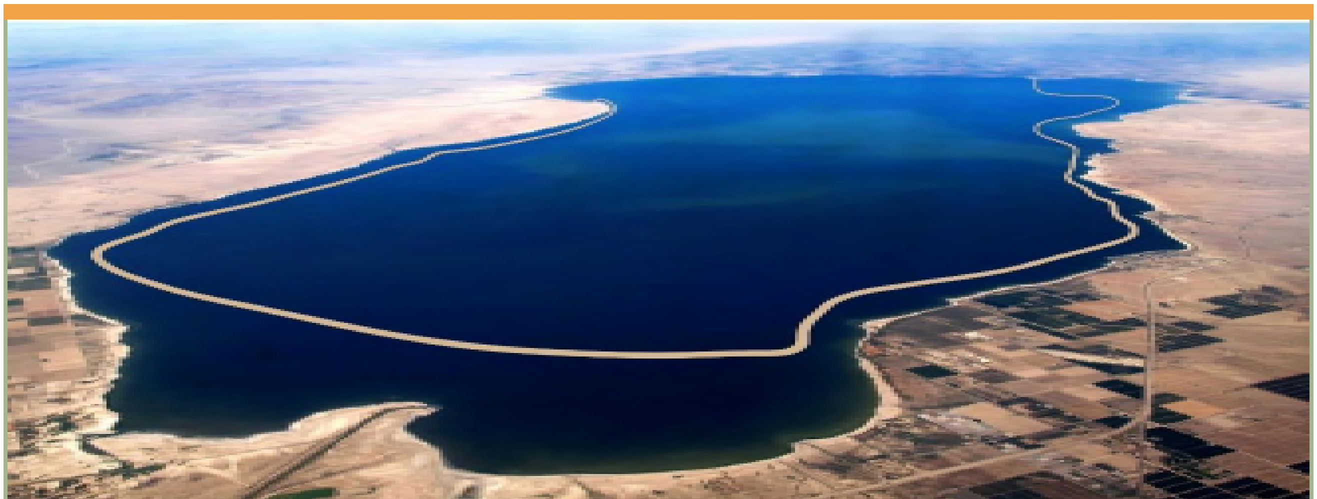
Salton Sea Funding and Feasibility Action Plan

Benchmark 4: Conceptual Plans and Cost Estimates
Volume 2: Smaller Sea Options – Perimeter Lake Concept

May 2016



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Comments will be reviewed and incorporated as appropriate. If substantive comments are received, a revised document may be produced and distributed.

Executive Summary

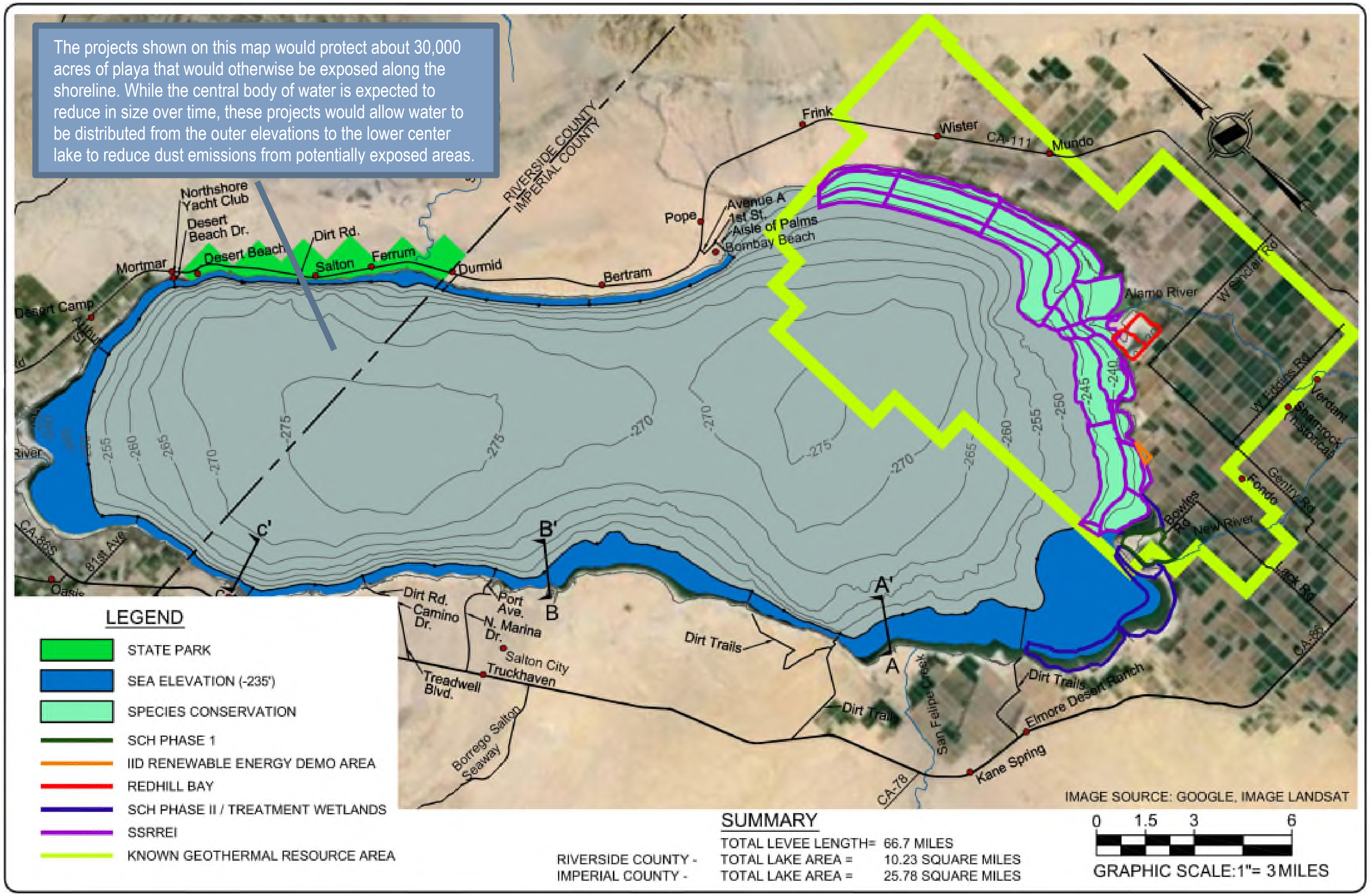
The work presented in this report was completed with support from a grant by the State of California Natural Resources Agency for the Funding and Feasibility Action Plan. The Benchmark 3 report, completed as part of the Funding and Feasibility Action Plan presented a wide range of earlier concepts for creating a smaller Sea. Following reviews of the features and benefits of these past plans, a new smaller lake concept has emerged. The new concept is referred to as the Perimeter Lake for the Salton Sea. It takes into account the immediate need for action, the limitations on water supply for the lake, and the possibility of constructing a project with incremental funding.

The new approach would involve constructing a lake around the perimeter of the Sea along with a central saline pool within the current Sea footprint. This concept is anticipated to work with other projects being planned by the State and the Imperial Irrigation District (IID) as part of an overall Salton Sea management program. The Perimeter Lake concept is illustrated on the following page.

This report describes what objectives the Perimeter Lake concept would meet and how the concept is designed. Important aspects of the concept that are outlined in this report include the following:

- Project goals and Perimeter Lake concept overview;
- Conceptual construction details;
- Water inflow requirements and water quality improvement in inflow;
- Conceptual design of spillways and air quality mitigation (AQM);
- Geotechnical feasibility study; and
- Construction Scenario, Cost Estimate, Funding, and Cost Comparisons to Past Alternatives

Two appendices are included. Appendix A is a geotechnical report that presents seismic stability and seepage analyses of the levees that would form the Perimeter Lake. Appendix B provides the details of the feasibility-level cost and schedule estimates that were prepared for two construction sequences: a base program and an accelerated program.


The projects shown on this map would protect about 30,000 acres of playa that would otherwise be exposed along the shoreline. While the central body of water is expected to reduce in size over time, these projects would allow water to be distributed from the outer elevations to the lower center lake to reduce dust emissions from potentially exposed areas.
RIVERSIDE COUNTY
IMPERIAL COUNTY
Northshore Yacht Club
Desert Beach Dr.
Desert Beach
Dirt Rd.
Salton
Ferrum
Mortmar
Dumid
Bertram
Pope
Avenue A
1st St.
Aisle of Palms
Bombay Beach
Frink
Wister
CA-111
Mundo
Alamo River
W Sinclair Rd
W Eddins Rd
Verdant
Shamrock
Historical
Gentry Rd
Fondo
Bowles Rd
New River
Lack Rd
CA-86
Desert Camp
River
CA-86S
81st Ave
Oasis
C'
B'
B
A'
A
-275
-270
-265
-260
-255
-250
-245
-240
Dirt Rd.
Camino Dr.
Port Ave.
N. Marina Dr.
Salton City
Truckhaven
Treadwell Blvd.
Borrego Salton Seaway
Dirt Trails
Dirt Trail
San Felipe Creek
Elmore Desert Ranch
Kane Spring
CA-78
IMAGE SOURCE: GOOGLE, IMAGE LANDSAT
LEGEND
STATE PARK
SEA ELEVATION (-235')
SPECIES CONSERVATION
SCH PHASE 1
IID RENEWABLE ENERGY DEMO AREA
REDHILL BAY
SCH PHASE II / TREATMENT WETLANDS
SSRREI
KNOWN GEOTHERMAL RESOURCE AREA
SUMMARY
TOTAL LEVEE LENGTH= 66.7 MILES
RIVERSIDE COUNTY - TOTAL LAKE AREA = 10.23 SQUARE MILES
IMPERIAL COUNTY - TOTAL LAKE AREA = 25.78 SQUARE MILES
0 1.5 3 6
GRAPHIC SCALE:1"= 3 MILES

Project Goals and Perimeter Lake Overview

Without implementation of a sound management plan, the Salton Sea is expected to enter into a period of rapid decline over the next decade. The Perimeter Lake concept is designed to be a key part of such a management plan, and intended to meet a set of performance objectives proposed by the Authority that include preserving the Sea as a repository for agricultural runoff, improving water quality, maintaining and improving habitat, addressing air quality concerns, and increasing recreational and economic potential. Background information on the Salton Sea, an overview of the Perimeter Lake concept, a description of how the project would meet each of the performance objectives, and the advantages of the concept are presented in Section 1.0.

Conceptual Construction Details

The Perimeter Lake concept has evolved over time, and would work in concert with IID's Salton Sea Restoration and Renewable Energy Initiative (SSRREI), the State of California's Species Conservation Habitat (SCH) project, and Imperial County (AQM) objectives. Section **Error! Reference source not found.** describes concept development and conceptual construction details for the Perimeter Lake. Various depths, levee configurations and lake sizes for the Perimeter Lake were considered. Three embankment configurations were considered for use as levees on the Seaside of the new lake configuration: Earthen Levees, Geotube® Levees, and Sheet Pile Levees. Each design was evaluated with respect to the following performance criteria: constructability, cost, maintenance, environmental considerations, permitting, footprint derived from angle of repose, and risk and uncertainty. To accomplish project goals, a two-phased sequencing plan for construction was developed. This plan can be completed with one team in approximately ten years, or it can be built with two teams working in parallel in approximately five years.

Water Inflow Requirements and Water Quality Improvement in Inflow

Section 3.0 includes a water budget analysis and a discussion of the residual saline pool. The water budget and salinity analysis for the Perimeter Lake is presented based on expected evaporation and seepage losses and other possible inflow considerations. Accounting for these variables, three scenarios were analyzed to estimate the water budget for the project: a base scenario that includes no releases for beneficial operations such as dust control, and two scenarios that would feature water releases for dust control or other beneficial uses.

Inflow water quality needs to be improved to achieve the full beneficial use potential of the Perimeter Lake. Treatment wetlands are proposed for this purpose and discussed in Section 4.0. These wetlands would be used to improve the water quality, particularly nutrients and suspended sediments, of the New River before they flow into the Perimeter Lake. Estimated area requirements are based on pilot wetland results from Brawley and Imperial, and to meet project targets of 2- 3 mg/l total nitrogen and 0.1-0.25 mg/l total phosphorus, the project would require surface areas from 590-1,150 acres under low infiltration conditions and 470-610 acres under mean infiltration conditions.

Conceptual Design of Spillways and Air Quality Mitigation

Although the Salton Sea is set in an arid region, it is subject to occasional floods, such that the Perimeter Lake design must account for them. Section 5.0 includes conceptual designs of overflow spillways to address both the average annual inflow as well as the occasional flooding produced from the rare storm event. The intent of the structures is to allow the average inflow of water to circulate within the Perimeter Lake while maintaining a desired water level, provide emergency flood relief to prevent overtopping of the levee, and still maintain sufficient freeboard for safety purposes. The overflow structures include three 20 ft bell mouth spillways near the North Shore Yacht Club, the Bombay Beach and the old base; and a 1,000 ft wide broad crested weir near the North Shore Yacht Club. These structures would stimulate clockwise internal circulation and exchange water inside the Perimeter Lake up to a rate equal to the entire lake volume twice annually.

As the Salton Sea recedes due to declining inflows, windblown dust emissions from the exposed dry lakebed (the playa) would increase in some areas, potentially leading to violations of particulate matter standards and human health risks. Potential air quality impacts from exposed Salton Sea playa must be monitored and mitigated through various steps including restricted access, research and monitoring, dust control measure implementation, and purchase of emission reduction credits. AQM elements are discussed in Section 6.0.

Geotechnical Feasibility Study

A feasibility-level geotechnical assessment was conducted to evaluate slope stability and seepage associated with the Perimeter Lake design. The evaluation did not identify any geotechnical factors that would preclude the successful design and construction of the project. However, several factors would require special consideration during the design, engineering and construction of the project. These factors would include dewatering of excavated materials and mechanical placement and compaction, mitigation of settlement and seepage, and soil liquefaction and seismic deformation mitigation, all of which were considered in developing the construction scenario and detailed cost estimates and schedules.

Construction Scenario, Cost Estimate, Funding, and Comparisons to Past Alternatives

Construction would involve sheet pile installation, geotextile deployment, dredging and stockpiling of sediments, construction of spillway structures, grading and armoring of the levees, construct of roadways on top of the levees, and construction of causeways. Bridges may also be built to allow linkage of the cells once causeways dividing the cells have been breached. A detailed feasibility-level cost estimate was prepared for two construction scenarios: construction of Phase 1 and 2 in series and construction of Phase 1 and 2 in parallel. While funding sources are still being investigated, a review of the State's funding plan from 2007 is included. Details on the construction scenarios, the cost estimate, and the funding sources can be viewed in Section 8.0. The features and benefits of the Perimeter Lake concept are discussed in Section 9.0 and compared with those of three past alternatives: an Import/Export scenario, the 2006 State Alternative, and the 2006 Authority Alternative. A final summary of the Perimeter Lake concept is presented in Section 10.0.

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Acronyms and Abbreviations

Acronyms and abbreviations used in the Work Plan are listed below.

AF	Acre-Feet
AFY	Acre-Feet per Year
ag	Agriculture/Agricultural
AQM	Air Quality Mitigation
Authority	Salton Sea Authority
BACM	Best Available Control Measure
BMSL	Below Mean Sea Level
CAAA	Clean Air Act Amendments
CARB	California Air Resources Board
CEQA	California Environmental Quality Act
CFS	Cubic Feet per Second
CO	Carbon Monoxide
CIMIS	California Irrigation Management Information System
DCM	Dust Control Measure
DSOD	Division of Safety of Dams
DEM	Digital Elevation Model
EIR	Environmental Impact Report
EIS	Environmental Impact Statement
ENR	Engineering News Record
EPA	United States Environmental Protection Agency
ET	Evaporation
FEMA	Federal Emergency Management Agency
ft	Foot/Feet
ICAPCD	Imperial County Air Pollution Control District
IID	Imperial Irrigation District
JPA	Joint Powers Authority
KAFY	Thousand Acre Feet per Year
KGRA	Known Geothermal Resources
MAFY	Million Acre Feet per Year
mg/L	Milligrams per liter
MMRP	Mitigation, Monitoring and Reporting Plan
MPN	Most Probable Number
msl	Mean Sea Level
NAAQS	National Ambient Air Quality Standards
NGVD	National Geodetic Vertical Datum
NO_2	Nitrogen Dioxide
NO_x	Nitrogen Oxides
NOAA	National Oceanic and Atmospheric Administration
O&M	Operations and Maintenance
O_3	Ozone
OHV	Off-Highway Vehicle

P	Precipitation
Pb	Lead
PEIR	Programmatic Environmental Impact Report
PM_{10}	Particulate Matter less than 10 Microns in Aerodynamic Diameter
$PM_{2.5}$	Particulate Matter less than 2.5 microns in Aerodynamic Diameter
SALSA	Salton Sea Analysis Model
SSAM	Salton Sea Accounting Model
QSA	Quantification Settlement Agreement
RACM	Reasonable Available Control Measures
RWQCB	Regional Water Quality Control Board
SCAQMD	South Coast Air Quality Management District
SCH	Species Conservation Habitat
SIP	State Implementation Plan
SO_2	Sulfur Dioxide
sq mi	Square Mile
SSA	Salton Sea Authority
SSRREI	Salton Sea Restoration and Renewable Energy Initiative
State	State of California
SWRCB	State Water Resources Control Board
TIN	Triangular Irregular Network
TN	Total Nitrogen
TP	Total Phosphorus
TSS	Total Suspended Solids
USGS	U.S. Geological Survey
VDE	Visible Dust Emissions
VOCs	Volatile Organic Carbons
WRDA	Water Resources Development Act

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1.0 Introduction

This section introduces the new Perimeter Lake concept that the Salton Sea Authority plans to build in concert with other mitigation efforts being conducted by The Imperial Irrigation District (IID) and the State of California (the State). A graphic of the preferred project plan is presented, and objectives and advantages to the new project are discussed.

1.1 Background

The Salton Sea is located in Southern California, north of El Centro and south of Indio, within Riverside and Imperial Counties. The Salton Sea was formed when a breached irrigation control structure along the Colorado River between 1905 and 1907. Agricultural drainage flows from the Imperial, Coachella, and Mexicali Valleys have sustained the Salton Sea since that time. The Salton Sea encompasses an area approximately 15 miles wide and 35 miles long and has a surface elevation of approximately 228 ft below mean sea level (MSL).

At the Salton Sea total dissolved solids have increased steadily from an average of 45 parts per thousand (PPT) in 2004 to an average of 55.7 PPT in 2014, classifying the sea's water as brine 54% saltier than ocean water (Benchmark 2 Report). Over the last few years, the water surface level at the Sea has been declining. Numerous factors have contributed to the salinity increase and the water level decline, including a decrease in the quantity of water inflows to the Salton Sea because of more efficient irrigation practices in the areas surrounding the sea reducing inflow as irrigation runoff and drought conditions.

The implications and ramifications of increased salinity have been under consideration for over 60 years. Flows to the Salton Sea have decreased, and it is estimated that within the next 15 years, flows would decrease by approximately 40 percent (Cohen 2014). Much of the recent decrease in flow can be attributed to water conservation as a result of greater irrigation efficiency. In 2018, a much more impactful decrease in inflow to the Salton Sea would occur as a result of the Quantification Settlement Agreement (QSA) between Imperial Irrigation District (IID) and the San Diego County Water Authority (SDCWA) that would reduce the amount of water flowing into the Imperial Valley. The agreement was signed in October 2003, and part of the agreement required deliveries of "mitigation water" to the Salton Sea to account for reductions of inflow. The mitigation water deliveries are only required until the end of 2017. Thus, it is estimated that the Salton Sea would enter into a period of rapid decline for the next decade if alternatives to restore flows to the Salton Sea are not implemented.

1.2 Goal and Objectives

The primary goal of this report is to identify a smaller lake configuration that would meet a series of performance objectives. The proposed construction methods and configuration presented here build on past plans discussed in the Benchmark 3 Report. This new approach would involve the construction of a Perimeter Lake around the Sea. The Perimeter Lake alternative incorporates several other key programs that are ongoing as part of the Salton Sea management process. These programs include the State's Species Conservation Habitat (SCH) Project, IID's Salton Sea Restoration and Renewable Energy Initiative (SSRREI), and IID's Air Quality Mitigation (AQM) Program.

With funding through a grant from the California Natural Resources Agency, the Authority has undertaken the Salton Sea Funding and Feasibility Action Plan. Through this program, the Authority has compiled and reviewed a large body of environmental data on the Sea and performed a comprehensive evaluation of past proposals for Restoration of the Sea. The goal of the program was to build upon the work that has already been conducted and utilize any components from past plans that make sense under the current fiscal and economic realities.

With that goal in mind, a review of objectives first published by the Authority in 2004 indicates that with slight modification those objectives still apply and can serve as a reasonable guideline for developing and evaluating lake management plans:

- Preserve the Sea as a Repository for Agricultural Runoff
- Provide Lake with Stable Elevation
- Improve Water Quality: Salinity
- Improve Water Quality: Nutrients/Other Constituents
- Maintain and Improve Habitat
- Achieve Water Quality and Habitat Objectives in a Timely Manner
- Respond to Inflow Changes
- Increase Recreational and Economic Potential
- Address Air Quality (PM_{10}) Concerns
- Provide High Safety Rating/Low Risk of Failure

- Overcome Institutional Barriers/Public Acceptance (Permitting)
- Reasonable Cost/High Probability of Financing

Note that these objectives have been incorporated from previous work by the Authority with only one minor adjustment (Authority 2004). The second objective was originally stated as "Provide a Large Marine Lake with Stable Elevation."

1.3 Overview

The proposal identified in this report is referred to as the Perimeter Lake. The Perimeter Lake would rely upon a system of low profile levees to create a reasonably affordable and sustainable water body. This system would generally resemble an in-stream reservoir built along a slowly flowing river, it would include wider recreational areas in the north and south ends of the Sea, although boating would be accommodated along the entire 60+ mi of lake front property. The exposed playa on the southern end of the Sea near the Perimeter Lake project site would be designated for IID's SSRREI. Built incrementally, the water used in the Perimeter Lake system would initially flow through a series of linked but separated elongated ponds.

Treatment wetlands, possibly those incorporated in the SCH project, are proposed near or upstream from the mouth of the New River to provide higher quality water entering the system, although no specific plans have been developed at this point. In sections ranging from 500 ft to over 2 mi in width, water entering the Perimeter Lake system would arrive in a wide area at the south end of the Sea, flow northward along the western shore, and arrive at another wide area in the north. Water would flow out of the northern area and move southward along the eastern shore to a terminus spillway. Here, at the terminus spillway, excess water would be channeled into a permanent saline pool in the center of the historic seabed.

Spillways at several locations within the system and the quantity and salinity of water diverted into the system would allow for management of salinity from near fresh to marine, with the expectation that the target salinity would be brackish (15-20 PPT). Excess salinity would concentrate in the saline pool located near the center of the Sea.

At full build out, the total length levee running parallel to the shore would be approximately 61 mi. Additionally, 13 perpendicular connector levees or dikes totaling 6 mi would connect to existing roads so that construction could proceed as individual cells. The total area of all 13 cells would be approximately 36 sq mi, with 10 sq mi in Riverside County and 26 sq mi in Imperial County. The levees would be constructed by dredging a channel along the lake side of the levee which would create a deep water habitat area of up to 25 ft in depth for the full length of the lake.

The annual inflow required to balance evaporative and seepage losses is estimated at 167,000 AFY (acre-ft per year). Initially, additional water could be run through the system to reduce salinity and nutrients in the water column and clean out detritus. Once in operation, the water body could be used to convey water to other habitat areas or for dust control.

Figure 1 shows the current plan for the Perimeter Lake project. Flow and salinity control is expected to occur near Bowles road and in the Bombay

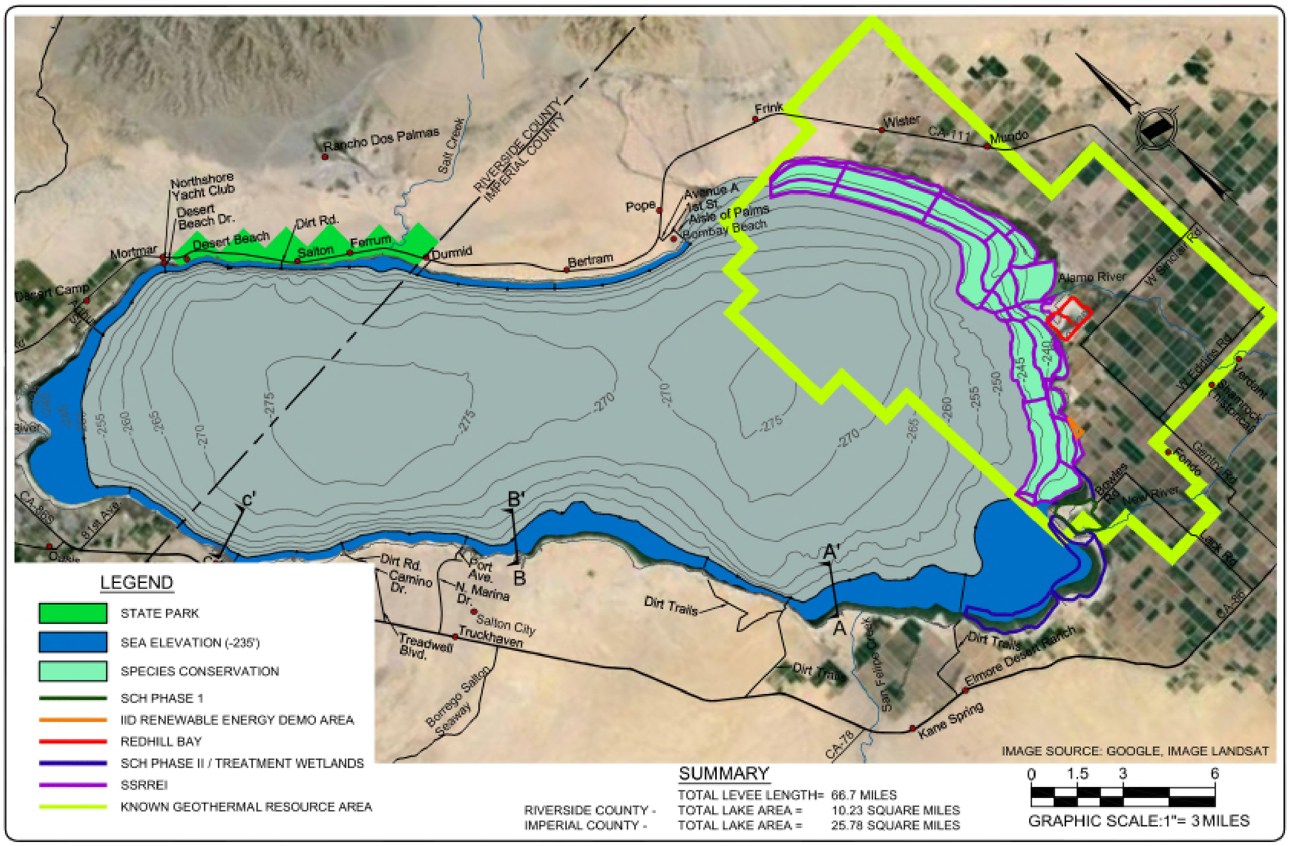

Figure 1 Perimeter Lake Plan for the Salton Sea with Levee at -245 ft NGVD

Beach area, and playa between those areas is expected to be used for SSRREI habitat and geothermal activity.

The saline pool would vary in size dependent upon annual inflows to the system. As previously mentioned, it is estimated that maintaining the Perimeter Lake would require a minimum inflow of 167,000 AFY. Any remaining flow would return to the central saline pool or be available for other beneficial uses. Other beneficial uses could include water supplies for habitat projects around the Sea and for mitigation of air quality emissions from areas potentially exposed between the Perimeter Lake system and the varying edge of the saline pool.

The Perimeter Lake concept is designed to meet many of the current challenges facing the Salton Sea. Results of the recent feasibility analysis show that this project would meet project goals and require less resources than the earlier smaller lake plans prepared by the Authority and the State. Below is a list of the objectives outlined in Salton Sea Authority (2004) Salton Sea Restoration/ Final Preferred Project Report.

- **Preserve the Sea as a Repository for Agricultural Runoff:** Agriculture constitutes the major economic base in Imperial County and a significant part of the economy in eastern Riverside County. The Imperial and Coachella valleys provide an important source of vegetables and other produce to the nation, particularly in the winter. Because of the importance of drainage to maintaining the agricultural economy and the lack of an alternative disposal site, the Sea serves as the repository for agricultural drainage. In 1924 and again in 1928, President Coolidge issued Executive Orders setting aside federal land under the Sea as a public water reserve for irrigation drainage. In 1968, the state of California declared by statute that the primary use of the Sea is for collecting agricultural drainwater, seepage, leaching, and control waters. Agriculture in its present form relies on the ability to discharge drainage into the Sea. The Perimeter Lake concept would preserve the Sea as an agricultural drainage repository.
- **Provide Lake with Stable Elevation:** The Perimeter Lake concept would feature a sustainable brackish water body at a stable elevation of -235 ft NGVD. The total lake area would have an area of approximately 36 sq mi, with 10 sq mi in Riverside County and 26 sq mi in Imperial County.
- **Improve Water Quality—Salinity:** Increasing salinity in the Sea, which is currently about 56 PPT, already may be threatening the reproductive ability of the tilapia population. If the current trend of increasing salinity continues, fish in the Salton Sea will likely be eliminated over the next decade. Therefore, controlling salinity is a critical need if the Salton Sea is to support biodiversity similar to what existed in the past. The Sea is located along the Pacific Flyway, the most western of the major migration corridors for waterfowl and other species. Therefore, the fish populations in the Sea are an important food source to fish-eating birds that use the Pacific Flyway.

Because of its impact on the ecology of the Sea, controlling salinity is a fundamental component of any Salton Sea management plan. The Perimeter Lake is planned as a brackish water body with salinity of 15-20 PPT (compared to ocean water salinity of about 35 PPT) that would support a diverse fish population.

- **Improve Water Quality—Nutrients/Other Constituents:** Treatment wetlands would provide a low cost system for filtering silts and nutrients from the New River and improving water quality in comparison to the water now present in the Salton Sea. Higher quality water from the Whitewater River in the north would also help improve water quality.
- **Maintain and Improve Habitat:** The biological resources of the Sea and its value to society are linked through the Sea's avian diversity, the productivity of its fishery, and its attraction as a recreational destination. With approximately 400 species of birds reported in the area, the Salton Sea ecosystem is one of the greatest areas of avian biodiversity in the nation. It also provides habitat to several special status species such as the California brown pelican (Pelecanus occidentalis), Yuma clapper rail (Rallus longirostris yumanensis) and the desert pupfish (Cyprinodon macularius), all listed as Federal Endangered Species. Historically, the sport fishery has been the most productive of any California inland water body, and in the past, the large biomass of fish has been the food base for the large number of fish-eating birds at the Sea. With rising salinity in the Sea, there have been substantial decreases in the number of fish in the Sea, likely because of a number of stress factors.

  Because of significant losses of interior wetlands, including over 90 percent of those within California, the Sea serves an important role in the international, regional, and local conservation of migratory birds. Significant proportions of some populations have become dependent on the Sea. For some of these species there may be no alternatives because of bioenergetics (the energy transformation and exchange between living organisms and their environment) associated with food availability (quantity and quality), travel distances between migration stopover points, and body condition relative to breeding success. The complex interrelationships of the Sea's ecosystem are a critical concern.

  The salinity of the water in the Salton Sea is continuing to rise and soon is expected to exceed 60 PPT, compared to 35 PPT, the salinity of ocean water. At such an elevated salinity, the Sea would no longer support a fishery. The plan for the Perimeter Lake is to maintain the salinity at a brackish level of 15-20 PPT that would support a variety of fish species that could serve as a food source for piscivorous birds. The lake would have about 130 miles of shallow habitat along the shoreline and levees with a 25 ft deep water channel running the entire 60+ miles of the lake. Additionally, the Perimeter Lake concept is being developed in concert with other Salton Sea management projects, such as the SCH and the SSRREI, that would also help satisfy habitat objectives.

- **Achieve Water Quality and Habitat Objectives in a Timely Manner:** The Perimeter Lake plan would be constructed in single cell increments. Because of the incremental nature of the concept, the time to produce deliverable results would be relatively short when compared to previous management alternatives. Multiple program objectives would be achieved on a smaller scale by the construction of the very first cell.

- **Respond to Inflow Changes:** Maintaining the Perimeter Lake would require a minimal flow of 167,000 AFY. This means that, at a minimum, the Perimeter Lake would require less than 25% of the total available future inflows which are projected to be between 689,000 and 865,000 AFY by 2077. The remaining flows could be used to support other habitat projects, dust control, the residual saline pool, and other beneficial uses.

- **Increase Recreational and Economic Potential:** The 36 sq mi brackish lake with wide areas in the north and south is expected to provide a wide range of recreational opportunities, and the expected benefits that would occur with the Perimeter Lake concept and other management efforts would increase property value in residential areas around the Sea. Additionally, the Perimeter Lake concept is designed to work in concert with other Salton Sea management efforts that may utilize the Salton Sea Known Geothermal Resource Area (KGRA) to bring in revenues through renewable energy.

- **Address Air Quality (PM_{10}) Concerns:** In the absence of a management plan, reduced inflows to the Salton Sea are expected to substantially reduce the size of the Sea and create large expanses of exposed playa. The Perimeter Lake will provide a cover for 36 sq mi of playa and provide a water source for irrigating emissive areas in exposed areas between the Perimeter Lake and the central, residual saline pool.

- **Provide High Safety Rating/Low Risk of Failure:** Because of the magnitude of the investment necessary to develop and sustain a viable management plan, a project of this scale must provide a high level of safety while at the same time having a low risk of failure. This is especially true for the construction of any water impoundment or barrier that must be designed to withstand an earthquake. Compared to other plans, the Perimeter Lake concept incorporates much smaller barriers than either the State Preferred Plan or the Previous Authority Preferred Plan. The majority of the levees are planned in 10 ft of water. Therefore, the risk of failure is much lower. In addition, the lake is being planned in a series of cells. If there is failure in one cell, temporary measures could be implemented to isolate a single cell, allowing for repairs to be conducted while other parts of the lake could continue to function.

- **Overcome Institutional Barriers/Public Acceptance (Permitting):** Because the levee heights are lower than in-Sea barriers in previous plans and the water requirements are less, permitting is expected to be achievable. In addition, the Perimeter Lake concept would have both ecological and recreational value and, therefore, it is expected that the project would overcome institutional barriers and gain public acceptance.
- **Reasonable Cost/High Probability of Financing:** This project is expected to have a reasonable overall cost when compared to earlier large lake plans, and the project has a higher probability of being financed than the previous alternatives that have been seriously considered. Cost estimates are presented in Section 9.0 along with some discussion of financing.

1.3.1 Advantages of the Perimeter Lake Plan

At -235 ft with respect to the National Geodetic Vertical Datum (NGVD), the Sea's elevation would be slightly below historic shorelines from the 1960-2010 period, and there would be more exposed playa present than at higher Sea levels. However, the preferred plan at -235 ft NGVD water surface, shown in Figure 1 and Figure 2, allows for the following advantages:

- The minimum water requirement to balance evaporation and seepage is estimated at 167,000 AFY;
- Treatment wetlands and flushing would provide improved water quality;
- Spillways present in the north and south areas would facilitate salinity control, allowing ranges from nearly fresh to marine;
- Large lake area of about 36 sq mi, with roughly 26 sq mi in Imperial County and 10 sq mi in Riverside County, would provide habitat for

fish and would maintain a food source for fish eating birds travelling along the Pacific Flyway;

- Perimeter habitat and energy projects (e.g., IID SSRREI projects) may be developed to provide ecological benefits and also bring in revenue;
- A gravity flow system with some elevation variation from north to south would be facilitated; and
- Using the same construction techniques and approximate cost, a larger lake by about 25% could be constructed at -235 ft NGVD compared to what could be constructed at -230 ft NGVD.

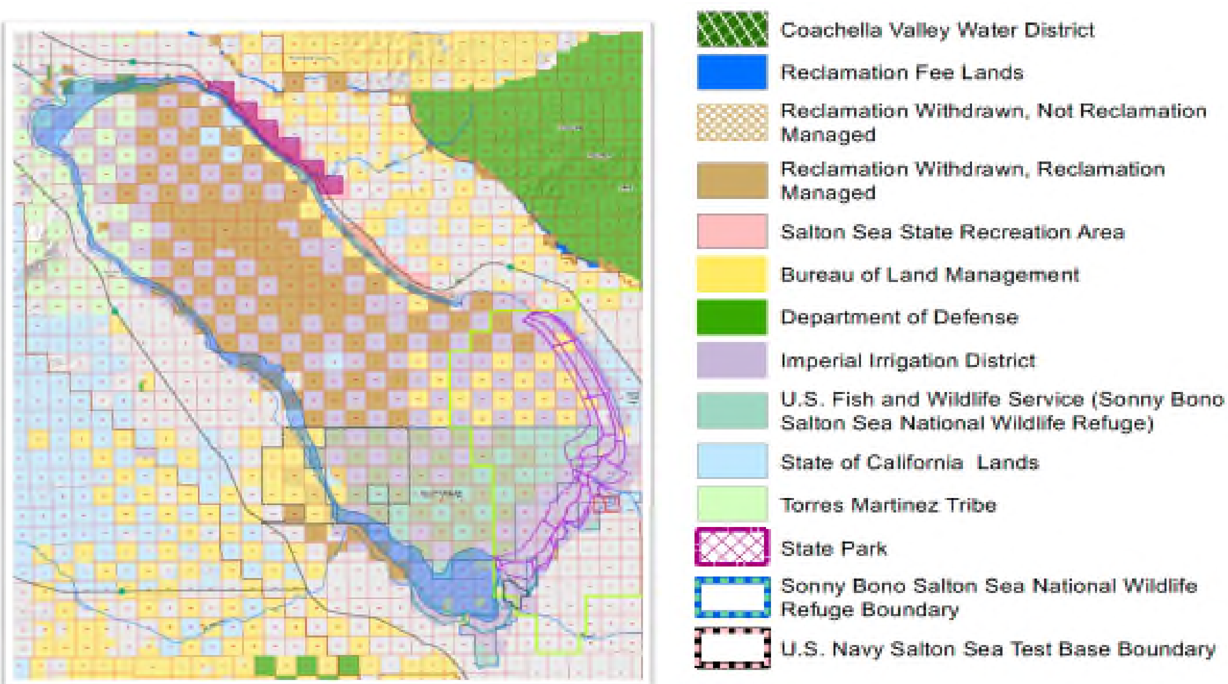

Figure 2 Land Ownership Map

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2.0 Conceptual Construction Details

This section provides a conceptual overview of levee design alternatives including discussion of the initial planning and early concepts for the Perimeter Lake. Three levee designs were created as conceptual outlines to evaluate the cost and feasibility of each of the three options: earthen levee section with gentle side slopes, Geotube® levee section with steep side slopes, and sheet-pile levee section with intermediate side slopes.

The Perimeter Lake concept has evolved over time, and would work in concert with IID's Salton Sea Restoration and Renewable Energy Initiative (SSRREI), the State of California's Species Conservation Habitat (SCH) project, and Imperial County air quality mitigation (AQM) objectives. This section describes concept development and conceptual construction details for the Perimeter Lake. During the initial planning phase, various depths, levee configurations and lake sizes for the Perimeter Lake were considered. Three embankment configurations were considered for use as levees on the Seaside of the new lake configuration.

2.1 Initial Planning

As described above, the Perimeter Lake concept changed during development. The initial concept for the Perimeter Lake would have begun at the southern end of the Sea, incorporated water from the New and Alamo rivers, and run northward along the western edge. From the western edge, it would have widened into a moderate sized recreational area at the north and flowed south along the eastern shore, passing the Yacht Club and ending just south of the Salton Sea State Recreational Area as shown in Figure 3. Major differences in this earlier design include the use of Alamo River inflows, more water along the southern shore of the Sea that would cover a portion of the KGRA, a perimeter lake that would not extend to Bombay Beach, and did not incorporate the full SSRREI. The Perimeter Lake was changed so that renewable energy could be developed within the KGRA, and so more inflow and excess water running from the Perimeter Lake could be used to aid IID projects. Incorporating IID's SSRREI and other projects would provide for AQM, habitat benefits, and economic benefits through renewable energy.

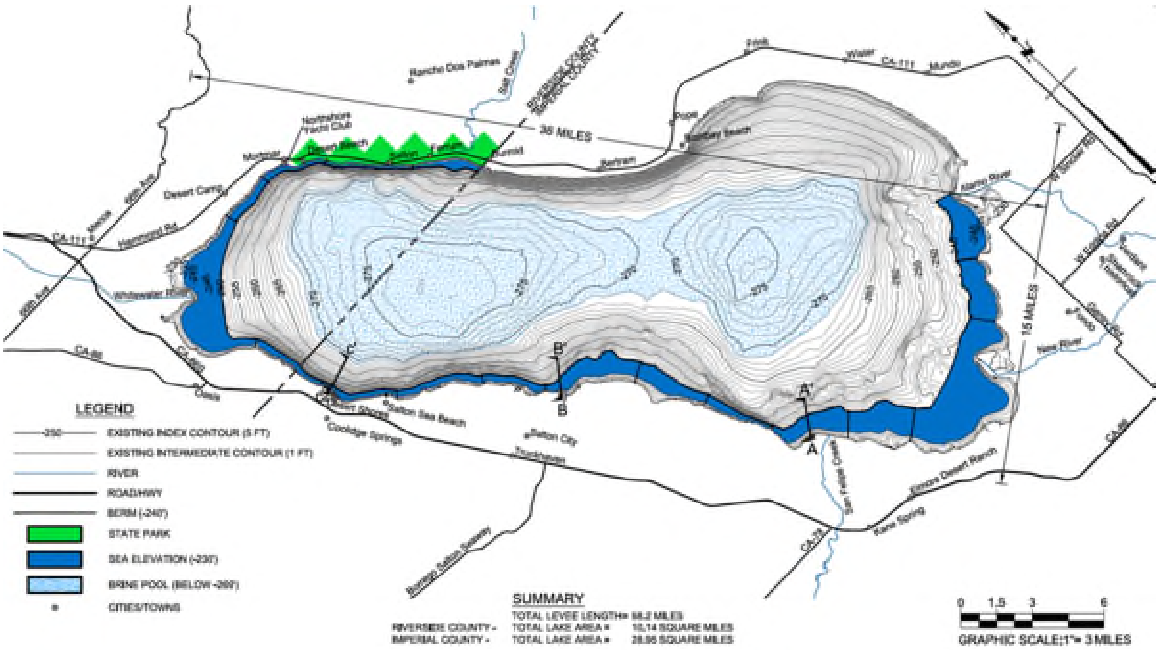

Figure 3 Earlier Perimeter Lake Concept for the Salton Sea

2.2 Water Depth and Surface Elevation

A variety of water depths at the levee, and water surface elevations for the lake were considered in the early phases of analysis. Water depths were considered as shallow as 6 ft and ranged to as deep as 20 ft. A water depth at the levee of 10 ft was selected as a compromise between a number of competing factors that included lake size and water requirement, constructability, and cost.

Once water depth was selected, several depth contour locations were considered along with the corresponding water surface elevation that would go along with a 10 ft water depth. Ultimately, two different water surface elevations were considered in more detail:

- A water surface elevation at -235 ft NGVD with levees at the -245 ft NGVD depth contour (the current Perimeter Lake concept shown in Figure 1 and the previous Perimeter Lake concept shown in **Error! Reference source not found.**); or
- A water surface elevation at -230 ft NGVD with levees at the -240 ft NGVD depth contour (the alternate layout shown in Figure 4).

With the levees constructed at the -240 ft NGVD depth contour and the water surface at -230 ft NGVD, the lake area would have been about 26 sq mi. With the levees constructed at the -245 ft NGVD depth contour and the water surface at -235 ft NGVD, the lake area would have been about 34 sq mi. The advantages of lower lake and levee levels are the following:

- The lake is about 30% larger at -235 ft NGVD water surface elevation, compared to the lake at -230 ft NGVD;
- Having the lake elevation at -235 ft NGVD facilitates gravity flow into the system;
- Having the lake elevation at -235 ft NGVD does not interfere with other habitat projects such as the SCH that would generally be above that elevation; and
- The levee length at -230 ft NGVD, would be about 10% longer than that at -235 ft NGVD and thus 10% more costly.

Therefore, a water surface elevation at -235 ft NGVD with levees at the -245 ft NGVD depth contour was retained for further development of the concept.

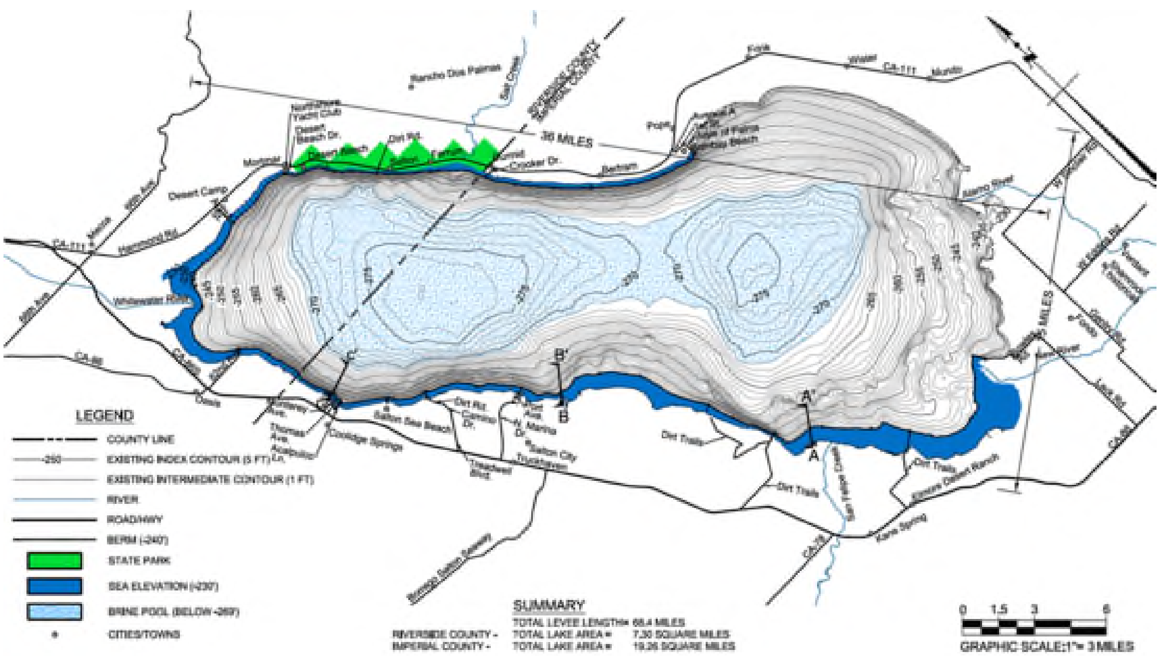

Figure 4 Alternate Bathymetry with Water Surface at -230 ft NGVD and the Levee at -240 ft NGVD

2.3 Refinements in the Northern Lake Area

The unique bathymetry in the northern area of the Perimeter Lake allowed for taking the levee into deeper water in this area. Three alternative configurations were considered:

- Figure 5 illustrates the levee location at depth contour -245 ft NGVD, in 10 ft of water, the same as all other Perimeter Lake levees;
- Figure 6 illustrates the levee location at depth contour -245 ft NGVD, in 15 ft of water, 5 ft deeper than other Perimeter Lake levees; and
- Figure 7 illustrates the levee location at depth contour -250 ft NGVD, in 20 ft of water, 5 ft deeper than other Perimeter Lake levees.

After considering all three options, it was decided to adopt the configuration with the levee in 15 ft of water, as shown in Figure 6. Although the added levee height would add cost, the shorter levee distance across the north end of the Salton Sea made for an economical trade off. In addition, this configuration adds about 2 sq mi to the lake surface for little or no additional cost which would increase the total Perimeter Lake area to about 36 sq mi. Therefore, the 15 ft deep levee in this area was retained for further development of the Perimeter Lake concept.

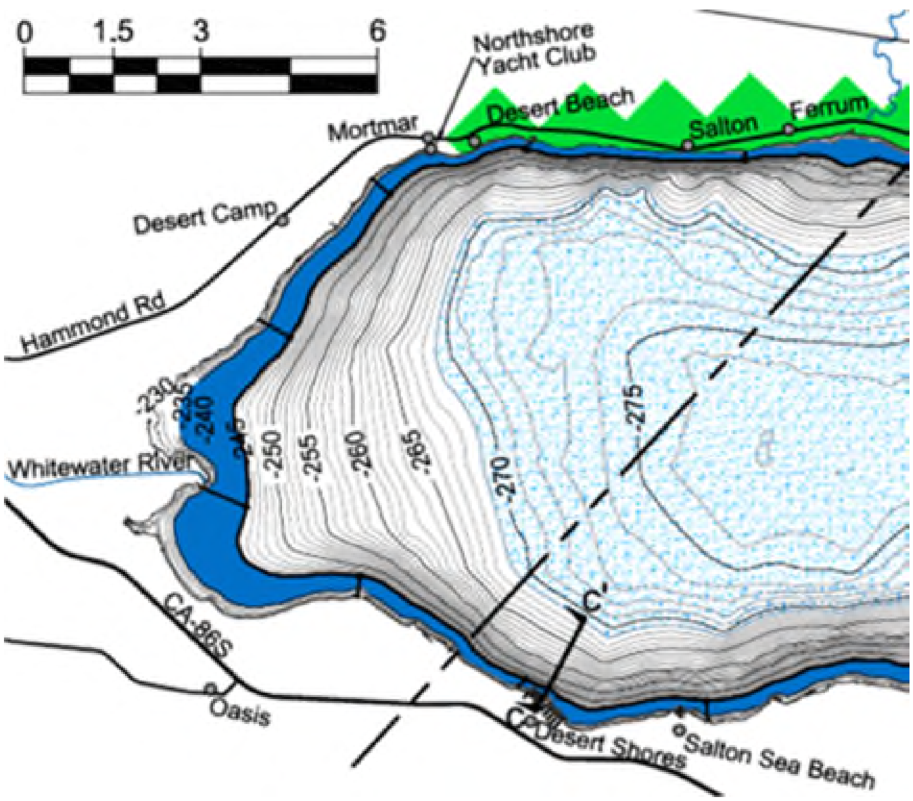

Figure 5 North End Levee in 10 ft Water

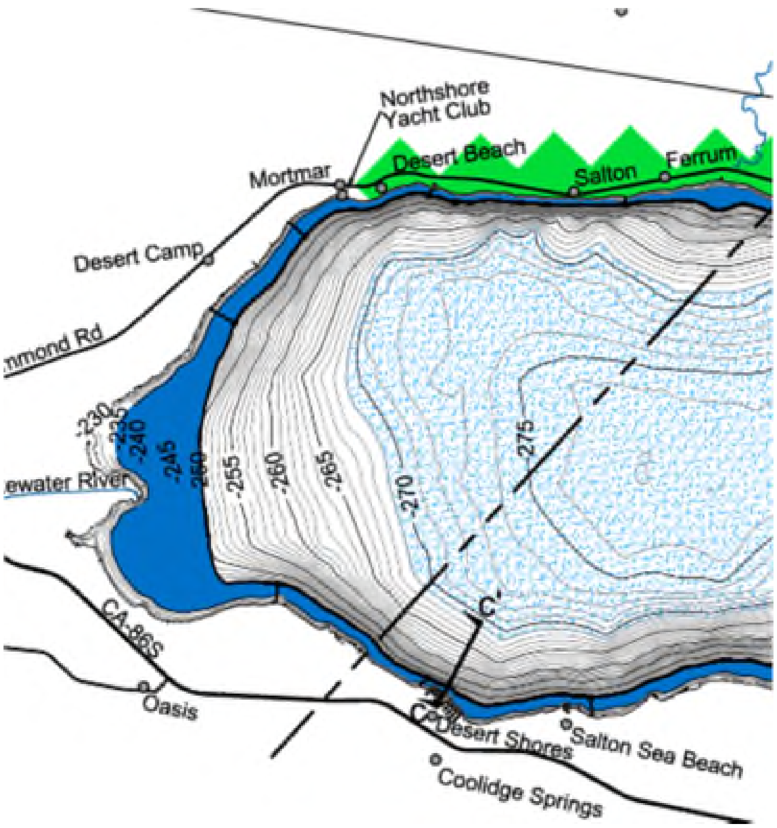

Figure 6 North End Levee in 15 ft Water- Perimeter Lake Plan

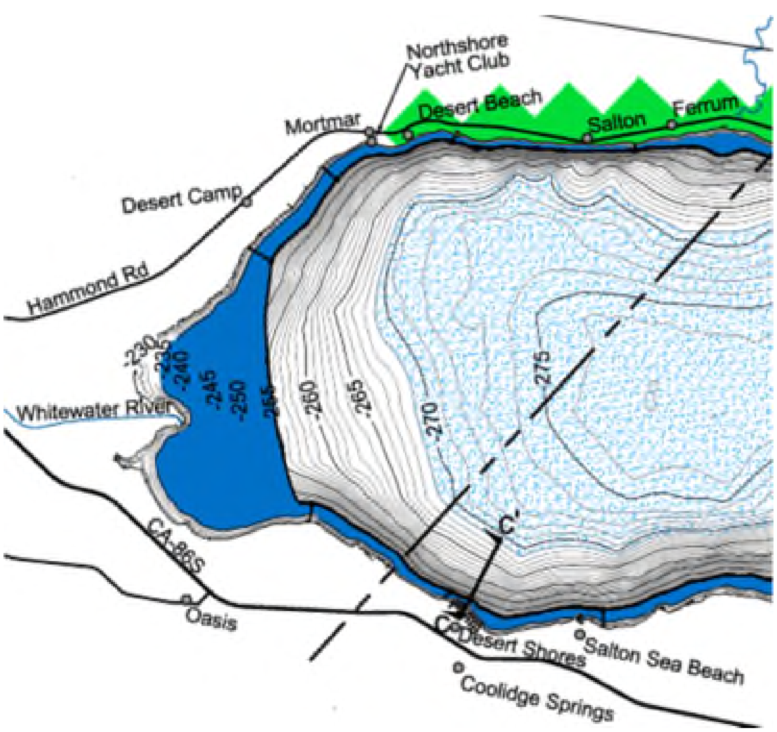

Figure 7 North End Levee in 20 ft Water

2.4 Levee Embankment Configuration

During initial concept planning, three embankment configurations were considered for use as levees on the Sea side of the Perimeter Lake. The three embankment configurations are as follows:

- Earthen Levee Section with Gentle Side Slopes
- Geotube® Levee Section with Steep Side Slopes
- Sheet Pile Levee Section with Intermediate Side Slopes

Each Configuration is discussed below.

2.4.1 Earthen Levee Section

For this configuration, the levee would be constructed by placing dredged material on native seabed. The levee would be 450 ft wide at the base and 30 ft wide at the crest. A woven geotextile may be used in portions of the project where subgrade conditions require it. The crest would be capped with Class II Road Base for use as a road during construction and maintenance. Turnout areas will be provided at regular intervals along the levee. It would have 15 to 1 side slopes with riprap slope armor on the shore side, using quarry run smaller stones. In select areas, beach sand could be placed along the levee face for recreational purposes. The Earthen Levee configuration is illustrated in Figure **8**. Figure **8** shows the levee construction at -245 ft NGVD with the water surface at -235 ft NGVD. The levee configuration would be the same if constructed at -240 ft NGVD, but the water surface would be at -230 ft NGVD.

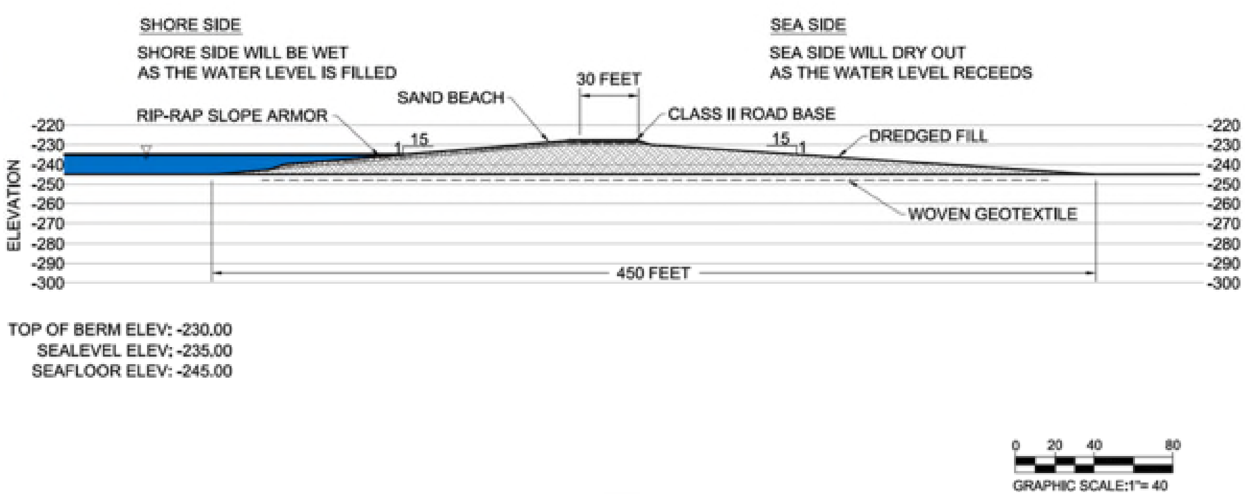

Figure 8 **Earthen Levee Section at -245 ft NGVD**

2.4.2 Geotube® Levee Section

Much like the design for an Earthen Levee Section, this levee would also be constructed by placing dredged material on a woven geotextile fabric base; however, unlike other levee designs, this design would feature Geotubes® within the interior support system of the berm. The levee would be 125 ft wide at the base and 50 ft wide at the crest. The crest would be capped with Class II Road Base for use as a road during construction and maintenance. It would have 2 to 1 side slopes with riprap slope armor on the shore side, using quarry run smaller stones. In select areas, beach sand could be placed along the levee face for recreational purposes. The Geotube® Levee configuration is illustrated in Figure 9. Figure 9 shows the levee construction at -245 ft NGVD with the water surface at -235 ft NGVD. The levee configuration would be the same if constructed at -240 ft NGVD, but the water surface would be at -230 ft NGVD.

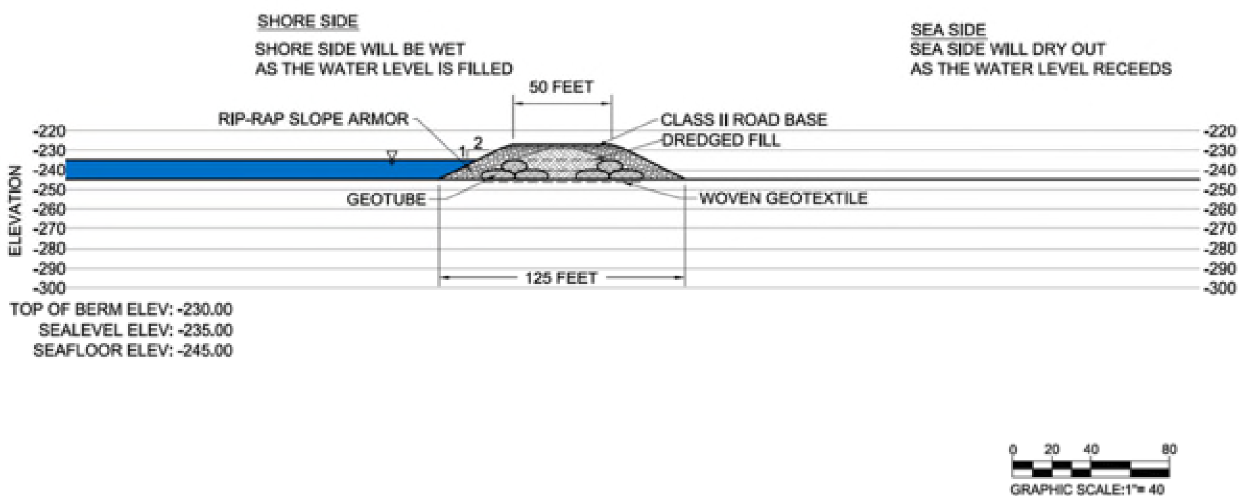

Figure 9 Geotube® Levee Section at -245 ft NGVD

2.4.3 Sheet Pile Levee Section

For this levee configuration, quarry run stones and dredging would be used to create an earth fill around a vinyl sheet-pile layer located in the core of the berm. The levee would be 280 ft wide at the base and 30 ft wide at the crest. The crest would be capped with Class II Road Base for use as a road during construction and maintenance. It would have 8 to 1 side slopes with a rock fill composed of quarry run stones present on the shore side. In select areas, beach sand could be placed along the levee face for recreational purposes. The Sheet Pile Levee configuration is illustrated in Figure 10. Figure 10 shows the levee construction at -245 ft NGVD with the water surface at -235 ft NGVD. The levee configuration would be the same if constructed at -240 ft NGVD, but the water surface would be at -230 ft NGVD.

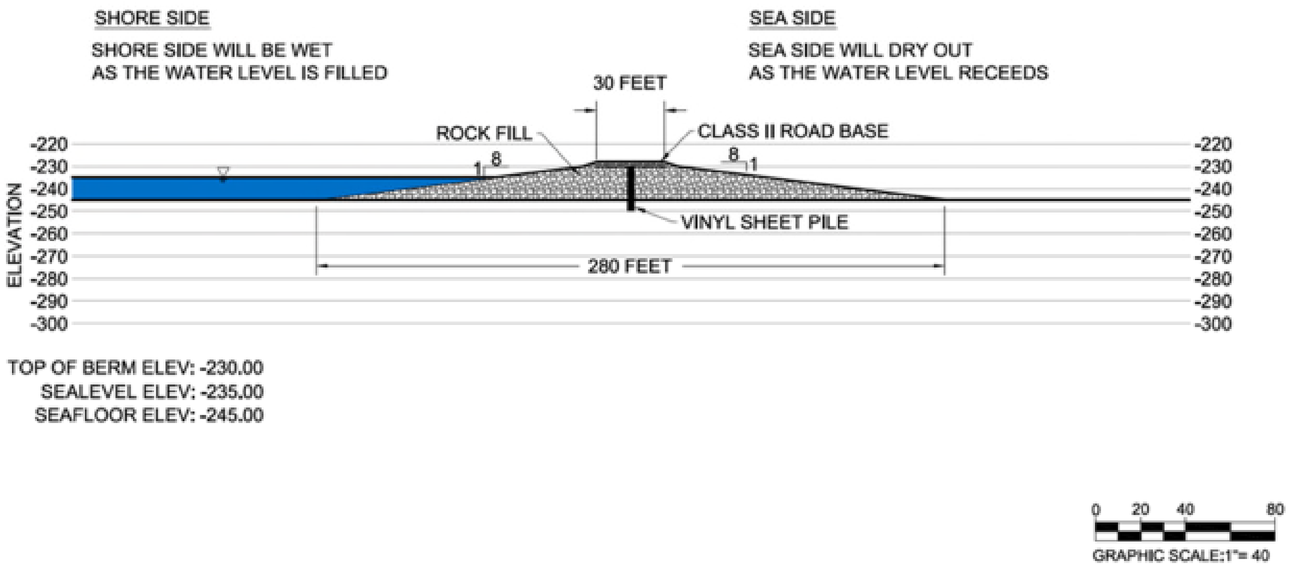

Figure 10 Vinyl Sheet Pile Levee at -245 ft NGVD

2.4.4 Cost and Feasibility Comparison

The three levee designs were created as conceptual outlines to estimate the cost and feasibility of each option. This overall feasibility study is presented in Table 1. Table 1 accounts the following performance criteria because of prior analysis: constructability, conceptual cost estimate, maintenance, environmental (impact), permitting, footprint derived from angle of repose, and risk and uncertainty. Additionally, each of these parameters was placed on a grading scale which consisted of the following ranks: most favorable (coded as a green highlight), areas of concern expected to mitigable (coded as a yellow highlight), and greatest (coded as a red highlight). The grading was done in such a way that each of the options could be compared in terms of feasibility with the other options being considered.

The performance criteria of each of the three construction methods is discussed below.

Geotubes®

- *Constructability:* Hydraulic dredging of sediments would be used to fill Geotubes® as embankment material, which, in turn, would create a steeper angle of repose than could be obtained with earth embankments alone without the Geotubes®. Because Salton Sea sediments are very fine in many areas, a large scale use of polymers would be necessary to flocculate the fine sediments so that they

Table 1 Cost and Feasibility Table

Performance Criteria	Geotubes®	Earthen Levee Embankment	Vinyl Sheet Piles
Constructability	Hydraulic dredge material fills Geotube® creating steeper angle of repose, but large scale use of flocculants unproven in Salton Sea	Mechanical dredging required with some challenges in shallow water areas	Vinyl sheet piles as structural member may have constructability challenge when supported by rock that may cause breakage
Screening Level Cost Estimate	$11.8 million/mile	$9.4 million/mile	$11.5 million/mile
Maintenance	UV exposure can degrade Geotube® material	Earthfill is repaired by additional dredging	Vinyl sheet Piles can expand and contract with temperature
Environmental	Flocculants may be an environmental concern	Would create a deepened channel	No major concerns identified
Permitting	Potential flocculants and dam safety concerns; least dredging disturbance	Traditional levee design; greatest dredge volume of three methods	No major permitting issues, although may be dam safety concerns
Base Width / Levee Slope	125' / 2:1	450' / 15:1	280' / 8:1
Risk and Uncertainty	Seepage and piping are possible; not tested for water retention	Slope stability and seepage needs analysis	Vinyl pile is embedded below levee to reduce seepage

Evaluation Code >>	Most favorable Rating	Area of Concern Expected to be Mitigable	Greatest Area of Concern

would not escape through the Geotube® fabric upon filling and placement. Preliminary tests indicate that suitable flocculating materials are available, but they have not yet been tested in Geotube® applications in the Sea.

- *Screening-Level Cost Estimate:* Based on preliminary conceptual designs, the Geotube® embankment was estimated to be the costliest of the three methods at $11.8 million/mile, about 25% higher than the earthen embankments.
- *Maintenance:* UV exposure can degrade Geotube® material, which could result in a long-term maintenance problem.
- *Environmental:* The polymer flocculants used to clump the fine sediment present at the Sea may be an environmental concern, and the method needs to be analyzed before implementation of this design.
- *Permitting:* Potential concerns over dam safety and the large-scale use of polymer flocculants may hinder the approval of the Geotubes® technology in the permitting process.
- *Footprint Derived from Angle of Repose:* With a 125 ft base and 2 to 1 side slopes, the Geotubes® design allowed for the steepest side slopes and displayed a clear advantage with its reduced angle of repose and footprint.
- *Risk and Uncertainty:* The Geotubes® design displayed a disadvantage due to potential seepage and piping issues that would need to be evaluated through pilot testing.

Earthen Levee Embankment: Selected for Use in the Perimeter Lake

- *Constructability:* Significantly more mechanical dredging would be required for this design compared to the Geotube® Embankment, and some challenges may be present when dredging in shallow areas of the Sea. It is envisioned that dredging would proceed from the south to the north and that the dredge would create a deeper channel that it could move into as it moves along this course.
- *Screening-Level Cost Estimate:* Based on preliminary conceptual designs, the Earthen Levee Embankment was estimated to be the least expensive of the three methods at $9.4 million/mile, about 25% lower than the Geotube® embankments with the lowest price taken as the base value.
- *Maintenance:* The Earthen Levee Embankment displayed a clear advantage. Earth fill would be repaired by additional dredging.

- *Environmental:* This method was ranked with a clear advantage in terms of environmental impact, and it would create deeper channels if implemented.
- *Permitting:* This method follows a traditional levee design that, in itself, would pose no major permitting concerns; however, this design calls for the most dredging of the three alternatives and may pose an environmental problem for that reason.
- *Footprint Derived from Angle of Repose:* With a 450 ft base and 15 to 1 side slopes, the Earthen Levee Embankment design would have a larger footprint than the other alternatives.
- *Risk and Uncertainty:* The flat, broad Earthen Levee Embankment design was judged the most stable. However, the potential risks associated with this design involve concerns over slope stability, required more analysis as discussed later in this report.

Vinyl Sheet Pile

- *Constructability:* The Vinyl Sheet Pile design displayed no clear advantage or disadvantage. Vinyl Sheet Piles would require vibration technology to be installed; however, due to the unreliability of soil conditions at the Sea, installation may be hindered by additional challenges.
- *Screening-Level Cost Estimate:* Based on preliminary conceptual designs, the Vinyl Sheet Piles embankment was estimated to be the second most expensive of the three methods at $11.5 million/mile. This cost represents a 22% increase with respect to Earthen Embankments.
- *Maintenance:* The Vinyl Sheet Pile embankment displayed no clear advantage or disadvantage. Though potential maintenance problems were more serious with the Geotube® embankments, vinyl sheet piles can expand and contract with temperature fluctuations.
- *Environmental:* No major environmental concerns were identified with this design, and it displayed a clear advantage in this regard.
- *Permitting:* The Vinyl Sheet Pile design displayed no clear advantage or disadvantage. No major issues were identified with the design, but dam safety issues may be of concern with this alternative.
- *Footprint Derived from Angle of Repose:* With a 280 ft base and 8 to 1 side slopes, the Vinyl Sheet Pile design allowed for intermediate side slopes and displayed no clear advantage or disadvantage in regard to an acceptable angle of repose and footprint.

- *Risk and Uncertainty:* The Vinyl Sheet Pile design displayed an advantage because the vinyl sheet piles would be embedded below the levee to reduce seepage, but further testing indicated that deeper sheet piles would likely be required to provide adequate protect against seepage in sand deposits within the sediments.

The earthen levee embankment was considered to have multiple advantages and was selected for further analysis in the Perimeter Lake concept. It was expected to be the lowest cost solution and rated best in constructability and related considerations. Furthermore, because a significant allocation of the construction cost would be for dredging which would have the advantage of creating deep water areas which would have ecological and recreational benefits.

2.5 Lake Width and Depth

The lake would vary from 500 ft to two miles at various points. During preliminary design work, cross sections were developed at three locations around the Sea. These cross sections can be viewed in relation to the whole alternative in Figure 1. These cross sections are part of a preliminary design effort, and they have an exaggerated vertical scale.

2.5.1 Section A-A’

The widest area of the surrounding lake would be located toward the south facing west, between the New River and Elmore Desert Ranch. The cross section shown in Figure 11 displays a view located near the San Felipe Creek, a few miles north of the widest point. At that point, the lake would be approximately 3,500 ft or about 2/3 of a mile wide. The water line is shown at -235 ft NGVD, and the dredged channel borrow area would reach down to depths of -260 ft creating a water depth of 25 ft in the channel running along the levee. The levee shown in the diagram would reach out of the water 5 ft, and its crest would be at -230 ft NGVD.

2.5.2 Cross Section C-C’

Cross Section C-C’ shown in Figure 12 depicts the narrowest portion of the lake assuming the levees are constructed at -245 ft NGVD. At C-C’, the lake would be approximately 500 ft or about one tenth of a mile wide. The water line is shown at a -235 ft NGVD, and the dredged channel borrow area would reach down to depths just above -260 ft NGVD creating a water depth a little lower than 25 ft. The levee shown in the diagram would reach out of the water 5 ft, and its crest would be at -230 ft NGVD.

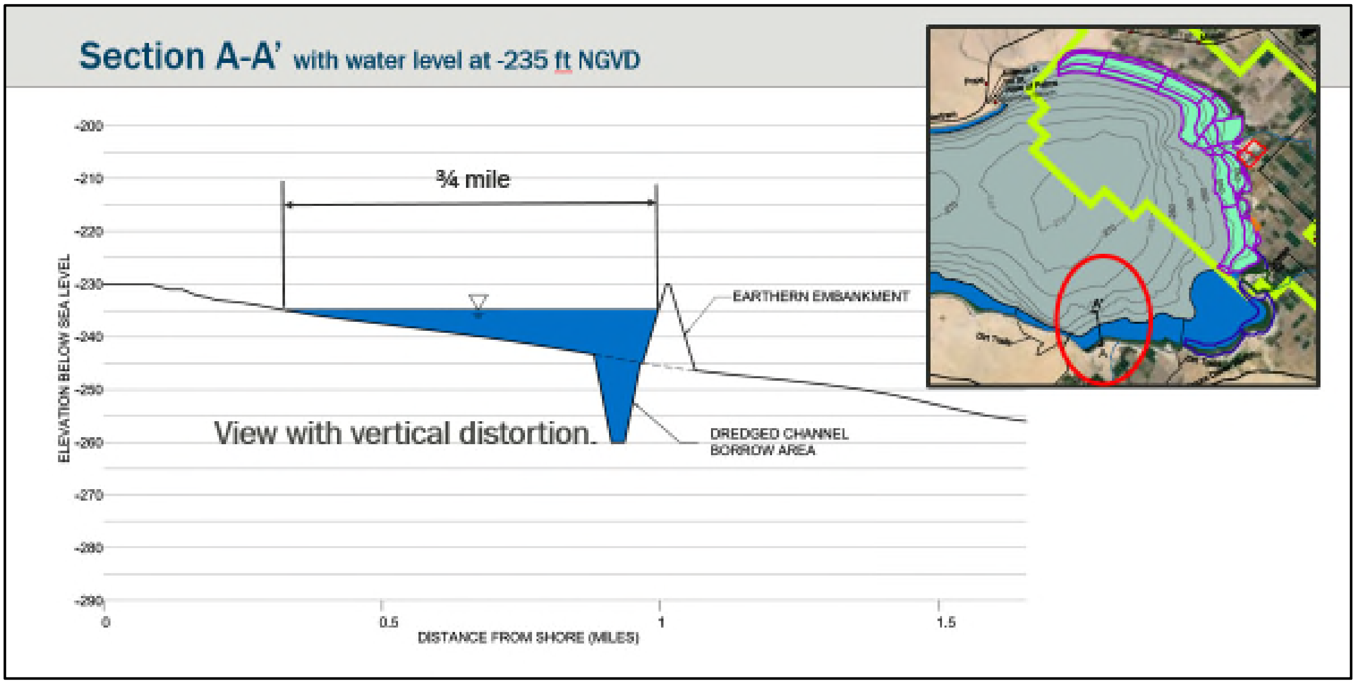

Figure 11 Cross Section A-A' with Vertical Exaggeration

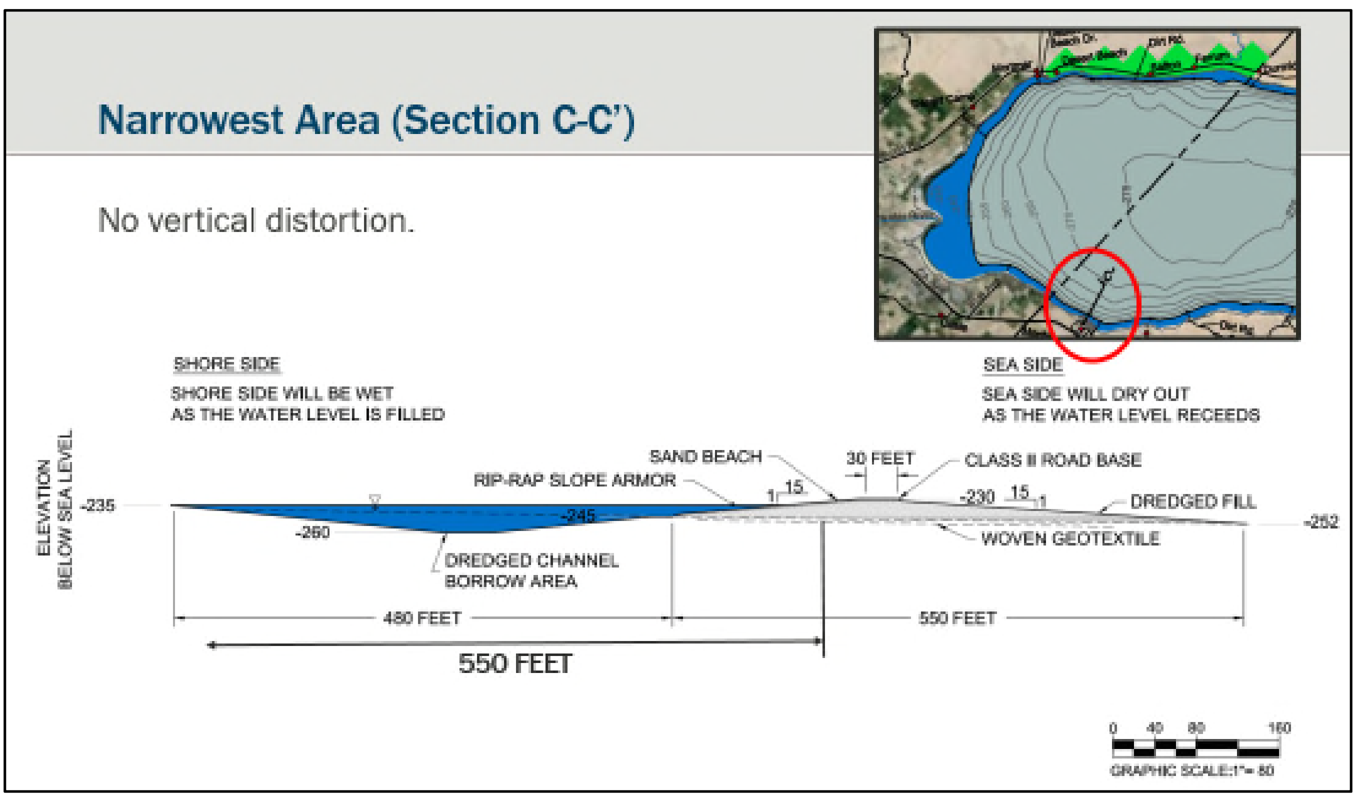

Figure 12 Cross Section C-C' without Vertical Exaggeration

2.6 Compatibility with Other Projects

An important aspect in designing the Perimeter Lake concept was to make the project compatible with other Salton Sea management plans, such as the SCH (Species Conservation Habitat) and the SSRREI (Salton Sea Restoration and Renewable Energy Initiative). Figure 13 shows a map of the Sea, at the preferred -235 ft NGVD water surface, with the implemented Perimeter Lake concept in relation to the known sites of other projects in the Sea. Though the Perimeter Lake concept is designed to work in concert with current Salton Sea management efforts, many past options have had to be eliminated. These eliminated past alternatives are discussed below in relation to the Perimeter Lake concept.

2.6.1 SSRREI

IID, Imperial County, the Salton Sea Authority, the State of California, and others are developing the Salton Sea Restoration and Renewable Energy Initiative (SSRREI). This plan is being developed in order to initiate Salton Sea Salton Sea management and partially address critical habitat needs until a full-scale Salton Sea management project is developed by the Authority. The SSRREI is the first part of a multi-phased plan, and its purpose is to provide a strategic framework for Salton Sea management. This framework would support the development of renewable energy resources and habitat improvements, and incorporate AQM to address potential human health risks from exposed playa. The SSRREI is planned to be implemented on playa that is exposed as the Salton Sea recedes (until approximately 2030) and in the immediately adjacent upland area. Part of the goal of the SSRREI is to coordinate three important aspects of work being performed at the Sea: renewable energy development, habitat improvements, and AQM.

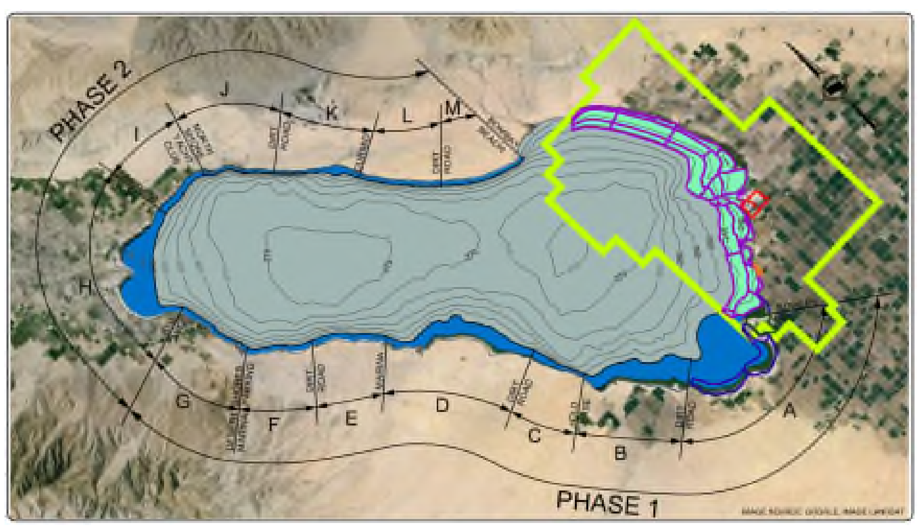

Figure 13 Sequencing Plan for the Perimeter Lake construction, labeled A through M. Also shown on the map is the KGRA (yellow-green polygon) and SSRREI areas (aqua with purple cell boundaries).

The SSRREI itself is divided into three parts. These parts are shown below as they are defined in IID's SSRREI Framework Document (2015):

- Part 1: The first part involves developing an initial plan for an incremental approach for Salton Sea management that would bridge the gap between current conditions and the longer-range Salton Sea Salton Sea management planning activities. It also includes development of currently permitted projects around the Salton Sea.
- Part 2: The second part includes construction of additional habitat in designated areas as funds become available, and construction of an infrastructure backbone that promotes development of renewable energy in areas of exposed playa. It would also address pupfish habitat requirements; provide water, power, and access roads for habitat; and provide air quality mitigation land uses around the Salton Sea.
- Part 3: The final part of the SSRREI includes construction of geothermal development and other renewable energy projects by others in those business sectors.

The SSRREI would work in concert with the proposed Perimeter Lake concept presented in this document. SSRREI management efforts could potentially benefit the project by helping to treat the problem of exposed playa. Additionally, the projected site of SSRREI activities is located in an identified KGRA, and it could bring revenue to Salton Sea management through renewable energy.

2.7 Sequencing

As discussed earlier, the Perimeter Lake concept would be composed of a series of linked but separated elongated ponds. These pond units can be referred to as separate cells that would allow for flexibility during construction and pilot testing. The cells would be separated by causeways, which would act as access roads for construction. The cells would be linked by culverts or pipe arches placed underneath the roads to allow flows to enter the subsequent cell. Once dredging of the levee is complete in one cell, the causeway with culverts would be completed. As construction is completed on the levee, the culverts would eventually be removed and the cells would be linked together. There would be two phases in the overall plan, and each phase would consist of the construction of approximately half of the cells in the overall project. The project would receive significant inflows from the New River, and this is where part of the construction in phase 1 is proposed to occur. Figure 13 shows a map of the sequencing plan for the overall project. In the map, Cell A reaches from Boles Road to a dirt road and Cell M reaches from another dirt road to Bombay Beach.

2.8 Seepage Control

Based on the geotechnical analysis completed as part of this feasibility study, a vinyl sheet-pile seepage barrier was added to the levee configuration to serve as seepage barrier. The geotechnical analysis is discussed in Section 7.0 of this report and the full technical report is included in Appendix A. The levee configuration with the sheet pile is shown in Figure 14.

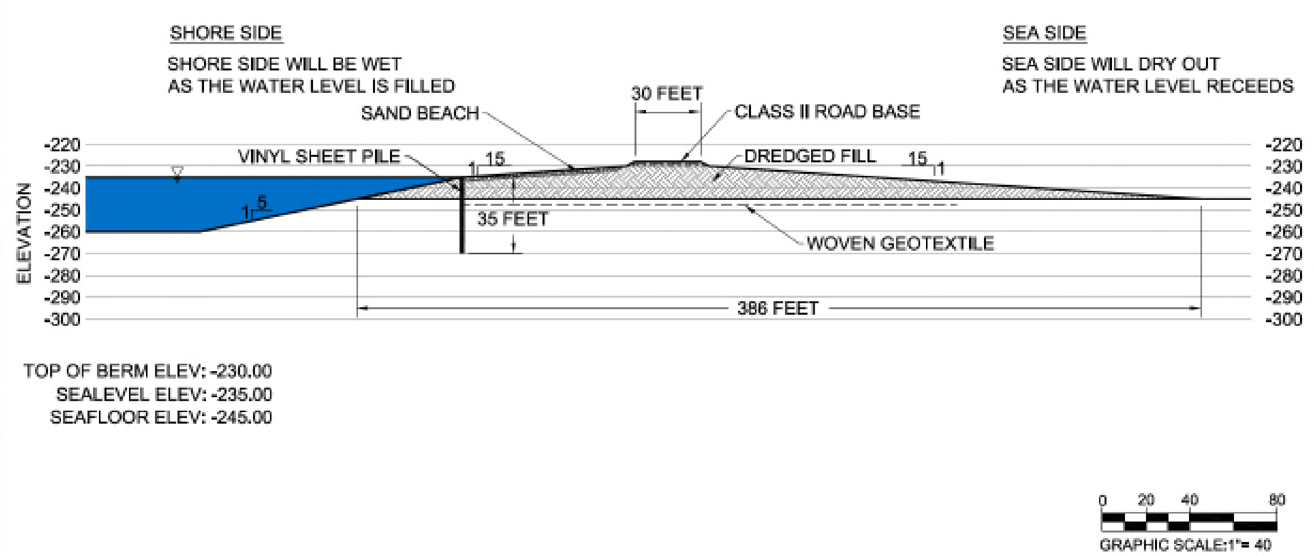

Figure 14 Levee Cross Section Configuration with Seepage Barrier

3.0 Water Inflow Requirements

This section estimates the water inflow requirements for the Perimeter Lake Plan. An estimate of overall water requirements for the project is presented, more detailed findings about seepage and evaporation losses are in a water budget analysis, and a study regarding residual saline pool evaporation is also included. Studies and estimates were run using IID and Bureau models, and they provide necessary tools for Perimeter Lake water budget estimates.

The expected water needs for the Perimeter Lake concept are as follows:

- Minimum Perimeter Lake Plan flow requirement to compensate for evaporation and seepage — 167,000 AFY
- SSRREI, other habitat programs/Dust mitigation, Saline pool Contingencies — 522,000 to 689,000 AFY

The water budget and sources of water for the Perimeter Lake along with some considerations for the residual saline pool are discussed below.

3.1 Water Budget Analysis

The water budget and salinity for the proposed Salton Sea Perimeter Lake was calculated based on the expected evaporation and seepage losses and possible inflow salinities. In addition to a base scenario, two scenarios are discussed for use of the lake as a reservoir for water releases for dust control in the downslope playa or for other beneficial uses.

The evaporation rate used in the calculations is 5.7 ft/yr. This is an historic value over many years that can be estimated from Evaporation = Inflow/Area for the Salton Sea. In addition to evaporation, it likely includes some infiltration losses as well as inflow from groundwater sources. Since the Perimeter Lake is in the existing Salton Sea basin and would have water depths up to 25 ft and temperature ranges comparable to the existing Sea, this number is considered reasonable. In fact, it may be conservative. The evaporation functions in both the Salton Sea Analysis Model (SALSA and SALSA2) originally developed for the State's Salton Sea Programmatic EIR in 2006 and the Bureau of Reclamation's Salton Sea Accounting Model (SSAM) both predict an evaporation rate of about 5.5 ft/yr when the lake salinity is at or below 20 PPT.

A seepage modeling analysis discussed in Section 8 and documented in Appendix A indicates that in areas where sand lenses are present, seepage barriers would need to be included in the final designs. With appropriate barriers such as sheet piles, the seepage losses are estimated at between 80 and 120 gallons/day/ft of levee. For the calculations presented in this document, the average rate of 100 gallons/day/ft was used.

As discussed above, a base inflow/outflow scenario plus two additional scenarios were investigated. A summary of the three scenarios is provided in Table 2. A graphical depiction of the inflow and inflow components of each scenario is provided in Figure 15. Each scenario is discussed briefly in the following paragraphs. These scenarios are provided for illustrative purposes and many other combinations are possible. A spreadsheet model is available upon request to evaluate multiple other scenarios.

Table 2 Inflow Scenarios

Components	Scenario 1	Scenario 2	Scenario 3
Evaporation (AFY)	131,000	131,000	131,000
Seepage Loss (AFY)	36,000	36,000	36,000
Releases for Dust Control or Habitat (AFY)	0	33,000	60,000
Inflow (AFY)	167,000	200,000	227,000
Perimeter Lake Salinity (PPT)	14.8	18.0	18.0
Inflow Salinity (PPT)	3.2	6.2	7.6

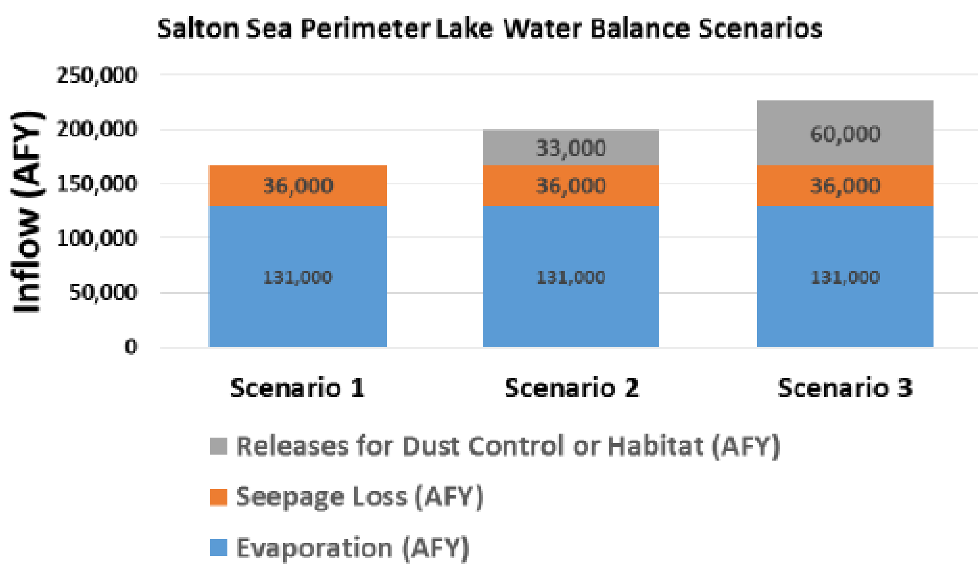

Figure 15 Inflow Scenarios

3.1.1 Inflow Scenario 1

For this scenario, there are no releases for beneficial uses such as dust control, although the seepage under the levee would go toward the playa and could have some benefits. An inflow of 167,000 AFY would be required to equal the combined evaporation and seepage losses. This scenario assumes that water would be supplied either from the New River at an inflow salinity of about 3 PPT or as a blend of water from the Whitewater and New Rivers plus some higher salinity water from the SCH project. The resulting salinity in the lake would be nearly 15 PPT. This value is less than half the salinity of ocean water and should be attractive for recreational uses. It is on the lower end of the range that is generally considered desirable for controlling vectors, discouraging fresh water macrophyte growth, and sequestering selenium in the sediments. The supporting calculations for this scenario are provided in Table 3.

3.1.2 Inflow Scenario 2

This scenario assumes that the total annual inflow to the Perimeter Lake would be about 200,000 AFY. After evaporative and seepage losses, there would be about 33,000 AFY available for release to assist with dust control or for habitat use or other beneficial purposes. In this scenario, it was assumed that the target salinity in the lake would be 18 PPT. In order to achieve this target salinity, the inflow salinity would need to be about 6.2 PPT. This salinity could be achieved by blending water from the two rivers with higher salinity outflows from the SCH. The supporting calculations for Scenario 2 are provided in Table 4.

3.1.3 Inflow Scenario 3

This scenario assumes that larger amounts of water would be needed to run through the lake for releases at various points to assist with dust control or for habitat use or other beneficial purposes. In this scenario, the total annual inflow to the lake would be about 227,000 AFY. After evaporative and seepage losses, there would be about 60,000 AFY available for beneficial releases. Similar to Scenario 2, in this scenario, it was assumed that the target salinity in the lake would be 18 PPT. In order to achieve this target salinity, the inflow salinity would need to be about 7.6 PPT as compared to 6.2 PPT for Scenario 2. This salinity could be achieved by blending larger quantities of water from the SCH project with the river water. If sufficient quantities of water are not available from SCH, the salinity in the lake could be lowered temporarily during the release period. For a more permanent solution, the brine line capacity in SCH could be expanded or an additional brine line could be added. The supporting calculations for Scenario 3 are provided in Table 5.

Table 3 Scenario 1: Inflow = 167,000 AFY, No Releases

Salton Sea Perimeter Lake: Preliminary Water Budget Estimate: Scenario 1

Evaporation					Rounded		Effective
sq mi	ac/sq mi	acres	ft/yr	AFY		Seepage	Total
36	640	23,040	5.7	131,328	131,000 AFY	Expressed	Evap +
						in ft/yr	Seepage
Seepage to Playa (Lo and Hi Estimates)						ft/yr	ft/yr
gal/ft/day	ft/mi	MG/mi/day	miles	MGD			
80	5,280	0.42	61.3	25.7	29,000 AFY	1.3	7.0
120	5,280	0.63	61.3	38.6	43,000 AFY	1.9	7.6
				Average	36,000 AFY		
Combined Evaporative and Seepage Losses					**167,000 AFY**		
Releases for Beneficial Uses (e.g. Dust Control)				Releases	0 AFY		
Total Required Inflow				Inflow	**167,000 AFY**		
Outflow (Releases Plus Seepage)				Outflow	**36,000 AFY**		
Salinity (PPT)							
Target Salinity in Lake (= Outflow Salinity)				Lake / Outflow	14.8 PPT	724,000	tons/yr
Required Salinity in Inflow (= PPT Out x (Inflow/Outflow))				Inflow	3.2 PPT	724,000	tons/yr

In this scenario, it is assumed that the inflow would be primarily from New River water with a salt concentration in the inflow to the lakewould be about **3 PPT** and the lake concentration would be about 15 **PPT**.

Table 4 Scenario 2: Inflow = 200,000 AFY, Releases = 35,000 AFY

Salton Sea Perimeter Lake: Preliminary Water Budget Estimate: Scenario 2

Evaporation					Rounded		Effective
sq mi	ac/sq mi	acres	ft/yr	AFY		Seepage	Total
36	640	23,040	5.7	131,328	131,000 AFY	Expressed	Evap +
						in ft/yr	Seepage
Seepage to Playa (Lo and Hi Estimates)						ft/yr	ft/yr
gal/ft/day	ft/mi	MG/mi/day	miles	MGD			
80	5,280	0.42	61.3	25.7	29,000 AFY	1.3	7.0
120	5,280	0.63	61.3	38.6	43,000 AFY	1.9	7.6
				Average	36,000 AFY		
Combined Evaporative and Seepage Losses					**167,000 AFY**		
Releases for Beneficial Uses (e.g. Dust Control)				Releases	33,000 AFY		
Total Required Inflow				Inflow	**200,000 AFY**		
Outflow (Releases Plus Seepage)				Outflow	**69,000 AFY**		
Salinity (PPT)							
Target Salinity in Lake (= Outflow Salinity)				Lake / Outflow	18.0 PPT	1,688,000	tons/yr
Required Salinity in Inflow (= PPT Out x (Inflow/Outflow))				Inflow	6.2 PPT	1,688,000	tons/yr

In this scenario, it is assumed that the inflow would blend New River water with outflow from SCH and the salt concentration in the inflow to the lake is **6.2 PPT** and the desired lake concentration is **18 PPT**.

Table 5 Scenario 3: Inflow = 227,000 AFY, Releases = 60,000 AFY

Salton Sea Perimeter Lake: Preliminary Water Budget Estimate: Scenario 3

Evaporation					Rounded		Effective
sq mi	ac/sq mi	acres	ft/yr	AFY		Seepage	Total
36	640	23,040	5.7	131,328	131,000 AFY	Expressed	Evap +
						in ft/yr	Seepage
Seepage to Playa (Lo and Hi Estimates)						ft/yr	ft/yr
gal/ft/day	ft/mi	MG/mi/day	miles	MGD			
80	5,280	0.42	61.3	25.7	29,000 AFY	1.3	7.0
120	5,280	0.63	61.3	38.6	43,000 AFY	1.9	7.6
				Average	36,000 AFY		
Combined Evaporative and Seepage Losses					**167,000 AFY**		
Releases for Beneficial Uses (e.g. Dust Control)				Releases	60,000 AFY		
Total Required Inflow				Inflow	**227,000 AFY**		
Outflow (Releases Plus Seepage)				Outflow	**96,000 AFY**		
Salinity (PPT)							
Target Salinity in Lake (= Outflow Salinity)				Lake / Outflow	18.0 PPT	2,348,000	tons/yr
Required Salinity in Inflow (= PPT Out x (Inflow/Outflow))				Inflow	7.6 PPT	2,348,000	tons/yr

In this scenario, it is assumed that the inflow would blend New River water with outflow from SCH and the salt concentration in the inflow to the lake is **7.5 PPT** and the desired lake concentration is **18 PPT**.

3.2 Water Sources

Primary water sources for the Perimeter Lake are the following:

- The New River in the south, with improved water quality through treatment wetlands;
- The Whitewater River in the north, which has generally good water quality; and
- Some inflows from groundwater.

Each source is discussed briefly below.

3.2.1 New River

The New River is expected to provide a major source of water to the Perimeter Lake, because of its proximity to the southern boundary of the lake and its relatively large volume of flow. Recent annual flow measurements from the New River to the Sea, although decreasing over the past two decades, are approximately 400,000 AFY (Figure 16). It is expected that the New River flows will decrease further, potentially by a third, consistent with estimates for overall reductions in Imperial Valley flows into the Sea (Table 6, Benchmark 2 Report). Despite this decrease, there would still be enough water in the New River to meet the needs of the Perimeter Lake Scenarios 1-3 (167,000-227,000 AFY), particularly since a portion of the water requirements is expected to be met from the Whitewater River and groundwater sources as discussed below.

A concern relating to the use of the New River for the Perimeter Lake is its poor water quality, with high levels of nutrients, coliforms, and selenium. Nitrogen and phosphorus levels may result in eutrophic conditions in receiving waters (nitrogen = 8.6 mg/L; phosphorus = 1.06 mg/L). Selenium levels averaged 6 µg/L, above the 5 µg/L criterion set by the California Toxics Rule. Also, fecal coliforms levels are very high on account of wastewater discharges upstream of the international boundary, and exceed 10^4 MPN/100 ml (MPN = most probable number). The presence of these contaminants, even when the Perimeter Lake is blended with Salton Sea water, has a high likelihood of adversely affecting the human and ecological beneficial uses of the Perimeter Lake. Therefore, water quality improvements through means such as sedimentation basins and treatment wetlands as discussed in Section 5.0 would be needed to improve the inflowing water quality.

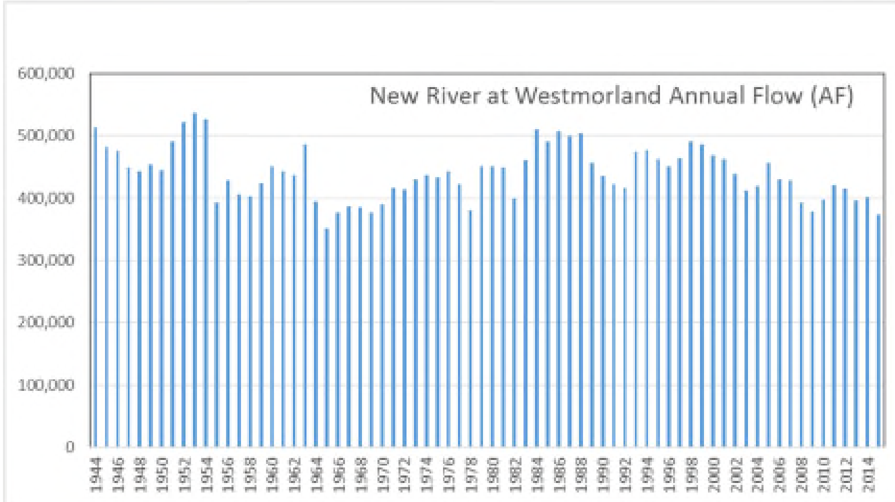

Figure 16 Measured inflows from the New River into the Salton Sea from WY 1943-2015

3.2.2 Whitewater River

The Whitewater River is expected to provide a portion of the water needs for the Perimeter Lake. Compared to the inflow needs estimated for Scenarios 1 to 3 above (167,000-227,000 AFY), the Whitewater River currently provides an inflow to the Salton Sea of about 40,000 AFY. However, this number has been higher in the recent past (Figure 17), and is also projected to be higher in future decades, possibly in excess of 100,000 AFY based on the Coachella Valley Management Plan 2010 update. Exact values depend on the extent of recycling and desalination that may be considered in the future.

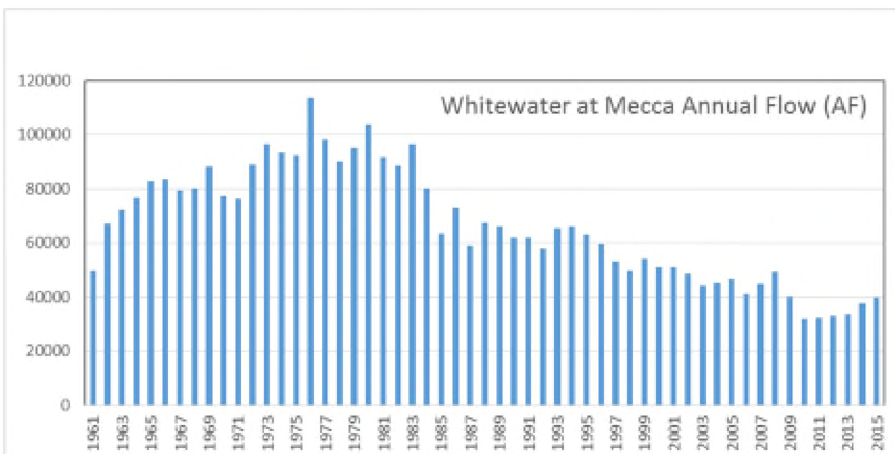

Figure 17 Measured inflows from the Whitewater River into the Salton Sea from WY 1961-2015

Water from the Whitewater River is beneficial for the Perimeter Lake because it is generally of better quality than New River water. For example, total dissolved solids and selenium concentrations less than half the levels in New River water (salinity average = 0.9 PPT in Whitewater River, compared to 3 PPT in New River; Se average 2.6 µg/L in Whitewater compared to 6.0 µg/L in the New River; summarized in Benchmark 2 report, Chapter 3). Coliform levels in Whitewater River water are also about 2 orders of magnitude lower than in the New River (100 MPN/100 ml compared to 10,000 MPN/100 ml). However, nutrient levels, both nitrogen and phosphorus, are higher in Whitewater River than in the New River. Therefore, while there would be some clear benefits to the use of Whitewater River water for the Perimeter Lake, concerns related to nutrients, and the associated impacts on algal blooms and potential low dissolved oxygen in the Perimeter Lake would still need to be considered.

3.2.3 Groundwater

Although much smaller than surface water sources and harder to quantify, groundwater seepage is a potential source of water to the Perimeter Lake. Recent estimates for the entire Salton Sea range of 12,000 AFY, with about 1,100 AFY each from the Imperial and Coachella Valleys (Salton Sea PEIR, 2006, Appendix H-2; Coachella Valley Water Management Plan, 2012) and 10,000 AFY from sources besides the Imperial and Coachella Valleys (based on Helys et al., 1966, and cited in Salton Sea PEIR, 2006, Appendix H-2). The specific location of this component of the groundwater flow is not well defined, and estimates that are more recent do not appear to be available.

Groundwater is expected to continue to provide a source of water for the Perimeter Lake. Based on the values above, it could be expected that about half the estimated flow, or 6,000 AFY could flow into the Perimeter Lake each year. Because the Perimeter Lake would be much smaller than the historic Salton Sea, the contribution of groundwater as a water source is expected to be a more important than in the past, although still small overall.

3.2.4 Summary of Water Sources

Based on the available water sources as discussed above, the approximate distribution of water supply sources can be determined. The water needed for the minimum inflow requirement of 167,000 AFY for evaporation and seepage would be approximately as follows:

- New River: 125,000 AFY (75%)
- Whitewater River: 36,000 AFY (21%)
- Groundwater: 6,000 AFY (4%)
- Total evaporation and seepage: 167,000 AFY (100%)

Note that 125,000 AFY would be slightly more than 1/3 of the expected future annual flows in the New River.

3.3 Estimation of Brine Pool and Water Losses

This section presents an estimate of the remaining residual saline pool in the Salton Sea following the implementation of the Perimeter Lake concept. The calculations are performed using a steady state approach and using the SSAM annual salt and water balance model modified by Tetra Tech in support of the 2014-2016 feasibility evaluation. Note that this update was necessitated because the other available salt and water balance model SALSA2, developed does not allow flexible variation of hydrology in the public domain version.

3.3.1 Estimate Using a Steady State Approach

The Salton Sea is estimated to have 494 million tons of salt by the year 2020. The annual inflow of salt is 3-4 million tons and can be ignored for the purpose of this calculation. We estimate the volume of water that would be associated with this quantity of salt for a 250,000 mg/l TDS level. The assumption is that from this level of salinity and beyond, as further evaporation occurs and salinity increases further, a salt crust would form on the edges as the residual saline pool recedes. This process would begin to slow with time as the evaporation rate decreases with corresponding to increases in salinity. Figure 18 shows the evaporation as a ratio of freshwater evaporation, with increasing salinity as computed through two applicable sources (calculations used in the SSAM and SALSA models). It is important to emphasize that the evaporation estimates at high salinities are extrapolations, and these relationships are somewhat uncertain in these ranges.

The following steps can be used to make an initial estimate of the residual saline pool area:

1. Volume corresponding to 250,000 mg/1 TDS = 1.6 million AF

2. Elevation estimate = -258 ft below MSL, NGVD 1929 (from the bathymetry of the Salton Sea), shown in Figure 19

3. Area estimate = 140,500 acres

Compared to an initial Sea area of 232,000 acres (elevation -230 ft below MSL, NGVD 1929), we estimate an exposed area of 92,000 acres.

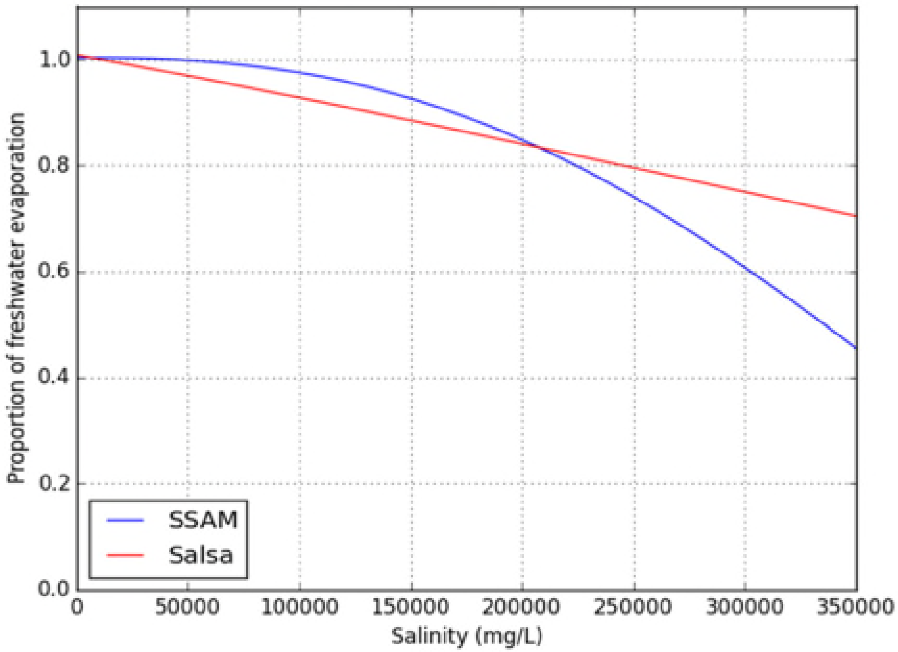

Figure 18 Comparison of Evaporation Estimates in the Hydrology Models.

Note: Larger differences at higher salinities reflects uncertainty in the higher range.

3.3.2 Future Flow Requirements for Steady State Estimate

Although we have developed the above estimate from a calculation taken from the mass of salt in the residual saline pool and a target concentration, we recognize that even at 250,000 mg/l some evaporation would occur. This is estimated to range between 4 and 4.4 ft per year (SALSA model and SSAM, respectively), and corresponds to a volume of 560,000 AFY to 616,000 AFY.

Other flows include the following:

- The water needs for the Perimeter Lake plan have been estimated at 167,000 AFY.
- In addition, assuming a full build-out of the SCH project (3,100 acres), the freshwater and seawater needs are estimated at 18,600 AFY (Tetra Tech modification to SSAM, 2015).
- Dust control estimates are based on 1 foot of water per acre, vary as the exposed area increases, and can be estimated to be 92,000 AFY.

Adding these flows, the requirements are 837,600 AFY for the SALSA estimate and 893,600 AFY for the SSAM estimate.

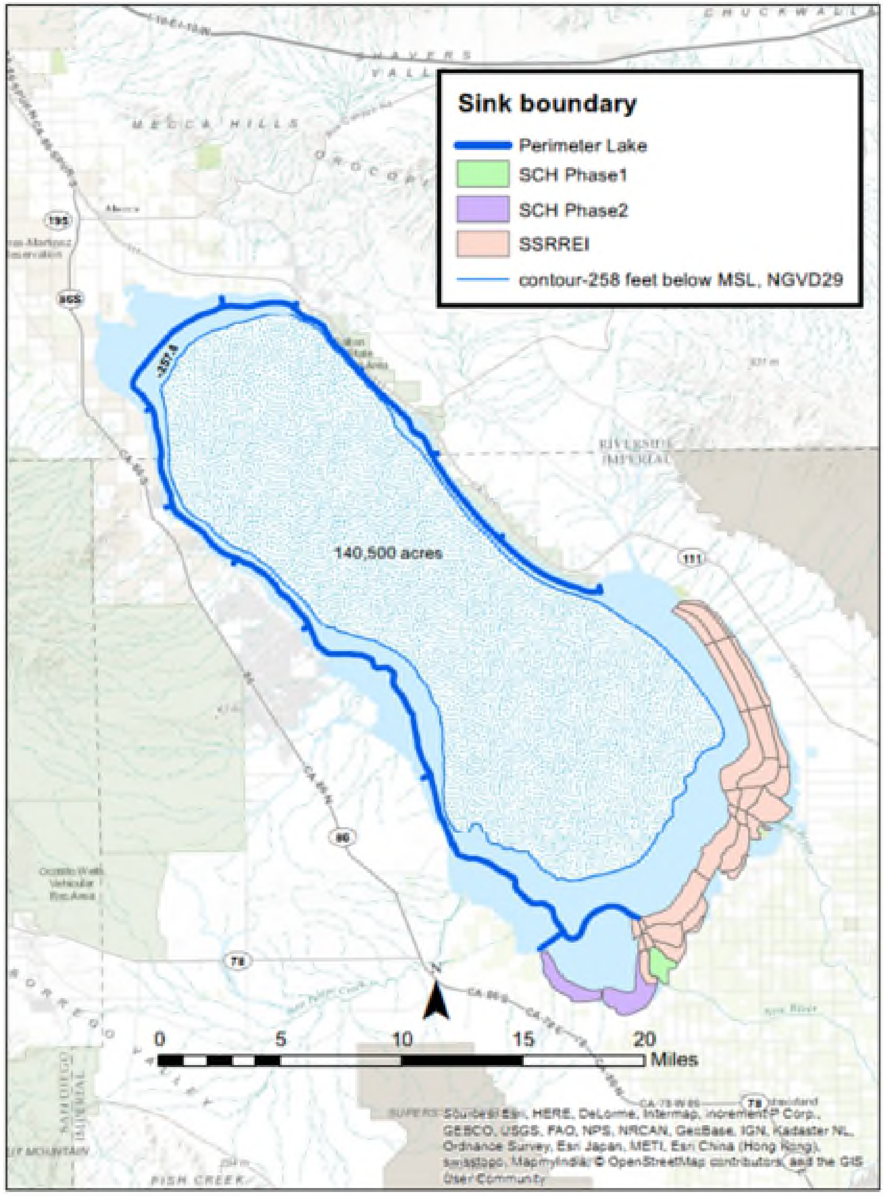

Figure 19 Sink Area Estimate Assuming Steady State Approach

3.3.3 Dynamic Estimate Allowing Hydrology to Vary Annually Using SSAM Model

For comparison to the steady state flow requirements, the 2020-2100 average hydrology used by IID is 873,500 for the baseline scenario and 705,200 for the uncertainty scenario. Using the inflow time series, allowing for variation in salinity, exposed playa, and depth, and also taking out 167,000 AFY for the Perimeter Lake concept from 2030 onwards results in an average remaining inflow of 727,000 and 559,000 AFY for the baseline and inflow scenarios (averaged over 2020-2100).

Assuming these inflow time series, the steady state area of the residual saline pool is 144,000 acres for the baseline hydrology and 130,000 acres for the uncertainty hydrology. Given the uncertainties in evaporation estimates at very high salinity, the SSAM estimates are similar to the steady state estimates.

3.3.4 Area Summary

A summary of the future estimated areas within the Salton Sea footprint can be found in Table 6. Features include the center residual saline pool and expected salt crust area that could be expected to form around it, the Perimeter Lake and its beach area between -230 ft and -235 ft NGVD, habitat areas within the Salton Sea Restoration and Renewable Energy (SSRREI) planning area, and the Species Conservation Habitat (SCH) area at full build out.

Table 6 Approximate Areas of Planned Features Within the Salton Sea Footprint.

Feature	Area (acres)
Est. Saline Pool with Surrounding Salt Crust Area	140,000
Perimeter Lake	23,000
Approximate Perimeter Beach Areas	4,000
SSRREI Habitat Area (Est.)	15,000
SCH Full Build-Out	3,000
Subtotal	185,000
Lake Bed Area Below -230 ft NGVD	230,000
Area of Exposed Playa for Dust Concerns	45,000

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4.0 Water Quality Improvement in Inflow Waters using Treatment Wetlands

A set of constructed wetlands may be developed to improve the water quality—particularly nutrients and suspended sediments—of the New and Alamo Rivers before they flow into the Perimeter Lake. The estimated area requirements are based on results from the two pilot wetlands at Brawley and Imperial, assuming similar design elements. To meet water quality targets of 2 – 3 mg/l total nitrogen and 0.1- 0.25 mg/l total phosphorus would require wetland surface areas from 590-1,150 acres under low infiltration conditions, and 470-610 acres under mean infiltration conditions.

Constructed wetlands, where the primary goal is to remove pollutants, have been used widely in North America for treatment of municipal, agricultural and industrial wastewaters (Tetra Tech, 2006). These wetlands function as natural biological reactors that can remove pollutants through settling, biological reactions that transform them into volatile or bioavailable forms or through uptake by the algae or plants.

The New and Alamo Rivers, which together provide about 80% of the flow into the Salton Sea, are polluted by nutrients, pesticides, coliforms and high suspended-sediments. Constructed wetlands have been under consideration for several years to reduce pollutant concentrations from the inflow from New and Alamo Rivers (Tetra Tech, 2007). Two pilot wetlands, the Brawley and Imperial wetlands, have been constructed and monitored for several years to provide insight on functions of these wetlands.

It is envisioned that the inflow to the proposed Perimeter Lake needs to meet some water quality criteria, not fully defined at this stage, so that it would not deteriorate water quality of the lake. Constructed wetlands may be used to treat these inflows prior to entering the Sea. Although wetlands are promising for the removal of many of the pollutants present in the Salton Sea inflows, especially because they are passive and do not use energy, a possible challenge to their acceptance is the presence of selenium in the inflow waters. Selenium has the potential to bioaccumulate in the wetlands creating elevated concentrations in biota. Ongoing work is evaluating the selenium risk more fully in the two pilot wetlands, and their final use would depend on the outcome of these studies.

Recognizing that the selenium concerns are not fully resolved at this point, treatment wetlands are not proposed as a final recommendation in this analysis. However, to provide an understanding of the potential role of wetlands in the Salton Sea management framework, this chapter presents an evaluation of the areal requirements of these treatment wetlands to meet a range of potential water quality targets.

4.1 Treatment Wetland Model

The design basis of treatment wetlands follows the approach developed by Kadlec and Knight (1996), where the removal of pollutants through wetlands can be modeled using a removal constant k, and can be described using the following formula:

$$\frac{C-C_a}{C_i-C_a} = \left(\frac{q_0}{q_i}\right)^{-\left(1+\frac{k+I}{q_o-q_i}\right)} \quad (1)$$

If $q_o = q_i$, (1) can be replaced by:

$$\frac{C-C_a}{C_i-C_a} = \exp\left(-\frac{k+I}{q_i}\right) \quad (2)$$

Where:

$$C_a = \frac{KC^*+PC_p}{q_o-q_i+I+k} \quad (3)$$

Where:
C = outlet concentration, mg/l
C_i = inlet concentration, mg/l
C_a = plateau concentration, mg/l
C* = background concentration, mg/l
Cp = rainfall concentration, mg/l
I = infiltration rate, m/yr
K = rate constant for pollutant removal, m/yr
P = rainfall, m/yr
q_i = inlet hydraulic loading rate, m/yr
q_o = outlet hydraulic loading rate, m/yr

Based on the water balance:

$$q_o - q_i = P - ET - I \quad (4)$$

4.2 Hydraulic Aspects of the Constructed Wetlands

Hydrology is the most important design variable for constructed wetlands. Without appropriate hydrologic conditions, it is difficult to maintain the chemical and biological conditions necessary for a properly functioning wetland and removal of pollutants. Hydrologic conditions can directly modify or change physical and chemical properties, such as soil salinity, pH, sediment properties, substrate anoxia, and nutrient availability in the wetlands.

Evapotranspiration and infiltration are two potential mechanisms for losses of water from the wetlands, and additions occur from infrequent rainfall in the region. Evapotranspiration estimates are available for stations throughout the California from California Irrigation Management Information System (CIMIS), operated by the Department of Water Resources. Infiltration is a significant component of water balance for treatment wetlands. Infiltration is a function of soil drainage characteristics of the system.

Another factor that influences wetland performance is the hydraulic loading rate. The hydraulic loading rate influences the residence time in a wetland and thus has an impact on how efficiently chemical constituents are removed from the water. Low hydraulic loading rates result in longer residence times that can allow for larger reductions in constituent concentrations than would be achieved at higher hydraulic loading rates.

The conceptual area estimation of the constructed wetlands would follow the same hydraulic characteristics such as infiltration rate, hydraulic loading rate, and hydraulic residence time of the two pilot wetlands.

Similar to the pilot wetlands, the constructed wetlands are proposed to contain sedimentation basins and wetland cells, and these components would possess similar hydraulic loading rates and soil conditions. The assumption is that with these similarities, the pollutant removal rates in the proposed wetlands would be in the same range as observed in the pilot wetlands. A summary of the key wetland properties and pollutant removal rates is shown in Table 7. The conceptual design of the constructed wetlands considered a range of soil infiltration rates observed in the pilot wetlands.

The hydraulic residence time of the sedimentation basin can be calculated as:

$$HRT = d/q_o \qquad (5)$$

where d is sedimentation or wetland depth.

With a desired HRT, the desired q_o can be calculated from the above formula. Based on equation (4)

$$q_o = q_i + P - ET - I \qquad (6)$$

Inflow loading rate q_i can be calculated based on the above formula. The precipitation (P) and evaporation (ET) can be derived from CIMIS.

The desired surface area can be calculated using the following formula:

$$qi = Q/A \qquad (7)$$

where Q is the design flow.

Table 7 Key Properties of Two Pilot Wetlands (Imperial and Brawley Wetlands).

Wetland	Imperial Wetland	Brawley Wetland
Sedimentation infiltration rate, cm/d	Min: 4.4 Max: 12.9 Mean: 7.3	Min: 1.2 Max: 10.4 Mean: 4.7
Wetland infiltration rate, cm/d	Min: 3.4 Max: 12.4 Mean: 6.4	Min: 0 Max: 9.2 Mean: 3.8
Sedimentation hydraulic residence time (HRT), days	Min: 3.5 Max: 10.6 Mean: 5.5	Min: 3.1 Max: 11.7 Mean: 6.0
Wetland hydraulic residence time (HRT), days	Min: 2.6 Max: 9.3 Mean: 4.4	Min: 5.3 Max: 20.6 Mean: 10.2
Total HRT, days	Min; 6.1 Max: 19.9 Mean: 9.9	Min: 8.4 Max: 29.3 Mean: 16.2
Hydraulic Loading Rate (HLR), cm/d sedimentation basin	34.0-53.7	32.3-43.5
HLR wetland, cm/d	23.4-36.9	9.7-12.3
HLR total, cm/d	7.3-9.3	12.9-20.2
N removal constant (k), m/yr	49.6	56
P removal constant (k), m/yr	46.4	18.5
Se removal constant (k), m/yr	29	4.4
TSS removal constant (k), m/yr	65.1	40.5
TSS sedimentation basin removal constant (k), m/yr	415	251

4.3 Removal of Total Suspended Solids

Removal of total suspended solids is achieved through the following: 1) settling from the sedimentation basin; and 2) settling and infiltration in the wetland cells. Previous studies in the pilot wetlands have shown that most of the removal of total suspended soils takes place in the sedimentation basin (Tetra Tech, 2006). At the Brawley wetland there are further reductions in load and concentration in the downgradient wetland cells as well. At Imperial, nearly all of the removal takes place in the sedimentation basins. Sediment removal rates of Brawley and Imperial wetlands were also compared to other free water surface wetlands in the U.S. Imperial generally performs better than most wetlands given the loading rate. The Brawley Wetland performs within the range of the other wetlands.

For the Imperial wetland, the overall removal rate constant was 222 m/yr, with a rate constant of 414 m/yr for the sedimentation alone and a rate of 65 m/yr for the wetland cells alone. For the proposed constructed wetlands, given the same hydraulic conditions, we assume removal rates as in the Imperial wetland. Using the TSS concentrations from the Alamo River for the period of 2003-2014, TSS concentrations from outlet of the sedimentation basins are about 15% of the inlet concentrations (19.2 mg/l; Figure 20). For the subsequent wetland cells, outlet TSS concentrations are generally between 5-10 mg/l, averaged at 5.6 mg/l.

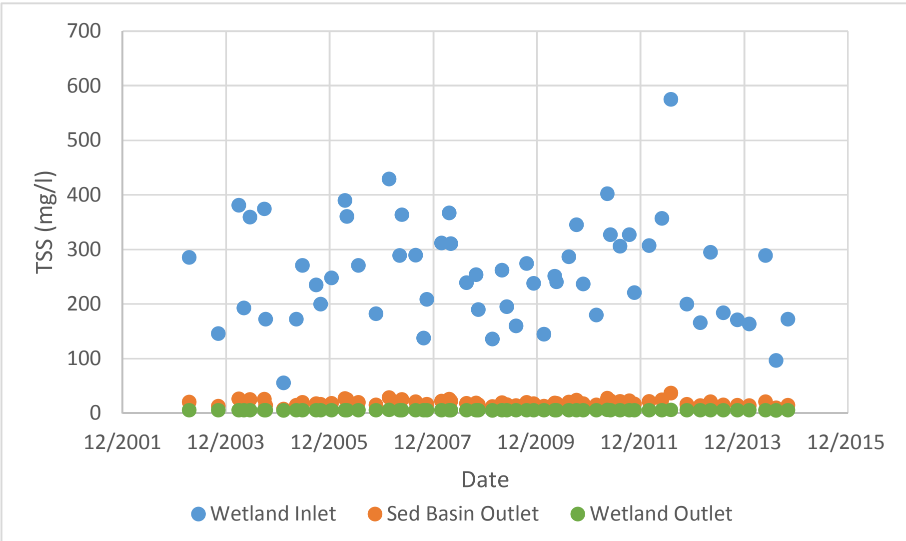

Figure 20 TSS Concentrations for Design Wetlands of the Alamo River

4.4 Removal of Nutrients

Uptake of nutrients, specifically nitrogen and phosphorus, is one of the most important functions of constructed wetlands. A variety of processes influence nutrient cycling and removal in wetlands. Processes that can play an important role in nitrogen cycling in wetlands include nitrification, denitrification, mineralization, immobilization, assimilation, N fixation, volatilization, and adsorption. Nitrogen compounds of several types are important in wetlands and receiving waters.

In the Brawley wetland, inlet concentrations ranged from around 5 mg/l to 10 mg/l. Concentrations were typically highest in mid-winter and lowest in late summer and early fall. In the Imperial wetland, inlet concentrations ranged from about 3 mg/l to near 13 mg/l. The average concentration was 6.7 mg/l and values were typically highest in mid-winter or early spring, slightly later than in the waters entering the Brawley wetland. The calculated total nitrogen removal rate constants were 56.3 m/yr for Brawley and 50.2 m/yr for Imperial.

Fewer processes are involved in phosphorus cycling. Phosphorus interacts strongly with wetland soils and biota, which provide short term and sustainable long-term storage of this nutrient. Soil sorption may provide initial removal, but this partly reversible storage eventually becomes saturated. Uptake by biota, including bacteria, algae, as well as macrophytes, forms an initial removal mechanism. Cycling through growth, death, and decomposition returns most of the biotic uptake, but an important residual contributes to long-term accretion in newly formed sediments and soils.

At Brawley, concentrations ranged from 0.8 mg/l to just over 2 mg/l, with a mean value of 1.4 mg/l. At Imperial, concentrations ranged from 0.25 mg/l to 7.5 mg/l and averaged 1.33 mg/l. The calculated removal rate constants were 17.8 m/yr for Brawley and 45.9 m/yr for Imperial. A background concentration value of C* = 0.02 mg/l was used for phosphorus rate constant determination.

TN concentrations in the inlet to design wetland range from 6-18 mg/l (Figure 21). With a removal rate of 50.2 m/yr (from Imperial wetland), resulting TN concentrations in the outlet are from 2-8 mg/l, with a mean of 7mg/l. The concentrations in the outlet are around 60% of the inlet concentrations.

TP concentrations in the inlet to design wetland generally range from 0.5-1.5 mg/l (mean of 0.91 mg/l; Figure 22). With a removal rate of 45.9 m/yr (from Imperial wetland), TP concentrations in the outlet are 0.1-0.7 mg/l, with a mean of 0.51 mg/l. The resulting concentrations in the outlet are about 57% of the inlet concentrations.

With the wetland area based on TSS concentration requirements, the remaining TN and TP concentrations are still high. A larger surface area is required if to further reduce the TN/TP concentrations.

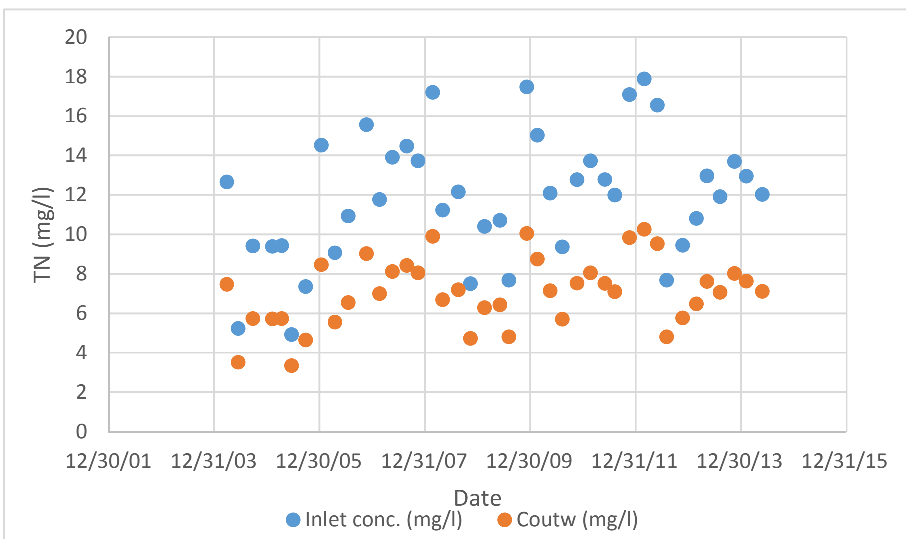

Figure 21 Total Nitrogen Concentrations for Design Wetland of the Alamo River

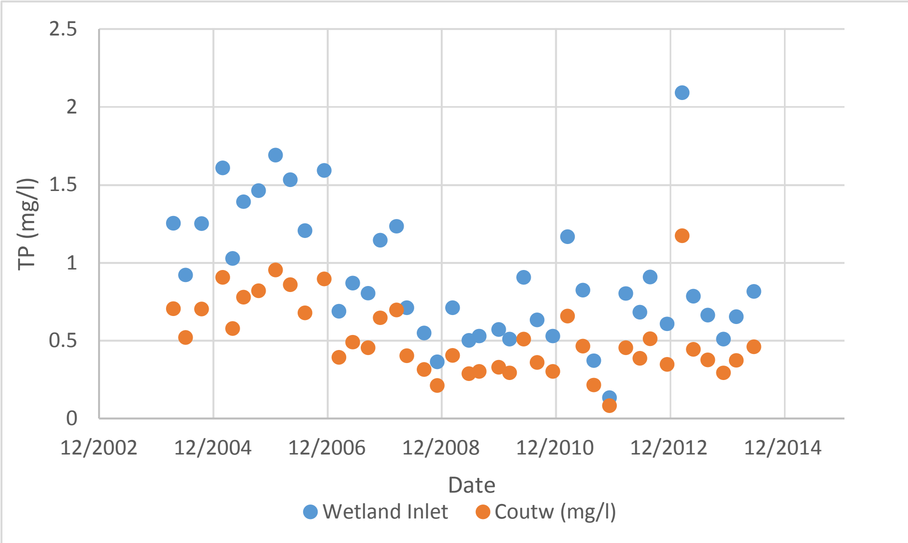

Figure 22 Total phosphorus concentrations for design wetland of the Alamo River

4.5 Scenarios

Due to the uncertainty in infiltration rates among wetlands, wetland performance, and water quality end-points, different scenarios were considered for evaluation. This included a range of infiltration rates, removal rate constants, water quality targets, and consideration of an increase in temperature and corresponding evapotranspiration. The effect of inflows is shown in Table 8, with the goal of attaining a specified hydraulic residence time (10 days, similar to what was observed in the Imperial Wetland). The required sedimentation basin areas are 132 – 141 acres for the mean and low infiltration cases (Table 8). Required wetland areas are 158 – 188 acres. Resulting mean concentrations in outflow are 5.6 mg/l for TSS, 7 mg/l for TN, 0.5 mg/l for TP, and 4.2-4.4 μg/l in total dissolved selenium.

With the above wetland area estimate, although a large portion of the TN and TP concentrations may be reduced through the wetlands, the remaining TN and TP concentrations are still high. A larger surface area is required to further reduce the TN/TP concentrations. The scenarios in Table 9 consider the following water quality targets: 1) TN targets of 2, 2.5 and 3 mg/l; 2) TP targets of 0.1 mg/l, 0.15 mg/l, 0.20 mg/l, and 0.25 mg/l. The required wetland area to meet a TN target of 2 mg/l is 675 acres under low infiltration (Table 8). The required wetland area to meet a TP target of 0.1 mg/l is 770 acres. A similar set of numbers was developed based on the Brawley Wetland characteristics.

The study also considered a potential future temperature increase of 2°C. With a temperature increase of 2^{o}C, the change in ET is calculated using the CIMIS ET approach. Although temperature increase changed ET by 3%, the changes in outlet concentrations are negligible and are not shown here.

Table 8 Concentrations in Outflow under Low and Mean Infiltration Scenarios for Imperial and Brawley Wetland Scenarios for a Hydraulic Resident Time of 10 Days

	Imperial Wetland (low Infiltration)	Imperial Wetland (mean Infiltration)	Brawley Wetland (low infiltration)	Brawley Wetland (mean infiltration)
Infiltration rate (cm/d)	4.4 sedimentation basin 3.4 wetland	7.3 sedimentation basin 6.4 wetland	4.4 sedimentation basin 3.4 wetland	7.3 sedimentation basin 6.4 wetland
Sedimentation area (acres)	141.1	131.8	158.8	147.2
Sedimentation depth (ft)	6.6	6.6	6.29	6.29
Wetland Area (acres)	188.0	158.0	435.4	320.5
Wetland depth (ft)	3.4	3.4	2.6	2.6
TSS in outflow (mg/l)	5.56 (mean)	5.59 (mean)	8.35 (mean)	3.87 (mean)
TN in outflow (mg/l)	7.05	6.86	3.58	3.87
TP in outflow (mg/l)	0.51	0.49	0.45	0.43

Table 9 Required Wetland Areas for Different Nutrient and Selenium Targets

Wetland Area (acres)	Imperial (low infiltration)	Imperial (mean infiltration)	Brawley (low infiltration)	Brawley (mean infiltration)
TN target = 2 mg/l	674.5	NA	838.6	
TN target = 2.5 mg/l		567.2		511.5
TN target = 3 mg/l	585.5	466.6		
TP target = 0.1 mg/l	769.7	607.1		
TP target = 0.15 mg/l	615.5	486.9	1149.0	
TP target = 0.2 mg/l			953.4	
TP target = 0.25 mg/l				553.5

4.6 Summary

An estimate of the range of constructed wetland areas needed to treat river inflows to the Perimeter Lake was based on the quantitative knowledge developed from the pilot wetlands at Imperial and Brawley, assuming that similar wetland performance would result if the proposed wetlands had similar characteristics such as depth and hydraulic loading rates.

Because water quality targets have not been developed yet, the calculations were performed for a range of wetland characteristics and targets. TSS targets are generally easier to meet. With a target TSS concentration of 5-10 mg/l, requirements are 130-160 acres for sedimentation basins, and 160-440 acres for wetland cells. However, these result in about 40% reduction in TN and TP, which may not be enough. To meet lower water quality targets of 2-3 mg/l TN and 0.1- 0.25 mg/l TP, requirements for wetland surface areas are from 590-1150 acres under low infiltration conditions, and 470-610 acres under mean infiltration conditions.

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5.0 Conceptual Design of Overflow Spillway Structures

Although the Salton Sea is set in an arid region, it is subject to occasional floods, such that the Perimeter Lake design must account for them. For feasibility and initial planning purposes, a conceptual system of overflow structures was developed that addresses both the average annual inflow as well as the occasional flooding produced from the rare storm event. The intent of the structures is to allow the average inflow of water to circulate within the Perimeter Lake, while maintaining a desired water level, provide emergency flood relief to prevent overtopping of the levee, and still maintain sufficient freeboard for safety purposes.

The conceptual design of the overflow spillway structures for the proposed Salton Sea Perimeter Lake was developed for planning purposes of the Salton Sea Funding and Feasibility Action Plan. A schematic of the Perimeter Lake with the overflow structures is shown in Figure 23. Data and information was gathered from various sources to provide a reasonable estimate of the size and feasibility of the spillway structures needed. The intent of the structures is to allow the average inflow of water to circulate within the Perimeter Lake, while maintaining a desired water level, provide emergency flood relief to prevent overtopping of the levee, and still maintain sufficient freeboard for safety purposes.

Future inflows to the Salton Sea have been estimated to be between 689,000 and 865,000 AFY by 2077. It is expected that the agricultural flows from the Alamo River, the IID drains, and a portion of the New River would supply other projects along the southern shore, such as the Salton Sea Restoration and Renewable Energy Initiative (SSRREI), and the Species Conservation Habitat (SCH). The inflow scenario may vary, based on the amount of water that is available and the desired lake salinity. For the purpose of determining feasibility and cost, an average annual inflow of 360,000 AFY was used to model the spillway structures as a conservative value. The capacities of the structures were assumed to be conservative and an increase in the average annual flowrate would not significantly change the design of the spillways.

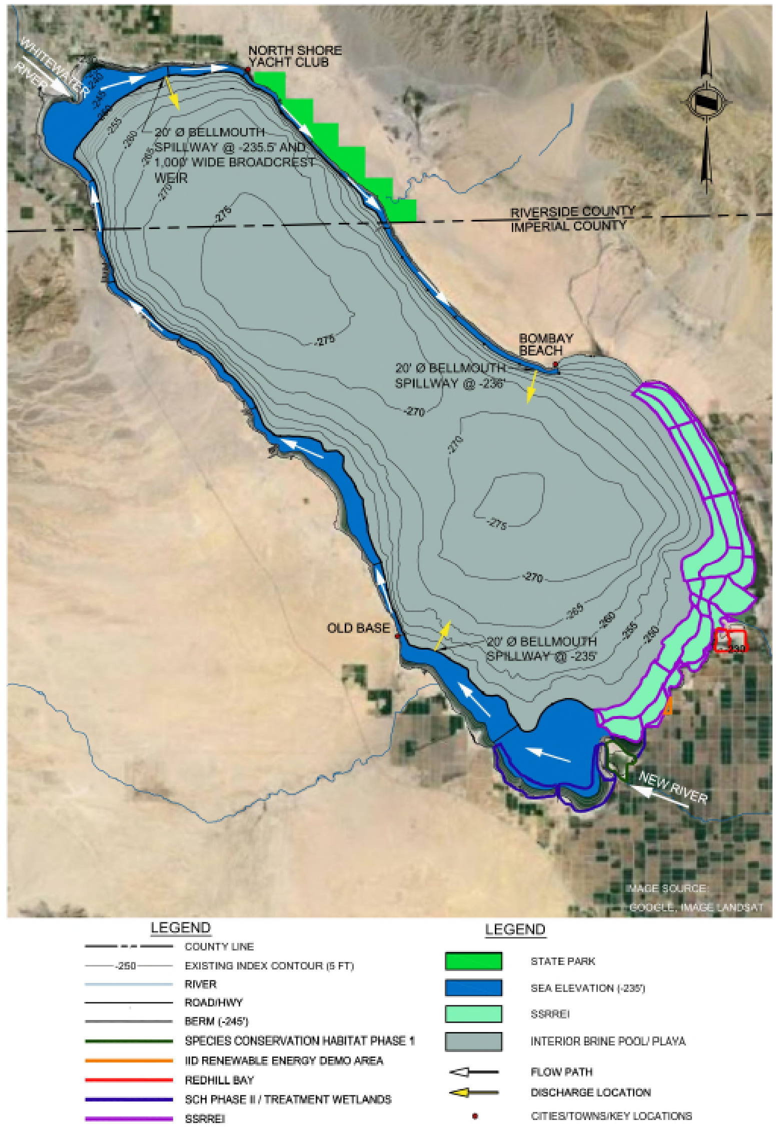

Figure 23 Flowpath and Overflow Structure Locations

The majority of the flows would come from the New River and the Whitewater River. Within the 36 square mile area of the Perimeter Lake, the average annual evaporation is estimated to be 131,000 AFY and the seepage loss through the levee is estimated to be about 36,000 AFY. The difference between the inflow and outflow yields an average balance of 193,000 AFY of water that overflows from the Perimeter Lake and replenishes the evaporation in the interior residual saline pool. This equates to an average flowrate of approximately 270 cubic ft per second (cfs) flowing from the primary source of the New River in the southwest to the primary discharge point near Bombay Beach which is located on the east shore of the lake. Locating the inflow and outflows on opposite ends of the Perimeter Lake would encourage clockwise internal circulation and exchange the water inside the Perimeter Lake up to a rate equivalent to the entire lake volume twice annually.

5.1 Perimeter Lake Assumptions

It is assumed that the steady state Salton Sea inflows can be balanced using the flow capacities of the spillway structures to achieve a desired shoreline elevation of -235 ft (NGVD 29). However, during periods of increased flow, the storage volume of the Perimeter Lake increases as water encroaches areas up the shoreline. Using AutoCAD software a digital elevation model (DEM) was created from the local bathymetry of the Salton Sea and surrounding shoreline. The Triangular Irregular Network (TIN) method was utilized with the AutoCAD software to prepare volume surfaces of the Perimeter Lake at various water level elevations. Approximately 50% of the levee volume was added to the Perimeter Lake volume, as the levee would be built from materials excavated from the lake floor. The Perimeter Lake is estimated to have a storage volume of 95,000 acre-ft with a surface at -235 ft elevation. This represents approximately 1.3% of the total storage volume of the current Salton Sea at 7.2 million acre-ft. Estimated Perimeter Lake volumes at various elevations are shown in Table 10.

Table 10 Perimeter Lake Volume

Water Elevation	Lake Volume (acre ft)
-235	95,205
-234	118,991
-233	144,340
-232	171,187
-231	199,420
-230	229,115

5.2 Regional Hydrology

The Salton Sea Transboundary Watershed lies in the Sonoran desert region in the southeastern corner of California. Highly varied mountainous and desert terrain surround the Salton Sea to the west, north and east, with low lying agricultural land to the south. Tributary areas include portions of San Bernardino, Riverside, San Diego, and Imperial Counties as well as a portion of northern Mexico. The overall watershed region ranges from over 11,000 ft in elevation to below sea level and is subject to varied storm data. The National Oceanic and Atmospheric Administration (NOAA) Atlas 14 precipitation frequency estimates the 100 year, 24 hour storm depth is 10.9 inches at the high elevation portion of the tributary and 4.21 inches at the Salton Sea. Even less rain falls at the US-Mexico border with only 3.85 inches recorded. The majority of the water flowing into the Salton Sea is supplied from the Colorado River through the All American and Coachella Canals which enter the Sea via the Alamo and New River.

The tributary watersheds can be divided into six distinct regions: the Alamo River, the New River, San Felipe Creek, Whitewater River, Salt Creek, and the Salton Sea, including the shoreline as well as groundwater flows. The tributary areas are shown on Table 11 and the watershed is illustrated in Figure 24. Hydrologic factors such as elevation, rainfall depth, soil type, and vegetation influence the rate of storm water runoff for each of the watersheds. Of the surrounding watersheds, the Whitewater River is known to convey the largest flowrate during flood events. The Federal Emergency Management Agency (FEMA) estimated the frequency discharges for the 10-, 50-, 100-, and 500- year events for the Whitewater River to be 9,000 cfs, 30,000 cfs, 47,000 cfs, and 110,000 cfs respectively. The discharges are based on a 1975 flood plain mapping and reference a hydrology study performed by the U.S Army Corps of Engineers dated 1966.

Table 11 Tributary Areas

Tributary Watershed	Area (mile^2)
Alamo River	2,435
New River	1,545
San Felipe Creek	1,933
Whitewater River	1,603
Salt Creek	550
Salton Sea	360

5.3 Purpose of Overflow Structures

Although the Salton Sea is located in an arid region of the Sonoran Desert, it has experienced historical floods when hurricanes or tropical storms enter the watershed due to its proximity to the Sea of Cortez. In 1976, hurricane Kathleen and in 1977 tropical storm Doreen each created 100 year storm events in two consecutive years. Combined with above average rainfall for seven years as well as increased agricultural runoff and increased flows from Mexico, by 1979 the Salton Sea's surface elevation had risen to -228' BMSL (NGVD 29) from an elevation of -233 ft BMSL (NGVD 29) recorded one decade previously.

While the majority of the annual runoff is supplied by the Colorado River through the Imperial Valley Agricultural Drain system, the Whitewater River watershed has the largest potential peak flowrate from seasonal precipitation flood events. For feasibility and initial planning purposes, a conceptual system of overflow structures was developed that addresses both the average annual inflow as well as the occasional flooding produced from the rare storm event. Hydraulic calculations for overflow weirs, spillway structures, and pipe flow capacities were performed using Flowmaster software.

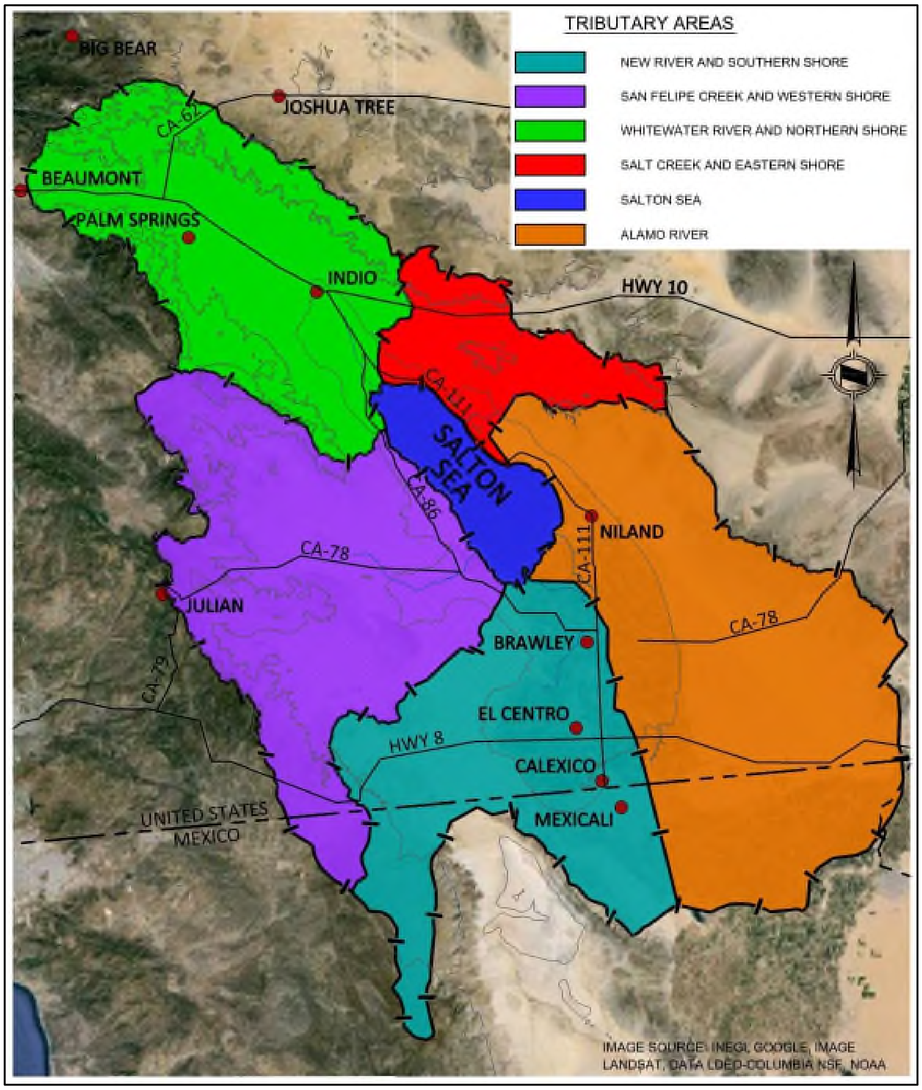

Figure 24 Tributary Areas

To convey the average annual flows, the overflow system should have a drop inlet type structure such as a bell-mouth spillway which would allow the overflow to enter the structure away from the levee, thereby preventing erosion caused by the increase in water velocity near the spillway. Three 20 ft diameter bell-mouth spillways up to one foot below the desired water level would address the average flowrate into the Perimeter Lake and maintain a lake elevation of -235 ft BMSL (NGVD 29). Overflow into the spillway structures could be conveyed under the levee in concrete box culverts. These culverts would flow into the interior of the lake and discharge away from the levee onto energy dissipation structures made of concrete and rock before sheet flowing over the playa and into the interior residual saline pool. A bell mouth spillway near the New River could be set at the desired water level of -235 to handle seasonal overflow within the southern cell. The spillway near the Northshore Yacht Club set slightly lower at -235.5 would allow a constant 70 cfs to overflow and also maintain the seasonal overflow within the northern cell. At the end of the perimeter levee system near Bombay Beach, an elevation of -236 would convey an average flow of 200 cfs into the interior residual saline pool and allow for circulation within the lake from the New River to Bombay in a clockwise fashion. Figure 23 shows the flowpath as well as the spillway structure locations.

During seasonal precipitation events and periodic flooding that originates in the mountainous portions of the Salton Sea transboundary watershed, additional structures must be able to convey larger flowrates that occur within a relatively short period of time. The storage capacity of the lake is able to increase significantly as the water levels rise along the shoreline. This condition provides the hydraulic head necessary to drive the emergency overflow structures. The 500-year flowrate from the Whitewater River was used to size an additional overflow spillway structure. The fluctuation in water level and storage capacity of the Perimeter Lake that would occur was modeled. The spreadsheet model was able to show that a flow capacity of 12% of the 500-year storm event would be sufficient in preventing the water levels from topping the levee while maintaining two ft of freeboard below the top of the levee at elevation -230 ft BMSL (NGVD 29).

Due to elevational constraints and the shallow gradients of the Salton Sea bathymetry, a structure that is capable of conveying 12% of a large storm event from a large tributary area such as the Whitewater River is only feasible by utilizing some type of spillway over the levee itself. A broad crested weir would need to be 1,000 ft wide to allow a sufficient flowrate with only two ft of hydraulic head. A reinforced concrete broad crested weir could be developed with concrete aprons to prevent scour and erosion and a downstream structure could convey the flows away from the levee before discharging onto a dissipation structure made of concrete and rock. The flows would ultimately sheet flow over the playa and into the residual saline pool. With adequate flood protection, the lake level would rise to an elevation no greater than -232 ft BMSL (NGVD 29). The storage volume that is gained from the shoreline would provide capacity for the rising flood levels and the weir structures would allow a significant flowrate to discharge. A 1,000' wide broad crested weir located close to the source of flooding at the North Shore levee at elevation -234.5 ft BMSL (NGVD) could convey 12,000 cfs with 2.5' of hydraulic head. The flood waters that are stored behind the levee would take several weeks to normalize to the desired elevation of- 235 ft BMSL (NGVD 29) due mainly to the diminishing flowrate as the lake approaches the desired elevation. Table 12 shows the flowrate capacities of the overflow structures at various elevations.

Table 12 Estimated Outfall Flowrate

Lake Elevation (ft, NGVD)	Flowrate (cfs)	Spillway Location at
-236	0	Bell-Mouth near Bombay Beach
-235.5	65	Bell-Mouth in North Shore Area
-235	270	Bell-Mouth near Old Navy Base
-234.5	650	Overflow Weir North Shore
-234	2,200	
-233.5	4,800	
-233	8,100	
-232.5	11,800	
-232	16,100	Maximum Flood Elevation
-231	25,900	
-230	37,100	Top of Levee

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6.0 Air Quality Mitigation

As the Salton Sea recedes due to declining inflows, windblown dust emissions from the exposed dry lakebed (the playa) would increase in some areas, leading potentially to violation of particulate matter standards and human health risks. According to the State Water Resources Control Board and IID's Water Conservation and Transfer Project, potential air quality impacts from exposed Salton Sea playa must be monitored and mitigated through various steps including restricted access; research and monitoring; dust control measure implementation, and purchase of emission reduction credits.

The Salton Sea Funding and Feasibility Action Plan produced an air quality and dust mitigation review (Benchmark 2). The Authority would expect to support IID, Imperial County, and State efforts mitigate dust emissions in playa areas not covered by the Perimeter Lake.

The Salton Sea's location encompasses the Salton Sea Air Basin (Basin), under the jurisdiction of two districts: Imperial County Air Pollution Control District (ICAPCD), southern Basin, and South Coast Air Quality Management District (SCAQMD), northern Basin. The Basin is subject to regulations under the Federal Clean Air Act and Clean Air Act Amendments (CAAA). In 1970 the United States Environmental Protection Agency (EPA) established National Ambient Air Quality Standards (NAAQS) for the following six "criteria" pollutants: Ozone (O_3), Particulate Matter (as PM_{10} or $PM_{2.5}$), Carbon Monoxide (CO), Nitrogen Oxides (including NO_2), Sulfur Dioxide (SO_2), and Lead (Pb). Primary standards are established to protect human health, whereas secondary standards are established to protect degradation of the environment. The US EPA classifies regions as "attainment" or "non-attainment" depending on whether ambient air quality data collected from permanent monitoring stations meet requirements stated in the primary standards. The CAAA of 1990 requires states with nonattainment areas to achieve NAAQS by developing an EPA-approved State Implementation Plan (SIP) and calls for specific emission reduction goals.

The General Conformity Rule (Section 176I(1) of the CAAA (42 USC section 7506(c))) prohibits the Federal government from "engag[ing] in, support[ing] in any way, or provid[ing] financial assistance for, licens[ing] or permit[ing] or approv[ing] any activity" that does not conform to an EPA-approved SIP. Thus any Federal agency involved in the Salton Sea management activities must not undermine SIP efforts in the area. A conformity review may be required if the Federal action would take place in a Federal non-attainment or maintenance area, and if the action would result in significant emissions of an air pollutant that is regulated due to the non-attainment or maintenance status of the region. If the emissions are expected to be significant, then it must be determined if the threshold levels would be exceeded. A conformity review is required if the threshold levels would be met or exceeded (40CFR section 93.153(b)).

States have the right to establish and enforce their own air quality standards, provided they are equal to or more stringent than the Federal standards. The California Clean Air Act (CCAA) of 1988 (California Health and Safety Code 25 section 39600 et seq.) called for similar designations of areas as attainment or non-attainment based on California standards and requires air quality plans with a range of control measures to reach attainment for ozone, carbon monoxide, nitrogen oxides (NO_x), and sulfur dioxide (SO_2). The California Air Resources Board (CARB) is the agency tasked with regulating air quality by setting standards for emissions and regulations for mobile emission sources (i.e., autos, trucks).

The pollutants of greatest concern in the Basin are the following: particulate matter (PM_{10} and $PM_{2.5}$) from wind erosion (fugitive dust), soil disturbance and fuel combustion, ozone and ozone precursors, nitrogen oxides (NO_x) and volatile organic carbons (VOCs), primarily from vehicle and equipment exhaust. Agriculture and transported pollutants from Mexico contribute to the air quality problems in the area (USGS 2013).

As the Salton Sea recedes due to declining inflows, windblown dust emissions from the exposed dry lakebed (the playa) would increase in some areas. This would lead to a potential human health risk, since a significant portion of this windblown dust is PM_{10}; particulate matter with an aerodynamic diameter of 10 micrometers or less that are small enough to be inhaled. Imperial County is designated as a serious non-attainment area for PM_{10} (i.e., the area does not attain federal or state air quality standards) and non-attainment for $PM_{2.5}$ NAAQS. Imperial Valley is designated as a state non-attainment area for ozone and PM10. As such, the potential for creating sources of PM_{10} is a public health concern (IID 2013). Part of the 2009 PM_{10} SIP revision contains requirements for an air quality assessment, an emission inventory, Best Available Control Measures (BACM) and Best Available Control Technologies (BACT), and transportation conformity budgets (CARB 2010).

As a consequence of the QSA water transfers, CEQA guidelines sections 15091 [d] and 15097 require that an agency adopt a program for reporting or monitoring mitigation measures that were adopted or made conditions of approval for a project. Such a program ensures that the mitigation measures identified in an EIR are implemented, and the mitigation, monitoring and reporting plan (MMRP) was created by IID in 2003. According to the State Water Resources Control Board (SWRCB) Order and IID's Water Conservation and Transfer Project MMRP (IID, 2003; SWRCB, 2002), potential air quality impacts from exposed Salton Sea playa must be monitored and mitigated by implementing the following four steps:

1. **Restrict public access.** Minimize disturbance of natural crusts and soil surfaces in exposed shoreline areas;
2. **Research and monitoring.** Conduct research to find effective and efficient dust control measures for the Exposed Playa, develop information to define the potential problem over time, and monitor the surrounding air quality;
3. **Emission reduction credits.** If monitoring results indicate exposed areas are emissive, create or purchase offsetting emissions reductions as part of a negotiated long-term program; and
4. **Dust control measures.** To the extent that offsets are not available, implement dust control measures (with feasible dust control measures and/or supplying water to re-wet emissive areas) on the emissive parts of the exposed playa.

The term "emissive" indicates that the land surface has a tendency to release enough dust to constitute or contribute to an air quality violation. "Non-emissive" is used to describe surfaces that do not emit sufficient dust to cause or contribute to air quality violations. All management alternatives must contain Air Quality Management actions related to this four-step process.

Access to exposed playa would be controlled in coordination with landowners and stakeholders to avoid disturbance and resulting emissions. In concert with the MMRP, a research program focusing on the development of cost effective, water efficient, and adaptive Air Quality Management has been initiated and would continue. In the long run, results of this effort would guide the Air Quality Management approaches implemented at the Salton Sea (IID 2013).

The State Water Resources Control Board (SWRCB) Order approving the water transfer (Order WRO-2002-0013) requires IID to evaluate dust control measures to determine feasibility in consultation with the Imperial County Air Pollution Control District, the South Coast Air Pollution Control District and the California Air Resources Board (IID 2013).

6.1 Dust Mitigation Program

In developing the details for Perimeter Lake concept, the Authority would work closely with IID and Imperial County as they further develop their dust mitigation strategy. The Perimeter Lake concept would add a strip of water along the perimeter of the Sea that would help with AQM. Due to the concordance with the Perimeter Lake concept and dust mitigating efforts being conducted by IID, IID's Air Quality Mitigation Program is explained in this section.

Significant data disparities exist regarding the extent and variability of Salton Sea playa emissivity (dust-emitting), future emissivity, and dust loading of PM10 in the region (Cohen 2014). However, exposed playa is expected to increase exponentially, creating a significant health risk that has yet to be fully characterized. To address this need IID is currently developing the Air Quality Mitigation Program along with Imperial County Air Pollution Control District (ICAPCD).

IID's JPA (Joint Power Authority) Dust Mitigation Plan includes an adaptive management framework to monitor ambient air quality, research and monitoring efforts to identify and map playa surface characteristics related to erosion and emission potential. Pollutants of concern include PM10, PM2.5, ozone, hydrogen sulfide, arsenic, selenium and others.

The IID Air Quality Mitigation Program contains four components that contribute toward the implementation of a science-based adaptive management plan to detect, locate, assess and mitigate PM10 emissions associated with the Water Transfer Project. Each component of the Air Quality Program would attempt to answer a set of questions or achieve a goal.

The Air Quality and Playa Characterization component seeks to differentiate the emissions sources, whether they are a direct consequence of the Water Transfer Project or not by analyzing data from an extensive ambient air quality monitoring network. In order to capture intermittent dust events, PM10 and PM2.5 would be measured with continuous monitors and verified with filter-based federal reference method monitors. The filters could initially be analyzed for contaminants (i.e. arsenic, selenium, pesticides) at regular intervals to characterize the problem of contaminated dust particle transport (IID 2013). Permanent and portable air quality stations would be used as necessary to document the spatial heterogeneity of dust emissions.

In the future, ambient air quality data would be used to assess the occurrence and magnitude of emissions from newly exposed playa and existing emission sources. This information would aid the development of a dust identification methodology to identify playa emission source areas, estimate emission characteristics and determine downwind impacts. Drawing from existing dust identification programs such as Owens Lake and forming new methodologies as necessary, the program would integrate information from research and monitoring efforts (IID 2013).

Hydrologic modeling would use the hydrologic analysis from the Water Transfer EIR/EIS and high-resolution bathymetry data to yield the estimated extent and time frame for additional playa exposure. The result would be planning level information about the location of projected playa exposure and ownership information. Research and monitoring would aid the understanding of salt crust formation, vulnerability to erosion and overall emission potential of various salt crust surfaces. The potential sources of PM10 emissions include playa salt crusts, sand sheets, beach deposits and soil surfaces. The main focus of research would be assessing the vulnerability of each potential emission source to erosion. This component also aims to identify specific areas of exposed playa that are emissive and source areas associated with erosion events. Properties to be mapped include crust type, crust thickness, soil moisture, crust relief, crust hardness, penetration resistance, surface erosion, free surface sand, percent vegetation, overflow and other features. Meteorological conditions, such as wind, precipitation, temperature and relative humidity, would be monitored and analyzed to determine environmental and climatic events that affect emission potential seasonally (IID 2013).

The Dust Control Measure (DCM) Research and Monitoring component would test and evaluate DCMs for feasibility and cost-effectiveness. Existing DCMs would be derived from a literature review, modeling studies and screening-level tests. Novel and untested measures would be incorporated into the DCM research via pilot field testing. The performance of DCMs would be monitored at the pilot project scale for overall performance and sensitive parameters such as habitat quality. DCM selection would be guided by the following principles:

1. Effective dust control is achieved by a combination of:
    a. Physical stabilization of the playa surface
    b. Reduction in wind velocity at the playa surface
    c. Enhanced net-sand capture rates
2. DCMs should enable constant dust control
3. Dust control should be based on achieving target level of emission control on a preventative, macro scale (not reactive, micro scale)
4. Water-based DCMs are effective, but are generally inefficient from a cost, water supply and water-use standpoint
5. DCMs that are designed to interrupt fetch and saltation protect downwind surfaces and capture sand.

6. DCMs with salt- and drought- tolerant vegetation can be challenging to establish and sustain, but are more water efficient and provide effective dust control.

Potential DCMs in Imperial County are discussed below and include surface stabilizers, vegetated swales, plant community enhancement, moat and row, water-efficient vegetation, tillage, alternative land use, species conservation habitat and other habitat-based uses (IID 2013).

Surface stabilizers are commonly used to suppress dust on disturbed lands including unpaved roads and construction sites. They are usually applied topically and can consist of water, salts and brines, organic non-petroleum products, synthetic polymers, organic petroleum products, or mulch and fiber mixtures. Surface stabilizers change the physical properties of the soil surface to reduce dust by forming crusts or protective surfaces on the soil, causing particles to agglomerate, or attracting moisture to the soil particles. Surface stabilizer efficacy varies with the stabilizer type, environmental conditions, soil type, weather, application rate, and application frequency.

Habitat swales are earthen channels with vegetation constructed by raising pairs of parallel berms, with adjacent pairs of berms. Habitat swales interrupt wind fetch (the distance that wind has traveled over an unobstructed area) on the playa, which reduces wind velocity at the soil surface and suppresses sand flux and dust emissions in downwind areas. Vegetated swales capture sand beneath the plant community's canopy. Regional dust suppression results due to periodic surface wetting, natural crusting, reduced sand motion, and reduced surface wind velocities due to sheltering of areas downwind of the swales.

With habitat swales, existing vegetation can be leveraged as the sea recedes to enhance dust suppression. Plant communities would follow successional patterns as the shoreline is exposed. Favorable growing conditions would exist where freshwater inflows create fresher, shallow groundwater and/or leach salts from newly exposed playa. Sedges, rushes, and similar wetland vegetation would likely appear near the wet shoreline; grasses and other herbaceous species near the middle of the landscape; and shrub species in drier areas near and above the historic shoreline. These plant communities can achieve plant cover densities that postpone or eliminate the need for more resource-intensive DCMs.

Moat and row consists of an array of earthen berms (rows) flanked on either side by ditches (moats). Moats capture moving soil particles and the rows physically shelter the downwind playa by lifting wind velocity profiles above the soil surface. Moats and rows are designed to run perpendicular to primary wind vectors. The efficacy of this DCM can be enhanced by reducing the distance between rows, increasing the height of the rows, vegetating rows, or using gravel, sand fences, etc. to enhance sand capture.

Water-efficient vegetation stabilizes and suppresses soil and sand movement beneath the canopy of salt- and drought tolerant species on playa surfaces. Similar to a habitat swale, vegetation is seeded or planted on raised beds spaced 5-15 ft apart. Findings from the literature indicate the most desirable species for dust control are salt- and drought-tolerant, may be rhizomatous (growth by the spread of underground roots and shoots), and must provide adequate cover even during dormant periods.

Native shrubs such as salt bushes (Atriplex spp.) and seepweed (Sueada moquinii) may be used alone or in combination with the common Saltgrass (Distichlis spicata). A mix of native species would provide the needed diversity to maintain adequate cover levels, reduce water demand, and suppress invasive species. Research is necessary to assess the dust control and economic efficiency of different levels of infrastructure, vegetation density, and vegetation uniformity.

Tillage involves roughening the land surface, which creates furrows that capture sand and lifts the boundary layer of moving air further above the land surface, thereby reducing erosion. Tillage may need to be repeated periodically to reverse land smoothing by erosion, sedimentation, and settling.

Tillage can be optimized to minimize turning and avoid traffic on untilled areas by tilling in blocks or strips. Tillage has some significant cost and operational advantages over other dust control approaches. Relative to other DCMs, it can be designed and installed at a fairly low cost with common implements used in agricultural production. However tillage needs to be conducted in a way that minimizes dust production. Tillage configurations are currently being evaluated for dust control at Owens Lake, and the results would be useful for implementation at the Salton Sea.

Alternative land use practices can cover exposed playa and eliminate or significantly mitigate the potential for emissions. Some relevant land use practices include the following:

- **Agricultural land.** Portions of exposed playa may be reclaimed for more conventional agricultural activities, including graminoid forage crops typically grown in the Imperial Valley, or aquaculture crops, such as algae. These crops may be harvested for protein (food) or used as biomass for energy conversion.

- Constraints on expanding agriculture onto exposed playa include irrigation infrastructure, irrigation water availability, and agricultural markets. Soil types are a major consideration: non-hydric and moderately to well drained soils found west of the New River delta are suitable for farming and less suitable soil types can be used for aquaculture farming (i.e. algae and other aquatic vegetation). IID is evaluating areas around the Sea for potential agricultural activity.
- IID is also evaluating several halophytic plants that might be suitable for crop use in playa areas with high salt content soils.

- **Energy Generation Projects.** Energy generation projects including geothermal and solar may also be located on exposed playa and could also, with prior planning and design modification, be co-located with habitat projects.
  - **Geothermal:** The Refined Conceptual Modeling and a New Resource Estimate for the Salton Sea Geothermal Field, Imperial Valley, California (Hulen, et. al. 2002 as cited in IID 2013) estimated a more extensive geothermal resource at the Salton Sea than previously thought. The "Salton Sea Shallow Thermal Anomaly" is mapped from east of the New River delta, through the Alamo River delta area and the Morton Bay/Mullet Island area and along the east side of the Salton Sea to the Imperial Wildlife Area-Wister Unit. The potential geothermal area extends out into the Sea up to three miles in some areas.
  - **Solar:** Two types of solar energy recovery are being considered for installation on exposed playa: photovoltaic panel technology and solar gradient ponds.
    - **Photovoltaic panel** technology is a relatively well proven technology, but it has not been tested in the extreme environment of the sea playa.
    - **Solar gradient ponds** extract energy by using solar rays to heat the lower water layer in a stratified impoundment. This technology has been moderately successful in other areas, but it has not been tested in the Imperial Valley.

Biological habitat can also cover exposed playa and eliminate or significantly mitigate the potential for emissions. Many habitat projects are proposed in the Salton Sea area in an effort to sustain the fish and wildlife currently dependent on the Sea. Some of these projects would extend onto areas of the playa that would otherwise be exposed. These projects include, but are not limited to, the following:

- The Species Conservation Habitat Project would be located at the southern end of the Sea and would create up to 3,770 acres of relatively shallow water habitat. Ponds to support fish and wildlife species would be constructed and operated by the CA Department of Fish and Wildlife and supplied with a combination of New River (brackish) and Sea (saline) water, blended to maintain a salinity range of 20-40 ppt.
- The US Fish and Wildlife Service has proposed developing approximately 700 acres of wading and shore bird habitat in Red Hill Bay in an effort to maintain wetland habitat values on this part of the National Wildlife Refuge.
- The Wister Unit of the Imperial Wildlife Area or the Sonny Bono Salton Sea National Wildlife Refuge Complex may expand the current habitat onto exposed playa (IID 2013).

The Dust Prevention and Mitigation component would answer the question: how can dust emissions including from off-highway vehicle (OHV) use be prevented or mitigated? Off-highway vehicles cause considerable surface disturbance and erodibility. An adaptive management framework would be in place to prevent dust emissions from OHVs. Dust mitigation strategies include creating or purchasing off-setting emission reduction credits, similar to a cap-and-trade program and direct emissions reductions at the Sea. IID would negotiate with the local air pollution control districts to create a long-term program that would enable the creation or purchase of off-setting PM10 emission reduction credits (IID 2013).

Plan Implementation would occur throughout the duration of the Water Transfer Project. In fact, ambient air quality and DCM pilot projects have already begun. IID would coordinate with regulatory agencies and provide periodic updates on the implementation of the Air Quality Program. As of 3013, IID has installed six ambient air quality stations in 2009, playa exposure modeling, playa shoreline monitoring, playa surface characterization, and playa emission characteristics have been underway. Pilot projects including a surface stabilizer product evaluation, shallow flooding at the New River and plant community enhancement at the New River have been completed. In addition, a vegetation swale pilot project is being planned (IID 2013). Remote sensing and advanced satellite-based radar techniques have been employed to characterize active OHV traffic areas on the playa.

6.2 New AQM Dust Control Plan

IID is working on an updated dust mitigation strategy for controlling PM10 emissions from exposed Salton Sea playa. A draft of this new plan is cited below.

Imperial County Regulation VIII

Current Regulation VIII was adopted on October 10, 1994, and it was revised on November 25, 1996, to comply with RACM (Reasonably Available Control Measures) to control fugitive dust emissions. On November 11, 2005, this regulation was revised again to include BACM (Best Air Control Measure) and was further divided in a series of seven individual rules. Regulation VIII contains BACM as required by the Clean Air Act for "serious" PM_{10} non-attainment areas. Regulation VIII requires BACM for source categories such as the following: construction activities, disturbed open areas, paved roads, and agricultural operations. Regulation VIII allows operators to determine the control techniques sufficient to limit visible dust emissions to 20 percent opacity and, if applicable to that source, to implement requirements for a stabilized surface. Dust control plans and recordkeeping are also required under the Regulation's provisions. Regulation VIII also includes test methods and standards.

Regulation VIII is divided into seven rules. Three of the rules—800, 804, and 806—are relevant to the SS AQ Program. A fourth rule, specific to Salton Sea playa, is currently under development. Each is described in more detail in the draft report.

DUST CONTROL STRATEGY

All exposed playa is subject to the ICAPCD Fugitive Dust Rules discussed above. Specifically, exposed playa is currently subject to Rule 804, Open Areas. As stated in Rule 804, if VDE (Visible Dust Emissions) exceeds 20 percent opacity or if stabilized surface conditions are not met (pursuant to Rule 800 specifications), then BACM (Best Available Control Measure) must be implemented. BACM for open areas includes the following: (1) applying water or chemical dust suppressants to all unvegetated areas, (2) establishing vegetation on previously disturbed areas, and (3) paving, applying and maintaining gravel, or applying and maintaining chemical dust suppressants. Rule 804 does not specify the timing for the VDE determination, nor does it specify the timing for BACM implementation.

IID and ICAPCD recognize the limitations associated with Rule 804, including the limited set of BACM dust control measures (DCMs) provided in the Rule as well as the procedures (including timing) for assessing emissions, implementing BACM, and evaluating DCM performance. ICAPCD and IID would work together to jointly develop a new rule specific to Salton Sea Playa. The new Rule, described below, is intended to refine and clarify the requirements and procedures in Rule 804, and to add flexibility in implementing new DCMs on future exposed Salton Sea playa.

DEVELOPMENT OF NEW RULE SPECIFIC TO SALTON SEA PLAYA

ICAPCD and IID would begin work immediately to draft a new rule specific to Salton Sea playa. The rule would contain provisions for approving new BACM for use on Salton Sea playa, including new BACM performance measures (i.e., determining if the surface is adequately stabilized). The new rule would also include updated methods for determining whether PM10 emissions from individual source areas are acceptable or unacceptable, and provisions for some form of rapid, proactive DCMs to be implemented as the shoreline recedes. The following sections outline these concepts in more detail.

CONCEPTUAL PROACTIVE DUST CONTROL STRATEGY

The goal of proactive dust control is to prevent exposed Salton Sea playa from becoming a significant source of PM10 emissions. The proactive dust control strategy would be collaboratively developed with ICAPCD and include broad-scale implementation of DCMs that are protective of air quality, but also flexible given the unknowns regarding temporal exposure and the magnitude of future emissions. As playa is exposed, the surface characteristics and emission potential would be rigorously evaluated. Results from these evaluations would be used to establish criteria to identify and prioritize areas of exposed playa that have high emission potential. Proactive dust control implementation would be prioritized and implemented on sites that meet these criteria. Site-specific playa surface characteristics and emissions monitoring data would be used to tailor dust control design and implementation. Each site would be monitored after dust control implementation to confirm that adequate surface stabilization is maintained. If the initial proactive dust control implementation on the site does not achieve a stabilized surface or if visible emissions occur, dust control would be further enhanced. This approach allows resources to be allocated efficiently and effectively, and in an expeditious manner to prevent significant sources of PM_{10}.

The success of a proactive dust control strategy requires the development and testing of BACM that can be quickly implemented, adequately maintain a stabilized surface, and prevent the spread of emissive source areas as playa is exposed. Several DCMs have been field-tested and proven to be effective on playas, while other measures need additional research prior to use at the

Salton Sea. Examples of proactive DCMs that could be used at the Sea include surface stabilizers, soil roughening, water-efficient vegetation, vegetated swales, vegetation beach ridge enhancement, and roughness elements, such as straw bales. Some of these measures require further pilot field testing to understand their effectiveness on Salton Sea playa. Pilot Testing for New BACM is described below.

PILOT-TESTING FOR NEW BACM

The dust control strategy includes the development and testing of new BACM that are specifically tailored to accomplish the following: work efficiently in the climate and soil conditions on and around the Salton Sea playa, and make efficient use of available resources. Some DCMs have been field-tested and proven to be effective, and some DCMs need additional research prior to use at the Sea. For the more novel and untested approaches, pilot field testing (pilot projects) would occur. The purpose of the pilot projects would be to perform field tests to support ICAPCD approval of various DCMs as BACM in the Revised Imperial Valley PM10 SIP.

As part of the SS AQ Program, IID is working cooperatively with ICAPCD on several DCM pilot projects. A surface stabilizer pilot project was completed in 2011. Pilot projects for soil roughening, vegetated swales, and plant community enhancement are currently being planned, and they are anticipated to be implemented in the fall/winter 2015. Pilot project sites have been selected to represent the range of future playa surface and emission characteristics. Potential sites also were screened according to factors influencing their suitability, including, but not limited to the following: size, land ownership, permitting challenges, compatibility with anticipated operations, and potential future land uses.

Pilot projects would allow IID and ICAPCD to gain experience and understanding of novel, locally-adapted methods of dust control and the site-specific factors that could affect their feasibility and cost. Pilot projects also are useful for determining the effectiveness of dust control and refining design criteria for full-scale implementation. This helps develop efficient approaches for the design, construction, and operation of DCMs on the playa.

6.3 Irrigation System for Emissive Areas

The Perimeter Lake could be used as a water source to support air quality management through regularly spaced outlets in levees that would enhance AQM. The outlets would provide an irrigation source for irrigating playa areas that become emissive as shown in Figure 25. A swale at the downslope toe of the levee would allow water to be distributed laterally for irrigation. A PVC pipe would take water in from the Perimeter Lake side and release it on the

Sea Side with a gate valve and a pop-up emitter in a 10 ft wide outlet. Irrigation of emissive playa could also be accomplished from the Perimeter Lake using a mobile solar pump and syphon system from the roadway along the top of the levee.

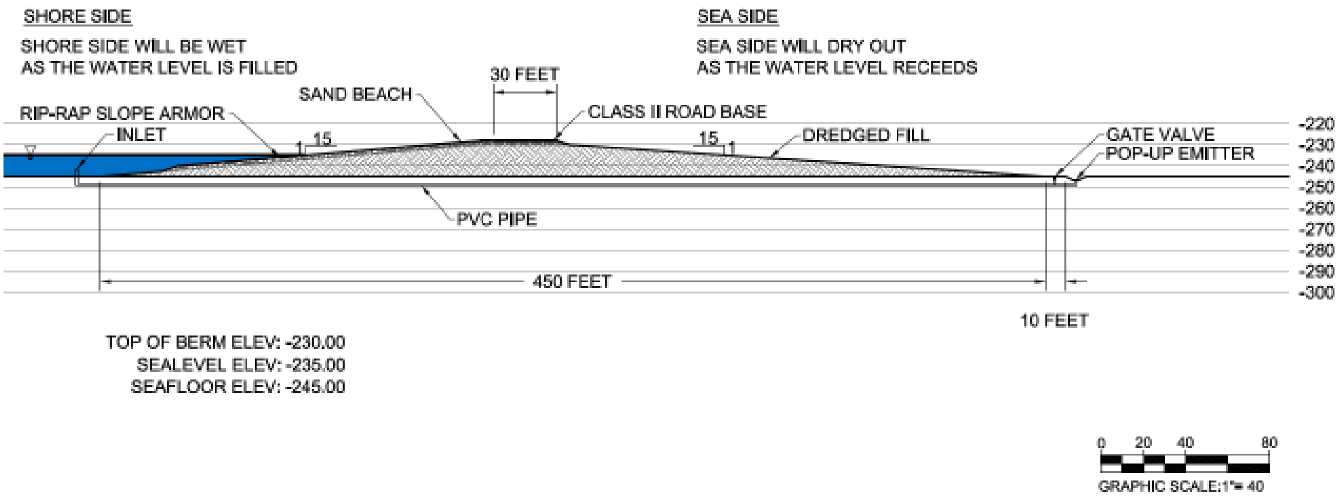

Figure 25 Irrigation System for Emissive Areas

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7.0 Geotechnical Feasibility Study

A feasibility level geotechnical assessment was conducted to evaluate slope stability and seepage associated with the Perimeter Lake design. An overview of the assessment is provided in the section and full the full report is provided in Appendix A.

A feasibility level geotechnical assessment was conducted to evaluate slope stability and seepage. The evaluation did not identify any geotechnical factors that would preclude the successful design and construction of the project. However, several factors would require special consideration during the design, engineering and construction of the project. The geotechnical report is included in Appendix A and the results are summarized here.

Levee Embankment Construction: For safety considerations, the proposed perimeter levee would need to be constructed with compacted, engineered fill for long-term stability. This would require a phased approach to construction that would involve stockpiling, dewatering and spreading excavated soils, drying the material to near optimum moisture content, and mechanical placement and compaction of the material.

Settlement Mitigation: Post-construction consolidation of the soft seafloor deposits, lacustrine and alluvial sediments would cause settlement of the perimeter levee embankment an estimated 2-4 ft. Detailed evaluation of settlement potential would need to be performed during the full design phases of the project. Several methods to mitigate the embankment settlement have been identified.

Seepage Mitigation: Under seepage caused by higher permeability sandy alluvial sediments under the levee could cause excessive exit gradients and/or excessive seepage to or near the downstream toe. Thorough subsurface investigation along the length of the proposed levee should be performed during the design process to provide better definition of areas where under seepage could be problematic. Under-seepage issues could be mitigated by one of several methods identified, including a sheet pile wall through the levee. For cost evaluation purposes, this method has been included along the full length of the levee in the feasibility level cost estimate prepared for the Perimeter Lake.

The preliminary seepage modeling indicates that seepage exiting from the downstream slope of the levee could also occur. If mitigation of the dispersive potential of levee fill is required, seepage through the levee would need to be controlled by a hydraulic barrier or filtered drainage installed within the levee embankment. Seepage volumes of 80 to 120 gallons/day/ft have been estimated assuming appropriate engineering controls and mitigation.

Soil Liquefaction and Seismic Deformation Mitigation: Preliminary analysis indicates that deformation up to approximately 6 ft horizontally could occur in response to the design level earthquake event and liquefaction of foundation soils. Thorough subsurface investigation should be performed during the design process to provide better definition of areas where liquefaction-susceptible material exists. The issue of liquefaction-induced deformation could be addressed by implementing one or more of the identified methods.

Further Studies: A comprehensive geotechnical investigation would be required to adequately support the design process and respond to the special considerations. This work would be essential in obtaining a better understanding of the engineering properties and distribution of the various soil deposits underlying the project site. It would also be valuable in identifying areas where problem conditions exist so that locally targeted and efficient geotechnical designs can be provided.

7.1 Assumed Subsurface Stratigraphy

The existing data indicates a variable subsurface stratigraphy consisting of deltaic, lacustrine and fluvial sediments. In order to develop a reasonable model for subsurface conditions, the results of exploratory borings and Cone Penetration Tests (CPTs) of Salton Sea sediments were evaluated. The data was obtained from geotechnical investigations conducted by the Authority and funded US Bureau of Reclamation in 2003 and 2006 (URS 2004, URS 2007a and b). Investigations that were conducted adjacent to or along the existing Salton Sea shoreline were reviewed. Based on this review, a general description of the various soil units included in the engineering model for this assessment is presented in Table 13.

7.2 Conceptual Design Cross-Section

The conceptual cross-section that was used for the engineering modeling was based on a conservative assessment of the typical existing terrain. A critical slope for the existing grade of about 1.25 percent toward the Salton Sea was assumed. The model utilized a levee embankment crest at elevation -230 ft with a width of 30 ft. The embankment fill slope on the waterway side was set at a gradient of 15H:1V to an elevation of –245 ft where it meets existing grade. At that point there is a 20 foot horizontal bench, and then a dredged cut slope at a gradient of 10H:1V to a bottom elevation of –260 ft. The embankment slope on the Salton Sea side was set at a gradient of 15H:1V to an elevation of -252 ft where it meets existing grade.

A water reservoir elevation of -235 ft was set on the waterway side of the levee. No water reservoir was assumed on the Salton Sea side of the levee as a long term condition. Father analysis may be required for interim conditions where there could be some water on the sea side of the levee.

Table 13 Assumed Subsurface Stratigraphy

Soil Unit	Assumed Thickness (ft)	General Description
Seafloor Deposits	4	Predominantly high plastic clay with some silty sand
Very Soft to Medium Stiff Lacustrine Deposits	6	Predominantly high plastic clay with interbeds of lean clay, silt and silty sand
Very Loose to Medium Dense Alluvial Deposits	8	Silty and clayey fines sands
Dense to Very Dense Alluvial Deposits	10	Silty and clayey fines sands
Stiff to Hard Lacustrine Deposits	> 20	Predominantly high plastic clay with some low plastic clay and silt

7.3 Seismic Demand

The evaluation of potential seismic shaking along the proposed perimeter levee alignment was performed utilizing a deterministic analysis in conformance with standard DSOD practice. The procedure establishes the Maximum Credible Earthquake (MCE) which controls the seismic design. Two fault systems were identified that would have the most potential impact on the project, including the San Andreas and San Jacinto fault systems. Due to the large size of the project, ground motion parameters were estimated at several locations along the Salton Sea perimeter. The peak ground acceleration (PGA) and spectral accelerations for the MCE event were determined with selected Next Generation Attenuation (NGA) – West 2 models, including Abrahamson and Silva (2014), Boore et al. (2014), Campbell and Bozorgnia (2014), and Chiou and Youngs (2014). Due to the high slip rates of both the San Andreas and San Jacinto fault systems and consequence of dam failure, DSOD procedures would require that the [8]4th percentile values be used for design purposes. The NGA-West 2 models were developed as part of a multidisciplinary research program coordinated by the Lifelines Program of the Pacific Earthquake Engineering Research Center (PEER), in partnership with the U.S. Geologic Survey (USGS) and the Southern California Earthquake Center (SCEC). The PGA and spectral acceleration values were calculated using the Excel spreadsheet developed by Seyhan (2014), assuming a shear wave velocity of 270 meters per second (m/s) for the upper 100 ft profile (URS, 2007a). A summary of the causative faults, associated fault parameters, and ground motion values for different areas along the levee alignment are presented in Table 14.

Table 14 Summary of Seismic Design Parameters

Location	Causative Fault	Moment Magnitude M_w	Fault Distance R_x (km)	Peak Ground Acceleration (g)
Eastern / Northern Levee	San Andreas (Coachella Section)	7.9	0.9	0.82
Western Levee	San Andreas (Coachella Section)	7.9	13.5	0.54
Western / Southern Levee	San Jacinto (Lone Tree Section)	6.6	4.3	0.64

7.4 Liquefaction Evaluation

The liquefaction potential of cohesionless (sandy) soils was evaluated based on the SPT blowcounts and laboratory test results taken from the referenced sources. The analysis utilized the procedure published in Idriss and Boulanger (2008). The analyses was based on standard penetration test (SPT) values taken from the referenced geotechnical investigation and utilized an energy ratio correction factor CE of 1.25. This ratio is based on a hammer efficiency of approximately 75 percent which is considered conservative for the automatic trip hammers that were used for the field exploration.

Liquefaction potential and seismic sensitivity of fine-grained soils was evaluated per Bray and Sancio (2006). The fine-grained soils are classified in the following 3 categories:

1. Fine-grained soils with Plasticity Index < 12 and moisture content > 85 percent of the liquid limit are classified as fine-grained soils susceptible to liquefaction (typically includes silts);

2. Fine-grained soils with Plasticity Index > 18 and a degree of sensitivity St > 6 are classified as fine-grained soils potentially susceptible to significant loss of strength during seismic shaking and require additional evaluation. The sensitivity of the on-site fine-grained soils is evaluated based on the water content, Atterberg limits, and

effective vertical stresses using the procedures suggested by Holtz and Kovacs (1981) and Terzaghi, Peck and Mesri (1996).

3. Fine-grained soils falling outside the two categories above are considered to behave like clays and are not considered susceptible to liquefaction or cyclic softening.

Results of liquefaction analyses of granular soils indicate that there is a potential for liquefaction and subsequent loss of shear strength and settlement of the saturated granular alluvial soils. The results of the analysis are summarized in Table 15.

The Plasticity Index of the on-site fine-grained soils generally varies 20 and 51. Analyses of the sensitivity of the saturated fine-grained soils indicated low sensitivity based on the estimated sensitivity ratios between 1 and 2. Consequently, the potential for significant loss of strength of fine-grained materials during seismic shaking is considered low.

Table 15 Summary of Liquefaction Potential of Granular Soils

Boring No.[1]	Depth of Liquefiable Material (below seafloor, ft)	Estimated Seismic Settlement (inches)	Estimated Post-Liquefaction Residual Strength[2] (psf)
B-2	N/A	N/A	N/A
B-11–0 - 6	1.8	1–0 - 220	
B-32	6-24; 47-50	3.6	220 – 520
B-38	12-13; 26-27.5	0.4	2–0 - 600
B-39	10-13.5; 38-49	2.8	1–0 - 750
B-47	2.5-6; 7.5-14	3.1	1–0 - 200
B-48	6-33.5	4.2	3–0 - 650
B-53	0-7; 18-23.5	7.1	–0 - 250
B-56	9-20	1.7	300
B-59	0-24; 36-44	9.9	80 – 700

26 [1] Perimeter Borings from URS (2004, 2007a).

[2] Lower bound value estimated based on equivalent clean-sand SPT-corrected blow count per Seed and Harder (1990). Upper bound value estimated based on normalized residual shear strength ratio per Idriss and Boulanger (2008).

In addition to the vertical settlement caused by of liquefaction as outlined in Table 16, there is also the potential for lateral movement, often referred to as lateral spread. Empirical relationships have been developed for estimating lateral spread for gently sloping terrain, Youd et. al. (2002), however, the relationships are most applicable for ground conditions sloping at less than 6 percent. For 15H:1V levee slopes and 10H:1V dredged slopes a more applicable evaluation of potential lateral movement would be a seismic slope deformation analysis which incorporates the post liquefaction, residual undrained shear strength of any liquefiable soils. This deformation analysis is presented in the Slope Stability section of this report.

7.5 Soil Parameters

In order to perform settlement, seepage and slope stability/deformation analysis the engineering properties for the various soil units presented in Table 16 were used. The parameters were based on the existing field and laboratory data presented in the referenced geotechnical investigations and on engineering judgement. The proposed levee embankment material was assumed to be compacted dredged material composed of a mixture of the upper three soil units.

7.6 Settlement

Static Conditions: Settlement analysis indicates that the underlying soils, particularly the recent sea deposits and soft lacustrine clay, would undergo consolidation under loading from the proposed perimeter levee. The estimated settlement under embankment loading is estimated to be on the order of 2 to 4 ft, depending on the thickness of the soft sediments. It is estimated that most of this settlement would occur within 3 years of levee construction. This amount of time could be significantly reduced by the placement of vertical drains such as wick drains or sand wells. This amount of settlement would need to be considered in the sizing of the initial embankment in order to compensate for the loss of freeboard.

Seismic Conditions: As presented in Table 15, liquefaction of the underlying granular soil deposits could result in vertical settlements up to roughly 10 inches. This amount of potential settlement should also be incorporated into sizing of the initial levee embankment.

7.7 Seepage and Slope Stability

7.7.1 Seepage Modeling

Seepage analyses were performed utilizing the finite element software SEEP/W. A steady state seepage analysis was performed on the conceptual design cross section of the proposed levee embankment utilizing the

Table 16 Summary of Soil Engineering Parameters

Soil Unit	Total Unit Weight (pcf)	Drained Strength		Undrained Strength		Post Liquefaction Residual Strength (psf)	Permeability		Compression Index $C_c/(1+e_0)$	Coefficient of Consolidation (ft^2/day)
		c' (psf'	φ' (deg)	c (psf)	φ (deg)		k_v (ft/sec)	k_h (ft/sec)		
Levee Embankment Fill	115	200	25	NA	NA	NA	1.64e-6	1.64e-5	NA	NA
Sea Floor Deposits	100	27	75	150	0	NA	3.28e-6	3.28e-5	0.25	18
Very Soft to Medium Stiff Lacustrine Deposits	110	27	100	500	0	NA	3.28e-6	3.28e-5	0.12	30
Very Loose to Medium Dense Alluvial Deposits	125	28	100	NA	NA	200	1.64e-3	3.28e-3	0.07	60
Dense to Very Dense Alluvial Deposits	125	30	120	NA	NA	NA	3.28e-4	6.56e-4	NA	NA
Stiff to Hard Lacustrine Deposits	115	23	175	2000	0	NA	1.64e-6	1.64e-5	0.10	30

subsurface stratigraphy outlined in Table 13. Results of seepage modeling are included in Appendix A.

The seepage modeling results indicate that the upper layer of granular alluvial soils could potentially act as conduit for significant underseepage below the levee, particularly if this layer is exposed upstream in the dredged waterway. This underseepage could develop high vertical exit gradients at or near the downstream toe of the levee where it is overlain by less permeable blanket layer of lacustrine and/or sea floor sediments. This condition of high vertical hydraulic gradient could initiate fissures, piping and sand boils if not mitigated. This condition could be exacerbated by the presence of dispersive soils within the low permeability blanket layer. The results of the dispersive potential tests (pin hole tests) performed during the referenced preliminary investigations indicated slight to moderate dispersive potential (grade ND3 and ND4 per ASTM D4647) for the near surface sea floor and lacustrine deposits.

A preliminary seepage quantity analysis was performed that included a continuous granular alluvial layer below the levee. This model estimated seepage losses of roughly 80 gallons/day/foot of levee through the levee, and roughly 210 gallons/day/foot below the levee. This model not only shows the potential for high hydraulic exit gradients but also a significant loss of water from the waterway.

It is recognized that these layers of granular alluvial soils (seepage layers) are not present everywhere and can exist as small deposits interfingered with the lacustrine deposits are as larger fan like deposits at the discharge point of drainages into the Sea. However, where continuous layers of granular alluvial soils are encountered across the levee footprint near or above the waterway dredge elevation, the condition would need to be mitigated by some form of hydraulic barrier, such as sheetpiling or other low permeability cutoff layer/wall. The potential for seepage losses on the landward side of the waterway dredging excavation may also need to be evaluated, but are likely less of an issue. It is expected that an effective hydraulic barrier to control the seepage below the levee could decrease seepage quantities by at least one order of magnitude. Therefore, with appropriate controls in place, total seepage could be in the range of 80 to 120 gallons/day/ft. or 27,000 to 40,000 acre-ft/year if projected over the entire length of the levee.

As discussed previously, the analysis indicated that without a hydraulic barrier, seepage would exit through the downstream face of the levee embankment. Due to the gentle slope of the levee (15H:1V) the horizontal hydraulic exit gradient within the slope is not excessive (<0.15). With properly compacted fill and the level of clay content provided by the source material (dredged material), this condition would generally not be expected to be problematic. As discussed previously, test performed on some of the seafloor deposits and upper lacustrine sediments did indicate slight to moderate dispersive potential. Further testing of soil materials along the levee path would need to be performed to evaluate whether measures to mitigate dispersive soils is necessary.

7.7.2 Slope Stability

The slope stability analysis was performed by utilizing the computer software SLOPE/W. Seepage conditions calculated by the SEEP/W model were directly input into the SLOPE/W model. Results of slope stability analyses are presented in Appendix A.

Static Conditions: Slope stability analysis performed on the conceptual cross-section conditions indicate that the proposed embankment slope should perform satisfactorily under static conditions. A summary of minimum factors of safety evaluated using both circular and block sliding methods is summarized in Table 17.

Table 17 Static Slope Stabili–y - Minimum Factors of Safety

Upstream (Waterway) Slope		Downstream (Salton Sea) Slope	
Circular	Block Slide	Circular	Block Slide
7.53	4.01	4.07	2.54

Seismic Conditions: Seismic stability evaluation was performed utilizing the deterministic MCE parameters discussed previously. Due to the very high seismicity of the area it is anticipated that even a low profile levee embankment would undergo some deformation during the design level event. The extent of deformation would depend largely on whether liquefaction of the saturated granular foundation soils would occur. In areas where significantly thick and continuous layers of loose to medium dense sands do exist, the potential for liquefaction is considered to be high.

Potential permanent seismic deformation was evaluated using the empirical relationships presented by Bray and Travasarou (2007) and the results are presented in Table 18, Table 19, and Table 20. The analysis was performed assuming the conceptual cross-section at several different locations within the project site. This is because seismic shaking varies considerably based on the distance to the major causative faults. The presented results demonstrate the range of possible seismic deformation. Case I assumes that no liquefaction of the subsurface soils would occur, and drained shear strength are utilized for all soil layers. Case II assumes liquefaction of granular foundations soils would not only occur but that these soil layers would lose strength very quickly after the onset of the design seismic event. Post-liquefaction residual shear strength is utilized for liquefiable alluvium and undrained shear strength is utilized for seafloor deposits and very soft to medium stiff lacustrine deposits.

The estimated permanent seismic slope deformation is assumed to be in the direction of slope movement, therefore, most of the deformation would be expected to be in the lateral (horizontal) direction, however, and there would be a significant amount of vertical movement also associated with the deformation. More rigorous analysis (e.g., finite element or finite difference methods) would be required to better define the post-deformation configuration of the levee embankment.

The amount of estimated slope movement, even for the full soil liquefaction condition, is not considered an impediment to the conceptual design, however, proper mitigation of this deformation potential should be included in the project design.

Table 18 Eastern and Northern Perimeter Levee – Seismic Slope Deformation (ft)

Subsurface Conditions	Upstream (Waterway) Slope		Downstream (Salton Sea) Slope	
	Circular	Block Slide	Circular	Block Slide
Case–I - No Liquefaction	3.3	0.5	3.3	0.5
Case –I -Liquefaction of Granular Soils	3.4	4.1	4.6	6.1

Table 19 Western Perimeter Levee – Seismic Slope Deformation (ft)

Subsurface Conditions	Upstream (Waterway) Slope		Downstream (Salton Sea) Slope	
	Circular	Block Slide	Circular	Block Slide
Case–I - No Liquefaction	1.2	0.2	1.5	0.2
Case –I -Liquefaction of Granular Soils	2.0	2.5	2.8	4.1

Table 20 Western and Southern Perimeter Levee – Seismic Slope Deformation (ft)

Subsurface Conditions	Upstream (Waterway) Slope		Downstream (Salton Sea) Slope	
	Circular	Block Slide	Circular	Block Slide
Case–I - No Liquefaction	1.1	0.3	1.3	0.3
Case –I -Liquefaction of Granular Soils	1.9	2.3	2.6	3.6

8.0 Construction Scenario, Cost Estimate, and Funding

The construction scenario would involve sheet pile installation, geotextile deployment, dredging and stockpiling of sediments, construction of spillway structures, grading and armoring of the levees, construct of roadways on top of the levees, and construction of causeways. Bridges may also be constructed once causeways dividing the cells have been breached to allow linkage of the cells. A detailed feasibility-level cost estimate was prepared for two construction scenarios: construction of Phase 1 and 2 in series and construction of Phase 1 and 2 in parallel. While funding sources are still being investigated, a review of the State's funding plan from 2007 is included.

Many past alternatives were designed to help facilitate and advance future Salton Sea management. Consequently, sources for funding the Perimeter Lake concept would be similar to proposed funding sources planned for past alternatives. A background providing past funding plans is, therefore, useful for future planning and would be provided in this section.

8.1 Construction Scenario and Approach

The perimeter levee plan involves some general assumptions regarding the timing and sequencing of construction, in particular the water level of the Salton Sea during various phases of the levee construction. It is assumed for the purposes of this feasibility study the levee construction would begin in the wet condition and that the lake would continue to recede throughout the construction period. Ultimately, the final portions of construction would be performed in a predominately-dry condition. A geotechnical investigation phase, which would include borings and cone penetrometer tests, would precede the design.

8.1.1 Sheet Pile Installation

Although the sheet pile installation could be performed after the levee earthwork has been placed, there are several advantages to constructing the sheet piles first. The sheet pile wall would protrude slightly above the water level and acts as a visible alignment for remaining phases of levee construction. By stacking material behind the sheet pile, some earth retention will aid in stacking height of the dredged material for stockpiling and allows closer access to the levee fill area by the dredge barge.

The vinyl sheet-pile installation would be conducted aboard a jack-up barge using a fixed mast lead rig with steel mandrel and vibratory pile claw. The vinyl sheet piles would be installed 25 ft below the lakebed and range from 35' to 40' in total length. The top of the sheet pile wall would be cut at approximately the Perimeter Lake design water elevation of -235 ft NGVD.

8.1.2 Geotextile Deployment

Woven geotextile or geogrid reinforcement may be used for portions of the project to improve areas where differential settlement under the levee is considered a problem. The textile would need to be ballasted and deployed from a barge and support vessels, and anchored in place at regular intervals using small piles.

8.1.3 Dredging and Stockpiling

The majority of earthwork would be performed by mechanical dredging from a barge illustrated in Figure 26. The barge-mounted crane would use a 20+ cubic yard clamshell bucket to excavate a channel ahead of the barge. As the level of the Salton Sea retreats, the channel is supplied with water from the New River, enabling the barge to float ahead and continue operation. Spoils from dredging activity are stacked on the interior brine side of the sheet pile.

The dredging operation would utilize the sheet pile to allow stockpiling of material above the ultimate profile of the levee. This initial upper stockpile allows the initial existing foundation fills to become "surcharged" to assist settlement and consolidation during the construction phase.

The dredging operation would be continuous, operating with two 10-hour shifts per day, 7 days per week. Over 50 million cubic yards of material would need to be moved, depending on the amount of settlement.

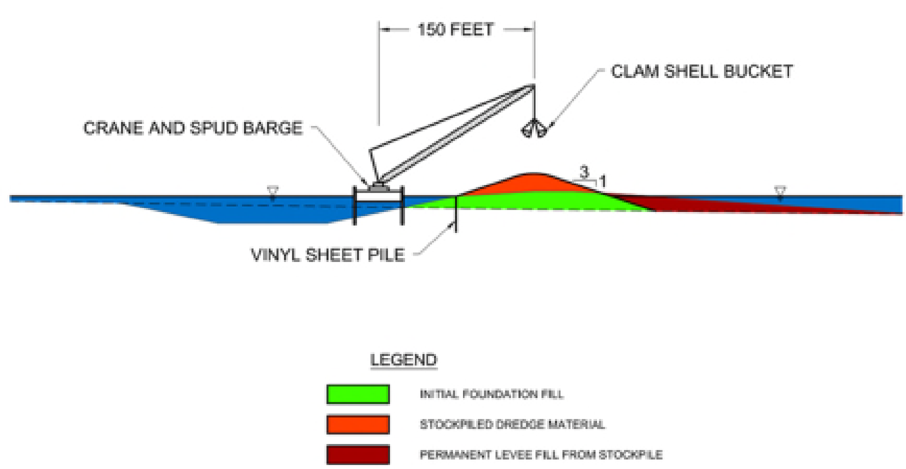

Figure 26 Dredging Sequence

8.1.4 Spillway Structures

Spillway structures would require over-excavation of subgrade materials. The areas would need to be dewatered in order to provide a competent subgrade for placement of items such as box culverts or formwork and reinforced concrete.

Construction of a cofferdam for dewatering would be accomplished by placing a dual row of sheet piles with dredged fill in between. The interior of the cofferdam would be pumped out and allowed to dry. Unsuitable soils would be excavated and competent bedding material would be imported or constructed of engineered fill. In the case of the bell mouth spillway with box culverts, the bell mouth spillways would be constructed on friction piles. The box culverts could be delivered precast and set using a crane. Concrete collars would need to be poured at regular intervals to prevent seepage through the bedding material. A photograph of a typical bell mouth spillway is provided in Figure 27 and a conceptual layout for the spillway is provided in Figure 28. Note that in the Perimeter Lake application, the bell mouth spillway would be secured with booms and fencing for boater safety purposes and fish screens would keep wildlife from entering the spillway. In addition, this configuration is being used primarily to develop feasibility level cost estimates. Final spillway configurations would be developed during the detailed design process.

Figure 27 Photo of a Typical Bellmouth Spillway

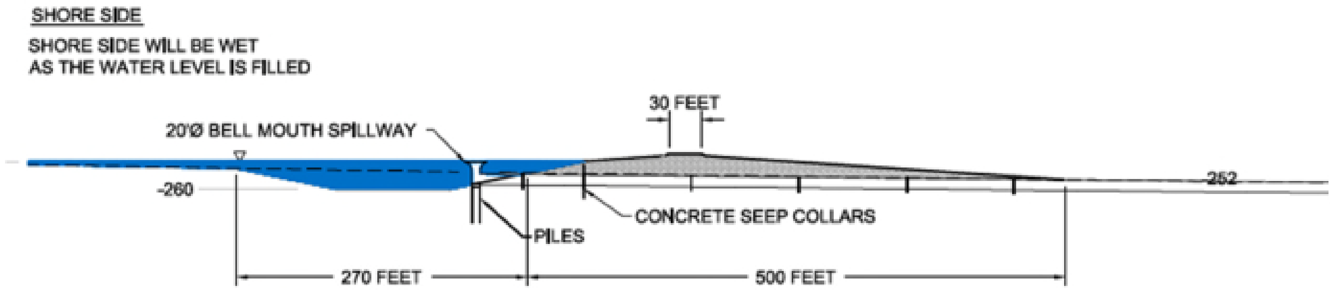

Figure 28 Conceptual Layout of Bellmouth Spillway

A broad-crested weir structure is planned for use as an emergency spillway, as illustrated in Figure 29. The broad-crested weir could be built in a similar manner by overexcavating inside of a cofferdam and placing engineered fill to create a competent subgrade. Concrete formworks would be installed along with reinforcing steel. The concrete could be pumped in using a boom truck then finished. In both cases, the backfill would be comprised of engineered fill and would be shaped to tie back into the levee geometry. A concrete apron and driveable access across the spillway would be necessary.

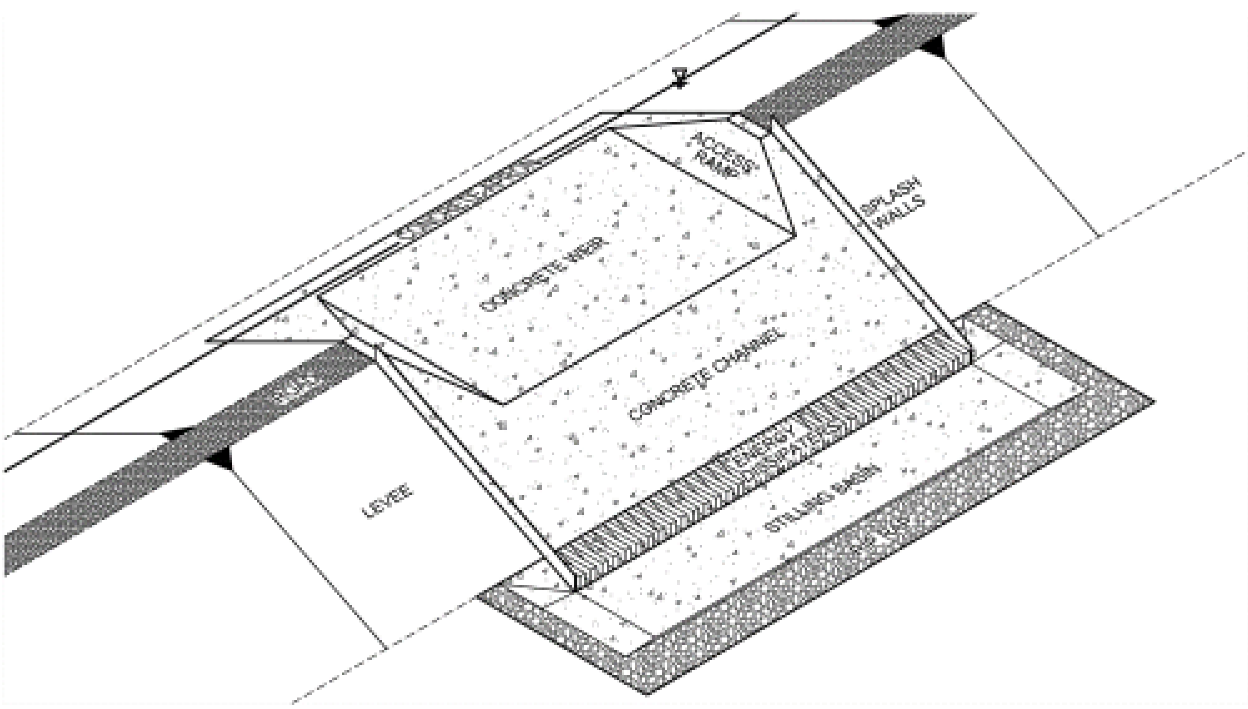

Figure 29 Broad Crested Weir Spillway

Splashwalls would contain the flows to the concrete lined portion of the outer levee slope. Energy dissipation baffles would disperse the flows prior to entering the stilling basin where the water would be allowed to decelerate. Ultimately the flows pass over a row of large rap-rap stone before sheet flowing over the playa and into the saline pool. Grade and Armor Levee and Construct Roadway.

8.1.5 Grade and Armor Levee and Construct Roadway

As the level of the sea retreats and the stockpiled material for the levee dewaters and begins to dry on both sides, traditional earthwork equipment would be used to excavate the stockpiled material and place it as engineered fill along the interior embankment. A mining operation could be created at the nearby Coolidge Mountain in order to provide a source for rock, gravel, and sand products. Imported crushed rock would be placed and compacted along the levee crest to develop a roadway. A filter fabric would be used to separate the road base and rip rap material from the earthen levee material. The road on the levee would be placed on top of the design crest elevation of -230 ft NGVD, which would actually give the levee and extra 1-2 ft of freeboard. Once access was developed, import of quarried materials would be in conventional trucks over the crest haul road. The compacted earthen surface would be reinforced with riprap revetment to protect from wave action along the Perimeter Lake side. Gravely sand would be placed above the rock to provide additional wind and wave erosion protection while creating a more desirable beach type surface. Gravel would be placed on the interior brine side of the levee to protect against wind erosion.

8.1.6 Causeways

Causeways or access spurs would be needed to provide multiple access points and reduce travel time to remote portions of the levee for construction and long-term maintenance. The causeways are anticipated being constructed from dredged fill and quarried rock. The causeways would need to be built at the ends of each reach or “cell” to provide the necessary access point. Temporary culvert structures would ensure water could flow through the causeways into the adjacent working cell to maintain adequate water levels within the working channel to float the barge.

8.1.7 Bridges

Once the levee system is completed, the dredge would be used to excavate channels in the causeways, in order to allow navigable boat access throughout the Perimeter Lake system, a series of openings in the causeways would allow boats to pass as well as land vehicles. A floating bridge or ferry barge could be used to transport maintenance vehicles to the levee after construction is complete. The floating bridge or ferry barge could be removed when not in use.

8.2 Cost Estimate

A cost estimate was prepared for Perimeter Lake construction in 2015 dollars. The basis of the estimate, included and excluded components, and assumptions are discussed below.

8.2.1 General Information

The purpose of this cost estimate is to determine the feasibility and probable cost of the construction of the low profile perimeter levee alternative as described in Section 16. The estimate provided is considered to be a Class 4 estimate as defined by The American Association of Cost Engineers in their Recommended Practice No. 18R-97. The estimator considers the estimate has a potential variation of +30% to -20% from the value of the cost estimate, including contingency for the scope of the work estimated. The contingency applied is considered to be adequate and customary given the project definition. The estimate is stated in 2015 US dollars.

8.2.2 Estimate Basis

The estimate is based upon the following drawings and documents:

- Levee configurations presented in this report;
- Overflow and spillway structures presented in this report;
- Draft Preliminary Geotechnical Feasibility Study, Perimeter Low Profile Levee Alternative, Dated September 18, 2015, presented in the appendix to this report;
- URS - In-Sea Embankment Concepts, Salton Sea Revitalization Plan, Dated June 27, 2007; and
- URS - Geotechnical Reconnaissance, Potential Rock Quarry at Coolidge Mountain for Salton Sea Revitalization Plan, Dated February, 2007.

The estimate is based on the Owner awarding the work represented by the estimate to a General Contractor who will implement the work under on contract. Should the work be divided into phases or multiple contracts, this would likely increase overall costs.

The estimate for project labor assumes that prevailing wage determinations will apply. Current determinations were obtained online and used to calculate the wage rates used in the estimate. Pricing for equipment and equipment maintenance costs are generally based upon the 2012 edition of Mine and Mill Equipment Costs published by InfoMine USA, Inc. Pricing was then adjusted for 2015 costs, including prevailing wages rates for maintenance labor and current energy costs. Pricing for the sheet pile is based upon initial vendor quotes (sales tax and freight added). Installation production is based upon the estimators experience and provides for the pile driving rig to be placed on a barge.

Dredging is scheduled on a 24-hour, 7 days per week, 350 days per year basis. A shift rotation called “12 hour 4X4” was used in the estimate. This rotation involves four crews working 12-hour, 4-day weeks (48 hours) with the following 4 days off.

8.2.3 Work Included

The estimate assumes and provides for Overall Management of the Project by the Owner. The estimate provides for installation of Owner offices and infrastructure on property purchased for that purpose. The estimate includes the cost for Owner personnel and expenses to manage and monitor the project implementation. It assumes progress and reports of the status of the project will be submitted to the various stakeholders.

Permitting efforts will include the following:

- Design and Performance of a test of dredge/embankment construction
- Preparation of an EIR/EIS including public review
- Substantive compliance with Federal, State or Local permit requirements.

Construction and planning within the estimated budget will require/allow for the following:

- Engineering for the construction of the project, including design drawings, equipment, material, construction specifications and construction quality control/quality assurance requirements and plans;
- Field construction management and engineering to assure that the Work is constructed in accordance with the drawings, specifications and approved Project Plans;
- Procurement of major materials and equipment, especially long lead items;
- Procurement of services from qualified contractors to construct the Work and administration of the contracts;
- Mobilization and demobilization of all required personnel, equipment and materials required to construct the work;
- Dredging from shore side of levee to provide deeper water for fish habitat and construct approximately 66.7 miles Levee;

- Construction of 12 access causeways of approximately 4.5 miles in total length from the shore to the Levee, including the installation of one pipe arch in each for the passage of water and small watercraft;
- Installation of a single sheet pile wall seepage control barrier for the entire length of the levee;
- Installation of Geotextile on the existing Sea bottom from the sheet pile barrier to the interior sea on which the levee embankment will be placed;
- Establishment and operation of a quarry and processing equipment to produce the aggregates and rock fill needed to construct the causeway access to the levee;
- Hauling and stockpiling of aggregates and rock fill to near the installation sites; and
- Installation of the aggregates from the stockpile to the levee for a road and armoring of the embankment against wind and wave erosion or damage.
- Installation of three bell mouth spillways and one broad crested weir spillway for level control of the perimeter sea and flood control. The spillways incorporate sluice gate valves to reduce the perimeter sea level in the event of an issue with the levee.

Several ancillary costs have been included in the estimate. For example, an allowance for the installation of settlement monitoring, salinity monitoring and seepage monitoring was included in the estimate for monitoring the consolidation and performance of the levee embankment. The cost for stockpiles of aggregates in the total quantity of 1,000,000 cubic yards in the area of the quarry was included for long-term maintenance of levee roads and erosion control. In addition, a crew of approximately 12 people was included, plus equipment, to perform maintenance and repairs on the access roads and levee for a period of 10-years after construction.

8.2.4 Work Excluded

The following costs/values were excluded from the overall estimate:

- Any and all costs prior to February 29, 2016;
- Costs for management, monitoring or measurement of water sources and quality to the Salton Sea including such things as water treatment, diversion works and/or channels, pumping stations and the like are not included here, but consideration for some of these elements is provided elsewhere in this document;

- Costs for management and dust control of the area to the water side of the levee (exposed playa and brine pool) are not included herein; and

Note also that a credit for the salvage value for any project purchased equipment upon completion of the Work is not considered in the cost estimates. It is anticipated that there will be some but likely not significant salvage value.

8.2.5 Assumptions

When calculating the cost estimate for constructing the project, the following assumptions were made:

- Permit fees for required Federal, State or Local permits are included and are assumed to be 1% of the total constructed value of the work.
- Property requirements for the quarry, rock processing plants, infrastructure and stockpiles has been estimated and either the lease or purchase of the required property is included in the estimate.
- The estimate assumes that in addition to a lease arrangement for use of the quarry property that a royalty for rock quarried and removed from the property of the landowner will be required and an allowance of $2.00 per ton is provided for this cost.
- The estimate assumes that property for stockpiling of rock products can be found near (+ or - 1 mile) the 12 planned causeways. Lease/rental cost for the required property is included in the estimate.
- The estimate assumes that purchases of equipment and materials by the project are subject to the State of CA sales tax.
- The estimate assumes that the material can be dredged mechanically, transported and placed in the embankment without significant materials handling problems.
- The estimate provides for a test dredge to evaluate the dredging and material handling difficulty.
- In the event the test dredge indicates the dredged material properties will not allow handling as assumed in the estimate, an alternate dredge and placement method will be evaluated.
- The estimator is reasonably convinced that a gantry dredge, bucket wheel dredge or a cutterhead suction dredge could be employed to construct the work, but would require considerable more dewatering efforts.

- An excavator, clamshell or dragline dredge was chosen due to the power and reach the machine has to offer in order excavate the Salton Sea floor deposits.
- The other dredging methods mentioned may actually be more cost effective than the mechanical options, assuming they can exceed the required production.
- The estimate assumes that a Project Specific Agreement can be negotiated with the Dredgers. This agreement will confirm that the 4 - 12 hour shift can be paid at 40 hours straight time and 8 hours at time and one half.

Lastly, the estimate assumes that funds for the construction of the project over a 5 to 10 year period are available on an as-needed basis from the owner. As such, financing or interest costs during construction, or other similar costs, are not included in the estimate.

8.2.6 Qualifications

The estimator, while generally familiar with geotechnical parameters for soils, is not a geotechnical engineer and assumptions regarding excavation of the sea floor soils with the excavator or other mechanical equipment will need to be field verified before equipment selection and purchase is completed. The contingency applied is considered adequate and customary given the project definition and conceptual level of design.

The estimate is stated in 2015 US dollars, and no future escalation is provided.

8.2.7 Perimeter Lake Cost Estimate

Cost estimates have been prepared for two alternative construction scenarios:

A. For this scenario, construction would be accomplished with one crew. Construction would start at southernmost Cell A and proceed in a clockwise direction until all thirteen cells are complete. Once design, environmental documentation and permitting are complete, the construction period for this scenario would be about 10 years.

B. For this scenario, construction would be accomplished with two crews. Construction would start at the southernmost Cell A and northern Cell H simultaneously. Both crews would proceed in a clockwise direction until all thirteen cells are complete. Once design, environmental documentation and permitting are complete, the construction period for this scenario would be about 5 years.

Table 21 provides a top-level cost estimate summary for each scenario. Alternative A is estimated at a total cost of $1.7 billion including contingencies. Alternative B is estimated at a total cost of $1.8 billion including contingencies. Table 22 shows an approximate breakdown of costs by cell. Cell locations are shown in Figure 30.

Table 21 Summary of Cost Estimates for Perimeter Lake Construction Alternative Scenarios A and B.

Permitting, Design and Construction of The Salton Sea Restoration Plan Alternative A and Alternative B Estimate Comparison PERIMETER LOW PROFILE LEVEE ALTERNATIVE					
Item	Description	Alternative A ($Millions)	Alternative B ($Millions)	Difference ($Millions)	Comments
1	Initial Activities for Project Approval	$24	$24	$0	
2	Permitting, Engineering and Procurement	$27	$28	$1	Additional Procurement and Inspection Expense for Equipment
3	Construction Management and Support	$163	$167	$5	Shorter Schedule Offset by Additional Personnel for Two Crews
4	Salton Sea Authority Management/Other Direct Expenses	$121	$109	($11)	SSA Management Organization on Site Less Time
5	Mobilization	$33	$47	$14	Mobilization and Assembly of Additional Equipment
6	Quarry Operation and Aggregate Production	$164	$191	$27	Increased Equipment Production and Operation Schedule
7	PVC Sheetpile Installation	$232	$238	$7	Added Another Independent Crew - Unit Price Slightly Higher
8	Install Spillways and Flood Control Structures	$65	$65	$0	
9	Dredging and Levee Construction	$509	$550	$41	Duplicate Equipment for Second Independent Crew
10	Grade and Armor Levee/Construct Access Points	$90	$100	$10	Increased Equipment and Operation Schedule
11	Other Miscellaneous Works to complete the Project	$10	$10	$0	Placeholder No Change
12	OM&M of the Constructed Project (10 Years is Assumed)	$47	$47	$0	No Change
	Subtotal	$1,483	$1,576	$93	
	Recommended Contingency (15%)	$222	$236	$14	
	Total	$1,705	$1,813	$108	

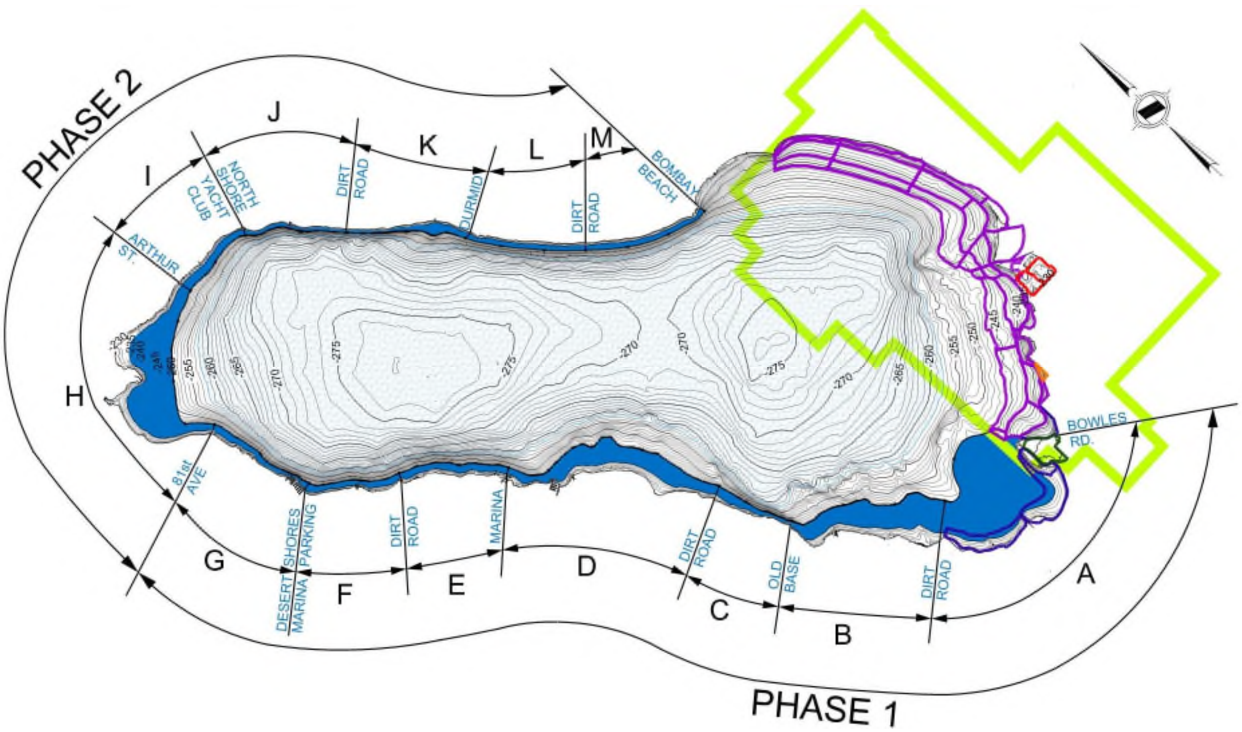

Figure 30 Access Levee Locations and Construction Phases

Table 22 Approximate Cost Distribution for Constructing Cells for Alternative A

Salton Sea Perimeter Levee Phased Cost Estimate
Direction: Clockwise Beginning from 6 O'Clock

Levee ID	Phase	Reach	Volume %	Sheetpile %	Earthwork ($M)	Sheetpile ($M)	Permit, Engineer, Procure & Owner Mgmt. ($M)	Total ($M)
Bowles Rd. to Dirt Rd	1	A	7.9%	7.8%	$95	$21	$13	**$129**
Dirt Rd to Old Base	1	B	9.5%	9.3%	114	25	16	**155**
Old Base to Dirt Road	1	C	4.5%	4.5%	54	12	8	**74**
Dirt Rd to Marina	1	D	14.1%	13.9%	170	38	24	**231**
Marina to Dirt road	1	E	6.4%	6.3%	77	17	11	**104**
Dirt Road to Desert Shores	1	F	5.2%	5.1%	63	14	9	**85**
Desert Shores to 81st Ave	1	G	6.5%	6.5%	79	17	11	**107**
81st Ave. to Arthur St.*	2	H	15.1%	12.0%	181	40	20	**242**
Arthur St to North Shore YC	2	I	4.4%	5.0%	53	12	8	**73**
North Shore YC to Dirt Rd	2	J	5.8%	6.5%	69	15	11	**96**
Dirt Rd to Crooker Dr	2	K	6.8%	7.6%	82	18	13	**113**
Crooker Dr to Dirt Rd	2	L	6.7%	7.6%	81	18	13	**112**
Dirt Rd to Bombay Beach	2	M	7.2%	8.1%	86	19	14	**119**
		Totals	100.0%	100.0%	$1,204	$266	$170	**$1,640**
Initial Activities for Project Approval (e.g. Demonstration Project, NEPA/CEQA)								**$24**
Program Mobilization								**$32**
Initial Project Approval and Mobilization Contingencies								**$8**
Total							**Total**	**$1,705**

* From 81st Ave. to Arthur St. there is a deepened levee section

A more detailed summary of estimated costs for Alternative Construction Scenario A is provided in Table 23. A similar cost summary table for Alternative Scenario B can be found in Appendix B along with supporting cost estimate details for both scenarios including material quantities, unit rates and other supporting details plus construction schedules for both scenarios.

8.3 Funding

A more detailed discussion of funding sources will be provided in the Benchmark 7 document, the final report for the Salton Sea Funding and Feasibility Action Plan of which this current Benchmark 4 document is a part. The funding will including analyses form the Benchmark 5 and 6 efforts. The Benchmark 6 document is complete and evaluates possible funding that could be related to alternative energy development. As of February 2016, the Benchmark 5 effort is on-going. Benchmark 5 includes an evaluation of funding sources related to incremental tax revenue that could be related development spurred by an effective Salton Sea management program.

As an interim measure, it is worthwhile to look at the funding plan that the State put together for their Salton Sea restoration plan from 2007.

Table 23 Itemized Cost Estimate Summary for Alternative Construction Scenario A

Permitting, Design and Construction of The Salton Sea Restoration Plan					
Alternative A - Base Case Estimate					
PERIMETER LOW PROFILE LEVEE ALTERNATIVE					
Item	**Description**	**Units**	**Unit Cost**	**Quantity/ Expenses %**	**Cost**
1	**Initial Activities for Project Approval**				
	Evaluate Alternatives and Prepare Recommendation for Preferred Alternative	Lot	$562,000	5%	$590,100
	Internal and Public Review Comment	Lot	$374,000	5%	$392,700
	Design and Implement a Demonstration Project to Define Technology to be Used	Lot	$1,630,000	25%	$2,037,500
	Final Geotechnical Investigation and Bathometry for Design	Lot	$842,000	5%	$884,100
	Prepare EIR/EIS	Lot	$8,736,000	10%	$9,609,600
	Prepare Preliminary Engineering for EIR/EIS Project Definition and Evaluation	Lot	$5,616,000	10%	$6,177,600
	EIR/EIS Agency/Public Review and Approval	Lot	$1,217,000	5%	$1,277,850
	Obtain required Permits (Local, State and Federal)	Lot	$2,574,000	10%	$2,831,400
				SUBTOTAL	**$23,800,900**
2	**Permitting, Engineering and Procurement**				
	Design Engineering and Preparation of Construction Drawings	Lot	$13,260,000	10%	$14,586,000
	Prepare Technical Specifications and QA/QC Plan	Lot	$4,976,000	5%	$5,224,800
	Procure and Deliver Dredging and Plant Equipment/Barges	Lot	$1,716,000	10%	$1,887,600
	Procure and Deliver PVC and Steel Sheetpile	Lot	$390,000	10%	$429,000
	Bid and Award Quarry Operation and Aggregates Production and Delivery to Site	Lot	$772,000	15%	$887,800
	Bid and Award Construction of Spillways and Flood Control Structures	Lot	$601,000	15%	$691,150
	Bid and Award Vinyl Sheetpile installation	Lot	$429,000	15%	$493,350
	Bid and Award Marine Construction Contract (Dredge, Process and Levee Rough grade)	Lot	$1,201,000	15%	$1,381,150
	Bid and Award Earthworks Contract (Grade and Armor Levee)	Lot	$601,000	15%	$691,150
	Bid and Award Contracts for Other Works to complete the Project	Lot	$343,000	15%	$394,450
	Bid and Award Contracts for Long Term OM&M of the Project	Lot	$429,000	10%	$471,900
				SUBTOTAL	**$27,138,400**
3	**Construction Management and Support**				
	Site Facilities and Expenses	week	$10,000	520	$5,210,000
	Construction Management and QA/QC (Field)	Lot	$74,763,000	25%	$93,453,750
	Construction Management and QA/QC (Office Support)	Lot	$13,856,700	5%	$14,549,535
	Field Environmental Monitoring and Reporting	Lot	$19,656,000	30%	$25,552,800
	Soils Testing Technician and Laboratory	Lot	$9,984,000	50%	$14,976,000
	Survey Control	Lot	$7,800,000	15%	$8,970,000
				SUBTOTAL	**$162,712,100**
4	**Owner Management/Other Direct Expenses**				
	Mobilization of Owner Offices/Facilities/Utilities for Oversight of the Project	Lot	$1,876,800	Included	$1,876,800
	Management/Administrative Personnel	Lot	$73,995,000	5%	$77,694,750
	Owner Offices/Facilities/Utilities/Insurance/Taxes Expense	week	$7,500	520	$3,900,000
	Federal, State and Local Permit Fees (allowance of 1% of inplace constructed value)	Lot	$1,229,000,000	1.00%	$12,290,000
	Lease and/or Purchase of Property for Project Use	Lot	$3,360,917	10%	$3,697,008
	Royalties on Quarried Rock (at $2.00 per ton)	tons	10,630,000	$2.00	$21,260,000
				SUBTOTAL	**$120,718,558**
				TOTAL THIS GROUP	**$334,400,000**
	LEVEE CONSTRUCTION				
5	**Mobilization**				
	Conduct Dredging Demonstration Project	Lot	$5,700,000	1	$5,700,000
	Conduct Geotechnical Investigation and Obtain Detailed Bathymetry	Lot	$2,239,680	1	$2,239,680
	Mobilize Men and Equipment for Sheetpile and Levee Construction	Lot	$1,596,000	1	$1,596,000
	Mobilize Men and Equipment for Quarry Setup and Operation	Lot	$819,000	1	$819,000
	Install Project Offices, Laydown and Maintenance Areas, Warehousing and Storage Areas	Lot	$4,167,680	1	$4,167,680
	Receive and Laydown Barges, Dredge, and Process Equipment	Lot	$1,172,160	1	$1,172,160
	Receive and Laydown Sheetpile and Other Miscellaneous Materials Incorporated in the Work	Lot	$976,800	1	$976,800
	Install Dredge and Levee Construction Components and Pre-Operational Testing	Lot	$6,914,560	1	$6,914,560
	Dismantle Dredging Equipment and Remove from Site	Lot	$2,765,824	1	$2,765,824
	Demobilization of Facilities (Not Required for OM&M) and Final Site Cleanup	Lot	$4,688,640	1	$4,688,640
	Demobilization of Equipment and Reclamation/Revegetation and Closure of the Quarry Site.	Lot	$1,562,880	1	$1,562,880
				SUBTOTAL	**$32,603,224**

Table 23 Itemized Cost Estimate Summary for Alternative Construction Scenario A (continued)

Permitting, Design and Construction of The Salton Sea Restoration Plan					
Alternative A - Base Case Estimate					
PERIMETER LOW PROFILE LEVEE ALTERNATIVE					
Item	**Description**	**Units**	**Unit Cost**	**Quantity/ Expenses %**	**Cost**
6	**Quarry Operation and Aggregate Production**				
	Capital Equipment Required to Quarry	Lot	$15,161,699	1	$15,161,699
	Rock Processing Units	Lot	$11,440,477	1	$11,440,477
	Capital Cost for Haul	Lot	$8,061,379	1	$8,061,379
	Drill and Blast/Load and Haul Rock for Processing	ton	$5.67	8,075,686	$45,789,142
	Produce Rock Products	cy	$4.96	4,703,345	$23,344,647
	Deliver Rock Products for Levee Access and Construction	cy	$13.74	4,703,345	$64,628,100
	Produce and Stockpile Aggregates for Long Term Project OM&M	cy	$10.63	1,000,000	$10,633,414
		cy	**$16.90**	**SUBTOTAL**	**$163,897,160**
7	**PVC Sheetpile Installation**				
	Furnish and Deliver Sheetpile	sf	$7.75	12,502,248	$96,861,166
	Install Sheetpile	sf	$10.77	12,502,248	$134,649,211
		sf	**$18.52**	**SUBTOTAL**	**$231,510,377**
8	**Install Spillways and Flood Control Structures**				
	Install North Shore Bellmouth Spillway and Flood Control Weir and Discharge Structure	Lot	$35,575,003	1	$35,575,003
	Install Bombay Beach Bellmouth Spillway and Discharge Structure	Lot	$14,171,244	1	$14,171,244
	Install Southwest Bellmouth Spillway and Discharge Structure	Lot	$14,957,187	1	$14,957,187
				SUBTOTAL	**$64,703,434**
9	**Dredging and Levee Construction**				
	Furnish and Deliver Major Equipment for Dredging and Levee Construction	Lot	$31,370,583	1	$31,370,583
	Furnish and Deliver Major Equipment for Geotextile Placement	Lot	$2,233,659	1	$2,233,659
	Furnish and Deliver Geotextile	sf	$0.22	88,145,112	$19,039,344
	Place Geotextile Ahead of embankment (15 foot Nominal Section)	sf	$0.34	76,665,600	$25,828,286
	Place Geotextile Ahead of embankment (20 foot Nominal Section)	sf	$0.31	11,479,512	$3,541,176
	Dredge, Process and Place Initial Levee Embankment (15 foot Nominal Section)	cy	$8.12	44,666,472	$362,710,045
	Dredge, Process and Place Initial Levee Embankment (20 foot Nominal Section)	cy	$8.12	7,917,616	$64,294,287
		Mile	**$7,631,445**	**SUBTOTAL**	**$509,017,380**
10	**Grade and Armor Levee/Construct Access Points**				
	Haul Rock Products from Stockpile	cy	$8.07	4,703,345	$37,940,563
	Furnish and Deliver Major Equipment for Levee Grading and Armor	Lot	$6,462,288	1	$6,462,288
	Grade and Armor Levee/Construct Access Points	lf	$116.85	375,936	$43,926,981
	Install Multi-Plate Pipe Arches	cy	$100,000	12	$1,200,000
		Mile	**$1,342,276**	**SUBTOTAL**	**$89,529,833**
11	**Other Miscellaneous Works to complete the Project**				
	Embankment Settlement Monitoring, Salinity Monitoring, inflow seepage, etc.	Lot	$1.00	10,000,000	$10,000,000
				SUBTOTAL	**$10,000,000**
12	**OM&M of the Constructed Project (10 Years is Assumed)**				
	Provide Dedicated Equipment and Personnel for Long Term OM&M				
	Personnel	year	$1,996,800.00	10	$19,968,000
	Equipment	year	$1,497,600.00	10	$14,976,000
	Expenses	year	$399,360.00	10	$3,993,600
	Owner Long Term Management and Expenses	year	$823,680.00	10	$8,236,800
				SUBTOTAL	**$47,174,400**
				TOTAL THIS GROUP	**$1,148,400,000**
				Project Total	**$1,482,800,000**
13	**Recommended Contingency**	**%**	**15.00%**		**$222,400,000**
			Total		**$1,705,000,000**

8.3.1 The State Funding Plan from 2007

In 2007, the State estimated that capital costs and O&M costs for their preferred alternative would be phased over a 75-year program. The estimated costs for the alternative were provided in five-year increments to allow for a cash flow analysis, and a variety of major funding sources would have been utilized for construction and O&M. The preferred alternative would have used the following sources for funding:

- **Salton Sea Restoration Fund—**The Restoration Fund was established and is administered pursuant to Fish and Game Code Section 2081.7 and 2932. Fund monies come from local water agencies, actions on the Colorado River, additional water transfers from the Imperial Irrigation District, and water transfers identified in Fish and Game Code Section 2081.7. The Restoration Fund was estimated to have over $20 million in 2007, and it was expected to be a major source of funding for the State's preferred plan.
- **State funding sources—**State funding sources could have included bond monies under Propositions 50 and 84. Most of the funds in Proposition 50 were allocated and were no longer available. However, Proposition 84 had authorized $5.4 billion in state general obligation bonds to fund a variety of water projects including $47 million for Salton Sea restoration. This allocated State funding may have been used to finance the State's preferred alternative.
- **Federal funding sources—**Federal funding sources included "line item" funding of specific projects within federal agency budgets, grant or loans, and appropriations by Congress.
- **Salton Sea Infrastructure Financial District—**In 1999, special legislation was enacted to amend the California Infrastructure Financing District Act to authorize the Salton Sea Authority to form an infrastructure-financing district to collect tax increment revenue to fund restoration projects. The Salton Sea Authority identified a preliminary geographical area around the Salton Sea for the Infrastructure Financing District. Further legislation may have been needed to allow the use of the Infrastructure Financing District to collect funds for operations and maintenance.
- **User fees—**User fees could have also been used to repay long-term borrowing for construction, such as for bonds, and for operations and maintenance. Although user fees were not adequate to fully fund the construction or operations and maintenance, they could have been used to defer some of the costs.

- **Other local agency funds—**Other local agency funds could have included the use of local bonds, reserve funds, or special assessments. Bonds could have been used to spread out payments over a long-time period, and they could have been repaid through user fees or special assessments. Reserve funds could have been used to fund construction without incurring debt. User fees, special assessments, and special taxes are frequently used to fund operations and maintenance and repay debt service and could have served as a useful source of funding for the project.
- **Private-public partnerships—**Partnerships between the public and private sectors in the public works industry could have ranged from providing basic services and supplies to the design, construction, operation, and ownership of facilities.

9.0 Relation to Past Alternatives

The Perimeter Lake concept is discussed with respect to Salton Sea management program objectives and compared to previous alternatives by the State and the Authority as well as Import/Export concepts.

The Perimeter Lake concept was designed to be included as part of a new Salton Sea management effort that addresses scarcities of water, time, and funding. In the following sections, objectives for the Perimeter Lake concept are explained, and the concept is compared to three previous alternatives: the State's 2006 preferred alternative, the Authority's preferred plan from 2006, and import/export alternatives discussed in Benchmark 4 Volume 1.

In Section 1.2 of this report, the Perimeter Lake was evaluated with respect to the following objectives that were first published by the Authority in 2004:

- Preserve the Sea as a Repository for Agricultural Runoff
- Provide Lake with Stable Elevation
- Improve Water Quality: Salinity
- Improve Water Quality: Nutrients/Other Constituents
- Maintain and Improve Habitat
- Achieve Water Quality and Habitat Objectives in a Timely Manner
- Respond to Inflow Changes
- Increase Recreational and Economic Potential
- Address Air Quality (PM_{10}) Concerns
- Provide High Safety Rating/Low Risk of Failure
- Overcome Institutional Barriers/Public Acceptance (Permitting)
- Reasonable Cost/High Probability of Financing

The objectives listed above were used in a comparison of the Perimeter Lake concept to three past alternative approaches: the 2006 State Preferred Plan, the 2006 Authority preferred plan, and an import/export scenario (Table 24). Cost estimates from the earlier alternatives were updated to bring all values to 2015 dollars using an ENR construction cost escalation factor, which added 35% to the original cost estimates.

Table 24 Alternative Evaluation

Objectives	Perimeter Lake	State 2006	Authority 2006	Import/Export
Preserve the Sea as a Repository for Agricultural Runoff	Yes	Yes	Yes	Yes
Provide Large Lake with Stable Elevation	Yes / Smallest	Larger than Perimeter Lake	Larger than State	Full Sea
Improve Water Quality: Salinity	5 – 35 PPT	35 PPT	35 PPT	45 - 50 PPT
Improve Water Quality: Nutrients/Other Constituents	Yes	Yes	Yes	Yes
Maintain and Improve Habitat	Yes	Yes	Yes	Yes
Timeframe to Achieve Water Quality and Habitat Objectives	Short	Medium	Medium	Long
Respond to Inflow Changes (Required Water Inflow)	167,000 AFY for evap. and seepage	~700,000 AFY	~700,000 AFY	~700,000 AFY
Increase Recreational and Economic Potential	Yes	Yes	Yes	Yes
Air Quality Mitigation	Good	Good	Good	Very Good
Provide High Safety Rating/Low Risk of Failure	Low	Moderate	Moderate	Moderate
Institutional Barriers/ Permitting	Average	Average	Difficult	Very Difficult
Reasonable Cost/ High Probability of Financing	Lowest cost with the highest probability of financing from State and Federal sources	Higher cost than Authority 2006 plan with low probability of financing from State and Federal sources	Higher cost than Perimeter Lake with low probability of financing from State and Federal sources	Highest cost with the low probability of financing from State and Federal sources

9.1 State Alternative 2006

In 2006, the State of California reviewed a list of eight alternatives and then released their findings in the Programmatic Environmental Impact Report (PEIR). The Preferred Alternative, shown in Figure 31, includes Saline Habitat Complex in the northern and southern seabed, a Marine Sea that extends around the northern shoreline from San Felipe Creek to Bombay Beach in a "horseshoe" shape, Air Quality Management facilities to reduce particulate emissions from the exposed playa, brine sink for discharge of salts, Sedimentation/Distribution facilities, and Early Start Habitat to provide habitat prior to construction of the habitat components. This option is very similar to the Perimeter Lake concept. However, the Perimeter Lake concept is much cheaper and includes levees for incremental construction.

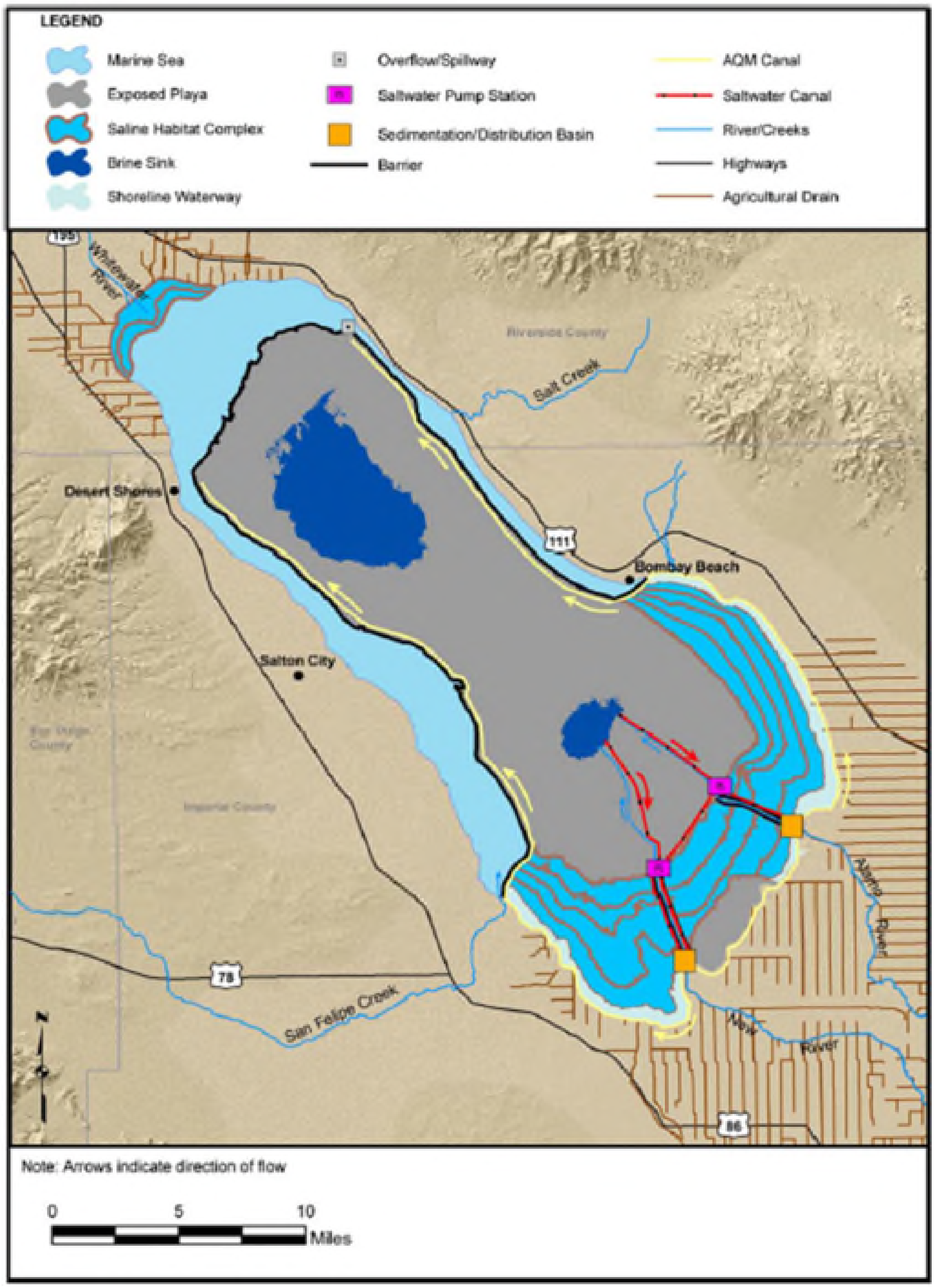

Figure 31 State's 1006 Preferred Alternative

- **Provide Large Marine Lake with Stable Elevation:** Under this alternative, a marine sea would be formed through the construction of a Barrier. The Marine Sea would stabilize at a surface water elevation of -230 ft msl with salinity levels between 30,000 mg/L and 40,000 mg/L.
- **Improve Water Quality: Salinity:** To reduce costs, this option could be adapted to a lower elevation level, and if it were implemented Salinity conditions in managed areas of the Sea would stabilize at Marine levels.
- **Improve Water Quality: Nutrients/Other Constituents:** Sediment/distribution facilities, air quality management canals, the Saline Habitat Complex, and a central brine sink would work to filter out nutrients and other sizable constituents to preserve water quality.
- **Maintain and Improve Habitat:** Bordering parts of the Marine Sea and the exposed playa there would be a Saline Habitat Complex, which would be split into habitat cells and include berms. This makes the habitat value of this plan relatively good, and restoration objects toward this end would be met.
- **Achieve Water Quality and Habitat Objectives in a Timely Manner (Timeframe):** While the timeframe for this option would not be as long as it would be in a pump in/out scenario, the timeframe would still be relatively long compared to the Perimeter Lake concept.
- **Respond to Inflow Changes:** The full-scale implementation of this plan would require approximately 700,000 AFY.
- **Increase Recreational and Economic Potential:** If this alternative were implemented it would provide a recreational area for fishing and boating, and would improve property values for human occupants.
- **Address Air Quality (PM_{10}) Mitigation:** This plan would utilize AQM and an irrigation system to control dust. Construction of the irrigation system would require excavations up to 8 ft deep for trenches throughout the exposed playa. Salt bush, or similar vegetation, would be planted every 5 ft apart in rows that would be separated by 10 ft. This makes the AQM incorporated into this plan relatively good.
- **Provide High Safety Rating/Low Risk of Failure:** The foundation conditions of the Sea have been investigated and found to be composed of a relatively thick layer of fine-grained sediments that create an engineering design challenge. For these reasons and more

constructability is expected to be difficult with this option and dam safety concerns have been expressed.

- **Overcome Institutional Barriers/Public Acceptance (Permitting):** The Preferred Alternative assumes that easements or deeds would be obtained for the entire seabed below elevation -228 ft msl to allow construction and operations and maintenance activities. If other land uses extend into the seabed, the Preferred Alternative would need to be modified in project-level analyses. For example, if exposed lands were to be converted to cultivated agriculture to an elevation of -235 ft msl, either the components would need to be constructed at lower elevations or displacement dikes would be required to protect the agricultural land. This makes permitting of a moderate difficulty when compared to other alternatives.
- **Reasonable Cost/High Probability of Financing:** While the State prepared a financing plan in 2007, the legislature never appropriated any funds and the cost estimate brought into 2015 dollars is $12 billion. Currently no efforts appear to be underway to secure financing for this plan. Maintenance of flow control structures, pumping and other factors would make the overall costs of O&M high. Annual operation costs were estimated at $142 million in 2006.

9.2 Authority Preferred Plan 2006

In 2006, the Authority proposed a plan that has since been eliminated from further consideration. The Authority's plan included the following components: an in-Sea barrier and circulation channels; water treatment facilities; habitat enhancement features; Colorado River water storage; and park, open space, and wildlife areas. The Authority's plan can be seen in Figure 32. The chief feature of the plan would have been an approximately 33.5-mile-long, rock-fill, in-Sea barrier. This engineered structure would have permanently separated the present 360-sq.-mile Sea into an outer 180-sq. mile lake water system, and an inner 180 sq. Mile habitat and salt deposit area in the south end of the current Sea. The plan was comprehensive, but it would have been a costly option that could never get through.

- **Provide Large Marine Lake with Stable Elevation:** An in-sea barrier and circulation channels were proposed to separate the Sea into two separate bodies (an outer "two lake" water system and multiple habitat complex areas, salt deposit area, and the residual saline pool) with a channel for circulating water between the two lakes in the outer water system. The outer 180 sq. mi. water system would satisfy the marine lake objective, and the inner 180 sq. mi. habitat and salt deposit area planned for the southern end of the Sea would help maintain stable levels of elevation and salinity.

Figure 32 Authority's 2006 Plan

- **Improve Water Quality: Salinity:** This option could be adjusted to be adapted to a lower salinity level, and if it were implemented salinity and elevation conditions at the Sea would dramatically improve.
- **Improve Water Quality: Nutrients/Other Constituents:** Planning to manage potentially harmful nutrients and other constituents included water treatment facilities, and treatment wetlands.
- **Maintain and Improve Habitat:** Habitat enhancement features were proposed to meet the needs of fish and bird populations consistent with State laws that required the "maximum feasible attainment" of specified ecosystem restoration goals. This plan also called for treatment wetlands along the Whitewater, New and Alamo Rivers which, if implemented, may have stimulated bioaccumulation.
- **Achieve Water Quality and Habitat Objectives in a Timely Manner (Timeframe):** While the timeframe for this option would not be as long as it would be in a pump in/out scenario, the timeframe would still be relatively long compared to the Perimeter Lake concept.
- **Respond to Inflow Changes:** The full-scale implementation of this plan would require approximately 700,000 AFY. The plan would be vulnerable to reduced lake elevations if inflows are reduced in the future below this inflow amount.
- **Increase Recreational and Economic Potential:** Treated water in the outer lake area was anticipated to meet recreational water quality standards set by the Regional Water Quality Control Board. Additionally, restoration work involved in this plan would economically benefit the surrounding area.
- **Address Air Quality (PM_{10}) Mitigation:** AQM would occur based on the structuring of the alternative because exposed playa would either be entrenched in water or present under a salt crust in the sink. However, this measures have been evaluated as fair with respect to other alternatives.
- **Provide High Safety Rating/Low Risk of Failure:** The foundation conditions of the Sea have been investigated and found to be composed of a relatively thick layer of fine-grained sediments that create an engineering design challenge. For these reasons and more constructability is expected to be difficult with this option and dam safety concerns have been expressed.
- **Overcome Institutional Barriers/Public Acceptance (Permitting):** Because of dam safety concerns, permitting is expected to be difficult with this option.

- **Reasonable Cost/High Probability of Financing:** Since the plan was prepared nearly 10 years ago, no funding sources have been secured. With an estimated capital cost of $4-5 billion in 2015 dollars using an ENR construction cost escalation factor, cost is a major challenge to this concept. Even at a lower elevation this plan would be costly. In addition, pumping operations and water treatment would require substantial O&M costs.

9.3 Import/Export

Due to the increasing salinity at the Sea, creating an outlet to the Gulf of California or Pacific Ocean has seemed like an attractive option to many. The basic idea behind such a system is that hypersaline water in the Sea would have an outlet while incoming ocean water would sustain the Sea. The pros and cons of such a scenario are the following:

- **Provide Large Marine Lake with Stable Elevation:** A large scale transfer of water between the Salton Sea and Gulf of California or the Pacific Ocean may theoretically provide a water supply that could help regulate the Sea level. However, even high exchange rates would leave the salinity in the Salton Sea higher than the salinity in the Gulf of California or the Pacific Ocean.
- **Improve Water Quality: Salinity:** Theoretically, this alternative would manage salinity by cycling water to and from the Sea. Additionally, this alternative would help manage surface elevation because a pipeline or pipelines combined with canals to the Gulf or Ocean would offer the opportunity of developing a return line that would bring water with ocean-like salinity back into the Sea. Pipelines for pumping water uphill from the Sea and the Gulf coupled with a canal system on the downslope side could also possibly provide a navigable waterway to the ocean.
- **Improve Water Quality: Nutrients/Other Constituents:** Pipelines to the Gulf of California or the Pacific Ocean could increase hypoxic conditions and create an unnatural environmental dead zone. Additionally, this option runs the risk of exchanging exotic species and bacteria between water bodies.
- **Maintain and Improve Habitat:** The exchange of water with the Gulf or Ocean faces ecological problems. For example, exotic species from the Sea could be introduced into the Gulf and vice versa. It is also possible that bacteria that create red tides in the ocean could be imported that would cause large fish mortality incidents in the Salton Sea. However, if these problems and others were found to be of no or little concern, the incoming water could benefit the local wildlife.

- **Achieve Water Quality and Habitat Objectives in a Timely Manner (Timeframe):** The massive amount of political and physical resources needed for this scenario make a timeline for this project very long.
- **Respond to Inflow Changes:** This type of planning includes full-scale restoration that would require a net inflow of approximately 700,000 AFY, which would be a balance of much larger import and export flows.
- **Increase Recreational and Economic Potential:** The benefits of these scenarios are outweighed by the costs, but they would potentially supply a useful source of water for the Sea if they were able to be implemented.
- **Address Air Quality (PM_{10}) Mitigation:** Maintaining sea elevation through this plan could theoretically reduce localized fugitive dust emissions by concealing otherwise exposed playa. This makes the potential AQM for this option very good.
- **Provide High Safety Rating/Low Risk of Failure:** The sheer size of transferring water between the Salton Sea and the Gulf of California or the Pacific Ocean would present a high level of safety concerns. In addition, due to the large capital cost associated with this alternative and the inability to implement such a project on a smaller-scale, this alternative would be very difficult to construct.
- **Overcome Institutional Barriers/Public Acceptance (Permitting):** Due to the magnitude of these projects permitting would be a large and complex process which could involve the following issues: crossing through densely populated and well-established communities; obtaining challenging easements, land acquisitions, and approvals, obtaining access to level ground for large diameter pipelines; and, for using the Gulf of California, obtaining approval to place infrastructure in Mexico.
- **Reasonable Cost/High Probability of Financing:** As indicated in Benchmark 4, Volume 1, a full import/export option that preserves the Sea at -230 ft NGVD and at a salinity of 50 PPT could cost in excess of $50 billion. At this cost, this type project would have a low probability of funding from traditional sources.

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10.0 Summary

The Perimeter Lake concept is summarized and an overview of the advantages is presented.

The analyses presented in this report indicate that the Perimeter Lake concept would meet objectives that were originally developed in concert with other stakeholders in 2004 and also would meet the realities of 2016 and the future demands on water in the Salton Basin:

- Preserve the Sea as a Repository for Agricultural Runoff
- Provide Lake with Stable Elevation
- Improve Water Quality: Salinity
- Improve Water Quality: Nutrients/Other Constituents
- Maintain and Improve Habitat
- Achieve Water Quality and Habitat Objectives in a Timely Manner
- Respond to Inflow Changes
- Increase Recreational and Economic Potential
- Address Air Quality (PM_{10}) Concerns
- Provide High Safety Rating/Low Risk of Failure
- Overcome Institutional Barriers/Public Acceptance (Permitting)
- Reasonable Cost/High Probability of Financing

The Perimeter Lake would rely upon a system of low profile levees to create a reasonably affordable and sustainable water body. This system would generally resemble an in-stream reservoir built along a slowly flowing river, it would include wider recreational areas in the north and south ends of the Sea, although boating would be accommodated along the entire 60+ mi of lake front property. The exposed playa on the southern end of the Sea near the Perimeter Lake project site would be designated for IID's SSRREI. Built incrementally, the water used in the Perimeter Lake system would initially flow through a series of linked but separated elongated ponds.

Treatment wetlands, possibly those incorporated in the SCH project, are proposed near or upstream from the mouth of the New River to provide higher quality water entering the system, although no specific plans have been developed at this point. In sections ranging from 500 ft to over 2 mi in width, water entering the Perimeter Lake system would arrive in a wide area at the south end of the Sea, flow northward along the western shore, and arrive at another wide area in the north. Water would flow out of the northern area and move southward along the eastern shore to a terminus spillway. Here, at the terminus spillway, excess water would be channeled into a permanent saline pool in the center of the historic seabed.

Spillways at several locations within the system and the quantity and salinity of water diverted into the system would allow for management of salinity from near fresh to marine, with the expectation that the target salinity would be brackish (15-20 PPT). Excess salinity would concentrate in the saline pool located near the center of the Sea.

At full build out, the total length levee running parallel to the shore would be approximately 61 mi. Additionally, 13 perpendicular connector levees or dikes totaling 6 mi would connect to existing roads so that construction could proceed as individual cells. The total area of all 13 cells would be approximately 36 sq mi, with 10 sq mi in Riverside County and 26 sq mi in Imperial County. The levees would be constructed by dredging a channel along the lake side of the levee which would create a deep water habitat area of up to 25 ft in depth for the full length of the lake.

The annual inflow required to balance evaporative and seepage losses is estimated at 167,000 AFY. Initially, additional water could be run through the system to reduce salinity and nutrients in the water column and clean out detritus. Once in operation, the water body could be used to convey water to other habitat areas or for dust control.

10.1 Advantages of the Perimeter Lake Concept

The Perimeter Lake concept would revitalize the Salton Sea and the surrounding area by providing the following benefits: stable shoreline with elevation control in a lake with an area of 36 sq mi, improved water quality with reduced salinity, a source of water for AQM, compatibility with other Salton Sea management projects, and a deep water habitat that would also be suitable for recreational uses. Spillways in the north and south would provide salinity control and allow management of water in the perimeter lake at brackish levels (15-20 PPT). Initial flushing would help remove detritus and nutrients that are already present in the lake at high levels, and proposed treatment wetlands would improve the quality of water flowing in from the New River.

Lake elevation with this plan would be slightly below historic shorelines from 1960-2010 period; however, these levels would reduce the water requirement for the Perimeter Lake component to only 167,000 AFY, and remaining inflow (522,000-689,000 AFY) could be used for other projects such as SCH, IID's SSRREI, AQM, or other habitat projects. The Perimeter Lake is planned to be outside the boundaries of the KGRA and thus would not interfere with opportunities for development of geothermal or other renewable energy projects.

The deep water areas of up to 25 ft have recreational value for boating and fishing, and they would also benefit habitat by providing a food source for resident and migratory piscivorous birds. Additionally, the Perimeter Lake plan would include 130 mi of shallow habitat along the existing shoreline and levees for wading birds. At 36 sq mi, the Perimeter Lake would be significantly larger than all other lakes in southern California, including the 32-sq mi Lake Havasu. A comparison of the northern and southern areas of the Perimeter Lake to three California lakes is shown in Figure 33.

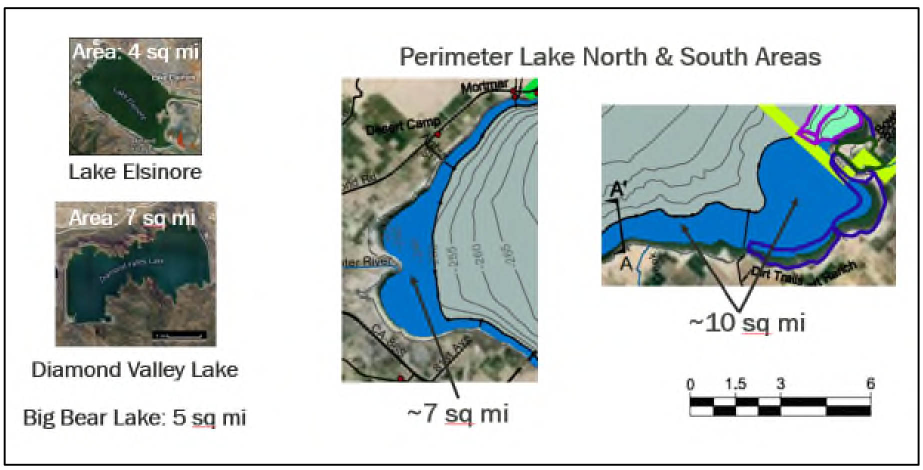

Figure 33 Comparison of North and South Areas of Perimeter Lake to Other Southern California Lakes

In addition to the general benefits of the Perimeter Lake plan, the plan would provide specific benefits in Imperial County and Riverside County.

Imperial County. Benefits in Imperial County include the following:

- A 26 square mile lake with areas up to 25 ft deep;
- A Lake with significantly cleaner and lower salinity water than the current Salton Sea;
- A stable shoreline for Imperial County communities such Bombay Beach, Desert Shores, Salton City & Salton Sea Beach;

- Dredging that would allow access to existing marinas;
- A deep reservoir in south to support the micro-climate for agriculture;
- A shallow habitat zone along nearly 100 miles along the existing shoreline and levees;
- Habitat/dust control in SSRREI area that allows full access to KGRA;
- Provisions for supporting the existing Air Quality Control Plan; and
- An irrigation source for emissive playa in Imperial County.

Riverside County. Benefits in Riverside County include the following:

- A 10 square mile lake with areas up to 25 ft deep;
- A shallow habitat zone along nearly 30 miles along the existing shoreline and levees;
- A lake with cleaner, lower salinity water;
- A Stable shoreline for Riverside County areas including the State Recreation Area;
- Dredging that would allow access to existing marinas such as North Shore Yacht Club; and
- An irrigation source for emissive playa in Riverside County.

As described in Benchmark 4 Volume 1, No Action would cause a rapid increase in salinity, a rapid decline in elevation, and a decreased Salton Sea area. Other efforts to address these concerns, such as importing and exporting large amounts of water, would require more money and water than what is needed for the Perimeter Lake Plan. As with any Salton Sea management project, funding and permitting the Perimeter Lake Plan would be a challenge; however, the needs (in terms of water and cost) along with the benefits of the plan make it a viable alternative.

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Appendix A: Geotechnical Report

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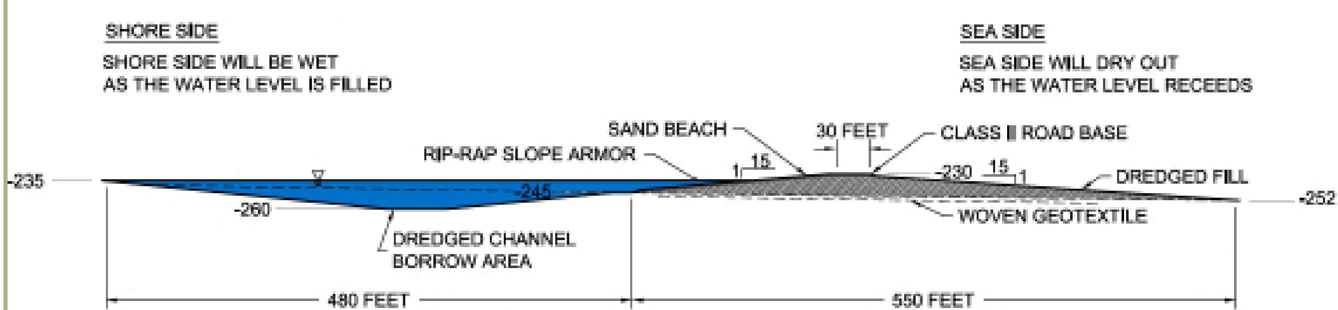
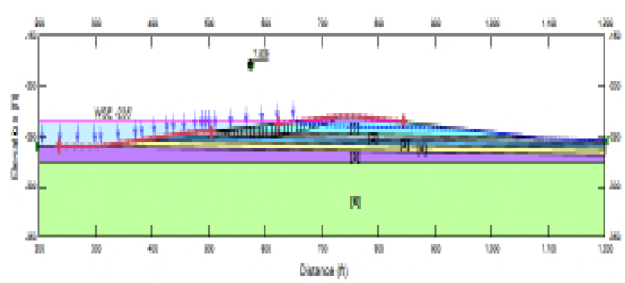
Salton Sea Funding and Feasibility Action Plan

Geotechnical Feasibility Study: Salton Sea Perimeter Lake Low Profile Levee Analysis

Benchmark 4: Volume 2, Technical Appendix A

May 2016





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This document is prepared as a living document for public review and comment. Comments may be provided to:

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Comments will be reviewed and incorporated as appropriate. If substantive comments are received, a revised document may be produced and distributed.

GEOTECHNICAL FEASIBILITY STUDY
SALTON SEA PERIMETER LAKE LOW PROFILE LEVEE ANALYSIS
Benchmark 4: Volume 2, Technical Appendix A

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1.0 Introduction

A feasibility and conceptual level geotechnical assessment was conducted to evaluate the Salton Sea Perimeter Lake Low Profile Levee Alternative. On the basis of this investigation, no geotechnical factors have been identified that would preclude the successful design and construction of the project. However, several factors will require special consideration during the design, engineering and construction of the project.

The assessment is based on the available subsurface information and testing data presented in previous geotechnical investigations performed within the Salton Sea area (URS 2003, 2007a, and 2007b). Because the proposed perimeter levee might be interpreted to function as a low dam, the initial evaluations were performed in the context of expected requirements of the California Division of Safety of Dams (DSOD), because this would be a conservative approach.

2.0 Summary of Findings

Levee Embankment Construction: For safety considerations, the proposed perimeter levee would need to be constructed with compacted, engineered fill for long term stability. This will require a phased approach to construction that would involve stockpiling, dewatering and spreading excavated soils, drying the material to near optimum moisture content, and mechanical placement and compaction of the material.

Settlement Mitigation: Post-construction consolidation of the soft seafloor deposits, lacustrine and alluvial sediments would cause settlement of the perimeter levee embankment an estimated 2-4 feet. Detailed evaluation of settlement potential would need to be performed during the full design phases of the project. Several methods to mitigate the embankment settlement have been identified.

Seepage Mitigation: Underseepage caused by higher permeability sandy alluvial sediments under the levee could cause excessive exit gradients and/or excessive seepage to or near the downstream toe. Thorough subsurface investigation along the length of the proposed levee should be performed during the design process to provide better definition of areas where underseepage could be problematic. Underseepage issues could be mitigated by one of several methods identified, including a sheetpile wall thru the levee and the underlying sand layers.

The preliminary seepage modeling indicates that seepage exiting from the downstream slope of the levee could also occur. If mitigation of the dispersive potential of levee fill is required, seepage through the levee would need to be controlled by a hydraulic barrier or filtered drainage installed within the levee embankment. Seepage of 80 to 120 gallons/day/ft. have been estimated assuming appropriate engineering controls and mitigation.

Soil Liquefaction and Seismic Deformation Mitigation: Preliminary analysis indicates that deformation up to approximately 6 feet horizontally could occur in response to the design level earthquake event and liquefaction of foundation soils. Thorough subsurface investigation should be performed during the design process to provide better definition of areas where liquefaction-susceptible material exists. The issue of liquefaction-induced deformation could be addressed by implementing one or more of the identified methods.

Further Studies: A comprehensive geotechnical investigation will be required to adequately support the design process and respond to the special considerations. This work will be essential in obtaining a better understanding of the engineering properties and distribution of the various soil deposits underlying the project site. It will also be valuable in identifying areas where problem conditions exist so that locally targeted and efficient geotechnical designs can be provided.

Modifications to the Conceptual Design: Several modifications to the conceptual design are being considered. After additional constructability reviews and updated forecasts of receding Sea levels, the conceptual design will likely evolve. These modifications could include steepening of the lake side slope of the levee, installing a sheet pile through the levee and leaving portions of the dredged fill (used to build the perimeter levee) in place without further mechanical compaction. These modifications will require further geotechnical evaluation, and would likely not allow the design to meet the rigorous requirements for a dam embankment as mandated by DSOD. In this event, the design would need to evolve into a levee embankment design meeting the requirements of DWR and/or Corps of Engineer criteria.

3.0 Scope of Work

The scope of services for this feasibility assessment consisted of the following tasks:

- Review of available background data, including in-house and/or Client-provided geotechnical data, geotechnical literature, and geologic maps relevant to the subject site.
- Estimation of settlement potential of the embankment due to consolidation of the underlying foundation soils.
- Evaluation of seepage through and beneath the proposed levee embankment including assessment of pore pressures and hydraulic gradients.
- Evaluation of liquefaction potential of foundation soils during and after a design level earthquake.
- Evaluation of stability of the levee embankment under hydraulic and seismic loading.
- Estimation of potential vertical and lateral deformation of the embankment under seismic loading.
- Presentation of conclusions and recommendations regarding the feasibility of the conceptual design and studies required to move forward with the levee concept.
- Preparation of this findings and summary report.

4.0 Conceptual Levee Design

The conceptual design alternative being evaluated by this geotechnical assessment involves the construction of a low profile levee within the sea, around a significant portion of the perimeter of the current sea. The levee would allow for the development of navigable waterways and lakes around the current sea perimeter. The concept would include dredging of waterways around the sea perimeter and construction of a confining levee on the seaward side of the new waterways. The levee would allow for the perimeter waterways and lakes to be conserved as the Salton Sea surface elevation recedes over the next 10 to 15 years. The waterways and levees would be constructed along the southern, western, northern, and northeastern perimeter of the existing sea.

The total length of the perimeter levee would be on the order of 60 miles. The conceptual layout of the perimeter levees are shown in Figure 1.

The current concept envisions dredging the perimeter waterways to a depth of approximately 15 feet below existing grade (bottom of dredging at elevation -260). The dredged material would be used to construct low profile levees between the dredged waterway and the Salton Sea. The current concept for the levee embankment includes a 30 foot crest width and side slopes constructed at an angle of 15 horizontal (H) : 1 vertical (V). It is expected that the levees would be constructed in phases; first stockpiling, spreading and drying the material as much as possible to obtain workable moisture contents, and then staged placement of the fill in order to allow for consolidation of the underlying foundation soils. The initial conceptual design cross section of the low profile levee is shown in Figure 2. It is recognized that refinement of the conceptual cross section is on-going. Preliminary constructability and feasibility assessments have recommended steepening the lake side slope in order to facilitate dredging operations and levee construction. The effect of steepening this slope, as well as other modifications to the evolving conceptual plan, should be further evaluated from a geotechnical standpoint as the design proceeds.

5.0 Assumed Subsurface Stratigraphy

The existing data indicates a fairly variable subsurface stratigraphy consisting of deltaic, lacustrine and fluvial sediments. In order to develop a reasonable model for subsurface conditions, the exploratory borings from the referenced URS investigations that were drilled adjacent to or along the existing Salton Sea shoreline were reviewed. Based on this review, a general description of the various soil units included in the engineering model for this assessment is presented in Table 1.

Table 1
Assumed Subsurface Stratigraphy

Soil Unit	Assumed Thickness (feet)	General Description
Seafloor Deposits	4	Predominantly high plastic clay with some silty sand
Very Soft to Medium Stiff Lacustrine Deposits	6	Predominantly high plastic clay with interbeds of lean clay, silt and silty sand
Very Loose to Medium Dense Alluvial Deposits	8	Silty and clayey fines sands
Dense to Very Dense Alluvial Deposits	10	Silty and clayey fines sands
Stiff to Hard Lacustrine Deposits	> 20	Predominantly high plastic clay with some low plastic clay and silt

6.0 Conceptual Design Cross-Section

The conceptual cross-section that was used for the engineering modeling was based on a conservative assessment of the typical existing terrain. A critical slope for the existing grade of about 1.25 percent toward the Salton Sea was assumed. The model utilized a levee embankment crest at elevation -230 feet with a width of 30 feet. The embankment fill slope on the waterway side was set at a gradient of 15H:1V to an elevation of –245 feet where it meets existing grade. At that point there is a 20 foot horizontal bench, and then a dredged cut slope at a gradient of 10H:1V to a bottom elevation of –260 feet. The embankment slope on the Salton sea side was set at a gradient of 15H:1V to an elevation of -252 feet where it meets existing grade. Some modifications to this conceptual design is likely to occur and will need to be evaluated from a geotechnical standpoint as the design proceeds.

A water reservoir elevation of -235 feet was set on the waterway side of the levee. No water reservoir was assumed on the Salton Sea side of the levee as a long term condition. Futher analysis may be required for interim conditions where there could be some water on the sea side of the levee

7.0 Seismic Demand

The evaluation of potential seismic shaking along the proposed perimeter levee alignment was performed utilizing a deterministic analysis in conformance with standard DSOD practice. The procedure establishes the Maximum Credible Earthquake (MCE) which controls the seismic design. Two fault systems were identified that would have the most potential impact on the project, including the San Andreas and San Jacinto fault systems. Due to the large size of the project, ground motion parameters were estimated at several locations along the Salton Sea perimeter. The peak ground acceleration (PGA) and spectral accelerations for the MCE event were determined with selected Next Generation Attenuation (NGA) – West 2 models, including Abrahamson and Silva (2014), Boore et al. (2014), Campbell and Bozorgnia (2014), and Chiou and Youngs (2014). Due to the high slip rates of both the San Andreas and San Jacinto fault systems and consequence of dam failure, DSOD procedures would require that the 84th percentile values be used for design purposes. The NGA-West 2 models were developed as part of a multidisciplinary research program coordinated by the Lifelines Program of the Pacific Earthquake Engineering Research Center (PEER), in partnership with the U.S. Geologic Survey (USGS) and the Southern California Earthquake Center (SCEC). The PGA and spectral acceleration values were calculated using the Excel spreadsheet developed by Seyhan (2014), assuming a shear wave velocity of 270 meters per second (m/s) for the upper 100 feet profile (URS, 2007a). A summary of the causative faults, associated fault parameters, and ground motion values for different areas along the levee alignment are presented in Table 2.

Table 2
Summary of Seismic Design Parameters

Location	Causative Fault	Moment Magnitude M_w	Fault Distance R_x (km)	Peak Ground Acceleration (g)
Eastern / Northern Levee	San Andreas (Coachella Section)	7.9	0.9	0.82
Western Levee	San Andreas (Coachella Section)	7.9	13.5	0.54
Western / Southern Levee	San Jacinto (Lone Tree Section)	6.6	4.3	0.64

8.0 Liquefaction Evaluation

The liquefaction potential of cohesionless (sandy) soils was evaluated based on the SPT blowcounts and laboratory test results taken from the referenced sources. The analysis utilized the procedure published in Idriss and Boulanger (2008). The analyses was based on standard penetration test (SPT) values taken from the referenced geotechnical investigation and utilized an energy ratio correction factor C_E of 1.25. This ratio is based on a hammer efficiency of approximately 75 percent which is considered conservative for the automatic trip hammers that were used for the field exploration.

Liquefaction potential and seismic sensitivity of fine-grained soils was evaluated per Bray and Sancio (2006). The fine-grained soils are classified in the following 3 categories:

1. Fine-grained soils with Plasticity Index < 12 and moisture content > 85 percent of the liquid limit are classified as fine-grained soils susceptible to liquefaction (typically includes silts);

2. Fine-grained soils with Plasticity Index > 18 and a degree of sensitivity $S_t > 6$ are classified as fine-grained soils potentially susceptible to significant loss of strength during seismic shaking and require additional evaluation. The sensitivity of the on-site fine-grained soils is evaluated based on the water content, Atterberg limits, and effective vertical stresses using the procedures suggested by Holtz and Kovacs (1981) and Terzaghi, Peck and Mesri (1996).

3. Fine-grained soils falling outside the two categories above are considered to behave like clays and are not considered susceptible to liquefaction or cyclic softening.

Results of liquefaction analyses of granular soils indicate that there is a potential for liquefaction and subsequent loss of shear strength and settlement of the saturated granular alluvial soils. The results of the analysis are summarized in Table 3.

The Plasticity Index of the on-site fine grained soils generally varies 20 and 51. Analyses of the sensitivity of the saturated fine-grained soils indicated low sensitivity based on the estimated sensitivity ratios between 1 and 2. Consequently, the potential for significant loss of strength of fine-grained materials during seismic shaking is considered low.

In addition to the vertical settlement caused by of liquefaction as outlined in Table 3, there is also the potential for lateral movement, often referred to as lateral spread. Empirical relationships have been developed for estimating lateral spread for gently sloping terrain, Youd et. al. (2002), however, the relationships are most applicable for ground conditions sloping at less than 6 percent. For 15H:1V levee slopes and 10H:1V dredged slopes a more applicable evaluation of potential lateral movement would be a seismic slope deformation analysis which incorporates the post liquefaction, residual undrained shear strength of any liquefiable soils. This deformation analysis is presented in the Slope Stability section of this report.

Table 3
Summary of Liquefaction Potential of Granular Soils

Boring No.[1]	Depth of Liquefiable Material (below seafloor, ft)	Estimated Seismic Settlement (inches)	Estimated Post-Liquefaction Residual Strength[2] (psf)
B-2	N/A	N/A	N/A
B-11	0 - 6	1.8	100 - 220
B-32	6-24; 47-50	3.6	220 – 520
B-38	12-13; 26-27.5	0.4	220 - 600
B-39	10-13.5; 38-49	2.8	190 - 750
B-47	2.5-6; 7.5-14	3.1	100 - 200
B-48	6-33.5	4.2	360 - 650
B-53	0-7; 18-23.5	7.1	80 - 250
B-56	9-20	1.7	300
B-59	0-24; 36-44	9.9	80 – 700
B-63	N/A	N/A	N/A

[1] Perimeter Borings from URS (2004, 2007a).
[2] Lower bound value estimated based on equivalent clean-sand SPT-corrected blow count per Seed and Harder (1990). Upper bound value estimated based on normalized residual shear strength ratio per Idriss and Boulanger (2008).

9.0 Soil Parameters

In order to perform settlement, seepage and slope stability/deformation analysis the engineering properties for the various soil units presented in Table 4 were used. The parameters were based on the existing field and laboratory data presented in the referenced geotechnical investigations and on engineering judgement. The proposed levee embankment material was assumed to be compacted dredged material composed of a mixture of the upper three soil units.

Table 4
Summary of Soil Engineering Parameters

Soil Unit	Total Unit Weight (pcf)	Drained Strength		Undrained Strength		Post Liquefaction Residual Strength (psf)	Permeability		Compression Index $C_c/(1+e_0)$	Coefficient of Consolidation (ft^2/year)
		c' (psf)	ϕ' (deg)	c (psf)	ϕ (deg)		k_v (ft/sec)	k_h (ft/sec)		
Levee Embankment Fill	115	200	25	NA	NA	NA	1.64e-6	1.64e-5	NA	NA
Sea Floor Deposits	100	75	27	150	0	NA	3.28e-6	3.28e-5	0.25	18
Very Soft to Medium Stiff Lacustrine Deposits	110	100	27	500	0	NA	3.28e-6	3.28e-5	0.12	30
Very Loose to Medium Dense Alluvial Deposits	125	100	28	NA	NA	200	1.64e-3	3.28e-3	0.07	60
Dense to Very Dense Alluvial Deposits	125	120	30	NA	NA	NA	3.28e-4	6.56e-4	NA	NA
Stiff to Hard Lacustrine Deposits	115	250	23	2000	0	NA	1.64e-6	1.64e-5	0.10	30

10.0 Settlement

Static Conditions: Settlement analysis indicates that the underlying soils, particularly the recent sea deposits and soft lacustrine clay, will undergo consolidation under loading from the proposed perimeter levee. The estimated settlement under embankment loading is estimated to be on the order of 2 to 4 feet, depending on the thickness of the soft sediments. It is estimated that most of this settlement will occur within 3 years of levee construction. This amount of time could be significantly reduced by the placement of vertical drains such as wick drains or sand wells. This amount of settlement will need to be considered in the sizing of the initial embankment in order to compensate for the loss of freeboard.

Seismic Conditions: As presented in Table 3, liquefaction of the underlying granular soil deposits could result in vertical settlements up to roughly 10 inches. This amount of potential settlement should also be incorporated into sizing of the initial levee embankment.

11.0 Seepage and Slope Stability

11.1 Seepage Modeling

Seepage analyses were performed utilizing the finite element software SEEP/W. A steady state seepage analysis was performed on the conceptual design cross section of the proposed levee embankment utilizing the subsurface stratigraphy outlined in Table 1. Results of seepage modeling are presented in Attachment A.

The seepage modeling results indicate that the upper layer of granular alluvial soils could potentially act as conduit for significant underseepage below the levee, particularly if this layer is exposed upstream in the dredged waterway. This underseepage could develop high vertical exit gradients at or near the downstream toe of the levee where it is overlain by less permeable blanket layer of lacustrine and/or sea floor sediments. This condition of high vertical hydraulic gradient could initiate fissures, piping and sand boils if not mitigated. This condition could be exacerbated by the presence of dispersive soils within the low permeability blanket layer. The results of the dispersive potential tests (pin hole tests) performed during the referenced preliminary investigations indicated slight to moderate dispersive potential (grade ND3 and ND4 per ASTM D4647) for the near surface sea floor and lacustrine deposits.

A preliminary seepage quantity analysis was performed that included a continuous granular alluvial layer below the levee. This model estimated seepage losses of roughly 80 gallons/day/foot of levee through the levee, and roughly 210 gallons/day/foot below the levee. This model not only shows the potential for high hydraulic exit gradients but also a significant loss of water from the waterway.

It is recognized that these layers of granular alluvial soils (seepage layers) are not present everywhere and can exist as small deposits interfingered with the lacustrine deposits are as larger fan like deposits at the discharge point of drainages into the sea. However, where continuous layers of granular alluvial soils are encountered across the levee footprint near or above the waterway dredge elevation, the condition will need to be mitigated by some form of hydraulic barrier, such as sheetpiling or other low permeability cutoff layer/wall. The potential for seepage losses on the landward side of the waterway dredging excavation may also need to be evaluated, but are likely less of an issue. It is expected that an effective hydraulic barrier to control the seepage below the levee could decrease seepage quantities by at least one order of magnitude. Therefore, with appropriate controls in place, total seepage could be in the range of 80 to 120 gallons/day/ft. or 27,000 to 40,000 acre-feet/year if projected over the entire length of the levee.

As discussed previously, the analysis indicated that without a hydraulic barrier, seepage would exit through the downstream face of the levee embankment. Due to the gentle slope of the levee (15H:1V) the horizontal hydraulic exit gradient within the slope is not excessive (<0.15). With properly compacted fill and the level of clay content provided by the source material (dredged material), this condition would generally not be expected to be problematic. As discussed previously, test performed on some of the seafloor deposits and upper lacustrine sediments did indicate slight to moderate dispersive potential. Further testing of soil materials along the levee path will need to be performed to evaluate whether measures to mitigate dispersive soils is necessary.

11.2 Slope Stability

The slope stability analysis was performed by utilizing the computer software SLOPE/W. Seepage conditions calculated by the SEEP/W model were directly input into the SLOPE/W model. Results of slope stability analyses are presented in Attachment B.

Static Conditions: Slope stability analysis performed on the conceptual cross-section conditions indicate that the proposed embankment slope should perform satisfactorily under static conditions. A summary of minimum factors of safety evaluated using both circular and block sliding methods is summarized in Table 5.

Table 5
Static Slope Stability - Minimum Factors of Safety

Upstream (Waterway) Slope		Downstream (Salton Sea) Slope	
Circular	Block Slide	Circular	Block Slide
7.53	4.01	4.07	2.54

Seismic Conditions: Seismic stability evaluation was performed utilizing the deterministic MCE parameters discussed previously. Due to the very high seismicity of the area it is anticipated that even a low profile levee embankment will undergo some deformation during the design level event. The extent of deformation will depend largely on whether liquefaction of the saturated granular foundation soils will occur. In areas where significantly thick and continuous layers of loose to medium dense sands do exist, the potential for liquefaction is considered to be high.

Potential permanent seismic deformation was evaluated using the empirical relationships presented by Bray and Travasarou (2007) and the results are presented in Tables 6a, 6b and 6c. The analysis was performed assuming the conceptual cross-section at several different locations within the project site. This is because seismic shaking varies considerably based on the distance to the major causative faults. The presented results demonstrate the range of possible seismic deformation. Case I assumes that no liquefaction of the subsurface soils will occur, and drained shear strength are utilized for all soil layers. Case II assumes liquefaction of granular foundations soils will not only occur but that these soil layers will lose strength very quickly after the onset of the design seismic event. Post-liquefaction residual shear strength is utilized for liquefiable alluvium and undrained shear strength is utilized for seafloor deposits and very soft to medium stiff lacustrine deposits.

The estimated permanent seismic slope deformation is assumed to be in the direction of slope movement, therefore, most of the deformation would be expected to be in the lateral (horizontal) direction, however, and there would be a significant amount of vertical movement also associated with the deformation. More rigorous analysis (e.g., finite element or finite difference methods) would be required to better define the post-deformation configuration of the levee embankment.

The amount of estimated slope movement, even for the full soil liquefaction condition, is not considered an impediment to the conceptual design, however, proper mitigation of this deformation potential should be included in the project design.

Table 6a
Eastern and Northern Perimeter Levee – Seismic Slope Deformation (feet)

Subsurface Conditions	Upstream (Waterway) Slope		Downstream (Salton Sea) Slope		Attachment C Page No.
	Circular	Block Slide	Circular	Block Slide	
Case I - No Liquefaction	3.3	0.5	3.3	0.5	C1 – C4
Case II - Liquefaction of Granular Soils	3.4	4.1	4.6	6.1	C5 – C8

Table 6b
Western Perimeter Levee – Seismic Slope Deformation (feet)

Subsurface Conditions	Upstream (Waterway) Slope		Downstream (Salton Sea) Slope		Attachment C Page No.
	Circular	Block Slide	Circular	Block Slide	
Case I - No Liquefaction	1.2	0.2	1.5	0.2	C9 – C12
Case II - Liquefaction of Granular Soils	2.0	2.5	2.8	4.1	C13 – C16

Table 6c
Western and Southern Perimeter Levee – Seismic Slope Deformation (feet)

Subsurface Conditions	Upstream (Waterway) Slope		Downstream (Salton Sea) Slope		Attachment C Page No.
	Circular	Block Slide	Circular	Block Slide	
Case I - No Liquefaction	1.1	0.3	1.3	0.3	C17 – C20
Case II - Liquefaction of Granular Soils	1.9	2.3	2.6	3.6	C21 – C24

12.0 Conclusions and Recommendations

Based on this feasibility and conceptual level geotechnical assessment it is our opinion that there are no geotechnical factors that would preclude the successful development of the conceptual design. However, several factors will require special consideration and geotechnical re-evaluation during the design, engineering and construction of the project.

Levee Embankment Construction: In order to meet DSOD requirements, the proposed perimeter levee will need to be constructed with compacted, engineered fill for long term stability. This will require a phased approach to construction that would involve stockpiling, dewatering and spreading excavated soils, drying the material to near optimum moisture content, and mechanical placement and compaction of the material.

Settlement Mitigation: Post-construction consolidation of the soft seafloor deposits, lacustrine and alluvial sediments will cause settlement of the perimeter levee embankment. Detailed evaluation of settlement potential should be performed as the design proceeds. Several methods can be considered to mitigate the embankment settlement including the following:

- Overbuild of the crest to provide sacrificial freeboard.
- Surcharging of the foundation areas with dredging spoils prior to construction.
- Installation of vertical drainage devices, such as wick drains or sand drains, to expedite consolidation of foundations soils.
- Selected removal of highly compressible material.

Seepage Mitigation: Underseepage caused by higher permeability sandy alluvial sediments under the levee could cause excessive exit gradients and/or excessive seepage to or near the downstream toe. Thorough subsurface investigation along the length of the proposed levee should be performed during the design process to provide better definition of areas where underseepage could be problematic. Underseepage issues could be mitigated by one of several methods including the following:

- Installation of a seepage barrier within the upstream portion of the perimeter levee. Barriers could be provided by low permeability slurry trenches, sheetpiles with water sealed joints, or upstream lining/cover.
- Installation of a filtered cutoff drain at the downstream toe.

The preliminary seepage modeling indicates that seepage exiting from the downstream slope of the levee could also occur. Further evaluation of the dispersive potential of the potential levee borrow material (dredged material) needs to be performed. If mitigation of the dispersive potential of levee fill is required, seepage through the levee would need to be controlled by a hydraulic barrier or filtered drainage installed within the levee embankment.

Soil Liquefaction and Seismic Deformation Mitigation: Preliminary analysis indicates that deformation up to approximately 6 feet could occur in response to the design level earthquake event and liquefaction of foundation soils. Thorough subsurface investigation should be performed during the design process to provide better definition of areas where liquefaction-susceptible material exists. The issue of liquefaction-induced deformation could be addressed by implementing one or more of the following methods:

- Overbuild of crest to provide sacrificial freeboard.
- Flattening of slope gradients.
- Localized improvement of loose foundations soils by:
  - Removal and re-compaction
  - Installation of geopiers
  - Vibro-densification
  - Installation of stone columns

Design Modifications and Further Studies: As stated previously, the conceptual design is still in a state of development. Due to project constraints and uncertainties, including construction scheduling, estimated rate of sea level retreat and other factors, several modifications to the conceptual design are being considered and will likely occur. These modifications could include steepening of the lake side slope of the levee, installing a sheet pile through the levee, and leaving portions of the dredged fill (used to build the perimeter levee) in place without further mechanical compaction. These modifications will require further geotechnical evaluation, and would likely not allow the design to meet the rigorous requirements for a dam embankment as mandated by DSOD. In this event, the design would need to evolve into a levee embankment design meeting the requirements of DWR and/or Corps of Engineer criteria. Regardless of which design criteria is utilized, a comprehensive geotechnical investigation will be required to adequately support the design process as it evolves. This work will be essential in obtaining a better understanding of the engineering properties and distribution of the various soil deposits underlying the project site. It will also be valuable in identifying areas where problem conditions exist so that locally targeted and efficient geotechnical designs can be provided.

A predominant factor in the success of the conceptual design is the engineering behavior of the dredged material. Factors such as how efficiently it can be excavated and placed (both below and above the water surface), how quickly it can be dried and re-compacted, and whether in-place densification methods are practical, are key factors that need to be determined. An engineered and monitored field test program is the best way to evaluate these issues. It is recommended that a test program be initiated early in the design process. The program should be designed to allow multiple tests including:

- Evaluation of dredge excavation slopes.
- Angle of repose of dredged stockpiles (below and above water).
- In-situ density of dredged material.
- Effectiveness of in-situ densification of dredged material (vibro-compaction, dynamic compaction etc.).
- Performance of driven sheet piling.
- Drying and re-compaction methods for dredged material.

13.0 Limitations

The investigators have endeavored to perform this evaluation using the degree of care and skill ordinarily exercised under similar circumstances by reputable geotechnical professionals with experience in this area in similar soil conditions. No other warranty, either expressed or implied, is made as to the conclusions and recommendations contained in this report.

The recommendations and opinions expressed in this report are based on a review of background documents and on the limited information obtained from field explorations and the associated laboratory testing performed by others. The investigation data currently available covers only a small portion of the Salton Sea area, and exploration locations are generally a considerable distance away from the current seashore. Significant extrapolation of observed conditions has been assumed in order to perform this feasibility level assessment. Due to the limited nature of the field explorations, conditions not observed and described in this report may be present on the site. Uncertainties relative to subsurface conditions can be reduced through additional subsurface exploration. It should be understood that conditions different from those anticipated in this report may be encountered during subsequent investigation.

This document is intended to be used only in its entirety. No portion of the document, by itself, is designed to completely represent any aspect of the project described herein. Tetra Tech should be contacted if the reader requires additional information or has questions regarding the content, interpretations presented, or completeness of this document. Reliance by others on the data presented herein or for purposes other than those stated in the text is authorized only if so permitted in writing by Tetra Tech. It should be understood that such an authorization may incur additional expenses and charges.

14.0 Closure

Tetra Tech appreciates the opportunity to be of service on this project. If you have any questions regarding this report or if we can be of further service, please do not hesitate to contact the undersigned.

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Figures

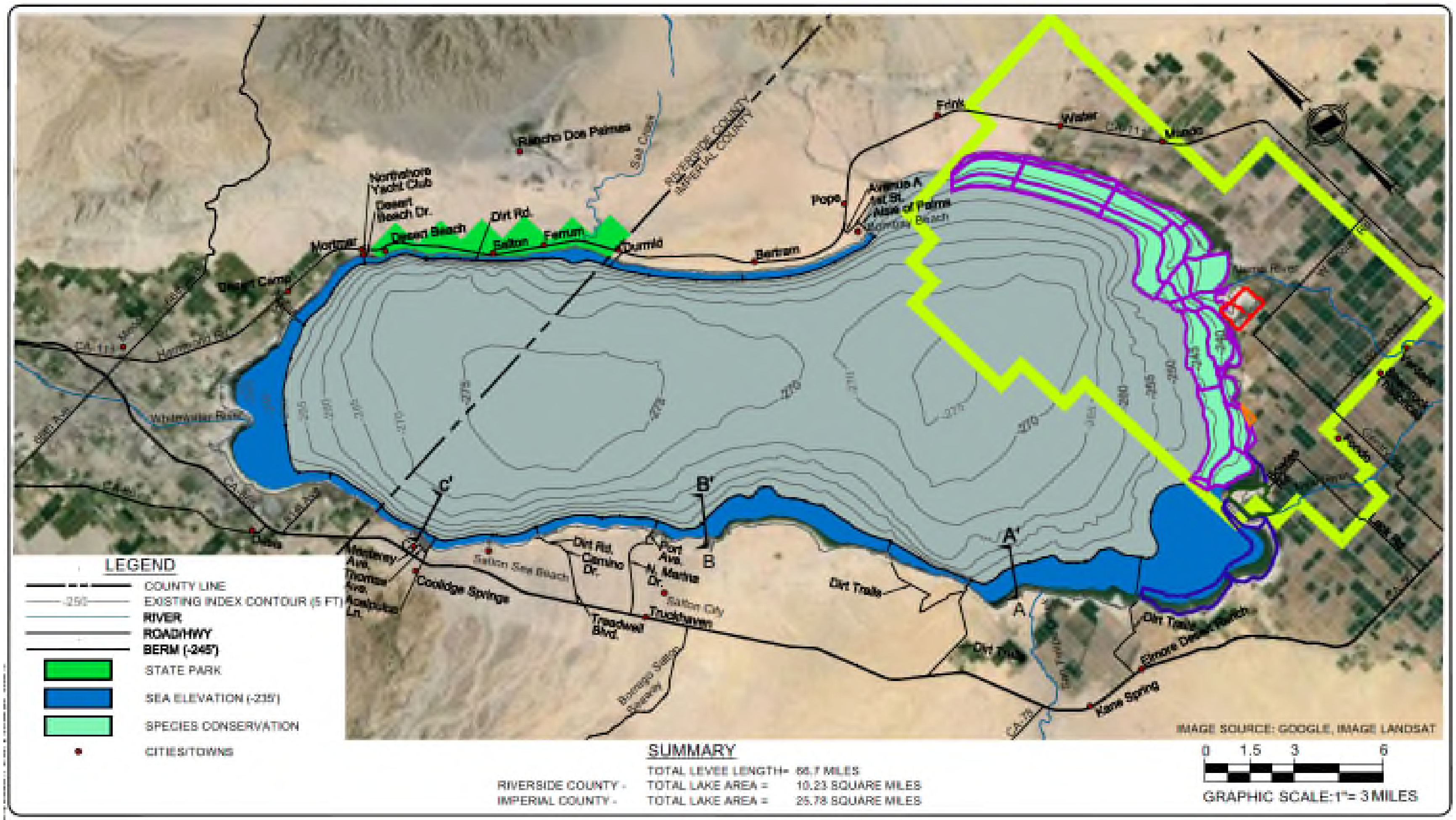


Figure 1 – Perimeter Lake Plan

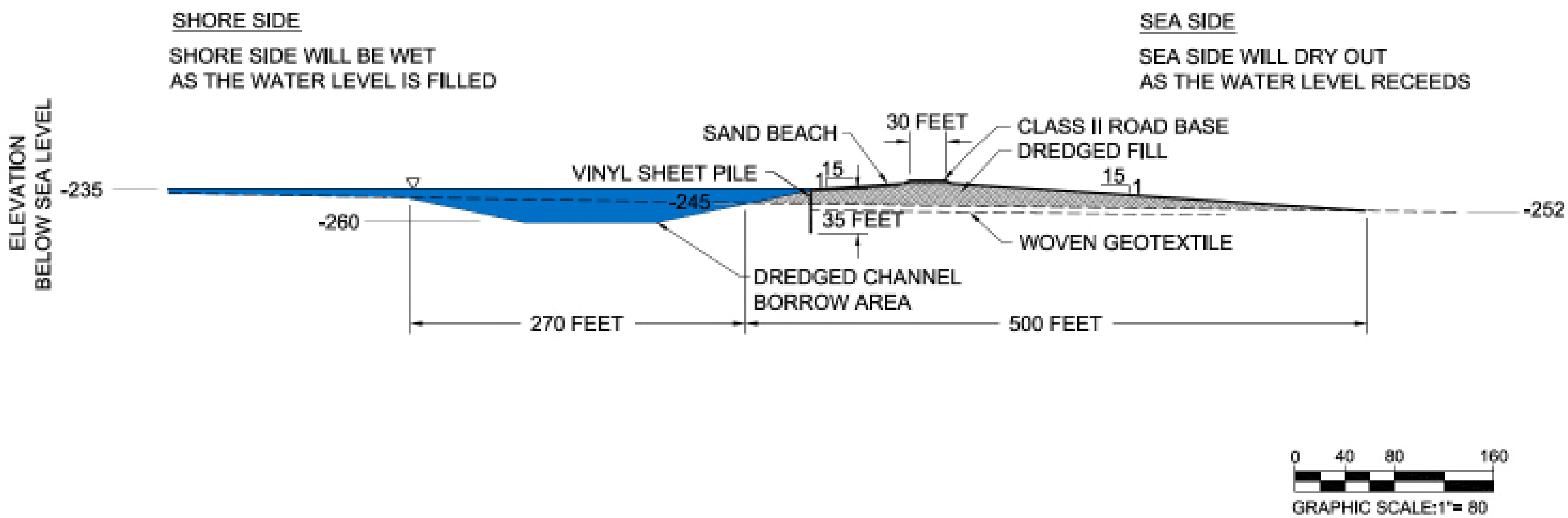


Figure 2 – Conceptual Design Cross Section

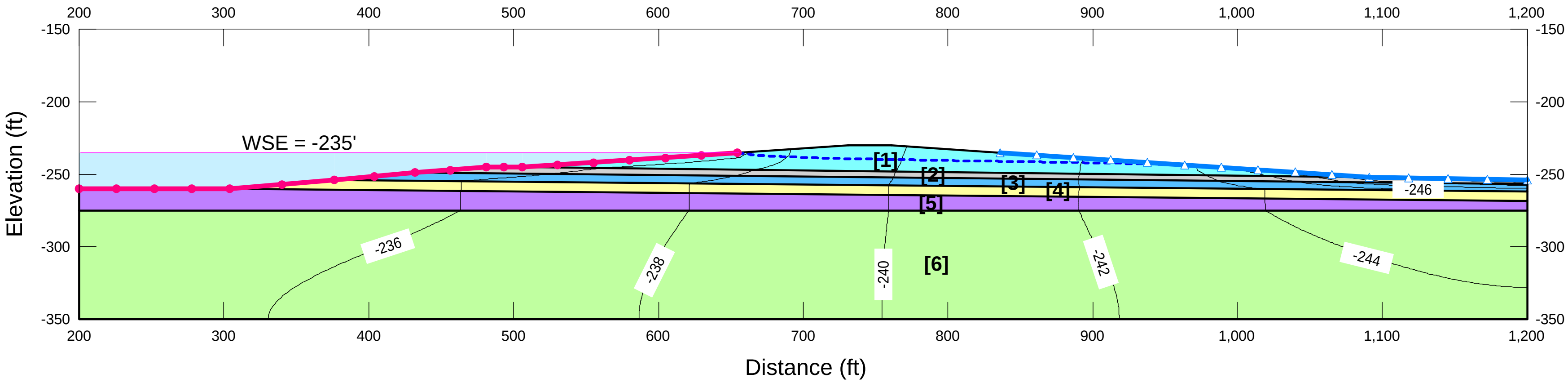
ATTACHMENT A

Seepage Modeling

Salton Sea Perimeter Levee

Steady State Seepage Analysis

Total Head Contour



Name: [1] Embankment
K-Function: Embankment
Ky'/Kx' Ratio: 0.1
Kx = 1.64E-5 ft/sec

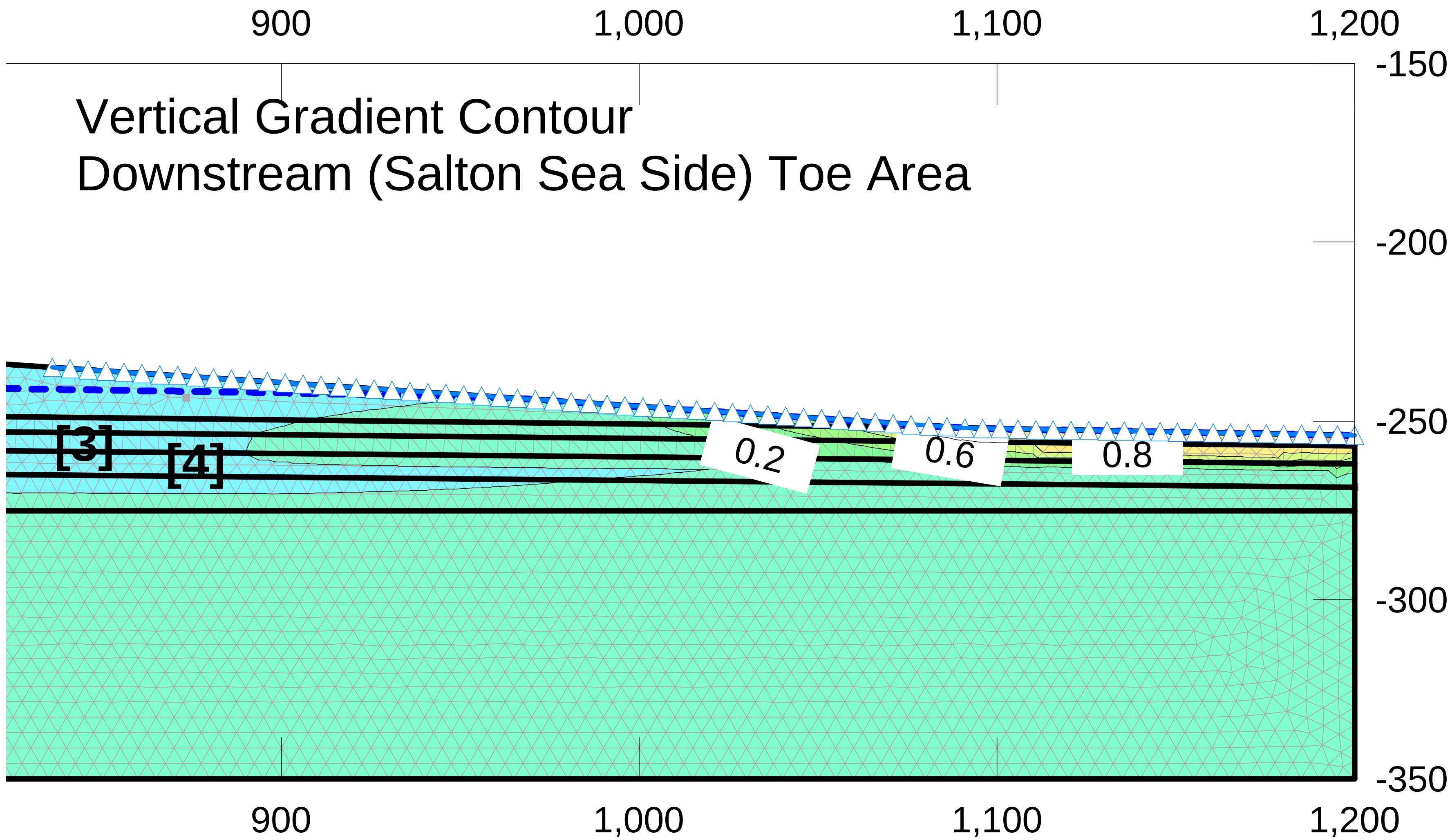
Name: [2] Seafloor Deposits
K-Function: Seafloor deposits
Ky'/Kx' Ratio: 0.1
Kx = 3.28E-5 ft/sec

Name: [3] Very Soft to Med Stiff Lacustrine
K-Function: Very soft to med stiff lacustrine
Ky'/Kx' Ratio: 0.1
Kx = 3.28E-5 ft/sec

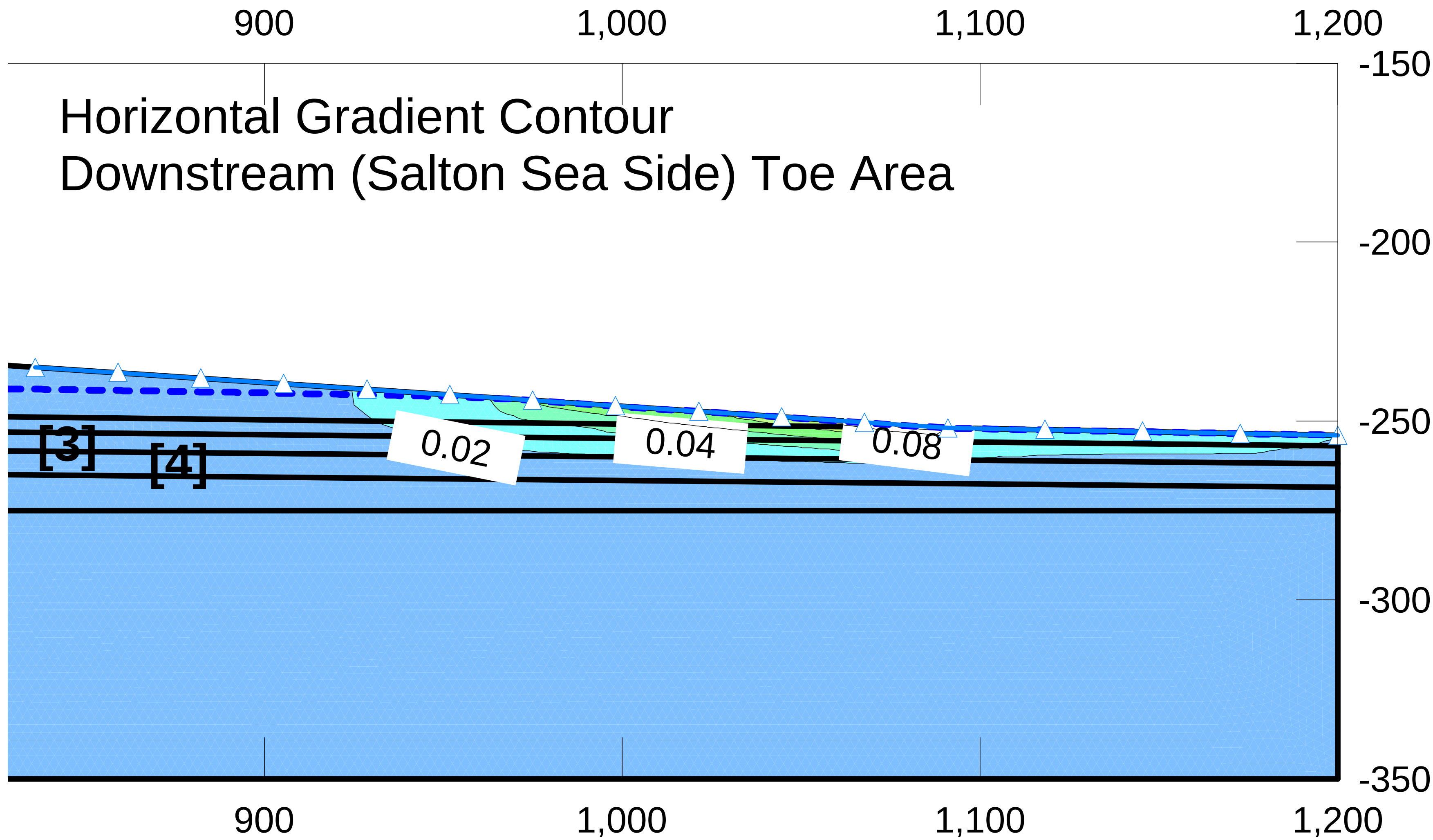
Name: [4] Very Loose to Med Dense Alluvium
K-Function: Very loose to med dense alluvium
Ky'/Kx' Ratio: 0.5
Kx =3.28E-3 ft/sec

Name: [5] Dense to Very Dense Alluvium
K-Function: Dense to very dense alluvium
Ky'/Kx' Ratio: 0.5
Kx = 6.56 E-4 ft/sec

Name: [6] Stiff to Hard Lacustrine
K-Function: Stiff to hard lacustrine
Ky'/Kx' Ratio: 0.1
Kx = 1.64 E-5 ft/sec



900
1,000
1,100
1,200
-150
Vertical Gradient Contour
Downstream (Salton Sea Side) Toe Area
-200
-250
[3]
[4]
0.2
0.6
0.8
-300
-350
900
1,000
1,100
1,200



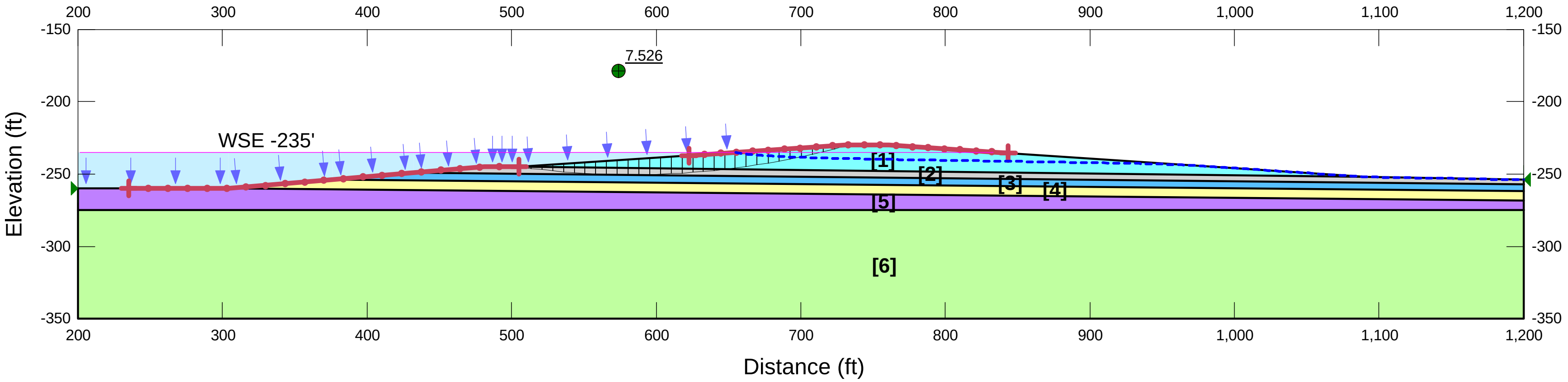
Horizontal Gradient Contour
Downstream (Salton Sea Side) Toe Area
900
1,000
1,100
1,200
-150
-200
-250
-300
-350
[3]
[4]
0.02
0.04
0.08

ATTACHMENT B

Slope Stability Analyses

Salton Sea Perimeter Lake

Description: Static stability
Method: Spencer
PWP Conditions Source: Parent Analysis
Optimize Critical Slip Surface Location: No
Horz Seismic Coef.: 0
Date: 9/15/2015



Name: [1] Embankment
Unit Weight: 115 pcf
Cohesion': 200 psf
Phi': 25 °

Name: [2] Seafloor Deposits
Unit Weight: 100 pcf
Cohesion': 150 psf
Phi': 0 °

Name: [3] Very Soft to Med Stiff Lacustrine
Unit Weight: 110 pcf
Cohesion': 500 psf
Phi': 0 °

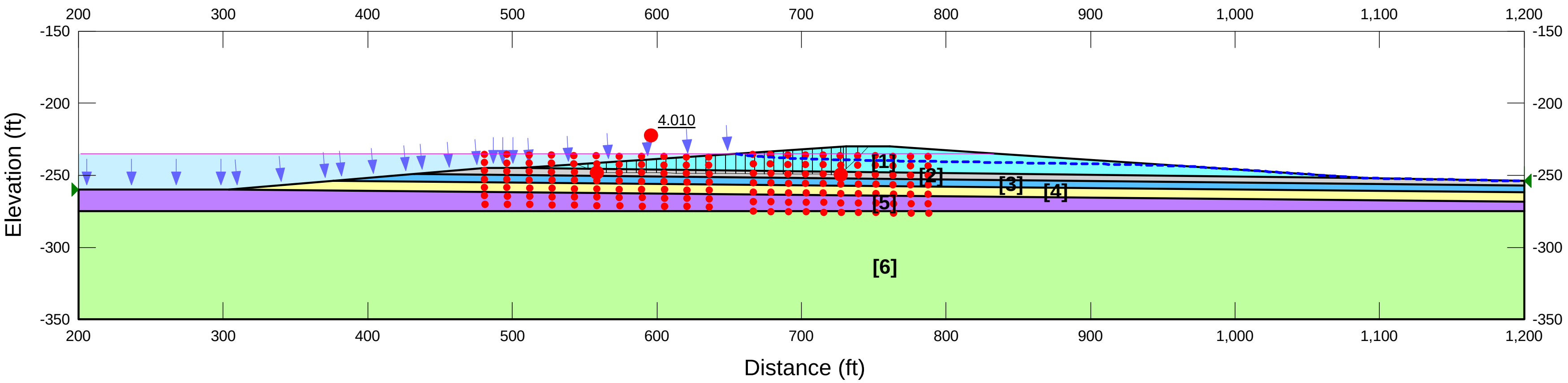
Name: [4] Very Loose to Med Dense Alluvium
Unit Weight: 125 pcf
Cohesion': 100 psf
Phi': 28 °

Name: [5] Dense to Very Dense Alluvium
Unit Weight: 125 pcf
Cohesion': 120 psf
Phi': 30 °

Name: [6] Stiff to Hard Lacustrine
Unit Weight: 115 pcf
Cohesion': 250 psf
Phi': 23 °

Salton Sea Perimeter Lake

Description: Static stability
Method: Spencer
PWP Conditions Source: Parent Analysis
Optimize Critical Slip Surface Location: No
Horz Seismic Coef.: 0
Date: 9/15/2015



Name: [1] Embankment
Unit Weight: 115 pcf
Cohesion': 200 psf
Phi': 25 °

Name: [2] Seafloor Deposits
Unit Weight: 100 pcf
Cohesion': 150 psf
Phi': 0 °

Name: [3] Very Soft to Med Stiff Lacustrine
Unit Weight: 110 pcf
Cohesion': 500 psf
Phi': 0 °

Name: [4] Very Loose to Med Dense Alluvium
Unit Weight: 125 pcf
Cohesion': 100 psf
Phi': 28 °

Name: [5] Dense to Very Dense Alluvium
Unit Weight: 125 pcf
Cohesion': 120 psf
Phi': 30 °

Name: [6] Stiff to Hard Lacustrine
Unit Weight: 115 pcf
Cohesion': 250 psf
Phi': 23 °

Salton Sea Perimeter Levee

Description: Static stability

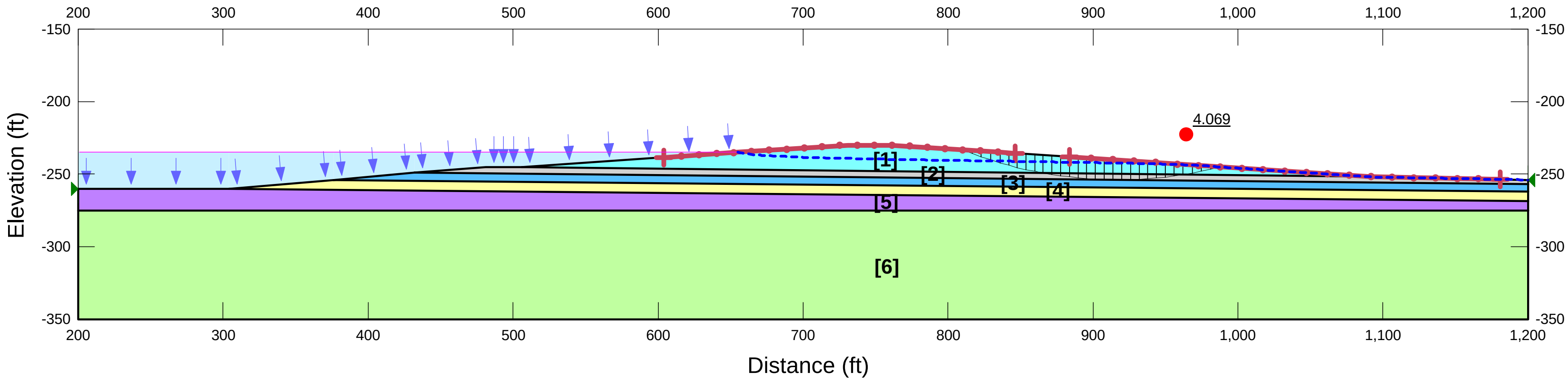
Method: Spencer

PWP Conditions Source: Parent Analysis

Optimize Critical Slip Surface Location: No

Horz Seismic Coef.: 0

Date: 9/14/2015



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Name: [2] Seafloor Deposits
Unit Weight: 100 pcf
Cohesion': 150 psf
Phi': 0 °

Name: [3] Very Soft to Med Stiff Lacustrine
Unit Weight: 110 pcf
Cohesion': 500 psf
Phi': 0 °

Name: [4] Very Loose to Med Dense Alluvium
Unit Weight: 125 pcf
Cohesion': 100 psf
Phi': 28 °

Name: [5] Dense to Very Dense Alluvium
Unit Weight: 125 pcf
Cohesion': 120 psf
Phi': 30 °

Name: [6] Stiff to Hard Lacustrine
Unit Weight: 115 pcf
Cohesion': 250 psf
Phi': 23 °

Salton Sea Perimeter Levee

Description: Static stability

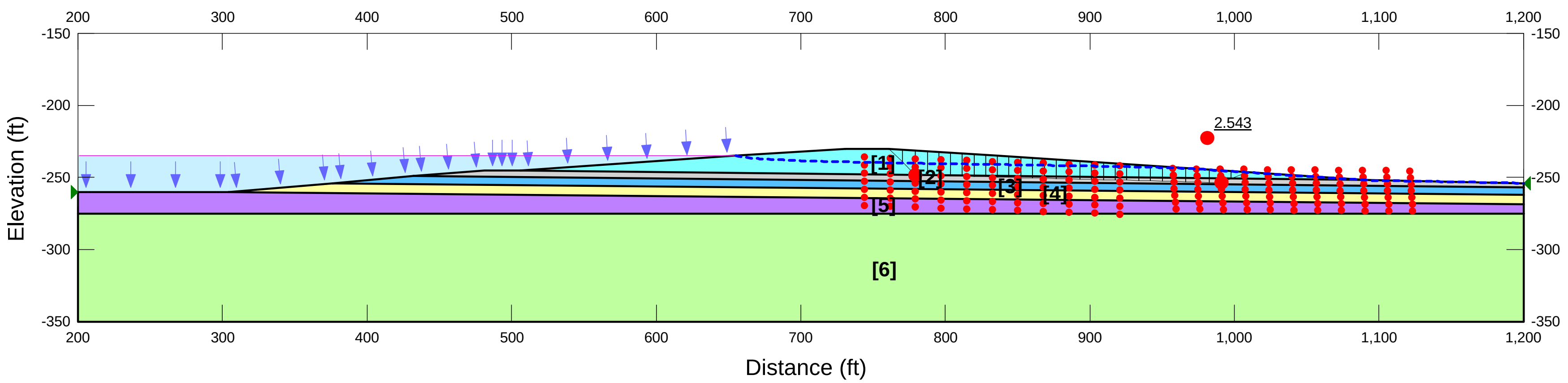
Method: Spencer

PWP Conditions Source: Parent Analysis

Optimize Critical Slip Surface Location: No

Horz Seismic Coef.: 0

Date: 9/14/2015



Name: [1] Embankment
Unit Weight: 115 pcf
Cohesion': 200 psf
Phi': 25 °

Name: [2] Seafloor Deposits
Unit Weight: 100 pcf
Cohesion': 150 psf
Phi': 0 °

Name: [3] Very Soft to Med Stiff Lacustrine
Unit Weight: 110 pcf
Cohesion': 500 psf
Phi': 0 °

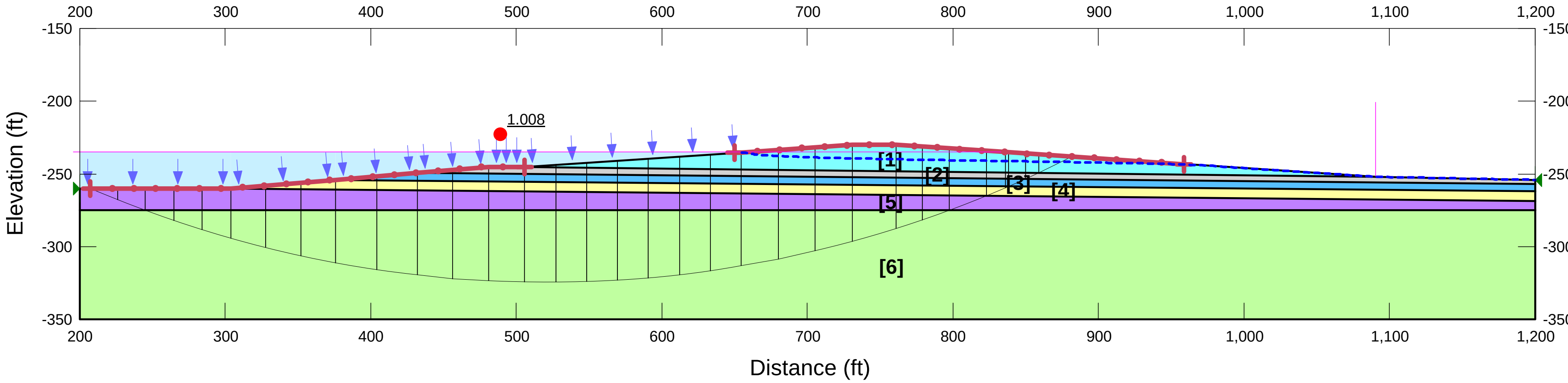
Name: [4] Very Loose to Med Dense Alluvium
Unit Weight: 125 pcf
Cohesion': 100 psf
Phi': 28 °

Name: [5] Dense to Very Dense Alluvium
Unit Weight: 125 pcf
Cohesion': 120 psf
Phi': 30 °

Name: [6] Stiff to Hard Lacustrine
Unit Weight: 115 pcf
Cohesion': 250 psf
Phi': 23 °

Salton Sea Perimeter Lake

Description: Yield Acceleration Determination
Method: Spencer
PWP Conditions Source: Parent Analysis
Optimize Critical Slip Surface Location: No
Horz Seismic Coef.: 0.247
Date: 9/14/2015



Name: [1] Embankment
Unit Weight: 115 pcf
Cohesion': 200 psf
Phi': 25 °

Name: [2] Seafloor Deposits
Unit Weight: 100 pcf
Cohesion': 75 psf
Phi': 27 °

Name: [3] Very Soft to Med Stiff Lacustrine
Unit Weight: 110 pcf
Cohesion': 100 psf
Phi': 27 °

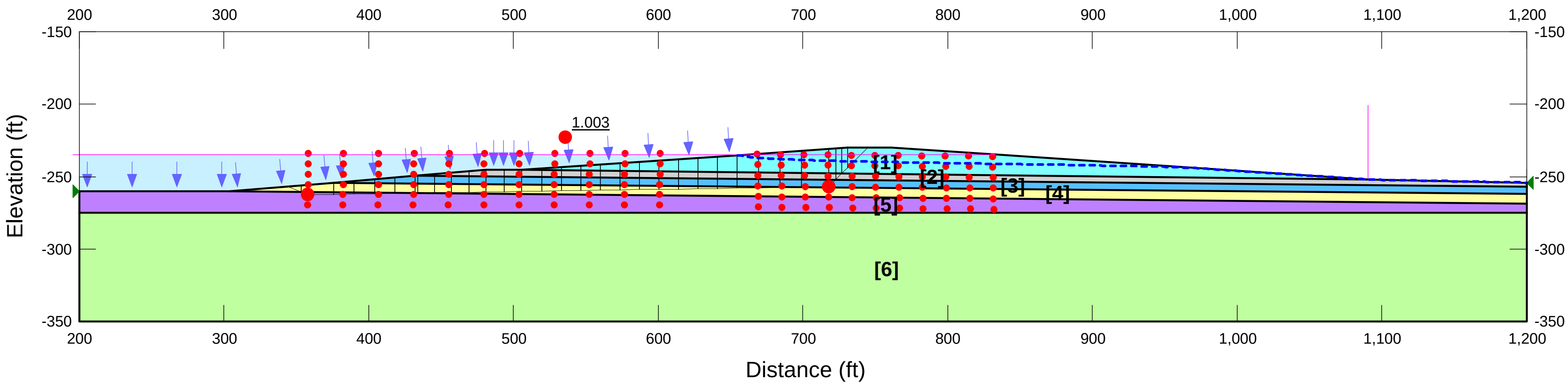
Name: [4] Very Loose to Med Dense Alluvium
Unit Weight: 125 pcf
Cohesion': 100 psf
Phi': 28 °

Name: [5] Dense to Very Dense Alluvium
Unit Weight: 125 pcf
Cohesion': 120 psf
Phi': 30 °

Name: [6] Stiff to Hard Lacustrine
Unit Weight: 115 pcf
Cohesion': 250 psf
Phi': 23 °

Salton Sea Perimeter Lake

Description: Yield acceleration determination
Method: Spencer
PWP Conditions Source: Parent Analysis
Optimize Critical Slip Surface Location: No
Horz Seismic Coef.: 0.324
Date: 9/14/2015



Name: [1] Embankment
Unit Weight: 115 pcf
Cohesion': 200 psf
Phi': 25 °

Name: [2] Seafloor Deposits
Unit Weight: 100 pcf
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Phi': 27 °

Name: [3] Very Soft to Med Stiff Lacustrine
Unit Weight: 110 pcf
Cohesion': 100 psf
Phi': 27 °

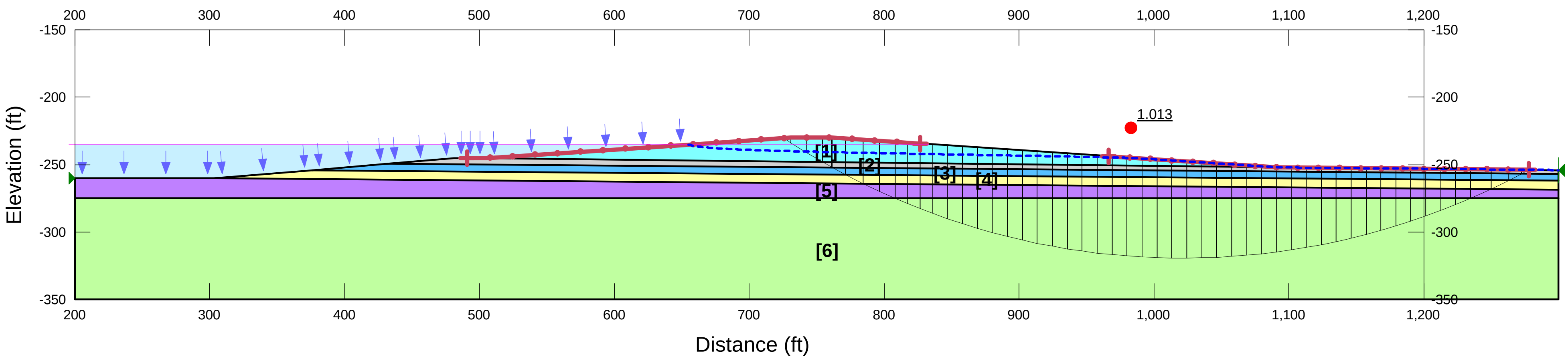
Name: [4] Very Loose to Med Dense Alluvium
Unit Weight: 125 pcf
Cohesion': 100 psf
Phi': 28 °

Name: [5] Dense to Very Dense Alluvium
Unit Weight: 125 pcf
Cohesion': 120 psf
Phi': 30 °

Name: [6] Stiff to Hard Lacustrine
Unit Weight: 115 pcf
Cohesion': 250 psf
Phi': 23 °

Salton Sea Perimeter Lake

Description: Yield Acceleration Determination
Method: Spencer
PWP Conditions Source: Parent Analysis
Optimize Critical Slip Surface Location: No
Horz Seismic Coef.: 0.215
Date: 9/18/2015



Name: [1] Embankment
Unit Weight: 115 pcf
Cohesion': 200 psf
Phi': 25 °

Name: [2] Seafloor Deposits
Unit Weight: 100 pcf
Cohesion': 75 psf
Phi': 27 °

Name: [3] Very Soft to Med Stiff Lacustrine
Unit Weight: 110 pcf
Cohesion': 100 psf
Phi': 27 °

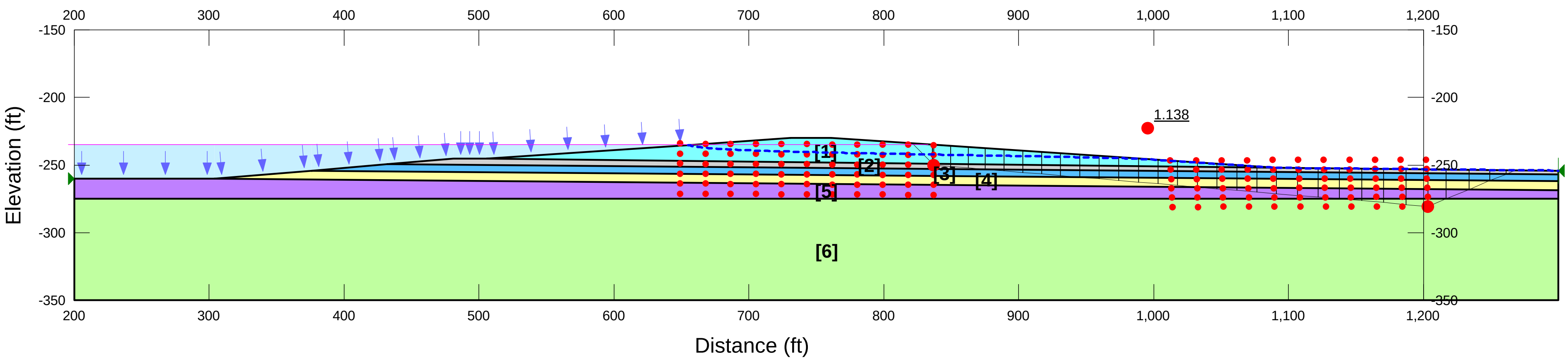
Name: [4] Very Loose to Med Dense Alluvium
Unit Weight: 125 pcf
Cohesion': 150 psf
Phi': 28 °

Name: [5] Dense to Very Dense Alluvium
Unit Weight: 125 pcf
Cohesion': 120 psf
Phi': 30 °

Name: [6] Stiff to Hard Lacustrine
Unit Weight: 115 pcf
Cohesion': 250 psf
Phi': 23 °

Salton Sea Perimeter Lake

Description: Yield Acceleration Determination
Method: Spencer
PWP Conditions Source: Parent Analysis
Optimize Critical Slip Surface Location: No
Horz Seismic Coef.: 0.23
Date: 9/18/2015



Name: [1] Embankment
Unit Weight: 115 pcf
Cohesion': 200 psf
Phi': 25 °

Name: [2] Seafloor Deposits
Unit Weight: 100 pcf
Cohesion': 75 psf
Phi': 27 °

Name: [3] Very Soft to Med Stiff Lacustrine
Unit Weight: 110 pcf
Cohesion': 100 psf
Phi': 27 °

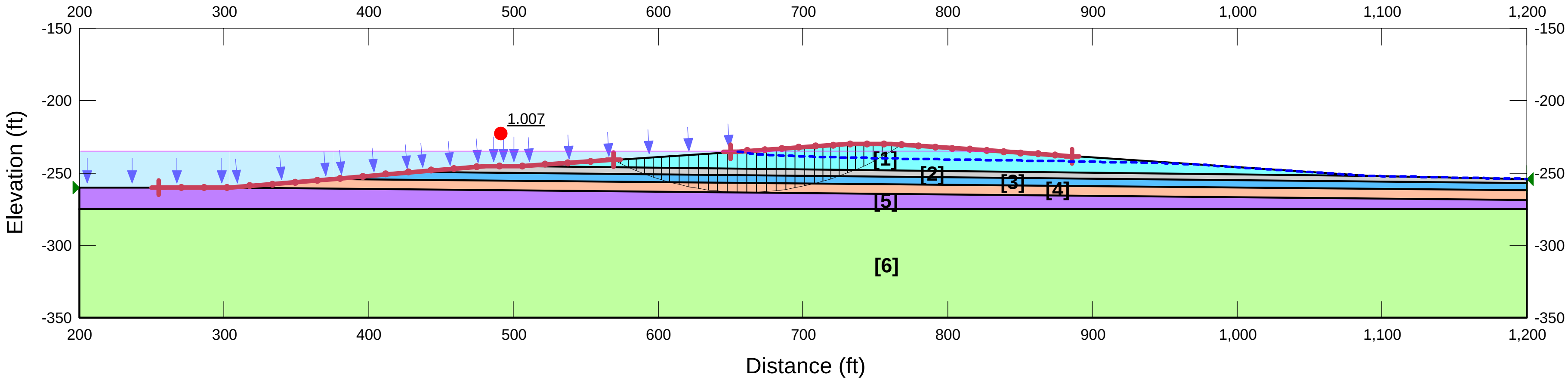
Name: [4] Very Loose to Med Dense Alluvium
Unit Weight: 125 pcf
Cohesion': 150 psf
Phi': 28 °

Name: [5] Dense to Very Dense Alluvium
Unit Weight: 125 pcf
Cohesion': 120 psf
Phi': 30 °

Name: [6] Stiff to Hard Lacustrine
Unit Weight: 115 pcf
Cohesion': 250 psf
Phi': 23 °

Salton Sea Perimeter Lake

Description: Yield Acceleration Determination
Method: Spencer
PWP Conditions Source: Parent Analysis
Optimize Critical Slip Surface Location: No
Horz Seismic Coef.: 0.115
Date: 9/11/2015



Name: [1] Embankment
Unit Weight: 115 pcf
Cohesion': 200 psf
Phi': 25 °

Name: [2] Seafloor Deposits
Unit Weight: 100 pcf
Cohesion': 150 psf
Phi': 0 °

Name: [3] Very Soft to Med Stiff Lacustrine
Unit Weight: 110 pcf
Cohesion': 500 psf
Phi': 0 °

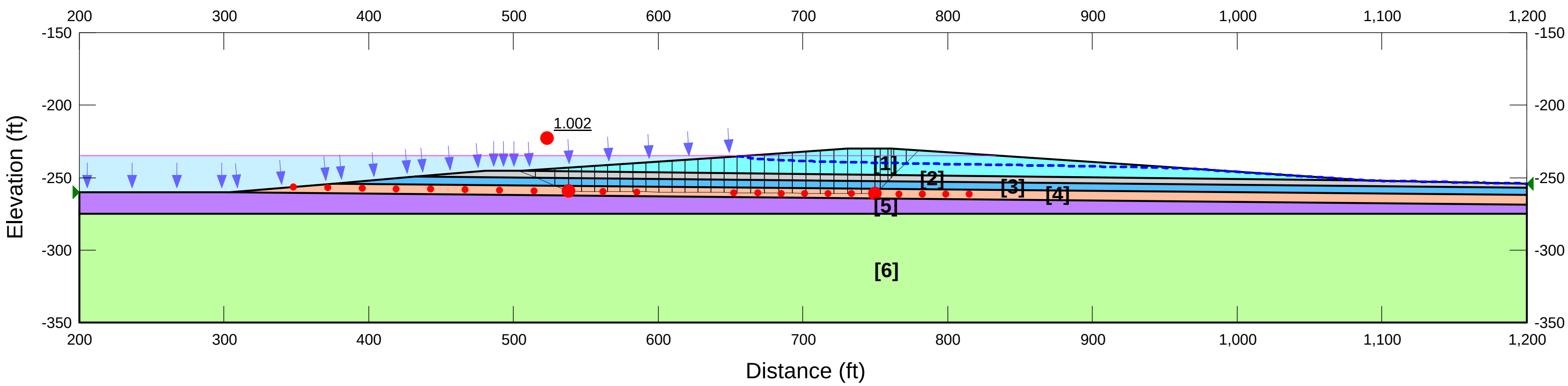
Name: [7] Liquefied Alluvium
Unit Weight: 115 pcf
Cohesion': 200 psf
Phi': 0 °

Name: [5] Dense to Very Dense Alluvium
Unit Weight: 125 pcf
Cohesion': 150 psf
Phi': 30 °

Name: [6] Stiff to Hard Lacustrine
Unit Weight: 115 pcf
Cohesion': 250 psf
Phi': 23 °

Salton Sea Perimeter Lake

Description: Yield Acceleration Determination
Method: Spencer
PWP Conditions Source: Parent Analysis
Optimize Critical Slip Surface Location: No
Horz Seismic Coef.: 0.086
Date: 9/10/2015



Name: [1] Embankment
Unit Weight: 115 pcf
Cohesion': 200 psf
Phi': 25 °

Name: [2] Seafloor Deposits
Unit Weight: 100 pcf
Cohesion': 150 psf
Phi': 0 °

Name: [3] Very Soft to Med Stiff Lacustrine
Unit Weight: 110 pcf
Cohesion': 500 psf
Phi': 0 °

Name: [7] Liquefied Alluvium
Unit Weight: 115 pcf
Cohesion': 200 psf
Phi': 0 °

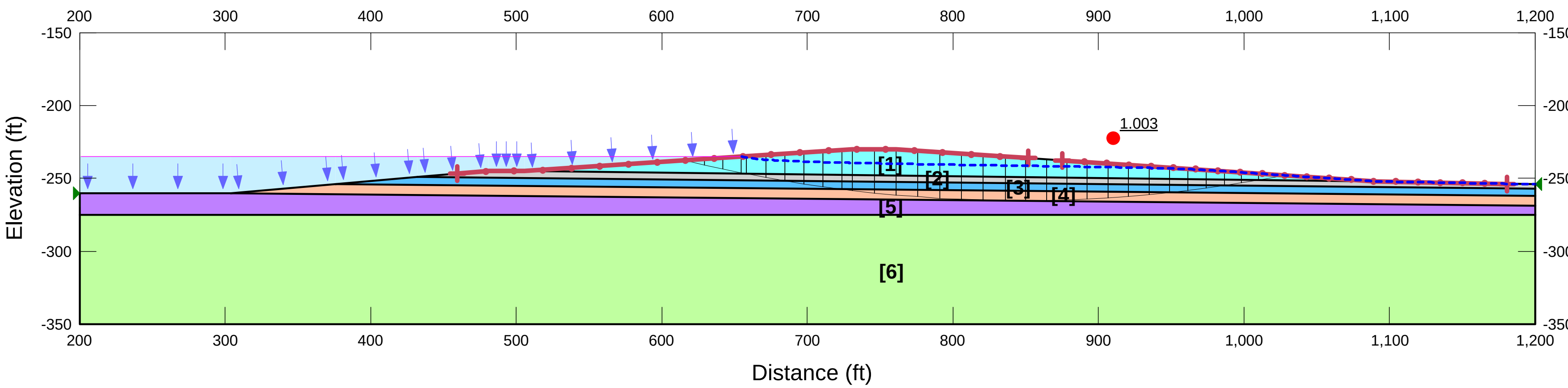
Name: [5] Dense to Very Dense Alluvium
Unit Weight: 125 pcf
Cohesion': 150 psf
Phi': 30 °

Name: [6] Stiff to Hard Lacustrine
Unit Weight: 115 pcf
Cohesion': 250 psf
Phi': 23 °

Salton Sea Perimeter Lake

Salton Sea Perimeter Levee

Description: Yield Acceleration Determination
Method: Spencer
PWP Conditions Source: Parent Analysis
Optimize Critical Slip Surface Location: No
Horz Seismic Coef.: 0.086
Date: 9/14/2015



Name: [1] Embankment
Unit Weight: 115 pcf
Cohesion': 200 psf
Phi': 25 °

Name: [2] Seafloor Deposits
Unit Weight: 100 pcf
Cohesion': 150 psf
Phi': 0 °

Name: [3] Very Soft to Med Stiff Lacustrine
Unit Weight: 110 pcf
Cohesion': 500 psf
Phi': 0 °

Name: [7] Liquefied Alluvium
Unit Weight: 115 pcf
Cohesion': 200 psf
Phi': 0 °

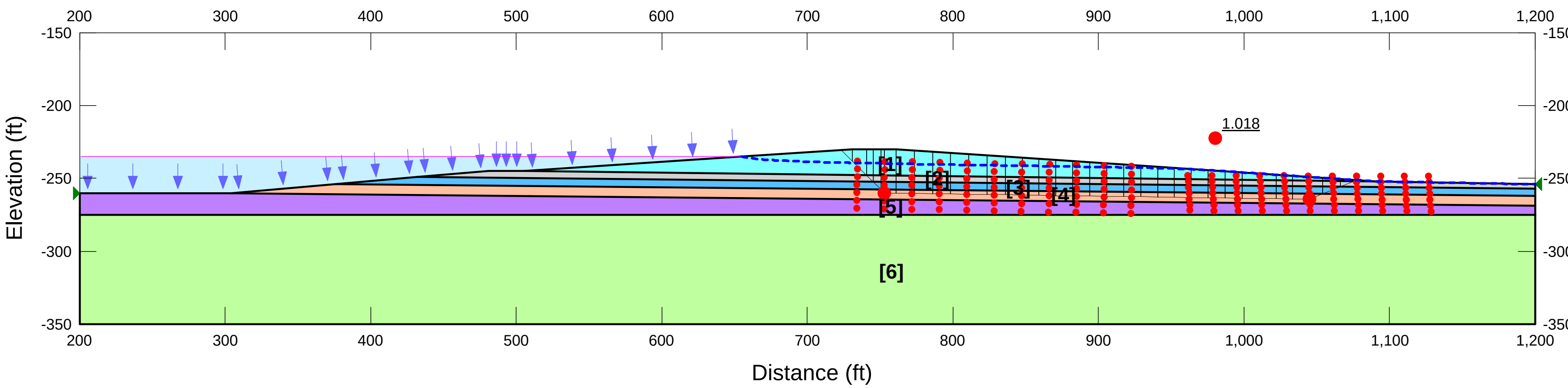
Name: [5] Dense to Very Dense Alluvium
Unit Weight: 125 pcf
Cohesion': 120 psf
Phi': 30 °

Name: [6] Stiff to Hard Lacustrine
Unit Weight: 115 pcf
Cohesion': 250 psf
Phi': 23 °

Salton Sea Perimeter Lake

Salton Sea Perimeter Levee

Description: Yield Acceleration Determination
Method: Spencer
PWP Conditions Source: Parent Analysis
Optimize Critical Slip Surface Location: No
Horz Seismic Coef.: 0.053
Date: 9/14/2015



Name: [1] Embankment
Unit Weight: 115 pcf
Cohesion': 200 psf
Phi': 25 °

Name: [2] Seafloor Deposits
Unit Weight: 100 pcf
Cohesion': 150 psf
Phi': 0 °

Name: [3] Very Soft to Med Stiff Lacustrine
Unit Weight: 110 pcf
Cohesion': 500 psf
Phi': 0 °

Name: [7] Liquefied Alluvium
Unit Weight: 115 pcf
Cohesion': 200 psf
Phi': 0 °

Name: [5] Dense to Very Dense Alluvium
Unit Weight: 125 pcf
Cohesion': 120 psf
Phi': 30 °

Name: [6] Stiff to Hard Lacustrine
Unit Weight: 115 pcf
Cohesion': 250 psf
Phi': 23 °

ATTACHMENT C

Seismic Deformation Analyses

Simplified Procedure for Estimating Earthquake Induced Deviatoric Slope Displacements
by Jonathan D. Bray and Thaleia Travasarou
Journal of Geotechnical and Geonvironmental Engineering, ASCE, V. 133(4), pp. 381-392, April 2007

SEE NOTES BELOW FOR GUIDANCE IN THE USE OF SPREADSHEET

Input Parameters			
Yield Coefficient (ky)	0.247		Based on pseudostatic analysis
Initial Fundamental Period (Ts)	0.38	seconds	1D: Ts=4H/Vs 2D: Ts=2.6H/Vs
Degraded Period (1.5Ts)	0.58	seconds	
Moment Magnitude (Mw)	7.9		
Spectral Acceleration (Sa(1.5Ts))	2.15	g	

Additional Input Parameters		
Probability of Exceedance #1 (P1)	84	%
Probability of Exceedance #2 (P2)	50	%
Probability of Exceedance #3 (P3)	16	%
Displacement Threshold (d_threshold)	15	cm

Intermediate Calculated Parameters			
Non-Zero Seismic Displacement Est (D)	100.52	cm	eq. (5) or (6)
Standard Deviation of Non-Zero Seismic D	0.66		

Results					
Probability of Negligible Displ. (P(D=0))	0.000				eq. (3)
D1	52.14	cm	**1.7**	ft	calc. using eq. (7)
D2	**100.52**	**cm**	**3.3**	**ft**	calc. using eq. (7)
D3	193.77	cm	**6.4**	inft	calc. using eq. (7)
P(D>d_threshold)	0.998				eq. (7)

Notes

1. Values highlighted in blue are input parameters
2. Probability of Exceedance is the desired probability of exceeding a particular displacement value.
3. Displacements D1, D2, and D3 correspond to P1, P2, and P3, respectively.
   (e.g., the probability of exceeding displacement D1 is P1)
4. Calculated seismic displacements are due to deviatoric deformation only (add in volumetrically induced movement).
5. ky may range between 0.01 and 0.5, Ts between 0 and 2 s, Sa between 0.002 and 2.7 g, M between 4.5 and 9
6. Rigid slope is assumed for Ts < 0.05 s
7. When a value for D is not calculated, D is < 1cm
8. ky may be estimated using the simplified equations shown below.
9. Examples of how Ts is estimated are shown below.
10. Vs = weighted avg. shear wave velocity for the sliding mass, e.g., for 2 layers, Vs = [(h1)(Vs1) + (h2)(Vs2)]/(h1 + h2)

Simplified Procedure for Estimating Earthquake Induced Deviatoric Slope Displacements
by Jonathan D. Bray and Thaleia Travasarou
Journal of Geotechnical and Geonvironmental Engineering, ASCE, V. 133(4), pp. 381-392, April 2007

SEE NOTES BELOW FOR GUIDANCE IN THE USE OF SPREADSHEET

Input Parameters			
Yield Coefficient (ky)	0.324		Based on pseudostatic analysis
Initial Fundamental Period (Ts)	0.09	seconds	1D: Ts=4H/Vs 2D: Ts=2.6H/Vs
Degraded Period (1.5Ts)	0.14	seconds	
Moment Magnitude (Mw)	7.9		
Spectral Acceleration (Sa(1.5Ts))	1.31	g	

Additional Input Parameters		
Probability of Exceedance #1 (P1)	84	%
Probability of Exceedance #2 (P2)	50	%
Probability of Exceedance #3 (P3)	16	%
Displacement Threshold (d_threshold)	15	cm

Intermediate Calculated Parameters			
Non-Zero Seismic Displacement Est (D)	14.63	cm	eq. (5) or (6)
Standard Deviation of Non-Zero Seismic D	0.66		

Results					
Probability of Negligible Displ. (P(D=0))	0.002				eq. (3)
D1	7.55	cm	**0.2**	ft	calc. using eq. (7)
D2	**14.60**	**cm**	**0.5**	**ft**	calc. using eq. (7)
D3	28.17	cm	**0.9**	inft	calc. using eq. (7)
P(D>d_threshold)	0.484				eq. (7)

Notes

1. Values highlighted in blue are input parameters
2. Probability of Exceedance is the desired probability of exceeding a particular displacement value.
3. Displacements D1, D2, and D3 correspond to P1, P2, and P3, respectively.
   (e.g., the probability of exceeding displacement D1 is P1)
4. Calculated seismic displacements are due to deviatoric deformation only (add in volumetrically induced movement).
5. ky may range between 0.01 and 0.5, Ts between 0 and 2 s, Sa between 0.002 and 2.7 g, M between 4.5 and 9
6. Rigid slope is assumed for Ts < 0.05 s
7. When a value for D is not calculated, D is < 1cm
8. ky may be estimated using the simplified equations shown below.
9. Examples of how Ts is estimated are shown below.
10. Vs = weighted avg. shear wave velocity for the sliding mass, e.g., for 2 layers, Vs = [(h1)(Vs1) + (h2)(Vs2)]/(h1 + h2)

Simplified Procedure for Estimating Earthquake Induced Deviatoric Slope Displacements
by Jonathan D. Bray and Thaleia Travasarou
Journal of Geotechnical and Geonvironmental Engineering, ASCE, V. 133(4), pp. 381-392, April 2007

SEE NOTES BELOW FOR GUIDANCE IN THE USE OF SPREADSHEET

Input Parameters			
Yield Coefficient (ky)	0.215		Based on pseudostatic analysis
Initial Fundamental Period (Ts)	0.27	seconds	1D: Ts=4H/Vs 2D: Ts=2.6H/Vs
Degraded Period (1.5Ts)	0.41	seconds	
Moment Magnitude (Mw)	7.9		
Spectral Acceleration (Sa(1.5Ts))	2.13	g	

Additional Input Parameters		
Probability of Exceedance #1 (P1)	84	%
Probability of Exceedance #2 (P2)	50	%
Probability of Exceedance #3 (P3)	16	%
Displacement Threshold (d_threshold)	15	cm

Intermediate Calculated Parameters			
Non-Zero Seismic Displacement Est (D)	101.61	cm	eq. (5) or (6)
Standard Deviation of Non-Zero Seismic D	0.66		

Results					
Probability of Negligible Displ. (P(D=0))	0.000				eq. (3)
D1	52.71	cm	**1.7**	ft	calc. using eq. (7)
D2	**101.61**	**cm**	**3.3**	**ft**	calc. using eq. (7)
D3	195.87	cm	**6.4**	inft	calc. using eq. (7)
P(D>d_threshold)	0.998				eq. (7)

Notes

1. Values highlighted in blue are input parameters
2. Probability of Exceedance is the desired probability of exceeding a particular displacement value.
3. Displacements D1, D2, and D3 correspond to P1, P2, and P3, respectively.
   (e.g., the probability of exceeding displacement D1 is P1)
4. Calculated seismic displacements are due to deviatoric deformation only (add in volumetrically induced movement).
5. ky may range between 0.01 and 0.5, Ts between 0 and 2 s, Sa between 0.002 and 2.7 g, M between 4.5 and 9
6. Rigid slope is assumed for Ts < 0.05 s
7. When a value for D is not calculated, D is < 1cm
8. ky may be estimated using the simplified equations shown below.
9. Examples of how Ts is estimated are shown below.
10. Vs = weighted avg. shear wave velocity for the sliding mass, e.g., for 2 layers, Vs = [(h1)(Vs1) + (h2)(Vs2)]/(h1 + h2)

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SEE NOTES BELOW FOR GUIDANCE IN THE USE OF SPREADSHEET

Input Parameters			
Yield Coefficient (ky)	0.23		Based on pseudostatic analysis
Initial Fundamental Period (Ts)	0.05	seconds	1D: Ts=4H/Vs 2D: Ts=2.6H/Vs
Degraded Period (1.5Ts)	0.08	seconds	
Moment Magnitude (Mw)	7.9		
Spectral Acceleration (Sa(1.5Ts))	1.05	g	

Additional Input Parameters		
Probability of Exceedance #1 (P1)	84	%
Probability of Exceedance #2 (P2)	50	%
Probability of Exceedance #3 (P3)	16	%
Displacement Threshold (d_threshold)	15	cm

Intermediate Calculated Parameters			
Non-Zero Seismic Displacement Est (D)	16.10	cm	eq. (5) or (6)
Standard Deviation of Non-Zero Seismic D	0.66		

Results					
Probability of Negligible Displ. (P(D=0))	0.001				eq. (3)
D1	8.34	cm	**0.3**	ft	calc. using eq. (7)
D2	**16.09**	**cm**	**0.5**	**ft**	calc. using eq. (7)
D3	31.02	cm	**1.0**	inft	calc. using eq. (7)
P(D>d_threshold)	0.542				eq. (7)

Notes

1. Values highlighted in blue are input parameters
2. Probability of Exceedance is the desired probability of exceeding a particular displacement value.
3. Displacements D1, D2, and D3 correspond to P1, P2, and P3, respectively.
   (e.g., the probability of exceeding displacement D1 is P1)
4. Calculated seismic displacements are due to deviatoric deformation only (add in volumetrically induced movement).
5. ky may range between 0.01 and 0.5, Ts between 0 and 2 s, Sa between 0.002 and 2.7 g, M between 4.5 and 9
6. Rigid slope is assumed for Ts < 0.05 s
7. When a value for D is not calculated, D is < 1cm
8. ky may be estimated using the simplified equations shown below.
9. Examples of how Ts is estimated are shown below.
10. Vs = weighted avg. shear wave velocity for the sliding mass, e.g., for 2 layers, Vs = [(h1)(Vs1) + (h2)(Vs2)]/(h1 + h2)

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Input Parameters			
Yield Coefficient (ky)	0.115		Based on pseudostatic analysis
Initial Fundamental Period (Ts)	0.14	seconds	1D: Ts=4H/Vs 2D: Ts=2.6H/Vs
Degraded Period (1.5Ts)	0.20	seconds	
Moment Magnitude (M_w)	7.9		
Spectral Acceleration (Sa(1.5Ts))	1.53	g	

Additional Input Parameters		
Probability of Exceedance #1 (P1)	84	%
Probability of Exceedance #2 (P2)	50	%
Probability of Exceedance #3 (P3)	16	%
Displacement Threshold (d_threshold)	15	cm

Intermediate Calculated Parameters			
Non-Zero Seismic Displacement Est (D)	104.02	cm	eq. (5) or (6)
Standard Deviation of Non-Zero Seismic D	0.66		

Results					
Probability of Negligible Displ. (P(D=0))	0.000				eq. (3)
D1	53.96	cm	**1.8**	ft	calc. using eq. (7)
D2	**104.02**	**cm**	**3.4**	**ft**	calc. using eq. (7)
D3	200.52	cm	**6.6**	inft	calc. using eq. (7)
P(D>d_threshold)	0.998				eq. (7)

Notes

1. Values highlighted in blue are input parameters
2. Probability of Exceedance is the desired probability of exceeding a particular displacement value.
3. Displacements D1, D2, and D3 correspond to P1, P2, and P3, respectively.
   (e.g., the probability of exceeding displacement D1 is P1)
4. Calculated seismic displacements are due to deviatoric deformation only (add in volumetrically induced movement).
5. ky may range between 0.01 and 0.5, Ts between 0 and 2 s, Sa between 0.002 and 2.7 g, M between 4.5 and 9
6. Rigid slope is assumed for Ts < 0.05 s
7. When a value for D is not calculated, D is < 1cm
8. ky may be estimated using the simplified equations shown below.
9. Examples of how Ts is estimated are shown below.
10. Vs = weighted avg. shear wave velocity for the sliding mass, e.g., for 2 layers, Vs = [(h1)(Vs1) + (h2)(Vs2)]/(h1 + h2)

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SEE NOTES BELOW FOR GUIDANCE IN THE USE OF SPREADSHEET

Input Parameters			
Yield Coefficient (ky)	0.086		Based on pseudostatic analysis
Initial Fundamental Period (Ts)	0.11	seconds	1D: Ts=4H/Vs 2D: Ts=2.6H/Vs
Degraded Period (1.5Ts)	0.17	seconds	
Moment Magnitude (Mw)	7.9		
Spectral Acceleration (Sa(1.5Ts))	1.44	g	

Additional Input Parameters		
Probability of Exceedance #1 (P1)	84	%
Probability of Exceedance #2 (P2)	50	%
Probability of Exceedance #3 (P3)	16	%
Displacement Threshold (d_threshold)	15	cm

Intermediate Calculated Parameters			
Non-Zero Seismic Displacement Est (D)	124.96	cm	eq. (5) or (6)
Standard Deviation of Non-Zero Seismic D	0.66		

Results					
Probability of Negligible Displ. (P(D=0))	0.000				eq. (3)
D1	64.82	cm	**2.1**	ft	calc. using eq. (7)
D2	**124.96**	**cm**	**4.1**	**ft**	calc. using eq. (7)
D3	240.89	cm	**7.9**	inft	calc. using eq. (7)
P(D>d_threshold)	0.999				eq. (7)

Notes

1. Values highlighted in blue are input parameters
2. Probability of Exceedance is the desired probability of exceeding a particular displacement value.
3. Displacements D1, D2, and D3 correspond to P1, P2, and P3, respectively.
   (e.g., the probability of exceeding displacement D1 is P1)
4. Calculated seismic displacements are due to deviatoric deformation only (add in volumetrically induced movement).
5. ky may range between 0.01 and 0.5, Ts between 0 and 2 s, Sa between 0.002 and 2.7 g, M between 4.5 and 9
6. Rigid slope is assumed for Ts < 0.05 s
7. When a value for D is not calculated, D is < 1cm
8. ky may be estimated using the simplified equations shown below.
9. Examples of how Ts is estimated are shown below.
10. Vs = weighted avg. shear wave velocity for the sliding mass, e.g., for 2 layers, Vs = [(h1)(Vs1) + (h2)(Vs2)]/(h1 + h2)

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Input Parameters			
Yield Coefficient (ky)	0.086		Based on pseudostatic analysis
Initial Fundamental Period (Ts)	0.14	seconds	1D: Ts=4H/Vs 2D: Ts=2.6H/Vs
Degraded Period (1.5Ts)	0.20	seconds	
Moment Magnitude (Mw)	7.9		
Spectral Acceleration (Sa(1.5Ts))	1.53	g	

Additional Input Parameters		
Probability of Exceedance #1 (P1)	84	%
Probability of Exceedance #2 (P2)	50	%
Probability of Exceedance #3 (P3)	16	%
Displacement Threshold (d_threshold)	15	cm

Intermediate Calculated Parameters			
Non-Zero Seismic Displacement Est (D)	141.22	cm	eq. (5) or (6)
Standard Deviation of Non-Zero Seismic D	0.66		

Results					
Probability of Negligible Displ. (P(D=0))	0.000				eq. (3)
D1	73.25	cm	**2.4**	ft	calc. using eq. (7)
D2	**141.22**	**cm**	**4.6**	**ft**	calc. using eq. (7)
D3	272.22	cm	**8.9**	inft	calc. using eq. (7)
P(D>d_threshold)	1.000				eq. (7)

Notes

1. Values highlighted in blue are input parameters
2. Probability of Exceedance is the desired probability of exceeding a particular displacement value.
3. Displacements D1, D2, and D3 correspond to P1, P2, and P3, respectively.
   (e.g., the probability of exceeding displacement D1 is P1)
4. Calculated seismic displacements are due to deviatoric deformation only (add in volumetrically induced movement).
5. ky may range between 0.01 and 0.5, Ts between 0 and 2 s, Sa between 0.002 and 2.7 g, M between 4.5 and 9
6. Rigid slope is assumed for Ts < 0.05 s
7. When a value for D is not calculated, D is < 1cm
8. ky may be estimated using the simplified equations shown below.
9. Examples of how Ts is estimated are shown below.
10. Vs = weighted avg. shear wave velocity for the sliding mass, e.g., for 2 layers, Vs = [(h1)(Vs1) + (h2)(Vs2)]/(h1 + h2)

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Input Parameters			
Yield Coefficient (ky)	0.053		Based on pseudostatic analysis
Initial Fundamental Period (Ts)	0.11	seconds	1D: Ts=4H/Vs 2D: Ts=2.6H/Vs
Degraded Period (1.5Ts)	0.17	seconds	
Moment Magnitude (Mw)	7.9		
Spectral Acceleration (Sa(1.5Ts))	1.44	g	

Additional Input Parameters		
Probability of Exceedance #1 (P1)	84	%
Probability of Exceedance #2 (P2)	50	%
Probability of Exceedance #3 (P3)	16	%
Displacement Threshold (d_threshold)	15	cm

Intermediate Calculated Parameters			
Non-Zero Seismic Displacement Est (D)	186.61	cm	eq. (5) or (6)
Standard Deviation of Non-Zero Seismic D	0.66		

Results					
Probability of Negligible Displ. (P(D=0))	0.000				eq. (3)
D1	96.80	cm	**3.2**	ft	calc. using eq. (7)
D2	**186.61**	**cm**	**6.1**	**ft**	calc. using eq. (7)
D3	359.73	cm	**11.8**	inft	calc. using eq. (7)
P(D>d_threshold)	1.000				eq. (7)

Notes

1. Values highlighted in blue are input parameters
2. Probability of Exceedance is the desired probability of exceeding a particular displacement value.
3. Displacements D1, D2, and D3 correspond to P1, P2, and P3, respectively.
   (e.g., the probability of exceeding displacement D1 is P1)
4. Calculated seismic displacements are due to deviatoric deformation only (add in volumetrically induced movement).
5. ky may range between 0.01 and 0.5, Ts between 0 and 2 s, Sa between 0.002 and 2.7 g, M between 4.5 and 9
6. Rigid slope is assumed for Ts < 0.05 s
7. When a value for D is not calculated, D is < 1cm
8. ky may be estimated using the simplified equations shown below.
9. Examples of how Ts is estimated are shown below.
10. Vs = weighted avg. shear wave velocity for the sliding mass, e.g., for 2 layers, Vs = [(h1)(Vs1) + (h2)(Vs2)]/(h1 + h2)

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Input Parameters			
Yield Coefficient (ky)	0.247		Based on pseudostatic analysis
Initial Fundamental Period (Ts)	0.38	seconds	1D: Ts=4H/Vs 2D: Ts=2.6H/Vs
Degraded Period (1.5Ts)	0.58	seconds	
Moment Magnitude (Mw)	7.9		
Spectral Acceleration (Sa(1.5Ts))	1.3	g	

Additional Input Parameters		
Probability of Exceedance #1 (P1)	84	%
Probability of Exceedance #2 (P2)	50	%
Probability of Exceedance #3 (P3)	16	%
Displacement Threshold (d_threshold)	15	cm

Intermediate Calculated Parameters			
Non-Zero Seismic Displacement Est (D)	36.79	cm	eq. (5) or (6)
Standard Deviation of Non-Zero Seismic D	0.66		

Results					
Probability of Negligible Displ. (P(D=0))	0.000				eq. (3)
D1	19.08	cm	**0.6**	ft	calc. using eq. (7)
D2	**36.79**	**cm**	**1.2**	**ft**	calc. using eq. (7)
D3	70.92	cm	**2.3**	inft	calc. using eq. (7)
P(D>d_threshold)	0.913				eq. (7)

Notes

1. Values highlighted in blue are input parameters
2. Probability of Exceedance is the desired probability of exceeding a particular displacement value.
3. Displacements D1, D2, and D3 correspond to P1, P2, and P3, respectively.
   (e.g., the probability of exceeding displacement D1 is P1)
4. Calculated seismic displacements are due to deviatoric deformation only (add in volumetrically induced movement).
5. ky may range between 0.01 and 0.5, Ts between 0 and 2 s, Sa between 0.002 and 2.7 g, M between 4.5 and 9
6. Rigid slope is assumed for Ts < 0.05 s
7. When a value for D is not calculated, D is < 1cm
8. ky may be estimated using the simplified equations shown below.
9. Examples of how Ts is estimated are shown below.
10. Vs = weighted avg. shear wave velocity for the sliding mass, e.g., for 2 layers, Vs = [(h1)(Vs1) + (h2)(Vs2)]/(h1 + h2)

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Input Parameters			
Yield Coefficient (ky)	0.324		Based on pseudostatic analysis
Initial Fundamental Period (Ts)	0.09	seconds	1D: Ts=4H/Vs 2D: Ts=2.6H/Vs
Degraded Period (1.5Ts)	0.14	seconds	
Moment Magnitude (M_w)	7.9		
Spectral Acceleration (Sa(1.5Ts))	0.97	g	

Additional Input Parameters		
Probability of Exceedance #1 (P1)	84	%
Probability of Exceedance #2 (P2)	50	%
Probability of Exceedance #3 (P3)	16	%
Displacement Threshold (d_threshold)	15	cm

Intermediate Calculated Parameters			
Non-Zero Seismic Displacement Est (D)	7.23	cm	eq. (5) or (6)
Standard Deviation of Non-Zero Seismic D	0.66		

Results					
Probability of Negligible Displ. (P(D=0))	0.035				eq. (3)
D1	3.43	cm	**0.1**	ft	calc. using eq. (7)
D2	**7.02**	**cm**	**0.2**	**ft**	calc. using eq. (7)
D3	13.73	cm	**0.5**	inft	calc. using eq. (7)
P(D>d_threshold)	0.130				eq. (7)

Notes

1. Values highlighted in blue are input parameters
2. Probability of Exceedance is the desired probability of exceeding a particular displacement value.
3. Displacements D1, D2, and D3 correspond to P1, P2, and P3, respectively.
   (e.g., the probability of exceeding displacement D1 is P1)
4. Calculated seismic displacements are due to deviatoric deformation only (add in volumetrically induced movement).
5. ky may range between 0.01 and 0.5, Ts between 0 and 2 s, Sa between 0.002 and 2.7 g, M between 4.5 and 9
6. Rigid slope is assumed for Ts < 0.05 s
7. When a value for D is not calculated, D is < 1cm
8. ky may be estimated using the simplified equations shown below.
9. Examples of how Ts is estimated are shown below.
10. Vs = weighted avg. shear wave velocity for the sliding mass, e.g., for 2 layers, Vs = [(h1)(Vs1) + (h2)(Vs2)]/(h1 + h2)

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Input Parameters			
Yield Coefficient (ky)	0.215		Based on pseudostatic analysis
Initial Fundamental Period (Ts)	0.27	seconds	1D: Ts=4H/Vs 2D: Ts=2.6H/Vs
Degraded Period (1.5Ts)	0.41	seconds	
Moment Magnitude (M_w)	7.9		
Spectral Acceleration (Sa(1.5Ts))	1.38	g	

Additional Input Parameters		
Probability of Exceedance #1 (P1)	84	%
Probability of Exceedance #2 (P2)	50	%
Probability of Exceedance #3 (P3)	16	%
Displacement Threshold (d_threshold)	15	cm

Intermediate Calculated Parameters			
Non-Zero Seismic Displacement Est (D)	44.41	cm	eq. (5) or (6)
Standard Deviation of Non-Zero Seismic D	0.66		

Results					
Probability of Negligible Displ. (P(D=0))	0.000				eq. (3)
D1	23.04	cm	**0.8**	ft	calc. using eq. (7)
D2	**44.41**	**cm**	**1.5**	**ft**	calc. using eq. (7)
D3	85.61	cm	**2.8**	inft	calc. using eq. (7)
P(D>d_threshold)	0.950				eq. (7)

Notes

1. Values highlighted in blue are input parameters
2. Probability of Exceedance is the desired probability of exceeding a particular displacement value.
3. Displacements D1, D2, and D3 correspond to P1, P2, and P3, respectively.
   (e.g., the probability of exceeding displacement D1 is P1)
4. Calculated seismic displacements are due to deviatoric deformation only (add in volumetrically induced movement).
5. ky may range between 0.01 and 0.5, Ts between 0 and 2 s, Sa between 0.002 and 2.7 g, M between 4.5 and 9
6. Rigid slope is assumed for Ts < 0.05 s
7. When a value for D is not calculated, D is < 1cm
8. ky may be estimated using the simplified equations shown below.
9. Examples of how Ts is estimated are shown below.
10. Vs = weighted avg. shear wave velocity for the sliding mass, e.g., for 2 layers, Vs = [(h1)(Vs1) + (h2)(Vs2)]/(h1 + h2)

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Input Parameters			
Yield Coefficient (ky)	0.23		Based on pseudostatic analysis
Initial Fundamental Period (Ts)	0.05	seconds	1D: Ts=4H/Vs 2D: Ts=2.6H/Vs
Degraded Period (1.5Ts)	0.08	seconds	
Moment Magnitude (M_w)	7.9		
Spectral Acceleration (Sa(1.5Ts))	0.72	g	

Additional Input Parameters		
Probability of Exceedance #1 (P1)	84	%
Probability of Exceedance #2 (P2)	50	%
Probability of Exceedance #3 (P3)	16	%
Displacement Threshold (d_threshold)	15	cm

Intermediate Calculated Parameters			
Non-Zero Seismic Displacement Est (D)	6.82	cm	eq. (5) or (6)
Standard Deviation of Non-Zero Seismic D	0.66		

Results					
Probability of Negligible Displ. (P(D=0))	0.032				eq. (3)
D1	3.27	cm	**0.1**	ft	calc. using eq. (7)
D2	**6.64**	**cm**	**0.2**	**ft**	calc. using eq. (7)
D3	12.96	cm	**0.4**	inft	calc. using eq. (7)
P(D>d_threshold)	0.112				eq. (7)

Notes

1. Values highlighted in blue are input parameters
2. Probability of Exceedance is the desired probability of exceeding a particular displacement value.
3. Displacements D1, D2, and D3 correspond to P1, P2, and P3, respectively.
   (e.g., the probability of exceeding displacement D1 is P1)
4. Calculated seismic displacements are due to deviatoric deformation only (add in volumetrically induced movement).
5. ky may range between 0.01 and 0.5, Ts between 0 and 2 s, Sa between 0.002 and 2.7 g, M between 4.5 and 9
6. Rigid slope is assumed for Ts < 0.05 s
7. When a value for D is not calculated, D is < 1cm
8. ky may be estimated using the simplified equations shown below.
9. Examples of how Ts is estimated are shown below.
10. Vs = weighted avg. shear wave velocity for the sliding mass, e.g., for 2 layers, Vs = [(h1)(Vs1) + (h2)(Vs2)]/(h1 + h2)

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Input Parameters			
Yield Coefficient (ky)	0.115		Based on pseudostatic analysis
Initial Fundamental Period (Ts)	0.14	seconds	1D: Ts=4H/Vs 2D: Ts=2.6H/Vs
Degraded Period (1.5Ts)	0.20	seconds	
Moment Magnitude (M_w)	7.9		
Spectral Acceleration (Sa(1.5Ts))	1.11	g	

Additional Input Parameters		
Probability of Exceedance #1 (P1)	84	%
Probability of Exceedance #2 (P2)	50	%
Probability of Exceedance #3 (P3)	16	%
Displacement Threshold (d_threshold)	15	cm

Intermediate Calculated Parameters			
Non-Zero Seismic Displacement Est (D)	60.54	cm	eq. (5) or (6)
Standard Deviation of Non-Zero Seismic D	0.66		

Results					
Probability of Negligible Displ. (P(D=0))	0.000				eq. (3)
D1	31.41	cm	**1.0**	ft	calc. using eq. (7)
D2	**60.54**	**cm**	**2.0**	**ft**	calc. using eq. (7)
D3	116.71	cm	**3.8**	inft	calc. using eq. (7)
P(D>d_threshold)	0.983				eq. (7)

Notes
1. Values highlighted in blue are input parameters
2. Probability of Exceedance is the desired probability of exceeding a particular displacement value.
3. Displacements D1, D2, and D3 correspond to P1, P2, and P3, respectively.
(e.g., the probability of exceeding displacement D1 is P1)
4. Calculated seismic displacements are due to deviatoric deformation only (add in volumetrically induced movement).
5. ky may range between 0.01 and 0.5, Ts between 0 and 2 s, Sa between 0.002 and 2.7 g, M between 4.5 and 9
6. Rigid slope is assumed for Ts < 0.05 s
7. When a value for D is not calculated, D is < 1cm
8. ky may be estimated using the simplified equations shown below.
9. Examples of how Ts is estimated are shown below.
10. Vs = weighted avg. shear wave velocity for the sliding mass, e.g., for 2 layers, Vs = [(h1)(Vs1) + (h2)(Vs2)]/(h1 + h2)

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Input Parameters			
Yield Coefficient (ky)	0.086		Based on pseudostatic analysis
Initial Fundamental Period (Ts)	0.11	seconds	1D: Ts=4H/Vs 2D: Ts=2.6H/Vs
Degraded Period (1.5Ts)	0.17	seconds	
Moment Magnitude (M_w)	7.9		
Spectral Acceleration (Sa(1.5Ts))	1.05	g	

Additional Input Parameters		
Probability of Exceedance #1 (P1)	84	%
Probability of Exceedance #2 (P2)	50	%
Probability of Exceedance #3 (P3)	16	%
Displacement Threshold (d_threshold)	15	cm

Intermediate Calculated Parameters			
Non-Zero Seismic Displacement Est (D)	76.57	cm	eq. (5) or (6)
Standard Deviation of Non-Zero Seismic D	0.66		

Results					
Probability of Negligible Displ. (P(D=0))	0.000				eq. (3)
D1	39.72	cm	**1.3**	ft	calc. using eq. (7)
D2	**76.57**	**cm**	**2.5**	**ft**	calc. using eq. (7)
D3	147.61	cm	**4.8**	inft	calc. using eq. (7)
P(D>d_threshold)	0.993				eq. (7)

Notes

1. Values highlighted in blue are input parameters
2. Probability of Exceedance is the desired probability of exceeding a particular displacement value.
3. Displacements D1, D2, and D3 correspond to P1, P2, and P3, respectively.
   (e.g., the probability of exceeding displacement D1 is P1)
4. Calculated seismic displacements are due to deviatoric deformation only (add in volumetrically induced movement).
5. ky may range between 0.01 and 0.5, Ts between 0 and 2 s, Sa between 0.002 and 2.7 g, M between 4.5 and 9
6. Rigid slope is assumed for Ts < 0.05 s
7. When a value for D is not calculated, D is < 1cm
8. ky may be estimated using the simplified equations shown below.
9. Examples of how Ts is estimated are shown below.
10. Vs = weighted avg. shear wave velocity for the sliding mass, e.g., for 2 layers, Vs = [(h1)(Vs1) + (h2)(Vs2)]/(h1 + h2)

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Input Parameters			
Yield Coefficient (ky)	0.086		Based on pseudostatic analysis
Initial Fundamental Period (Ts)	0.14	seconds	1D: Ts=4H/Vs 2D: Ts=2.6H/Vs
Degraded Period (1.5Ts)	0.20	seconds	
Moment Magnitude (M_w)	7.9		
Spectral Acceleration (Sa(1.5Ts))	1.11	g	

Additional Input Parameters		
Probability of Exceedance #1 (P1)	84	%
Probability of Exceedance #2 (P2)	50	%
Probability of Exceedance #3 (P3)	16	%
Displacement Threshold (d_threshold)	15	cm

Intermediate Calculated Parameters			
Non-Zero Seismic Displacement Est (D)	86.64	cm	eq. (5) or (6)
Standard Deviation of Non-Zero Seismic D	0.66		

Results					
Probability of Negligible Displ. (P(D=0))	0.000				eq. (3)
D1	44.95	cm	**1.5**	ft	calc. using eq. (7)
D2	**86.64**	**cm**	**2.8**	**ft**	calc. using eq. (7)
D3	167.03	cm	**5.5**	inft	calc. using eq. (7)
P(D>d_threshold)	0.996				eq. (7)

Notes

1. Values highlighted in blue are input parameters
2. Probability of Exceedance is the desired probability of exceeding a particular displacement value.
3. Displacements D1, D2, and D3 correspond to P1, P2, and P3, respectively.
   (e.g., the probability of exceeding displacement D1 is P1)
4. Calculated seismic displacements are due to deviatoric deformation only (add in volumetrically induced movement).
5. ky may range between 0.01 and 0.5, Ts between 0 and 2 s, Sa between 0.002 and 2.7 g, M between 4.5 and 9
6. Rigid slope is assumed for Ts < 0.05 s
7. When a value for D is not calculated, D is < 1cm
8. ky may be estimated using the simplified equations shown below.
9. Examples of how Ts is estimated are shown below.
10. Vs = weighted avg. shear wave velocity for the sliding mass, e.g., for 2 layers, Vs = [(h1)(Vs1) + (h2)(Vs2)]/(h1 + h2)

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Input Parameters			
Yield Coefficient (ky)	0.053		Based on pseudostatic analysis
Initial Fundamental Period (Ts)	0.11	seconds	1D: Ts=4H/Vs 2D: Ts=2.6H/Vs
Degraded Period (1.5Ts)	0.17	seconds	
Moment Magnitude (Mw)	7.9		
Spectral Acceleration (Sa(1.5Ts))	1.05	g	

Additional Input Parameters		
Probability of Exceedance #1 (P1)	84	%
Probability of Exceedance #2 (P2)	50	%
Probability of Exceedance #3 (P3)	16	%
Displacement Threshold (d_threshold)	15	cm

Intermediate Calculated Parameters			
Non-Zero Seismic Displacement Est (D)	124.69	cm	eq. (5) or (6)
Standard Deviation of Non-Zero Seismic D	0.66		

Results					
Probability of Negligible Displ. (P(D=0))	0.000				eq. (3)
D1	64.68	cm	**2.1**	ft	calc. using eq. (7)
D2	**124.69**	**cm**	**4.1**	**ft**	calc. using eq. (7)
D3	240.36	cm	**7.9**	inft	calc. using eq. (7)
P(D>d_threshold)	0.999				eq. (7)

Notes

1. Values highlighted in blue are input parameters
2. Probability of Exceedance is the desired probability of exceeding a particular displacement value.
3. Displacements D1, D2, and D3 correspond to P1, P2, and P3, respectively.
   (e.g., the probability of exceeding displacement D1 is P1)
4. Calculated seismic displacements are due to deviatoric deformation only (add in volumetrically induced movement).
5. ky may range between 0.01 and 0.5, Ts between 0 and 2 s, Sa between 0.002 and 2.7 g, M between 4.5 and 9
6. Rigid slope is assumed for Ts < 0.05 s
7. When a value for D is not calculated, D is < 1cm
8. ky may be estimated using the simplified equations shown below.
9. Examples of how Ts is estimated are shown below.
10. Vs = weighted avg. shear wave velocity for the sliding mass, e.g., for 2 layers, Vs = [(h1)(Vs1) + (h2)(Vs2)]/(h1 + h2)

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Input Parameters			
Yield Coefficient (ky)	0.247		Based on pseudostatic analysis
Initial Fundamental Period (Ts)	0.38	seconds	1D: Ts=4H/Vs 2D: Ts=2.6H/Vs
Degraded Period (1.5Ts)	0.58	seconds	
Moment Magnitude (Mw)	6.6		
Spectral Acceleration (Sa(1.5Ts))	1.47	g	

Additional Input Parameters		
Probability of Exceedance #1 (P1)	84	%
Probability of Exceedance #2 (P2)	50	%
Probability of Exceedance #3 (P3)	16	%
Displacement Threshold (d_threshold)	15	cm

Intermediate Calculated Parameters			
Non-Zero Seismic Displacement Est (D)	33.14	cm	eq. (5) or (6)
Standard Deviation of Non-Zero Seismic D	0.66		

Results					
Probability of Negligible Displ. (P(D=0))	0.000				eq. (3)
D1	17.19	cm	**0.6**	ft	calc. using eq. (7)
D2	**33.14**	**cm**	**1.1**	**ft**	calc. using eq. (7)
D3	63.89	cm	**2.1**	inft	calc. using eq. (7)
P(D>d_threshold)	0.885				eq. (7)

Notes

1. Values highlighted in blue are input parameters
2. Probability of Exceedance is the desired probability of exceeding a particular displacement value.
3. Displacements D1, D2, and D3 correspond to P1, P2, and P3, respectively.
   (e.g., the probability of exceeding displacement D1 is P1)
4. Calculated seismic displacements are due to deviatoric deformation only (add in volumetrically induced movement).
5. ky may range between 0.01 and 0.5, Ts between 0 and 2 s, Sa between 0.002 and 2.7 g, M between 4.5 and 9
6. Rigid slope is assumed for Ts < 0.05 s
7. When a value for D is not calculated, D is < 1cm
8. ky may be estimated using the simplified equations shown below.
9. Examples of how Ts is estimated are shown below.
10. Vs = weighted avg. shear wave velocity for the sliding mass, e.g., for 2 layers, Vs = [(h1)(Vs1) + (h2)(Vs2)]/(h1 + h2)

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Input Parameters			
Yield Coefficient (ky)	0.324		Based on pseudostatic analysis
Initial Fundamental Period (Ts)	0.09	seconds	1D: Ts=4H/Vs 2D: Ts=2.6H/Vs
Degraded Period (1.5Ts)	0.14	seconds	
Moment Magnitude (Mw)	6.6		
Spectral Acceleration (Sa(1.5Ts))	1.17	g	

Additional Input Parameters		
Probability of Exceedance #1 (P1)	84	%
Probability of Exceedance #2 (P2)	50	%
Probability of Exceedance #3 (P3)	16	%
Displacement Threshold (d_threshold)	15	cm

Intermediate Calculated Parameters			
Non-Zero Seismic Displacement Est (D)	7.86	cm	eq. (5) or (6)
Standard Deviation of Non-Zero Seismic D	0.66		

Results					
Probability of Negligible Displ. (P(D=0))	0.007				eq. (3)
D1	4.01	cm	**0.1**	ft	calc. using eq. (7)
D2	**7.82**	**cm**	**0.3**	**ft**	calc. using eq. (7)
D3	15.11	cm	**0.5**	inft	calc. using eq. (7)
P(D>d_threshold)	0.163				eq. (7)

Notes

1. Values highlighted in blue are input parameters
2. Probability of Exceedance is the desired probability of exceeding a particular displacement value.
3. Displacements D1, D2, and D3 correspond to P1, P2, and P3, respectively.
   (e.g., the probability of exceeding displacement D1 is P1)
4. Calculated seismic displacements are due to deviatoric deformation only (add in volumetrically induced movement).
5. ky may range between 0.01 and 0.5, Ts between 0 and 2 s, Sa between 0.002 and 2.7 g, M between 4.5 and 9
6. Rigid slope is assumed for Ts < 0.05 s
7. When a value for D is not calculated, D is < 1cm
8. ky may be estimated using the simplified equations shown below.
9. Examples of how Ts is estimated are shown below.
10. Vs = weighted avg. shear wave velocity for the sliding mass, e.g., for 2 layers, Vs = [(h1)(Vs1) + (h2)(Vs2)]/(h1 + h2)

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Input Parameters			
Yield Coefficient (ky)	0.215		Based on pseudostatic analysis
Initial Fundamental Period (Ts)	0.27	seconds	1D: Ts=4H/Vs 2D: Ts=2.6H/Vs
Degraded Period (1.5Ts)	0.41	seconds	
Moment Magnitude (Mw)	6.6		
Spectral Acceleration (Sa(1.5Ts))	1.59	g	

Additional Input Parameters		
Probability of Exceedance #1 (P1)	84	%
Probability of Exceedance #2 (P2)	50	%
Probability of Exceedance #3 (P3)	16	%
Displacement Threshold (d_threshold)	15	cm

Intermediate Calculated Parameters			
Non-Zero Seismic Displacement Est (D)	40.95	cm	eq. (5) or (6)
Standard Deviation of Non-Zero Seismic D	0.66		

Results					
Probability of Negligible Displ. (P(D=0))	0.000				eq. (3)
D1	21.24	cm	**0.7**	ft	calc. using eq. (7)
D2	**40.95**	**cm**	**1.3**	**ft**	calc. using eq. (7)
D3	78.93	cm	**2.6**	inft	calc. using eq. (7)
P(D>d_threshold)	0.936				eq. (7)

Notes

1. Values highlighted in blue are input parameters
2. Probability of Exceedance is the desired probability of exceeding a particular displacement value.
3. Displacements D1, D2, and D3 correspond to P1, P2, and P3, respectively.
   (e.g., the probability of exceeding displacement D1 is P1)
4. Calculated seismic displacements are due to deviatoric deformation only (add in volumetrically induced movement).
5. ky may range between 0.01 and 0.5, Ts between 0 and 2 s, Sa between 0.002 and 2.7 g, M between 4.5 and 9
6. Rigid slope is assumed for Ts < 0.05 s
7. When a value for D is not calculated, D is < 1cm
8. ky may be estimated using the simplified equations shown below.
9. Examples of how Ts is estimated are shown below.
10. Vs = weighted avg. shear wave velocity for the sliding mass, e.g., for 2 layers, Vs = [(h1)(Vs1) + (h2)(Vs2)]/(h1 + h2)

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Input Parameters			
Yield Coefficient (ky)	0.23		Based on pseudostatic analysis
Initial Fundamental Period (Ts)	0.05	seconds	1D: Ts=4H/Vs 2D: Ts=2.6H/Vs
Degraded Period (1.5Ts)	0.08	seconds	
Moment Magnitude (Mw)	6.6		
Spectral Acceleration (Sa(1.5Ts))	0.9	g	

Additional Input Parameters		
Probability of Exceedance #1 (P1)	84	%
Probability of Exceedance #2 (P2)	50	%
Probability of Exceedance #3 (P3)	16	%
Displacement Threshold (d_threshold)	15	cm

Intermediate Calculated Parameters			
Non-Zero Seismic Displacement Est (D)	7.96	cm	eq. (5) or (6)
Standard Deviation of Non-Zero Seismic D	0.66		

Results					
Probability of Negligible Displ. (P(D=0))	0.004				eq. (3)
D1	4.09	cm	**0.1**	ft	calc. using eq. (7)
D2	**7.93**	**cm**	**0.3**	**ft**	calc. using eq. (7)
D3	15.32	cm	**0.5**	inft	calc. using eq. (7)
P(D>d_threshold)	0.168				eq. (7)

Notes

1. Values highlighted in blue are input parameters
2. Probability of Exceedance is the desired probability of exceeding a particular displacement value.
3. Displacements D1, D2, and D3 correspond to P1, P2, and P3, respectively.
   (e.g., the probability of exceeding displacement D1 is P1)
4. Calculated seismic displacements are due to deviatoric deformation only (add in volumetrically induced movement).
5. ky may range between 0.01 and 0.5, Ts between 0 and 2 s, Sa between 0.002 and 2.7 g, M between 4.5 and 9
6. Rigid slope is assumed for Ts < 0.05 s
7. When a value for D is not calculated, D is < 1cm
8. ky may be estimated using the simplified equations shown below.
9. Examples of how Ts is estimated are shown below.
10. Vs = weighted avg. shear wave velocity for the sliding mass, e.g., for 2 layers, Vs = [(h1)(Vs1) + (h2)(Vs2)]/(h1 + h2)

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Input Parameters			
Yield Coefficient (ky)	0.115		Based on pseudostatic analysis
Initial Fundamental Period (Ts)	0.14	seconds	1D: Ts=4H/Vs 2D: Ts=2.6H/Vs
Degraded Period (1.5Ts)	0.20	seconds	
Moment Magnitude (Mw)	6.6		
Spectral Acceleration (Sa(1.5Ts))	1.33	g	

Additional Input Parameters		
Probability of Exceedance #1 (P1)	84	%
Probability of Exceedance #2 (P2)	50	%
Probability of Exceedance #3 (P3)	16	%
Displacement Threshold (d_threshold)	15	cm

Intermediate Calculated Parameters			
Non-Zero Seismic Displacement Est (D)	57.57	cm	eq. (5) or (6)
Standard Deviation of Non-Zero Seismic D	0.66		

Results					
Probability of Negligible Displ. (P(D=0))	0.000				eq. (3)
D1	29.87	cm	**1.0**	ft	calc. using eq. (7)
D2	**57.57**	**cm**	**1.9**	**ft**	calc. using eq. (7)
D3	110.99	cm	**3.6**	inft	calc. using eq. (7)
P(D>d_threshold)	0.979				eq. (7)

Notes

1. Values highlighted in blue are input parameters
2. Probability of Exceedance is the desired probability of exceeding a particular displacement value.
3. Displacements D1, D2, and D3 correspond to P1, P2, and P3, respectively.
   (e.g., the probability of exceeding displacement D1 is P1)
4. Calculated seismic displacements are due to deviatoric deformation only (add in volumetrically induced movement).
5. ky may range between 0.01 and 0.5, Ts between 0 and 2 s, Sa between 0.002 and 2.7 g, M between 4.5 and 9
6. Rigid slope is assumed for Ts < 0.05 s
7. When a value for D is not calculated, D is < 1cm
8. ky may be estimated using the simplified equations shown below.
9. Examples of how Ts is estimated are shown below.
10. Vs = weighted avg. shear wave velocity for the sliding mass, e.g., for 2 layers, Vs = [(h1)(Vs1) + (h2)(Vs2)]/(h1 + h2)

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Input Parameters			
Yield Coefficient (ky)	0.086		Based on pseudostatic analysis
Initial Fundamental Period (Ts)	0.11	seconds	1D: Ts=4H/Vs 2D: Ts=2.6H/Vs
Degraded Period (1.5Ts)	0.17	seconds	
Moment Magnitude (M_w)	6.6		
Spectral Acceleration (Sa(1.5Ts))	1.25	g	

Additional Input Parameters		
Probability of Exceedance #1 (P1)	84	%
Probability of Exceedance #2 (P2)	50	%
Probability of Exceedance #3 (P3)	16	%
Displacement Threshold (d_threshold)	15	cm

Intermediate Calculated Parameters			
Non-Zero Seismic Displacement Est (D)	70.33	cm	eq. (5) or (6)
Standard Deviation of Non-Zero Seismic D	0.66		

Results					
Probability of Negligible Displ. (P(D=0))	0.000				eq. (3)
D1	36.48	cm	**1.2**	ft	calc. using eq. (7)
D2	**70.33**	**cm**	**2.3**	**ft**	calc. using eq. (7)
D3	135.58	cm	**4.4**	inft	calc. using eq. (7)
P(D>d_threshold)	0.990				eq. (7)

Notes

1. Values highlighted in blue are input parameters
2. Probability of Exceedance is the desired probability of exceeding a particular displacement value.
3. Displacements D1, D2, and D3 correspond to P1, P2, and P3, respectively.
   (e.g., the probability of exceeding displacement D1 is P1)
4. Calculated seismic displacements are due to deviatoric deformation only (add in volumetrically induced movement).
5. ky may range between 0.01 and 0.5, Ts between 0 and 2 s, Sa between 0.002 and 2.7 g, M between 4.5 and 9
6. Rigid slope is assumed for Ts < 0.05 s
7. When a value for D is not calculated, D is < 1cm
8. ky may be estimated using the simplified equations shown below.
9. Examples of how Ts is estimated are shown below.
10. Vs = weighted avg. shear wave velocity for the sliding mass, e.g., for 2 layers, Vs = [(h1)(Vs1) + (h2)(Vs2)]/(h1 + h2)

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Input Parameters			
Yield Coefficient (ky)	0.086		Based on pseudostatic analysis
Initial Fundamental Period (Ts)	0.14	seconds	1D: Ts=4H/Vs 2D: Ts=2.6H/Vs
Degraded Period (1.5Ts)	0.20	seconds	
Moment Magnitude (M_w)	6.6		
Spectral Acceleration (Sa(1.5Ts))	1.33	g	

Additional Input Parameters		
Probability of Exceedance #1 (P1)	84	%
Probability of Exceedance #2 (P2)	50	%
Probability of Exceedance #3 (P3)	16	%
Displacement Threshold (d_threshold)	15	cm

Intermediate Calculated Parameters			
Non-Zero Seismic Displacement Est (D)	79.98	cm	eq. (5) or (6)
Standard Deviation of Non-Zero Seismic D	0.66		

Results					
Probability of Negligible Displ. (P(D=0))	0.000				eq. (3)
D1	41.49	cm	**1.4**	ft	calc. using eq. (7)
D2	**79.98**	**cm**	**2.6**	**ft**	calc. using eq. (7)
D3	154.19	cm	**5.1**	inft	calc. using eq. (7)
P(D>d_threshold)	0.994				eq. (7)

Notes

1. Values highlighted in blue are input parameters
2. Probability of Exceedance is the desired probability of exceeding a particular displacement value.
3. Displacements D1, D2, and D3 correspond to P1, P2, and P3, respectively.
   (e.g., the probability of exceeding displacement D1 is P1)
4. Calculated seismic displacements are due to deviatoric deformation only (add in volumetrically induced movement).
5. ky may range between 0.01 and 0.5, Ts between 0 and 2 s, Sa between 0.002 and 2.7 g, M between 4.5 and 9
6. Rigid slope is assumed for Ts < 0.05 s
7. When a value for D is not calculated, D is < 1cm
8. ky may be estimated using the simplified equations shown below.
9. Examples of how Ts is estimated are shown below.
10. Vs = weighted avg. shear wave velocity for the sliding mass, e.g., for 2 layers, Vs = [(h1)(Vs1) + (h2)(Vs2)]/(h1 + h2)

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Input Parameters			
Yield Coefficient (ky)	0.053		Based on pseudostatic analysis
Initial Fundamental Period (Ts)	0.11	seconds	1D: Ts=4H/Vs 2D: Ts=2.6H/Vs
Degraded Period (1.5Ts)	0.17	seconds	
Moment Magnitude (Mw)	6.6		
Spectral Acceleration (Sa(1.5Ts))	1.25	g	

Additional Input Parameters		
Probability of Exceedance #1 (P1)	84	%
Probability of Exceedance #2 (P2)	50	%
Probability of Exceedance #3 (P3)	16	%
Displacement Threshold (d_threshold)	15	cm

Intermediate Calculated Parameters			
Non-Zero Seismic Displacement Est (D)	109.18	cm	eq. (5) or (6)
Standard Deviation of Non-Zero Seismic D	0.66		

Results					
Probability of Negligible Displ. (P(D=0))	0.000				eq. (3)
D1	56.64	cm	**1.9**	ft	calc. using eq. (7)
D2	**109.18**	**cm**	**3.6**	**ft**	calc. using eq. (7)
D3	210.47	cm	**6.9**	inft	calc. using eq. (7)
P(D>d_threshold)	0.999				eq. (7)

Notes

1. Values highlighted in blue are input parameters
2. Probability of Exceedance is the desired probability of exceeding a particular displacement value.
3. Displacements D1, D2, and D3 correspond to P1, P2, and P3, respectively.
   (e.g., the probability of exceeding displacement D1 is P1)
4. Calculated seismic displacements are due to deviatoric deformation only (add in volumetrically induced movement).
5. ky may range between 0.01 and 0.5, Ts between 0 and 2 s, Sa between 0.002 and 2.7 g, M between 4.5 and 9
6. Rigid slope is assumed for Ts < 0.05 s
7. When a value for D is not calculated, D is < 1cm
8. ky may be estimated using the simplified equations shown below.
9. Examples of how Ts is estimated are shown below.
10. Vs = weighted avg. shear wave velocity for the sliding mass, e.g., for 2 layers, Vs = [(h1)(Vs1) + (h2)(Vs2)]/(h1 + h2)

Appendix B: Cost Estimate and Construction Schedule

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ESTIMATE BASIS, WORK INCLUDED, WORK EXCLUDED, ASSUMPTIONS AND QUALIFICATIONS

2016 FEASIBILITY LEVEL COST ESTIMATE
SALTON SEA RESTORATION PLAN
PERIMETER LOW PROFILE LEVEE ALTERNATIVE
ALTERNATIVE A - BASE CASE

Estimate for the Permitting, Design and Construction of The Salton Sea Restoration Plan

GENERAL INFORMATION

The estimate contained in this workbook was prepared, in part, based upon information provided by Tetra Tech BAS during a meeting in their Diamond Bar, CA offices on October 7, 2015 and subsequent updated drawings and additional information sent by email. Additional information was supplied in January and February by Tetra Tech BAS concerning the location and conceptual design of the spillways and flood control structures.

The estimate was prepared by James C Juliani (estimator) using his 48 years of experience estimating large and complex construction projects. The purpose of the estimate is to determine the feasibility and probable cost of the construction of The Salton Sea Restoration Plan, Perimeter Low Profile Levee Alternative being developed by Tetra Tech BAS.

The estimate provided is considered to be a Class 4 estimate as defined by The American Association of Cost Engineers in their Recommended Practice No. 18R-97. The estimator considers the estimate has a potential variation of +30% to -20% from the value of the cost estimate including contingency for the scope of the work estimated.

ESTIMATE BASIS

The estimate is based upon the following drawings and documents:

- Drawing titled - Salton Sea Feasibility Study, Northshore Levee @ -250' (Drawing indicates a total levee length of 66.7 miles)
- Drawing titled - Salton Sea Feasibility Study, Dredge and Sheet pile Section @ -245'
- Tetra Tech BAS Report - Draft Preliminary Geotechnical Feasibility Study, Perimeter Low Profile Levee Alternative, Dated September 18, 2015.
- URS - In-Sea Embankment Concepts, Salton Sea Revitalization Plan, Dated June 27, 2007
- URS - Geotechnical Reconnaissance, Potential Rock Quarry at Coolidge Mountain for Salton Sea Revitalization Plan, Dated February, 2007
- Draft Technical Memo, Salton Sea Perimeter Lake Overflow Spillway Analysis and Assumptions, Prepared by Jeffrey S. Nikolas, PE dated January 20, 2016.
- Email from Jeff Nikolas to estimator dated February 11, 2016 with Subject Updated Salton Sea Spillway Quantities.

The estimate is based on the Owner awarding the Work represented by the estimate to a General EPCM Contractor who will implement the Work.

The estimate for project labor assumes that prevailing wage determinations will apply. Current determinations were obtained online and used to calculate the wage rates used in the estimate.

Pricing for equipment and equipment maintenance costs are generally based upon the 2012 edition of Mine and Mill Equipment Costs published by InfoMine USA, Inc. Pricing is then adjusted for 2015 costs, prevailing wages rates for maintenance labor and current energy costs.

Pricing for the vinyl sheetpile is based upon information from Tetra Tech BAS as to material cost (sales tax and freight added). Installation production is based upon the estimators experience and provides for the pile driving rig to be placed on a barge.

Dredging is scheduled on a 24-hour, 7 days per week, 350 days per year basis. A shift rotation called 12 hour 4X4 was used in the estimate. This rotation involves four crews working 12-hour, 4 day weeks (48 hours) with the following 4 days off.

WORK INCLUDED

The estimate assumes and provides for Overall Management of the Project by the Owner. The estimate provides for installation of Owner offices and infrastructure on property purchased for that purpose. The estimate includes the cost for Owner personnel and expenses to manage and monitor the project implementation and progress and report the status of the project to the various stakeholders.

Permitting

- Design and Performance of a test dredge/embankment construction
- Preparation of an EIR/EIS including public review
- Substantive compliance with Federal, State or Local permit requirements.

Engineering required for the construction of the project including design drawings, equipment, material, construction specifications and construction quality control/quality assurance requirements and plans.

Procurement of major materials and equipment especially long lead items.

Procurement of services of qualified contractors to construct the Work and administration of the contracts

Field construction management and engineering to assure that the Work is constructed in accordance with the drawings, specifications and approved Project Plans.

Mobilization and demobilization of all required personnel, equipment and materials required to construct the work.

Dredge from shore side to provide deeper water for fish habitat and construct approximately 66.7 miles Levee.

Construct 12 access causeways of approximately 4.5 miles in total length from the shore to the Levee including installation of one pipe arch in each for the passage of water and small watercraft.

Install a single sheetpile wall seepage barrier the entire length of the levee

Install Geotextile on the existing Sea bottom from the sheetpile barrier to the sea side either 220 feet (15' levee) or 295 feet (20' levee) wide on which the levee embankment will be placed.

Install a total of three bellmouth spillways and one broad crested weir spillway for level control of the perimeter sea and flood control. The spillways incorporate Sluce Gate valves to reduce the perimeter sea level in the event of an issue with the levee.

Establish and operate a quarry and processing equipment to produce the aggregates and rock fill needed to construct the causeway access to the levee.

Haul the aggregates and rockfill to near the installation sites and stockpile.

Install the aggregates from stockpile to the levee for road access and armoring of the embankment against wind and wave erosion or damage.

The estimate includes an allowance to install settlement monitoring, salinity monitoring and seepage monitoring, etc. to monitor the consolidation and performance of the levee embankment

Provide stockpiles of aggregates in the total quantity of 1,000,000 cubic yards in the area of the quarry for long term maintenance of levee roads and erosion control

Provide a crew of approximately 12 people plus equipment to perform maintenance and repairs on the access roads and levee for a period of 10-years. The estimate assumes this maintenance group is employed/contracted and managed by the Owner.

ESTIMATE BASIS, WORK INCLUDED, WORK EXCLUDED, ASSUMPTIONS AND QUALIFICATIONS

2016 FEASIBILITY LEVEL COST ESTIMATE
SALTON SEA RESTORATION PLAN
PERIMETER LOW PROFILE LEVEE ALTERNATIVE
ALTERNATIVE A - BASE CASE

Estimate for the Permitting, Design and Construction of The Salton Sea Restoration Plan

WORK EXCLUDED

Any and all costs prior to October 1, 2015

Costs for management, monitoring or measurement of water sources to the Salton Sea including such things as water treatment, diversion works and/or channels, pumping stations and the like are not included.

Costs for management of and dust control in the area to the inside of the Levee (exposed beach and brine pool) are not included.

The estimate does not include salvage value for any purchased equipment upon completion of the Work. It is anticipated that there will be some but likely not significant salvage value.

ASSUMPTIONS

Permit fees for required Federal, State or Local permits are included and are assumed to be 1% of the total inplace constructed value of the work.

Property requirements for the quarry, rock processing plants, infrastructure and stockpiles has been estimated and either the lease or purchase of the required property is included in the estimate.

The estimate assumes that in addition to a lease arrangement for use of the quarry property that a royalty for rock quarried and removed from the property of the landowner will be required and an allowance of $2.00 per ton is provided for this cost.

The estimate assumes that property for stockpiling of rock products can be found near (+ or - 1 mile) the 12 planned causeways. Lease cost for the required property is included in the estimate.

The estimate assumes that purchases of equipment and materials by the project is subject to the State of CA sales tax.

The estimate assumes that the material can be dredged, dewatered, transported by conveyor and placed in the embankment without significant materials handling problems. The estimate provides for a test dredge to evaluate the dredging and material handling difficulty. In the event the test dredge indicates the dredged material properties will not allow handling as assumed in the estimate an alternate dredge and placement method will be evaluated. The estimator is reasonably convinced that a gantry dredge, bucketwheel dredge or a cutterhead suction dredge could be employed to construct the Work. The excavator dredge was chosen due to the power the machine has to excavate the Salton Sea floor deposits. The other dredging methods mentioned may actually be more cost effective than the excavator assuming they can meet the required production.

The estimate assumes that a Project Specific Agreement and be negotiated with the Dredgers such that the 4 - 12 hour shift can be paid at 40 hours straight time and 8 hours at time and one half.

The estimate assume that funds for the construction of the project are available on an as needed basis from the stakeholders and as such there are not any financing, interest during consctuction or similar costs included in the estimate.

QUALIFICATIONS

The estimator, while generally familiar with geotechnical parameters for soils, is not a geotechnical engineer and assumptions regarding excavation of the sea floor soils with the excavator or other equipment will need to be verified before equipment selection is completed. The estimate does include additional geotechnical investigation and a test dredge for this purpose.

The estimate is stated in October 2015 US$ and no future escalation is provided.

The contingency applied is considered by the estimator to be adequate and customary given the project definition.

2016 FEASIBILITY LEVEL COST ESTIMATE
SALTON SEA RESTORATION PLAN

Permitting, Design and Construction of The Salton Sea Restoration Plan
Alternative A - Base Case Estimate
PERIMETER LOW PROFILE LEVEE ALTERNATIVE

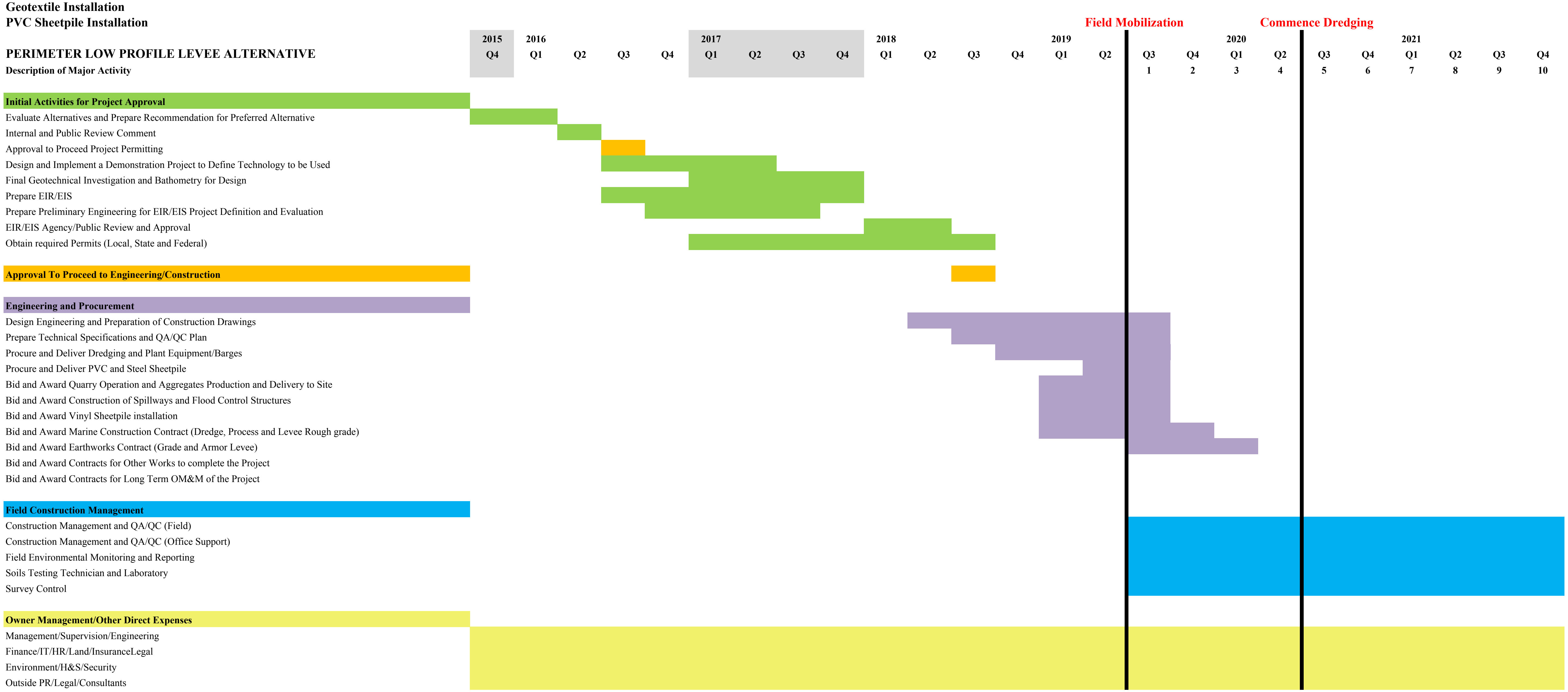
Item	Description	Units	Unit Cost	Quantity/ Expenses %	Cost
1	**Initial Activities for Project Approval**				
	Evaluate Alternatives and Prepare Recommendation for Preferred Alternative	Lot	$562,000	5%	$590,100
	Internal and Public Review Comment	Lot	$374,000	5%	$392,700
	Design and Implement a Demonstration Project to Define Technology to be Used	Lot	$1,630,000	25%	$2,037,500
	Final Geotechnical Investigation and Bathometry for Design	Lot	$842,000	5%	$884,100
	Prepare EIR/EIS	Lot	$8,736,000	10%	$9,609,600
	Prepare Preliminary Engineering for EIR/EIS Project Definition and Evaluation	Lot	$5,616,000	10%	$6,177,600
	EIR/EIS Agency/Public Review and Approval	Lot	$1,217,000	5%	$1,277,850
	Obtain required Permits (Local, State and Federal)	Lot	$2,574,000	10%	$2,831,400
				SUBTOTAL	**$23,800,900**
2	**Permitting, Engineering and Procurement**				
	Design Engineering and Preparation of Construction Drawings	Lot	$13,260,000	10%	$14,586,000
	Prepare Technical Specifications and QA/QC Plan	Lot	$4,976,000	5%	$5,224,800
	Procure and Deliver Dredging and Plant Equipment/Barges	Lot	$1,716,000	10%	$1,887,600
	Procure and Deliver PVC and Steel Sheetpile	Lot	$390,000	10%	$429,000
	Bid and Award Quarry Operation and Aggregates Production and Delivery to Site	Lot	$772,000	15%	$887,800
	Bid and Award Construction of Spillways and Flood Control Structures	Lot	$601,000	15%	$691,150
	Bid and Award Vinyl Sheetpile installation	Lot	$429,000	15%	$493,350
	Bid and Award Marine Construction Contract (Dredge, Process and Levee Rough grade)	Lot	$1,201,000	15%	$1,381,150
	Bid and Award Earthworks Contract (Grade and Armor Levee)	Lot	$601,000	15%	$691,150
	Bid and Award Contracts for Other Works to complete the Project	Lot	$343,000	15%	$394,450
	Bid and Award Contracts for Long Term OM&M of the Project	Lot	$429,000	10%	$471,900
				SUBTOTAL	**$27,138,400**
3	**Construction Management and Support**				
	Site Facilities and Expenses	week	$10,000	520	$5,210,000
	Construction Management and QA/QC (Field)	Lot	$74,763,000	25%	$93,453,750
	Construction Management and QA/QC (Office Support)	Lot	$13,856,700	5%	$14,549,535
	Field Environmental Monitoring and Reporting	Lot	$19,656,000	30%	$25,552,800
	Soils Testing Technician and Laboratory	Lot	$9,984,000	50%	$14,976,000
	Survey Control	Lot	$7,800,000	15%	$8,970,000
				SUBTOTAL	**$162,712,100**
4	**Owner Management/Other Direct Expenses**				
	Mobilization of Owner Offices/Facilities/Utilities for Oversight of the Project	Lot	$1,876,800	Included	$1,876,800
	Management/Administrative Personnel	Lot	$73,995,000	5%	$77,694,750
	Owner Offices/Facilities/Utilities/Insurance/Taxes Expense	week	$7,500	520	$3,900,000
	Federal, State and Local Permit Fees (allowance of 1% of inplace constructed value)	Lot	$1,229,000,000	1.00%	$12,290,000
	Lease and/or Purchase of Property for Project Use	Lot	$3,360,917	10%	$3,697,008
	Royalties on Quarried Rock (at $2.00 per ton)	tons	10,630,000	$2.00	$21,260,000
				SUBTOTAL	**$120,718,558**
				TOTAL THIS GROUP	**$334,400,000**
	LEVEE CONSTRUCTION				
5	**Mobilization**				
	Conduct Dredging Demonstration Project	Lot	$5,700,000	1	$5,700,000
	Conduct Geotechnical Investigation and Obtain Detailed Bathymetry	Lot	$2,239,680	1	$2,239,680
	Mobilize Men and Equipment for Sheetpile and Levee Construction	Lot	$1,596,000	1	$1,596,000
	Mobilize Men and Equipment for Quarry Setup and Operation	Lot	$819,000	1	$819,000
	Install Project Offices, Laydown and Maintenance Areas, Warehousing and Storage Areas	Lot	$4,167,680	1	$4,167,680
	Receive and Laydown Barges, Dredge, and Process Equipment	Lot	$1,172,160	1	$1,172,160
	Receive and Laydown Sheetpile and Other Miscellaneous Materials Incorporated in the Work	Lot	$976,800	1	$976,800
	Install Dredge and Levee Construction Components and Pre-Operational Testing	Lot	$6,914,560	1	$6,914,560
	Dismantle Dredging Equipment and Remove from Site	Lot	$2,765,824	1	$2,765,824
	Demobilization of Facilities (Not Required for OM&M) and Final Site Cleanup	Lot	$4,688,640	1	$4,688,640
	Demobilization of Equipment and Reclamation/Revegetation and Closure of the Quarry Site.	Lot	$1,562,880	1	$1,562,880
				SUBTOTAL	**$32,603,224**

2016 FEASIBILITY LEVEL COST ESTIMATE
SALTON SEA RESTORATION PLAN

Permitting, Design and Construction of The Salton Sea Restoration Plan					
Alternative A - Base Case Estimate					
PERIMETER LOW PROFILE LEVEE ALTERNATIVE					
Item	**Description**	**Units**	**Unit Cost**	**Quantity/ Expenses %**	**Cost**
6	**Quarry Operation and Aggregate Production**				
	Capital Equipment Required to Quarry	Lot	$15,161,699	1	$15,161,699
	Rock Processing Units	Lot	$11,440,477	1	$11,440,477
	Capital Cost for Haul	Lot	$8,061,379	1	$8,061,379
	Drill and Blast/Load and Haul Rock for Processing	ton	$5.67	8,075,686	$45,789,142
	Produce Rock Products	cy	$4.96	4,703,345	$23,344,647
	Deliver Rock Products for Levee Access and Construction	cy	$13.74	4,703,345	$64,628,100
	Produce and Stockpile Aggregates for Long Term Project OM&M	cy	$10.63	1,000,000	$10,633,414
		cy	**$16.90**	**SUBTOTAL**	**$163,897,160**
7	**PVC Sheetpile Installation**				
	Furnish and Deliver Sheetpile	sf	$7.75	12,502,248	$96,861,166
	Install Sheetpile	sf	$10.77	12,502,248	$134,649,211
		sf	**$18.52**	**SUBTOTAL**	**$231,510,377**
8	**Install Spillways and Flood Control Structures**				
	Install North Shore Bellmouth Spillway and Flood Control Weir and Discharge Structure	Lot	$35,575,003	1	$35,575,003
	Install Bombay Beach Bellmouth Spillway and Discharge Structure	Lot	$14,171,244	1	$14,171,244
	Install Southwest Bellmouth Spillway and Discharge Structure	Lot	$14,957,187	1	$14,957,187
				SUBTOTAL	**$64,703,434**
9	**Dredging and Levee Construction**				
	Furnish and Deliver Major Equipment for Dredging and Levee Construction	Lot	$31,370,583	1	$31,370,583
	Furnish and Deliver Major Equipment for Geotextile Placement	Lot	$2,233,659	1	$2,233,659
	Furnish and Deliver Geotextile	sf	$0.22	88,145,112	$19,039,344
	Place Geotextile Ahead of embankment (15 foot Nominal Section)	sf	$0.34	76,665,600	$25,828,286
	Place Geotextile Ahead of embankment (20 foot Nominal Section)	sf	$0.31	11,479,512	$3,541,176
	Dredge, Process and Place Initial Levee Embankment (15 foot Nominal Section)	cy	$8.12	44,666,472	$362,710,045
	Dredge, Process and Place Initial Levee Embankment (20 foot Nominal Section)	cy	$8.12	7,917,616	$64,294,287
		Mile	**$7,631,445**	**SUBTOTAL**	**$509,017,380**
10	**Grade and Armor Levee/Construct Access Points**				
	Haul Rock Products from Stockpile	cy	$8.07	4,703,345	$37,940,563
	Furnish and Deliver Major Equipment for Levee Grading and Armor	Lot	$6,462,288	1	$6,462,288
	Grade and Armor Levee/Construct Access Points	lf	$116.85	375,936	$43,926,981
	Install Multi-Plate Pipe Arches	cy	$100,000	12	$1,200,000
		Mile	**$1,342,276**	**SUBTOTAL**	**$89,529,833**
11	**Other Miscellaneous Works to complete the Project**				
	Embankment Settlement Monitoring, Salinity Monitoring, inflow seepage, etc.	Lot	$1.00	10,000,000	$10,000,000
				SUBTOTAL	**$10,000,000**
12	**OM&M of the Constructed Project (10 Years is Assumed)**				
	Provide Dedicated Equipment and Personnel for Long Term OM&M				
	Personnel	year	$1,996,800.00	10	$19,968,000
	Equipment	year	$1,497,600.00	10	$14,976,000
	Expenses	year	$399,360.00	10	$3,993,600
	Owner Long Term Management and Expenses	year	$823,680.00	10	$8,236,800
				SUBTOTAL	**$47,174,400**
				TOTAL THIS GROUP	**$1,148,400,000**
				Project Total	**$1,482,800,000**
13	**Recommended Contingency**	**%**	**15.00%**		**$222,400,000**
			Total		**$1,705,000,000**

Estimated Work Schedule

Dredge, Process Soil and Embankment Construction
Demonstration Project
Mobilization, Project Setup, Temporary Facilities, Demob
Quarry Operations and Hauling/Stockpiling Rock Products
Grade and Armor Levee/Construct Causways
Install Spillways and Flood Control Structures
Geotextile Installation
PVC Sheetpile Installation



Estimated Work Schedule

PERIMETER LOW PROFILE LEVEE ALTERNATIVE

Description of Major Activity	2015	2016				2017				2018				2019				2020				2021			
	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
																1	2	3	4	5	6	7	8	9	10

Mobilization/Site Preparation/Demobilization

Conduct Dredging Demonstration Project
Conduct Geotechnical Investigation and Obtain Detailed Bathymetry
Mobilize Men and Equipment for Sheetpile and Levee Construction
Mobilize Men and Equipment for Quarry Setup and Operation
Install Project Offices, Laydown and Maintenance Areas, Warehousing and Storage Areas
Receive and Laydown Barges, Dredge, and Process Equipment
Receive and Laydown Sheetpile and Other Miscellaneous Materials Incorporated in the Work
Install Dredge and Levee Construction Components and Pre-Operational Testing
Dismantle Dredging Equipment and Remove from Site
Demobilization of Facilities (Not Required for OM&M) and Final Site Cleanup
Demobilization of Equipment and Reclamation/Revegetation and Closure of the Quarry Site.

Quarry Operation and Aggregate Production

Produce and Deliver Road Base Material for Levee and Levee Access
Produce and Deliver Sea Side Wind Erosion Gravel
Produce and Deliver Shore Side Gravely Sand
Produce and Deliver Shore Side Have Erosion Gravel
Produce and Deliver Rockfill for Levee Access
Produce and Stockpile Aggregates for Long Term Project OM&M

PVC Sheetpile Installation

Install Sheetpile (35-foot Nominal Depth)
Install Sheetpile (40-foot Nominal Depth)

Install Spillways and Flood Control Structures

Crew 1 Install North Shore Bellmouth Spillway and Flood Control Weir and Discharge Structure
Crew 2 Install Bombay Beach Bellmouth Spillway and Discharge Structure
Crew 2 Install Southwest Bellmouth Spillway and Discharge Structure

Dredging and Levee Construction

Place Geotextile Ahead of embankment (15 foot Nominal Section)
Place Geotextile Ahead of embankment (20 foot Nominal Section)
Dredge, Process and Place Initial Levee Embankment (15 foot Nominal Section)
Dredge, Process and Place Initial Levee Embankment (20 foot Nominal Section)

Grade and Armor Levee/Construct Access Points

Grade Levee
Place Road Base
Place Sea Side Wind Erosion Gravel
Place Shore Side Gravely Sand
Place Shore Side Wave Erosion Gravel
Place Rockfill for Levee Access
Install Multi-Plate Pipe Arches

Other Miscellaneous Works to complete the Project

OM&M of the Constructed Project (10 Years is Assumed)

Estimated Work Schedule

Dredge, Process Soil and Embankment Construction
Demonstration Project
Mobilization, Project Setup, Temporary Facilities, Demob
Quarry Operations and Hauling/Stockpiling Rock Products
Grade and Armor Levee/Construct Causways
Install Spillways and Flood Control Structures
Geotextile Installation
PVC Sheetpile Installation

PERIMETER LOW PROFILE LEVEE ALTERNATIVE	2022				2023				2024				2025				2026				2027				2028				2029			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Description of Major Activity	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42

Initial Activities for Project Approval
Evaluate Alternatives and Prepare Recommendation for Preferred Alternative
Internal and Public Review Comment
Approval to Proceed Project Permitting
Design and Implement a Demonstration Project to Define Technology to be Used
Final Geotechnical Investigation and Bathometry for Design
Prepare EIR/EIS
Prepare Preliminary Engineering for EIR/EIS Project Definition and Evaluation
EIR/EIS Agency/Public Review and Approval
Obtain required Permits (Local, State and Federal)

Approval To Proceed to Engineering/Construction

Engineering and Procurement
Design Engineering and Preparation of Construction Drawings
Prepare Technical Specifications and QA/QC Plan
Procure and Deliver Dredging and Plant Equipment/Barges
Procure and Deliver PVC and Steel Sheetpile
Bid and Award Quarry Operation and Aggregates Production and Delivery to Site
Bid and Award Construction of Spillways and Flood Control Structures
Bid and Award Vinyl Sheetpile installation
Bid and Award Marine Construction Contract (Dredge, Process and Levee Rough grade)
Bid and Award Earthworks Contract (Grade and Armor Levee)
Bid and Award Contracts for Other Works to complete the Project
Bid and Award Contracts for Long Term OM&M of the Project

Field Construction Management
Construction Management and QA/QC (Field)
Construction Management and QA/QC (Office Support)
Field Environmental Monitoring and Reporting
Soils Testing Technician and Laboratory
Survey Control

Owner Management/Other Direct Expenses
Management/Supervision/Engineering
Finance/IT/HR/Land/InsuranceLegal
Environment/H&S/Security
Outside PR/Legal/Consultants

Estimated Work Schedule

PERIMETER LOW PROFILE LEVEE ALTERNATIVE

Description of Major Activity	2022 Q1	Q2	Q3	Q4	2023 Q1	Q2	Q3	Q4	2024 Q1	Q2	Q3	Q4	2025 Q1	Q2	Q3	Q4	2026 Q1	Q2	Q3	Q4	2027 Q1	Q2	Q3	Q4	2028 Q1	Q2	Q3	Q4	2029 Q1	Q2	Q3	Q4
	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42

Mobilization/Site Preparation/Demobilization

- Conduct Dredging Demonstration Project
- Conduct Geotechnical Investigation and Obtain Detailed Bathymetry
- Mobilize Men and Equipment for Sheetpile and Levee Construction
- Mobilize Men and Equipment for Quarry Setup and Operation
- Install Project Offices, Laydown and Maintenance Areas, Warehousing and Storage Areas
- Receive and Laydown Barges, Dredge, and Process Equipment
- Receive and Laydown Sheetpile and Other Miscellaneous Materials Incorporated in the Work
- Install Dredge and Levee Construction Components and Pre-Operational Testing
- Dismantle Dredging Equipment and Remove from Site
- Demobilization of Facilities (Not Required for OM&M) and Final Site Cleanup
- Demobilization of Equipment and Reclamation/Revegetation and Closure of the Quarry Site.

Quarry Operation and Aggregate Production

- Produce and Deliver Road Base Material for Levee and Levee Access
- Produce and Deliver Sea Side Wind Erosion Gravel
- Produce and Deliver Shore Side Gravely Sand
- Produce and Deliver Shore Side Have Erosion Gravel
- Produce and Deliver Rockfill for Levee Access
- Produce and Stockpile Aggregates for Long Term Project OM&M

PVC Sheetpile Installation

- Install Sheetpile (35-foot Nominal Depth)
- Install Sheetpile (40-foot Nominal Depth)

Install Spillways and Flood Control Structures

- Crew 1 Install North Shore Bellmouth Spillway and Flood Control Weir and Discharge Structure
- Crew 2 Install Bombay Beach Bellmouth Spillway and Discharge Structure
- Crew 2 Install Southwest Bellmouth Spillway and Discharge Structure

Dredging and Levee Construction

- Place Geotextile Ahead of embankment (15 foot Nominal Section)
- Place Geotextile Ahead of embankment (20 foot Nominal Section)
- Dredge, Process and Place Initial Levee Embankment (15 foot Nominal Section)
- Dredge, Process and Place Initial Levee Embankment (20 foot Nominal Section)

Grade and Armor Levee/Construct Access Points

- Grade Levee
- Place Road Base
- Place Sea Side Wind Erosion Gravel
- Place Shore Side Gravely Sand
- Place Shore Side Wave Erosion Gravel
- Place Rockfill for Levee Access
- Install Multi-Plate Pipe Arches

Other Miscellaneous Works to complete the Project

OM&M of the Constructed Project (10 Years is Assumed) — To 2038

Unit Price Development for Place Geotextile Ahead of Levee Embankment Placement

Dredge and Embankment placement Operation Production is 153 Feet Per Day

Quantity	Equipment/Crew/Consumables	Rate Including All Markups Hr	Daily	Production Per Hour Shift	Unit
	Placement for 15-Foot High Embankment		**8**		
2	Push Boat, 250 hp	$120.00	$1,920.00		
1	Work Platform (5000 sf)	$50.00	$400.00	43372	sf
1	Supply Pontoon	$20.00	$160.00		
0.8	Yard Crane	$120.00	$768.00		
2	Support Boats	$50.00	$800.00		
9	Geotextile Crew	$146.72	$10,563.88		
	Total		$14,611.88		
	Cost Per Square Foot		$0.34		
	Placement for 20-Foot High Embankment		**8**		
2	Push Boat, 250 hp	$120.00	$1,920.00		
1	Work Platform (5000 sf)	$50.00	$400.00	43965	sf
1	Supply Pontoon	$20.00	$160.00		
0.8	Yard Crane	$120.00	$768.00		
2	Support Boats	$50.00	$800.00		
9	Geotextile Crew	$132.14	$9,514.08		
	Total		$13,562.08		
	Cost Per Square Foot		$0.31		

Unit Price Development for Dredging and Initial Levee Embankment Construction

Quantity	Equipment/Crew/Consumables	Rate Including All Markups Hr	Daily	Production Per Hour Shift	Unit
			24		
1	Hydraulic Excavator (Liebherr P995 or equal)	$967.85	$23,228.50	21600	cy
1	Modular Processing Plant 1200 tph design	$1,219.61	$29,270.67		
1	Conveyors, 1500 tph, Total Length 1700 lf	$611.66	$14,679.93		
2	Push Boat Tug, 500 hp	$192.98	$9,262.90		
5%	Allowance for Miscellaneous Equipment	$149.61	$3,590.53		
	Labor Crew (26 persons)	$3,814.73	$91,553.59		
	Shift Overlap at 25 hours in 24	$158.95	$3,814.73		
	Total		$175,400.85		
	Unit Price for Estimate		$8.12		

Notes	Value		Unit
Excavator Bucket Capacity	23.50		cy
Excavator Cycle	60.00		sec
Buckets Per Hour	60.00		ea
Max Production Per Hour	1410.00		cy
Bucket Load Factor	80%		
Overall Efficiency/Availability	80%		
Annual Average Hourly Production	902	Use 900	cy
Annual Hours of Dredge Operation	8,400		
Annual Average Production	7,560,000		
Total Quantity Required	52,580,000		

Total Dredge Quantity Calculation

Volume of 15-foot Embankment

Segment	Width	Height	Factor	Area (sf)	Length	Volume
5:1 up	50	10	0.5	250.0		
15:1 Up	75	5	0.5	187.5		
15:1 Up	75	10	1	750.0		
Center	30	15	1	450.0		
15:1 down	225	15	0.5	1,687.5		
Lines and Grade Vol				3,325.0		
Insitu Consolidation				308.0		
Levee Consolidation				172.0		
Total				3,805.0	316,950	44,666,472

Total Dredge Quantity Calculation

Volume of 20-foot Embankment

Segment	Width	Height	Factor	Area	Length	Volume
5:1 up	75	15	0.5	562.5		
15:1 Up	75	5	0.5	187.5		
15:1 Up	75	15	1	1,125.0		
Center	30	20	1	600.0		
15:1 down	300	20	0.5	3,000.0		
Lines and Grade Vol				5,475.0		
Insitu Consolidation				383.0		
Levee Consolidation				210.0		
Total				6,068.0	35,230	7,917,616
		6.7				
		52,584,089				

Adjust Operating Rates for Labor and Fuel/Power

Rate (CostMine)	Labor	Power	Bare Rate	Labor	Power	Total	Per Unit Hr	
	303%	182%						
$137.80	$48.94	35.1	$53.76	$148.25	$63.82	$265.83	$132.91	Jaw Crusher (500 tph)
$218.20	$88.64	37.66	$91.90	$268.51	$68.47	$428.88	$214.44	Secondary crushing/Screening Plant
$66.52	$34.96	6.68	$24.88	$105.90	$12.15	$142.93	$35.73	Conveyor (400 lf)
$56.45	$30.55	4.2	$21.70	$92.54	$7.64	$121.88	$24.38	Conveyor (200 lf)
$49.56	$22.20	10.05	$17.31	$67.25	$18.27	$102.83	$34.28	Stackers

Capital Cost

$930,000	Motorgrader
$1,410,000	Excavator with Long Stick
$352,000	Loader
$1,355,600	Dozer
$1,494,000	Compactor
$392,000	Water Truck
$50,000	Water Pump with Hoses (2-inch)

Unit Price Development for Quarry Processing

Quantity	Equipment/Crew/Consumables	Rate Including All Markups Hr	Daily	Production Per	Unit
			8	Hour Shift	
2	Jaw Crusher (500 tph)	$132.91	$2,126.60		
2	Secondary crushing/Screening Plant	$214.44	$3,431.02		
4	Conveyor (400 lf)	$35.73	$1,143.40		
5	Conveyor (200 lf)	$24.38	$975.02		
3	Stackers	$34.28	$822.64		
	Subtotal Equipment		$8,498.69		
	Operating Equipment will be 75% at any time		$6,374.02	2704	
	Labor				
8	Laborer (average of groups used)	$110.11	$7,047.05		
	Total Cost Per Day		$13,421.07		
	Unit Processing Price		$4.96	per cy	

Unit Price Development to Grade and Armor the Levee
200 lf Per Day

Quantity	Equipment/Crew/Consumables	Rate Including All Markups Hr	Daily	Production Per	Unit
			8	Hour Shift	
2	Motorgrader	$76.96	$1,231.32		
2	Excavator with Long Stick	$90.48	$1,447.60		
2	Loader	$38.44	$615.10		
2	Dozer	$98.66	$1,578.51		
2	Compactor	$154.66	$2,474.60		
1	Water Truck	$96.46	$771.65		
2	Water Pump with Hoses (2-inch)	$10.00	$160.00		
	Labor				
4	Laborer (average of groups used)	$94.98	$3,039.23		
10	Equipment Operator or Mechanic	$116.15	$9,292.19		
1	Truck Driver	$103.26	$826.07		
2	Foreman	$120.82	$1,933.12		
	Subtotal				
	Tax	8%			
	Total		$23,369.39	1	Crew Day
	Cost Per Crew Day		$116.85	200	lf Per Day

DESCRIPTION	QUANTITY	UNIT	UNIT PRICE OR VALUE (October 2015)	TOTAL PRICE	NOTES/CALCULATION
Percentage for Miscellaneous Expenses as Percent of Labor		%	3%		
Percentage for Miscellaneous Expenses as Percent of Labor		%	5%		
Percentage for Miscellaneous Expenses as Percent of Labor		%	10%		
Percentage for Miscellaneous Expenses as Percent of Labor		%	15%		
Contractors Markup for Purchases Administration		%	7%		
Sales Tax for Direct Purchase (Riverside and Imperial Counties)		%	8%		
Third Party Engineering and Construction Management					
Principal		$/Hour	$225.00		
Project Director		$/Hour	$185.00		
Senior Project Engineer		$/Hour	$165.00		
Engineer/Geologist		$/Hour	$140.00		
Junior Engineer		$/Hour	$115.00		
Field Engineer (QAQC)		$/Hour	$105.00		
Senior Technician		$/Hour	$95.00		
Technician/Senior Draftsperson/CAD		$/Hour	$85.00		
Administrative		$/Hour	$75.00		
Composite Rate For Permitting, Engineering and Construction Management		$/Hour	$150.00		
Salton Sea Authority Management Organization					
General Manager and Administration		$/Hour	$146.43		6
Finance		$/Hour	$110.71		3
Human Resources		$/Hour	$100.00		1
Environment		$/Hour	$108.93		2
Health and Safety		$/Hour	$117.86		1
IT/Communications		$/Hour	$117.86		1
Security		$/Hour	$60.71		4
Land/Permitting		$/Hour	$132.14		2
Insurance Legal		$/Hour	$132.14		1
Composite Rate for Owner Management		$/Hour	$115.00		
Allowance of Owner Travel/Subsistence		$/Hour	$15.00		Average per hour worked
Marine Construction Labor Rate Development					Assumes a Project Agreement can be negotiated for 12-hour 4X4 shift Schedule Providing for 40 straight time and 8 at 1 1/2 time
Prevailing Wage Contractor Labor for Marine Operations					Determination SC-63-12-23-2015-1
Deck Captain		$/Hour	$71.55		
Leverman		$/Hour	$74.55		
Deckmate		$/Hour	$68.47		
Deckhand		$/Hour	$67.38		
Hydrographic Surveyor		$/Hour	$69.34		
Welder		$/Hour	$69.97		
Estimated Wage Contractor Labor for Marine Operations					
General Foreman		$/Hour	$82.01		
Forman		$/Hour	$78.28		
Contractors Payroll additives (FICA, USL&H Insurance, Employment Security and Unemployment)		%	25.00%		Assumes 10% premium on wage for USL&H Insurance
Contractors General Conditions		%	5.00%		Allowance
Contractors Overhead and Profit on Labor		%	15.00%		
Total Multiplier to Wage			150.94%		
Allowance for Travel and Subsistence		Crew$/Hour	$734.20		4 Hours In/Out+$150/Day Living+100/Day+7%Fee
Average Hourly Wage for Marine Works Crew		Crew$/Hour	$3,080.53		
All in Wage for Dredge/Levee Construction Crew		$/Hour	$3,814.73		
Total Annual Cost For Marine Construction		Annual	$32,043,755		Using 12-Hour 4X4 Shift Roster
Blended Rate for Marine Construction	1	mh	$118.48		
Travel and Subsistence Cost for Marine Construction	1	mh	$28.24		Travel and Subsistence
Total Manhour Cost for Marine Construction Prevailing Wage	1	mh	$146.72		
Total Manhour Premium for Marine Construction Prevailing Wage			163%		Assumes non-prevailing wage all in marine construction is $90
Adjustment Factor for CostMine Operating Rates for Labor			404%		CostMine wage Used in Operation Rate $36.35
Upland Construction Labor Rate Development					
Contractor Labor (Average of all Classifications) For General Construction					
Laborer		$/Hour	$51.98		Prevailing Wage for Riverside/Imperial Counties
Equipment Operator or Mechanic		$/Hour	$67.23		Prevailing Wage for Riverside/Imperial Counties
Truck Driver		$/Hour	$57.95		Prevailing Wage for Riverside/Imperial Counties
Foreman		$/Hour	$70.59		Prevailing Wage for Riverside/Imperial Counties
General Foreman		$/Hour	$73.95		Prevailing Wage for Riverside/Imperial Counties
Contractors Payroll additives (FICA, Workmen's Comp, Employment Security and Unemployment)		%	15.00%		
Contractors General Conditions		%	5.00%		Allowance
Contractors Overhead and Profit on Labor		%	15.00%		
Total Multiplier to Wage			138.86%		
Allowance for Travel and Subsistence plus		$/Hour	$22.80		3 Hours In/Out+$150/Day Living+7%Fee

Contractor Labor Including All Costs and OH&P					
Laborer (average)		$/Hour	$94.98		
Equipment Operator or Mechanic		$/Hour	$116.15		
Truck Driver		$/Hour	$103.26		$2.84
Foreman		$/Hour	$120.82		
Superintendent		$/Hour	$125.49		
Blended Rate for General Construction/Quarry Operation			$110.11		1 Labor + 3 Op +2 Team +1 Forman
Total Manhour Premium for Construction Prevailing Wage			147%		Assumes non-prevailing wage all in construction is $90
Adjustment Factor for CostMine Operating Rates for Labor			303%		
Mobilization/Demobilization to/from Site (Assume Contractor is Local Southern CA)					
Minor Pieces and Tool Trailers	1	Lot	$1,500.00		
Mobilization and Demobilization from Outside California of Major Pieces	1	Lot	$4,500.00		
Mobilization of offices and ancillary support buildings and Utilities	1	buildsf	$150.00		
Personnel	1	Lot	$600.00		3 hours each way at $100 Average
Equipment Rates (Excluding Operator and Replacement , Fully Maintained)			1.15		Including Contractors OH&P on Equipment If applicable
Push Boat Tug, 500 hp		$/Hour	$192.98		
Hydraulic Excavator (Liebherr P995 or equal)		$/Hour	$967.85		
Modular Processing Plant 1200 tph design		$/Hour	$1,219.61		
Conveyors, 1500 tph, Total Length 1700 lf		$/Hour	$611.66		
Major Purchased Equipment for Dredge/Levee Construction					
Push Boat Tug, 500 hp	3	ea	$450,000	$1,350,000	3 units required
Excavator, Liebherr P995 (or Equal)	1	ea	$6,057,900	$6,057,900	
Modular Barges (See Quote from Poseidon Barge)	1	lot	$11,481,048	$11,481,048	Price includes Sales Tax but not freight
Modular Barges Freight Estimate (See Quote from Poseidon Barge)	83	loads	$9,037	$750,100	Shipped from Fort Wayne, IN
Modular Processing Plant 1200 cyh design	1	lot	$5,505,216	$5,505,216	4x300 cyh Plant Escalated plus 20% for sand recovery cyclones
Conveyors, Total of 1700 lf, 8 ea	1	lot	$2,047,400	$2,047,400	
Platework allowance for Dredge Bin and Levee Feed Bin (60 tons each at $5000 per ton)	2	ea	$300,000	$600,000	
Sales Tax at 8%	8%	%	$15,560,516.00	$1,244,841	
Freight (Use 15% of Cost)	15%	%	$15,560,516.00	$2,334,077	
Subtotal Equipment				$31,370,583	
Unit Price for Floating Work Platforms	1	sf	$167.97	$167.97	Equals 3,472,000 Plus freight at $223,400 Divided by 22,000 sf
Major Purchased Equipment for Geotextile Installation					
Push Boat, 250 hp	2	ea	$250,000.00	$500,000	
Work Platform (5000 sf)	5000	sf	$167.97	$839,864	
Supply Pontoon	1	ea	$201,567.27	$201,567	
Support Boats	2	ea	$50,000.00	$100,000	
Ancillary and Support Equipment and Freight at 20% of Primary	20	%	$16,414.31	$328,286	
Spare Parts Inventory at 6% of Primary	6	%	$16,414.31	$98,486	
Sales Tax at 8%	8	%	$20,682.03	$165,456	
Subtotal Equipment				$2,233,659	
Furnish and Deliver Materials/Install Materials					
Geotextile 16-Ounce	88,145,112	sf	$0.22	$19,039,344	Price Includes Freight and Sales Tax. Quantities include a 10% allowance for overlap and waste.
Furnish and Deliver Sheetpile	12,502,248	sf	$7.75	$96,861,166	Vendor Quoted $7 per square foot - Add sales Tax and freight
					Assume delivery in 20 ton loads at $1500 per load
Install Sheetpile	12,502,248	sf	$10.77	$134,649,211	It is doubtful that Contractors Quote of $5 to $7 includes Marine Construction Prevailing wage Labor plus travel and subsistence. Use $6 and assume 60% is labor. $3.60 Labor times 1.56 equals $5.62 Labor. Estimate that barge mounted pile driver will be 2x installation on upland. Us $2.40 times 2 equals $4.80 for equipment. For Double Shift assume shift change productivity loss plus shift differential equals 1 hour lost per day(Add $1,845 for 5254 sf/per day = $0.35)

Install Steel Sheetpile for Spillways and Flood Control Structures					
Furnish and Deliver Sheetpile	4,960	Tons	$1,814.40	$8,999,424	
Labor	760,800	sf	$11.50	$8,749,200	
Equipment	760,800	sf	$8.10	$6,162,480	
Average unit price for all steel sheetpiling	760,800		$31.43	$23,911,104	
Quarry Operation and Processing to Produce Project Required Aggregates					
Total Rock Products Required Plus 10% Processing loss/Stockpiles/Roads/Other Use.	5,703,345	cy			
Calculate Tons of Rock	9,695,686	Tons			
Tons in Stockpile at Quarry Site	1,700,000	Tons			
Tons Hauled to Levee	7,995,686	Tons			
Tons of Rock products required for Spillway and Flood Control					
Rock required for fill	650,250	tons	$22.35	$38.00	Per CY (Includes a 50% premium on placement)
Rock required for Rip Rap	65,620	tons	$25.88	$44.00	Per CY (Includes a 100% premium on placement plus $2 per load x 2 for Handling difficulty)
Rock required for concrete aggregate	25,956	tons			
Rock required for road base/structural fill	52,866	tons			
Rock products required for Spillways and flood control	794,692				
Cost for Quarry Drill, Blast Load and Haul to Course Ore Stockpile	1	Tons	$5.67		Unit price from Mine estimate in 2015 adjusted for Wage Rate and Economy of Scale
Capital Equipment Required to Quarry					Escalated 6% (2012 to 2015)
Drills	2	ea	$806,660	$1,613,320	
Shovel	1	ea	$1,745,820	$1,745,820	
Trucks	3	ea	$780,160	$2,340,480	
Wheel Loader	1	ea	$840,580	$840,580	
Dozers	2	ea	$1,057,880	$2,115,760	
Water Truck	1	ea	$680,520	$680,520	
Motorgrader	1	ea	$810,900	$810,900	
Subtotal Primary Equipment				$10,147,380	
Ancillary and Support Equipment at 20% of Primary				$2,029,476	
Spare Parts Inventory at 6% of Primary				$608,843	
Total Capital Equipment for Quarry Operation				$12,785,699	
Estimate Office, Warehouse, Maintenance Shop Including Services	15840	sf	$150.00	$2,376,000	Office 24x60, Warehouse/Dry 60x80, Maint Shop 80x120
Total Capital Cost for Quarry				$15,161,699	
Rock Processing Units					
Crushers	2	ea	$652,000	$1,304,000	
Cone Crushers and Screens	2	ea	$1,170,000	$2,340,000	
Conveyors	4	ea	$292,030	$1,168,120	
Conveyors	5	ea	$223,130	$1,115,650	
Stackers	2	Ea	$111,512	$223,024	
Subtotal Processing Equipment				$6,150,794	
Ancillary and Support Equipment at 20% of Primary				$1,230,159	
Equipment Installation at 50% of Capital Cost				$3,690,476	
Spare Parts Inventory at 6% of Primary				$369,048	
Total Capital Cost for Processing				$11,440,477	

Capital Cost for Haul					
Haul Trucks, 13 cy per load	27	ea		$5,708,880	
Loader 5 cy	2	ea		$689,040	
Subtotal Haul Equipment				$6,397,920	
Ancillary and Support Equipment at 20% of Primary				$1,279,584	
Spare Parts Inventory at 6% of Primary				$383,875	
Total Capital Cost for Haul				$8,061,379	
Mobilization Calculations					Use labor rate of $146.00 for Marine and $110.00 for upland
Conduct Dredging Demonstration Project	0.5	Mile	$11,400,000.00	$5,700,000	Use 150% of Rate for 66.7 miles of Levee
Conduct Geotechnical Investigation and Obtain Detailed Bathymetry	1	Lot	$2,239,680.00	$2,239,680	on average at $5,000 plus Engineers and preparation of Report of 2000 manhours. Bathymetry Allowance of $250,000
Mobilize Men and Equipment for Sheetpile and Levee Construction	1	Lot	$1,596,000.00	$1,596,000	Mobilize 160 People Plus 50 Major Loads Plus 50 Minor Loads Plus Facilities
Mobilize Men and Equipment for Quarry Setup and Operation	1	Lot	$819,000.00	$819,000	Mobilize 90 People Plus 30 Major Loads Plus 60 Minor Loads Plus Facilities
Install Project Offices, Laydown and Maintenance Areas, Warehousing and Storage Areas	1	Lot	$4,167,680.00	$4,167,680	Allowance for 16 people for 8 months
Receive and Laydown Barges, Dredge, and Process Equipment	1	Lot	$1,172,160.00	$1,172,160	Allowance for 6 people for 6 months
Receive and Laydown Sheetpile and Other Miscellaneous Materials Incorporated in the Work	1	Lot	$976,800.00	$976,800	Allowance for 6 people for 5 months
Install Dredge and Levee Construction Components and Pre-Operational Testing	1	Lot	$6,914,560.00	$6,914,560	Crew of 20 people for 8 months
Dismantle Dredging Equipment and Remove from Site	1	Lot	$2,765,824.00	$2,765,824	Crew of 16 people for 4 months
Demobilization of Facilities Not Required for OM&M and Final Site Cleanup	1	Lot	$4,688,640.00	$4,688,640	Crew of 16 people for 9 months
Demobilization of Equipment and Reclamation/Revegetation and Closure of the Quarry Site.	1	Lot	$1,562,880.00	$1,562,880	Crew of 12 people for 4 months
Mobilization of Owner Offices/Facilities/Utilities for Oversight of the Project	1	Lot	$1,876,800.00	$1,876,800	Crew of 10 people for 3 months Plus 6000 sf Facilities/Utilities at $150/sf
Armor Block for flood spillway (temporary)	1	sf	$15.00		Assume 8" thick articulated blocks (7.00 purchase + 3.00 deliver + 5.00 Install)

Haul Calculation

						Load			2 min		13 cy				Labor Factor		303%		2 min		7.5 cy
Haul From Quarry to Access Points				Total	4,703,345	Unload			1 min		Haul from Access points to Levee								1 min		
						loaded															
Point	Haul Dist	Levee	%	Cy to Point	Haul loaded speed	Return Empty speed	Total trip(min)	Trips	Total Hours		Point	Haul Dist	CY to Levee	Ave Trip Speed	Total trip(min)	Trips	Total Hours				
12	40	7	10%	491,394	50	55	95	37,800	59,620		12	9	491,394	25	25	65,519	26,863				
11	35	4	6%	280,797	50	55	83	21,600	29,945		11	6	280,797	25	17	37,440	10,857				
10	31	4	6%	280,797	45	50	82	21,600	29,352		10	6	280,797	25	17	37,440	10,857				
9	27	3	4%	210,598	45	50	71	16,200	19,278		9	5	210,598	25	15	28,080	7,020				
8	24	5	7%	350,996	40	45	71	27,000	31,950		8	7	350,996	25	20	46,799	15,444				
7	11	6	9%	421,195	45	50	31	32,400	16,668		7	8	421,195	25	22	56,159	20,779				
6	7	5	7%	350,996	40	45	23	27,000	10,275		6	7	350,996	25	20	46,799	15,444				
5	8	5	7%	350,996	35	40	29	27,000	12,921		5	7	350,996	25	20	46,799	15,444				
4	10	7	10%	491,394	35	40	35	37,800	22,140		4	9	491,394	25	25	65,519	26,863				
3	22	7	10%	491,394	40	45	65	37,800	41,160		3	9	491,394	25	25	65,519	26,863				
2	20	6	9%	421,195	45	50	54	32,400	28,980		2	8	421,195	25	22	56,159	20,779				
1	28	8	12%	561,593	50	55	67	43,199	48,344		1	10	561,593	25	27	74,879	33,696				
		67	1	4,703,345				361,796	350,631	truck Hours						627,113	230,908				
									389,590	Truck Hours at 90%							256,565	Truck Hours at 90%			

	Total days			1777		
	At 8 hrs			14216		
	Trucks Required Calculatec			0.00		
					1.08	Tax
Purchase Trucks		30	$176,200	$5,286,000	$5,708,880	
Purchase Loaders		2	$319,000	$638,000	$689,040	
Operating Per Hour		28	$42.98	2	$56.28	
		28	$103.26	2	$116.15	
			$146.24		$172.44	
	Use		$152.69		$180.88	
			$59,485,354		$5,142,746	

	Total days			1777		
	At 8 hrs			14216		
				0.00		
					1.08	Tax
Purchase Trucks		20	$93,400	$1,868,000	$2,017,440	
Purchase Loaders		2	$176,000	$352,000	$380,160	
Operating Per Hour		18	$23.35	2	$38.44	
		18	$103.26	2	$116.15	
			$126.61		$154.60	
	Use		$130.11		$160.36	
			$33,381,128		$4,559,435	

Property Calculation

Quarry/Project Laydown/ Offices/Access Points/Stockpiles Property Required

Utilities 16200
Desert 5400 Per acre

Point/Location	Stored CY from above	cf/10-feet/43560 Approximate Acres Needed	Spillways Use	Notes	Value of Area	Lease at .0.36% per Mo x 2 Points at 50% (	Months	Lease Purchase Cost
12	491,394	30	40	Lease for Project Duration	216000	$1,555	54	$83,981
11	280,797	17	20	Lease for Project Duration	108000	$778	54	$41,990
10	280,797	17	20	Lease for Project Duration	108000	$778	54	$41,990
9	210,598	13	15	Lease for Project Duration	81000	$583	54	$31,493
8	350,996	22	30	Lease for Project Duration	162000	$1,166	54	$62,986
7	421,195	26	30	Lease for Project Duration	162000	$1,166	54	$62,986
6	350,996	22	25	Lease for Project Duration	135000	$972	54	$52,488
5	350,996	22	25	Lease for Project Duration	135000	$972	54	$52,488
4	491,394	30	30	Lease for Project Duration	162000	$1,166	54	$62,986
3	491,394	30	30	Lease for Project Duration	162000	$1,166	54	$62,986
2	421,195	26	30	Lease for Project Duration	162000	$1,166	54	$62,986
1	561,593	35	40	Lease for Project Duration	216000	$1,555	54	$83,981
SSA Administration			10	Purchase for Long Term Use. Say 30 persons	162000			$162,000
Contractors Facilities			120	Lease for Project Duration	648000	$4,666	108	$503,885
Quarry/Process/Batch Plant			320	Lease for Project Duration + Royality Payment of 2.00 per ton removed from the Site	1728000	$12,442	108	$1,343,693
Long Term Stockpile	1,000,000	62	120	Purchase for Long Term Use	648000			$648,000
							Total	$3,360,917

COST ESTIMATE

EM,S CCode	ITEM AND DESCRIPTION	QUANTITY	UNIT	UNIT COST	SUB-CONT.	TOTAL
	Salton Sea Restoration					
	Details of Estimate Components					
	Install North Shore Bellmouth Spillway and Flood Control Weir and Discharge Structure					
	Bellmouth Spillway Installation					
	Construct causeway from shore to levee location (included in estimate item 10)					
S	Allowance to extend causeway to Spillway Location (300 lf)	15,600	cy	$22.35	$348,706	$348,706
S	Drive sheetpiles for double wall cofferdam	220,800	sf	$31.43	$6,939,500	$6,939,500
S	Dewater cofferdam and remove unsuitable material (2-feet)	5,100	cy	$33.30	$169,830	$169,830
S	Place fill for cofferdam	43,400	cy	$25.60	$1,111,040	$1,111,040
S	Install cross ties (assume 10-feet c-c)	266	ea	$2,430.00	$646,380	$646,380
S	Place road base on cofferdam road	5,100	cy	$37.80	$192,780	$192,780
S	Dewater inside of cofferdam (10 cfs for 2.3 million)(allowance for labor/pump/hoses)	65	hours	$300.00	$19,500	$19,500
S	Excavate for inlet structure and box culvert including fill and seepage control	44,800	cy	$6.00	$268,800	$268,800
S	Place 2-feet structural fill under inlet structure and box culvert	5,800	cy	$37.80	$219,240	$219,240
S	Install foundation piles (four clusters of 12 each)	48	each	$6,000.00	$288,000	$288,000
	Install Bell/Drop inlet structure concrete					
S	Base	117	cy	$400.00	$46,800	$46,800
S	Walls	192	cy	$740.00	$142,080	$142,080
S	Floors	109	cy	$1,010.00	$110,090	$110,090
S	Bell	70	cy	$1,500.00	$105,000	$105,000
S	Furnish, deliver and install sluice gate valves (8x8-feet)	3	each	$160,000.00	$480,000	$480,000
S	Furnish, deliver and install precast box culvert	1,000	lf	$2,480.00	$2,480,000	$2,480,000
S	Furnish, deliver and install building/security structure for spillway inlet	1,050	sf	$250.00	$262,500	$262,500
S	Backfill for inlet structure and box culvert	30,900	cy	$22.35	$690,706	$690,706
S	Install discharge structure at outlet of box culvert (allowance)	100	cy	$740.00	$74,000	$74,000
S	Place riprap for discharge structure including excavation/geotextile as needed	3,000	cy	$44.00	$132,000	$132,000
	Install Flood Control Weir and Discharge Structure					
	Construct causeway from shore to levee location (included in estimate item 10)					
S	Allowance to extend causeway to Weir Location (500 lf)	25,900	cy	$22.35	$578,941	$578,941
S	Drive sheetpiles for levee low permeability core core	98,400	sf	$31.43	$3,092,603	$3,092,603
S	Dewater low permeability core and remove unsuitable material (2-feet)	2,700	cy	$33.30	$89,910	$89,910
S	Place low permeability fill	25,700	cy	$25.60	$657,920	$657,920
S	Install cross ties (assume 10-feet c-c)	100	ea	$2,430.00	$243,000	$243,000
S	Place pile caps to form broadcrested weir	710	cy			
S	Place levee fill (rockfill from quarry)	194,300	cy	$22.35	$4,343,176	$4,343,176
S	Allowance to Install Armor Block on inside Levee Face	259,600	sf	$15.00	$3,894,000	$3,894,000
S	Install Concrete face on spillway as interior sea level reduces	11,500	cy	$400.00	$4,600,000	$4,600,000
	Install Sill and plunge pool at spillway discharge					
S	Install sill structure including cutoff wall	3,330	cy	$570.00	$1,898,100	$1,898,100
S	Plunge pool/stilling area excavation	37,000	cy	$4.00	$148,000	$148,000
S	Plunge pool/stilling area rock fill (80% of excavation)	29,600	cy	$44.00	$1,302,400	$1,302,400
	Total for North Shore				$35,575,003	$35,575,003
	Install Bombay Beach Bellmouth Spillway and Discharge Structure					
	Construct causeway from shore to levee location (included in estimate item 10)					
S	Allowance to extend causeway to Spillway Location (500 lf)	25,900	cy	$22.35	$578,941	$578,941
S	Drive sheetpiles for double wall cofferdam	220,800	sf	$31.43	$6,939,500	$6,939,500
S	Dewater cofferdam and remove unsuitable material (2-feet)	5,100	cy	$33.30	$169,830	$169,830
S	Place fill for cofferdam	43,400	cy	$25.60	$1,111,040	$1,111,040
S	Install cross ties (assume 10-feet c-c)	266	ea	$2,430.00	$646,380	$646,380
S	Place road base on cofferdam road	5,100	cy	$37.80	$192,780	$192,780
S	Dewater inside of cofferdam (10 cfs for 2.3 million)	65	hours	$300.00	$19,500	$19,500
S	Excavate for inlet structure and box culvert including fill and seepage control	44,800	cy	$6.00	$268,800	$268,800
S	Place 2-feet structural fill under inlet structure and box culvert	5,400	cy	$37.80	$204,120	$204,120
S	Install foundation piles (four clusters of 12 each)	48	each	$6,000.00	$288,000	$288,000
	Install Bell/Drop inlet structure concrete					
S	Base	117	cy	$400.00	$46,800	$46,800
S	Walls	192	cy	$740.00	$142,080	$142,080
S	Floors	109	cy	$1,010.00	$110,090	$110,090
S	Bell	70	cy	$1,500.00	$105,000	$105,000
S	Furnish, deliver and install sluice gate valves (6x6-feet)	3	each	$90,000.00	$270,000	$270,000
S	Furnish, deliver and install precast box culvert	1,000	lf	$1,870.00	$1,870,000	$1,870,000
S	Furnish, deliver and install building/security structure for spillway inlet	1,050	sf	$250.00	$262,500	$262,500
S	Backfill for inlet structure and box culvert	33,100	cy	$22.35	$739,882	$739,882
S	Install discharge structure at outlet of box culvert (allowance)	100	cy	$740.00	$74,000	$74,000
S	Place riprap for discharge structure including excavation/geotextile as needed	3,000	cy	$44.00	$132,000	$132,000
	Total for Bombay Beach				$14,171,244	$14,171,244

COST ESTIMATE

EM,S CCode	ITEM AND DESCRIPTION	QUANTITY	UNIT	UNIT COST	SUB-CONT.	TOTAL
	Salton Sea Restoration					
	Details of Estimate Components					
	Install Southwest Bellmouth Spillway and Discharge Structure					
S	Construct causeway from shore to levee location (included in estimate item 10)					
S	Allowance to extend causeway to Spillway Location (500 lf)	25,900	cy	$22.35	$578,941	$578,941
S	Drive sheetpiles for double wall cofferdam	220,800	sf	$31.43	$6,939,500	$6,939,500
S	Dewater cofferdam and remove unsuitable material (2-feet)	5,100	cy	$33.30	$169,830	$169,830
S	Place fill for cofferdam	43,400	cy	$25.60	$1,111,040	$1,111,040
S	Install cross ties (assume 10-feet c-c)	266	ea	$2,430.00	$646,380	$646,380
S	Place road base on cofferdam road	5,100	cy	$37.80	$192,780	$192,780
S	Dewater inside of cofferdam (20 cfs for 2.3 million)	65	hours	$300.00	$19,500	$19,500
S	Excavate for inlet structure and box culvert including fill and seepage control	44,800	cy	$6.00	$268,800	$268,800
S	Place 2-feet structural fill under inlet structure and box culvert	5,800	cy	$37.80	$219,240	$219,240
S	Install foundation piles (four clusters of 12 each)	48	each	$6,000.00	$288,000	$288,000
	Install Bell/Drop inlet structure concrete					
S	Base	117	cy	$400.00	$46,800	$46,800
S	Walls	192	cy	$740.00	$142,080	$142,080
S	Floors	109	cy	$1,010.00	$110,090	$110,090
S	Bell	70	cy	$1,500.00	$105,000	$105,000
S	Furnish, deliver and install sluice gate valves (8x8-feet)	3	each	$160,000.00	$480,000	$480,000
S	Furnish, deliver and install precast box culvert	1,000	lf	$2,480.00	$2,480,000	$2,480,000
S	Furnish, deliver and install building/security structure for spillway inlet	1,050	sf	$250.00	$262,500	$262,500
S	Backfill for inlet structure and box culvert	30,900	cy	$22.35	$690,706	$690,706
S	Install discharge structure at outlet of box culvert (allowance)	100	cy	$740.00	$74,000	$74,000
S	Place riprap for discharge structure including excavation/geotextile as needed	3,000	cy	$44.00	$132,000	$132,000
	Total for Southwest				$14,957,187	$14,957,187

ESTIMATE BASIS, WORK INCLUDED, WORK EXCLUDED, ASSUMPTIONS AND QUALIFICATIONS

2016 FEASIBILITY LEVEL COST ESTIMATE
SALTON SEA RESTORATION PLAN
PERIMETER LOW PROFILE LEVEE ALTERNATIVE
ALTERNATIVE B - ACCELERATED CONSTRUCTION BY USING TWO WORK FRONTS

Estimate for the Permitting, Design and Construction of The Salton Sea Restoration Plan

GENERAL INFORMATION

The estimate contained in this workbook was prepared, in part, based upon information provided by Tetra Tech BAS during a meeting in their Diamond Bar, CA offices on October 7, 2015 and subsequent updated drawings and additional information sent by email. Additional information was supplied in January and February by Tetra Tech BAS concerning the location and conceptual design of the spillways and flood control structures. This alternative B estimate is based upon an accelerated schedule for completion of the Levee through the use of two independent Levee construction crews. Other required construction (Geotextile, Sheet Pile, Quarry Operation and Haul) to support the Levee construction was adjusted from the Alternative A estimate by adding shifts or overtime as needed to provide the production needed.

The estimate was prepared by James C Juliani (Estimator) using his 48 years of experience estimating large and complex construction projects. The purpose of the estimate is to determine the feasibility and probable cost of the construction of The Salton Sea Restoration Plan, Perimeter Low Profile Levee Alternative being developed by Tetra Tech BAS.
The estimate provided is considered to be a Class 4 estimate as defined by The American Association of Cost Engineers in their Recommended Practice No. 18R-97. The estimator considers the estimate has a potential variation of +30% to -20% from the value of the cost estimate including contingency for the scope of the work estimated.

ESTIMATE BASIS

The estimate is based upon the following drawings and documents:
- Drawing titled - Salton Sea Feasibility Study, Northshore Levee @ -250' (Drawing indicates a total levee length of 66.7 miles)
- Drawing titled - Salton Sea Feasibility Study, Dredge and Sheet pile Section @ -245'
- Tetra Tech BAS Report - Draft Preliminary Geotechnical Feasibility Study, Perimeter Low Profile Levee Alternative, Dated September 18, 2015
- URS - In-Sea Embankment Concepts, Salton Sea Revitalization Plan, Dated June 27, 2007
- URS - Geotechnical Reconnaissance, Potential Rock Quarry at Coolidge Mountain for Salton Sea Revitalization Plan, Dated February, 2007
- Draft Technical Memo, Salton Sea Perimeter Lake Overflow Spillway Analysis and Assumptions, Prepared by Jeffrey S. Nikolas, PE dated January 20, 2016.
- Email from Jeff Nikolas to estimator dated February 11, 2016 with Subject Updated Salton Sea Spillway Quantities.

The estimate is based on the Owner awarding the Work represented by the estimate to a General EPCM Contractor who will implement the Work.
The estimate for project labor assumes that prevailing wage determinations will apply. Current determinations were obtained online and used to calculate the wage rates used in the estimate.
Pricing for equipment and equipment maintenance costs are generally based upon the 2012 edition of Mine and Mill Equipment Costs published by InfoMine USA, Inc. Pricing is then adjusted for 2015 costs, prevailing wages rates for maintenance labor and current energy costs.
Pricing for the sheetpile is based upon information from Tetra Tech BAS as to material cost (sales tax and freight added). Installation production is based upon the estimators experience and provides for the pile driving rig to be placed on a barge.
Dredging is scheduled on a 24-hour, 7 days per week, 350 days per year basis. A shift rotation called 12 hour 4X4 was used in the estimate. This rotation involves four crews working 12-hour, 4 day weeks (48 hours) with the following 4 days off.
This estimate (Alternative B) provides for accelerating the construction schedule for the Project by utilizing two totally independent construction crews. The equipment and organization from Alternative A is duplicated with each crew constructing about 50% of the Work. Quarry operations are also expanded to meet the rock products requirement schedule.

WORK INCLUDED

The estimate assumes and provides for Overall Management of the Project by the Owner. The estimate provides for installation of Owner offices and infrastructure on property purchased for that purpose. The estimate includes the cost for Owner personnel and expenses to manage and monitor the project implementation and progress and report the status of the project to the various stakeholders.
Permitting
- Design and Performance of a test dredge/embankment construction
- Preparation of an EIR/EIS including public review
- Substantive compliance with Federal, State or Local permit requirements.

Engineering required for the construction of the project including design drawings, equipment, material, construction specifications and construction quality control/quality assurance requirements and plans.
Procurement of major materials and equipment especially long lead items.
Procurement of services of qualified contractors to construct the Work and administration of the contracts
Field construction management and engineering to assure that the Work is constructed in accordance with the drawings, specifications and approved Project Plans.
Mobilization and demobilization of all required personnel, equipment and materials required to construct the work.
Dredge from shore side to provide deeper water for fish habitat and construct approximately 66.7 miles Levee.
Construct 12 access causeways of approximately 4.5 miles in total length from the shore to the Levee including installation of one pipe arch in each for the passage of water and small watercraft.
Install a single sheetpile wall seepage barrier the entire length of the levee
Install Geotextile on the existing Sea bottom from the sheetpile barrier to the sea side either 220 feet (15' levee) or 295 feet (20' levee) wide on which the levee embankment will be placed.
Install a total of three bellmouth spillways and one broad crested weir spillway for level control of the perimeter sea and flood control. The spillways incorporate Sluce Gate valves to reduce the perimeter sea level in the event of an issue with the levee.
Establish and operate a quarry and processing equipment to produce the aggregates and rock fill needed to construct the causeway access to the levee.
Haul the aggregates and rockfill to near the installation sites and stockpile.
Install the aggregates from stockpile to the levee for road access and armoring of the embankment against wind and wave erosion or damage.
The estimate includes an allowance to install settlement monitoring, salinity monitoring and seepage monitoring, etc. to monitor the consolidation and performance of the levee embankment
Provide stockpiles of aggregates in the total quantity of 1,000,000 cubic yards in the area of the quarry for long term maintenance of levee roads and erosion control
Provide a crew of approximately 12 people plus equipment to perform maintenance and repairs on the access roads and levee for a period of 10-years. The estimate assumes this maintenance group is employed/contracted and managed by the owner.

ESTIMATE BASIS, WORK INCLUDED, WORK EXCLUDED, ASSUMPTIONS AND QUALIFICATION

2016 FEASIBILITY LEVEL COST ESTIMATE
SALTON SEA RESTORATION PLAN
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ALTERNATIVE B - ACCELERATED CONSTRUCTION BY USING TWO WORK FRONTS

Estimate for the Permitting, Design and Construction of The Salton Sea Restoration Plan

WORK EXCLUDED

Any and all costs prior to October 1, 2015

Costs for management, monitoring or measurement of water sources to the Salton Sea including such things as water treatment, diversion works and/or channels, pumping stations and the like are not included.

Costs for management of and dust control in the area to the inside of the Levee (exposed beach and brine pool) are not included.

The estimate does not include salvage value for any purchased equipment upon completion of the Work. It is anticipated that there will be some salvage value and that that salvage value will be higher than for Alternative A. However the salvage value is subject to fluctuation depending upon the demand for used equipment at the time of sale and therefor any estimate will have a high risk so it is considered prudent to assume no salvage for this estimate as for the Alternative A estimate at this time.

ASSUMPTIONS

Permit fees for required Federal, State or Local permits are included and are assumed to be 1% of the total inplace constructed value of the work.

Property requirements for the quarry, rock processing plants, infrastructure and stockpiles has been estimated and either the lease or purchase of the required property is included in the estimate.

The estimate assumes that in addition to a lease arrangement for use of the quarry property that a royalty for rock quarried and removed from the property of the landowner will be required and an allowance of $2.00 per ton is provided for this cost.

The estimate assumes that property for stockpiling of rock products can be found near (+ or - 1 mile) the 12 planned causeways. Lease cost for the required property is included in the estimate.

The estimate assumes that purchases of equipment and materials by the project is subject to the State of CA sales tax.

The estimate assumes that the material can be dredged, dewatered, transported by conveyor and placed in the embankment without significant materials handling problems. The estimate provides for a test dredge to evaluate the dredging and material handling difficulty. In the event the test dredge indicates the dredged material properties will not allow handling as assumed in the estimate an alternate dredge and placement method will be evaluated. The estimator is reasonably convinced that a gantry dredge, bucketwheel dredge or a cutterhead suction dredge could be employed to construct the Work. The excavator dredge was chosen due to the power the machine has to excavate the Salton Sea floor deposits. The other dredging methods mentioned may actually be more cost effective than the excavator assuming they can meet the required production.

The estimate assumes that a Project Specific Agreement and be negotiated with the Dredgers such that the 4 - 12 hour shift can be paid at 40 hours straight time and 8 hours at time and one half.

The estimate assume that funds for the construction of the project are available on an as needed basis from the stakeholders and as such there are not any financing, interest during consctuction or similar costs included in the estimate.

QUALIFICATIONS

The estimator, while generally familiar with geotechnical parameters for soils, is not a geotechnical engineer and assumptions regarding excavation of the sea floor soils with the excavator or other equipment will need to be verified before equipment selection is completed. The estimate does include additional geotechnical investigation and a test dredge for this purpose.

The estimate is stated in October 2015 US$ and no future escalation is provided.

The contingency applied is considered by the estimator to be adequate and customary given the project definition.

2016 FEASIBILITY LEVEL COST ESTIMATE
SALTON SEA RESTORATION PLAN

Permitting, Design and Construction of The Salton Sea Restoration Plan

Alternative B - Accelerated Schedule

PERIMETER LOW PROFILE LEVEE ALTERNATIVE

Item	Description	Units	Unit Cost	Quantity/ Expenses %	Cost
1	**Initial Activities for Project Approval**				
	Evaluate Alternatives and Prepare Recommendation for Preferred Alternative	Lot	$562,000	5%	$590,100
	Internal and Public Review Comment	Lot	$374,000	5%	$392,700
	Design and Implement a Demonstration Project to Define Technology to be Used	Lot	$1,630,000	25%	$2,037,500
	Geotechnical Investigation and Bathometry for Design	Lot	$842,000	5%	$884,100
	Prepare EIR/EIS	Lot	$8,736,000	10%	$9,609,600
	Prepare Preliminary Engineering for EIR/EIS Project Definition and Evaluation	Lot	$5,616,000	10%	$6,177,600
	EIR/EIS Agency/Public Review and Approval	Lot	$1,217,000	5%	$1,277,850
	Obtain required Permits (Local, State and Federal)	Lot	$2,574,000	10%	$2,831,400
				SUBTOTAL	**$23,800,900**
2	**Permitting, Engineering and Procurement**				
	Design Engineering and Preparation of Construction Drawings	Lot	$13,260,000	10%	$14,586,000
	Prepare Technical Specifications and QA/QC Plan	Lot	$4,976,000	5%	$5,224,800
	Procure and Deliver Dredging and Plant Equipment/Barges	Lot	$2,028,000	10%	$2,230,800
	Procure and Deliver PVC and Steel Sheetpile	Lot	$390,000	10%	$429,000
	Bid and Award Quarry Operation and Aggregates Production and Delivery to Site	Lot	$858,000	15%	$986,700
	Bid and Award Construction of Spillways and Flood Control Structures	Lot	$601,000	15%	$691,150
	Bid and Award Vinyl Sheetpile installation	Lot	$429,000	15%	$493,350
	Bid and Award Marine Construction Contract (Dredge, Process and Levee Rough grade)	Lot	$1,544,000	15%	$1,775,600
	Bid and Award Earthworks Contract (Grade and Armor Levee)	Lot	$686,000	15%	$788,900
	Bid and Award Contracts for Other Works to complete the Project	Lot	$343,000	15%	$394,450
	Bid and Award Contracts for Long Term OM&M of the Project	Lot	$429,000	10%	$471,900
				SUBTOTAL	**$28,072,700**
3	**Construction Management and Support**				
	Site Facilities and Expenses	week	$10,000	325	$3,260,000
	Construction Management and QA/QC (Field)	Lot	$76,939,000	25%	$96,173,750
	Construction Management and QA/QC (Office Support)	Lot	$14,414,400	5%	$15,135,120
	Field Environmental Monitoring and Reporting	Lot	$20,654,000	30%	$26,850,200
	Soils Testing Technician and Laboratory	Lot	$10,670,000	50%	$16,005,000
	Survey Control	Lot	$8,528,000	15%	$9,807,200
				SUBTOTAL	**$167,231,300**
4	**Owner Management/Other Direct Expenses**				
	Mobilization of Owner Offices/Facilities/Utilities for Oversight of the Project	Lot	$2,222,160	Included	$2,222,160
	Management/Administrative Personnel	Lot	$63,238,000	5%	$66,399,900
	Owner Offices/Facilities/Utilities/Insurance/Taxes Expense	week	$8,500	300	$2,550,000
	Federal, State and Local Permit Fees (allowance of 1% of inplace constructed value)	Lot	$1,326,600,000	1%	$13,266,000
	Lease and/or Purchase of Property for Project Use	Lot	$3,360,917	10%	$3,697,008
	Royalties on Quarried Rock (at $2.00 per ton)	tons	10,630,000	$2.00	$21,260,000
				SUBTOTAL	**$109,395,068**
				TOTAL THIS GROUP	**$328,500,000**
	LEVEE CONSTRUCTION				
5	**Mobilization**				
	Conduct Dredging Demonstration Project	Lot	$6,200,000	1	$6,200,000
	Conduct Geotechnical Investigation and Obtain Detailed Bathymetry	Lot	$2,239,680	1	$2,239,680
	Mobilize Men and Equipment for Sheetpile and Levee Construction	Lot	$3,111,000	1	$3,111,000
	Mobilize Men and Equipment for Quarry Setup and Operation	Lot	$819,000	1	$819,000
	Install Project Offices, Laydown and Maintenance Areas, Warehousing and Storage Areas	Lot	$5,209,600	1	$5,209,600
	Receive and Laydown Barges, Dredge, and Process Equipment	Lot	$2,344,320	1	$2,344,320
	Receive and Laydown Sheetpile and Other Miscellaneous Materials Incorporated in the Work	Lot	$976,800	1	$976,800
	Install Dredge and Levee Construction Components and Pre-Operational Testing	Lot	$13,829,120	1	$13,829,120
	Dismantle Dredging Equipment and Remove from Site	Lot	$5,185,920	1	$5,185,920
	Demobilization of Facilities Not Required for OM&M and Final Site Cleanup	Lot	$7,032,960	1	$7,032,960
	Demobilization of Equipment and Reclamation/Revegetation and Closure of the Quarry Site.				
				SUBTOTAL	**$46,948,400**

2016 FEASIBILITY LEVEL COST ESTIMATE
SALTON SEA RESTORATION PLAN

Permitting, Design and Construction of The Salton Sea Restoration Plan
Alternative B - Accelerated Schedule
PERIMETER LOW PROFILE LEVEE ALTERNATIVE

Item	Description	Units	Unit Cost	Quantity/ Expenses %	Cost
6	**Quarry Operation and Aggregate Production**				
	Capital Equipment Required to Quarry	Lot	$15,161,699	1	$15,161,699
	Rock Processing Units	Lot	$14,479,717	1	$14,479,717
	Capital Cost for Haul	Lot	$8,540,925	1	$8,540,925
	Drill and Blast/Load and Haul Rock for Processing	ton	$6.54	8,075,686	$52,814,989
	Produce Rock Products	cy	$5.32	4,703,345	$25,014,471
	Deliver Rock Products for Levee Access and Construction	cy	$16.62	4,703,345	$78,148,306
	Produce and Stockpile Aggregates for Long Term Project OM&M	cy	$11.86	1,000,000	$11,858,443
		cy	**$19.68**	**SUBTOTAL**	**$190,856,852**
7	**PVC Sheetpile Installation**				
	Furnish and Deliver Sheetpile	sf	$7.75	12,502,450	$96,862,731
	Install Sheetpile	sf	$11.31	12,502,450	$141,383,956
		sf	**$19.06**	**SUBTOTAL**	**$238,246,687**
8	**Install Spillways and Flood Control Structures**				
	Install North Shore Bellmouth Spillway and Flood Control Weir and Discharge Structure	Lot	$35,575,003	1	$35,575,003
	Install Bombay Beach Bellmouth Spillway Discharge Structure	Lot	$14,171,244	1	$14,171,244
	Install Southwest Bellmouth Spillway and Discharge Structure	Lot	$14,957,187	1	$14,957,187
				SUBTOTAL	**$64,703,434**
9	**Dredging and Levee Construction**				
	Furnish and Deliver Major Equipment for Dredging and Levee Construction	Lot	$69,623,963	1	$69,623,963
	Furnish and Deliver Major Equipment for Geotextile Placement	Lot	$3,939,434	1	$3,939,434
	Furnish and Deliver Geotextile	sf	$0.22	88,134,035	$19,036,952
	Place Geotextile Ahead of embankment (15 foot Nominal Section)	sf	$0.35	48,842,860	$17,152,579
	Dredge, Process and Place Initial Levee Embankment (15 foot Nominal Section)	cy	$8.12	28,444,000	$230,976,928
	Place Geotextile Ahead of embankment (20 foot Nominal Section)		$0.31	11,432,135	$3,536,268
	Place Geotextile Ahead of embankment (15 foot Nominal Section)		$0.35	27,859,040	$9,783,505
	Dredge, Process and Place Initial Levee Embankment (20 foot Nominal Section)		$8.12	7,918,000	$64,297,402
	Dredge, Process and Place Initial Levee Embankment (15 foot Nominal Section)		$8.12	16,223,000	$131,737,403
		Mile	**$8,247,143**	**SUBTOTAL**	**$550,084,434**
10	**Grade and Armor Levee/Construct Access Points**				
	Haul Rock Products from Stockpile	cy	$9.87	4,703,345	$46,434,159
	Furnish and Deliver Major Equipment for Levee Grading and Armor	ac	$8,142,483	1	$8,142,483
	Grade and Armor Levee/Construct Access Points	lf	$116.88	375,936	$43,940,644
	Install Multi-Plate Pipe Arches	cy	$100,000	12	$1,200,000
		Mile	**$1,495,012**	**SUBTOTAL**	**$99,717,285**
11	**Other Miscellaneous Works to complete the Project**				
	Embankment Settlement Monitoring, Salinity Monitoring, inflow seepage, etc.	Lot	$1.00	10,000,000	$10,000,000
				SUBTOTAL	**$10,000,000**
12	**OM&M of the Constructed Project (10 Years is Assumed)**				
	Provide Dedicated Equipment and Personnel for Long Term OM&M				
	Personnel	year	$1,996,800.00	10	$19,968,000
	Equipment	year	$1,497,600.00	10	$14,976,000
	Expenses	year	$399,360.00	10	$3,993,600
	Owner Long Term Management and Expenses	year	$823,680.00	10	$8,236,800
				SUBTOTAL	**$47,174,400**
				TOTAL THIS GROUP	**$1,247,700,000**
				Project Total	**$1,576,200,000**
13	**Recommended Contingency**	**%**	**15.00%**		**$236,400,000**
			Total		**$1,813,000,000**

Work Schedule Assumptions for Schedule Calculation

Dredge, Process Soil and Embankment Construction
Demonstration Project
Mobilization, Project Setup, Temporary Facilities, Demob
Quarry Operations and Hauling/Stockpiling Rock Products
Grade and Armor Levee/Construct Causeways
Install Spillways and Flood Control Structures
Geotextile Installation
PVC Sheetpile Installation

PERIMETER LOW PROFILE LEVEE ALTERNATIVE
Description of Major Activity

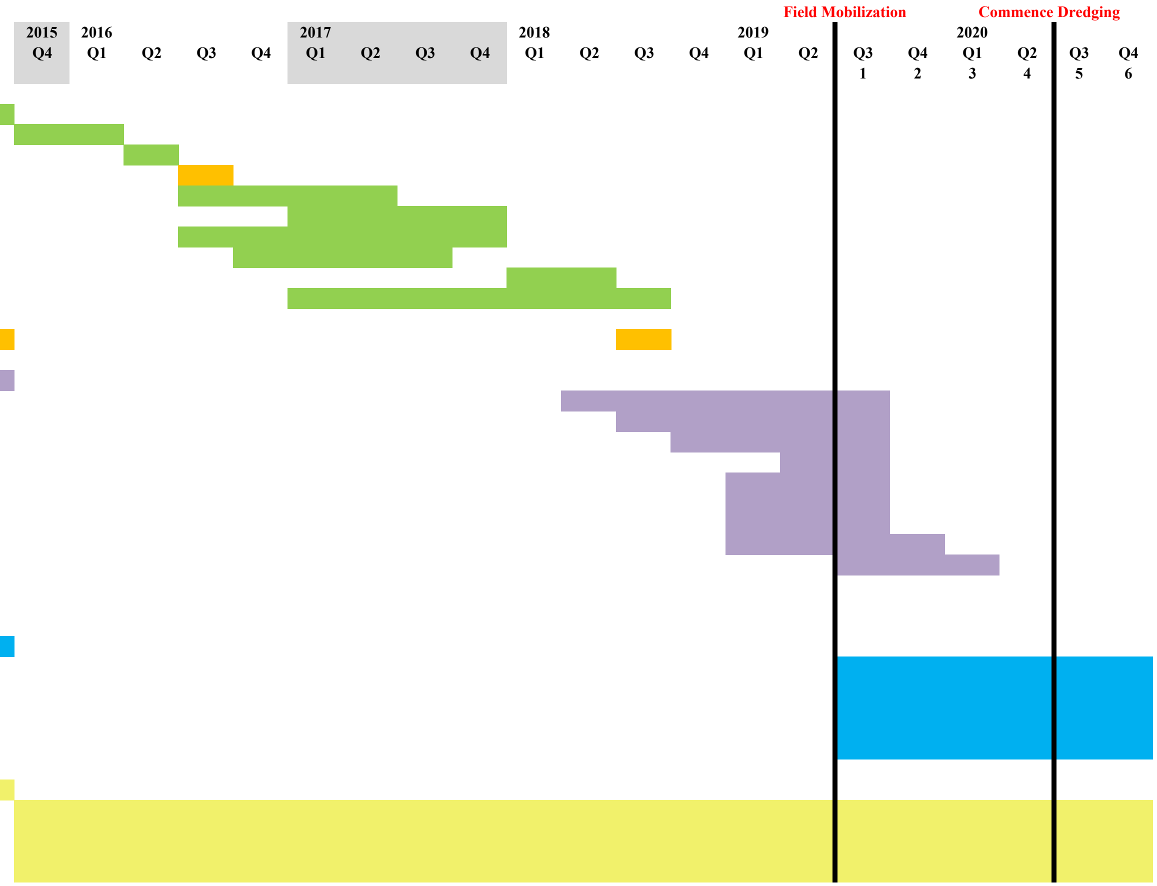
Initial Activities for Project Approval
Evaluate Alternatives and Prepare Recommendation for Preferred Alternative
Internal and Public Review Comment
Approval to Proceed with Project Permitting
Design and Implement a Demonstration Project to Define Technology to be Used
Geotechnical Investigation and Bathometry for Design
Prepare EIR/EIS
Prepare Preliminary Engineering for EIR/EIS Project Definition and Evaluation
EIR/EIS Agency/Public Review and Approval
Obtain required Permits (Local, State and Federal)

Approval To Proceed to Engineering/Construction

Engineering and Procurement
Design Engineering and Preparation of Construction Drawings
Prepare Technical Specifications and QA/QC Plan
Procure and Deliver Dredging and Plant Equipment/Barges
Procure and Deliver PVC and Steel Sheetpile
Bid and Award Quarry Operation and Aggregates Production and Delivery to Site
Bid and Award Construction of Spillways and Flood Control Structures
Bid and Award Vinyl Sheetpile installation
Bid and Award Marine Construction Contract (Dredge, Process and Levee Rough grade)
Bid and Award Earthworks Contract (Grade and Armor Levee)
Bid and Award Contracts for Other Works to complete the Project
Bid and Award Contracts for Long Term OM&M of the Project

Field Construction Management
Construction Management and QA/QC (Field)
Construction Management and QA/QC (Office Support)
Field Environmental Monitoring and Reporting
Soils Testing Technician and Laboratory
Survey Control

Owner Management/Other Direct Expenses
Management/Supervision/Engineering
Finance/IT/HR/Land/InsuranceLegal
Environment/H&S/Security
Outside PR/Legal/Consultants



Work Schedule Assumptions for Schedule Calculation

PERIMETER LOW PROFILE LEVEE ALTERNATIVE Description of Major Activity	2015 Q4	2016 Q1	Q2	Q3	Q4	2017 Q1	Q2	Q3	Q4	2018 Q1	Q2	Q3	Q4	2019 Q1	Q2	Q3 1	Q4 2	2020 Q1 3	Q2 4	Q3 5	Q4 6

Mobilization/Site Preparation/Demobilization

Conduct Dredging Demonstration Project
Conduct Geotechnical Investigation and Obtain Detailed Bathymetry
Mobilize Men and Equipment for Sheetpile and Levee Construction
Mobilize Men and Equipment for Quarry Setup and Operation
Install Project Offices, Laydown and Maintenance Areas, Warehousing and Storage Areas
Receive and Laydown Barges, Dredge, and Process Equipment
Receive and Laydown Sheetpile and Other Miscellaneous Materials Incorporated in the Work
Install Dredge and Levee Construction Components and Pre-Operational Testing
Dismantle Dredging Equipment and Remove from Site
Demobilization of Facilities Not Required for OM&M and Final Site Cleanup
Demobilization of Equipment and Reclamation/Revegetation and Closure of the Quarry Site.

Quarry Operation and Aggregate Production

Produce and Deliver Road Base Material for Levee and Levee Access
Produce and Deliver Sea Side Wind Erosion Gravel
Produce and Deliver Shore Side Gravely Sand
Produce and Deliver Shore Side Have Erosion Gravel
Produce and Deliver Rockfill for Levee Access
Produce and Stockpile Aggregates for Long Term Project OM&M

PVC Sheetpile Installation

Crew 1 Install Sheetpile (35-foot Nominal Depth)
Crew 2 Install Sheetpile (40-foot Nominal Depth)
Crew 2 Install Sheetpile (35-foot Nominal Depth)

Install Spillways and Flood Control Structures

Crew 1 Install North Shore Bellmouth Spillway and Flood Control Weir and Discharge Structure
Crew 2 Install Bombay Beach Bellmouth Spillway Discharge Structure
Crew 2 Install Southwest Bellmouth Spillway and Discharge Structure

Dredging and Levee Construction

Crew No 1

Place Geotextile Ahead of embankment (15 foot Nominal Section)
Dredge, Process and Place Initial Levee Embankment (15 foot Nominal Section)

Crew No 2

Place Geotextile Ahead of embankment (20 foot Nominal Section)
Place Geotextile Ahead of embankment (15 foot Nominal Section)
Dredge, Process and Place Initial Levee Embankment (20 foot Nominal Section)
Dredge, Process and Place Initial Levee Embankment (15 foot Nominal Section)

Grade and Armor Levee/Construct Access Points

Grade Levee
Place Road Base
Place Sea Side Wind Erosion Gravel
Place Shore Side Gravely Sand
Place Shore Side Wave Erosion Gravel
Place Rockfill for Levee Access
Install Multi-Plate Pipe Arches

Other Miscellaneous Works to complete the Project

OM&M of the Constructed Project (10 Years is Assumed)

Work Schedule Assumptions for Schedule Calculation

Dredge, Process Soil and Embankment Construction
Demonstration Project
Mobilization, Project Setup, Temporary Facilities, Demob
Quarry Operations and Hauling/Stockpiling Rock Products
Grade and Armor Levee/Construct Causeways
Install Spillways and Flood Control Structures
Geotextile Installation
PVC Sheetpile Installation

	2021				2022				2023				2024				2025				
PERIMETER LOW PROFILE LEVEE ALTERNATIVE	**Q1**	**Q2**	**Q3**	**Q4**	**Q1**	**Q2**	**Q3**	**Q4**	**Q1**	**Q2**	**Q3**	**Q4**	**Q1**	**Q2**	**Q3**	**Q4**	**Q1**	**Q2**	**Q3**	**Q4**	**Q4**
Description of Major Activity	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**	**26**	**30**
Initial Activities for Project Approval																					
Evaluate Alternatives and Prepare Recommendation for Preferred Alternative																					
Internal and Public Review Comment																					
Approval to Proceed with Project Permitting																					
Design and Implement a Demonstration Project to Define Technology to be Used																					
Geotechnical Investigation and Bathometry for Design																					
Prepare EIR/EIS																					
Prepare Preliminary Engineering for EIR/EIS Project Definition and Evaluation																					
EIR/EIS Agency/Public Review and Approval																					
Obtain required Permits (Local, State and Federal)																					
Approval To Proceed to Engineering/Construction																					
Engineering and Procurement																					
Design Engineering and Preparation of Construction Drawings																					
Prepare Technical Specifications and QA/QC Plan																					
Procure and Deliver Dredging and Plant Equipment/Barges																					
Procure and Deliver PVC and Steel Sheetpile																					
Bid and Award Quarry Operation and Aggregates Production and Delivery to Site																					
Bid and Award Construction of Spillways and Flood Control Structures																					
Bid and Award Vinyl Sheetpile installation																					
Bid and Award Marine Construction Contract (Dredge, Process and Levee Rough grade)																					
Bid and Award Earthworks Contract (Grade and Armor Levee)																					
Bid and Award Contracts for Other Works to complete the Project																					
Bid and Award Contracts for Long Term OM&M of the Project																					
Field Construction Management																					
Construction Management and QA/QC (Field)																					
Construction Management and QA/QC (Office Support)																					
Field Environmental Monitoring and Reporting																					
Soils Testing Technician and Laboratory																					
Survey Control																					
Owner Management/Other Direct Expenses																					
Management/Supervision/Engineering																					
Finance/IT/HR/Land/InsuranceLegal																					
Environment/H&S/Security																					
Outside PR/Legal/Consultants																					

Work Schedule Assumptions for Schedule Calculation

PERIMETER LOW PROFILE LEVEE ALTERNATIVE Description of Major Activity	2021 Q1 7	Q2 8	Q3 9	Q4 10	2022 Q1 11	Q2 12	Q3 13	Q4 14	2023 Q1 15	Q2 16	Q3 17	Q4 18	2024 Q1 19	Q2 20	Q3 21	Q4 22	2025 Q1 23	Q2 24	Q3 25	Q4 26	Q4 30
Mobilization/Site Preparation/Demobilization																					
Conduct Dredging Demonstration Project																					
Conduct Geotechnical Investigation and Obtain Detailed Bathymetry																					
Mobilize Men and Equipment for Sheetpile and Levee Construction																					
Mobilize Men and Equipment for Quarry Setup and Operation																					
Install Project Offices, Laydown and Maintenance Areas, Warehousing and Storage Areas																					
Receive and Laydown Barges, Dredge, and Process Equipment																					
Receive and Laydown Sheetpile and Other Miscellaneous Materials Incorporated in the Work																					
Install Dredge and Levee Construction Components and Pre-Operational Testing																					
Dismantle Dredging Equipment and Remove from Site																					
Demobilization of Facilities Not Required for OM&M and Final Site Cleanup																					
Demobilization of Equipment and Reclamation/Revegetation and Closure of the Quarry Site.																					
Quarry Operation and Aggregate Production																					
Produce and Deliver Road Base Material for Levee and Levee Access																					
Produce and Deliver Sea Side Wind Erosion Gravel																					
Produce and Deliver Shore Side Gravely Sand																					
Produce and Deliver Shore Side Have Erosion Gravel																					
Produce and Deliver Rockfill for Levee Access																					
Produce and Stockpile Aggregates for Long Term Project OM&M																					
PVC Sheetpile Installation																					
Crew 1 Install Sheetpile (35-foot Nominal Depth)																					
Crew 2 Install Sheetpile (40-foot Nominal Depth)																					
Crew 2 Install Sheetpile (35-foot Nominal Depth)																					
Install Spillways and Flood Control Structures																					
Crew 1 Install North Shore Bellmouth Spillway and Flood Control Weir and Discharge Structure																					
Crew 2 Install Bombay Beach Bellmouth Spillway Discharge Structure																					
Crew 2 Install Southwest Bellmouth Spillway and Discharge Structure																					
Dredging and Levee Construction																					
Crew No 1																					
Place Geotextile Ahead of embankment (15 foot Nominal Section)																					
Dredge, Process and Place Initial Levee Embankment (15 foot Nominal Section)																					
Crew No 2																					
Place Geotextile Ahead of embankment (20 foot Nominal Section)																					
Place Geotextile Ahead of embankment (15 foot Nominal Section)																					
Dredge, Process and Place Initial Levee Embankment (20 foot Nominal Section)																					
Dredge, Process and Place Initial Levee Embankment (15 foot Nominal Section)																					
Grade and Armor Levee/Construct Access Points																					
Grade Levee																					
Place Road Base																					
Place Sea Side Wind Erosion Gravel																					
Place Shore Side Gravely Sand																					
Place Shore Side Wave Erosion Gravel																					
Place Rockfill for Levee Access																					
Install Multi-Plate Pipe Arches																					
Other Miscellaneous Works to complete the Project																					
OM&M of the Constructed Project (10 Years is Assumed)																					to 2035

Unit Price Development for Place Geotextile Ahead of Levee Embankment Placement
Dredge and Embankment placement Operation Production is 153 Feet Per Day

Quantity	Equipment/Crew/Consumables	Rate Including All Markups Hr	Daily	Production Per Hour Shift	Unit	
			8			
	Placement for 15-Foot High Embankment					
2	Push Boat, 250 hp	$120.00	$1,920.00			Eff/Util
1	Work Platform (5000 sf)	$50.00	$400.00	41608	sf	81%
1	Supply Pontoon	$20.00	$160.00			
0.8	Yard Crane	$120.00	$768.00			
2	Support Boats	$50.00	$800.00			
9	Geotextile Crew	$146.72	$10,563.88			
	Total		$14,611.88			
	Cost Per Square Foot		$0.35			
	Placement for 20-Foot High Embankment					
2	Push Boat, 250 hp	$120.00	$1,920.00			Eff/Util
1	Work Platform (5000 sf)	$50.00	$400.00	41982	sf	68%
1	Supply Pontoon	$20.00	$160.00			
0.2	Yard Crane	$120.00	$192.00			
2	Support Boats	$50.00	$800.00			
9	Geotextile Crew	$132.14	$9,514.08			
	Total		$12,986.08			
	Cost Per Square Foot		$0.31			

Unit Price Development for Dredging and Initial Levee Embankment Construction
Per Crew - Alternative B Requires Two Totally Autonomous Crews

Quantity	Equipment/Crew/Consumables	Rate Including All Markups Hr	Daily	Production Per Hour Shift	Unit
			24		
1	Hydraulic Excavator (Liebherr P995 or equal)	$967.85	$23,228.50	21600	cy
1	Modular Processing Plant 1200 tph design	$1,219.61	$29,270.67		
1	Conveyors, 1500 tph, Total Length 1700 lf	$611.66	$14,679.93		
2	Push Boat Tug, 500 hp	$192.98	$9,262.90		
5%	Allowance for Miscellaneous Equipment	$149.61	$3,590.53		
	Labor Crew (26 persons)	$3,814.73	$91,553.59		
	Shift Overlap at 25 hours in 24	$158.95	$3,814.73		
	Total		$175,400.85		
	Unit Price for Estimate		$8.12		

Notes	Value		
Excavator Bucket Capacity	23.50		cy
Excavator Cycle	60.00		sec
Buckets Per Hour	60.00		ea
Max Production Per Hour	1410.00		cy
Bucket Load Factor	80%		
Overall Efficiency/Availability	80%		
Annual Average Hourly Production	902	Use 900	cy
Annual Hours of Dredge Operation	8,400		
Annual Average Production	7,560,000		
Total Quantity Required	52,580,000		

Unit Price Development for Quarry Processing

Quantity	Equipment/Crew/Consumables	Rate Including All Markups Hr	Daily	Production Per	Unit
			10	Hour Shift	
2	Jaw Crusher (500 tph)	$257.96	$5,159.12		
3	Secondary crushing/Screening Plant	$256.31	$7,689.31		
4	Conveyor (400 lf)	$43.99	$1,759.54		
5	Conveyor (200 lf)	$30.15	$1,507.40		
3	Stackers	$41.27	$1,238.04		
	Subtotal Equipment		$17,353.40		
	Operating Equipment will be 75% at any time		$13,015.05	4620	
	Labor				
8	Laborer (average of groups used)	$144.45	$11,556.15		
	Total Cost Per Day		$24,571.21		
	Unit Processing Price		$5.32	per cy	

Unit Price Development to Grade and Armor the Levee
200 lf Per Day

Quantity	Equipment/Crew/Consumables	Rate Including All Markups Hr	Daily	Production Per	Unit
			10	Hour Shift	
2	Motorgrader	$76.96	$1,539.15		
2	Excavator with Long Stick	$90.48	$1,809.50		
2	Loader	$38.44	$768.88		
2	Dozer	$98.66	$1,973.14		
2	Compactor	$154.66	$3,093.24		
1	Water Truck	$96.46	$964.56		
2	Water Pump with Hoses (2-inch)	$10.00	$200.00		
	Labor				
4	Laborer (average of groups used)	$127.73	$5,109.22		
10	Equipment Operator or Mechanic	$151.13	$15,112.77		
1	Truck Driver	$136.88	$1,368.82		
2	Foreman	$156.29	$3,125.70		
	Subtotal				
	Tax	8%			
	Total		$35,064.99	1	Crew Day
	Cost Per Crew Day		$116.88	300	lf Per Day

Total Dredge Quantity Calculation

Volume of 15-foot Embankment

Segment	Width	Height	Factor	Area (sf)	Length	Volume
5:1 up	50	10	0.5	250.0		
15:1 Up	75	5	0.5	187.5		
15:1 Up	75	10	1	750.0		
Center	30	15	1	450.0		
15:1 down	225	15	0.5	1,687.5		
Lines and Grade Vol				3,325.0	123	
Insitu Consolidation				308.0		
Levee Consolidation				172.0		
Total				3,805.0	316,950	44,666,472
Volume per lf				141	cy	
				114%		

Total Dredge Quantity Calculation

Volume of 20-foot Embankment

Segment	Width	Height	Factor	Area	Length	Volume
5:1 up	75	15	0.5	562.5		
15:1 Up	75	5	0.5	187.5		
15:1 Up	75	15	1	1,125.0		
Center	30	20	1	600.0		
15:1 down	300	20	0.5	3,000.0		
Lines and Grade Vol				5,475.0	203	
Insitu Consolidation				383.0		
Levee Consolidation				210.0		
Total				6,068.0	35,230	7,917,616
				225	cy	
		66.7		111%		
		52,584,089				

Adjust Operating Rates for Labor and Fuel/Power

Rate (CostMine)	Labor	Power	Bare Rate	Labor	Power	Total	Per Unit Hr	
	397%	182%						
$220.08	$93.72	20.92	$105.44	$372.44	$38.04	$515.91	$257.96	Jaw Crusher (500 tph)
$218.20	$88.64	37.66	$91.90	$352.25	$68.47	$512.62	$256.31	Secondary crushing/Screening Plant
$66.52	$34.96	6.68	$24.88	$138.93	$12.15	$175.95	$43.99	Conveyor (400 lf)
$56.45	$30.55	4.2	$21.70	$121.40	$7.64	$150.74	$30.15	Conveyor (200 lf)
$49.56	$22.20	10.05	$17.31	$88.22	$18.27	$123.80	$41.27	Stackers

Capital Cost

$930,000	Motorgrader
$1,410,000	Excavator with Long Stick
$352,000	Loader
$1,355,600	Dozer
$1,494,000	Compactor
$392,000	Water Truck
$50,000	Water Pump with Hoses (2-inch)

DESCRIPTION	QUANTITY	UNIT	UNIT PRICE OR VALUE (October 2015)	TOTAL PRICE	NOTES/CALCULATION
Percentage for Miscellaneous Expenses as Percent of Labor		%	3%		
Percentage for Miscellaneous Expenses as Percent of Labor		%	5%		
Percentage for Miscellaneous Expenses as Percent of Labor		%	10%		
Percentage for Miscellaneous Expenses as Percent of Labor		%	15%		
Contractors Markup for Purchases Administration		%	7%		
Sales Tax for Direct Purchase (Riverside and Imperial Counties)		%	8%		
Third Party Engineering and Construction Management					
Principal		$/Hour	$225.00		
Project Director		$/Hour	$185.00		
Senior Project Engineer		$/Hour	$165.00		
Engineer/Geologist		$/Hour	$140.00		
Junior Engineer		$/Hour	$115.00		
Field Engineer (QAQC)		$/Hour	$105.00		
Senior Technician		$/Hour	$95.00		
Technician/Senior Draftsperson/CAD		$/Hour	$85.00		
Administrative		$/Hour	$75.00		
Composite Rate For Permitting, Engineering and Construction Management		$/Hour	$150.00		
Salton Sea Authority Management Organization					
General Manager and Administration		$/Hour	$146.43		10
Finance		$/Hour	$103.57		4
Human Resources		$/Hour	$100.00		1
Environment		$/Hour	$105.95		3
Health and Safety		$/Hour	$117.86		2
IT/Communications		$/Hour	$117.86		1
Security		$/Hour	$60.71		4
Land/Permitting		$/Hour	$132.14		2
InsuranceLegal		$/Hour	$132.14		1
Composit Rate for Owner Management			$118.00		
Allowance of Owner Travel/Subsistence		$/Hour	$15.00		
Marine Construction Labor Rate Development					Assumes a Project Agreement can be negotiated for 12-hour 4X4 shift Schedule Providing for 40 straight time and 8 at 1 1/2 time
Prevailing Wage Contractor Labor for Marine Operations					Determination SC-63-12-23-2015-1
Deck Captain		$/Hour	$71.55		
Leverman		$/Hour	$74.55		
Deckmate		$/Hour	$68.47		
Deckhand		$/Hour	$67.38		
Hydrographic Surveyor		$/Hour	$69.34		
Welder		$/Hour	$69.97		
Estimated Wage Contractor Labor for Marine Operations					
General Foreman		$/Hour	$82.01		
Forman		$/Hour	$78.28		
Contractors Payroll additives (FICA, USL&H Insurance, Employment Security and Unemployment)		%	25.00%		Assumes 10% premium on wage for USL&H Insurance
Contractors General Conditions		%	5.00%		Allowance
Contractors Overhead and Profit on Labor		%	15.00%		
Total Multiplier to Wage			150.94%		
Allowance for Travel and Subsistence		Crew$/Hour	$734.20		4 Hours In/Out+$150/Day Living+100/Day+7%Fee
Average Hourly Wage for Marine Works Crew		Crew$/Hour	$3,080.53		
All in Wage for Dredge/Levee Construction Crew		$/Hour	$3,814.73		
Total Annual Cost For Marine Construction		Annual	$32,043,755		Using 12-Hour 4X4 Shift Roster
Blended Rate for Marine Construction	1	mh	$118.48		
Travel and Subsistence Cost for Marine Construction	1	mh	$28.24		Travel and Subsistence
Total Manhour Cost for Marine Construction Prevailing Wage	1	mh	$146.72		
Total Manhour Premium for Marine Construction Prevailing Wage			163%		Assumes non-prevailing wage all in marine construction is $90
Adjustment Factor for CostMine Operating Rates for Labor			404%		CostMine wage Used in Operation Rate $36.35
Upland Construction Labor Rate Development					
Contractor Labor (Average of all Classifications) For General Construction					
Laborer		$/Hour	$51.98		Prevailing Wage for Riverside/Imperial Counties
Equipment Operator or Mechanic		$/Hour	$67.23		Prevailing Wage for Riverside/Imperial Counties
Truck Driver		$/Hour	$57.95		Prevailing Wage for Riverside/Imperial Counties
Foreman		$/Hour	$70.59		Prevailing Wage for Riverside/Imperial Counties
General Foreman		$/Hour	$73.95		Prevailing Wage for Riverside/Imperial Counties
Contractors Payroll additives (FICA, Workmen's Comp, Employment Security and Unemployment)		%	15.00%		
Contractors General Conditions		%	5.00%		Allowance
Contractors Overhead and Profit on Labor		%	15.00%		
Total Multiplier to Wage			138.86%		
Allowance for Travel and Subsistence plus		$/Hour	$22.80		3 Hours In/Out+$150/Day Living+7%Fee

Contractor Labor Including All Costs and OH&P					
Laborer (average)		$/Hour	$94.98		
Equipment Operator or Mechanic		$/Hour	$116.15		
Truck Driver		$/Hour	$103.26		2.84
Foreman		$/Hour	$120.82		
Superintendent		$/Hour	$125.49		
Blended Rate for General Construction/Quarry Operation			$110.11		1 Labor + 3 Op +2 Team +1 Forman
Total Manhour Premium for Construction Prevailing Wage			147%		Assumes non-prevailing wage all in construction is $90
Adjustment Factor for CostMine Operating Rates for Labor			303%		40 hour week
			397%		60 hour week
Mobilization/Demobilization to/from Site (Assume Contractor is Local Southern CA)					
Minor Pieces and Tool Trailers	1	Lot	$1,500.00		
Mobilization and Demobilization from Outside California of Major Pieces	1	Lot	$4,500.00		
Mobilization of offices and ancillary support buildings and Utilities	1	buildsf	$150.00		
Personnel	1	Lot	$600.00		3 hours each way at $100 Average
Equipment Rates (Excluding Operator and Replacement , Fully Maintained)			1.15		Including Contractors OH&P on Equipment If applicable
Push Boat Tug, 500 hp		$/Hour	$192.98		
Hydraulic Excavator (Liebherr P995 or equal)		$/Hour	$967.85		
Modular Processing Plant 1200 tph design		$/Hour	$1,219.61		
Conveyors, 1500 tph, Total Length 1700 lf		$/Hour	$611.66		
Major Purchased Equipment for Dredge/Levee Construction (Two Independent Crews)					
Push Boat Tug, 500 hp	6	ea	$450,000	$2,700,000	3 units required
Excavator, Liebherr P995 (or Equal)	2	ea	$6,057,900	$12,115,800	
Modular Barges (See Quote from Poseidon Barge)	2	lot	$11,481,048	$22,962,096	Price includes Sales Tax but not freight
Modular Barges Freight Estimate (See Quote from Poseidon Barge)	166	loads	$9,037	$1,500,200	Shipped from Fort Wayne, IN
Modular Processing Plant 1200 cyh design	2	lot	$5,505,216	$11,010,432	4x300 cyh Plant Escalated plus 20% for sand recovery cyclones
Conveyors, Total of 1700 lf, 8 ea	2	lot	$2,047,400	$4,094,800	
Platework allowance for Dredge Bin and Levee Feed Bin (60 tons each at $5000 per ton)	4	ea	$300,000	$1,200,000	
Ancillary and Support Equipment and Freight at 10% of Primary	2	lot	$1,556,052	$3,112,103	
Spare Parts Inventory at 6% of Primary	6	%	$58,695,431	$3,521,726	
Sales Tax at 8%	8%	%	$34,233,135	$2,738,651	
Freight (Use 15% of Cost)	15%	%	$31,121,032	$4,668,155	
Subtotal Equipment				$69,623,963	
Unit Price for Floating Work Platforms	1	sf	$167.97	$167.97	Equals 3,472,000 Plus freight at $223,400 Divided by 22,000 sf
Major Purchased Equipment for Geotextile Installation (Two Independent Crews)					
Push Boat, 250 hp	4	ea	$250,000.00	$1,000,000	
Work Platform (5000 sf)	10000	sf	$167.97	$1,679,727	
Supply Pontoon	2	ea	$201,567.27	$403,135	
Support Boats	4	ea	$50,000.00	$200,000	
Ancillary and Support Equipment and Freight at 20% of Primary	20	%	$32,828.62	$656,572	
Spare Parts Inventory at 6% of Primary	6	%	$32,828.62	$196,972	
Sales Tax at 8%	8	%	$41,364.06	$330,912	
Subtotal Equipment				$3,939,434	
Furnish and Deliver Materials/Install Materials					
Geotextile 16-Ounce	88,134,035	sf	$0.22	$19,036,952	Includes Freight and Sales Tax
Furnish and Deliver Sheetpile	12,502,450	sf	$7.75	$96,862,731	Vendor Quoted $7 per square foot - Add sales Tax and Freight
					Assume delivery in 20 ton loads at $1500 per load
Install Sheetpile	12,502,450	sf	$11.31	$141,383,956	Quote of $5 to $7 does not include Marine Construction Prevailing wage Labor plus travel and subsistence. Use $6 and assume 60% is labor. $3.60 Labor times 1.56 equals $5.62 Labor. Estimate that barge mounted pile driver will be 2x installation on upland. Use $2.40 times 2 equals $4.80 for equipment. For Double Shift assume shift change productivity loss plus shift differential equals 1 hour lost per day(Add $1,845 for 5254 sf/per day = $0.35) For Two crews use additional cost of 5%

Install Steel Sheetpile for Spillways and Flood Control Structures					
Furnish and Deliver Sheetpile	4,960	Tons	$1,814.40	$8,999,424	
Labor	760,800	sf	$11.50	$8,749,200	
Equipment	760,800	sf	$8.10	$6,162,480	
Average unit price for all steel sheetpiling	760,800		$31.43	$23,911,104	
Quarry Operation and Processing to Produce Project Required Aggregates					
Total Rock Products Required Plus 10% Processing Loss/Stockpiles/Roads/Other Use.	5,703,345	cy			
Calculate Tons of Rock	9,695,686	Tons			Assume 1.7 ton/cy in place
Tons in Stockpile at Quarry Site	1,700,000				
Tons Hauled to Levee	7,995,686				
Tons of Rock products required for Spillway and Flood Control					
Rock required for fill	650,250	tons	$22.35	$38.00	Per CY (Includes a 50% premium on placement)
Rock required for Rip Rap	65,620	tons	$25.88	$44.00	Per CY (Includes a 100% premium on placement plus $2 per load x 2 for Handling difficulty)
Rock required for concrete aggregate	25,956	tons			
Rock required for road base/structural fill	52,866	tons			
Rock products required for Spillways and flood control	794,692				
Cost for Quarry Drill, Blast Load and Haul to Course Ore Stockpile	1	Tons	$6.54		Unit price from Mine estimate in 2015 adjusted for Wage Rate and Economy of Scale. Adjust for 60-hour week at 397/303 = 1.31*2.83 + 2.83 = 6.54
Capital Equipment Required to Quarry					Escalated 6% (2012 to 2015)
Drills	2	ea	$806,660	$1,613,320	
Shovel	1	ea	$1,745,820	$1,745,820	
Trucks	3	ea	$780,160	$2,340,480	
Wheel Loader	1	ea	$840,580	$840,580	
Dozers	2	ea	$1,057,880	$2,115,760	
Water Truck	1	ea	$680,520	$680,520	
Motorgrader	1	ea	$810,900	$810,900	
Subtotal Primary Equipment				$10,147,380	
Ancillary and Support Equipment and Freight at 20% of Primary				$2,029,476	
Spare Parts Inventory at 6% of Primary				$608,843	
Total Capital Equipment for Quarry Operation				$12,785,699	
Estimate Office, Warehouse, Maintenance Shop Including Services	15840	sf	$150.00	$2,376,000	Office 24x60, Warehouse/Dry 60x80, Maint Shop 80x120
Total Capital Cost for Quarry				$15,161,699	
Rock Processing Units					
Crushers	2	ea	$884,000	$1,768,000	
Cone Crushers and Screens	3	ea	$1,170,000	$3,510,000	
Conveyors	4	ea	$292,030	$1,168,120	
Conveyors	5	ea	$223,130	$1,115,650	
Stackers	2	Ea	$111,512	$223,024	
Subtotal Processing Equipment				$7,784,794	
Ancillary and Support Equipment and Freight at 20% of Primary				$1,556,959	
Equipment Installation at 50% of Capital Cost				$4,670,876	
Spare Parts Inventory at 6% of Primary				$467,088	
Total Capital Cost for Processing				$14,479,717	

Capital Cost for Haul					
Haul Trucks, 13 cy per load	32	ea		$6,089,472	
Loader 5 cy	2	ea		$689,040	
Subtotal Haul Equipment				$6,778,512	
Ancillary and Support Equipment and Freight at 20% of Primary				$1,355,702	
Spare Parts Inventory at 6% of Primary				$406,711	
Total Capital Cost for Haul				$8,540,925	
Mobilization Calculations					Use labor rate of $146.00 for Marine and $110.00 for upland
Conduct Dredging Demonstration Project	0.5	Mile	$12,400,000.00	$6,200,000	Use 150% of Rate for 66.7 miles of Levee
Conduct Geotechnical Investigation and Obtain Detailed Bathymetry	1	Lot	$2,239,680.00	$2,239,680	on average at $5,000 plus Engineers and preparation of Report of 2000 manhours. Bathymetry Allowance of $250,000
Mobilize Men and Equipment for Sheetpile and Levee Construction	1	Lot	$3,111,000.00	$3,111,000	Mobilize 310 People Plus 100 Major Loads Plus 100 Minor Loads Plus Facilities
Mobilize Men and Equipment for Quarry Setup and Operation	1	Lot	$819,000.00	$819,000	Mobilize 90 People Plus 30 Major Loads Plus 60 Minor Loads Plus Facilities
Install Project Offices, Laydown and Maintenance Areas, Warehousing and Storage Areas	1	Lot	$5,209,600.00	$5,209,600	Allowance for 20 people for 8 months
Receive and Laydown Barges, Dredge, and Process Equipment	1	Lot	$2,344,320.00	$2,344,320	Allowance for 12 people for 6 months
Receive and Laydown Sheetpile and Other Miscellaneous Materials Incorporated in the Work	1	Lot	$976,800.00	$976,800	Allowance for 6 people for 5 months
Install Dredge and Levee Construction Components and Pre-Operational Testing	1	Lot	$13,829,120.00	$13,829,120	2 crews of 20 people for 8 months (Overlap)
Dismantle Dredging Equipment and Remove from Site	1	Lot	$5,185,920.00	$5,185,920	Crew of 24 people for 5 months
Demobilization of Facilities Not Required for OM&M and Final Site Cleanup	1	Lot	$7,032,960.00	$7,032,960	Crew of 24 people for 9 months
Demobilization of Equipment and Reclamation/Revegetation and Closure of the Quarry Site.	1	Lot	$1,562,880.00	$1,562,880	Crew of 12 people for 4 months
Mobilization of Owner Offices/Facilities/Utilities for Oversight of the Project	1	Lot	$2,222,160.00	$2,222,160	Crew of 12 people for 3 months Plus 7000 sf Facilities/Utilities at $150/sf
Armor Block for flood spillway (temporary)	1	sf	$15.00		Assume 8" thick articulated blocks (7.00 purchase + 3.00 deliver + 5.00 Install)

Salton Sea Perimeter Levee Volumes for Phased Approach					
Levee ID	Crew	Reach	Length	Volume/LF	Total Volume
Bowles Rd. to Dirt Rd	1	A	29360	140.93	4,138,000
Dirt Rd to Old Base	1	B	35330	140.93	4,979,000
Old Base to Dirt Road	1	C	16880	140.93	2,379,000
Dirt Rd to Marina	1	D	52630	140.93	7,417,000
Marina to Dirt road	1	E	23800	140.93	3,354,000
Dirt Road to Desert Shores	1	F	19400	140.93	2,734,000
Desert Shores to 81st Ave	1	G	24430	140.93	3,443,000
81st Ave. to Arthur St.	2	H	35230	224.74	7,918,000
Arthur St to North Shore YC	2	I	16460	140.93	2,320,000
North Shore YC to Dirt Rd	2	J	21490	140.93	3,028,000
Dirt Rd to Durmid	2	K	25270	140.93	3,561,000
Durmid to Dirt Rd	2	L	25160	140.93	3,546,000
Dirt Rd to Bombay Beach	2	M	26740	140.93	3,768,000
				Total Volume	**52,585,000**

Volumes By Phase	
Phase	Volume
1	28,444,000
2	24,141,000
Total	52,585,000

Volumes by Phase

Haul Calculation

						Load	2 min		13 cy		Labor Factor		303%		2 min	7.5 cy	
Haul From Quarry to Access Points				Total	4,703,345	Unload	1 min			Haul from Access points to Levee					1 min		
						loaded											
Point	Haul Dist	Levee	%	Cy to Point	Haul loaded speed	Return Empty speed	Total trip(min)	Trips	Total Hours	Point	Haul Dist	CY to Levee	Ave Trip Speed	Total trip(min)	Trips	Total Hours	
12	40	7	10%	491,394	50	55	95	37,800	59,620	12	9	491,394	25	25	65,519	26,863	
11	35	4	6%	280,797	50	55	83	21,600	29,945	11	6	280,797	25	17	37,440	10,857	
10	31	4	6%	280,797	45	50	82	21,600	29,352	10	6	280,797	25	17	37,440	10,857	
9	27	3	4%	210,598	45	50	71	16,200	19,278	9	5	210,598	25	15	28,080	7,020	
8	24	5	7%	350,996	40	45	71	27,000	31,950	8	7	350,996	25	20	46,799	15,444	
7	11	6	9%	421,195	45	50	31	32,400	16,668	7	8	421,195	25	22	56,159	20,779	
6	7	5	7%	350,996	40	45	23	27,000	10,275	6	7	350,996	25	20	46,799	15,444	
5	8	5	7%	350,996	35	40	29	27,000	12,921	5	7	350,996	25	20	46,799	15,444	
4	10	7	10%	491,394	35	40	35	37,800	22,140	4	9	491,394	25	25	65,519	26,863	
3	22	7	10%	491,394	40	45	65	37,800	41,160	3	9	491,394	25	25	65,519	26,863	
2	20	6	9%	421,195	45	50	54	32,400	28,980	2	8	421,195	25	22	56,159	20,779	
1	28	8	12%	561,593	50	55	67	43,199	48,344	1	10	561,593	25	27	74,879	33,696	
		67	1	4,703,345				361,796	350,631	Truck Hours					627,113	230,908	Truck Hours
									389,590	Truck Hours at 90%						256,565	Truck Hours at 90%
							Total days		1330					Total days		1173	
							At 10 hrs		13299					At 10 hrs		11731	

Trucks Required Calculated			29.30		
				1.08	Tax
Purchase Trucks	32	$176,200	$5,638,400	$6,089,472	
Purchase Loaders	2	$319,000	$638,000	$689,040	
Operating Per Hour	29	$42.98	2	$56.28	
	29	$136.88	2	$144.45	
		$179.86		$200.74	
Use		$186.31		$209.18	
		$72,584,667		$5,563,639	

			21.87		
				1.08	Tax
Purchase Trucks	24	$93,400	$2,241,600	$2,420,928	
Purchase Loaders	2	$176,000	$352,000	$380,160	
Operating Per Hour	22	$23.35	2	$38.44	
	22	$136.88	2	$144.45	
		$160.23		$182.90	
Use		$163.73		$188.66	
		$42,007,687		$4,426,471	

Property Calculation

Quarry/Project Laydown/ Offices/Access Points/Stockpiles Property Required

Utilities 16200

Desert 5400 Per acre

Point/Location	Stored CY from above	cf/10-feet/43560 Approximate Acres Needed	Spillways Use	Notes	Value of Ar	Lease at .0.36% per Mo x 2 Points at 50% o	Months	Lease Purchase Cost
12	491,394	30	40	Lease for Project Duration	216000	$1,555	54	$83,981
11	280,797	17	20	Lease for Project Duration	108000	$778	54	$41,990
10	280,797	17	20	Lease for Project Duration	108000	$778	54	$41,990
9	210,598	13	15	Lease for Project Duration	81000	$583	54	$31,493
8	350,996	22	30	Lease for Project Duration	162000	$1,166	54	$62,986
7	421,195	26	30	Lease for Project Duration	162000	$1,166	54	$62,986
6	350,996	22	25	Lease for Project Duration	135000	$972	54	$52,488
5	350,996	22	25	Lease for Project Duration	135000	$972	54	$52,488
4	491,394	30	30	Lease for Project Duration	162000	$1,166	54	$62,986
3	491,394	30	30	Lease for Project Duration	162000	$1,166	54	$62,986
2	421,195	26	30	Lease for Project Duration	162000	$1,166	54	$62,986
1	561,593	35	40	Lease for Project Duration	216000	$1,555	54	$83,981
SSA Administration			10	Purchase for Long Term Use. Say 30	162000			$162,000
Contractors Facilities			120	Lease for Project Duration	648000	$4,666	108	$503,885
Quarry/Process/Batch Plant			320	Duration + Royality Payment of 2.00 per ton removed from the Site	1728000	$12,442	108	$1,343,693
Long Term Stockpile	1,000,000	62	120	Purchase for Long Term Use	648000			$648,000
							Total	$3,360,917

COST ESTIMATE

EM,S CCode	ITEM AND DESCRIPTION	QUANTITY	UNIT	UNIT COST	SUB-CONT.	TOTAL
	Salton Sea Restoration					
	Details of Estimate Components					
	Install North Shore Bellmouth Spillway and Flood Control Weir and Discharge Structure					
	Bellmouth Spillway Installation					
	Construct causeway from shore to levee location (included in estimate item 10)					
S	Allowance to extend causeway to Spillway Location (300 lf)	15,600	cy	$22.35	$348,706	$348,706
S	Drive sheetpiles for double wall cofferdam	220,800	sf	$31.43	$6,939,500	$6,939,500
S	Dewater cofferdam and remove unsuitable material (2-feet)	5,100	cy	$33.30	$169,830	$169,830
S	Place fill for cofferdam	43,400	cy	$25.60	$1,111,040	$1,111,040
S	Install cross ties (assume 10-feet c-c)	266	ea	$2,430.00	$646,380	$646,380
S	Place road base on cofferdam road	5,100	cy	$37.80	$192,780	$192,780
S	Dewater inside of cofferdam (10 cfs for 2.3 million)(allowance for labor/pump/hoses)	65	hours	$300.00	$19,500	$19,500
S	Excavate for inlet structure and box culvert including fill and seepage control	44,800	cy	$6.00	$268,800	$268,800
S	Place 2-feet structural fill under inlet structure and box culvert	5,800	cy	$37.80	$219,240	$219,240
S	Install foundation piles (four clusters of 12 each)	48	each	$6,000.00	$288,000	$288,000
	Install Bell/Drop inlet structure concrete					
S	Base	117	cy	$400.00	$46,800	$46,800
S	Walls	192	cy	$740.00	$142,080	$142,080
S	Floors	109	cy	$1,010.00	$110,090	$110,090
S	Bell	70	cy	$1,500.00	$105,000	$105,000
S	Furnish, deliver and install sluice gate valves (8x8-feet)	3	each	$160,000.00	$480,000	$480,000
S	Furnish, deliver and install precast box culvert	1,000	lf	$2,480.00	$2,480,000	$2,480,000
S	Furnish, deliver and install building/security structure for spillway inlet	1,050	sf	$250.00	$262,500	$262,500
S	Backfill for inlet structure and box culvert	30,900	cy	$22.35	$690,706	$690,706
S	Install discharge structure at outlet of box culvert (allowance)	100	cy	$740.00	$74,000	$74,000
S	Place riprap for discharge structure including excavation/geotextile as needed	3,000	cy	$44.00	$132,000	$132,000
	Install Flood Control Weir and Discharge Structure					
	Construct causeway from shore to levee location (included in estimate item 10)					
S	Allowance to extend causeway to Weir Location (500 lf)	25,900	cy	$22.35	$578,941	$578,941
S	Drive sheetpiles for levee low permeability core core	98,400	sf	$31.43	$3,092,603	$3,092,603
S	Dewater low permeability core and remove unsuitable material (2-feet)	2,700	cy	$33.30	$89,910	$89,910
S	Place low permeability fill	25,700	cy	$25.60	$657,920	$657,920
S	Install cross ties (assume 10-feet c-c)	100	ea	$2,430.00	$243,000	$243,000
S	Place pile caps to form broadcrested weir	710	cy			
S	Place levee fill (rockfill from quarry)	194,300	cy	$22.35	$4,343,176	$4,343,176
S	Allowance to Install Armor Block on inside Levee Face	259,600	sf	$15.00	$3,894,000	$3,894,000
S	Install Concrete face on spillway as interior sea level reduces	11,500	cy	$400.00	$4,600,000	$4,600,000
	Install Sill and plunge pool at spillway discharge					
S	Install sill structure including cutoff wall	3,330	cy	$570.00	$1,898,100	$1,898,100
S	Plunge pool/stilling area excavation	37,000	cy	$4.00	$148,000	$148,000
S	Plunge pool/stilling area rock fill (80% of excavation)	29,600	cy	$44.00	$1,302,400	$1,302,400
	Total for North Shore				$35,575,003	$35,575,003
	Install Bombay Beach Bellmouth Spillway and Discharge Structure					
	Construct causeway from shore to levee location (included in estimate item 10)					
S	Allowance to extend causeway to Spillway Location (500 lf)	25,900	cy	$22.35	$578,941	$578,941
S	Drive sheetpiles for double wall cofferdam	220,800	sf	$31.43	$6,939,500	$6,939,500
S	Dewater cofferdam and remove unsuitable material (2-feet)	5,100	cy	$33.30	$169,830	$169,830
S	Place fill for cofferdam	43,400	cy	$25.60	$1,111,040	$1,111,040
S	Install cross ties (assume 10-feet c-c)	266	ea	$2,430.00	$646,380	$646,380
S	Place road base on cofferdam road	5,100	cy	$37.80	$192,780	$192,780
S	Dewater inside of cofferdam (10 cfs for 2.3 million)	65	hours	$300.00	$19,500	$19,500
S	Excavate for inlet structure and box culvert including fill and seepage control	44,800	cy	$6.00	$268,800	$268,800
S	Place 2-feet structural fill under inlet structure and box culvert	5,400	cy	$37.80	$204,120	$204,120
S	Install foundation piles (four clusters of 12 each)	48	each	$6,000.00	$288,000	$288,000
	Install Bell/Drop inlet structure concrete					
S	Base	117	cy	$400.00	$46,800	$46,800
S	Walls	192	cy	$740.00	$142,080	$142,080
S	Floors	109	cy	$1,010.00	$110,090	$110,090
S	Bell	70	cy	$1,500.00	$105,000	$105,000
S	Furnish, deliver and install sluice gate valves (6x6-feet)	3	each	$90,000.00	$270,000	$270,000
S	Furnish, deliver and install precast box culvert	1,000	lf	$1,870.00	$1,870,000	$1,870,000
S	Furnish, deliver and install building/security structure for spillway inlet	1,050	sf	$250.00	$262,500	$262,500
S	Backfill for inlet structure and box culvert	33,100	cy	$22.35	$739,882	$739,882
S	Install discharge structure at outlet of box culvert (allowance)	100	cy	$740.00	$74,000	$74,000
S	Place riprap for discharge structure including excavation/geotextile as needed	3,000	cy	$44.00	$132,000	$132,000
	Total for Bombay Beach				$14,171,244	$14,171,244

COST ESTIMATE

EM,S CCode	ITEM AND DESCRIPTION	QUANTITY	UNIT	UNIT COST	SUB-CONT.	TOTAL
	Salton Sea Restoration					
	Details of Estimate Components					
	Install Southwest Bellmouth Spillway and Discharge Structure					
S	Construct causeway from shore to levee location (included in estimate item 10)					
S	Allowance to extend causeway to Spillway Location (500 lf)	25,900	cy	$22.35	$578,941	$578,941
S	Drive sheetpiles for double wall cofferdam	220,800	sf	$31.43	$6,939,500	$6,939,500
S	Dewater cofferdam and remove unsuitable material (2-feet)	5,100	cy	$33.30	$169,830	$169,830
S	Place fill for cofferdam	43,400	cy	$25.60	$1,111,040	$1,111,040
S	Install cross ties (assume 10-feet c-c)	266	ea	$2,430.00	$646,380	$646,380
S	Place road base on cofferdam road	5,100	cy	$37.80	$192,780	$192,780
S	Dewater inside of cofferdam (20 cfs for 2.3 million)	65	hours	$300.00	$19,500	$19,500
S	Excavate for inlet structure and box culvert including fill and seepage control	44,800	cy	$6.00	$268,800	$268,800
S	Place 2-feet structural fill under inlet structure and box culvert	5,800	cy	$37.80	$219,240	$219,240
S	Install foundation piles (four clusters of 12 each)	48	each	$6,000.00	$288,000	$288,000
	Install Bell/Drop inlet structure concrete					
S	Base	117	cy	$400.00	$46,800	$46,800
S	Walls	192	cy	$740.00	$142,080	$142,080
S	Floors	109	cy	$1,010.00	$110,090	$110,090
S	Bell	70	cy	$1,500.00	$105,000	$105,000
S	Furnish, deliver and install sluice gate valves (8x8-feet)	3	each	$160,000.00	$480,000	$480,000
S	Furnish, deliver and install precast box culvert	1,000	lf	$2,480.00	$2,480,000	$2,480,000
S	Furnish, deliver and install building/security structure for spillway inlet	1,050	sf	$250.00	$262,500	$262,500
S	Backfill for inlet structure and box culvert	30,900	cy	$22.35	$690,706	$690,706
S	Install discharge structure at outlet of box culvert (allowance)	100	cy	$740.00	$74,000	$74,000
S	Place riprap for discharge structure including excavation/geotextile as needed	3,000	cy	$44.00	$132,000	$132,000
	Total for Southwest				$14,957,187	$14,957,187

2016 FEASIBILITY LEVEL COST ESTIMATES
SALTON SEA RESTORATION PLAN

Permitting, Design and Construction of The Salton Sea Restoration Plan Alternative A and Alternative B Estimate Comparison PERIMETER LOW PROFILE LEVEE ALTERNATIVE					
Item	**Description**	**Alternative A ($Millions)**	**Alternative B ($Millions)**	**Difference ($Millions)**	**Comments**
1	**Initial Activities for Project Approval**	$24	$24	$0	
2	**Permitting, Engineering and Procurement**	$27	$28	$1	Additional Procurement and Inspection Expense for Equipment
3	**Construction Management and Support**	$163	$167	$5	Shorter Schedule Offset by Additional Personnel for Two Crews
4	**Salton Sea Authority Management/Other Direct Expenses**	$121	$109	($11)	SSA Management Organization on Site Less Time
5	**Mobilization**	$33	$47	$14	Mobilization and Assembly of Additional Equipment
6	**Quarry Operation and Aggregate Production**	$164	$191	$27	Increased Equipment Production and Operation Schedule
7	**PVC Sheetpile Installation**	$232	$238	$7	Added Another Independent Crew - Unit Price Slightly Higher
8	**Install Spillways and Flood Control Structures**	$65	$65	$0	
9	**Dredging and Levee Construction**	$509	$550	$41	Duplicate Equipment for Second Independent Crew
10	**Grade and Armor Levee/Construct Access Points**	$90	$100	$10	Increased Equipment and Operation Schedule
11	**Other Miscellaneous Works to complete the Project**	$10	$10	$0	Placeholder No Change
12	**OM&M of the Constructed Project (10 Years is Assumed)**	$47	$47	$0	No Change
	Subtotal	**$1,483**	**$1,576**	**$93**	
	Recommended Contingency (15%)	$222	$236	$14	
	Total	**$1,705**	**$1,813**	**$108**	

Appendix C: Perimeter Lake Construction Sequencing

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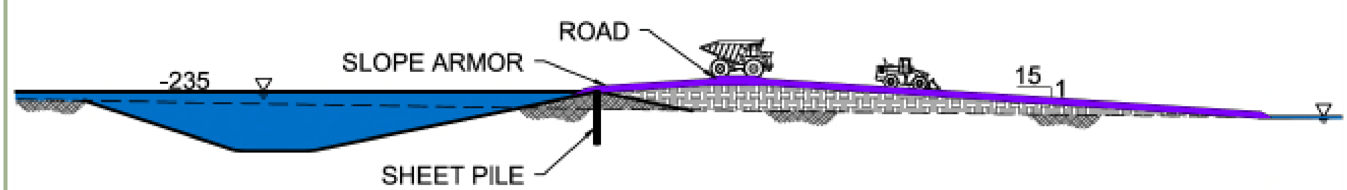
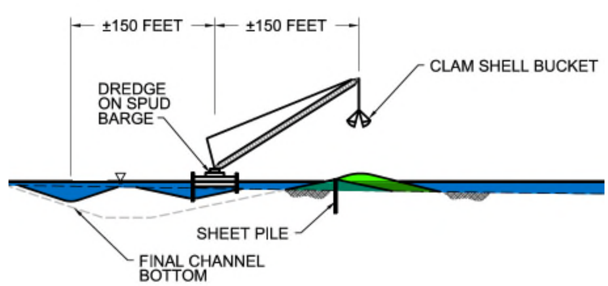
Salton Sea Funding and Feasibility Action Plan

Perimeter Lake Construction Sequencing

Benchmark 4: Volume 2, Technical Appendix C
May 2016





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This document is prepared as a living document for public review and comment. Comments may be provided to:

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Comments will be reviewed and incorporated as appropriate. If substantive comments are received, a revised document may be produced and distributed.

PERIMETER LAKE CONSTRUCTION SEQUENCING
Benchmark 4: Volume 2, Technical Appendix C

11 May 2016

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1.0 Introduction

This appendix provides a conceptual overview of how the construction sequence for the Perimeter Lake. A series of six construction sequence graphics illustrates the series of event that would be involved in successive steps of the levee construction. Each of the six steps is discussed below. A discussion and graphical illustration of some of the key steps in constructing the first cell is presented following the discussion of the levee construction sequence.

2.0 Construction Scenario and Approach

The perimeter levee plan involves some general assumptions regarding the timing and sequencing of construction, in particular the declining water level of the Salton Sea during various phases of the levee construction. It is assumed for the purposes of this feasibility study the levee construction would begin in the wet condition and that the lake would continue to recede throughout the construction period as anticipated. Ultimately, the final portions of construction would be performed in a predominately-dry condition. A geotechnical investigation phase, including borings and cone penetrometer tests, would precede the construction. The geotechnical work would be completed prior to the construction phase illustrated in this appendix.

2.1 Step 1: Sheet Pile Installation

Although the sheet pile installation could be performed after the levee earthwork has been placed, there are several advantages to constructing the sheet piles first (Figure C-1). The sheet pile wall would protrude slightly above the water level and acts as a visible alignment for remaining phases of levee construction. By stacking material behind the sheet pile, some earth retention will aid in stacking height of the dredged material for stockpiling and allows closer access to the levee fill area by the dredge barge.

The vinyl sheet-pile installation would be conducted aboard a jack-up barge using a fixed mast lead rig with steel mandrel and vibratory pile claw. The vinyl sheet piles would be installed approximately 25 ft below the lakebed and range from 35' to 40' in total length. The top of the sheet pile wall would be cut at approximately the Perimeter Lake design water elevation of -235 ft NGVD.

2.2 Step 2: Initial Dredging

The majority of earthwork would be performed by mechanical dredging from a barge illustrated in the Construction Sequence 2 graphic (Figure C-2). The barge-mounted crane would use a 20+ cubic yard clamshell bucket to excavate a channel ahead of the barge. As the level of the Salton Sea retreats, the channel is supplied with water from the New River, enabling the barge to float and move ahead, and therefore continue operation. Spoils from dredging activity are stacked on the interior brine side of the sheet pile.

The dredging operation would utilize the sheet pile to assist in stockpiling of material above the ultimate profile of the levee. This initial upper stockpile allows the initial existing foundation fills to become "surcharged" to assist in settlement and consolidation during the construction phase.

The dredging operation is continuous at two 10-hour shifts per day, for 7 days per week. Over 50 million cubic yards of material would need to be moved, depending on the amount of settlement.

2.3 Steps 3 and 4: Dredging and Stockpiling

As the dredging would continue, a stockpile mound would begin to build up on the Seaside of the sheet pile as illustrated in the Construction Sequence 3 and 4 graphics (Figures C-3 and C-4, respectively). The stockpiling would be accomplished by the mechanical dredge in a series of lifts. Based on geotechnical testing, in those areas needing additional reinforcement, a geotextile fabric would be placed on the seafloor prior to stockpiling. The geotextile fabric would be placed by rolling out from a barge. As the construction sequencing continues, it is expected the level in the lake would continue to drop, which would leave more and more of the stockpiled material above water level. The saturated soils stockpiled would slowly dewater over time and could be reshaped and compacted later.

The channel in which the barge is floated and moved along the levee construction area would continue to be excavated as the material is stockpiled. Construction Sequence 4 shows a wedge of material above the final channel bottom, which is indicated with a dashed line. This material would be removed and used as fill during the grading and compaction stage of construction, when the lake level has dropped.

2.4 Step 5: Grading and Compaction and Armoring

The Construction Sequence 5 graphic (Figure C-5) illustrates a later phase of construction when the stockpiled material has dried for a while and can be re-graded and compacted. The grading and compaction would be accomplished with standard earth moving equipment which would access the levee area from the land side from the initial levee shoreline connection of from one of the cell dividing causeways.

2.5 Step 6: Armoring and Final Grading

The Construction Sequence 6 graphic(Figure C-6) illustrates the final phase of construction when the top of the levee would be armored with Class II road base material would be placed along the top of the levee and side slopes. This phase would include final grading of the roadway along the top of the levee. Once the levee construction is complete and the causeway and culverts are installed to close the cell, the cell could be filled to design water level of -235 feet NGVD. The top of the levee would be at -230 feet NGVD, with the road built atop of this elevation. Filling would be accomplished with water from the New River.

3.0 Initial Cell Construction

A conceptual plan for construction of the initial cell is illustrated in Figure C-7. The graphic illustrates a sequence of events envisioned for the construction of the first cell starting near the mouth of the New River. The steps for construction of the initial cell are illustrated with numbers in circles. Each phase is discussed briefly below:

1. Initial project startup would involve the construction of an access road and project wharf and launch area to be constructed with imported fill.
2. Next, a diversion structure, diversion channel and culverts would be constructed to divert water from one side of the construction area to the other. During various phases of construction, it would be beneficial to divert water from one side to the other depending on the specific needs as the construction progresses. At certain times, it would be beneficial to divert water away from the cell and at other times, to divert it into the cell.
3. After Steps 1 and 2 are complete, vinyl sheet pile installation could begin along the levee alignment.
4. Following sheet pile installation, dredging could begin along with stockpiling of dredge material as discussed in Section 2.0 of this appendix report.
5. Dredging of the channel would proceed past the location of the first causeway, creating a channel for the continuing operation of the dredge as the water level in the Salton Sea may be declining. After the channel is dredged far enough into the next cell area to allow for operation of the dredging functions in Cell 2, the causeway could be closed. The causeway would be closed from the landside and culverts could be installed to allow ultimate passage of water from Cell 1 to Cell 2 once all construction sequences are completed as discussed in Section 2.0 of this appendix.

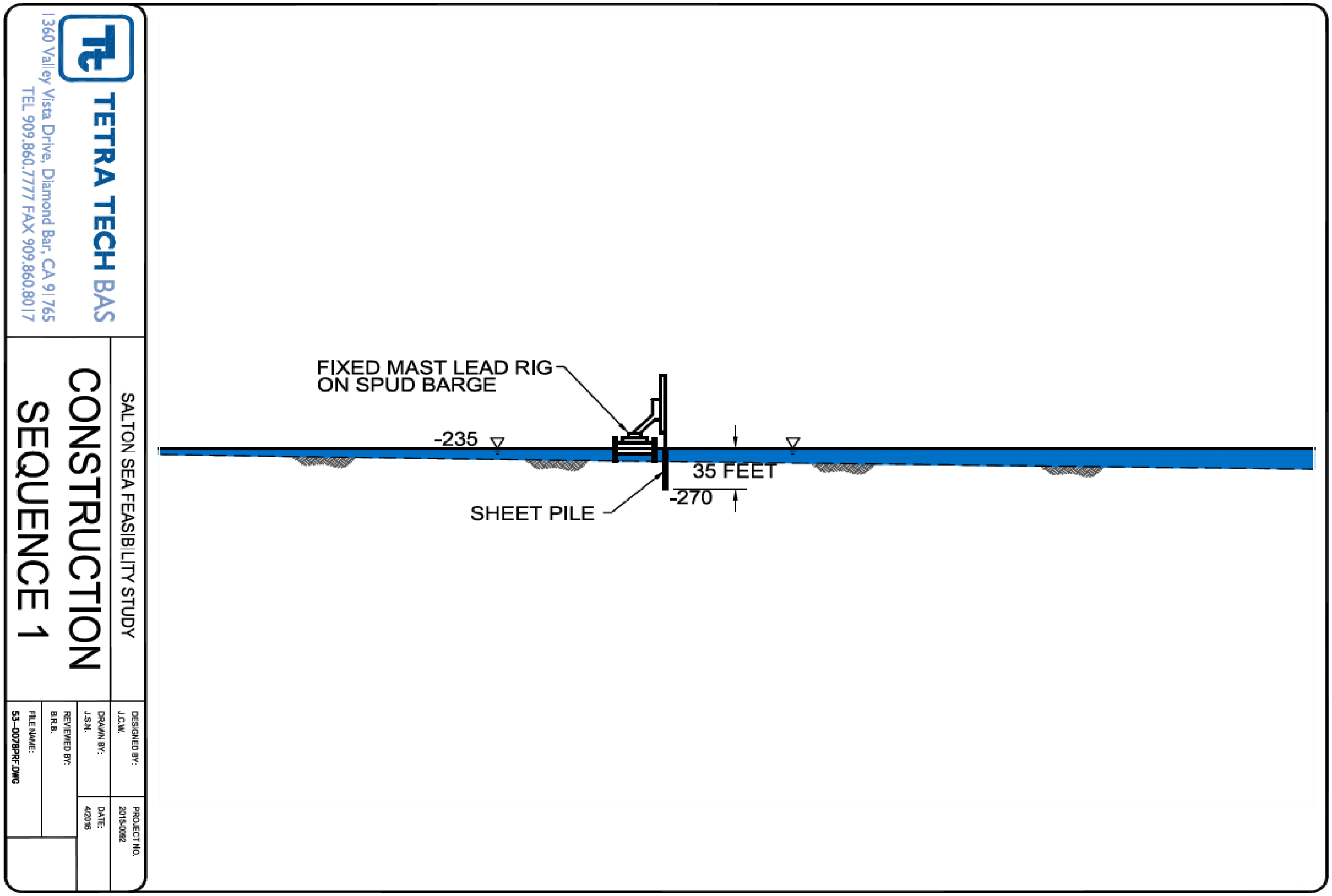

Figure C-1. Construction Sequence 1.

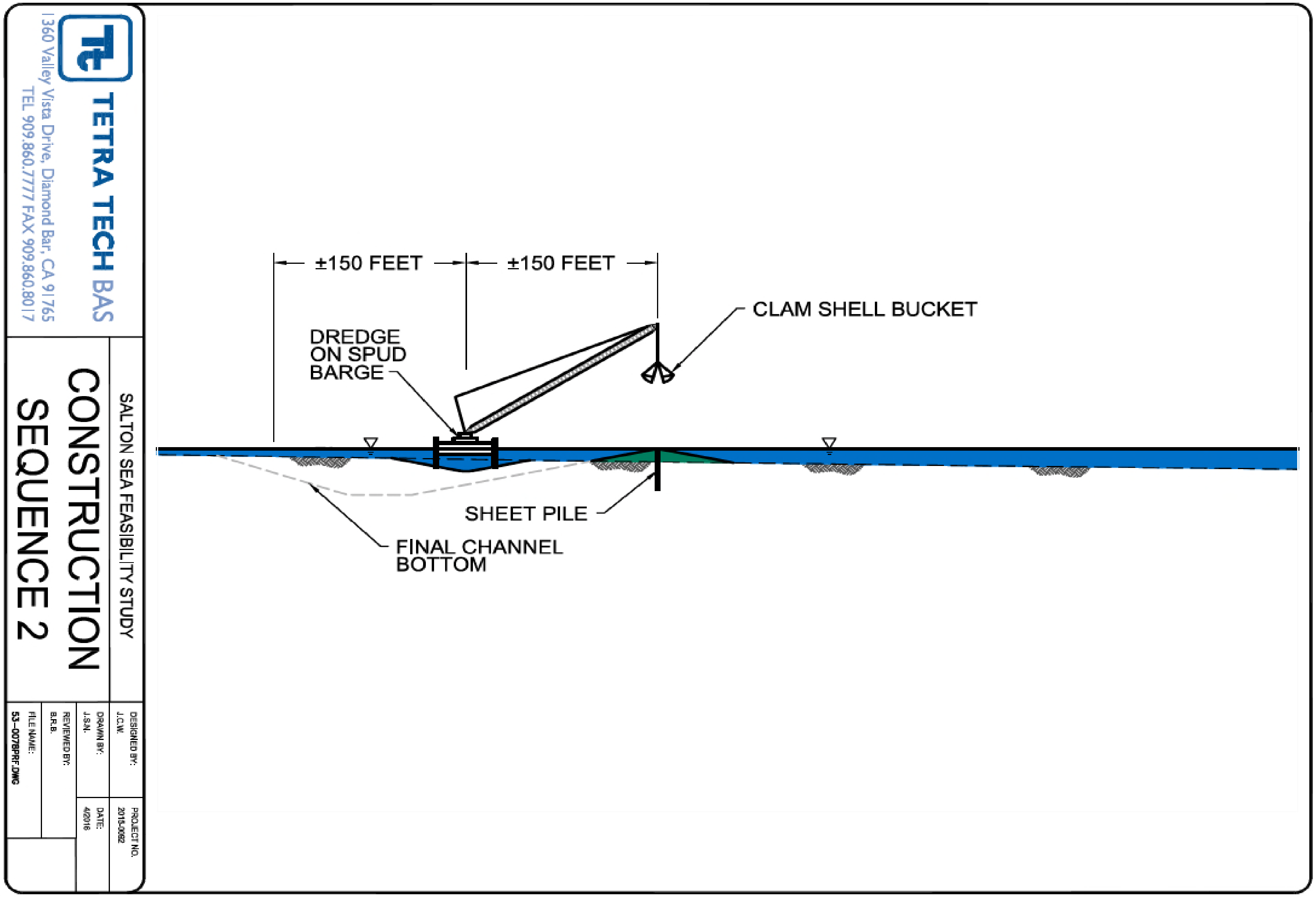

Figure C-2. Construction Sequence 2.

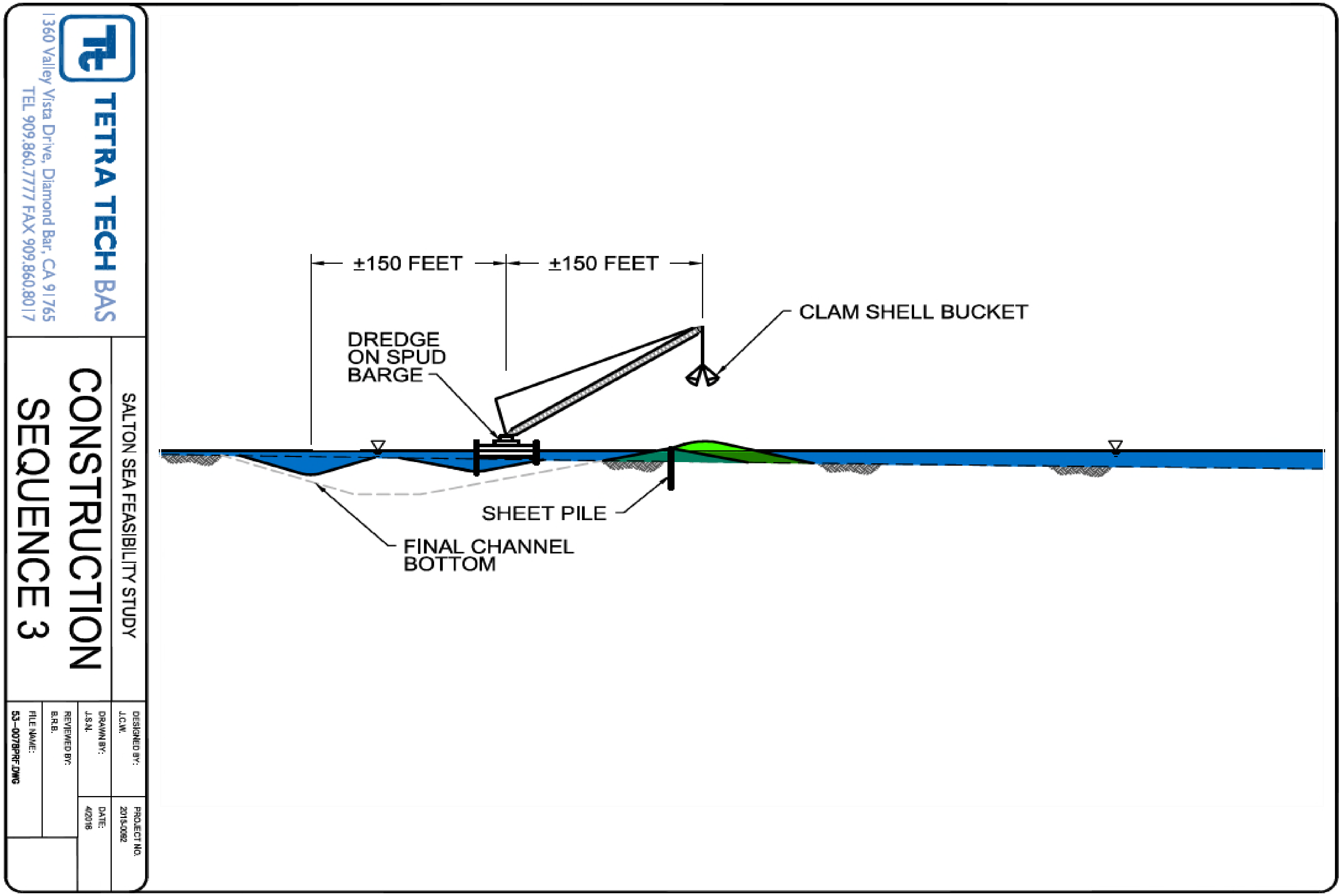

Figure C-3. Construction Sequence 3.

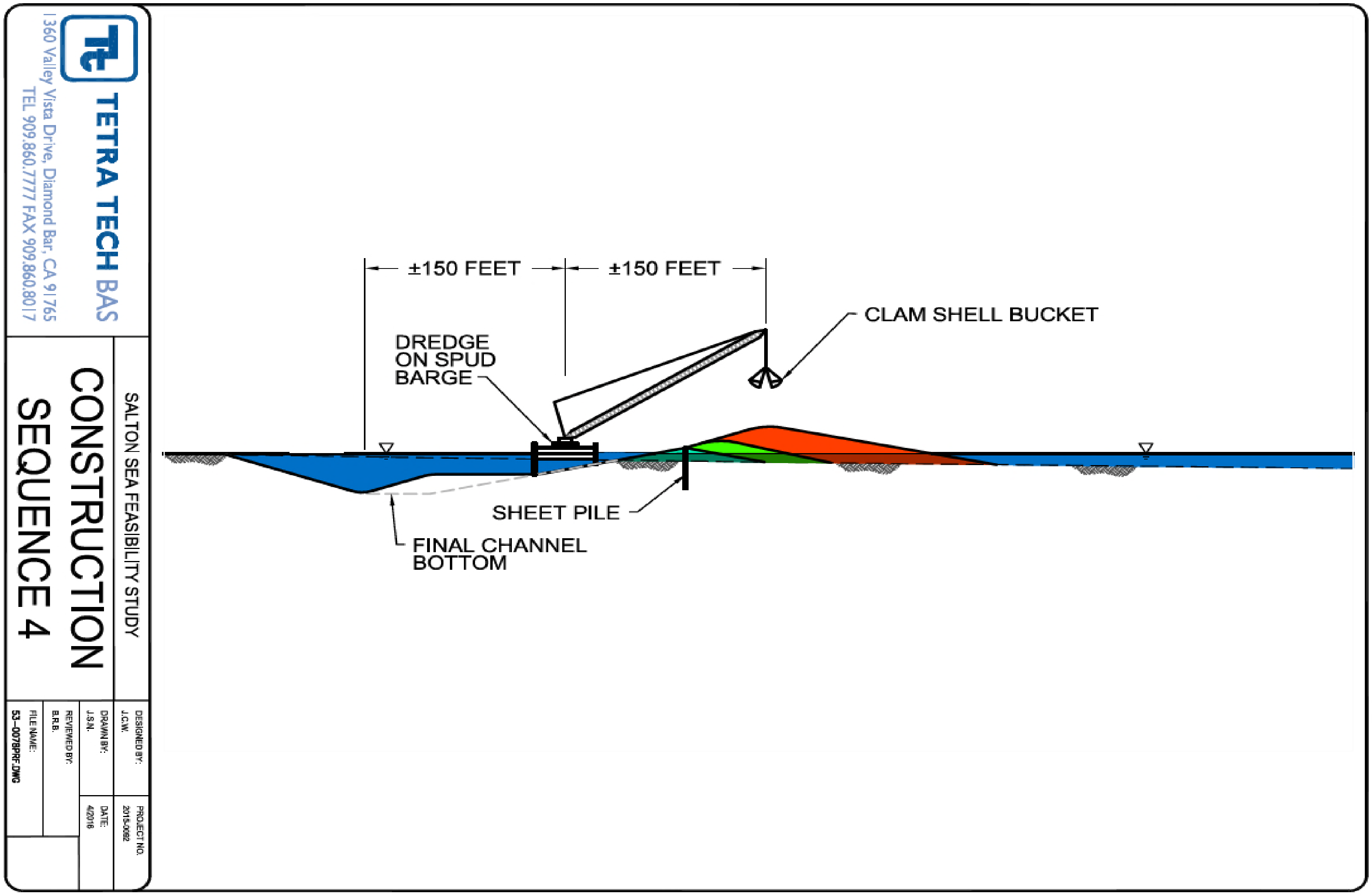

Figure C-4. Construction Sequence 4.

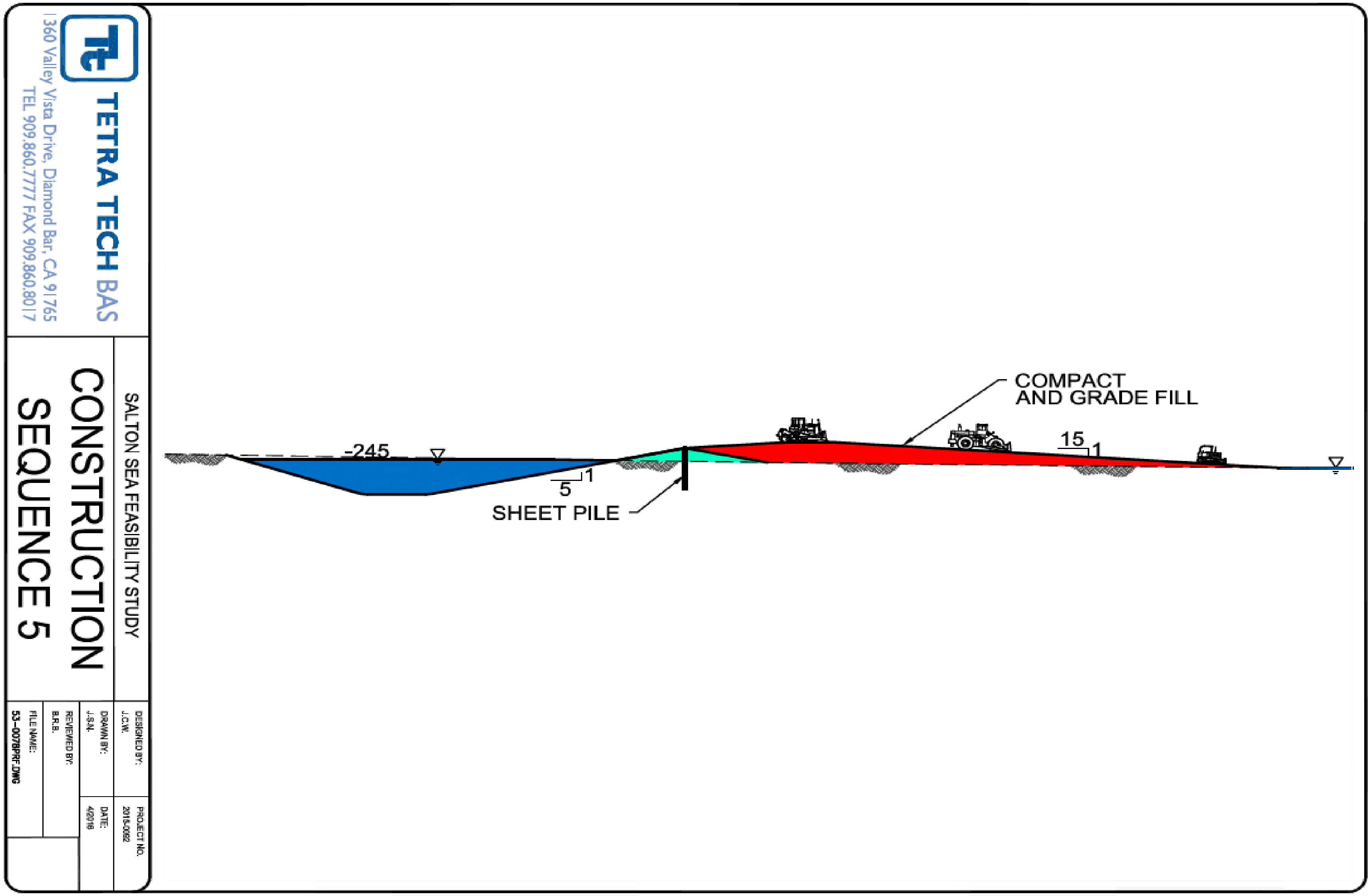

Figure C-5. Construction Sequence 5.

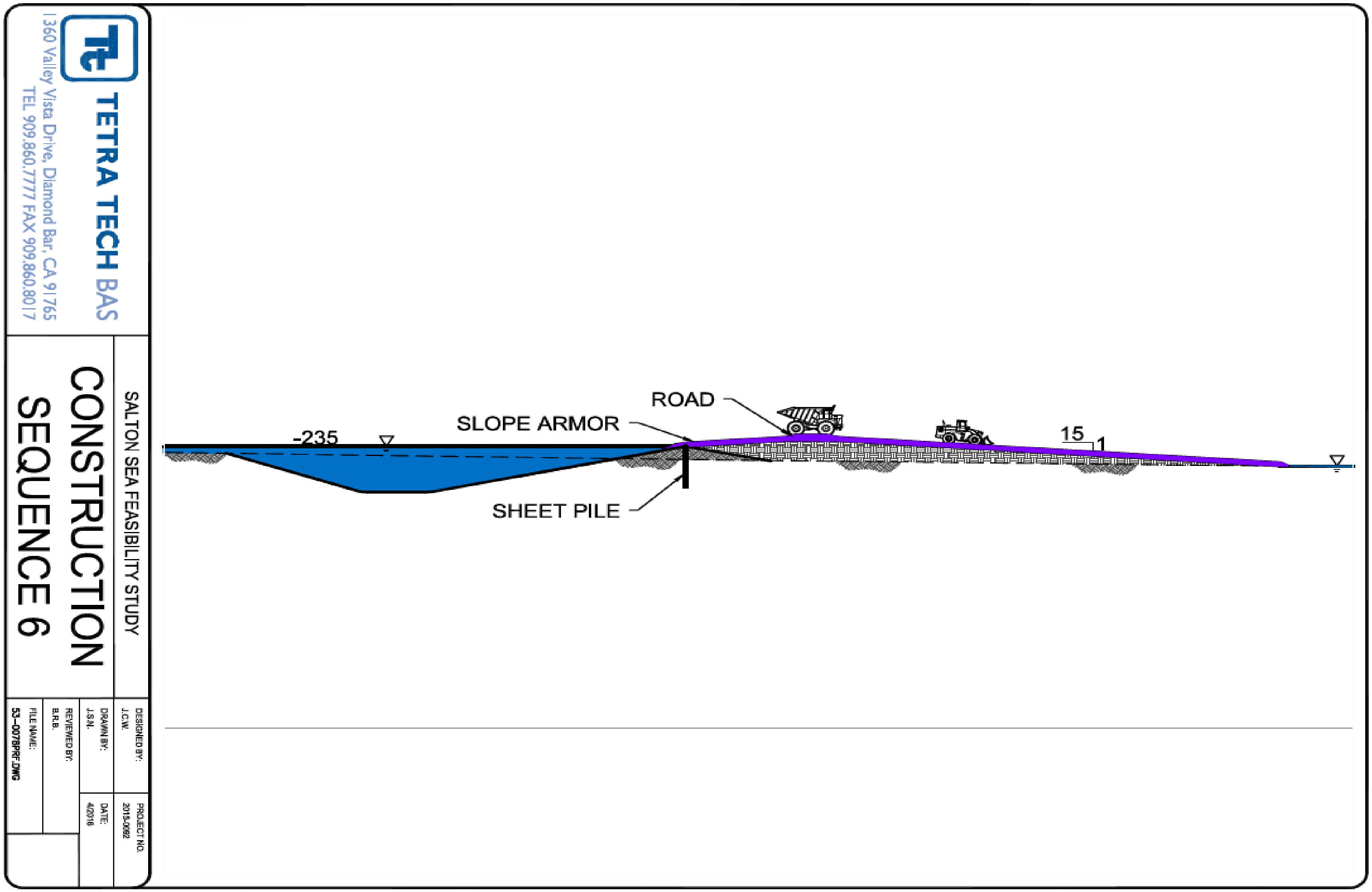

Figure C-6. Construction Sequence 6.

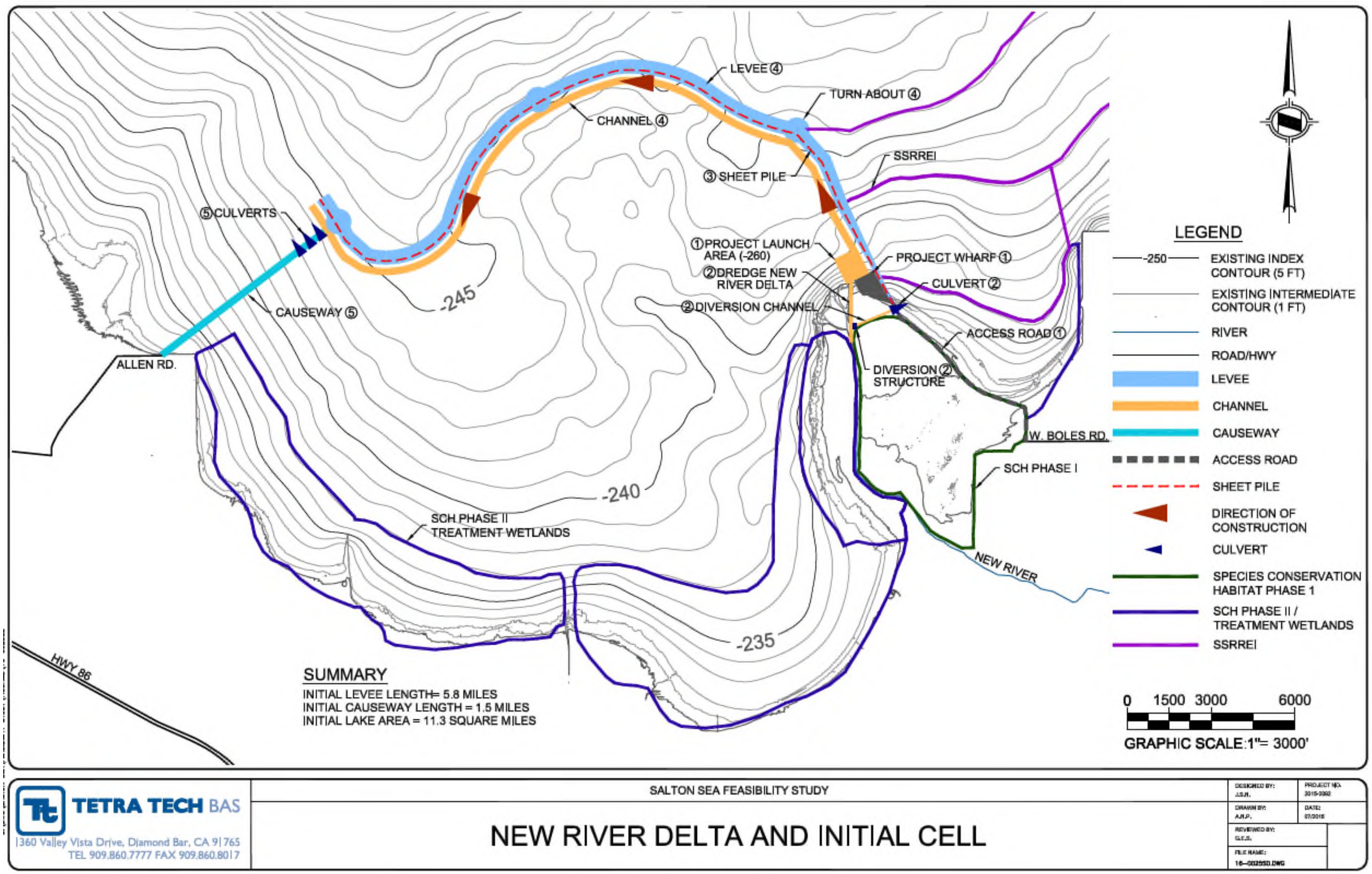

Figure C-7. Initial Cell Construction.