- **Improve the Survival of Anadromous Fish.** Participants are supportive of actions that benefit salmon, steelhead, and other anadromous fish species of concern in the Sacramento River watershed. The ability of Sites Reservoir to benefit salmon largely depends on the ability to use Sites Reservoir for in-lieu deliveries to Central Valley Project (CVP) contractors or to meet other CVP requirements. This enables the conservation of the coldwater pool in Shasta and Folsom Lakes. The species benefit from improved coldwater pool management, lower river water temperatures and supplemental flows to prevent the dewatering of redds. Negotiations are ongoing with Reclamation to establish a mutually agreeable operation.
- **Enhance the Delta Ecosystem.** Water released from Sites Reservoir would be conveyed to the Yolo Bypass toe drain to convey biomass to the Delta to help supply food for Delta smelt.

Alternatives include opportunities to achieve the following secondary objectives:

- **Provide Opportunities for Recreation**. This benefit is being funded through WSIP. The WSIP funding will support the construction of new recreation facilities, including Stone Corral Recreation Area on the east side of the reservoir, a boat ramp on the west side of the reservoir, and the Peninsula Hills Recreation Area on the west side of the reservoir.
- **Provide Flood Damage Reduction**. This benefit is being funded through WSIP. The WSIP application focused on flood-damage reduction resulting from the construction of Sites Dam on Stone Corral Creek. Once completed, Sites Dam will reduce the likelihood of flooding in the Stone Corral Creek watershed, and Golden Gate Dam will improve flood damage reduction for extreme events on Funks Creek.

Previously published benefits included hydropower production. The Value Planning Workgroup decided not to require facilities for pumpback generation in the value planning alternatives. Most costs associated with pumpback hydropower are attributable to Fletcher Reservoir. If pumpback generation is not required, then there is no requirement for a forebay/afterbay arrangement and Fletcher Reservoir can be eliminated, resulting in significant cost savings.

Although hydropower is not a Project objective, the cost estimates for the value planning alternatives include turbines in the pumping plants for generation on release. These turbines are not a major cost driver for the Project and are likely to significantly reduce operations, maintenance, and replacement (OM&R) costs by offsetting the costs for power to pump water into Sites. The benefit derived from retaining turbines can be reassessed to optimize the design as the Project progresses and energy markets fluctuate.

2.2 Participants

The Project facilities are to be limited to those that directly benefit the current participants (WSIP and local entity participants). Reclamation and the State of California, through the CVP and the State Water Project (SWP), were assumed to be cooperating partners not investors. The State may contract for WSIP benefits through the California Water Commission, the California Department of Fish and Wildlife, DWR, or the State Water Resources Control Board; nevertheless, the WSIP participation level is currently capped at $816 million (some of which is allocated to recreation and flood control benefits), and deliveries were constrained to correspond to this level. Beyond the State, current financial participants include the following:

- City of American Canyon
- Antelope Valley-East Kern Water Agency
- Carter Mutual Water Company
- Coachella Valley Water District
- Colusa County
- Colusa County Water Agency
- Cortina Water District
- Davis Water District
- Desert Water Agency
- Dunnigan Water District
- Glenn-Colusa Irrigation District (GCID)
- LaGrande Water District
- Metropolitan Water District of Southern California
- Reclamation District 108
- San Bernardino Valley Municipal Water District
- San Gorgonio Pass Water Agency
- Santa Clara Valley Water District
- Santa Clarita Valley Water District
- Westside Water District
- Wheeler Ridge-Maricopa Water Storage District
- Zone 7 Water Agency

3. Overview of Project Components

The Project includes many facilities. Most of the Project costs are associated with four essential Project functions: diversions, conveyance for releases, storage, and roads and bridges. The following sections provide an overview of the overall Project components, with focus on those that were closely evaluated during the value planning process.

3.1 Diversions

At the October 2, 2019 meeting of the Ad Hoc Value Planning Workgroup, it was decided to focus alternatives on the use of existing diversions (Red Bluff and Hamilton City pumping plants) rather than constructing a new pumping plant on the Sacramento River.

Diversion facilities include pipelines, canals, and pumping plants required to fill Sites Reservoir. Alternative D (1.8 MAF reservoir) relied on three diversions, including the existing Tehama-Colusa (T-C) Canal diversion at Red Bluff, the existing GCID Main Canal diversion at Hamilton City, and a new diversion on the Sacramento River for the Delevan pipeline. The lowest cost options use the existing pumping plants and canals. Together, the T-C and GCID Main Canals can deliver approximately 3,900 cubic feet per second (cfs). Eliminating the new Delevan pumping plant provides substantial cost savings (approximately $260 million). Although this reduces the ability to fill Sites Reservoir, the workshop participants believed that two diversions would provide adequate conveyance capacity consistent with the likely permittable diversion capacity.

3.1.1 Diversion Criteria

Sites Reservoir would be filled through the diversion of excess Sacramento River flows that originate primarily from unregulated tributaries to the Sacramento River downstream from Keswick Dam. Diversions would be allowed when operational criteria are met, which would be set by permitting requirements. Based on current permitting discussions, the diversion criteria included in Table 3-1 were assumed for the value planning analysis. These criteria are often referred to as "Scenario B."

TABLE 3-1. ASSUMED DIVERSION AND OPERATIONS CRITERIA (SCENARIO B)

Location	Criteria
Wilkins Slough Bypass Flow	8,000 cfs April/May 5,000 cfs all other times
Fremont Weir Notch	Prioritize the Fremont Weir Notch, Yolo Bypass preferred alternative, flow over weir within 5%
Flows into the Sutter Bypass System	No restriction due to flow over Moulton, Colusa, and Tisdale Weirs
Freeport Bypass Flow	Modeled WaterFix Criteria (applied on a daily basis) Post-Pulse Protection (applied on a moving 7-day average) Post-Pulse (3 levels) = January–March Level 2 starts January 1 Level 1 is initiated by the pulse trigger
Net Delta Outflow Index (NDOI) Prior to Project Diversions	44,500 cfs between March 1 and May 31

For more information on the assumed diversion and operations criteria, refer to Appendix B.

3.1.2 Pumping Facilities

Once water is diverted from the Sacramento River, it must be pumped into Sites Reservoir. This requires pumping plants with regulating reservoirs at the existing T-C and GCID Main Canals.

Pumping from T-C Canal to Sites Reservoir

The Tehama-Colusa Canal Authority (TCCA) diversion facility is located on the Sacramento River near Red Bluff. The Red Bluff Pumping Plant has an existing pumping capacity of 2,000 cfs, which is used to meet current agricultural water demand. The Project would include installation of one additional pump (250 cfs) and

[redacted]

one backup pump to the existing pump grouping, which would increase the overall pumping capacity to 2,250 cfs to fully use the 2,100 cfs capacity for diversion through the T-C Canal to Sites Reservoir.

For value planning, two regulating reservoir options were considered for the T-C Canal: the existing Funks Reservoir and a new Tehama-Colusa Regulating Reservoir (TCRR). The primary advantages of a new northern regulating reservoir (TCRR) are that it would eliminate almost all impacts on T-C Canal operations, and it would allow for early filling of Sites Reservoir. Two locations were considered, with one near Road 68 and a second to the northwest near Hunters Creek. Preliminary cost estimates indicate that both locations would have comparable cost for implementation. The Hunters Creek location reduces the length of pipeline needed to lift water into Sites Reservoir by approximately 2 miles, but it is less accessible for construction and maintenance and has greater environmental impacts because of streambed impacts. Using the existing Funks Reservoir minimizes the length of pipeline and does not require constructing a new regulating reservoir into Sites Reservoir and, therefore, has the lowest cost.

Pumping from GCID Main Canal to Sites Reservoir

Under proposed Project operations, the GCID Main Canal would convey water pumped from the existing Hamilton City pumping facility to Sites Reservoir. The Hamilton City pumping facility has a 3,000 cfs diversion capacity at the Sacramento River intake, and the capacity of the GCID Main Canal is 1,800 cfs. Table 3-2 shows the flows that are assumed to occupy capacity in the canal during existing winter operations. A dedicated annual 2-week maintenance shutdown period is assumed in the last week of January through the first week of February.

TABLE 3-2. OCCUPIED CAPACITY IN THE GCID MAIN CANAL DURING EXISTING WINTER OPERATIONS

Month	October	November	December	January	February	March
Occupied Capacity (cfs)	513	534	389	235	56	48

Conveying water from the GCID Main Canal requires the construction of the Terminal Regulating Reservoir (TRR) to regulate levels in the canal with the operation of the new pumping plant to convey water to Sites Reservoir. Therefore, construction of the TRR was included in each alternative.

Forebay/Afterbay and Sites Pumping/Generating Plants

Alternative D of the Draft EIR/EIS (1.8 MAF reservoir) included a forebay/afterbay (Fletcher Reservoir) where all diversions collected were then lifted into Sites Reservoir using the Sites Pumping/Generating Plant. This arrangement maximized the potential for pumpback generation (cycling between the upper and lower reservoir to provide dispatchable power). The Value Planning Workshop participants decided to eliminate pumpback generation from the Project at this time. This enables the elimination of Fletcher Reservoir (approximately $190 million). It also allows consideration of eliminating the Sites Pumping/Generating Plant (the most expensive single Project facility, at $800 million), provided some additional investment is made to the other pumping plants to compensate for increased head to pump directly into Sites Reservoir.

3.2 Conveyance for Releases

Shasta Exchange for Project Demands: It is possible to release water from Sites Reservoir to meet CVP Sacramento Valley agricultural water service and Settlement contractor CVP demands. Meeting CVP needs from Sites Reservoir in the T-C Canal and GCID Canal service areas south of Funks Reservoir allows water to be conserved in Shasta Lake for subsequent delivery to meet Project demands. This could include refuge water supply or South of Delta participant needs. The amount of additional conveyance (for example, Delevan conveyance or Dunnigan conveyance) that must be constructed to release water directly from Sites Reservoir to the Sacramento River depends on the amount and timing of water that could be cooperatively exchanged through Shasta for Project demands.

Delevan Pipeline or Canal: Alternative D (1.8 MAF Reservoir) included two pipelines with a combined capacity of 1,500 cfs back to the Sacramento River for releasing water directly to the Sacramento River. The value planning effort considered a reduced capacity of 750 cfs using a canal in place of a pipeline where

[redacted]

possible to reduce costs. Constructing a canal is less costly but increases environmental impacts by introducing potential flooding issues and creating a barrier to terrestrial species migration.

Dunnigan Release: A new option introduced by the Value Planning Workgroup is the use of the existing T-C Canal to deliver water to the southern terminus of the canal. Water could be conveyed from the southern end of the T-C Canal to either the Colusa Basin Drain (CBD) or the Sacramento River. Three conveyance approaches were considered:

- Conveyance through existing drainage channels to the CBD
- Conveyance through a new canal to the CBD
- Conveyance through a pipeline to the CBD or river

Gravity releases through existing drainage channels to the CBD are possible but would result in significant water loss attributable to seepage and evaporation and, therefore, were eliminated. The environmental team has recommended pipeline release versus a canal as the preferred option to minimize environmental impacts. Conveyance through a pipeline to the CBD or river can be done by gravity without a pump station. The ability of the T-C Canal to operate using a gravity pipeline to the CBD or river was evaluated, with results summarized in Section 5.

3.2.1 Release Criteria

Sites Reservoir would be operated in cooperation with CVP and SWP operations to coordinate releases from Shasta Lake, Lake Oroville, and Folsom Lake. Sites releases could allow reduced releases from other reservoirs while maintaining minimum instream flow objectives, Sacramento River temperature requirements, and Delta salinity control requirements assigned to CVP and SWP. Through reduction in releases from CVP and SWP reservoirs, storage could be conserved in Shasta Lake, Lake Oroville, and Folsom Lake to increase operational flexibility.

Releases from Sites Reservoir to the Sacramento River would be operated to achieve multiple benefits associated with the Project's primary objectives in specific water year types and months of the year. Most releases are likely to occur in dry and critical water years when members request releases from storage, and when state water (WSIP) is likely to be released for environmental benefits. Priority operations would include the following:

- Provide water to Project participants north and south of the Delta.
- Provide water to the Cache Slough area via the Yolo Bypass.
- Provide water for Incremental Level 4 refuge deliveries.
- Support Reclamation goals through exchange. Goals could include improved Shasta Lake temperature management and Sacramento River fall flow stabilization to improve spawning and rearing success of anadromous fish.

Sites releases to Sacramento Valley members include deliveries to TCCA members, GCID, Reclamation District 108 (RD 108), Colusa County, and other members. Most of these deliveries are conveyed through the T-C Canal.

TCCA historical monthly diversion data for 1999 through 2013 were reviewed to assess seasonal diversion patterns and variations in water use for a range of hydrologic conditions and CVP allocations. The historical data were used to verify that the total irrigation demands and diversion patterns generally represented actual water operations. TCCA's CVP Agricultural Water Service Contracts are subject to shortage allocations based on CVP storage and annual hydrologic conditions. Sites deliveries to TCCA participants will be used to supplement existing CVP contract supplies.

GCID and RD 108 are CVP Sacramento River Settlement Contractors and are subject to a 25 percent contract reduction in severe drought years under specific shortage criteria in their contracts. Sites water will be used to supplement existing CVP settlement contract supplies.

It is assumed that South of Delta SWP Contractors will take delivery of Sites water to supplement SWP Table A allocations in dry and critical water years. Sites Reservoir releases to SWP contractors are assumed to be initiated when the SWP allocation is less than 85 percent of Table A values. If the SWP allocation is less than

65 percent of Table A values, releases to SWP members are assumed to become more aggressive to supplement decreased supplies.

3.3 Dams and Reservoir

Alternative D of the EIR/EIS proposed a 1.8 MAF reservoir for Sites. The capacity of the reservoir depends on the size of the dams. The height of Golden Gate and Sites Dams is reduced for a 1.5, 1.3, or 1.0 MAF reservoir, and some of the saddle dams are eliminated with the smaller reservoir.

Reducing the capacity of the reservoir would also reduce the height and number of gates required for the inlet/outlet tower. Dam safety regulations also require the ability to rapidly reduce the amount of water stored behind a dam in the event of imminent failure. The reservoir inlet/outlet tunnels are designed to meet this rapid drawdown requirement, instead of normal service levels. Smaller reservoirs require smaller-diameter tunnels, further reducing the cost.

Finally, reducing the reservoir size also reduces the head on the pumping facilities needed to fill Sites Reservoir. The value planning effort focused on 1.5, 1.3, and 1.0 MAF facilities to reduce construction costs.

Three alternative construction methods for dams were considered. The original DWR concept was for a zoned rockfill dam. Reduced cost is likely with an earthfill dam or a hardfill dam; however, the variance in cost based on the dam construction method is much less than the potential savings associated with reducing the size of the reservoir.

3.4 Roads and Bridge

Alternative D (1.8 MAF reservoir) included a new bridge approximately 1.5 miles in length to maintain emergency and public access from Maxwell to Lodoga. Other alternatives considered included a pair of shorter-span bridges along with the use of constructed fill (causeways) between the sections and a combination of a shorter bridge with a tunnel for the smaller reservoir.

A new road around the southern end of Sites Reservoir that would connect over to Lodoga was considered as an alternative to building a bridge.

All alternatives include a road to the southern end of Sites Reservoir to provide access for residents who would otherwise be stranded by the new reservoir.

The road and bridge options are described more fully in Appendix A.

4. Value Planning Alternatives

4.1 Alternative Development

Project alternatives were developed that combine different types and sizes of diversion, release, reservoir, and road and bridge facilities described in Section 3. Initial alternatives were developed following the October 2, 2019 kickoff meeting and then refined in the following months to develop a recommended alternative. Initial alternatives are described in Appendix A. The refined alternatives are described in this section, with the preferred alternative discussed in Section 8. Figures for the refined alternatives are provided in Appendix A.

4.2 Initial Alternatives

Representatives from the Reservoir Committee and Authority Board met on October 2, 2019, to discuss approaches that could potentially lower the Project cost. Several facility modifications were identified, and appraisal-level costs are provided in this analysis to allow a comparison of alternatives. The Value Planning Analysis Technical Memorandum is in Appendix A of this report; however, additional alternatives were identified in subsequent meetings on November 15 and December 16, 2019, and during the value planning alternatives field trip on January 14, 2020. The costs for the refined alternatives are provided in Appendix A.

4.3 Evaluation of Alternatives Selected for Further Study

The following approach was used to develop and evaluate the initial alternatives (VP1 through VP4).

Identify the two best diversion facilities, road facilities, and release facilities ⇨ Combine them into alternatives for a 1.3 MAF reservoir and evaluate the alternatives ⇨ Consider alternative costs for the 1.5 MAF and 1.0 MAF reservoirs

4.3.1 Evaluation of Facilities

Diversion Facilities: Diversion facilities considered are described in Section 3.1 and are evaluated in Table 4-1.

TABLE 4-1. INITIAL SCREENING OF DIVERSION FACILITIES (750 cfs)

Option	Initial Cost	Advantages	Disadvantages	Rank
Delevan Pipeline and Pumping Plant	$859M	Direct release to river	Requires new intake Impact on landowners Giant garter snake habitat High cost	Low
TCRR, Pipeline, and Pumping Plant	$634M	Existing Red Bluff pumping Independent regulation for TCCA Early fill (2-3 years earlier)	Impacts additional real estate Cost of new regulating reservoir Pipeline distance	Medium
TRR, Pipeline, and Pumping Plant	$474M	Existing Hamilton City pumping	—	Best
Funks, Channel, and Pumping Plant	$256M	Closest to Sites Reservoir No additional regulating reservoir required	Must avoid T-C Canal impacts	Best

Roads and Bridges: Options for roads and bridges at Sites Reservoir are discussed in Section 3.4 and are evaluated in Table 4-2.

TABLE 4-2. ROADS AND BRIDGES

Option	Initial Cost	Advantages	Disadvantages	Rank
South Road to Residents	$41M	Provide access to stranded property	—	Required
North Construction Bypass – construction traffic only (paved)	$30M	Avoid traffic through Maxwell	—	Required
Bridge	Varies	Shortest travel time Lower maintenance cost Less environmental impact	—	Best
South Road	$224M	Avoids bridge	Higher maintenance More acres affected	Medium

Release Facilities: Options for conveyance for releases from Sites Reservoir are discussed in Section 3.2 and are evaluated in Table 4-3.

TABLE 4-3. INITIAL SCREENING OF RELEASE FACILITIES (750 CFS)

Option	Initial Cost	Advantages	Disadvantages	Rank
Delevan Pipeline	$389M	Direct release to river	Impact on landowners Giant garter snake habitat High cost	Low
Delevan Canal	$360M	Direct release to river	Impact on landowners Giant garter snake habitat Complicates local drainage Additional pump station at CBD High cost	Low
Dunnigan to CBD[a]	$54M	Less acreage affected May avoid a 408 permit	Potential losses in CBD	Best
Dunnigan to River	$173M	Avoid loss in CBD	Impact additional acreage	Medium

[a] CBD – Colusa Basin Drain

An evaluation of conveyance facility sizing was performed, with results provided in Section 5.

4.3.2 Refined Alternatives

Four alternatives were developed for the 1.3 MAF reservoir with combinations of the highest ranked facilities to bookend the value planning options for the March 2, 2020 review meeting. An additional three alternatives were developed during the review meeting:

- Alternative VP 5 – This alternative includes a 1.3 MAF reservoir and uses the Funks Reservoir and the TRR to fill Sites Reservoir with releases (1,000 cfs) from the southern end of the T-C Canal through a pipeline that would go to the CBD.
- Alternative VP 6 – This alternative includes a 1.3 MAF reservoir and uses the Funks Reservoir and the TRR to fill Sites Reservoir with releases (1,000 cfs) from the southern end of the T-C Canal through a pipeline that would extend to the Sacramento River.
- Alternative VP 7 – This alternative This alternative includes a 1.5 MAF reservoir and uses the Funks Reservoir and the TRR to fill Sites Reservoir with releases (1,000 cfs) from the southern end of the T-C Canal through a pipeline that would go to the CBD.

The refined alternatives are shown in Table 4-4.

TABLE 4-4. RECOMMENDED ALTERNATIVE AND ALTERNATES

Major Facilities	VP5	VP6	VP7
	Alternate 1	Alternate 1A	**Recommended**
Reservoir Size	1.3 MAF	1.3 MAF	1.5 MAF
Bridge Size (avoids future traffic Interruption)	1.5 MAF	1.5 MAF	1.5 MAF
South Road to Local Residents	Included	Included	Included
Misc. Local and Project Roads	Included	Included	Included
Diversion Locations	Funks and TRR	Funks and TRR	Funks and TRR
Dunnigan Release	1,000 cfs to CBD	1,000 cfs to River	1,000 cfs to CBD
Direct Cost	$1,787,000,000	$1,870,000,000	$1,902,000,000
Non-Contract Costs	$485.000,000	$508,000,000	$516,000,000
Contingency	$557,000,000	$583,000,000	$592,000,000
Total Estimated Cost (2019 dollars)	$2,855,000,000	$2,988,000,000	$3,037,000,000

Cost estimating details are provided in Appendix A-4.

The availability of site data and design information to support preparing cost estimates varies between the facilities that constitute the Sites Reservoir project. Some facilities (like the main dams) are advanced enough to support a lower-bound Class 3 estimate as defined by the Association for Advancement of Cost Engineering, International. Other facilities, like the Dunnigan conveyance from the T-C Canal to the CBD have no supporting geotechnical evaluation and only a preliminary screening of potential utility conflicts. These estimates are at a Class 5 level.

A contingency of 10% was first applied for design, followed by a 15% contingency for construction. The compounded contingency is approximately 30% of the direct cost for construction. Non-contract costs were estimated at 17% of the total estimated cost.

5. Operational Assessment of Sites Release Capacity for Value Planning

5.1 Participant Subscriptions

The value planning alternatives evaluated the ability of several reservoir sizes and conveyance capacities to meet participant subscriptions. Table 5-1 shows the current member participation for the Sites Reservoir Project by region and delivery type. WSIP deliveries for Refuge Incremental Level 4 and Yolo Bypass are estimated to be about 40 TAFY.

TABLE 5-1. CURRENT SITES RESERVOIR PARTICIPATION

Member	Reservoir Participation (AFY)
Public Water Agencies	
North of Delta	52,142
South of Delta	140,750
Subtotal Public Water Agencies	192,892
State of California (WSIP)	
Refuge Incremental Level 4 and Yolo Bypass	~40,000
Total Requirement	~230,000

5.2 Evaluation of Reservoir Size and Release Capacity

A sensitivity analysis for a range of reservoir sizes and release capacities for Sites Reservoir was conducted to evaluate the quantity of water that could be released under different conveyance capacities. The analysis included a surrogate approximation of the potential to exchange water between Sites Reservoir and Shasta Lake based on the analysis presented in Section 5.3. This exchange would be implemented through the release of Sites water to meet Sacramento Valley CVP contract demands and Delta regulatory obligations. The exchange assumes a corresponding reduction in Shasta Lake releases that preserves storage in the lake and contributes to water temperature management and Sacramento River flow stability benefits. Based on Scenario B diversion criteria (see Table 3-1), it is assumed that approximately 60 TAF could be exchanged on an average annual basis, with most of these exchanges occurring in dry and critical water year types. This also assumes integration with the SWP to facilitate operations and deliveries to South of Delta members.

Three conveyance capacities for Sites Reservoir releases were evaluated: 750, 1,000, and 1,500 cfs. Each conveyance capacity was assessed using three storage capacities for the reservoir: 1.5, 1.3, and 1.0 MAF, with assumed reservoir dead storage of 120 TAF. All nine combinations of these capacities were run under Scenario B. For each scenario, releases from Sites Reservoir were quantified using monthly releases, as reported by CalSim II modeling. Deliveries include releases for TCCA, GCID, RD 108, Colusa County, Sacramento Valley members, South of Delta members, Refuge Level 4, and Yolo Bypass.

Table 5-2 shows average annual releases under different combinations of potential Sites storage and release capacities. -Releases highlighted in green meet current participant demand, while releases highlighted in orange do not meet current participant demands.

TABLE 5-2. SITES RESERVOIR RELEASES UNDER VARYING STORAGE AND RELEASE CAPACITIES

	Long-term Average		
Storage Capacity (MAF)	1,500 cfs Release Capacity (TAF)	1,000 cfs Release Capacity (TAF)	750 cfs Release Capacity (TAF)
1.5	253	243	236
1.3	243	234	230
1.0	207	195	191
Meets participant demand (193+40=233)			
Does not meet participant demand			

Table 5-3 shows average annual releases for Sacramento Valley Index water year types. Maximum Sites releases generally occur in dry water years, as highlighted yellow, because there is increased water demand and available Delta export capacity. Overall, decreasing Sites' release capacity from 1,000 to 750 cfs reduces average annual releases by 1.6 to 2.7 percent, depending on reservoir size.

Overall, decreasing Sites' release capacity from 1,500 to 1,000 cfs reduces average annual releases by 4.0 to 6.2 percent. Further reducing the release capacity to 750 cfs reduces average annual deliveries by an additional 1.6 to 2.7 percent.

Releases from Sites are greatest during dry years. Consequently, dry years are more critical to the conveyance capacity of Sites releases than any other year type. For example, the average annual delivery of a 1.5 MAF reservoir decreases by 13.5 percent when its release capacity is reduced from 1,500 to 750 cfs.

Based on this sensitivity analysis, the combination of a 1.5 MAF reservoir and a 1,000 cfs release capacity provides about a 243 TAF average annual release for Sites Reservoir, which meets current participation and provides additional operational flexibility.

TABLE 5-3. SITES RESERVOIR RELEASES UNDER VARYING STORAGE AND RELEASE CAPACITIES, BY WATER YEAR TYPE

Year Type	Storage Capacity (MAF)	1,500 cfs Release Capacity (TAF)	1,000 cfs Release Capacity (TAF)	750 cfs Release Capacity (TAF)
Wet	1.5	115	116	112
	1.3	122	115	113
	1.0	118	112	109
Above Normal	1.5	275	286	280
	1.3	287	299	303
	1.0	185	186	194
Below Normal	1.5	285	273	277
	1.3	278	263	266
	1.0	237	217	213
Dry	1.5	422	382	365
	1.3	392	364	345
	1.0	343	309	301
Critically Dry	1.5	243	237	225
	1.3	205	204	204
	1.0	185	184	177

Note: Recommended range to account for uncertainty is simulated values less 30,000 acre-feet.

5.3 Evaluation of Potential for Shasta Lake Exchange

The Ad Hoc Value Planning Workgroup wanted to evaluate the proposed alternatives without Reclamation investing in the Project financially. In this scenario, water stored in Sites Reservoir could be exchanged with Shasta Lake to meet CVP TCCA agricultural water service and Settlement Contractor obligations as well as downstream flow and Delta water quality requirements. Therefore, a portion of the water demand within the CVP service area along the T-C Canal and GCID Main Canal south of Sites Reservoir could be met from releases from Sites Reservoir in the spring and allow an equal amount of water to be retained in Shasta Lake (via exchange) to improve summer cold water pool management.

The exchange could occur when Sacramento River flows at Keswick and temperatures at Clear Creek are within a specific range and not compromised by reduced Shasta Lake releases into the Sacramento River. This exchange would likely occur in April through May (and possibly June) in dry and critically dry years.

Shasta Lake releases of exchange water are proposed to be scheduled to benefit downstream temperatures in the Sacramento River, which would likely occur in September, October, or November. Withdrawals from Shasta would be coordinated with Reclamation. Based on conversations with Reclamation, this analysis assumes that no carryover storage of exchange water would be allowed between years.

The exchange operation would likely be subject to the following constraints provided by Reclamation to protect the interests of the CVP and to comply with State and federal laws and regulations:

- All water stored in Shasta would be subject to spill at any date and would be the first water in Shasta to spill.
- All operations associated with this exchange would be subject to river temperature constraints. This ensures there is no impact by reducing releases to store, and ensures a benefit when water is released later in the year.
- All operations are subject to approval by the State Water Resources Control Board and must comply with any applicable State or federal laws, regulations, or guidelines.

A post-processing analysis was performed for the 82-year simulation period of CalSim II to evaluate Shasta exchanges under a series of criteria that were assumed for the Sacramento River at Clear Creek, Keswick flow, Shasta storage, and water year types.

Figure 5-1 shows the exceedance probability of the annual volume of exchangeable water (TAF) for the nine scenarios evaluated. Overall, the annual exchange with Shasta ranges from 0 to 300 TAF for the scenarios with no Delevan Pipeline.

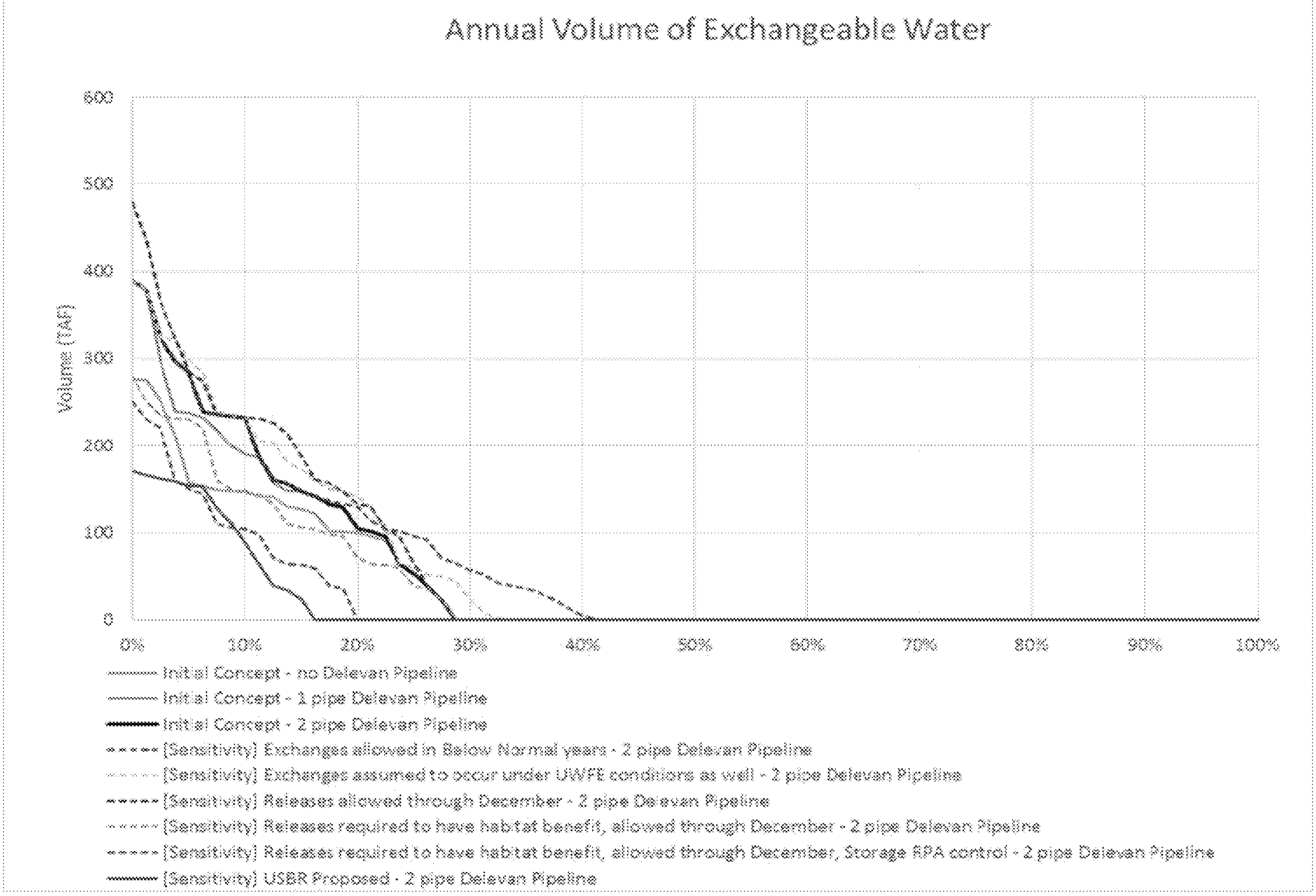


FIGURE 5-1. ANNUAL VOLUME OF EXCHANGEABLE WATER WITH SHASTA LAKE

5.4 Evaluation of T-C Canal Available Capacity

A screening analysis of historical daily diversion data was completed to estimate available capacity in the lower T-C Canal below Funks Reservoir for conveyance of releases from Sites Reservoir. Based on an approximation of the proportion of total T-C Canal diversions that were conveyed in the canal below Funks Reservoir, it appears the lower T-C Canal may have up to 1,000 cfs of available capacity for Project releases on an average monthly basis, during the peak summer diversion season when TCCA contractors receive a 100 percent contract allocation.

A check was then conducted to verify that the T-C Canal had enough available capacity to convey Sites releases to TCCA members, plus additional Sites releases to the Sacramento River. An analysis was conducted of Sites Reservoir monthly releases through the T-C Canal to the TCCA members using a 1,000 cfs conveyance capacity and three different storage capacities (1.0, 1.3, and 1.5 MAF). For this particular analysis, the releases assume no exchange with Shasta Lake. The results of this analysis indicate that simulated monthly Sites deliveries to T-C Canal members along the canal never exceed more than 500 cfs, while total deliveries through the T-C Canal, including South of Delta releases, rarely exceed 1,100 cfs. Based on this preliminary analysis, the lower T-C Canal appears to have sufficient capacity to convey CVP TCCA contractor deliveries, Sites releases to TCCA members, plus additional Sites releases to the Sacramento River, during the peak summer diversion season.

5.5 Evaluation of Colusa Basin Drain Available Capacity

The rate of flow from the Colusa Basin Drain into the Sacramento River through the Knight's Landing Outfall Gates (KLOG) depends on the differential stage in the Sacramento River and in the CBD at KLOG. The stage in the CBD at KLOG is dependent upon the operation of both KLOG and the Wallace Weir. The flow in the CBD has historically been difficult to measure due to backwater effects.

RD 108 completed an appraisal level assessment of historical flows through KLOG to estimate a range of flows that generally result in flooding of adjacent agricultural fields. Flooding was estimated to occur with flows ranging from 1,370 cfs to 2,220 cfs indicating that flows of 1,000 cfs from Sites are possible, though further analysis should be conducted.

Using the CBD for conveyance of Sites Reservoir water will include coordination with the local landowners regarding the project operation and timing of the additional flows. In order to understand how water released from Sites Reservoir could be moved through the CBD and into the Sacramento River at Knights Landing, the hydraulics between the CBD, KLOG, and Wallace Weir need to be investigated.

5.6 Operations Conclusions

Based on the preliminary analysis performed, the value planning alternatives with reservoir sizes of 1.3 to 1.5 MAF, including Scenario B Diversion Criteria, would be able to provide enough water to meet current participant demands. In addition, the use of the T-C Canal and the CBD as the conveyance systems appears possible based on preliminary analysis. Additional hydraulic analyses will be needed to confirm downstream conveyance conditions in the CBD, and the capacity of the T-C Canal downstream of Funks Reservoir should be confirmed. Discussions with Reclamation on non-investment exchanges with Shasta Lake are ongoing. Annual average Shasta Lake exchanges included with Scenario B analyses are estimated at about 60 TAF. While field verification and additional analysis are required, the value planning alternatives with reservoir sizes of 1.3 to 1.5 MAF appear feasible from an operations standpoint.

6. Environmental and Permitting Assessment of Alternatives

Appendix C summarizes considerations for the value planning effort from the environmental planning and permitting perspective and includes the following:

- Key differences between the value planning alternatives when compared with Alternative D, as described in the Draft EIR/EIS
- Species within the alternative's footprint that could potentially be affected through construction and operation of the Project
- Key permits and approvals required to construct and operate the Project, including any additional regulatory requirements beyond those identified in the Draft EIR/EIS
- Environmental planning considerations related to California Environmental Quality Act/National Environmental Policy Act (CEQA/NEPA) analysis
- Qualitative change in mitigation cost as compared with Alternative D
- A relative weighting associated with environmentally related criteria (and associated metrics) compared with Alternative D.

6.1 Environmental Permitting Assessment

The analysis of the value planning alternatives determined that the alternatives considered (Alternatives 1 through VP7) would result in little, if any, substantial change in timing or cost of key permits because of the same relative magnitude of impacts associated with the Project footprint and operations when compared with Alternative D. However, using the scoring methodology provided in Table 4 of Appendix C, obtaining permits from regulatory resource agencies for Alternatives 5a, 6a, VP1, VP2, VP5, and VP7 would be relatively easier because of the (1) reduced inundation areas (within reservoir footprint), (2) lack of a pipeline easement to the Sacramento River, (3) removal of the northern regulating reservoir facilities, and (4) shorter conveyance off the T-C Canal (to CBD).

6.2 Environmental Planning Assessment

The Draft EIR/EIS identified potentially significant environmental effects on aquatic, botanical, and terrestrial biological resources. However, with the exception of golden eagles, mitigation was identified to reduce effects to less than significant levels. Similarly, effects on wetlands and other jurisdictional waters were considered less than significant after implementation of proposed mitigation. However, the Draft EIR/EIS determined that Alternative D (as well as the other build alternatives) would result in potentially significant and unavoidable direct and indirect effects to (1) terrestrial biological resources (golden eagle), (2) paleontological resources, (3) cultural resources (historical and tribal resources, human remains), (4) land use (community of Sites and existing land uses), (5) air quality, (6) climate change and greenhouse gas emissions, and (7) growth-inducing impacts.

Appendix C provides CEQA/NEPA considerations for each alternative vetted during the value planning process. As with permitting, considerations were developed in a screening-level comparison to Alternative D. Table 6-1 briefly discusses the CEQA/NEPA considerations associated with each of the refined value planning alternatives identified on March 2, 2020. It should be noted that each of the value planning alternatives addressed below rely substantially on the use of existing conveyance facilities and minimize the need for new construction and associated ground disturbance, thereby reducing overall environmental effects.

TABLE 6-1. VALUE PLANNING CEQA/NEPA CONSIDERATIONS

Alternative	CEQA/NEPA Key Considerations
VP5 Alternate 1	Reduction in reservoir size may reduce effects on cultural, biological, and land use (agriculture) resources, but not to less-than-significant levels. Elimination of the Delevan pipeline or canal would potentially reduce land use (agricultural) effects, but effects would likely still be considered significant and unavoidable for the overall Project. Earthfill dam rather than rockfill dam would need to be analyzed for potential changes in environmental effects. Release from the southern terminus of the T-C Canal to the CBD would require additional study.
VP6 Alternate 1A	Similar to Alternative VP5, reduction in reservoir size may reduce effects on cultural, biological, and land use (agriculture) resources, but not to less-than-significant levels. Elimination of Delevan pipeline or canal would potentially reduce agricultural effects, but effects would likely still be considered significant and unavoidable for the overall Project. Release from the southern terminus of the T-C Canal would require additional study; the proposed Dunnigan pipeline to Sacramento River may affect federal project levees (though likely less than Alternative D). Earthfill dam rather than rockfill dam would need to be analyzed for potential changes in environmental effects.
VP7 Recommended	Similar to VP5 and VP6, reduction in reservoir size may reduce effects on cultural, biological, and land use (agriculture) resources, but not to less-than-significant levels. Elimination of Delevan pipeline or canal would potentially reduce agricultural effects, but effects would likely still be considered significant and unavoidable for the overall Project. Earthfill dam rather than rockfill dam would need to be analyzed for potential changes in environmental effects. Release from the southern terminus of the T-C Canal to the CBD would require additional study.

7. Costs and Repayment

7.1 Cost Estimates

Construction cost estimates were derived from detailed appraisal-level estimates for a 1.3 MAF reservoir (Alternative A in the EIR/EIS and feasibility report) and for a 1.8 MAF reservoir (Alternative D in the EIR/EIS and feasibility report). These estimates reflect the current Project concepts and conceptual level of Project design, with appropriate allowances for contingencies, non-contracts costs, and forward escalation. Other project-related costs are also provided, including environmental mitigation and temporary and permanent easement acquisition. Estimated prices were developed in October 2015 dollars in support of the Authority's

WSIP application and have been escalated in this estimate. Additional details on the estimate are provided in Appendix A.

7.2 Repayment Analyses

7.2.1 Methodology

A repayment analysis based on the estimated construction, operations, and maintenance costs, and the estimated releases, was conducted to estimate the annual repayment costs per AF of releases from Sites Reservoir. The analysis was conducted both with and without a Water Infrastructure Finance and Innovation Act (WIFIA) loan. The methodology was very similar to prior value planning analysis conducted in late 2019 and as described in the full financial model technical memorandum in Appendix D. One item of significant note is that the reporting base year has changed versus that analysis, resulting in an increase of cost per acre-feet due to inflation. Participants' annual costs are provided in 2020 dollars. When comparing with the prior metric of using 2018 dollars, a $600/AF cost at a 2% inflation rate will add approximately $25 by reporting in 2020 dollars.

7.3 Key Assumptions

The analysis was conducted using the full amount of the U.S. Department of Agriculture (USDA) loan available to construct the Maxwell Intertie. This loan of $439 million is at a lower interest rate (3.85 percent) than the revenue bond assumed interest rate (5.00 percent). This analysis assumes that Project changes would not affect the terms of the USDA loan. The use of the USDA loan results in an overall reduction in the cost by approximately $20 per acre-foot. A full table of assumptions is provided in Appendix D.

7.4 Repayment Results

The ability to reduce project costs to approximately $3 billion while still constructing a 1.5 MAF reservoir and thereby maintaining higher releases (ranging from 230 to 243 TAF of average annual releases) results in a reduction in the dollar per acre-feet repayment down to the $600 range in 2020 dollars. This range of payments – which is lower than the VP1 through VP4 alternatives - can be seen in the VP5, VP6, and VP7 scenarios (Table 7-1). A cash flow tool, including operations and maintenance costs and annualized debt service, is included as Attachment D-2.

TABLE 7-1. ANNUAL REPAYMENT COSTS PER ACRE-FOOT OF RELEASE

	VP1			**VP2**			**VP3**		**VP4**		**VP5**	**VP6**	**VP7**
Reservoir Size (MAF)	1.0	1.3	1.5	1.0	1.3	1.5	1.3	1.5	1.3	1.5	1.3	1.3	1.5
Release Capacity (cfs)	750			750			1,500		1,000		1,000	1,000	1,000
Project Cost (2019 $, billions)	3.2	3.4	3.6	2.7	2.9	3.1	3.4	3.6	2.9	3.1	2.9	3.0	3.0
Annualized acre-feet/year Release (TAF)	191	230	236	191	230	236	243	253	234	243	234	234	243
PWA Annual Costs During Repayment Without WIFIA[a] Loan (2020 $, $/acre-feet)	862	776	805	730	667	693	738	754	660	678	644	674	661
PWA Annual Costs During Repayment With WIFIA Loan (2020 $, $/acre-feet)	799	724	755	665	614	641	689	708	608	628	592	621	611

[a] Water Infrastructure Finance and Innovation Act

8. Recommended Project

The recommended Project was developed by the Ad Hoc Value Planning Workgroup through a sequential process that included initial and refined alternatives. Important considerations included total project cost, impacts on landowners, impacts on traffic and public safety, ability to meet participant demands, ability to provide public benefits to the State, relative magnitude of environmental impacts, and the estimated cost per acre-foot of water delivered. The recommended Project and two options for consideration are shown in Table 8-1.

TABLE 8-1. VALUE PLANNING GROUP RECOMMENDED PROJECTS

	VP5	**VP6**	**VP7**
	Option 1	**Option 2**	**Recommended**
Reservoir Size	1.3 MAF	1.3 MAF	1.5 MAF
Dunnigan Release Capacity (cfs)	1,000 cfs to CBD	1,000 cfs to River	1,000 cfs to CBD
Estimated Cost (2019 dollars)	$2,855,000,000	$2,988,000,000	$3,037,000,000
Estimated Cost per Acre-Foot with WIFIA[a] (2020)	$592	$621	$611
Estimated Deliveries (Long-Term Average in TAF)	234	234	243

[a] Water Infrastructure Finance and Innovation Act

The recommended project (Alternative VP7) includes a 1.5 MAF reservoir to provide additional storage for dry and critical years. All options include a bridge to minimize travel times and provide emergency access for communities on the west side of the reservoir. The bridge for all options was sized based on the maximum water surface elevation for a 1.5 MAF facility to avoid future traffic impacts that could arise if climate change or other factors necessitated expanding a smaller reservoir. All alternatives also include a new unpaved road to maintain access for residents along the southern portion of the reservoir.

All options, including the recommended alternative, would release water through the T-C Canal. A 1,000 cfs release near the end of the canal would deliver water to either the CBD (Alternatives VP5 and VP7) or to the Sacramento River (Alternative VP6).

The Value Planning Workgroup recommends the Project proceed as Alternative VP7. Although Alternative VP5 had the lowest overall cost and lower cost per acre-foot, the Value Planning Workgroup recommends VP7 based on higher deliveries at a comparable cost and improved operational flexibility with a 1.5 MAF reservoir. The proposed facility locations associated with VP7 are shown in Figure 8-1.

The Value Planning Workgroup also recommends the subsequent analyses of the Project include a 1.3 MAF reservoir (per VP5) and a Dunnigan to Sacramento River 1000 cfs release pipeline (per VP6) in order to provide flexibility to respond to any future condition changes that might result in such facilities becoming preferable.

The Recommended Project results in the following significant changes to the original Alternative D 1.8 MAF Project:

- Reduced project size and footprint
- Reduced Sacramento River diversions
- Elimination of Delevan Sacramento River diversion and release facility
- Elimination of Delevan Pipeline and associated impacts to landowners and wildlife refuges along that alignment
- Reduced costs and improved affordability to the Project's funding participants.

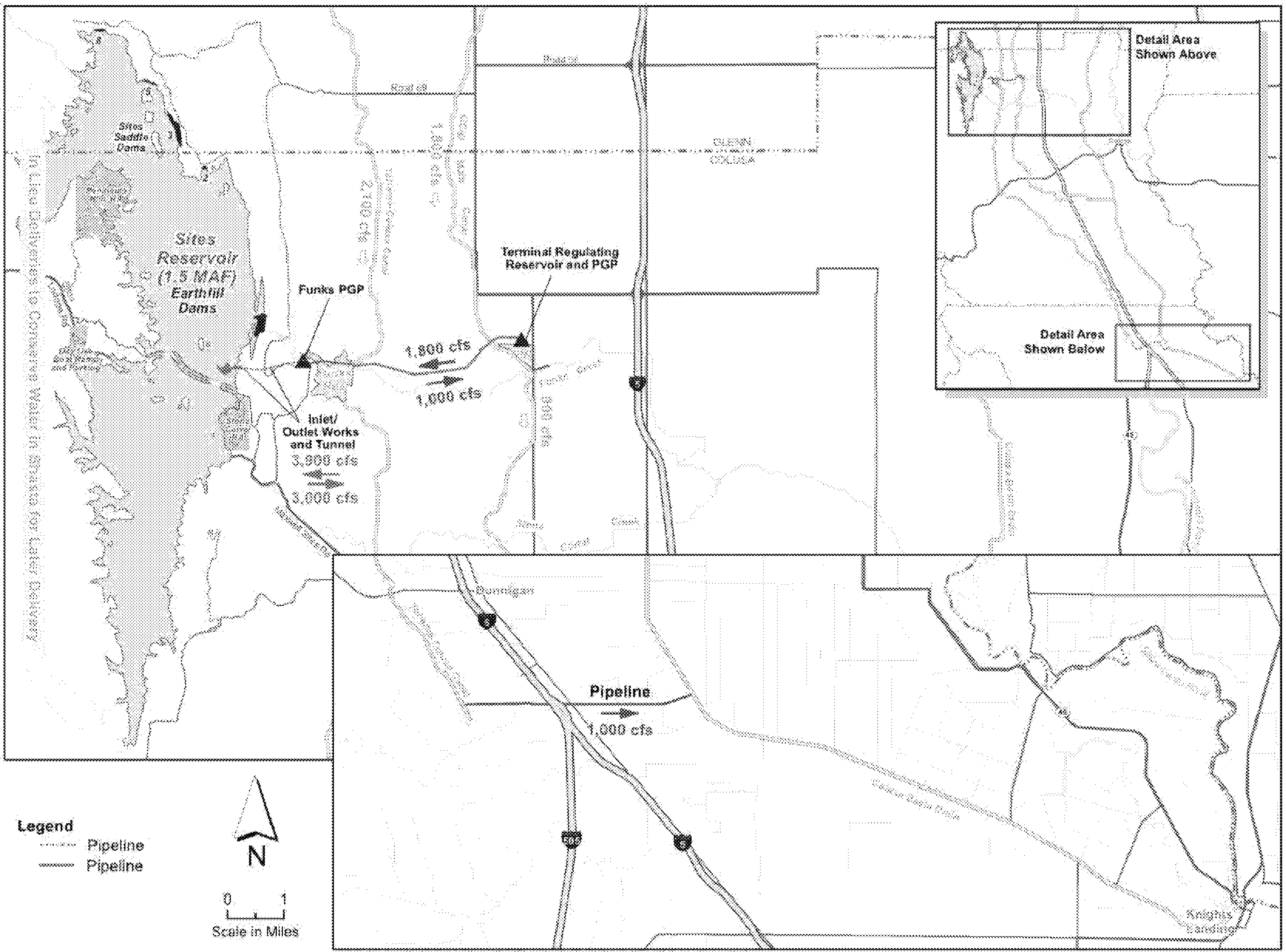


FIGURE 8-1. RECOMMENDED VALUE PLANNING ALTERNATIVE (VP7)

This page is intentionally blank.

Appendix A – Value Planning Alternatives and Costs

Value Planning Analysis Technical Memorandum

Sites
Program Management Team

To: Mike Azevedo, Lewis Bair, Thad Bettner, Gary Evans, Rob Kunde, Shelly Murphy, Randall Neudeck, Dan Ruiz, Jeff Sutton, Jamie Traynham, Bill Vanderwaal

CC: Rob Tull

Date: November 13, 2019

From: Joe Barnes, Jeff Herrin, Pete Rude (Jacobs), Jeff Smith (Jacobs)

1.0 Value Planning Effort

Representatives from the Reservoir Committee and Authority Board met on October 2, 2019 to discuss approaches that could potentially lower the cost of the project. Several facility modifications were identified, and appraisal level costs are provided in this analysis to allow a comparison of alternatives.

At this level of evaluation, the analysis is useful for identifying alternatives that merit further evaluation. The analysis is not sufficiently refined to distinguish between two alternatives of similar cost (e.g., + 10 to 15%).

Construction cost estimates for many of the facilities were derived from appraisal-level estimates for a 1.3 million acre feet (MAF) reservoir (Alternative A in the Environmental Impact Report/Environmental Impact Statement [EIR/S] and feasibility report) and for a 1.8 MAF reservoir (Alternative D in the EIR/S and feasibility report). Several new facilities were estimated, where possible using the unit rates from similar facilities in the existing estimates. Estimated prices were developed in October 2015 dollars and have been escalated in this estimate.

The actual project construction cost ultimately would depend on the final design details of the preferred project alternative and the labor and material costs, market conditions, and other variable factors existing at the time of bid. Accordingly, the final project cost is expected to vary from the preliminary estimates presented in this section.

2.0 General Limitations

AECOM represents that our services were conducted in a manner consistent with the standard of care ordinarily applied as the state of practice in the profession within the limits prescribed by our client. No other warranties, either expressed or implied, are included or intended in this brief appraisal-level cost estimate.

We have used background information, conceptual designs, and data by others to prepare this appraisal-level cost estimate. We have relied on this information, as furnished, and is neither responsible for nor has confirmed the accuracy of this information.

The appraisal-level cost estimate presented herein is for the current study only and should not be extended or used for any other purposes.

3.0 Value Planning Facility Options and Alternatives

The meeting on October 2, 2019 identified both modifications to previously evaluated facilities and alternative facilities to reduce cost. A comprehensive table showing approximately 59 facility options that were considered in this analysis, along with their respective costs, is provided in Attachment 2.

There are numerous ways of combining the individual facility options into alternatives. To speed the analysis, we have looked at nine complete alternatives. There are many other ways of combining the facilities that can be further evaluated at the direction of the Value Planning working group.

The initial alternatives are shown in Table 1.

Table 1. Initial Alternatives for consideration.

Features	**Initial Alternatives**								
	1	**2**	**3**	**4a**	**4b**	**5a**	**5b**	**6a**	**6b**
1.5 MAF Reservoir	•	•	•	•	•	•	•	•	
1.3 MAF Reservoir									•
Funks/Sites PGP	•	•		•	•	•	•		
TCRR and Upgraded TRR PGP			•					•	•
Delevan Canal/Pipeline Release	•	•	•	•	•				
Dunnigan Canal to CBD Release						•		•	
Dunnigan to River Release							•		•
Multi-Span Bridge	•		•	•	•	•	•	•	•
South Road to Lodoga		•							
South Road to Residents	•		•	•	•	•	•	•	•
Rockfill Embankment Dam	•	•	•			•	•		
Earthfill Dam				•				•	•
Hardfill Dam					•				

MAF = million acre feet
PGP = Pumping/Generating Plant
TCRR = Tehama-Colusa Regulating Reservoir
TRR = Terminal Regulating Reservoir

For purposes of comparison, we have included Alternative D, the alternative presented in the WSIP application in the comparison of alternatives. The new alternatives include the following:

- Alternative 1 – Refer to Figure 1. This alternative reduces the size of the reservoir to 1.5 MAF and uses a multi-span bridge to reduce costs. The other features are generally consistent with Alternative D.

- Alternative 2 – Refer to Figure 2. This alternative is very similar to Alternative 1 but uses the southern road with the more direct route to Lodoga in place of the bridge.

- Alternative 3 – Refer to Figure 3. This alternative eliminates the Sites Pumping/Generating Plant and replaces it with the Tehama-Colusa Regulating Reservoir (TCRR) and Pumping Plant near Road 69 in combination with an upgraded Terminal Regulating Reservoir (TRR) to fill Sites Reservoir. Water would be released to the Sacramento River through a canal/pipeline to the Delevan release structure. The canal portion would begin at the TRR and continue east to the Colusa Basin Drain (CBD). It would be necessary to siphon under the CBD and pump the water to the river. The two-span bridge is used in this alternative.

- Alternatives 4a and 4b – Refer to Figures 4a and 4b. These alternatives include the single Sites Pumping/Generating Plant (PGP) with releases through the Delevan Canal/Pipeline. Alternative 4a uses an earthfill dam and Alternative 4b uses a hardfill dam in place of the zoned rockfill dam.
- Alternatives 5a and 5b – Refer to Figures 5a and 5b. These alternatives replace the Delevan Canal/Pipeline with a southern release near the southern terminous of the Tehama-Colusa (T-C) Canal. Alternative 5a releases water to the CBD. Water released to the CBD would be conveyed through the lower portion of the CBD to the Sacramento River. Alternative 5b conveys water by canal to the CBD, then uses a siphon and pumping plant to convey water on to the river.
- Alternatives 6a and 6b – Refer to Figures 6a and 6b. These alternatives combine the TCRR and upgraded TRR with the southern release structure and an earthfill dam. Alternative 6a appears to have the lowest construction cost.

A summary of alternative costs, including a cost comparison with Alternative D, is included in Table 2.

Table 2. Summary of Estimated Costs

Alternative	**Estimated Costs ($2018) (financing cost not included)**	**Cost Reduction from Alternative D**
Alternative D	$5,235 million	0%
Alternative 1	$3,970 million	24%
Alternative 2	$3,988 million	24%
Alternative 3	$3,868 million	26%
Alternative 4a	$3,828 million	27%
Alternative 4b	$3,861 million	26%
Alternative 5a	$3,548 million	32%
Alternative 5b	$3,876 million	26%
Alternative 6a	$3,417 million	35%
Alternative 6b	$3,584 million	32%

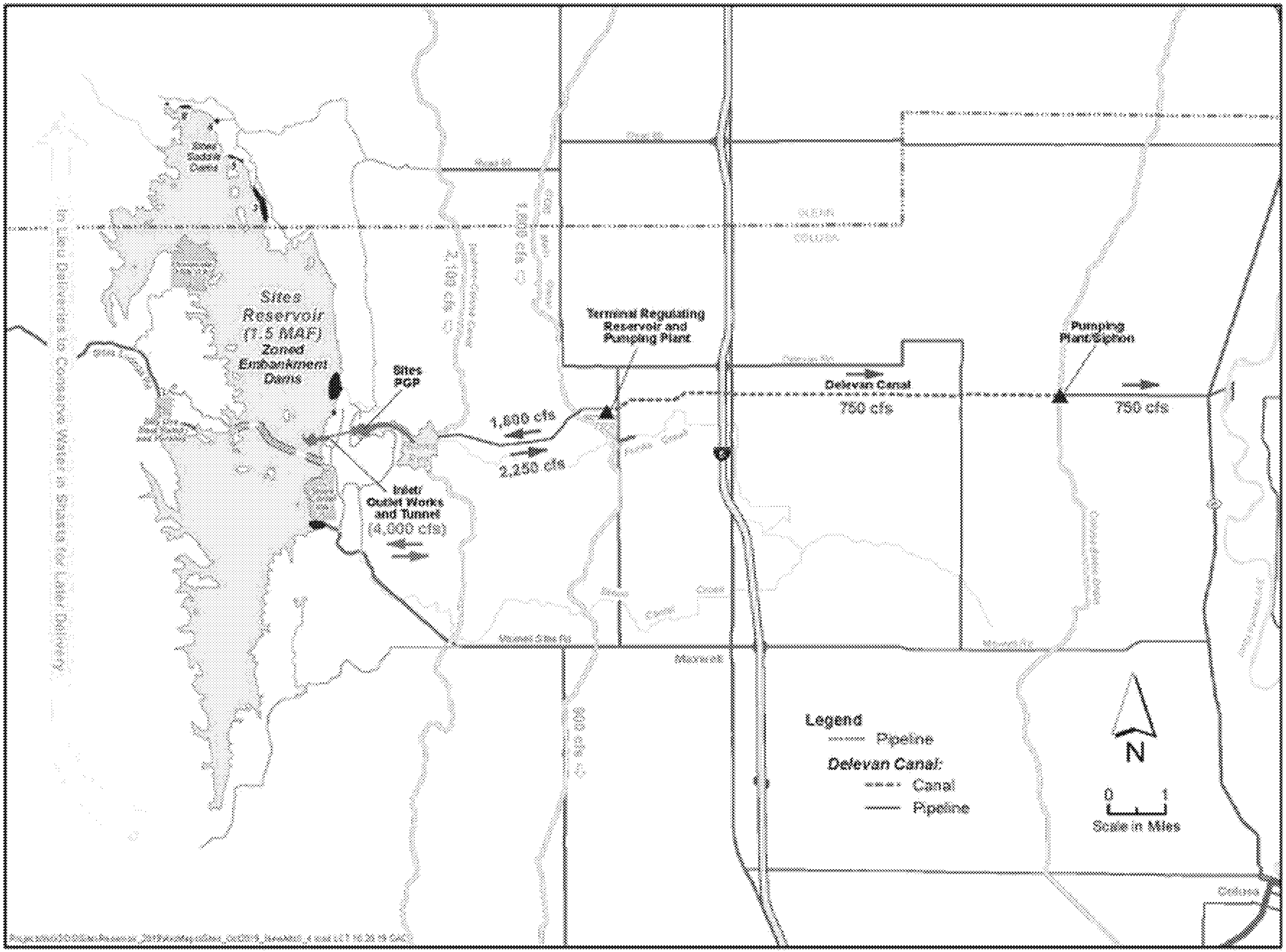


Figure 1. Alternative 1 (Estimated cost - $3,970 million)

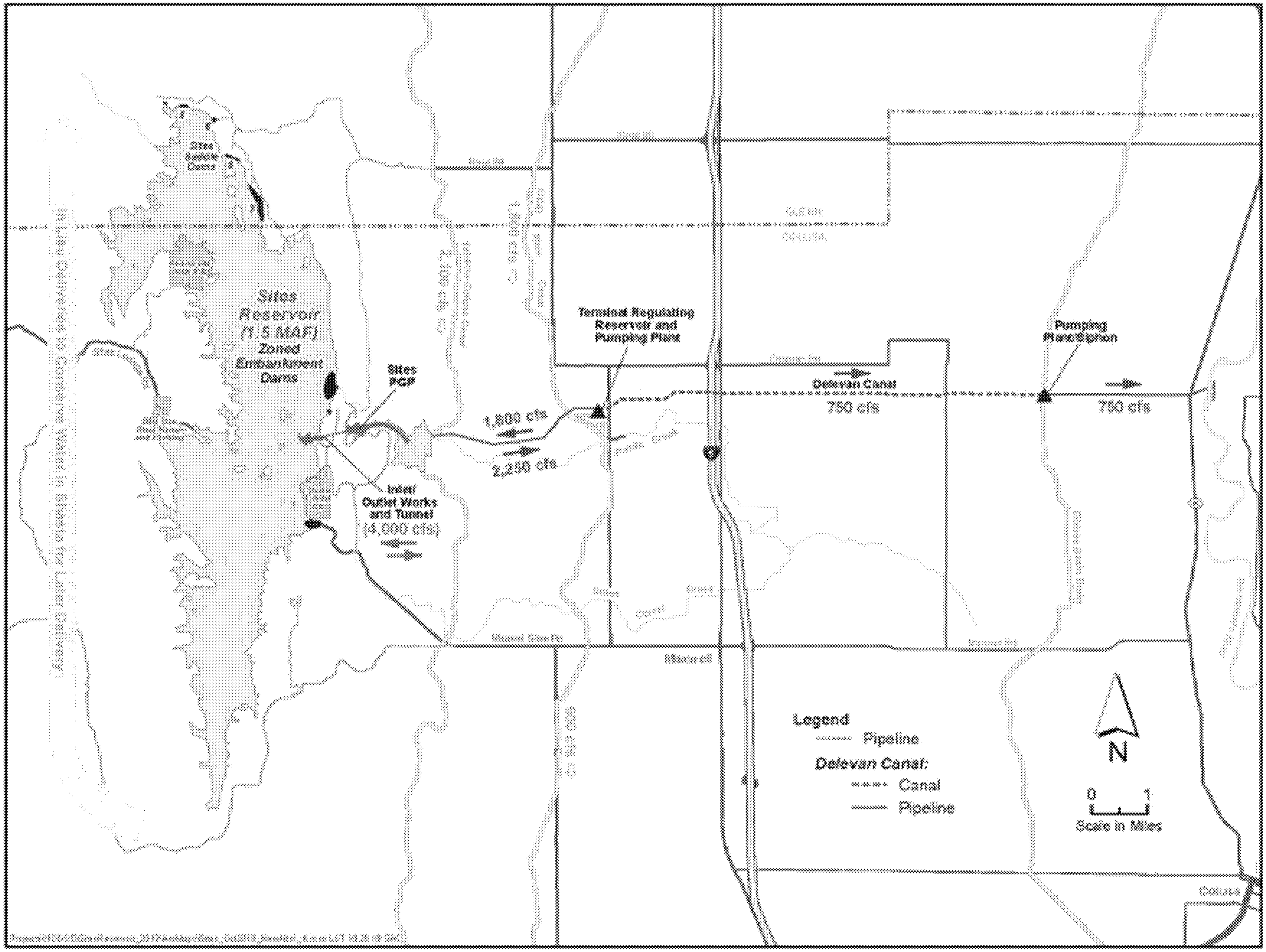


Figure 2. Alternative 2 (Estimated cost - $3,988 million)

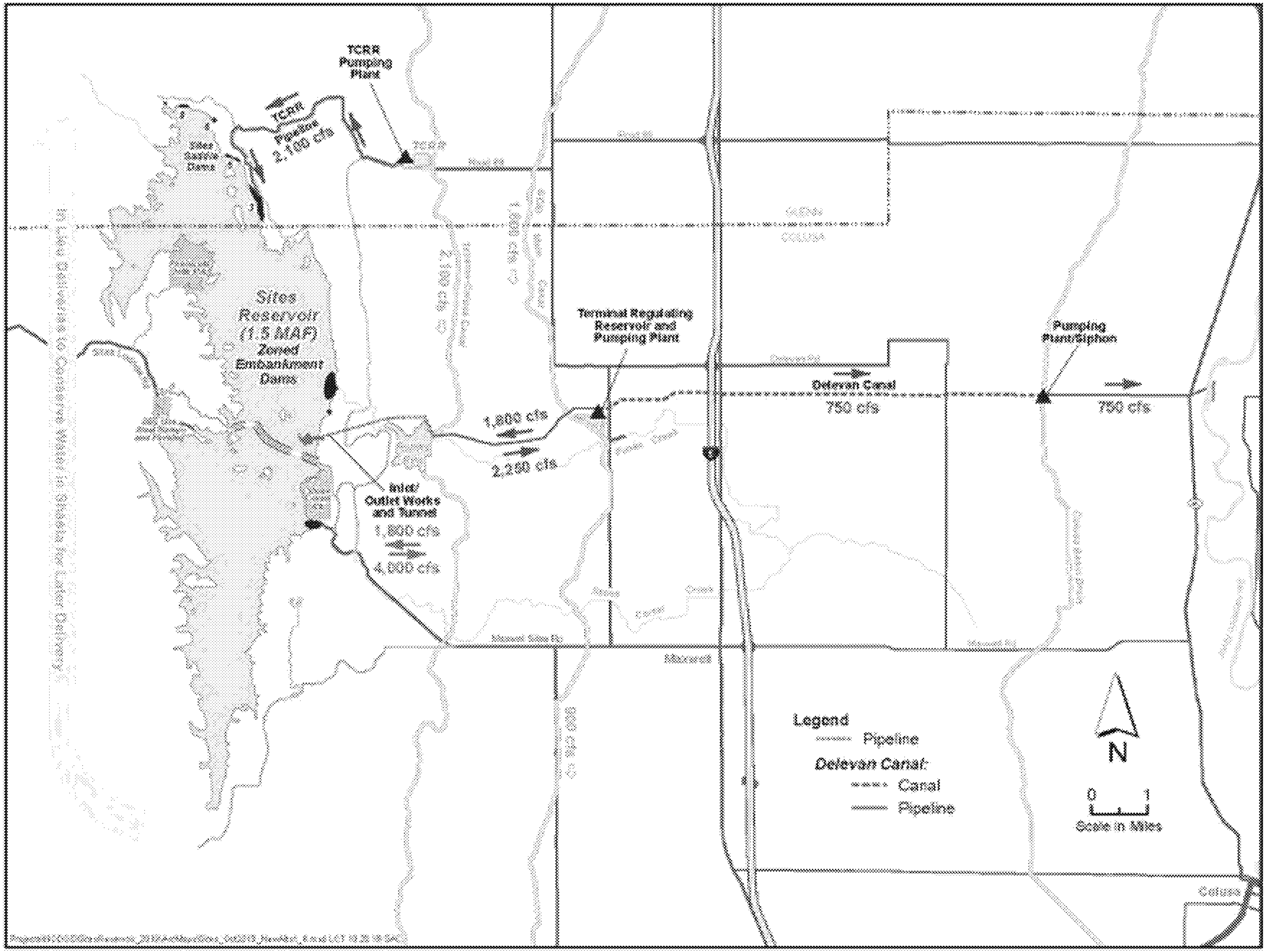


Figure 3. Alternative 3 (Estimated cost - $3,868 million)

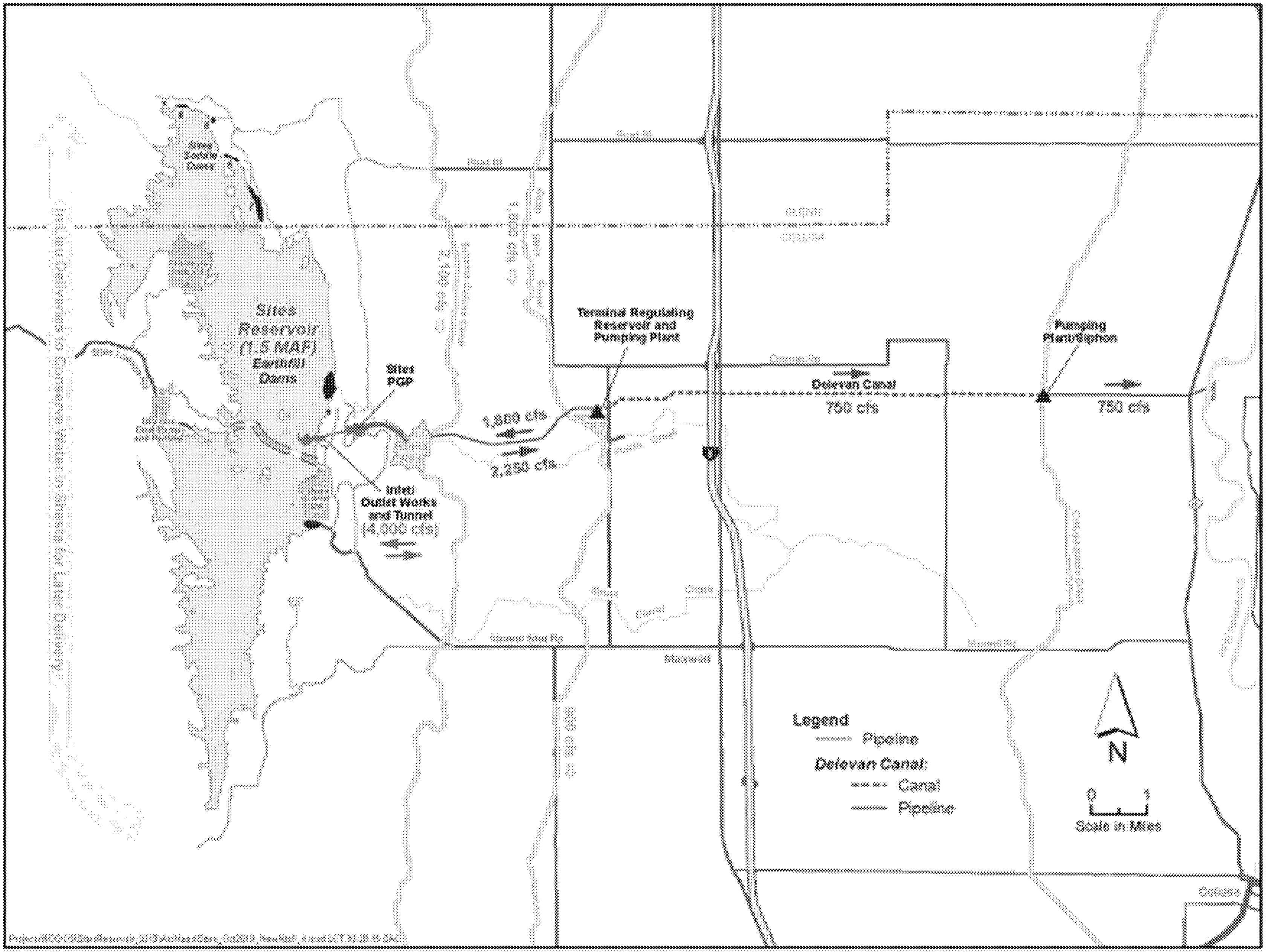


Figure 4a. Alternative 4a (Estimated cost - $3,828 million)

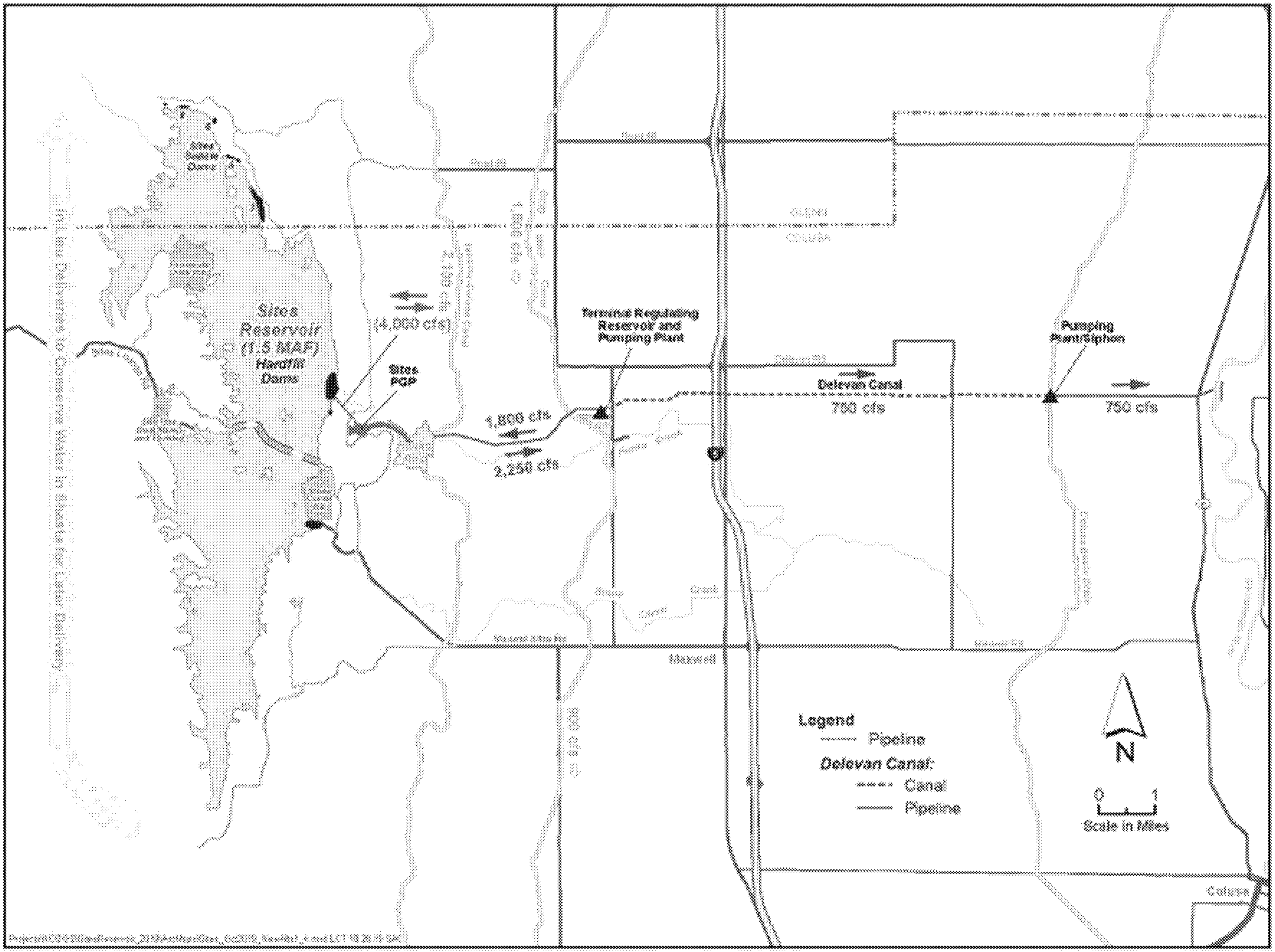


Figure 4b. Alternative 4b (Estimated cost - $3,861 million)

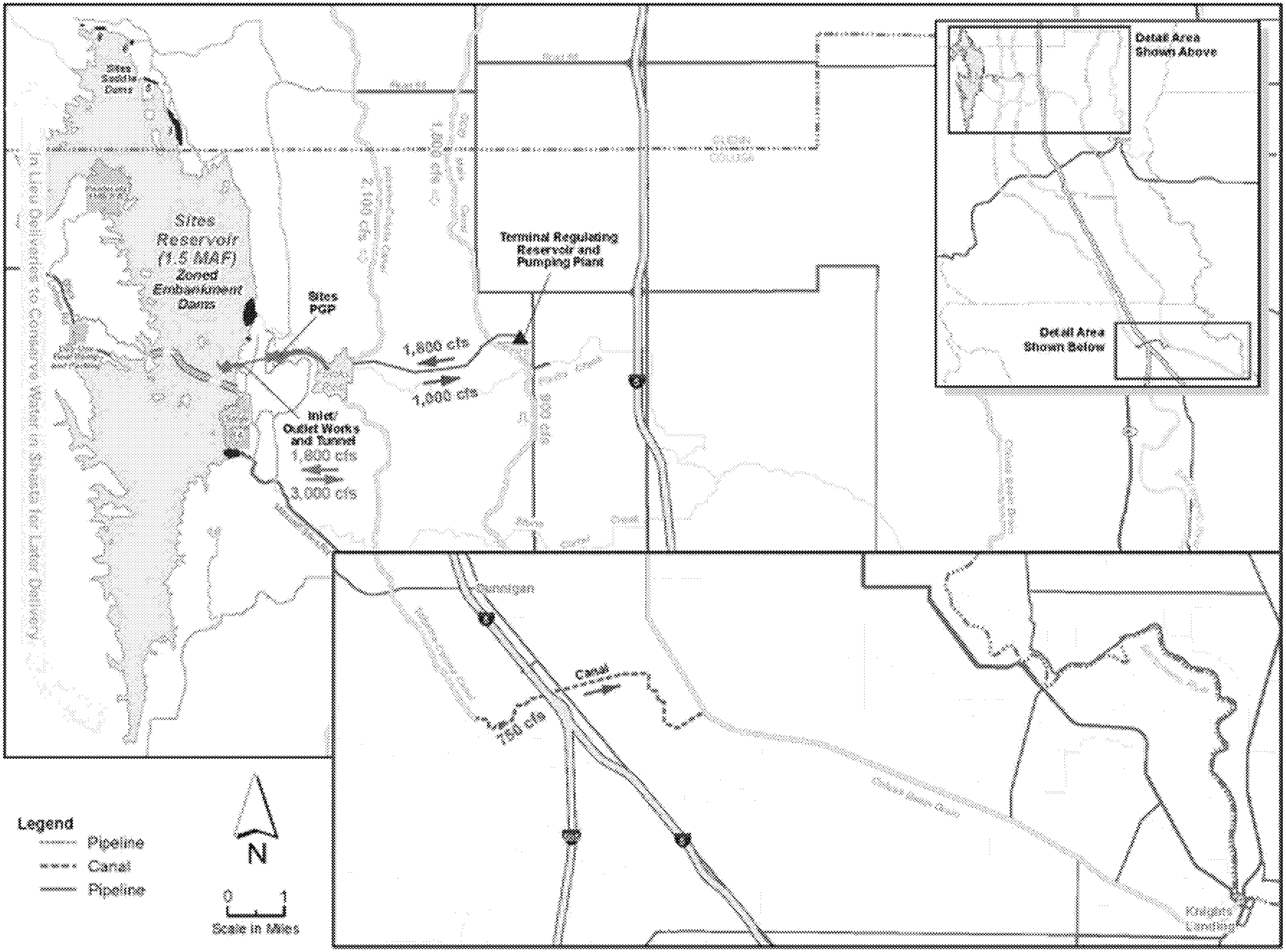


Figure 5a. Alternative 5a (Estimated cost - $3,548 million)

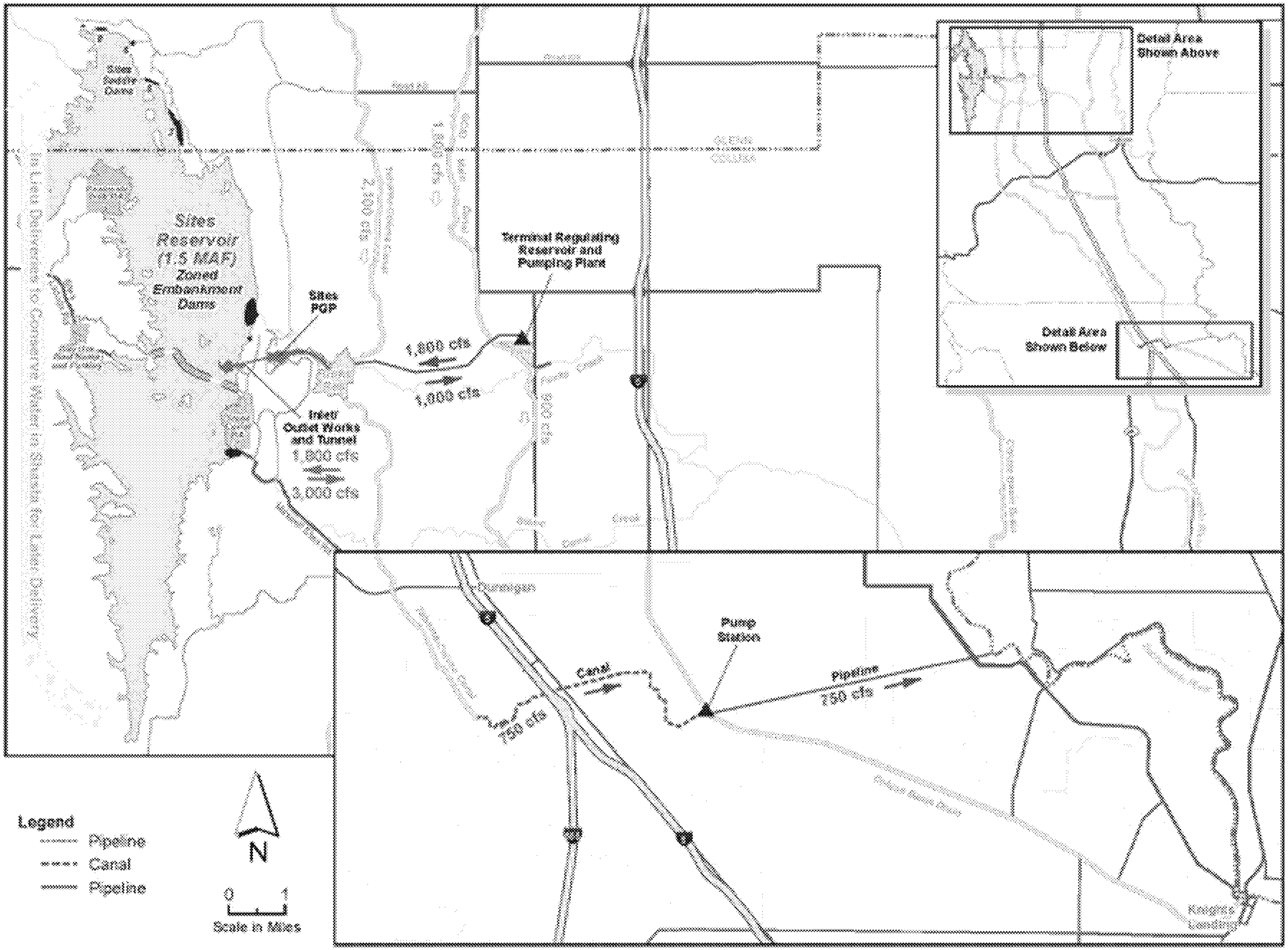


Figure 5b. Alternative 5b (Estimated cost - $3,876 million)

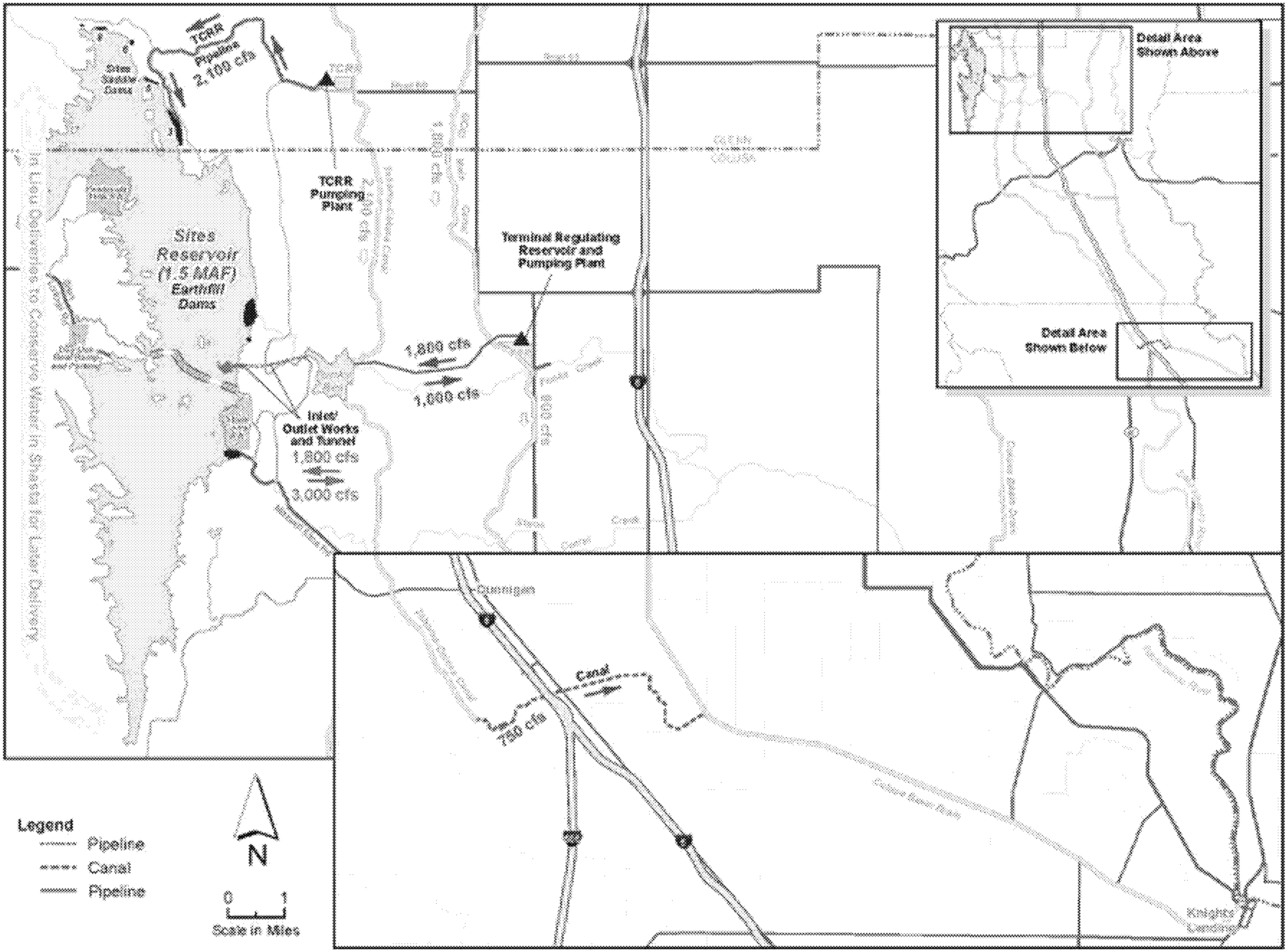


Figure 6a. Alternative 6a (Estimated cost - $3,417 million)

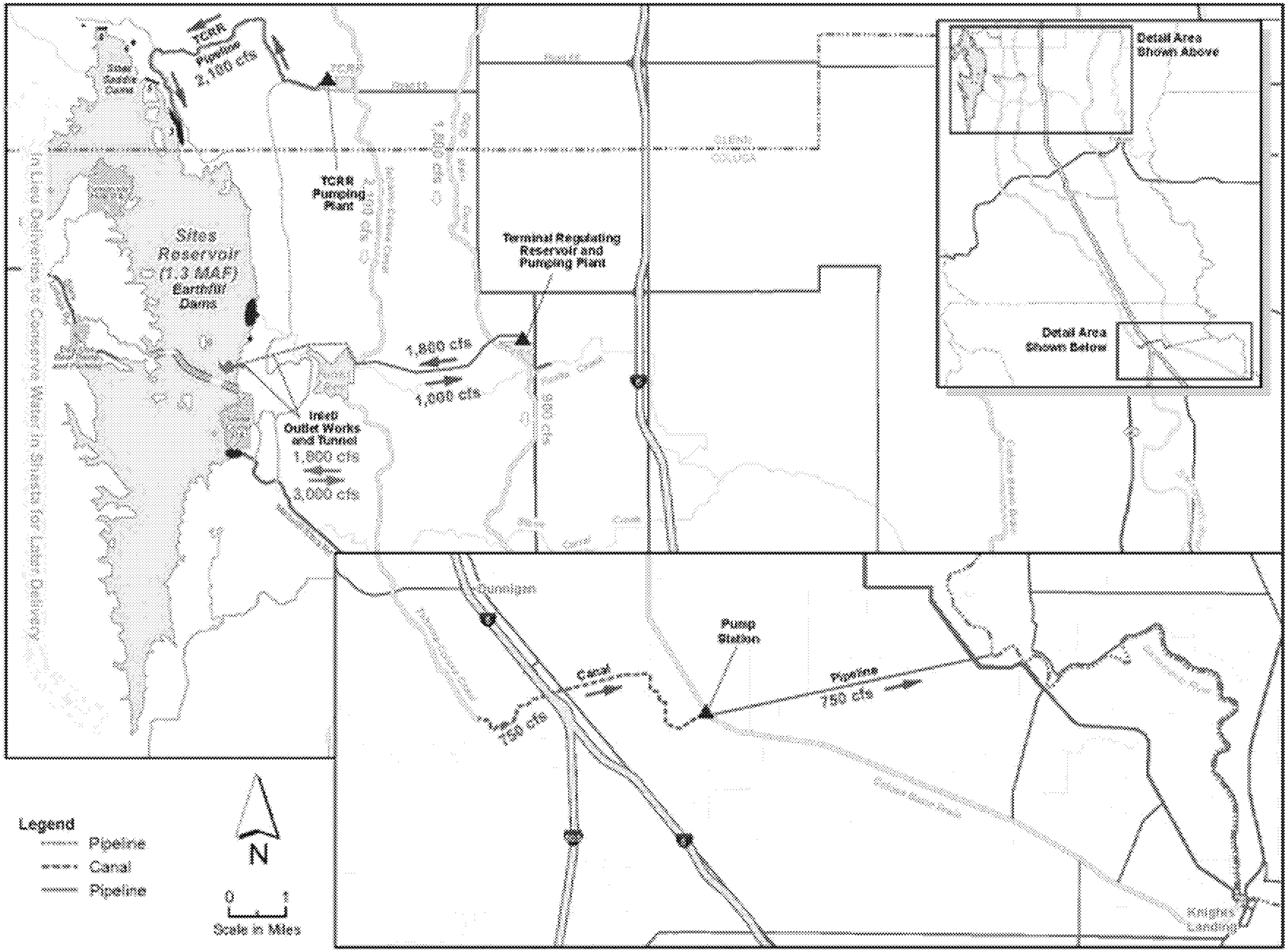


Figure 6b. Alternative 6b (Estimated cost - $3,584 million)

4.0 Environmental Mitigation

HDR reviewed the existing mitigation cost estimates currently being used and found that when applied to the Value Planning Alternatives, the estimated mitigation costs do not result in any significant changes in estimated mitigation costs (>$50M). Their October 11, 2019 memorandum concluded that until additional analysis can be performed on a specific project description, the existing $500M estimate should be retained.

5.0 Emergency Reservoir Drawdown

It is proposed to distribute the emergency reservoir release flow required by the State of California Department of Water Resources, Division of Safety of Dams (DSOD) to different locations around Sites Reservoir. For the alternative project evaluation, it is assumed that these release points would include Hunters Creek, Stone Corral Creek, Funks Creek, the Glenn-Colusa Irrigation District (GCID) and T-C Canals, and an open channel that would connect the TRR with the CBD. For the channel, it is assumed that emergency release water would be conveyed to TRR through the TRR Pipeline.

The emergency release flow required is a function of the size of Sites Reservoir. DSOD requires that 10-percent of the height of the reservoir must be reduced over a period of seven days. Table 3 provides an estimate of the average 7-day emergency release flow required for various reservoir sizes to meet the criteria. Also shown in the table is AECOM's assumed distribution of the required release to the creeks and canals listed above. Additional evaluation of the downstream watersheds and the downstream impacts will be needed to refine the distribution of releases between the candidate release points.

Regarding the canal to the CBD, AECOM assumes that the capacity would be between 750 and 1,000 cubic feet per second (cfs), which would be the equivalent release for one of the two 12-foot-diameter Delevan Pipes. A flow of 1,000 cfs is used in the table. In distributing the remaining flows as shown in the table, the following assumption were made:

1. The flows allocated to Stone Corral Creek and Funks Creek are approximately equivalent to 50-year flows estimated from published regression curves for Coastal Range areas. These flows are estimated at the Sites and Golden Gate Dams.

2. The flows allocated to the GCID and TC Canals represent minimum spare capacity that could be available to convey emergency releases. Capacity could be higher during certain time of the year.

3. After accounting for the releases described above, the balance of the required release was assigned to Hunters Creek at the north end of the valley. This release could be distributed to two or three of the larger saddle dams at the north end of Sites Reservoir, which are adjacent to Hunters Creek, or are on tributaries. At each release point, an outlet works pipeline would be provided at the base of the dam with energy dissipation valve(s) at the downstream end.

4. The release to Hunters Creek is sizeable. One feasible approach to reduce impacts would be to provide a dry dam on the creek with sized outlet works that would use storage routing to reduce the flow released to the creek downstream. There is at least one suitable site for such a dam on the creek where it passes out of the eastern ridge into the valley. This is not included with this cost estimate.

Also shown on the Table 3 is the estimated size of the twin outlet works tunnels required to pass the water being released to Funks Creek, the GCID and T-C canals, and the canal to the CBD. Tunnel size is based on the assumed distribution of the required emergency release to the various discharge points.

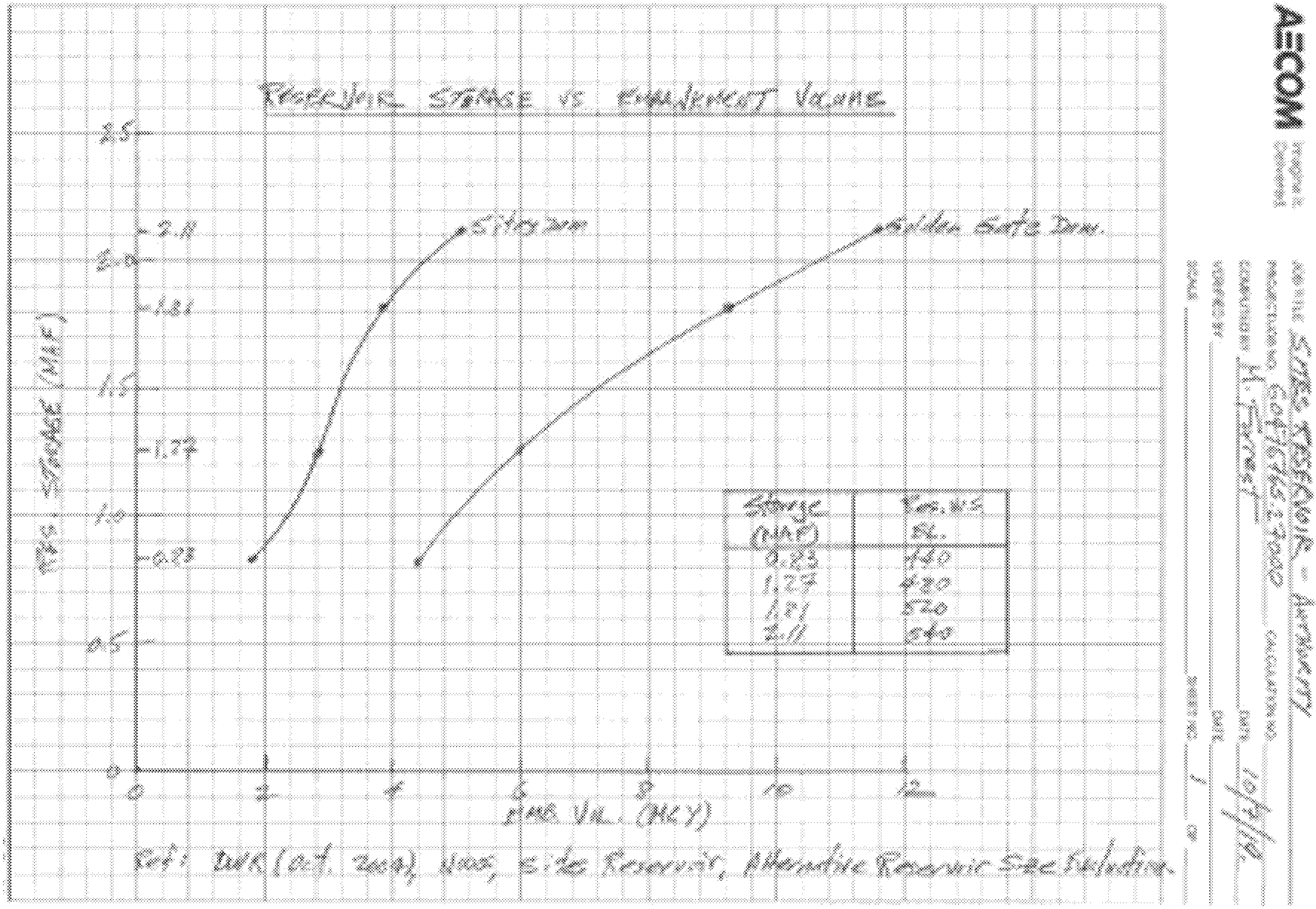
Table 3. Emergency Release – Assumed Distribution of Flows

Reservoir Size	**1.8 MAF**	**1.5 MAF**	**1.3 MAF**	**1.0 MAF**	**0.8 MAF**
Emergency Release Required (cfs)	21,700	17,950	15,450	12,000	9,650
Stream Releases (cfs)					
Hunters Creek Release Structure	11,250	7,500	5,000	4,500	3,000
Stone Corral Creek	3,500	3,500	3,500	3,500	3,500
Total =	14,750	11,000	8,500	8,000	6,500
Remaining Release Required =	**6,950**	**6,950**	**6,950**	**4,000**	**3,150**
I/O Tower and Tunnel Releases					
Funks Creek	4,500	4,500	4,500	2,550	3,150
GCID Main Canal	700	700	700	700	0
T-C Canal	750	750	750	750	0
Canal Conveyance to Colusa Basin Drain	1,000	1,000	1,000	0	0
Total =	6,950	6,950	6,950	4,000	3,150
I/O Tunnel Required Release (cfs) =	**6,950**	**6,950**	**6,950**	**4,000**	**3,150**
Estimated Twin I/O Tunnel Sizes (feet) for 20 feet per second (fps) maximum velocity (ft) =	**15**	**15**	**15**	**11**	**10**

6.0 Attachments

	Component Cost	Alternative D	Alternative 1	Alternative 2	Alternative 3	Alternative 4a	Alternative 4b	Alternative 5a	Alternative 5b	Alternative 6a	Alternative 6b
Total ($2018) w/o financing cost		$5,234,596,920	$3,969,916,920	$3,988,276,920	$3,868,396,920	$3,828,436,920	$3,860,836,920	$3,547,636,920	$3,875,956,920	$3,416,956,920	$3,584,356,920
% cost reduction		0%	24%	24%	26%	27%	26%	32%	26%	35%	32%
Total ($2015)		$4,846,849,000	$3,675,849,000	$3,692,849,000	$3,581,849,000	$3,544,849,000	$3,574,849,000	$3,284,849,000	$3,588,849,000	$3,163,849,000	$3,318,849,000
RESERVOIRS AND DAMS											
Develop Sites Reservoir Area	$255,000,000	$255,000,000	$255,000,000	$255,000,000	$255,000,000	$255,000,000	$255,000,000	$255,000,000	$255,000,000	$255,000,000	$255,000,000
Single Span Bridge	$215,000,000	$215,000,000									
Short Span Bridges	$125,000,000		$125,000,000		$125,000,000	$125,000,000	$125,000,000	$125,000,000	$125,000,000	$125,000,000	$125,000,000
Lodoga Road (Long Route)	$114,000,000										
Lodoga Road (Direct Route)	$180,000,000			$180,000,000							
South Road Property Access	$36,000,000		$36,000,000		$36,000,000	$36,000,000	$36,000,000	$36,000,000	$36,000,000	$36,000,000	$36,000,000
Construct Main Dams (1.8 MAF) - Zoned Embankment	$610,000,000	$610,000,000									
Construct Main Dams (1.5 MAF) - Zoned Embankment	$511,000,000		$511,000,000	$511,000,000	$511,000,000			$511,000,000	$511,000,000		
Construct Main Dams (1.5 MAF) - Earthfill	$380,000,000					$380,000,000				$380,000,000	
Construct Main Dams (1.5 MAF) - Hardfill	$690,000,000						$690,000,000				
Construct Main Dams (1.3 MAF) - Zoned Embankment	$400,000,000										
Construct Main Dams (1.3 MAF) - Earthfill	$320,000,000										$320,000,000
Construct Saddle Dams (1.8 MAF)	$270,000,000	$270,000,000									
Construct Saddle Dams (1.5 MAF)	$183,000,000		$183,000,000	$183,000,000	$183,000,000	$183,000,000	$183,000,000	$183,000,000	$183,000,000	$183,000,000	
Construct Saddle Dams (1.3 MAF)	$94,000,000										$94,000,000
Construct Forebay/Afterbay (Fletcher/Holthouse)	$190,000,000	$190,000,000									
Funks Reservoir Structures/Dredging	$22,000,000		$22,000,000	$22,000,000		$22,000,000	$22,000,000	$22,000,000	$22,000,000		
Construct TRR Reservoir	$39,000,000	$39,000,000	$39,000,000	$39,000,000	$39,000,000	$39,000,000	$39,000,000	$39,000,000	$39,000,000	$39,000,000	$39,000,000
North T-C Regulating Reservoir	$39,000,000				$39,000,000					$39,000,000	$39,000,000
Hunters Creek Release Structures (at 3 Saddle Dams)	$84,000,000		$84,000,000	$84,000,000	$84,000,000	$84,000,000	$84,000,000	$84,000,000	$84,000,000	$84,000,000	$84,000,000
PUMPING AND GENERATING PLANTS											
Construct I/O Structure and Single 30' Diameter Tunnel	$210,000,000	$210,000,000					$0				
Construct I/O Struture and Twin 15" Diameter Tunnels	$280,000,000		$280,000,000	$280,000,000	$280,000,000	$280,000,000	$0	$280,000,000	$280,000,000	$280,000,000	$280,000,000
Sites Pumping-Generating Plant (5,900 cfs) - with Delevan	$800,000,000	$800,000,000									
Sites Pumping-Generating Plant (4,000 cfs) - w/o Delevan	$634,000,000		$634,000,000	$634,000,000		$634,000,000	$634,000,000	$634,000,000	$634,000,000		
T-C North Pumping Plant - 2100 cfs	$185,000,000				$185,000,000					$185,000,000	$185,000,000
TRR Pumping-Generating Plant - 1800 cfs	$160,000,000	$160,000,000	$160,000,000	$160,000,000		$160,000,000	$160,000,000	$160,000,000	$160,000,000		
Increased Head TRR PumpGen Plant - 1800 cfs	$185,000,000				$185,000,000					$185,000,000	$185,000,000
CBD Pumping Plant for Delevan Release (750 cfs)	$34,000,000		$34,000,000	$34,000,000		$34,000,000	$34,000,000				
Sacramento River Pumping-Generating Plant (2000 cfs)	$260,000,000	$260,000,000									
Sacramento River Release Structure - 1500 cfs	$16,000,000										
Sacramento River Release Structure - 750 cfs	$8,000,000		$8,000,000	$8,000,000	$8,000,000	$8,000,000	$8,000,000				
Sacramento River Fish Screen Structure	$55,000,000	$55,000,000									
Red Bluff Pump Addition	$3,849,000	$3,849,000	$3,849,000	$3,849,000	$3,849,000	$3,849,000	$3,849,000	$3,849,000	$3,849,000	$3,849,000	$3,849,000
CBD Pumping Plant for T-C Extension (750 cfs)	$34,000,000								$34,000,000		$34,000,000
Canals and Conduits											
Construct Channel to Holthouse	$49,000,000	$49,000,000									
Reduced Channel with Hunters Creek Discharge	$31,000,000		$31,000,000	$31,000,000	$31,000,000	$31,000,000	$31,000,000	$31,000,000	$31,000,000	$31,000,000	$31,000,000
Construct Delevan Pipeline - Two Pipeline	$660,000,000	$660,000,000									
Construct Delevan Pipeline - One Pipeline	$389,400,000										
Delevan Canal to CBD (750 cfs)	$150,000,000		$150,000,000	$150,000,000	$150,000,000	$150,000,000	$150,000,000				
CBD Siphon and Pipeline to River (750 cfs)	$210,000,000		$210,000,000	$210,000,000	$210,000,000	$210,000,000	$210,000,000				
TCRR Pipeline to Sites Reservoir (2100 cfs)	$410,000,000				$410,000,000					$410,000,000	$410,000,000
Construct TRR Pipeline - Four Pipelines (with Afterbay)	$350,000,000	$350,000,000									
Construct TRR Pipeline - Three Pipelines	$280,000,000		$280,000,000	$280,000,000		$280,000,000	$280,000,000				
Construct TRR Pipeline - Two Pipelines	$210,000,000				$210,000,000			$210,000,000	$210,000,000	$210,000,000	$210,000,000
T-C Canal Extension to CBD	$73,000,000							$73,000,000	$73,000,000	$73,000,000	$73,000,000
Siphon, Turnout, and Pipeline from CBD to River	$270,000,000								$270,000,000		$270,000,000
Release Structure - 750 cfs for South Outfall	$8,000,000							$8,000,000	$8,000,000	$8,000,000	$8,000,000
Stony Creek Diversion to TC	$37,000,000										
Transmission Lines, Switchyards and Substations											
Sites PGP and Colusa Substations,Switchyards, Transmission	190,000,000	190,000,000									
Sites PGP Substation, Switchyard, Transmission	98,000,000		98,000,000	98,000,000		98,000,000	98,000,000	98,000,000	98,000,000		
TRR and T-C from Cogen Substation	105,000,000				$105,000,000					$105,000,000	$105,000,000
General Property											
Recreation and O&M Facility	30,000,000	30,000,000	30,000,000	30,000,000	30,000,000	30,000,000	30,000,000	30,000,000	30,000,000	30,000,000	30,000,000
Mitigation ($350M construction + $150M operation)											
Construction Impacts	350,000,000	350,000,000	350,000,000	350,000,000	350,000,000	350,000,000	350,000,000	350,000,000	350,000,000	350,000,000	350,000,000
Operation Impacts	150,000,000	150,000,000	150,000,000	150,000,000	150,000,000	150,000,000	150,000,000	150,000,000	150,000,000	150,000,000	150,000,000

Attachment 2. Res Storage vs Embank Vol Plot.pdf and Alt Dam ROM Costs



Storage (MAF)	Res. WS El.
0.83	440
1.27	480
1.81	520
2.11	540

Ref: DWR (Oct. 2019), NODOS, Sites Reservoir, Alternative Reservoir Size Evaluation

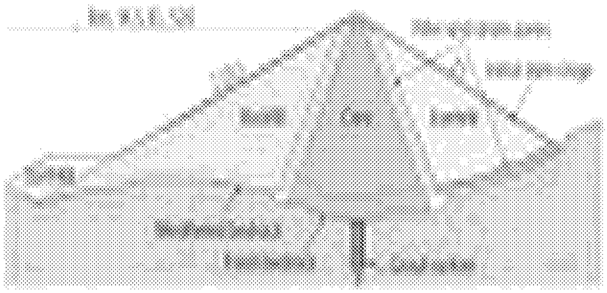
AECOM Imagine it. Delivered.

JOB TITLE Sites Reservoir - Authority
PROJECT/JOB NO. 60476765.13000 CALCULATION NO.
COMPUTED BY H. Forrest DATE 10/7/19.
VERIFIED BY DATE
SCALE SHEET NO. 1 OF

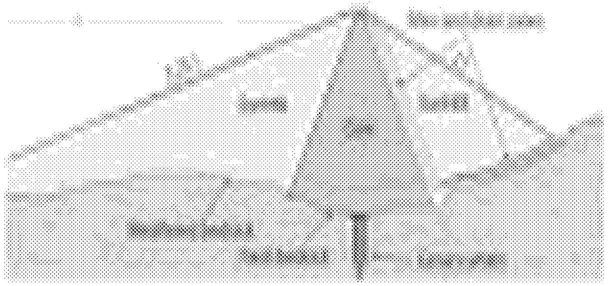
Attachment 3. Alternative-section_dams

Dam Types Drive Affordability

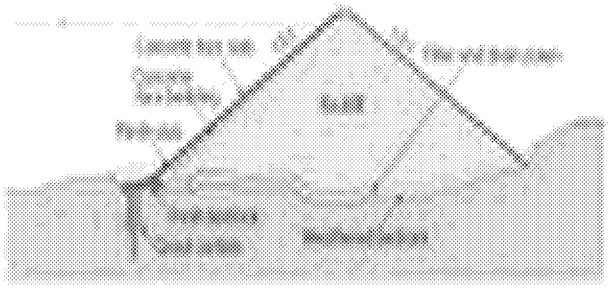
Option #1 Zoned Earth- and Rockfill Dams



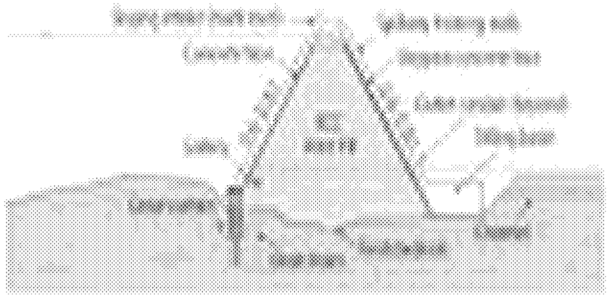
Option #2 Zoned Earthfill Dams



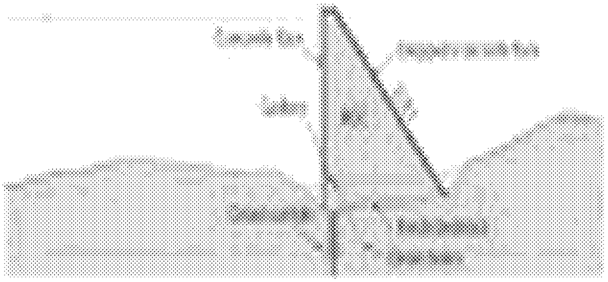
Option #3 Concrete Faced Rockfill Dams



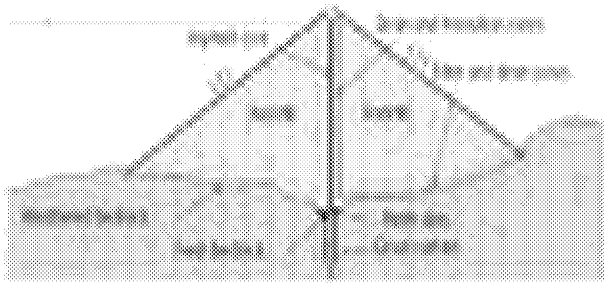
Option #4 RCC Hardfill Dams



Option #5 RCC Dams



Option #6 Asphalt Core Rockfill Dams



Value Planning Analysis Authority Staff Review Comments

Date: October 22, 2019

Subject: Value Planning Analysis Authority Staff Review Comments

---

1.0 Purpose

On October 18, 2019, representatives from the Reservoir Committee requested staff to identify potential issues with the Sites Reservoir Project Alternatives presented three Technical Memorandums. The memorandums that were reviewed included the following:

1. Value Planning: Mitigation Cost Estimate Update of 2016 Technical Memorandum, October 11, 2019.
2. Value Planning Analysis Technical Memorandum, October 14, 2019.
3. Value Planning Effort Technical Memorandum, October 15, 2019.

2.0 Review Comments

In their review, staff did not identify anything that would be considered a "fatal flaw". Staff review comments are presented below:

General

1. The value planning effort included development of appraisal level costs. The draft Sites Authority Principles and Requirements for Feasibility Study and the Technical Reference for the Water Storage Investment Program (WSIP) reference their cost estimates to the Association for the Advancement of Cost Engineering (AACE) International classifications. The AACE classifications correspond to the percent that project design has been completed and the associated expected range in accuracy of the cost estimate. It is recommended that the value planning cost estimates and contingencies follow the AACE classifications and guidelines.
2. The I/O structure changes from a single 30 foot diameter tunnel in Alternative D to twin 15 foot diameter tunnels. Because this change increases costs by around $70 million, it would be beneficial to explain the reasoning.
3. It is recognized that many of the staff comments would be addressed after the value planning effort is complete and the alternatives are being further evaluated to screen them down to identify a preferred plan. Examples are as follows:
    a. Incorporate an emergency spillway and revise the freeboard and dam crest elevation, if appropriate.
    b. Finalize the emergency drawdown facilities and associated flowage easements, if appropriate.
    c. Further evaluate the compatibility of the portion of the Delevan Canal that will be located in the right overbank floodplain of the CBD, as well as potential upstream hydraulic impacts.
4. The CEQA Guidelines, Section 15088.5 (a) addresses the requirements associated with changes in a project and the need for recirculation of an EIR prior to certification. Specifically:

    "A lead agency is required to recirculate an EIR when significant new information is added to the EIR after public notice is given of the availability of the draft EIR for public review under Section 15087 but before certification. As used in this section, the term "information" can include changes in the project or environmental setting as well as additional data or other information. New information added to an EIR is not "significant" unless the EIR is changed in a way that deprives the public of a meaningful opportunity to comment upon a substantial adverse environmental effect of the project or a feasible way to mitigate or avoid such an effect (including a feasible project alternative) that the project's proponents have declined to implement."

Each alternative should be reviewed for potential changes in the significance of an impact and/or inability to implement mitigation previously identified in the EIR.

5. According to CEQA, an EIR must describe a reasonable range of alternatives to a proposed project that could feasibly attain most of the basic project objectives, and would avoid or substantially lessen any of the proposed project's significant effects. Any new alternative should be reviewed in light of comments received on the Draft EIR/EIS and in consideration of reducing significant adverse effects.

Specific

1. The EIR/EIS found that the Project's conversion of Prime Farmland, Unique Farmland or Farmland of Statewide importance to non-agricultural use would result in significant and unavoidable impacts. In all alternatives, replacement of the Delevan pipeline with open canal may result in additional environmental effects associated with agricultural land conversion as it may render additional land unsuitable for agricultural production; while this may not substantially increase an already significant and unavoidable effect, it would increase costs for mitigation at the 1:1 ratio currently proposed.
2. Alternative 2 proposes the use of a roadway around the southern end of the reservoir rather than a bridge crossing. This may result in additional vehicle miles traveled and associated air quality and greenhouse gas effects as well as affect emergency response times. Other effects that may be in excess of those associated with Alternative D would be ground disturbing effects to cultural and/or biological resources; however, it is likely that the roadway could be designed to avoid significant resources.

   Alternatives 5a, 5b, 6a and 6b would be implemented outside of the previously analyzed project footprint and would be most likely to trigger recirculation of the Draft EIR/EIS due to the change in environmental setting and potential for previously undisclosed environmental effects.

Feature	Potential Major Permitting Effect Compared to Alt D
1.5 MAF Reservoir	∝ Reduce effect to grassland threatened and endangered (T&E) species ∞ Reduced effect to streams, wetlands and cultural resources
1.3 MAF Reservoir	∝ Reduce effect to grassland T&E species ∞ Reduced effect to streams, wetlands and cultural resources
Funks/Sites PGP	∝ Reduce impact to grassland T&E species ∞ Reduced effect to streams, wetlands and cultural resources
TCRR and Upgraded TRR PGP	∞ No major change in effects anticipated ∞ Unknown effects to cultural resources
Delevan Canal/Pipeline Release	∝ Reduced effect to river channel ∞ Reduced effect to riparian vegetation ∞ Reduced effect to riverine species (aquatic and terrestrial)
Dunnigan Canal to CBD Release	∝ Reduced effect to riverine species (aquatic and terrestrial ∞ Increased (new) effect to CA tiger salamander ∞ Reduced effect to Giant Garter Snake ∞ New water quality effect ∞ New in-river flow reduction effect ∞ Unknown effects to cultural resources
Dunnigan to River Release	∝ Reduced effect to riparian vegetation ∞ Reduced effect to riverine species (aquatic and terrestrial ∞ Increased (new) effect to CA tiger salamander ∞ New in-river flow reduction effect ∞ Unknown effects to cultural resources
Multi-Span Bridge	∝ No major change in effects anticipated
South Road to Lodoga	∝ No major change in effects anticipated ∞ Unknown effects to cultural resources
South Road to Residents	∞ Minor change in impacts/mitigation for grassland T&E species ∞ Unknown effects to cultural resources
Rockfill Embankment Dam	∝ Assuming fill comes from within the current project footprint, no major change in effects anticipated; If fill sites outside of the current project footprint are necessary, additional analysis would be needed
Earthfill Dam	∝ Assuming fill comes from within the current project footprint, no major change in effects anticipated; If fill sites outside of the current project footprint are necessary, additional analysis would be needed
Hardfill Dam	∝ Assuming fill comes from within the current project footprint, no major change in effects anticipated; If fill sites outside of the current project footprint are necessary, additional analysis would be needed

Alternative 1

1. No issues to consider.

Alternative 2

1. The community's "preferred" road connection is the bridge. The South Road will require extensive local community engagement to get "acceptance" of the road.
2. South Road affects landowners who are not currently impacted by the project – will require extensive outreach to "newly" impacted landowners.
3. South Road increases the amount of property that would be needed to acquire…increases land that would need TROE agreements for studies.

Alternative 3

1. TCRR and pumping plant affects landowners who are not currently impacted by the project – will require extensive outreach to "newly" impacted landowners.
2. Any revisions to the GCID TRR (size/footprint) could create landowner issues.
3. Depending on the sizing and location of the Delevan Canal…could be an increase in land needed for acquisition, would move us to permanent take rather than easements over the buried pipeline, could cause the created of bifurcated/remnant parcels, could be a bigger impact to existing farming operations.

Alternative 4a

1. Same issues as Alternative 3 – Delevan Canal.

Alternative 4b

1. Same issues as Alternative 3 – Delevan Canal.

Alternative 5a

1. TC Canal Southern Release affects landowners who are not currently impacted by the project – will require extensive outreach to "newly" impacted landowners – as well as Yolo County.

Alternative 5b

1. TC Canal Southern Release affects landowners who are not currently impacted by the project – will require extensive outreach to "newly" impacted landowners – as well as Yolo County.

Alternative 6a

1. TCRR and pumping plant affects landowners who are not currently impacted by the project – will require extensive outreach to "newly" impacted landowners.

2. TC Canal Southern Release affects landowners who are not currently impacted by the project – will require extensive outreach to “newly” impacted landowners – as well as Yolo County.

Alternative 6b

1. TCRR and pumping plant affects landowners who are not currently impacted by the project – will require extensive outreach to “newly” impacted landowners.
2. TC Canal Southern Release affects landowners who are not currently impacted by the project – will require extensive outreach to “newly” impacted landowners – as well as Yolo County.

Appendix A-2 Road and Bridge Analysis
Technical Memorandum

To:	Value Planning Work Group
CC:	Lee Frederiksen
Date:	February 28, 2020
From:	AECOM
Subject:	Road and Bridge Analysis

1.0 Introduction

Several alternatives for realigning Sites-Ladoga Road across and around the planned reservoir have been considered. These alternatives were discussed with Colusa and Glenn Counties on January 28, 2020. Important considerations include the following:

- Avoid comingling construction traffic with the general public
- An access road is required for residents at the southern end of Sites Reservoir
- Consider travel time and maintenance costs in the development of alternatives
- Consider public safety in developing the designs, including high winds and potential jumping hazards/nuisance

It is proposed to bring construction traffic in from the north via Road 68 onto a paved construction bypass. The general public would continue to travel on the existing Sites-Lodoga Road until either a new road/bridge across the reservoir or southern bypass road is constructed and opened for use, at which point the existing Sites-Lodoga Road could be closed and construction on Sites Dam could begin.

Four realignment alternatives for the Sites-Ladoga Road are being considered. Three road/bridge realignment alternatives (A, B, and C) and one fully road realignment alternative (D) are depicted in Figure F-1 below. The combination of roadway fill and bridge is being considered for access across the reservoir to reduce the project cost associated with a full-length bridge. Approximate travel times for these alternatives are provided in Table A2-1.

Table A2-1. Approximate Travel Times for Road Options (1.8 MAF Reservoir)

	SQUAW CREEK TO COLUSA CANAL			
Alternative	A - BLUE	B - ORANGE	C - GREEN	D - PINK
Align. Length (mi)	16.5	18.3	21.3	18.9
Assumed Ave Travel Speed (mph)	35	30	30	30
Time of Travel (min)	28	37	43	38
Relative Travel Time (min)	-	(8)	(14)	(10)

Alternative A, the South Road/Bridge alignment, is the most direct route with the shortest travel time.

2.0 South Road/Bridge Alignment (Alternative A – Blue)

Recently, three varying sizes of reservoir have been considered – 1.0 MAF, 1.3 MAF, and 1.8 MAF. As the size of the reservoir increases, the water surface elevation also increases, which elevates the road/bridge crossing. Larger reservoirs require longer bridges with taller piers and taller roadway fill prisms. When considering various size reservoirs and possibly phasing the reservoir to increase water storage over time, Table F-2 shows how road and bridge costs vary for different reservoir sizes. The table includes a least cost 1 MAF, non-phasable alternative with a tunnel; A least cost 1 MAF, non-phasable alternative without a tunnel; A least cost 1.3 MAF, non-phasable alternative; And phaseable options from 1 MAF to 1.8 MAF, plus 1.3 MAF to 1.8 MAF.

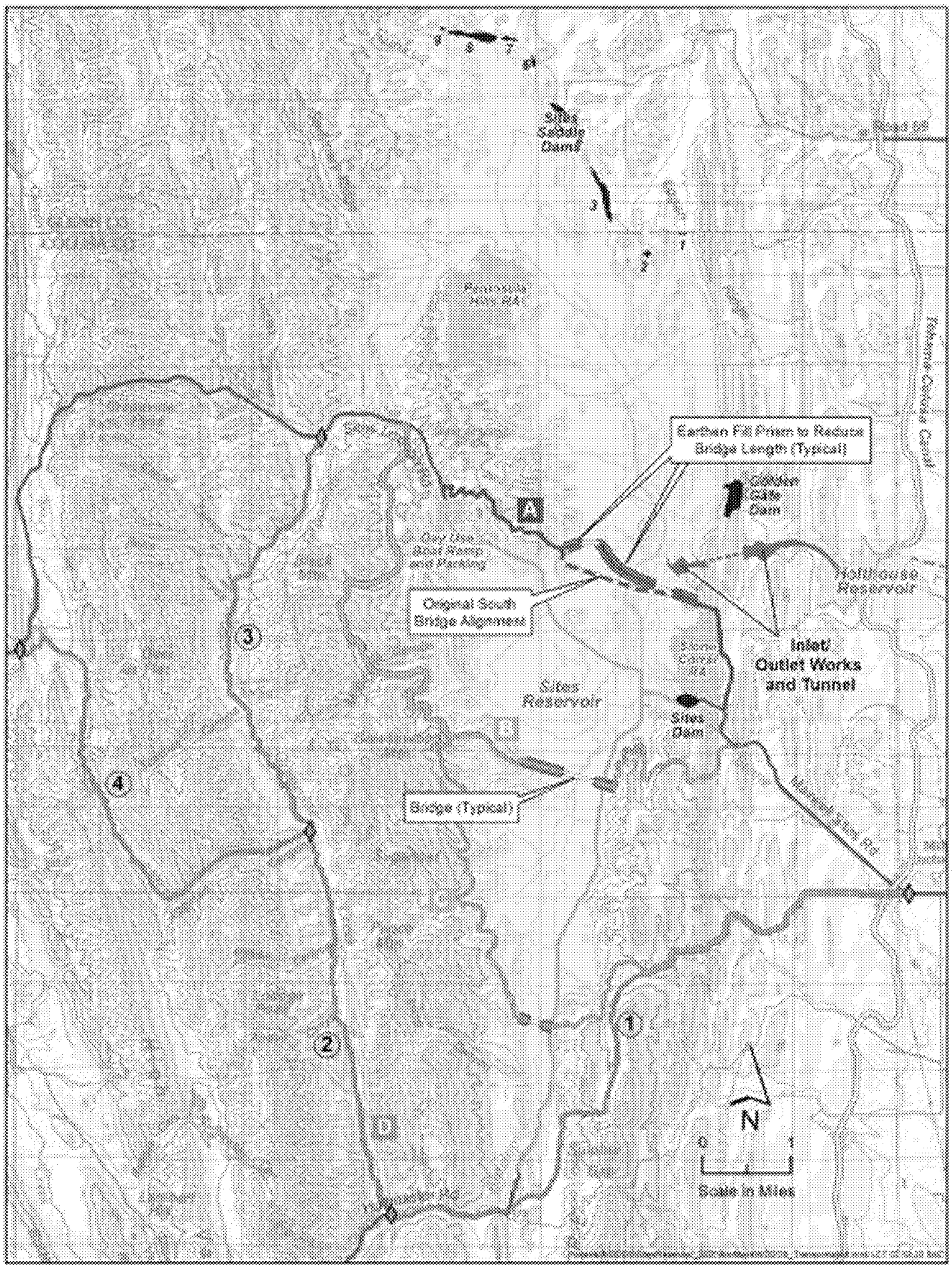


Figure A2-1. Public Transportation Route Alternatives

Table A2-2. Approximate Cost for South Bridge Options (Option A in Figure F-1)

Reservoir Data				Blue Alternative - Planning-Level Construction Cost Estimate ($M)								
MAF	Storage WSE	Max Flood Δ in WSE + Wave Ht. (ft') =	10	Road	Reservoir Crossing			Tunnel	Phase 1 Total	Phase 2 (to 1.8 MAF)	Total Phase 1 & 2	Total Blue Alternative
		= Roadway Hinge Point Elevation			Bridge		Road Fill					
					L (ft)	Cost						
1	457	467		$43	748	$23	$30	$95	$191	Not Phasable	$191	$191
1	457	467		$47	748	$23	$30	$0	$99	Not Phasable	$99	$99
1	457	467		$47	748	$23	$79	$0	$149	$65	$213	$213
1.3	481	491		$47	844	$26	$53	$0	$126	Not Phasable	$126	$126
1.3	481	491		$47	844	$26	$97	$0	$170	$35	$205	$205
1.5	498	508		$46	1106	$25	$47	$0	$118	Not Phasable	$118	$118
1.8	520	530		$45	1500	$46	$105	$0	$196	NA	$196	$196

Page is intentionally blank.

3.0 Southern Road Alignment (Alternative D – Pink)

The alternative to avoid constructing a bridge is the southern road alignment. As noted in Section F.1, an access road to properties at the southern end of Sites Reservoir is required regardless of which alternative is selected. If a bridge were not constructed, it would be necessary to construct a paved road to the southern end of the reservoir that would continue north and west on the west side of the reservoir to maintain access to Lodoga and other communities to the west.

Table A2-3 provides an approximate cost for a paved road for each of the four numbered road segments depicted in Figure F-1.

Table A2-3. Conceptual Cost for Road Segments

Southern Road (Pink Alternative in Figure F-1)		
Road Segment	**Segment Length (mi)**	**Construction Cost Est. ($M)**
1	7.4	$85.3
2	6.0	$69.7
3	5.6	$64.4
4	5.9	$68.7
Total Cost of Seg. 1, 2, & 4		$224
Total Cost of Seg. 1, 2, & 3		$219

4.0 Other Roads

Additional public and project roads are included in all alternatives. These include access to the communication towers on the east side of the reservoir; access to Stone Corral, Peninsula Hills, and boat ramps; roads internal to the recreation areas, and roads to access all project facilities for maintenance. Costs budgeted for public roads include the following:

Construction Bypass Road - $30M
Stone Corral Eastside Access and Boat Ramp - $9.7M
Westside Boat Ramp Access and Access to Peninsula Hills Recreation - $5.2M
Eastside Road to Communication Tower - $6.3M
Peninsula Hills Park Roads - $2.7M (excludes parking lots)

Appendix A-3 Conveyance System Technical Memorandum

To:	Value Planning Work Group
CC:	Lee Frederiksen
Date:	April 9, 2020
From:	Jacobs
Subject:	Conveyance System

1.0 Background

In October 2019, a Value Planning analysis draft technical memorandum was completed with the objective of looking at alternative project components to reduce the cost of the Sites reservoir project. This technical memorandum provided several viable alternatives that reduced the overall project costs from the original $5.2B to a new range of $3.4 to $4.0B. The lowest cost alternative, known as Alternative 6A, includes a 1.5 million acre-foot reservoir, a pump station on the Tehama-Colusa (T-C) Canal to lift water to the reservoir, and use of the Tehama-Colusa Canal to discharge water from the Reservoir to the Sacramento River. Specifically, water would be discharged from the reservoir into the T-C canal, conveyed down the T-C canal near the end in Dunnigan and then new facilities built to convey it from T-C canal to either the Colusa Basin Drain (CBD) or the Sacramento River.

2.0 Purpose

The purpose of this TM is to look at various alternatives to convey water from the end of T-C canal to the CBD or Sacramento River for flows of 750 cfs and 1,000 cfs. Members of the Reservoir Committee visited the area on January 14, 2020 to look at conveyance alternatives to be analyzed.

3.0 Alternatives Development

The alternatives developed by members of the Reservoir Committee are as follows and provided as exhibits at the end of this Technical Memorandum:

3.1 Alternative 6A-1

This alternative is sized for a flow of 750 cfs and includes a turnout on the T-C canal located about 1,500 feet upstream of the end of T-C canal, then a pipeline east until it intercepts Bird Creek and then flow is discharge into Bird Creek where it flows to the Colusa basin Drain. Total length of this alternative is 20,000 feet with 6,600 feet of pipeline and 13,400 feet of open channel (Bird Creek).

3.2 Alternative 6A-2 CBD

This alternative is sized for a flow of 750 cfs and includes a turnout on the T-C canal located about 1,500 feet upstream of the end of T-C canal, then a pipeline east all the way to the Colusa basin Drain, and ends with a flow control/pressure reducing valve to discharge to the CBD. This pipeline follows roughly the same alignment as Alt 6A-1. Total length of this alternative is 20,000 feet.

3.3 Alternative 6A-2 Sac Riv

This alternative is sized for a flow of 750 cfs and includes a turnout on the T-C canal located about 1,500 feet upstream of the end of T-C canal, then a pipeline east all the way to the Sacramento River, and ends with a flow control/pressure reducing valve to discharge to the Sacramento River. This pipeline follows roughly the same alignment as Alt 6A-1, but then continues east across farmland to the Sacramento River. Total length of this alternative is 51,000 feet.

3.4 Alternative 6A-3

This alternative is sized for a flow of 750 cfs and includes a turnout on the end of the T-C canal that discharges to a small, winding ditch (created by discharges from T-C Canal), then intercepts Bird Creek and continues to flow in Bird Creek where it ends by flowing into the Colusa basin Drain. Total length of this alternative is 24,600 feet with 4,000 feet of small ditch and 20,600 feet of open channel (Bird Creek).

3.5 Alternative 6A-4

This alternative is sized for a flow of 750 cfs and includes a turnout on the T-C canal located about 27,000 feet upstream of the end of T-C canal where it crosses Hunter Creek. Flow is discharge to Hunter Creek where it ends by flowing into the Colusa basin Drain. Total length of this alternative is about 32,500 feet of open channel (Hunter Creek).

3.6 Alternative 6A-5 CBD

This alternative is essentially the same layout as Alterative 6A-2 CBD except the flow is increased from 750 cfs to 1,000 cfs.

3.7 Alternative 6A-5 Sac River

This alternative is essentially the same layout as Alterative 6A-2 Sac River except the flow is increased from 750 cfs to 1,000 cfs.

4.0 Initial Screening of Alternatives

Based on a field visit on February 11, 2020, it was determined that discharging flow directly to the existing open channels would result in significant water loss due to seepage and evaporation. This is based on the visual evidence of the existing creek beds showing sandy and gravels that have high infiltration rates. In addition, these creeks have significant debris to impede flow and would require high maintenance to reshape. Lastly, these creeks are wide and the 750 cfs flow would be very shallow, contributing to an increase in evaporation and seepage. As a result, it was determined that all open channels will need to be lined. Given that Hunter Creek is significantly longer than the other open ditch options, it was decided to eliminate Alternative 6A-4 from further consideration.

A second criteria used to evaluate these alternatives includes an assumption that Bird Creek needs to maintain their current shape to accommodate storm runoff flows that created them. Calculations were performed using topographic data to determine the canal cross required for the 750 cfs flow for the different segments. The existing ditch has depth that varies from 7-10 feet. Using a water depth of 5 feet, a 2:1 side slope, frictional coefficient of 0.02, calculations showed the bottom width of a trapezoidal channel to be about 12 feet. The existing channel has a bottom width that ranges from 20-25 feet and a top width of about 50 feet. Lining the existing channel to accommodate stormwater flows (as a criteria), would be very expensive and unnecessary given that the channel needs to accommodate the 750 cfs is less than half of the channel width. If this channel was lined, then significant maintenance would be required to remove all the debris accumulated from stormwater runoff. As a result, it was decided to eliminate using the existing creeks for conveying the water. Therefore, alternatives 6A-1 and 6-A3 were eliminated, leaving only the piping alternatives.

5.0 Evaluation of Alternative 6A-2 and 6A-5 Alternatives

Calculations were performed to determine the pipeline sizes required for the two remaining options. An assumption was made to have both pipelines sized to allow for gravity flow. Following are the assumptions used in these calculations:

- Water Surface elevation in T-C Canal =175 feet
- Water surface elevation in Colusa Basin Drain = 32 feet
- Water surface elevation at Sacramento river = 40 feet (typically lower, but required to go high in levee per Army Corps Standards)
- Hazen-Williams Friction Factor C-value = 130

The results of these calculations resulted in the following:

5.1 Alternative 6A-2 CBD

The pipeline will carry 750 cfs and be 7.5-foot (90-inch) internal diameter with two tunneled crossings (I-5 and 99W/RR) that require 9-foot (108") casings. The total length of pipeline is 20,000 feet with 300-foot and 250-foot tunneled crossings. A 72-inch flow control/pressure reducing valve will be placed at the discharge to dissipate energy and adjust the flow.

5.2 Alternative 6A-2 Sac Riv

The pipeline will be 9.5-foot (114-inch) internal diameter with three tunneled crossings (I-5 and 99W/RR and CBD) that require 11-foot (132") casings. The total length of pipeline is 51,600 feet with 300-, 250-, and 250-foot tunneled crossings. A 72-inch flow control/pressure reducing valve will be placed at the discharge to dissipate energy and adjust the flow.

5.3 Alternative 6A-5 CBD

The pipeline will carry a flow of 1,000 cfs and be 9-foot (108-inch) internal diameter with three tunneled crossings (I-5 and 99W/RR and CBD) that require 10.5-foot (126") casings. The total length of pipeline is 20,000 feet with 300-foot and 250-foot tunneled crossings. A 78-inch flow control/pressure reducing valve will be placed at the discharge to dissipate energy and adjust the flow.

5.4 Alternative 6A-5 Sac River

The pipeline will carry a flow of 1,000 cfs and be 10.5-foot (126-inch) internal diameter with three tunneled crossings (I-5 and 99W/RR and CBD) that require 12-foot (144") casings. The total length of pipeline is 51,600 feet with 300-, 250-, and 250-foot tunneled crossings. A 78-inch flow control/pressure reducing valve will be placed at the discharge to dissipate energy and adjust the flow.

6.0 Cost Analysis

A Class 5 cost estimate was prepared based on limited information, where little more than proposed plant type, its location, and the capacity are known. Strategic planning purposes include but are not limited to, market studies, assessment of viability, evaluation of alternate schemes, project screening, location and evaluation of resource needs and budgeting, and long-range capital planning. Examples of estimating methods used would include cost/capacity curves and factors, scale-up factors, and parametric and modeling techniques. Typically, little time is expended in the development of this estimate. The expected accuracy ranges for this class estimate are –20 to –50 percent on the low side and +30 to +100 percent on the high side. These estimate includes a Contractors overhead and profit, a 10% contingency, and 17% for soft costs (admin, design, construction management). These estimates include costs for real estate acquisition based on a 100-foot wide corridor at $15,000 per acre.

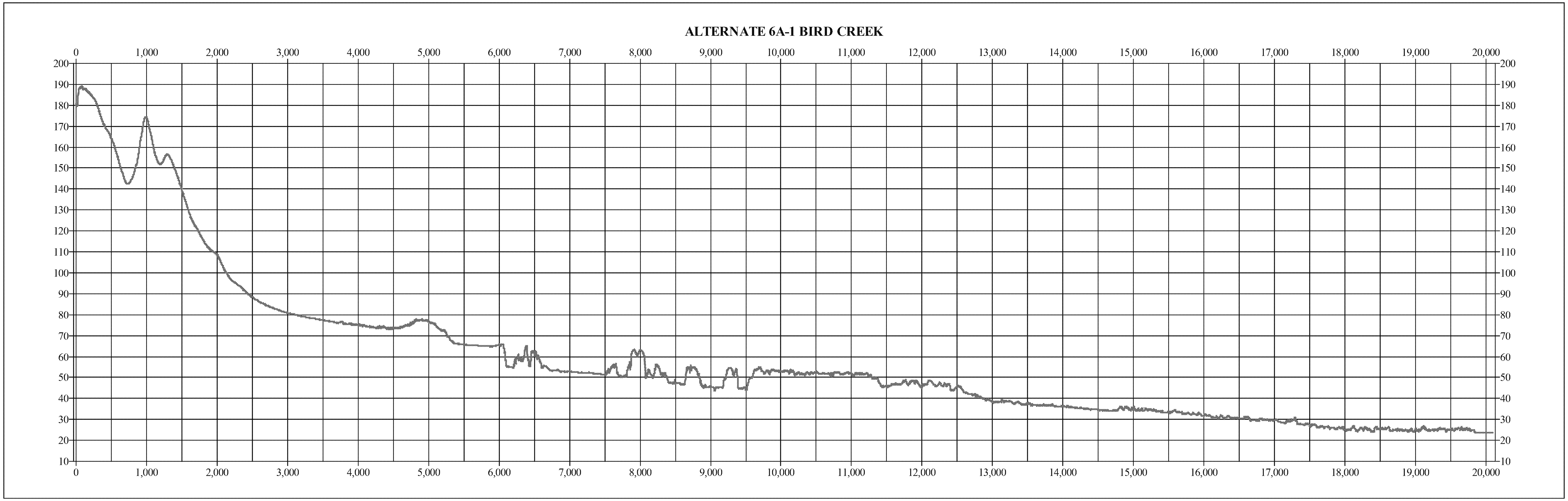
Cost for Alt 6A-2 750 cfs to Colusa Basin Drain = **$54.8M ($30/di-lf)**

Cost for Alt 6A-2 750 cfs to Sacramento River = **$175.2M ($30/di-lf)**

Cost for Alt 6A-5 1,000 cfs to Colusa Basin Drain = **$65.2M ($30/di-lf)**

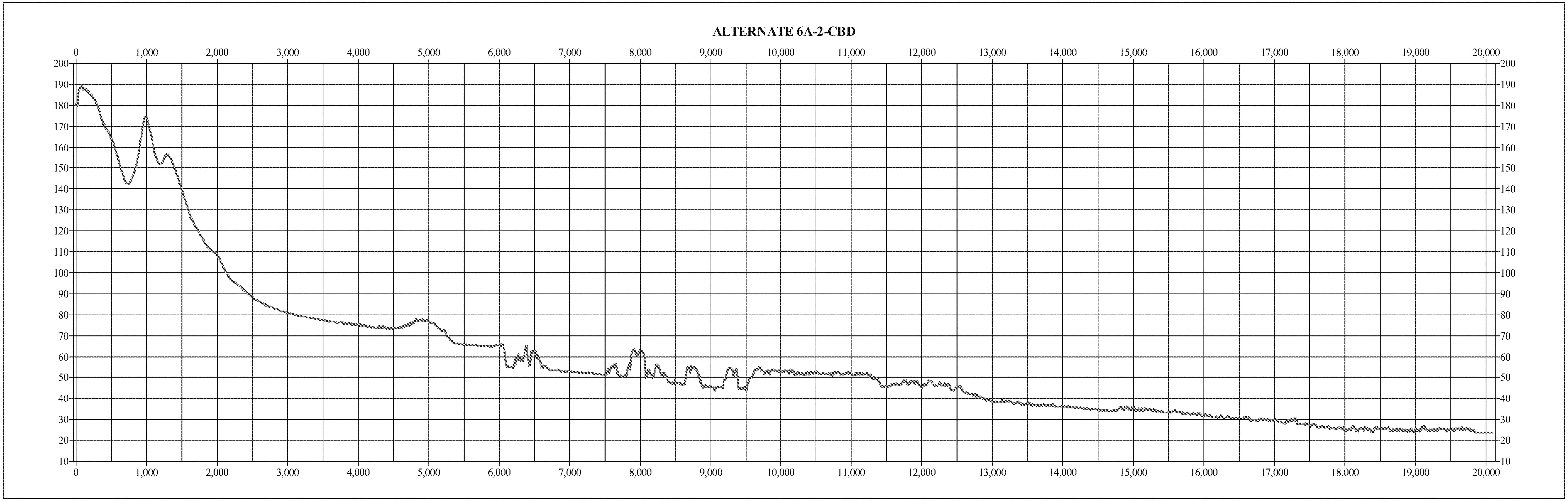
Cost for Alt 6A-5 1,000 cfs to Sacramento River = **$192.5M ($30/di-lf)**

The comparison of costs shows extending the pipeline to the Sacramento River will cost an additional $120M for the 750 cfs flow and $130M for the 1,000 cfs flow. These differences are primarily due to the added length and the additional tunnel to get under the Colusa Basin Drain, as well as the larger diameter pipes for the 1,000 cfs case.

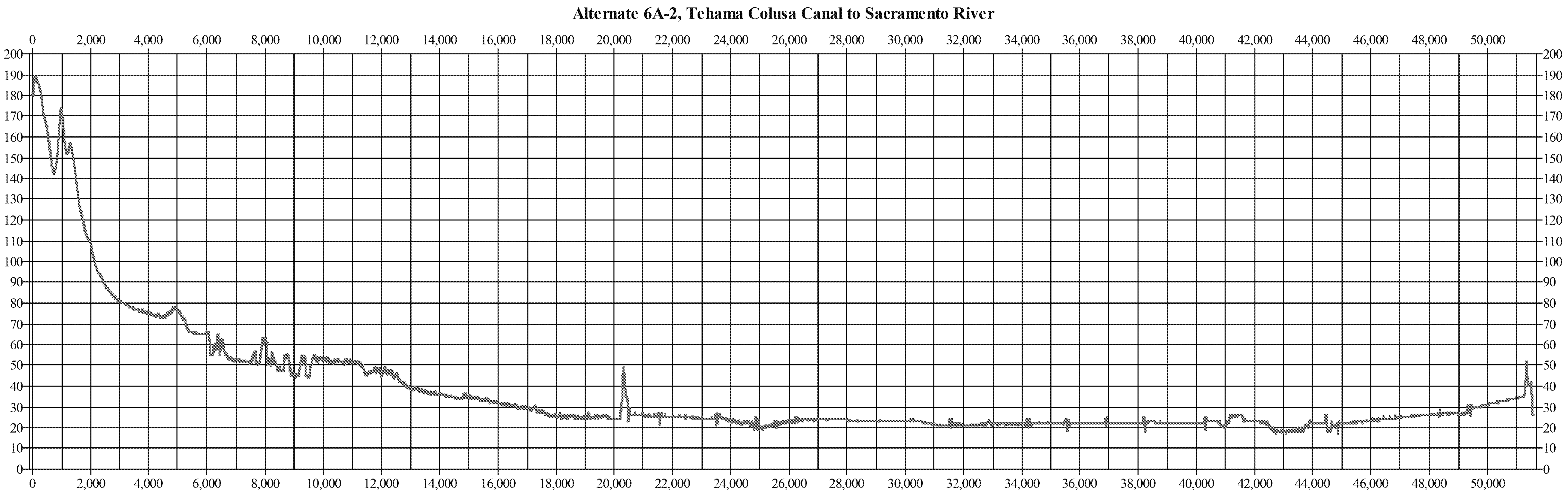


ALTERNATE 6A-1 BIRD CREEK

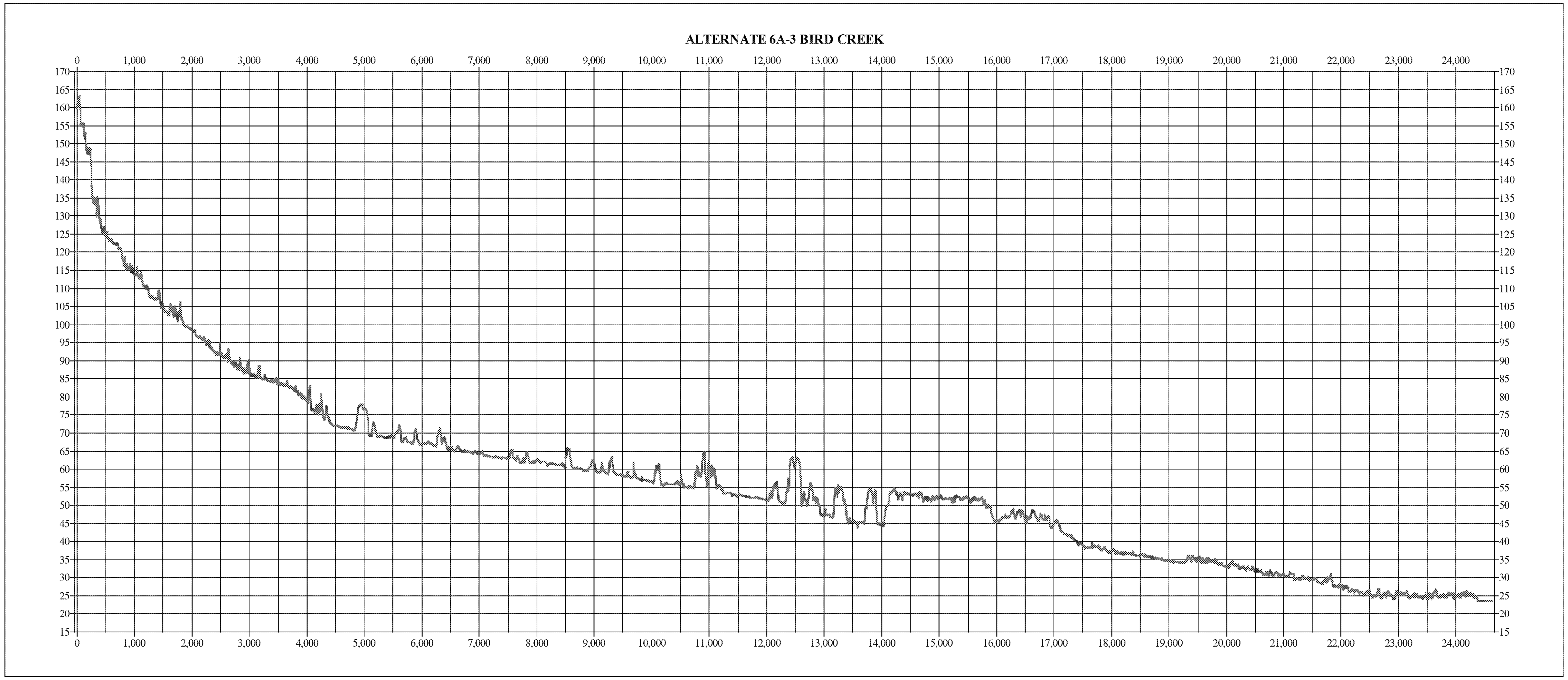
ALTERNATE 6A-1
BIRD CREEK VP PLAN/PROFILE


ALTERNATE 6A-2-CBD
0
1,000
2,000
3,000
4,000
5,000
6,000
7,000
8,000
9,000
10,000
11,000
12,000
13,000
14,000
15,000
16,000
17,000
18,000
19,000
20,000
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10

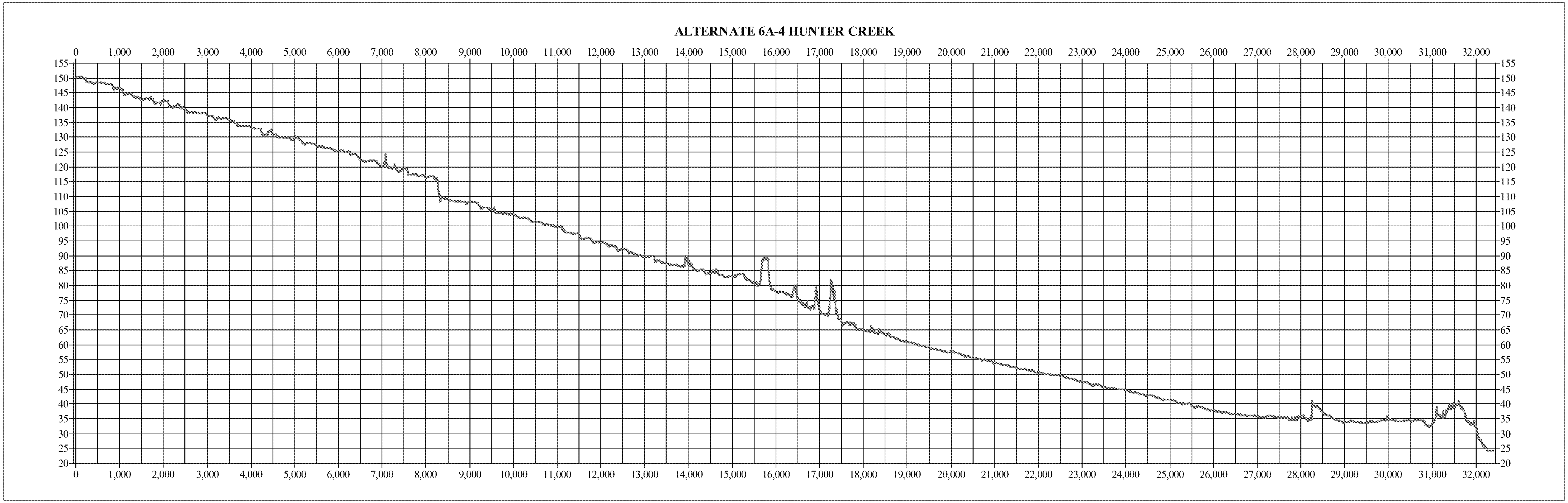

ALTERNATE 6A-2-CBD
Legend
N
Feet
0
500
1,000
Pipe
Boundary Fire LiDAR West/CVFPP East
Westerly Limits of CVFED Data
CA Levee Database Levee CL
0
1000
2000
3000
4000
5000
6000
7000
8000
9000
10000
11000
12000
13000
14000
15000
16000
17000
18000
19000
20000


Alternate 6A-2, Tehama Colusa Canal to Sacramento River
0
2,000
4,000
6,000
8,000
10,000
12,000
14,000
16,000
18,000
20,000
22,000
24,000
26,000
28,000
30,000
32,000
34,000
36,000
38,000
40,000
42,000
44,000
46,000
48,000
50,000
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0


Tehama Colusa Canal
Colusa Basin Drain
Sacramento River
0
1000
2000
3000
4000
5000
6000
7000
8000
9000
10000
11000
12000
13000
14000
15000
16000
17000
18000
19000
20000
21000
22000
23000
24000
25000
26000
27000
28000
29000
30000
31000
32000
33000
34000
35000
36000
37000
38000
39000
40000
41000
42000
43000
44000
45000
46000
47000
48000
49000
50000
51000
ALTERNATE 6A-2
SACRAMENTO RIVER
Legend
N
Feet
0 1,000 2,000
PIPE
Boundary Fire LiDAR West/CVFPP East
Westerly Limits of CVFED Data
CA Levee Database Levee CL


ALTERNATE 6A-3 BIRD CREEK
0
1,000
2,000
3,000
4,000
5,000
6,000
7,000
8,000
9,000
10,000
11,000
12,000
13,000
14,000
15,000
16,000
17,000
18,000
19,000
20,000
21,000
22,000
23,000
24,000
170
165
160
155
150
145
140
135
130
125
120
115
110
105
100
95
90
85
80
75
70
65
60
55
50
45
40
35
30
25
20
15


ALTERNATE 6A-3
BIRD CREEK VP PLAN/PROFILE
Legend
Bird Creek
Defined Channel
Boundary Fire LiDAR West/CVFPP East
Westerly Limits of CVFED Data
CA Levee Database Levee CL
N
0
500
1,000
Feet
0
1000
2000
3000
4000
5000
6000
7000
8000
9000
10000
11000
12000
13000
14000
15000
16000
17000
18000
19000
20000
21000
22000
23000
24000


ALTERNATE 6A-4 HUNTER CREEK
0
1,000
2,000
3,000
4,000
5,000
6,000
7,000
8,000
9,000
10,000
11,000
12,000
13,000
14,000
15,000
16,000
17,000
18,000
19,000
20,000
21,000
22,000
23,000
24,000
25,000
26,000
27,000
28,000
29,000
30,000
31,000
32,000
155
150
145
140
135
130
125
120
115
110
105
100
95
90
85
80
75
70
65
60
55
50
45
40
35
30
25
20


ALTERNATE 6A-4
HUNTER CREEK VP PLAN/PROFILE
Legend
Hunter Creek
End Hunter to CBD
Boundary Fire LiDAR West/CVFPP East
Westerly Limits of CVFED Data
CA Levee Database Levee CL
N
Feet
0
500
1,000
N
Feet
0
1,000
2,000
0
1000
2000
3000
4000
5000
6000
7000
8000
9000
10000
11000
12000
13000
14000
15000
16000
17000
18000
19000
20000
21000
22000
23000
24000
25000
26000
27000
28000
29000
30000
31000
32000

Appendix A-4 Cost Estimate Technical Memorandum

To:	Sites Value Planning Group
CC:	Lee Frederiksen
Date:	January 28, 2020
From:	AECOM
Subject:	Cost Estimate

Construction cost estimates were derived from detailed appraisal-level estimates for a 1.3 MAF reservoir (Alternative A in the EIR/S and feasibility report) and for a 1.8 MAF reservoir (Alternative D in the EIR/S and feasibility report). These estimates reflect the current project concepts and conceptual level of project design, with appropriate allowances for contingencies, non-contracts costs, and forward escalation. Other project-related costs are also provided, including environmental mitigation, and temporary and permanent easement acquisition. The Alternative D estimate was used to support the Authority's WSIP application. Estimated prices were developed in October 2015 dollars and have been escalated in this estimate.

The actual project construction cost ultimately would depend on the final design details of the preferred project alternative and the labor and material costs, market conditions, and other variable factors existing at the time of bid. Accordingly, the final project cost would vary from the preliminary estimates presented in this section.

Major assumptions made to prepare the preliminary feasibility cost estimates include:

- Competitive market conditions would prevail at the time of bid tender.
- Work would be packaged for bidding so that the magnitude of the contract would not unduly restrict competition.
- The construction schedule assumes a start of field construction activities in the second quarter of 2022 for all scenarios.
- Environmental mitigation and ecosystem enhancement measures would be consistent with those currently used in practice and would be the same for each alternative.
- Builder's Risk Insurance would be available to the contractor.
- Materials such as sand, gravel, and cement would remain available within the haul distances used to prepare the estimates.

1.0 Level and Classification of Cost Estimates

The availability of site data and design information to support preparing cost estimates varies between the facilities that constitute the Sites Reservoir project. Some facilities (like the main dams) are advanced enough to support a lower-bound Class 3 estimate as defined by the Association for Advancement of Cost Engineering, International. Other facilities, like the Dunnigan conveyance from the T-C Canal to the CBD have no supporting geotechnical evaluation and only a preliminary screening of potential utility conflicts. These estimates are considered to be at a Class 5 level.

The estimate for the 1.8, 1.3, and 0.8 MAF reservoir dams used dimensions, quantities, and cost ratios previously developed by DWR (DWR DOE. 2004. Sites Reservoir Engineering Feasibility Study – Sites

Reservoir Alternative Reservoir Size Evaluation. October.). The estimate for the 1.0 MAF reservoir was interpolated from the 0.8 MAF and 1.3 MAF facilities.

1.1 Estimate Base and Escalation

The contract, field, and construction cost estimates presented in this section were compiled using individual-estimate worksheets for each NODOS/Sites Reservoir Project feature. All costs are provided in October 2015 dollars. Escalation of construction costs to a notice to proceed date in mid-2022 has been included. Escalation was evaluated using various sources, including the USACE Civil Works Construction Cost Index and the Consumer Price Index. Results varied from 15.3 percent to 15.8 percent over the escalation period. For the project alternatives, 15 percent over 7 years has been applied for each alternative.

1.2 Allowances and Contingency

Construction contingency is a percentage allowance added to develop the field cost. Contingencies are funds for use after construction starts to compensate the contractor for such issues as unforeseen or changed site conditions, owner-directed orders for change, and differences between estimated and actual quantities. Contingency allowances are generally higher for appraisal-level estimates than for feasibility-level estimates.

For a Class 4 estimate, the overall cost variability can range per AACE from negative 15% to 30% on the low range to positive 20% to 50% on the high range, depending on the level of design information available to support the estimate. This report uses a construction contingency of 15 percent to establish for all features, but also applies a higher contingency to high risk and new facilities developed during the value planning effort where less supporting information is available.

- A 30% contingency was applied for an upper end estimate for the new Funks pumping facilities. Although these were not previously studied, they are in the footprint where geotechnical investigations have been performed in the past.
- A 65% contingency was applied to establish the upper range of costs for the Dunnigan release facilities. There is no information from prior investigations or topography for these facilities. These facilities are at a Class 5 level.
- A 40% contingency was applied to establish the upper range of costs for the TRR. Geotechnical information is limited and there is a potential liquefaction concern.

Table A4-1 presents the allowances and average contingency percentages adopted and applied to the feasibility-level cost estimate for the alternative projects.

Table A4-1. Allowances and Contingencies for Estimating

Allowances and Contingencies	Percentages
Mobilization/Demobilization	5 percent
Design Contingency	10 percent
Construction Contingency	15 to 65 percent
Non-Contract Costs	17 percent

The mobilization/demobilization allowance and design and construction contingencies were applied to the contractor costs to develop the contract cost. The construction contingency was applied to the contract cost to arrive at the field cost.

1.3 Non-Contract Costs

Non-contract costs include Authority staff, engineering and design, surveying, geotechnical investigation, construction management and inspection, project close-out, administration, legal services, permitting, etc. For the estimates presented in this section, the non-contract costs were estimated to be 17 percent of the total field costs (contract cost plus contingency). Actual non-contract costs would vary from facility to facility; however, 17 percent is assumed to represent the average value.

1.4 Environmental Mitigation

Many environmental laws affect the State's major water supply programs, and environmental concerns play a major role in water policy and planning. Mitigation costs for the original alternatives were based on *Sites Reservoir Feasibility Study Technical Memorandum: Mitigation Measure Evaluation and Cost Estimate* (AECOM 2016).

2.0 Estimates

Estimate summaries are provided for Alternatives VP1 through VP 3 in Tables A4-2 through A4-4, respectively.

The Value Planning Work Group subsequently selected three alternatives for further analysis. These are shown in Table A4-5.

Table A4-2. Estimate Summary for Alternative VP 1

Facility	1.0 MAF ($ Millions)	1.3 MAF ($ Millions)	1.5 MAF ($ Millions)
Develop Sites Reservoir, including Land and Project Roads, Clearing and Demolition	$143,000,000	$143,000,000	$143,000,000
Other Roads (Project and Recreation)	$79,000,000	$79,000,000	$79,000,000
South Road to Residents (Unpaved)	$41,000,000	$41,000,000	$41,000,000
Bridge	$99,000,000 To $116,000,000	$126,000,000 To $147,000,000	$154,000,000 To $180,000,000
North Construction Access Road (Paved)	$30,000,000	$30,000,000	$30,000,000
Construct Sites Dam and Golden Gate Dam	$255,000,000	$345,000,000	$410,000,000
Construct Saddle Dams	$92,000,000	$101,000,000	$197,000,000
Construct TRR	$42,000,000 To $51,000,000	$42,000,000 To $51,000,000	$42,000,000 To $51,000,000
Construct TCRR	$42,000,000 To $51,000,000	$42,000,000 To $51,000,000	$42,000,000 To $51,000,000
Funks Reservoir Dredging/Structures	$24,000,000	$24,000,000	$24,000,000
Hunters Creek Release Structures	$91,000,000	$91,000,000	$91,000,000
Construct I/O Structure and Tunnels for Reservoir	$183,000,000	$280,000,000	$302,000,000
Construct TCRR Pumping/Generating Plant	$200,000,000	$200,000,000	$200,000,000
Construct TRR Pumping/Generating Plant	$200,000,000	$200,000,000	$200,000,000
Red Bluff Pump Addition	$4,000,000	$4,000,000	$4,000,000
Construct Funks Release Channel	$34,000,000	$34,000,000	$34,000,000
Construct TCRR Pipeline	$443,000,000 To $508,000,000	$443,000,000 To $508,000,000	$443,000,000 To $508,000,000
Construct TRR Pipeline	$227,000,000	$227,000,000	$227,000,000
Construct Dunnigan Pipeline to River	$177,000,000 To $292,000,000	$177,000,000 To $292,000,000	$177,000,000 To $292,000,000
River Release Structure	$9,000,000	$9,000,000	$9,000,000
Transmission Lines, Substations, Switchyards	$113,000,000	$113,000,000	$113,000,000
General Property, including Recreation Areas and OM&R Facilities	$32,000,000	$32,000,000	$32,000,000
Mitigation	$540,000,000	$540,000,000	$540,000,000
Construction Cost (2019)	$3,057,000,000 To $3,262,000,000	$3,281,000,000 To $3,490,000,000	$3,493,000,000 To $3,707,000,000

Key:
I/O = inlet/outlet
OM&R = operation, maintenance, and replacement
TCRR = Regulating Reservoir for T-C Canal
TRR = Terminal Regulating Reservoir for GCID Main Canal

Table A4-3. Estimate Summary for Alternative VP 2

Facility	1.0 MAF ($ Millions)	1.3 MAF ($ Millions)	1.5 MAF ($ Millions)
Develop Sites Reservoir, including Land and Project Roads, Clearing and Demolition	$143,000,000	$143,000,000	$143,000,000
Other Roads (Project and Recreation)	$79,000,000	$79,000,000	$79,000,000
South Road to Residents (Unpaved)	$41,000,000	$41,000,000	$41,000,000
Bridge	$99,000,000 To $116,000,000	$126,000,000 To $147,000,000	$154,000,000 To $180,000,000
North Construction Access Road (Paved)	$30,000,000	$30,000,000	$30,000,000
Construct Sites Dam and Golden Gate Dam	$255,000,000	$345,000,000	$410,000,000
Construct Saddle Dams	$92,000,000	$101,000,000	$197,000,000
Construct TRR	$42,000,000 To $51,000,000	$42,000,000 To $51,000,000	$42,000,000 To $51,000,000
Funks Reservoir Dredging/Structures	$24,000,000	$24,000,000	$24,000,000
Hunters Creek Release Structures	$91,000,000	$91,000,000	$91,000,000
Construct I/O Structure and Tunnels for Reservoir	$183,000,000	$280,000,000	$302,000,000
Construct TRR Pumping/Generating Plant	$200,000,000	$200,000,000	$200,000,000
Construct Funks Pumping/Generating Plant	$200,000,000	$200,000,000	$200,000,000
Construct Funks Release Channel	$34,000,000	$34,000,000	$34,000,000
Red Bluff Pump Addition	$4,000,000	$4,000,000	$4,000,000
Construct Funks Release Channel	$31,000,000	$31,000,000	$31,000,000
Construct TRR Pipeline	$227,000,000	$227,000,000	$227,000,000
Construct Dunnigan Pipeline to CBD	$56,000,000 To $90,000,000	$56,000,000 To $90,000,000	$56,000,000 To $90,000,000
Transmission Lines, Substations, Switchyards	$113,000,000	$113,000,000	$113,000,000
General Property, including Recreation Areas and OM&R Facilities	$32,000,000	$32,000,000	$32,000,000
Mitigation	$540,000,000	$540,000,000	$540,000,000
Construction Cost (2019)	$2,613,000,000 To $2,754,000,000	$2,837,000,000 To $2,982,000,000	$2,996,000,000 To $3,199,000,000

Key:
I/O = inlet/outlet
OM&R = operation, maintenance, and replacement
TRR = Terminal Regulating Reservoir

Table A4-4. Estimate Summary for Alternative VP 3

Facility	1.3 MAF ($ Millions)	1.5 MAF ($ Millions)
Develop Sites Reservoir, including Land and Project Roads, Clearing and Demolition	$143,000,000	$143,000,000
Other Roads (Project and Recreation)	$79,000,000	$79,000,000
South Road to Residents (Unpaved)	$41,000,000	$41,000,000
Bridge	$126,000,000 To $147,000,000	$154,000,000 To $180,000,000
North Construction Access Road (Paved)	$30,000,000	$30,000,000
Construct Sites Dam and Golden Gate Dam	$345,000,000	$410,000,000
Construct Saddle Dams	$101,000,000	$197,000,000
Construct TRR	$42,000,000 To $51,000,000	$42,000,000 To $51,000,000
Funks Reservoir Dredging/Structures	$24,000,000	$24,000,000
Hunters Creek Release Structures	$91,000,000	$91,000,000
Construct I/O Structure and Tunnels for Reservoir	$280,000,000	$302,000,000
Construct TRR Pumping/Generating Plant	$200,000,000	$200,000,000
Construct Funks Pumping/Generating Plant	$200,000,000	$200,000,000
Construct Funks Release Channel	$34,000,000	$34,000,000
Red Bluff Pump Addition	$4,000,000	$4,000,000
Construct Funks Release Channel	$31,000,000	$31,000,000
Construct TRR Pipeline	$227,000,000	$227,000,000
Construct Delevan Pipeline	$713,000,000	$713,000,000
Transmission Lines, Substations, Switchyards	$113,000,000	$113,000,000
General Property, including Recreation Areas and OM&R Facilities	$32,000,000	$32,000,000
Mitigation	$540,000,000	$540,000,000
Construction Cost (2019)	$3,373,000,000 To $3,402,000,000	$3,585,000,000 To $3,619,000,000

Key:
I/O = inlet/outlet
OM&R = operation, maintenance, and replacement
TRR = Terminal Regulating Reservoir

The estimated costs for Alternatives VP1 through VP 3 were determined for the 1.0 MAF, 1.3 MAF, and 1.5 MAF reservoir sizes. Estimated costs are presented in Table A4-5.

Table A4-5. Alternative Costs ($millions)

Reservoir Size	Alternative VP 1 TCRR, TRR, 750 cfs Release to Sacramento River	Alternative VP 2 Funks Reservoir, TRR, 750 cfs Release to CBD	Alternative VP 3 Funks Reservoir, TRR, 1,500 cfs Delevan Release
1.0 MAF	$3,057 to $3,262	$2,613 to $2,754	NA
1.3 MAF	$3,281 to $3,490	$2,837 to $2,982	$3,373 to $3,402
1.5 MAF	$3,493 to $3,707	$2,996 to $3,199	$3,585 to $3,619

The Value Planning Work Group subsequently selected three alternatives for consideration as the Authority's proposed project description. These are shown in Table A4-6. Alternative VP7 was chosen as the recommended project.

Table A4-6. Estimate Summary for Recommended Alternative and Alternates

Facility	VP-5 ($ Millions)	VP-6 ($ Millions)	VP-7 ($ Millions)
Develop Sites Reservoir, including Land and Project Roads, Clearing and Demolition	$143,000,000	$143,000,000	$143,000,000
Other Roads (Project and Recreation)	$79,000,000	$79,000,000	$79,000,000
South Road to Residents (Unpaved)	$41,000,000	$41,000,000	$41,000,000
Bridge (Corresponds to 1.5 MAF reservoir for all alternatives)	$180,000,000	$180,000,000	$180,000,000
North Construction Access Road (Paved)	$30,000,000	$30,000,000	$30,000,000
Construct Sites Dam and Golden Gate Dam (1.5 MAF)			$450,000,000
Construct Sites Dam and Golden Gate Dam (1.3 MAF)	$386,000,000	$386,000,000	
Construct Saddle Dams (1.5 MAF)			$198,000,000
Construct Saddle Dams (1.3 MAF)	$102,000,000	$102,000,000	
Construct TRR	$51,000,000	$51,000,000	$51,000,000
Funks Reservoir Dredging/Structures	$24,000,000	$24,000,000	$24,000,000
Hunters Creek Release Structures	$91,000,000	$91,000,000	$91,000,000
Construct I/O Structure and Tunnels for Reservoir (1.5 MAF)			$302,000,000
Construct I/O Structure and Tunnels for Reservoir (1.3 MAF)	$280,000,000	$280,000,000	
Construct TRR Pumping/Generating Plant	$200,000,000	$200,000,000	$200,000,000
Construct Funks Pumping/Generating Plant	$200,000,000	$200,000,000	$200,000,000
Construct Funks Release Channel	$34,000,000	$34,000,000	$34,000,000
Red Bluff Pump Addition	$4,000,000	$4,000,000	$4,000,000
Construct TRR Pipeline	$227,000,000	$227,000,000	$227,000,000
Construct Dunnigan Pipeline to CBD (1,000 cfs)	$66,000,000		$66,000,000
Construct Dunnigan Pipeline to River (1,000 cfs)		$194,000,000	
Release Structure	$8,600,000	$8,600,000	$8,600,000
Transmission Lines, Substations, Switchyards	$136,000,000	$136,000,000	$136,000,000
General Property, including Recreation Areas and OM&R Facilities	$32,000,000	$32,000,000	$32,000,000
Mitigation	$540,000,000	$540,000,000	$540,000,000
Construction Cost (2019)	$2,855,000,000	$2,988,000,000	$3,037,000,000

Key:
I/O = inlet/outlet
OM&R = operation, maintenance, and replacement
TRR = Terminal Regulating Reservoir

3.0 Operations, Maintenance, and Replacement Costs

The financial model requires estimated costs for OM&R. Many long-term OM&R costs are proportional to diversions (e.g., energy for pumping and wheeling costs for GCID and Reclamation facilities). Variable and fixed repair and replacement costs were estimated using INEL Guidelines (Estimation of Economic Parameters of U.S. Hydropower Resources for estimating O&M, 2003) and through comparison to costs for the Central Utah and Animas La Plata Projects. Estimated OM&R costs are summarized in Table A4-7 Wheeling costs are conservatively estimated at $22/AF. Power costs were derived from modeling by PARO (DWR, 2016).

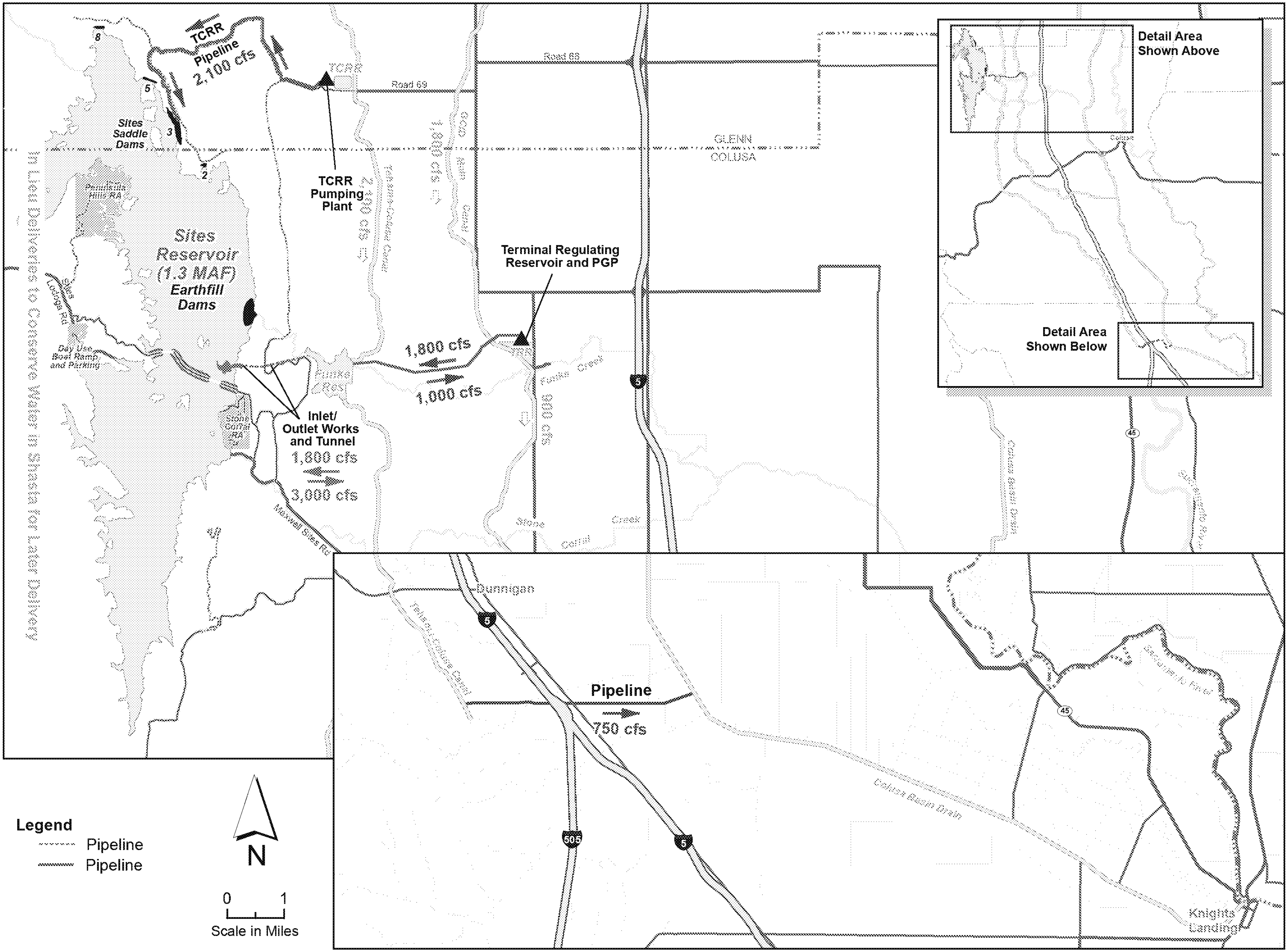
The resulting cost per acre foot was used to adjust the cost estimate to correspond to modeling results.

Table A4-7. OM&R Costs (2016)

Size	Total Flow	Est. Div	SOD Flow	Pump ($1000s)	Wheeling ($1000s)	Variable ($1000s)	Var/AF	Fixed/ AF	$/AF	Total without Generation ($M/yr)	Gen/AF	Potential Savings
1.5	375	394	98	$8,679	$10,819	$19,498	$50	$20	$70	$26,064	$11	$4,052
1.3	359	377	88	$8,309	$10,229	$18,538	$49	$21	$70	$25,149	$10	$3,713
1.0	317	333	60	$7,337	$8,643	$15,980	$48	$24	$72	$22,713	$9	$2,895

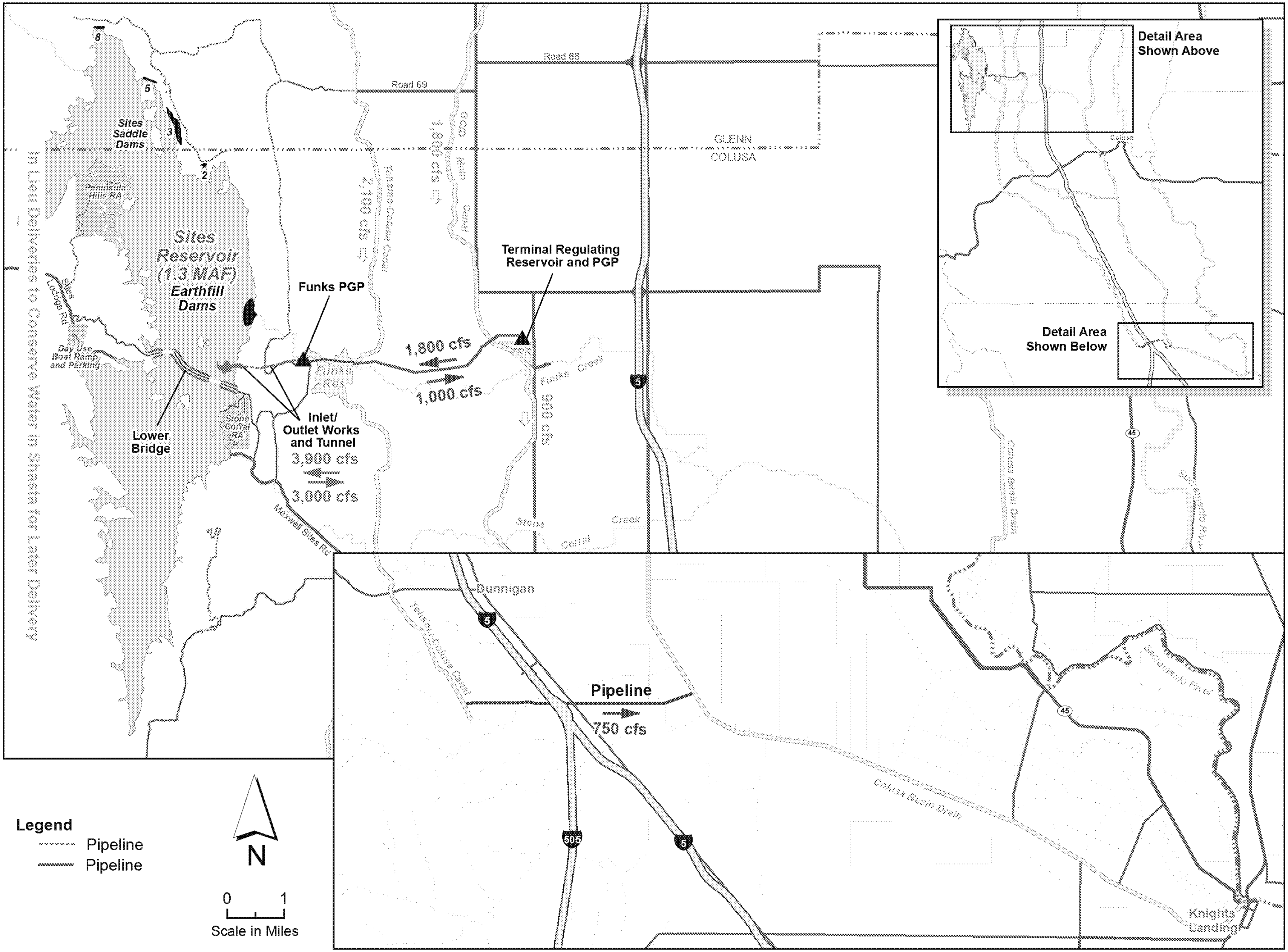
Attachment A-4-1

Value Planning Alternatives



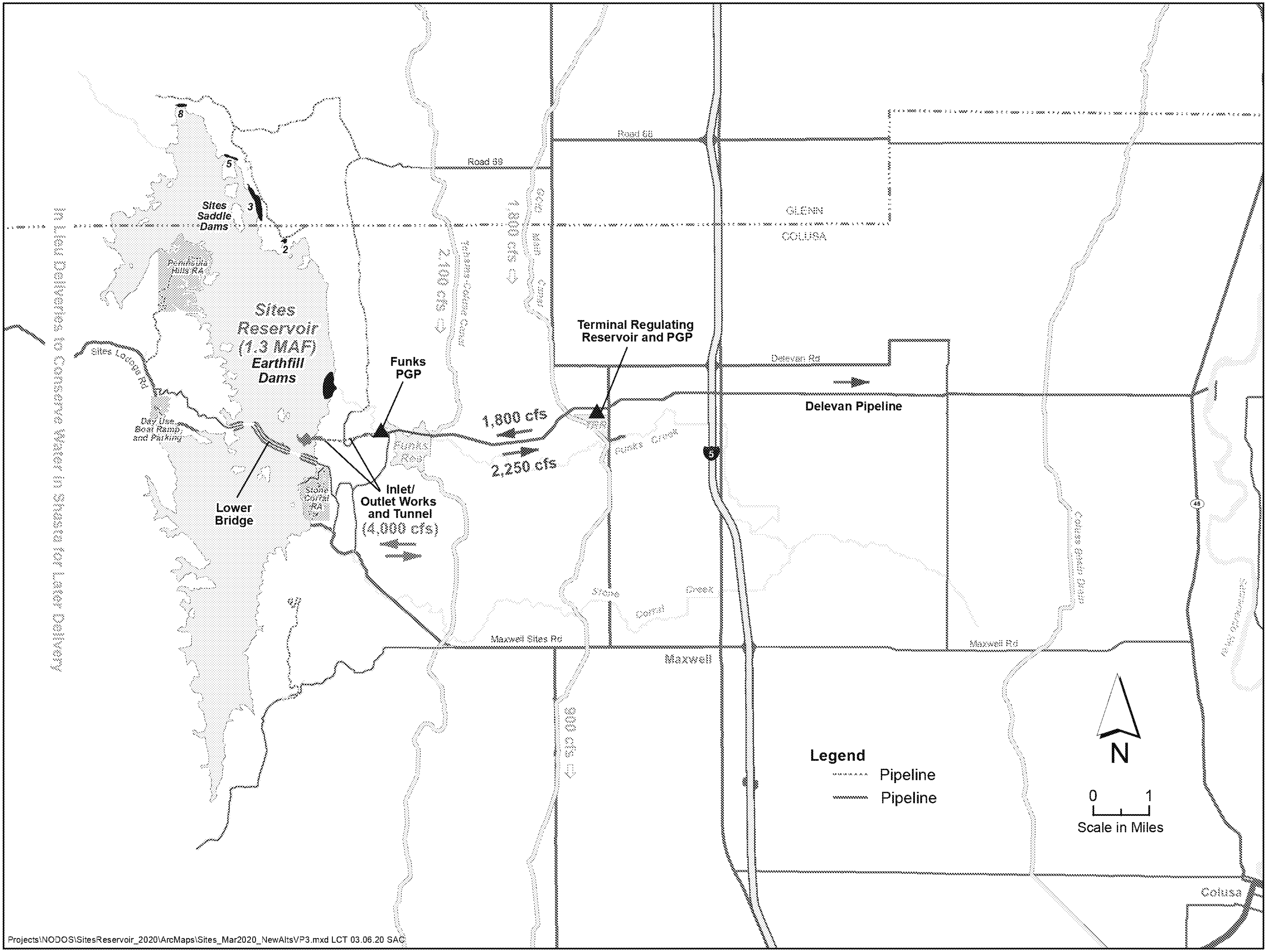
Projects\NODOS\SitesReservoir_2020\ArcMaps\Sites_Mar2020_NewAltsVP1-7.mxd LCT 03.06.20 SAC

VP1



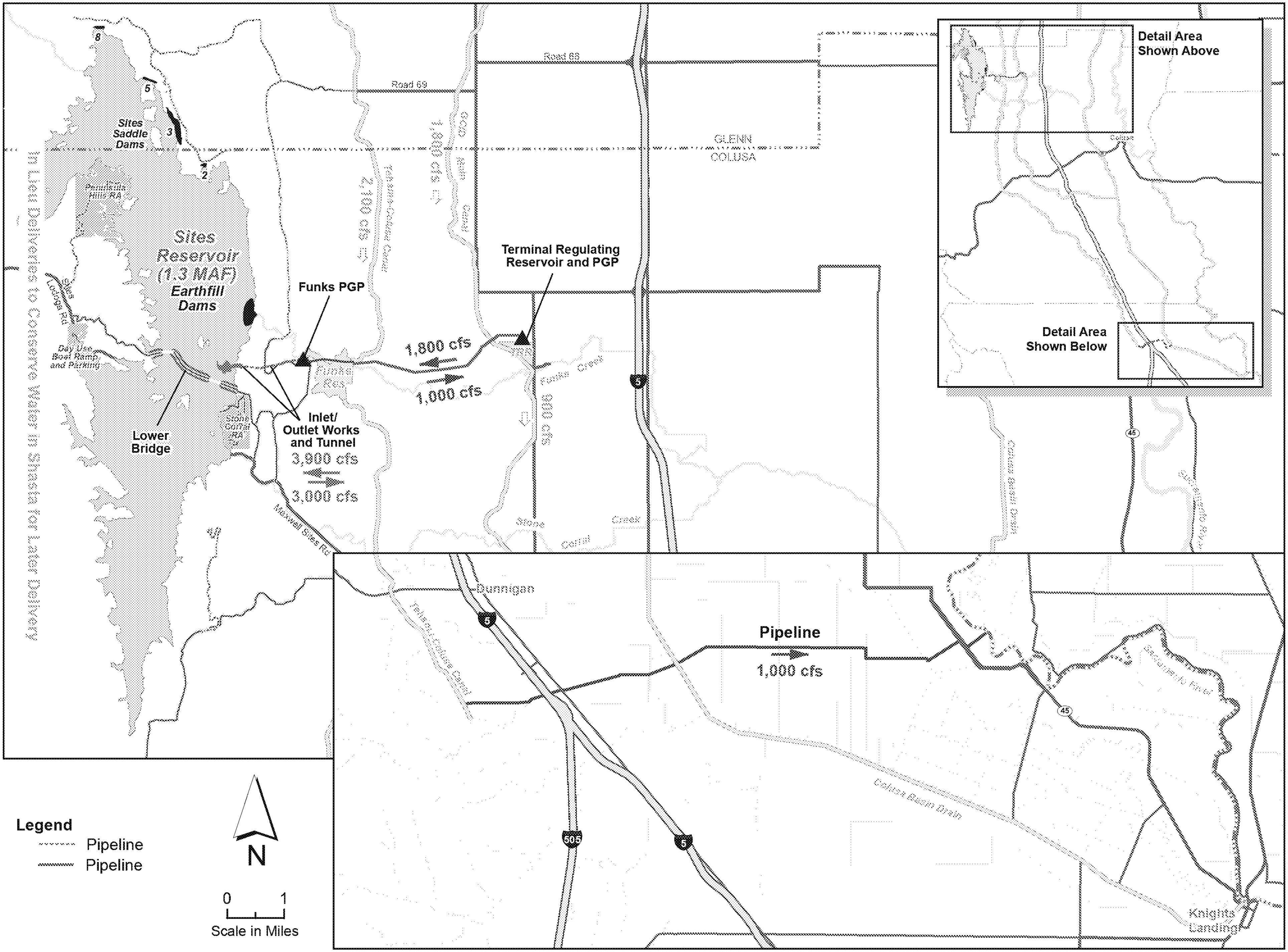
Projects\NODOS\SitesReservoir_2020\ArcMaps\Sites_Mar2020_NewAltsVP1-7.mxd LCT 03.06.20 SAC

VP2



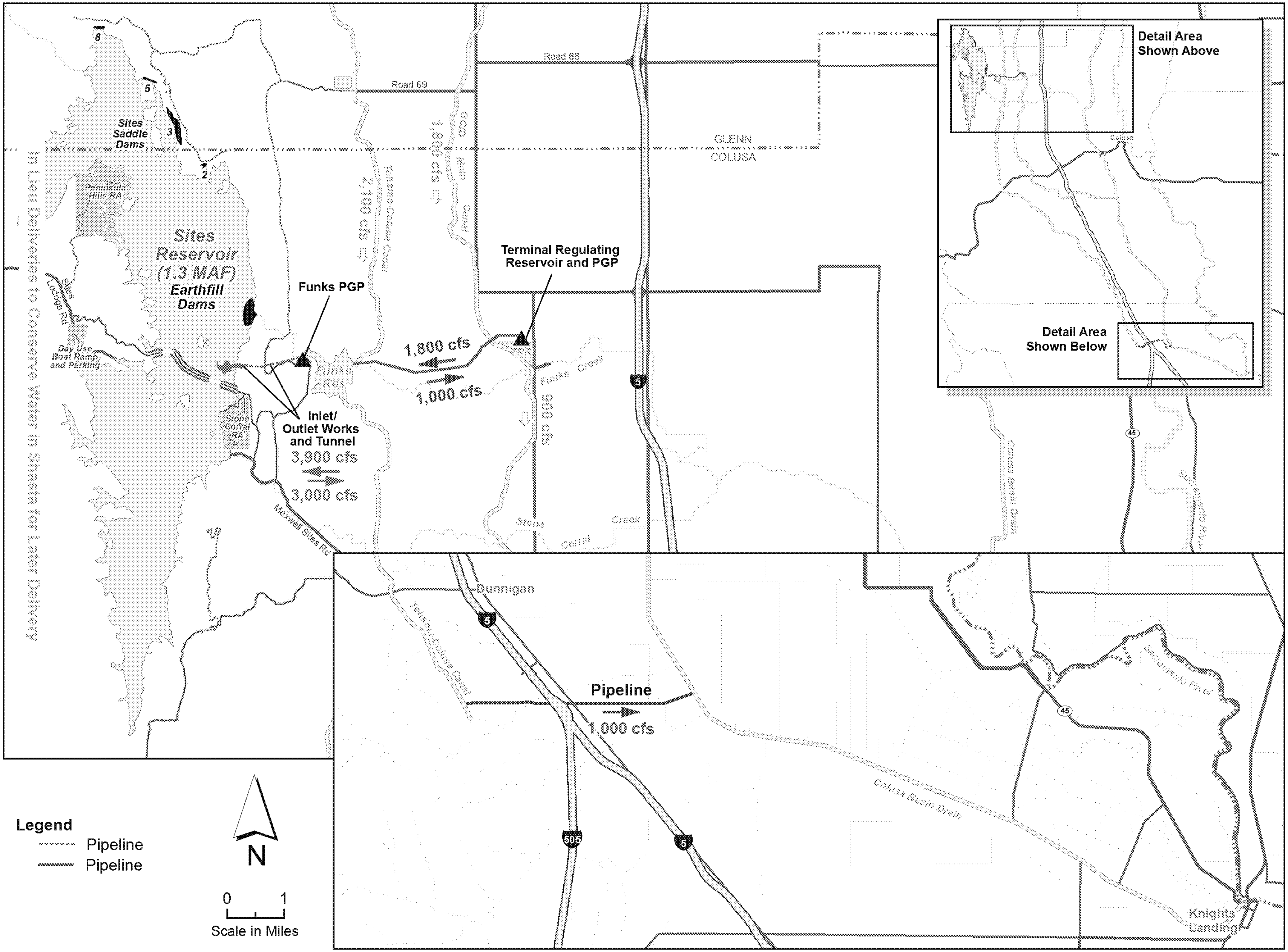
In Lieu Deliveries to Conserve Water in Shasta for Later Delivery
8
5
3
2
Sites Saddle Dams
Peninsula Hills RA
Sites Reservoir (1.3 MAF) Earthfill Dams
Sites Lodoga Rd
Day Use, Boat Ramp, and Parking
Lower Bridge
Stone Corral RA
Inlet/ Outlet Works and Tunnel (4,000 cfs)
Funks PGP
Funks Res
1,800 cfs
2,250 cfs
Road 69
Road 68
2,100 cfs
Tehama-Colusa Canal
1,800 cfs
Glenn Main Canal
GLENN
COLUSA
Terminal Regulating Reservoir and PGP
TRR
Funks Creek
Delevan Rd
Delevan Pipeline
5
Stone Corral Creek
Maxwell Sites Rd
Maxwell
Maxwell Rd
900 cfs
Colusa Basin Drain
45
Sacramento River
Colusa
Legend
Pipeline
Pipeline
N
0
1
Scale in Miles
Projects\NODOS\SitesReservoir_2020\ArcMaps\Sites_Mar2020_NewAltsVP3.mxd LCT 03.06.20 SAC

VP3



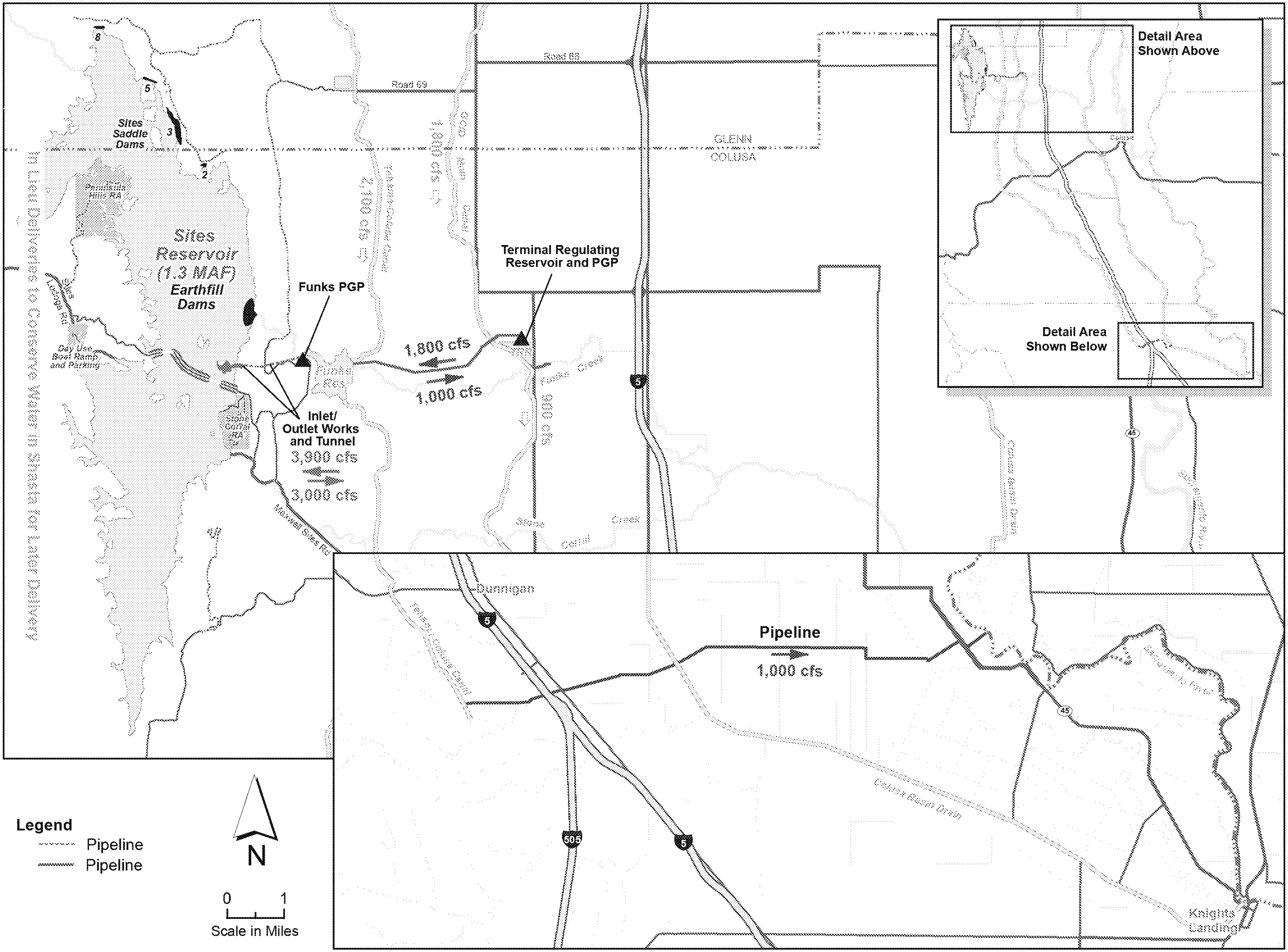
Projects\NODOS\SitesReservoir_2020\ArcMaps\Sites_Mar2020_NewAltsVP1-7.mxd LCT 03.06.20 SAC

VP4



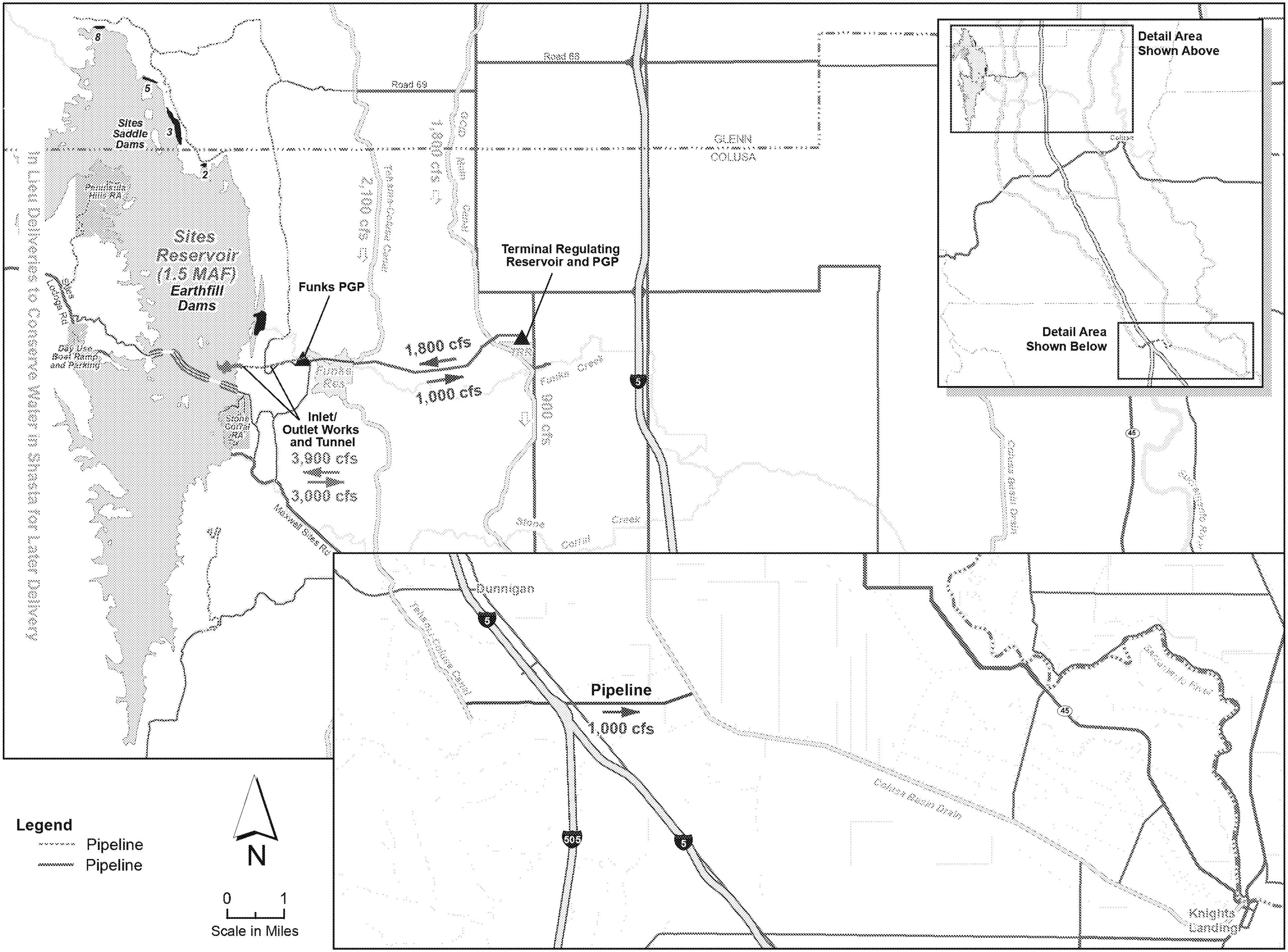
Projects\NODOS\SitesReservoir_2020\ArcMaps\Sites_Mar2020_NewAltsVP1-7.mxd LCT 03.06.20 SAC

VP5



Projects\NODOS\SitesReservoir_2020\ArcMaps\Sites_Mar2020_NewAltsVP1-7.mxd LCT 03.06.20 SAC

VP6



Projects\NODOS\SitesReservoir_2020\ArcMaps\Sites_Mar2020_NewAltsVP1-7.mxd LCT 03.06.20 SAC

VP7

Appendix B – Operations

Appendix B-1 Release Capacity and Reservoir Size Technical Memorandum

To:	Value Planning Work Group
CC:	Lee Frederiksen
Date:	March 12, 2020
From:	Rob Tull, CH2M
Quality Review by:	Erin Heydinger
Authority Agent Review by:	Ali Forsythe
Subject:	Release Capacity and Reservoir Size

This memorandum includes a sensitivity analysis for a range of reservoir sizes and release capacities for Sites Reservoir. The purpose of this analysis is to evaluate the quantity of water from Sites Reservoir that could be released under different conveyance capacities.

1.0 Assumptions

Three conveyance capacities for Sites Reservoir releases were evaluated: 750 cubic feet per second (cfs), 1,000 cfs, and 1,500 cfs. Each conveyance capacity was assessed using three storage capacities for the reservoir: 1.5 million acre-feet (MAF), 1.3 MAF, and 1.0 MAF. All nine combinations were run under Scenario B, an operations scenario that was developed through previous discussions with the California Department of Fish and Wildlife (CDFW). Assumptions and diversion criteria for Scenario B operations are detailed in Attachment 1.

The following scenarios were evaluated:

1. Scenario B – 750 cfs conveyance capacity & 1.5 MAF storage capacity
2. Scenario B – 750 cfs conveyance capacity & 1.3 MAF storage capacity
3. Scenario B – 750 cfs conveyance capacity & 1.0 MAF storage capacity
4. Scenario B – 1,000 cfs conveyance capacity & 1.5 MAF storage capacity
5. Scenario B – 1,000 cfs conveyance capacity & 1.3 MAF storage capacity
6. Scenario B – 1,000 cfs conveyance capacity & 1.0 MAF storage capacity
7. Scenario B – 1,500 cfs conveyance capacity & 1.5 MAF storage capacity
8. Scenario B – 1,500 cfs conveyance capacity & 1.3 MAF storage capacity
9. Scenario B – 1,500 cfs conveyance capacity & 1.0 MAF storage capacity

For each scenario, releases from Sites Reservoir were quantified using monthly releases, as reported by CalSim II modeling. Deliveries include releases for Phase 2 project participants including members along the Tehema-Colusa Canal (T-C Canal), Glenn-Colusa Irrigation District, Reclamation District 108, Colusa County, other Sacramento Valley participants, South of Delta participants, plus Proposition 1 deliveries for Incremental Level 4 refuge water supply (Refuge Level 4) and Yolo Bypass.

The type of facility selected to convey Sites Reservoir releases is yet to be determined (at the time the analysis was conducted). Releases may be through a canal, creek, or pipe. The results of this sensitivity analysis are unaffected by facility choice and additional analysis to account for seepage losses and downstream hydraulic conditions will be needed in the future.

These sensitivity analyses include a surrogate approximation of the potential to exchange water between Sites Reservoir and Shasta Lake. This exchange would be implemented through the release of Sites water to meet Sacramento Valley Central Valley Project (CVP) contract demands and Delta regulatory obligations. There would be a corresponding reduction in Shasta Lake releases that preserves storage in the lake and contributes to water temperature management and Sacramento River flow stability benefits. Based on previous analyses it is assumed that about 60 thousand acre-feet (TAF) could be exchanged on an average annual basis with the majority of these exchanges occurring in dry and critical water year types. This also assumes integration with the State Water Project (SWP) to facilitate operations and deliveries to South-of-Delta members. Work is on-going to develop the capability to simulate the Reclamation no investment exchange and integration of operations with the SWP.

2.0 Release Results

Table B1-1 shows the reservoir releases for Scenario B under all nine combinations of Sites storage and release capacities. The table includes average annual deliveries for the full 82-year simulation period and each water year type, as classified by DWR's Sacramento Valley Water Year Hydrologic Index.

Overall, decreasing Sites' release capacity from 1,500 cfs to 1,000 cfs reduces average annual releases by 4.0% to 6.2%. Bringing the release capacity down to 750 cfs reduces average annual deliveries by another 1.6% to 2.7%.

Releases from Sites are greatest during Dry years. Consequently, dry years are more critical to the conveyance capacity of Sites releases than any other year type. For example, the average annual delivery of a 1.5 MAF reservoir decreases by 13.5% when its' release capacity is reduced from 1,500 cfs to 750 cfs.

Based on this sensitivity analysis, the combination of a 1.3 MAF reservoir and a 750 cfs release capacity provides about a 230 TAF average annual release for Sites Reservoir.

It is recommended that a lower range estimate also be considered, to account for uncertainty, that is 30 TAF less than the simulated values shown in Table B1-1.

Table B1-1. Sites Reservoir Releases under Varying Storage and Release Capacities

<table>
<tr><td colspan="4">Preliminary - Sensitivity</td></tr>
<tr><td colspan="4">**Conveyance Release Analysis – Scenario B**</td></tr>
<tr><td colspan="4">Reservoir Release (TAF)</td></tr>
<tr><td colspan="4">Long-term Average</td></tr>
<tr><td>Storage Capacity (MAF)</td><td>Scenario B – 1,500 cfs Release Capacity</td><td>Scenario B – 1,000 cfs Release Capacity</td><td>Scenario B – 750 cfs Release Capacity</td></tr>
<tr><td>1.5</td><td>253</td><td>243</td><td>236</td></tr>
<tr><td>1.3</td><td>243</td><td>234</td><td>230</td></tr>
<tr><td>1.0</td><td>207</td><td>195</td><td>191</td></tr>
<tr><td colspan="4">Wet Years</td></tr>
<tr><td>Storage Capacity (MAF)</td><td>Scenario B – 1,500 cfs Release Capacity</td><td>Scenario B – 1,000 cfs Release Capacity</td><td>Scenario B – 750 cfs Release Capacity</td></tr>
<tr><td>1.5</td><td>115</td><td>116</td><td>112</td></tr>
<tr><td>1.3</td><td>122</td><td>115</td><td>113</td></tr>
<tr><td>1.0</td><td>118</td><td>112</td><td>109</td></tr>
<tr><td colspan="4">Above Normal Years</td></tr>
<tr><td>Storage Capacity (MAF)</td><td>Scenario B – 1,500 cfs Release Capacity</td><td>Scenario B – 1,000 cfs Release Capacity</td><td>Scenario B – 750 cfs Release Capacity</td></tr>
<tr><td>1.5</td><td>275</td><td>286</td><td>280</td></tr>
<tr><td>1.3</td><td>287</td><td>299</td><td>303</td></tr>
<tr><td>1.0</td><td>185</td><td>186</td><td>194</td></tr>
<tr><td colspan="4">Below Normal Years</td></tr>
<tr><td>Storage Capacity (MAF)</td><td>Scenario B – 1,500 cfs Release Capacity</td><td>Scenario B – 1,000 cfs Release Capacity</td><td>Scenario B – 750 cfs Release Capacity</td></tr>
<tr><td>1.5</td><td>285</td><td>273</td><td>277</td></tr>
<tr><td>1.3</td><td>278</td><td>263</td><td>266</td></tr>
<tr><td>1.0</td><td>237</td><td>217</td><td>213</td></tr>
<tr><td colspan="4">Dry Years</td></tr>
<tr><td>Storage Capacity (MAF)</td><td>Scenario B – 1,500 cfs Release Capacity</td><td>Scenario B – 1,000 cfs Release Capacity</td><td>Scenario B – 750 cfs Release Capacity</td></tr>
<tr><td>1.5</td><td>422</td><td>382</td><td>365</td></tr>
<tr><td>1.3</td><td>392</td><td>364</td><td>345</td></tr>
<tr><td>1.0</td><td>343</td><td>309</td><td>301</td></tr>
<tr><td colspan="4">Critically Dry Years</td></tr>
<tr><td>Storage Capacity (MAF)</td><td>Scenario B – 1,500 cfs Release Capacity</td><td>Scenario B – 1,000 cfs Release Capacity</td><td>Scenario B – 750 cfs Release Capacity</td></tr>
<tr><td>1.5</td><td>243</td><td>237</td><td>225</td></tr>
<tr><td>1.3</td><td>205</td><td>204</td><td>204</td></tr>
<tr><td>1.0</td><td>185</td><td>184</td><td>177</td></tr>
</table>

3.0 T-C Canal Capacity Analysis

It is necessary to determine whether there is enough capacity in the T-C Canal to accommodate Sites releases to the Sacramento River in addition to releases for Tehama-Colusa Canal Authority (TCCA) members. It is assumed there is 750 cfs of available capacity through the canal.

To confirm the available capacity in the T-C Canal, historical daily diversion data were obtained. Figure B1-1 shows historical daily diversions through the T-C Canal for the period from January 2014 to February 2020. CVP TCCA contractors received a 100 percent contract allocation for 2016 through 2019. The total recorded diversions at Red Bluff Pumping Plant were reduced by one-third to approximate the level of flow in the reach of the TCC below Funks Reservoir. As shown, the estimated daily canal flows never exceed 800 cfs. Assuming the T-C Canal has a capacity of 1,900 cfs below Funks Reservoir, there would be at least 1,000 cfs capacity available for Sites releases even under 100 percent allocation years. Figure B1-2 shows the average monthly approximation for historical diversions through the lower T-C Canal. The figure shows that with some smoothing of the daily values that could be accomplished by forecasting, the lower T-C Canal may have up to 1,000 cfs capacity for Project releases on an average monthly basis, during the peak summer diversion season when TCCA contractors receive a 100 percent contract allocation.

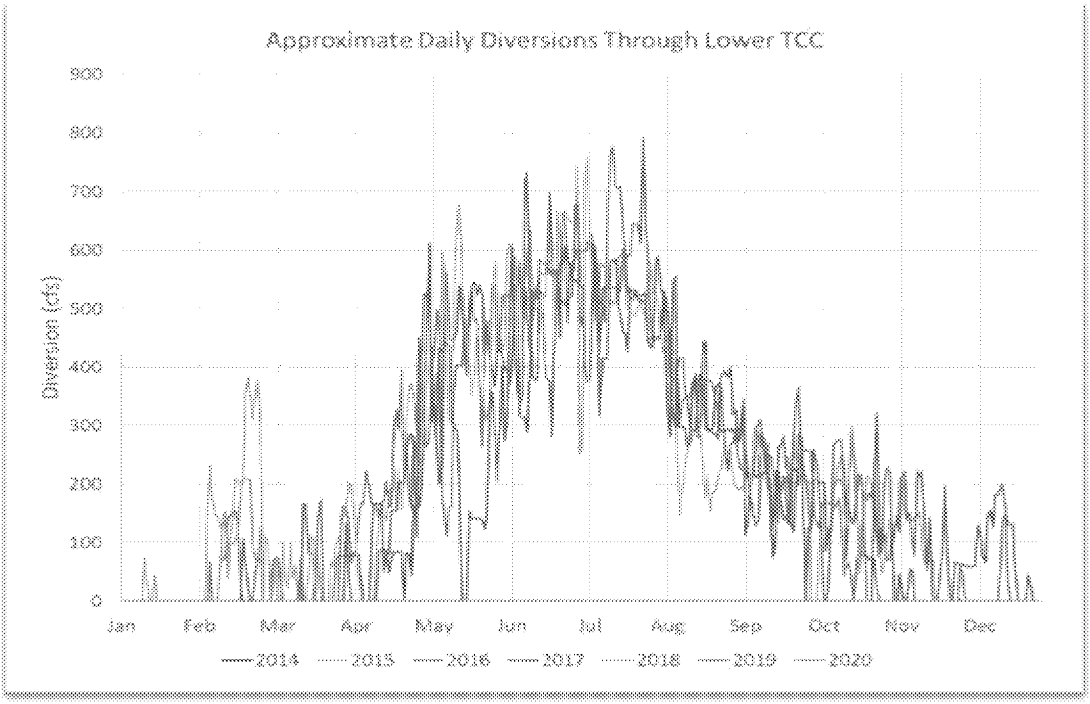


Figure B1-1. Approximated Daily Diversions through the Lower T-C Canal for 2014 to 2020

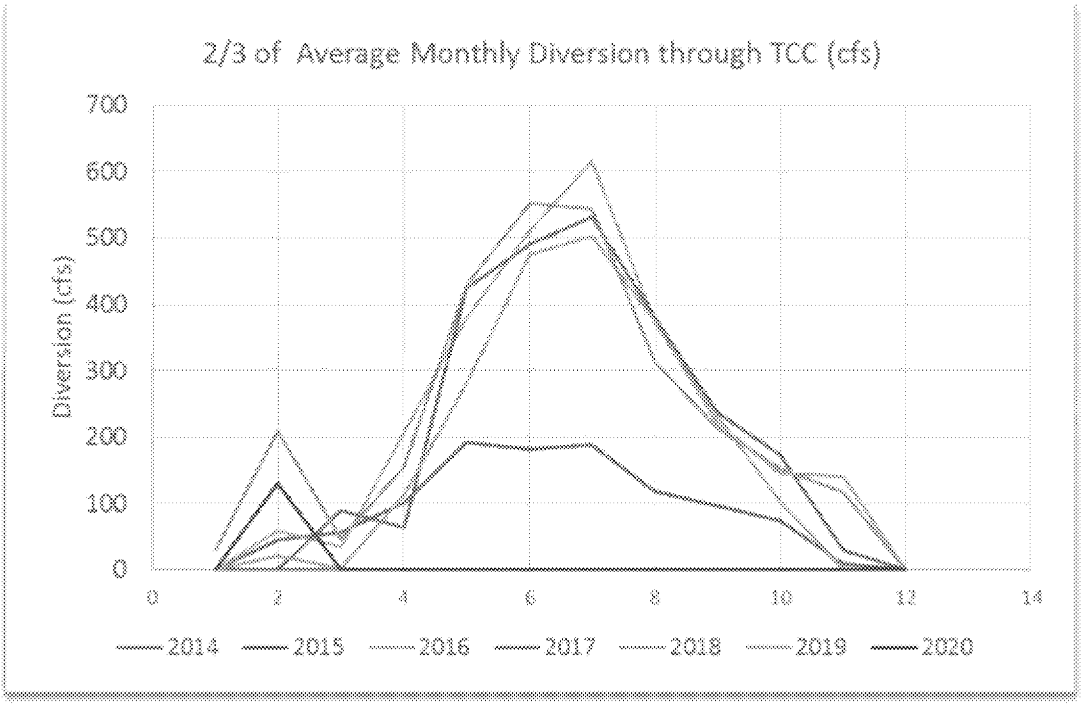


Figure B1-2. Approximated Average Monthly Diversion through the lower T-C Canal for 2014 to 2020

Figure B1-3 shows Sites Reservoir releases through the T-C Canal to the TCCA members under Scenario B using a 1,000 cfs conveyance capacity and three different storage capacities (1.0 MAF, 1.3 MAF, and 1.5 MAF). The releases assume no exchange with Shasta Lake. Figure B1-4 shows total release through the T-C Canal under the assumption that the T-C Canal is the only option for release conveyance. This release includes CVP deliveries to TCCA members and releases from Sites Reservoir under the assumption of no exchange with Shasta Lake. It also includes Sites releases for Colusa County, other Sacramento Valley members, South-of-Delta members, and state deliveries for Level 4 Refuges and Yolo Bypass objectives. As shown, simulated monthly Sites deliveries through T-C Canal to members along the canal never exceed much more than 500 cfs, while total deliveries through T-C Canal including South of Delta releases rarely exceeds 1,100 cfs. Based on this preliminary analysis, the lower T-C Canal appears to have sufficient capacity to convey CVP TCCA contractor deliveries, Sites releases to TCCA members, plus additional Sites releases to the Sacramento River, during the peak summer diversion season.

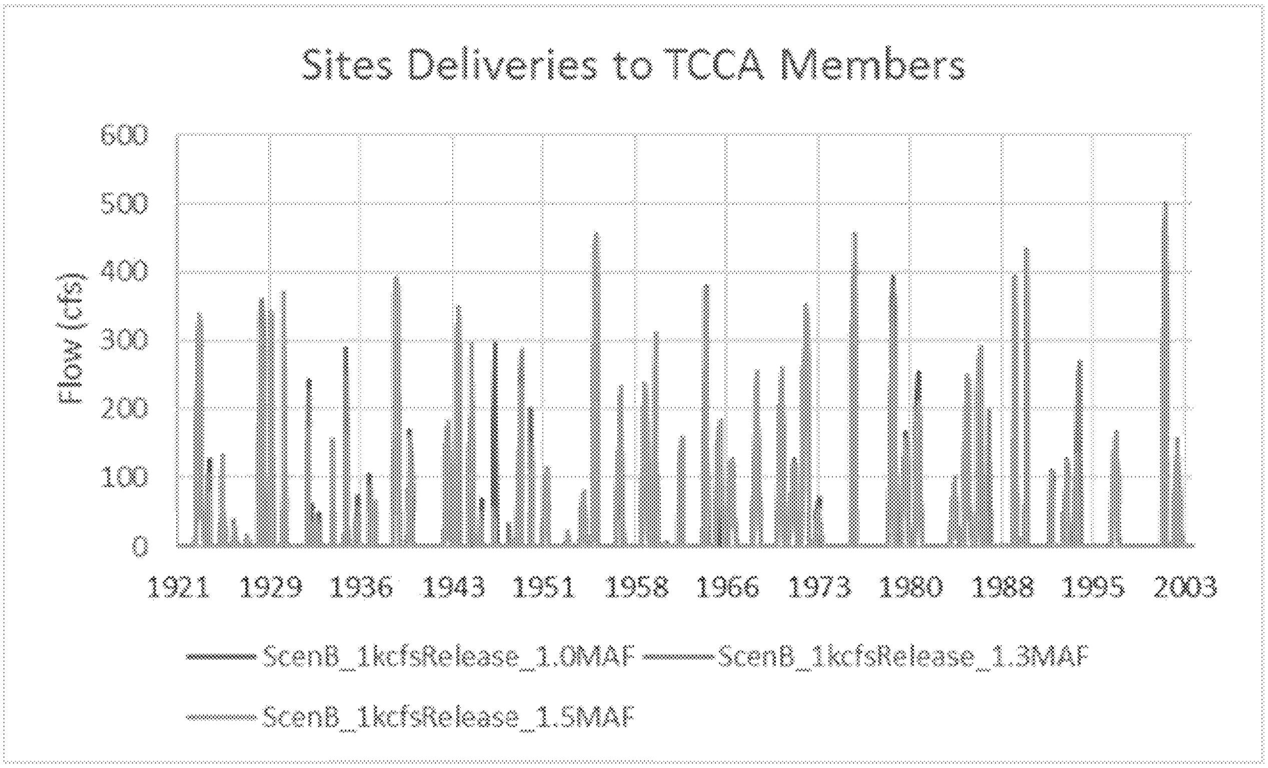


Figure B1-3. Sites Deliveries to TCCA Members under Scenario B

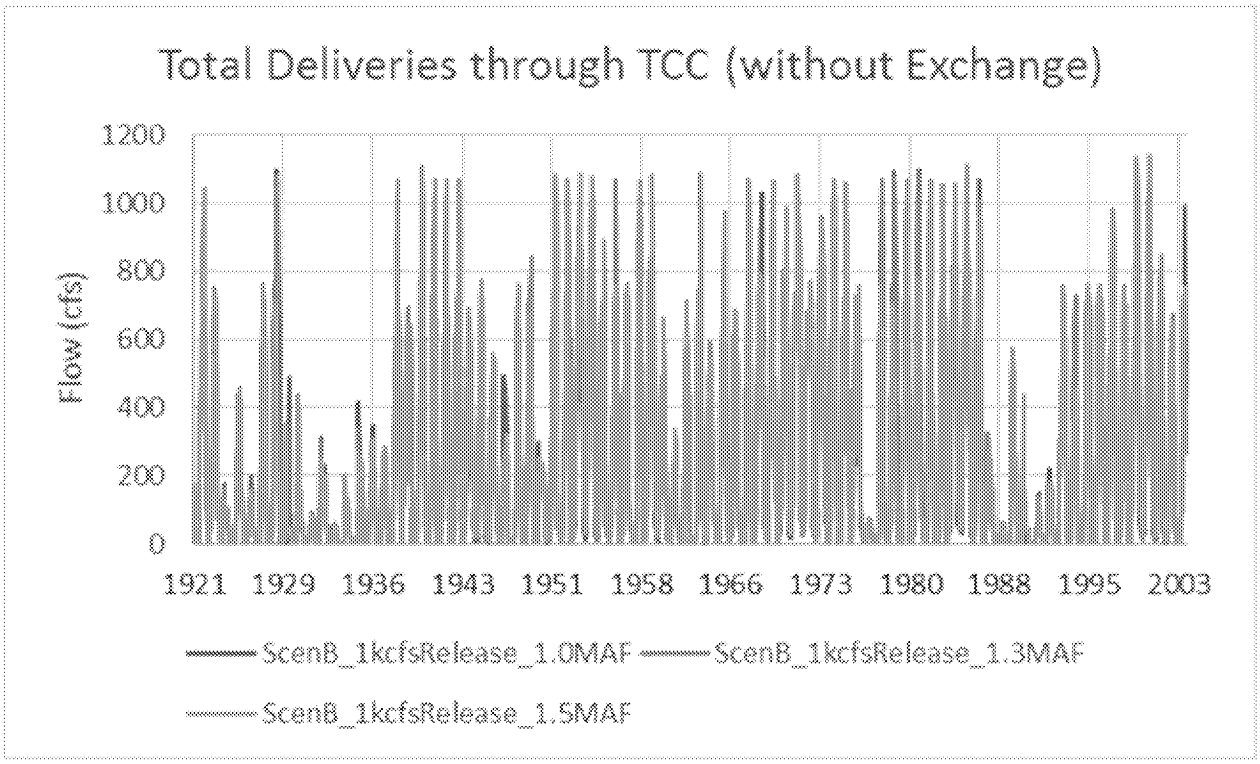


Figure B1-4. Total Deliveries through the T-C Canal under Scenario B

4.0 Limitations

This evaluation was conducted as a sensitivity analysis to support the value planning process and there are a number of limitations that need to be taken into consideration.

- This analysis evaluates conveyance sizing under assumed Scenario B diversion criteria.
- Monthly model time step is appropriate for value planning purposes. More detailed modeling analysis will be needed to confirm these results.
- Estimates of conveyance release capability presented in Table B1-1 are upper range estimates based on model simulated results and do not account for uncertainty.
- It is recommended that a lower range estimate also be considered to account for uncertainty. The lower range estimate values would be 30 TAF below the Table B1-1 values to account for uncertainty associated with 1) interpretation of Scenario B diversion criteria, 2) need to preserve functional spills into the Sutter and Yolo bypasses, 3) river flow routing and real-time operational controls and decisions, 4) need to further refine assumptions and model simulation of CVP no investment exchange and SWP operations integration.

Attachment B-1-1

Sites Operations Scenario B

Attachment 1. Operations Scenario B

This attachment provides modeling assumptions for Sites Project operations Scenario B used to evaluate the release capacity of Sites Reservoir. Scenario B was developed based on previous discussions with CDFW in December of 2019.

Criteria	Scenario B
Reservoir Size	1.0 MAF, 1.3 MAF, or 1.5 MAF
GCC Maintenance Window	2 weeks (Jan/Feb)
Upstream Pulse Flow Protection	Bypass the first pulse flow event in October – May for up to 7 days during pulse of 15,000 to 25,000 cfs as measured at Bend Bridge
Wilkins Slough Bypass Flow	8,000 cfs April/May; 5,000 cfs all other times
Fremont Weir Notch	Prioritize the Fremont Weir Notch, Yolo Bypass preferred alternative, flow over weir within 5%
Flows into the Sutter Bypass System	No restriction due to flow over Moulton, Colusa, and Tisdale Weirs
Freeport Bypass Flow	Modeled WaterFix Criteria (applied on a daily basis) Post-Pulse Protection (applied on a moving 7-day average) Post-Pulse (3 levels) = Jan-Mar Level 2 starts Jan 1 Level 1 is initiated by the pulse trigger
Net Delta Outflow Index (NDOI) Prior to Project Diversions	44,500 cfs between March 1 and May 31

Appendix B-2 Shasta Lake Exchanges with No Reclamation Investment
Technical Memorandum

Sites
Program Management Team

To:	Value Planning Work Group
CC:	Lee Frederiksen
Date:	March 9, 2020
From:	CH2M
Subject:	Shasta Lake Exchanges with No Reclamation Investment

1.0 Purpose

- Conduct a preliminary evaluation of the potential for exchanging Sites Project water with Shasta Lake without dedicated Bureau of Reclamation (Reclamation) investment in the Sites Project (Project).
- Implement feedback on exchange criteria provided by Reclamation.
- Investigate the potential temperature benefits of the operation.

2.0 Background

With Reclamation participation to the Project, but no investment, water stored in Sites Reservoir could be exchanged with Shasta Lake to meet Central Valley Project (CVP) Tehama Colusa Canal Authority (TCCA) Agricultural water Service and Settlement Contractor obligations and downstream flow and Delta water quality requirements. Therefore, a portion of the water demand within the CVP service area along the Tehama Colusa Canal (TCC) and the Glenn Colusa Canal (GCC) south of Sites Reservoir could be met from releases from Sites Reservoir in the spring and allow an equal amount of water to be retained in Lake Shasta (via exchange) to improve summer cold water pool management.

The exchange could occur when Sacramento River flows at Keswick and temperatures at Clear Creek are within a specific range and not compromised by reduced Lake Shasta releases into the Sacramento River. This exchange could likely occur in April through May (and possibly June) in Dry and Critical years.

Lake Shasta releases of exchange water would be scheduled to benefit downstream temperatures in the Sacramento River, which would likely occur in September, October, or November. Withdrawals from Shasta would be coordinated with Reclamation and no carry over storage of exchange water would be allowed between years.

The exchange operation would likely be subject to the following constraints provided by Reclamation to protect the interests of the CVP and to comply with State and Federal laws and regulations:

- All water stored in Shasta would be subject to spill at any date and would be the first water in Shasta to spill.
- All operations associated with this operation would be subject to river temperature constraints to ensure that there is not an impact by reducing releases to store and to ensure a benefit when released later in the year.

- All operations are subject to approval by the State Water Resources Control Board (SWRCB), and any applicable state or federal laws, regulations, or guidelines.

3.0 Operations Analysis

3.1 Approach

- A post-processing approach was used for this preliminary analysis due to extensive code changes that will be needed to implement this operation in the CalSim II model.
- All calculations were performed using results from the CalSim II DCR 2015 Merged Model No Action Alternative (NAA).
- The post-processing analysis was performed for the years 1922 through 2002, consistent with the time period modeled in CalSim II.
- A series of criteria was established, as defined in the attached table, for each scenario. If all criteria were met, the operation was permitted for that year. Criteria included Sacramento River temperature at Clear Creek, Keswick flow, Shasta storage, and water year types. Additional criteria were provided by Reclamation for analysis.
- In all scenarios, Keswick outflow and Sacramento River at Clear Creek temperature requirements between April and June were protected to maintain NAA conditions.
- Nine scenarios were evaluated to assess the volume and frequency of water that could be exchanged between Sites and Shasta Lake.

  1) The “Initial Concept”, based on Thad Bettner’s Aug 8 email, allows for exchanges with Shasta Lake between April and July and releases between August and November 15 during Dry and Critical years. Releases from Shasta storage were based on available Banks Pumping Plant capacity. The exchange operation is only permitted when the Sacramento Valley is in “In-basin Use” (IBU) conditions. Under the “Initial Concept”, three scenarios were evaluated:
     a. No Delevan Pipeline, assuming that the exchange operation is not facilitated through the Delevan Pipeline.
     b. One-pipe Delevan Pipeline.
     c. Two-pipe Delevan Pipeline.
  2) Additionally, several sensitivity analyses were performed on the “Initial Concept” with a two-pipe Delevan Pipeline:
     a. Includes the exchange operation in Below Normal water years.
     b. Exchanges assumed to occur under UWFE conditions as well.
     c. Shasta Lake releases allowed through December.
  3) Two scenarios were designed to maximize Delta export and habitat benefits from the exchange operation with the release of the stored water:
     a. Releases are delayed to improve river temperatures and provide fall flow stability habitat benefits in August through December.
     b. The same criteria as above, with the additional requirement that Shasta Lake storage be above 1,900 TAF in September, consistent with the RPA.
  4) Reclamation provided additional criteria for the exchange operation on January 16, 2020:
     a. The exchange period is limited to April and May. This reflects Reclamation’s comments on what is needed to meet estimated targets for Sacramento River temperatures at Clear Creek, Keswick flows above minimum, and deliveries to the Sacramento River Settlement Contractors.

b. Withdrawals of Sites water stored in Shasta would most likely occur in September, October, and November.

c. The exchange is limited to Dry and Critically Dry water years.

d. Sacramento River Temperature at Clear Creek must be below the following targets for the exchange to occur:

Table B2-1. Temperatures (°F) on the Sacramento River at Clear Creek, from ROC on LTO Proposed Action

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEPT
Wet (32%)	53.3	54.6	51.4	47.5	46.3	47.1	49.2	50.2	51.5	52.0	52.8	52.9
Above Normal (16%)	53.1	53.9	50.8	47.7	46.4	47.4	49.9	50.3	51.0	51.4	52.8	53.7
Below Normal (13%)	54.3	54.7	51.5	48.2	47.4	49.0	51.1	50.6	51.2	52.1	53.0	54.2
Dry (24%)	54.0	54.6	51.1	48.4	48.0	49.0	51.2	51.1	51.5	52.7	53.6	54.4
Critical (15%)	59.5	56.3	51.4	48.6	48.2	49.6	51.6	52.2	53.4	55.0	57.4	60.5

░	Within 1 °F of Tier 1 limit (52.5 °F – 53.5 °F)
▒	53.6 °F – 55.9 °F
▓	Tier 4 (> 56 °F)

3.2 General Assumptions

- The exchange concept with Shasta Lake is permissible by the Bureau of Reclamation.
- Water year types are based on the Sacramento Valley D-1641 index and are assigned on a January-December calendar-year basis.
- It is assumed that no Sites Project water is carried over in Shasta Lake between calendar years.
- It is assumed that there is sufficient water in Sites Reservoir to facilitate the operation.
- It is assumed that all active storage in Sites Reservoir is available for exchange.
- The exchange operation is based on the replacement of both CVP agricultural deliveries and water released from Shasta to meet Delta requirements.

3.3 Results

Results are summarized in the attached time series, bar chart, and exceedance figures. A summary of the results is provided below.

Table B2-2. Summary of Average Annual Exchange Volumes by Water Year (TAF)

WYT	Initial Concept - no Delevan Pipeline Exchange	Initial Concept - 1 pipe Delevan Pipeline	Initial Concept - 2 pipe Delevan Pipeline	[Sensitivity] Exchanges allowed in Below Normal years - 2 pipe Delevan Pipeline	[Sensitivity] Exchanges assumed to occur under UWFE conditions as well - 2 pipe Delevan Pipeline	[Sensitivity] Releases allowed through December - 2 pipe Delevan Pipeline	[Sensitivity] Releases required to have habitat benefit, allowed through December - 2 pipe Delevan Pipeline	[Sensitivity] Releases required to have habitat benefit, allowed through December, Storage RPA control - 2 pipe Delevan Pipeline	[Sensitivity] USBR Proposed - 2 pipe Delevan Pipeline
W	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
AN	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
BN	n/a	n/a	n/a	43	n/a	n/a	n/a	n/a	n/a
D	119	141	144	144	156	177	100	100	43
C	80	114	130	130	149	133	104	9	56

Depending on the scenario considered, Sites Reservoir storage may not be available for this type of operation due to constraints on diversions-to-fill and other constraints of the scenario. When compared against storage volumes for a simulated 1.3 MAF reservoir using CDFW Scenario B, in 10 of the 21 years that the exchange occurs, there is not sufficient water in Sites Reservoir to facilitate the exchange operation.

3.4 Recommendations

- This preliminary evaluation demonstrates there is enough volume and frequency of water available for exchange to warrant further evaluation of these potential operations in more detail in a systemwide CVP/SWP context.
- Based on comments, use the post-processing spreadsheet to evaluate additional combinations of operational exchange criteria.

Sites Project with no Reclamation Investment

Sites-Shasta Exchange Operation

Alternatives
Initial Concept - no Delevan Pipeline
Initial Concept - 1 pipe Delevan Pipeline
Initial Concept - 2 pipe Delevan Pipeline
[Sensitivity] Exchanges allowed in Below Normal years - 2 pipe Delevan Pipeline
[Sensitivity] Exchanges assumed to occur under UWFE conditions as well - 2 pipe Delevan Pipeline
[Sensitivity] Releases allowed through December - 2 pipe Delevan Pipeline
[Sensitivity] Releases required to have habitat benefit, allowed through December - 2 pipe Delevan Pipeline
[Sensitivity] Releases required to have habitat benefit, allowed through December, Storage RPA control - 2 pipe Delevan Pipeline
[Sensitivity] USBR Proposed- 2 pipe Delevan Pipeline

Export required			
Initial Concept - no Delevan Pipeline	Initial Concept - 1 pipe Delevan Pipeline	Initial Concept - 2 pipe Delevan Pipeline	[Sensitivity] Exchanges allowed in Below Normal years
Exchange limited to conditions with limited flow/temperature impact potential			
Storage accrued in Shasta by exchange			
Banks export capacity must be available			
Storage released from Shasta for export starting in August			
No Delevan Pipeline	1-pipe Delevan Pipeline	2-pipe Delevan Pipeline	2-pipe Delevan Pipeline
Storage must be released from Shasta by Nov 15	Storage must be released from Shasta by Nov 15	Storage must be released from Shasta by Nov 15	Storage must be released from Shasta by Nov 15
Only Dry and Critically Dry years considered	Only Dry and Critically Dry years considered	Only Dry and Critically Dry years considered	Below Normal, Dry, and Critically Dry years considered

Exchange Operation	Keswick Flow (cfs)		Keswick Flow (cfs)		Keswick Flow (cfs)		Keswick Flow (cfs)	
Sac Flow check	April	6,000	April	6,000	April	6,000	April	6,000
Prior to Summer	May	6,000	May	6,000	May	6,000	May	6,000
- All scenarios	Jun	10,000	Jun	10,000	Jun	10,000	Jun	10,000
	Jul	12,000	Jul	12,000	Jul	12,000	Jul	12,000

Exchange Operation	Sac R blw Clear Creek Temp (F)		Sac R blw Clear Creek Temp (F)		Sac R blw Clear Creek Temp (F)		Sac R blw Clear Creek Temp (F)	
Sac Temperature check	April	No Rule	April	No Rule	April	No Rule	April	No Rule
Prior to Summer	May	56	May	56	May	56	May	56
- All scenarios	Jun	56	Jun	56	Jun	56	Jun	56
	Jul	53.5	Jul	53.5	Jul	53.5	Jul	53.5

Hold Operation	Shasta Storage (TAF)		Shasta Storage (TAF)		Shasta Storage (TAF)		Shasta Storage (TAF)	
Storage over Summer	April	No Rule	April	No Rule	April	No Rule	April	No Rule
- Habitat scenarios	May	No Rule	May	No Rule	May	No Rule	May	No Rule
	Jun	No Rule	Jun	No Rule	Jun	No Rule	Jun	No Rule
	Jul	No Rule	Jul	No Rule	Jul	No Rule	Jul	No Rule
	Sep - low	No Rule	Sep - low	No Rule	Sep - low	No Rule	Sep - low	No Rule
	Sep - high	No Rule	Sep - high	No Rule	Sep - high	No Rule	Sep - high	No Rule

Release Operation	Maximum Keswick Flow (cfs)		Maximum Keswick Flow (cfs)		Maximum Keswick Flow (cfs)		Maximum Keswick Flow (cfs)	
- Habitat scenarios	Aug	10,000	Aug	10,000	Aug	10,000	Aug	10,000
delayed release	Sep	12,000	Sep	12,000	Sep	12,000	Sep	12,000
- other scenarios	Oct	No Rule	Oct	No Rule	Oct	No Rule	Oct	No Rule
release starts in Aug	Nov	No Rule	Nov	No Rule	Nov	No Rule	Nov	No Rule
	Dec	No Rule	Dec	No Rule	Dec	No Rule	Dec	No Rule

Release Operation	Release Schedule		Release Schedule		Release Schedule		Release Schedule	
various	Aug	All month	Aug	All month	Aug	All month	Aug	All month
	Sep	All month	Sep	All month	Sep	All month	Sep	All month
	Oct	All month	Oct	All month	Oct	All month	Oct	All month
	Nov	Through Nov 15	Nov	Through Nov 15	Nov	Through Nov 15	Nov	Through Nov 15
	Dec	No Release	Dec	No Release	Dec	No Release	Dec	No Release

Year Types	WYT Control		WYT Control		WYT Control		WYT Control	
various	W	0	W	0	W	0	W	0
	AN	0	AN	0	AN	0	AN	0
	BN	0	BN	0	BN	0	BN	1
	D	1	D	1	D	1	D	1
	C	1	C	1	C	1	C	1
	COA Conditions Permitted		COA Conditions Permitted		COA Conditions Permitted		COA Conditions Permitted	
	IBU	Yes	IBU	Yes	IBU	Yes	IBU	Yes
	UWFE	No	UWFE	No	UWFE	No	UWFE	No

Export required		Habitat benefit and export required	
[Sensitivity] Exchanges assumed to occur under UWFE conditions as well	[Sensitivity] Releases allowed through December	[Sensitivity] Releases required to have habitat benefit, allowed through December	[Sensitivity] Releases required to have habitat benefit, allowed through December, Storage RPA control
Exchange limited to conditions with limited flow/temperature impact potential			
Storage accrued in Shasta by exchange			
Banks export capacity must be available			
Storage released from Shasta for export starting in August			
2-pipe Delevan Pipeline	2-pipe Delevan Pipeline	2-pipe Delevan Pipeline	2-pipe Delevan Pipeline
Storage must be released from Shasta by Nov 15	Storage must be released from Shasta by Nov 15	Storage is carried into December at risk of spill	Storage is carried into December at risk of spill
Only Dry and Critically Dry years considered	Only Dry and Critically Dry years considered	Only Dry and Critically Dry years considered	Only Dry and Critically Dry years considered

Exchange Operation	Keswick Flow (cfs)		Keswick Flow (cfs)		Keswick Flow (cfs)		Keswick Flow (cfs)	
Sac Flow check	April	6,000	April	6,000	April	6,000	April	6,000
Prior to Summer	May	6,000	May	6,000	May	6,000	May	6,000
- All scenarios	Jun	10,000	Jun	10,000	Jun	10,000	Jun	10,000
	Jul	12,000	Jul	12,000	Jul	12,000	Jul	12,000
Exchange Operation	Sac R blw Clear Creek Temp (F)		Sac R blw Clear Creek Temp (F)		Sac R blw Clear Creek Temp (F)		Sac R blw Clear Creek Temp (F)	
Sac Temperature check	April	No Rule	April	No Rule	April	No Rule	April	No Rule
Prior to Summer	May	56	May	56	May	56	May	56
- All scenarios	Jun	56	Jun	56	Jun	56	Jun	56
	Jul	53.5	Jul	53.5	Jul	53.5	Jul	53.5
Hold Operation	Shasta Storage (TAF)		Shasta Storage (TAF)		Shasta Storage (TAF)		Shasta Storage (TAF)	
Storage over Summer	April	No Rule	April	No Rule	April	No Rule	April	No Rule
- Habitat scenarios	May	No Rule	May	No Rule	May	No Rule	May	No Rule
	Jun	No Rule	Jun	No Rule	Jun	No Rule	Jun	No Rule
	Jul	No Rule	Jul	No Rule	Jul	No Rule	Jul	No Rule
	Sep - low	No Rule	Sep - low	No Rule	Sep - low	No Rule	Sep - low	1,900
	Sep - high	No Rule	Sep - high	No Rule	Sep - high	No Rule	Sep - high	No Rule
Release Operation	Maximum Keswick Flow (cfs)		Maximum Keswick Flow (cfs)		Maximum Keswick Flow (cfs)		Maximum Keswick Flow (cfs)	
- Habitat scenarios	Aug	10,000	Aug	10,000	Aug	10,000	Aug	10,000
delayed release	Sep	12,000	Sep	12,000	Sep	12,000	Sep	12,000
- other scenarios	Oct	No Rule	Oct	No Rule	Oct	12,000	Oct	12,000
release starts in Aug	Nov	No Rule	Nov	No Rule	Nov	6,000	Nov	6,000
	Dec	No Rule	Dec	No Rule	Dec	5,000	Dec	5,000
Release Operation	Release Schedule		Release Schedule		Release Schedule		Release Schedule	
various	Aug	All month	Aug	All month	Aug	All month	Aug	All month
	Sep	All month	Sep	All month	Sep	All month	Sep	All month
	Oct	All month	Oct	All month	Oct	All month	Oct	All month

Nov	Through Nov 15	Nov	All month	Nov	All month	Nov	All month
Dec	No Release	Dec	All month	Dec	All month	Dec	All month

Year Types
various

WYT Control		WYT Control		WYT Control		WYT Control	
W	0	W	0	W	0	W	0
AN	0	AN	0	AN	0	AN	0
BN	0	BN	0	BN	0	BN	0
D	1	D	1	D	1	D	1
C	1	C	1	C	1	C	1

COA Conditions Permitted		COA Conditions Permitted		COA Conditions Permitted		COA Conditions Permitted	
IBU	Yes	IBU	Yes	IBU	Yes	IBU	Yes
UWFE	Yes	UWFE	No	UWFE	No	UWFE	No

[Sensitivity] USBR Proposed
Exchange limited to conditions with limited flow/temperature impact potential
Storage accrued in Shasta by exchange
Banks export capacity must be available
Storage released from Shasta for export starting in September
2-pipe Delevan Pipeline
Storage must be released from Shasta by Nov 15
Only Dry and Critically Dry years considered

Exchange Operation
Sac Flow check
Prior to Summer

Keswick Flow (cfs)	
April	6,000
May	6,000

Exchange Operation
Sac Temperature check
Prior to Summer
- All scenarios

Sac R blw Clear Creek Temp (F)		
Month	D	C
April	51.2	51.6
May	51.1	52.2
Jun	51.5	53.4
Jul	52.7	55.0

Hold Operation
Storage over Summer
- Habitat scenarios

Shasta Storage (TAF)	
April	No Rule
May	No Rule
Jun	No Rule
Jul	No Rule
Sep - low	No Rule
Sep - high	No Rule

Release Operation
- Habitat scenarios
  delayed release
- other scenarios
  release starts in Aug

Maximum Keswick Flow (cfs)	
Aug	No Rule
Sep	No Rule
Oct	No Rule
Nov	No Rule
Dec	No Rule

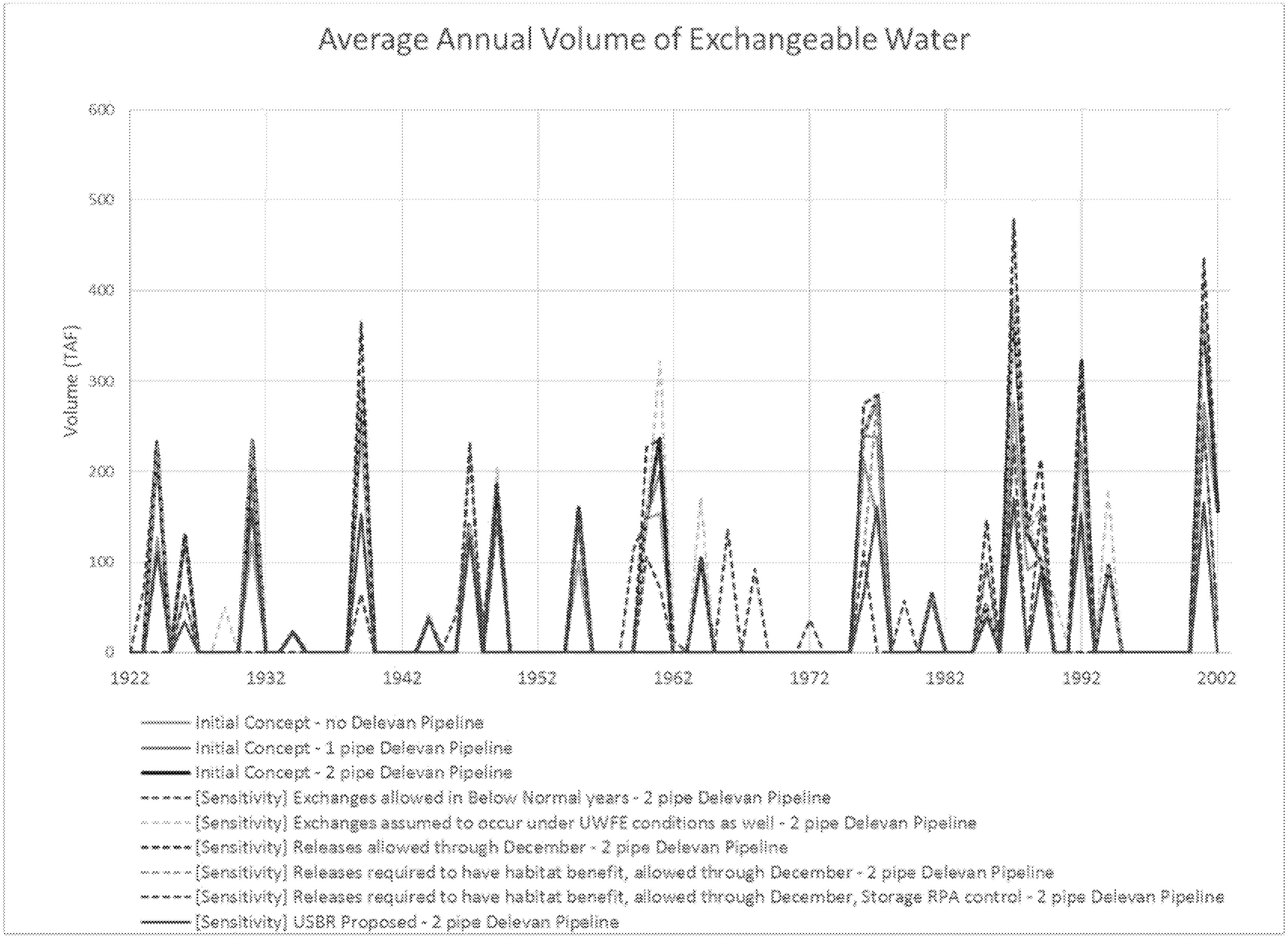
Release Operation
various

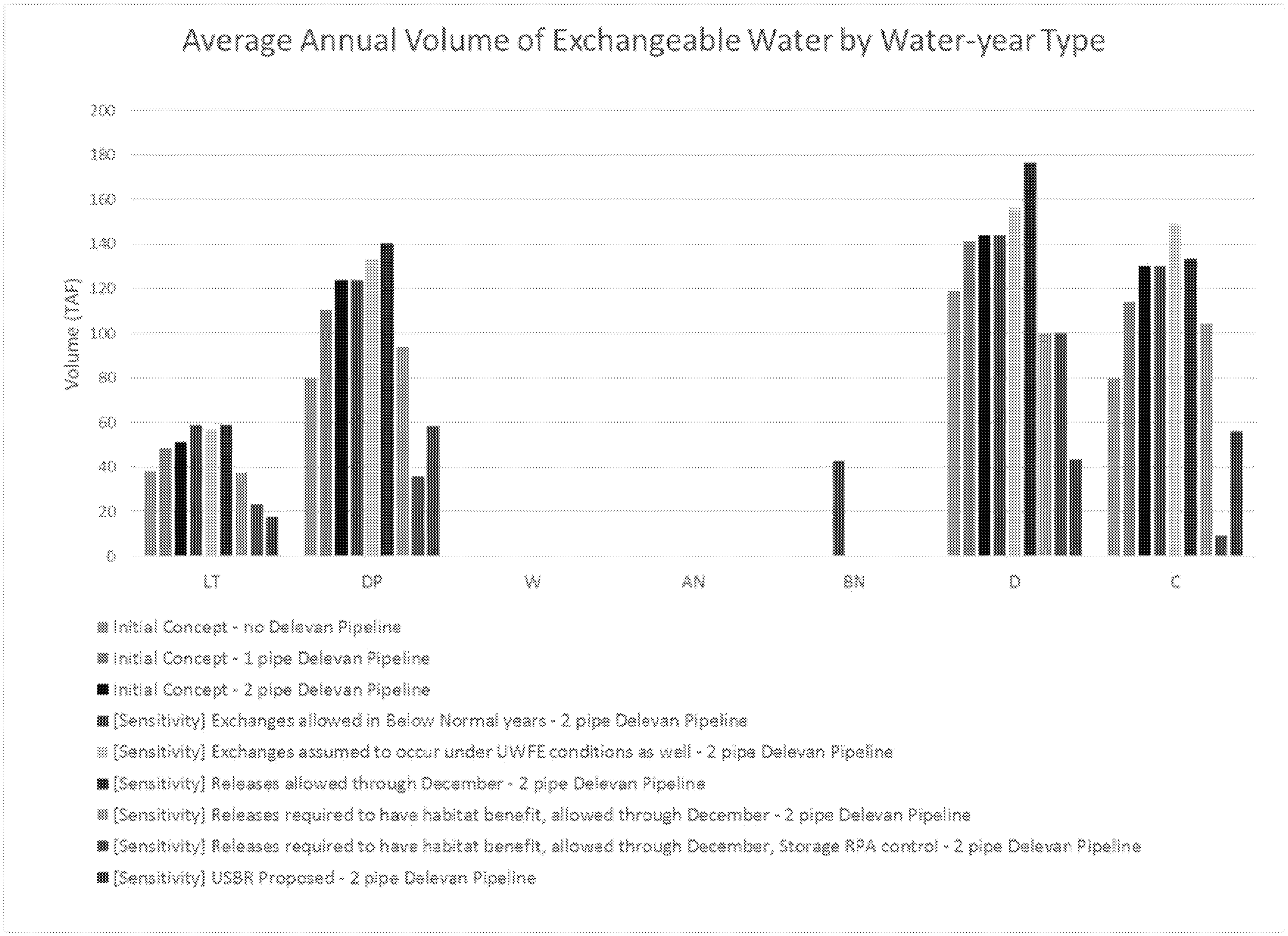
Release Schedule	
Aug	No Release
Sep	All month
Oct	All month
Nov	All Month
Dec	No Release

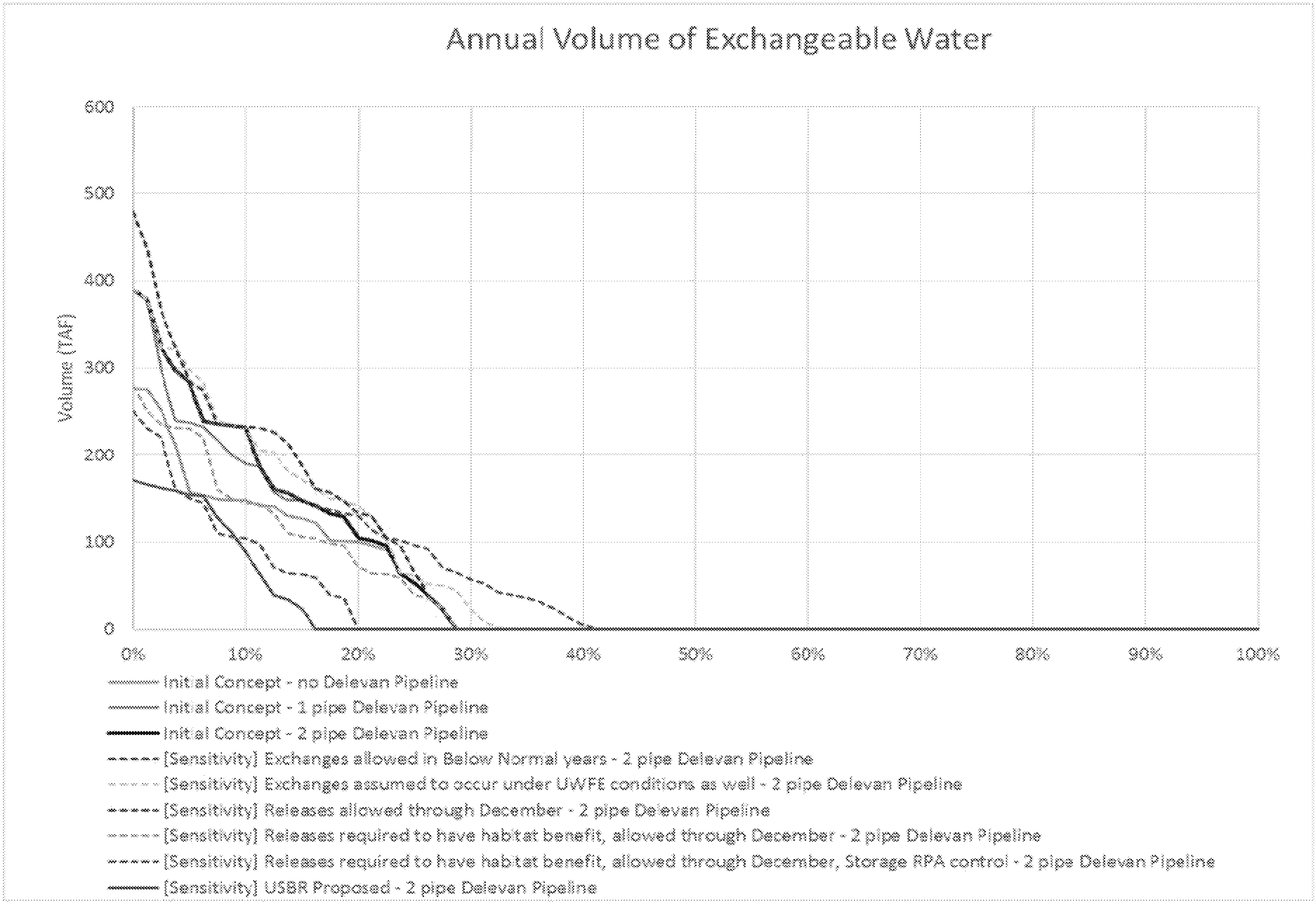
Year Types
various

WYT Control	
W	0
AN	0
BN	0
D	1
C	1

COA Conditions Permitted	
IBU	Yes
UWFE	No


Average Annual Volume of Exchangeable Water
Volume (TAF)
600
500
400
300
200
100
0
1922
1932
1942
1952
1962
1972
1982
1992
2002
Initial Concept - no Delevan Pipeline
Initial Concept - 1 pipe Delevan Pipeline
Initial Concept - 2 pipe Delevan Pipeline
[Sensitivity] Exchanges allowed in Below Normal years - 2 pipe Delevan Pipeline
[Sensitivity] Exchanges assumed to occur under UWFE conditions as well - 2 pipe Delevan Pipeline
[Sensitivity] Releases allowed through December - 2 pipe Delevan Pipeline
[Sensitivity] Releases required to have habitat benefit, allowed through December - 2 pipe Delevan Pipeline
[Sensitivity] Releases required to have habitat benefit, allowed through December, Storage RPA control - 2 pipe Delevan Pipeline
[Sensitivity] USBR Proposed - 2 pipe Delevan Pipeline


Average Annual Volume of Exchangeable Water by Water-year Type
Volume (TAF)
200
180
160
140
120
100
80
60
40
20
0
LT
DP
W
AN
BN
D
C
Initial Concept - no Delevan Pipeline
Initial Concept - 1 pipe Delevan Pipeline
Initial Concept - 2 pipe Delevan Pipeline
[Sensitivity] Exchanges allowed in Below Normal years - 2 pipe Delevan Pipeline
[Sensitivity] Exchanges assumed to occur under UWFE conditions as well - 2 pipe Delevan Pipeline
[Sensitivity] Releases allowed through December - 2 pipe Delevan Pipeline
[Sensitivity] Releases required to have habitat benefit, allowed through December - 2 pipe Delevan Pipeline
[Sensitivity] Releases required to have habitat benefit, allowed through December, Storage RPA control - 2 pipe Delevan Pipeline
[Sensitivity] USBR Proposed - 2 pipe Delevan Pipeline


Annual Volume of Exchangeable Water
Volume (TAF)
600
500
400
300
200
100
0
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Initial Concept - no Delevan Pipeline
Initial Concept - 1 pipe Delevan Pipeline
Initial Concept - 2 pipe Delevan Pipeline
[Sensitivity] Exchanges allowed in Below Normal years - 2 pipe Delevan Pipeline
[Sensitivity] Exchanges assumed to occur under UWFE conditions as well - 2 pipe Delevan Pipeline
[Sensitivity] Releases allowed through December - 2 pipe Delevan Pipeline
[Sensitivity] Releases required to have habitat benefit, allowed through December - 2 pipe Delevan Pipeline
[Sensitivity] Releases required to have habitat benefit, allowed through December, Storage RPA control - 2 pipe Delevan Pipeline
[Sensitivity] USBR Proposed - 2 pipe Delevan Pipeline

4.0 Temperature Post-processing Analysis

Several scenarios were further evaluated for temperature benefits to assess the viability of the exchange. The "Initial Concept - 2 pipe Delevan Pipeline" and "USBR Proposed" scenarios were evaluated as follows:

4.1 Approach

- A post-processing exercise was conducted using the estimated exchange volumes calculated in the previous section.
- Shasta Lake releases were adjusted in the CalSim II output for the DCR 2015 Merged Model No Action Alternative (NAA). This was performed for two scenarios:

  1) "Releases Limited by Delivery Capacity": From April through July, releases are reduced to match the exchange operation developed in the post-processing. From August through November, exchanged water is released at a rate no greater than the delivery capacity calculated in the post-processing until there is no exchanged water left to release. In November, any water remaining is released.
  2) "Scheduled Releases": This scenario assumes that the system can be re-operated to deliver any water released. In this scenario, from April through July, releases are reduced to match the exchange operation developed in the post-processing. In August, 40% of the exchanged water is released. In September, an additional 40% is released. In September, the final 20% is released. In the "USBR – Proposed" scenario, 40% is released in September, 40% is released in October, and 20% is released in November.
  3) Since the operation only occurs in dry and critically dry water years, the averages for only those water year types are presented. Within those water year types, only years where the action is greater than 50 TAF are included. This includes 14 of the 18 dry years and 7 of the 12 critically dry years. In dry years with an exchange greater than 50 TAF, the average exchange operation was 182 TAF when releases were limited by delivery capacity and 311 TAF when releases were scheduled. In critically dry years with an exchange greater than 50 TAF, the average exchange was 220 TAF when releases were limited by delivery capacity and 225 TAF when releases were scheduled.
  4) Under the USBR Proposed scenario, the exchange only occurred in 5 of the 18 dry years and 5 of the 12 critically dry years. In dry years with an exchange greater than 50 TAF, the average exchange operation was 141 TAF when releases were limited by delivery capacity and 167 TAF when releases were scheduled. In critically dry years with an exchange greater than 50 TAF, the average exchange was 130 TAF when releases were limited by delivery capacity and 130 TAF when releases were scheduled.
  5) The Upper Sacramento River Water Quality Model (USRWQM) in HEC-5Q was run using the revised CalSim II outputs.

4.2 Results

Temperature results are in the tables below. Our preliminary screening analysis shows that there is some potential for temperature reduction below the targets specified by Reclamation, but further analysis will be needed to further evaluate the benefits of the exchange operation.

Temperature changes (°F) between No Project and Project with no Reclamation Investment
Initial Concept - 2-pipe Delevan Pipeline

Releases Limited by Delivery Capacity
Dry Year Averages (with action >50 TAF)

		APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV
Sacramento River below Keswick	No Action	48.2	48.7	49.5	50.9	52.6	52.9	54.7	54.3
	With Project	48.2	49.0	49.6	50.8	52.1	52.6	54.0	53.9
	Difference	0.0	0.2	0.1	-0.1	-0.5	-0.4	-0.7	-0.4
Sacramento River below Clear Creek	No Action	49.7	50.3	51.0	52.2	54.0	54.6	55.2	54.1
	With Project	49.7	50.7	51.3	52.2	53.4	54.1	54.5	53.8
	Difference	0.0	0.4	0.3	0.1	-0.6	-0.5	-0.7	-0.3

Critically Dry Year Averages (with action >50 TAF)

		APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV
Sacramento River below Keswick	No Action	48.9	50.6	51.8	53.0	55.5	58.1	57.9	55.4
	With Project	48.8	50.4	51.8	52.9	54.2	57.7	57.9	55.5
	Difference	0.0	-0.3	-0.1	-0.2	-1.3	-0.4	0.1	0.1
Sacramento River below Clear Creek	No Action	50.2	52.2	53.2	54.4	56.8	59.4	58.2	55.2
	With Project	50.3	52.2	53.3	54.3	55.4	58.9	58.3	55.2
	Difference	0.1	0.0	0.1	-0.1	-1.4	-0.5	0.0	0.1

Initial Concept - 2-pipe Delevan Pipeline

Scheduled Releases (40% Aug, 40% Sep, 20% Oct)
Dry Year Averages (with action >50 TAF)

		APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV
Sacramento River below Keswick	No Action	48.2	48.7	49.5	50.9	52.6	52.9	54.7	54.3
	With Project	48.2	49.0	49.7	50.8	51.9	52.1	54.5	54.3
	Difference	0.0	0.2	0.1	-0.1	-0.6	-0.9	-0.1	0.0
Sacramento River below Clear Creek	No Action	49.7	50.3	51.0	52.2	54.0	54.6	55.2	54.1
	With Project	49.8	50.7	51.3	52.3	53.2	53.4	55.0	54.1
	Difference	0.0	0.4	0.3	0.1	-0.8	-1.2	-0.2	0.0

Critically Dry Year Averages (with action >50 TAF)

		APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV
Sacramento River below Keswick	No Action	48.9	50.6	51.8	53.0	55.5	58.1	57.9	55.4
	With Project	48.9	50.4	51.8	52.9	54.3	57.3	58.0	55.6
	Difference	0.0	-0.2	0.0	-0.1	-1.2	-0.8	0.1	0.1
Sacramento River below Clear Creek	No Action	50.2	52.2	53.2	54.4	56.8	59.4	58.2	55.2
	With Project	50.3	52.2	53.3	54.3	55.5	58.4	58.3	55.3
	Difference	0.1	0.0	0.1	-0.1	-1.3	-1.0	0.1	0.1

Temperature changes (°F) between No Project and Project with no Reclamation Investment

USBR Proposed- 2-pipe Delevan Pipeline

Releases Limited by Delivery Capacity

Dry Year Averages (with action >50 TAF)

		APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV
Sacramento River below Keswick	No Action	48.5	48.9	50.0	51.5	53.4	53.8	55.4	55.2
	With Project	48.5	49.4	49.8	51.2	53.2	53.2	55.3	55.1
	Difference	0.0	0.5	-0.2	-0.3	-0.2	-0.6	-0.1	-0.1
Sacramento River below Clear Creek	No Action	50.2	50.3	51.3	52.7	54.7	55.5	56.0	55.0
	With Project	50.2	51.3	51.2	52.4	54.6	54.7	55.8	54.9
	Difference	0.0	1.0	-0.1	-0.3	-0.2	-0.8	-0.2	-0.1

Critically Dry Year Averages (with action >50 TAF)

		APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV
Sacramento River below Keswick	No Action	49.0	51.0	52.4	53.2	56.3	59.5	58.3	55.3
	With Project	49.0	50.9	52.3	53.1	55.3	58.7	58.5	55.4
	Difference	0.0	-0.1	-0.1	-0.1	-1.0	-0.9	0.2	0.1
Sacramento River below Clear Creek	No Action	50.3	52.5	53.8	54.6	57.6	60.6	58.7	55.1
	With Project	50.5	52.6	53.7	54.5	56.6	59.6	58.8	55.2
	Difference	0.2	0.1	-0.1	-0.1	-1.0	-1.0	0.1	0.1

USBR Proposed- 2-pipe Delevan Pipeline

Scheduled Releases (40% Sep, 40% Oct, 20% Nov)

Dry Year Averages (with action >50 TAF)

		APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV
Sacramento River below Keswick	No Action	48.5	48.8	49.9	51.5	53.3	53.6	55.4	55.2
	With Project	48.5	49.4	49.8	51.2	53.1	53.1	55.3	55.0
	Difference	0.0	0.5	-0.2	-0.3	-0.2	-0.5	-0.1	-0.1
Sacramento River below Clear Creek	No Action	50.1	50.2	51.3	52.8	54.7	55.3	55.9	54.9
	With Project	50.1	51.2	51.2	52.5	54.5	54.6	55.8	54.8
	Difference	0.0	1.0	-0.1	-0.3	-0.2	-0.7	-0.2	-0.1

Critically Dry Year Averages (with action >50 TAF)

		APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV
Sacramento River below Keswick	No Action	49.0	51.0	52.4	53.2	56.3	59.5	58.3	55.3
	With Project	49.0	50.9	52.3	53.0	55.3	58.5	58.4	55.5
	Difference	0.0	-0.1	-0.1	-0.1	-1.0	-1.0	0.0	0.1
Sacramento River below Clear Creek	No Action	50.3	52.5	53.8	54.6	57.6	60.6	58.7	55.1
	With Project	50.5	52.6	53.7	54.5	56.6	59.6	58.7	55.3
	Difference	0.2	0.1	-0.1	-0.1	-1.0	-1.0	0.0	0.2

Appendix B-3 Colusa Basin Drain Value Planning Evaluation Technical Memorandum

To:	Value Planning Work Group
CC:	Lee Frederiksen
Date:	April 7, 2020
From:	Anne Williams - MBK
Subject:	Colusa Basin Drain Value Planning Alternative

The Sites Reservoir Project is currently undergoing a value planning process to investigate various potential alternatives of the Sites Reservoir Project operations. As part of this process, one alternative proposes that water released from Sites Reservoir is conveyed through the Tehama Colusa Canal (TC Canal) to its terminus, and then to the Colusa Basin Drain (CBD) through Bird Creek or a pipeline near the same location. The alternative proposes to move up to 1,000 cfs of water during May through October through the CBD, and either through the Knights Landing Outfall Gates (KLOG) and into the Sacramento River near Knights Landing, or through the Knights Landing Ridge Cut (Ridge Cut) to the Yolo Bypass and then to the Sacramento River near Rio Vista. The purpose of this memorandum is to provide background information and MBK Engineer's (MBK) knowledge based on experience about the CBD, and to identify potential considerations or risks associated with this proposed alternative to the Sites Reservoir Project Value Planning Work Group (Work Group).

This memorandum is organized by topic, based on a list of questions provided by the Work Group. It is intended to identify initial considerations at a high level, based on MBK's experience and information that was readily available. Attached to this memorandum is a brief presentation with background information and key facilities along the CBD, which was provided and discussed with the Work Group at a meeting on February 13, 2020.

1.0 Flow

In order to understand how water released from Sites Reservoir could be moved through the CBD and into the Sacramento River at Knights Landing, the hydraulics between the CBD, KLOG, and Wallace Weir need to be investigated. MBK has requested any available analyses from Reclamation District 108 (RD 108), which may have been conducted for the KLOG and/or Wallace Weir rehabilitation projects.

The rate of flow from the CBD into the Sacramento River through KLOG, depends on the differential stage in the Sacramento River and in the CBD at KLOG. The stage in the CBD at KLOG is dependent upon the operation of both KLOG and the Wallace Weir. The flow in the CBD has historically been difficult to measure due to backwater effects. To fully understand how far upstream backwater may extend from KLOG, a hydraulic analysis would need to be conducted. Based on the experience of MBK and the landowners, it is estimated that water levels can be affected by the KLOG and Wallace Weir operation to County Line Road, approximately 15 miles upstream of the Ridge Cut and approximately 4 miles upstream of Bird Creek.

Currently, MBK is aware of measurements at the following locations, generally identified from upstream to downstream.

- Colusa Drain near Sidds Rd (Glenn-Colusa Irrigation District [GCID]: Flow, Stage, Water Temperature, pH, Specific Conductance, Salinity, Dissolved Solids, and Dissolved O2)
- Colusa Drain near Road 68 (GCID: Flow, Stage, Water Temperature, pH, Specific Conductance, Salinity, Dissolved Solids, and Dissolved O2)
- Colusa Drain at Lurline Road (GCID: Flow, Stage, Water Temperature, pH, Specific Conductance, Salinity, Dissolved Solids, and Dissolved O2)
- Colusa Drain near Highway 20 (CDEC – CDR: Flow & Stage)
- Colusa Drain at Davis Weir (GCID: Flow, Stage, Water Temperature, pH, Specific Conductance, Salinity, Dissolved Solids, and Dissolved O2)
- Colusa Basin Drain at Knights Landing (CDEC – KLG: Stage & Gate Openings)
- Sacramento River at Knights Landing (CDEC – KNL: Stage)
- Ridge Cut Slough at Knights Landing (CDEC – RCS: Flow, Stage, Velocity, and Water Temperature[1])
- Ridge Cut at Wallace Weir (RD 108 & the California Department of Water Resources [DWR] – RD 108 with approval by DWR: Flow & Stage)
- Yolo Bypass near Woodland (CDEC – YBY: Flow & Stage)

Pursuant to the 1937 Hershey Agreement, DWR limits water levels at KLOG during the irrigation season to no greater than 25.5 ft United States Engineering Datum (USED, also known as the U.S. Army Corps of Engineers Datum). During this period DWR also attempts to maintain a water level of no less than 24.5 ft USED. These elevations are identified to prevent localized flooding and impacts to the ability to drain fields in the lower portion of the CBD and the Ridge Cut (which may occur at levels greater than 25.5 ft) and avoid limiting the ability of diverters to pump water for irrigation purposes (which may occur at levels lower than 24.5 ft).

In July 2016, state and federal agencies and local water users and landowners coordinated an Emergency Action for Delta Smelt. The goal of the program was to generate a pulse flow in the Yolo Bypass, using about 400 cfs of water pumped from the Sacramento River into the CBD by GCID and RD 108 over a two-week period in July[2]. The approximate 400 cfs pulse flow was in addition to existing flows in the CBD at the time, about 200 cfs measured at Davis Weir. The resulting maximum flow in the CBD below Davis Weir during the effort was about 850 cfs. The pulse flow was conveyed to the Yolo Bypass using the CBD, Wallace Weir, and the Tule Canal. The action generated a total flow pulse of 12,700 acre-feet in the Yolo Bypass.

Additional Delta Smelt experiments occurred in the fall of 2018 and 2019, planned to generate estimated pulses of 24,000 acre-feet in the Yolo Bypass. These more recent experiments involved the rerouting of agricultural return flow/rice drain water (not the addition of Sacramento River water) from the CBD into the Yolo Bypass via the Ridge Cut (rather than discharging the water to the Sacramento River at KLOG). The 2018 flow action occurred for about one month, late August to late September, and water levels in the CBD at KLOG were raised to 27.0 ft. Measured CBD flows at the Davis Weir during the peak of the 2018 action were about 3,000 cfs. The actual pulse generated in the Yolo Bypass is estimated to have been about 20,000 acre-feet. Similarly, the 2019 flow action raised water levels in the CBD at KLOG to 27.0 ft over a several week period, during late August and September. Measured CBD flows at the Davis Weir during the peak of the 2019 action were about 2,500 cfs, and a pulse was generated in the Yolo Bypass. These efforts were possible with

---

[1] In addition, certain water quality data (i.e. dissolved oxygen, pH, specific conductance, turbidity, chlorophyll) is available during periods of the Delta Smelt actions, collected by DWR.

[2] The 2016 action occurred in July due to the construction schedule of the Wallace Weir. Similar programs in the future were identified as more likely to occur in the fall.

significant coordination with local landowners, although they did result in some localized flooding/drainage issues.

Any alternatives that utilize the CBD for conveyance of Sites Reservoir water, should include coordination with the local landowners regarding the project operation and timing of the additional flows. The project should also consider levee improvements (particularly along the western levee which is lower than the eastern Project levee) and other improvements or arrangements that would address flooding and drainage issues due to the increased flows.

The Work Group raised concerns regarding losses due to seepage and groundwater pumping. The area primarily consists of clay soils and therefore losses due to seepage are not a major concern; however, local landowners have expressed concern regarding the potential for seepage through the levees when water levels exceed 25.5 ft. Similarly, the effect of local groundwater pumping is likely minimal, although this has not been investigated. With the implementation of the Sustainable Groundwater Management Act, groundwater pumping in the area may be more restricted in the future.

2.0 Environmental

As previously described, in 2016, 2018, and 2019, as part of the Delta Smelt Emergency Action, pulse flows were generated through the Yolo Bypass. The purpose of these experiments were to improve the food supply in the Northern Delta, focusing on Delta smelt. It is MBK's understanding that these types of experiments may continue in the future.

Another consideration of the Work Group is related to water temperature. Temperature management for fish species is a major operational consideration on the upper Sacramento River. However, MBK is not aware of temperature concerns in the Sacramento River this far downstream (i.e. near Knights Landing). It seems that water released from Sites Reservoir would be the same temperature or colder than summer drain water in the CBD. There is currently water temperature data at several points in the Colusa Drain collected by GCID, in the Ridge Cut (CDEC – RCS) and in the Sacramento River: upstream of Knights Landing at Wilkins Slough (CDEC – WLK) and downstream at Verona (CDEC – VON).

The giant garter snake is the primary endangered species concern in this area. Other special status species identified as potentially found within the area include the California tiger salamander, yellow-billed cuckoo, Western snowy plover, least Bell's vireo, Delta smelt, Central Valley steelhead, Chinook salmon, green sturgeon, Conservancy fairy shrimp, vernal pool fairy shrimp, Valley elderberry longhorn beetle, vernal pool tadpole shrimp, Hoover's spruge, palmate-bracted bird's-beak, Colusa grass, hairy Orcutt grass, slender Orcutt grass, Keck's checker-mallow, and Greene's tuctoria[3].

3.0 Water Rights

Landowners and irrigation districts hold varying water rights along the CBD, Ridge Cut, Tule Canal, and Yolo Bypass. MBK conducted an initial review of existing water rights along the CBD downstream of Sites Reservoir using the State Water Resources Control Board's electronic files (see Draft Memorandum: Summary of Downstream Water Rights, dated September 17, 2019). Based on this research there are approximately ten water rights along the CBD between Bird Creek and the Knights Landing Outfall Gates[4]. Generally, these are licensed direct diversion water rights for irrigation purposes during April to October.

In addition, many lands are within the Colusa Drain Mutual Water Company (CDMWC), which holds a contract with the U.S. Bureau of Reclamation (Reclamation) for supplemental water supplies for its shareholders who divert water from the CBD under their respective water rights. As allowed under the contract with Reclamation the CDMWC has purchased supplemental water supplies from GCID for the past several years.

---

[3] Source: https://www.usbr.gov/mp/nepa/includes/documentShow.php?Doc_ID=32942

[4] Research was not conducted to identify existing water rights along the Ridge Cut, Tule Canal, Sacramento River, or within the Delta.

Appendix C – Environmental Permitting and Planning

Appendix C-1 – Permitting and Environmental Planning Impacts Assessment Technical Memorandum

To:	Value Planning Work Group
CC:	Lee Frederiksen
Date:	March 3, 2020
From:	John Spranza, Jelica Arsenijevic - HDR Laurie Warner Herson – Phenix Environmental
Subject:	Permitting and Environmental Planning Impacts Assessment

1.0 Introduction

The Sites Project Authority (Authority) is pursuing development of the Sites Reservoir Project (Project), a new above-ground surface storage reservoir offstream of the Sacramento River in Colusa and Glenn counties, approximately 10 miles west of the town of Maxwell, California. The Project, in addition to providing other important water storage and operational benefits, is being proposed to increase the reliability of water supplies for environmental, agricultural and urban uses. A draft California Environmental Quality Act (CEQA) and National Environmental Policy Act (NEPA) Environmental Impact Report/Environmental Impact Statement (EIR/EIS)[1] has been prepared and was circulated for public review and comment in August, 2017.

In October 2019, the Authority began value planning efforts to identify an alternative that would serve the current needs of the Project participants and potentially reduce overall cost of the Project. The value planning effort has identified several facility modifications, which resulted in 16 new alternatives being considered.

This memorandum (memo) has been prepared to assist with the value planning effort from the environmental permitting and planning perspective. The memo summarizes the alternatives being considered, describing:

- Key differences of the value planning alternatives when compared to Alternative D as described in the Draft EIR/EIS;
- Species within the alternatives footprint that could potentially be impacted through construction and operation of the Project;
- Key permits and approvals required to construct and operate the Project including any additional regulatory requirements beyond those identified in the Draft EIR/EIS;
- Environmental planning considerations related to CEQA/NEPA analysis;
- Qualitative change in mitigation cost; and
- A relative weighting associated with environmentally related criteria (and associated metrics) compared to Alternative D in the Draft EIR/EIS.

Although qualitative in nature, the analysis and conclusions presented in this memo may be used to support the Authority in identifying a revised locally-preferred alternative.

---

[1] Sites Reservoir Project Draft Environmental Impact Report/Environmental Impact Statement (Sites Project Authority and Reclamation 2017)

2.0 Summary of Alternative D

The Draft EIR/EIS addressed a range of alternatives (Alternatives A, B, C, C1, and D). All alternatives included a Sites Reservoir that would be filled using existing Sacramento River diversion facilities and a proposed Delevan Pipeline on the Sacramento River to allow for release of flows into the Sacramento River. All but one alternative also used the proposed Delevan Pipeline to divert Sacramento River water. The proposed operations varied between Alternatives A, B, C, C1, and those included in Alternative D. The specific operational parameters included in the Draft EIR/EIS were identified to support/evaluate the upper bound of potential impacts. The operations evaluated for Alternative D were based on operations included in the application to the California Water Commission for the Water Storage Investment Program. The operations included in that application were specifically selected to respond to the requirements of that program and its evaluation criteria.

In a letter to Reclamation dated June 25, 2018, the Authority identified Alternative D as the locally preferred alternative:

> "As the planning process is nearing completion, the Authority requests Reclamation use Alternative D as the basis for implementing the project and for identifying the federal interest. The current Reclamation-prepared draft Feasibility Report, dated August 14, 2017, identified Alternative D as providing the highest net Regional Economic Development (RED) benefits and as representing the Locally Preferred Alternative; which aligns with the Authority's decision on June 13, 2016, to formally select Alternative D as our proposed project under CEQA and as the basis for our Proposition 1 application to the Water Commission."

Alternative D consists of constructing and operating a 1.8 million-acre-foot (MAF) reservoir. The reservoir would be created by constructing two main dams, one on Funks Creek and one on Stone Corral Creek, and nine saddle dams. Under Alternative D, Sites Reservoir would be filled by diverting unappropriated flows originating primarily from tributary streams to the Sacramento River below Keswick Dam. These flows would be diverted from the Sacramento River from using surplus capacity at the Tehama-Colusa Canal (T-C Canal) diversion facility near Red Bluff, and Glenn-Colusa Irrigation District's (GCID) diversion Facility near Hamilton City. A new diversion facility near Delevan would be constructed to provide additional diversion capacity for filling the reservoir. A pipeline would be constructed to carry water from the Delevan diversion to the forebay/afterbay for Sites Reservoir.

Under Alternative D, modifications would have to be made to the existing infrastructure to accommodate the operation of the reservoir. These include construction of a terminal reregulating reservoir (TRR) on the Glenn-Colusa Canal, expansion of the existing reregulation reservoir on the Tehama-Colusa Canal (known as Funks Reservoir) into a larger reservoir to serve as the forebay/afterbay for Sites Reservoir and to accommodate a pump storage power generating facility, and an inlet/outlet works for moving water in and out of Sites Reservoir. Alternative D has two options under consideration for expansion of Funks Reservoir one primarily to the south that would be named Holthouse Reservoir; and the other to the north and east would be named Fletcher Reservoir.

2.1 Species Potentially Affected

Table C1-1 identifies the federal and state special-status fish and wildlife species that were potentially affected by the construction and operation of Alternative D.

Table C1-1. Special-Status Species Potentially Affected by Alternative D

Species	Listing Status[1]	Critical Habitat
Keck's checkermallow	FE	
Palmate-bracted bird's beak	FE, SE	
Conservancy fairy shrimp	FE	
Vernal pool fairy shrimp	FT	
Vernal pool tadpole shrimp	FE	
Valley elderberry longhorn beetle	FT	
California red-legged frog	FT	
Foothill yellow-legged frog	ST	
California tiger salamander	FE,ST	
Giant garter snake	FT, ST	
Western yellow-billed cuckoo	FT, SE	X
Swainson's hawk	ST	
Bank swallow	ST	
Tricolored blackbird	ST	
Delta smelt	FT	X
Longfin smelt	ST, FC[2]	
Southern Distinct Population Segment of North American green sturgeon	FT	X
Sacramento River winter-run Chinook salmon Evolutionarily Significant Unit	FE	X
Central Valley spring-run Chinook salmon	FT	X
Central Valley steelhead	FT	X

[1] Acronyms: FE – federally listed as endangered FT – federally listed as threatened; FC – federally listed as a candidate species; SE – state listed as endangered ST – state listed as threatened

[2] Federal candidacy is only for San Francisco Bay-Delta distinct population segment.

2.2 Permits and Approvals Required

Alternative D identified over 20 permits that would be required from regulatory agencies, including, but not limited to California Department of Fish and Wildlife (CDFW), U.S. Fish and Wildlife Service (USFWS), U.S. Army Corps of Engineers (USACE), Regional Water Quality Control Board (RWQCB), State Water Resources Control Board (SWRCB), National Marine Fisheries Service (NMFS), and State Historic Preservation Office (SHPO). Table C1-2 identifies the key permits and approvals required for Alternative D, as well as the agency responsible for issuance of permit/approval, recommended pre-requisites for submittal, and estimated processing time. Key permits are those permits that have the ability to significantly affect the cost or schedule of the construction and operation of the Project.

Table C1-2. Summary of Key Permits and Approvals Required for Alternative D

Agency and Associated Permit or Approval	Recommended Pre-requisites for Submittal	Estimated Processing Time
Federal		
USACE Clean Water Act (CWA) Section 404 Nationwide Permit or Individual Permit Rivers and Harbors Act Section 10 Permit	Application Biological Assessment for submittal to USFWS/NMFS Section 401 Water Quality Certification permit or application NEPA document Section 106 compliance documentation Wetland delineation Mitigation and Monitoring Plan Alternatives analysis (for Individual Permit)	4 to 6 months for Nationwide Permit 8 to 24 months for Individual Permit
USFWS/NMFS Endangered Species Act Section 7 Consultation Biological Opinion(s) Magnuson-Stevens Fisheries Conservation and Management Act	Ongoing informal technical consultation Biological Assessment NEPA document	135 days
USFWS Fish and Wildlife Coordination Act Report	Ongoing informal technical consultation Biological Assessment NEPA document	Generally accompanies USFWS's Biological Opinion
USFWS National Wildlife Refuge Special Use Permit	Application Biological Assessment Section 106 compliance documentation	Over 6 months
SHPO National Historic Preservation Act Section 106 Programmatic Agreement	Cultural Resources Survey and Evaluation Report (if mitigation is necessary to resolve adverse effects to historic properties, then additional reports would be required for SHPO consultation that detail the results of these efforts)	9 months (up to 18 months, if mitigation necessary)
State		
RWQCB Clean Water Act Section 401 Water Quality Certification	Application Fish and Game Code Section 1602 Notification or Alteration Agreement CWA Section 404 permit or application CEQA document	8 to 24 months
SWRCB Water Right Permit	Application Water Availability Analysis Coordination with SWRCB Staff Coordinate with potential protesters CEQA document and Mitigation Plan	18 to 24 months
CDFW California Endangered Species Act 2081 Incidental Take Statement	Ongoing informal technical consultation Application Biological document for 2081 Permit, if requesting Incidental Take Permit CEQA document and Mitigation Plan	6 to 24 months
CDFW	Notification Package	6 to 8 months

Agency and Associated Permit or Approval	Recommended Pre-requisites for Submittal	Estimated Processing Time
Fish and Game Code Section 1602 Notification Section 1603 Streambed Alteration Agreement	Section 401 Water Quality Certification or application CWA Section 404 permit or application CEQA document and Mitigation Plan	

2.3 Summary of Environmental Effects

The Project has the potential to influence Central Valley Project (CVP) and State Water Project (SWP) system operations and water deliveries. For the Draft EIR/EIS analysis, three study areas were developed to evaluate potential Project impacts: the Extended, Secondary, and Primary study areas. Based on the analysis, implementation of all alternatives would affect environmental resources in all three study areas to varying degrees, with most impacts potentially occurring in the Primary Study Area. Under Alternative D, potentially significant environmental effects to aquatic, botanical, and terrestrial biological resources were identified but mitigation was identified to mitigate effects to less than significant levels, except for effects to golden eagles. Similarly, effects to wetlands and other jurisdictional waters were considered less than significant after implementation of proposed mitigation.

The Draft EIR/EIS determined that Alternative D (as well as the other alternatives) would likely result in the following potentially significant and unavoidable direct and indirect environmental effects:

Terrestrial Biological Resources (Golden Eagle)

Construction and filling of the proposed Sites Reservoir Inundation Area, as well as construction of the proposed Recreation Areas, would result in the permanent loss of foraging and nesting habitat for the golden eagle. Although implementation of compensatory mitigation including land preservation and/or acquisition is proposed, these measures would not reduce this loss of habitat to less-than-significant levels.

Paleontological Resources

Construction of the proposed Project facilities could affect paleontological resources. Mitigation measures would reduce the impacts, but not to a less-than-significant level if such resources are encountered during construction.

Cultural Resources (Historical and Tribal Resources, Human Remains)

Construction of the proposed Project facilities would affect built historical and tribal resources, as well as human remains associated with a designated cemetery and adjacent areas. If these resources and/or areas are determined to be eligible for listing in the California Register of Historical Resources or National Register of Historic Places, mitigation measures would not reduce the impact to less-than-significant levels.

Land Use (Community of Sites and Existing Land Uses)

Construction and filling of the proposed Sites Reservoir Inundation Area would result in the physical division and loss of the community of Sites, resulting in a significant and unavoidable impact. Construction of the proposed Project facilities would result in conversion of Prime Farmland, Unique Farmland or Farmland of Statewide Importance to non-agricultural use, resulting in significant and unavoidable impacts. Implementation of mitigation measures would not reduce these impacts to less-than-significant levels.

Air Quality (PM10, ROG, and NOx)

Construction activities associated with all proposed Primary Study Area Project facilities, as well as activities (such as use of roads, recreation, electricity generation and consumption, and sediment dredging) associated with the long-term operation and maintenance of the Project, would result in significant and unavoidable emissions of particulate matter less than 10 microns in diameter (PM10), reactive organic gas (ROG), and nitrogen oxide (NOx).

Climate Change and Greenhouse Gas Emissions

The greenhouse gas (GHG) emissions estimated for construction, operation, and maintenance of the Project when compared to applicable county standards would contribute to a cumulatively considerable effect that would be significant and unavoidable.

Growth-inducing Impacts

Implementation of the Project would improve water supply reliability for agricultural, urban, and environmental uses; provide more options for water management; increase recreational opportunities; and increase temporary and permanent employment opportunities. Although it is not anticipated that the water made available from the Project would result in a direct increase in population or employment, the potential exists for the quantity of water made available by the Project to result in secondary effects of growth consistent with local general plans and regional growth projections in an agency's respective service area.

These significant and unavoidable environmental effects were common to all of the alternatives analyzed in the Draft EIR/EIS due to the magnitude of construction activities and future reservoir-related inundation of resources. There were changes in the level of effects for some alternatives depending on construction and operation of the Delevan Intake including:

- Impact Fish-1c: Hydrostatic Pressure Waves, Noise, and Vibration – Delevan Facilities.
- Impact Fish-1d: Predation Risk – Delevan Facilities.
- Impact Fish-1e: Stranding, Impingement, and Entrainment – Delevan Facilities.
- Impact Fish 1f: Modification of Pulse Flows and Entrainment during Diversions at the Delevan Facilities.

However, the Draft EIR/EIS concluded that these effects were less than significant after implementation of mitigation.

2.4 Estimated Mitigation Costs

In 2016, costs for potential mitigation requirements of Alternative D were estimated to be approximately $500 million. The 2016 estimated mitigation costs identified that there was uncertainty in the estimate as the Project's impact assessment and associated mitigation ratios/acres had yet to be finalized and determined by the state and federal regulatory agencies in their respective permits and approvals. The HDR Permitting Integration Team reviewed the 2016 estimated mitigation costs in late 2019 and found that the addition of new facilities and removal/refinement of proposed facilities resulting from the Value Planning provides the same challenges to providing an accurate estimate of mitigation requirements (see Attachment 1 of Sites Project Value Planning Alternatives Appraisal Report [2020]).

3.0 Value Planning Alternatives

As described above, 16 new alternatives have been developed during the value planning effort. Table C1-3 below presents the differences among each alternative, including cost, size of reservoir, diversion, conveyance, bridge and road considerations, and type of dam.

Table C1-3. Alternatives Considered During Value Planning

	Value Planning Alternatives															
Features	**1**	**2**	**3**	**4a**	**4b**	**5a**	**5b**	**6a**	**6b**	**VP1**	**VP2**	**VP3**	**VP4**	**VP5**	**VP6**	**VP7**
Cost ($billions)	$4.0	$4.0	$3.9	$3.8	$3.9	$3.5	$3.9	$3.4	$3.6	$3.3	$2.8	$3.3	$3.0	$2.7	$2.9	$2.9
Savings from 1.8 MAF Alternative D ($billions)	$1.2	$1.2	$1.3	$1.4	$1.3	$1.7	$1.3	$1.8	$1.6	$1.9	$2.3	$1.9	$2.1	$2.4	$2.2	$2.2
1.5 MAF Reservoir	•	•	•	•	•	•	•	•								•
1.3 MAF Reservoir									•	•	•	•	•	•	•	
Funks/Sites PGP	•	•		•	•	•	•									
Funks PGP											•	•	•	•	•	•
TRR and TRR PGP	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
TCRR with Pumping Plant and Pipeline			•					•	•	•						
Delevan Canal/Pipeline Release	•	•	•	•	•											
Delevan Pipeline												•				
Dunnigan Pipeline to CBD Release (750 cfs)						•		•		•	•					
Dunnigan Pipeline to CBD Release (1,000 cfs)														•		•
Dunnigan to River Release (750 cfs)							•		•							
Dunnigan Pipeline to River Release (1,000 cfs)													•		•	
Bridge (sized for 1.3 MAF)									•		•	•	•			
Bridge (sized for 1.5 MAF)	•		•	•	•	•	•	•		•				•	•	•
South Road to Lodoga		•														
South Road to Local Residents	•		•	•	•	•	•	•	•	•	•	•	•	•	•	•
Rockfill Embankment Dam	•	•	•			•	•									
Earthfill Dam				•				•	•	•	•	•	•	•	•	•
Hardfill Dam					•											

Note: Alternatives VP1, VP2, and VP3 were also evaluated at 1.0 MAF and 1.5 MAF. Alternative VP4 was also evaluated at 1.5 MAF.

Acronyms: PGP – pumping/generating plant; TCRR – Tehama-Colusa regulating reservoir; CBD – Colusa Basin Drain

3.1 Alternative 1

Compared to Alternative D in the EIR/EIS, Alternative 1 reduces the size of the reservoir to 1.5 MAF and uses a multi-span bridge to reduce costs (Figure C1-1 in Appendix A of main report). The other features are generally consistent with Alternative D, including a facility at Funks Reservoir, Delevan Canal, construction of a multi-spanning bridge and southern road for local residents, and conveyance of water through a pipeline to the Sacramento River.

It is assumed that the Delevan Canal would have a maximum capacity of approximately 750 cubic-feet-per-second (cfs) of water.

They key difference between Alternative D and Alternative 1, is that a new diversion facility at Delevan on the Sacramento River is not proposed. Only an outlet is proposed.

3.1.1 Species Potentially Affected

Alternative 1 would potentially affect the same species and critical habitat as Alternative D due to the same relative magnitude of impacts associated with the Project footprint and operations.

3.1.2 Permits and Approvals Required

Like Alternative D, the same environmental permits and approvals identified for Alternative D (Table C1-2) would be required for Alternative 1. There would be little, if any, substantial change in timing or cost of these permits due to the same relative magnitude of impacts associated with the Project footprint and operations.

3.1.3 CEQA/NEPA Considerations

The reduction in reservoir size may reduce effects to inundated cultural, biological, and land use (agricultural) resources but not to less-than-significant levels. A Delevan Canal rather than pipeline could increase significant and unavoidable effects to agriculture through severing parcels and leaving portions of parcels with challenging access for large agricultural equipment or leaving smaller parcels that would no longer be economically viable for production.

3.1.4 Mitigation Differences and Considerations

Due to this alternative's similar relative magnitude of impacts associated with the Project footprint and operations, the challenges of detailed costing for mitigation identified within Attachment 1 continue to place the approximate cost of mitigation at $500 million (ICF [2020] memorandum in Attachment 1). However, some mitigation costs associated with facilities that would not be built (i.e., Delevan diversion) or reduced in size (i.e., smaller construction footprint of river outfall pipeline) would result in some level of mitigation cost savings compared to those of Alternative D. These costs could be developed once a final Value Planning Alternative is selected and some level of initial design detail of the Project footprint is completed. Considerations for seeking to avoid and/or minimize impacts to the extent possible during the design process would also be important to reducing mitigation cost.

3.1.5 Summary of Score

Table C1-4, *Relative Permitability of Each Alternative Compared to Alternative D*, provides a comparison of relative permitting difficulty of each Value Planning Alternative to that of Alternative D (0 = more difficult; 1 = approximately the same; 2 = slightly less difficult; 3 = moderately less difficult). To provide a comparable permitability estimate Table C1-4 holds permitting regulations static from the time when the Draft EIR/EIS was first published (2017) and does not take into consideration new regulations, modeling or other changes in baseline conditions that would prevent an equitable relative comparison between Alternative D and a Value Planning Alternative.

Using the scoring methodology provided in Table C1-4, with no Delevan diversion, a slightly smaller inundation area (smaller size), a narrower easement to river and a river outfall/outlet, Value Planning Alternative 1 is relatively less difficult to permit than Alternative D with a total score of 15 points and an average score of 1.88.

3.2 Alternative 2

Alternative 2 (Figure C1-2 in Appendix A) is very similar to Alternative 1. Alternative 2 uses the southern road to the town of Lodoga in place of the multi-span bridge. Like Alternative 1, it is assumed that approximately 750 cfs of water would be conveyed to the Sacramento River through the Delevan Canal and pipeline. No diversion facility is proposed at Delevan on the Sacramento River.

3.2.1 Species Potentially Affected

Alternative 2 would potentially affect the same species and critical habitat as Alternative D due to the very similar footprint.

3.2.2 Permit Considerations

Like Alternative D, the same environmental permits and approvals would be required for Alternative 2. Table C1-2 identifies the key permits and approvals required for Alternative 2.

3.2.3 CEQA/NEPA Considerations

Similar to Alternative 1, the reduction in reservoir size may reduce effects to inundated cultural, biological, and land use (agricultural) resources but not to less-than-significant levels. For the same reasons as identified for Alternative 1, a Delevan Canal rather than pipeline could increase significant and unavoidable effects to agriculture.

The proposed addition of the South Road to Lodoga would require additional studies to determine environmental effects but it is assumed that through the additional ground disturbance associated with road construction there would be an increase in potential environmental effects.

3.2.4 Mitigation Differences and Considerations

Due to this alternative's similar relative magnitude of impacts associated with the Project footprint and operations, the challenges of detailed costing for mitigation identified within Attachment 1 continue to place the approximate cost of mitigation at $500 million (ICF [2020] memorandum in Attachment 1). However, some mitigation costs associated with facilities that would not be built (i.e., Delevan diversion) or reduced in size (i.e., smaller construction footprint of river outfall pipeline) would result in some level of mitigation cost savings compared to those of Alternative D. These costs could be developed once a final Value Planning Alternative is selected and some level of initial design detail of the Project footprint is completed. Considerations for seeking to avoid and/or minimize impacts to the extent possible during the design process would also be important to reducing mitigation cost.

3.2.5 Summary of Score

Using the scoring methodology provided in Table C1-4, with no Delevan diversion, a slightly smaller inundation area (smaller size), a narrower easement to river and a river outfall/outlet, Value Planning Alternative 2 is relatively less difficult to permit compared to Alternative D with a total score of 15 points and an average score of 1.88.

3.3 Alternative 3

Alternative 3 (Figure C1-3 in Appendix A) eliminates the Sites Pumping/Generating Plant and replaces it with the TCRR and Pumping Plant near Road 69 in combination with an upgraded TRR to fill Sites Reservoir. Water would be released to the Sacramento River through a canal/pipeline to the Delevan release structure. The two-span bridge is used in this alternative.

Like Alternatives 1 and 2, it is assumed that approximately 750 cfs of water would be conveyed to the Sacramento River through the Delevan Canal and pipeline. No diversion facility is proposed at Delevan on the Sacramento River.

3.3.1 Species Potentially Affected

Alternative 3 would potentially affect the same species as Alternative D due to the similar footprint. The newly proposed facilities at the northernmost portion of the future reservoir is outside of the footprint already analyzed; however, the same species would be analyzed for potential Project effects.

3.3.2 Permit Considerations

Like Alternative D, the same environmental permits and approvals would be required for Alternative 3. Table C1-2 identifies the key permits and approvals required for Alternative 3.

3.3.3 CEQA/NEPA Considerations

Similar to Alternatives 1 and 2, the reduction in reservoir size may reduce effects to inundated cultural, biological, and land use (agricultural) resources but not to less-than-significant levels. For the same reasons as identified for Alternative 1, a Delevan Canal rather than pipeline could increase significant and unavoidable effects to agriculture through stranding parcels that would no longer be viable for production.

Replacement of the Funks/Sites Pumping/Generating Plant (PGP) with the TCRR and upgraded TRR PGP would result in the potential for similar environmental effects but in areas on the northeast side of the proposed reservoir.

3.3.4 Mitigation Differences and Considerations

Due to this alternative's similar relative magnitude of impacts associated with the Project footprint and operations, the challenges of detailed costing for mitigation identified within Attachment 1 continue to place the approximate cost of mitigation at $500 million (ICF [2020] memorandum in Attachment 1). However, more specific costs could be developed once a final Value Planning Alternative is selected and some level of initial design detail of the Project footprint is completed. Considerations for seeking to avoid and/or minimize impacts to the extent possible during the design process would also be important to reducing mitigation cost.

3.3.5 Summary of Score

Using the scoring methodology provided in Table C1-4, with no Delevan diversion, a slightly smaller inundation area (smaller size), a narrower easement to river and a river outfall/outlet, Value Planning Alternative 3 is relatively less difficult to permit compared to Alternative D with a total score of 15 points and an average score of 1.88.

3.4 Alternatives 4a and 4b

Alternatives 4a and 4b (Figures C1-4a and C1-4b in Appendix A) include the single Sites PGP with releases through the Delevan Canal/Pipeline. Alternative 4a uses an earthfill dam and Alternative 4b uses a hardfill dam in place of the zoned rockfill dam.

Like Alternatives 1 and 2, it is assumed that approximately 750 cfs of water would be conveyed to the Sacramento River through the Delevan Canal/Pipeline. No diversion facility is proposed at Delevan on the Sacramento River.

3.4.1 Species Potentially Affected

Alternatives 4a and 4b would potentially affect the same species as Alternative D due to the similar footprint.

3.4.2 Permit Considerations

Like Alternative D, the same environmental permits and approvals would be required for Alternatives 4a and 4b. Table C1-2 identifies the key permits and approvals required for Alternatives 4a and 4b.

3.4.3 CEQA/NEPA Considerations

Similar to Alternatives 1, 2 and 3, the reduction in reservoir size may reduce effects to inundated cultural, biological, and land use (agricultural) resources but not to less-than-significant levels. For the same reasons as identified for Alternative 1, a Delevan Canal rather than pipeline could increase significant and unavoidable effects to agriculture.

Proposed construction under Alternative 4a of an earthfill dam and under Alternative 4b of a hardfill dam rather than rockfill embankment dam would need to be analyzed for potential changes in environmental effects associated with construction technique (e.g., borrow on site versus hauling) and materials (e.g., onsite cement batch plant) including potential air quality, greenhouse gas, noise and transportation effects.

3.4.4 Mitigation Differences and Considerations

Due to this alternative's similar relative magnitude of impacts associated with the Project footprint and operations, the challenges of detailed costing for mitigation identified within Attachment 1 continue to place the approximate cost of mitigation at $500 million (ICF [2020] memorandum in Attachment 1). However, more specific costs could be developed once a final Value Planning Alternative is selected and some level of initial design detail of the Project footprint is completed. Considerations for seeking to avoid and/or minimize impacts to the extent possible during the design process would also be important to reducing mitigation cost.

3.4.5 Summary of Score

Using the scoring methodology provided in Table C1-4, with no Delevan diversion, a slightly smaller inundation area (smaller size), a narrower easement to river and a river outfall/outlet, Value Planning Alternative 4a and 4b are relatively less difficult to permit compared to Alternative D with a total score of 15 points and an average score of 1.88.

3.5 Alternative 5a and 5b

Alternatives 5a and 5b (Figures C1-5a and C1-5b in Appendix A) replace the Delevan Canal/Pipeline with a southern release near the southern terminus of the T-C Canal. Alternative 5a releases water to the CBD. Water released to the CBD would be conveyed through the lower portion of the CBD to the Sacramento River. Alternative 5b conveys water by canal to the CBD, then uses a siphon and pumping plant to convey water to the Sacramento River.

Under Alternatives 5a and 5b, the canal and pipeline being considered to convey water to either the CBD or Sacramento River would have a capacity of 750 cfs.

Compared to Alternative D, no diversion facility or outlet is proposed at Delevan on the Sacramento River.

3.5.1 Species Potentially Affected

Alternatives 5a and 5b would potentially affect the same species as Alternative D due to the similar footprint. However, due to new facilities, diversions, conveyance features proposed south of Dunnigan, new species have the potential to occur and may be affected by the construction and/or operation of the Project. California tiger salamander is known to occur in the vicinity of those Project features.

3.5.2 Permit Considerations

Like Alternative D, the same environmental permits and approvals would be required for Alternatives 5a and 5b. Table C1-2 identifies the key permits and approvals required for Alternatives 5a and 5b. However, a USFWS special-use permit would not be required for Alternatives 5a and 5b, as the Delevan Canal/Pipeline is not proposed.

3.5.3 CEQA/NEPA Considerations

Similar to the prior alternatives, the reduction in reservoir size may reduce effects to inundated cultural, biological, and land use (agricultural) resources but not to less-than-significant levels. Eliminating releases through a Delevan pipeline or canal would potentially reduce agricultural effects in that area but effects would still be considered significant and unavoidable for the Project as a whole due to effect of the reservoir inundation.

Release from the southern terminus of the T-C Canal to the CBD would require additional study. This expands the direct impact area of the Project beyond what was previously analyzed in the Draft EIR/EIS. While it is assumed that significant and unavoidable effects identified in the Draft EIR/EIS would be the same or similar, the potential for new significant effects would need to be analyzed. Areas that would need to be considered would include, but may not be limited to, seepage along the CBD and ensuring and additional use of the CBD does not affect its existing water delivery, flood control and flood conveyance purposes.

3.5.4 Mitigation Differences and Considerations

Due to these alternative's similar relative magnitude of impacts associated with the Project footprint and operations, the challenges of detailed costing for mitigation identified within Attachment 1 continue to place the approximate cost of mitigation at $500 million (ICF [2020] memorandum in Attachment 1). However, more specific costs could be developed once a final Value Planning Alternative is selected and some level of initial design detail of the Project footprint is completed. Considerations for seeking to avoid and/or minimize impacts to the extent possible during the design process would also be important to reducing mitigation cost.

3.5.5 Opportunities Associated with the CBD Alternatives

Moving water through the CBD provides multiple opportunities under Alternative 5a. Recent activities within the lower portions of the CBD have included integrating floodplain agricultural and water delivery activities to create pulse flows containing plankton blooms to provide food for the federally listed Delta smelt. Under the pulse flow, water is redirected from the Sacramento River down the CBD, through the Knights Landing Ridge Cut Slough, past Wallace Weir, through the Yolo Bypass and into the Delta where it is utilized by Delta smelt and other planktivorus fish.

Additional mitigation opportunities that could be realized include upgrading and/or adding gauge structures along the CDB, upgrading of grade control facilities in the CBD to better control the flow of water and the acquisition of CBD lands from willing sellers that are prone to flooding that could be used for wetland and state and federal listed species mitigation for the Project. The potential to improve water quality in the CBD also exists and would also need to be assessed in detail.

3.5.6 Summary of Score

3.5.6.1 Alternative 5a

Using the scoring methodology provided in Table C1-4, with no Delevan diversion, a slightly smaller inundation area (smaller size), no pipeline easement to river, a shorter conveyance off T-C Canal, and northern regulating reservoir facilities, Value Planning Alternative 5a is relatively less difficult to permit compared to Alternative D with a total score of 19 points and an average score of 2.38.

3.5.6.2 Alternative 5b

Using the scoring methodology provided in Table C1-4, with no Delevan diversion, a slightly smaller inundation area (smaller size), no Delevan pipeline easement to river, an easement to the river off the T-C Canal, a river outfall and northern regulating reservoir facilities, Value Planning Alternative 5b is relatively less difficult to permit compared to Alternative D with a total score of 13 points and an average score of 1.63.

3.6 Alternative 6a and 6b

Alternatives 6a and 6b (Figures C1-6a and C1-6b in Appendix A) combine the TCRR and upgraded TRR with the southern release structure and an earthfill dam. More specifically, the TCRR pipeline and TCRR pumping plant would be constructed to release approximately 2,100 cfs of water into the northernmost portion of the 1.5 MAF proposed reservoir.

Under Alternatives 6a and 6b, the canal and pipeline being considered to convey water to either the CBD or Sacramento River would have a capacity of 750 cfs.

Compared to Alternative D, no diversion facility or outlet is proposed at Delevan on the Sacramento River.

3.6.1 Species Potentially Affected

Alternatives 6a and 6b would potentially affect the same species as Alternative D due to the similar footprint. However, due to new facilities, diversions, conveyance features proposed south of Dunnigan, new species have the potential to occur and may be affected by the construction and/or operation of the Project. California tiger salamander is known to occur in the vicinity of those Project features.

3.6.2 Permit Considerations

Like Alternative D, the same environmental permits and approvals would be required for Alternatives 6a and 6b. Table C1-2 identifies the key permits and approvals required for Alternatives 6a and 6b. However, a USFWS special-use permit would not be required for Alternatives 5a and 5b, as the Delevan Canal/Pipeline is not proposed.

3.6.3 CEQA/NEPA Considerations

As noted above, these alternatives combine the TCRR and upgraded TRR under Alternative 3 with the southern release structure of Alternatives 6a and 6b.

Similar to the prior alternatives, the reduction in reservoir size may reduce effects to inundated cultural, biological, and land use (agricultural) resources but not to less-than-significant levels. Eliminating releases through a Delevan pipeline or canal would potentially reduce agricultural effects in that area but effects would still be considered significant and unavoidable for the Project as a whole due to effect of the reservoir inundation.

Replacement of the Funks/Sites PGP with the TCRR and upgraded TRR PGP would result in the potential for similar environmental effects but in areas on the northeast side of the proposed reservoir.

Release from the southern terminus of the T-C Canal to the CBD would require additional study. This expands the direct impact area of the Project beyond what was previously analyzed in the Draft EIR/EIS. While it is assumed that significant and unavoidable effects identified in the Draft EIR/EIS would be the same or similar, the potential for new significant effects would need to be analyzed. Areas that would need to be considered would include, but may not be limited to, seepage along the CBD and ensuring and additional use of the CBD does not affect its existing water delivery, flood control and flood conveyance purposes.

3.6.4 Mitigation Differences and Considerations

Due to these alternative's similar relative magnitude of impacts associated with the Project footprint and operations, the challenges of detailed costing for mitigation identified within Attachment 1 continue to place the approximate cost of mitigation at $500 million (ICF [2020] memorandum in Attachment 1). However, more specific costs could be developed once a final Value Planning Alternative is selected and some level of initial design detail of the Project footprint is completed. Considerations for seeking to avoid and/or minimize impacts to the extent possible during the design process would also be important to reducing mitigation cost.

3.6.5 Opportunities Associated with the CBD Alternatives

Moving water through the CBD under Alternative 6a has the potential to provide the same benefits as described under Alternative 5a (see section 3.5.5).

3.6.6 Summary of Score

3.6.6.1 Alterative 6a

Using the scoring methodology provided in Table C1-4, with no Delevan diversion, a slightly smaller inundation area (smaller size), no pipeline easement to river, a shorter conveyance off T-C Canal, and northern regulating reservoir facilities, Value Planning Alternative 6a is relatively less difficult to permit compared to Alternative D with a total score of 19 points and an average score of 2.38.

3.6.6.2 Alternative 6b

Using the scoring methodology provided in Table C1-4, with no Delevan diversion, a slightly smaller inundation area (smaller size), no Delevan pipeline easement to river, an easement to the river off the T-C Canal, a river outfall and northern regulating reservoir facilities, Value Planning Alternative 6b is relatively less difficult to permit compared to Alternative D with a total score of 13 points and an average score of 1.63.

4.0 Refined Value Alternatives

Further refinement to alternatives occurred during the Value Planning process. This resulted in the identification of following additional alternatives, VP1 through VP7. All of the refined value planning alternatives propose earthfill dams and include reservoir sizes that are less than the 1.8 MAF proposed under Alternative D. Similar to the prior alternatives, the reduction in reservoir size may reduce effects to inundated cultural, biological, and land use (agricultural) resources but not to less-than-significant levels. Construction of an earthfill dam rather than rockfill embankment dam would need to be analyzed for potential changes in environmental effects associated with construction technique (e.g., borrow on site versus hauling) including potential air quality, greenhouse gas, noise and transportation effects. All of the VP alternatives also propose the south road to local residents and a bridge crossing to serve the western side of the reservoir, similar to Alternative D and therefore assumed to have similar environmental effects.

4.1 Alternative VP1

In addition to design features noted above, Alternative VP1 (Appendix A) uses the TCRR and TRR to fill Sites Reservoir and water is conveyed from the T-C Canal into the CBD at a maximum rate of 750 cfs. VP1 proposes construction of a bridge sized for a 1.5 MAF reservoir.

Compared to Alternative D, no diversion facility or outlet is proposed at Delevan on the Sacramento River.

4.1.1 Species Potentially Affected

Alternative VP1 would potentially affect the same species as Alternative D due to the similar footprint. However, due to new facilities, diversions, conveyance features proposed south of Dunnigan, new species have the potential to occur and may be affected by the construction and/or operation of the Project. California tiger salamander is known to occur in the vicinity of those Project features.

4.1.2 Permit Considerations

Like Alternative D, the same environmental permits and approvals would be required for Alternative VP1. Table C1-2 identifies the key permits and approvals required for Alternative VP1. However, a USFWS special-use permit would not be required for Alternative VP1, as the Delevan Canal/Pipeline is not proposed.

4.1.3 CEQA/NEPA Considerations

Replacement of the Funks/Sites PGP with the TCRR and upgraded TRR PGP would result in the potential for similar environmental effects to those identified under Alternative D but in areas on the northeast side of the proposed reservoir.

Release from the southern terminus of the T-C Canal to the CBD would require additional study. This expands the direct impact area of the Project beyond what was previously analyzed in the Draft EIR/EIS. While it is assumed that significant and unavoidable effects identified in the Draft EIR/EIS would be the same or similar, the potential for new significant effects would need to be analyzed. Areas that would need to be considered include, but may not be limited to seepage along the CBD and ensuring and additional use of the CBD does not affect its existing water delivery, flood control and flood conveyance purposes.

4.1.4 Mitigation Differences and Considerations

Due to this alternative's similar relative magnitude of impacts associated with the Project footprint and operations, the challenges of detailed costing for mitigation identified within Attachment 1 continue to place the approximate cost of mitigation at $500 million (ICF [2020] memorandum in Attachment 1). However, more specific costs could be developed once a final Value Planning Alternative is selected and some level of initial design detail of the Project footprint is completed. Considerations for seeking to avoid and/or minimize impacts to the extent possible during the design process would also be important to reducing mitigation cost.

4.1.5 Opportunities Associated with the CBD Alternatives

Moving water through the CBD (750 cfs) under Alternative VP1 has the potential to provide the same benefits as described under Alternative 5a (see section 3.5.5).

4.1.6 Summary of Score

Using the scoring methodology provided in Table C1-4, with no Delevan diversion, a reduced inundation area, no pipeline easement to river and a shorter conveyance off the T-C Canal, Alternative VP1 is relatively less difficult to permit compared to Alternative D with a total score of 19 points and an average score of 2.38.

4.2 Alternatives VP2 and VP3

In addition to design features noted above, VP2 and VP3 (Figures VP2 and VP 3 in Appendix A) fill the reservoir using the Funks Reservoir and TRR and include a bridge sized for a 1.3 MAF reservoir. Primary changes are related to where and how releases occur. VP2 proposes releases of 750 cfs from the T-C Canal to the CBD via a pipeline at Dunnigan. VP3 proposes releases of 1,500 cfs to the Sacramento River via a Delevan Pipeline.

Compared to Alternative D, no diversion facility or outlet is proposed at Delevan on the Sacramento River under VP2.

4.2.1 Species Potentially Affected

Alternatives VP2 and VP3 would potentially affect the same species as Alternative D due to the similar footprint. However, due to new facilities, diversions, conveyance features proposed south of Dunnigan under VP2, new species have the potential to occur and may be affected by the construction and/or operation of the Project. California tiger salamander is known to occur in the vicinity of those Project features being considered under VP2.

4.2.2 Permit Considerations

Like Alternative D, the same environmental permits and approvals would be required for Alternatives VP2 and VP3. Table C1-2 identifies the key permits and approvals required for Alternatives VP2 and VP3. However, a USFWS special-use permit would not be required for Alternative VP2, as the Delevan Canal/Pipeline is not proposed.

4.2.3 CEQA/NEPA Considerations

Changes in bridge configuration under VP2 and VP3 and use of a Delevan pipeline for releases to the Sacramento River under VP3 would result in effects similar to those identified in the Draft EIR/EIS under Alternative D.

Eliminating releases through a Delevan pipeline or canal as proposed under VP2 would potentially reduce agricultural effects in that area but effects would still be considered significant and unavoidable for the Project as a whole due to reservoir inundation.

Releases from the southern terminus of the T-C Canal to the CBD proposed under VP2 would require additional study. This expands the direct impact area of the Project beyond what was previously analyzed in the Draft EIR/EIS. While it is assumed that significant and unavoidable effects identified in the Draft EIR/EIS would be the same or similar, the potential for new significant effects would need to be analyzed. Areas that would need to be considered would include, but may not be limited to, seepage along the CBD and ensuring that the additional use of the CBD does not affect its existing water delivery, flood control and flood conveyance purposes.

4.2.4 Mitigation Differences and Considerations

Due to this alternative's similar relative magnitude of impacts associated with the Project footprint and operations, the challenges of detailed costing for mitigation identified within Attachment 1 continue to place the approximate cost of mitigation at $500 million (ICF [2020] memorandum in Attachment 1). However, more specific costs could be developed once a final Value Planning Alternative is selected and some level of initial design detail of the Project footprint is completed. Considerations for seeking to avoid and/or minimize impacts to the extent possible during the design process would also be important to reducing mitigation cost.

4.2.5 Opportunities Associated with the CBD Alternatives

Moving water through the CBD under Alternative VP2 has the potential to provide the same benefits as described under Alternative 5a and 6a.

4.2.6 Summary of Score

Using the scoring methodology provided in Table C1-4, with no Delevan diversion, a reduced inundation area, no pipeline easement to river and a shorter conveyance off T-C Canal, Value Planning Alternative VP2 is relatively less difficult to permit compared to Alternative D with a total score of 19 points and an average score of 2.38.

However, with VP3 proposing to release of 1,500 cfs to the Sacramento River via a Delevan Pipeline, a Section 408 permit would be trigged. Alternative VP3 is relatively less difficult to permit compared to Alternative D with a total score of 15 points and an average score of 1.88.

4.3 Alternative VP4

Alternative VP4 (VP4 in Appendix A) fills the reservoir from Funks Reservoir and the TRR with releases of 1,000 cfs from the southern end of the T-C Canal into the CBD. Similar to Alternatives 6b, VP2, and VP3, VP4 has a bridge that is sized for a 1.3 MAF reservoir.

Compared to Alternative D, no diversion facility or outlet is proposed at Delevan on the Sacramento River under VP2.

4.3.1 Species Potentially Affected

Alternative VP4 would potentially affect the same species as Alternative D due to the similar footprint. However, due to new facilities, diversions, conveyance features proposed south of Dunnigan under VP4, new species have the potential to occur and may be affected by the construction and/or operation of the Project. California tiger salamander is known to occur in the vicinity of those Project features being considered under VP4.

4.3.2 Permit Considerations

Like Alternative D, the same environmental permits and approvals would be required for Alternative VP4. Table C1-2 identifies the key permits and approvals required for Alternative VP4. However, a USFWS special-use permit would not be required for Alternative VP4, as the Delevan Canal/Pipeline is not proposed.

4.3.3 CEQA/NEPA Considerations

Changes in bridge configuration under VP4 would result in effects similar to those identified in the Draft EIR/EIS under Alternative D.

Eliminating releases through a Delevan pipeline or canal as proposed under VP4 would potentially reduce agricultural effects in that area but effects would still be considered significant and unavoidable for the Project as a whole due to reservoir inundation.

Releases from the southern terminus of the T-C Canal to the Sacramento River proposed under VP4 would require additional study. This expands the direct impact area of the Project beyond what was previously analyzed in the Draft EIR/EIS. While it is assumed that significant and unavoidable effects identified in the Draft EIR/EIS would be the same or similar, the potential for new significant effects would need to be analyzed. In addition, the pipeline be constructed in proximity to federal project levees which may also require supplemental environmental analysis under NEPA for the Section 408 permitting process.

4.3.4 Mitigation Differences and Considerations

Due to this alternative's similar relative magnitude of impacts associated with the Project footprint and operations, the challenges of detailed costing for mitigation identified within Attachment 1 continue to place the approximate cost of mitigation at $500 million (ICF [2020] memorandum in Attachment 1). However, more specific costs could be developed once a final Value Planning Alternative is selected and some level of initial design detail of the Project footprint is completed. Considerations for seeking to avoid and/or minimize impacts to the extent possible during the design process would also be important to reducing mitigation cost.

4.3.5 Opportunities Associated with the CBD Alternatives

Moving water through the CBD under Alternative VP4 has the potential to provide the same benefits as described under Alternative 5a and 6a.

4.3.6 Summary of Score

Using the scoring methodology provided in Table C1-4, with no Delevan diversion, a reduced inundation area, a pipeline easement to the Sacramento River off the T-C Canal, VP4 is relatively less difficult to permit compared to Alternative D with a total score of 15 points and an average score of 1.88. Similar to VP3, a Section 408 permit would be triggered with construction of a pipeline on the levee, east of the CBD.

4.4 Alternatives VP5, VP6, and VP7

During a meeting of the Ad Hoc Value Planning Work Group on March 2, 2020, the proposed value planning alternatives were further refined. Three alternatives were recommended for consideration in determining the preferred project. Table C1-4 provides a summary of facilities under each alternative.

Table C1-4. Recommended Alternatives and Alternates

Major Facilities	VP5	VP6	VP7 Recommended
Reservoir Size	1.3 MAF	1.3 MAF	1.5 MAF
Bridge Size (avoids future traffic Interruption)	1.5 MAF	1.5 MAF	1.5 MAF
South Road to Local Residents	Included	Included	Included
Misc. Local and Project Roads	Included	Included	Included
Diversion Locations	Funks and TRR	Funks and TRR	Funks and TRR
Dunnigan Release	1,000 cfs to CBD	1,000 cfs to River	1,000 cfs to CBD

As indicated in Table C1-4, VP5, VP6, and VP7 (Figures VP5, VP6, and VP7 in Appendix A) all propose the use of Funks PGP, the TRR and TRR PGP, an earthfill dam and a bridge sized for a 1.5 MAF reservoir. However, VP5 and VP6 propose a 1.3 MAF reservoir size while VP7, identified as the recommended preferred alternative, proposes a 1.5 MAF reservoir. Both VP5 and VP7 would release 1,000 cfs from the T-C Canal to the CBD via a pipeline at Dunnigan. VP6 would release 1,000 cfs from the T-C Canal through a pipeline to the Sacramento River at Dunnigan.

4.4.1 Species Potentially Affected

Alternatives VP5, 6, and 7 would potentially affect the same species as Alternative D due to the similar footprint. However, due to new facilities, diversions, conveyance features proposed south of Dunnigan under VP5, VP6 and VP7, new species have the potential to occur and may be affected by the construction and/or operation of the Project. California tiger salamander is known to occur in the vicinity of those Project features being considered under the three alternatives.

4.4.2 Permit Considerations

Like Alternative D, the same environmental permits and approvals would be required for Alternatives VP5, VP6, and VP7. Table C1-2 identifies the key permits and approvals required for Alternative VP5, VP6, and VP7. However, a USFWS special-use permit would not be required for these alternatives, as the Delevan Pipeline/Canal is not proposed.

4.4.3 CEQA/NEPA Considerations

As noted above, eliminating releases through a Delevan pipeline or canal would potentially reduce agricultural effects in that area but effects would still be considered significant and unavoidable for the Project as a whole due to reservoir inundation. Effects related to bridge size and configuration would likely be similar to those identified in the Draft EIR/EIS for Alternative D.

Releases from the southern terminus of the T-C Canal to the CBD proposed under VP5 and VP7 would require additional study. This expands the direct impact area of the Project beyond what was previously analyzed in the Draft EIR/EIS. While it is assumed that significant and unavoidable effects identified in the Draft EIR/EIS would be the same or similar, the potential for new significant effects would need to be analyzed. Areas that would need to be considered would include, but may not be limited to, seepage along the CBD and ensuring that the additional use of the CBD does not affect its existing water delivery, flood control and flood conveyance purposes.

Releases from the southern terminus of the T-C Canal to the Sacramento River proposed under VP6 would also require additional study. This expands the direct impact area of the Project beyond what was previously analyzed in the Draft EIR/EIS. While it is assumed that significant and unavoidable effects identified in the Draft EIR/EIS would be the same or similar, the potential for new significant effects would need to be analyzed. In addition, the pipeline would be constructed in proximity to federal project levees which may require supplemental environmental analysis under NEPA for the Section 408 permitting process.

4.4.4 Mitigation Differences and Considerations

Due to this alternative's similar relative magnitude of impacts associated with the Project footprint and operations, the challenges of detailed costing for mitigation identified within Attachment 1 continue to place the approximate cost of mitigation at $500 million (ICF [2020] memorandum in Attachment 1). However, more specific costs could be developed once a final Value Planning Alternative is selected and some level of initial design detail of the Project footprint is completed. Considerations for seeking to avoid and/or minimize impacts to the extent possible during the design process would also be important to reducing mitigation cost.

4.4.5 Opportunities Associated with the CBD Alternatives

Moving water through the CBD under Alternatives VP5, VP6, and VP7 has the potential to provide the same benefits as described under Alternative 5a and 6a.

4.4.6 Summary of Score

Using the scoring methodology provided in Table C1-4, with no Delevan diversion, a reduced inundation area, no pipeline easement to river and a shorter conveyance off T-C Canal, VP5 through VP7 is relatively less difficult to permit compared to Alternative D with a total score of 19 points and an average score of 2.38. VP6 would release 1,000 cfs from the T-C Canal through a pipeline to the Sacramento River at Dunnigan, thereby has a reduced total score for VP6 is 15 and an average score of 1.88.

Table C1-5. Relative Permitability of Each Alternative Compared to Alternative D

Permits	Alternatives															
	D (EIR/EIS)	1	2	3	4a and 4b	5a	5b	6a	6b	VP1	VP2	VP3	VP4	VP5	VP6	VP7
Federal																
Clean Water Act (404)	1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Section 408	1	2	2	2	2	3	2	3	2	3	3	1	1	3	1	3
Federal ESA (NMFS and USFWS)	1	2	2	2	2	3	2	3	2	3	3	2	2	3	2	3
Section 106	1	2	2	2	2	3	2	3	2	3	3	2	2	3	2	3
State																
Clean Water Act (401) and Wetland Policy	1	2	2	2	2	2	1	2	1	2	2	2	2	2	1	2
California ESA	1	2	2	2	2	3	2	3	2	3	3	2	2	3	2	3
1602 Lake and/or Streambed Alteration Agreements	1	2	2	2	2	2	1	2	1	2	2	1	2	2	1	2
Water Right(s)	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
sum of points	8	15	15	15	15	19	13	19	13	19	19	15	15	19	15	19
Average	**1.00**	**1.88**	**1.88**	**1.88**	**1.88**	**2.38**	**1.63**	**2.38**	**1.63**	**2.38**	**2.38**	**1.88**	**1.88**	**2.38**	**1.88**	**2.38**

Notes:
Relative Permeability Scale: 0 = more difficult; 1 = approximately the same; 2 = slightly less difficult; 3 = moderately less difficult
higher number - relatively easier to obtain permit/approval from regulatory resource agency compared to Alternative D

▒	No Delevan diversion, slightly smaller inundation (smaller size), narrower Delevan easement to river, river outfall
░	No Delevan diversion, slightly smaller inundation (smaller size), no easement to river, shorter conveyance off T-C Canal, northern regulating reservoir facilities (6a)
▓	No Delevan diversion, slightly smaller inundation (smaller size), no Delevan easement to river, easement to river off T-C Canal and river outfall, northern regulating reservoir facilities (6b)
▓	No Delevan diversion, slightly smaller inundation (smaller size), no Delevan easement to river, easement to river off T-C Canal and river outfall, northern regulating reservoir facilities removed
▒	No Delevan diversion, slightly smaller inundation (smaller size), Delevan Canal/Pipeline easement to river, easement to river off T-C Canal and river outfall, northern regulating reservoir facilities removed

This page intentionally left blank

Attachment C-1-1

Sites Reservoir Project: Review of Value Planning - Mitigation Cost Estimate

Update of 2016 Technical Memorandum & Evaluation of Value Planning Alternatives

March 23, 2020

Mr. John Spranza, MS, CCN
Senior Ecologist/Regulatory Specialist
HDR
2379 Gateway Oaks Drive, Suite 200
Sacramento, CA 95833

Subject: **Sites Reservoir Project: Review of Value Planning - Mitigation Cost Estimate Update of 2016 Technical Memorandum & Evaluation of Value Planning Alternatives 1 – 7 (VP1 – VP7)**

Dear Mr. Spranza:

Per your request, ICF has completed our review of the Value Planning technical memorandum (memo), dated October 11, 2019, that was developed by Sites Project team members as part of the initial review and evaluation of the mitigation measures and associated costs for the Sites Project alternatives. The stated purpose of the Value Planning memo was to review the mitigation cost estimate prepared in 2016 (AECOM 2016), based on the then preferred project Alternative C, and to refine the mitigation cost estimate, if possible, to consider the current project alternatives 1, 2, 3, 4a, 4b, 5a, 5b, 6a and 6b being considered in the Value Planning process. In addition to memo review, ICF also evaluated the potential impacts, mitigation measures and associated costs for the recently formulated Value Planning (VP) Alternative 1 – 7.

The memo was developed based on Site's Permitting Integration Team's initial review and applicability of the 2016 mitigation cost estimate, a mitigation planning analysis performed in 2019 by ICF International, and Alternatives developed during the Value Planning process, including most recent versions of Alternatives 6a and 6b.

The findings of the memo are consistent with ICF's 2019 review of the 2016 mitigation acreage assumptions and mitigation cost estimate for the project alternatives, including Alternative 6a, 6b, and VP1- VP7. As stated in the Value Planning memo, a detailed comparison of the 2016 mitigation cost estimate to the present-day project mitigation requirements cannot be performed with precision because 1) the project's impact assessment on terrestrial and aquatic resources, including listed species, has yet to be finalized, and 2) the associated mitigation ratios/acres have yet to be determined by the state and federal regulatory agencies. ICF also concurs with the memo's finding that review of existing analyses and mitigation cost estimates currently being used do not result in any significant changes in estimated mitigation costs (>$50M) when applied to the Value Planning Alternatives.

ICF's 2019 evaluation of the 2016 mitigation assumptions and mitigation cost estimate did not include the more recently developed Alternatives 6a and 6b or VP1 – VP7. A detailed evaluation and comparison of mitigation and mitigation costs associated with Alternatives 6a, 6b and VP1 – VP7 cannot be performed with precision because the project's impact assessment on terrestrial and aquatic resources, including listed species, has yet to be finalized. Based on an evaluation of aerial imagery available on Google Earth, Alternative 6a would appear to affect fewer terrestrial and aquatic resources and Alternative 6b could have impacts comparable to a Delevan diversion. Other considerations that will factor into future evaluations of mitigation and mitigation costs associated with Alternatives 6a, 6b and VP1 – VP7 include the following:

- Alternatives 6a and 6b would eliminate the proposed Delevan diversion and rely on other existing diversions and would include either a Dunnigan release to the Colusa Basin Drain (Alternative 6a) or the Sacramento River (Alternative 6b).
- VP4 and VP7 would both have 1.5 million acre feet (MAF) and therefore more impacts than the other five VP alternatives which would have 1.3MAF reservoirs.
- VP2 – VP7 would include a Funks Pumping/Generating Plant (PGP). Alternatives 1 – 6b and VP1 would not include a Funks PGP however the biological impacts associated with this PGP would not significantly increase the overall project related impacts.
- VP3 would include a Delevan Pipeline to the Sacramento River. VP1, VP2, VP5 and VP7 alternatives would include a Dunnigan Pipeline to Colusa Basin Drain releases and would therefore have fewer impacts associated than VP3. VP4 and VP6 alternatives would include a Dunnigan Pipeline to the River and impacts would likely be comparable to VP3.

Thank you for the opportunity to review the Value Planning technical memo and the recently formulated VP alternatives. Please contact Monique Briard or me if you have any questions.

Sincerely,

Harry Oakes

Harry Oakes
Senior Restoration Ecologist

cc: Monique Briard - ICF

Value Planning: Mitigation Cost Estimate Update of 2016 Technical Memorandum

Sites Reservoir Project

To: Robert J. Kunde, P.E.
CC: Jeff Herrin, AECOM
Date: October 11, 2019
From: John Spranza, HDR-Sites Integration
Reviewed by: Jelica Arsenijevic, HDR-Sites Integration
Subject: Mitigation Measure Evaluation and Cost Estimate Review of 2016 Technical Memorandum

1.0 Background

In October 2016, AECOM, on behalf of the Sites Project Authority (Authority), prepared a technical memorandum (TM) that presented the results of a mitigation measure evaluation and cost estimate that was developed as a planning-level tool for assessing costs associated with implementing select mitigation measures for the Sites Reservoir (AECOM 2016). The 2016 evaluation and cost estimate was based on the mitigation measures developed for North-of-the-Delta-Offstream Storage (NODOS) Mitigation Monitoring Plan (DWR and Reclamation 2013) and then applied to Alternative C, which are directly applicable in scale and magnitude to Alternative D that was included in the Joint Draft EIR/EIS. These estimates have also been included in the current cost planning and financing efforts that have been occurring for project.

A Value Planning effort has been undertaken by Sites Project members to revisit the current Project (Alternative D) and identify items and actions that could be included, excluded or undertaken to provide clarification on the following items:

A. ***Operational*** – as measured by the participants in the Reservoir Project committee based on the storage and delivery reports and progress on the Principles of Agreement with Reclamation and DWR
B. ***Permittable*** – as measured by the inclusion of the Sites Project in the California Water Resiliency Portfolio and by discussions with permitting agencies with CDFW and NMFS.
C. ***Affordable*** – as measured by the participants in the Reservoir Project committee based on the Affordability Analysis.
D. ***Feasible*** – as identified and addressed in the value planning activity and defined by the Authority Feasibility Criteria. This also includes the refinement of operational criteria and the further development of the Principles of an Agreement with Reclamation and DWR.

This memorandum (memo) summarizes HDR's Permitting Integration Team's initial review and applicability of the 2016 mitigation cost estimate, a mitigation planning analysis performed by ICF International (ICF 2019) and Alternatives developed during the Value Planning process to add to the evaluation process of A through D above.

2.0 Purpose

The purpose of this review is to evaluate the mitigation cost estimate included in the 2016 TM, refine the mitigation cost estimate if/where possible to (+/- $50M) and take into consideration the Alternatives being considered in the Value Panning process. To accomplish this and provide the appropriate context this memo includes: 1) a broad-level review of the line items included in the 2016 mitigation cost estimate; 2) mitigation acreage requirements, unit costs, total costs, and assumptions in the 2016 mitigation cost estimate to identify

[redacted]

and assess their applicability to the project's present mitigation needs and; 3) current market costs that were provided by ICF (2019).

It's important to note that this review is focused on large changes in mitigation liability based off of information that had already been prepared for the project. This evaluation is intended to provide the Sites Project Authority context in mitigation costing and a summary of the issues and concerns that result in the current wide-ranging estimates of mitigation costs during the Value Planning process. It is a gross relative estimation and is for comparison/discussion purposes during the Value Planning process only.

3.0 Alternatives Resulting from the Value Planning

The initial Value Planning meeting on October 2, 2019 identified both modifications to previously evaluated facilities and alternative facilities to reduce cost. To speed the analysis, nine alternatives were developed. They are listed below and in Table 1.

- ***Alternative 1*** – This alternative reduces the size of the reservoir to 1.5 MAF and uses a multi-span bridge to reduce costs. The other features are generally consistent with Alternative D.
- ***Alternative 2*** – This alternative is very similar to Alternative 1, but uses the southern road with the more direct route to Lodoga in place of the bridge.
- ***Alternative 3*** – This alternative eliminates the Sites Pumping/Generating Plant and replaces it with the Tehama-Colusa Regulating Reservoir (TCRR) and Pumping Plant near Road 69 in combination with an upgraded Terminal Regulating Reservoir (TRR) to fill Sites Reservoir. Water would be released to the Sacramento River through a canal/pipeline to the Delevan release structure. The canal portion would begin at the TRR and continue east to the Colusa Basin Drain (CBD). It would be necessary to siphon under the CBD and pump the water to the river. The two-span bridge is used in this alternative.
- ***Alternatives 4a and 4b*** – These alternatives include the single Sites Pumping/Generating Plant (PGP) with releases through the Delevan Canal/Pipeline. Alternative 4a uses an earthfill dam and Alternative 4b uses a hardfill dam in place of the zoned rockfill dam.
- ***Alternatives 5a and 5b*** – These alternatives replace the Delevan Canal/Pipeline with a southern release near the southern terminus of the T-C Canal. Alternative 5a releases water to the CBD. Water released to the CBD would be conveyed through the lower portion of the CBD to the Sacramento River. Alternative 5b conveys water by canal to the CBD, then uses a siphon and pumping plant to convey water on to the Sacramento River.
- ***Alternatives 6a and 6b*** – These alternatives combine the TCRR and upgraded TRR with the southern release structure and an earthfill dam. These alternatives appear to have the lowest construction cost.

Table 1. Initial Value Planning Alternatives for Consideration.

	Initial Alternatives								
Features	1	2	3	4a	4b	5a	5b	6a	6b
1.5 MAF Reservoir	•	•	•	•	•	•	•	•	
1.3 MAF Reservoir									•
Funks/Sites PGP	•	•		•	•	•	•		
TCCR and Upgraded TRR PGP			•					•	•
Delevan Canal/Pipeline Release	•	•	•	•	•				
Dunnigan Canal to CBD Release						•		•	
Dunnigan to River Release							•		•
Multi-Span Bridge	•		•	•	•	•	•	•	•
South Road to Lodoga		•							
South Road to Residents	•		•	•	•	•	•	•	•
Rockfill Embankment Dam	•	•	•			•	•		
Earthfill Dam				•				•	•
Hardfill Dam					•				

4.0 Review and Applicability of 2016 Cost Estimate to Alternative D and Value Planning Alternatives

This section provides a discussion of the estimated mitigation costs by resource category that resulted from the 2016 TM as well as a comparison of that estimate, and it's applicability to Alternative D. This then provides a basis for evaluating potential changes in mitigation costs of +/-$50M resulting from the Value Planning alternatives. As previously discussed, review is a gross relative estimation and is for comparison/discussion purposes during the Value Planning process only.

A detailed comparison of the 2016 cost estimate to the present-day project mitigation requirements cannot be performed with precision as the project's impact assessment and associated mitigation ratios/acres have yet to be finalized and determined by the state and federal regulatory agencies[1]. It is anticipated that this information will be obtained in 2020/21 during the permitting and agreement process. However, ICF (2019) did identify assumptions used for the 2016 AECOM TM and Cost Estimate (Table 2) that could result in changes in mitigation-related cost and should be re-evaluated as the project design and environmental documentation phases move forward. These changes are also applicable to any refinements resulting from the Value Planning process and could result in an increase or decrease to the overall $350M[2] – $500M[3] mitigation-related cost estimate. However, as discussed in the bullets below, ICF (2019) determined there are too many unknown variables to accurately estimate a percent change in total cost at the time their review was undertaken. Similarly, the HDR's Permitting Integration Team's current review and mitigation cost analysis continues to find that the addition of new facilities and removal/refinement of proposed facilities resulting from the Value Planning provides the same challenges to providing an accurate estimate of mitigation requirements.

Table 2. Initial 2016 Cost Estimation for Alternative C Mitigation

Habitat Type	Estimated Mitigation Costs
Construction-Related Mitigation[1]	
Vegetation Communities/Botanical Resources	$91,800,000.00
Wetlands/Surface Waters	$83,000,000.00
Aquatic Resources	$56,000,000.00
Wildlife Habitat	$53,000,000.00
Cultural/Historic/Paleontological Resources	$35,000,000.00
Land and Agriculture	$31,000,000.00
Air Quality	$200,000.00
Total Construction Mitigation	**$350,000,000.00**
Operational-Related Mitigation[2]	
Riverine-based species and habitats	$150,000,000.00
Total Estimated Mitigation	**$500,000,000.00**

Note: Total includes Mobilization and Contract Cost Allowances
[1]Source: Sites Reservoir Feasibility Study Technical Memorandum Mitigation Measure Evaluation and Cost Estimate, October 2016, AECOM
[2] Source: Estimate from WISP Application for Alternative D

- ***Project Alternative***: The 2016 TM was based on impacts for the Alternative C project features and presumed mitigation ratios required by the state and federal regulatory agencies in 2016. Alternative D is now the preferred project alternative. Although the two alternatives are similar, Alternative D includes components that were either not part of Alternative C or have been modified since the 2016 evaluation.

---

[1] California Endangered Species Act, federal Endangered Species Act and Clean Water Act

[2] $350M taken from the AECOM 2016 TM

[3] $500M taken from the updated estimate provided during the September 2019 Joint Workshop.

The addition of new facilities and removal/refinement of proposed facilities resulting from the Value Planning provides the same challenges.

- ***Impact Acreage***: The TM impact assessment for the proposed project, both Alternative D and any refinements resulting from the Value Planning continues to be under development and the total acreage of compensatory state and federal regulatory agency mitigation that will ultimately be required for the project is unknown. Therefore, a direct and accurate 1:1 comparison of mitigation measures related to impact/mitigation acreage to the current project alternative and Value Planning refinements cannot be developed at this time but a comparison that applies some general assumptions and analysis has been included below to provide the requested Value Planning update.
- ***Mitigation Ratios***: Mitigation ratios for Alternative D and any Value Planning refinements have yet to be determined by the regulatory agencies. Although some of the presumed mitigation ratios presented in the 2016 TM may ultimately be applied, some of the mitigation ratios in the "Estimate Worksheet" tables in Attachment 2 of the 2016 evaluation appear to be low and could be subject to change. For example, the mitigation ratio used for permanent impacts to the Blue Oak Woodland vegetation community is 1:1, current mitigation ratios required for onsite/offsite Blue Oak Woodland creation are higher that 1:1. Additionally, it is unknown at this time how mitigation ratios may be applied, or overlap, in terms of permanent/temporary impacts for vegetation communities and for special-status species mitigation. This information will be developed during the mitigation planning phase once a preferred project has been identified.
- ***Land Acquisition Costs***: Some of the mitigation measures assumed the purchase of land through fee-title or the establishment of conservation easement. The unit prices used in the 2016 evaluation for natural vegetation communities ranged from $2,500/acre for annual grassland to $3,000/acre for blue/valley oak woodland. The unit prices used in the 2016 evaluation for agricultural land cover types ranged from $2,000/acre for dryland grain and seed crops to $4,500/acre for deciduous orchards. It is likely that the land acquisition costs assumed in the 2016 evaluation have increased, or will have increased, by the time land is acquired for mitigation purposes. In some instances, higher-than-market prices may be realized because willing sellers could raise the asking prices based on the nature of the project and the conservation easement requirements that could be placed upon their lands.
- ***Mitigation Bank Credit Availability***: Based on the anticipated mitigation acreage required it is unlikely that there will be sufficient mitigation bank credits available for purchase on the open market to meet the need of Alternative D and/or any Value Planning refinements that may occur. It may be beneficial to develop a project specific bank(s) to address some of the mitigation requirements. Bank development costs were not assumed in the 2016 TM, although the mitigation bank unit prices per acre that were assumed may adequately cover bank development costs. Further investigation of mitigation banking feasibility and costs will occur during the mitigation planning phase once a preferred project has been identified.
- ***Vegetation Community Unit Costs***: The accuracy of the estimated costs based on present-day rates vary based on the type of habitat.
    - The unit cost for wetland habitats was based on mitigation bank credit prices and are comparable to present-day unit costs.
    - The unit cost for riparian restoration ($65,000) may be low because there are numerous variables that could factor in to restoring riparian habitat (e.g., grading costs, water costs).
    - Oak woodland mitigation is assumed to be covered by conservation easements of existing habitat. The current cost estimate does not include oak woodland creation which could be considerably higher than $3,000/acre.
- ***Onsite Mitigation and Associated Costs***: Costs assumptions for onsite mitigation were not included in the "Estimate Worksheet" tables in the 2016 evaluation and could not be reviewed. Onsite mitigation was assumed for impacts to streams and aquatic habitat and some terrestrial communities. Stream impacts are presented on an acreage basis as determined by stream length and width categories (e.g., streams 5-10 feet wide). Based on an assumed 2:1 mitigation ratio, a total of 455 acres of onsite stream restoration would be required. It is unknown if this mitigation could be restored/created onsite

and what level of planning and construction would be required to implement onsite restoration for streams, aquatic habitat and terrestrial communities.

- ***O&M Phase Mitigation Costs***: Table 3 in the 2016 TM summarizes the O&M mitigation phase costs. The total estimated annual cost was approximately $5.5 million. The estimate annual cost for some mitigation categories appears to be low and should be re-evaluated in more detail as project mitigation measures are developed and finalized (e.g., vegetation communities/botanical resources [$85,000]; wildlife habitat [$12,400]).
- ***Onsite Land Management***: Annual mitigation land management and monitoring costs for on-site restoration were assumed to be $400/acre. Onsite restoration monitoring was assumed to be required for 31 acres ($12,400/year). This cost appears to be low and should be re-evaluated in more detail as project mitigation measures are developed and finalized.
- ***Design Contingency***: Table 1 in the 2016 TM summarizes the cost estimate allowances and contingencies for mitigation costs and recommended that the design contingency be increased to 12% of project costs to account for design and scope changes and cost estimate refinements. This increase could cover costs of future opportunities and constraints analysis, mitigation site suitability assessments, and studies required to develop mitigation site plans (e.g., hydraulic studies, soil and rare plant surveys).
- ***Cultural Resources Costs***: The potential mitigation costs for each individual measure are estimates based on finding from surveys that still need to be conducted, conditions found during construction, and mitigation that will be developed during consultation so conducting a cost estimate at an individual measure level was not performed. However, the overall estimated cost of $27M should be sufficient for these variables.
- ***Air Quality Costs***: ICF (2019) confirmed that neither Colusa nor Glenn County currently have a voluntary offset program that will require annual mitigation fees to offset construction NOx emissions. The overall cost of $200,000 appears to be reasonable.

4.1 Potential Mitigation Cost Refinements for Value Planning

Construction-based Mitigation Costs

After assessing estimated relative changes in construction-based mitigation types and volumes among the Value Planning Alternatives no substantial changes (>$50M) in the costs of mitigation from those identified in the 2016 TM are readily apparent. The reason for this is twofold. First there is a general lack of readily available data on impacts by habitat/resource type for the Value Planning Alternatives which makes direct computational comparisons not possible. Second, when looked at as a package by each Alternative, construction-based impacts tend to have counterbalancing effects that nullify the overall increase/decrease of any specific effect.

An example of this is that Alternatives 1, 2, and 3 all have a change from a Delevan pipeline to a Delevan canal. While this may have substantial construction cost savings, the footprint of the two variations are approximately the same and although there would undoubtedly be a change in mitigation costs, that difference would be muted by the overall magnitude of the residual mitigation requirement. Table 3 provides an example of this for the changes estimated mitigation costs associated with impacts to vegetation communities. In this case, the largest difference between the all Alternatives is the size of the reservoir and the resulting effects to vegetation communities/botanical resources, which is the largest overall construction-related mitigation cost Table 3. The Alternative C and D reservoirs are 1.8 MAF and would impact 14,200 acres of annual grassland where Alternative 6b is 1.3 MAF impacting 12,500 acres of annual grassland. When those values are used in the calculation of potential annual grassland mitigation costs, it results in an approximate 9 percent reduction of annual grassland mitigation costs ($8.26M), which equates to an approximately 2.3 percent reduction in overall construction mitigation costs. Consequently, although a 1,700 acre reduction in grassland impacts is substantial, when working at such large scales it is a relatively small change in the overall project's estimated construction-related mitigation costs and the $350M estimate in Table 3 should be retained until additional analysis can be performed on a better-defined project description.

Operational-based Mitigation Costs

The removal of the Delevan diversion results in the elimination of a major operational component that would reduce the overall operational effects of the Value Planning Alternatives. It would eliminate the need for approximately $7.5M in aquatic studies (15 @$500k) as well as the cost of mitigating for the entrainment/impingement of fish at the diversion and mitigation costs associated with the diversion of up to 2,000 cfs from the River. Although the Alternatives would be taking less water overall, the place of diversion would be shifted upstream from a priority at Delevan, to Red Bluff and Hamilton City. As the River reach from below Keswick Dam to Hamilton City has a higher biological value to spawning and rearing salmonids, the reduction in overall pumping from three diversions to two does not directly relate to a net reduction in riverine effects and resulting mitigation costs due to the change in pumping locations and resulting effects on riverine resources. Review of existing modeling and analysis performed for the Joint draft EIR/EIS, Biological Assessment and CDFW 60-day negotiations, as well as discussions with the Jacobs modeling team has not resulted in the identification of any currently-available analysis that is reliable enough to identify and quantify the net change in potential operational-mitigation costs. Consequently, the $150M estimate in Table 3 should been retained until additional modeling can be performed.

Table 3. Mitigation Cost Comparison Example

Habitat Type	Estimated Mitigation Costs Alt C	Estimated Potential Change	Estimated Change in Costs
Construction-Related Mitigation[1]			
Vegetation Communities/Botanical Resources	$91,800,000.00	-9%	-$8,262,000.00
Wetlands/Surface Waters	$83,000,000.00	[redacted]	[redacted]
Aquatic Resources	$56,000,000.00	[redacted]	[redacted]
Wildlife Habitat	$53,000,000.00	[redacted]	[redacted]
Cultural/Historic/Paleontological Resources	$35,000,000.00	[redacted]	[redacted]
Land and Agriculture	$31,000,000.00	[redacted]	[redacted]
Air Quality	$200,000.00	[redacted]	[redacted]
Total Construction Mitigation	**$350,000,000.00**	[redacted]	[redacted]
Operational-Related Mitigation[2]			
Riverine-based species and habitats	$150,000,000.00	unknown	unknown
Total Estimated Mitigation	**$500,000,000.00**	**-2.3%**	**-$8,262,000.00**

Note: Total includes Mobilization and Contract Cost Allowances

[1] Source: Sites Reservoir Feasibility Study Technical Memorandum Mitigation Measure Evaluation and Cost Estimate, October 2016, AECOM

[2] Source: Estimate from WISP Application for Alternative D

5.0 Findings

Review of existing analyses and mitigation cost estimates currently being used did not result in any significant changes in estimated mitigation costs (>$50M) when applied to the Value Planning Alternatives. While there will certainly be changes in cost among and between mitigation categories in Table 3 when a final project description is selected, until additional analysis can be performed on a specific project description the $500M estimate in Tables 2 and Table 3 should be retained.

6.0 Sources

AECOM. 2016. Sites Reservoir Feasibility Study Technical Memorandum Mitigation Measure Evaluation and Cost Estimate, October.

DWR and Reclamation 2013. Mitigation Monitoring Plan Costs for North-of-the-Delta Off stream Storage. Prepared for the California Department of Water Resource and United States Department of Interior, Bureau of Reclamation. Sacramento, CA. November.

ICF International. 2019. Mitigation Measure Evaluation and Cost Estimate Review of 2016 AECOM Technical Memorandum. May.

Appendix D – Repayment

Appendix D Financial Analysis in Support of March 2020 Value Planning

To: Value Planning Work Group
CC: JP Robinette
Date: April 10, 2020
From: Brian Grubbs
Quality Review by: Doug Montague
Authority Agent Review by: Lee Frederiksen
Subject: Financial Analysis in Support of March 2020 Value Planning

1.0 Purpose and Background

This memorandum documents the financial evaluation of the delivered cost of water given variations in project facility configuration and operational flows in support of the Value Planning Analysis. Montague DeRose and Associates (MDA) provided the following analysis in support of the overall project affordability analysis for the Sites Project Authority (SPA).

- Review of public agencies similar to SPA to determine the potential credit rating for revenue bonds
- Review of historical tax-exempt revenue bond interest rates to determine a projected cost of borrowing for SPA
- Review of Bureau of Labor Statistics indices to determine appropriate escalation factors for construction and labor costs
- Development of an enterprise financial model (FM) to support projected revenues, expenses and appropriate cash balances during the design and construction and through project operations.

2.0 Analysis

2.1 Description of Scenarios

Scenarios analyzed consisted of various combinations of construction costs, hydrological conditions and financing options. AECOM and Jacobs coordinated to provide costs for 13 different facility cost scenarios based on reservoir size and amount of water available for release at FOB Holthouse. The financial model did not add additional costs for transportation of water past that point. These scenarios were entered in the financial model and run through potential financing options including with and without a Water Infrastructure Finance and Innovation Act (WIFIA) Loan of $1.1 billion. There was no funding from the US Bureau of Reclamation (USBR) assumed in these scenarios. The below table provides a summary of these scenarios with relevant details for financial modeling. Additional details of specific items to be constructed are provided in the engineering technical memorandum.

Scenario Name	Reservoir Size	Water Release at Holt House	Average Cost from AECOM Range
	(MAF)	(TAF)	(2019$ billion)

VP1	1.0	191	3.160
	1.3	230	3.386
	1.5	236	3.600
VP2	1.0	191	2.684
	1.3	230	2.910
	1.5	236	3.098
VP3	1.0	not analyzed	
	1.3	243	3.388
	1.5	253	3.602
VP4	1.0	not analyzed	
	1.3	234	2.927
	1.5	243	3.115
VP5	1.3	234	2.855
VP6	1.3	234	2.988
VP7	1.5	243	3.037

2.2 Methodology

MDA developed an enterprise financial model (FM) based on monthly cash flows of the expected revenue and expense streams. The difference between revenue and expense streams determines that amount of funding needed from external borrowing (revenue bonds) and the monthly cash flow modeling provides the timing of when those funds are needed. While many of the revenues are technically grants or loans, this document will refer to all sources of funds as revenues.

Funding Priority: The FM sets up two primary funds to transfer money for construction. The first is the Construction Fund. Inflows are (in order of priority based on lowest cost): WSIP funds, WIIN Act Funds (if available), Cash from Participants, Interim Loan Draws, WIFIA Loan Draws and finally revenue bond draws. Transfers from the Construction Fund will fund the Interim Loan Payoff at the end of Phase 2 and Construction Expenses. The model is programmed to maintain a minimum Construction Fund balance each month to reflect prudent cash flow management practices. When expenses would result in the monthly ending balance dropping below the minimum balance, draws are initiated from the available sources in priority order. Each year in June from 2023 to 2029, revenue bonds are issued to provide enough funds to cover expenses and not allow the Construction fund to fall below the minimum balance before the next revenue bond issue is sold.

The other fund utilized during project construction is the Revenue Bond Fund. Starting in June 2023, a revenue bond is issued to refinance the Phase 2 interim loan balance and provide funds (along with the other sources of revenue) to pay for construction expenses until the next revenue bonds are issued. The initial revenue bond sale in 2023 provides the initial deposit to the Revenue Bond Fund and each month a draw is made to transfer funds from the Revenue Bond Fund to the Construction Fund. Funds remaining in the Revenue Bond Fund earn interest at a short-term rate. Additionally, with each revenue bond offering, a portion of the proceeds will be deposited in a Revenue Bond Fund subaccount called the Debt Service Reserve Fund (DSRF) where it will be held for the benefit of revenue bondholders if there is ever a shortfall in debt service payments on revenue bonds. The DSRF balance earns interest at a long-term rate. These interest earnings add to the Revenue Bond Fund balance and are used pay construction costs. For the VP7 scenario (with WIFIA loan), the interest earned from 2023-2030 on the Revenue Bond Fund balance is projected to be $31 million. The interest earned on the DSRF from 2023-2030 is $5 million. Following the end of construction, interest earned in the DSRF is used to reduce the annual revenue bond debt service cost.

Construction Cost Expense: AECOM provided monthly pre-construction and quarterly construction cash flows for a 1.8 MAF reservoir in June 2018 in 2015$. These estimated cash flows were for January 2019 through June 2030. With guidance from AECOM, the Value Planning scenarios have a reduced construction schedule due to no longer constructing the Delevan Pipeline. Instead of starting construction in July 2022, it now begins in July 2023. Construction is still completed in June 2030. This is seven years of construction as compared to the prior analysis having eight years of construction. AECOM provided scenarios of construction costs in 2019$, however these were not provided as monthly or quarterly cash flow, but instead for total costs for construction. As the total construction costs varied by scenario, the prior AECOM 2015$ monthly and quarterly cash flows were scaled with the Excel Goal Seek function to output the desired total cost in 2019$. Once 2019$ construction costs had been calculated, escalation factors were applied for inflation to determine total pre-construction and construction costs in nominal$. Pre-construction and construction nominal costs were further escalated by a 4.2% risk mitigation factor provided by AECOM to account for project delays or cost overruns. A sub-category in the construction costs of environmental mitigation costs was escalated for inflation, however it was not escalated by the risk mitigation factor, under guidance from AECOM.

The table below shows the cost schedule for the VP7 scenario (with WIFIA) in 2019$, the cost escalation factor used for escalating construction costs (pre-construction costs are escalated by a different percentage), and the total costs for the reservoir in nominal$. Additional detail on cost escalation is provided in the Assumptions section.

	Costs Schedule ($millions, 2019$)					**Percent Cost Escalation for Construction**	**Costs Schedule ($millions, nominal$)**				
	Pre Const	**Cons**	**Enviro**	**Risk Adder**	**Total**		**Pre Const**	**Cons**	**Enviro**	**Risk Adder**	**Total**
2021	75	-	-	3	78	4.1%	77	-	-	3	80
2022	84	-	-	4	88	6.2%	88	-	-	4	92
2023	64	182	13	10	270	8.3%	68	198	14	11	291
2024	-	431	22	18	471	10.5%	-	476	24	20	520
2025	-	439	10	18	467	12.7%	-	494	11	21	526
2026	-	367	10	15	393	15.0%	-	423	11	18	452
2027	-	367	10	15	393	17.3%	-	431	12	18	461
2028	-	367	10	15	393	19.7%	-	440	12	18	470
2029	-	367	10	15	393	22.1%	-	449	12	19	480
2030	-	184	5	8	196	24.6%	-	229	6	10	245
Total	**223**	**2,705**	**89**	**123**	**3,140**		**233**	**3,139**	**102**	**142**	**3,616**

Water Storage Investment Program (WSIP) Revenues: WSIP revenues are projected to total $816 million. WSIP revenues do not escalate for inflation or vary based on the size of the reservoir. The FM draws WSIP revenues to cover the construction expenses allocated to the State. Based on input provided by Larsen Wurzel & Associates, Inc., each March, 75% of the current year's costs allocated to the State are drawn and transferred to the Construction Fund. Also in March, an additional 20% of the prior year's costs are drawn and transferred to the Construction Fund. The final 5% of State allocated costs are drawn upon when significant construction points are completed which was estimated to occur every three years during construction. This formulation results in WSIP revenues being provided each year through 2030. The highest WSIP revenue year is 2026 when $139 million is provided.

Water Infrastructure Improvements for the Nation (WIIN Act) Revenues: In the Value Planning analysis no WIIN Act revenues are assumed.

US Department of Agriculture (USDA) Loan: In November 2018, the U.S. Department of Agriculture approved a $439 million USDA Community Facilities Direct Loan for the permanent financing of the Maxwell Intertie. The FM transfers the full USDA loan proceeds to the Revenue Bond Fund in December 2024 and treats the transfer as it would a transfer of the proceeds of a revenue bond sale. The USDA loan debt service is based on 40-year principal amortization starting in December 2025 and with last payment in December 2064. Per the USDA Letter of Conditions, a $10 million Depreciation Fund will be funded that "may be used only for emergency maintenance and for replacement of short-lived assets which have a useful life significantly less than the repayment period of the loan." Additionally, a debt service reserve fund will also be funded to equal 10% of the annual loan debt service.

Interim Loan: To provide funds during the balance of Phase 2 an interim loan is modeled as a bank line of credit. Interest is due each month based on the outstanding balance of the bank line. Any un-utilized amount of the bank line is also charged a lower un-utilized bank fee. The first revenue bonds issued will refinance the principal balance of the interim loan.

Water Infrastructure Finance and Innovation Act (WIFIA) Loan: While the SPA has not yet applied for a WIFIA loan, a scenario run using the FM was the inclusion of a $1.1 billion loan. The main benefit of a WIFIA loan is the potential for a lower interest rate than revenue bond financing. Upon loan closing, the WIFIA loan rate will be set based on the yield of the US Treasury Bond that most closely matches the projected average life of the WIFIA loan plus 1 basis point (.01%). Once the loan is approved, the WIFIA loan performs like a line-of-credit that can be drawn upon over time. The FM assumes the first draw from the WIFIA line of credit occurs in June 2023 and because it is expected to have a lower borrowing cost than revenue bonds, it eliminates the need for any revenue bond financing for the next several years. Interest is due each month on the total amount drawn to date, with the amortization of the full amount beginning within five years of substantial project completion. The WIFIA loan must be fully repaid within 35 years of substantial project completion. The FM assumes the amortization will begin in 2030 with final payments made in 2064.

Revenue Bonds: To meet the construction draw schedule, revenue bonds are generally assumed to be issued each year in June from 2023 through 2029. The first issue in June 2023 is the largest as if must refinance the interim loan that paid for pre-construction costs as well as fund construction costs for the next year. For the VP7 scenario without a WIFIA loan this first revenue bond issue is $401 million. Follow-on issuances are less than $400 million each. The bonds are issued as 40-year bonds with interest-only payments until the project is complete. The first bonds issued in June 2023 have eight years of interest-only payments and 32 years of principal and interest payments. The last bond issuance in June 2029 has two years of interest-only payments and 38 years of principal and interest payments. All revenue bond principal payments begin in 2032 which is the "worst-case" year to begin water deliveries, assuming the reservoir takes two years to fill.

The funding schedule for VP7 scenario with and without a WIFIA loan is:

Funding Schedule ($millions, nominal$)					
	WSIP	**WIINACT**	**Revenue Bonds**	**USDA**	**WIFIA**
2020	8	-	-	-	-
2021	18	-	-	-	-
2022	10	-	-	-	-
2023	37	-	561	-	-
2024	97	-	-	439	-
2025	112	-	331	-	-
2026	139	-	327	-	-
2027	98	-	361	-	-
2028	100	-	350	-	-
2029	119	-	379	-	-
2030	79	-	-	-	-
Total	**816**	**-**	**2,309**	**439**	**-**

WIFIA - Funding Schedule ($millions, nominal$)					
	WSIP	**WIINACT**	**Revenue Bonds**	**USDA**	**WIFIA**
2020	8	-	-	-	-
2021	18	-	-	-	-
2022	10	-	-	-	-
2023	37	-	-	-	382
2024	97	-	-	439	423
2025	112	-	-	-	295
2026	139	-	118	-	-
2027	98	-	362	-	-
2028	100	-	352	-	-
2029	119	-	381	-	-
2030	79	-	-	-	-
Total	**816**	**-**	**1,213**	**439**	**1,100**

Following the construction of the project there will be ongoing operational revenues and expenses.

Operation, Maintenance and Repair Expenses: AECOM provided annual estimates of expenses for various categories of OM&R.

Fixed Expenses: These costs were split into Operation and Maintenance, and Administrative and General categories based on files from AECOM provided in June 2018. Updated expenses were provided for the

Value Planning in 2016$. These expenses were fixed and did not vary by the size of the reservoir. These costs, on a per AF basis, are higher for the smaller sized reservoirs. This is due to the fact that there is less water being released across which to spread the costs. The costs in 2016$ are escalated each year by the inflation rate as found in the assumptions section.

Variable Expense: These costs were split into sub-categories of Fill Wheeling Cost and Pumping Costs based on files provided by AECOM in June 2018. Updated expenses were provided in 2016$. These costs are impacted by the reservoir size as they are dependent on the amount of water passing through the reservoir. These costs were annualized and tied to the amount of water being filled for each reservoir size. The 2016$ costs were escalated each year by the inflation rate found in the assumptions section. Since each annualized cost is based on a projected level of water flows, when the water flows are adjusted by various operational scenarios the expense is scaled proportionally.

Electrical Generation Revenue: AECOM provided electrical generation revenue estimates in June 2018 and updated them in 2016$. These revenues are impacted by the reservoir size as they are a function of the amount of water being released. These revenues were annualized and tied to the amount of water being released for each reservoir size. The 2016$ revenues were escalated each year by the inflation rate found in the assumptions section. Since each annualized revenue is based on the projected level of water releases when the water releases are adjusted by various operational scenarios the revenue is scaled proportionally. Following AECOM scenarios, there are no pump-back operations in the Value Planning scenarios.

2.3 Assumptions

Item	Value	Notes
Interim Loan		
Interest Rate	3.00%	
Unutilized Rate	0.75%	
Revenue Bonds		
Interest Rate	5.00%	1
DSRF% of Maximum Annual Debt Service	50%	
DSRF Earnings Rate	4.00%	
Bond Fund Interest Earnings Rate	2.00%	
First Maturity	12/1/2032	
Final Maturity	6/1/2066	
USDA Loan		
Interest Rate	3.875%	
WIFIA Loan		
Interest Rate	3.500%	2
Construction Risk Mitigation Percentage	4.20%	3
Inflation Escalators		
Pre-Construction Escalation/year	1.50%	4
Construction Escalation/year	2.02%	5
Labor Inflation Rate/year	2.00%	6
Non-Labor inflation rate/year	2.00%	7
Electrical Generation Price Escalation/year	2.00%	8
Months for Generation post COD	24	

Note 1: Based on the 20-year average (Jul 1999-Jun 2019) of the Municipal Market Data Index of 30-year "AAA" rated municipal revenue bond issues. 40 basis points has been added to the interest rate to reflect the higher borrowing cost for an "A" rated water utility. The resultant average interest rate was 4.87%. The FM uses 5%.

Note 2: Based on the 10-year average of the 30-year Treasury Bond (Aug 2009-Jul 2019) and adding one basis point. This equaled 3.27%. The FM uses 3.50%.

Note 3: As provided by AECOM.

Note 4: Based on average of BLS Series PCU5416-5416, the PPI for management and technical consulting = 0.98% over last 10 years and BLS Series PCU5413-5413, the PPI for architectural and engineering services = 1.32% over last 10 years.

Note 5: Based on discussions with AECOM, based on the type of construction involved which is mainly the movement of dirt as opposed to construction of office buildings or hotels which would be a much higher rate. This amount is equal to 15% over seven years and is supported by the Army Corps of Engineers and the Bureau of Reclamation.

Note 6: Based on BLS Series CWUR0400SA0, the CPI for all West urban wage earners = 1.45 over last 10 years.

Note 7: Based on BLS Series CUUR0400SA0, the CPI for all West urban consumers = 1.53 over last 10 years.

Note 8: June-2018 NYMEX ticker for California ISO NP 15 peak and off-peak power was 3.6% per year over the next 54 months. MDA believes this is too high for conservative estimation of future revenues. MDA believes 2% per year escalation is more prudent.

2.4 Results

Additional details for these scenarios are provided in the attached file: “Sites Value Planning-FM-VP Alternatives - 04-10-2020.xlsx”

[redacted]

Scenario			VP1			VP2			VP3			VP4			VP5	VP6	VP7
Reservoir Size		(MAF)	1.0	1.3	1.5	1.0	1.3	1.5	1.0	1.3	1.5	1.0	1.3	1.5	1.3	1.3	1.5
Project Cost	(2019$)	($millions)	3,160	3,386	3,600	2,684	2,910	3,098		3,388	3,602		2,927	3,115	2,855	2,988	3,037
Project Cost	($nominal)	($millions)	3,784	4,055	4,311	3,214	3,485	3,710		4,057	4,313		3,505	3,730	3,419	3,578	3,637
Capital Funds																	
PWA (revenue bonds)	($nominal)	($millions)	2,529	2,800	3,056	1,959	2,230	2,455		2,802	3,058		2,250	2,475	2,164	2,323	2,382
PWA (USDA loan)	($nominal)	($millions)	439	439	439	439	439	439		439	439		439	439	439	439	439
Total PWA	($nominal)	($millions)	2,968	3,239	3,495	2,398	2,669	2,894		3,241	3,497		2,689	2,914	2,603	2,762	2,821
State (WSIP)	($nominal)	($millions)	816	816	816	816	816	816		816	816		816	816	816	816	816
Federal (WIIN Act)	($nominal)	($millions)	-	-	-	-	-	-		-	-		-	-	-	-	-
Capital Funds Percentage																	
PWA		(%)	78%	80%	81%	75%	77%	78%		80%	81%		77%	78%	76%	77%	78%
State		(%)	22%	20%	19%	25%	23%	22%		20%	19%		23%	22%	24%	23%	22%
Federal		(%)	0%	0%	0%	0%	0%	0%		0%	0%		0%	0%	0%	0%	0%
Annualized AF/year Releases																	
PWA NOD		(TAF)	44	53	55	42	52	54		56	59		53	55	52	53	55
PWA SOD		(TAF)	117	143	148	113	139	144		151	159		141	149	141	142	148
PWA		(TAF)	**161**	**196**	**203**	**155**	**191**	**198**		**207**	**218**		**194**	**204**	**193**	**195**	**203**
State		(TAF)	30	34	33	36	39	38		36	35		40	39	41	39	40
Federal		(TAF)	-	-	-	-	-	-		-	-		-	-	-	-	-
Total		(TAF)	191	230	236	191	230	236		243	253		234	243	234	234	243
PWA Annual Costs During Repayment																	
Debt Service (w/o WIFIA)	(2020$)	($millions)	124	135	146	99	111	121		136	147		112	121	108	115	117
Operating Costs	(2020$)	($millions)	16	19	19	16	18	19		19	20		18	19	18	19	19
Operating Revenue	(2020$)	($millions)	(1)	(2)	(2)	(1)	(2)	(2)		(2)	(2)		(2)	(2)	(2)	(2)	(2)
Total	(2020$)	($millions)	139	152	164	114	127	137		153	164		128	138	124	131	134
	(2020$)	**($/AF)**	**862**	**776**	**805**	**730**	**667**	**693**		**738**	**754**		**660**	**678**	**644**	**674**	**661**
With WIFIA Loan of $1.1 Billion (Operating Cost and Operating Revenue do not change)																	
Debt Service (w/WIFIA)	(2020$)	($millions)	114	125	136	89	101	110		125	136		102	111	98	105	107
Total	(2020$)	($millions)	129	142	153	103	117	127		143	154		118	128	114	121	124
	(2020$)	**($/AF)**	**799**	**724**	**755**	**665**	**614**	**642**		**689**	**708**		**608**	**628**	**592**	**622**	**611**
Cost Difference Due to WIFIA loan			(63)	(52)	(50)	(65)	(53)	(51)		(49)	(46)		(52)	(50)	(52)	(52)	(50)

Page is intentionally blank.

3.0 Limitations and Risks

All scenarios were prepared using a projected revenue bond interest rate of 5.00% and scenarios with WIFIA loans were based on a 3.50% loan rate. These interest rates are dependent on interest rate levels at the time of the initiation of each revenue bond series and the closing of the WIFIA loan, respectively. While current interest rates are lower than these projected rates, MDA used long-term historical averages to determine the most prudent interest rate for this analysis and then used a discount rate when necessary to provide costs in current dollars as desired by SPA.

The value of the results from this modeling is dependent on the quality and reasonableness of the inputs provided by the other members of the Sites project team. The FM is built as a cash flow model that incorporates the time value of money through interest rates and inflation escalators. If construction is delayed, pushing costs farther into the future, this will escalate those costs. Additionally, if State and Federal funds are not made available at the times and in the amounts projected in our modeling, the costs the Federal and/or State monies would have funded will need to be funded with additional revenue bonds or interim loans. This will increase costs. Likewise, if the construction schedule proves to be conservative and actual construction occurs ahead of schedule, this would have the potential to lower both construction costs and debt costs.

4.0 Conclusions and Recommendations

As with any long-term construction project steps can be taken to lower the final construction and borrowing cost. These include:

1. Reduction in the cost of construction.
2. Pursuit of the additional funding grants from State and Federal programs.
3. Pursuit of low interest loans such as WIFIA and similar programs such as the Reclamation Infrastructure Finance and Innovation Act (RIFIA). The analysis used a $1.1 billion WIFIA loan, however the WIFIA program may be able to provide more funds, if pursued.
4. Working to have grants and lower cost financing made available earlier in the construction period to reduce interim financing costs before permanent financing begins.
5. Increasing the strength of the Participant credit pool by either adding new rated participants to the project or increasing the percentage participation of existing rated Participants, allowing lower cost financing to be obtained in the credit markets.

Additionally, MDA recommends a review of the value of the future water Sites Reservoir will make available. Any financial decision is most easily understood when it can be brought down to the basics of revenue and expenses over time. The certainty of 30 years of un-escalating level debt service payments provides an opportunity for substantial value if the potential revenue stream is not level but increases each year with inflation. The analysis provided here has focused solely on the expenses in building the Sites Reservoir. If clarity can be obtained on the potential revenue stream (or avoided expenses) that the AF of released water represents then clarity can be obtained on the best financial course for participants to take.

2020 Urban Water Management Plans, Delta Plan and Sites Reservoir
Key Points for Members
June 29, 2020
Draft – For Discussion Purposes Only

Challenge:

Sites M&I members are preparing their 2020 Urban Water Management Plans (UWMPs). Members may describe in their UWMPs how Sites would contribute to a reduced reliance on the Delta consistent with the 2009 Delta Reform Act. This paper provides some key points for members use in this effort.

Key Points:

- Sites Reservoir does not meet the definition of a "covered action" under the Delta Plan consistent with a~~the~~ letter from the Delta Stewardship Council to the Sites Project Authority on May 2, 2018.

- Each member should complete a thorough analysis of its ability and actions to reduce reliance on the Delta consistent with the Delta Plan's policy WR P1, Reduced Reliance on the Delta through Improved Regional Water Self-Reliance, as applicable.

Commented [SJ1]: So WR P1 only applies to "covered actions" so how does this fit with bullet one?

- Sites Reservoir and the Proposition 1, Water Supply Infrastructure Program benefits that would result ~~from~~from construction and operation of Sites Reservoir would provide ~~result in~~ measurable improvements in the Delta and Delta tributaries, consistent with the ~~Prop~~Proposition 1 requirements. These benefits include the following:
  - Enhancements to the Delta ecosystem by providing water to convey food resources from the floodplain to the Delta thereby improving the foodchain and quality of the Delta's estuarine habitat for the benefit of pelagic fishes in the north Delta (e.g. Cache Slough).
  - Additional Incremental Level 4 Refuge Water Supply water for use in the Delta watershed to improve habitat for waterfowl and native species.
  - Improved cold water pool management in Shasta Reservoir through coordination and exchanges with the Bureau of Reclamation to benefit anadromous fish.

- Sites Reservoir would result in a more sustainable and resilient use of the Delta watershed.
  - Sites results in increased storage upstream of the Delta in years when water is available above that needed to satisfy existing water rights and environmental and water quality requirements.
  - The majority of this water would then be used in subsequent dry and critically dry years – improving ecosystem conditions through~~u~~ the use of the Proposition 1 water and possibly through~~u~~ improvements in ~~the~~ cold-water pool management in Shasta Reservoir ~~thru~~ via exchanges with the United States Bureau of Reclamation.

  - This improved dry and critically dry year reliability provided by Sites Reservoir reduces the need for Sites' members to find other, less sustainable water sources in these years, while providing environmental enhancement and benefits in the years when its needed most for the environment.

- Sites Reservoir also presents a flexible water supply – allowing water to be moved through~~u~~ the Delta to south-of-Delta members when conditions are more favorable for the Delta ecosystem. Water could then be stored in south-of-Delta reservoirs for later use.

From: Spranza, John [John.Spranza@hdrinc.com]
Sent: 6/30/2020 11:27:16 AM
To: Vondergeest, Michael [Michael.Vondergeest@icf.com]; Briard, Monique [Monique.Briard@icf.com]
CC: Alicia Forsythe [aforsythe@sitesproject.org]
Subject: RE: Talk about design needed for CVFPB

I'll send an invite out for 10 tomorrow. Thanks.

John Spranza

D 916.679.8858 M 818.640.2487

From: Vondergeest, Michael [mailto:Michael.Vondergeest@icf.com]
Sent: Tuesday, June 30, 2020 11:24 AM
To: Spranza, John <John.Spranza@hdrinc.com>; Briard, Monique <Monique.Briard@icf.com>
Cc: aforsythe (aforsythe@sitesproject.org) <aforsythe@sitesproject.org>
Subject: RE: Talk about design needed for CVFPB

CAUTION: [EXTERNAL] This email originated from outside of the organization. Do not click links or open attachments unless you recognize the sender and know the content is safe.

Hi John,
I am available today until 2:30 and anytime tomorrow.
Thanks,
Mike

From: Spranza, John <John.Spranza@hdrinc.com>
Sent: Monday, June 29, 2020 11:10 AM
To: Briard, Monique <Monique.Briard@icf.com>; Vondergeest, Michael <Michael.Vondergeest@icf.com>
Cc: aforsythe (aforsythe@sitesproject.org) <aforsythe@sitesproject.org>
Subject: RE: Talk about design needed for CVFPB

Mike needs to be in the conversation so we will find a time if the ones below don't work.

John Spranza

D 916.679.8858 M 818.640.2487

From: Briard, Monique [mailto:Monique.Briard@icf.com]
Sent: Monday, June 29, 2020 11:08 AM
To: Spranza, John <John.Spranza@hdrinc.com>; Vondergeest, Michael <Michael.Vondergeest@icf.com>
Cc: aforsythe (aforsythe@sitesproject.org) <aforsythe@sitesproject.org>
Subject: RE: Talk about design needed for CVFPB

CAUTION: [EXTERNAL] This email originated from outside of the organization. Do not click links or open attachments unless you recognize the sender and know the content is safe.

I'm available from 1-2 tomorrow and will be available on Wednesday, though I'll be on the road to Portland so I may have intermittent cell service. I'd really like for Mike to be a part of the conversation and he is out today so hopefully this can come together for tomorrow. If not, can we push it to early next week or possibly Thursday?

From: Spranza, John <John.Spranza@hdrinc.com>
Sent: Monday, June 29, 2020 10:32 AM
To: Briard, Monique <Monique.Briard@icf.com>; Vondergeest, Michael <Michael.Vondergeest@icf.com>
Cc: aforsythe (aforsythe@sitesproject.org) <aforsythe@sitesproject.org>
Subject: Talk about design needed for CVFPB

Monique and Mike,
Would either of the time slots listed below work to have a 30 minute call to talk about what exactly we need for the CVFPB so that it is covered in CEQA and we ensure it gets into the Phase 2 engineering scope and schedule? I was getting a lot of questions on Friday from the engineers and I would like to start providing some specific answers to them and to Ali/Laurie.

Tues 6/26 any time after 1
Wednesday 6/27: 10-noon or 2:30 - 4

I know that if any proposed work is located within the State Plan of Flood Control, within 300 feet of a Designated Floodway that has been adopted by the CVFPB, or within 30 feet from the banks of a CVFPB Regulated Stream an encroachment permit will be required. I have attached 2 maps that show that the CBD is a Designated Floodway and that the project will be within the San and San Joaquin Drainage District The map also shows that Alternative 2, which has the pipeline going to the Sac River will need to cross a Corps' levee on the east side of the CBD and one west side of the Sac River. The Corps levee will trigger 408, and Sites has agreed that that permit will be pushed out to a future date but I still want to discuss the timing and needs of it so that we can adjust that schedule and scope throughout the service areas.

Agenda:
1) What facilities or actions will require CVFBP permit coverage under the revised EIR/EIS
2) What design elements do we need for
a. Initial discussions
b. CEQA coverage in 2021 project document
c. Permit application and approval
3) What other permits would this effect (i.e., 408, local, 404)?

John
John Spranza, MS, CCN
Senior Ecologist / Regulatory Specialist

HDR
2379 Gateway Oaks Drive, Suite 200
Sacramento, CA 95833
D 916.679.8858 M 818.640.2487
john.spranza@hdrinc.com

hdrinc.com/follow-us
hdrinc.com/follow-us

2020 Urban Water Management Plans, Delta Plan and Sites Reservoir
Key Points for Members
June 29, 2020
Draft – For Discussion Purposes Only

Challenge:

Sites M&I members are preparing their 2020 Urban Water Management Plans (UWMPs). Members may describe in their UWMPs how Sites will contribute to a reduced reliance on the Delta consistent with the 2009 Delta Reform Act. This paper provides some key points for members use in this effort.

Key Points:

- Sites Reservoir does not meet the definition of a covered action under the Delta Plan consistent with the letter from the Delta Stewardship Council to the Sites Project Authority on May 2, 2018.
- Each member should complete a thorough analysis of its ability and actions to reduce reliance on the Delta consistent with WR P1, Reduced Reliance on the Delta through Improved Regional Water Self-Reliance, as applicable.
- ~~Sites Reservoir and the~~ Through the Proposition 1, Water Supply Infrastructure Program benefits, ~~that would result from~~ Sites Reservoir would result in measurable improvements in the Delta and Delta tributaries, consistent with the Prop 1 requirements. These benefits include the following:
    - Enhancements to the Delta ecosystem by providing water to convey food resources from the floodplain to the Delta thereby improving the foodchain and quality of the Delta's estuarine habitat for the benefit of pelagic fishes in the north Delta (e.g. Cache Slough).
    - Additional Incremental Level 4 Refuge Water Supply water for use in the Delta watershed to improve habitat for waterfowl and native species.
    - Improved cold water pool management in Shasta Reservoir through coordination and exchanges with the Bureau of Reclamation to benefit anadromous fish.
- Sites Reservoir would result in a more sustainable and resilient use of the Delta watershed.
    - Sites results in increased storage upstream of the Delta in years when water is available above that needed to satisfy existing water rights and environmental and water quality requirements.
    - The majority of Sites Reservoir~~this~~ water would then be used in subsequent dry and critically dry years – improving ecosystem conditions through~~u~~ the use of the Prop 1 water and possibly through improvements in the cold-water pool in Shasta Reservoir through exchanges with the Bureau of Reclamation.
    - This improved dry and critically dry year reliability provided by Sites Reservoir reduces the need for Sites members to find other, less sustainable water sources in these years, while providing

environmental enhancement and benefits in the years when its needed most for the environment.

- Sites Reservoir also presents a flexible water supply – allowing water to move through~~u~~ the Delta to south-of-Delta members when conditions are more favorable for the Delta ecosystem. Water could then be stored in south-of-Delta reservoirs for later use.