

Sites Reservoir Project: Conveyance Capacity Technical Memorandum



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Executive Summary

The Sites Project diverts winter floodwaters off the Sacramento River at Red Bluff Pumping Plant at the head of the Tehama-Colusa Canal (TCC) and at the Hamilton City Pumping Plant at the head of the Glenn-Colusa Irrigation District (GCID) main canal. Water is conveyed down these two irrigation canals from north to south to the regulating reservoirs (Funks Reservoir and Terminal Regulating Reservoir [TRR]). From the two regulating reservoirs, water is pumped up into Sites Reservoir, where it is stored. When participants want water, it is released either down to the TRR and then into the GCID canal for local use; or it is released into Funks Reservoir down the TCC, into the Dunnigan Pipeline and into the Colusa Basin Drain (CBD) to the Sacramento River for other uses. A schematic of the system is shown on Figure 1.

This technical memorandum demonstrates the capacity of the TCC and the GCID canal to convey Sites Project water into and out of Sites Reservoir; and the capacity of the CBD to convey Sites Project water from the Dunnigan Pipeline outlet into the Sacramento River. The TCC, GCID canal, and CBD are the controlling conveyance elements for the Sites Project and therefore govern the maximum flow capacity of the overall system. This document also provides a comparison of facilities and costs if the Dunnigan Pipeline is extended all the way to the Sacramento River in lieu of using the CBD as a conveyance facility.

The TCC, under as-built conditions, has sufficient modeled hydraulic capacity to convey Sites Project flows, particularly during the winter diversion season when irrigation demands are minimal. Modeling for the canal indicates capacity up to approximately 2,400 cubic feet per second (cfs) upstream of Funks Reservoir and 1,900 cfs downstream of Funks Reservoir while maintaining acceptable freeboard. The canal functions in two distinct operational segments for the Sites Project:

1. The reach upstream of Funks Reservoir conveys diversions from the Sacramento River to Sites Reservoir, which would occur November 1 through June 30.
2. The reach downstream of Funks Reservoir conveys releases from Sites Reservoir to the Dunnigan Pipeline and ultimately back to the Sacramento River. These releases would occur

April 1 through November 30, whereas releases primarily for South-of-Delta participants through the Dunnigan Pipeline would occur during July 1 through November 30.

Daily coordination with Tehama-Colusa Canal Authority (TCCA) operations may be required to accommodate existing deliveries with Sites Project flows. In addition, localized subsidence between Checks 10 and 12 in the upstream reach reduces available freeboard and may constrain operations; however, TCCA is already planning to mitigate this subsidence. Overall, the TCC remains a reliable primary conveyance facility but requires seasonal coordination and prioritization of existing water deliveries.

The GCID main canal has an upstream channel capacity of approximately 3,000 cfs and reduces to 2,150 cfs near the TRR. Canal availability to convey Sites Project diversions is generally favorable during the winter diversion season but becomes limited in mid-April through June when irrigation demands increase. While these periods can coincide with conditions when the Sites Project is able to divert, Sites Project diversions are not expected during peak irrigation demand periods, reflecting the priority of GCID deliveries. Additional constraints include short maintenance outages, typically occurring in January. Accordingly, the GCID canal represents a viable conveyance pathway, provided that daily coordination with GCID operations is maintained to balance Sites Project diversions with agricultural demands.

The CBD can convey up to 1,000 cfs of Sites Project releases to the Sacramento River. Current modeling indicates that Sites Project flow may increase water surface elevations by up to approximately 1.8 feet, resulting in potential inundation of adjacent lands during periods of elevated ambient flow in late August and early September. Consequently, the Sites Project has shifted from western bank improvement measures to an operational strategy that includes controlled release timing and interagency coordination, with releases limited during periods when ambient flows approach levels that may result in overbank flooding. Therefore, the CBD represents a cost-effective but operationally constrained conveyance option requiring careful management and monitoring. A conservative planning-level estimate of available channel conveyance capacity is 1,500 cfs pending completion of additional survey data collection and hydraulic model calibration.

The Dunnigan Pipeline is evaluated as a key conveyance component, with a base configuration from the TCC to the CBD and an Alternative 2 extension to the Sacramento River. The base pipeline provides a controlled, reliable conveyance facility with a capacity of 1,000 cfs at an estimated cost of approximately \$215 million; however, it requires coordination with downstream CBD operations and associated constraints. The Alternative 2 extension would continue the pipeline directly to the Sacramento River, eliminating these downstream operational limitations and reducing uncertainty with water losses; however, this increases project costs by approximately \$315 million (total of \$530 million) and introduces additional permitting and environmental requirements. Overall, the base pipeline offers a lower-cost solution that depends on coordinated operations, while the extension provides greater assurance that released water is successfully conveyed to the Sacramento River.

The combined conveyance system demonstrates that the Sites Project is feasible using existing and planned infrastructure. While the facilities have sufficient physical conveyance capacity, the capacity available to the Project at specific times is influenced by the need to coordinate with existing irrigation demands. The TCC and GCID canals provide sufficient capacity for diversion, while downstream conveyance presents a strategic choice between the lower-cost but constrained CBD option and the higher-cost but fully controlled Dunnigan Pipeline alternative directly to the Sacramento River.

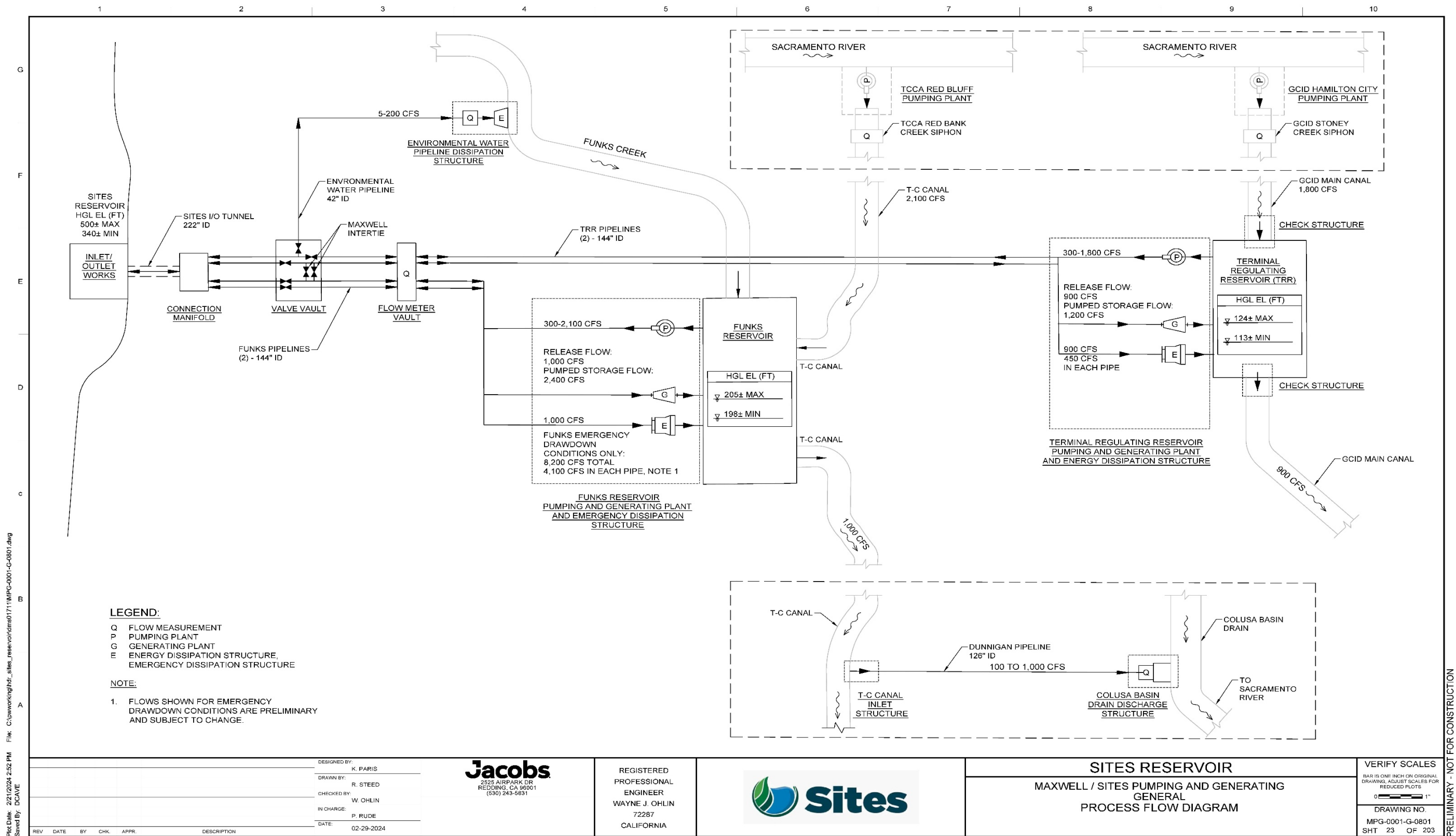


Figure 1. Conveyance Process Flow Diagram

1.0 Tehama-Colusa Canal Facilities

This section describes the existing Tehama-Colusa Canal Authority (TCCA) facilities, status of modeling efforts, impacts of subsidence between Checks 10 and 12 and presents Tehama-Colusa Canal (TCC) excess capacity available for conveyance of Sites water.

1.1 System Description

The Red Bluff Pumping Plant (RBPP) and fish screen was constructed in 2010 to 2012, became operational in 2012, and is designed to divert water at a rate of up to 2,500 cubic feet per second (cfs) from the Sacramento River into the TCC. The fish screen has a current capacity of 2,500 cfs, and the RBPP has a current pumping capacity of 2,000 cfs. The RBPP lifts the water into an afterbay that leads to the TCC. The TCC is a concrete-lined channel that was completed in 1976 by the Bureau of Reclamation (Reclamation), extends 110.8 miles from the RBPP in Tehama County to south of Dunnigan in Yolo County, and serves approximately 150,000 acres of irrigated agriculture. The TCC has 26 automated check structures and approximately 75 turnouts.

The TCC has a capacity of 2,530 cfs at its headworks, reducing to 2,100 cfs by the time it gets to Funks Reservoir that sits between Check 16 and Check 17. Modeled capacity in this reach is 2,400 cfs with 2 feet of concrete freeboard. Downstream of Funks Reservoir, the TCC has a capacity of 2,100 cfs and then reduces to 1,700 cfs at Check 23 until its terminus at Check 26. Modeled capacity in this reach is 1,900 cfs with 1.5 to 3.5 feet of concrete freeboard.

Funks Reservoir is located approximately 66 miles downstream and south of the RBPP, and its initial storage capacity was 2,250 acre-feet (ac-ft). However, this volume has been reduced to approximately 1,100 ac-ft (Jacobs 2021a) since its construction in 1976 due to sediment deposition (primarily from natural flows from Funks Creek).

The TCC typically shuts down for about 6 weeks from mid-December to the end of January for maintenance, depending on the water year. With the Sites Project, this maintenance window will be shortened to allow for TCC maintenance and Sites Project diversions during periodic winter diversions off the Sacramento River that occur during flood events.

Red Bluff Pumping Plant/Sites Project Diversion Constraint and Loss Assumptions

The TCC diversion at Red Bluff for the Sites Project is constrained by a maximum instantaneous diversion in the California Department of Fish and Wildlife (CDFW) 2024 Incidental Take Permit (ITP) Flow Dependent Diversion Criteria, which is represented by a flow dependent diversion table with a maximum value of 2,120 cfs. For operations modeling, the ITP serves as the governing diversion constraint, while the maximum diversion used in the operations model represents the planned diversion required to achieve the target delivery at Funks after accounting for conveyance losses. Under these assumptions, the ITP constraint and the maximum diversion used for operations are both 2,120 cfs at the RBPP. This diversion rate is required to achieve a target delivery of 2,100 cfs at Funks, reflecting a modeled 1% conveyance loss year-round. A summary of these details is included in Table 1.

Table 1. Red Bluff Pumping Plant/Sites Diversion Constraint and Operations Loss Assumptions

Metric	TCC (RBPP to Funks)
Diversion Constraint	CDFW 2024 ITP Flow Dependent Diversion Criteria (2,120 cfs)
Maximum Diversion Operations	2,120 cfs at RBPP
Target Delivery	2,100 cfs at Funks
Operations Modeling CalSim 3 - Canal Losses	1% year-round

CalSim = California Simulation Model

1.2 Level of Service Assessment

A one-dimensional (1D) steady-state hydraulic analysis of the TCC was conducted using U.S. Army Corps of Engineer's (USACE's) Hydrologic Engineering Center's River Analysis System (HEC-RAS) to evaluate canal conveyance capacity and available freeboard under both as-built and subsided conditions. The analysis was conducted in support of planning and design efforts for the proposed Sites Reservoir and associated increases in diversion flows through the TCC for the Sites Project. The model provides a technical reference for identifying subsidence-affected portions of the canal corridor and estimating embankment height modifications necessary to restore available freeboard, which are intended to regain the original designed canal conveyance capacity.

An existing 1D hydraulic model of the TCC developed by Walton et al. (2004) served as the foundation for this effort. The legacy model represented the canal from Check 1 to Check 16, just upstream of Funks Reservoir. As part of the current study, the model domain was extended to include the full canal length to its terminal end at Check 26. The Walton et al. (2004) model provided key cross-sectional and structural details for canal Reaches 1 to 5. Jacobs incorporated the geometry developed by Walton et al., and added canal details for Reaches 6 to 8, creating an updated, full-length HEC-RAS model.

Reclamation originally designed the TCC in the 1960s with a - capacity of approximately 2,530 cfs at the upstream end, decreasing to a capacity of 1,700 cfs at its terminus. However, observed land subsidence near Orland has led to a gradual loss of available freeboard along the upstream portions of the canal in Reach 3, which has in turn reduced the canal's effective capacity use over time. To assess these effects, the following two modeling scenarios were evaluated:

1. A baseline (as-built, non-subsided) geometry
2. A subsided geometry incorporating survey-based subsidence adjustments

Survey data collected by R.E.Y. Engineers, Inc. (R.E.Y.) in December 2025 were used to quantify land subsidence and modify the canal geometry accordingly over a portion of the canal between Checks 10 and 12 (R.E.Y. 2026). Subsidence adjustments were applied using a linear interpolation technique between surveyed control points and were smoothly tapered beyond the surveyed limits to avoid abrupt changes in canal invert elevations.

Both scenarios were simulated using identical modeling assumptions, including the following:

- Steady state
- Subcritical flow conditions
- Consistent boundary conditions
- Uniform Manning's roughness coefficients
- Fully open gate settings at all inline check structures
- A fixed storage area water surface elevation (WSE) representing the upper end of the operating range in Funks Reservoir

Model results were used to compare WSEs and calculate freeboard to the top of the concrete lining.

Multiple flow profiles were analyzed by varying inflow discharges between 2,100 cfs and 2,500 cfs upstream of Funks Reservoir and between 1,000 cfs and 1,900 cfs downstream of Funks Reservoir. Analysis was conducted to evaluate maximum conveyance achievable under each scenario, subject to available freeboard constraints.

As-Built Condition Model Capacity Results

The model results for as-built conditions show at least 2 feet of freeboard for flows up to 2,400 cfs from Check 1 to Funks Reservoir. For the Sites Project, flows from Check 1 to Funks Reservoir are expected to occur in the winter/spring between November 1 and June 30. The TCC modeled capacity between RBPP and Funks Reservoir, by month is provided in Table 2 and uses 2025 data. Agricultural flow for 2025 was selected as a year when TCCA received its full allotment of water and it is a year when Sites could have diverted water off the river. The maximum Sites Project diversion is 2,120 cfs but varies by month and is based on the CalSim 3 "Top Speed" Scenario. The TCC frost water and future groundwater recharge is estimated between 100 and 200 cfs, but for this effort 200 cfs was assumed.

Table 2 indicates that in November the TCC has plenty of capacity for Sites water. Then in December through April the TCC is near capacity with Sites Project water and in May and June there is plenty of capacity for Sites Project water. This analysis is based on monthly average flows. In recent years the TCC has had peak daily flows of more than 1,450 cfs for short periods in May and more sustained daily peaks of more than 1,100 cfs in June and July. What this indicates is that there will need to be daily coordination between the Sites Project and TCCA during diversions for Sites Project water and there may be days when Sites gets less than their full diversion capacity.

Table 2. Red Bluff Pumping Plant from Check #1 to Check #16 into Funks Reservoir

Sites Diversion Operation Window: November 1 through June 30

Month	TCC Modeled Capacity with 2-foot concrete freeboard (cfs)	Monthly Average TCC Agricultural Flows (cfs)	TCC Frost Water and Future Groundwater Recharge (cfs)	Sites CalSim 3 Top Speed Scenario Diversion Maximum Flow (cfs)	Combined Flows (cfs) [2+3+4]	TCC Remaining Modeled Capacity (cfs) [1-5]
Column #	[1]	[2]	[3]	[4]	[5]	[6]
January	2,400	0	200	2,120	2,320	80
February	2,400	0	200	2,120	2,320	80
March	2,400	1	200	2,120	2,321	79
April	2,400	0	200	2,120	2,320	80
May	2,400	823	0	1,375	2,198	202
June	2,400	757	0	820	1,577	823
July	2,400	795	0	0	795	1,605
August	2,400	546	0	0	546	1,854
September	2,400	332	0	0	332	2,068
October	2,400	167	0	0	167	2,233
November	2,400	71	200	1,475	1,746	654
December	2,400	42	200	2,120	2,362	38

Notes:

The capacities shown in this table are modeled capacities used for the Sites Project analysis. TCC design capacity from Check #1 to Check #2 is 2,530 cfs, from Check #2 through Check #4 is 2,300 cfs, and from Check #5 through Check #16 is 2,100 cfs per TCCA.

TCC Ag Winter Flows (November 1 to April 30) vary between 100 cfs and 200 cfs for groundwater recharge and frost water upstream of Funks Reservoir.

TCC Ag Summer Flows (April 1 through November 30) from 2025 data per TCCA.

Table 3 shows the available modeled conveyance capacity in the TCC from Funks Reservoir (Check 17) to the Dunnigan Pipeline inlet (Check 26). Releases of Sites Project water from Sites Reservoir through Funks Reservoir, the TCC, and the Dunnigan Pipeline are expected to occur between April 1 and November 30. For purposes of the Sites Project capacity assessment, a modeled canal capacity of 1,900 cfs was used, representing the maximum flow that can be conveyed while maintaining approximately 1.5 to 3.5 feet of freeboard. Available capacity was evaluated using 2025 operational data, which was selected because TCCA received its full water allotment and Sites Reservoir could have diverted water from the Sacramento River during that year. During the April through November operational period, Sites Reservoir releases are expected to be a maximum of 1,000 cfs. In addition, TCC frost protection deliveries and future groundwater recharge demands downstream of Funks Reservoir are estimated to range from 50 to 150 cfs; for this assessment, 150 cfs was assumed.

Table 3 indicates that in April 1 through November 30 the TCC has sufficient conveyance capacity for Sites Project water. In recent years, the TCC agricultural flows downstream of Funks Reservoir have rarely exceeded peak daily flows of 600 cfs. Even with a maximum Sites Project release of 1,000 cfs, agricultural flows of up to approximately 600 cfs, and an assumed 150 cfs for frost protection and groundwater recharge demands, adequate conveyance capacity remains available within the 1,900-cfs canal capacity. However, daily coordination between TCCA and Sites will be required to convey Sites water when releases occur.

Table 3. From Funks Reservoir at Check #17 to end of TCC near Dunnigan Pipeline Inlet just Upstream of Check #26

Sites Releases Operation Window: April 1 through November 30

Month	TCC Modeled Capacity with 1.5- to 3.5-foot concrete freeboard (cfs)	Monthly Average TCC Agricultural Flows (cfs)	TCC Frost Water and Future Groundwater Recharge (cfs)	Sites Reservoir Releases Maximum Flow (cfs)	Combined Flows (cfs) [2+3+4]	TCC Remaining Modeled Capacity (cfs) [1-5]
Column #	[1]	[2]	[3]	[4]	[5]	[6]
January	1,900	0	150	0	150	1,750
February	1,900	0	150	0	150	1,750
March	1,900	0	150	0	150	1,750
April	1,900	0	150	1,000	1,150	750
May	1,900	435	0	1,000	1,435	465
June	1,900	418	0	1,000	1,418	482
July	1,900	419	0	1,000	1,419	481
August	1,900	308	0	1,000	1,308	592
September	1,900	192	0	1,000	1,192	708
October	1,900	145	0	1,000	1,145	755
November	1,900	68	150	1,000	1,218	682
December	1,900	42	150	0	192	1,708

Notes:

The capacities shown in this table are modeled capacities used for the Sites Project analysis. TCC design capacity from Check #17 through Check #22 is 2,100 cfs and from Check #23 to #26 is 1,700 cfs per TCCA.

TCC Ag Winter Flows (November 1 to April 30) vary between 50 and 150 cfs for groundwater recharge and frost water downstream of Funks Reservoir.

TCC Ag Summer Flows (April 1 through November 30) from 2025 data per TCCA.

Subsidence Impacts on Modeled Capacity

The decrease in capacity with recently observed subsidence just south of Orland was quantified, and model results show limited freeboard of about 6 inches near Check 11 at flows of 2,100 cfs. Under as-built conditions, the canal could pass 2,400 cfs at this location with 2 feet of freeboard to the top of the concrete lining. Project team members and TCCA staff have observed water levels at the top of the concrete liner near Check 11 at flows of 1,450 cfs. This observation at 1,450 cfs is seemingly at odds with model predictions (at 2,100 cfs with gates at the check structures fully open); however, the observations were made when check structure gates were at the controlling stage, not at a full capacity condition when gates were all opened to maximize flow. To address this discrepancy, a canal capacity assessment and field verification test are planned for fall 2026 to confirm the existing canal's conveyance capacity under maximum-flow conditions with check structure gates fully open.

Model results from the subsided conditions were used to support cost estimates for necessary canal lining and bank mitigation efforts to restore design freeboard and counter recent subsidence, as provided in Section 2.2.

1.3 Considerations and Potential Improvements

The RBPP was designed and constructed to accommodate the Sites Project and includes space to add two additional 250-cfs pumping units, bringing the total pumping capacity to 2,500 cfs. These costs are included in the 30% design construction cost estimate.

Funks Reservoir is planned to be dredged during construction to regain its original design capacity; these costs are included in the 30% design construction cost estimate.

Subsidence in Reach 3 between Checks 10 and 12, was confirmed in a topographic survey conducted by R.E.Y. in December 2025 and is documented in the TCC Hydraulic Modeling Technical Memorandum (TM) in Appendix 1. Results showed subsidence ranging from 0.1 to 2.0 feet during the period from 2008 to 2025. A 5% level of design has been completed on this issue.

Figure 2 shows the approximate location and required freeboard raising to meet the 2-foot freeboard requirements. Work would have to be done on both sides of the canal to raise the liner. Further engineering and cost estimates will be completed as part of final design efforts in 2027.

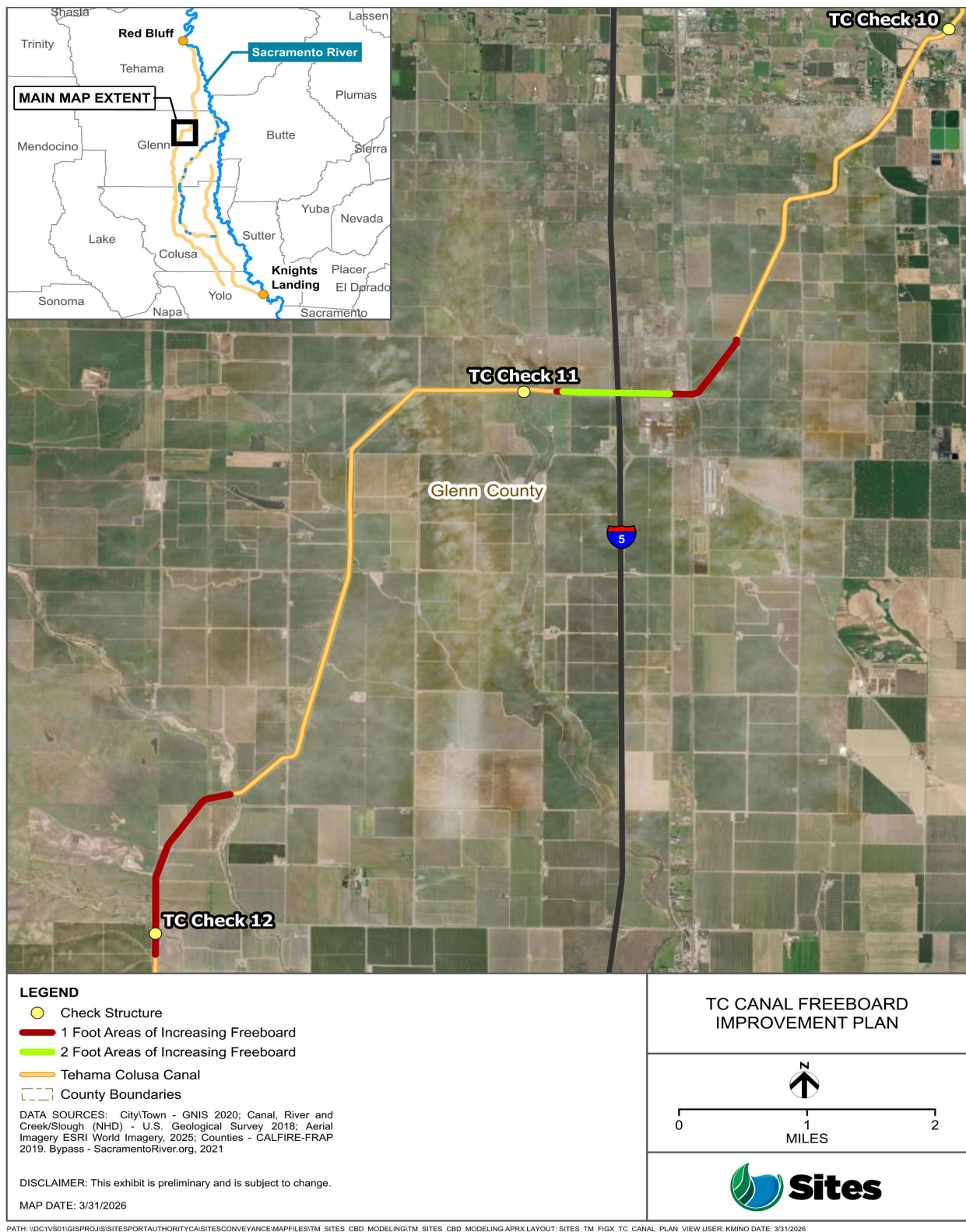


Figure 2. Tehama-Colusa Canal Freeboard Improvement Plan

Figure 3 illustrates the proposed work to raise the concrete liner and operation and maintenance road.

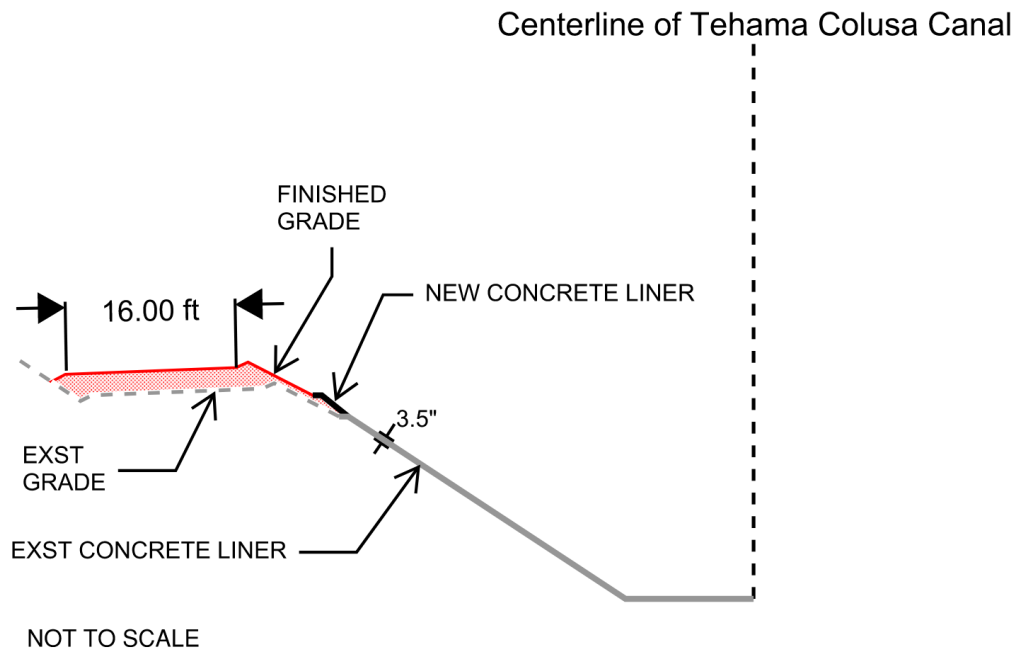


Figure 3. Tehama-Colusa Canal Cross Section Improvements

Jacobs has developed a Class 5 cost estimate based on Reclamation design standards and freeboard raising requirements and on the survey information compiled by R.E.Y. About 13,560 linear feet (LF) of canal need to be raised 1 foot, and 2,580 LF of canal need to be raised 2 feet. The cost estimate for this freeboard raising is \$6.5 million and is documented in Appendix 2. Because the TCC is a Reclamation-owned facility, they will bear the cost of raising the canal liner.

2.0 Glenn-Colusa Irrigation District Facilities

This section contains a description of the existing Glenn-Colusa Irrigation District (GCID) facilities, modeling efforts that have been completed, potential GCID system improvements and presents GCID canal excess capacity available for conveyance of Sites Project water.

2.1 System Description

The GCID Pumping Plant and fish screen are located at Hamilton City on the Sacramento River. These facilities have a diversion capacity of 3,000 cfs. The main canal delivers water from the Sacramento River to water users along its route, from its diversion point approximately 5 miles northwest of Hamilton City to southeast of the City of Williams. The canal is a 65-mile unlined earthen channel, with capacity varying from 3,000 cfs at the upstream end to 300 cfs at the southern terminus, where it spills into the Colusa Basin Drain (CBD). At the TRR vicinity near Willows Check, the available channel capacity is approximately 2,150 cfs, which is the primary controlling capacity for conveyance of Sites Project flows to the TRR. Water conveyed by the canal is pumped by the Hamilton City main pumping plant into the GCID main canal.

For the Sites Project, the GCID canal improvements 10% design construction cost estimate from June 2021 has been updated to 2024 costs and was documented in the 30% design costs. The design was not advanced to a 30% design level. Improvements to the GCID main canal for the Sites Project will include a 3,000-cfs headworks structure just downstream of the Hamilton City Diversion; several miles of canal bank improvements; and some potential improvements to the fish screen trash rack.

Hamilton City Pumping Plant/Sites Project Diversion Constraint and Loss Assumptions

The GCID canal diversion at Hamilton City is constrained by a maximum instantaneous diversion in the CDFW 2024 ITP Flow Dependent Diversion Criteria, which is represented by a flow dependent diversion table with a maximum value of 2,070 cfs. For operations modeling, the ITP serves as the governing diversion constraint, while the maximum diversion used in the operations model represents the planned diversion required to achieve the target delivery at TRR after accounting for conveyance losses. Under these assumptions, the ITP constraint and the maximum diversion used for operations is 2,070 cfs at the Hamilton City Pumping Plant. This diversion rate is required to achieve a target delivery of 1,800 cfs at TRR, reflecting modeled conveyance losses of 2% from November through March and 13% from April through June. The details described previously herein are summarized in Table 4.

Table 4. Hamilton City Pumping Plant and Sites Diversion Constraint and Operations Loss Assumptions

Metric	GCID Canal (Hamilton City Pumping Plant to TRR)
Diversion Constraint	CDFW 2024 ITP Flow Dependent Diversion Criteria (2,070 cfs)
Maximum Diversion Operations	2,070 cfs at Hamilton City Pumping Plant
Target Delivery	1,800 cfs at TRR
Operations Modeling CalSim 3 - Canal Losses	2% (Nov-Mar); 13% (Apr-Jun)

2.2 Level of Service Assessment

In 2021, Jacobs developed a 1D HEC-RAS model of the GCID main canal from the head gates downstream of the Hamilton City Pumping Plant on the Sacramento River to the Funks Siphon, approximately 41 miles downstream. Water for the Sites Project would be diverted off the main canal at the Terminal Regulating Reservoir (TRR), which would be located approximately 1 mile upstream of the Funks Siphon that conveys the main canal under Funks Creek.

All check structures and siphons upstream of Funks Siphon are included in the hydraulic model. The *Hydraulic Modeling of the Glenn-Colusa Main Canal* TM presented results of model calibration and a steady flow capacity and freeboard analysis within the study area for conditions when 1,800 cfs was being delivered to Sites Reservoir (Jacobs 2021b). Preliminary model studies were conducted to quantify internal canal storage during emergency flow conditions, when power was lost at the TRR and GCID Pumping Plant, resulting in manual override controls and preventing water from being pumped to Sites Reservoir. Multiple scenarios were studied with differences in assumptions related to emergency outflows to adjacent creeks.

Following work documented in the Jacobs (2021b) TM, Jacobs performed an additional analysis focused on emergency flow operations. Refinements were made to the HEC-RAS hydraulic model to simulate

dynamic conditions in the main canal, with improved resolution on flows using estimates from a daily model. Previous flow estimates for diversions at Hamilton City were provided by the CalSim II model, which has a monthly time step.

Work documented in the updated July 17, 2023, TM (Jacobs 2023) included the following:

- Refinements to Emergency Operations model to reflect dynamic conditions, various flow rates, assumptions for gate operations, and various TRR storage volumes
- Use of daily model results for finer resolution description of diversions into the GCID main canal for Sites Reservoir
- Review of historical Willows flows (supervisory control and data acquisition [SCADA] and field surveys) to justify maximum modeled flow of 2,150 cfs
- Review of seasonality of historical GCID use of main canal, and comparison with requested use for Sites water
- Investigation of fish screen operational constraints on predicted diversion at Hamilton City

Results of the 2023 modeling include the following:

- The review of historical flows at Willows Check demonstrated that the 2,150-cfs maximum flow used in the TRR sizing analysis was sufficient. Peak flows from the SCADA system were 1,813 cfs. Comparison of SCADA measurements with field surveys indicated that the SCADA measurements are likely low by approximately 20%.
- Historical usage of the GCID main canal was analyzed to determine the percentage of days (by month) in which the canal was not used to move water for GCID. This measure at canal availability was compared to the percentage of days per month when the Sites Project would move water through the GCID main canal to Sites Reservoir. The analysis demonstrated that there are sufficient days available to move Sites water based on historical use of the canal.
- An updated HEC-RAS model was developed for the emergency operations simulations. Scenarios 1 through 3 looked at summertime and wintertime operations with flows ranging from 1,850 to 2,150 cfs, which include 1,800 cfs for the Sites Reservoir Project (Project); and 50 to 350 cfs assumed as through-flow for GCID deliveries downstream of Funks Check. Model simulations indicate that, for certain assumptions, the TRR can be downsized from 600 ac-ft to 450 ac-ft in volume and still meet freeboard requirements of 1.5 feet.
 - A new Scenario 4 was developed with a flow of 1,800 cfs and wintertime operations; this scenario demonstrates that a reduction in the TRR size from 600 ac-ft to 450 ac-ft is viable with a 1.5-foot freeboard requirement in accordance with GCID. This 1,800-cfs flow scenario reflects conditions when Sites would be moving water and GCID would not, based on review of the historical analysis of GCID main canal flows.

GCID and Sites decided to keep the TRR at 600 ac-ft for the 30% design and construction cost estimate.

Sensitivity tests were conducted with the daily model to investigate the impact of flow constraints related to operations of the fish screens at the Hamilton Intake on diversion to Sites Reservoir. Model results indicate the following:

- An 18,000 ac-ft per year reduction in average annual diversion to Sites if the Hamilton Intake was inactive when the Sacramento River exceeded 20,000 cfs locally

Currently, the fish screen brush arm cleaner cannot be operated in high flood flows exceeding 20,000 cfs in the Sacramento River. This issue will be addressed during final design.

2.3 Additional Canal Capacity Assessment

Under current conditions, the main canal has sufficient capacity to convey the planned Sites Project delivery of approximately 1,800 cfs to the TRR. This delivery rate reflects the maximum Sites Project diversion of 2,070 cfs at Hamilton City under the CalSim 3 Top Speed Scenario, after accounting for conveyance losses. GCID and Sites will be working together in the fall of 2026 to verify that there is adequate capacity near the Railroad Siphon and the Willows Check to convey the 1,800 cfs to the TRR and up to 350 cfs of expected GCID deliveries during the same operational window.

Tables 5, 6, and 7 present the results of the GCID main canal capacity analysis for the Sites diversion period (November 1 through June 30) for 3 recent water years. The water years of 2023, 2024, and 2025 were chosen because they were years in which the best data were available; GCID received its full water allocation and Sacramento River flows were sufficient to allow Sites Project diversions.

The results show that the GCID canal can convey Sites Project diversion flows off the Sacramento River (with the canal bank improvements noted in the 10% design drawings) and deliver them to the TRR (Mile Post 41.3). Canal capacity availability is generally favorable during the winter diversion season but becomes limited in mid-April through June when irrigation demands increase. Additional constraints include maintenance outages that typically occur between early January and late February. Accordingly, daily coordination between GCID and Sites will be needed to verify that GCID demands are met and Sites diversions are maximized. This is especially true during two time periods:

1. In January and February, when there is typically a 6-week shutdown of the canal for maintenance purposes, this is planned to be shortened to 2 to 3 weeks to the extent possible for the Sites Project.
2. In mid-April through June, when GCID rice field flood up is at its peak, and when Sites would have the ability to divert in outlier years when there are floodwaters available in the Sacramento River.

Table 5. GCID Main Canal Capacity Analysis for November 2022 through June 2023 (Water Year Type: Wet Year)

Sites Diversion Operation Window: November 1 through June 30

Month	GCID Flow Statistics	GCID Diversion at SCS (cfs) ^[a]	Available Capacity at SCS (cfs)	GCID Diversion at Willows Check (cfs) ^[a]	Available Capacity at Willows Check (cfs)	Sites CalSim 3 Top Speed Scenario Maximum Diversion (cfs)	Available Capacity for Sites Diversion (%)
<i>Column #</i>	<i>[1]</i>	<i>[2]</i>	<i>[3]</i>	<i>[4]</i>	<i>[5]</i>	<i>[6]</i>	<i>[7]</i>
November 1 to 30	Minimum	25	2,825	51	2,099	850	100
	Midpoint	189	2,662	127	2,024		100
	Maximum	352	2,498	202	1,948		100
December 1 to 15	Minimum	84	2,766	39	2,111	1,450	100
	Midpoint	314	2,536	197	1,954		100
	Maximum	544	2,306	354	1,796		100
December 16 to 31	Minimum	0	2,850	97	2,053	1,450	100
	Midpoint	296	2,554	222	1,928		100
	Maximum	592	2,258	347	1,803		100
January 1 to 7	Minimum	30	2,820	84	2,066	1,600	100
	Midpoint	149	2,701	92	2,059		100
	Maximum	268	2,582	99	2,051		100
January 8 to 31	Minimum	0	2,850	0	2,150	1,150	100
	Midpoint	0	2,850	0	2,150		100
	Maximum	0	2,850	0	2,150		100
February 1 to 22	Minimum	0	2,850	0	2,150	1,200	100
	Midpoint	173	2,678	0	2,150		100
	Maximum	345	2,505	0	2,150		100
February 23 to 28	Minimum	100	2,750	0	2,150	1,800	100
	Midpoint	175	2,675	11	2,140		100
	Maximum	250	2,600	21	2,129		100
March	Minimum	0	2,850	0	2,150	1,600	100
	Midpoint	150	2,700	40	2,110		100
	Maximum	300	2,550	80	2,070		100
April 1 to 15	Minimum	0	2,850	24	2,126	2,070	100
	Midpoint	111	2,739	83	2,067		100
	Maximum	222	2,628	142	2,008		97 (2,008 cfs)

Month	GCID Flow Statistics	GCID Diversion at SCS (cfs) ^[a]	Available Capacity at SCS (cfs)	GCID Diversion at Willows Check (cfs) ^[a]	Available Capacity at Willows Check (cfs)	Sites CalSim 3 Top Speed Scenario Maximum Diversion (cfs)	Available Capacity for Sites Diversion (%)
Column #	[1]	[2]	[3]	[4]	[5]	[6]	[7]
April 16 to 30	Minimum	208	2,642	116	2,034	2,070	98
	Midpoint	946	1,905	512	1,638		79
	Maximum	1,683	1,167	908	1,242		56 (1,167 cfs)
May	Minimum	2,055	795	1,072	1,078	1,100	72
	Midpoint	2,435	416	1,451	699		38
	Maximum	2,814	36	1,830	320		3 (36 cfs)
June	Minimum	2,031	819	1,214	936	480	100
	Midpoint	2,335	516	1,448	703		100
	Maximum	2,638	212	1,681	469		44 (212 cfs)

Column Notes:

[1] Minimum, Midpoint, and Maximum flow are from GCID daily flow data. The midpoint is calculated as the value halfway between the minimum and maximum flows.

[2] SCS operational capacity for Sites analysis: 2,850 cfs.

[2] There are no irrigation deliveries along the main canal between the HCPP and the SCS.

[2] Currently, the main canal is taken out of service annually for maintenance between January 7 and February 22.

[4] Willows Check modeled capacity: 2,150 cfs.

[7] The available capacity shown represents the lower (more limiting) available capacity between the SCS and Willows checks.

[7] Values shown in bold font indicate that the available capacity for Sites diversions is less than 100%.

[7] Values shown in parentheses indicate the available flow capacity (cfs) for the maximum GCID flow during the time period listed.

Notes:

Water Year 2022 was a drought year, and GCID's diversion was limited to 25% of its water right allocation. Therefore, only diversions from November and December 2022, after drought-related restrictions were lifted, were used in the analysis.

Water Years 2023, 2024, and 2025 were years in which GCID received its full water allocation, and Sacramento River flows were sufficient to allow Sites Reservoir diversions.

GCID diversion flows include deliveries to landowners, Reclamation refugee deliveries, and in-basin transfers established prior to Sites Project substantial completion.

^[a]Daily flow data from GCID at the SCS and Willows Check were used for the period November 2022 through June 2023.

HCPP = Hamilton City Pumping Plant

SCS = Stoney Creek Siphon

Table 6. GCID Main Canal Capacity Analysis for November 2023 through June 2024 (Water Year Type: Above Normal Year)

Sites Diversion Operation Window: November 1 through June 30

Month	GCID Flow Statistics	GCID Diversion at SCS (cfs) ^[a]	Available Capacity at SCS (cfs)	GCID Diversion at Willows Check (cfs) ^[a]	Available Capacity at Willows Check (cfs)	Sites CalSim 3 Top Speed Scenario Maximum Diversion (cfs)	Available Capacity for Sites Diversion (%)
<i>Column #</i>	<i>[1]</i>	<i>[2]</i>	<i>[3]</i>	<i>[4]</i>	<i>[5]</i>	<i>[6]</i>	<i>[7]</i>
November 1 to 30	Minimum	1,090	1,760	753	1,397	850	100
	Midpoint	1,274	1,577	840	1,310		100
	Maximum	1,457	1,393	927	1,223		100
December 1 to 15	Minimum	1,002	1,848	547	1,603	1,450	100
	Midpoint	1,124	1,726	674	1,476		100
	Maximum	1,246	1,604	801	1,349		93 (1,349 cfs)
December 16 to 31	Minimum	912	1,938	473	1,677	1,450	100
	Midpoint	1,031	1,819	603	1,547		100
	Maximum	1,150	1,700	733	1,417		98 (1,417 cfs)
January 1 to 7	Minimum	607	2,243	196	1,954	1,600	100
	Midpoint	737	2,113	346	1,805		100
	Maximum	867	1,983	495	1,655		100
January 8 to 31	Minimum	0	2,850	0	2,150	1,150	100
	Midpoint	290	2,561	132	2,018		100
	Maximum	579	2,271	264	1,886		100
February 1 to 22	Minimum	0	2,850	0	2,150	1,200	100
	Midpoint	0	2,850	42	2,108		100
	Maximum	0	2,850	84	2,066		100
February 23 to 28	Minimum	0	2,850	0	2,150	1,800	100
	Midpoint	0	2,850	0	2,150		100
	Maximum	0	2,850	0	2,150		100
March	Minimum	50	2,800	0	2,150	1,600	100
	Midpoint	129	2,722	38	2,112		100
	Maximum	207	2,643	76	2,074		100
April 1 to 15	Minimum	183	2,667	0	2,150	2,070	100
	Midpoint	214	2,636	96	2,055		99
	Maximum	245	2,605	191	1,959		95 (1,959 cfs)

Month	GCID Flow Statistics	GCID Diversion at SCS (cfs) ^[a]	Available Capacity at SCS (cfs)	GCID Diversion at Willows Check (cfs) ^[a]	Available Capacity at Willows Check (cfs)	Sites CalSim 3 Top Speed Scenario Maximum Diversion (cfs)	Available Capacity for Sites Diversion (%)
Column #	[1]	[2]	[3]	[4]	[5]	[6]	[7]
April 16 to 30	Minimum	183	2,667	6	2,144	2,070	100
	Midpoint	801	2,050	310	1,841		89
	Maximum	1,418	1,432	613	1,537		69 (1,432 cfs)
May	Minimum	1,670	1,180	345	1,805	1,100	100
	Midpoint	2,282	568	986	1,165		52
	Maximum	2,894	0	1,626	524		0 (0 cfs)
June	Minimum	2,221	629	1,074	1,076	480	100
	Midpoint	2,559	291	1,327	823		61
	Maximum	2,897	0	1,580	570		0 (0 cfs)

Column Notes:

[1] Minimum, Midpoint, and Maximum flow are from GCID daily flow data. The midpoint is calculated as the value halfway between the minimum and maximum flows.

[2] SCS operational capacity for Sites analysis: 2,850 cfs. Values shown in bold font indicate that the SCS operational capacity was exceeded.

[2] There are no irrigation deliveries along the main canal between the HCPP and the SCS.

[2] Currently, the main canal is taken out of service annually for maintenance between January 7 and February 22.

[4] Willows Check modeled capacity: 2,150 cfs.

[7] The available capacity shown represents the lower (more limiting) available capacity between the SCS and Willows checks.

[7] Values shown in bold font indicate that the available capacity for Sites diversions is less than 100%.

[7] Values shown in parentheses indicate the available flow capacity (cfs) for the maximum GCID flow during the time period listed.

Notes:

Water Years 2023, 2024, and 2025 were years in which GCID received its full water allocation, and Sacramento River flows were sufficient to allow Sites Reservoir diversions.

GCID diversion flows include deliveries to landowners, Reclamation refugee deliveries, and in-basin transfers established prior to Sites Project substantial completion.

^[a]Daily flow data from GCID at the SCS and Willows Check were used for the period November 2023 through June 2024.

Table 7. GCID Main Canal Capacity Analysis for November 2024 through June 2025 (Water Year Type: Above Normal Year)

Sites Diversion Operation Window: November 1 through June 30

Month	GCID Flow Statistics	GCID Diversion at SCS (cfs) ^[a]	Available Capacity at SCS (cfs)	GCID Diversion at Willows Check (cfs) ^[a]	Available Capacity at Willows Check (cfs)	Sites CalSim 3 Top Speed Scenario Maximum Diversion (cfs)	Available Capacity for Sites Diversion (%)
<i>Column #</i>	<i>[1]</i>	<i>[2]</i>	<i>[3]</i>	<i>[4]</i>	<i>[5]</i>	<i>[6]</i>	<i>[7]</i>
November 1 to 30	Minimum	98	2,752	0	2,150	850	100
	Midpoint	887	1,963	450	1,700		100
	Maximum	1,676	1,174	900	1,250		100
December 1 to 15	Minimum	244	2,606	128	2,022	1,450	100
	Midpoint	669	2,182	340	1,810		100
	Maximum	1,093	1,757	552	1,598		100
December 16 to 31	Minimum	57	2,793	55	2,095	1,450	100
	Midpoint	476	2,375	217	1,933		100
	Maximum	894	1,956	379	1,771		100
January 1 to 7	Minimum	576	2,274	109	2,041	1,600	100
	Midpoint	656	2,194	223	1,927		100
	Maximum	736	2,114	337	1,813		100
January 8 to 31	Minimum	0	2,850	0	2,150	1,150	100
	Midpoint	370	2,481	155	1,995		100
	Maximum	739	2,111	310	1,840		100
February 1 to 22	Minimum	0	2,850	0	2,150	1,200	100
	Midpoint	261	2,589	0	2,150		100
	Maximum	522	2,328	0	2,150		100
February 23 to 28	Minimum	0	2,850	0	2,150	1,800	100
	Midpoint	172	2,679	40	2,111		100
	Maximum	343	2,507	79	2,071		100
March	Minimum	98	2,752	0	2,150	1,600	100
	Midpoint	163	2,688	70	2,081		100
	Maximum	227	2,623	139	2,011		100
April 1 to 15	Minimum	142	2,708	52	2,098	2,070	100
	Midpoint	259	2,591	130	2,021		98
	Maximum	376	2,474	207	1,943		94 (1,943 cfs)

Month	GCID Flow Statistics	GCID Diversion at SCS (cfs) ^[a]	Available Capacity at SCS (cfs)	GCID Diversion at Willows Check (cfs) ^[a]	Available Capacity at Willows Check (cfs)	Sites CalSim 3 Top Speed Scenario Maximum Diversion (cfs)	Available Capacity for Sites Diversion (%)
Column #	[1]	[2]	[3]	[4]	[5]	[6]	[7]
April 16 to 30	Minimum	347	2,503	146	2,004	2,070	97
	Midpoint	1,215	1,635	635	1,516		73
	Maximum	2,083	767	1,123	1,027		37 (767 cfs)
May	Minimum	2,088	762	944	1,206	1,100	69
	Midpoint	2,449	402	1,462	689		37
	Maximum	2,809	41	1,979	171		4 (41 cfs)
June	Minimum	1,957	893	1,325	825	480	100
	Midpoint	2,412	438	1,517	634		91
	Maximum	2,867	0	1,708	442		0 (0 cfs)

Column Notes:

[1] Minimum, Midpoint, and Maximum flow are from GCID daily flow data. The midpoint is calculated as the value halfway between the minimum and maximum flows.

[2] SCS operational capacity for Sites analysis: 2,850 cfs. Values shown in bold font indicate that the SCS operational capacity was exceeded.

[2] There are no irrigation deliveries along the main canal between the HCPP and the SCS.

[2] Currently, the Main Canal is taken out of service annually for maintenance between January 7 and February 22.

[4] Willows Check modeled capacity: 2,150 cfs.

[7] The available capacity shown represents the lower (more limiting) available capacity between the SCS and Willows checks.

[7] Values shown in bold font indicate that the available capacity for Sites diversions is less than 100%.

[7] Values shown in parentheses indicate the available flow capacity (cfs) for the maximum GCID flow during the time period listed.

Notes:

Water Years 2023, 2024, and 2025 were years in which GCID received its full water allocation, and Sacramento River flows were sufficient to allow Sites Reservoir diversions.

GCID diversion flows include deliveries to landowners, Reclamation refugee deliveries, and in-basin transfers established prior to Sites Project substantial completion.

^[a]Daily flow data from GCID at the SCS and Willows Check were used for the period November 2024 through June 2025.

2.4 Considerations and Potential Improvements

The GCID main canal Head Gates Structure and improvements to several miles of canal banks to regain freeboard as identified during the modeling completed in 2023 and included in the 10% design and cost estimate. These costs were escalated to \$6.3 million for the 30% design construction costs, as documented in the May 2025 Basis of Estimate Report.

The improvements at the fish screen structure (including the fish screen brush arm cleaner and pumping plant flap gate valves) were captured as a contingency but were not directly identified or estimated in the 30% design construction cost estimate.

3.0 Colusa Basin Drain Facilities

This section contains a description of the CBD, modeling efforts that have been completed, and potential CBD system improvements.

3.1 System Description

The Project intends to release water between April 1 and November 30, depending on the water year type down the TCC, into the Dunnigan Pipeline, and into the CBD to the Sacramento River. The CBD hydraulic modeling evaluates the potential impacts on the ambient WSE and surrounding land with the addition of up to 1,000 cfs of Sites Project water discharging through the Dunnigan Pipeline.

The CBD is a drainage feature that drains approximately 1,036,000 acres and stretches about 75 miles from north to south (U.S. Government Publishing Office 2000). The focus for the Project is the southern portion (approximately 25 miles), which has been defined as the Lower CBD System. This reach extends from the Balsdon Weir to the Knights Landing Outfall Gates (KLOG) structure at the confluence with the Sacramento River, as shown on Figure 4. Figure 4 displays the Lower CBD System Reach hydraulic reaches (further divided into upper, middle, and lower reaches) and infrastructure components that are included in this section.

GCID measures their flow in the CBD at the Davis Weir at River Mile (RM) 31.5, which primarily consists of rice field drainage water during the summer. The Davis Weir spans the CBD and is the closest upstream flow measurement point to the Dunnigan Pipeline outfall (RM 11.6). The Balsdon Weir (RM 25) also spans the CBD and acts as a hydraulic barrier, preventing backwater from extending upstream from the Dunnigan Pipeline outfall.

Flow within the CBD bifurcates downstream of these structures. Water may pass through KLOG and discharge into the Sacramento River, or it may continue along the Knights Landing Ridge Cut (KLRC) ultimately reaching the Wallace Weir and discharging into the Yolo Bypass. The CBD and KLRC are hydraulically connected, with no physical control structure separating the two channels.

Operational conditions of the CBD vary seasonally. During the irrigation season (summer months), the KLOG and Wallace Weir maintain elevated WSEs, creating a managed pool that allows agricultural diversions by local water districts. In contrast, during winter flood events, the system conveys high flows either through KLOG to the Sacramento River or through the KLRC to the Yolo Bypass, depending on hydraulic conditions. Flap gates located on the downstream side of the KLOG structure prevent elevated stages in the Sacramento River from propagating upstream into the CBD. These flap gates close during periods of high river stage, restricting discharge through KLOG and effectively routing CBD flows downstream through the KLRC and Wallace Weir into the Yolo Bypass.

The KLOG structure is a California Department of Water (DWR) facility and was built in the early 1900s as a flood control structure to prevent high Sacramento River flows from backing up into the CBD and inundating agricultural land. In addition, it was built to hold a relatively constant WSE in the CBD during the irrigation season according to the Hershey Agreement.¹

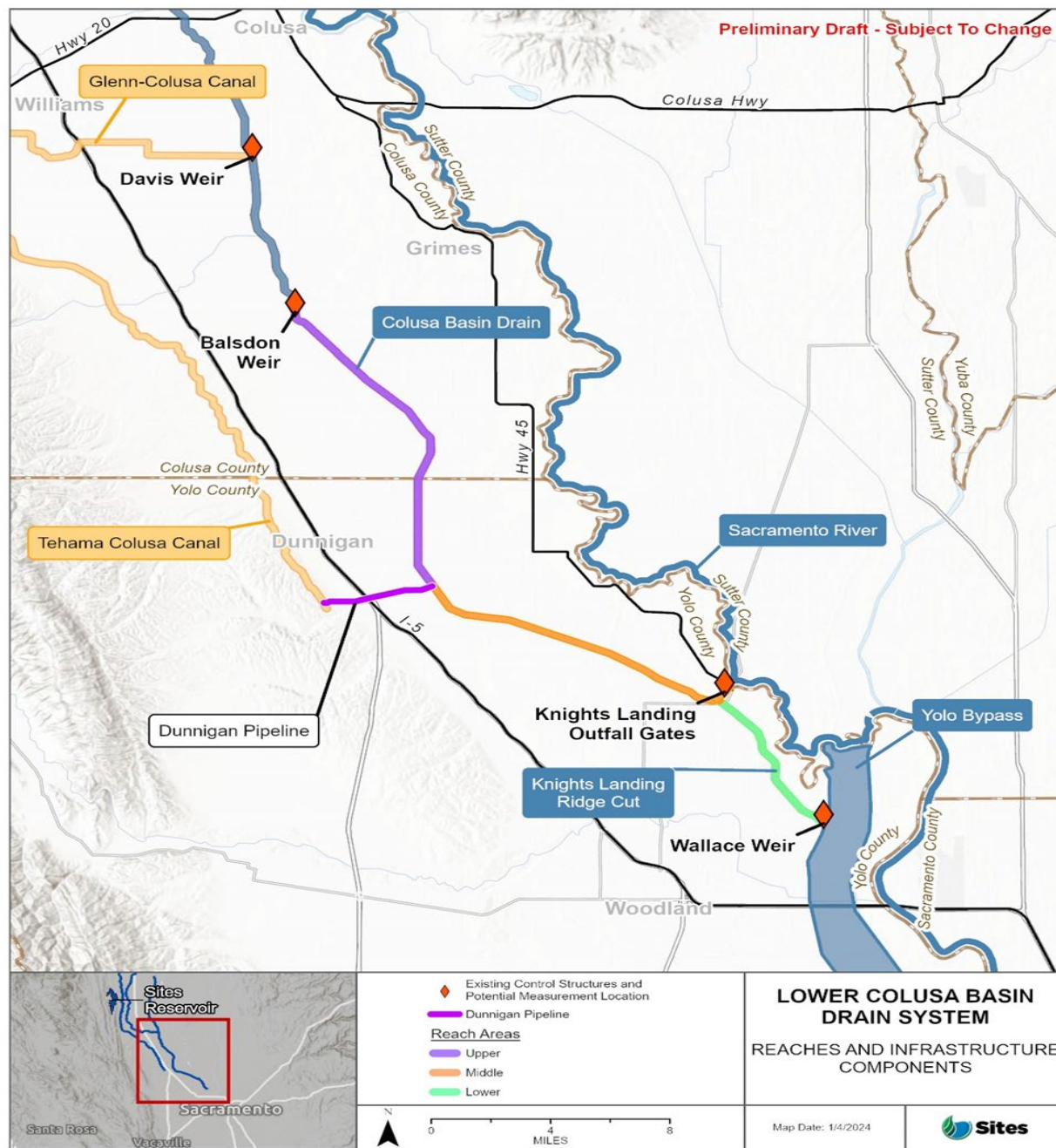


Figure 4. Lower Colusa Basin Drain System Reach Hydraulic Reaches and Infrastructure Components

¹ *Hershey Family v. Sacramento San Joaquin Drainage District*. Option and Agreement Deed No. 907. July 17, 1937.

3.2 Level of Service Assessment

A 1D steady-state hydraulic analysis of the CBD was conducted using HEC-RAS to evaluate the CBD conveyance capacity and potential impacts with the addition of up to 1,000 cfs of Sites Project water.

The hydraulic modeling and coordination completed in 2023 and 2024 revealed a need for improvement to the existing model and to understand the current operation and seasonality of the Lower CBD System. Efforts to improve hydraulic models of the CBD in 2025 and early 2026 focused on refining the model to a 1D/two-dimensional (2D) hybrid model to resolve issues revealed by previous analyses, including the following:

- Refinement of bank elevations that control inundation of habitat areas and agricultural fields
- Understanding of inflows and the influence of seasonal water user demands on channel flows and, thus, Project impacts

The revised model provides improved estimates of inundation of habitat lands and agricultural fields under both existing and Project conditions. The 1D/2D model was used to estimate bank improvements required to eliminate inundation of any agricultural lands west of the CBD for full Project flow releases and ambient flows up to 1,870 cfs.

The results shown in Table 8 were conducted for the 2016 flow conditions and modeled between June 1 and November 30 during these flow conditions. Year 2016 was a Below Normal water year and was selected because it is the most recent year with available DWR-provided KLOG flow data for review against the model results. It had high ambient flows in the CBD, during a 2-week period at the end of August (1,870 cfs) and a 1-week period at the end of November (1,800 cfs). The 2-week period at the end of August corresponds to the release of rice field water at GCID, and the 1-week period at the end of November was a rainstorm.

Table 8. Inundated Area by Land Type and Model Run

Land Type	Run 1: Ambient Flow (acres)	Run 2: Ambient Flow + 1,000 cfs Project Flows (acres)
Agricultural	507	1,292
Habitat	319	2,204

Following discussions with local stakeholders in March 2026, the approach of implementing bank improvements was discontinued. Instead, the current focus is on establishing flowage agreements for the areas identified herein as potentially subject to inundation. Localized bank improvements were determined to pose potential operations and maintenance challenges and could restrict water access to adjacent properties. Additionally, constructing new berms within designated floodways introduces increased flood risk due to the placement of fill in these areas.

Figure 5 presents longitudinal profiles of the western bank elevations along the CBD along with predicted maximum WSEs along the drain for a high flow rice water release scenario from the peak day of August 29, 2016. Water elevation profiles are shown for existing (ambient) conditions and Project conditions, which include a constant release of 1,000 cfs from the Dunnigan Pipeline. The impact of the Project is shown in the dashed green line read on the right-hand vertical axis, showing a maximum increase of 1.8 feet because of Project releases. When the water level exceeds the local bank elevation,

inundation outside of the main drain channel will occur. This inundation affects both habitat areas and agricultural fields, as discussed previously. It should be noted that low points in the western bank elevation profile (black line) will be verified through additional survey efforts scheduled for 2027.

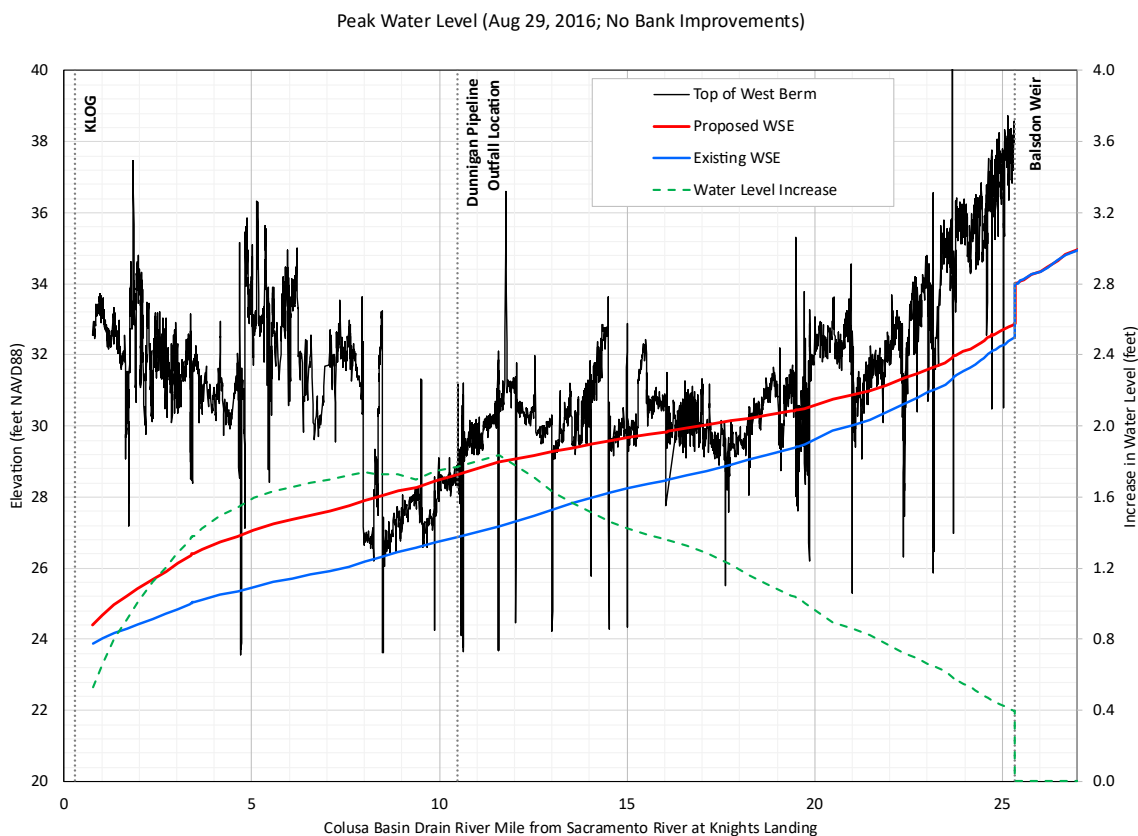


Figure 5. Longitudinal Profiles of Water Levels, Bank Elevations, and Water Level Increase with Project Water and no Bank Improvements

Coordinating the use of the Dunnigan Pipeline to convey Sites Reservoir releases will be necessary to avoid potential inundation of agricultural fields during high ambient flows whether from rice water drainage or late spring and early fall storm events. Sites could plan to hold releases during the annual rice water release event, which generally occurs for up to 2 weeks sometime between mid-August and mid-September every year.

The flow rate associated with west bank overflow has not been verified; however, 1,500 cfs is considered a conservative planning-level threshold based on preliminary modeling results and historical information. Previous Jacobs analyses estimated a channel capacity of approximately 1,750 cfs near RM 8.9, corresponding to a WSE of 26.5 feet at a localized low point along the west bank where agricultural field inundation may occur. Additional survey data and hydraulic model refinement are planned to improve confidence in channel capacity estimates and overflow thresholds within the Project reach.

3.3 Flow Split Between Colusa Basin Drain and Knights Landing Ridge Cut

The flow split between CBD and KLRC was analyzed to quantify potential losses of Project water down the KLRC. Existing operations of the Wallace Weir are coordinated with KLOG operations to maintain required water levels. During high runoff events in the CBD, water reaching the junction of the CBD and KLRC can flow either east out of the KLOG into the Sacramento River or south into the KLRC that flows into the Yolo Bypass, depending on local gradients.

Initial simulations with the 1D/2D model indicate some loss of Project water down the KLRC under current operations of the KLOG and Wallace Weir. At the junction of the CBD and the KLRC, the channel invert elevations are approximately 11.1 feet in the CBD and 16.9 feet in the KLRC. Downstream of this junction and just upstream of Wallace Weir, the channel invert elevation is approximately 14.1 feet. Therefore, once water enters the KLRC from the CBD, it follows a positive drainage gradient toward the Wallace Weir structure.

The Sites Project water loss occurs because of how the Wallace Weir operations are included in the model to match those prescribed at KLOG. If the gates at Wallace Weir are not closed, then Sites Project water can be lost down the KLRC. With the Wallace Weir closed, any flow down the KLRC will just temporarily fill channel storage because KLRC is a dead-end canal without flow leaving through Wallace Weir. This assumes that seepage losses are negligible in terms of Sites Project flows.

Model simulations were conducted with the Wallace Weir gates closed during Project releases to demonstrate that there is no loss down the KLRC. Absent coordination between operations of Wallace Weir and Sites Reservoir, there could be minor losses of Project water down the KLRC depending on other variables like ambient flow in the CBD and stage at the junction. Modeling indicates the setpoint of the KLOG operations does influence flows at the junction.

3.4 Flow Measurement in the Lower Colusa Basin Drain

In accordance with agreements that the Sites Authority is working on with DWR and Reclamation, releases through the Dunnigan Pipeline are required to be measured before entering the Lower CBD and as conveyed through KLOG. The Sites Authority will be credited for the lesser of Sites releases measured in the Dunnigan Pipeline (accounting for travel time), or the amount of flow measured through KLOG. Measurement of the flows into the Lower CBD (discharge of the Dunnigan Pipeline) will be via magnetic flowmeters in the Dunnigan Pipeline outfall structure. Measurement of flow being released into the Sacramento River from the Lower CBD will be taken at the KLOG. Differences between these two measurements are not included in the operations model, because these differences will be measured and credited based on real-time data. Table 9 outlines the potential causes of measurement differentials.

Table 9. Measurement Differential Sources in Lower Colusa Basin Drain

Measurement Differential Sources	Considerations
Evapotranspiration of vegetation within the CBD	• This varies seasonally and annually, with higher rates expected in dry years due to increased plant, soil, and atmospheric demand. • Losses are difficult to quantify and will require multi-year monitoring and analysis to better define.
Measurement limitations	• Existing locations of flow and stage measurement are limited on the Lower CBD. • The extensive number of required flow measurements of Lower CBD inflows and outflows make accurate measurements in the Lower CBD extremely difficult. Measurements would need to account for inflow creeks, flows over Balsdon Weir, seepage, evapotranspiration rates, water diversions and drain back flows, and others. • Measurement inaccuracies compound as the number of measurements increases. • It can take time to identify measurement locations, install measurement devices, and calibrate those devices under varying flow conditions. • Sites is looking at adding additional stage and flow monitoring gages in CBD. • Note that measured flows through KLOG may include a component of ambient water in addition to Project water that might offset potential measurement differentials listed in this table.
Unauthorized take	• Agriculture land is predominantly rice along the Lower CBD. Demands are usually low during most periods of the transfer window (April 1 through November 30). • Habitat land (Duck Clubs) diversion starts in late September/early October, typically a few weeks before duck season (third weekend in October) and continues through the end of January. This overlaps with a portion of the Project transfer window. • Unauthorized take without a water right is an unknown and complicated to determine with the number of water right holders along the CBD and the variety of rights claimed.
Seepage and losses in CBD and KLRC	• When operated at higher flows, the existing intermittent west berm and areas along the KLRC are reported by landowners/farmers to seep onto adjacent lands in some areas. The extent of this seepage is unknown but may not be substantial due to the more clay-rich soils in some areas. • Better defining seepage will take at least 5 years. The process will require obtaining land access, installing piezometers, and then gathering and analyzing data. • Due to the invert elevations at the CBD-KLRC junction, some Project water may enter the KLRC, with the magnitude of potential losses dependent on hydraulic conditions and Wallace Weir operations.

Table 9. Measurement Differential Sources in Lower Colusa Basin Drain

Measurement Differential Sources	Considerations
Overflow onto adjacent lands	• Operations of the Lower CBD with Site's flows are anticipated to be limited to flow rates that will stay within the Lower CBD channel. • The flow rate when west bank overflows occur has not been verified, but a conservative estimate is 1,500 cfs based initial modeling results (noting that this is based on a partially calibrated model). • Additional modeling and model verification is needed to focus on a Lower CBD maximum-flow rate without inundation and to determine the base line flows in the Lower CBD during the transfer window.
Startup filling of Lower CBD	• The volume required to fill the Lower CBD from dry conditions to initial discharge at KLOG is estimated at 2,620 ac-ft (assuming a KLOG setpoint of 23.73 feet NAVD88). At a Dunnigan Pipeline flow of 1,000 cfs, this volume would fill in approximately 1.3 days.

3.5 Conclusion

The evaluation of the Lower CBD indicates that the system can be utilized to convey up to 1,000 cfs of Sites Project release flows to the Sacramento River; however, its use is subject primarily to operational constraints associated with ambient flows and agricultural field inundation risk. Current hydraulic modeling indicates that Sites Project flows can increase WSEs by up to approximately 1.8 feet under certain conditions, resulting in potential inundation of adjacent agricultural and habitat lands during elevated ambient flow periods.

Based on these findings, the Sites Project has shifted away from structural mitigation measures, such as continuous west bank berm improvements, due to concerns related to constructability, long-term maintenance, potential impacts to land access, and increased flood risk within designated floodways. Instead, the current approach focuses on a combination of the following:

- Operational controls, including timing and ramping of releases to avoid high ambient flow periods
- Coordination with existing system operators (such as DWR and GCID)
- Development of flowage easements to allow flow within the channel banks

Operational limitations are a key consideration for use of the CBD. Sites Project releases will need to be managed to avoid periods when ambient flows approach or exceed approximately 1,500 cfs, such as during peak rice drainage events in late summer and during storm-driven flow events in the spring and fall. Historical data indicate that such conditions occur periodically and may limit the number of days available for conveyance of Sites Project flows in certain years. The flow level at which western bank inundation may occur has not been verified; therefore, 1,500 cfs is used as a conservative planning-level estimate pending additional model refinement and survey data collection.

Additional uncertainties remain that are related to the following:

- Flow measurement accuracy and water volume accounting between the Dunnigan Pipeline and KLOG
- Potential seepage, evapotranspiration, and unauthorized diversions
- Flow split behavior between the CBD and KLRC under varying operational conditions

To address these uncertainties, the Sites Project will require implementation of the following:

- Enhanced monitoring infrastructure
- Continued model refinement and calibration
- Development of clear operational criteria defining when releases can occur without causing unacceptable impacts

Overall, the CBD provides a viable and cost-effective conveyance pathway for Sites Project releases, but its use will depend on real-time conditions, interagency coordination, and implementation of operational measures to manage risk and uncertainty. A detailed summary of the CBD modeling work conducted to date is provided in Appendix 3.

4.0 Dunnigan Pipeline

The following subsections describe the 30% design of the Dunnigan Pipeline from the TCC to the CBD; the proposed extension of the pipeline from the CBD to the Sacramento River (Alternative 2); and a level of service and cost comparison between these two options.

4.1 System Description, Tehama-Colusa Canal to Colusa Basin Drain

The 30% design for the Dunnigan Pipeline consists of a 10.5-foot-diameter gravity-flow pipeline from the TCC to the CBD with a design capacity of 1,000 cfs (flow velocity is approximately 11.5 feet per second [fps]) and maximum conveyance capacity of 1,300 cfs (flow velocity is approximately 15.0 fps). Figure 6 shows the hydraulic grade line (hydraulic head available) at the CBD as a function of flow for pipe diameters ranging from 10.5 feet to 12 feet. The headwater elevation at the TCC is 175.0, while the tailwater elevation at the CBD is 28.5 (wet water year maximum), as shown in the 30% design hydraulic profile.

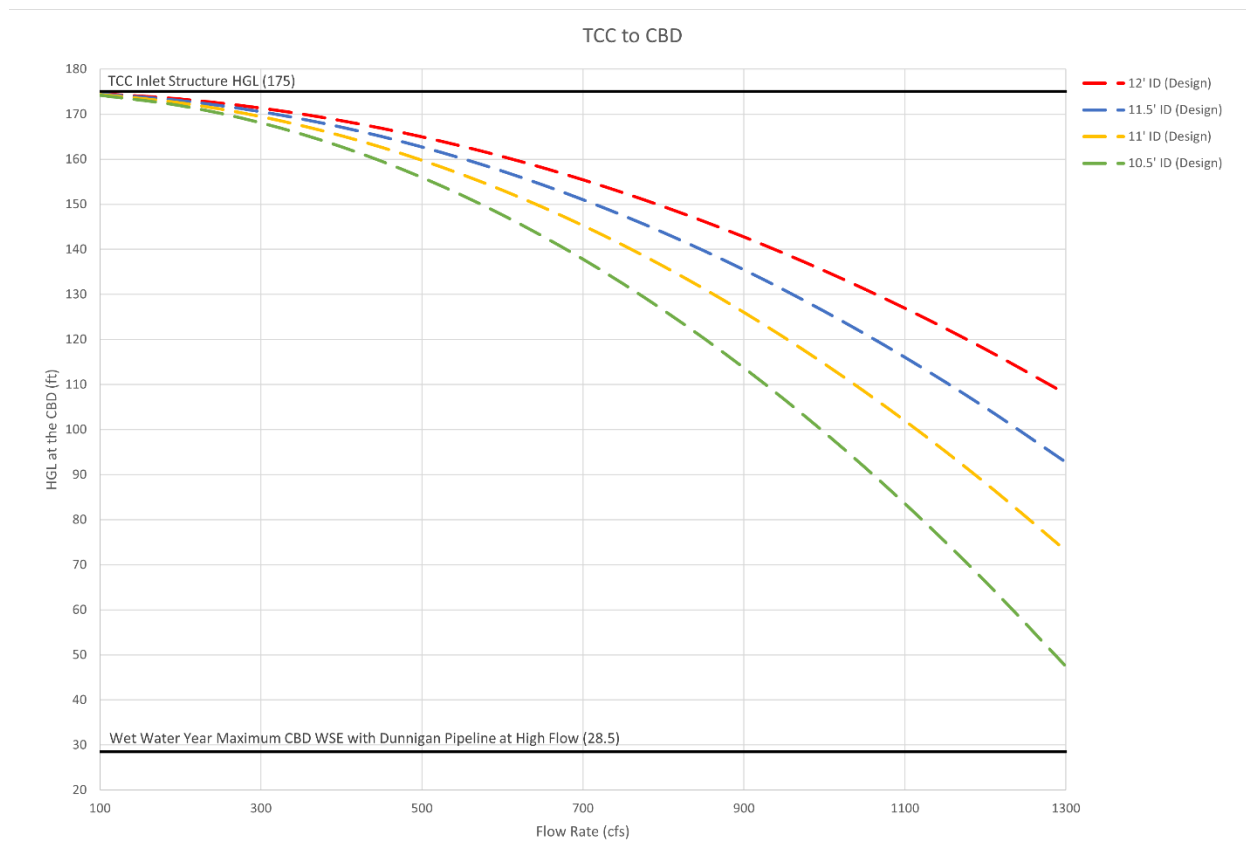


Figure 6. Hydraulic Grade Line at Colusa Basin Drain Discharge Structure – TCC to CBD

The design includes a stub-out (tee, pipe, and blind flange), located upstream of the CBD Discharge Structure, to accommodate a potential future extension of the pipeline to the Sacramento River. The pipeline, consisting of a 10.5-foot-diameter segment from the TCC to the CBD and a 12-foot-diameter segment from the CBD to the Sacramento River (potential future extension), can convey up to 1,000 cfs from the TCC to the Sacramento River.

The 30% design construction cost estimate for the Dunnigan Pipeline has been developed to reflect pipeline installation, associated appurtenances, and tunneling activities necessary to support the planned conveyance system. Based on current design assumptions and available engineering data, the estimated construction cost for the Dunnigan Pipeline from the TCC to the CBD is approximately \$215 million.

This estimate represents preliminary engineering-level accuracy and will continue to be refined as design progresses; Project requirements are validated; and additional geotechnical, environmental, and constructability information becomes available.

Refer to the 30% Design Basis of Design Report and Drawings dated February 2025 (Jacobs 2024a, b) for additional information.

4.2 System Description, Extension to Sacramento River – Alternative 2

The Dunnigan Pipeline extension to the Sacramento River would connect to the stub-out located upstream of the CBD Discharge Structure, then continue east beneath the CBD via tunnel construction.

It will traverse rice fields; cross Highway 45 and the adjacent levee via traditional open-cut construction; and ultimately discharge into the river through the proposed Sacramento River Discharge Structure. The length of the extension from the CBD to the Sacramento River is approximately 5.7 miles.

Figure 7 shows that a 12-foot-diameter pipeline from the CBD to the Sacramento River is the smallest pipe size capable of achieving a hydraulic grade line elevation greater than 51.6 feet at the manifold sump under design conditions. This means that it is the smallest pipe size capable of conveying 1,000 cfs from the CBD to the Sacramento River when a 10.5-foot-diameter pipe is used from the TCC to the CBD. The hydraulic grade line at the manifold sump is preliminary and is based on the headwater elevation required to convey the design flow through the proposed discharge pipes extending through the levee crown, as described in Section 7.2 of the TM titled *Hydraulic Design for the Dunnigan Pipeline and Colusa Basin Drain Discharge Structure* (Jacobs 2024c).

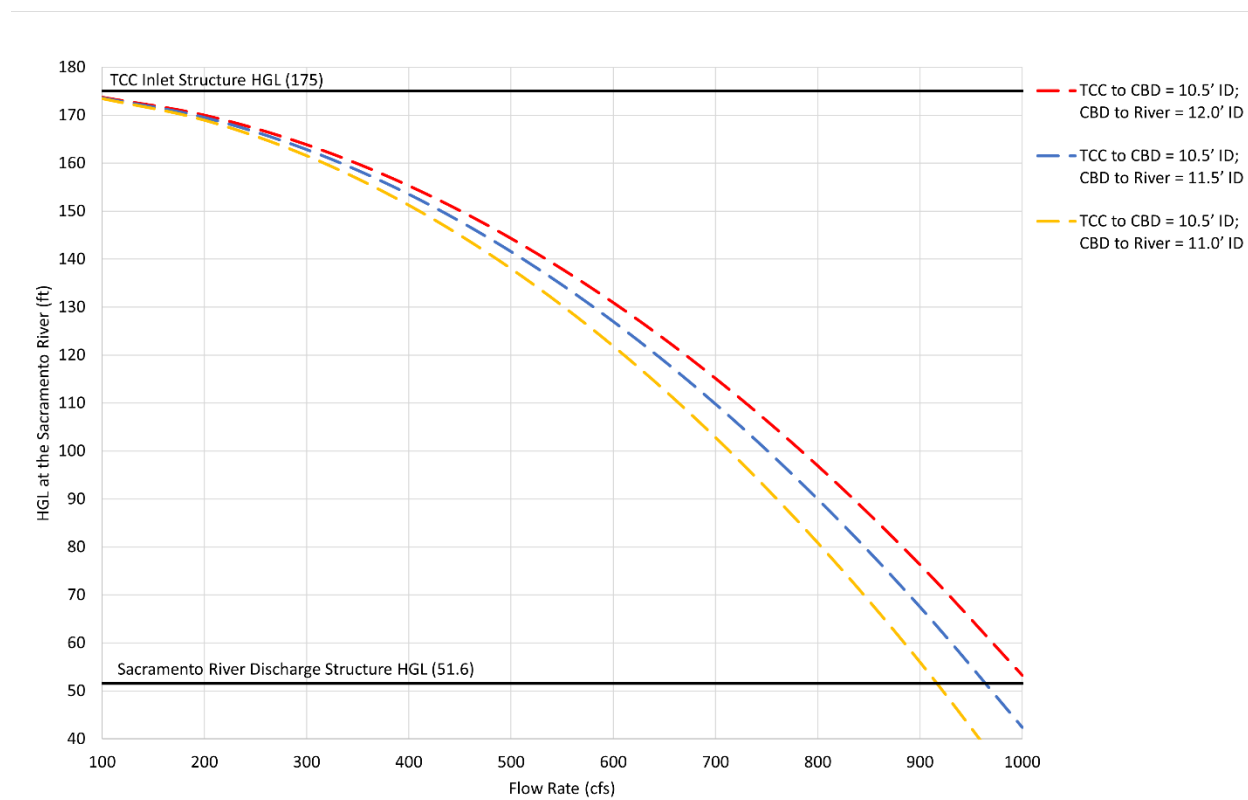


Figure 7. Hydraulic Grade Line at Sacramento River Discharge Structure Manifold Sump – Multiple Diameters from Tehama-Colusa Canal to Sacramento River

The engineer's opinion of probable construction costs for the extension is based in part on the HC Conveyance Facilities Feasibility Design Basis of Estimate (10% design) (Jacobs 2021a), supplemented with 2025 HC Conveyance Facilities unit costs that are indexed to March 2024 labor and construction costs. Based on current design assumptions and available engineering data, the estimated construction cost for the extension is approximately \$315 million. This is documented in Appendix 4.

This estimate represents preliminary engineering-level accuracy and will continue to be refined as design progresses; Project requirements are validated; and additional geotechnical, environmental, and constructability information becomes available.

4.3 Alternative Comparison – Level of Service Assessment

Table 10 provides a comparison of the Dunnigan Pipeline in two segments. To convey water to the CBD would be \$215 million, and to convey water to the Sacramento River would be an additional \$315 million, resulting in a total of \$530 million.

Table 10. Alternative Comparison

Description	30% Design (TCC to CBD)	10% Design (CBD to Sacramento River) - Alternative 2
Length of Pipeline Segment	3.8 miles	5.7 miles
Pipe Inside Diameter	10.5 feet (126 inches)	12.0 feet (144 inches)
Design Flow	1,000 cfs	1,000 cfs
Minimum Flow	100 cfs	100 cfs
Maximum Flow	1,300 cfs	1,000 cfs
Reason for Pipe Size	This must accommodate a potential future extension of pipeline to the Sacramento River. Minimize pipe size to reduce construction costs and optimize flow velocity at minimum flow. Dissipation of excess hydraulic head through pipeline friction decreases the required energy dissipation at the outlet structure.	Must achieve a hydraulic grade line greater than 51.6 feet at the Sacramento River Discharge Structure
Special Crossings ^[a]	I-5, Hwy 99, CFNR tracks	CBD, Hwy 45, USACE Jurisdictional Levees
Environmental Impacts	Analyzed in the Final EIR/EIS	Analyzed in the Final EIR/EIS
Permitting	USACE, CVFPB, Caltrans, CFNR	USACE, CVFPB, USFWS, NMFS, CDFW, Caltrans
Real Estate Impacts	PE: Approximately 37 acres TCE: Approximately 100 acres	PE: Approximately 53 acres TCE: Approximately 144 acres
Construction Cost	\$215 million	\$315 million

^[a] All special crossings are assumed to be constructed via tunneling methods except at Highway 45, which is assumed to be installed via a traditional open-cut.

Caltrans = California Department of Transportation

CFNR = California Northern Railroad

CVFPB = Central Valley Flood Protection Board

EIR = environmental impact report

EIS = environmental impact statement

Hwy = highway

NMFS = National Marine Fisheries Service

PE = permanent easement

TCE = temporary construction easement

USFWS = United States Fish and Wildlife Service

4.4 Comparison of Using the Colusa Basin Drain versus Dunnigan Alternative 2 to Convey Water to the Sacramento River

Use of the CBD to convey water to the Sacramento River is described as follows:

- **Level of Services Assessment:** Use of the Lower CBD for conveyance is assumed to incur certain fixed, itemized costs associated with improvements to KLOG, Wallace Weir, and other system infrastructure within the drain, as well as flowage agreements, totaling approximately \$6.4 million. In addition, due to the uncertainties associated with the CBD Facilities, annual costs are assumed for operations and maintenance, estimated water losses, additional losses in critically dry years, and missed opportunity costs. Based on an average annual Project flow of 138,000 ac-ft, the total conveyance cost is estimated at \$33 per ac-ft, which is recommended to carry in the Plan of Finance.
- **Operational Parameters:** Additional flow and stage monitoring, along with updated channel cross sections, are needed to calibrate and refine the hydraulic model and confirm its results. Completion of this effort is necessary before establishing operational parameters.

Use of the Dunnigan Pipeline (Alternative 2) to convey water directly to the Sacramento River is described as follows:

- **Level of Services Assessment:** Extending the Dunnigan Pipeline to the Sacramento River (10% design) would require increasing the pipe diameter at the CBD to 12 feet to maintain a design flow of 1,000 cfs, with an estimated construction cost of approximately \$315 million. Total construction costs for the Dunnigan Pipeline would be approximately \$530 million, consisting of \$215 million from TCC to the CBD and \$315 million from the CBD to the Sacramento River.
- **Planning and Permitting:** An additional 2 years would be required for planning and permitting. This would include revising California Environmental Quality Act (CEQA)/National Environmental Policy Act (NEPA) documents due to the Sites Project Authority Board's selection of Alternative 1 (30% Design), as well as adding coordination with Reclamation and USACE. This alternative would also introduce salmonid-related permitting requirements involving USFWS, NMFS, and CDFW.
- **Mitigation Requirements:** Additional mitigation costs are estimated at approximately 12% of the \$315 million construction costs, or about \$38 million.
- **Water Losses:** No water losses to the CBD would occur under this alternative, and the operational limitations during the CBD transfer window described herein would be eliminated.
- The following tentative design/permitting/construction schedule in Table 11 allows for a decision point in June 2029 on staying with the CBD or extending the pipeline to the Sacramento River.

Table 11. Sites Project Tentative Schedule

Schedule	Start	End
Lower CBD Flow/Stage Monitoring, Model Calibration, Definition of Operational Parameters	April 2027	August 2029
Decision Point for Extending Pipeline to River	June 2029	September 2029
Land Access from CBD to Sacramento River	April 2027	April 2028
Geotechnical Investigations	April 2028	April 2029
Pipeline to River Design	April 2027	February 2030
Pipeline to River EIR/EIS & CEQA/NEPA Updates	December 2027	December 2028
Sacramento River 408 Permit	May 2029	September 2031
401, 404, Biological Opinion, CDFW LSAA, State Lands Commission and ITP Amendments	August 2027	November 2031
Bidding and Award	November 2031	March 2032
Construction	August 2031	November 2034

5.0 References

Jacobs. 2021a. *Sites Reservoir Project HC Conveyance Facilities – Feasibility Design Basis of Estimate*. June 2.

Jacobs. 2021b. *Technical Memorandum: Hydraulic Modeling of the Glen Colusa Main Canal*. Draft Final. December 22.

Jacobs. 2023. *Technical Memorandum: Hydraulics and Emergency Operations in the GCID Main Canal for the Sites Reservoir Project*. July 17.

Jacobs. 2024a. *30 Percent Design – Draft Basis of Design Report – HC Conveyance Facilities Sites Reservoir Project*. February 5.

Jacobs. 2024b. *Sites Reservoir Dunnigan Pipeline Project Pipeline and Facilities 30% Design – Client Review*. February 5.

Jacobs. 2024c. *Technical Memorandum: Hydraulic Design for the Dunnigan Pipeline and Colusa Basin Drain Discharge Structure*. February 5.

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Appendix 1
Tehama-Colusa Canal
HEC-RAS Hydraulic Modeling TM

Tehama – Colusa Canal HEC-RAS Hydraulic Modeling Technical Memorandum



To:	Sites Project Joint Powers Authority
CC:	Rob Natoli, P.E./Sites
Date:	June 12, 2026
From:	Kumar Aman/ Jacobs and Kyle Winslow PhD, P.E./Jacobs
Quality Review:	Peter Rude, P.E./Jacobs
Authority Agent Review:	Reviewer
Subject:	Tehama – Colusa Canal HEC-RAS Hydraulic Modeling

Executive Summary

This memorandum presents the results of a one-dimensional (1D) steady-state hydraulic analysis of the Tehama-Colusa Canal (TCC) conducted using U.S. Army Corps of Engineer’s Hydrologic Engineering Center’s River Analysis System (HEC-RAS) to evaluate canal conveyance capacity and available freeboard under both as-built and subsided conditions. The analysis was conducted in support of planning and design efforts for the proposed Sites Reservoir and associated increases in diversion flows through the TCC for the Sites Project. The TCC is a concrete-lined conveyance canal, approximately 110.8 miles long, that provides water to 150,000 acres of irrigated agriculture. This memorandum also provides a technical reference for identifying subsidence-affected portions of canal corridor and for estimating embankment height modifications necessary to restore available freeboard to regain the original designed canal conveyance capacity.

An existing 1D hydraulic model of the TCC developed by Walton et al. (2004) served as the foundation for this effort. The legacy model represented the canal from Check 1 to Check 16, just upstream of Funks Reservoir. As part of the current study, the model domain was extended to include the full canal length to its terminal end at Check 26. The Walton et al. (2004) model provided key cross-sectional and structural details for canal Reaches 1 to 5. Jacobs incorporated the geometry developed by Walton et al., added canal details for Reaches 6 to 8, and created an updated, full-length HEC-RAS model.

The TCC was originally designed by the U.S. Bureau of Reclamation in the 1960s with a nominal capacity of approximately 2,300 cubic feet per second (cfs) at the upstream end and decreased to a capacity of 1,700 cfs at its terminus (Reclamation 1994). However, observed land subsidence near Orland has led to a gradual loss of available freeboard along the upstream portions of the canal, which has in turn reduced the canal’s effective capacity use over time. To assess these effects, two modeling scenarios were evaluated:

1. A baseline (as-built, non-subsided) geometry
2. A subsided geometry incorporating survey-based subsidence adjustments

Survey data collected by R.E.Y. Engineers, Inc. in December 2025 were used to quantify land subsidence and modify the canal geometry accordingly over a portion of the canal between Checks 10 and 12 (R.E.Y. 2026). Subsidence adjustments were applied using a linear interpolation technique between surveyed control points and were smoothly tapered beyond the surveyed limits to avoid abrupt changes in canal invert elevations.

Both scenarios were simulated using identical modeling assumptions, including the following:

- Steady-state
- Subcritical flow conditions
- Consistent boundary conditions
- Uniform Manning's roughness coefficients
- Fully open gate settings at all inline check structures
- A fixed storage area water surface elevation (WSE) representing the upper end of the operating range in Funks Reservoir

Model results were used to compare WSEs and calculate freeboard to the top of the concrete lining.

Multiple flow profiles were analyzed by varying inflow discharges between 2,100 cfs and 2,500 cfs upstream of Funks Reservoir and between 1,000 cfs and 1,900 cfs downstream of Funks Reservoir. Analysis was conducted to evaluate maximum conveyance achievable under each scenario, subject to available freeboard constraints.

The model results for as-built conditions (Baseline simulation) show at least 2 feet of freeboard for flows up to 2,400 cfs from Check 1 to Funks Reservoir. For the Sites Project, flows from Check 1 to Funks Reservoir are expected to occur in the winter/spring between November 1 and June 30. During this period, Sites Reservoir flows are expected to be a maximum of 2,100 cfs with Tehama-Colusa Canal Authority (TCCA); winter flows are expected to be 100 to 200 cfs for groundwater recharge and frost water (November 1 to April 30); and agricultural flows are expected to be 0 to 1,000 cfs (April 1 to December 15) for a total maximum combined flow of 2,400 cfs. Where theoretical flows are greater than 2,400 cfs (which may occur in April/May/June), Sites flows would have to be reduced, as TCCA flows have priority over Sites Reservoir flows.

The model results for as-built conditions (Baseline simulation) show 1.5 to 3.5 feet of freeboard to the top of the concrete liner at flows up to 1,900 cfs downstream of Funks Reservoir. For the Sites Project, flows downstream of Funks Reservoir are expected to occur between April 1 and November 31. During this period, Sites Reservoir flows are expected to be a maximum of 1,000 cfs (with potential short periods of up to 1,300 cfs), and TCCA agricultural flows are expected to be a maximum of 600 cfs, for a total combined flow of 1,600 cfs to 1,900 cfs.

The decrease in capacity with recently observed subsidence just south of Orland was quantified, and model results show limited freeboard of about 6 inches near Check 11 at flows of 2,100 cfs. Under as-built conditions (Baseline simulation), the canal could pass 2,400 cfs at this location with 2 feet of freeboard to the top of the concrete lining. Project team members and TCCA staff have observed water levels at the top of the concrete liner near Check 11 at flows of 1,450 cfs. This observation is seemingly

at odds with model predictions, but the observations were made when gates were at the controlling stage, not at a full capacity condition when gates were all opened to maximize flow.

Model results from the subsided conditions were used to support cost estimates for necessary canal lining and bank mitigation efforts to restore design freeboard and counter recent subsidence. Jacobs provided the cost estimate for this mitigation in the Conveyance Capacity Technical Memorandum.

Based on this analysis, the TCC should have the capacity to accommodate Sites Project flows in coordination with TCCA operations. This is further discussed in the Conveyance Capacity Technical Memorandum.

1.0 Background

The Tehama-Colusa Canal (TCC) is a major water conveyance facility that diverts water from the Sacramento River near Red Bluff, California, and delivers water to multiple irrigation districts within the Tehama-Colusa Canal Authority (TCCA) (Figure 1). The canal was originally designed and constructed by U.S. Bureau of Reclamation (Reclamation) in the 1960s, with a nominal design capacity of approximately 2,300 cubic feet per second (cfs). Actual design canal capacity as provided by Reclamation varies from 2,530 cfs at the head of the canal to 1,700 cfs at the end of the canal. Since its construction, the canal has served as a critical component of regional agricultural water supply infrastructure.

The Sites Project Joint Powers Authority is currently developing the off-stream storage reservoir, known as the Sites Reservoir, located approximately 10 miles west of Maxwell, California, near the community of Sites. The proposed reservoir would be filled primarily through diversions from the Sacramento River during winter flooding events, thereby requiring evaluation of the ability of existing conveyance infrastructure, including the TCC, to accommodate the winter flows within the limits of the designed free-board requirements.

A one-dimensional (1D) hydraulic model of the TCC was previously developed by Walton et al. (2004) but represented the canal only up to a location upstream of Funks Reservoir and did not include the full downstream extent of the canal. This legacy model provided valuable geometric and structural information for the first five reaches of the canal upstream of Funks Reservoir, including cross-sectional details and representations of inline and check structures.

As part of the current effort, the legacy hydraulic model was expanded to include the full length of the canal to its terminal end at Check 26. The legacy model geometry and structure data were incorporated where applicable, and a new extended geometry was developed using as-built plans of the canal to complete the downstream reaches. The expanded model was then used to perform a comprehensive evaluation of canal capacity and associated freeboard for as-built conditions

Given the age of the canal and the observations of land subsidence near Orland, additional model simulations were required to quantify the effects of subsidence on hydraulic performance. December 2025 survey data were used to develop a subsided canal geometry, allowing for direct comparison between as-built (non-subsided) and subsided conditions. The resulting analyses provide a technical basis for assessing the canal's current conveyance limitations and identifying potential mitigation measures, including raising the existing embankment height, to restore design available freeboard and capacity.

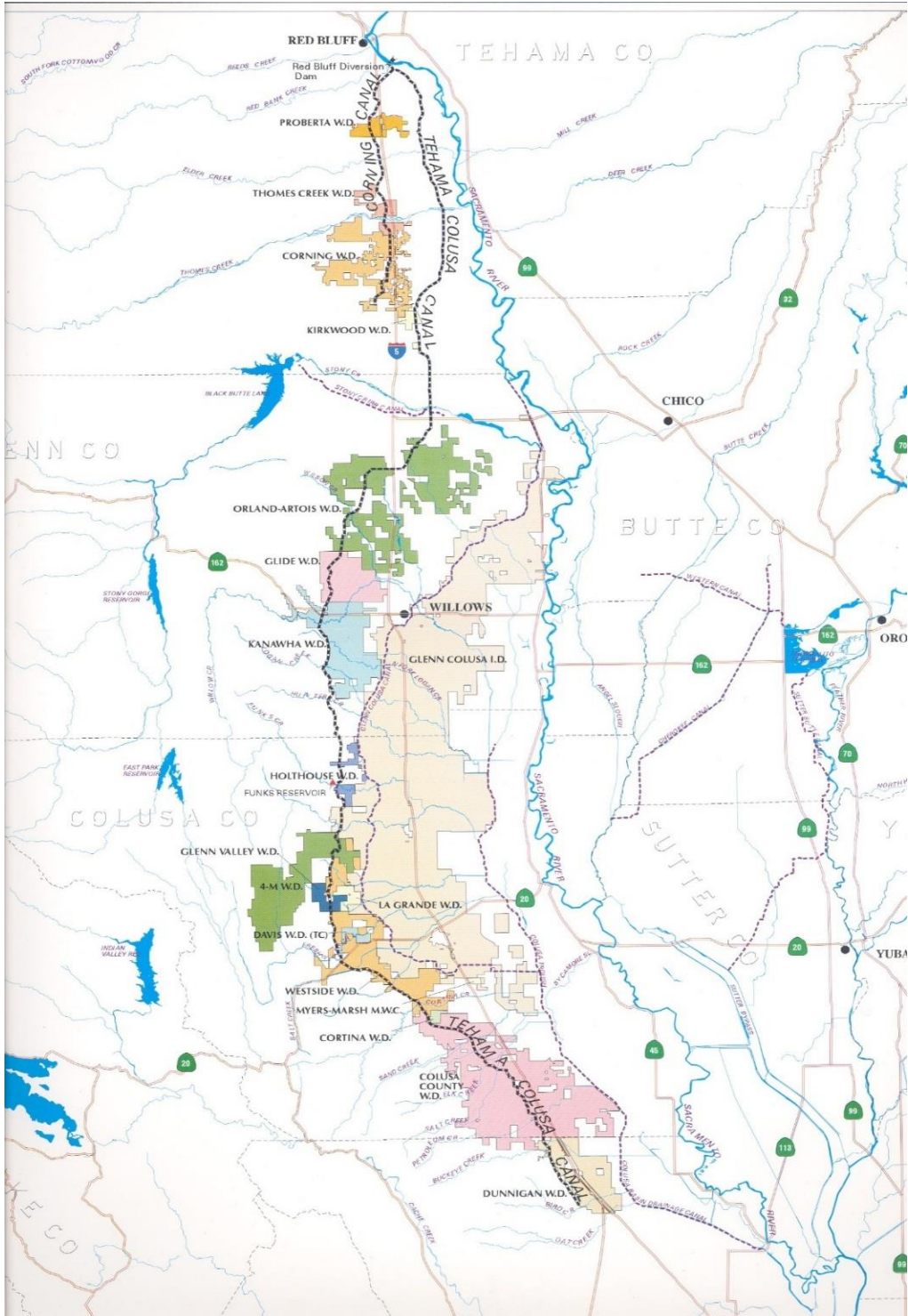


Figure 1. Tehama-Colusa Canal Site Map

2.0 Data Collection

Jacobs used data collected from publicly available sources as well as the TCCA, Reclamation, and the existing hydraulic model developed by Walton et al. (2004) to obtain necessary inputs for model development. Table 1 provides a summary of the datasets used for model development.

Table 1. Summary of the Data Used for the 1D Hydraulic Model Development

Required Data	Data Source
LiDAR Survey Data	3-foot and 30-foot LiDAR from USGS (n.d.)
Canal Network	Watershed boundaries and river/stream network: https://www.usgs.gov/streamstats
Cross Sections (Reach 1 through 5)	Hydraulic model study conducted by Walton et al. (2004); TCCA plan drawings for Reach 3 (USBR Tehama-Colusa Canal, Reach 3, Central Valley Project, California, 1976.)
Cross Sections (Reach 6 through 8)	TCCA plan drawings for Reaches 6 (USBR Tehama-Colusa Canal, Reach 6, Central Valley Project, California, 1977), 7 (USBR Tehama-Colusa Canal, Reach 7, Central Valley Project, California, 1977, and 8 (USBR Tehama-Colusa Canal, Reach 8, Central Valley Project, California, 1979)
Boundary Conditions	TCCA daily flow records
Structural Details (Reach 1 through 5)	Hydraulic model study conducted by Walton et al. (2004)
Structural Details (Reach 6 through 8)	TCCA plan drawings for Reaches 6, 7, and 8 Check structures data provided by TCCA
Funks Reservoir Information	Stage-Area-Capacity details from Reclamation (Funks Dam and Reservoir, Central Valley Project 2007)
Land Subsidence	R.E.Y. Engineers, Inc. technical memorandum

LiDAR = Light Detection and Ranging

USBR = U.S. Bureau of Reclamation

USGS = U.S. Geological Survey

3.0 Hydraulic Model Development

The hydraulic analysis was performed using the U.S. Army Corps of Engineer’s Hydrologic Engineering Center’s River Analysis System (HEC-RAS), Version 6.6 (USACE 2024). The hydraulic model was developed using HEC-RAS 1D to simulate flow behavior along the existing TCC. The canal was designed and constructed in reaches, with standard cross sections defined for each reach. The canal was built in a standard cross section shape, with the bottom width, side slopes, and canal depth varying slightly through the canal. The model used a standard schematic for each cross section with six points: two for the channel invert, two for the top of the concrete lining, and two for the top of bank. A spreadsheet was developed to automatically generate the HEC-RAS geometry file using these standard sections along with station-specific invert elevations derived from construction plan and profile drawings. These cross sections were spaced appropriately to capture changes in bed slope and key hydraulic features such as bends, confluences, and infrastructure (for example, bridges and siphons).

3.1 Assumptions

The following assumptions were required in the development and application of the 1D HEC-RAS model of the TCC:

- **1D Flow:** The model assumes that flow occurs primarily in the longitudinal direction (along the canal reach), with lateral and vertical variations either negligible or accounted for through empirical adjustments.
- **Steady or Gradually Varied Flow:** Depending on the simulation type, the model may assume steady-state conditions (constant flow over time) or gradually varied unsteady flow, ignoring rapid changes like hydraulic jumps unless explicitly modeled.
- **Hydrostatic Pressure Distribution:** The vertical pressure distribution is assumed to be hydrostatic, which is valid for subcritical and gradually varied flow conditions.
- **Uniform Roughness:** Manning's roughness coefficients are assumed to be constant within each cross section or reach, even though actual channel roughness may vary spatially. The model was developed with a separate roughness for the natural portion of the bank lying above the concrete-lined portion of the cross section.
- **Simplified Geometry:** Cross sections are idealized representations of the canal channel and overbanks, often interpolated between surveyed points, which may not capture all local irregularities.
- **Neglect of Lateral Inflows:** Lateral inflows from tributaries, storm drains, or overland flow are ignored in this model.
- **Boundary Conditions:** Upstream and downstream boundary conditions (for example, flow hydrographs, normal depth) are assumed to be accurate and representative of real-world conditions.
- **No Sediment Transport or Water Quality:** In this hydraulic model, sediment transport, erosion, deposition, and water quality processes are not considered.

3.2 Terrain Data

Topographic data provided the foundation for developing hydraulic model geometry. High-resolution topographic data were obtained from publicly available LiDAR datasets from USGS (n.d.), which provided information for the canal reach. These datasets were merged to create a composite terrain to capture canal alignment throughout the reach. The spatial reference system used for this model is NAD_1983_2011_StatePlane_California_III_FIPS_0403_Ft_US. All elevations are provided in feet, referenced to the National Geodetic Vertical Datum of 1929 (NGVD29). Figure 2 provides an overview of the site terrain. Terrain was not used to set cross section geometry in the model, just to set the canal alignment. There are minor shifts in portions of the alignment on the order of tens of feet, but this is not expected to influence model results. This was necessary to maintain channel stationing consistent with the original model.

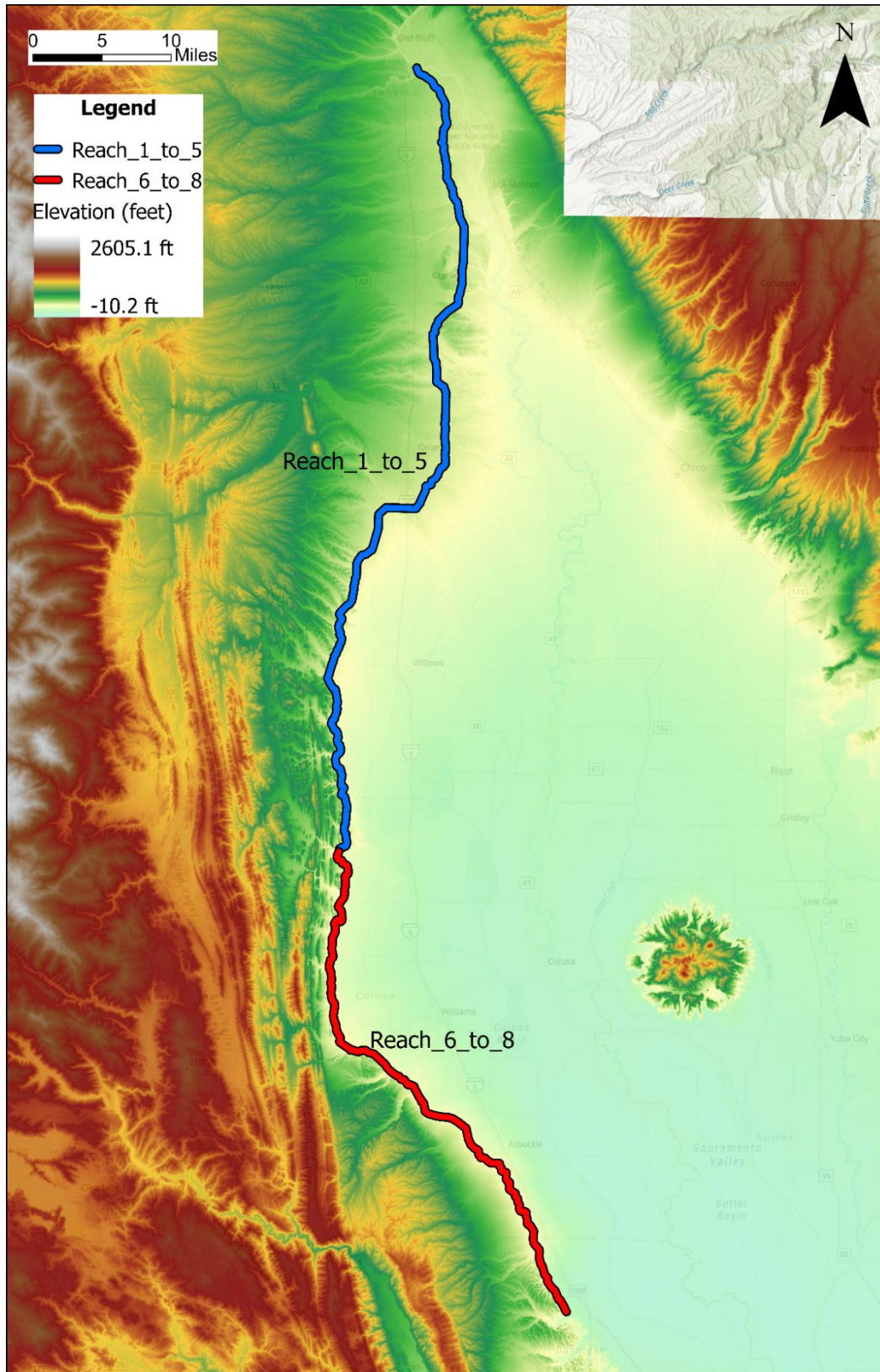


Figure 2. Spatial Coverage of the Terrain Data and Canal Alignment

3.3 Model Geometry

The HEC-RAS model geometry consists of two connected reaches through an inline storage area (Figure 3). The geometric configuration was designed to accurately represent the physical characteristics of the TCC, which are detailed as follows:

- Reaches 1 to 5: Characterize the upstream segment of TCC, which include Reaches 1 to 5 from TCCA plan drawings. The primary inflow boundary is located at the upstream end of this reach. These reaches include 146 structures, of which 16 are check structures numbered from Check 1 to Check 16. Cross sections and structure details located in this reach were imported from the legacy model (Figure 4).
- Storage Area: The upstream and downstream reaches are connected by an inline storage area representing Funks Reservoir, details of which are in Section 3.5 of this memorandum.
- Reaches 6 to 8: Represent the downstream segment of TCC, which includes Reaches 6 to 8 from TCCA plan drawings. The end boundary of this reach is a terminal structure (Check 26 was not modeled as a flow-through check). These reaches have 44 structures, 9 of which are check structures numbered from Check 17 to Check 25. To create cross sections in these reaches, a spreadsheet was developed to automatically generate the HEC-RAS geometry file using the standard sections along with station-specific invert elevations derived from construction plan and profile drawings provided by TCCA (Figure 5).

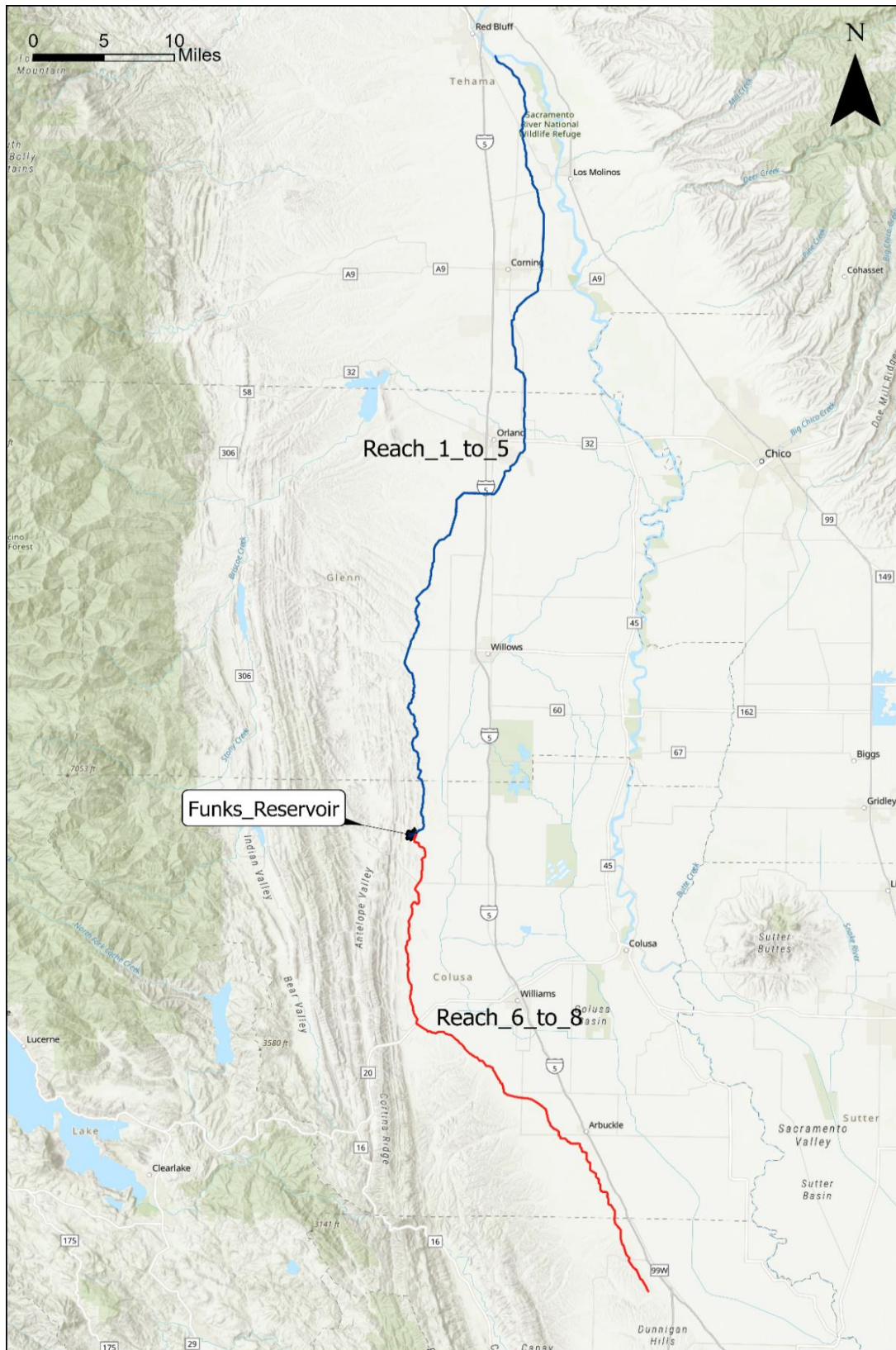


Figure 3. Model Domain and Geometry

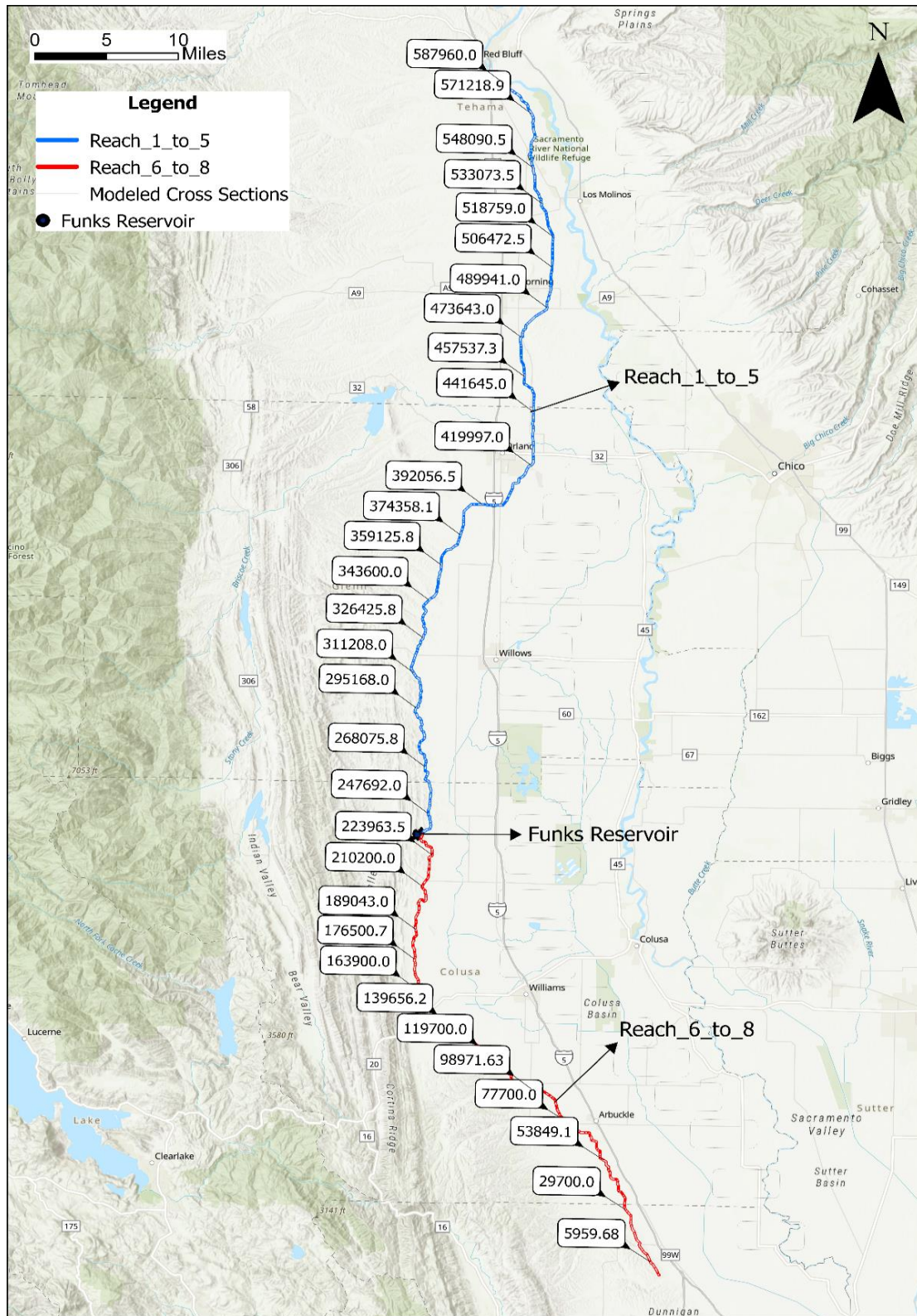


Figure 4. Model Cross Sections

(CROSS SECTIONS ARE CLOSELY SPACED ALONG THE REACH; THEREFORE, ONLY REPRESENTATIVE CROSS SECTIONS ARE SHOWN ON THE MAP FOR CLARITY)

Figure 5 shows the standard cross section used to set model geometry, where “ss” is inverse side slope, “d” is water depth, “h” is depth to top of concrete lining, “h(b)” is depth to top of bank, and “b” is bottom width. Information summarized in Table 2 was used in an Excel spreadsheet to automate development of the HEC-RAS geometry file specifying each cross section in the model domain. Columns provide parameters for section details defined on Figure 5, with “s” the slope in feet per foot down the canal.

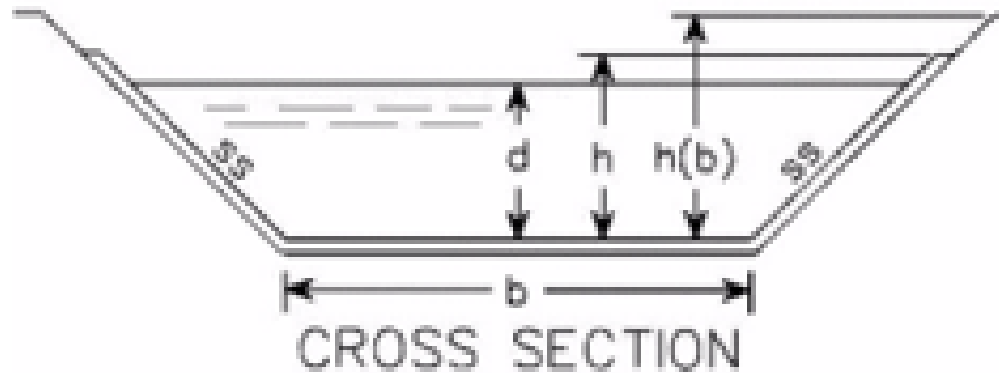


Figure 5. Schematic of Canal Cross Section

Table 2. Canal Cross Section Details in Each Reach

Reach	Section	Distance Mile from Upstream Point	Depth to Top of Bank (feet)	Depth to Top of Concrete Lining (feet)	Bottom Width (feet)	Water Depth (feet)	Slope (foot/foot)	Inverse Side Slope (foot/foot)
DPC	DPC	0.59 to 3.69	12.50	12.50	100	6.59	0.00027	2:1
1	1A	3.72 to 10.30	18.2	15.99	24	13.99	0.00009	1.5:1
1	1B	10.32 to 12.99	20.4	18.19	24	16.19	0.00005	1.5:1
1	1C	13.17 to 13.20	20	17.84	24	15.84	0.00005	1.5:1
2	2A	13.20 to 26.32	20	17.84	24	15.84	0.00005	1.5:1
2	2B	26.33 to 29.74	12.20	10.00	52	8.00	0.000183	1.5:1
3	3A	29.74 to 29.76	12.2	10.00	52	8.00	0.000183	1.5:1
3	3B	29.92 to 32.51	12.2	10.00	52	8.00	0.000167	1.5:1
3	3C	32.53 to 41.74	19.7	17.47	24	15.47	0.00005	1.5:1
4	4	41.81 to 55.38	18.2	15.99	24	13.99	0.000075	1.5:1
5	5	55.44 to 66.00	18	15.77	24	13.77	0.00008	1.5:1

Reach	Section	Distance Mile from Upstream Point	Depth to Top of Bank (feet)	Depth to Top of Concrete Lining (feet)	Bottom Width (feet)	Water Depth (feet)	Slope (foot/foot)	Inverse Side Slope (foot/foot)
FUNKS RESERVOIR								
6	6	66.88 to 82.86	18	15.77	24	13.77	0.00008	1.5:1
7	7	82.86 to 96.32	18	15.77	24	13.77	0.00008	1.5:1
8	8	96.32 to 111.38	16.5	14.28	22	12.38	0.00008	1.5:1

DPC =Dual Purpose Canal, which is the portion of the TCC before it splits into the Corning Canal and the TCC

3.4 Structures

The model incorporates 191 structures, 25 of which are check structures. Hydraulic structures along the canal, including checks (25), siphons (30), wash siphons (10), overchutes (42), bridges (72), and irrigation or gas pipe crossings (12), were represented in the HEC-RAS model using the available design and construction drawings. These were grouped into categories that could be modeled using the capabilities of HEC-RAS, as indicated in Table 3.

Table 3. Structures Modeled in HEC-RAS

Canal Feature	Number Modeled	HEC-RAS Method
Inverted siphon	30	Buried culvert
Check structure	25	Inline structure (Gates)
Bridges/Farm Road	72	Bridge
Wash siphon	10	Bridge/Culvert
Overchute	42	Bridge
Irrigation or gas pipe crossing	12	Bridge

The majority of bridges modeled have some support structure in the channel that must be modeled to understand energy losses. Some bridges were modeled only as clear-span bridge decks in the original model: these were retained in the updated model. For modeling check structures as inline structures, the geometry dimensions, crest elevations, and invert elevations were incorporated based on the check structures data provided by TCCA as provided in Table 4. Figure 6 shows the locations of 166 non-check structures, and Figure 7 shows the location of the 25 modeled checks.

Table 4. Details of Check Structures

Check No.	End Mile Post	RADIAL GATES		FLOATWELL INVERTS		CHECK INVERTS		NORMAL UPSTREAM	
		No. of Gates	Size (Width x Height)	Upstream	Downstream	IN	OUT	Elevation	Depth (feet)
1	0.59	3.00	14 feet x 12 feet	227.54	241.31	239.74	241.31	249.00	21.46
2	3.72	3.00	14 feet x 14 feet	232.74	228.15	232.74	228.19	245.00	12.26
3	5.03	2.00	18 feet x 18 feet	227.55	227.17	225.49	225.49	241.53	13.99
4	8.02	2.00	18 feet x 18 feet	225.16	224.66	223.05	223.05	239.14	13.99
5	10.3	2.00	18 feet x 22 feet	219.86	219.02	216.02	216.02	236.04	16.18
6	18.44	2.00	18 feet x 17 feet	217.28	216.95	216.53	216.53	233.12	15.84
7	24.57	2.00	18 feet x 17 feet	214.71	214.71	213.96	213.86	230.55	15.84
8	26.32	3.00	18 feet x 9 feet	220.13	220.02	219.62	219.62	228.12	7.99
9	29.77	3.00	18 feet x 9 feet	217.57	218.64	217.07	217.07	225.57	8.00
10	31.69	3.00	18 feet x 9 feet	215.12	214.95	214.61	214.61	223.11	8.00
11	32.51	2.00	18 feet x 17 feet	205.03	204.53	204.30	204.30	220.50	15.47
12	41.74	2.00	18 feet x 15.5 inches	203.61	203.48	203.50	203.50	217.59	13.98
13	49.45	2.00	18 feet x 15.5 inches	200.50	200.37	200.39	200.39	214.49	13.99
14	55.37	2.00	18 feet x 15.5 inches	197.47	196.69	197.38	197.38	211.46	13.99
15	60.50	2.00	18 feet x 15.5 inches	193.96	193.84	193.86	193.86	207.73	13.77
16	66.00	2.00	18 feet x 15.5 inches	191.52	187.33	191.42	191.42	205.29	13.77
17	66.87	2.00	18 feet x 22 feet	187.33	187.16	187.16	187.16	205.30	17.97
18	70.36	2.00	18 feet x 15.5 inches	185.89	182.71	185.69	185.69	199.46	13.77
19	75.97	2.00	18 feet x 15.5 inches	180.64	180.52	180.54	180.54	194.41	13.77
20	81.56	2.00	18 feet x 15.5 inches	178.19	177.58	178.19	178.19	191.95	13.77
21	86.23	2.00	18 feet x 15.5 inches	175.14	174.42	175.14	175.14	188.91	13.77
22	91.55	2.00	18 feet x 15.5 inches	171.72	171.60	171.62	171.62	185.49	13.77

Check No.	End Mile Post	RADIAL GATES		FLOATWELL INVERTS		CHECK INVERTS		NORMAL UPSTREAM	
		No. of Gates	Size (Width x Height)	Upstream	Downstream	IN	OUT	Elevation	Depth (feet)
23	96.32	2.00	14 feet x 14 feet	169.01	169.79	170.40	170.40	182.78	13.77
24	101.21	2.00	14 feet x 14 feet	167.04	168.92	166.94	166.94	179.42	12.38
25	105.54	2.00	14 feet x 14 feet	164.27	163.48	164.27	164.27	176.65	12.38

Source: Reclamation Tehama-Colusa Canal Check Structure Information February 2004

No. = number

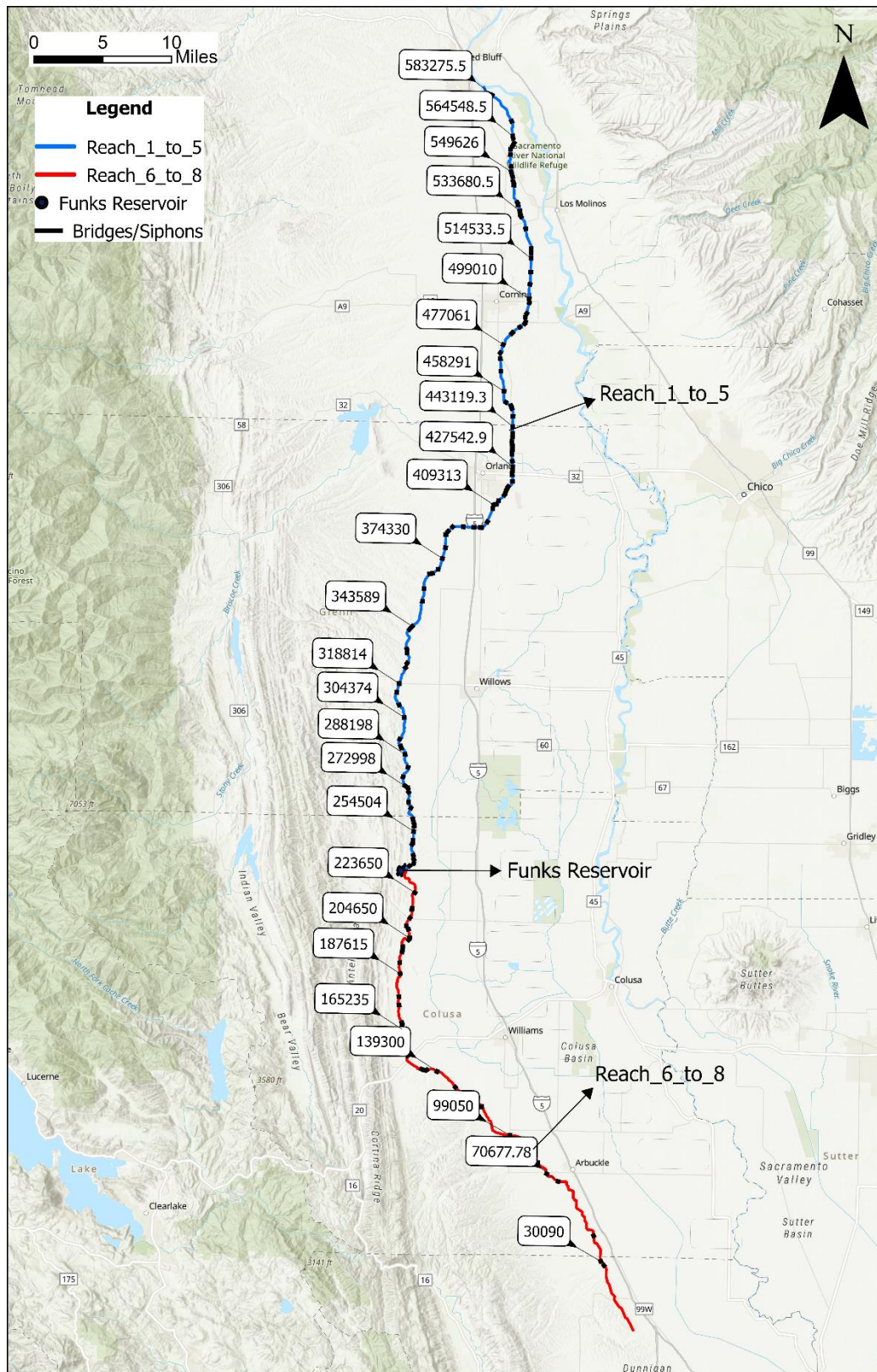


Figure 6. Model Bridges/Siphons
 (DUE TO SCALE LIMITATIONS, ONLY A SUBSET OF BRIDGES/SIPHONS ARE SHOWN ON THIS MAP)

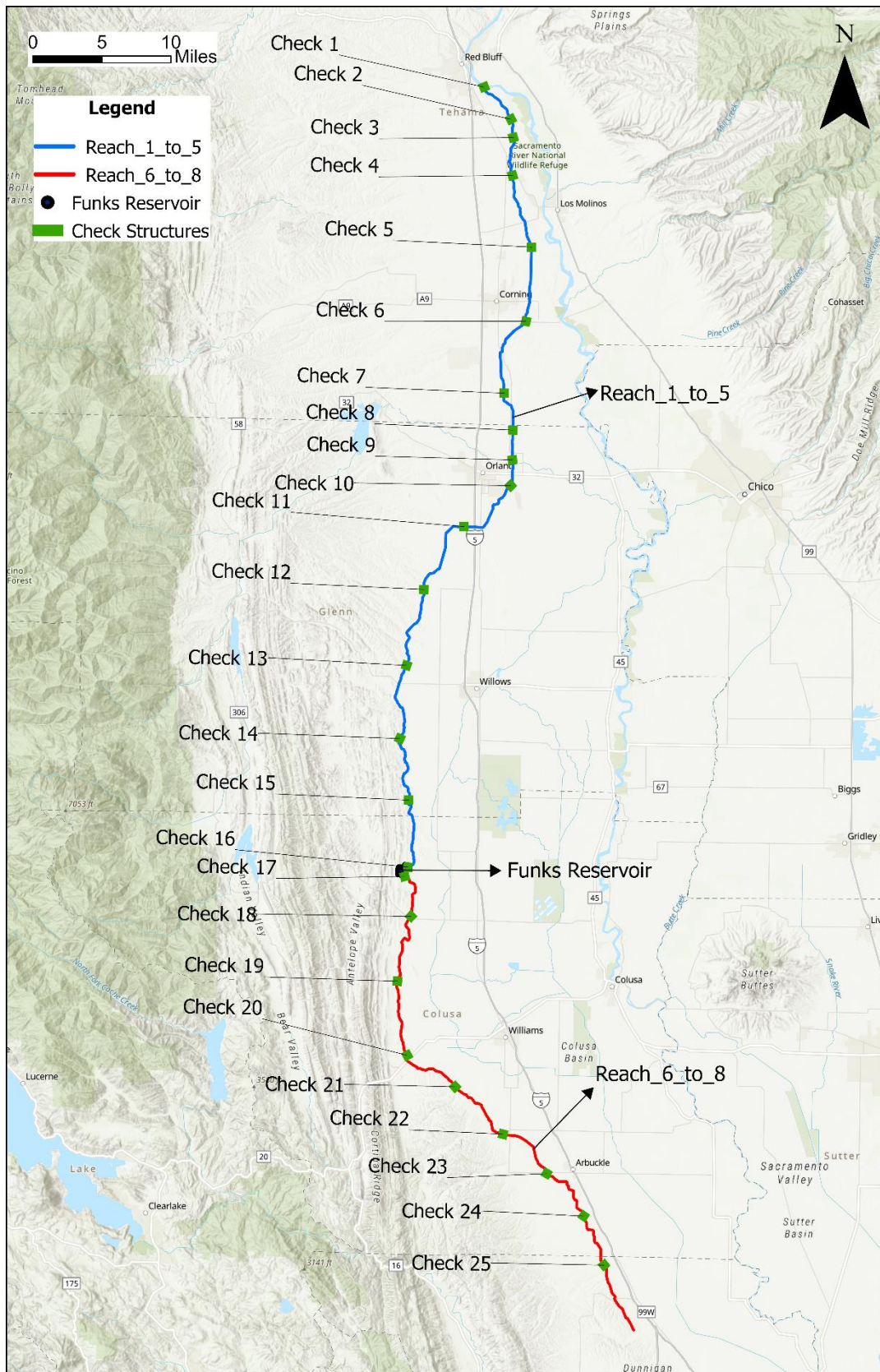


Figure 7. Model Check Structures

3.5 Storage Areas

A 1D storage area was included in the HEC-RAS model to represent Funks Reservoir storage associated with the canal system (Figure 8). The stage-area-capacity relationship for the storage area was provided by TCCA (Reclamation, Funks Dam and Reservoir, Central Valley Project 2007) and was incorporated directly into the model to define storage behavior and water surface response. Details of the stage-area-capacity for Funks Reservoir are provided in Table 5. Standard operating water levels in Funks Reservoir are 202 to 204 feet (Jacobs 2024). For the capacity analysis, the initial WSE in Funks Reservoir was set at the top of this range (204 feet).

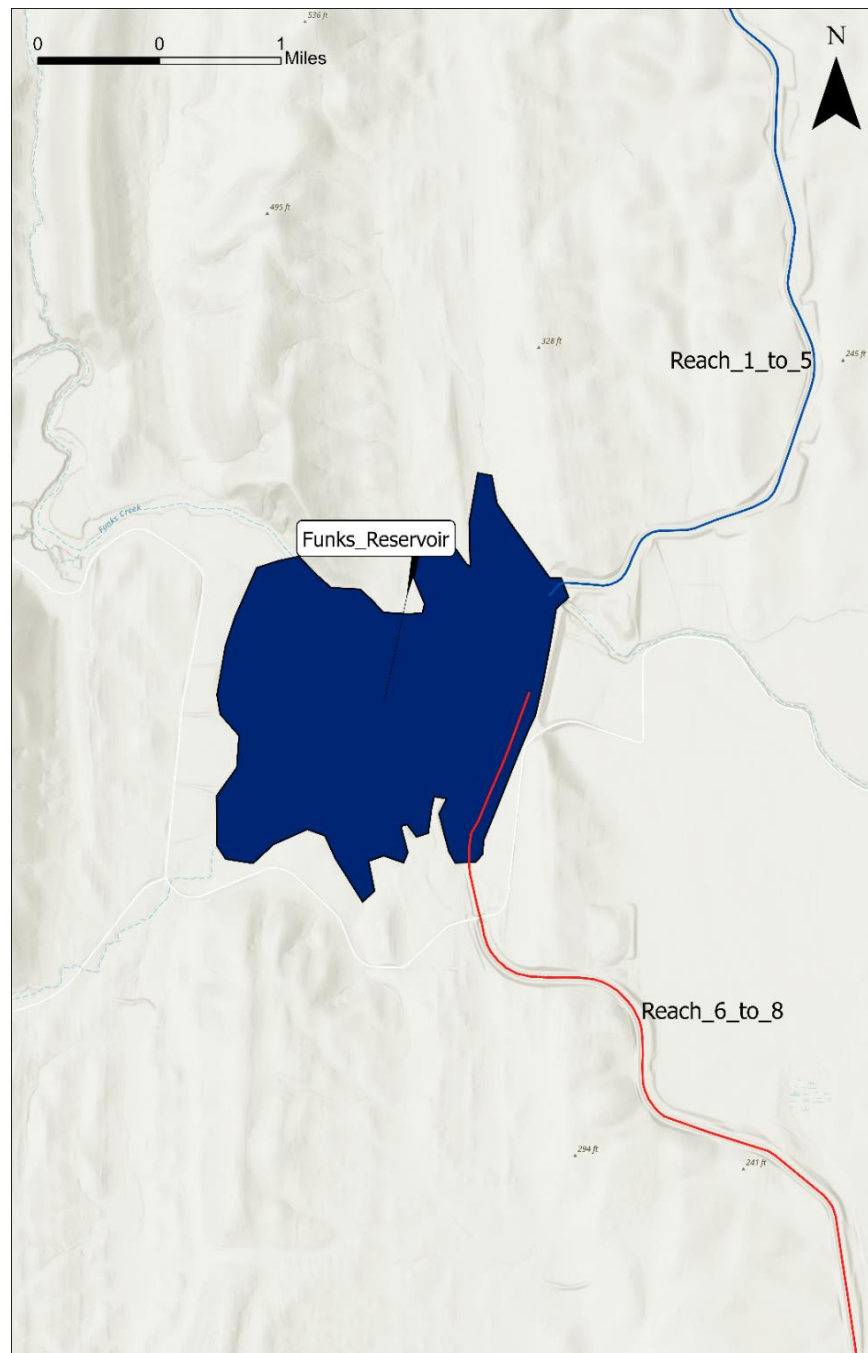


Figure 8. Funks Reservoir Modeled as Storage Area

Table 5. Stage-Area-Capacity Relationship for Funks Reservoir

Elevation (feet)	Area (acres)	Capacity (acre-foot/feet)
170.1	0	0
171	0.003	0.001
172	0.006	0.006
173	0.127	0.073
174	0.306	0.289
175	0.421	0.652
176	0.56	1.143
177	0.653	1.75
178	0.737	2.445
179	0.927	3.277
180	1.92	4.701
181	2.763	7.042
182	3.177	10.012
183	3.678	13.44
184	4.488	17.523
185	5.643	22.588
186	7.609	29.214
187	12.309	39.173
188	16.928	53.791
189	22.53	73.52
190	31.16	100.365
191	39.214	135.552
192	49.026	179.672
193	56.619	232.495
194	64.14	292.875
195	73.68	361.785
196	82.296	439.773
197	94.669	528.255
198	128.916	640.047
199	184.451	796.731
200	203.261	990.587
201	206.218	1,195.327

Elevation (feet)	Area (acres)	Capacity (acre-foot/feet)
202	208.459	1,402.666
203	210.49	1,612.141
204	212.681	1,823.726
205	214.952	2,037.542
206	217.075	2,253.555
206.5	218.046	2,362.335

Source: Reclamation 2007

3.6 Roughness Values

Manning’s roughness coefficients were assigned based on typical values for concrete-lined canal sections and adjacent earthen overbank areas. A constant Manning’s n value of 0.014 was assumed for the concrete-lined portion of the main channel throughout the modeled reaches. A Manning’s n value of 0.03 was applied uniformly to the bank areas above the concrete liner to represent rougher flow conditions outside the concrete channel.

3.7 Land Subsidence Survey

R.E.Y. Engineers, Inc. (R.E.Y.) conducted field surveys to support evaluation of land subsidence effects along the TCC within Reach 3 (R.E.Y. 2026). On December 12, 2025, R.E.Y. collected canal cross section data and elevations at select locations between Checks 10 and 12. Comparison of historical and current control point elevations indicates measurable land subsidence within the study area, which was subsequently incorporated into the hydraulic analysis (Table 6).

The field survey indicated that there was subsidence ranging from 0.4 foot to 3 feet in a stretch of about 9 miles, with a main zone of subsidence within a 1.5-mile stretch ranging from 2.5 to 3 feet.

For four surveyed locations, plan elevations were unavailable for direct comparison with the measured elevations, because the Reach 4 drawing was not available to the Sites Project team during model development. Accordingly, a conservative approach was adopted, whereby the maximum subsidence observed at the nearest upstream or downstream control points was assigned to these locations.

The surveyed subsidence data were incorporated into the hydraulic model through linear interpolation between adjacent control points. For each canal cross section located between two surveyed points, subsidence was interpolated based on the relative position between the bounding upstream and downstream points. Additionally, to avoid sudden discontinuities in canal invert elevations, the subsidence data were extended beyond the surveyed limits and smoothly tapered over 5,000 feet at the upstream end (above Check 10) and 10,000 feet at the downstream end of the modeled reach (below Check 12).

Table 6. Subsidence Survey Data Provided by R.E.Y. Engineers, Inc.

Survey Point No.	R.E.Y. Point No.	Location	Station	Feature	TCC Drawing	2026 NAVD88	Adjacent to NGVD29	TCC Plan Elevation (NGVD29)	Possible Subsidence Since 1975
1	807	Check 10	1706+50	Top of structure	602-D-1915, 1916	229.2	226.9	No Information Available	No Information Available
2	806	CR 200	1721+55	Top of flume headwall	602-D-1952, 1953	230.27	227.97	228.41	-0.44
3	805	CR 20	1751+67	Top of headwall	602-D-1199	228.79	226.49	No Information Available	No Information Available
4	804	CR 21	1783+58	Top of headwall	602-D-1957, 1958	229.48	227.18	227.67	-0.49
5	803	CR 24	1829+74	Top of headwall	602-D-1957, 1958	229.3	227	227.42	-0.42
6	802	S of CR 25	1890+00	Top of headwall	No Information Available	226.47	224.17	No Information Available	No Information Available
7	812	99W	1924+34	Top of headwall	602-D-1957, 1958	226.26	223.96	226.65	-2.69
8	1012	W of 99W	1925+16	TCC Invert	602-237-1684	205.1	202.8	205.38	-2.58
9	1020	E of I-5	1946+60	TCC Invert	602-237-1685	204.5	202.2	205.25	-3.05
10	808	Check 11	1987+50	Top of structure ^[a]	602-D-1213	226.82	224.52	224.72	-0.2
11	809	CR F	2029+60	Top of headwall	602-D-1957, 1958	226.89	224.59	225.42	-0.83
12	810	CR 28	2120+52	Top of headwall	602-D-1961, 1962	226.49	224.19	224.94	-0.75
13	811	CR D	2209+32	Top of headwall	602-D-1957, 1958	226.25	223.95	224.37	-0.42

Survey Point No.	R.E.Y. Point No.	Location	Station	Feature	TCC Drawing	2026 NAVD88	Adjacent to NGVD29	TCC Plan Elevation (NGVD29)	Possible Subsidence Since 1975
14	813	Siphon	2236+00	Top of headwall ^[a]	602-D-1222	224.71	222.41	223.86	-1.45
15	814	Check 12	No Information Available	Top of structure	No Information Available	224.69	222.39	No Information Available	No Information Available

TCC Drawing Source: Reclamation Central Valley Project, Tehama-Colusa Canal – Reach 3, 1976

^[a] Uncertain that the elevation pulled from the TCC plans is at the correct location; will be revised when all plan sets are obtained from TCCA.

CR = County Road

NAVD88 = North American Vertical Datum of 1988

3.8 Boundary Conditions

To establish hydraulic conditions within the canal system, boundary conditions were defined at the upstream ends of both reaches and at the final downstream end of the model. The upstream boundary conditions were specified as constant inflow discharges, while the downstream boundary condition was represented using a normal depth assumption based on the canal bed slope of 0.00008. Multiple conditions were evaluated by varying the applied inflow discharges ranging from 1,000 cfs to 2,500 cfs, and all simulations were performed under steady-state flow conditions.

The upstream and downstream reaches are connected through a storage area boundary condition, with the storage area WSE held constant at 204 feet for all modeled scenarios.

For the capacity simulations, all check structures within the modeled reaches were assumed to be fully operational, with all gates set to their maximum open position. This assumption was made to represent maximum conveyance conditions for each modeled flow discharge (Table 7) and was verified by TCCA operations staff.

Table 7. Check Structure Gate Boundary Conditions for Capacity Simulations

Reach	Structure	Number of Gates	Gate Height (feet)	Number of Open Gates	Gate Height Open (feet)
Reach 1 to 5	Check 1	3	12	3	12
Reach 1 to 5	Check 2	3	14	3	14
Reach 1 to 5	Check 3	2	18	2	18
Reach 1 to 5	Check 4	2	18	2	18
Reach 1 to 5	Check 5	2	22	2	22
Reach 1 to 5	Check 6	2	17	2	17
Reach 1 to 5	Check 7	2	17	2	17
Reach 1 to 5	Check 8	3	9	3	9
Reach 1 to 5	Check 9	3	9	3	9
Reach 1 to 5	Check 10	3	9	3	9
Reach 1 to 5	Check 11	2	17	2	17
Reach 1 to 5	Check 12	2	15.5	2	15.5
Reach 1 to 5	Check 13	2	15.5	2	15.5
Reach 1 to 5	Check 14	2	15.5	2	15.5
Reach 1 to 5	Check 15	2	15.5	2	15.5
Reach 1 to 5	Check 16	2	15.5	2	15.5
Reach 6 to 8	Check 17	2	22	2	22
Reach 6 to 8	Check 18	2	15.5	2	15.5
Reach 6 to 8	Check 19	2	15.5	2	15.5
Reach 6 to 8	Check 20	2	15.5	2	15.5

Reach	Structure	Number of Gates	Gate Height (feet)	Number of Open Gates	Gate Height Open (feet)
Reach 6 to 8	Check 21	2	15.5	2	15.5
Reach 6 to 8	Check 22	2	15.5	2	15.5
Reach 6 to 8	Check 23	2	14	2	14
Reach 6 to 8	Check 24	2	14	2	14
Reach 6 to 8	Check 25	2	14	2	14

4.0 Model Simulations

Hydraulic simulations were performed using the steady-state flow module in HEC-RAS to evaluate water surface profiles and hydraulic performance of the canal system. The flow regime for all simulations was specified as subcritical, reflecting the expected hydraulic behavior of the canal with gates fully open out of the water column. The steady-state approach allowed direct comparison of hydraulic response under different flow scenarios (as mentioned in the following subsections) and facilitated evaluation of canal capacity and local freeboard as a function of discharge.

4.1 Model Calibration and Validation

Jacobs performed a model calibration and validation exercise using flows and check gate positions provided by TCCA. Daily flow and gate information were provided in summary spreadsheets. Jacobs identified two dates where flows and gate operations were relatively consistent to use in the calibration (July 11, 2024) and validation (June 25, 2025) simulations. These periods were chosen for relatively high flows (1,200 cfs) to get as close as possible to channel capacity, thereby supporting the use of the calibrated model for the capacity analysis. Decreasing flows were applied in the downstream direction to account for TCCA deliveries. Gate positions were fixed using the average gate position at each check.

Data used in the calibration and validation simulations were checked against hourly gate position data to understand variations in gate positions throughout the day. Some inconsistencies were found in the datasets that led the modeling team to limit additional efforts at validation. Discussions with TCCA staff confirmed that there are known issues with instrumentation at select locations in the TCC, where the downstream check records a higher WSE than the upstream check. The model cannot reproduce the reported water levels in these instances.

Data inconsistencies prevented reproduction of historical water levels provided by the supervisory control and data acquisition (SCADA) system. The model is sensitive to gate positions, and adjustment of individual gate positions away from the position data provided by TCCA could reproduce measured water levels at individual check structures. Sensitivity tests indicate that the model is not sensitive to entrance and exit loss specifications at individual check structures, with water level changes of a few tenths of a foot for reasonable ranges in loss parameters.

Given the data issues, the calibration effort focused on channel roughness. Simulations were conducted with varying Manning's n values of 0.12, 0.014, 0.016, and 0.018. The average absolute error in predicted WSE was minimized for a roughness coefficient of 0.014. With the calibrated roughness value of 0.014, the model has a slight tendency to overestimate WSEs by an average of about 3 to 6 inches. This provides a level of conservatism for the capacity analysis.

4.2 Baseline Simulation

In this scenario, hydraulic simulations were performed for the baseline (as-built, non-subsided) canal geometry. The baseline condition represents the canal geometry matching the as-built plans before incorporation of observed subsidence; it also serves as the reference condition for comparison of the original conveyance capacity of the canal and associated freeboard.

4.3 With Subsidence Simulation

In this scenario, land subsidence effects were incorporated into the hydraulic model to evaluate their impact on canal capacity and available freeboard. The canal geometry for Reach 1 to Reach 5 was modified primarily between Check 10 and Check 12 in Reach 3 to reflect subsidence based on survey data provided by R.E.Y. The surveyed elevations were used to adjust the canal invert and cross section geometry by the methodology described in Section 4.7, and a new subsided geometry was developed in HEC-RAS.

The subsidence-adjusted geometry was simulated using the same boundary conditions and modeling assumptions applied to the existing (non-subsided) condition, including steady-state, subcritical flow conditions. Model results from the subsided geometry were compared to the existing condition to assess changes in WSEs, conveyance capacity, freeboard availability, and capacity use resulting from land subsidence.

5.0 Hydraulic Model Results and Discussion

The model results were used to evaluate canal capacity, available freeboard, and capacity use under the range of simulated discharges, thereby identifying the maximum flow that can be conveyed while maintaining acceptable freeboard of 2 feet to the top of the concrete channel lining.

This section presents the simulated WSEs and freeboard results for various flow profiles, along with the analysis conducted to understand where the maximum effects of land subsidence can be seen. The HEC-RAS model was run under two scenarios: baseline conditions and with subsidence conditions to evaluate the impacts of subsidence on the simulated WSEs and available freeboard.

The original canal design by Reclamation required a minimum of 2 feet of freeboard for the concrete lining and an additional 2 feet of freeboard of earthen canal embankment on both sides of the canal for operations and maintenance roads. Thus, there was a total of a minimum of 4 feet of freeboard along the entire 110.8-mile length of canal. The freeboard analysis in Sections 6.1 and 6.2 focuses on the minimum concrete liner freeboard of 2 feet. The figures show freeboard relative to top of concrete lining (TOC).

5.1 Baseline Freeboard Profiles

Figures 9 through 16 present both the freeboard and WSE results for the baseline simulation. Results along the 110.8-mile canal are covered in four separate pairs of figures to enable more resolution of local results. The horizontal red line in the freeboard figures represents the required minimum of 2 feet of freeboard to the TOC. Discussion is provided after each set of figures summarizing important results.

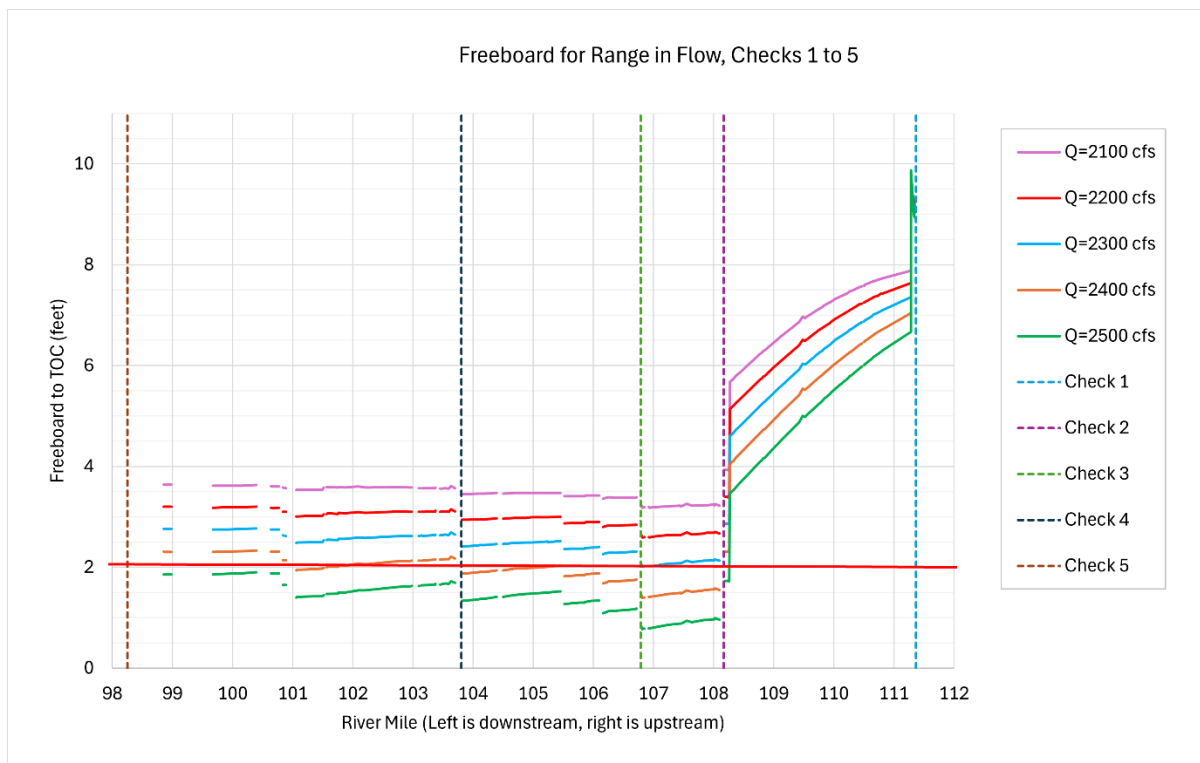


Figure 9. Freeboard for Different Flows, Checks 1 to 5 (Baseline)
(TOC – Top of concrete lining)

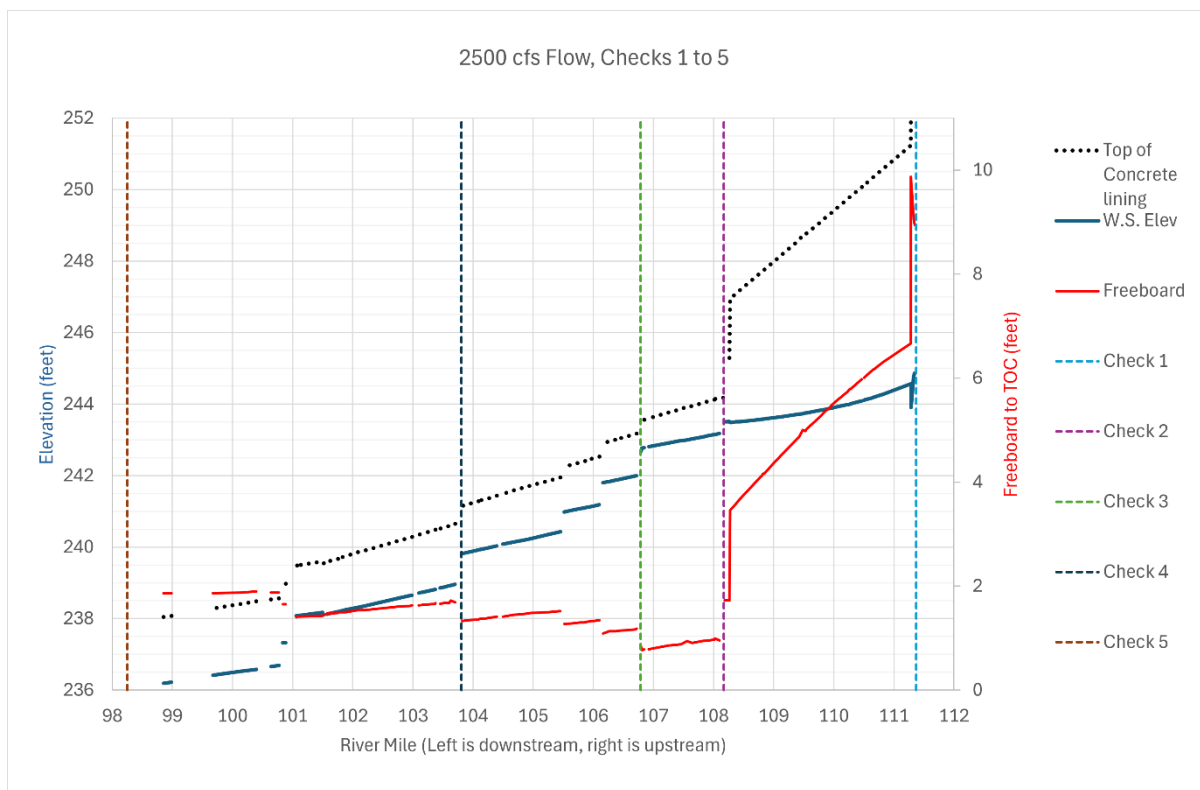


Figure 10. WSE Profile for 2,500 cfs, Checks 1 to 5 (Baseline)

Figure 9 and 10 present results between Checks 1 and 5, with Figure 9 showing longitudinal profiles of freeboard for five flows between 2,100 cfs and 2,500 cfs. Figure 10 shows elevations of the top of the concrete lining, the WSE at a flow of 2,500 cfs, and the freeboard read on the right-hand vertical axis. Freeboard upstream of Check 2 ranges from 3.5 to almost 8 feet for the range of flows shown, because the channel is wider in this section and thus flow depths are shallower. Freeboard is lowest between Checks 2 and 3, with results indicating a capacity of 2,300 cfs in this reach to maintain 2 feet of freeboard.

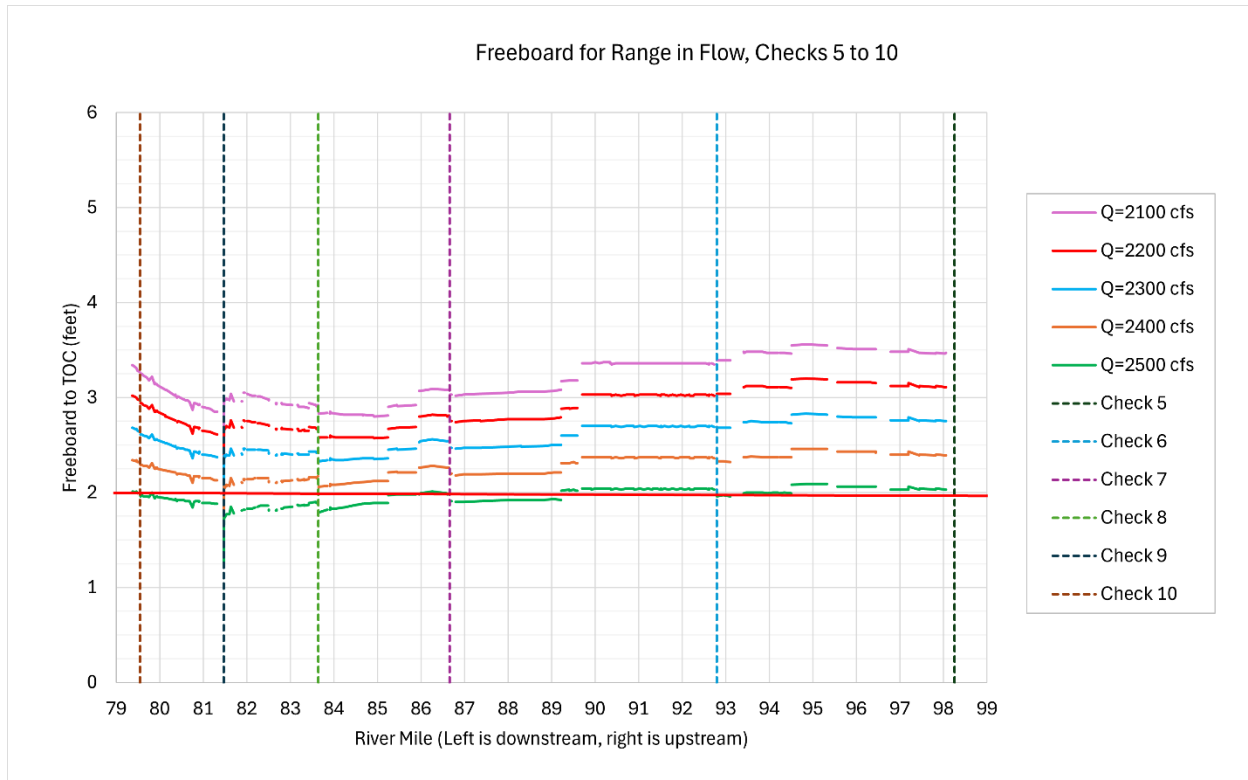


Figure 11. Freeboard for Different Flows, Checks 5 to 10 (Baseline)

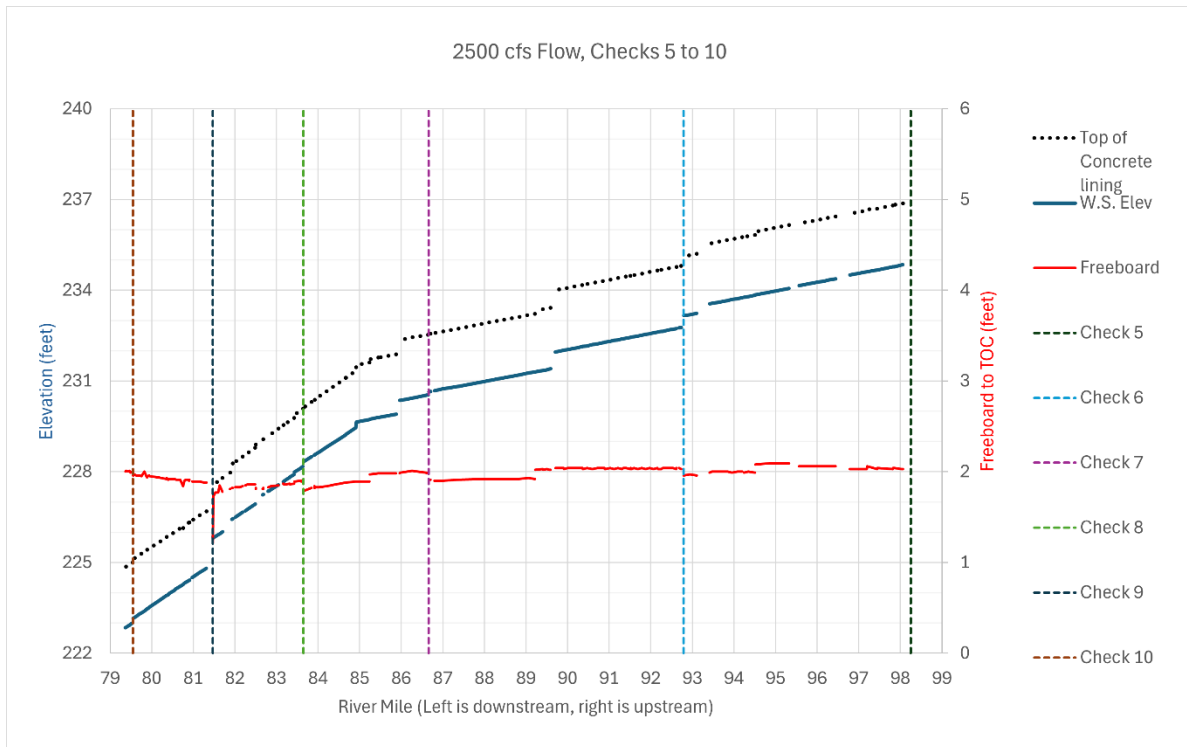


Figure 12. WSE Profile for 2,500 cfs, Checks 5 to 10 (Baseline)

Figure 11 and 12 present freeboard and elevation results between Checks 5 and 10, showing a capacity of 2,400 cfs in this reach to maintain 2 feet of freeboard. At 2,500 cfs freeboard dips under 2 feet.

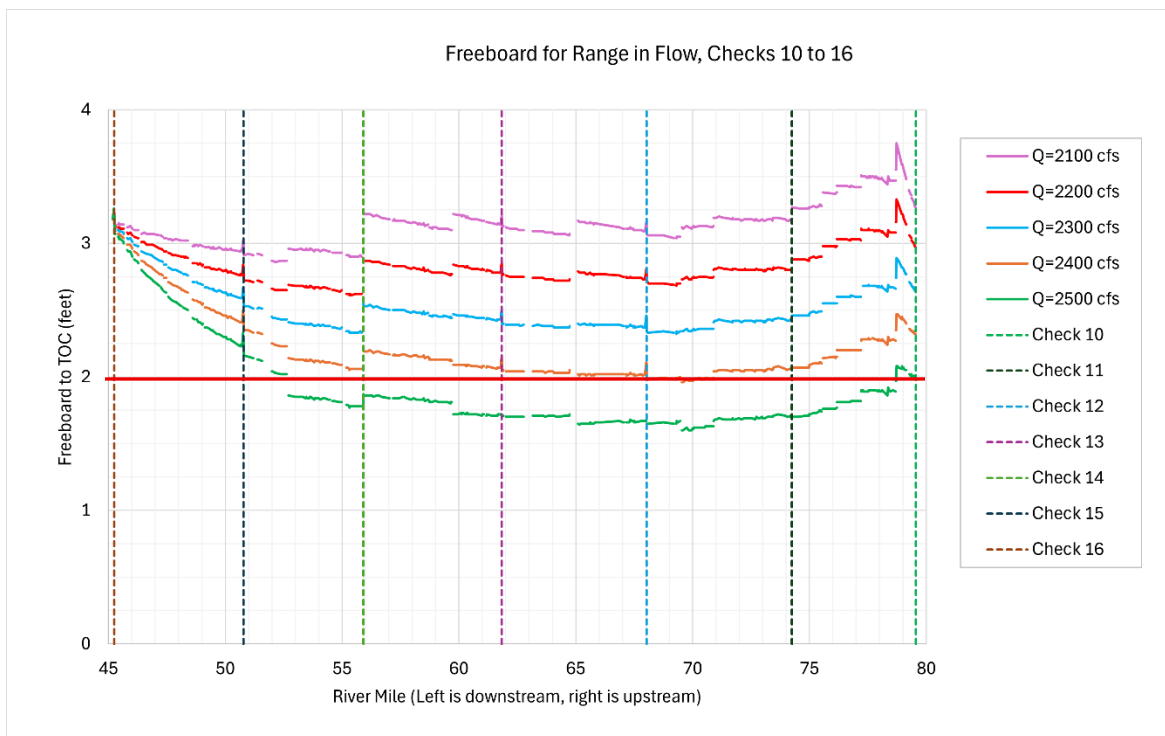


Figure 13. Freeboard for Different Flows, Checks 10 to 16 (Baseline)

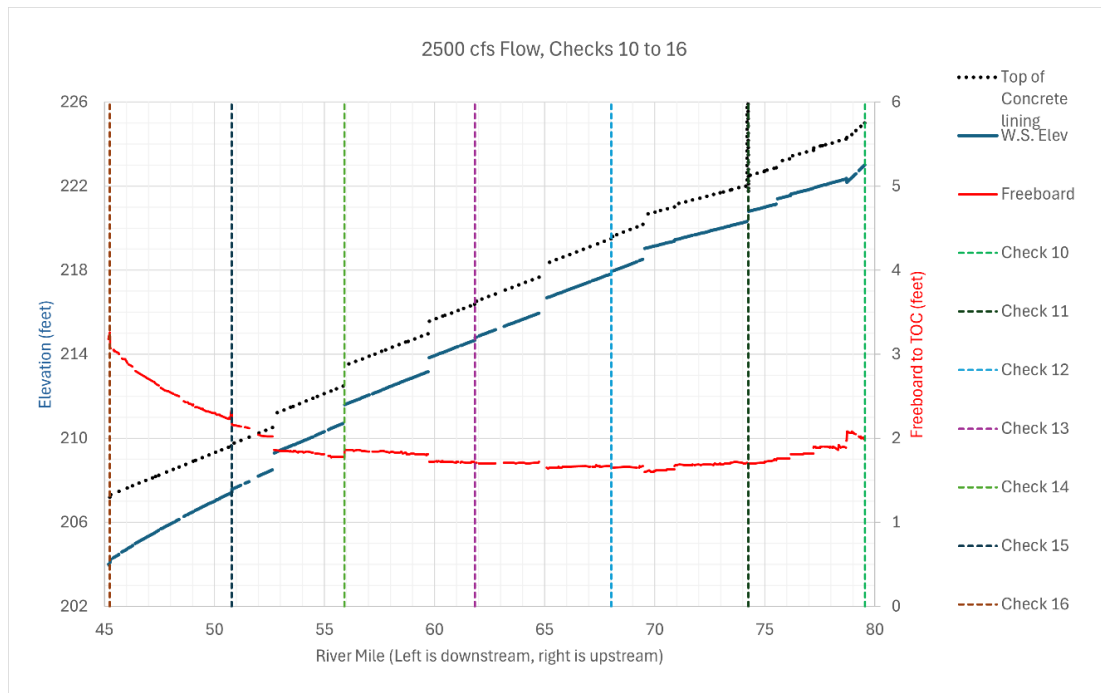


Figure 14. WSE Profile for 2,500 cfs, Checks 10 to 16 (Baseline)

Figure 13 and Figure 14 show results between Checks 10 and 16 at flows ranging from 2,100 cfs to 2,500 cfs and freeboard ranging from 1.8 feet at the highest flow to 3.5 feet at the lowest flow. This indicates that there is a canal capacity of 2,400 cfs with a freeboard of at least 2 feet.

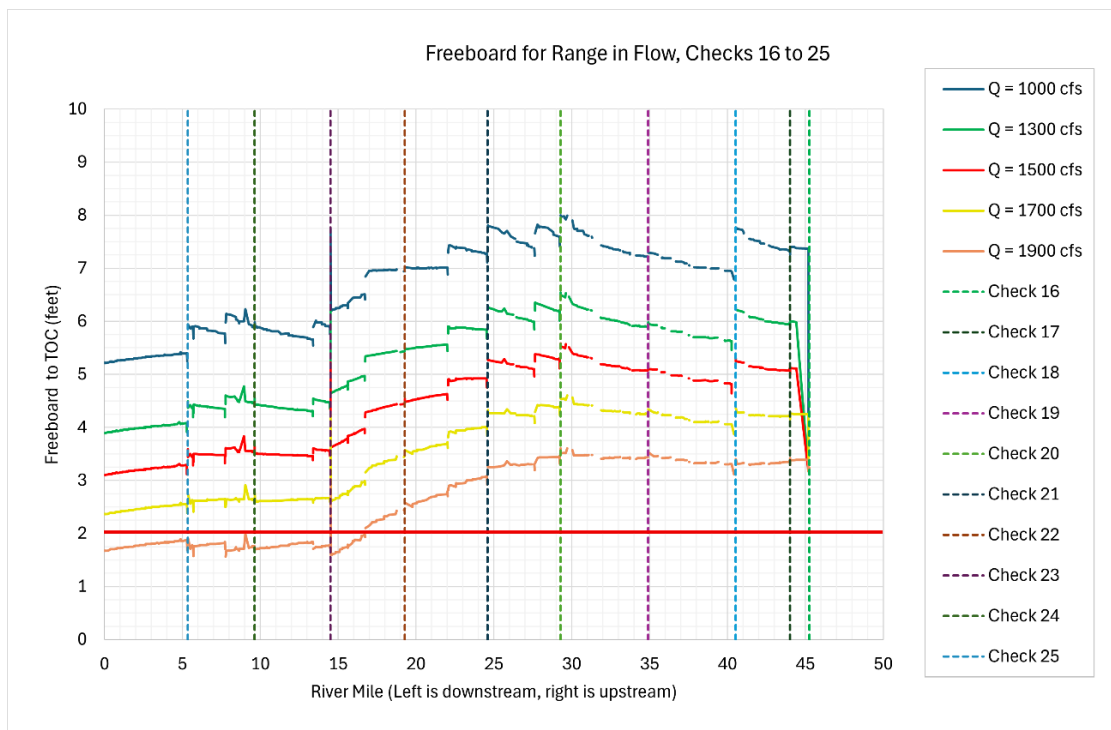


Figure 15. Freeboard for Different Flows, Checks 16 to 25 (Baseline)

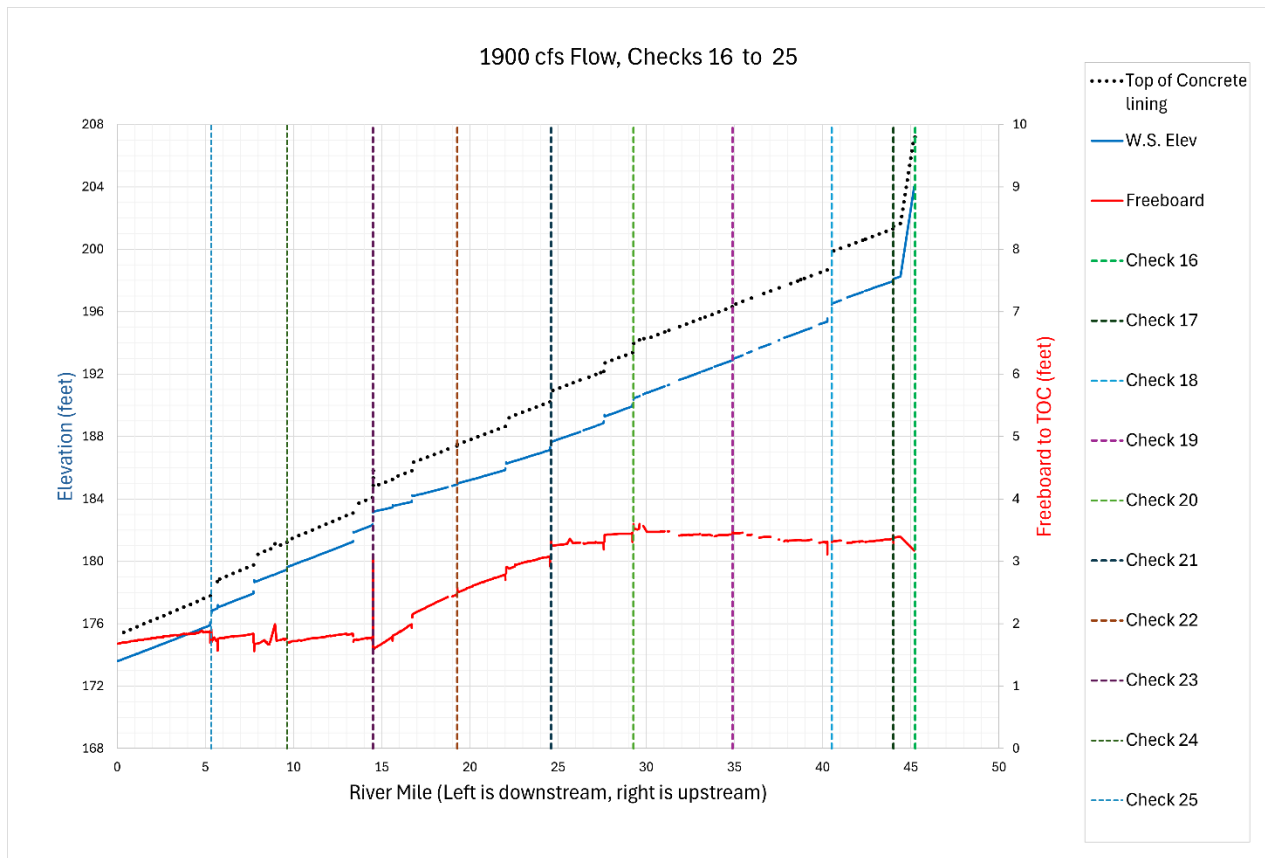


Figure 16. WSE Profile for 1,900 cfs, Checks 16 to 25 (Baseline)

Figure 15 and 16 show the freeboard range downstream of Funks Reservoir from Check 16 (upstream end of Funks Reservoir) to Check 25 for a range of flows between 1,000 cfs and 1,900 cfs. A capacity of 1,700 cfs is required to maintain 2 feet of freeboard in this reach. However, results indicate that there is 3.5 feet to 1.5 feet of freeboard downstream of Check 16 for a flow of 1,900 cfs.

5.2 With Subsidence Freeboard Profiles

Figures 17 through 19 show reductions in freeboard for present day conditions that account for measured subsidence between Checks 10 and 12. Subsidence quantified by recent surveys indicates significant spatial variability, which influences the model results presented on Figure 17 and Figure 18. The lowest freeboard is seen upstream of Check 11, with only 0.5 foot of freeboard at a flow of 2,100 cfs (Figure 19). WSEs are predicted to just exceed the top of the concrete lining at a flow of 2,300 cfs and encroach approximately 1 vertical foot into the unlined portion of the canal section at a flow of 2,500 cfs.

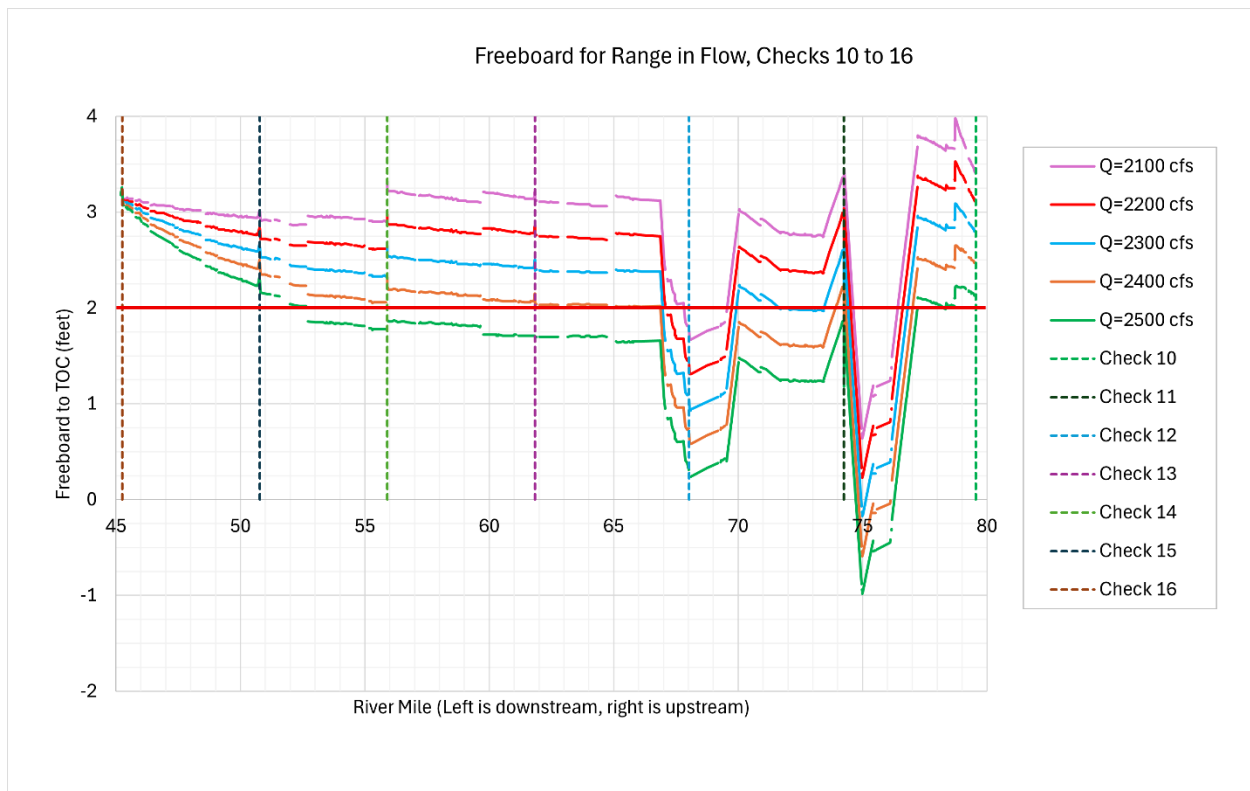


Figure 17. Freeboard for Different Flows, Checks 10 to 16 (Subsided)

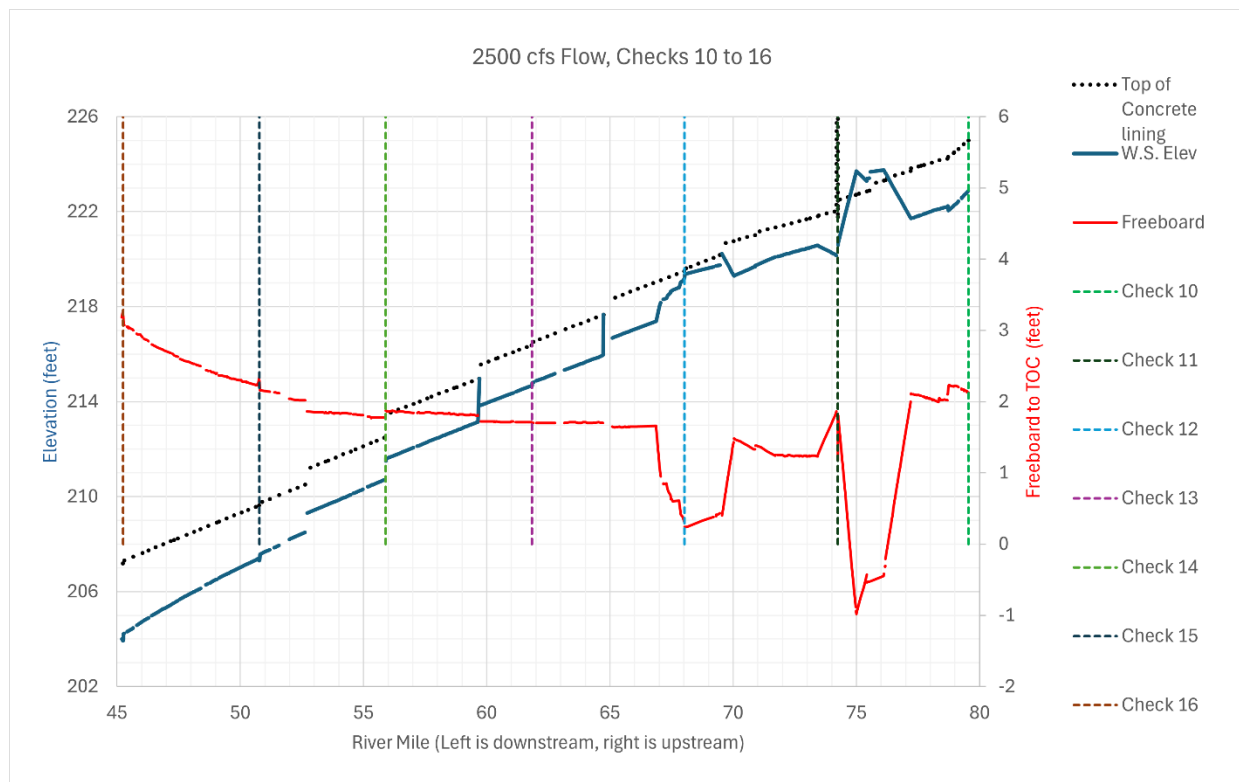


Figure 18. WSE Profile and Freeboard for 2,500 cfs, Checks 10 to 16 (Subsided)

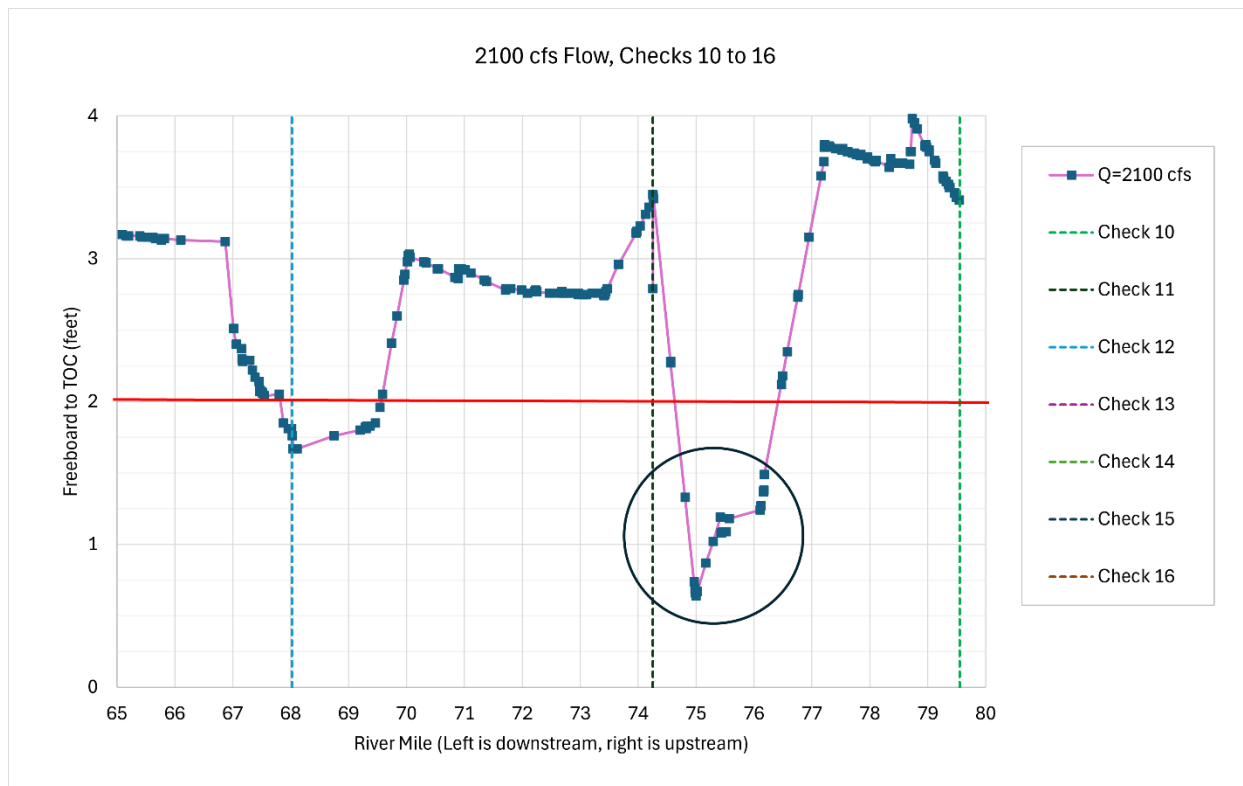


Figure 19. Freeboard for 2,100 cfs, Checks 10 to 12 (Subsided)

6.0 Conclusions and Recommendations

Jacobs expanded the existing 1D HEC-RAS model of the TCC to cover the full length of the canal from Check 1 to Check 26; Jacobs also conducted simulations with as-built geometry and a revised geometry accounting for recent subsidence near Orland. The results of the model were used to quantify freeboard under present conditions and the loss of freeboard relative to as-built conditions.

The model results for as-built conditions (Baseline simulation) show at least 2 feet of freeboard for flows up to 2,400 cfs from Check 1 to Funks Reservoir. The model results for as-built conditions downstream of Funks Reservoir show 1.5 to 3.5 feet of freeboard to the TOC at flows up to 1,900 cfs and at 1,700 cfs there is a minimum of 2.5 feet of freeboard.

Observed land subsidence near Orland has led to a significant reduction in available freeboard along portions of the canal. Model results indicate a flow of 2,100 cfs near Check 11 only provides about 6 inches of freeboard to the top of the concrete lining, showing good agreement with anecdotal observations of limited freeboard near Check 11 in the existing subsided conditions. Under as-built conditions, the canal could pass 2,400 cfs at this location with 2 feet of freeboard to the top of the concrete lining.

Model results were used to support cost estimates for necessary bank mitigation efforts to restore design freeboard and counter recent subsidence. Jacobs provided the cost estimates in the Conveyance Capacity Technical Memorandum.

Based on this analysis, the TCC should have the capacity to accommodate Sites Project flows in coordination with TCCA operations. This is further discussed in the Conveyance Capacity Technical Memorandum.

Recommendations for future work include the following:

- Performing additional surveys to quantify subsidence outside of the section between Checks 10 and 12
- Calibrating water level gages used by TCCA's SCADA system to report conditions upstream and downstream of each check
- Reviewing tools used by TCCA to generate daily summary reports of gate positions

7.0 References

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Attachment 1
Additional Figures with Subsidence

There is negligible difference in model results upstream of Check 10 and downstream of Check 16, with the channel inverts updated to reflect subsidence as documented by R.E.Y. Engineers, Inc. between Check 10 and Check 12. Figures A1-1 through A1-6 present results upstream of Check 10 and downstream of Check 16 for completeness.

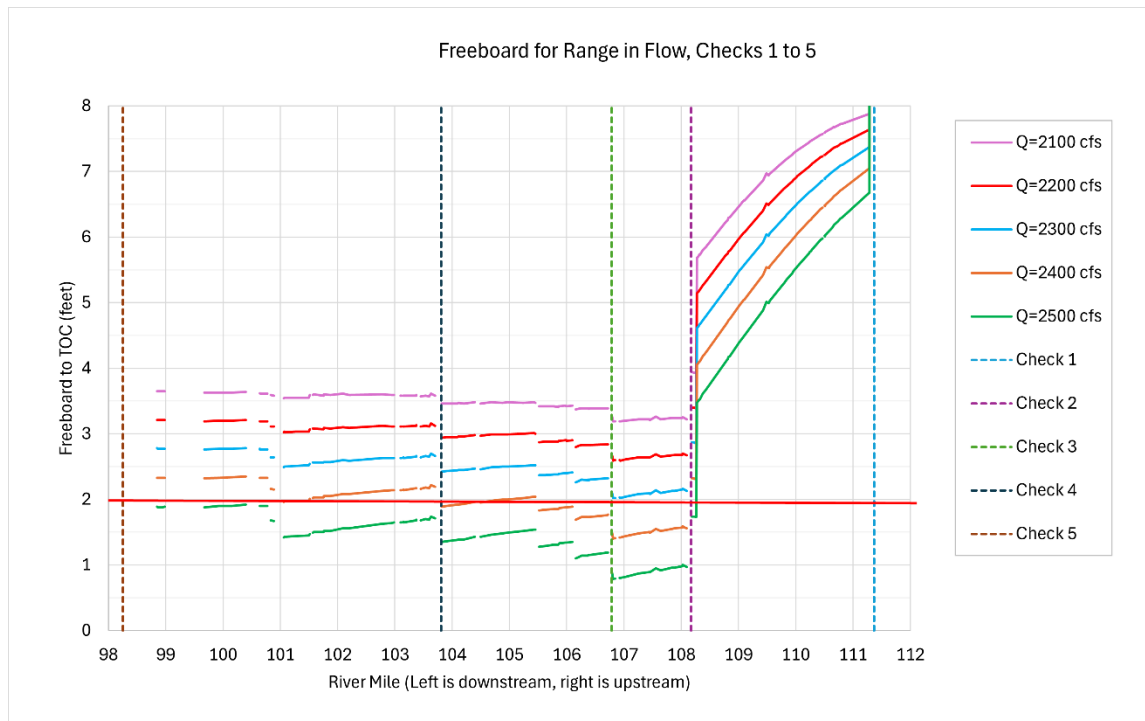


Figure A1-1. Freeboard for Different Flows, Checks 1 to 5 (Subsided)

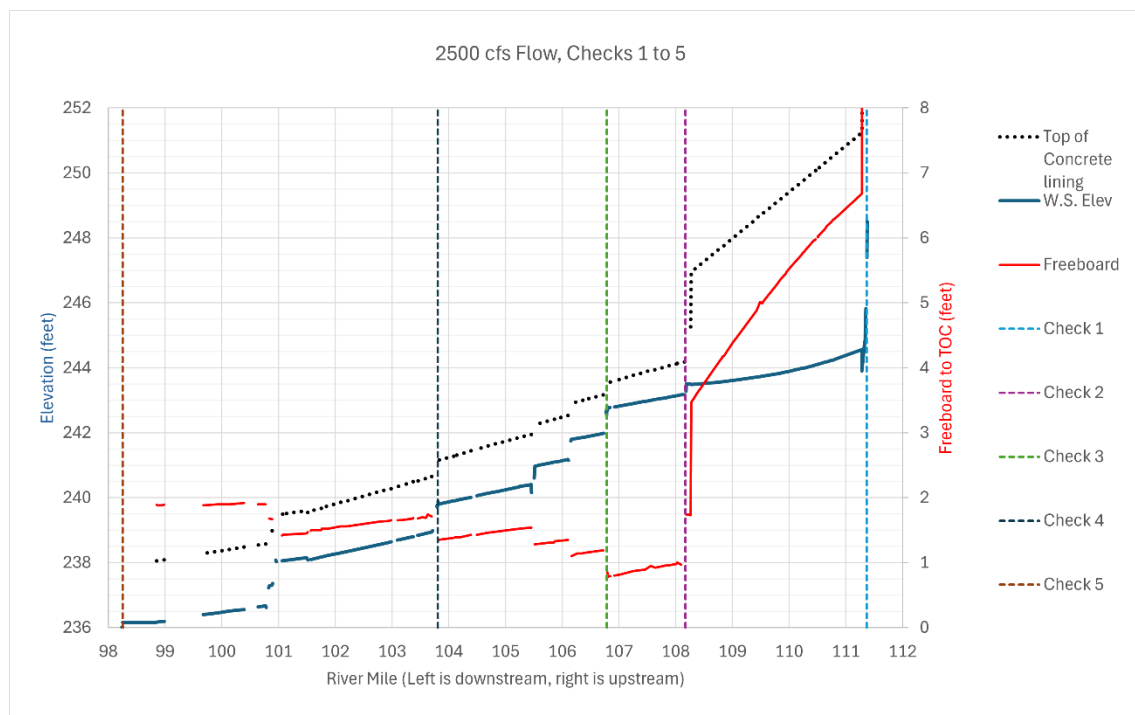


Figure A1-2. Water Surface Elevation Profile for 2,500 cfs, Checks 1 to 5 (Subsided)

Freeboard upstream of Check 2 ranges from 3.5 feet to almost 8 feet for the range of flows shown, because the channel is wider in this section and flow depths are shallower accordingly (Figure A1-1). Freeboard is lowest between Checks 2 and 3, with results indicating a capacity of 2,300 cubic feet per second (cfs) in this reach to maintain 2 feet of freeboard (Figure A1-2).

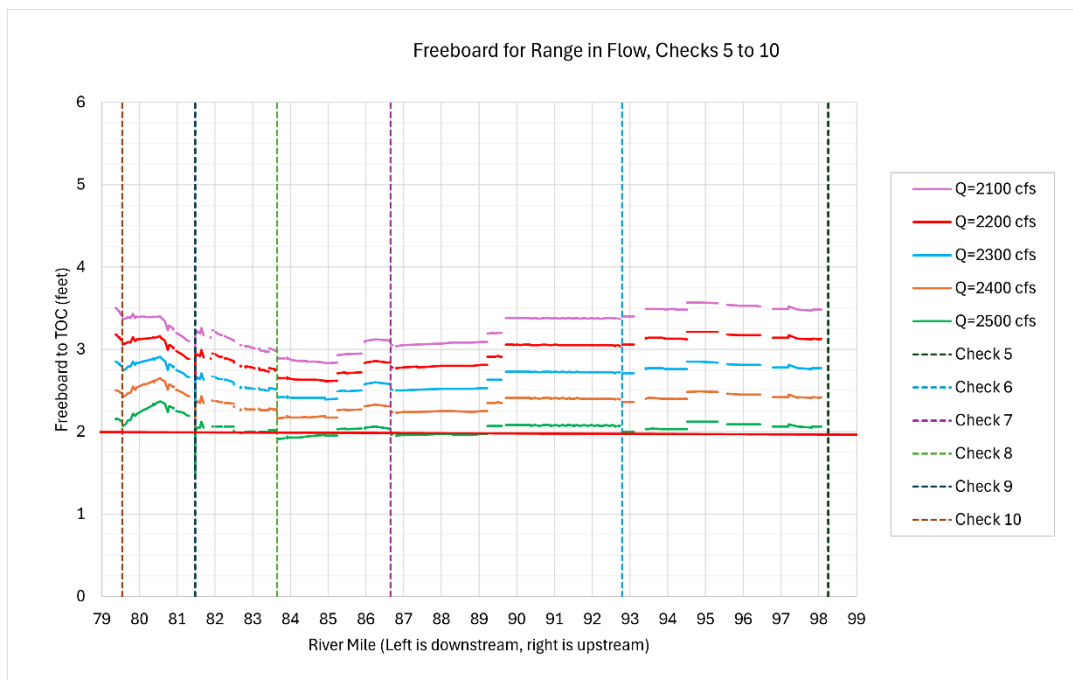


Figure A1-3. Freeboard for Different Flows, Checks 5 to 10 (Subsided)

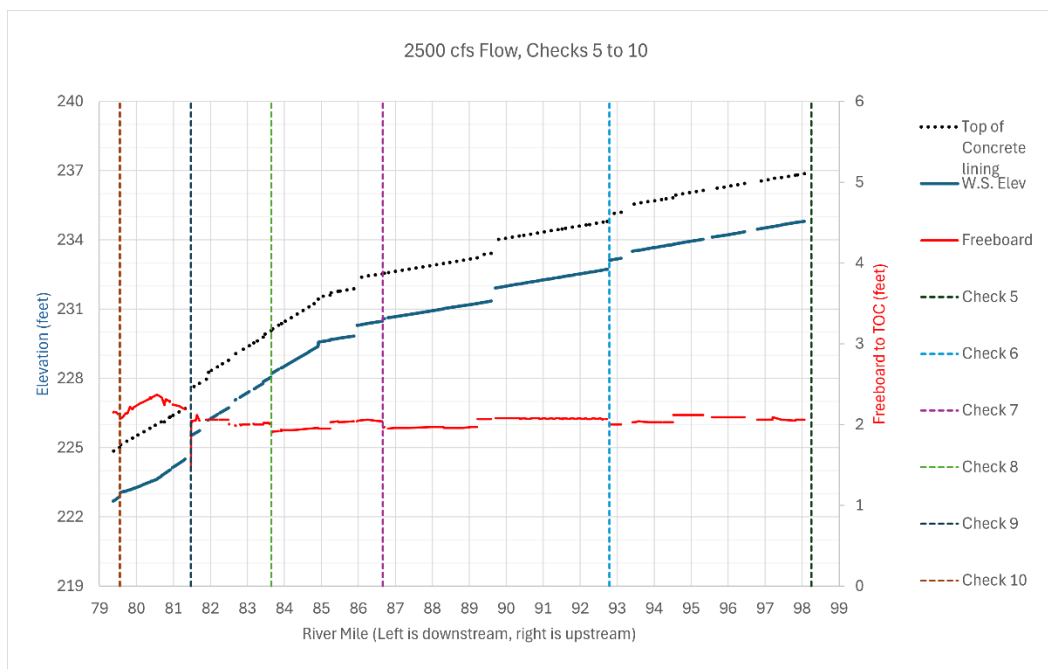


Figure A1-4. Water Surface Elevation Profile for 2,500 cfs, Checks 5 to 10 (Subsided)

Figure A1-3 shows freeboard of 2 feet or higher between Check 5 and Check 10 for flows of 2,400 cfs. Figure A1-4 shows freeboard near 2 feet for a 2,500 cfs flow.

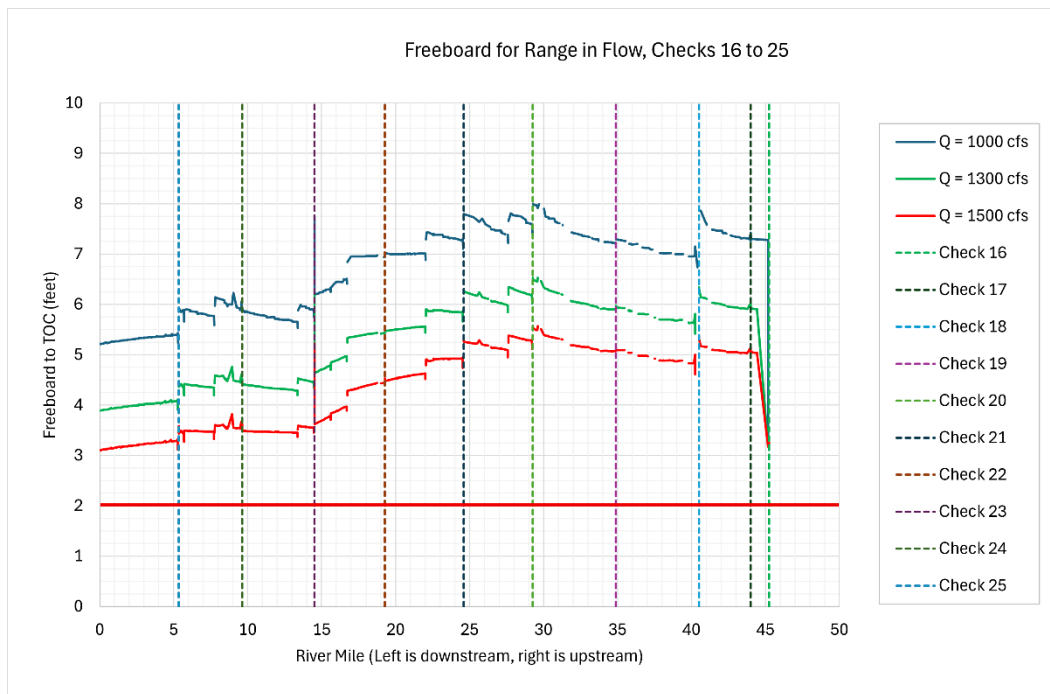


Figure A1-5. Freeboard for Different Flows, Checks 16 to 25 (Subsided)

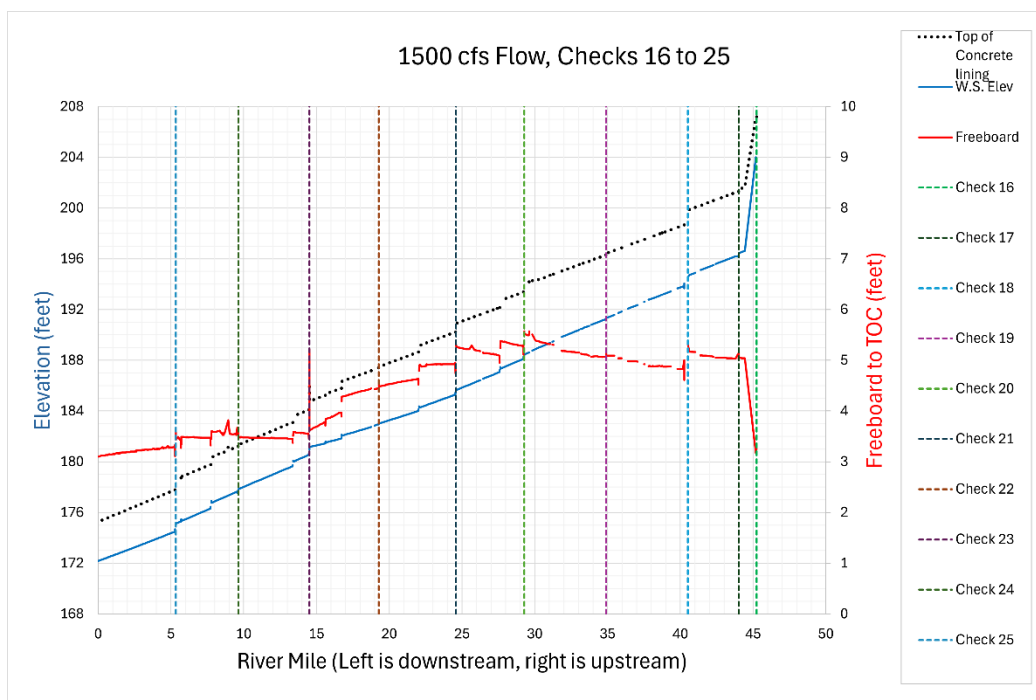


Figure A1-6. Water Surface Elevation Profile for 1,500 cfs, Checks 16 to 25 (Subsided)

Figures A1-5 and A1-6 show sufficient freeboard of 3 feet or greater for flows up to 1,500 cfs downstream of Funks Reservoir.

Appendix 2
TC Canal Improvements
Basis of Estimate



TC Canal Improvements

Feasibility Design Basis of Estimate

March 2026

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Appendix B AACEI Classification

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Acronyms and Abbreviations

AACEI	Association for the Advancement of Cost Engineering International
CBD	Colusa Basin Drain
GC	General Conditions or General Contractor
NTP	Notice to Proceed
TCC	Tehama-Colusa Canal
VE	Value Engineering

1. Executive Summary

1.1 Project Overview

The Sites Reservoir Project consists of a large reservoir, ancillary roads, and conveyance facilities. The Sites Project Authority decided to segregate the design of these facilities into an HR (Segment H Reservoir) segment that is responsible for the design of the reservoir features, including several dams and inlet/outlet tunnels at Golden Gate Dam, as well as relocation of roads displaced by the reservoir. The other segment is known as the HC (Segment H Conveyance) segment and consists of improvements to the two existing diversion canals from the Sacramento River to the Project Area (Tehama-Colusa Canal [TCC] and Glenn-Colusa Irrigation District Main Canal), regulating reservoirs (existing Funks Reservoir and new Terminal Regulating Reservoir), two pumping/generating plants (PGP), large-diameter pipelines from each PGP to Sites Reservoir, and a large-diameter pipeline to convey water from the TCC to the Colusa Basin Drain (CBD) or Sacramento River near Dunnigan, California.

This estimate only covers the TC Canal improvements to raise the banks and liner by 1 to 2 feet at certain locations between Check #10 and Check #12 near Orland, California due to potential subsidence.

Table 1-1. Project Overview
Estimate Information

Estimate Classification	Class 5
Requested By	Sites Project Authority
Estimated By	Tom Jones - Jacobs
Estimate Date	March 2026

1.2 Overall Costs

The cost estimate has been prepared for guidance in project evaluation and implementation, based on the information available at the time of the estimate. The final costs of the project will depend on actual labor and materials costs, competitive market conditions, final project costs, implementation schedule, and other variable factors. As a result, the final project costs will vary from the estimate presented herein. Table 1-2 summarizes the overall costs. See Appendix A for detailed cost estimates.

Costs are presented in 2024 dollars to match the other program costs that were developed in 2025. Escalation is excluded from this estimate but should be added to the costs presented below to account for the probable costs to the midpoint of construction.

Table 1-2. Overall Costs*

	Low Range (-30%)	Estimated Costs	High Range (+50%)
Construction Cost Excluding Non-Contract Costs	\$4,540,000	\$6,490,000	\$9,740,000

* See Attachment A for cost estimate details.

2. Estimate Information

2.1 Purpose of Estimate

The purpose of this estimate of construction costs is to establish an engineer's opinion of probable construction costs at a feasibility level of design development.

2.2 Scope of Work

The TC Canal Improvement project includes the raising of the canal concrete liner and embankment 1 to 2 feet at certain locations between Check #10 and Check #12 near Orland, California due to potential subsidence. The raising of the liner and embankment would re-establish the free board design criteria by the Owner, the U.S. Bureau of Reclamation. There are approximately 13,557 linear feet of canal that need to be raised 1 foot and 2,579 linear feet of canal needing to be raised 2 feet. Approximately 45,500 cubic yards of imported fill will be required for the project to raise the adjacent roadway and berm.

2.3 Estimate Classification

This cost estimate is considered a "Concept Screening" or "Class 5" estimate as defined by the Association for the Advancement of Cost Engineering International (AACEI). Refer to Appendix B for more details.

Project feasibility and funding needs must be carefully reviewed prior to making specific financial decisions to help promote proper project evaluation and adequate funding. This estimate is based on material, equipment, and labor pricing as of December 2024.

This cost estimate is based on the use of conceptual and stochastic costs and detailed items using separate labor, materials, and equipment costs. The estimate uses parametric costs where design information or details are insufficient to allow a detailed item method. Quotations, allowances, and other costs are as described in Section 3.

3. Basis of Estimate

3.1 Estimate Methodology

This cost estimate is considered a bottom-rolled-up-type estimate, with cost items and breakdown of labor, materials, and equipment.

In developing this cost estimate, there were systems that have yet to be defined enough for basing a scope of work for estimates. In these instances, Jacobs provided parametric costing based on a unit of measurement (such as, cost per square foot or cost per unit). The cost is typically developed by averaging similar projects and analysis of historical costs. Using this approach, estimators generated a basic system design that fit the parameters of the structure and its proposed function.

Finally, pricing has been geographically adjusted to reflect local labor and material rates and job site conditions and requirements. As the design process progresses and the details are more defined, the parametric costing can be replaced with a detailed takeoff and estimated accordingly.

The estimate was updated to 2024 dollars by using RS Means 2024 Labor and Construction Equipment Rates. Also certain Material pricing was updated to current Jacobs database values, and others adjusted by estimator judgement.

3.2 Estimate Major Assumptions

The estimate assumes the work will be done on a competitive-bid basis and the contractor will have a reasonable amount of time to complete the work. All contractors are equal, with a reasonable project schedule and no overtime, constructed as under a single contract, with no liquidated damages.

This estimate should be evaluated for market changes after 90 days of the issue date. It is assumed that much of the fabricated equipment will be shipped from the mainland United States.

3.3 Estimate Exclusions

The cost estimate excludes the following costs:

- Remediation of hazardous materials
- Material adjustment allowances above and beyond those included at the time of the cost estimate
- Non-Contract costs

3.4 Project Delivery and Methodology

It is assumed that this project will be procured using the traditional design-bid-build method. The general contractor will contract directly with the owner.

3.5 Labor, Material, Subcontracts, and Other Direct Costs

3.5.1 Labor

The estimate has been adjusted for local area labor rates, based upon 2024 national union rates.

Labor unit prices reflect a burdened rate, including: workers compensation, unemployment taxes, fringe benefits, and medical insurance.

3.5.2 Materials

Materials pricing is based on the national averages, as determined by RS Means or other data sources. Quotes on certain items may have been obtained and included in this estimate. Many quotes given for engineering estimates are budgetary and may not reflect actual contractor pricing.

3.5.3 Subcontracts

It is assumed that General Contractors will subcontract a portion of the work. Items listed in the cost estimate as “subcontractor” include all anticipated markups that a general contractor would receive.

3.5.4 Construction Equipment

Equipment items listed in this cost estimate are for the construction equipment necessary for installation of the work. Equipment rates in this estimate are assumed to be 100% of the 2024 Blue Book value.

3.6 Markups, Taxes, and Other Indirect Costs

It is assumed that this project will be procured using the traditional design-bid-build method. The general contractor will contract directly with the owner. Table 3-1 summarized estimates for markups, taxes, and other indirect costs.

Table 3-1. Markups, Taxes, and Other Indirect Costs Estimate Summary

Item	Unit	Comments
Subcontractor Markups	20.00% to 25.00%	Varies by trade
Materials Sales Tax	8.25%	Current sales tax rate for Orland, California
General Conditions	5.00%	
Mobilization/Demobilization	3.00%	
Prime Contractor Overhead	10.00%	Includes home office and construction site overhead
Prime Contractor Profit	6.00%	
Bonds and Insurances	2.17%	
Contractor Contingency	3.00%	
Design Contingency	30.00%	
Escalation		No escalation included in this estimate
Non-Contract Costs	0.00%	Excluded from estimate

3.7 Design Contingency

A design contingency of 30% is included to account for the level of design detail and the potential for additional unforeseen site conditions identified during the design phase. The contingencies are intended to allow for scope inherent in the individual projects, but not yet identified in the design documentation. This contingency would be fully consumed or released by the completion of the procurement documents.

3.8 Contractor Contingency

Contractor contingency is intended to cover unforeseen conditions or changes post contract award. It remains under the control of the owner, separate from the bid award. Contractor contingencies vary from 3 to 5% based on the construction project types. Electrical transmission lines and PG&E substations include 5%. All other HC estimates include 3%.

3.9 Escalation Costs

There is no escalation included in this estimate.

3.10 Non-Contract Costs

Non-contract costs include geotechnical investigation, engineering, construction management, administration, real estate, legal services, permitting costs, environmental monitoring, and other owner costs attributable to the project. These costs are not included in this estimate.

3.11 Market Conditions

During volatile economic conditions, an estimate may have a market conditions amount applied. This adjustment is done to account for the current volatility in the construction market and/or the location of a project. However, based on the current construction market, and location of the work proposed in this estimate, a market conditions adjustment was not applied.

3.12 Cost Resources

Cost resources used in the development of the cost estimate include the following:

- R.S. Means 2024 data
- CH2M HILL and Jacobs historical data
- Vendor quotes, where available
- Estimator judgment

3.13 Disclaimer

The opinions of cost (estimates) shown, and any resulting conclusions on project financial or economic feasibility or funding requirements, have been prepared for guidance in project evaluation and implementation from the information available at the time the opinion was prepared. The final costs of the project and resulting feasibility will depend on actual labor and material costs, competitive market

conditions, actual site conditions, final project scope, implementation schedule, continuity of personnel and engineering, and other variable factors. The recent increases or decreases in materials pricing may have a significant impact that is not predictable. Careful review or consideration must be used in evaluating materials prices. As a result, the final project costs will vary from the opinions of cost presented herein. Because of these factors, project feasibility, benefit/cost ratios, risks, and funding needs must be carefully reviewed prior to making specific financial decisions or establishing project budgets to help promote proper project evaluation and adequate funding.

Appendix A

Detailed Cost Estimate



Summary Report

Project Name: TC Canal Improvements
Project Number: D3380605
Design Stage: Concept Screening

Estimator: Tom Jones
Rev No. / Data: R01 - 03/30/2026
Class Estimate: Class 5

Facility	WorkActiv	Description	Takeoff Quantity	Grand Total Price	Grand Total Amount
01		TC Canal Improvements			
	01.00.700	Erosion Controls and Dust Abatement	24.00 MO	19,149.52 /MO	459,588
	02.01.01.0010	Sawcut and Remove Existing Liner Top Edge	16,136.21 SF	11.63 /SF	187,595
	03.10.05.0010	Concrete Liner, 1' Freeboard Increase	62,446.77 SF	22.67 /SF	1,415,959
	03.10.05.0020	Concrete Liner, 2' Freeboard Increase	19,338.75 SF	17.90 /SF	346,260
	31.00.700	Gravel Surfacing	28,687.00 SY	42.75 /SY	1,226,250
	31.00.728	Import Aggregate Base	45,463.00 CY	62.87 /CY	2,858,184
		01 TC Canal Improvements	1.00 LS	6,493,835.93 /LS	6,493,836

Estimate Totals

Description	Amount	Totals	Hours	Rate
Labor	2,718,955		20,266.668	
Material	2,252,267			
Allowance	22,971			
Equipment	1,499,643		12,636.185	
Other				
Total Construction Cost	6,493,836	6,493,836		



Detail Report

Project Name: TC Canal Improvements
Project Number: D3380605
Design Stage: Concept Screening

Estimator: Tom Jones
Rev No. / Data: R01 - 03/30/2026
Class Estimate: Class 5

Facility	WorkActiv	Work Pkg	Unit Price	Description	Takeoff Quantity	Labor Hours	Labor Amount	Material Amount	Sub Amount	Equip Amount	Other Amount	Total Cost/Unit	Total Amount	Grand Total Price	Grand Total Amount
01				TC Canal Improvements											
	01.00.700			Erosion Controls and Dust Abatement											
		01.0		General Requirements											
			01.01.05.00	General Conditions, Other											
				Erosion Controls and Dust Abatement Allowance	24.00 MO		120,000	24,000	-	120,000	-	11,000.00 /MO	264,000	19,149.52 /MO	459,588
				01.01.05.00 General Conditions, Other	24.00 MO		120,000	24,000		120,000		11,000.00 /MO	264,000	19,149.52 /MO	459,588
				01.0 General Requirements	24.00 MO		120,000	24,000		120,000		11,000.00 /MO	264,000	19,149.52 /MO	459,588
				01.00.700 Erosion Controls and Dust Abatement	24.00 MO		120,000	24,000		120,000		11,000.00 /MO	264,000	19,149.52 /MO	459,588
	02.01.01.0010			Sawcut and Remove Existing Liner Top Edge											
		02.0		Existing Conditions											
			02.01.01.00	General Site Demolition											
				Selective demolition, cutout, slab on grade, non-reinforced, to 6" thick, 8-16 S.F., excludes loading and disposal	16,136.21 SF	323	20,263	-	-	2,571	-	1.42 /SF	22,834	2.45 /SF	39,580
				Sawcutting, concrete slabs, mesh or bar reinforcing, up to 3" deep	32,272.42 lf	527	38,857	4,195	-	22,309	-	2.03 /lf	65,361	3.52 /lf	113,641
				02.01.01.00 General Site Demolition	16,136.21 SF	850	59,120	4,195		24,881		5.47 /SF	88,196	9.50 /SF	153,222
			31.20.15.00	Earthworks, Sitework, Hauling and Dump Fees											
				Selective demolition, dump charges, typical urban city, building construction materials, includes tipping fees only	175.00 CY		-	12,950	-	-	-	74.00 /CY	12,950	134.37 /CY	23,515
				Hauling,excavated borrow material,loose cubic yards,10 mile round trip,.6 loads/hr ,base wide rate,12 cy truck,highway haulers,excludes loading	18.00 ld	36	2,632	-	-	3,632	-	348.01 /ld	6,264	603.23 /ld	10,858
				31.20.15.00 Earthworks, Sitework, Hauling and Dump Fees	175.00 CY	36	2,632	12,950		3,632		109.80 /CY	19,214	196.42 /CY	34,374
				02.0 Existing Conditions	16,136.21 SF	886	61,752	17,145		28,513		6.66 /SF	107,410	11.63 /SF	187,595
				02.01.01.0010 Sawcut and Remove Existing Liner Top Edge	16,136.21 SF	886	61,752	17,145		28,513		6.66 /SF	107,410	11.63 /SF	187,595
	03.10.05.0010			Concrete Liner, 1' Freeboard Increase											
		03.0		Concrete Work											
			03.10.05.04	Cast-In-Place Concrete, Slabs on Grade, 4" thick											
				Fine grade, for slab on grade, by hand	62,446.77 sf	437	25,455	1,873	-	-	-	0.44 /sf	27,329	0.76 /sf	47,525
				Concrete pumping, subcontract, all inclusive price	674.58 cy		-	-	10,119	-	-	15.00 /cy	10,119	26.00 /cy	17,539
				Slab on grade edge forms, up to 6"	27,124.61 lf	1,438	103,413	7,052	-	-	-	4.07 /lf	110,465	7.08 /lf	192,058
				Slab on grade bulkhead form	365.17 sf	110	7,880	456	-	-	-	22.83 /sf	8,337	39.68 /sf	14,488
				Keyway form	27,115.40 lf	4,067	292,578	13,558	-	-	-	11.29 /lf	306,136	19.61 /lf	531,763
				Expansion joint material, closed cell neoprene, 1"	365.17 sf	11	788	2,191	-	-	-	8.16 /sf	2,979	14.64 /sf	5,345
				Speed Dowels, #3	5,422.00 ea		-	27,110	-	-	-	5.00 /ea	27,110	9.08 /ea	49,228
				Wire welded fabric, 6 x 6 - W1.4 x W1.4	62,446.77 sf	624	50,363	4,996	-	-	-	0.89 /sf	55,358	1.54 /sf	96,369
				Concrete, ready mix, 4500 psi	674.58 CY		-	89,044	-	-	-	132.00 /CY	89,044	239.69 /CY	161,693
				Add for concrete waste, 4500 psi	33.73 cy		-	4,452	-	-	-	132.00 /cy	4,452	239.69 /cy	8,085
				Placing concrete, concrete pump	674.58 cy	506	29,462	-	-	-	-	43.67 /cy	29,462	75.70 /cy	51,069
				Finishing floors, monolithic, broom finish	62,446.77 SF	1,873	127,721	1,249	-	-	-	2.07 /SF	128,970	3.58 /SF	223,655
				Curing, membrane spray	62,446.77 sf	125	7,273	2,498	-	-	-	0.16 /sf	9,771	0.27 /sf	17,142
				03.10.05.04 Cast-In-Place Concrete, Slabs on Grade, 4" thick	674.58 CY	9,191	644,933	154,480	10,119			1,200.05 /CY	809,532	2,099.03 /CY	1,415,959
				03.0 Concrete Work	674.58 CY	9,191	644,933	154,480	10,119			1,200.05 /CY	809,532	2,099.03 /CY	1,415,959
				03.10.05.0010 Concrete Liner, 1' Freeboard Increase	62,446.77 SF	9,191	644,933	154,480	10,119			12.96 /SF	809,532	22.67 /SF	1,415,959
	03.10.05.0020			Concrete Liner, 2' Freeboard Increase											
		03.0		Concrete Work											
			03.10.05.04	Cast-In-Place Concrete, Slabs on Grade, 4" thick											
				Fine grade, for slab on grade, by hand	19,338.75 sf	135	7,883	580	-	-	-	0.44 /sf	8,463	0.76 /sf	14,718
				Concrete pumping, subcontract, all inclusive price	208.91 cy		-	-	3,134	-	-	15.00 /cy	3,134	26.00 /cy	5,432
				Slab on grade edge forms, up to 6"	5,172.00 lf	274	19,718	1,345	-	-	-	4.07 /lf	21,063	7.08 /lf	36,621
				Slab on grade bulkhead form	113.75 sf	34	2,455	142	-	-	-	22.83 /sf	2,597	39.68 /sf	4,513
				Keyway form	5,157.00 lf	774	55,645	2,579	-	-	-	11.29 /lf	58,223	19.61 /lf	101,135
				Expansion joint material, closed cell neoprene, 1"	113.75 sf	3	245	683	-	-	-	8.16 /sf	928	14.64 /sf	1,665
				Speed Dowels, #3	1,032.00 ea		-	5,160	-	-	-	5.00 /ea	5,160	9.08 /ea	9,370
				Wire welded fabric, 6 x 6 - W1.4 x W1.4	19,338.75 sf	193	15,597	1,547	-	-	-	0.89 /sf	17,144	1.54 /sf	29,844
				Concrete, ready mix, 4500 psi	208.91 CY		-	27,576	-	-	-	132.00 /CY	27,576	239.69 /CY	50,074
				Add for concrete waste, 4500 psi	10.45 cy		-	1,379	-	-	-	132.00 /cy	1,379	239.69 /cy	2,504
				Placing concrete, concrete pump	208.91 cy	157	9,124	-	-	-	-	43.67 /cy	9,124	75.70 /cy	15,815
				Finishing floors, monolithic, broom finish	19,338.75 SF	580	39,553	387	-	-	-	2.07 /SF	39,940	3.58 /SF	69,262
				Curing, membrane spray	19,338.75 sf	39	2,252	774	-	-	-	0.16 /sf	3,026	0.27 /sf	5,309
				03.10.05.04 Cast-In-Place Concrete, Slabs on Grade, 4" thick	208.91 CY	2,189	152,472	42,150	3,134			946.62 /CY	197,755	1,657.49 /CY	346,260
				03.0 Concrete Work	208.91 CY	2,189	152,472	42,150	3,134			946.62 /CY	197,755	1,657.49 /CY	346,260
				03.10.05.0020 Concrete Liner, 2' Freeboard Increase	19,338.75 SF	2,189	152,472	42,150	3,134			10.23 /SF	197,755	17.90 /SF	346,260
	31.00.700			Gravel Surfacing											
		32.0		Exterior Improvements											
			32.40.04.00	Site Improvements, Access Roads, Gravel											
				Fine grading, for roadway, base or leveling course, large area, 6,000 S.Y. or more	28,687.00 SY	229	16,417	-	-	15,965	-	1.13 /SY	32,382	1.96 /SY	56,130
				Base course drainage layers,aggregate base course for levee road,crushed stone base,compacted,crushed 1-1/2"stone base,6"deep	28,687.00 sy	483	35,370	547,922	-	37,456	-	21.64 /sy	620,748	39.08 /sy	1,121,187
				Base course drainage layers, prepare and roll sub-base, large areas over 2500 S.Y.	28,687.00 sy	197	14,679	-	-	13,551	-	0.98 /sy	28,230	1.71 /sy	48,933
				32.40.04.00 Site Improvements, Access Roads, Gravel	28,687.00 SY	909	66,467	547,922		66,972		23.75 /SY	681,360	42.75 /SY	1,226,250
				32.0 Exterior Improvements	1.00 LS	909	66,467	547,922		66,972		681,360.45 /LS	681,360	1,226,249.98 /LS	1,226,250
				31.00.700 Gravel Surfacing	28,687.00 SY	909	66,467	547,922		66,972		23.75 /SY	681,360	42.75 /SY	1,226,250
	31.00.728			Import Aggregate Base											
		31.0		Earthwork											
			31.20.07.00	Earthworks, Sitework, Cut/Fill											
				Excavating, Levee Key, common earth, 3/4 C.Y. excavator, 4' to 6' deep, excavator, excludes sheeting or dewatering	5,000.00 cy	267	19,673	-	-	15,561	-	7.05 /cy	35,234	12.21 /cy	61,074
				Construct Levee Fill w/200 HP dozer	45,463.00 CY	742	55,401	-	-	87,183	-	3.14 /CY	142,584	5.44 /CY	247,150
				Purchase and Deliver Levee Fill Material	45,463.00 cy	4,546	332,371	454,630	-	414,250	-	26.42 /cy	1,201,251	46.63 /cy	2,119,713
				Compaction, water for, 3000 gallon truck, 3 mile haul	50,463.00 cy	404	31,066	-	-	23,500	-	1.08 /cy	54,566	1.87 /cy	94,583
				Compaction, structural, common fill, 8" lifts, sheepfoot	50,463.00 cy	454	33,891	-	-	29,549	-	1.26 /cy	63,441	2.18 /cy	109,966
				Grading Levee Fill top/sideslopes w/dozer	75,302.00 sy	678	50,573	-	-	79,635	-	1.73 /sy	130,208	3.00 /sy	225,698



Detail Report

Project Name: TC Canal Improvements
Project Number: D3380605
Design Stage: Concept Screening

Estimator: Tom Jones
Rev No. / Data: R01 - 03/30/2026
Class Estimate: Class 5

Facility	WorkActiv	Work Pkg	Unit Price	Description	Takeoff Quantity	Labor Hours	Labor Amount	Material Amount	Sub Amount	Equip Amount	Other Amount	Total Cost/Unit	Total Amount	Grand Total Price	Grand Total Amount
				31.20.07.00 Earthworks, Sitework, Cut/Fill	45,463.00 CY	7,091	522,976	454,630		649,678		35.79 /CY	1,627,284	62.87 /CY	2,858,184
				31.0 Earthwork	45,463.00 CY	7,091	522,976	454,630		649,678		35.79 /CY	1,627,284	62.87 /CY	2,858,184
				31.00.728 Import Aggregate Base	45,463.00 CY	7,091	522,976	454,630		649,678		35.79 /CY	1,627,284	62.87 /CY	2,858,184
				01 TC Canal Improvements	1.00 LS	20,267	1,568,599	1,240,327	13,252	865,163		3,687,341.35 /LS	3,687,341	6,493,835.93 /LS	6,493,836



Estimate Totals

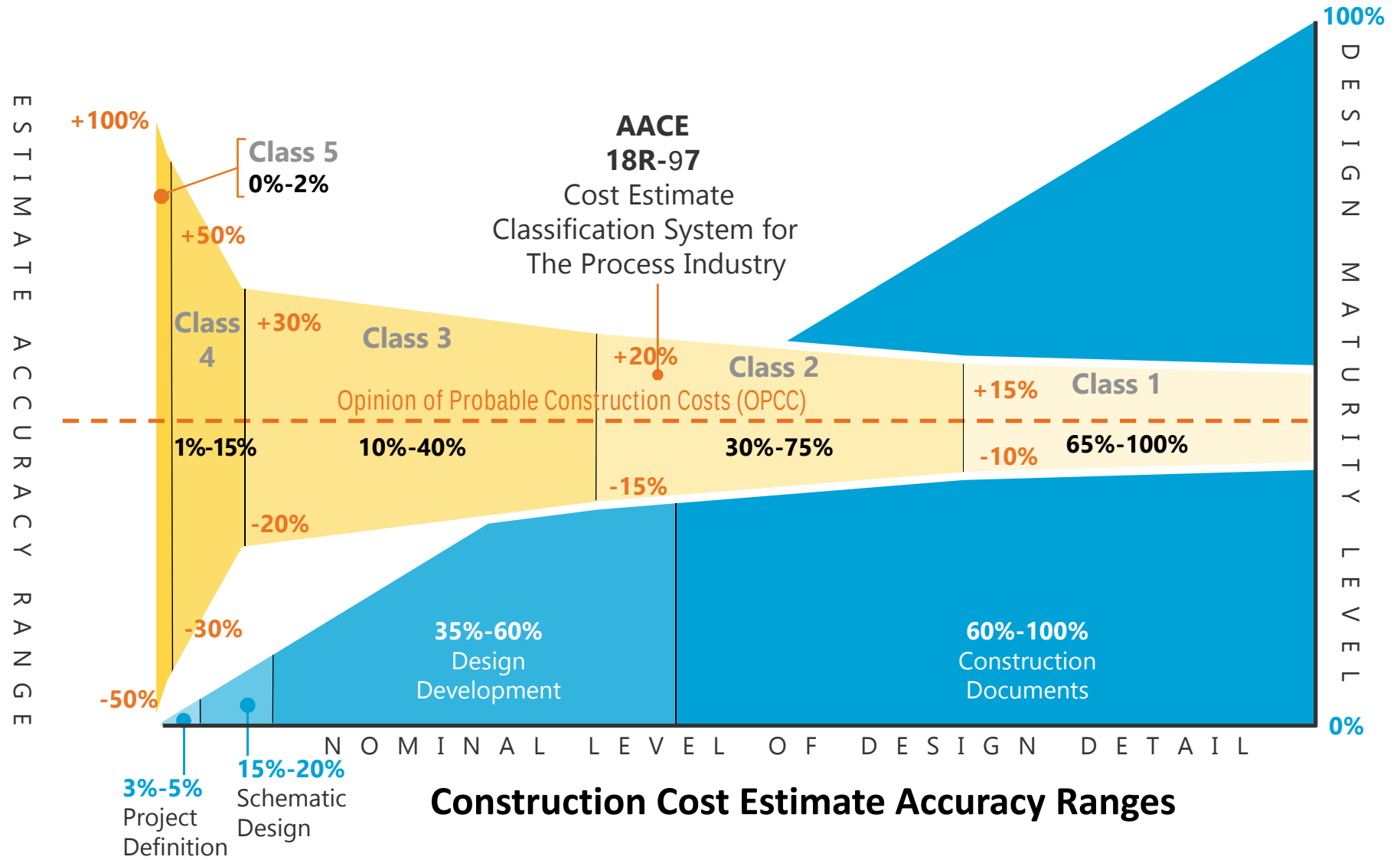
Description	Amount	Totals	Hours	Rate
Labor	1,568,599		20,266.668	
Material	1,240,327			
Allowance	13,252			
Equipment	865,163		12,636.185	
Other				
Subtotal Direct Costs	3,687,341	3,687,341		
Material Sales Tax, Orland Ca	102,327			8.25 %
Subtotal W/ Sales Tax	102,327	3,789,668		
Electrical Work I,OH&P				25.00 %
Instruments & Controls I,OH&P				20.00 %
Subtotal W/ Subcontractor OH&P		3,789,668		
General Conditions	189,483			5.00 %
Subtotal W/ General Conditions	189,483	3,979,152		
Mobilization/Demobilization	119,375			3.00 %
Prime Contractor Overhead	409,853			10.00 %
Prime Contractor Profit	270,503			6.00 %
Bonds & Insurance	103,702			2.17 %
Subtotal W/ Prime Markups	903,432	4,882,583		
Contractor Contingency	146,478			3.00 %
Design Contingency	1,464,775			30.00 %
Subtotal W/ Contingency	1,611,253	6,493,836		
Total Construction Cost		6,493,836		

Appendix B

AACEI Classification

Estimate Class	Class 5		Class 4		Class 3		Class 2		Class 1	
LEVEL OF PROJECT DEFINITION Expressed as a % of complete definition	0% to 2%		1% to 15%		10% to 40%		30% to 75%		65% to 100%	
END USAGE Typical Purpose of Estimate	Concept Screening		Study or Feasibility		Budget Authorization, or Control		Control or Bid / Tender		Check Estimate or Bid / Tender	
METHODOLOGY Typical estimating method	Capacity Factored, Parametric Models, Judgment, or Analogy		Equipment Factored or Parametric Models		Semi-Detailed Unit Costs with Assembly Level Line Items		Detailed Unit Cost with Forced Detailed Take-Off		Detailed Unit Cost with Detailed Take-Off	
EXPECTED ACCURACY RANGE Typical variation in low and high ranges [a]	L: -20% to -50%	H: +30% to +100%	L: -15% to -30%	H: +20% to +50%	L: -10% to -20%	H: +10% to +30%	L: -5% to -15%	H: +5% to +20%	L: -3% to -10%	H: +3% to +15%
REFINED CLASS DEFINITION	Class 5 estimates are generally prepared based on very limited information, and subsequently have very wide accuracy ranges. As such, some companies and organizations have elected to determine that due to the inherent inaccuracies, such estimates cannot be classified in a conventional and systematic manner. Class 5 estimates, due to the requirements of end use, may be prepared within a very limited amount of time and with very little effort expended - sometimes requiring less than 1 hour to prepare. Often, little more than proposed plant type, location, and capacity are known at the time of estimate preparation.		Class 4 estimates are generally prepared based on very limited information, and subsequently have very wide accuracy ranges. They are typically used for project screening, determination of feasibility, concept evaluation, and preliminary budget approval. Typically, engineering is from 1% to 5% complete, and would comprise at a minimum the following: plant capacity, block schematics, indicated layout, process flow diagrams (PFDs) for main process systems and preliminary engineered process and utility equipment lists. Level of Project Definition Required: 1% to 15% of full project definition.		Class 3 estimates are generally prepared to form the basis for budget authorization, appropriation, and/or funding. As such, they typically form the initial control estimate against which all actual costs and resources will be monitored. Typically, engineering is from 10% to 40% complete, and would comprise at a minimum the following: process flow diagrams, utility flow diagrams, preliminary piping and instrument diagrams, utility flow diagrams, preliminary piping and instrument diagrams, plot plan, developed layout drawings, and essentially complete engineering process and utility equipment lists. Level Of Project Definition Required: 10% to 40% of full project definition.		Class 2 estimates are generally prepared to form a detailed control baseline against which all project work is monitored in terms of cost and progress control. For contractors, this class of estimate is often used as the "bid" estimate to establish contract value. Typically, engineering is from 30% to 70% complete, and would comprise at a minimum the following: Process flow diagrams, utility flow diagrams, piping and instrument flow diagrams, heat and material balances, final plot plan, final layout drawings, complete engineered process and utility equipment lists, single line diagrams for electrical, electrical equipment and motor schedules, vendor quotations, detailed project execution plans, resourcing and work force plans, etc.		Class 1 estimates are generally prepared for discrete parts or sections of the total project rather than generating this level of detail for the entire project. The parts of the project estimated at this level of detail will typically be used by subcontractors for bids, or by owners for check estimates. The updated estimate is often referred to as the current control estimate and becomes the new baseline for cost/schedule control of the project. Class 1 estimates may be prepared for parts of the project to comprise a fair price estimate or bid check estimate to compare against a contractor's bid estimate, or to evaluate/dispute claims. Typically, engineering is from 65% to 100% complete, and would comprise virtually all engineering and design documentation of the project, and complete project execution and commissioning plans. Level for Project Definition Required: 50% to 100% of full project definition.	
MATURITY LEVEL OF PROJECT DELIVERABLES	Key deliverable and target status: Block flow diagram agreed by key stakeholders. 0% to 2% of full project definition.		Key deliverable and target status: Process flow diagrams (PFDs) issued for design. 1% to 15% of full project definition.		Key deliverable and target status: Piping and instrumentation diagrams (P&IDs) issued for design. 10% to 40% of full project definition.		Key deliverable and target status: All specifications and datasheets complete including for instrumentation. 30% to 75% of full project definition.		Key deliverable and target status: All deliverables in the maturity matrix complete. 65% to 100% of full project definition.	
END USAGE DEFINED	Class 5 estimates are prepared for any number of strategic business planning purposes, such as but not limited to market studies, assessment of initial viability, evaluation of alternate schemes, project screening, project location studies, evaluation of resource needs and budgeting, long-range capital planning, etc.		Class 4 estimates are prepared for a number of purposes, such as but not limited to, detailed strategic planning, business development, project screening at more developed stages, alternative scheme analysis, confirmation of economic and/or technical feasibility, and preliminary budget approval or approval to proceed to next stage.		Class 3 estimates are typically prepared to support full project funding requests, and become the first of the project phase control estimates against which all actual costs and resources will be monitored for variations to the budget. They are used as the project budget until replaced by more detailed estimates. In many owner organizations, a Class 3 estimate is often the last estimate required and could very well form the only basis for cost/schedule control.		Class 2 estimates are typically prepared as the detailed control baseline against which all actual costs an resources will now be monitored for variation to the budget, and form a part of the change/variation control program.		Generally, owners and EPC contractors use Class 1 estimates to support their change management process. They may be used to evaluate bid checking, to support vendor/contractor negotiations, or for claim evaluations and dispute resolution. Construction contractors may prepare Class 1 estimates to support their bidding and to act as their final control baseline against which all actual costs and resources will now be monitored for variations to their bid. During construction, Class 1 estimates may be prepared to support change management.	
ESTIMATING METHODOLOGY	Class 5 estimates virtually always use stochastic estimating methods such as cost/capacity curves and factors, scale of operations factors, Lang factors, Hand factors, Chilton factors, Peters-Timmerhaus factors, Guthrie factors, and other parametric and modeling techniques.		Class 4 estimates virtually always use stochastic estimating methods such as cost/capacity curves and factors, scale of operations factors, Lang factors, Hand factors, Chilton factors, Peters-Timmerhaus factors, Guthrie factors, the Miller method, gross unit costs/ratios, and other parametric and modeling techniques.		Class 3 estimates usually involve more deterministic estimating methods that stochastic methods. They usually involve a high degree of unit cost line items, although these may be at an assembly level of detail rather than individual components. Factoring and other stochastic methods may be used to estimate less-significant areas of the project.		Class 2 estimates always involve a high degree of deterministic estimating methods. Class 2 estimates are prepared in great detail, and often involve tens of thousands of unit cost line items. For those areas of the project still undefined, an assumed level of detailed takeoff (forced detail) may be developed to use as line items in the estimate instead of relying on factoring methods.		Class 1 estimates involve the highest degree of deterministic estimating methods, and require a great amount of effort. Class 1 estimates are prepared in great detail, and thus are usually performed on only the most important or critical areas of the project. All items in the estimate are usually unit cost line items based on actual design quantities.	
EXPECTED ACCURACY RANGE	Typical accuracy ranges for Class 5 estimates are -20% to -50% on the low side, and +30% to +100% on the high side, depending on the technological complexity of the project, appropriate reference information and other risks (after inclusion of an appropriate contingency determination). Ranges could exceed those shown if there are unusual risks.		Typical accuracy ranges for Class 4 estimates are -15% to -30% on the low side, and +20% to +50% on the high side, depending on the technological complexity of the project, appropriate reference information, and the inclusion of an appropriate contingency determination. Ranges could exceed those shown in unusual circumstances.		Typical accuracy ranges for Class 3 estimates are -10% to -20% on the low side, and +10% to +30% on the high side, depending on the technological complexity of the project, appropriate reference information, and the inclusion of an appropriate contingency determination. Ranges could exceed those shown in unusual circumstances.		Typical accuracy ranges for Class 2 estimates are -5% to -15% on the low side, and +5% to +20% on the high side, depending on the technological complexity of the project, appropriate reference information, and the inclusion of an appropriate contingency determination. Ranges could exceed those shown in unusual circumstances.		Typical accuracy ranges for Class 1 estimates are -3% to -10% on the low side, and +3% to +15% on the high side, depending on the technological complexity of the project, appropriate reference information, and the inclusion of an appropriate contingency determination. Ranges could exceed those shown in unusual circumstances.	
EFFORT TO PREPARE (for US\$20MM project):	As little as 1 hour or less to prepare to perhaps more than 200 hours, depending on the project and the estimating methodology used.		Typically, as little as 20 hours or less to perhaps more than 300 hours, depending on the project and the estimating methodology used.		Typically, as little as 150 hours or less to perhaps more than 1500 hours, depending on the project and the estimating methodology used.		Typically, as little as 300 hours or less to perhaps more than 3000 hours, depending on the project and the estimating methodology used. Bid Estimates typically require more effort than estimates used for funding or control purposes		Class 1 estimates require the most effort to create, and as such are generally developed for only selected areas of the project, or for bidding purposes. A complete Class 1 estimate may involve as little as 600 hours or less, to perhaps more than 6,000 hours, depending on the project and the estimating methodology used. Bid estimate typically require more effort than estimates used for funding or control purposes.	
ANSI Standard Reference Z94.2-1989 name; Alternate Estimate Names, Terms, Expressions, Synonyms:	Order of Magnitude Estimate; Ratio, ballpark, blue sky, seat-of-pants, ROM, idea study, prospect estimate, concession license estimate, guesstimate, rule-of thumb.		Budget Estimate; Screening, top-down, feasibility, authorization, factored, pre-design, pre-study.		Budget, scope, sanction, semi-detailed, authorization, preliminary control, concept study, feasibility (for metals processes) development, basic engineering phase estimate, target estimate.		Detailed control, forced detail, execution phase, master control, engineering, bid, tender, change order estimate.		Full detail, release, fall-out, tender, firm price, bottoms-up, final, detailed control, forced detail, execution phase, master control, fair price, definitive, change order estimate.	

Estimate Class	Class 5	Class 4	Class 3	Class 2	Class 1
Estimate Input Checklist and Maturity Index	Class 5	Class 4	Class 3	Class 2	Class 1
GENERAL PROJECT DATA					
Project Scope Description	General	Preliminary	Defined	Defined	Defined
Plant Production / Facility Capacity	Assumed	Preliminary	Defined	Defined	Defined
Plant Location	General	Approximate	Specific	Specific	Specific
Soils & Hydrology	None	Preliminary	Defined	Defined	Defined
Integrated Project Plan	None	Preliminary	Defined	Defined	Defined
Project Master Schedule	None	Preliminary	Defined	Defined	Defined
Escalation Strategy	None	Preliminary	Defined	Defined	Defined
Work Breakdown Structure	None	Preliminary	Defined	Defined	Defined
Project Code of Accounts	None	Preliminary	Defined	Defined	Defined
Contracting Strategy	Assumed	Assumed	Preliminary	Defined	Defined
ENGINEERING DELIVERABLES:	Class 5	Class 4	Class 3	Class 2	Class 1
Block Flow Diagrams	Started / Preliminary	Preliminary / Complete	Complete	Complete	Complete
Plot Plans		Started / Preliminary	Complete	Complete	Complete
Process Flow Diagrams (PFDs)		Preliminary	Complete	Complete	Complete
Utility Flow Diagrams (UFDs)		Started / Preliminary	Complete	Complete	Complete
Piping & Instrument Diagrams (P&IDs)		Started / Preliminary	Complete	Complete	Complete
Heat and Material Balances		Started / Preliminary	Complete	Complete	Complete
Process Equipment List		Started / Preliminary	Complete	Complete	Complete
Utility Equipment List		Started / Preliminary	Complete	Complete	Complete
Electrical One Line Drawings		Started / Preliminary	Complete	Complete	Complete
Specifications and Datasheets		Started	Preliminary / Complete	Complete	Complete
General Equipment Arrangement Drawings		Started	Complete	Complete	Complete
Spare Parts Lists			Preliminary	Preliminary	Complete
Architectural Details / Schedules		Started	Preliminary	Preliminary / Complete	Complete
Structural Details		Started	Preliminary	Preliminary / Complete	Complete
Mechanical Discipline Drawings			Started / Preliminary	Preliminary / Complete	Complete
Electrical Discipline Drawings			Started / Preliminary	Preliminary / Complete	Complete
System Discipline Drawings			Started / Preliminary	Preliminary	Complete
Site Plan		Started	Started / Preliminary	Complete	Complete
Civil/Site Discipline Drawings			Started / Preliminary	Preliminary	Complete
Demolition Details		Started	Started / Preliminary	Preliminary / Complete	Complete



Appendix 3
Colusa Basin Drain HEC-RAS Modeling and
Associated Analyses Updates
2025 and 2026 Technical Memorandum

Colusa Basin Drain HEC-RAS Modeling and Associated Analyses Updates 2025 and 2026 Technical Memorandum



To:	Sites Project Authority
CC:	Henry Luu, P.E./HDR
Date:	June 12, 2026
From:	Jacobs; Jessie Hekl, P.E./Jacobs, Kerilyn Paris, P.E./Jacobs
Quality Review:	Kyle Winslow PhD, P.E./Jacobs, Peter Rude, P.E./Jacobs
Authority Agent Review:	
Subject:	Colusa Basin Drain HEC-RAS Model Updates 2025 and 2026

Executive Summary

This technical memorandum (TM) presents the results of additional model development and analyses conducted in 2025 and 2026 for the Colusa Basin Drain (CBD) hydraulics in relation to the Sites Reservoir Project (Project) flows to the CBD. Building on previous analyses documented in TMs from August 2020, December 2021, and December 2024, this TM updates the hydraulic modeling analysis with recent improvements and findings. The subsequent sections of the TM present detailed model development and validation details, simulated flow results, preliminary findings, conclusions, and recommended next steps for further improvements.

A major change in the CBD hydraulic analysis occurred in the spring of 2025 when the Department of Water Resources (DWR) decided not to have environmental flows go down the Knights Landing Ridge Cut (KLRC) and into the Yolo Bypass, but to stay in the CBD and be released through the Knights Landing Outfall Gates (KLOG) and into the Sacramento River along with all the other Sites Reservoir participant flows.

The objectives of the analysis are as follows:

- Understand Sites Reservoir release constraints due to ambient flow conditions in the CBD.
- Evaluate the effects on water surface elevations (WSEs) in the Lower CBD System caused by Sites Reservoir releases of up to 1,000 cubic feet per second (cfs) using Project operation estimates from the Upper Sacramento River Daily Operations Model (USRDOM) simulation.
- Quantify the increase in WSE along the CBD to understand potential channel west bank improvements needed at critical points along the Lower CBD System.
- Understand the impacts of Project releases on flows down the KLRC to Wallace Weir.

The following improvements were made to the CBD model:

- The Project inflow simulation was updated to a daily time step from a monthly time step, transitioning from CalSim 2 model output to USRDOM model output. This provides a more resolute look at the frequency and duration of peak releases from Sites to the CBD.
- The existing conditions model simulations were validated against existing gage data from the Riggs Ranch gage installed in October 2022.
- A revised hydraulic model was developed with a two-dimensional (2D) representation in the channel to specifically investigate the flow split at the KLRC. This model does not have the same upstream extent as the original model.
- The one-dimensional (1D)/2D full CBD model was refined to better represent the local bank elevations governing overflow from the CBD to fields to the west under existing conditions.
- The 1D/2D model was modified to represent possible bank improvements to reduce flooding of agricultural fields during times of high flow in the CBD, either from the annual drainage of rice water in late August-early September or during rainfall-induced runoff events in late fall. These bank improvements were both external to the fields (directly connecting the CBD to the fields) and internal to the field to prevent water flooding habitat areas from then progressing to agricultural fields.

In addition to hydraulic modeling improvements, supplementary research and coordination has revealed information on the following: possible uncontrolled tributary channels that have been identified as locations of interest; known water right diversions along the CBD; documented local subsidence in the area; history related to the KLOG maintained pool elevation or setpoint; and seepage along the KLRC.

The key findings are as follows:

- The updated hybrid 1D/2D model facilitates improved tracking of water as it exits the CBD, influencing better quantification of Project release constraints, impacts, and potential improvements.
- Modeling indicates that western bank improvements along approximately 5.8 miles (non-contiguous) may be required to accommodate Project flows of 1,000 cfs in the July through November nonflood season to avoid inundation of agricultural fields during late summer rice water release events and occasional late fall rainfall events.
- Ungaged water diversions along the CBD and a lack of historical information to validate the model result in a very conservative model that overestimates stages and inundation.
- The model's conservative assumptions regarding boundary inflows and diversions in the CBD impact model results. The model has a slight tendency to overpredict net flows in the CBD; thus, predicted stages and corresponding required improvement measures are potentially overestimated. Installation of additional flow and stage gages in the CBD will improve the accuracy of necessary bank improvements.

The next steps identified are summarized with the following two general efforts: improve the existing model, and update quantification of Project impacts.

1. Improve Existing Model

- a. **Field Visits:** Continue to engage with landowners and agencies to discuss conditions and operations.
- b. **KLOG Analysis:** Refine KLOG model representation, validate new flow calculations, and verify with measurements.
- c. **Subsidence Quantification:** Assess and address subsidence in the Lower CBD System in the hydraulic modeling.
- d. **KLOG Setpoint Update:** Adjust setpoint to reflect current conditions reported by local gages.
- e. **Model Calibration:** Calibrate and validate the model with new data and historical gate operations, including new stage gage data discussed in Section 10.2.
- f. **Terrain and Structure Data:** Update model with new survey data, including bathymetry and Light Detection and Ranging (LiDAR) data.

2. Update Quantification of Project Impact

- a. Based on improving the model as described herein, better understand the potential increase in WSE along the CBD due to the Project. This will enable an understanding of potential improvements needed at critical points along the Lower CBD System, where low points in the western bank allow inundation of some agricultural fields and habitat lands when flows in the CBD are elevated.

3. Request for New and Improved Gages

- a. Add additional gages along the CBD to provide historical records of flow and stage. These additional gages will provide data to better calibrate the existing Hydrologic Engineering Center's River Analysis System (HEC-RAS) model and to also better document the pre-Project conditions and post-Project impacts.

This hydraulic analysis is important for stakeholders aiming to effectively manage the Project releases into the CBD. The insights gleaned from this updated hydraulic modeling effort will inform the decision-making processes and facilitate the ongoing development and operation of the Sites Reservoir Project. The hydraulic modeling will provide insight on ways to optimize delivery of Project water to the Sacramento River while minimizing any impacts to agricultural lands bordering the CBD.

1.0 Introduction

This technical memorandum (TM) presents results of additional model development and analysis, performed in 2025 through February 2026, of the Colusa Basin Drain (CBD) hydraulics with Sites Reservoir Project (Project) inflows. The analysis builds on previous work in the August 2020 TM (Jacobs 2020), December 2021 TM (Jacobs 2021) and December 2024 TM (Jacobs 2024), which documents model development, data sources, model calibration, preliminary results, and next steps. This TM provides an update on recent improvements to the hydraulic modeling analysis. The first portion of this TM includes a summary of the background, analysis, and information that involves the

operation of the CBD that was completed in 2025, since the December 2024 TM (Sections 2 through 7). The second portion of the TM describes the preliminary results from the 2025/2026 modeling effort (Sections 8 and 9). The third portion (Chapter 10) summarizes the conclusions and next steps. These sections are outlined as follows:

- Background (Section 2)
- Knights Landing Outfall Gates (KLOG) Flap Gates Closed Analysis with High Sacramento River Stage (Section 3)
- Preliminary Analysis of Water Rights Diversions (Section 4)
- Flood Flow Analysis required by United States Army Corps of Engineers (USACE) Section 408 Permit (Section 5)
- Locations of Interest along the CBD (Section 6)
- Current Understanding of KLOG Gate Operations (Section 7)
- Model Updates (Section 8)
- Preliminary Results (Section 9)
- Conclusions and Next Steps (Section 10)

2.0 Background

The Project diverts winter flood waters off the Sacramento River; it then conveys and pumps the water into Sites Reservoir, where it is stored. When participants want the water, it is released either down the Glenn-Colusa Irrigation District (GCID) canal for local use or down the Tehama-Colusa Canal, into the Dunnigan Pipeline and into the CBD to the Sacramento River for other uses. The CBD hydraulic modeling reviews the potential effects on the ambient water surface elevation (WSE) and surrounding land with the addition of up to 1,000 cubic feet per second (cfs) of Project water discharging through the Dunnigan Pipeline outfall.

The CBD is a drainage feature that drains approximately 1,036,000 acres and stretches approximately 75 miles from north to south (US Government Publishing Office 2000). The focus for the Project is the southern portion (approximately 25 miles), which has been defined as the Lower CBD System: it extends from the Balsdon Weir to the KLOG at the confluence with the Sacramento River as shown on Figure 1. Figure 1 shows the Lower CBD System Reach hydraulic reaches (further broken into upper, middle, and lower reaches) and infrastructure components that are included in this TM.

GCID measures their flow at the Davis Weir, which primarily consists of rice field drainage water during the summer. The Davis Weir spans the CBD and is the closest flow measurement point to the Dunnigan Pipeline outfall. The Balsdon Weir also spans the CBD and acts as a hydraulic barrier, preventing backwater from extending upstream from the Dunnigan Pipeline outfall.

Flow within the CBD bifurcates downstream of these structures. Water may pass through KLOG and discharge into the Sacramento River, or it may continue along the KLRC ultimately reaching the Wallace Weir and discharging into the Yolo Bypass. The CBD and KLRC are hydraulically connected, with no physical control structure separating the two channels.

Operational conditions of the CBD vary seasonally. During the irrigation season (summer months), the KLOG and Wallace Weir maintain elevated water surface elevations, creating a managed pool that allows agricultural diversions by local water districts. In contrast, during winter flood events, the system conveys high flows either through KLOG to the Sacramento River or through the KLRC to the Yolo Bypass, depending on hydraulic conditions. Flap gates located on the downstream side of the KLOG structure prevent elevated stages in the Sacramento River from propagating upstream into the CBD. During periods of high river stage, these flap gates close and restrict discharge through KLOG; this effectively routes CBD flows downstream through the KLRC and Wallace Weir into the Yolo Bypass.

The KLOG facility was built in the early 1900s as a flood control structure to prevent high Sacramento River flows from backing up into the CBD and inundating agricultural land. In addition, it was built to hold a relatively constant WSE in the CBD during the irrigation season according to the Hershey Agreement.¹

Figure 2 shows the existing historical gage data and critical infrastructure along the Lower CBD System as referenced in this TM.

¹ *Hershey Family v. Sacramento San Joaquin Drainage District*. Option and Agreement Deed No. 907. July 17, 1937.

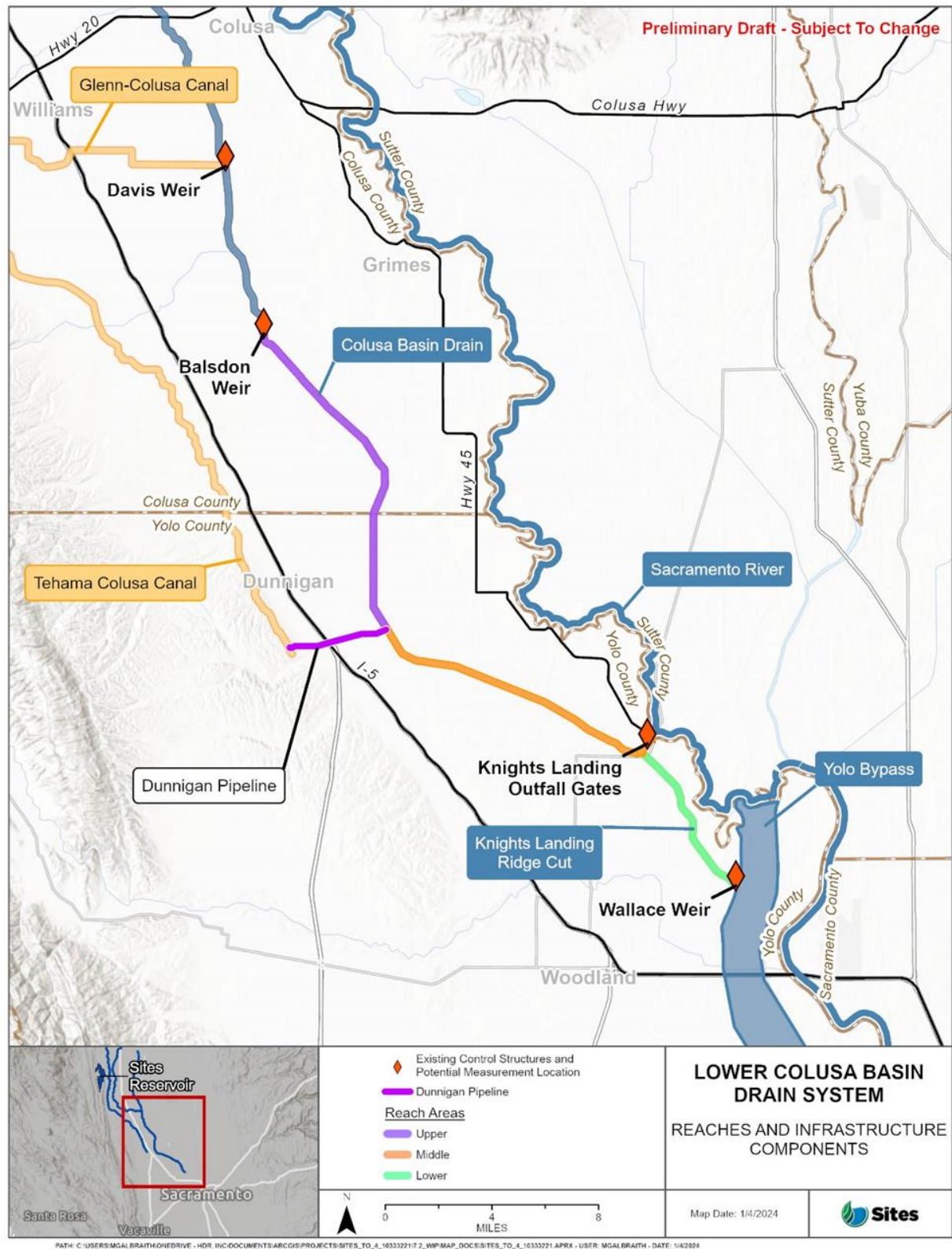


Figure 1. Lower CBD System Reach Hydraulic Reaches and Infrastructure Components

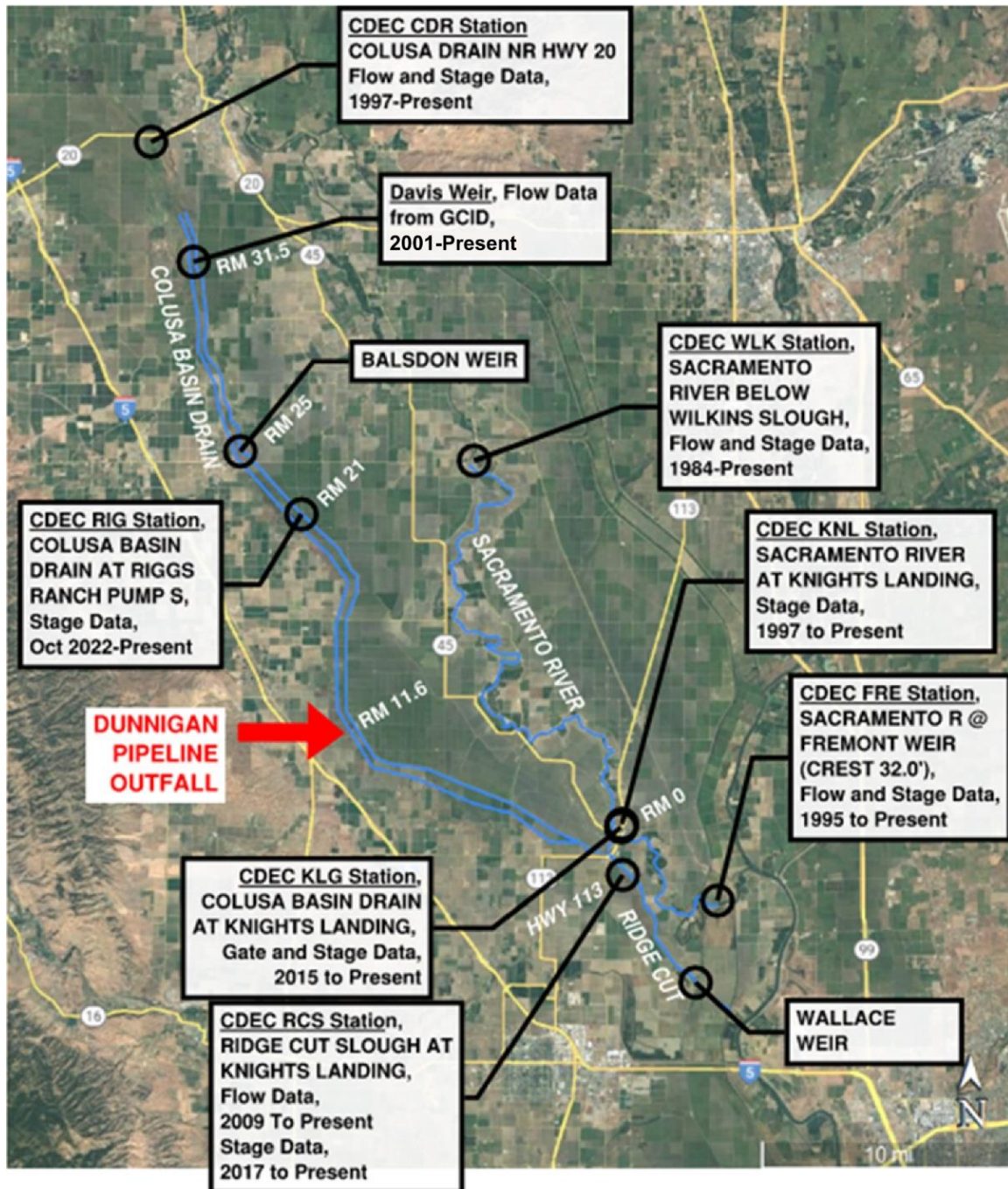


Figure 2. Existing Historical Gage Data

CDEC = California Data Exchange Center
 HWY = highway
 NR = North Region
 RM = river mile
 R = river
 S = station

3.0 KLOG Flap Gates Closed Analysis with High Sacramento River Stage

An analysis was conducted to determine the frequency of the KLOG flap gates being closed during high stages in the Sacramento River. The rationale is that Project water deliveries will not reach the Sacramento River when the KLOG flap gates are closed. Project water deliveries could occur between April 1 and November 30; however, most deliveries will be for South of Delta users, and their deliveries are between July 1 and November 30. The following assumptions were made to conduct the analysis:

- The analysis used the California Water Data Library (WDL) A02200 Sacramento River stage gage (elevation United States Elevation Datum [USED]) for years 1988 to 2020 (33 years).² More current data are available on the CDEC website, but those data are not quality checked. The WDL data are quality checked and were preferred for this analysis (DWR 2020). Figure 3 shows the location of the A0220 Sacramento River stage gage.
- Minimum WSE where flap gates will be fully closed is elevation 22.25 feet North American Vertical Datum of 1988 (NAVD88), which is equal to elevation 24.02 feet USED. This elevation is based on the crown elevation of the 66-inch-diameter openings in the structure, from the 2011 DWR Colusa Drain Outfall Gates Rehabilitation Drawings (DWR 2012). Figure 4 details the 66-inch-diameter openings in the KLOG structure.



Figure 3. Sacramento River Stage Gage A02200

² USED elevation = NAVD 88 elevation + 1.77 feet. Datum conversion between USED and NAVD 88 confirmed with Kjeldsen, Sinnock & Neudeck, Inc. (KSN) by Reclamation District 108 (RD108) per email 07/14/2020 (O'Regan pers. comm. 2020).

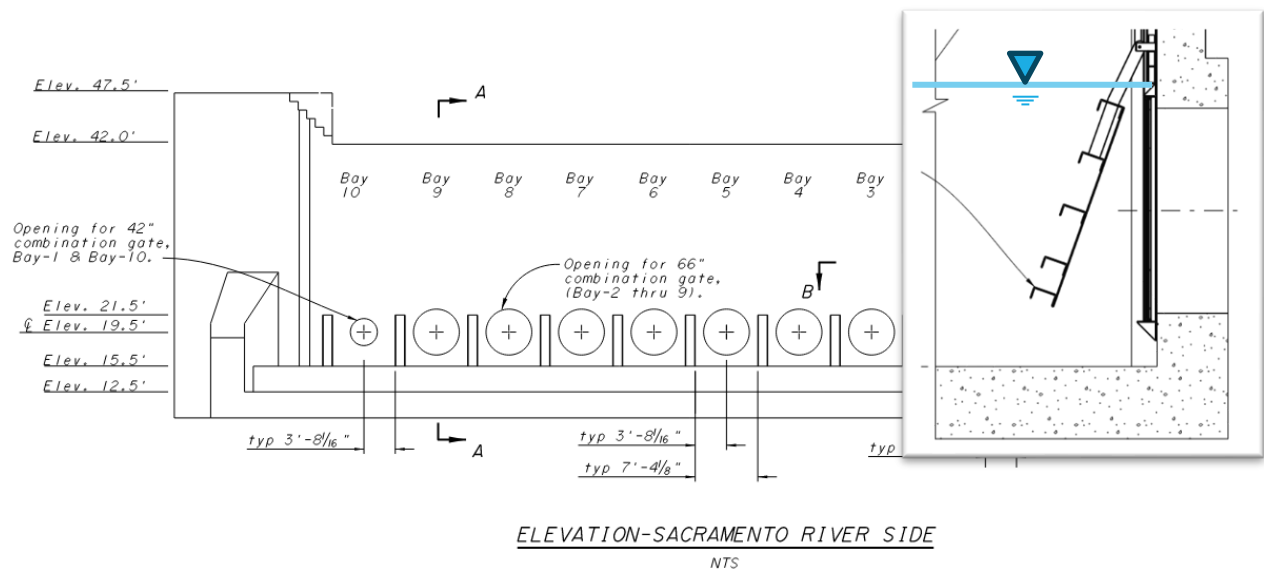


Figure 4. Detail of 66-inch-diameter Openings in the KLOG Structure

The analysis developed the frequency that the KLOG flap gates were closed on a monthly basis, based on the historical data. These frequencies were compared with the monthly average and maximum Project flows (from the Upper Sacramento River Daily Operations Model [USRDOM] 82-year daily projection flow simulation, with 81 full water years). The analysis was completed for the five water year types:

- Wet Year (26 years total)
- Above Normal Year (11 years total)
- Below Normal Year (14 years total)
- Dry Year (18 years total)
- Critical Year (12 years total)

The results of this analysis are shown in graphs for all five water years (Figures 5 through 9). The graphs show the percent frequency of the KLOG flap gate closures, alongside the monthly average and maximum Project flows. The main months of interest for the Project are June 1 through November 30, when South of Delta participants are allowed to move their water from Sites Reservoir to the Sacramento River to their diversion points.

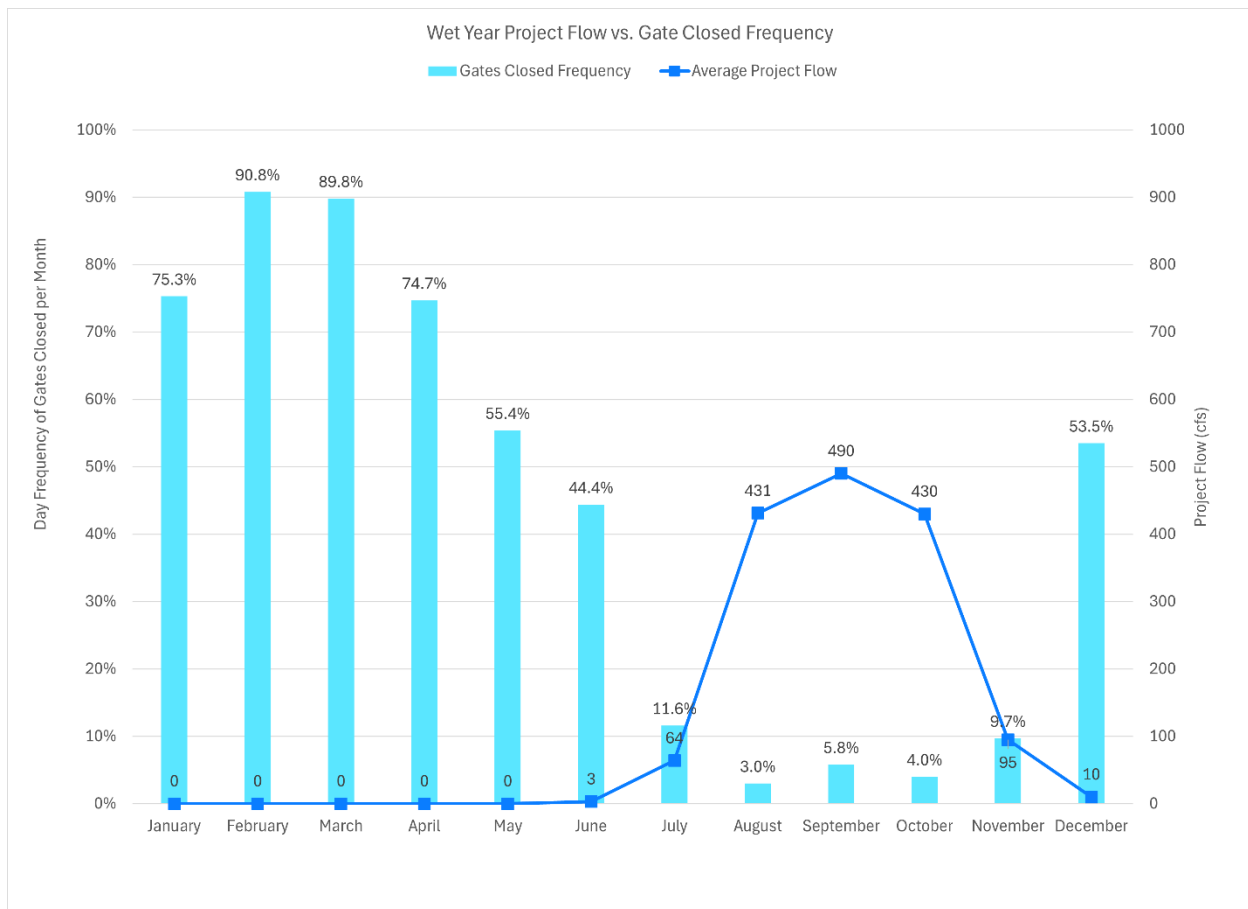


Figure 5. KLOG Gates Closed Frequencies, Average and Maximum Project Flows – Wet Year



Figure 6. KLOG Gates Closed Frequencies, Average and Maximum Project Flows – Above Normal Year

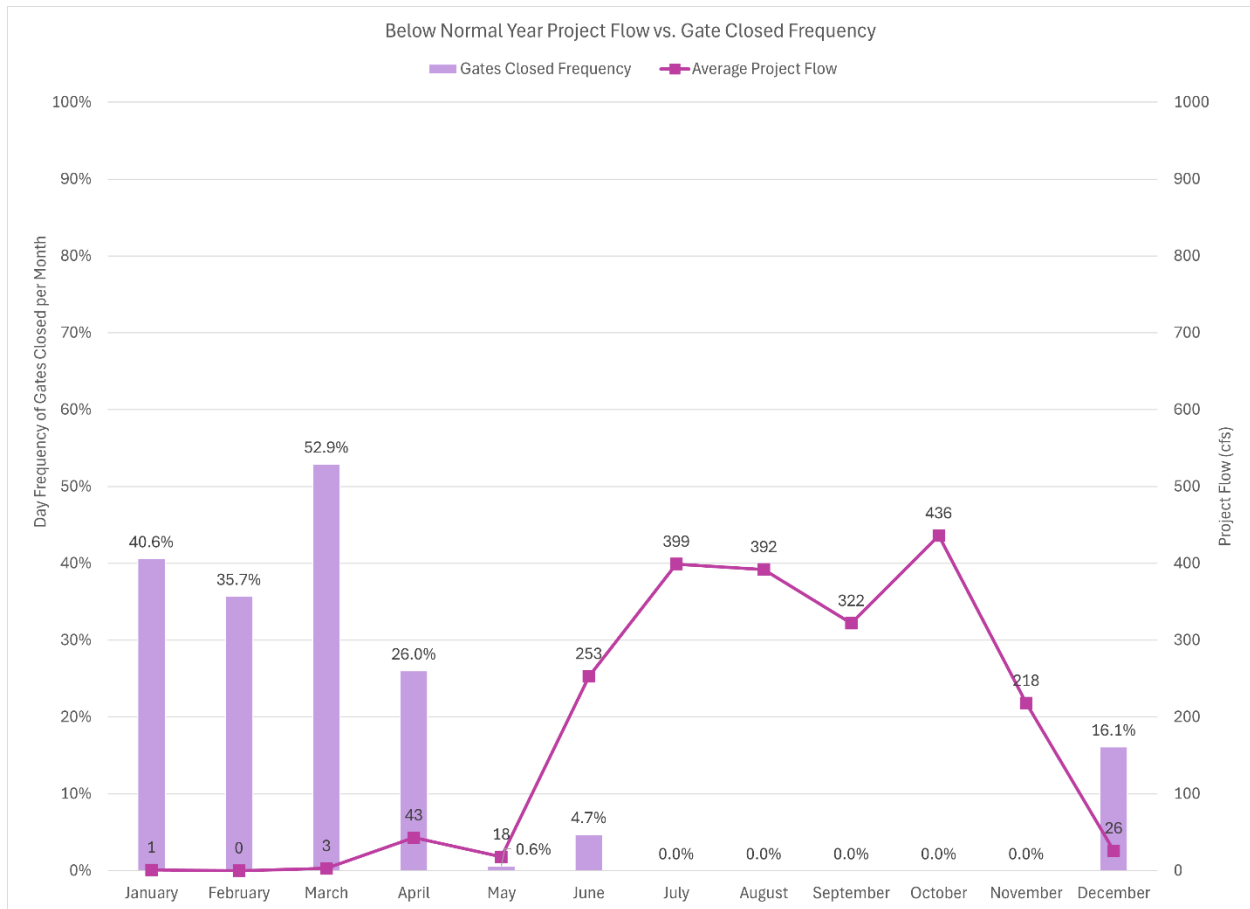


Figure 7. KLOG Gates Closed Frequencies, Average and Maximum Project Flows – Below Normal Year

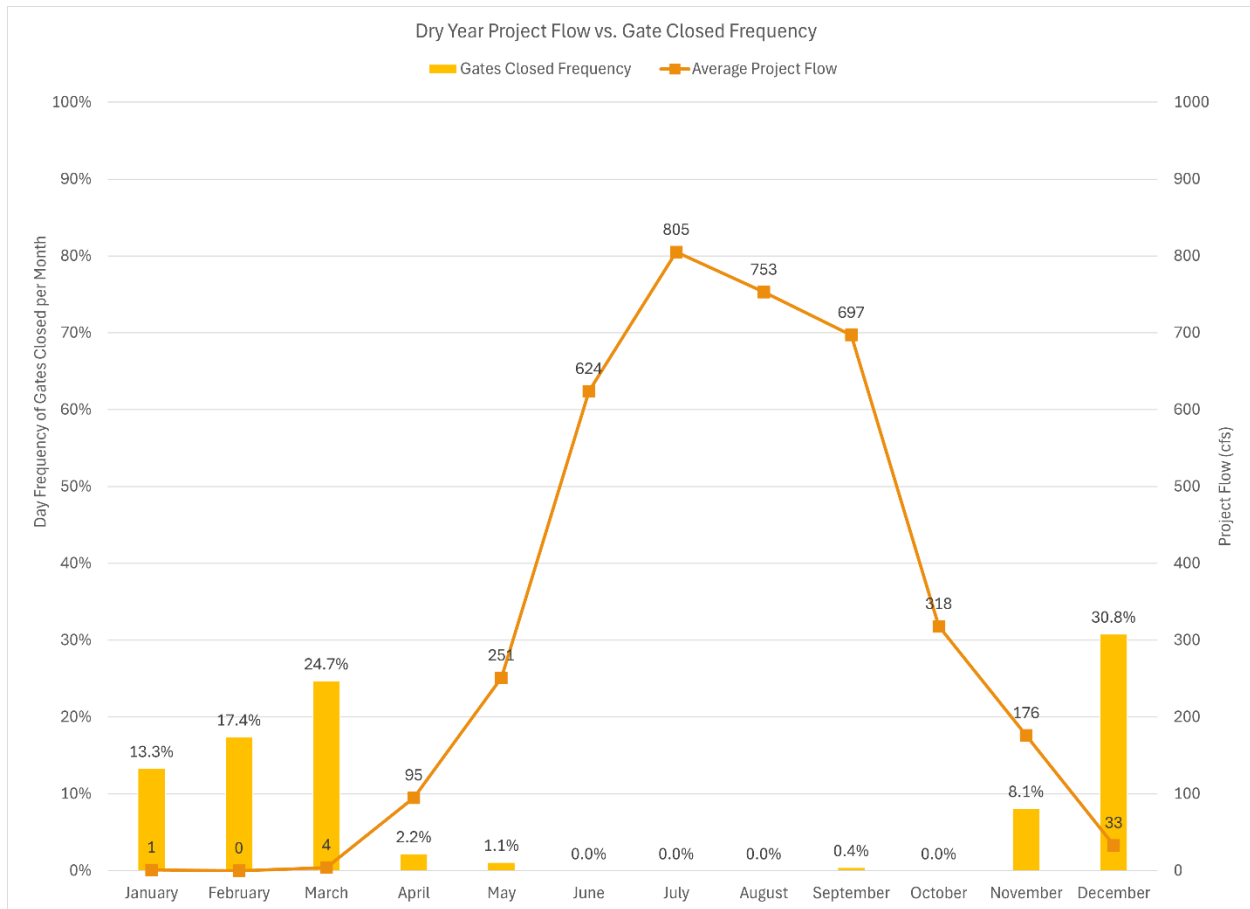


Figure 8. KLOG Gates Closed Frequencies, Average and Maximum Project Flows – Dry Year

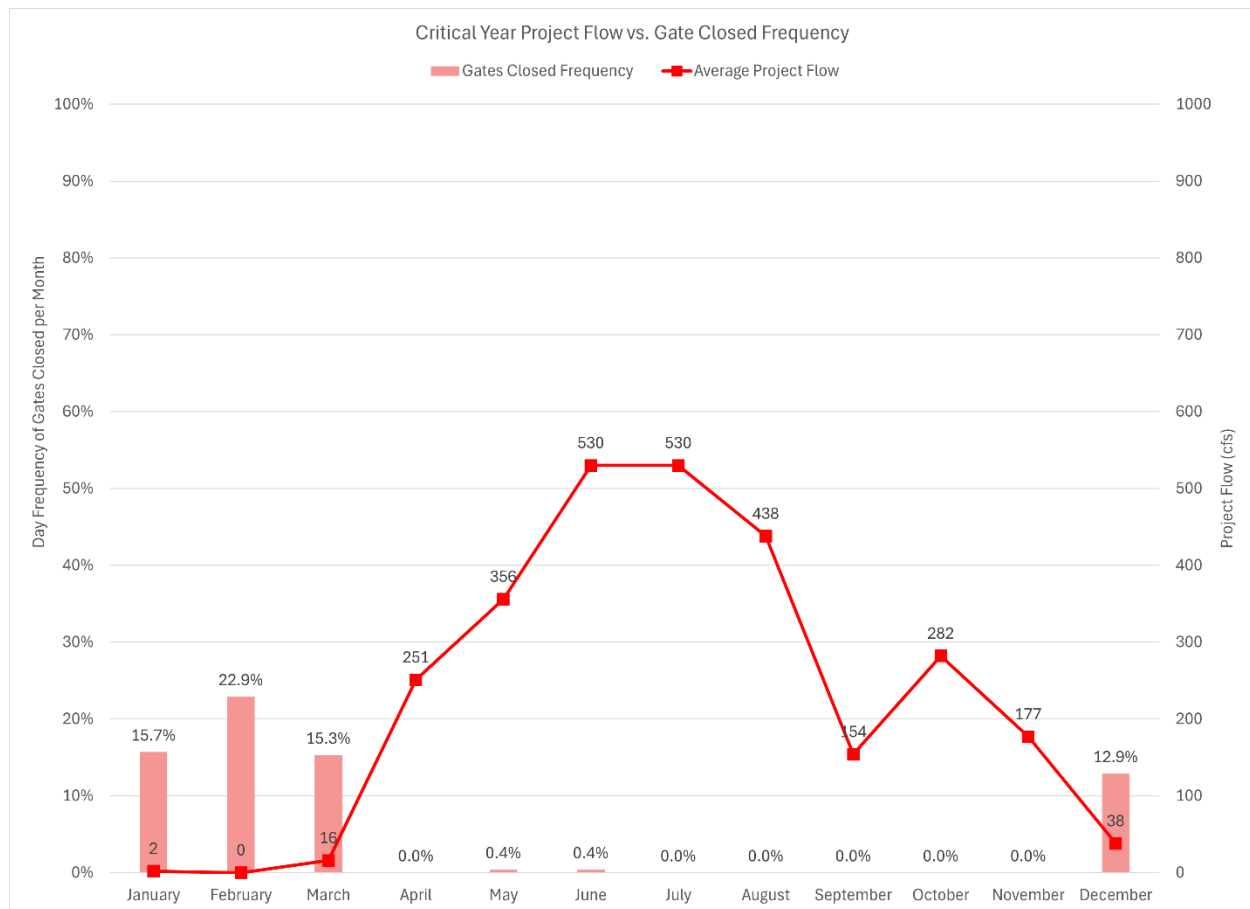


Figure 9. KLOG Gates Closed Frequencies, Average and Maximum Project Flows – Critical Year

The results of the KLOG flap gates closed are as follows:

- Some spring or early winter months where there is abnormal rainfall could result in the KLOG flap gates being closed.
- There will need to be some water level monitoring on the Sacramento River side that would be correlated with the ability to send Project flow to the Dunnigan Pipeline, to the CBD, and through KLOG.
- Given the fact that Sites Reservoir will not be releasing Project water during Sacramento River high flow events (that is, when the KLOG flap gates are closed), there is minimal risk that Sites Reservoir investors would not be able to get their water through KLOG and into the Sacramento River.

4.0 Preliminary Analysis of Water Rights Diversions

The following sections discuss the impact of diversions on flow capacity in the CBD, the three methods by which the hydraulic model could account for water rights diversions downstream of the Davis Weir, validating diversions within the model, and analyzing when the CBD could convey ambient and Project flows with diversions.

4.1 Water Rights Diversions Investigation

The 2024 hydraulic model represented ambient flow in the CBD downstream of the Davis Weir because the only flow data available in the lower CBD are at Davis Weir. However, downstream of Davis Weir, farmers divert water from the CBD to irrigate rice fields and add drainage water when draining the rice fields. To understand and estimate irrigation diversions from the CBD, Jacobs coordinated with consulting firm MBK Engineers (MBK) to highlight the location of 67 water rights diversions south of Davis Weir in the CBD and in Knights Landing Ridge Cut (KLRC) (Bezzone pers. comm. 2024). These locations and details are discussed in the *2024 CBD Hydrologic Engineering Center's River Analysis System (HEC-RAS) Model Updates* Draft TM (Appendix 1). Figure 10 shows the locations of these water rights diversions. The following diversions were identified:

- Davis to Balsdon Weir (CBD) - 16 diversions
- Balsdon Weir to Dunnigan Outfall (CBD) - 23 diversions
- Dunnigan Outfall to KLOG (CBD) - 12 diversions
- KLOG to Wallace Weir (KLRC) - 16 diversions

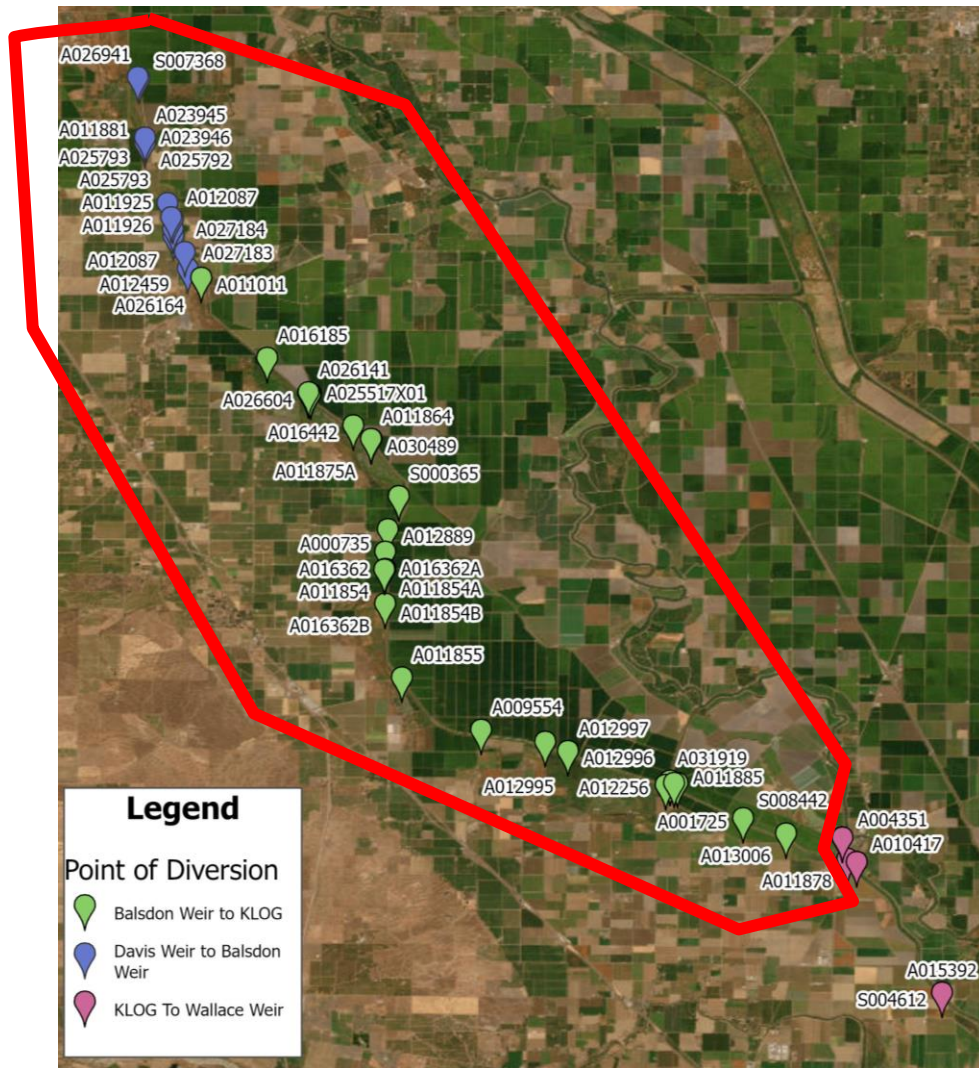


Figure 10. Water Rights Diversion Locations

Coordination with MBK highlighted the locations of 67 water right diversions along the Lower CBD System (Bezzone pers. comm. 2024).

Four ambient flow scenarios were analyzed to evaluate the flows existing in the CBD. Under the following scenarios, flow was adjusted at the Davis Weir:

- **Scenario 1 (Davis Base):** Total Davis Weir flow, with data sourced from GCID
- **Scenario 2 (100% of water rights):** Total Davis Weir flow minus full 100% water right diversion flow in the CBD by calendar day (Bezzone pers. comm. 2024)
- **Scenario 3 (50% of water rights):** Total Davis Weir flow minus 50% of the Water Right diversion flow in the CBD by calendar day (half of flows from Scenario 1 [Bezzone pers. comm. 2024]); this scenario provides a more conservative approach because it is unknown how much water right is being used

- **Scenario 4 (Rice Water Use):** Davis Weir flows minus rice water use (Bezzone pers. comm. 2024) by calendar day; generally, it assumed the entire acreage for all the water rights land in the reach were planted as rice and applied as water usage per acre to that land

Figure 11 shows the seasonal pattern in flow at Davis Weir for 11 years from 2013 to 2023. Flows for 2016 and 2023 were used for Scenario 1. Adjustments to the 2016 and 2023 inflows were made based on the seasonal diversion patterns presented on Figure 12 for Scenarios 2 through 4.

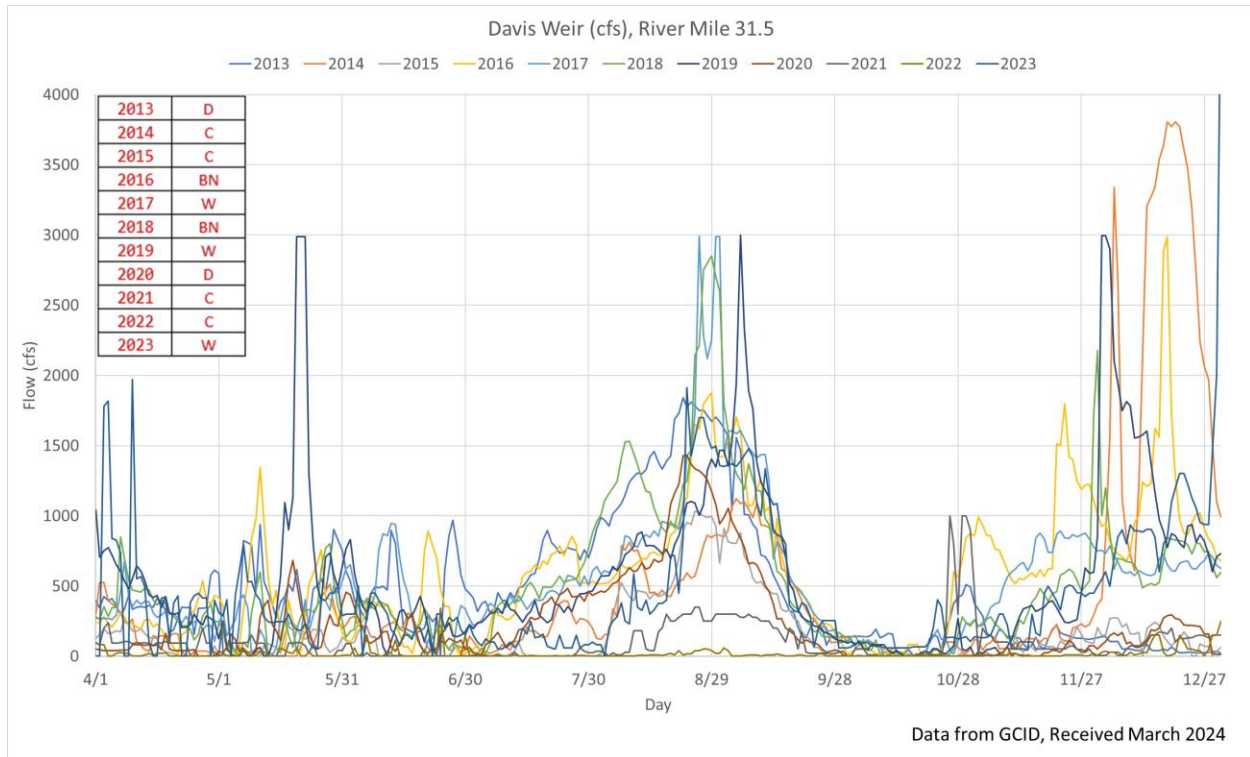


Figure 11. Total Davis Weir Flow – Scenario 1

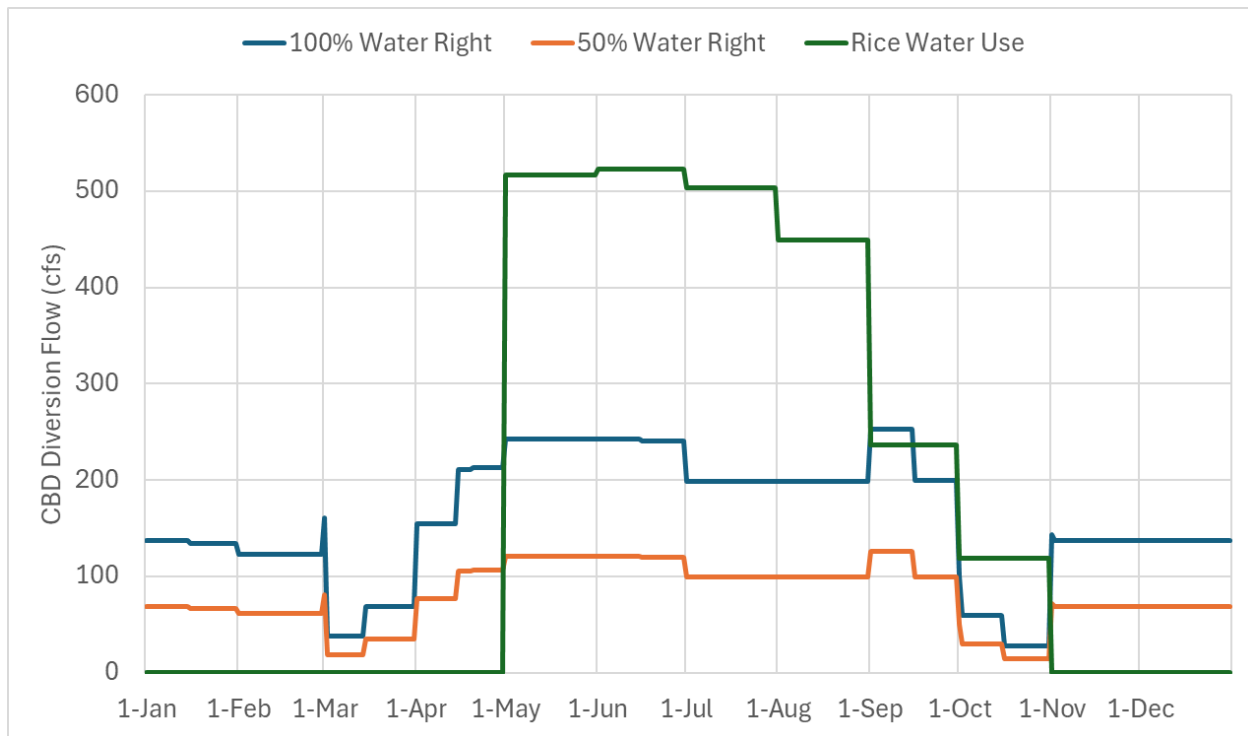


Figure 12. Total Davis Weir Flow – Scenarios 2 through 4 (Data from MBK)

These four scenarios were incorporated into the Davis Weir flow boundary condition of the one-dimensional (1D)/two-dimensional (2D) hydraulic model as four different versions of ambient inflow boundary conditions. The model results were compared against existing gage data (both flow and stage) to see which ambient flow model scenario best matches the historical data.

4.1.1 Water Rights Diversions Preliminary Validation with 1D/2D Model

Model validation runs were conducted with historical data from 2016 and 2023 to validate results against available data. For each year, four versions of the inflow at Davis Weir were applied to the model (Scenarios 1 to 4). The first validation run was conducted for historical conditions in 2016, a Below Normal water year with a peak summertime inflow of about 1,800 cfs. Results from this simulation were compared against flow data at KLOG provided by cbec eco engineering, a Verdantas Company (cbec) and DWR. This is the only recent year with flow data at KLOG available to compare with model results. As shown on Figure 13, Scenario 4 (Rice Water Use) provides the best match for the cbec and DWR data of the four scenarios, while Scenario 2 provides the second-best match. Also, it was found that adjusting the KLOG setpoint does not affect Riggs Ranch stage significantly in the model because Riggs Ranch is 21 miles upstream.

The second validation run used historical data for 2023, a wet year with maximum summertime Davis Weir inflow of about 1,900 cfs. In this simulation, the modeled stage at Riggs Ranch with the 22.4 feet elevation KLOG setpoint was compared to the measured Riggs Ranch data. The year 2023 was selected so that the results could be compared against the stage data from Riggs Ranch: a new gage was installed in October 2022 with data only available via CDEC and not the WDL. As shown on Figure 14, Scenario 3 (50% Water Right) provided the best fit and Scenario 2 (100% Water Right) provided the second-best fit to the Riggs Ranch stage data. The model was shown to be underestimating the stage in late June through August, then overestimating the stage in late August and early September. The

underestimated stages in the model during the peak diversion period (June through August) could be related to the physical location of the diversions along the CBD. For simplicity, all diversions were removed from the inflow time series near Davis Weir. If more flow was removed from the CBD further south, the modeled stage and performance at Riggs Ranch would increase during this period.

The 2023 validation results were also used to validate model performance using measured stage data in the KLRC (CDEC Station RCS). Figure 15 shows that Scenario 2 (100% Water Right) is the best fit, and Scenario 3 provides the second-best fit for the CDEC data in Ridge Cut Slough. This validation run clearly showed that adjusting the setpoint to elevation 22.4 feet allows for a better match to the Ridge Cut Slough gage data. This adjustment is discussed in more detail in the Next Steps section of this TM.

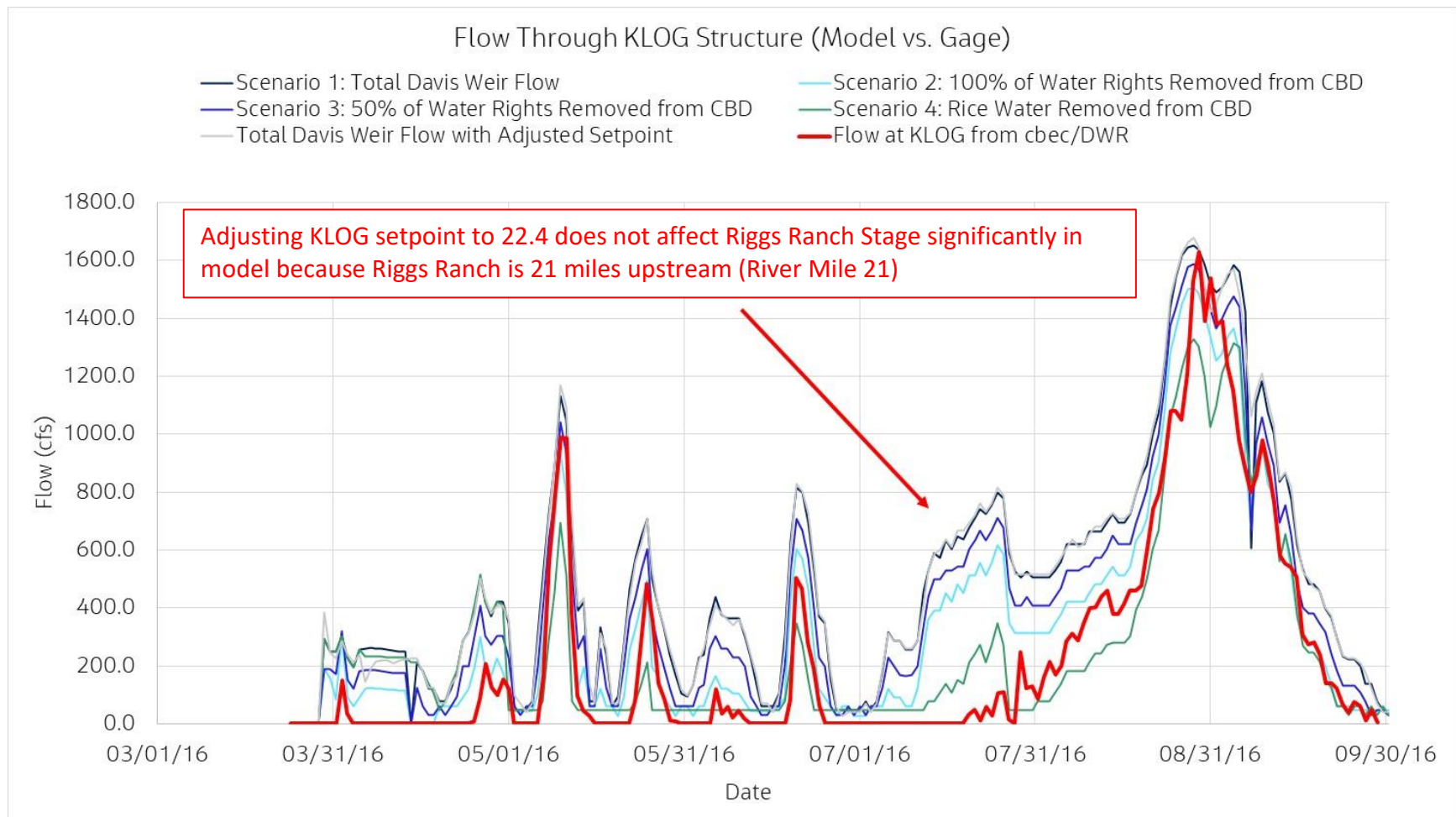


Figure 13. 2016 Below Normal Conditions KLOG Flow Model Compared with Gage Data from cbec and DWR

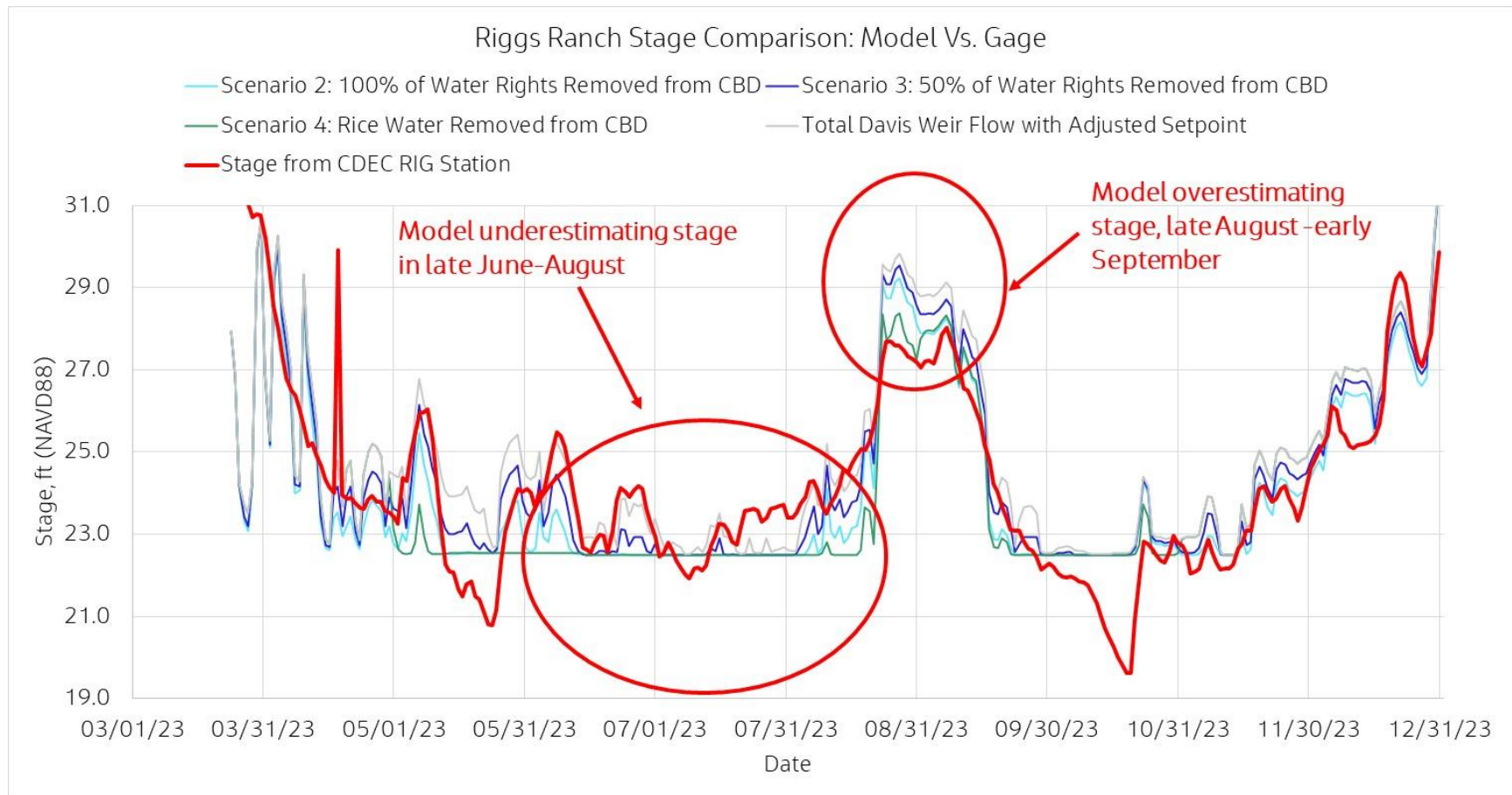


Figure 14. Wet Year – Riggs Ranch Stage Model (with Elevation 22.4 feet KLOG Setpoint) Compared with Gage Data from CDEC

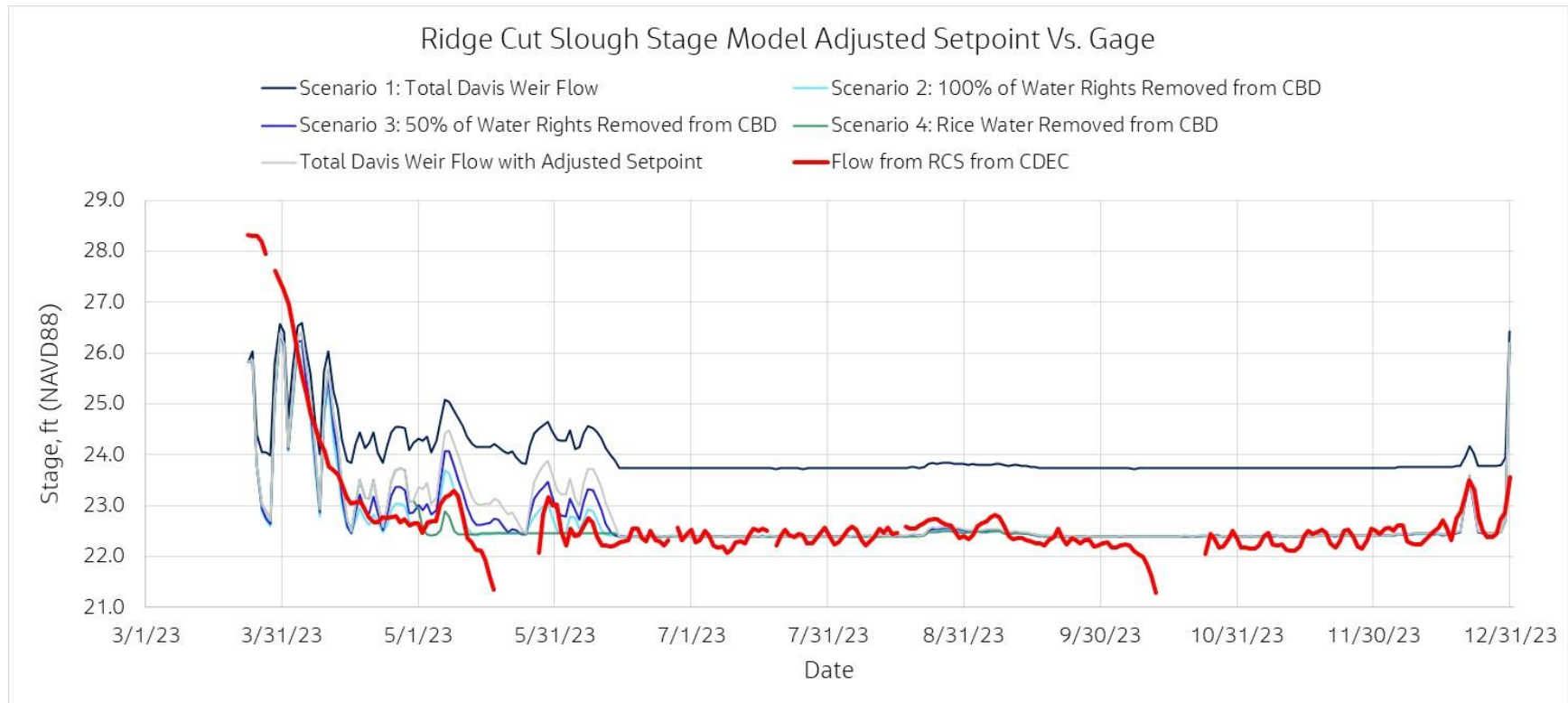


Figure 15. 2023 Wet Year – Ridge Cut Slough Stage Model Compared with Gage Data from CDEC

4.1.2 Flow Loss Analysis with 2001 to 2012 Davis Weir Flows Compared Against Water Rights Diversion

On April 15, 2025, Jacobs received Davis Weir flow data prior to 2013 (complete dataset from 2001 to 2025) from GCID. Additionally, KLOG flow data are available from 1984 to 2012 from the WDL website (DWR 2020). The overlapping years of daily flow data (2001 to 2012) were used to calculate the average flow loss between Davis Weir and KLOG. This average flow loss was then compared with the cumulative water rights diversions.

Table 1 shows the count of years by water year type for the period between 2001 and 2012.

Table 1. Water Year Types for Period of Analysis: 2001 to 2012

Water Year Type	Count of Years
Above Normal	2
Below Normal	3
Critical	1
Dry	4
Wet	2

Figure 16 shows the comparison between the average flow loss (based on water year type) and the scenarios discussed in Section 4.1.1. The monthly average flow loss for all water year types (purple dashed line) generally falls between the cumulative 100% Water Right (blue solid line, Scenario 2) and 50% Water Right (orange solid line, Scenario 3) Total Flow Diversion scenarios. The monthly average flow loss for the wet year (orange dashed line) and dry year only (blue dashed line) generally also fall between 100% and 50% water right scenarios (Scenarios 2 and 3). It can be concluded that using the 100% Water Right (Scenario 2) and 50% Water Right (Scenario 3) as bookends for ambient (or existing flow) conditions in the model would be a conservative approach, based on this gage data validation effort.

Accounting for water rights diversions improves the ability of the CBD to convey ambient water and Project water without causing nuisance inundation of agricultural fields during periods of elevated ambient flows combined with Project water releases. However, the critical flow case, for full summertime Project releases, coincides with the annual draining of rice water from agricultural fields, which generally occurs for up to 2 weeks and begins sometime between mid-August and early September. For this critical case when model results indicate Project impacts are at their highest, there are not likely to be many active diversions from water users along the CBD; thus, exclusion of diversion for the critical flow case is a reasonable model assumption.

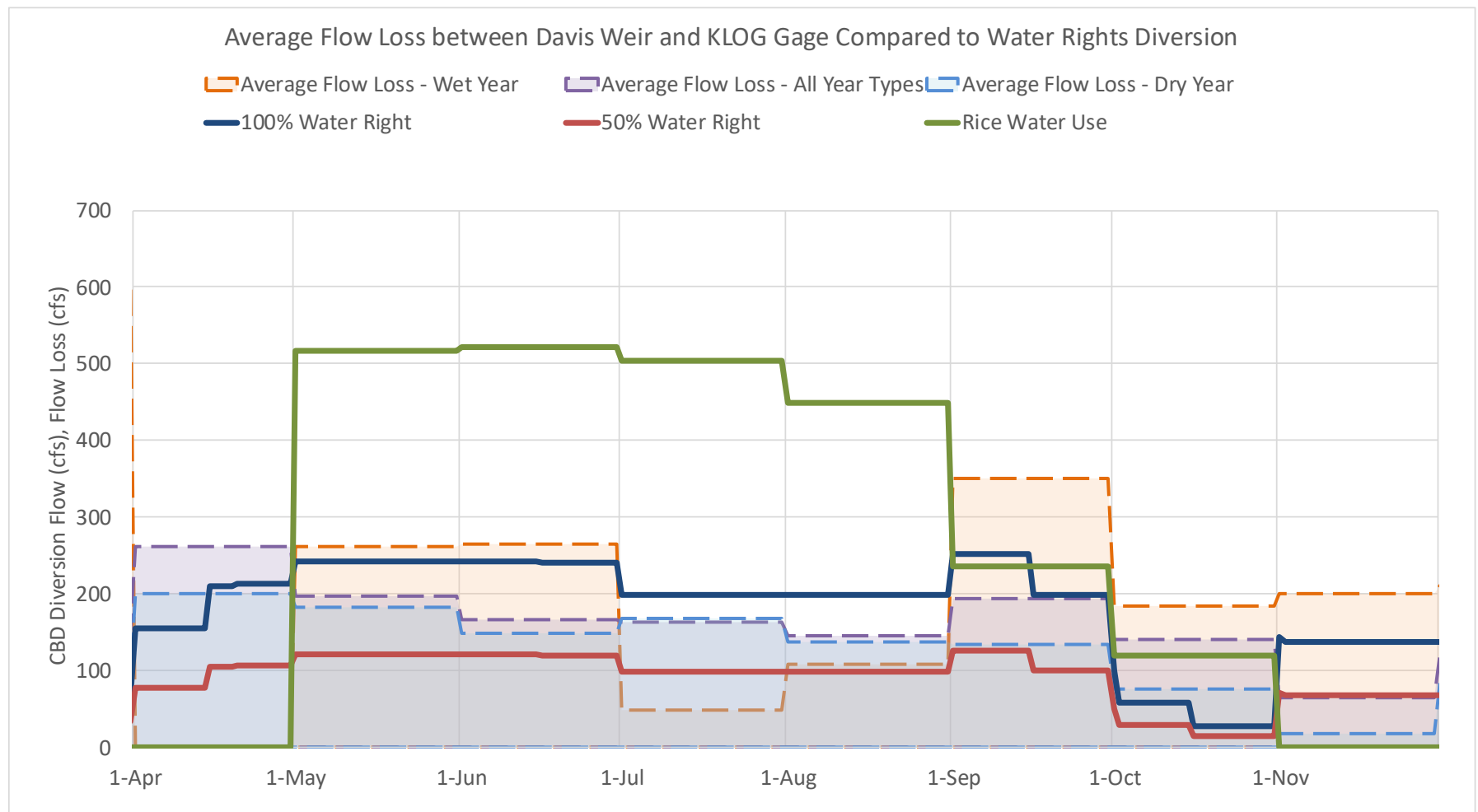


Figure 16. Average Flow Loss Between Davis Weir and KLOG Gage Compared With Water Rights Diversion Sources

4.1.3 Water Rights Diversion Project Flow Analysis

Jacobs conducted an analysis to quantify the percentage of time each month that the CBD could convey ambient water and combined Project releases, considering likely water diversions based on one of three assumptions for the diversion amount. This analysis was conducted on a water year basis, acknowledging the significant range in ambient flows by water year type.

The analysis used 11 years of Davis Weir flow data (2013 to 2023) and pre-dated the receipt of an additional 12 years of historical daily flows at Davis Weir. This analysis was also superseded by detailed adjustments of western bank elevations and subsequent quantification of bank improvements required to stop nuisance flooding of agricultural fields during periods of elevated ambient flow releases in the CBD combined with Project water releases. While this analysis provides a simplistic summary of the improvements in CBD capacity with diversions considered, considerable work has been done since this analysis to better quantify conveyance capacity and Project impacts.

To complete the water rights diversion analysis, the maximum daily Project flows per water year type (from the 82-year daily Project flow simulation) were used, based on results of the USRDOM analysis. The analysis was completed for only the four water year types during the 11-year period of record for Davis Weir flows (2013 to 2023). The Above Normal water year was not analyzed because there are no Above Normal years during the 11-year period. Note that this analysis was conducted prior to receiving the 2001 to 2012 Davis Weir flows. This analysis should be extended with the larger historical Davis Weir flow dataset, but results are not expected to be significantly different from those presented in Table 2.

In the 2021 TM, existing channel capacity was estimated at 1,750 cfs at RM 8.9 (Jacobs 2021). This is equivalent to WSE 26.5, where landowners noted some mitigation could avoid the inundation of local agricultural fields in this area. The total Project flow capacity (before inundation at RM 8.9) was calculated by taking the flow of 1,750 cfs and subtracting analyzed daily ambient flow. The monthly average percent Project flow capacity by water year was calculated by dividing the total Project flow capacity by the total daily Project flow by water year (from the 82-year simulation).

Table 2 provides a summary to document this analysis. Table 2 highlights the need for some west bank improvements: without bank improvements, conveyance capacity can drop to 70% in August in Below Normal and Dry water year types. This means that, on average, full Project deliveries can be made for only 70% of the days in August of those year types without producing water levels that would cause inundation of agricultural fields. Values in Table 2 assume 100% water rights diversion occur each month.

Table 2. Average Percent Conveyance Capacity for Project Flows Assuming 100% Water Rights Diversions (for 1,750 cfs Capacity without Project-induced Inundation)

	Wet	Below Normal	Dry	Critical
June	100%	100%	100%	100%
July	100%	100%	100%	100%
August	86%	70%	71%	100%
September	82%	89%	96%	100%
October	100%	100%	100%	100%
November	100%	90%	100%	100%

In terms of channel flow capacity, including the CBD, water right diversions significantly increase the capacity of the CBD to convey Project flows in all scenarios when compared with only using Davis Weir flow from GCID for ambient conditions. As anticipated, the Rice Water Use Scenario (Scenario 4) allows the greatest increase in percentage of Project flow. However, as discussed earlier, Rice Water Use might be an overestimation of actual diversion conditions. The most significant increase in capacity is during the months of August and September, when the water right diversion flow is higher. In August and September, it does not appear that the limited existing channel capacity at RM 8.9 will allow for full Project flows (up to 1,000 cfs).

Therefore, some bank improvements (that is, raising west bank levees) may be required. Note that this does not account for any landowner releases (that is, rice drainage water downstream of the Davis Weir) into the channel, which would reduce the capacity to send Project flow. This analysis is planned to be improved with the additional Davis Weir flow received on April 15, 2025 (refer to the Next Steps section of this TM). A more detailed look at bank improvements is presented in Section 9.

The outcome of this water rights analysis (flow capacity analysis and others discussed subsequently herein) is that conveyance capacity for Project flows is limited when there are high ambient flows in the CBD, which come from an annual release of rice water and storm events. Sites operations should plan on holding releases during the annual rice water release event, which generally occurs for up to 2 weeks between mid-August and mid-September every year. An updated modeling effort conducted in 2026 determined that inundation may occur when existing flows within the CBD reach approximately 1,870 cfs. The implications of this threshold are discussed in Section 9, along with the identified bank improvements. An evaluation of historical Davis Weir flow records indicates that flows exceeded 1,870 cfs in 9 of the past 24 years, with exceedances lasting up to 11 days in the most severe year.

5.0 Flood Flow Analysis - USACE Section 408 Permit

The current 30% design for the Dunnigan Pipeline Discharge to the CBD is designed to dissipate energy for the full range of anticipated discharge flows: 50 to 1,000 cfs. As part of the USACE Section 408 Permit, the Project will need to analyze the impact of these flows on the CBD for flood capacity. A high-level, preliminary analysis was conducted and concluded the following:

- The current highest WSE with Project flows modeled is an elevation of 29.4 feet (NAVD88) in August/early September. The design elevation for the jurisdictional east levees and flood structures is closer to 41 feet (NAVD88).
- On average, for about 30 days per year (December through April, mainly during wet years), the CBD will see a WSE above an elevation of 29.4 feet (NAVD88).
- Project would not send releases through Dunnigan Pipeline during flood events.
- Project releases alone will not impact flood infrastructure.

Although this high-level analysis concludes that Project releases alone will not impact flood infrastructure, addition modeling will be required for the USACE Section 408 Permit.

On April 9, 2025, the Central Valley Flood Protection Board (CVFPB), USACE, Sites Joint Powers Authority, and Jacobs held a meeting to discuss flood flow in the CBD. In that meeting, the CVFPB stated that the design flow to be analyzed is 26,000 cfs, based on floodway details. The model will need to be

updated to accommodate this large flow and made fully 2D. A pre-Project and post-Project model will be run to analyze inundation and WSEs for both model results (Refer to Section 10.2).

Sites will not be releasing any flow to the CBD when ambient flows are 26,000 cfs. Rather, the CVFPB wants to understand the increase in local flood elevations from the outlet structure of the Dunnigan Pipeline. It is expected that impacts will be minimal because flooding will extend westward from the CBD into agricultural lands.

6.0 Locations of Interest

To supplement the hydraulic modeling and further inform the potential Project impact analysis, aerial imagery and topography were used to identify locations of interest along the western bank of the upper and middle reaches and both banks of the lower reach of the Lower CBD System. These identified low points along the bank are possible uncontrolled drainages, diversions, and irrigation canals that connect directly to the CBD system. These locations of interest could be affected by the Project, because increased WSEs could allow CBD water to flow freely up into these channels and result in impacts farther upstream or along the tributary channel banks. In addition to understanding the nature of these locations of interest during proposed field visits, outreach and communication with the landowners is expected during the visit to better understand concerns related to the Project and historical knowledge of the CBD. The 10 locations of interest identified for field visits (labeled with LOC) are shown on Figure 17 and listed in Table 1.

The Project Real Estate team was able to secure permissions for 6 of the 10 locations in March 2025.

6.1 Field Visit Summary – Part 1

The Jacobs team conducted a field visit on March 28, 2025, to Locations (LOCs) 4, 5, 5A, 6, 7, and Ridge Cut Location 1 (Figure 17). Table 3 shows the description of each location and the connection to the CBD (for the locations that were visited). Figure 18 shows a photograph of a landowner explaining concerns about the CBD WSE being too high to allow gravity drainage of rice water around August 20 through early September. The rice field drainage structure shown on Figure 18 has the flashboards removed, which allows water to drain into the CBD. Figure 19 shows the locations of global positioning system (GPS) shots to capture elevations along the drainage structure to give a better understanding of the critical elevations for drainage.

At Location 4, the Buckeye Creek Outlet, there is a large sediment deposit that has created an island within the CBD that can impede channel flow and redirect flow toward the banks, leading to erosion (Figure 20). The island is not currently represented in the model bathymetry. Figure 21 includes a snippet of the terrain currently used in the model.

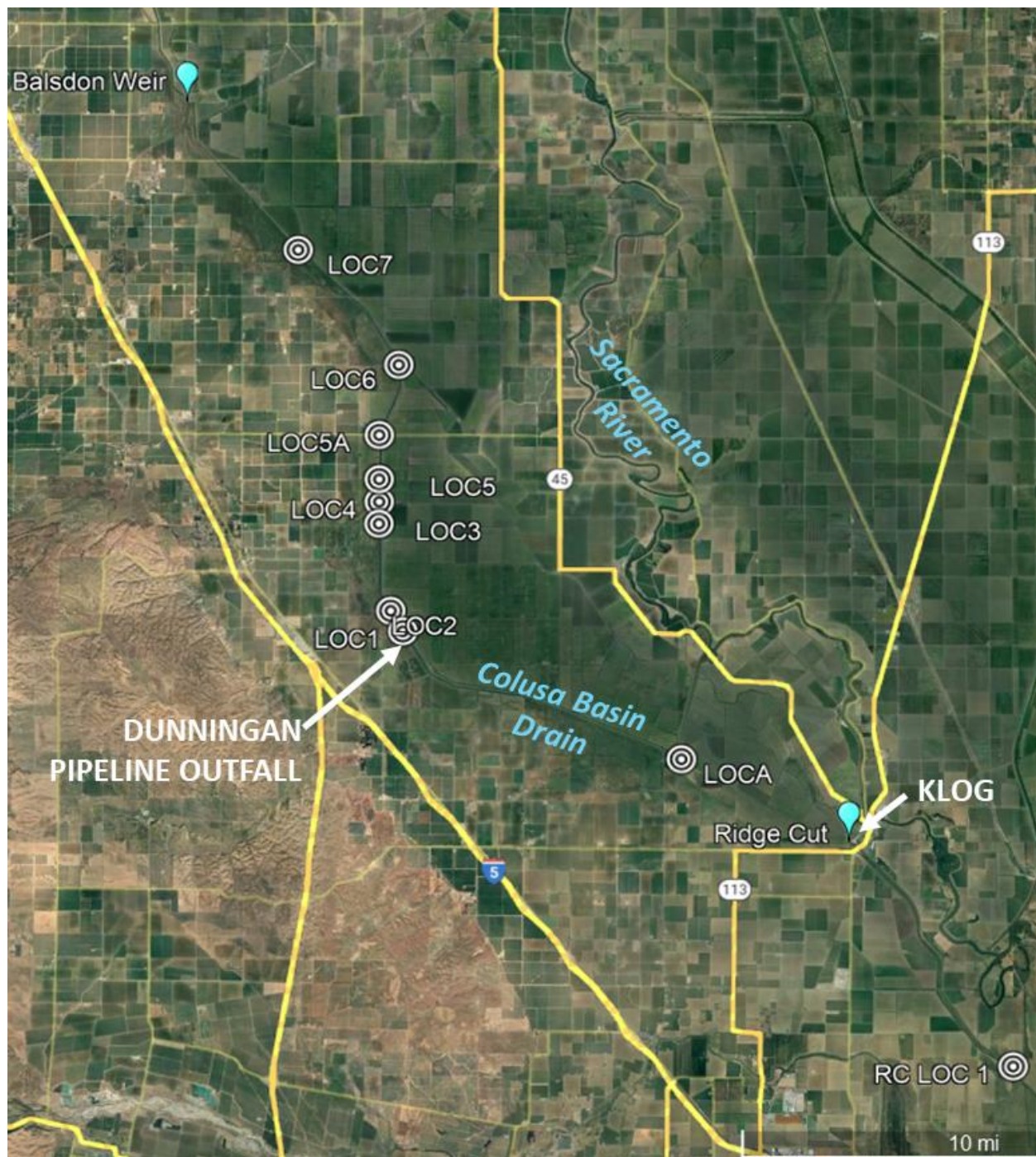


Figure 17. Locations of Interest Along the Lower CBD System

Table 3. Locations of Interest

Name	Approximate CBD RM	Description; Connection to CBD
LOCA	4.8	Channel
LOC1	11.5	Bird Creek
LOC2	12.0	Channel
LOC3	14.0	Bridge over channel
LOC4	14.6	Buckeye Creek; directly connected
LOC5	15.0	Channel; directly connected irrigation diversion
LOC5A	16.0	Channel south of Yolo County Line Road; low roadside drainage ditch – directly connected
LOC6	17.8	Channel; directly connected to a conservation area
LOC7	21.0	End of Clark’s Ditch; controlled pumped diversion location
Ridge Cut LOC1	Not applicable	Just upstream of Wallace Weir; controlled drainage



Figure 18. Rice Field Drainage Structure, with Flashboards Removed, Allowing Water to Drain into CBD



Figure 19. Drainage Structure – GPS Elevation Location



Figure 20. Location 4 – Buckeye Creek Outlet - Large Sediment Deposit

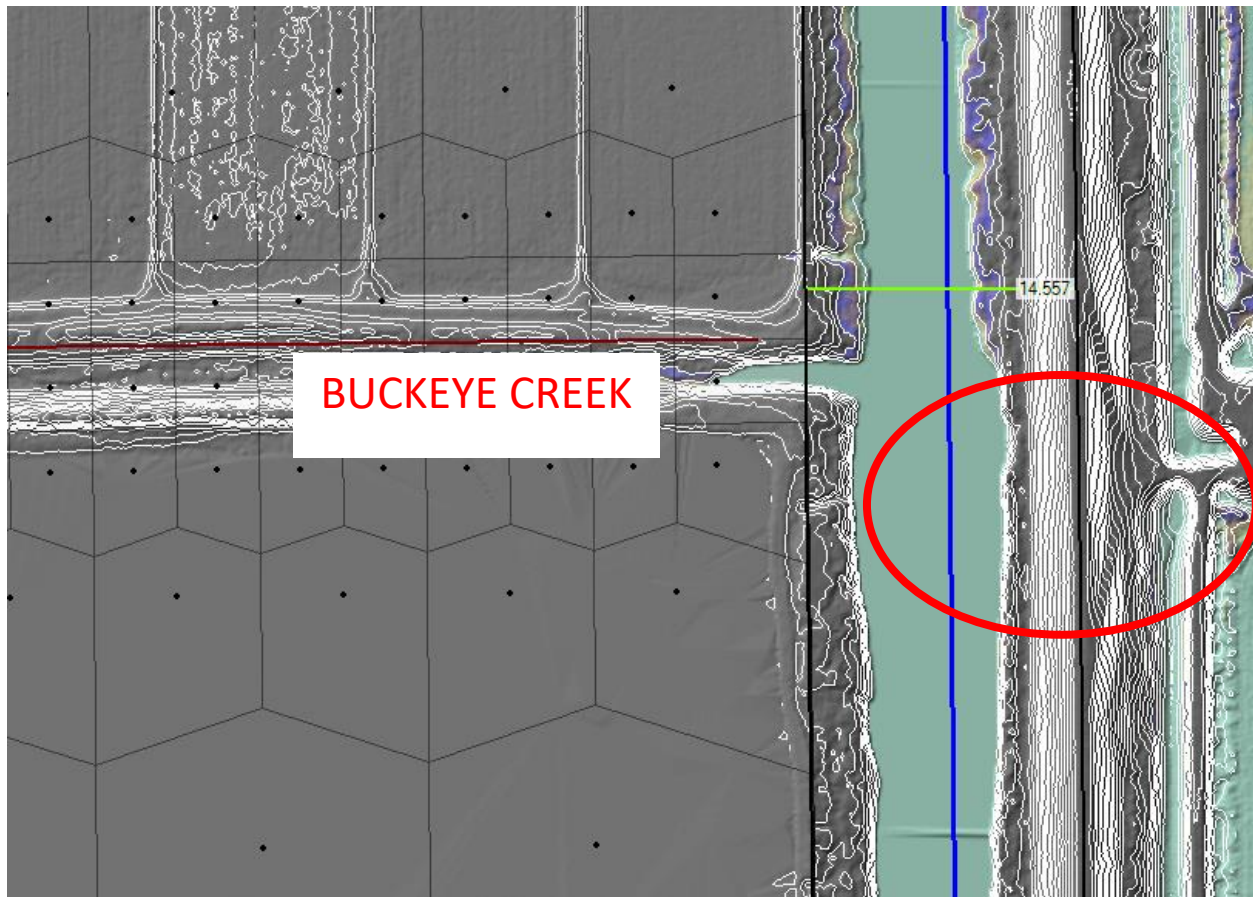


Figure 21. Location 4 – Buckeye Creek Outlet - Large Sediment Deposit – Not Included in Current Model

7.0 Current Understanding of KLOG Gate Operations

Sites Project Authority and Jacobs held meetings with the DWR KLOG Operations team on December 16, 2024, and June 9, 2025. The following sections detail what was learned in these meetings.

7.1 KLOG Outfall Gates Rehabilitation

The most recent KLOG gate rehabilitation project occurred in 2013. In this project, the slide and combination flap gates were updated. Slide gates were upgraded from circular bases to 66-inch trapezoidal and 42-inch square bases. Flap gates were upgraded to square bases.

7.2 KLOG Flap Gates – Downstream Side of Structure

Because the KLOG is a flood control structure, there is no control or monitoring of the flap gates since it is not part of the operator's responsibility. Therefore, the operators have no indication of when the flap gates will close. The flap gates, located on the downstream side of the KLOG structure, were assumed to be closed based on the WSE of 22.25 (NAVD88) in the Sacramento River. This approach is considered conservative because this covers the top of the flap gate. The KLOG flap gate operation does not use the upstream WSE due to subsidence and different datums between the upstream CBD KLOG gage (KLG) and downstream Sacramento River CBD gage (KNL).

The operation of the KLOG flap gates is not coordinated with RD-108 or the operation of Wallace Weir, and no supervisory control and data acquisition (SCADA) system exists between the two structures.

7.3 KLOG Slide Gates – Upstream of Structure

There are 10 slide gates on the upstream side of the KLOG structure. When operated automatically, the gates will open and close by themselves to maintain a setpoint elevation. If the upstream WSE is higher than the setpoint, the first gate will open in 10% increments over 10 minutes and continue sequentially through to the ninth gate as needed. If the upstream WSE is lower than the setpoint, the ninth gate will close first and continue sequentially to the first gate as needed. The tenth gate always stays closed. Within the system, slide gate values of less than or equal to zero are considered a closed gate. The slide gates will continue to operate based on the setpoint even if the flap gates are closed.

One or more of the gates can be operated manually to allow for maintenance while the others try to maintain the setpoint elevation. This might be needed when sending Project flows out of the KLOG. It is recommended to work with DWR to test different scenarios to see how partial manual and automatic control of the gates would work in practice with Project flows.

7.4 Operations of Maintaining KLOG Setpoint

The operational purpose of the KLOG is to maintain the setpoint during irrigation season through the Hershey Agreement and act as a flood control structure during the fall, winter, and spring. The setpoint elevation of 25.5 (USED), which is equal to 23.73 (NAVD88), has been used for the KLOG for many years. The setpoint has changed temporarily in recent years, most notably to 25.1 when the Wallace Weir was being constructed, but it has always come back to 25.5. The setpoint was temporarily raised slightly several years ago for the Fish Food Subsidies Pilot Program. The setpoint may be changed in the future due to subsidence or datum issues.

7.5 Sites Reservoir Coordination with KLOG Operations

Sites will need to coordinate with DWR to assure that Project flow makes it through the KLOG. Due to the needs to maintain irrigation diversions under the Hershey Agreement, DWR could not guarantee that the KLOG setpoint could be lowered during low flow years to allow for Project flow to exit.

8.0 Model Updates

These sections describe the updates to the CBD model including the Wallace Weir Geometry, CBD/KLRC junction, combined 1D/2D model, and verification of CBD cross sections.

8.1 Wallace Weir Geometry

The Wallace Weir is located at the downstream end of the KLRC and controls water before it enters the Yolo Bypass. The Wallace Weir geometry was updated to match the cbec TUFLOW model setup and the Wallace Weir design drawings (KSN 2016). The cbec is a consultant to Reclamation District No. 108, a member of the Sites Project Authority. In 2024, the Jacobs team coordinated with cbec related to their TUFLOW hydrodynamic model of the CBD. In 2025, these updates were included to more accurately model the backwater from the KLRC. The model updates consisted of the following:

- Inflatable gates were changed from 32 feet to 33 feet in width.

- Northeastern gate invert was lowered from elevation 20 to 15.74 feet NAVD88. This gate was previously set at elevation 20 feet in the Jacobs model.
- The overtopping weir elevation was confirmed to be set at 28 feet (NAVD88 elevation).

Figure 22 shows the Wallace Weir gate geometry shown in the HEC-RAS model, and Figure 23 shows the 2016 Wallace Weir design drawings (KSN 2016).

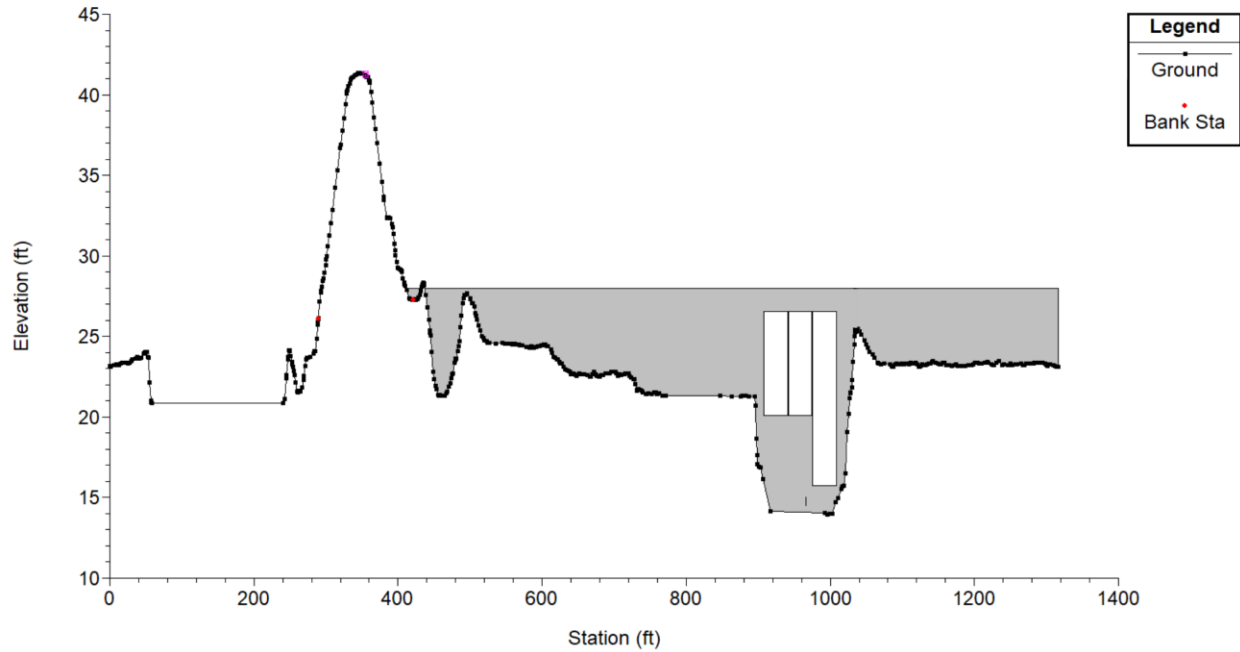


Figure 22. Wallace Weir Gate Geometry, Looking Upstream, as Shown in HEC-RAS Model

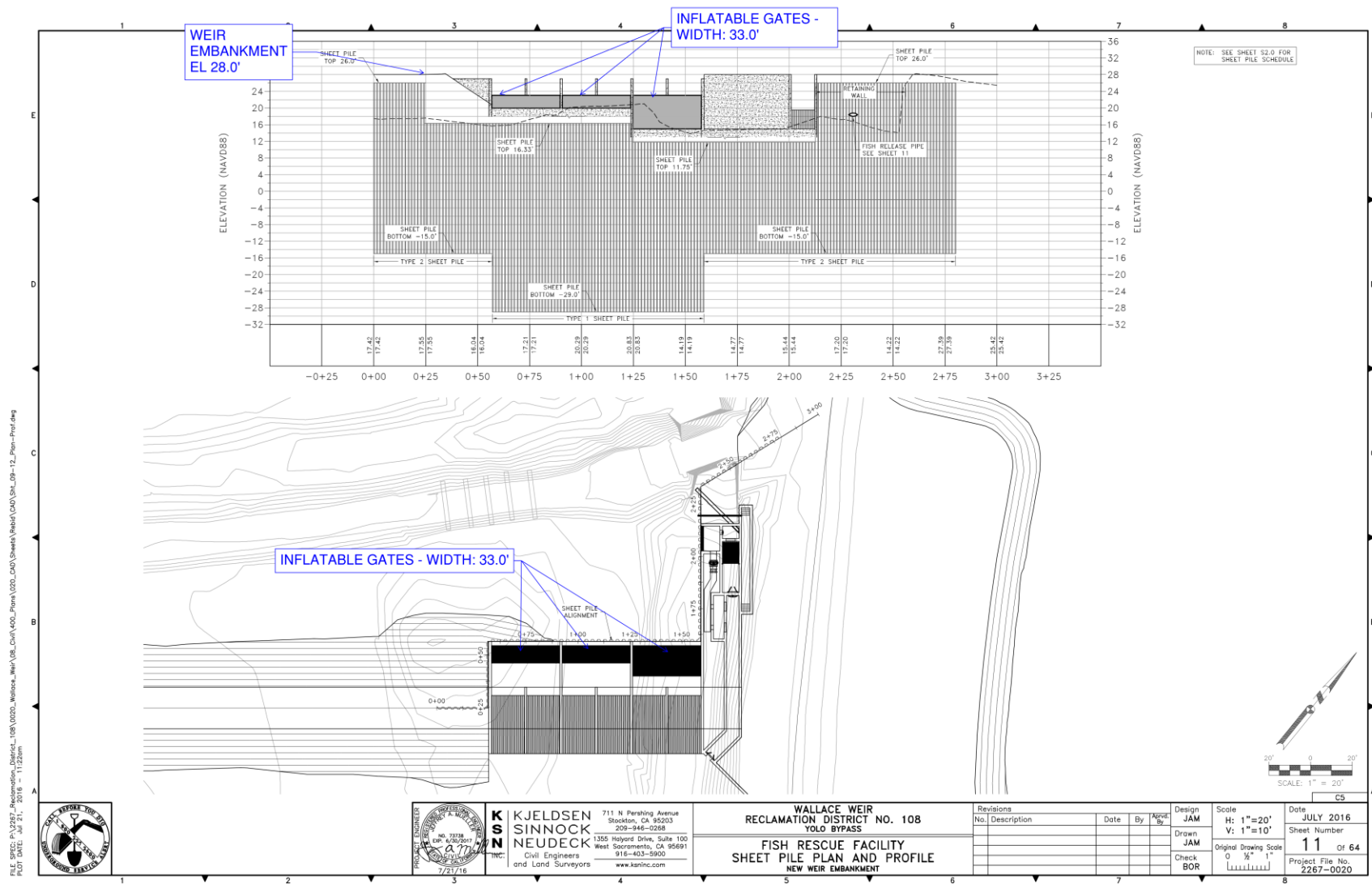


Figure 23. Wallace Weir Design Drawings (KSN 2016)

8.2 CBD/KLRC Junction Flow Split

Jacobs updated the model to better reflect the CBD and KLRC junction and flow split. Figure 24 shows a sketch of this update. This improvement to the 2D model should allow full momentum/velocity of flow in main CBD channel reach toward the KLOG structure, rather than stopping at the storage area then overflowing to either the KLRC or KLOG.

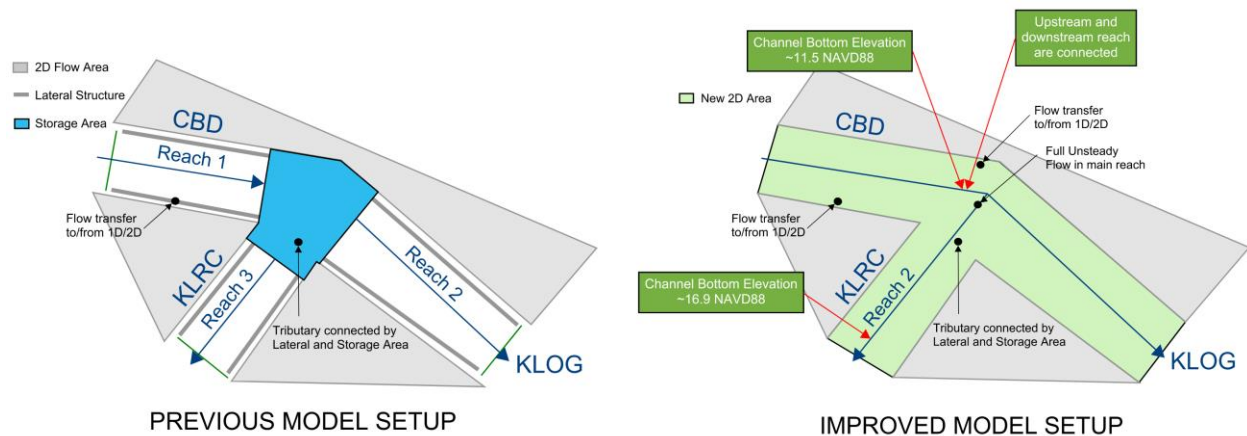


Figure 24. Previous and Improved Model Setup for the CBD and KLRC Junction

8.3 Progress with 2D Model Update for CBD/KLRC Junction Flow Split

In the fall of 2025, a series of updates were made to the 2D version of the CBD hydraulic model to improve the representation of the junction between the CBD and the Ridge Cut Slough. The reason behind the use of a fully 2D model to investigate this junction was that the 1D model used a junction representation that does not account for flow momentum at junctions whereas the 2D model does. Because initial runs with the 1D model indicated the potential for a fraction of Project water to flow into the Ridge Cut Slough, a more robust representation of hydraulics at the junction was warranted. Development and refinement of the 2D model included the following updates to improve the representation of the CBD/KLRC junction flow split:

- Converted to fully 2D model to allow for velocity/momentum at CBD/KLRC Junction
- Clipped model domain to just upstream of Dunnigan Pipeline Outfall to reduce processing/cleanup time
- Interpolated 2D area in the channel between cross sections of channel bathymetry in the 1D model
- Updated mesh/breaklines to reduce leaking between cells
- Added Manning's n layer (USGS 2024)
- Fixed issues in the 2009 Central Valley Floodplain Evaluation and Delineation (CVFED) Light Detection and Ranging (LiDAR)
- Fixed issues with channel bathymetry interpolated from 1D cross sections

- Updated flap gates at KLOG so there is no inflow from the Sacramento River to CBD
- Model run time for a May through December simulation varies from 2 to 3 days, depending on the calculation time step (4 to 10 seconds)

8.4 Progress with 1D/2D Model Update

The combined 1D/2D model was updated to better represent existing conditions with the following updates:

- Model was updated using the complete Davis Weir dataset from 2001 to 2025, providing a more robust view of the frequency of high ambient flow conditions in the CBD.
- Model was updated using CalSim 2 (82 years of record) and using USRDOM Daily Alt 3 Results, providing more resolution on the daily flows in the Dunnigan Pipeline. Previously, CalSim results were used and provided only average monthly flows. The daily flows provide a more granular look at the frequency of full flow (1,000 cfs) events in the pipeline.
- Detailed review was conducted of terrain, grid structure, and lateral structure weir elevations to better represent inundation during higher flow events in the CBD. This involved updating breaklines—not just along the bank of the CBD, but also in the agricultural fields and habitat areas—to better track overflows from the CBD during high flow events. With these adjustments, water that overtops the natural west bank of the drain and inundates habitat lands or agricultural fields is less likely to continue moving downstream on the floodplain.

8.5 CBD Cross Sections: 2025 Survey Comparison – Verification of Model Cross Section

In December 2025, Jacobs received permission to collect seven cross sections along the CBD between RM 8.3 and RM 12.5. This area represents the low western bank area and where the Dunnigan Pipeline Outfall will be located. The purpose of the limited field survey was to see if the CBD channel bathymetry had changed in the 16 years since DWR had collected bathymetry/LiDAR in 2008/2009. The DWR data were used in the CBD HEC-RAS model.

R.E.Y Engineering, Inc. collected the cross sections on December 17, 2025. Their information is compared with the DWR 2008/2009 and is described in Appendix 2. In general, the 2025 cross sections compare very well with the DWR data. It provides confidence that, at least in this reach of the CBD, the model is representative of existing conditions.

9.0 Preliminary Results

The following results were conducted for the 2016 flow conditions and modeled between June 1 and November 30 during these flow conditions. 2016 was a Below Normal water year and was calibrated with flow and stage data at KLOG. It had high ambient flows in the CBD, during a 2-week period at the end of August (1,870 cfs) and a 1-week period at the end of November (1,800 cfs).

9.1 Results of Western Bank Improvements Analysis

An analysis was conducted to understand where the western bank of the CBD needs to be raised to convey the maximum of 1,000 cfs without inundation of the agriculture fields. The process was iterative: (1) the bank would be raised to provide 2.5 feet of freeboard in areas where agriculture fields were being flooded, then (2) the model was run to see where the flooding migrated to, then (3) that bank

would be raised to provide 2.5 feet of freeboard. After several iterations, the necessary bank raises were determined. The 1D/2D model was run for July 1 through November 30, covering the period when South of Delta Investors can take water from Sites Reservoir. Three simulations were conducted:

- Ambient flow base case (existing condition, no western bank improvements)
- With Project flow of 1,000 cfs with no western bank improvements
- With Project flow of 1,000 cfs with western bank improvements to protect agricultural fields only

The first run represents ambient flow in the CBD canal and is the base case without Project flow. The results of the base case are shown on Figure 25. The agricultural land on the west bank by RM 8.9 were inundated, along with some habitat lands by RM 19.5. Additional agricultural lands were inundated by RM 23.2 and 22.7. This was because in 2016, the CBD had high ambient flows during a 2-week period at the end of August and a 1-week period at the end of November.

The second run added the Project flow of 1,000 cfs to the ambient flow in the CBD canal. In this run, as shown on Figure 26, there was much more inundation of the agricultural and habitat lands on the western bank. Specifically, there is major agricultural land inundation downstream of RM 10.469 and between RM 17.133 and 14.557.

The third and final run includes the western bank improvements along with the flow scenario from the second run. The purpose of this run was to see how high the western banks needed to be raised to remove any agricultural land inundation from the combined ambient and Project flows. The bank and berm improvements required for this run are 26,260 linear feet (LF) and 4,062 LF, respectively, and are shown in Appendix 3. In this run, as shown on Figure 27, only habitat lands were inundated, mostly between RM 22.380 to RM 17.133, RM 14.067 to 12.517, and RM 8.010 to RM 5.045. Table 4 shows the number of acres inundated for each land type in each run.

Table 4. Inundated Area by Type and Run

Land Type	Run 1: Ambient Flow (acres)	Run 2: Ambient Flow + Project Flows (acres)	Run 3: Ambient Flows + Project Flows with Bank Improvements (acres)
Agricultural	507	1,292	0
Habitat	319	2,204	2,804

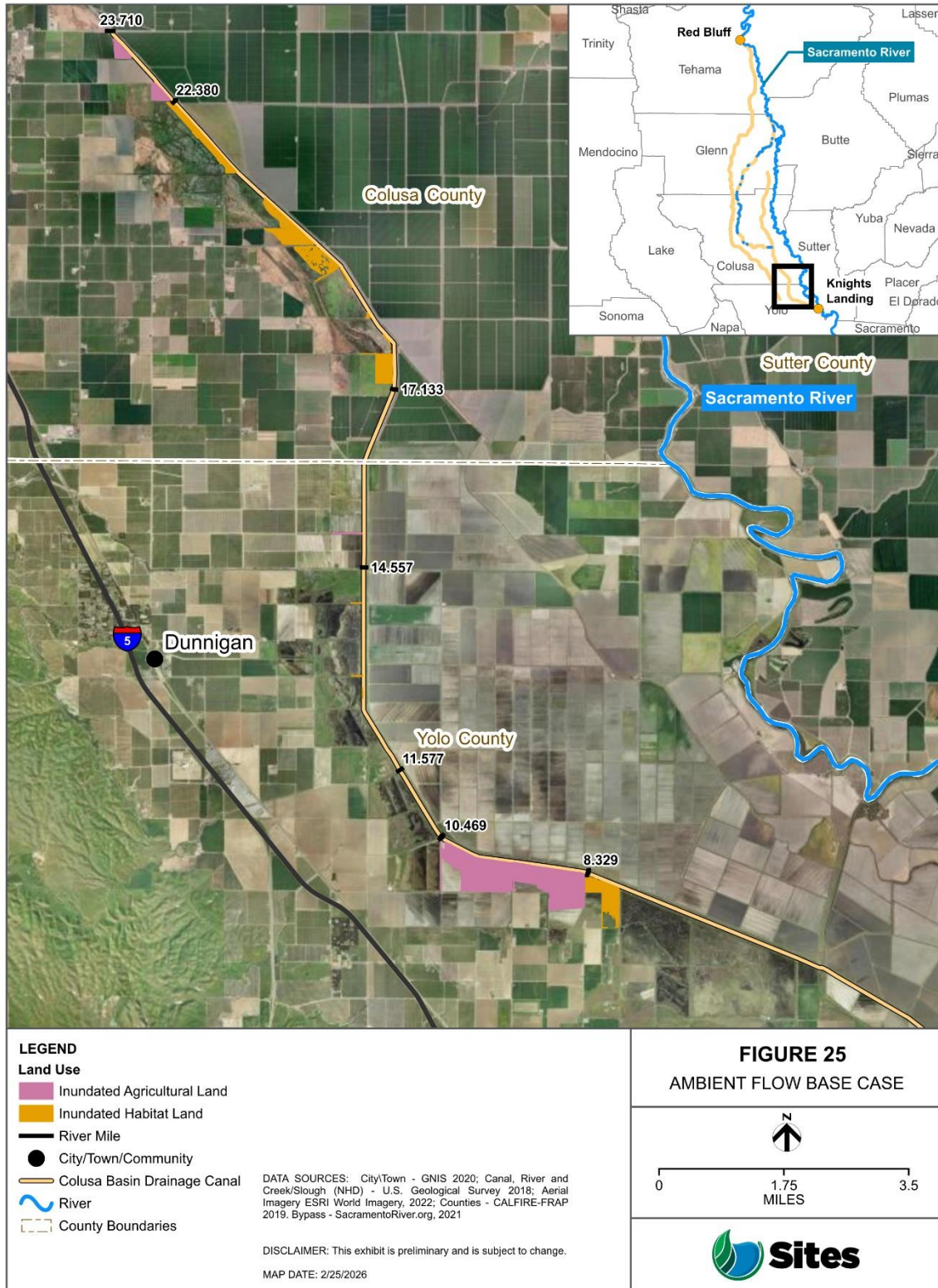
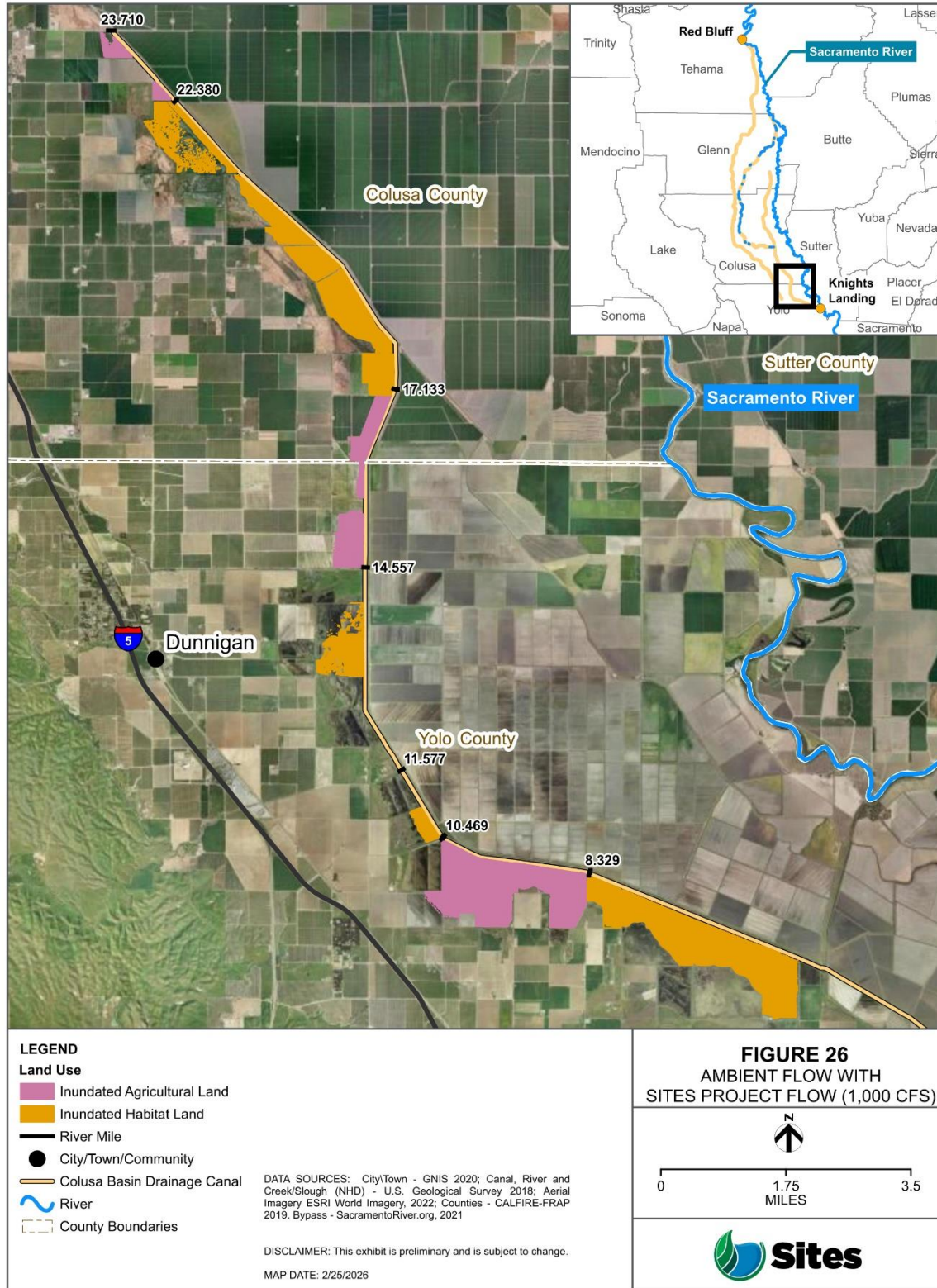


Figure 25. Ambient CBD Base Flow Model Inundation



PATH: \\DC1V5011GIS\PROJ\SITES\PORTAL\AUTHORITY\CA\SITES\CONVEYANCE\MAPFILES\ITM_SITES_CBD_MODELING\ITM_SITES_CBD_MODELING.APRX LAYOUT: SITES_TM_FIG26_AMBIENTFLOW_1000CFS USER: KMINO DATE: 2/25/2026

Figure 26. Ambient CBD with Project Flow Model Results

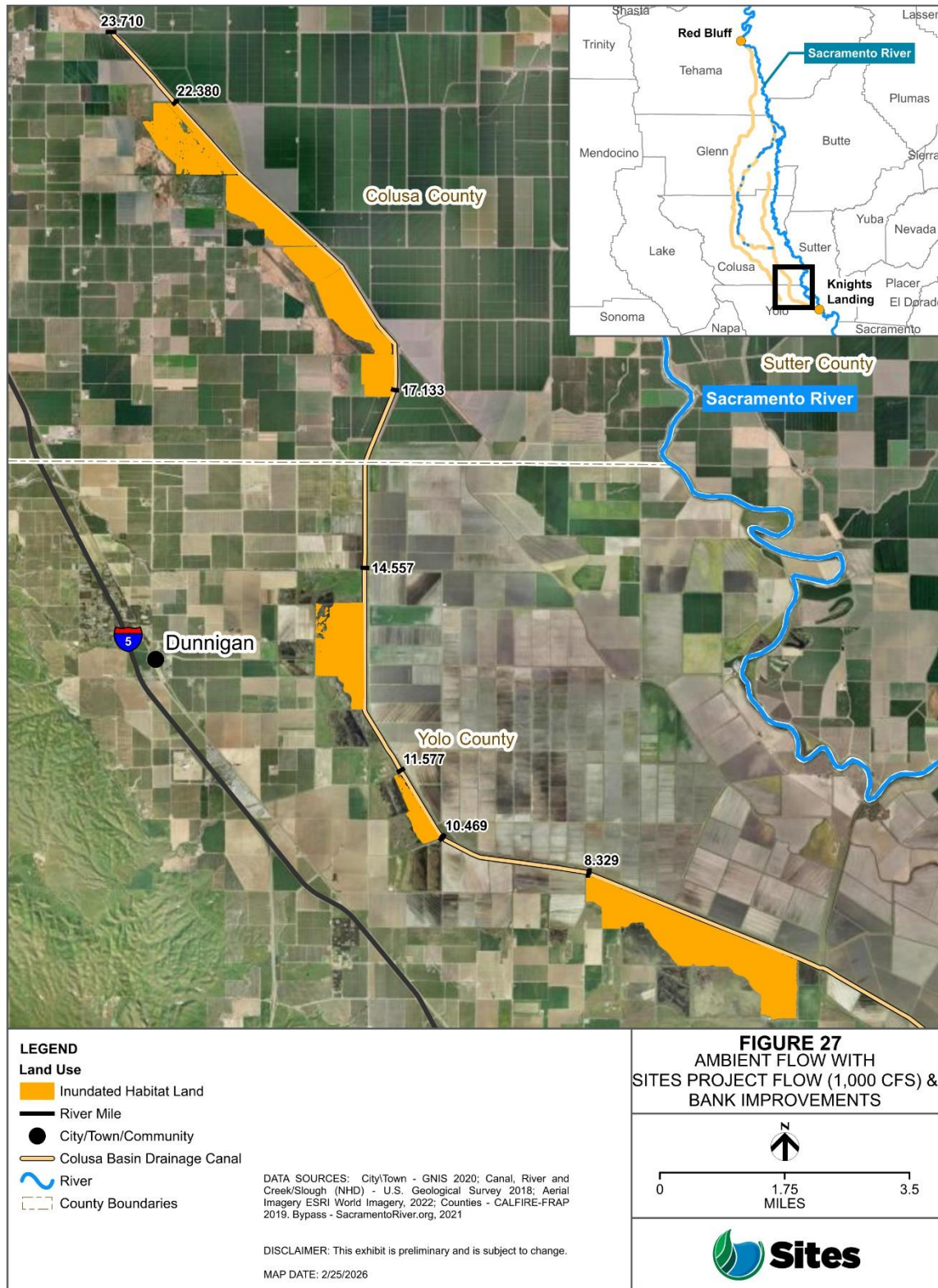


Figure 27. Ambient CBD with Project Flow Model and Bank Improvements Model Results

Figure 28 presents longitudinal profiles of the western bank elevations along the CBD along with predicted maximum WSEs along the drain for a high flow rice water release scenario from August 2016. Water elevation profiles are shown for existing conditions and Project conditions, which include a constant release of 1,000 cfs from the Dunnigan Pipeline. The impact of the Project is shown in the dashed green line read on the right-hand vertical axis, showing a maximum increase of 1.8 feet because of Project releases. When the water level exceeds the local bank elevation, inundation outside of the main drain channel will occur. This inundation affects both habitat areas and agricultural fields, as discussed previously.

Figure 29 presents a similar plot but with the western banks raised in select locations to eliminate inundation of agricultural fields in the August 2016 scenario with ambient Davis Weir flows of 1,870 cfs combined with Project flows of 1,000 cfs. With the prescribed bank improvements, visible as horizontal lines in the bank elevation (RM 8.6 to 10.5, 14.7 to 17.0, and 23.2 to 23.3), there is no inundation of agricultural fields at the same flow condition. Some inundation of habitat areas does occur, as periodic inundation of habitat areas was deemed acceptable.

Quantification of bank improvements did not consider reducing ambient inflows for water rights diversions because the critical flow scenario for bank improvements is when rice fields are draining water in late August / early September. These are the improvements discussed above necessary to avoid nuisance inundation of agricultural fields is not considered excessively conservative because of the exclusion of water rights diversion.

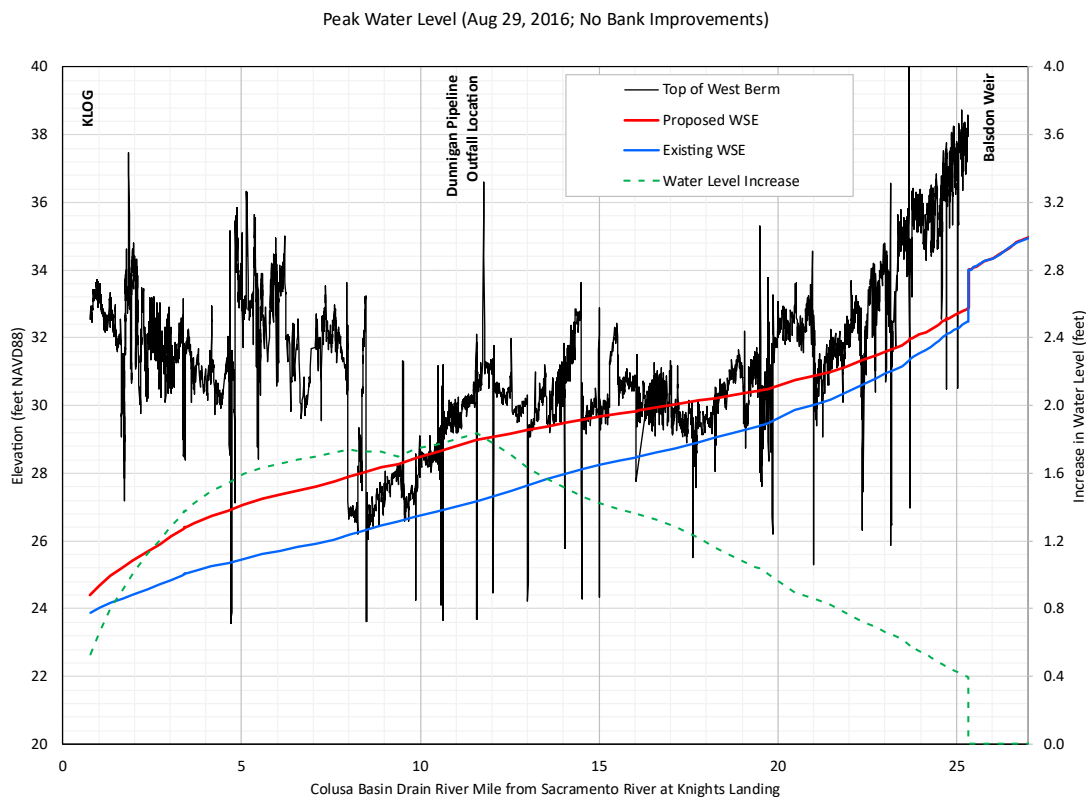


Figure 28. Longitudinal Profiles of Water Levels, Bank Elevations, and Water Level Increase with Project Water and no Bank Improvements

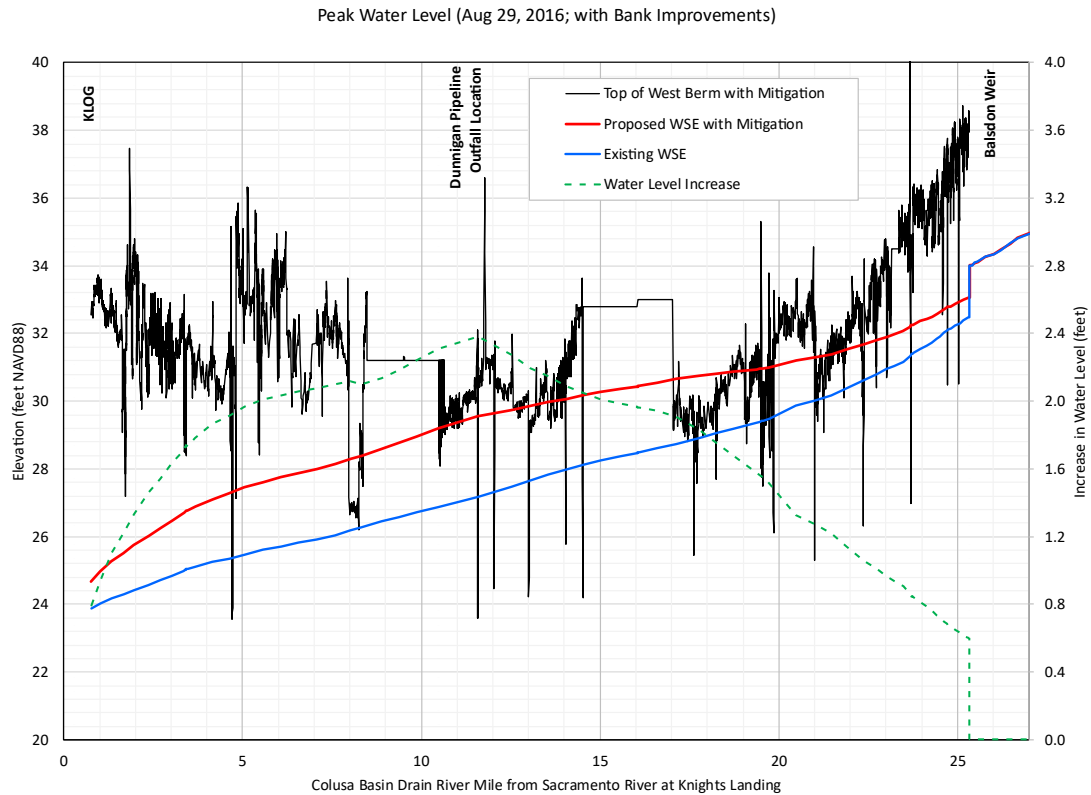


Figure 29. Longitudinal Profiles of Water Levels, Bank Elevations, and Water Level Increase with Project Water and with Bank Improvements

A feasibility level cost estimate was developed for raising the western bank of the CBD using previously developed costs for bank improvements; this estimate expands costs to include newly identified bank improvements. The cost estimate provided in Appendix 4 was \$7.6 million for 2.5 miles of improvement. Using this estimate and reducing to a cost per LF of bank improvement results in improvement costs of \$575/LF. Using the bank and berm improvements as identified in the 2016 modeling results resulted in 26,260 LF of bank improvements and 4,060 LF of berm improvements. At \$575/LF, the improvements would then cost approximately \$17.5 million.

9.2 Flow Split Between CBD and KLRC

The flow split between CBD and KLRC was analyzed to quantify potential losses of Project water down the KLRC. Existing operations of the Wallace Weir are coordinated with KLOG operations to maintain required water levels. During high runoff events in the CBD, water reaching the junction of the CBD and KLRC can flow either east out of the KLOG or south into the Ridge Cut, depending on local gradients.

Historical flow splits at the junction under existing conditions were analyzed using available data from Davis Weir and the gage in Ridge Cut Slough near the junction (CDEC RCS gage). Model simulations were also used to quantify how the flow split changed with Project flows added to the CBD, using model predictions for flow at KLOG and into the KLRC.

9.2.1 Gage Data for Davis Weir Flow Compared to Ridge Cut Slough Flow

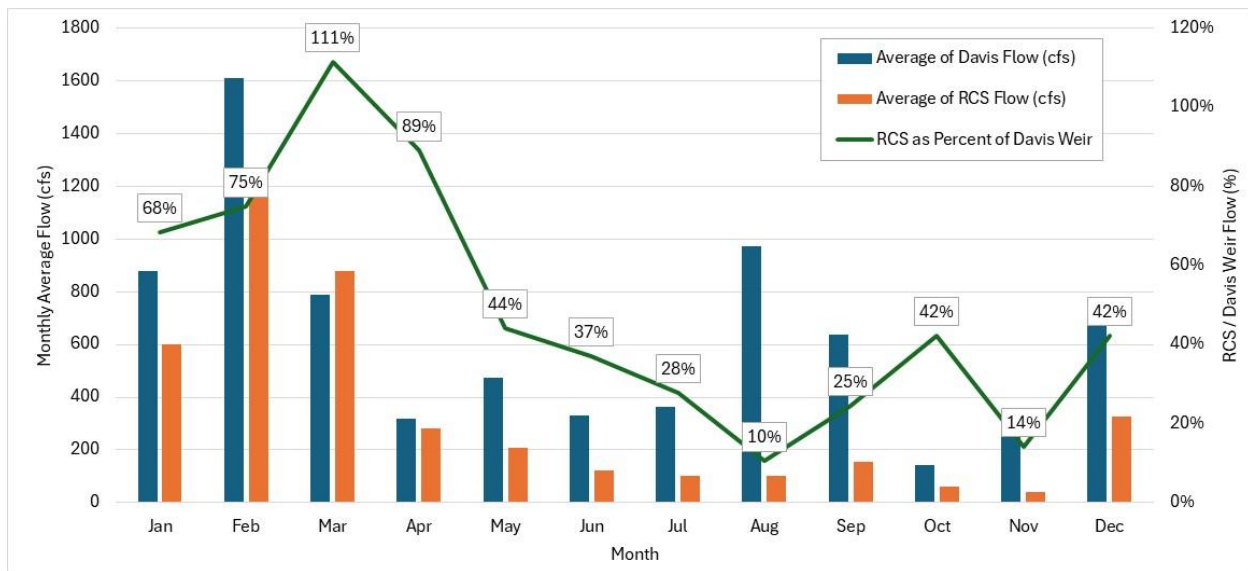


Figure 30. CBD/KLRC Junction Flow Split (Gage Data from 2013-2023)

The flow split between the CBD and KLRC was calculated using existing gage data from 2013 to 2023, shown on Figure 30 as monthly averaged flow values over the 11-year period of record and the percentage of the average Ridge Cut Slough flow compared to the Davis Weir flow. This analysis is planned to be updated with the new Davis Weir flows (2001 to 2012 [Section 10.2]). The following observations were made regarding historical data presented on Figure 30 and for assumed Project operations:

- The values that are higher than 100% could be due to wet weather inflows into the CBD downstream of the Davis Weir in the early spring. Davis Weir is approximately 31 miles upstream of the CBD/KLRC junction.
- Under existing conditions, an average of 24% of the water in the drain goes down the Ridge Cut (July to November). This flow split is related to the operations of both KLOG and Wallace Weir.
- The high percentage of flow going down the KLRC in the winter months is most likely due to the KLOG flap gates being closed and CBD flood waters directed down the KLRC into the Yolo Bypass.
- When there is high ambient flow and Project flow, there is no control structure at CBD/KLRC junction to direct flow through KLOG rather than KLRC.
- When there is low ambient flow and Project flow, the KLOG gates will try to maintain the setpoint and hold a pool when needed, which will not necessarily direct full Project flow through the KLOG structure.

9.2.2 Model Approximation of Flow Split between KLOG and KLRC

Initial simulations with the 1D/2D model indicate some loss of Project water down the KLRC under current operations of the KLOG and Wallace Weir. At the junction of the CBD and the KLRC, the channel invert elevations are approximately 11.1 feet in the CBD and 16.9 feet in the KLRC. These flowline

elevations can be seen in Figure 24. Downstream of this junction, just upstream of Wallace Weir, the channel invert elevation is approximately 14.1 feet. Therefore, once water enters the KLRC from the CBD, it follows a positive drainage gradient toward the Wallace Weir structure.

The Project water loss occurs because of how the Wallace Weir operations are included in the model to match those prescribed at KLOG. If the gates at Wallace Weir are not closed, then Project water can be lost down the KLRC. With the Wallace Weir closed, any flow down the KLRC will just temporarily fill channel storage because the KLRC is a dead-end canal without flow leaving through Wallace Weir. This assumes that seepage losses are negligible in terms of Project flows.

Model simulations were conducted with the Wallace Weir gates closed during Project releases to demonstrate that there is no loss down the KLRC. Absent coordination between operations of Wallace Weir and Sites Reservoir, there could be minor losses of Project water down the KLRC depending on other variables like ambient flow in the CBD and stage at the junction. Modeling indicates the setpoint of the KLOG operations does influence flows at the junction, and thus lowering the setpoint during periods of Project releases would reduce any flows down the KLRC.

10.0 Conclusions and Next Steps

This section presents the conclusions and next steps for the CBD hydraulic modelling efforts related to the Project.

10.1 Conclusions

The hydraulic modeling and coordination completed in 2023 and 2024 revealed a need for improvement to the existing model and to understanding the current operation and seasonality of the Lower CBD System. Efforts to improve hydraulic models of the CBD in 2025 and early 2026 focused on issues revealed by previous analyses, including refinement of bank elevations that control inundation of habitat areas and agricultural fields, and understanding of inflows and the influence of seasonal water user demands on channel flows and thus Project impacts.

The revised model provides improved estimates of inundation of habitat lands and agricultural fields under both existing and Project conditions. The 1D/2D model was used to estimate bank improvements required to eliminate inundation of any agricultural lands west of the CBD for full Project flow releases and ambient flows up to 1,870 cfs. Bank improvements totaling 26,260 LF and 4,060 LF of berm improvements adjacent to agricultural fields will eliminate inundation up to modeled events in August 2016 (1,870 cfs).

Flows at Davis Weir exceeding 1,870 cfs could result in some inundation of agricultural fields west of the CBD channel. Coordinating the use of the Dunnigan Pipeline to convey Sites Reservoir releases will be necessary to avoid potential inundation of agricultural fields during ambient flows that exceed 1,870 cfs, whether from rice water drainage or from early fall storm events. Sites could plan on holding releases during the annual rice water release event, which generally occurs for up to 2 weeks sometime between mid-August and mid-September every year. Review of historical Davis Weir flows indicates the 1,870 cfs flow was exceeded 9 of the past 24 years for up to 11 days in the worst year.

The existing condition model tends to overestimate flow and stage in the CBD when compared with the existing gages (flow at KLOG and stage at Riggs Ranch) during the simulation period of April through December. The ungaged diversion of water to local uses between the Davis Weir and the Dunnigan Pipeline outlet complicates the quantification of Project impacts on local water levels. Model results

demonstrate that consideration of some diversions downstream of Davis Weir would lead to improvements in the model accuracy. These diversions, however, are likely not active during the rice water drainage period when Project flows are likely to have the highest impact on water level. Thus, the improvements delineated to avoid inundation of agricultural fields during rice water release events is likely not overestimated by any significant amount.

Additionally, there are still uncertainties about the operations of KLOG and Wallace Weir, including setpoint levels related to gages that may be experiencing subsidence. A better representation of the existing conditions in the CBD and updates to the Project operations will better quantify Project release constraints, water level impacts, and banks improvements necessary along the Lower CBD System to reduce or eliminate nuisance inundation of agricultural fields. Planned enhancements to the hydraulic modeling efforts to address modeling uncertainties and limitations are discussed in the following section.

10.2 Next Steps

The next steps identified have been separated into three categories: Improve Existing Model, Update Project Operations, and Improve Ability to Quantify Project Impacts and Inform Project Operations. More detail on each of these steps is described in Sections 10.2.1 through 10.2.3. In addition, the next steps are identified for the final design phase of the Project.

10.2.1 Improve Existing Model

The following next steps are earmarked for final design phase modeling efforts:

1. Continue field visits to locations of interest and further discussions with landowners and regulating agencies to discuss existing conditions and operations along the Lower CBD System.
 - a. Visit remaining four locations: LOC3, 2, 1, and 1A.
 - b. Compare critical elevations against updated gage data and model.
2. Further analyze and refine the KLOG representation in the model, including geometry and operations.
 - a. The KLOG flow data have not been publicly available since the construction of the rectangular and some trapezoidal base slide gates. The cbec provided flow data from 2016, which they received from DWR, and more analysis into and validation of a new flow calculation is necessary. Additionally, more discussions with DWR on the KLOG flow and additional work to create new calculations for flow should be explored. Calculated flow should be verified by taking flow measurements at discrete time periods on the western side of the gates. Flow regressions would be developed from measurements of stage to allow estimation of flow from ongoing stage measurements. Stage measurements to local gages must be resurveyed to address any local subsidence.
 - b. Test KLOG setpoint adjustments in coordination with DWR.
 - c. Explore lowering the setpoint in August/September when rice fields are draining and farmers have concerns about water being too high. This could reduce the amount of bank improvements

necessary to stop nuisance Project-induced inundation during rice water drain periods in August and September.

3. Incorporate existing water rights diversions from MBK.
 - a. MBK provided updated data and analysis on the existing water right diversions along the CBD. A preliminary analysis of these water rights diversions is summarized in this TM. However, these diversions need to be incorporated into the model at the correct time periods with the use of pumps or another method to reduce the modeled ambient flow in the CBD from Davis Weir downstream to KLOG and Wallace Weir. This should improve the agreement between modeled and measured stages in the CBD. Additional flow gages in the system would reduce model uncertainty regarding diversions.
 - b. Provide further analysis of water rights.
 - 1) Update to Project flow capacity analysis with 2001 to 2012 Davis Weir flow data from GCID. This would provide improved estimates of flow frequency and inform Sites release operations during periods of high ambient flow.
 - 2) Provide a potential interactive dashboard looking at the water rights diversions reduction in the model and how it impacts the results.
 - 3) Conduct additional meeting(s) with MBK to discuss water rights diversion and incorporation into model.
4. Update KLOG setpoint to align with cbec's model and the reported Ridge Cut Slough stage gage.
 - a. To account for subsidence at KLOG and more accurately capture the current WSE in the CBD, the HEC-RAS hydraulic model KLOG setpoint will be updated from 23.73 to 22.4 to match the elevations reported at the Ridge Cut Slough gage and align with cbec's TUFLOW hydrodynamic model. Preliminary investigation indicates that a reduced setpoint in the model would yield more accurate stage predictions in the lower CBD. Survey of the KLOG gage should be conducted to quantify recent subsidence.
5. Calibrate and validate the CBD HEC-RAS model for additional events with historical gate operations.
 - a. With proposed new and improved gages and additional years of analysis, the HEC-RAS model should be compared against the new available data and adjusted to match the existing stage and flow where possible.
 - b. Provide additional model calibration with existing and proposed gage data:
 - 1) Include a comparison of existing model WSE results in the Sacramento River downstream of KLOG structure against the KNL stage gage.
 - 2) Conduct additional model runs with a wider range of ambient flows given the recently received Davis Weir flow data, which now extends the flow record back to 2001. The larger dataset provides an improved estimate of flow frequency in the system and allows for an improved understanding of Project impacts during high ambient flow conditions.

6. Update the model with new surveyed terrain data and existing structure data survey.
 - a. New terrain data will more accurately represent the existing channel geometry and improve estimates of inundated areas. This update to the terrain should include bathymetry, western bank survey, and LiDAR, which should be incorporated into the model for future Project phases. Comparing the old and new surveys will also aid in quantifying subsidence in the area since the 2008 to 2009 survey was completed.
 - b. Conduct additional survey to collect geometric data for Balsdon Weir because as-builts do not exist for the structure.
 - c. Increase the 2D modeling domain to cover up to Davis Weir.
7. Provide permitting requirements for the Flood Flow Analysis 408 Permit.
 - a. Conduct a hydraulic impact analysis of the Dunnigan Pipeline Outfall structure to support permit application. The design flow to be analyzed is 26,000 cfs based on the CVFPB designated floodway details and meeting held with Sites Project Authority, Jacobs, CVFPB, and USACE on April 9, 2025.
 - b. The model will need to be updated to accommodate this large flow and to correctly represent the outfall structure to quantify Project impacts.
 - c. A pre-Project and post-Project model will be run to analyze inundation and WSEs for both model conditions.
8. Quantify subsidence in the Lower CBD System and how it will be addressed in the model, with particular attention to model bathymetry and KLOG operations.

10.2.2 Update Project Operations – For 2026 and Beyond

Project operations are continually being refined, with new scenarios and optimization of deliveries under various constraints, including climate change. The hydraulic model should incorporate revised operations at key points in the design. The following operational conditions should be incorporated into the CBD model:

1. Update Project Operations
 - a. Further coordination with Operations team about KLOG gates closed and incorporation into their CalSim 3 model: update from CalSim 2 – Alt 3B to CalSim 3 results
 - b. Further discussion and coordination of Project flow updates from historical climate conditions to climate change conditions with a 2035 Central-Tendency Operations model and updated transfers/releases in coordination with the Sites Reservoir Operations team
 - c. Investigation of modifications to the seasonal water release from Sites to avoid nuisance inundation from Project releases during periods of rice water drainage in late August and early September

10.2.3 Improve Ability to Quantify Project Impacts and Inform Project Operations (Request for Improved and New Gages)

Due to the lack of existing flow and stage monitoring within the CBD, additional gages have been proposed to provide historical records of flow and stage. These additional gages will provide data to better calibrate the existing HEC-RAS model, document the pre-Project conditions and post-Project impacts, and enable ambient conditions to inform Project operations.

Request for the additional gage information in the CBD has been discussed with RD108 and in the public meetings with the Lower CBD Working Group. RD108 requested grant funding through DWR's Stream Gage Improvement Program in October 2024 for new Gages 1 and 2 and improvements to Gage 5, as shown on Figure 31 and in Table 5. Improvements to Gages 3 and 4 are still being discussed for a future date and would provide measurements necessary for the operation of the Lower CBD System post-Project construction. Unfortunately, this grant application was denied in 2025. RD108 is targeting potential Proposition 4 funding in 2026.

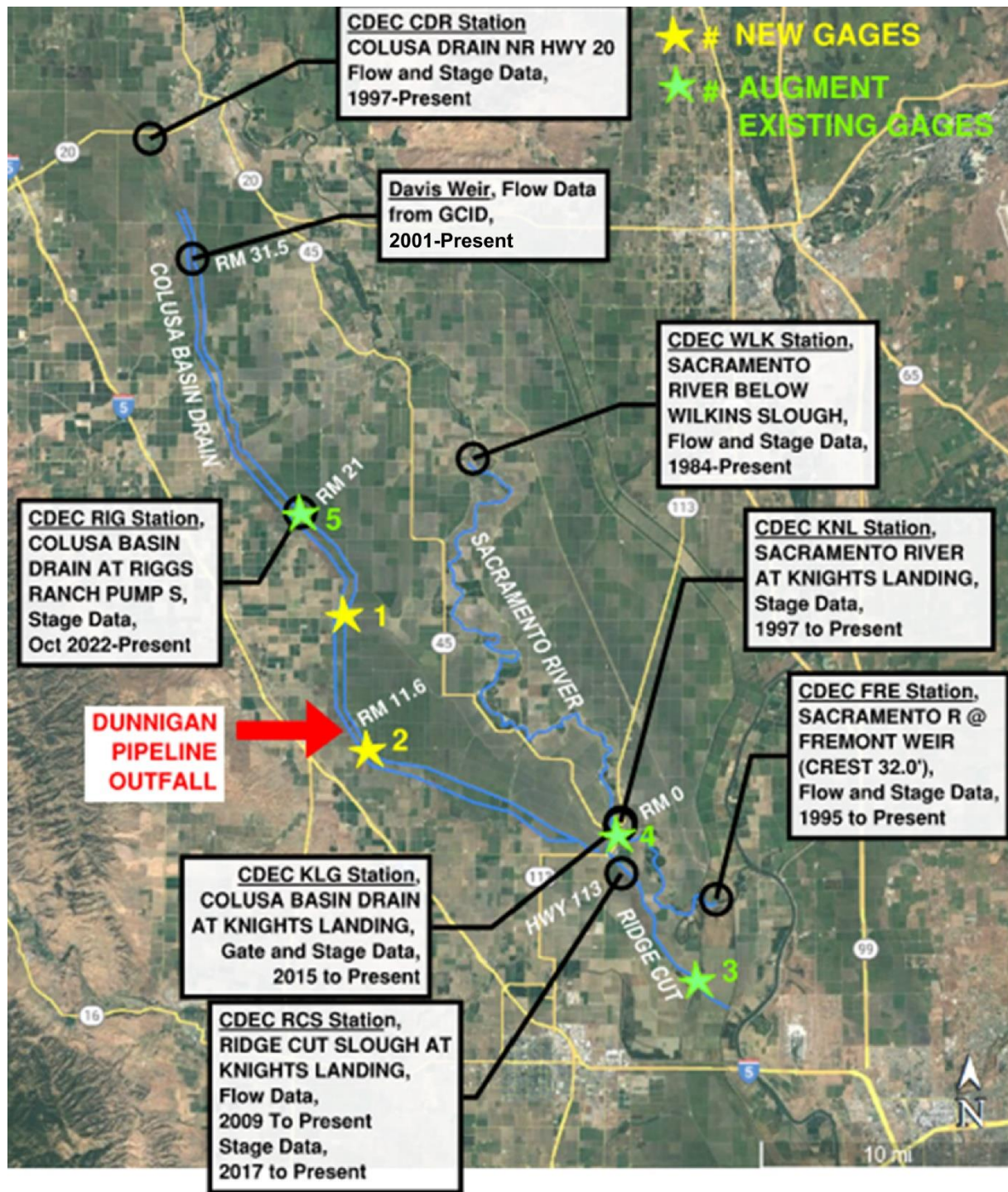


Figure 31. Requested New Gages and Gage Improvements

Table 5. Requested New Gages and Gage Improvements

Gage No.	Location	Details/Location of New Gage
1	RM 16	At County Line Road, which would be about halfway between the existing Riggs Ranch gage and proposed Dunnigan Outfall gage. Stage and flow measurements are requested.
2	RM 11	Just downstream of the proposed Dunnigan Pipeline Outfall. Stage and flow measurements are requested.
3	Wallace Weir (Improvement)	Stage and flow gage improvement. Current data collected are not publicly available.
4	KLOG (Improvement)	Addition of a flow gage. Stage information already exists.
5	Riggs Ranch (Improvement)	Addition of a flow gage. Stage information already exists.

11.0 References

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Appendix 1
Colusa Basin Drain HEC-RAS Model
Updates Draft Technical Memorandum –
December 20, 2024

Colusa Basin Drain HEC-RAS Model Updates Draft Technical Memorandum



To: Sites Project Authority

CC: Henry Luu, P.E. (HDR)

Date: December 20, 2024

From: Jacobs; Jessie Hekl, P.E./Jacobs

Quality Review: Kyle Winslow Ph.D., P.E./Jacobs, Peter Rude, P.E./Jacobs

Authority Agent Review:

Subject: Colusa Basin Drain HEC-RAS Model Updates 2023 and 2024

Executive Summary

This technical memorandum (TM) presents the results of additional model development and analyses conducted in 2023 and 2024 for the Colusa Basin Drain (CBD) hydraulics in relation to the Sites Reservoir Project (Project) inflows. Building on previous analyses from August 2020 and December 2021, this TM updates the hydraulic modeling analysis with recent improvements and findings. The subsequent sections of the TM present detailed model development and validation details, simulated flow results, critical findings and conclusions, and outline recommended next steps for further improvements.

Objectives:

- Understanding Sites Reservoir release constraints due to ambient flow conditions in the CBD.
- Evaluating the effects on water surface elevations (WSEs) in the Lower CBD System caused by Sites Reservoir releases of up to 1,000 cubic feet per second (cfs) using project operation estimates from the Upper Sacramento River Daily Operations Model (USRDOM) simulation.
- Quantify the increase in WSE along the CBD to understand potential channel bank improvements needed at critical points along the Lower CBD System.
- Quantify the impacts of stage variations in the set point controlling WSE at the Knights Landing Outfall Gates (KLOG) at the downstream end of the CBD.
- Understanding the impacts of Sites releases on flows down the Knights Landing Ridge Cut (KLRC) to Wallace Weir.

Hydraulic Model Improvements:

- The Project inflow simulation was updated to a daily time step from a monthly time step.
- The one-dimensional (1D) model was updated to a hybrid 1D and two-dimensional (2D) model to better generate inundation area estimates.
- The model's unsteady flow from April 1 through December 31 was updated to simulate more recent water years, expanding the analysis period from 4 water years (2013, 2014, 2015, and 2017) to include 6 additional water years.
- The existing conditions model simulations were validated against existing gage data.

In addition to hydraulic modeling improvements, supplementary research and coordination has revealed information on possible uncontrolled tributary channels that have been identified as locations of interest, known water right diversions along the CBD, documented local subsidence in the area, history related to the KLOG maintained pool elevation or set point, and seepage along the KLRC.

Key Findings:

- The daily model simulation results show slightly higher water levels than the monthly model simulations.
- The update to a hybrid 1D-2D model facilitates improved tracking of water as it exits the CBD, influencing better quantification of project release constraints, impacts, and potential improvements.
- There are still uncertainties about how the CBD is operated seasonally and the accuracy of the existing gages.
- The model results show the west bank overtopping in the existing conditions model during the late summer, which should not occur due to local knowledge of the Lower CBD System.
- Unaccounted-for water usage along the CBD and lack of historical information to validate the model results in a very conservative model that overestimates stages and flooding.
- The model's overestimation of flow and stages compared to the measurements of existing gages could present a need for significant improvements due to project impacts that may be unwarranted.

Next Steps:

The next steps identified are summarized with three general efforts: improve the existing model, update project operations, and quantify project impact improvements.

1. Improve Existing Model:

- a. **Field Visits:** Engage with landowners and agencies to discuss conditions and operations.
- b. **KLOG Analysis:** Refine KLOG model representation, validate new flow calculations, and verify with measurements.
- c. **Wallace Weir Update:** Adjust model to match as-built drawings, including gate dimensions and bridge deck.
- d. **Water Rights Diversions:** Incorporate data on water rights diversions to improve model accuracy.
- e. **CBD and KLRC Junction:** Improve junction representation to better capture flow dynamics.
- f. **KLOG Set point Update:** Adjust set point to reflect current conditions reported by local gages.
- g. **Model Calibration:** Calibrate and validate the model with new data and historical gate operations.
- h. **Terrain and Structure Data:** Update model with new survey data, including bathymetry and LiDAR.
- i. **Subsidence Quantification:** Assess and address subsidence in the Lower CBD System in the hydraulic modeling.

2. Update Project Operations:

- a. **Frequency Analysis:** Analyze project release constraints related to KLOG flap gates being closed.
- b. **Environmental Flows:** Ensure project-released environmental flows reach the Yolo Bypass.
- c. **Climate Change Adaptation:** Update project flows from historical to climate change conditions.

3. Quantify Project Impact Improvements

- a. Quantify the increase in WSE along the CBD due to the project to understand potential improvements needed at critical points along the Lower CBD System.

This hydraulic analysis is crucial for stakeholders aiming to ensure effective management of project releases into the CBD. The insights gleaned from this updated hydraulic modeling effort will inform decision-making processes and facilitate the ongoing development and operation of the Sites Reservoir Project.

1.0 Introduction

This technical memorandum (TM) presents results of additional model development and analysis, performed in 2023 and 2024, of the Colusa Basin Drain (CBD) hydraulics with Sites Reservoir Project (project) inflows. The analysis builds on previous work in the August 2020 TM (Jacobs 2020) and December 2021 TM (Jacobs 2021), which documents model development, data sources, and model calibration. This TM provides an update on recent improvements to the hydraulic modeling analysis. The current objectives of the CBD hydraulic modeling analysis are:

- Understanding Sites Reservoir release constraints due to ambient flow conditions in the CBD.
- Evaluating the effects on water surface elevations (WSEs) in the Lower CBD System caused by Sites Reservoir releases of up to 1,000 cubic feet per second (cfs) using project operation estimates from the Upper Sacramento River Daily Operations Model (USRDOM) simulation.
- Quantify the increase in WSE along the CBD to understand potential channel bank improvements needed at critical points along the Lower CBD System.
- Quantify the impacts of stage variations in the set point controlling WSE at the Knights Landing Outfall Gates (KLOG) at the downstream end of the CBD.
- Understanding the impacts of Sites releases on flows down the Knights Landing Ridge Cut (KLRC) to Wallace Weir.

The TM includes sections on model development and calibration, flow simulation results, conclusions, and next steps.

2.0 Model Development and Known Data Sources

A one-dimensional (1D) Hydrologic Engineering Center River Analysis System (HEC-RAS) model of the CBD and Sacramento River reaches was used in the 2020 and 2021 model development and analyses. This HEC-RAS model was originally a truncated version of the California Department of Water Resources' (DWR's) Central Valley Floodplain Evaluation and Delineation (CVFED) Program Task Order 34 Sacramento River System Routing Model described in Sacramento River Basin Integrated HEC-RAS 1D-2D System Model Documentation from June 2017 (CH2M 2017). The modifications to the model are described in the previous Jacobs TMs (Jacobs 2020 and Jacobs 2021). An overview of the available data within the model domain is provided as follows.

2.1 Hydraulic Analysis Domain

The hydraulic model domain includes the CBD between Davis Weir in the north and KLOG in the southeast, as well as the KLRC between the CBD and Wallace Weir and portions of the Sacramento River upstream and downstream of the KLOG. The hydraulic impact analysis of the Lower CBD System has been broken up into three reaches, the Upper, Middle, and Lower. These are shown on Figure 1.

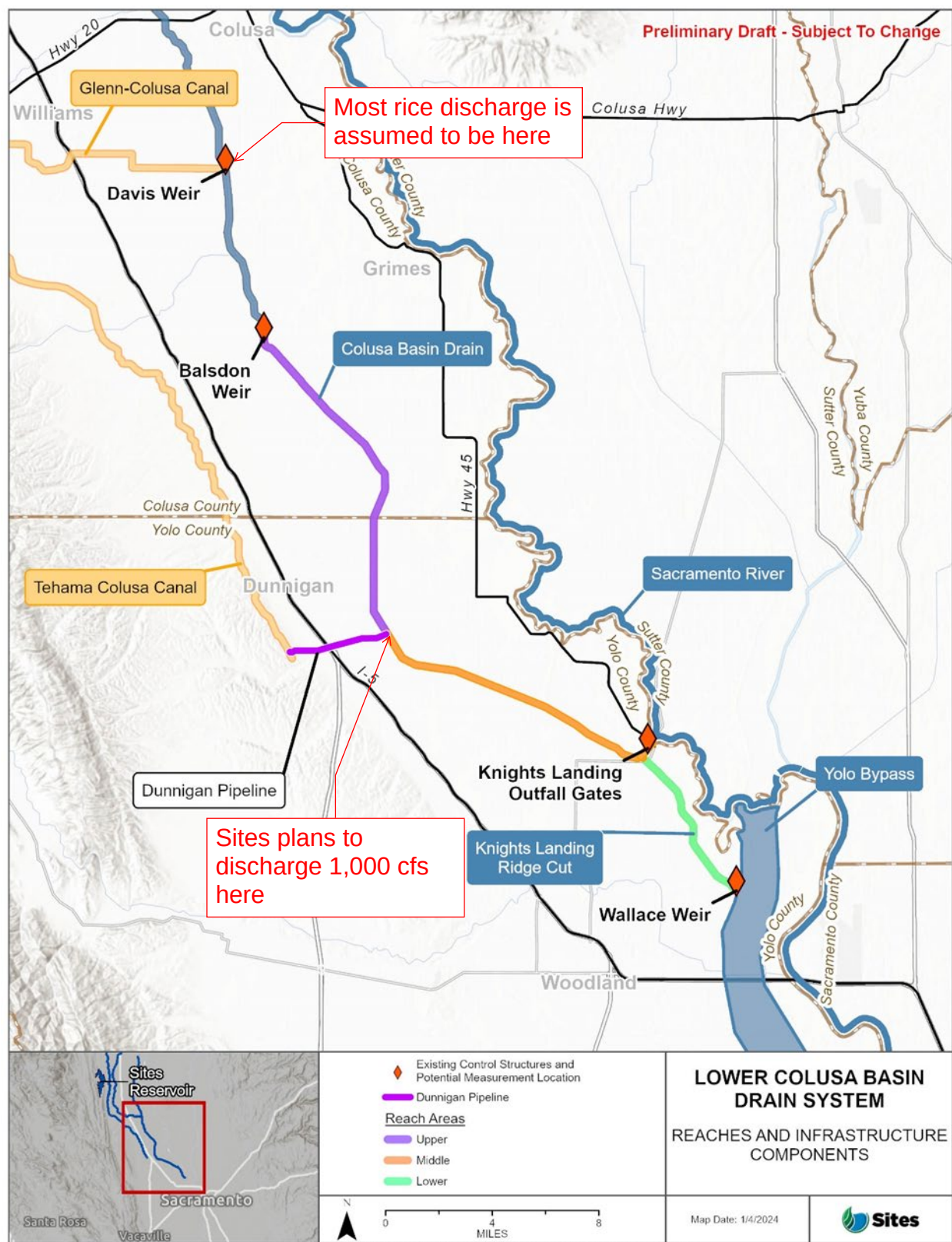


Figure 1. Lower Colusa Basin Drain System Reach Hydraulic Reaches and Infrastructure Components

2.2 Terrain and Bathymetry

2.2.1 2008 to 2009 Bathymetry and Light Detection and Ranging Data

The original CVFED bathymetry and light detection and ranging (LiDAR) data were collected between 2008 and 2009 and processed in 2016 (CH2M 2017). This LiDAR and bathymetry are still used in the existing model. All elevations in the model are referenced to North American Vertical Datum of 1988 (NAVD 88). The bathymetry has not been updated to reflect recent subsidence in the southern portion of the CBD. Additional hydrographic surveys of the drain would reduce uncertainties in model predictions. More details on the known subsidence in the area and updates to the topographic survey are provided in Section 8.0, Subsidence, and Section 12.2, Next Steps.

2.2.2 2021 LiDAR

LiDAR data were collected in 2021 by REY Engineers for the Sites Reservoir Project. The extent of this new LiDAR covers the CBD from the Dunnigan Pipeline Outfall to the KLOG and Wallace Weir. These LiDAR data were analyzed to be used for hydraulic analysis. Due to a lack of bathymetry information and elevation differences that would not allow a cohesive tie-in to the 2009 CVFED terrain, the 2021 LiDAR data were not used for the hydraulic modeling effort at this time.

2.3 Structural As-Built and Operations

The HEC-RAS 1D model includes hydraulic structures that were developed from as-built drawings and operations manuals as described in the 2020 Jacobs TM. In 2023 and 2024, there has been further coordination with the consulting firm cbec, Inc., related to their TUFLOW hydrodynamic model of the CBD (cbec is a consultant to Reclamation District No. 108, a member of the Sites Project Authority). The discussions have revealed some differences in the model setup at Wallace Weir and KLOG. The cbec model setup is being examined for incorporation into the Jacob's HEC-RAS hydraulic model and is discussed in Section 12.2, Next Steps. The current KLOG set point or maintained pool elevation within the model for KLOG and Wallace Weir is 23.73 NAVD 88. More details on this set point are discussed in Section 9.0, Hershey Agreement and KLOG Set Point.

Per coordination with cbec, DWR, and RD-108, in 2012, the KLOG structure was renovated, and the gates were changed from circular to rectangular with some trapezoidal bases. The new gate configuration is detailed in the 2012 construction plans (DWR 2012) that were used to update the structure in the HEC-RAS model as described in the 2020 TM. According to Brian Murphy at DWR, since the structure updates, new flow equations have not been developed for the new gates. However, 2016 flow data were provided to cbec by Lester Grade at DWR for 2016. These flow data are being analyzed and are described in Section 12.2, Next Steps.

2.4 Existing Historical Gage Data and Investigation

The following historical gage records shown on Figure 2 are available within the model domain. Additional details of the existing data collected are described in the 2020 TM (Jacobs 2020). The publicly

available gage data are available through the California Data Exchange Center (CDEC)¹ and DWR's Water Data Library (WDL).²

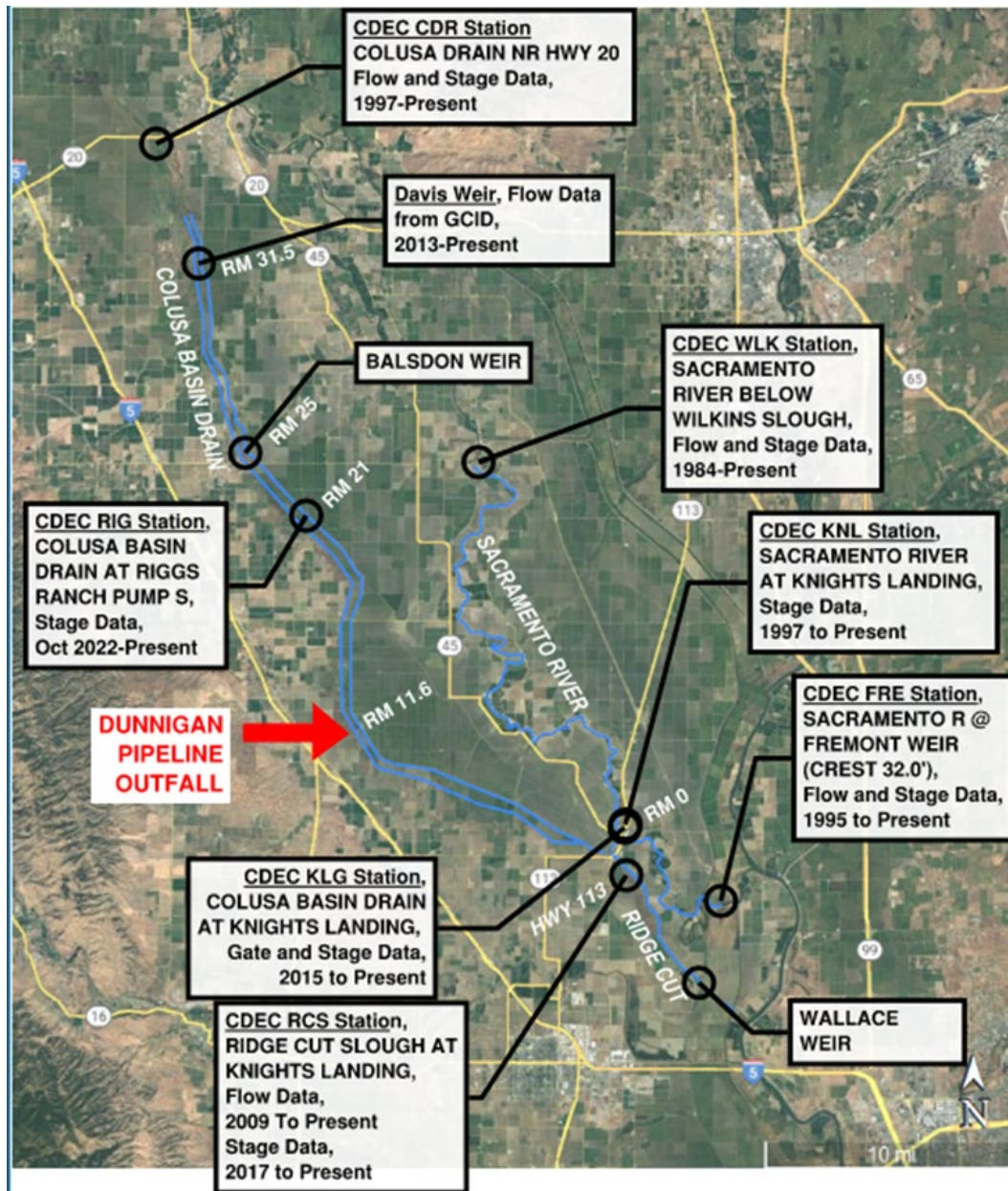


Figure 2. Existing Historical Gage Data

GCID = Glenn-Colusa Irrigation District

HWY = highway

KNL = Knight's Landing

NR = North Region

¹ Real-time gage data can be found at the CDEC, <https://cdec.water.ca.gov/>.

² Reviewed historical gage data can be found at WDL, <https://wdl.water.ca.gov/waterdatalibrary/>.

Additional analysis of these existing gage data was completed in 2024. The Glenn-Colusa Irrigation District (GCID) Davis Weir flows from 2013 to 2023 are shown on Figure 3. The figure also includes the water year type designation for each year.³ As can be seen on the figure, flows in the CBD are higher than average from August through October when rice fields are draining, and high flows associated with winter rainfall and runoff occur during the months of November through April. The Davis Weir flow is the most upstream boundary condition for the CBD in the hydraulic model. Downstream boundary conditions are provided on the Sacramento River downstream of KLOG and at the terminus of the KLRC near the Yolo Bypass. There is also an inflow boundary condition on the Sacramento River near Wilkins Slough.

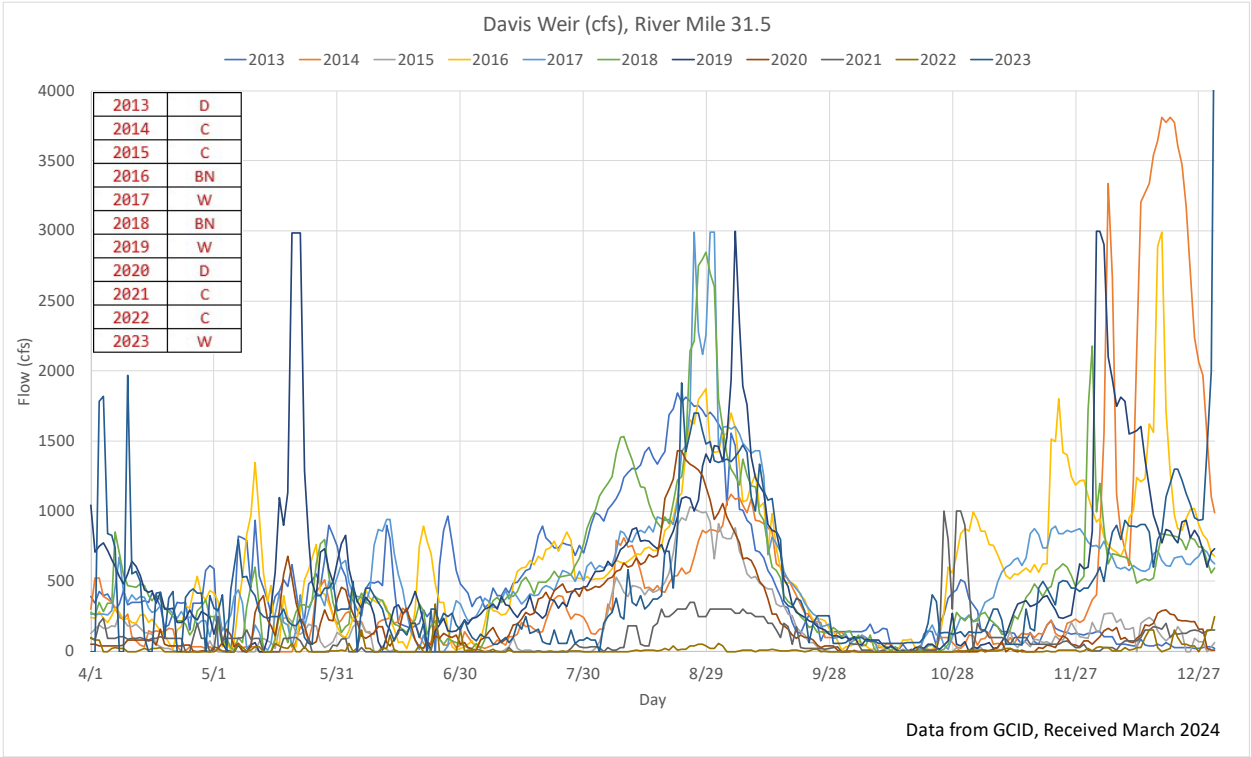


Figure 3. Davis Weir Flows by Year with Designated Water Year Type

The existing stage data at three gage locations in the CBD were also analyzed. The Colusa Basin Drain at Riggs Ranch Pump S (RIG), Colusa Basin Drain at Knights Landing (KLG), and in the Ridge Cut Slough at Knights Landing (RCS) are compared on Figure 4. The RCS and KLG gages are approximately 0.6 mile from each other in the KLRC and CBD, respectively. Due to their proximity, it could be assumed that the RCS and KLG gages should report relatively similar WSEs at the same time, especially during times when the KLOG gates are closed because of high stages in the Sacramento River and the stage at KLOG should equal the stage at the Ridge Cut junction. However, the RCS gage generally reports over a foot lower than the KLG gage. Additionally, the RIG gage is approximately 20 miles upstream of KLG and the RCS WSE is lower than KLG’s during several months. These incongruities indicate further understanding of

³ Water year types in this analysis are defined based on the 40-30-30 Sacramento Valley Water Index. There are five water year types Wet (W), Above Normal (AN), Below Normal (BN), Dry (D), and Critical (C). For a description of how the Sacramento Valley Water Index is calculated, refer to https://www.usbr.gov/mp/nepa/includes/documentShow.php?Doc_ID=4871.

the operation and existing conditions in the system is still needed. There is known subsidence in this area; however, a full investigation of subsidence for this project has not been conducted yet.

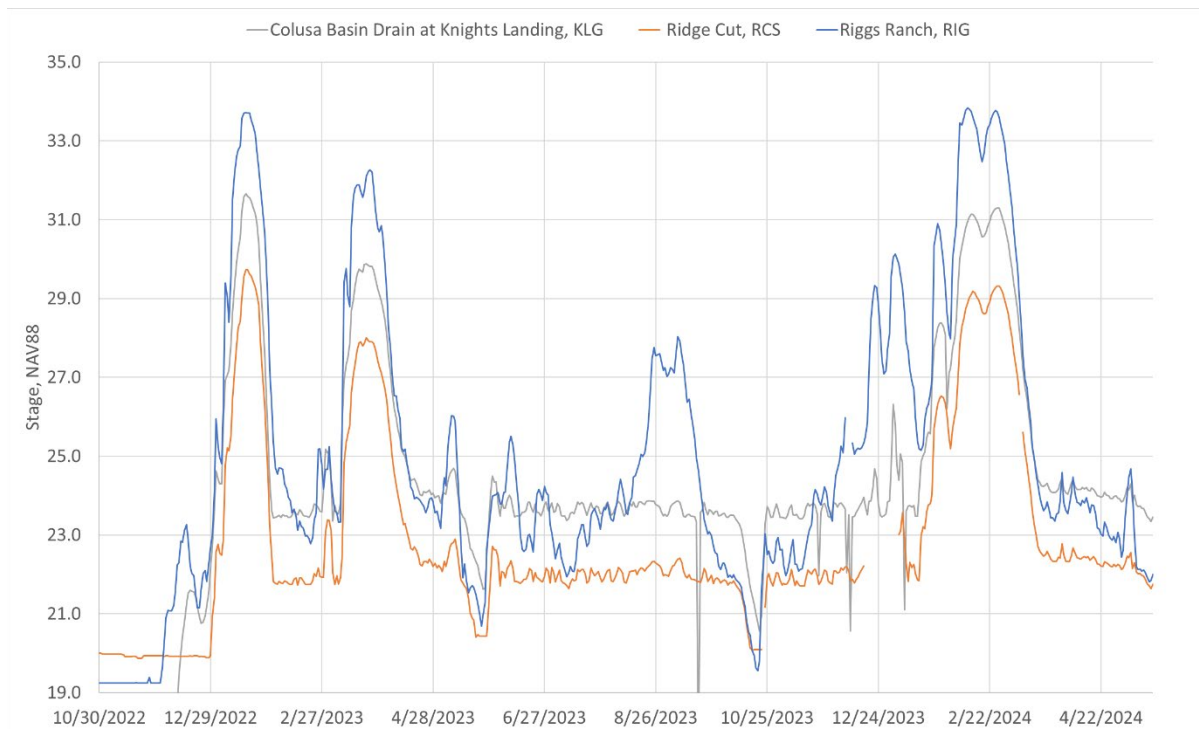


Figure 4. Comparison of Existing Stage Gage Data for RIG, KLG, and RCS Gages

The KLG gage WSE was converted from NAVD 88 to USED⁴ and then it was compared against the KLOG set point of 25.5 USED. This comparison is shown on Figure 5. While the standard operations are described to maintain a WSE close to the set point of 25.5 USED during irrigation season, which occurs mainly during the summer, there are fluctuations in the WSE above and below the set point during that time. However, most of the fluctuations above the set point occur in the winter when the KLOG structure is closed. This variation from the set point conveys the difficulty in accurately modeling the operations at KLOG, which affects the entire Lower CBD System that is modeled. The current model will not allow water surface elevations to drop below the set point because gate operation in the model enforce that as a minimum elevation. It is clear from the water surface data that the simplistic representation of gate operations in the model needs to be reviewed and updated. More discussion on improvements to better improve the model is in Section 12.2, Next Steps.

⁴ United States Engineering Datum; USED elevation = NAVD 88 elevation + 1.77 feet. Datum conversion between USED and NAVD 88 confirmed with Kjeldsen, Sinnock & Neudeck, Inc. (KSN) by Reclamation District 108 (RD108) per email 07/14/2020 (O'Regan, pers. comm. 2020).

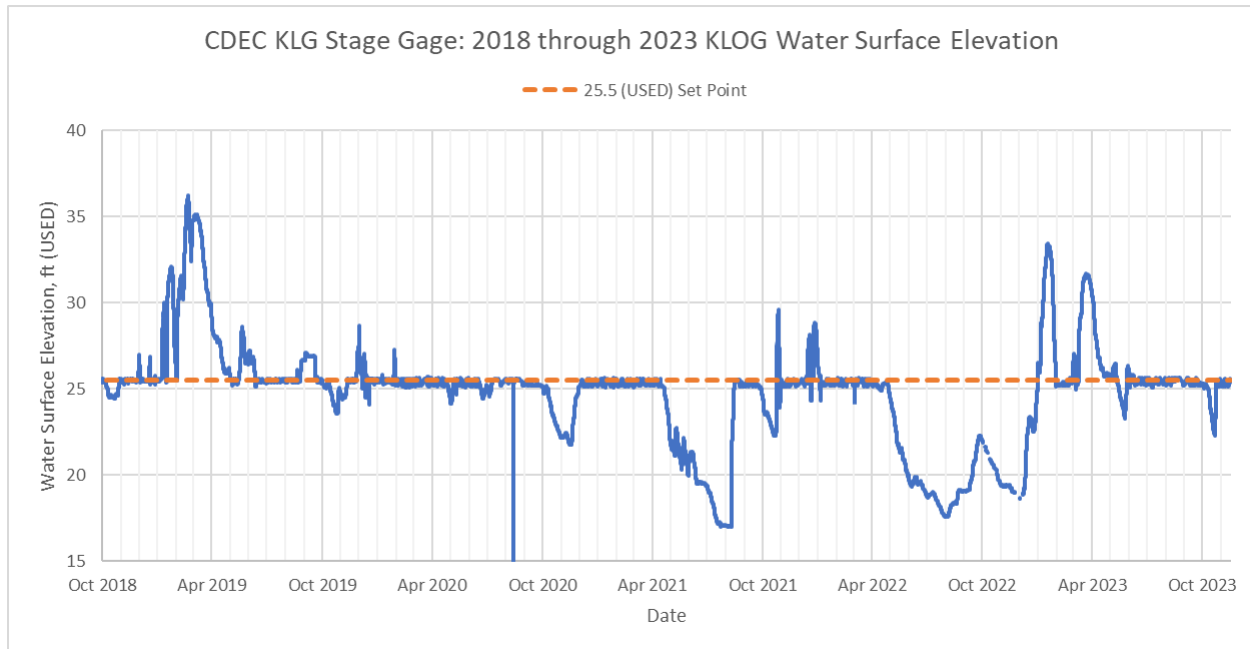


Figure 5. Comparison of Colusa Basin Drain at Knights Landing Gage against KLOG Set Point

2.5 Existing Model Boundary Conditions

The HEC-RAS model is simulated as an unsteady-state model with time-varying flow and stage conditions. The boundary conditions for the existing model were applied using the historical flow and stage records for the analysis periods. More information on the existing boundary conditions used in the model is provided in the 2020 Jacobs TM.

3.0 Model Updates

3.1 Sites Project Inflows (Spring 2023)

Water released from the Sites Reservoir will travel through various existing and proposed conveyance facilities travel to benefit local, state, and federal water supply needs. Figure 6 shows a hydraulic schematic of the project's conveyance facilities for Sites Reservoir releases. The Dunnigan Pipeline and CBD are part of the Sites Downstream Participants.

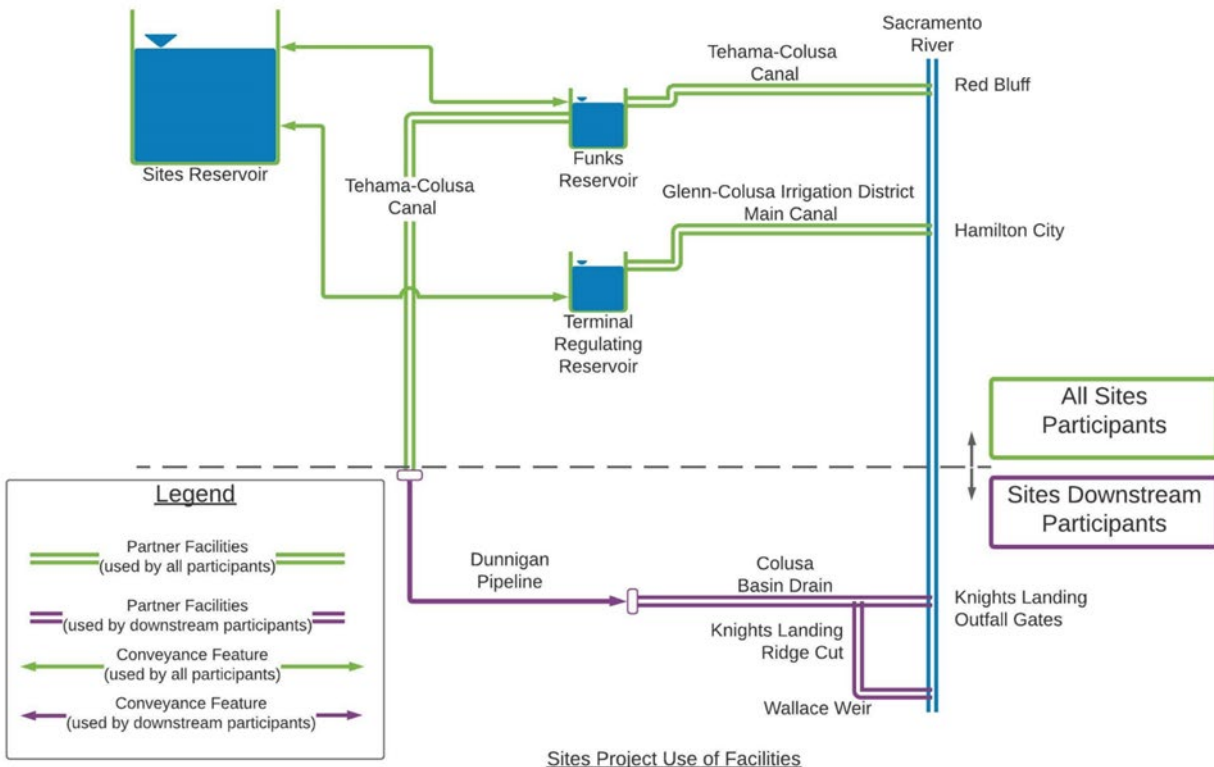


Figure 6. Hydraulic Schematic of the Project's Use of Conveyance Facilities by All Sites Participants and Participants Downstream of Sites Reservoir Releases

The previous analysis by Jacobs in 2020 used a constant 1,000 cfs for the Sites Reservoir Project releases through the CBD because this is the maximum capacity of the Dunnigan Pipeline. The model updates by Jacobs in 2021 used monthly average, time-variable flows developed from results of the 82-year CALSIM⁵ Alternative 1B (Alt 1B) simulations. The current analysis improves on the 2021 work by incorporating daily flows from the updated 82 years of record Alternative 3 (Alt 3) simulation. Updating from a monthly time step to a daily time step provides more granular information on the system's capacity and potential impacts of the project operations.

This 82-year daily project time series was developed using other modeling software used by the operations modeling team at Jacobs, which includes Upper Sacramento River Daily Operations Model (USDOM) and the GoldSim model. During initial daily model analysis using Sites GoldSim, it was found that some extra daily opportunities for diversions could happen, but only during short time windows (shorter than a month). The initial GoldSim model runs suggested that additional diversions could be up to 12% larger when compared with CALSIM monthly estimates. It was extrapolated that if diversions would increase by 12%, releases also could increase, but no more than 12%. This percentage was applied to the CALSIM results modified to a daily time step using USDOM to estimate flows through the Dunnigan Pipeline over the 82-year simulation.

Similar to the Jacobs 2021 effort, the daily Alt 3 flows used in the hydraulic analysis for with-project conditions consist of five water year-type, specific, daily, average, and maximum flow series. The project

⁵ CALSIM is the model developed to simulate California Stage Water Project (SWP)/Central Valley Project (CVP) operations; it has been used to model Sites Reservoir operations along with SWP and CVP operations.

water year type flows were derived from the 82-year Daily Alt 3 simulation by water year type⁶ and day. Figure 7 through Figure 11 show monthly project flow statistics for each of the five water year types (wet, above normal, below normal, dry, and critical). There are differences in flow magnitude and in the seasonal pattern of releases between the five water year types. Table 1 summarizes the average and maximum flows per month for all years of the Alt 3 82-year simulation. Some shoulder months rarely see project flows. The daily time series of project flows was derived in part from the monthly CALSIM model, and the daily model can smooth out large monthly changes in flow by lowering flows in the last few days of a month and increasing flows in the first few days of the following month. When averaged over the 82-year simulation period, these small adjustments are shown in Table 1 as small values. Project releases of less than 10 cfs are likely not practical. Table 2 presents the frequency of 1,000 cfs project flow over the 82-year simulation. The maximum flow of the Dunnigan Pipeline is 1,000 cfs.

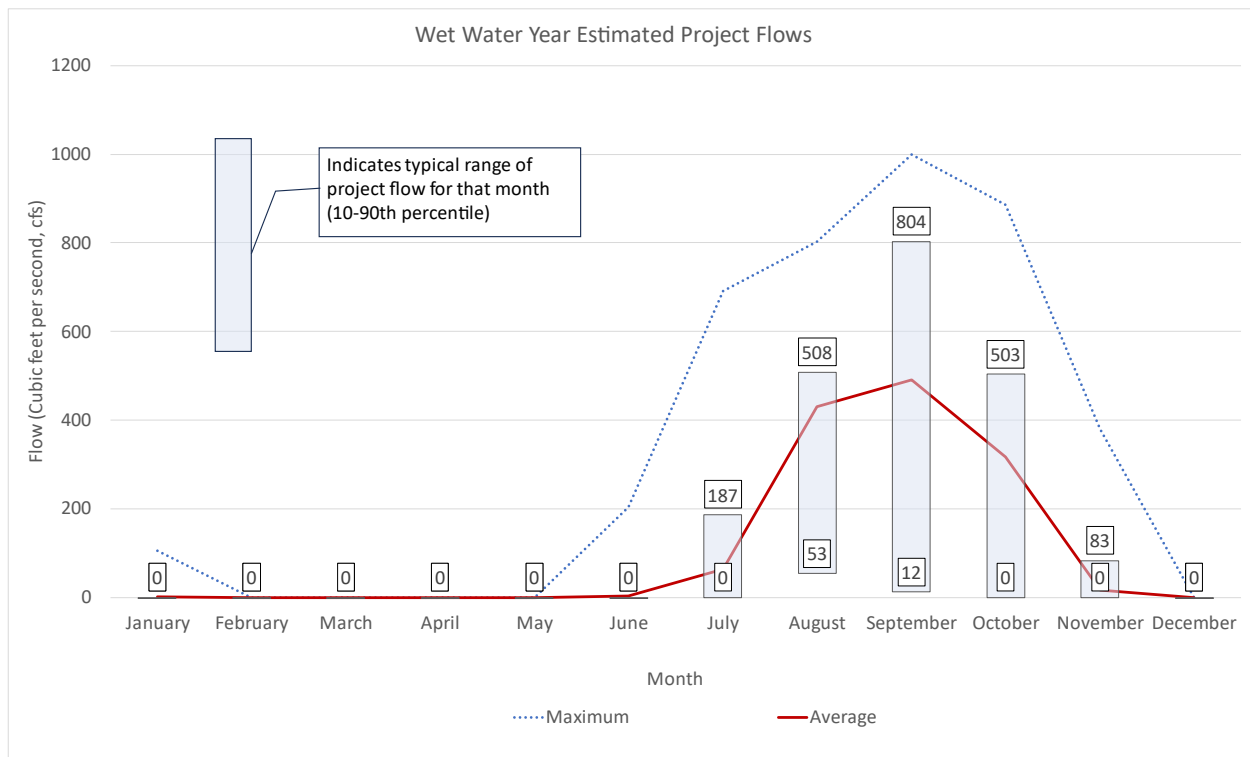


Figure 7. Estimated Project Releases from 82-Year Alt 3 Simulation into the Lower CBD System During a Wet Water Year

⁶ In this analysis, the water year type sorting for the modeled project flows to the CBD is based on the calendar year (January through December).

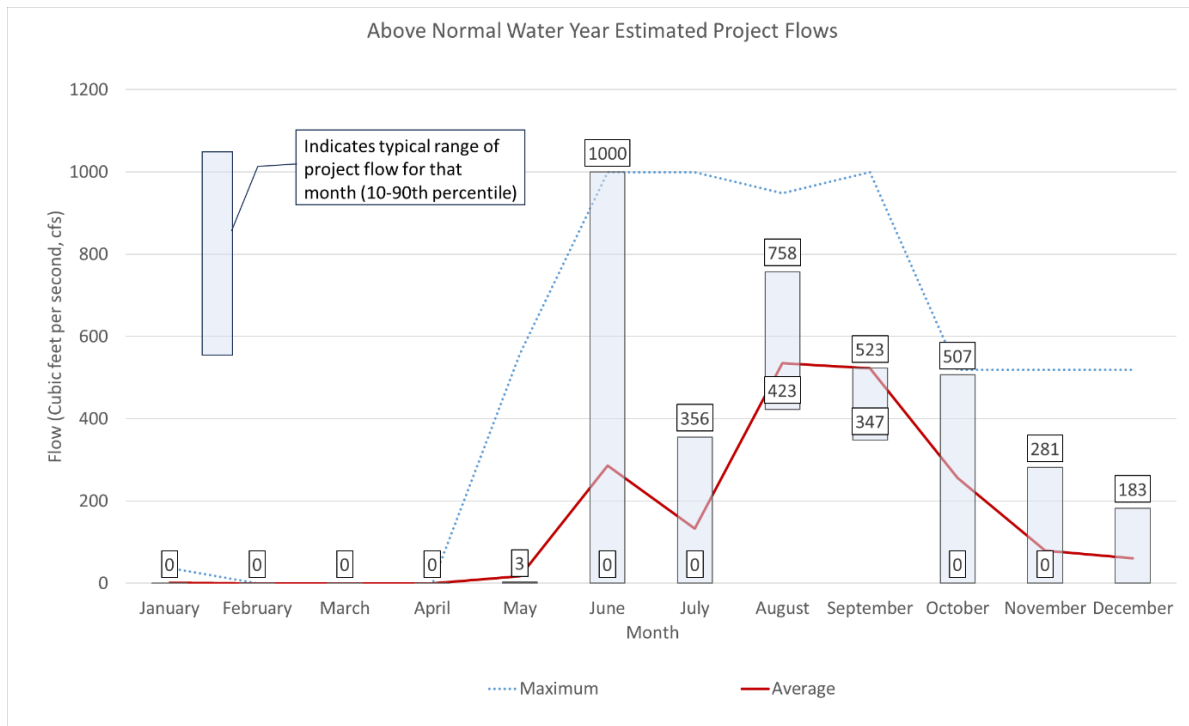


Figure 8. Estimated Project Releases from 82-Year Alt 3 Simulation into the Lower CBD System During an Above-Normal Water Year

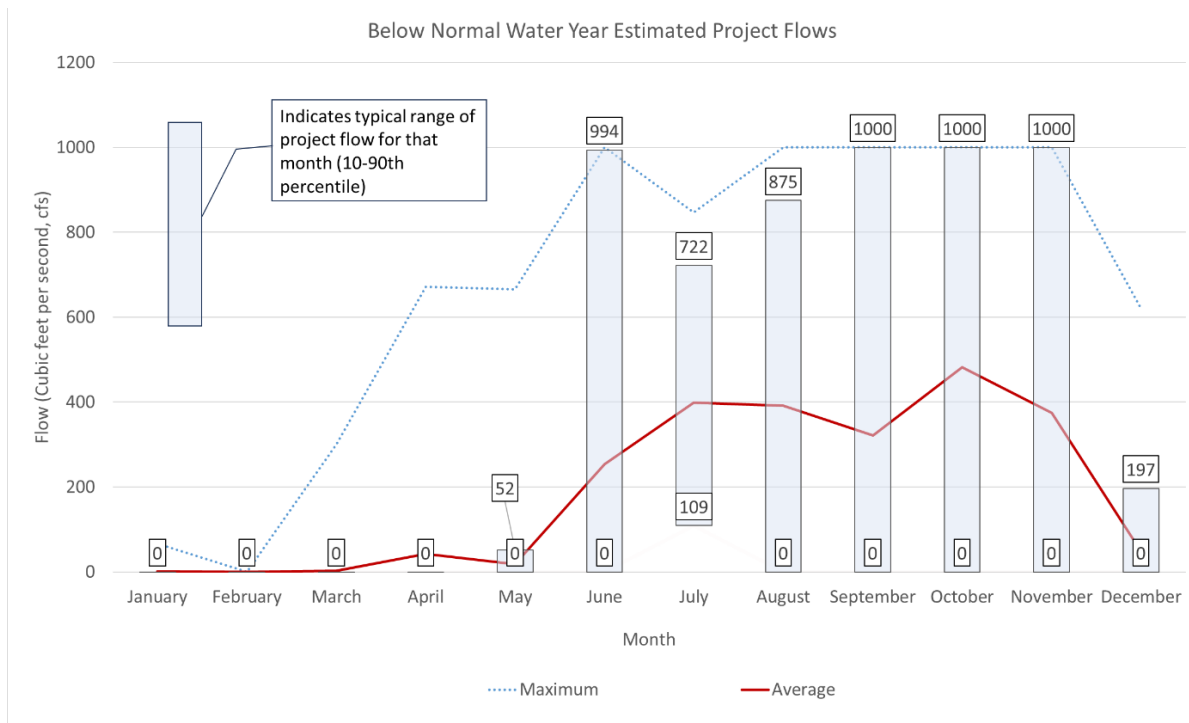


Figure 9. Estimated Project Releases from 82-Year Simulation into the Lower CBD System During a Below-Normal Water Year

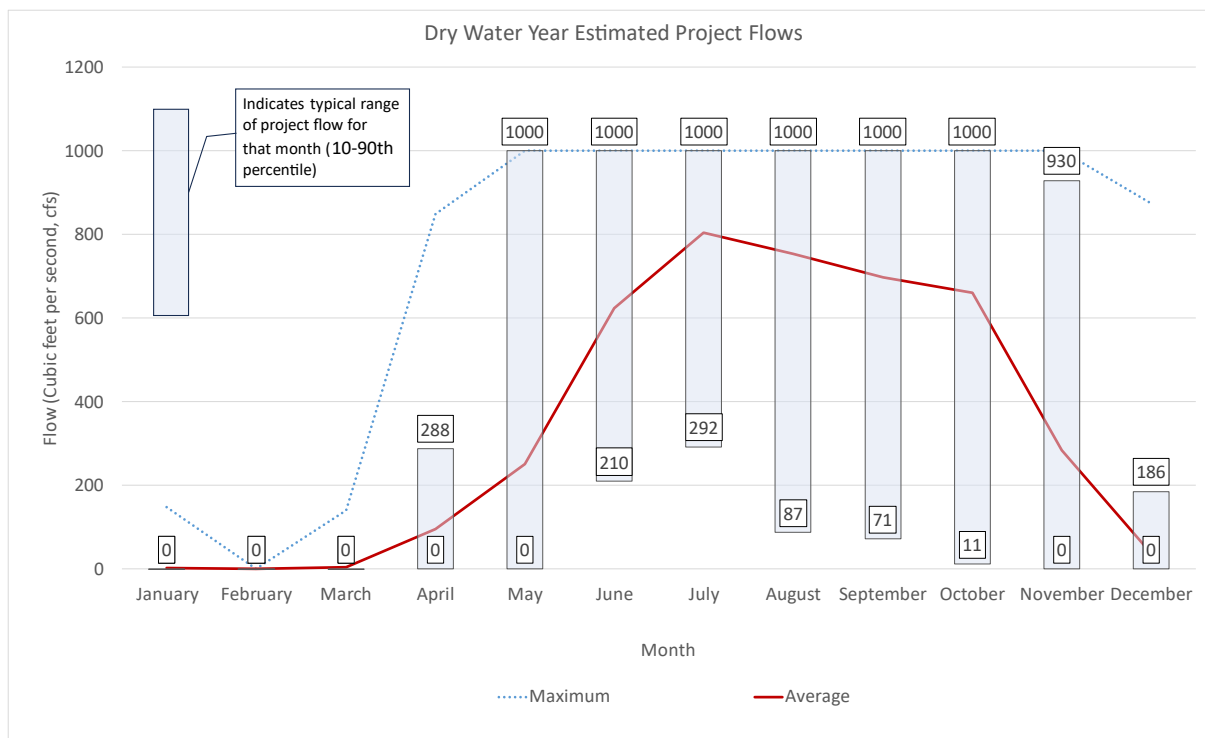


Figure 10. Estimated Project Releases from 82-Year Alt 3 Simulation into the Lower CBD System During a Dry Water Year

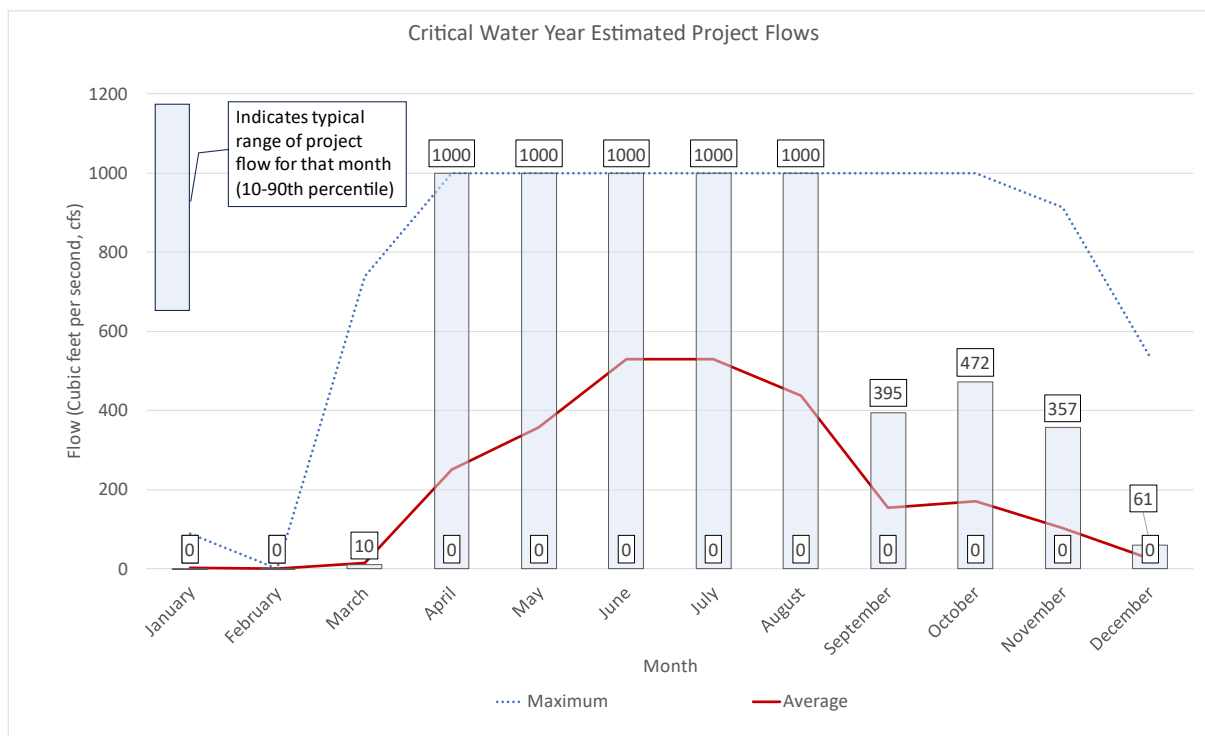


Figure 11. Estimated Project Releases from 82-Year Alt 3 Simulation into the Lower CBD System During a Critical Water Year

Table 1. All Water Year Type Monthly Average and Maximum Dunnigan Flows per 82-Year Alt 3 Simulation

Month	Average Flow (cfs)	Maximum Flow (cfs)
January	1 ^[a]	149
February	0	0
March	4 ^[a]	739
April	65	1,000
May	113	1,000
June	300	1,000
July	362	1,000
August	511	1,000
September	462	1,000
October	390	1,000
November	158	1,000
December	29	874

^[a] Flows of less than 10 cfs are unlikely. These small flows are artifacts of the daily model smoothing.

Table 2. Frequency of 1,000 cfs Project Flow from 82-Year Alt 3 Simulation

	Jan	Feb	March	April	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Years with 1,000 cfs Max Flow (of 82)	0	0	0	2	6	16	17	17	17	17	15	5
Percentage of Years with 1,000 cfs	0%	0%	0%	2%	7%	20%	21%	21%	21%	21%	18%	6%

3.2 1D Model Simulations and Analysis with Daily Project Flows (2023)

The same four water years used in the 2020 and 2021 TMs were modeled with daily average and maximum flows for comparison: 2013 (Dry Year), 2014 (Critical Year), 2015 (Critical Year), and 2017 (Wet Year). The 2013 Dry Year and 2017 Wet Year model results were highlighted in the following analysis because they provide bookends for the largest project impact. The selected water years include dry and critical years because these illustrate typical years for the largest project releases into the CBD. A wet water year was also selected to model the conditions when the Sacramento River stages are high and KLOG flap gates are closed. Because these water years are limited to the years when Davis Weir flow data are available, an above-normal water year could not be modeled. A below-normal water year simulation was not used for analysis at this time.

The previous preliminary hydraulic analysis (Jacobs 2021) focused on conditions near CBD RM 8.9 on the Middle Reach of the Lower CBD System because it represents the low point in the western bank where agricultural fields are flooded when water levels exceed 25.3 feet NAVD 88 or 27.1 feet USED. Bank

improvements are also being explored along this reach and the Lower CBD System in the recent model updates, which include the daily Alt 3 project flows. Results for these preliminary 1D model results were described in Lower Colusa Basin Drain System, Initial Assessment and Next Steps (Sites Project Authority 2024).

The preliminary analysis conclusions/next steps from this analysis were also presented in the following:

- August 4, 2023 Colusa Basin Drain status report meeting (Henry Luu and JP Robinette)
- September 11, 2023 Lower CBD System Working Group Meeting (Public Working Group)
- November 3, 2023 Conveyance Ad Hoc Subcommittee Meeting (Sites Internal Team)
- November 14, 2023 Lower CBD System Working Group Meeting (Public Working Group)

General summary of the results included the following:

- The daily Alt 3 model simulation results show slightly higher water levels than the monthly Alt 1B model simulations.
- The 2013 Dry Year had the highest project impact on an already high existing WSE in the model.
- The 2017 Wet Year had the highest WSE in both existing and with project conditions of 4 years modeled (2013, 2014, 2015, and 2017).
- The KLOG set point was reviewed with the Alt 3 daily flows and preliminary simulations show the set point would still need to be raised 1 foot to allow environmental flows to Yolo Bypass through Wallace Weir. This effort was described in the December 2021 TM (Jacobs 2021). More details on the KLOG set point and the environmental flow are discussed in Section 9.0.
- Overtopping of the west bank that causes western field inundation occurs during the existing condition model around flows of 1,700 cfs, and the addition of project flows could exacerbate these flooding impacts.
- The with-project increases in WSE compared to existing conditions occur up to Baldson Weir, because the water backs up from project flows due to the shallow CBD gradient.
- These results led to proposed improvements to the existing model, which included incorporating two-dimensional (2D) modeling to better generate inundation area estimates. This effort is described in the following section.

3.3 2D Model Updates (December 2023 to March 2024)

The original HEC-RAS model of the CBD used 1D cross sections to represent the local terrain. When water leaves the CBD by overtopping local low points along the western bank or moving through canals used to drain the adjacent fields, the ability to correctly track that water is limited by the 1D terrain representation in the model. Because water leaving the CBD can inundate fields and move downstream, parallel to the CBD, and re-enter the CBD, proper representation of local storage basins is required to accurately represent the interaction of flows between the CBD and the fields. Water is prevented from leaving the CBD and going to the east because of the large jurisdictional levee along the eastern bank of the CBD.

A 2D representation of the fields and local berms improves the ability of the model to correctly reproduce these flow patterns. The ability to model the impacts of proposed bank improvements requires a 2D model. Because of these driving factors, in early 2024, the 1D HEC-RAS model was updated to a hybrid 1D-2D model. Additionally, the model was updated from HEC-RAS version 5.04 to version 6.4.1 for better performance of the 2D section of the model. The 2D updates to the model are shown on Figure 12. Water that overtops the western bank of the upper and middle reaches will now flow to the new 2D area, but the rest of the model remains 1D.

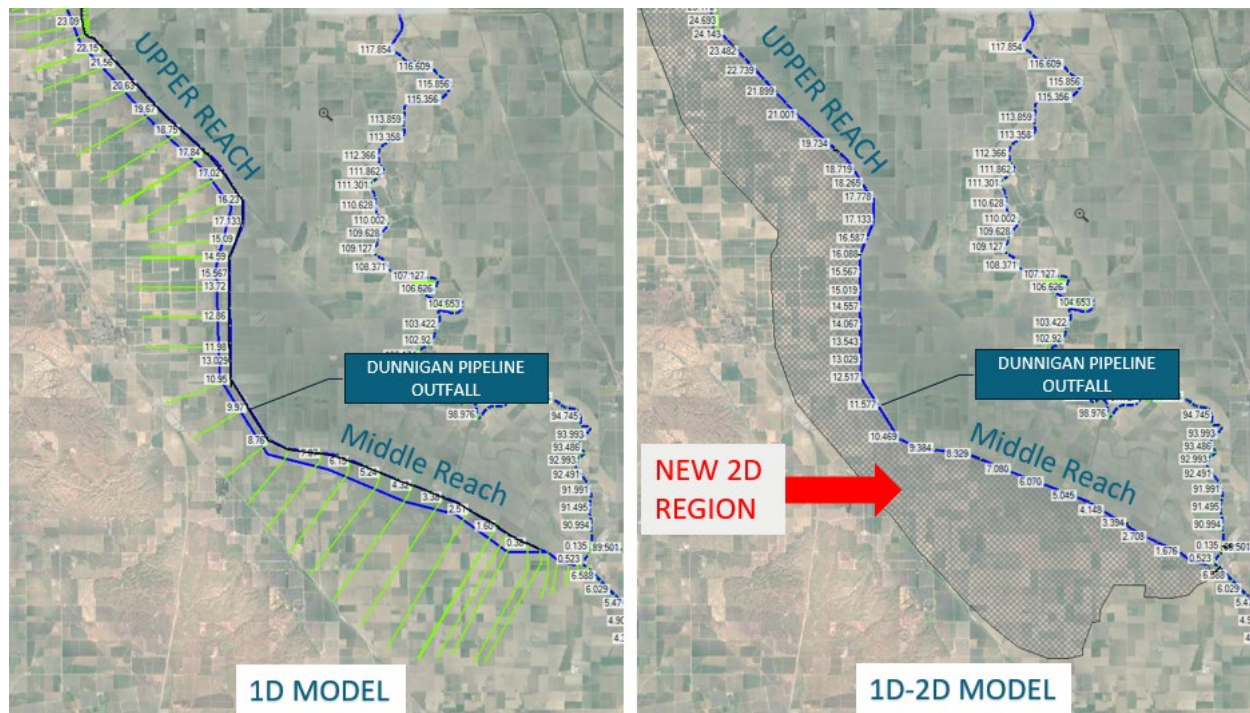


Figure 12. Original 1D and 1D-2D Model Development

3.3.1 Existing Western Bank Lateral Structure Update

A lateral structure is a HEC-RAS representation of a hydraulic feature that runs parallel to a river reach and is used to connect a river reach to another reach or 2D area. The lateral structures along the western bank of the CBD in the 1D HEC-RAS model were not geo-referenced and did not align vertically with the LiDAR terrain at their location. Additionally, the LiDAR data, which have a resolution of approximately 3 feet laterally, can easily pick up lower elevations in the agricultural drains, rather than the higher bank elevation.

To improve the existing model, the western bank lateral structures were georeferenced and spatially updated to capture high ground in the LiDAR dataset. The elevations of the lateral structures were thoroughly reviewed to correctly represent low points along the channel edges that would allow spills into adjacent fields. The updates included review of aerial imagery to identify water control structures as side channels draining local fields. The LiDAR data can pick up low elevations in a channel that has a control gate and thus a low point alone is not indicative of a hydraulic connection. Section 5.0 discusses the revised low point locations of interest.

Bank improvements at CBD RM 8.9 proposed by Jacobs (Jacobs 2021) are not included in the revised existing conditions model. Figure 13 presents the crest elevations along the lateral structures in the

lower 25 miles of the CBD for both the original 1D structures and the revised 1D-2D structures. The large changes in the elevations are from matching the lateral structure elevation to the existing LiDAR in that georeferenced location. Additionally, the overflow computation method in HEC-RAS for the lateral structures changed from “Weir Equation” to “Normal 2D Equation Domain.” This is expected to improve the calculation of flows leaving the main channel because the west bank does not contain a levee or weir structures.

Because this LiDAR terrain was completed in 2008 and has a resolution of approximately 3 feet, a new ground survey should be completed to better represent the existing conditions of the western bank because this area could have the highest project impact. This updated survey is discussed further in Section 12.2, Next Steps.

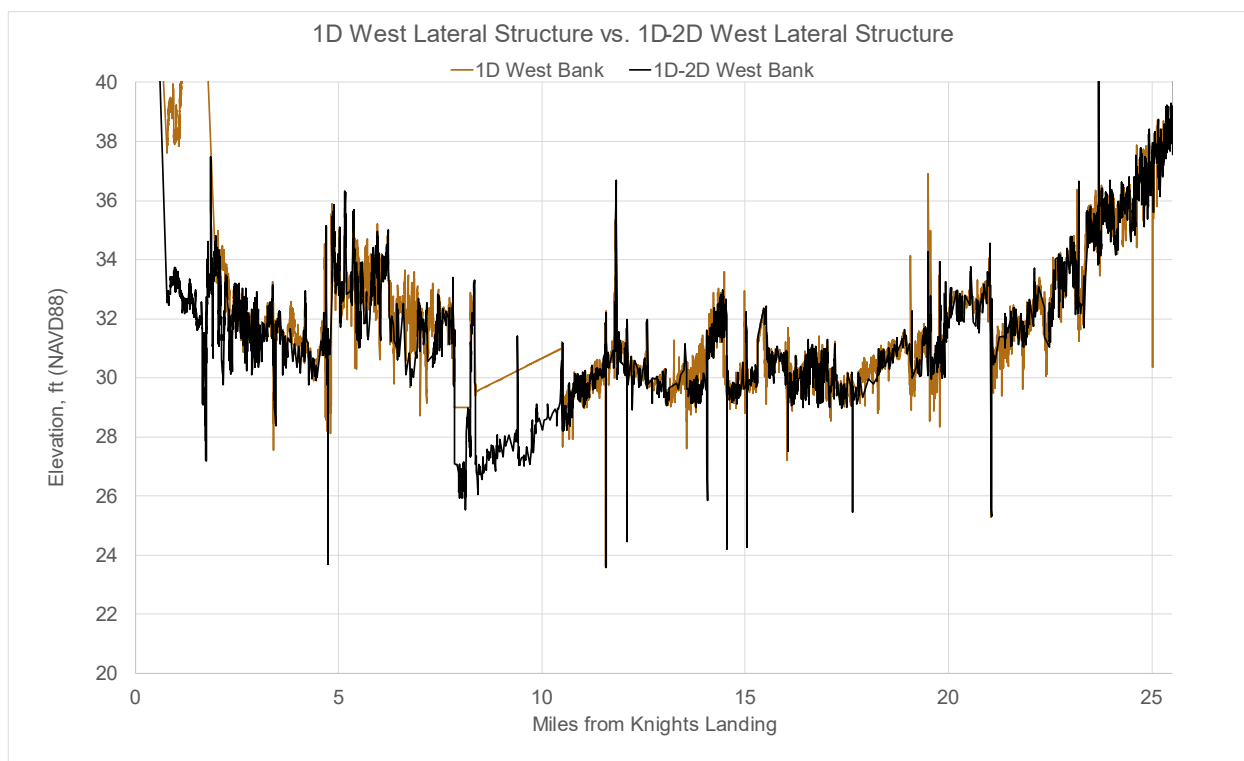


Figure 13. 1D Western Bank Elevations Versus 1D-2D Western Bank Elevations in CBD

3.3.2 Comparison of 1D to 1D-2D Hybrid Model Existing Conditions

In the initial comparison of the existing condition simulation results of the 1D model to hybrid 1D-2D model, water levels are higher in the 2D model because it has a higher resolution representation of the available floodplain storage west of the CBD. These preliminary results are shown on Figure 14 and Figure 15. In the 2013 Dry Year simulation, there is minimal west bank overtopping where the water level is higher than the top of the west bank. The west bank overtops only at RMs 8.9, 17.8, and 21.5. In the 2017 Wet Year simulation, water surface elevations in the CBD are higher than local west bank ground elevations in numerous locations, leading to spills onto the western fields. This west bank inundation is predicted to occur in late August and early September when the rice fields are draining. However, based on local historical knowledge, west bank overtopping does not occur during this time. This variance of historical knowledge and the model simulation reveals the need for more calibration of the model against existing gages and understanding of the seasonality and

operations along the CBD. Based on this finding, the hydraulic modeling effort has been focused on creating a calibrated model that best represents existing conditions in the CBD.

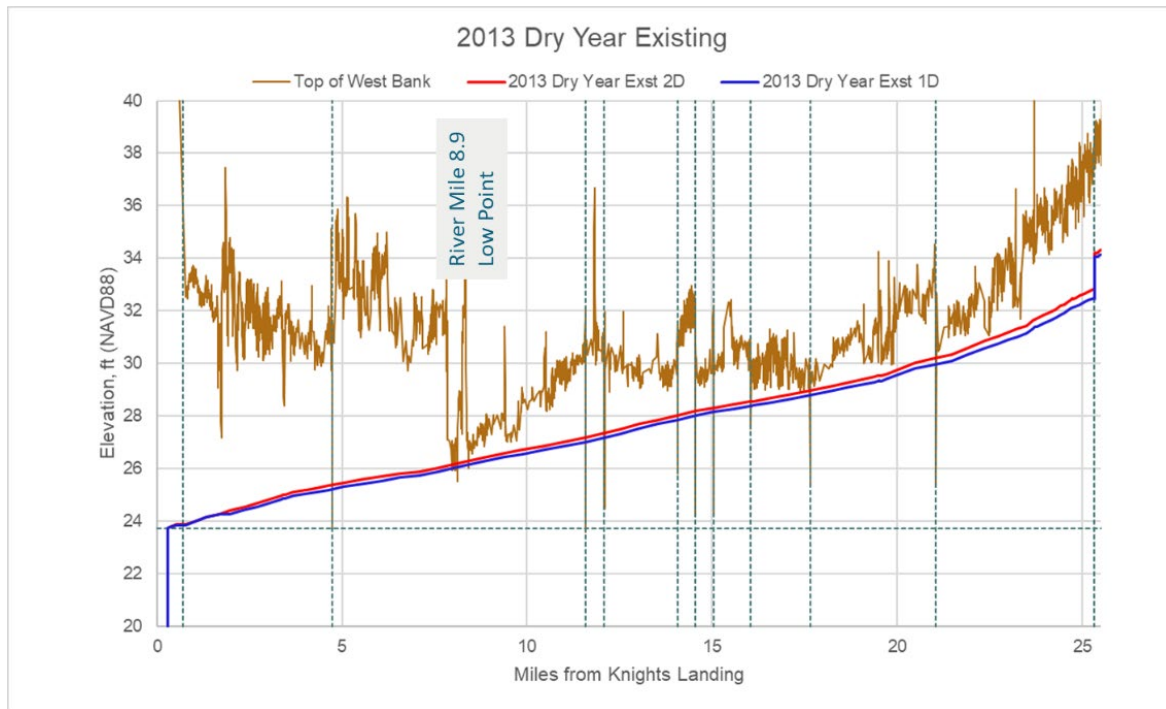


Figure 14. 2013 Dry Year Existing Conditions Simulation Comparing 1D and 1D-2D Hybrid Model Results Against the Top of the Western Bank (Maximum Day August 26, 2013)

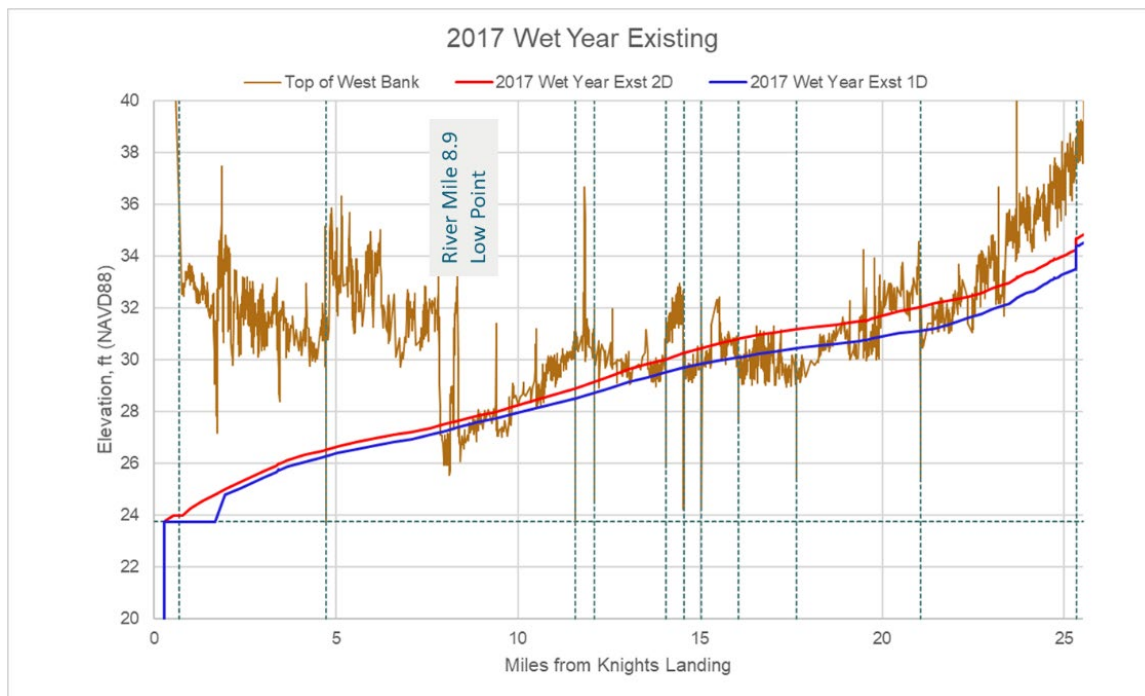


Figure 15. 2017 Wet Year Existing Condition Simulation Comparing 1D And 1D-2D Hybrid Model Results Against the Top of the Western Bank (Maximum Day September 1, 2017)

3.4 Updates to Analysis Period (April 2024)

To better understand the existing conditions in the CBD through various water years, the existing unsteady flow in the model was updated to simulate more recent water years. Previously 4 water years were modeled (2013, 2014, 2015 and 2017). The analysis period was updated to include April 1 through December 31 of the 6 additional water years shown in Table 3.

Table 3. Selected Water Years for Updated Model

Water Year	Water Year Type	Reason for selection
2016	Below Normal	Only modeling year where there were flow data at KLOG for calibration
2019	Wet	In wet water years the Sacramento River stages are high and KLOG flap gates could be closed
2020	Dry	Typical year the Sites releases will be made
2021	Critical	Typical year the Sites releases will be made
2022	Critical	Typical year the Sites releases will be made
2023	Wet	Only modeling year where there were stage data at Riggs Ranch for calibration

4.0 2D Simulation Results and Analysis

The preliminary analysis conclusions/next steps from this analysis were also presented in the following:

- March 15, 2024 CBD status report meeting (Henry Luu, JP Robinette, Dawning Wu, Amparo Flores, Richard Newens)
- June 4, 2024 Lower CBD System Working Group Meeting (Public Working Group)
- July 17, 2024 CBD status report meeting (Richard Newens, Amparo Flores)
- July 25, 2024 Facility Partner 30% Design Review (RD108)
- September 27, 2024 CBD status report meeting (Richard Newens, Amparo Flores)
- October 28, 2024 Lower CBD System Working Group Meeting (Public Working Group)

4.1 Model Simulation Validation with Gages

The new RIG gage has publicly available data starting in late 2022. The RIG data have not previously been compared to the hydraulic model simulation. The 2023 Wet Water year simulation was used to compare modeled predicted water surface elevations to field measurements. The difference between the model simulation at RM 21.001 and recorded RIG data are shown on Figure 16. Generally, the model overestimates water stage data during the late spring to early fall. Additionally, the model WSE remains above the KLOG set point (23.73 NAVD 88) and the historical gage WSE reports as low as elevation 19.5, assumingly when the CBD is dry. This difference between the simulation and recorded stage indicates further calibration of the model is needed to better represent existing conditions.

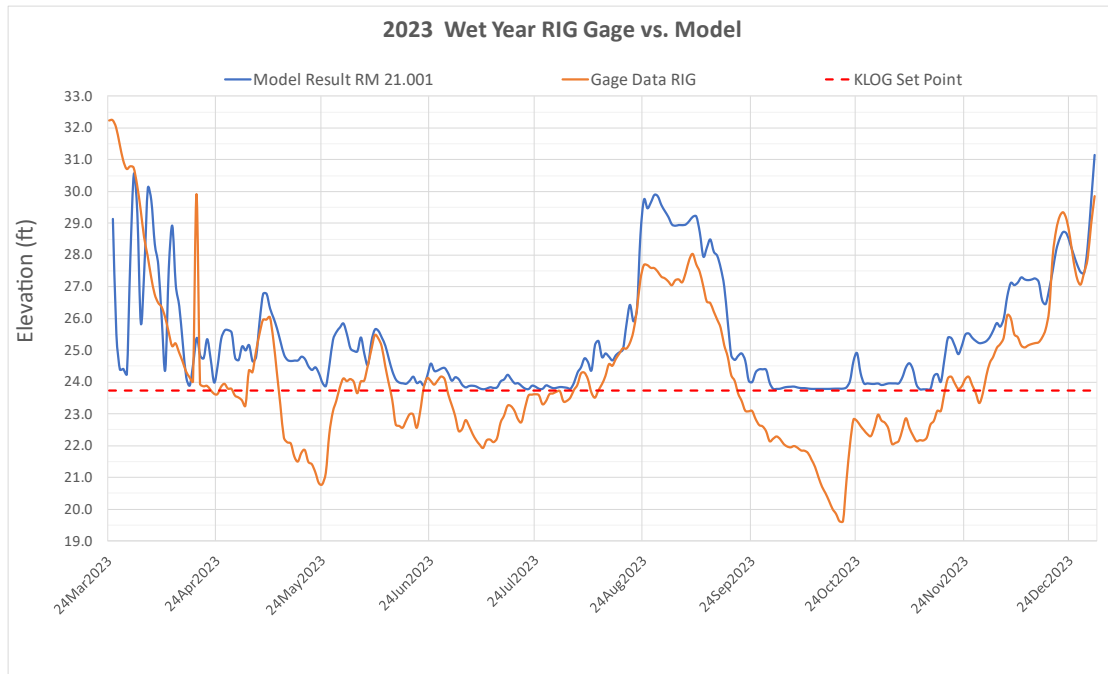


Figure 16. 2023 Wet Year Riggs Ranch Stage Model Results Versus Rig Gage Data

The comparison between model simulation at RM 0.292 and the gage data for KLG is shown on Figure 17 and Figure 18. For the Dry and Critical Water Years, the model simulations maintain the KLOG set point and the WSE does not capture the low water surface elevations that are measured by the KLG gage. Based on historical knowledge, in Critical Water Years we know that the CBD can be dry in the summer months, which is shown in the KLG gage data, but not the HEC-RAS model. As mentioned in the 2020 TM, it was concluded that historical KLOG gate operations are not consistent with the standard operating rules and operations vary from event to event based on the conditions that existed. The HEC-RAS modeled stages are determined to be representative of the CBD WSE under standard operating conditions that assume all 10 KLOG gates would be operated to maintain the mandated set point.

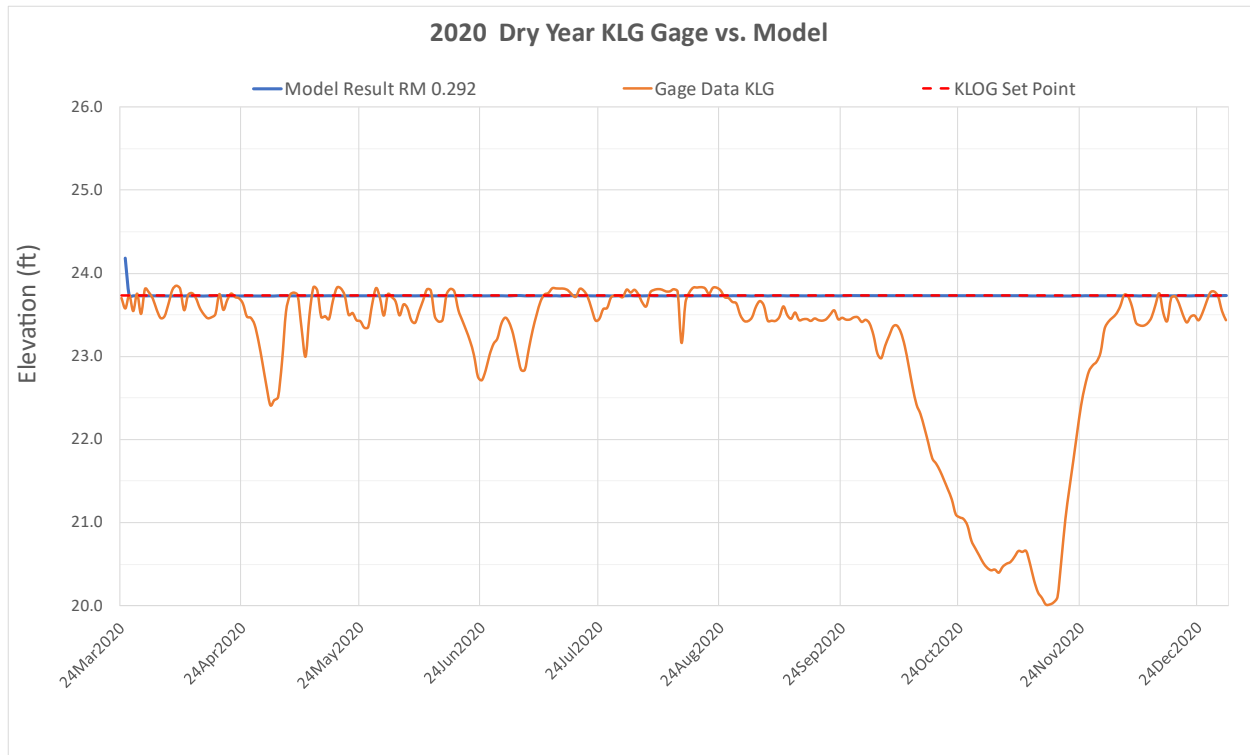


Figure 17. 2020 Dry Year KLOG Stage Model Results Versus KLG Gage Data

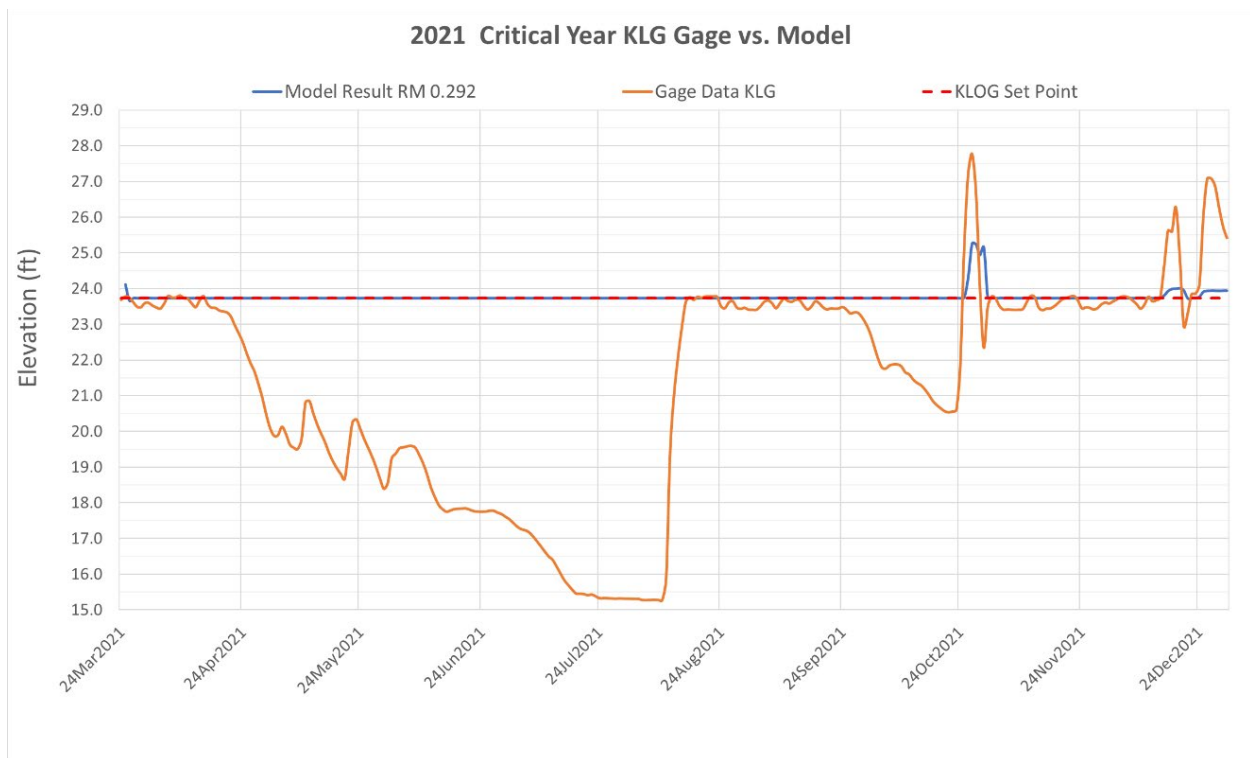


Figure 18. 2021 Critical Year KLOG Stage Model Results Versus KLG Gage Data

Further discussions with the operator of KLOG, DWR, are necessary to better understand current operating conditions of the gates in April through December. Flow data are no longer being reported at KLOG and this reporting ended in 2012. Consulting firm cbec provided 2016 flow data at KLOG, which they received from DWR. These data are being analyzed and are discussed in Section 12.2, Next Steps.

The RCS gage, located in the KLRC, was also compared to the model simulation results. This comparison is shown on Figure 19 and Figure 20. Because the RCS gage is less than a mile from the KLOG structure, the model simulation at cross-section (XC) 6.935 in the KLRC holds the WSE at the KLOG set point similar to CBD RM 0.292 shown on Figures 17 and 18. The RCS gage data typically fluctuate around 1 to 2 feet below the model results and KLOG set point in both the 2020 Dry Year and 2021 Critical Year time periods analyzed. Adjusting the KLOG set point in the model to better capture the RCS gage reported stages is discussed in Section 12.2, Next Steps.

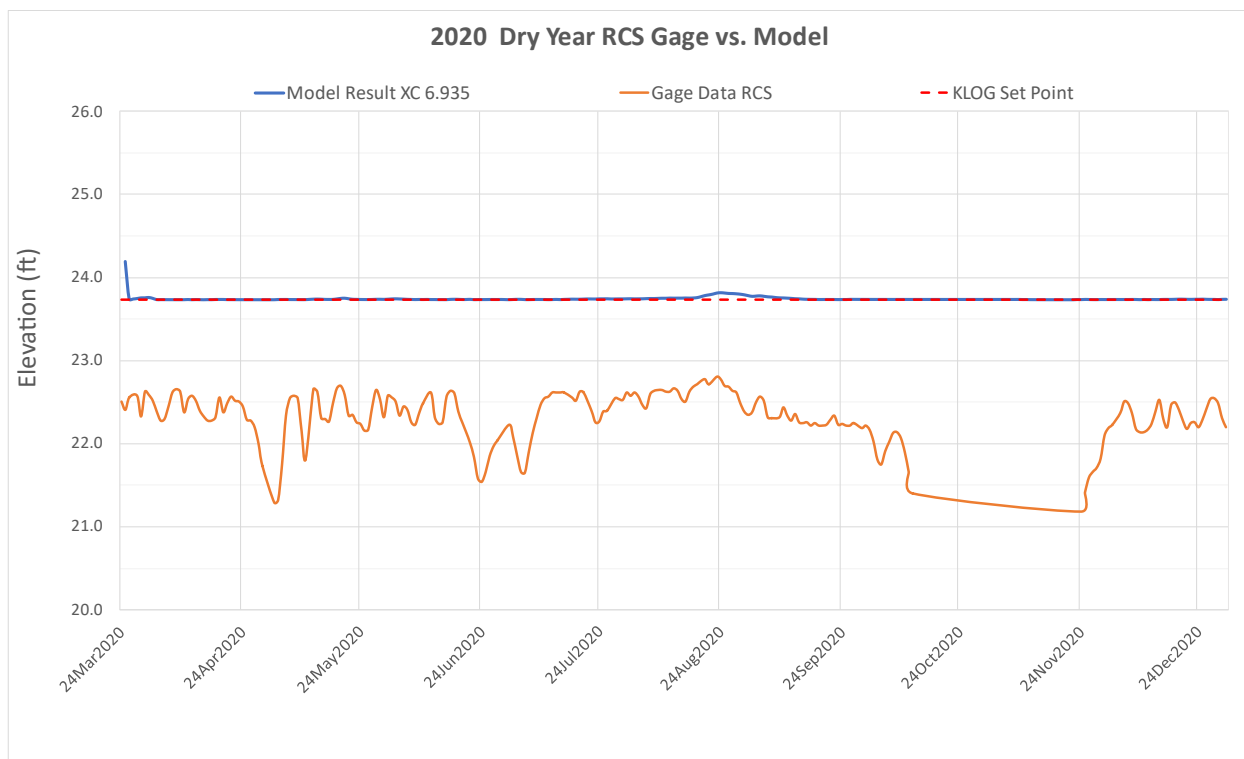


Figure 19. 2020 Dry Year KLRC Stage Model Results Versus RCS Gage Data

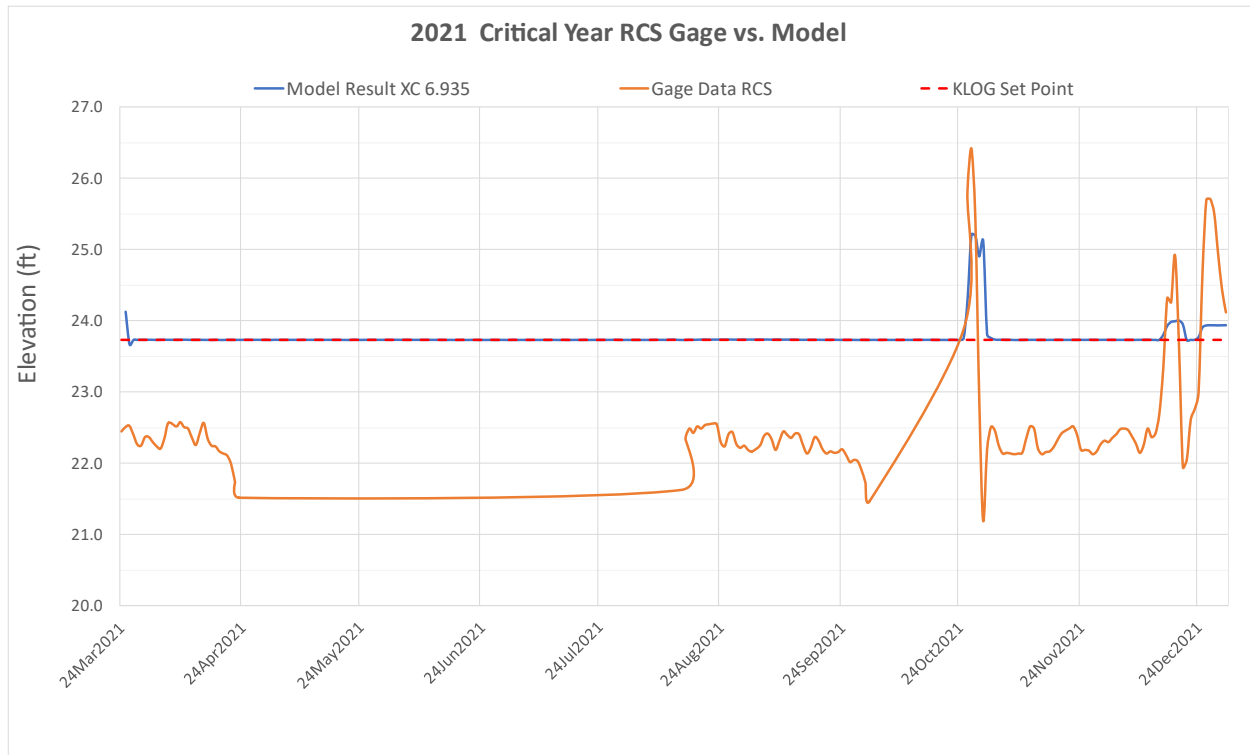


Figure 20. 2021 Critical Year KLRC Stage Model Results Versus RCS Gage Data

Flow data at the RCS gage were also compared against the model in the 2020 Dry Year. Generally, the comparison shows that the flow simulated in the model is typically lower than the reported historical flows during a dry year. Additional validation of the flow in the KLRC is necessary to better represent how the existing system operates. Improvement to the modeled junction between the CBD and the KLRC is discussed in Section 12.2, Next Steps.

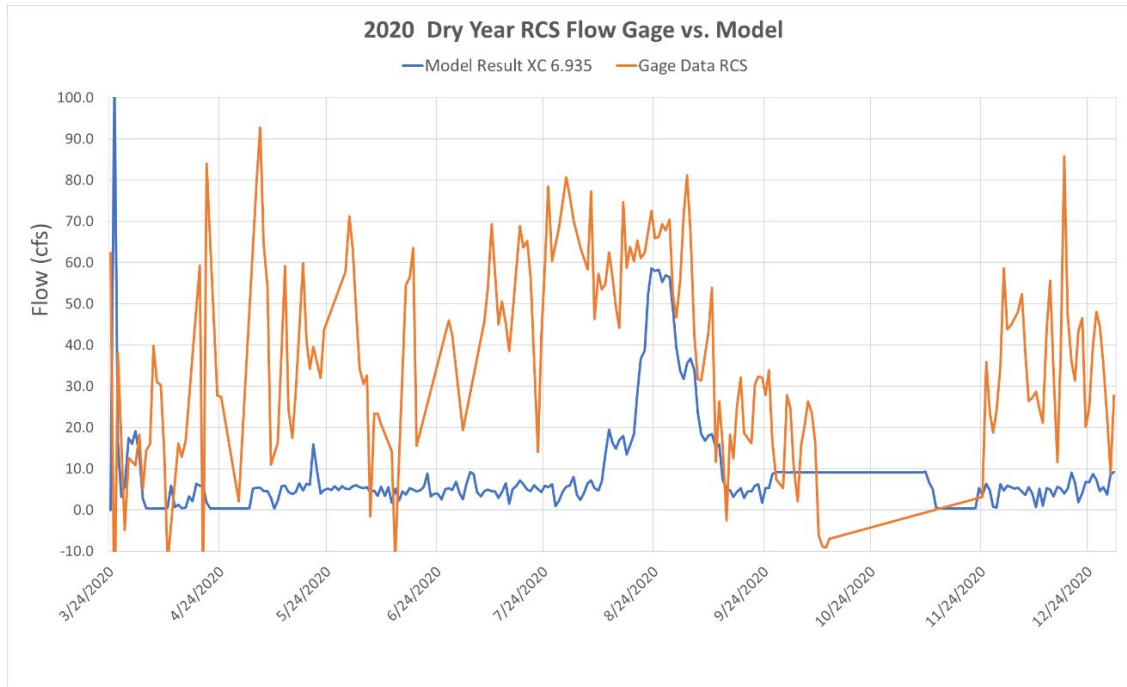


Figure 21. 2020 Dry Year KLRC Flow Model Results Versus RCS Gage Data

4.2 Summary of 2D Simulated Results and Analysis

Additional model simulations with project flows (daily average, daily maximum, and a consistent 1,000 cfs) were also conducted, but the results are not presented here. The analysis of the existing conditions simulated models has concluded that further improvement is needed to better represent ambient conditions before understanding the potential project impacts. In general, the summary of the 2D model results is as follows:

- The 1D-2D hybrid model provides a better representation of existing flow patterns in the western overbank area.
- There are still uncertainties about how the CBD is operated seasonally and the accuracy of the existing gages.
- The model results show the west bank overtopping in the existing conditions model during the late summer, which should not occur due to local knowledge of the Lower CBD System.
- Unaccounted-for water usage along the CBD and lack of historical information to validate the model results in a very conservative model that overestimates stages and flooding. This unaccounted-for water usage is still being explored for input into the model, as discussed in Section 6.0, Known Water Right Diversions.
- The model's overestimation of flow and stages compared to existing gages could present a need for significant improvements due to project impacts that may be unwarranted.

5.0 Locations of Interest

To supplement the hydraulic modeling and further inform the potential project impact analysis, aerial imagery and topography were used to identify locations of interest along the west bank of the Upper and Middle Reaches and both banks of the Lower Reach of the Lower CBD System. These identified low points along the bank are possible uncontrolled drainages, diversions, and irrigation canals that connect directly to the CBD system. These locations of interest could be affected by the project because increased water surface elevations could allow CBD water to flow freely up into these channels and result in project impacts farther upstream or along the tributary channel banks. In addition to understanding the nature of these locations of interest during proposed field visits, outreach and communication with the landowners is expected during the visit to better understand concerns related to the project and historical knowledge of the CBD. The 10 locations of interest identified for field visits (labeled with LOC) are shown on Figure 22 and listed in Table 4.

Jacobs requested permission in September 2023 to conduct field visits at these 10 locations of interest. Since then, this request has been with the Sites Real Estate team, and no site visits have been granted. In October 2024, one landowner was contacted to request a site visit, but then the area was inundated with rain and flood waters and the visit was cancelled.

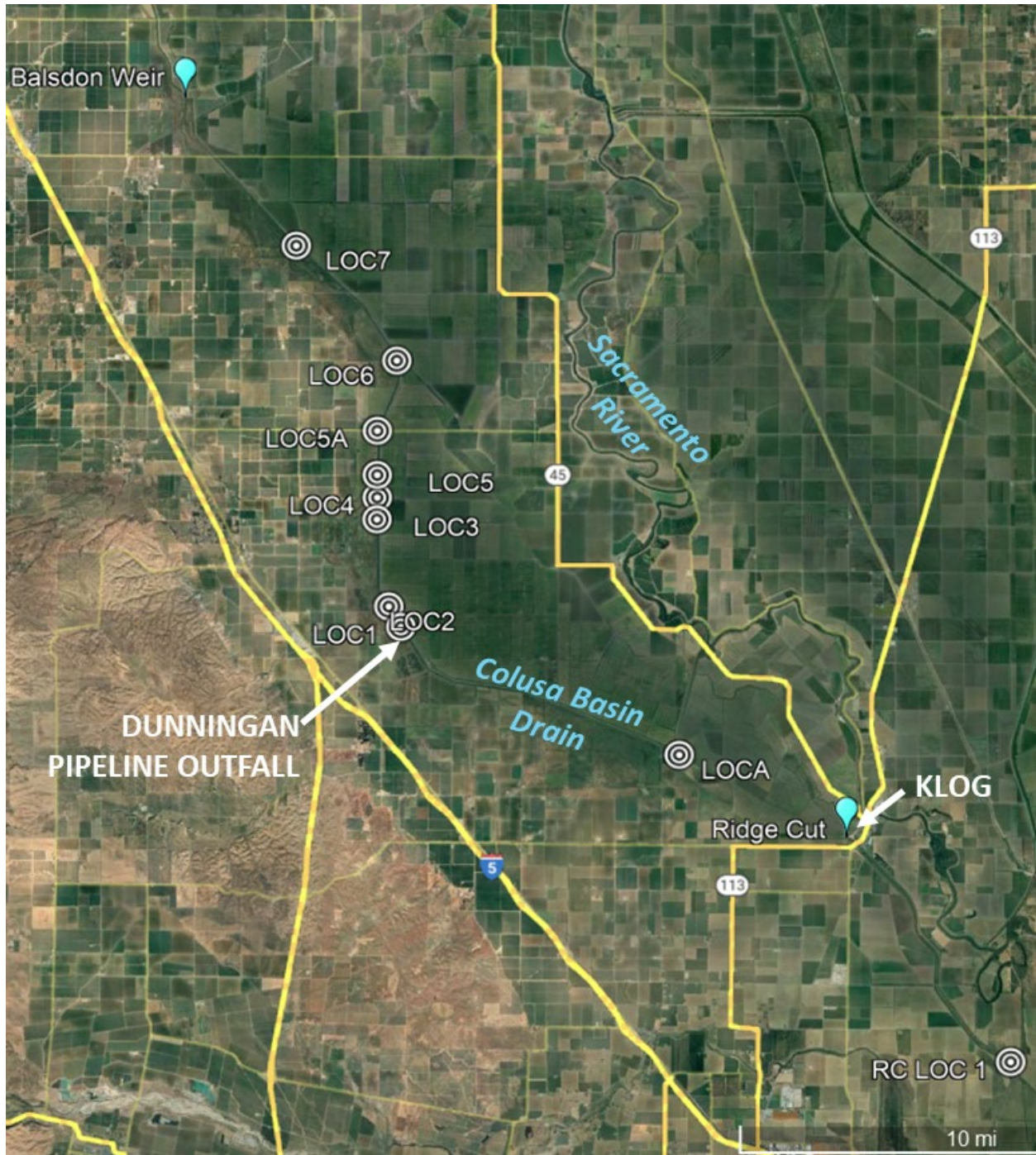


Figure 22. Locations of Interest Along the Lower CBD System

Table 4. Locations of Interest

Name	Approximate CBD RM	Description
LOCA	4.8	Channel
LOC1	11.5	Bird Creek
LOC2	12.0	Channel
LOC3	14.0	Bridge over channel
LOC4	14.6	Buckeye Creek
LOC5	15.0	Channel
LOC5A	16.0	Channel south of Yolo County line road
LOC6	17.8	Channel
LOC7	21.0	End of Clark's Ditch
Ridge Cut (RC) LOC1	not applicable	Just upstream of Wallace Weir

6.0 Known Water Right Diversions

Coordination with consulting firm MBK Engineers (MBK) has highlighted the location of 67 water right diversions along the Lower CBD System (Bezzone, pers. comm. 2024). These water right diversion data are extracted from the State Water Resources Control Board's Electronic Water Rights Information Management System database. MBK provided an updated version of the diversion data of the CBD downstream of Davis Weir in October 2024 to Jacobs. MBK also estimated the potential water usage for rice with the same water right properties. MBK provided details and figures of the water right flows and estimated water usage for rice for the following three reaches: Davis Weir to Balsdon Weir, Balsdon to KLOG, and KLOG to Wallace Weir. The summary of combined water rights for all the reaches and estimated water usage for rice per month are shown on Figure 23.

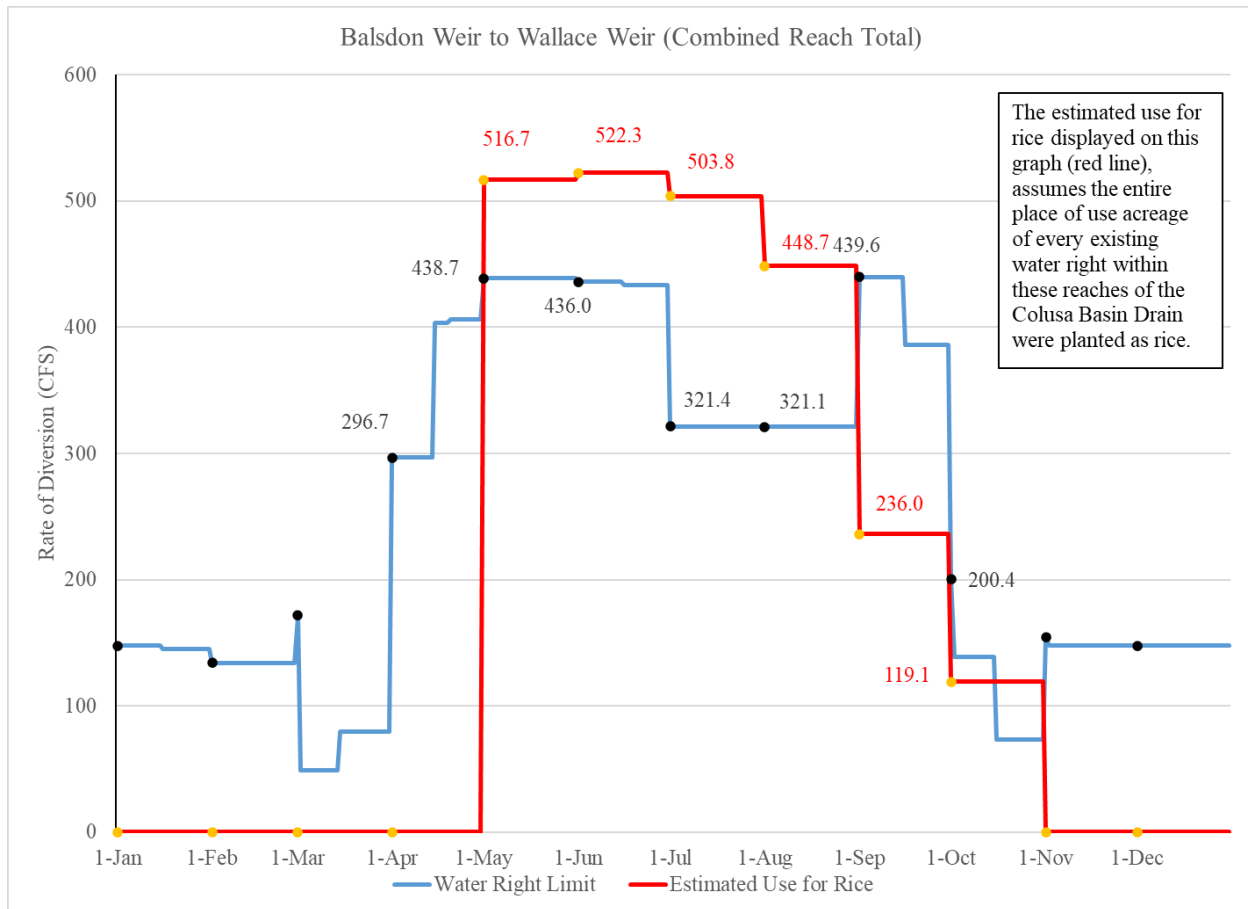


Figure 23. Combined Diversions Rates Under Water Right and Theoretical Rice Water Demand for the Acreage of the Water Right (Source: Bezzone, pers. comm. 2024)

The estimated water rice usage shows higher flows needed in the summer months than the allotted water rights. This estimated use of water for rice was determined using the following assumptions by MBK (Bezzone, pers. comm. 2024):

- “The entire place of use acreage of all water rights within this reach was planted as rice, typically the crop with the highest water use in the region.
- The directly applied water was determined using calculations developed by the Irrigation Research and Training Center for rice in this region during a dry year.
- These calculations also relied on using precipitation and evapotranspiration from a nearby weather station maintained by the Department of Water Resources.
- Additional water applied for the first flood-up during May was assumed as 6 inches of water over the entire acreage.
- Additional water applied for maintenance flows was assumed as a constant rate of 0.005 CFS for the months of June, July, August, and September.

- Additional water applied for rice straw decomposition was assumed equivalent to one month's worth of maintenance flows, despite occurring over a shorter period of time.
- The ratio between total applied water and the total rice acreage should be between 5 [and] 6 Acre-Feet per Acre."

Because these water rights diversions are not currently in HEC-RAS, it is assumed the model is overestimating existing condition flows. Further development of the existing model to incorporate these diversions is identified in Section 12.2, Next Steps.

7.0 Request for Improved and New Gages

Due to the lack of existing flow and stage monitoring within the CBD, additional gages have been proposed to provide historical records of flow and stage. These additional gages will provide data to better calibrate the existing HEC-RAS model and to also better document the pre-project conditions and post-project impacts.

Request for the additional gage information in the CBD has been discussed with RD108 and in the public meetings with the Lower CBD working Group. RD108 requested grant funding through DWR's Stream Gage Improvement Program⁷ in October 2024 for new Gages 1 and 2 and improvements to Gage 5, as shown on Figure 24 and in Table 5. Improvements to Gages 3 and 4 are still being discussed for a future date and would provide measurements necessary for the operation of the Lower CBD System post-project construction.

⁷ DWR Stream Gage Improvement Program (<https://water.ca.gov/Work-With-Us/Technical-Assistance/Stream-Gage-Improvement-Program>)

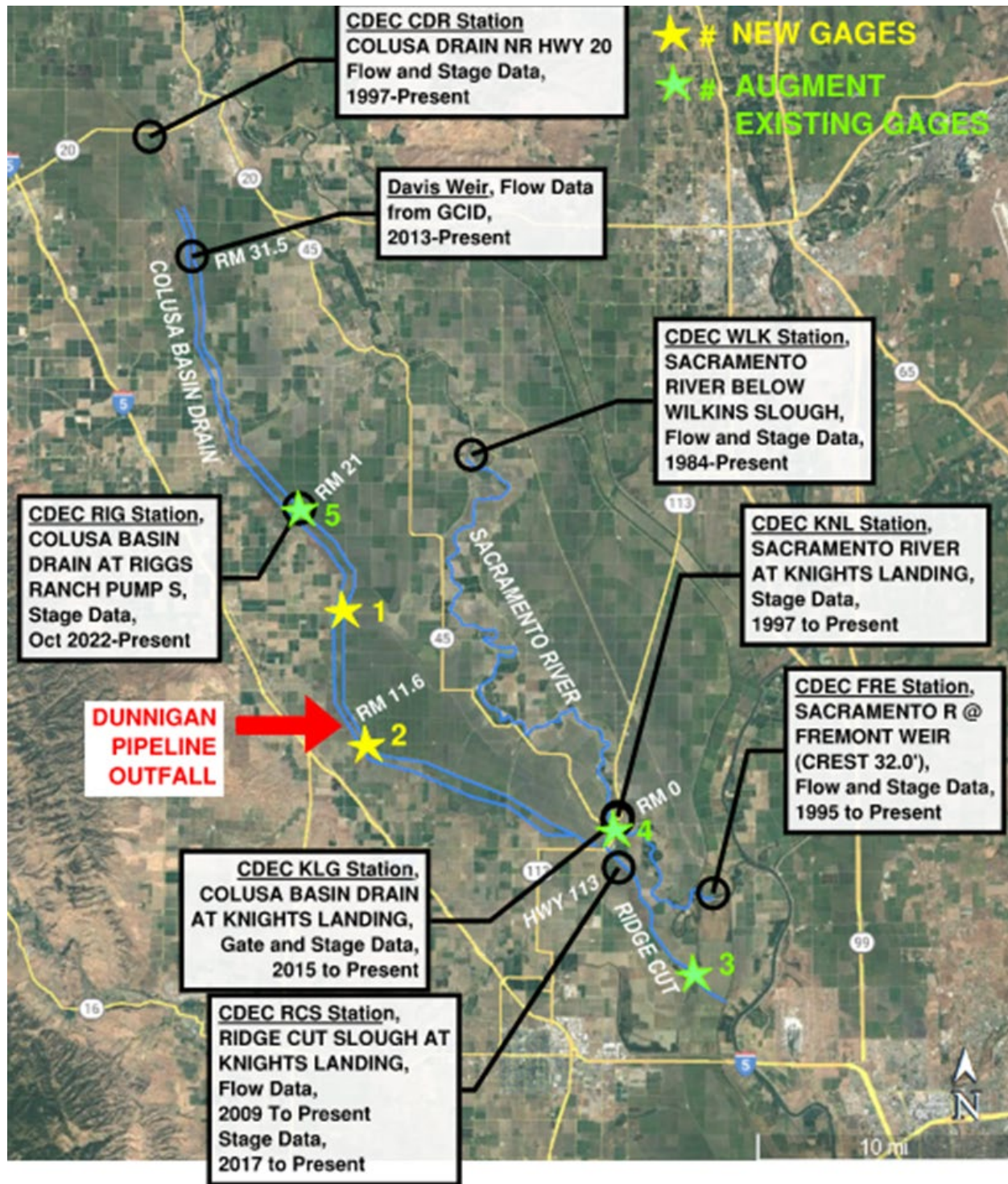


Figure 24. Requested New Gages and Gage Improvements

Table 5. Requested New Gages and Gage Improvements

Gage No.	Location	Details/Location of New Gage
1	River Mile 16	At County Line Road, which would be about halfway between the existing Riggs Ranch gage and proposed Dunnigan Outfall gage. Stage and flow measurements are requested.
2	River Mile 11	Just downstream of the proposed Dunnigan Pipeline Outfall. Stage and flow measurements are requested.
3	Wallace Weir (Improvement)	Stage and flow gage improvement. Current data collected are not publicly available.
4	KLOG (Improvement)	Addition of a flow gage. Stage information already exists.
5	Riggs Ranch (Improvement)	Addition of a flow gage. Stage information already exists.

8.0 Subsidence

DWR, cbec, KSN, and R.E.Y. Engineers, Inc. have documented subsidence in the lower CBD area, with the extent varying by location. cbec developed a technical memorandum in 2023 that provided a summary of the subsidence at the KLG gage (cbec 2023). There has been between 1 to 1.2 feet of subsidence between 2008 and 2017 at known geodetic stations in the Lower CBD area.

In the metadata for the KLG gage on the Water Data Library website, the following description is provided: "DATUM OF GAGE: Zero on gage = -0.467 ft USED. Datum on gage was documented to be 0.00 ft USED when it was established, until a ground survey from Benchmark # F859R to RP #1 on September 13, 2010 revealed that the staff was 0.467 feet lower. There has been recent evidence that the gages may still be changing vertically. The document, 2017 GPS Survey of the Sacramento Valley Subsidence Network published by DWR in 2018 reported that the elevation of BM #F859R have changed by -0.913 feet between the period of 2008 and 2017. UPDATED BY: P. Huckabay/DWR 09/29/2020" (DWR 2020).

These metadata reveal that there has been reported subsidence at the KLG gage of 0.913 foot between 2008 and 2017 and stream gage readings at KLG have likely been affected further by subsidence since 2017. In cbec's research into subsidence in the Lower CBD system, a stage validation survey was completed at the KLG and RCS gages. This survey indicates that the KLG gage continues to be affected by subsidence, whereas the RCS gage is not. This subsidence at KLOG results in the KLG gage WSE reporting higher stage values than the surveyed elevations, which is illustrated on Figure 4 with the differences between the KLG, RCS, and RIG gages. To compensate for the drifting KLOG gage elevations, cbec has used a KLOG set point of 22.4 to match the elevations reported at the RCS gage in their hydraulic model (cbec 2023).

Subsidence is likely to have an impact on the HEC-RAS model simulation results and has not been accounted for. The terrain within the model is from 2008 and 2009, which is likely higher than the ground there today due to the ground settlement. Further effort on how to incorporate subsidence into the existing model is still being explored and is mentioned in Section 12.2, Next Steps.

9.0 Hershey Agreement and KLOG Set Point

In 1937, an agreement was executed between the Hershey Family (landowners in the KLRC area) and the Sacramento and San Joaquin Drainage District, setting the terms for the Hershey Family's continued

access to irrigation water from KLRC. Among many other stipulations, the “Hershey Agreement” provided flowage easements to Sacramento and San Joaquin Drainage District (SSDD) over Hershey properties in Yolo County and set water surface elevations during the irrigation season. DWR, representing the State of California, is now responsible for meeting the terms of the Hershey Agreement. While the Hershey Agreement refers to approximate water levels of 24.9 feet and 25.4 feet, the KLOG is currently operated between 24.5 and 25.5 feet USED to fulfill those irrigation requirements.” (Sites Project Authority 2024; Hershey Family/Sacramento San Joaquin Drainage District 1937). The set point elevation of 23.73 NAVD 88 (25.5 USED)⁸ is used in the Jacobs hydraulic model.

The project flows being released into the CBD from the Dunnigan Pipeline include environmental flows earmarked for the Yolo Bypass, by way of the KLRC and Wallace Weir. These flows include up to 27,600 acre-feet per month (approximately 460 cfs) in the months of August, September, and October. The 2021 Jacobs TM documents a sensitivity analysis that determined that an increase in the KLOG set point of approximately 1 foot was necessary to achieve a 460 cfs environmental flow through the Ridge Cut to the Wallace Weir. While adjusting the set point was not discussed in this TM, further effort at attaining this flow in the Yolo Bypass is being analyzed and discussed in Section 12.2, Next Steps.

10.0 Seepage Modeling

There have been reports of seepage through the KLRC levees by adjacent landowners. Because of the communicated observation of seepage, a groundwater model of the KLRC was requested to calculate seepage rates at several locations within this domain. A TM presenting the model methodology, results, and analysis of seepage in the KLRC can be found in Attachment 1.

11.0 Current Model Assumptions

The current model includes the following assumptions:

- The KLOG circular gate dimensions based on the 2012 reconstruction (DWR 2012) were approximated using rectangular gates with equivalent cross-sectional areas in the HEC-RAS model (Jacobs 2020).
- The KLOG gate operations were assumed to follow standard operating rules, with all 10 gates operating to maintain a set point of 23.73 feet, NAVD 88 (25.5 feet USED) for the historical events and proposed conditions (Jacobs 2020). This precludes modeled water surface elevations from ever dropping below 23.73 feet at the KLOG structure.
- Gage data in the model domain are accurate.
- The historical daily flow records for CBD at Davis Weir were assumed to be routed through the CBD channel to KLOG without seepage or loss (Jacobs 2020).
- There are negligible inflows into the CBD below Davis Weir.

⁸ Set point elevation 25.5 feet USED was verified with DWR per email on October 23, 2023 (Anfinson, pers. comm. 2023).

Some of these assumptions will be discussed further in Section 12.2, Next Steps.

12.0 Conclusions and Next Steps

12.1 Conclusions

The hydraulic modeling and coordination completed in 2023 and 2024 has revealed a need for improvement to the existing model and to understand the current operation and seasonality of the Lower CBD System. The existing condition model is overestimating flow and stage when compared to the existing gages during the simulation period of April through December. The ungaged diversion of water to local uses between the Davis Weir and the Dunnigan Pipeline outlet complicates the quantification of project impacts on local water levels. Additionally, there are still uncertainties about the operations of KLOG and Wallace Weir. A better representation of the existing conditions in the CBD and updates to the project operations will better quantify project release constraints, impacts, and improvements necessary along the Lower CBD System. These enhancements to the hydraulic modeling are discussed in the following section.

12.2 Next Steps

The next steps identified have been broken into three categories: Improve Existing Model, Update Project Operations, and Quantify Project Impact Improvements. More detail on each of these steps is described as follows.

12.2.1 Improve Existing Model

The following next steps are earmarked for year 2025 modeling efforts:

1. Field visits to locations of interest and further discussions with landowners and regulating agencies to discuss existing conditions and operations along the Lower CBD System.
2. Further analysis and refinement of the KLOG representation in the model, including geometry and operations.
 - a. The KLOG flow data have not been publicly available since the construction of the rectangular and some trapezoidal base slide gates. cbec provided flow data from 2016, which they received from DWR, and more analysis into and validation of a new flow calculation is necessary. Additionally, more discussions with DWR on the KLOG flow and additional work to create new calculations for flow should be explored. Calculated flow should be verified by taking flow measurements at discrete time periods on the west side of the gates.
3. Update the Wallace Weir structure to better match existing conditions.
 - a. Currently the Wallace Weir structure is modeled as three 32-foot-wide gate openings, all with the same invert, and no bridge deck over the top of the structure. This configuration is different from the 2016 as-built drawings provided by RD108, which includes three 33-foot-wide gates, with one gate at a lower invert, and a bridge deck over the top. The Wallace Weir inline structure will be updated in the HEC-RAS model to match the as-builts and cbec's TUFLOW hydrodynamic model setup.

4. Incorporate existing water rights diversions from MBK.
 - a. MBK provided updated data and analysis on the existing water right diversions along the CBD. These diversions need to be incorporated into the model at the correct time periods with the use of pumps or another method to reduce the modeled ambient flow in the CBD from Davis Weir downstream to KLOG and Wallace Weir. This should improve the agreement between modeled and measured stages in the CBD.
5. Improve the representation of the CBD and KLRC junction in the HEC-RAS model.
 - a. Currently, the confluence of the CBD and KLRC reaches is modeled as a storage area rather than a junction. A 1D storage area does not consider the momentum of the water traveling in the main CBD reach toward KLOG and may influence flow split calculations. Following the improvements to this junction, analysis of the flow split to KLOG versus the KLRC is necessary to quantify the project water that is sent to the Sacramento River or Yolo Bypass from the CBD.
6. Update KLOG set point to align with cbec's model and the reported RCS stage gage.
 - a. To account for subsidence at KLOG and more accurately capture the current WSE in the CBD, the HEC-RAS hydraulic model KLOG set point will be updated from 23.73 to 22.4 to match the elevations reported at the RCS gage and align with cbec's TUFLOW hydrodynamic model.
7. Calibrate and validate the CBD HEC-RAS model for additional events with historical gate operations.
 - a. With proposed new and improved gages and additional years of analysis, the HEC-RAS model should be compared against the new available data and adjusted to match the existing stage and flow where possible.

The following next steps are earmarked for year 2026 and beyond modeling efforts:

8. Update the model with new surveyed terrain data and existing structure data survey.
 - a. New terrain data will more accurately represent the existing channel geometry and inundated area. This update to the terrain should include bathymetry, western bank survey, and LiDAR, which should be incorporated into the model for future project phases. Comparing the old and new surveys will also aid in quantifying subsidence in the area since the 2008 to 2009 survey was completed.
 - b. Additional survey to collect geometric data for Balsdon Weir because as-builts do not exist for the structure.
9. Quantify subsidence in the Lower CBD System and how it will be addressed in the model.

12.2.2 Update Project Operations – For 2025 and Beyond

1. Conduct a frequency analysis of when the WSE in the Sacramento River is high enough to close the flap gates on the downstream side of the KLOG structure using historical gage data at the Sacramento River at Knight's Landing.

- a. Compare the results of the frequency analysis to the proposed project releases to summarize any release constraints when project flow is not possible to the Sacramento River through KLOG.
2. Additional efforts to ensure environmental flows released by the project end up in the Yolo Bypass. This will likely require coordination with DWR and RD108 because the flow split is controlled by the KLOG set point.
3. Further discussion and coordination of updating the project flows from historical climate conditions to climate change conditions with a 2035 Central-Tendency Operations model.

12.2.3 Quantify Project Impact Improvements – For 2025

1. Quantify the increase in WSE along the CBD due to the project to understand potential improvements needed at critical points along the Lower CBD System.

13.0 References

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June 28.

Attachment 1
Colusa Basin Drain Ridge Cut Seepage
Modeling Draft Technical Memorandum

Colusa Basin Drain Ridge Cut Seepage Modeling Draft Technical Memorandum



To:	Sites Project Authority
CC:	Henry Luu, P.E. (HDR)
Date:	September 20, 2024
From:	Dan Dolmar/Jacobs
Quality Review:	Peter Lawson/Jacobs, Peter Rude, P.E./Jacobs
Authority Agent Review:	Reviewer
Subject:	Colusa Basin Drain Ridge Cut Seepage Modeling

Executive Summary

A groundwater model was constructed of the Ridge Cut Slough (RCS) between County Road 16 and Wallace Weir to estimate potential seepage at three water levels (stages) within the slough. The seven-layer MODFLOW-NWT model had homogeneous hydraulic properties in each layer and relatively simple model input from readily available sources, but also included a relatively detailed digital elevation model and bathymetry estimate within RCS. The model estimates that, at all three stages, depths to groundwater will be less than 2 feet below groundwater surface in some farmland adjacent to RCS. The model results also indicate that direct seepage of groundwater to the surface may occur (that is, the depth to groundwater may be zero in some locations).

Collecting site-specific lithology data along RCS via drilling and geologic logging within the modeled domain is recommended as a next step. Locations for exploratory geotechnical borings and (co-located) monitoring wells were selected for their apparent accessibility from aerial photography. Geologic and water level information from these efforts would enhance our understanding of the surface water/groundwater connection in the vicinity of RCS, and would provide stratigraphic and hydrologic data that could be used to enhance the forecasting ability of the groundwater model developed for this effort. Additional physical details, such as an estimate of the low hydraulic gradient in RCS, may also be added the groundwater model in the future.

1.0 Introduction

Jacobs is the responsible designer for the Segment H Conveyance element of the Sites Reservoir Project. Task HC22.8 of Task Order Amendment No. 4 to Task Order 4 of the Segment H Conveyance project, for Sites Project Authority, outlines the following tasks for Jacobs:

As part of the overall work along the Colusa Basin Drain, develop a steady-state seepage model to estimate the seepage along the Ridge Cut between County Road 16 and the Wallace Weir that may affect adjacent agricultural fields. A simplified 3-D groundwater model will be used to estimate seepage at three

different Ridge Cut water levels (at KLOG¹ set point, one foot greater than KLOG set point, and at flood stage). Review publicly available documentation on the Ridge Cut Levees and nearby areas regarding levee materials and soils information from CA DWR [Department of Water Resources], USGS [U.S. Geological Survey], and NRCS [Natural Resources Conservation Service] for local geologic and hydrogeologic data. A georeferenced land surface will be used for the levees, the Ridge Cut, and adjacent agricultural land. Hydraulic properties will be populated from data generated by the literature and online resources review. The model will be used to calculate seepage rates at several locations along the Ridge Cut. These results, along with the model set-up and the method of seepage flow calculations will be documented in a short technical memorandum and in a power point presentation.

Jacobs assumptions:

- Use only publicly available data; no geotechnical field investigations will be done
- The seepage model will be a steady-state model
- Further guidance from the Jacobs project manager has indicated that depths to water are more useful than quantitative seepage estimates

This technical memorandum documents the methodology used to develop the steady-state seepage model and the preliminary results of this effort.

2.0 Ground Surface and Bathymetric Elevation

Figure 1 shows the vicinity of the Ridge Cut, Knights Landing, and the groundwater model extent between County Road 16 and the Wallace Weir.

A 2008 surface digital elevation model (DEM) was obtained from DWR for previous CBD work. However, the DEM does not include submerged details of the bathymetry in RCS, and is truncated at approximately 22 feet above datum through most of its reach.² Therefore, eight cross-sections from an existing HEC-RAS model³ of RCS were used to interpolate an estimate of bathymetric details within the RCS that the DWR model does not contain.

Figure 2 presents the DWR DEM and HEC-RAS model sections represented in Earth Volumetric Studio (EVS). The five upstream-most (more northern) section lines disappear beneath the DEM, indicating the submerged bathymetry. Warmer colors on the DEM indicate higher elevations: the top of the levees on both sides are typically 43 feet above datum, whereas the blue scoured channels at the southeast end are approximately 13 to 16 feet above datum. The water surface in the DEM shown in light blue is approximately 22 feet above datum. A central island running through RCS at approximately 25 to 27 feet above datum divides the scour channels throughout most of this reach of RCS.

¹ KLOG is Knights Landing Outfall Gates.

² Vertical datum is North American Vertical Datum 1988 (NAVD 88).

³ Colusa Basin Drain Modeling Update, presentation delivered to Lower CBD Working Group November 14, 2023.

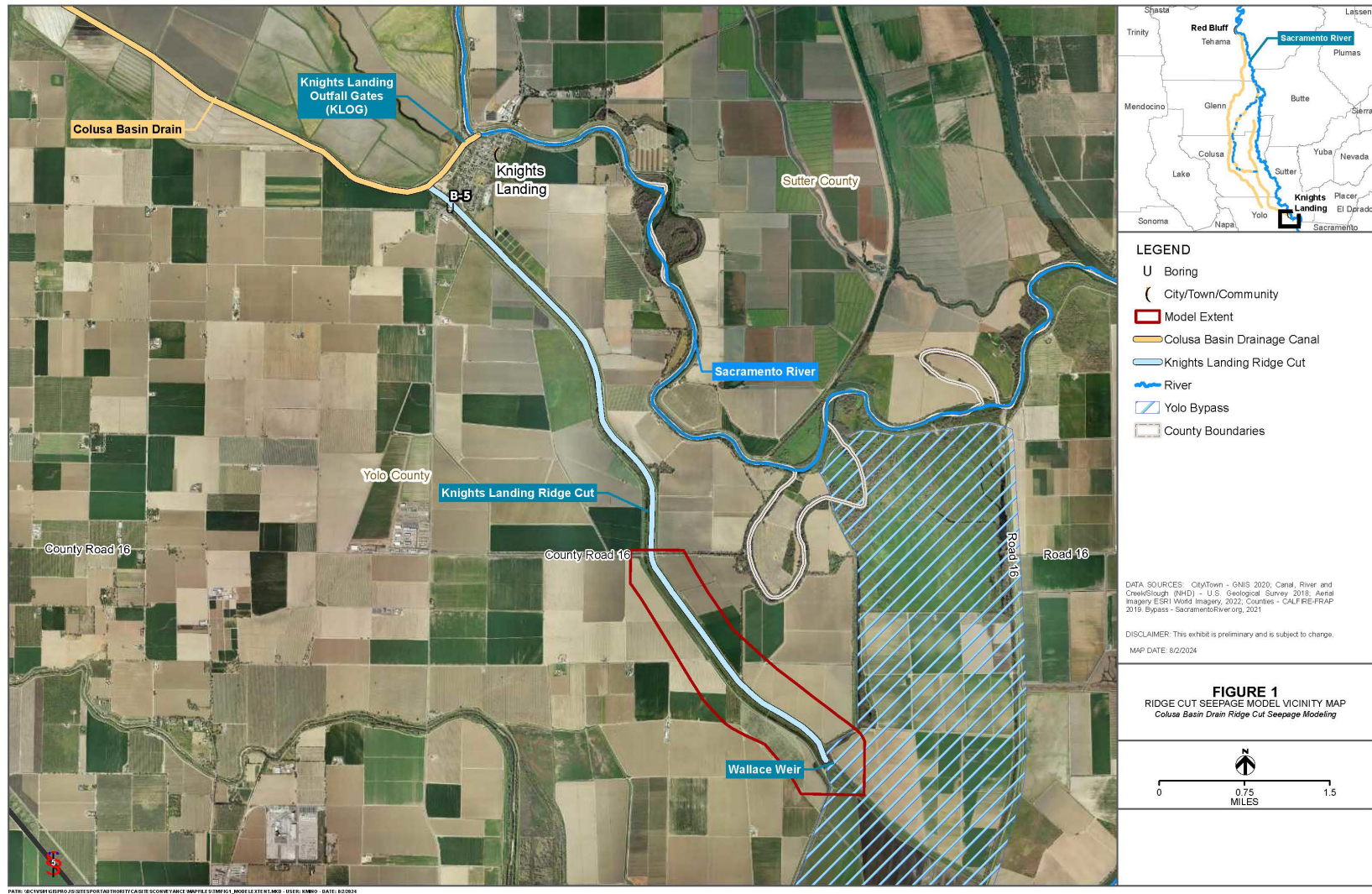
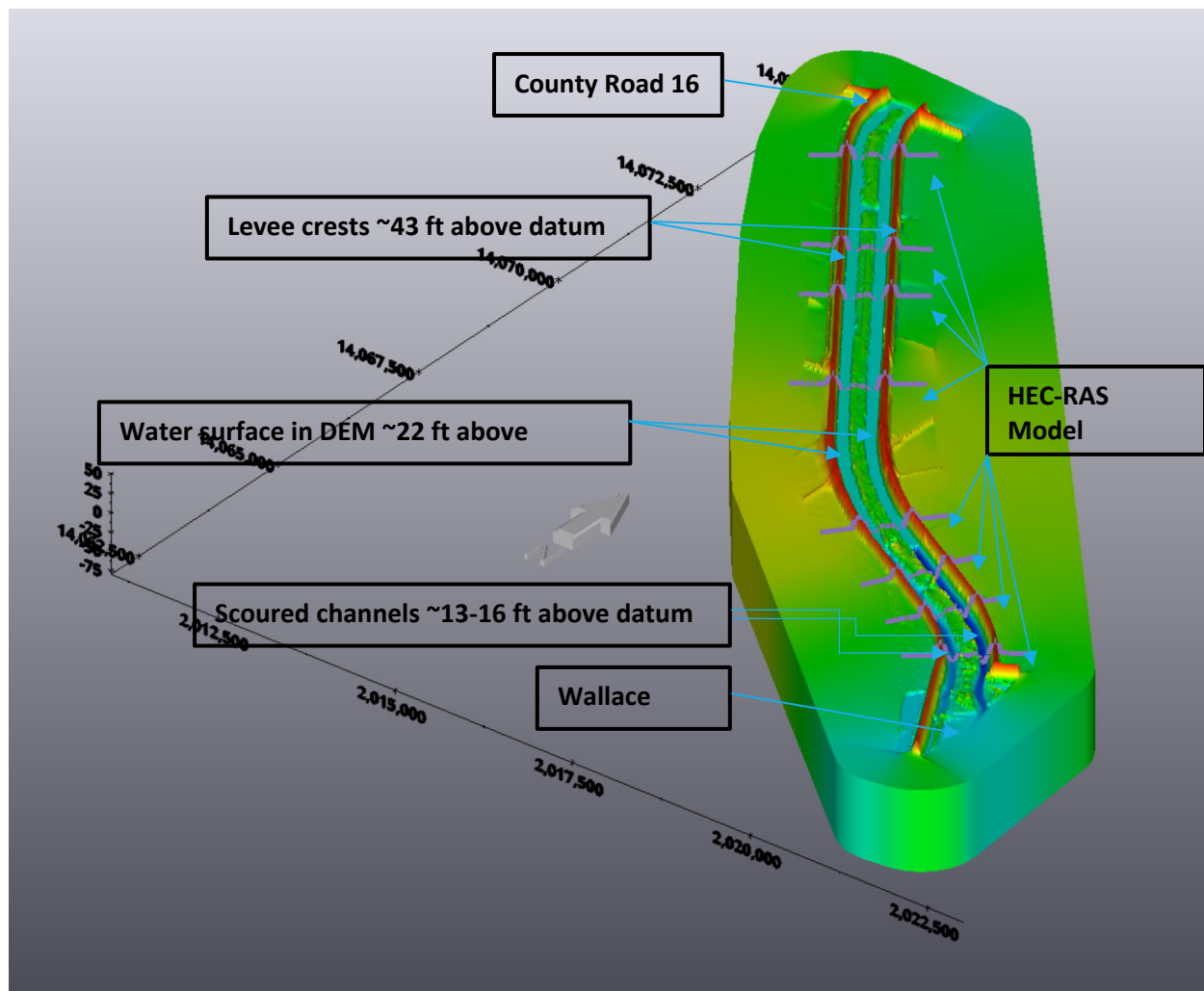


Figure 1. Ridge Cut Seepage Model Vicinity Map



Note: Warmer colors indicate higher elevations.

~ approximately
ft = feet

The HEC-RAS model cross-sections were used to develop a more accurate bathymetric elevation distribution in the upper reaches of the modeled RCS section, with deeper scoured channels, by interpolation in Golden Software Surfer. The grid of these interpolated elevations was substituted into the DWR DEM between the levees. The resulting elevation map, shown on Figure 3, was used as the top surface of the groundwater model.

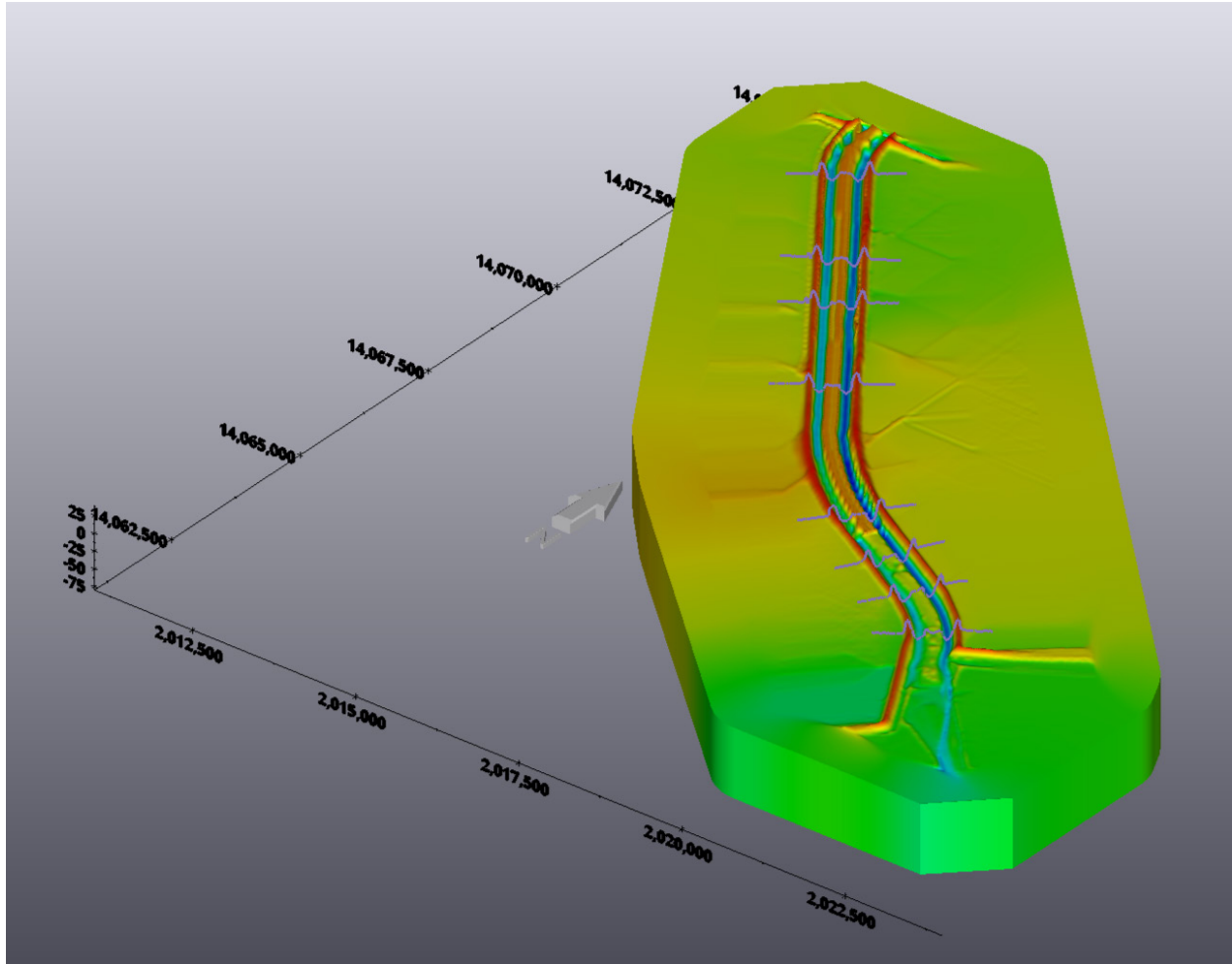


Figure 3. EVS Visualization of Corrected Ground Surface and Bathymetric Model used in the RCS Seepage Model

3.0 Flood Stage

To estimate the flood stage for one of the simulations, water level data were obtained from the RCS measurement station⁴ at Knight's Landing, approximately 3.5 miles upstream from County Road 16. The entire record of data from this station is shown on the upper plot of Figure 4. The highest flood stage since recording began in 2017 was 33.49 feet above datum, occurring in late February 2019.

⁴ <https://cdec.water.ca.gov/webgis/?appid=cdecstation&sta=RCS>

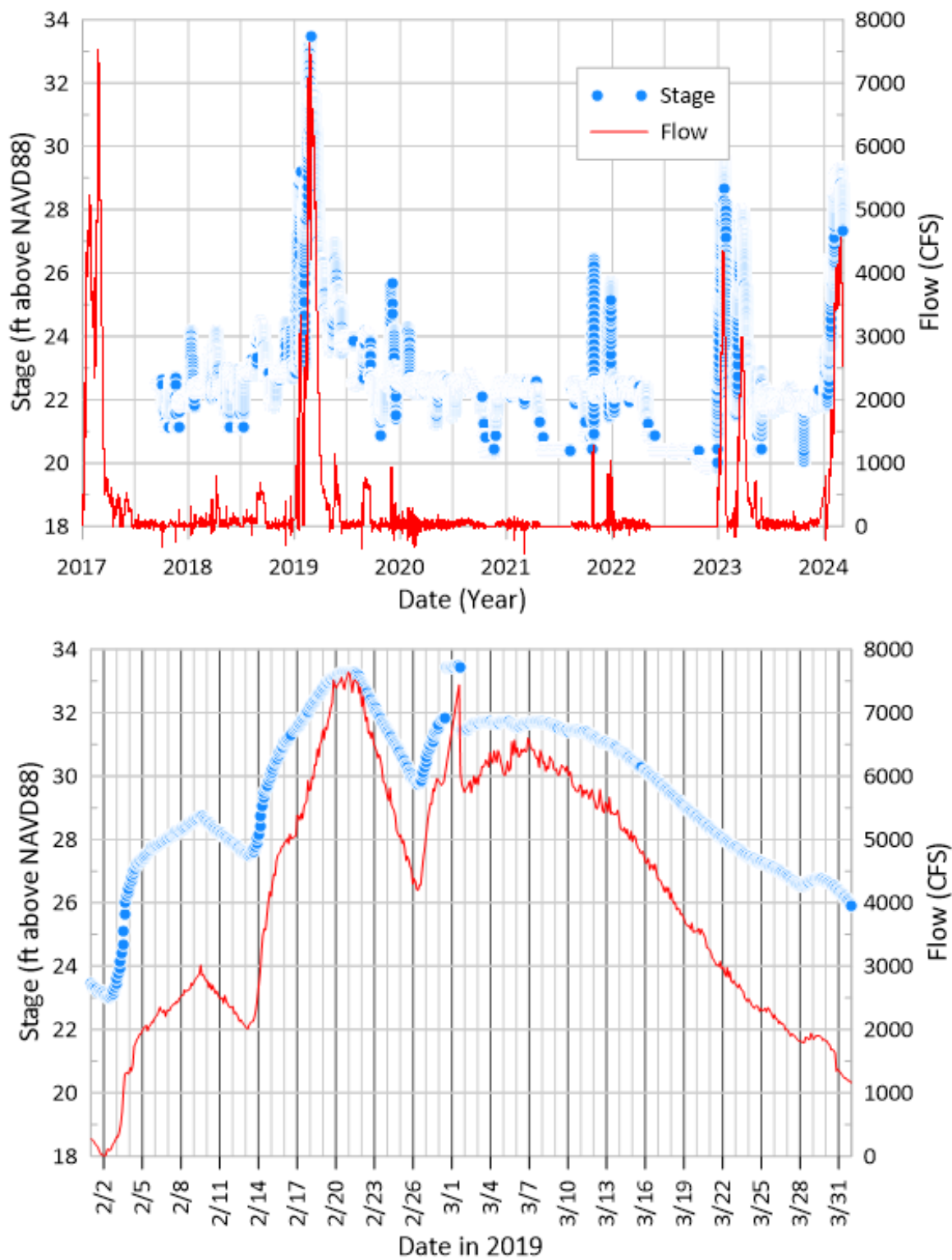


Figure 4. RCS Stage (Hydrograph) and Flow Versus Time at Knights Landing

CFS = cubic feet per second

The three RCS stages to be modeled were:

- KLOG set point of 23.73 feet above datum
- One foot above KLOG set point, 24.73 feet above datum
- Flood stage at 33.49 feet above datum

The intersection of a horizontal plane at each of these three elevations was used in the EVS visualization to estimate the wetted surface within the levees for the three simulations. Figure 5 indicates the intersection of the KLOG set point plane at 23.73 feet with the (solid) DEM model shown on Figure 3. The planar intersection of the KLOG set point with land is shown in green. The wetted surface at this stage is the split gray region between the levees and the divide between the scour channels.

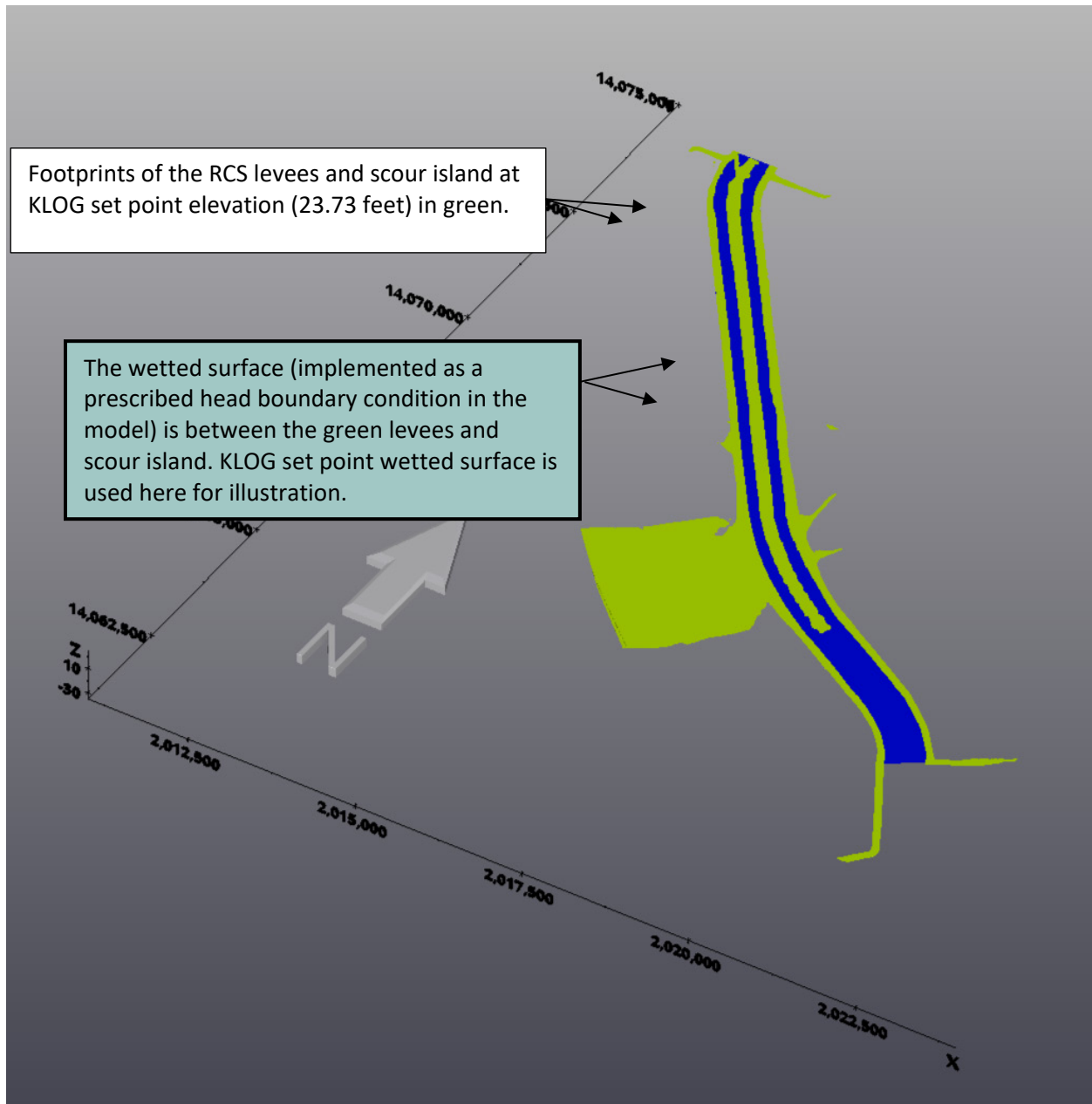


Figure 5. Intersection of the KLOG Set Point Elevation (23.73 feet) and the Land Model of Figure 3

Similar wetted surface areas were developed for 24.73 feet and 33.49 feet mean sea level.

Groundwater elevations were estimated from maps contained within a Yolo Subbasin Annual Report (Yolo Subbasin Groundwater Agency 2024) to fluctuate between 0 and 20 feet above datum, with very little gradient (although data about the area in the immediate vicinity of RCS are sparse).

Similarly, geotechnical data around RCS are sparse. According to Mark Twede, geotechnical engineer at Jacobs, "The one consistent characteristic in the vicinity is highly stratified alluvial soil layers." Lithologic borings from the vicinity of Knights Landing were used to estimate lithology throughout the study area. Figure 6 indicates the stratigraphy at Boring B-5 (California Department of Transportation, Knights Landing Ridge Cut Bridge, Log of Test Borings, 1994), which was indicated to be the best estimate available for a general geologic section for the modeling. The indicated depths on Figure 6 are from the base of the levee, where ground surface elevation is 24.6 feet above datum.

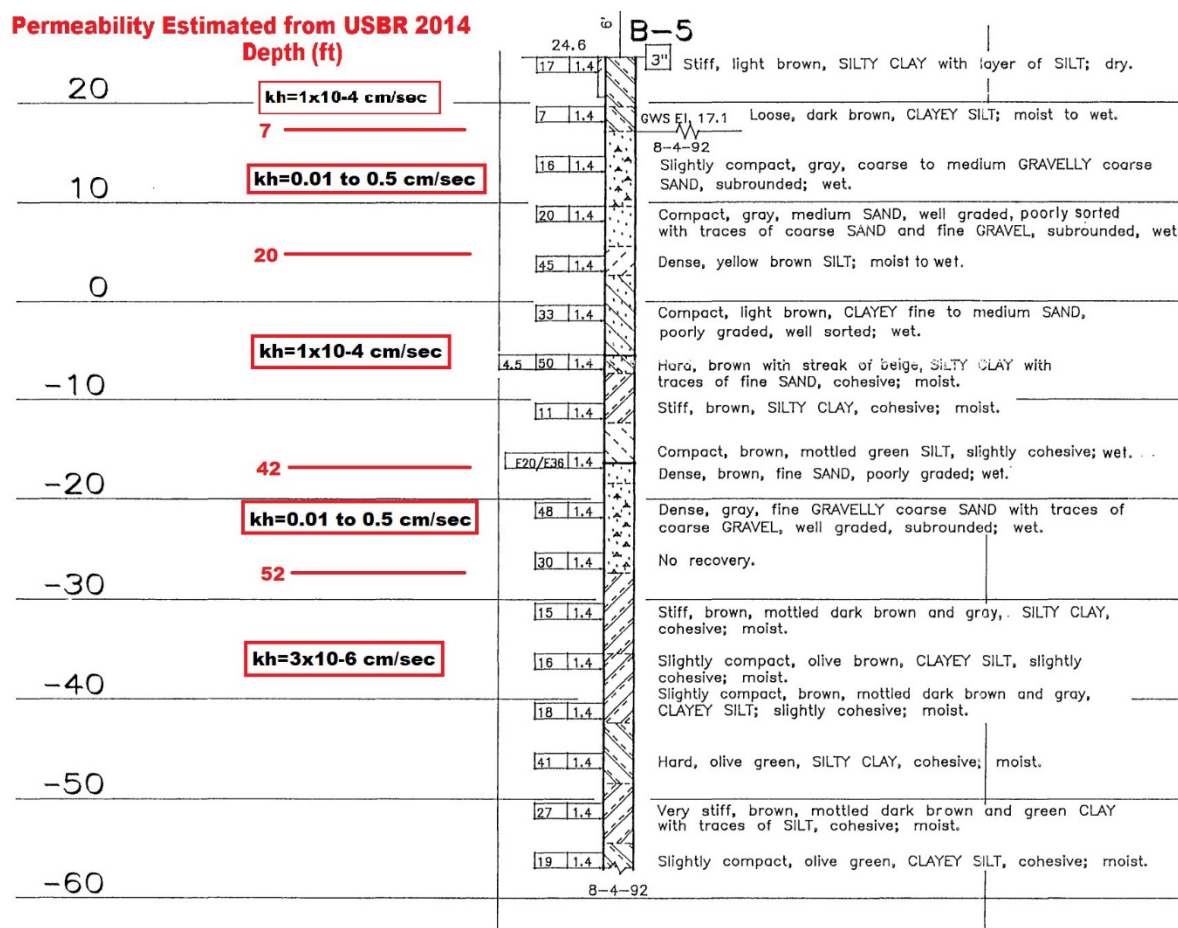


Figure 6. Representative Boring in Vicinity of Knights Landing, Used for Stratigraphy of Model

Source: USBR 2014

cm/sec = centimeter(s) per second

Kh = horizontal hydraulic conductivity

USBR = Bureau of Reclamation

Table 1 indicates the stratigraphy and assumed conductivities that were generated from Boring B-5, as shown on Figure 6. The horizontal to vertical anisotropy was assumed to be 10 to 1 throughout the model.

Table 1. Stratigraphy and Conductivities Used in RCS Groundwater Model

Model Layer	Bottom Elevation (feet above datum)	Layer Thickness (feet)	Horizontal Hydraulic Conductivity (feet/day) ^[a]
1	17.6 ^[b]	0.1 to 26.4	1.93×10^{-2}
2	4.6	13	2.00×10^{-2} ^[b]
3	-17.4	22	1.93×10^{-2}
4	-27.4	10	2.00×10^{-2} ^[c]
5	-57.4	30	5.78×10^{-4}
6	-81.4	24	5.78×10^{-4}
7	-100	19.6	5.78×10^{-4}

^[a] Vertical hydraulic conductivities are assumed to be 1/10th of horizontal hydraulic conductivities.

^[b] Uniform except in scour channels where bathymetric surface elevations are lower than 17.6 feet, where the thickness of Layer 1 was set to 0.1 foot.

^[c] Geometric mean of Kh range 0.01 to 0.5 cm/sec for sandy soils from Figure 6 (Boring B-5).

4.0 Groundwater Model

A groundwater model was constructed using MODFLOW-NWT (Niswonger et al. 2011) running in the Groundwater Vistas Version 8 (from Environmental Simulations, Inc.) graphical user interface. The model contains 450 rows by 438 columns and 7 layers (503,510 active model cells) with a uniform horizontal grid spacing of 25 feet. This implies overall dimensions of 10,950 feet by 11,250 feet. The levees of RCS are approximately 100 feet across, which implies approximately four model cells across each levee. Model layering and conductivities are indicated in Table 1.

According to project instructions, the seepage modeling was to be performed at three RCS stages. These were:

- KLOG set point of 23.73 feet above datum
- One foot above KLOG set point, 24.73 feet above datum
- Flood stage at 33.49 feet above datum

Prescribed heads at these elevations were inserted into the model at these elevations.

Figure 7 shows the Layer 1 model grid along with two base maps and the wetted area for prescribed heads at the KLOG set point determined in the EVS visualization.

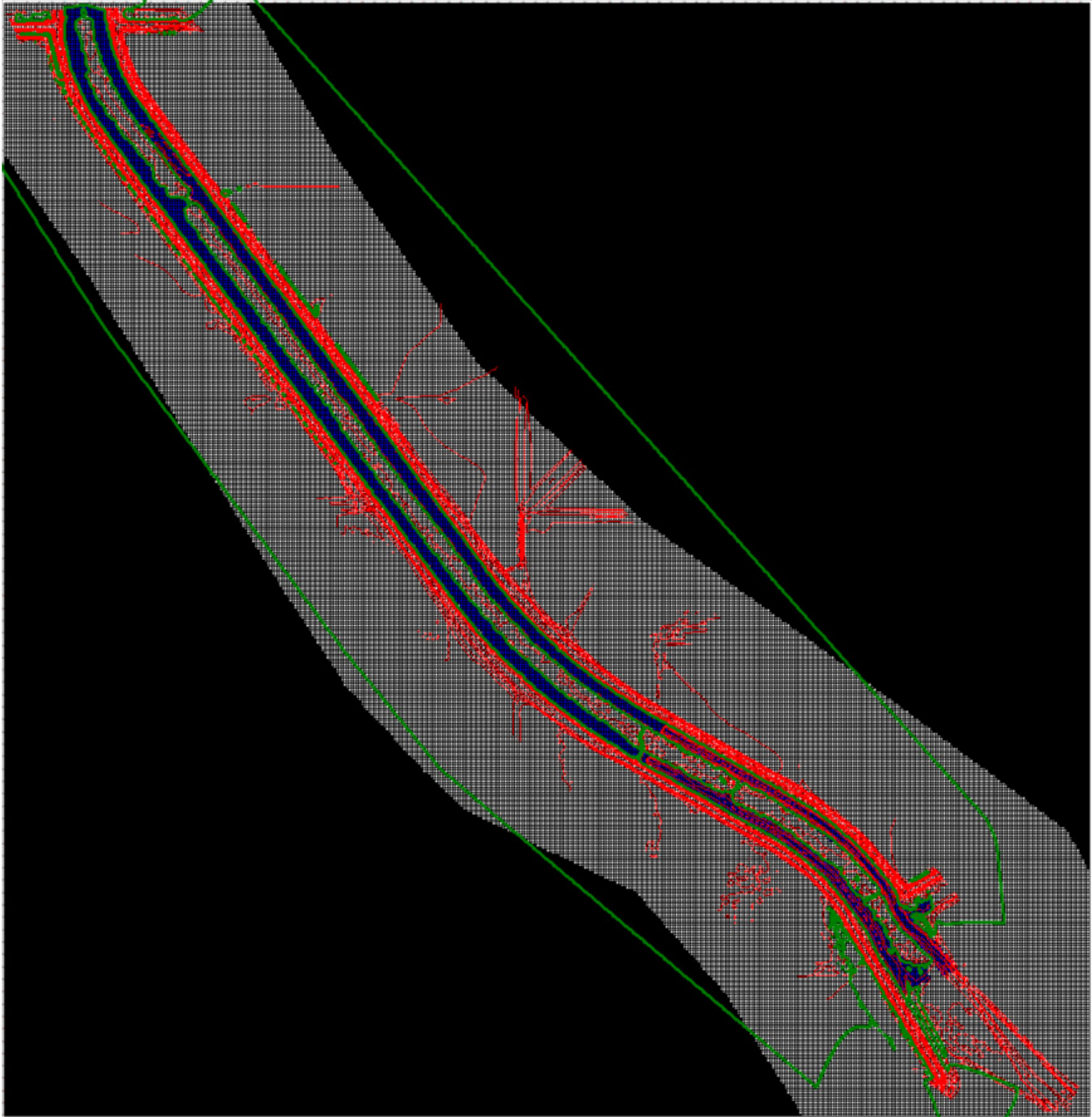


Figure 7. Model Grid (gray), with Base Maps of Elevation Contours (red), Wetted Surface for KLOG Set Point (green), and Prescribed Head Cells for the RCS Surface Water (blue)

Note: Model block (including the no-flow areas in black) is 10,950 feet (east-to-west) by 11,250 feet.

Figure 8 shows a typical cross-section of the model east-to-west along rows, just south of County Road 16. Note that the relatively low hydraulic conductivity (K) model Layer 1 is gouged through by the eastern scour channel. In locations where this occurs, the layer thickness of model Layer 1 was set to 0.1 foot.

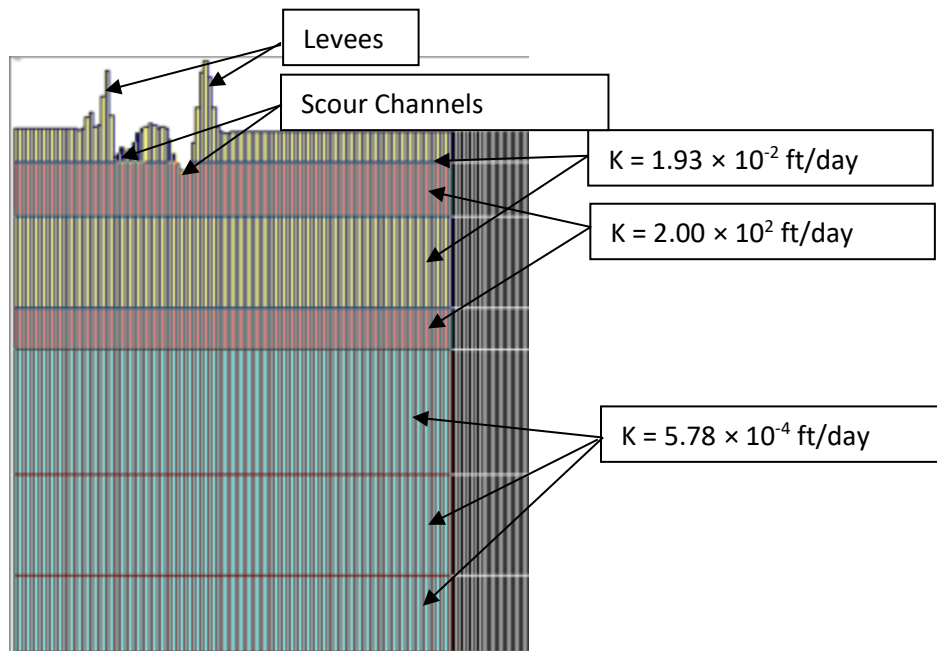


Figure 8. Cross-Section Schematic of Seven-Layer Model in Groundwater Vistas

Note: Section is east-to-west just south of County Road 16.

To simulate underflow, general head boundary cells were incorporated into model Layer 2 at the north and southeast edges of the model at 11 feet and 10 feet above datum, respectively. The actual hydraulic gradient is unknown, but the 2024 Yolo Subbasin Annual Report (Yolo Subbasin Groundwater Agency, 2024) groundwater maps indicated a nearly flat regional water table between approximately 0 and 20 feet above datum.

Models with the three surface water elevations in RCS were each run in steady state. Seepage was considered to have occurred if groundwater elevation exceeded land surface elevation outside the levees. If seepage occurred it was quantified by adding drain boundaries in model Layer 1, with elevation set at the ground surface and an effective hydraulic conductivity of 1,000 feet per day.

5.0 Model Results

The result of the first simulation, with surface water at the KLOG set point 23.73 feet above datum, was that no seepage occurred. Figure 9 shows the depth to water as contours at the end of the simulation. Outside the levees, the depth to water is notably less than 2 feet in a farming region east of RCS, suggesting an area that may be prone to flooding from upwelling groundwater.

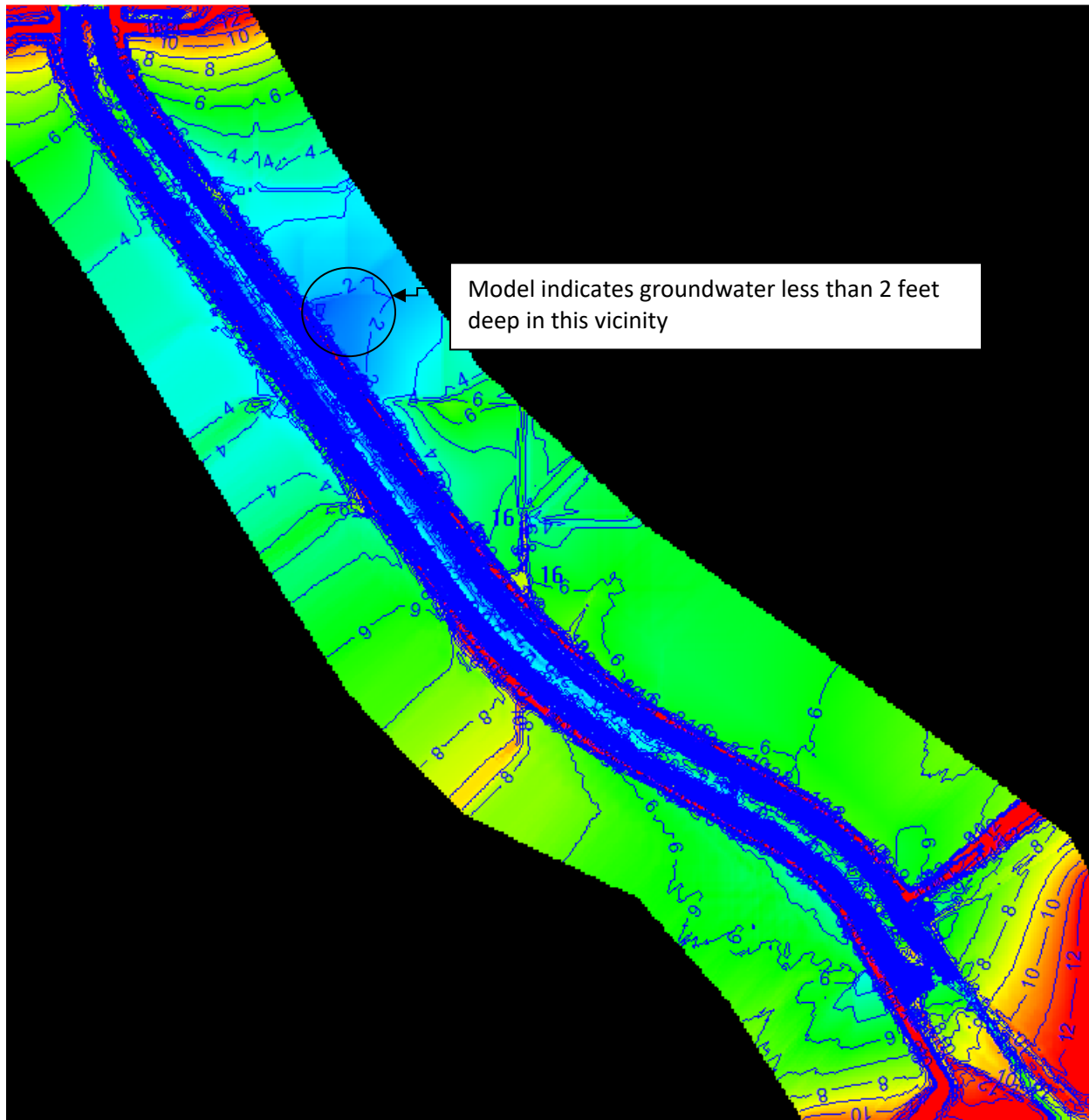


Figure 9. Depth to Water in First Simulation, with KLOG Set Point = 23.73 Feet Above Datum

In the second simulation, with surface water at 24.73 feet above datum at steady state, flooding from upwelling groundwater occurred in a relatively small area near a topographic low approximately 4,000 feet southeast of County Road 16 on the east side of RCS. Figure 10 indicates the location in the model.

The third flood-stage simulation was deemed unrealistic because flood stages are non-steady (almost by definition). Therefore, a transient simulation was developed that approximates the RCS stages in the February-to-March 2019 flood event indicated on the lower plot of Figure 4. Figure 11 shows the simulated depths to water for this simulation at the end of the flood stage, when groundwater elevations outside the levees are estimated to be at maximum. Once again, depth to water is forecasted

to be less than 2 feet beneath the fields on the east side of RCS. Figures 9 through 11 also show significant boundary effects at the up- and downgradient ends of the model, suggesting that the regional water levels obtained from available maps may be too low and do not accurately reflect the groundwater elevations that would be present in those areas near the RCS during higher flow conditions in the canal.

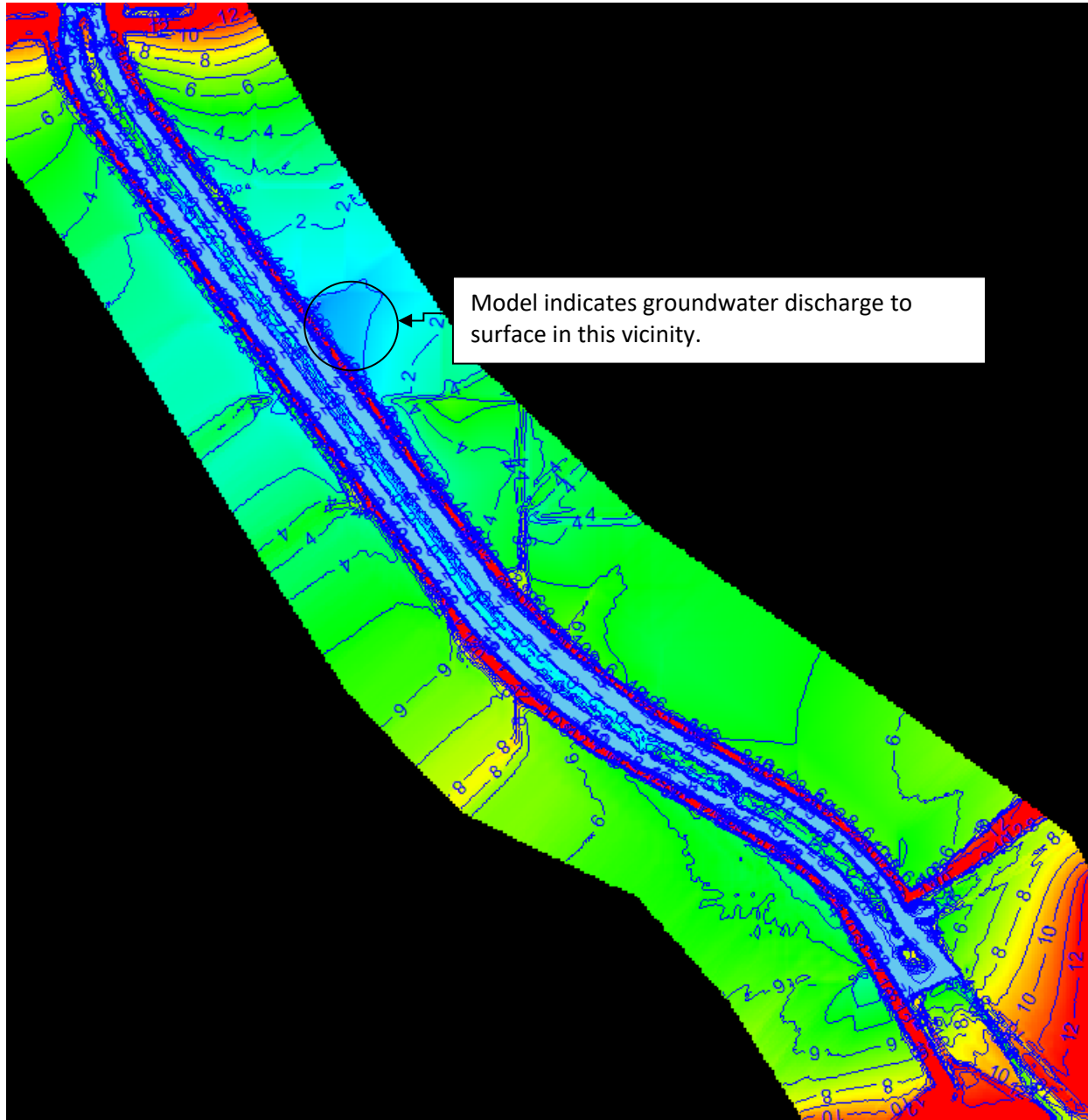


Figure 10. Depth to Water in Second Simulation, with KLOG Set Point = 24.73 Feet Above Datum

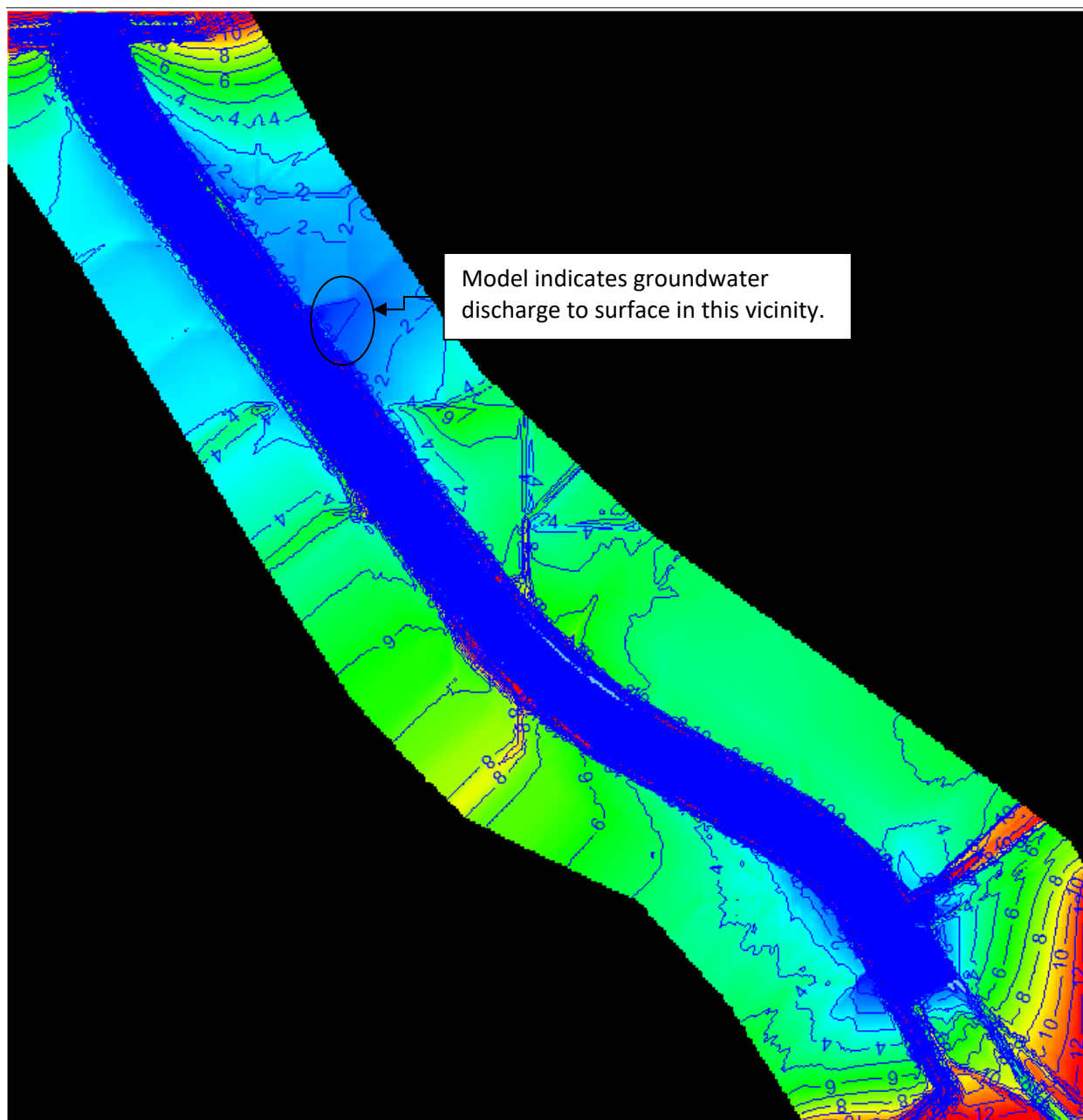


Figure 11. Depth to Water in a Supplemental Transient Simulation, with Variable RCS Stages Approximating the 1999 Flood Event Shown on the Lower Plot of Figure 4

6.0 Model Limitations

The model assumes uniform hydraulic properties throughout simple horizontal layers. It is quite possible that, in some locations, the high-K sands are in better hydraulic contact with RCS surface water and the land surface outside the levees than is represented in the model. In that case seepage may occur in other areas.

The model further assumes that the KLOG set point is a good approximate water level for this vicinity. But the outfall gates at Knights Landing are approximately 3.5 miles to the north. Thus, a more refined

water level estimate for the RCS south of County Road 16 may account for the shallow hydraulic gradient in the vicinity. Lower water levels in the model would naturally lead to less seepage.

The model also has a relatively limited lateral extent perpendicular to RCS, which could potentially cause simulated seepage to be higher than it would be with a more expanded lateral domain. However, given the relatively limited seepage that occurred in most of the modeling (except in the unrealistic steady-state flood-stage simulation), this does not appear to have been a significant problem in these simulations.

The model's general head boundary conditions, while set consistent with regional water table maps, could be set higher to limit the boundary effects observed in the hydraulic contours at the up- and downgradient ends of the model (refer to Figures 9 through 11).

7.0 Recommendations for Further Investigation

Given that the lithology in the specific area of RCS is still unknown, the model's ability to estimate where flooding may occur, or to quantify groundwater upwelling or seepage, is limited. If a better estimate of seepage flows is desired, then the most fruitful effort may be additional borings drilled within the model domain (between County Road 16 and Wallace Weir) to establish the specific lithology in this region. Figure 12 indicates five recommended geotechnical boring locations that, if drilled, would allow local determination of near-surface sediments and site-specific depths of contacts between sedimentary layers. If implemented in this groundwater model, these site-specific sediments and contacts would improve the model's ability to simulate local hydrogeologic conditions and the likelihood of flooding under various scenarios. Monitoring wells should be completed within the borings to provide additional water level data for model calibration and to monitor the relationship between RCS stage and groundwater elevations.

8.0 References

Niswonger, R. G., Sorab Panday, and Motomu Ibaraki. 2011. *MODFLOW-NWT, a Newton formulation for MODFLOW 2005*: U.S. Geological Survey Techniques and Methods 6–A37.

Twede, Mark, geotechnical engineer, Jacobs. 2024. Personal communication (email) with Dan Dolmar, Jacobs. April 10.

United States Bureau of Reclamation (USBR). 2014. *Design Standards No. 13, Embankment Dams. Chapter 8: Seepage*. January.

Yolo Subbasin Groundwater Agency. 2024. Yolo Subbasin Annual Report, Water Year 2023. <https://yologroundwater.specialdistrict.org/files/187dcedb7/Annual+Report+2024+FINAL.pdf>.

Appendix 2
Colusa Basin Drain Cross Sections: 2025
Survey Comparison Information

Colusa Basin Drain Cross-Sections: 2025 Survey Comparison Information



To:	Sites Project Authority
CC:	Henry Luu, P.E./HDR
Date:	March 18, 2026
From:	Jacobs; Megan Campbell, P.E./Jacobs
Quality Review:	Kyle Winslow PhD., P.E./Jacobs, Peter Rude, P.E./Jacobs
Authority Agent Review:	
Subject:	Colusa Basin Drain Cross-Sections: 2025 Survey Comparison Information

Jacobs created a report titled *Cross-Section Comparison: REY Dec 2025 Survey, REY 2022 LiDAR, and 2008-09 LiDAR* on January 26, 2026. This report compares cross section survey data from the following three sources:

- Central Valley Floodplain Evaluation and Delineation (CVFED) Light Detection and Ranging (LiDAR) data from November 2008 to 2009
- R.E.Y Engineers, Inc. (REY) LiDAR data from 2022
- REY survey data from 2025

The location of these cross sections is shown on Figure 1.

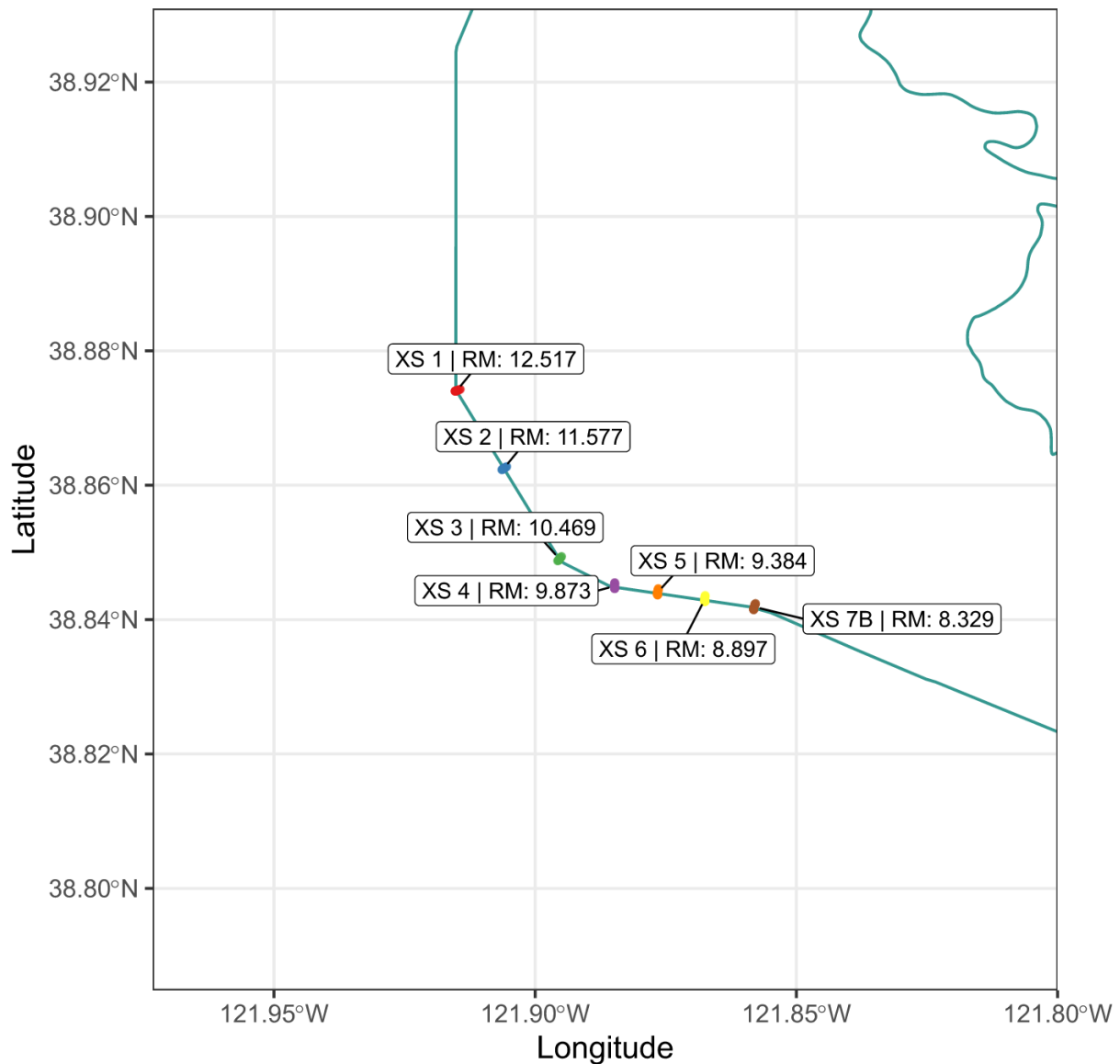


Figure 1. Colusa Basin Drain Cross Section Map (Jacobs 2026)

Vertical data from these seven cross sections along the Colusa Basin Drain (CBD) was plotted in graphs for comparison. The first cross section, located at River Mile (RM) 12.517, is 50 feet downstream of the compared CBD model cross section location and does not have any LiDAR data from 2022. The plotted data, shown on Figure 2, shows that the 2025 survey data are slightly lower than the 2008-2009 LiDAR data.

Cross Section Comparison: XS 1 | 12.517

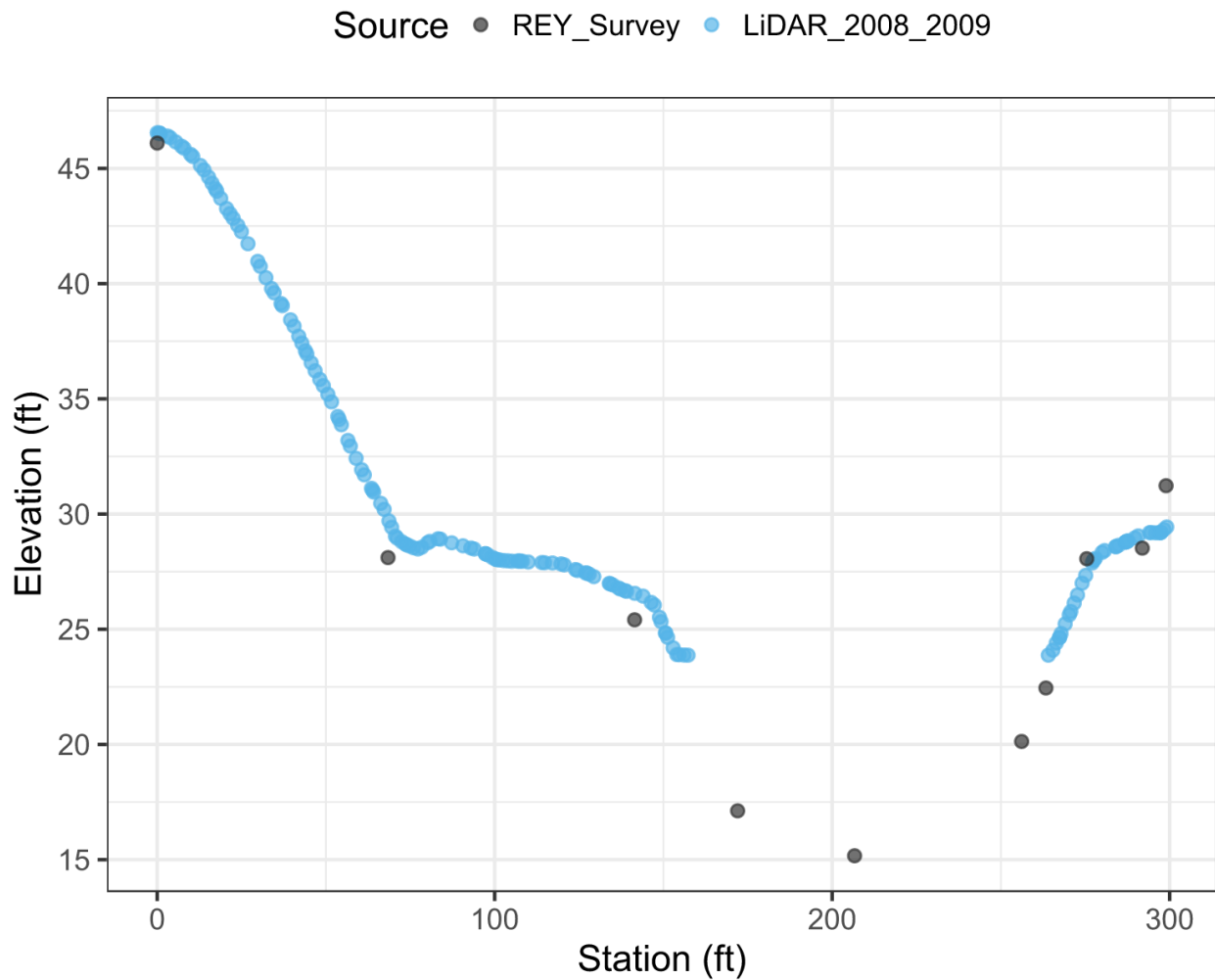


Figure 2. Cross Section 1 (XS 1) (Jacobs 2026)

Cross Section 2, located at RM 11.577, is 30 feet downstream of a CBD model cross section and near the Dunnigan Pipeline Outfall. The plotted data, shown on Figure 3, show that the 2025 survey data are lower than the 2022 and 2008-2009 LiDAR data.

Cross Section Comparison: XS 2 | 11.577 (Dunnigan Pipeline Outfall)

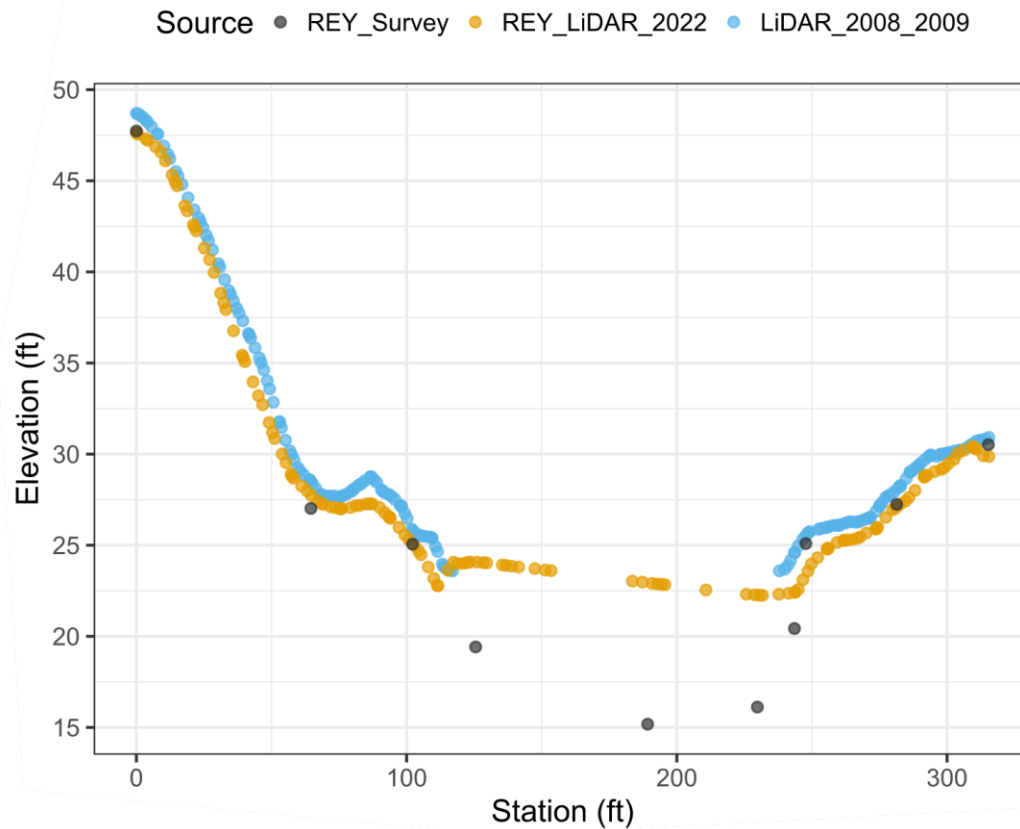


Figure 3. Cross Section 2 (XS 2) (Jacobs 2026)

Cross Section 3, located at RM 10.469, is located 50 feet upstream of a CBD model cross section location. The plotted data, shown on Figure 4, show that the 2025 survey and 2022 LiDAR are very similar and slightly lower than the 2008-2009 LiDAR data.

Cross Section Comparison: XS 3 | 10.469

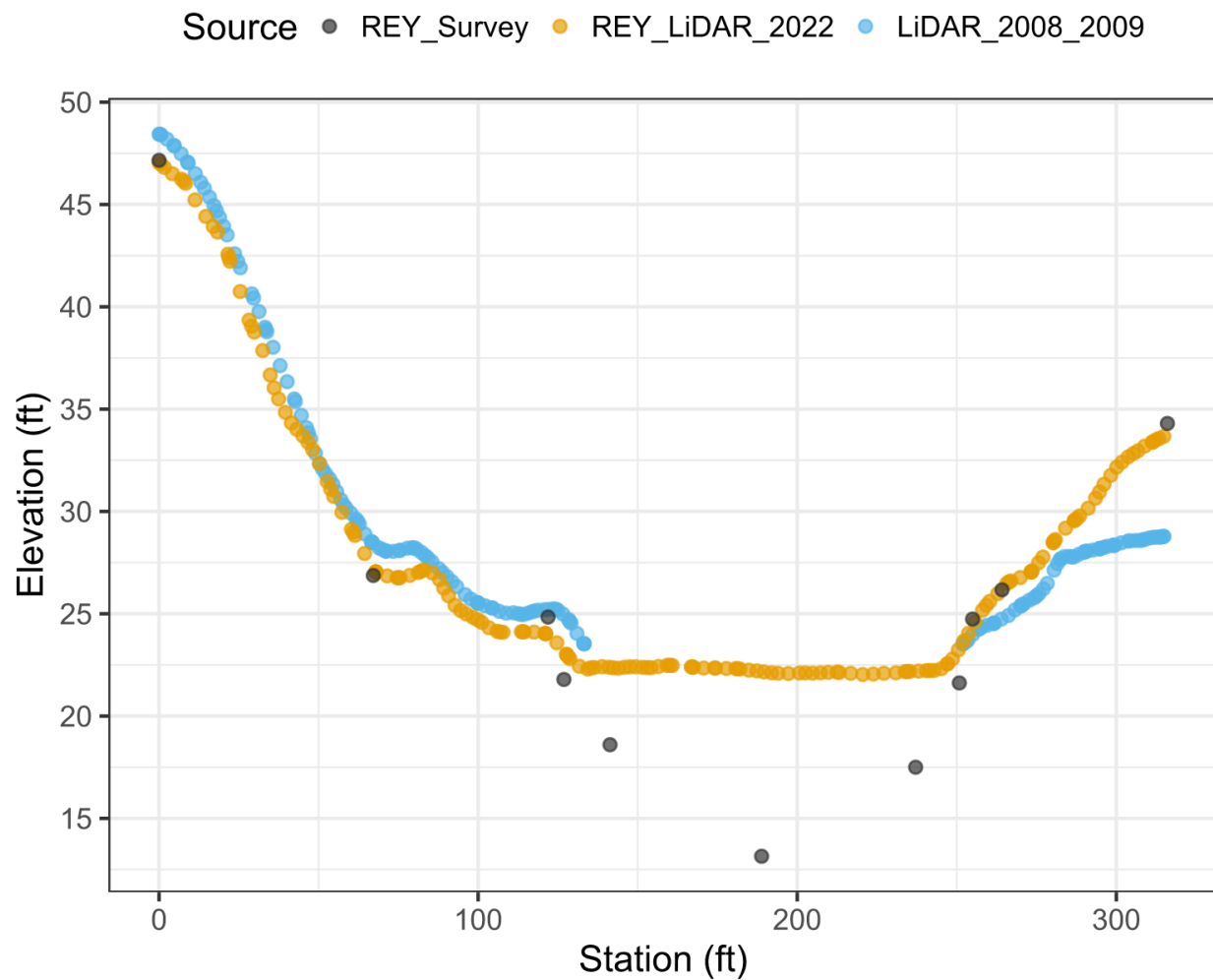


Figure 4. Cross Section 3 (XS 3) (Jacobs 2026)

Cross Section 4, located at RM 9.873, is located 190 feet downstream of a CBD model cross section location. The plotted data, shown on Figure 5, show that the 2025 survey and 2022 LiDAR are very similar and slightly lower than the 2008-2009 LiDAR data.

Cross Section Comparison: XS 4 | 9.873

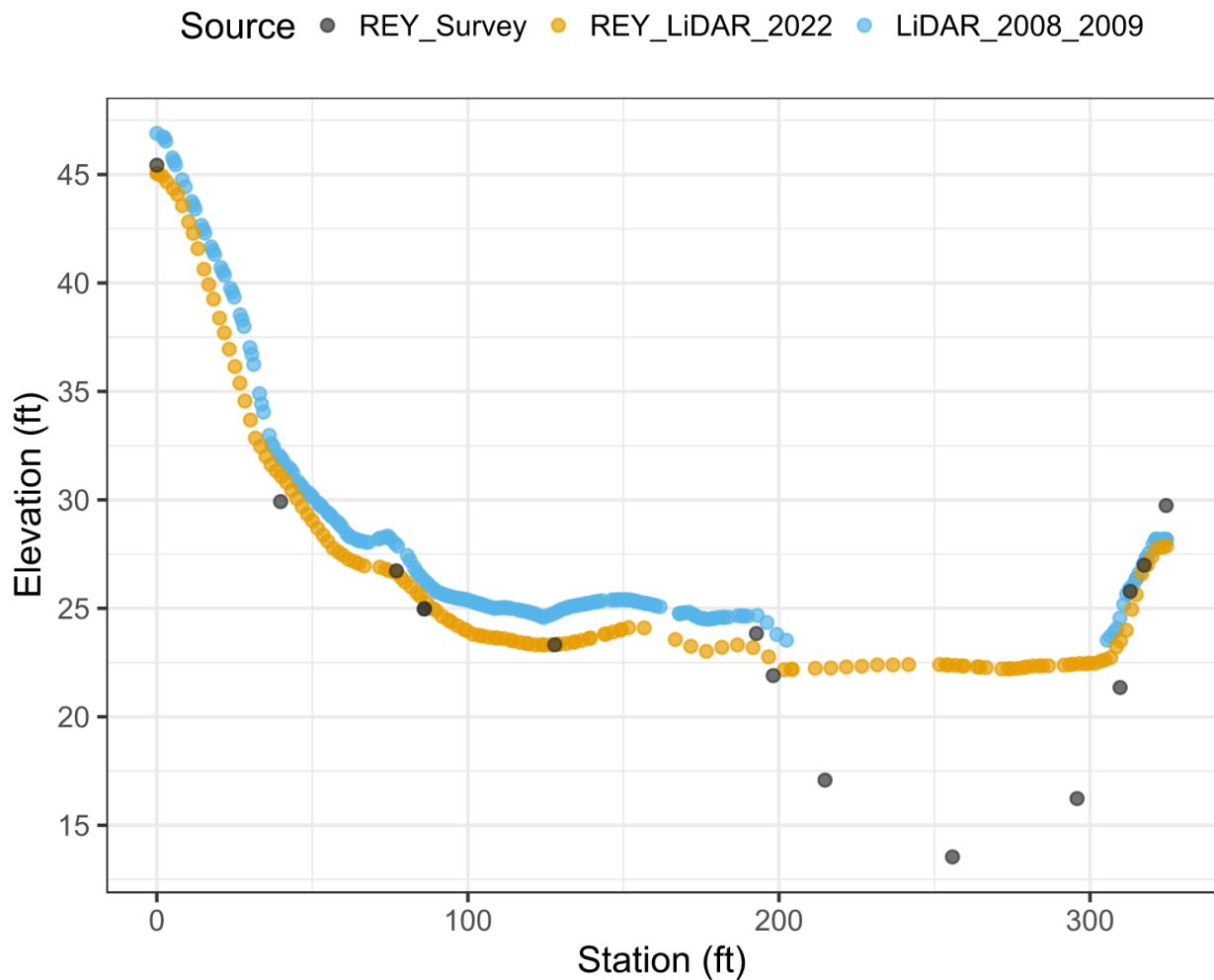


Figure 5. Cross Section 4 (XS 4) (Jacobs 2026)

Cross Section 5 (Figure 6), located at RM 9.384, shows that the 2025 survey and 2022 LiDAR are very similar and slightly lower than the 2008-2009 LiDAR data.

Cross Section Comparison: XS 5 | 9.384

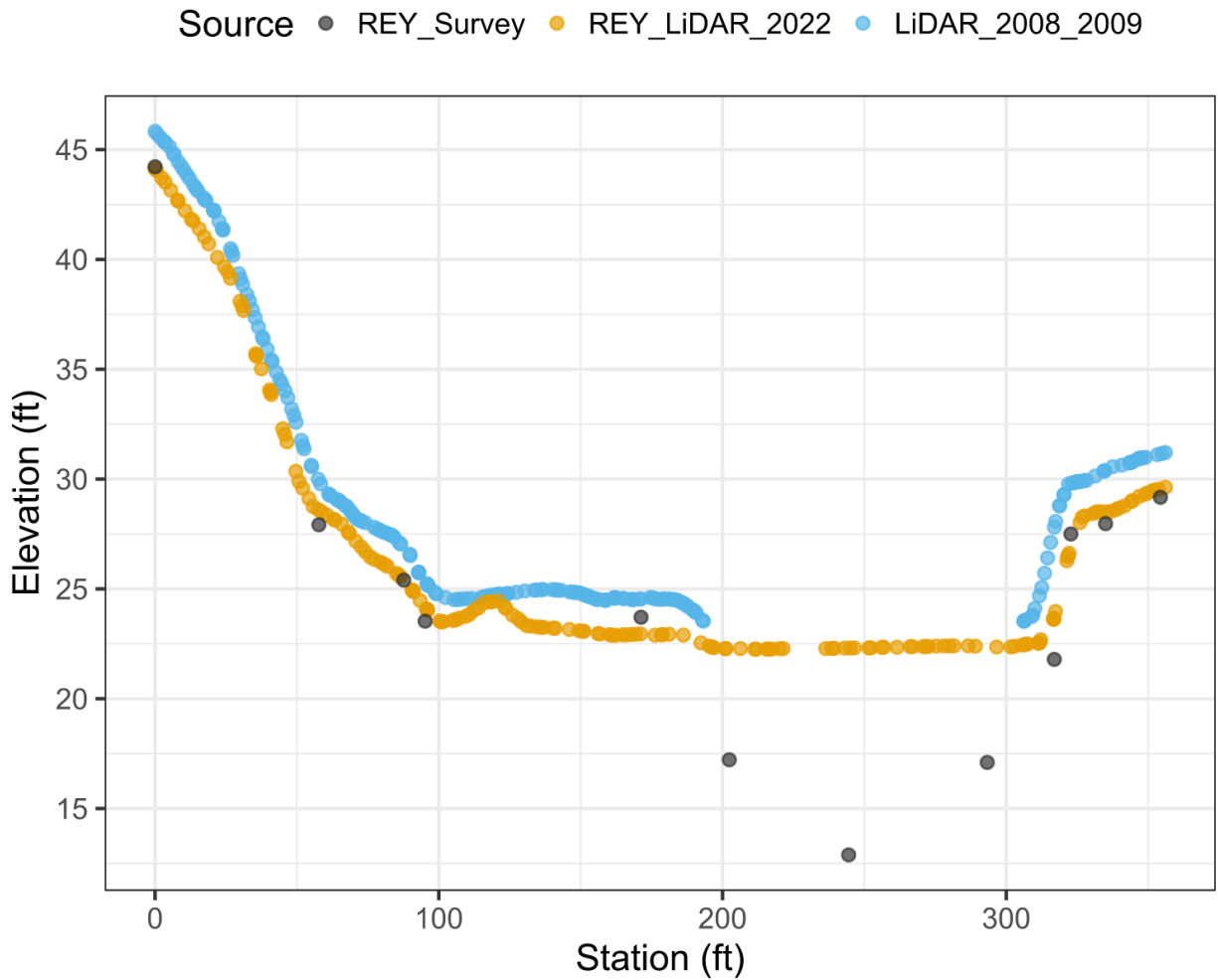


Figure 6. Cross Section 5 (XS 5) (Jacobs 2026)

Cross Section 6 (Figure 7), located at RM 8.897, shows that the 2025 survey data is lower than the 2022 and 2008-2009 LiDAR data.

Cross Section Comparison: XS 6 | 8.897

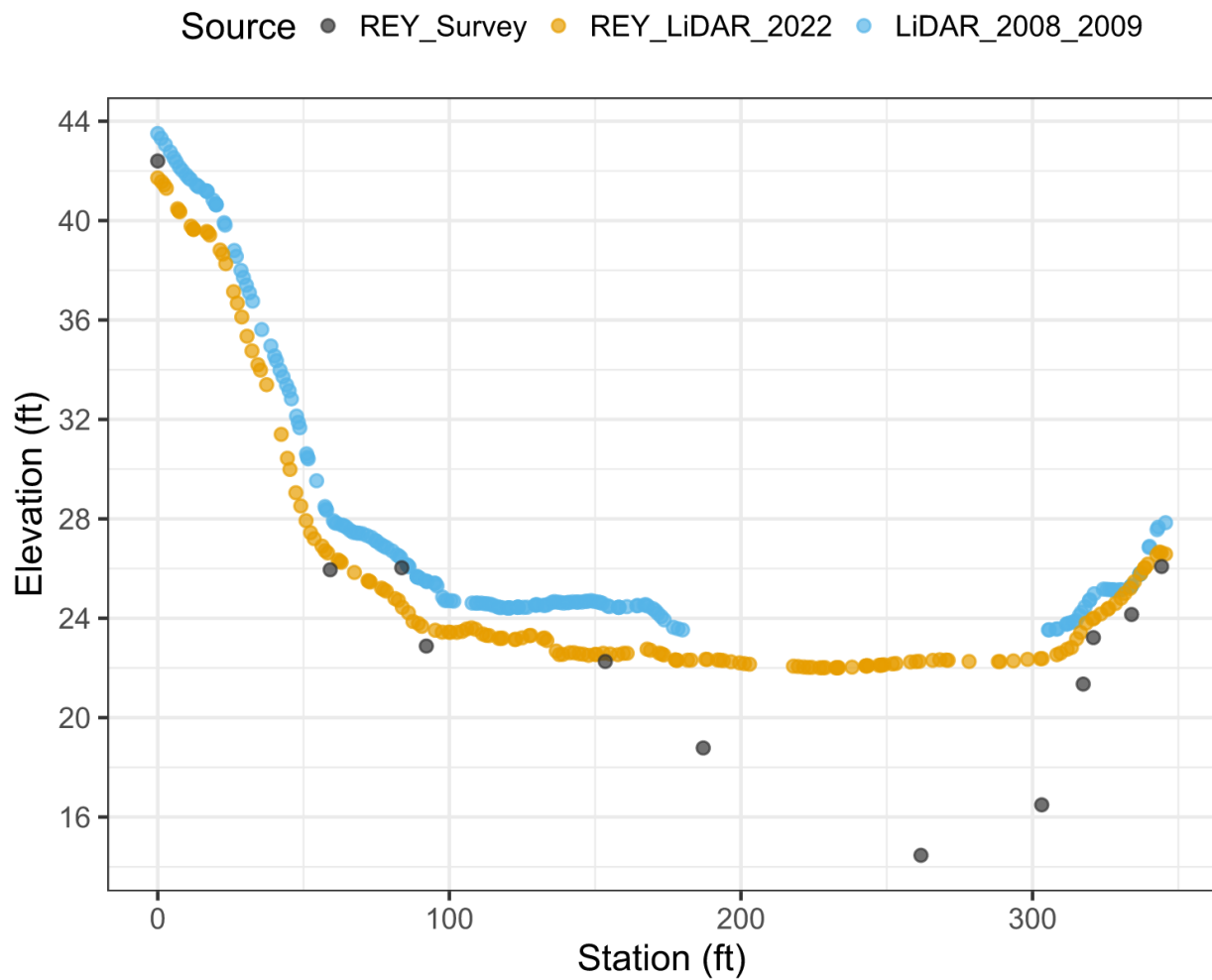


Figure 7. Cross Section 6 (XS 6) (Jacobs 2026)

Cross Section 7B (Figure 8), located at RM 8.329, shows that the 2025 survey and 2022 LiDAR are similar and lower than the 2008-2009 LiDAR data.

Cross Section Comparison: XS 7B | 8.329

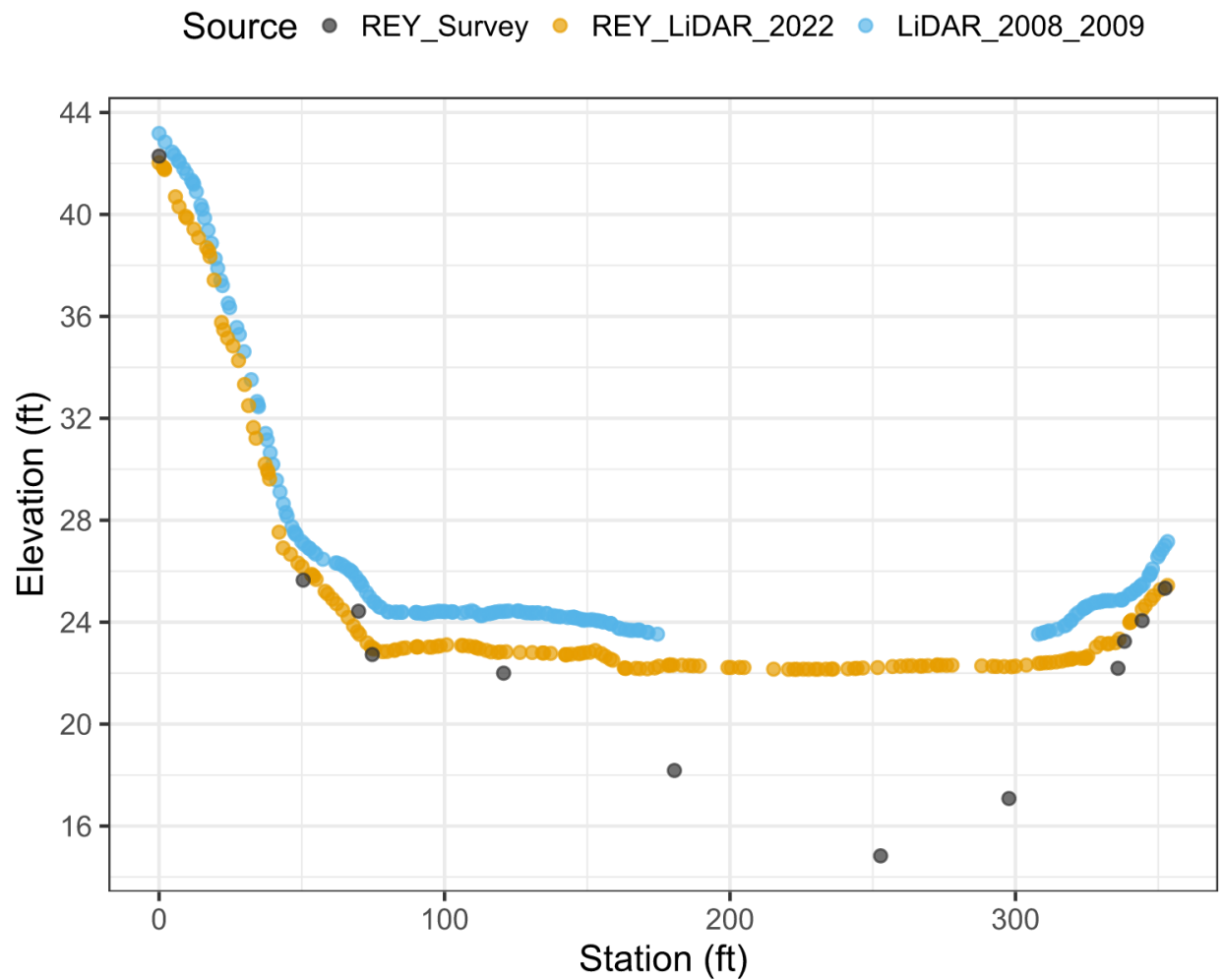


Figure 8. Cross Section 7B (XS 7B) (Jacobs 2026)

In general, the 2025 survey data are 1 to 2 feet lower than the 2008-2009 LiDAR data.

References:

Jacobs. 2026. *Cross-Section Comparison: REY Dec 2025 Survey, REY 2022 LiDAR, and 2008-09 LiDAR*. January 26.

Appendix 3

Colusa Basin Drain Bank and Berm Improvement Figures

Colusa Basin Drain Bank and Berm Improvement Figures



To: Sites Project Authority

CC: Henry Luu, P.E./HDR

Date: March 18, 2026

From: Jacobs; Megan Campbell, P.E./Jacobs

Quality Review: Kyle Winslow PhD., P.E./Jacobs, Peter Rude, P.E./Jacobs

Authority Agent Review:

Subject: Bank and Berm Improvement Figures

To run the model with ambient flows and Project flows but no agricultural land inundation, bank and berm improvements were required to be modeled. Figure 1 shows the overview of the bank and berm improvements required. Figures 2 through 4 show the detailed extents of the improvements. In total, roughly 26,260 linear feet (LF) of bank improvements and 4,062 LF of berm improvements were required for this run.

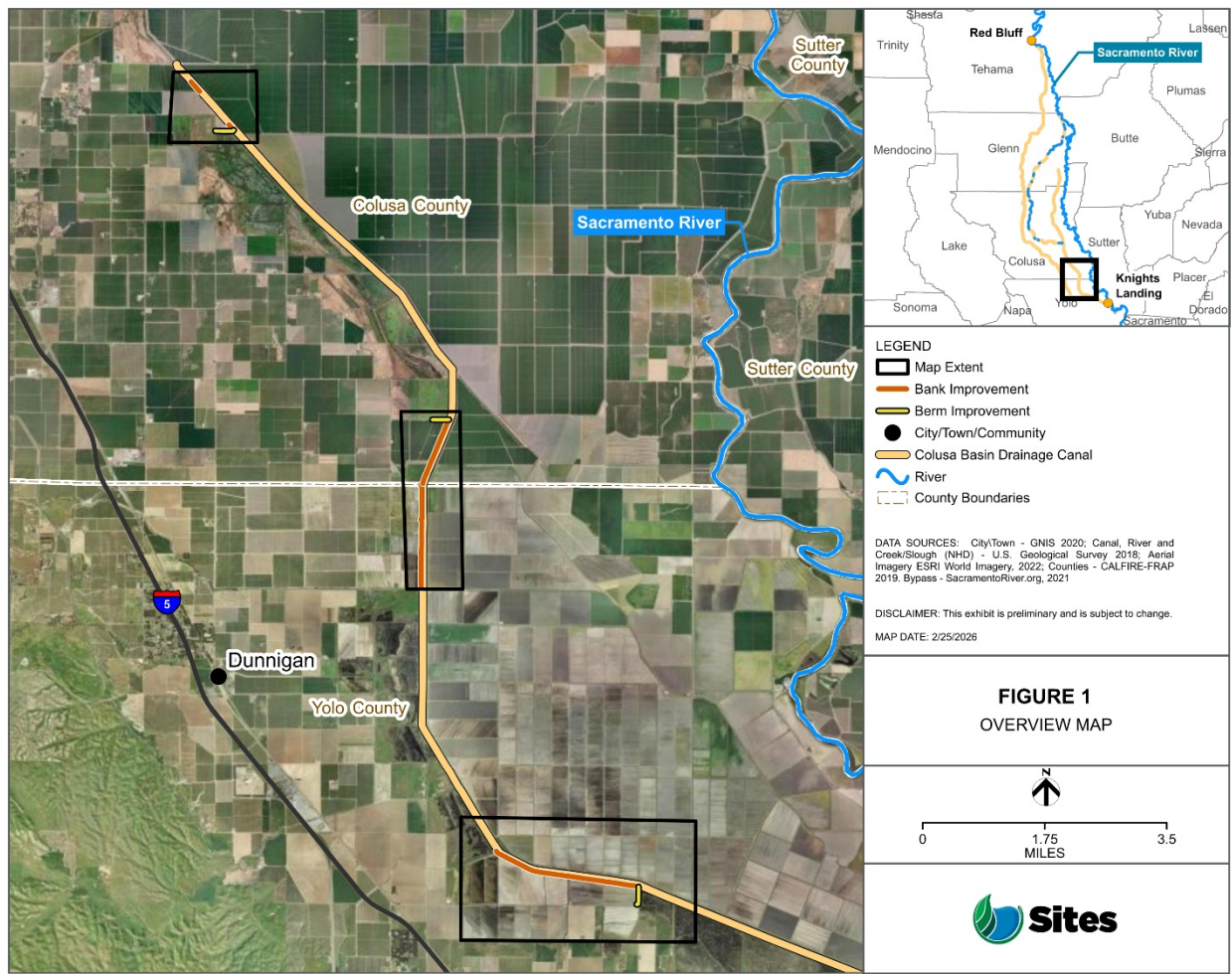


Figure 1. Berm and Bank Improvements Overview

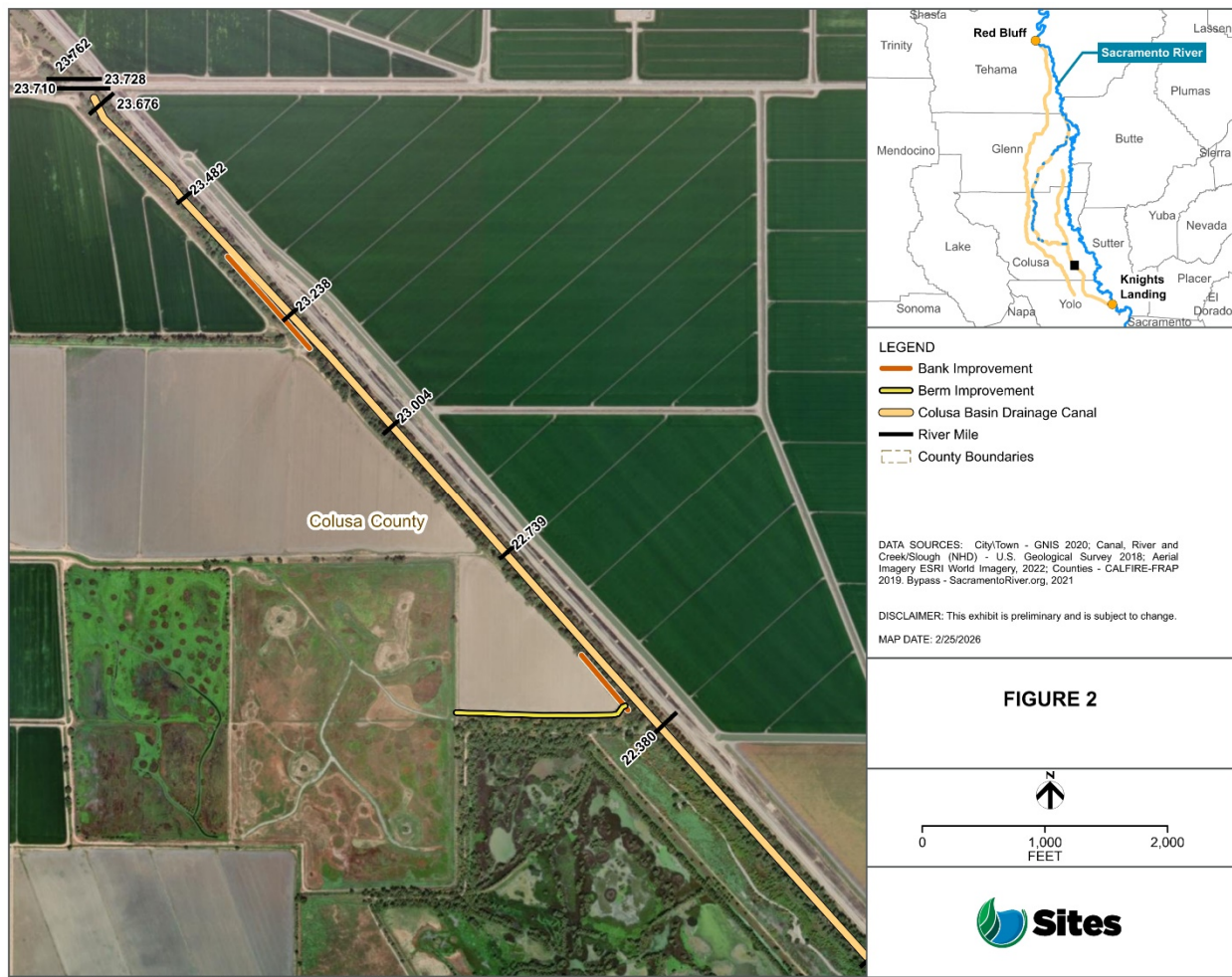


Figure 2. Berm and Bank Improvements Near River Mile 23.2

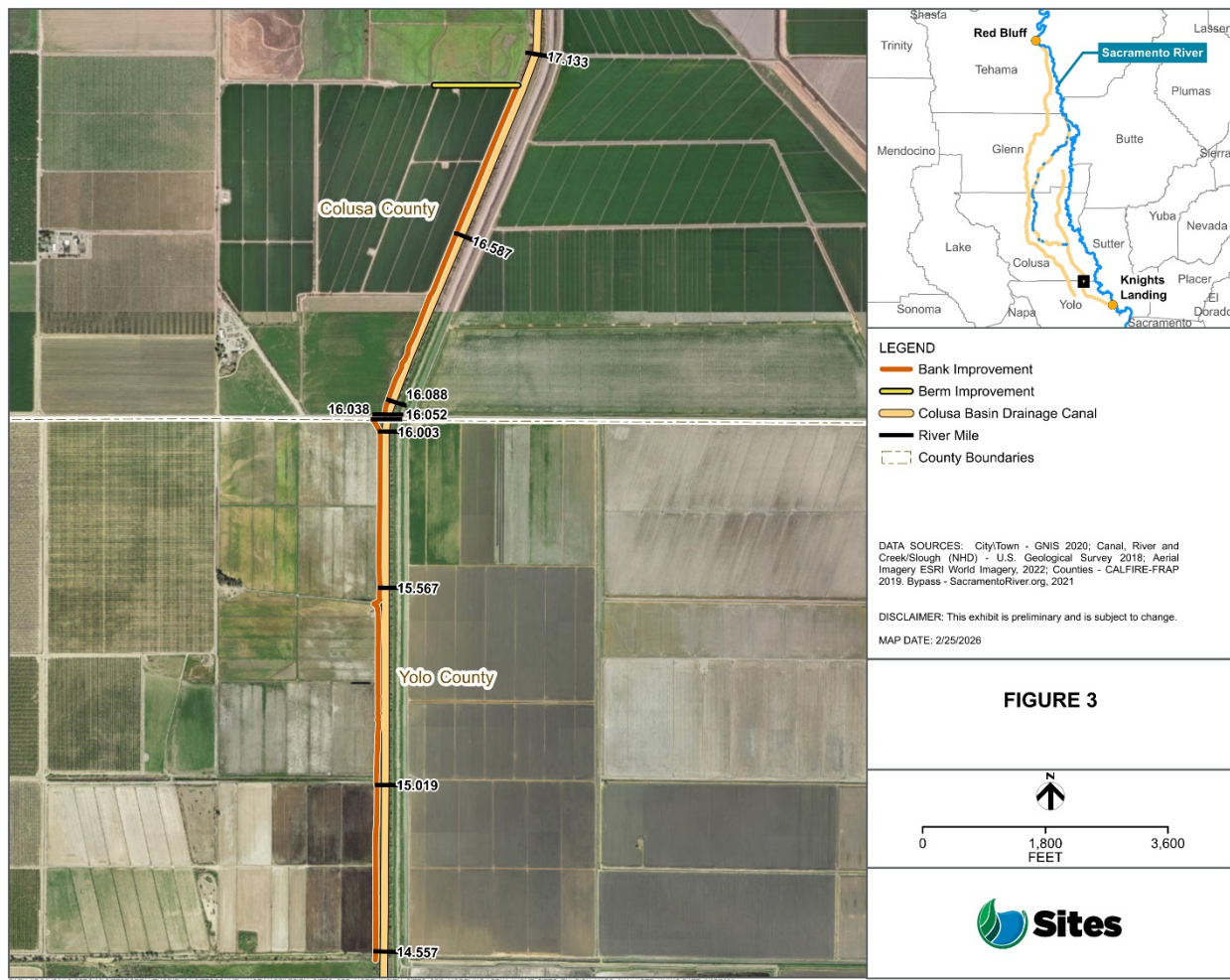


Figure 3. Berm and Bank Improvements Near River Mile 16

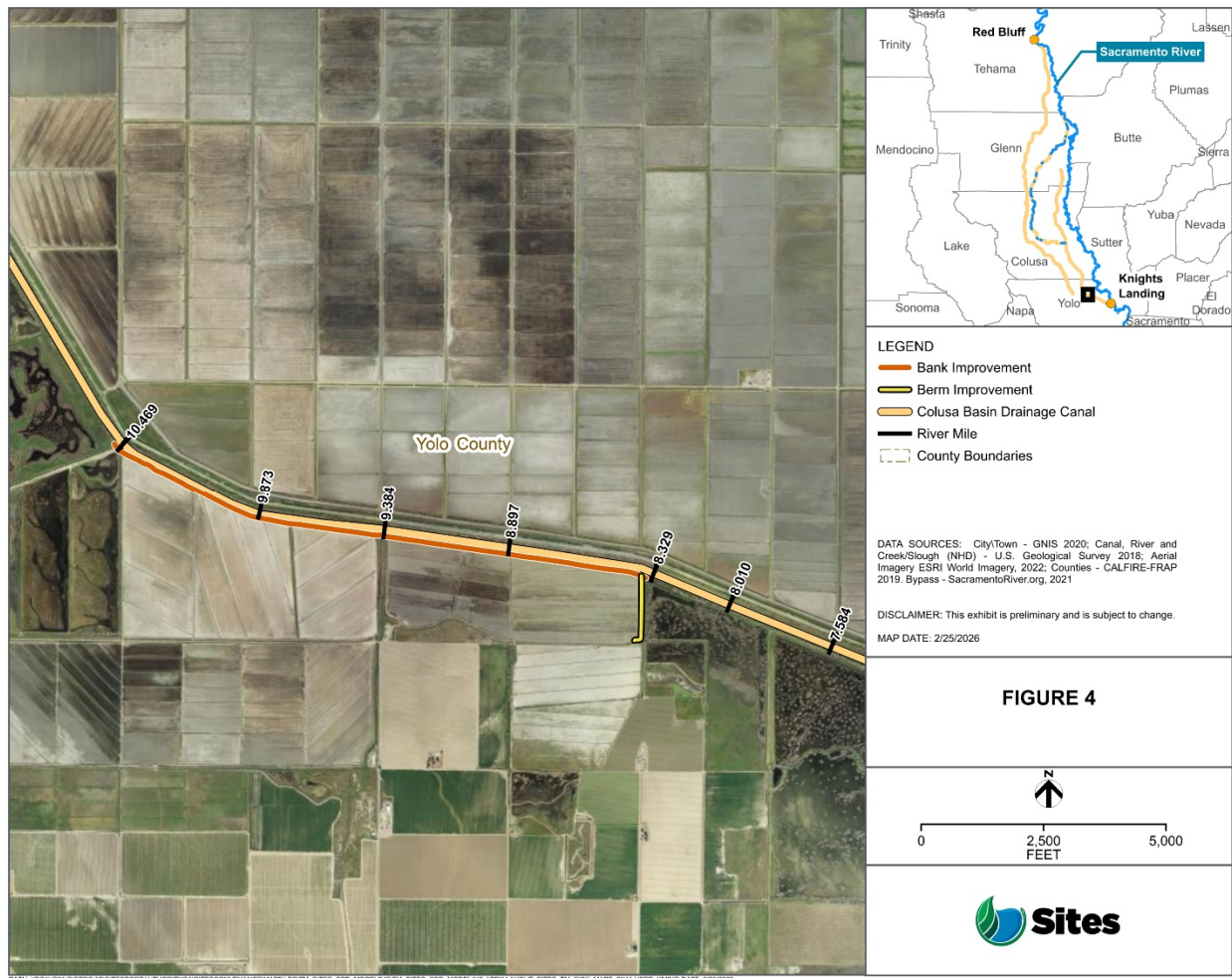


Figure 4. Berm and Bank Improvements Near River Mile 9.4

Appendix 4
Colusa Basin Drain West Bank
Improvements Basis of Estimate



Colusa Basin Drain West Bank Improvements

Feasibility Design Basis of Estimate

February 2026

Update December 2021 Estimate to 2024 Dollars - Draft

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Appendixes

Appendix A Detailed Cost Estimate

Appendix B AACEI Classification

Tables

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Acronyms and Abbreviations

AACEI	Association for the Advancement of Cost Engineering International
CBD	Colusa Basin Drain
GC	General Conditions or General Contractor
NTP	Notice to Proceed
TCC	Tehama-Colusa Canal
VE	Value Engineering

1. Executive Summary

1.1 Project Overview

The Sites Reservoir Project consists of a large reservoir, ancillary roads, and conveyance facilities. The Sites Project Authority decided to segregate the design of these facilities into an HR (Segment H Reservoir) segment that is responsible for the design of the reservoir features, including several dams and inlet/outlet tunnels at Golden Gate Dam, as well as relocation of roads displaced by the reservoir. The other segment is known as the HC (Segment H Conveyance) segment and consists of improvements to the two existing diversion canals from the Sacramento River to the Project Area (Tehama-Colusa Canal [TCC] and Glenn-Colusa Irrigation District Main Canal), regulating reservoirs (existing Funks Reservoir and new Terminal Regulating Reservoir), two pumping/generating plants (PGP), large-diameter pipelines from each PGP to Sites Reservoir, and a large-diameter pipeline to convey water from the TCC to the Colusa Basin Drain (CBD) or Sacramento River near Dunnigan, California.

This estimate only covers the CBD west bank improvements that were previously priced in 2021. The CBD west bank improvement facilities are further described in Section 2.2.

Table 1-1. Project Overview
Estimate Information

Estimate Classification	Class 4
Requested By	Sites Project Authority
Estimated By	Nick Cavalleri – Jacobs (Updated Tom Jones – Jacobs)
Estimate Date	December 2021 (Updated February 23, 2026)

1.2 Overall Costs

The cost estimate has been prepared for guidance in project evaluation and implementation, based on the information available at the time of the estimate. The final costs of the project will depend on actual labor and materials costs, competitive market conditions, final project costs, implementation schedule, and other variable factors. As a result, the final project costs will vary from the estimate presented herein. Table 1-2 summarizes the overall costs. See Appendix A for detailed cost estimates.

Costs are presented in 2024 dollars to match the other program costs that were developed in 2025. Escalation is excluded from this estimate but should be added to the costs presented below to account for the probable costs to the midpoint of construction.

Table 1-2. Overall Costs*

	Low Range (-30%)	Estimated Costs	High Range (+50%)
Construction Cost Excluding Non-Contract Costs	\$5,290,000	\$7,560,000	\$11,340,000

* See Attachment A for cost estimate details.

2. Estimate Information

2.1 Purpose of Estimate

The purpose of this estimate of construction costs is to establish an engineer's opinion of probable construction costs at a feasibility level of design development.

2.2 Scope of Work

The CBD west bank improvement work consists of raising the levee banks on the western side of the CBD approximately 4 feet, for approximately 2.5 miles, adding two 25 horsepower drainage pumps; approximately 1.8 miles of drainage ditch; 5 culverts; and a 20-foot-wide, all-weather, gravel road on top of the western bank. Approximately 80,000 cubic yards of imported fill will be required for the project. The feasibility level design is documented in 7 drawings dated November 2021.

2.3 Estimate Classification

This cost estimate is considered a "Budget" or "Class 4" estimate as defined by the Association for the Advancement of Cost Engineering International (AACEI). Refer to Appendix B for more details.

Project feasibility and funding needs must be carefully reviewed prior to making specific financial decisions to help promote proper project evaluation and adequate funding. This estimate is based on material, equipment, and labor pricing as of December 2024.

This cost estimate is based on the use of conceptual and stochastic costs and detailed items using separate labor, materials, and equipment costs. The estimate uses parametric costs where design information or details are insufficient to allow a detailed item method. Quotations, allowances, and other costs are as described in Section 3.

3. Basis of Estimate

3.1 Estimate Methodology

This cost estimate is considered a bottom-rolled-up-type estimate, with cost items and breakdown of labor, materials, and equipment.

In developing this cost estimate, there were systems that have yet to be defined enough for basing a scope of work for estimates. In these instances, Jacobs provided parametric costing based on a unit of measurement (such as, cost per square foot or cost per unit). The cost is typically developed by averaging similar projects and analysis of historical costs. Using this approach, estimators generated a basic system design that fit the parameters of the structure and its proposed function.

Finally, pricing has been geographically adjusted to reflect local labor and material rates and job site conditions and requirements. As the design process progresses and the details are more defined, the parametric costing can be replaced with a detailed takeoff and estimated accordingly.

The estimate was updated to 2024 dollars by using RS Means 2024 Labor and Construction Equipment Rates. Also certain Material pricing was updated to current Jacobs database values, and others adjusted by estimator judgement.

3.2 Estimate Major Assumptions

The estimate assumes the work will be done on a competitive-bid basis and the contractor will have a reasonable amount of time to complete the work. All contractors are equal, with a reasonable project schedule and no overtime, constructed as under a single contract, with no liquidated damages.

This estimate should be evaluated for market changes after 90 days of the issue date. It is assumed that much of the fabricated equipment will be shipped from the mainland United States.

This estimate includes an allowance for Electrical Service and connections to the new pumps.

3.3 Estimate Exclusions

The cost estimate excludes the following costs:

- Remediation of hazardous materials
- Material adjustment allowances above and beyond those included at the time of the cost estimate
- Non-Contract costs

3.4 Project Delivery and Methodology

It is assumed that this project will be procured using the traditional design-bid-build method. The general contractor will contract directly with the owner.

3.5 Labor, Material, Subcontracts, and Other Direct Costs

3.5.1 Labor

The estimate has been adjusted for local area labor rates, based upon 2024 national union rates.

Labor unit prices reflect a burdened rate, including: workers compensation, unemployment taxes, fringe benefits, and medical insurance.

3.5.2 Materials

Materials pricing is based on the national averages, as determined by RS Means or other data sources. Quotes on certain items may have been obtained and included in this estimate. Many quotes given for engineering estimates are budgetary and may not reflect actual contractor pricing.

3.5.3 Subcontracts

It is assumed that General Contractors will subcontract a portion of the work. Items listed in the cost estimate as “subcontractor” include all anticipated markups that a general contractor would receive.

3.5.4 Construction Equipment

Equipment items listed in this cost estimate are for the construction equipment necessary for installation of the work. Equipment rates in this estimate are assumed to be 100% of the 2024 Blue Book value.

3.6 Markups, Taxes, and Other Indirect Costs

It is assumed that this project will be procured using the traditional design-bid-build method. The general contractor will contract directly with the owner. Table 3-1 summarized estimates for markups, taxes, and other indirect costs.

Table 3-1. Markups, Taxes, and Other Indirect Costs Estimate Summary

Item	Unit	Comments
Subcontractor Markups	20.00% to 25.00%	Varies by trade
Materials Sales Tax	7.25%	Current sales tax rate for Dunnigan, California
General Conditions	5.00%	
Mobilization/Demobilization	3.00%	
Prime Contractor Overhead	10.00%	Includes home office and construction site overhead
Prime Contractor Profit	6.00%	
Bonds and Insurances	2.17%	
Contractor Contingency	3.00%	
Design Contingency	30.00%	
Escalation		No escalation included in this estimate
Non-Contract Costs	0.00%	Excluded from estimate

3.7 Design Contingency

A design contingency of 30% is included to account for the level of design detail and the potential for additional unforeseen site conditions identified during the design phase. The contingencies are intended to allow for scope inherent in the individual projects, but not yet identified in the design documentation. This contingency would be fully consumed or released by the completion of the procurement documents.

3.8 Contractor Contingency

Contractor contingency is intended to cover unforeseen conditions or changes post contract award. It remains under the control of the owner, separate from the bid award. Contractor contingencies vary from 3 to 5% based on the construction project types. Electrical transmission lines and PG&E substations include 5%. All other HC estimates include 3%.

3.9 Escalation Costs

There is no escalation included in this estimate.

3.10 Non-Contract Costs

Non-contract costs include geotechnical investigation, engineering, construction management, administration, real estate, legal services, permitting costs, environmental monitoring, and other owner costs attributable to the project. These costs are not included in this estimate.

3.11 Market Conditions

During volatile economic conditions, an estimate may have a market conditions amount applied. This adjustment is done to account for the current volatility in the construction market and/or the location of a project. However, based on the current construction market, and location of the work proposed in this estimate, a market conditions adjustment was not applied.

3.12 Cost Resources

Cost resources used in the development of the cost estimate include the following:

- R.S. Means 2024 data
- CH2M HILL and Jacobs historical data
- Vendor quotes, where available
- Estimator judgment

3.13 Disclaimer

The opinions of cost (estimates) shown, and any resulting conclusions on project financial or economic feasibility or funding requirements, have been prepared for guidance in project evaluation and implementation from the information available at the time the opinion was prepared. The final costs of the project and resulting feasibility will depend on actual labor and material costs, competitive market

conditions, actual site conditions, final project scope, implementation schedule, continuity of personnel and engineering, and other variable factors. The recent increases or decreases in materials pricing may have a significant impact that is not predictable. Careful review or consideration must be used in evaluating materials prices. As a result, the final project costs will vary from the opinions of cost presented herein. Because of these factors, project feasibility, benefit/cost ratios, risks, and funding needs must be carefully reviewed prior to making specific financial decisions or establishing project budgets to help promote proper project evaluation and adequate funding.

Appendix A

Detailed Cost Estimate



Summary Report

Project Name: CBD Mitigation Rev 3
Project Number: D3380605
Design Stage: Feasibility

Estimator: Tom Jones
Rev No. / Data: R03 - 02/23/2026
Class Estimate: Class 4

Facility	WorkActiv	Description	Takeoff Quantity	Grand Total Price	Grand Total Amount
01		CBD Mitigation			
	01.00.700	Erosion Controls and Dust Abatement	2.00 MO	70,280.40 /MO	140,561
	31.00.700	Gravel Surfacing	32,676.55 SY	42.69 /SY	1,394,829
	31.00.728	Levee Fill	86,500.00 CY	57.03 /CY	4,932,925
	31.00.729	Drainage Ditch and Berm	13,354.00 LF	18.70 /LF	249,704
	44.00.000	25 HP Pump Assemblies	2.00 EA	419,959.56 /EA	839,919
		01 CBD Mitigation	1.00 LS	7,557,938.24 /LS	7,557,938

Estimate Totals

Description	Amount	Totals	Hours	Rate
Labor	1,908,831		14,542.421 hrs	
Material	3,411,531			
Allowance				
Equipment	2,237,577		20,203.130 hrs	
Other				
Total Construction Cost	7,557,938	7,557,938		



Detail Report

Project Name: CBD Mitigation Rev 3
Project Number: D3380605
Design Stage: Feasibility

Estimator: Tom Jones
Rev No. / Data: R03 - 02/23/2026
Class Estimate: Class 4

Facility	WorkActiv	Work Pkg	Unit Price	Description	Takeoff Quantity	Labor Hours	Labor Amount	Material Amount	Sub Amount	Equip Amount	Other Amount	Total Cost/Unit	Total Amount	Grand Total Price	Grand Total Amount
01				CBD Mitigation											
	01.00.700			Erosion Controls and Dust Abatement											
		01.0		General Requirements											
			01.01.05.00	General Conditions, Other											
				Erosion Controls and Dust Abatement Allowance	2.00 MO		20,000	20,000	-	40,000	-	40,000.00 /MO	80,000	70,280.40 /MO	140,561
				01.01.05.00 General Conditions, Other	2.00 MO		20,000	20,000		40,000		40,000.00 /MO	80,000	70,280.40 /MO	140,561
				01.0 General Requirements	2.00 MO		20,000	20,000		40,000		40,000.00 /MO	80,000	70,280.40 /MO	140,561
	31.00.700			01.00.700 Erosion Controls and Dust Abatement	2.00 MO		20,000	20,000		40,000		40,000.00 /MO	80,000	70,280.40 /MO	140,561
				Gravel Surfacing											
		32.0		Exterior Improvements											
			32.40.04.00	Site Improvements, Access Roads, Gravel											
				Fine grading, for roadway, base or leveling course, large area, 6,000 S.Y. or more	32,676.55 SY	261	18,701	-	-	18,185	-	1.13 /SY	36,886	1.96 /SY	64,140
				Base course drainage layers,aggregate base course for levee road,crushed stone base,compacted,crushed 1-1/2"stone base,6"deep	32,676.55 sy	550	40,289	624,122	-	42,665	-	21.64 /sy	707,077	39.01 /sy	1,274,774
				Base course drainage layers, prepare and roll sub-base, large areas over 2500 S.Y.	32,676.55 sy	224	16,721	-	-	15,435	-	0.98 /sy	32,156	1.71 /sy	55,915
				32.40.04.00 Site Improvements, Access Roads, Gravel	32,676.55 SY	1,036	75,711	624,122		76,286		23.75 /SY	776,118	42.69 /SY	1,394,829
				32.0 Exterior Improvements	1.00 LS	1,036	75,711	624,122		76,286		776,118.40 /LS	776,118	1,394,829.39 /LS	1,394,829
				31.00.700 Gravel Surfacing	32,676.55 SY	1,036	75,711	624,122		76,286		23.75 /SY	776,118	42.69 /SY	1,394,829
	31.00.728			Levee Fill											
		31.0		Earthwork											
			31.20.07.00	Earthworks, Sitework, Cut/Fill											
				Excavating, Levee Key, common earth, 3/4 C.Y. excavator, 4' to 6' deep, excavator, excludes sheeting or dewatering	10,400.00 cy	555	40,921	-	-	32,367	-	7.05 /cy	73,288	12.25 /cy	127,439
				Construct Levee Fill w/200 HP dozer	86,500.00 CY	1,413	105,408	-	-	165,878	-	3.14 /CY	271,286	5.45 /CY	471,736
				Purchase and Deliver Levee Fill Material	79,400.00 cy	7,940	580,478	794,000	-	723,477	-	26.42 /cy	2,097,954	46.67 /cy	3,705,666
				Compaction, water for, 3000 gallon truck, 3 mile haul	96,900.00 cy	775	59,653	-	-	45,126	-	1.08 /cy	104,779	1.88 /cy	182,199
				Compaction, structural, common fill, 8" lifts, sheepsfot	96,900.00 cy	872	65,079	-	-	56,741	-	1.26 /cy	121,820	2.19 /cy	211,831
				Grading Levee Fill top/sideslopes w/dozer	77,842.44 sy	701	52,280	-	-	82,321	-	1.73 /sy	134,601	3.01 /sy	234,055
				31.20.07.00 Earthworks, Sitework, Cut/Fill	86,500.00 CY	12,255	903,818	794,000		1,105,910		32.41 /CY	2,803,728	57.03 /CY	4,932,925
				31.0 Earthwork	86,500.00 CY	12,255	903,818	794,000		1,105,910		32.41 /CY	2,803,728	57.03 /CY	4,932,925
				31.00.728 Levee Fill	86,500.00 CY	12,255	903,818	794,000		1,105,910		32.41 /CY	2,803,728	57.03 /CY	4,932,925
	31.00.729			Drainage Ditch and Berm											
		31.0		Earthwork											
			31.20.07.00	Earthworks, Sitework, Cut/Fill											
				Excavating, Ditch, common earth, 3/4 C.Y. excavator, 4' to 6' deep, excavator, excludes sheeting or dewatering	10,800.00 CY	576	42,494	-	-	33,612	-	7.05 /CY	76,106	12.25 /CY	132,340
				Construct Berm w/200 HP dozer	3,700.00 CY	60	4,509	-	-	7,095	-	3.14 /CY	11,604	5.45 /CY	20,178
				Compaction, water for, 3000 gallon truck, 3 mile haul	3,700.00 cy	30	2,278	-	-	1,723	-	1.08 /cy	4,001	1.88 /cy	6,957
				Compaction, structural, common fill, 8" lifts, sheepsfot	3,700.00 cy	33	2,485	-	-	2,167	-	1.26 /cy	4,652	2.19 /cy	8,088
				Grading Levee Fill top/sideslopes w/dozer	13,354.00 sy	120	8,969	-	-	14,122	-	1.73 /sy	23,091	3.01 /sy	40,153
				31.20.07.00 Earthworks, Sitework, Cut/Fill	14,500.00 CY	820	60,735			58,719		8.24 /CY	119,454	14.33 /CY	207,717
				31.0 Earthwork	14,500.00 CY	820	60,735			58,719		8.24 /CY	119,454	14.33 /CY	207,717
		33.0		Utilities											
			33.00.23.36	Buried Pipe, Culvert, 36"											
				Culverts,corrugated hdpe,type s,bell and spigot,with gaskets,36"diam, complete	220.00 LF	112	8,004	14,740	-	787	-	106.96 /LF	23,531	190.85 /LF	41,987
				33.00.23.36 Buried Pipe, Culvert, 36"	220.00 LF	112	8,004	14,740		787		106.96 /LF	23,531	190.85 /LF	41,987
				33.0 Utilities	1.00 LS	112	8,004	14,740		787		23,531.39 /LS	23,531	41,987.04 /LS	41,987
				31.00.729 Drainage Ditch and Berm	13,354.00 LF	932	68,739	14,740		59,507		10.71 /LF	142,985	18.70 /LF	249,704
	44.00.000			25 HP Pump Assemblies											
		26.0		Electrical Work											
			26.00.99.00	Electrical, Other											
				Electrical Allowance, Includes Electrical Service to and Terminations at New Pumps	2.00 ea	192	16,836	40,000	-	3,200	-	30,018.24 /ea	60,036	61,152.82 /ea	122,306
				26.00.99.00 Electrical, Other	1.00 LS	192	16,836	40,000		3,200		60,036.48 /LS	60,036	122,305.64 /LS	122,306
				26.0 Electrical Work	1.00 LS	192	16,836	40,000		3,200		60,036.48 /LS	60,036	122,305.64 /LS	122,306
		33.0		Utilities											
			44.05.42.02	Vertical Turbine Pump: 25hp											
				Furnish and Install 25 HP Vertical Turbine Pumps	2.00 EA	48	4,188	364,000	-	560	-	184,373.76 /EA	368,748	333,799.74 /EA	667,599
				Pump Support/Culvert Pump Well	2.00 ea	48	3,226	15,000	-	565	-	9,395.74 /ea	18,791	16,881.85 /ea	33,764
				Platform Pump Access	2.00 ea	32	2,795	6,000	-	300	-	4,547.54 /ea	9,095	8,125.14 /ea	16,250
				44.05.42.02 Vertical Turbine Pump: 25hp	2.00 EA	128	10,208	385,000		1,426		198,317.03 /EA	396,634	358,806.73 /EA	717,613
				33.0 Utilities	1.00 LS	128	10,208	385,000		1,426		396,634.06 /LS	396,634	717,613.47 /LS	717,613
				44.00.000 25 HP Pump Assemblies	2.00 EA	320	27,045	425,000		4,626		228,335.27 /EA	456,671	419,959.56 /EA	839,919
				01 CBD Mitigation	1.00 LS	14,542	1,095,312	1,877,862		1,286,328		4,259,502.31 /LS	4,259,502	7,557,938.24 /LS	7,557,938



Estimate Totals

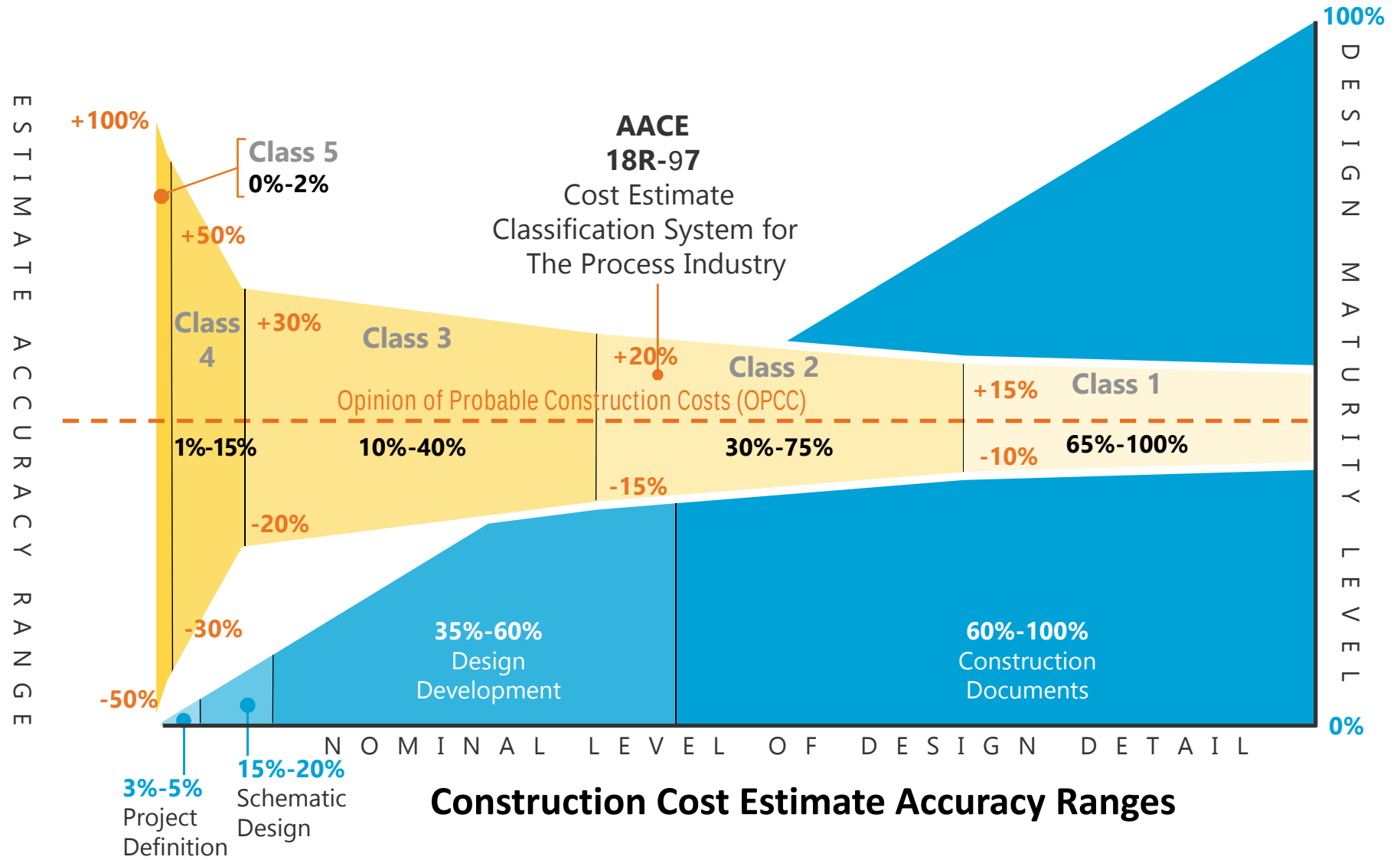
Description	Amount	Totals	Hours	Rate
Labor	1,095,312		14,542.421 hrs	
Material	1,877,862			
Allowance				
Equipment	1,286,328		20,203.130 hrs	
Other				
Subtotal Direct Costs	4,259,502	4,259,502		
Material Sales Tax, Dunnigan Ca	136,145			7.250 %
Subtotal W/ Sales Tax	136,145	4,395,647		
Electrical Work I,OH&P	15,009			25.000 %
Instruments & Controls I,OH&P				20.000 %
Subtotal W/ Subcontractor OH&P	15,009	4,410,656		
General Conditions	220,533			5.000 %
Subtotal W/ General Conditions	220,533	4,631,189		
Mobilization/Demobilization	138,936			3.000 %
Prime Contractor Overhead	477,012			10.000 %
Prime Contractor Profit	314,828			6.000 %
Bonds & Insurance	120,695			2.170 %
Subtotal W/ Prime Markups	1,051,471	5,682,660		
Contractor Contingency	170,480			3.000 %
Design Contingency	1,704,798			30.000 %
Subtotal W/ Contingency	1,875,278	7,557,938		
Total Construction Cost		7,557,938		

Appendix B

AACEI Classification

Estimate Class	Class 5		Class 4		Class 3		Class 2		Class 1	
LEVEL OF PROJECT DEFINITION Expressed as a % of complete definition	0% to 2%		1% to 15%		10% to 40%		30% to 75%		65% to 100%	
END USAGE Typical Purpose of Estimate	Concept Screening		Study or Feasibility		Budget Authorization, or Control		Control or Bid / Tender		Check Estimate or Bid / Tender	
METHODOLOGY Typical estimating method	Capacity Factored, Parametric Models, Judgment, or Analogy		Equipment Factored or Parametric Models		Semi-Detailed Unit Costs with Assembly Level Line Items		Detailed Unit Cost with Forced Detailed Take-Off		Detailed Unit Cost with Detailed Take-Off	
EXPECTED ACCURACY RANGE Typical variation in low and high ranges [a]	L: -20% to -50%	H: +30% to +100%	L: -15% to -30%	H: +20% to +50%	L: -10% to -20%	H: +10% to +30%	L: -5% to -15%	H: +5% to +20%	L: -3% to -10%	H: +3% to +15%
REFINED CLASS DEFINITION	Class 5 estimates are generally prepared based on very limited information, and subsequently have very wide accuracy ranges. As such, some companies and organizations have elected to determine that due to the inherent inaccuracies, such estimates cannot be classified in a conventional and systematic manner. Class 5 estimates, due to the requirements of end use, may be prepared within a very limited amount of time and with very little effort expended - sometimes requiring less than 1 hour to prepare. Often, little more than proposed plant type, location, and capacity are known at the time of estimate preparation.		Class 4 estimates are generally prepared based on very limited information, and subsequently have very wide accuracy ranges. They are typically used for project screening, determination of feasibility, concept evaluation, and preliminary budget approval. Typically, engineering is from 1% to 5% complete, and would comprise at a minimum the following: plant capacity, block schematics, indicated layout, process flow diagrams (PFDs) for main process systems and preliminary engineered process and utility equipment lists. Level of Project Definition Required: 1% to 15% of full project definition.		Class 3 estimates are generally prepared to form the basis for budget authorization, appropriation, and/or funding. As such, they typically form the initial control estimate against which all actual costs and resources will be monitored. Typically, engineering is from 10% to 40% complete, and would comprise at a minimum the following: process flow diagrams, utility flow diagrams, preliminary piping and instrument diagrams, utility flow diagrams, preliminary piping and instrument diagrams, plot plan, developed layout drawings, and essentially complete engineering process and utility equipment lists. Level Of Project Definition Required: 10% to 40% of full project definition.		Class 2 estimates are generally prepared to form a detailed control baseline against which all project work is monitored in terms of cost and progress control. For contractors, this class of estimate is often used as the "bid" estimate to establish contract value. Typically, engineering is from 30% to 70% complete, and would comprise at a minimum the following: Process flow diagrams, utility flow diagrams, piping and instrument flow diagrams, heat and material balances, final plot plan, final layout drawings, complete engineered process and utility equipment lists, single line diagrams for electrical, electrical equipment and motor schedules, vendor quotations, detailed project execution plans, resourcing and work force plans, etc.		Class 1 estimates are generally prepared for discrete parts or sections of the total project rather than generating this level of detail for the entire project. The parts of the project estimated at this level of detail will typically be used by subcontractors for bids, or by owners for check estimates. The updated estimate is often referred to as the current control estimate and becomes the new baseline for cost/schedule control of the project. Class 1 estimates may be prepared for parts of the project to comprise a fair price estimate or bid check estimate to compare against a contractor's bid estimate, or to evaluate/dispute claims. Typically, engineering is from 65% to 100% complete, and would comprise virtually all engineering and design documentation of the project, and complete project execution and commissioning plans. Level for Project Definition Required: 50% to 100% of full project definition.	
MATURITY LEVEL OF PROJECT DELIVERABLES	Key deliverable and target status: Block flow diagram agreed by key stakeholders. 0% to 2% of full project definition.		Key deliverable and target status: Process flow diagrams (PFDs) issued for design. 1% to 15% of full project definition.		Key deliverable and target status: Piping and instrumentation diagrams (P&IDs) issued for design. 10% to 40% of full project definition.		Key deliverable and target status: All specifications and datasheets complete including for instrumentation. 30% to 75% of full project definition.		Key deliverable and target status: All deliverables in the maturity matrix complete. 65% to 100% of full project definition.	
END USAGE DEFINED	Class 5 estimates are prepared for any number of strategic business planning purposes, such as but not limited to market studies, assessment of initial viability, evaluation of alternate schemes, project screening, project location studies, evaluation of resource needs and budgeting, long-range capital planning, etc.		Class 4 estimates are prepared for a number of purposes, such as but not limited to, detailed strategic planning, business development, project screening at more developed stages, alternative scheme analysis, confirmation of economic and/or technical feasibility, and preliminary budget approval or approval to proceed to next stage.		Class 3 estimates are typically prepared to support full project funding requests, and become the first of the project phase control estimates against which all actual costs and resources will be monitored for variations to the budget. They are used as the project budget until replaced by more detailed estimates. In many owner organizations, a Class 3 estimate is often the last estimate required and could very well form the only basis for cost/schedule control.		Class 2 estimates are typically prepared as the detailed control baseline against which all actual costs an resources will now be monitored for variation to the budget, and form a part of the change/variation control program.		Generally, owners and EPC contractors use Class 1 estimates to support their change management process. They may be used to evaluate bid checking, to support vendor/contractor negotiations, or for claim evaluations and dispute resolution. Construction contractors may prepare Class 1 estimates to support their bidding and to act as their final control baseline against which all actual costs and resources will now be monitored for variations to their bid. During construction, Class 1 estimates may be prepared to support change management.	
ESTIMATING METHODOLOGY	Class 5 estimates virtually always use stochastic estimating methods such as cost/capacity curves and factors, scale of operations factors, Lang factors, Hand factors, Chilton factors, Peters-Timmerhaus factors, Guthrie factors, and other parametric and modeling techniques.		Class 4 estimates virtually always use stochastic estimating methods such as cost/capacity curves and factors, scale of operations factors, Lang factors, Hand factors, Chilton factors, Peters-Timmerhaus factors, Guthrie factors, the Miller method, gross unit costs/ratios, and other parametric and modeling techniques.		Class 3 estimates usually involve more deterministic estimating methods that stochastic methods. They usually involve a high degree of unit cost line items, although these may be at an assembly level of detail rather than individual components. Factoring and other stochastic methods may be used to estimate less-significant areas of the project.		Class 2 estimates always involve a high degree of deterministic estimating methods. Class 2 estimates are prepared in great detail, and often involve tens of thousands of unit cost line items. For those areas of the project still undefined, an assumed level of detailed takeoff (forced detail) may be developed to use as line items in the estimate instead of relying on factoring methods.		Class 1 estimates involve the highest degree of deterministic estimating methods, and require a great amount of effort. Class 1 estimates are prepared in great detail, and thus are usually performed on only the most important or critical areas of the project. All items in the estimate are usually unit cost line items based on actual design quantities.	
EXPECTED ACCURACY RANGE	Typical accuracy ranges for Class 5 estimates are -20% to -50% on the low side, and +30% to +100% on the high side, depending on the technological complexity of the project, appropriate reference information and other risks (after inclusion of an appropriate contingency determination). Ranges could exceed those shown if there are unusual risks.		Typical accuracy ranges for Class 4 estimates are -15% to -30% on the low side, and +20% to +50% on the high side, depending on the technological complexity of the project, appropriate reference information, and the inclusion of an appropriate contingency determination. Ranges could exceed those shown in unusual circumstances.		Typical accuracy ranges for Class 3 estimates are -10% to -20% on the low side, and +10% to +30% on the high side, depending on the technological complexity of the project, appropriate reference information, and the inclusion of an appropriate contingency determination. Ranges could exceed those shown in unusual circumstances.		Typical accuracy ranges for Class 2 estimates are -5% to -15% on the low side, and +5% to +20% on the high side, depending on the technological complexity of the project, appropriate reference information, and the inclusion of an appropriate contingency determination. Ranges could exceed those shown in unusual circumstances.		Typical accuracy ranges for Class 1 estimates are -3% to -10% on the low side, and +3% to +15% on the high side, depending on the technological complexity of the project, appropriate reference information, and the inclusion of an appropriate contingency determination. Ranges could exceed those shown in unusual circumstances.	
EFFORT TO PREPARE (for US\$20MM project):	As little as 1 hour or less to prepare to perhaps more than 200 hours, depending on the project and the estimating methodology used.		Typically, as little as 20 hours or less to perhaps more than 300 hours, depending on the project and the estimating methodology used.		Typically, as little as 150 hours or less to perhaps more than 1500 hours, depending on the project and the estimating methodology used.		Typically, as little as 300 hours or less to perhaps more than 3000 hours, depending on the project and the estimating methodology used. Bid Estimates typically require more effort than estimates used for funding or control purposes		Class 1 estimates require the most effort to create, and as such are generally developed for only selected areas of the project, or for bidding purposes. A complete Class 1 estimate may involve as little as 600 hours or less, to perhaps more than 6,000 hours, depending on the project and the estimating methodology used. Bid estimate typically require more effort than estimates used for funding or control purposes.	
ANSI Standard Reference Z94.2-1989 name; Alternate Estimate Names, Terms, Expressions, Synonyms:	Order of Magnitude Estimate; Ratio, ballpark, blue sky, seat-of-pants, ROM, idea study, prospect estimate, concession license estimate, guesstimate, rule-of thumb.		Budget Estimate; Screening, top-down, feasibility, authorization, factored, pre-design, pre-study.		Budget, scope, sanction, semi-detailed, authorization, preliminary control, concept study, feasibility (for metals processes) development, basic engineering phase estimate, target estimate.		Detailed control, forced detail, execution phase, master control, engineering, bid, tender, change order estimate.		Full detail, release, fall-out, tender, firm price, bottoms-up, final, detailed control, forced detail, execution phase, master control, fair price, definitive, change order estimate.	

Estimate Class	Class 5	Class 4	Class 3	Class 2	Class 1
Estimate Input Checklist and Maturity Index	Class 5	Class 4	Class 3	Class 2	Class 1
GENERAL PROJECT DATA					
Project Scope Description	General	Preliminary	Defined	Defined	Defined
Plant Production / Facility Capacity	Assumed	Preliminary	Defined	Defined	Defined
Plant Location	General	Approximate	Specific	Specific	Specific
Soils & Hydrology	None	Preliminary	Defined	Defined	Defined
Integrated Project Plan	None	Preliminary	Defined	Defined	Defined
Project Master Schedule	None	Preliminary	Defined	Defined	Defined
Escalation Strategy	None	Preliminary	Defined	Defined	Defined
Work Breakdown Structure	None	Preliminary	Defined	Defined	Defined
Project Code of Accounts	None	Preliminary	Defined	Defined	Defined
Contracting Strategy	Assumed	Assumed	Preliminary	Defined	Defined
ENGINEERING DELIVERABLES:	Class 5	Class 4	Class 3	Class 2	Class 1
Block Flow Diagrams	Started / Preliminary	Preliminary / Complete	Complete	Complete	Complete
Plot Plans		Started / Preliminary	Complete	Complete	Complete
Process Flow Diagrams (PFDs)		Preliminary	Complete	Complete	Complete
Utility Flow Diagrams (UFDs)		Started / Preliminary	Complete	Complete	Complete
Piping & Instrument Diagrams (P&IDs)		Started / Preliminary	Complete	Complete	Complete
Heat and Material Balances		Started / Preliminary	Complete	Complete	Complete
Process Equipment List		Started / Preliminary	Complete	Complete	Complete
Utility Equipment List		Started / Preliminary	Complete	Complete	Complete
Electrical One Line Drawings		Started / Preliminary	Complete	Complete	Complete
Specifications and Datasheets		Started	Preliminary / Complete	Complete	Complete
General Equipment Arrangement Drawings		Started	Complete	Complete	Complete
Spare Parts Lists			Preliminary	Preliminary	Complete
Architectural Details / Schedules		Started	Preliminary	Preliminary / Complete	Complete
Structural Details		Started	Preliminary	Preliminary / Complete	Complete
Mechanical Discipline Drawings			Started / Preliminary	Preliminary / Complete	Complete
Electrical Discipline Drawings			Started / Preliminary	Preliminary / Complete	Complete
System Discipline Drawings			Started / Preliminary	Preliminary	Complete
Site Plan		Started	Started / Preliminary	Complete	Complete
Civil/Site Discipline Drawings			Started / Preliminary	Preliminary	Complete
Demolition Details		Started	Started / Preliminary	Preliminary / Complete	Complete



Appendix 4
Dunnigan Pipeline – Alternate 2
Basis of Estimate



Dunnigan Pipeline – Alternate No. 2

Feasibility Design Basis of Estimate

February 2026

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Acronyms and Abbreviations

AACEI	Association for the Advancement of Cost Engineering International
CBD	Colusa Basin Drain
GC	General Conditions or General Contractor
NTP	Notice to Proceed
TCC	Tehama-Colusa Canal
VE	Value Engineering

1. Executive Summary

1.1 Project Overview

The Sites Reservoir Project consists of a large reservoir, ancillary roads, and conveyance facilities. The Sites Project Authority decided to segregate the design of these facilities into an HR (Segment H Reservoir) segment that is responsible for the design of the reservoir features, including several dams and inlet/outlet tunnel near Golden Gate Dam, as well as relocation of roads displaced by the reservoir. The other segment is known as the HC (Segment H Conveyance) segment and consists of improvements to the two existing diversion canals from the Sacramento River to the Project Area (Tehama-Colusa Canal [TCC] and Glenn-Colusa Irrigation District Main Canal), regulating reservoirs (existing Funks Reservoir and new Terminal Regulating Reservoir), two pumping/generating plants (PGP), large-diameter pipelines from each PGP to Sites Reservoir, and a large-diameter pipeline to convey water from the TCC to the Colusa Basin Drain (CBD) or Sacramento River near Dunnigan, California.

This estimate only covers the Dunnigan Pipeline Alternate 2 which conveys water from the end of the Dunnigan pipeline near the west bank of the CBD to the Sacramento River.

Table 1-1. Project Overview
Estimate Information

Estimate Classification	Class 4
Requested By	Sites Project Authority
Estimated By	Tom Jones – Jacobs
Estimate Date	February 2026 (Priced in 2024 dollars)

1.2 Overall Costs

The cost estimate has been prepared for guidance in project evaluation and implementation, based on the information available at the time of the estimate. The final costs of the project will depend on actual labor and materials costs, competitive market conditions, final project costs, implementation schedule, and other variable factors. As a result, the final project costs will vary from the estimate presented herein. Table 1-2 summarizes the overall costs. See Appendix A for detailed cost estimates.

Costs are presented in 2024 dollars to match the other program costs that were developed in 2025. Escalation is excluded from this estimate but should be added to the costs presented below to account for the probable costs to the midpoint of construction.

Table 1-2. Overall Costs*

	Low Range (-30%)	Estimated Costs	High Range (+50%)
Construction Cost	\$220,080,000	\$314,400,000	\$471,600,000

* See Attachment A for cost estimate details.

2. Estimate Information

2.1 Purpose of Estimate

The purpose of this estimate of construction costs is to establish an engineer's opinion of probable construction costs at a feasibility level of design development.

2.2 Scope of Work

The detailed cost estimate is organized by the following Work Breakdown Structure (WBS).

- o Level 1 – Bid Item
 - Level 2 – Work Package
 - Level 3 – Trade Package
 - o Level 4 – Work Activity
 - Level 5 – Unit Price

The following are the Level 1 categories used in this estimate.

- 5000 – General Conditions
- 5021 – Dunnigan Pipeline (216+20 to 505+79)
- 5022 – Valve Vault
- 5025 – Dunnigan Pipeline, Tunneling
- 5300 – Dunnigan – Sac River Discharge Structure

The estimate is based off the 10% design of the Dunnigan Pipeline Alt 2 drawings (Task Order 2 – Feasibility Study – HC Conveyance Facilities Rev 3: April 3, 2021). The major change is that the pipeline was increased to 12-foot diameter based on knowledge gained during the 30% design of the Dunnigan Pipeline. The Alt 2 pipeline would tee off the Dunnigan pipeline just upstream of the CBD outlet structure, and tunnel under the CBD to the east side of the RD108 levee, then using open-cut methods continue east to the Sacramento River.

2.3 Estimate Classification

This cost estimate is considered a “Budget” or “Class 4” estimate as defined by the Association for the Advancement of Cost Engineering International (AACEI). Refer to Appendix B for more details.

Project feasibility and funding needs must be carefully reviewed prior to making specific financial decisions to help promote proper project evaluation and adequate funding. This estimate is based on material, equipment, and labor pricing as of December 2024.

This cost estimate is based on the use of conceptual and stochastic costs and detailed items using separate labor, materials, and equipment costs. The estimate uses parametric costs where design information or details are insufficient to allow a detailed item method. Quotations, allowances, and other costs are as described in Section 3.

3. Basis of Estimate

3.1 Estimate Methodology

This cost estimate is considered a bottom-rolled-up-type estimate, with cost items and breakdown of labor, materials, and equipment.

In developing this cost estimate, there were systems that have yet to be defined enough for basing a scope of work for estimates. In these instances, Jacobs provided parametric costing based on a unit of measurement (such as, cost per square foot or cost per unit). The cost is typically developed by averaging similar projects and analysis of historical costs. Using this approach, estimators generated a basic system design that fit the parameters of the structure and its proposed function.

Finally, pricing has been geographically adjusted to reflect local labor and material rates and job site conditions and requirements. As the design process progresses and the details are more defined, the parametric costing can be replaced with a detailed takeoff and estimated accordingly.

The estimate was updated to 2024 dollars by using RS Means 2024 Labor and Construction Equipment Rates. Also, certain Material pricing was updated to current Jacobs database values, and others adjusted by estimator judgement.

3.2 Estimate Major Assumptions

The estimate assumes the work will be done on a competitively-bid basis and the contractor will have a reasonable amount of time to complete the work. All contractors are equal, with a reasonable project schedule and no overtime, constructed as under a single contract, with no liquidated damages.

This estimate should be evaluated for market changes after 90 days of the issue date. It is assumed that much of the fabricated equipment will be shipped from the mainland United States.

3.3 Estimate Exclusions

The cost estimate excludes the following costs:

- Remediation of hazardous materials
- Material adjustment allowances above and beyond those included at the time of the cost estimate

3.4 Project Delivery and Methodology

It is assumed that this project will be procured using the traditional design-bid-build method. The general contractor will contract directly with the owner.

3.5 Labor, Material, Subcontracts, and Other Direct Costs

3.5.1 Labor

The estimate has been adjusted for local area labor rates, based upon 2024 DIR Index rates.

Labor unit prices reflect a burdened rate, including: workers compensation, unemployment taxes, fringe benefits, and medical insurance.

3.5.2 Materials

Materials pricing is based on the national averages, as determined by RS Means or other data sources. Quotes on certain items may have been obtained and included in this estimate. Many quotes given for engineering estimates are budgetary and may not reflect actual contractor pricing.

3.5.3 Subcontracts

It is assumed that General Contractors will subcontract a portion of the work. Items listed in the cost estimate as “subcontractor” include all anticipated markups that a general contractor would receive.

3.5.4 Construction Equipment

Equipment items listed in this cost estimate are for the construction equipment necessary for installation of the work. Equipment rates in this estimate are assumed to be 100% of the 2024 Blue Book value.

3.6 Markups, Taxes, and Other Indirect Costs

It is assumed that this project will be procured using the traditional design-bid-build method. The general contractor will contract directly with the owner. Table 3-1 summarized estimates for markups, taxes, and other indirect costs.

Table 3-1. Markups, Taxes, and Other Indirect Costs Estimate Summary

Item	Unit	Comments
Subcontractor Markups	20.00%	
Profit on Tunnel Work	10.00%	
Materials Sales Tax	7.25%	Current sales tax rate for Dunnigan, California
Mobilization/Demobilization	3.00%	
Prime Contractor Overhead	10.00%	
Prime Contractor Profit	6.00%	
Bonds and Insurances	2.17%	
Contractor Contingency	3.00%	
Design Contingency	30.00%	
Escalation		No escalation included in this estimate
Non-Contract Costs	0.00%	Excluded from estimate

3.7 Design Contingency

A design contingency of 30% is included to account for the level of design detail and the potential for additional unforeseen site conditions identified during the design phase. The contingencies are intended to allow for scope inherent in the individual projects but not yet identified in the design documentation. This contingency would be fully consumed or released by the completion of the procurement documents.

3.8 Contractor Contingency

Contractor contingency is intended to cover unforeseen conditions or changes post contract award. It remains under the control of the owner, separate from the bid award. Contractor contingencies vary from 3 to 5% based on the construction project types. Electrical transmission lines and PG&E substations include 5%. All other HC estimates include 3%.

3.9 Escalation Costs

There is no escalation included in this estimate.

3.10 Non-Contract Costs

Non-contract costs include geotechnical investigation, engineering, construction management, administration, real estate, legal services, permitting costs, environmental monitoring, and other owner costs attributable to the project. These costs are not included in this estimate.

3.11 Market Conditions

During volatile economic conditions, an estimate may have a market conditions amount applied. This adjustment is done to account for the current volatility in the construction market and/or the location of a project. However, based on the current construction market, and location of the work proposed in this estimate, a market conditions adjustment was not applied.

3.12 Cost Resources

Cost resources used in the development of the cost estimate include the following:

- R.S. Means 2024 data
- CH2M HILL and Jacobs historical data
- Vendor quotes, where available
- Estimator judgment

3.13 Disclaimer

The opinions of cost (estimates) shown, and any resulting conclusions on project financial or economic feasibility or funding requirements have been prepared for guidance in project evaluation and implementation from the information available at the time the opinion was prepared. The final costs of the project and resulting feasibility will depend on actual labor and material costs, competitive market

conditions, actual site conditions, final project scope, implementation schedule, continuity of personnel and engineering, and other variable factors. The recent increases or decreases in materials pricing may have a significant impact that is not predictable. Careful review or consideration must be used in evaluating materials prices. As a result, the final project costs will vary from the opinions of cost presented herein. Because of these factors, project feasibility, benefit/cost ratios, risks, and funding needs must be carefully reviewed prior to making specific financial decisions or establishing project budgets to help promote proper project evaluation and adequate funding.

Appendix A

Detailed Cost Estimate



Summary Report

Project Name: Dunnigan Pipeline - Alternate No. 2
Project Number: D3380605
Design Stage: 10% Design

Estimator: Tom Jones
Rev No. / Data: R03 - 02/24/2026
Class Estimate: Class 4

Bid Item	Description	Takeoff Quantity	Grand Total Price	Grand Total Amount
5000	General Conditions	1.00 LS	20,731,928.39 /LS	20,731,928
5021	Dunnigan Pipeline (216+20 to 505+79)	28,960.00 LF	5,783.22 /LF	167,482,005
5022	Valve Vault	1.00 LS	6,172,833.70 /LS	6,172,834
5025	Dunnigan Pipeline, Tunneling	840.00 LF	40,042.53 /LF	33,635,728
5300	Dunnigan - Sac River Discharge Structure	11,690.00 SF	715.93 /SF	8,369,221

Estimate Totals

Description	Amount	Totals	Hours	Rate
Labor	76,274,935		571,475.852	
Material	116,635,040			
Subcontractor	7,221,983			
Equipment	32,171,839		276,776.942	
Other	4,087,918			
Subtotal w/ Prime Markups	236,391,715	236,391,715		
Contractor Contingency	7,091,751			3.000 %
Design Contingency	70,917,514			30.000 %
Opinion of Probable Construction Costs	78,009,266	314,400,981		



Work Activity Summary Report

Project Name: Dunnigan Pipeline - Alternate No. 2
Project Number: D3380605
Design Stage: 10% Design

Estimator: Tom Jones
Rev No. / Data: R03 - 02/24/2026
Class Estimate: Class 4

Bid Item	Work Pkg	Trade Pkg	WorkActiv	Description	Takeoff Quantity	Grand Total Price	Grand Total Amount
5000				General Conditions			
	01.0			General Requirements			
		01.01		Construction Operations			
			01.15.000	General Conditions, Other	1.00 LS	304,868.65 /LS	304,869
			01.15.005	GC Labor	1.00 LS	7,518,201.53 /LS	7,518,202
			01.15.010	Jobsite Office	1.00 LS	791,567.66 /LS	791,568
			01.15.011	Temporary Facilities	1.00 LS	2,096,691.68 /LS	2,096,692
			01.15.012	Temporary Services	1.00 LS	414,804.74 /LS	414,805
			01.15.013	Travel	1.00 LS	1,856,971.38 /LS	1,856,971
			01.15.014	Site Cleanup	1.00 LS	551,991.70 /LS	551,992
			01.15.014A	Site Safety	1.00 LS	1,302,379.93 /LS	1,302,380
			01.15.015	GC Equip, Tools, & Consumables	1.00 LS	1,740,854.60 /LS	1,740,855
			01.15.016	Material Handling	1.00 LS	2,169,832.22 /LS	2,169,832
			01.15.020	GC Indirect Services & Support	1.00 LS	566,646.64 /LS	566,647
			01.16.000	Quality Control	1.00 LS	1,417,117.66 /LS	1,417,118
				01.01 Construction Operations	24.00 MO	863,830.35 /MO	20,731,928
				01.0 General Requirements	24.00 MO	863,830.35 /MO	20,731,928
				5000 General Conditions	1.00 LS	20,731,928.39 /LS	20,731,928
5021				Dunnigan Pipeline (216+20 to 505+79)			
	33.0			Pipelines			
		33.03		Buried Process Pipe, Carbon Steel			
			33.00.05.10.5-1a	Dunnigan Pipeline, Single Pipe Trench, (3123-110)	28,960.00 LF	5,783.22 /LF	167,482,005
				33.03 Buried Process Pipe, Carbon Steel	28,960.00 LF	5,783.22 /LF	167,482,005
				33.0 Pipelines	28,960.00 LF	5,783.22 /LF	167,482,005
				5021 Dunnigan Pipeline (216+20 to 505+79)	28,960.00 LF	5,783.22 /LF	167,482,005
5022				Valve Vault			
	03.0			Concrete Work			
		03.18		Cast-In-Place Concrete, Slabs on Grade			
			03.00.100	Dunnigan - Valve Vault Structure, Foundation Slab	223.75 CY	938.94 /CY	210,089
				03.18 Cast-In-Place Concrete, Slabs on Grade	223.75 CY	938.94 /CY	210,089
		03.20		Cast-In-Place Concrete, Straight Walls			
			03.00.102	Dunnigan - Valve Vault Structure, Concrete Walls	257.50 CY	1,697.38 /CY	437,076
				03.20 Cast-In-Place Concrete, Straight Walls	257.50 CY	1,697.38 /CY	437,076
		03.24		Cast-In-Place Concrete, Elevated Slabs			
			03.00.104	Dunnigan - Valve Vault Structure, Elevated Slab	72.00 CY	2,205.35 /CY	158,785
				03.24 Cast-In-Place Concrete, Elevated Slabs	72.00 CY	2,205.35 /CY	158,785
		03.40		Precast Concrete			
			03.02.000	Valve Vault Elevated Slab Pre-Cast Concrete Covers	315.00 SF	90.63 /SF	28,549
				03.40 Precast Concrete	315.00 SF	90.63 /SF	28,549
				03.0 Concrete Work	553.25 CY	1,508.36 /CY	834,499
	05.0			Metals			
		05.00		Metals			
			05.00.000	Dunnigan - Valve Vault Structure Maintenance and Storage BLDG, Metals	1.00 LS	10,982.50 /LS	10,983
			05.00.002	Dunnigan - Valve Vault Structure Admin and Operations BLDG, Metals	1.00 LS	10,502.18 /LS	10,502
			05.00.005	Dunnigan - Valve Vault Structure, Grating and Structural Supports	1.00 LS	62,059.54 /LS	62,060
			05.00.006	Dunnigan - Valve Vault Structure, Trash Racks	1.00 LS	41,117.67 /LS	41,118
				05.00 Metals	1.00 LS	124,661.89 /LS	124,662
				05.0 Metals	1.00 LS	124,661.89 /LS	124,662
	09.0			Finishes			
		09.90		Painting and Coating			
			09.00.000	Dunnigan - Valve Vault Structure Maintenance and Storage BLDG, Finishes	1.00 LS	36,839.64 /LS	36,840
				09.90 Painting and Coating	1.00 LS	36,839.64 /LS	36,840
				09.0 Finishes	1.00 LS	36,839.64 /LS	36,840
	23.0			HVAC			
		23.00		HVAC			
			23.00.000	Dunnigan - Valve Vault Structure Maintenance and Storage BLDG, HVAC	1.00 LS	43,968.81 /LS	43,969
				23.00 HVAC	1.00 LS	43,968.81 /LS	43,969
				23.0 HVAC	1.00 LS	43,968.81 /LS	43,969
	26.0			Electrical Work			
		26.00		Electrical			
			26.00.000	Electrical	1.00 LS	187,679.41 /LS	187,679
				26.00 Electrical	1.00 LS	187,679.41 /LS	187,679
				26.0 Electrical Work	1.00 LS	187,679.41 /LS	187,679
	31.0			Earthwork			
		31.20		Earthworks, Site			
			31.00.000	Structural Earthworks	4,124.33 CY	81.16 /CY	334,712
				31.20 Earthworks, Site	1.00 LS	334,712.33 /LS	334,712
				31.0 Earthwork	4,124.33 CY	81.16 /CY	334,712
	40.0			Process Pipe			
		40.11		Process Pipe, Carbon Steel			
			40.00.000	Valve Vault Piping and Appurtenances	1.00 LS	360,600.91 /LS	360,601
			40.20.06.0010	144" Isolation Valve	1.00 EA	4,095,026.71 /EA	4,095,027
				40.11 Process Pipe, Carbon Steel	50.00 LF	89,112.55 /LF	4,455,628



Bid Item	Work Pkg	Trade Pkg	WorkActiv	Description	Takeoff Quantity	Grand Total Price	Grand Total Amount
	40.9			40.0 Process Pipe	50.00 LF	89,112.55 /LF	4,455,628
				Instrumentation & Controls			
		40.90		Instrumentation & Controls			
			40.90.000	I&C	1.00 LS	154,845.39 /LS	154,845
				40.90 Instrumentation & Controls	1.00 LS	154,845.39 /LS	154,845
				40.9 Instrumentation & Controls	1.00 LS	154,845.39 /LS	154,845
				5022 Valve Vault	1.00 LS	6,172,833.70 /LS	6,172,834
5025				Dunnigan Pipeline, Tunneling			
	33.0			Pipelines			
		33.60		Trenchless Technology, Tunneling			
			33.00.106	Dunnigan Pipeline, Trenchless Pipe Installation, at CBD	840.00 LF	40,042.53 /LF	33,635,728
				33.60 Trenchless Technology, Tunneling	840.00 LF	40,042.53 /LF	33,635,728
				33.0 Pipelines	840.00 LF	40,042.53 /LF	33,635,728
				5025 Dunnigan Pipeline, Tunneling	840.00 LF	40,042.53 /LF	33,635,728
5300				Dunnigan - Sac River Discharge Structure			
	01.0			General Requirements			
		01.01		Construction Operations			
			01.00.202	Dunnigan - Sac River Discharge Structure, Removal and Control of Water	3.00 MO	55,744.33 /MO	167,233
				01.01 Construction Operations	3.00 MO	55,744.33 /MO	167,233
				01.0 General Requirements	3.00 MO	55,744.33 /MO	167,233
	03.0			Concrete Work			
		03.13		Cast-In-Place Concrete, Continuous Footings			
			03.00.116	Dunnigan - Sac River Discharge Structure, Discharge Pipes Support Wall	56.00 CY	885.47 /CY	49,586
				03.13 Cast-In-Place Concrete, Continuous Footings	56.00 CY	885.47 /CY	49,586
		03.18		Cast-In-Place Concrete, Slabs on Grade			
			03.00.112	Dunnigan - Sac River Discharge Structure, Elevated Slab and Beams	509.00 CY	901.51 /CY	458,866
			03.00.118	Dunnigan - Sac River Discharge Structure, Stilling Basin and Apron	506.00 CY	919.10 /CY	465,065
				03.18 Cast-In-Place Concrete, Slabs on Grade	1,015.00 CY	910.28 /CY	923,931
		03.20		Cast-In-Place Concrete, Straight Walls			
			03.00.114	Dunnigan - Sac River Discharge Structure, Concrete Walls	1,622.00 CY	1,252.24 /CY	2,031,136
			03.00.116	Dunnigan - Sac River Discharge Structure, Discharge Pipes Support Wall	96.00 CY	2,042.68 /CY	196,097
			03.00.118	Dunnigan - Sac River Discharge Structure, Stilling Basin and Apron	114.00 CY	2,025.12 /CY	230,864
				03.20 Cast-In-Place Concrete, Straight Walls	1,832.00 CY	1,341.76 /CY	2,458,097
				03.0 Concrete Work	2,903.00 CY	1,182.09 /CY	3,431,614
	05.0			Metals			
		05.00		Metals			
			05.00.004	Dunnigan - Sac River Discharge Structure, Grating and Structural Supports	1,310.00 SF	120.10 /SF	157,333
				05.00 Metals	1.00 LS	157,332.51 /LS	157,333
				05.0 Metals	1.00 LS	157,332.51 /LS	157,333
	31.0			Earthwork			
		31.25		Earthworks, Structural			
			31.00.104	Dunnigan - Sac River Discharge Structure, Excavation and Backfill	26,405.00 CY	61.03 /CY	1,611,621
				31.25 Earthworks, Structural	26,405.00 CY	61.03 /CY	1,611,621
				31.0 Earthwork	26,405.00 CY	61.03 /CY	1,611,621
	40.0			Process Pipe			
		40.11		Process Pipe, Carbon Steel			
			33.00.112	Dunnigan - Sac River Discharge Structure, Above Grade Piping	3,405.00 LF	881.47 /LF	3,001,420
				40.11 Process Pipe, Carbon Steel	3,405.00 LF	881.47 /LF	3,001,420
				40.0 Process Pipe	3,405.00 LF	881.47 /LF	3,001,420
				5300 Dunnigan - Sac River Discharge Structure	11,690.00 SF	715.93 /SF	8,369,221

Estimate Totals

Description	Amount	Totals	Hours	Rate
Labor	76,274,935		571,475.852	
Material	116,635,040			
Subcontractor	7,221,983			
Equipment	32,171,839		276,776.942	
Other	4,087,918			
Subtotal w/ Prime Markups	236,391,715	236,391,715		
Contractor Contingency	7,091,751			3.000 %
Design Contingency	70,917,514			30.000 %
Opinion of Probable Construction Costs	78,009,266	314,400,981		



Detail Report

Project Name: Dunnigan Pipeline - Alternate No. 2
Project Number: D3380605
Design Stage: 10% Design

Estimator: Tom Jones
Rev No. / Data: R03 - 02/24/2026
Class Estimate: Class 4

Bid Item	Work Pkg	Trade Pkg	WorkActiv	Unit Price	Description	Takeoff Quantity	Labor Hours	Labor Amount	Material Amount	Sub Amount	Equip Amount	Other Amount	Total Cost/Unit	Total Amount	Grand Total Price	Grand Total Amount
5000					General Conditions											
	01.0				General Requirements											
		01.01			Construction Operations											
			01.I5.000		General Conditions, Other											
				01.01.05.00	General Conditions, Other											
					Drug Tests	100.00 ea		-	7,500	0	-	-	75.00 /ea	7,500	98.34 /ea	9,834
					Miscellaneous Health & Safety Programs	1.00 ls			150,000	-	-	0	150,000.00 /ls	150,000	196,689.46 /ls	196,689
					Project Environmental Requirements	1.00 ls			75,000	-	-	-	75,000.00 /ls	75,000	98,344.72 /ls	98,345
					01.01.05.00 General Conditions, Other	24.00 MO			232,500				9,687.50 /MO	232,500	12,702.86 /MO	304,869
					01.I5.000 General Conditions, Other	1.00 LS			232,500				232,500.00 /LS	232,500	304,868.65 /LS	304,869
			01.I5.005		GC Labor											
				01.01.06.01	GC Labor											
					Project Executive	12.00 mo	1,920	374,400	-	-	-	-	31,200.00 /mo	374,400	38,649.41 /mo	463,793
					Assist Project Manager	24.00 mo	3,840	599,040	-	-	-	-	24,960.00 /mo	599,040	30,919.52 /mo	742,069
					Project Manager	24.00 MO	3,840	599,040	-	-	-	-	24,960.00 /MO	599,040	30,919.53 /MO	742,069
					Superintendent	24.00 mo	3,840	460,800	-	-	-	-	19,200.00 /mo	460,800	23,784.25 /mo	570,822
					Asst Superintendent (2)	24.00 mo	3,840	460,800	-	-	-	-	19,200.00 /mo	460,800	23,784.25 /mo	570,822
					Project Engineer	24.00 mo	3,840	441,600	-	-	-	-	18,400.00 /mo	441,600	22,793.24 /mo	547,038
					Field Engineer (4)	48.00 mo	7,680	729,600	-	-	-	-	15,200.00 /mo	729,600	18,829.20 /mo	903,802
					Admin Asst.	24.00 mo	3,840	249,600	-	-	-	-	10,400.00 /mo	249,600	12,883.14 /mo	309,195
					Scheduling Manager	24.00 mo	3,840	445,440	-	-	-	-	18,560.00 /mo	445,440	22,991.44 /mo	551,795
					Assistant Safety Manager	24.00 mo	3,840	576,000	-	-	-	-	24,000.00 /mo	576,000	29,730.31 /mo	713,528
					Safety Manager	12.00 mo	1,920	288,000	-	-	-	-	24,000.00 /mo	288,000	29,730.31 /mo	356,764
					Site Skilled Labor (4)	48.00 mo	7,680	844,800	-	-	-	-	17,600.00 /mo	844,800	21,802.23 /mo	1,046,507
					01.01.06.01 GC Labor	24.00 MO	49,920	6,069,120					252,880.00 /MO	6,069,120	313,258.40 /MO	7,518,202
					01.I5.005 GC Labor	1.00 LS	49,920	6,069,120					6,069,120.00 /LS	6,069,120	7,518,201.53 /LS	7,518,202
			01.I5.010		Jobsite Office											
				01.01.06.00	Project Office											
					Telephone/fax setup	1.00 ea		-	3,000		-	-	3,000.00 /ea	3,000	3,933.79 /ea	3,934
					Telephone/fax monthly cost	24.00 mo		-	12,000	-	-	-	500.00 /mo	12,000	655.63 /mo	15,735
					High Speed Connection - Install	1.00 ea		-	10,000		-	-	10,000.00 /ea	10,000	13,112.64 /ea	13,113
					High Speed Connection - Consumption	24.00 mo		-	12,000	-	-	-	500.00 /mo	12,000	655.63 /mo	15,735
					Mobile Phone	24.00 mo		-	0	-	22,800	-	950.00 /mo	22,800	1,176.83 /mo	28,244
					Field Office Demob	2.00 ea	120	12,928	-	-	-	-	6,464.04 /ea	12,928	8,007.42 /ea	16,015
					Field Office Tear Down	2.00 ea	240	25,856	-	-	-	-	12,928.08 /ea	25,856	16,014.83 /ea	32,030
					Field Office Set-up	2.00 ea	360	38,784	-	-	21,600	-	30,192.12 /ea	60,384	37,400.88 /ea	74,802
					Field Office Mob	2.00 ea	120	12,928	-	0	-	-	6,464.04 /ea	12,928	8,007.42 /ea	16,015
					Conference Trailer Rent	24.00 mo		-	45,000		-	-	1,875.00 /mo	45,000	2,458.62 /mo	59,007
					Field Office Trailer Rent (60 x 12) (3)	48.00 mo		-	84,000	-	-	-	1,750.00 /mo	84,000	2,294.71 /mo	110,146
					Office Furniture	2.00 ea		-	1,550	-	-	-	775.00 /ea	1,550	1,016.23 /ea	2,032
					Office Furniture - Rental	48.00 mo		-	36,000	-	-	-	750.00 /mo	36,000	983.45 /mo	47,205
					Conference Room Furniture	1.00 ea		-	1,000	-	-	-	1,000.00 /ea	1,000	1,311.25 /ea	1,311
					Server & Network	1.00 ea		-	55,000	-	-	-	55,000.00 /ea	55,000	72,119.48 /ea	72,119
					Printer	1.00 ea		-	15,000	-	-	-	15,000.00 /ea	15,000	19,668.94 /ea	19,669
					Computer Software - Document Control	1.00 ea		-	65,000	-	-	-	65,000.00 /ea	65,000	85,232.11 /ea	85,232
					Water Cooler Services	24.00 mo		-	3,480	-	-	-	145.00 /mo	3,480	190.13 /mo	4,563
					Kitchen Equipment	1.00 ea		-	15,000	-	-	-	15,000.00 /ea	15,000	19,668.94 /ea	19,669
					Printing & Reproduction	24.00 mo		-	41,400	-	-	-	1,725.00 /mo	41,400	2,261.93 /mo	54,286
					Postage & Courier	24.00 mo		-	8,400	-	-	-	350.00 /mo	8,400	458.94 /mo	11,015
					Misc. Supplies	24.00 mo		-	68,400	-	-	-	2,850.00 /mo	68,400	3,737.10 /mo	89,690
					01.01.06.00 Project Office	1.00 LS	840	90,497	476,230		44,400		611,126.56 /LS	611,127	791,567.66 /LS	791,568
					01.I5.010 Jobsite Office	1.00 LS	840	90,497	476,230		44,400		611,126.56 /LS	611,127	791,567.66 /LS	791,568
			01.I5.011		Temporary Facilities											
				01.01.06.02	GC Temporary Facilities & Services											
					Temporary offsite Parking and Laydown Area @ 17,250 per month	24.00 mo		-	414,000		-	-	17,250.00 /mo	414,000	22,619.29 /mo	542,863
					Temporary bussing of workers to site - 1 shuttle full time	24.00 mo	4,152	311,400			103,800	-	17,300.00 /mo	415,200	21,430.60 /mo	514,334
					Laydown Area	8,000.00 sy	240	28,686	16,000		11,439	-	7.02 /sy	56,125	8.84 /sy	70,686
					Temporary Parking - Office	500.00 sy	15	1,793	1,000		715	-	7.02 /sy	3,508	8.84 /sy	4,418
					Temporary Parking - Site	1,000.00 sy	30	3,586	2,000		1,430	-	7.02 /sy	7,016	8.84 /sy	8,836
					Temporary Fence - Office	1,600.00 lf	96	10,342	8,000		-	-	11.46 /lf	18,342	14.56 /lf	23,302
					Temporary Gate - Office	2.00 ea	64	6,895	2,400	0	-	-	4,647.49 /ea	9,295	5,844.15 /ea	11,688
					Guard Shack - Set Up	2.00 ea	72	7,757	-	0	-	-	3,878.43 /ea	7,757	4,804.45 /ea	9,609
					Tempoary Warehouse rental	24.00 MO		-	91,200	-	-	-	3,800.00 /MO	91,200	4,982.80 /MO	119,587
					Guard Shack - Rent (2)	48.00 mo		-	57,600	-	-	-	1,200.00 /mo	57,600	1,573.52 /mo	75,529
					Site Security Services	24.00 mo		539,760	-	-	-	-	22,490.00 /mo	539,760	27,859.78 /mo	668,635
					Site security - personnel background checks and badging	100.00 ea		-	36,000		-	-	360.00 /ea	36,000	472.05 /ea	47,205
					01.01.06.02 GC Temporary Facilities & Services	24.00 MO	4,669	910,219	628,200		117,384		68,991.78 /MO	1,655,803	87,362.15 /MO	2,096,692
					01.I5.011 Temporary Facilities	1.00 LS	4,669	910,219	628,200		117,384		1,655,802.69 /LS	1,655,803	2,096,691.68 /LS	2,096,692
			01.I5.012		Temporary Services											
				01.01.06.02	GC Temporary Facilities & Services											
					Electric Power - Consumption	24.00 MO		-	204,000	-	-	-	8,500.00 /MO	204,000	11,145.74 /MO	267,498
					Water - Install	1.00 ls		-	5,000		-	-	5,000.00 /ls	5,000	6,556.31 /ls	6,556
					Water - Consumption	24.00 mo		-	8,571	0	-	-	357.14 /mo	8,571	468.31 /mo	11,239
					Sewer - Install buried holding tank	1.00 ls		-	12,500	0	-	-	12,500.00 /ls	12,500	16,390.78 /ls	16,391
					Sewer - Septic Service	24.00 mo		40,000		0	-	-	1,666.67 /mo	40,000	2,064.61 /mo	49,551
					Hand Washing Station (3)	48.00 mo		-	7,680		-	-	160.00 /mo	7,680	209.80 /mo	10,070
					Portable Toilets (3)	48.00 mo		-	18,000	0	-	-	375.00 /mo	18,000	491.72 /mo	23,603
					Janitorial Service (3)	48.00 mo		-	22,800	0	-	-	475.00 /mo	22,800	622.85 /mo	29,897
					01.01.06.02 GC Temporary Facilities & Services	24.00 MO		40,000	278,551				13,272.98 /MO	318,551	17,283.53 /MO	414,805
					01.I5.012 Temporary Services	1.00 LS		40,000	278,551				318,551.45 /LS	318,551	414,804.74 /LS	414,805
			01.I5.013		Travel											
				01.01.06.02	GC Temporary Facilities & Services											
					Construction Delivery - Daily Hotel Per Diem \$150.00/day (Mgmt Staff)	132.00 mo		-	428,670	-	-	-	3,247.50 /mo	428,670	4,258.33 /mo	562,099



Detail Report

Project Name: Dunnigan Pipeline - Alternate No. 2
Project Number: D3380605
Design Stage: 10% Design

Estimator: Tom Jones
Rev No. / Data: R03 - 02/24/2026
Class Estimate: Class 4

Bid Item	Work Pkg	Trade Pkg	WorkActiv	Unit Price	Description	Takeoff Quantity	Labor Hours	Labor Amount	Material Amount	Sub Amount	Equip Amount	Other Amount	Total Cost/Unit	Total Amount	Grand Total Price	Grand Total Amount
				01.01.06.02	GC Temporary Facilities & Services											
					Construction Delivery - Air Fare (mgmt 1 flight per month)	132.00 ea		-	49,500	-	-	0	375.00 /ea	49,500	491.72 /ea	64,908
					Business travel - Air Fare	132.00 ea		-	72,600	-	-	0	550.00 /ea	72,600	721.19 /ea	95,198
					Business travel - Hotel	240.00 day		-	32,400	-	-	0	135.00 /day	32,400	177.02 /day	42,485
					Business travel - Rental Car	240.00 day		-	18,000	-	-	0	75.00 /day	18,000	98.34 /day	23,603
					Temporary housing (Shared Single family home) - Assumed 4 GCManagement Staff	132.00 mo		-	594,000	-	-		4,500.00 /mo	594,000	5,900.68 /mo	778,890
					Temporary housing (4 to share a single family home) Specialty Contractors	24.00 MO		-	108,000	-	-		4,500.00 /MO	108,000	5,900.68 /MO	141,616
					Personnel moving expense for 4 GC Management Staff	6.00 EA		-	33,000	-	-		5,500.00 /EA	33,000	7,211.95 /EA	43,272
					Personnel moving expense for 8 specialty workers	16.00 EA		-	80,000	-	-		5,000.00 /EA	80,000	6,556.32 /EA	104,901
					01.01.06.02 GC Temporary Facilities & Services	24.00 MO			1,416,170				59,007.08 /MO	1,416,170	77,373.81 /MO	1,856,971
					01.I5.013 Travel	1.00 LS			1,416,170				1,416,170.00 /LS	1,416,170	1,856,971.38 /LS	1,856,971
			01.I5.014		Site Cleanup											
				01.01.06.02	GC Temporary Facilities & Services											
					Office Daily Cleaning up	104.00 wk	1,040	93,879	-	-	-	-	902.68 /wk	93,879	1,118.21 /wk	116,293
					Jobiste Daily Cleaning up	104.00 wk	2,080	187,757	16,640	-	-	-	1,965.36 /wk	204,397	2,446.22 /wk	254,406
					Dumpster Rental	24.00 MO		-	28,800	-	-	-	1,200.00 /MO	28,800	1,573.52 /MO	37,764
					Dumpster Pulls	104.00 ea		-	80,600	-	-	-	775.00 /ea	80,600	1,016.23 /ea	105,688
					Final Clean-up	1.00 ls	600	27,900	2,500	-	-	-	30,400.00 /ls	30,400	37,839.65 /ls	37,840
					01.01.06.02 GC Temporary Facilities & Services	24.00 MO	3,720	309,536	128,540				18,253.17 /MO	438,076	22,999.65 /MO	551,992
					01.I5.014 Site Cleanup	1.00 LS	3,720	309,536	128,540				438,076.16 /LS	438,076	551,991.70 /LS	551,992
			01.I5.014A		Site Safety											
				01.01.06.02	GC Temporary Facilities & Services											
					Safety Equipment and devices	1.00 ls		-	50,000	-	-	-	50,000.00 /ls	50,000	65,563.15 /ls	65,563
					Site Safety Training - non productive time	24.00 MO	10,920	985,727	-	-	-	-	41,071.94 /MO	985,727	50,878.40 /MO	1,221,082
					First Aid Consumables	24.00 mo		-	12,000	-	-	-	500.00 /mo	12,000	655.63 /mo	15,735
					01.01.06.02 GC Temporary Facilities & Services	24.00 MO	10,920	985,727	62,000				43,655.27 /MO	1,047,727	54,265.83 /MO	1,302,380
					01.I5.014A Site Safety	1.00 LS	10,920	985,727	62,000				1,047,726.56 /LS	1,047,727	1,302,379.93 /LS	1,302,380
			01.I5.015		GC Equip, Tools, & Consumables											
				01.01.06.03	GC Equip, Tools, & Consumables											
					Staff Vehicles (4)	96.00 mo		-	-	-	77,952	-	812.00 /mo	77,952	1,005.88 /mo	96,564
					Yard Pickup Truck (4)	96.00 mo		-	-	-	77,952	-	812.00 /mo	77,952	1,005.88 /mo	96,564
					Staff Vehicle Fuel	96.00 mo		-	840,000	-	-	-	8,750.00 /mo	840,000	11,473.55 /mo	1,101,461
					Water Truck	24.00 mo		-	15,000	-	60,000	-	3,125.00 /mo	75,000	3,916.45 /mo	93,995
					Site Storage Connex boxes	5.00 ea		-	3,750	-	-	-	750.00 /ea	3,750	983.45 /ea	4,917
					Small Tools (~0.5% Labor)	1.00 ls		-	250,000	-	-	-	250,000.00 /ls	250,000	327,815.76 /ls	327,816
					Ice Machine	24.00 MO		-	6,000	-	-	-	250.00 /MO	6,000	327.82 /MO	7,868
					Coolers & Drinking Cups	24.00 mo		-	2,400	-	-	-	100.00 /mo	2,400	131.13 /mo	3,147
					Project Sign	1.00 ea		-	6,500	-	-	-	6,500.00 /ea	6,500	8,523.20 /ea	8,523
					01.01.06.03 GC Equip, Tools, & Consumables	1.00 LS			1,123,650		215,904		1,339,554.00 /LS	1,339,554	1,740,854.60 /LS	1,740,855
					01.I5.015 GC Equip, Tools, & Consumables	1.00 LS			1,123,650		215,904		1,339,554.00 /LS	1,339,554	1,740,854.60 /LS	1,740,855
			01.I5.016		Material Handling											
				01.01.06.03	GC Equip, Tools, & Consumables											
					150 tn Crawler, with Operator	24.00 MO	4,160	541,746	559,920	-	476,280	-	65,747.77 /MO	1,577,946	83,137.33 /MO	1,995,296
					Crane setup and removal	4.00 ea	180	23,441	6,000	-	35,622	-	16,265.63 /ea	65,063	20,258.01 /ea	81,032
					Crane Pads and Removal (5 m x 5 m)	4.00 ea	240	31,254	26,826	-	15,832	-	18,478.00 /ea	73,912	23,376.08 /ea	93,504
					01.01.06.03 GC Equip, Tools, & Consumables	1.00 LS	4,580	596,441	592,746		527,734		1,716,920.88 /LS	1,716,921	2,169,832.22 /LS	2,169,832
					01.I5.016 Material Handling	1.00 LS	4,580	596,441	592,746		527,734		1,716,920.88 /LS	1,716,921	2,169,832.22 /LS	2,169,832
			01.I5.020		GC Indirect Services & Support											
				01.01.06.04	GC Indirect Services & Support											
					Video Survey of Site	1.00 ea		-	12,520	0	-	-	12,520.00 /ea	12,520	16,417.02 /ea	16,417
					Aerial Photos	20.00 ea		-	5,500	0	-	-	275.00 /ea	5,500	360.60 /ea	7,212
					Construction Photos	24.00 MO		-	8,400	0	-	-	350.00 /MO	8,400	458.94 /MO	11,015
					Web Camera	1.00 ea		-	25,000	-	-	-	25,000.00 /ea	25,000	32,781.60 /ea	32,782
					Miscellaneous third party testing and inspections	1.00 ls		250,000	-	0	-	-	250,000.00 /ls	250,000	309,690.75 /ls	309,691
					Survey Consultant	125.00 day	1,000	95,000	-		58,000	-	1,224.00 /day	153,000	1,516.25 /day	189,531
					01.01.06.04 GC Indirect Services & Support	24.00 MO	1,000	345,000	51,420		58,000		18,934.17 /MO	454,420	23,610.28 /MO	566,647
					01.I5.020 GC Indirect Services & Support	1.00 LS	1,000	345,000	51,420		58,000		454,420.00 /LS	454,420	566,646.64 /LS	566,647
			01.I6.000		Quality Control											
				01.01.06.01	GC Labor											
					Quality Control	24.00 MO	4,160	478,391	-	-	-	-	19,932.95 /MO	478,391	24,692.20 /MO	592,613
					Quality Mgr. (3)	24.00 mo	4,160	665,587	-	-	-	-	27,732.80 /mo	665,587	34,354.37 /mo	824,505
					01.01.06.01 GC Labor	24.00 MO	8,320	1,143,978	-				47,665.75 /MO	1,143,978	59,046.57 /MO	1,417,118
					01.I6.000 Quality Control	1.00 LS	8,320	1,143,978	-				1,143,978.00 /LS	1,143,978	1,417,117.66 /LS	1,417,118
					01.01 Construction Operations	24.00 MO	83,969	10,490,517	4,990,007		963,422		685,164.43 /MO	16,443,946	863,830.35 /MO	20,731,928
					01.0 General Requirements	24.00 MO	83,969	10,490,517	4,990,007		963,422		685,164.43 /MO	16,443,946	863,830.35 /MO	20,731,928
					5000 General Conditions	1.00 LS	83,969	10,490,517	4,990,007		963,422		16,443,946.30 /LS	16,443,946	20,731,928.39 /LS	20,731,928
5021					Dunnigan Pipeline (216+20 to 505+79)											
	33.0				Pipelines											
		33.03			Buried Process Pipe, Carbon Steel											
			33.00.05.10.5-1a		Dunnigan Pipeline, Single Pipe Trench, (3123-110)											
				31.00.01.01	Trenching, Backfill, and Compaction											
					Structural concrete,ready mix,flowable fill,structural,50 psi,includes ash,cement,aggregate,sand,water,delivered,excludes all additives and treatments	117,985.18 cy		-	8,848,889	-	-	-	75.00 /cy	8,848,889	98.34 /cy	11,603,220
					Structural concrete, placing, foundation mat, pumped, over 20 C.Y., includes strike off & consolidation, excludes material	117,985.18 cy	31,463	3,012,527	-	-	443,188	-	29.29 /cy	3,455,715	36.28 /cy	4,280,812
					Excavating, trench or continuous footing, dense hard clay, 3 C.Y. excavator, 14' to 20' deep, excludes sheeting or dewatering	730,616.18 CY	13,284	1,469,347	-	-	2,027,763	-	4.79 /CY	3,497,111	5.93 /CY	4,332,092
					Backfill, 12" layers, compaction in layers, roller compaction with operator walking, ABOVE PIPE ZONE	491,323.63 ecy	39,306	4,468,569	-	-	526,279	-	10.17 /ecy	4,994,848	12.59 /ecy	6,187,433
					Hauling,excavated borrow material,loose cubic yards,20 mile round trip,0.4 load/hr,base wide rate,12 cy truck,highway haulers,excludes loading	239,292.55 lcy	49,086	4,868,554	-	-	4,952,687	-	41.04 /lcy	9,821,241	50.84 /lcy	12,166,191



Detail Report

Project Name: Dunnigan Pipeline - Alternate No. 2
Project Number: D3380605
Design Stage: 10% Design

Estimator: Tom Jones
Rev No. / Data: R03 - 02/24/2026
Class Estimate: Class 4

Bid Item	Work Pkg	Trade Pkg	WorkActiv	Unit Price	Description	Takeoff Quantity	Labor Hours	Labor Amount	Material Amount	Sub Amount	Equip Amount	Other Amount	Total Cost/Unit	Total Amount	Grand Total Price	Grand Total Amount
				31.00.01.01	Trenching, Backfill, and Compaction											
					Erosion and Dust Controls Allowance	956.00 DY				4,780,000			5,000.00 /DY	4,780,000	6,193.82 /DY	5,921,287
					31.00.01.01 Trenching, Backfill, and Compaction	730,616.18 CY	133,139	13,818,997	8,848,889	4,780,000	7,949,918	48.45 /CY	35,397,804	60.90 /CY	44,491,035	
				31.15.01.00	Site Preparation, Clearing and Grubbing											
					Dump charges, typical urban city, fees only, demo lbr, trees, brush	27,233.13 cy		-	272,331		-	-	10.00 /cy	272,331	13.11 /cy	357,098
					Clearing & grubbing, brush, including stumps	67.52 AC	6,482	698,753	-	-	762,531	-	21,642.24 /AC	1,461,284	26,809.61 /AC	1,810,185
					Hauling, excavated or borrow material, loose cubic yards, 20 mile round trip, 0.5 loads/hour, 20 C.Y. dump trailer, highway haulers, excludes loading	27,233.13 cy	2,793	277,024	-	-	254,508	-	19.52 /cy	531,532	24.18 /cy	658,442
					31.15.01.00 Site Preparation, Clearing and Grubbing	67.52 AC	9,275	975,777	272,331		1,017,039		33,547.79 /AC	2,265,147	41,850.18 /AC	2,825,724
				31.15.02.00	Dewatering											
					Dewatering,excavate drainage trench, with backhoe, 2' wide x 2' deep	4,344.00 cy	772	83,416	-	-	13,647	-	22.34 /cy	97,064	27.68 /cy	120,239
					Dewatering, pumping, 8 hr., attended 2 hours per day, 2" diaphragm pump used for 8 hours, includes 20 l.f. suction hose and 100 l.f. of discharge hose	1,158.40 day	3,475	395,085	-	-	22,000	-	360.05 /day	417,085	446.02 /day	516,670
					Dewatering, sump hole construction, includes excavation and gravel pit	36,200.00 cf	695	70,784	39,096	-	8,188	-	3.26 /cf	118,068	4.12 /cf	149,093
					Wellpoints, single stage system, 0.75 labor hours per L.F., installation and removal	28,960.00 lf	21,652	1,970,276	-	-	-	-	68.03 /lf	1,970,276	84.28 /lf	2,440,705
					Wellpoints, pump operation, 4 @ 6 hour shifts, per 4.3 week month	46.34 mo	33,729	3,110,142	-	-	-	-	67,121.50 /mo	3,110,142	83,147.64 /mo	3,852,729
					Wellpoints,complete installation,2"wellpoints, 20'oc, 100'long header,6"diameter,includes one month operation,equipment rental,fuel and removal system	144.80 hdr	1,435	177,210	22,299	-	-	-	1,377.83 /hdr	199,509	1,717.97 /hdr	248,761
					Wellpoints,complete installation,2"wellpoints,20'oc, 200'long header,8"diameter,includes one month operation,equipment rental,fuel and removal system	144.80 hdr	3,475	395,086	21,286	-	58,511	-	3,279.58 /hdr	474,883	4,073.28 /hdr	589,810
					31.15.02.00 Dewatering	28,960.00 lf	65,233	6,201,999	82,681		102,346		220.55 /lf	6,387,027	273.41 /lf	7,918,007
				32.40.11.01	Surface Restorations											
					Final Grading	326,797.51 SY	5,229	564,785	-	-	363,733	-	2.84 /SY	928,518	3.52 /SY	1,150,214
					Topsoil placement and grading, loam or topsoil, fine grading and seeding, with equipment	326,797.51 sy	15,686	1,521,961	183,007	-	92,400	-	5.50 /sy	1,797,368	6.85 /sy	2,239,781
					Seeding, mechanical seeding hydro or air seeding for large areas, includes lime, fertilizer and seed with wood fiber mulch added	326,797.51 sy	6,482	681,066	725,490	-	298,955	-	5.22 /sy	1,705,511	6.63 /sy	2,165,323
					32.40.11.01 Surface Restorations	326,797.51 SY	27,397	2,767,812	908,497		755,088		13.56 /SY	4,431,397	17.00 /SY	5,555,317
				33.00.05.144	Buried Pipe, WSP, 144"											
					144" CS butt weld, 1/2" wall	1,448.00 ea	72,784	9,296,244	726,577		1,338,505	-	7,846.22 /ea	11,361,327	9,755.99 /ea	14,126,668
					Piping, WSP 0.688" Wt Polyurethane Lined and Coated, 144" diameter	28,960.00 LF	81,088	8,447,887	58,933,600	-	3,451,013	-	2,445.87 /LF	70,832,499	3,177.40 /LF	92,017,368
					33.00.05.144 Buried Pipe, WSP, 144"	28,960.00 LF	153,872	17,744,131	59,660,177		4,789,518		2,838.18 /LF	82,193,826	3,665.19 /LF	106,144,037
				33.10.05.98	Access Manway											
					36" Accessway	7.00 EA	168	19,007	56,000	-	4,200	-	11,315.34 /EA	79,207	14,597.02 /EA	102,179
					Utility area drains,catch basins manhls catch basins manhls frames and covers,cast iron,heavy traffic,36"dm,1150lb, excluds footing,excavtn,and backfill	7.00 ea	56	5,703	20,300	-	660	-	3,808.98 /ea	26,663	4,928.67 /ea	34,501
					Manholes, Frames, and Covers, concrete, precast, 9' inside diameter, 8' deep, excludes footing, excavation, backfill, frame and cover	7.00 ea	224	22,812	95,200	-	1,979	-	17,141.66 /ea	119,992	22,220.45 /ea	155,543
					Storm Drainage Manholes, Frames, and Covers, precast concrete, 9' diameter manhole, 8" thick top	7.00 ea	56	5,703	10,500	-	495	-	2,385.41 /ea	16,698	3,063.71 /ea	21,446
					Storm Drainage Manholes, Frames, and Covers, steps, standard sizes, galvanized steel	42.00 ea	8	866	1,218	-	-	-	49.63 /ea	2,084	63.58 /ea	2,670
					ARV and Piping	1.00 ea	16	1,836	6,500	-	-	-	8,336.34 /ea	8,336	10,798.00 /ea	10,798
					Misceclaneous Items and Consumables Allowance	1.00 ls		3,000	5,000	-	2,000	-	10,000.00 /ls	10,000	12,750.13 /ls	12,750
					33.10.05.98 Access Manway	7.00 EA	528	58,929	194,718		9,334		37,568.63 /EA	262,980	48,555.35 /EA	339,887
				33.10.06.98	CARV											
					10" CARV, Includes Piping and Valving	6.00 EA	144	16,527	60,000	-	-	-	12,754.50 /EA	76,527	16,524.81 /EA	99,149
					Utility area drains,catch basins manhls catch basins manhls frames and covers,cast iron,heavy traffic,36"dm,1150lb, excluds footing,excavtn,and backfill	6.00 ea	48	4,888	17,400	-	565	-	3,808.98 /ea	22,854	4,928.67 /ea	29,572
					Manholes, Frames, and Covers, concrete, precast, 6' inside diameter., 6' deep, excludes footing, excavation, backfill, frame and cover	6.00 ea	192	19,553	25,200	-	1,696	-	7,741.66 /ea	46,450	9,894.58 /ea	59,367
					Storm Drainage Manholes, Frames, and Covers, precast concrete, 6' diameter manhole, 8" thick top	6.00 ea	48	4,888	9,000	-	424	-	2,385.42 /ea	14,312	3,063.72 /ea	18,382
					Manholes, Frames, and Covers, steps, standard sizes, galvanized steel	24.00 ea	5	495	696	-	-	-	49.63 /ea	1,191	63.58 /ea	1,526
					33.10.06.98 CARV	6.00 EA	437	46,352	112,296		2,686		26,889.06 /EA	161,334	34,666.09 /EA	207,997
					33.00.05.10.5-1a Dunnigan Pipeline, Single Pipe Trench, (3123-110)	28,960.00 LF	389,882	41,613,998	70,079,589	4,780,000	14,625,929		4,526.92 /LF	131,099,516	5,783.22 /LF	167,482,005
					33.03 Buried Process Pipe, Carbon Steel	28,960.00 LF	389,882	41,613,998	70,079,589	4,780,000	14,625,929		4,526.92 /LF	131,099,516	5,783.22 /LF	167,482,005
					33.0 Pipelines	28,960.00 LF	389,882	41,613,998	70,079,589	4,780,000	14,625,929		4,526.92 /LF	131,099,516	5,783.22 /LF	167,482,005
					5021 Dunnigan Pipeline (216+20 to 505+79)	28,960.00 LF	389,882	41,613,998	70,079,589	4,780,000	14,625,929		4,526.92 /LF	131,099,516	5,783.22 /LF	167,482,005
5022					Valve Vault											
	03.0				Concrete Work											
		03.18			Cast-In-Place Concrete, Slabs on Grade											
			03.00.100		Dunnigan - Valve Vault Structure, Foundation Slab											
				03.10.05.42	Cast-In-Place Concrete, Slabs on Grade, 42" thick											
					C.I.P. concrete forms, slab on grade, edge, wood, over 12", 4 use, includes erecting, bracing, stripping and cleaning	308.00 sfca	28	2,942	730	-	-	-	11.92 /sfca	3,672	17.32 /sfca	5,335
					Reinforcing Steel, in place, slab on grade, #3 to #7, A615, grade 60, incl labor for accessories, excl material for accessories	19.50 ton	312	36,505	29,250	-	-	-	3,372.03 /ton	65,755	4,960.30 /ton	96,726
					Reinforcing in place, unloading & sorting, add to above - slabs	19.50 ton	11	1,302	-	-	452	-	89.94 /ton	1,754	129.41 /ton	2,523
					Struct concrete,ready mix,normal wt,4500 psi,includes local aggregate,sand,portland cement and water,delivered,excludes all additives and treatments	230.50 cy		-	51,863	-	-	-	225.00 /cy	51,863	340.03 /cy	78,378
					Structural concrete, placing, slab on grade, pumped, over 6" thick, includes strike off & consolidation, excludes material	223.75 CY	147	14,095	-	-	1,389	-	69.20 /CY	15,484	99.57 /CY	22,278
					Cfnsh,flrs,for spcf rndm acce flrs aci clss 1,2,3 and 4,achv a cmps ovrl flr fltn&lvin val f35/25,bull fit,mchn fit&stl twl (wlk-bhn),excl plcn,strkn	1,725.75 sf	24	2,203	-	-	88	-	1.33 /sf	2,291	1.91 /sf	3,296
					Curing, sprayed membrane curing compound	17.26 csf	3	264	276	-	-	-	31.33 /csf	541	46.23 /csf	798
					Fine grading, fine grade for slab on grade, machine	191.75 sy	3	319	-	-	205	-	2.73 /sy	524	3.93 /sy	754
					03.10.05.42 Cast-In-Place Concrete, Slabs on Grade, 42" thick	223.75 CY	528	57,630	82,119		2,134		634.11 /CY	141,882	938.94 /CY	210,089
					03.00.100 Dunnigan - Valve Vault Structure, Foundation Slab	223.75 CY	528	57,630	82,119		2,134		634.11 /CY	141,882	938.94 /CY	210,089
					03.18 Cast-In-Place Concrete, Slabs on Grade	223.75 CY	528	57,630	82,119		2,134		634.11 /CY	141,882	938.94 /CY	210,089
		03.20			Cast-In-Place Concrete, Straight Walls											
			03.00.102		Dunnigan - Valve Vault Structure, Concrete Walls											



Detail Report

Project Name: Dunnigan Pipeline - Alternate No. 2
Project Number: D3380605
Design Stage: 10% Design

Estimator: Tom Jones
Rev No. / Data: R03 - 02/24/2026
Class Estimate: Class 4

Bid Item	Work Pkg	Trade Pkg	WorkActiv	Unit Price	Description	Takeoff Quantity	Labor Hours	Labor Amount	Material Amount	Sub Amount	Equip Amount	Other Amount	Total Cost/Unit	Total Amount	Grand Total Price	Grand Total Amount
				03.10.06.42	Cast-In-Place Concrete, Straight Walls, 42" thick											
					12" Dia Wall Pipes	2.00 ea	56	5,834	41,600	-	2,383	-	24,908.74 /ea	49,817	37,345.78 /ea	74,692
					Forms in place, wall, steel framed plywood, >16" high, 3 use/month	4,187.50 sfca	442	47,073	22,822	-	-	-	16.69 /sfca	69,895	24.41 /sfca	102,217
					Form oil, coverage varies greatly, maximum, includes material only	8.38 gal	-	-	230	-	-	-	27.50 /gal	230	41.56 /gal	348
					Reinforcing Steel, in place, walls, #3 to #7, A615, grade 60, incl labor for accessories, excl material for accessories	22.50 ton	360	42,121	33,750	-	-	-	3,372.03 /ton	75,871	4,960.30 /ton	111,607
					Reinforcing in place, unloading & sorting, add - walls, cols, beams	22.50 ton	13	1,502	-	-	522	-	89.94 /ton	2,024	129.41 /ton	2,912
					Reinforcing, crane cost for handling, add to above, walls, cols, beams	22.50 ton	14	1,633	-	-	567	-	97.76 /ton	2,200	140.66 /ton	3,165
					Concrete, ready mix, regular weight, walls/cols/beams, 5000 psi	262.50 cy	-	-	65,625	-	-	-	250.00 /cy	65,625	377.82 /cy	99,177
					Structural concrete, placing, walls, pumped, 15" thick, includes strike off & consolidation, excludes material	257.50 CY	218	20,841	-	-	2,464	-	90.51 /CY	23,306	130.22 /CY	33,531
					Concrete finishing, walls, burlap rub with grout, includes breaking ties and patching voids	3,958.50 sf	70	6,428	119	-	-	-	1.65 /sf	6,547	2.38 /sf	9,428
					03.10.06.42 Cast-In-Place Concrete, Straight Walls, 42" thick	257.50 CY	1,172	125,432	164,146		5,936		1,147.63 /CY	295,514	1,697.38 /CY	437,076
					03.00.102 Dunnigan - Valve Vault Structure, Concrete Walls	257.50 CY	1,172	125,432	164,146		5,936		1,147.63 /CY	295,514	1,697.38 /CY	437,076
					03.20 Cast-In-Place Concrete, Straight Walls	257.50 CY	1,172	125,432	164,146		5,936		1,147.63 /CY	295,514	1,697.38 /CY	437,076
		03.24			Cast-In-Place Concrete, Elevated Slabs											
			03.00.104		Dunnigan - Valve Vault Structure, Elevated Slab											
				03.10.10.16	Cast-In-Place Concrete, Elevated Decks, 16" thick											
					Slab shoring	33,211.00 cf	232	25,187	1,661	-	-	-	0.81 /cf	26,847	1.17 /cf	38,747
					C.I.P. concrete forms, elevated slab, flat plate, plywood, to 15" high, 4 use, includes shoring, erecting, bracing, stripping and cleaning	1,470.75 sf	126	13,434	3,824	-	-	-	11.73 /sf	17,258	17.07 /sf	25,107
					Cip concrete forms,elevated slab,box-out for shallow slab openings,over 10 sf (use perimeter),includes shoring,erecting,bracing,stripping and cleaning	102.50 lf	8	874	453	-	-	-	12.95 /lf	1,327	18.95 /lf	1,942
					C.I.P. concrete forms, elevated slab, edge forms, 7" to 12" high, 3 use, includes shoring, erecting, bracing, stripping and cleaning	109.25 sfca	16	1,645	142	-	-	-	16.36 /sfca	1,787	23.63 /sfca	2,581
					Reinforcing Steel, in place, elevated slabs, #4 to #7, A615, grade 60, incl labor for accessories, excl material for accessories	5.39 ton	86	10,087	8,082	-	-	-	3,372.03 /ton	18,169	4,960.30 /ton	26,726
					Reinforcing in place, unloading & sorting, add to above - decks	5.39 ton	3	360	-	-	125	-	89.94 /ton	485	129.41 /ton	697
					Reinforcing steel, crane cost for handling, maximum, add	5.39 ton	9	1,028	-	-	357	-	256.98 /ton	1,385	369.73 /ton	1,992
					Concrete, ready mix, regular weight, elevated decks, 4000 psi	62.75 cy	-	-	12,550	-	-	-	200.00 /cy	12,550	302.25 /cy	18,966
					Structural concrete, placing, elevated slab, pumped, over 10" thick, includes strike off & consolidation, excludes material	61.50 CY	41	3,931	-	-	392	-	70.30 /CY	4,324	101.15 /CY	6,221
					Finishing elev. slabs, manual screed, bull float, machine float & trowel	1,245.25 sf	17	1,590	-	-	63	-	1.33 /sf	1,653	1.91 /sf	2,378
					Curing, sprayed membrane curing compound, elevated decks	12.45 csf	2	191	199	-	-	-	31.33 /csf	390	46.23 /csf	576
					03.10.10.16 Cast-In-Place Concrete, Elevated Decks, 16" thick	61.50 CY	541	58,325	26,911		938		1,401.20 /CY	86,174	2,047.71 /CY	125,934
				03.10.11.20	Cast-In-Place Concrete, Elevated Beams, 20"											
					C.I.P. concrete forms, beams and girders, interior, plywood, 24" wide, 4 use, includes shoring, erecting, bracing, stripping and cleaning	103.00 sfca	13	1,334	158	-	-	-	14.48 /sfca	1,491	20.94 /sfca	2,157
					Shores, horizontal members, joists and stringers, aluminum, includes erect and strip by hand	4.50 ea	1	131	-	-	-	-	29.05 /ea	131	41.80 /ea	188
					Shores, horizontal members, adjustable beam, steel, includes erect and strip by hand	3.00 ea	1	116	-	-	-	-	38.74 /ea	116	55.73 /ea	167
					Shores, vertical members, to 13' high, includes erect and strip by hand	3.25 ea	1	113	-	-	-	-	34.87 /ea	113	50.16 /ea	163
					Shores, reshoring	34.50 sf	0	43	8	-	-	-	1.49 /sf	51	2.15 /sf	74
					Shores, horizontal, rent for job duration, aluminum joists, @ 2' O.C., per mo.	34.50 flr	-	25	-	-	-	-	0.71 /flr	25	1.07 /flr	37
					Form oil, coverage varies greatly, maximum, includes material only	0.28 gal	-	-	8	-	-	-	27.50 /gal	8	41.53 /gal	11
					Reinforcing Steel, in place, beams and girders, #8 to #18, A615, grade 60, incl labor for accessories, excl material for accessories	0.44 ton	7	820	657	-	-	-	3,372.03 /ton	1,477	4,960.30 /ton	2,173
					Reinforcing in place, unloading & sorting, add - walls, cols, beams	0.44 ton	0	29	-	-	10	-	89.95 /ton	39	129.43 /ton	57
					Reinforcing, crane cost for handling, add to above, walls, cols, beams	0.44 ton	0	32	-	-	11	-	97.76 /ton	43	140.66 /ton	62
					Concrete, ready mix, regular weight, walls/cols/beams, 4000 psi	2.00 cy	-	-	400	-	-	-	200.00 /cy	400	302.26 /cy	605
					Structural concrete, placing, beam, large, elevated, pumped, includes strike off & consolidation, excludes material	1.75 CY	2	171	-	-	22	-	110.72 /CY	194	159.30 /CY	279
					Concrete finishing, walls, burlap rub with grout, includes breaking ties and patching voids	103.00 sf	2	167	3	-	-	-	1.65 /sf	170	2.38 /sf	245
					03.10.11.20 Cast-In-Place Concrete, Elevated Beams, 20"	1.75 CY	27	2,957	1,258		44		2,433.27 /CY	4,258	3,553.02 /CY	6,218
				03.10.11.24	Cast-In-Place Concrete, Elevated Beams, 24" x 48"											
					C.I.P. concrete forms, beams and girders, interior, plywood, 24" wide, 4 use, includes shoring, erecting, bracing, stripping and cleaning	432.75 sfca	53	5,604	662	-	-	-	14.48 /sfca	6,266	20.94 /sfca	9,063
					Shores, horizontal members, joists and stringers, aluminum, includes erect and strip by hand	18.61 ea	5	541	-	-	-	-	29.05 /ea	541	41.80 /ea	778
					Shores, horizontal members, adjustable beam, steel, includes erect and strip by hand	12.12 ea	4	469	-	-	-	-	38.74 /ea	469	55.73 /ea	675
					Shores, vertical members, to 13' high, includes erect and strip by hand	12.98 ea	4	453	-	-	-	-	34.86 /ea	453	50.16 /ea	651
					Shores, reshoring	144.11 sf	2	179	35	-	-	-	1.49 /sf	214	2.15 /sf	310
					Shores, horizontal, rent for job duration, aluminum joists, @ 2' O.C., per mo.	144.11 flr	-	102	-	-	-	-	0.71 /flr	102	1.07 /flr	155
					Form oil, coverage varies greatly, maximum, includes material only	1.18 gal	-	-	32	-	-	-	27.50 /gal	32	41.55 /gal	49
					Reinforcing Steel, in place, beams and girders, #8 to #18, A615, grade 60, incl labor for accessories, excl material for accessories	1.88 ton	30	3,510	2,813	-	-	-	3,372.03 /ton	6,323	4,960.30 /ton	9,301
					Reinforcing in place, unloading & sorting, add - walls, cols, beams	1.88 ton	1	125	-	-	43	-	89.95 /ton	169	129.42 /ton	243
					Reinforcing, crane cost for handling, add to above, walls, cols, beams	1.88 ton	1	136	-	-	47	-	97.77 /ton	183	140.67 /ton	264
					Concrete, ready mix, regular weight, walls/cols/beams, 4000 psi168	9.00 cy	-	-	1,800	-	-	-	200.00 /cy	1,800	302.25 /cy	2,720
					Structural concrete, placing, beam, large, elevated, pumped, includes strike off & consolidation, excludes material	8.75 CY	9	857	-	-	112	-	110.73 /CY	969	159.31 /CY	1,394
					Concrete finishing, walls, burlap rub with grout, includes breaking ties and patching voids	432.75 sf	8	703	13	-	-	-	1.65 /sf	716	2.38 /sf	1,031
					03.10.11.24 Cast-In-Place Concrete, Elevated Beams, 24" x 48"	8.75 CY	116	12,577	5,457		202		2,084.15 /CY	18,236	3,043.82 /CY	26,633
					03.00.104 Dunnigan - Valve Vault Structure, Elevated Slab	72.00 CY	685	73,859	33,626		1,184		1,509.28 /CY	108,668	2,205.35 /CY	158,785
					03.24 Cast-In-Place Concrete, Elevated Slabs	72.00 CY	685	73,859	33,626		1,184		1,509.28 /CY	108,668	2,205.35 /CY	158,785
		03.40			Precast Concrete											
			03.02.000		Valve Vault Elevated Slab Pre-Cast Concrete Covers											
				03.44.41.95	Precast Concrete - Solid Core Planks - Removable Concrete Covers											
					Lightweight concrete roof slab, short pieces, 4-3/4" thick	315.00 SF	20	2,202	15,750	-	1,097	-	60.47 /SF	19,049	90.63 /SF	28,549
					03.44.41.95 Precast Concrete - Solid Core Planks - Removable Concrete Covers	315.00 SF	20	2,202	15,750		1,097		60.47 /SF	19,049	90.63 /SF	28,549
					03.02.000 Valve Vault Elevated Slab Pre-Cast Concrete Covers	315.00 SF	20	2,202	15,750		1,097		60.47 /SF	19,049	90.63 /SF	28,549



Detail Report

Project Name: Dunnigan Pipeline - Alternate No. 2
Project Number: D3380605
Design Stage: 10% Design

Estimator: Tom Jones
Rev No. / Data: R03 - 02/24/2026
Class Estimate: Class 4

Bid Item	Work Pkg	Trade Pkg	WorkActiv	Unit Price	Description	Takeoff Quantity	Labor Hours	Labor Amount	Material Amount	Sub Amount	Equip Amount	Other Amount	Total Cost/Unit	Total Amount	Grand Total Price	Grand Total Amount
					03.40 Precast Concrete	315.00 SF	20	2,202	15,750		1,097		60.47 /SF	19,049	90.63 /SF	28,549
					03.0 Concrete Work	553.25 CY	2,405	259,123	295,640		10,351		1,021.44 /CY	565,114	1,508.36 /CY	834,499
	05.0				Metals											
		05.00			Metals											
			05.00.000		Dunnigan - Valve Vault Structure Maintenance and Storage BLDG, Metals											
			05.50.04.10		Metals, Pipe and Tube Railings											
					Railing, pipe, steel, galvanized, 2 rails, 3'-6" high, posts @ 5' O.C., 1-1/2" dia, shop fabricated	43.50 LF	9	1,087	2,719	-	41	-	88.43 /LF	3,847	131.76 /LF	5,731
					24" Self Closing Gate	2.00 ea	16	1,999	1,500	-	75	-	1,787.07 /ea	3,574	2,625.55 /ea	5,251
					05.50.04.10 Metals, Pipe and Tube Railings	43.50 LF	25	3,086	4,219		116		170.59 /LF	7,421	252.47 /LF	10,983
					05.00.000 Dunnigan - Valve Vault Structure Maintenance and Storage BLDG, Metals	1.00 LS	25	3,086	4,219		116		7,420.70 /LS	7,421	10,982.50 /LS	10,983
			05.00.002		Dunnigan - Valve Vault Structure Admin and Operations BLDG, Metals											
			05.50.03.20		Metal Ladders, Steel w/o Cage											
					Ladder, shop fabricated, steel, 20" W, bolted to concrete, excl cage includes walkthrough	2.00 EA	32	3,998	3,000	-	150	-	3,574.14 /EA	7,148	5,251.09 /EA	10,502
					05.50.03.20 Metal Ladders, Steel w/o Cage	2.00 EA	32	3,998	3,000		150		3,574.14 /EA	7,148	5,251.09 /EA	10,502
					05.00.002 Dunnigan - Valve Vault Structure Admin and Operations BLDG, Metals	1.00 LS	32	3,998	3,000		150		7,148.28 /LS	7,148	10,502.18 /LS	10,502
			05.00.005		Dunnigan - Valve Vault Structure, Grating and Structural Supports											
			05.50.05.00		Metals, Gratings											
					Structural steel member, W6x12, A992 steel, shop fabricated, incl shop primer, bolted connections	2.50 lf	3	348	68	-	137	-	221.02 /lf	553	319.95 /lf	800
					Structural steel member, W8x24, A992 steel, shop fabricated, incl shop primer, bolted connections	12.50 lf	14	1,739	544	-	686	-	237.51 /lf	2,969	344.88 /lf	4,311
					Structural steel member, W8x31, A992 steel, shop fabricated, incl shop primer, bolted connections	34.50 lf	39	4,801	1,932	-	1,893	-	250.01 /lf	8,625	363.77 /lf	12,550
					Structural steel member, W8x40, A992 steel, shop fabricated, incl shop primer, bolted connections	15.00 lf	17	2,087	1,305	-	823	-	281.01 /lf	4,215	410.62 /lf	6,159
					Angles, single or double, floor framing (closure, ledgers, support)	520.00 lb	15	1,839	1,024	-	92	-	5.68 /lb	2,955	8.32 /lb	4,326
					Floor grating, steel, gavy, 2-1/4" x 3/16" bearing bars @ 1-3/16" O.C., cross bars @ 4" O.C., up to 300 S.F., field fabricated from panels	185.75 SF	39	4,795	9,845	-	3,309	-	96.63 /SF	17,949	142.87 /SF	26,538
					Miscellaneous Items and Consumables Allowance	1.00 ls		1,250	2,500	-	1,250	-	5,000.00 /ls	5,000	7,375.07 /ls	7,375
					05.50.05.00 Metals, Gratings	185.75 SF	126	16,859	17,217		8,190		227.54 /SF	42,266	334.10 /SF	62,060
					05.00.005 Dunnigan - Valve Vault Structure, Grating and Structural Supports	1.00 LS	126	16,859	17,217		8,190		42,266.36 /LS	42,266	62,059.54 /LS	62,060
			05.00.006		Dunnigan - Valve Vault Structure, Trash Racks											
			05.50.05.20		Metals, Floor Hatches											
					Doors, specialty, access, floor, industrial, aluminum, 150 psf L.L., double leaf, 6' x 8', 442 lb	2.00 EA	16	1,984	17,000	-	536	-	9,760.15 /EA	19,520	14,658.79 /EA	29,318
					Miscellaneous Items and Consumables Allowance	1.00 ls		2,000	4,000	-	2,000	-	8,000.00 /ls	8,000	11,800.10 /ls	11,800
					05.50.05.20 Metals, Floor Hatches	2.00 EA	16	3,984	21,000		2,536		13,760.15 /EA	27,520	20,558.83 /EA	41,118
					05.00.006 Dunnigan - Valve Vault Structure, Trash Racks	1.00 LS	16	3,984	21,000		2,536		27,520.29 /LS	27,520	41,117.67 /LS	41,118
					05.00 Metals	1.00 LS	198	27,928	45,436		10,992		84,355.63 /LS	84,356	124,661.89 /LS	124,662
					05.0 Metals	1.00 LS	198	27,928	45,436		10,992		84,355.63 /LS	84,356	124,661.89 /LS	124,662
	09.0				Finishes											
		09.90			Painting and Coating											
			09.00.000		Dunnigan - Valve Vault Structure Maintenance and Storage BLDG, Finishes											
			09.00.99.00		Finishes, Other											
					Valve Vault and Appurtenances Paintings and Coatings Allowance	1.00 ls	115	10,484	12,016	-	2,499	-	24,999.57 /ls	25,000	36,839.64 /ls	36,840
					09.00.99.00 Finishes, Other	1.00 LS	115	10,484	12,016		2,499		24,999.57 /LS	25,000	36,839.64 /LS	36,840
					09.00.000 Dunnigan - Valve Vault Structure Maintenance and Storage BLDG, Finishes	1.00 LS	115	10,484	12,016		2,499		24,999.57 /LS	25,000	36,839.64 /LS	36,840
					09.90 Painting and Coating	1.00 LS	115	10,484	12,016		2,499		24,999.57 /LS	25,000	36,839.64 /LS	36,840
					09.0 Finishes	1.00 LS	115	10,484	12,016		2,499		24,999.57 /LS	25,000	36,839.64 /LS	36,840
	23.0				HVAC											
		23.00			HVAC											
			23.00.000		Dunnigan - Valve Vault Structure Maintenance and Storage BLDG, HVAC											
			23.00.02.00		Mechanical, HVAC											
					Fans,Exhaust Fans 9600 CFM	1.00 ea	25	2,923	25,000	-	1,250	-	29,173.41 /ea	29,173	37,951.42 /ea	37,951
					Electric heating, cabinet unit heaters, ceiling mount, 208 to 480 volt, three pole, 24 kW	1.00 ea	13	1,391	3,275	-	-	-	4,665.89 /ea	4,666	6,017.39 /ea	6,017
					23.00.02.00 Mechanical, HVAC	1.00 LS	38	4,314	28,275		1,250		33,839.30 /LS	33,839	43,968.81 /LS	43,969
					23.00.000 Dunnigan - Valve Vault Structure Maintenance and Storage BLDG, HVAC	1.00 LS	38	4,314	28,275		1,250		33,839.30 /LS	33,839	43,968.81 /LS	43,969
					23.00 HVAC	1.00 LS	38	4,314	28,275		1,250		33,839.30 /LS	33,839	43,968.81 /LS	43,969
					23.0 HVAC	1.00 LS	38	4,314	28,275		1,250		33,839.30 /LS	33,839	43,968.81 /LS	43,969
	26.0				Electrical Work											
		26.00			Electrical											
			26.00.000		Electrical											
			26.00.99.00		Electrical, Other											
					Electrical Equipment and Fitout Allowance, Based on Crew, Crew Hours, and Material Allowance	1.00 ls	78	8,148	36,617		5,234	-	49,999.15 /ls	49,999	64,591.84 /ls	64,592
					Site Electrical - Trafo, ductbanks, manholes, cable and FO	1.00 ls	119	12,445	74,562		7,993	-	94,999.47 /ls	94,999	123,087.57 /ls	123,088
					26.00.99.00 Electrical, Other	1.00 LS	197	20,593	111,179		13,226		144,998.62 /LS	144,999	187,679.41 /LS	187,679
					26.00.000 Electrical	1.00 LS	197	20,593	111,179		13,226		144,998.62 /LS	144,999	187,679.41 /LS	187,679
					26.00 Electrical	1.00 LS	197	20,593	111,179		13,226		144,998.62 /LS	144,999	187,679.41 /LS	187,679
					26.0 Electrical Work	1.00 LS	197	20,593	111,179		13,226		144,998.62 /LS	144,999	187,679.41 /LS	187,679
	31.0				Earthwork											



Detail Report

Project Name: Dunnigan Pipeline - Alternate No. 2
Project Number: D3380605
Design Stage: 10% Design

Estimator: Tom Jones
Rev No. / Data: R03 - 02/24/2026
Class Estimate: Class 4

Bid Item	Work Pkg	Trade Pkg	WorkActiv	Unit Price	Description	Takeoff Quantity	Labor Hours	Labor Amount	Material Amount	Sub Amount	Equip Amount	Other Amount	Total Cost/Unit	Total Amount	Grand Total Price	Grand Total Amount	
		31.20			Earthworks, Site												
			31.00.000		Structural Earthworks												
				31.15.01.00	Site Preparation, Clearing and Grubbing												
					Dump charges, typical urban city, fees only, demo lbr, trees, brush	50.50	cy	-	505		-	-	10.00 /cy	505	13.11 /cy	662	
					Clearing & grubbing, brush, including stumps	0.06	AC	12	1,304	-	1,423	-	43,284.40 /AC	2,727	53,618.89 /AC	3,378	
					Hauling, excavated or borrow material, loose cubic yards, 20 mile round trip, 0.5 loads/hour, 20 C.Y. dump trailer, highway haulers, excludes loading	50.50	cy	5	514	-	472	-	19.52 /cy	986	24.18 /cy	1,221	
					31.15.01.00 Site Preparation, Clearing and Grubbing	0.06	AC	17	1,818			1,895	66,945.60 /AC	4,218	83,510.95 /AC	5,261	
				31.15.04.00	Site Preparation, Erosion Controls												
					Erosion Controls Allowance	1.00	ls			12,500	-	-	12,500.00 /ls	12,500	15,484.55 /ls	15,485	
					31.15.04.00 Site Preparation, Erosion Controls	1.00	LS				12,500	-	12,500.00 /LS	12,500	15,484.55 /LS	15,485	
				31.16.01.00	Earthworks, Sheetting and Shoring												
					Shoring Allowance	2,759.00	SF			179,335	-	-	65.00 /SF	179,335	80.52 /SF	222,154	
					31.16.01.00 Earthworks, Sheetting and Shoring	2,759.00	SF				179,335	-	65.00 /SF	179,335	80.52 /SF	222,154	
				31.20.06.00	Earthworks, Sitework, Strip Topsoil												
					Stripping, strip topsoil, clay, very hard, 400 HP dozer, ideal condtn	16.33	CY	1	108	-	-	323	-	26.41 /CY	431	32.72 /CY	534
					31.20.06.00 Earthworks, Sitework, Strip Topsoil	16.33	CY	1	108			323	-	26.41 /CY	431	32.72 /CY	534
				31.25.01.00	Earthworks, Structural, Excavation												
					Excavating, trench or continuous footing, common earth, 3/4 C.Y. excavator, 10' to 14' deep, excludes sheeting or dewatering	2,237.50	CY	218	24,145	-	-	12,738	-	16.48 /CY	36,884	20.42 /CY	45,690
					Stockpile Excavated Spoils	2,237.50	cy	65	7,445	-	6,604	-	6.28 /cy	14,049	7.78 /cy	17,404	
					31.25.01.00 Earthworks, Structural, Excavation	2,237.50	CY	284	31,591		19,342	-	22.76 /CY	50,933	28.20 /CY	63,094	
				31.25.02.00	Earthworks, Structural, Import Aggregates (Slab)												
					Fill, gravel fill, compacted, under floor slabs, alternate pricing method, 12" deep	75.50	CY	16	1,598	3,360	-	101	-	67.00 /CY	5,059	86.23 /CY	6,510
					31.25.02.00 Earthworks, Structural, Import Aggregates (Slab)	75.50	CY	16	1,598	3,360		101	-	67.00 /CY	5,059	86.23 /CY	6,510
				31.25.03.00	Earthworks, Structural, Backfill												
					Fill, from stockpile, 130 H.P., 2-1/2 C.Y., 300' haul, spread fill, with front-end loader, excludes compaction	897.50	CY	15	1,749	-	-	1,645	-	3.78 /CY	3,394	4.68 /CY	4,204
					Fill from Stockpile	897.50	cy	26	2,986	-	2,649	-	6.28 /cy	5,635	7.78 /cy	6,981	
					31.25.03.00 Earthworks, Structural, Backfill	897.50	CY	42	4,736		4,294	-	10.06 /CY	9,029	12.46 /CY	11,185	
				31.25.03.10	Earthworks, Structural, Compaction												
					Compaction, 4 passes, 6" lifts, riding, sheepfoot or wobbly wheel roller	897.50	CY	15	1,749	-	-	1,001	-	3.06 /CY	2,750	3.80 /CY	3,407
					Compaction, water for, 3000 gallon truck, 3 mile haul	897.50	cy	8	853	1,068	-	443	-	2.63 /cy	2,363	3.35 /cy	3,005
					31.25.03.10 Earthworks, Structural, Compaction	897.50	CY	23	2,602	1,068		1,444	-	5.70 /CY	5,114	7.14 /CY	6,412
				32.40.11.01	Surface Restorations												
					Topsoil placement and grading, loam or topsoil, fine grading and seeding, with equipment	302.50	SY	15	1,409	169	-	86	-	5.50 /SY	1,664	6.85 /SY	2,073
					Seeding, mechanical seeding hydro or air seeding for large areas, includes lime, fertilizer and seed with wood fiber mulch added	302.50	sy	6	630	672	-	277	-	5.22 /sy	1,579	6.63 /sy	2,004
					32.40.11.01 Surface Restorations	302.50	SY	21	2,039	841		362	-	10.72 /SY	3,242	13.48 /SY	4,078
					31.00.000 Structural Earthworks	4,124.33	CY	404	44,491	5,774	191,835	27,761	65.43 /CY	269,861	81.16 /CY	334,712	
					31.20 Earthworks, Site	1.00	LS	404	44,491	5,774	191,835	27,761	269,860.91 /LS	269,861	334,712.33 /LS	334,712	
					31.0 Earthwork	4,124.33	CY	404	44,491	5,774	191,835	27,761	65.43 /CY	269,861	81.16 /CY	334,712	
40.0					Process Pipe												
		40.11			Process Pipe, Carbon Steel												
			40.00.000		Valve Vault Piping and Appurtenances												
				40.00.99.01	Process Pipe, Other												
					144" CS butt weld, 1/2" wall	2.00	ea	101	12,840	1,004		1,849	-	7,846.22 /ea	15,692	9,755.99 /ea	19,512
					144" CS Class D flange, 150#	2.00	ea		-	31,553	-	-	-	15,776.55 /ea	31,553	20,687.21 /ea	41,374
					144" Bolt & Gasket Kits, CS, 150# (Need Pricing & MHs)	2.00	ea	42	4,843		-	-	-	2,421.67 /ea	4,843	2,999.88 /ea	6,000
					Ball valve, Flgd, 10"	1.00	ea	32	3,277	9,600	-	600	-	13,476.64 /ea	13,477	17,390.36 /ea	17,390
					Plunger valve, Flgd, 10"	1.00	ea	32	3,277	12,300	-	600	-	16,176.64 /ea	16,177	20,930.78 /ea	20,931
					12" CARV With Swivel Outlet	2.00	ea	64	6,553	22,000	-	1,200	-	14,876.64 /ea	29,753	19,226.13 /ea	38,452
					Piping and Appurtenances	1.00	ls	561	58,451	87,668	-	23,878	-	169,996.56 /ls	169,997	216,941.38 /ls	216,941
					40.00.99.01 Process Pipe, Other	1.00	LS	832	89,241	164,124		28,126	-	281,492.00 /LS	281,492	360,600.91 /LS	360,601
					40.00.000 Valve Vault Piping and Appurtenances	1.00	LS	832	89,241	164,124		28,126	-	281,492.00 /LS	281,492	360,600.91 /LS	360,601
			40.20.06.0010		144" Isolation Valve												
				40.20.06.99	Butterfly Valves, >96"												
					Install butterfly valve, Flgd, fab. steel, 144"	1.00	ea	50	5,739	-	-	-	-	5,738.55 /ea	5,739	7,108.68 /ea	7,109
					FURNISH Butterfly valve, iron body, Flgd, MTR OPER MOD, 150#, 144"	1.00	EA		-		-	-	3,300,000	3,300,000.00 /EA	3,300,000	4,087,918.03 /EA	4,087,918
					40.20.06.99 Butterfly Valves, >96"	1.00	EA	50	5,739			3,300,000	-	3,305,738.55 /EA	3,305,739	4,095,026.71 /EA	4,095,027
					40.20.06.0010 144" Isolation Valve	1.00	EA	50	5,739			3,300,000	-	3,305,738.55 /EA	3,305,739	4,095,026.71 /EA	4,095,027
					40.11 Process Pipe, Carbon Steel	50.00	LF	882	94,980	164,124		28,126	-	3,300,000	3,587,231	89,112.55 /LF	4,455,628
					40.0 Process Pipe	50.00	LF	882	94,980	164,124		28,126	-	3,300,000	3,587,231	89,112.55 /LF	4,455,628
40.9					Instrumentation & Controls												
		40.90			Instrumentation & Controls												
			40.90.000		I&C												
				40.90.99.01	I&C, Other												
					I&C Allowance, Based on 8% of Total	1.00	ls			125,000	-	-	125,000.00 /ls	125,000	154,845.39 /ls	154,845	
					40.90.99.01 I&C, Other	1.00	LS			125,000			-	125,000.00 /LS	125,000	154,845.39 /LS	154,845
					40.90.000 I&C	1.00	LS			125,000			-	125,000.00 /LS	125,000	154,845.39 /LS	154,845
					40.90 Instrumentation & Controls	1.00	LS			125,000			-	125,000.00 /LS	125,000	154,845.39 /LS	154,845
					40.9 Instrumentation & Controls	1.00	LS			125,000			-	125,000.00 /LS	125,000	154,845.39 /LS	154,845
					5022 Valve Vault	1.00	LS	4,240	461,913	662,445	316,835	94,205	3,300,000	4,835,398.28 /LS	4,835,398	6,172,833.70 /LS	6,172,834
5025					Dunnigan Pipeline, Tunneling												
	33.0				Pipelines												
		33.60			Trenchless Technology, Tunneling												
			33.00.106		Dunnigan Pipeline, Trenchless Pipe Installation, at CBD												
				33.60.01.07	Pipeline Specials, Tunneling, 144" Piping in 18'dia. TBM												



Detail Report

Project Name: Dunnigan Pipeline - Alternate No. 2
Project Number: D3380605
Design Stage: 10% Design

Estimator: Tom Jones
Rev No. / Data: R03 - 02/24/2026
Class Estimate: Class 4

Bid Item	Work Pkg	Trade Pkg	WorkActiv	Unit Price	Description	Takeoff Quantity	Labor Hours	Labor Amount	Material Amount	Sub Amount	Equip Amount	Other Amount	Total Cost/Unit	Total Amount	Grand Total Price	Grand Total Amount		
				33.60.01.07	Pipeline Specials, Tunneling, 144" Piping in 18'dia. TBM													
					Mobilization	0.33	Is	4,540	347,628	165,000		118,256	1,911,769.12	/Is	630,884	2,595,655.82	/Is	856,566
					Launch Shaft	40.00	vlf	3,854	317,521	1,253,303	4,722	118,500	42,351.15	/vlf	1,694,046	58,957.97	/vlf	2,358,319
					Reception Shaft	35.00	vlf	3,099	255,415	947,575	3,377	96,771	37,232.52	/vlf	1,303,138	51,798.71	/vlf	1,812,955
					Turn Under at Launch Shaft	1.00	Is	816	67,589	23,145		31,970	122,703.74	/Is	122,704	165,949.25	/Is	165,949
					Assemble 18 Foot TBM	1.00	Is	5,359	450,429	280,320		361,874	1,092,622.72	/Is	1,092,623	1,483,086.11	/Is	1,483,086
					Excavate & Support Long Tunnel 18' Dia. - Tunnel A	840.00	LF	23,046	1,897,401	679,888	23,999	866,981	4,128.89	/LF	3,468,268	5,583.43	/LF	4,690,081
					Muck Haul & Dump	7,917.00	cy	158	12,751	64,999	98,963	8,550	23.40	/cy	185,263	30.67	/cy	242,839
					Furnish & Install Carrier Pipe Tunnel 18' Dia. - 12' Dia. Carrier - Tunnel A	915.00	lf	9,335	759,679	2,455,302		310,304	3,852.77	/lf	3,525,284	5,352.49	/lf	4,897,530
					Indirects	13.00	MO	28,674	2,503,261	2,745,795			403,773.55	/MO	5,249,056	555,870.20	/MO	7,226,313
					Plant & Equipment	840.00	lf					7,351,680	8,752.00	/lf	7,351,680	11,716.85	/lf	9,842,157
					Demobilization	0.33	Is	480	40,085			4,682	135,656.94	/Is	44,767	181,612.52	/Is	59,932
					33.60.01.07 Pipeline Specials, Tunneling, 144" Piping in 18'dia. TBM	840.00	LF	79,362	6,651,759	8,615,326	131,060	9,269,568	29,366.33	/LF	24,667,713	40,042.53	/LF	33,635,728
					33.00.106 Dunnigan Pipeline, Trenchless Pipe Installation, at CBD	840.00	LF	79,362	6,651,759	8,615,326	131,060	9,269,568	29,366.33	/LF	24,667,713	40,042.53	/LF	33,635,728
					33.60 Trenchless Technology, Tunneling	840.00	LF	79,362	6,651,759	8,615,326	131,060	9,269,568	29,366.33	/LF	24,667,713	40,042.53	/LF	33,635,728
					33.0 Pipelines	840.00	LF	79,362	6,651,759	8,615,326	131,060	9,269,568	29,366.33	/LF	24,667,713	40,042.53	/LF	33,635,728
					5025 Dunnigan Pipeline, Tunneling	840.00	LF	79,362	6,651,759	8,615,326	131,060	9,269,568	29,366.33	/LF	24,667,713	40,042.53	/LF	33,635,728
5300					Dunnigan - Sac River Discharge Structure													
	01.0				General Requirements													
		01.01			Construction Operations													
			01.00.202		Dunnigan - Sac River Discharge Structure, Removal and Control of Water													
				31.15.02.01	Dewatering													
					CBD Discharge Structure, Removal and Control of Water	3.00	MO			135,000	-	-	45,000.00	/MO	135,000	55,744.33	/MO	167,233
					31.15.02.01 Dewatering	3.00	MO			135,000			45,000.00	/MO	135,000	55,744.33	/MO	167,233
					01.00.202 Dunnigan - Sac River Discharge Structure, Removal and Control of Water	3.00	MO			135,000			45,000.00	/MO	135,000	55,744.33	/MO	167,233
					01.01 Construction Operations	3.00	MO			135,000			45,000.00	/MO	135,000	55,744.33	/MO	167,233
					01.0 General Requirements	3.00	MO			135,000			45,000.00	/MO	135,000	55,744.33	/MO	167,233
	03.0				Concrete Work													
		03.13			Cast-In-Place Concrete, Continuous Footings													
			03.00.116		Dunnigan - Sac River Discharge Structure, Discharge Pipes Support Wall													
				03.10.02.24	Cast-In-Place Concrete, Continuous Footings, 24" thick													
					C.I.P. concrete forms, footing, keyway, tapered wood, 2" x 6", 4 use, includes erecting, bracing, stripping and cleaning	124.00	lf	16	1,772	92	-	-	15.03	/lf	1,864	21.68	/lf	2,688
					Reinforcing Steel, in place, footings, #4 to #7, A615, grade 60, incl labor for accessories, excl material for accessories	4.90	ton	75	8,736	6,738	-	-	3,157.89	/ton	15,474	4,643.14	/ton	22,751
					Reinforcing steel, unload and sort, add to base	4.90	ton	3	327	-	-	114	89.94	/ton	441	129.40	/ton	634
					Reinforcing steel, crane cost for handling, average, add	4.90	ton	3	356	-	-	124	97.77	/ton	479	140.66	/ton	689
					Struct concrete,ready mix,normal wt,4500 psi,includes local aggregate,sand,portland cement and water,delivered,excludes all additives and treatments	58.00	cy		-	12,760	-	-	220.00	/cy	12,760	332.48	/cy	19,284
					Structural concrete, placing, continuous footing, deep, pumped, includes strike off & consolidation, excludes material	56.00	CY	22	2,145	-	-	316	43.93	/CY	2,460	63.21	/CY	3,540
					03.10.02.24 Cast-In-Place Concrete, Continuous Footings, 24" thick	56.00	CY	119	13,335	19,589		553	597.81	/CY	33,477	885.47	/CY	49,586
					03.00.116 Dunnigan - Sac River Discharge Structure, Discharge Pipes Support Wall	56.00	CY	119	13,335	19,589		553	597.81	/CY	33,477	885.47	/CY	49,586
					03.13 Cast-In-Place Concrete, Continuous Footings	56.00	CY	119	13,335	19,589		553	597.81	/CY	33,477	885.47	/CY	49,586
		03.18			Cast-In-Place Concrete, Slabs on Grade													
			03.00.112		Dunnigan - Sac River Discharge Structure, Elevated Slab and Beams													
				03.10.05.48	Cast-In-Place Concrete, Slabs on Grade, 48" thick													
					C.I.P. concrete forms, slab on grade, edge, wood, over 12", 4 use, includes erecting, bracing, stripping and cleaning	1,336.00	sfca	124	12,982	2,659	-	-	11.71	/sfca	15,641	16.99	/sfca	22,696
					Reinforcing Steel, in place, slab on grade, #3 to #7, A615, grade 60, incl labor for accessories, excl material for accessories	44.54	ton	713	83,380	61,243	-	-	3,247.03	/ton	144,623	4,771.40	/ton	212,518
					Reinforcing in place, unloading & sorting, add to above - slabs	44.54	ton	25	2,973	-	-	1,033	89.94	/ton	4,006	129.41	/ton	5,764
					Reinforcing in place, unloading & sorting, add - walls, cols, beams	44.54	ton	25	2,973	-	-	1,033	89.94	/ton	4,006	129.41	/ton	5,764
					Struct concrete,ready mix,normal wt,4500 psi,includes local aggregate,sand,portland cement and water,delivered,excludes all additives and treatments	525.00	cy		-	115,500	-	-	220.00	/cy	115,500	332.48	/cy	174,551
					Structural concrete, placing, slab on grade, pumped, over 6" thick, includes strike off & consolidation, excludes material	509.00	CY	176	16,860	-	-	2,480	38.00	/CY	19,340	54.67	/CY	27,826
					Cfnsh,flrs,for spcf rndm acce flrs aci cls 1,2,3 and 4,achv a cmps ovrl flr fltn&lvln val f35/25,bull flt,mchn flt&stl trwl (wlk-bhn),excl plcn,strkn	3,432.00	sf	48	4,381	-	-	175	1.33	/sf	4,556	1.91	/sf	6,555
					Curing, sprayed membrane curing compound	34.32	csf	6	526	619	-	-	33.38	/csf	1,145	49.33	/csf	1,693
					Fine grading, fine grade for slab on grade, machine	381.33	sy	6	634	-	-	408	2.73	/sy	1,042	3.93	/sy	1,499
					03.10.05.48 Cast-In-Place Concrete, Slabs on Grade, 48" thick	509.00	CY	1,123	124,710	180,021		5,129	608.76	/CY	309,860	901.51	/CY	458,866
					03.00.112 Dunnigan - Sac River Discharge Structure, Elevated Slab and Beams	509.00	CY	1,123	124,710	180,021		5,129	608.76	/CY	309,860	901.51	/CY	458,866
			03.00.118		Dunnigan - Sac River Discharge Structure, Stilling Basin and Apron													
				03.10.00.18	Concrete, Cast-in-Place, Grade Walls, 18" Wide													
					Reinforcing Steel, in place, footings, #4 to #7, A615, grade 60, incl labor for accessories, excl material for accessories	4.30	ton	69	8,050	5,913	-	-	3,247.03	/ton	13,962	4,771.40	/ton	20,517
					Reinforcing steel, unload and sort, add to base	4.30	ton	2	287	-	-	100	89.94	/ton	387	129.41	/ton	556
					Reinforcing steel, crane cost for handling, average, add	4.30	ton	3	312	-	-	108	97.77	/ton	420	140.67	/ton	605
					Struct concrete,ready mix,normal wt,4500 psi,includes local aggregate,sand,portland cement and water,delivered,excludes all additives and treatments	51.00	cy		-	11,220	-	-	220.00	/cy	11,220	332.48	/cy	16,956
					Structural concrete, placing, continuous footing, deep, pumped, includes strike off & consolidation, excludes material	49.00	CY	20	1,877	-	-	276	43.93	/CY	2,153	63.21	/CY	3,097
					Excavating, trench or continuous footing, common earth, 1/2 C.Y. excavator, 4' to 6' deep, excludes sheeting or dewatering	49.00	bcy	4	423	-	-	89	10.47	/bcy	513	15.06	/bcy	738
					Hauling, excavated or borrow material, loose cubic yards, 20 mile round trip, 0.5 loads/hour, 20 C.Y. dump trailer, highway haulers, excludes loading	49.00	lcy	5	498	-	-	458	19.52	/lcy	956	28.08	/lcy	1,376



Detail Report

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Project Number: D3380605
Design Stage: 10% Design

Estimator: Tom Jones
Rev No. / Data: R03 - 02/24/2026
Class Estimate: Class 4

Bid Item	Work Pkg	Trade Pkg	WorkActiv	Unit Price	Description	Takeoff Quantity	Labor Hours	Labor Amount	Material Amount	Sub Amount	Equip Amount	Other Amount	Total Cost/Unit	Total Amount	Grand Total Price	Grand Total Amount
					03.10.00.18 Concrete, Cast-in-Place, Grade Walls, 18" Wide	49.00 CY	102	11,447	17,133		1,031		604.31 /CY	29,611	894.81 /CY	43,846
				03.10.02.24	Cast-In-Place Concrete, Continuous Footings, 24" thick											
					C.I.P. concrete forms, footing, keyway, tapered wood, 2" x 6", 4 use, includes erecting, bracing, stripping and cleaning	130.00 lf	17	1,858	96	-	-	-	15.03 /lf	1,954	21.68 /lf	2,818
					Reinforcing Steel, in place, footings, #4 to #7, A615, grade 60, incl labor for accessories, excl material for accessories	5.10 ton	78	9,093	7,013	-	-	-	3,157.89 /ton	16,105	4,643.14 /ton	23,680
					Reinforcing steel, unload and sort, add to base	5.10 ton	3	340	-	-	118	-	89.95 /ton	459	129.41 /ton	660
					Reinforcing steel, crane cost for handling, average, add	5.10 ton	3	370	-	-	129	-	97.77 /ton	499	140.66 /ton	717
					Struct concrete,ready mix,normal wt,4500 psi,includes local aggregate,sand,portland cement and water,delivered,excludes all additives and treatments	60.00 cy		-	13,200	-	-	-	220.00 /cy	13,200	332.48 /cy	19,949
					Structural concrete, placing, continuous footing, deep, pumped, includes strike off & consolidation, excludes material	58.00 CY	23	2,221	-	-	327	-	43.93 /CY	2,548	63.21 /CY	3,666
					03.10.02.24 Cast-In-Place Concrete, Continuous Footings, 24" thick	58.00 CY	124	13,882	20,309		574		599.39 /CY	34,764	887.76 /CY	51,490
				03.10.05.12	Cast-In-Place Concrete, Slabs on Grade, 12" thick											
					C.I.P. concrete forms, slab on grade, edge, wood, over 12", 4 use, includes erecting, bracing, stripping and cleaning	298.00 sfca	28	2,896	593	-	-	-	11.71 /sfca	3,489	16.99 /sfca	5,062
					Reinforcing Steel, in place, slab on grade, #3 to #7, A615, grade 60, incl labor for accessories, excl material for accessories	34.92 ton	559	65,371	48,015	-	-	-	3,247.03 /ton	113,386	4,771.40 /ton	166,617
					Reinforcing in place, unloading & sorting, add to above - slabs	34.92 ton	20	2,331	-	-	810	-	89.94 /ton	3,141	129.41 /ton	4,519
					Reinforcing in place, unloading & sorting, add - walls, cols, beams	34.92 ton	20	2,331	-	-	810	-	89.94 /ton	3,141	129.41 /ton	4,519
					Struct concrete,ready mix,normal wt,4500 psi,includes local aggregate,sand,portland cement and water,delivered,excludes all additives and treatments	411.00 cy		-	90,420	-	-	-	220.00 /cy	90,420	332.48 /cy	136,648
					Structural concrete, placing, slab on grade, pumped, over 6" thick, includes strike off & consolidation, excludes material	399.00 CY	138	13,216	-	-	1,944	-	38.00 /CY	15,161	54.67 /CY	21,813
					Cfnsh,firs,for spcf rndm accs firs aci clss 1,2,3 and 4,achv a cmps ovrl fir fltn&lvln val f35/25,bull fit,mchn fit&std trwl (wlk-bhn),excl plcn,strkn	10,757.00 sf	151	13,733	-	-	548	-	1.33 /sf	14,281	1.91 /sf	20,546
					Curing, sprayed membrane curing compound	107.57 csf	18	1,649	1,942	-	-	-	33.38 /csf	3,590	49.33 /csf	5,306
					Fine grading, fine grade for slab on grade, machine	1,195.22 sy	18	1,986	-	-	1,279	-	2.73 /sy	3,265	3.93 /sy	4,698
					03.10.05.12 Cast-In-Place Concrete, Slabs on Grade, 12" thick	399.00 CY	951	103,513	140,970		5,391		626.25 /CY	249,874	926.64 /CY	369,729
					03.00.118 Dunnigan - Sac River Discharge Structure, Stilling Basin and Apron	506.00 CY	1,177	128,843	178,411		6,996		621.05 /CY	314,249	919.10 /CY	465,065
					03.18 Cast-In-Place Concrete, Slabs on Grade	1,015.00 CY	2,299	253,553	358,431		12,124		614.89 /CY	624,109	910.28 /CY	923,931
		03.20			Cast-In-Place Concrete, Straight Walls											
			03.00.114		Dunnigan - Sac River Discharge Structure, Concrete Walls											
				03.10.06.48	Cast-In-Place Concrete, Straight Walls, 48" thick											
					C.I.P. concrete forms, wall, box out for opening, includes erecting, bracing, stripping and cleaning	581.00 lf	179	19,050	2,620	-	-	-	37.30 /lf	21,670	53.99 /lf	31,368
					Forms in place, wall, steel framed plywood, >16' high, 3 use/month	22,344.00 sfca	2,357	251,176	121,775	-	-	-	16.69 /sfca	372,951	24.41 /sfca	545,417
					Form oil, coverage varies greatly, maximum, includes material only	59.60 gal		-	1,937	-	-	-	32.50 /gal	1,937	49.12 /gal	2,927
					Reinforcing Steel, in place, walls, #3 to #7, A615, grade 60, incl labor for accessories, excl material for accessories	142.00 ton	2,272	265,829	195,250	-	-	-	3,247.03 /ton	461,079	4,771.40 /ton	677,538
					Reinforcing in place, unloading & sorting, add - walls, cols, beams	142.00 ton	80	9,479	-	-	3,293	-	89.94 /ton	12,772	129.41 /ton	18,376
					Reinforcing, crane cost for handling, add to above, walls, cols, beams	142.00 ton	86	10,304	-	-	3,579	-	97.76 /ton	13,883	140.66 /ton	19,974
					Struct concrete,ready mix,normal wt,4500 psi,includes local aggregate,sand,portland cement and water,delivered,excludes all additives and treatments	1,670.00 cy		-	367,400	-	-	-	220.00 /cy	367,400	332.48 /cy	555,238
					Structural concrete, placing, walls, pumped, 15" thick, includes strike off & consolidation, excludes material	1,622.00 CY	865	82,829	-	-	12,185	-	58.58 /CY	95,015	84.28 /CY	136,704
					Finishing: break ties & patch voids (walls, cols or beams)	21,888.00 sf		29,610	657	-	-	-	1.38 /sf	30,266	1.99 /sf	43,593
					03.10.06.48 Cast-In-Place Concrete, Straight Walls, 48" thick	1,622.00 CY	6,163	668,277	689,639		19,057		848.93 /CY	1,376,972	1,252.24 /CY	2,031,136
					03.00.114 Dunnigan - Sac River Discharge Structure, Concrete Walls	1,622.00 CY	6,163	668,277	689,639		19,057		848.93 /CY	1,376,972	1,252.24 /CY	2,031,136
			03.00.116		Dunnigan - Sac River Discharge Structure, Discharge Pipes Support Wall											
				03.10.06.18	Cast-In-Place Concrete, Straight Walls, 18" thick											
					C.I.P. concrete forms, wall, box out for opening, includes erecting, bracing, stripping and cleaning	189.00 lf	106	11,347	852	-	-	-	64.55 /lf	12,199	93.19 /lf	17,613
					Forms in place, wall, steel framed plywood, >16' high, 3 use/month	3,596.00 sfca	379	40,424	19,598	-	-	-	16.69 /sfca	60,022	24.41 /sfca	87,778
					Form oil, coverage varies greatly, maximum, includes material only	9.60 gal		-	312	-	-	-	32.50 /gal	312	49.12 /gal	472
					Reinforcing Steel, in place, walls, #3 to #7, A615, grade 60, incl labor for accessories, excl material for accessories	8.40 ton	134	15,725	11,550	-	-	-	3,247.03 /ton	27,275	4,771.40 /ton	40,080
					Reinforcing in place, unloading & sorting, add - walls, cols, beams	8.40 ton	5	561	-	-	195	-	89.94 /ton	756	129.41 /ton	1,087
					Reinforcing, crane cost for handling, add to above, walls, cols, beams	8.40 ton	5	610	-	-	212	-	97.76 /ton	821	140.66 /ton	1,182
					Struct concrete,ready mix,normal wt,4500 psi,includes local aggregate,sand,portland cement and water,delivered,excludes all additives and treatments	99.00 cy		-	21,780	-	-	-	220.00 /cy	21,780	332.48 /cy	32,915
					Structural concrete, placing, walls, pumped, 15" thick, includes strike off & consolidation, excludes material	96.00 CY	51	4,902	-	-	721	-	58.58 /CY	5,624	84.28 /CY	8,091
					Finishing: break ties & patch voids (walls, cols or beams)	3,454.00 sf		4,672	104	-	-	-	1.38 /sf	4,776	1.99 /sf	6,879
					03.10.06.18 Cast-In-Place Concrete, Straight Walls, 18" thick	96.00 CY	732	78,241	54,196		1,128		1,391.30 /CY	133,565	2,042.68 /CY	196,097
					03.00.116 Dunnigan - Sac River Discharge Structure, Discharge Pipes Support Wall	96.00 CY	732	78,241	54,196		1,128		1,391.30 /CY	133,565	2,042.68 /CY	196,097
			03.00.118		Dunnigan - Sac River Discharge Structure, Stilling Basin and Apron											
				03.10.06.12	Cast-In-Place Concrete, Straight Walls, 12" thick											
					Forms in place, wall, steel framed plywood, >16' high, 3 use/month	2,606.00 sfca	275	29,295	14,203	-	-	-	16.69 /sfca	43,498	24.41 /sfca	63,612
					Form oil, coverage varies greatly, maximum, includes material only	7.00 gal		-	228	-	-	-	32.50 /gal	228	49.12 /gal	344
					Reinforcing Steel, in place, walls, #3 to #7, A615, grade 60, incl labor for accessories, excl material for accessories	4.50 ton	72	8,424	6,188	-	-	-	3,247.03 /ton	14,612	4,771.40 /ton	21,471
					Reinforcing in place, unloading & sorting, add - walls, cols, beams	4.50 ton	3	300	-	-	104	-	89.94 /ton	405	129.40 /ton	582
					Struct concrete,ready mix,normal wt,4500 psi,includes local aggregate,sand,portland cement and water,delivered,excludes all additives and treatments	51.00 cy		-	11,220	-	-	-	220.00 /cy	11,220	332.48 /cy	16,956
					Structural concrete, placing, walls, pumped, 15" thick, includes strike off & consolidation, excludes material	49.00 CY	26	2,502	-	-	368	-	58.58 /CY	2,870	84.28 /CY	4,130
					Finishing: break ties & patch voids (walls, cols or beams)	2,606.00 sf	39	3,525	78	-	-	-	1.38 /sf	3,604	1.99 /sf	5,190
					03.10.06.12 Cast-In-Place Concrete, Straight Walls, 12" thick	49.00 CY	414	44,047	31,916		472		1,559.91 /CY	76,435	2,291.56 /CY	112,286
				03.10.06.18	Cast-In-Place Concrete, Straight Walls, 18" thick											
					Forms in place, wall, steel framed plywood, >16' high, 3 use/month	2,340.00 sfca	247	26,305	12,753	-	-	-	16.69 /sfca	39,058	24.41 /sfca	57,119



Detail Report

Project Name: Dunnigan Pipeline - Alternate No. 2
Project Number: D3380605
Design Stage: 10% Design

Estimator: Tom Jones
Rev No. / Data: R03 - 02/24/2026
Class Estimate: Class 4

Bid Item	Work Pkg	Trade Pkg	WorkActiv	Unit Price	Description	Takeoff Quantity	Labor Hours	Labor Amount	Material Amount	Sub Amount	Equip Amount	Other Amount	Total Cost/Unit	Total Amount	Grand Total Price	Grand Total Amount
				03.10.06.18	Cast-In-Place Concrete, Straight Walls, 18" thick											
					Form oil, coverage varies greatly, maximum, includes material only	6.25 gal		-	203	-	-	-	32.50 /gal	203	49.12 /gal	307
					Reinforcing Steel, in place, walls, #3 to #7, A615, grade 60, incl labor for accessories, excl material for accessories	5.70 ton	91	10,671	7,838	-	-	-	3,247.03 /ton	18,508	4,771.40 /ton	27,197
					Reinforcing in place, unloading & sorting, add - walls, cols, beams	5.70 ton	3	381	-	-	132	-	89.94 /ton	513	129.41 /ton	738
					Reinforcing, crane cost for handling, add to above, walls, cols, beams	5.70 ton	3	414	-	-	144	-	97.77 /ton	557	140.66 /ton	802
					Struct concrete,ready mix,normal wt,4500 psi,includes local aggregate,sand,portland cement and water,delivered,excludes all additives and treatments	67.00 cy		-	14,740	-	-	-	220.00 /cy	14,740	332.48 /cy	22,276
					Structural concrete, placing, walls, pumped, 15" thick, includes strike off & consolidation, excludes material	65.00 CY	35	3,319	-	-	488	-	58.58 /CY	3,808	84.28 /CY	5,478
					Finishing: break ties & patch voids (walls, cols or beams)	2,340.00 sf	35	3,165	70	-	-	-	1.38 /sf	3,236	1.99 /sf	4,660
					03.10.06.18 Cast-In-Place Concrete, Straight Walls, 18" thick	65.00 CY	414	44,254	35,604		764		1,240.34 /CY	80,622	1,824.27 /CY	118,577
					03.00.118 Dunnigan - Sac River Discharge Structure, Stilling Basin and Apron	114.00 CY	828	88,301	67,520		1,237		1,377.70 /CY	157,058	2,025.12 /CY	230,864
					03.20 Cast-In-Place Concrete, Straight Walls	1,832.00 CY	7,724	834,819	811,355		21,421		910.26 /CY	1,667,595	1,341.76 /CY	2,458,097
					03.0 Concrete Work	2,903.00 CY	10,142	1,101,707	1,189,375		34,098		800.96 /CY	2,325,181	1,182.09 /CY	3,431,614
05.0					Metals											
		05.00			Metals											
			05.00.004		Dunnigan - Sac River Discharge Structure, Grating and Structural Supports											
				05.50.05.00	Metals, Gratings											
					Grating frame, aluminum, 1" to 1-1/2" D, field fabricated	282.00 lf	32	3,997	1,348	-	-	-	18.95 /lf	5,345	27.62 /lf	7,788
					Grating frame, aluminum, 1" to 1-1/2" D, field fabricated, for each corner, add	4.00 ea		-	18	-	-	-	4.61 /ea	18	6.97 /ea	28
					Floor grating, steel, galv, 2-1/4" x 3/16" bearing bars @ 1-3/16" O.C., cross bars @ 2" O.C., over 300 S.F., field fabricated from panels	1,310.00 SF	163	20,254	72,050	-	7,986	-	76.56 /SF	100,290	114.14 /SF	149,517
					05.50.05.00 Metals, Gratings	1,310.00 SF	195	24,251	73,416		7,986		80.65 /SF	105,653	120.10 /SF	157,333
					05.00.004 Dunnigan - Sac River Discharge Structure, Grating and Structural Supports	1,310.00 SF	195	24,251	73,416		7,986		80.65 /SF	105,653	120.10 /SF	157,333
					05.00 Metals	1.00 LS	195	24,251	73,416		7,986		105,653.13 /LS	105,653	157,332.51 /LS	157,333
					05.0 Metals	1.00 LS	195	24,251	73,416		7,986		105,653.13 /LS	105,653	157,332.51 /LS	157,333
31.0					Earthwork											
		31.25			Earthworks, Structural											
			31.00.104		Dunnigan - Sac River Discharge Structure, Excavation and Backfill											
				31.16.01.00	Earthworks, Sheetting and Shoring											
					Three Sided Shoring of Excavation	10,380.00 SF				467,100			45.00 /SF	467,100	55.74 /SF	578,626
					31.16.01.00 Earthworks, Sheetting and Shoring	10,380.00 SF				467,100			45.00 /SF	467,100	55.74 /SF	578,626
				31.25.01.00	Earthworks, Structural, Excavation											
					Structural Excavation, excludes sheeting or dewatering	6,800.00 CY	227	25,072	-	-	24,329	-	7.26 /CY	49,401	9.00 /CY	61,196
					Stockpile Excavated Spoils	6,800.00 cy	102	11,596	1,700	-	10,286	-	3.47 /cy	23,582	4.31 /cy	29,336
					31.25.01.00 Earthworks, Structural, Excavation	6,800.00 CY	329	36,668	1,700		34,615		10.73 /cy	72,983	13.31 /CY	90,532
				31.25.02.00	Earthworks, Structural, Import Aggregates (Slab)											
					Fill, gravel fill, compacted, under floor slabs, alternate pricing method, 12" deep	605.00 CY	132	12,807	21,175	-	806	-	57.50 /CY	34,789	73.77 /CY	44,630
					31.25.02.00 Earthworks, Structural, Import Aggregates (Slab)	605.00 CY	132	12,807	21,175		806		57.50 /CY	34,789	73.77 /CY	44,630
				31.25.03.00	Earthworks, Structural, Backfill											
					Backfill, Native material	19,000.00 CY	1,425	162,004		-	35,926	-	10.42 /CY	197,930	12.90 /CY	245,188
					Purchase and Deliver Fill Material	12,200.00 cy			427,000	-		-	35.00 /cy	427,000	45.89 /cy	559,909
					Compaction, 4 passes, 6" lifts, riding, sheepsfoot or wobbly wheel roller	15,200.00 cy	152	17,280	-	-	9,890	-	1.79 /cy	27,170	2.21 /cy	33,657
					Compaction, 4 passes, 13" to 18", 8" lifts, rammer tamper	3,800.00 cy	78	7,093	-	-	875	-	2.10 /cy	7,968	2.60 /cy	9,870
					Compaction, water for, 6000 gallon wagon, 6 mile haul	19,000.00 cy	95	9,422	22,800	-	6,167	-	2.02 /cy	38,389	2.59 /cy	49,208
					31.25.03.00 Earthworks, Structural, Backfill	19,000.00 CY	1,750	195,800	449,800		52,857		36.76 /CY	698,457	47.25 /CY	897,833
					31.00.104 Dunnigan - Sac River Discharge Structure, Excavation and Backfill	26,405.00 CY	2,211	245,275	472,675	467,100	88,278		48.22 /CY	1,273,328	61.03 /CY	1,611,621
					31.25 Earthworks, Structural	26,405.00 CY	2,211	245,275	472,675	467,100	88,278		48.22 /CY	1,273,328	61.03 /CY	1,611,621
					31.0 Earthwork	26,405.00 CY	2,211	245,275	472,675	467,100	88,278		48.22 /CY	1,273,328	61.03 /CY	1,611,621
40.0					Process Pipe											
		40.11			Process Pipe, Carbon Steel											
			33.00.112		Dunnigan - Sac River Discharge Structure, Above Grade Piping											
				40.10.02.36	Process Pipe, Carbon Steel, 36"											
					Piping, pipe, WSP, plain end, welded, 36" diameter, excludes excavation or backfill	3,405.00 LF	1,315	137,003	1,362,000	-	55,966	-	456.67 /LF	1,554,969	594.71 /LF	2,024,983
					TideFlex Check Valves, 36" Dia	20.00 ea	160	18,102	476,000	-	10,400	-	25,225.11 /ea	504,502	32,973.44 /ea	659,469
					Miscellaneous Items Allowance	1.00 ls		62,150	124,300	-	62,150	-	248,600.00 /ls	248,600	316,968.24 /ls	316,968
					40.10.02.36 Process Pipe, Carbon Steel, 36"	3,405.00 LF	1,475	217,255	1,962,300		128,516		677.85 /LF	2,308,071	881.47 /LF	3,001,420
					33.00.112 Dunnigan - Sac River Discharge Structure, Above Grade Piping	3,405.00 LF	1,475	217,255	1,962,300		128,516		677.85 /LF	2,308,071	881.47 /LF	3,001,420
					40.11 Process Pipe, Carbon Steel	3,405.00 LF	1,475	217,255	1,962,300		128,516		677.85 /LF	2,308,071	881.47 /LF	3,001,420
					40.0 Process Pipe	3,405.00 LF	1,475	217,255	1,962,300		128,516		677.85 /LF	2,308,071	881.47 /LF	3,001,420
					5300 Dunnigan - Sac River Discharge Structure	11,690.00 SF	14,023	1,588,488	3,697,767	602,100	258,879		525.85 /SF	6,147,233	715.93 /SF	8,369,221



Estimate Totals

Description	Amount	Totals	Hours	Rate
Labor	60,806,674		571,475.852	
Material	88,045,134			
Subcontractor	5,829,995			
Equipment	25,212,003		276,776.942	
Other	3,300,000			
Subtotal Direct Costs	183,193,807	183,193,807		
Material Sales Tax, Dunnigan Ca	6,383,272			7.250 %
Subtotal w/ Sales Tax	6,383,272	189,577,079		
Concrete Sub OH&P	578,059			20.000 %
Architectural Sub OH&P	43,002			20.000 %
Tunnel Profit	2,453,665			10.000 %
Subtotal w/ Sub Markup	3,074,726	192,651,805		
Mobilization/Demobilization	5,779,554			3.000 %
Prime Contractor Overhead	19,843,136			10.000 %
Prime Contractor Profit	13,096,470			6.000 %
Bonds & Insurance	5,020,750			2.170 %
Subtotal w/ Prime Markups	43,739,910	236,391,715		
Contractor Contingency	7,091,751			3.000 %
Design Contingency	70,917,514			30.000 %
Subtotal w/ Contingency	78,009,266	314,400,981		
Opinion of Probable Construction Costs		314,400,981		

Appendix B

AACEI Classification

Estimate Class	Class 5		Class 4		Class 3		Class 2		Class 1	
LEVEL OF PROJECT DEFINITION Expressed as a % of complete definition	0% to 2%		1% to 15%		10% to 40%		30% to 75%		65% to 100%	
END USAGE Typical Purpose of Estimate	Concept Screening		Study or Feasibility		Budget Authorization, or Control		Control or Bid / Tender		Check Estimate or Bid / Tender	
METHODOLOGY Typical estimating method	Capacity Factored, Parametric Models, Judgment, or Analogy		Equipment Factored or Parametric Models		Semi-Detailed Unit Costs with Assembly Level Line Items		Detailed Unit Cost with Forced Detailed Take-Off		Detailed Unit Cost with Detailed Take-Off	
EXPECTED ACCURACY RANGE Typical variation in low and high ranges [a]	L: -20% to -50%	H: +30% to +100%	L: -15% to -30%	H: +20% to +50%	L: -10% to -20%	H: +10% to +30%	L: -5% to -15%	H: +5% to +20%	L: -3% to -10%	H: +3% to +15%
REFINED CLASS DEFINITION	Class 5 estimates are generally prepared based on very limited information, and subsequently have very wide accuracy ranges. As such, some companies and organizations have elected to determine that due to the inherent inaccuracies, such estimates cannot be classified in a conventional and systematic manner. Class 5 estimates, due to the requirements of end use, may be prepared within a very limited amount of time and with very little effort expended - sometimes requiring less than 1 hour to prepare. Often, little more than proposed plant type, location, and capacity are known at the time of estimate preparation.		Class 4 estimates are generally prepared based on very limited information, and subsequently have very wide accuracy ranges. They are typically used for project screening, determination of feasibility, concept evaluation, and preliminary budget approval. Typically, engineering is from 1% to 5% complete, and would comprise at a minimum the following: plant capacity, block schematics, indicated layout, process flow diagrams (PFDs) for main process systems and preliminary engineered process and utility equipment lists. Level of Project Definition Required: 1% to 15% of full project definition.		Class 3 estimates are generally prepared to form the basis for budget authorization, appropriation, and/or funding. As such, they typically form the initial control estimate against which all actual costs and resources will be monitored. Typically, engineering is from 10% to 40% complete, and would comprise at a minimum the following: process flow diagrams, utility flow diagrams, preliminary piping and instrument diagrams, utility flow diagrams, preliminary piping and instrument diagrams, plot plan, developed layout drawings, and essentially complete engineering process and utility equipment lists. Level Of Project Definition Required: 10% to 40% of full project definition.		Class 2 estimates are generally prepared to form a detailed control baseline against which all project work is monitored in terms of cost and progress control. For contractors, this class of estimate is often used as the "bid" estimate to establish contract value. Typically, engineering is from 30% to 70% complete, and would comprise at a minimum the following: Process flow diagrams, utility flow diagrams, piping and instrument flow diagrams, heat and material balances, final plot plan, final layout drawings, complete engineered process and utility equipment lists, single line diagrams for electrical, electrical equipment and motor schedules, vendor quotations, detailed project execution plans, resourcing and work force plans, etc.		Class 1 estimates are generally prepared for discrete parts or sections of the total project rather than generating this level of detail for the entire project. The parts of the project estimated at this level of detail will typically be used by subcontractors for bids, or by owners for check estimates. The updated estimate is often referred to as the current control estimate and becomes the new baseline for cost/schedule control of the project. Class 1 estimates may be prepared for parts of the project to comprise a fair price estimate or bid check estimate to compare against a contractor's bid estimate, or to evaluate/dispute claims. Typically, engineering is from 65% to 100% complete, and would comprise virtually all engineering and design documentation of the project, and complete project execution and commissioning plans. Level for Project Definition Required: 50% to 100% of full project definition.	
MATURITY LEVEL OF PROJECT DELIVERABLES	Key deliverable and target status: Block flow diagram agreed by key stakeholders. 0% to 2% of full project definition.		Key deliverable and target status: Process flow diagrams (PFDs) issued for design. 1% to 15% of full project definition.		Key deliverable and target status: Piping and instrumentation diagrams (P&IDs) issued for design. 10% to 40% of full project definition.		Key deliverable and target status: All specifications and datasheets complete including for instrumentation. 30% to 75% of full project definition.		Key deliverable and target status: All deliverables in the maturity matrix complete. 65% to 100% of full project definition.	
END USAGE DEFINED	Class 5 estimates are prepared for any number of strategic business planning purposes, such as but not limited to market studies, assessment of initial viability, evaluation of alternate schemes, project screening, project location studies, evaluation of resource needs and budgeting, long-range capital planning, etc.		Class 4 estimates are prepared for a number of purposes, such as but not limited to, detailed strategic planning, business development, project screening at more developed stages, alternative scheme analysis, confirmation of economic and/or technical feasibility, and preliminary budget approval or approval to proceed to next stage.		Class 3 estimates are typically prepared to support full project funding requests, and become the first of the project phase control estimates against which all actual costs and resources will be monitored for variations to the budget. They are used as the project budget until replaced by more detailed estimates. In many owner organizations, a Class 3 estimate is often the last estimate required and could very well form the only basis for cost/schedule control.		Class 2 estimates are typically prepared as the detailed control baseline against which all actual costs an resources will now be monitored for variation to the budget, and form a part of the change/variation control program.		Generally, owners and EPC contractors use Class 1 estimates to support their change management process. They may be used to evaluate bid checking, to support vendor/contractor negotiations, or for claim evaluations and dispute resolution. Construction contractors may prepare Class 1 estimates to support their bidding and to act as their final control baseline against which all actual costs and resources will now be monitored for variations to their bid. During construction, Class 1 estimates may be prepared to support change management.	
ESTIMATING METHODOLOGY	Class 5 estimates virtually always use stochastic estimating methods such as cost/capacity curves and factors, scale of operations factors, Lang factors, Hand factors, Chilton factors, Peters-Timmerhaus factors, Guthrie factors, and other parametric and modeling techniques.		Class 4 estimates virtually always use stochastic estimating methods such as cost/capacity curves and factors, scale of operations factors, Lang factors, Hand factors, Chilton factors, Peters-Timmerhaus factors, Guthrie factors, the Miller method, gross unit costs/ratios, and other parametric and modeling techniques.		Class 3 estimates usually involve more deterministic estimating methods that stochastic methods. They usually involve a high degree of unit cost line items, although these may be at an assembly level of detail rather than individual components. Factoring and other stochastic methods may be used to estimate less-significant areas of the project.		Class 2 estimates always involve a high degree of deterministic estimating methods. Class 2 estimates are prepared in great detail, and often involve tens of thousands of unit cost line items. For those areas of the project still undefined, an assumed level of detailed takeoff (forced detail) may be developed to use as line items in the estimate instead of relying on factoring methods.		Class 1 estimates involve the highest degree of deterministic estimating methods, and require a great amount of effort. Class 1 estimates are prepared in great detail, and thus are usually performed on only the most important or critical areas of the project. All items in the estimate are usually unit cost line items based on actual design quantities.	
EXPECTED ACCURACY RANGE	Typical accuracy ranges for Class 5 estimates are -20% to -50% on the low side, and +30% to +100% on the high side, depending on the technological complexity of the project, appropriate reference information and other risks (after inclusion of an appropriate contingency determination). Ranges could exceed those shown if there are unusual risks.		Typical accuracy ranges for Class 4 estimates are -15% to -30% on the low side, and +20% to +50% on the high side, depending on the technological complexity of the project, appropriate reference information, and the inclusion of an appropriate contingency determination. Ranges could exceed those shown in unusual circumstances.		Typical accuracy ranges for Class 3 estimates are -10% to -20% on the low side, and +10% to +30% on the high side, depending on the technological complexity of the project, appropriate reference information, and the inclusion of an appropriate contingency determination. Ranges could exceed those shown in unusual circumstances.		Typical accuracy ranges for Class 2 estimates are -5% to -15% on the low side, and +5% to +20% on the high side, depending on the technological complexity of the project, appropriate reference information, and the inclusion of an appropriate contingency determination. Ranges could exceed those shown in unusual circumstances.		Typical accuracy ranges for Class 1 estimates are -3% to -10% on the low side, and +3% to +15% on the high side, depending on the technological complexity of the project, appropriate reference information, and the inclusion of an appropriate contingency determination. Ranges could exceed those shown in unusual circumstances.	
EFFORT TO PREPARE (for US\$20MM project):	As little as 1 hour or less to prepare to perhaps more than 200 hours, depending on the project and the estimating methodology used.		Typically, as little as 20 hours or less to perhaps more than 300 hours, depending on the project and the estimating methodology used.		Typically, as little as 150 hours or less to perhaps more than 1500 hours, depending on the project and the estimating methodology used.		Typically, as little as 300 hours or less to perhaps more than 3000 hours, depending on the project and the estimating methodology used. Bid Estimates typically require more effort than estimates used for funding or control purposes		Class 1 estimates require the most effort to create, and as such are generally developed for only selected areas of the project, or for bidding purposes. A complete Class 1 estimate may involve as little as 600 hours or less, to perhaps more than 6,000 hours, depending on the project and the estimating methodology used. Bid estimate typically require more effort than estimates used for funding or control purposes.	
ANSI Standard Reference Z94.2-1989 name; Alternate Estimate Names, Terms, Expressions, Synonyms:	Order of Magnitude Estimate; Ratio, ballpark, blue sky, seat-of-pants, ROM, idea study, prospect estimate, concession license estimate, guesstimate, rule-of thumb.		Budget Estimate; Screening, top-down, feasibility, authorization, factored, pre-design, pre-study.		Budget, scope, sanction, semi-detailed, authorization, preliminary control, concept study, feasibility (for metals processes) development, basic engineering phase estimate, target estimate.		Detailed control, forced detail, execution phase, master control, engineering, bid, tender, change order estimate.		Full detail, release, fall-out, tender, firm price, bottoms-up, final, detailed control, forced detail, execution phase, master control, fair price, definitive, change order estimate.	

Estimate Class	Class 5	Class 4	Class 3	Class 2	Class 1
Estimate Input Checklist and Maturity Index	Class 5	Class 4	Class 3	Class 2	Class 1
GENERAL PROJECT DATA					
Project Scope Description	General	Preliminary	Defined	Defined	Defined
Plant Production / Facility Capacity	Assumed	Preliminary	Defined	Defined	Defined
Plant Location	General	Approximate	Specific	Specific	Specific
Soils & Hydrology	None	Preliminary	Defined	Defined	Defined
Integrated Project Plan	None	Preliminary	Defined	Defined	Defined
Project Master Schedule	None	Preliminary	Defined	Defined	Defined
Escalation Strategy	None	Preliminary	Defined	Defined	Defined
Work Breakdown Structure	None	Preliminary	Defined	Defined	Defined
Project Code of Accounts	None	Preliminary	Defined	Defined	Defined
Contracting Strategy	Assumed	Assumed	Preliminary	Defined	Defined
ENGINEERING DELIVERABLES:	Class 5	Class 4	Class 3	Class 2	Class 1
Block Flow Diagrams	Started / Preliminary	Preliminary / Complete	Complete	Complete	Complete
Plot Plans		Started / Preliminary	Complete	Complete	Complete
Process Flow Diagrams (PFDs)		Preliminary	Complete	Complete	Complete
Utility Flow Diagrams (UFDs)		Started / Preliminary	Complete	Complete	Complete
Piping & Instrument Diagrams (P&IDs)		Started / Preliminary	Complete	Complete	Complete
Heat and Material Balances		Started / Preliminary	Complete	Complete	Complete
Process Equipment List		Started / Preliminary	Complete	Complete	Complete
Utility Equipment List		Started / Preliminary	Complete	Complete	Complete
Electrical One Line Drawings		Started / Preliminary	Complete	Complete	Complete
Specifications and Datasheets		Started	Preliminary / Complete	Complete	Complete
General Equipment Arrangement Drawings		Started	Complete	Complete	Complete
Spare Parts Lists			Preliminary	Preliminary	Complete
Architectural Details / Schedules		Started	Preliminary	Preliminary / Complete	Complete
Structural Details		Started	Preliminary	Preliminary / Complete	Complete
Mechanical Discipline Drawings			Started / Preliminary	Preliminary / Complete	Complete
Electrical Discipline Drawings			Started / Preliminary	Preliminary / Complete	Complete
System Discipline Drawings			Started / Preliminary	Preliminary	Complete
Site Plan		Started	Started / Preliminary	Complete	Complete
Civil/Site Discipline Drawings			Started / Preliminary	Preliminary	Complete
Demolition Details		Started	Started / Preliminary	Preliminary / Complete	Complete

