Appendix E1. Design and Construction of Wilkerson Dam South of SR 12 on Bouldin Island

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Under Alternative 3, Bouldin Island and Holland Tract would be operated as reservoir islands. Water would be stored on Bouldin Island up to +6 feet elevation south of State Route (SR) 12. To retain water and protect the existing highway, a dam will be required south of SR 12. The dam is intended to provide flood protection to SR 12 and the remainder of the island from water stored in the reservoir. Because the dam will retain more than 6 feet of water, its design and construction will be performed under the review and approval of the California Department of Water Resources' (DWR's) Division of Safety of Dams (DSOD). Extensive geotechnical studies have been conducted for the levee south of SR 12, and results of the studies and design criteria have been developed and submitted to DSOD for review and approval (Harding Lawson Associates [HLA] 1992).

GEOTECHNICAL INVESTIGATIONS

HLA, under contract to Delta Wetlands (DW), conducted geotechnical investigations and design studies for the interior levee south of SR 12 on Bouldin Island (Wilkerson Dam) (HLA 1992). HLA submitted several interim design and characterization reports to DSOD as part of its coordination activities.

Site-specific soil properties were determined through extensive field investigations and laboratory analyses. The field exploration included constructing a full-scale test fill to evaluate soil properties and performance under embankment loading. Laboratory testing of representative soils determined shear strength, consolidation, and density. HLA developed engineering parameters for the design of Wilkerson Dam using data collected during field and laboratory investigations. Primary engineering and design considerations include embankment stability, settlement under embankment loads, seismic stability, seepage through the embankment, and protection of the interior face of the dam from wave erosion. (HLA 1992.)

DESIGN

Wilkerson Dam will parallel the highway for most of its length and abut existing flood control levees on the east and west sides of the island. A typical cross section of the dam embankment is shown in Figure E1-1 (HLA 1993). The dam will be set back from the SR 12 right-of-way to ensure that levee settlement during and after construction does not affect roadbed stability or the feasibility of eventual SR 12 expansion. The setback distance may range from 240 feet to 370 feet (HLA 1993). Erosion protection material, such as riprap, a high-density polyethylene (HDPE) liner, or soil cement, will be used on the reservoir side of the dam.

The foundation material for most of the length of the dam is weak, compressible peat and soft clay; therefore, a wide flat dam will be constructed in stages over 2-3 years to compensate for settlement of foundation material during construction. To reduce the potential for cracking caused by placement of fill against the existing perimeter levees, embankment slopes will be flattened to 25:1 within 500 feet of abutments (HLA 1993).

HLA, under contract to DW, developed site-specific seismic design criteria for Wilkerson Dam based on regional geology, regional seismicity, and site conditions (HLA 1992). Seismicity impacts on levee reliability are discussed in Chapter 3D, "Flood Control".

The greatest seismic risk to the project islands would be caused by a magnitude 8.3 earthquake on the San Andreas fault, a magnitude 7.0 earthquake on the Antioch fault, or a magnitude 6.5 earthquake on any fault within 14 kilometers of the project islands (HLA 1992). Ground acceleration and earthquake magnitude data were modeled from the 1989 Loma Prieta earthquake and from maximum credible earthquake events on the San Andreas and Hayward faults to design an embankment that would maintain reliability during such events. Using data obtained from modeling analyses, HLA calculated maximum possible deformation and slope stability performance during maximum credible earthquakes. Modeling results also indicated that four areas along the proposed dam alignment are highly susceptible to liquefaction (HLA 1992).

Design criteria for Wilkerson Dam were developed using seismic modeling results. The dam would be flared at abutments with existing levees at the east and west ends of Bouldin Island to reduce movement between the embankment and abutments during earthquakes. Soils in two areas most susceptible to liquefaction would be modified to reduce their liquefaction potential. The exact method of densifying sands with higher liquefaction potential has not yet been determined but could consist of removal and recompaction, deep dynamic densification, or vibroflotation. The dam would provide sufficient freeboard to accommodate settlement and deformation during earthquakes (HLA 1992). These proposed design features reduce the potential for adverse impacts on Wilkerson Dam during earthquakes.

CONSTRUCTION

Settlement of fill is expected during and after construction of Wilkerson Dam. The dam would be constructed in stages with the wide stability berm placed first. As foundation material consolidates and strengthens, additional fill can be placed to raise the center section of the dam.

The east end of the proposed alignment would be constructed in two stages; the west end would require three stages of construction. Greater settlement is expected in the west end because the underlying sediments are characterized by thick deposits of compressible peat and soft silt. Subsurface sediments in the east end include peaty silt and stiff silt and are expected to experience less settlement.

Slope inclinometers, settlement plates, and piezometers will be installed to provide information on settlement and deformation during and after the construction phase of Wilkerson Dam. Most settlement is expected to occur within 3-5 years after construction (HLA 1992). A monitoring and maintenance program will be presented with final design specifications for the dam. Maintenance activities may include periodically regrading and raising the dam crest to accommodate settlement (HLA 1992, 1993).

The dam will be constructed primarily with locally available materials, such as sands and silts, excavated from borrow sites within the planned reservoir areas south of SR 12. Approximately 8.9 million cubic yards of sand would be required for dam construction. Borrow material will be moved hydraulically or with earthmoving equipment and compacted to required densities to provide stable fill.

Imported materials will likely include graded filter and drainage materials for an internal drain and quarry stone or cement to create either a riprap or soil cement erosion protection for the reservoir side of the dam.

SEEPAGE CONTROL FEATURES

Levee cracks caused by differential settlement of fill after construction and increased hydraulic head from water storage may increase seepage through the dam. Existing seepage drainage ditches are located just outside the SR 12 right-of-way on the north and south sides. The existing ditch on the north side of SR 12 ends approximately 0.75 mile from the east end of Bouldin Island; DW would extend this ditch to the east end of the island as part of project construction. Because increased seepage rates combined with stormwater runoff could cause the drainage ditch to overflow, the drainage ditch would be designed and possibly enlarged to handle the increased flow. However, constructing levees along SR 12 would greatly reduce the area of the watershed that drains into the ditch during storms, making the risk of local flooding much lower than it is now (Hultgren pers. comm.).

Groundwater levels beneath the SR 12 roadbed and in the seepage drainage ditches on both sides of the highway are controlled by farming practices. Water levels in the ditches vary by as much as 6 feet over 1 year because of cyclical flooding and irrigation. Water from the existing drainage ditches would be pumped to stabilize groundwater levels in the ditches and beneath the SR 12 roadbed. To ensure that the project does not cause a significant increase in water levels, DW, in coordination with the California Department of Transportation (Caltrans), will establish a seepage performance level for Wilkerson Dam. Groundwater levels along SR 12 would be regulated by pumps that maintain water levels in the drainage ditch along SR 12 being set to activate automatically if ditch water levels exceed the performance standard established by Caltrans and DW. Use of the pumps to control groundwater levels to the agreed-on threshold would avoid the need for installation of piezometers along SR 12 to monitor groundwater fluctuations and maintain desired water levels in the drainage ditches.

An internal drainage system and HDPE liner, which would reduce and direct seepage, and a cutoff trench, an excavation in the dam filled with material of low permeability that substantially reduces water flowing through the dam, will be used to control seepage through Wilkerson Dam. An internal drainage system (Figure E1-2) would require facilities to collect seepage from the drainage ditch at the levee toe next to SR 12 and pump it back into the reservoir or into the adjacent slough. Extending the HDPE liner to cut off seepage rather than reduce flow rates would reduce the volume of seepage through the dam, resulting in a less extensive pumping system being required to collect seepage. Final design specifications will be included in the final plans submitted to DSOD for approval (HLA 1992, 1993).

Seepage through Wilkerson Dam also may be reduced through installation of a 3-foot-wide cutoff trench extending vertically from the dam crest into foundation soils (HLA 1992). The small amount of water seeping after installation of a cutoff trench could be collected in a shallow toe drain (HLA 1992).

CITATIONS

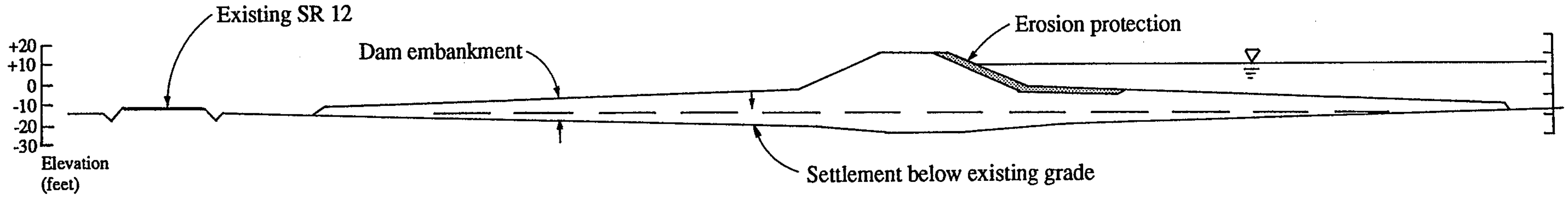
Printed References

Harding Lawson Associates. 1992. Phreatic surface in perimeter levees for the Delta Wetland project. Letter report by K. Tillis and E. Hultgren to J. Winther, Delta Wetlands. January 9, 1992. (HLA No. 18749,007.03.) Concord, CA. Prepared for Delta Wetlands, Lafayette, CA.

__________. 1993. Description of Wilkerson Dam on Bouldin Island for the Delta Wetlands project. Letter report by K. Tillis and E. Hultgren to J. Winther, President, Delta Wetlands. November 17, 1993. (HLA No. 11471,007.) Concord, CA. Prepared for Delta Wetlands, Lafayette, CA.

Personal Communications

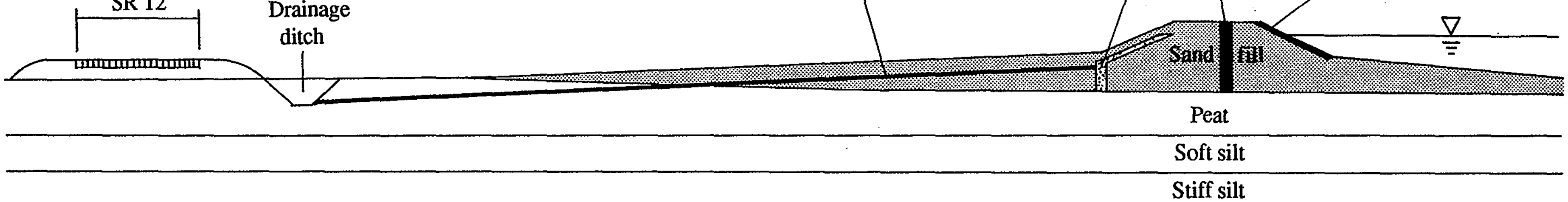
Hultgren, Edwin. Geotechnical engineer. Hultgren Geotechnical Engineers, Concord, CA. April 7, 1994 - letter to Mary Novak of Ellison, Schneider & Lennihan regarding technical review of Appendix E1 administrative draft.



Dam Profile for +6 Feet Pool Elevation

Source: Harding Lawson Associates 1993.

Figure E1-1.
Typical Cross Section of Wilkerson Dam (South of SR 12)
for Alternative 3



NOT TO SCALE

Source: Harding Lawson Associates 1992.

Figure E1-2.
Typical Internal Drainage System, Cutoff Trench, and HDPE Liner for Alternative 3