5.0 Optimized South- and North-Sea Dams, Perimeter Dikes, Concentric Lakes Dikes, and Habitat Pond Embankments Cross-Sections

5.1 General

Upon selection of the preferred cross-section configuration for the mid-Sea dam and upon completion of the risk analysis described in Section 6 below, additional "optimization" designs were performed to establish the cross-section characteristics of the north- and south-Sea dams, perimeter dikes, concentric lakes dikes, and habitat pond embankments. Sub-sections 5.2 through 5.4 below present summaries of the "optimized" embankment configurations for these items. These cross-sections, like the optimized mid-Sea dam and barrier were developed based on a general assessment of construction material sources, stability, seepage and deformation evaluations, risk, and consideration of construction means and methods that may be used. All "optimized" cross-sections meet the appropriate static and seismic design criteria and the specified configuration parameters (such as crest elevation and freeboard) outlined in Chapter 4.0. It should be noted that the appraisal level studies by Reclamation (Reclamation, 2005) had established the crest elevation of the "lakes" dikes with one-half (0.5) foot of freeboard (see Figure 4.3) when the exterior shells of the dikes were to be constructed of rockfill. The revised configuration of Alternative 1 shown on Figure 3.1 calls for a marine lake elevation of –230 msl. In order to provide adequate freeboard for a "sand dam", the freeboard for the perimeter dikes was set at 5 feet above the marine lake elevation, or –225 msl. A similar freeboard was used for the concentric lakes dikes due to the fetch length of the lakes and the use of sand as the primary embankment material. Supplemental stability and seepage analyses completed as part of the "optimization" process are presented in Appendix 2E. It should be noted that the deformation analysis presented in Appendix 2C was performed on a smaller cross-section with different elevations than indicated above.

5.2 South- and North-Sea Dams

5.2.1 South-Sea Dam

The "optimized" south-Sea dam cross-section, based on the preferred sand dam with stone columns concept is shown on Figure 5.1. This cross section would be constructed by a combination of placing methods including end dumping or conveyor placement for the upper portions of the central embankment materials and by dumping/placing directly into the water from barges for the lower portion of the central section, and for the outer portions of the embankment including the riprap slope protection.

The south-Sea dam design includes the following features in the general order in which they would be constructed:

- ✓ Removal of all Seafloor deposits beneath the entire footprint of the dam. An assessment of the available subsurface information suggested that the depth of the Seafloor deposits materials is on the order of 2 feet along the proposed alignment.
- ✓ Removal of soft lacustrine or upper alluvial deposits from beneath the central portion of the embankment. For the maximum section shown on Figure 5.1, this removal would be for a length of about 75 feet symmetrical about the centerline axis of the dam. As the section becomes lower in height near the edges of the Sea, the dimensions of the cross-section would be appropriately reduced while still meeting required static and seismic design criteria. Dredged slopes would be established to provide adequate stability for the period of the open dredged excavation. Available subsurface information suggests that the upper alluvial and/or soft lacustrine deposits are an average of about 13 feet thick along the south-Sea dam alignment.
- ✓ Treatment of the zone of upper alluvial and soft lacustrine deposits that would be left in place under the outer shells of the dam with wick drains (square pattern on 5-foot centers) to facilitate consolidation/settlement of these materials.
- ✓ Placement of sand/gravel (Type A) embankment material in the dredged central section back to an elevation that is the same as the upper alluvium or soft lacustrine surface prior to dredging. The Type A sand/gravel materials would extend over the upper alluvial or soft lacustrine materials under the downstream outer shell sand/gravel (Type B) to serve as a filter blanket. These materials would be placed by over-water methods.
- ✓ Placement of the 3-foot-thick sand/gravel (Type B with low fines content) blanket drain in the downstream portion of the cross-section by over-water methods.
- ✓ Placement of the remainder of the Type A sand/gravel by end dump or conveyor methods. The crest elevation at the end of construction would include an appropriate overbuild to accommodate consolidation/settlement of the upper stiff lacustrine deposits as well as settlement that may occur beneath the central section of the dam during stone column placement. The cross-section on Figure 5.1 shows the crest having a width of about 100 feet to create a platform for subsequent stone column placement. It also shows that the outer slopes of the Type A material would be placed at about 1.5H:1V. The actual outer slope angles of these materials will have to be adjusted to suit actual field conditions in order to prevent the

possibility of a construction slope failure through the soft lacustrine foundation materials.

- ✓ Placement of the outer shells using Type B sand/gravel.
- ✓ Installation of the stone columns (triangular pattern on 10-foot centers) to form the interior densified sand/gravel section with 1.5H:1V upstream and downstream slopes.
- ✓ Installation of a 3-foot-wide soil-cement-bentonite (SCB) slurry wall through the central densified sand/gravel (Type A) materials, and penetrating into the upper stiff lacustrine deposit to a depth that is 35 feet below the upper alluvial/stiff lacustrine or soft/stiff lacustrine interface. The SCB wall would not be required immediately and could be constructed at a later date under a separate construction contract prior to the development of more than 5 feet of differential water levels on the marine lake and brine poolsides of the dam.
- ✓ Placement of the riprap slope protection materials over the upstream and downstream slopes of the dam

Results of stability and deformation evaluations indicate that the required finished upstream and downstream slopes of the dam would be on the order of 2.5H:1V.

The gradations of the Type A sand/gravel core material that is also used for the downstream filter blanket would be designed to be filter compatible with the finer grained portions of the soft lacustrine or upper alluvial deposits.

A modified section has also been developed to withstand up to 6 feet of ground rupture associated with potential movement of the fault movement in the Imperial/San Andreas Fault Transition Zone. This section is also illustrated on Figure 5.1. Modifications to the “optimized” section include 1) widening of the cross-section, 2) addition of 5 feet of embankment freeboard, 3) addition of outer zones of fine rockfill to serve as a crack stopper (upstream slope) and to provide additional filtered drainage of the downstream slope, and 4) widening of the SCB wall to a total width of 9 feet. The widened SCB wall would be created by constructing 3 side-by-side 3-foot-wide slurry walls. In addition to the above, about 12 miles of the western perimeter dike crest would be armored with 3-feet of riprap cover to withstand overtopping by a seiche wave that would likely occur as a result of the fault rupture.

5.2.2 North-Sea Dam

The “optimized” north-Sea dam cross-section, based on the preferred sand dam with stone columns concept is shown on Figure 5.2. This cross section would be constructed by a combination of placing methods including end dumping or conveyor placement for the upper portions of the central embankment materials and by dumping/placing directly into the water from barges for the lower portion of the central section, and for the outer portions of the embankment including the riprap slope protection.

The north-Sea dam design is very similar to the mid-Sea sand dam with stone columns configuration. Some notable characteristics of the cross section in the general order in which it would be constructed:

- ✓ An assessment of the available subsurface information suggested that the depth of the Seafloor Deposits materials is on the order of 12 feet along the proposed alignment
- ✓ Removal of soft lacustrine or upper alluvial deposits from beneath the central portion of the embankment. For the maximum section shown on Figure 5.2, this removal would be for a length of about 280 feet symmetrical about the centerline axis of the dam. Available subsurface information suggests that the upper alluvial and/or soft lacustrine deposits are an average of about 16 feet thick along the dam alignment
- ✓ Treatment of the zone of upper alluvial and/or soft lacustrine deposits that would be left in place under the outer shells of the dam with wick drains (square pattern on 5-foot centers) to facilitate consolidation/settlement of these materials
- ✓ Placement of sand/gravel (Type A) embankment material in the dredged central section back to an elevation that is about 3 feet above the elevation of the upper alluvium or soft lacustrine surface prior to dredging. The Type A sand/gravel materials would extend over the upper alluvial or soft lacustrine materials under the downstream outer shell sand/gravel (Type B) to serve as a filter blanket and would extend to the planned interface with the outer shell Type B material in the upstream portion of the section. These materials would be placed by over-water methods
- ✓ Placement of the 5-foot-thick sand/gravel (Type B with low fines content) blanket drain in the downstream portion of the cross-section by over-water methods
- ✓ Placement of the remainder of the Type A sand/gravel by end dump or conveyor methods. The crest elevation at the end of construction would include an appropriate overbuild to accommodate consolidation/settlement of the upper stiff lacustrine deposits as well as settlement that may occur beneath the central section of the dam during stone column placement. The cross-section on Figure 5.2 shows the crest having a width of about 280 feet to create a platform for subsequent stone column placement. It also shows that the outer slopes of the Type A material would be placed at about 3H:1V. The actual outer slope angles of these materials would have to be adjusted to suit actual field conditions in order to prevent the possibility of a construction slope failure through the soft lacustrine foundation materials
- ✓ Placement of the outer shells using Type B sand/gravel

- ✓ Installation of the stone columns to form the interior densified sand/gravel section with 3H:1V upstream and downstream slopes
- ✓ Installation of a 5-foot-wide soil-cement-bentonite (SCB) slurry wall through the central densified sand/gravel (Type A) materials, and penetrating into the upper stiff lacustrine deposit to elevation –350 msl or 40 feet below the soft/stiff lacustrine or upper alluvium/stiff lacustrine interface. The SCB wall would not be required immediately and could be constructed at a later date under a separate construction contract prior to the development of more than 5 feet of differential water levels on the marine lake and brine pool sides of the dam
- ✓ Placement of the riprap slope protection materials over the upstream and downstream slopes of the dam

Results of stability and deformation evaluations indicate that the required finished upstream and downstream slopes of the dam would be on the order of 5H:1V.

5.3 Perimeter and Concentric Lakes Dikes

The “optimized” perimeter dikes and concentric lakes dikes cross-section, based on the preferred sand dam with stone columns concept, is shown on Figure 5.3. This cross section would be constructed by a combination of placing methods including end dumping or conveyor placement for the upper portions of the central embankment materials and by dumping/placing directly into the water from barges for the lower portion of the central section, and for the outer portions of the embankment including the riprap slope protection.

The design of the dike cross-section shown on Figure 5.3 is for both static and seismic design criteria. It includes the following features in the general order in which they would be constructed:

- ✓ Removal of all Seafloor Deposits beneath the entire footprint of the dike. An assessment of the available subsurface information suggested that the average depth of the Seafloor Deposits materials is on the order of 3 feet along the proposed outer alignments, with thicker deposits along the inner concentric lakes dikes alignments of the outer two dikes and thickens for the inner lakes
- ✓ Removal of soft lacustrine and/or upper alluvial deposits from beneath the central portion of the embankment. For the maximum section shown on Figure 5.3, this removal would be for a length of about 40 feet symmetrical about the centerline axis of the dike. Dredged slopes would be established to provide adequate stability for the period of the open dredged excavation. Available subsurface information suggests that the upper alluvial and/or soft lacustrine deposits are an average of about 18 feet thick along the dike alignments

- ✓ Treatment of the zone of upper alluvial and soft lacustrine deposits that would be left in place under the outer shells of the dike with wick drains (square pattern on 5-foot centers) to facilitate consolidation/settlement of these materials
- ✓ Placement of sand/gravel (Type A) embankment material in the dredged central section back to an elevation that is the same as the upper alluvium or soft lacustrine surface prior to dredging. These materials would be placed by over-water methods
- ✓ Placement of the 3-foot-thick sand/gravel (Type B with low fines content) blanket drain in the downstream portion of the cross-section by over-water methods
- ✓ Placement of the remainder of the Type A sand/gravel by end dump or conveyor methods. The crest elevation at the end of construction would include an appropriate overbuild to accommodate consolidation/settlement of the upper stiff lacustrine deposits as well as settlement that may occur beneath the central section of the dike during stone column placement. The cross-section on Figure 5.3 shows the crest having a width of about 75 feet to create a platform for subsequent stone column placement. It also shows that the outer slopes of the Type A material would be placed at about 1.5H:1V. The actual outer slope angles of these materials will have to be adjusted to suit actual field conditions in order to prevent the possibility of a construction slope failure through the soft lacustrine foundation materials
- ✓ Placement of the outer shells using Type B sand/gravel
- ✓ Installation of the stone columns (triangular pattern on 10-foot centers) to form the interior densified sand/gravel section with 1.5H:1V upstream and downstream slopes
- ✓ Installation of a 3-foot-wide soil-cement-bentonite (SCB) slurry wall through the central densified sand/gravel (Type A) materials, and penetrating into the upper stiff lacustrine deposit to a depth that is 35 feet below the upper alluvial/stiff lacustrine or soft/stiff lacustrine interface. The SCB wall would not be required immediately and could be constructed at a later date under a separate construction contract prior to the development of more than 5 feet of differential water levels on the marine lake and brine poolsides of the dike
- ✓ Placement of the riprap slope protection materials over the upstream and downstream slopes of the dike

Results of stability and deformation evaluations indicate that the required finished upstream and downstream slopes of the dike would be on the order of 2.5H:1V. The gradation of the Type B sand/gravel material that is to be used for the downstream blanket drain would be designed to be filter compatible with the finer grained portions of the soft lacustrine or upper alluvial deposits.

Evaluation of the consequences associated with failure of a concentric lakes dike indicates the potential for no life loss. However, the Risk Assessment Team (See Section 6 and Appendix 2D) has identified a potential significant economic impact or environmental consequence if the concentric lakes dikes were to fail under either static or seismic loading conditions. If significant consequences are determined, the concentric lakes dikes would be classified as "significant" hazard structures. To make a risk-based assessment of these consequences and to determine the associated hazard classification of these structures, a cross-section meeting only static design criteria, and a cross-section meeting both static and seismic design criteria were developed and costed. The results of the economic and environmental/social risk based analyses of the concentric lakes dikes are presented in Volume 1 of Reclamation's Salton Sea restoration report.

Likewise, portions of the concentric lake dikes will cross both the Imperial Fault and the Imperial/San Andreas Fault Transition Zone. Reclamation has preliminarily identified the potential for up to 2 meters of ground rupture in the Imperial/San Andreas Fault Transition Zone and up to 5 meters of ground rupture along the San Andreas and Imperial faults. The actual amount of potential rupture for that portion of the Imperial Fault under the Sea is unknown at this time. Hence, mitigation concepts for the concentric lakes dikes have not been developed to mitigate the fault and associated ground rupture hazard.

5.4 Habitat Pond Embankments

The "optimized" habitat pond embankment cross-section, based on Reclamation's appraisal level study concept, is shown on Figure 5.4. This option would be constructed in the dry after the lake level has receded.

The design of the dike cross-section shown on Figure 5.4 is for static design criteria. It includes the following features in the general order in which they would be constructed:

- ✓ Removal of all Seafloor deposits beneath the entire footprint of the dike embankment
- ✓ Removal of sufficient soft lacustrine and/or upper alluvial deposits from beneath the embankment as necessary to achieve a competent foundation for the embankment. For the section shown on Figure 5.4, it has been assumed that the total excavation depth would be 10 feet and the bottom width of the excavation would be 40 feet. Excavated slopes would be established to provide adequate stability for the period of the open excavation
- ✓ Placement of compacted clay and silt materials back to the surface elevation of the Seafloor deposits

- ✓ Placement of a 2-foot-thick filter/drain blanket layer of Type A material under the downstream shell of the dike
- ✓ Placement of the remainder of the embankment fill to the required crest elevation
- ✓ The finished exterior slopes of the embankment would be 3H:1V. The finished crest width of the embankment would be 15 feet.