Subject:	**Southern Forebay Conceptual Configuration (Final Draft)**
Project feature:	Southern Forebay
Prepared for:	California Department of Water Resources (DWR) / Delta Conveyance Office (DCO)
Prepared by:	Delta Conveyance Design and Construction Authority (DCA)
Copies to:	File
Date/Version:	December 23, 2021 / Version 3
Reference no.:	EDM_FB_CE_TMO_SF-Conceptual-Configuration_000959_V03_FD_20211223

1. Purpose and Introduction

The Delta Conveyance Project (Project) would include intakes along the Sacramento River between its confluences with American River and Sutter Slough, as well as a tunnel between the intakes and a forebay at the downstream terminus of the main tunnel (the Southern Forebay). Water would either flow by gravity or be lifted by the pumping plant from the tunnel into the Southern Forebay (SF). Discharge from the SF would occur through the Southern Forebay Outlet Structure, at the southern end of the reservoir, into the South Delta Conveyance facilities for connection to the existing State Water Project Harvey O. Banks Pumping Plant and possibly the Central Valley Project C.W. Bill Jones Pumping Plant.

The SF would include a perimeter earthen embankment to retain the storage and an emergency spillway. This technical memorandum (TM) summarizes the following considerations for the development of the SF:

- Configuration and structure layout of the SF on Byron Tract
- Development of the embankment and emergency spillway crest elevations to provide adequate freeboard for internal reservoir overtopping protection and to provide external flood protection
- The construction sequencing of the SF perimeter embankment

2. Background

The SF would be located on Byron Tract near the existing Clifton Court Forebay (Figure 2-1). The SF would be an at-grade storage reservoir that would provide the storage needed to balance Project supply and demand. The forebay would be formed by an earthen embankment with a perimeter length of approximately 4.7 miles and a minimum crest Elevation (El) of +28.0 feet. The elevations provided in this TM are based on the North American Vertical Datum of 1988 (NAVD88).

The California Department of Water Resources (DWR), Division of Safety of Dams (DSOD) is the State agency with jurisdiction over the design, construction, and safe operations of the planned SF embankments. As mandated by DSOD, an emergency spillway would be required to safely convey reservoir inflows and prevent the perimeter earthen embankment from being overtopped from potential excess water supplied to the reservoir from the tunnel system. From the exterior side of the embankment, the Project would be designed to be protected from the 200-year flood event (0.5-percent annual exceedance interval) with anticipated sea level rise and climate change hydrology in Year 2100.

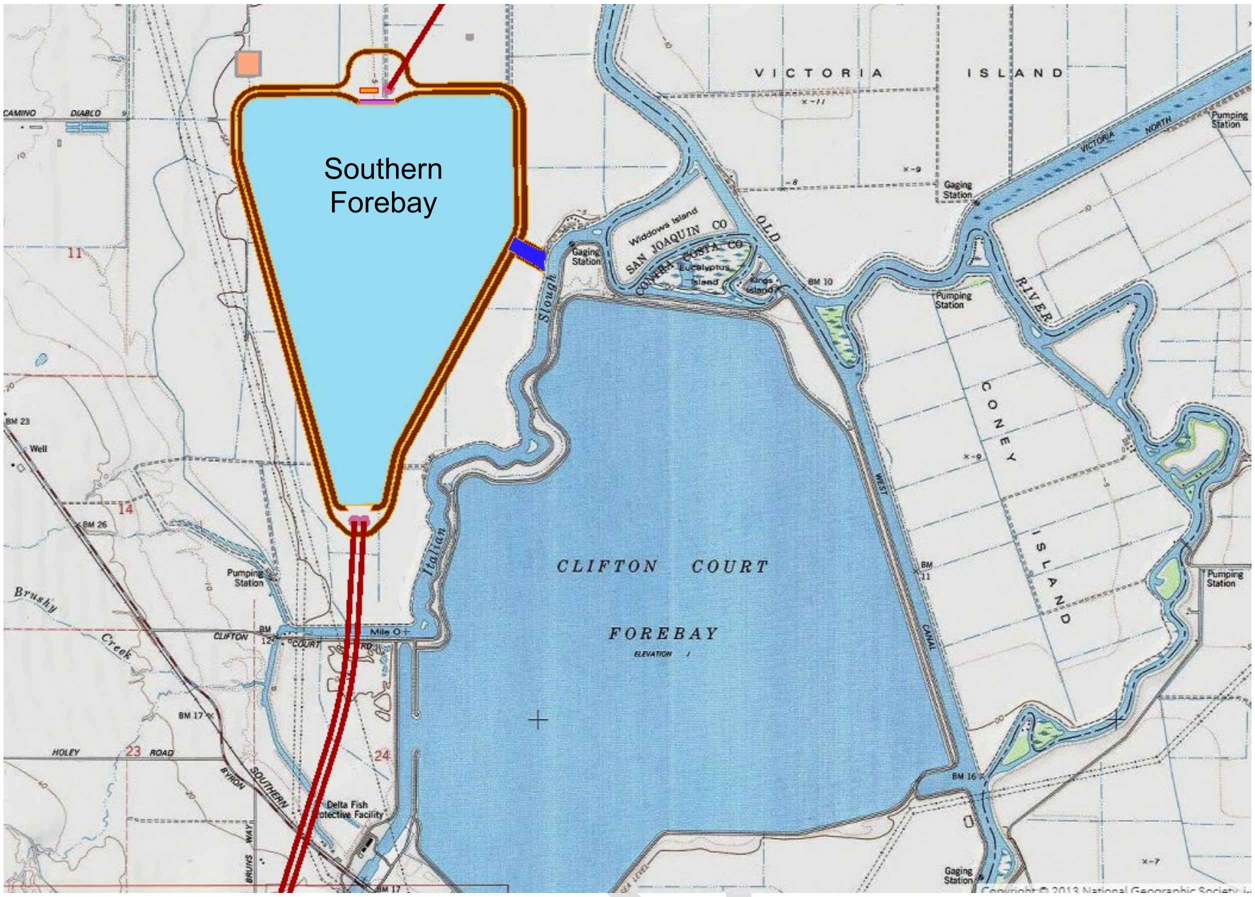

Figure 2-1. Conceptual Location of Southern Forebay. Source: DCA.

3. Configuration and Structure Layout

The SF inflow and outflow could vary throughout a typical day based on diversion flow rates at the intakes and operations of the SWP Clifton Court Forebay and Banks Pumping Plant. The SF capacity was defined at 9,000 AF to provide operational storage to balance flows from the SF and Clifton Court Forebay at the SWP Banks Pumping Plant. Using the normal operating range of the water surface inside the SF of 12 feet (elevation 5.5 to 17.5 feet), and the 9,000 AF of storage in accordance with a projected normal export pumping maintenance scenario, a water surface area of about 750 acres would be required (DCA, 2021c). This area, coupled with the setback distances, the width of the embankment, and the other area requirements described below, was used as the basis for layout of the SF embankments.

The east side of the SF embankments was located assuming a minimum offset of 300 feet (toe of embankment to toe of embankment) from the existing Italian Slough embankments to avoid new facilities impacting the structural integrity of existing levees. The 300 feet setback was assumed for the purposes of conceptual design and is based on the potential impacts to existing seepage characteristics and/or surcharging of soft soils beneath existing levees. Further discussion of this consideration is included within the Flood Risk Management TM (DCA, 2021b).

The west side of the SF embankments were located assuming a minimum offset of 500 feet from the existing high voltage transmission lines owned by PG&E. While the specific PG&E requirements are unknown, the following restrictions were assumed based on input received from other large transmission line operators in the area. These operators indicated that an excavation should be at least 100 feet away from transmission tower footings, and forebay levees should be located no less than 500 feet from transmission line right-of-way. Based on this input, a setback of 500 feet was used for the conceptual design. Other layout considerations on the west side included adjustments to logistical features including rail, road, intersections, segment storage pads, and contractor staging areas, which were shifted to avoid sensitive habitat areas.

The confluence of the east and west setbacks and the proximity to an assumed lineament likely associated with the West Tracy Fault, located immediately south of the forebay site, were used to establish the southern terminus of the SF. It is currently unknown whether the West Tracy Fault is capable of rupturing to the ground surface. Therefore, the SF was shifted north to avoid a direct conflict with the approximate location of the West Tract fault as described in the West Tracy Fault Preliminary Displacement Hazard Analysis (DCA, 2021d).

After the east, west, and south extents of the SF were established, the northern extent was adjusted as necessary to meet the minimum water surface area requirements. The conceptual SF layout is shown in Figure 2-1.

4. Crest Elevation Development

The SF embankments and spillway crest elevations would be established based on interior freeboard considerations mandated by DSOD and exterior flood condition data provided by DWR, using criteria described in the *Conceptual Design Criteria for Forebays* TM developed for the Project (DCA, 2021a). The following subsections describe these two controlling factors and the results of this preliminary assessment for spillway and embankment crest elevations.

4.1 Interior Freeboard

The SF would include a spillway with sufficient capacity to safely convey the maximum peak discharge that could occur at the reservoir, to prevent the perimeter embankments from being overtopped. The maximum peak discharge could either be from flow diverted at the intakes or from the maximum peak pumping capacity at the pumping plant that discharges into the reservoir. The crest of the spillway weir would be set at an elevation at or greater than the maximum normal operating water surface elevation (WSE), plus operating freeboard. For the SF, the maximum normal operating WSE is assumed to El. 17.5 feet. Setting the spillway invert at El. 21.0 feet would provide 3.5 feet of operating freeboard to minimize spills due to internal wind-driven wave runup and exterior backflow.

Wave runup in the Delta was evaluated and described in the *Flood Elevations and Protections* TM prepared by the DWR Delta Habitat Conservation & Conveyance Program (DHCCP, 2009). That TM tabulates wave runup heights ranging between 1.5 to 5.0 feet for different fetch lengths between 3,000 and 30,000 feet. The longest interior fetch distance for the currently conceived SF would be approximately 9,000 feet corresponding to an estimated wave runup of 2.5 to 3.0 feet. Accordingly, a minimum wave runup height of 3.0 feet has been assumed in establishing conceptual interior freeboard requirements for the SF.

The spillway would be designed to pass the maximum peak discharge with 2.5 feet of water height over the spillway weir corresponding to a maximum WSE of El. 23.5 feet. The maximum flow height of 2.5 feet over the spillway weir was established to minimize the overall embankment height requirements. Incorporation of wave runup (3.0 feet) and the DSOD-required residual freeboard of 1.5 feet results in a required embankment crest of El. 28.0 feet (Figure 4-1) (DSOD, 2018).

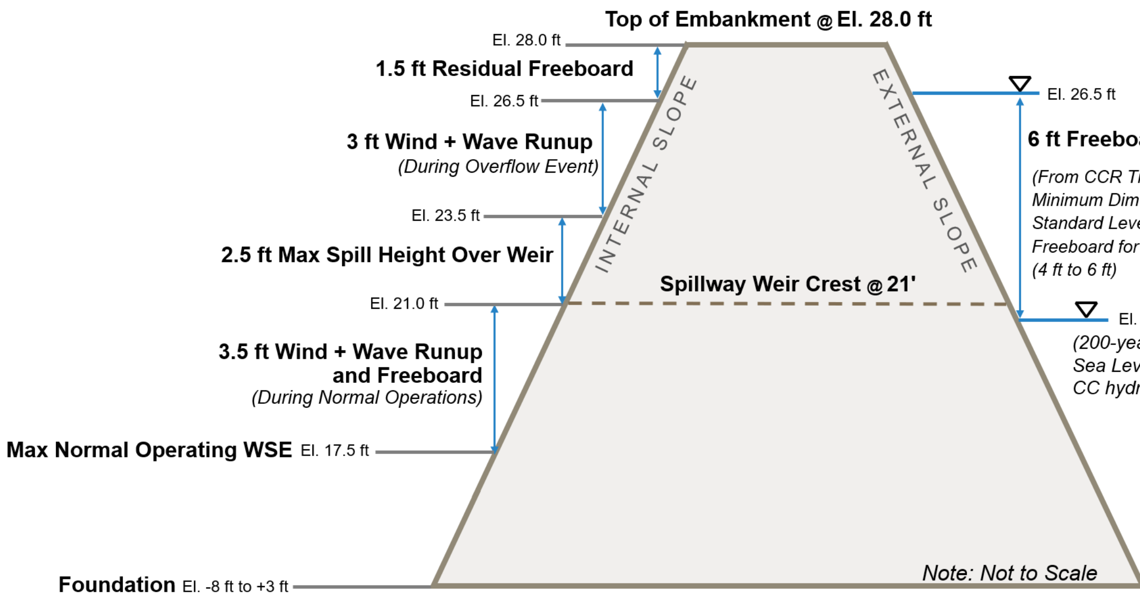

Figure 4-1. Southern Forebay Water Surface Elevation and Crest Elevation Schematic

4.2 Exterior Flood Protection

An external flood WSE was considered in establishing the SF embankment crest and spillway weir crest. A WSE of 20.5 feet was provided by DWR's recent hydrology and hydraulic analyses near the SF for the 200-year flood event with anticipated sea level rise and climate change hydrology in Year 2100 as documented in the Preliminary Flood Water Surface Elevations (Not for Construction) memorandum (DWR, 2020). Wind-driven wave runup on the forebay embankment due to external flooding conditions would be addressed by adding 6 feet of freeboard above the 200-year WSE consistent with California Code of Regulations, Title 23 Waters, Division 1, Minimum Dimensions of Standard Levee Sections, Freeboard for Bypasses (CCR, 2014). This recommendation would result in a minimum-required SF embankment crest elevation of 26.5 feet, which would be less than the elevation established from the interior freeboard calculations above. The spillway weir crest would be set at El. 21.0 feet to limit backflow into the reservoir during 200-year external flood condition, although some water may lap over the spillway weir due to external wind-driven wave action during an extreme flood event (Figure 4-1).

5. Embankment Construction Sequencing

Available information indicates the SF foundation transitions from deltaic deposits to alluvial/fan deposits generally from east to west and, to a lesser extent, from north to south. Similarly, the groundwater table is somewhat deeper along the western side of the site compared to the topographically lower areas closer to Italian Slough. Geotechnical conditions for the SF site, and particularly along the eastern portion of the site, consist of peaty, organic soils within the upper foundation overlying high-plasticity clays and sand.

The following construction sequencing has been developed based on the current understanding of the site geotechnical conditions but should be updated as additional geotechnical information is obtained at the site.

Initially, vegetation and upper soil layers on the site would be stripped up to 6 inches of topsoil over the entire SF footprint. This stripping would allow for segregation of the topsoil for later reuse at the site.

Next, excavation and replacement of at least 6 feet of the upper SF embankment foundation would be performed for the entire perimeter. The excavation and replacement would create a consistent embankment foundation and remove shallow foundation discontinuities. Deeper excavation and replacement may be performed, if practical, to remove unsuitable foundation materials, such as peat, highly organic soils, or loose sands. The width of this excavation would vary based on the existing ground surface elevation at the site. The width of the excavation would vary between approximately 250 and 300 feet, with sides sloping away from the excavation at 2H:1V. The construction of the embankments would follow the following general sequence:

1) Use suitable material from on-site undercut and initial grading of forebay floor to backfill the new Pumping Plant pad and SF Outlet Structure pad to original grade.
2) Construct DMM (CDSM) foundation improvements (25 percent ARR) beneath Pumping Plant pad and SF Outlet Structure pad from original grade.
3) Construct Pumping Plant pad and SF Outlet Structure pad using suitable excavated materials from the initial 6 foot undercut.
4) Install vertically-driven sheetpiles and dewatering wells around perimeter of spillway structure foundation.
5) Perform open cut excavation to remove anticipated peat/organic soils to 15 feet below original grade below spillway structure foundation. Backfill/compact with RTM or suitable on-site fill to original grade. Remove sheetpiles used for excavation support of the spillway structure foundation.
6) The unsuitable peat/organic soils from the 6 feet undercut or spillway structure excavation would be placed in the permanent stockpile located immediately to the north of the SF. A 5-foot-thick layer of topsoil would be used to cover the peat to limit oxidation of the organic peat material.
7) Install prefabricated vertical drains (PVDs) in deeper soft clay deposits beneath the spillway foundation to be used as dewatering wells during construction. Add drainage layer on top of PVDs.
8) Apply surcharge loads to east embankment foundation using RTM materials. The preloading soil would likely be placed in multiple sequences over a 2 to 2.5-year period. Each layer of soil would have a height of approximately 10 feet, with a total preloading height of up to 30 feet.
9) Degrade surcharge loads to original grade and construct DMM (CDSM) ground improvement where needed.
10) Reconstruct embankment to elevation 18 feet using RTM, on-site suitable fill material, and imported drainage material. Construct seepage cutoff wall from working platform at elevation 18 feet, including below the spillway structure.
11) Complete embankment construction to finished grade using RTM and/or on-site suitable fill and complete spillway structure and discharge channel embankments including riprap lining. Breach a portion of the levee at Italian Slough for the emergency spillway discharge channel.

Riprap and filter material would be placed over the inboard slopes of the forebay embankments and topsoil salvaged from the site would be placed on the outboard slopes. A 24-foot wide gravel access road would be constructed on the crest of the embankment and an additional 16-foot wide gravel access road would be constructed at the toe of the outboard slope of the embankment. Based on available information on potential embankment fill sources, it is assumed for conceptual design that the embankment would be constructed as a zoned embankment with a slurry trench cutoff wall, a fine grained core above the slurry trench cutoff wall, 4H:1V slopes, a toe drain, with the following dimensions and elevations:

- Top of Forebay Embankment Elevation: 28.0 feet
- Bottom of Embankment Foundation Elevation: -8.0 to 0.0 feet

6. Conclusions and Recommendations

Figure 4-1 summarizes the WSEs and resulting embankment crest and spillway weir crest elevations discussed in this TM. As the figure shows, the internal freeboard development ultimately controls the crest height of the embankment. The spillway weir crest elevation was established to satisfy both the exterior criteria, to minimize backflow; and interior criteria, to limit inadvertent spills due to internal wave runup.

The following recommendation should be considered during the initial design phase.

- A site specific wind and wave analysis should be performed to further evaluate freeboard requirements at the maximum normal operating water level and peak water level during an emergency discharge. If the analysis indicated less freeboard would be required to comply with DSOD requirements, external freeboard would be reconsidered to comply with the California Code of Regulations, Title 23 that requires 4 to 6 feet elevations for bypasses.
- Site specific analyses of the Italian Slough levee stability were not performed as part of the conceptual design process but should be considered during future design phases. For the purposes of conceptual design, it was assumed that all SF embankments would be placed 300 feet away from the existing levee toe to limit potential impacts associated with placement of fill; however, specific analyses should be considered at the connection of the emergency spillway discharge channel embankments and the Italian Slough levees.
- The configuration of the SF embankment and foundation and construction sequencing should be further considered during final design following collection of additional site-specific subsurface information and detailed analyses.

7. References

California Code of Regulations (CCR). 2014. *Title 23 Waters, Div 1 Central Valley Flood Protection Board*.

California Department of Water Resources Division of Safety of Dams (DSOD). 2018. *Division of Safety of Dams Inspection and Reevaluation Protocols*.

California Department of Water Resources (DWR). 2020. *Preliminary Flood Water Surface Elevations (Not for Construction).* September.

Delta Conveyance Design and Construction Authority (DCA). 2021a. *Conceptual Design Criteria for Forebays Technical Memorandum*. Final Draft.

Delta Conveyance Design and Construction Authority (DCA). 2021b. *Flood Risk Management*. Final Draft.

Delta Conveyance Design and Construction Authority (DCA). 2021c. *Southern Forebay Siting Analysis*. Final Draft.

Delta Conveyance Design and Construction Authority (DCA). 2021d. *West Tracy Fault Preliminary Displacement Hazard Analysis*. Final Draft.

Delta Habitat Conservation and Conveyance Program (DHCCP). 2009. *Flood Elevations and Protection Technical Memorandum*.

8. Document History and Quality Assurance

Reviewers listed have completed an internal quality review check and approval process for deliverable documents that is consistent with procedures and directives identified by the Engineering Design Manager (EDM) and the DCA.

Approval Names and Roles			
Prepared by	**Internal Quality Control review by**	**Consistency review by**	**Approved for submission by**
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This interim document is considered preliminary and was prepared under the responsible charge of Craig Hall, California Professional Engineering License GE2556.

Note to Reader

This is an early foundational technical document. Contents therefore reflect the timeframe associated with submission of the initial and final drafts. Only minor editorial and document date revisions have been made to the current Conformed Final Draft for Administrative Draft Engineering Project Report version.