

EAST BAY MUNICIPAL UTILITY DISTRICT

DATE: March 25, 2026

MEMO TO: Priyanka K. Jain, Program Manager FERC 2916 Relicensing

FROM: Michelle L. Workman, Manager of Natural Resources

SUBJECT: Technical Memorandum (TM) for Preliminary Design Concepts for Two Temperature Control Device Alternatives at Camanche Reservoir

We are pleased to transmit the subject memorandum for your information. This TM presents an early stage, preliminary investigation of infrastructure improvements that could be pursued at Camanche Dam to improve the ability to manage release temperatures. The objective of exploring potential infrastructure improvements is to increase the flexibility to manage releases to improve conditions for downstream salmonids. The study identified several alternatives for capital improvements that could allow for different release strategies to potentially improve temperature management. A screening process led to the selection of two alternatives, an outlet tower and temperature curtain, for which conceptual designs and cost estimates were prepared. Additional investigation is necessary to better define the intended objectives of such a project and determine whether those objectives can be met by the identified alternatives.

Furthermore, please note that the cost estimates included in the TM are preliminary and likely understated. For example, the cost estimates in the TM do not fully capture the complexity of underwater construction activities, atypical construction methods, or the additional challenges posed by unknown submerged and subterranean conditions at the project site. As the investigation progresses, we expect construction costs to increase as we refine the overall objective and quantify specific aspects of the constructability and operability of the alternatives, including the risks related to access, staging, permitting, and long-term maintenance.

Potential Next Steps:

- Define specific objectives the infrastructure needs to meet for improvement of downstream salmon health.
- Conduct additional modeling including reservoir re-operation scenarios (not included in this assessment), focused on maximizing the District's capability to meet downstream release targets while maintaining other operational needs (e.g., treatability of drinking water supply, hydropower).
- Confirm suitability of the proposed concepts to meet temperature objectives in future climate change scenarios.
- Initiate early discussions with construction specialists to validate assumptions related to means and methods, and to refine cost estimates.
- Begin informal outreach with permitting agencies to identify regulatory requirements that could influence design alternatives and schedule.

We welcome your feedback to ensure that the project remains feasible, environmentally sound, and aligned with operational goals. Please reach out if you have any questions or comments.

Attachment: Preliminary Design Concepts for Two Temperature Control Device Alternatives at Camanche Reservoir Technical Memorandum

TECHNICAL MEMORANDUM

TO: I-Pei Hsiu, East Bay Municipal Utility District
CC: Michelle Workman, East Bay Municipal Utility District
PREPARED BY: Max Storms, Woodard & Curran
REVIEWED BY: Xavier Irias, Woodard & Curran
DATE: June 28, 2024
RE: Preliminary Design Concepts for Two Temperature Control Device Alternatives at Camanche Reservoir

1. BACKGROUND AND OBJECTIVES

1.1 Project Background

The East Bay Municipal Utility District (District) currently operates Camanche Reservoir and Pardee Reservoir in tandem to optimize cold-water releases and experiences challenges maintaining its required cold-water pool at Camanche Reservoir during exceptionally wet years. During wet years, the lack of selectivity of points for flow releases forces the District to discharge cold water throughout the summer to prevent reservoir overflow. Rising ambient temperatures and increased intensity of wet years create pressure on cold-water pools maintained in both reservoirs for the benefit of river fisheries downstream. This is particularly acute for the fall release period.

The District retained Woodard & Curran (with support from Terra Engineers, Watercourse Engineering, and Water Resources Engineering) to provide technical assistance in developing alternatives for temperature control devices (TCD) at Camanche Reservoir to increase real-time flexibility of reservoir operations for temperature management of downstream releases throughout the year. The project identified and evaluated potential alternatives to improve management of cold-water releases from Camanche Reservoir. The scope of work outlined in **Table 1** below summarizes the work done under each task of the project as well as key project deliverables associated with each Task. The project team identified goals, boundaries, and evaluation criteria for alternatives identified during the project in Task 2. Alternatives were developed and screened in Task 3 before being more thoroughly analyzed in Task 4. Selected alternatives were modeled in Task 5 to assess their effectiveness in meeting downstream temperature targets. This technical memorandum (TM) summarizes work completed in Task 6 to develop preliminary designs and cost estimates for the top two alternatives.

Table 1: Scope of Work

Task	Task Title	Description of Work	Deliverables
1	Project Management	Progress meetings, reporting, invoicing, etc.	<ul style="list-style-type: none"> • Monthly progress reports and invoices
2	Review Existing Information and Future Needs	Review existing information and identify key drivers and criteria for evaluating developed alternatives	<ul style="list-style-type: none"> • Future Drivers & Criteria Workshop (September 2022)
3	Alternatives Development	Develop up to eight (8) alternatives for consideration; perform preliminary screening of top four (4) alternatives.	<ul style="list-style-type: none"> • Alternatives Development Workshop (October 2022) • Alternatives Screening Workshop (December 2022) • Alternatives Development & Screening TM (April 2023)
4	Analysis of Selected Alternatives	Refine top four (4) alternatives; develop cost estimates and prepare performance assessments for those alternatives; identify three (3) alternatives for additional analysis	<ul style="list-style-type: none"> • Alternatives Analysis Workshop (March 2023) • Alternatives Analysis TM (August 2023)
5	Modeling of Top Alternatives	Model up to three (3) alternatives using EBMUD’s existing software model (a CE-QUAL-W2 model).	<ul style="list-style-type: none"> • Alternatives Modeling Report (October 2023) • Model Calibration Report (February 2024) • Alternatives Benefits Analysis TM (April 2024)
6	5% Design and Preliminary Cost Estimate	Prepare 5% design drawings and preliminary cost estimates for up to two (2) alternatives	<ul style="list-style-type: none"> • Preliminary Design Concepts TM (June 2024)

1.2 Role of Release Temperature in Fishery Health

The alternatives developed as part of this effort seek to improve the District’s control of the temperature of its releases from Camanche Reservoir into the Mokelumne River. Greater temperature control might allow the District to better meet the seasonal needs of the native Chinook salmon population and ideally promote growth of that population. The District operates its Mokelumne fisheries program under its 1998 Joint Settlement Agreement (JSA), which is made part of the Federal Energy Regulatory Commission (FERC) Project 2916 License and is also

included in the District’s water right under D-1641. The JSA requires the District to provide flow and non-flow measures to support a healthy fishery, and in part towards achievement of the 1992 Central Valley Project Improvement Act (CVPIA)’s goal to double the natural production of anadromous fish in Central Valleys streams.

Chinook salmon populations in the Mokelumne River have doubled, in alignment with the 1992 goal; however, most of that population improvement is due to the success of the Mokelumne River hatchery, which was remodeled in 2002 to enlarge its rearing space. **Table 2** below illustrates the ratio of hatchery to natural-origin Chinook salmon in the Mokelumne River based on the California Department of Fish and Wildlife (CDFW)’s annually produced Constant Fractional Marking reports.

Table 2: Hatchery-Origin vs. Natural-Origin Escapement in the Mokelumne River

Year	Hatchery Escapement		In-River Escapement	
	Hatchery-Reared Population (%)	Natural-Origin Population (%)	Hatchery-Reared Population (%)	Natural-Origin Population (%)
2015	96	4	94	6
2016	90	10	81	19
2017	94	6	86	14
2018	99	1	87	13
2019	89	11	73	27
2020	86	14	No Data	No Data
2021	89	11	No Data	No Data
2022	86	14	74	26

Hatchery-reared Chinook salmon experience reduced fitness in natural environments relative to natural-origin fish due to domestication selection (or adaptation to the hatchery environment).¹

¹ Howe, N., M. Hale, C. Waters, S. Schaal, K. Shedd, W. Larson. 2024. Genomic evidence for domestication selection in three hatchery populations of Chinook salmon, *Oncorhynchus tshawytscha*. *Evolutionary Applications*. February 2024.

This reduced fitness can be passed onto later generations and may take several generations of cross-breeding with wild fish to recover. Improving in-stream egg-to-fry survival would bolster the natural-origin population. The District provided tailbay temperature targets that a temperature control device should aim to meet for the purpose of improving in-stream survivability. These temperature targets, summarized in **Table 3**, are informed by literature¹ and the context of downstream releases from Camanche Reservoir into the Mokelumne River.

Table 3: Seven-Day Average Daily Maximum (7ADM) Target Temperatures

Month	Life Stage	Temperature, °C
January	Egg incubation	12-14
February	Egg incubation	12-14
March	Egg incubation	12-14
April	Rearing/migration	16
May	Rearing/migration	16
June	Rearing/migration	16
July	Steelhead oversummer	18
August	Steelhead oversummer	18
September	Steelhead oversummer / Chinook salmon migration	18
October	Spawning/incubation	12-14
November	Spawning/incubation	12-14
December	Spawning/incubation	12-14

The existing infrastructure available at Camanche Reservoir does not allow the District to meet the temperature targets summarized in **Table 3** in all year types. This lack of temperature control has led to low in-stream egg survival of fry, with survival rates ranging from 6% to 18% in most years². The basis of this analysis is to investigate the feasibility of temperature control alternatives

¹ EPA. 2003. EPA Region 10 Guidance For Pacific Northwest Stat and Tribal Temperature Water Quality Standards.

Rich, A. 2024. Impacts of Water Temperature on Fall-Run Chinook Salmn and Steelhead in the San Joaquin River System. Prepared for the California Department of Fish and Game. September 2024.

Pagliughi, S. 2008. Reach Specific Thermal Tolerance by Life Stage for Fall-Run Chinook Salmon and Winter-Run Steelhead. Prepared for East Bay Municipal Utility District. May 2008.

² EBMUD. Unpublished data. .

to improve conditions for naturally produced fish. The purpose is to evaluate what methods are available to improve downstream temperatures and the associated costs of those methods to determine if there is a feasible alternative the District can support. For this analysis, the upper range temperature of 14°C for the egg incubation and spawning/incubation life stages was used because reservoir waters are often warmer than 12°C in the fall throughout the water column.

1.3 Technical Memorandum Objective

This TM presents preliminary design concepts and cost estimates for the top two alternatives identified at the conclusion of Task 5 – the temperature control curtain concept (“TCC”) and the selective withdrawal via multi-level outlet tower concept (“outlet tower”). The TM highlights how each alternative seeks to meet the goals for a TCD at Camanche Reservoir identified as part of Task 2 and provides an overview of how each alternative would operate. The goals for a TCD at Camanche reservoir identified as part of Task 2 include:

- Improve downstream release temperatures in fall without exceeding seasonal threshold targets at other times (with a maximum release temperature of 18°C in summer)
- Maintain 28 TAF fall cold water pool (the volume of water colder than 16.4°C) at Camanche Reservoir
 - More volume is better.
 - Colder is better (within practical limitations)
- Meet seasonal temperature thresholds to support downstream fishery life stages in springtime and summertime.
- Maintain flood control functionality.
- Maintain hydropower production flexibility.
- Maintain current levels of recreation.
- Not impact dam safety.
- Not impact water quality provided to District customers; this goal has been implicit but was added to provide clarity.

Preliminary design concepts are developed to consider the unique challenges associated with the alternatives and the existing conditions at Camanche Dam, including consideration of local topography and the existing outlet works. The TM is organized as follows:

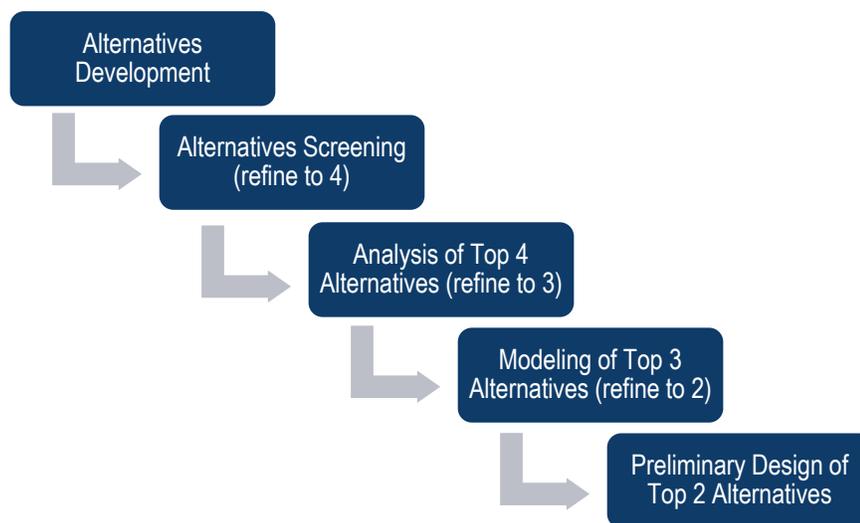
- **Section 2: Selection of Preferred Alternatives** – summarizes how the top two alternatives were selected.
- **Section 3: Key Design Assumptions** – provides an overview of key assumptions made during the preliminary design process.
- **Section 4: Temperature Control Curtain Concept** – describes the preliminary design for the TCC concept.

- **Section 5: Selective Withdrawal Via Multi-Level Outlet Tower Concept** – describes the preliminary design for the outlet tower concept.
- **Section 6: Summary of Concepts & Recommended Next Steps** – identifies next steps for the project.

2. SELECTION OF PREFERRED ALTERNATIVES

The outlet tower and TCC concepts were selected for preliminary design from a group of preliminary alternatives. Preliminary alternatives were developed to meet the needs of the project, and then further screened and analyzed based on how they met the goals and criteria established in Task 2. The outlet tower and TCC concepts are considered the most promising alternatives based at this time. **Figure 1** below illustrates the alternatives selection process.

Figure 1: Alternatives Selection Process



A preliminary list of alternative concepts was developed in Task 3 and presented during the Alternatives Development Workshop. These concepts were considered practical alternatives considering the needs specific to Camanche Reservoir, and fell into five broad categories, including:

1. Selective withdrawal
 - a. Directly plumbed to existing outlet works
 - b. Water-gapped device, near (but not touching) existing outlet works
 - c. Standalone outlet devices
2. Curtain near Camanche outlet
3. Conveyance of Pardee cold water to Camanche outlet via pipe or curtain
4. Chiller Device
5. Mixing device near Camanche outlet

Concepts 3, 4, and 5 were considered less promising for myriad factors, including prohibitive costs (Concept 3 and 4), negative impacts to lake stratification (Concept 5), and an inability to meet the project goals (Concept 3). Concepts 1 and 2, identified as more promising than other alternatives, were selected for further analysis. Development and screening of alternatives is described with

more detail in the Alternatives Development & Screening TM delivered in April 2023. Concept 1, selective withdrawal, was further refined into three variants:

- Plumbed to existing lower outlet works
 - A traditional outlet tower with gates at varied elevations. The TCD could be connected to either or both existing lower-level outlet pipes. In either case, the connection could be made without major modifications to the existing infrastructure.
- Water-gapped device using a pump to send water into the existing lower-level outlet
 - Water is selected from near the surface and pumped in the direction of the lower-level outlet via a ‘water-jet’.
- Up and Over Concept
 - A floating intake at the surface connected to conduit that bypasses the existing outlet works by going over the dam to discharge warm water downstream of the dam.

Each of these variants seeks to allow the District to select warmer water from higher elevations in the reservoir during the summer months to protect the cold-water pool for when it is needed during the fall. These three variants, along with the TCC concept, were analyzed further in Task 4. This analysis evaluated each alternative against the goals, metrics, and criteria identified in Task 2. The results of that analysis are summarized in the Alternatives Analysis TM delivered in August 2023. At the conclusion of Task 4, District staff selected three alternatives for further analysis in Task 5. These include:

- Selective withdrawal
 - Outlet tower directly plumbed to existing lower outlet works
 - Water-gapped device
- Temperature control curtain

A calibrated CE-QUAL-W2 model was applied to assess the identified alternatives during four model years (2003-2006). These model years were identified by the District for assessment as they were representative of conditions that posed the most acute cold-water pool challenges. These model years were wetter years during which the District needed to discharge water to avoid spilling at Camanche Reservoir, thereby depleting the cold-water pool since the primary existing Camanche outlet is at the bottom of the lake where the water is coldest. The W&C team modeled the ability of temperature control device alternatives to meet tailbay temperature targets provided by the District, as described in **Table 3** above.

Because leakage along the curtain’s bottom cannot be predicted at this stage of development, the TCC concept was conservatively modeled under varying levels of leakage along the curtain’s bottom: zero, 50 and 200 cubic feet per second (cfs). Larger leakage levels were not assessed. **Figure 2** through **Figure 5** describe how each alternative and the existing condition perform relative to the target temperature. The existing condition shown in the figures below is a modeled condition assuming existing facilities (including the upper outlet) are available.

Figure 2: CE-QUAL-W2 Model Results for 2003

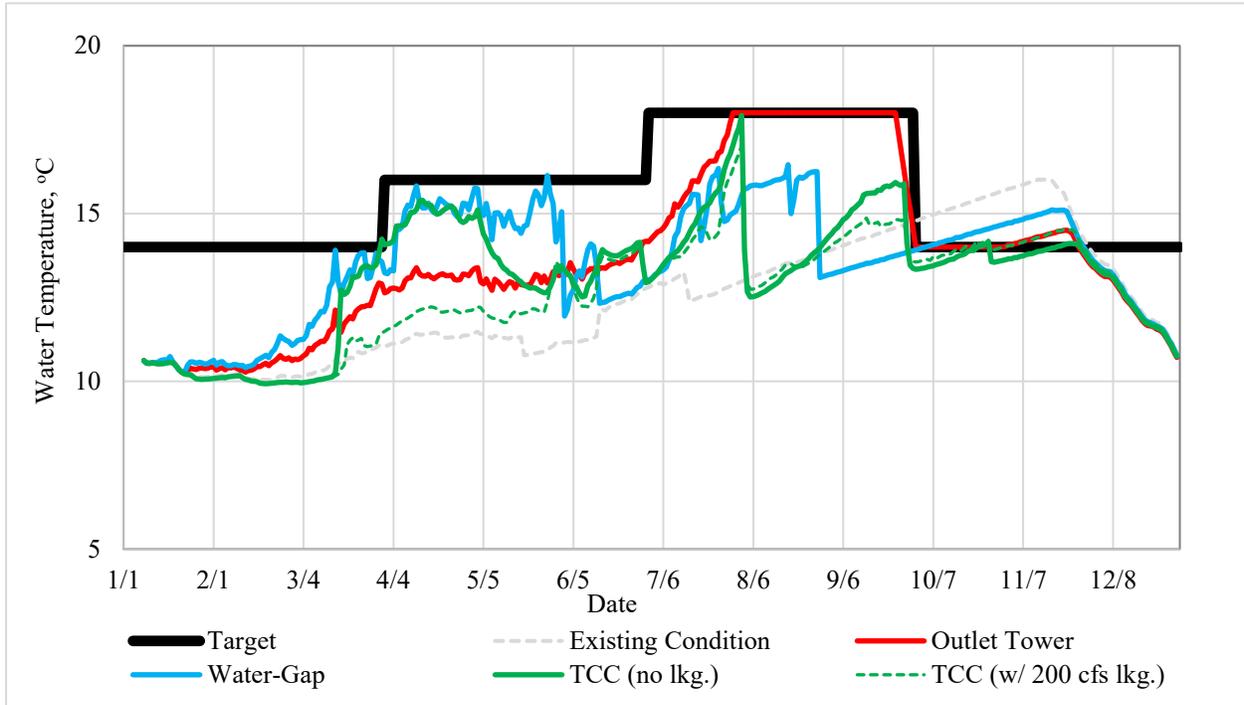


Figure 3: CE-QUAL-W2 Model Results for 2004

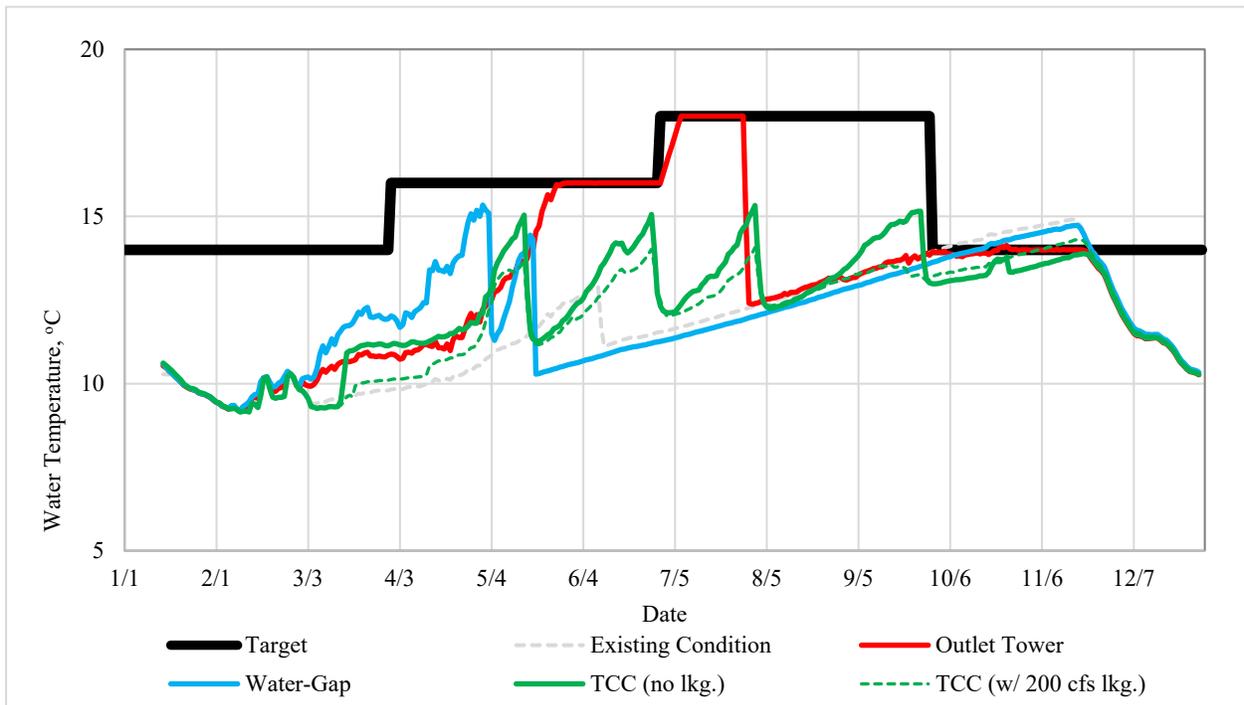


Figure 4: CE-QUAL-W2 Model Results for 2005

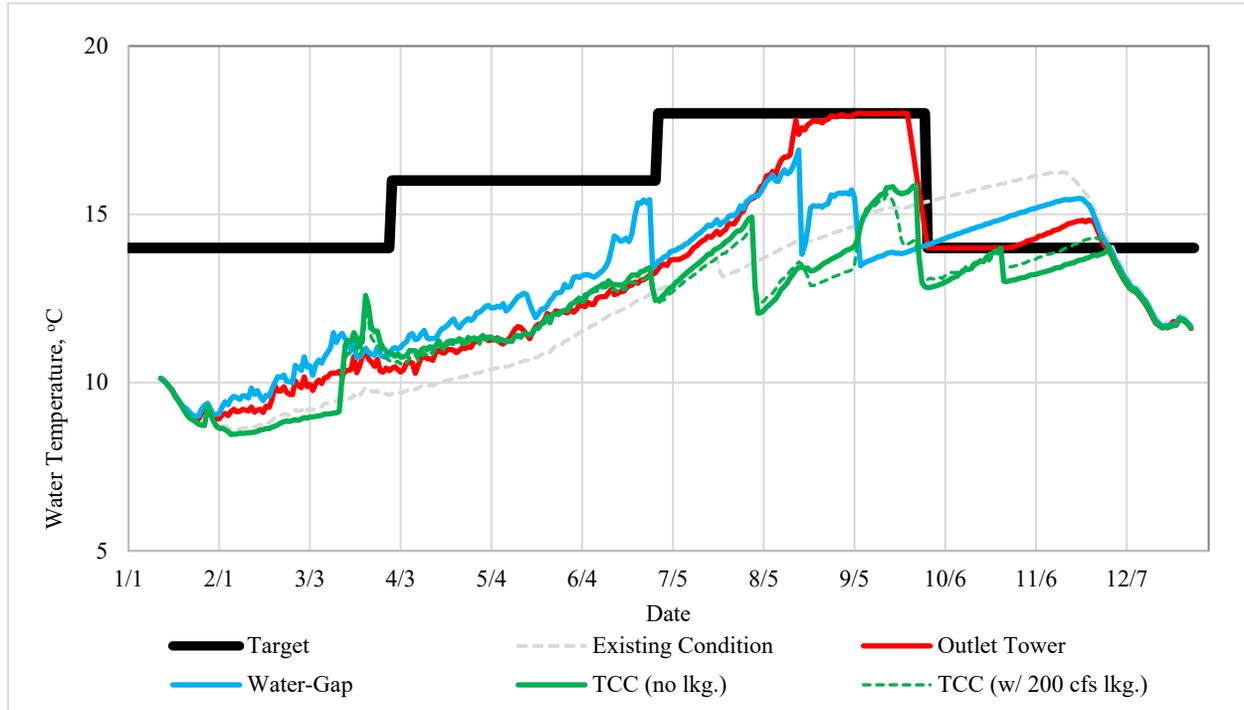
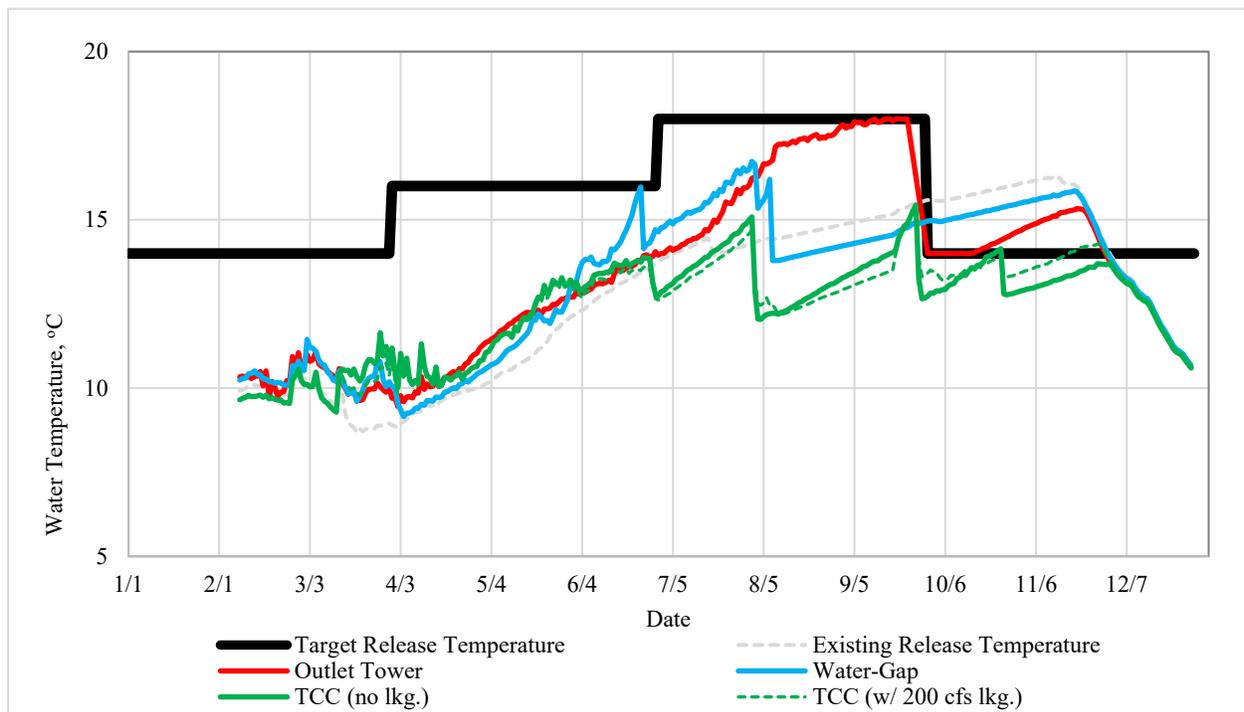


Figure 5: CE-QUAL-W2 Model Results for 2006



CE-QUAL-W2 modeling illustrates that each of the temperature control device alternatives performs better than the existing condition in meeting the temperature target for the fall release period (October through December). The modeled alternatives do not meet the 14°C fall release temperature target; however, it is likely that the outlet tower's configuration could be optimized to meet the 14°C target by having additional gates or by having gates at different elevations than those modeled. Further, each alternative provides greater control and flexibility to meet targets at other times during the year. It is also clear from the modeling that the outlet tower and TCC concepts perform somewhat better than the water-gap concept. The modeling also shows that the TCC's performance is relatively insensitive to leakage.

The modeled release temperatures were used to estimate benefits to downstream fisheries of the various alternatives. The Alternatives Benefits Analysis TM, delivered in April 2024, assesses daily fry and egg mortality based on modeled release temperatures by applying a survival model¹ developed in a recent publication of early salmon life stage survival on the American River. The daily mortalities for the existing condition and each alternative were applied to a sample population of 100 fry and 100 eggs. Fry survival was estimated based on release temperatures from January 1 through March 31. Egg survival was based on release temperatures from October 1 through December 30 for the assessed years to estimate how many eggs would survive in each scenario. Survival rates for the modeled years are summarized in **Table 4**.

Based on the performance of each alternative, the TCC and outlet tower concept were selected for preliminary design. Modeling indicated that neither alternative contributed to increased fry survival from existing conditions due to high survival for the existing conditions. Notably, existing conditions on the Mokelumne River for fry temperatures are already in optimal range, and management for fall benefits has some low-level impact on fry stage survival based on modeling. Fry survival for the alternatives is slightly worse than the existing condition for the 2003 and 2004 model years; this slight discrepancy is due to higher release temperatures during the spring and summer to preserve cold-water pool for the fall release period. Benefits were, however, seen in egg survival modeling results, where existing conditions are limiting for egg survival.

¹ Bratovich, P., M. Neal, A. Ransom, P. Bedore, and M. Bryan. 2020. Chinook Salmon Early Lifestage Survival & Folsom Dam Power Bypass Considerations. Prepared for the Sacramento Water Forum. September 2020.

² Modeled existing conditions for egg survival are significantly higher than empirical data from the Mokelumne, but relative improvement of TCD options remains appropriate for analysis of alternatives.

Table 4: Modeled Survival (number of fish surviving assuming an initial population of 100) for Existing Conditions and Alternatives

Model Year	Fry Survival				Egg Survival			
	Exist. Cond.	Outlet Tower	Water-Gap	TCC	Exist. Cond. ²	Outlet Tower	Water-Gap	TCC
2003	100	99	96	97	74	94	90	96
2004	100	100	99	100	92	96	94	97
2005	100	100	100	100	63	93	85	97
2006	100	100	100	100	62	89	77	97

3. KEY DESIGN ASSUMPTIONS

While the TCC and outlet tower concepts are different in design and operation, there are common assumptions that impact the design and construction of both alternatives. These assumptions play a critical role in design decisions and have large impacts on project costs and construction schedule. These assumptions include:

- Camanche Reservoir cannot be drained to construct a TCD.
- A TCD cannot disturb Camanche Dam and its normal operation including hydropower generation
- A TCD cannot impact the operation and drawdown of Camanche Reservoir in an emergency.

These assumptions were made to meet project criteria around regulatory support (the extent to which regulatory agencies will find the alternative favorable) and regulatory compliance (an alternative must be compliant with all regulations, or it cannot be considered). Regulatory support was considered a priority from the following agencies:

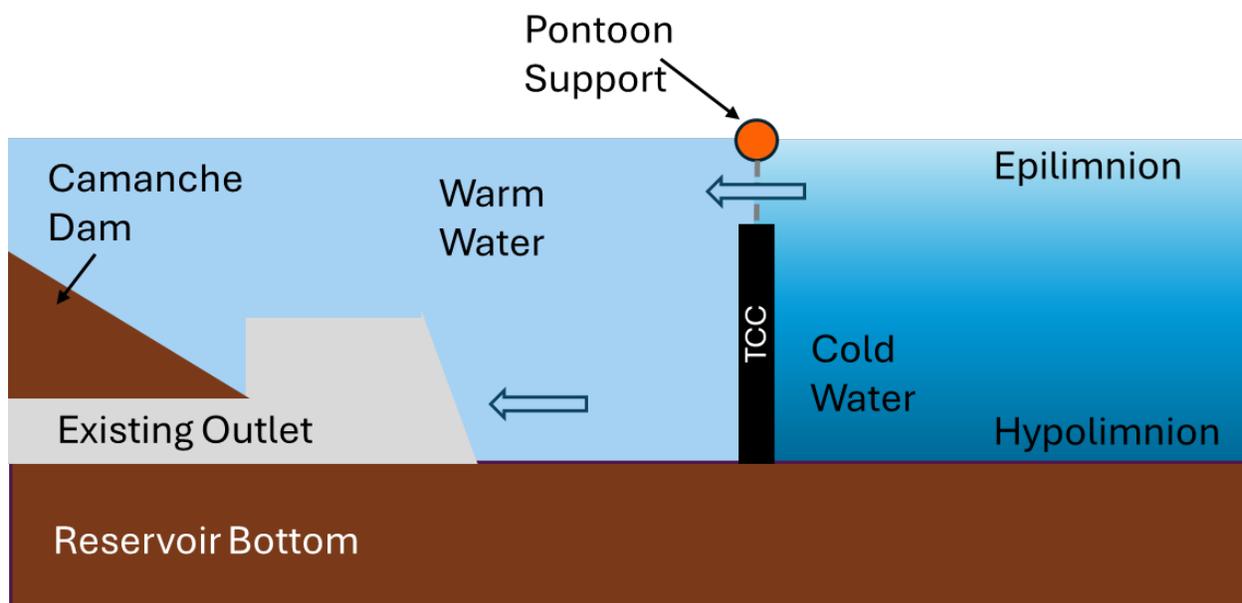
- Federal Energy Regulatory Commission (FERC)
- Division of Safety of Dams (DSOD)
- U.S. Army Corps of Engineers (USACE)
- California Department of Fish and Wildlife (CDFW)
- U.S. Fish and Wildlife Service (USFWS)

4. TEMPERATURE CONTROL CURTAIN CONCEPT

4.1 Project Description

A temperature control curtain (TCC) seeks to preserve the cold-water pool by allowing warm water to pass over the top of the curtain and into the existing outlet works at Camanche Reservoir while in use, effectively acting as a weir. This strategy is illustrated in **Figure 6** below. The TCC concept uses the natural stratification of the water column to target the warmest available water in the epilimnion during the summer months ahead of the fall release period, keeping cold water in the metalimnion and hypolimnion behind the curtain and out of the Mokelumne River when it is not needed. The TCC would be attached to a floating pontoon support system, with winches to allow the top of the curtain to be raised or lowered to target water at the appropriate temperature to meet downstream targets. Raising or lowering of the curtain is expected to occur seasonally. The TCC would be raised from the reservoir bottom in the spring and periodically lowered over the summer as the reservoir stratigraphy and downstream temperature targets changed. The TCC would be lowered to the bottom of the reservoir when the cold-water pool is required to meet downstream temperature targets in October and November. In this analysis, raising and lowering the curtain would be accomplished manually; winches would be accessed by boat. Future considerations could include automation to improve Operations and Maintenance flexibility, at an increased cost.

Figure 6: Conceptual Operation for a TCC at Camanche Reservoir



A TCC at Camanche Reservoir would run parallel to Camanche Dam, spanning approximately 3,400 linear feet(LF), with a setback of 500 feet from the toe of the dam and the existing outlet works. The alignment for the TCC as well as appropriate setbacks for TCC anchoring are shown in **Figure 7** below. TCC components can be mostly pre-fabricated and assembled on-site.

Construction could be staged in the area north of Camanche Dam, as indicated in **Figure 7**. Along with the buoy system shown conceptually in **Figure 6**, the TCC would be supported by soldier beams along its bottom and anchored to soldier beams on either side of the TCC. The curtain would be weighted with chains at appropriate intervals to promote contact with the reservoir bottom and thereby limit leakage of cold water beneath the TCC. These design elements are further discussed in Section 4.2. TCCs have been implemented elsewhere, notably at Iron Gate Reservoir outside of Hornbrook, CA. The TCC at Iron Gate Reservoir employs design elements similar to those presented below, although a key difference is that the Iron Gate curtain seeks to pass water under the curtain, not over the curtain as for Camanche.

Figure 7: TCC Project Area



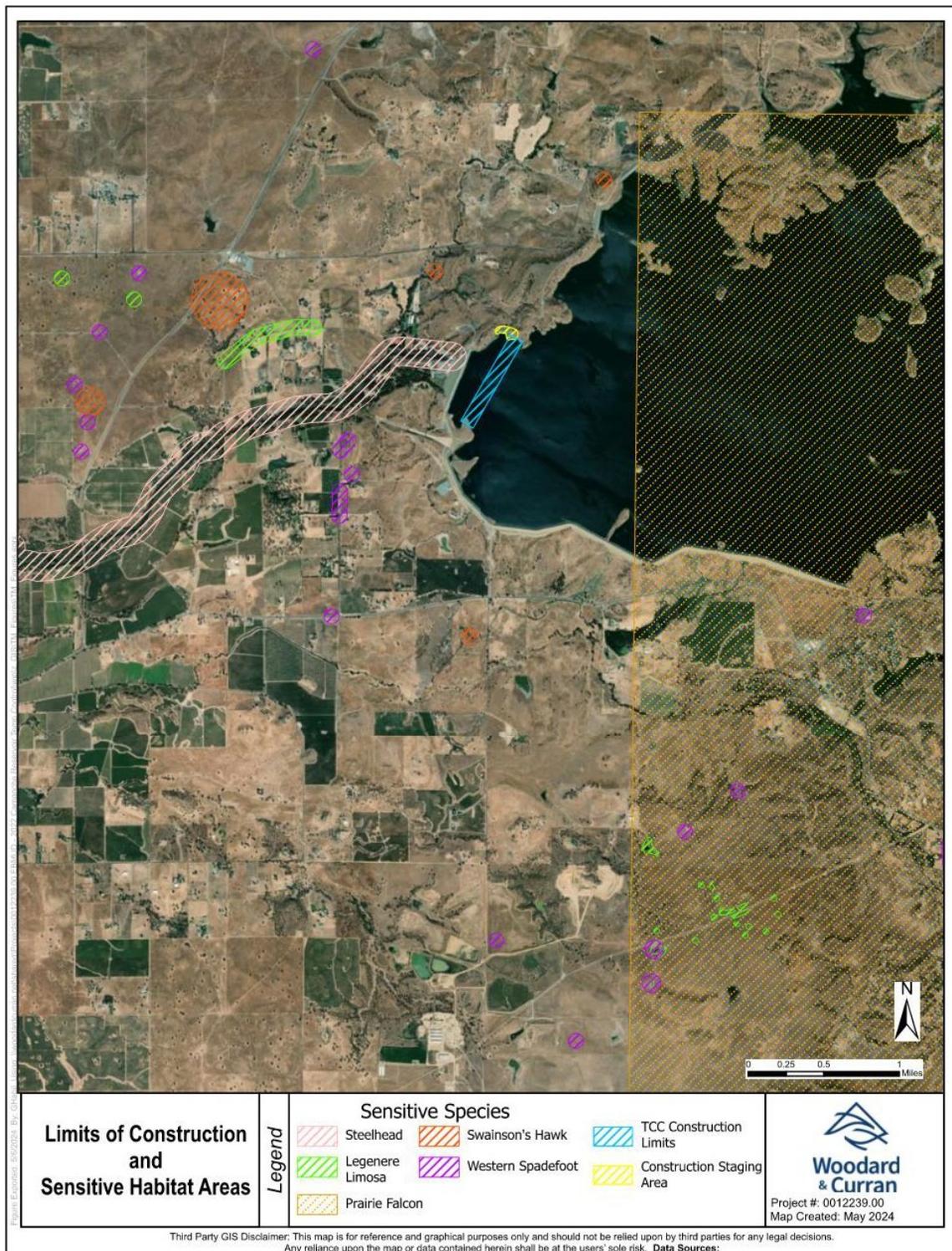
Construction of the TCC would require fabrication of the TCC material, a 6” x 6” netting support, the pontoon supports, and installation of the soldier piles. Installation of the soldier piles is assumed to require use of a barge-mounted pile driver. Connection of the curtain to the soldier beams along its bottom and connection of anchor chains to the soldier beams on either side of the TCC would need to be performed by divers. Preparation of the reservoir bottom may be necessary if significant irregularities (i.e., boulders or unexpected crevices) are found during site surveys. Construction activity is expected to take place within the limits defined in **Figure 8** below. Sensitive floral and fauna habitat as described in the California Natural Diversity Database (CNDDDB) are also indicated in **Figure 8**, and include Swainson’s hawk, steelhead, prairie falcon, tiger salamander, *legenere limosa*, and western spadefoot. The limits of construction do not intersect with mapped habitat for any of the identified species.

As indicated in Section 3 above, regulatory support and regulatory compliance were key considerations in developing alternatives for a TCD at Camanche Reservoir. The TCC concept was developed to consider how it might comply with regulations and garner approval from regulatory agencies. Potential permits or certifications for the construction and operation of the TCC are expected to include:

- California Environmental Quality Act (CEQA)
 - Initial Study
 - Notice of Exemption (NOE), Mitigated Negative Declarations (MND), or Environmental Impact Report (EIR) as appropriate based on the initial study
- National Environmental Protection Act (NEPA)
 - Possibly not required unless federal funding is used
 - General steps are similar to those required for CEQA
- CDFW, USACE, SWRCB/RWQCB, and USFWS
 - Lakebed alteration agreement
 - 401/404 permits
 - Section 7 consultation, ESA
- SHPO
 - Cultural Assessment/107 compliance
- FERC
 - Plan review and approval
 - Compliance with existing license terms and conditions
- DSOD
 - Plan review and approval

This list identifies probable permitting requirements and may not be exhaustive. If the TCC concept is refined through preliminary and final design, other permitting requirements may be identified.

Figure 8: Limits of Construction and Sensitive Habitat Areas



4.2 Preliminary Design Criteria & Concepts

4.2.1 Preliminary Design Criteria

The TCC’s design was developed by focusing on the goals for the TCD – namely to allow warm, near-surface water from the epilimnion to flow freely over the top of the TCC while preventing deeper, cold water from the hypolimnion from passing. A successful TCC at Camanche Reservoir must, at minimum, meet the following design criteria:

- Allow for warm water to pass freely over the top of the TCC.
- Minimize leakage of cold water beneath the TCC.
- Allow for raising and lowering of the TCC to access water at different temperatures.
- Minimize asymmetric loads along the TCC’s alignment.
- Resist or accommodate lateral loads from wind and wave action.
- Resist or accommodate lateral loads from differing densities resulting from differing temperatures of water on either side of the TCC.
- Minimize potential impacts of failure (i.e., TCC failure should not cause dam failure).

Additional criteria may be identified during the design process, but these criteria are critical if a TCC is to be successful.

4.2.2 TCC Alignment

The TCC alignment was selected to accomplish three goals: (1) effectively isolate a pool around the existing outlet works intake structure from the rest of Camanche Reservoir; (2) provide sufficient setback to avoid interference with the existing outlet works intake structure’s operations; (3) avoid interference or disturbance of the material comprising Camanche Dam.

The alignment spans approximately 3,400 LF with a 500-foot setback from the toe of Camanche Dam and the existing intake structure. Alternative alignments were considered during Task 3 and Task 4; these alignments involved minimizing the volume of the warm-water pool near the intake structure and minimizing the span of the TCC. These alignments involved pivot points, which would introduce asymmetric forces along the TCC and would involve complex anchoring mechanisms. These alignments also required attachment to the upstream face of Camanche Dam. The linear alignment presented in this TM avoids these complexities, and limits impacts to existing structures. However, it appears likely that the existing Speece cone would need to be relocated further away from the dam if the TCC were built in the depicted alignment. This issue would need to be further investigated during design of the TCC, as relocation of the Speece cone may impact its intended impact to water quality.

4.2.3 TCC Materials

The TCC operates as a non-permeable barrier to prevent cold water from entering the existing intake structure. The proposed fabric for the curtain is Seman Corp. 3024 24-ounce XR5 fabric –

this fabric was identified in the technical report¹ for the TCC at Iron Gate Reservoir and has been used for TCCs in other locations. The fabric would be cut to match the reservoir floor along the TCC's alignment. To provide stability and uniform folding (or flaking) as the TCC is raised and lowered, the fabric should be reinforced with ¾-inch, 5.5-lb/ft chain at 10-foot intervals. To provide sufficient weighting at the reservoir bottom to prevent leakage, it is recommended to provide reinforcement at 1-foot intervals. The top of the TCC should be strengthened with a steel beam to allow attachment to the floating support system.

Additional support to the non-permeable barrier would be provided with a 6-inch by 6-inch netting barrier on the downstream side of the TCC. The netting would be constructed from a braided polyester cord, knotted construction. The netting would be cut to match the non-permeable barrier and would be attached to the non-permeable barrier at regular intervals. The netting would provide additional support for the non-permeable barrier and prevent large portions of the TCC from entering the existing intake structure should the TCC break or otherwise fail.

The TCC would be suspended from a floating support system. The floating support is constructed from custom-fabricated, foam-filled, 18-inch diameter HDPE pipes. These pipes are connected via steel backing rings and an HDPE flange welded to each end. Manual winches are mounted to HDPE sections at 50-foot intervals. Each HDPE section includes a winch-mount and “through hole” for the lift line to pass through, as shown in **Figure 9** and **Figure 10** below. Winches would be operated manually to raise or lower the curtain to allow access to different temperatures in the water column.

¹ Pacific Netting Products. 2015. Conceptual Design for Proposed Algae Barrier at Pacificorp Iron Gate Dam. Prepared for Pacificorp Energy.

Figure 9: HDPE Float Section from Iron Gate Dam

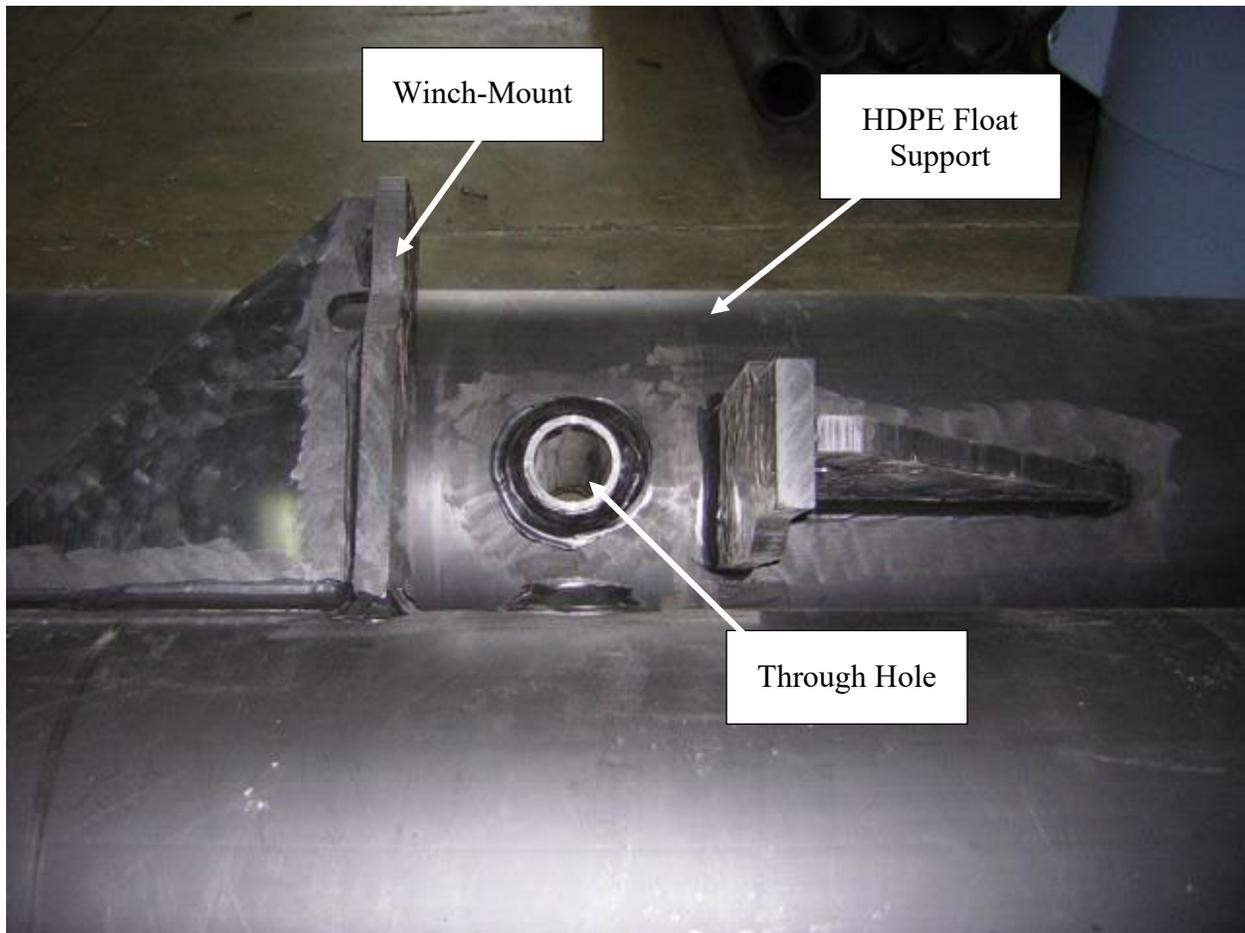
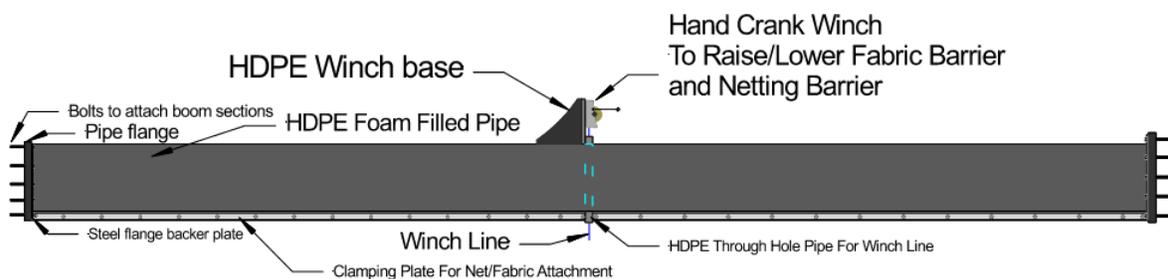


Figure 10: Typical HDPE Float Section



4.2.4 TCC Anchoring

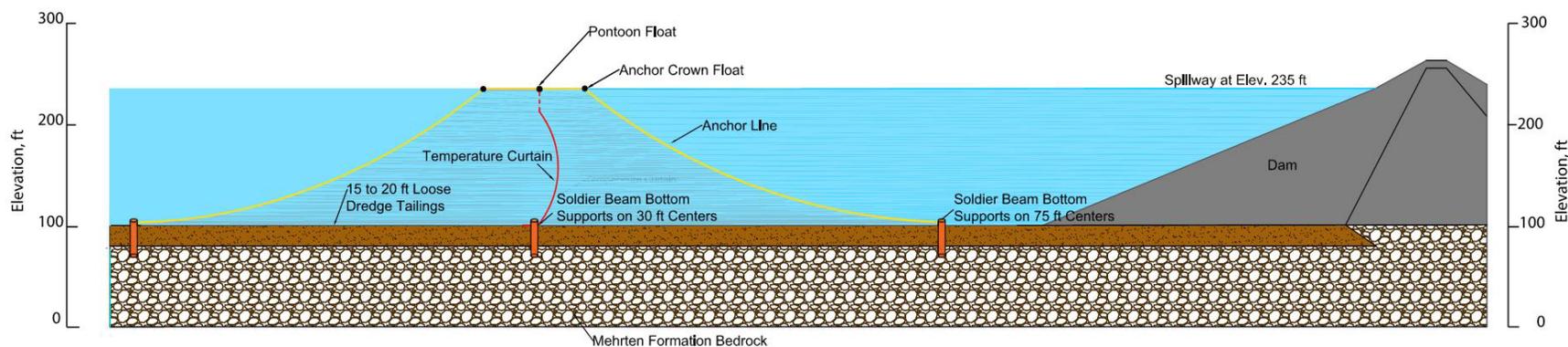
Anchoring the TCC to the reservoir bottom serves two purposes: (1) affixes the TCC bottom to the reservoir floor, helping to prevent leakage, and (2) allows the TCC to resist shear forces. Shear

forces might occur across the TCC due to wind and wave action, the flow of water over the TCC, and the density differential of the water on either side of the TCC (driven by the effective temperature management provided by the TCC).

TCC anchors are proposed to be soldier piles for their ease of installation and their ability to withstand probable loads faced by a TCC at Camanche Reservoir. Soldier piles can be driven into the reservoir floor via a barge-mounted pile driver. Attachment of the TCC to the soldier piles along its alignment would require divers, but could consist of a simple attachment, such as an eye-hook and D-ring. The soldier piles along the TCC alignment are suggested at 30-foot centers, as shown in **Figure 11**.

Similarly, soldier piles are proposed on 75-foot centers for anchoring on either side of the TCC. These soldier piles would attach to an anchor-crown float, attached to the floating support system to provide additional stability to resist wind and wave forces.

Figure 11: Curtain Elements at Maximum Section



4.3 Project Costs

4.3.1 Capital Costs

Project costs are based largely on costs prepared in support of the preliminary design report for the TCC at Iron Gate Dam¹, escalated from 2015 to 2024. The California Department of General Services Data reports the construct cost index for the San Francisco / Los Angeles area at 6,073 for January 2015 (the date of the preliminary design report) to 9,166 in February 2024. Estimated construction costs associated with the TCC at Camanche Dam are summarized in **Table 5** below.

Table 5: Estimated Construction Costs for a TCC at Camanche Dam

Item Description	Unit Price	Quantity	Units	Cost
Curtain Material	\$11.79	250,635	SF	\$2,950,000
6-inch by 6-inch Netting	\$8.11	250,635	SF	\$2,000,000
HDPE Pontoons	\$343.01	3,400	LF	\$1,200,000
Flexible Float Line	\$408.00	180	LF	\$75,000
Crown Floats and Anchor Chain	\$6,000	95	EA	\$575,000
<i>Materials Sub-Total</i>				<i>\$6,800,000</i>
On-site Assembly		1.00	% total	\$75,000
Shipping		1.00	% total	\$250,000
<i>Sub-total for Pacific Netting</i>				<i>\$7,125,000</i>

¹ Pacific Netting Products. 2015. Conceptual Design for Proposed Algae Barrier at Pacificorp Iron Gate Dam. Prepared for Pacificorp Energy.

Item Description	Unit Price	Quantity	Units	Cost
Installation Contractor	1x Materials Cost			\$7,125,000
<i>Sub-total not including Soldier Piles</i>				<i>\$14,250,000</i>
Soldier Piles along TCC Bottom	\$30,000	120	EA	\$3,600,000
Soldier Piles for Anchors	\$30,000	95	EA	\$2,850,000
<i>Sub-total for Soldier Piles</i>				<i>\$6,450,000</i>
<i>Direct Totals</i>				<i>\$20,700,000</i>
<i>25% Design Contingency</i>				<i>\$5,175,000</i>
<i>25% Estimating Contingency</i>				<i>\$5,175,000</i>
<i>Total Cost</i>				<i>\$31,050,000</i>

The construction costs presented in **Table 5** consider currently available information and are based on preliminary, conceptual design elements. As more information becomes available, these costs are likely to change, and should be considered a lower-bound. These costs represent a significant increase from the construction costs presented in the Alternatives Analysis TM presented as a part of Task 4 (\$5M). Those costs were developed for a shorter alignment, did not consider curtain reinforcement, and assumed less anchoring would be required.

4.3.2 O&M Costs

Successful deployment of the TCC concept would require periodic raising and lowering of the curtain to target water from appropriate depths in Camanche Reservoir to meet downstream temperature targets. The raising and lowering process is expected to include manual operation of the winches mounted to the HDPE floats described in **Figure 9** and **Figure 10**. A typical schedule for TCC operations was presented in the Alternatives Modeling Report dated October 2023 developed as part of Task 5; this schedule is presented in **Table 6** below.

Table 6: Sample TCC Operating Schedule

Start / End Dates	TCC Top Elevation (ft)	Operating Description
January 1 – March 15	101.4 (Reservoir Bottom)	No action
March 15 – June 29	193.2	Raise the curtain from Reservoir Bottom to 193.2’ (91.9’)
June 29 – August 3	186.7	Lower curtain 6.5’
August 3 – September 28	170.3	Lower curtain 16.4’
September 28 – October 27	153.9	Lower curtain 16.4’
October 27 – December 31	101.4 (Reservoir Bottom)	Drop curtain to reservoir bottom (52.5’)

During the fall and winter release period, the TCC would sit at the reservoir bottom and provide no temperature control. In the spring of every year, depending on the reservoir’s stratification and downstream conditions, the District would raise the TCC from the reservoir bottom and begin TCC operations. This would be done by operating the 68 winches installed at 50-foot intervals along the TCC’s 3,400 LF alignment. At this stage, it’s assumed that the winches would be operated in sequence, raising the TCC in 10-foot intervals to avoid excessive loads on any individual winch. Winches would be accessed via boat and operated by two-person crews. Raising the TCC from the reservoir bottom is estimated to require 340 staff hours, as shown in **Table 7**. Inspection of the winches might occur during this period as well.

Table 7: Staff Time Needed to Raise Curtain

Number of Winches	Time Needed to Raise Curtain 10-feet at Each Winch (minutes)	Total Number of Winch Operations to Raise Curtain	Total Time to Raise Curtain (hours)	Total Staff Time to Raise Curtain (assumes two-person crews) (hours)
68	15	10	170	340

Lowering the TCC to target appropriate temperatures would occur periodically over the course of the summer and fall and would culminate with “dropping” the TCC to the reservoir bottom when temperature control is no longer required. This would be accomplished in four lowering-stages, to occur at different times during the year as described in **Table 6**. Lowering the TCC would follow a similar procedure to raising the TCC; each winch would be operated to lower the TCC in up to 10-foot intervals. The lowering operation is described in **Table 8**, and is estimated to require 374 staff hours.

Table 8: Staff Time Needed to Lower Curtain

Lowering Stage	Number of Winches	Time Needed to Lower Curtain at Each Winch (minutes)	Total Number of Winch Operations to Lower Curtain	Total Time to Lower Curtain (hours)	Total Staff Time to Lower Curtain (assumes two-person crews) (hours)
1	68	15	1	17	34
2	68	15	2	34	68
3	68	15	2	34	68
4	68	15	6	102	204

The District will need administrative staff time to plan for TCC operations, review and update a standard operating procedure (SOP) for operating the TCC efficiently and training new staff on how the TCC is designed to be operated. Reviewing and updating the SOP after TCC operations have been completed (i.e., after the TCC has been dropped to the reservoir floor) should follow a standard review process. Staff time needed to plan for raising and lowering operations, training, and SOP review and update is summarized in **Table 9**.

Table 9: Administrative Staff Time Needed for TCC Operations

Activity	Assumptions	Total Staff Time Needed (hours)
Planning Raising and Lowering Operations	Five, two-hour meetings with up to six staff members present to plan for raising and lowering	60
Training	One, four-hour training session with up to 4 staff present	16
SOP Review and Update	One, two-hour meeting with up to six staff after lowering operations are completed; eight hours for one staff to update SOP; four hours for review of SOP updates for up to two staff	28

Total staff time and associated costs for TCC operations are summarized in **Table 10**. It should be noted that the total staff time reported represents a likely best-case scenario and does not consider complications with access to winches or complications with operations in general (e.g., winches become seized during operation). The TCC is expected to provide benefits during Normal and

Above (N) or Below Normal year (BN) types¹ as discussed in the Alternatives Benefits Analysis TM delivered in April 2024 as part of Task 5. These year types have occurred in 59 of the 94 years in the historical record. Raising and lowering the TCC may not occur annually.

Table 10: Operating Costs

Activity	Total Estimated Staff Time (hours)	Direct Labor Cost (\$/hour)	Estimated Operating Cost (\$/year)
Raising TCC	340	\$100	\$34,000
Lowering TCC	374	\$100	\$37,400
Administrative Activity	104	\$150	\$15,600
Totals	818		\$87,000

Tidal Marine Services also provided a quote to perform the described operations; the daily cost for contracting curtain operations to Tidal Marine Services is \$6,550 for two staff members. A total of 45 days is assumed in the tables above, for a total contracted cost of \$295,000 per year. The quote from Tidal Marine is attached to this TM as Appendix A. Tidal Marine’s costs include the cost of the boat and travel to and from Camanche Reservoir. The costs included in **Table 10** only consider direct costs for in-house labor. Maintenance of the TCC is expected to include annual inspection and occasional rehabilitation, repair, or replacement of project components. Surface parts, including the winches, HDPE floats, and portions of the winch line of the TCC will be exposed to typical outdoor elements (sun, wind, and rain) and will be partially submerged. Submerged parts, including the impermeable curtain fabric, 6-inch by 6-inch support netting, and anchoring chains will be exposed to typical underwater conditions. Inspection of surface parts should occur during TCC operations; winches are likely to be typical parts and easily replaced while the HDPE floats are to be custom fabricated. Spare HDPE float sections might be stored by the District in the event of unexpected damage to existing HDPE floats. Inspection of submerged parts will require divers; inspection should occur while the TCC is raised.

4.3.3 Potential Automation of the Winch System

Automating the raising and lowering activity could be accomplished with installation of servos/ motors at each winch. Initial design of the manual winch configuration may consider future retrofitting for automation. Partial automation is also an option – winches might be configured to allow for motorized operation instead of manual cranking. A motor could be brought to each winch

¹Based on the April to September JSA year type criteria. Normal and Above represents 890 TAF unimpaired runoff into Pardee; Below Normal represents 500 – 889 TAF unimpaired runoff into Pardee.

location and attached to the winch to allow for more efficient raising and lowering. Both the fully and partially automated alternatives should be considered if manual operation is deemed too cumbersome by the District.

W&C developed a range of magnitude cost estimates for an automated winch system. Given that the system is quite novel, it would be implemented as a custom solution and there is significant uncertainty in costs at this early stage of project development. The following concepts underpin the estimate:

1. Approximately winch tension is 5 kips, based on each winch handling a tributary width of 50' of curtain and up to 110' of curtain height. This value would be refined during design.
2. A slow rise rate is desirable since this approach reduces power needs. The most important aspect of a power-frugal design is to run only one winch at a time, so a curtain raise or lowering is accomplished by orchestrated small rotations at each winch in sequence, repeating as needed until the curtain is at its desired elevation.

Assume a curtain rise rate of about four inches per minute (10 cm/minute), which would correspond to a duration of 300 minutes, or five hours, for the annual "raise" from the bottom to a height of about 30m or about 100'.

3. Since the power-frugal philosophy allows only one winch to be operated at a time, the curtain will be raised or lowered by small, sequential operations of individual winches. Thus the speed of each individual winch must be 68x the desired rise rate, plus a margin for any time-delay. Assume 100x for cost estimating purposes, or 1000 cm/minute per winch to achieve a curtain rise rate of 10 cm/minute. 1000 cm/minute is approximately 0.167 mps, say 0.2 mps.
4. The winch motors need to be submersible, and this implies low-voltage DC. Assume 42 VDC since that's the maximum "standard" voltage used in marine environments. The final design voltage needs to consider safety as well as efficiency of transmission.
5. Power required per winch is based on the force applied. Power in watts = WV where W is the weight in newtons and V is the velocity in meters per second. Required mechanical power is $5,000 \text{ lb} \times 4.45\text{N/lb} \times 0.2\text{mps} = 4,450 \text{ watts}$, say 4.5 kw.
6. 4.5 kw at 42 vdc implies an amperage of $4,500\text{w}/42\text{v} = 107 \text{ amps}$.
7. Assume we use a bundle of #0000 copper cables aka 4/0, each 11.7 mm (.46") diameter. Unit weight per cable is 0.64 plf, unit cost is \$10/lf.
8. If we target a voltage drop of no more than 10% of the nominal 42 VDC (assume the motors can accept a voltage that's 10% less than nominal), we need 11 cables (see tool at <https://www.omnicalculator.com/physics/dc-wire-size>). Effective unit cost of the bundle is thus about \$110 plf, unit weight is about 7 plf. Cable cost is about $3,400' \times \$110 = \374K , round to \$400K.

9. Winches will require various sensors and controls:
 - a. a position sensor that is based on a count of shaft rotations; this sensor reading, together with a “rating curve” to account for winch gearing, drum diameter, and the effect of cable wrap on effective drum diameter, provides a measure of cable played out at a given winch.
 - b. load cell to report cable tension
 - c. torque reading
 - d. voltage reading
 - e. winch control (on-off, speed selection)
 - f. pressure cell on the top of curtain at each winch location, to provide approximate curtain depth at each winch location
10. Power for each winch’s I&C system will be drawn from the DC power feed.
11. Assume that the I&C system will be based on the RS-485 communication standard, likely in concert with the Modbus protocol. The RS485 standard allows up to 1,200 meters (4,000’) of run using fairly inexpensive cable (likely 16 AWG in at least two twisted pairs), and facilitates “bused” operations which would be required to manage control of the 68 winches with a single run of copper cable (RS485 can handle up to 127 devices). Fiber optic would be another option but could prove to be an O&M challenge due to its greater fragility. Cable cost is approximately \$6/lf.
12. Each winch assembly consist of the following elements:
 - a. Submersible DC motor; sealed at the shaft to keep out water at low pressure.
 - b. Various sensors and controls in a submersible housing
 - c. Custom logic board, also in the submersible housing
 - d. Winch drum and cable, with appropriate gearing.
13. The shore-based power and control system includes:
 - a. AC power drop (e.g., from PG&E)
 - b. DC power supply
 - c. PLC to control and monitor the various winches
 - d. Hardware to allow remote monitoring and operation
 - e. Enclosure, slab, protective bollards
 - f. Conduits for power and I&C, running from the power-and-control box to the curtain

- g. Assume that basic network for remote monitoring already exists, and that remote network can be implemented with a simple YAGI antenna

Table 11: Capital Cost of Winch Automation

Item	Unit cost	Unit	Qty ¹	Price	Notes
<i>Materials</i>					
Custom logic board prototype	50,000	ea	1	50,000	
Custom logic boards	4,000	ea	100	400,000	
Shore-based power and control center including slab, enclosure, power meter, power supply, RTU, antenna	150,000	ea	1	150,000	Allowance
Power cable bundle	110	lf	3,400	400,000	Insulation requirements to be determined
Data cable	6	lf	3,400	20,400	Weatherproof, waterproof required
Winch motor & drum assembly	10,000	Ea	75	750,000	Allowance, includes custom sensors and controls
Data connectors	20,000	Ea	1	20,000	Allowance

¹ Quantities of winch-related items include reasonable spare-parts inventory and thus exceeds the nominal count of 68 winches. The appropriate inventory of specific parts would depend upon component reliability, lead time, and economics.

Item	Unit cost	Unit	Qty1	Price	Notes
Power connectors and fittings	20,000	Ea	1	20,000	Allowance
<i>Materials Subtotal</i>				<i>\$1,810,400</i>	
<i>Labor</i>					
Installation of power and control center with associated conduits				100,000	
Installation of winches and controls	10,000	ea	68	680,000	Allowance
Installation of power and data cables	50,000	Ea	1	50,000	Allowance
<i>Labor Subtotal</i>				<i>830,000</i>	
<i>Other</i>					
Power drop	50,000	Ea	1	50,000	Allowance
<i>Other Subtotal</i>				<i>50,000</i>	
<i>Sub-total Raw Construction</i>				<i>2,700,000</i>	<i>rounded</i>
Estimating allowance	~30%			800,000	
<i>Adjust Raw Construction Cost</i>				<i>3,500,000</i>	
General Conditions	10%			350,000	
<i>Construction Cost</i>				<i>\$4,000,000</i>	<i>rounded</i>

Given significant uncertainties regarding the frequency of winch operation, and the details of each raise and lower operation, it may be beneficial to initially deploy a manual system. An automated system might have never pay for itself, given that the maintenance burden of a novel, distributed control system for 68 winches might be substantial and could even exceed the O&M burden of a manual system. A key reason that automation might not be cost-effective is that curtain operations are envisioned to be relatively infrequent. Thus, while automation would likely produce a net savings for a curtain system that operated 100 times per year, it's unlikely to produce a net savings for this specific application.

4.4 Project Uncertainties & Additional Areas of Study

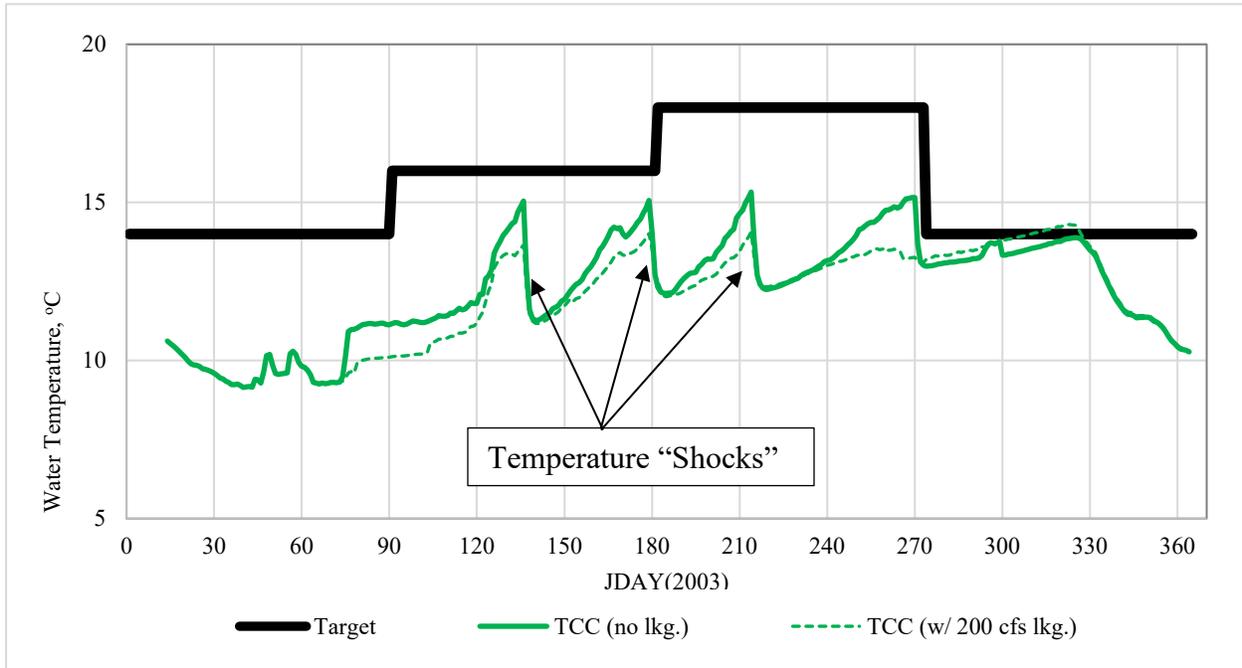
The design concepts presented above seek to meet the needs for a TCC at Camanche Reservoir that effectively manages the temperature of downstream releases. However, uncertainties still exist for the TCC concept. While TCCs have been deployed elsewhere with success, they have not been deployed in a similar manner to the suggested approach at Camanche. TCCs are typically designed to drop from the water surface and allow colder water to pass beneath the curtain, keeping warmer water from passing. The TCC at Iron Gate Reservoir operates to prevent algae entrainment into the intake by preventing movement of algal blooms at the water-surface from entering the area near the intake. Investigating how intermittent failures would impact downstream release targets and preservation of the cold-water pool at Camanche Dam could alleviate some concerns (i.e., how long would the curtain need to be out of service to materially impact cold-water pool in October?).

There are also uncertainties related to the operation of the TCC. The operational strategy outlined in Section 4.1 suggest seasonal raising and lowering of the TCC. This seasonal lowering of the curtain leads to surges of colder water entering the Mokelumne River during the summer period, as shown in **Figure 12**. The impact of these temperature “shocks” on downstream fisheries has not been investigated as part of this project. These “shocks” could be mitigated by modifying operations to slowly lower the TCC over a longer period – this would require additional operational resources or the ability to remotely operate the winches.

The durability of the TCC is also an area of uncertainty. The outlet tower presented in Section 5 is a relatively permanent structure, with a lifecycle typical of large infrastructure projects. The TCC is made from less robust components that may need replacement at regular intervals. These components may also be damaged during storm events if the TCC is not robust enough to withstand forces from wind and wave action. The District recently installed a turbidity curtain at Pardee Reservoir; this curtain experienced extensive damage during a February 2024 storm event. Some of the components can be easily replaced, but others will require re-installation on the reservoir floor. Maintaining the TCC is also atypical and will require specialized expertise and familiarity with the project's components, as well as the need for divers and overwater specialty contractors to repair and maintain the components. Discussion of TCC maintenance with TCC operators at Iron Gate Dam and elsewhere is suggested to better understand operations and maintenance needs for the TCC.

TCC leakage was assessed in the CE-QUAL-W2 modeling done as part of Task 5. However, this analysis assessed sensitivity of the TCC concept’s performance to leakage as high as 200 cfs. The reason for the sensitivity analysis is that TCC leakage cannot be determined with certainty at this stage of project development.

Figure 12: CE-QUAL-W2 Model Results for 2004, TCC Concept

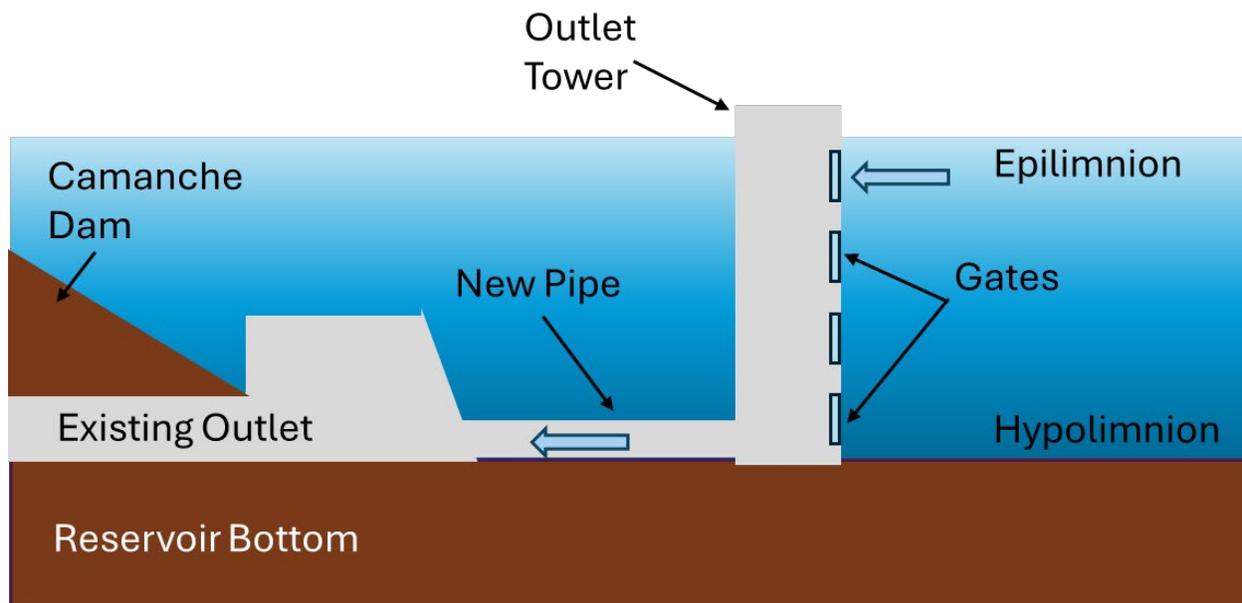


5. SELECTIVE WITHDRAWAL VIA MULTI-LEVEL OUTLET TOWER CONCEPT

5.1 Project Description

An outlet tower seeks to preserve the cold-water pool by selectively withdrawing water from appropriate levels in the water column and piping that selected water to the existing outlet works at Camanche Reservoir. This strategy is illustrated in **Figure 13** below. The outlet tower concept consists of a free-standing tower structure affixed with gates at differing elevations to select water at the appropriate temperature for releases in the spring and summer period, saving colder water for the fall months. The outlet tower structure would be connected to one of the two existing 8-foot diameter outlet pipes. Use of the gates is expected to occur throughout the year; a gate at the bottom of the outlet tower would be available to access the coldest available water during the fall release period. The outlet tower would be operated remotely with shore-based controls, similar to the outlet towers used elsewhere in the District.

Figure 13: Conceptual Operation for an Outlet Tower at Camanche Reservoir



An outlet tower at Camanche Reservoir would be constructed 200-feet from the existing outlet works. An 8-foot diameter pipe could be constructed from the outlet tower to one of the two existing 8-foot diameter outlet pipes; while the reservoir-bottom is at roughly 100-feet in elevation, the new pipeline could be tied into the existing intake structure between 110-feet and 120-feet, allowing both the tower and the pipeline to be supported on an elevated steel structure, supported on steel soldier piles. **Figure 14** below illustrates the location of the proposed outlet tower relative to the toe of the dam and the existing intake structure.

One key design criterion for the outlet tower concept is that the structure must be constructed without draining the reservoir. The outlet tower concept described in this TM focuses on elements that can be constructed “in-the-wet.” Should conditions change (or should the District need to drain the reservoir for other reasons), the District may elect to construct the outlet tower in a more traditional manner. Given this constraint, the outlet tower would be a steel decagon shell with seven-foot wide steel plate facets. The tower will be fitted with eight, 60-inch diameter valves. Valves would be placed on either side of the structure to evenly distribute their weight. **Figure 15** provides an isometric view of the outlet tower concept.

Figure 14: Plan View of Multi-Level Intake Tower

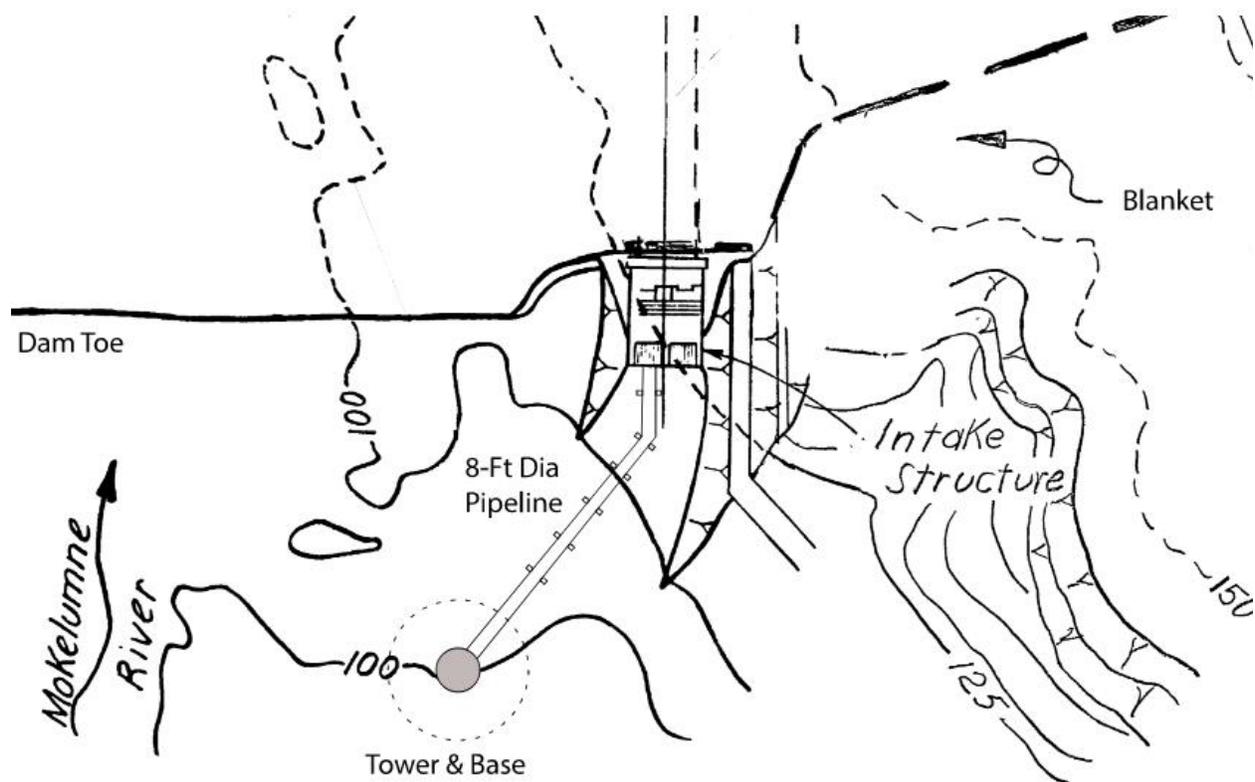
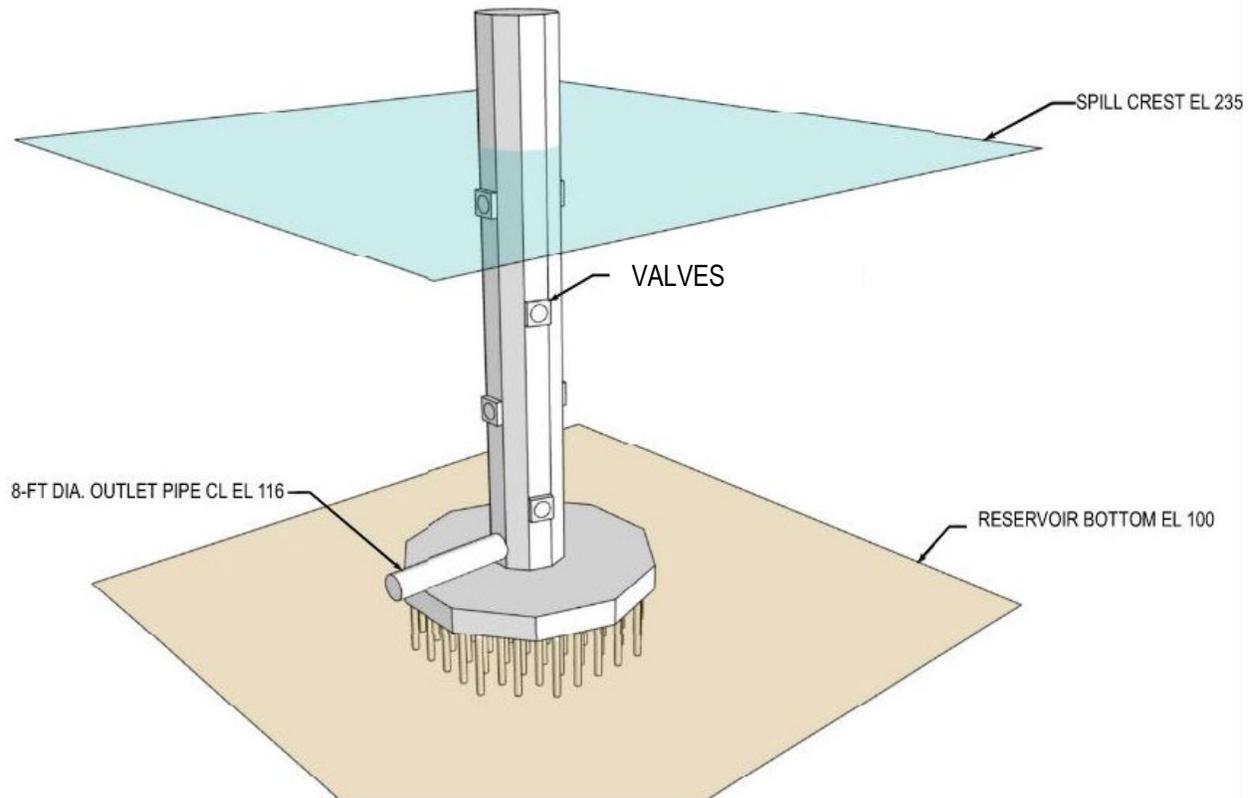


Figure 15: Isometric View of Multi-Level Intake Tower



Construction of the outlet tower would require installation of the soldier piles and elevated steel foundation structure, installation of the decahedral shell structure with valves, and construction of the pipe connecting the tower to the existing inlet structure. Divers may be required for installation of some components. Preparation of the reservoir bottom may be necessary if significant irregularities (i.e., boulders or unexpected crevices) are found during site surveys. Construction activity is expected to take place near the upstream toe of the dam. Sensitive floral and fauna habitat as described in the CNDDDB will be similar to those identified in **Figure 8**, and include Swainson's hawk, steelhead, prairie falcon, tiger salamander, *legenere limosa*, and western spadefoot. The limits of construction are not expected to intersect with mapped habitat for any of the identified species.

As indicated in Section 3 above, regulatory support and regulatory compliance were key considerations in developing alternatives for a TCD at Camanche Reservoir. The outlet tower concept was developed to consider how it might comply with regulations and garner approval from regulatory agencies. Potential permits, reviews and approvals, or certifications for the construction and operation of the outlet tower are expected to include:

- California Environmental Quality Act (CEQA)
 - Initial Study
 - Notice of Exemption (NOE), Mitigated Negative Declarations (MND), or Environmental Impact Report (EIR) as appropriate based on the initial study
- National Environmental Protection Act (NEPA)
 - Possibly not required unless federal funding is used
 - General steps are similar to those required for CEQA
- CDFW, USACE, SWRCB/RWQCB, and USFWS
 - Lakebed alteration agreement
 - 401/404 permits
 - Section 7 consultation, ESA
- SHPO
 - Cultural Assessment/107 compliance
- FERC
 - Plan review and approval
 - Compliance with existing license terms and conditions
- DSOD
 - Plan review and approval

This list identifies probable permitting requirements and may not be exhaustive. If the outlet tower concept is refined through preliminary and final design, other permitting requirements may be identified.

5.2 Preliminary Design Criteria & Concepts

5.2.1 Preliminary Design Criteria

The outlet tower's design was developed by focusing on the goals for the TCD – namely to allow the District to select water from varying depths in the water column to release into the Mokelumne River, preventing the need to release cold water during the summer months. A successful outlet tower at Camanche Reservoir must, at minimum, meet the following design criteria:

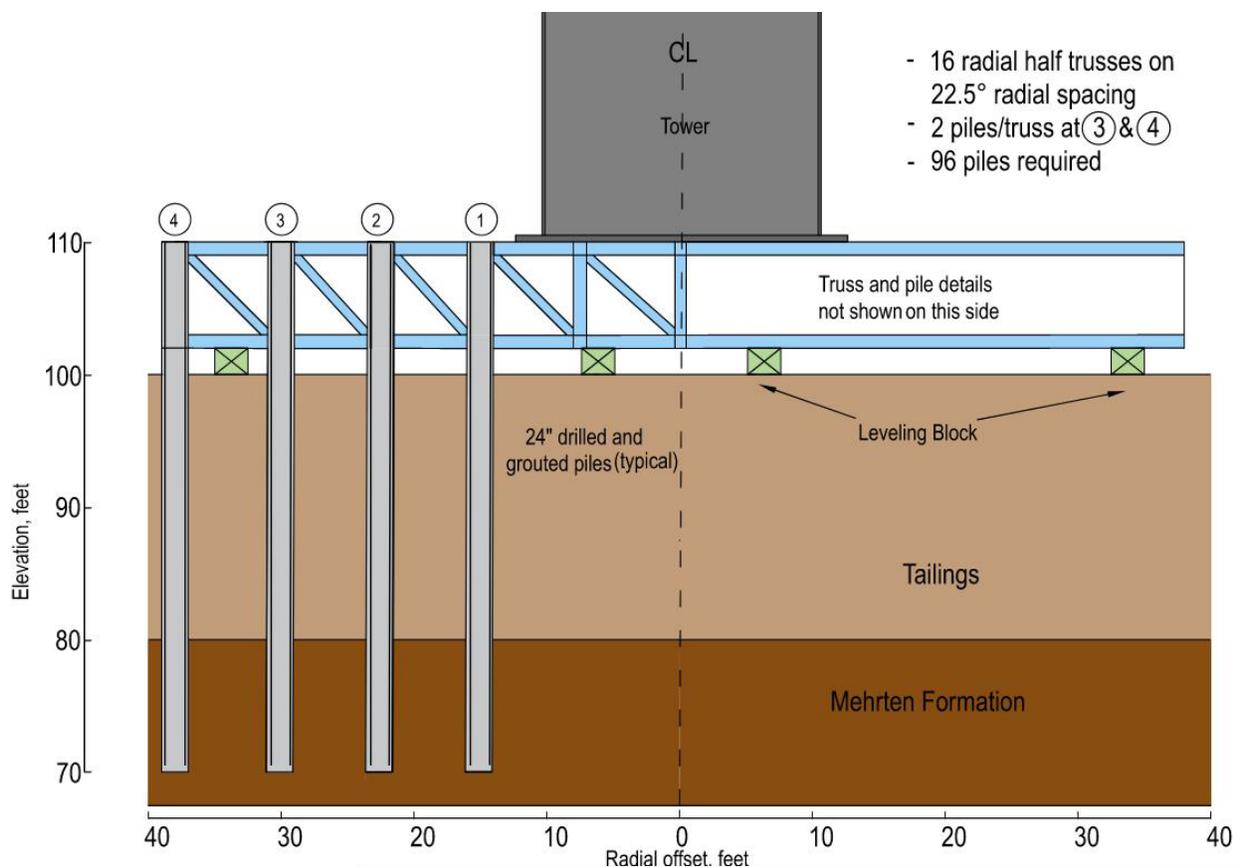
- Be constructed without drawing down the reservoir (i.e., “in-the-wet”).
- Allow for selection at varying depths in the water column.
- Cannot impact Camanche Dam and its normal operations including hydropower generation.
- Cannot impact the drawdown of Camanche Reservoir in an emergency
- Allow for remote operations.
- Minimize potential impacts of failure (i.e., outlet tower failure should not cause dam failure).

Additional criteria may be identified during the design process, but these criteria are critical if an outlet tower is to be successful.

5.2.2 Elevated Steel Foundation

The outlet tower would be supported on a pile supported, 75-foot diameter, 8-foot thick, circular steel structure that includes 16 radially arranged main steel trusses with circumferential lateral bracing. The structure would be supported on 96 steel soldier piles grouted into 24-inch diameter holes drilled into the Mehrten Formation bedrock with sub-horizontal sandstone, siltstone, and claystone layers. Drilling for the pile supports may be accomplished with a barge mounted drill. **Figure 16** below illustrates the elements of the proposed foundation.

Figure 16: Outlet Tower Base and Foundation



5.2.3 Tower Structure & Connection to Outlet

The outlet tower will be a steel decagon shell with 7-foot-wide steel plate facets. The diameter of the circles tangent to the inside and outside of the decagon are 21.5-feet and 22.6 feet. The bottom of the tower would be at 110-feet in elevation with the roof of the tower at 270-feet. For reference, the dam crest is 263-feet, and the spill elevation is 235-feet. The tower will be located approximately 200-feet from the toe of the dam. The thickness of the steel plate forming the walls of the outlet tower would be 2-inches between 110-feet and 155-feet, 1.5-inches between 155-feet

and 210-feet, 1.0-inches between 210-feet and 2-40 feet, and 0.5 inches between elevation 240-feet and 270-feet.

The tower will be fitted with eight 60-inch diameter valves, two at each of four different elevations and located on either side of the outlet tower to evenly distribute their weight. The CE-QUAL-W2 modeling done as part of this effort assumed gates at 103.5-feet, 151.0-feet, 198.5-feet, and 223.1-feet. The hydraulically actuated valves would be operated remotely from the shore using shore power and controls connected to specially designed electric hydraulic power units mounted at each of the eight valves. The valves would also be operable from a hydraulic control cabinet in an equipment room at elevation 260-feet, beneath the roof of the tower. This equipment room would be accessible by boat.

The 8-foot diameter steel pipe connecting the outlet tower to the existing intake structure will be supported on steel soldier piles, similar to those supporting the tower structure. The connection at the existing intake structure will require removing trash racks over the entrance of the intake structure on the left side (looking downstream) and covering the openings with a steel plate fitted with a 8-foot diameter pipe nipple that is bolted to the concrete face of the intake structure using threaded rods drilled and grouted in place by divers.

5.3 Project Costs

Capital project costs are outlined in **Table 12** below and include 25% allowances for design and estimating contingency. Operations of the outlet tower are expected to be consistent with the existing operations at Camanche Reservoir and added operational costs are expected to be negligible.

Table 12: Estimated Construction Costs for an Outlet Tower at Camanche Dam

Item Description	Quantity	Units	Cost
Mobilization and Demobilization	1	LS	\$675,000
Furnish Base Assembly	1	LS	\$2,450,000
Set Base Assembly	1	EA	\$650,000
Drill Pilot Holes for Pile Supports	96	EA	\$6,750,000
Stab and Grout Piles	96	EA	\$2,250,000
Grout Pile to Sleeve Connection in Base Frame	96	EA	\$1,925,000

Item Description	Quantity	Units	Cost
Furnish & Install 2-inch-thick ring for Tower Structure (Elevation 110 to 155 ft)	9	EA	\$1,850,000
Furnish & Install 1.5-inch-thick ring for Tower Structure (Elevation 155 to 210 ft)	10	EA	\$1,200,000
Furnish & Install 1-inch-thick ring for Tower Structure (Elevation 210 to 240 ft)	6	EA	\$625,000
Furnish & Install 0.5-inch-thick ring for Tower Structure (Elevation 240 to 270 ft)	6	EA	\$350,000
Furnish & Install 60-inch diameter valves	8	EA	\$6,200,000
Assemble Equipment Module	1	LS	\$750,000
Install Equipment Module	1	LS	\$250,000
Remove existing trash rack and cover opening	1	LS	\$550,000
Furnish & Install 8-foot diameter pipe	1	LS	\$1,300,000
Furnish & Install Shore Based Equipment Module	1	LS	\$350,000
Furnish & Install Control & Power Wiring between Shore and Tower	1,000	LF	\$1,125,000
<i>Direct Totals</i>			<i>\$29,200,000</i>
<i>25% Design Contingency</i>			<i>\$7,300,000</i>
<i>25% Estimating Contingency</i>			<i>\$7,300,000</i>
<i>Total Cost</i>			<i>\$43,800,000</i>

Maintenance of the outlet tower is expected to include annual inspection and occasional rehabilitation, repair, or replacement of project components. Submerged parts, including the valves, tower structure, piping, and foundation will be subject to typical underwater conditions. Inspection of submerged parts will require divers or use of underwater remotely operated vehicles (ROVs). Inspection may occur annually.

5.4 Project Uncertainties & Additional Areas of Study

Multi-level outlet towers are common infrastructure, in place at many reservoirs across the world. If constructed, the outlet tower would allow the District to select water for release from four (or more) elevations in the water column. The efficacy of the outlet tower concept is not as uncertain as the TCC concept. However, the construction of an outlet tower “in-the-wet” would require atypical methods and an innovative approach. The structure outlined in this TM consists of prefabricated steel parts. Whether these pre-fabricated steel components will have the same useful life as a more traditionally constructed, concrete outlet tower is an area of uncertainty. The District should investigate the need for coating of steel components or cathodic protection if a steel outlet tower is considered for use at Camanche Reservoir.

The capital costs presented in **Table 12** are another area of uncertainty. No meaningful cost basis exists for an outlet tower constructed in this manner, so estimating that construction activity is a challenge. The District might consider performing a more thorough investigation of probable construction costs with the preliminary design elements outlined in this memo (or a more refined design) through a mock-bid process with contractors familiar with underwater construction. Construction is likely to require specialized techniques, the use of divers, and added liability for contractors.

6. SUMMARY OF CONCEPTS & RECOMMENDED NEXT STEPS

This TM discusses preliminary design elements and costs for the two most promising alternatives identified for a temperature control device at Camanche Reservoir: the temperature control curtain and the outlet tower. Both alternatives seek to improve the District’s ability to control temperature of downstream releases into the Mokelumne River to benefit fisheries. **Table 13** presents a high-level summary of costs and design elements for both alternatives.

Table 13: Summary of TCC and Outlet Tower Concepts

Criteria	Outlet Tower	Temperature Control Curtain
Capital Cost	\$43.8M	\$31M
Annualized Capital Cost ¹	\$1.6M	\$1.7M
Constructability	<ul style="list-style-type: none"> Challenging “in-the-wet” Pre-fabricated structure a possibility 	<ul style="list-style-type: none"> Specialized construction Requires attachment to reservoir bottom
Operability	<ul style="list-style-type: none"> Consistent with existing infrastructure Remote operations Minimal operating costs 	<ul style="list-style-type: none"> Requires monthly, manual operation (will be time intensive) Operating Costs: \$295,000/year
Track Record	<ul style="list-style-type: none"> Robust solution; has been implemented elsewhere 	<ul style="list-style-type: none"> Limited track record; has not been deployed in this manner elsewhere

The TCC concept has been deployed elsewhere, but typically with a different operating strategy. The TCC concept at Camanche Reservoir acts as a weir, affixed to the reservoir’s bottom and allowing water to pass freely over the top. TCCs in place elsewhere are dropped from the surface and allow water to freely pass beneath. The outlet tower concept has a more extensive track record for success; however, the construction of an outlet tower at Camanche Reservoir would need to be done without draining the reservoir. “In-the-wet” construction of outlet towers is atypical. Based on results from the CE-QUAL-W2 modeling done as part of this effort, both concepts out-perform

¹ Assumes 25-year lifespan for TCC and 50-year lifespan for Outlet Tower; assumes discount rate is USBR’s 2.75% Water Resources Planning Rate

the existing condition in modeled egg survival based on release temperatures for the fall release period (October through December).

Both alternatives presented in this TM come with uncertainties; the District might pursue next steps to address those uncertainties as it considers its options for a temperature control device at Camanche Reservoir. Next steps might include:

- **Additional Modeling:** This effort did not consider reservoir re-operations; with a newly calibrated and updated CE-QUAL-W2, the District may have more confidence in model results and evaluate alternative operational strategies to improve temperature of downstream releases. Additional modeling should focus on maximizing the District’s capability to meet downstream release targets while considering the District’s other operational needs (i.e., quality of drinking water supply from Pardee, power generation, etc.). The calibrated and updated CE-QUAL-W2 model may be able to aid in identifying strategies to use water from Pardee to support appropriate release temperatures at Camanche.
- **Further Investigate Curtain Loading:** The TCC concept relies on the TCC’s ability to stay in service; the design elements in this TM consider possible loads that might impact the TCC. Improving understanding of those loads would further inform future designs of the concept. Loads may be more or less than what was considered at this point in time. Further investigation of curtain loading should seek to quantify potential wind-and-wave loads that the TCC may experience while it is in operation. The District should also investigate likely modes for failure of the TCC and identify potential design parameters or features that will facilitate more desirable failure modes. Building in these features might allow the TCC to fail in a way that is not catastrophic.
- **Assess Costs for Constructing an Outlet Tower “In-the-Wet”:** Engage specialty contractors to verify and refine key assumptions.
- **CEQA/NEPA Analysis:** Development of environmental documentation is a critical step for all major construction projects; the District should analyze environmental impacts of one or both alternatives.
- **Informal Discussions with Regulators:** The District could approach regulators (DSOD, CDFW, FERC, etc.) to discuss both alternatives and to identify any concerns those regulators might have about both TCD concepts. That discussion could inform project selection and also help refine assumptions.
- **Identify and Apply for Grant Funding:** With the feasibility study complete, the District might consider pursuing grant funding to support some of the foregoing actions, or for design and construction of the selected alternative.