Appendix B11. Intake Flood Management (Final Draft)

1. Introduction and Purpose

The purpose of this technical memorandum (TM) is to outline the regulatory requirements and design criteria used to establish and maintain flood management during and after the North Delta Intake facilities are constructed for the Delta Conveyance Project (Project).

The Project includes two tee screen intake structures, C-E-3 and C-E-5, located at river mile (RM) 39.4 and 36.8 on the Sacramento River, each capable of conveying up to 3,000 cubic-feet-per-second (cfs) for a total Project flow capacity of 6,000 cfs.

1.1 Organization

- Introduction and Purpose
- Background
- Flood Protection Levee(s)
- Flood Protection During Construction
- Postconstruction Flood Management
- Conclusions
- References

2. Background

The flood control levee with State Route 160 was constructed as part of the Sacramento River Flood Control Project Levee (Project Levee) program established by the U.S. Army Corps of Engineers (USACE) to provide flood management for surrounding lands. This type of levee is considered a jurisdictional levee that requires approval by the USACE and Central Valley Flood Protection Board (CVFPB) before it is modified and requires flood control criteria to be maintained continuously during the construction of any modifications.

The California Department of Water Resources (DWR) performed a preliminary hydraulic analysis to determine the maximum water surface elevations (WSEL) at each potential intake location. These WSELs are based on:

- The 200-year Central Valley Flood Protection Plan (CVFPB, 2017) updated elevations
- Impacts to the river flow rates and associates WSELs with climate change (CC) hydrology
- A projected sea level rise (SLR) for the year 2100

Table 1 shows the values of the maximum WSEL and the top-of-levee for each site, which includes 3 feet (ft) of freeboard. The top-of-levee represents the minimum elevation required to maintain flood protection.

Table 1. Water Surface & Flood Protection Levee Elevations

Intake	River Mile	200-Yr Max WSEL + CC+ SLR (ft)	Top of Levee (ft)
C-E-3	39.4	27.3	30.3
C-E-5	36.8	26.3	29.3

Notes:
Note the following nomenclature with reference to the Project environmental documentation: Intake C-E-3 = Intake B, and Intake C-E-5 = Intake C
ft = feet
Max = maximum
Yr = year(s)

3. Flood Protection Levee(s)

Currently, a jurisdictional levee and State Route 160 parallels the Sacramento River and provides flood protection to the surrounding areas. The existing levee at the intake site would be impacted by construction of the new intake facilities and would need to be supplemented with additional flood control measures during the work. Therefore, a temporary jurisdictional levee would be required at the intake site to allow the intake facilities to be constructed along the river while maintaining continuous flood protection. The temporary levee would also facilitate the construction sequencing of the permanent jurisdictional levee around the perimeter of the intake sedimentation basin and tunnel inlet channel.

The permanent jurisdictional flood control levee would be the perimeter embankment of the intake sedimentation basins, the intake outlet channel, and the intake outlet shaft. This levee would tie into the existing levee both upstream and downstream of the site.

A non-jurisdictional levee would be included along the approximate alignment of the existing river levee and would be located between the intake structure and the sedimentation basins. This levee would be constructed similar to jurisdictional levees, but would have conveyance conduits penetrating through it from the intake structure to the sedimentation basins. Flood isolation gates would be included on the conduits on both the river and land side of this non-jurisdictional levee as an added level of protection at the site.

Each flood control levee (jurisdictional and non-jurisdictional) constructed at the intake sites would be constructed according to levee design and construction regulatory requirements of the USACE EM 1110-2-1913 *Engineering and Design – Design and Construction of Levees* (USACE, 2000), California Department of Water Resources - *Urban Levee Design Criteria (ULDC)* (DWR, 2012), and California Code of Regulations (CCR) Title 23 (California Water Boards, 2019). Those requirements require detailed engineering analysis to be conducted using site specific hydrological and geotechnical information. The analyses will establish the levee configuration, including, among other details:

- Minimum crest width
- Stable slide slopes
- Foundation requirements
- Slurry cutoff wall requirements
- Levee fill material and zoning requirements

Currently, the configuration portrayed in the engineering concept drawings (Figure 1) includes the following levee features:

- Minimum crest width as required by ULDC would be 20 ft for a major river. Due to the presence of electrical equipment at the intake sites, the levee crest would also need to meet California Fire Code (California Building Standards Commission, 2016) which would require at least 20 ft wide roads, with 4 ft shoulders (total 28 ft wide). To provide adequate turning radii for construction, O&M, and emergency vehicles on the jurisdiction levee, a two-lane road, 12 ft each, with 8 ft shoulders was selected (40 ft total). Additional refinement based on coordination with local fire code officials and further consideration of O&M requirements may modify the levee crest design.
- Levee side slopes of 3 horizonal to 1 vertical (3H:1V) for both the interior and exterior slopes, as required for all new levees per the ULDC (DWR, 2012). Exceptions allow for steeper side slopes if the levee crest is oversized and seepage and stability criteria are met. The side slopes may be revised with further analysis.
- Slurry cutoff walls will be constructed beneath all levees. The top of the cutoff wall will be constructed to the maximum flood water level elevation, or a fine-grained levee core within the levee fill section will be constructed as shown in Figure 1. The levee fill material for the jurisdictional levee would be expected to be sourced on-site, however the material specifications are unknown at this time and core material could need to be imported. The fine-grained levee core and slurry cutoff walls will ensure the jurisdictional levee meets underseepage and through seepage requirements.
- Ground improvement beneath levee embankment to provide stability relative to settlement of the fill material and to protect the levee from liquefaction of subsurface material in a seismic event
- Inspection trench beneath levee foundation on water side of crest, per California Code of Regulations (CCR) Title 23 (California Water Boards, 2019)
- Minimal work in the levee prism (area within projection of side slopes downward beneath finished embankments) below constructed grade; limited to drilled piers and the tunnel shaft
- Slope protection, including rock, articulated mats, and vegetation, as applicable, to minimize slope erosion

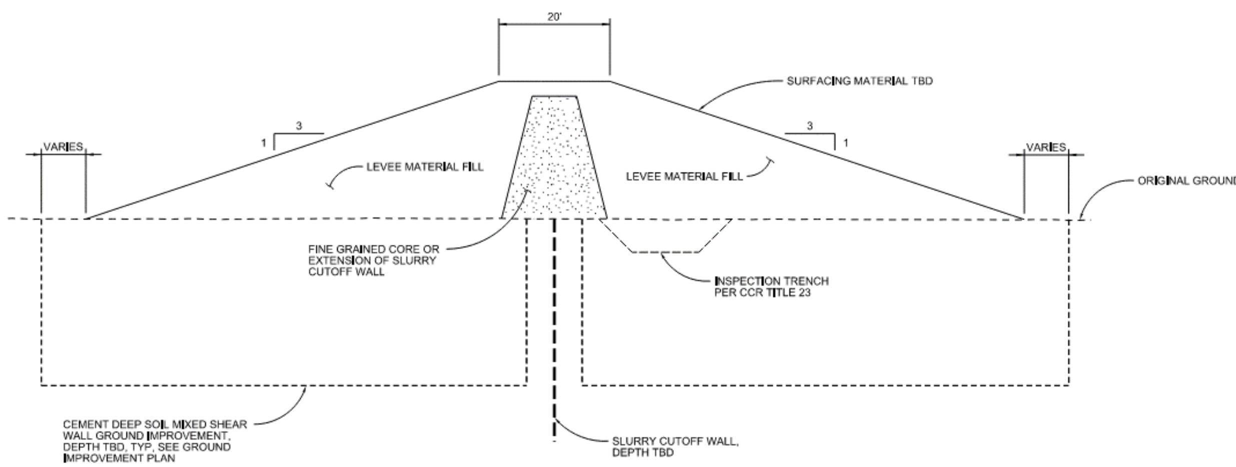

Figure 1. Typical Minimum Jurisdictional Levee Section

Levees would be constructed over previously installed slurry cutoff walls and ground improvement. Fill meeting the engineering design requirements would be placed and compacted in lifts to achieve the desired levee configuration. It is expected that site soils are available that meet the requirements for the levee fill. If suitable soils were not found at the site, site soils would be improved, or suitable material would be imported to the site. The specific fill requirements would depend on the engineering analyses for the site and would be developed in detail for final design and USACE levee permit acquisition activities.

Levees would be tied into or transitioned to existing or previously placed levees by properly configuring the slurry walls and ground improvement beneath the levees at these transition sites, as well as by using applicable levee fill materials to allow the connection with continuous suitable fill material. Then, the new levee would be compacted against the existing or previously placed levee in lifts keyed into the older levee in a stepped configuration.

3.1 Ground Improvement

Due to the ground conditions beneath the intake site, liquefaction and associated surface settling could occur during seismic events. This increases the possibility of surface and differential settling. Therefore, ground improvement that would consist of a grid of deep mechanical mixed walls would be constructed to provide stability for embankments at the site. Cement would be mixed with existing in situ soil in a wall panel configuration to strengthen the ground for supporting overlying structures and embankments. This work would extend under all levee areas, as shown in the engineering concept drawings.

The quantity of improved ground required would vary, depending on actual site conditions and the final size and configuration of the intake facilities, which would be determined during detailed design.

3.2 Slurry Cutoff Walls Material and Preparation

Slurry cutoff walls would be installed at the intakes to protect adjacent existing groundwater levels and quality, facilitate the dewatering of the sedimentation basins, and to provide jurisdictional levee cutoffs to control seepage. The slurry cutoff walls would reduce groundwater and river water seepage into the excavation, would help stabilize levee sections, and would minimize the exfiltration of diverted water into the surrounding groundwater. The slurry cutoff walls consist of soil, bentonite, and cement slurry and would be installed at the following locations:

- Along the alignment of the temporary levee under the relocated footprint of State Route 160 (jurisdictional)
- Between the proposed intake structure and the land side toe of the existing levee (non-jurisdictional, support basin excavation dewatering)
- Along the alignment of the new jurisdictional levee surrounding the sedimentation basins and intake outlet channel (jurisdictional)
- Along existing levee to transition from new facilities to existing levee (jurisdictional)

The slurry cutoff walls would transition to the existing levee along, or immediately adjacent to, State Highway 160 at the edges of the disturbed area to facilitate future extensions by others.

The slurry material would be prepared in the mixing tanks and pumped to the active excavation at the slurry wall cutter. Soil cuttings would be mixed with bentonite and discharged into the active excavation area. Slurry would then be pumped from the excavation to the separation plant, where the bentonite would be reclaimed and returned to the excavation until the excavation was completed. Then the slurry material would be mixed with cement and soil cuttings for filling the slurry walls excavations with a soil, bentonite, and cement material. When the cutoff wall material set, it would provide a barrier that reduces seepage of groundwater. During construction, this reduction in seepage would limit the volume of dewatering required to the area inside the slurry wall; and would therefore reduce the amount of water that would be pumped. After construction, the cutoff wall would reduce groundwater seepage into, or out off, the sedimentation basins and would facilitate future dewatering when the basin needed to be drained for maintenance purposes.

4. Flood Protection During Construction

4.1 Temporary Jurisdictional Levee

A temporary jurisdictional levee would be constructed offset on the land side of the existing levee to allow the existing levee to be modified as part of constructing the intake structure. The temporary levee would serve the same regional flood control purpose as the existing levee as well as provide flood control for the land side construction activities. It would be constructed prior to any modifications to the existing levee.

Once the permanent levee around the intake facilities is in place, and accepted by the applicable regulatory agencies, the temporary levee would be removed and the basin excavation, final grading, and related earthwork under its footprint would be completed.

4.2 Intake Structure

To facilitate the construction of the river intake structure, and to mitigate flooding, a cofferdam with internal bracing would be installed to isolate the intake structure construction area from the river. The cofferdam would include sheet pile walls and deep mechanically mixed (DMM) back wall. The contractor would install the cofferdam sheet piles for the front and side perimeter of the intake structure at a predetermined distance from the permanent structure walls (about 5 feet). The sheet piles would include "Z" sheet piles. Similarly, the contractor would install the cofferdam back wall at a predetermined distance from the permanent structure walls (potentially as the rear form for the back permanent structure wall). The back wall would also be used as a seepage cutoff wall behind the intake structure (non-jurisdictional, as described above). The cofferdam walls would extend above the river level to a contractor-selected height (normally above typical flood levels, but somewhat lower than the top of structure). The sheet pile cofferdam would remain in place for the full duration of construction of the intake structure. The back wall would remain in place permanently.

Sheet pile training walls, similar to the cofferdam walls, would extend in an arc reaching back to the finished grade along the levee upstream and downstream of the intake structure. The training walls would transition the face of the structure to the existing river embankment and levee. The training walls would provide improved river hydraulics and facilitate vehicular access to the operating deck and State Route 160. Each training wall would extend at a continuous radius of 200 ft from the structure toward the limits of the jurisdictional levee. These walls would remain in place after construction as a permanent structure and would be installed to approximately finished grade. Detailed dimensions of these walls are shown on the engineering concept drawings.

The enclosed area within the cofferdam would be excavated to the level of the structural and tremie seal subgrade, using clam shell or long-reach backhoes, after ground improvement (if needed), then foundation pier installation and tremie seal placement would take place. The tremie seal would provide a barrier to help control water flow into the construction site and serve as an additional method of flood control for the construction site. A reinforced concrete drilled pier foundation would be installed to resist the lateral structural loads. Drilled pier design would be in general accordance with applicable Federal Highway Administration (FHWA) design procedures (FHWA, 2018). Lateral load design is expected to be the controlling factor. Lateral foundation deflections would be limited to amounts less than permitted by the USACE and the CVFPB, but would be expected to be less than 1 inch.

After both ground improvement and foundation installation was complete, a tremie concrete seal would be placed around the piers within the entire enclosed area of the cofferdam. The thickness of the tremie concrete would be commensurate with the design uplift pressure and the uplift capacity of the drilled piers that are to be installed as part of the intake structure foundation. Once the tremie slab had cured sufficiently, the cofferdam would be dewatered to allow other construction activities to be carried out in the dry. All water removed from the cofferdam would be treated to meet permit requirements before discharging back into the river.

After the intake structure was constructed, divers would cut away the river-facing sheet pile cofferdam wall to an elevation just below the screen sill, as shown on the engineering concept drawings. This action would expose the intake structure face to the river.

4.3 Intake Outlet Shaft Construction Pad

The intake outlet shaft would be configured in conjunction with the levee embankment around the intake outlet channel to protect the shaft opening from the 200-yr peak flood elevations plus sea level rise during operations. During construction of the shaft, a lower flood protection elevation may be possible for portions of the shaft pad to help reduce fill quantities around the shaft. However, for most tunnel shaft pads, the working platform elevation would be similar to the existing levee, which is very close to the proposed new levee crest elevation. Given the level of protection afforded by the new temporary levee and the proposed permanent levee, it is reasonable to expect a lower pad elevation could be used for portions of the shaft pad. However, for this TM, the construction phase pad height is shown at the same elevation as the final levee (see Figure 2). The specific height should be determined during final design in conjunctions with USACE input and ongoing analysis of the sequencing of these aspects of the work.

Because the construction pad would be within the slurry cutoff walls for the jurisdictional levees that are to be constructed around the intake facility, no slurry cutoff wall would be required to control groundwater flow. The pad would be constructed from materials excavated onsite and placed in a conical shape around the opening and would be a non-jurisdictional temporary addition to the levees, as shown on Figure 2.

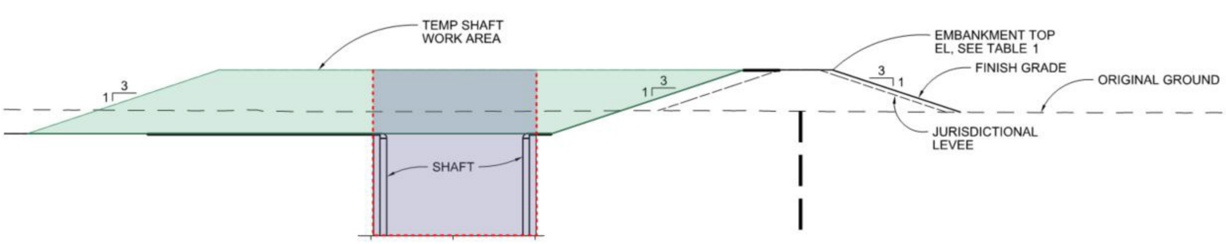

Figure 2. Levee and Construction Pad Section View

The tunnel would be approximately 100 feet below the original ground surface and would pass beneath the new levee placed around the perimeter of the intake sedimentation basins, intake outlet channel, and intake outlet shaft.

When the shaft and conveyance tunnel were complete, the outlet shaft construction pad would be removed in lifts to the finish grade of the levee and outlet channel. For further details on the timeline of events for the construction of the intake, refer to the Concept Engineering Report (CER)Appendix B12 *North Delta Intake Facilities Configuration, Construction, and Operations*.

5. Post Construction Flood Management

While the permanent jurisdictional levees would be located along the boundaries of the intake facilities, an additional non-jurisdictional levee would provide supplemental flood management for the site. This levee is shown on the Phase 3 Site Plan of the conceptual engineering drawings, with State Route 160 indicated. This portion of the levee would be constructed to the same elevations shown in Table 1, and it would meet several of the same standards required by USACE and CCR Title 23, including a cutoff wall. However, due to the number of penetrations for conveyance conduits this portion of the levee would not be considered jurisdictional by the USACE or CVFPB. If the facility became flooded through the intake structure, the jurisdictional levee surrounding the site would provide flood protection to the surrounding areas.

In conjunction to the levees serving as a flood prevention measure, the valves/gates at the intake structure and the conveyance conduits leading to the sedimentation basin could be closed to prevent water from entering the sedimentation basins during extreme flood events. The radial gates at the back side of the sedimentation basins could also be closed to isolate the intake outlet channel and shaft, as well as the downstream facilities, from the higher river levels. This feature is useful in actual practice, but note that all downstream facilities would be designed to either contain the full river flood height, or pass the maximum gravity induced flows into downstream water bodies at controlled locations. Specific jurisdictional aspects of these control gates and related structures would be determined during later design phases. Note that the radial gate structure is integral to the levee system at the intakes and would be designed in accordance with DWR requirements as well as those of the applicable flood control agencies. Conformance with CCR Tile 23 (California Water Boards 2019), and USACE ETL 1110-2-584 (USACE 2014), USACE EM 1110-2-2702 (USACE 2000b) would also be included in future design efforts.

6. Conclusions

To provide flood management along the Sacramento River at each of the proposed intake sites, several Project flood mitigation measures would be in place during and after construction, including:

- Jurisdictional levees (both permanent and temporary) would be constructed to meet the USACE and CVFPB (CCR Title 23) requirements. This measure includes borrow material and earthwork compaction standards, ground improvements, and slurry cutoff walls to mitigate groundwater seepage and migration. Levees would be keyed into the existing U.S. Highway 160 jurisdictional levee to provide continuous flood protection.
- Cofferdams would be placed in the Sacramento River along the face of the proposed intake structure, to enable the construction of the intakes and to provide a contractor-selected level of construction phase flood protection within the confines of the cofferdams.
- The cofferdam would be placed in a configuration to reduce hydraulic impacts to the Sacramento River.
- Flow control valves/gates, and radial gates would be installed and can be fully closed in times of extreme flood events.

- Temporary measures that will be in place only during particular construction sequences, such as the cofferdam or the temporary jurisdictional levee, would be removed either fully or partially after the completion of each construction task. Partially removed temporary features would not be included as part of permanent jurisdictional flood protection features.

7. References

California Building Standards Commission. 2016. 2016 California Fire Code: California Code of Regulations Title 24, Part 9.

California Department of Water Resources. 2012. Urban Levee Design Criteria.

California Water Boards. 2019. California Code of Regulations (CCR) Title 23, Waters.

Central Valley Flood Protection Board (CVFPB). 2017. Central Valley Flood Protection Plan.

Federal Highway Administration (FHWA). 2018. Geotechnical Engineering Circular No. 10 – Drilled Shafts: Construction and Design Methods.

U.S. Army Corps of Engineers (USACE). 2000a. USACE EM 1110-2-1913 Engineering and Design – Design and Construction of Levees.

U.S. Army Corps of Engineers (USACE). 2000b. USACE EM 1110-2-2702 Engineering and Design – Design and Spillway Tainter Gates.

U.S. Army Corps of Engineers (USACE). 2014. USACE EM 1110-2-584 Engineering and Design – Design and Hydraulic Steel Structures.

U.S. Army Corps of Engineers (USACE). 2020. Sacramento River Flood Control Project Levee.